Electronic Supplementary Material (ESI) for Green Chemistry.

Base-promoted ring-closing carbonyl–allene metathesis for the synthesis of 2,4-disubstituted Pyrroles

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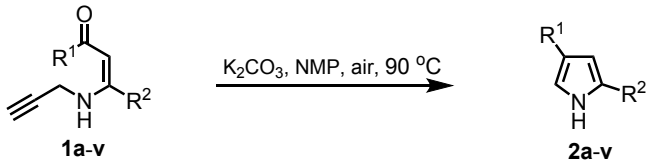
1. General Information

All reagents were used directly without further purification. Silica gel was purchased from Qing Dao Hai Yang Chemical Industry Co. ^{1}H and ^{13}C NMR spectra were measured on a 400 MHz Bruker spectrometer (^{1}H 400 MHz, ^{13}C100 MHz) or a 500 MHz Bruker spectrometer (^{1}H 500 MHz, ^{13}C125 MHz) using $CDCl_3$ or DMSO-D_6 as the solvent with tetramethylsilane (TMS) as the internal standard at room temperature. HRMS-ESI spectra were obtained on Agilent UPLC1290-QTOF6545. The products listed below were determined by ^{1}H, ^{13}C NMR. PE is petroleum ether (60–90 ^{o}C).

2. General Procedure for Synthesis of Preparation of *N*-propargyl *β*-enaminones 1a-v.[1]

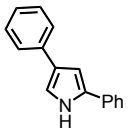
A mixture of propargylamine (1.1 g, 20 mmol), propynones (20 mmol), and CH_3OH (50 mL) was stirred at room temperature under air overnight. After propynones was exhausted completely (monitored by TLC), the solvent was evaporated and the residue was purified by chromatography (silica gel, 5% EtOAc in PE) to give **1**.

3. General Procedure for Synthesis of 2a-v



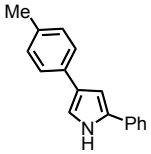
To a 15 mL Schlenk tube equipped with a magnetic stir bar were added K_2CO_3 (13.8 mg, 0.1 mmol), enaminones **1** (0.1 mmol), and NMP (1.0 mL). The solution was stirred at 90 °C under air atmosphere for 12 h. After the reaction finished, the reaction system was directly purified by column chromatography (ethyl acetate/PE = 1/50) to yield the desired products.

Spectroscopic Data for Products



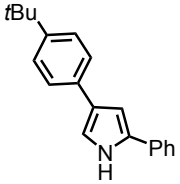
2,4-diphenyl-1*H*-pyrrole (2a)[2]

White solid (20.4 mg, 93% yield); m.p. 177-179 °C; ^{1}H NMR (400 MHz, DMSO) δ 11.44 (s, 1H), 7.69 (d, *J* = 7.8 Hz, 2H), 7.62 (d, *J* = 7.7 Hz, 2H), 7.35 (m, 5H), 7.15 (m, 2H), 6.96 (s, 1H); ^{13}C NMR (100 MHz, DMSO) δ 136.2, 133.1, 132.7, 129.1, 129.0, 126.1, 125.5, 125.2, 124.9, 123.9, 117.0, 103.6.



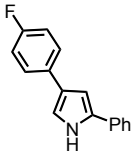
2-phenyl-4-(*p*-tolyl)-1*H*-pyrrole (2b)[2]

White solid (21.0 mg, 90% yield); m.p. 194-196 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.40 (s, 1H), 7.48 (dd, *J* = 17.2, 7.9 Hz, 4H), 7.38 (t, *J* = 7.6 Hz, 2H), 7.22 (d, *J* = 7.4 Hz, 1H), 7.17 (d, *J* = 7.8 Hz, 2H), 7.10 (s, 1H), 6.80 (s, 1H), 2.36 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 135.2, 132.9, 132.5, 129.3, 128.9, 126.6, 126.4, 125.1, 123.8, 115.2, 103.9, 21.0.



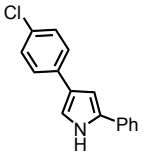
4-(4-(*tert*-butyl)phenyl)-2-phenyl-1*H*-pyrrole (2c)

White solid (17.6 mg, 64% yield); m.p. 165-167 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.35 (s, 1H), 7.53 – 7.45 (m, 4H), 7.41 – 7.33 (m, 4H), 7.21 (dd, *J* = 10.3, 3.7 Hz, 1H), 7.09 – 7.01 (m, 1H), 6.80 (d, *J* = 1.6 Hz, 1H), 1.34 (d, *J* = 2.7 Hz, 9H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 148.6, 132.8, 132.7, 132.5, 128.9, 126.5, 126.3, 125.5, 124.9, 123.7, 115.4, 104.0,34.4, 31.3; HRMS (ESI) calcd for $C_{20}H_{22}N$ [M+H]+ 276.1747, found: 276.1754.



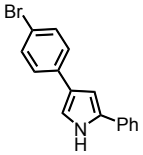
4-(4-fluorophenyl)-2-phenyl-1*H*-pyrrole (2d)[2]

White solid (22.3 mg, 94% yield); m.p. 191-194 °C; ^{1}H NMR (400 MHz, DMSO) δ 11.44 (s, 1H), 7.69 (d, *J* = 7.9 Hz, 2H), 7.64 (dd, *J* = 7.5, 5.7 Hz, 2H), 7.38 (t, *J* = 7.4 Hz, 2H), 7.32 (s, 1H), 7.22 – 7.12 (m, 3H), 6.93 (s, 1H); ^{13}C NMR (100 MHz, DMSO) δ 160.7 (d, *J* = 241.1 Hz), 133.1, 132.8, 132.8, 129.2, 126.5 (d, *J* = 7.6 Hz), 126.2, 124.3, 123.9, 117.0, 115.7 (d, *J* = 21.2 Hz), 103.7; ^{19}F NMR (376 MHz, DMSO) δ -118.2.



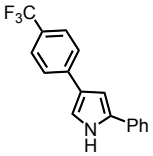
4-(4-chlorophenyl)-2-phenyl-1*H*-pyrrole (2e)[2]

White solid (21.0 mg, 83% yield); m.p. 206-208 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.44 (s, 1H), 7.48 (t, *J* = 7.4 Hz, 4H), 7.38 (t, *J* = 7.6 Hz, 2H), 7.31 (d, *J* = 8.4 Hz, 2H), 7.24 (t, *J* = 7.3 Hz, 1H), 7.10 (s, 1H), 6.77 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 134.0, 133.3, 132.2, 131.2, 128.9, 128.7, 126.6, 126.3, 125.5, 123.9, 115.6, 103.8.



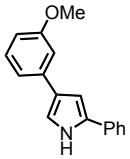
4-(4-bromophenyl)-2-phenyl-1*H*-pyrrole (2f)[3]

White solid (23.3 mg, 78% yield); m.p. 188-191 °C; ^{1}H NMR (400 MHz, DMSO) δ 11.51 (s, 1H), 7.68 (d, *J* = 7.9 Hz, 2H), 7.60 – 7.55 (m, 2H), 7.49 (d, *J* = 7.4 Hz, 2H), 7.42 – 7.35 (m, 3H), 7.18 (t, *J* = 7.3 Hz, 1H), 6.97 (s, 1H); ^{13}C NMR (100 MHz, DMSO) δ 135.5, 132.9, 131.8, 129.1, 126.8, 126.2, 123.9, 123.9, 118.0, 117.5, 103.6.



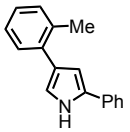
2-phenyl-4-(4-(trifluoromethyl)phenyl)-1*H*-pyrrole (2g)

White solid (20.1 mg, 70% yield); m.p. 201-208 °C; ^{1}H NMR (400 MHz, DMSO) δ 11.59 (s, 1H), 7.80 (d, *J* = 7.1 Hz, 2H), 7.65 (dd, *J* = 20.9, 7.2 Hz, 4H), 7.50 (s, 1H), 7.36 (t, *J* = 6.7 Hz, 2H), 7.18 (t, *J* = 6.6 Hz, 1H), 7.04 (s, 1H); ^{13}C NMR (100 MHz, DMSO) δ 140.4, 133.3, 132.8, 129.2, 126.4, 125.9 (q, *J* = 4.4 Hz), 125.5, 125.1, 124.8 (q, *J* = 201.8 Hz), 124.0, 123.8, 118.6, 103.9; ^{19}F NMR (376 MHz, DMSO) δ -60.49; HRMS (ESI) calcd for $C_{17}H_{13}F_3N$ [M+H]+ 288.0995, found: 288.0996.



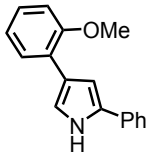
4-(4-methoxyphenyl)-2-phenyl-1*H*-pyrrole (2h)

White solid (19.9 mg, 80% yield); m.p. 117-118 °C ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.44 (s, 1H), 7.50 (d, *J* = 7.8 Hz, 2H), 7.38 (t, *J* = 7.6 Hz, 2H), 7.30 – 7.20 (m, 2H), 7.17 (d, *J* = 7.6 Hz, 1H), 7.11 (s, 2H), 6.84 – 6.72 (m, 2H), 3.85 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 159.9, 136.9, 133.0, 132.4, 129.6, 128.9, 126.5, 123.8, 117.8, 115.7, 111.1, 110.9, 104.0, 55.2; HRMS (ESI) calcd for $C_{17}H_{16}NO$ [M+H]+ 250.1226, found: 250.1232.



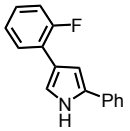
2-phenyl-4-(*o*-tolyl)-1*H*-pyrrole (2i)[2]

White solid (18.0 mg, 77% yield); m.p. 110-113 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.39 (s, 1H), 7.52 – 7.45 (m, 2H), 7.44 – 7.32 (m, 3H), 7.27 – 7.13 (m, 4H), 6.90 (dd, *J* = 2.4, 1.6 Hz, 1H), 6.68 (dd, *J* = 2.5, 1.6 Hz, 1H), 2.46 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 135.5, 135.2, 132.5, 131.8, 130.5, 129.1, 128.9, 126.3, 126.1, 126.0, 125.8, 123.7, 117.7, 106.9, 21.3.



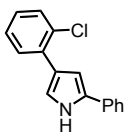
4-(2-methoxyphenyl)-2-phenyl-1*H*-pyrrole (2j)

Colorless oil (17.7 mg, 71% yield); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.44 (s, 1H), 7.59 (d, *J* = 7.6 Hz, 1H), 7.49 (d, *J* = 8.0 Hz, 2H), 7.35 (t, *J* = 7.5 Hz, 3H), 7.24 – 7.14 (m, 2H), 7.02 – 6.89 (m, 3H), 3.89 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 156.1, 132.6, 131.8, 128.8, 127.8, 126.5, 126.2, 124.2, 123.8, 122.0, 120.7, 119.0, 111.1, 105.5, 55.3; HRMS (ESI) calcd for $C_{17}H_{16}NO$ [M+H]+ 250.1226, found: 250.1233.



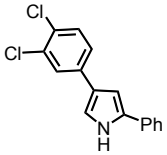
4-(2-fluorophenyl)-2-phenyl-1*H*-pyrrole (2k)

White solid (17.8 mg, 75% yield); m.p. 104-106 °C; ^{1}H NMR (400 MHz, DMSO) δ 11.58 (s, 1H), 7.74 – 7.68 (m, 3H), 7.39 (t, *J* = 7.5 Hz, 2H), 7.32 (s, 1H), 7.23 – 7.19(m, 4H), 7.01 (s, 1H); ^{13}C NMR (100 MHz, DMSO) δ 159.3 (d, *J* = 245.3 Hz), 132.9, 132.4, 129.2, 128.1 (d, *J* = 4.9 Hz), 126.9 (d, *J* = 8.4 Hz), 126.4, 125.0 (d, *J* = 3.2 Hz), 124.0, 123.6 (d, *J* = 12.9 Hz), 119.5 (d, *J* = 9.7 Hz), 118.7, 116.3 (d, *J* = 22.3 Hz), 104.9 (d, *J* = 3.1 Hz); ^{19}F NMR (376 MHz, $CDCl_3$) δ -115.08; HRMS (ESI) calcd for $C_{16}H_{13}FN$ [M+H]+ 238.1027, found: 238.1035.



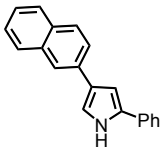
4-(2-chlorophenyl)-2-phenyl-1*H*-pyrrole (2l)

White solid (15.2 mg, 60% yield); m.p. 108-110 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.52 (s, 1H), 7.52 (t, *J* = 7.6 Hz, 3H), 7.46 – 7.35 (m, 3H), 7.30 – 7.20 (m, 3H), 7.15 (t, *J* = 7.5 Hz, 1H), 6.84 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 134.3, 132.3, 132.0, 131.7, 130.3, 130.1, 128.9, 126.9, 126.7, 126.1, 123.9, 123.3, 118.8, 106.7; HRMS (ESI) calcd for $C_{16}H_{13}ClN$ [M+H]+ 254.0731, found: 254.0734.



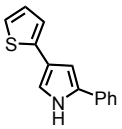
4-(3,4-dichlorophenyl)-2-phenyl-1*H*-pyrrole (2m)

White solid (20.1 mg, 70% yield); m.p. 123-124 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.50 (s, 1H), 7.63 (s, 1H), 7.50 (d, *J* = 8.0 Hz, 2H), 7.44 – 7.34 (m, 4H), 7.25 (t, *J* = 6.8 Hz, 1H), 7.11 (s, 1H), 6.75 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 135.7, 133.5, 132.5, 132.0, 130.4, 129.0, 129.0, 126.8, 126.7, 124.3, 124.3, 123.9, 115.9, 103.7; HRMS (ESI) calcd for $C_{16}H_{12}Cl_2N$ [M+H]+ 288.0341, found: 288.0349.



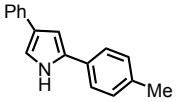
4-(naphthalen-2-yl)-2-phenyl-1*H*-pyrrole (2n)

White solid (22.1 mg, 82% yield); m.p. 229-230 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.49 (s, 1H), 7.99 (s, 1H), 7.82 (t, *J* = 8.9 Hz, 3H), 7.76 – 7.69 (m, 1H), 7.55 (d, *J* = 7.4 Hz, 2H), 7.47-7.38 (m, 4H), 7.26 (d, *J* = 5.2 Hz, 2H), 6.96 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 134.0, 133.3, 132.9, 132.4, 132.0, 128.9, 128.1, 127.6, 127.6, 126.6, 126.5, 126.0, 124.9, 124.5, 123.9, 122.6, 115.9, 104.1; HRMS (ESI) calcd for $C_{20}H_{16}N$ [M+H]+ 270.1277, found: 270.1285.



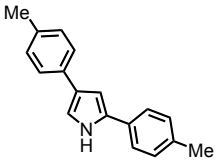
2-phenyl-4-(thiophen-2-yl)-1*H*-pyrrole (2o)

White solid (15.3 mg, 68% yield); m.p. 155-156 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.35 (s, 1H), 7.47 (d, *J* = 7.6 Hz, 2H), 7.37 (t, *J* = 7.7 Hz, 2H), 7.23 (dd, *J* = 8.3, 6.4 Hz, 1H), 7.10 (dd, *J* = 9.5, 4.0 Hz, 2H), 7.01 (dd, *J* = 8.7, 4.8 Hz, 2H), 6.70 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 139.0, 132.9, 132.1, 128.9, 127.4, 126.6, 123.9, 121.9, 121.3, 120.5, 115.5, 104.5; HRMS (ESI) calcd for $C_{14}H_{12}NS$ [M+H]+ 226.0685, found: 226.0688.



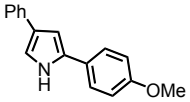
4-phenyl-2-(*p*-tolyl)-1*H*-pyrrole (2p)[2]

White solid (20.0 mg, 86% yield); m.p. 205-207 °C; ^{1}H NMR (400 MHz, DMSO) δ 11.35 (s, 1H), 7.58 (t, *J* = 8.3 Hz, 4H), 7.36 – 7.27 (m, 3H), 7.18 (d, *J* = 7.8 Hz, 2H), 7.12 (t, *J* = 7.1 Hz, 1H), 6.88 (s, 1H), 2.30 (s, 3H); ^{13}C NMR (100 MHz, DMSO) δ 136.2, 135.2, 132.8, 130.4, 129.7, 128.9, 125.4, 125.0, 124.8, 123.8, 116.6, 103.0, 21.1.



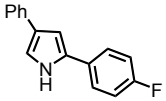
2,4-di-*p*-tolyl-1*H*-pyrrole(2q)[3]

White solid (15.6 mg, 63% yield); m.p. 203-204 °C ^{1}H NMR (400 MHz, DMSO) δ 11.29 (s, 1H), 7.56 (d, *J* = 7.7 Hz, 2H), 7.48 (d, *J* = 7.6 Hz, 2H), 7.23 (s, 1H), 7.17 (d, *J* = 7.8 Hz, 2H), 7.12 (d, *J* = 7.8 Hz, 2H), 6.84 (s, 1H), 2.29 (s, 3H), 2.28 (s, 3H); ^{13}C NMR (100 MHz, DMSO) δ 135.2, 134.3, 133.4, 132.6, 130.5, 129.7, 129.5, 125.0, 124.7, 123.8, 116.1, 102.9, 21.1, 21.1.



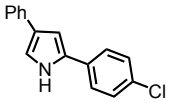
2-(4-methoxyphenyl)-4-phenyl-1*H*-pyrrole (2r)[2]

White solid (17.9 mg, 72% yield); m.p. 212-213 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.34 (s, 1H), 7.60 – 7.54 (m, 2H), 7.47 – 7.43 (m, 2H), 7.35 (t, *J* = 7.7 Hz, 2H), 7.19 (t, *J* = 7.4 Hz, 1H), 7.13 – 7.08 (m, 1H), 6.98 – 6.90 (m, 2H), 6.74 – 6.70 (m, 1H), 3.84 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.4, 135.6, 133.1, 128.6, 126.5, 125.6, 125.5, 125.3, 125.1, 114.8, 114.4, 103.0, 55.3.



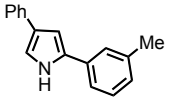
2-(4-fluorophenyl)-4-phenyl-1*H*-pyrrole (2s)[2]

White solid (18.5 mg, 78% yield); m.p. 174-176 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.33 (s, 1H), 7.55 (d, *J* = 7.1 Hz, 2H), 7.45 (s, 2H), 7.35 (t, *J* = 7.3 Hz, 2H), 7.20 (t, *J* = 7.2 Hz, 1H), 7.14 – 7.01 (m, 3H), 6.74 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 161.6 (d, *J* = 245.8 Hz), 135.4, 132.3, 128.9 (d, *J* = 3.3 Hz), 128.7, 126.6, 125.8, 125.5 (d, *J* = 7.9 Hz), 125.2, 115.9 (d, *J* = 21.8 Hz), 115.5, 103.9; ^{19}F NMR (376 MHz, $CDCl_3$) δ -115.7.



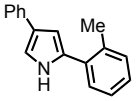
2-(4-chlorophenyl)-4-phenyl-1*H*-pyrrole (2t)[2]

White solid (17.2 mg, 68% yield); m.p. 186-187 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.39 (s, 1H), 7.55 (d, *J* = 7.3 Hz, 2H), 7.43 (d, *J* = 8.1 Hz, 2H), 7.35 (d, *J* = 7.8 Hz, 4H), 7.21 (t, *J* = 7.3 Hz, 1H), 7.14 (s, 1H), 6.80 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 135.2, 132.0, 131.9, 131.0, 129.1, 128.6, 126.8, 125.8, 125.2, 125.0, 115.8, 104.4.



4-phenyl-2-(*m*-tolyl)-1*H*-pyrrole (2u)[4]

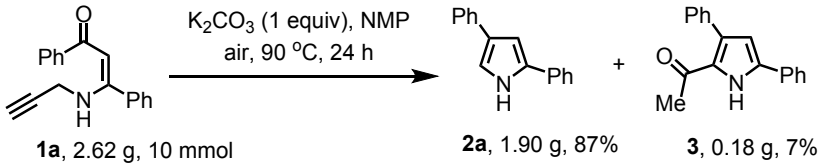
White solid (19.1 mg, 82% yield); m.p. 144-146 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.41 (s, 1H), 7.65 – 7.51 (m, 2H), 7.37 – 7.24 (m, 5H), 7.19 (t, *J* = 7.4 Hz, 1H), 7.15 – 7.09 (m, 1H), 7.05 (d, *J* = 7.1 Hz, 1H), 6.81 (dd, *J* = 2.5, 1.7 Hz, 1H), 2.39 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 138.5, 135.5, 133.2, 132.4, 128.8, 128.6, 127.3, 126.5, 125.6, 125.1, 124.6, 120.9, 115.3, 103.8, 21.5.



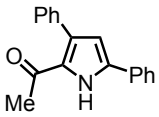
4-phenyl-2-(*o*-tolyl)-1*H*-pyrrole (2v)[4]

White solid (15.1 mg, 65% yield); m.p. 81-84 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.24 (s, 1H), 7.57 (d, *J* = 7.5 Hz, 2H), 7.36 (dt, *J* = 12.7, 4.7 Hz, 3H), 7.30 – 7.11 (m, 5H), 6.64 (s, 1H), 2.50 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 135.6, 135.1, 132.5, 132.3, 131.0, 128.6, 127.9, 127.0, 126.0, 125.8, 125.6, 125.1, 114.6, 106.8, 21.2.

4. Procedure for Gram-Scale Synthesis of 2a



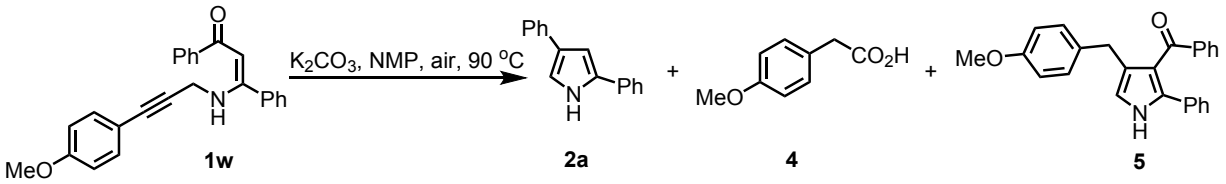
K_2CO_3 (1.38 g, 10 mmol) was added to a solution of enaminone **1a** (2.62 g, 10 mmol) in NMP (50 mL). The solution was stirred at 90 °C under air atmosphere for 24 h. After the reaction finished, the reaction system was quenched by water (200 mL), and extracted with Et_2O (5 x 20 mL). The combined Et_2O extracts were dried over Na_2SO_4 and concentrated. Then solvent was evaporated and the residue was purified by chromatography (ethyl acetate/PE = 1/50) to yield **2a** (1.9 g, 87%) and **3** (0.18 g, 7% yield).



1-(3,5-diphenyl-1H-pyrrol-2-yl)ethan-1-one (3)

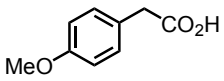
White solid; m.p. 90-91 °C; ^{1}H NMR (500 MHz, $CDCl_3$) δ 9.72 (s, 1H), 7.63 (d, *J* = 7.4 Hz, 2H), 7.48 – 7.30 (m, 8H), 6.56 (d, *J* = 3.0 Hz, 1H), 2.09 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 188.6, 136.2, 136.1, 134.3, 130.7, 129.7, 129.3, 129.1, 128.2, 128.2, 127.7, 125.0, 110.8, 27.5; HRMS (ESI) calcd for $C_{18}H_{16}NO$ [M+H]+ 262.1226, found: 262.1227.

5. Procedure for Synthesis of 4 and 5



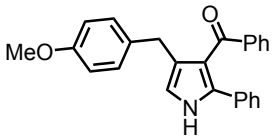
K_2CO_3 (27.6 mg, 0.2 mmol) and enaminone **1w** (73.4 mg, 0.2 mmol) were added in NMP (2.0 mL). The solution was stirred at 90 °C under air atmosphere for 24 h. After the reaction finished, the reaction system was quenched by

1M HCl (10 mL), and extracted with Et_2O (5 x 5 mL). The combined Et_2O extracts were dried over Na_2SO_4 and concentrated. Then solvent was evaporated and the residue was purified by chromatography (ethyl acetate/AcOH PE = 1/1/50 to 1/1/10) to yield **2a** (13.4 mg, 31%), **4** (8.0 mg, 24% yield), and **5** (36.7 mg, 50% yield).



2-(4-methoxyphenyl)acetic acid (4)

^{1}H NMR (500 MHz, $CDCl_3$) δ 11.50 (s, 1H), 7.18 (d, *J* = 8.4 Hz, 2H), 6.85 (d, *J* = 8.6 Hz, 2H), 3.77 (s, 3H), 3.56 (s, 2H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 178.5, 158.7, 130.3, 125.2, 114.0, 55.2, 40.1.



(4-(4-methoxybenzyl)-2-phenyl-1H-pyrrol-3-yl)(phenyl)methanone (5)

White solid; m.p. 72-75 °C; ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.61 (s, 1H), 7.59 (dd, *J* = 8.2, 1.1 Hz, 2H), 7.26 (t, *J* = 7.4, 7.4 Hz, 1H), 7.14 – 7.05 (m, 9H), 6.78 – 6.74 (m, 2H), 6.38 (d, *J* = 2.4 Hz, 1H), 3.89 (s, 2H), 3.74 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 194.8, 157.6, 139.3, 136.4, 133.4, 132.1, 131.7, 129.8, 129.7, 128.2, 128.0, 127.6, 127.3, 127.3, 119.6, 117.6, 113.6, 55.2, 31.5; HRMS (ESI) calcd for $C_{25}H_{22}NO_2$ [M+H]+ 368.1645, found: 368.1651.

Reference：

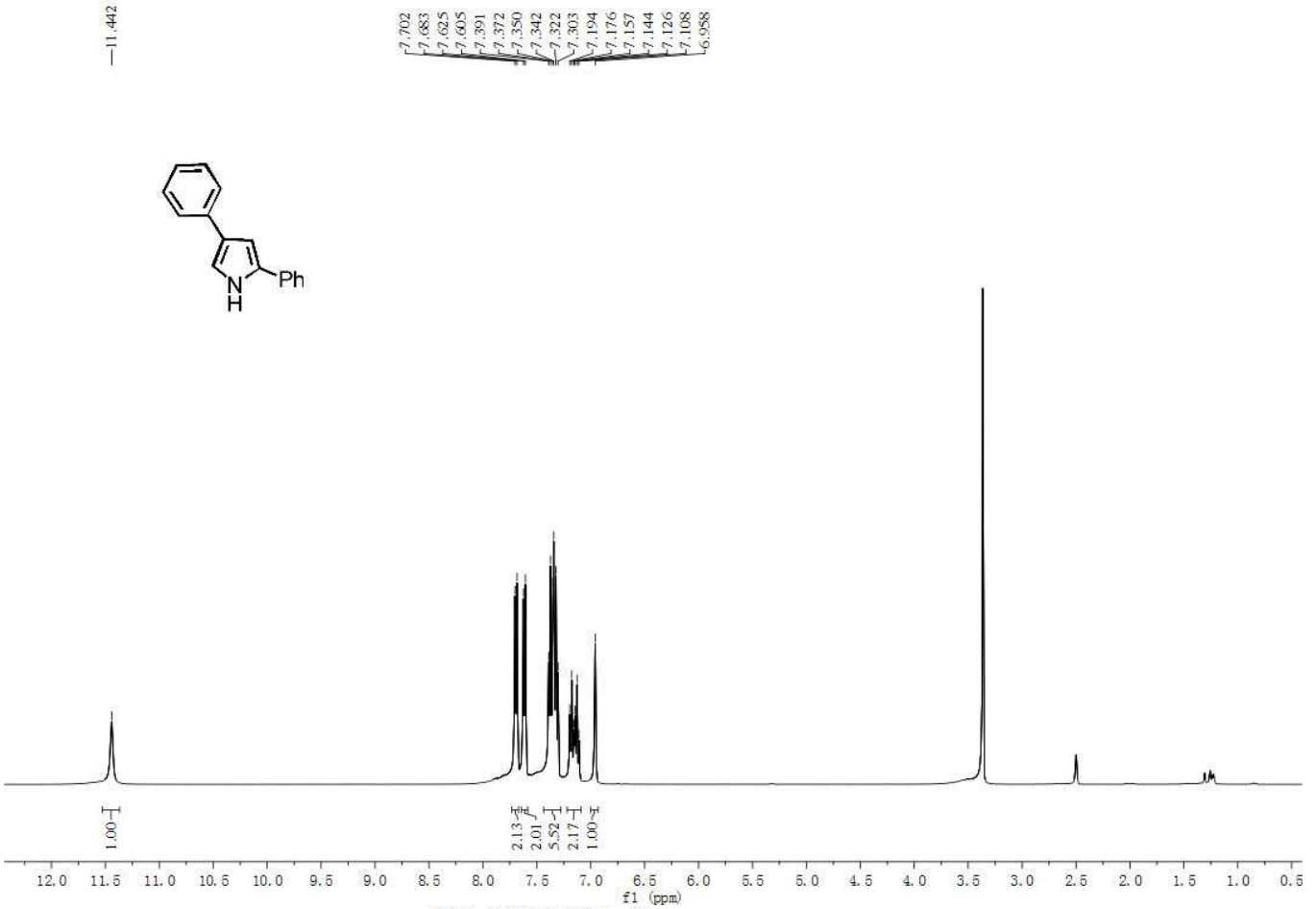
1. K. Goutham, D. Ashok Kumar, S. Suresh, B. Sridhar, R. Narender and G. V. Karunakar, *J. Org. Chem.* 2015, **80**, 11162.

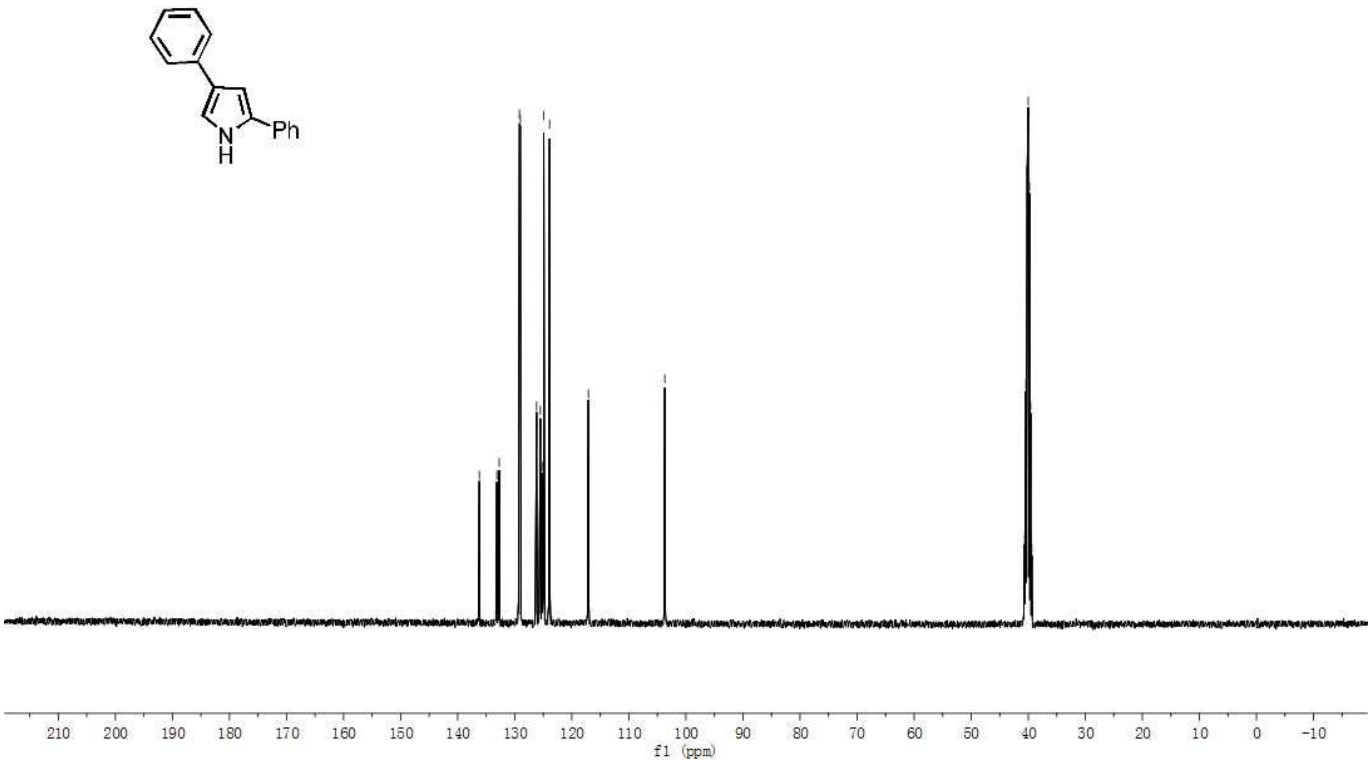
2. F. Chen, T. Shen, Y. Cui and N. Jiao, *Org. Lett.*, 2012, **14**, 4926.

3. M. Adib, N. Ayashi, F. Heidari and P. Mirzaei, *Synlett*, 2016, **27**, 1738.

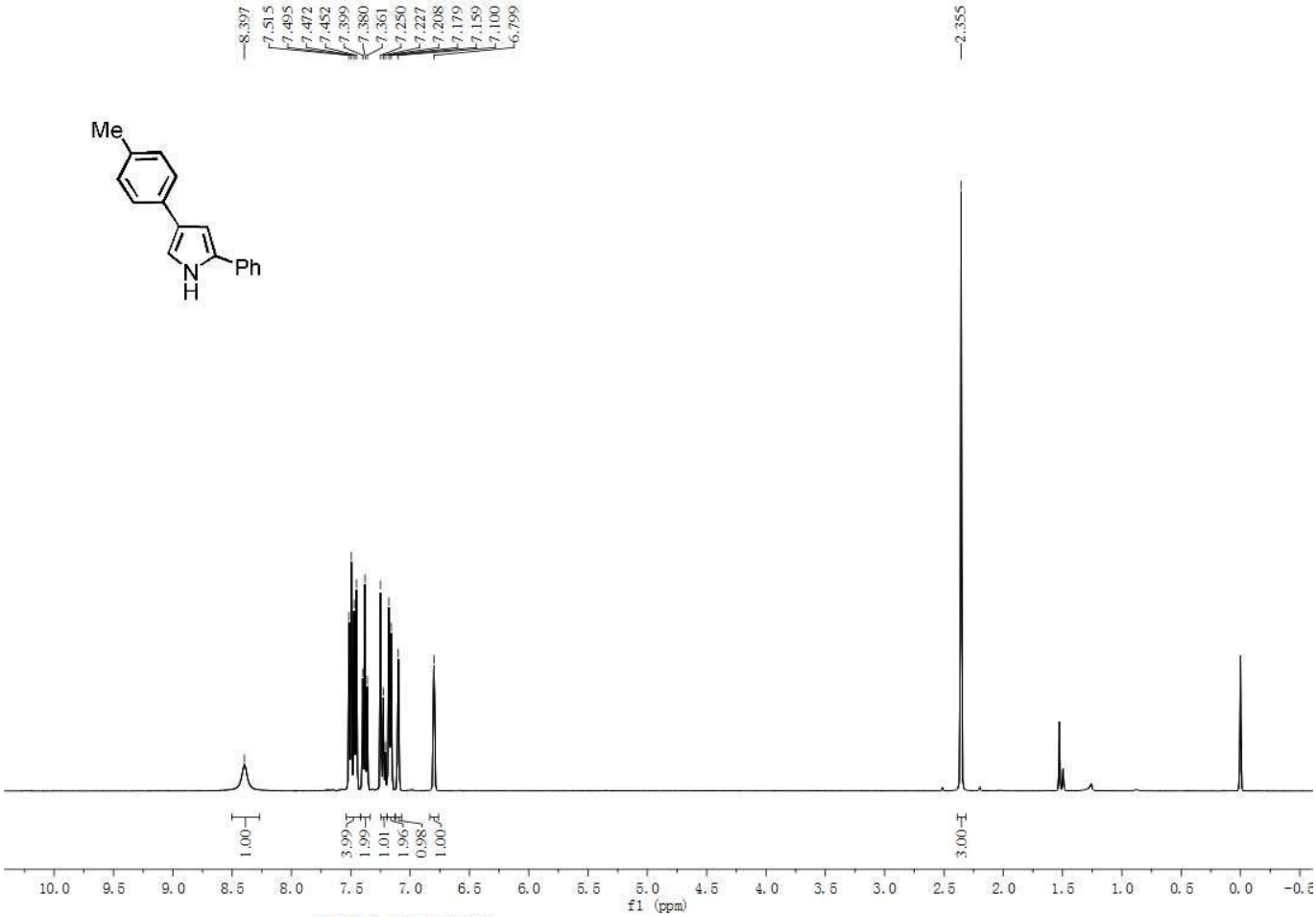
4. R. Umeda, T. Mashino and Y. Nishiyama, *Tetrahedron*, 2014, **70**, 4395.

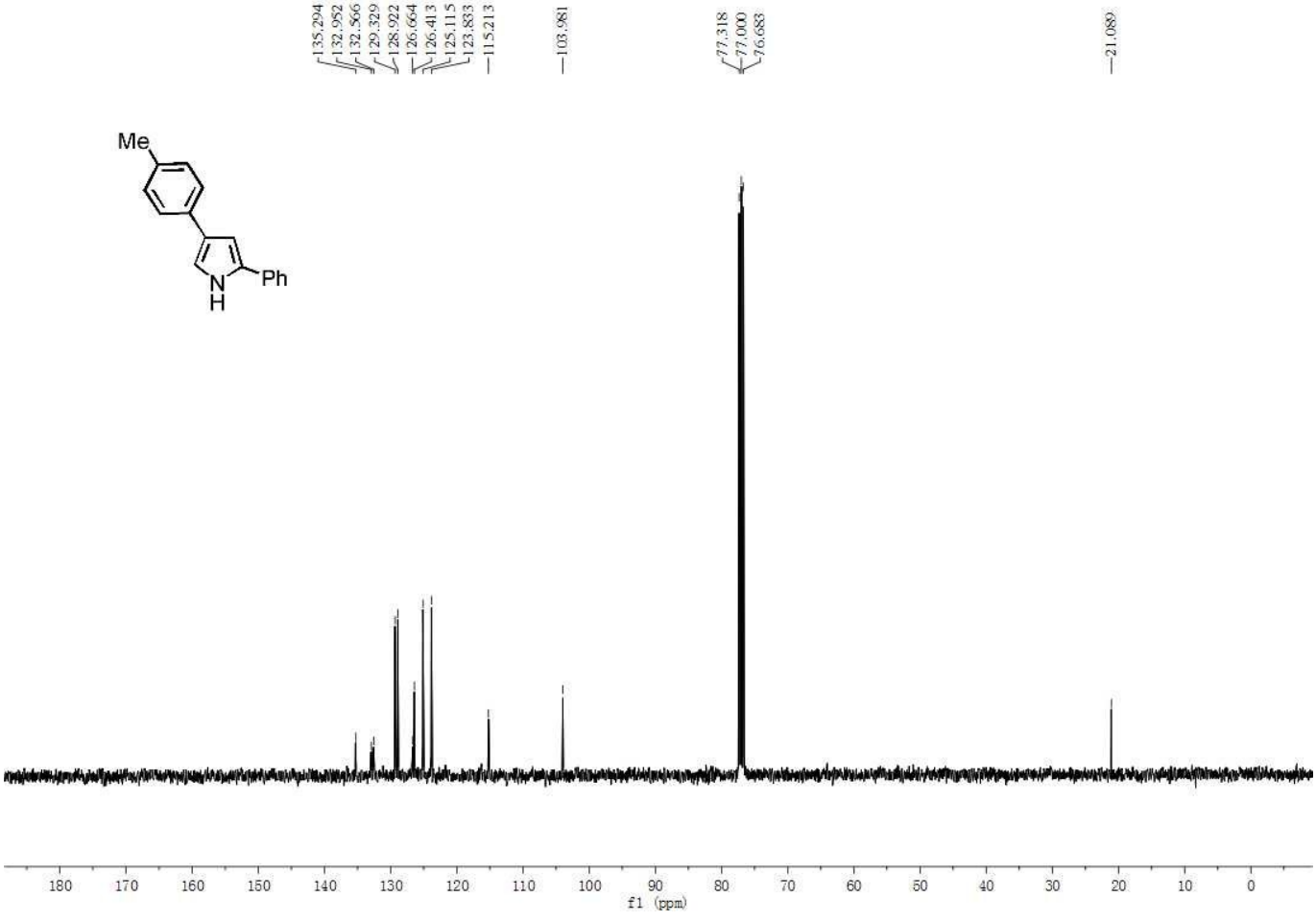
^{1}H and ^{13}C NMR Spectra of 2a



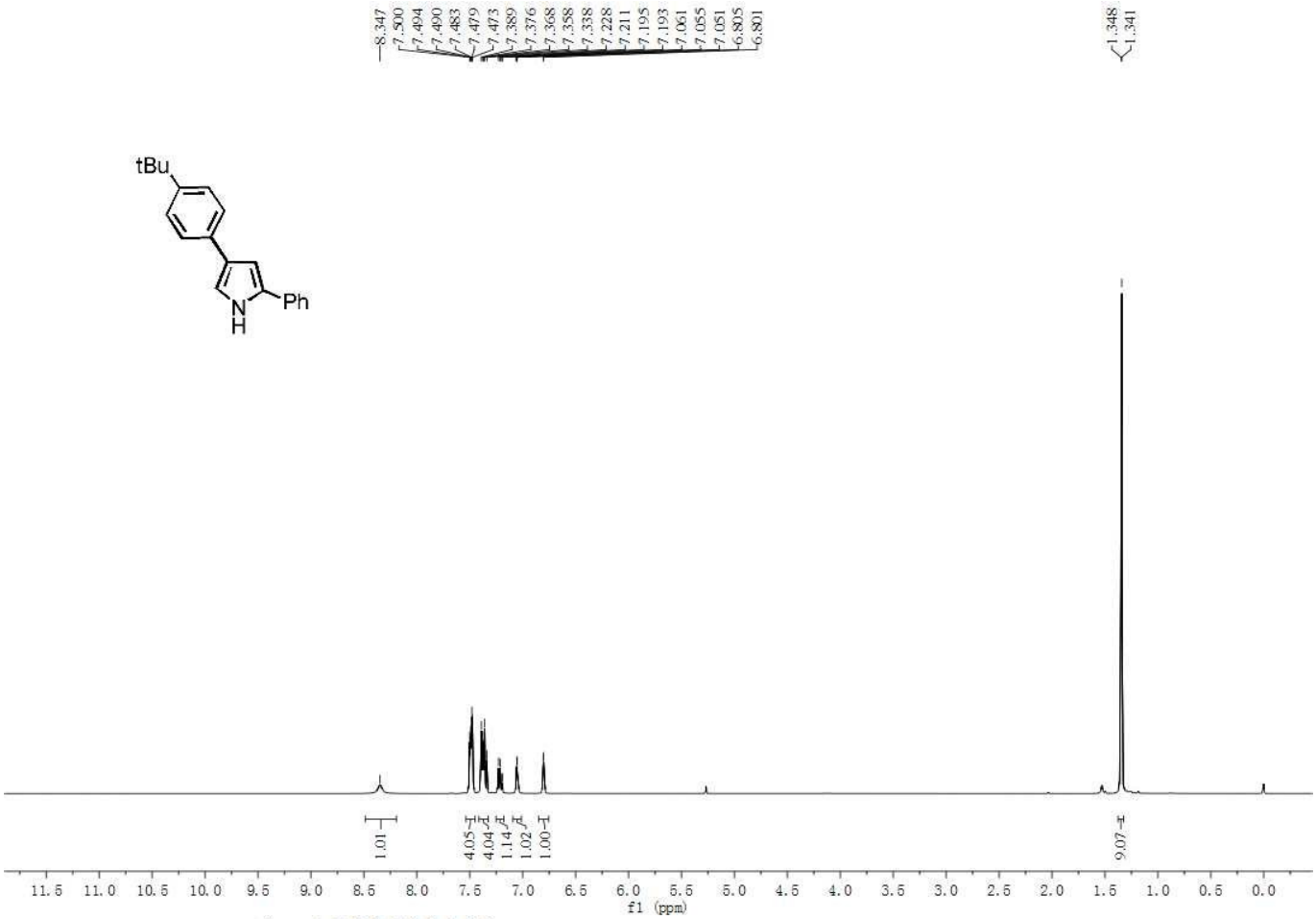


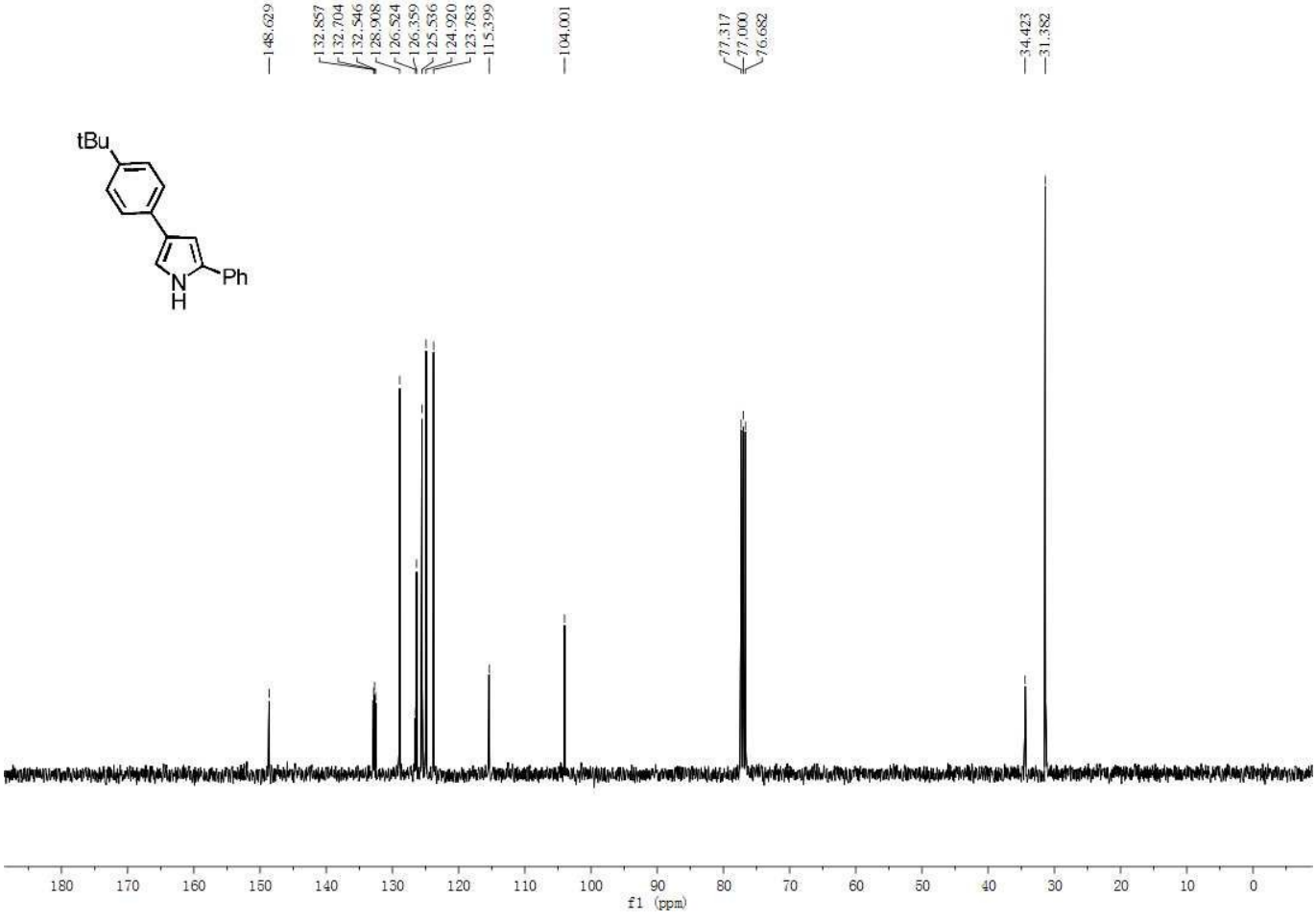
^{1}H and ^{13}C NMR Spectra of 2b



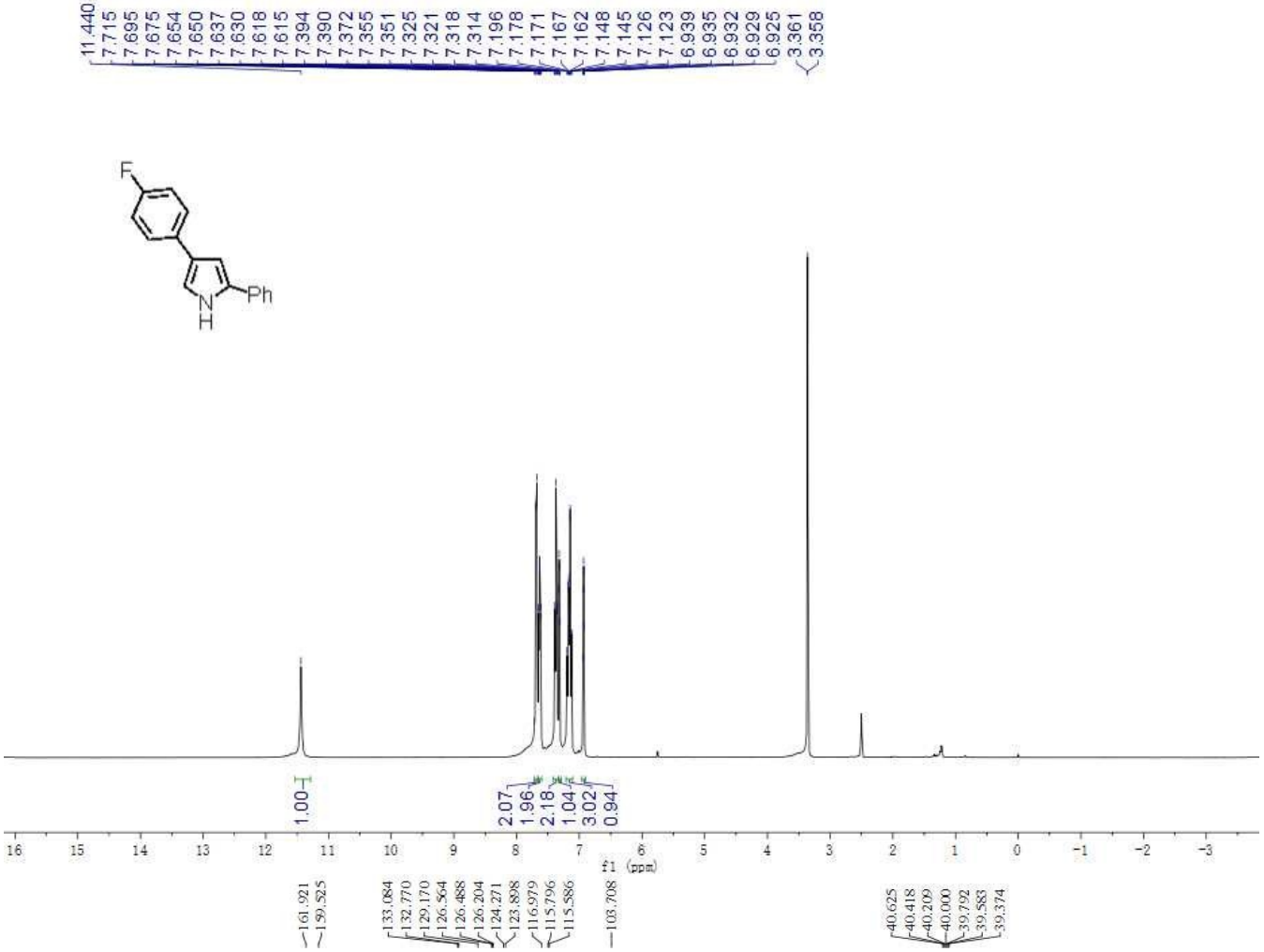


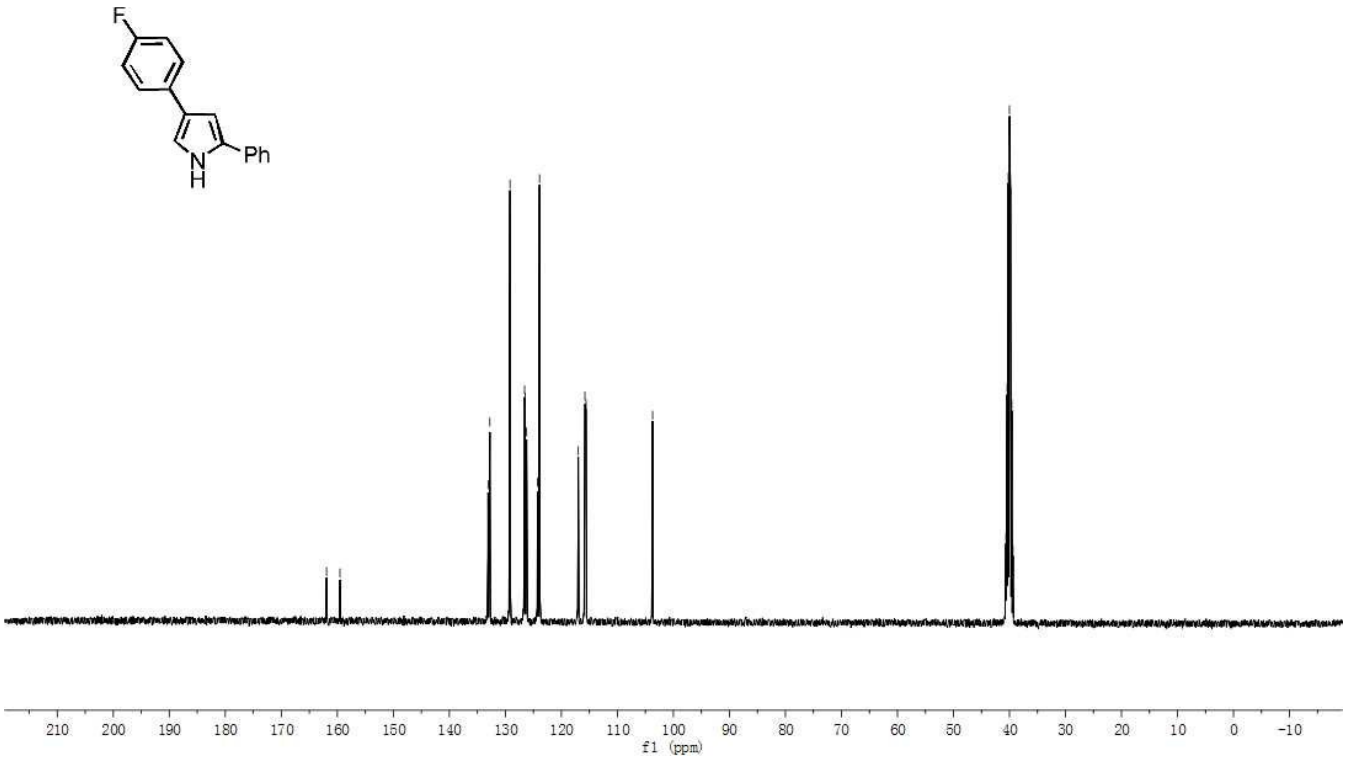
^{1}H and ^{13}C NMR Spectra of 2c

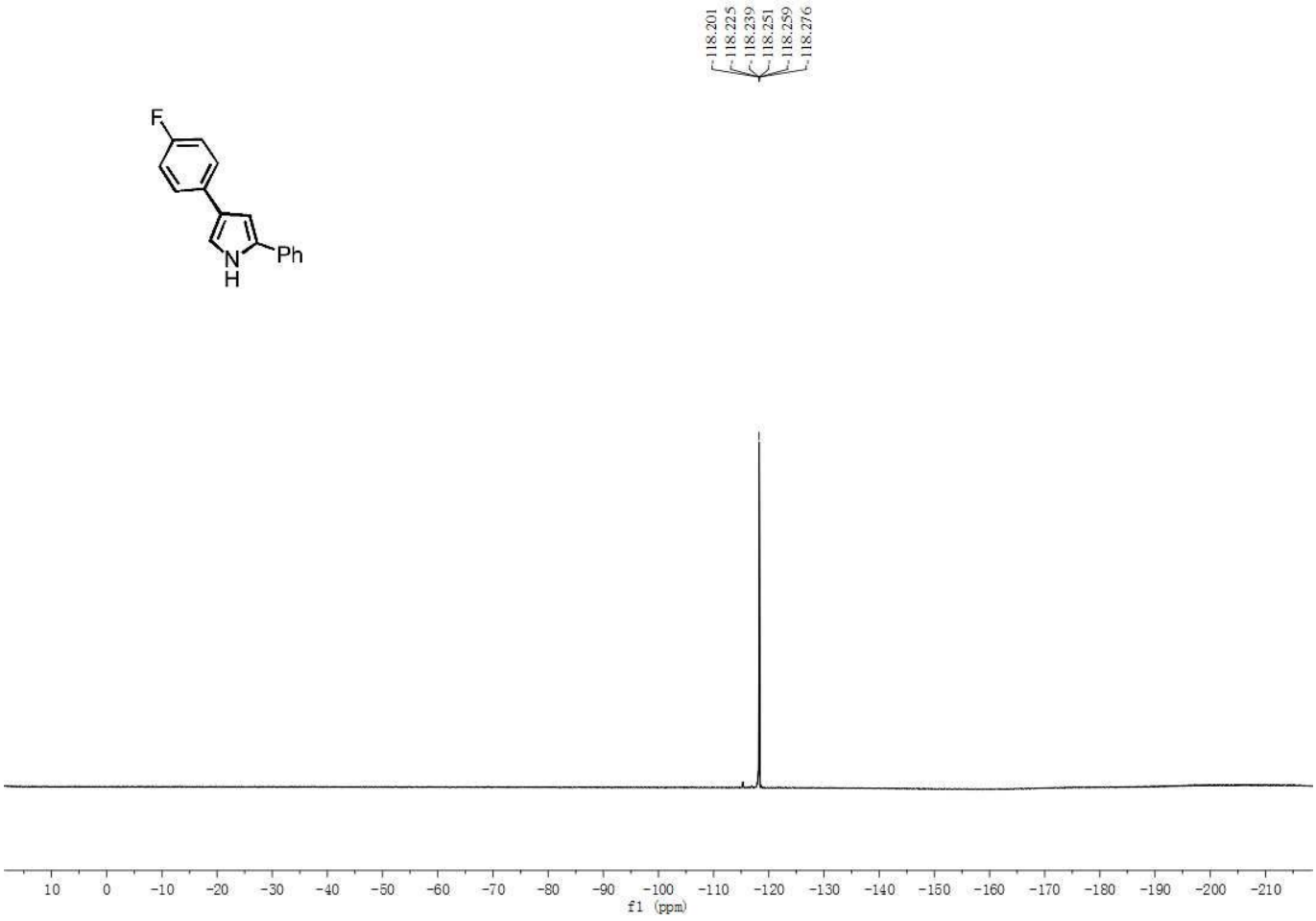




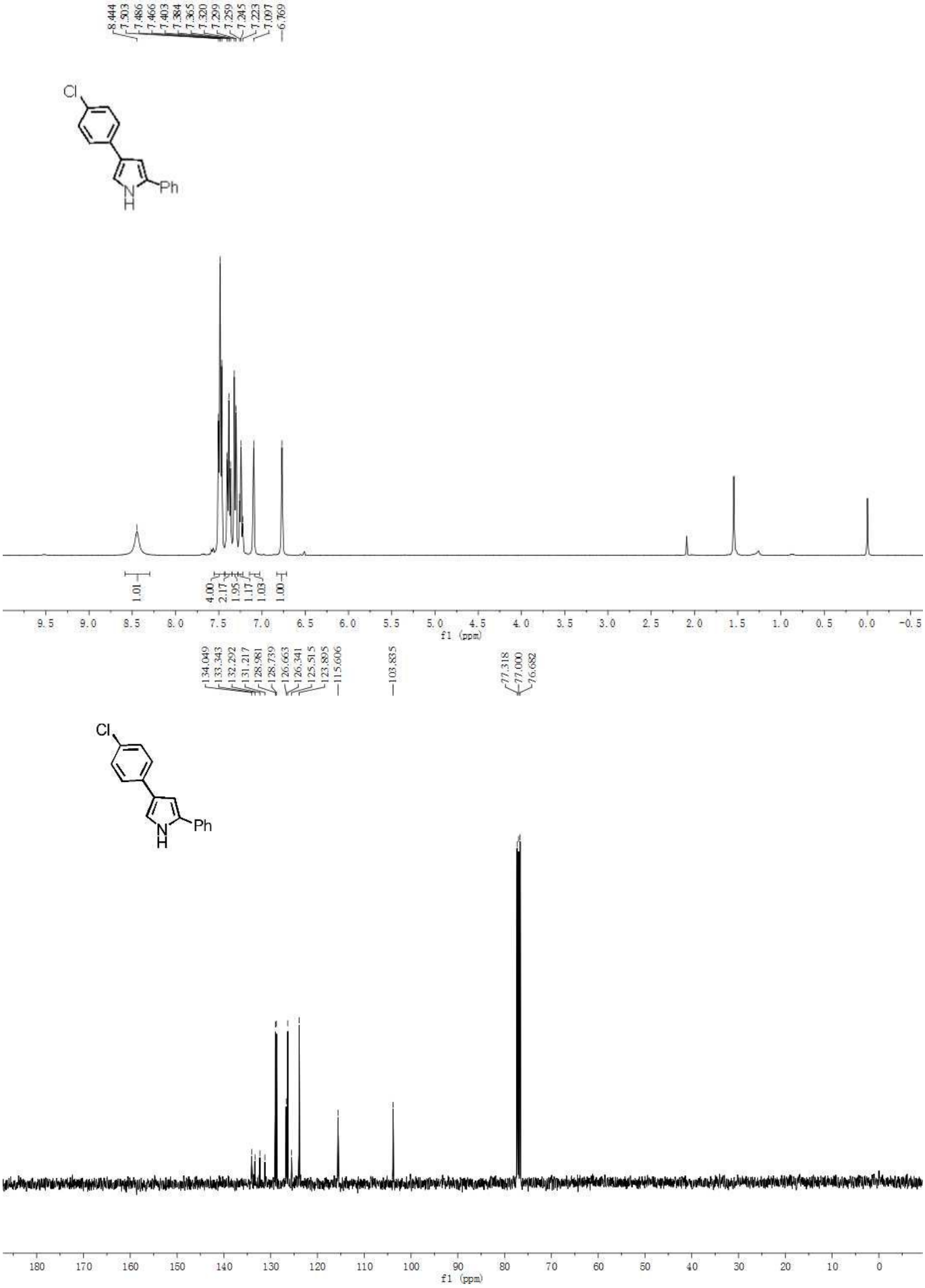
^{1}H, ^{13}C and ^{19}F NMR Spectra of 2d



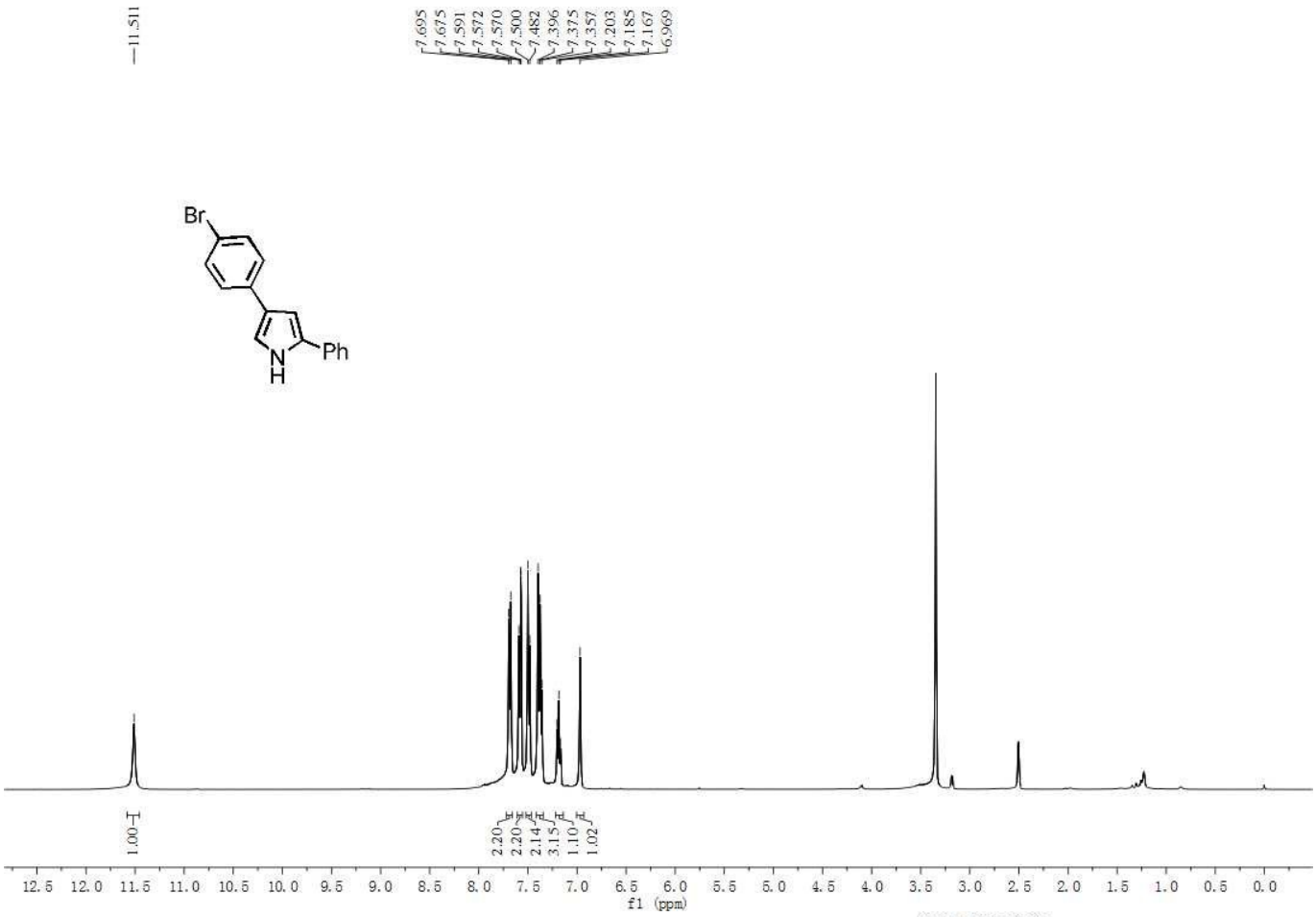


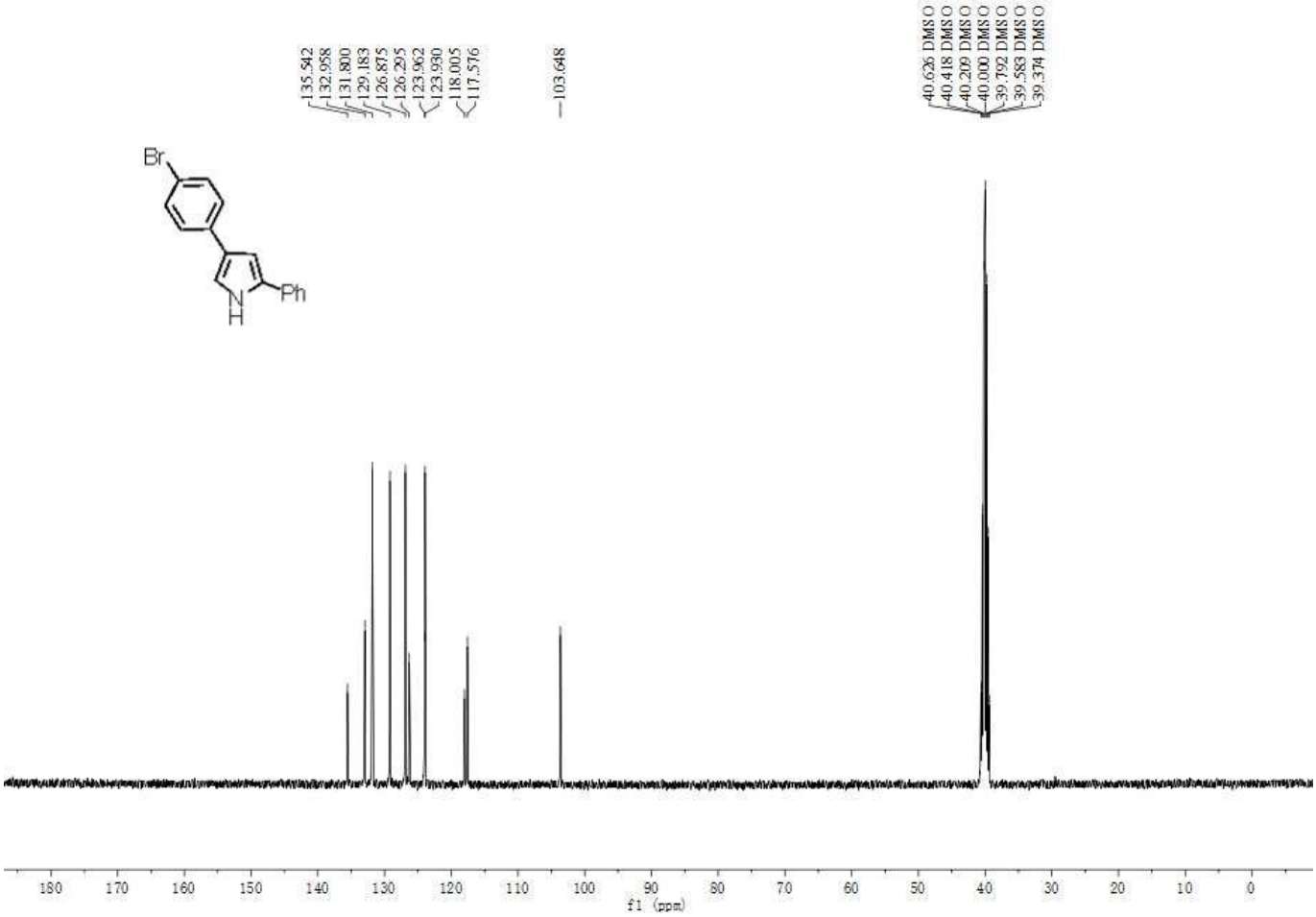

118.201
118.225
118.239
118.251
118.259
118.276
F
N
H
Ph
10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210
f1 (ppm)

^{1}H and ^{13}C NMR Spectra of 2e

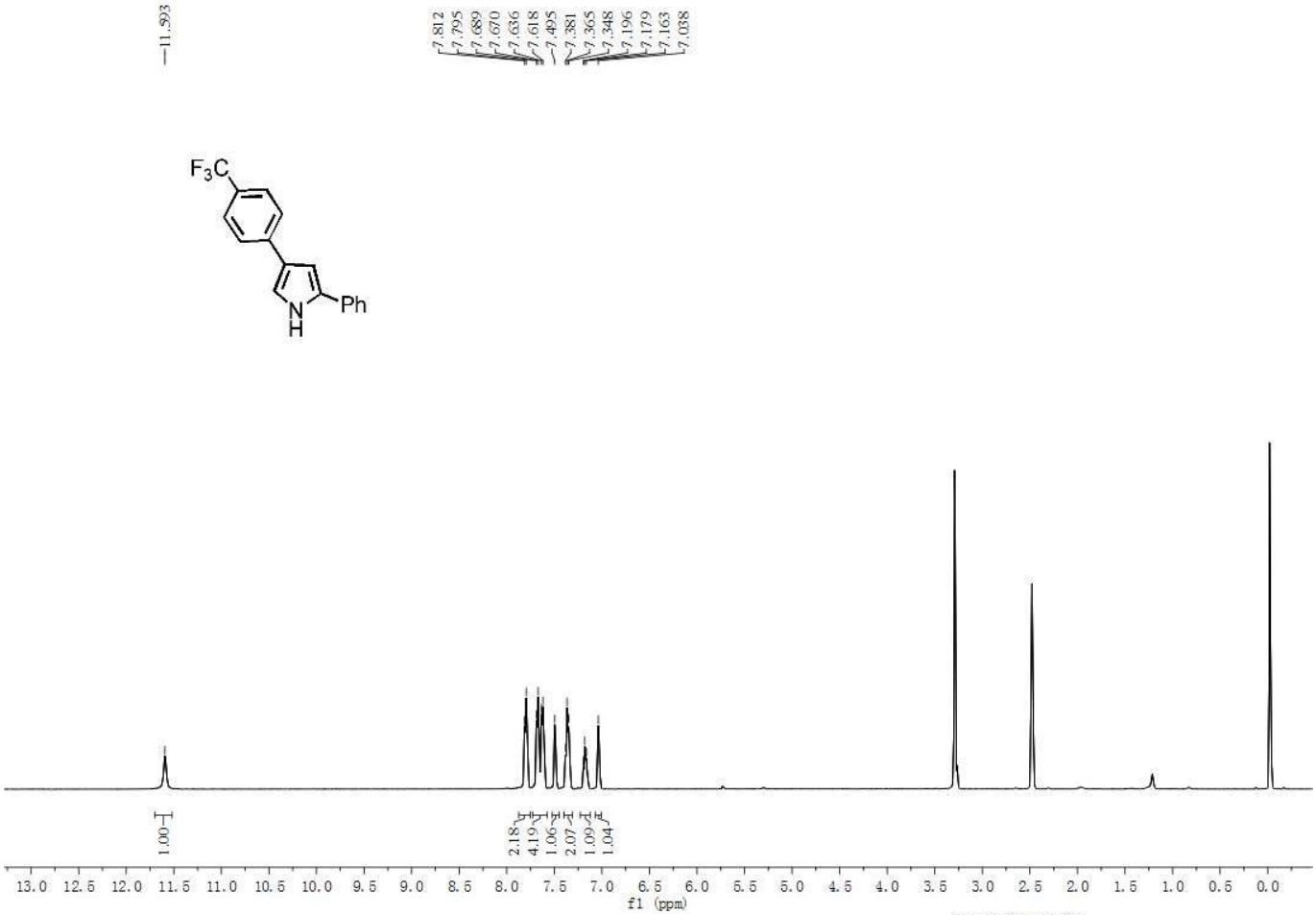


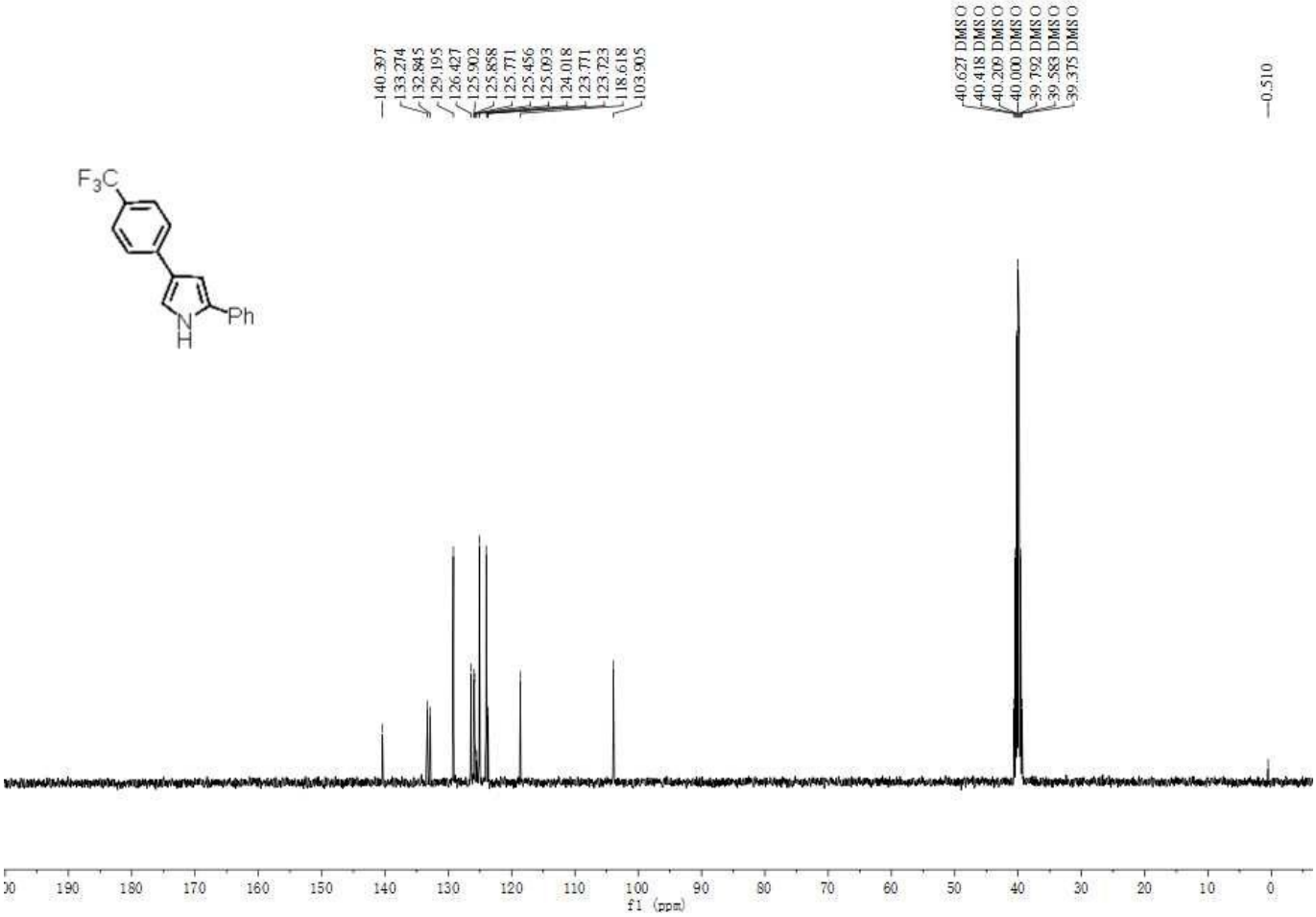
^{1}H and ^{13}C NMR Spectra of 2f

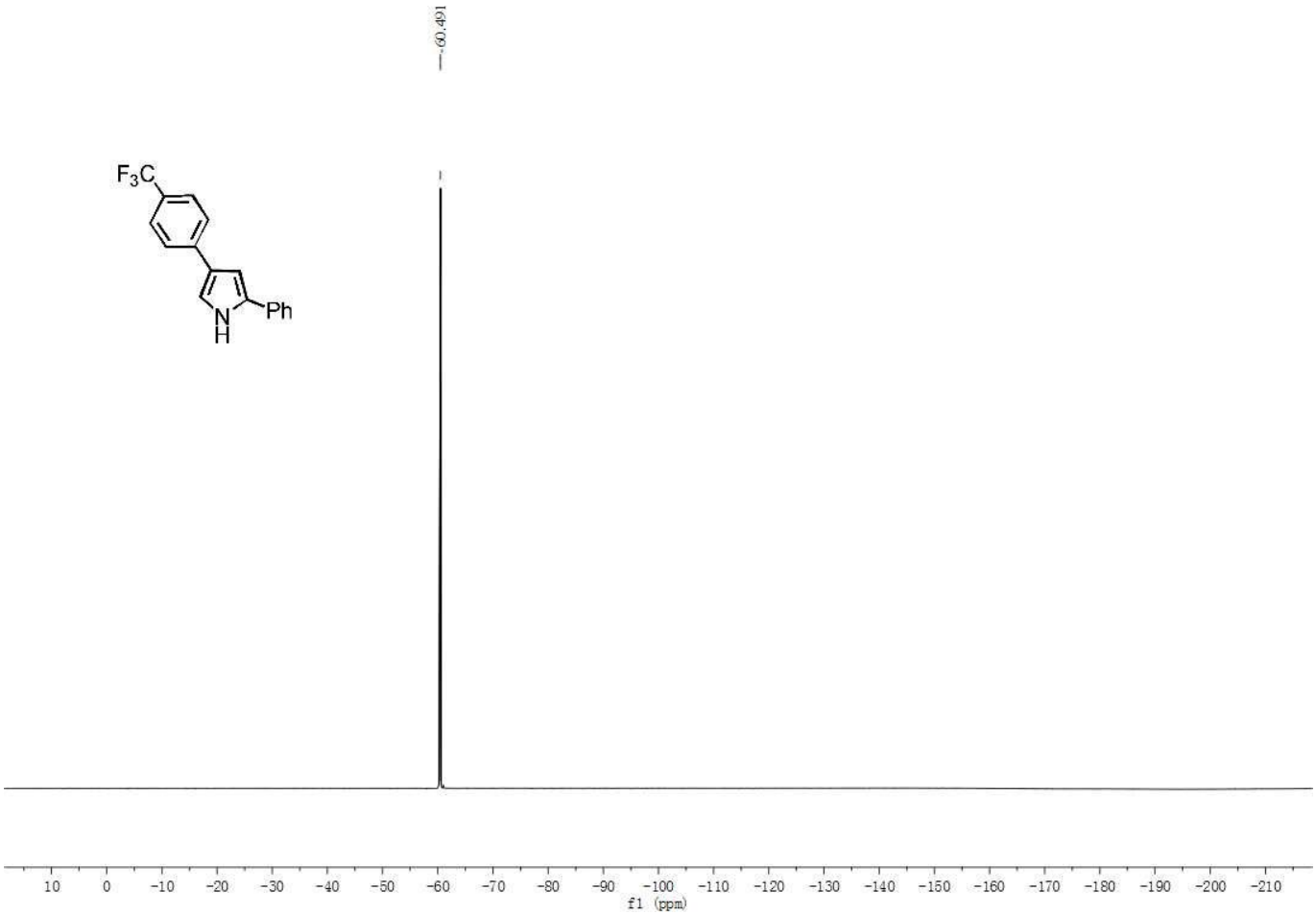




^{1}H, ^{13}C and ^{19}F NMR Spectra of 2g






-60.491
F3C
Ph
N
H
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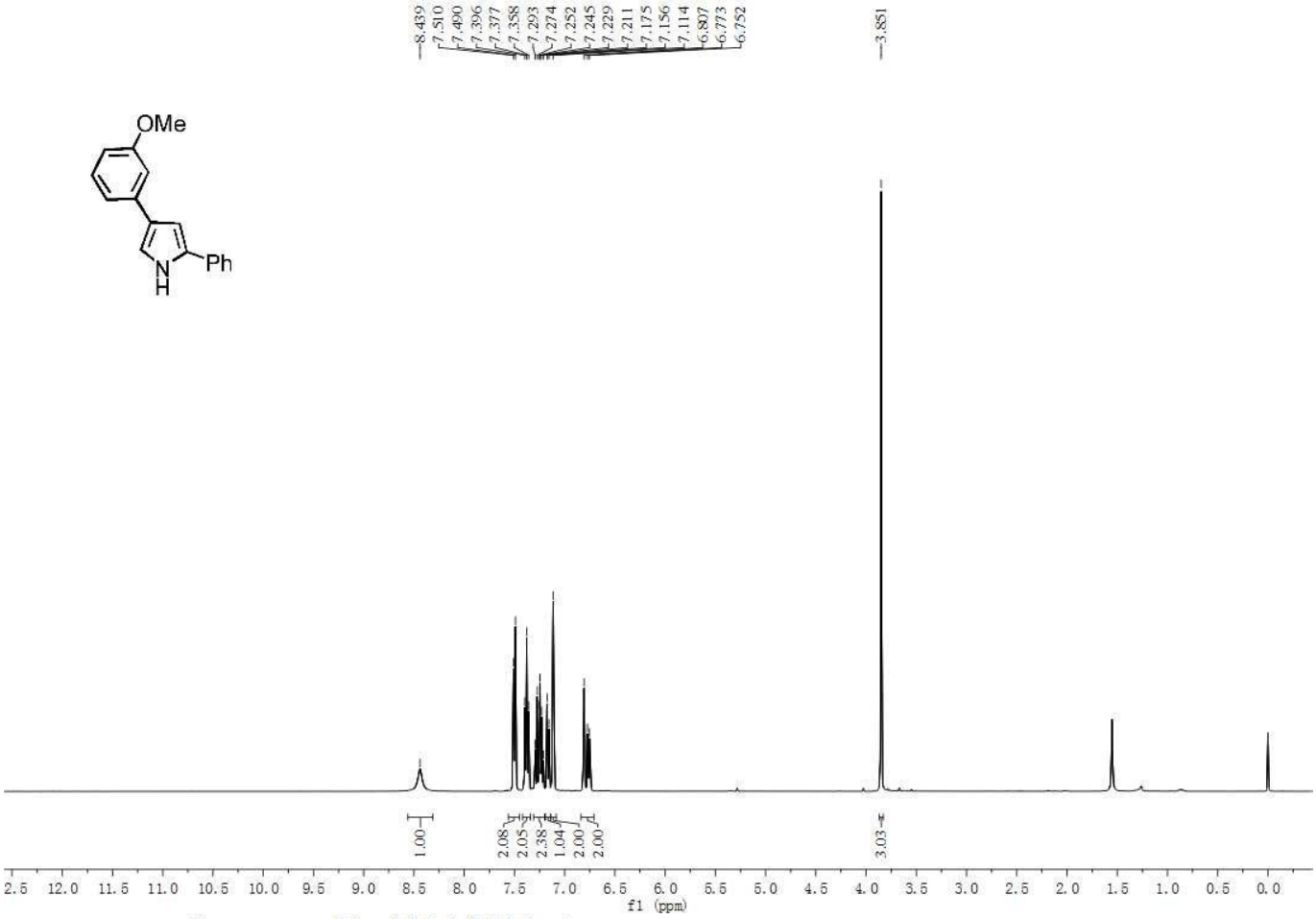
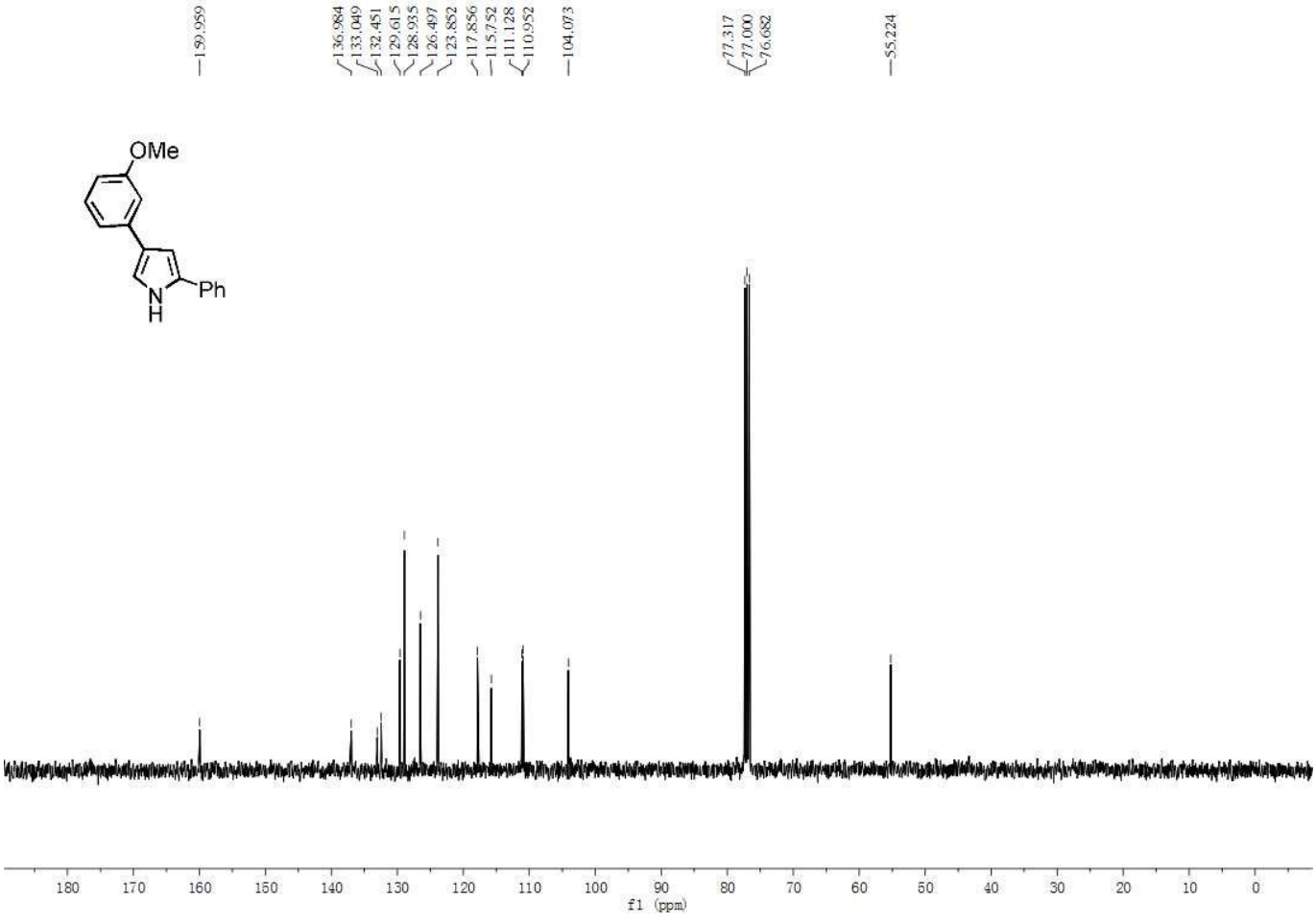
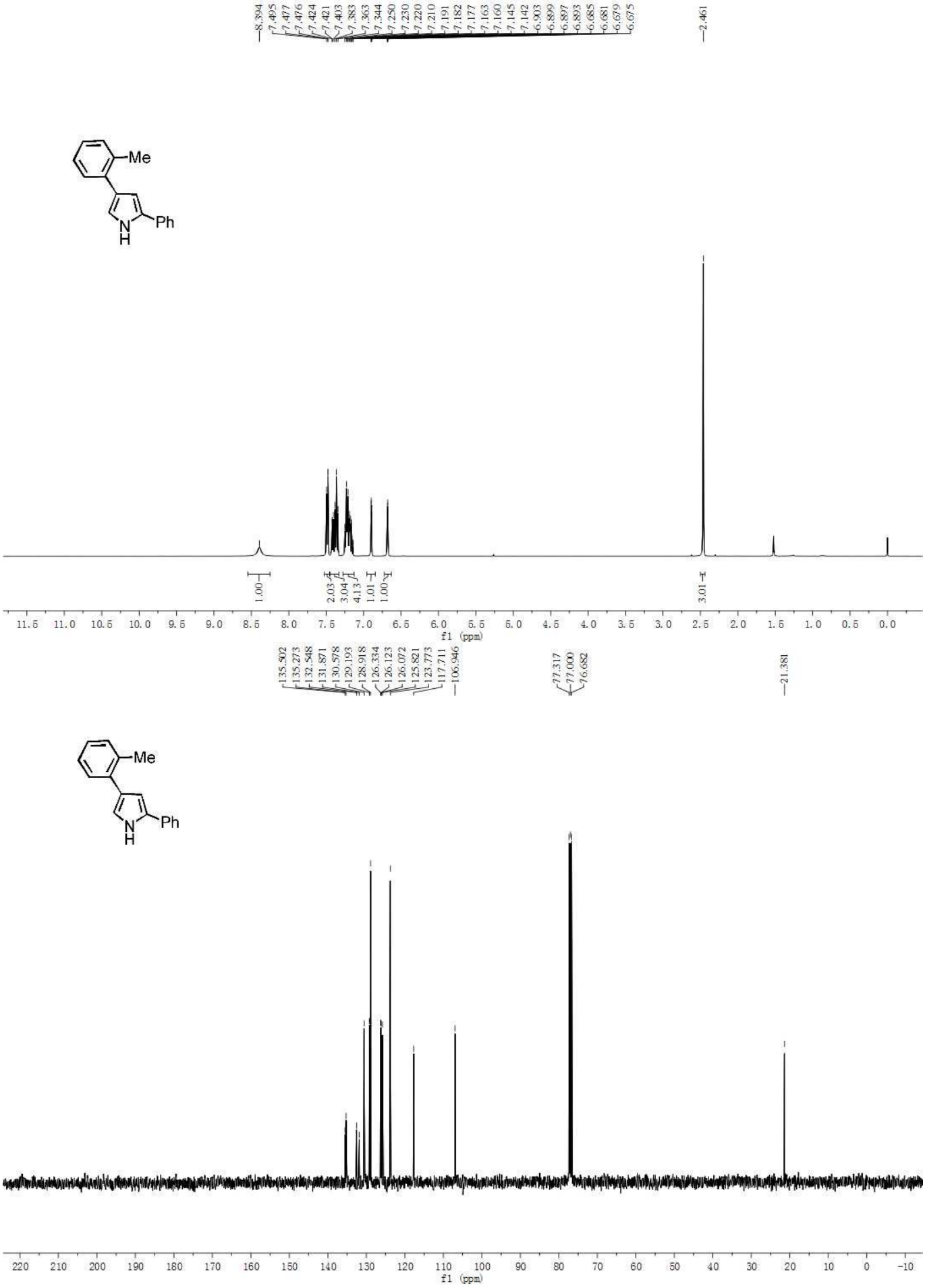
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200
-210
f1 (ppm)

^{1}H and ^{13}C NMR Spectra of 2h

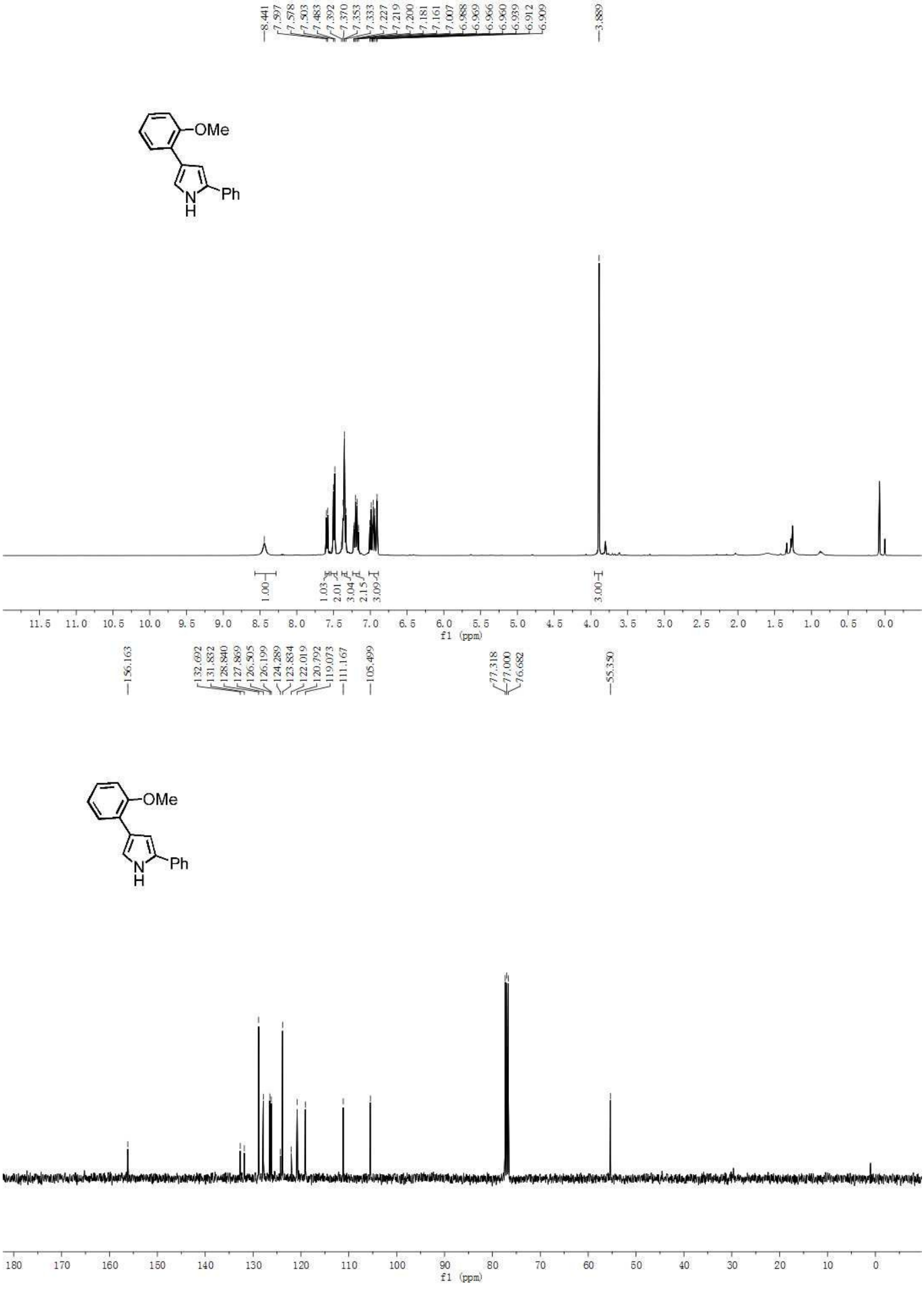




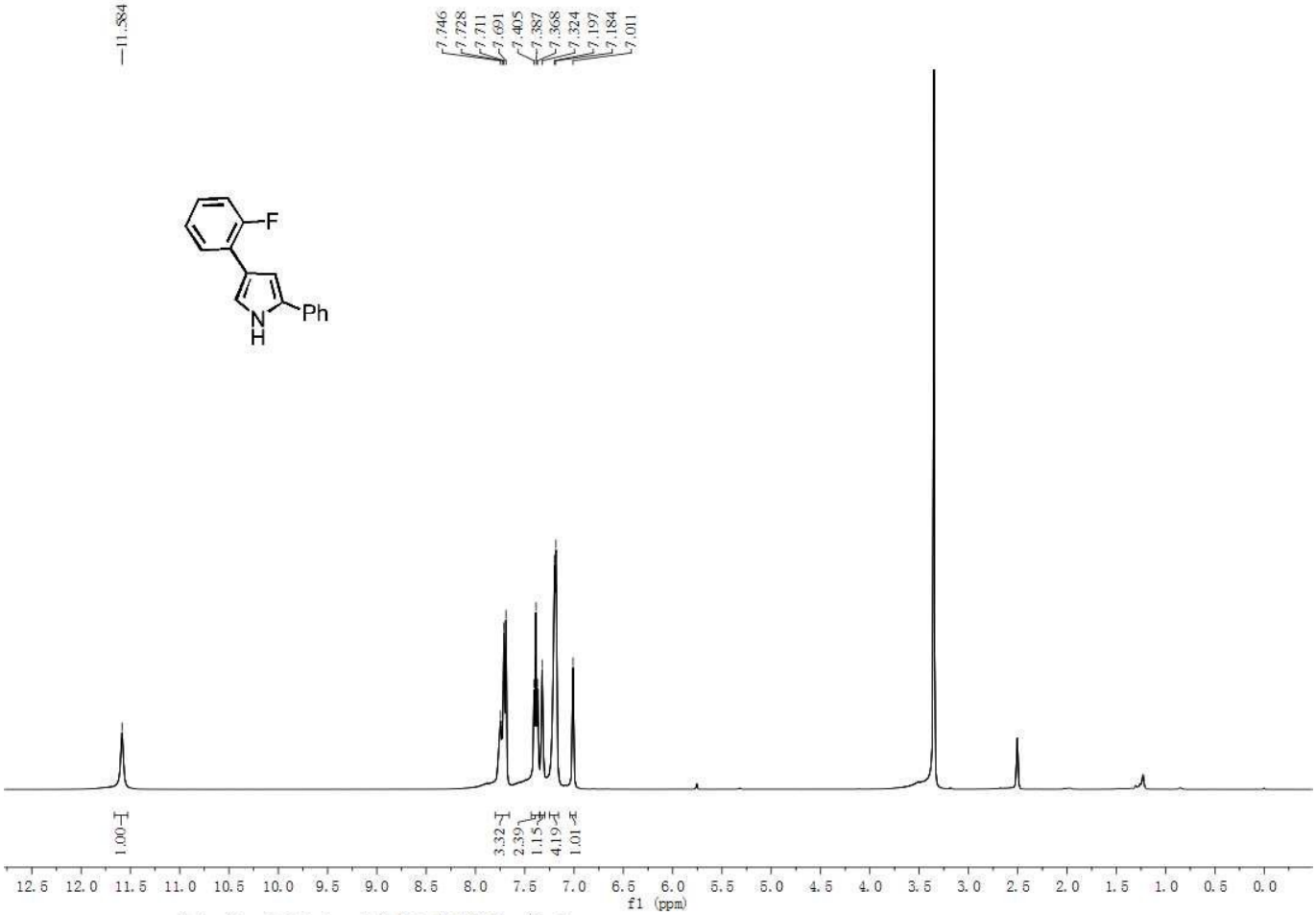
^{1}H and ^{13}C NMR Spectra of 2i

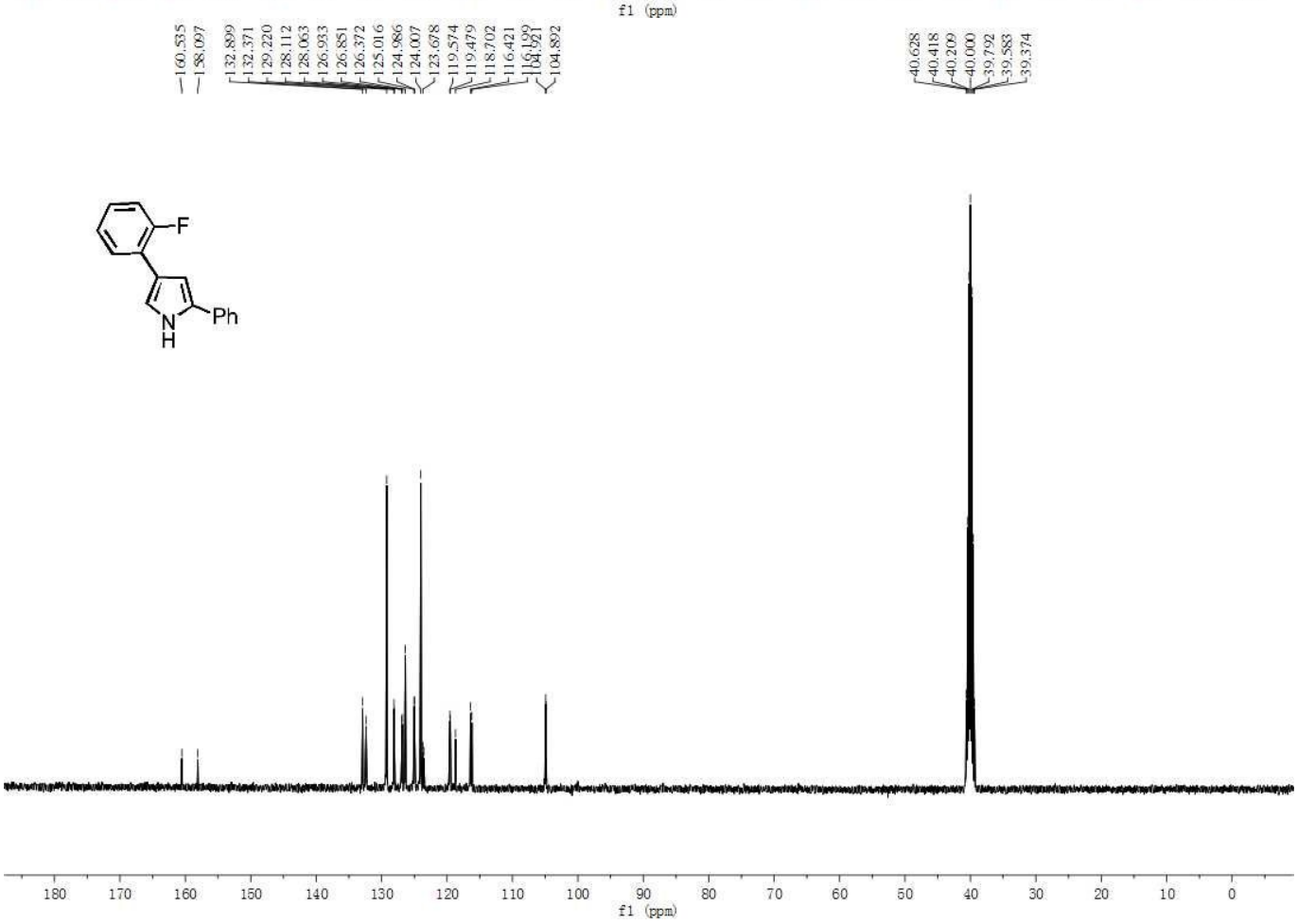


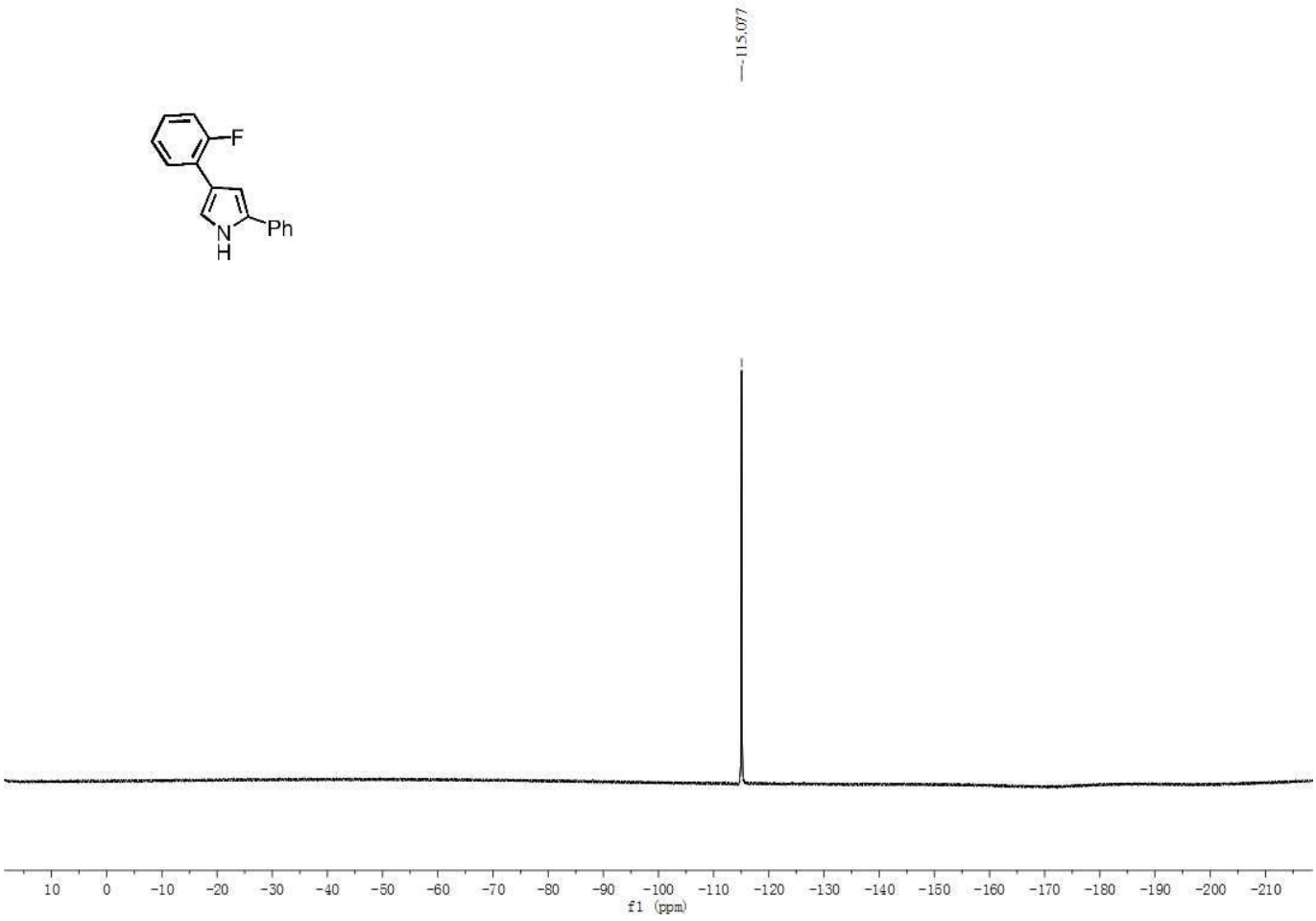
^{1}H and ^{13}C NMR Spectra of 2j



^{1}H, ^{13}C and ^{19}F NMR Spectra of 2k



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F
Ph
N
H
10
0
-10
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-30
-40
-50
-60
-70
-80
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-110
-120
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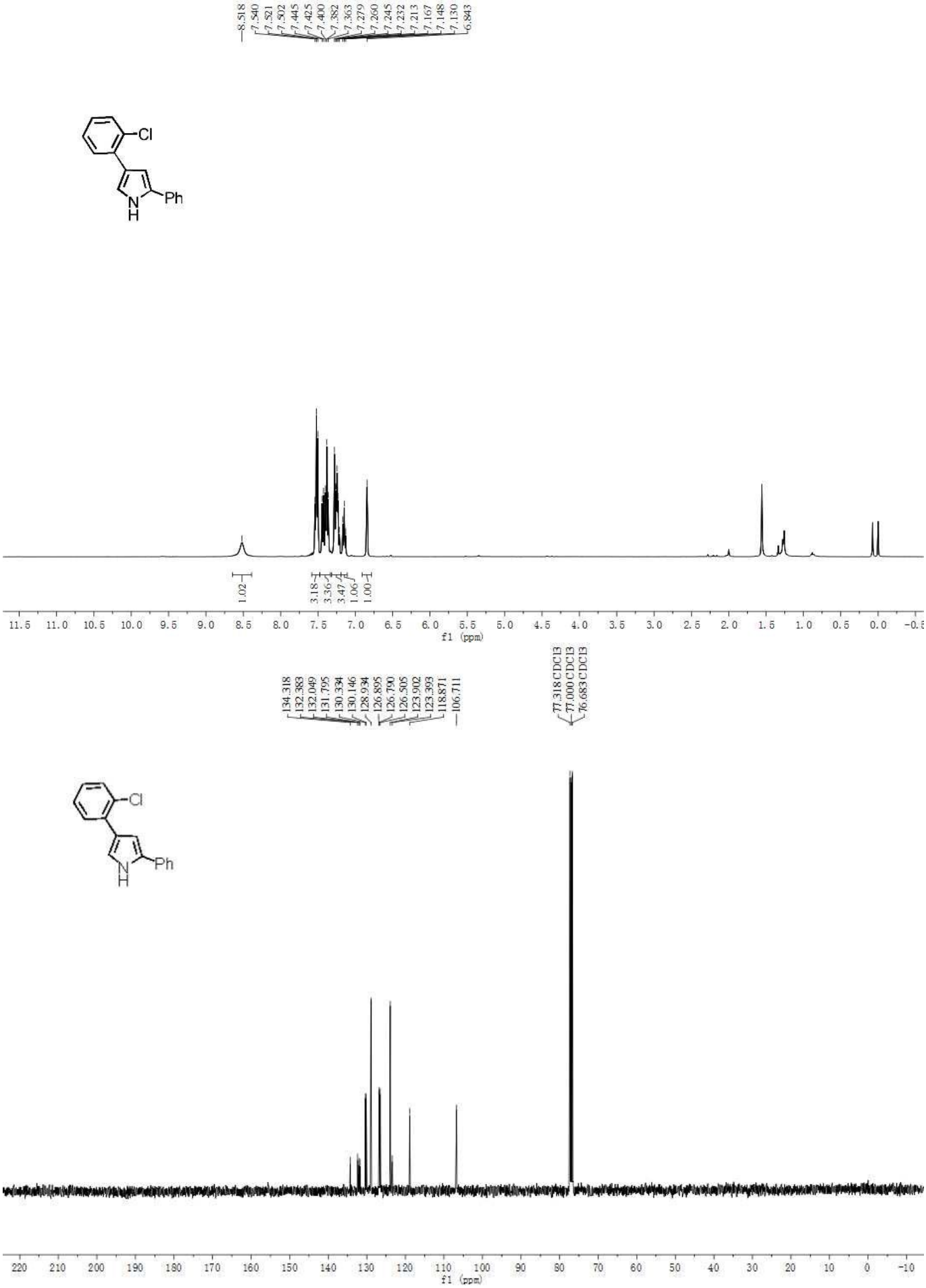
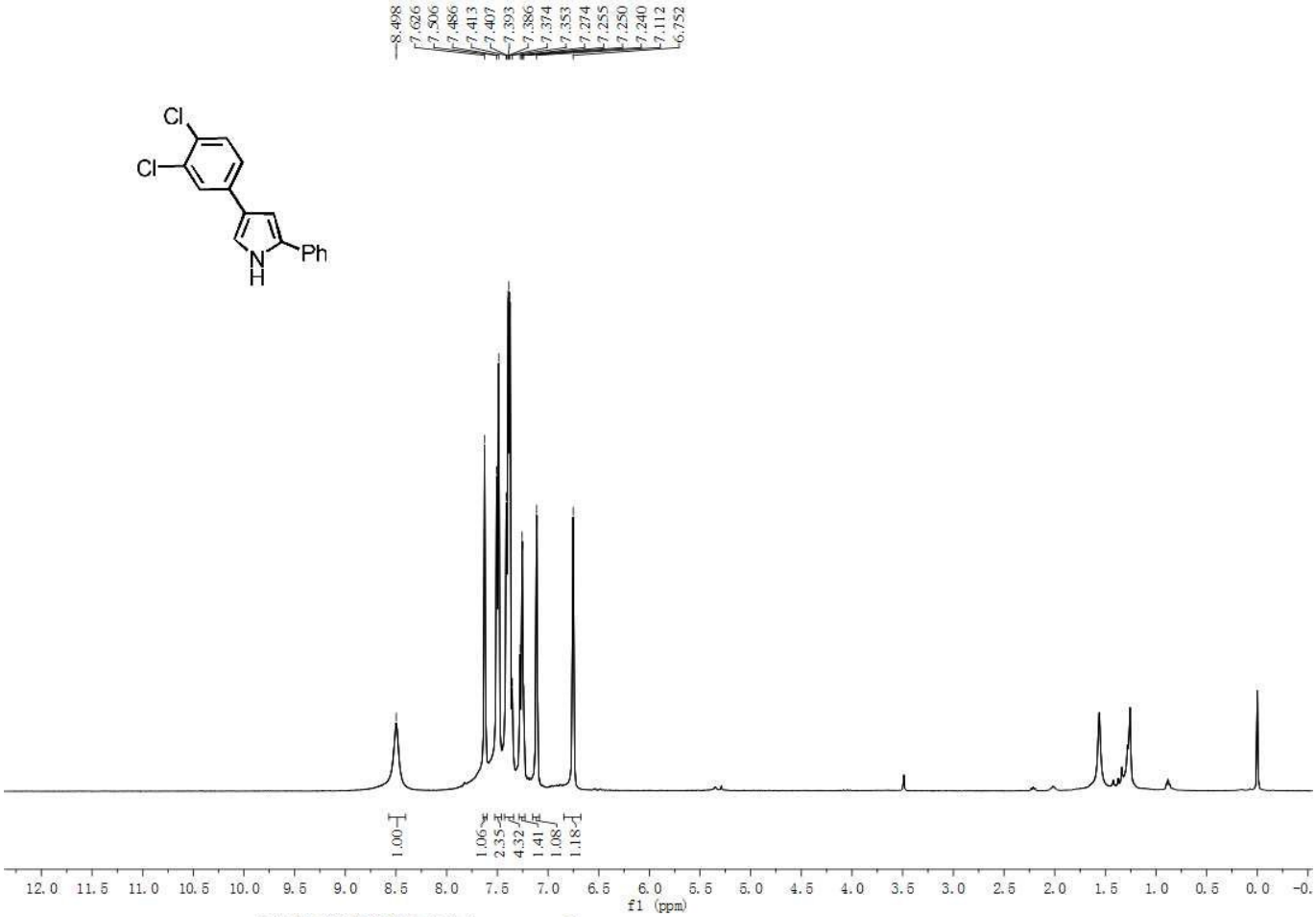
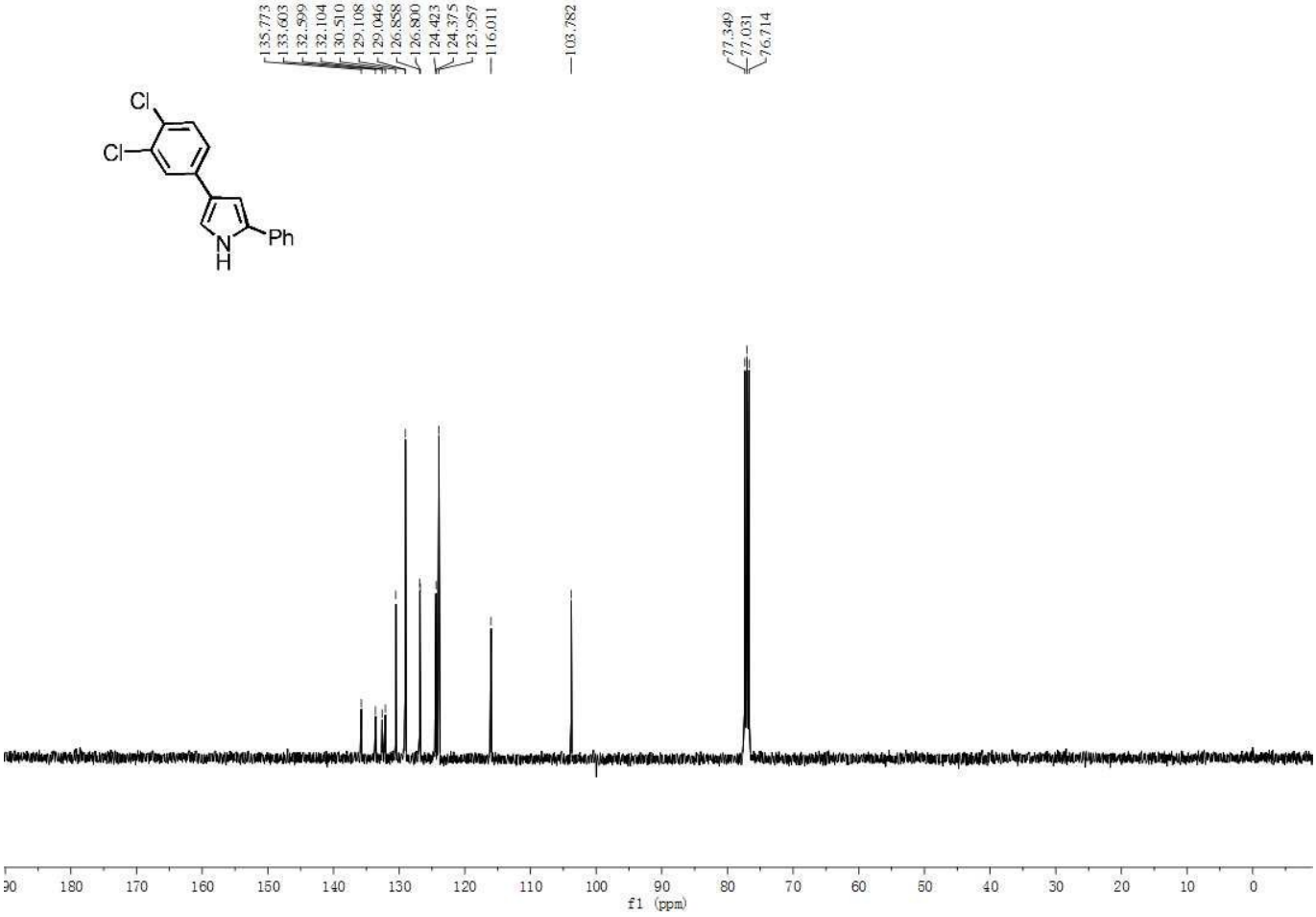
-140
-150
-160
-170
-180
-190
-200
-210
f1 (ppm)

^{1}H and ^{13}C NMR Spectra of 2l

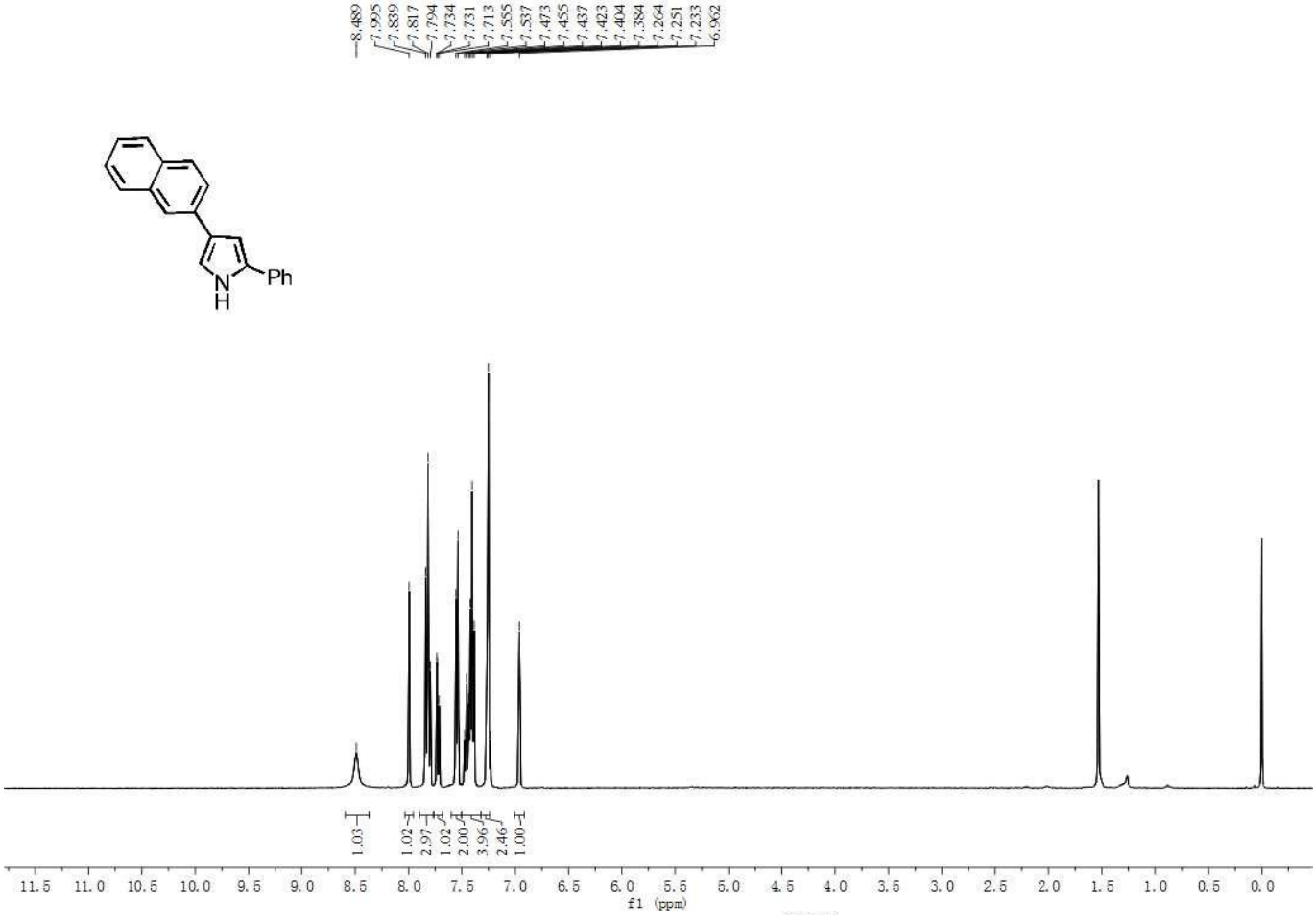


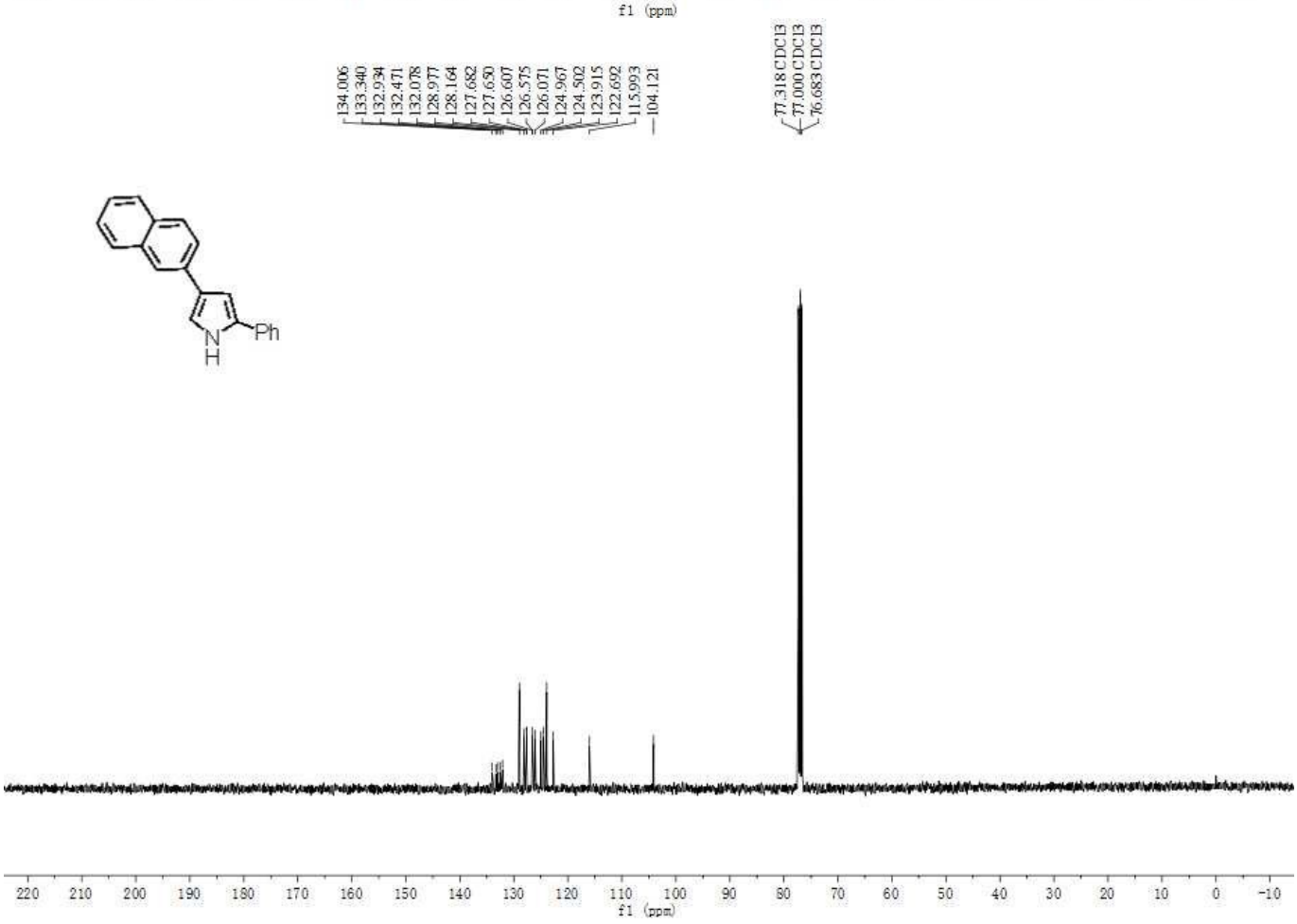
^{1}H and ^{13}C NMR Spectra of 2m



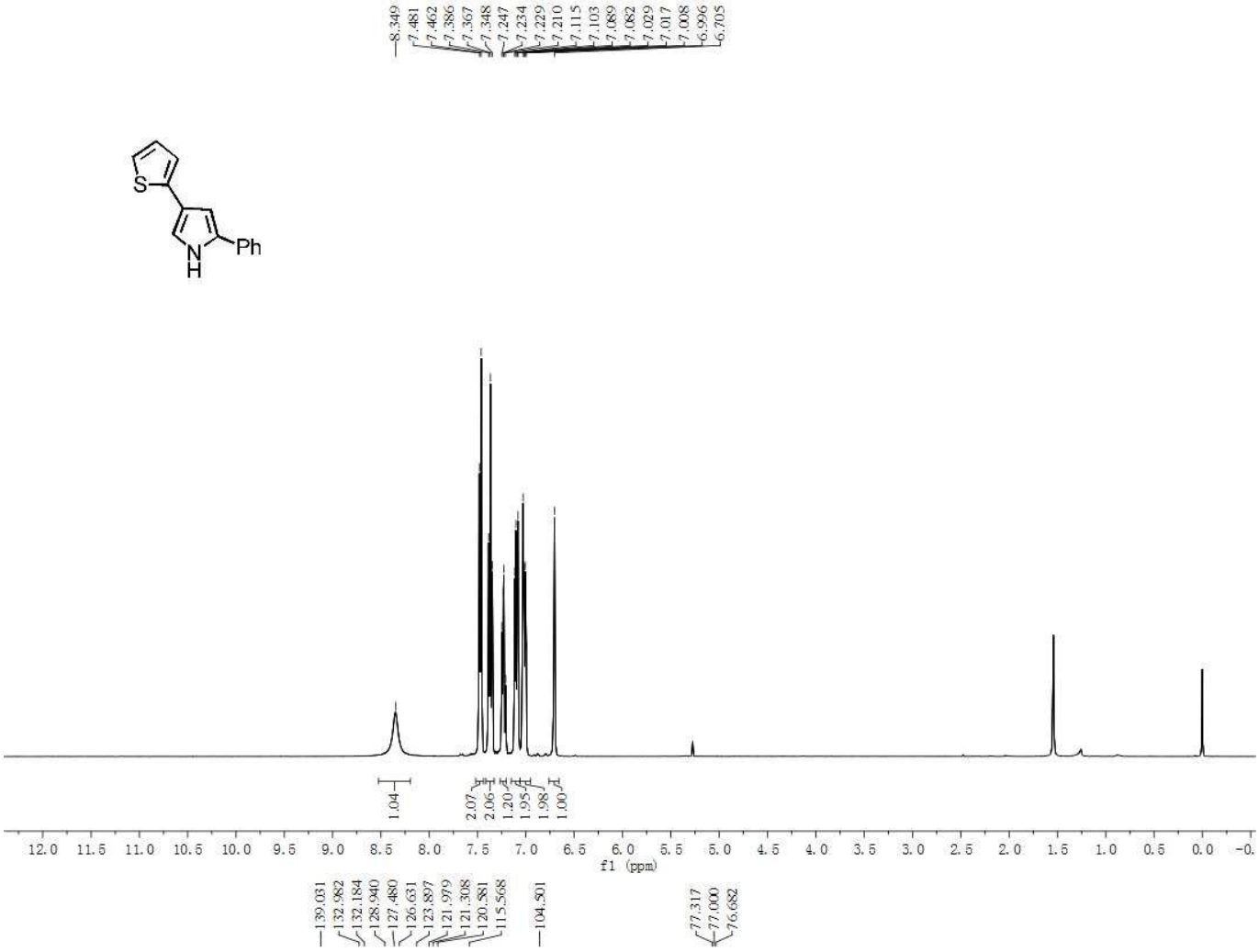


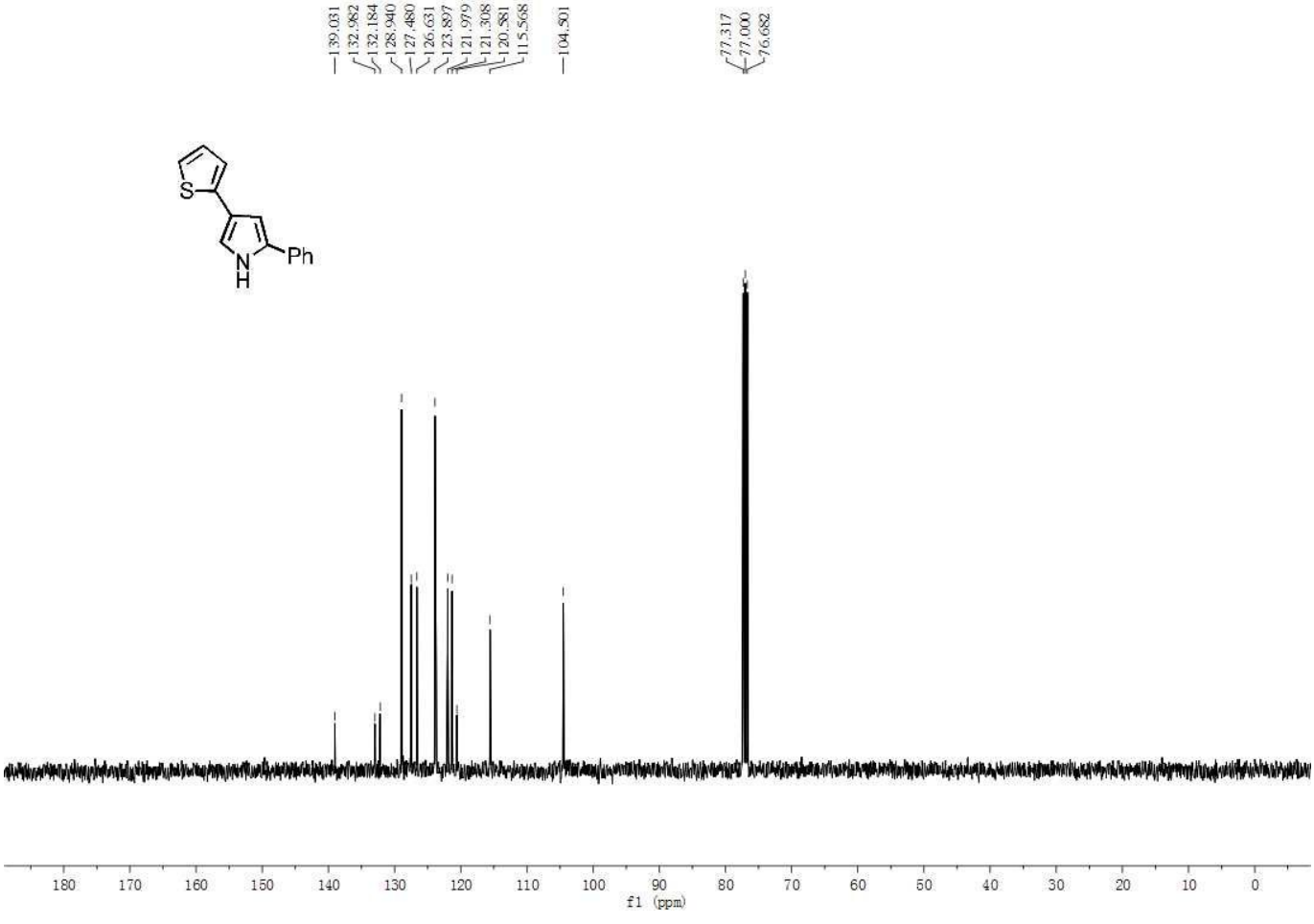
^{1}H and ^{13}C NMR Spectra of 2n



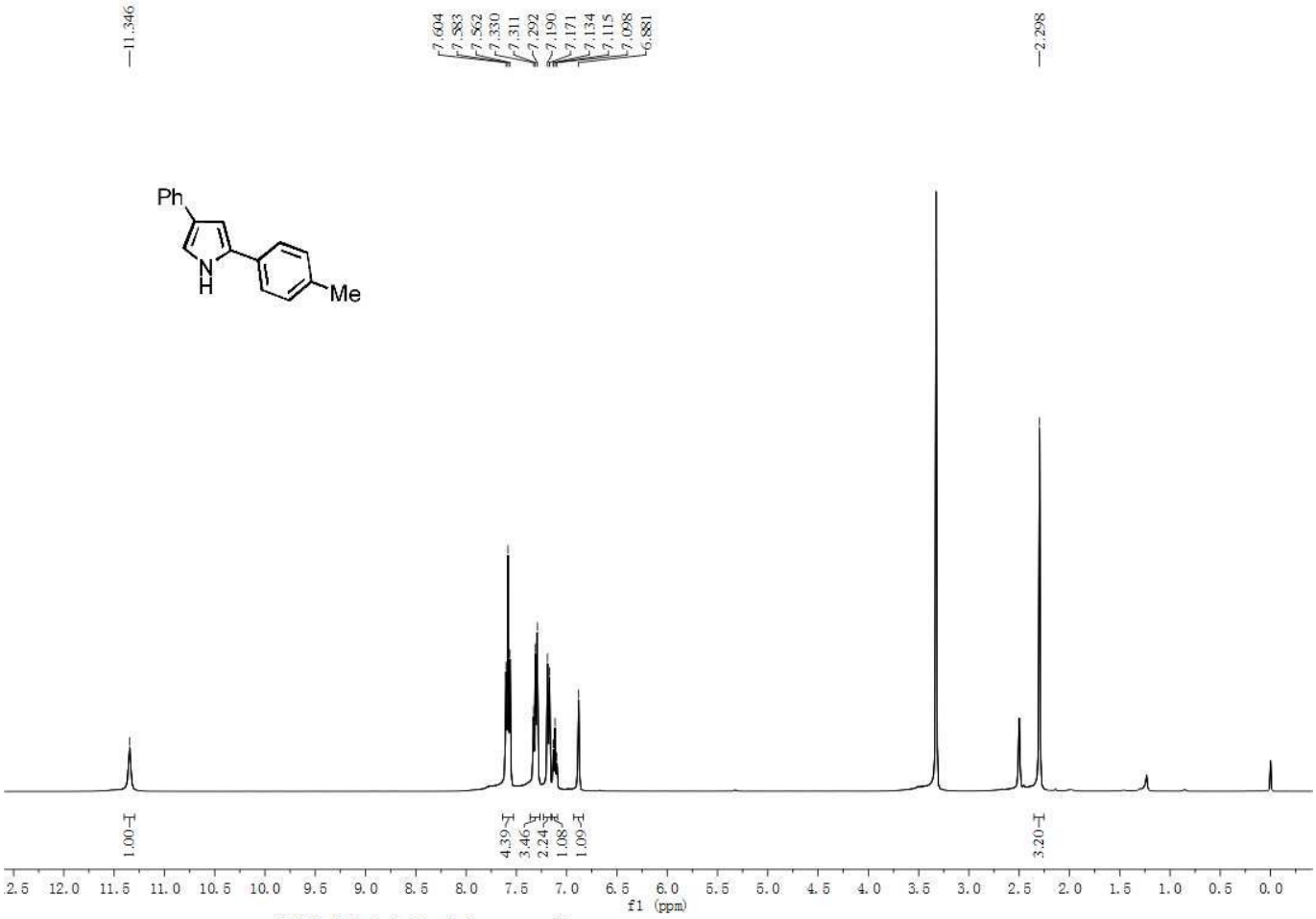


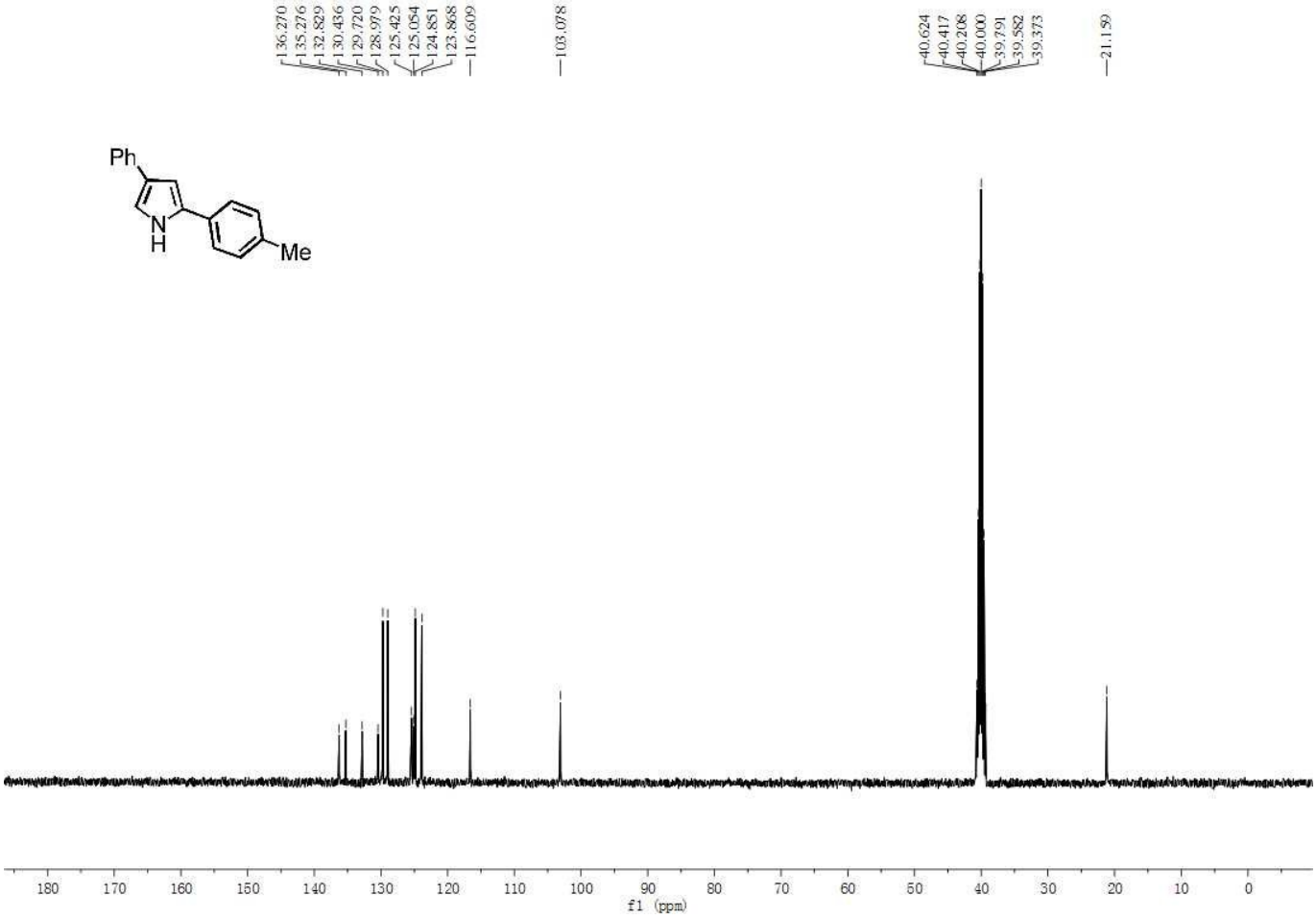
^{1}H and ^{13}C NMR Spectra of 2o



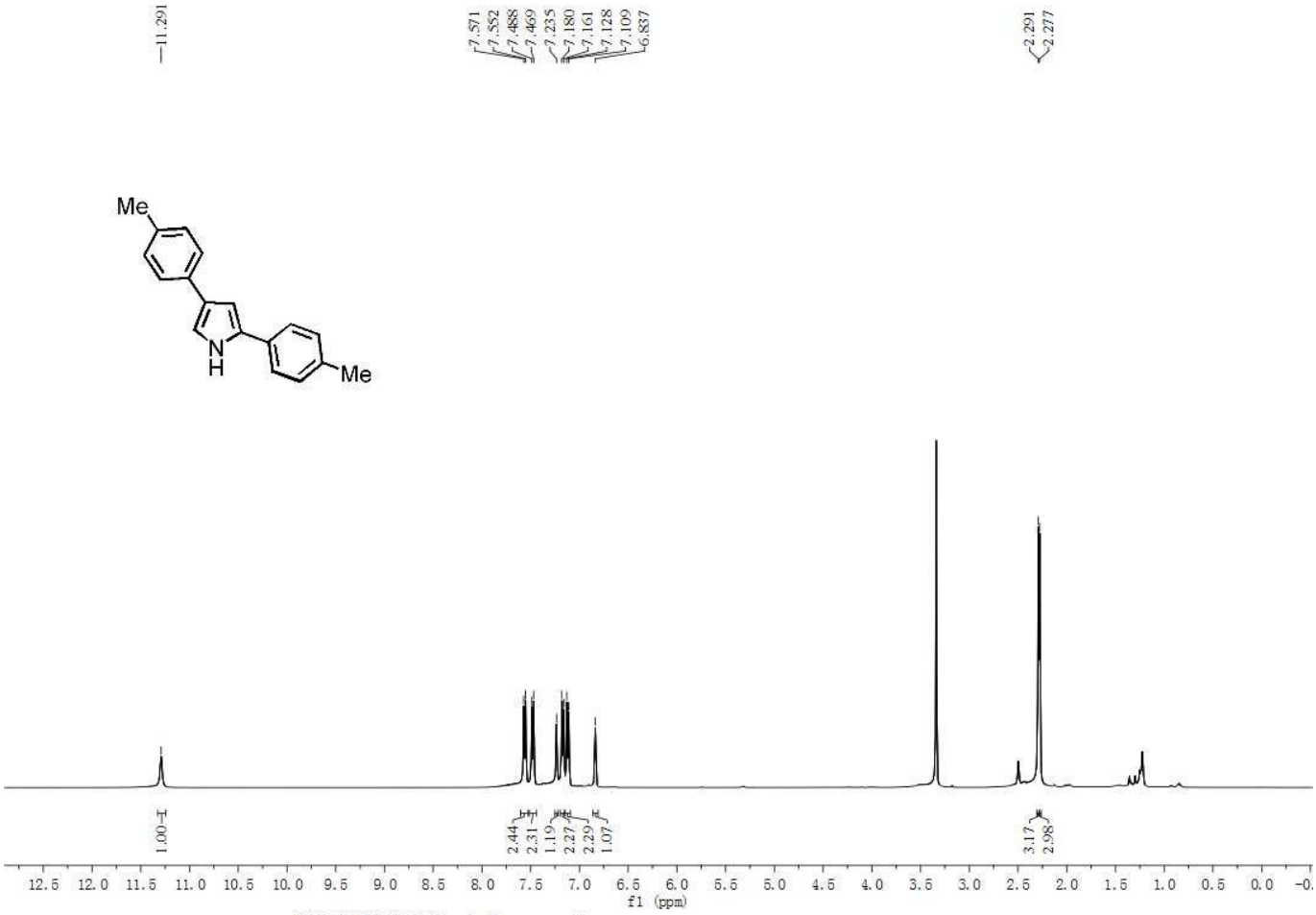


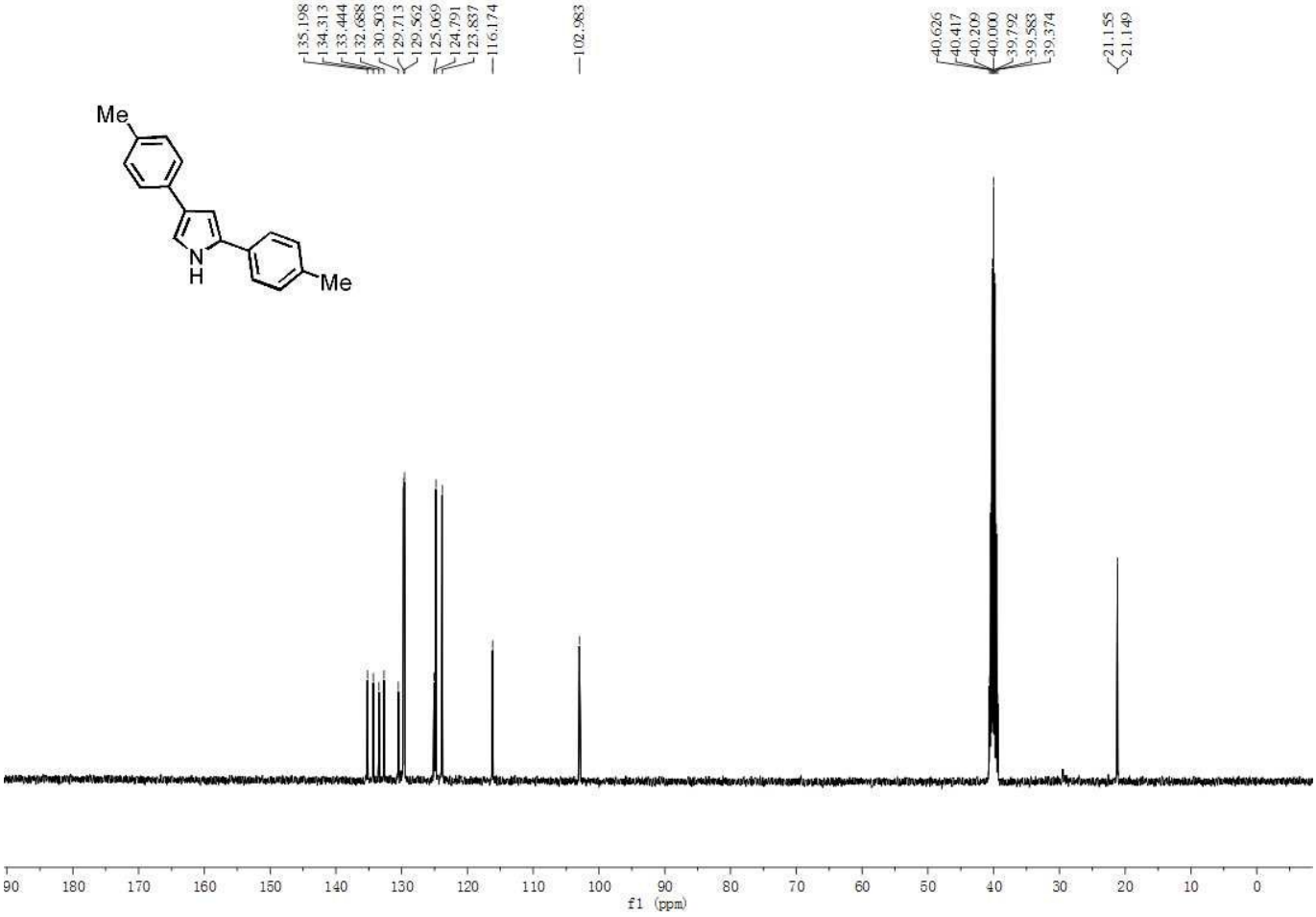
^{1}H and ^{13}C NMR Spectra of 2p



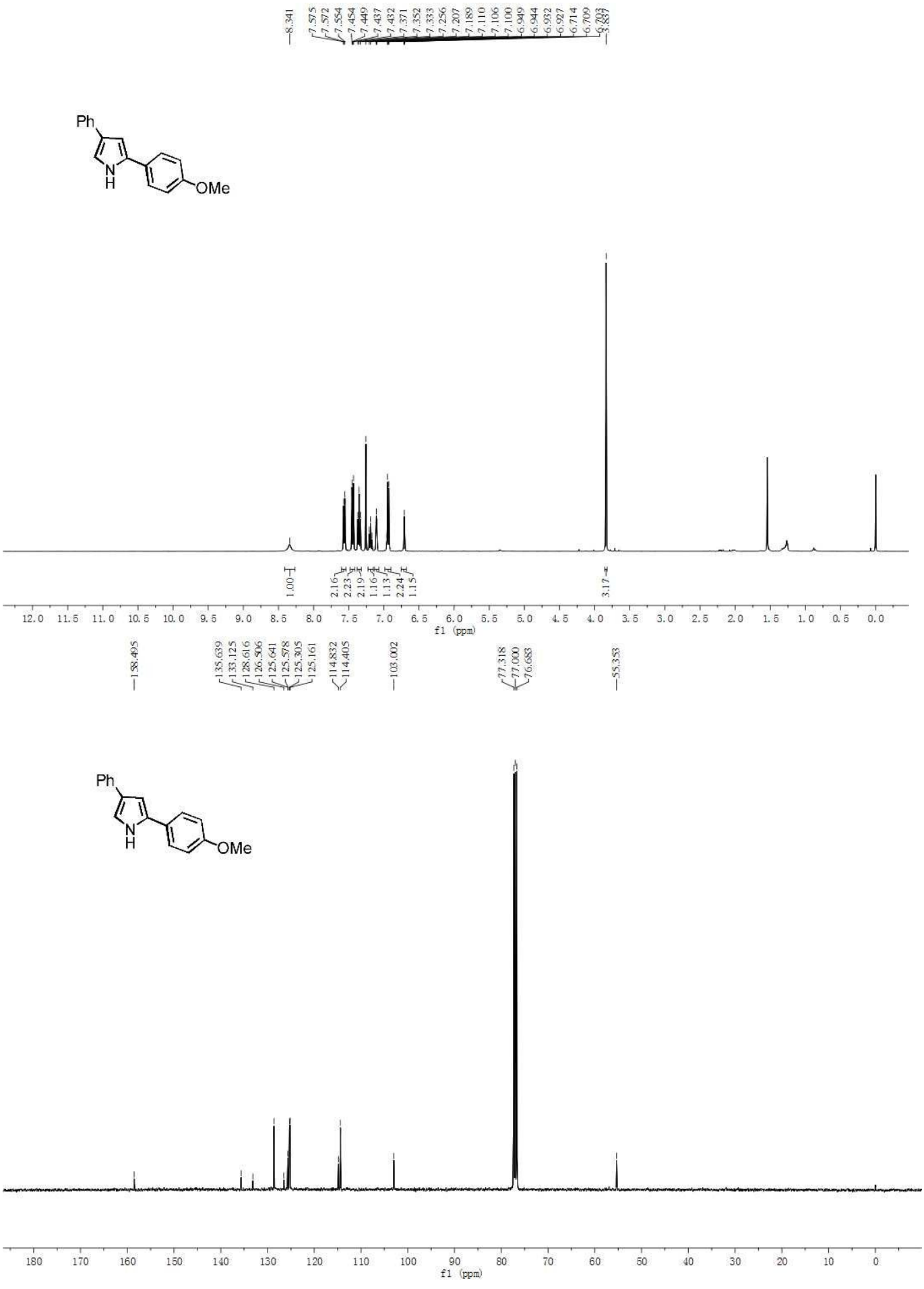


^{1}H and ^{13}C NMR Spectra of 2q

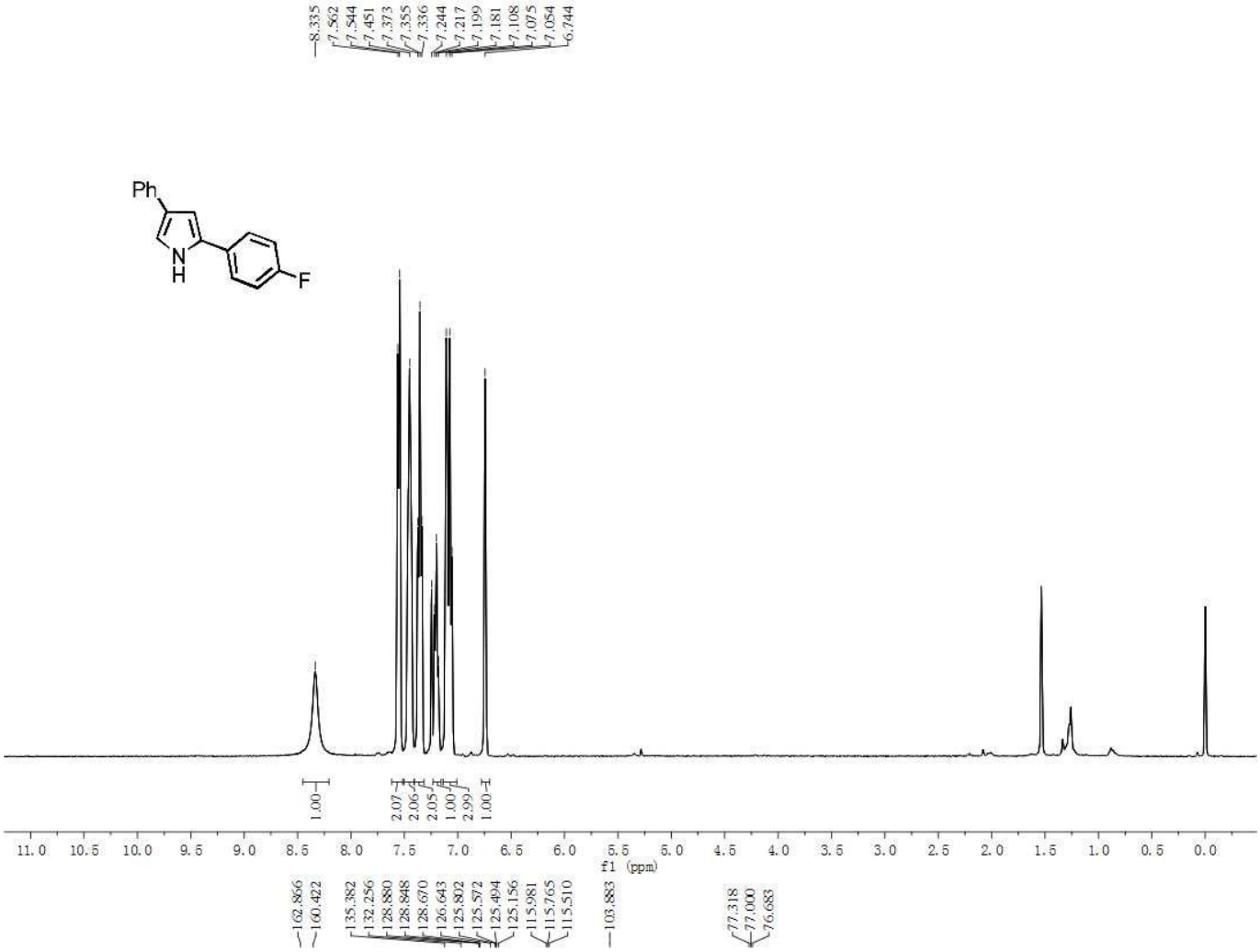


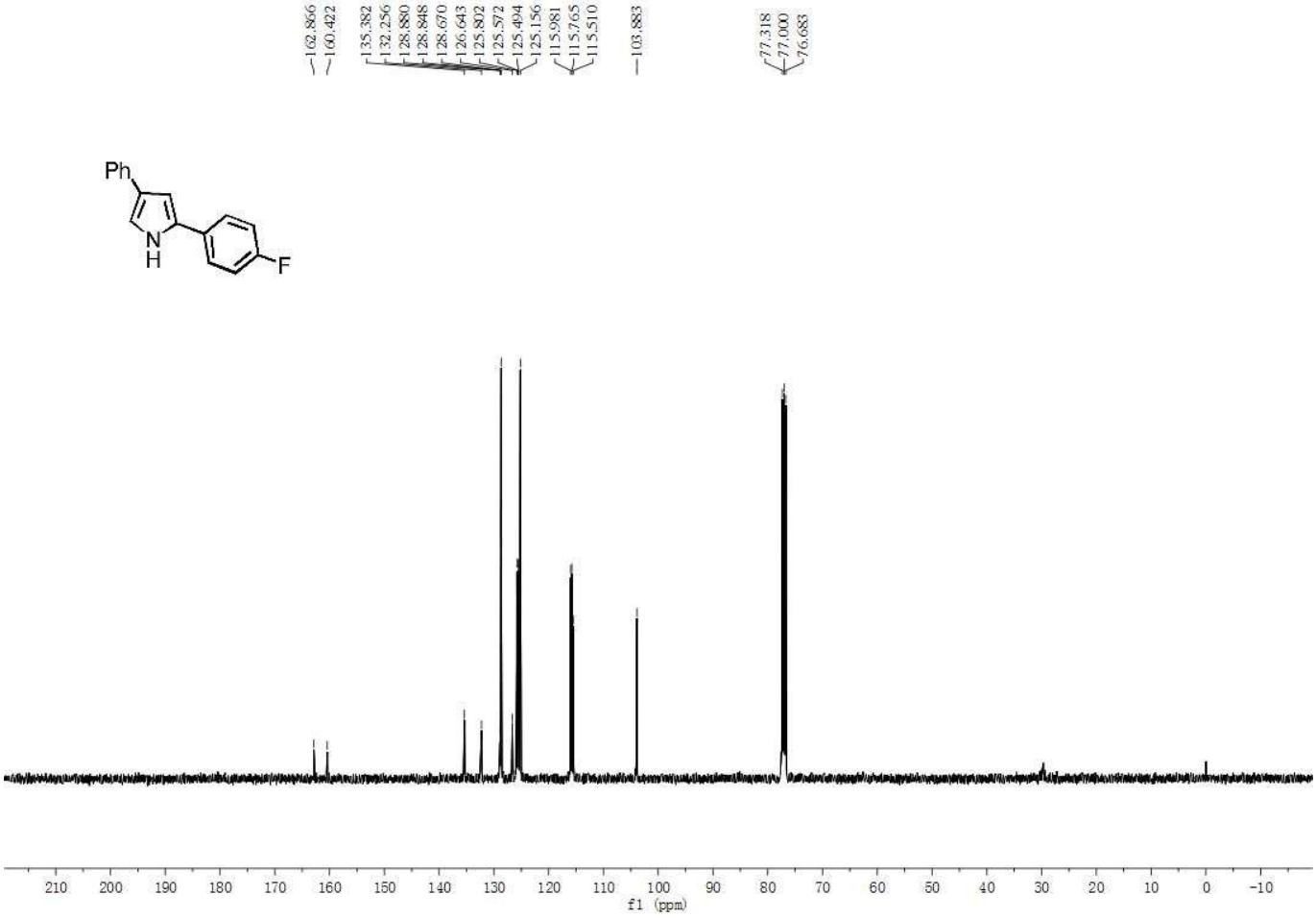


^{1}H and ^{13}C NMR Spectra of 2r

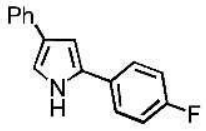


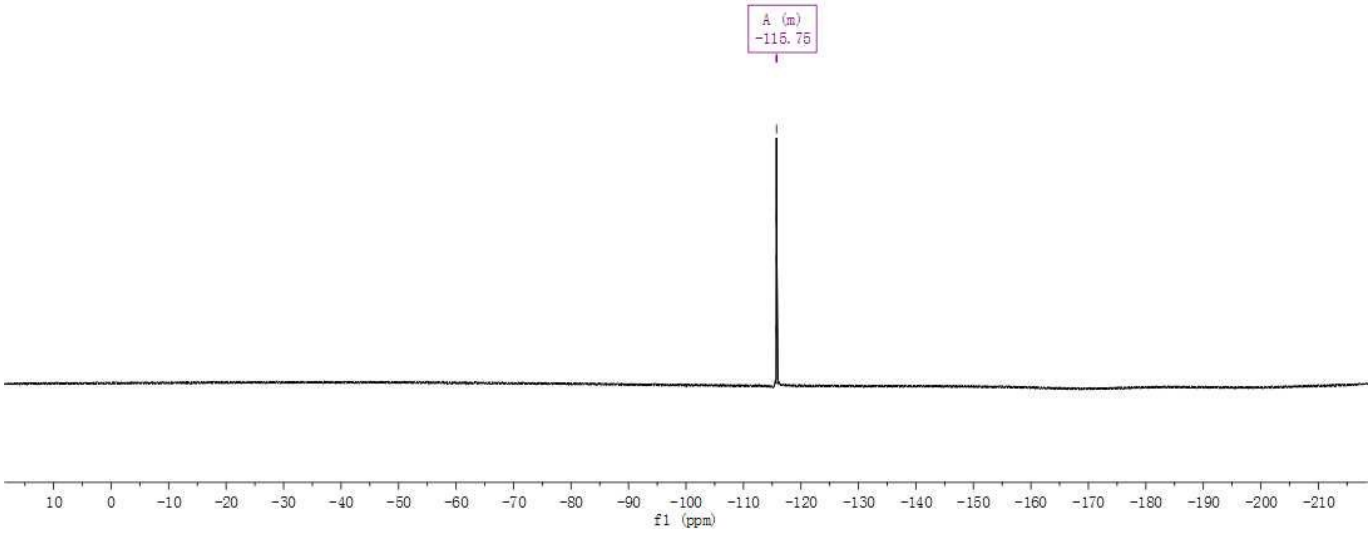
^{1}H, ^{13}C and ^{19}F NMR Spectra of 2s



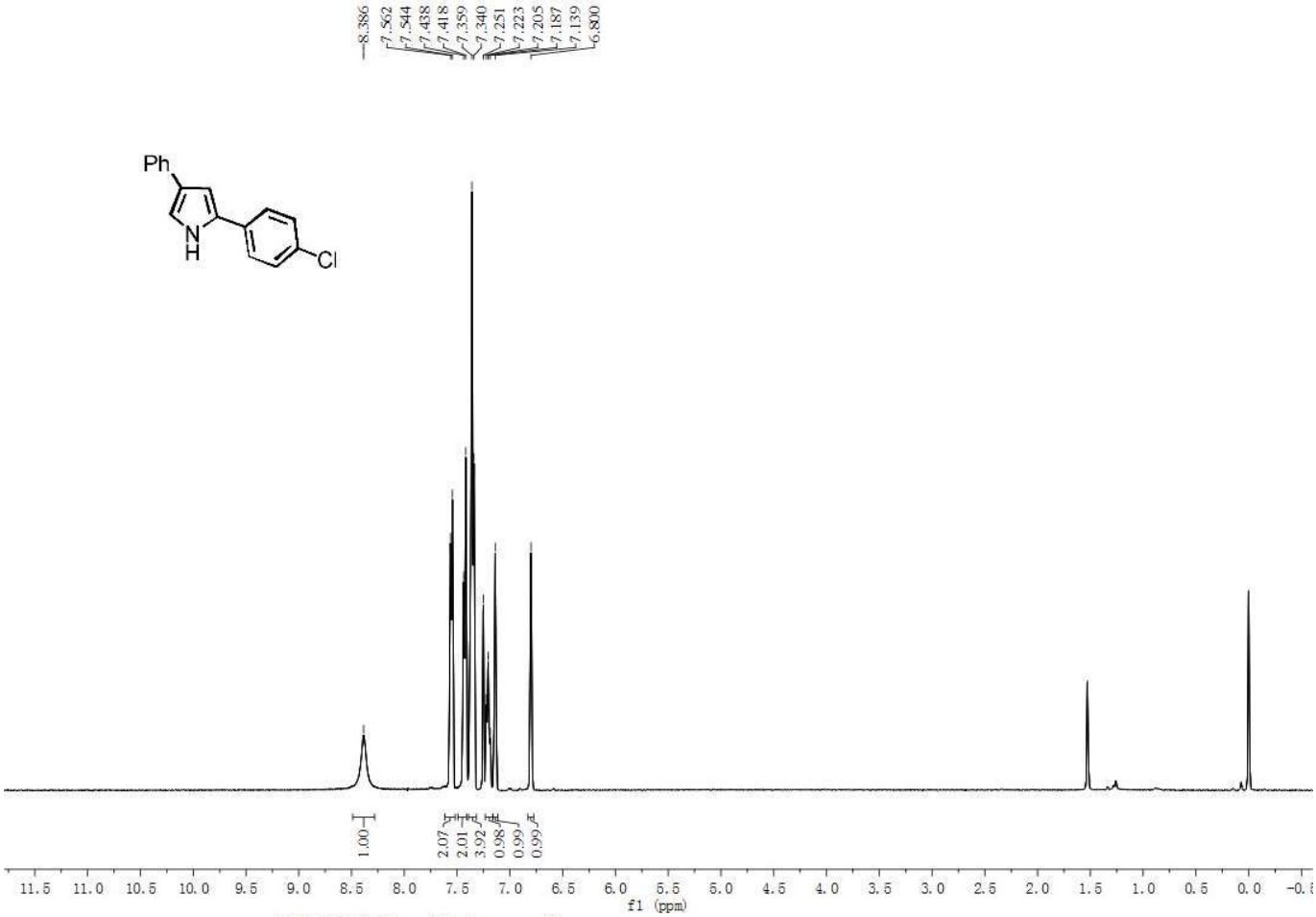


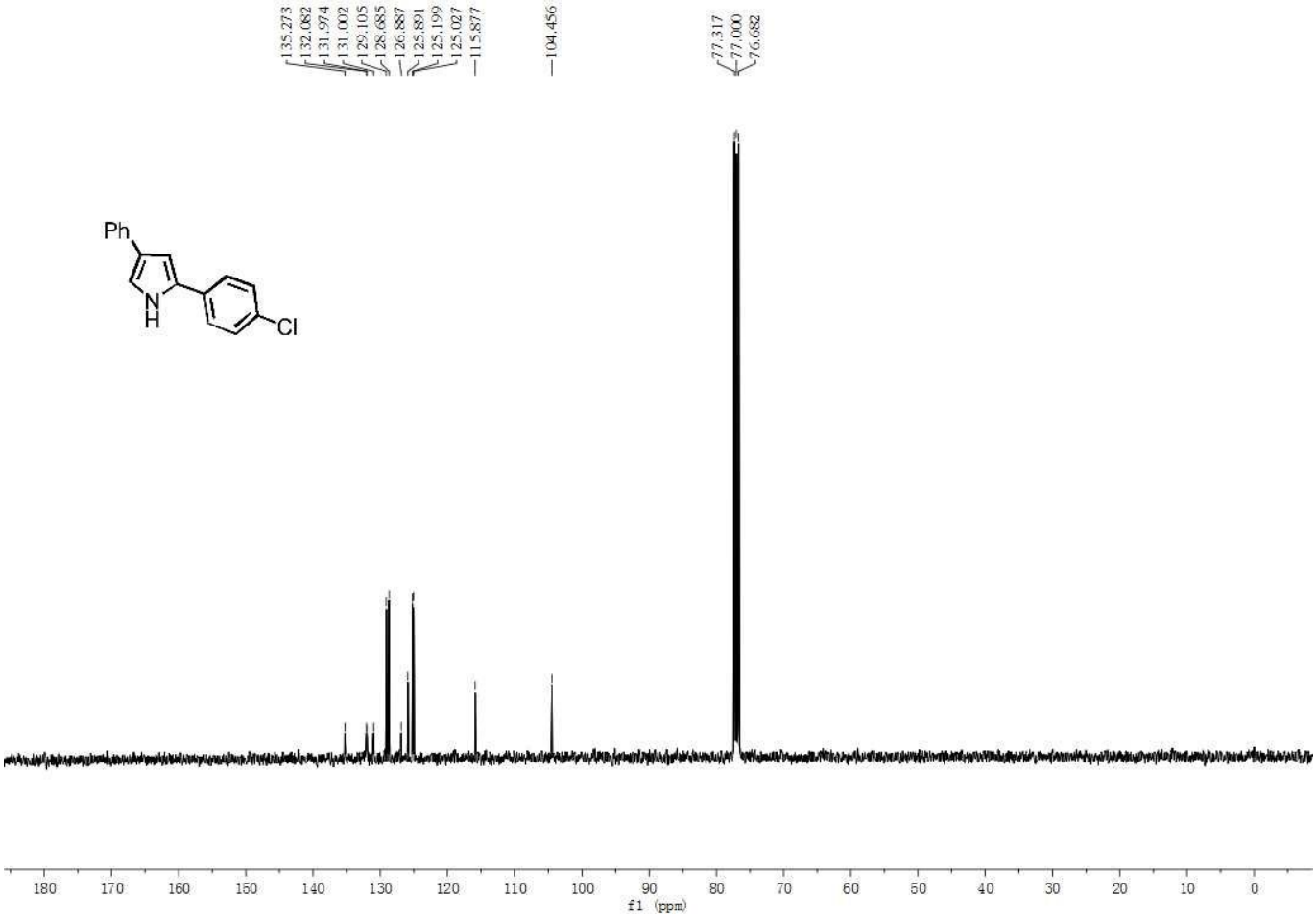

115.712
115.726
115.735
115.748
115.762
115.770
115.784


Ph
N
H
F

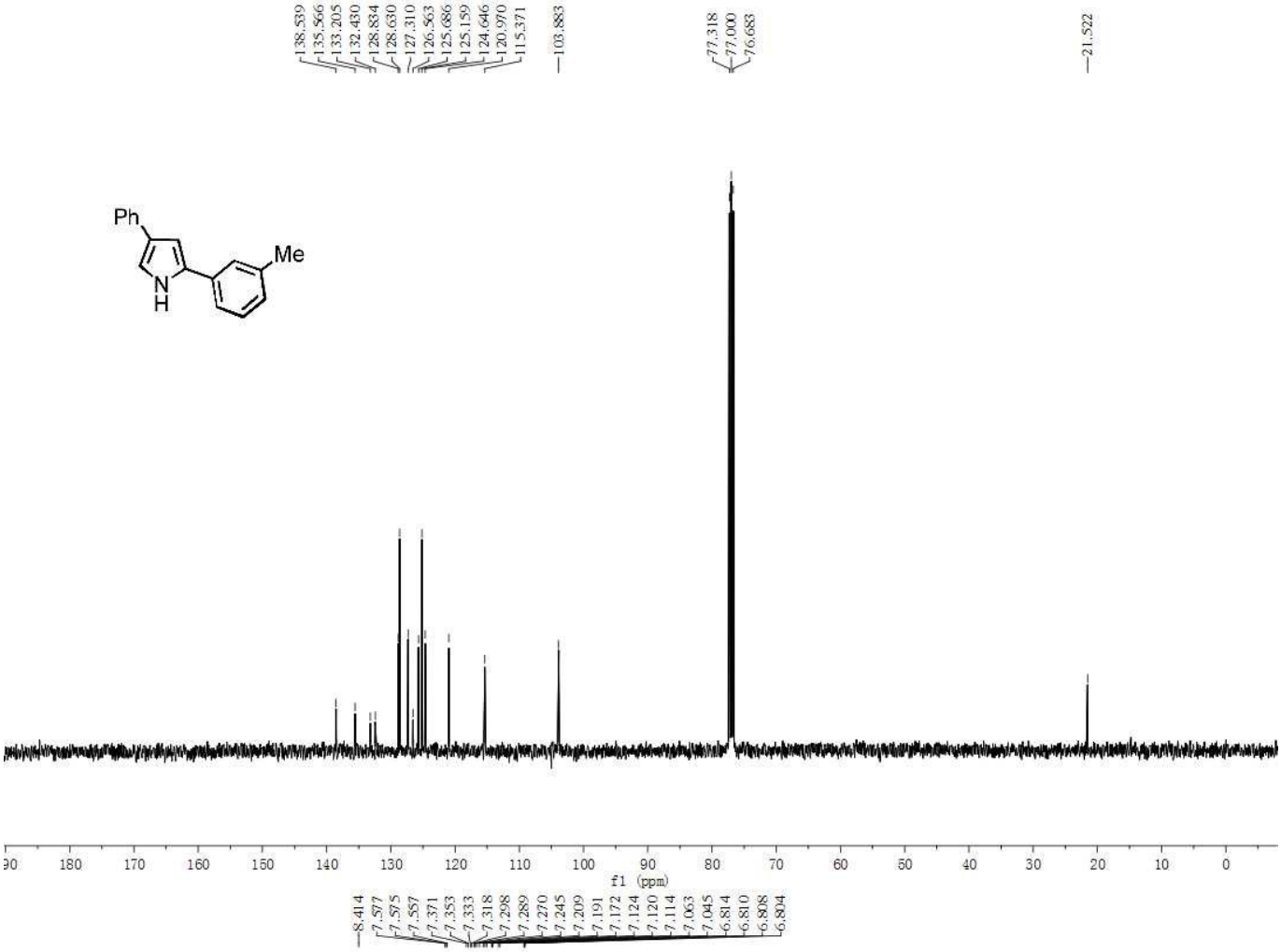

A (m)
-115.75
10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210
f1 (ppm)

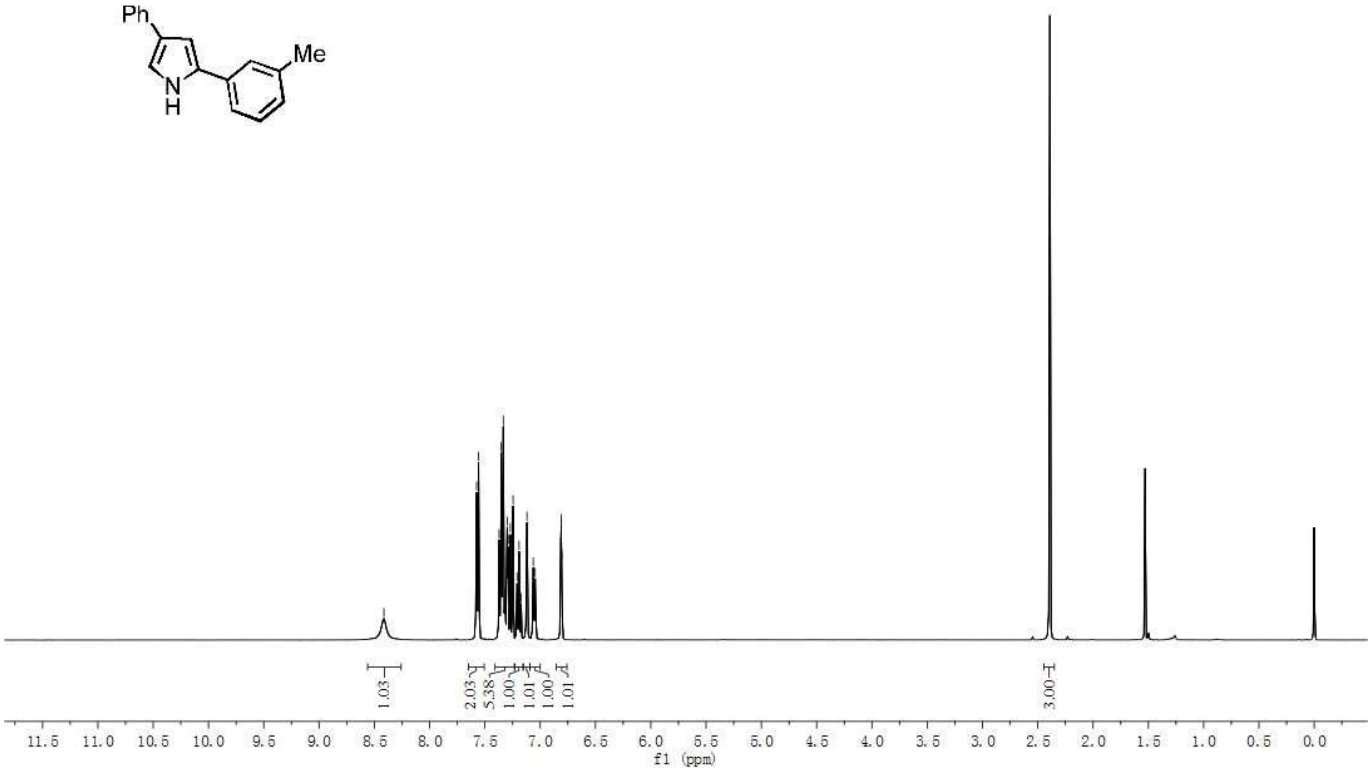
^{1}H and ^{13}C NMR Spectra of 2t



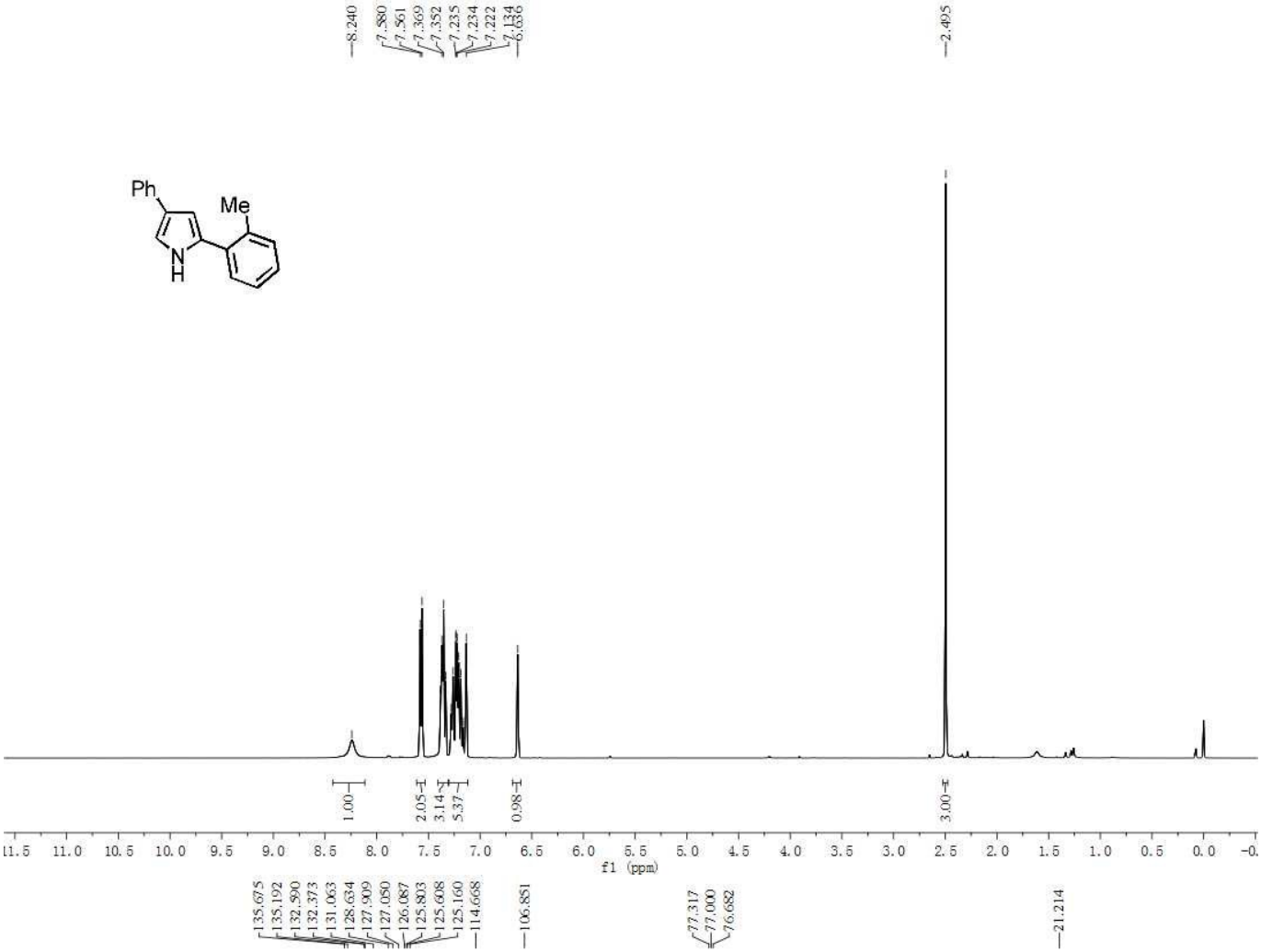


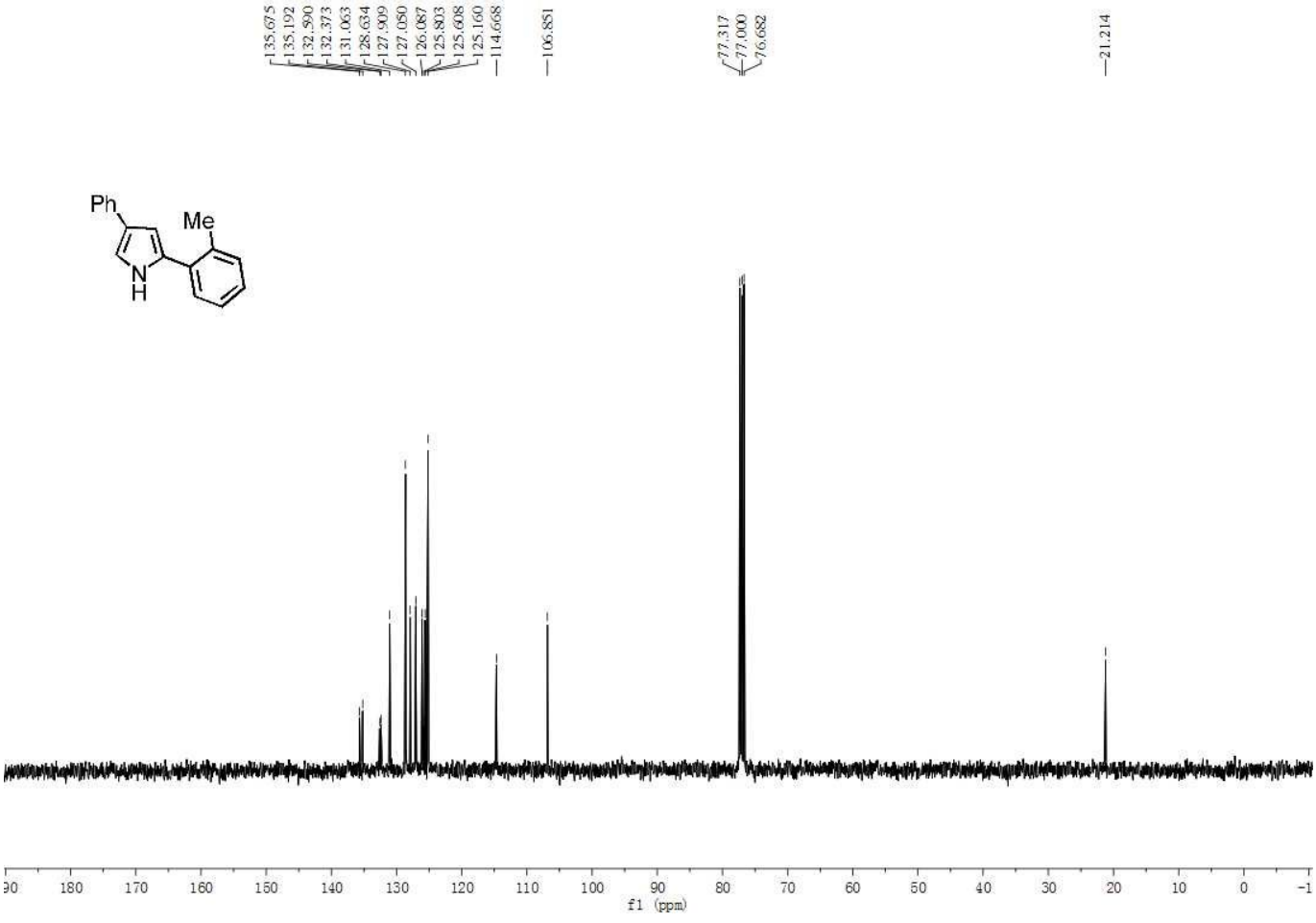
^{1}H and ^{13}C NMR Spectra of 2u



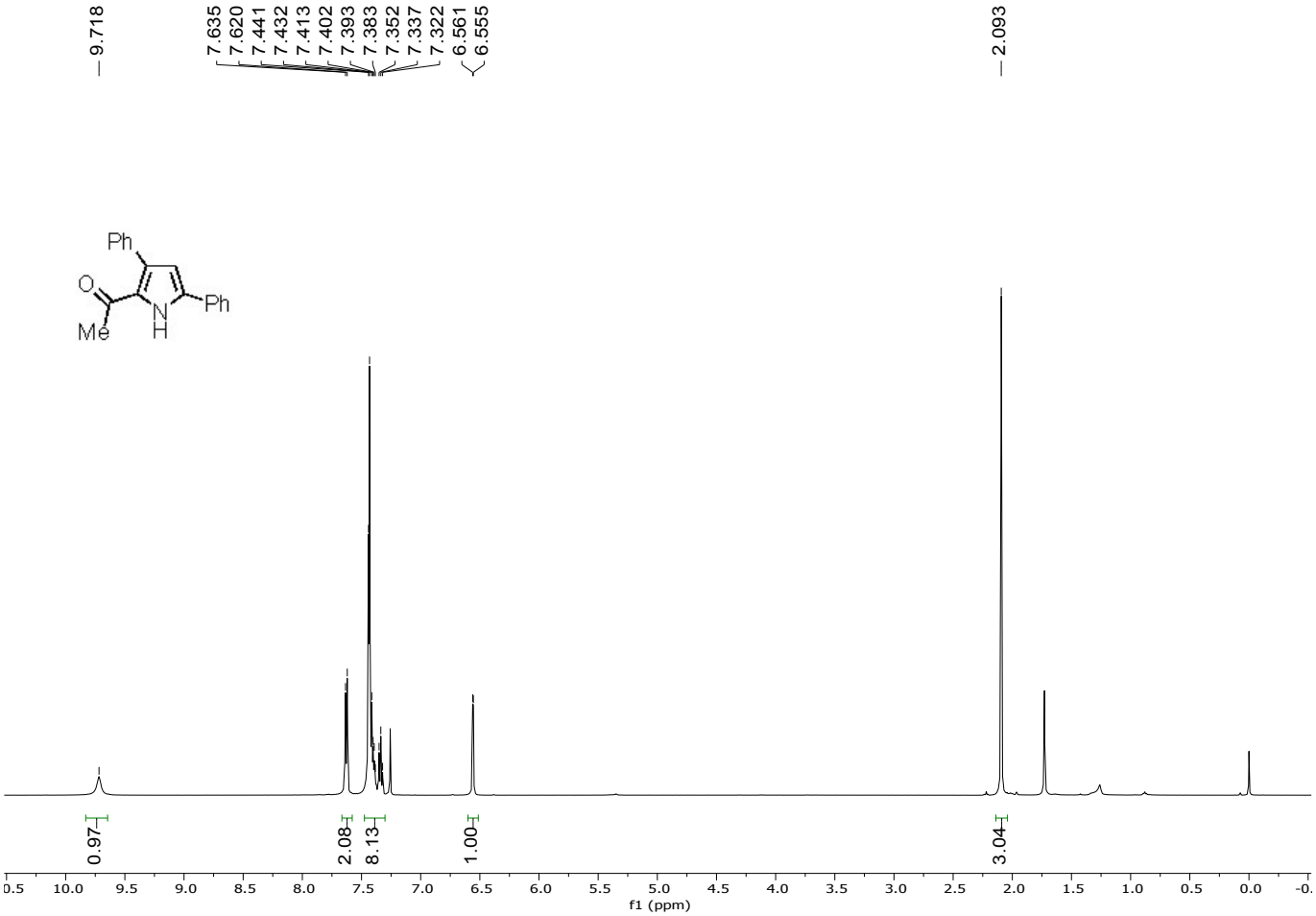


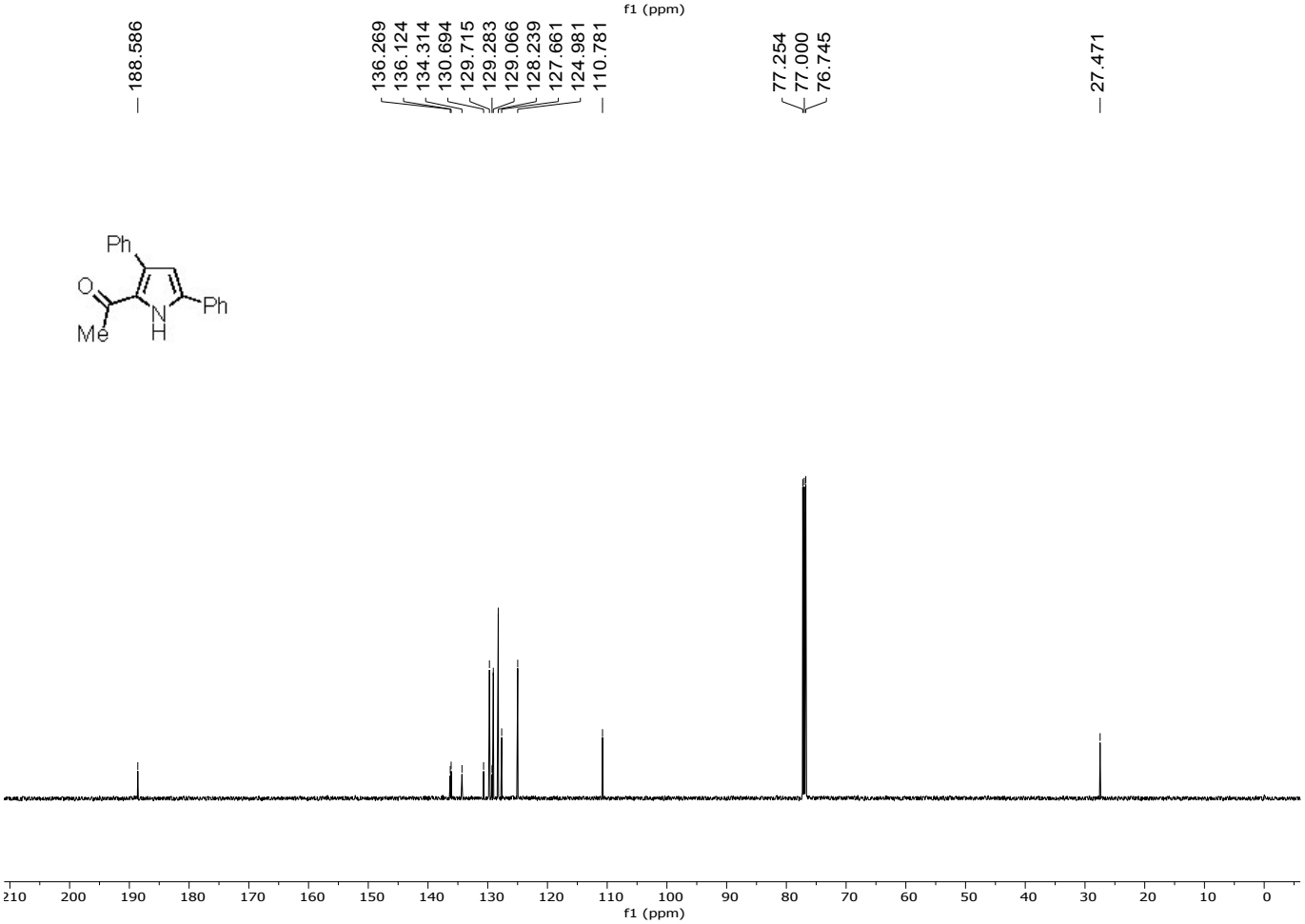
^{1}H and ^{13}C NMR Spectra of 2v



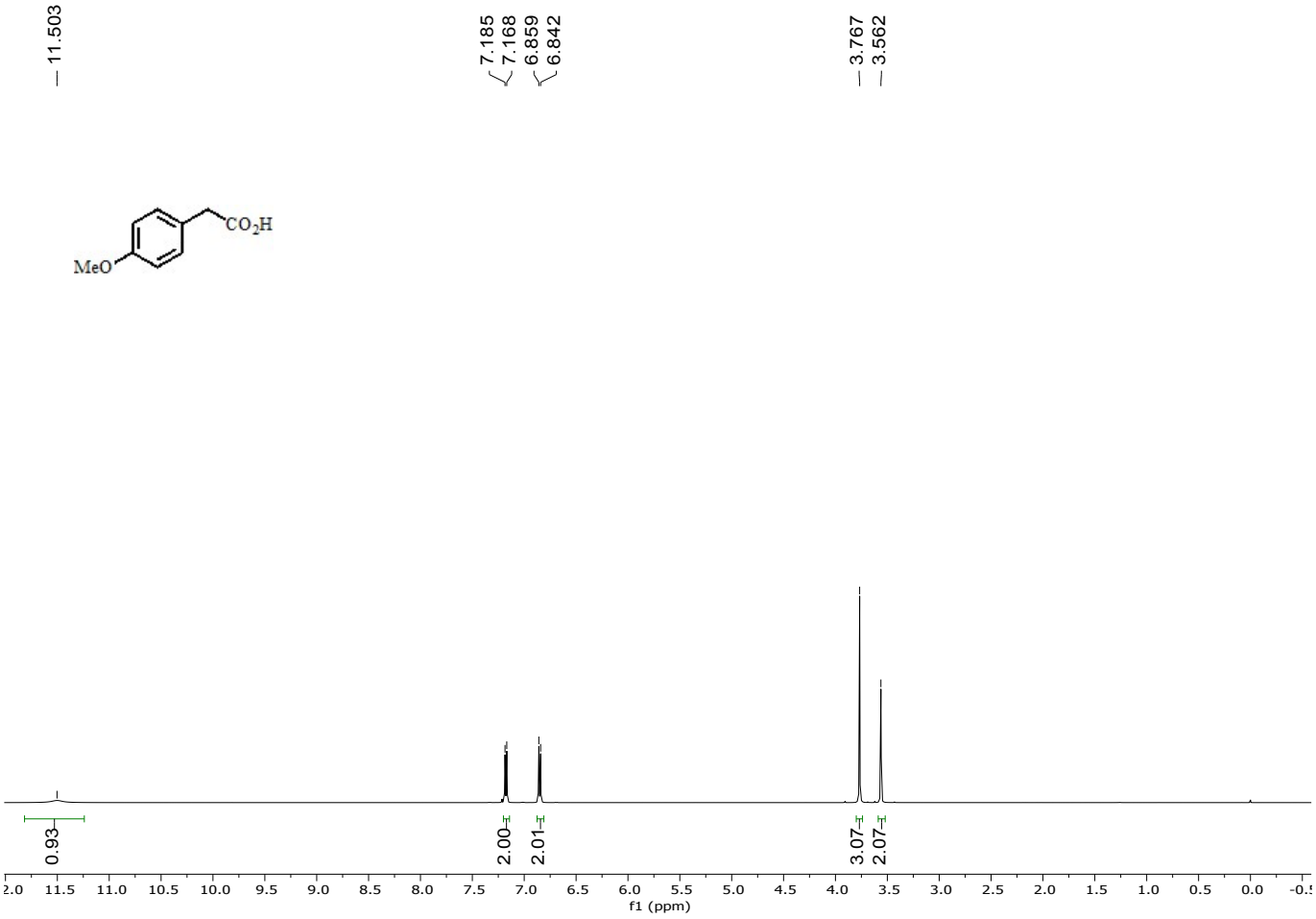


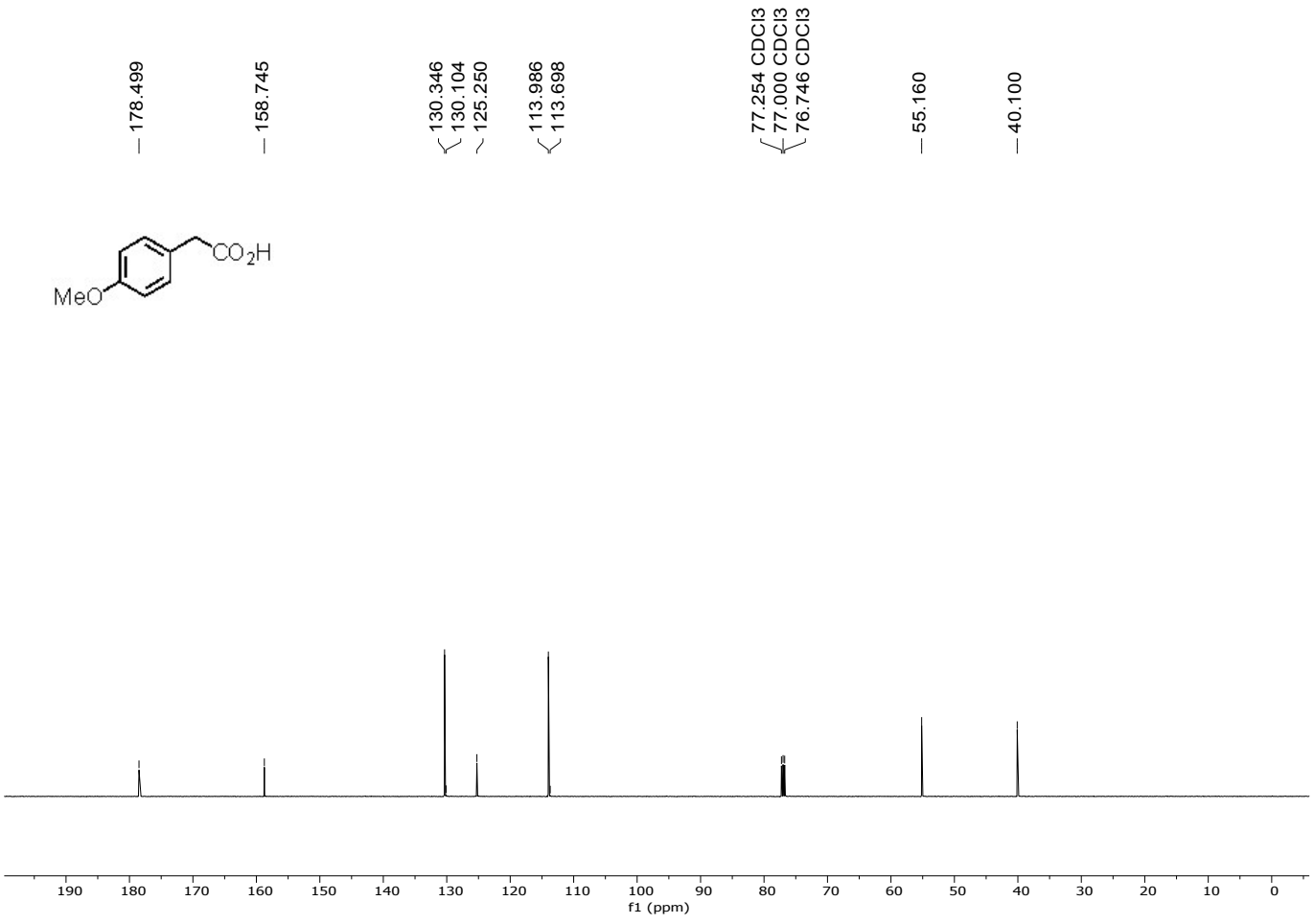
^{1}H and ^{13}C NMR Spectra of 3e





^{1}H and ^{13}C NMR Spectra of 4





^{1}H and ^{13}C NMR Spectra of 5