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Acetylene based short route from 2,2,6,6-tetramethylpiperidin-4-one oxime to 2-(pyrazol-5-yl)-4,5,6,7-tetrahydropyrrolo[3,2-*c*]pyridines

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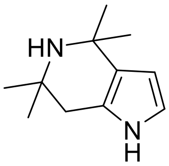
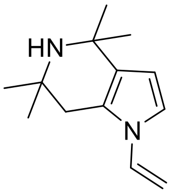
IR spectra were obtained using a Bruker IFS-25 spectrometer in KBr pellets in 400–4000 cm^{-1} range. ^{1}H (400.13 MHz) and ^{13}C (100.6 MHz) NMR spectra were recorded on a Bruker Avance 400 instrument in $CDCl_3$ or acetone-d_6. The assignment of signals in the ^{1}H NMR spectra was made using COSY and NOESY experiments. Resonance signals of carbon atoms were assigned based on ^{1}H–^{13}C HSQC and ^{1}H–^{13}C HMBC experiments. The ^{1}H chemical shifts δ were referenced to HMDS (0.05 ppm) or to the residual proton in $CDCl_3$ (7.26 ppm), the ^{13}C chemical shifts were expressed with respect to the deuterated solvent (77.10 ppm for $CDCl_3$ and 29.84 ppm for acetone-d_6). The chemical shifts were given in ppm. The microanalyses were performed using a Flash EA 1112 CHNS-O/MAS (CHN Analyzer) instrument. The bromine content was determined by mercurimetric titration. Melting points (uncorrected) were measured using a Stuart Scientific melting point SMP3 apparatus.

4,4,6,6-Tetramethyl-4,5,6,7-tetrahydro-1*H*-pyrrolo[3,2-*c*]pyridine **1a**.



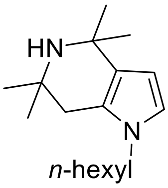
A mixture of 2,2,6,6-tetramethylpiperidin-4-one oxime (17.03 g, 100 mmol), $KOH \cdot 0.5H_2O$ (11.98 g, 185 mmol), DMSO (200 ml) and water (20 ml) was placed in a steel autoclave (1 l), saturated with acetylene at initial pressure ~16 atm and heated at 80–85 °C under stirring for 5 h. After cooling to room temperature, the reaction mixture was extracted with diethyl ether (8 × 50 ml) and extract was concentrated to 150 ml. The remaining reaction mixture was diluted with saturated NaCl solution (250 ml) and extracted again with diethyl ether (8 × 50 ml). Combined extracts were washed with saturated NaCl solution (4 × 40 ml) and dried over K_2CO_3. After removal of the solvent, the residue was purified by flash chromatography on Al_2O_3 with hexane–diethyl ether (3 : 1). Yield 11.94 g (67%), cream crystals, mp 128–129 °C. Spectral characteristics of compound **1a** are in agreement with the known data.[1]

4,4,6,6-Tetramethyl-1-vinyl-4,5,6,7-tetrahydropyrrolo[3,2-*c*]pyridine **1b**.



A mixture of 2,2,6,6-tetramethylpiperidin-4-one oxime (6.81 g, 40 mmol), KOH·0.5H_2O (4.79 g, 74 mmol) and DMSO (115 ml) was placed in a steel autoclave (0.5 l), saturated with acetylene at initial pressure ~16 atm and heated at 85–90 ^{o}C under stirring for 4 h. After cooling to room temperature, the reaction mixture was diluted with saturated NaCl solution (300 ml) and extracted with diethyl ether (8 × 30 ml). The extracts were washed with H_2O (3 × 50 ml) and dried over K_2CO_3. After removal of the solvent, the residue was purified by flash chromatography on Al_2O_3 with hexane–diethyl ether. Yield 6.46 g (79%), yellow oil. Spectral characteristics of compound **1b** are given in reference.[1]

1-*n*-Hexyl-4,4,6,6-tetramethyl-4,5,6,7-tetrahydropyrrolo[3,2-*c*]pyridine **1c**.



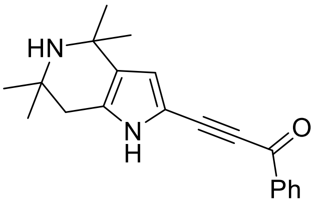
A mixture of 4,4,6,6-tetramethyl-4,5,6,7-tetrahydro-1*H*-pyrrolo[3,2-*c*]pyridine **1a** (5.35 g, 30 mmol), KOH·0.5H_2O (3.91 g, 60 mmol) and DMSO (60 ml) was stirred at room temperature for 0.5 h, then a solution of 1-bromohexane (6.44 g, 39 mmol) in DMSO (15 ml) was added over 1 h. The reaction mixture was stirred for 16 h, then diluted with saturated NaCl solution (80 ml) and extracted with diethyl ether (5 × 40 ml). The extracts were washed with H_2O (3 × 30 ml), dried over K_2CO_3, And the solvent was removed. Yield 7.56 g (96%), yellow oil.

^{1}H NMR (400.13 MHz, $CDCl_3$) δ: 6.54 (d, *J* 2.7 Hz, 1H, H-3 pyrrole), 5.95 (d, *J* 2.7 Hz, 1H, H-2 pyrrole), 3.72–3.69 (m, 2H, CH_2-Hex), 2.37 (s, 2H, CH_2-7), 1.67–1.62 (m, 2H, CH_2-Hex), 1.42 (br s, 1H, NH), 1.36 (s, 6H, 2Me-4), 1.29–1.28 (m, 6H, 3CH_2-Hex) 1.22 (s, 6H, 2Me-6), 0.89–0.86 (m, 3H, Me-Hex). ^{13}C NMR (100.6 MHz, $CDCl_3$) δ: 124.5 (C-7a), 123.6 (C-3a), 119.0 (C-2), 103.0 (C-3), 51.2 (C-4), 50.9 (C-6), 46.1 (CH_2-Hex), 35.5 (CH_2-Hex), 33.2 (2Me), 31.5 (CH_2-7), 31.4 (2Me), 30.5 (CH_2-Hex), 26.4 (CH_2-Hex), 22.5 (CH_2-Hex), 13.9 (Me-Hex). IR (KBr, ν/cm^{-1}): 3315, 3095, 2954, 2864, 1693, 1457, 1369, 1241, 1118, 1014, 712. Found (%): C, 78.02; H, 11.90; N, 10.33. Calc. for $C_{17}H_{30}N_2$ (%): C, 77.80; H, 11.52; N, 10.67.

General procedure for the synthesis of 1-aryl-3-(4,4,6,6-tetramethyl-4,5,6,7-tetrahydro-1*H*-pyrrolo[3,2-*c*]pyridin-2-yl)prop-2-yn-1-ones **3**.

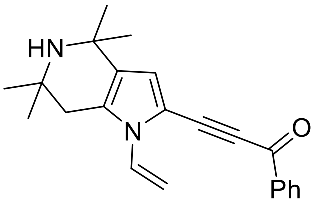
4,4,6,6-Tetramethyl-4,5,6,7-tetrahydro-1*H*-pyrrolo[3,2-*c*]pyridine **1a**−**c** (1 mmol) and aroylbromoacetylene **2a**,**b** (1.2 mmol) were carefully ground in a porcelain mortar with K_2CO_3 (10 fold w/w of the total weight for compounds **1** and **2**) at room temperature for 5 min. The reaction mixture was left for 7 h. Then the mixture was subjected to column chromatography on alumina with hexane, then hexane–Et_2O (9 : 1) to give products **3a**–**f**.

1-Phenyl-3-(4,4,6,6-tetramethyl-4,5,6,7-tetrahydro-1*H*-pyrrolo[3,2-*c*]pyridin-2-yl)prop-2-yn-1-one **3a**.



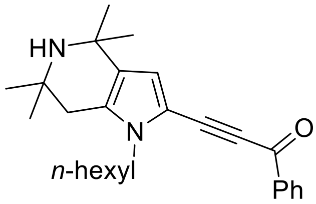
Yield 0.190 g (62%), yellow crystals, mp 173–175 °C. ^1H NMR (400.13 MHz, $CDCl_3$) δ: 8.65 (br s, 1H, NH), 8.38 (br s, 1H, NH), 8.17–8.16 (m, 2H, H-2,6 Ph), 7.62–7.58 (m, 1H, H-4 Ph), 7.52–7.48 (m, 2H, H-3,5 Ph), 6.72 (d, *J* 1.9 Hz, 1H, H-3 pyrrole), 2.50 (s, 2H, CH_2-7), 1.40 (s, 6H, 2Me-4), 1.23 (s, 6H, 2Me-6). ^{13}C NMR (100.6 MHz, $CDCl_3$) δ: 177.6 (C=O), 137.1 (C-1 Ph), 133.7 (C-4 Ph), 132.1 (C-7a), 129.3 (C-2,6 Ph), 128.6 (C-3,5 Ph), 126.7 (C-3a), 117.5 (C-3), 108.3 (C-2), 93.6 (≡C), 90.9 (C≡), 51.0 (C-4, C-6), 37.0 (C-7), 33.3 (2Me), 30.3 (2Me). IR (KBr, ν/cm^{-1}): 3439, 3121, 3054, 2960, 2159, 1618, 1476, 1343, 1228, 1086, 1040, 972, 835, 788, 699, 655. Found (%): C, 78.32; H, 7.15; N, 8.97. Calc. for $C_{20}H_{22}N_2O$ (%): C, 78.40; H, 7.24; N, 9.14.

1-Phenyl-3-(4,4,6,6-tetramethyl-1-vinyl-4,5,6,7-tetrahydropyrrolo[3,2-*c*]pyridin-2-yl)prop-2-yn-1-one **3b**.



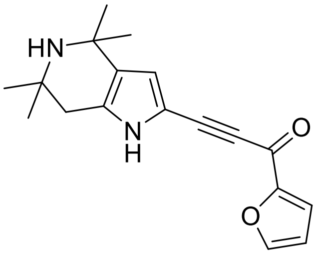
Yield 0.229 g (69%), yellow crystals, mp 116–117 °C. ^1H NMR (400.13 MHz, $CDCl_3$) δ: 8.17–8.15 (m, 2H, H-2,6 Ph), 7.62–7.58 (m, 1H, H-4 Ph), 7.52–7.48 (m, 2H, H-3,5 Ph), 7.04 (dd, *J* 16.0, 9.0 Hz, 1H, H_X), 6.79 (s, 1H, H-3 pyrrole), 5.44 (dd, *J* 16.0, 0.7 Hz, 1H, H_B), 5.11 (dd, *J* 9.0, 0.7 Hz, 1H, H_A), 2.56 (s, 2H, CH_2-7), 1.42 (br s, 1H, NH), 1.40 (s, 6H, 2Me-4), 1.23 (s, 6H, 2Me-6). ^{13}C NMR (100.6 MHz, $CDCl_3$) δ: 177.3 (C=O), 137.3 (C-1 Ph), 133.7 (C-4 Ph), 132.2 (C-7a), 129.8 (HC=), 129.3 (C-2,6 Ph), 128.6 (C-3,5 Ph), 128.0 (C-3a), 119.2 (C-3), 111.2 (C-2), 105.9 (=CH_2), 95.9 (≡C), 88.5 (C≡), 50.9 (C-4), 50.7 (C-6), 37.8 (C-7), 33.2 (2Me), 30.5 (2Me). IR (KBr, ν/cm^{-1}): 3466, 3063, 2960, 2158, 1617, 1569, 1478, 1386, 1268, 1224, 876, 701, 631. Found (%): C, 79.12; H, 7.44; N, 8.07. Calc. for $C_{22}H_{24}N_2O$ (%): C, 79.48; H, 7.28; N, 8.43.

1-Phenyl-3-(1-*n*-hexyl-4,4,6,6-tetramethyl-4,5,6,7-tetrahydropyrrolo[3,2-*c*]pyridin-2-yl)-1-phenylprop-2-yn-1-one **3c**.



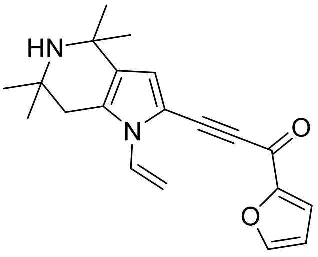
Yield 0.332 g (85%), yellow solid, mp 47–49 °C. ^{1}H NMR (400.13 MHz, $CDCl_3$) δ: 8.17–8.15 (m, 2H, H-2,6 Ph), 7.61–7.58 (m, 1H, H-4 Ph), 7.52–7.48 (m, 2H, H-3,5 Ph), 6.70 (s, 1H, H-3 pyrrole), 4.03–3.99 (m, 2H, CH_2-Hex), 2.44 (s, 2H, CH_2-7), 1.77–1.73 (m, 2H, CH_2-Hex), 1.50 (br s, 1H, NH), 1.38 (s, 6H, 2Me-4), 1.33–1.29 (m, 4H, 2CH_2-Hex), 1.24 (s, 6H, 2Me-6), 1.22–1.19 (m, 2H, CH_2-Hex), 0.88–0.85 (m, 3H, Me-Hex). ^{13}C NMR (100.6 MHz, $CDCl_3$) δ: 177.1 (C=O), 137.5 (C-1 Ph), 133.4 (C-4 Ph), 132.7 (C-7a), 129.1 (C-2,6 Ph), 128.5 (C-3,5 Ph), 126.5 (C-3a), 117.1 (C-3), 111.0 (C-2), 96.4 (≡C), 89.7 (C≡), 50.9 (C-4, C-6), 45.1 (CH_2-Hex), 36.5 (C-7), 33.5 (2Me), 31.5 (CH_2-Hex), 31.3 (CH_2-Hex), 30.5 (2Me), 26.5 (CH_2-Hex), 22.6 (CH_2-Hex), 14.0 (Me-Hex). IR (KBr, ν/cm^{-1}): 3326, 3062, 2959, 2862, 2156, 1625, 1459, 1374, 1261, 1012, 698, 648. Found (%): C, 80.12; H, 8.81; N, 7.31. Calc. for $C_{26}H_{34}N_2O$ (%): C, 79.96; H, 8.77; N, 7.17.

1-(Furan-2-yl)-3-(4,4,6,6-tetramethyl-4,5,6,7-tetrahydro-1*H*-pyrrolo[3,2-*c*]pyridin-2-yl)prop-2-yn-1-one **3d**.



Yield 0.160 g (54%), yellow crystals, mp 212 °C. ^{1}H NMR (400.13 MHz, $CDCl_3$) δ: 8.57 (br s, 1H, NH), 7.65–7.64 (m, 1H, H-5 furan), 7.33–7.32 (m, 1H, H-3 furan), 6.68 (d, *J* 1.9 Hz, 1H, H-3 pyrrole), 6.57 (dd, *J* 3.2, 1.2 Hz, 1H, H-4 furan), 2.49 (s, 2H, CH_2-7), 1.42 (br s, 1H, NH), 1.39 (s, 6H, 2Me-4), 1.22 (s, 6H, 2Me-6). ^{13}C NMR (100.6 MHz, $CDCl_3$) δ: 164.8 (C=O), 153.3 (C-2 furan), 147.4 (C-5 furan), 132.0 (C-7a), 126.6 (C-3a), 119.5 (C-3 furan), 117.5 (C-3), 112.6 (C-4 furan), 108.2 (C-2), 92.6 (≡C), 89.6 (C≡), 51.1 (C-4, C-6), 37.0 (C-7), 33.2 (2Me), 30.3 (2Me). IR (KBr, ν/cm^{-1}): 3400, 2969, 2160, 1607, 1454, 1388, 1336, 1196, 1050, 825, 776, 597. Found (%): C, 72.82; H, 6.73; N, 9.31. Calc. for $C_{18}H_{20}N_2O_2$ (%): C, 72.95; H, 6.80; N, 9.45.

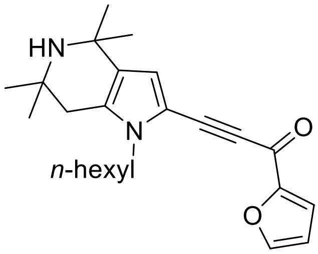
1-(Furan-2-yl)-3-(4,4,6,6-tetramethyl-1-vinyl-4,5,6,7-tetrahydropyrrolo[3,2-*c*]pyridin-2-yl)prop-2-yn-1-one **3e**.



Yield 0.181 g (56%), yellow oil. ^{1}H NMR (400.13 MHz, $CDCl_3$) δ: 7.66 (dd, *J* 1.6, 0.8 Hz, 1H, H-5 furan), 7.31 (dd, *J* 3.6, 0.8 Hz, 1H, H-3 furan), 7.02 (dd, *J* 16.0, 9.2 Hz, 1H, H_X), 6.76 (s, 1H, H-3 pyrrole), 6.58 (dd, *J* 3.6, 1.6 Hz, 1H, H-4 furan), 5.47 (dd, *J* 16.0, 1.2 Hz, 1H, H_B), 5.10 (dd, *J* 9.2, 1.2 Hz, 1H, H_A), 2.55 (s, 2H, CH_2-7), 1.45 (br s, 1H, NH), 1.38

(s, 6H, 2Me-4), 1.22 (s, 6H, 2Me-6). ^{13}C NMR (100.6 MHz, $CDCl_3$) δ: 164.4 (C=O), 153.3 (C-2 furan), 147.4 (C-5 furan), 132.2 (C-7a), 129.7 (HC=), 127.9 (C-3a), 119.2 (C-3 furan), 119.2 (C-3), 112.5 (C-4 furan), 110.9 (C-2), 105.6 (=CH_2), 95.0 (≡C), 87.5 (C≡), 50.9 (C-4), 50.7 (C-6), 37.7 (C-7), 33.1 (2Me), 30.4 (2Me). IR (KBr, ν/cm^{-1}): 3320, 3126, 2967, 2167, 1618, 1565, 1463, 1384, 1285, 1211, 1086, 1038, 965, 910, 766, 678. Found (%): C, 74.48; H, 6.64; N, 8.71. Calc. for $C_{20}H_{22}N_2O_2$ (%): C, 74.51; H, 6.88; N, 8.69.

1-(Furan-2-yl)-3-(1-*n*-hexyl-4,4,6,6-tetramethyl-4,5,6,7-tetrahydropyrrolo[3,2-*c*]pyridin-2-yl)prop-2-yn-1-one **3f**.



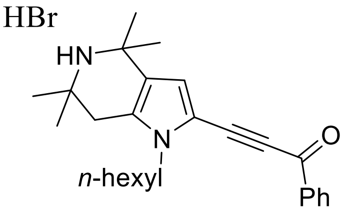
Yield 0.278 g (73%), yellow crystals, mp 212 °C. ^{1}H NMR (400.13 MHz, $CDCl_3$) δ: 7.64–7.63 (m, 1H, H-5 furan), 7.30–7.29 (m, 1H, H-3 furan), 6.66 (s, 1H, H-3 pyrrole), 6.58 (dd, *J* 3.6, 1.6 Hz, 1H, H-4 furan), 4.02–3.98 (m, 2H, CH_2-Hex), 2.43 (s, 2H, CH_2-7), 1.74–1.71 (m, 2H, CH_2-Hex), 1.42 (br s, 1H, NH), 1.37 (s, 6H, 2Me-4), 1.30–1.29 (m, 4H, 2CH_2-Hex), 1.23 (s, 6H, 2Me-6), 0.90–0.84 (m, 5H, CH_2-Hex, Me-Hex). ^{13}C NMR (100.6 MHz, $CDCl_3$) δ: 164.5 (C=O), 153.5 (C-2 furan), 147.0 (C-5 furan), 132.8 (C-7a), 126.4 (C-3a), 118.4 (C-3 furan), 117.0 (C-3), 112.4 (C-4 furan), 110.8 (C-2), 95.5 (≡C), 89.0 (C≡), 50.9 (C-4), 50.8 (C-6), 45.0 (CH_2-Hex), 36.4 (C-7), 33.4 (2Me), 31.4 (CH_2-Hex), 31.2 (CH_2-Hex), 30.4 (2Me), 26.4 (CH_2-Hex), 22.5 (CH_2-Hex), 13.9 (Me-Hex). IR (KBr, ν/cm^{-1}): 3324, 3126, 2961, 2928, 2863, 2160, 1617, 1463, 1385, 1286, 1166, 1041, 912, 733, 601. Found (%): C, 72.82; H, 6.73; N, 9.31. Calc. for $C_{24}H_{32}N_2O_2$ (%): C, 75.75; H, 8.48; N, 7.36.

Reaction of 1-*n*-hexyl-4,4,6,6-tetramethyl-4,5,6,7-tetrahydropyrrolo[3,2-*c*]pyridine **1c** with benzoylbromoacetylene **2a** with solid Al_2O_3.

1-*n*-Hexyl-4,4,6,6-tetramethyl-4,5,6,7-tetrahydropyrrolo[3,2-*c*]pyridine **1c** (0.262 g, 1 mmol) and benzoylbromoacetylene **2a** (0.251 g, 1.2 mmol) were carefully ground in a porcelain mortar with Al_2O_3 (5 g) at room temperature for 5 min. The reaction mixture was left for 24 h. Then the mixture was subjected to column chromatography on Al_2O_3 with hexane, then hexane–Et_2O (4 : 1), affording starting tetrahydropyrrolo[3,2-*c*]pyridine **1c** (0.073 g), then hydrobromide **5** (0.141 g, 30%).

To obtain compound **3c**, 100 mg (0.212 mmol) of its salt **5** was dissolved in 5 ml of hot water, aqueous ammonia was added dropwise until cloudy appearance. The mixture was extracted with diethyl ether (3 x 5 ml), the combined organic solutions were washed with water (3 × 5 ml) and dried over K_2CO_3. Diethyl ether was removed to give 0.051 g (61%) of compound **3c**.

3-(1-*n*-Hexyl-4,4,6,6-tetramethyl-4,5,6,7-tetrahydropyrrolo[3,2-*c*]pyridin-2-yl)-1-phenylprop-2-yn-1-one hydrobromide **5**.

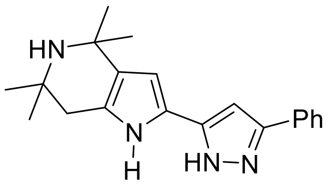


Yield 0.141 g (30%), yellow solid, mp 125–126 °C. ^{1}H NMR (400.13 MHz, $CDCl_3$) δ: 9.22 (br s, 2H, NH, HBr), 8.16–8.14 (m, 2H, H-2,6 Ph), 7.64–7.60 (m, 1H, H-4 Ph), 7.53–7.49 (m, 2H, H-3,5 Ph), 6.65 (s, 1H, H-3 pyrrole), 4.02–3.99 (m, 2H, CH_2-Hex), 2.97 (s, 2H, CH_2-7), 1.94 (s, 6H, 2Me-4), 1.80 (s, 6H, 2Me-6), 1.78–1.73 (m, 2H, CH_2-Hex), 1.36–1.29 (m, 6H, 3CH_2-Hex), 0.88–0.85 (m, 3H, Me-Hex). ^{13}C NMR (100.6 MHz, $CDCl_3$) δ: 177.2 (C=O), 137.1 (C-1 Ph), 133.9 (C-4 Ph), 129.2 (C-2,6 Ph), 128.7 (C-3,5 Ph), 127.6 (C-7a), 121.4 (C-3a), 115.4 (C-3), 113.3 (C-2), 95.2 (≡C), 86.7 (C≡), 59.1 (C-4), 58.2 (C-6), 45.7 (CH_2-Hex), 33.6 (C-7), 31.4 (2Me), 31.3 (CH_2-Hex), 30.6 (2Me), 27.1 (CH_2-Hex), 26.6 (CH_2-Hex), 22.6 (CH_2-Hex), 14.0 (Me-Hex). IR (KBr, ν/cm^{-1}): 3438, 3100, 2954, 2802, 2736, 2457, 2167, 1693, 1630, 1573, 1469, 1375, 1244, 1170, 1015, 753, 699. Found (%): C, 66.02; H, 7.64; Br, 17.10; N, 5.58. Calc. for $C_{26}H_{35}BrN_2O$ (%): C, 66.23; H, 7.48; Br, 16.95; N, 5.94.

General procedure for the synthesis of 4,4,6,6-tetramethyl-2-(3-aryl-1*H*-pyrazol-5-yl)-4,5,6,7-tetrahydropyrrolo[3,2-*c*]pyridines **4a**–**e**.

An excess of hydrazine hydrate (~4 ml) was added to a solution of compound **3** (1 mmol) in EtOH (20 ml). Reaction mixture was stirred at 40 °C for 2 h and diluted with H_2O (60 ml), the residue was filtered off affording compound **4**.

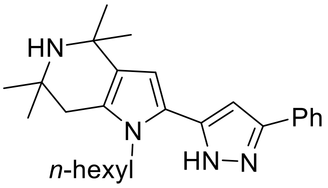
4,4,6,6-Tetramethyl-2-(3-phenyl-1*H*-pyrazol-5-yl)-4,5,6,7-tetrahydro-1*H*-pyrrolo[3,2-*c*]pyridine **4a**.



Yield 0.304 g (95%), light yellow crystals, mp 215–217 °C. ^{1}H NMR (400.13 MHz, $CDCl_3$) δ: 8.51 (br s, 1H, NH), 7.64–7.62 (m, 2H, H-2,6 Ph), 7.45–7.42 (m, 2H, H-3,5 Ph), 7.38–7.34 (m, 1H, H-4 Ph), 6.63 (s, 1H, H-3 pyrrole), 6.32 (s, 1H, H-4 pyrazole), 2.49 (s, 2H, CH_2-7), 1.62 (br s, 1H, NH), 1.43 (s, 6H, 2Me-4), 1.25 (s, 6H, 2Me-6). ^{13}C NMR (100.6

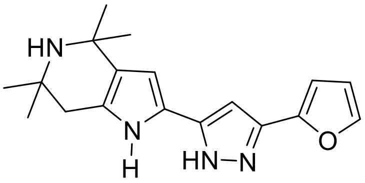
MHz, acetone-d_6) δ: 143.1 (C-5 pyrazole), 133.5 (C-1 Ph), 129.5 (C-2,6 Ph), 128.4 (C-4 Ph), 126.5 (C-7a), 126.1 (C-3,5 Ph), 125.3 (C-3a), 123.0 (C-3 pyrazole), 103.2 (C-3), 103.1 (C-4 pyrazole), 97.9 (C-2), 51.4 (C-4), 51.3 (C-6), 37.2 (C-7), 33.8 (2Me), 30.8 (2Me). IR (KBr, ν/cm^{-1}): 3394, 3280, 2964, 2221, 1629, 1571, 1457, 1374, 1169, 1072, 962, 808, 762, 728, 689. Found (%): C, 74.62; H, 7.33; N, 17.38. Calc. for $C_{20}H_{24}N_4$ (%): C, 74.97; H, 7.55; N, 17.48.

1-*n*-Hexyl-4,4,6,6-tetramethyl-2-(3-phenyl-1*H*-pyrazol-5-yl)-4,5,6,7-tetrahydropyrrolo[3,2-*c*]pyridine **4b**.



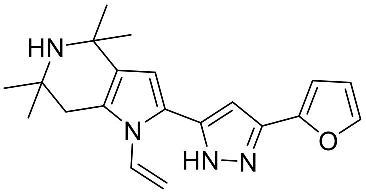
Yield 0.384 g (95%), light yellow solid, mp 133–135 °C. ^{1}H NMR (400.13 MHz, $CDCl_3$) δ: 7.77–7.75 (m, 2H, H-2,6 Ph), 7.46–7.42 (m, 2H, H-3,5 Ph), 7.37–7.33 (m, 1H, H-4 Ph), 6.61 (s, 1H, H-3 pyrrole), 6.22 (s, 1H, H-4 pyrazole), 4.00–3.97 (m, 2H, CH_2-Hex), 2.46 (s, 2H, CH_2-7), 1.65–1.61 (m, 2H, CH_2-Hex), 1.41–1.40 (m, 7H, 2Me-4, NH), 1.27–1.26 (m, 12H, 2Me-6, 3CH_2-Hex), 0.87–0.84 (m, 3H, Me-Hex). ^{13}C NMR (100.6 MHz, $CDCl_3$) δ: 140.7 (C-5 pyrazole), 132.3 (C-1 Ph), 128.8 (C-2,6 Ph), 128.0 (C-4 Ph), 127.5 (C-7a), 125.6 (C-3,5 Ph), 124.3 (C-3a), 122.4 (C-3 pyrazole), 105.0 (C-3), 100.9 (C-2, C-4 pyrazole), 51.1 (C-4), 51.0 (C-6), 44.3 (CH_2-Hex), 36.1 (C-7), 33.3 (2Me), 31.5 (CH_2-Hex), 31.4 (CH_2-Hex), 30.6 (2Me), 26.5 (CH_2-Hex), 22.6 (CH_2-Hex), 14.0 (Me-Hex). IR (KBr, ν/cm^{-1}): 3440, 3260, 2959, 2923, 2858, 1608, 1562, 1458, 1371, 1183, 1072, 960, 765, 691. Found (%): C, 77.13; H, 8.84; N, 13.55. Calc. for $C_{26}H_{36}N_4$ (%): C, 77.18; H, 8.97; N, 13.85.

2-[3-(Furan-2-yl)-1*H*-pyrazol-5-yl]-4,4,6,6-tetramethyl-4,5,6,7-tetrahydro-1*H*-pyrrolo[3,2-*c*]pyridine **4c**.



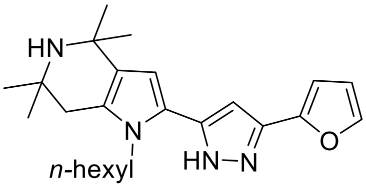
Yield 0.298 g (96%), white solid, mp 228–230 °C. ^{1}H NMR (400.13 MHz, $CDCl_3$) δ: 8.59 (br s, 1H, NH), 7.47–7.46 (m, 1H, H-5 furan), 6.63–6.62 (m, 1H, H-3 furan), 6.55 (s, 1H, H-3 pyrrole), 6.49 (dd, *J* 3.2, 1.6 Hz, 1H, H-4 furan), 6.31 (s, 1H, H-4 pyrazole), 2.47 (s, 2H, CH_2-7), 1.42 (br s, 1H, NH), 1.41 (s, 6H, 2Me-4), 1.24 (s, 6H, 2Me-6). ^{13}C NMR (100.6 MHz, acetone-d_6) δ: 149.1 (C-2 furan), 142.7 (C-5 furan), 141.6 (C-5 pyrazole), 126.7 (C-7a), 125.4 (C-3a), 122.7 (C-3 pyrazole), 112.2 (C-3 furan), 106.2 (C-3), 103.4 (C-4 furan), 97.5 (C-2, C-4 pyrazole), 51.4 (C-4), 51.3 (C-6), 37.2 (C-7), 33.9 (2Me), 30.9 (2Me). IR (KBr, ν/cm^{-1}): 3299, 2966, 1628, 1568, 1455, 1371, 1169, 1014, 891, 801, 729, 593. Found (%): C, 69.35; H, 7.07; N, 17.86. Calc. for $C_{18}H_{22}N_4O$ (%): C, 69.65; H, 7.14; N, 18.05.

2-[3-(Furan-2-yl)-1*H*-pyrazol-5-yl]-4,4,6,6-tetramethyl-1-vinyl-4,5,6,7-tetrahydropyrrolo[3,2-*c*]pyridine **4d**.



Yield 0.330 g (98%), yellow solid, mp 98–100 °C. ^{1}H NMR (400.13 MHz, $CDCl_3$) δ: 7.47–7.46 (m, 1H, H-5 furan), 7.01 (dd, *J* 16.0, 9.2 Hz, 1H, H_X), 6.68–6.67 (m, 1H, H-3 furan), 6.56 (s, 1H, H-3 pyrrole), 6.48 (dd, *J* 3.2, 1.6 Hz, 1H, H-4 furan), 6.31 (s, 1H, H-4 pyrazole), 5.06–5.00 (m, 2H, H_B, H_A), 2.58 (s, 2H, CH_2-7), 1.56 (br s, 1H, NH), 1.41 (s, 6H, 2Me-4), 1.24 (s, 6H, 2Me-6). ^{13}C NMR (100.6 MHz, $CDCl_3$) δ: 147.5 (C-2 furan), 141.9 (C-5 furan), 139.8 (C-5 pyrazole), 131.2 (HC=), 127.1 (C-7a), 126.2 (C-3a), 122.9 (C-3 pyrazole), 111.4 (C-3 furan), 106.9 (C-3), 106.2 (=CH_2), 105.9 (C-4 furan), 101.3 (C-2, C-4 pyrazole), 51.2 (C-4), 51.1 (C-6), 37.9 (C-7), 32.8 (2Me), 30.3 (2Me). IR (KBr, ν/cm^{-1}): 3137, 2967, 2241, 1641, 1563, 1428, 1379, 1272, 1219, 1077, 1012, 969, 906, 802, 733, 594. Found (%): C, 71.25; H, 7.12; N, 16.71. Calc. for $C_{20}H_{24}N_4O$ (%): C, 71.40; H, 7.19; N, 16.65.

2-[3-(Furan-2-yl)-1*H*-pyrazol-5-yl]-1-*n*-hexyl-4,4,6,6-tetramethyl-4,5,6,7-tetrahydropyrrolo[3,2-*c*]pyridine **4e**.



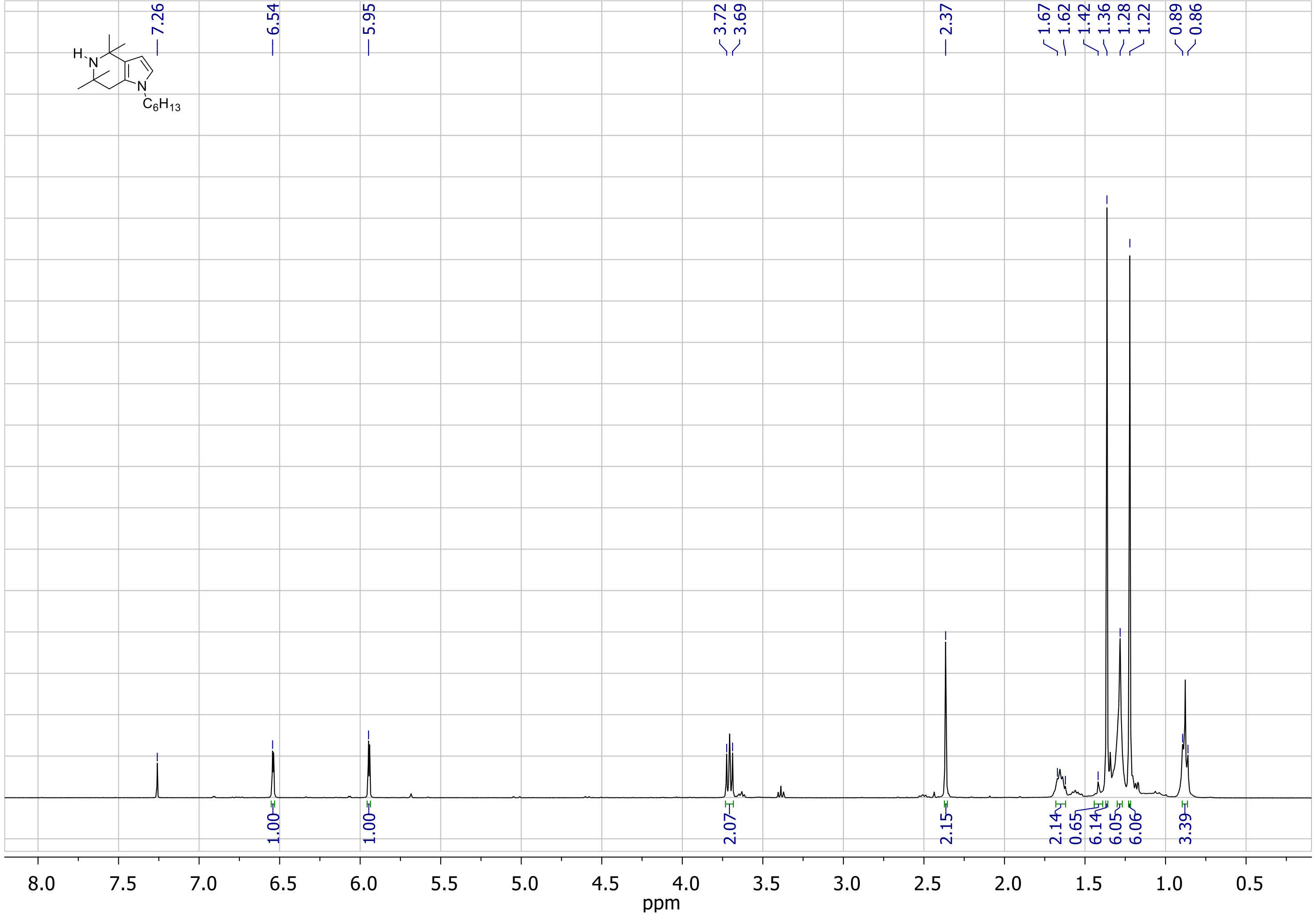
Yield 0.363 g (92%), light yellow crystals, mp 151–153 °C. ^{1}H NMR (400.13 MHz, $CDCl_3$) δ: 7.47–7.46 (m, 1H, H-5 furan), 6.67–6.66 (m, 1H, H-3 furan), 6.53 (s, 1H, H-3 pyrrole), 6.49 (dd, *J* 3.2, 1.6 Hz, 1H, H-4 furan), 6.22 (s, 1H, H-4 pyrazole), 4.00–3.96 (m, 2H, CH_2-Hex), 2.45 (s, 2H, CH_2-7), 1.63–1.59 (m, 2H, CH_2-Hex), 1.42 (br s, 1H, NH), 1.39 (s, 6H, 2Me-4), 1.27–1.26 (m, 12H, 2Me-6, 3CH_2-Hex), 0.87–0.84 (m, 3H, Me-Hex). ^{13}C NMR (100.6 MHz, acetone-d_6) δ: 148.6 (C-2 furan), 142.9 (C-5 furan, C-5 pyrazole), 128.2 (C-7a), 125.0 (C-3a), 123.8 (C-3 pyrazole), 112.3 (C-3 furan), 106.4 (C-3), 105.8 (C-4 furan), 100.4 (C-2, C-4 pyrazole), 51.5 (C-4), 51.4 (C-6), 44.8 (CH_2-Hex), 36.5 (C-7), 34.0 (2Me), 32.2 (CH_2-Hex), 32.0 (CH_2-Hex), 31.0 (2Me), 27.0 (CH_2-Hex), 23.3 (CH_2-Hex), 14.2 (Me-Hex). IR (KBr, ν/cm^{-1}): 3237, 2962, 2924, 2858, 2360, 1607, 1557, 1459, 1372, 1268, 1181, 1064, 1010, 972, 891, 787, 731, 677. Found (%): C, 73.31; H, 8.79; N, 14.18. Calc. for $C_{24}H_{34}N_4O$ (%): C, 73.06; H, 8.69; N, 14.20.

References

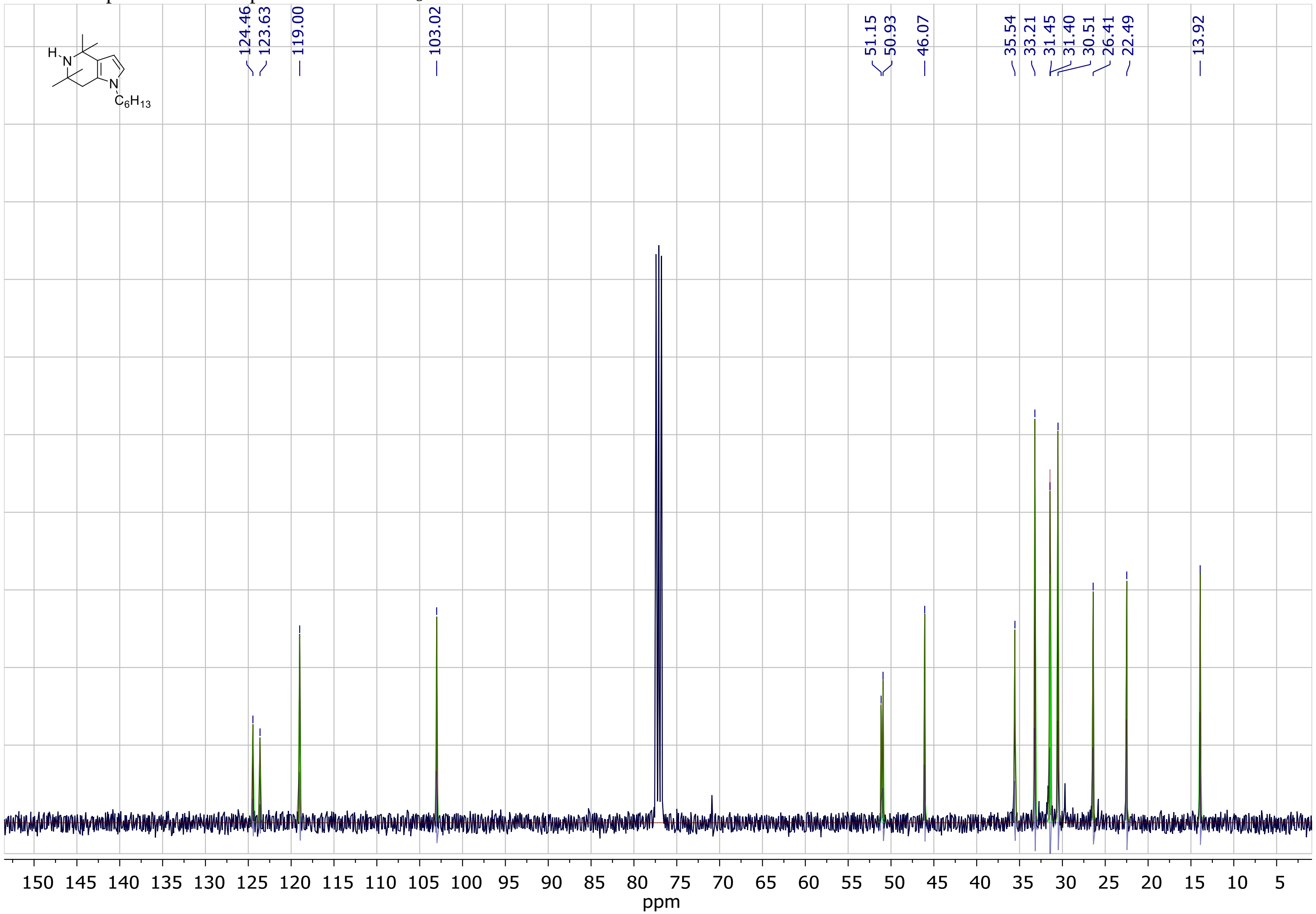
1. B. A. Trofimov, A. B. Shapiro, R. N. Nesterenko, A. I. Mikhaleva, G. A. Kalabin, N. I. Golovanova, I. V. Yakovleva and S. E Korostova, *Chem. Heterocycl. Compd.*, 1988, **24**, 285 (*Khim. Geterotsikl. Soedin.*, 1988, **24**, 350).

1. Copies of ^{1}H and ^{13}C NMR spectra

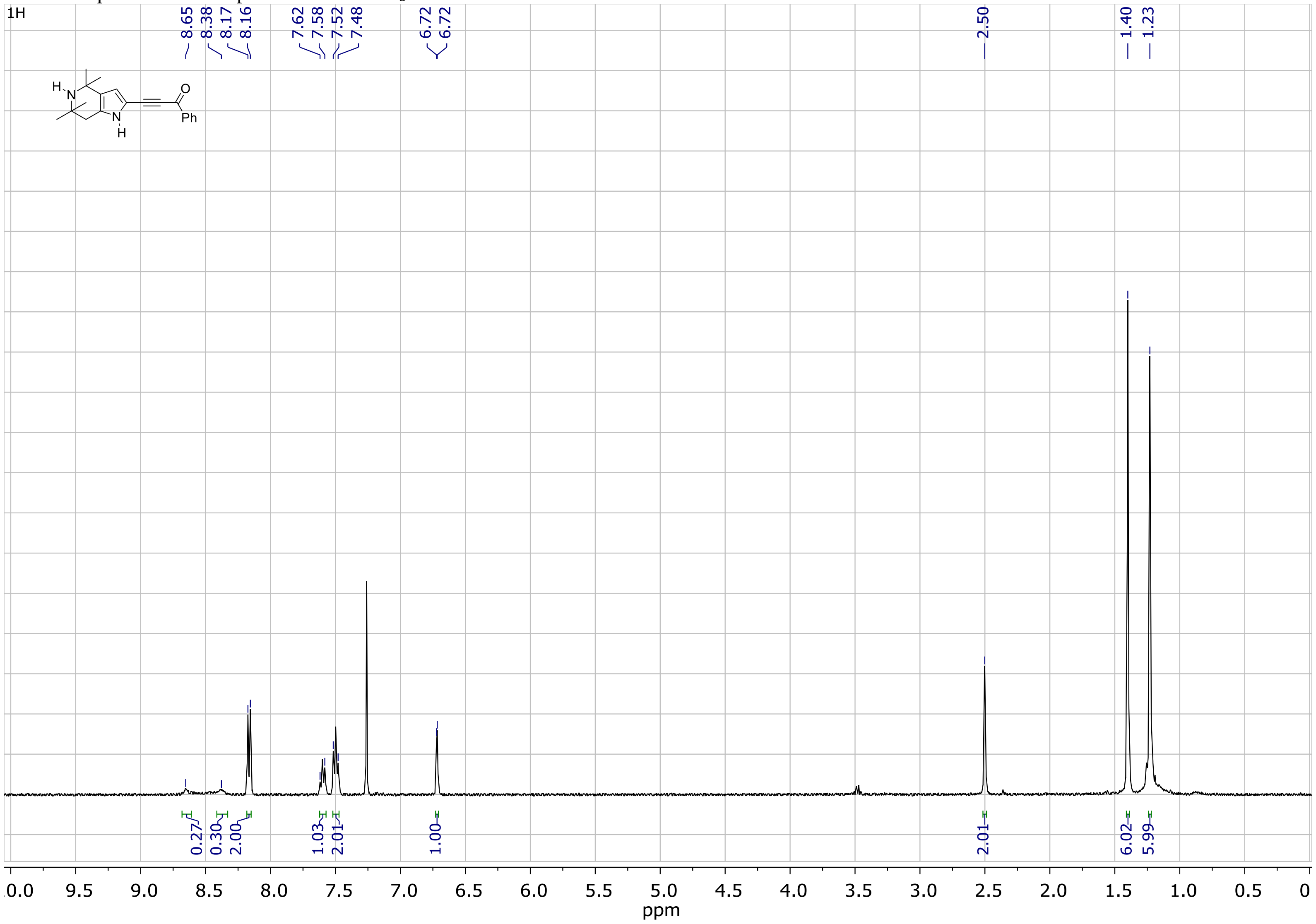
^{1}H NMR spectrum of compound **1c** in $CDCl_3$.



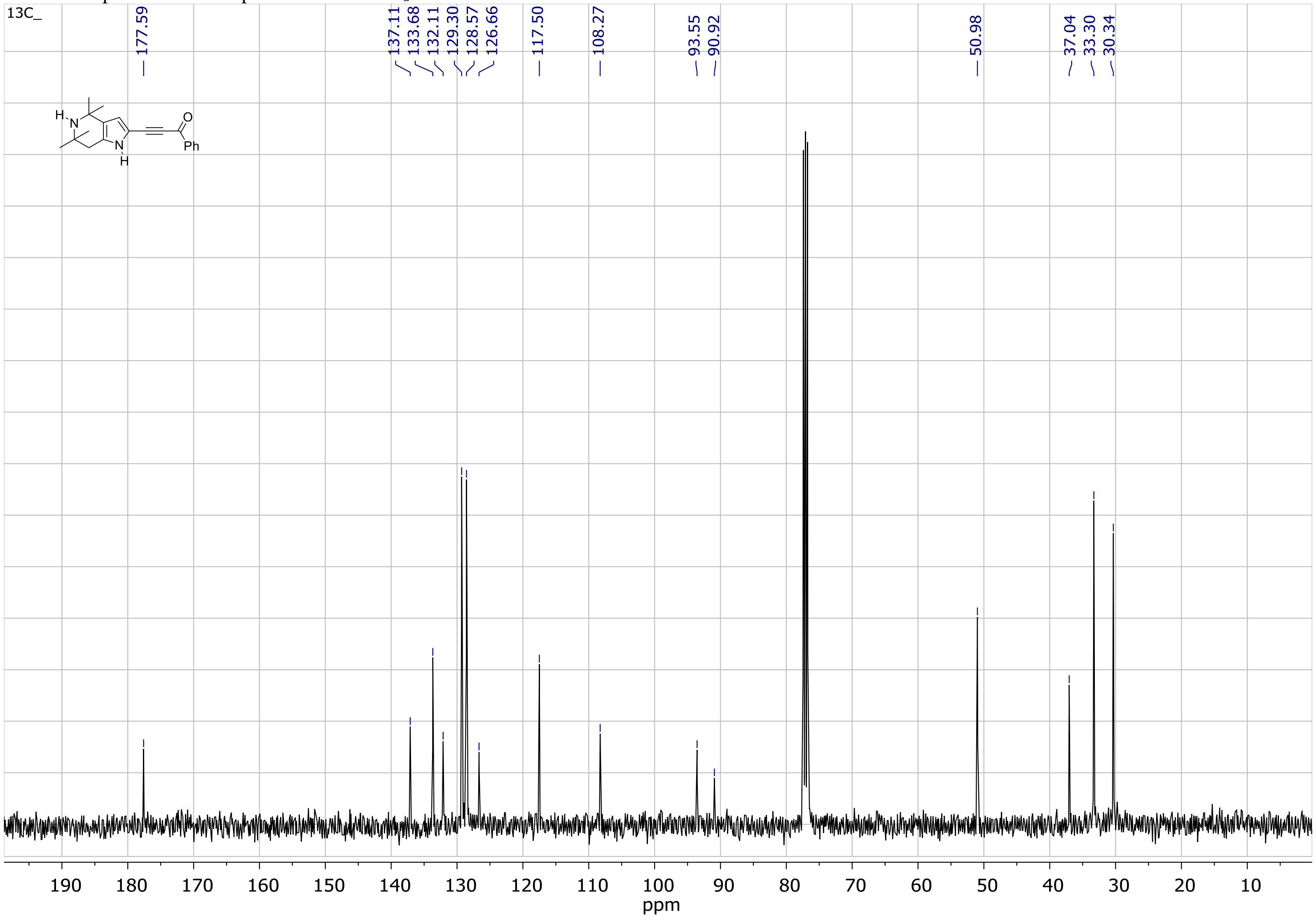
^{13}C NMR spectrum of compound **1c** in $CDCl_3$.



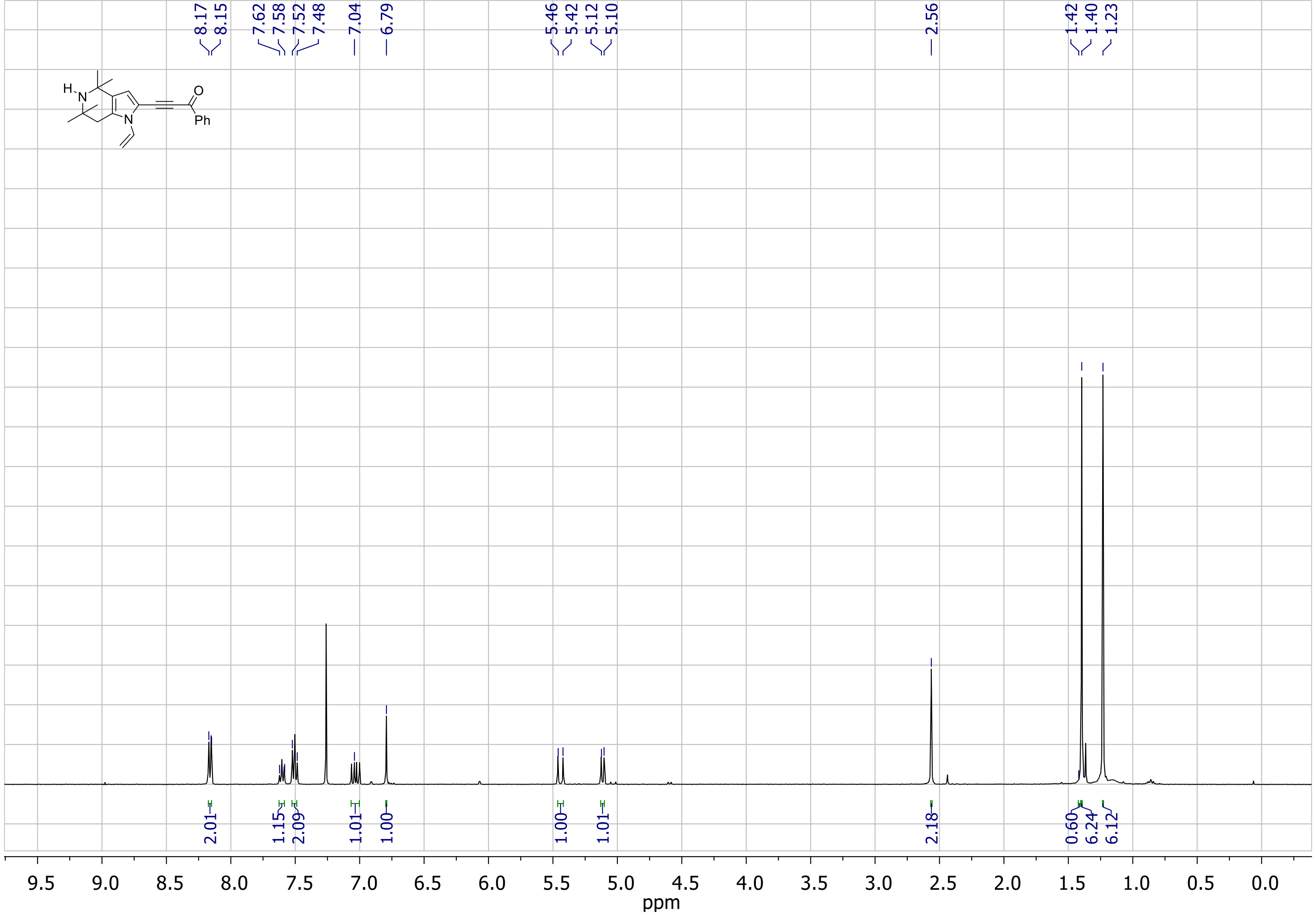
^{1}H NMR spectrum of compound **3a** in $CDCl_3$.



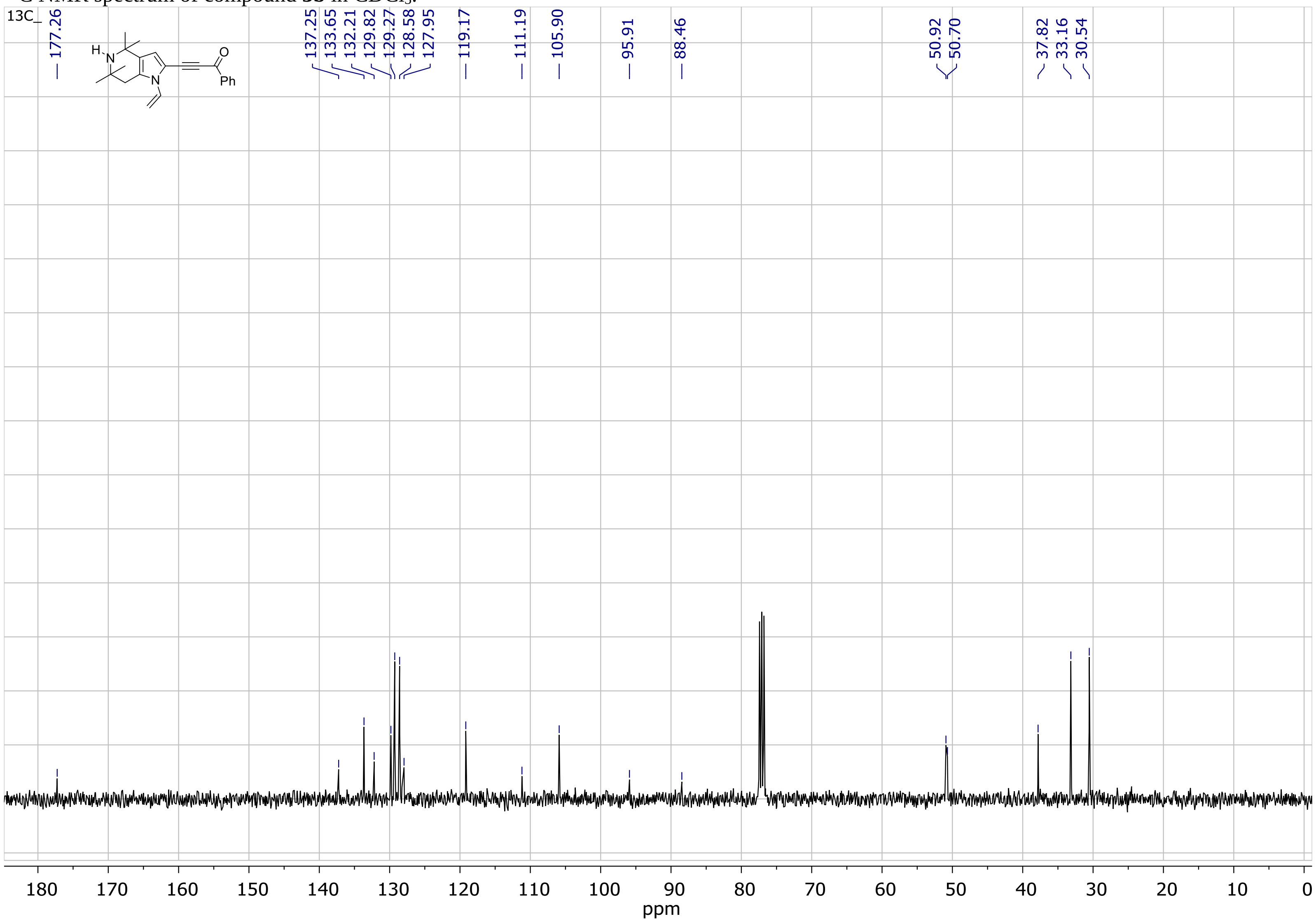
^{13}C NMR spectrum of compound **3a** in $CDCl_3$.



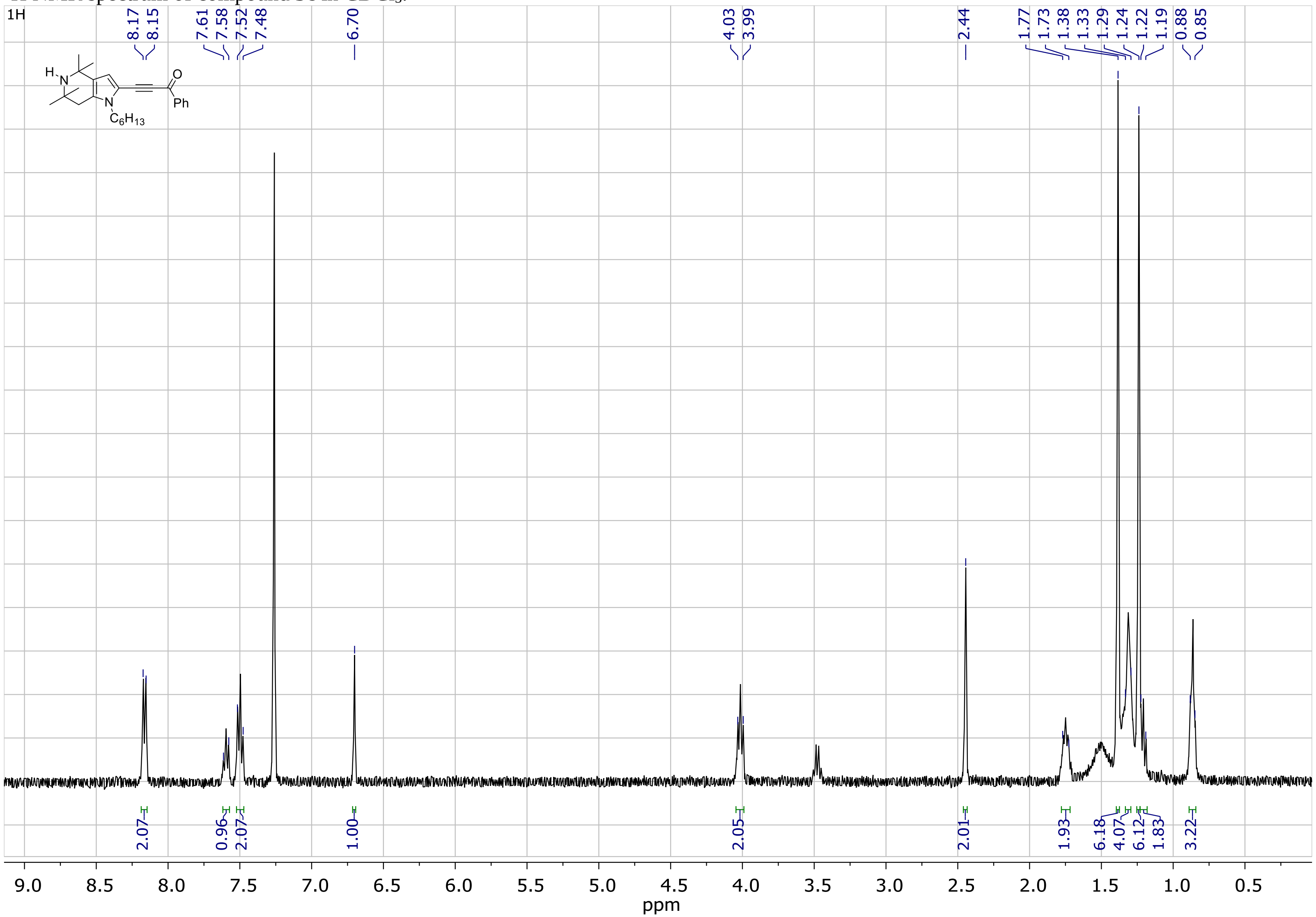
^{1}H NMR spectrum of compound **3b** in $CDCl_3$.



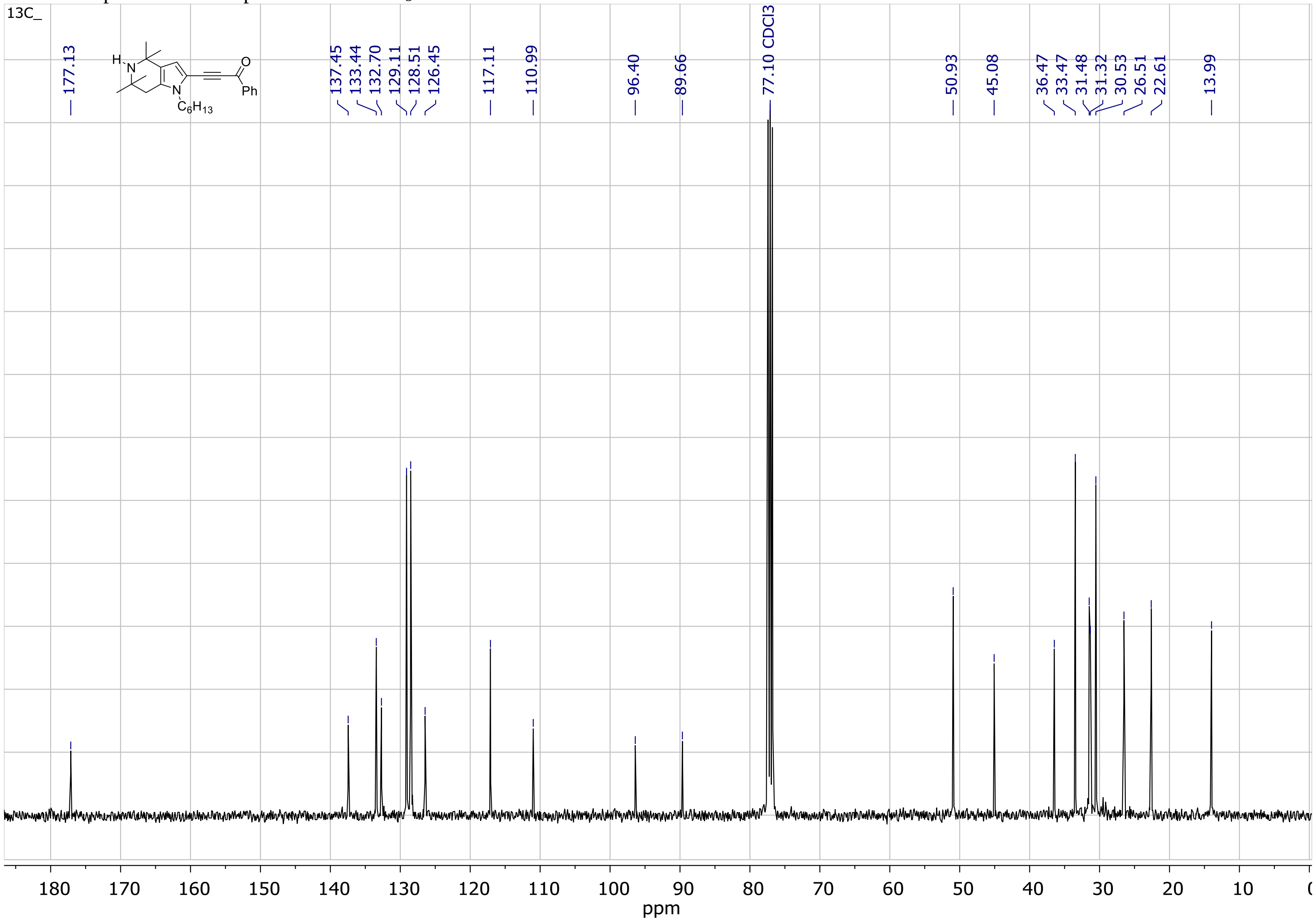
^{13}C NMR spectrum of compound **3b** in $CDCl_3$.



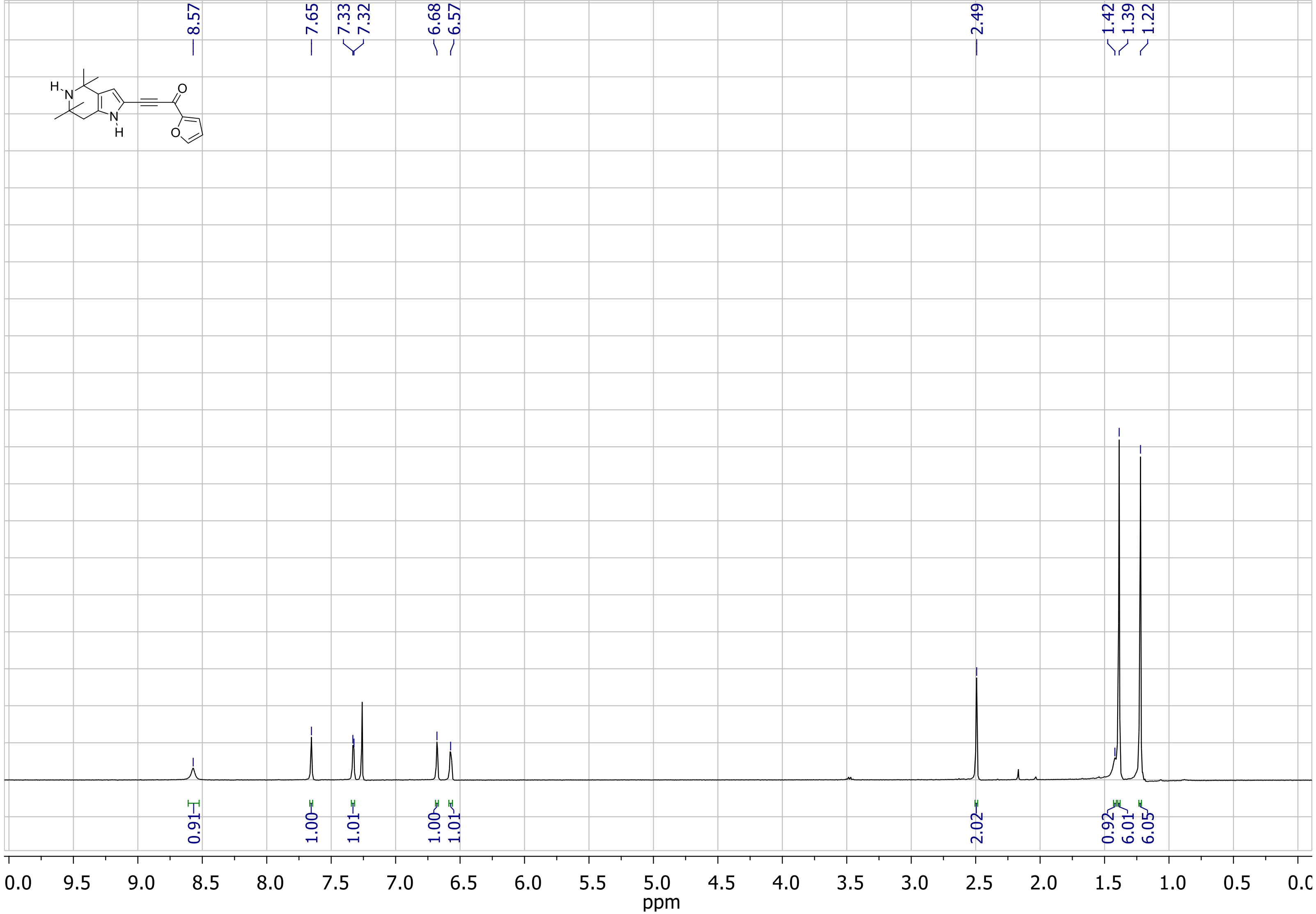
^{1}H NMR spectrum of compound **3c** in $CDCl_3$.



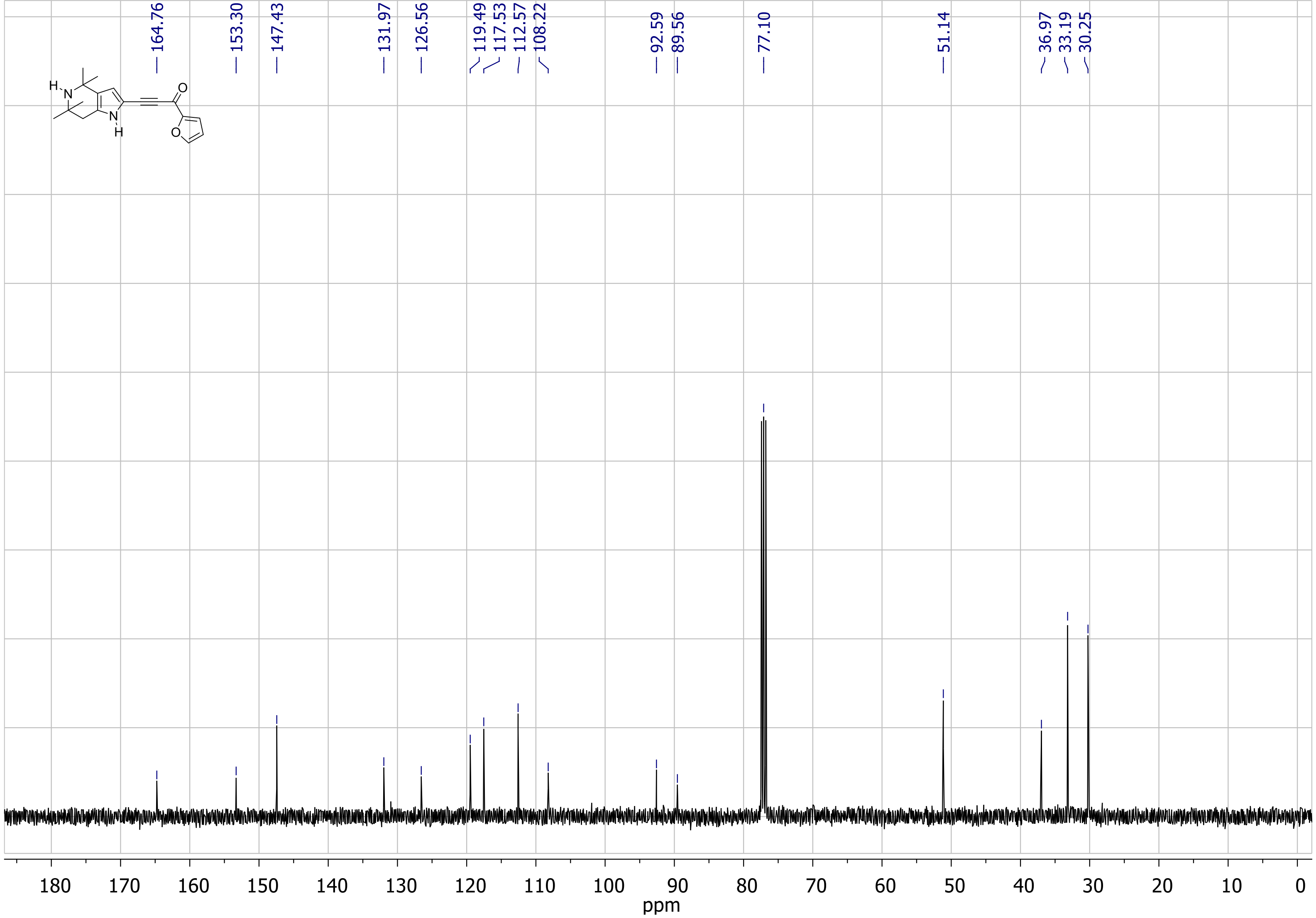
^{13}C NMR spectrum of compound **3c** in CDCl$_3$.



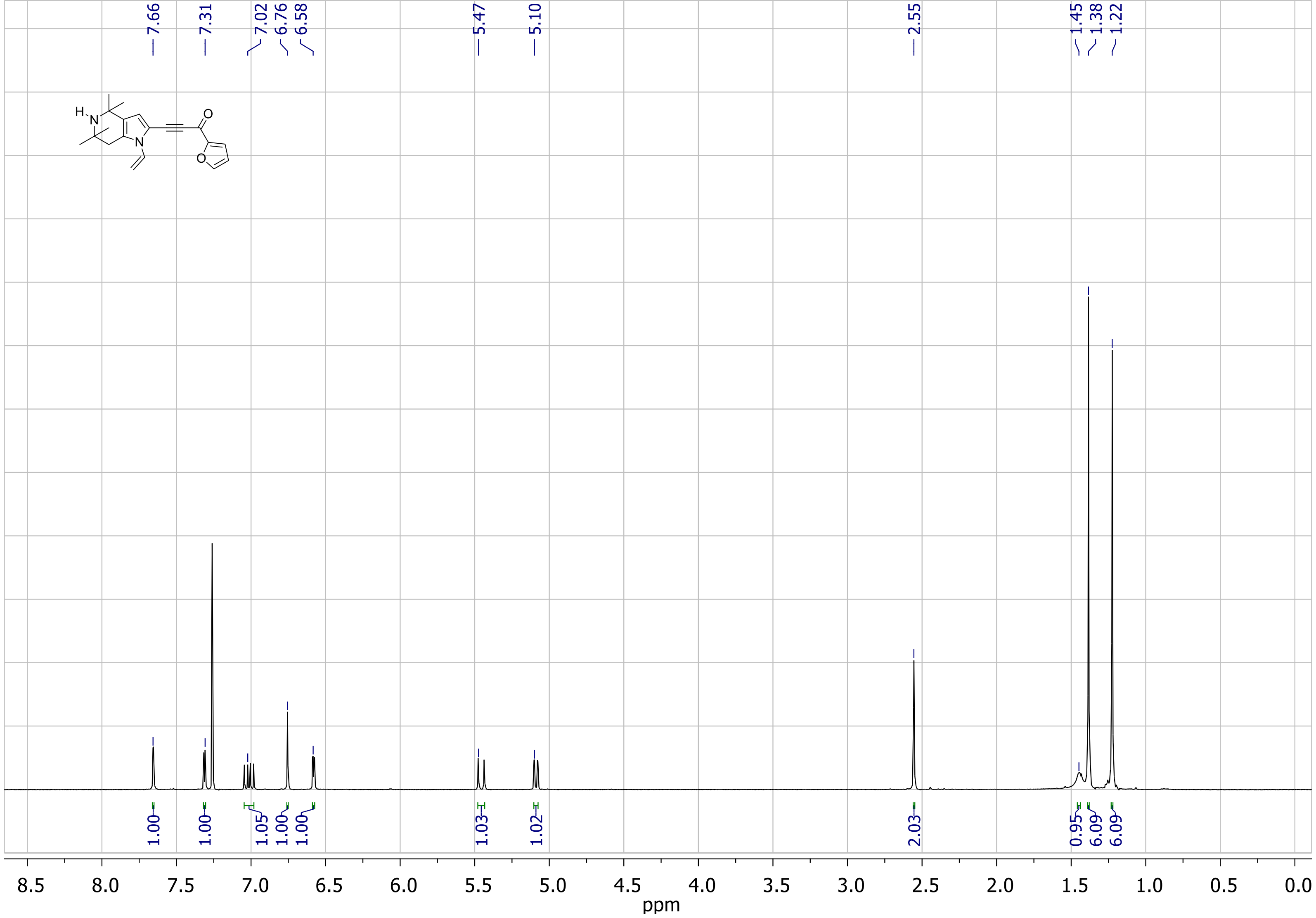
^{1}H NMR spectrum of compound **3d** in $CDCl_3$.



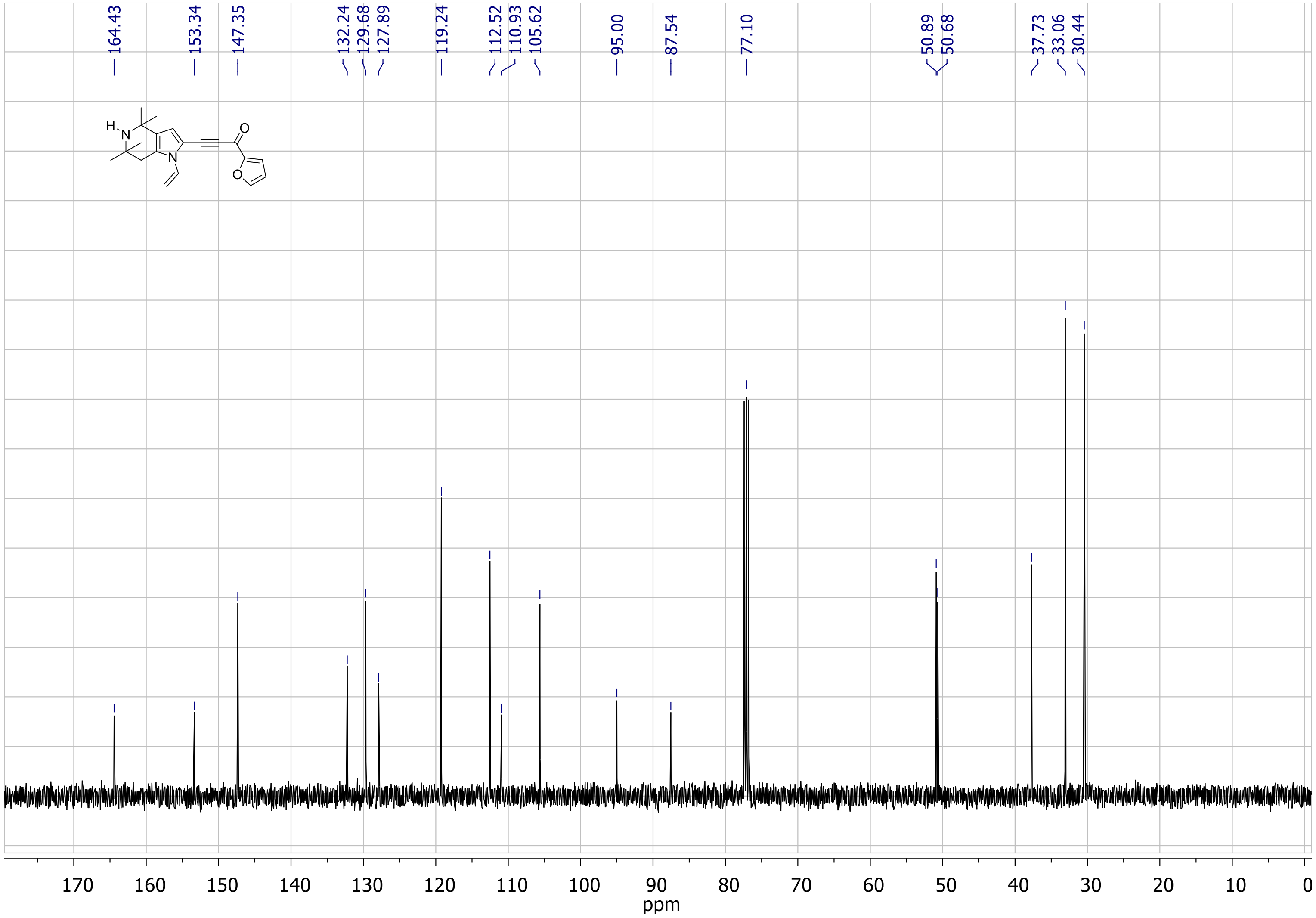
^{13}C NMR spectrum of compound **3d** in $CDCl_3$.



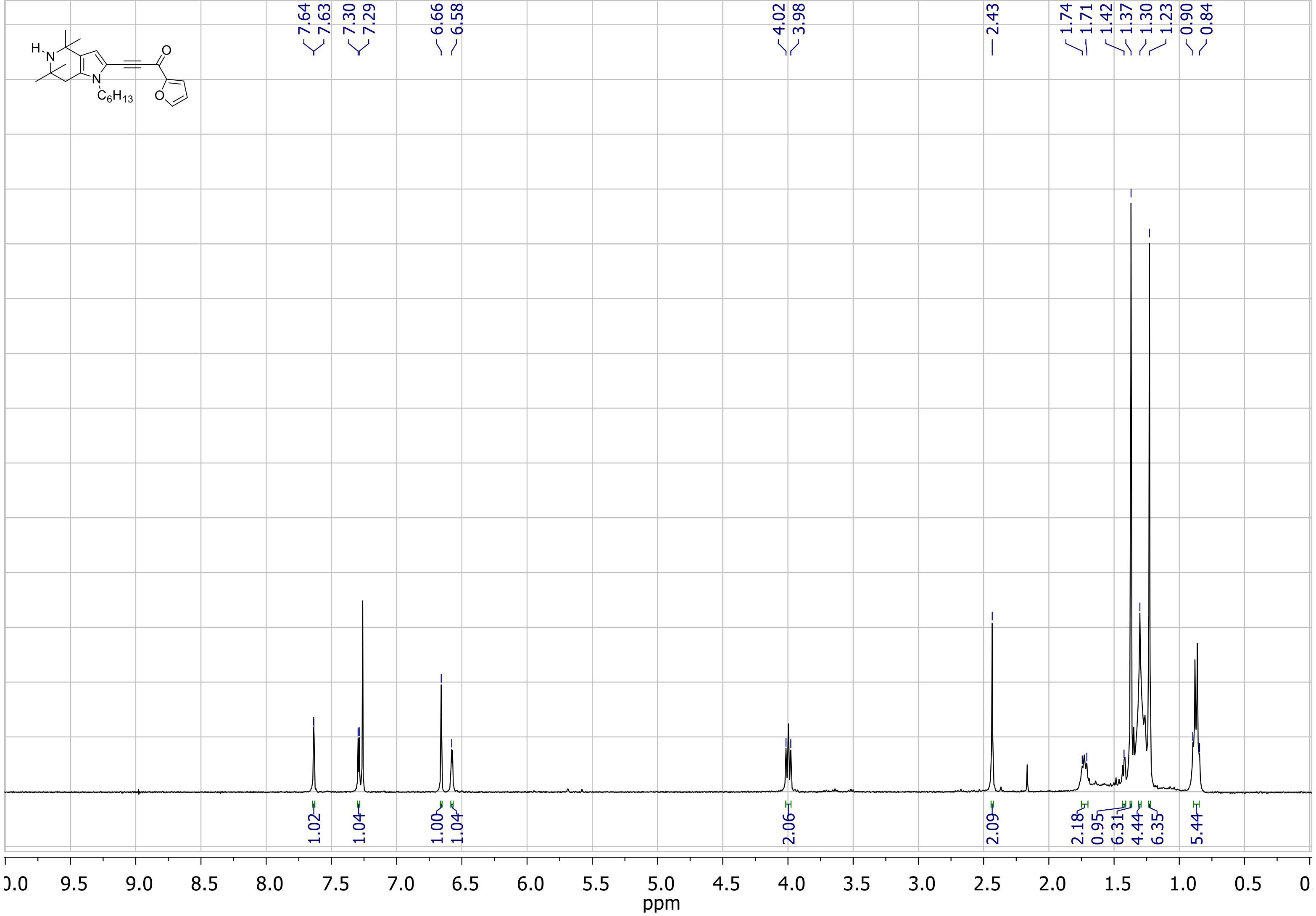
^{1}H NMR spectrum of compound **3e** in $CDCl_3$.



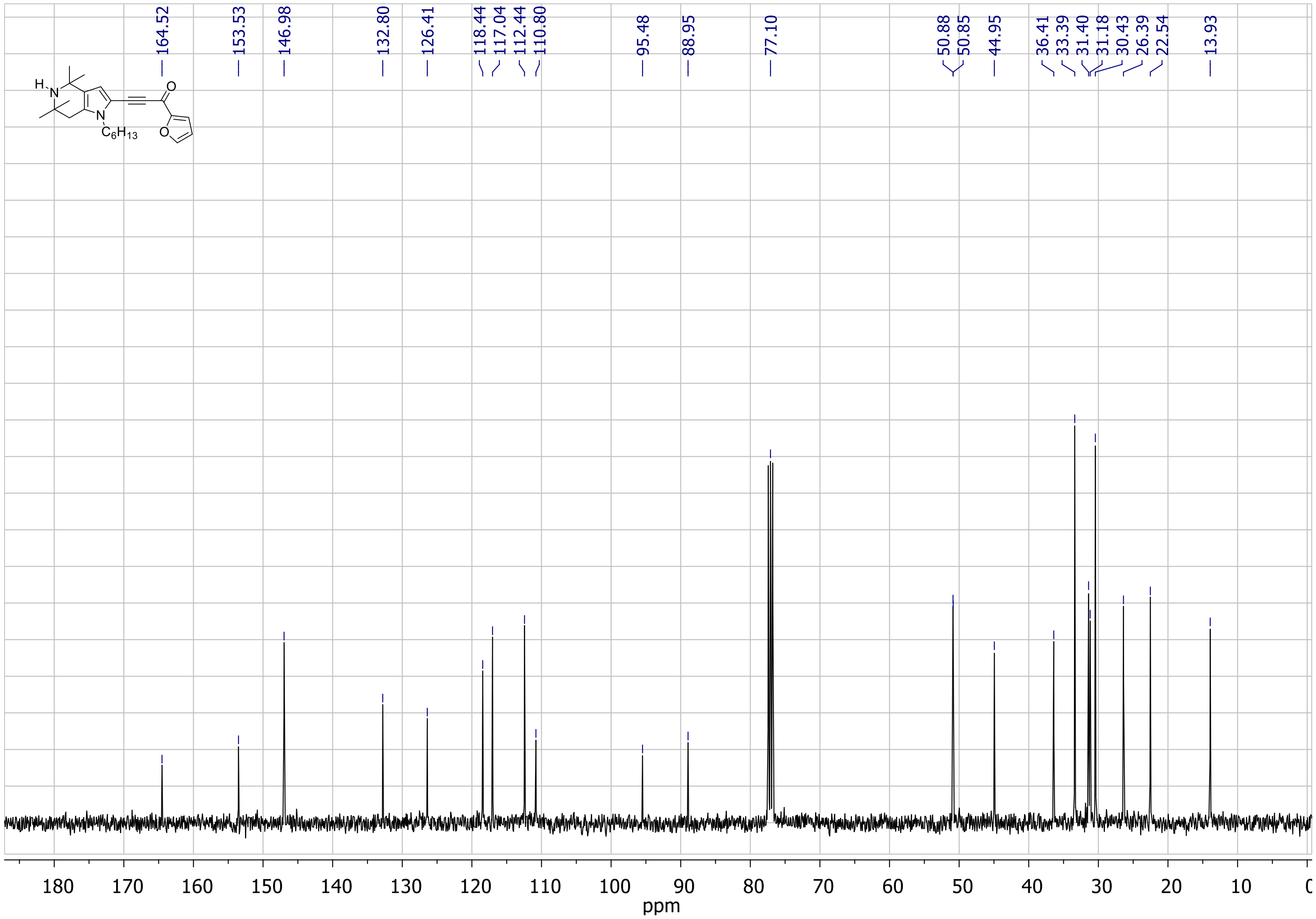
^{13}C NMR spectrum of compound **3e** in CDCl$_3$.



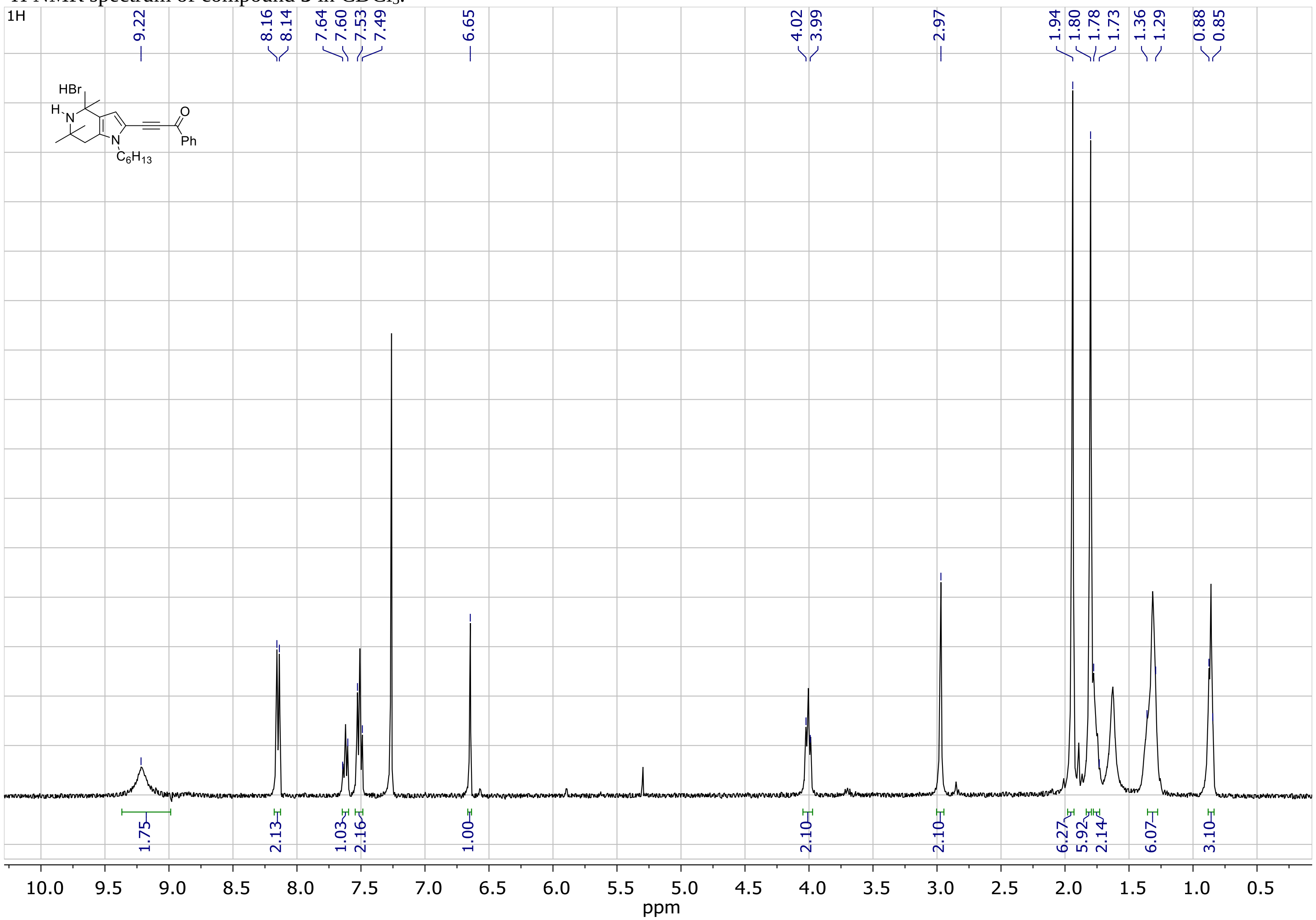
^{1}H NMR spectrum of compound **3f** in $CDCl_3$.



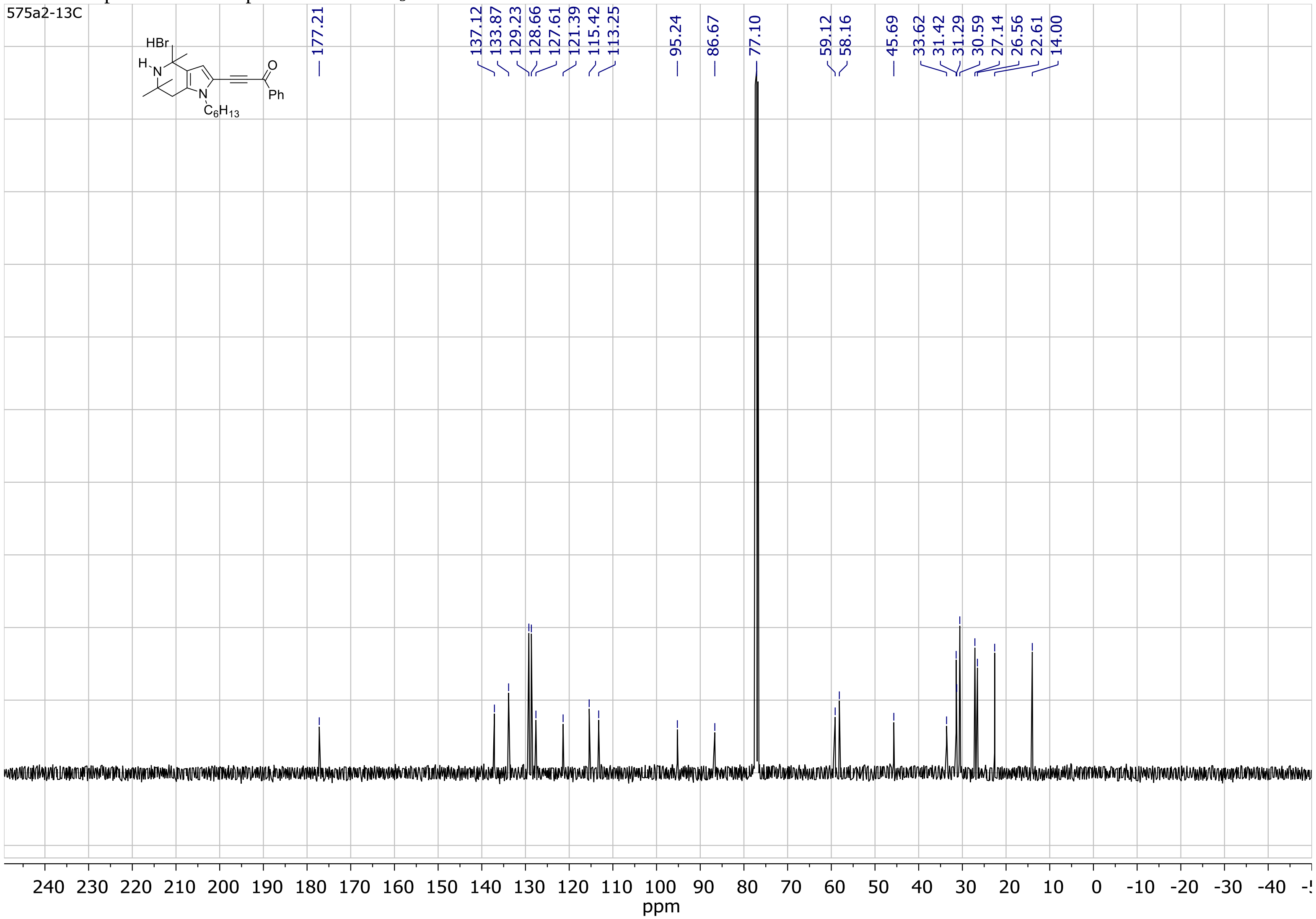
^{13}C NMR spectrum of compound **3f** in CDCl$_3$.



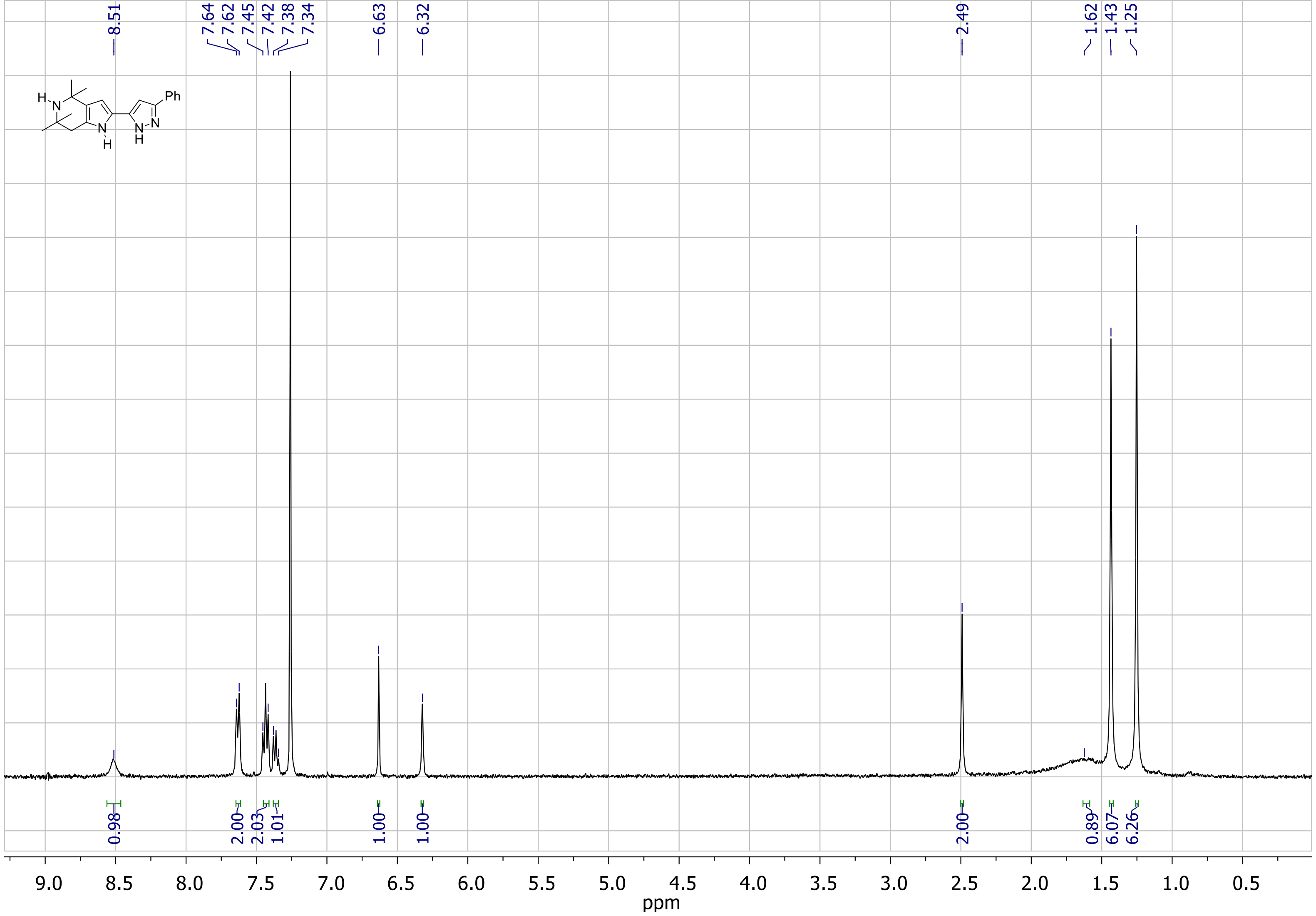
^{1}H NMR spectrum of compound **5** in $CDCl_3$.



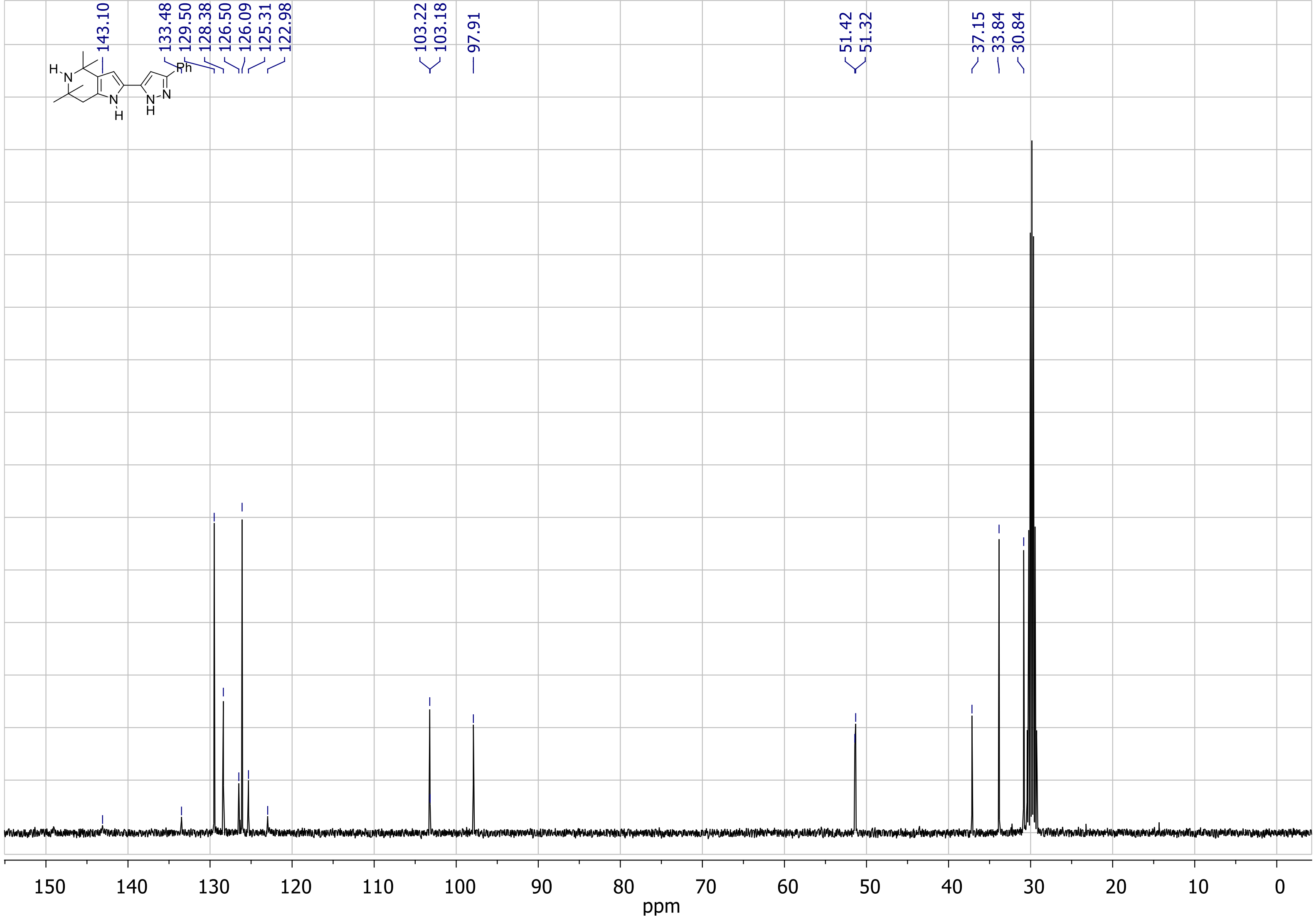
^{13}C NMR spectrum of compound **5** in CDCl$_3$.



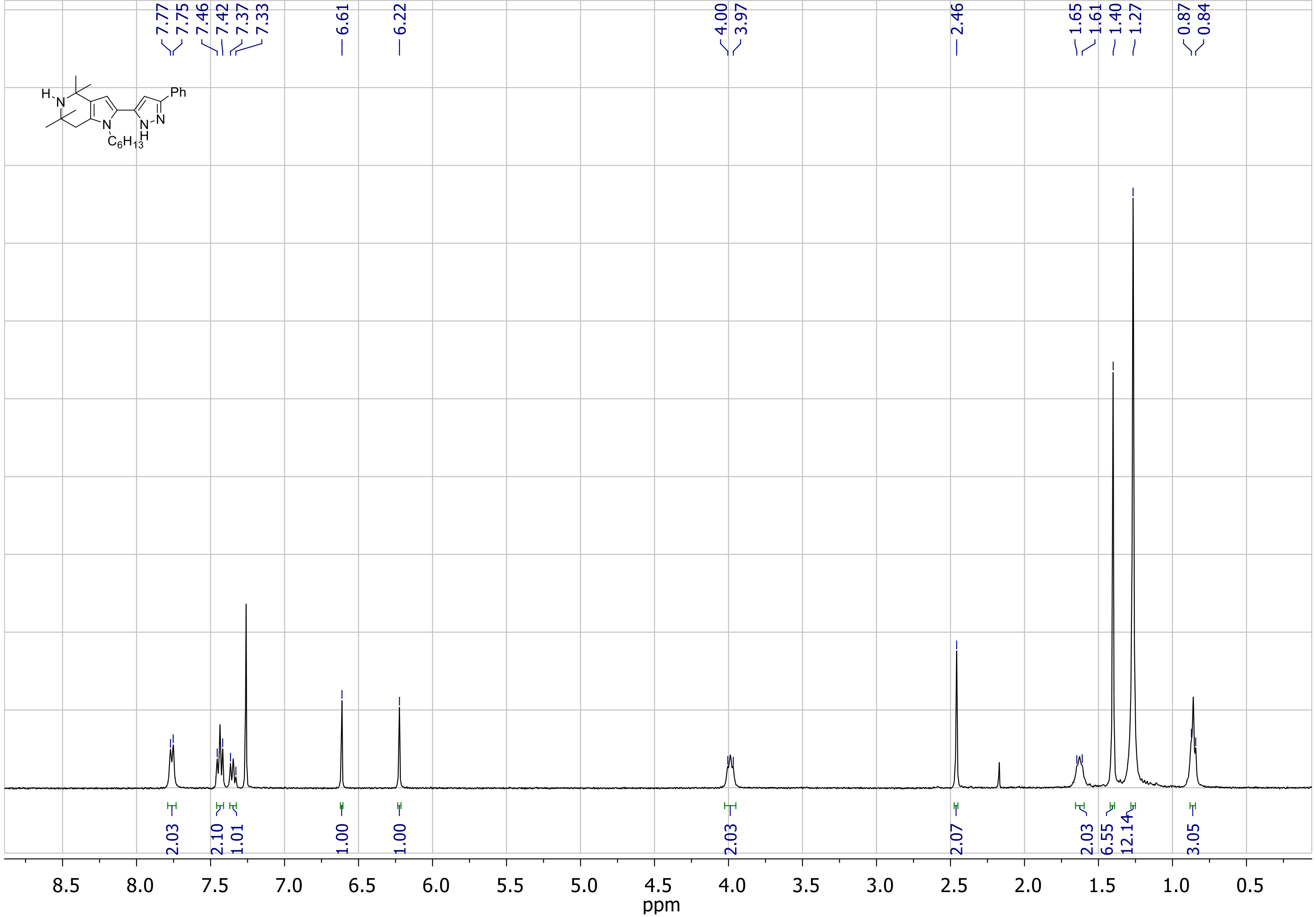
^{1}H NMR spectrum of compound **4a** in CDCl$_3$.



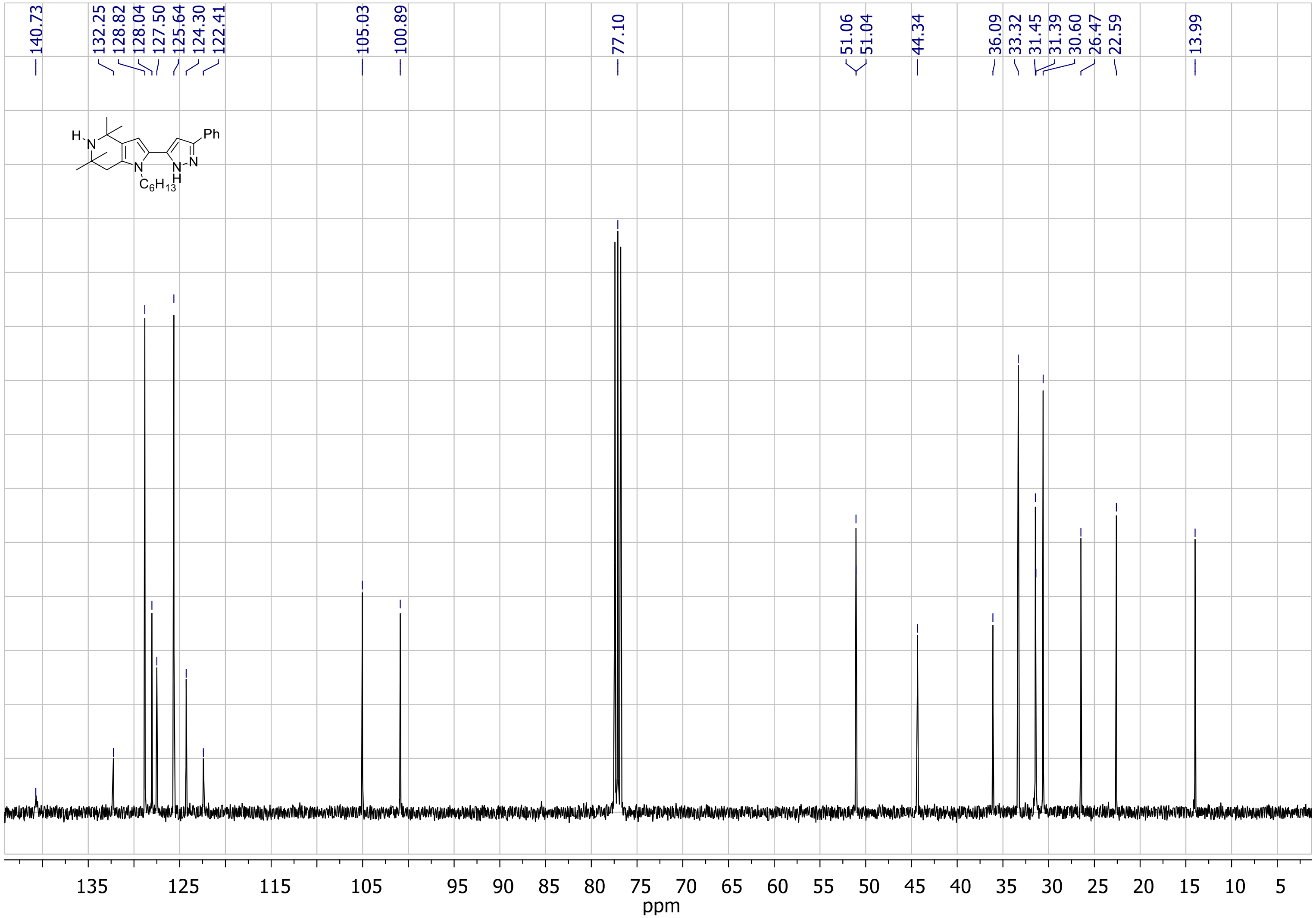
^{13}C NMR spectrum of compound **4a** in acetone-d_6.



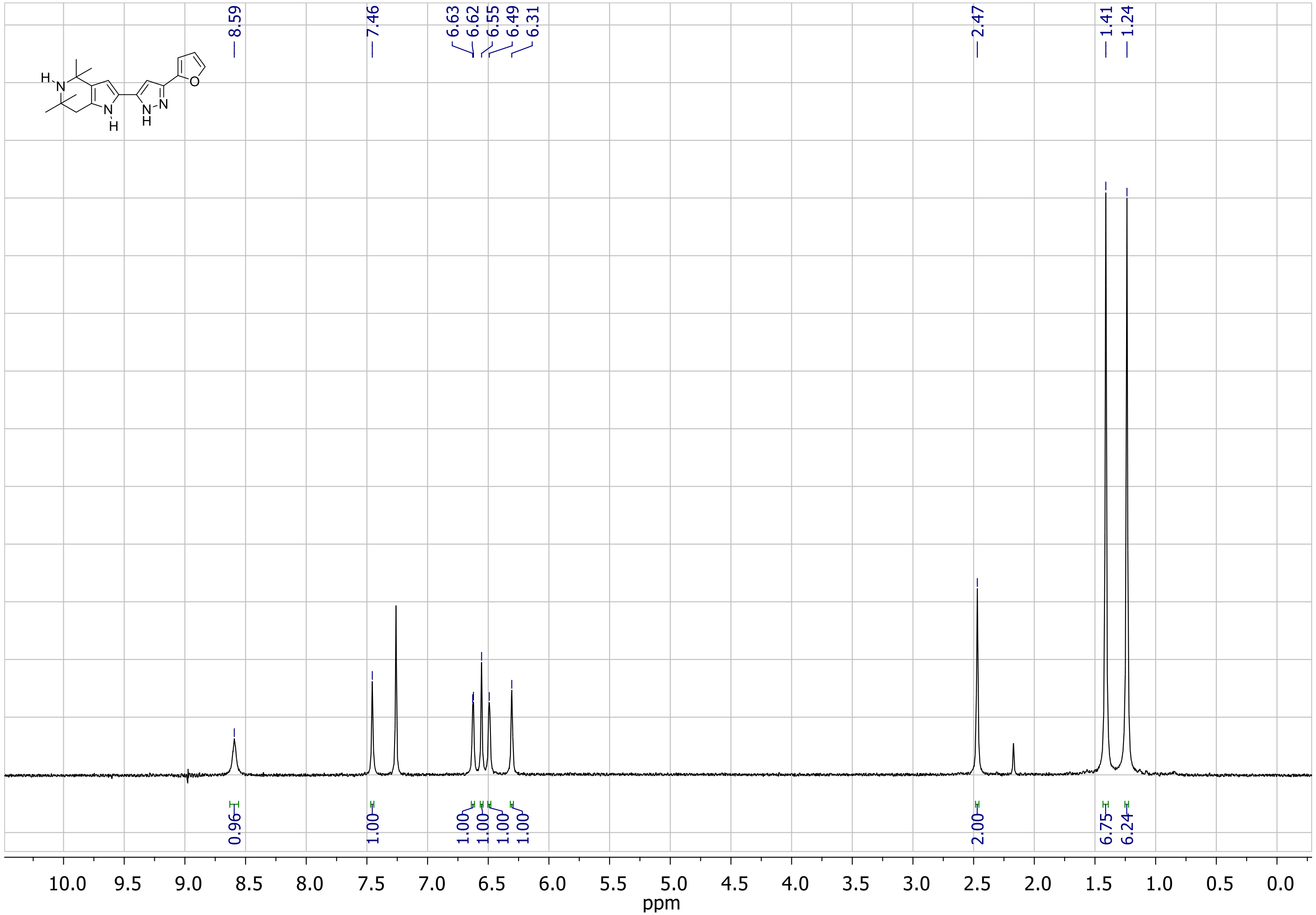
^{1}H NMR spectrum of compound **4b** in $CDCl_3$.



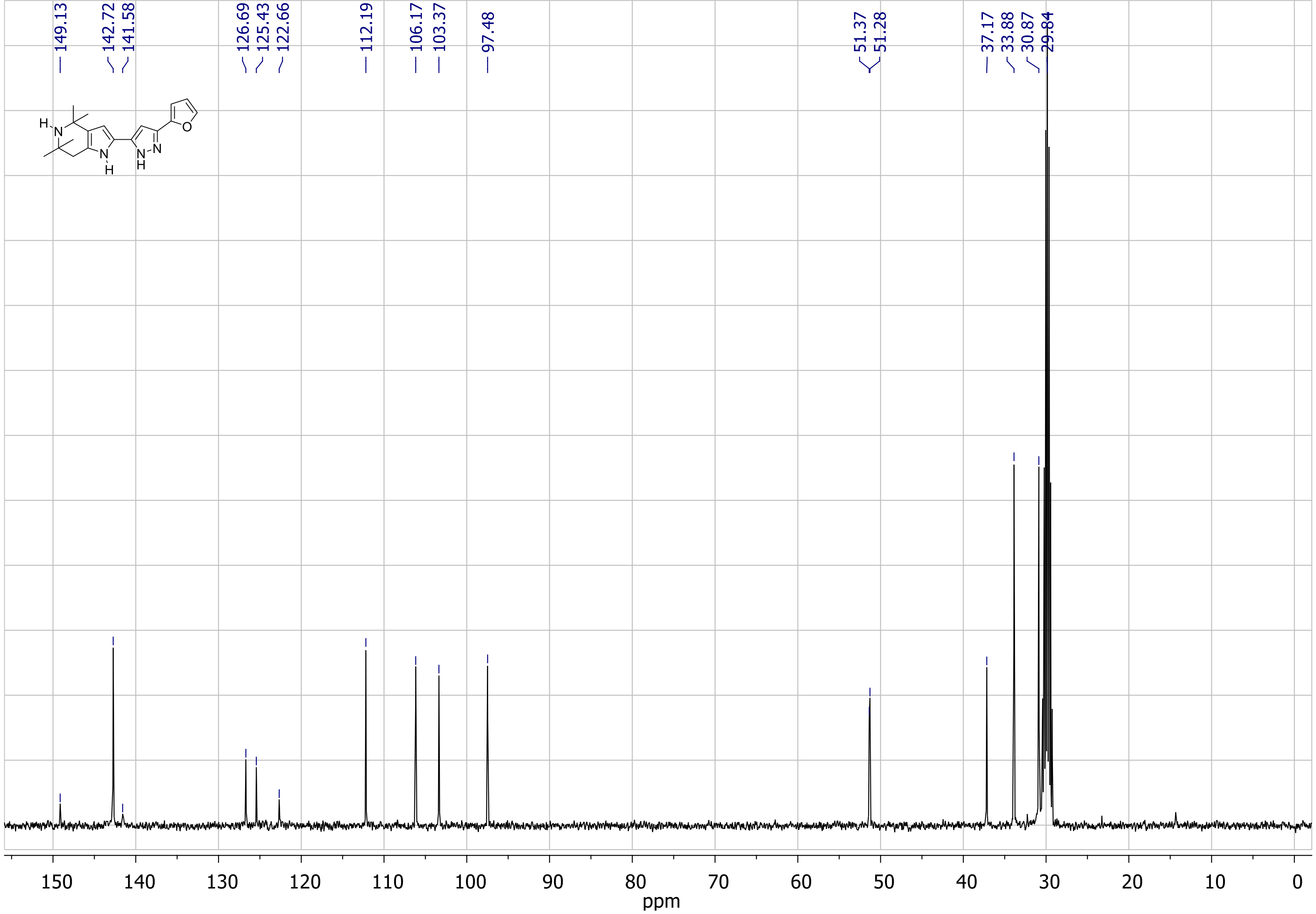
^{13}C NMR spectrum of compound **4b** in $CDCl_3$.



^{1}H NMR spectrum of compound **4c** in $CDCl_3$.



^{13}C NMR spectrum of compound **4c** in acetone-d_6.



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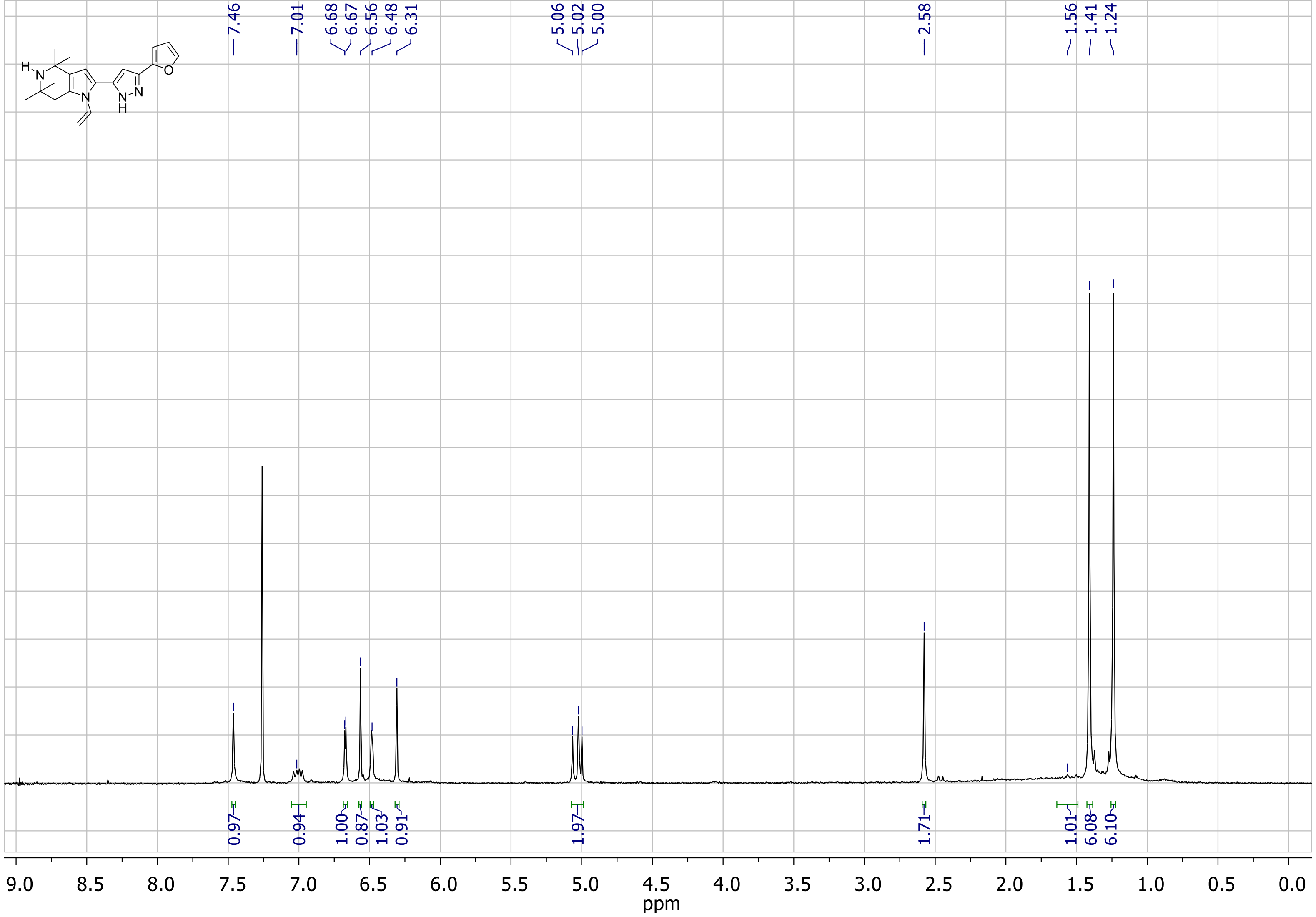

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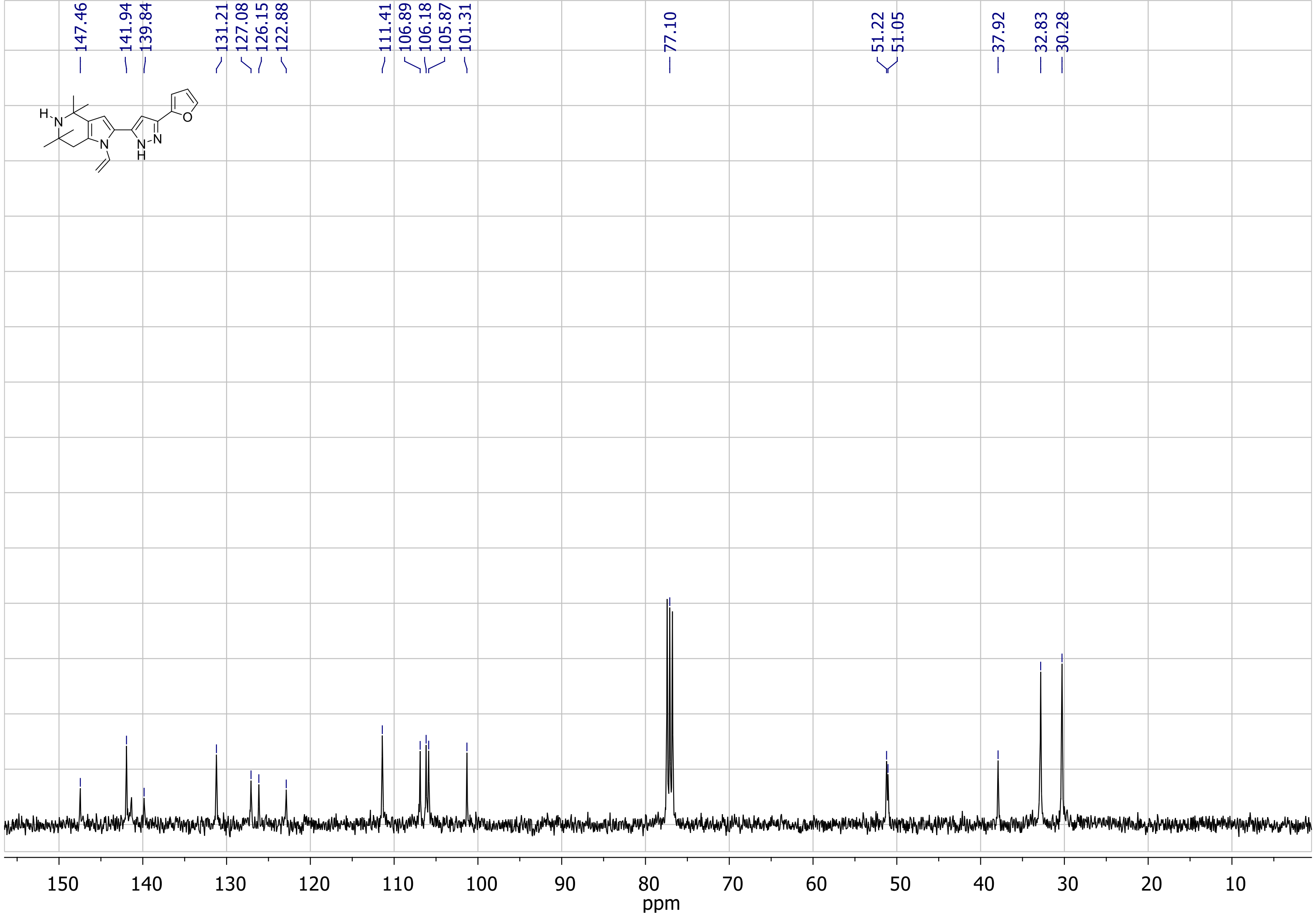
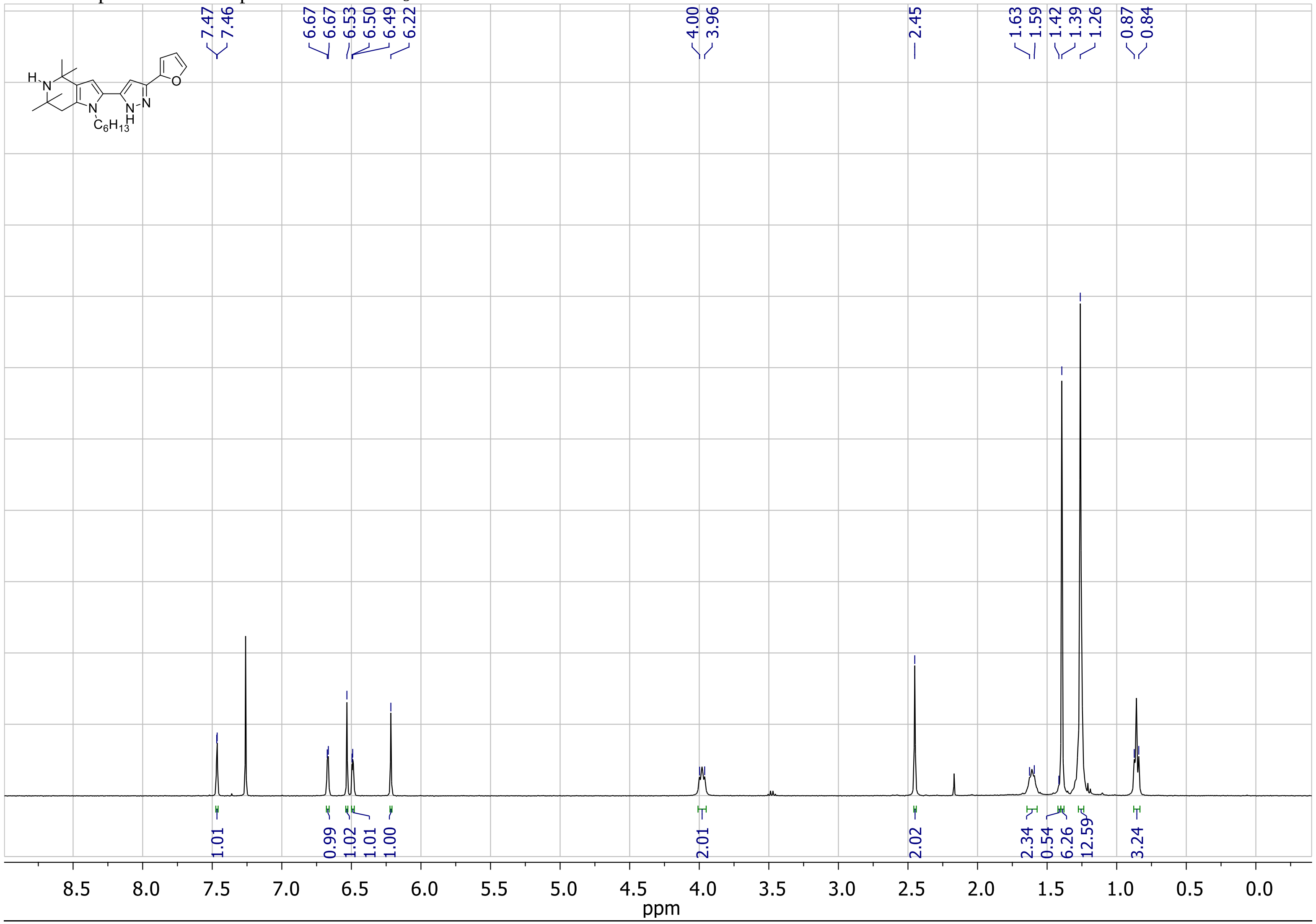
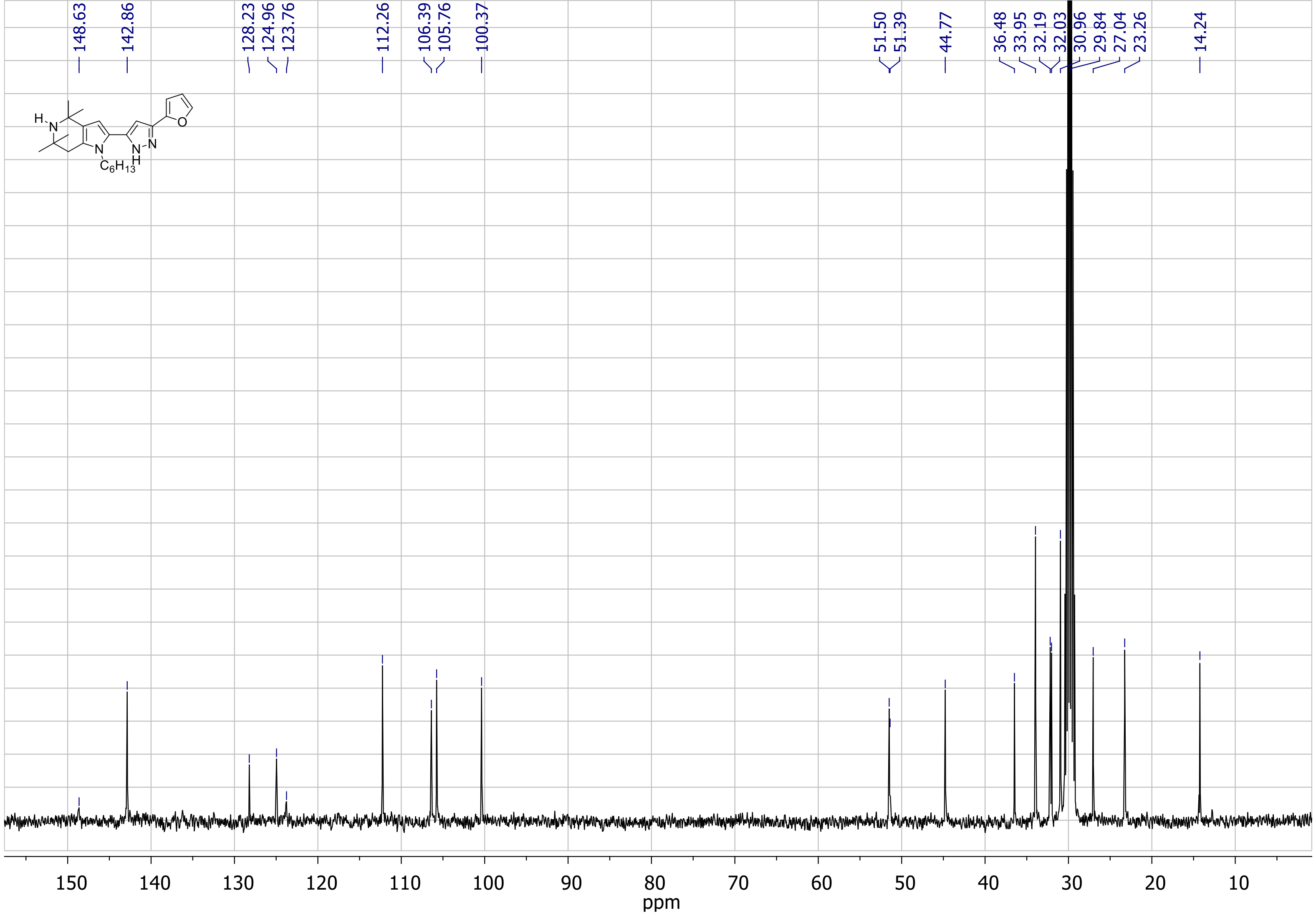


^{1}H NMR spectrum of compound **4e** in $CDCl_3$.

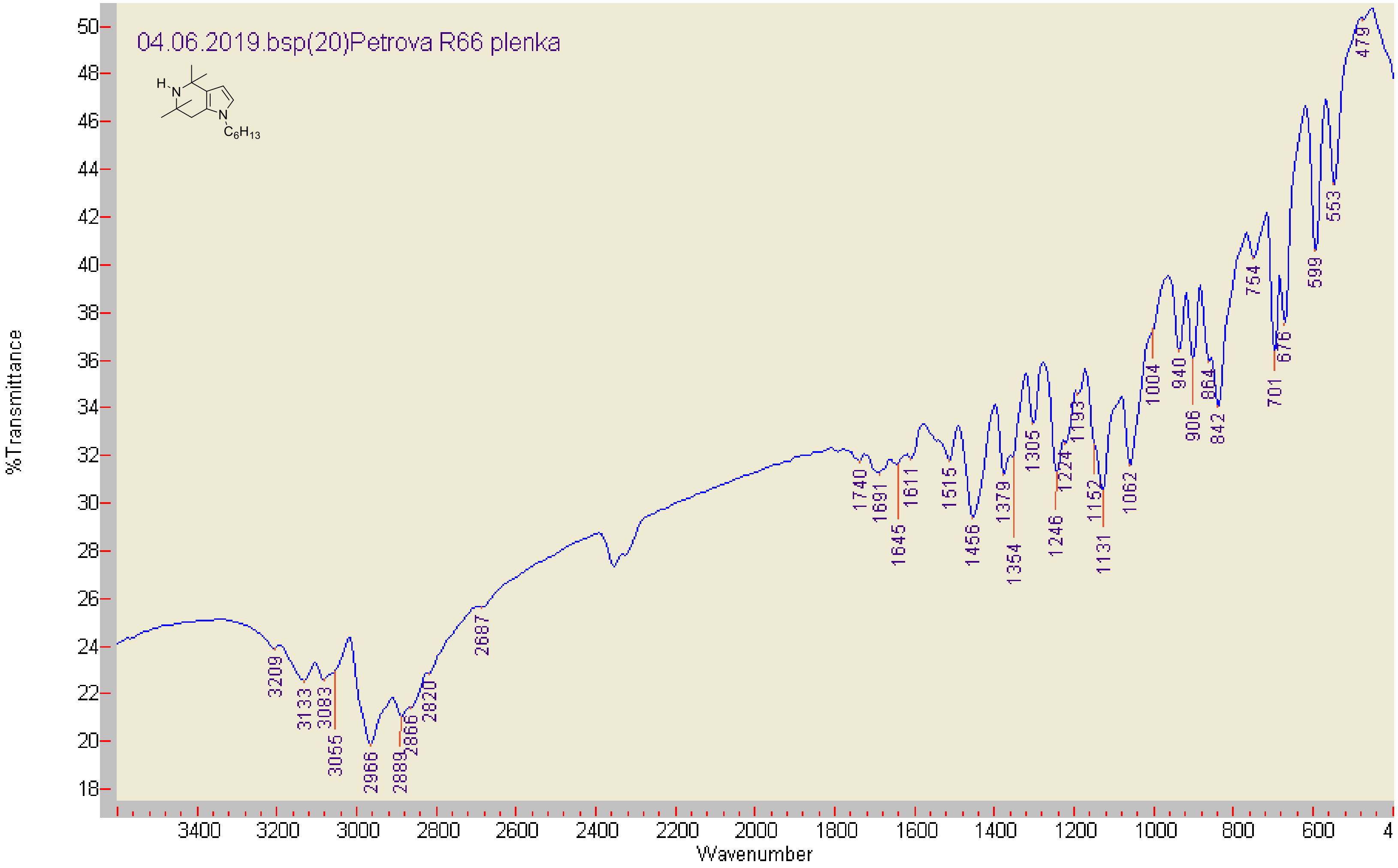


^{13}C NMR spectrum of compound **4e** in acetone-d_6.

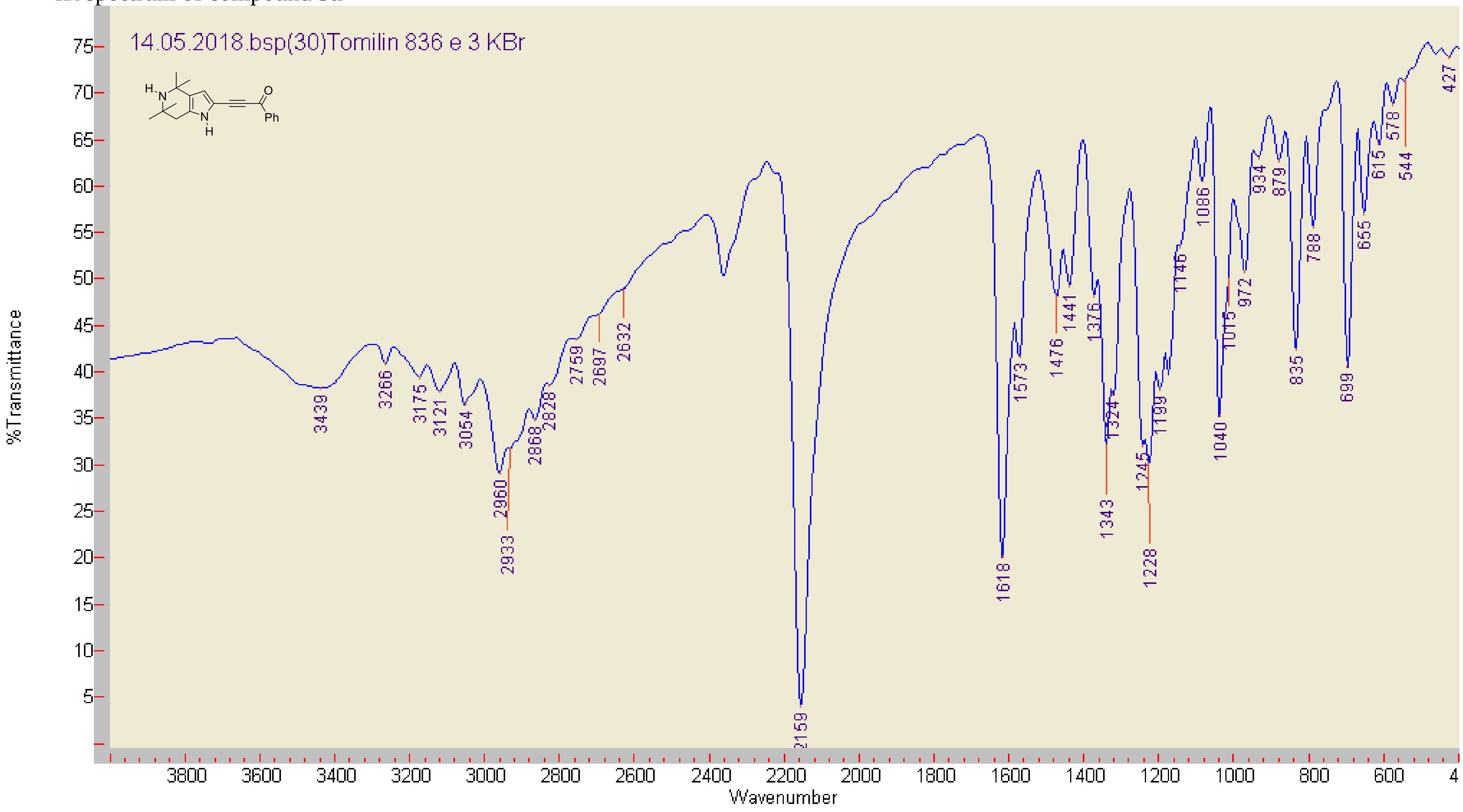


2. Copies of IR spectra of compounds 1c, 3a–f, 4a–e and 5

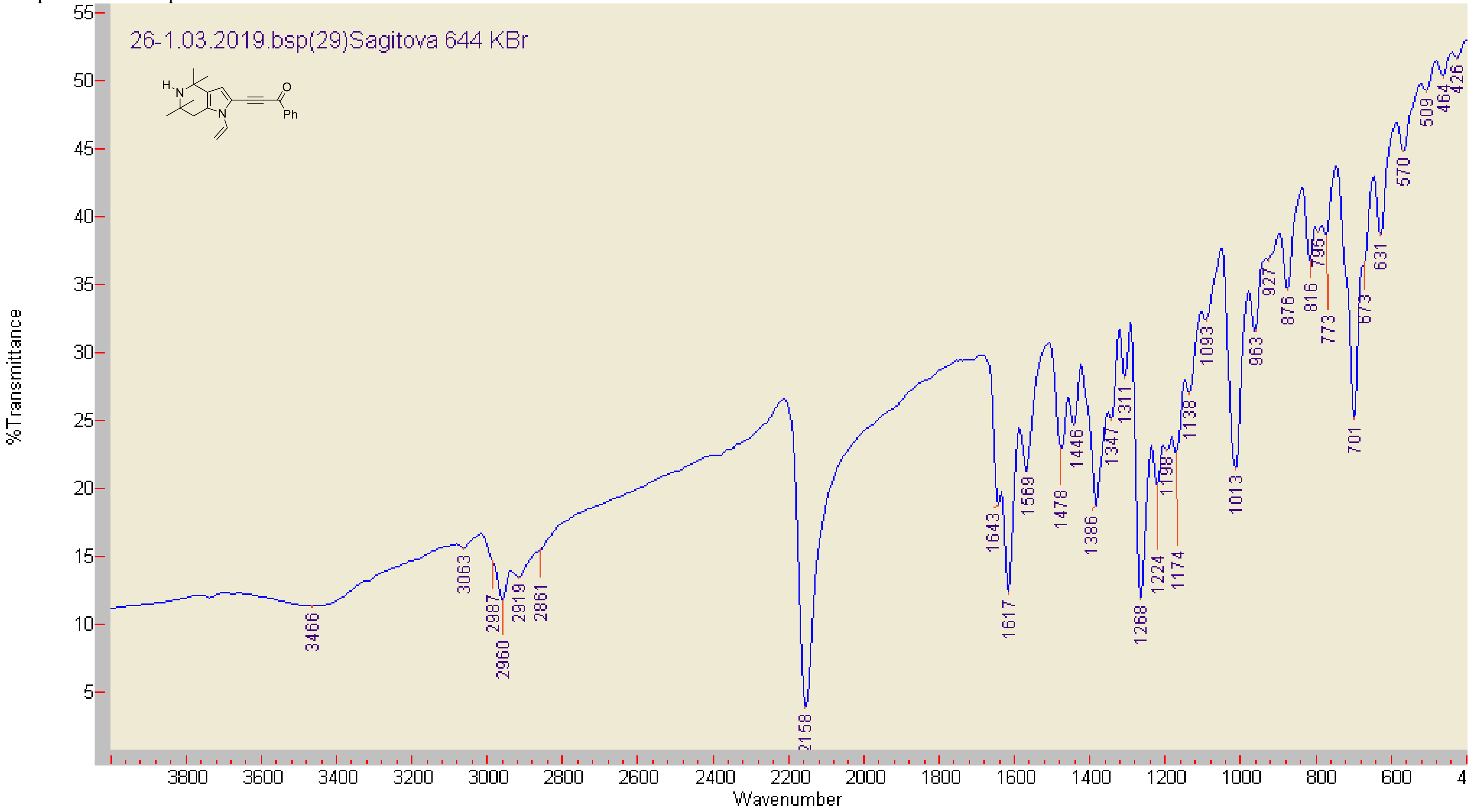
IR spectrum of compound **1c**



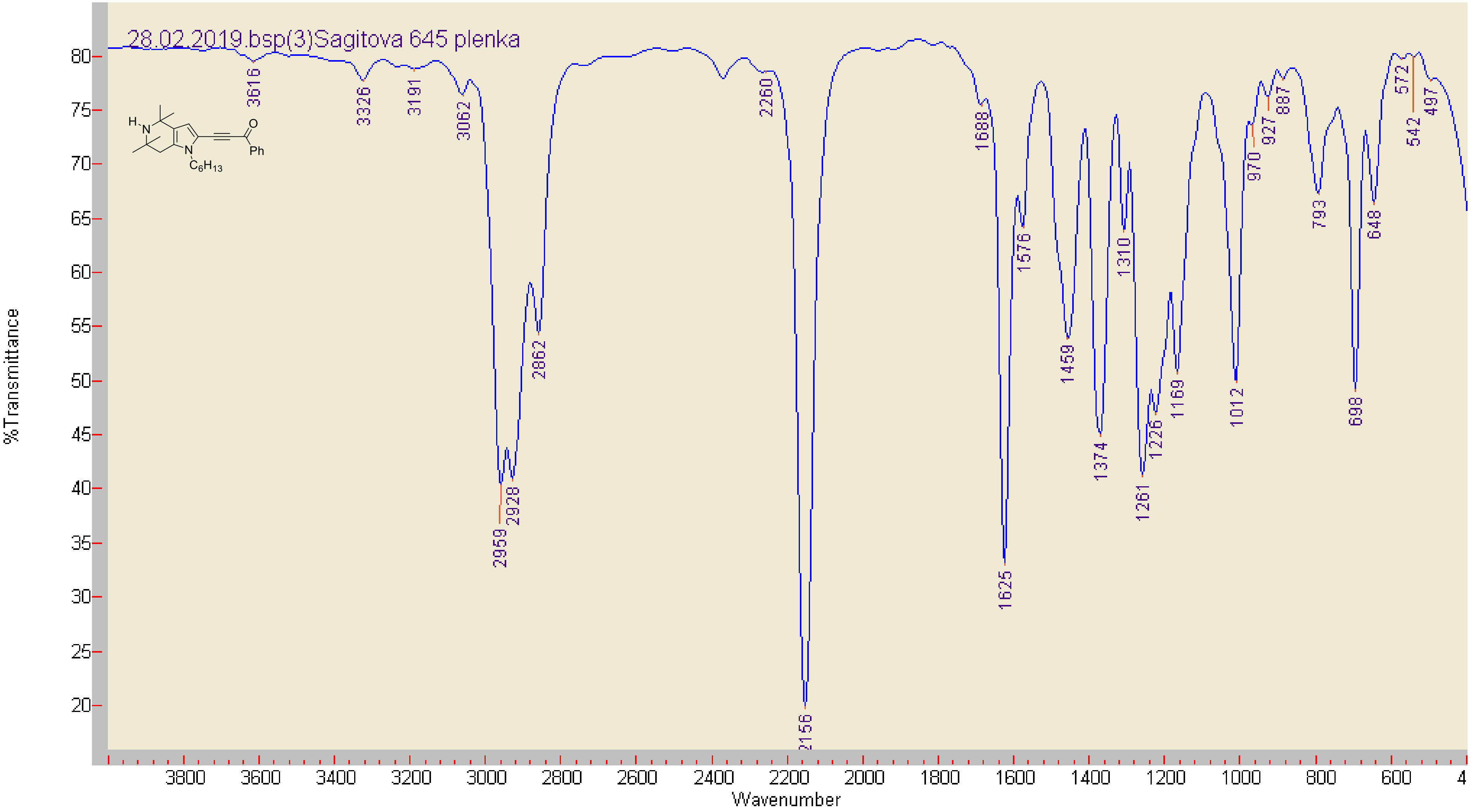
IR spectrum of compound **3a**



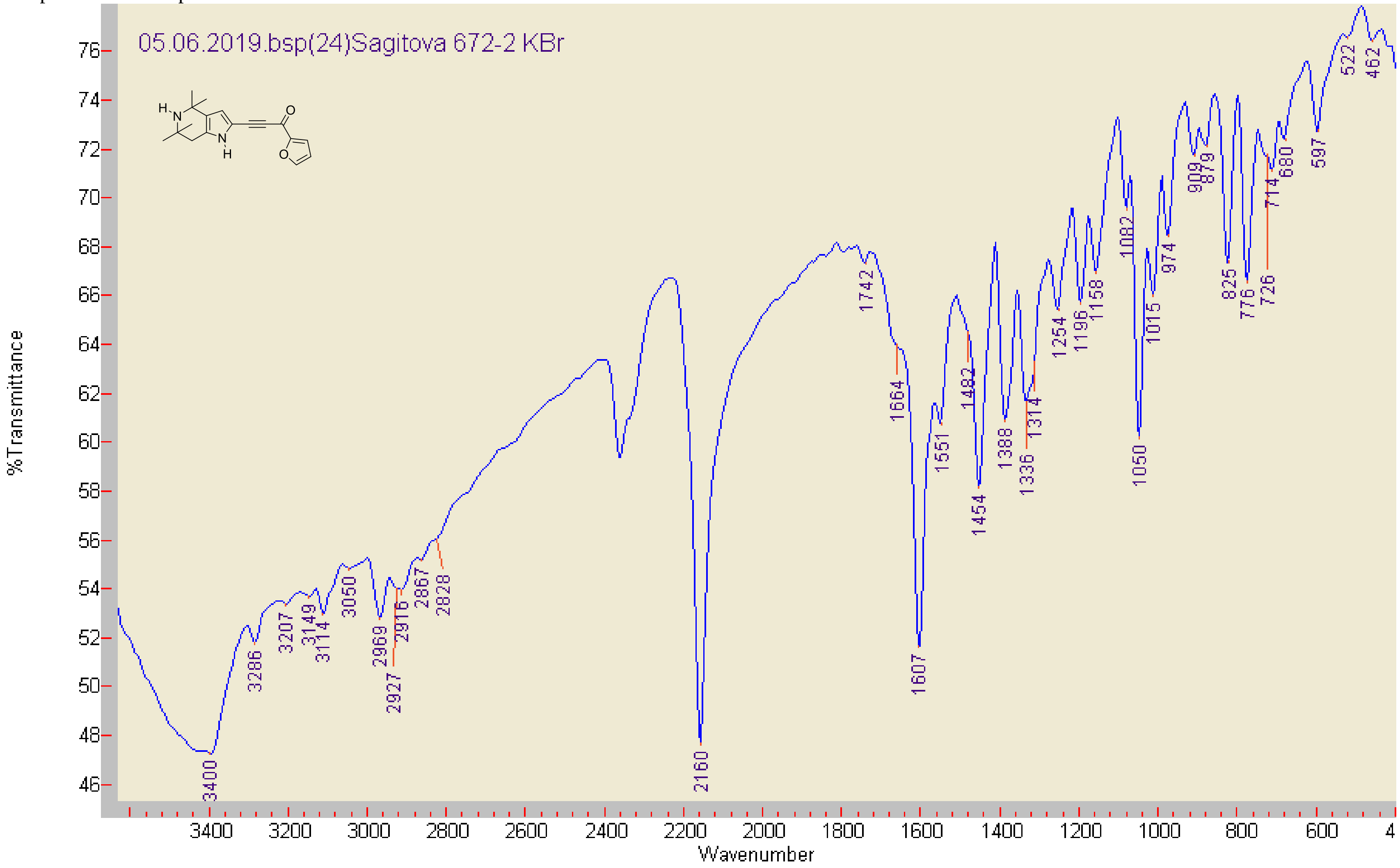
IR spectrum of compound **3b**



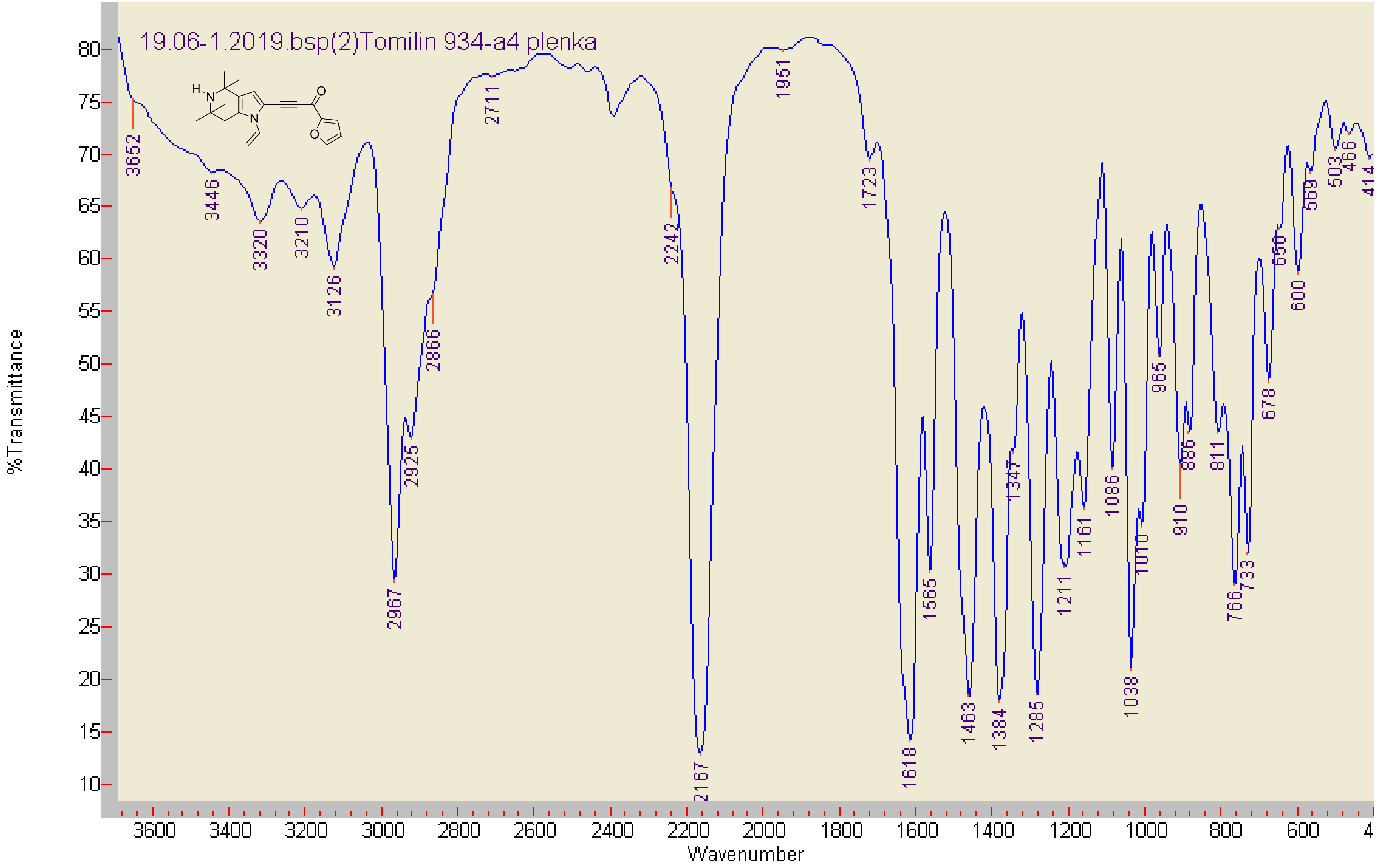
IR spectrum of compound **3c**



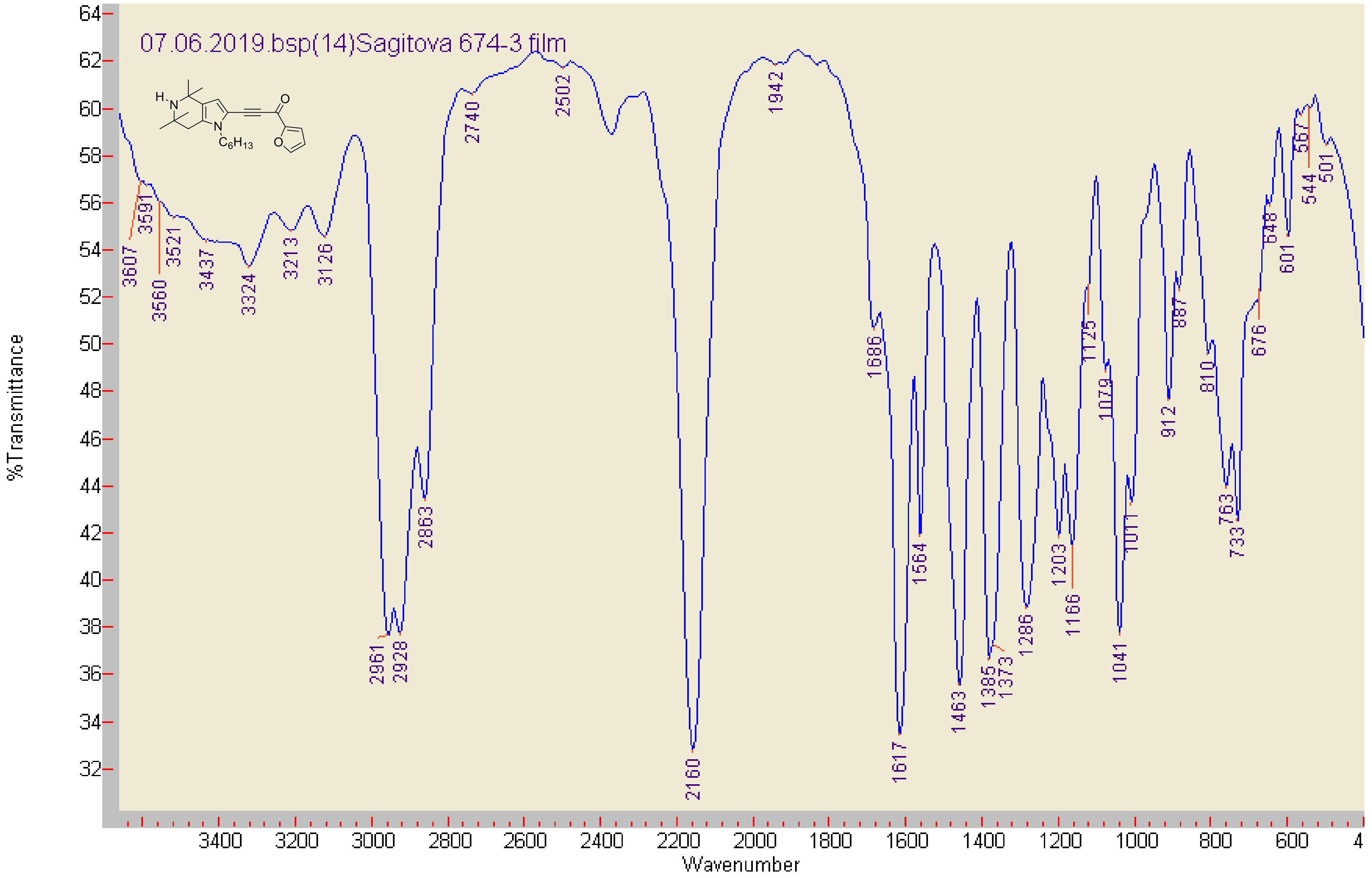
IR spectrum of compound **3d**



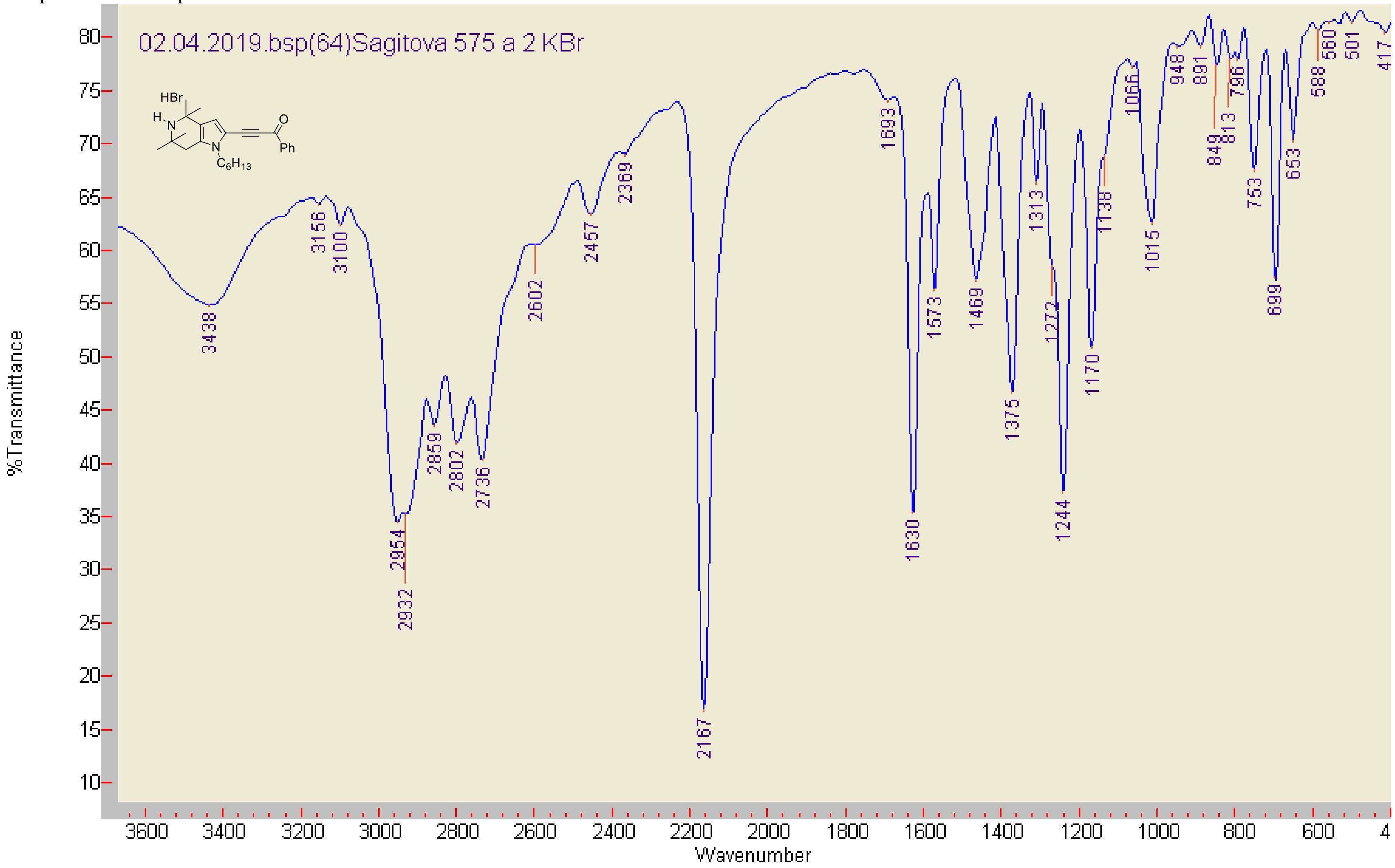
IR spectrum of compound **3e**



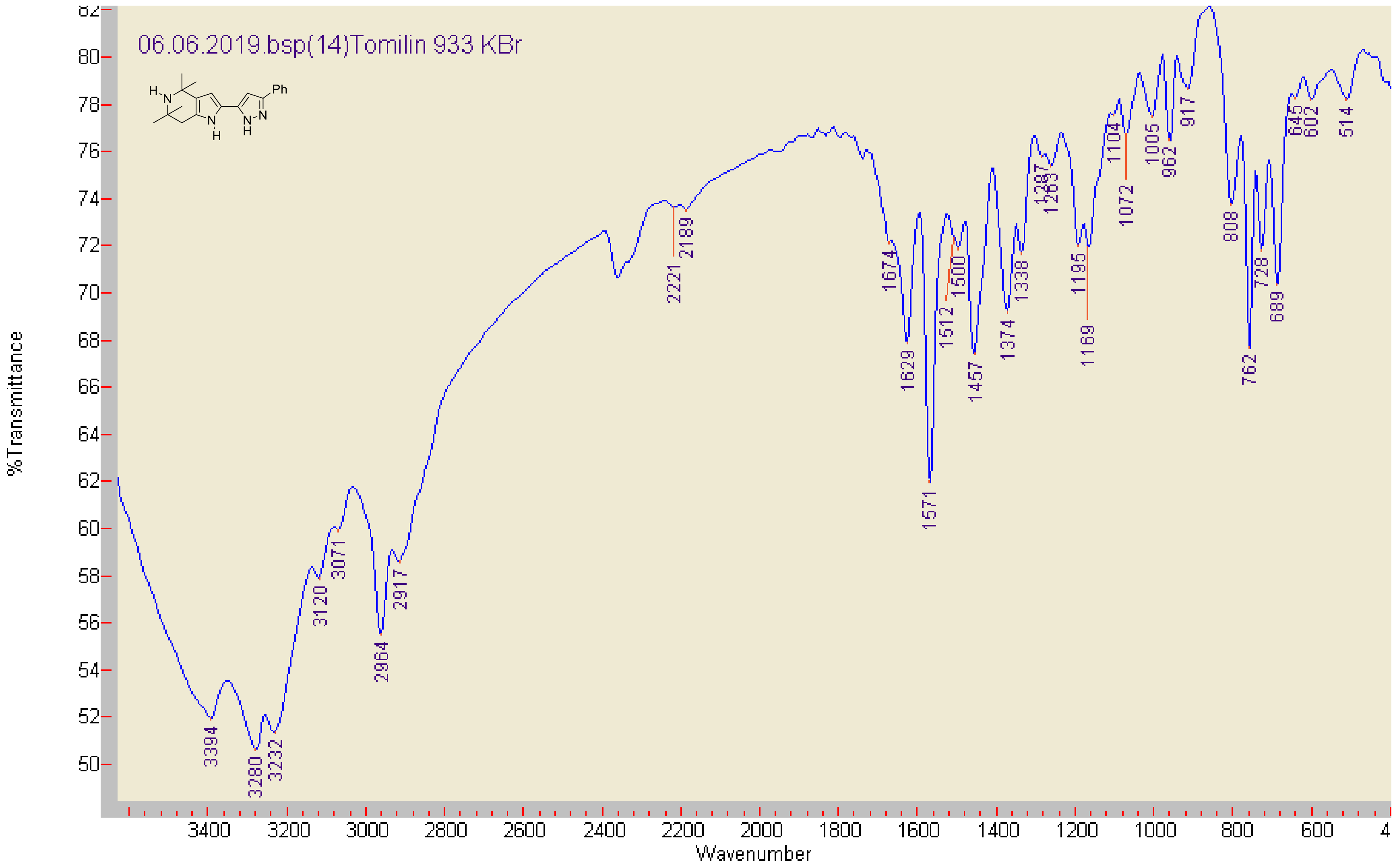
IR spectrum of compound **3f**



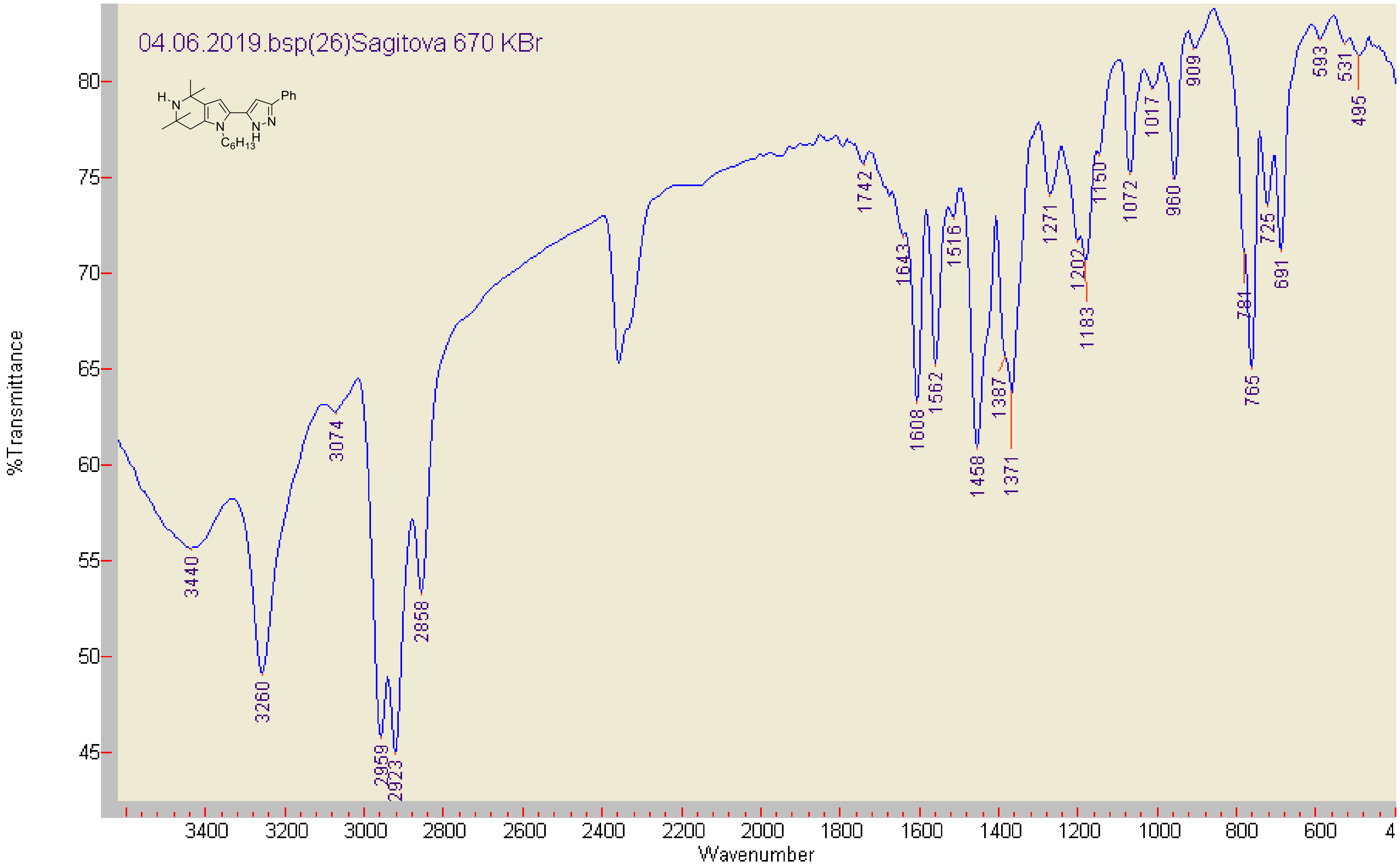
IR spectrum of compound **5**



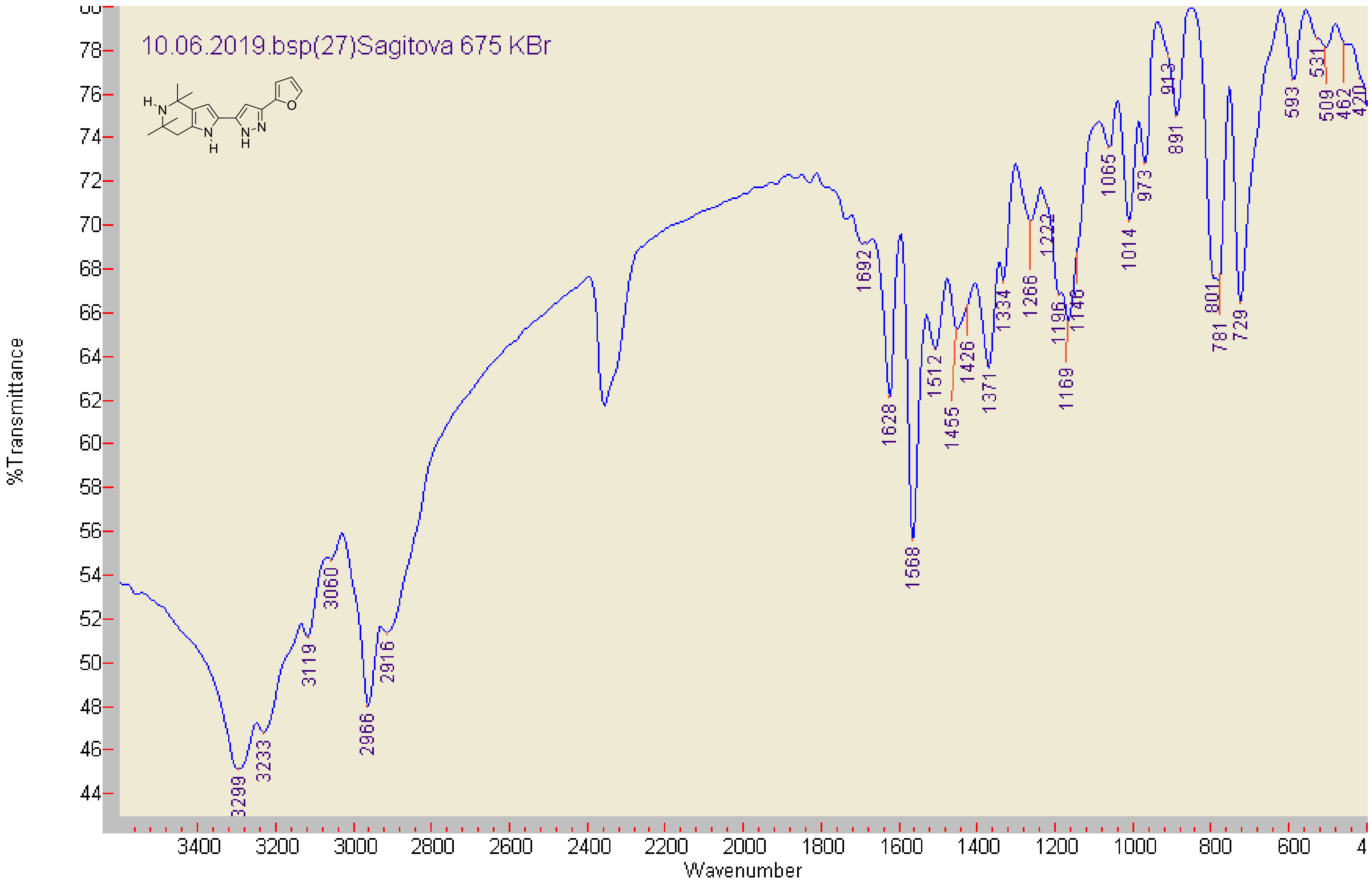
IR spectrum of compound **4a**



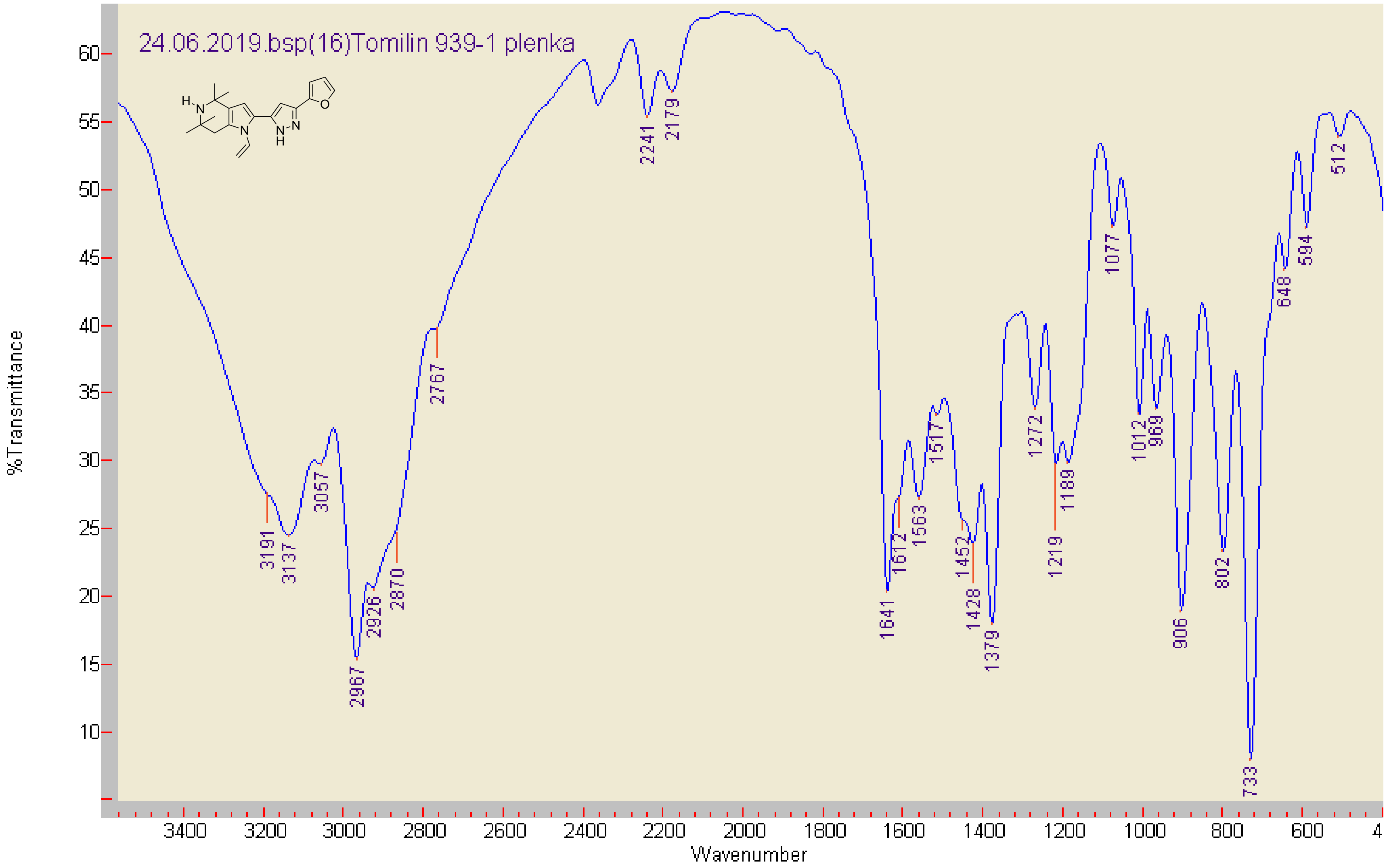
IR spectrum of compound **4b**



IR spectrum of compound **4c**



IR spectrum of compound **4d**



IR spectrum of compound **4e**