Electronic Supplementary Material (ESI) for Organic Chemistry Frontiers.

Supporting Information

Palladium(II)-catalyzed three-component tandem reactions: synthesis of multiply substituted quinolines

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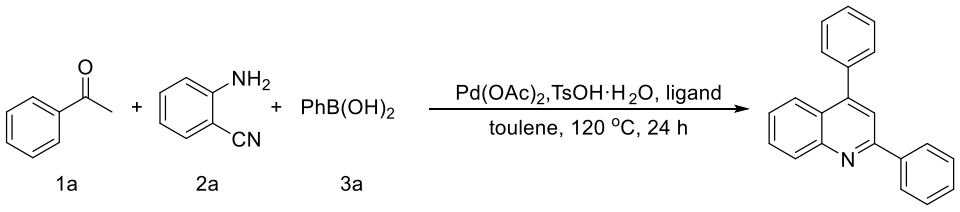
1. General Information

Chemicals were received from commercial sources without further purification or prepared by literature methods. Melting points are uncorrected and recorded on Digital Melting Point Apparatus WRS-1B. ^{1}H NMR and ^{13}C NMR spectra were measured on a 500 MHz Bruker spectrometer, using DMSO-d_6 or $CDCl_3$ as the solvent with tetramethylsilane (TMS) as the internal standard at room temperature. Chemical shifts are given in δ relative to TMS, the coupling constants J are given in Hz. High-resolution mass spectra were recorded on an ESI-Q-TOF mass spectrometer.

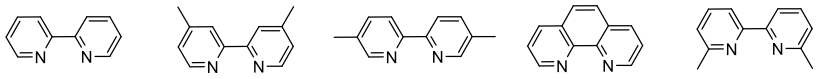
2. Experimental Section

2.1 Optimization of Reaction Conditions

Table S1 Optimization of the ligands.[a]



1a 2a 3a

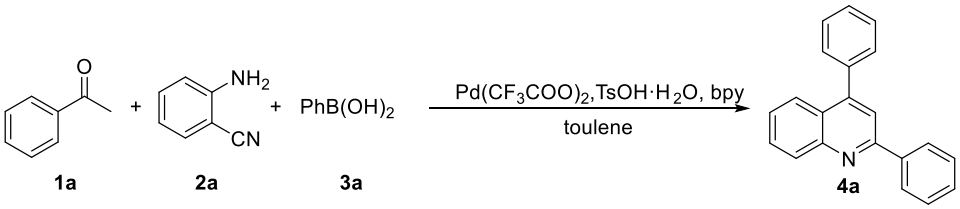


L1 L2 L3 L4 L5

entry	ligand	yield(%)[b]
1	L1	86
2	L2	84
3	L3	84
4	L4	85
5	L5	50

[a] Reaction Conditions: 1a (0.2 mmol), 2a (0.2 mmol), 3a (0.24 mmol), $Pd(OAc)_2$ (10 mol %), ligand (20 mol %), $TsOH·H_2O$ (10 eq), Toluene (2 ml). [b] Isolated yield.

Table S2 Optimization of the Reaction time.[a]

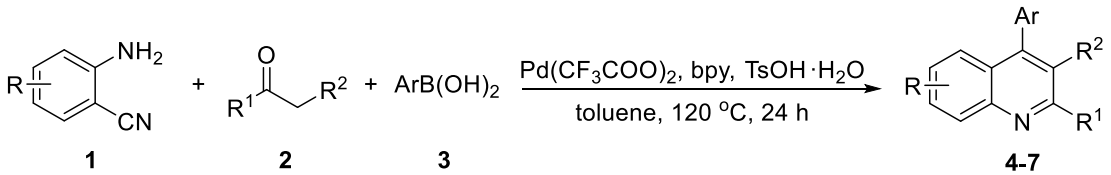


1a **2a** **3a** **4a**

entry	time	yield(%)[b]
1	6 h	69
2	12 h	80
3	24 h	90
4	48 h	89

[a] Reaction Conditions: **1a** (0.2 mmol), **2a** (0.2 mmol), **3a** (0.24 mmol), $Pd(CF_3COO)_2$ (10 mol %), ligand (20 mol %), $TsOH·H_2O$ (5.0 eq), Toluene (2 ml), 120 °C. [b] Isolated yield.

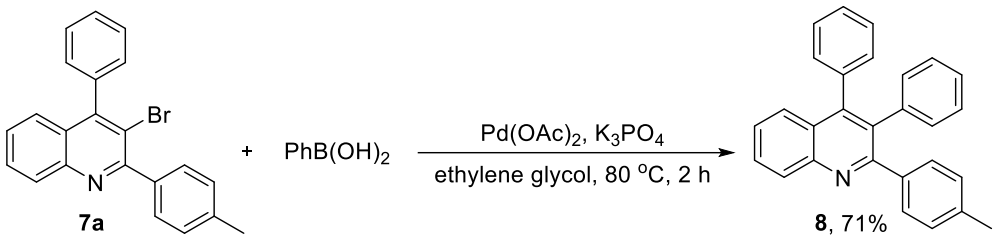
2.2 General Procedure for the Synthesis of Quinoline



1 **2** **3** **4-7**

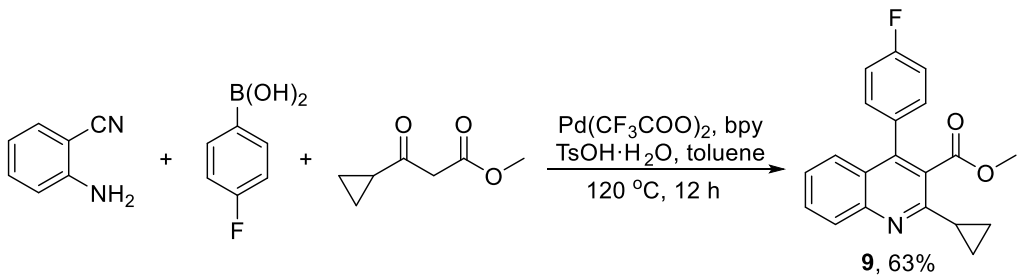
2-aminobenzonitrile (0.2 mmol), ketone (0.2 mmol), arylboronic acid (0.24 mmol), $Pd(OAc)_2$ (4.6 mg, 0.02 mmol), 2,2'-bpy (12.4 mg, 0.04 mmol), $TsOH \cdot H_2O$ (380.4 mg, 2.0 mmol) and toluene (2.0 mL) were successively added to a Schlenk reaction tube. The reaction mixture was stirred vigorously at 120 °C for 24 hours. After the reaction mixture was cooled to room temperature, washed with saturated Na_2CO_3, and extracted with ethyl acetate (3 × 10 ml). The combined organic layers were evaporated under a vacuum. The residue was purified by flash column chromatography with petroleum ether/ ethyl acetate (16:1) to afford desired product.

2.3 General Procedure for the Synthesis of 3,4-diphenyl-2-(p-tolyl)quinoline



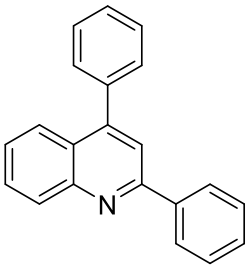
3-bromo-4-phenyl-2-(p-tolyl)quinoline **7a** (0.2 mmol), $Pd(OAc)_2$ (10 mol %), K_3PO_4 (5.0 equiv.) and phenylboronic acid (1.25 eq) were added to a 10 mL Schlenk reaction tube. Ethylene glycol (3.0 mL) was added and the solution was then purged with N_2 for 15 min. The flask was sealed and heated to 80 °C with stirred for 2 h. Then allowed to cool to rt. The reaction mixture was then diluted with DCM (20 mL) and washed with water (20 mL). The organic layer was separated, dried over Na_2SO_4 and the solvent removed in vacuo to yield an orange solid. Purification by flash chromatography afforded **8**.

2.4 General Procedure for the Synthesis of methyl 2-cyclopropyl-4-(4-fluorophenyl)quinoline-3-carboxylate

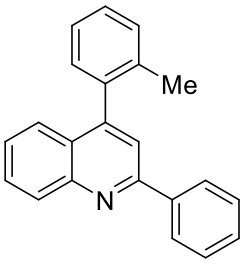


2-aminobenzonitrile (0.2 mmol), methyl 3-cyclopropyl-3-oxopropanoate (0.4 mmol), (4-fluorophenyl)boronic acid (0.24 mmol), $Pd(OAc)_2$ (0.02 mmol), 2,2'-bpy (0.04 mmol), TsOH • H_2O (0.6 mmol) and toluene (2.0 mL) were successively added to a Schlenk reaction tube. The reaction mixture was stirred vigorously at 120 ℃ for 12 hours. After the reaction mixture was cooled to room temperature, washed with saturated Na_2CO_3, and extracted with ethyl acetate (3 × 10 ml). The combined organic layers were evaporated under a vacuum. The residue was purified by flash column chromatography with petroleum ether/ ethyl acetate (16:1) to afford desired product **9**.

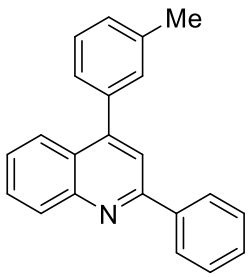
3. Analytical Data for All Products



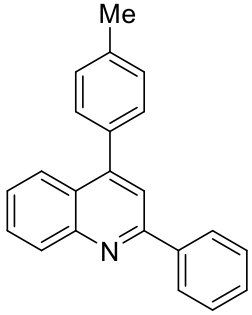
*2,4-diphenylquinoline (**4a**)*: Pale yellow oil (50.6 mg, 90%) (lit.[1] Oil). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.29 (d, *J* = 8.0 Hz, 1H), 8.24-8.22 (m, 2H), 7.93 (d, *J* = 8.5 Hz, 1H), 7.85 (s, 1H), 7.76 (dd appear t, J_1 = 7.5 Hz, J_2 = 7.5 Hz, 1H), 7.59-7.48 (m, 9H); ^{13}C NMR (125 MHz, DMSO-d_6) δ 156.9, 149.2, 148.9, 139.7, 138.5, 130.2, 129.6, 129.5, 129.4, 128.9, 128.6, 128.4, 127.6, 126.4, 125.8, 125.7, 119.4.



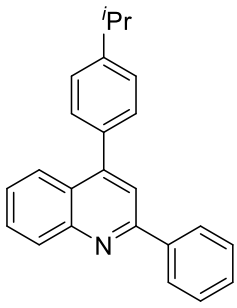
*2-phenyl-4-(o-tolyl)quinoline (**4b**)*: Pale yellow oil (18.9 mg, 32%) (lit.[2] Oil). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.28 (d, *J* = 8.5 Hz, 1H), 8.23-8.18 (m, 2H), 7.78 (s, 1H), 7.73 (dd appear t, J_1 = 7.0 Hz, J_2 = 7.0 Hz, 1H), 7.56-7.47 (m, 4H), 7.45-7.34 (m, 4H), 7.29 (d, *J* = 7.0 Hz, 1H), 2.10 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 156.9, 149.4, 148.4, 139.5, 137.8, 136.2, 130.2, 130.0, 129.7, 129.6, 129.4, 128.9, 128.5, 127.6, 126.4, 126.3, 125.8, 125.7, 119.4, 20.0.



*2-phenyl-4-(m-tolyl)quinoline (**4c**)*: Pale yellow oil (51.4 mg, 87%) (lit.[1] Oil). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.29 (d, *J* = 8.5 Hz, 1H), 8.23 (d, *J* = 7.5 Hz, 2H), 7.95 (d, *J* = 8.5 Hz, 1H), 7.84 (s, 1H), 7.75 (dd appear t, J_1 = 8.0 Hz, J_2 = 8.0 Hz,, 1H), 7.55 (t, *J* = 7.0 Hz, 2H), 7.51-7.44 (m, 3H), 7.41-7.34 (m, 3H), 2.49 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 156.9, 149.5, 148.8, 139.7, 138.4, 138.3, 130.2, 130.1, 129.5, 129.4, 129.2, 128.9, 128.5, 127.7, 126.7, 126.3, 125.9, 125.8, 119.3, 21.5.

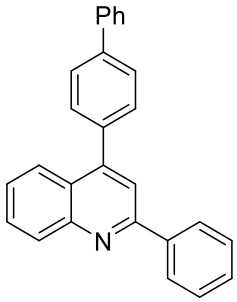


*2-phenyl-4-(p-tolyl)quinoline (**4d**)*: Pale yellow oil (44.3 mg, 75%) (lit.[1] Oil). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.28 (d, *J* = 8.5 Hz, 1H), 8.23-8.20 (m, 2H), 7.96 (d, *J* = 8.5 Hz, 1H), 7.83 (s, 1H), 7.75 (dd appear t, J_1 = 7.0 Hz, J_2 = 7.0 Hz,, 1H), 7.55 (dd appear t, J_1 = 7.0 Hz, J_2 = 7.0 Hz, 2H), 7.48-7.49 (m, 4H), 7.38 (d, *J* = 7.5 Hz, 2H), 2.50 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 156.9, 149.3, 148.8, 139.7, 138.4, 135.5, 130.1, 129.5, 129.3, 128.9, 127.7, 126.3, 125.9, 125.8, 119.4, 21.3.

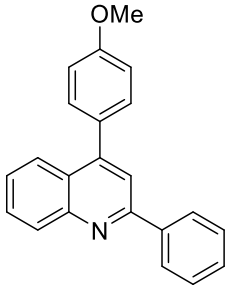


4-*(4-isopropylphenyl)-2-phenylquinoline (**4e**)*: Pale yellow oil (45.9 mg, 71%) (lit.[3] Gum). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.28 (d, *J* = 8.5 Hz, 1H), 8.22 (d, *J* = 7.0 Hz,

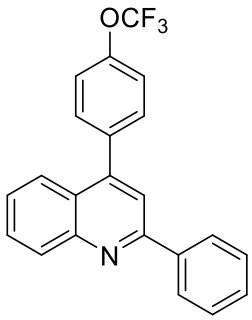
2H), 7.99 (d, J = 8.5 Hz, 1H), 7.85 (s, 1H), 7.75 (dd appear t, J_1 = 8.5 Hz, J_2 = 8.5 Hz, 1H), 7.56-7.47 (m, 6H), 7.43 (d, J = 8.0 Hz, 2H), 3.09-3.03 (m, 1H), 1.38 (d, J = 7.0 Hz, 6H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 156.9, 149.3, 149.2, 148.9, 139.8, 135.9, 130.1, 129.6, 129.5, 129.3, 128.9, 127.7, 126.7, 126.3, 126.0, 125.8, 119.4, 34.0, 24.1.



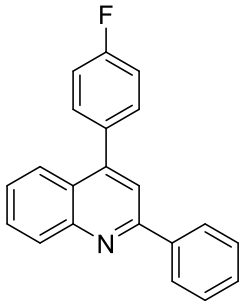
*4-(Biphenyl-4-yl)-2-phenylquinoline (**4f**)*: Pale yellow solid (48.6 mg, 68%), mp 106-108 °C (lit.[1] 108-109 °C). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.32 (d, J = 8.5 Hz, 1H), 8.25 (d, J = 7.0 Hz, 2H), 8.02 (d, J = 8.5 Hz, 1H), 7.89 (s, 1H), 7.81-7.76 (m, 3H), 7.73 (d, J = 7.5 Hz, 2H), 7.66 (d, J = 8.0 Hz, 2H), 7.58-7.49 (m, 6H), 7.43 (dd appear t, J_1 = 7.5 Hz, J_2 = 7.5 Hz, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 157.0, 148.9, 148.8, 141.4, 140.5, 139.7, 137.4, 130.2, 130.1, 129.6, 129.4, 129.0, 128.9, 127.7, 127.6, 127.4, 127.2, 126.5, 125.8, 125.7, 119.4.



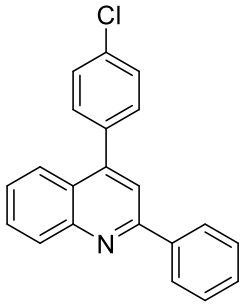
4-*(4-methoxyphenyl)-2-phenylquinoline (**4g**)*: Pale yellow oil (52.2 mg, 43%) (lit.[1] Oil). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.27 (d, J = 8.5 Hz, 1H), 8.21-8.17 (m, 2H), 7.96 (d, J = 8.5 Hz, 1H), 7.80 (s, 1H), 7.74 (dd appear t, J_1 = 8.0 Hz, J_2 = 8.0 Hz, 1H), 7.55-7.47 (m, 6H), 7.09 (d, J = 8.5 Hz, 2H), 3.92 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 160.0, 156.9, 149.1, 148.7, 139.6, 130.8, 130.7, 130.0, 129.5, 129.4, 128.8, 127.7, 126.3, 126.0, 125.7, 119.4, 114.1, 55.4.



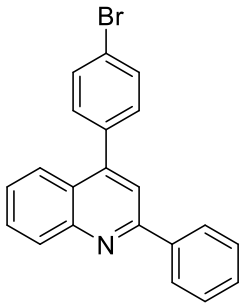
*2-phenyl-4-(4-(trifluoromethoxy)phenyl)quinoline (**4h**)*: Pale yellow oil (35.8 mg, 49%). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.27 (d, *J* = 8.5 Hz, 1H), 8.20 (d, *J* = 7.5 Hz, 2H), 7.85 (d, *J* = 8.5 Hz, 1H), 7.81 (s, 1H), 7.76 (dd appear t, J_1 = 8.0 Hz, J_2 = 8.0 Hz, 1H), 7.60 (d, *J* = 8.5 Hz, 2H), 7.56-7.47 (m, 4H), 7.42 (d, *J* = 8.0 Hz, 2H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 156.9, 149.4, 148.8, 147.7, 139.4, 137.1, 131.1, 130.3, 129.8, 129.5, 128.9, 127.6, 126.7, 125.6, 125.2, 121.1, 120.6 (d, *J* = 255.0 Hz), 119.4. HRMS (ESI) calcd for $C_{22}H_{15}F_3NO$ $[M+H]^+$: 366.1100, found 366.1107



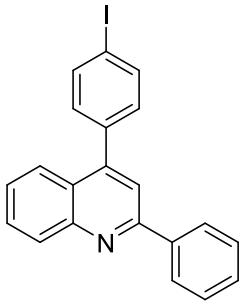
*4-(4-fluorophenyl)-2-phenylquinoline (**4i**)*: Pale yellow oil (35.3 mg, 59%) (lit.[1] Oil). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.28 (d, *J* = 8.5 Hz, 1H), 8.20 (d, *J* = 7 Hz, 2H), 7.87 (d, *J* = 8 Hz, 1H), 7.80 (s, 1H), 7.75 (dd appear t, J_1 = 8.5 Hz, J_2 = 8.5 Hz, 1H), 7.56-7.46 (m, 6H), 7.28-7.23 (m, 2H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 163.0 (d, *J* = 247.5 Hz), 162.0, 156.9, 148.8, 148.2, 139.5, 134.4 (d, *J* = 3.8 Hz), 131.3 (d, *J* = 8.8 Hz), 130.2, 129.7, 129.5, 128.9, 127.6, 126.5, 125.8, 125.4, 119.4, 115.7 (d, *J* = 21.3 Hz).



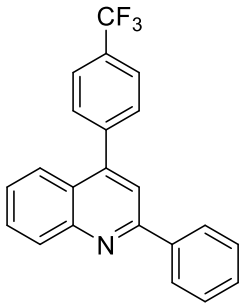
*4-(4-chlorophenyl)-2-phenylquinoline (**4j**)*: Pale yellow oil (38.5 mg, 61%) (lit.[1] Oil). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.27 (d, *J* = 8.5 Hz, 1H), 8.20 (d, *J* = 7 Hz, 2H), 7.85 (d, *J* = 8.0 Hz, 1H), 7.79 (s, 1H), 7.75 (dd appear t, J_1 = 8.0 Hz, J_2 = 8.0 Hz, 1H), 7.56-7.47 (m, 8H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 156.9, 148.8, 147.9, 139.5, 136.8, 134.7, 130.9, 130.2, 129.7, 129.5, 128.9, 127.6, 126.6, 125.6, 125.3, 119.3.



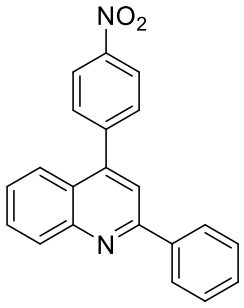
*4-(4-bromophenyl)-2-phenylquinoline (**4k**)*: Pale yellow oil (45.4 mg, 63%) (lit.[1] Oil). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.27 (d, *J* = 8.5 Hz, 1H), 8.19 (d, *J* = 8.0 Hz, 2H), 7.85 (d, *J* = 8.5 Hz, 1H), 7.78 (s, 1H), 7.77-7.73 (m, 1H), 7.69 (d, *J* = 8.5 Hz, 2H), 7.56-7.43 (m, 6H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 156.9, 148.8, 148.0, 139.4, 137.3, 131.9, 131.2, 130.2, 129.7, 129.5, 128.9, 127.6, 126.6, 125.5, 125.3, 122.9, 119.2.



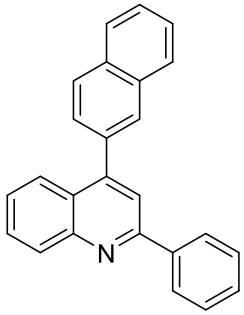
*4-(4-iodophenyl)-2-phenylquinoline (**4l**)*: Pale yellow oil (50.5 mg, 62%). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.27 (d, *J* = 8.5 Hz, 1H), 8.20-8.17 (m, 2H), 7.89 (d, *J* = 8.5 Hz, 2H), 7.85 (d, *J* = 8.5 Hz, 1H), 7.78 (s, 1H), 7.75 (dd appear t, J_1 = 8.0 Hz, J_2 = 8.0 Hz, 1H), 7.54 (dd appear t, J_1 = 7.5 Hz, J_2 = 7.5 Hz, 2H), 7.51-7.46 (m, 2H), 7.30 (d, *J* = 8.5 Hz, 2H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 156.9, 148.8, 148.1, 139.4, 137.9, 137.8, 131.4, 130.2, 129.8, 129.5, 128.9, 127.6, 126.6, 125.4, 125.3, 119.2, 94.5. HRMS (ESI) calcd for $C_{21}H_{15}IN$ $[M+H]^+$: 408.0244, found 408.0243



2-*phenyl-4-(4-(trifluoromethyl)phenyl)quinoline (**4m**)*: Pale yellow solid (32.1 mg, 46%), mp 122-124 ^{o}C (lit.[1] Oil). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.30 (d, *J* = 8.5 Hz, 1H), 8.20 (d, *J* = 7 Hz, 2H), 7.84-7.76 (m, 5H), 7.69 (d, *J* = 8.0 Hz, 2H), 7.56-7.47 (m, 4H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 156.9, 148.7, 147.7, 142.1, 139.3, 130.7 (d, *J* = 32.5 Hz), 130.3, 130.0, 129.9, 129.6, 128.9, 127.6, 126.8, 125.6 (q, *J* = 3.2Hz), 125.3, 125.1, 124.1 (d, *J* = 270.0 Hz), 119.3.

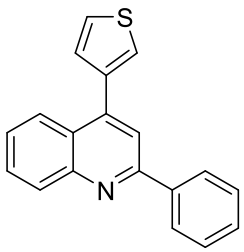


*4-(4-nitrophenyl)-2-phenylquinoline (**4n**)*: Yellow solid (14.4 mg, 22%), mp 162-163 ^{o}C (lit.[1] 162-163 ^{o}C). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.43 (d, *J* = 8.5 Hz, 2H), 8.32 (d, *J* = 8.5 Hz, 1H), 8.20 (d, *J* = 7.5 Hz, 2H), 7.82-7.74 (m, 5H), 7.57-7.48 (m, 4H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 156.8, 148.6, 148.0, 146.9, 145.0, 138.9, 130.6, 130.3, 130.2, 129.8, 129.0, 127.6, 127.1, 125.0, 124.8, 123.9, 119.2.

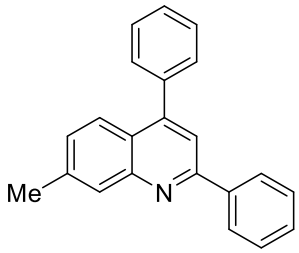


*4-(naphthalen-2-yl)-2-phenylquinoline (**4o**)*: Pale yellow oil (45.7 mg, 69%) (lit.[4] Oil). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.33 (d, *J* = 8.5 Hz, 1H), 8.25 (d, *J* = 7 Hz, 2H), 8.05-8.01 (m, 2H), 7.98-7.94 (m, 4H), 7.77 (dd appear t, J_1 = 7.0 Hz, J_2 = 7.0 Hz, 1H),

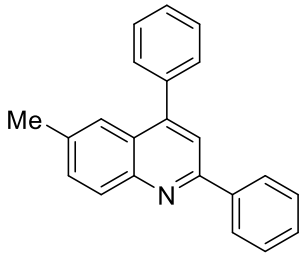
7.70-7.68 (m, 1H), 7.60-7.55 (m, 4H), 7.51-7.47 (m, 2H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 156.9, 149.2, 148.9, 139.7, 135.9, 133.3, 133.1, 130.2, 129.6, 129.4, 128.9, 128.8, 128.3, 128.2, 127.9, 127.7, 127.4, 126.7, 126.5, 126.0, 125.8, 119.7.



2-*phenyl-4-(thiophen-3-yl)quinoline (**4p**)*: Yellow oil (13.2 mg, 23%) (lit.[5] Oil). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.27 (d, *J* = 8.5 Hz, 1H), 8.20 (d, *J* = 7.5 Hz, 2H), 8.07 (d, *J* = 8.5 Hz, 1H), 7.87 (s, 1H), 7.75 (dd appear t, J_1 = 7.5 Hz, J_2 = 7.5 Hz, 1H), 7.58-7.47 (m, 6H), 7.40 (d, *J* = 5.0 Hz, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 157.0, 148.8, 144.1, 139.5, 138.9, 130.1, 129.7, 129.4, 128.9, 128.9, 127.6, 126.5, 126.3, 125.8, 125.5, 125.0, 119.2.

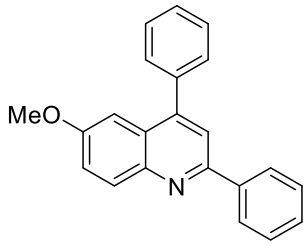


*7-methyl-2,4-diphenylquinoline (**5a**)*: Pale yellow oil (42.5 mg, 72%) (lit.[6] Oil). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.21 (d, *J* = 7.0 Hz, 2H), 8.08 (s, 1H), 7.82 (d, *J* = 8.5 Hz, 1H), 7.78 (s, 1H), 7.58-7.46 (m, 8H), 7.33 (d, *J* = 8.5 Hz, 1H), 2.60 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 156.9, 149.1, 149.0, 139.8, 138.6, 129.6, 129.3, 129.2, 128.8, 128.6, 128.4, 127.6, 125.4, 123.8, 118.6, 21.8.

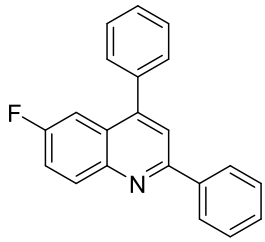


*6-methyl-2,4-diphenylquinoline (**5b**)*: Pale yellow oil (44.3 mg, 75%) (lit.[6] Oil). ^{1}H

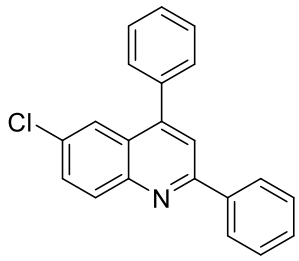
NMR (500 MHz, $CDCl_3$) δ 8.21-8.17 (m, 3H), 7.80 (s, 1H), 7.68 (s, 1H), 7.60-7.52 (m, 8H), 7.47 (dd appear t, J_1 = 7.5 Hz, J_2 = 7.5 Hz, 1H), 2.49 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 156.0, 148.5, 147.4, 139.8, 138.7, 136.3, 131.8, 129.9, 129.6, 129.2, 128.8, 128.6, 128.3, 127.5, 125.8, 124.4, 119.4, 21.8.



*6-methoxy-2,4-diphenylquinoline (**5c**)*: Colorless oil (40.5 mg, 65%) (lit.[6] Oil). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.19-8.17 (m, 3H), 7.79 (s, 1H), 7.60-7.51 (m, 7H), 7.46 (d, J = 7.0 Hz, 1H), 7.42-7.40 (m, 1H), 7.21 (d, J = 2.5 Hz, 1H), 3.80 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 157.9, 154.6, 147.9, 144.9, 139.7, 138.8, 131.6, 129.4, 129.0, 128.8, 128.7, 128.4, 127.4, 126.7, 121.8, 119.7, 103.8, 55.5.

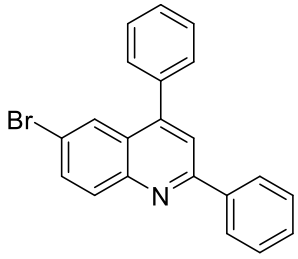


*6-fluoro-2,4-diphenylquinoline (**5d**)*: Pale yellow oil (46.1 mg, 77%) (lit.[6] Oil). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.28-8.25 (m, 1H), 8.20-8.19 (m, 2H), 7.85 (s, 1H), 7.59-7.47 (m, 10H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 160.6 (d, J = 245.0 Hz), 156.3, 148.7, 145.9, 139.3, 138.0, 132.6 (d, J = 8.8 Hz), 129.5, 129.4, 128.8, 128.7 (d, J = 27.5 Hz), 127.5, 126.6 (d, J = 8.8 Hz), 119.9, 119.7 (d, J = 25.0 Hz), 109.2, 109.0.

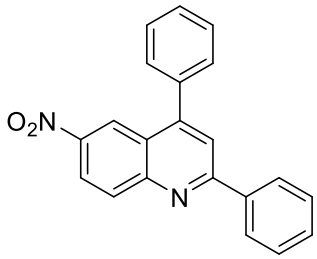


*6-chloro-2,4-diphenylquinoline (**5e**)*: Pale yellow solid (53.1 mg, 84%), mp 124-126 ^{o}C (lit.[7] 127-128 ^{o}C). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.21-8.18 (m, 3H), 7.89 (d, J = 2.5 Hz, 1H), 7.85 (s, 1H), 7.68-7.66 (m, 1H), 7.59-7.47 (m, 8H); ^{13}C NMR (125 MHz,

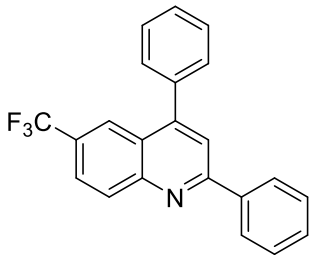
$CDCl_3$) δ 157.1, 148.5, 147.2, 139.2, 137.8, 132.3, 131.7, 130.5, 129.6, 129.5, 128.9, 128.8, 128.7, 127.6, 126.5, 124.5, 120.0.



*6-bromo-2,4-diphenylquinoline (**5f**)*: Pale yellow solid (57.6 mg, 80%), mp 153-155 °C (lit.[7] 154-155 °C). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.19 (d, *J* = 7.0 Hz, 2H), 8.12 (d, *J* = 9.0 Hz, 1H), 8.04 (s, 1H), 7.84-7.79 (m, 2H), 7.59-7.47 (m, 8H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 157.2, 148.5, 147.4, 139.1, 137.7, 133.1, 131.8, 129.7, 129.5, 128.9, 128.8, 128.7, 127.8, 127.6, 127.0, 120.5, 120.1.

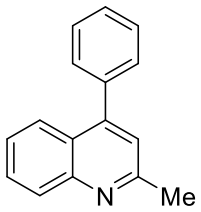


*6-nitro-2,4-diphenylquinoline (**5g**)*: White solid (54.8 mg, 84%), mp 238-241 °C (lit.[8] 265-266). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.85 (d, *J* = 2.5 Hz, 1H), 8.49-8.47 (m, 1H), 8.35 (d, *J* = 9.5 Hz, 1H), 8.25-8.24 (m, 2H), 7.97 (s, 1H), 7.64-7.51 (m, 8H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 160.0, 151.3, 151.0, 145.5, 138.4, 136.9, 131.7, 130.5, 129.5, 129.4, 129.1, 129.0, 127.9, 124.8, 123.1, 122.9, 120.7.

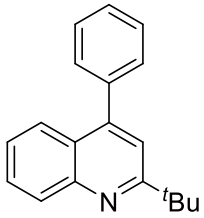


*2,4-diphenyl-6-(trifluoromethyl)quinoline (**5h**)*: White solid (48.9 mg, 70%), mp 150-151 °C (lit.[9] 148-150 °C). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.36 (d, *J* = 9.0 Hz, 1H), 8.23 (d, *J* = 7.0 Hz, 3H), 7.92-7.91 (m, 2H), 7.62-7.50 (m, 8H); ^{13}C NMR (125 MHz,

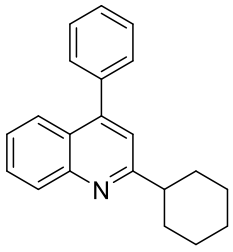
$CDCl_3$) δ 158.8, 150.2, 149.9, 138.9, 137.4, 131.3, 130.0, 129.5, 129.0, 128.9, 128.1 (d, *J* = 32.5 Hz), 127.8, 125.3, 125.2, 124.9, 123.7 (d, *J* = 3.8 Hz), 123.1, 120.4.



*2-methyl-4-phenylquinoline (**6a**)*: Yellow solid (36.8 mg, 84%) (lit.[1] Oil). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.10 (d, *J* = 8.5 Hz, 1H), 7.86 (d, *J* = 8.5 Hz, 1H), 7.69 (dd appear t, J_1 = 8.0 Hz, J_2 = 8.0 Hz, 1H), 7.53-7.47 (m, 5H), 7.44-7.41 (m, 1H), 7.23 (s, 1H), 2.78 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 158.5, 148.6, 148.4, 138.2, 129.5, 129.3, 129.0, 128.5, 128.3, 125.8, 125.7, 125.1, 122.2, 25.3.

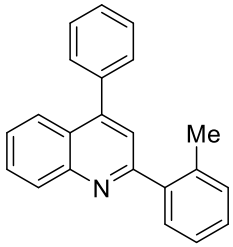


2-*(tert-butyl)-4-phenylquinoline (**6b**)*: Pale yellow solid (23.5 mg, 45%), mp 86-88 °C (lit.[11] 86-87 °C). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.17 (d, *J* = 8.0 Hz, 1H), 7.87 (d, *J* = 8.5 Hz, 1H), 7.70 (dd appear t, J_1 = 8.0 Hz, J_2 = 8.0 Hz, 1H), 7.55-7.50 (m, 5H), 7.48-7.43 (m, 2H), 1.53 (s, 9H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 168.8, 148.3, 147.9, 138.9, 129.8, 129.6, 128.9, 128.5, 128.2, 125.7, 125.4, 125.1, 118.5, 38.2, 30.2.

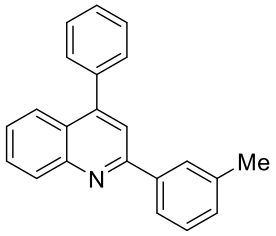


*2-cyclohexyl-4-phenylquinoline (**6c**)*: Pale yellow oil (23.6 mg, 41%) (lit.[5] Oil). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.14 (d, *J* = 8.5 Hz, 1H), 7.86 (d, *J* = 8.0 Hz, 1H), 7.68 (dd appear t, J_1 = 8.0 Hz, J_2 = 8.0 Hz, 1H), 7.54-7.47 (m, 5H), 7.43 (dd appear t, J_1 = 7.5 Hz, J_2 = 7.5 Hz, 1H), 7.28 (s, 1H), 3.00-2.96 (m, 1H), 2.09-2.07 (m, 2H), 1.92-1.89 (m, 2H), 1.81-1.78 (m, 1H), 1.71-1.63 (m, 2H), 1.53-1.45 (m, 2H), 1.37-1.31 (m, 1H);

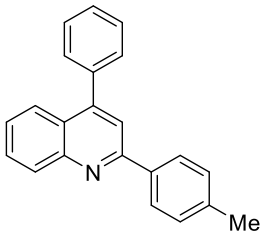
^{13}C NMR (125 MHz, $CDCl_3$) δ 166.3, 148.8, 148.2, 138.6, 129.6, 129.3, 129.2, 128.5, 128.3, 125.7, 125.6, 125.5, 119.9, 77.3, 77.0, 76.8, 47.6, 32.9, 26.6, 26.1.



*4-phenyl-2-(o-tolyl)quinoline (**6d**)*: Pale yellow oil (41.4 mg, 70%) (lit.[6] Oil). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.28 (d, J = 8.5 Hz, 1H), 7.99 (d, J = 8.0 Hz, 1H), 7.77 (dd appear t, J_1 = 8.0 Hz, J_2 = 8.0 Hz, 1H), 7.59-7.51 (m, 8H), 7.35-7.32 (m, 3H), 2.51 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 159.9, 148.6, 148.5, 140.7, 138.2, 136.1, 130.9, 130.1, 129.8, 129.6, 129.5, 128.6, 128.5, 128.4, 126.5, 126.1, 125.7, 125.4, 122.6, 20.5.

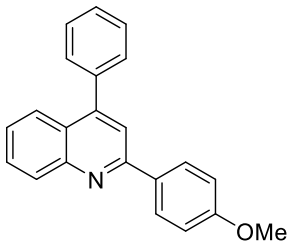


*4-phenyl-2-(m-tolyl)quinoline (**6e**)*: Pale yellow oil (44.3 mg, 75%) (lit.[13] 62-64 °C). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.32 (d, J = 8.0 Hz, 1H), 8.10 (s, 1H), 8.01 (d, J = 7.5 Hz, 1H), 7.94 (d, J = 8.0 Hz, 1H), 7.85 (s, 1H), 7.76 (dd appear t, J_1 = 8.0 Hz, J_2 = 8.0 Hz, 1H), 7.60-7.43 (m, 7H), 7.32 (d, J = 7.5 Hz, 1H), 2.52 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 157.0, 149.1, 148.8, 139.5, 138.4, 130.1, 130.0, 129.5, 129.4, 128.7, 128.6, 128.4, 128.3, 126.2, 125.7, 125.6, 124.7, 119.4, 21.5.

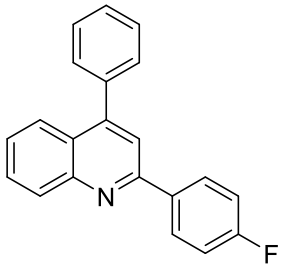


*4-phenyl-2-(p-tolyl)quinoline (**6f**)*: Pale yellow solid (47.3 mg, 80%) (lit.[6] Oil). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.27 (d, J = 8.0 Hz, 1H), 8.13 (d, J = 8.0 Hz, 2H), 7.92 (d, J = 8.0 Hz, 1H), 7.83 (s, 1H), 7.74 (dd appear t, J_1 = 8.0 Hz, J_2 = 8.0 Hz, 1H),

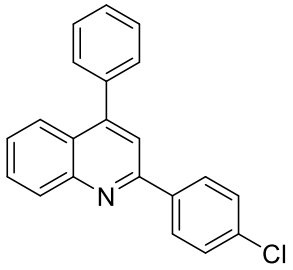
7.59-7.52 (m, 5H), 7.47 (dd appear t, J_1 = 8.0 Hz, J_2 = 8.0 Hz, 1H), 7.35 (d, J = 8.0 Hz, 2H), 2.46 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 156.9, 149.1, 148.9, 139.5, 138.6, 136.9, 130.1, 129.6, 129.5, 128.6, 128.4, 127.5, 126.2, 125.8, 125.7, 119.2, 21.4.



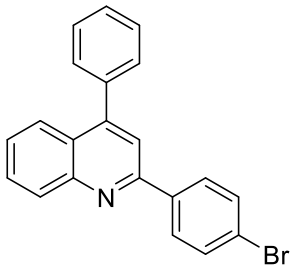
2-*(4-methoxyphenyl)-4-phenylquinoline (**6g**)*: Yellow solid (48.0 mg, 77%) (lit.[4] Oil). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.25 (d, J = 8.5 Hz, 1H), 8.18 (d, J = 8.5 Hz, 2H), 7.89 (d, J = 8.0 Hz, 1H), 7.78 (s, 1H), 7.72 (dd appear t, J_1 = 8.0 Hz, J_2 = 8.0 Hz, 1H), 7.58-7.51 (m, 5H), 7.45 (dd appear t, J_1 = 8.0 Hz, J_2 = 8.0 Hz, 1H), 7.05 (d, J = 8.5 Hz, 2H), 3.89 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 161.0, 156.4, 149.2, 148.7, 138.5, 132.0, 129.8, 129.6, 129.5, 129.0, 128.6, 128.4, 126.0, 125.6, 125.5, 118.9, 114.3, 55.4.



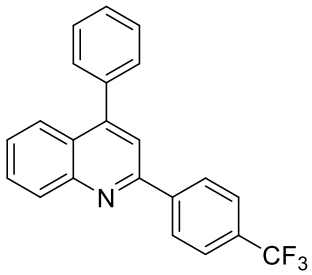
*2-(4-fluorophenyl)-4-phenylquinoline (**6h**)*: Pale yellow oil (47.9 mg, 80%) (lit.[4] Oil). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.25 (d, J = 8.5 Hz, 1H), 8.22-8.19 (m, 2H), 7.91 (d, J = 8.5 Hz, 1H), 7.78 (s, 1H), 7.74 (dd appear t, J_1 = 7.5 Hz, J_2 = 7.5 Hz, 1H), 7.57-7.53 (m, 5H), 7.48 (dd appear t, J_1 = 7.5 Hz, J_2 = 7.5 Hz, 1H), 7.21 (dd appear t, J_1 = 8.5 Hz, J_2 = 8.5 Hz, 2H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 163.9 (d, J = 247.5 Hz), 155.7, 149.4, 148.8, 138.4, 135.8, 135.7, 130.1, 129.7, 129.6, 129.5 (d, J = 8.8 Hz), 128.6, 128.5, 126.4, 125.7 (d, J = 5.0 Hz), 119.0, 115.8 (d, J = 21.3 Hz).



*2-(4-chlorophenyl)-4-phenylquinoline (**6i**)*: Pale yellow oil (51.8 mg, 88%) (lit.[4] Oil). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.25 (d, *J* = 8.5 Hz, 1H), 8.16 (d, *J* = 8.5 Hz, 2H), 7.91 (d, *J* = 8.5 Hz, 1H), 7.78 (s, 1H), 7.74 (dd appear t, J_1 = 8.0 Hz, J_2 = 8.0 Hz, 1H), 7.57-7.53 (m, 5H), 7.50-7.47 (m, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 155.5, 149.5, 148.8, 138.3, 138.0, 135.6, 130.1, 129.7, 129.6, 129.0, 128.9, 128.7, 128.5, 126.6, 125.9, 125.7, 118.9.

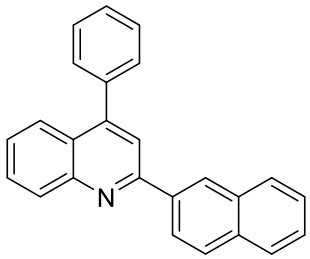


2-*(4-bromophenyl)-4-phenylquinoline (**6j**)*: Yellow solid (56.9 mg, 79%), mp 125-127 °C (lit.[7] 124-126 °C). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.24 (d, *J* = 8.5 Hz, 1H), 8.09 (d, *J* = 8.5 Hz, 2H), 7.91 (d, *J* = 8.5 Hz, 1H), 7.77 (s, 1H), 7.74 (dd appear t, J_1 = 8.5 Hz, J_2 = 8.5 Hz, 1H), 7.65 (d, *J* = 8.5 Hz, 2H), 7.56-7.53 (m, 5H), 7.49 (dd appear t, J_1 = 8.0 Hz, J_2 = 8.0 Hz, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 155.5, 149.5, 148.8, 138.5, 138.3, 132.0, 130.1, 129.7, 129.6, 129.1, 128.7, 128.5, 126.6, 125.9, 125.7, 124.0, 118.8.

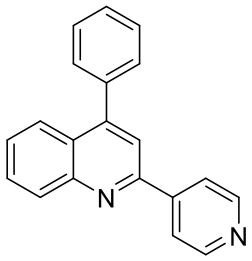


*4-phenyl-2-(4-(trifluoromethyl)phenyl)quinoline (**6k**)*: Yellow solid (54.5 mg, 78%), mp 76-78 °C (lit.[7] 80-82 °C). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.32 (d, *J* = 8.0 Hz, 2H), 8.28 (d, *J* = 8.5 Hz, 1H), 7.94 (d, *J* = 8.5 Hz, 1H), 7.83 (s, 1H), 7.80-7.75 (m, 3H),

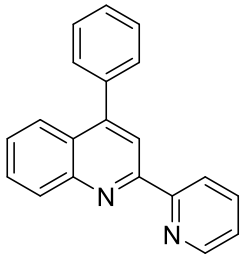
7.58-7.50 (m, 6H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 155.2, 149.7, 148.8, 142.9, 138.2, 131.2 (d, *J* = 32.5 Hz), 130.3, 129.8, 129.6, 128.7, 128.6, 127.9, 126.9, 126.1, 125.7 (d, *J* = 3.8 Hz), 124.3 (d, *J* = 271.3 Hz), 119.1.



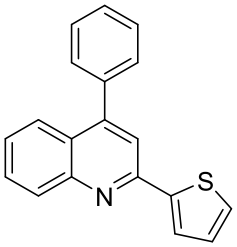
*2-(naphthalen-2-yl)-4-phenylquinoline (**6l**)*: Pale yellow solid (49.7 mg, 75%), mp 159-160 °C (lit.[7] 162-163 °C). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.68 (s, 1H), 8.44 (d, *J* = 8.5 Hz, 1H), 8.34 (d, *J* = 8.5 Hz, 1H), 8.03-7.99 (m, 3H), 7.95 (d, *J* = 8.0 Hz, 1H), 7.92-7.90 (m, 1H), 7.78 (dd appear t, J_1 = 8.0 Hz, J_2 = 8.0 Hz, 1H), 7.63-7.49 (m, 8H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 156.7, 149.3, 148.9, 138.5, 136.9, 134.0, 133.6, 130.2, 129.6, 128.9, 128.7, 128.6, 128.5, 127.8, 127.2, 126.8, 126.5, 126.4, 125.9, 125.7, 125.1, 119.5.



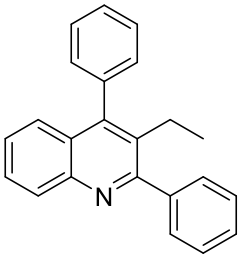
*4-phenyl-2-(pyridin-4-yl)quinoline (**6m**)*: Yellow solid (52.0 mg, 92%), mp 137-138 °C (lit.[15] 137-139 °C). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.76 (d, *J* = 4.5 Hz, 2H), 8.25 (d, *J* = 8.5 Hz, 1H), 8.08-8.07 (m, 2H), 7.92 (d, *J* = 8.5 Hz, 1H), 7.82-7.81 (m, 1H), 7.75 (dd appear t, J_1 = 8.5 Hz, J_2 = 8.5 Hz, 1H), 7.54-7.50 (m, 6H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 153.9, 150.4, 149.8, 148.8, 146.7, 138.0, 130.4, 130.0, 129.5, 128.7, 128.6, 127.3, 126.4, 125.8, 121.6, 118.8.



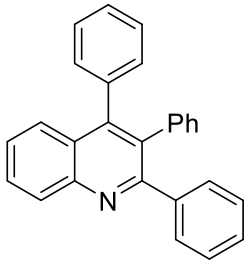
*4-phenyl-2-(pyridin-2-yl)quinoline (**6n**)*: Yellow solid (24.8 mg, 44%), mp 136-138 °C (lit.[15] 138-142 °C). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.73-8.70 (m, 2H), 8.53 (s, 1H), 8.28 (d, *J* = 8.0 Hz, 1H), 7.96 (d, *J* = 8.5 Hz, 1H), 7.88 (dd appear t, J_1 = 8.0 Hz, J_2 = 8.0 Hz, 1H), 7.76-7.73 (m, 1H), 7.61-7.59 (m, 2H), 7.55-7.47 (m, 4H), 7.36-7.34 (m, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 156.3, 155.6, 149.4, 149.2, 148.5, 138.4, 137.0, 130.2, 129.7, 129.4, 128.5, 128.3, 126.8, 125.8, 124.1, 121.9, 119.3.



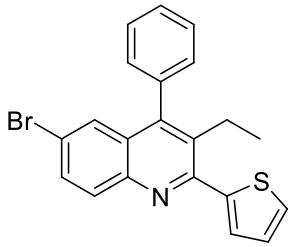
*4-phenyl-2-(thiophen-2-yl)quinoline (**6o**)*: Pale Yellow solid (40.8 mg, 71%), mp 91-92 °C (lit.[12] 90-92 °C). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.18 (d, *J* = 8.5 Hz, 1H), 7.85 (d, *J* = 8.0 Hz, 1H), 7.74-7.69 (m, 3H), 7.56 (s, 5H), 7.48-7.42 (m, 2H), 7.16 (s, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 151.9, 149.1, 148.7, 145.4, 138.2, 129.7, 129.6, 129.5, 128.7, 128.6, 128.5, 128.1, 126.2, 126.0, 125.9, 125.7, 118.0.



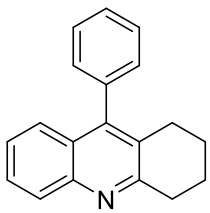
*3-ethyl-2,4-diphenylquinoline (**6p**)*: Yellow solid (47.0 mg, 76%), mp 135-137 °C (lit.[3] 136-137 °C). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.18 (d, *J* = 8.5 Hz, 1H), 7.65 (dd appear t, J_1 = 7.5 Hz, J_2 = 7.5 Hz, 1H), 7.60-7.59 (m, 2H), 7.56-7.43 (m, 7H), 7.41-7.38 (m, 1H), 7.34-7.31 (m, 3H), 2.62 (q, *J* = 7.5 Hz, 2H), 0.79 (t, *J* = 7.5 Hz, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 161.1, 147.5, 146.0, 141.7, 137.4, 133.1, 129.5, 129.4, 128.7, 128.6, 128.4, 128.3, 128.0, 127.8, 127.52, 126.3, 126.2, 23.4, 15.1.



*2,3,4-triphenylquinoline (**6q**)*: Yellow solid (56.5 mg, 79%), mp 200-201 °C (lit.[1] 195-196 °C). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.29 (d, *J* = 8.0 Hz, 1H), 7.76-7.73 (m, 1H), 7.61 (d, *J* = 8.0 Hz, 1H), 7.48-7.45 (m, 1H), 7.41-7.39 (m, 2H), 7.31-7.27 (m, 3H), 7.23-7.22 (m, 3H), 7.17-7.15 (m, 2H), 7.02-7.01 (m, 3H), 6.92-6.90 (m, 2H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 159.0, 147.8, 147.3, 141.1, 138.4, 137.0, 133.0, 131.4, 130.3, 130.0, 129.7, 129.4, 127.8, 127.7, 127.6, 127.4, 127.3, 126.7, 126.6, 126.4.

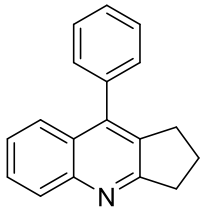


*6-bromo-3-ethyl-4-phenyl-2-(thiophen-2-yl)quinoline (**6r**)*: Yellow solid (50.3 mg, 64%), mp 156-157 °C. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.99 (d, *J* = 9.0 Hz, 1H), 7.70-7.68 (m, 1H), 7.57-7.49 (m, 5H), 7.37 (d, *J* = 1.5 Hz, 1H), 7.28 (d, *J* = 7.0 Hz, 2H), 7.16-7.15 (m, 1H), 2.84 (q, *J* = 7.5 Hz, 2H), 1.02 (t, *J* = 7.5 Hz, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 153.4, 147.2, 144.7, 144.1, 136.6, 133.7, 132.3, 131.0, 129.3, 128.7, 128.5, 128.2, 128.2, 128.0, 127.6, 127.5, 120.5, 23.7, 15.0. HRMS (ESI) calcd for $C_{21}H_{17}BrNS$ $[M+H]^+$: 394.0260, found 394.0261

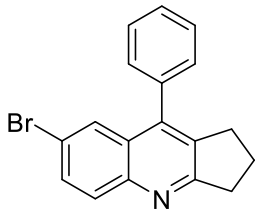


*9-phenyl-1,2,3,4-tetrahydroacridine (**6s**)*: Yellow solid (48.2 mg, 93%), mp 136-138 °C (lit.[12] 136-138 °C). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.03-8.02 (m, 1H), 7.60-7.58 (m, 1H), 7.52-7.49 (m, 2H), 7.47-7.45 (m, 1H), 7.31-7.30 (m, 2H), 7.23-7.22 (m, 2H),

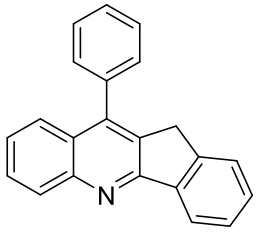
3.22-3.19 (m, 2H), 2.61-2.59 (m, 2H), 1.96-1.95 (m, 2H), 1.79-1.77 (m, 2H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 159.1, 146.5, 146.3, 137.2, 129.1, 128.6, 128.4, 128.3, 127.7, 126.7, 125.8, 125.4, 34.2, 28.0, 23.0, 22.9.



*9-phenyl-2,3-dihydro-1H-cyclopenta[b]quinoline (**6t**)*: Yellow solid (47.1 mg, 96%), mp 131-134 °C (lit.[12] 130-132 °C). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.08 (d, J = 8.0 Hz, 1H), 7.63-7.59 (m, 2H), 7.51 (dd appear t, J_1 = 7.5 Hz, J_2 = 7.5 Hz, 2H), 7.45 (dd appear t, J_1 = 7.5 Hz, J_2 = 7.5 Hz, 1H), 7.38-7.34 (m, 3H), 3.23 (t, J = 7.5 Hz, 2H), 2.89 (t, J = 7.5 Hz, 2H), 2.18-2.12 (m, 2H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 167.4, 148.0, 142.7, 136.8, 133.6, 129.3, 128.8, 128.5, 128.2, 128.0, 126.2, 125.6, 125.5, 35.2, 30.3, 23.5.

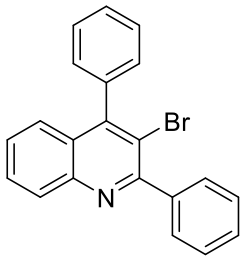


7-bromo-9-phenyl-2,3-dihydro-1H-cyclopenta[b]quinoline (**6u**)[18]; Light yellow solid (62.3 mg, 96%), mp 118-119 °C. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.95 (d, J = 9.0 Hz, 1H), 7.75 (d, J = 2.0 Hz, 1H), 7.69 (dd, J = 9.0, 2.0 Hz, 1H), 7.57-7.47 (m, 3H), 7.37-7.31 (m, 2H), 3.22 (t, J = 7.5 Hz, 2H), 2.90 (t, J = 7.5 Hz, 2H), 2.17 (p, J = 7.5 Hz, 2H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 167.9, 146.3, 142.1, 135.9, 134.8, 131.7, 130.4, 129.2, 128.8, 128.4, 127.8, 127.6, 119.6, 35.1, 30.4, 23.4.

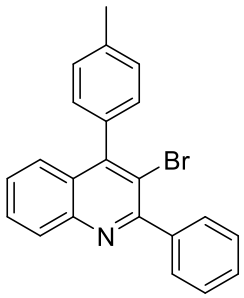


*10-phenyl-11H-indeno[1,2-b]quinoline (**6v**)*: Pale yellow solid (52.2 mg, 89%), mp 146-148 °C (lit.[12] 144-148 °C). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.36 (d, J = 7.5 Hz, 1H),

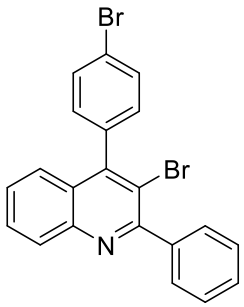
8.28 (d, *J* = 8.0 Hz, 1H), 7.71-7.68 (m, 2H), 7.59-7.40 (m, 9H), 3.82 (s, 2H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 161.1, 148.6, 145.2, 143.6, 140.6, 136.6, 133.0, 130.0, 129.3, 128.7, 128.3, 127.5, 126.4, 125.8, 125.7, 125.3, 122.2, 34.0.



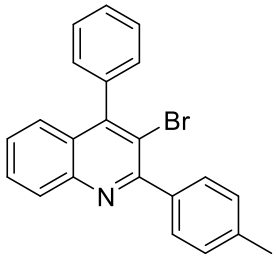
3-*bromo-2,4-diphenylquinoline (**7a**)*: Yellow solid (44.0 mg, 61%), mp 98-100 °C (lit.[17] 92-94 °C). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.20 (d, *J* = 8.5 Hz, 1H), 7.77-7.72 (m, 3H), 7.59-7.45 (m, 8H), 7.37 (d, *J* = 7.5 Hz, 2H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 159.0, 149.7, 146.5, 141.0, 138.1, 129.8, 129.6, 129.5, 129.3, 128.7, 128.6, 128.5, 128.0, 127.9, 127.3, 126.4, 118.6.



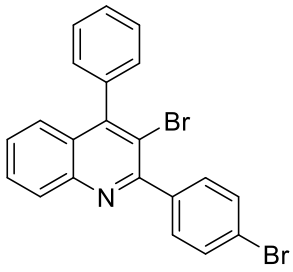
*3-bromo-2-phenyl-4-(p-tolyl)quinoline (**7b**)*: Yellow solid (29.1 mg, 39%), mp 132-133 °C. ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.17 (d, *J* = 8.5 Hz, 1H), 7.73-7.70 (m, 3H), 7.51-7.41 (m, 5H), 7.36 (d, *J* = 7.5 Hz, 2H), 7.24 (d, *J* = 7.5 Hz, 2H), 2.48 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 159.0, 150.0, 146.4, 141.1, 138.3, 135.2, 129.8, 129.6, 129.5, 129.3, 129.2, 128.7, 128.1, 128.0, 127.2, 126.5, 118.7, 21.5. HRMS (ESI) calcd for $C_{22}H_{17}BrN$ $[M+H]^+$: 374.0539, found 374.0539



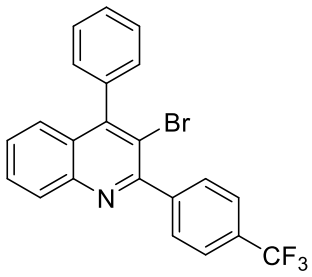
3-*bromo-4-(4-bromophenyl)-2-phenylquinoline (**7c**)*: Yellow solid (33.2 mg, 38%), mp 167-168 °C. ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.19 (d, *J* = 8.5 Hz, 1H), 7.75-7.69 (m, 5H), 7.51-7.45 (m, 4H), 7.40 (d, *J* = 8.5 Hz, 1H), 7.23 (d, *J* = 8.5 Hz, 2H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 159.0, 148.5, 146.4, 140.7, 136.9, 131.9, 131.1, 130.0, 129.7, 129.4, 128.8, 128.1, 127.6, 127.6, 126.1, 122.9, 118.4. HRMS (ESI) calcd for $C_{21}H_{14}Br_2N$ $[M+H]^+$: 437.9488, found 437.9488



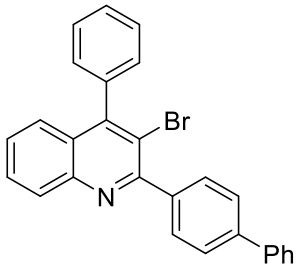
*3-bromo-4-phenyl-2-(p-tolyl)quinoline (**7d**)*: Pale yellow oil (53.7 mg, 72%). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.19 (d, *J* = 8.5 Hz, 1H), 7.75-7.71 (m, 1H), 7.66 (d, *J* = 8.0 Hz, 2H), 7.59-7.53 (m, 3H), 7.44-7.42 (m, 2H), 7.38-7.32 (m, 4H), 2.45 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 159.0, 149.6, 146.5, 138.7, 138.2, 138.2, 129.8, 129.6, 129.4, 129.3, 128.7, 128.6, 128.5, 127.9, 127.2, 126.4, 118.7, 21.5. HRMS (ESI) calcd for $C_{22}H_{17}BrN$ $[M+H]^+$: 374.0539, found 374.0539



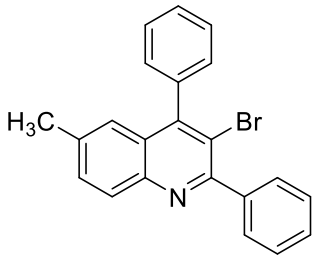
*3-bromo-2-(4-bromophenyl)-4-phenylquinoline (**7e**)*: Yellow solid (73.4 mg, 84%), mp 132-133 °C. ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.16 (d, *J* = 8.5 Hz, 1H), 7.76-7.72 (m, 1H), 7.64 (s, 4H), 7.59-7.53 (m, 3H), 7.48-7.42 (m, 2H), 7.35-7.34 (m, 2H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 157.7, 149.9, 146.5, 139.8, 137.9, 131.2, 130.0, 129.6, 129.2, 128.6, 128.6, 128.0, 127.5, 126.5, 123.2, 118.1. HRMS (ESI) calcd for $C_{21}H_{14}Br_2N$ $[M+H]^+$: 437.9488, found 437.9488



*3-bromo-4-phenyl-2-(4-(trifluoromethyl)phenyl)quinoline (**7f**)*: Yellow solid (58.1 mg, 68%), mp 140-143 °C. ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.18 (d, *J* = 8.5 Hz, 1H), 7.88 (d, *J* = 8.0 Hz, 2H), 7.79-7.75 (m, 3H), 7.60-7.55 (m, 3H), 7.49-7.46 (m, 2H), 7.37 (d, *J* = 7.0 Hz, 2H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 157.5, 150.1, 146.5, 144.4, 137.8, 130.7 (d, *J* = 32.5 Hz), 130.1, 130.0, 129.7, 129.6, 129.2, 128.6, 128.2, 127.8, 126.5, 125.0 (d, *J* = 3.8 Hz) 124.2 (d, *J* = 271.3 Hz), 117.9. HRMS (ESI) calcd for $C_{22}H_{14}BrF_3N$ $[M+H]^+$: 428.0256, found 428.0253

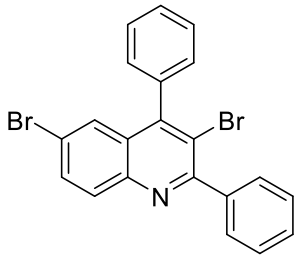


2-*([1,1'-biphenyl]-4-yl)-3-bromo-4-phenylquinoline (**7g**)*: Pale yellow oil (67.0 mg, 77%). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.22 (d, *J* = 8.5 Hz, 1H), 7.86 (d, *J* = 8.0 Hz, 2H), 7.76-7.68 (m, 3H), 7.70-7.68 (m, 2H), 7.61-7.53 (m, 3H), 7.50-7.44 (m, 4H), 7.40-7.38 (m, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 158.6, 149.8, 146.5, 141.6, 140.8, 139.8, 138.1, 130.0, 129.9, 129.6, 129.3, 128.9, 128.6, 128.5, 128.0, 127.5, 127.4, 127.3, 126.8, 126.5, 118.5. HRMS (ESI) calcd for $C_{27}H_{19}BrN$ $[M+H]^+$: 436.0696, found 436.0694

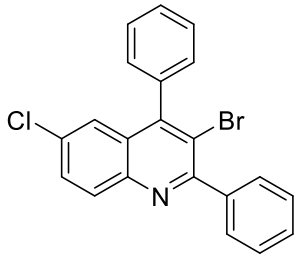


*3-bromo-6-methyl-2,4-diphenylquinoline (**7h**)*: Pale yellow solid (41.2 mg, 55%), mp

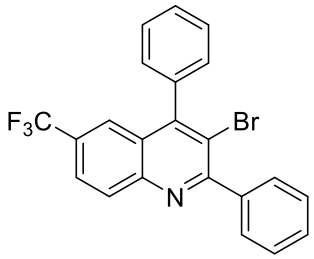
80-81 °C (lit.[15] 79-81 °C). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.10 (d, *J* = 8.5 Hz, 1H), 7.74 (d, *J* = 7.0 Hz, 2H), 7.60-7.45 (m, 7H), 7.36 (d, *J* = 7.0 Hz, 2H), 7.17 (s, 1H), 2.43 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 158.0, 149.0, 145.1, 141.1, 138.3, 137.5, 132.1, 129.5, 129.3, 128.6, 128.6, 128.4, 128.0, 127.9, 125.1, 118.6, 21.8.



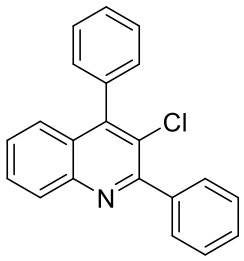
*3,6-dibromo-2,4-diphenylquinoline (**7i**)*: Yellow solid (50.7 mg, 58%), mp 165-167 °C. ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.04 (d, *J* = 9.0 Hz, 1H), 7.80-7.78 (m, 1H), 7.75-7.73 (m, 2H), 7.61-7.48 (m, 7H), 7.35 (d, *J* = 8.0 Hz, 2H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 159.4, 148.9, 145.1, 140.7, 137.4, 133.4, 131.4, 129.4, 129.2, 129.0, 128.9, 128.8, 128.4, 128.1, 121.6, 119.7. HRMS (ESI) calcd for $C_{21}H_{14}Br_2N$ $[M+H]^+$: 437.9488, found 437.9488



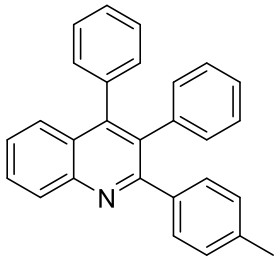
*3-bromo-6-chloro-2,4-diphenylquinoline (**7j**)*: yellow solid (48.1 mg, 61%), mp 149-150 °C (lit.[16] 151-153 °C). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.12 (d, *J* = 8.5 Hz, 1H), 7.75 (d, *J* = 7.0 Hz, 2H), 7.67-7.65 (m, 1H), 7.61-7.56 (m, 3H), 7.54-7.49 (m, 3H), 7.41 (d, *J* = 2.0 Hz, 1H), 7.35 (d, *J* = 7.0 Hz, 2H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 159.3, 149.0, 144.9, 140.7, 137.5, 133.3, 131.3, 130.8, 129.4, 129.2, 128.9, 128.8, 128.6, 128.1, 125.1, 119.7.



*3-bromo-2,4-diphenyl-6-(trifluoromethyl)quinoline (**7k**)*: Pale yellow solid (40.1 mg, 47%), mp 159-160 °C. ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.30 (d, *J* = 9.0 Hz, 1H), 7.90 (d, *J* = 9.0 Hz, 1H), 7.77-7.74 (m, 3H), 7.63-7.58 (m, 3H), 7.55-7.50 (m, 3H), 7.37-7.36 (m, 2H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 161.2, 150.7, 147.4, 140.5, 137.1, 130.9, 129.4, 129.2 (d, *J* = 27.5 Hz), 129.1, 129.0 (d, *J* = 22.5 Hz), 128.8, 128.1, 127.0, 125.5, 125.4, 124.3 (d, *J* = 3.8 Hz), 123.8 (d, *J* = 271.3 Hz), 120.1. HRMS (ESI) calcd for $C_{22}H_{14}BrF_3N$ $[M+H]^+$: 428.0256, found 428.0253.

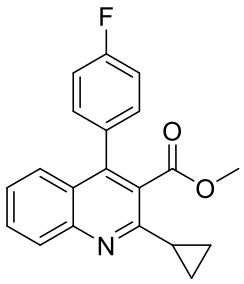


3-*chloro-2,4-diphenylquinoline (**7l**)*: Pale yellow solid (50.5 mg, 80%), mp 104-106 °C (lit.[17] 106-108 °C). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.22 (d, *J* = 8.5 Hz, 1H), 7.82 (d, *J* = 7.0 Hz, 2H), 7.74-7.71 (m, 1H), 7.60-7.47 (m, 8H), 7.42-7.40 (m, 2H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 157.6, 147.1, 146.2, 139.4, 135.9, 129.7, 129.6, 129.5, 128.9, 128.6, 128.5, 128.1, 127.8, 127.3, 126.5, 126.2.



3,4-diphenyl-2-(p-tolyl)quinoline (**8**); White solid (52.8 mg, 71%), mp 203-205 °C. ^{1}H NMR (500 MHz, CDCl3) δ 8.24 (d, *J* = 8.5 Hz, 1H), 7.71 (dd appear t, J_1 = 7.0 Hz, J_2 = 7.0 Hz, 1H), 7.56 (d, *J* = 8.5 Hz, 1H), 7.45-7.28 (m, 6H), 7.13-6.90 (m, 2H), 2.28 (s,

3H);^{13}C NMR (125 MHz, CDCl3) δ 158.9, 138.5, 137.5, 137.0, 133.0, 131.4, 130.3, 129.9, 129.5, 129.4, 128.4, 128.3, 127.8, 127.4, 127.3, 126.6, 126.5, 126.3, 21.2. HRMS (ESI) calcd for $C_{28}H_{22}N$ $[M+H]^+$: 372.1747, found 372.1746.



methyl 2-cyclopropyl-4-(4-fluorophenyl)quinoline-3-carboxylate (**9**): White solid (40.5 mg, 63%). mp 118-119 °C (lit.[19] 126-127 °C). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.99 (d, *J* = 8.5 Hz, 1H), 7.69-7.65 (m, 1H), 7.50 (d, *J* = 8.0 Hz, 1H), 7.40-7.34 (m, 3H), 7.21-7.17 (m, 2H), 3.63 (s, 3H), 2.22-2.14 (m, 1H), 1.39-1.35 (m, 2H), 1.10-1.04 (m, 2H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 169.1, 162.8 (d, *J* = 247.5 Hz), 158.3, 148.0, 144.6, 131.7 (d, *J* = 3.8 Hz), 131.2 (d, *J* = 7.5 Hz), 130.2, 129.1, 127.7, 126.1, 126.1, 124.9, 115.4 (d, *J* = 21.3 Hz), 52.3, 15.5, 10.5.

4. Reference

(1) W. Zheng, W. Yang, D. Luo, L. Min, X. Wang and Y. Hu. *Adv. Synth. Catal*., 2019, **361**, 1995.

(2) J. Yang, X. Meng, K. Lu, Z. Lu, M. Huang, C. Wang and F. Sun. *RSC Adv*., 2018, **8**, 31603.

(3) I. N. C. Kiran, R. S. Reddy, C. Lagishetti, H. Xu, Z. Wang and Y. He. *J. Org. Chem*., 2017, **82**, 1823.

(4) Y. Li, X. Zhou, Z. Wu, J. Cao, C. Ma, Y. He and G. Huang. *RSC Adv*., 2015, **5**, 88214.

(5) F. Zhang, Q. Lai, X. Shi, Z. Song. *Chin. Chem. Lett*., 2019, **30**, 392.

(6) J. Zhu, W. Hu, S. Sun, J. Yu and J. Cheng. *Adv. Synth. Catal*., 2017, **359**, 3725.

(7) Y. Liu, S. Li, X. Chen, L. Fan, X. Li, S. Zhu, L. Qu and B. Yu. *Adv. Synth. Catal*., 2020, **362**, 688.

(8) S. Anvar, I. M. Baltork, S. Tangestaninejad, M. Moghadam, V. Mirkhani, A. R. Khosropour and R. Kia. *RSC Adv.*, 2012, **2**, 8713.

(9) M. Rehan, G. Hazra and P. Ghorai. *Org. Lett*., 2015, **17**, 1668.

(10) B. Gabriele, R. Mancuso, G. Salerno, G. Ruffolo and P. Plastina. *J. Org. Chem*., 2007, **72**, 6873.

(11) Y. Wang, C. Chen, J. Peng and M. Li. *Angew. Chem. Int. Ed*., 2013, **52**, 5323.

(12) R. Venkatesham, A. Manjula and B. Vittal Rao. *J. Heterocyclic Chem*., 2012, **49**, 833.

(13) Z. Zhang and H. Du. *Org. Lett.*, 2015, **17**, 6266.

(14) X. Pang, M. Wu, J. Ni, F. Zhang, J. Lan, B. Chen and R. Yan. *J. Org. Chem*., 2017, **82**, 10110.

(15) D. Chen, J. Li, P. Cui, Y. Shan, Y. Zhao and G. Qiu. *Eur. J. Org. Chem.*, 2020, **2020**, 169.

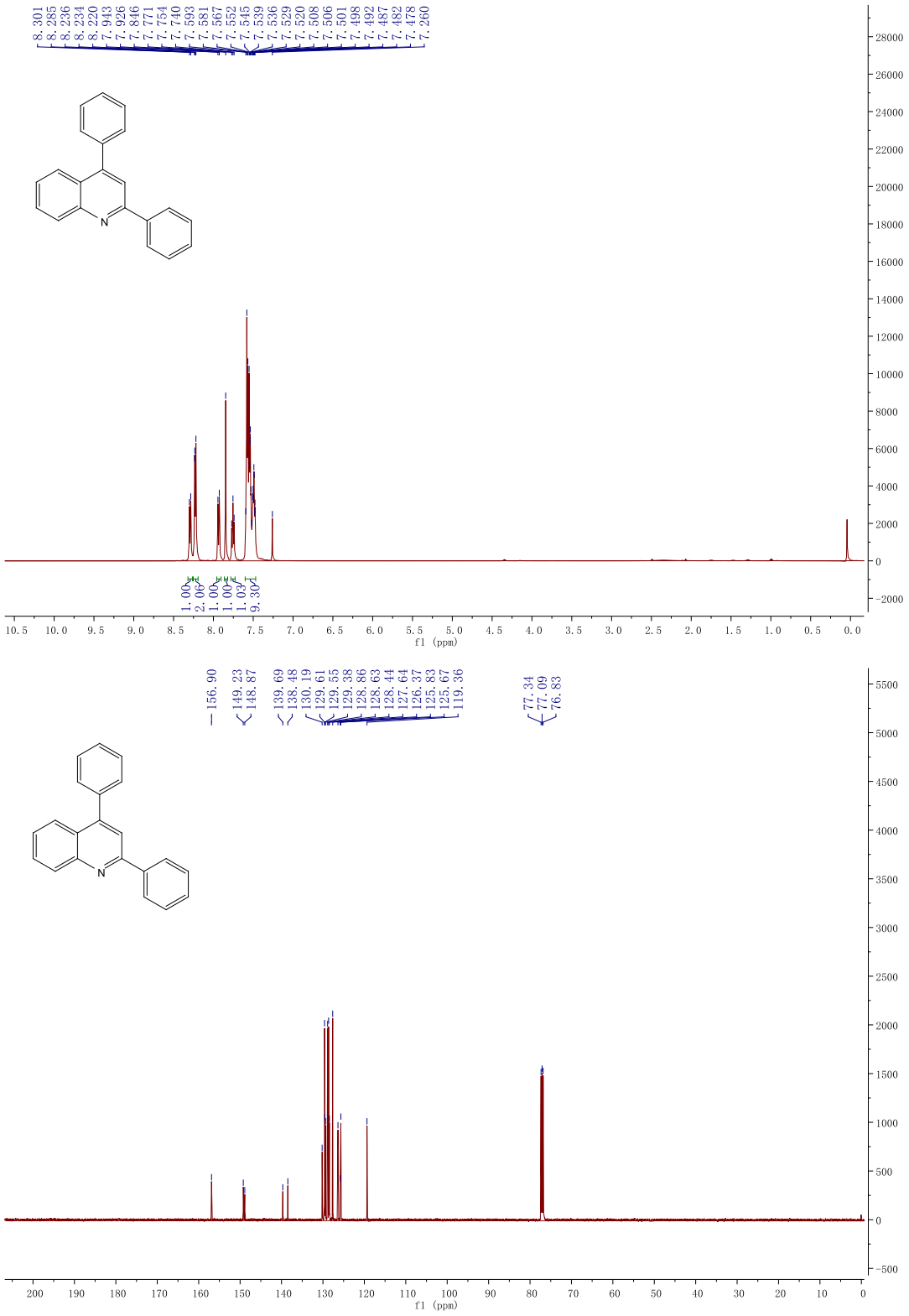
(16) M. Jida and B. Deprez. *New J. Chem.*, 2012, **36**, 869.

(17) X. Wang, X. Wang, D. Huang, C. Liu, X. Wang and Y. Hu. *Adv. Synth. Catal*., 2016, **358**, 2332.

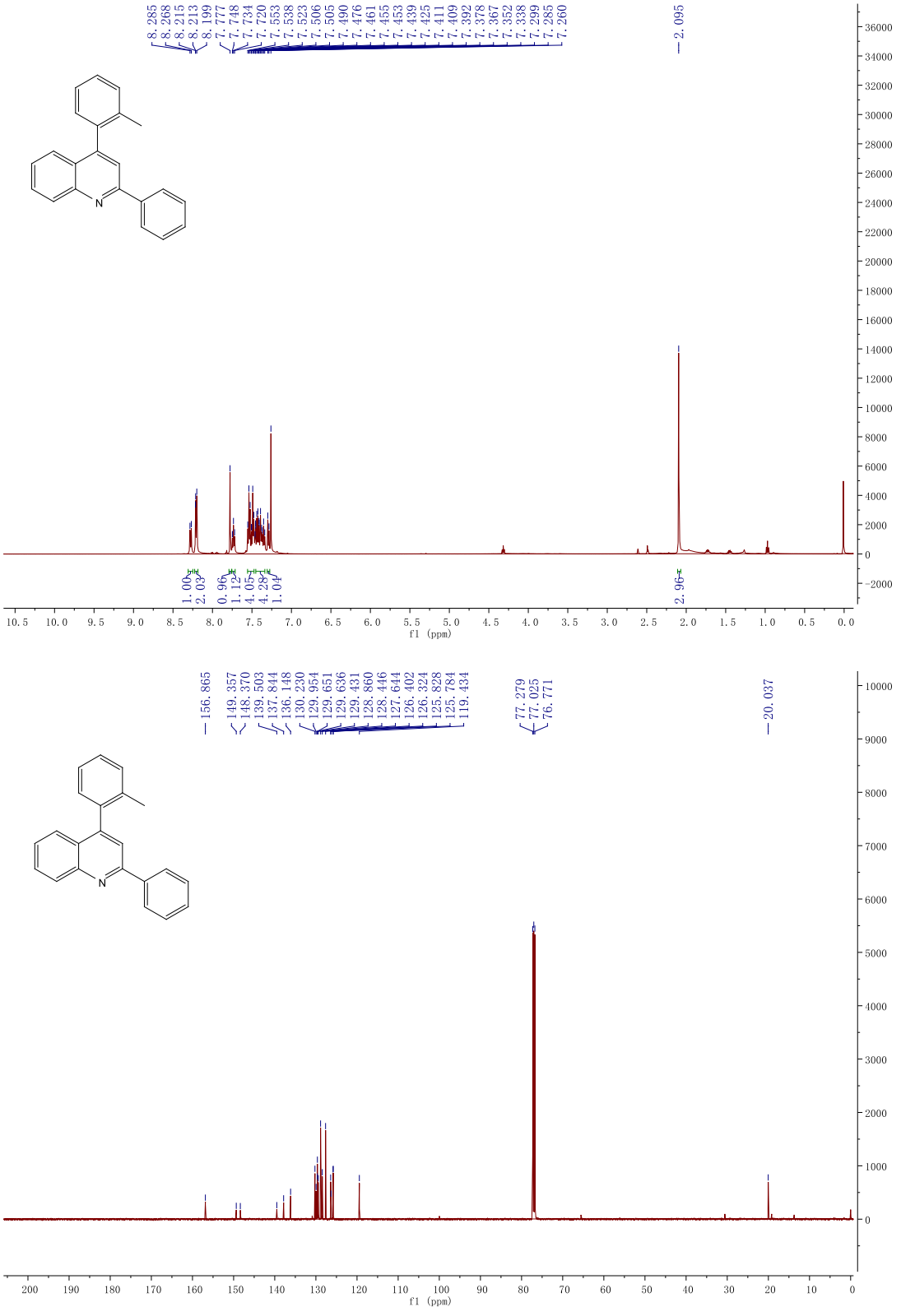
(18) J. Chen, C. Chen, J. Chen, H. Gao and H. Qu. Synlett 2014, **25**, 2721.

(19) M. Suzuki, H. Iwasaki, Y. Fujikawa, M. Kitahara, M. Sakashitab and R. Sakoda. Bioorg. Med. Chem. 2001, **9**, 2727.

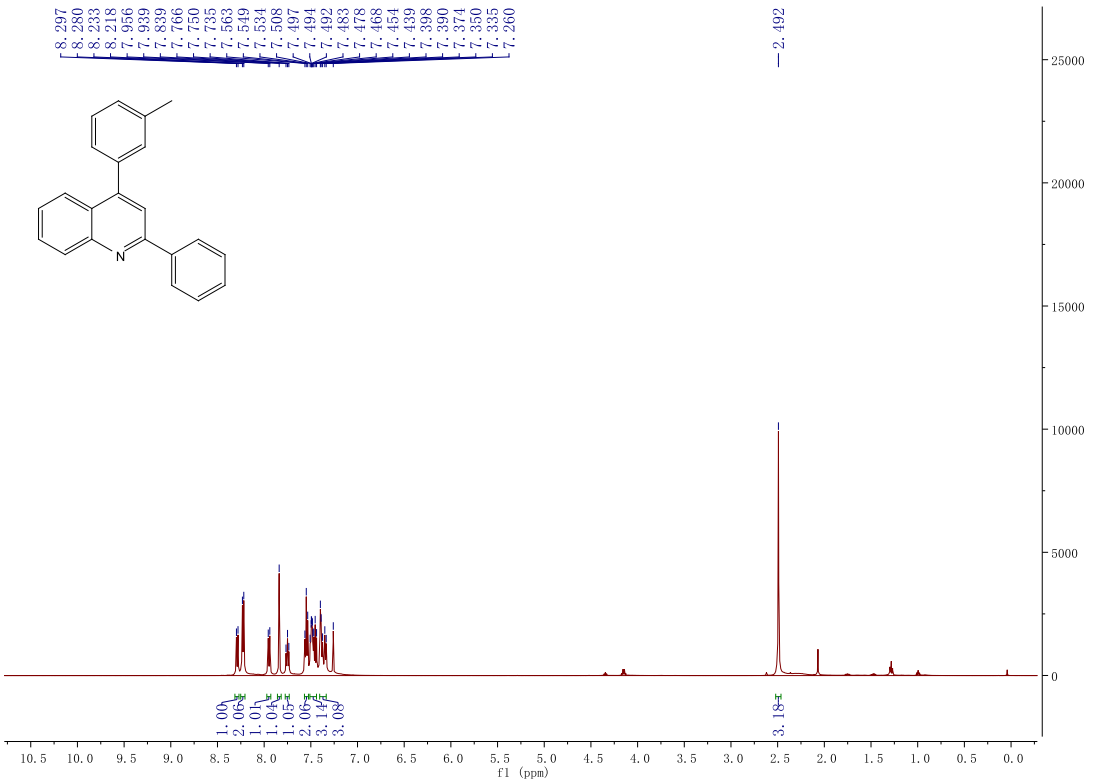
5. NMR Spectra for All Products

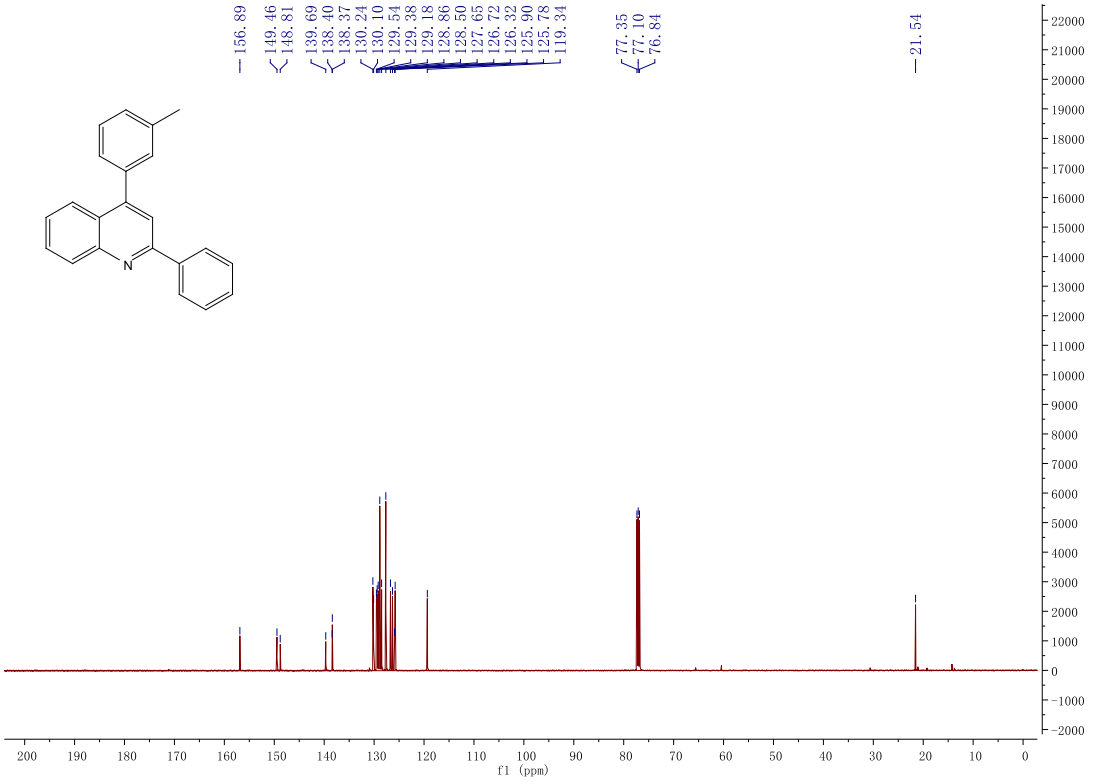


^{1}H NMR of **4a** (500 MHz, $CDCl_3$) and ^{13}C NMR of **4a** (125 MHz, $CDCl_3$).

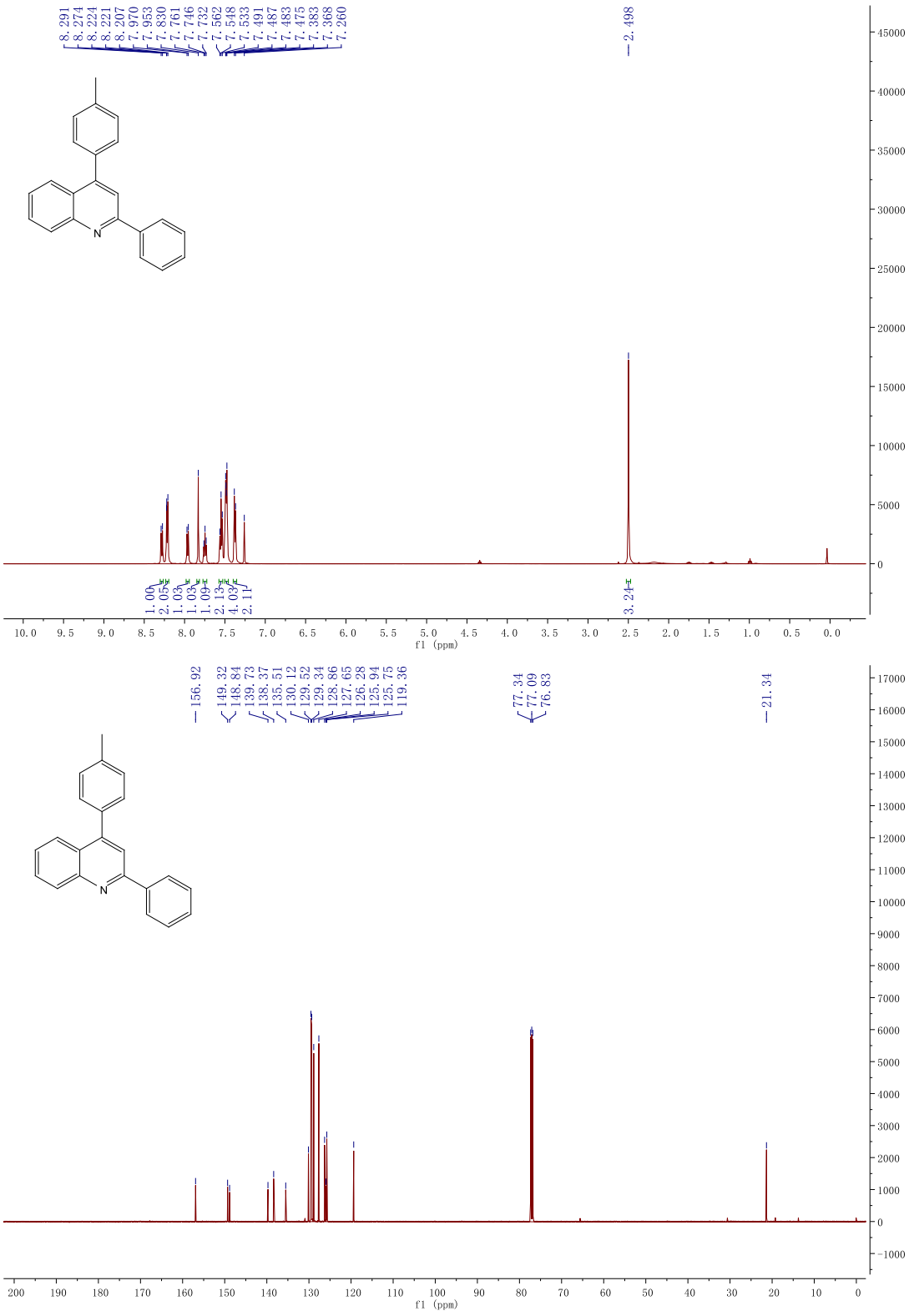


^{1}H NMR of **4b** (500 MHz, $CDCl_3$) and ^{13}C NMR of **4b** (125 MHz, $CDCl_3$).

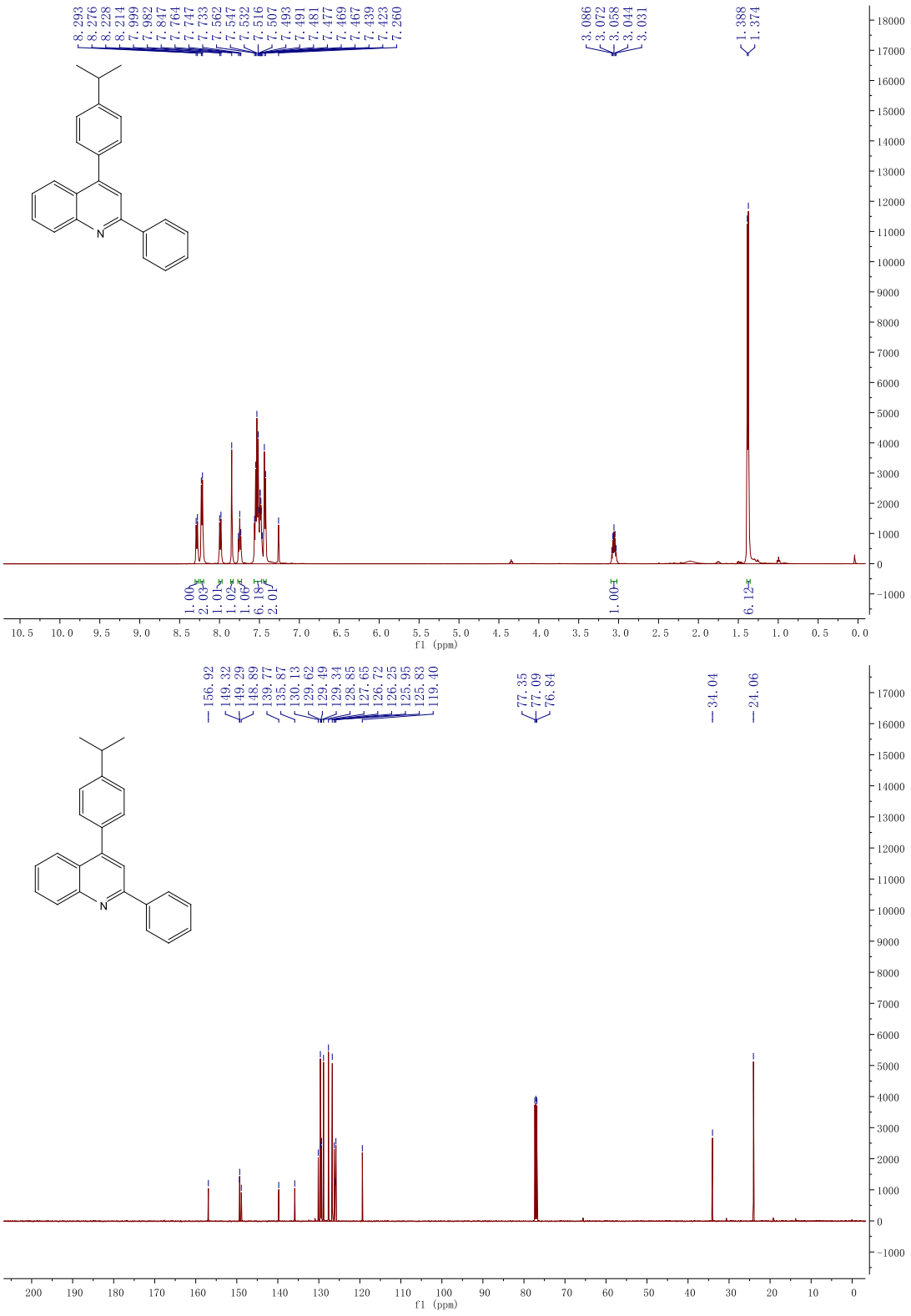




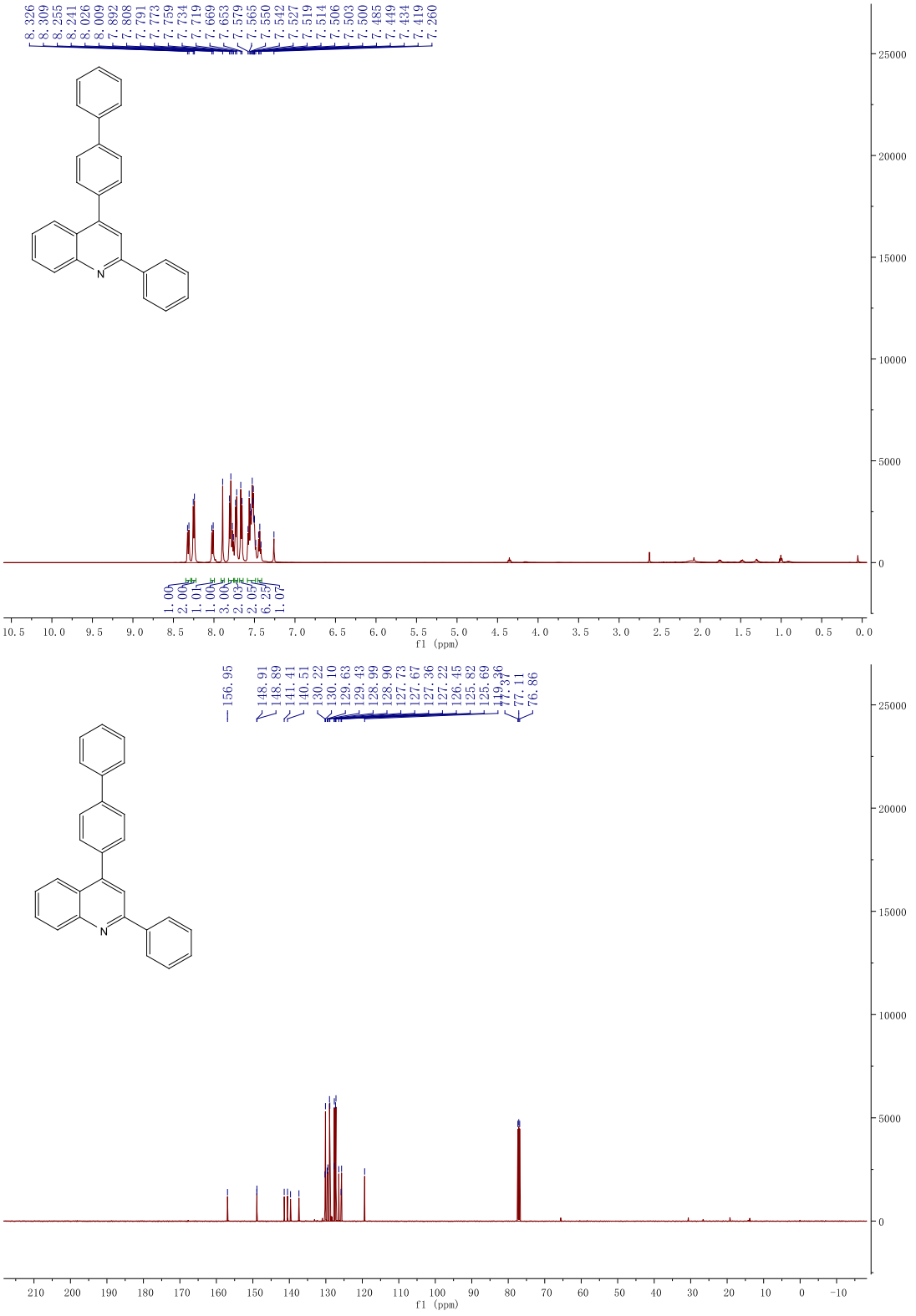
^{1}H NMR of **4c** (500 MHz, $CDCl_3$) and ^{13}C NMR of **4c** (125 MHz, $CDCl_3$).



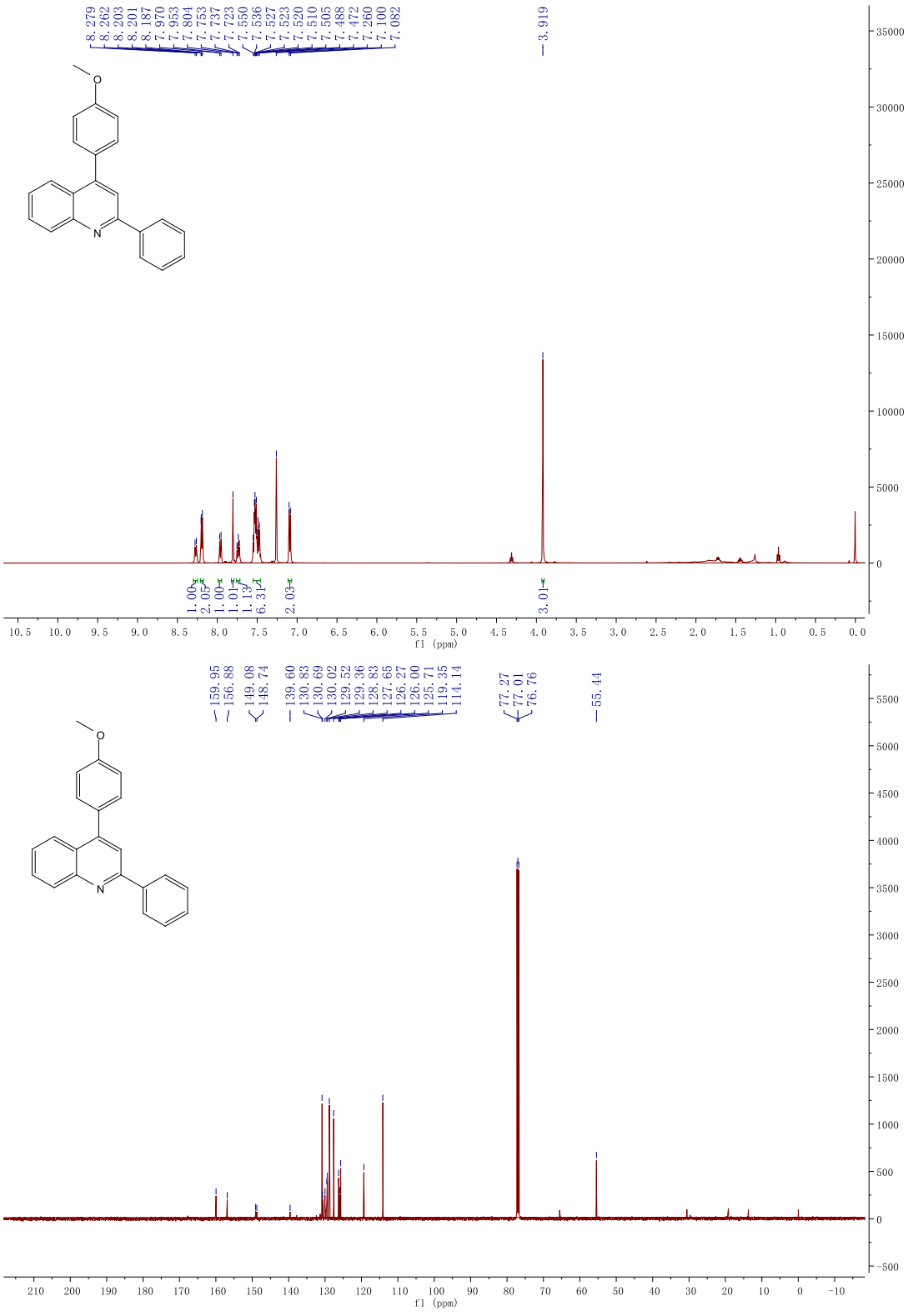
^{1}H NMR of **4d** (500 MHz, $CDCl_3$) and ^{13}C NMR of **4d** (125 MHz, $CDCl_3$).



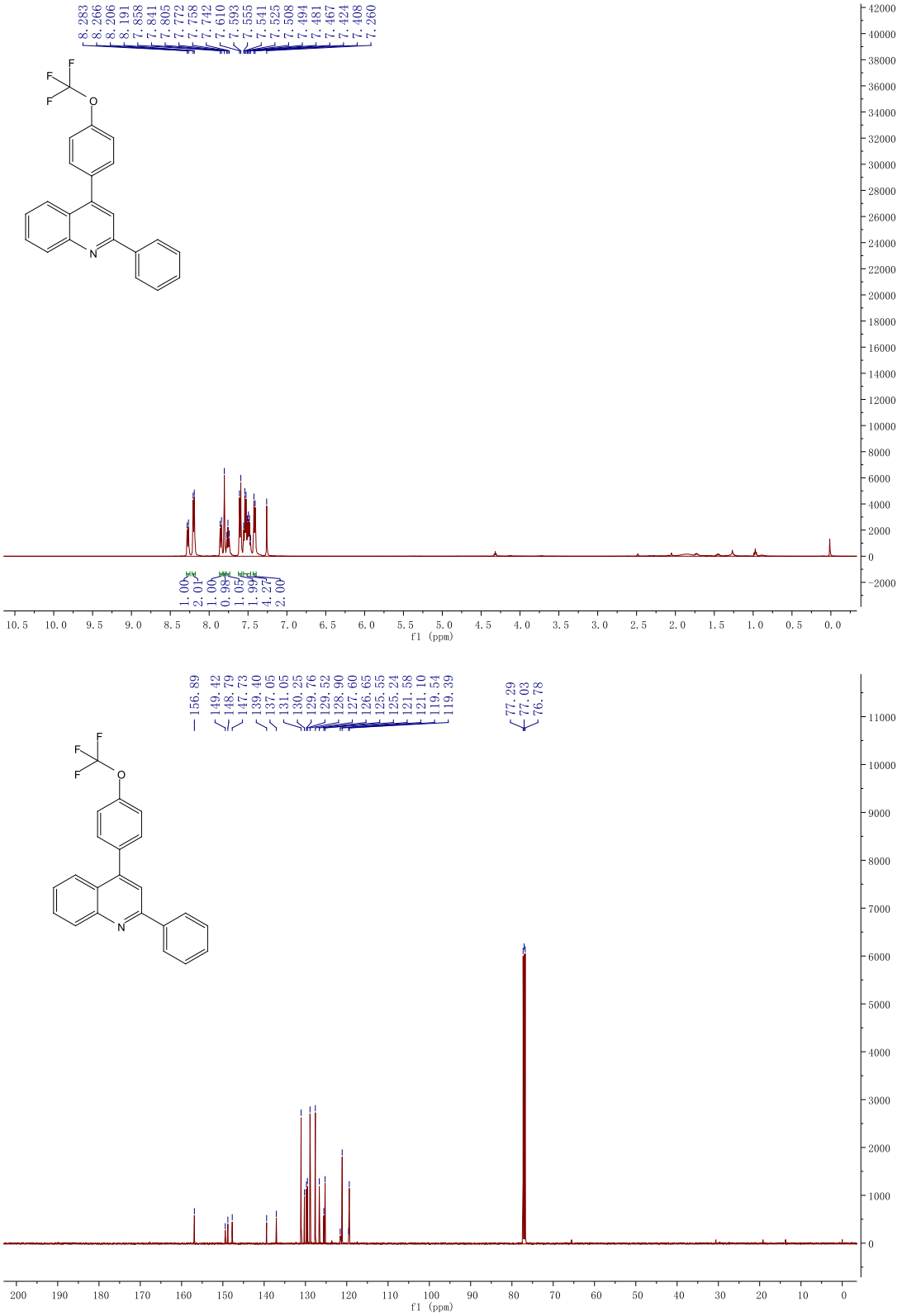
^{1}H NMR of **4e** (500 MHz, $CDCl_3$) and ^{13}C NMR of **4e** (125 MHz, $CDCl_3$).



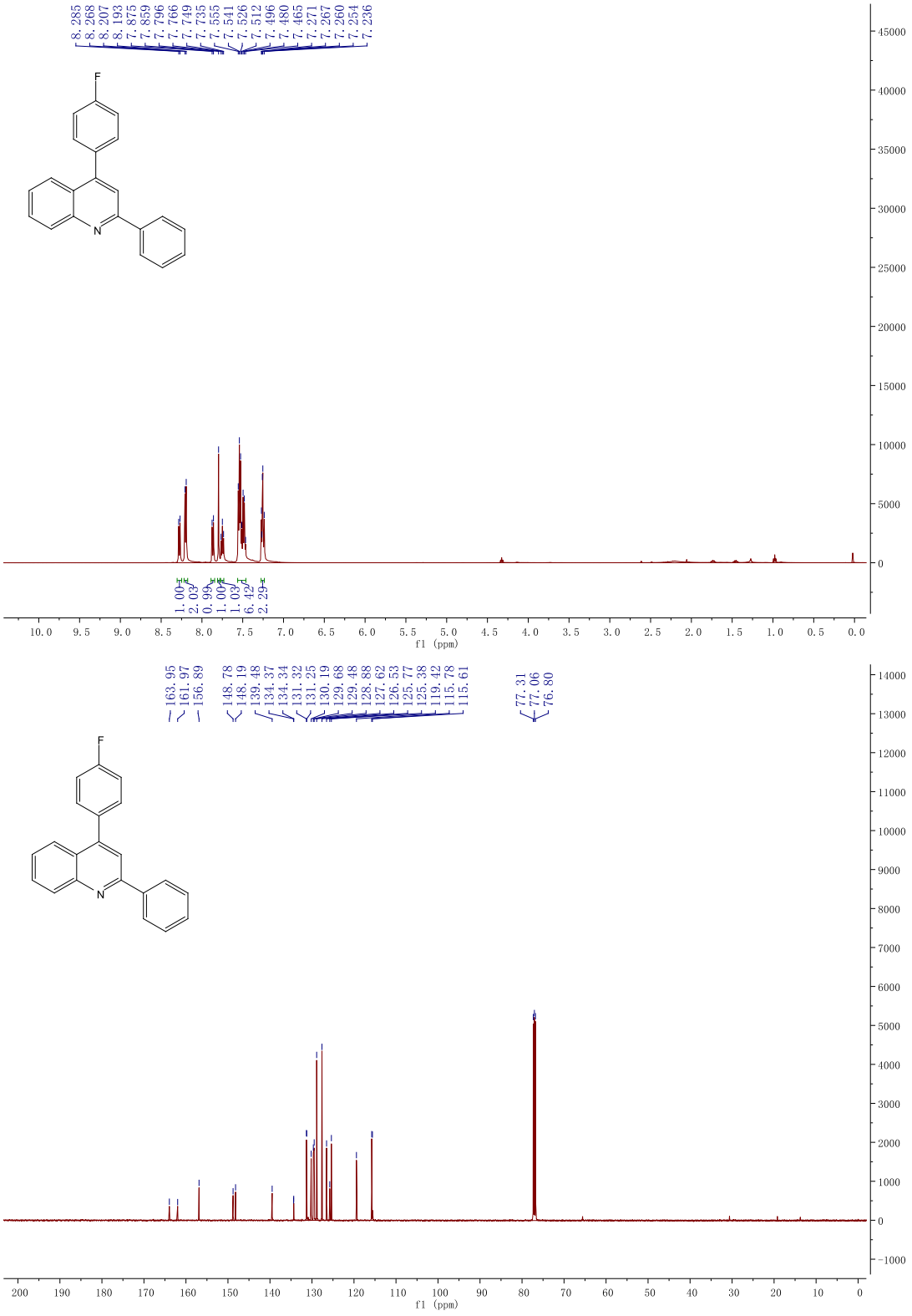
^{1}H NMR of **4f** (500 MHz, $CDCl_3$) and ^{13}C NMR of **4f** (125 MHz, $CDCl_3$).



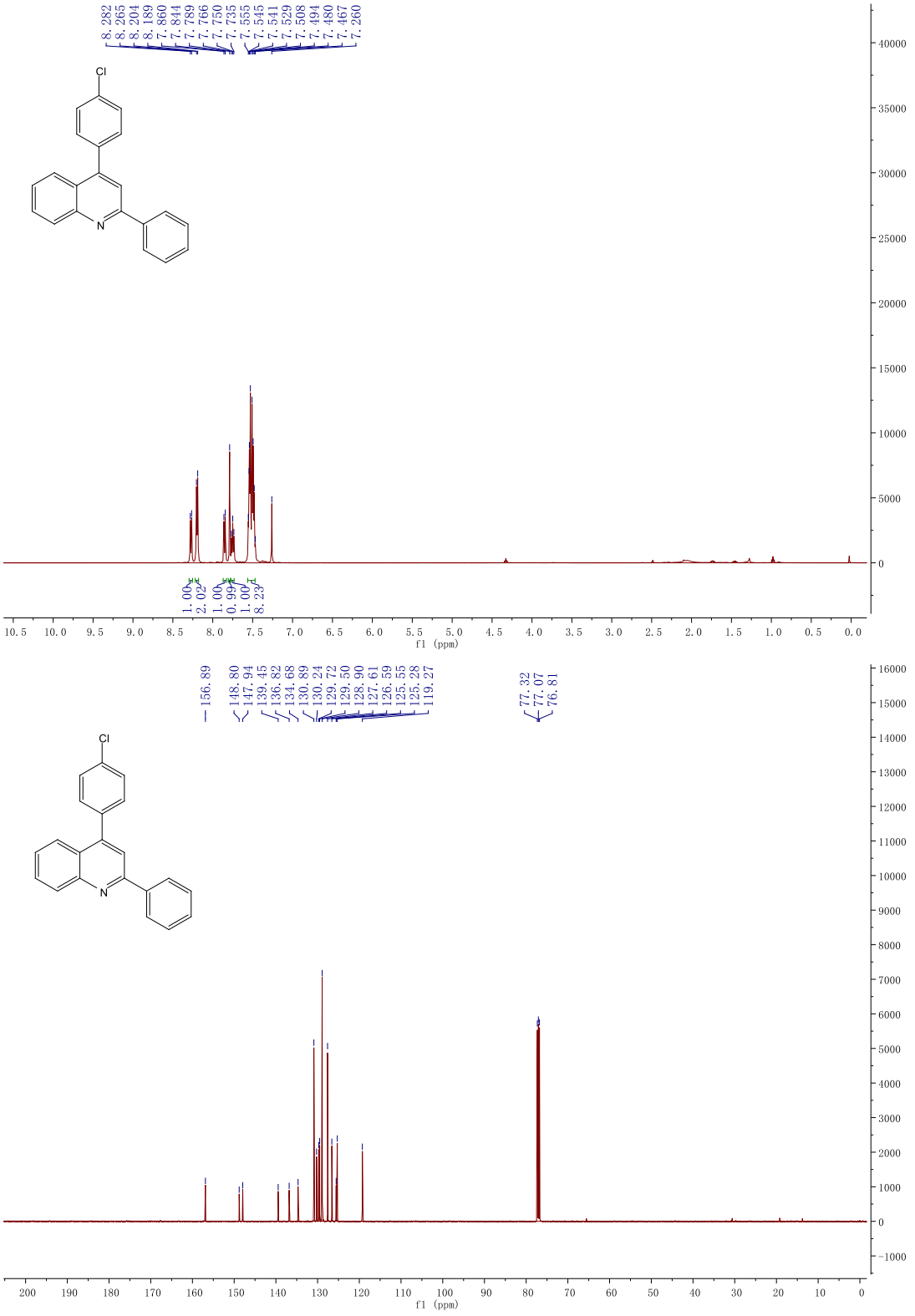
^{1}H NMR of **4g** (500 MHz, $CDCl_3$) and ^{13}C NMR of **4g** (125 MHz, $CDCl_3$).



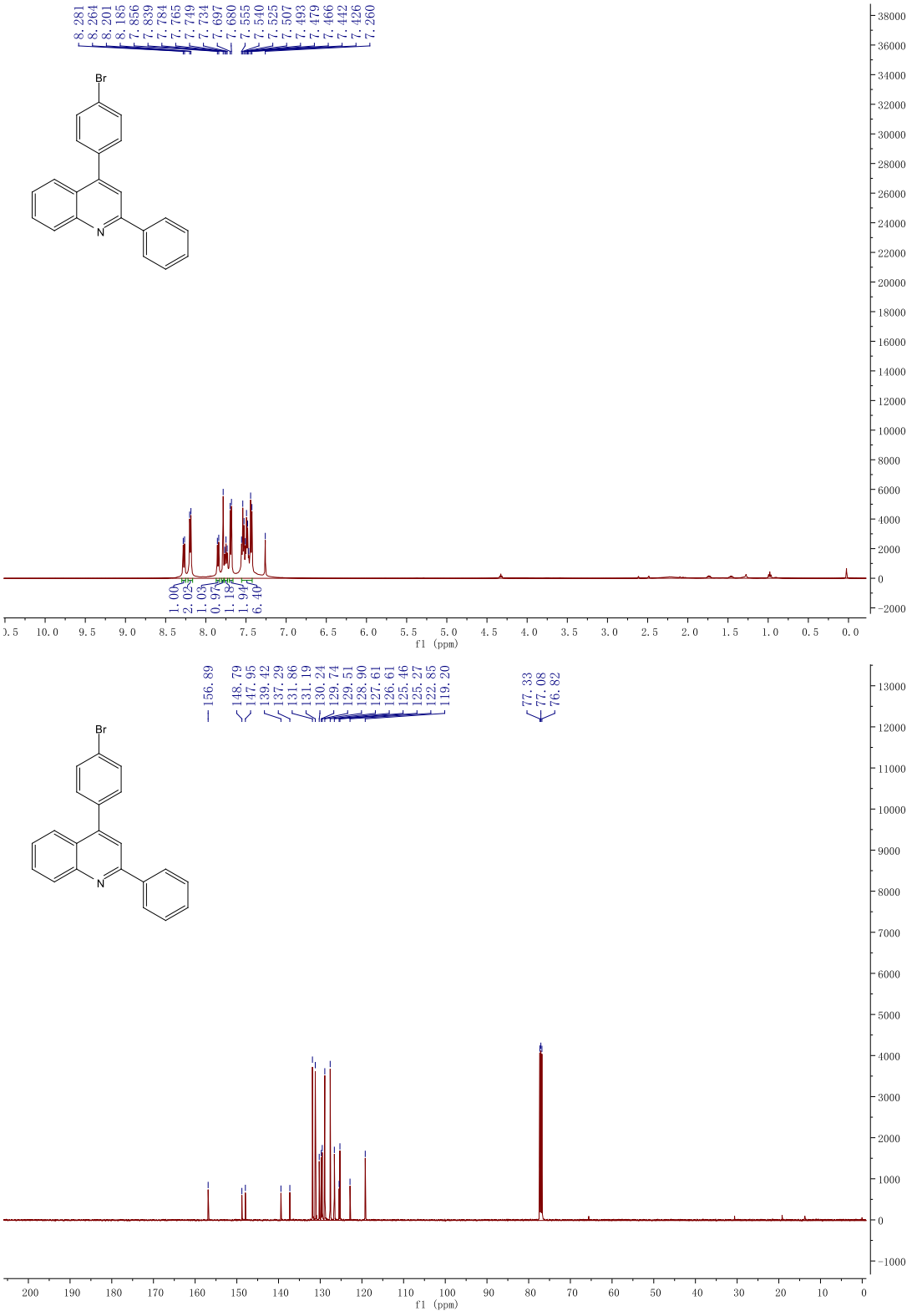
^{1}H NMR of **4h** (500 MHz, $CDCl_3$) and ^{13}C NMR of **4h** (125 MHz, $CDCl_3$).



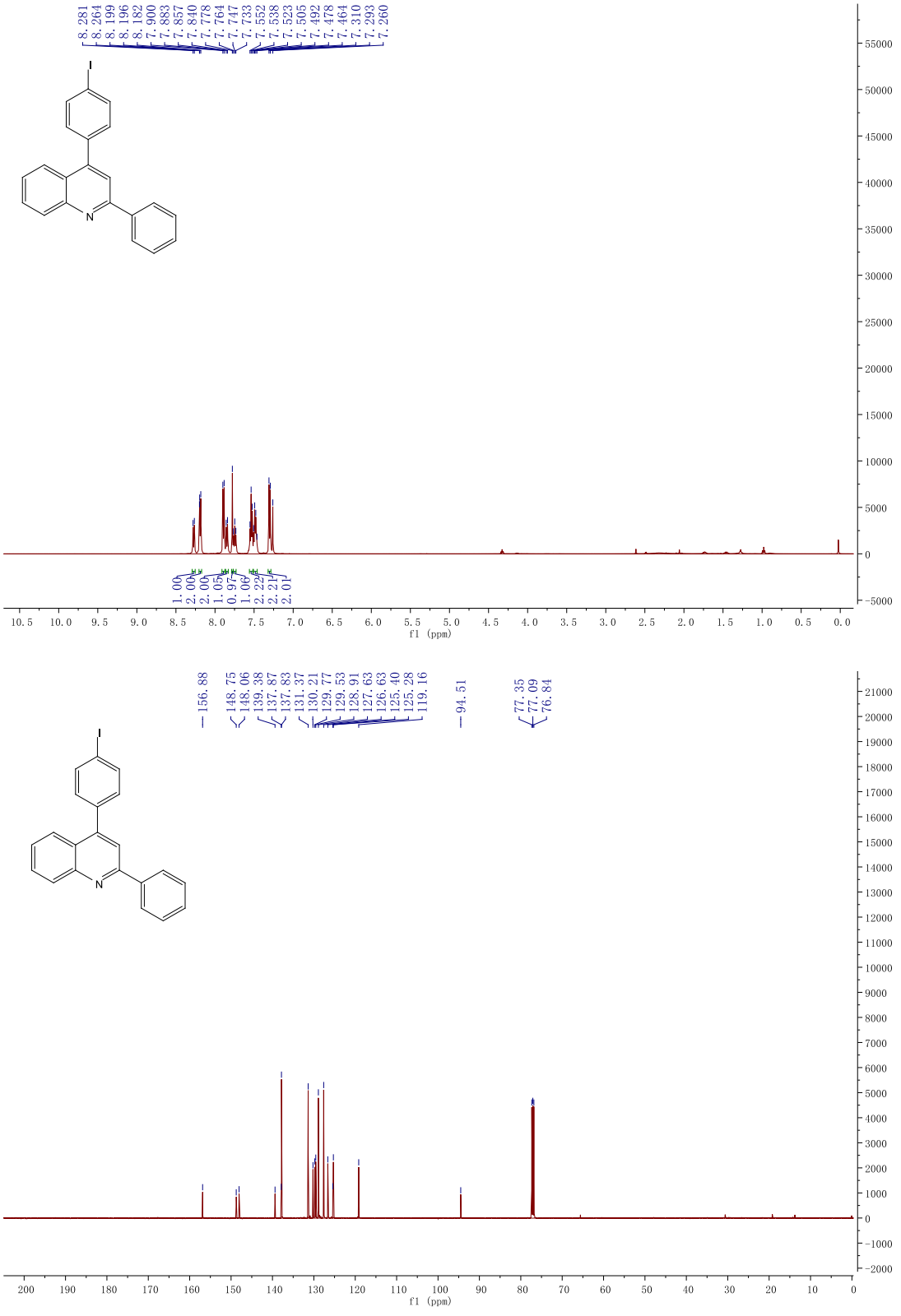
^{1}H NMR of **4i** (500 MHz, $CDCl_3$) and ^{13}C NMR of **4i** (125 MHz, $CDCl_3$).



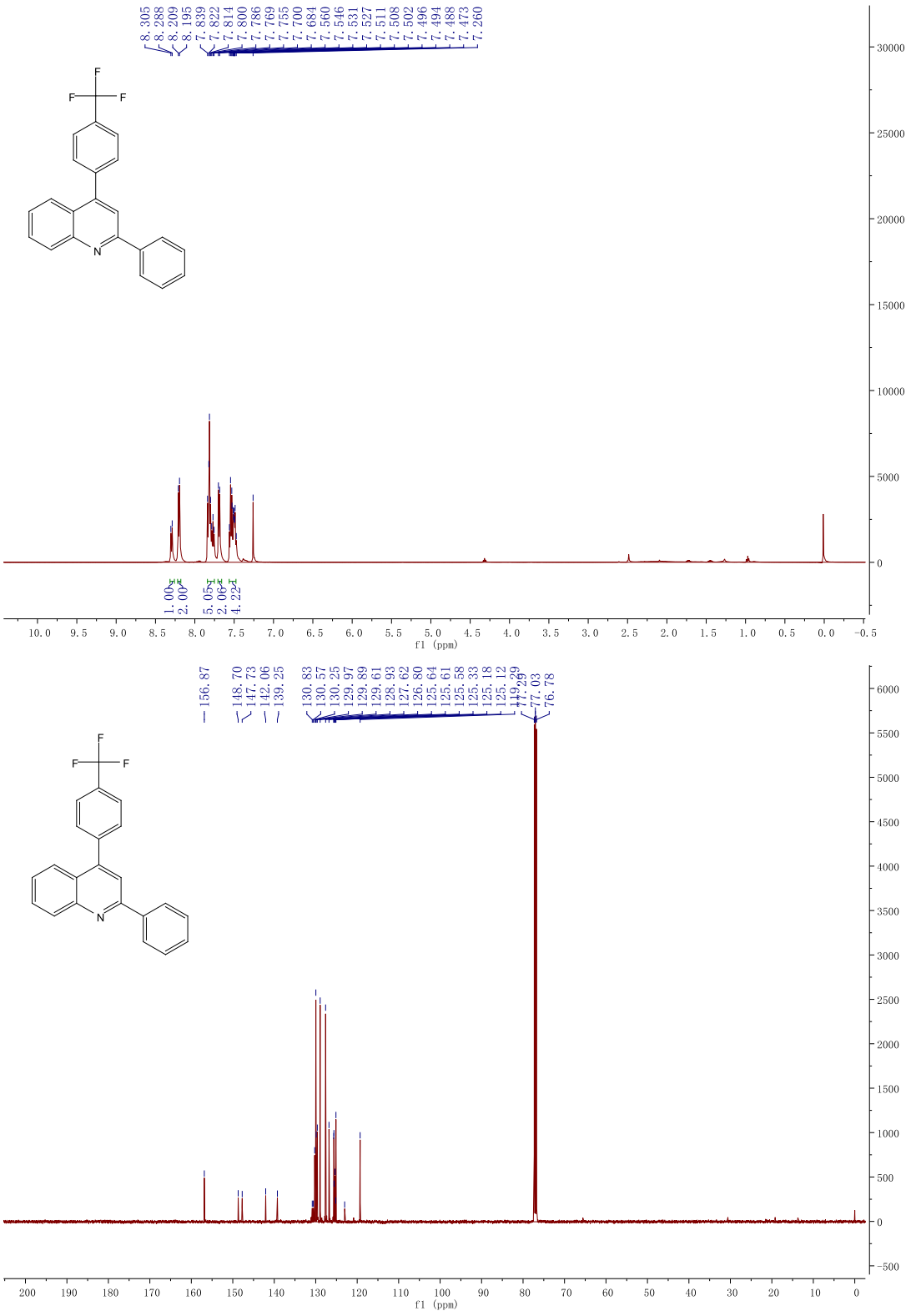
^{1}H NMR of **4j** (500 MHz, $CDCl_3$) and ^{13}C NMR of **4j** (125 MHz, $CDCl_3$).



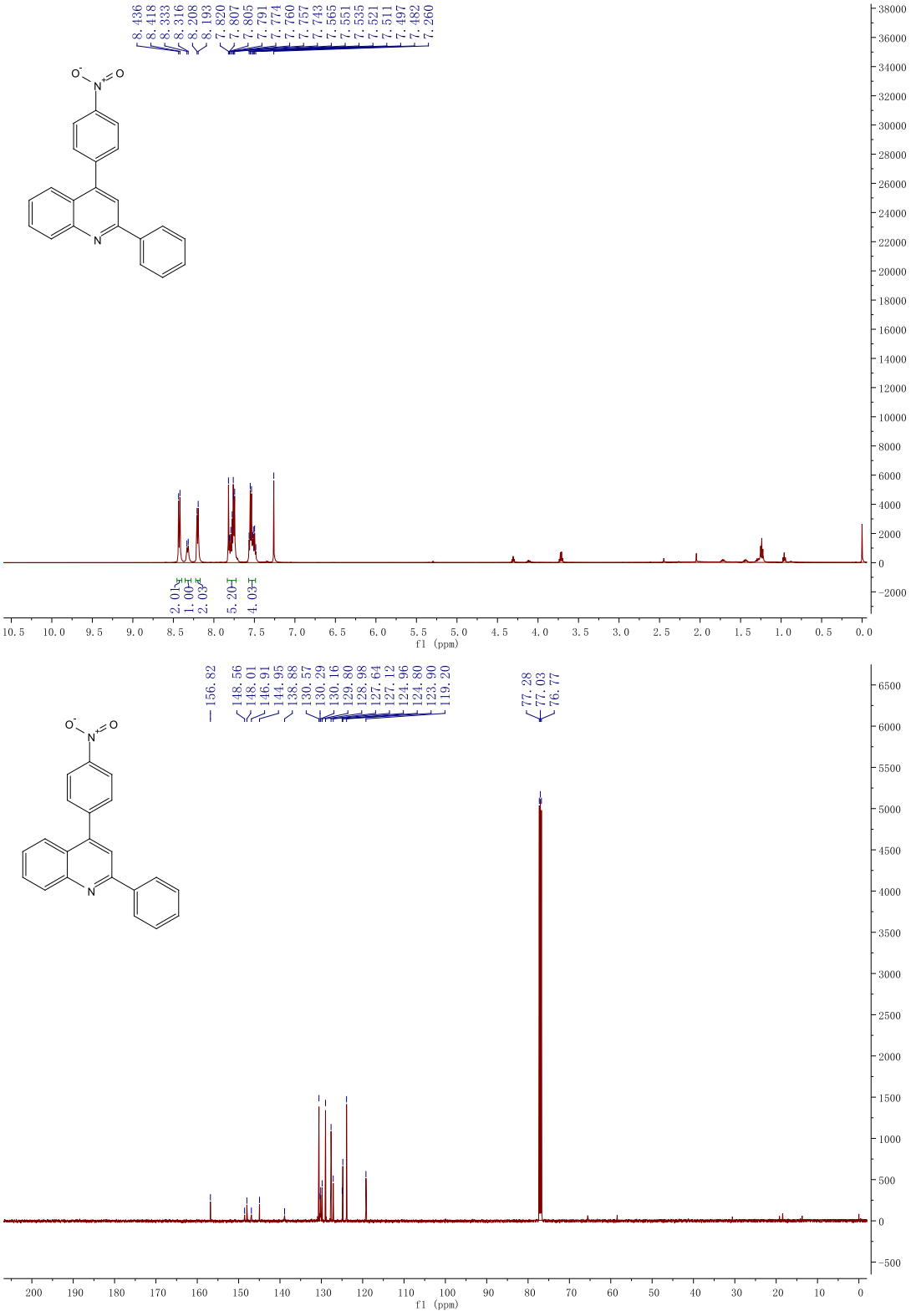
^{1}H NMR of **4k** (500 MHz, $CDCl_3$) and ^{13}C NMR of **4k** (125 MHz, $CDCl_3$).



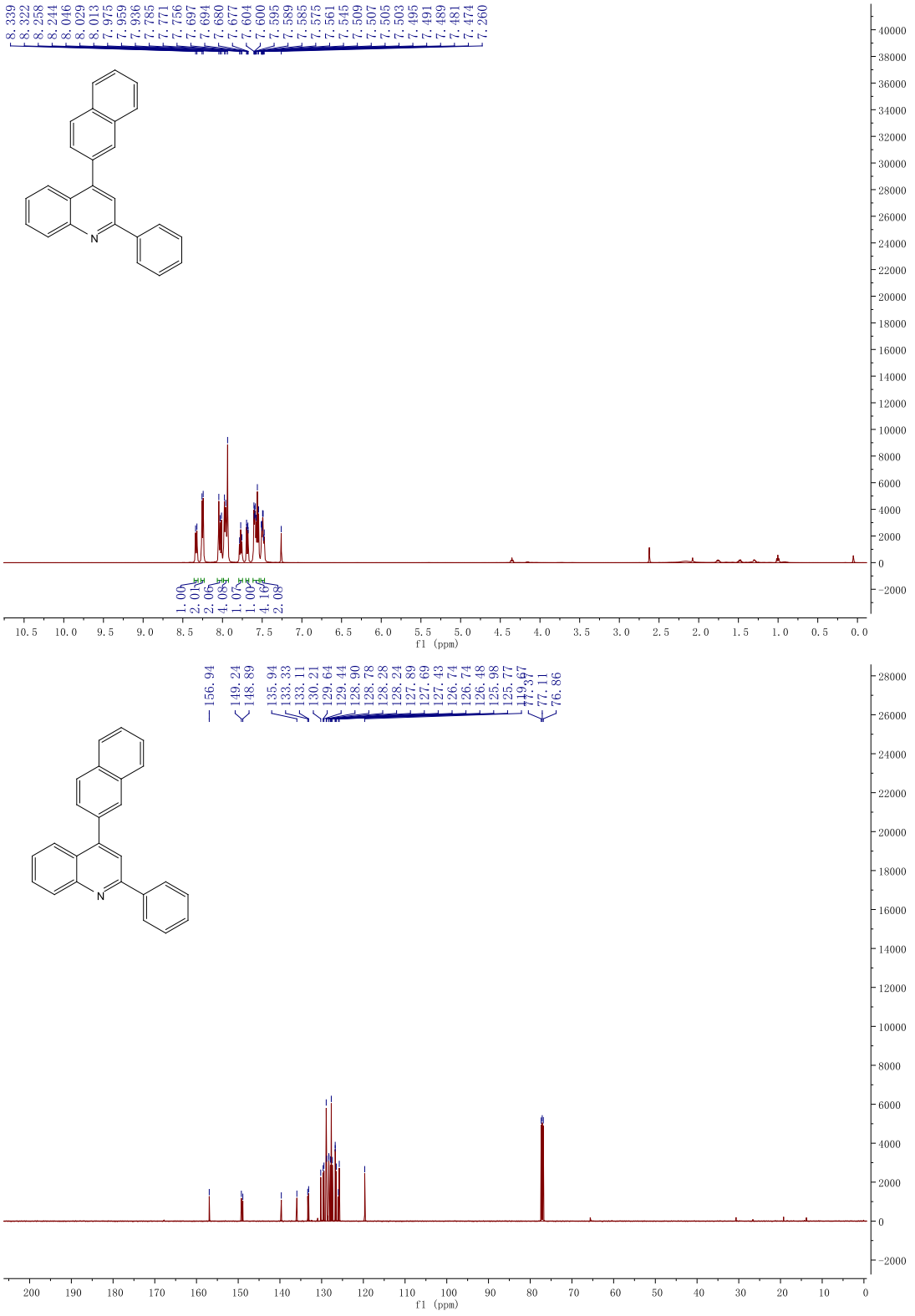
^{1}H NMR of **4l** (500 MHz, $CDCl_3$) and ^{13}C NMR of **4l** (125 MHz, $CDCl_3$).



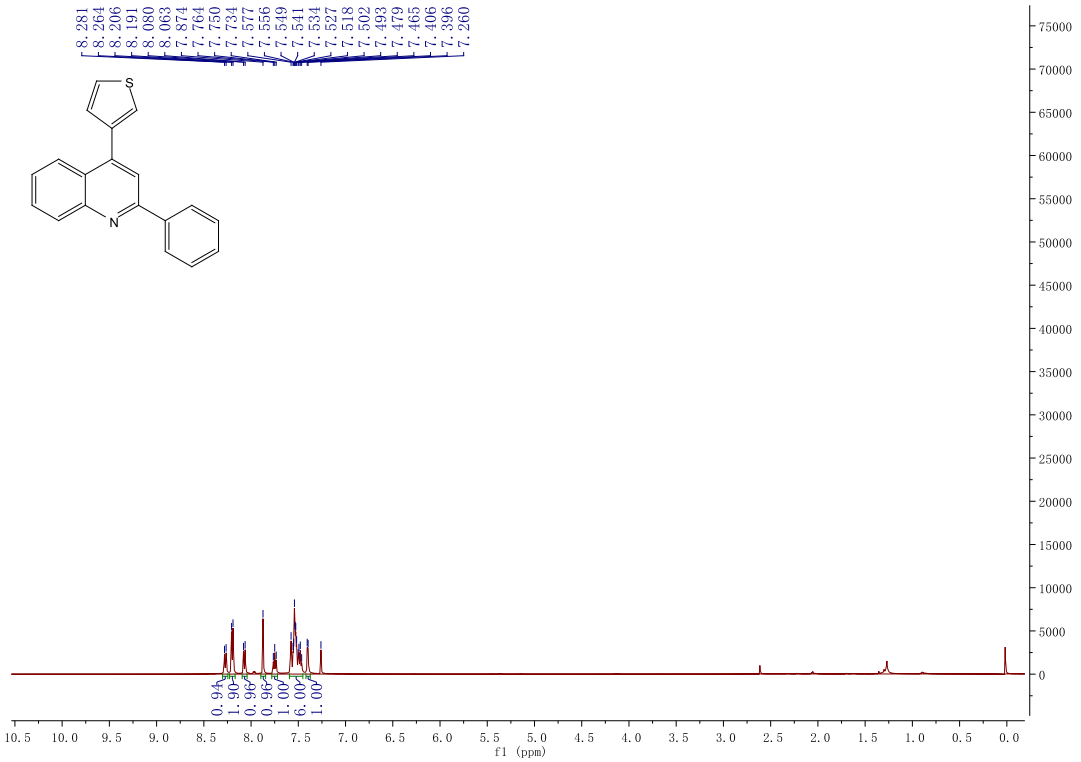
^{1}H NMR of **4m** (500 MHz, $CDCl_3$) and ^{13}C NMR of **4m** (125 MHz, $CDCl_3$).

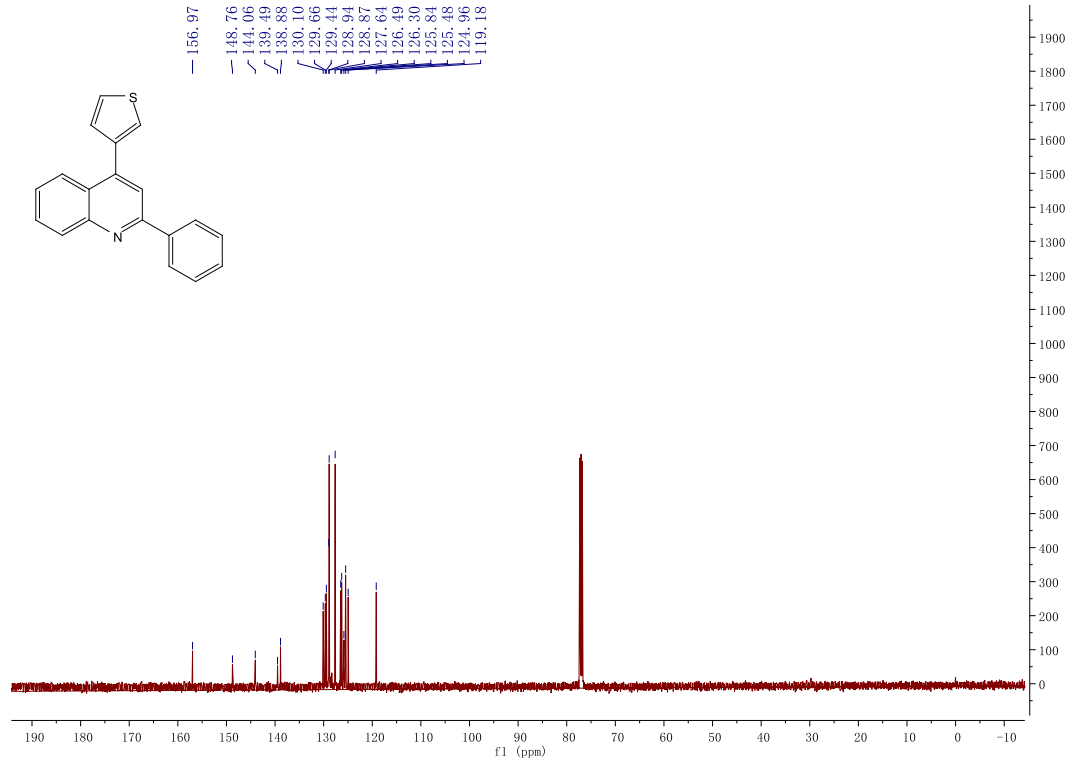


^{1}H NMR of **4n** (500 MHz, $CDCl_3$) and ^{13}C NMR of **4n** (125 MHz, $CDCl_3$).

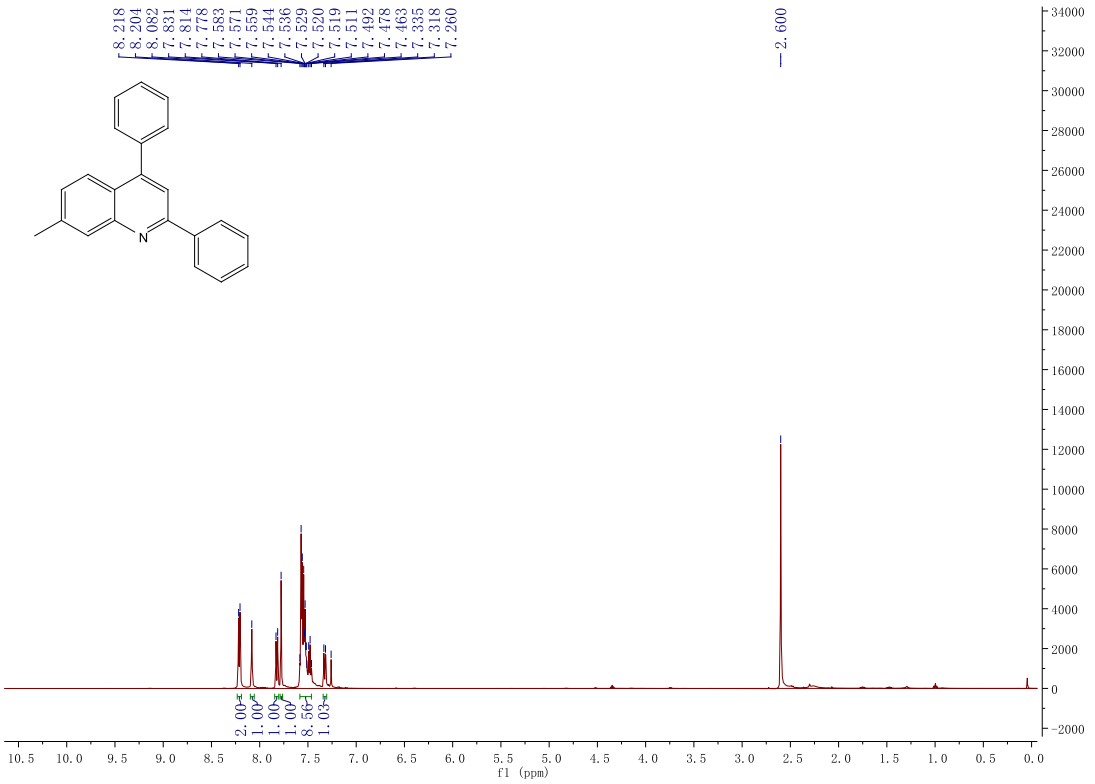


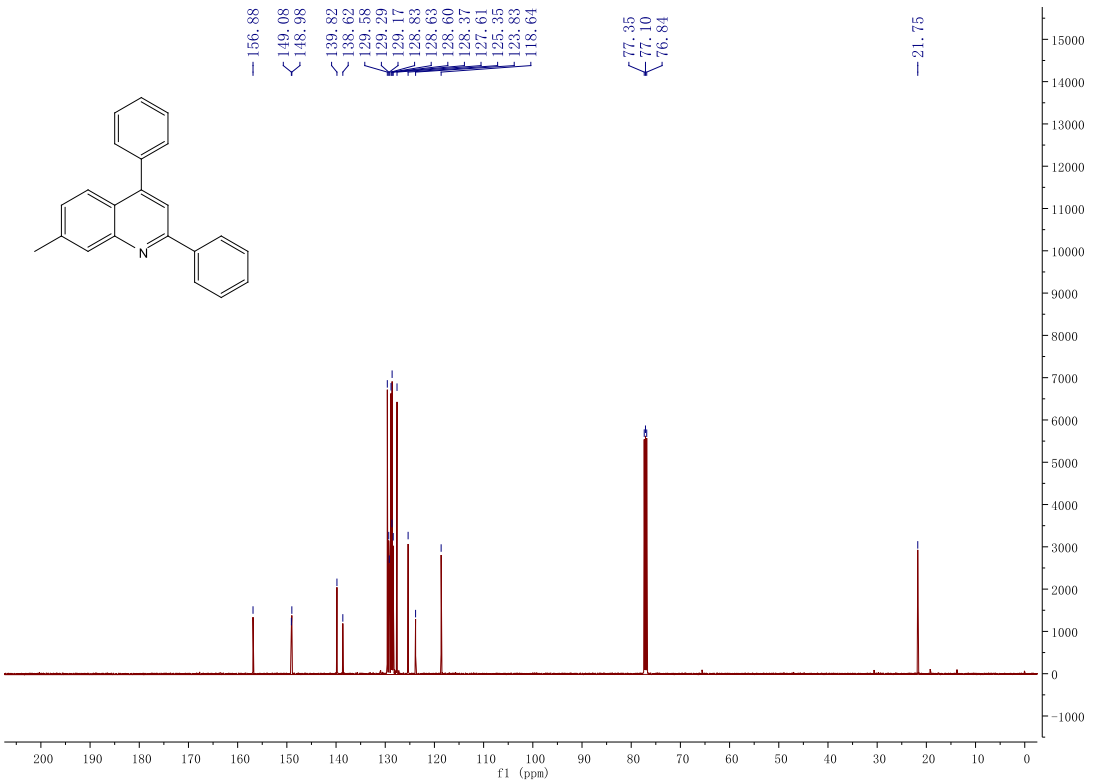
^{1}H NMR of **4o** (500 MHz, $CDCl_3$) and ^{13}C NMR of **4o** (125 MHz, $CDCl_3$).



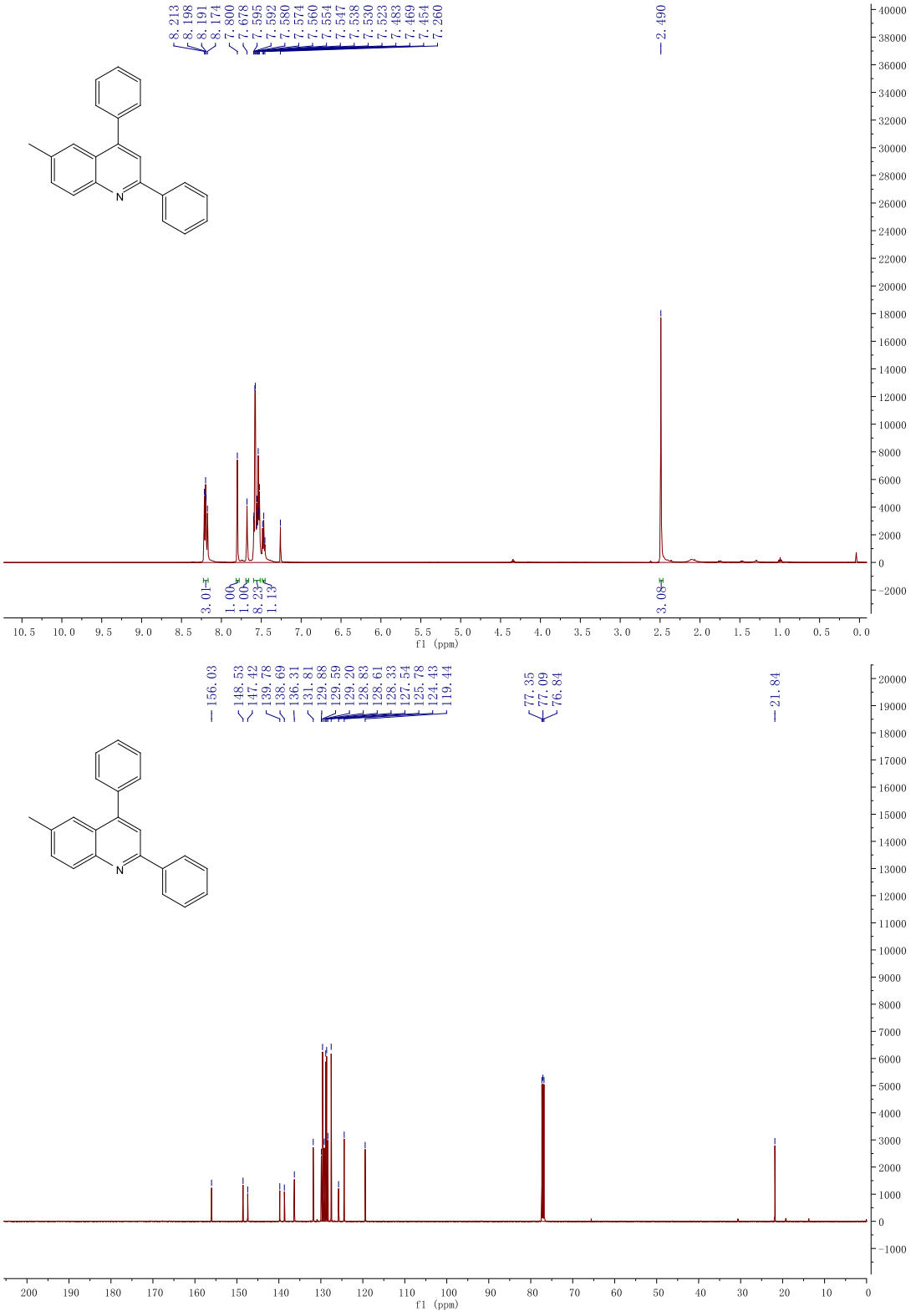


^{1}H NMR of **4p** (500 MHz, $CDCl_3$) and ^{13}C NMR of **4p** (125 MHz, $CDCl_3$).

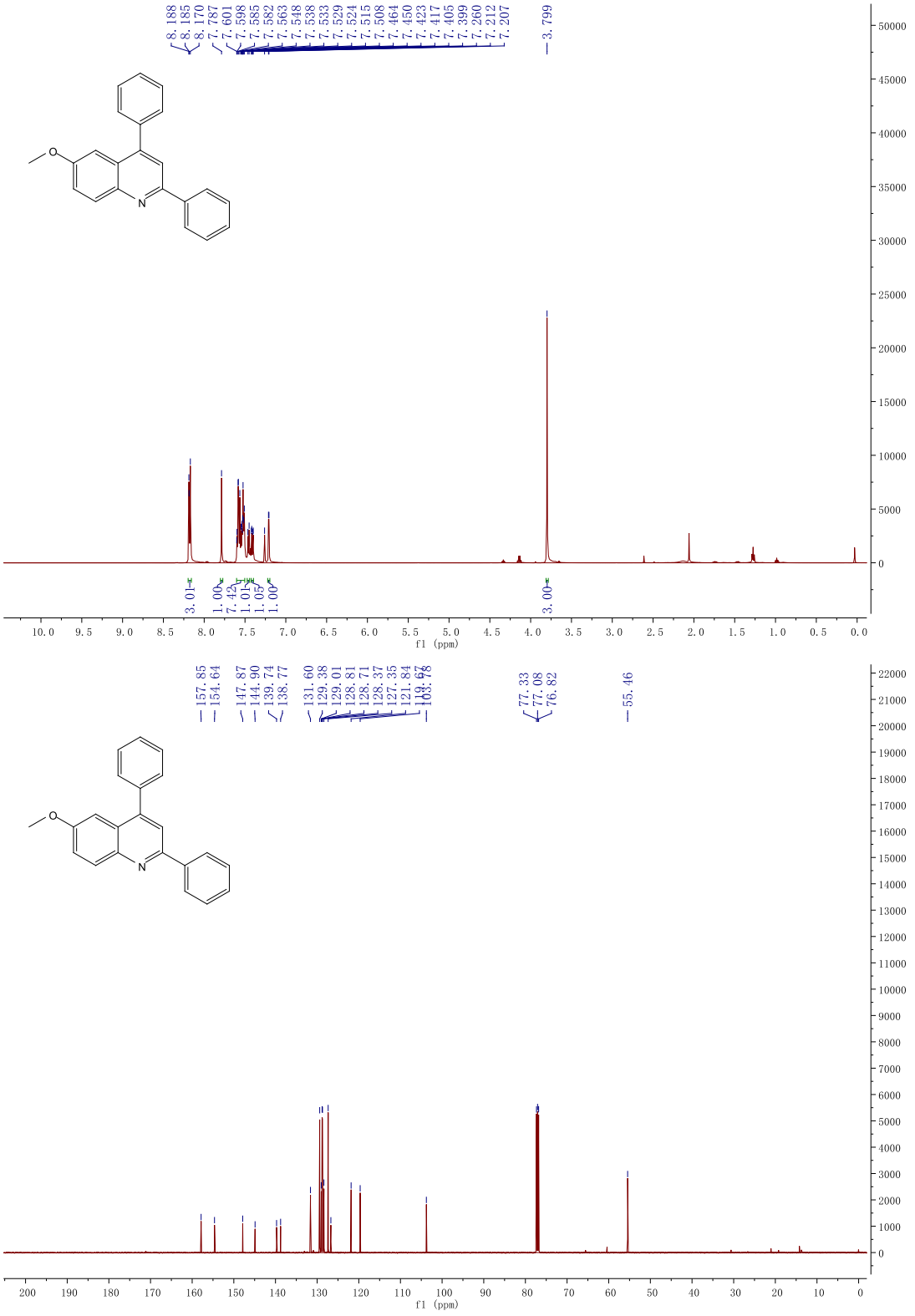




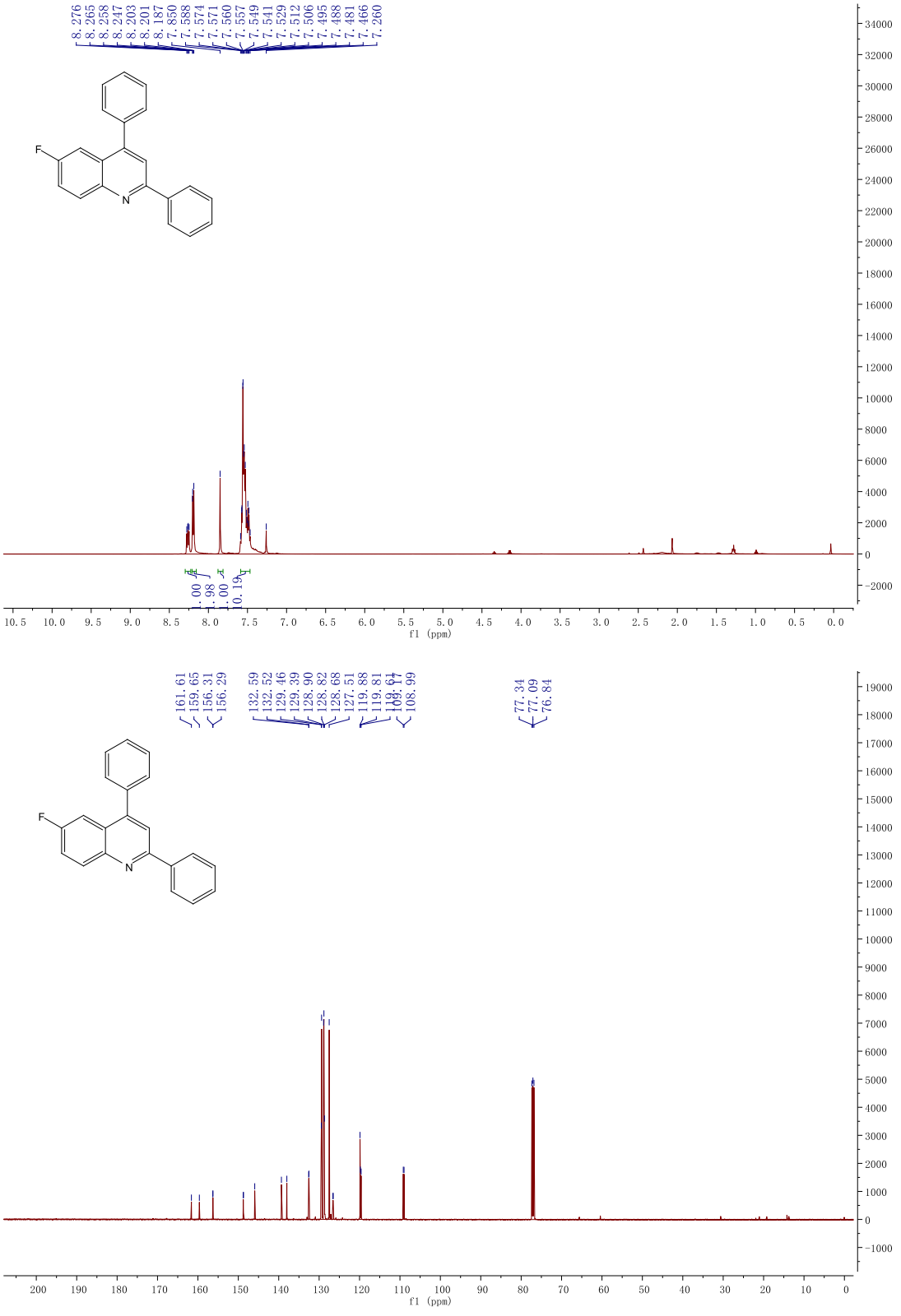
^{1}H NMR of **5a** (500 MHz, $CDCl_3$) and ^{13}C NMR of **5a** (125 MHz, $CDCl_3$).



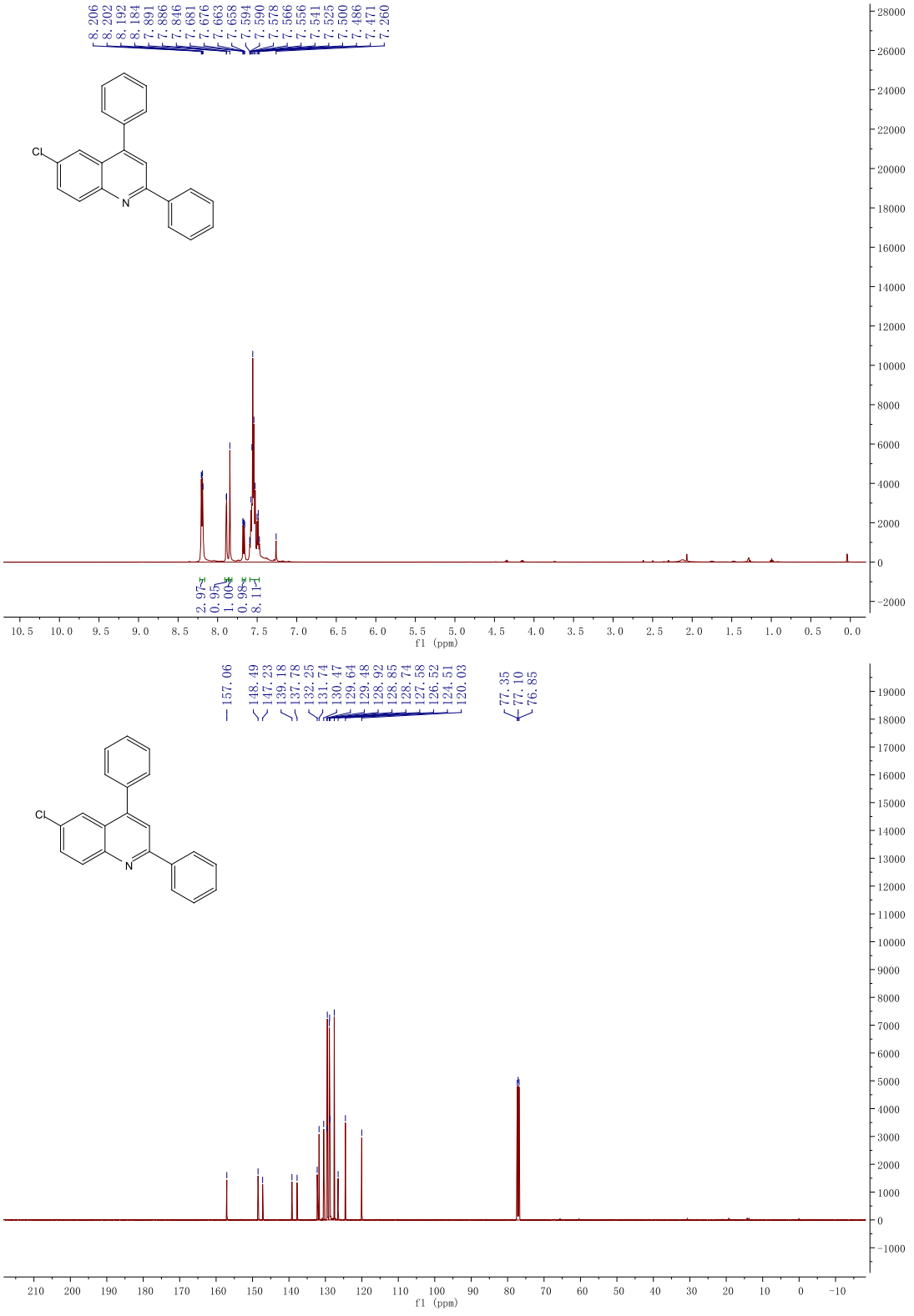
^{1}H NMR of **5b** (500 MHz, $CDCl_3$) and ^{13}C NMR of **5b** (125 MHz, $CDCl_3$).



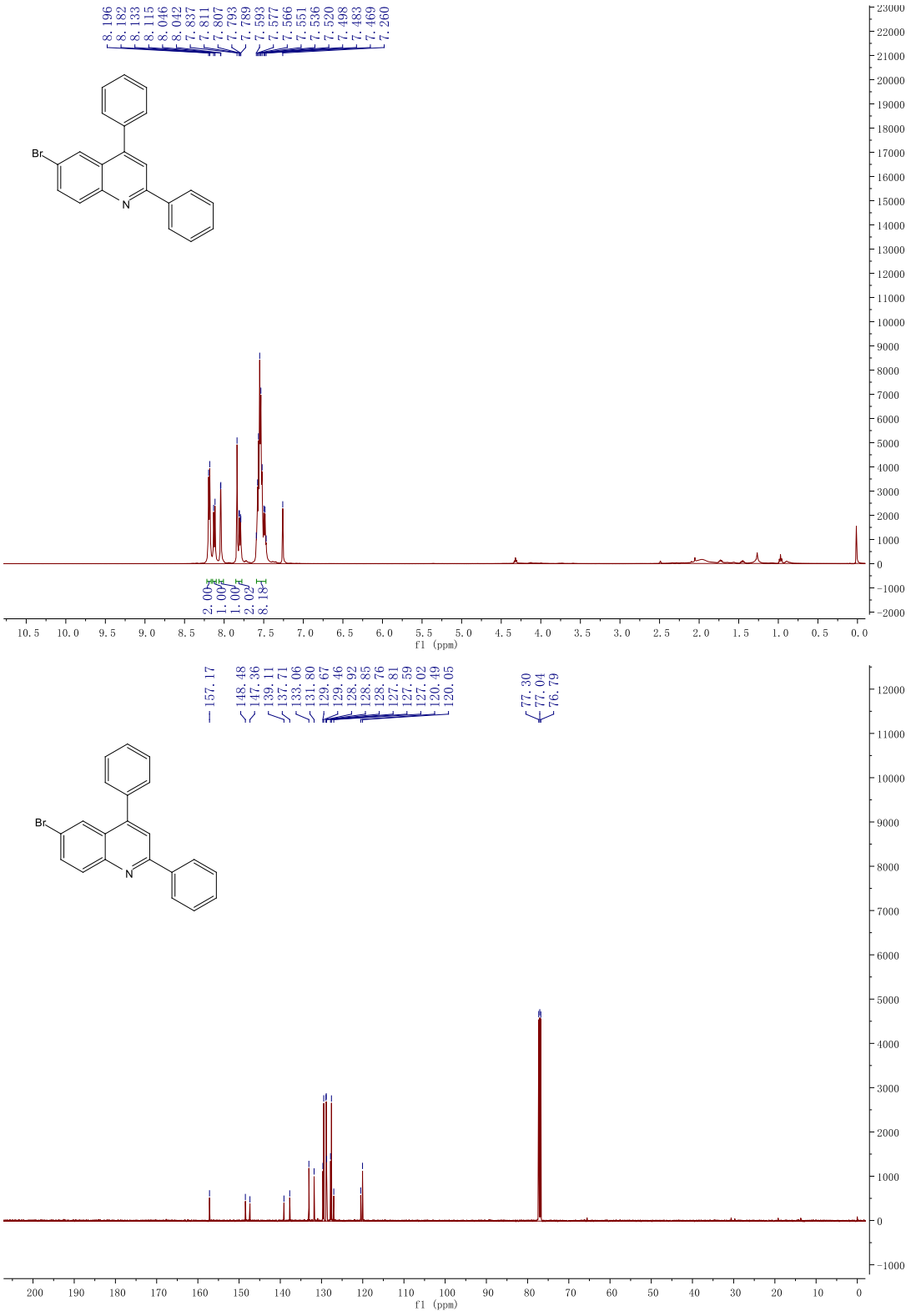
^{1}H NMR of **5c** (500 MHz, $CDCl_3$) and ^{13}C NMR of **5c** (125 MHz, $CDCl_3$).



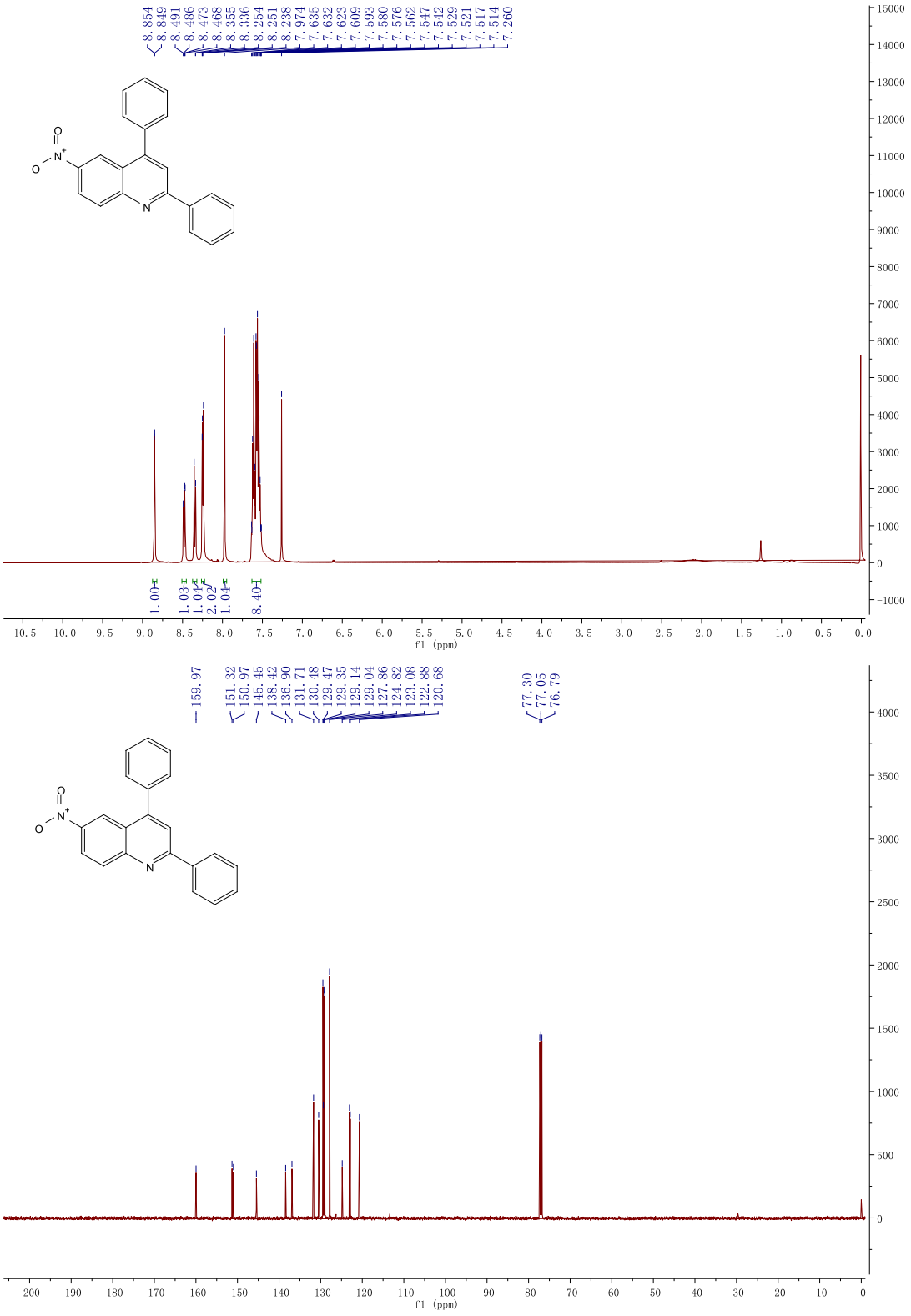
^{1}H NMR of **5d** (500 MHz, $CDCl_3$) and ^{13}C NMR of **5d** (125 MHz, $CDCl_3$).



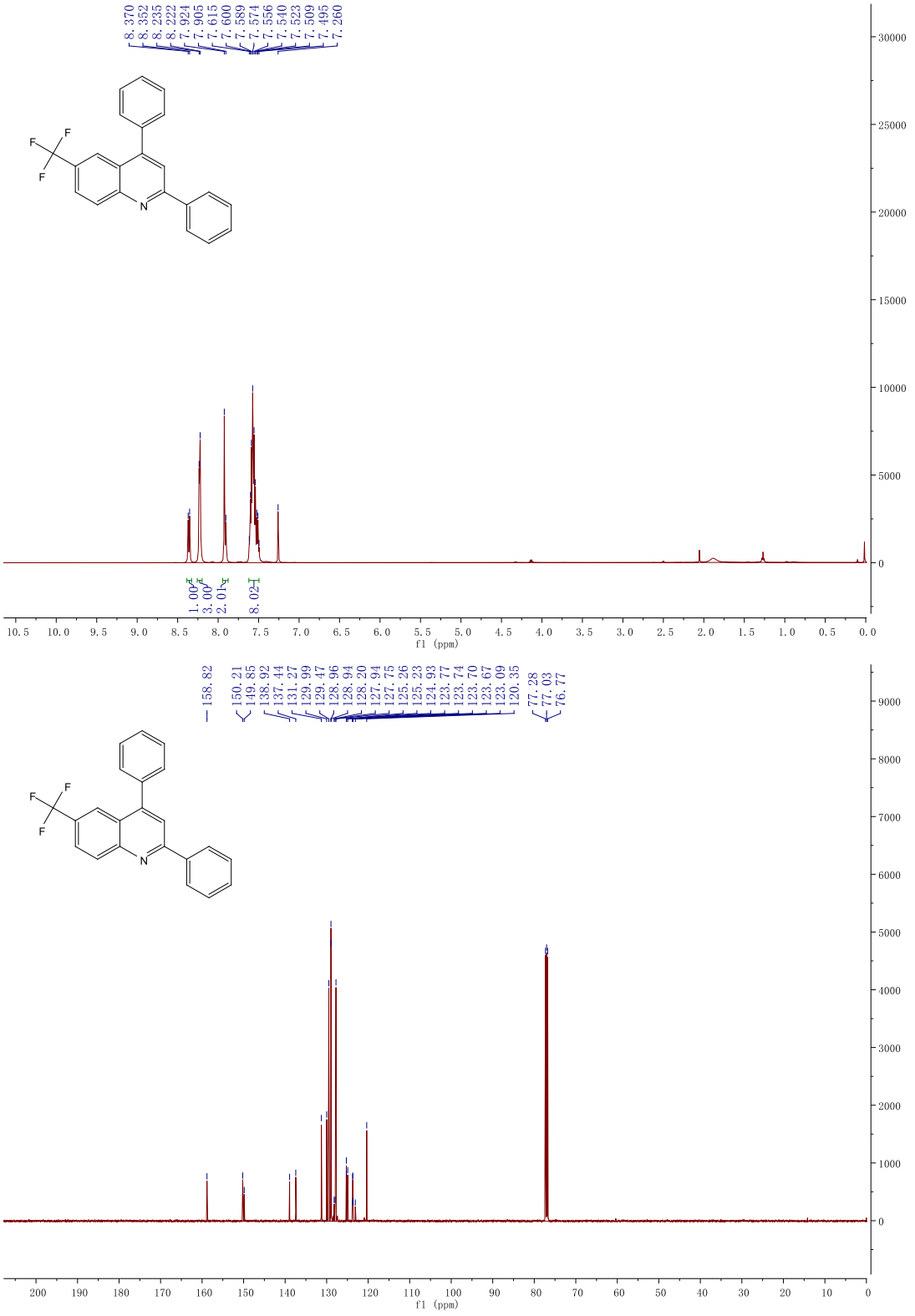
^{1}H NMR of **5e** (500 MHz, $CDCl_3$) and ^{13}C NMR of **5e** (125 MHz, $CDCl_3$).



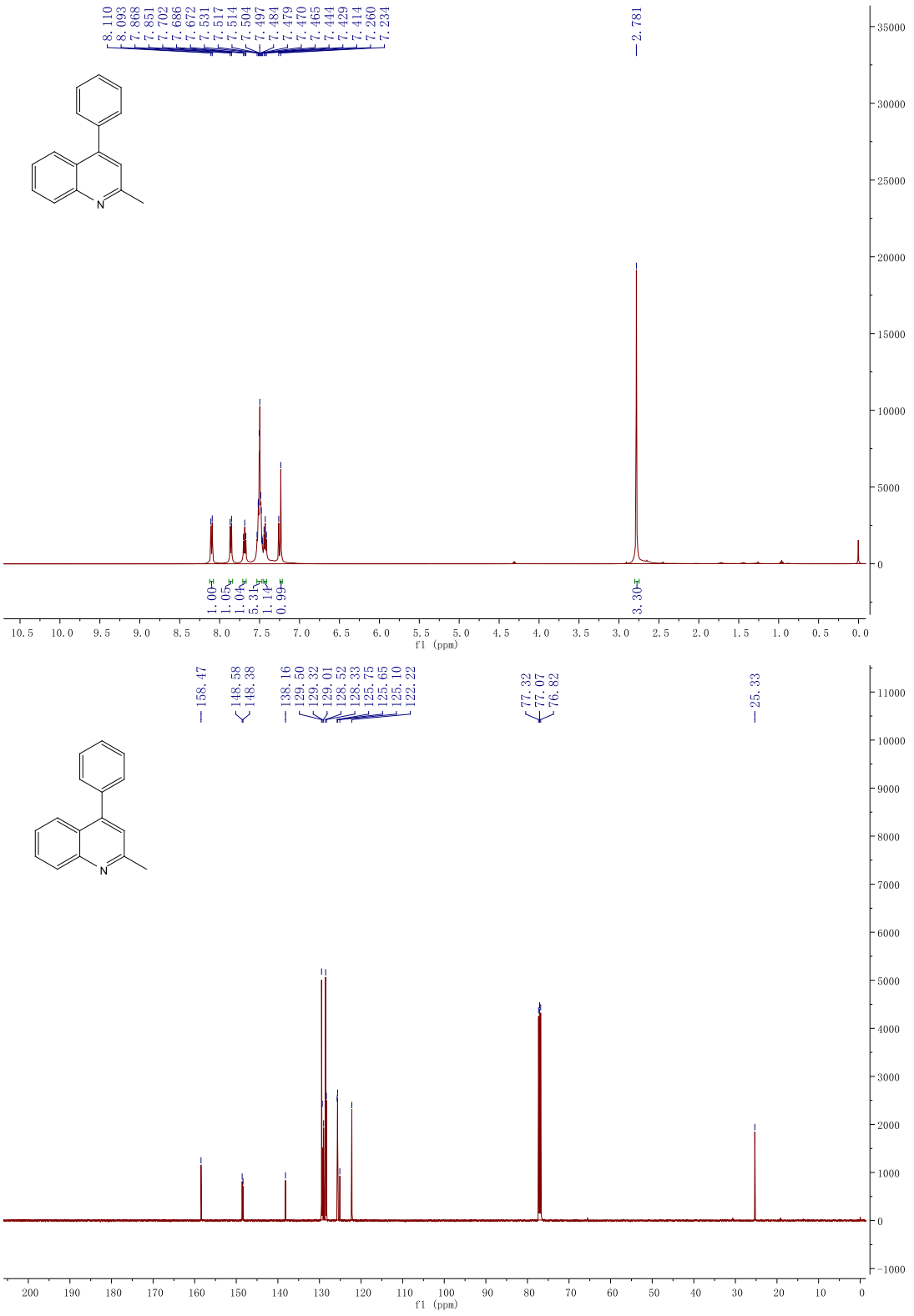
^{1}H NMR of **5f** (500 MHz, $CDCl_3$) and ^{13}C NMR of **5f** (125 MHz, $CDCl_3$).



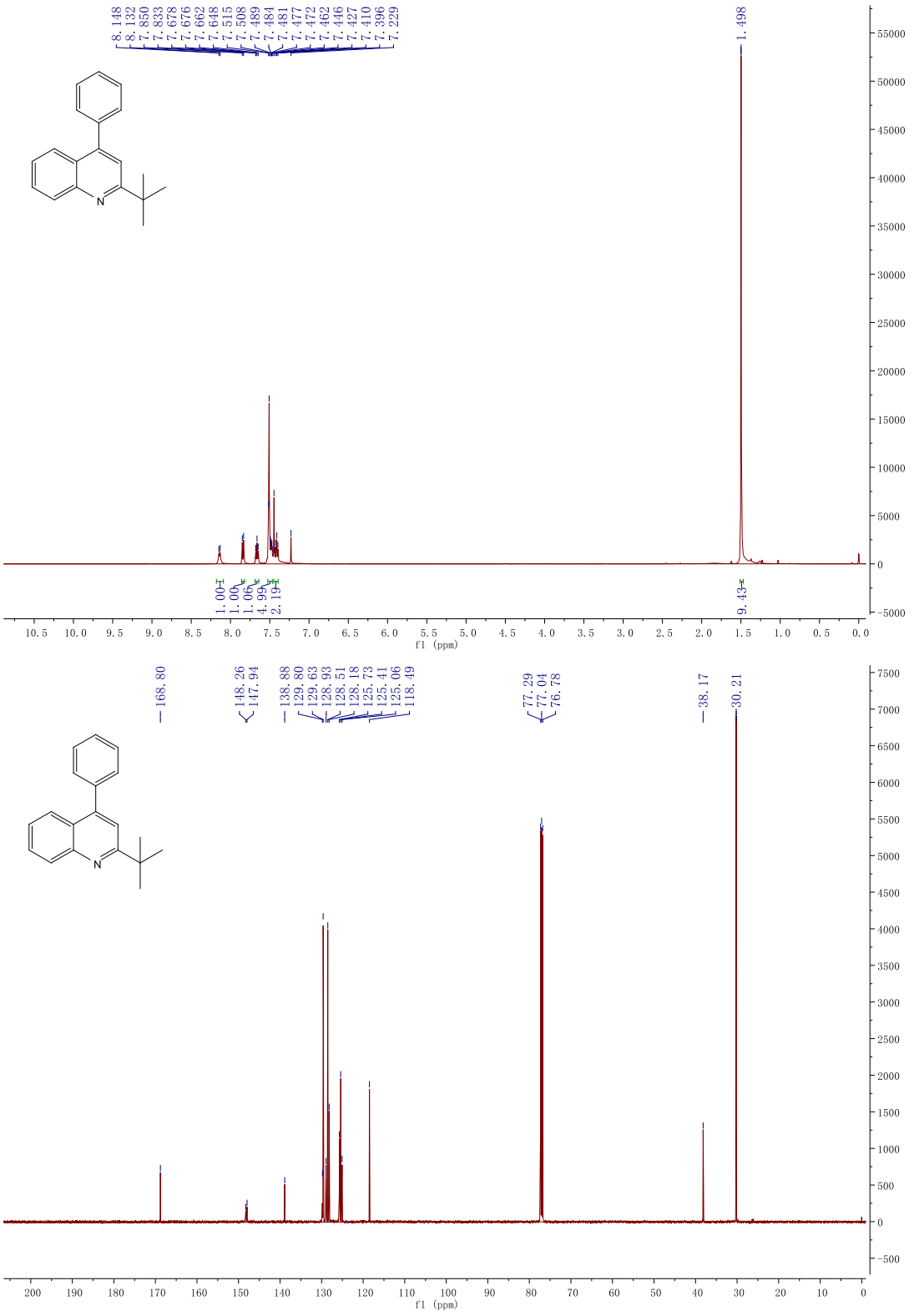
^{1}H NMR of **5g** (500 MHz, $CDCl_3$) and ^{13}C NMR of **5g** (125 MHz, $CDCl_3$).



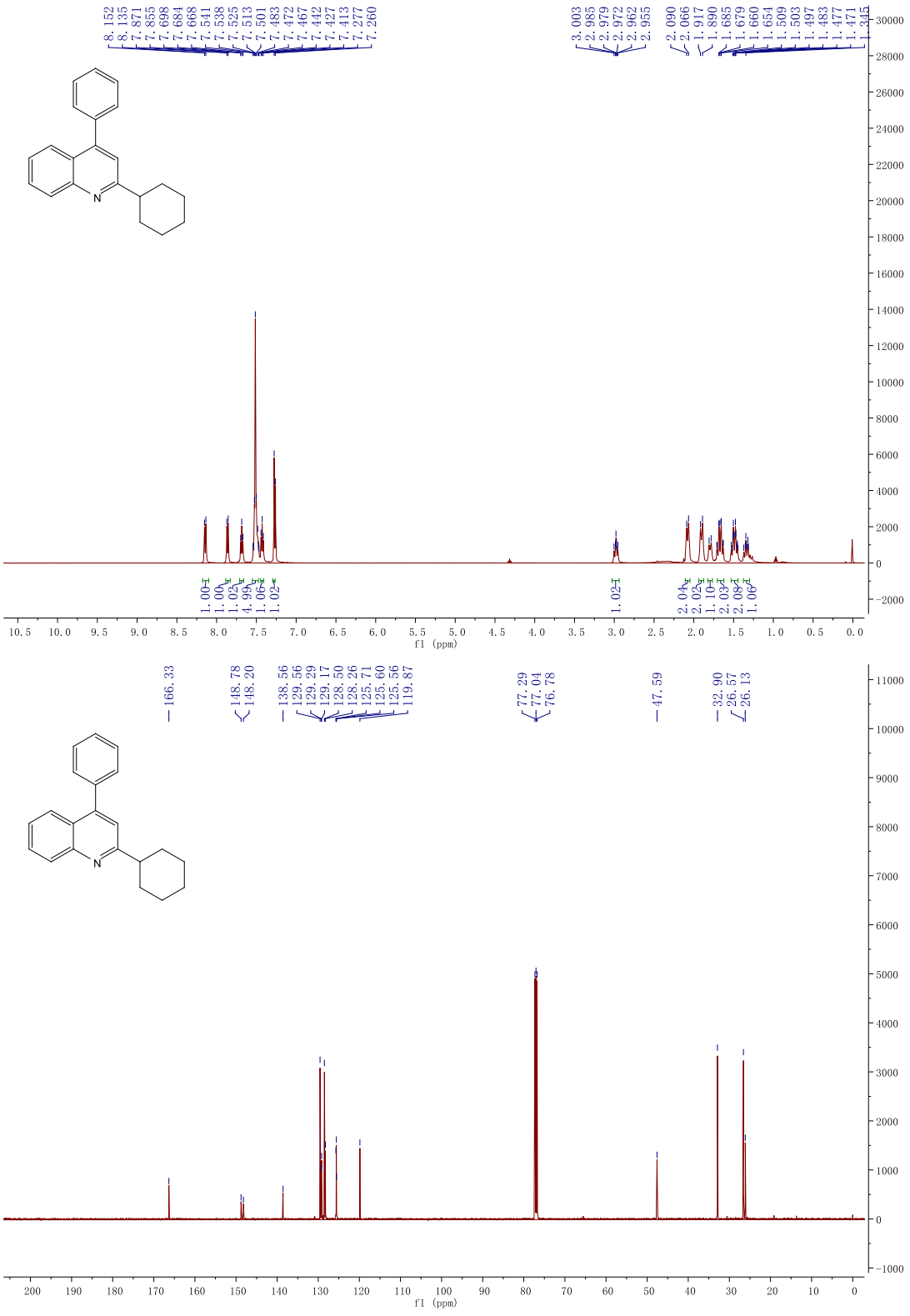
^{1}H NMR of **5h** (500 MHz, $CDCl_3$) and ^{13}C NMR of **5h** (125 MHz, $CDCl_3$).



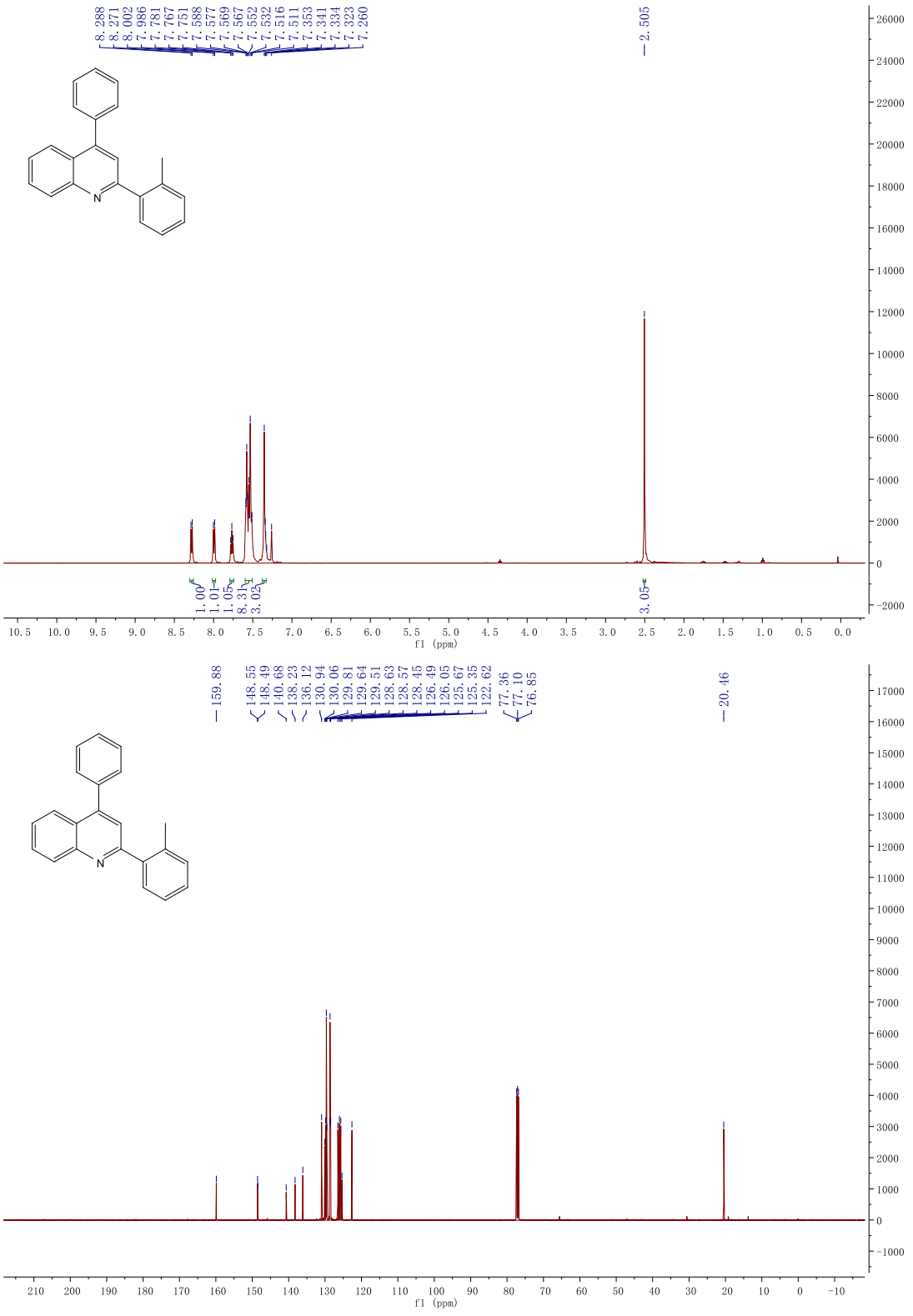
^{1}H NMR of **6a** (500 MHz, $CDCl_3$) and ^{13}C NMR of **6a** (125 MHz, $CDCl_3$).



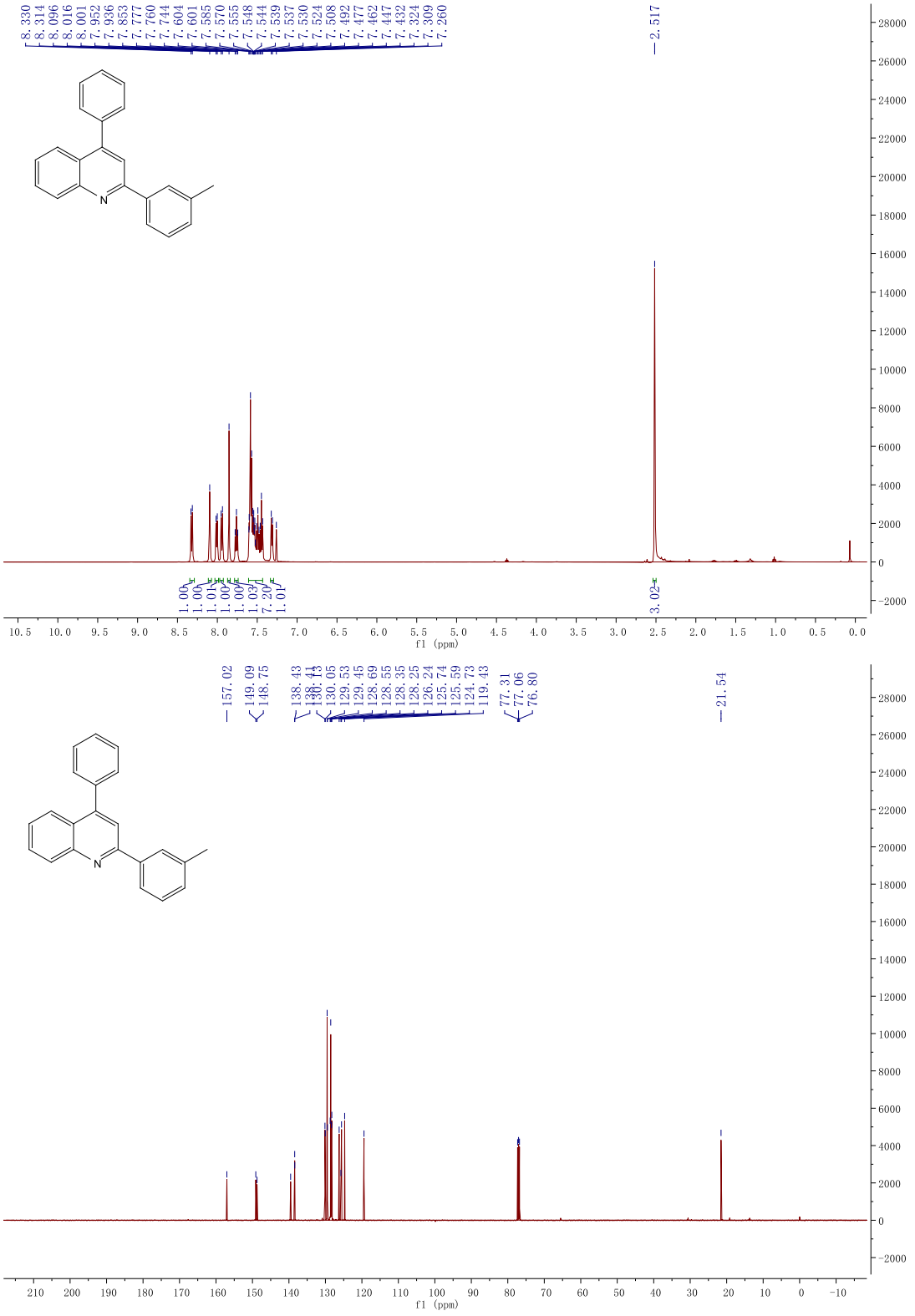
^{1}H NMR of **6b** (500 MHz, $CDCl_3$) and ^{13}C NMR of **6b** (125 MHz, $CDCl_3$).



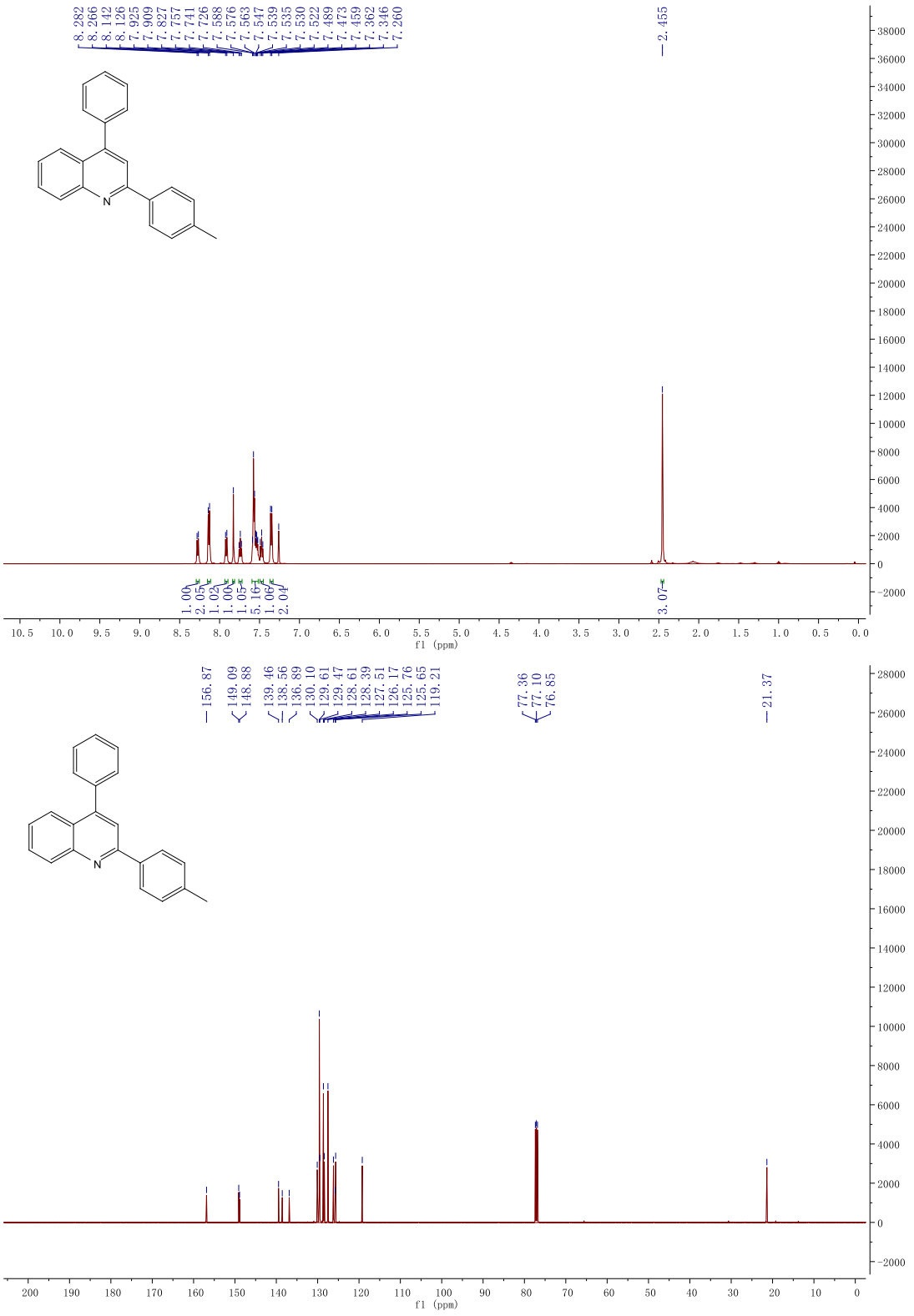
^{1}H NMR of **6c** (500 MHz, $CDCl_3$) and ^{13}C NMR of **6c** (125 MHz, $CDCl_3$).



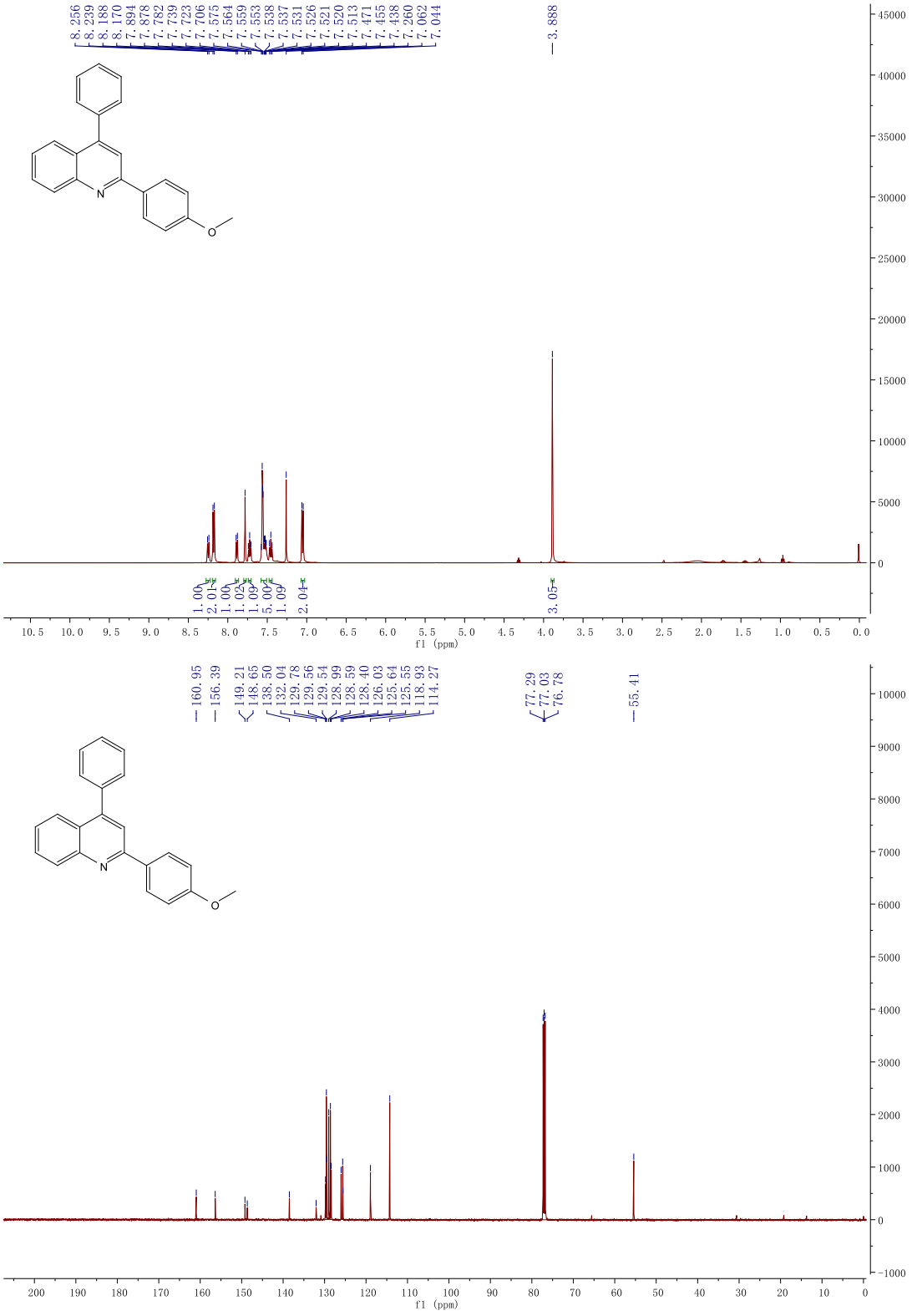
^{1}H NMR of **6d** (500 MHz, $CDCl_3$) and ^{13}C NMR of **6d** (125 MHz, $CDCl_3$).



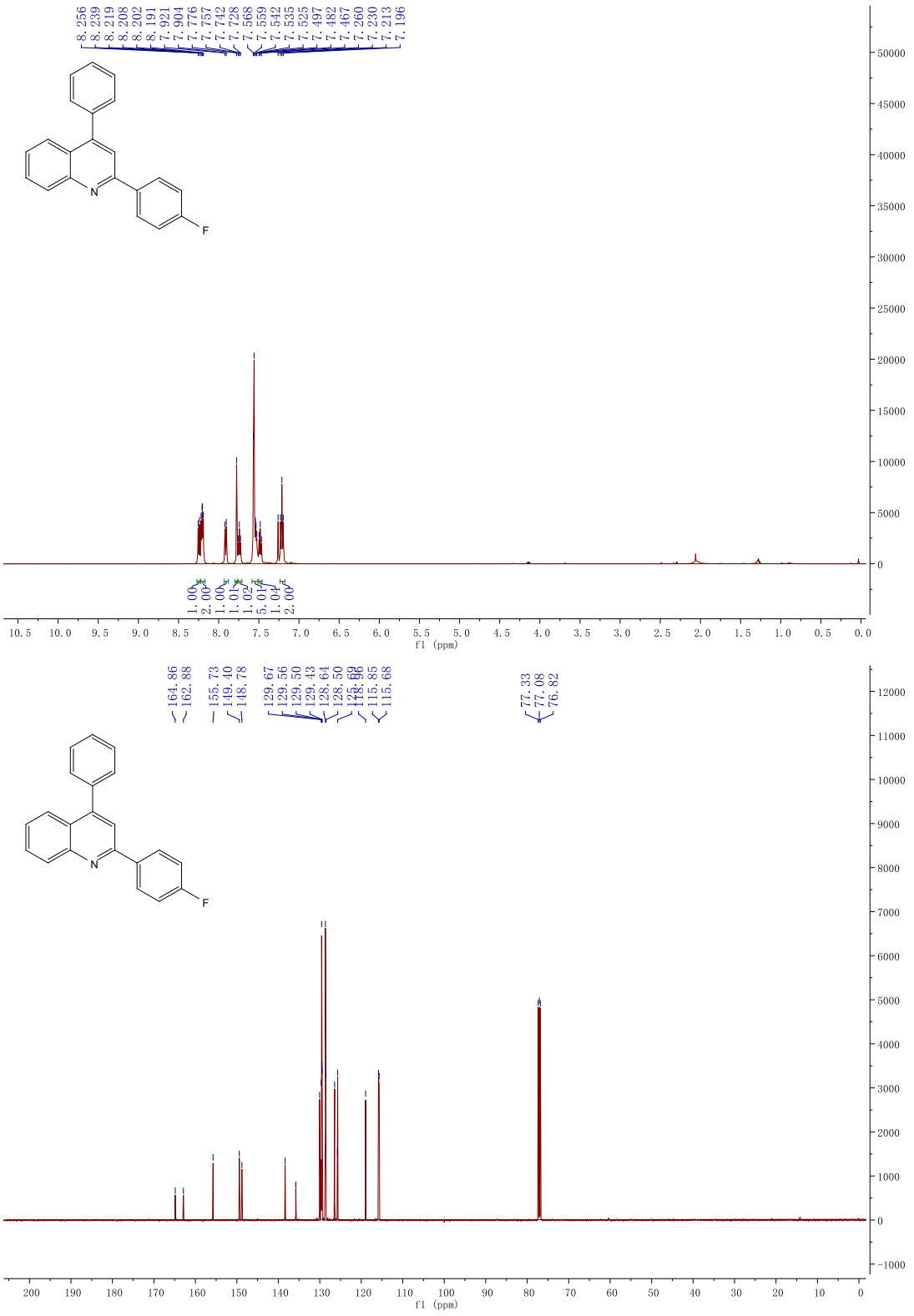
^{1}H NMR of **6e** (500 MHz, $CDCl_3$) and ^{13}C NMR of **6e** (125 MHz, $CDCl_3$).



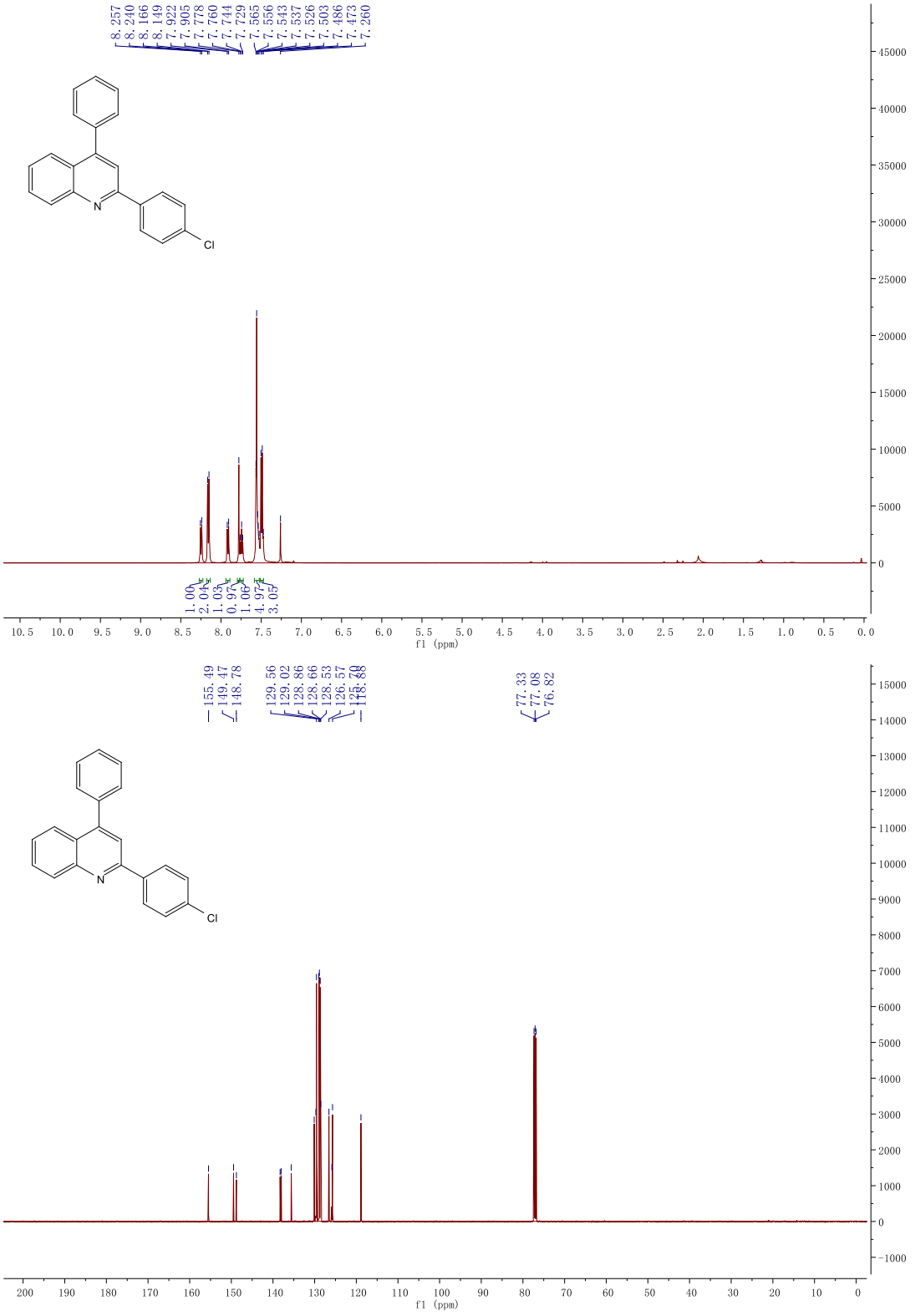
^{1}H NMR of **6f** (500 MHz, $CDCl_3$) and ^{13}C NMR of **6f** (125 MHz, $CDCl_3$).



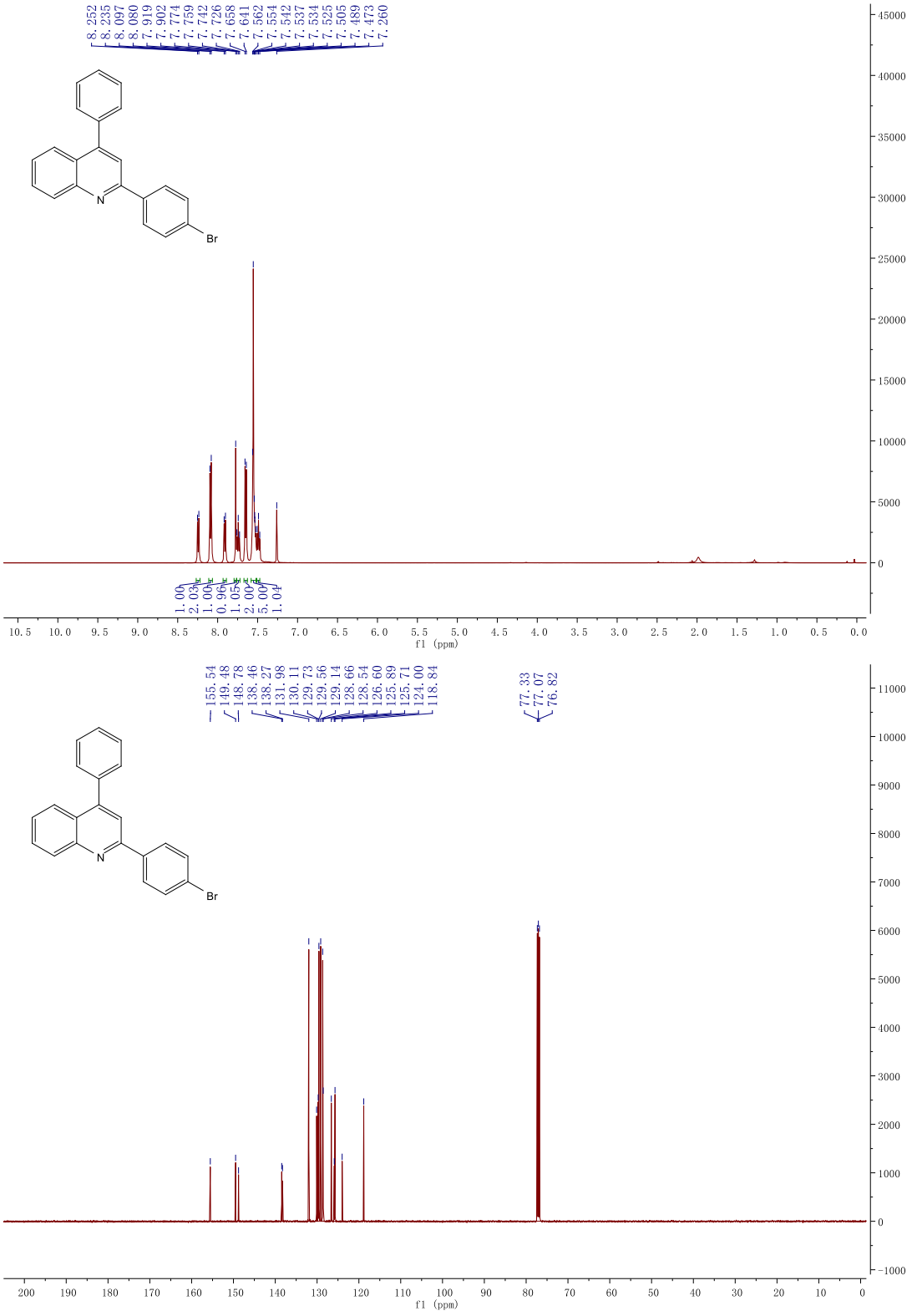
^{1}H NMR of **6g** (500 MHz, $CDCl_3$) and ^{13}C NMR of **6g** (125 MHz, $CDCl_3$).



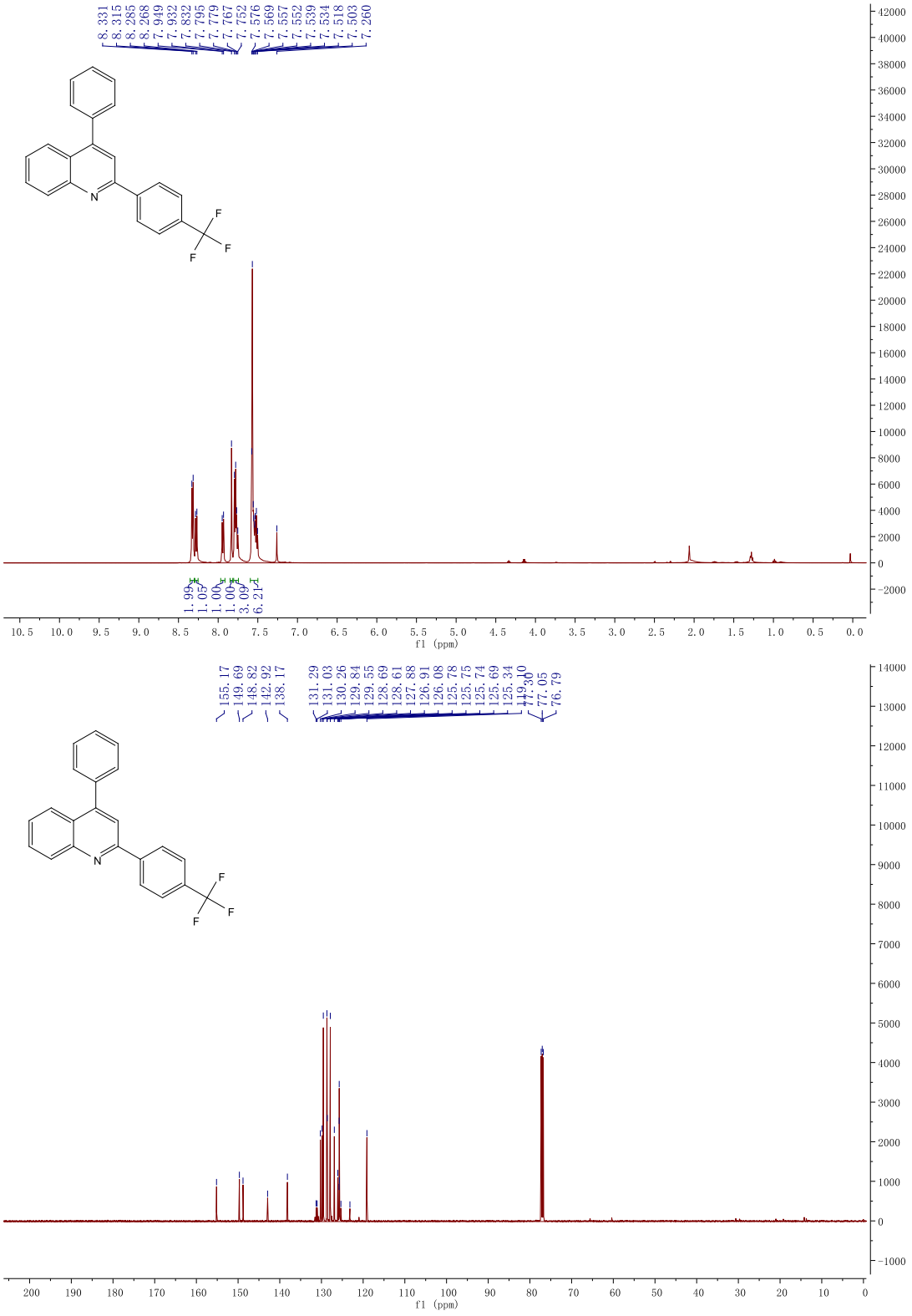
^{1}H NMR of **6h** (500 MHz, $CDCl_3$) and ^{13}C NMR of **6h** (125 MHz, $CDCl_3$).



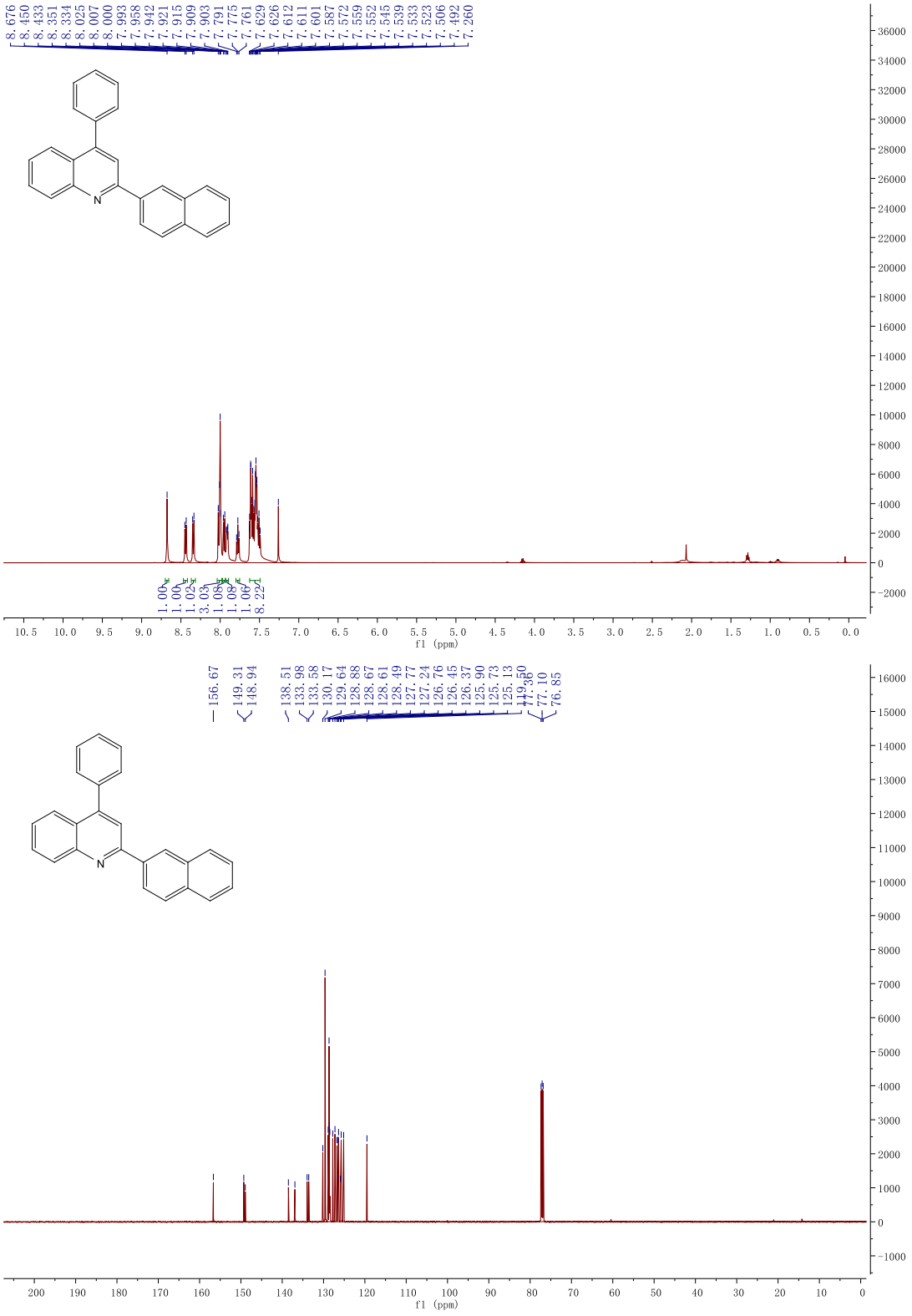
^{1}H NMR of **6i** (500 MHz, $CDCl_3$) and ^{13}C NMR of **6i** (125 MHz, $CDCl_3$).



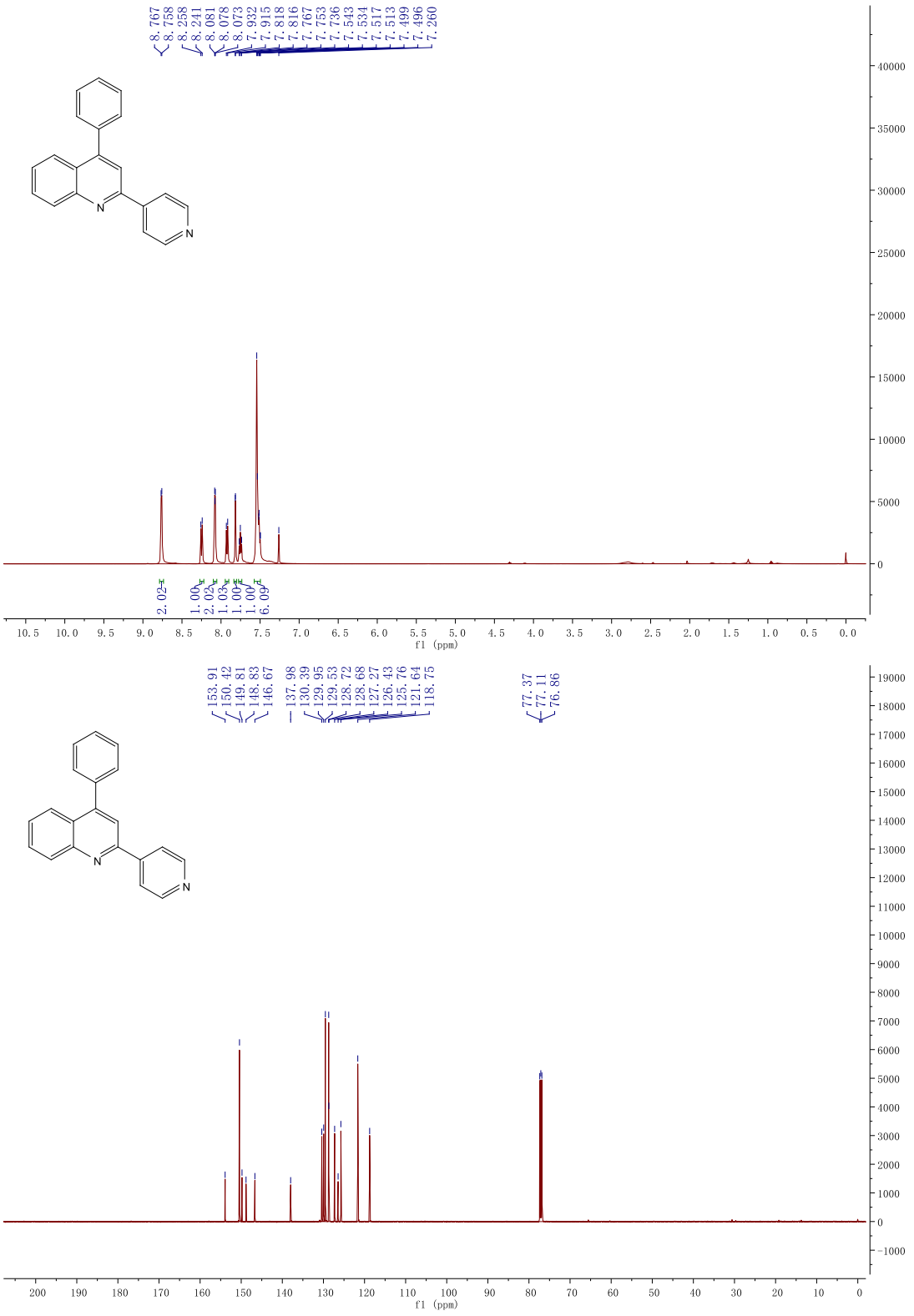
^{1}H NMR of **6j** (500 MHz, $CDCl_3$) and ^{13}C NMR of **6j** (125 MHz, $CDCl_3$).



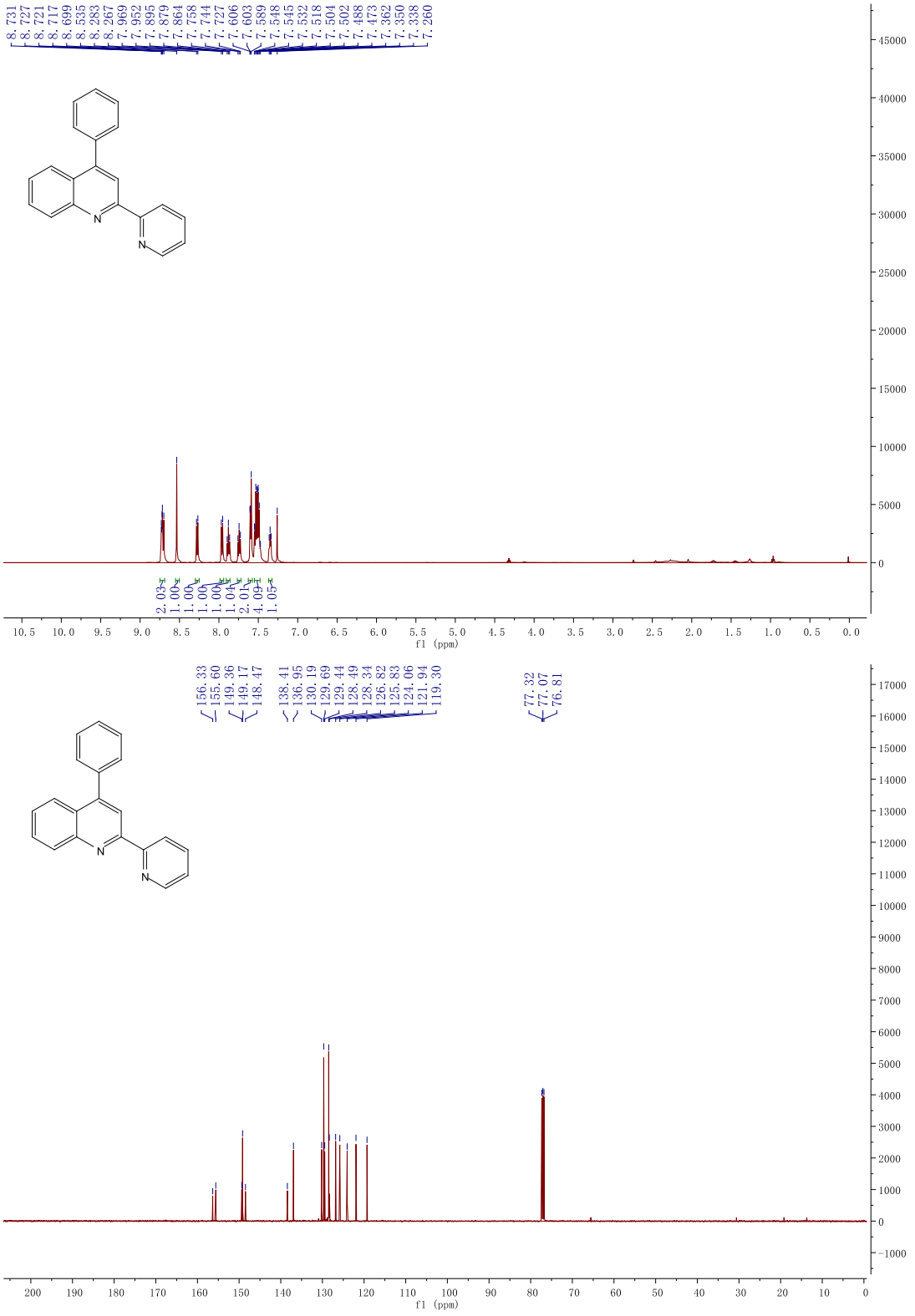
^{1}H NMR of **6k** (500 MHz, $CDCl_3$) and ^{13}C NMR of **6k** (125 MHz, $CDCl_3$).



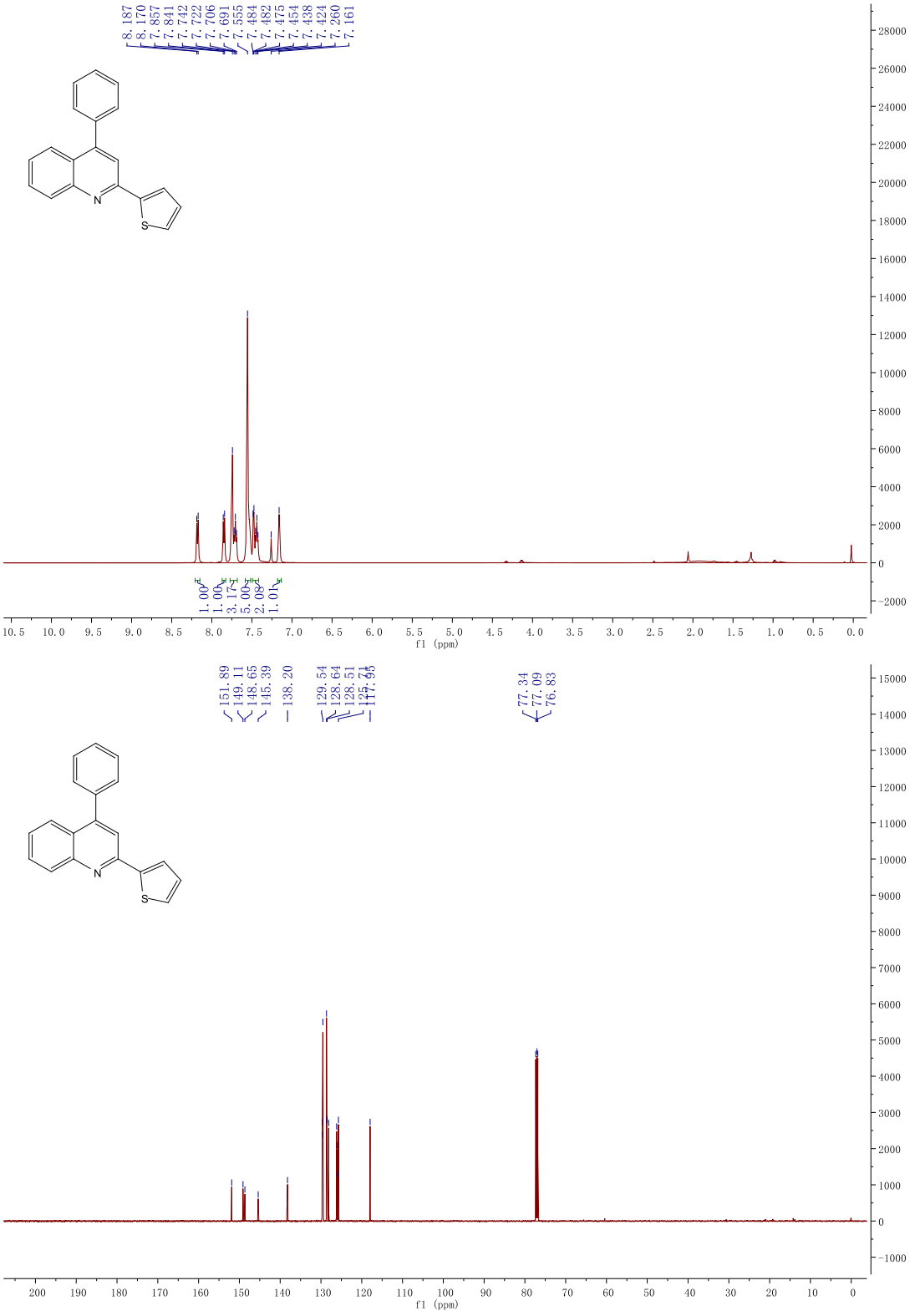
^{1}H NMR of **6l** (500 MHz, $CDCl_3$) and ^{13}C NMR of **6l** (125 MHz, $CDCl_3$).



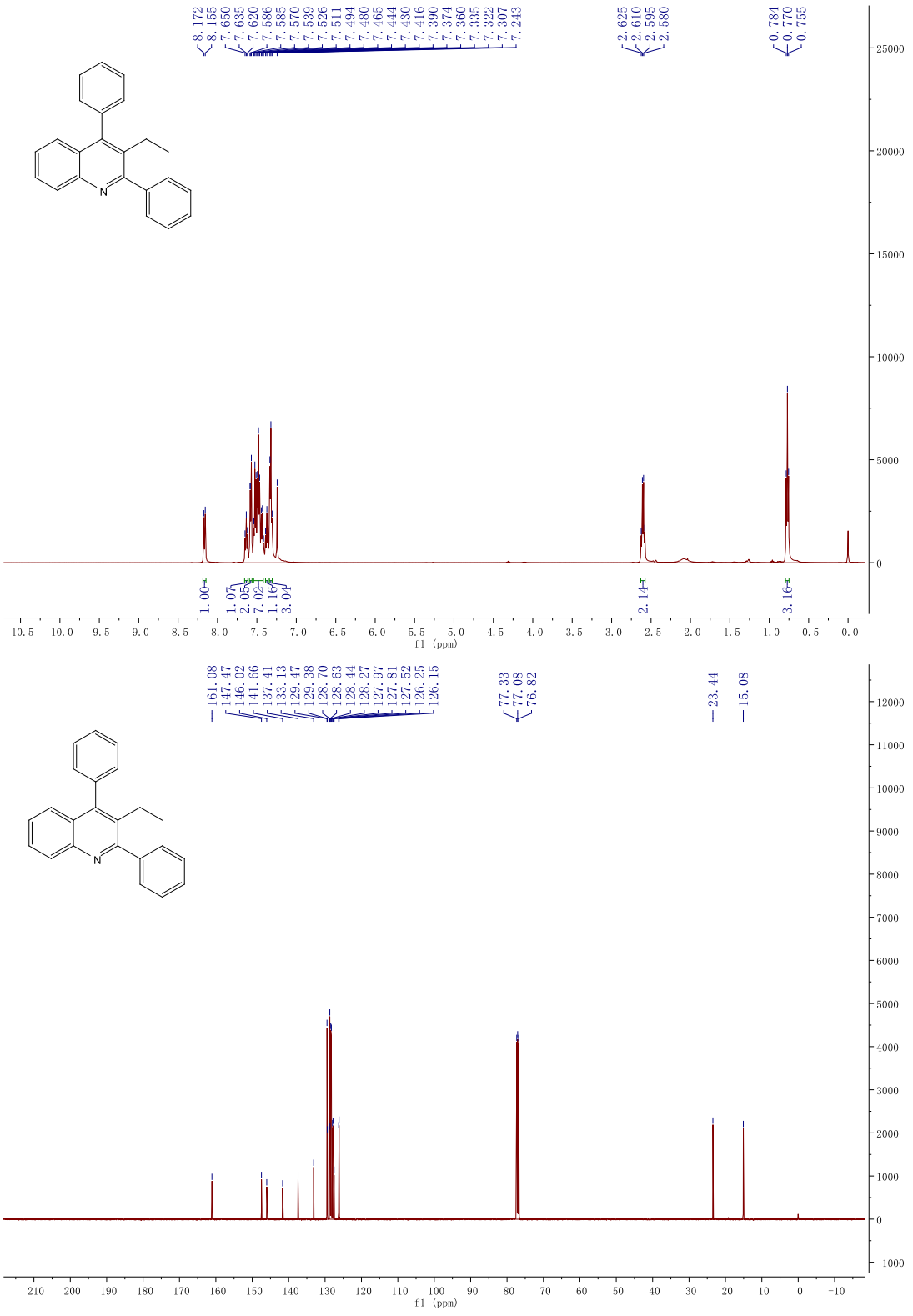
^{1}H NMR of **6m** (500 MHz, $CDCl_3$) and ^{13}C NMR of **6m** (125 MHz, $CDCl_3$).



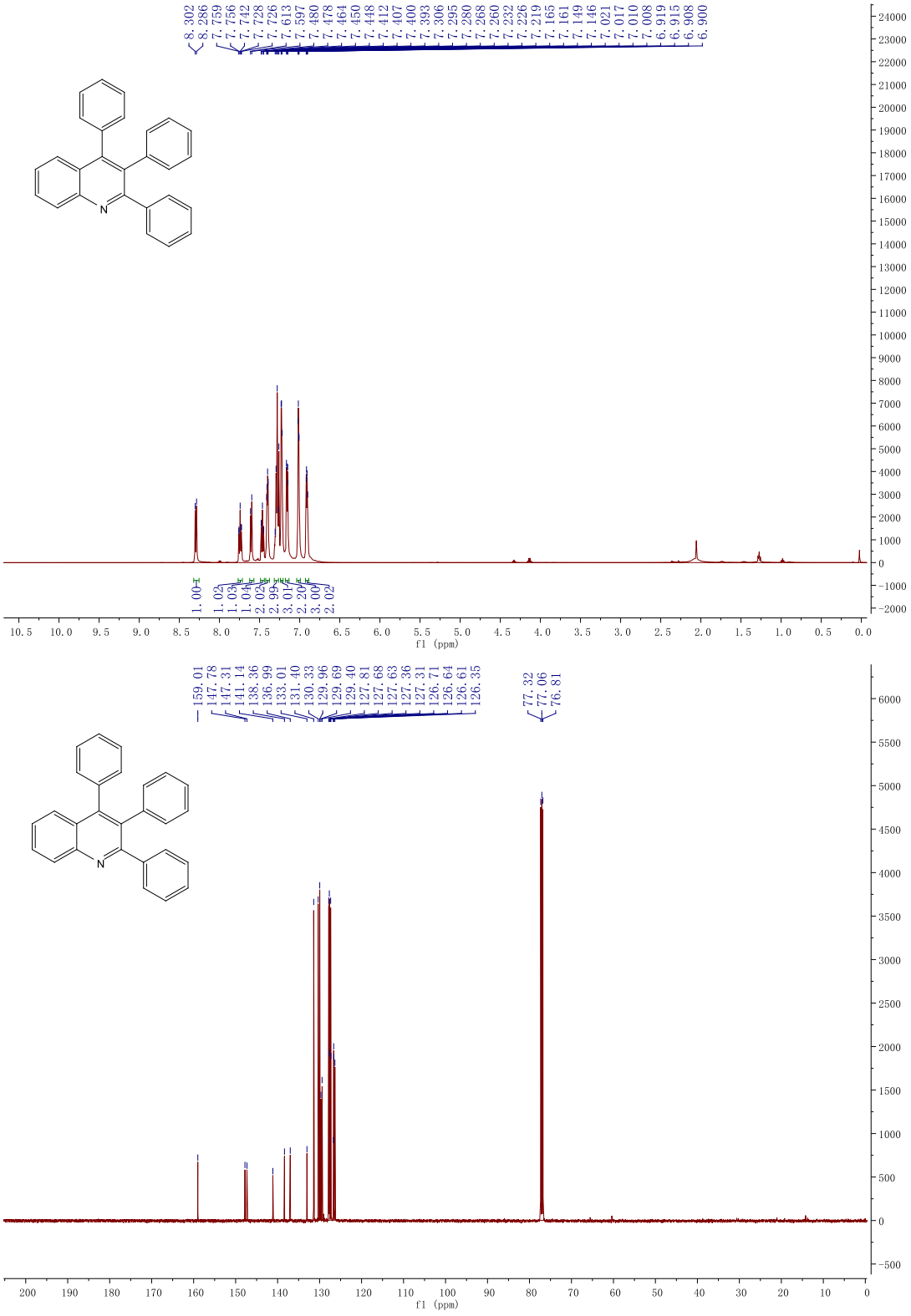
^{1}H NMR of **6n** (500 MHz, $CDCl_3$) and ^{13}C NMR of **6n** (125 MHz, $CDCl_3$).



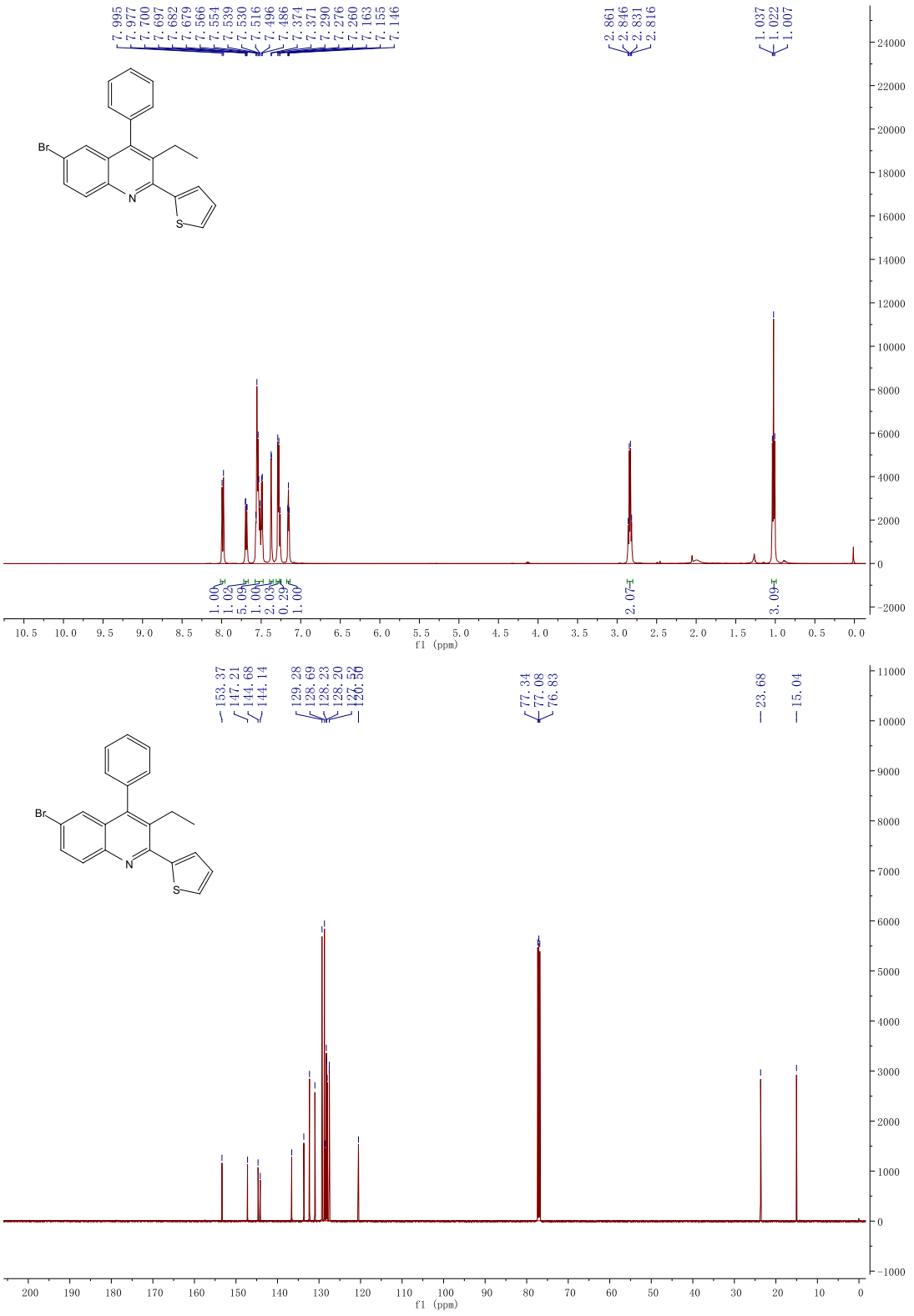
^{1}H NMR of **6o** (500 MHz, $CDCl_3$) and ^{13}C NMR of **6o** (125 MHz, $CDCl_3$).



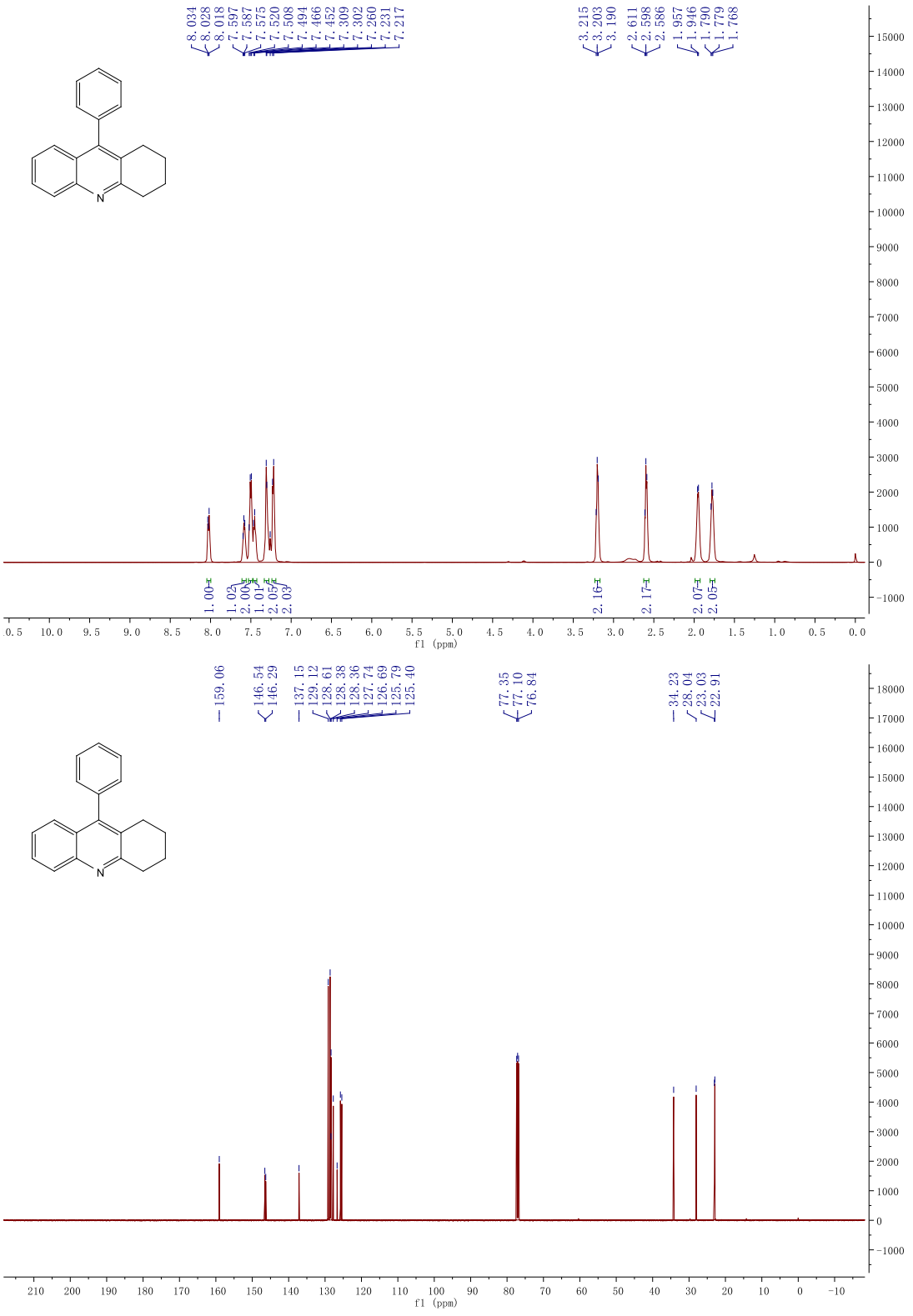
^{1}H NMR of **6p** (500 MHz, $CDCl_3$) and ^{13}C NMR of **6p** (125 MHz, $CDCl_3$).



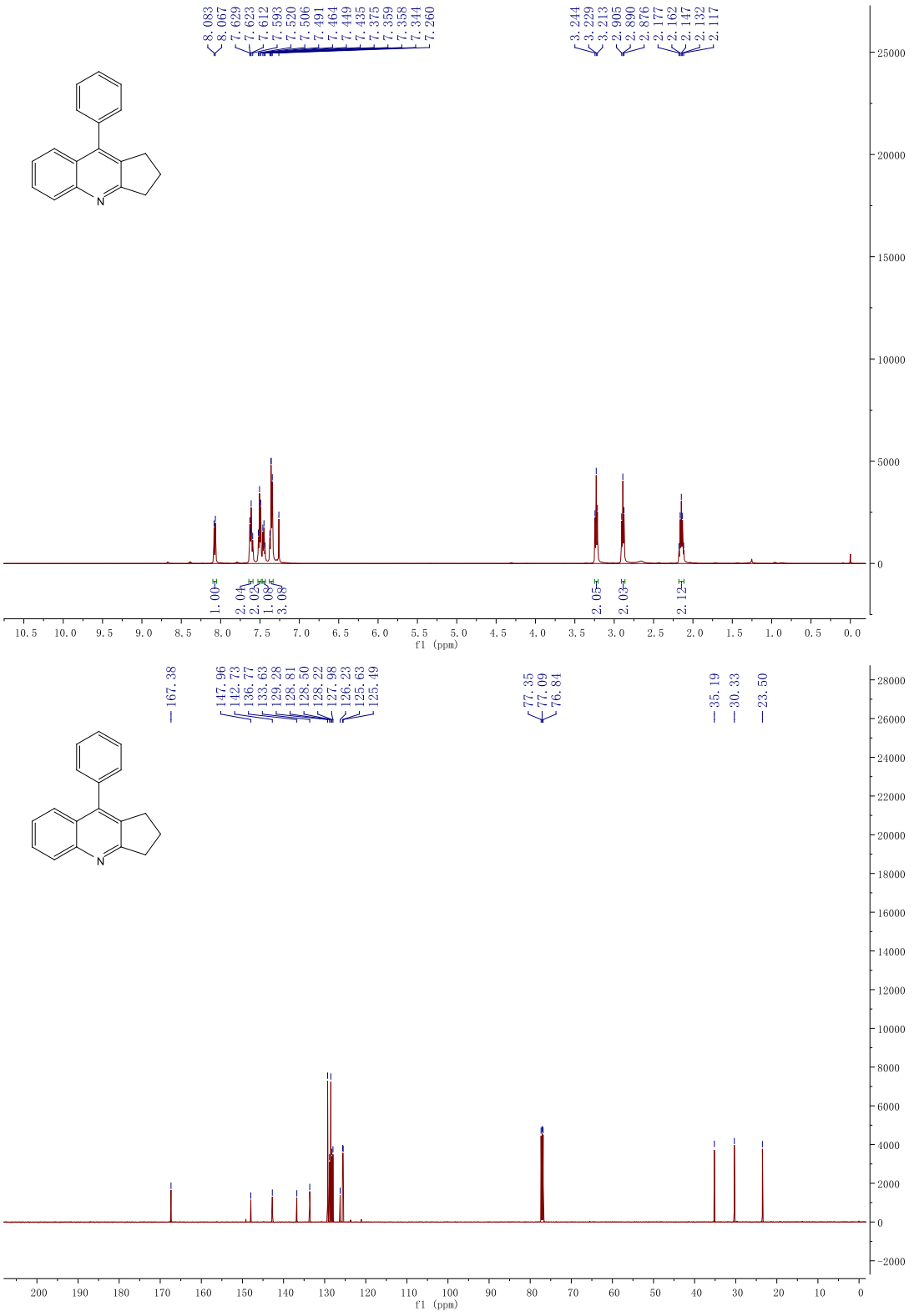
^{1}H NMR of **6q** (500 MHz, $CDCl_3$) and ^{13}C NMR of **6q** (125 MHz, $CDCl_3$).



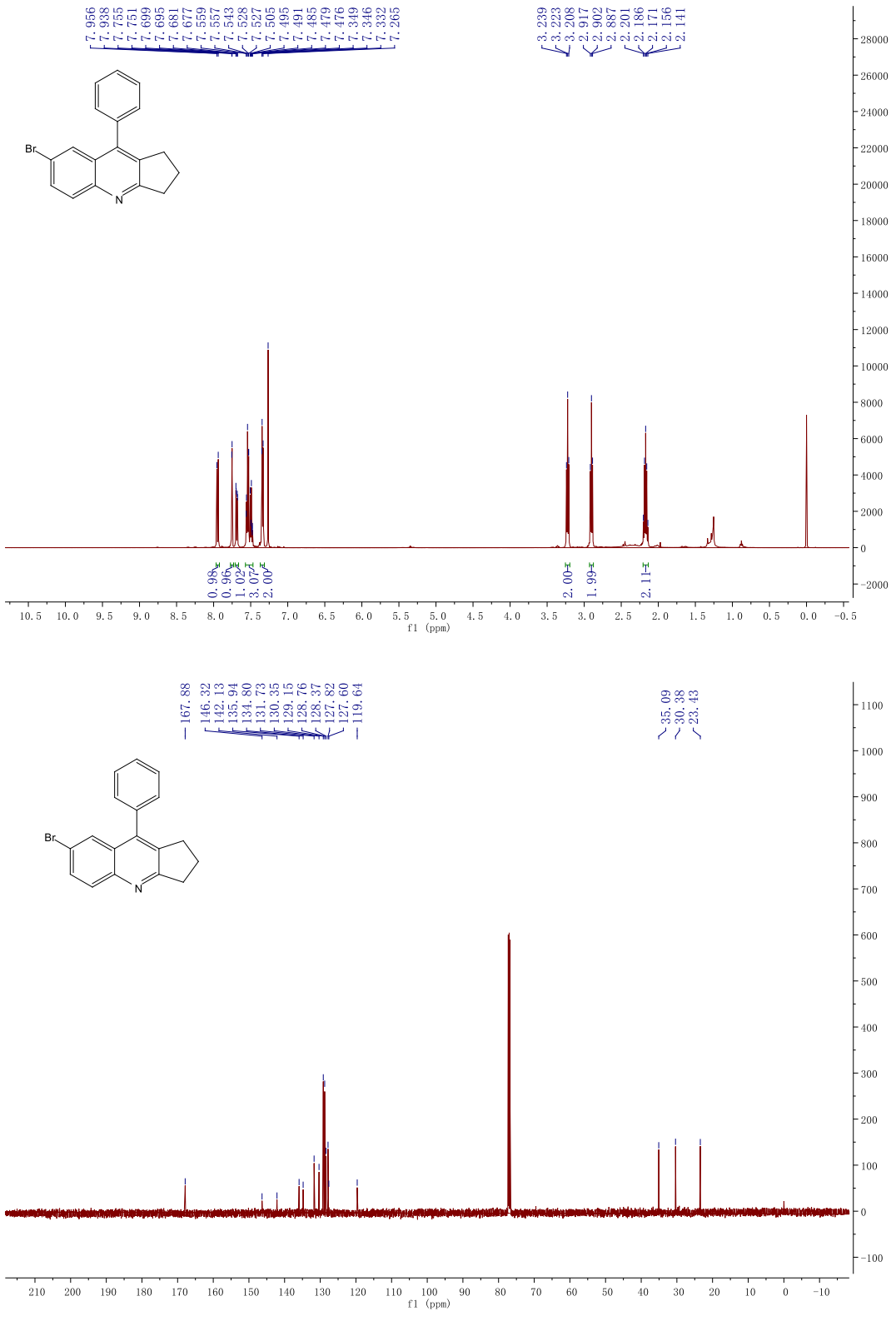
^{1}H NMR of **6r** (500 MHz, $CDCl_3$) and ^{13}C NMR of **6r** (125 MHz, $CDCl_3$).



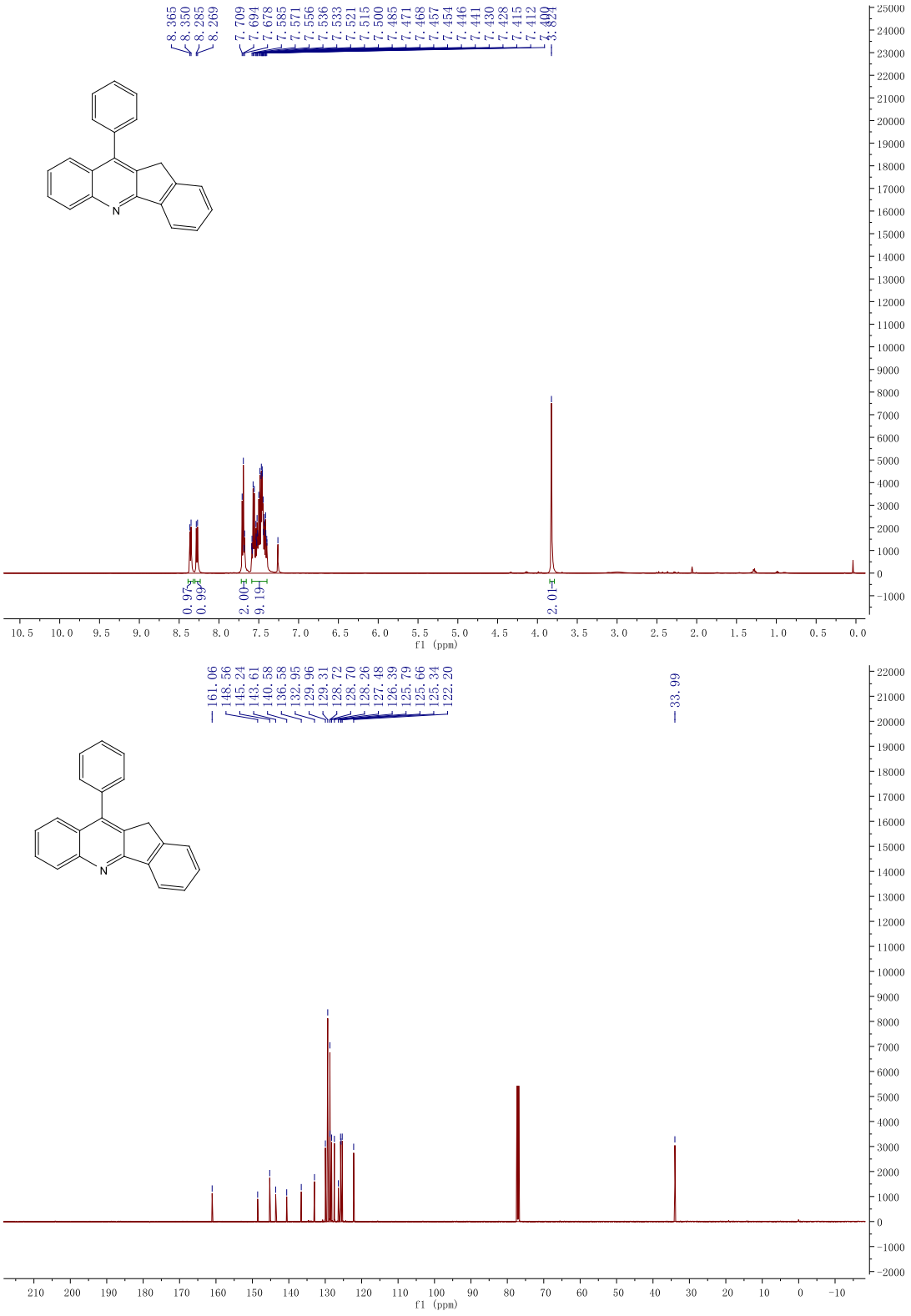
^{1}H NMR of **6s** (500 MHz, $CDCl_3$) and ^{13}C NMR of **6s** (125 MHz, $CDCl_3$).



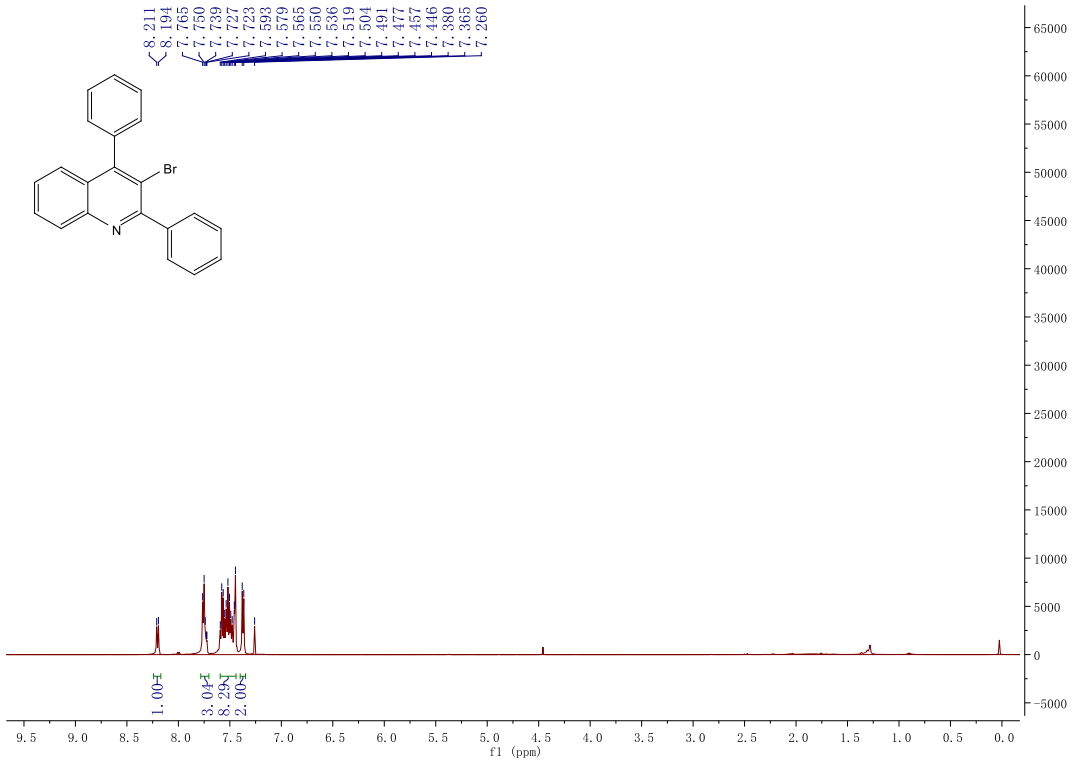
^{1}H NMR of **6t** (500 MHz, $CDCl_3$) and ^{13}C NMR of **6t** (125 MHz, $CDCl_3$).

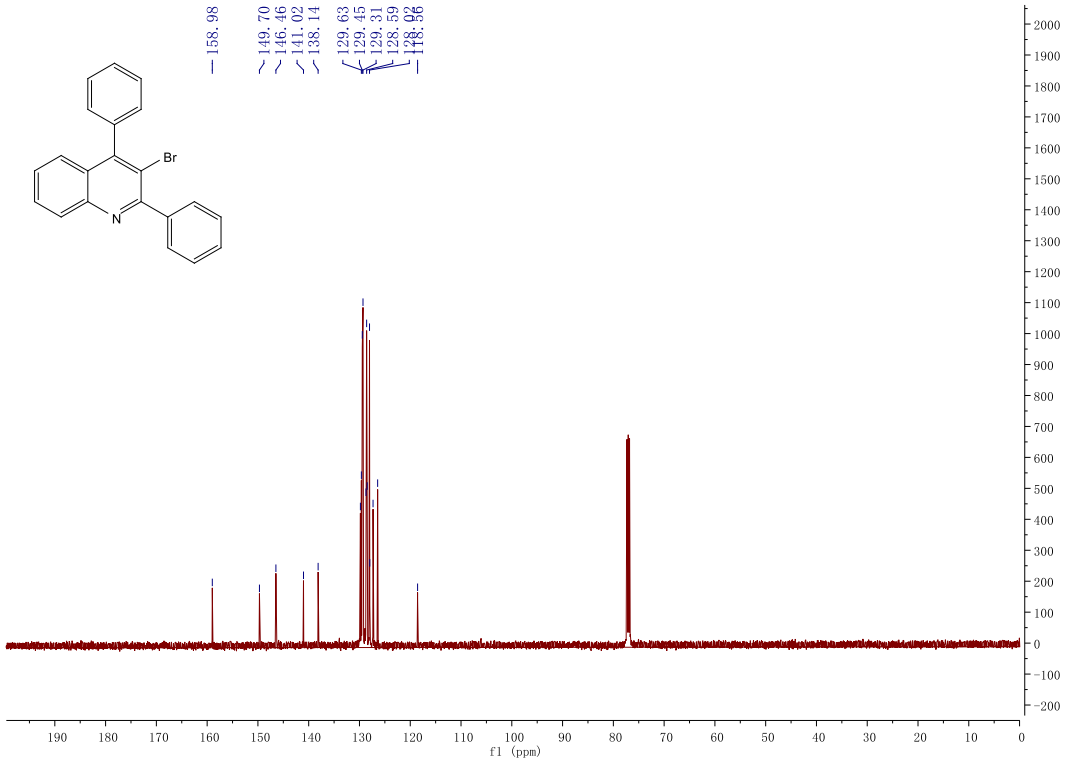


^{1}H NMR of **6u** (500 MHz, $CDCl_3$) and ^{13}C NMR of **6u** (125 MHz, $CDCl_3$).

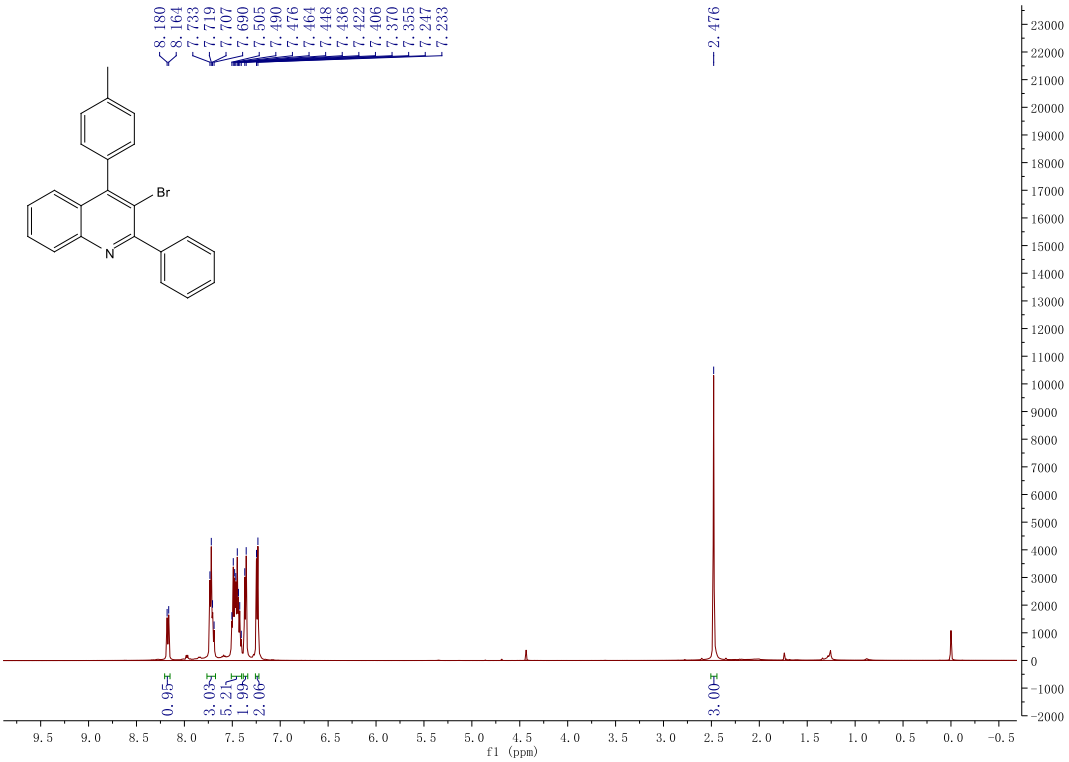


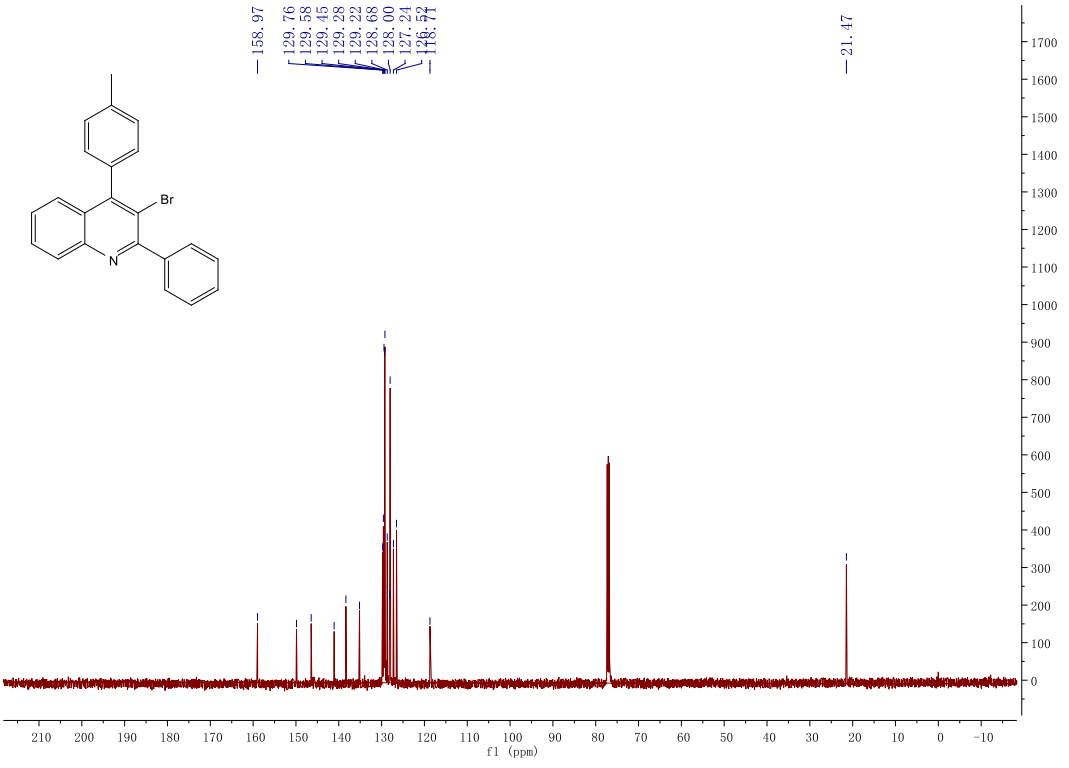
^{1}H NMR of **6v** (500 MHz, $CDCl_3$) and ^{13}C NMR of **6v** (125 MHz, $CDCl_3$).



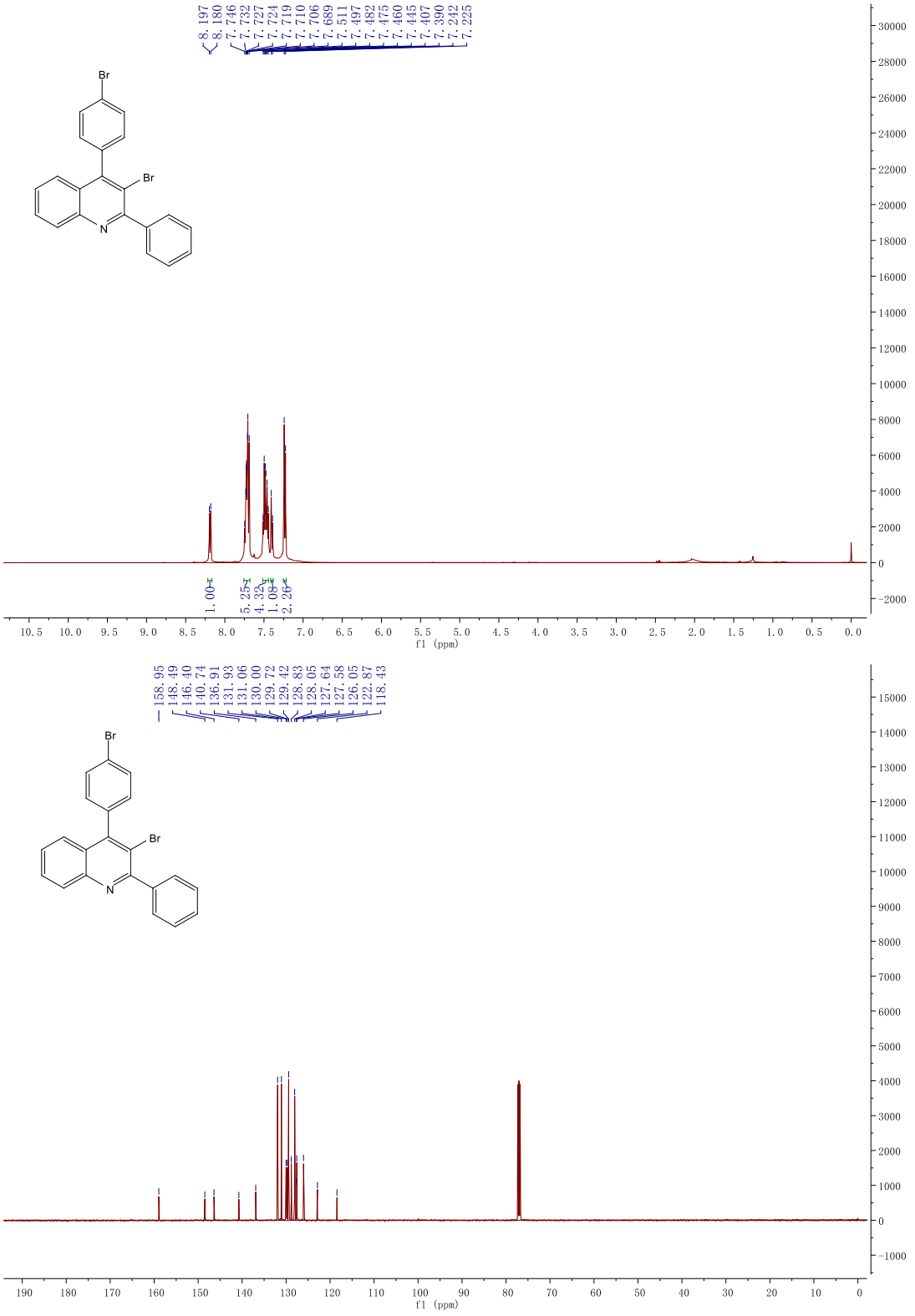


^{1}H NMR of **7a** (500 MHz, $CDCl_3$) and ^{13}C NMR of **7a** (125 MHz, $CDCl_3$).

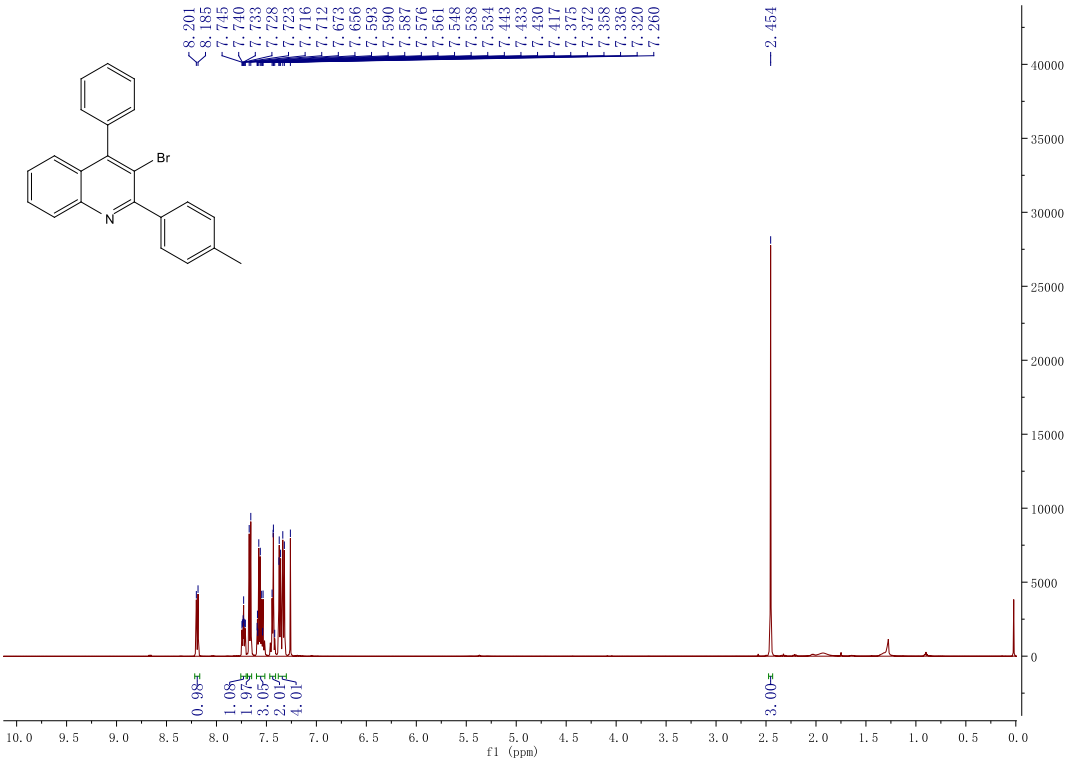


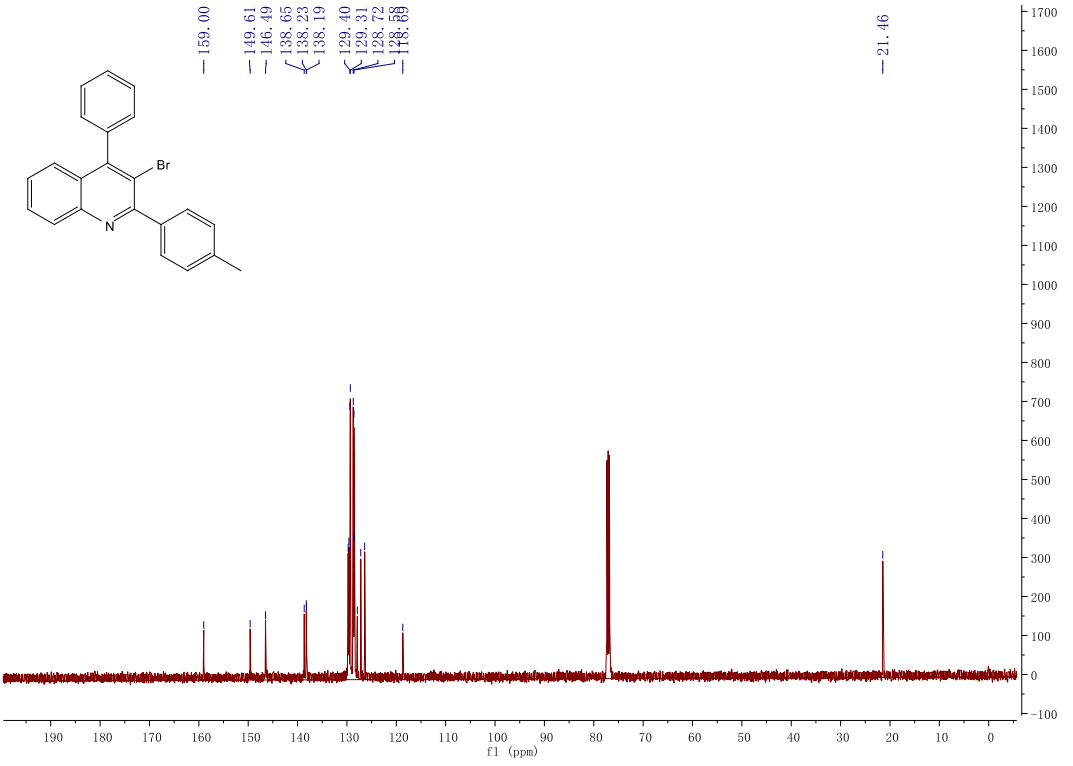


^{1}H NMR of **7b** (500 MHz, $CDCl_3$) and ^{13}C NMR of **7b** (125 MHz, $CDCl_3$).

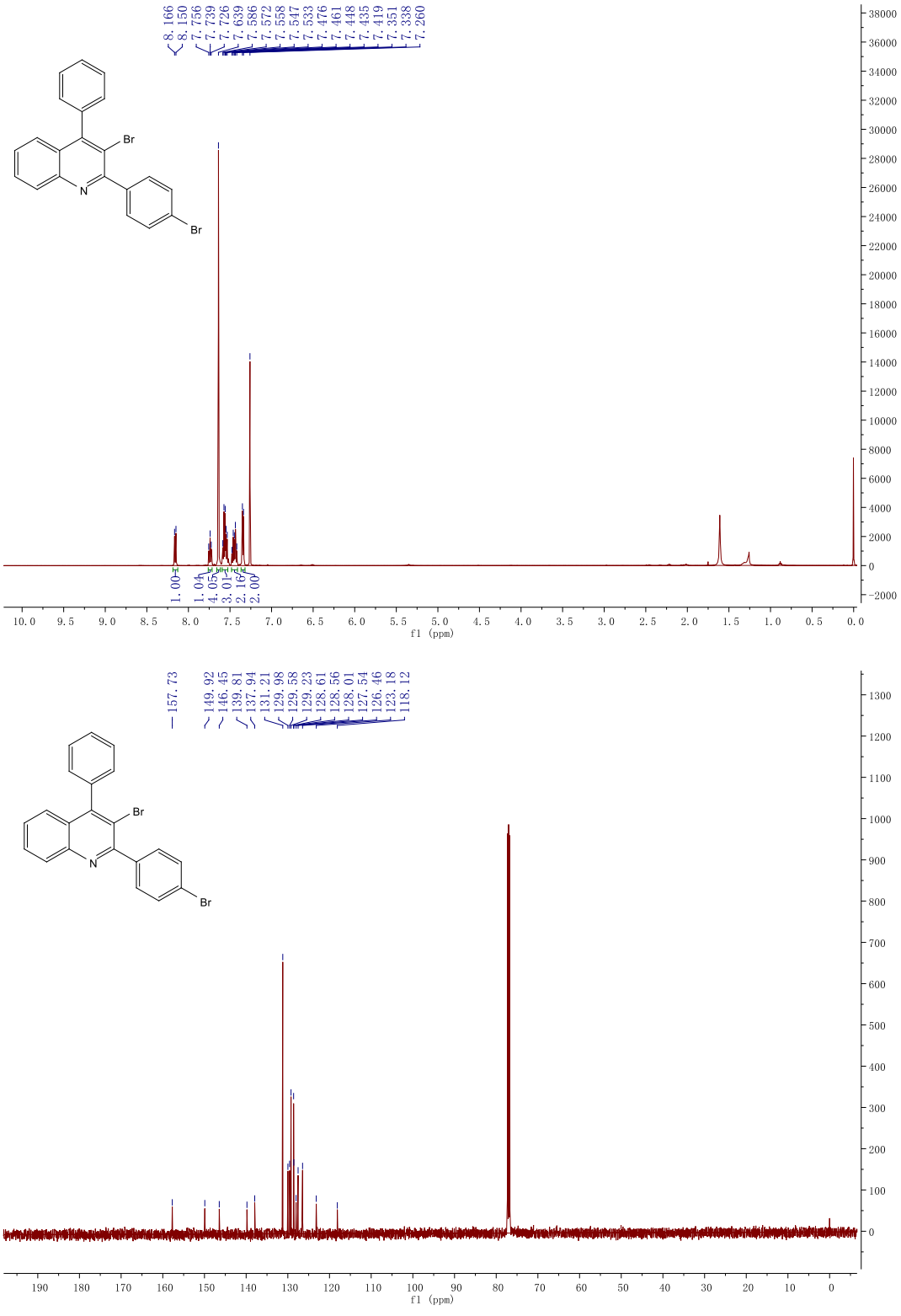


^{1}H NMR of **7c** (500 MHz, $CDCl_3$) and ^{13}C NMR of **7c** (125 MHz, $CDCl_3$).

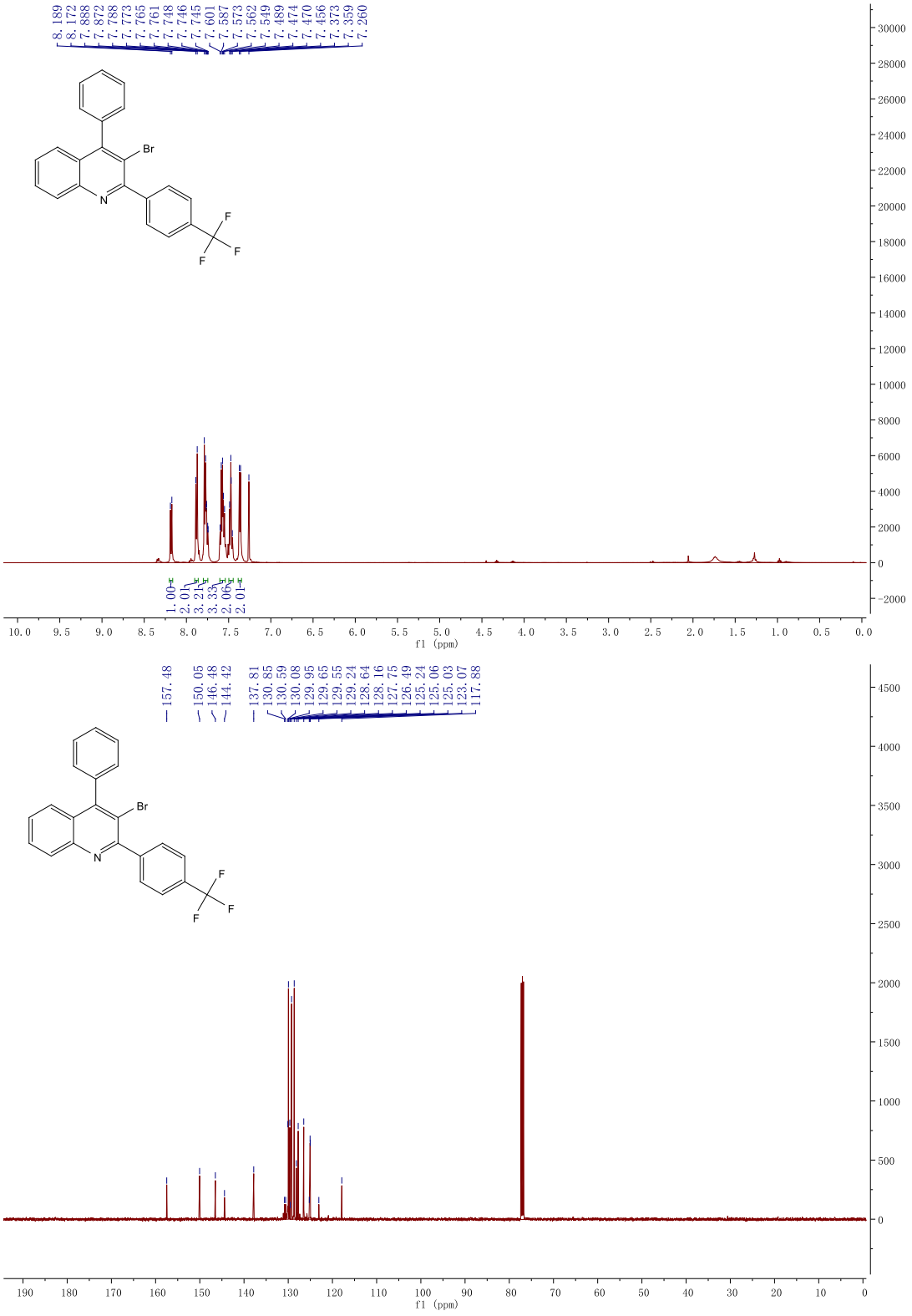




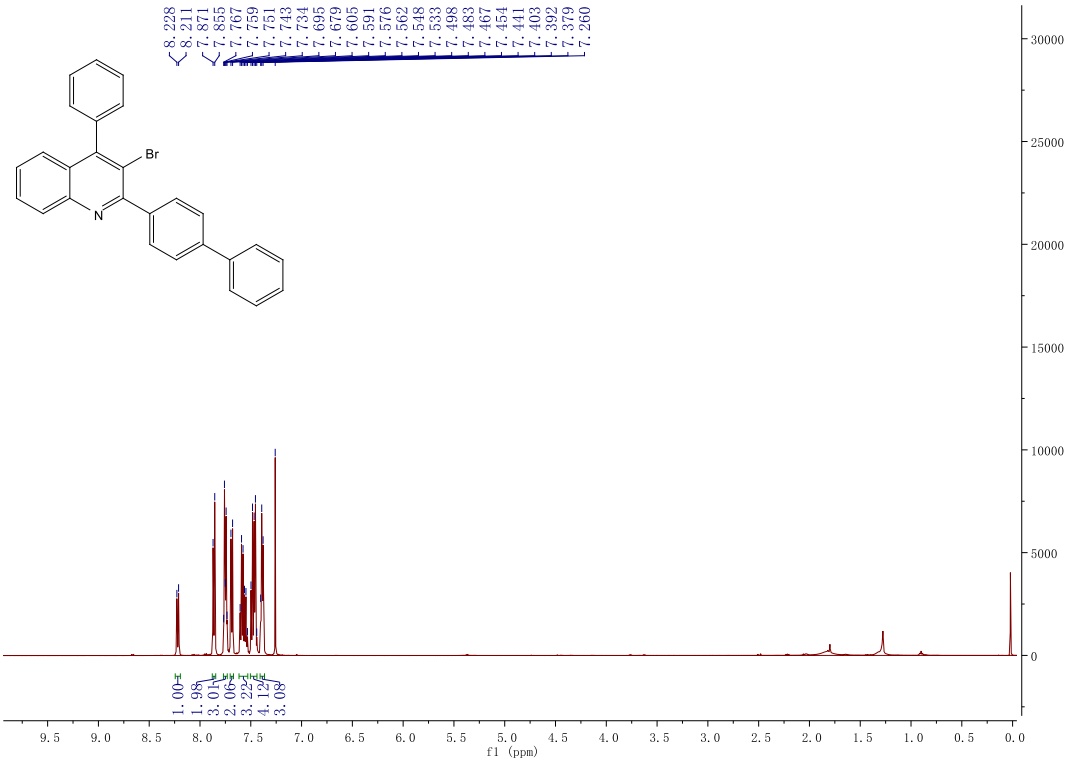
^{1}H NMR of **7d** (500 MHz, $CDCl_3$) and ^{13}C NMR of **7d** (125 MHz, $CDCl_3$).

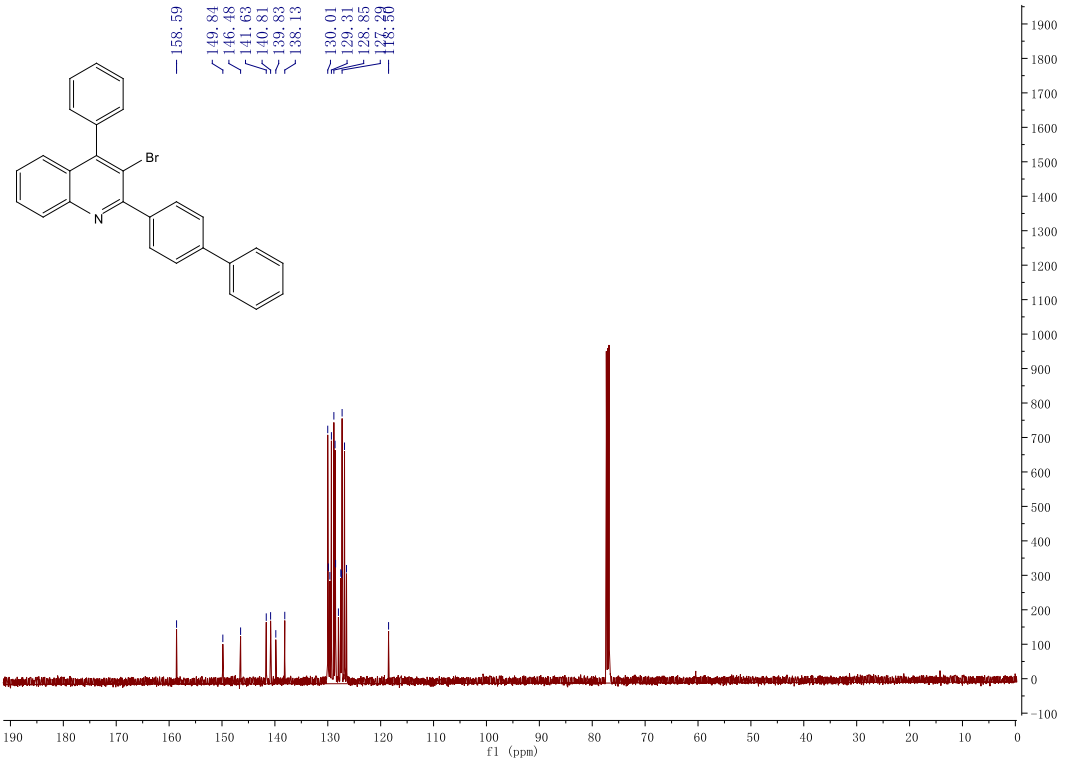


^{1}H NMR of **7e** (500 MHz, $CDCl_3$) and ^{13}C NMR of **7e** (125 MHz, $CDCl_3$).

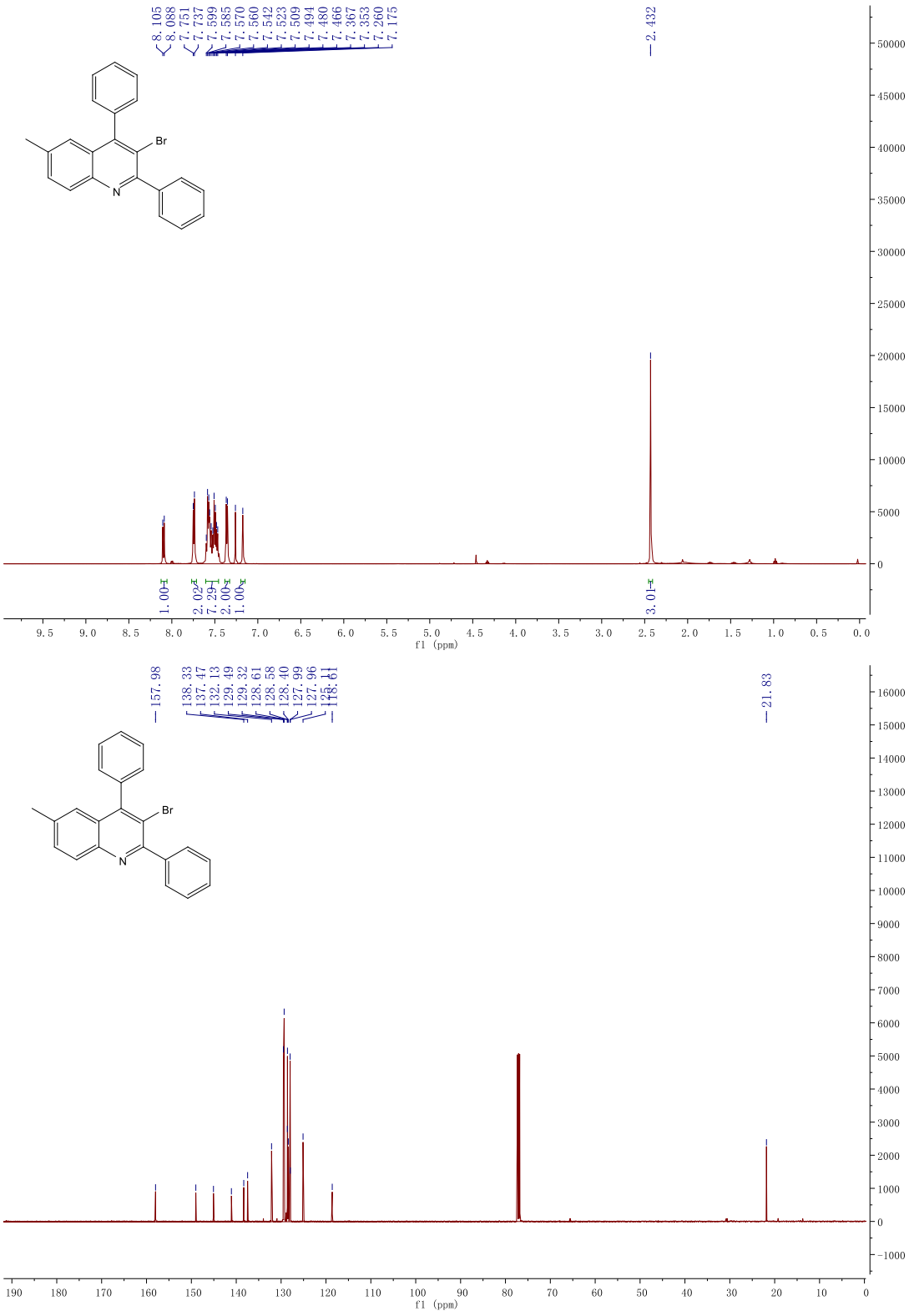


^{1}H NMR of **7f** (500 MHz, $CDCl_3$) and ^{13}C NMR of **7f** (125 MHz, $CDCl_3$).

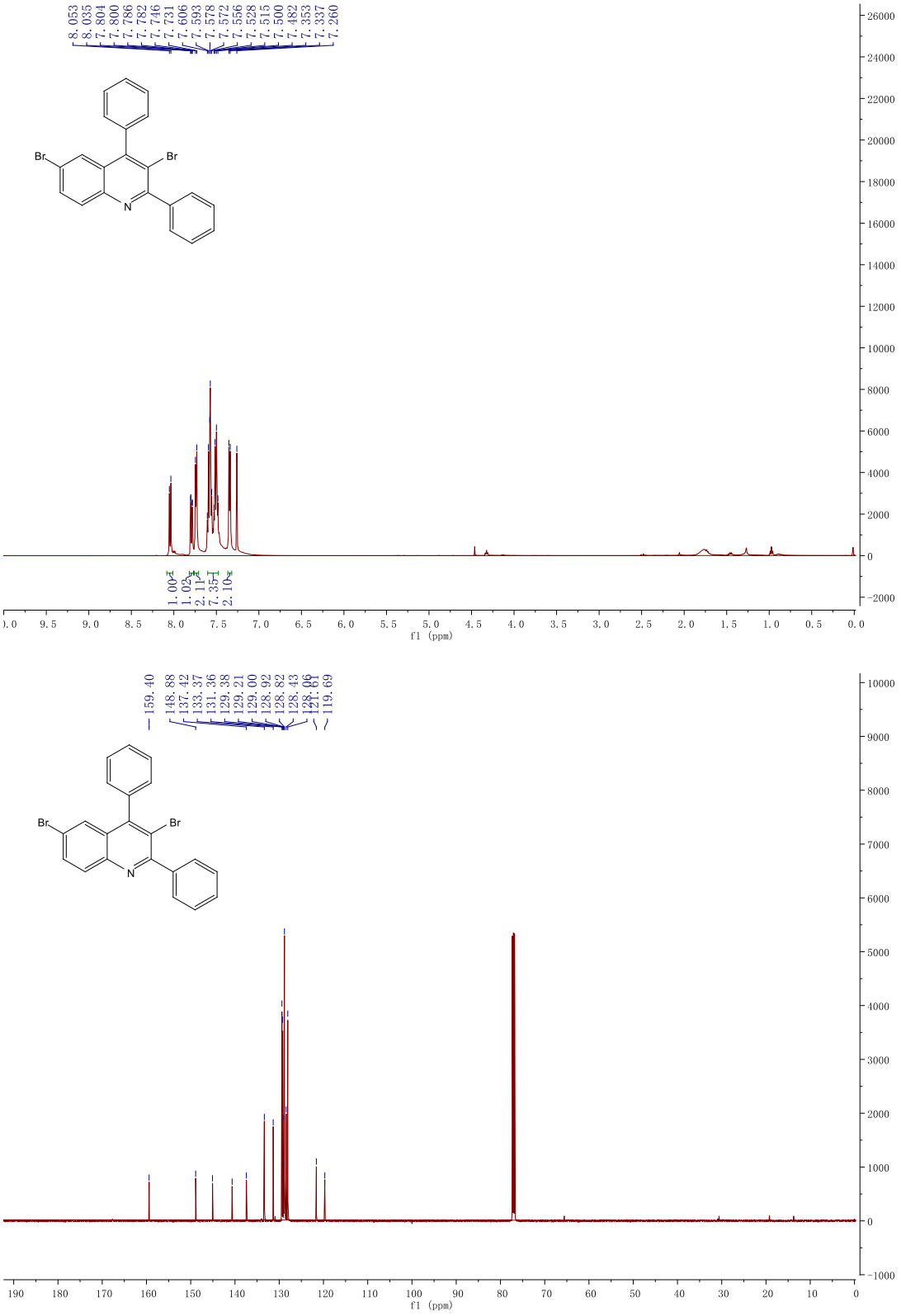




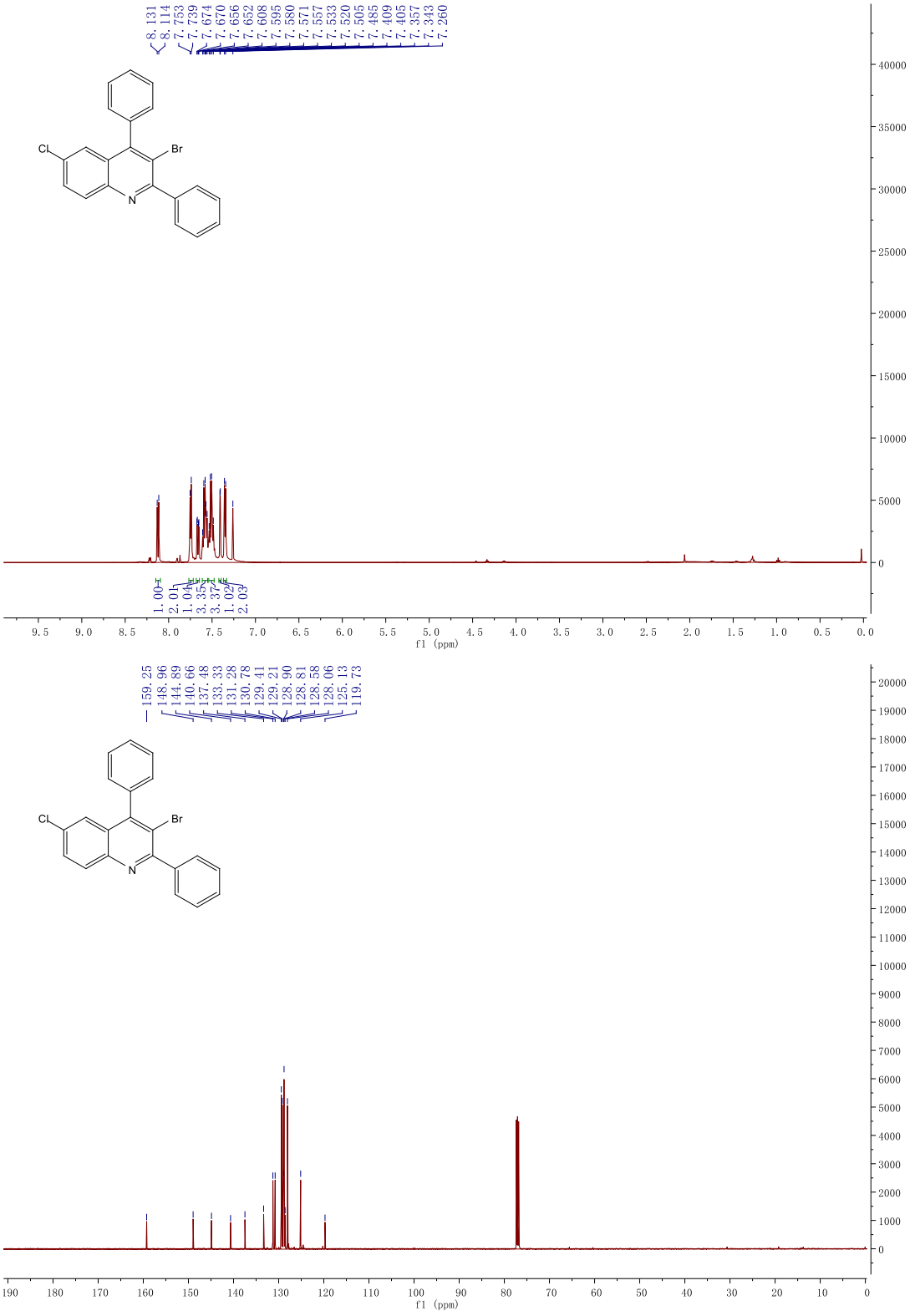
^{1}H NMR of **7g** (500 MHz, $CDCl_3$) and ^{13}C NMR of **7g** (125 MHz, $CDCl_3$).



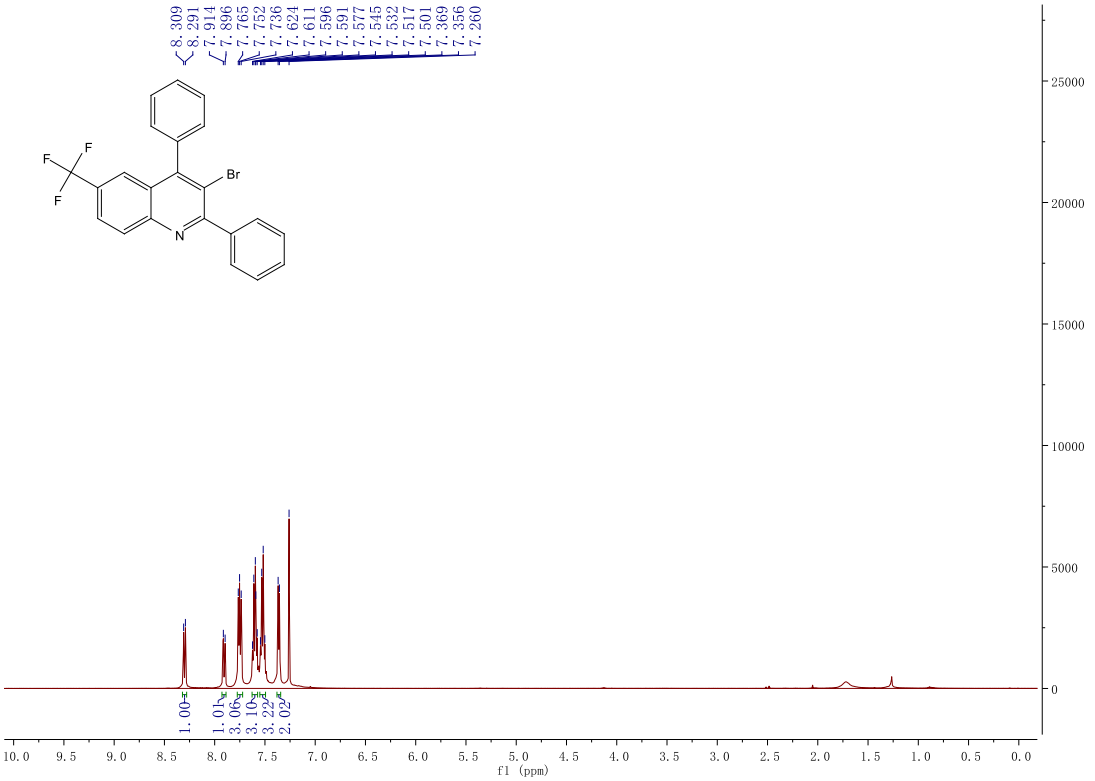
^{1}H NMR of **7h** (500 MHz, $CDCl_3$) and ^{13}C NMR of **7h** (125 MHz, $CDCl_3$).

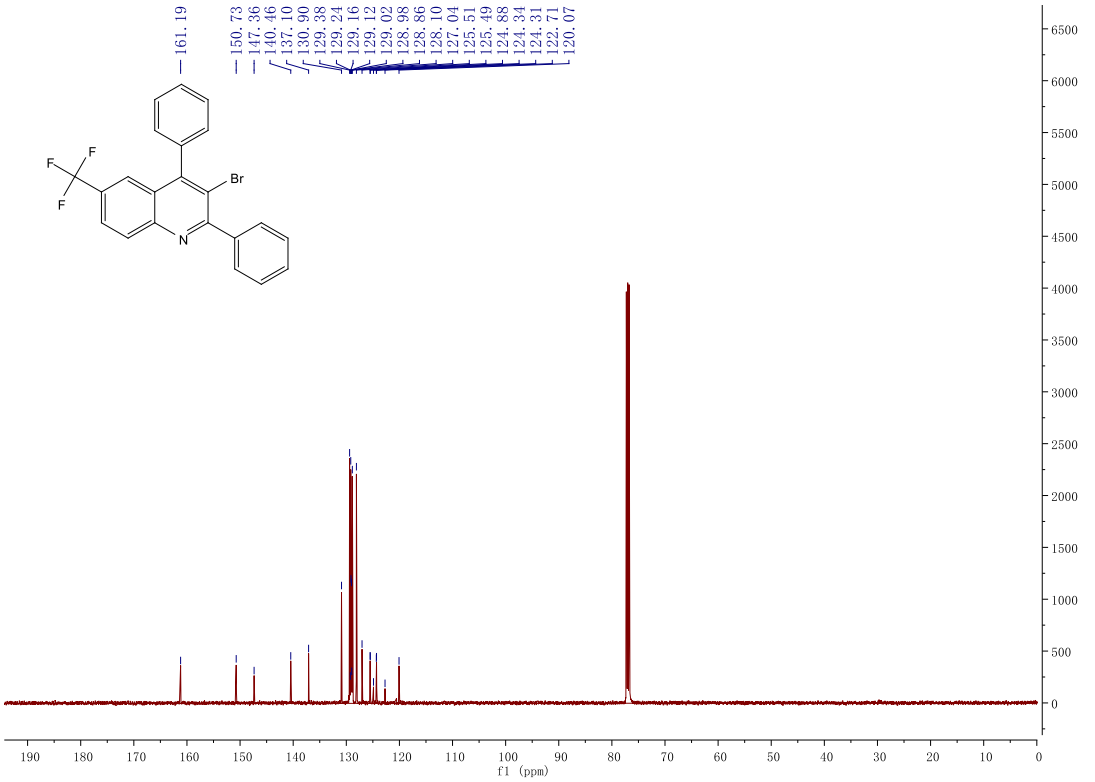


^{1}H NMR of **7i** (500 MHz, $CDCl_3$) and ^{13}C NMR of **7i** (125 MHz, $CDCl_3$).

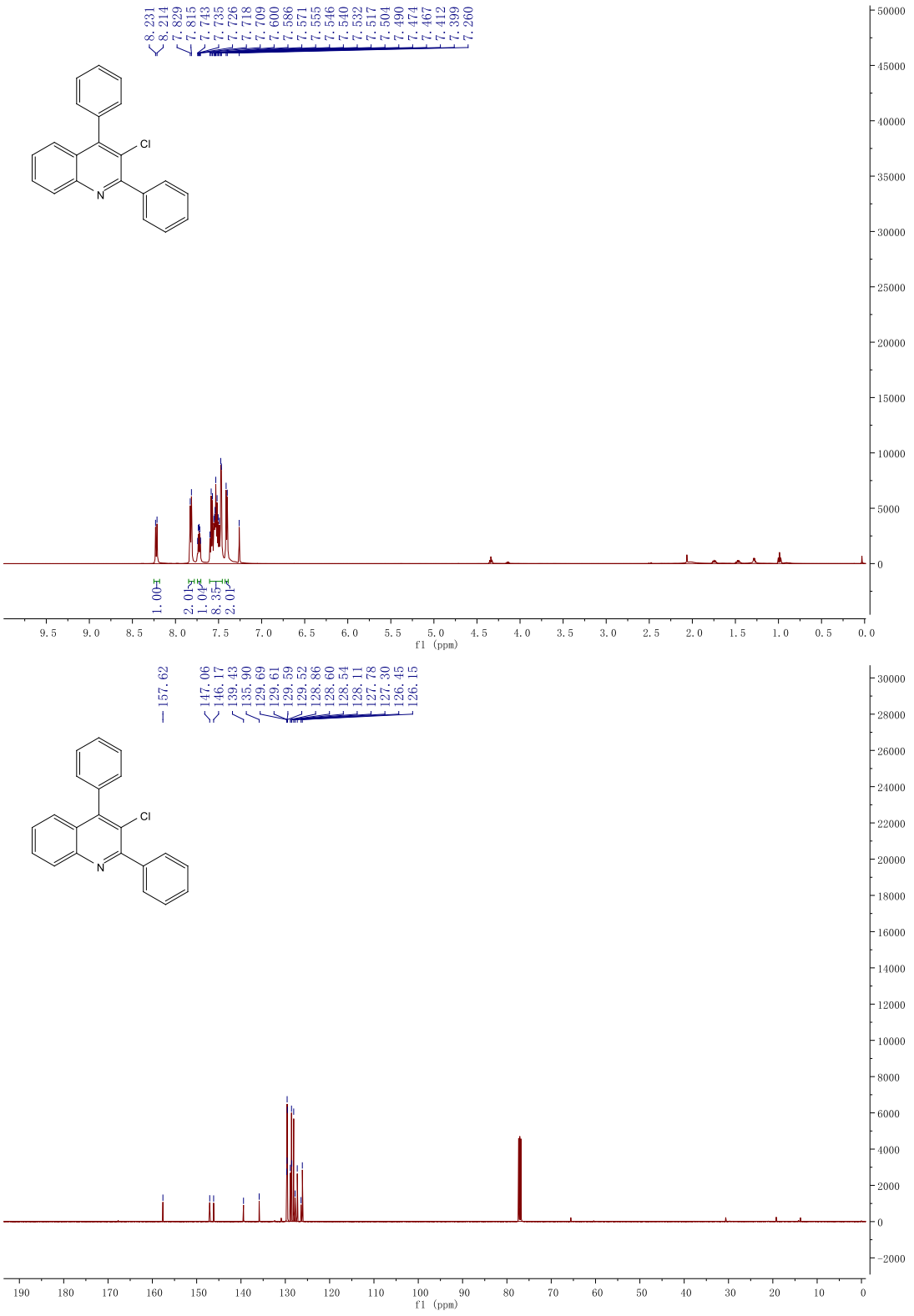


^{1}H NMR of **7j** (500 MHz, $CDCl_3$) and ^{13}C NMR of **7j** (125 MHz, $CDCl_3$).

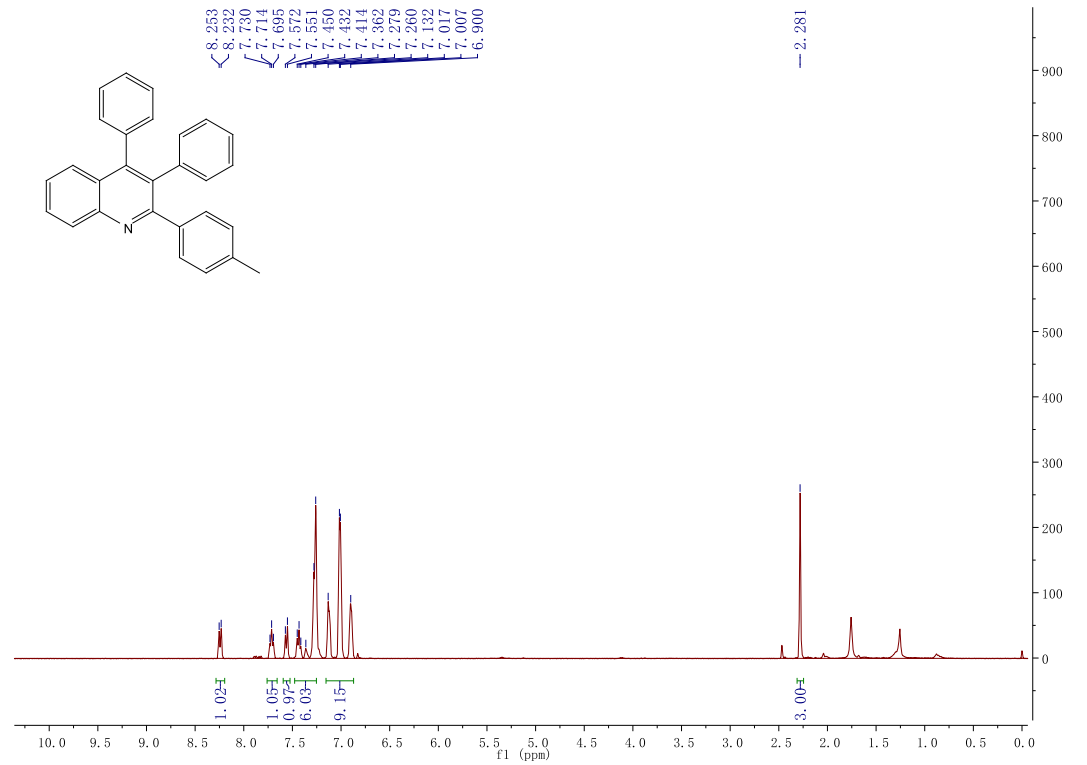


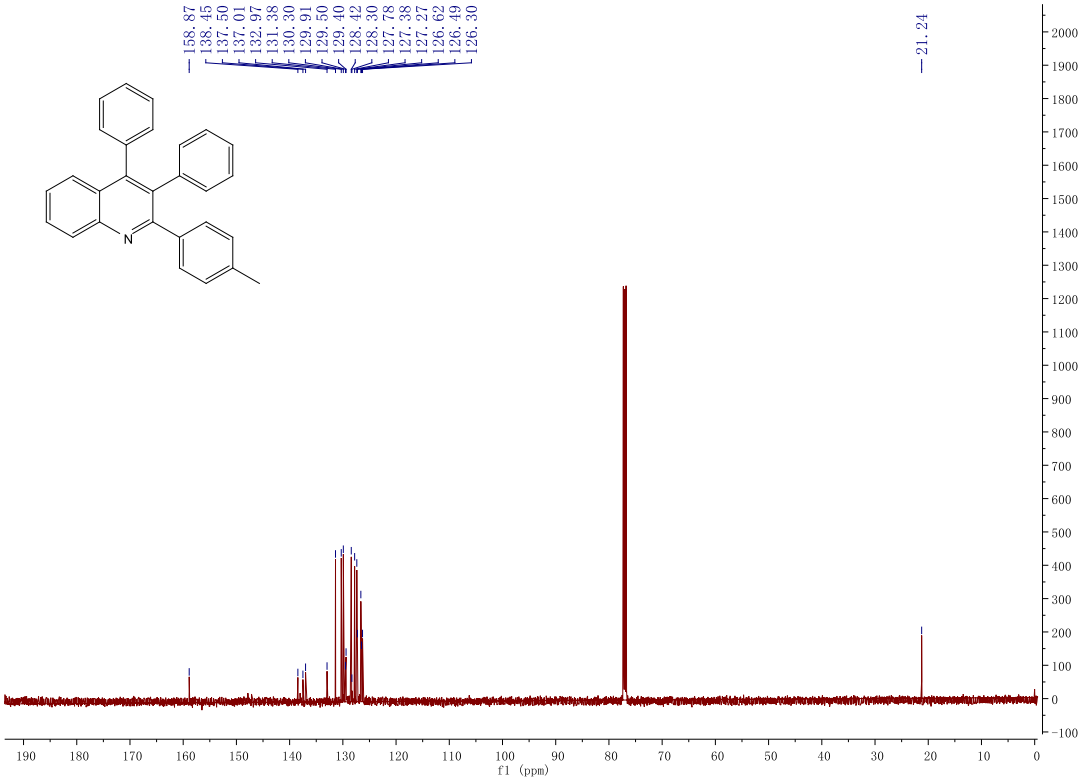


^{1}H NMR of **7k** (500 MHz, $CDCl_3$) and ^{13}C NMR of **7k** (125 MHz, $CDCl_3$).

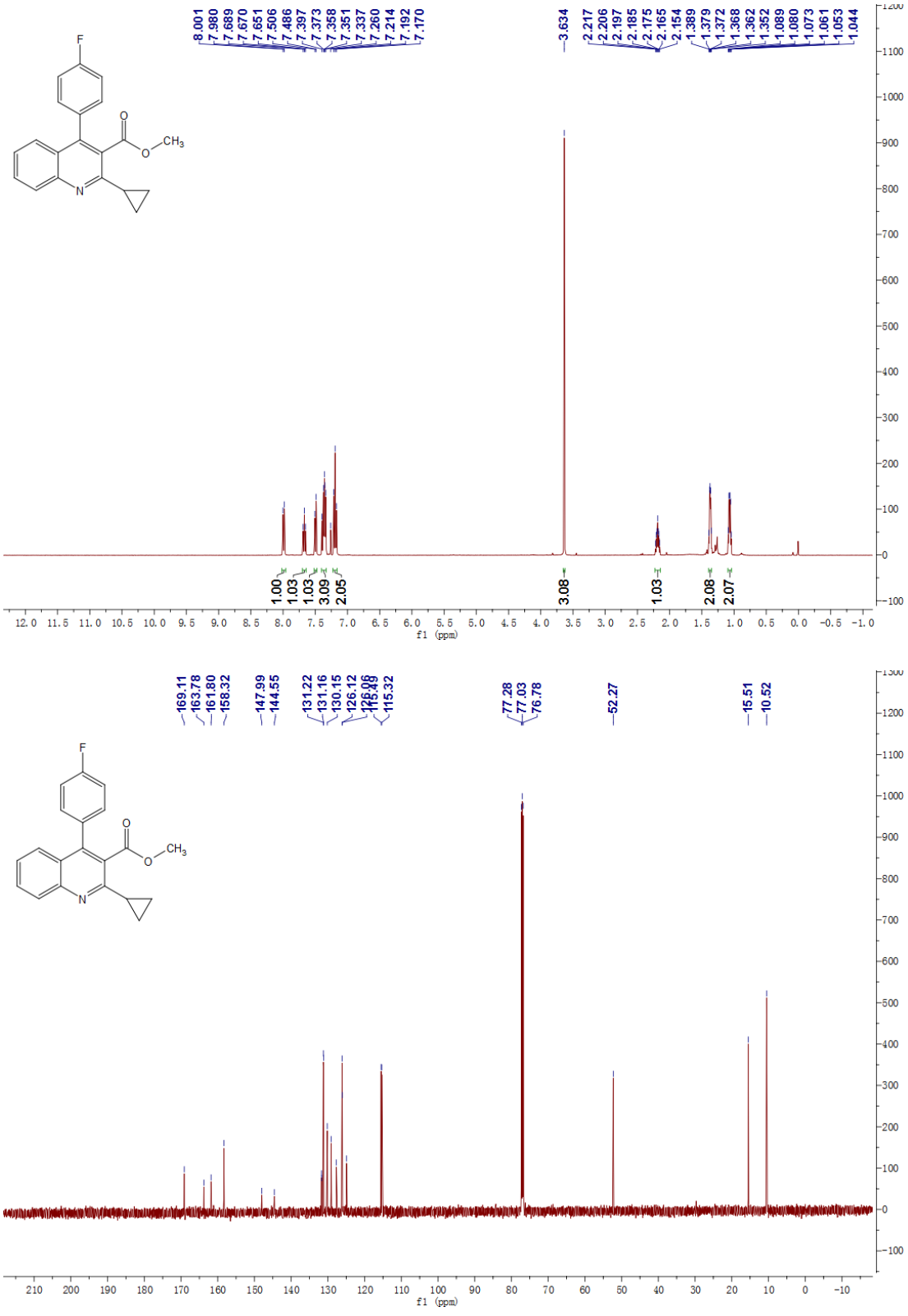


^{1}H NMR of **7l** (500 MHz, $CDCl_3$) and ^{13}C NMR of **7l** (125 MHz, $CDCl_3$).





^{1}H NMR of **8** (500 MHz, $CDCl_3$) and ^{13}C NMR of **8** (125 MHz, $CDCl_3$).



^{1}H NMR of **9** (500 MHz, $CDCl_3$) and ^{13}C NMR of **9** (125 MHz, $CDCl_3$).