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SYNTHESIS, CHEMICAL ANALYSIS AND ANTIMICROBIAL STUDIES OF PLATINUM AND COPPER COMPLEXES OF CONDENSATES OF SALICYLALDEHYDE AND 2-HYDROXYANILINE

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ABSTRACT

The incidence of drug resistance to microbes causing diseases to man and animal, even plants have necessitated further research towards development of molecular compounds that would break the barrier of resistance, guarantee safety and potency of pharmaceutical products. This study synthesis, chemical analysis and antimicrobial studies of Platinum(II) and Copper (II) as well as their mixed ligand of 2-Phenyliminomethylphenol (PMP) and 2,2-Hydroxybenzylideneaminophenol (HAP) is one of such attempts of development of new molecular compounds capable of breaking the barrier of resistances. The PMP and HAP were prepared by reacting Aniline and 2-aminophenol with salicylaldehyde respectively. The unmixed metal complexes were prepared by addition of either of 0.29 mmol 2-phenyliminomethylphenol ligand into the metal salt or 0.29 mmol 2,2-hydroxybenzylideneaminophenol ligand into the metal salt, while the mixed metal complexes were prepared by addition of equimolar amount of ligands of 2-Phenyliminomethylphenol and 2,2-Hydroxybenzylideneaminophenol into the metal salt. The molecular structures of the ligand and their complexes have been determined and characterized using spectroscopic techniques which includes GC-MS, FTIR, UV-Vis, ^{1}HNMR, and X-Ray Diffraction studies. The melting point and solubility of the ligands and complexes synthesized were equally determined. Antimicrobial Screening were carried with ligands PMP and HAP and the metal complexes using clinical isolates of Gram Positive Bacteria (Staphylococcus aureus and Bacillus substilis), Gram Negative Bacteria (Escherichia coli and Pseudomonas aeruginosa) and Fungi (Candida albicans and Aspergillus niger). All complexes and ligands were found to be soluble in dimethylsulfoxide (DMSO). The molecular ion, molecular weight and molecular formula of the synthesized ligands and metal complexes were detected using the various fragments produced by the ligands and metal complexes based on their mass to charge ratio obtained from GC-MS spectra. Asymmetric octahedral geometry was observed for both Platinum(II) and Copper(II) complexes with PMP, HAP, and mixed ligands. A bidentate ligand is coordinated to the metal ions through oxygen atoms of carbonyl groups and nitrogen atoms of two imine groups for Platinum(II) and Copper(II) complexes. The XRD pattern indicates that the ligand and metal complexes are crystalline with high crystallite size of 119.23 nm to 638.67 nm. The FTIR spectra for 2-phenyliminomethylphenol (PMP) showed absorbance at the band 1569.2cm^{-1} as indicated by the stretching C=C bond in the benzene rings, bands at 1613.9 cm-^{1} as indicated by =C-N stretching in the benzene ring were actually observed. The electronic spectra of the complexes formed showed energy absorbed in the ultraviolet/visible region produced changes in the electronic energy of the compound resulting from transition of valence electrons in the complexes. The XRD results indicate the crystal formed by the ligands and their respective complexes are large. However, the ligands had higher size compared to the complexes formed, which could be due to the complexation reactions. X-Ray Diffractograms of the metal complexes investigated showed good intense peaks indicating high crystallinity. The ligand of 2-Phenyliminomethylphenol (PMP) and 2,2-hydroxybenzylideneaminophenol (HAP) showed partial inhibitory action on the clinical isolates of Gram Postive, Gram Negative and no inhibitory action on the Fungi while metal complexes of Pt(II), both mixed and unmixed showed either strong or stronger inhibition. Copper(II) was found to differ as its complexes all exhibited stronger inhibition on the clinical isolates of Gram Positve, Gram Negative and Fungi isolates. It was concluded that the synthesized ligands and complexes are purely crystalline as revealed by the chemical analysis, exhibited inhibitory actions on Gram Positive, Gram Negative and Fungi Species.

KEYWORDS: 2-Phenyliminomethylphenol, Metal complexes, Salicylaldehyde, 2-hydroxyaniline, Ligands.

1. INTRODUCTION

The ever growing industrial and technological development combined with the desire for new functions generate enormous enthusiasm among scientists for novel materials (Crichton *et al*., 2008 and Vanparia *et al*., 2010). The ideas of combining organic and inorganic components into a new complex had been done from very ancient times. Organic-inorganic hybrid materials are now interesting research area because of their micro-sized organization, conversion from single functional to multifunctional compounds and wide applications achieved in the field of Biochemistry, Biotechnology and Drug Industry. One such popular approach that has shown rapid growth and wonderful success in recent years is coordination compounds (Vanparia *et al*., 2010). Coordination chemistry is one of the fascinating areas of chemistry. Numerous interesting and important properties of complexes are being investigated. The coordination chemistry of transition metal ions is rapidly increasing owing to the relevance of these compounds in basic and applied research in different scientific areas ranging from chemistry to material science to life sciences (Budimir, 2011).

Rare earth ions possess the properties of antibacterial, antitumor and antivirus agents when coordinated with organic ligands and participate effectively in many important life processes. Many researchers have studied preparation, characterization, antimicrobial, and toxicological activities of mixed ligand complexes of transition metal ions (Zhang *et al*., 2005 and Song *et al*., 2006). Some mixed ligands complexes of derivatives of salicyclic acids and 8-hydroxyquinoline were reported and proved to be valuable as fungistatic agents. On the other hand, a growing interest is being evidenced in the study of mixed ligand complexes which might serve as models for biochemical reactions (Budimir, 2011; Patel and Patel, 2017).

One of the complexing agents that is of great importance in coordination and analytical chemistry is salicylaldehyde. It is also important in other fields of chemistry, as well as in biology and medicine. Due to the fact that many of the important functions of salicylaldehyde occur through metal ion complexation, studies have focused on developing metal complexes involving salicylaldehyde. Salicylaldehyde (C_6H_4CHO-2-OH) is colorless oily liquid with a bitter taste, and has an almond odour at higher concentration. Salicylaldehyde is a key precursor to a variety of chelating agents, some of which are commercially important. It is a phenolic phytohormone and is found in plants, where it performs roles in plant growth and development. Salicylaldehyde is biosynthesized from the amino acid phenylalanine and can be produced by sodium salicylate. Salicylaldehyde is prepared in the laboratory from Chloroform by heating with Sodium Hydroxide or Potassium Hydroxide in a Reimer-Tiemann reaction (Bruhne *et al*., 2008). Alternatively, salicylaldehyde is produced by condensation of phenol or its derivation with formaldehyde to give hydroxybenzyalcohol which is oxidized to aldehyde (Trond *et al*., 2005). In modern medicine, salicylaldehyde and its derivatives are used as constituents of some rubefacient products. For example, methyl salicylate is used as a liniment to soothe joint and muscle pain, choline salicylate is used typically to relieve the pain of aphthous ulcers. It is also used as an anti-inflammatory drug (Praveen *et al*., 2016).

Another compound that is of immense importance in formation of metal complexes is 2-amino-phenol. This compound and its isomer 4-aminophenol, are amphoteric molecules and reducing agents, useful for the synthesis of dyes and heterocyclic compounds (Mitchell *et al*., 2002). Reflecting its slight hydrophilic character, it is white powder, moderately soluble in alcohols and can be recrystallized from hot water. They are industrially synthesized by reducing the corresponding nitrophenol by hydrogen in the presence of various catalysts. The nitrophenols can also be reduced with iron (Mitchell *et al*., 2002). The compound exhibits intra- and intermolecular hydrogen bonding involving the neighbouring amine and hydroxyl groups. As a result, 2-aminophenol has a relatively high melting point (174 °C) compared to other compounds with a similar molecular mass; for example, 2-methylphenl melts at 31 °C (Smith *et al*., 2007). 2-Aminophenol has a variety of applications, it is an intermediate in the synthesis of dyes and particularly useful in yielding metal-complex dyes when diazotized and coupled to a phenol, naphthol, or other aromatic or resonant dye species. Metal complex dyes with copper or chromium are commonly used for producing dull colours (Grychtol *et al*., 2002 & Hunger *et al*., 2002).

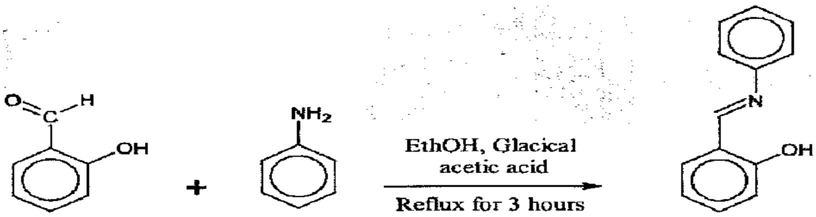
Generally, amine compounds are important compounds used in inorganic chemistry as reagents or intermediates and in many industrial fields (Nugent et al, 2010; Turhan and Yasar, 2020). Aniline, the simplest aromatic amine (Wojcit, 2007), is a very important commodity chemical in coordination chemistry as well as versatile starting material for fine chemical synthesis. One of its large scale use is in the synthesis of methylenedianiline (a precursor to polyurethanes) and related compounds by condensation with formaldehyde (Karl *et al*., 2007; Huang *et al*., 2013). Various oxidizing agents convert aniline to quinone, azobenzene, nitrosobenzene, *p*-aminophenol, and the phenazine dye aniline black (Caskey *et al*., 1985; Karl *et al*., 2007). Different substituted amine derivatives can be obtained by reducing the imines such as 2-phenyliminomethylphenol (PMP) and 2,2-hydroxybenzylideneaminophenol (HAP). Most bioactivities of PMP and HAP originate from their chelating ability. As previously mentioned, metal imbalance is the leading cause for many diseases, therefore, PMP and HAP are potent chelators that may restore metal balance and be useful for the treatment of metal-related diseases. Other important applications have been used extensively to construct highly sensitive fluorescent chemosensors for sensing and imaging of metal ions of important biological and environmental significance (Swetha *et al*., 2019 & Mason *et al*., 2020).

Coordination compounds, otherwise known as complex compounds, are molecules formed by complexation reaction which possess one or multiple metal centers that are 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 (Jackson *et al*., 2004). A metal ion in solution does not exist in isolation, but in combination with ligands such as solvent molecules or simple ions or chelating groups, giving rise to complex ions or coordination compounds. These complexes contain a central atom or ion, often a transition metal, and a cluster of ions or neutral molecules surrounding it. Ligands are ions or neutral molecules that bond to a central metal atom or ion. Ligands act as Lewis bases (electron pair donors), and the central atom acts as a Lewis acid (electron pair acceptor). Ligands have at least one donor atom with an electron pair used to form covalent bonds with the central atom. The complexation of metals with ligands can drastically change the physicochemical and biological properties of the metal species (Gua *et al*., 1999). This present study aims to synthesize and characterize Pt(II) and Cu(II) mixed ligand complexes of 2-phenyliminomethylphenol (PMP) and 2,2-hydroxybenzylideneaminophenol (HAP) and to investigate into the antimicrobial inhibitory action of the synthesized complexes.

2. Experimental Procedures

2.1 Synthesis of the ligand 2-phenyliminomethylphenol

Aniline (0.02M) dissolved in 20mL absolute ethanol was added to a solution of salicylaldehyde (0.02M) in 20 mL absolute ethanol contained in 100mL round bottomed flask, few drops of glacial acetic acid was added. The mixture was refluxed on a heating mantle at 50^{o}C and stirred with magnetic stirrer for 3 hours as illustrated in Equation 1. The content was left to cool at room temperature. The yellow precipitate formed was washed several times using deionized water and then cold ethanol. Recrystallization was carried out with hot ethanol and left to dry in air. The yield is 87% and the melting point is 52°C.

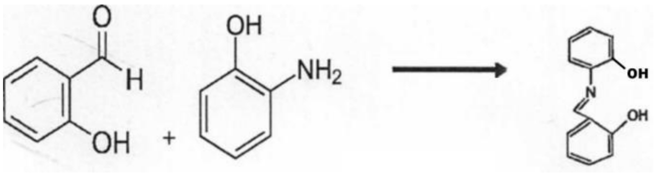


Salicylaldehyde 2-((phenylimino) methyl) phenol

Equation 1. Scheme of reaction for the synthesis of the ligand 2-phenyliminomethylphenol

2.2 Synthesis of the ligand 2,2-hydroxybenzyleneaminophenol

Exactly 5.3 g of salicylaldehyde was refluxed with 5.5 g of 2-aminophenol in ethanol for 2 hours to obtain an orange solution. The solution was reduced under suction and an orange precipitate was obtained in accordance with Equation 2. The precipitate was filtered under suction, washed with ethanol and recrystallized from ethanol. It was dried over silica gel in a desiccator.



Equation 2. Scheme of reaction for the synthesis of the ligand 2, 2-hydroxybenzylideneaminophenol.

2.3 Synthesis of mononuclear metal ligand complexes of 2-phenyliminomethylphenol (PMP)

The metal complexes of Pt(II) and Cu(II) were prepared by addition of 2-phenyliminomethylphenol ligand of 0.29 mmol into 30 mL of ethanol with the metal salts ($PtCl_2$ and $CuCl_2$ of 0.22 g, 1 mmol each. The solution was mixed thoroughly and the resulting mixture was heated under reflux at 60°C for 3 hours and allowed to cool. It was then collected and purified by washing with ethanol and diethyl ether and finally air dried.

2.4 Synthesis of mononuclear metal ligand complexes of 2,2-hydroxybenzylideneaminophenol (HAP)

The metal complexes of Pt (II) and Cu (II) were prepared by addition of 2, 2-hydroxybenzylideneaminophenol ligand of 0.29 mmol into 30 mL of ethanol with the metal salts ($PtCl_2$ and $CuCl_2$) of 0.22 g, 1 mmol. The solution was mixed thoroughly and the resulting mixture was heated under reflux at 60°C for 3 hours and allowed to cool. It was then collected and purified by washing with ethanol and diethyl ether and finally air dried.

2.5 Synthesis of mononuclear metal mixed ligand complexes of 2-phenyliminomethylphenol (PMP) and 2, 2 hydroxybenzylideneaminophenol (HAP)

The metal complexes of Pt(II) and Cu(II) were prepared by addition of 2-phenyliminomethehylphenol ligand (PMP) of 0.29 mmol and 2,2-hydroxybenzylideneaminophenol (HAP) of 0.29mmole into 30 mL of ethanol with the metal salts ($PtCl_2$ and $CuCl_2$) of 0.22 g, 1 mmol each. The solution was mixed thoroughly and the resulting mixture was heated under reflux at 60°C for 3 hours and allowed to cool. It was then collected and purified by washing with ethanol and Diethyl ether and finally air dried.

2.6 Molar conductivity, Infrared, UV and X-ray diffractometric analyses of synthesized metal complexes

Molar conductance for all the complexes were measured by preparing the 10^{-3} M solution in dimethyl sulfoxide (DMSO) as solvent, using conductivity meter of Model EQ664 with inbuilt magnetic stirrer. The infrared spectra of the ligands and complexes were recorded in KBr pellets in the range (400 - 4000 cm-^{1}) on IR Affinity-1S FT-IR spectrophotometer. The electronic spectra (UV analysis) were recorded on Aquamate scientific spectrophotometer model V 4.60. The X-Ray diffraction analysis of the mixed ligand complexes powder form was recorded on X-Ray diffractometer, Smartlab (Model VT/VRH/PXRD350), carried out using CuKa radiation (α=1.54059A), the applied voltage and the tube current was 40Kv.

2.7 Proton nuclear magnetic resonance (H-NMR) spectral analysis

Proton Nuclear Magnetic Resonance Spectral were recorded on Spectrometer. 10mg of the recrystallized 2-PhenyliminomethylPhenol (PMP) and 2, 2-HydroxybenzylideneaminoPhenol (HAP) were dissolved in a minimum amount of a Deuterated solvent (DimethylSulphoxide) and introduced into the NMR Spectrometer. The Spectra were run at about 300MHz while the chemical shifts were quoted delta and related to that of the solvent.

2.8 GC-MS analysis

Agilent GC 7890A combined with a triple axis detector 5975 C single quadrupole mass spectrometer were used for GC-MS analysis. The chromatographic column was an Agilent HP 5MS column (30 m × 0.25 mm × 0.25 μm film thickness), with high-purity helium as the gas carrier at a flow rate of 1 mL/min. The injector temperature was 250°C, and it was equipped with a splitless injector at 20: 1. The source temperature of MS was set at 230°C, and the quad temperature was set at 150°C The oven temperature was initially at 40°C (held for 1 min), then was increased to 150°C at 10°C min −1(held for 1 min), and then increased further to 300°C at10°C min −1for 1 min. The injection volume was 1 μL, and the scan range was set at 50–800mass ranges at 70 eV electron energy and the solvent delay of 3 minutes. Finally, unknown compounds were identified by comparing the spectra with that of the NIST 2008 (National Institute of Standard and Technology library). The total time required for analyzing a single sample was 30 minutes.

2.9 Antimicrobial studies

The clinical isolates of *Staphylococcus aureus* and *Bacillus substilis* representative of Gram Positive Bacteria, then *Escherichia coli* and *Pseudomonas aeruginosa* representative of Gram Negative Bacteria then *Candida albicans* and Aspergillus niger representative of Fungi were collected. The isolates were subcultured on Sterile Nutrient agar. The antimicrobial activity of the metal Complexes was antiseptically dropped into the agar wells, the already inoculated Nutrient agar Plates containing the test microbes were incubated at 37^{o}C for 24hours for the development of zones of inhibition, the zones of inhibition were observed and recorded.

3 RESULTS AND DISCUSSION

3.1 Melting point and solubility characterization of metal complexes

The results for the melting point and solubility characteristics of the prepared ligand and its complexes are presented in Table 1. The melting point (or, rarely liquefaction point) of a substance is the temperature at which it changes state from solid to liquid. At the melting point the solid and liquid phase exists in equilibrium.

Table 1: Ligands and complexes and their melting points.

Ligands and Complexes	Melting Point
PMP	94°C
HAP	106°C
$[Pt(PMP)_2.Cl_2]$	232°C
$[Pt(HAP)_2.Cl_2]$	209°C
$[Pt(PMP+HAP).Cl_2]$	208°C
$[Cu(PMP)_2.Cl_2]$	102°C
$[Cu(HAP)_2.Cl_2]$	96°C
$[Cu(PMP+HAP).Cl_2]$	78°C

The melting point were significantly higher than ligand which was higher than the ligands 2-Phenyliminomethylphenol (PMP), 50°C and 2,2-hydroxybenzylideneaminophenol (HAP) 106°C except for 2,2-hydroxybenzylideneaminophenol (HAP) whose melting point is higher than some complexes with exception of platinum complexes. The increases in melting point are attributed to the increase in mass of the formed complexes and thus provided evidence for the formation of metal complexes. The melting points of other complexes with exception Platinum complexes were differently lower than that of the ligand 2,2-hydroxybenzylideneaminophenol (HAP) which may also be due to complexation (Ogwuegbu *et al.*, 2017). It is also observed that melting points of mixed complexes were slightly lower than the unmixed complexes with exception of [Fe(PMP+HAP).Cl$_2$] and [Mn(PMP+HAP).Cl$_2$] and this could be attributed to atomic size contraction as it is observed with decrease in atomic number of the bivalent first transition series.

Solubility is the property of a solid, liquid or gaseous chemical substance called solute to dissolve in a solid, liquid or gaseous solvent. The solubility of a substance fundamentally depends on the physical and chemical properties of the solute and solvent as well as on temperature, pressure and presence of other chemicals including changes to the pH of the solution. The solubility test results for the prepared ligands and their metal complexes are presented in Table 2. All complexes formed as well as the ligands were strongly soluble in dimethylysulfoxide (DMSO) while insoluble in n-Hexane, Ethanol except 2-Phenyliminomethylphenol (PMP) and 2,2-hydroxybenzylideneaminophenol (HAP), both were slightly soluble in n-Hexane and Ethanol, Carbon tetrachloride except 2-Phenyliminomethylphenol (PMP) slightly soluble in carbon tetrachloride, water and carbon disulphide except PMP and HAP which were both strongly and slightly soluble respectively. The ligands PMP and HAP were strongly soluble in acetone, while the mixed ligand complexes of the both Pt and Cu were insoluble. Furthermore, [Pt(PMP)$_2$.Cl) [Pt(HAP)$_2$.Cl$_2$), [Cu(PMP)$_2$.Cl$_2$], and [Cu(HAP)$_2$.Cl$_2$], showed moderate solubility and were insoluble and slightly soluble in acetone. The results of the solubility of the Ligand and complexes formed provided information on the right solvent to be used for dissolution for further analysis and research.

Table 2: Melting point and solubility values of the metal complexes.

	Melting Point	**Ac**	**MeOH**	**EtOH**	**Diethyl-ether**	**N-Hexane**	**CCl$_4$**	**Water**	**CS$_2$**	**DMSO**
PMP	50°C	SS	SS	SIS	SS	IS	SIS	IS	SS	SS
HAP	106°C	SS	MS	SIS	MS	IS	IS	IS	SIS	SS
[Pt(PMP)$_2$.Cl$_2$]	232°C	IS	IS	IS	SIS	IS	IS	IS	IS	SS
[Pt(HAP)$_2$.Cl$_2$]	209°C	MS	SIS	IS	IS	IS	IS	IS	IS	SS
[Pt(PMP+HAP).Cl$_2$]	208°C	MS	SIS	IS	IS	IS	IS	IS	IS	SS
[Cu(PMP)$_2$.Cl$_2$]	102°C	SIS	IS	IS	IS	IS	IS	IS	IS	SS
[Cu(HAP)$_2$.Cl$_2$]	78°C	IS	IS	IS	IS	IS	IS	IS	IS	SS
[Cu(PMP+HAP)$_2$.Cl$_2$]	77°C	IS	IS	IS	IS	IS	IS	IS	IS	SS

SS: **Strongly Soluble;** MS: **Moderately Soluble;** IS: **Insoluble;** SIS: **Slightly Soluble**

3.2 NMR Analysis

The NMR spectral data for the ligands are presented in Appendix 1 and 2. The Schiff base ligands exist in enol form, as indicated by the non-splitting of the methine proton see Appendix 1 and 2, the appearance of the phenolic protons. The phenolic hydroxyl proton in the aldehyde moiety of the ligands absorbed downfield as a broad singlet at 8 - 9 ppm, while the broad signal at 9.79 - 9.77 ppm was attributable to the hydroxyl proton of the ortho-aminophenol moiety. The broadness of the signals was due to a strong hydrogen bonding between the imine N and the hydroxyl protons. All the aromatic protons were accounted for and absorbed at 6.50 - 7.50 ppm and amine NH$_2$ ($\delta = 3 – 4$ ppm); in the ligands spectra.

3.3 GC-MS Analysis

The Gas Chromatography-Mass Spectrometry (GC-MS) is a significant analytical tool for the Assessment of metal Complexes. It is an analytical method that combines the features of Gas Chromatography and Mass Spectrometry to identify different substances present within a test sample. It is used to separate volatile component in a mixture and works by heating a liquid sample until it converts into a vapour that can be carried by a gas like helium and hydrogen. The carrier gas or mobile face transport the sample through a long, thin glass or metal tube (column) that is coated with a chemical of stationary phase as the vaporize compounds are pushed through the column, they slow down when they interact with the stationary phase. Different chemicals will take longer or shorter times to reach the end of the column base on their chemical properties (http://www.cpeo.org, https://en.m.wikipedia.org). As the compounds are separated, they are transferred to the mass spectrometer which identifies and measures the vaporized compounds separated in gas chromatography. While the gas chromatograph provides retention time and peak intensity information, the mass spectrometer provides mass information that can be used to identify, quantify, and determine the structural and chemical properties of the molecules. It finds application in the detection of pharmacological potency of metals complexes exposing the therapeutics and medicinal active molecule present and responsible pharmaceutical activities (https://www.agilent.com, https://www.jblscience.org). The GC-MS reveals the structure-activities-functions of complexes following the fragmentation pattern and matching them with clinically relevant therapeutic molecules present. All compounds present in the metal-ligand complexes of both mixed and unmixed complexes were identified and confirmed by matching their molecular ion, mass fragmentation with respect to mass to charge ratio of the chromatograms, and as presented in Appendices 3 to 10 highlighting molecular ions, depicting rate (min), area (PCT), name of fragmented compounds, mass to charge ratio, molecular weight and molecular formula of the fragments of the samples: 2-Phenyliminomethylphenol(PMP), 2,2-hydroxybenzylideneaminophenol(HAP), [Pt(PMP)$_2$.Cl$_2$], [Pt(HAP)$_2$.Cl$_2$], [Pt(PMP+HAP).Cl$_2$], [Cu(PMP)$_2$.Cl$_2$], [Cu(HAP)$_2$.Cl$_2$] and [Cu(PMP+HAP).Cl$_2$]. The detected compounds/fragments belonged to unsaturated phenolic moiety, an indication of potential activity. Database used for the elucidation of constituents employed Shaimadzu GC-MS library Class-5000, ver2.0 (1996) software and NIST Mass Spectral Search Program for the NIST/EPA/NIH Mass Spectral library ver.16d (1998), Gaithersburg MD, USA. Available literature revealed number of constituents revealed by GC-MS Chromatograms were pharmacological active compounds and proved to possess therapeutic activities which may contribute to antimicrobial inhibition potency observed and recorded and could possibly possess anticancer, antitumor, antimutagenic, anti-inflammatory properties especially with the platinum complexes which previous literatures have revealed anticancer activities with Ciplatin. Again, identification of these GC-MS fragmented compounds in the complexes serves as the basis for the determination of bioactive therapeutic constituents present and other possible health benefits of the metal complexes, leading to further pharmaceutical and biological studies regarding their anticancer, antimutagenic, antitumor and anti-inflammatory applications.

Table 3: GC-MS fragments of sample A (PMP); Molecular ion of 2-Phenyliminomethylphenol (PMP) = 197.23g/mol.

S/N	RT (min)	Area (Pct)	Name of Compounds	*m/z*	Mol. Weight	Mol. Formula
1	7.115	67,000	Mercaptamine	59	77.149g/mol	C_2H_7NS
2	9.909	45,000	Aniline	97	93.13 g/mol	$C_6H_5NH_2$
3	11.718	97,000	Benzaldehyde, 2-hydroxy-	96	122.1213g/mol	$C_7H_6O_2$
4	12.360	102,000	Benzaldehyde, 2-hydroxy-	94	122.1213g/mol	$C_7H_6O_2$
5	16.017	52,000	Fumaramic acid	37	116.07g/mol	$C_4H_4O_4$
6	20.978	94,000	Propanamide, N-acetyl-N-(3-Methylbutyl) acetamide	38	129.2001g/mol	$C_7H_{15}NO$
7	22.142	96,000	Decane	64	142.28g/mol	$C_{10}H_{22}$
8	26.493	120,000	7-Heptadecene, 1-chloro-	30	272.9g/mol	$C_{17}H_{33}Cl$
9	31.723	803,000	Salicylidene aniline	98	**197.23g/mol**	$C_{13}H_{11}NO$
10	32.094	11,000	Salicylidene aniline	95	197.23g/mol	$C_{13}H_{11}NO$
11	32.642	48,000	Hexadecanoic acid, ethyl ester	90	284.4772g/mol	$C_{18}H_{36}O_2$
12	33.487	726,000	9-Octadecenoic acid (Z)-, 2-hydroxy-1-(hydroxymethyl)ethyl ester	93	356.5g/mol	$C_{21}H_{40}O_4$
13	33.653	559,000	17-Pentatriacontene	96	490.9303g/mol	$C_{35}H_{70}$
14	33.989	115,000	9-Octadecenoic acid	94	282.5g/mol	$C_{18}H_{34}O_2$
15	34.172	46,000	5-Eicosene, (E)-	78	280.5316g/mol	$C_{20}H_{40}$
16	34.287	240,000	9-Octadecenamide, (Z)-	95	281.4766g/mol	$C_{18}H_{35}NO$
17	34.970	267,000	9-Octadecenoic acid (Z)-, 2, 3-dihydroxypropyl ester	90	356.5399g/mol	$C_{21}H_{40}O_4$
18	35.097	133,000	1H-Indene, 5-butyl-6-hexyloctahydro-	60	264.5g/mol	$C_{19}H_{36}$
19	35.912	3,999,000	9-Octadecenamide, (Z)-		96 281.4766g/mol	$C_{18}H_{35}NO$
20	36.138	383,000	Octadecanamide	93	283.5g/mol	$C_{18}H_{37}NO$
21	36.766	1,997,000	Oleic Acid	80	282.5g/mol	$C_{18}H_{34}O_2$

Table 4: Showing GC-MS fragments of Sample B (HAP); Molecular Ion of 2,2-Hydroxybenzylideneaminophenol (HAP) = 214.34g/mol.

S/N	RT (min)	Area (Pct)	Name of Compounds	*m/z*	Mol. Weight	Mol. Formula
1	5.817	267,000	2-Hexanol, 3-methyl-	53	116.2013g/mol	$C_7H_{16}O$
2	10.888	209,000	Ethanol, 2-bromo-	38	124.96g/mol	C_2H_5BrO
3	13.522	162,000	3-Pentanone, dimethylhydrazone	50	128.22g/mol	$C_7H_{16}N_2$
4	20.845	246,000	4-Hexenoic acid, 6-hydroxy-4-methyl-, methyl ester, (E)-	40	158.19g/mol	$C_8H_{14}O_3$
5	32.7164	1,144,360	Undecanoic acid, ethyl ester	49	**214.3443g/mol**	$C_{13}H_{26}O_2$

5	29.087	863,000	2-Methyl-Z,Z-3,13-octadecadienol	78	280.5g/mol	$C_{19}H_{36}O$
6	32.094	37,000	Hexadecanoic acid, methyl ester	60	270.4507g/mol	$C_{17}H_{34}O_2$
7	32.643	90,000	Hexadecanoic acid, ethyl ester	64	284.4772g/mol	$C_{18}H_{36}O_2$
8	33.482	220,000	9,17-Octadecadienal, (Z)-	83	264. 4g/mol	$C_{18}H_{32}O$
9	33.674	46,000	Heptadecanoic acid, heptadecyl ester	55	354.6g/mol	$C_{23}H_{46}O_2$
10	34.000	187,000	9-Octadecenoic acid	95	282.5g/mol	$C_{18}H_{34}O_2$
11	34.179	106,000	Oleic Acid	41	282.5g/mol	$C_{18}H_{34}O_2$
12	35.107	1,098,000	Octadecanal	83	268.4778g/mol	$C_{18}H_{36}O$
13	35.755	6,420,000	17-Pentatriacontene	95	490.9303g/mol	$C_{35}H_{70}$
14	36.772	51,000	cis-13-Octadecenoic acid	53	282.5g/mol	$C_{18}H_{34}O_2$

Table 5: Showing GC-MS fragments of Sample C [Pt(PMP)$_2$.Cl$_2$]; Molecular Ion of [Pt(PMP)$_2$.Cl$_2$] = 660.084g/mol.

S. no.	**RT (min)**	**Area (Pct)**	**Name of Compounds**	***m/z***	**Mol. Weight**	**Mol. Formula**
1	5.1446	14,310	Methanesulfinothioic acid, S-1-propyl ester	22	136.23g/mol	$C_4H_8OS_2$
2	5.2072	93,720	S-Methyl methanethiosulphonate	16	126.20g/mol	$C_2H_5O_2S_2$
3	5.249	128,620	S-Methyl methanethiosulphonate	27	126.20g/mol	$C_2H_5O_2S_2$
4	5.2966	98,550	S-Methyl methanethiosulphonate	27	126.20g/mol	$C_2H_5O_2S_2$
5	5.3276	113,930	$(CH_3)_2NCl$	9	79.5g/mol	C_2H_6CIN
6	5.3471	111,350	Dimethyl Sulfoxide	7	78.13g/mol	$(CH_3)_2SO$
7	5.3963	502,440	Methanesulfinothioic acid, S-1-propyl ester	22	136.23g/mol	$C_4H_8OS_2$
8	5.4798	128,220	2-Chloroethyl methyl sulfoxide	35	126.61g/mol	C_3H_7ClOS
9	5.5069	178,430	Dimethyl Sulfoxide	7	78.13g/mol	$(CH_3)_2SO$
10	5.5528	129,900	Dimethyl Sulfoxide	37	78.13g/mol	$(CH_3)_2SO$
11	5.5804	171,690	Ethene, (Methylsulfonyl)-	9	106.144g/mol	$C_3H_6O_2S$
12	5.6208	254,230	2-Chloroethyl methyl sulfone	9	110.61g/mol	C_3H_7ClS
13	5.6794	166,190	Methyl hydrogen disulfide	9	80.17246g/mol	CH_4S_2
14	5.7046	246,490	2-Chloroethyl methyl sulfoxide	25	126.61g/mol	C_3H_7ClOS
15	5.7458	132,620	2-Chloroethyl methyl sulfone	9	110.61 g/mol	C_3H_7ClOS
16	5.7774	198,320	Dimethyl Sulfoxide	7	78.13g/mol	$(CH_3)_2SO$
17	5.7981	87,760	Methyl hydrogen disulfide	10	80.17246g/mol	CH_4S_2
18	5.85	327,340	Dimethyl Sulfoxide	7	78.13g/mol	$(CH_3)_2SO$
19	5.9049	114,760	Ethene, (methylsulfonyl)-	38	106.144g/mol	$C_3H_6O_2S$
20	5.9263	120,450	Ethene, (methylsulfonyl)-	35	106.144g/mol	$C_3H_6O_2S$
21	5.9505	233,220	S-Methyl methanethiosulphonate	16	126.20g/mol	$C_2H_5O_2S_2$
22	5.9756	138,310	S-Methyl methanethiosulphonate	16	126.20g/mol	$C_2H_5O_2S_2$
23	6.0633	141,800	Methyl hydrogen disulfide	10	80.17246g/mol	CH_4S_2
24	6.0895	157,080	Sulfamide	10	96.11g/mol	$H_4N_2O_2S$
25	6.1071	174,830	S-Methyl methanethiosulphonate	12	126.20g/mol	$C_2H_5O_2S_2$
26	6.1429	137,280	Dimethyl Sulfoxide	7	78.13g/mol	$(CH_3)_2SO$
27	6.2224	419,910	$(CH_3)_2NCl$	9	79.50g/mol	C_2H_6CIN
28	6.2485	332,510	Sulfamide	9	96.11g/mol	$H_4N_2O_2S$
29	6.3572	324,130	S-Methyl methanethiosulphonate	16	126.20g/mol	$C_2H_5O_2S_2$
30	6.3994	268,350	Methanesulfinothioic acid, S-1-propyl ester	12	136.23g/mol	$C_4H_8OS_2$
31	6.4199	229,810	Methanesulfinothioic acid, S-1-propyl ester	12	136.23g/mol	$C_4H_8OS_2$
32	6.4442	104,200	Methyl hydrogen disulfide	10	80.17246g/mol	CH_4S_2
33	6.4606	141,700	2-Chloroethyl methyl sulfone	9	110.61 g/mol	C_3H_7ClOS
34	6.4965	141,010	Methyl hydrogen disulfide	10	80.17246g/mol	CH_4S_2
35	6.5141	156,040	S-Methyl methanethiosulphonate	10	126.20g/mol	$C_2H_5O_2S_2$
36	6.5312	303,500	1-Propanone, 1-(2-pyridinyl)-	9	135.1632g/mol	C_8H_9NO
37	6.5806	225,900	2-Chloroethyl methyl sulfone	9	110.61 g/mol	C_3H_7ClOS
38	6.6292	172,860	Methyl hydrogen disulfide	10	80.17246g/mol	CH_4S_2
39	6.6562	434,660	$(CH_3)_2NCl$	9	79.50g/mol	C_2H_6CIN
40	6.7946	200,720	Ethene, (methylsulfonyl)-	32	106.144g/mol	$C_3H_6O_2S$
41	6.8102	146,050	Dimethyl Sulfoxide	7	78.13g/mol	$(CH_3)_2SO$
42	6.8607	341,270	$(CH_3)_2NCl$	9	79.50g/mol	C_2H_6CIN
43	6.884	160,220	3,3,4,4-Tetrafluoro-1,2-oxazetidine	10	281.94312g/mol	$C_3F_5NO_2$
44	6.9486	515,980	Methanesulfinothioic acid, S-1-propyl ester	10	136.23g/mol	$C_4H_8OS_2$
45	7.0005	151,780	Dimethyl Sulfoxide	7	78.13g/mol	$(CH_3)_2SO$
46	7.0218	244,230	Methanesulfinothioic acid, S-1-propyl ester	22	136.23g/mol	$C_4H_8OS_2$

47	7.1058	162,000	Dimethyl Sulfoxide	94	78.13g/mol	$(CH_3)_2SO$
48	7.6451	99,660	Dimethyl Sulfoxide	90	78.13g/mol	$(CH_3)_2SO$
49	8.2684	56,650	Dimethyl Sulfoxide	60	78.13g/mol	$(CH_3)_2SO$
50	9.3242	-4,040	Dimethyl Sulfoxide	91	78.13g/mol	$(CH_3)_2SO$
51	10.5076	13,870	Dimethyl Sulfoxide	90	78.13g/mol	$(CH_3)_2SO$
52	11.2428	12,030	Dimethyl Sulfoxide	90	78.13g/mol	$(CH_3)_2SO$
53	30.897	5,160	9,12-Octadecadienoic acid, methyl ester	99	294.4721g/mol	$C_{19}H_{34}O_2$
54	30.9404	14,700	9-Octadecenoic acid (Z)-, methyl ester	99	296.4879g/mol	$C_{19}H_{36}O_2$
55	31.1308	7,620	Methyl stearate	99	298.51g/mol	$C_{19}H_{38}O_2$
56	31.4139	69,100	(E)-9-Octadecenoic acid ethyl ester	91	310.521260g/mol	$C_{20}H_{38}O_2$
57	31.5253	10,650	Oleic Acid	96	282.46g/mol	$C_{20}H_{40}O_2$
58	31.5778	10,290	Octadecanoic acid, ethyl ester	97	312.5304g/mol	$C_{22}H_{42}O_2$
59	34.2998	8,663	Erucic acid	53	338.57g/mol	$C_{21}H_{36}O_2$
60	35.2486	67,670	i-Propyl 9-tetradecenoate	47	320.5g/mol	
61	37.0758	71,340	Heptadecanolide	46	270.5g/mol	$C_{17}H_{34}O_2$
62	38.9030	75,010	3,3-diamino-dichloro(N-hexatriacontanoic acid)	49	**660.084g/mol**	$C_{36}H_{65}Cl_2N_2O_4$

Table 6: Showing GC-MS Fragments Of Sample D [Pt(HAP)$_2$.Cl$_2$]; Molecular Ion of [Pt(HAP)$_2$.Cl$_2$] = 694.28g/mol.

S/N	RT (min)	Area (Pct)	Name of Compounds	M/Z	Mol. Weight	Mol. Formular
1	6.3383	162,030	Dimethyl Sulfoxide	58	78.13g/mol	$(CH_3)_2SO$
2	7.2024	172,900	Dimethyl Sulfoxide	49	78.13g/mol	$(CH_3)_2SO$
3	7.58	44,360	Benzaldehyde, 2-hydroxy-	95	122.1213g/mol	C_7H_6O
4	7.8622	157,110	Carbonic acid, 2-chloroethyl 2-pentyl ester	37	194.656g/mol	$C_8H_{15}ClO_3$
5	8.8555	128,490	3-Pentanone, dimethylhydrazone	52	128.22g/mol	$C_7H_{16}N_2$
6	10.4265	125,110	1,2,3,4-Butanetetrol, [S-(R*,R*)]-	59	106.121g/mol	$C_4H_{10}O_3$
7	11.0378	125,090	Xanthine, 8-[4-[[(isopropylamino)carbonyl] methoxy]phenyl]-1,3-dipropyl	59	414.5g/mol	$C_{19}H_{23}N_5O_4$
8	11.6491	125,220	2, 4-diamino-dichlorooctatriacontanoic acid	59	**694.28g/mol**	$C_{38}H_{75}Cl_2N_2O_4$
8	11.7984	125,000	Tetraacetyl-d-xylonic nitrile	47	343.28608g/mol	$C_{14}H_{17}NO_9$
9	13.2922	120,730	3H-Indazol-3-one, 1,2-dihydroxyl	49	150.135g/mol	$C_7H_6N_2O$
10	15.1409	100,770	2,4-Bis(hydroxylamino)-5-nitropyrimidine	59	142.049075g/mol	$C_4H_6N_4O_2$
11	16.1187	104,370	N-(3,5-Dinitropyridin-2-yl)-L-aspartic acid	59	299.19g/mol	$C_9H_8N_4O_8$
12	17.6565	118,030	3-Methyl-3,5- -(cyanoethyl)tetrahydro-4-thiopyranone	62	125.17g/mol	$C_7H_{11}NO$
13	19.0609	178,690	Tetraacetyl-d-xylonic nitrile	56	343.28608g/mol	$C_{14}H_{17}NO_9$
14	19.7005	163,630	Butanamine, 2,2-dinitro-N-methyl-	46	177.16g/mol	$C_5H_{11}N_3O_4$
15	19.896	12,350	Hydroxylamine, O-decyl-	58	173.2957g/mol	$C_{10}H_{23}NO$
16	20.3518	47,530	Butylated Hydroxytoluene	97	220.35g/mol	$C_{15}H_{24}O$
17	20.613	110,170	Acetamide, N-(aminocarbonyl)-2-chloro	53	136.003955g/mol	$C_3H_5ClN_2O_2$
18	23.464	110,140	5-Aminoisoxazole	59	84.08g/mol	C3H4N2O
19	24.1444	37,150	E-14-Hexadecenal	95	238.40900g/mol	$C_{16}H_{30}O$
20	24.2916	29,750	3-Heptadecene, (Z)-	89	238.4519g/mol	$C_{17}H_{34}$
21	24.5494	134,750	Alanylproline, TMS derivative	43	187.3116g/mol	$C_8H_{17}NO_2Si$
22	24.6515	100,610	Heptadecane	86	240.50g/mol	$C_{17}H_{36}$
23	25.3262	209,740	1,4-Butanediamine, N-(3-aminopropyl)-	58	238.80g/mol	$C_{11}H_{28}N_4$
24	26.2004	210,850	3-Methyl-3,5- -(cyanoethyl)tetrahydro-4-thiopyranone	50	236.34g/mol	$C_{12}H_{16}N_2OS$
25	27.1079	243,910	Alanyglycine, TMS derivative	64	218.3256g/mol	$C_8H_{18}N_2O_3Si$
26	28.0185	179,670	2-Amino-1-(o-methoxyphenyl)propane	58	165.2322g/mol	$C_{10}H_{15}NO$
27	29.2535	27,880	Hexadecanoic acid, Methyl ester	97	270.4507g/mol	$C_{17}H_{34}O_2$
28	30.0116	131,300	Hexadecanoic acid, ethyl ester	95	284.4772g/mol	$C_{18}H_{36}O_2$
29	30.9298	789,180	9-Octadecenoic acid (Z)-, methyl ester	99	296.4879g/mol	$C_{19}H_{36}O$
30	31.1293	44,260	Methyl stearate	98	298.51g/mol	$C_{19}H_{28}O_2$
31	31.4124	269,730	Ethyl Oleate	91	310.51g/mol	$C_{20}H_{38}O_2$
32	31.5823	101,000	Octadecanoic acid, ethyl ester	99	310.51g/mol	$C_{20}H_{38}O_2$
33	32.0003	178,240	Oleic acid	95	282.46g/mol	$C_{18}H_{34}O_2$
34	32.412	233,060	Methyl 6,9,12,15,18-heneicosapentaenoate	91	340.4g/mol	$C_{22}H_{24}O_2$
35	32.5868	154,730	Erucic acid	89	338.57g/mol	$C_{22}H_{42}O_2$

36	32.7156	121,910	Ethyl 9-hexadecenoate	53	282.4614g/mol	$C_{18}H_{34}O$
37	33.2658	2,346,730	Butyl 9-octadecenoate or 9-18:1	44	338.6g/mol	$C_{22}H_{34}O_2$
38	33.8844	20,660	Ethyl 9-hexadecenoate	46	282.4614g/mol	$C_{22}H_{34}O_2$
39	35.797	2,328,380	Pyridine-3-carboxamide, oxime,N-(2-trifluoromethylphenyl)-	74	281.23g/mol	$C_{13}H_{10}F_3N_3O$

Table 7: Showing GC-MS fragments of Sample E [Pt(PMP+HAP).Cl_2]; Molecular Ion of [Pt(PMP+HAP).Cl_2] = 677.47g/mol.

S/N	RT (min)	Area (Pct)	Name of Compounds	*m/z*	Mol. Weight	Mol. Formula
1	5.4774	164,450	Dimethyl Sulfoxide	50	78.13g/mol	$(CH_3)_2SO$
2	6.347	257,520	1,4-Oxathin, 2,3-dihydro-6-methyl-	59	235.302g/mol	$C_{12}H_{13}NO_2S$
3	7.1493	209,320	Pyrimidine-2,4,6(1H,3H,5H)-trione, 5-(5-nitro-2-thienylmethylene)-1-phenyl-	38	286.077599g/mol	$C_{15}H_{14}N_2O_2S$
4	7.5504	150,980	Benzeneethanamine, 4-methoxy-.alpha.-methyl-	38	165.2322g/mol	$C_{10}H_{15}NO$
5	7.5866	37,220	Diglycolamine	43	105.136g/mol	$C_4H_{11}NO_2$
6	8.2308	111,600	1-Octanamine	27	129.24g/mol	$C_8H_{19}N$
7	8.2489	48,020	1-Decanamine	43	157.30g/mol	$C_{10}H_{23}N$
8	8.7195	151,790	2-Amino-4-dimethylaminomethylenepentane Dinitrile	52	126.20g/mol	$C_7H_{14}N_2$
9	9.3904	132,320	3-Pentanone, dimethylhydrazone	47	128.22g/mol	$C_7H_{16}N_2$
10	12.2243	108,660	Pyrazole[4,5-b]imidazole, 1-formyl-3-ethyl-6-.beta.-d-ribofuranosyl-	46	296.27924g/mol	$C_{12}H_{16}N_4O_5$
11	13.0422	-28,270	Imidazole, 2-amino-5-[(2-carboxy)vinyl]-	50	153.13868g/mol	$C_6H_7N_3O_2$
12	14.6311	-19,070	Alanylglycine, TMS derivative	47	218.3256g/mol	$C_8H_{18}N_2O_3Si$
13	15.8866	88,340	(Cyclohex-3-enylmethyl)[2-(2-methyl-5-trifluoromethoxy-1H-indol-3-yl) ethyl]amine	47	352.4g/mol	$C_{19}H_{23}F_3N_2O$
14	21.1195	160,080	8-Azabicyclo[4.3.1]decan-10-one, 8-methyl-	59	167.25g/mol	$C_{10}H_{17}NO$
15	22.6423	104,070	Dimethyl dimethylphosphoramidate	47	181.1699g/mol	$C_6H_{16}NO_3P$
16	23.7501	129,510	Metaraminol	49	167.208g/mol	$C_9H_{13}NO_2$
17	25.3455	26,120	Methyl tetradecanoate	95	242.40g/mol	$C_{15}H_{30}O_2$
18	28.0371	139,860	3-Propoxyamphetamine	53	289.8g/mol	$C_{14}H_{23}NO_3.HCl$
19	29.2609	717,390	Hexadecanoic acid, methyl ester	97	284.4772g/mol	$C_{18}H_{36}O_2$
20	29.7872	99,810	Tricyclo[4.3.1.1(3,8)]undecane-1-carboxylic acid	49	194.28g/mol	$C_{12}H_{18}O_2$
21	30.014	1,541,680	Hexadecanoic acid, ethyl ester	98	284.4772g/mol	$C_{18}H_{36}O_2$
22	30.901	330,390	9,12-Octadecenoic acid, methyl ester	99	294.4721g/mol	$C_{19}H_{34}O_2$
23	30.9449	791,670	7-Octadecenoic acid, methyl ester	99	296.5g/mol	$C_{19}H_{36}O_2$
24	31.1316	102,250	Methyl stearate	98	298.51g/mol	$C_{19}H_{38}O_2$
25	31.4144	427,090	Ethyl Oleate	99	310.51g/mol	$C_{20}H_{38}O_2$
26	31.5835	132,890	Octadecanoic acid, ethyl ester	99	312.53g/mol	$C_{20}H_{40}O_2$
27	32.0154	111,640	n-Propyl 11-octadecenoate	95	324.5g/mol	$C_{21}H_{40}O_2$
28	32.4473	132,890	2,4-diamino-dichloro(N-heptatriacontane)	86	**677.47g/mol**	$C_{37}H_{70}Cl_2N_2O_4$
28	32.0622	46,670	9-Octadecenoic acid (Z)-, 2-hydroxyl-1-(hydroxymethyl) ethyl ester	86	356.5g/mol	$C_{21}H_{40}O_4$
29	32.1795	133,420	Oleic acid	64	282.46g/mol	$C_{18}H_{34}O_2$
30	32.2382	194,750	cis-Vaccenic acid	91	282.461g/mol	$C_{18}H_{34}O_2$
31	32.306	179,720	Oleic acid	90	282.46g/mol	$C_{18}H_{34}O_2$
32	32.3719	302,720	Methyl 18-methylnonadecanote	78	326.6g/mol	$C_{21}H_{42}O_2$
33	32.4112	449,590	9,12,15-Octadecatrien-1-ol, (Z,Z,Z)-	96	264.4g/mol	$C_{18}H_{32}O$
34	35.1751	299,370	N-(3-Methylbutyl)acetamide	22	129.20g/mol	$C_7H_{15}NO$
35	35.2898	138,470	9-Octadecenoic acid (Z)-, 2,3-dihydroxypropyl ester	42	356.5399g/mol	$C_{20}H_{38}O_3$
36	35.5853	1,044,300	n-Propyl 11-octadecenoate	74	324.5g/mol	$C_{21}H_{40}O_2$
37	35.6208	216,250	9-Octadecenoic acid (Z)-, 2,3-dihydroxypropyl ester	30	356.5399g/mol	$C_2OH_{38}O_3$
38	35.6463	765,440	9-Octadecenoic acid (Z)-, 2,3-dihydroxypropyl ester	56	356.5399g/mol	$C_2OH_{38}O_3$
39	36.9808	660	2,3-Dihydroxypropyl elaidate	41	356.5g/mol	$C_{21}H_{40}O$

40	37.1588	-560	Cyclohexane, 1,1'-(2-propyl-1,3-propanediyl) bis-	25	250.4626g/mol	$C_{18}H_{34}$
41	37.2243	1,860	Oleic acid	25	282.46g/mol	$C_{18}H_{34}O_2$

Table 8: Showing GC-MS fragments of Sample F [Cu(PMP)$_2$.Cl$_2$]; Molecular Ion of [Cu(PMP)$_2$.Cl$_2$] = 528.5g/mol.

S/N	RT (min)	Area (Pct)	Name of Compounds	*m/z*	Mol. Weight	Mol. Formula
1	5.1641	-44,980	Propanoic acid, 2-choro-, methyl ester, (R)-	43	122.550g/mol	$C_4H_7ClO_2$
2	6.1431	280,020	(3-Chloropropionamido)sulfur pentafluoride	25	233.5879g/mol	$C_3H_5ClF_5NOS$
3	7.0583	118,250	1-Tridecanamine	35	199.3761g/mol	$C_{13}H_{29}N$
4	7.0844	58,730	1-Nitrobiuret	22	148.079g/mol	$C_2H_4N_4O$
5	8.7479	115,790	N-Methoxy-1-ribofuranosyl-4-imidazolecarboxylic amide	50	273.24g/mol	$C_{10}H_{15}N_3O_6$
6	9.722	121,900	Pyrazole[4,5,-b]imidazole, 1-formyl-3-ethyl-6-.beta.-d-ribofuranosyl-	38	296.27924g/mol	$C_{12}H_{16}N_4O_5$
7	9.7685	35,000	Ethyl 2-(2-choroacetamido)-3,3,3-trifluorolactate	50	356.70g/mol	$C_{13}H_{13}ClF_4N_2O_3$
8	10.6668	92,960	5-Nonanone, dimethylhydrazone	53	114.19g/mol	$C_6H_{14}N_2$
9	10.6821	48,750	5-Bromo-N,N-dimethyl-2H-1,2,4-triazole-3-carboxamide	50	219.04g/mol	$C_5H_7BrN_4O$
10	11.8454	78,320	N-Formyl-beta-alanine	45	117.10g/mol	$C_4H_7NO_3$
11	11.8809	58,430	5-Bromo-N,N-dimethyl-2H-1,2,4-triazole-3-carboxamide	46	114.19g/mol	$C_6H_{14}N_2$
12	13.0058	129,670	N-(3,5-Dinitropyridin-2-yl)-L-aspartic acid	50	299.19g/mol	$C_{10}H_9N_3O_8$
13	14.4417	65,590	8-Bromoadenosine-N(1)-oxide	64	346.14g/mol	$C_{10}H_{12}BrN_5O_4$
14	14.4584	23,160	Imidazole, 2-amino-5-[(2-carboxy)vinyl]-	47	153.13868g/mol	$C_6H_7N_3O_2$
15	16.4688	123,400	Pyrazole[4,5-b]imidazole, 1-formyl-3-ethyl-6-.beta.-d-ribofuranosyl-	50	296.27924g/mol	$C_{12}H_{16}N_4O_5$
16	17.8797	104,400	Dimefox	64	154.125g/mol	$C_4H_{12}FN_2OP$
17	19.2471	61,860	(-)-Norephedrine	43	151.206g/mol	$C_9H_{13}NO$
18	19.2672	14,420	Phenylephrine	60	167.205g/mol	$C_9H_{13}NO_2$
19	19.2907	33,940	3-Methyl-3,5- - (cyanoethyl)tetrahydro-4-thiopyranone	50	236.34g/mol	$C_{12}H_{16}N_2OS$
20	19.5232	19,130	Benzene, 1-(1,5-dimethyl-4-hexenyl)-4-methyl-	98	202.3352g/mol	$C_{15}H_{22}$
21	20.16	22,510	.beta.-Bisabolene	98	204.35g/mol	$C_{15}H_{24}$
21	20.7968	19,435	4,4-diamino-dichloro(N-heptacosane)	98	**528.5g/mol**	$C_{27}H_{41}Cl_2N_2O_4$
22	20.333	21,040	Butylated Hydroxytoluene	98	220.35g/mol	$C_{15}H2_4O$
23	21.0931	46,650	Acetamide, 2,2,2-trichloro-	50	162.402g/mol	$C_2H_2Cl_3NO$
24	21.1504	31,730	Folic acid	49	441.4g/mol	$C_{19}H_{19}N_7O_6$
25	21.1728	26,270	Piperidine, 3-(bromomethyl)-	50	278.19g/mol	$C_{11}H_{20}BrNO_2$
26	23.2661	128,660	Methanesulfonamide, N,N-dimethyl-	47	123.17g/mol	$C_3H_9NO_2S$
27	23.2834	71,250	Imidazole, 2-amino-5-[(2-carboxy)vinyl]-	55	153.13868g/mol	$C_6H_7N_3O_2$
28	24.1298	28,020	E-14-Hexadecenal	86	238.4088g/mol	$C_{16}H_{30}O$
29	24.2966	46,780	2,4-Dimethylamphetamine	43	163.264g/mol	$C_{11}H_{17}N$
30	24.373	76,690	2H-Azepin-2-one, hexahydro-1-methyl	52	127.1842g/mol	$C_7H_{13}NO$
31	24.4183	60,870	2-Iodohiistidine	30	155.1546g/mol	$C_6H_9N_3O_2$
32	26.4917	81,550	4-tert-butylamphetamine	43	191.32g/mol	$C_{13}H_{21}N$
33	26.5459	42,750	Piperidine, 3-phenyl-	30	161.24g/mol	$C_{11}H_{15}N$
34	26.5873	43,300	Amidephrine	47	183.20g/mol	$C_9H_{13}NO_3$
35	28.7378	315,580	Ledol	25	222.372g/mol	$C_{15}H_{26}O$
36	28.8044	153,540	cis-11-Hexadecenal	45	238.4088g/mol	$C_{16}H_{30}O$
37	29.2453	42,500	Hexadecanoic acid, methyl ester	96	270.45g/mol	$C_{17}H_{34}O_2$
38	30.0046	201,330	Hexadecanoic acid, ethyl ester	97	284.5g/mol	$C_{18}H_{36}O_2$
39	30.584	32,690	E,E-10,12-Hexadecadein-1-ol	68	238.40900g/mol	$C_{16}H_{30}O$
40	30.6915	50,620	Oleic acid	70	282.46g/mol	$C_{18}H_{34}O_2$
41	30.8459	250,730	Oleic acid	53	282.46g/mol	$C_{18}H_{34}O_2$
42	30.8901	507,990	9,12-Octadecadienoic acid, ethyl ester	99	294.4721g/mol	$C_{19}H_{34}O_2$
43	30.9327	1,529,600	9-Octadecenoic acid (Z)-, methyl ester	99	296.4879g/mol	$C_{19}H_{36}O_2$
44	31.122	88,450	Methyl stearate	97	296.4879g/mol	$C_{19}H_{36}O_2$
45	31.3733	46,520	9,12-Octadecadienoic acid, ethyl ester	99	308.4986g/mol	$C_{20}H_{36}O_2$

46	31.407	529,860	(E)-9-Octadecenoic acid ethyl ester	99	310.52126000g/mol	$C_{20}H_{38}O_2$
47	31.5764	256,270	Octadecanoic acid, ethyl ester	99	310.5g/mol	$C_{20}H_{38}O_2$
48	31.8276	210,790	Oleic acid	90	282.46g/mol	$C_{18}H_{34}O_2$
49	32.0093	720,890	Oleic acid	94	282.46g/mol	$C_{18}H_{34}O_2$
50	32.0507	663,210	Oleic acid	55	282.46g/mol	$C_{18}H_{34}O_2$
51	32.4049	10,960	9,12,15-Octadecatrien-1-ol, (Z,Z,Z)-	83	264.4g/mol	$C_{18}H_{32}O$
52	33.8752	13,470	Ethyl 9-hexadecenoate	70	282.4614g/mol	$C_{18}H_{34}O_2$
53	34.6973	113,160	Z-8-Pentadecen-1-ol acetate	59	268.4g/mol	$C_{17}H_{32}O_2$
54	34.7328	36,880	13-Octadecenoic acid, methyl ester	51	296.4879g/mol	$C_{19}H_{36}O_2$
55	35.1088	1,087,940	Oleic acid	62	282.46g/mol	$C_{18}H_{34}O_2$
56	35.1269	100,740	Oleic acid	41	282.46g/mol	$C_{18}H_{34}O_2$
57	35.1739	769,490	Z-8-Pentadecen-1-ol acetate	48	268.4g/mol	$C_{17}H_{32}O_2$

Table 9: Showing GC-MS fragments of Sample G [Cu(HAP)$_2$.Cl$_2$]; Molecular Ion of [Cu(HAP)$_2$.Cl$_2$] = 654.5g/mol.

S/N	RT (min)	Area (Pct)	Name of Compounds	M/Z	Mol. Weight	Mol. Formula
1	5.4772	292,980	2-Nonanol	43	144.25g/mol	$C_9H_{20}O$
2	6.3998	258,530	Ethanol, 2-[(2-chloroethyl)dithio]-	30	140.63g/mol	C_4H_9ClOS
3	6.8197	131,180	2-(Oxan-3-yl)ethanamine	43	129.20g/mol	$C_7H_{15}NO$
4	6.8356	107,470	2-(Oxan-3-yl)ethanamine	50	129.20g/mol	$C_7H_{15}NO$
5	7.5674	232,630	1-Octanamine	53	129.24g/mol	$C_8H_{19}N$
6	8.0756	174,690	1-Octanamine	47	129.20g/mol	$C_8H_{19}N$
7	8.1147	47,960	dl-Allo-cystathionine	53	222g/mol	$C_7H_{14}N_2O_4S$
8	8.5784	183,270	2-(Oxan-3-yl)ethanamine	80	129.20g/mol	$C_7H_{15}NO$
9	9.3621	165,380	2-(Oxan-3-yl)ethanamine	43	129.20g/mol	$C_7H_{15}NO$
10	10.4954	-43,570	Pyrazole[4,5-b]imidazole, 1-formyl-3-ethyl-6-.beta.-d-ribofuranosyl-	32	296.28g/mol	$C_{12}H_{16}N_4O_5$
11	10.5207	2,080	8-Azabicyclo[4.3.1]decan-10-one, 8-methyl-	43	167.25g/mol	$C_{10}H_{17}NO$
12	11.8129	200,930	Tetrahydro-4H-pyran-4-ol	38	102.13g/mol	$C_5H_{10}O_2$
13	13.1694	68,740	Dimefox	50	154.125g/mol	$C_4H_{12}FN_2OP$
14	13.1895	41,700	Pterin-6-carboxylic acid	52	207.15g/mol	$C_7H_5N_5O_3$
15	13.9246	83,330	N<2>,N<2>,N<2>,N<2>-Tetramethyl-4,6-bis(trifluoromethyl)-1,3,5,2.lambda.<5>-triazaphosphinine-2,2-diamine	64	144.26g/mol	$C_8H_{20}N_2$
16	13.9569	42,190	N<2>,N<2>,N<2>,N<2>-Tetramethyl-4,6-bis(trifluoromethyl)-1,3,5,2.lambda.<5>-triazaphosphinine-2,2-diamine	59	144.26g/mol	$C_8H_{20}N_2$
17	15.1492	-38,180	Pterin-6-carboxylic acid	68	207.15g/mol	$C_7H_5N_5O_3$
18	16.9954	-19,250	N,N'-Dimethyl-decane-1,10-diamine	59	200.225g/mol	$C_{12}H_{28}N_2$
19	18.6834	8,880	Benezeneethanamine, 2,5-difluoro-.beta.,3,4-trihydroxy-N-methyl-	59	219.18g/mol	$C_9H_{11}F_2NO_3$
20	20.0609	7,270	Hexamethylthiophosphoramide	50	179.2g/mol	$C_6H_{18}N_3OP$
21	20.0905	1,270	Metaraminol	50	167.208g/mol	$C_9H_{13}NO_2$
22	23.4644	-35,270	Imidazole, 2-amino-5-[(2-carboxy)vinyl]-	64	153.13868g/mol	$C_6H_7N_3O_2$
23	25.3223	120,990	Guanidine, N,N-dimethyl-	47	112.13g/mol	$C_6H_8N_4$
24	25.3444	70,820	Propanamide, 3-cyclopentyl-N-(hept-2-yl)-	38	239.40g/mol	$C_{15}H_{29}NO$
24	25.3665	50,170	2,2-diamino-dicholo(N-pentatriacontane)	38	**654.5g/mol**	$C_{35}H_{71}Cl_2N_2O_4$
25	27.0446	76,300	2-Amino-1-(o-methoxyphenyi)propane	46	165.2322g/mol	$C_{10}H_{15}NO$
26	27.0743	70,380	N.omega.-Nitro-L-arginine	47	219.20g/mol	$C_6H_{13}N_5O_4$
27	28.5036	131,840	2H-Azepin-2-one, hhexahydro-1-methyl-	49	127.1842g/mol	$C_7H_{13}NO$
28	28.5216	71,330	dl-Phenylephrine	38	203.66g/mol	$C_9H_{14}ClNO_2$
29	29.2566	24,490	Pentadecanoic acid, 14-methyl-, methyl ester	97	270.4507g/mol	$C_{17}H_{34}O_2$
30	30.0148	166,130	Hexadecanoic acid, ethyl ester	98	284.4772g/mol	$C_{18}H_{36}O_2$
31	30.8533	28,100	Propanal, 2,3-dihydroxyl-, (S)-	43	90.08g/mol	
32	30.899	98,150	9,12-Octadecadienoic acid (Z,Z)-, methyl ester	99	294.4721g/mol	$C_{19}H_{34}O_2$
33	30.9402	321,930	9-Octadecenoic acid (Z)-, methyl ester	99	296.4879g/mol	$C_{19}H_{36}O_2$
34	31.1344	257,580	Methyl stearate	92	298.50g/mol	$C_{19}H_{38}O_2$
35	31.216	180,020	Oleic acid	95	282.46g/mol	$C_{18}H_{34}O_2$
36	31.2753	287,260	Oleic acid	87	282.46g/mol	$C_{18}H_{34}O_2$

37	31.3791	110,510	Linoleic acid ethyl ester	99	308.4986g/mol	$C_{20}H_{36}O_2$
38	31.4123	537,590	Ethyl Oleate	99	310.51g/mol	$C_{20}H_{38}O_2$
39	31.5831	84,810	Octadecanoic acid, ethyl ester	99	312.53g/mol	$C_{20}H_{40}O_2$
40	32.7148	16,000	Heptadecanoic acid, ester	50	298.51026000g/mol	$C_{19}H_{38}O$
41	33.7755	237,580	9-Octadecenoic acid (Z)-, 2-hydroxy-1 -(hydroxymethyl)ethyl ester	89	356.5g/mol	$C_{21}H_{40}O_4$
42	33.8183	61,160	Oleic acid	55	282.46g/mol	$C_{18}H_{34}O_2$
43	33.8853	239,250	Ethyl 9-hexadecenoate	58	282.46g/mol	$C_{18}H_{34}O$
44	34.1346	1,162,120	Cyclohexane, 1,1'-(2-propyl-1,3-propanediyl) bis-	37	250.5g/mol	$C_{18}H_{34}$
45	34.171	181,200	Z-8-Pentadecenoic acid (Z)-, 2,3-dihydroxypropyl ester	46	268.4g/mol	$C_{17}H_{32}O_2$
46	34.1979	980,780	9-Octadecenoic acid (Z)-, 2,3-dihydroxypropyl ester	46	356.5399g/mol	$C_{21}H_{40}O$
47	36.3532	239,900	Erucic acid	59	338.57g/mol	$C_{22}H_{42}O_2$
48	36.6915	1,296,560	13-Octadecenoic acid, methyl ester	25	296.5g/mol	$C_{19}H_{36}O_2$
49	36.7464	1,033,000	9-Octadecenoic acid (Z)-,2 hydroxyethyl ester	25	326.5139g/mol	$C_{20}H_{38}O$

Table 10: Showing GC-MS fragments of Sample H [Cu(PMP+HAP).Cl_2]; Molecular Ion of [Cu(PMP+HAP).Cl_2] = 637.5g/mol.

S/N	RT (min)	Area (Pct)	Name of Compounds	*m/z*	Mol. Weight	Mol. For
1	6.0323	21,860	Pyridine, 3-methyl-	87	129.59g/mol	C_6H_8CIN
2	6.377	179,590	Acetic acid, cyano-	35	85.06g/mol	$C_3H_3NO_2$
3	7.233	195,270	1,2,4-Triazole, 4-[N-(2-hydroxyethyl)-N-nitro]amino-	50	173.13g/mol	$C_4H_7N_5O_3$
4	7.5703	27,480	Benzaldehyde, 2-hydroxy-	95	240.26g/mol	$C_{14}H_{12}N_2O_2$
4	7.9076	167,790	2,4-diamino-dichloro(N-tetratriacontane)	95	**637.5g/mol**	$C_{34}H_{66}Cl_2N_2O_4$
5	8.1796	195,710	Phosphoric triamide, pentamethyl-	52	165.1738g/mol	$C_5H_{16}N_3OP$
6	8.8971	192,220	1-Decanamine	40	157.30g/mol	$C_{10}H_{23}N$
7	9.4282	228,010	2-Dimethylaminomethyl-4-chloro-1-naphthol	35	178.61g/mol	$C_{10}H_7ClO$
8	10.0022	143,270	2-(Oxan-3-yl)ethanamine	52	129.20g/mol	$C_7H_{15}NO$
9	11.1516	116,230	Benzeneethanamine, 2,5-difluoro-.beta.,3, 4-trihydroxy-N-methyl	50	219.185346g/mol	$C_9H_{11}F_2NO_3$
10	12.9834	119,090	Urea, formyltrimethyl-	59	130.15g/mol	$C_5H_{10}N_2O_2$
11	13.793	121,210	N<2>,N<2>,N<2>,N<2>,-Tetramethyl-4, 6-bis(trifluoromethyl)-1,3, 5,2.lambda.<5>-triazaphosphinine-2,2-diamine	59	144.26g/mol	$C_8H_{20}N_2$
12	15.4307	119,500	N-Methoxy-1-ribofluranosyl-4-imadazolecarboxylic amide	50	273.24g/mol	$C_{10}H_{15}N_3O_6$
13	16.731	145,830	Phenethylamine, p-methoxy-.alpha.-methyl-, hydrochloride	43		
14	18.5763	95,920	N<2>,N<2>,N<2>,N<2>,-Tetramethyl-4, 6-bis(trifluoromethyl)-1,3, 5,2.lambda.<5>-triazaphosphinine-2,2-diamine	53	144.26g/mol	$C_8H_{20}N_2$
15	20.3538	33,020	Butylated Hydroxytoluene	97	220.35g/mol	$C_{10}H_{15}N_3O_6$
16	20.6847	123,270	Pteridine-8-oxide, 6-aldoximino-2-amino-4 (3H)-oxo	64	314.2994g/mol	$C_7H_6N_6O_3$
17	21.7033	127,530	4-Fluorohistamine	47	129.14g/mol	$C_5H_8FN_3$
18	23.8366	116,540	Metaraminol	47	167.208g/mol	$C_9H_{13}NO_3$
19	25.398	121,020	Propanenitrile, 3-amino-2,3-di(hydroxymino)-	43	84.12g/mol	$C_4H_8N_2$
20	28.1604	180,980	Salicylidene aniline	90	197.23g/mol	$C_{13}H_{11}NO$
21	29.2548	53,980	Hexadecanoic acid, methyl ester	97	270.45g/mol	$C_{17}H_{30}O_2$
22	29.7687	42,100	Phthalic acid, isobutyl non-5-yn-3-yl ester	50	306.3966g/mol	$C_{18}H_{26}O_4$
23	30.0124	352,800	Hexadecanoic acid, ethyl ester	99	284.5g/mol	$C_{18}H_{36}O_2$
24	30.3247	439,640	Histidine, 1,N-dimethyl-4-nitro-	35	155.20g/mol	$C_6H_9N_3O_2$
25	30.9363	83,650	6-Octadecenoic acid, methyl ester, (Z)-	99	296g/mol	$C_{19}H_{36}O_2$

26	31.1326	10,790	Methyl stearate	76	298.50g/mol	$C_{19}H_{38}O_2$
27	31.4125	274,530	Ethyl Oleate	95	310.51g/mol	$C_{20}H_{38}O_2$
28	31.5822	100,090	Octadecanoic acid, ethyl ester	99	312.53g/mol	$C_{20}H_{38}O_2$
29	32.0071	128,990	Z-(13,14-Epoxy)tetradic-11-en-1-ol acetate	94	268.39g/mol	$C_{16}H_{28}O_3$
30	33.0179	3,182,270	9-Octadecenoic acid (Z)-, 2,3-dihydroxypropyl ester	52	372.5g/mol	$C_{21}H_{40}O_5$
31	33.4616	68,080	Z-8-Pentadecen-1-ol acetate	56	268.4g/mol	$C_{17}H_{32}O_2$
32	34.302	2,632,800	9-Octadecenoic acid (Z)-, 2,3-dihydroxypropyl ester	45	372.5g/mol	$C_{21}H_{40}O_5$
33	35.4576	4,400	Ethyl 9-hexadecenoate	43	282.4614g/mol	$C_{18}H_{34}O_2$
34	35.7903	22,340	2,6,10-Dodecatrien-1-ol, 3,7,11-trimethyl-	64	298.5g/mol	$C_{21}H_{30}O$

3.4 FTIR Spectra

The FTIR spectra for the ligand and metal complexes are presented in Appendix 11 to 18 while the data and assignment for interpretation are presented in Tables 11 to 18. The FTIR spectra for 2-phenyliminomethylphenol (PMP) is presented in Appendix 11. The absorbance at 1569.2 cm^{-1} indicated the stretching C=C bond in the benzene rings, bands at 1613.9 cm^{-1} the bands indicated =C-N stretching in the benzene ring. Furthermore, vC-H stretching was also seen at 2653.9 to 2851.4 cm^{-1}, vC-H vibrations in ring was seen at 3056.4 while vO-H stretching of phenol was assigned to the band at 3213 and 3652.8 cm^{-1} respectively. The FTIR spectra for 2-phenyliminomethylphenol (PMP) were in agreement with previous reports of Turhan and Yaşar (2020). FTIR spectra for 2,2-hydroxybenzylideneaminophenol (HAP) is presented in Appendix 24 and the Spectral interpretation is presented in Table 14. An assignment of vibrational stretching C-H was assigned 2691.1 to 2926.0cm^{-1} a vibrational C-H within the benzene ring was assigned to bands 1804.6 cm^{-1}, 1848.8 cm^{-1}, 1990.4 cm^{-1} and 3045.2 cm^{-1} respectively, C=C vibrations within the benzene ring and C=N vibrations were seen at 1528.2 cm^{-1} and 1610.2 cm^{-1} respectively. vO-H stretching of phenol was also assigned to the band at 3634.2 cm^{-1} and 3678.0 cm^{-1} respectively.

The infrared spectra of FTIR spectra for 2-phenyliminomethylphenol Platinum(II) Chloride complex [Pt(PMP)$_2$.Cl$_2$], 2,2-hydroxybenzylideneaminophenol Platinum(II)Chloride complex [Pt(HAP)$_2$.Cl$_2$] and mixed ligand of PMP and HAP of Platinum(II)Chloride[Pt(PMP+HAP).Cl$_2$] are presented in Appendix 13, 14 and 15 and the spectral interpretation given in Table 13, 14 and 15 respectively. The spectra for the metal complexes were compared with that of the original ligand PMP and HAP. The original ligand and complexes showed dissimilarity in their spectra suggesting the bonding of Pt^{2+} with PMP and HAP and Cl^{-}. For [Pt(PMP)$_2$.Cl$_2$], vC=C vibrations in Benzene rings were at bands of 1524.5cm^{-1} and 1576.7cm^{-1} repectively, and vC=N stretching were observed at bands of 2105.0cm-^{1} -2370.6cm^{-1} and vO-H stretching were found at 3060.1 -39063cm^{-1} bands. For [Pt(HAP)$_2$.Cl$_2$]. The vC=C stretching were found at 1543.3 bands while vC=N stretching were at bands 2113.4cm^{-1} and 2374.3cm^{-1} respectively, the vC-H stretching were at 2557.0cm^{-1} bands and vO-H stretching were between 3019.1cm^{-1} and 3869.1cm^{-1}.For the mixed ligands of [Pt(PMP+HAP).Cl$_2$], vC=N stretching were found at 2009.0cm^{-1} -2419.0cm^{-1} bands, vC=C stretching of the aromatic rings observed at 2922.9cm^{-1} bands and vO-H stretching were noticed at 3131.0cm^{-1} -3936.1cm^{-1}. The broad absorption band at the 3936.1 cm^{-1} for the mixed Pt^{2+} which were present in the spectra of the metal complexes of Pt^{2+} was assigned to vOH of the enol form of the ligand (Chris & John, 2007). However, the broad band appearing in the 3583.3 cm^{-1} of the FTIR spectra region for Pt^{2+} complexes have been attributed to vOH of adduct of water molecules coordinated to the central metal ion or residing in the crystal lattices of the complexes (Ogwuegbu *et al.*, 2019). Furthermore, the absorption band at 2419.0 cm^{-1} due to C=N vibration in the spectrum of 2-phenyliminomethylphenol was shifted in the spectra of the prepared complex. This shows that the coordination of [Pt(PMP)$_2$.Cl$_2$] is between N of the C=N (imine) group and the metal of the complex.

The infrared spectra of FTIR spectra for 2-phenyliminomethylphenol Copper(II)Chloride complex [Cu(PMP)$_2$.Cl$_2$], 2,2-hydroxybenzylideneaminophenol Copper(II)Chloride complex [Cu(HAP)$_2$.Cl$_2$] and mixed ligand of PMP and HAP of Copper(II)Chloride [Cu(PMP+HAP).Cl$_2$] are presented in Appendix 16, 17 and 18 and the spectral interpretation given in Tables 16, 17 and 18 respectively. The spectra for the metal complexes were compared with that of the original ligand PMP and HAP. The original ligand and complexes showed dissimilarity in their spectra suggesting the bonding of Cu^{2+} with PMP and HAP and Cl^{-}. For [Cu(PMP)$_2$.Cl$_2$], an assignment of vC=C vibrations in Benzene rings were at bands of 1524.5cm^{-1} and 1606.5cm^{-1} repectively. vC=N stretching were observed at bands of 2113.4cm-^{1} and vO-H stretching were found at 3224.4cm^{-1} bands. For [Cu(HAP)$_2$.Cl$_2$], vC=N stretching were at bands 1528.2cm^{-1} and vO-H stretching were found at 3168.0cm^{-1}- 3809.3cm^{-1}. For the mixed ligands of [Cu(PMP+HAP).Cl$_2$], vC=N stretching were found at 2109.7cm^{-1} bands, vC=Cstretching vibration were at 1524.5cm^{-1} bands and vO-H stretching were noticed at 3309.8cm^{-1} . The broad absorption band at the 3309.8 cm^{-1} for the mixed Cu^{2+} which were present in the spectra of the metal complexes of Cu^{2+} were attributed to vOH of the enol form of the ligand (Chris and John, 2007).

Table 11: Showing the FTIR spectrum data for the ligand 2-phenyliminomethylphenol (PMP) of the characteristics infrared absorption frequencies.

Assignment of Bond	Frequency Range in cm^{-1}	Functional Group Type
vC=N stretching	1569.2	Aromatic Amines
C-H bending	1613.9	Aromatic Amines
C-H bending	1833.3	Aromatic ring
C-H bending	1919.6	Aromatic ring
vC=N stretching	2109.7	Aromatic Amines
vC-H stretching	2653.9	Aromatic ring
vC-H stretching	2713.5	Aromatic ring
vC-H stretching	2851.4	Aromatic ring
vC-H stretching	2991.9	Aromatic ring
vC-H vibrations in ring	3056.4	Aromatic ring
vO-H	3213.0	Phenolic
vO-H	3652.8	Phenolic

Table 12: Showing the FTIR spectrum data for the ligand 2,2-hydroxybenzylideneaminophenol (HAP) of the characteristics infrared absorption frequencies.

Assignment of Bond	Frequency Range in cm^{-1}	Functional Group Type
vC-H stretching	1528.2	Aromatic ring
vC-H stretching	1804.8	Aromatic ring
vC-H stretching	1848.0	Aromatic ring
vC-H vibrations in ring	1990.4	Aromatic ring
vC-H stretching	2113.4	Aromatic ring
vC-H stretching	2374.3	Aromatic ring
vC-H stretching	2542.0	Aromatic ring
vC-H stretching	2691.1	Aromatic ring
vC-H stretching	2851.4	Aromatic ring
vC-H stretching	2926.0	Aromatic ring
vC-H vibrations in ring	3045.2	Aromatic ring
vO-H	3634.2	Phenolic
vO-H	3678.9	Phenolic

Table 13: Showing the FTIR spectrum data for 2-phenyliminomethylphenol platinum(II) chloride complex of the characteristics infrared absorption frequencies.

Assignment of Bond	Frequency Range in cm^{-1}	Functional Group Type
vC=C	1524.5	Aromatic ring
vC=C	1576.7	Aromatic Alkene
vC=N	1730.5	Phenolic
C-H bending	1796.6	Aromatic ring
C-H bending	1871.1	Aromatic ring
C-H bending	1945.7	Aromatic ring
C-H bending	1982.9	Aromatic ring
vC=N stretching	2105.9	Aromatic Amine
vC=N stretching	2318.4	Aromatic ring
vC=N stretching	2370.6	Amines
vC-H stretching	2650.1	Aromatic Alkenes
vO-H vibration in rings	3060.1	Phenolic
vO-H	3123.5	Phenolics
vO-H	3198.1	Phenolics
vO-H	3511.2	Phenolics
vO-H	3585.7	Phenolics
vO-H	3712.4	Phenolics
vO-H	3749.7	Phenolics
vO-H	3805.6	Phenolics
vO-H	3906.3	Phenolics

Table 14: Showing the FTIR spectrum data for 2,2-hydroxybenzylideneaminophenol platinum(II) chloride complex of the characteristics infrared absorption frequencies.

Assignment of Bond	Frequency Range in cm^{-1}	Functional Group Type
vC=C aromatics	1543.3	Aromatic ring
vC=C aromatics	1628.8	Aromatic Ring
vC=N C-H bending (aromatic) vC=N stretching vC=N stretching vC-H stretching vO-H vibrational rings vO-H vO-H vO-H vO-H vO-H vO-H	1790.6 1871.1 2113.4 2374.3 2557.0 3019.1 3511.2 3618.2 3570.8 3712.4 3753.4 3869.0	Amines Aromatic Ring Amines Amines Aromatic Alkenes Phenolic Phenolic Phenolic Phenolic Phenolic Phenolic Phenolic Phenolic

Table 15: Showing the FTIR spectrum data for mixed ligand of PMP+HAP platinum(II) chloride complex of the characteristics infrared absorption frequencies.

Assignment of Bond	Frequency Range in cm^{-1}	Functional Group Type
C-H bending (aromatic)	1736.9	Aromatic Alkene
C-H bending (aromatic)	1774.2	Aromatic Alkene
vC=N stretching	2009.0	Aromatic Amines
vC=N stretching	2219.4	Aromatic Amines
vC=N stretching	2139.5	Aromatic Amines
vC=N stretching	2419.0	Aromatic Amines
vC=C stretching	2519.7	Aromatic Ring
VC=C stretching	2605.4	Aromatic Ring
VC=C stretching	2810.4	Aromatic Ring
VC=C stretching in ring	2858.9	Aromatic Ring
VC=C stretching	2922.9	Phenolic
vO-H	3131.0	Phenolic
vO-H	3213.0	Phenolic
vO-H	3272.0	Phenolic
vO-H	3444.1	Phenolic
vO-H	3529.8	Phenolic
vO-H	3583.3	Phenolic
vO-H	3649.1	Phenolic
vO-H	3675.2	Phenolic
vO-H	3820.5	Phenolic
vO-H	3857.8	Phenolic
vO-H	3936.1	Phenolic

Table 16: Showing the FTIR spectrum data for 2-phenyliminomethylphenol copper(II)chloride complex of the characteristics infrared absorption frequencies.

Assignment of Bond	Frequency Range in cm^{-1}	Functional Group Type
vC=C aromatics	1524.5	Aromatic ring
vC=C aromatics	1606.5	Phenolic
C-H bending (aromatic) C-H bending (aromatic) vC=N stretching vO-H vibration rings	1893.5 1982.9 2113.4 3224.1	Phenolic Aromatic Alkenes Aromatic Alkenes Amines Aromatic Ring

Table 17: Showing the FTIR spectrum data for 2,2-hydroxybenzylideneaminophenol copper(II)chloride complex of the characteristics infrared absorption frequencies.

Assignment of Bond	Frequency Range in cm^{-1}	Functional Group Type
vC=N stretching	1528.2	Aromatic Amines
C-H bending (aromatic)	1927.0	Aromatic Alkenes
vC-N stretching	2370.6	Aromatic Amines
vC-H vibration in rings	3060.1	Aromatic Alkenes
vO-H	3168.0	Aromatic Ring
vO-H	3652.8	Phenolic
vO-H	3710.2	Phenolic
vO-H	3753.4	Phenolic
vO-H	3809.3	Phenolic

Table 18: Showing the FTIR spectrum data for mixed ligand of PMP+HAP copper(II)chloride complex of the characteristics infrared absorption frequencies.

Assignment of Bond	Frequency Range in cm^{-1}	Functional Group Type
vC=C stretching	1524.5	Aromatic Ring
vC-H stretching	1606.5	Aromatic Ring
vC=N stretching	2109.7	Aromatic Amines
vO-H	3309.8	Aromatic Amines Phenolic

3.5 Electronic Spectra

The Electronic spectra of the complexes formed are presented in Appendix 19 to 24 while the spectral data were listed in Table 19. The energy absorbed in the ultraviolet/visible region produced changes in the electronic energy of the compound resulting from transition of valence electrons in the complexes. These transitions consist of the excitation of an electron from a filled molecular orbital (usually a non-bonding (n) or a bonding $\pi \rightarrow \pi^*$ molecular orbital of an unfilled molecular orbital. It is not all transition from filled to unfilled molecular orbital is allowed (Waheb and Adedibu, 2003; Ogwuegbu *et al.*, 2017). The UV-Vis spectrum of the complexes were characterized mainly by one absorption and thus appear to have virtually identical spectra, and absorb in the near visible region around λ_1 =295nm, 297nm, 498nm, 349nm, 435nm and 295nm for $[Pt(PMP)_2.Cl_2]$, $[Pt(HAP)_2.Cl_2]$, $[Pt(PMP+HAP)_2.Cl_2]$, $[Cu(PMP)_2.Cl_2]$, $[Cu(HAP)_2.Cl_2]$ and $[Cu(PMP+HAP).Cl_2]$ complexes. These absorptions are ascribed to $\pi \rightarrow \pi^*$. The close absorption spectra of the ligand and the metal complexes suggest that the π -bonding system of the free nitro group is intact in the ligand of the metal complexes (Ogwuegbu & Maseka, 1998), indicating that there are no interaction between the metal ions and π-bonding system of the ligand. The coordination between the ligand and the metal ions is therefore through bond formation between the metal ions and the O atom of the hydroxyl group of the ligand.

Table 19: UV-Visible spectra for mixed ligand platinum and copper(II) chloride complexes.

Compounds	Wavelength (nm)	Elemental Transition
$[Pt(PMP)_2.Cl_2]$	295	$\pi \rightarrow \pi^*$
$[Pt(HAP)_2.Cl_2]$	297	$\pi \rightarrow \pi^*$
$[Pt(PMP+HAP).Cl_2]$	498	$\pi \rightarrow \pi^*$
$[Cu(PMP)_2.Cl_2]$	349	$\pi \rightarrow \pi^*$
$[Cu(HAP).Cl_2]$	435	$\pi \rightarrow \pi^*$
$[Cu(PMP+HAP).Cl_2]$	295	$\pi \rightarrow \pi^*$

3.6 XRD Analysis

X-ray diffraction analysis (XRD) is a technique used to determine the crystallographic structure of the synthesized complexes. XRD works by irradiating a material with incident X-rays and then measuring the intensities and scattering angles of the X-rays that leave the compounds. The XRD spectral (powder study) for the different synthesized ligands PMP and HAP and $Pt^{2+}$and Cu^{2+} complexes are presented in Appendix 25 to 32 and the spectral interpretation given in Table 20 to 27. X-ray diffractograms of the metal complexes investigated showed good intense peaks indicating high crystallinity except for 2-phenyliminomethylphenol platinum(II), 2,2-hydroxybenzylideneaminophenol platinum(II), and mixed ligand (PMP+HAP) platinum(II) complexes which have reduced and broadened peak indicating their less crystalline. Similar observation was made for Cu(II) complexes of 4(4-(dimethylamino) benzylideneamino)benzoic acid (Khan *et al.*, 2013). Crystalline nature of the complexes was indicated by comparing the diffractograms with their respective ligands and results showed marked differences, which indicate complexation have really occurred.

Table 20: FWHM Values, Average Crystallite Sizes Calculated Using Scherrer's Formula, D-Spacing, And Bragg's Diffraction Degree of 2-Phenyliminomethylphenol Ligand Synthesized.

Bragg's diffraction [°2ϴ]	Full width at half maximum (FWHM) (degrees)	d-spacing [Å]
PMP		
9.8808	0.1574	8.95195
11.7117	0.1574	7.55628
12.4831	0.1968	7.09100
12.9439	0.1378	6.83958
13.8742	0.4723	6.38301
15.4647	0.1378	5.72993
16.7218	0.2362	5.30191
17.1345	0.1181	5.17511
18.4386	0.1181	4.81192
18.8751	0.1181	4.70163
19.0686	0.0984	4.65435
21.4763	0.1771	4.13768
23.7810	0.2362	3.74164
25.6052	0.3936	3.47907
27.6052	0.6298	3.23139
28.0226	0.1181	3.18420
28.8981	0.1181	3.08970
29.3573	0.2755	3.04240
30.4013	0.3149	2.94026
34.2139	0.0787	2.62084
38.0036	0.1574	2.36776
38.8284	0.3149	2.31934
39.7807	0.2362	2.26599
44.2773	0.1968	2.04574
48.1090	0.4723	1.89138
49.9102	0.3936	1.82726
64.4521	0.3149	1.44570
Average crystallite size = 459.09 nm		

Table 21: FWHM values, average crystallite sizes calculated using Scherrer's formula, d-spacing, and Bragg's diffraction degree of 2,2-hydroxybenzylideneaminophenol ligand synthesized.

Bragg's diffraction [°2ϴ]	Full width at half maximum (FWHM) (degrees)	d-spacing [Å]
HAP		
8.5287	0.4723	10.36788
9.3516	0.0984	9.45732
9.6897	0.2362	9.12802
13.2924	0.1378	6.66104
13.6907	0.2755	6.46813
14.7029	0.1181	6.02507
15.1847	0.1771	5.83495
15.3412	0.1181	5.77577
19.3409	0.4723	4.58943
20.8612	0.6298	4.25827
22.5581	0.9446	3.94164
24.3965	0.1181	3.64864
27.2967	0.1574	3.26721
34.2415	0.1181	2.61879
35.5234	0.6298	2.52717
38.0154	0.1968	2.36705
39.7603	0.1181	2.26710
44.2581	0.0787	2.04659
45.8873	0.4723	1.97764

49.5299	0.2362	1.84040
64.4553	0.1181	1.44564
68.8234	0.2362	1.36416
Average crystallite size = 473.52 nm		

Table 22: FWHM values, average crystallite sizes calculated using Scherrer's formula, d-spacing, and Bragg's diffraction degree of 2-phenylaminomethylphenol platinum(II) chloride complex synthesized.

Bragg's diffraction [°2Θ]	**Full width at half maximum (FWHM) (degrees)**	**d-spacing [Å]**
[Pt(PMP)$_2$.Cl$_2$]		
7.694	0.213	11.482
16.00	0.17	5.536
18.57	0.30	4.775
22.23	1.04	3.995
24.036	0.92	3.699
25.68	0.27	3.467
34.18	0.133	2.6213
37.976	0.179	2.3674
44.193	0.182	2.0478
64.44	0.14	1.4447
68.792	0.15	1.3636
Average crystallite size = 423.27 nm		

Table 23: FWHM values, average crystallite sizes calculated using Scherrer's formula, d-spacing, and Bragg's diffraction degree of 2,2-hydroxybenzylideneaminophenol platinum(II)chloride complex synthesized.

Bragg's diffraction [°2Θ]	**Full width at half maximum (FWHM) (degrees)**	**d-spacing [Å]**
[Pt(HAP)$_2$.Cl$_2$]		
8.710	0.31	10.14
9.639	0.256	9.168
13.453	0.34	6.576
14.918	0.271	5.934
15.377	0.245	5.757
17.31	0.25	5.119
19.217	0.283	4.6149
20.147	0.316	4.404
20.844	0.222	4.258
22.04	0.41	4.031
23.954	0.25	3.7119
24.407	0.293	3.6441
26.512	0.27	3.3592
27.186	0.260	3.2775
29.98	0.30	2.978
31.18	0.54	2.866
31.694	0.24	2.8209
34.258	0.213	2.6154
38.053	0.169	2.3628
38.89	0.19	2.3138
Average crystallite size = 322.45 nm		

Table 24: FWHM values, average crystallite sizes calculated using Scherrer's formula, d-spacing, and Bragg's diffraction degree of mixed ligand (PMP+HAP) platinum(II) chloride complex synthesized.

Bragg's diffraction [°2Θ]	**Full width at half maximum (FWHM) (degrees)**	**d-spacing [Å]**
[Pt(HAP+PMP).Cl$_2$]		
7.67	1.42	11.52
18.68	1.7	4.75
23.59	1.5	3.768

34.080	0.115	2.6287
37.924	0.152	2.3706
39.613	0.113	2.2733
44.135	0.156	2.0503
64.384	0.138	1.44586
68.71	0.15	1.3649
Average crystallite size = 469.78 nm		

Table 25: FWHM values, average crystallite sizes calculated using Scherrer's formula, d-spacing, and Bragg's diffraction degree of 2-phenyliminomethylphenol copper(II) chloride complex synthesized.

Bragg's diffraction [°2Θ]	Full width at half maximum (FWHM) (degrees)	d-spacing [Å]
[Cu(PMP)$_2$.Cl$_2$]		
8.55	1.01	10.34
16.4	1.0	5.40
34.175	0.126	2.6215
37.988	0.145	2.3667
44.125	0.152	2.05076
68.83	0.14	1.3630
Average crystallite size = 460.17 nm		

Table 26: FWHM values, average crystallite sizes calculated using Scherrer's formula, d-spacing, and Bragg's diffraction degree of 2,2-hydroxybenzylideneaminophenol copper(II) chloride complex synthesized.

Bragg's diffraction [°2Θ]	Full width at half maximum (FWHM) (degrees)	d-spacing [Å]
[Cu(HAP)$_2$.Cl$_2$]		
8.38	1.01	10.54
28.6	1.5	3.12
34.18	0.17	2.6211
37.980	0.180	2.3672
39.72	0.19	2.267
44.221 64.53	0.191 0.25	2.0465 1.4430
Average crystallite size = 353.57 nm		

Table 27: FWHM values, average crystallite sizes calculated using Scherrer's formula, d-spacing, and Bragg's diffraction degree of mixed ligand (PMP+HAP) copper(II) chloride complex synthesized.

Bragg's diffraction [°2Θ]	Full width at half maximum (FWHM) (degrees)	d-spacing [Å]
[Cu(PMP+HAP).Cl$_2$]		
34.22	0.13	2.6180
38.036	0.174	2.3638
44.237	0.12	2.0458
Average crystallite size = 638.67 nm		

The average crystal size of the synthesized ligands and metal complexes were determined from the most intense peaks using Debye–Scherrer's equation. The Debye–Scherrer's equation is given as Equation (3)

$$D = \frac{k\lambda}{\beta \cos\theta} \qquad (3)$$

where K = 0.94 is Scherrer's constant, λ = 1.54 nm is the X-ray wavelength, θ is Bragg's diffraction angle, and β is the full width at half maximum (FWHM).

3.7 Microbial Chemistry and Antimicrobial Activities of the Synthesized Ligands and Metal Complexes

Microbial Chemistry is the branch of microbiology that deals with the study of biochemical ions taking place in microorganisms which help in their growth, development and/or inhibition of developmental mechanisms of pathogenesis. It is the study of interaction of metal complexes with microorganisms resulting in active inhibition or promotion of growth and development (Adeshina *et al*., 2009).

Microbial chemistry extends to the correct identification and studying of the bacterial isolates or other microbes in the laboratory for the development of precise treatment measures against the microorganism. The antimicrobial activity studies becomes the study of agents that kills microorganisms (microbicide) or agents that inhibits their growth (bacteriostatic agent). It is also the process of killing or inhibiting the disease-causing microbes (Andrews, 2001). Ligands and metals complexes can get as microbicide and bacteriostatic agents. This study investigated antimicrobial activities of the ligands PMP and HAP and the metal complexes of divalent metals of Pt^{2+} and Cu^{2+}, both mixed and unmixed ligands complexes. The results obtained showed that the PMP and HAP showed weak inhibition activity, but when complexed with the divalent metals there were stronger and improved inhibitive action on Gram-Positive, Gram-Negative and fungi when sensitivity test on these microbes were conducted. PMP and HAP showed partial inhibitory action on staphylococcus aureus and Bacillus Substilis of Gram-Positive bacteria. Furthermore, PMP and HAP showed weak inhibitory action on Pseudomonas aeruginosa, while HAP showed strong inhibitory action on *Escherichia coli* but PMP showed partial inhibitory action of the Gram-Negative bacteria. The sensitivity on the fungi have different inhibitory action as to PMP and HAP showed no inhibitory action on *Candida albicans* while HAP showed weak inhibitory action on the fungi specie: *Aspergillus niger*, PMP showed no inhibitory action.

Table 28: Showing inhibitory action of platinum and copper metal complexes across different classes of micro-organisms.

	PMP	HAP	$[Pt(PMP)_2.Cl_2]$	$[Pt(HAP)_2.Cl_2]$	$[Pt(PMP+HAP).Cl_2]$	$[Cu(PMP)_2.Cl_2]$	$[Cu(HAP)_2.Cl_2]$	$[Cu(PMP+HAP)_2.Cl_2]$
Gram Positive Bacteria								
Staphylococcus aureus	+	+	++	+++	+++	+++	+++	+++
Bacillus substilis	+	++	++	++	+++	+++	+++	+++
Gram Negative Bacteria								
Escherichia coli	+	++	+	++	++	+++	+++	+++
Pseudomonas aeruginosa	+	+	++	++	+++	+++	+++	+++
Fungi Pathogenic Specie								
Candida albicans	-	-	+	+	++	+++	+++	+++
Aspergillus niger	-	+	++	++	++	+++	+++	+++

- shows no inhibitory action, + shows weak or partial inhibitory action, ++ shows stronger inhibitory action, +++ shows strongest inhibitory action, – shows no inhibition.

SUGGESTED STRUCTURES

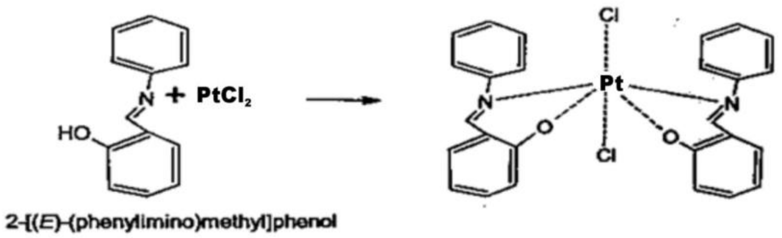


Figure 1: 2-phenyliminomethylphenol of platinum (II) complex.

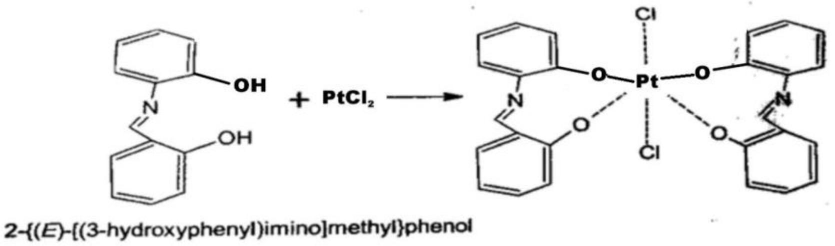


Figure 2: 2,2-hydroxybenzylideneaminophenol of platinum (II) complex.

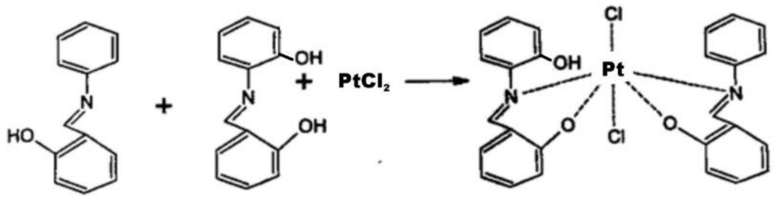


Figure 3: mixed ligand (PMP+HAP) of platinum (II) complex.

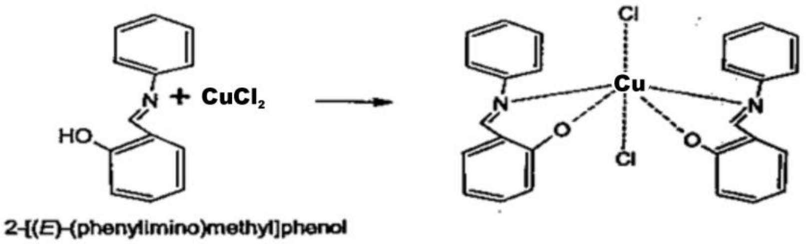


Figure 4: 2-phenyliminomethylphenol of copper (II) complex.

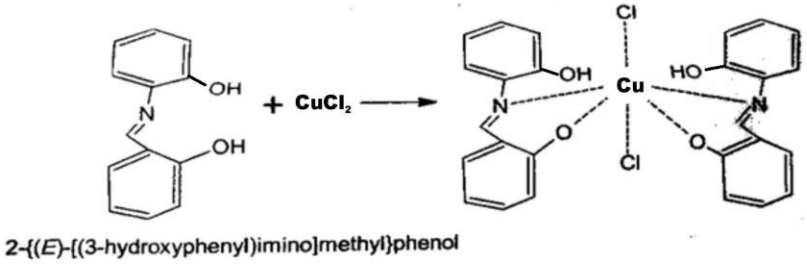


Figure 5: 2,2-hydroxybenzylideneaminophenol of copper (II) complex.

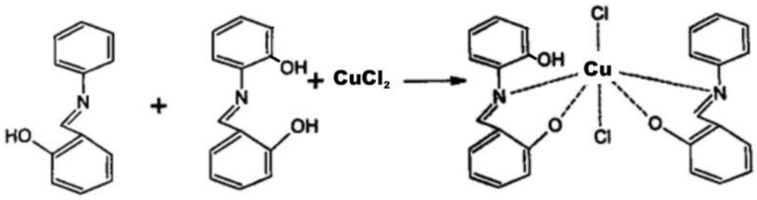


Figure 6: mixed ligand (PMP+HAP) of copper (II) complex.

The [Pt(PMP)$_2$.Cl$_2$] showed strong inhibitory action on both Staphylococcus aureus and Bacillus Substilis of Gram Positive Bacteria, strong inhibitory Pseudomonas aeruginosa, weak inhibitory action on Escherichia coli of Gram Negative Bacteria, on the Fungi, it showed weak inhibition on Candida albican but stronger inhibition on *Aspergillus niger*, [Pt(HAP) $_2$.Cl$_2$] showed strongest inhibition on Staphylococcus aureus and only strong inhibition on Bacillus Substilis of Gram Positive Bacteria, on Gram Negative Bacteria it showed stronger inhibition on both Escherichia coli and Pseudomonas aeruginosa while Fungi specie it showed only stronger inhibition on Aspergillus niger but partial inhibition on Candida albicans, [Pt(PMP+HAP)$_2$.Cl$_2$] the mixed ligand of Platinum showed strongest inhibition on both *Staphylococcus aureus* and *Bacillus substilis* of Gram Positive while it showed stronger inhibition on Pseudonmas aeruginosa, it showed only stronger inhibition on Escherichia coli of Gram Negative Bacteria, on the Fungi specie the mixed ligand of Platinum showed stronger inhibition on both *Candida albicans* and *Aspergillus niger*. All the copper complexes both mixed and unmixed showed strongest inhibitory action on all the Gram Positive Bacteria, Gram Negative Bacteria and all the Fungi species. That is to say it had better inhibitory action than other metal complexes synthesized.

4. CONCLUSION

From the results, the following conclusions can be drawn;

The complexes involving 2-phenyliminomethylphenol (PMP) *i.e* [Pt(PMP)$_2$.Cl$_2$], [Cu(PMP)$_2$.Cl$_2$], [Pt(HAP)$_2$.Cl$_2$], [Cu(HAP)$_2$.Cl$_2$], [Pt(PMP+HAP).Cl$_2$], and [Cu(PMP+HAP).Cl$_2$], have been synthesized and the following melting points 232°C, 102°C, 209°C, 78°C, 208°C and 77°C respectively, which was higher than the ligand (50°C). The increases in melting point are attributed to the increase in mass of the formed complexes and thus provide evidence for complexation. However, for the 2,2-hydroxybenzylideneaminophenol (HAP) with melting point of 106°C, was higher than it formed metal complexes with 209°C, 78°C, 208°C and 77°C for [Pt(HAP)$_2$.Cl$_2$], [Cu(HAP)$_2$.Cl$_2$], Pt(PMP+HAP).Cl$_2$], and [Cu(PMP+HAP).Cl$_2$] respectively. All complexes formed as well as their ligands were strongly soluble in Dimethylsulfoxide (DMSO). The Platinum(II) and Copper(II) are found to have octahedral geometry with 2-phenyliminomethylphenol and octahedral with 2,2-hydroxybenzylideneaminophenol distorted-octahedral with the mixed ligands. The ligand behaves as a bidentated ligand coordinated to the metal ions via oxygen atom of carbonyl group and nitrogen atoms of two imine groups for the complexes of platinum(II) and copper(II). The XRD pattern is indicative that the ligand and metal complexes are crystalline in nature with large crystallite size. The ligands 2-phenyliminomethylphenol(PMP) and 2,2-hydroxybenzylideneaminophenol(HAP) showed weak inhibitory action on the Clinical isolates of Gram Positive Bacteria, Gram Negative and no inhibition on Fungi Species while the metal complexes of Pt(II) showed either stronger or strongest inhibition which all the complexes exhibited strongest inhibitory action. This observation places Copper(II) complexes of 2-phenyliminomethylphenol (PMP) and 2,2-hydroxybenzylideneaminophenol (HAP) and its mixed ligand complexes with higher therapeutic value in terms of antimicrobial activities.

5. RECOMMENDATIONS

1. It is recommended that further research on other pharmaceutical and medicinal application such as anticancer, antitumor and antimutagenic investigations rather than only antimicrobial activities of these complexes be done.
2. Investigations on the industrial applications of these complexes such as catalysis, epoxidation reactions, metathesis, polymerization agents, metallocenes, etc be carried out.
3. Investigations on other economic viability of the complexes should also be done.
4. Toxicological studies on complexes should further be carried out.

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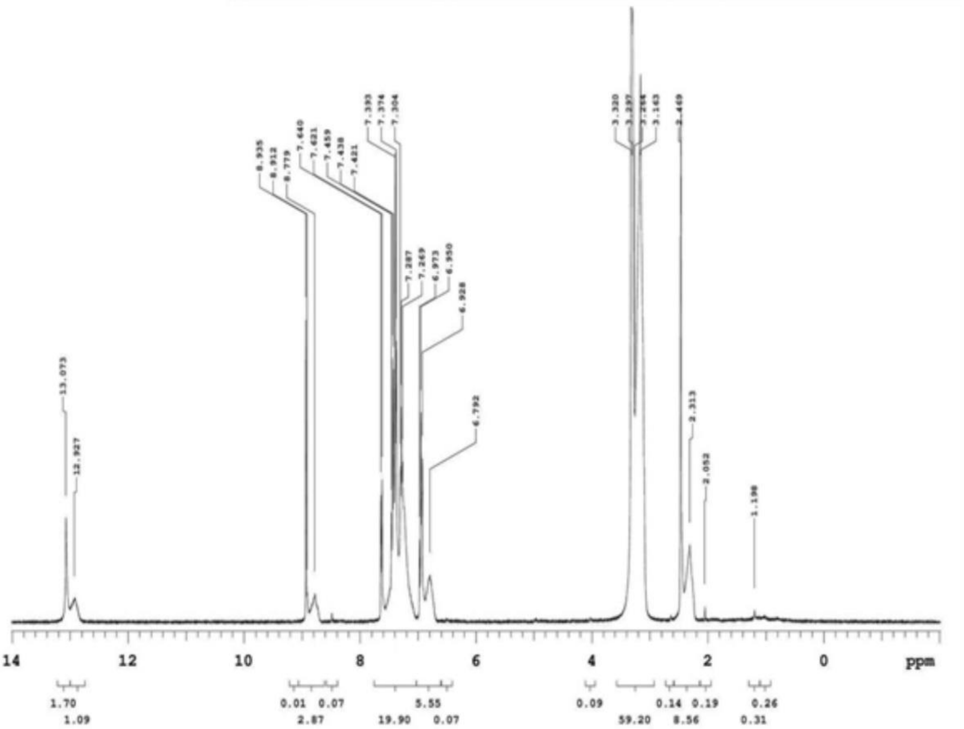
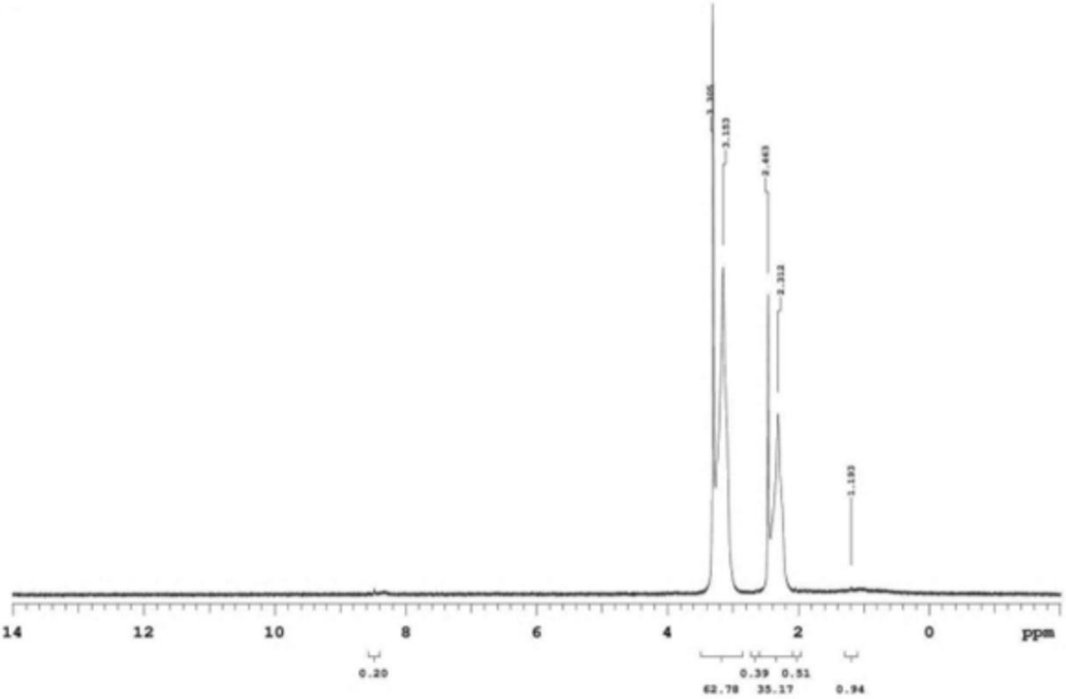
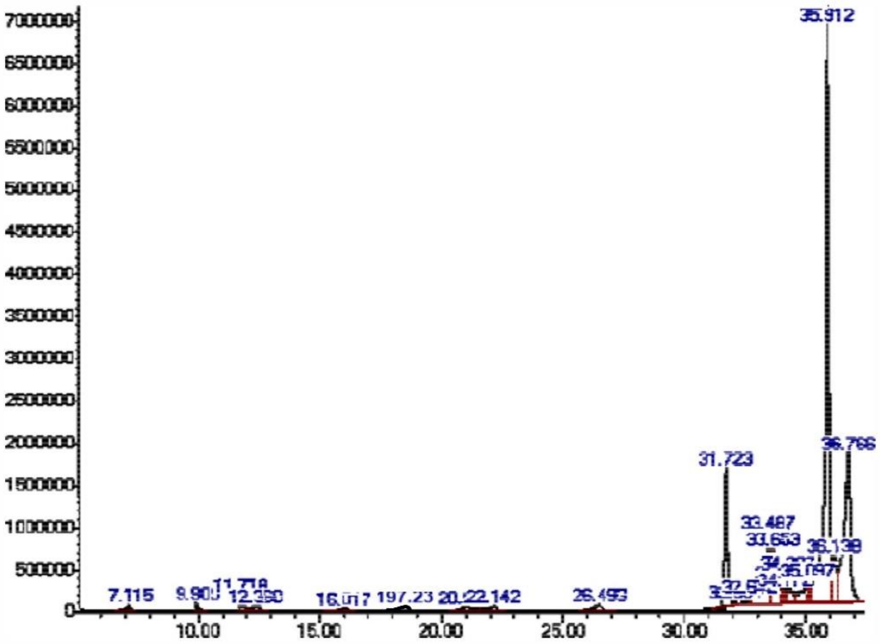
APPENDICES



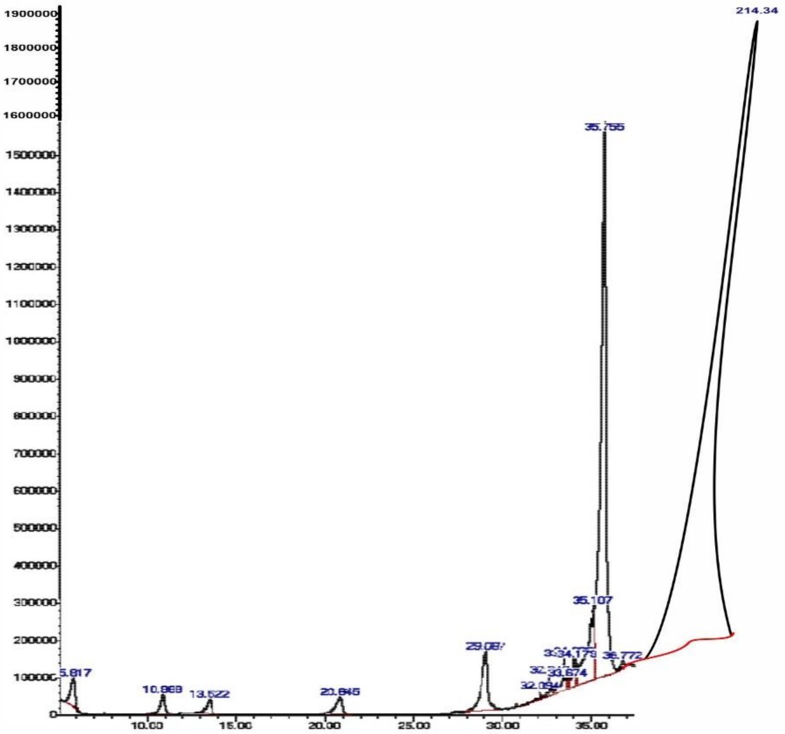
Appendix 1: Showing Proton ^{1}HNMR Spectra for 2-Phenyliminomethylphenol (PMP).



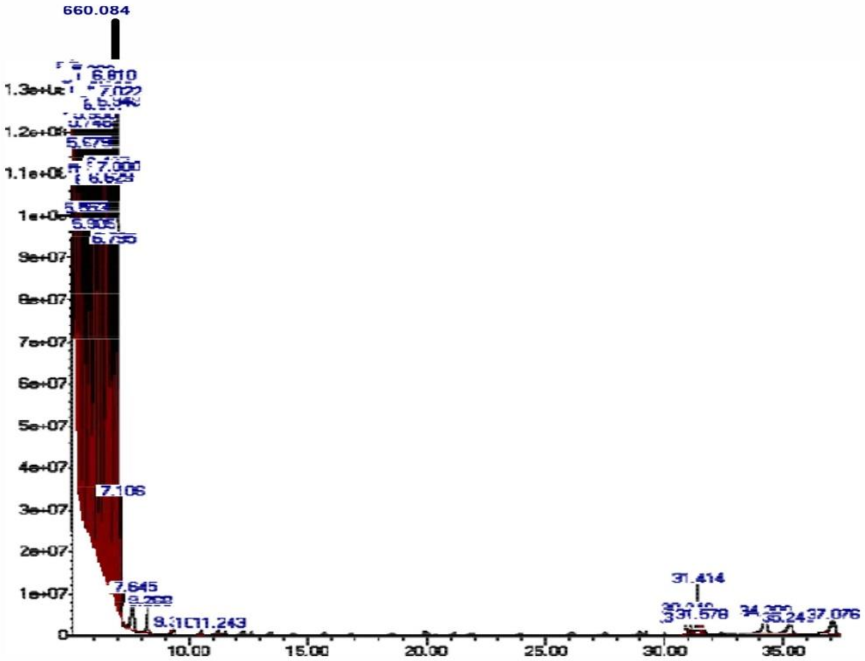
Appendix 2: Showing Proton ^{1}HNMR Spectra for 2,2-Hydroxybenzylideneaminophenol (HAP).



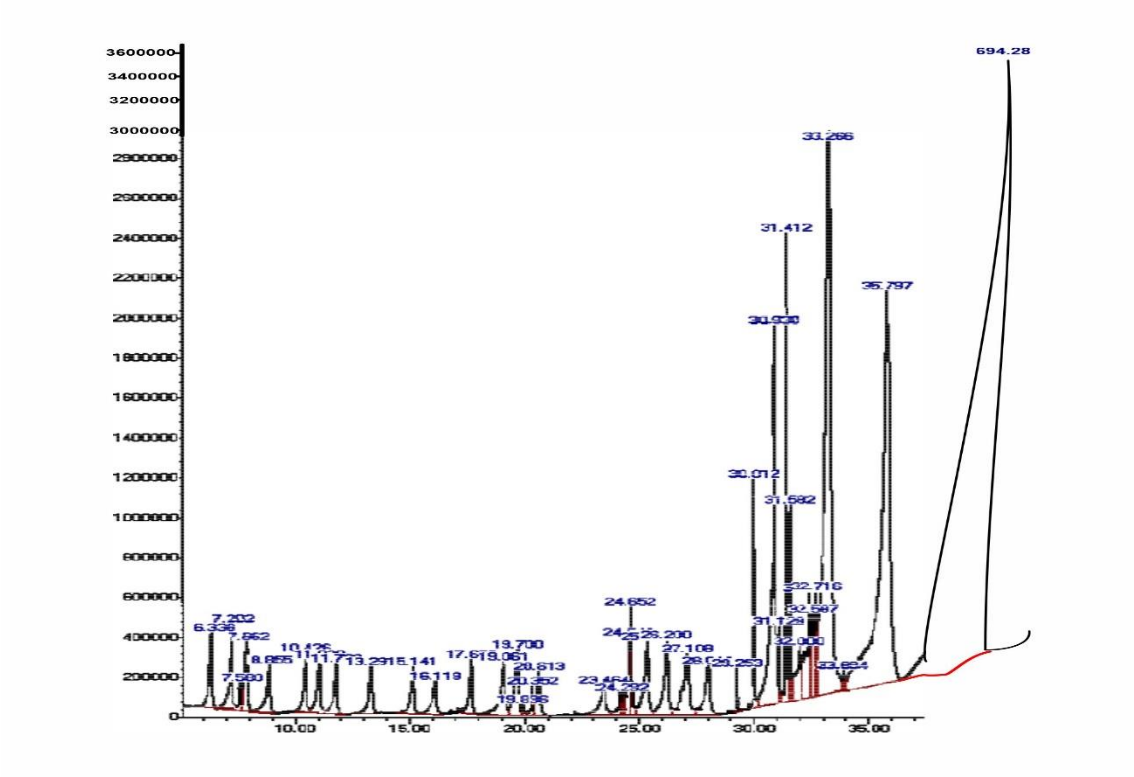
Appendix 3: Showing the GC-MS Spectrum of Sample A (PMP).



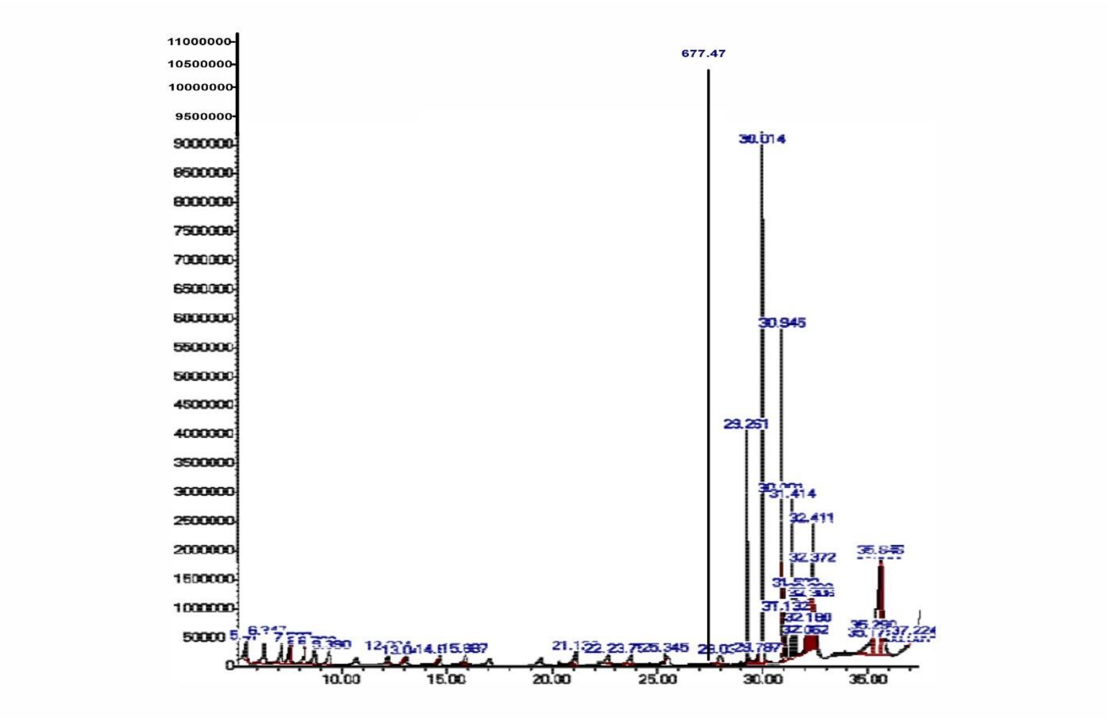
Appendix 4: Showing the GC-MS Spectrum of Sample B (HAP).



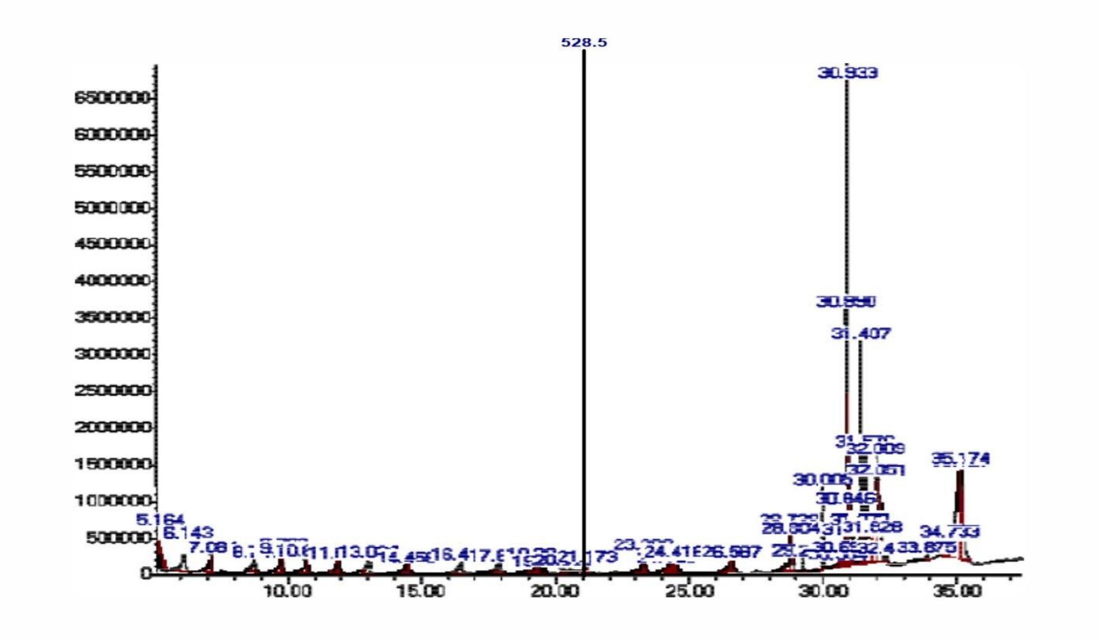
Appendix 5: Showing The GC-MS Spectrum of Sample C [Pt(PMP)$_2$.Cl$_2$].



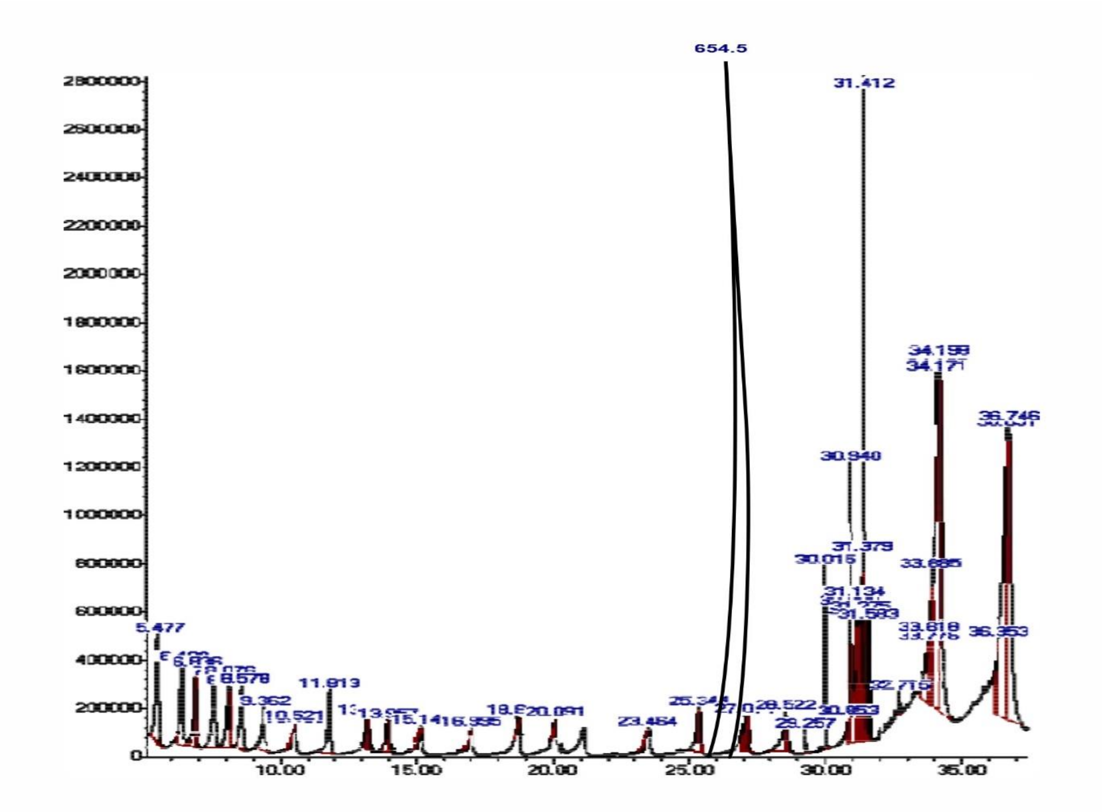
Appendix 6: Showing the GC-MS Spectrum Of Sample D [Pt(HAP)$_2$.Cl$_2$].



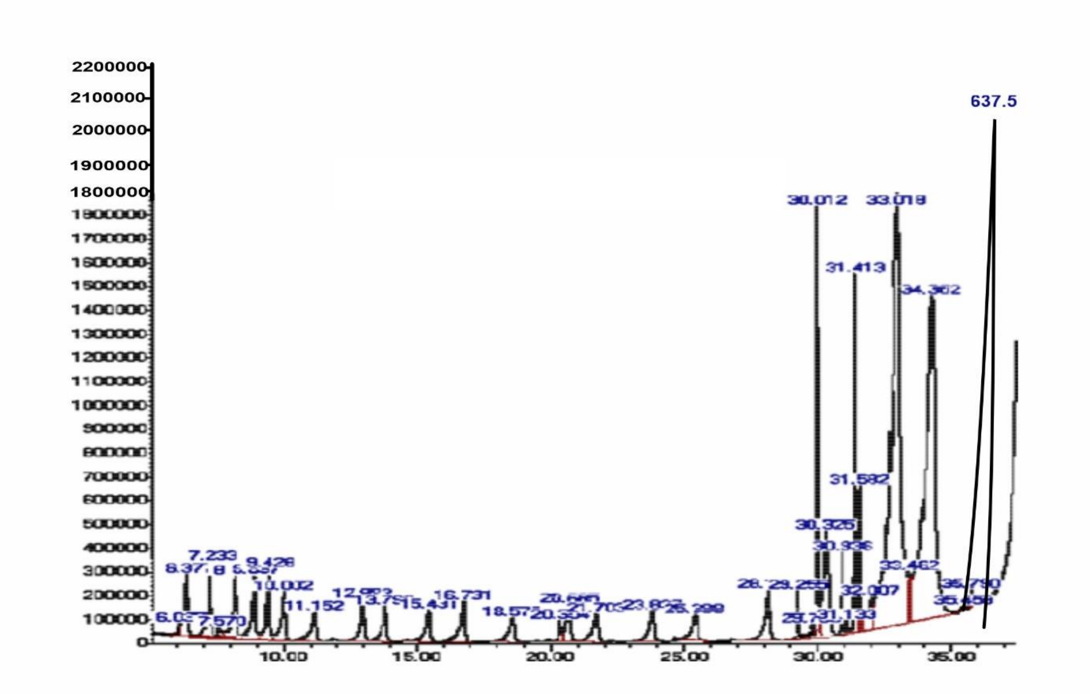
Appendix 7: Showing GC-MS Spectrum of Sample E [Pt(PMP+HAP).Cl_2].



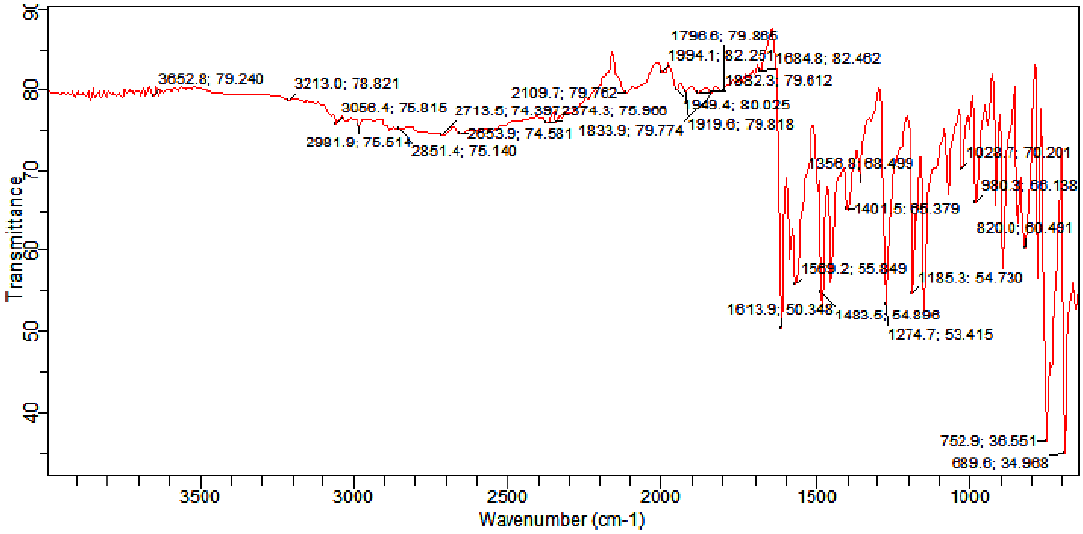
Appendix 8: Showing GC-MS Spectrum of Sample F [Cu$(PMP)_2$.Cl_2].



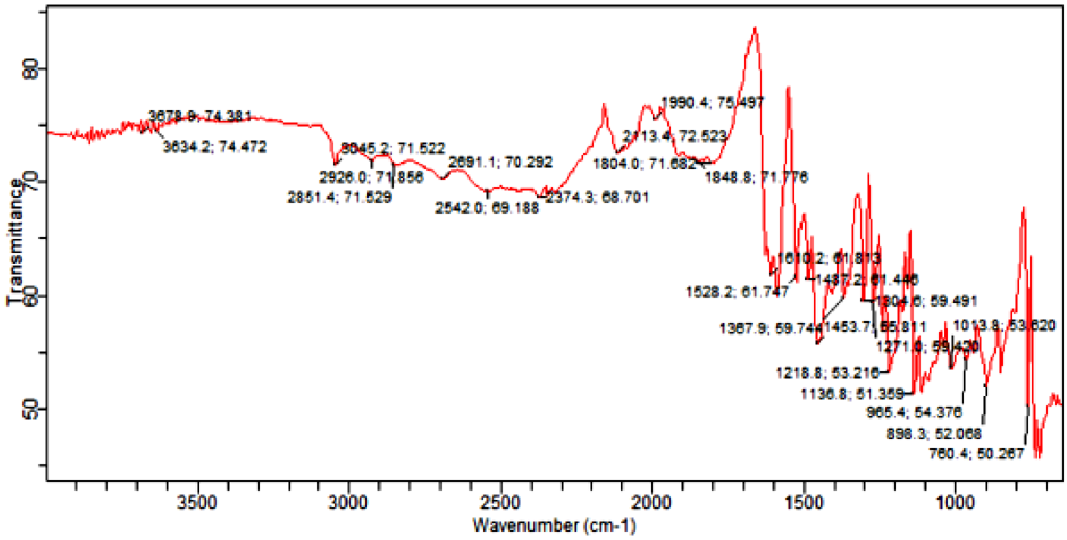
Appendix 9: Showing the GC-MS Spectrum of Sample G [Cu(HAP)$_2$.Cl$_2$].



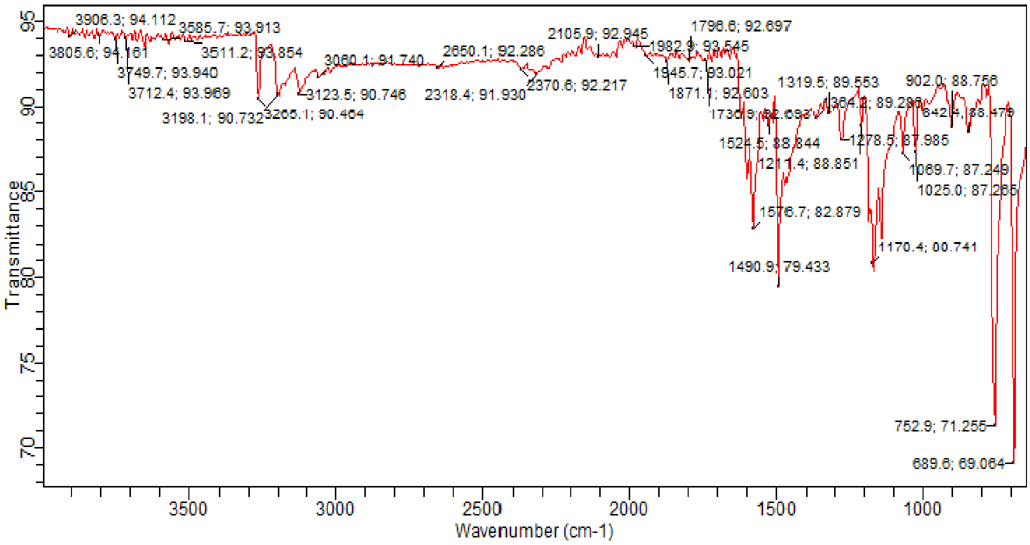
Appendix 10: Showing GC-MS Spectrum of Sample H [Cu(PMP+HAP).Cl$_2$].



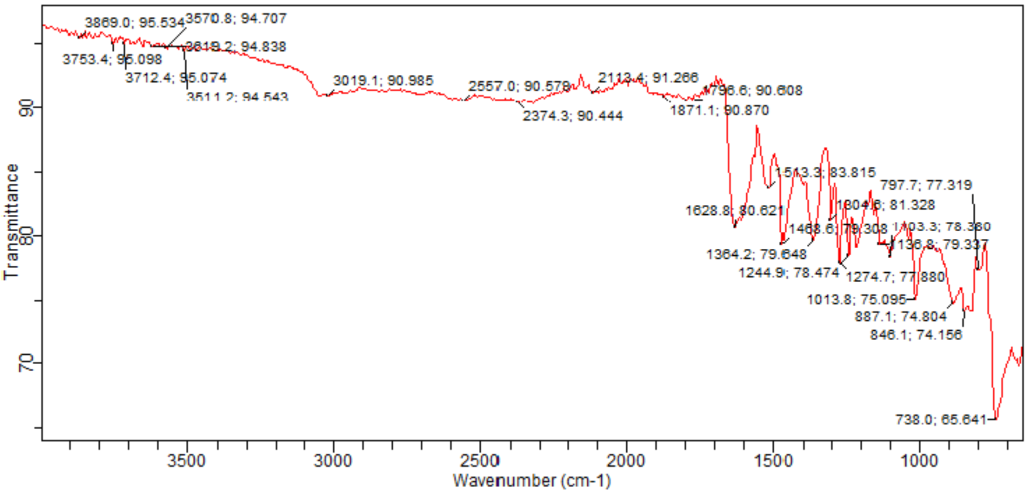
Appendix 11: Showing The FTIR Spectra For 2-Phenyliminomethylphenol (PMP).



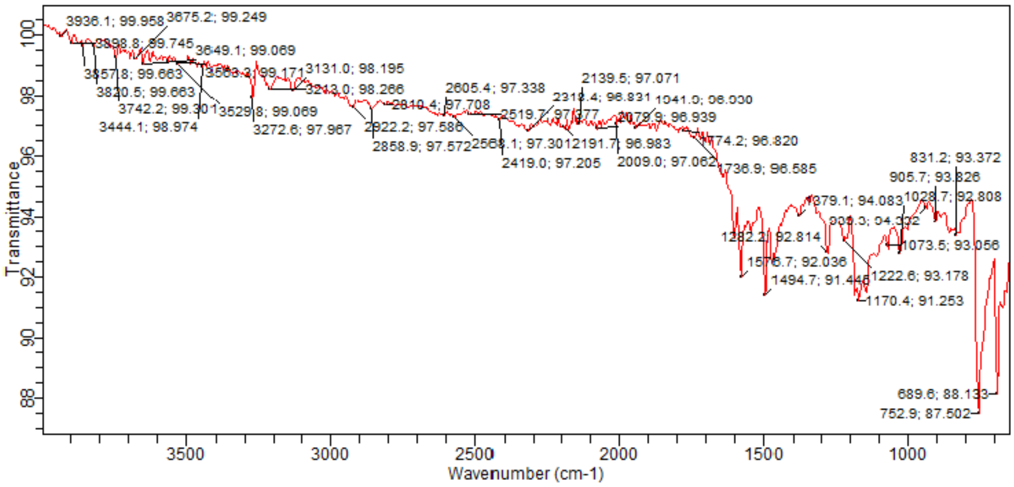
Appendix 12: Showing FTIR Spectra For 2,2-Hydroxybenzylideneaminophenol (HAP).



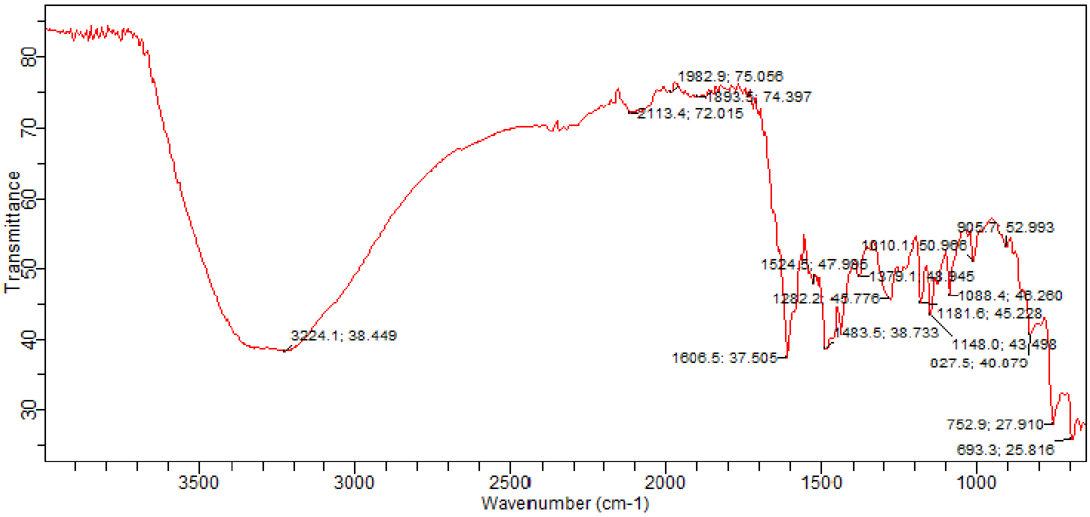
Appendix 13: Showing The FTIR Spectra For 2-Phenyliminomethylphenol Platinum(II) Chloride Complex, [Pt(PMP)$_2$.Cl$_2$].



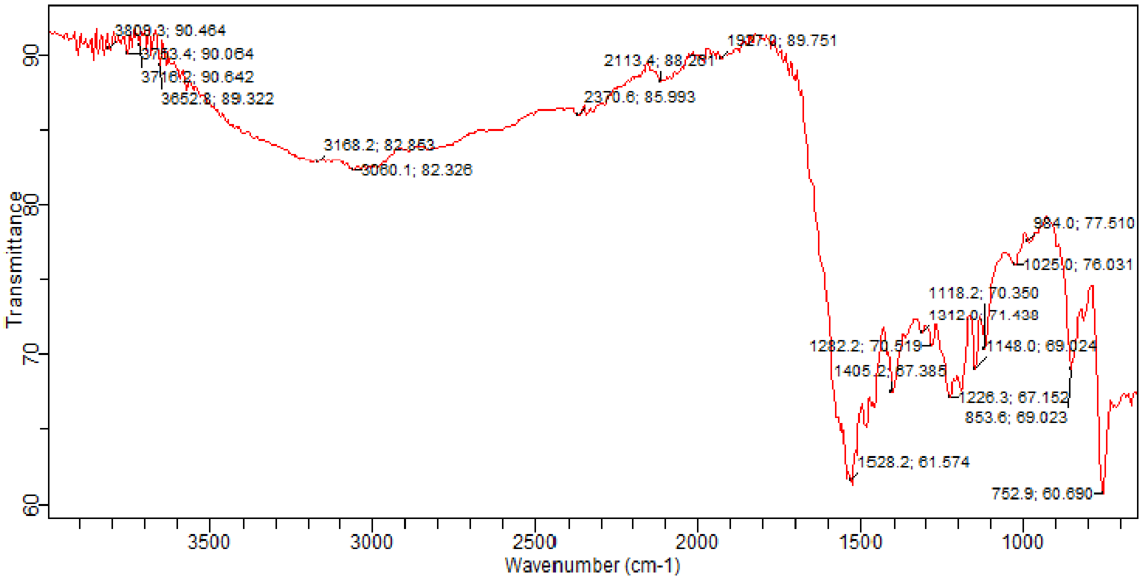
Appendix 14: Showing FTIR spectra for 2,2-hydroxybenzylideneaminophenol platinum(II) chloride complex, [Pt(HAP)$_2$.Cl$_2$].



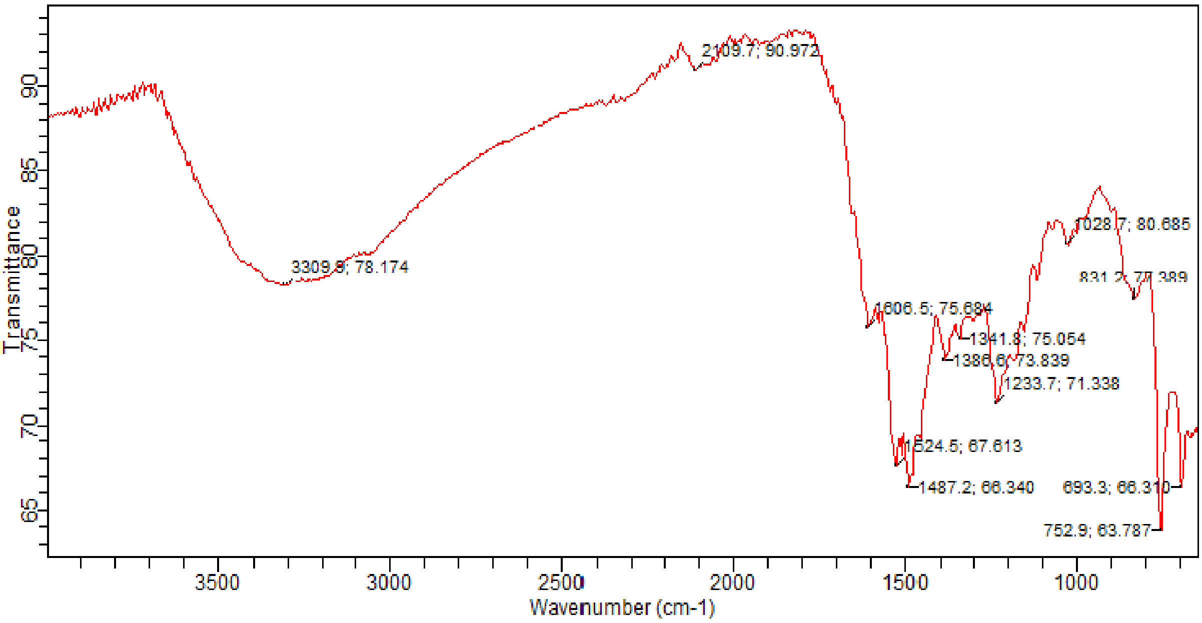
Appendix 15: Showing FTIR Spectra Mixed Ligand of PMP+HAP Platinum(II) chloride Complex, [Pt(PMP+HAP).Cl$_2$].



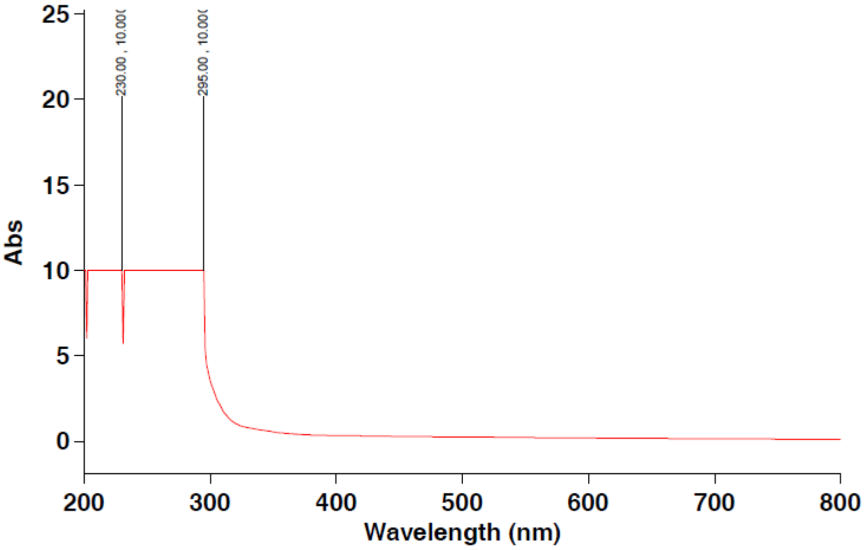
Appendix 16: Showing The FTIR Spectra For 2-Phenyliminomethylphenol Copper(II)Chloride Complex, [Cu(PMP)$_2$.Cl$_2$].



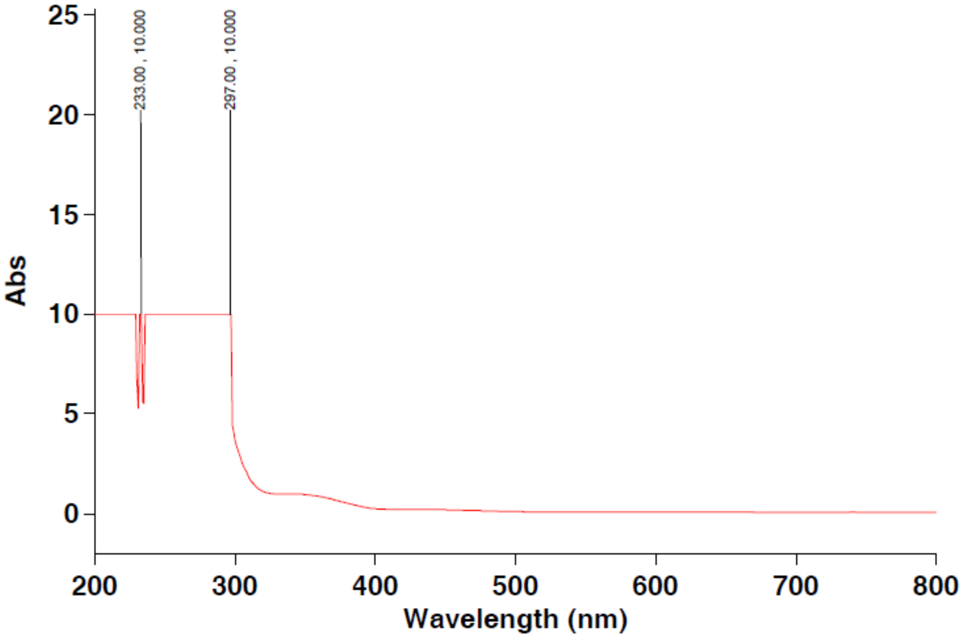
Appendix 17: Showing FTIR Spectra For 2,2-Hydroxybenzylideneaminophenol Copper(II) Chloride Complex, [Cu(HAP)$_2$.Cl$_2$].



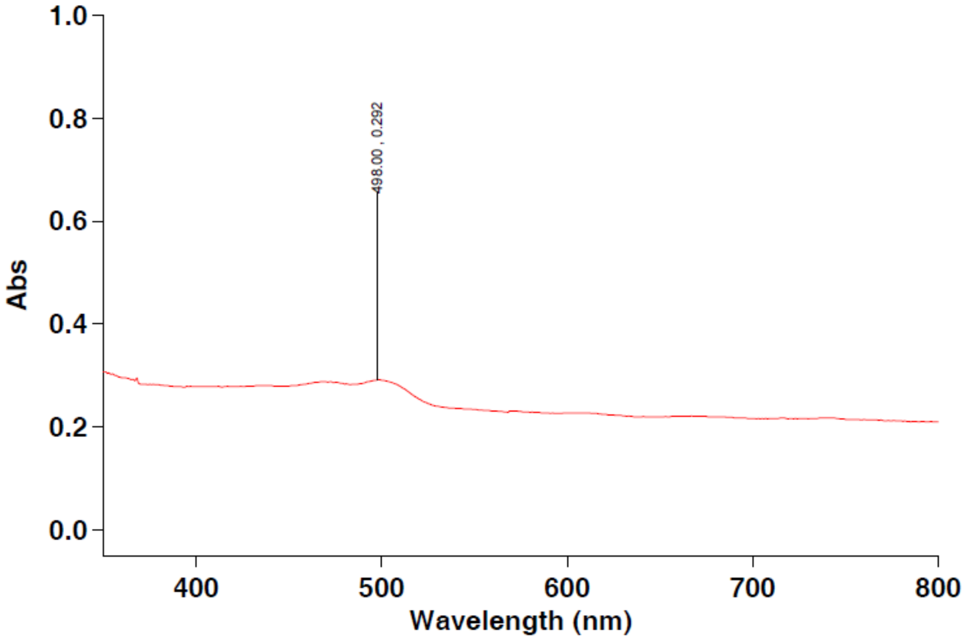
Appendix 18: Showing Ftir Spectra Mixed Ligand Of Pmp+Hap Copper(II) Chloride Complex, [Cu(PMP+HAP).Cl$_2$].



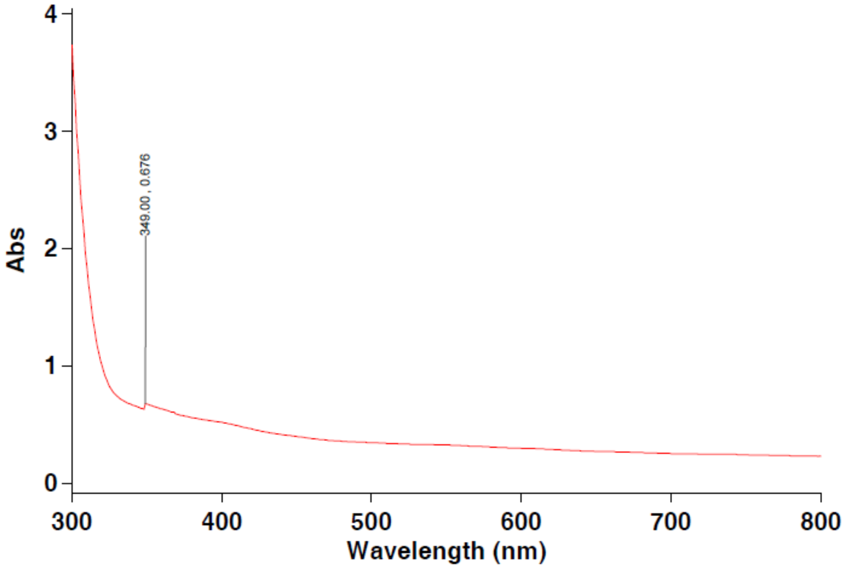
Appendix 19: UV-Visible Spectra For 2-Phenyliminomethylphenol Platinum(II) Chloride Complex, [Pt(PMP)$_2$.Cl$_2$]



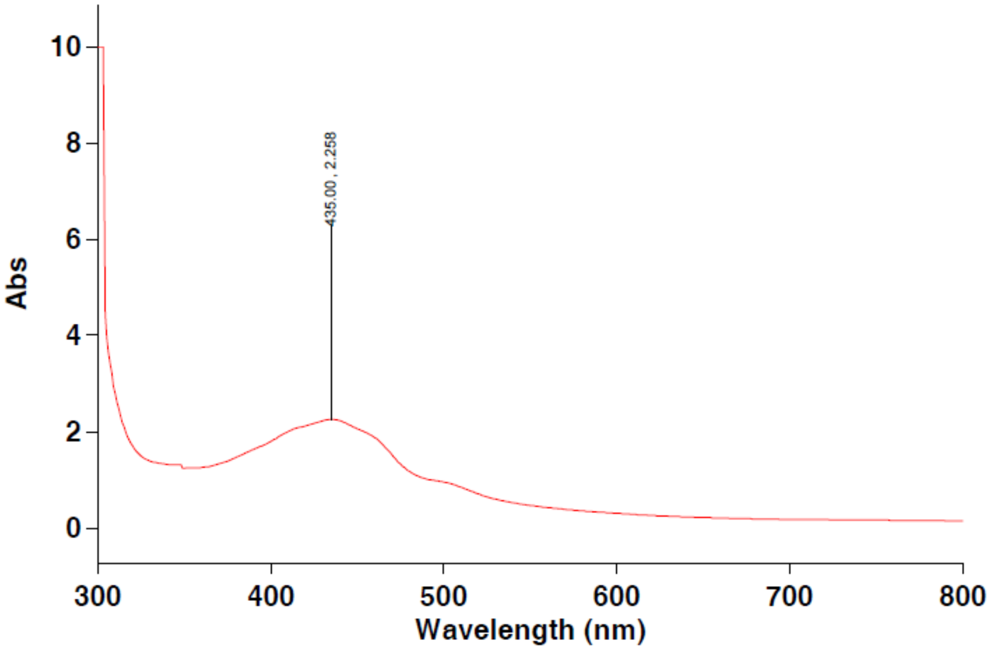
Appendix 20: UV-Visible spectra for 2,2-hydroxybenzylideneaminophenol platinum (II) chloride complex, [Pt(HAP)$_2$.Cl$_2$].



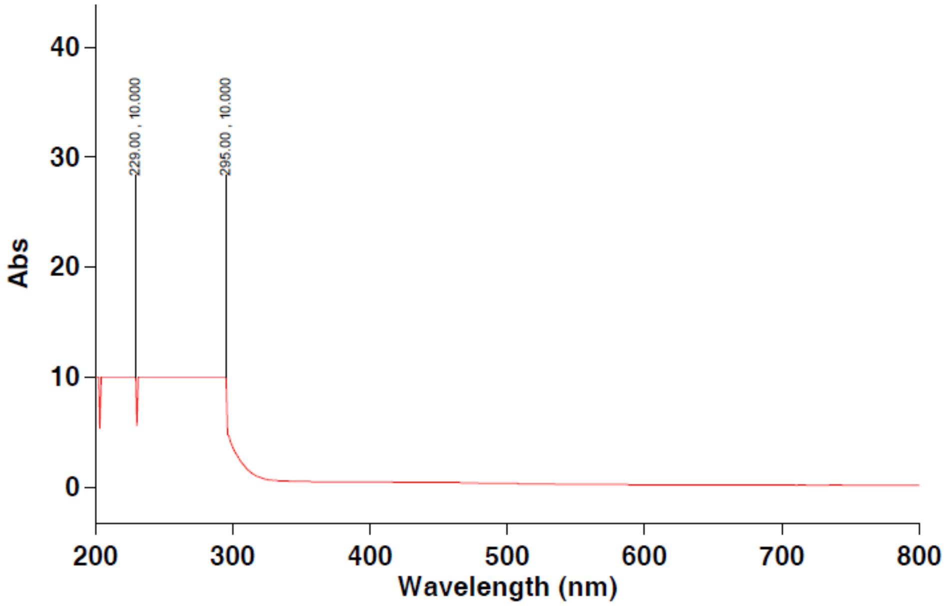
Appendix 21: UV-Visible spectra for mixed ligand (PMP+HAP) platinum (II) chloride complexes, [Pt(PMP+HAP).Cl_2]



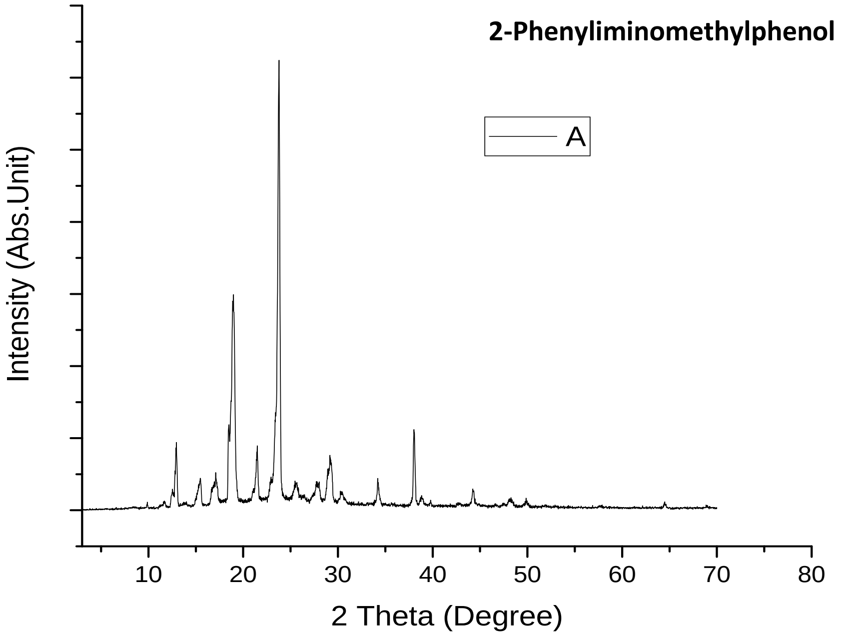
Appendix 22: UV-Visible spectra for 2-phenyliminomethylphenol copper(II) chloride complex, [Cu$(PMP)_2$.Cl_2].



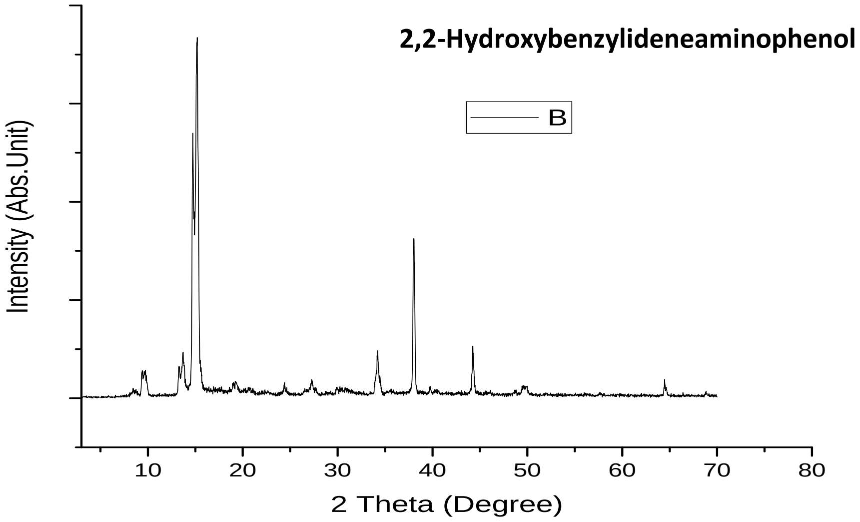
Appendix 23: UV-Visible spectra for 2,2-hydroxybenzylideneaminophenol copper(II)chloride complex, [Cu(HAP).Cl_2].



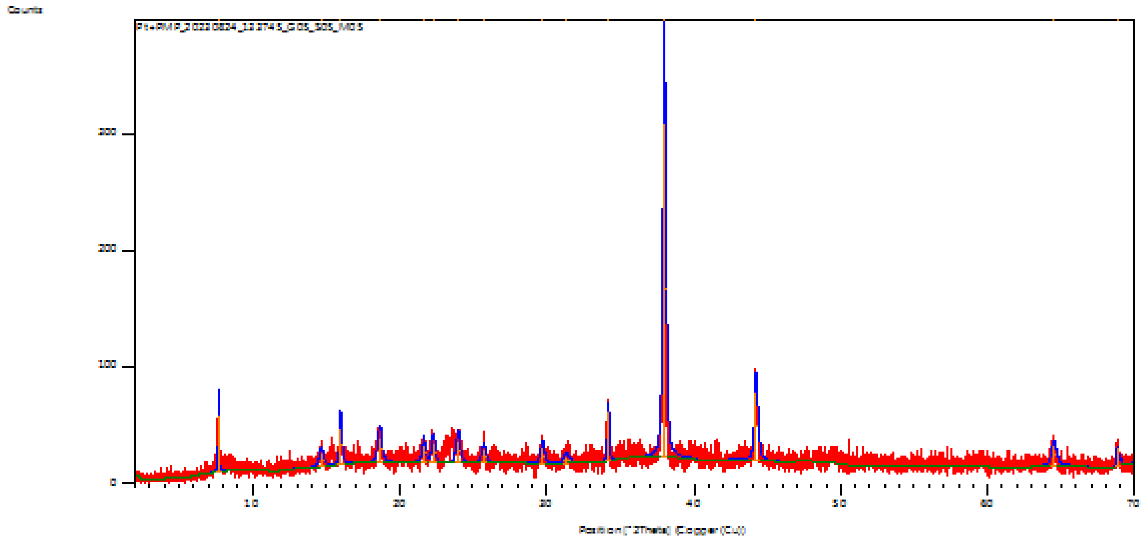
Appendix 24: UV-Visible spectra for mixed ligand (PMP+HAP) copper (II) chloride complexes, [Cu(PMP+HAP).Cl_2].



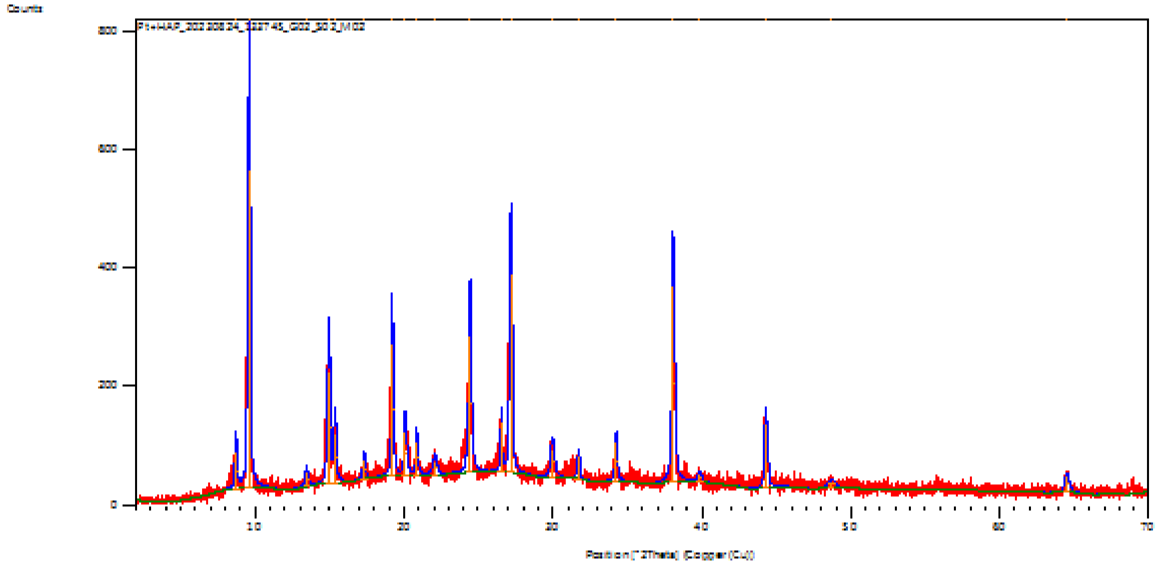
Appendix 25: XRD Spectra for 2-phenyliminomethylphenol ligand.



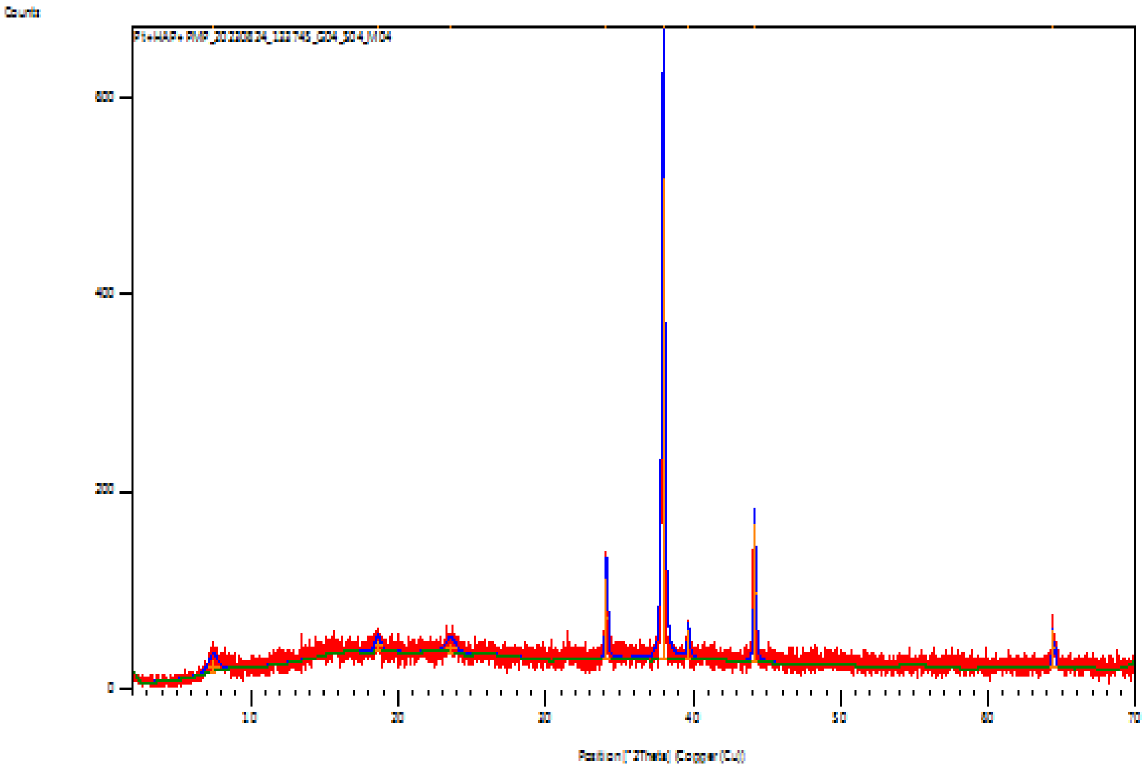
Appendix 26: XRD spectra for 2,2-hydroxybenzylideneaminophenol ligand.



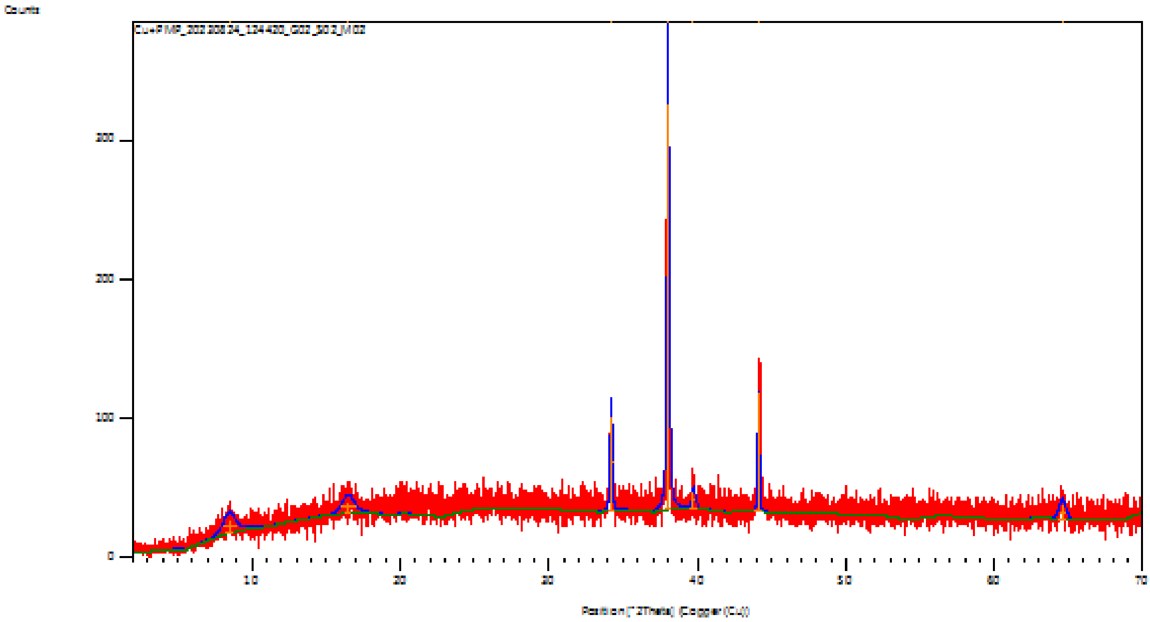
Appendix 27: XRD spectra for 2-phenyliminomethylphenol platinum(II) chloride complex, $[Pt(PMP)_2.Cl_2]$.



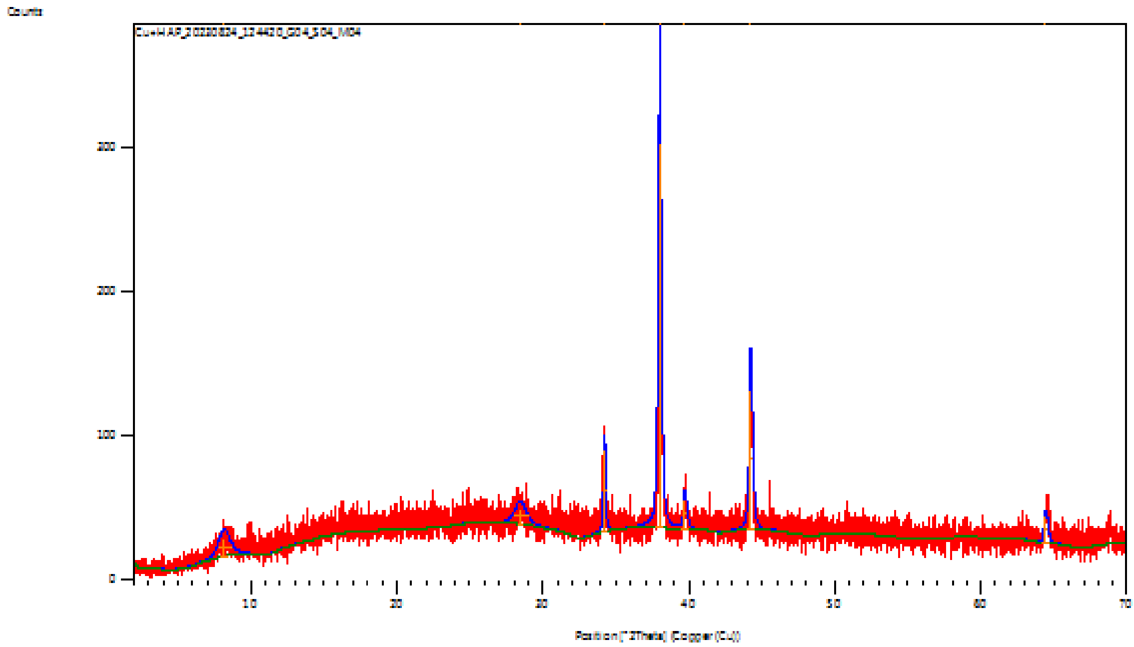
Appendix 28: XRD spectra for 2,2-hydroxybenzylideneaminophenol platinum(II) chloride complex, $[Pt(HAP)_2.Cl_2]$.



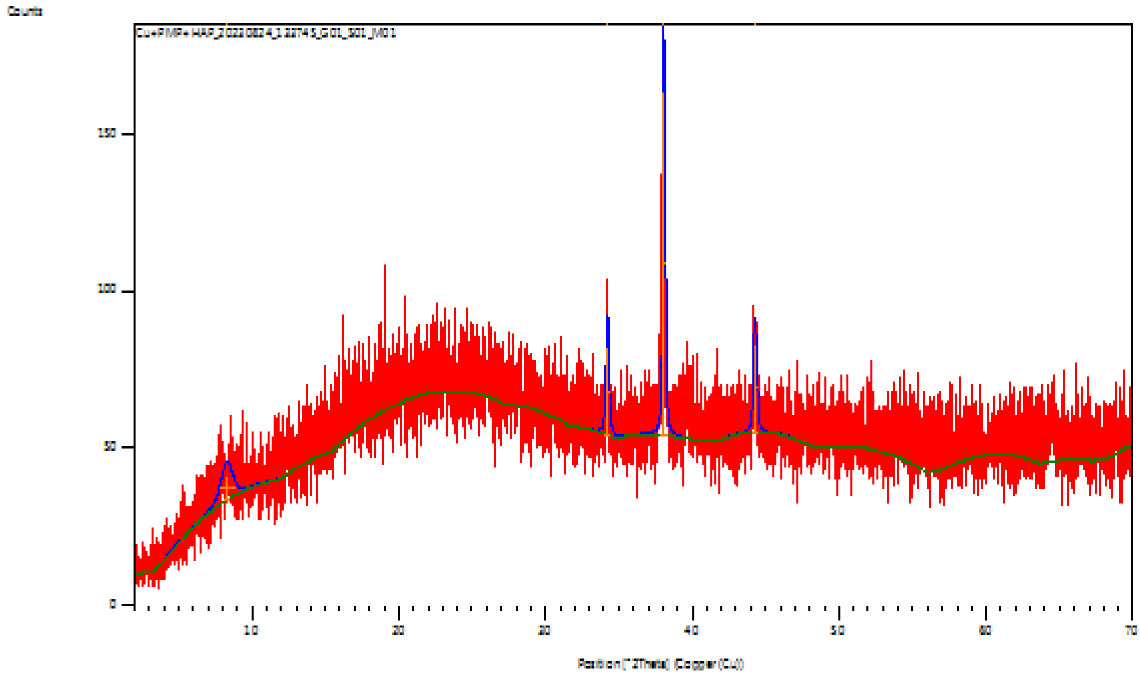
Appendix 29: XRD spectra for mixed ligand (PMP+HAP) platinum(II) chloride complex, [Pt(PMP+HAP).Cl$_2$]



Appendix 30: XRD Spectra For 2-Phenyliminomethylphenol Copper (II) Chloride Complex, [Cu(PMP)$_2$.Cl$_2$].



Appendix 31: XRD spectra for 2,2-hydroxybenzylideneaminophenol copper(II) chloride complex, [Cu(HAP)$_2$.Cl$_2$].



Appendix 32: XRD spectra for mixed ligand (PMP+HAP) copper(II) chloride complex, [Cu(PMP+HAP).Cl$_2$]