

Synthesis, Characterization of Schiff Bases Derived from Salicylaldehyde with Some Amino Acids by a New Developed Method

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Abstract

Amino acids are molecules containing an amine group; a carboxylic acid group and aside chain that varies between different amino acids. These molecules are particularly important in biochemistry, Amino acids containing uncharged amino groups, at physiological PH values, may also undergo Schiff base formation, which presents another potential mechanism for metal complexes. In this study, four new amino acid Schiff base compounds namely; 5-Chlorosalicylaldehyde-glycine (H₂L₁), 5-Chlorosalicylaldehyde-alanine (H₂L₂), 5-Nitrosalicylaldehyde-glycine (H₂L₃), 5-Nitrosalicylaldehyde-alanine (H₂L₄). Derived from condensation reaction of substituted salicylaldehyde with some amino acids; glycine and α -alanine, with a new alternative method. The development includes the use of 10-2mole sodium hydroxide as a new catalyst, which is added to the classical method of Schiff bases synthesis. The four Schiff bases were characterized by elemental analysis (C.H.N) and spectroscopic methods; IR, ¹H and ¹³C NMR. These methods were applied successfully for characterization of the prepared Schiff bases.

Keywords: Synthesis, spectroscopic analysis, amino acid, Schiff bases.

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INTRODUCTION

Schiff bases are condensation products of primary amines with carbonyl compounds and they were first reported by Hugo Schiff [1] in 1864. The common structural feature of these compounds is the azomethine group with a general formula RHC=N-R1, where R and R1 are alkyl, aryl, cyclo alkyl or heterocyclic groups which may be variously substituted. These compounds are also known as anils, imines or azomethines. Several studies [2-8] showed that the presence of a lone pair of electrons in nitrogen atom of azomethine group is of considerable chemical and biological importance. Because of the relative easiness of preparation synthetic flexibility and the special

property of C=N group Schiff bases are generally excellent chelating agents [6-12] especially when a functional group like -OH or -SH is present close to the azomethine group so as to form a five or six membered ring with the metal ion [1-12].

Schiff bases are classified according to the number of electrons that the molecule has or to the type of atoms or donor atom group that the molecule contains. The donor atom can be nitrogen, oxygen,

phosphorous or sulphur. These donor atoms that stabilize the structure of Schiff bases and that determine the bioactivity. In nitrogen compounds the presence of a -C=N- group in Schiff bases enhances bioactivity [13, 14] and most of the nitrogen donor Schiff bases complexes have been used as precursors in different homogeneous catalytic reactions [15-18].

The objectives of this study are to synthesize four new Schiff bases by condensation reactions of glycine and α -alanine with 5-chlorosalicylaldehyde and 5-nitrosalicylaldehyde:

{[(E)-(5-chloro-2-hydroxyphenyl) methylidene] amino} acetic acid, {[(E) - (5 - chloro - 2-hydroxyphenyl) methylidene] amino} propanoic acid, (E-(2-hydroxy-5 nitrophenyl) methylidene) amino} acetic acid and {[(E)-(2-hydroxy-5-nitrophenyl) methylidene] amino} propanoic acid. Followed by analyze and identify the structures of the synthesized Schiff bases by elemental Analysis (EA) and spectroscopic methods such as; IR, (¹H and ¹³C) NMR.

EXPERIMENTAL

Materials and measurements

All chemicals and solvents of the highest analytical grade were used as received from Sigma-Aldrich chemical company USA. Infrared spectral of the prepared compounds were recorded on FT-IR spectrometer 10.5.1, Frontier (MIR)- Perkin Elmer-ZnSe/Diamond-ATR. ^1H and ^{13}C NMR spectra of the prepared compounds were recorded on Bruker AVIII 40,126,500 US. The elemental analysis of prepared compounds were recorded on HEKAtech EURO EA (CHN).

Synthesis of Schiff Bases (H_2L_1 and H_2L_2)

To a 250 ml round bottom flask containing 150 ml absolute ethanol 10mmol of (5-chlorosalicylaldehyde(1.565g), 10mmol of glycine (0.75g) or α -alanine (0.85g) and 10mmol of NaOH were added and the content was refluxed with stirring for 5h. After cooling to room temperature the content was added to 100 ml of water in 0°C in a baker and kept in an ice bath for 2h. The yellow crystals were filtered off and washed with slightly cold water and dried in an oven [21].

H_2L_1 :{[(E)-(5-chloro-2-hydroxyphenyl) methylidene] amino} acetic acid

(1.97g), (92% yield) as shiny yellow needles (from ethanol), Anal. Calcd for $\text{C}_9\text{H}_8\text{ClNO}_3$ (213.617g/mole), C, 50.55; H, 3.77; N, 6.56. Found: C, 50.30; H, 3.40; N, 6.53. Selected IR data ($\nu_{\text{max}}/\text{cm}^{-1}$): 3100 ($\nu_{\text{Ar-OH}}$), 3050 ($\nu_{\text{Carboxyl-OH}}$), 1910 ($\nu_{\text{C=O}}$), 1680 ($\nu_{\text{C=N}}$). ^1H NMR (400 MHz, D_2O , δ/ppm): 7.37-6.59 (s, C-H ring), 9.90 (s, COOH), 3.37 (CH_2COOH), 8.15 (CH=N), 4.70 (D_2O). ^{13}C NMR (400 MHz, CDCl_3): 118.32(C-1 ring), 167.07(C-2 ring-OH), 125.30(C-3 ring), 115.93(C-4 ring), 129.79(C-5 ring), 124.74(C-6 ring), 172.66(C-7 azomethine), 42.15(C-8), 193.30(C-9).

H_2L_2 :2-{[(E)-(5-chloro-2-hydroxyphenyl) methylidene] amino} propanoic acid

(2.18g), (96.08% yield) as Bright Yellow needles (from ethanol), Anal. Calcd for $\text{C}_{10}\text{H}_{10}\text{ClNO}_3$ (227.644g/mole), C, 52.76; H, 4.43; N, 6.15. Found: C, 52.46; H, 4.42; N, 11.46. Selected IR data ($\nu_{\text{max}}/\text{cm}^{-1}$): 3059.56($\nu_{\text{Ar-OH}}$), 3000.17($\nu_{\text{Carboxyl-OH}}$), 2111.68 ($\nu_{\text{C=O}}$), 1737.06 ($\nu_{\text{C=N}}$). ^1H NMR (400 MHz, D_2O , δ/ppm): 7.37-6.57(s, C- H ring), 9.90 (s, COOH), 8.22 (CH=N), 1.49 (CH_3CH), 1.08(CH_3CH), 4.70 (D_2O). ^{13}C NMR (400 MHz, CDCl_3): 121.57(C-1 ring), 165.47(C-2 ring-OH), 123.33(C-3 ring), 118.31(C-4 ring), 124.27(C-5 ring), 125.27(C-6 ring), 177.59(C-7 azomethine), 50.68(C-8), 193.28(C-9), 18.87(C-10).

Synthesis of Schiff Bases (H_2L_3 and H_2L_4)

To a 250 ml round bottom flask containing 150 ml absolute ethanol 10mmol (5-nitrosalicylaldehyde (1.671g)), 10mmol of glycine(0.75g) or α -alanine(0.85g) and 10mmol of NaOH were added and

the content was refluxed with stirring for 5h. After cooling to room temperature the content was added to 100ml of water in 0°C in a baker and kept in an ice bath for 2h. The yellow crystals were filtered off and washed with slightly cold water and dried in an oven [21].

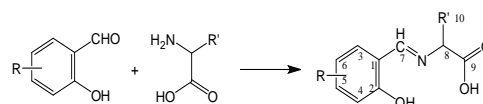
H_2L_3 : {[(E)-(2-hydroxy-5-nitrophenyl) methylidene] amino} acetic acid

(1.939g), (86% yield) as Faint Yellow needles (from ethanol), Anal. Calcd for $\text{C}_9\text{H}_8\text{N}_2\text{O}_5$ (224.17g/mole), C, 48.17; H, 3.60; N, 12.50. Found: C, 48.08; H, 3.14; N, 12.30. Selected IR data ($\nu_{\text{max}}/\text{cm}^{-1}$): 2890 ($\nu_{\text{Ar-OH}}$), 2605($\nu_{\text{Carboxyl-OH}}$), 1725 ($\nu_{\text{C=O}}$), 1650 ($\nu_{\text{C=N}}$). ^1H NMR (400 MHz, D_2O , δ/ppm): 8.05-6.52 (s, C- H ring), 9.92 (s, COOH), 3.45 (CH_2COOH), 8.3 (CH=N), 4.70 (D_2O). ^{13}C NMR (400 MHz, CDCl_3): 128.53(C-1 ring), 172.49(C-2 ring-OH), 124.00(C-3 ring), 123.25(C-4 ring), 131.18(C-5 ring), 135.10(C-6 ring), 179.68(C-7 azomethine), 41.43(C-8), 193.57(C-9).

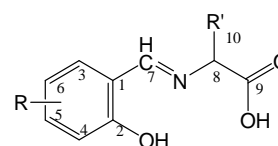
H_2L_4 :2-{[(E)-(2 hydroxynitrophenyl) methylidene] amino} propanoic acid

Propanoic acid

(2.194g), (92% yield) as Faint yellow needles (from ethanol), Anal. Calcd for $\text{C}_{10}\text{H}_{10}\text{N}_2\text{O}_5$ (238.197g/mole), C, 50.42.; H, 4.23; N, 11.76. Found: C, 50.32; H, 4.03; N, 11.46. Selected IR data ($\nu_{\text{max}}/\text{cm}^{-1}$): 3067 ($\nu_{\text{Ar-OH}}$), 2987.53($\nu_{\text{Carboxyl-OH}}$), 1735.89 ($\nu_{\text{C=O}}$), 1612.30 ($\nu_{\text{C=N}}$). ^1H NMR (400 MHz, D_2O , δ/ppm): 8.00-6.52(s, C-H ring), 9.92 (s, COOH), 8.4(CH=N), 3.67(CH_3CH), 1.38(CH_3CH), 4.70(D_2O). ^{13}C NMR (400 MHz, CDCl_3): 128.5(C-1 ring), 175.98(C-2 ring-OH), 124.00(C-3 ring), 123.26(C-4 ring), 131.18(C-5 ring), 133.99(C-6 ring), 179.70(C-7 azomethine), 50.47(C-8), 193.57(C-9), 16.18(C-10).



Scheme-1: Synthesis of Schiff Bases (H_2L_1 , H_2L_2 , H_2L_3 and H_2L_4)



H_2L_1 ; R= Cl, R'=H / H_2L_2 ; R= NO_2 , R'= H / H_2L_3 ; R= Cl / R'= CH_3 / H_2L_4 ; R= NO_2 , R'= CH_3

Fig-1: Structure of Schiff bases (H_2L_1 , H_2L_2 , H_2L_3 and H_2L_4)

RESULTS AND DISCUSSION

The synthesized Schiff bases (H_2L_1 , H_2L_2 , H_2L_3 and H_2L_4) were characterized using spectroscopic

methods (IR, ^1H and ^{13}C NMR) and elemental analysis.

The details are given below.

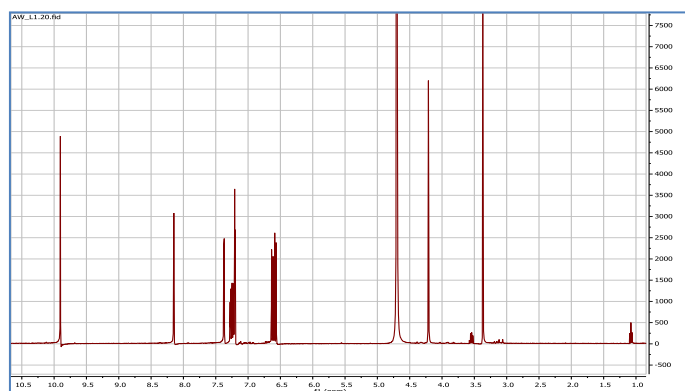


Fig-1: ^1H NMR for the H_2L_1

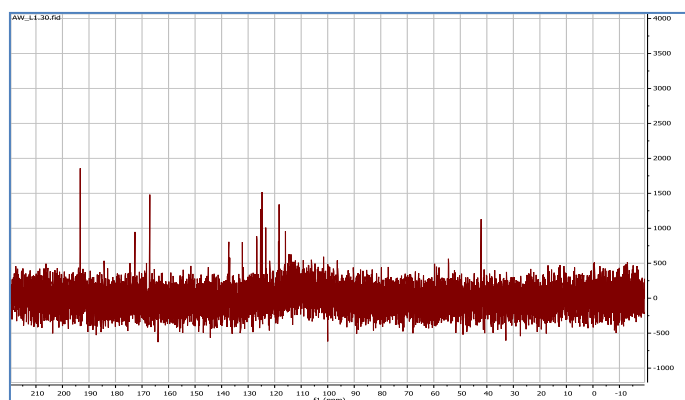


Fig-2: ^{13}C NMR for the H_2L_1

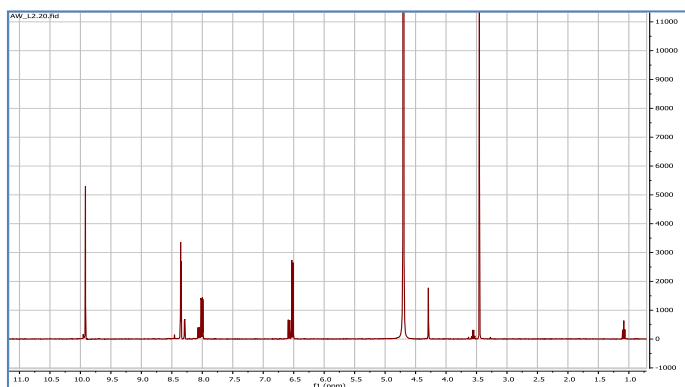


Fig-3: ^1H NMR for the H_2L_2

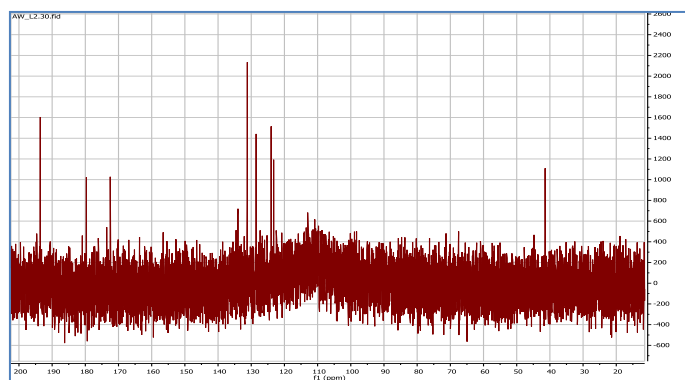


Fig-4: ^{13}C NMR for the H_2L_2

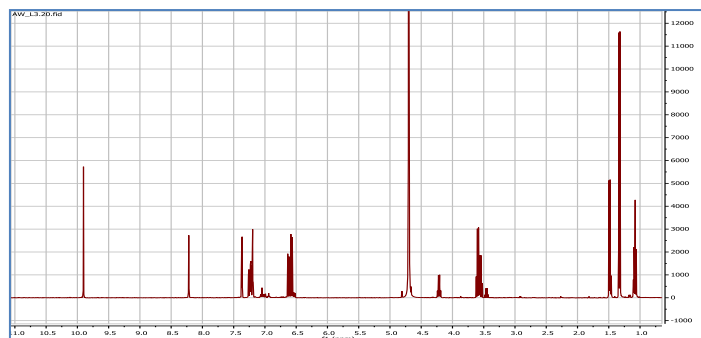


Fig-5: ¹H NMR for the H₂L₃

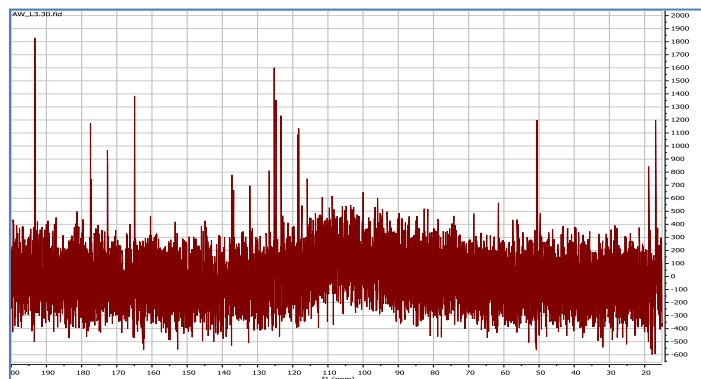


Fig-6: ¹³C NMR for the H₂L₃

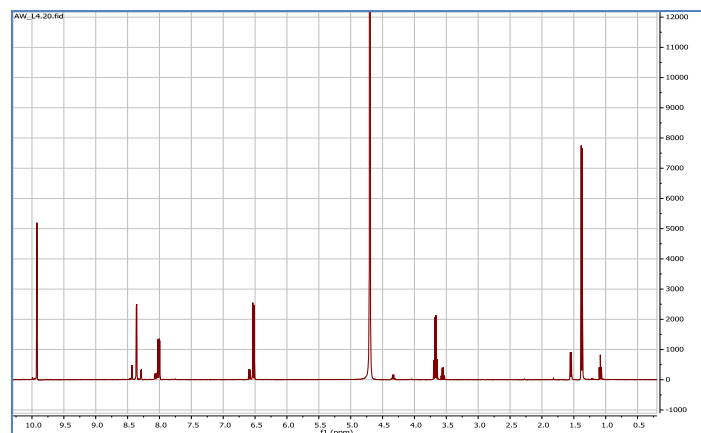


Fig-7: ¹H NMR for the H₂L₄

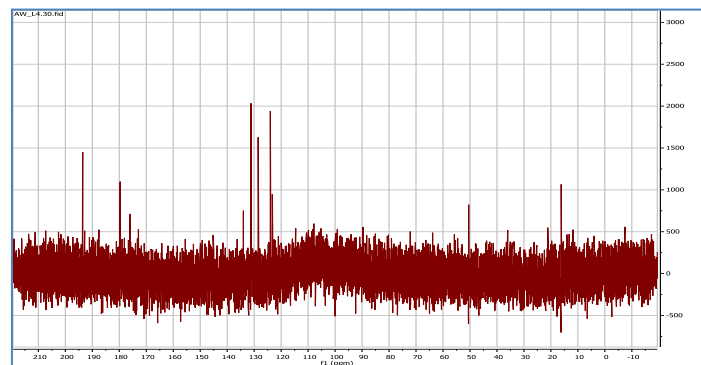


Fig-8: ¹³C NMR for the H₂L₄

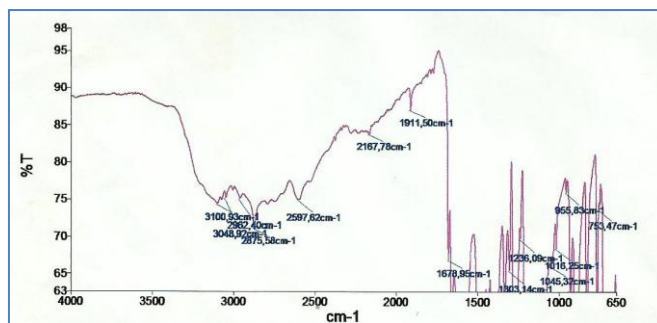


Fig-9: IR Spectral of the H₂L₁

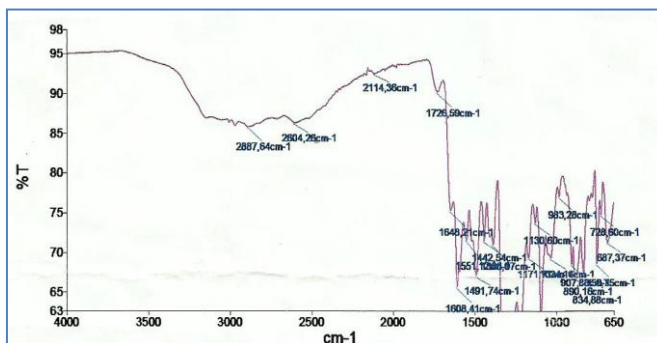


Fig-10: IR Spectral of the H₂L₂

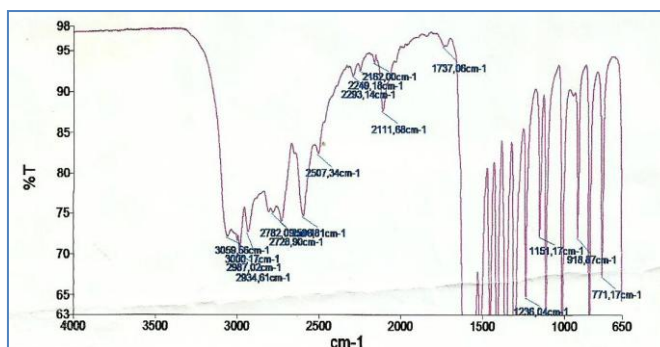


Fig-11: IR Spectral of the H₂L₃

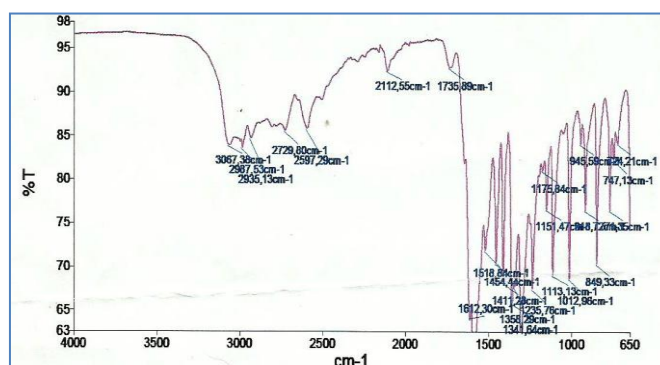


Fig-12: IR Spectral of the H₂L₄

Table-1: IR frequencies of the Prepared Schiff Bases

Compounds	v(OH)	v(C=O)	v(C=N)
H ₂ L ₁	3100.93, 3048.92	1911.50	1678.95
H ₂ L ₂	2887.64, 2604.26	1726.59	1648.21
H ₂ L ₃	3059.56, 3000.17	2111.68	1737.06
H ₂ L ₄	3067.38, 2987.53	1735.89	1612.30

Table-2: Elemental analysis of the Prepared Schiff Bases

Compounds	H%(calculated)	C%(calculated)	N%(calculated)
H ₂ L ₁	3.40(3.77)	50.30(50.55)	6.53(6.56)
H ₂ L ₂	3.14(3.60)	48.08(48.17)	12.30(12.50)
H ₂ L ₃	4.42(4.43)	52.46(52.76)	6.05(6.15)
H ₂ L ₄	4.03(4.23)	50.32(50.42)	11.46(11.76)

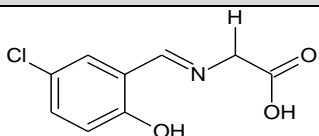
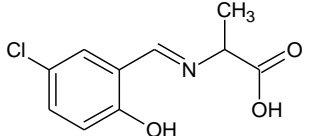
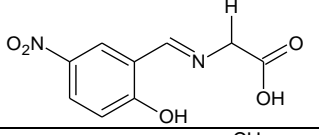
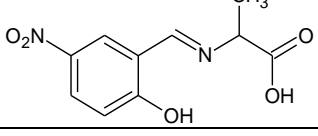
Table-3: ¹H NMR of Prepared Schiff Bases H₂L₁, H₂L₂, H₂L₃ and H₂L₄

Compounds	C-H _{ring}	COOH	CH ₂ COOH	CH=N	CH ₃ CH	CH ₃ CH	D ₂ O
H ₂ L ₁	7.37-6.59	9.90	3.37	8.15	-	-	4.70
H ₂ L ₂	8.05-6.52	9.92	3.45	8.3	-	-	4.70
H ₂ L ₃	7.37-6.57	9.90	-	8.22	1.49	1.08	4.70
H ₂ L ₄	8.00-6.52	9.92	-	8.4	3.67	1.38	4.70

Table-2: ¹³C NMR of the Prepared Schiff Bases H₂L₁, H₂L₂, H₂L₃ and H₂L₄

Compounds	C ₉ =O	C ₇ azomethine	C ₂ OH	C ₅ ring	C ₃ ring	C ₆ ring	C ₁ ring	C ₄ ring	C ₈ H ₂	C10
H ₂ L ₁	193.30	172.66	167.07	129.79	125.30	124.74	118.32	115.93	42.15	-
H ₂ L ₂	193.57	179.68	172.49	131.18	124.00	135.10	128.53	123.25	41.43	-
H ₂ L ₃	193.28	177.59	165.47	124.27	123.33	125.27	121.57	118.31	50.68	18.87
H ₂ L ₄	193.57	179.70	175.98	131.18	124.00	133.99	128.5	123.26	50.47	16.18

Table-5: Structures of Prepared Schiff Bases (H₂L₁, H₂L₂, H₂L₃ and H₂L₄)

Compounds	Name	Structure
H ₂ L ₁	[(E)-(5-chloro-2-hydroxyphenyl) methylidene]amino} acetic acid	
H ₂ L ₂	2-[[E)-(5-chloro-2-hydroxyphenyl)methylidene]amino} propanoic acid	
H ₂ L ₃	{[(E)-(2-hydroxy-5-nitrophenyl)methylidene]amino} acetic acid	
H ₂ L ₄	2-[[E)-(2-hydroxy-5-nitrophenyl) methylidene]amino} propanoic acid	

Characterization of the prepared Schiff bases by (¹H and ¹³C) NMR spectroscopy

The ¹H NMR and ¹³C NMR data are reported below. All the protons were found at their expected region. The ¹H NMR spectra of Schiff bases (H₂L₁, H₂L₂, H₂L₃ and H₂L₄) using D₂O as the solvent in (400 MHz) exhibit singlet signals at expected region of protons calculated from the integration curves and those obtained also from the values of the expected (CHN) analyses agree with each other.

The ¹H NMR spectral data of H₂L₁, the OH proton is showed a chemical shift value of 9.90 signal due to the involvement of one proton in -COOH in glycine amino acid and other OH group hiding due to chloro group orientation in benzene ring [20]. This is confirmed by the presence of C₂ in benzene ring and

OH group IR band at 3048 cm⁻¹ [22]. The proton observed as a signal at 8.15 ppm corresponding to azomethine group CH=N this is confirmed by hiding of the aldehyde proton [21]. The (C-H) protons in benzene ring appeared within the (6.59-7.37) ppm range. This is confirmed by IR spectra [21]. The peak at 3.37 ppm is due to the two protons (CH₂COOH) of the glycine amino acid [21].

The ¹³C NMR analysis of H₂L₁ the amine carbon (C₇) was found at δ 172.66, the aromatic carbon atoms ring are shown of δ 118.32 (C₁), δ 167.07 (C₂), δ 125.30 (C₃), δ 115.93 (C₄), δ 129.79 (C₅), δ 124.74 (C₆). The signal at δ 193.30 is due to the (C₉=O) group, the methyl group carbon atom was shown at δ 42.1 (C₈H₂), all these confirmed by IR spectra and carbon atoms found by elemental analysis [21].

The ^1H NMR spectral data of H_2L_2 is shown, the azomethine proton ($\text{CH}=\text{N}$) is assigned signal at δ 8.22 ppm [21]. The OH proton has shown the chemical shift value of δ 9.90 ppm due to carbonyl proton in the amino acid and the other OH proton in the hiding due to chloro orientation in benzene ring [20], confirmed by IR spectra and protons elemental analysis. The ring protons have shown chemical shift at (6.57-7.37)ppm due to (C-H)[21]. The peaks at 1.08 and 1.49 ppm are assigned to the protons of amino acid due to three protons in CH_3CH and one proton in CH_3CH respectively.

The ^{13}C NMR analysis of H_2L_2 below. The carbon atom in azomethine ($\text{C}_7=\text{N}$) has shown peak at 177.59 ppm. The aromatic ring carbon atoms are shown at (C_1) 121.57 ppm, (C_2) 165.47 ppm, (C_3) 123.33ppm, (C_4) 118.31 ppm, (C_5) 124.27 ppm and (C_6) 125.27 ppm. The carbonyl carbon atom ($\text{C}_9=\text{O}$) was found at 193.30 ppm [21]. The (C_8H_2) observed peak at 50.68 ppm. The (C_{10}) shown peak at 18.87 ppm. All these carbon atoms confirmed by elemental analysis and all carbon atoms agree with each other.

The ^1H NMR spectral data of H_2L_3 The (OH) proton showed a chemical shift value at to 9.92 ppm due to the amino acid hydroxyl group and the OH group proton in the aromatic ring shielded by the (NO_2) group [20]. The azomethine proton is observed at 8.30 ppm is attributed to the $\text{CH}=\text{N}$ [21]. The peak at 3.45 ppm is due to two protons (CH_2COOH) in glycine amino acid, whereas the peak at 9.92 ppm is assigned to one proton in (COOH) group [22]. The protons in aromatic ring have shown a chemical shift at (6.52-8.05) ppm due to (C=H). All these protons confirmed by elemental analysis protons [21].

The ^{13}C NMR analysis of H_2L_3 the azomethine carbon (C_7) was found at δ 179.68 ppm. The aromatic carbon atoms in the ring appeared at δ 128.53 ppm (C_1), δ 172.49m, ppm (C_2), δ 124.00 ppm (C_3), δ 123.25 ppm (C_4) δ 131.18 ppm (C_5), δ 135.10 ppm (C_6). Signal at δ 193.57ppm due to carbonyl group ($\text{C}_9=\text{O}$). Methyl group carbon atom is shown at δ 41.4 ppm (C_8H_2) [21].

The ^1H NMR spectral data of H_2L_4 . The proton has shown chemical shift value at 8.4ppm due to azomethine group ($\text{CH}=\text{N}$).The OH proton showed a chemical shift value at 9.92 ppm due to the carbonyl amino acid group. The proton of the OH group of the aromatic ring was not observed due to the presence and orientation of the electronegative group (NO_2)[20]. This proton is further confirmed by the OH group band in the IR spectra of the ligands. The protons agree with each other by elemental analysis). The(C-H) protons in the aromatic ring appeared in the (6.52-8.00) ppm range [21]. The peak at 3.67 ppm is due to three protons (CH_3CH) in amino α -alanine acid [21]. The peak at 1.38ppm is assigned to one proton in CH_3CH in the amino acid.

The ^{13}C NMR analysis of H_2L_4 the azomethine group carbon (C_7) was found at δ 179.70ppm. the aromatic carbon atoms ring are shown δ 128.5 ppm (C_1), δ 175.98ppm (C_2), δ 124.00ppm(C_3), δ 123.26ppm(C_4) δ 131.18ppm(C_5), δ 133.99ppm(C_6). The signal at δ 193.57 is due to ($\text{C}_9=\text{O}$) carbonyl group. The methyl group carbon atom is shown peak at δ 50.47ppm (C_8H_2) [21]. The (C_{10}) showed a peak at 16.18ppm, all carbon atoms confirmed by elemental analysis percentages.

Characterization of the prepared Schiff bases by IR spectroscopy

The IR spectra of the Schiff bases H_2L_1 the sharp band at 1678.95 cm^{-1} is assigned to($\text{C}=\text{N}$). The formation of the latter is confirmed by disappearance of the ($\text{C}=\text{O}$) band of the aldehyde and the appearance of only one carbonyl of the amino acid [19]. The IR band at 1911.50 cm^{-1} is assigned to ($\text{C}=\text{O}$) and it showed a high frequency for a chloro substituent compared with nitro derivatives and salicylaldehyde carbonyl group[22]. The absorption peaks at 3100.93 cm^{-1} and $3048,92\text{ cm}^{-1}$ are assigned to (OH) vibrations [21].

The IR spectral data of the Schiff bases H_2L_2 show stretching vibration frequency of azomethine group ($\text{C}=\text{N}$) at 1648.21 [19]. The absorption peak at 1726.59 cm^{-1} is attributed to ($\text{C}=\text{O}$) vibration in amino acid [22]. The absorption displayed two broad bands at 2887.64 and 2604.26 that may be assigned to the (OH) groups of the Schiff base [22].

The IR spectral data Schiff base H_2L_3 are [19]. The band at 1737.06 cm^{-1} is due to azomethine ($\text{C}=\text{N}$), that condensation between the aldehyde and amino acid [22]. The two broad bands at 3059.56 and 3000.17 are assigned to (OH) group [22].

The IR spectral data of the ligand H_2L_4 are reported sharp band at 1612.30 is assigned to ($\text{C}=\text{N}$)[19]. The peak at 1735.89 indicating a ($\text{C}=\text{O}$) vibrations. Two broad bands 3067.38 and 2987.53 are assigned to (OH) vibrations [22].

These bands in which frequencies of complexes indicating the involvement of the ($-\text{C}=\text{N}$) metal ion coordination.

CONCLUSION

In conclusion the four new Schiff bases namely; 5-chlorosalicylaldehyde-glycine (H_2L_1), 5-chlorosalicylaldehyde-alanine (H_2L_2), 5-nitrosalicylaldehyde-glycine (H_2L_3) and 5-nitrosalicylaldehyde-alanine (H_2L_4) were prepared by consideration reaction and were characterized by using spectroscopic methods (IR, ^1H and ^{13}C NMR) and elemental analysis (EA).

Conflicts of interest

There are no conflicts to declare.

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