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RESEARCH PAPER

Synthesis , Antibacterial Activity of Sm(III) Complex With L-phenylalanine

Kamaran Basheer Hussein
Department of Chemistry ,College of Education ,Salahaddin University,Erbil, Iraq.

A B S T R A C T:

Samarium–amino acid complex in aqueous solution was synthesized in formula:$[Sm(phen)_3].H_2O$, by reaction of L-phenylalanine (phen) with samarium chloride hexahydrate ($SmCl_3.6H_2O$) in (1:3) M:L mole ratio . The structure was confirmed by FT-IR, UV-Vis. spectroscopy and ^{1}H-NMR ^{13}C-NMR techniques, and characterized by elemental analysis and molar conductivity measurements, molar conductance values in DMSO indicate the non-electrolyte behaver of $[Sm(phen)_3].H_2O$ complex with mole ratio (1:3). The ligand (L-phenylalanine) behaves as bidentate. Coordination sites is oxygen atom of carboxylate group –COOH after deprotonation and nitrogen atom from amino group $–NH_2$ the obtained data indicated that the complex has octahedral geometry.The samarium complex seem to be more active than L-phenylalanine ligand in terms of antimicrobial activity , these results show that Sm(III) complex has an antibacterial effect can be apply as antimicrobial active species.

KEY WORDS: L-phenylalanine, Sm(III) , Complex , Synthesis , antimicrobial activity.
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1. INTRODUCTION:

L-phenylalanine has two functional groups carboxylate and amino group each one behaves as donor atoms donate pair of electrons to form coordination bond with Sm(III) metal ion. Phenylalanine is an essential amino acid with the formula $C_9H_{11}NO$ is found naturally in the breast milk of mammals. It is used in the produce of food and drink output, it not synthesized again in humans and other animals(Le Minh and pham,2007, Konaka et al.,2008). There are many studies on the uses of phenylalanine as ligand to prepare many compounds. Amino acid with one or more than one coordination site along with different functional groups has a significant role in metal chelation(Singh et al., 2014) .Review of the literature shows that search on the samarium complex formation with L-phenylalanine amino acid need to be attracts attention for solving the disagreements on the coordination modes between Sm(III) and amino acids, although not many structures of lanthanide/amino acid complexes have been reported. (Woźnicka et al., 2007, Zong- Biao et al., 1996, Chen et al., 2014, Yan et al., 2008, Evans and Hoveyda, 1990). The lanthanide elements reside aspecial place in the periodic table of elements . They are located at the bottom of the periodic table , one period above the actinides. The lighter lanthanides are more abundant than the heavier ones and the elements with even atomic number are more abundant than those with odd atomic number(Cotton., 2013, Kumar and Singh.,2008, Medina et al.,2018, Movassaghi et al.,2018). In recent years number of studies have received much attention about lanthanide complexes with amino acides have rapidly increased high coordination numbers recognized generally 6-12(Cardozo et al., 2015, Prados et al.,1974, Qizhuang et al., 2006, Meijerink et al., 2006). The aim of this work is to synthesize and characterize the complex between (phen) and Sm(III) metal ion

* **Corresponding Author:**
Kamaran Basheer Hussein
E-mail: kamaran1963@gmail.com
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using a variety of teachniques , and study of the antimicrobial activities of coordination compound $[Sm(phen)_3].H_2O$ .According to the spectroscopic information suggested that the (phen) coordinate through both their amino and carboxylate ion donor atoms in octahedral geometry. The antimicrobial activities of L-phenylalanine and amino acid chelates have been reported against the bacterial species *staphylococcus* (Sa.) and *Escherichiacoli* (E.coli) (Temitayo Olufunmilayo et al., 2012, Farrell, 2012). In this study, the formation of samarium(III)phenylalanine complex will be studied. The coordination of Sm(III) with (Phen) will be clarified by using IR, ^{1}H-NMR and ^{13}C-NMR spectroscopy.

2. Experimental

2.1- Materials

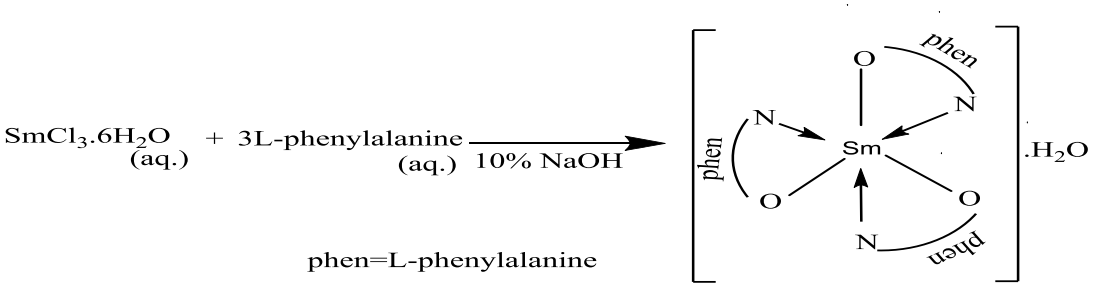
The reagents used in the synthesis are of analytical grad. Samarium(III)chloride hexahydrate , sodium hydroxide , L-phenylalanine and dimethyl sulfoxide DMSO were supplied from Sigma-Aldrich used without further purification and distilled water was used.

2.2-Measurements

Digital Electrothermal 1100 was used to calculate melting points . The Molar conductivity was experimentally estimated using Jenway conductivity meter model 4020 (0.90 Cell constant) (UK). Conductivity of the complex measured in concentrated (DMSO) at room temperature. The ^{1}H,^{13}C-NMR spectra were performed on a Bruker Ultra-Shield 300MHz with TMS as internal references, in Al-al-Bayt central Labs (Jordan). The infrared spectra were performed in solid KBr discs using instrument Shimadzu spectrophotometer, FT-IR spectra in the 4000-400 cm^{-1} range at Department of Chemistry, Education College, Salahaddin University Erbil, Iraq. The Ultraviolet-Visible spectra were obtained in DMSO and distilled water solution for Sm(III) complex and (phen) ligand (1.0×10^{-4}M) at room temperature on Shimadzu 1800 UV-Visible Spectrophotometer, in quartz cell (1cm) width at (200-500)nm wave length region . elemental analysis was performed to estimate the percentage of each element, carbon, hydrogen and nitrogen, analysis was performed using a Perkin AA elemental analyzer 4000/Italy in Al-al-Bayt central Labs (Jordan).For determining the M:L ratio of the Sm(III) complex , the absorbance of a series of metal salt in distilled water and phenylalanine ligand in the same solvent mixtures which were prepared from their 10^{-4} mol/L solution data were analyzed using mole ratio method. The amino acid complex was tested against microorganisms, in Erbil Medical Technical Institute ,Kurdistan region, Iraq.

2.3- Synthesis of $[Sm(phen)_3].H_2O$ complex

The complex was synthesized from aqueous solution of $SmCl_3.6H_2O$ (0.364.8 g , 1mmol) was mixed with an aqueous solution of phenylalanine (0.495g , 3mmol). Deprotonation of the amino acid was occurred by adding 0.5mL 10% NaOH. The solution was under stirring about 50min. until formation of pale yellow precipitate , filtered , washed in distilled water ,and complex dried in a desiccator for five days over silica gel. The results of the elemental analysis showed that the mole ratio M:L of samarium to phenylalanine , is 1:3, theoretical (Cal.): (C,37.01%) ,(H,3.99%), (N,4.79%), Found (C,37%), (H,4%), (N,4.77%) and Sm(III) 41% ,the percentage of Sm(III) metal ion was determined by volumetric analysis using EDTA (Welcher, 1963), m.p=295^{o}C, yield, 0.77g, (88%). Samarium complex is insoluble in water, methanol and other organic solvents only soluble in DMSO and DMF .The molar conductivity measurements of the Sm(III) complex were taken in DMSO the observed molar conductivity values of the complex indicate their non-electrolytic nature ($1.77x10^{-6}$ $\Omega^{-1}mol/dm^3$) .The preparation reaction for the complex formation illustrated in Scheme 1.



Scheme-1- The chemical reaction of preparation tris(phenylalanito)samarium(III)hydrate complex .

3. Result and Discussion

3.1- Infrared Spectra

Data about the samarium (III) ion coordination was obtained by comparing the IR vibrations of the ligand with those of the Sm(III) complex . IR spectra of amino acid ligand (phen) and Sm(III) complex which were showed in Fig. 1&2 respectively . phenylalanine ligand exhibits two weak bands between 1492 and 1411 cm^{-1} they were weak as a result of the zwitterion nature of the ligand can be attributed to symmetric and asymmetric frequency of carboxylate ion COO^- , in the spectrum of the complex is shifted to higher frequency after coordination with Sm(III) (1577-1496) cm^{-1} which also indicates the participation of this group in coordination. Zwitterion form which is shown in Fig.3, (Phen) exist as Zwitterion in solution and in solid phase, (Nakamoto, 2009, Temitayo Olufunmilayo et al., 2012). Broad bands at 3358cm^{-1} in the Sm(III) complex indicated bonding of ligand through the nitrogen atom at the amino group $–NH_2$ (Saunders, 2009, Pavia et al., 2001). In Sm(III) complex spectrum a broad band at 1340 cm^{-1} however confirmed the intramolecular hydrogen bonding N-H…..O(Konstantinovic et al., 2003). New bands at (526 and 482) cm^{-1} in the samarium complex spectrum, which correspond to the expansion vibrations of M-O and M-N bands respectively indicate that the (phen) act as bidentate .Coordination occur from oxygen carboxylate group and nitrogen amino group to central metal ion .Another broad band appear in Smararium complex at 3433cm^{-1} due to O-H absorption band which is for H_2O molecule as counterion in complex structure (Abou Sekkina et al., 2011).The L-phenylalanine (ligand) spectrum was measured for the purpose of comparison with the spectrum of Sm(III) complex ,and note the displacements that occur. Infrared studies of the samarium complex with phenylalanine amino acid have shown that a useful technique in structural studies

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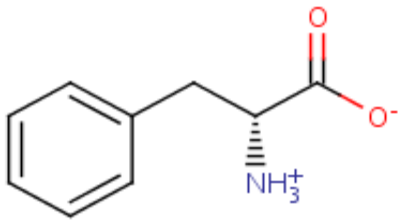
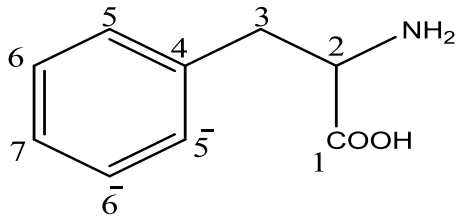


Fig..3. The zwitterionic form of L-Phenylalanine

3.2- ^1H,^{13}C-NMR spectral studies

The complex and L-phenylalanine ligand were investigated by using ^1H and ^{13}C-NMR spectra in d_6 –DMSO and TMS (tetramethyl silane) as standard at room temperature . The ^1H-NMR and ^{13}C-NMR spectrum of the Sm(III) complex of L-phenylalanine undergo ashift to lower and higher field when it was compared with free ligand.^1H-NMR spectra of free phenylalanine ligand shows doublet signal at δ(2.41)ppm assigned to the two protons of (CH_2.C3) , in the Sm(III) complex shifted to δ (3.29) ppm which is different from the free ligand (phen). The multiplets of aromatic protons in (Phen) ligand appeared within the range (7-7.5)ppm (Mandal et al., 2012, Cotton, 2013), refers to aromatic ring in ligand structure .Multiple signals at (8-8.5) ppm ascribed to the protons of aromatic rings in the complex structure Fig.(4&5) shows NMR spectra of (phen) and Sm(III) complex respectively, the small upfield shift is due to slight increase in deshielding resulting from increased donation from the carboxylic groups to the metal ion Sm(III) . Overall , these shifting and broadness at 8.89ppm prove that contribution of amino group (-NH_2) at C2 in the complexation with central metal ion Sm(III). The ^1H- NMR spectrum is broad and some splitting is disappeared when compared with amino acid ligand, the effect of zwitterion is clear on a spectrum of L-phenylalanine (Ligand) because the signal of the carboxylate group proton dose n't appear Fig.4. The ^{13}C-NMR spectrum of (phen) ligand, displayed seven singlet peaks for nine types of carbon atoms in different chemical shifts Scheme.2. , the (C1,C2,C3) appear at (172.75,54.35,35.90) ppm respectively the other

four peaks at (126.30, 136.89, 129.30, 129.06) were adapted to six aromatic carbon atoms (C4,C7,C6,C6^{-},C5,C5^{-}) respectively, as shown in Fig.6.



Scheme.2. The numbering scheme for the L-phenylalanine structure

3.3-UV-Vis. spectra

Scanning samarium chloride hexahydrate($SmCl_3.6H_2O$) in the UV-Vis. region gives six significant line like absorption bands due to f-f transitions Fig. (7.a). The 4f- electrons of Ln^{3+} produce two types of transition such as f-f and f-d transitions. The f-f transitions which give rise to sharp, narrow bands of comparatively weak intensities which are laporte forbidden, whereas allowed f-d transitions are relatively broad and intense(Sharma et al., 1981). The absorption peaks of the phenylalanine corresponded to the n-δ* (220nm,45.000cm^{-1}), n-π* (250nm,40,000cm^{-1}) and π*-π* transition of –NH_2 and –COO^{-} Fig.(7.b), the essential chromophores, and phenyl group, indicated coordination. The shape and strength of the peaks on the Sm(III) complex majorly depends of the phenylalanine ligand (Hui et al., 2006, Beaty and Kerber, 1978).The complex presented a broad absorption band at (405nm, 20.000cm^{-1}) (Fig.7.c).

3.4- Antimicrobial Activity Studies

The very simple way of determining the susceptibilities of microorganism to antibiotic is to inoculate an agar plate with the culture and to allow the antibiotic is to diffuse into the agar medium. After disk impregnated with an antibiotic is applied to the surface of an agar plate containing the microorganism to be tested. Inhibition zone including the disc diameter was measured for each treatment after 5 days of incubation. The metal complex $[Sm(phen)_3].H_2O$ and (phen) ligand were tested on Gram positive bacteria, *Staphylococcus* (Sa.) and Gram negative, *Escherichia coli* (E. coli). Chloramphenicol as a standard antibacterial agent or reference was evaluated for their antibacterial activity and the result was compared with its Samarium complex. The comparison of the biological activities of the synthesized complex and free ligand shows that the amino acid ligand (phen) and its metal complex have more antibacterial effect than that of the standard and Sm(III) complex have higher antimicrobial activity than the ligand and standard , such increased activity of the complex, its explanation based on chelation theory (Stănilă et al., 2011). On chelation the polarity of the metal ion will be reduced to greater extent due to the overlap of the ligand orbitals and partial sharing of the positive charge of the metal ion with donor groups (Washington, 2012), and possible electron delocalization over the whole chelate ring inner transition complexes have been found to exhibit anticancer and fungicidal properties (Barry, 1986).The results of biological activity are given in Table (1).

Conclusions

New complex of Samarium-amio acid complex in aqueous solution was synthesized $[Sm(phen)_3].H_2O$. The IR spectra show that phenylalanine (ligand) behaves as a bidentate with coordination includes the oxygen atom (COOH) and the nitrogen donor atom of the amino (-NH_2) group. The biological effect testing of the synthesized complex was done. It was found that amino acid L-phenylalanine and Sm(III) complex have activity toward a *Staphylococcus* (Sa.) and *Escherichia coli* (*E. coli*) bacterial. Anti-bacterial data for (chloramphenicol) as standard used against serious infections such as typhoid fever, anti-bacterial data for chloramphenicol as standard are also included in Table (1). There is strong confirm that the bonding between Sm(III) ion and (phen) is occured with oxygen atom of the carboxylate , and that the bonding via the nitrogen of the amino group in a pH equal to 8. The amino acid molecule surrounding the metal ion in an octahedral geometrical shape the complex has 1:3 metal to ligand ratio.

Table (1) Effect of varied concentration of phenylalanine ligand and samarium(III)complex on the mean radial growth (in cms).

Compound	G(+) *Staphylococcus* (Sa.) 60mg/10ml	50mg/10ml	40mg/10ml		G(-) *Escherichia coli* (*E. coli*) 60mg/10ml	50mg/10ml	40mg/10ml
Phenylalanine	0.8	1	1.3		0.9	1.4	1.1
$[Sm(phen)_3].H_2O$	1	1.5	1.9		1	1.8	1.6
Standard	0.6	0.55	0.6		0.8	0.9	0.7

Standard: Chloramphenicol for anti-bacterial activities .

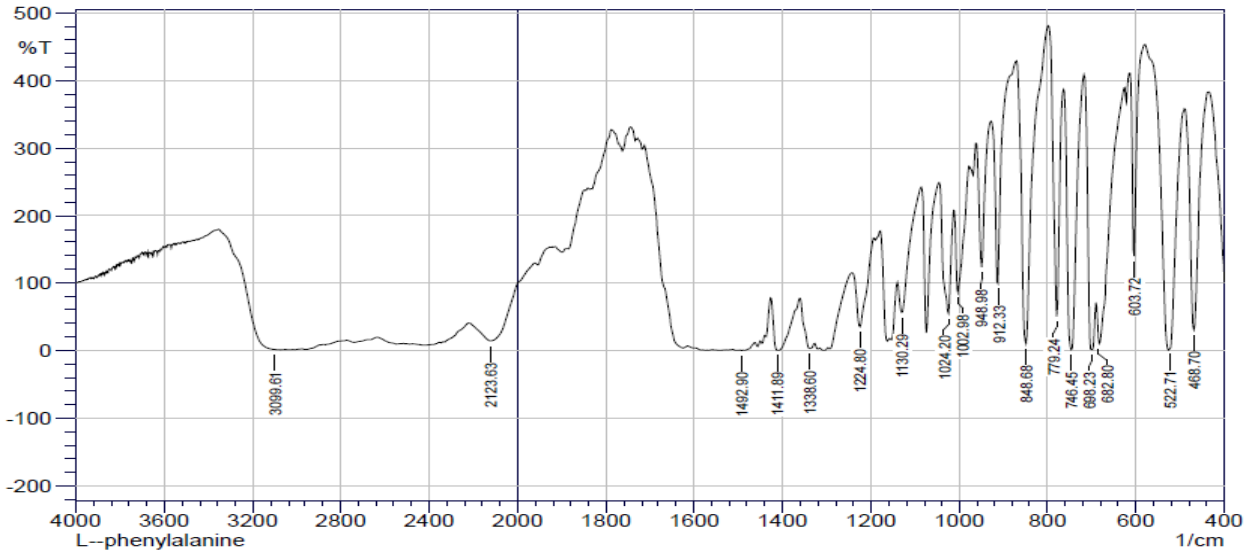


Fig. (1) Infrared spectrum of L-phenylalanine

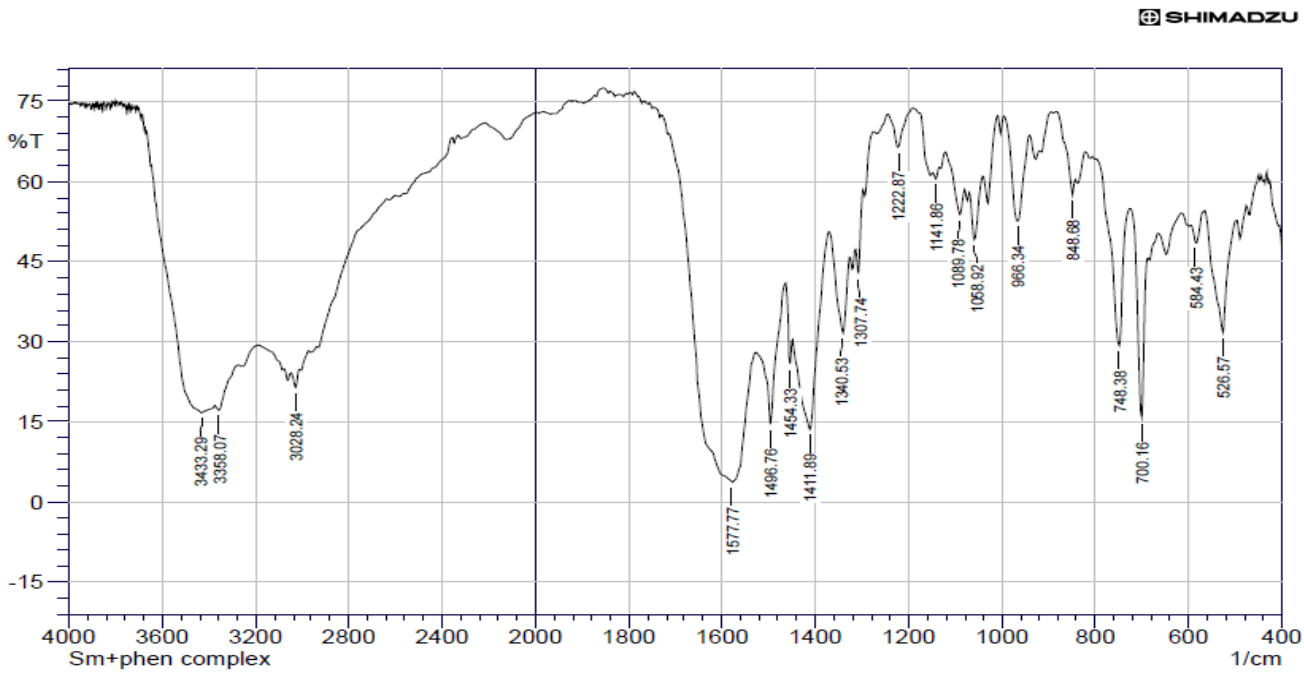


Fig. (2) Infrared spectrum of Samarium(III) Complex

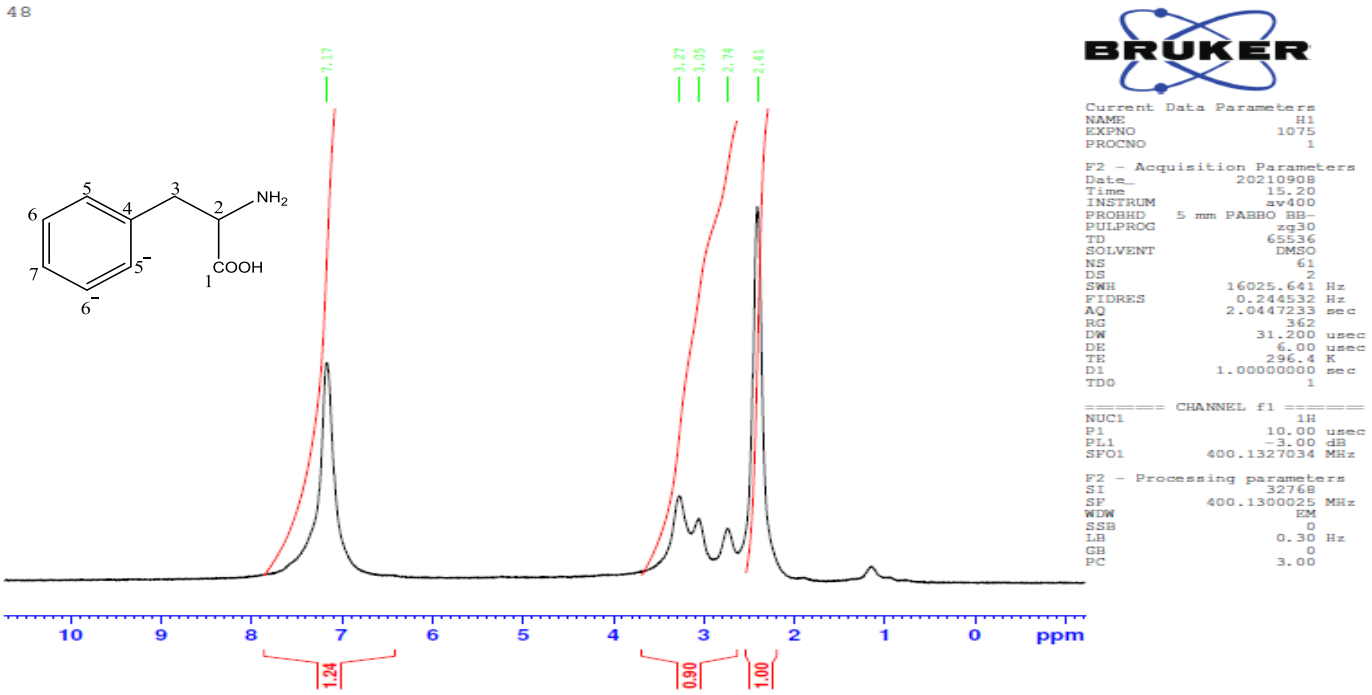


Fig. (4) ^{1}H-n.m.r spectrum of phenylalanine (phen) ligand

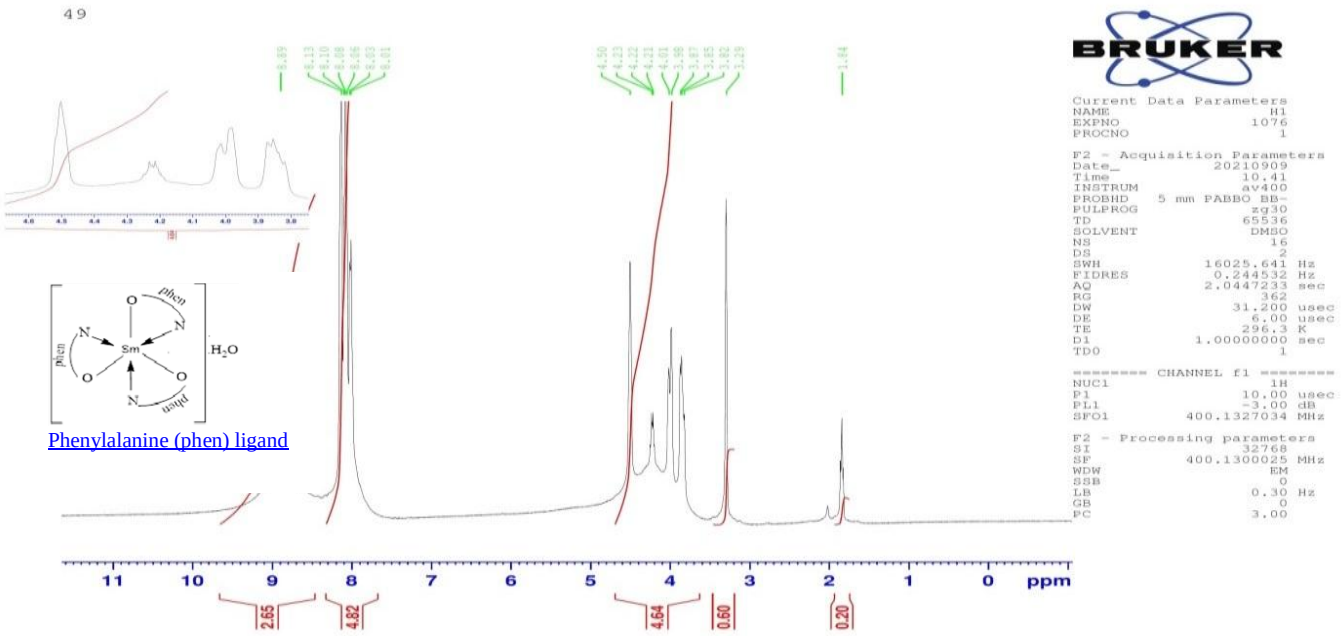


Fig. 5. ^{1}H-n.m.r spectrum of [Sm(phen)$_3$].H$_2$O complex

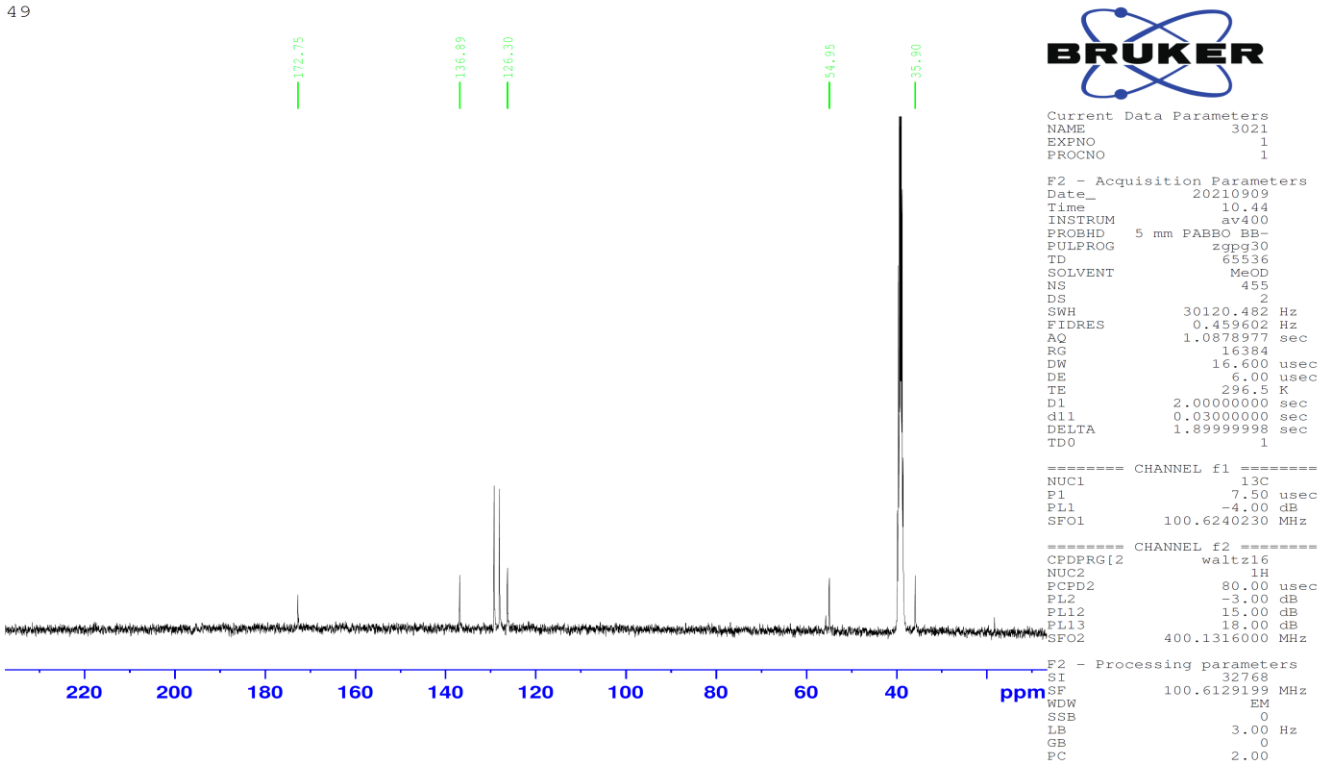


Fig. 6. ^{13}C-n.m.r spectrum of (phen) ligand.

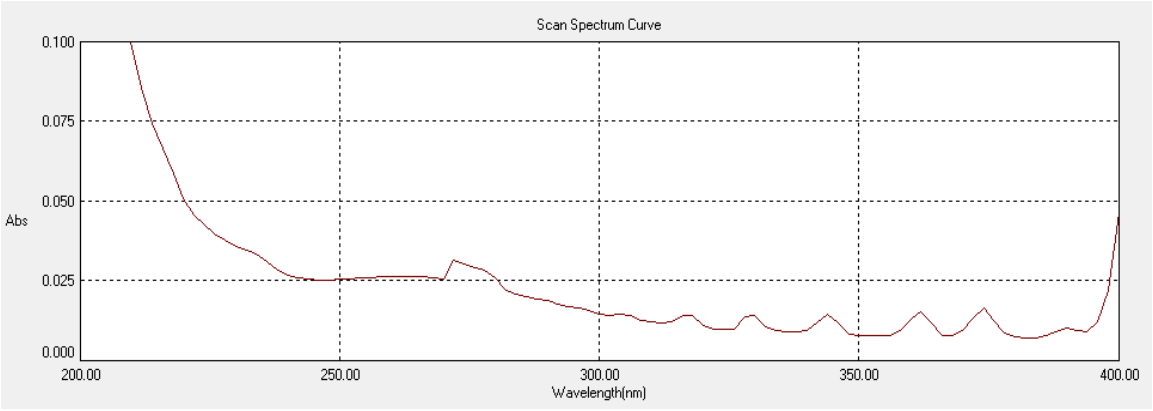


Fig. 7.a.- Ultraviolet-Visible spectrum of Samarium (III)metal ion (f-f transition) in distilled water

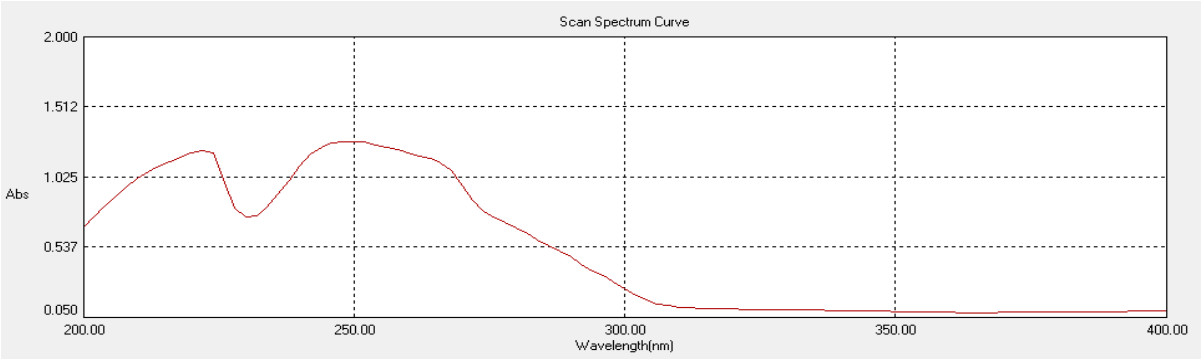


Fig. 7.b- Ultraviolet-Visible spectrum of phenylalanine ligand in distilled water

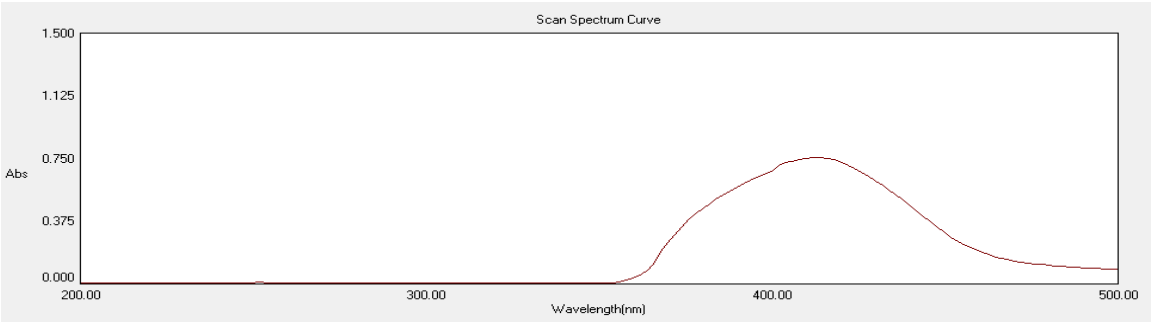


Fig. 7.c- Ultraviolet-Visible spectrum of Sm(III) complex in DMSO (1.0 x 10^{-4}M**)**

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