Supporting Information

HMPA Catalysed Cascade Transfer Hydrogenations of 3-carbonyl Pyridines and other N-heteroarenes with Trichlorosilane

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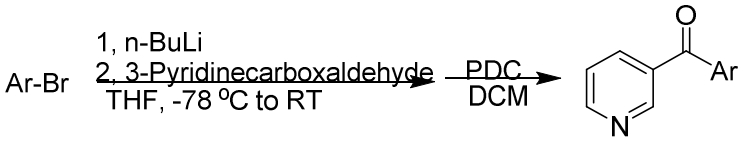
Table of Contents

General Information

All solvents used in the reactions were distilled from appropriate drying agents prior to use. Reactions were monitored by thin layer chromatography using silica gel HSGF254 plates. Flash chromatography was performed using silica gel HG/T2354-92. ^{1}H - and ^{13}C NMR (400 and 100 MHz, respectively) spectras were recorded in $CDCl_3$. ^{1}H NMR chemical shifts are reported in ppm (**δ**) relative to tetramethylsilane (TMS) with the solvent resonance employed as the internal standard ($CDCl_3$, **δ** 7.26 ppm). Datas were reported as follows: chemical shift, multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet, br = broad, dd = double doublet), coupling constants (Hz) and integration. ^{13}C NMR chemical shifts were reported in ppm from tetramethylsilane (TMS) with the solvent resonance as the internal standard ($CDCl_3$, **δ** 77.0 ppm). ESIMS spectras were recorded on BioTOF Q.

Preparation of Starting Materials

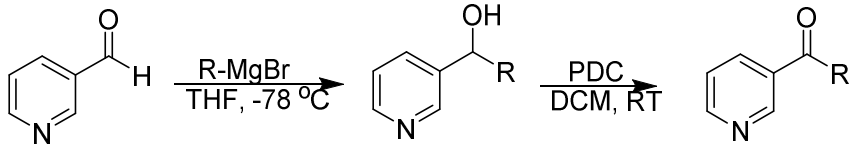
The substrates **1a**[1], **1b**[2], **1c**[2], **1u**[3], **1y**[4], **3b**[5], **3c**[6], **3d**[7], **1q**, **1r**, **1s**[8] were prepared according to the previous reported procedures. The substrates **1t**, **3a**, **3b**, **3e**, **3f**, **3g**, **3h** were purchased from commercial sources.



Scheme 1 Synthesis of **1d**, **1e** and **1h**.

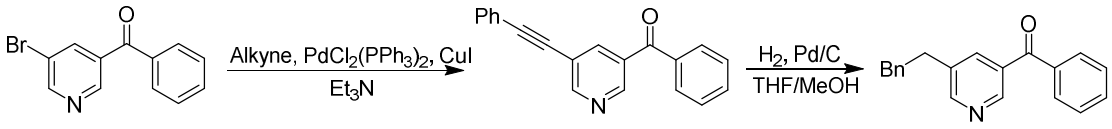
n-Butyllithium (2.5 M solution in hexane, 0.88 mL, 2.2 mmol) was added dropwise to a solution of aryl bromide (2.0 mmol) in THF (10 mL) at -78 °C for 30 min. And then 3-pyridinecarboxaldehyde (261 mg, 2.1 mmol) was added to the mixture at -78 °C. The obtained mixture was stirred at room temperature for 1 h and monitored with TLC. Saturated NH_4Cl solution was added to quench the reaction. The mixture was extracted with EA. The combined organic layers were dried over Na_2SO_4, concentrated under vacuum to get the crude product. The crude was dissolved in DCM (20 mL), and then PDC (1.02 g, 2.7 mmol)

was added. The reaction mixture was stirred for 3 hours at room temperature and monitored with TLC. The mixture was filtered through Celite and washed with DCM. The combined organic layers were washed with brine, dried over Na_2SO_4, concentrated under vacuum to afford the crude product. The desired products were obtained by column chromatography on silica gel.



Scheme 2 Synthesis of **1f**, **1g**.

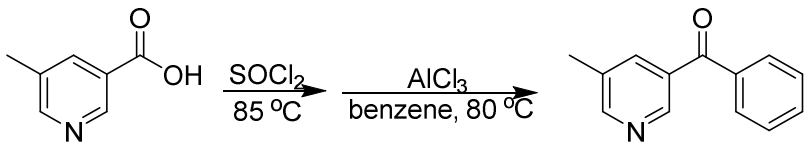
R-MgBr (1 M solution in THF, 0.88 mL, 2.2 mmol) was added dropwise to a solution of 3-pyridinecarboxaldehyde (201.1 mg, 2 mmol) in THF (10 mL) at -78 oC for 30 min. The obtained mixture was stirred at room temperature for 1 h and monitored with TLC. Saturated NH4Cl solution was added to quench the reaction. The mixture was extracted with EA. The combined organic layers were dried over Na2SO4, concentrated under vacuum to get the crude product. The crude product was dissolved in DCM, and PDC (1.02 g, 2.7 mmol) was added. The reaction was stirred at room temperature for 3 h and monitored with TLC. The mixture was filtered through a bed of Celite and later washed with DCM. The combined organic layers were washed with brine, dried over Na_2SO_4, concentrated under vacuum to afford the crude product. The desired products were obtained by column chromatography on silica gel.



Scheme 3 Synthesis of **1i**

$PdCl_2(PPh_3)_2$ (148 mg, 0.21 mmol) and CuI (120.6 mg, 0.63 mmol) were added to a solution of (5-bromopyridin-3-yl)(phenyl)methanone (1.1 g, 4.22 mmol) in Et_3N (10 mL) under N_2, and the resulting mixture was stirred for 30 min. Then ethynylbenzene (516 mg, 5.1 mmol) was added dropwise and the reaction mixture was stirred overnight at room temperature, followed by filtration over Celite and evaporation under vacuum. Purification by column chromatography on silica gel afforded the desired product.

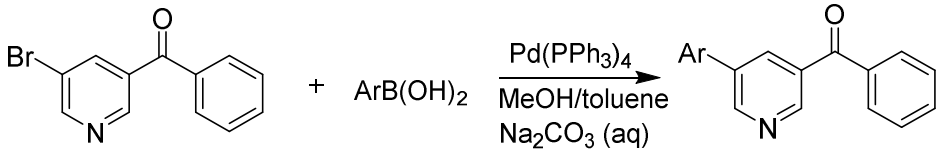
To the crude product in a mixture of THF (12 mL) and MeOH (12 mL) was added 10% Pd on carbon (80 mg), and the atmosphere was changed to H_2 (2.5 bar). The resulting mixture was stirred in a Parr hydrogenation apparatus overnight at room temperature, followed by filtration over Celite and evaporation under vacuum. Purification by column chromatography on silica gel afforded the desired product.



Scheme 4 Synthesis of **1j**

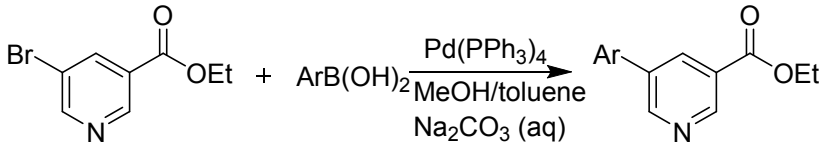
A suspension of 5-methylnicotic acid (2 mmol) in thionyl chloride (10 mL) was heated at 85 °C for 90 min. The excess of thionyl chloride was evaporated under vacuum, and the crude

residue was treated with benzene (15mL) and portion wise while stirring with anhydrous aluminum chloride (6 mmol) at 0 °C. The mixture was refluxed for 6 h, and then cooled, poured on ice containing 37% HCl (5 mL), and extracted with chloroform. The organic solution was washed with 1 N NaOH (5 mL) and brine (5 mL), and then dried and evaporated under vacuum. The residue was passed through a silica gel column chromatography to give the desired product.



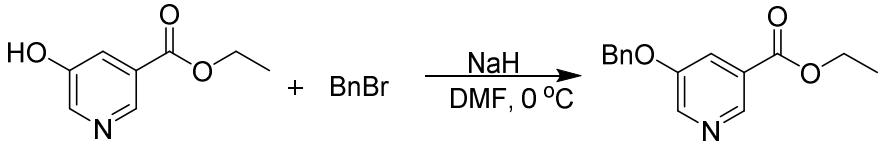
Scheme 5 Synthesis of **1k**, **1l**, **1m**, **1n**, **1o** and **1p**

$Pd(PPh_3)_4$ (17.3 mg, 0.015 mmol) was added to a solution of 3-benzoy-5-bromo pyridine (130.1 mg, 0.5 mmol) and aryl boronic acid (0.6 mmol) in MeOH (0.2 mL), toluene (0.8 mL), and 2 M Na_2CO_3 (0.2mL) under N_2. The mixture was heated to 75 °C for 2 h, and then cooled to room temperature and concentrated under reduced pressure. Water was added to the residue and the aq. phase was extracted with DCM (3 × 5 mL). The combined organic layers were washed with brine, dried over Na_2SO_4, and evaporated to obtain the crude product. Purification by column chromatography on silica gel afforded the desired product.



Scheme 6 Synthesis of **1v**, **1w**, **1x**

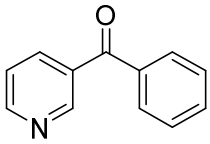
$Pd(PPh_3)_4$ (17.3 mg, 0.015 mmol) was added to a solution of 5-bromonicotinic acid ethyl ester(115.1 mg, 0.5 mmol) and aryl boronic acid (0.6 mmol) in MeOH (0.2 mL), toluene (0.8 mL), and 2 M Na_2CO_3 (0.2mL) under N_2. The mixture was heated to 75 °C for 2 h, then cooled to room temperature and concentrated under reduced pressure. Water was added to the residue and the aq. phase was extracted with DCM (3 × 5 mL). The combined organic layers were washed with brine, dried over Na_2SO_4, and evaporated to obtain the crude product. Purification by column chromatography on silica gel afforded the desired product.



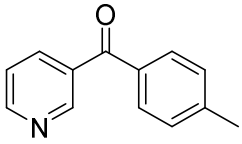
Scheme 7 Synthesis of **1y**

In an oven dried 25 ml flask, ethyl 5-hydroxynicotinate (5 mmol, 835 mg) was dissolved in 5 mL DMF under nitrogen atmosphere. This solution was transferred via cannula to another flask containing DMF (2 mL) solution of sodium hydride (55% in mineral oil, pre-washed with dry hexane) (10 mmol, 436 mg) and stirred under ice-cold condition for 30 minutes. To this solution, benzyl bromide (5 mmol, 593.7 µl) was slowly added under ice-cold condition and then the reaction mixture was allowed to warm to room temperature and stirred for 12 h. Upon completion, the reaction mixture was poured into ice-cold water and extracted with dichloromethane. The combined organic layers were dried over Na2SO4 and evaporated under reduced pressure. The crude reaction mixture was purified by column

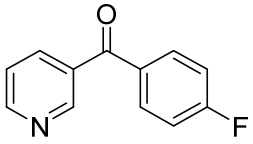
chromatography.



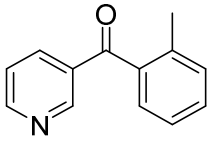
Phenyl(pyridin-3-yl)methanone(1a)[1]. Yellow oil. Yield: 78%. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 9.00 (d, *J* = 1.6 Hz, 1H), 8.81 (dd, *J* = 4.9, 1.7 Hz, 1H), 8.13 - 8.11 (m, 1H), 7.86 - 7.78 (m, 2H), 7.64 - 7.62 (m, 1H), 7.52 - 7.50 (m, 2H), 7.46 - 7.44 (m, 1H).



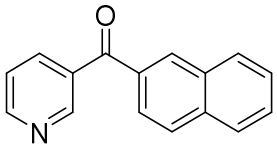
Pyridin-3-yl(p-tolyl)methanone(1b)[2]. Yellow oil. Yield: 58%. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 8.99 (d, *J* = 1.2 Hz, 1H), 8.87 - 8.76 (m, 1H), 8.11 - 8.09 (m, 1H), 7.74 (d, *J* = 8.1 Hz, 2H), 7.45 (dd, *J* = 7.8, 4.7 Hz, 1H), 7.32 (d, *J* = 7.9 Hz, 2H), 2.46 (s, 3H).



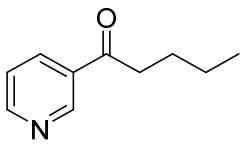
(4-fluorophenyl)(pyridin-3-yl)methanone (1c)[2]. Yellow solid. Yield: 46%. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 8.99 (d, *J* = 1.7 Hz, 1H), 8.84 (dd, *J* = 4.8, 1.7 Hz, 1H), 8.12 - 8.10 (m, 1H), 7.89 - 7.87 (m, 2H), 7.49 (dd, *J* = 7.9, 4.9 Hz, 1H), 7.25 - 7.20 (m, 2H).



Pyridin-3-yl(o-tolyl)methanone(1d)[9]. White solid. Yield: 68%. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 8.96 (d, *J* = 1.7 Hz, 1H), 8.82 (dd, *J* = 4.8, 1.2 Hz, 1H), 8.15 (d, *J* = 7.9 Hz, 1H), 7.49 - 7.43 (m, 2H), 7.35 (d, *J* = 5.6 Hz, 2H), 7.32 - 7.28 (m, 1H), 2.39 (s, 3H).

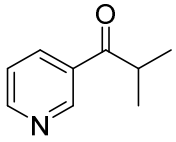


Naphthalen-2-yl(pyridin-3-yl)methanone (1e). White solid. Yield: 78%. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 9.10 (d, *J* = 1.6 Hz, 1H), 8.88 (dd, *J* = 4.9, 1.7 Hz, 1H), 8.30 (s, 1H), 8.23 - 8.20 (m, 1H), 8.03 - 7.95 (m, 4H), 7.70 - 7.59 (m, 1H), 7.64 - 7.55 (m, 1H), 7.54 - 7.51 (m, 1H). **^{13}C NMR** (101 MHz, $CDCl_3$): δ 196.3, 153.4, 151.6, 137.4, 135.0, 134.0, 133.9, 132.3, 130.8, 128.7, 128.6, 127.8, 126.8, 125.4, 124.3, 123.5.

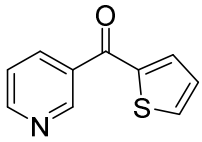


1-(pyridin-3-yl)pentan-1-one (1f)[10]. Yellow oil. Yield: 58%. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 9.18 (d, *J* = 1.7 Hz, 1H), 8.78 (dd, *J* = 4.8, 1.6 Hz, 1H), 8.25– 8.23 (m, 1H), 7.44 (dd, *J* = 7.9, 4.8 Hz,

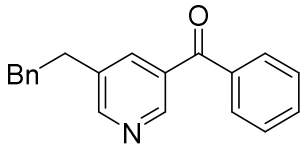
1H), 3.00 (t, *J* = 7.4 Hz, 2H), 1.77 - 1.75 (m, 2H), 1.50 - 1.36 (m, 2H), 0.97 (t, *J* = 7.3 Hz, 3H).



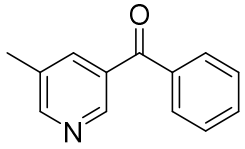
2-methyl-1-(pyridin-3-yl)propan-1-one(1g). Yellow oil. Yield: 43%. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 9.16 (dd, *J* = 2.2, 0.6 Hz, 1H), 8.76 (dd, *J* = 4.8, 1.7 Hz, 1H), 8.27 - 8.17 (m, 1H), 7.42–7.40 (m, 1H), 3.54 - 3.50 (m, 1H), 1.24 (d, *J* = 6.9 Hz, 6H). **^{13}C NMR** (101 MHz, $CDCl_3$): δ 203.15, 153.2, 149.7, 135.7, 131.4, 123.7, 35.9, 18.8.



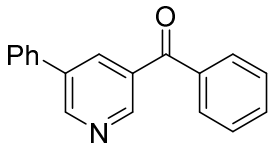
Pyridin-3-yl(thiophen-2-yl)methanone(1h)[11]. Yellow solid. Yield: 56%. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 9.11 (d, *J* = 1.5 Hz, 1H), 8.85 (dd, *J* = 4.9, 1.7 Hz, 1H), 8.18 - 8.16 (m, 1H), 7.82 (dd, *J* = 4.9, 1.1 Hz, 1H), 7.69 (dd, *J* = 3.8, 1.1 Hz, 1H), 7.49 - 7.47 (m, 1H), 7.23 (dd, *J* = 4.9, 3.9 Hz, 1H).



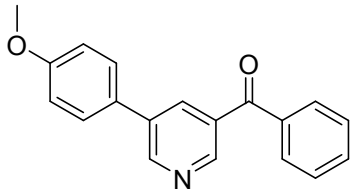
(5-phenethylpyridin-3-yl)(phenyl)methanone(1i). Yellow solid.Yield: 78%. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 8.84 (d, *J* = 1.6 Hz, 1H), 8.63 (d, *J* = 2.0 Hz, 1H), 7.87 - 7.85 (m, 1H), 7.77 (d, *J* = 7.3 Hz, 2H), 7.67 - 7.65 (m, 1H), 7.54 - 7.51 (m, 2H), 7.31 - 7.25 (m, 3H), 7.17 (d, *J* = 7.1 Hz, 2H), 3.20 - 2.93 (m, 4H). **^{13}C NMR** (101 MHz, $CDCl_3$): δ 195.0, 153.1, 148.7, 140.3, 137.0, 136.8, 136.7, 133.1, 132.8, 130.0, 128.6, 128.6, 128.5, 126.4, 37.3, 34.7.



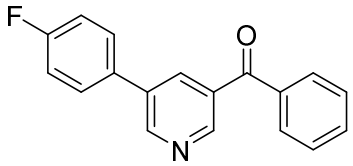
(5-methylpyridin-3-yl)(phenyl)methanone(1j). Yellow oil. Yield: 73%. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 8.80 (d, *J* = 1.8 Hz, 1H), 8.67 (d, *J* = 1.7 Hz, 1H), 7.96 - 7.94 (m, 1H), 7.84 - 7.81 (m, 2H), 7.70 - 7.61 (m, 1H), 7.54 - 7.52 (m, 2H), 2.46 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$): δ 195.2, 153.4, 148.2, 137.4, 136.9, 133.2, 133.1, 132.8, 130.0, 128.6, 18.4.



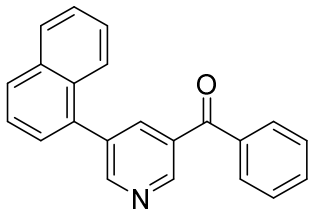
Phenyl(5-phenylpyridin-3-yl)methanone(1k). White solid. Yield: 88%. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 9.07 (d, *J* = 2.0 Hz, 1H), 8.98 (d, *J* = 2.0 Hz, 1H), 8.33 - 8.32 (m, 1H), 7.95 - 7.86 (m, 2H), 7.74 - 7.62 (m, 3H), 7.56 - 7.54 (m, 4H), 7.48 - 7.46 (m, 1H). **^{13}C NMR** (101 MHz, $CDCl_3$): δ 194.9, 151.3, 149.5, 136.8, 136.8, 136.6, 135.4, 135.3, 133.3, 133.2, 130.1 129.3, 128.7, 127.3.



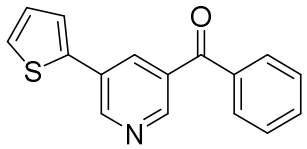
(5-(4-methoxyphenyl)pyridin-3-yl)(phenyl)methanone(1l). White solid. Yield: 72%. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 9.03 (d, *J* = 2.4 Hz, 1H), 8.92 (d, *J* = 2.0 Hz, 1H), 8.29 - 8.28 (m, 1H), 7.95 - 7.85 (m, 2H), 7.68 - 7.52 (m, 5H), 7.08 - 7.05 (m, 2H), 3.90 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$): δ 195.1, 160.2, 150.9, 148.9, 136.8, 136.2, 134.8, 133.2, 133.1, 130.1, 129.1, 128.7, 128.4, 114.8, 55.4.



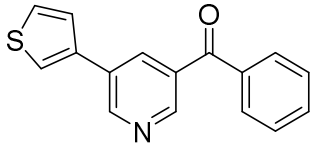
(5-(4-fluorophenyl)pyridin-3-yl)(phenyl)methanone(1m). White solid. Yield: 78%. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 9.03 (d, *J* = 2.0 Hz, 1H), 8.96 (d, *J* = 2.0 Hz, 1H), 8.30 - 8.29 (m, 1H), 7.93 - 7.86 (m, 2H), 7.72 - 7.57 (m, 5H), 7.23 - 7.20 (m, 2H). **^{13}C NMR** (101 MHz, $CDCl_3$): δ 194.8, 163.2 (d, *J* = 249.5 Hz), 151.0, 149.5, 136.7, 135.7, 135.1, 133.3, 133.2, 132.9 (d, *J* = 3.0 Hz), 130.1, 129.0 (d, *J* = 8.1 Hz), 128.7, 116.3 (d, *J* = 20.2 Hz).



(5-(naphthalen-1-yl)pyridin-3-yl)(phenyl)methanone(1n). White solid. Yield: 63%.**^{1}H NMR** (400 MHz, $CDCl_3$): δ 9.09 (d, *J* = 1.6 Hz, 1H), 8.99 (d, *J* = 2.0 Hz, 1H), 8.28 - 8.27 (m, 1H), 7.98 - 7.67 (m, 5H), 7.67 - 7.52 (m, 7H). **^{13}C NMR** (101 MHz, $CDCl_3$): δ 194.9, 153.6, 149.7, 138.3, 136.8, 136.3, 135.2, 133.8, 133.3, 132.9, 131.3, 130.1, 129.1, 128.7, 128.7, 127.7, 126.9, 126.3, 125.4, 124.9.

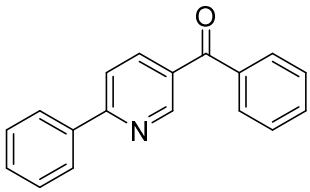


Phenyl(5-(thiophen-2-yl)pyridin-3-yl)methanone(1o). Yellow solid. Yield: 84%. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 9.08 (d, *J* = 2.4 Hz, 1H), 8.90 (d, *J* = 2.0 Hz, 1H), 8.32 - 8.31 (m, 1H), 7.92 - 7.85 (m, 2H), 7.72 - 7.47 (m, 6H). **^{13}C NMR** (101 MHz, $CDCl_3$): δ 194.9, 150.5, 149.2, 137.7, 136.8, 134.4, 133.3, 133.3, 131.5, 130.1, 128.7, 127.4, 125.8, 122.4.

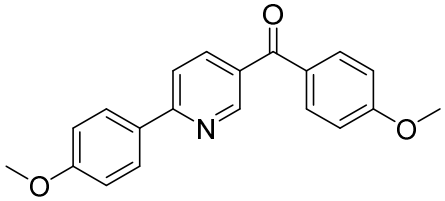


Phenyl(5-(thiophen-3-yl)pyridin-3-yl)methanone(1p). Yellow solid. Yield: 87%. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 9.09 (d, *J* = 2.4 Hz, 1H), 8.88 (d, *J* = 2.0, Hz, 1H), 8.32 - 8.31 (m, 1H), 7.92 - 7.86 (m, 2H), 7.72 - 7.65 (m, 1H), 7.61 - 7.53 (m, 2H), 7.48 - 7.45 (m, 2H), 7.18 (s, 1H). **^{13}C NMR** (101 MHz, $CDCl_3$): δ 194.6, 149.8, 149.3, 139.2, 136.7, 133.7, 133.3, 133.2, 130.5, 130.1, 128.7,

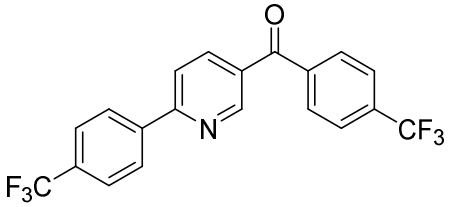
128.5, 126.9, 125.1.



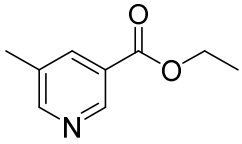
Phenyl(6-phenylpyridin-3-yl)methanone(1q)[8]. White solid. Yield: 56%. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 9.10 (dd, *J* = 2.2, 0.7 Hz, 1H), 8.25 (dd, *J* = 8.3, 2.3 Hz, 1H), 8.15 - 8.08 (m, 2H), 7.95 - 7.84 (m, 3H), 7.71 - 7.65 (m, 1H), 7.60 - 7.47 (m, 5H).



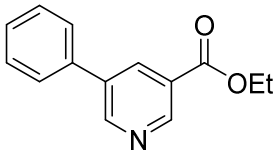
(4-methoxyphenyl)(6-(4-methoxyphenyl)pyridin-3-yl)methanone(1r). White solid. Yield: 69%. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 9.06 (d, *J* = 1.9 Hz, 1H), 8.20 (dd, *J* = 8.3, 2.2 Hz, 1H), 8.02 (d, *J* = 8.2 Hz, 2H), 7.87 (d, *J* = 8.3 Hz, 1H), 7.80 (d, *J* = 8.2 Hz, 2H), 7.35 (d, *J* = 8.0 Hz, 4H), 2.49 (s, H), 2.46 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$): δ 194.4, 160.2, 151.1, 143.9, 140.2, 138.1, 135.5, 134.5, 131.3, 130.2, 129.7, 129.3, 127.2, 119.6, 21.7, 21.4.



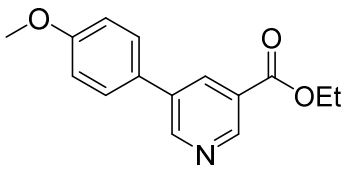
(4-(trifluoromethyl)phenyl)(6-(4-(trifluoromethyl)phenyl)pyridin-3-yl)methanone(1s).
White solid. Yield: 60%. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 9.12 (d, *J* = 2.0 Hz, 1H), 8.34 – 8.20 (m, 3H), 7.98 (dd, *J* = 8.0, 5.4 Hz, 3H), 7.85 - 7.80 (m, 4H). **^{13}C NMR** (101 MHz, $CDCl_3$): δ 193.4, 159.2, 151.3, 141.2, 139.8, 138.4, 134.5 (q, *J* = 32.8 Hz), 131.9 (q, *J* = 32.6 Hz), 131.2, 130.1, 127.7, 125.9 (q, *J* = 3.8 Hz), 125.8 (q, *J* = 3.7 Hz), 124.0 (q, *J* = 273.7 Hz), 123.5 (q, *J* = 273.7 Hz), 120.4.



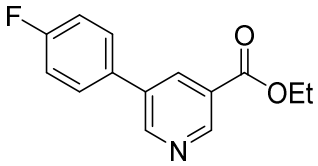
Ethyl 5-methylnicotinate(1u)[3]**.** Yellow oil. Yield: 89%. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 9.03 (d, *J* = 1.6 Hz, 1H), 8.60 (d, *J* = 1.6 Hz, 1H), 8.12-8.10 (m, 1H), 4.41 (q, *J* = 7.1 Hz, 2H), 2.41 (d, *J* = 0.6 Hz, 3H), 1.42 (t, *J* = 7.1 Hz, 3H).



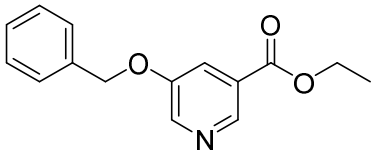
Ethyl 5-phenylnicotinate(1v)[12]**.** White solid.Yield: 87%. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 9.22 (d, *J* = 1.8 Hz, 1H), 9.02 (d, *J* = 2.2 Hz, 1H), 8.52 - 8.50 (m, 1H), 7.65 (dd, *J* = 5.3, 3.4 Hz, 2H), 7.56 – 7.50 (m, 2H), 7.50 – 7.43 (m, 1H), 4.47 (q, *J* = 7.1 Hz, 2H), 1.46 (t, *J* = 7.1 Hz, 3H).



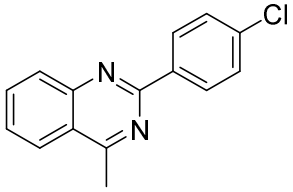
Ethyl 5-(4-methoxyphenyl)nicotinate(1w). White solid, Yield: 80%. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 9.16 (d, *J* = 1.8 Hz, 1H), 8.98 (d, *J* = 2.2 Hz, 1H), 8.46– 8.45 (m, 1H), 7.63 – 7.56 (m, 2H), 7.12 – 7.01 (m, 2H), 4.46 (q, *J* = 7.1 Hz, 2H), 1.45 (t, *J* = 7.1 Hz, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$): δ 165.4, 160.1, 151.3, 148.7, 136.1, 134.7, 129.1, 128.3, 126.3, 114.7, 61.5, 55.4, 14.3.



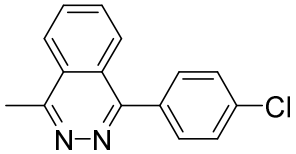
Ethyl 5-(4-fluorophenyl)nicotinate(1x)[4]. White solid.Yield: 85%. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 9.20 (s, 1H), 8.96 (s, 1H), 8.44 (s, 1H), 7.60 (dd, *J* = 7.9, 5.4 Hz, 2H), 7.22 - 7.18 (m, 2H), 4.46 (q, *J* = 7.0 Hz, 2H), 1.45 (t, *J* = 7.1 Hz, 3H).



Ethyl 5-(benzyloxy)nicotinate(1y). Yellow oil. Yield: 67%. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 8.87 (s, 1H), 8.57 (s, 1H), 7.88 (dd, *J* = 2.7, 1.5 Hz, 1H), 7.51 – 7.34 (m, 5H), 5.17 (s, 2H), 4.43 (q, *J* = 7.1 Hz, 2H), 1.43 (t, *J* = 7.1 Hz, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$): δ 165.3, 143.2, 142.7, 135.6, 128.8, 128.5, 128.5, 127.6, 127.0, 121.3, 70.6, 61.6, 14.3.



2-(4-chlorophenyl)-4-methylquinazoline(3c)[6]. White solid. Yield: 65%. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.68 – 8.54 (m, 2H), 8.17 – 8.00 (m, 2H), 7.92 – 7.88 (m, 1H), 7.65 – 7.60 (m, 1H), 7.56 – 7.43 (m, 2H), 3.04 (s, 3H).



1-(4-chlorophenyl)-4-methylphthalazine(3d)[7]**.** Yellow solid. Yield: 48%. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.19 (d, *J* = 8.2 Hz, 1H), 8.04 (d, *J* = 8.2 Hz, 1H), 7.99 – 7.92 (m, 1H), 7.92 – 7.85 (m, 1H), 7.74 – 7.69 (m, 2H), 7.60 – 7.53 (m, 2H), 3.09 (s, 3H).

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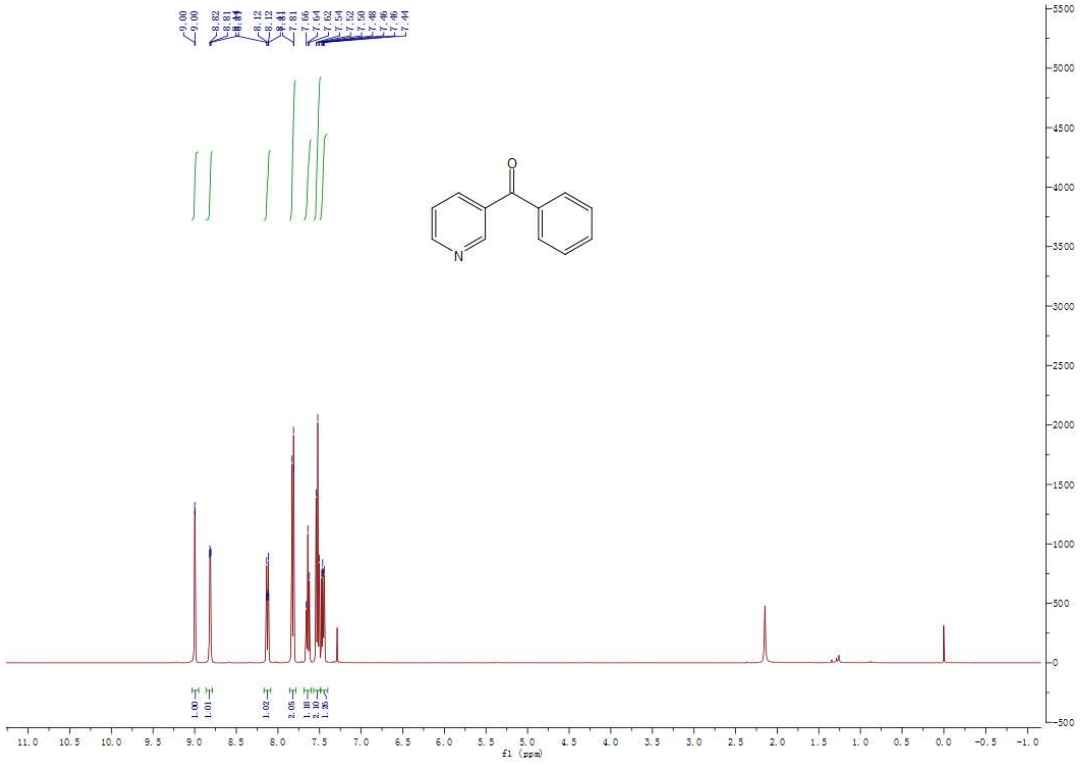
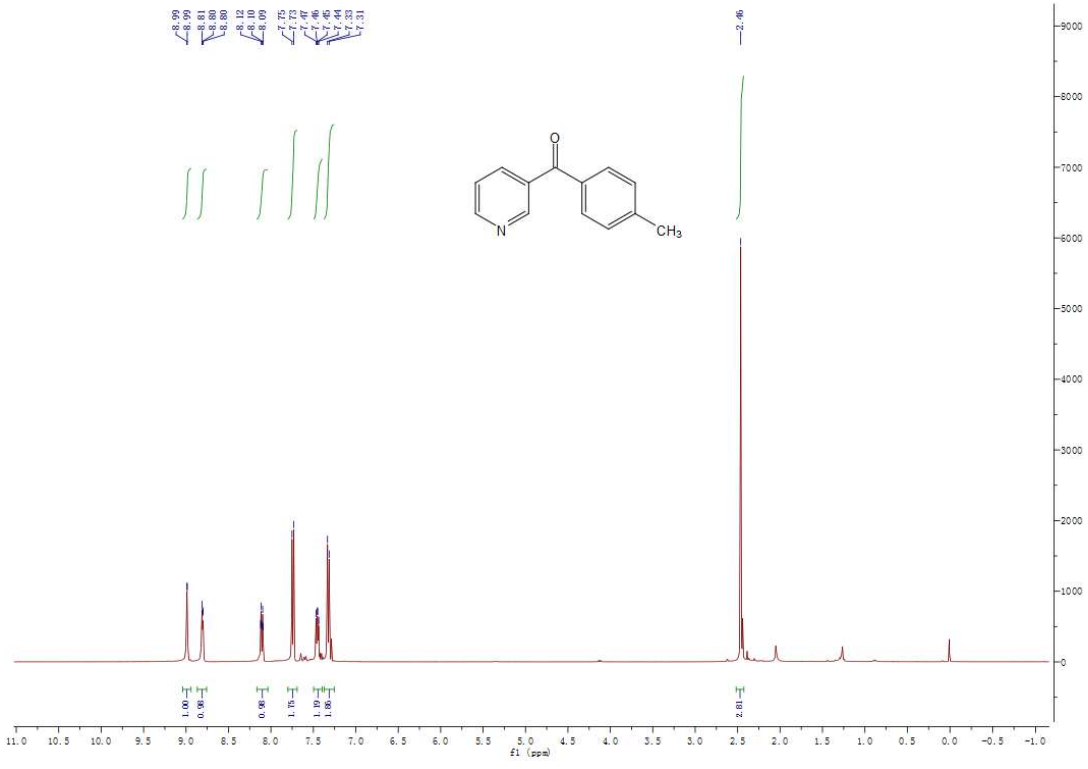
NMR Spectra

The NMR spectra of 1a



The NMR spectra of 1b



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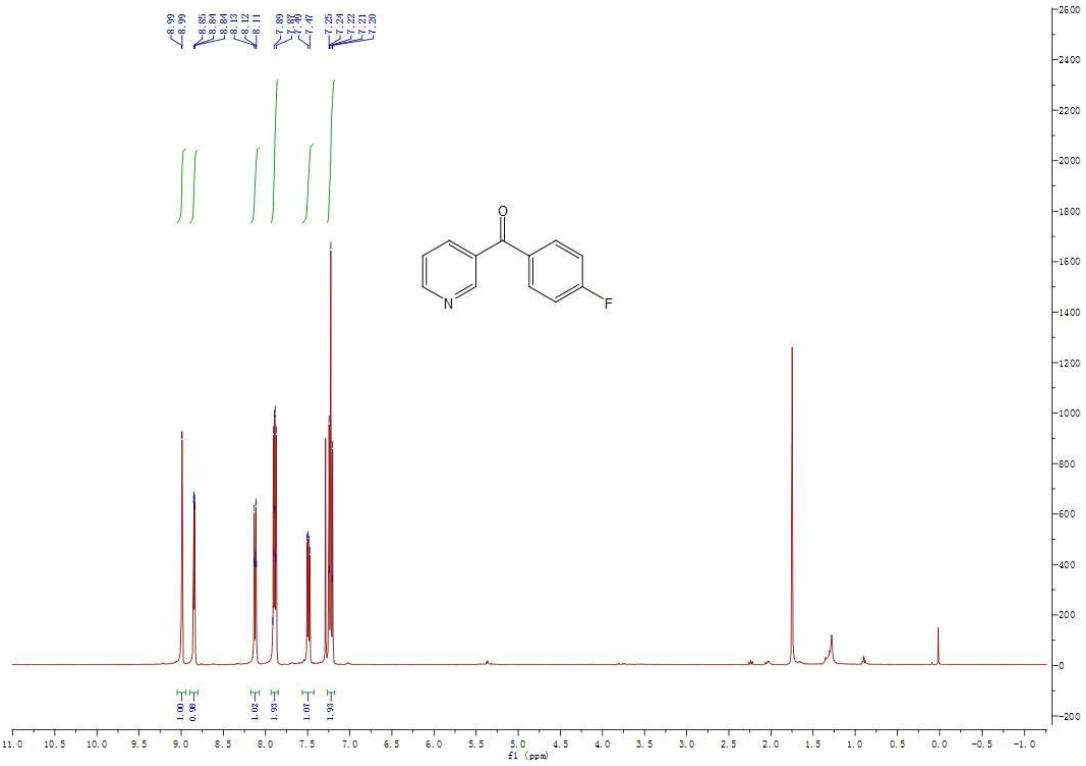

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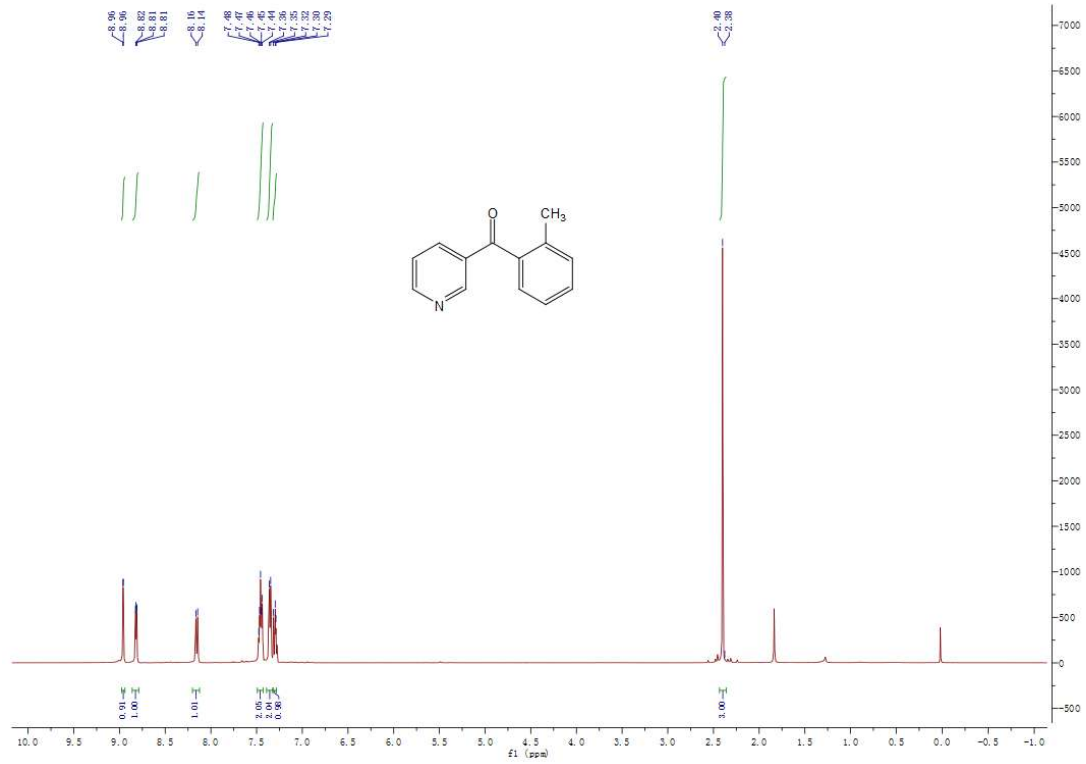

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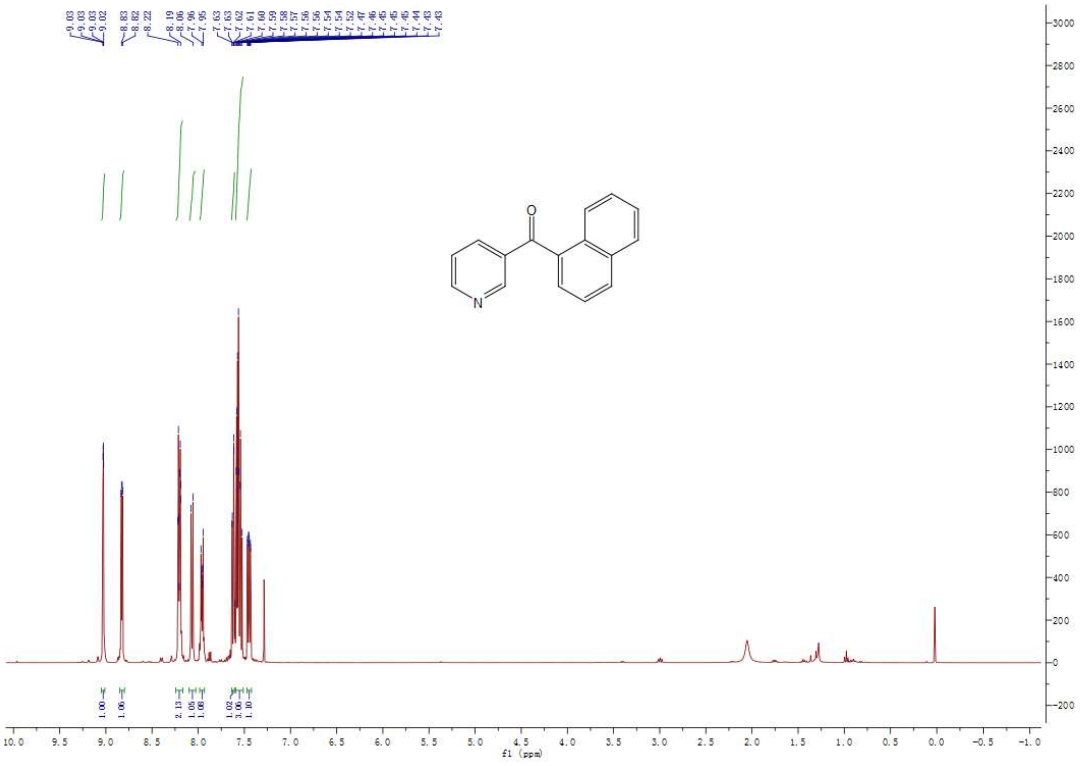

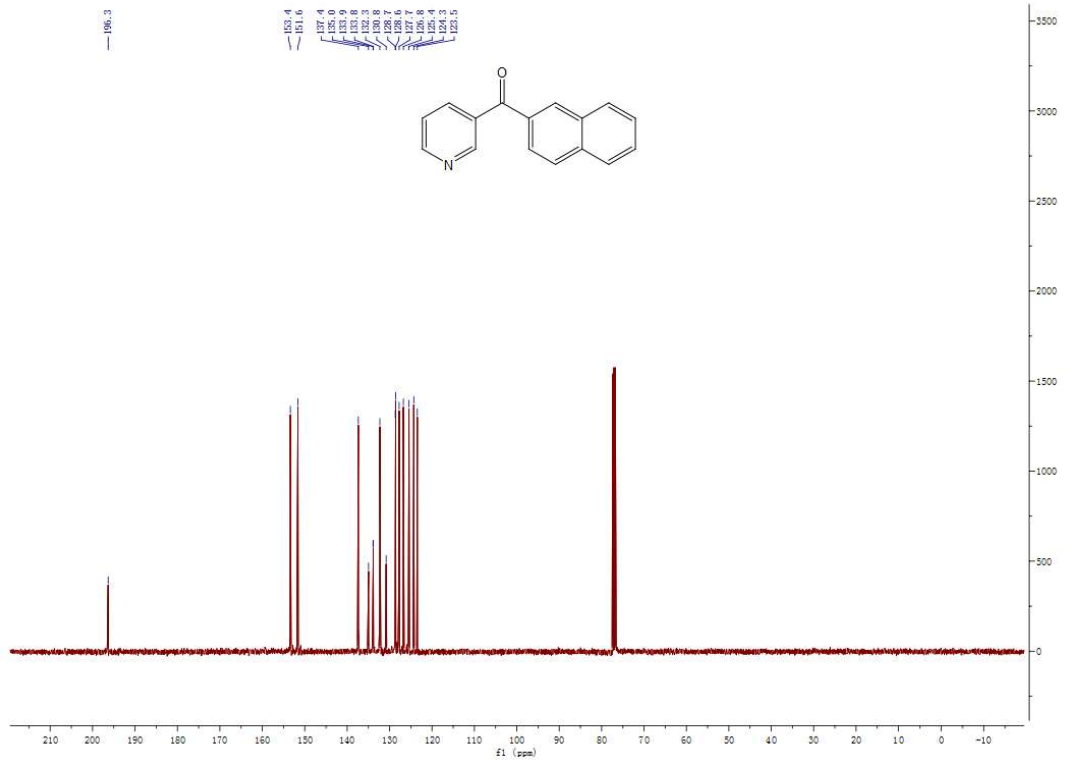

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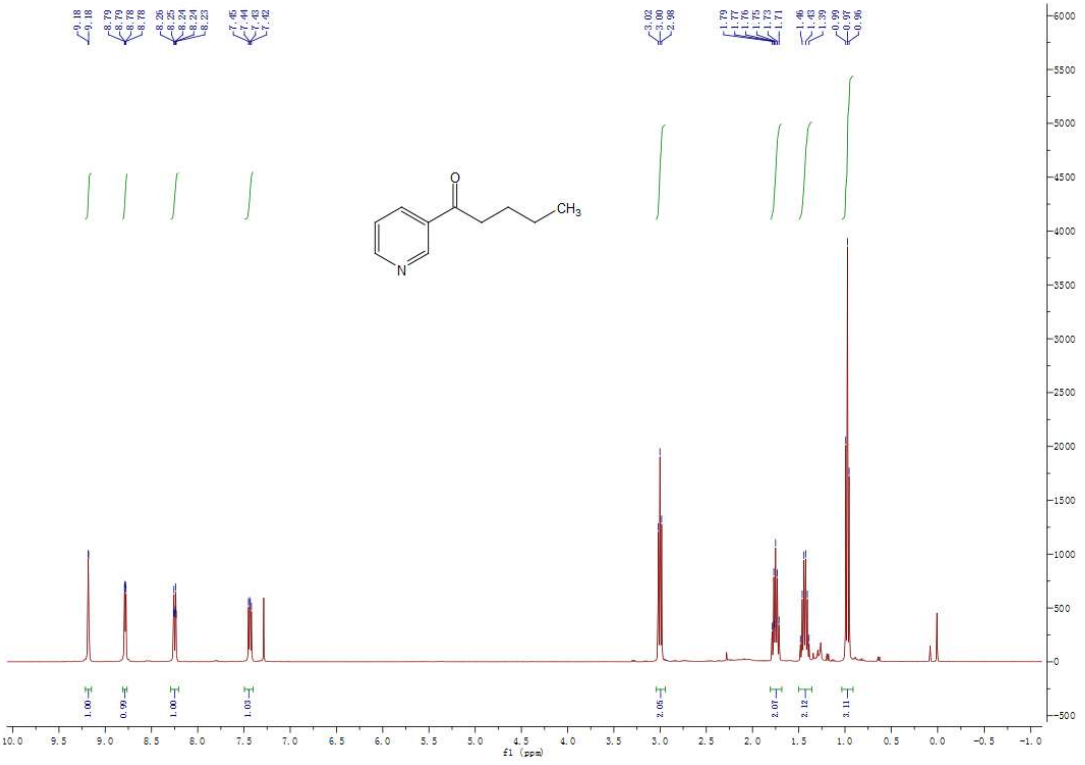

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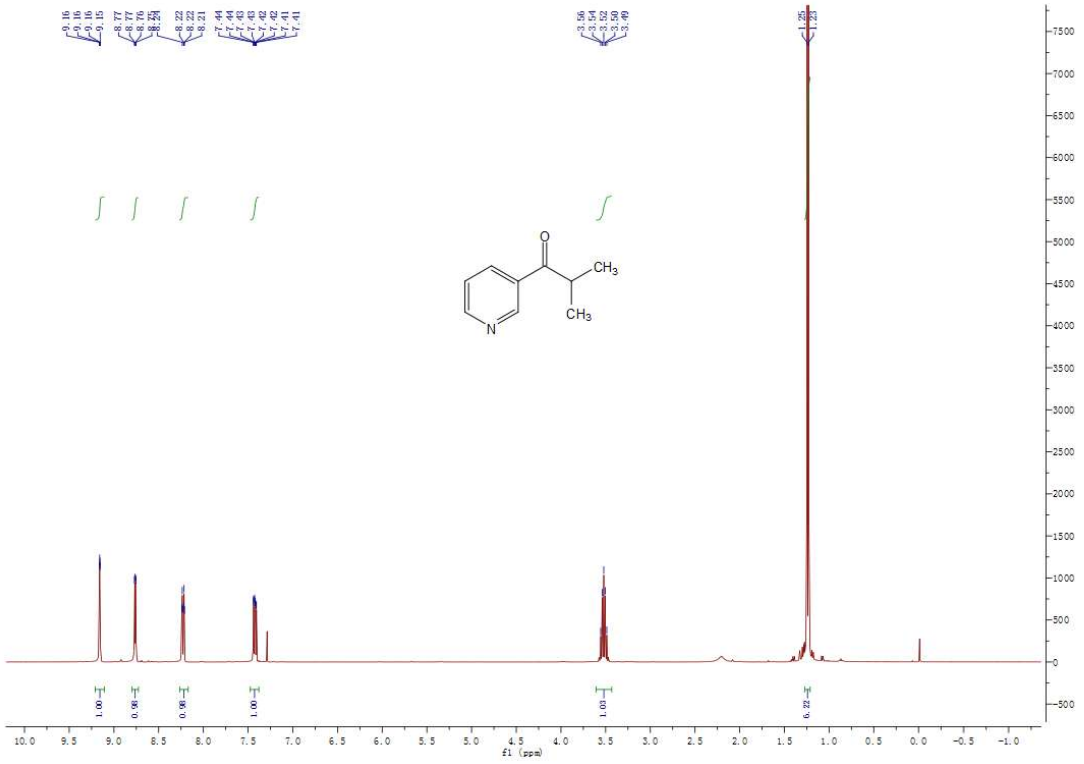
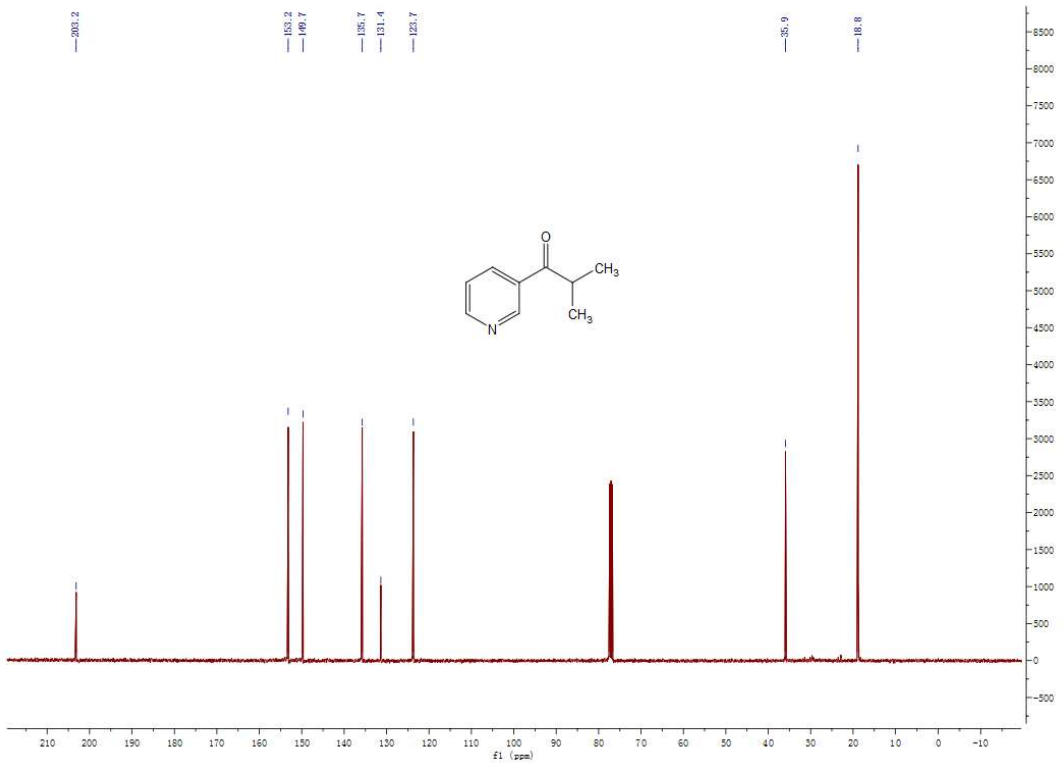
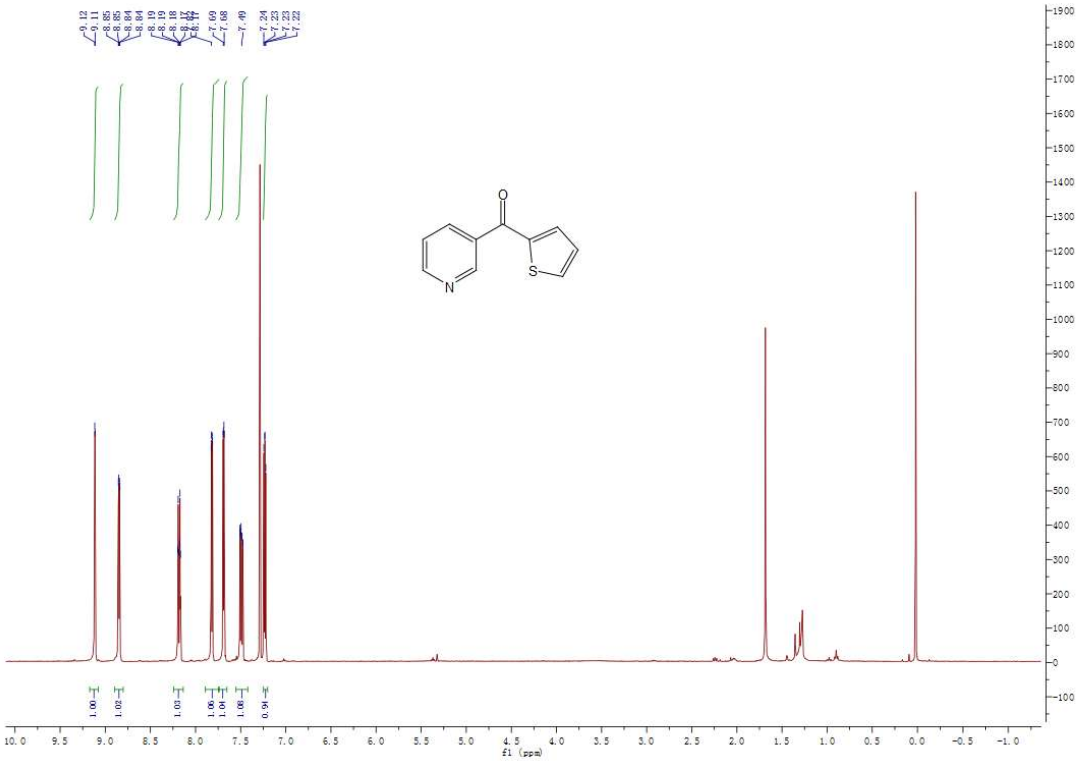
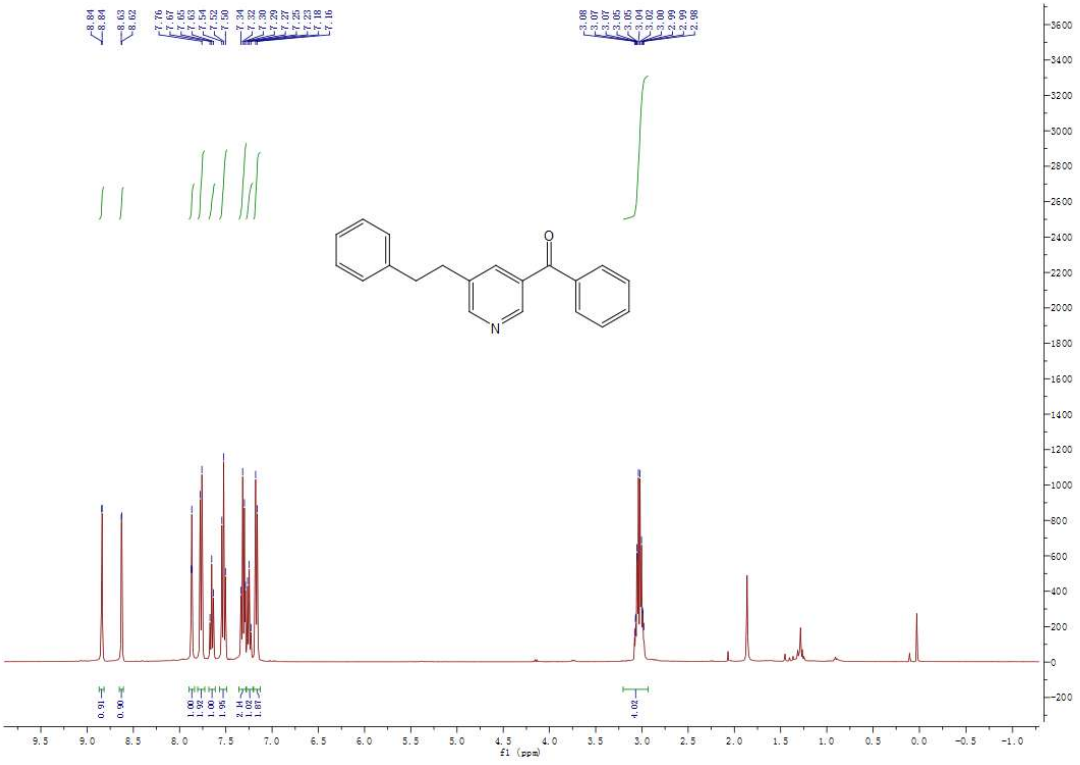


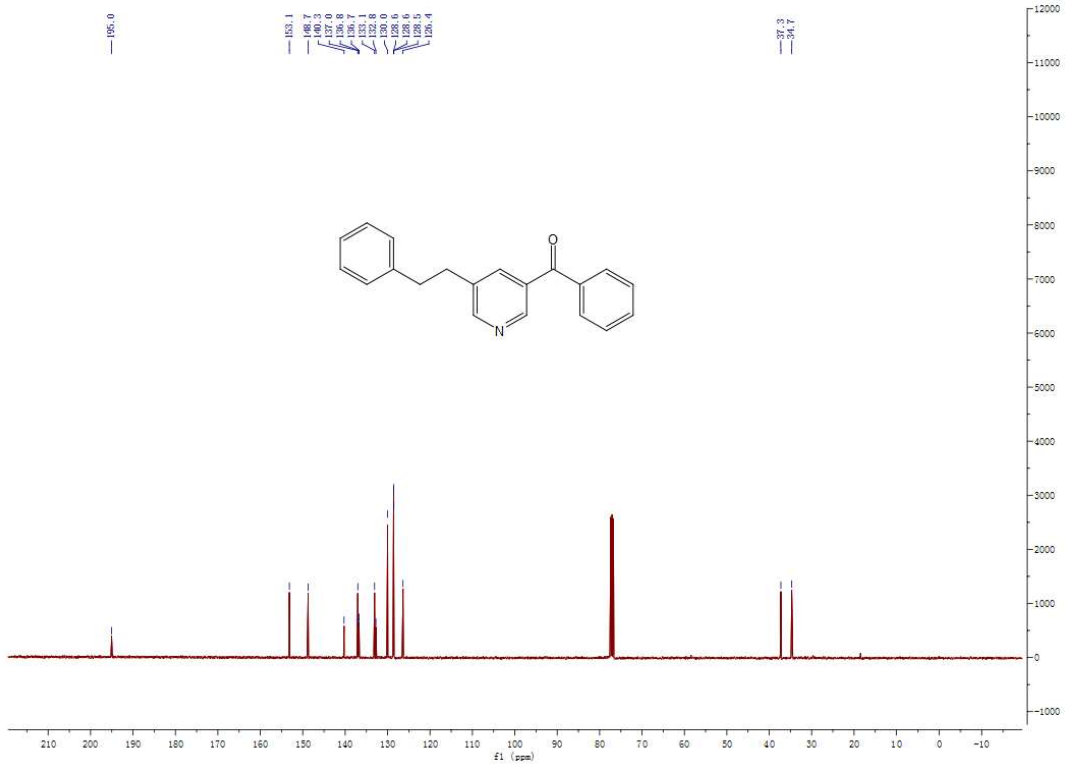


The NMR spectra of 1h

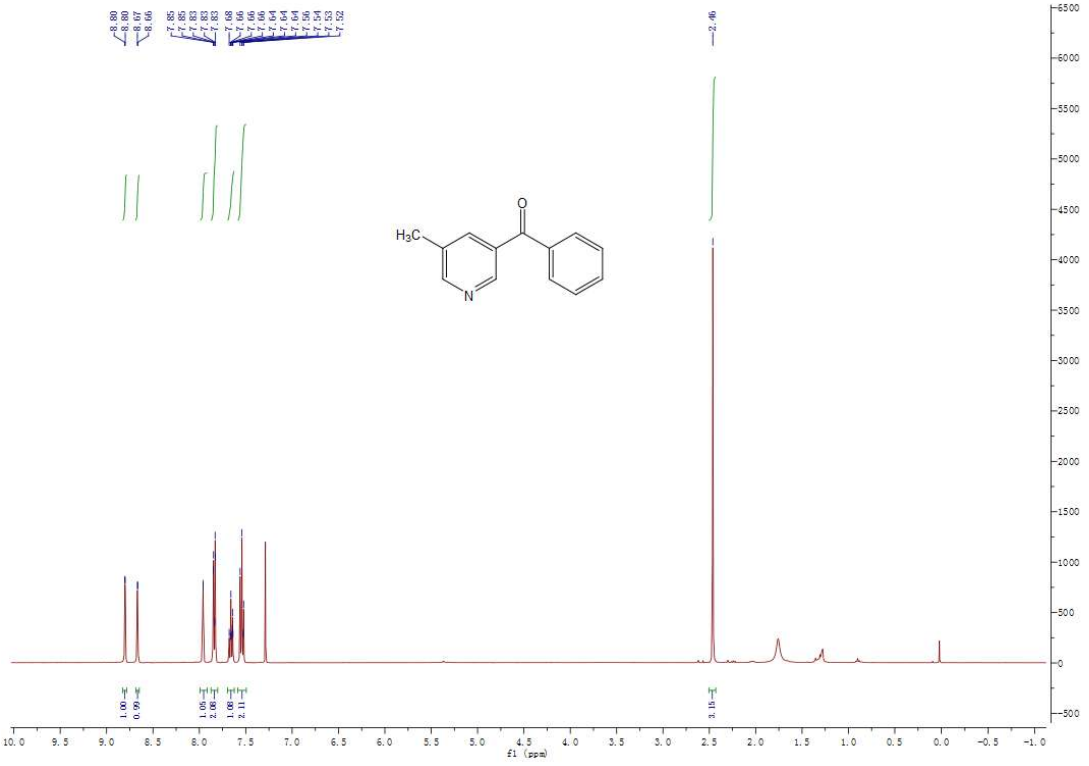


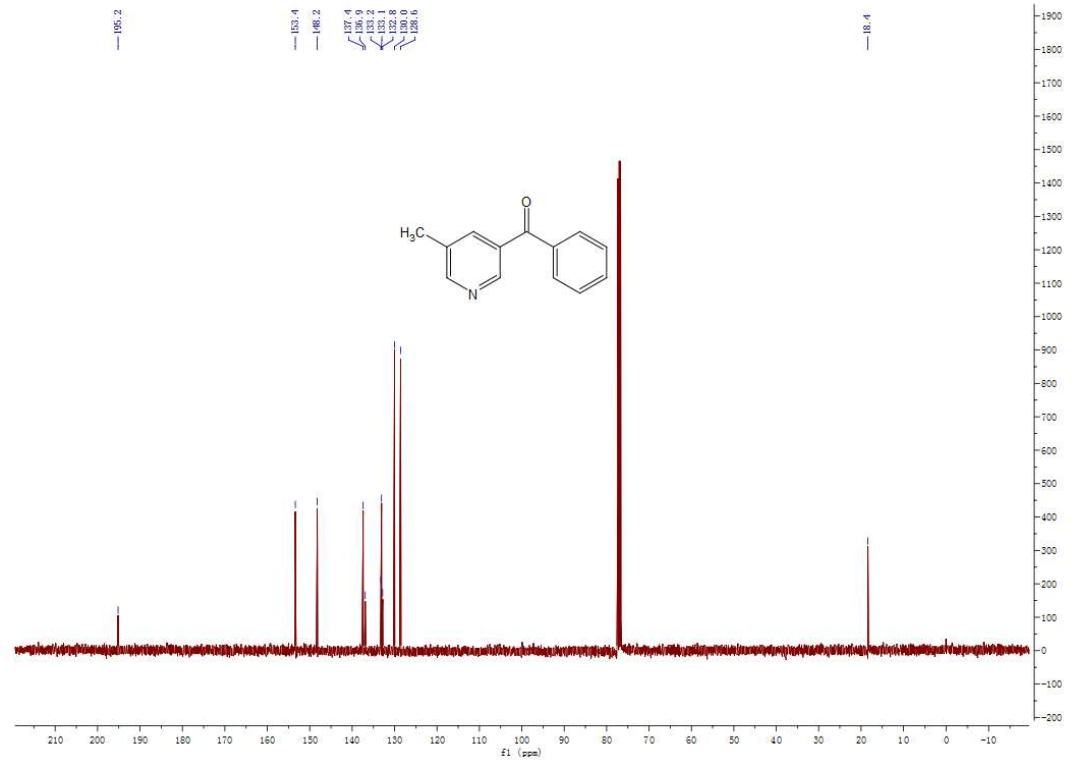
The NMR spectra of 1i



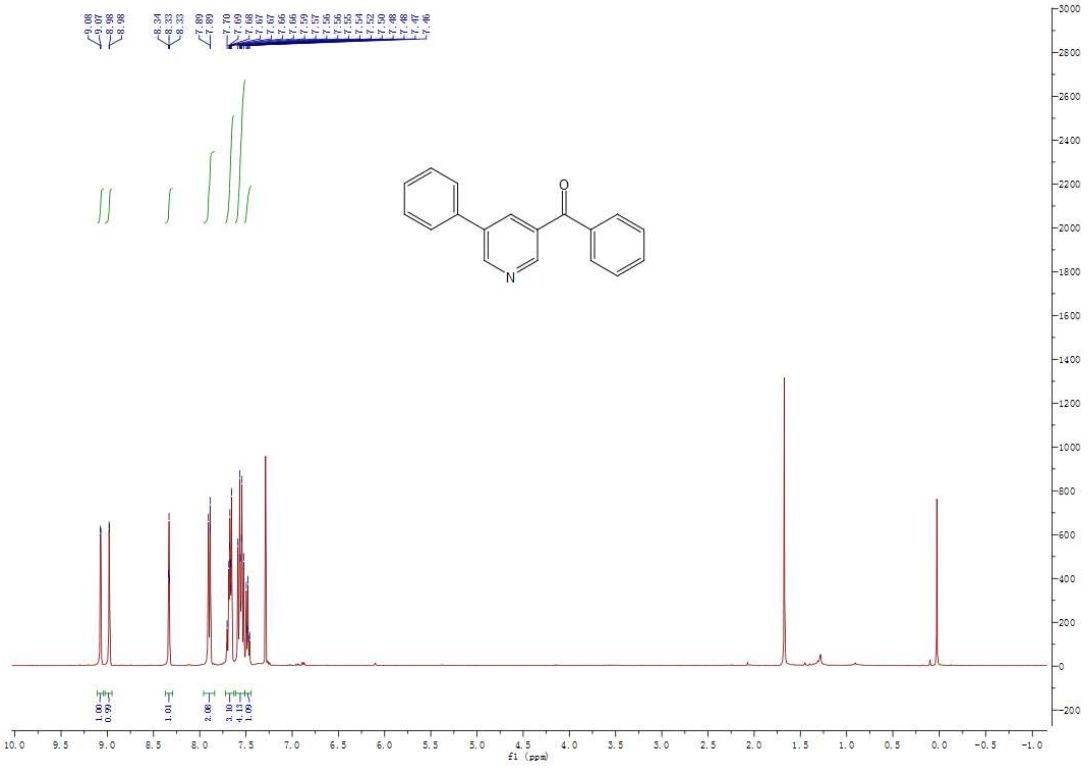


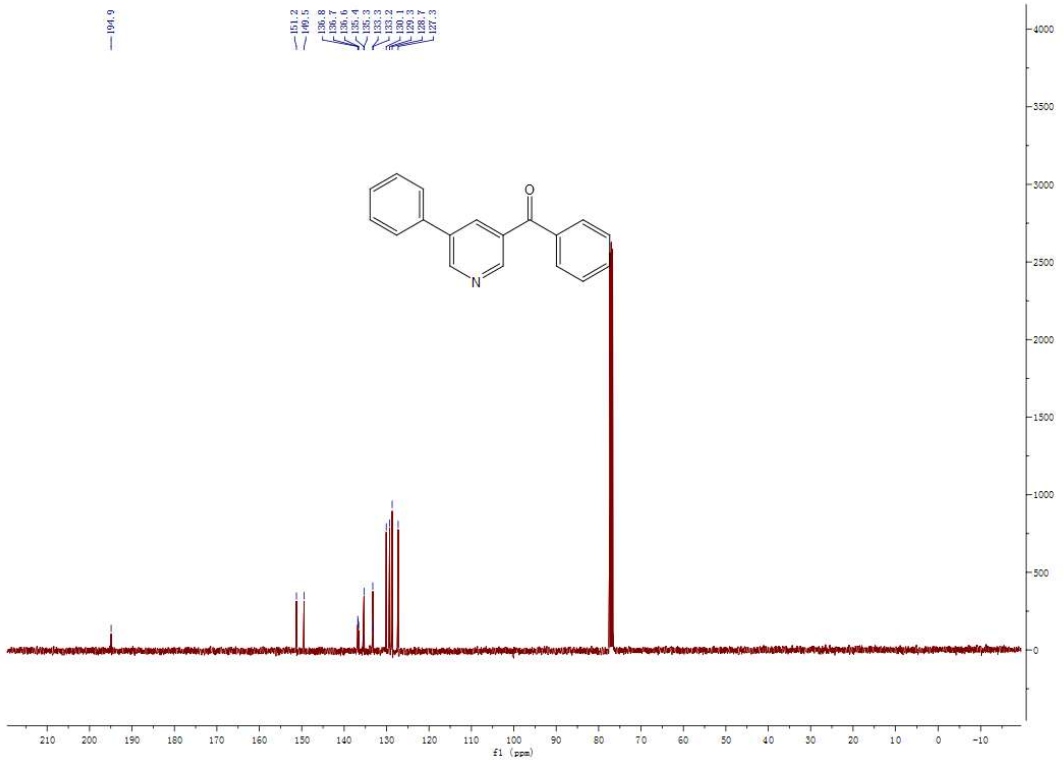
The NMR spectra of 1j



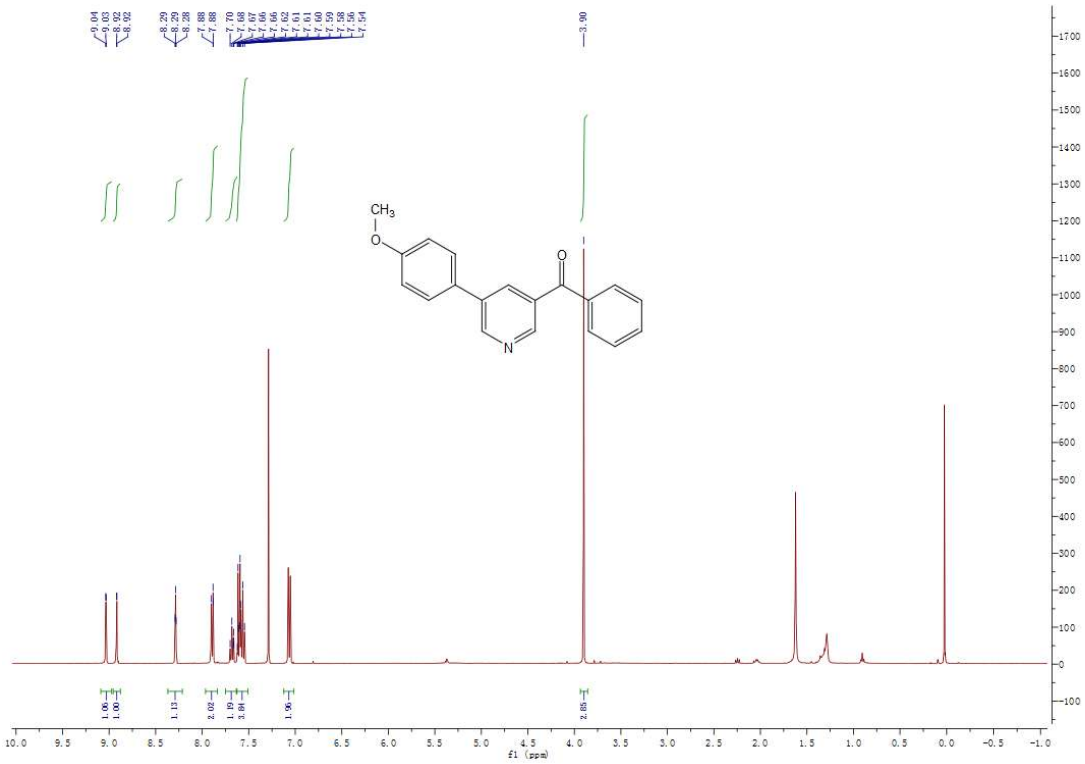


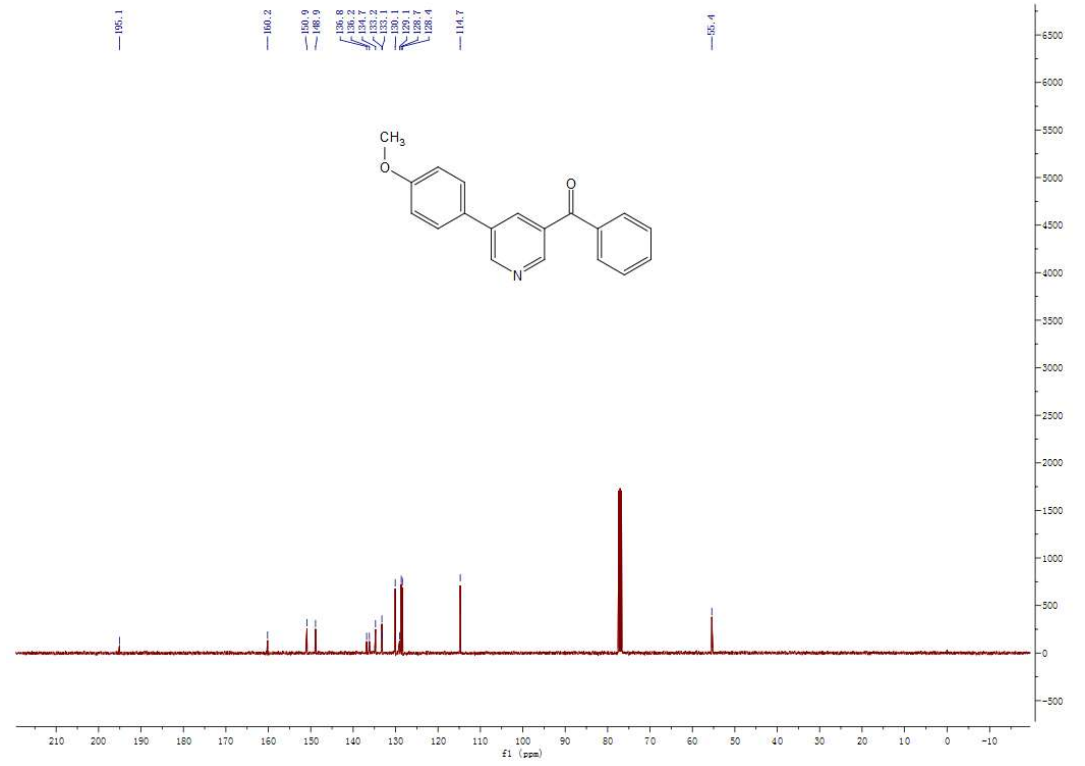
The NMR spectra of 1k



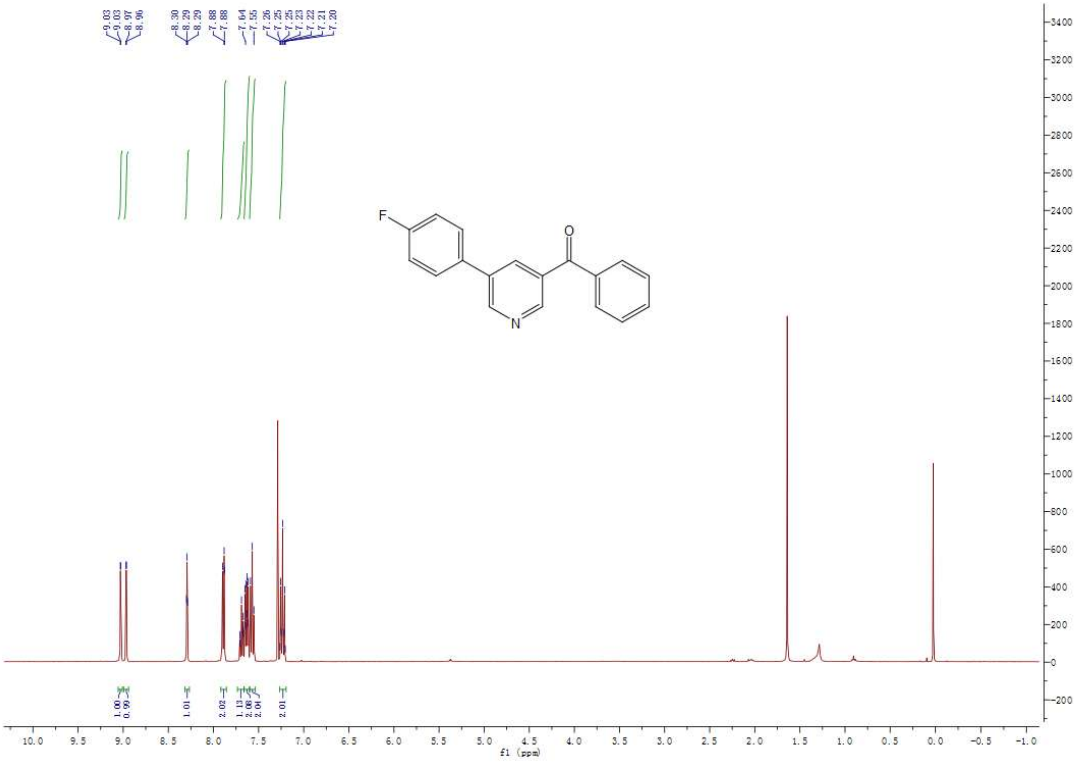


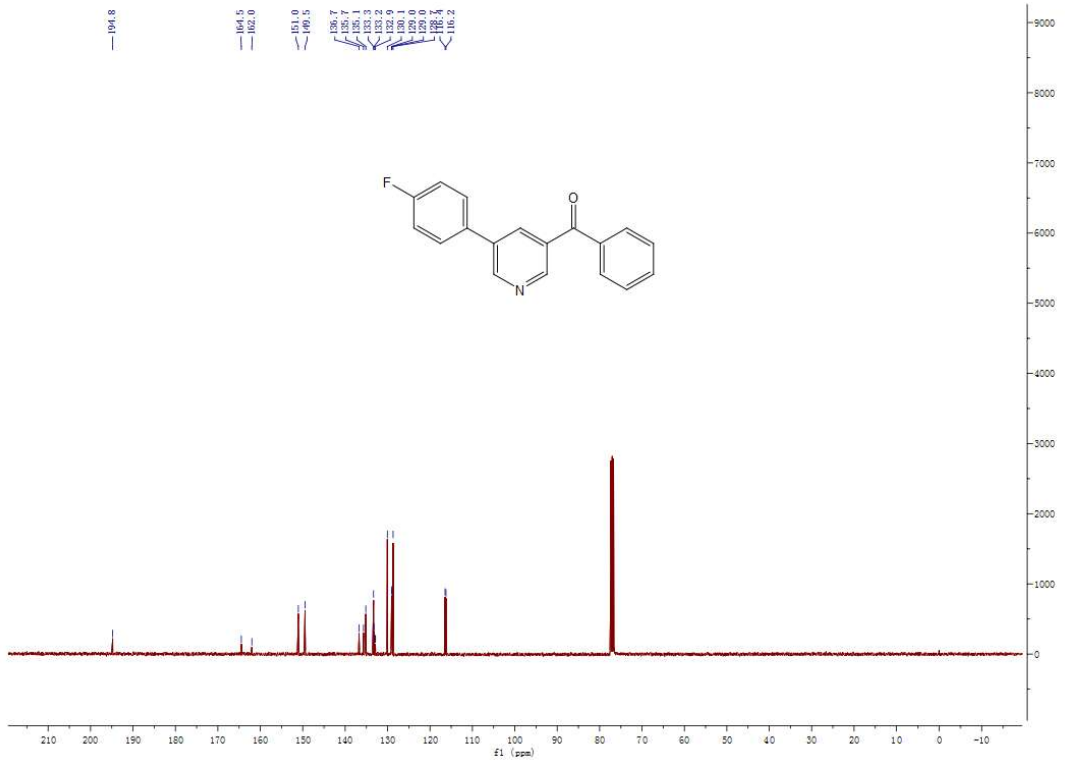
The NMR spectra of 1l



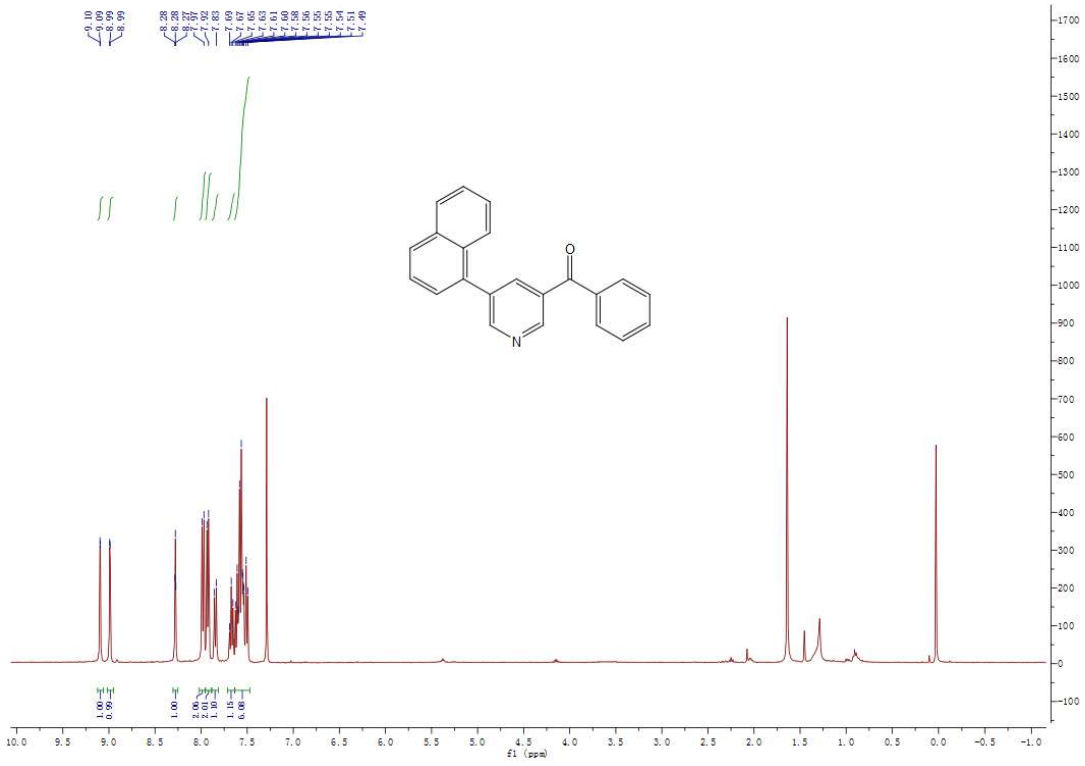


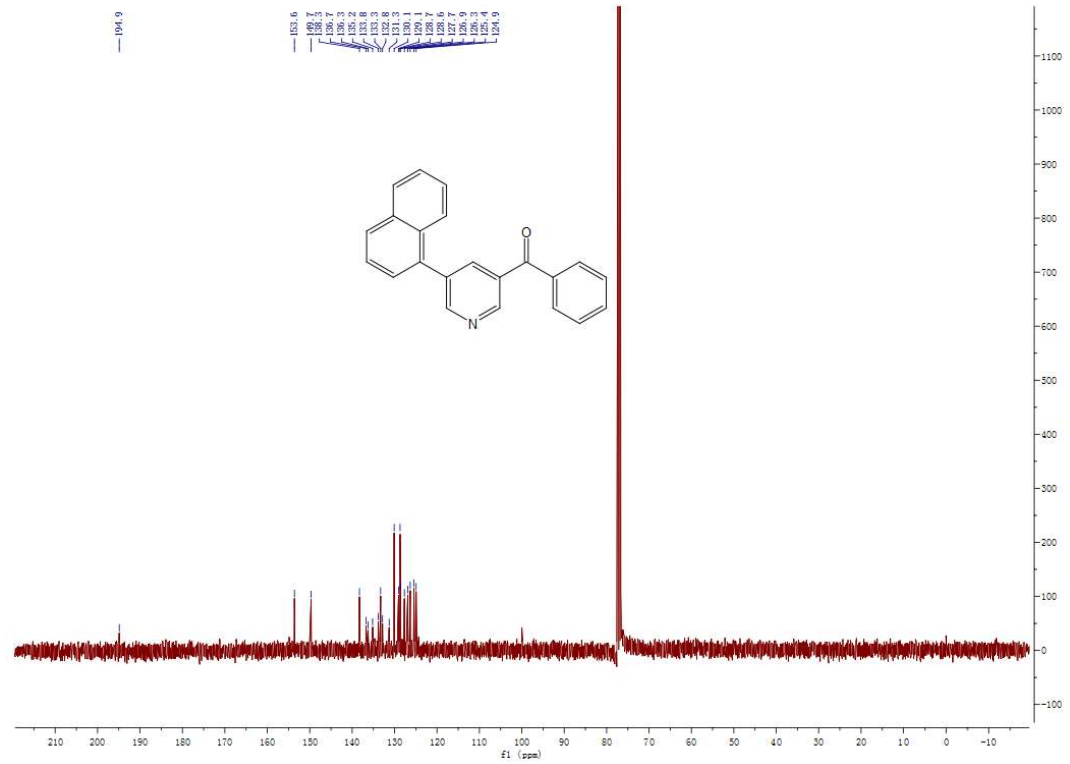
The NMR spectra of 1m



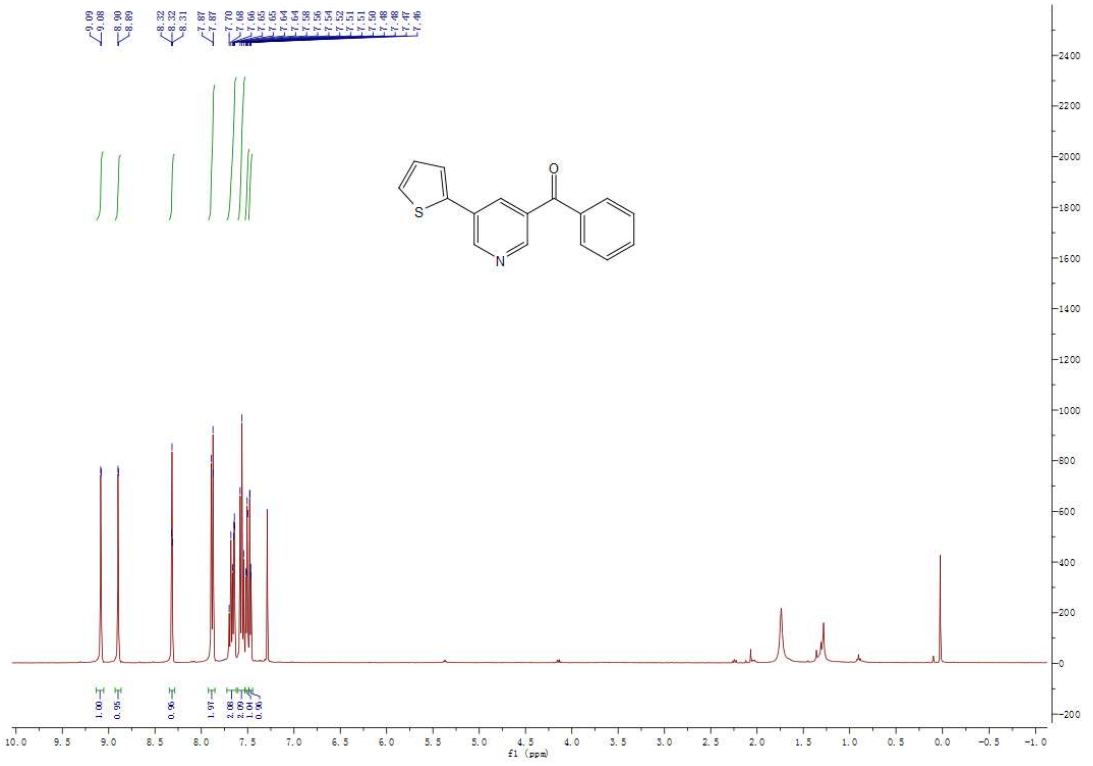


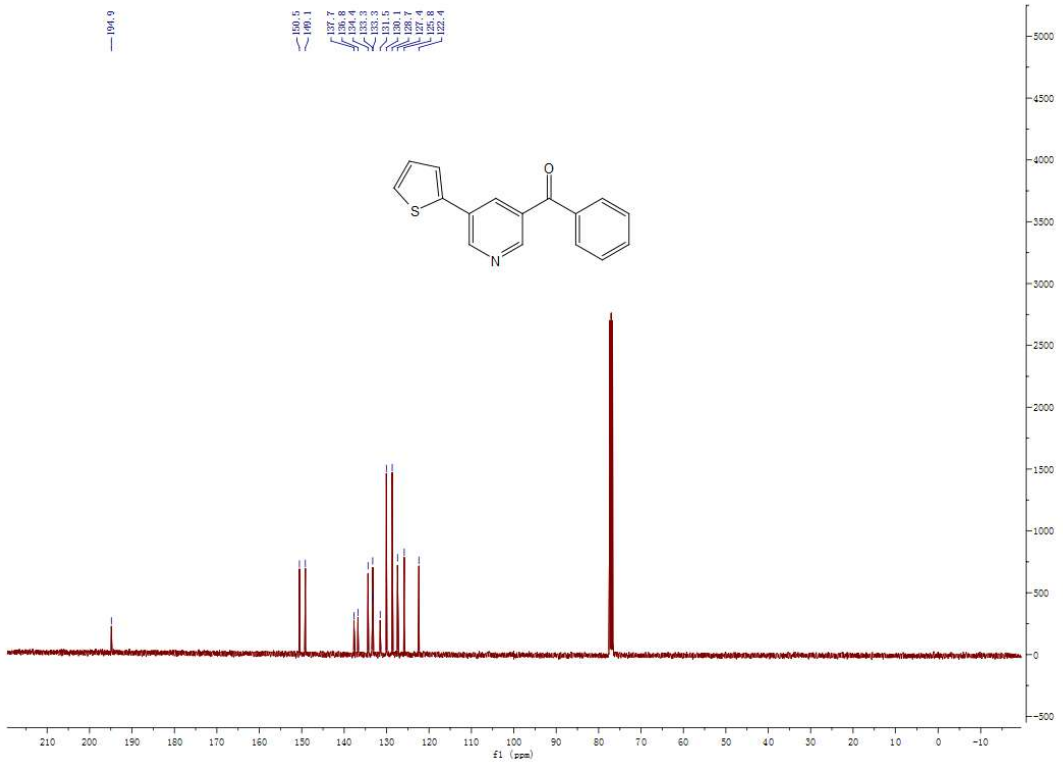
The NMR spectra of 1n



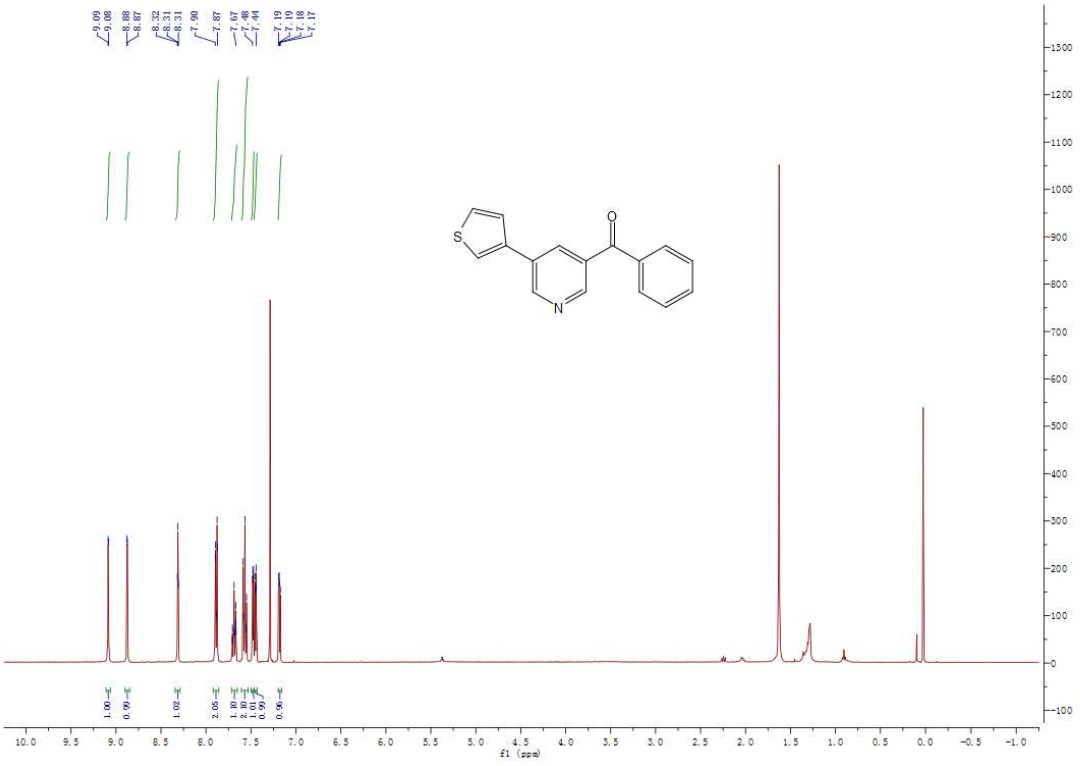


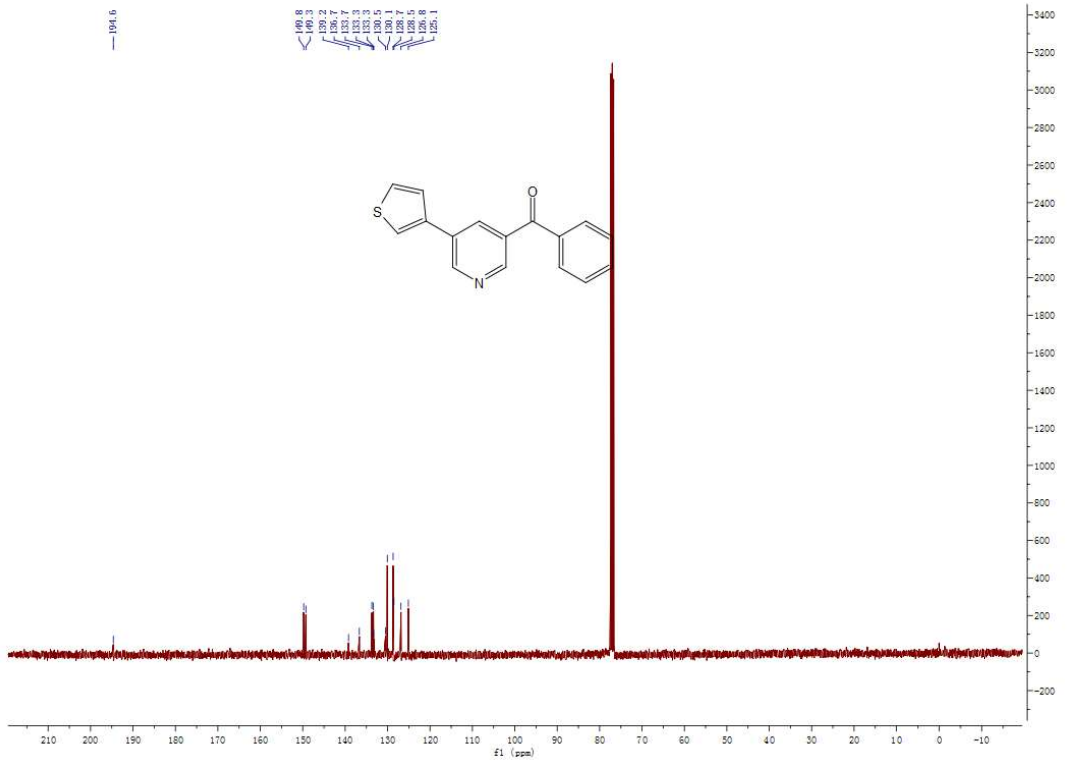
The NMR spectra of 1o



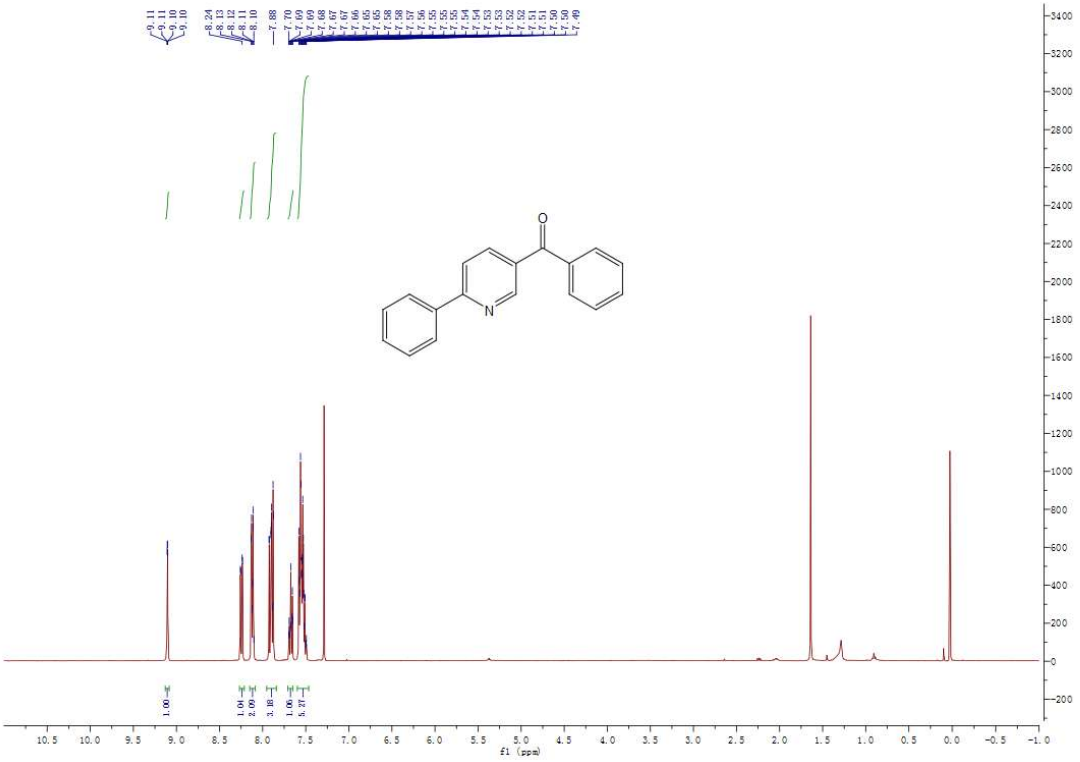


The NMR spectra of 1p

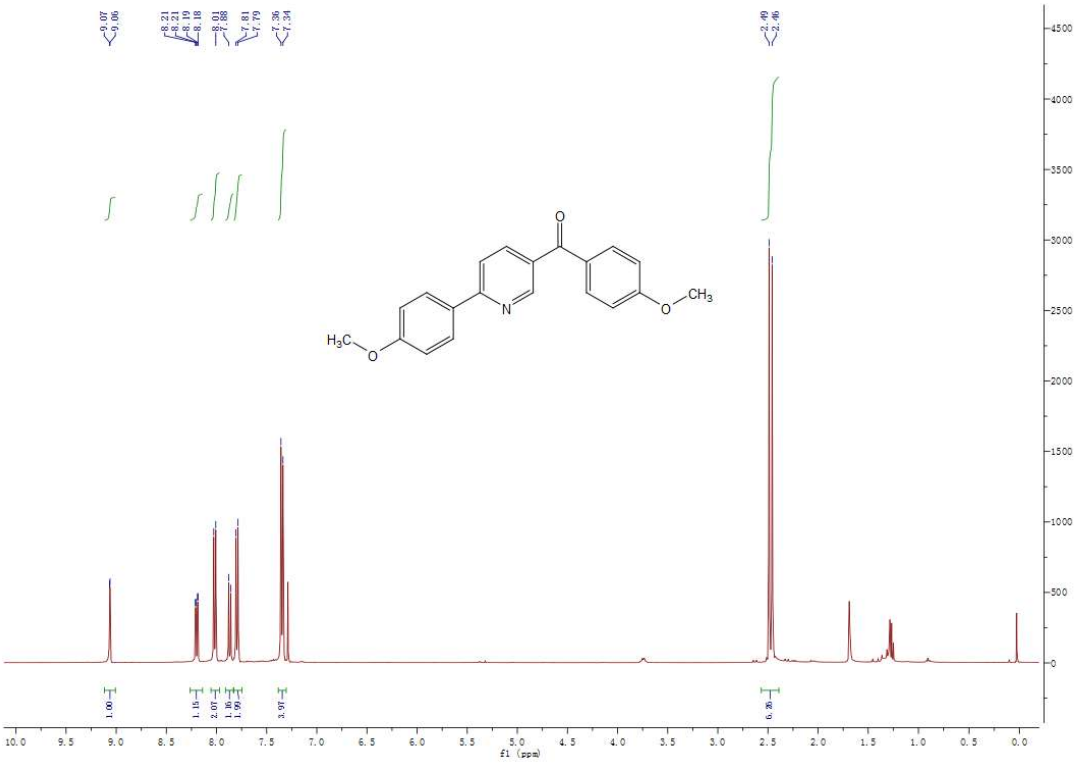


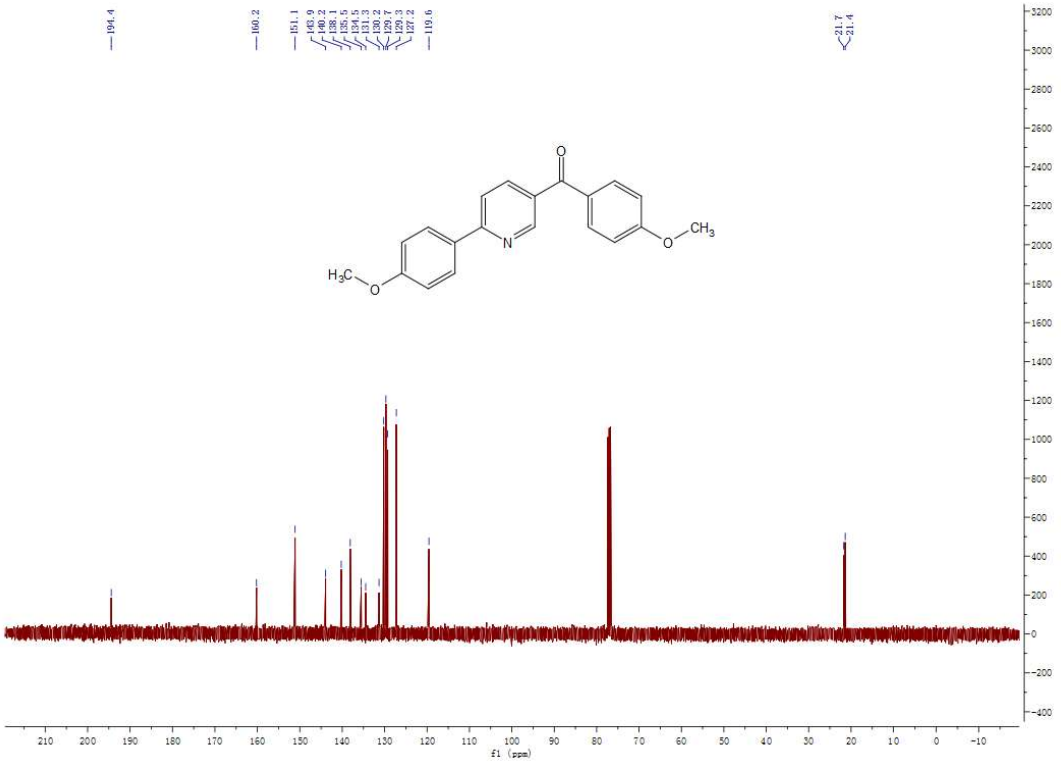


The NMR spectra of 1q

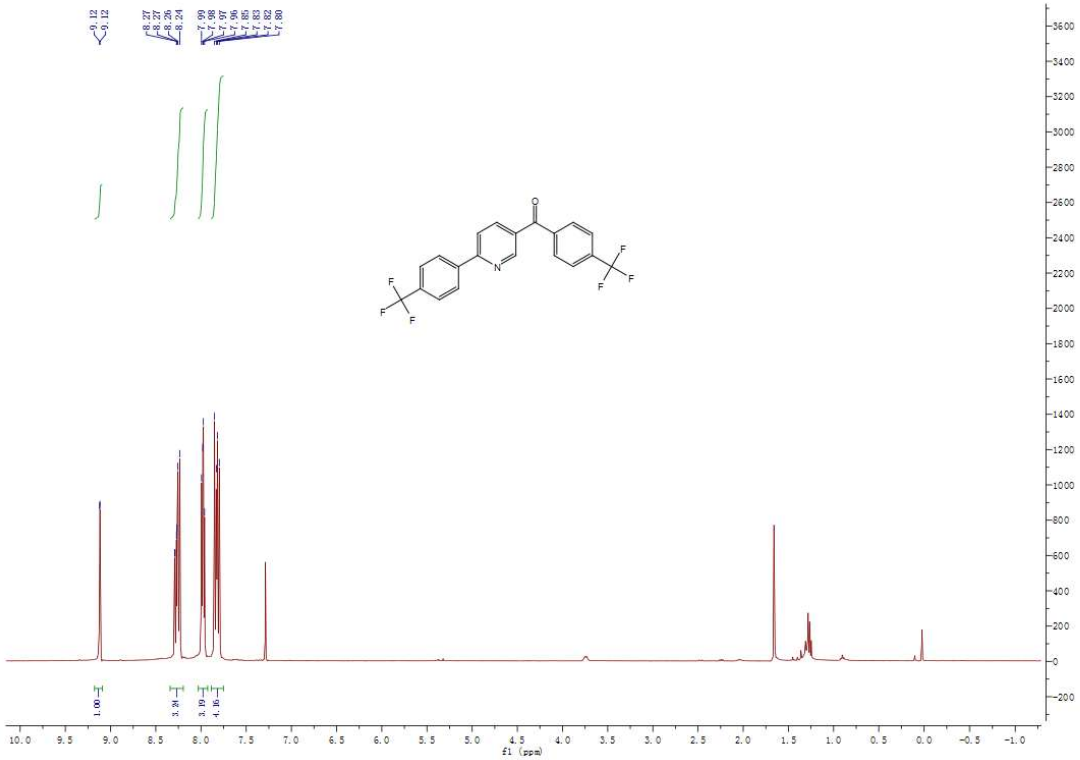


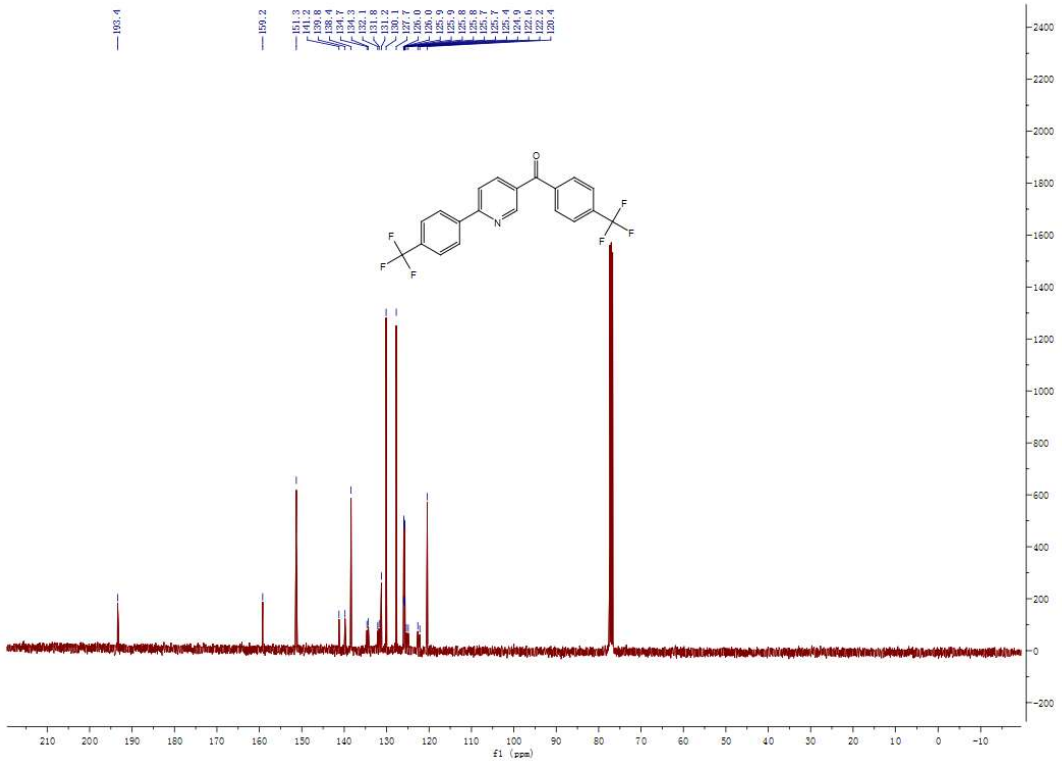
The NMR spectra of 1r



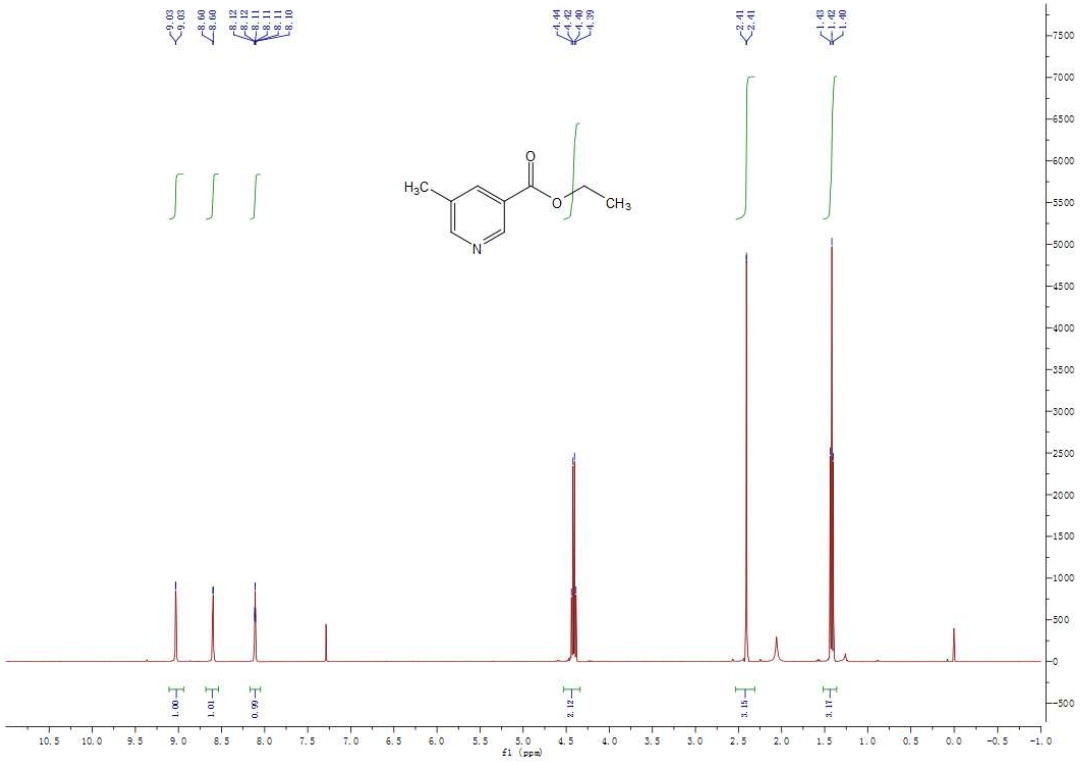


The NMR spectra of 1s

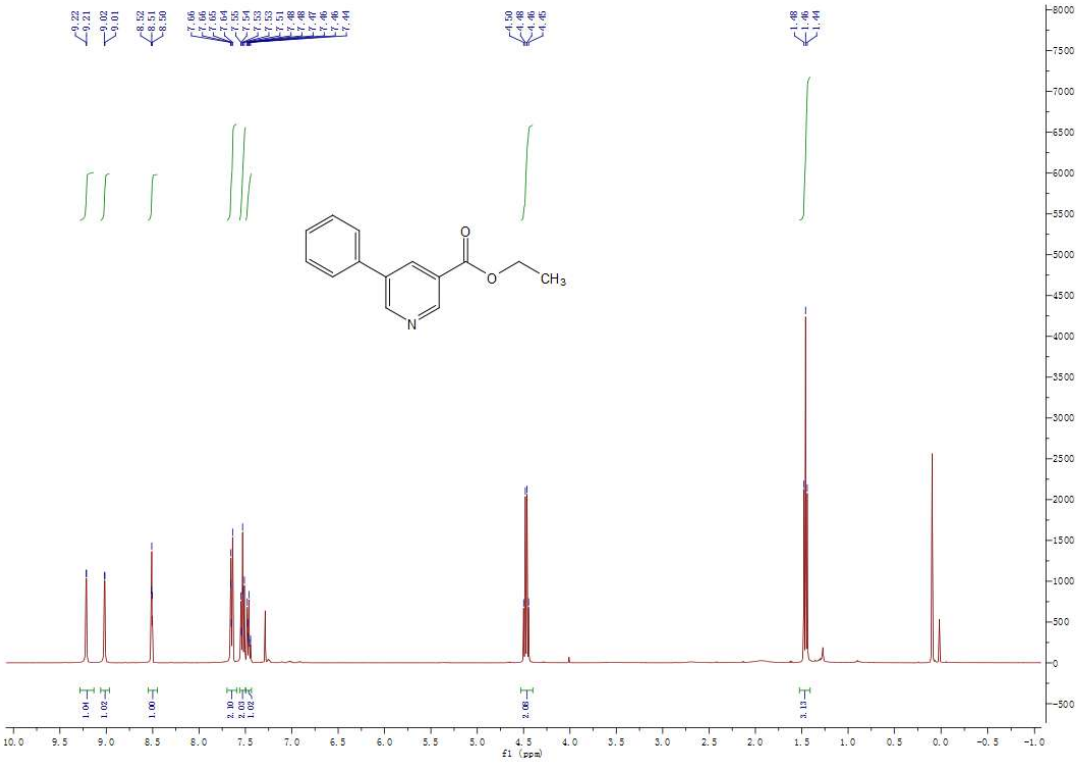




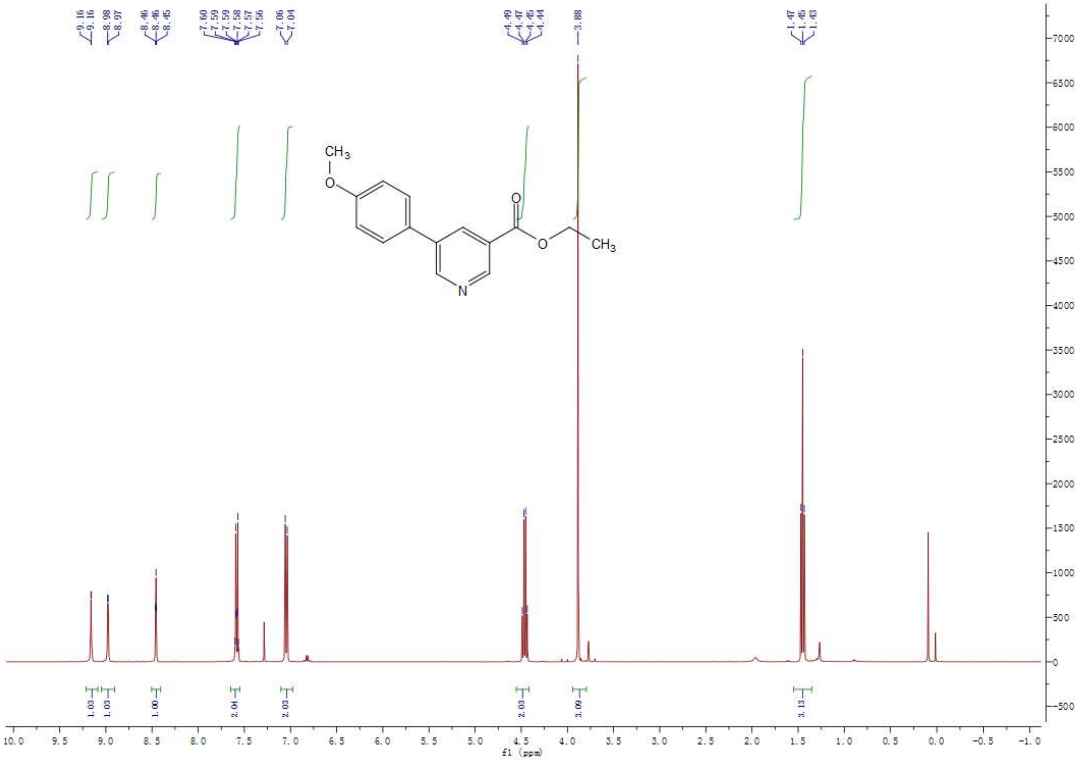
The NMR spectra of 1u

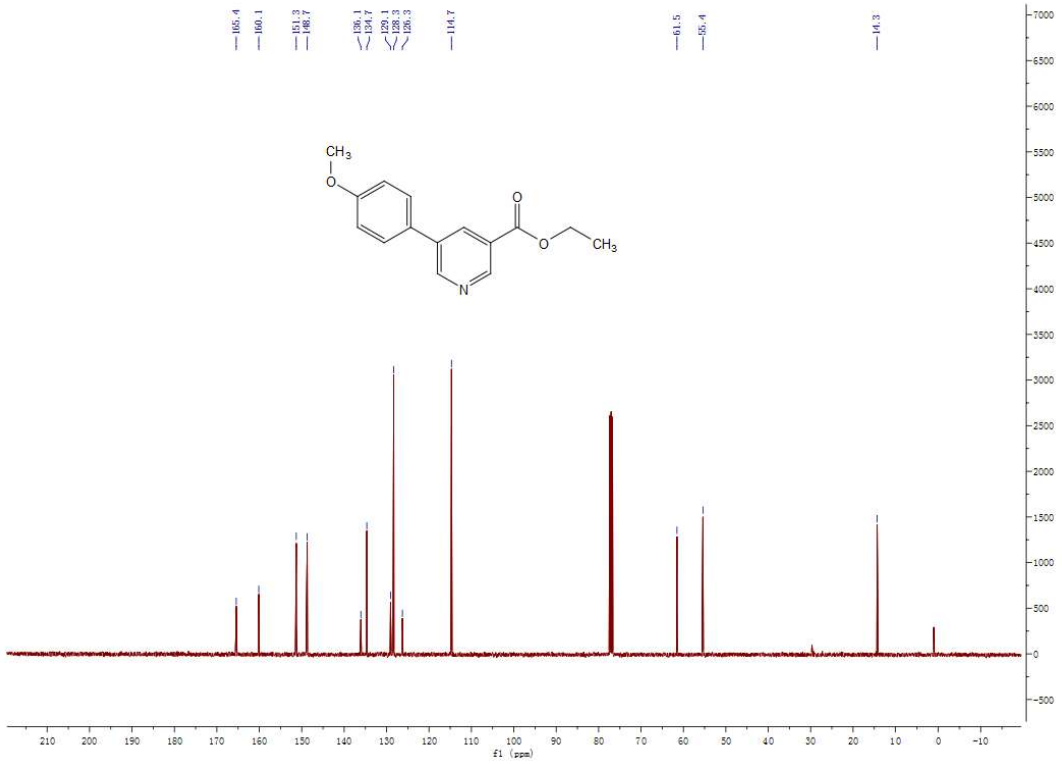


The NMR spectra of 1v

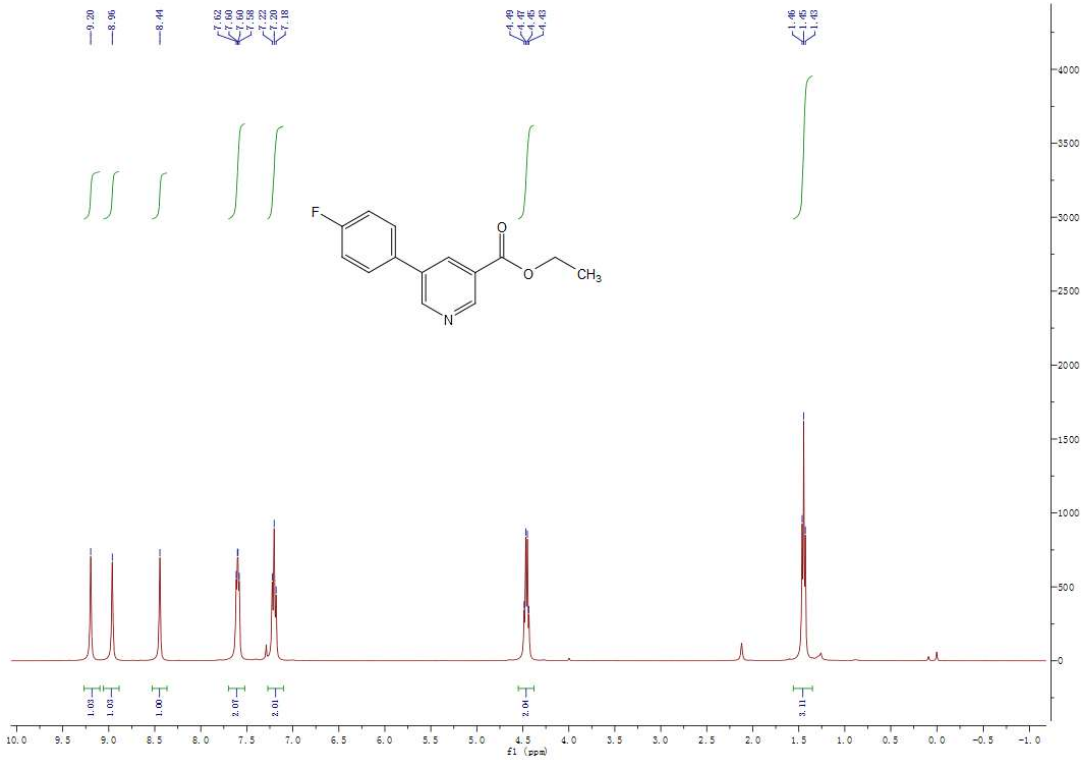


The NMR spectra of 1w

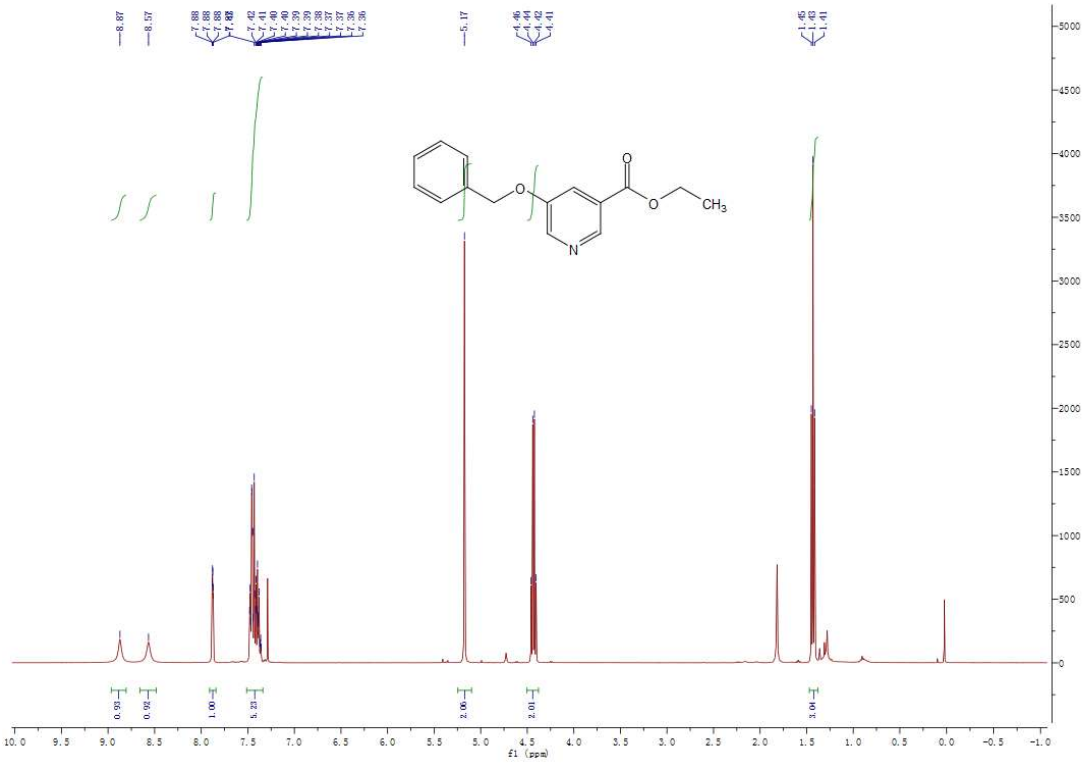


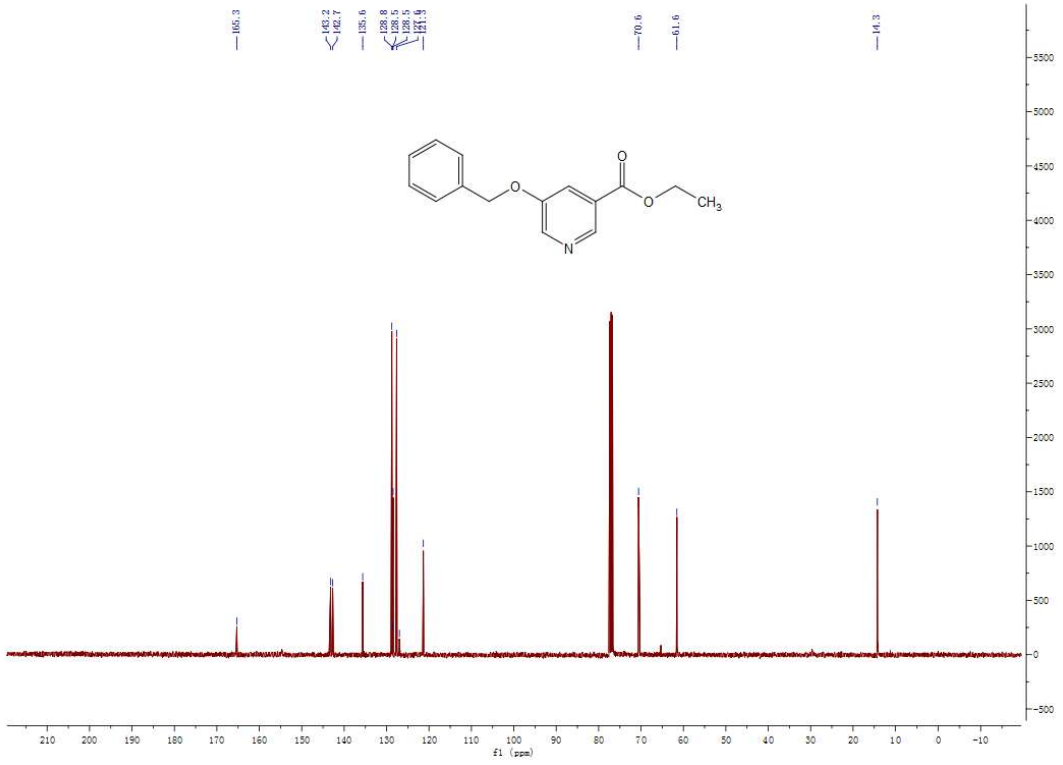


The NMR spectra of 1x

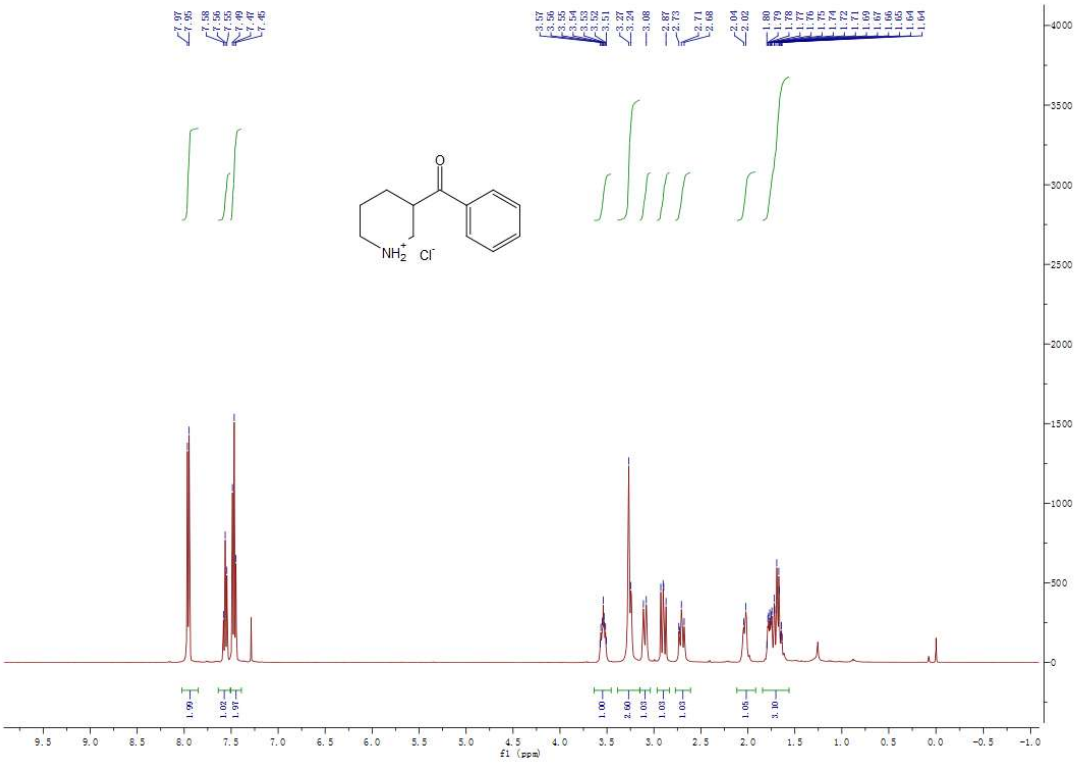


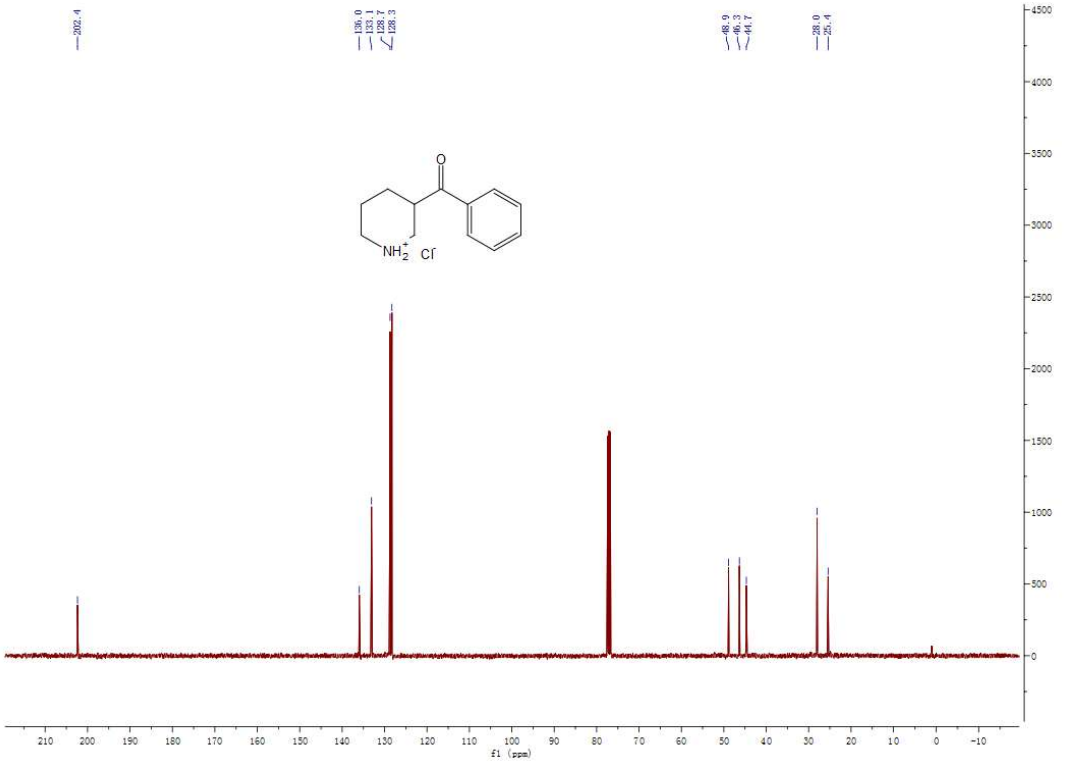
The NMR spectra of 1y



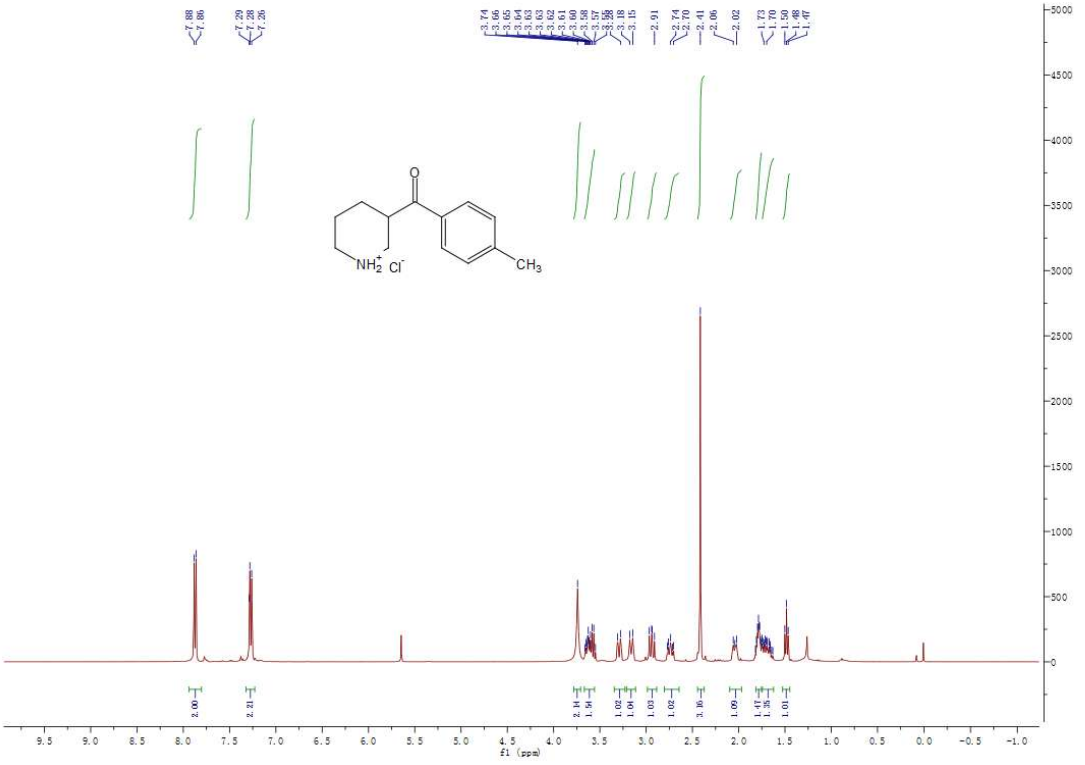


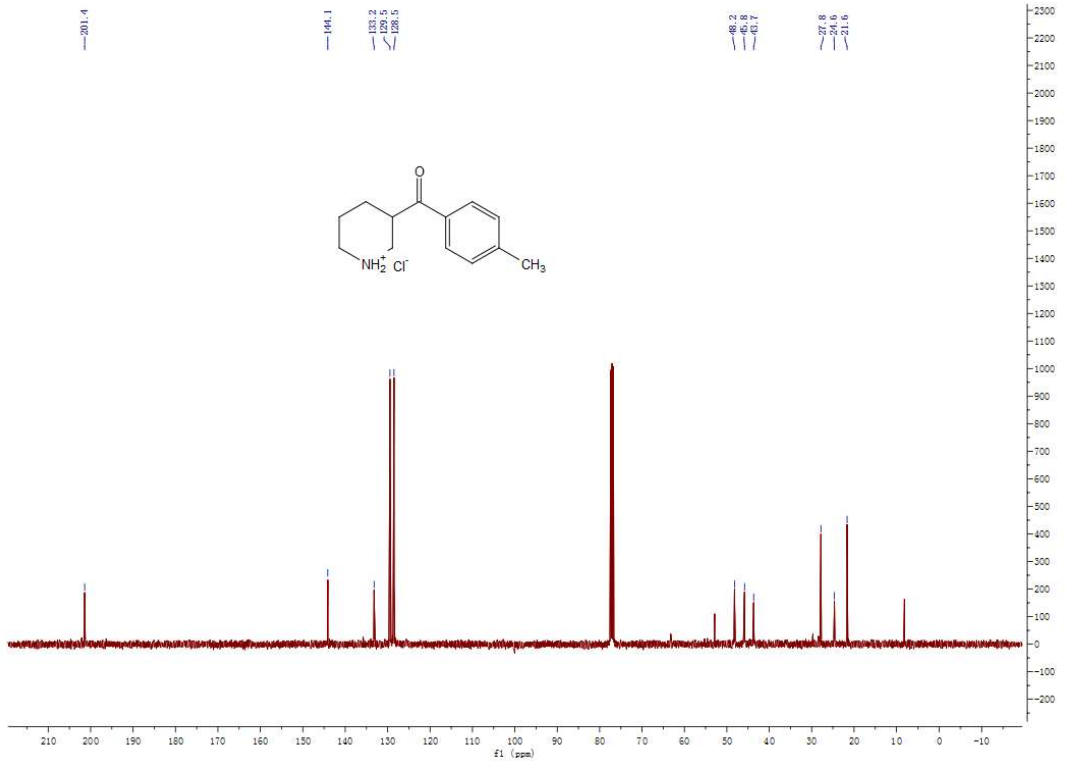
The NMR spectra of 2a



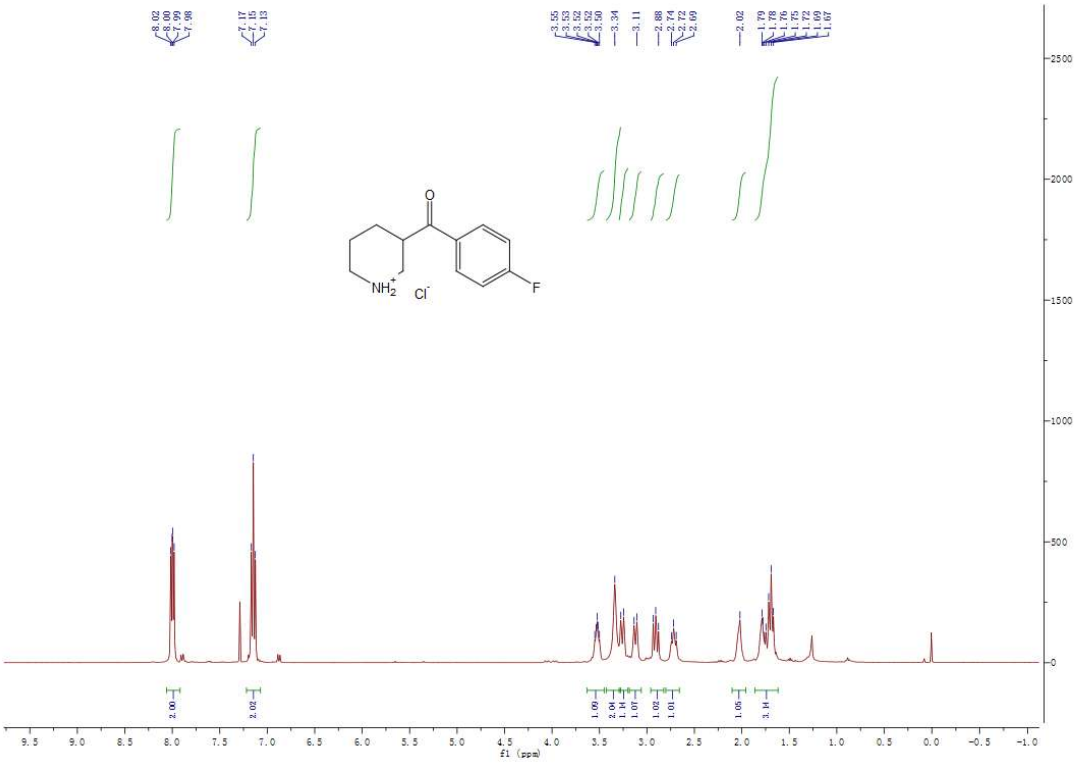


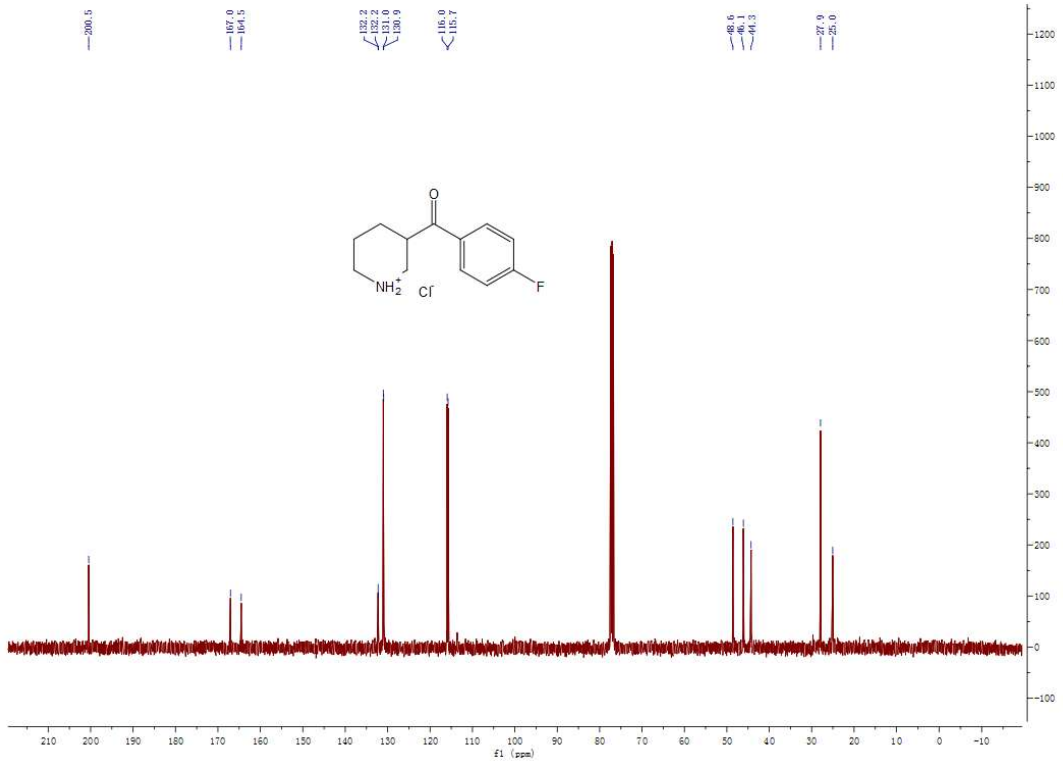
The NMR spectra of 2b



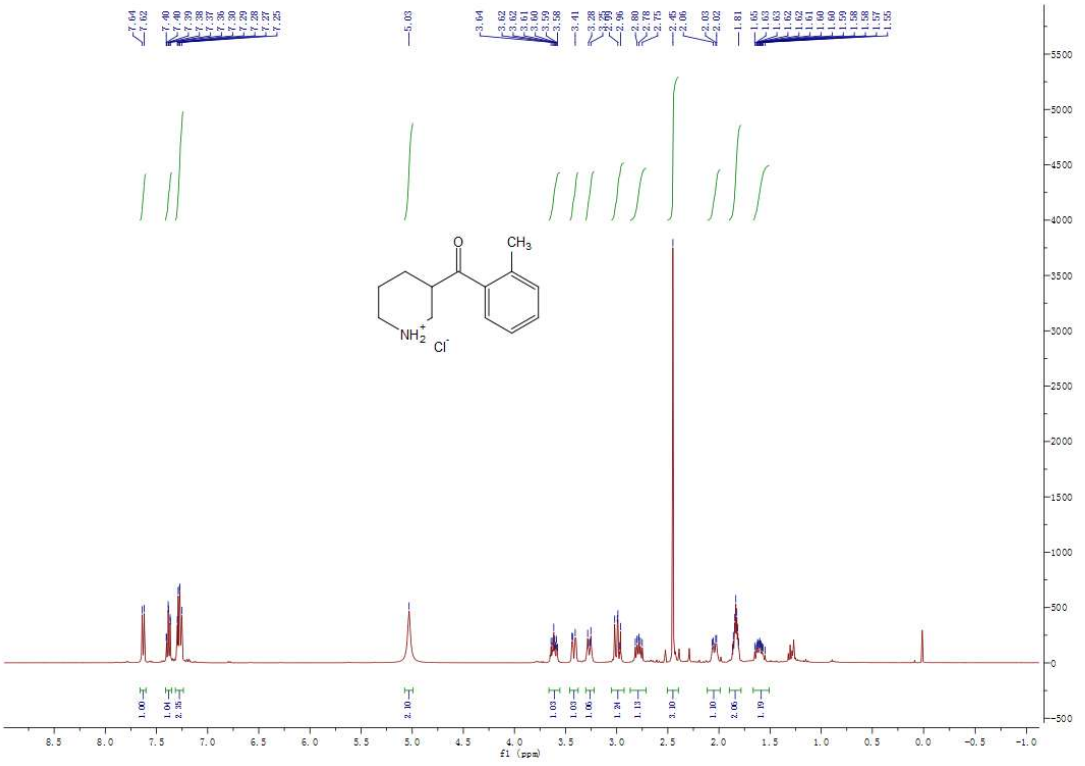


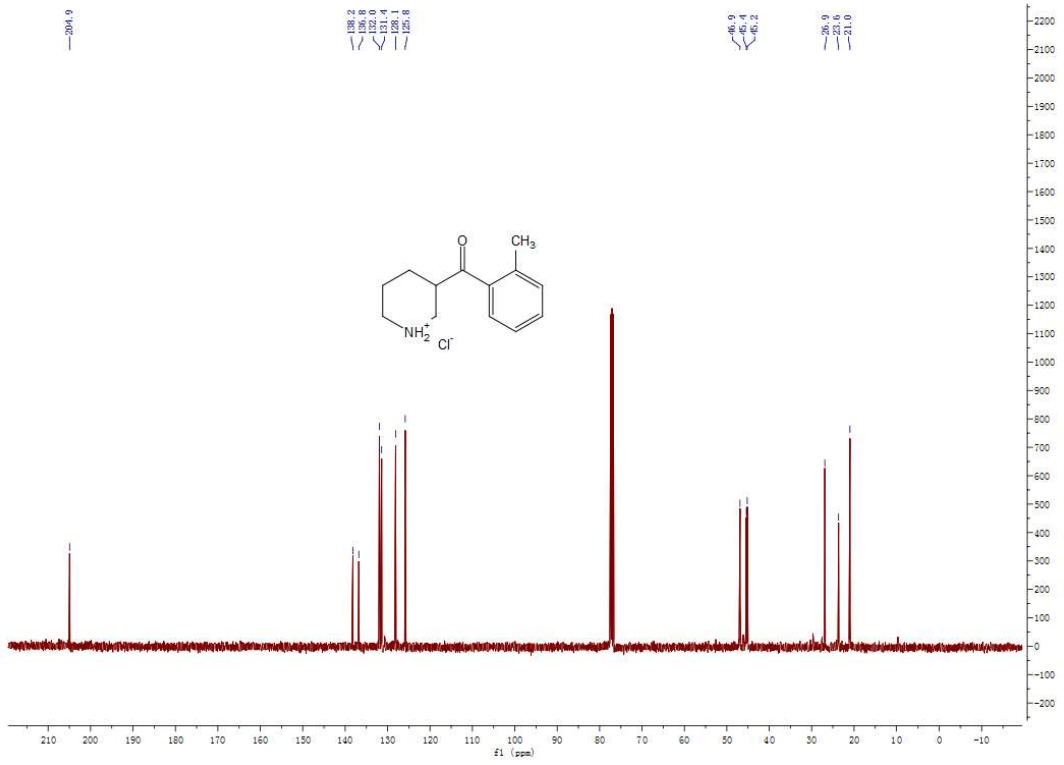
The NMR spectra of 2c



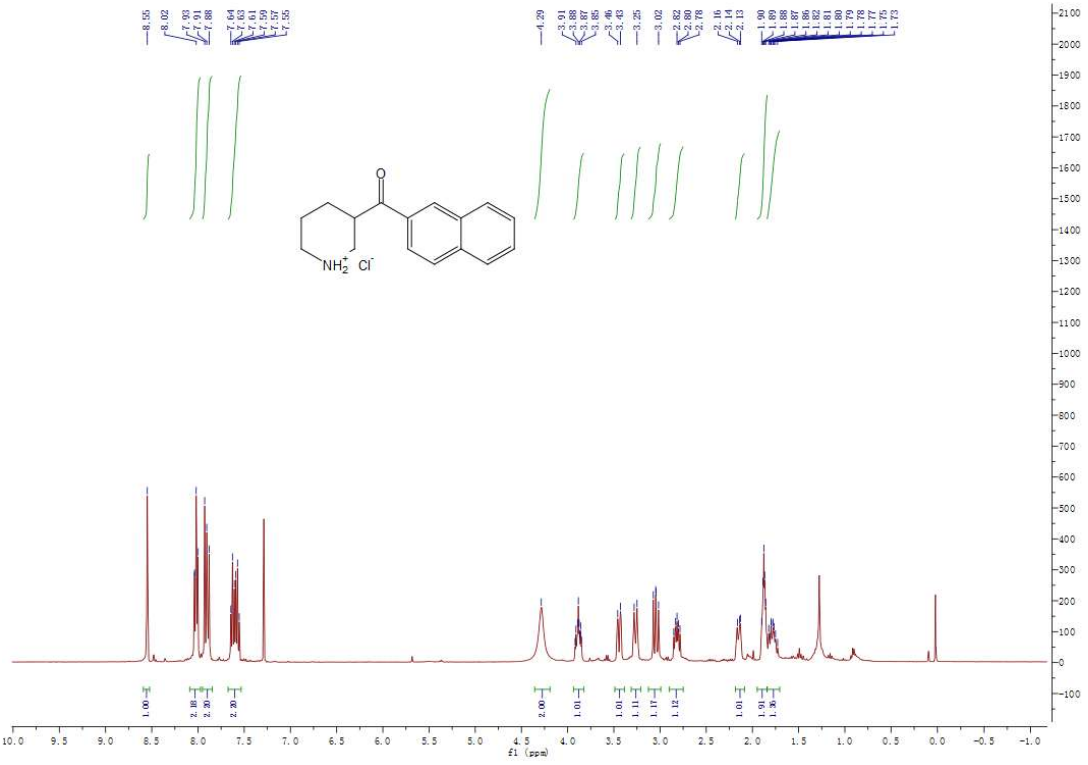


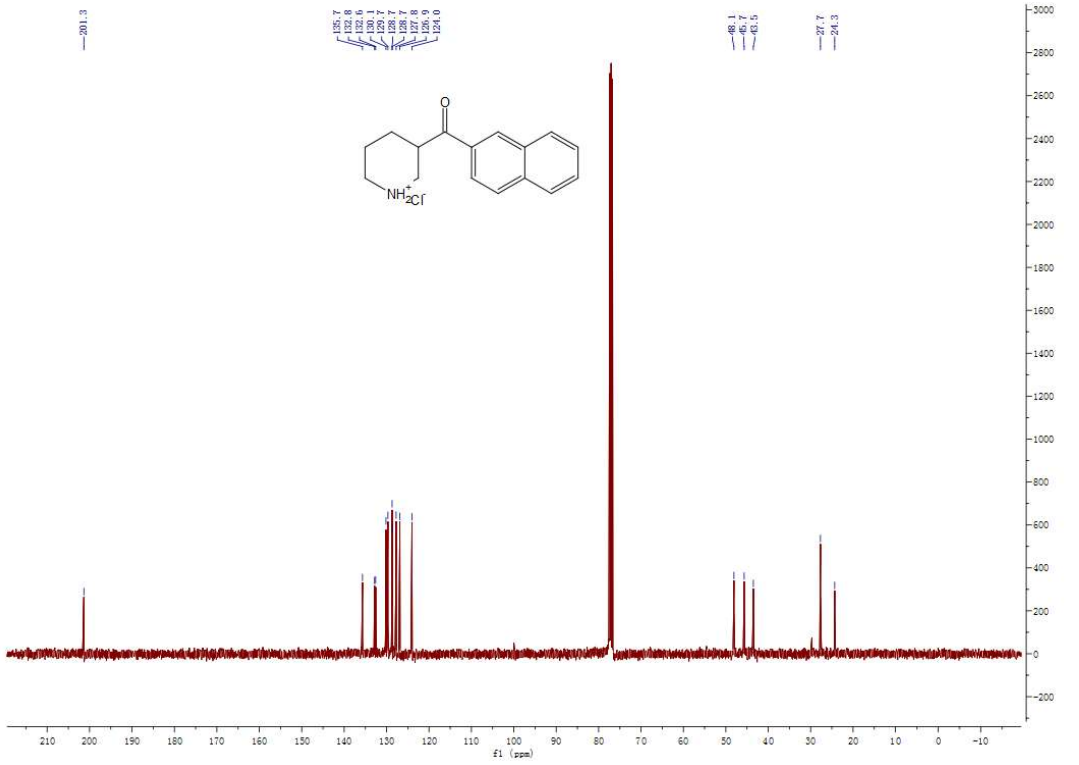
The NMR spectra of 2d



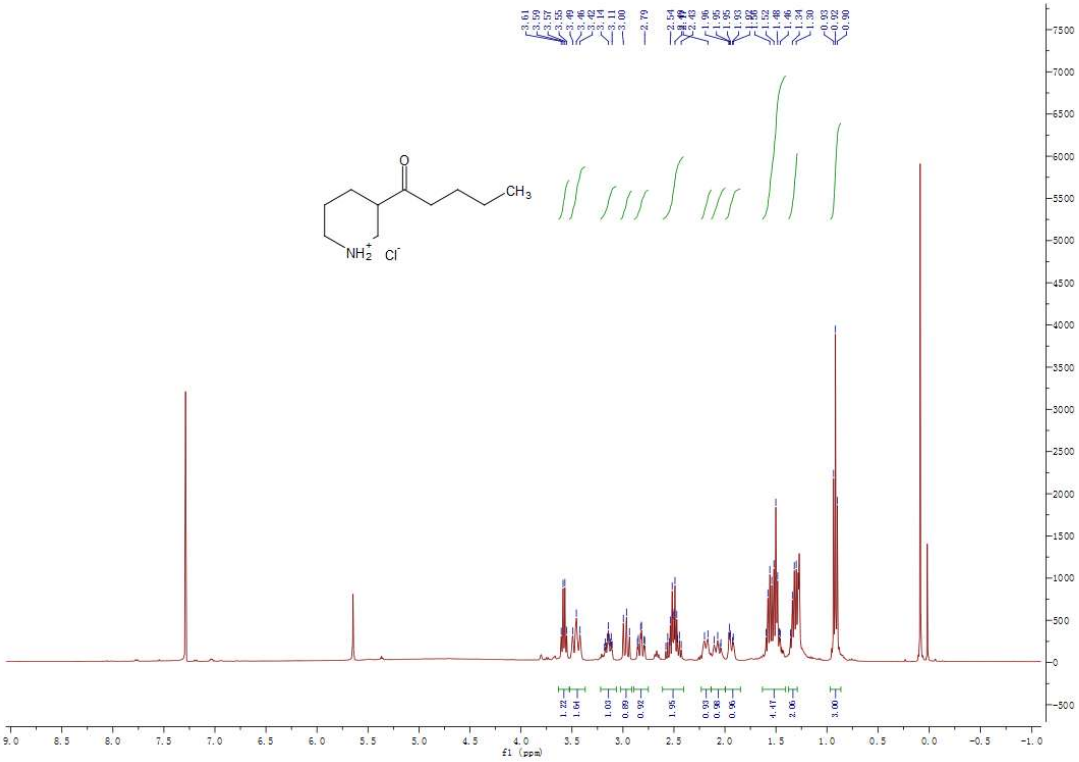


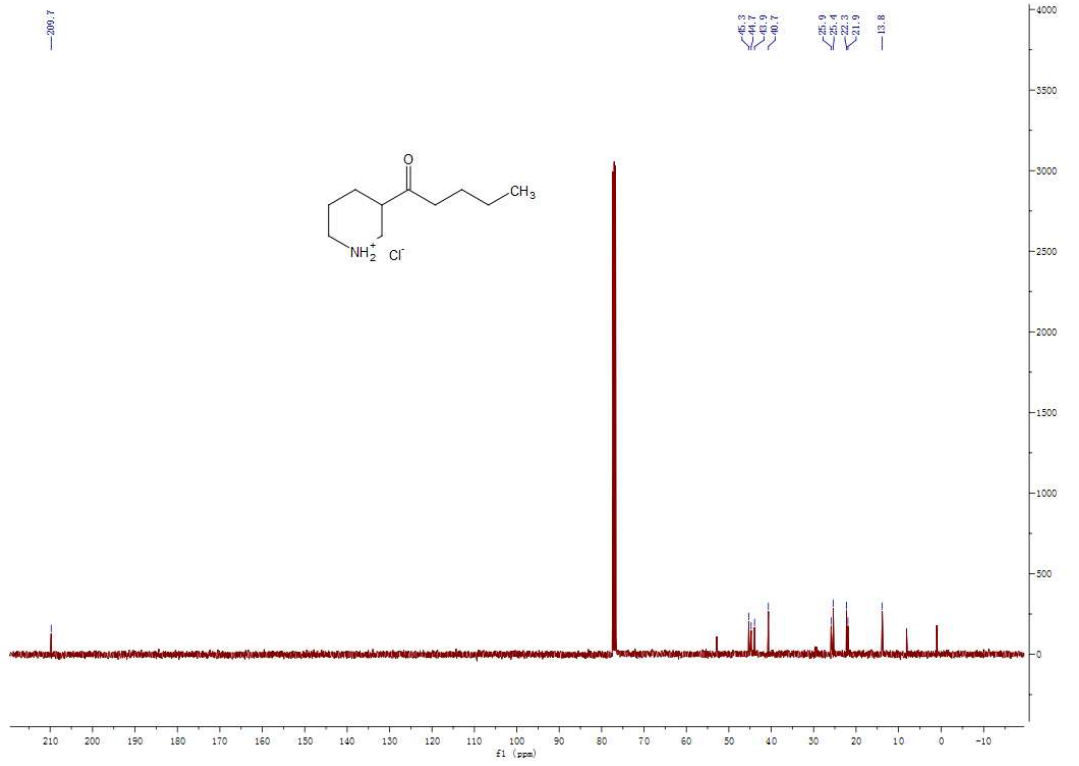
The NMR spectra of 2e



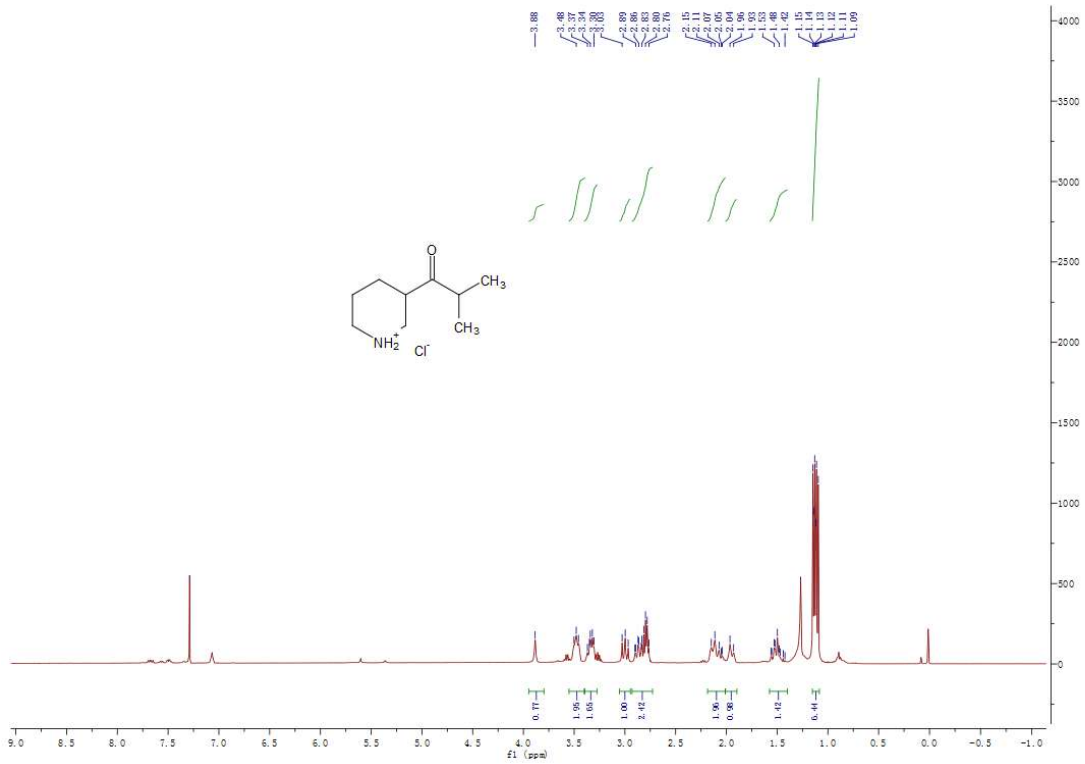


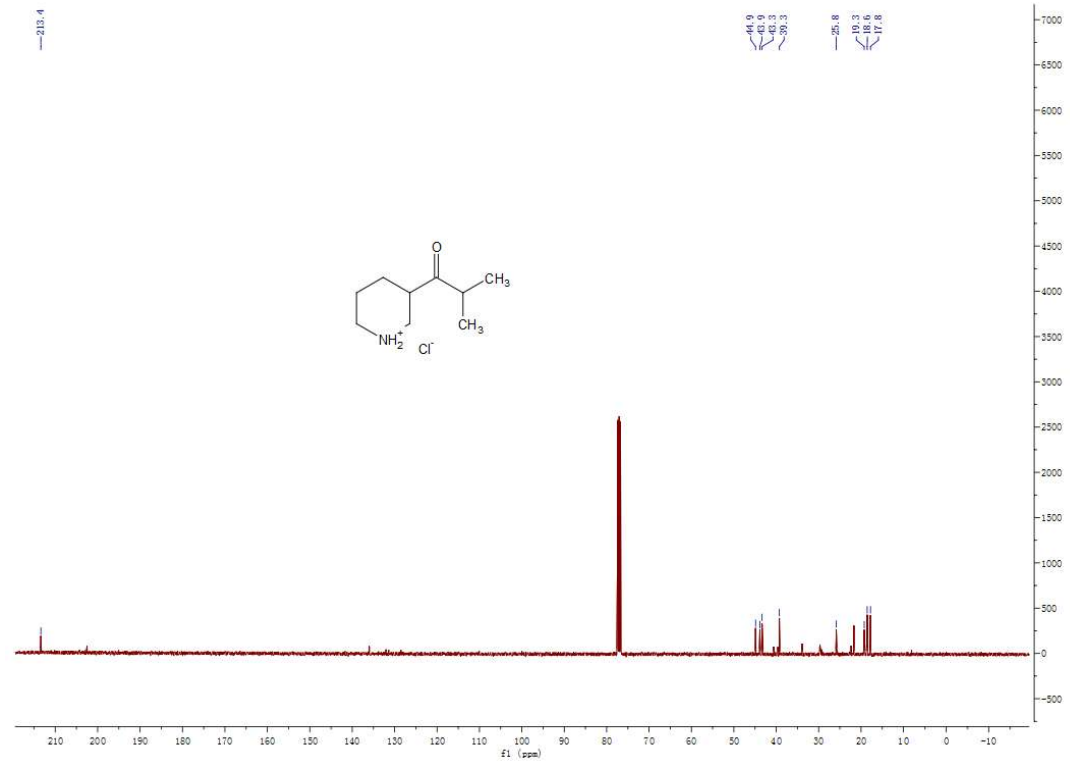
The NMR spectra of 2f



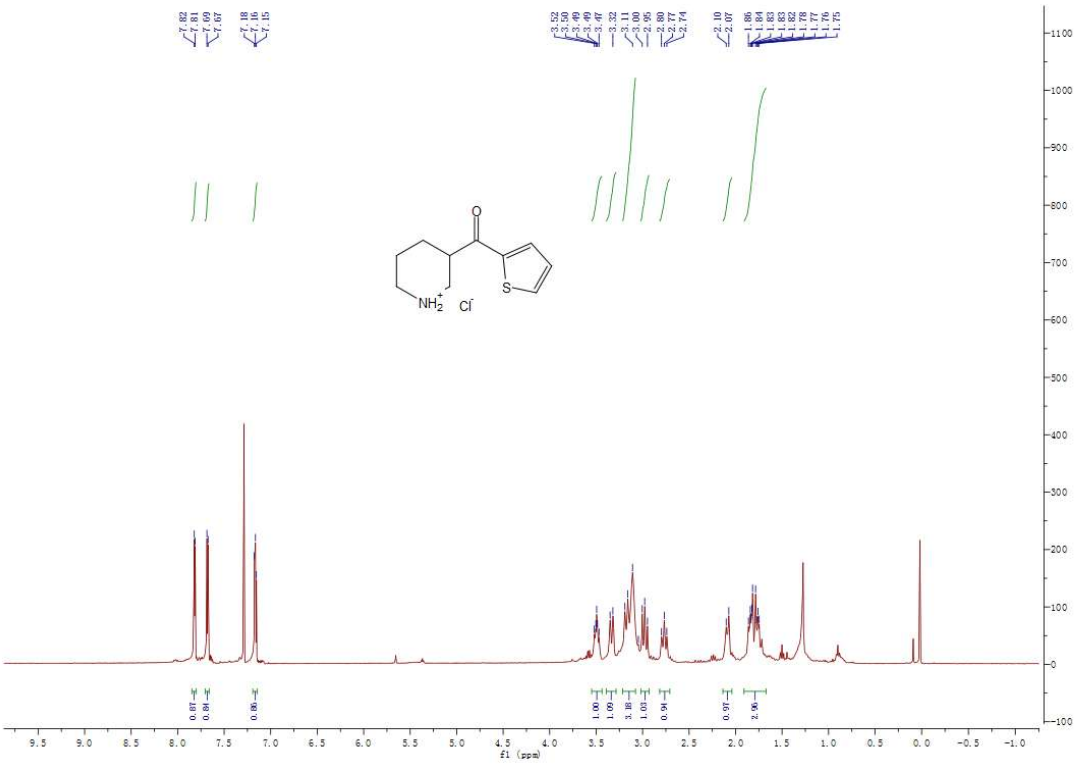


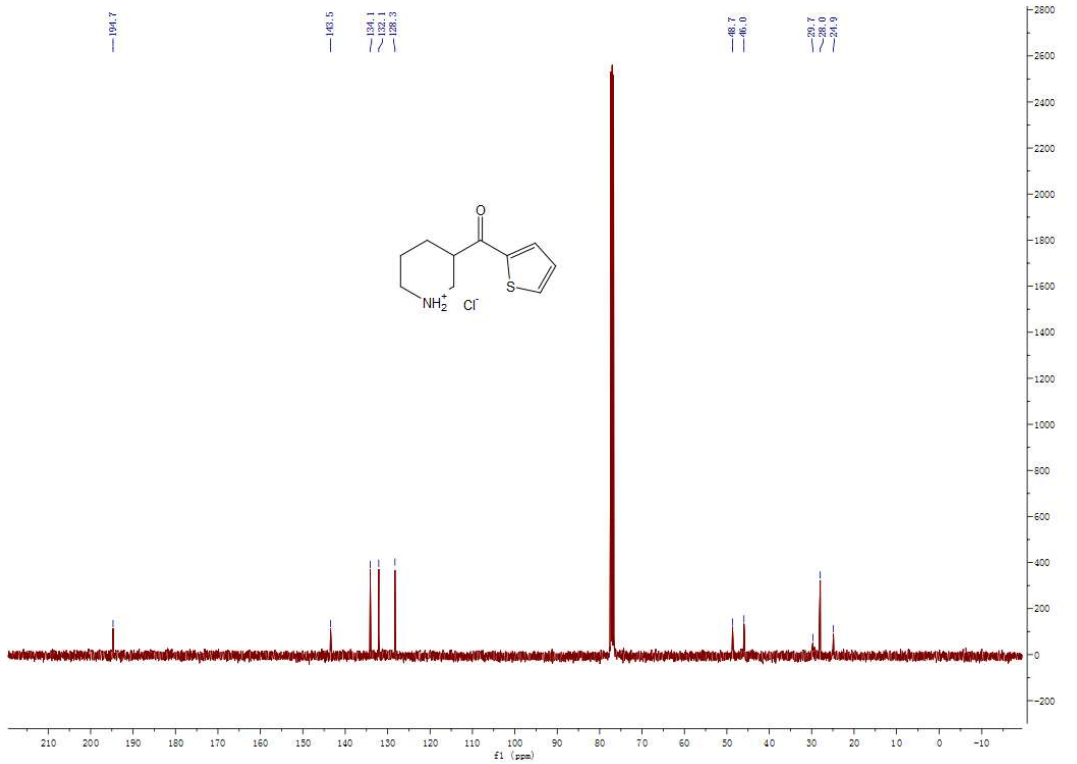
The NMR spectra of 2g



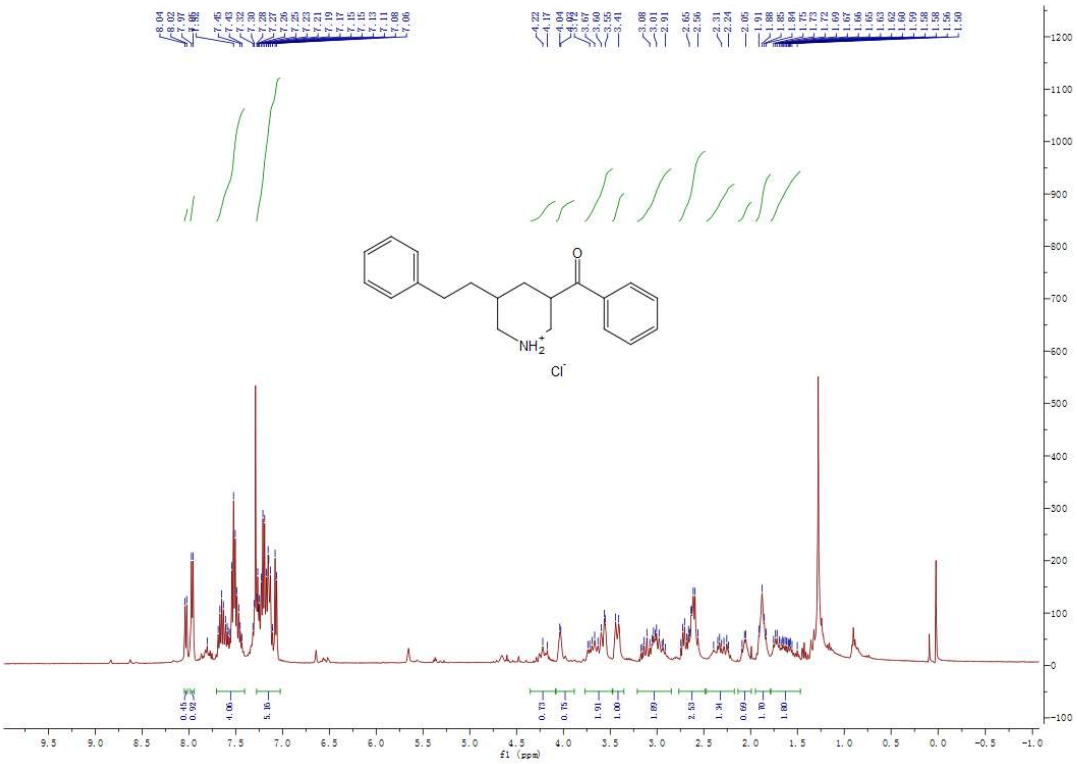


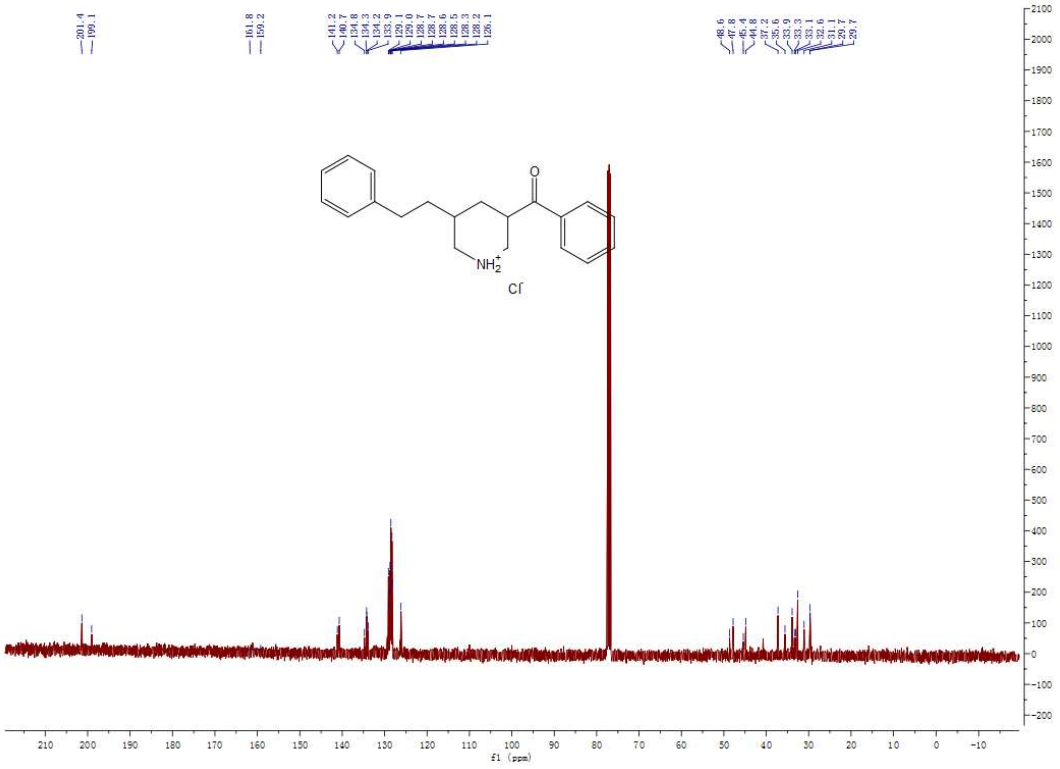
The NMR spectra of 2h



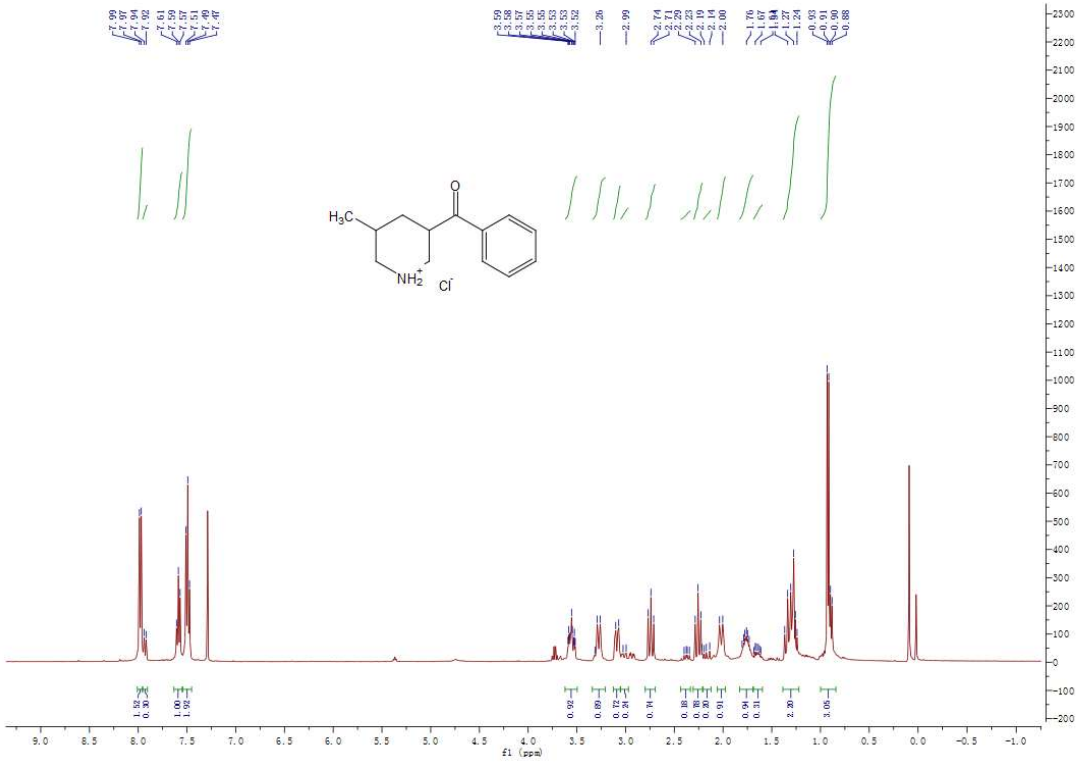


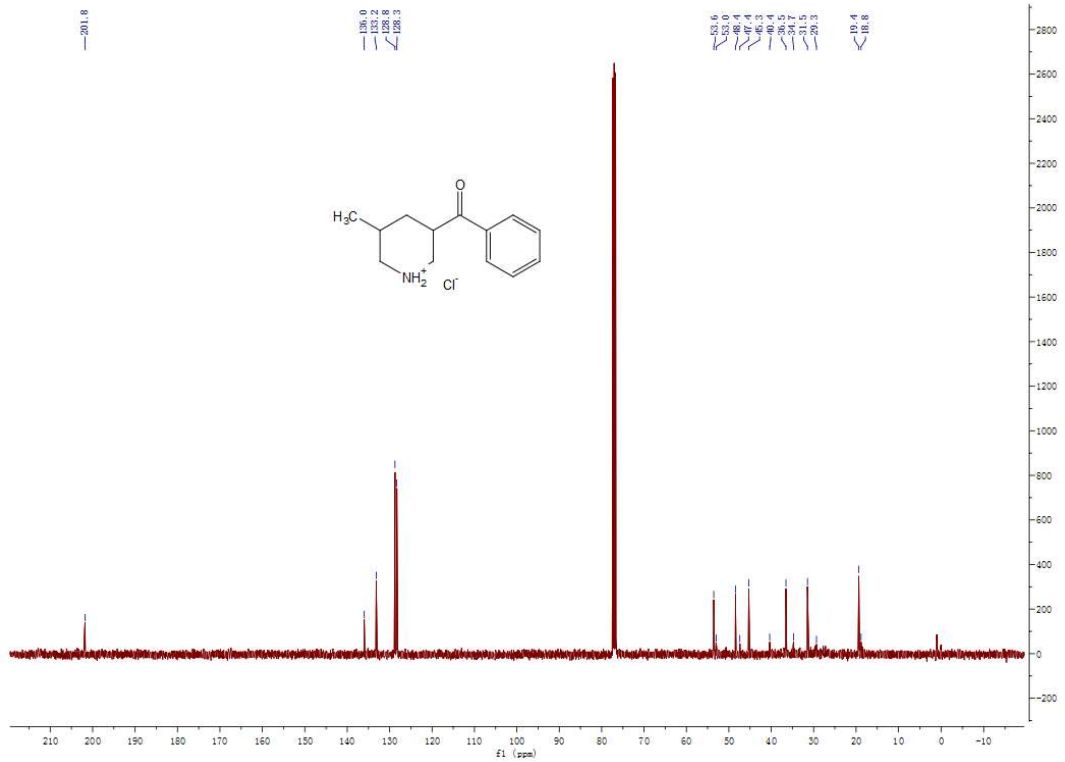
The NMR spectra of 2i



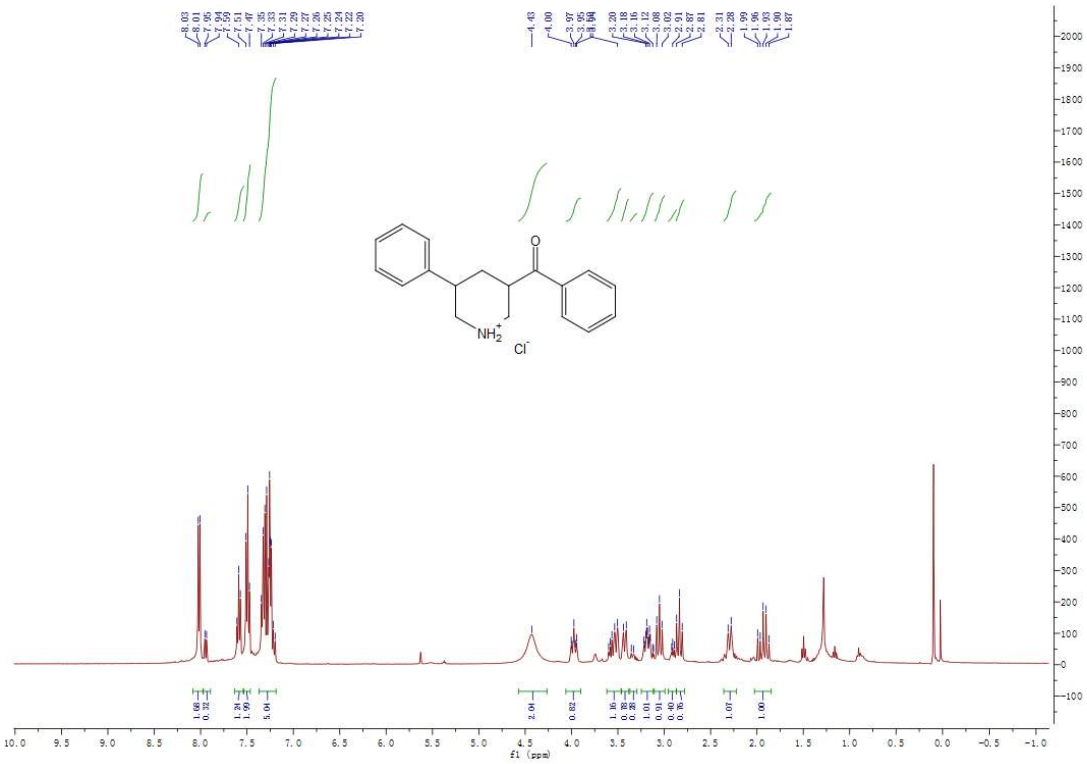


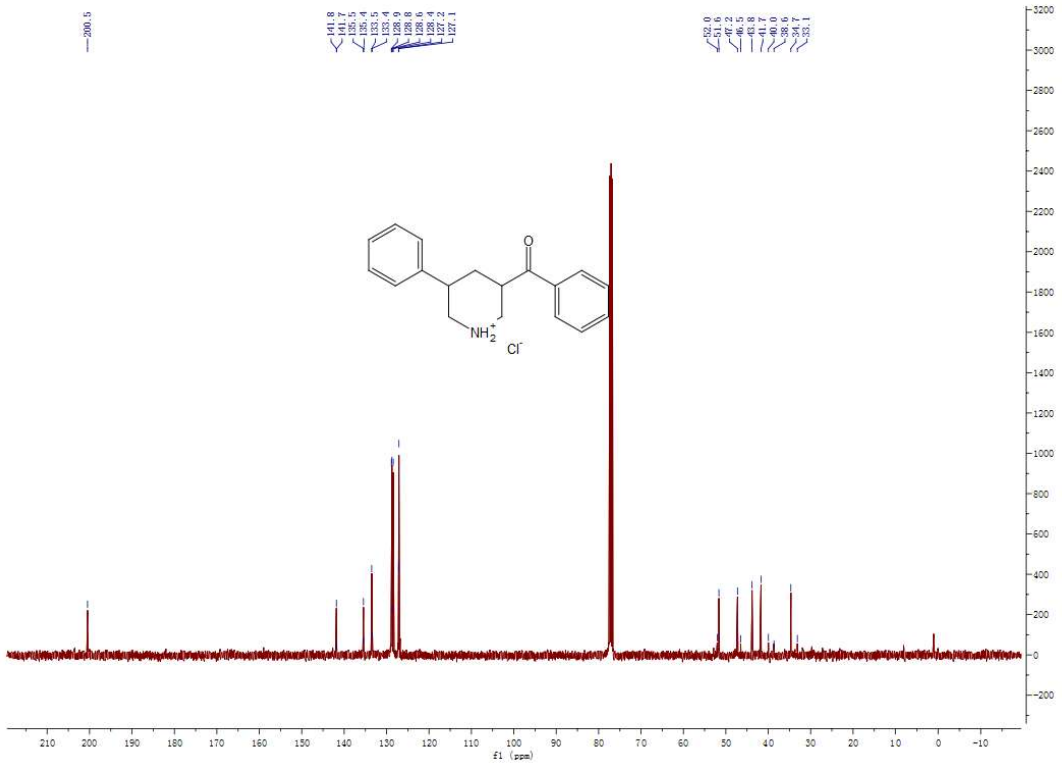
The NMR spectra of 2j



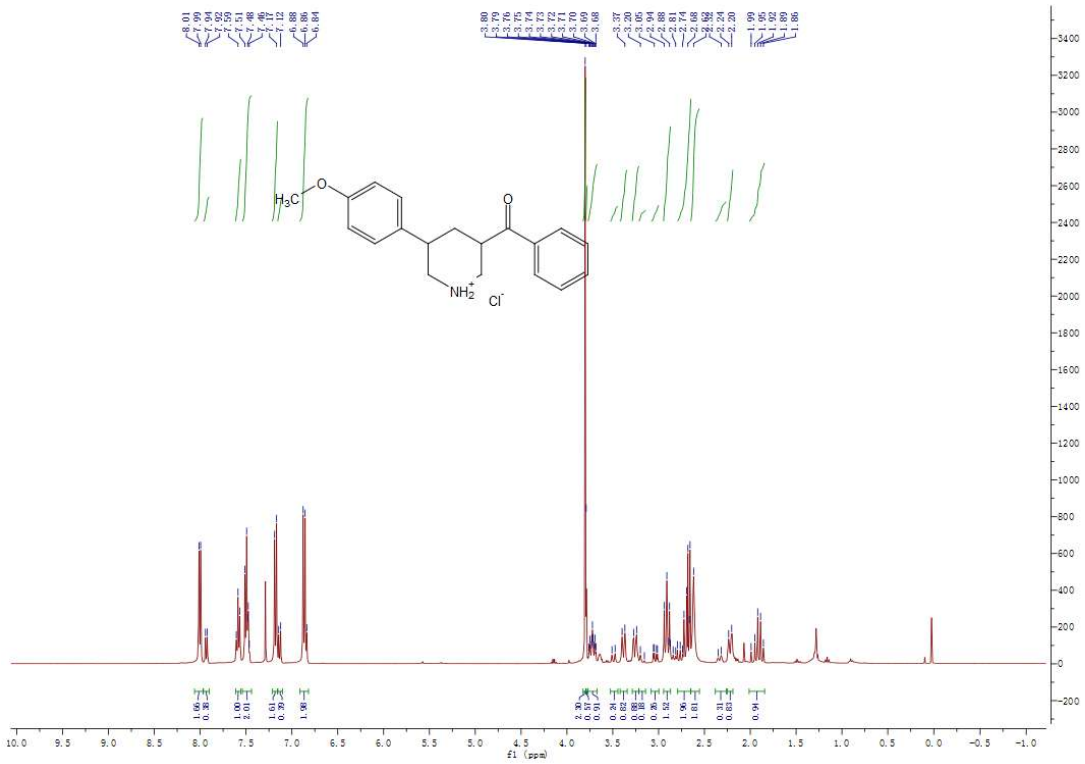


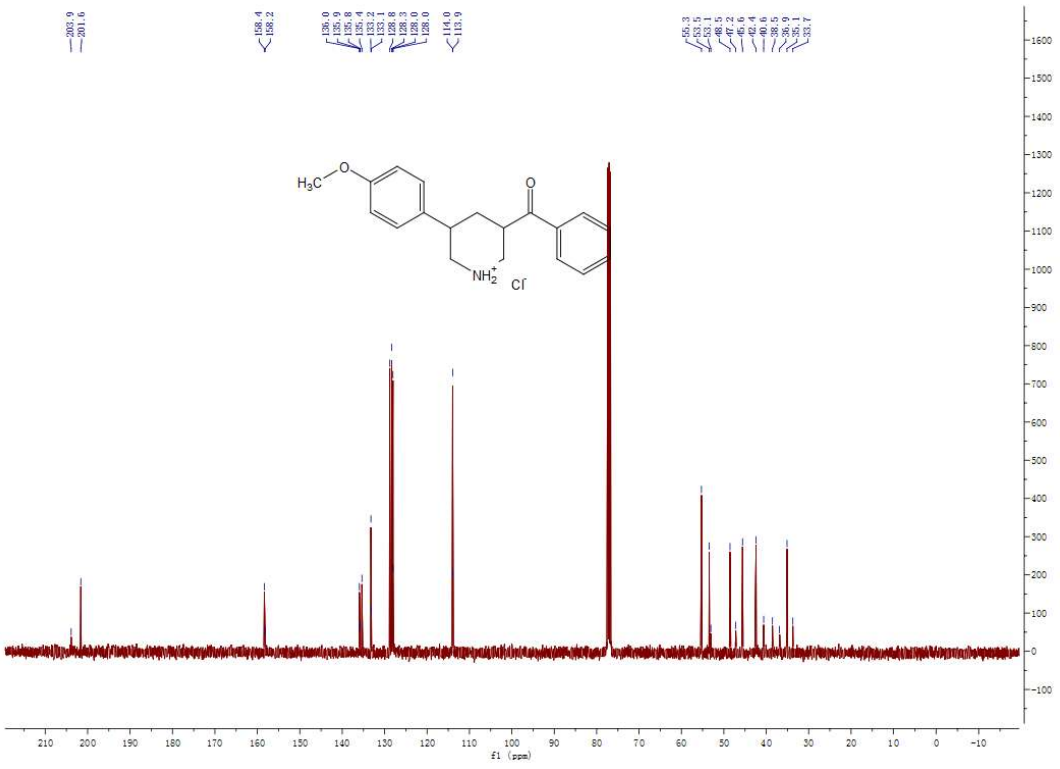
The NMR spectra of 2k



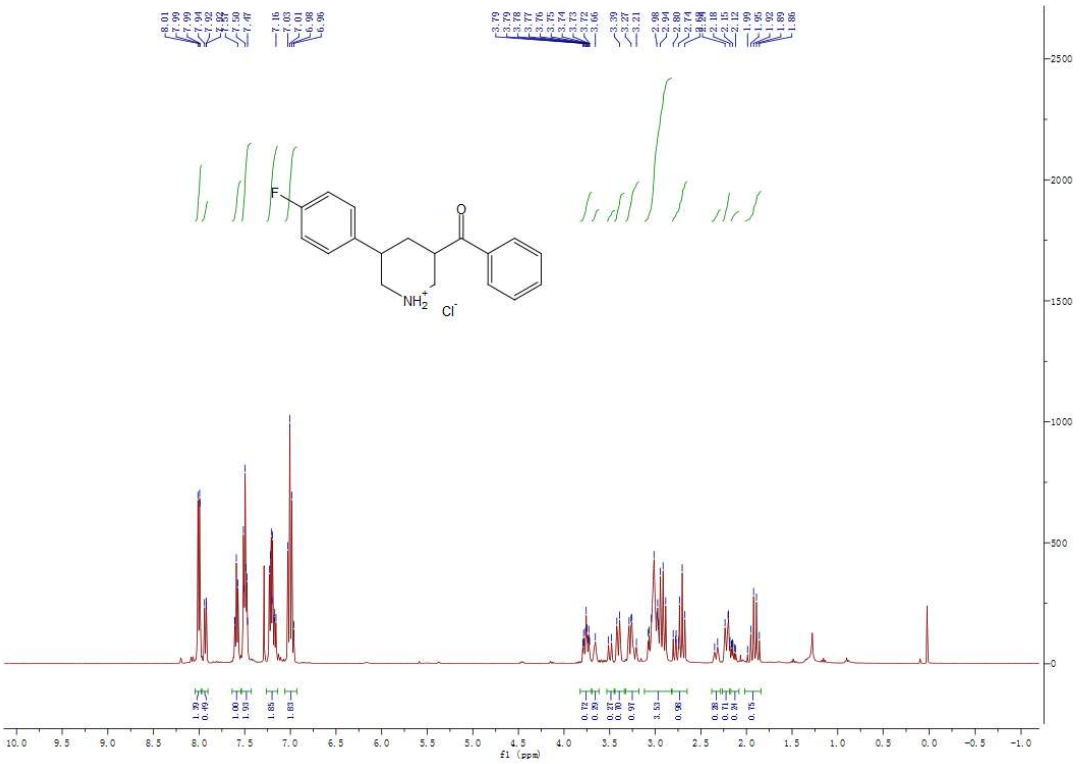


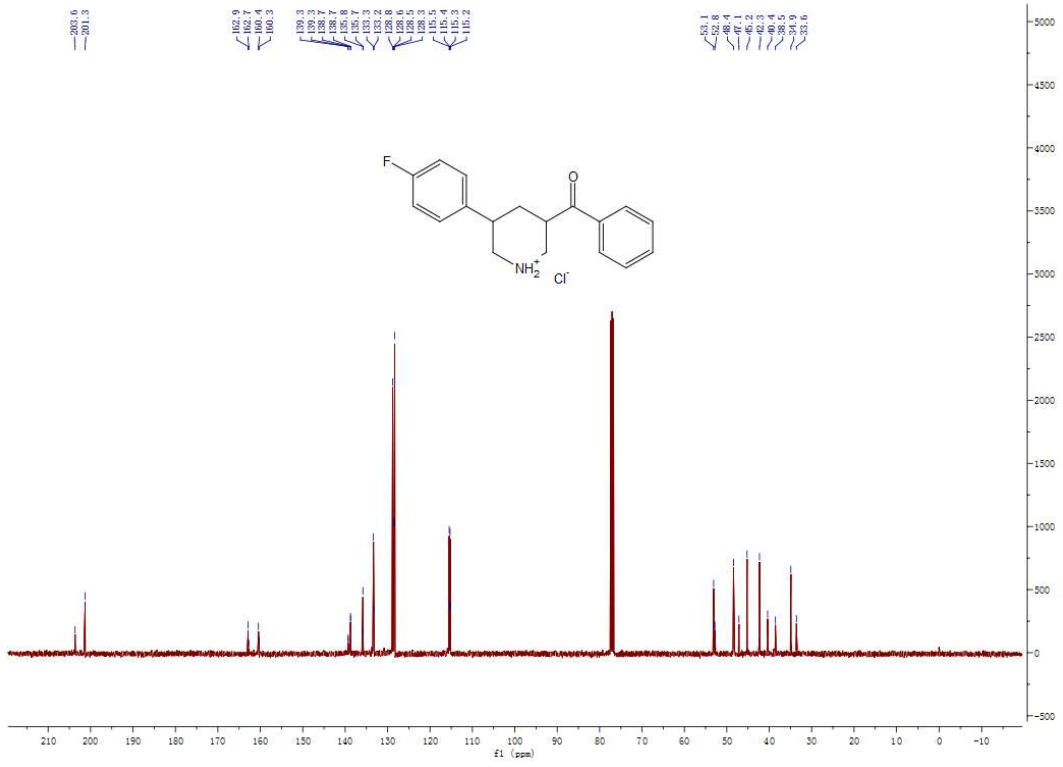
The NMR spectra of 2l



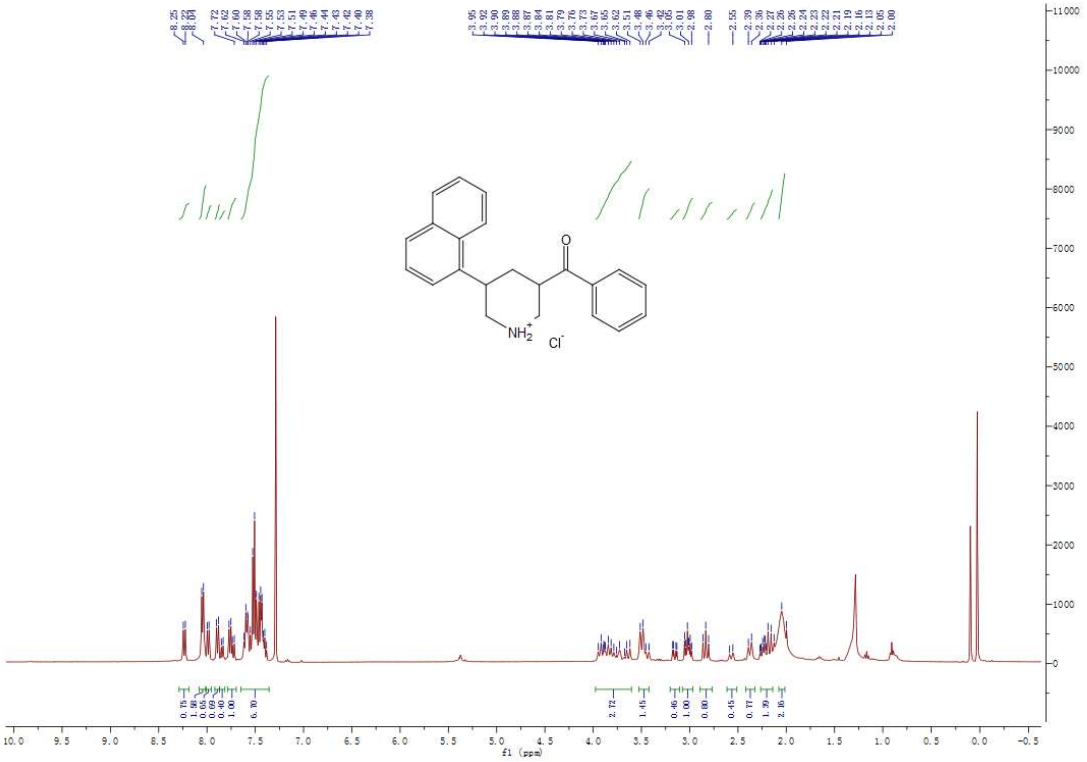


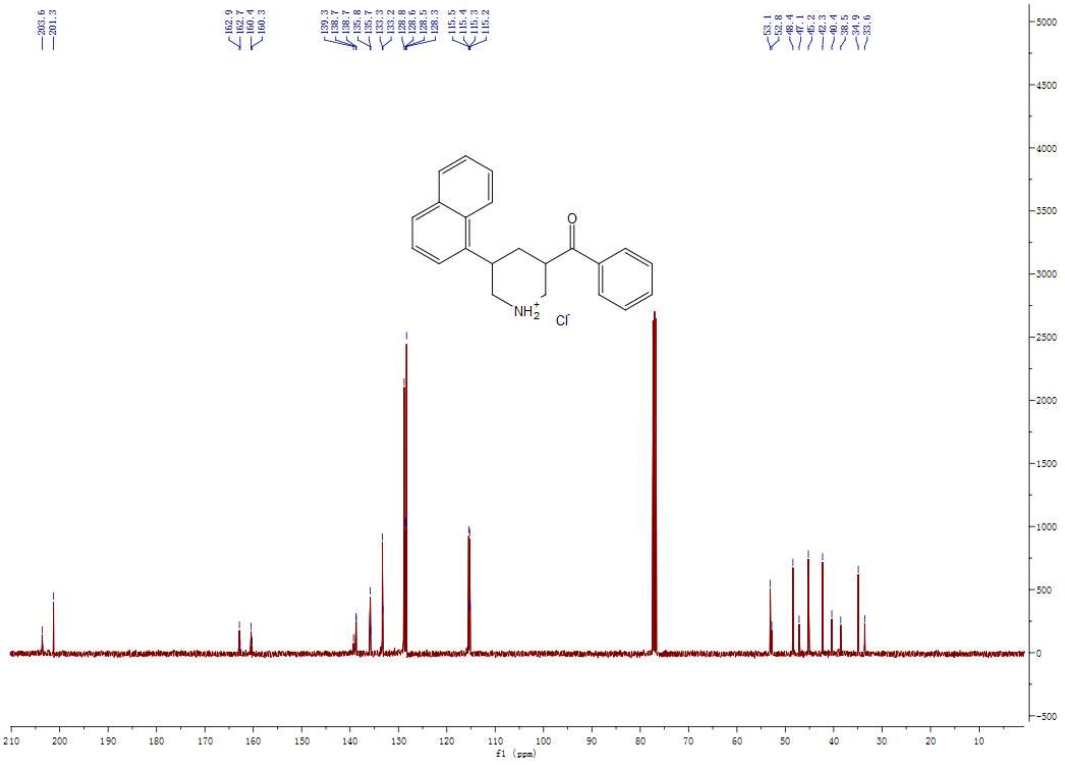
The NMR spectra of 2m



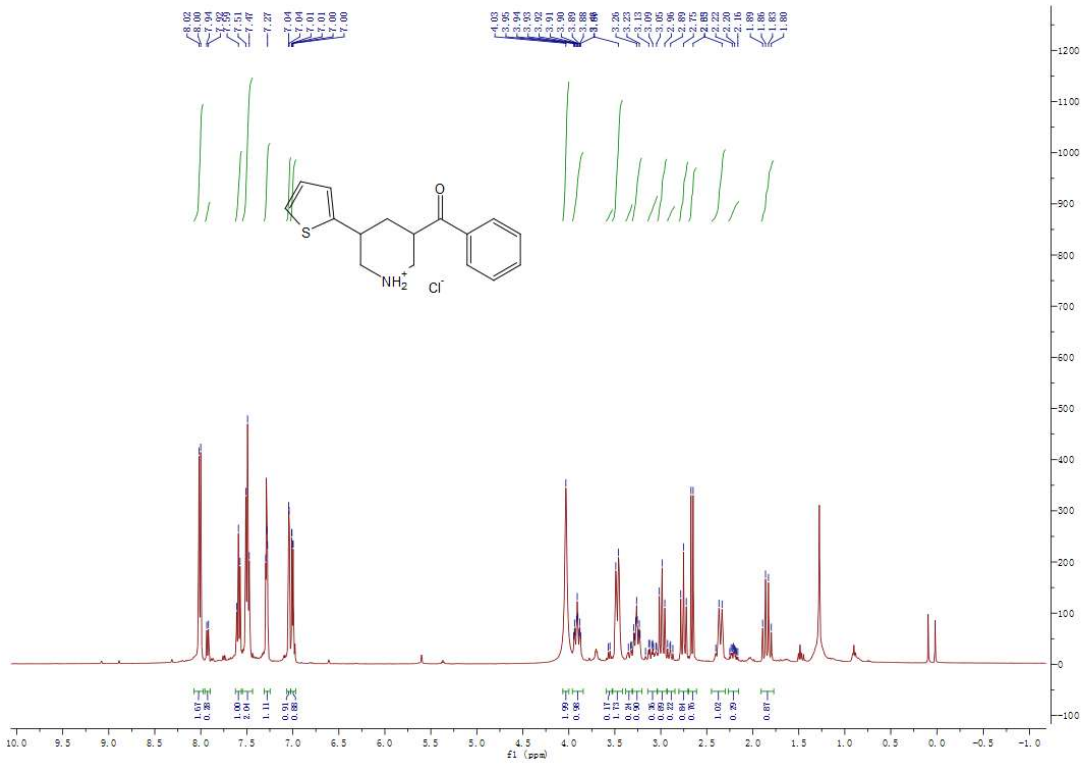


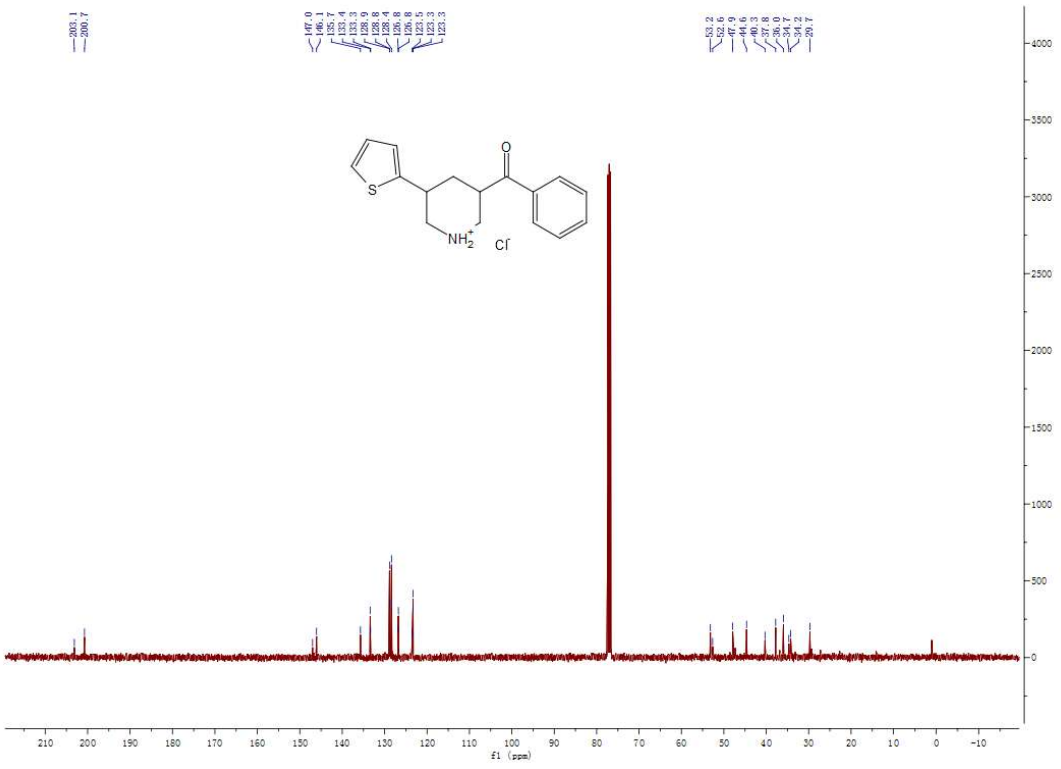
The NMR spectra of 2n



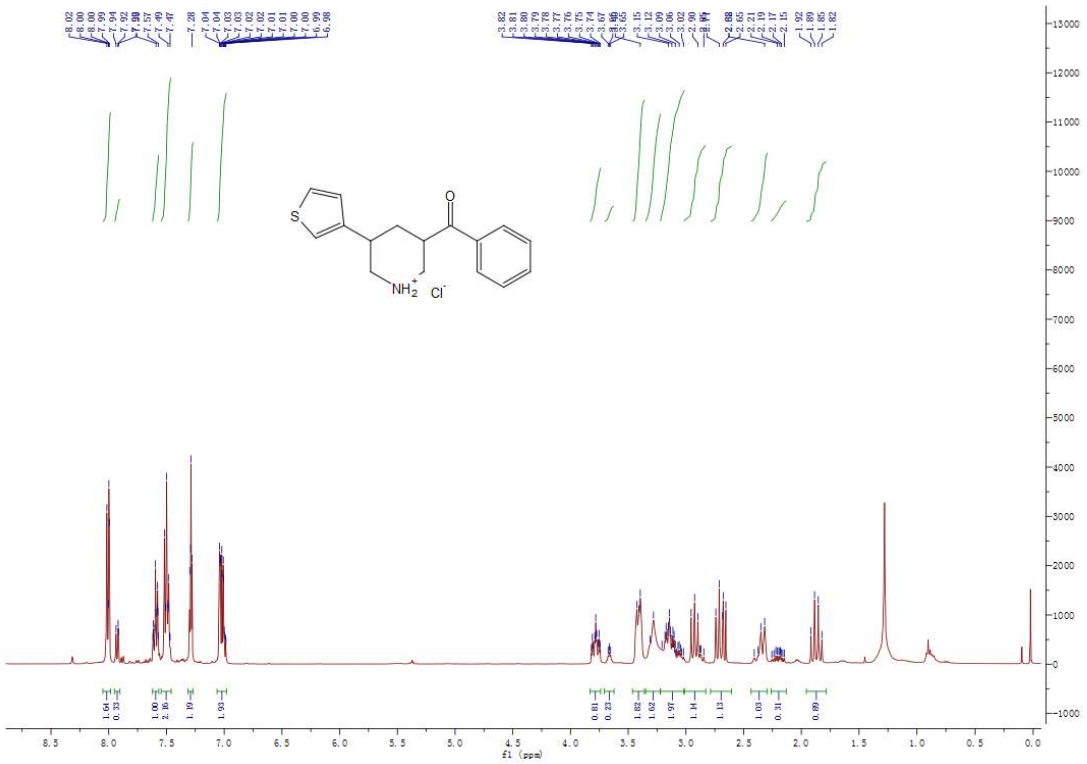


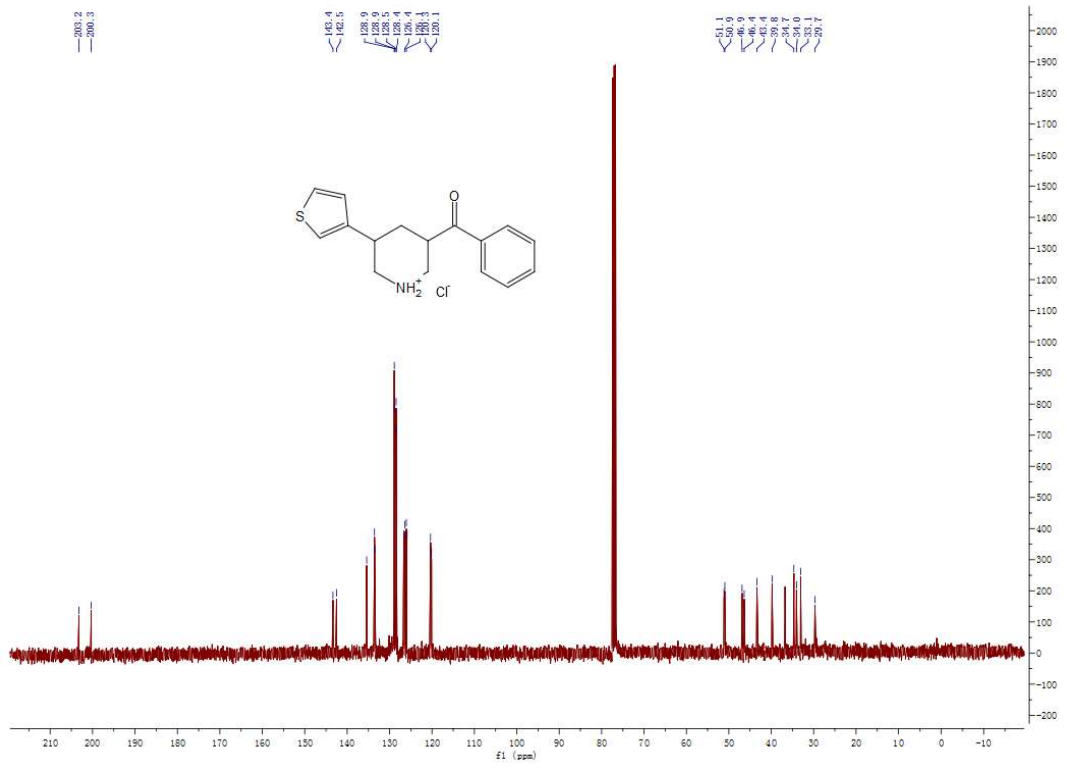
The NMR spectra of 2o



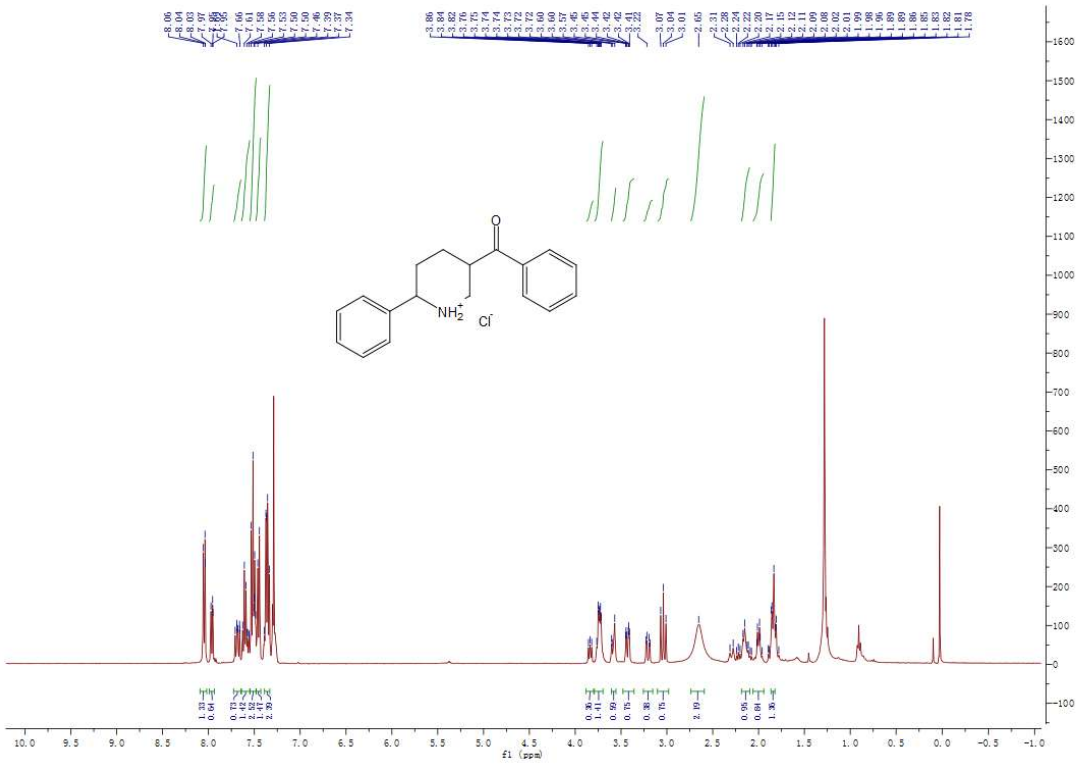


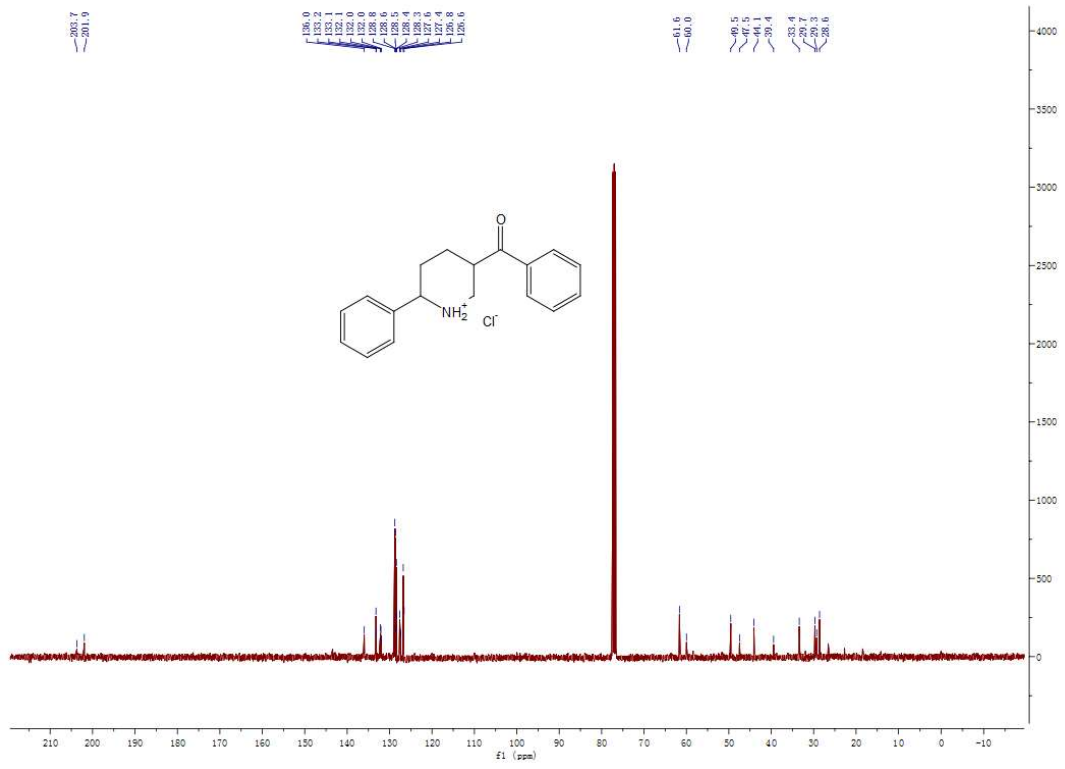
The NMR spectra of 2p



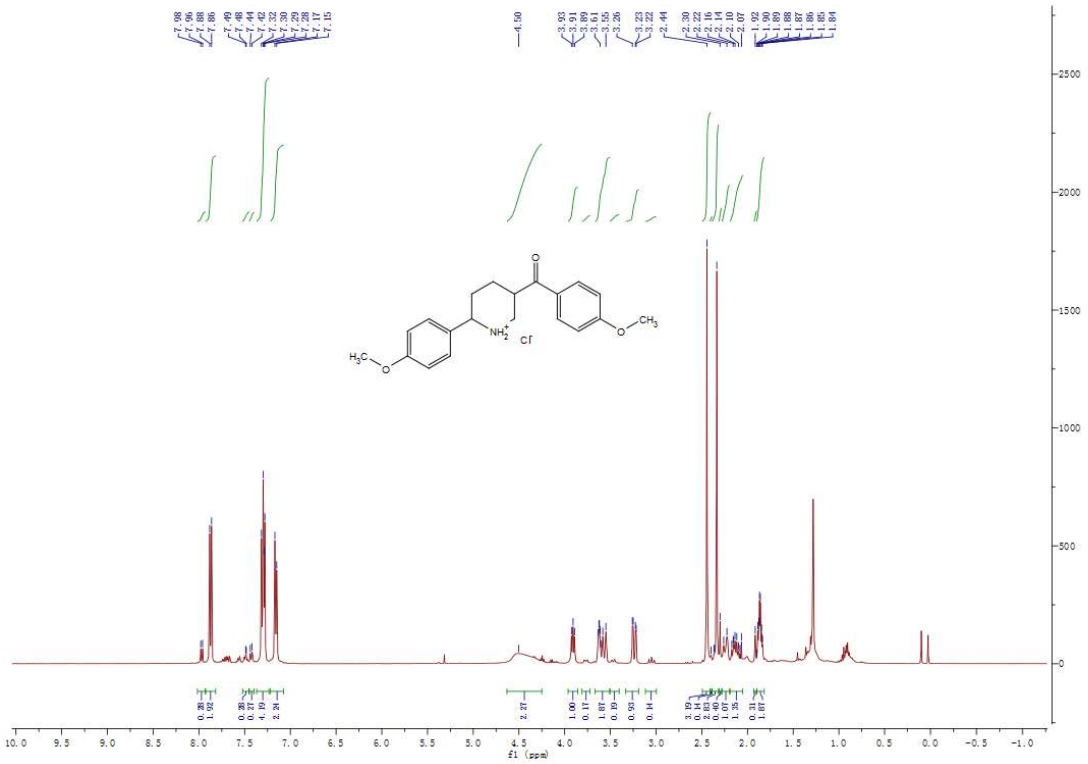


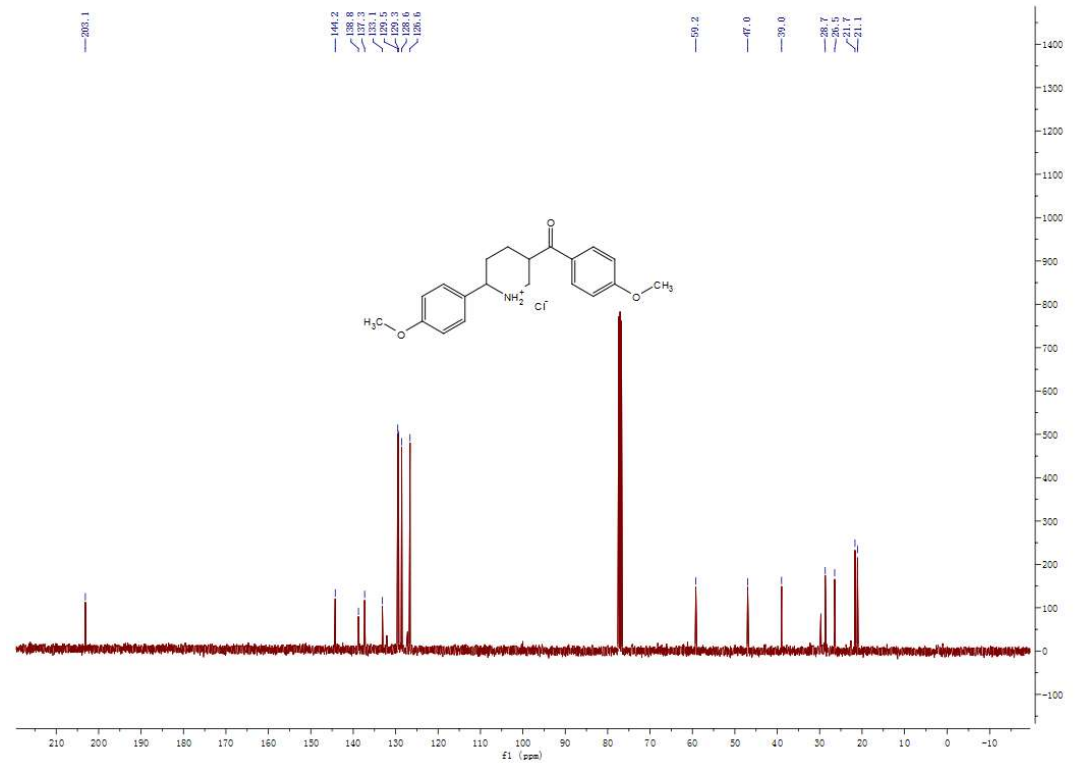
The NMR spectra of 2q



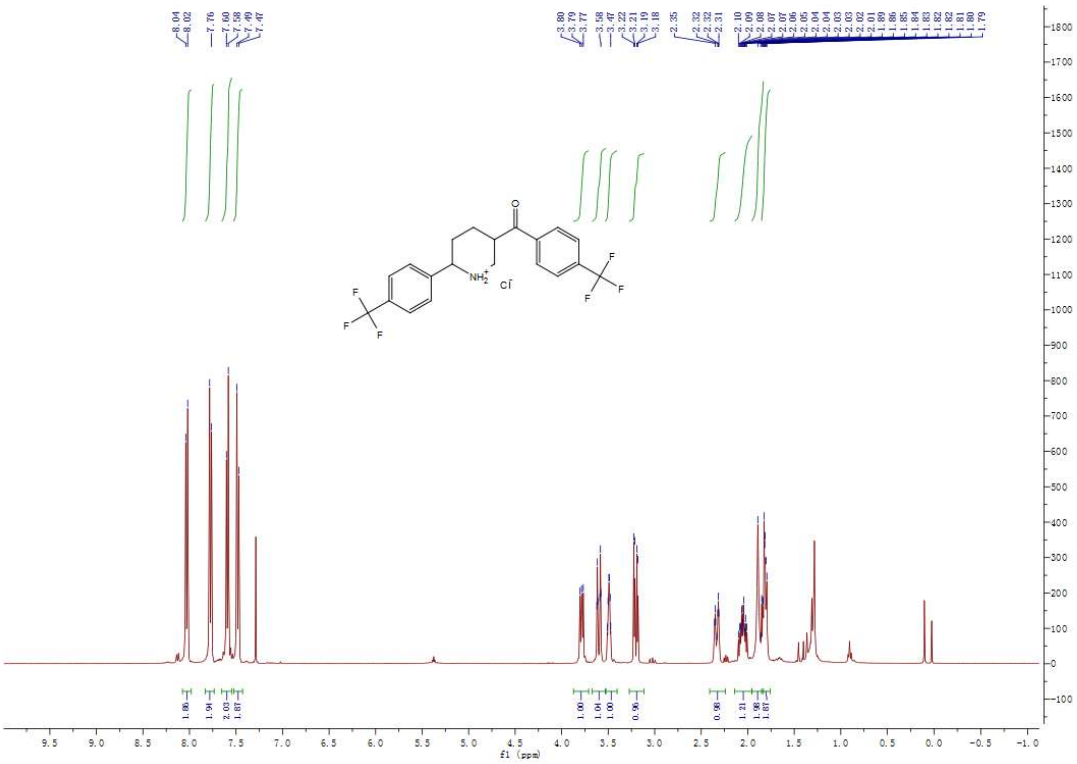


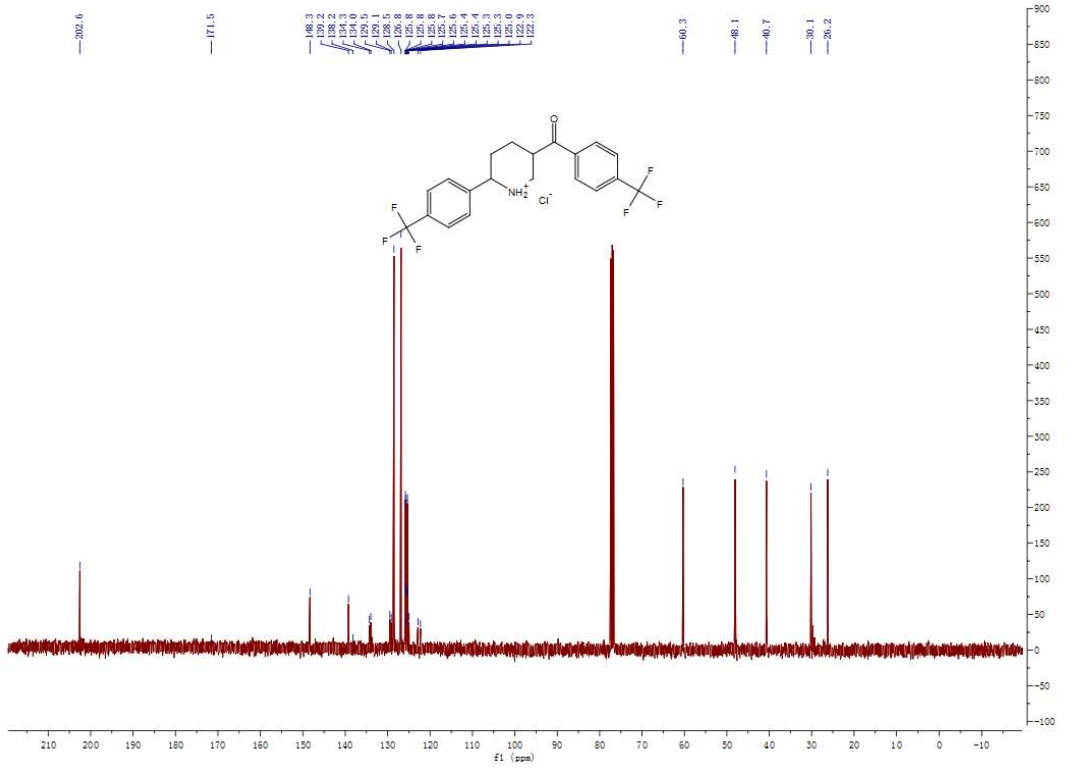
The NMR spectra of 2r



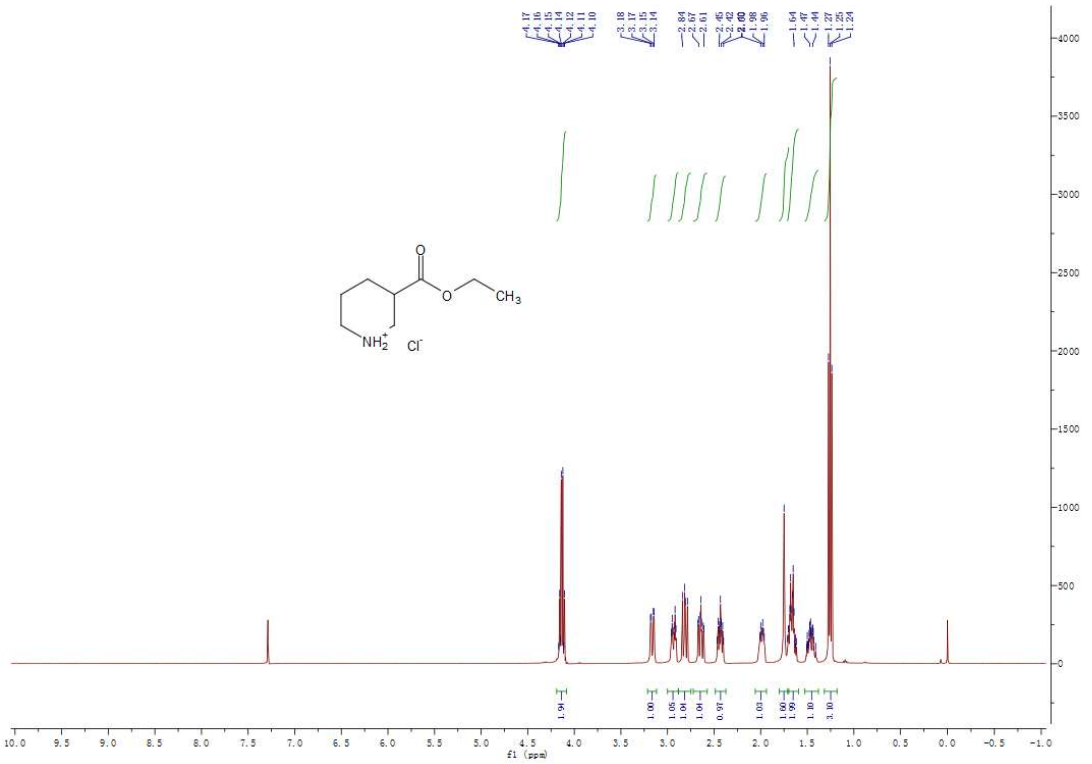


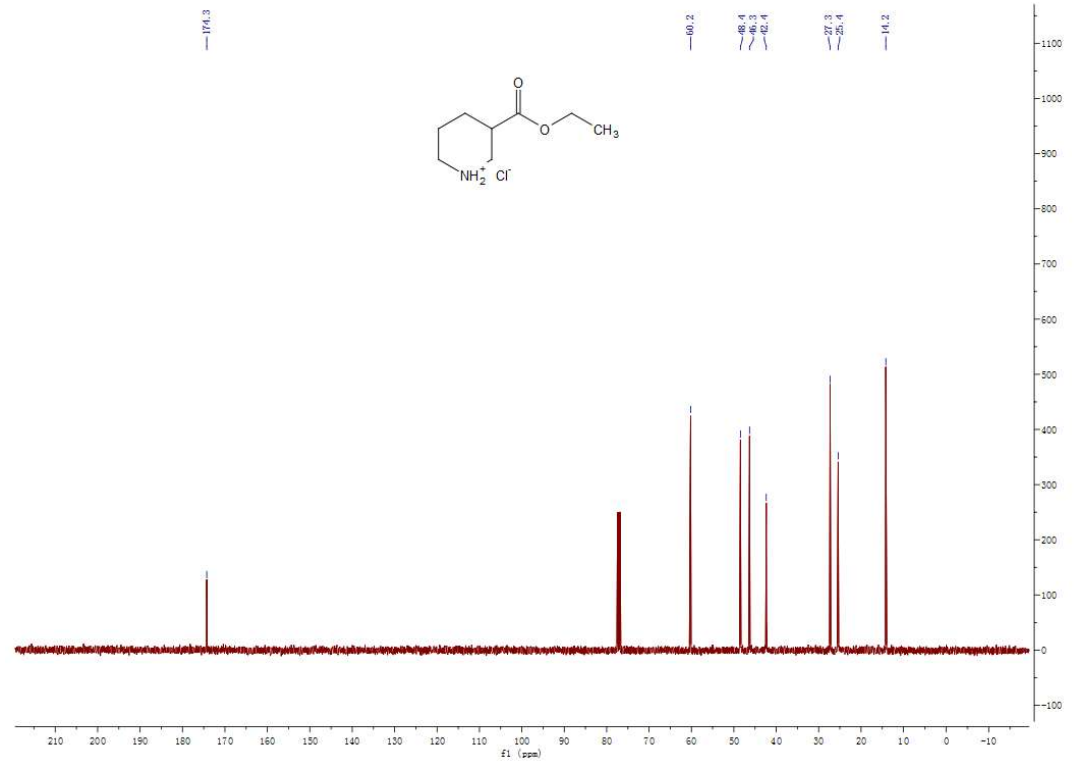
The NMR spectra of 2s



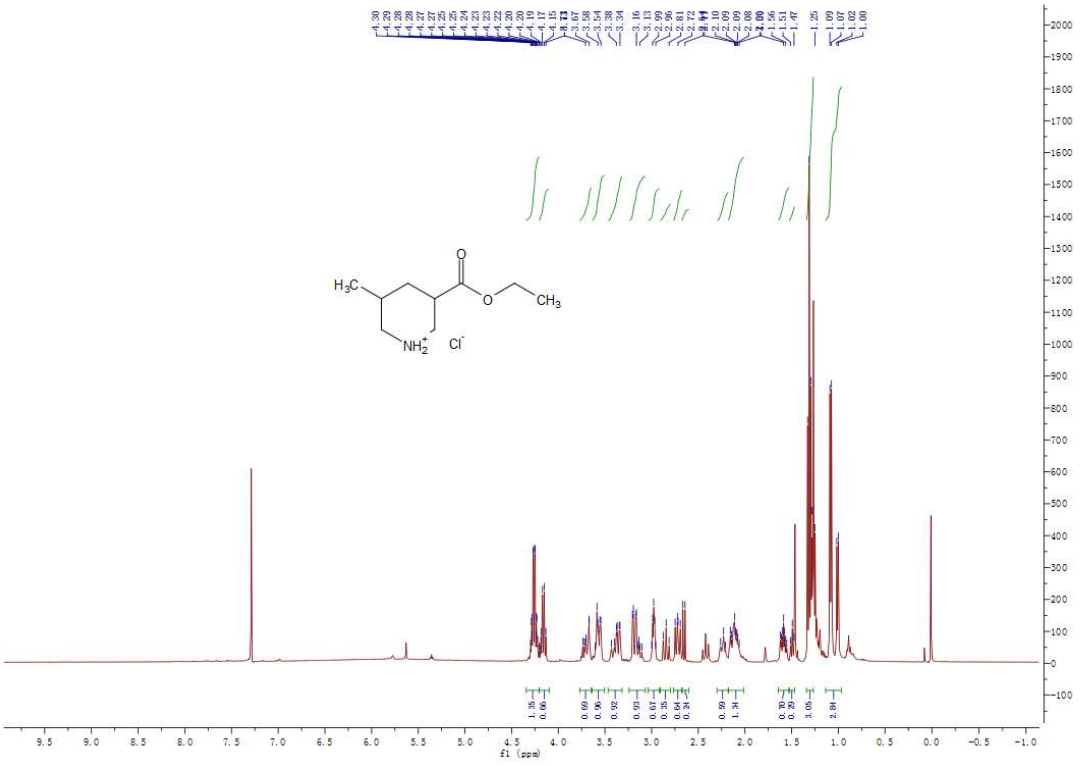


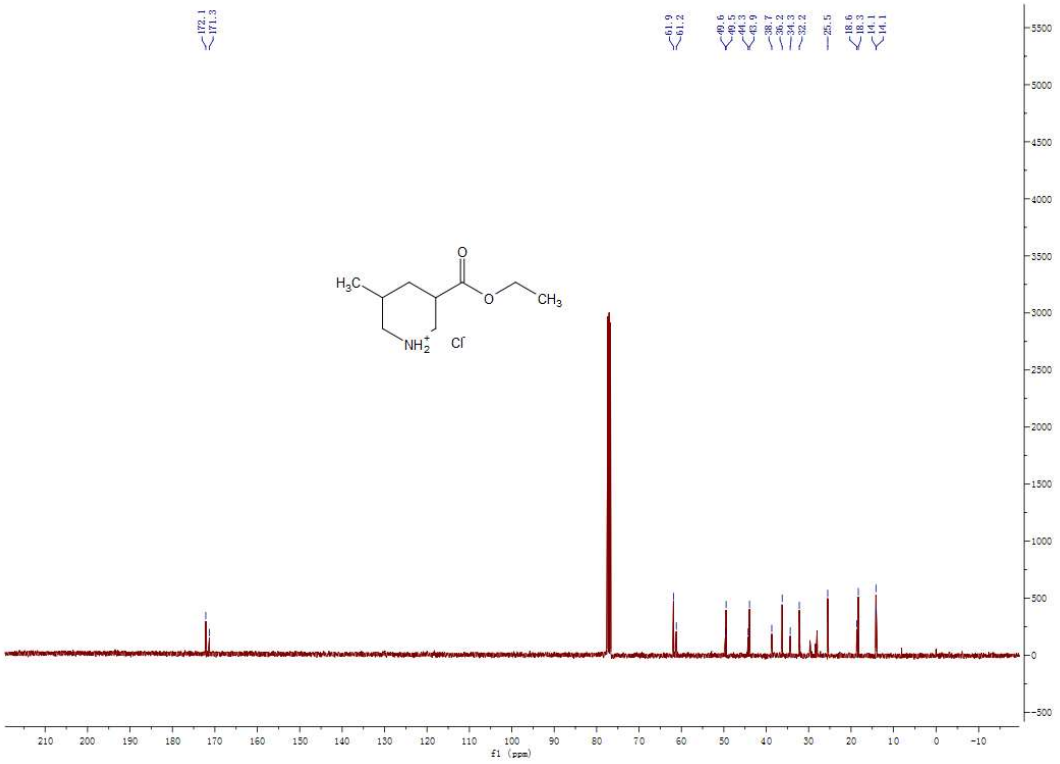
The NMR spectra of 2t



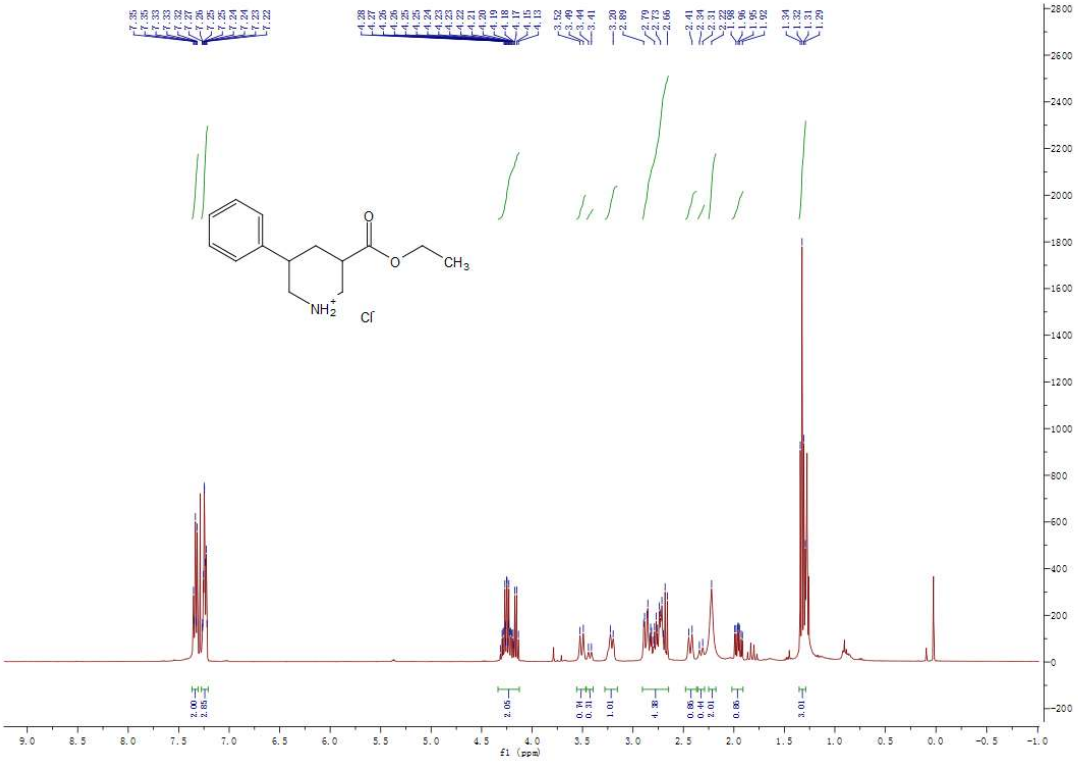


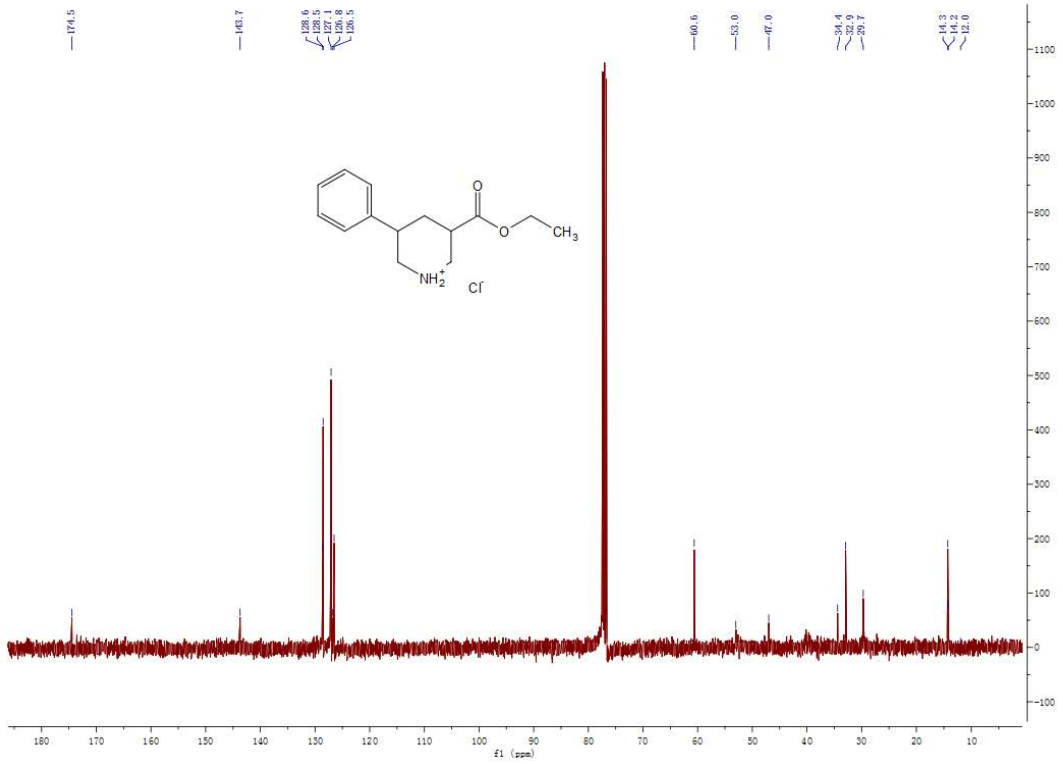
The NMR spectra of 2u



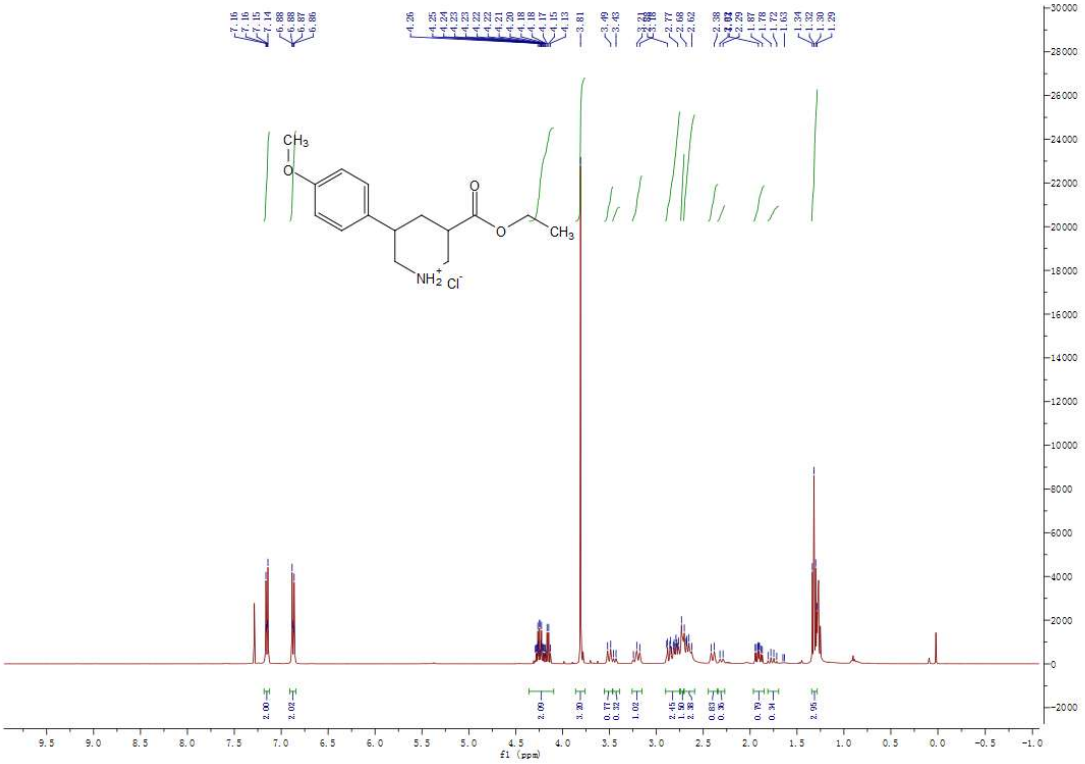


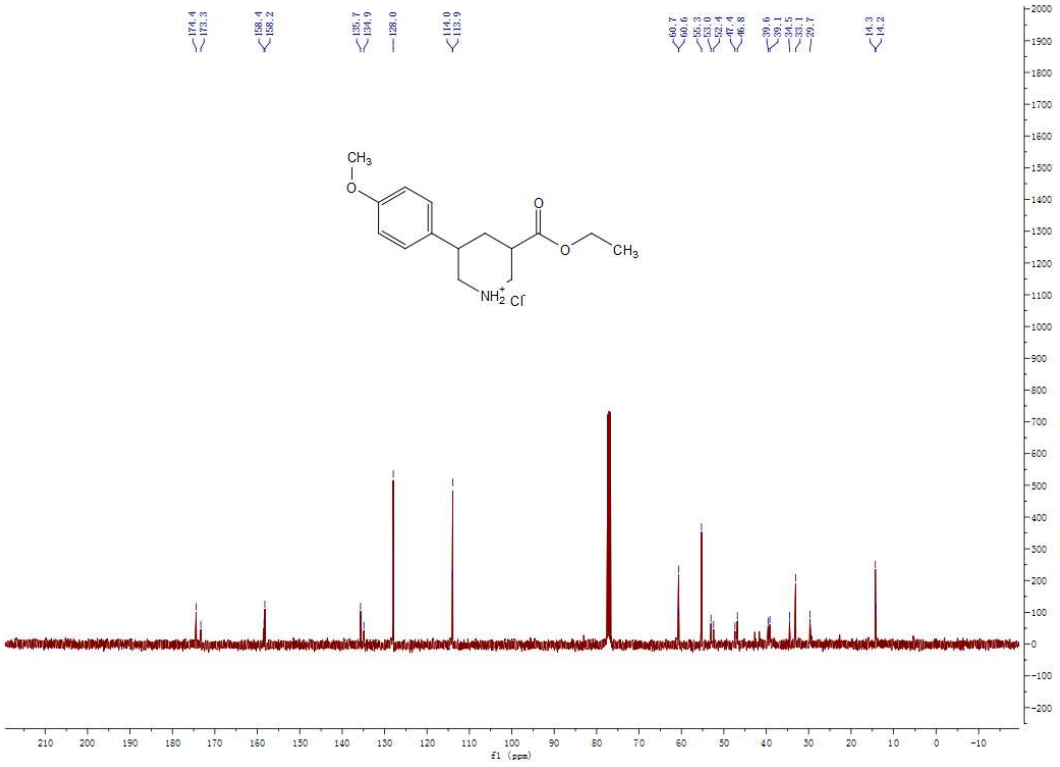
The NMR spectra of 2v



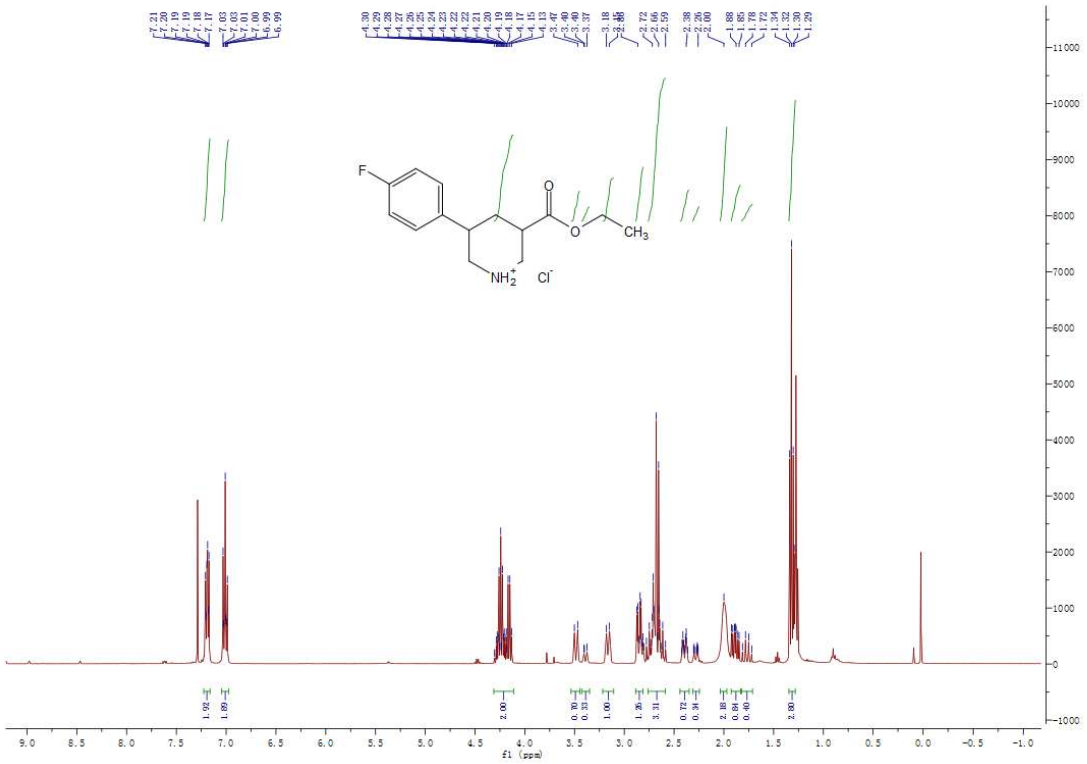


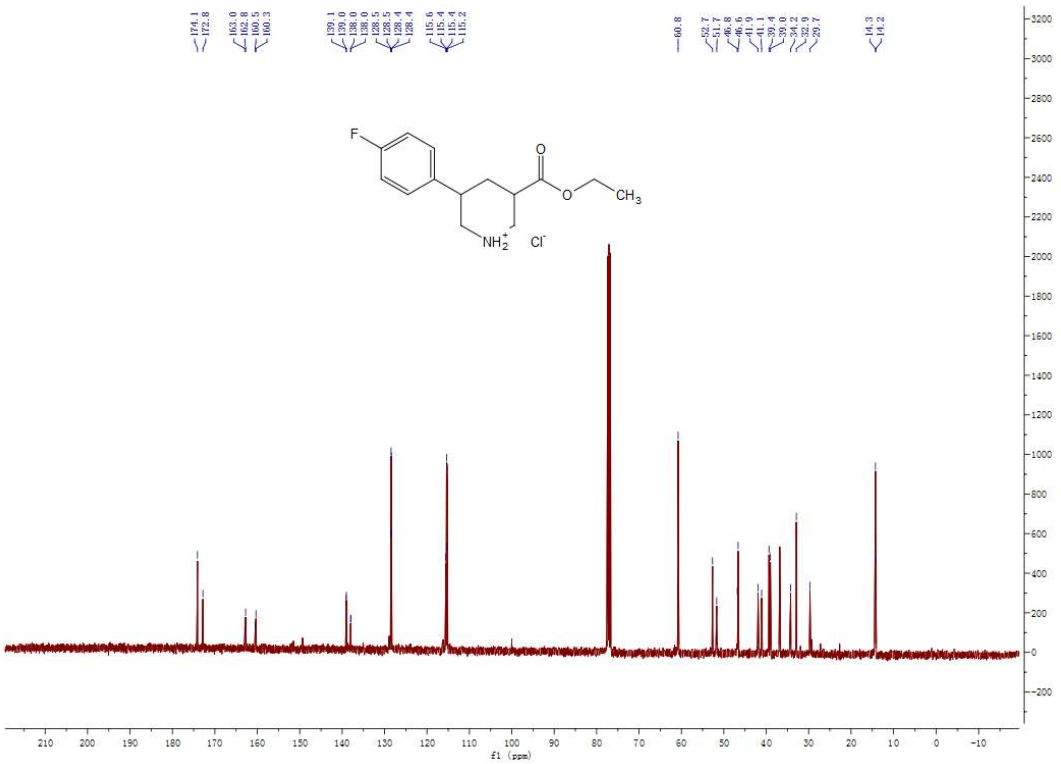
The NMR spectra of 2w



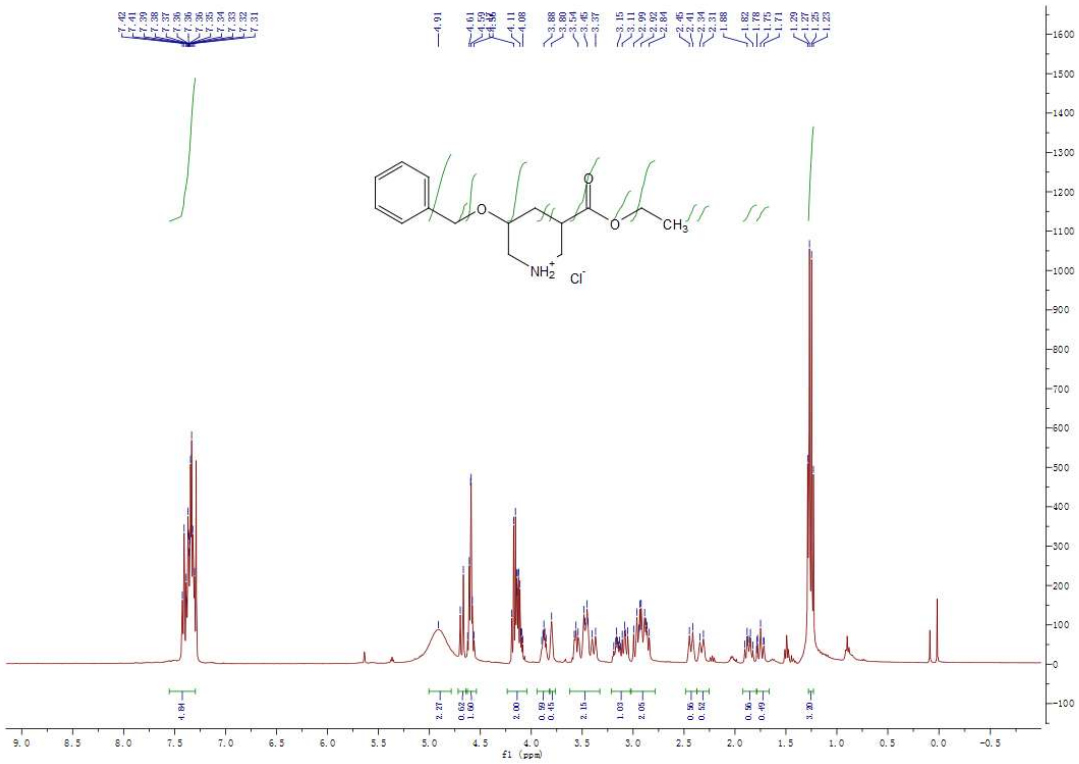


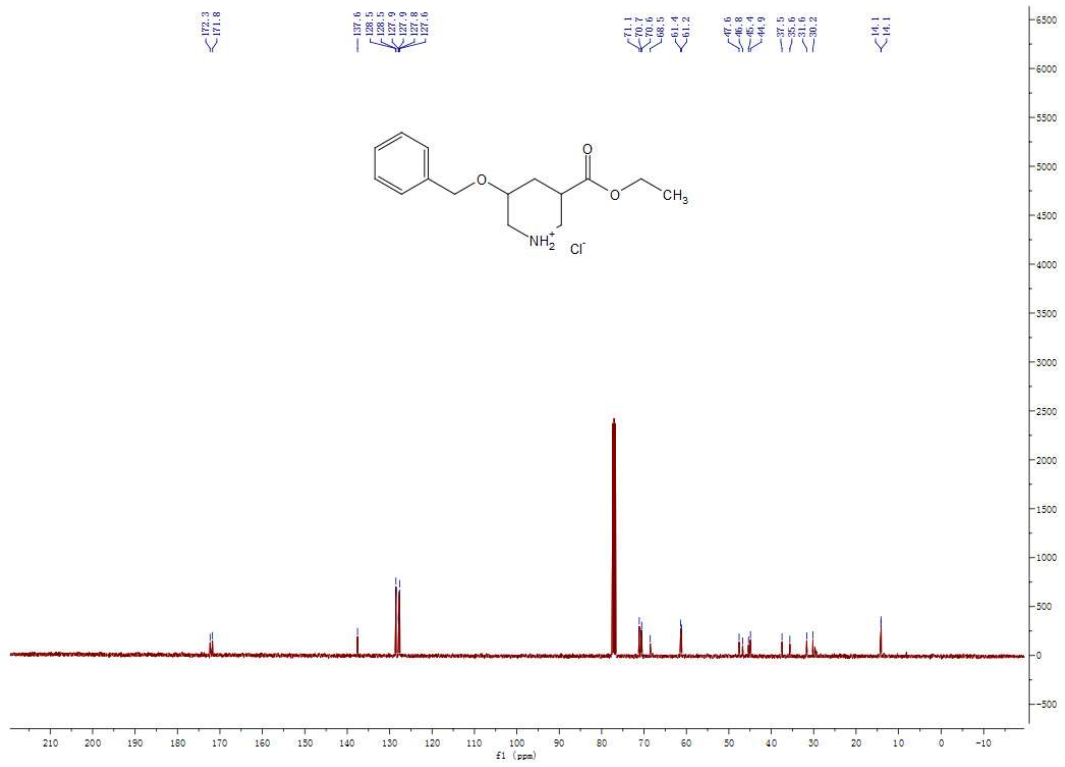
The NMR spectra of 2x



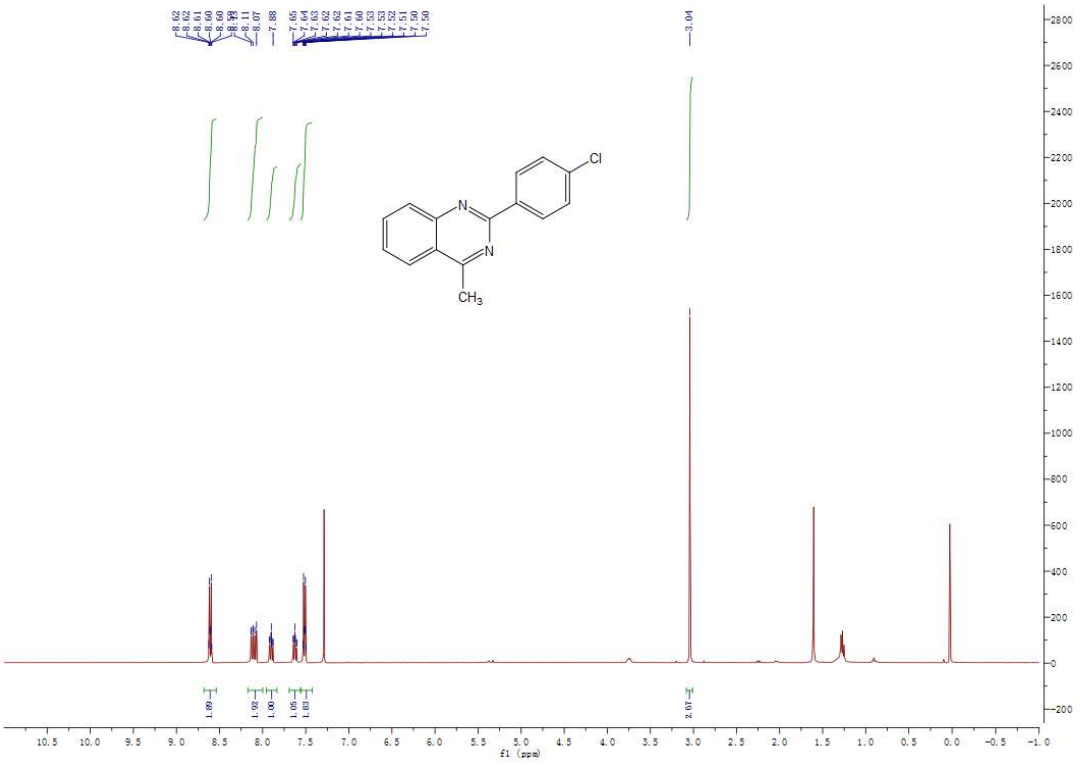


The NMR spectra of 2y

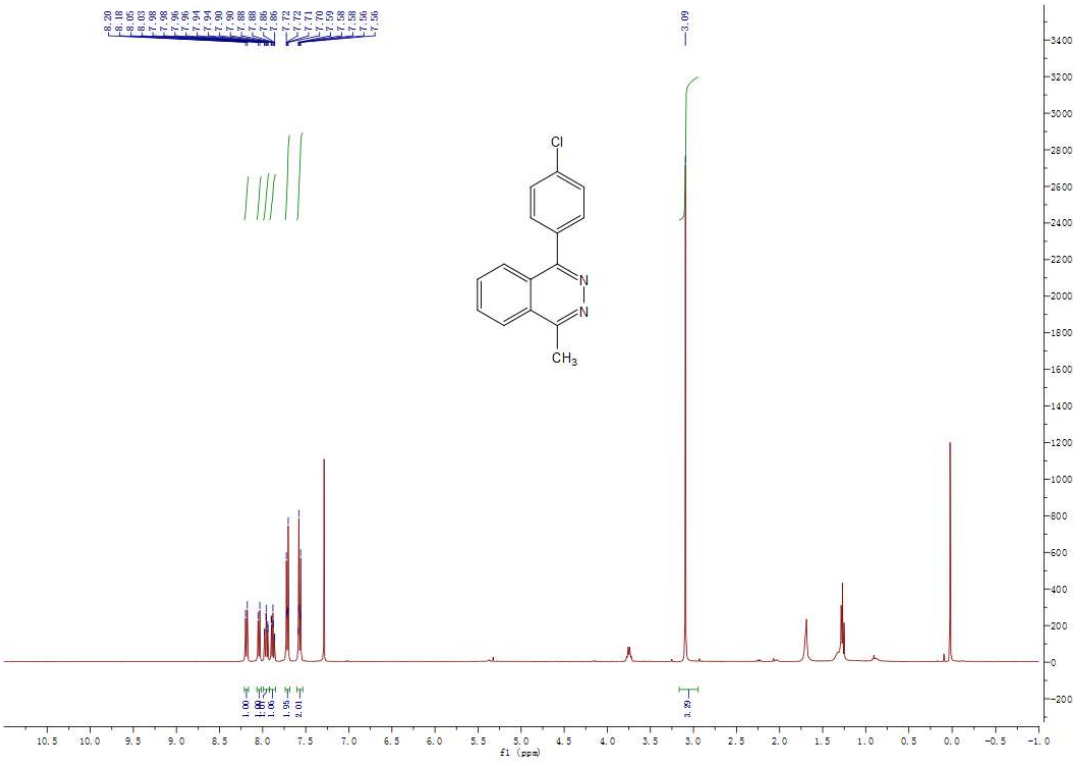




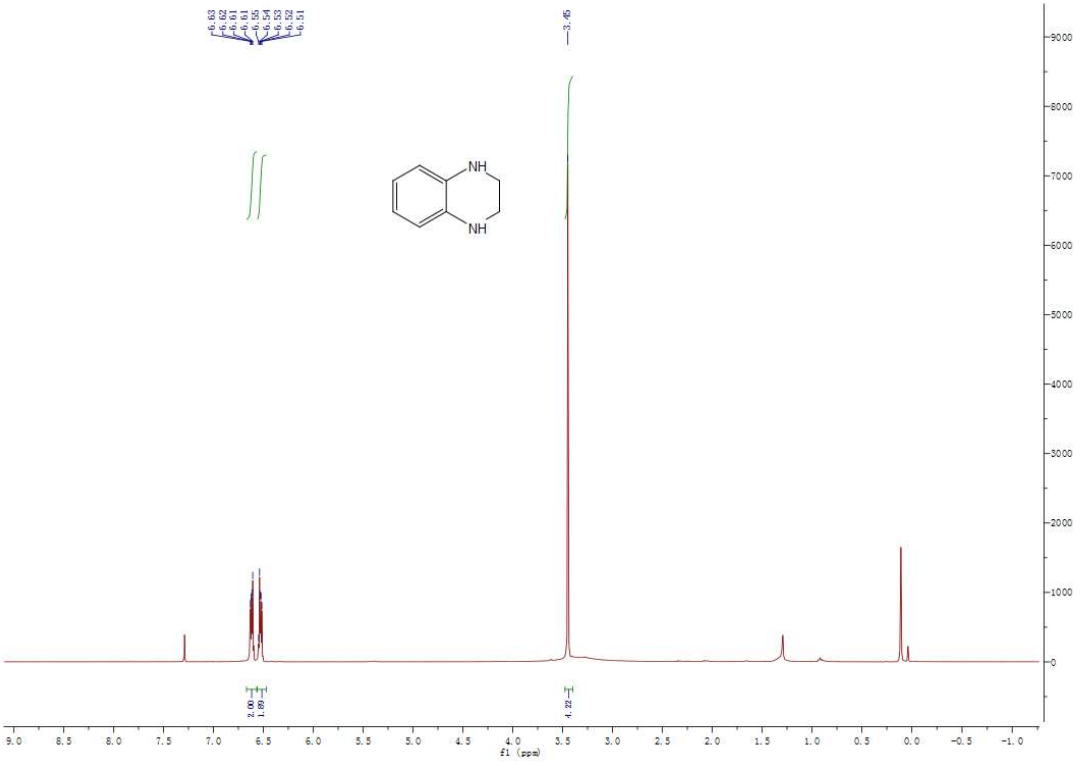
The NMR spectra of 3c

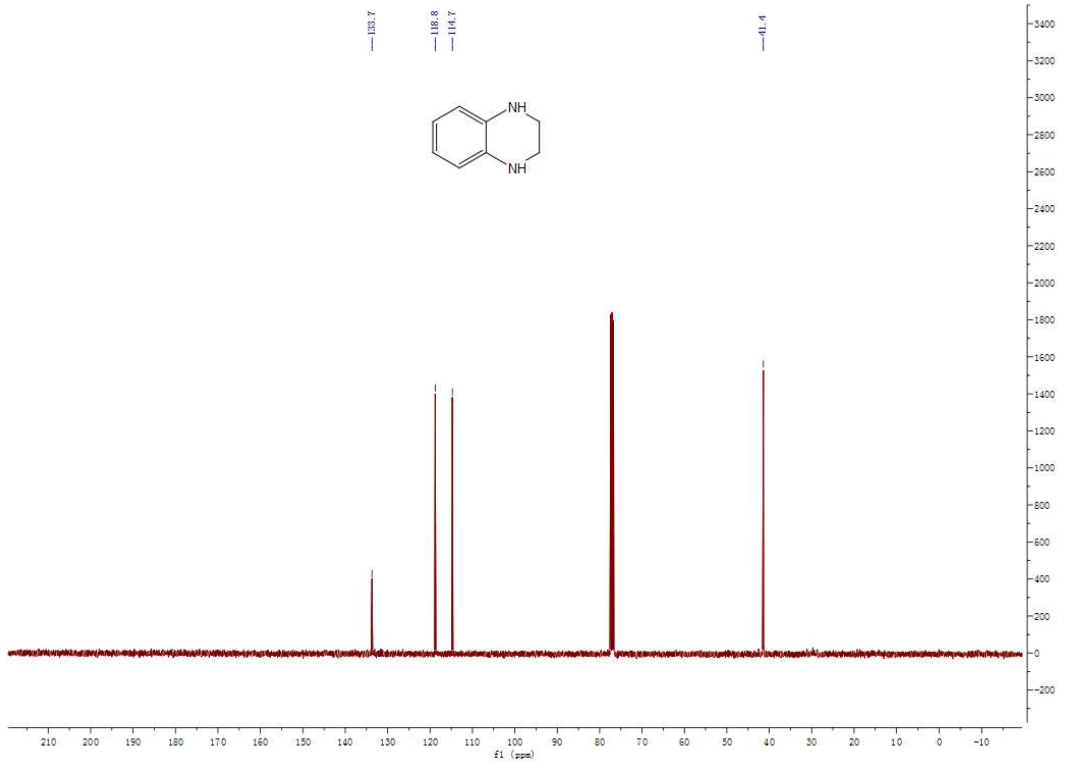


The NMR spectra of 3d

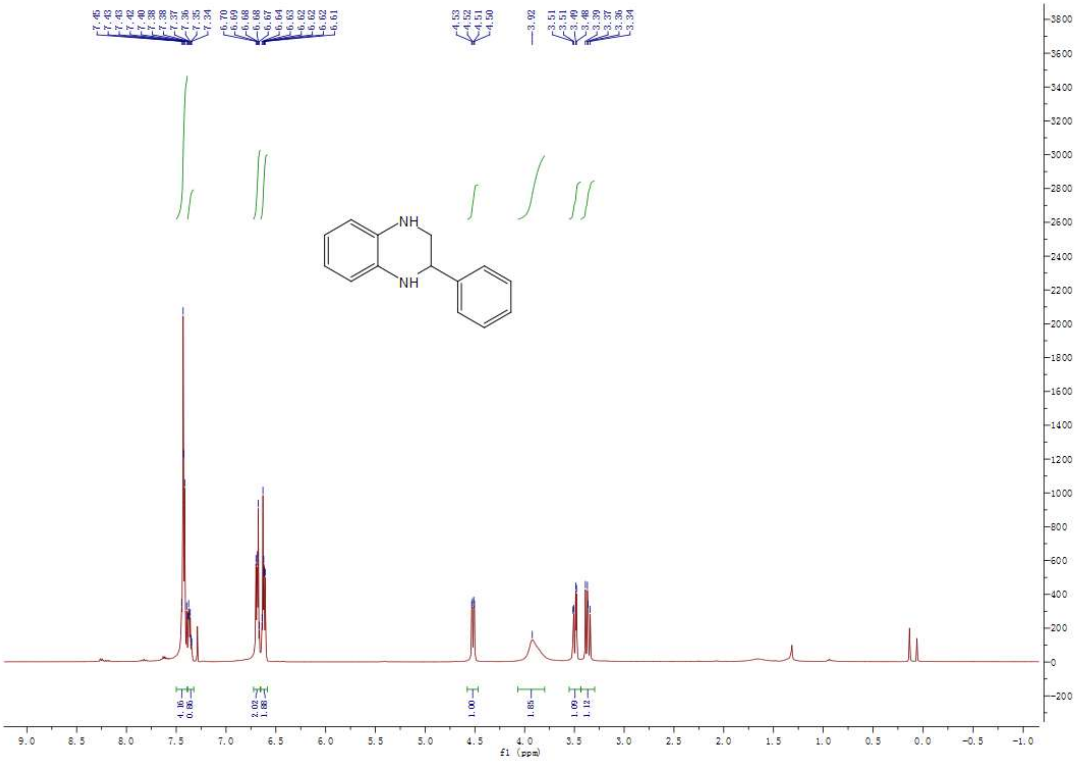


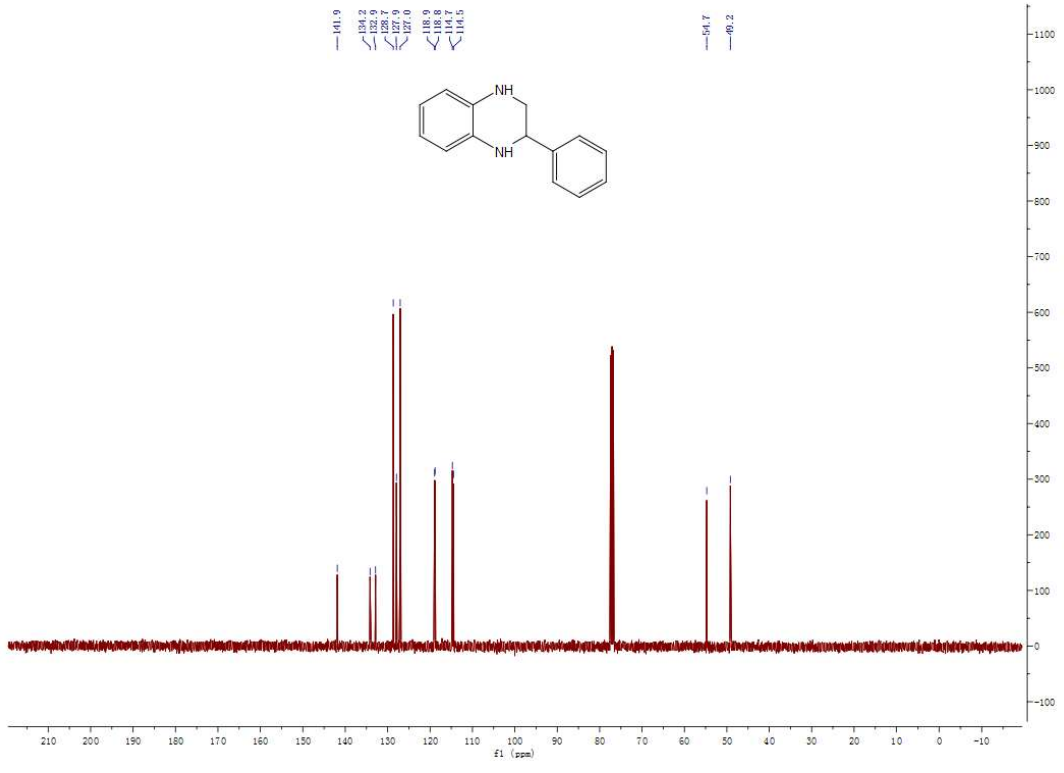
The NMR spectra of 4a



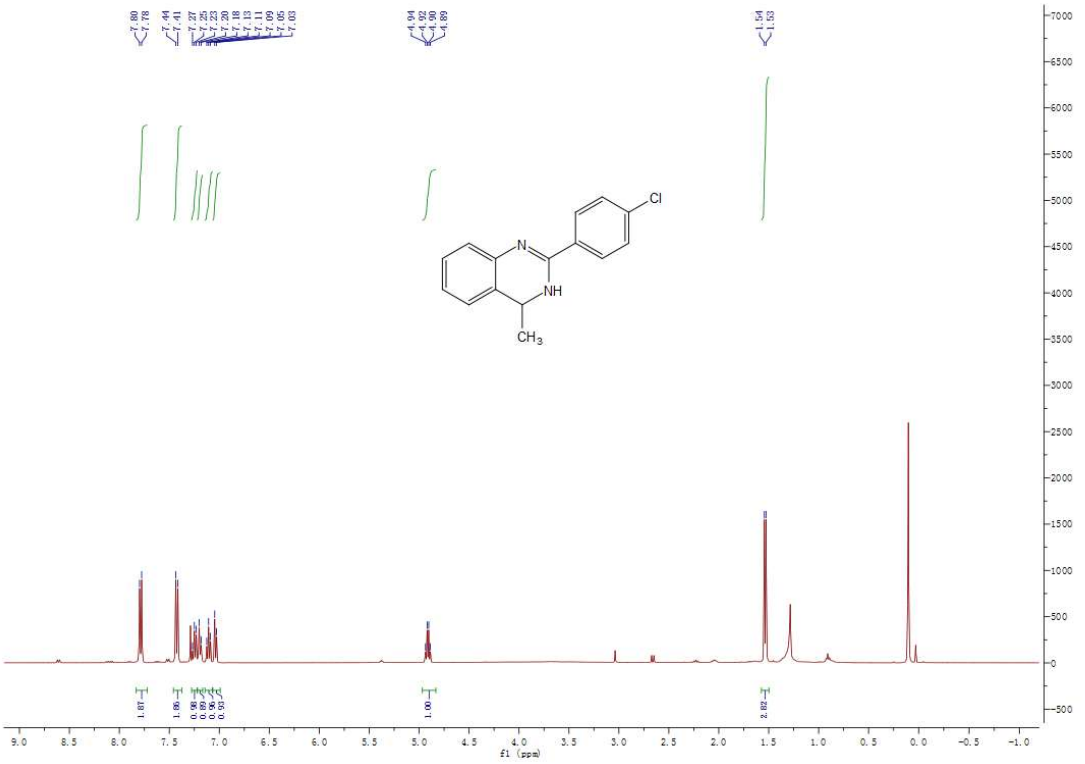


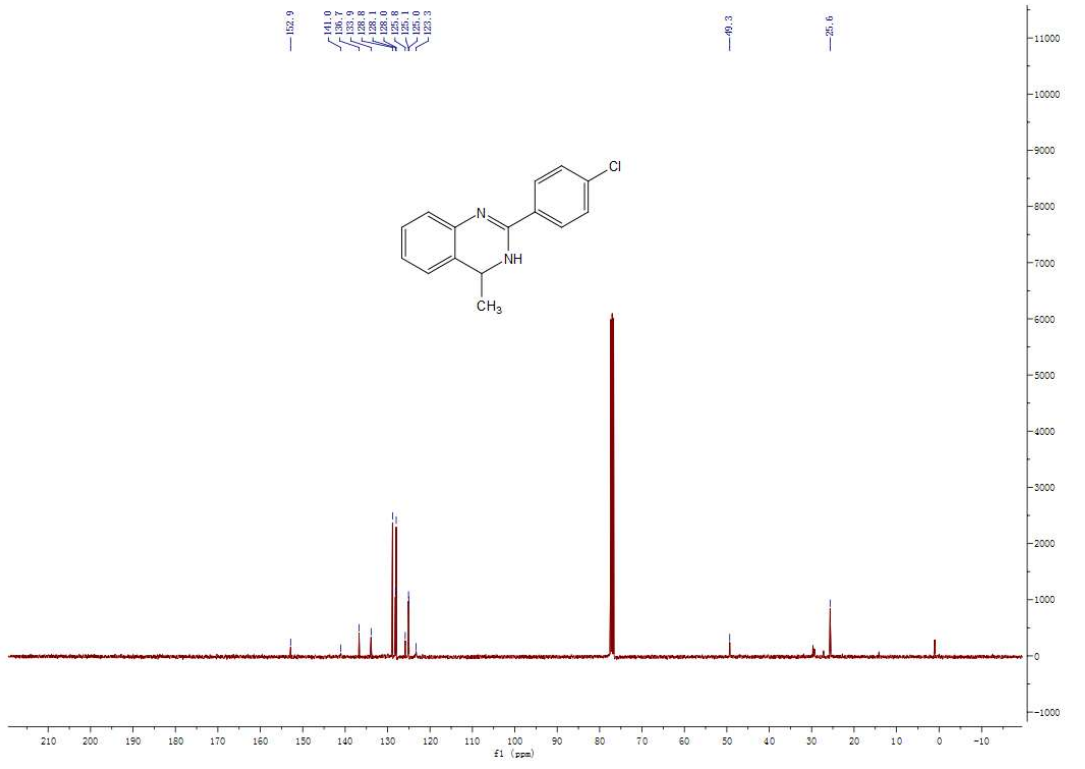
The NMR spectra of 4b



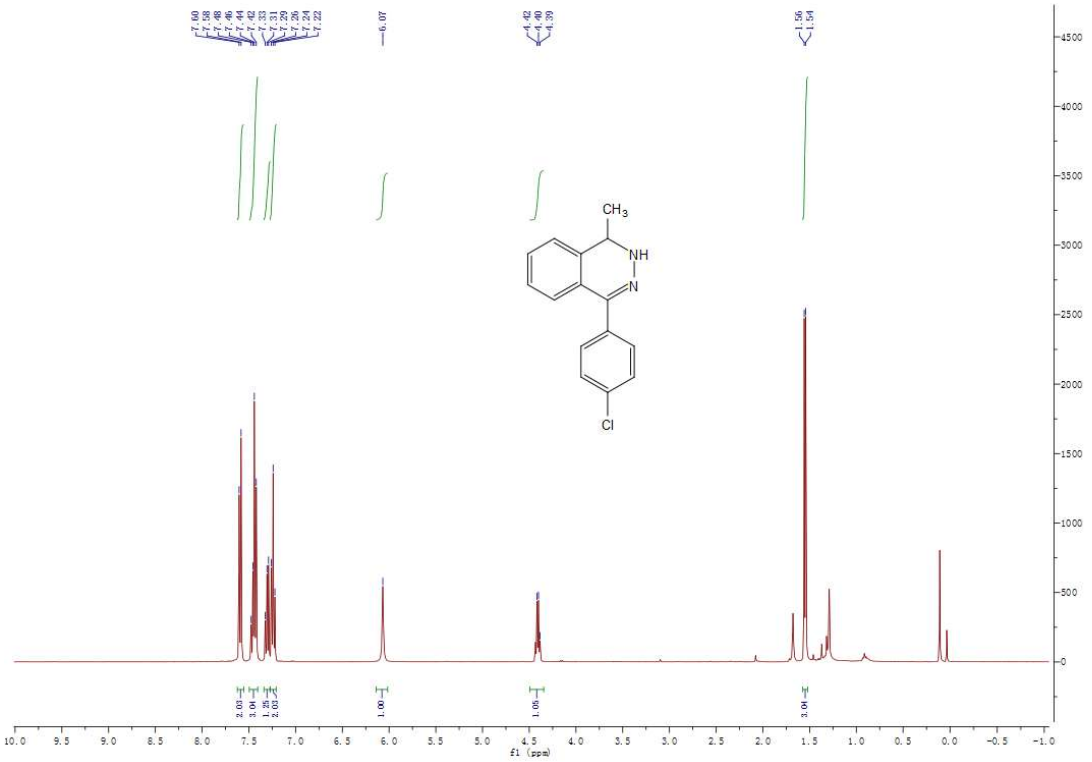


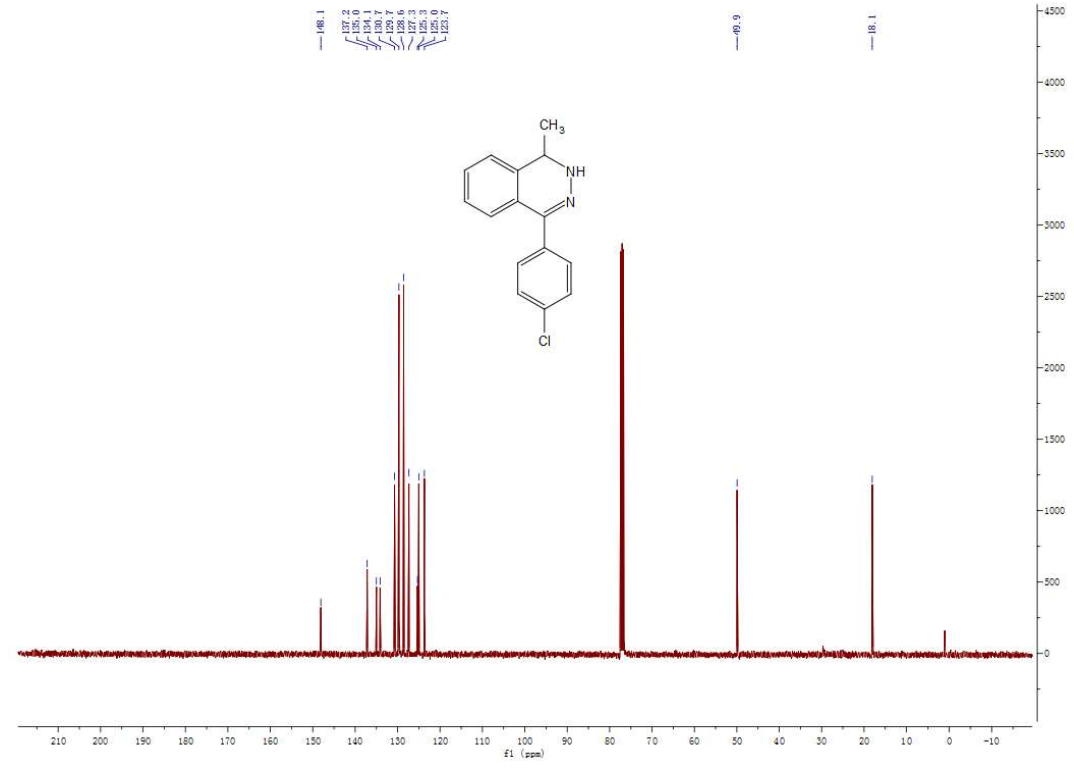
The NMR spectra of 4c



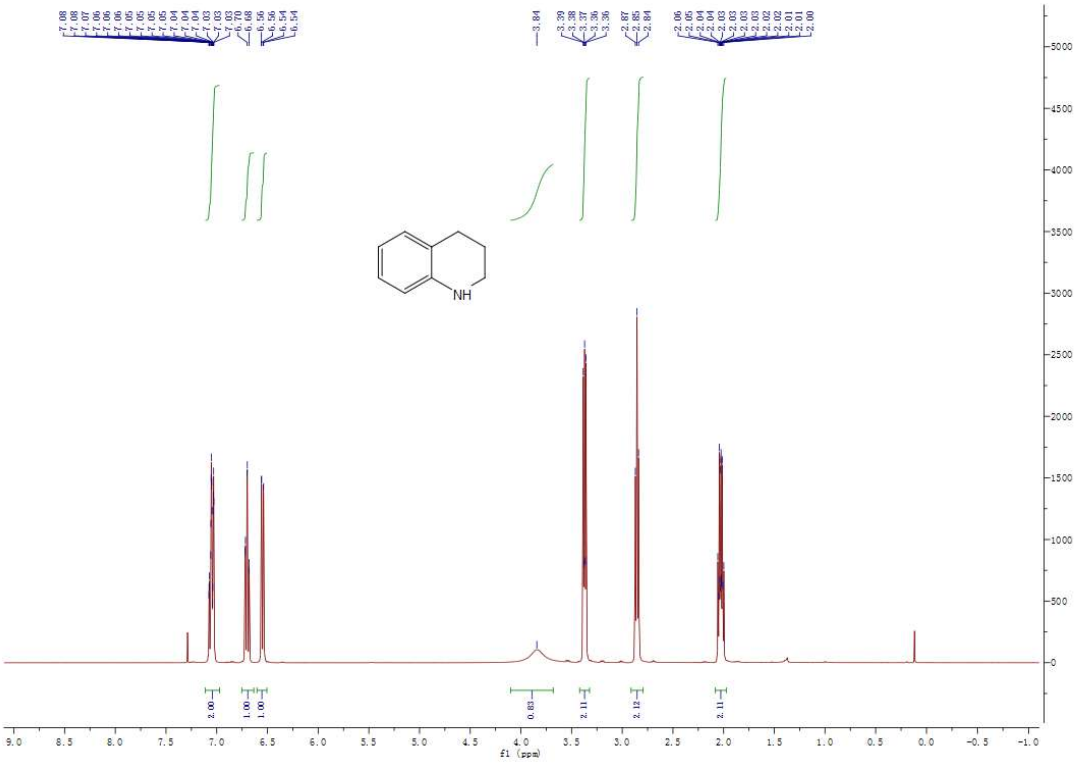


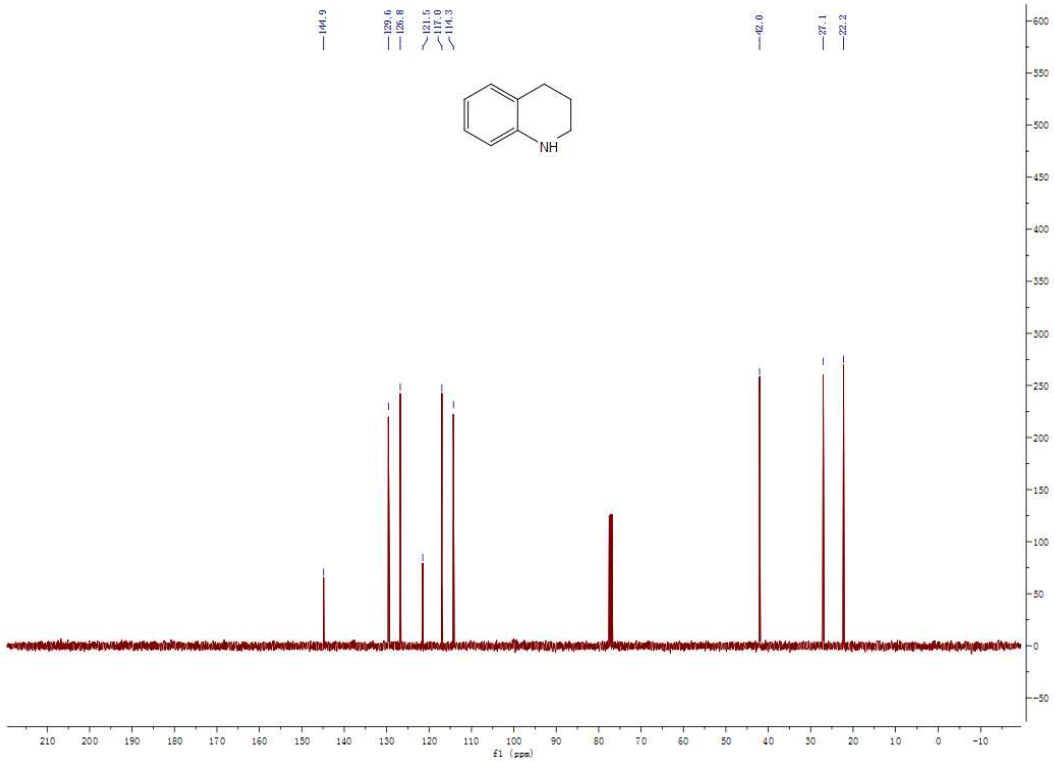
The NMR spectra of 4d



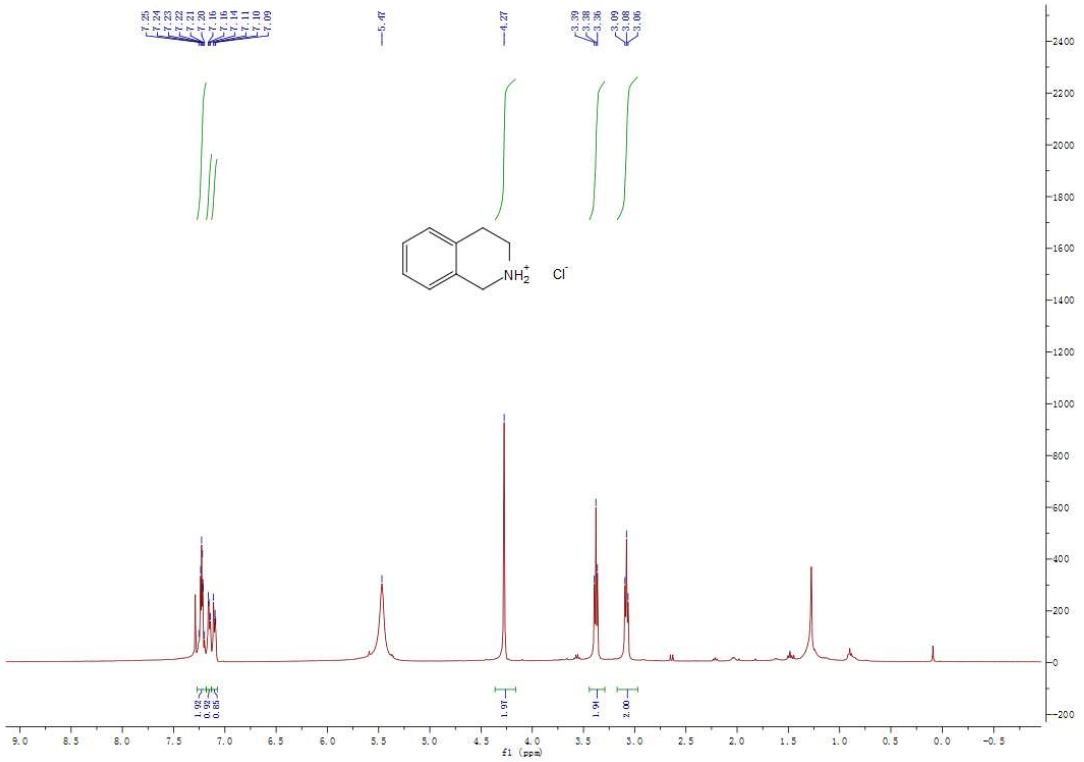


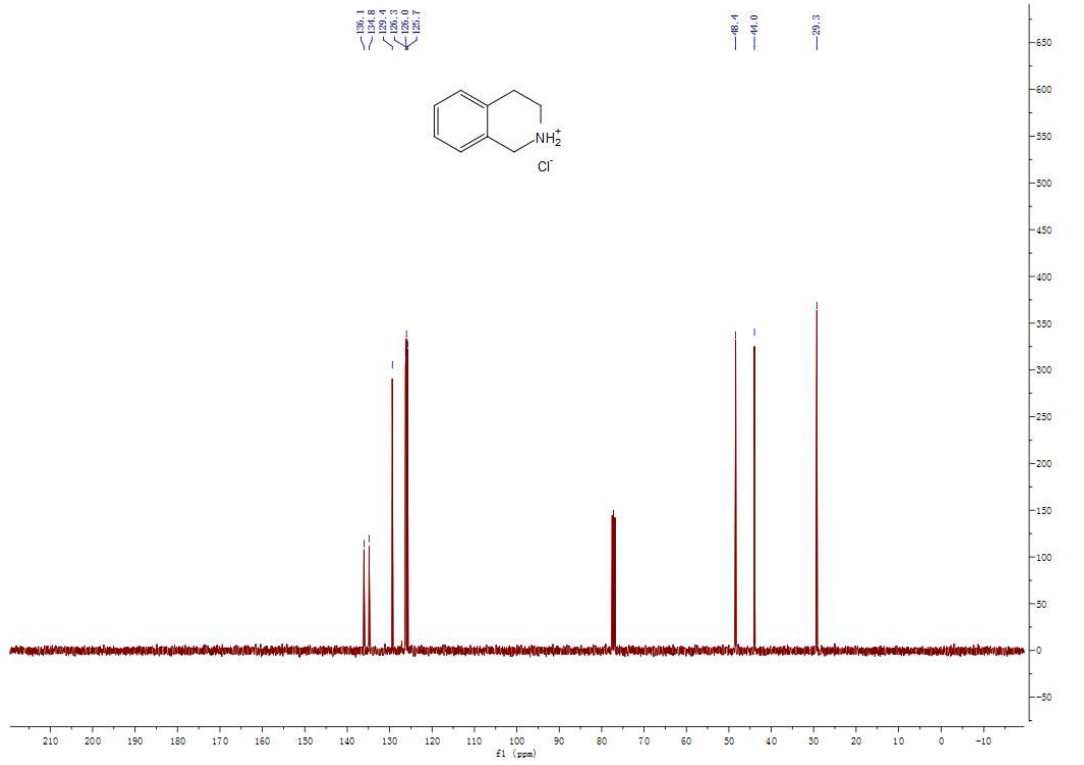
The NMR spectra of 4e



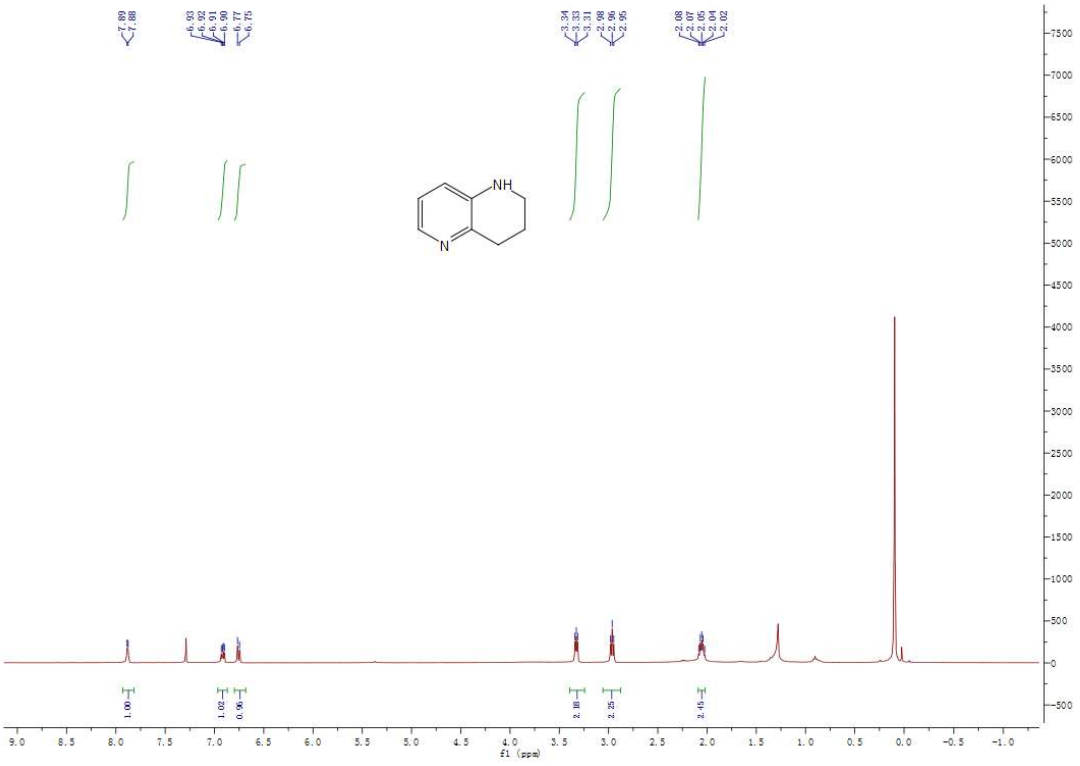


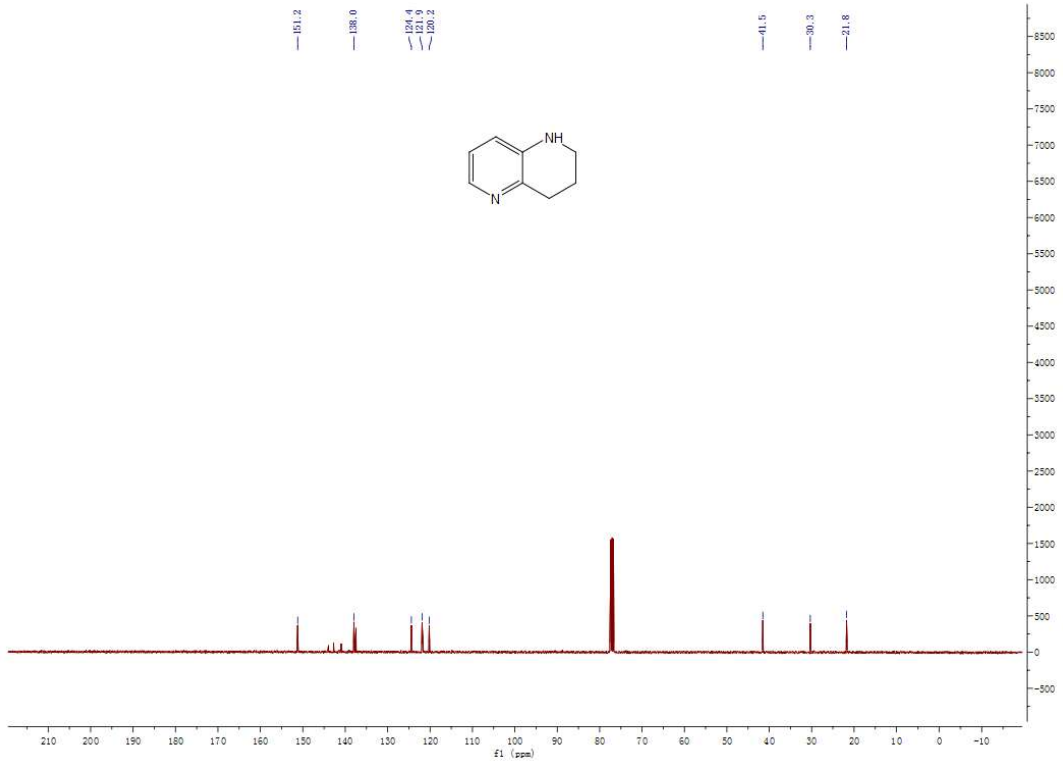
The NMR spectra of 4f



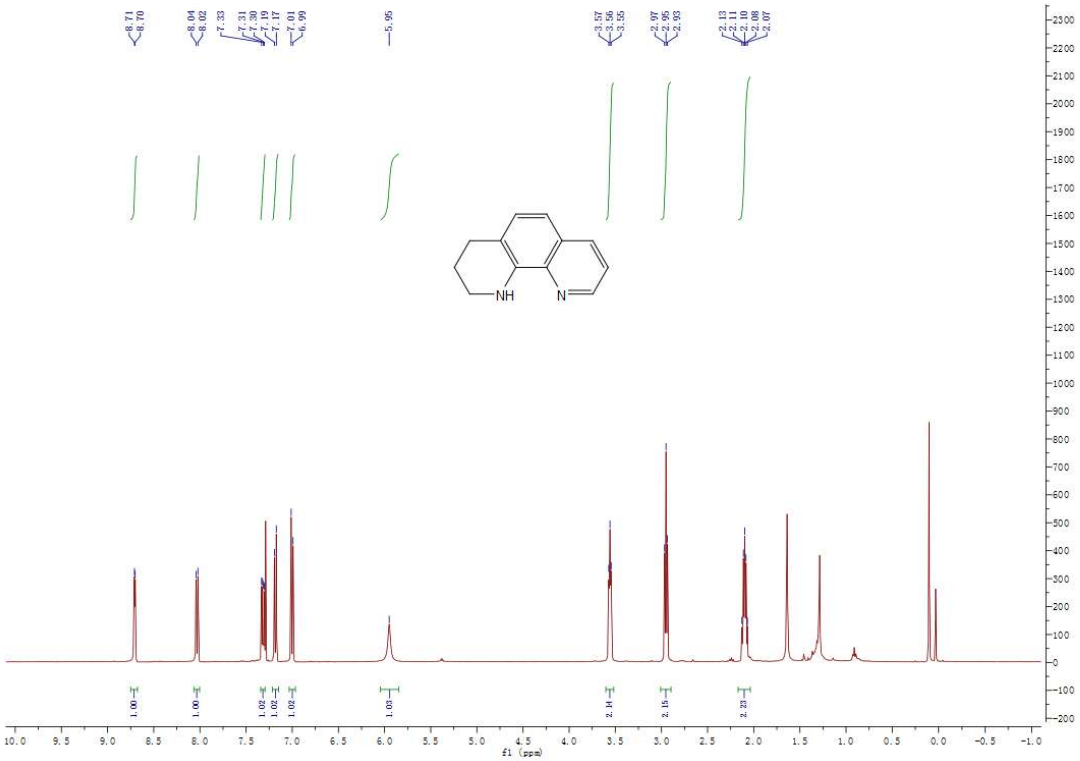


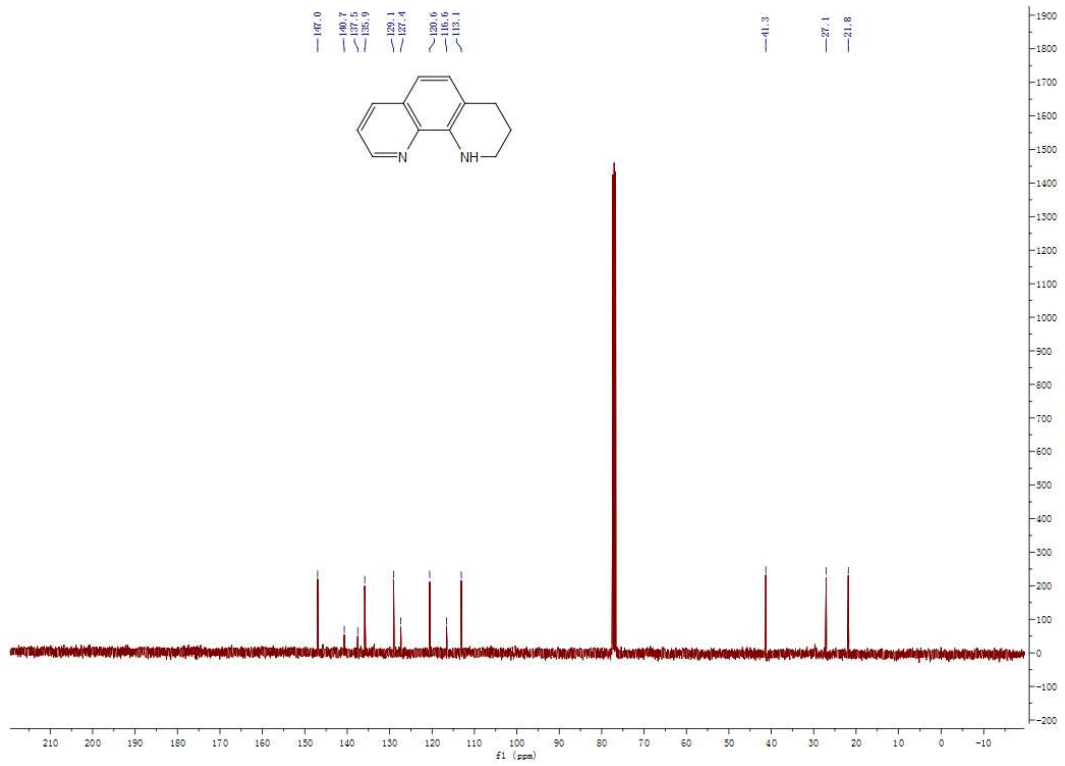
The NMR spectra of 4g



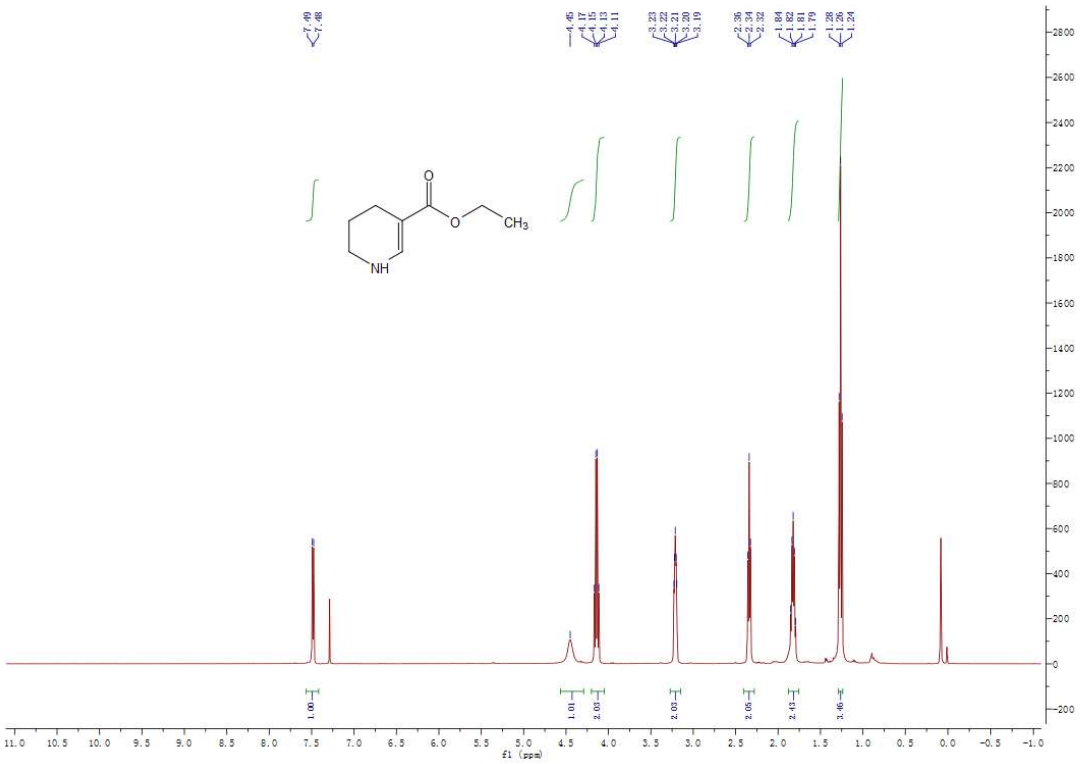


The NMR spectra of 4h

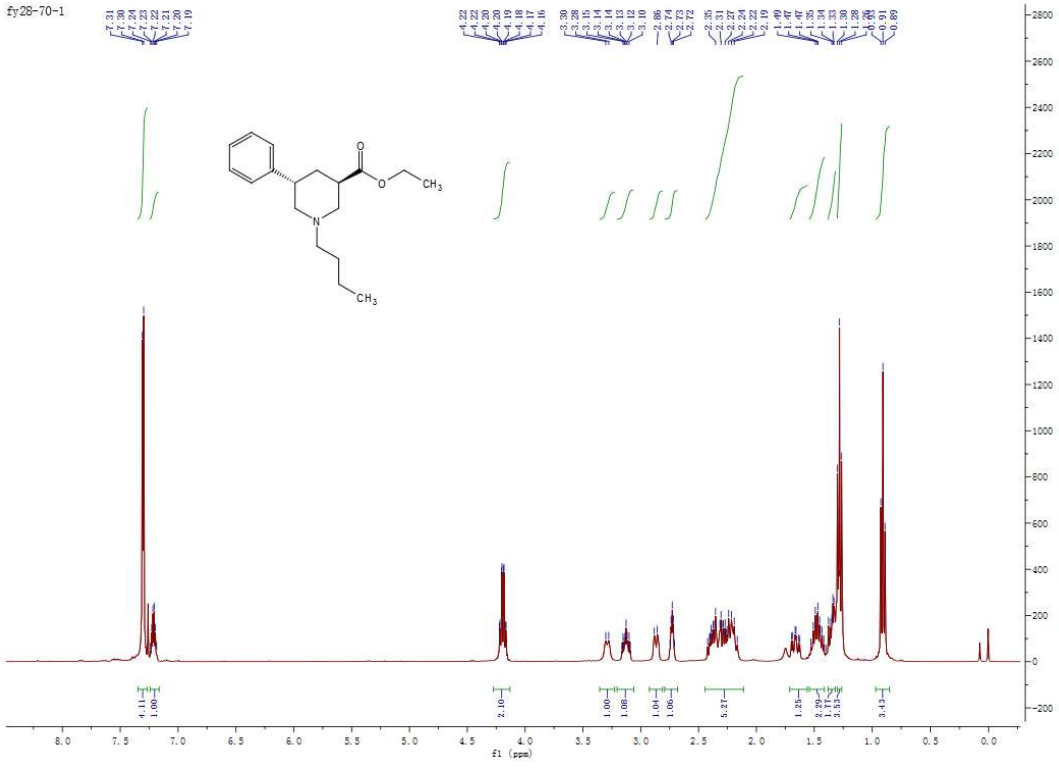




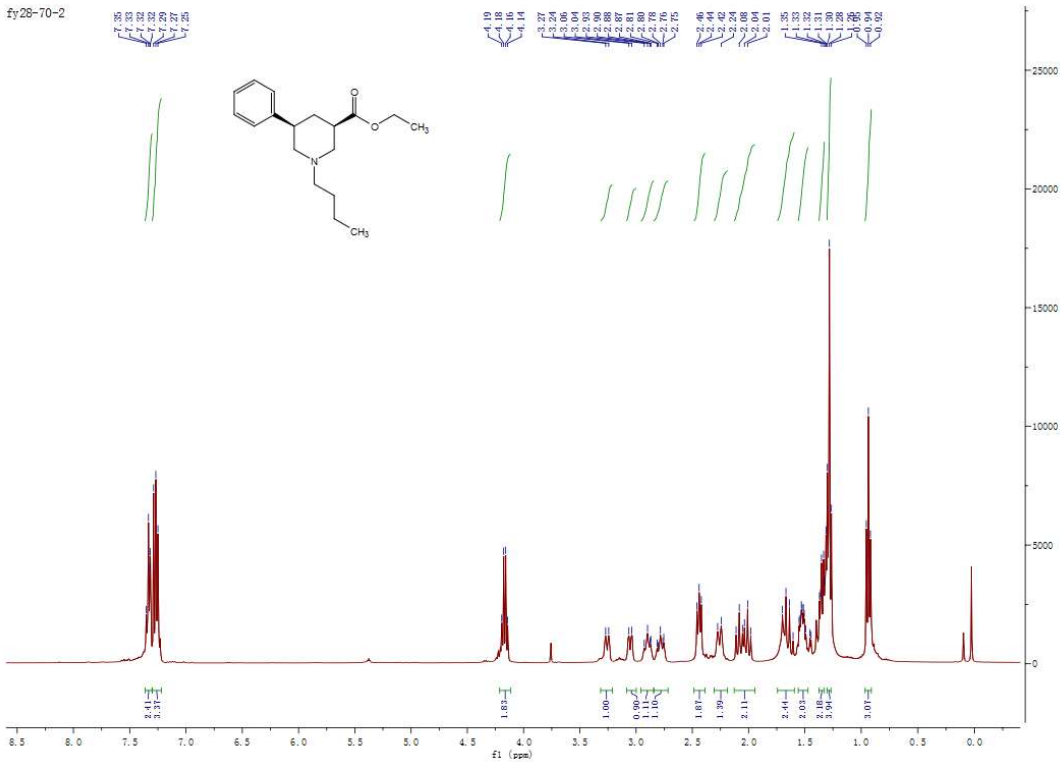
The NMR spectra of intermediate C



The NMR spectra of 5



The NMR spectra of 6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f1 (ppm)