Electronic Supporting Information

Copper-catalyzed C2 alkenylation of pyridine-*N*-oxides with alkynes

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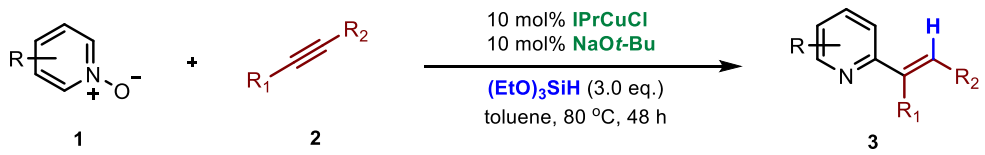
1. General information

Unless otherwise noted, all reactions were performed under an argon atmosphere (purity ≥ 99.999%) using standard Schlenk-type tubes on a dual-manifold Schlenk line. Various reagents were purchased from commercial sources and used without further purification. All the solvents were refluxed with CaH_2 for 12 h, then distilled, further degassed by bubbling with argon for 20 min at room temperature, and stored with activated 4 Å molecular sieves. Isolated yields were determined after purification of the crude product by column chromatography with 10 ~ 40 μm silica gel. Literature methods[1] were used to synthesize IMesCuCl, SIMesCuCl, IPrCuCl, SIPrCuCl and ICyCuCl.

^1H NMR and ^{13}C NMR spectra were recorded on Bruker Advance III HD 500 spectrometer with complete proton decoupling. All NMR data were obtained in $CDCl_3$ at ambient temperature. High-resolution mass spectrometric (HRMS) were recorded on a solariX-70FT-MS. X-ray crystallographic analysis was carried out by Bruker APEII CCD.

2. General procedure for alkenylation of pyridine-*N*-oxides

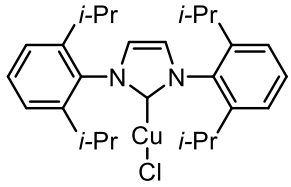


To an oven-dried Schlenk tube were added IPrCuCl (24.4 mg, 0.05 mmol), NaO*t*-Bu (4.8 mg, 0.05 mmol) and alkyne **2** (1.0 mmol, if the alkyne is solid). The tube was evacuated and backfilled with argon for three times. Under argon atmosphere, 0.5 mL toluene was syringed into the reaction tube by a disposable syringe. The reaction mixture was stirred at room temperature for 30 minutes, and then used a microliter syringe to add triethoxysilane (1.5 mmol) into the reaction tube. After stirring for 10 minutes, pyridine-*N*-oxide **1** (0.5 mmol) and toluene (0.5 mL) was syringed into the tube by a microliter syringe. The resultant mixture was stirred at 80 °C for 48 hours. After cooling to room temperature, an ethanol solution of sodium hydroxide was added into the system to quench the reaction. The combined organic layers were concentrated in vacuo and purified by chromatography on silica gel using ethyl acetate/petroleum ether as the eluent to give products **3**.

3. Characterization data

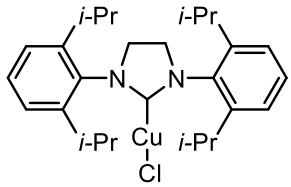
3.1 Characterization of the catalysts

[1,3-Bis[2,6-diisopropylphenyl)]imidazol-2-ylidene]copper(I) chloride (IPrCuCl) [1]**:**



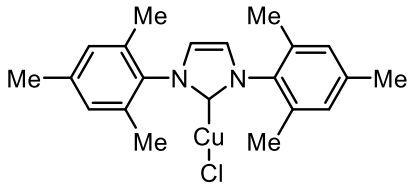
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.49 (t, *J* = 7.8 Hz, 2H), 7.31 – 7.29 (m, 4H), 7.13 (s, 2H), 2.60 – 2.53 (m, 4H), 1.30 (d, *J* = 6.9 Hz, 12H), 1.23 (d, *J* = 6.9 Hz, 12H).

[1,3-Bis[2,6-(diisopropylphenyl)]imidazolidin-2-ylidene]copper(I) chloride (SIPrCuCl) [1]**:**



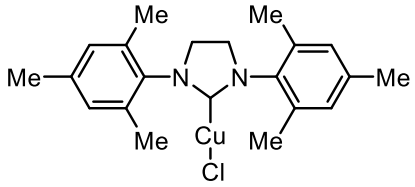
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.40 (t, *J* = 7.8 Hz, 2H), 7.29 – 7.20 (m, 4H), 4.02 (s, 4H), 3.07 (dt, *J* = 13.8, 6.9 Hz, 4H), 1.38 – 1.34 (m, 24H).

[1,3-Bismesitylimidazol-2-ylidene]copper(I) chloride (IMesCuCl) [1]**:**



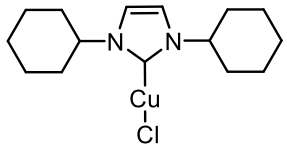
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.05 (s, 2H), 7.00 (s, 4H), 2.35 (s, 6H), 2.11 (s, 12H).

[1,3-Bis(2,4,6-trimethylphenyl)imidazolidin-2-ylidene]copper(I) chloride (SIMesCuCl) [1]**:**



^{1}H NMR (500 MHz, $CDCl_3$) δ 6.95 (s, 4H), 3.95 (s, 4H), 2.31 – 2.30 (m, 18H).

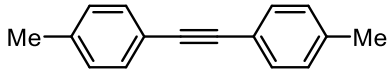
[1,3-dicyclohexylimidazol-2-ylidene]copper(I) chloride (ICyCuCl) [1]**:**



^{1}H NMR (500 MHz, $CDCl_3$) δ 6.93 (s, 2H), 4.30 (tt, *J* = 12.0, 3.6 Hz, 2H), 2.08 (d, *J* = 11.7 Hz, 4H), 1.89 (d, *J* = 13.7 Hz, 4H), 1.76 (d, *J* = 13.2 Hz, 2H), 1.65 (qd, *J* = 12.5, 3.2 Hz, 4H), 1.50 – 1.41 (m, 4H), 1.23 (ddd, *J* = 13.0, 10.1, 3.4 Hz, 2H).

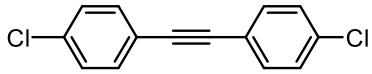
3.2 Characterization of the aryl acetylenes

1,2-di-p-tolylethyne (2b) [2]**:**



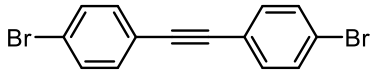
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.42 (d, *J* = 8.1 Hz, 4H), 7.15 (d, *J* = 7.9 Hz, 4H), 2.37 (s, 6H).

1,2-bis(4-chlorophenyl)ethyne (2c) [2]**:**



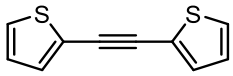
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.52 – 7.41 (m, 4H), 7.36 – 7.30 (m, 4H).

1,2-bis(4-bromophenyl)ethyne (2d) [2]**:**



^{1}H NMR (500 MHz, $CDCl_3$) δ 7.49 (d, *J* = 8.3 Hz, 4H), 7.38 (d, *J* = 8.3 Hz, 4H).

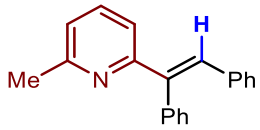
1,2-di(thiophen-2-yl)ethyne (2e) [2]**:**



^{1}H NMR (500 MHz, $CDCl_3$) δ 7.31 (d, *J* = 5.1 Hz, 2H), 7.29 (d, *J* = 3.6 Hz, 2H), 7.02 (dd, *J* = 5.1, 3.7 Hz, 2H).

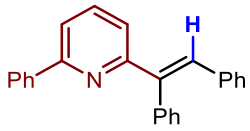
3.3 Characterization of the 2-alkenylpyridines

(*E*)-2-(1,2-diphenylvinyl)-6-methylpyridine (3aa):



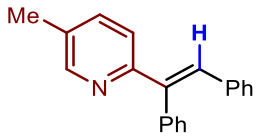
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.89 (s, 1H), 7.43 – 7.34 (m, 4H), 7.27 – 7.23 (m, 2H), 7.13 – 7.09 (m, 3H), 7.07 – 7.04 (m, 2H), 7.02 (d, *J* = 7.6 Hz, 1H), 6.70 (d, *J* = 7.8 Hz, 1H), 2.64 (s, 3H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 158.04, 157.87, 140.55, 139.38, 136.94, 136.41, 130.62, 130.28, 130.01, 128.90, 127.80, 127.46, 127.04, 121.61, 119.62, 24.82. **HRMS** (ESI): *m/z* $[M + H]^+$ calcd for $C_{20}H_{18}N$:272.1439, found 272.1435.

(*E*)-2-(1,2-diphenylvinyl)-6-phenylpyridine (3ba):



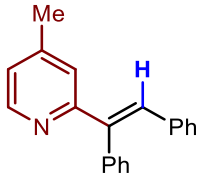
^{1}H NMR (500 MHz, $CDCl_3$) δ 8.19 – 8.14 (m, 3H), 7.63 (d, *J* = 5.0 Hz, 1H), 7.52 (d, *J* = 7.7 Hz, 2H), 7.44 (dt, *J* = 17.7, 8.7 Hz, 4H), 7.15 (t, *J* = 6.1 Hz, 3H), 7.13 – 7.11 (m, 4H), 7.10 (s, 1H), 6.89 (d, *J* = 7.4 Hz, 1H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 158.11, 156.31, 140.45, 139.53, 139.29, 130.95, 130.31, 130.07, 128.98, 128.68, 127.89, 127.52, 127.17, 127.10, 120.79, 118.58. **HRMS** (ESI): *m/z* $[M + H]^+$ calcd for $C_{25}H_{20}N$:334.1596, found 334.1605.

(*E*)-2-(1,2-diphenylvinyl)-5-methylpyridine (3ca):



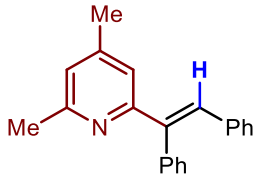
^{1}H NMR (500 MHz, $CDCl_3$) δ 8.49 (dd, *J* = 4.7, 1.0 Hz, 1H), 7.48 (dd, *J* = 7.6, 0.8 Hz, 1H), 7.24 – 7.19 (m, 5H), 7.19 – 7.16 (m, 5H), 7.15 – 7.13 (m, 1H), 6.80 (s, 1H), 2.14 (s, 3H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 160.85, 146.81, 141.77, 139.09, 138.65, 136.98, 131.96, 131.81, 129.85, 129.71, 128.47, 128.08, 127.47, 127.23, 122.40, 19.81. **HRMS** (ESI): *m/z* $[M + H]^+$ calcd for $C_{20}H_{18}N$:272.1439, found 272.1442.

(*E*)-2-(1,2-diphenylvinyl)-4-methylpyridine (3da):



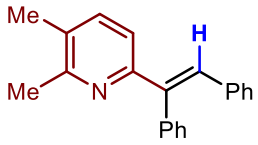
^{1}H NMR (500 MHz, $CDCl_3$) δ 8.52 (d, *J* = 4.9 Hz, 1H), 7.81 (s, 1H), 7.43 – 7.37 (m, 3H), 7.25 (dt, *J* = 4.0, 2.2 Hz, 2H), 7.14 – 7.09 (m, 3H), 7.06 – 7.02 (m, 2H), 6.98 (d, *J* = 4.8 Hz, 1H), 6.79 (s, 1H), 2.23 (s, 3H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 158.81, 149.03, 147.38, 140.61, 139.29, 136.87, 130.87, 130.28, 130.01, 129.01, 127.91, 127.59, 127.18, 123.39, 123.01, 21.14. **HRMS** (ESI): *m/z* $[M + H]^+$ calcd for $C_{20}H_{18}N$:272.1434, found 272.1431.

(*E*)-2-(1,2-diphenylvinyl)-4,6-dimethylpyridine (3ea):



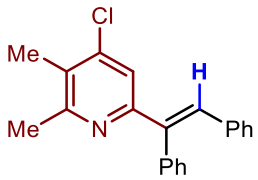
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.86 (s, 1H), 7.38 (q, *J* = 6.9 Hz, 3H), 7.26 – 7.23 (m, 2H), 7.11 – 7.08 (m, 3H), 7.05 – 7.01 (m, 2H), 6.86 (s, 1H), 6.53 (s, 1H), 2.59 (s, 3H), 2.16 (s, 3H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 158.00, 157.64, 147.32, 140.67, 139.44, 137.02, 130.60, 130.30, 129.98, 128.85, 127.75, 127.40, 126.92, 122.63, 120.66, 24.62, 20.92. **HRMS** (ESI): *m/z* $[M + H]^+$ calcd for $C_{21}H_{20}N$: 286.1596, found 286.1606.

(*E*)-6-(1,2-diphenylvinyl)-2,3-dimethylpyridine (3fa):



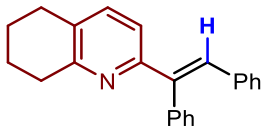
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.86 (s, 1H), 7.36 (ddt, *J* = 9.0, 5.3, 3.5 Hz, 3H), 7.26 – 7.20 (m, 3H), 7.09 (dd, *J* = 6.0, 3.9 Hz, 3H), 7.06 – 7.03 (m, 2H), 6.64 (d, *J* = 7.8 Hz, 1H), 2.58 (s, 3H), 2.26 (s, 3H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 156.54, 155.53, 140.52, 139.49, 137.18, 137.08, 130.26, 129.90, 129.88, 129.61, 128.81, 127.74, 127.35, 126.82, 120.07, 23.00, 18.85. **HRMS** (ESI): *m/z* $[M + H]^+$ calcd for $C_{21}H_{20}N$:286.1596, found 286.1588.

(*E*)-4-chloro-6-(1,2-diphenylvinyl)-2,3-dimethylpyridine (3ga):



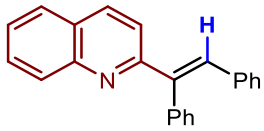
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.89 (s, 1H), 7.44 – 7.35 (m, 3H), 7.23 (dd, *J* = 7.6, 1.6 Hz, 2H), 7.14 – 7.08 (m, 3H), 7.03 (dd, *J* = 6.8, 2.8 Hz, 2H), 6.73 (s, 1H), 2.63 (s, 3H), 2.34 (s, 3H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 157.95, 155.96, 144.19, 139.43, 138.70, 136.68, 130.80, 130.16, 129.99, 129.06, 128.02, 127.83, 127.68, 127.18, 120.77, 24.04, 15.41. **HRMS** (ESI): *m/z* $[M + H]^+$ calcd for $C_{21}H_{19}ClN$:320.1206, found 320.1212.

(*E*)-2-(1,2-diphenylvinyl)-5,6,7,8-tetrahydroquinoline (3ha):



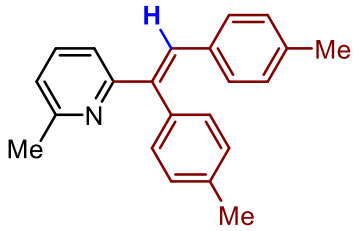
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.72 (s, 1H), 7.30 – 7.20 (m, 3H), 7.18 – 7.13 (m, 2H), 7.06 (d, *J* = 8.0 Hz, 1H), 7.02 – 6.96 (m, 3H), 6.96 – 6.91 (m, 2H), 6.54 (d, *J* = 8.0 Hz, 1H), 2.92 (t, *J* = 6.5 Hz, 2H), 2.63 (t, *J* = 6.3 Hz, 2H), 1.86 – 1.79 (m, 2H), 1.74 – 1.67 (m, 2H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 156.77, 155.76, 140.56, 139.47, 137.03, 136.76, 130.77, 130.22, 129.89, 129.78, 128.77, 127.69, 127.32, 126.80, 119.90, 32.91, 28.49, 23.15, 22.75. **HRMS** (ESI): *m/z* $[M + H]^+$ calcd for $C_{23}H_{22}N$:312.1752, found 312.1760.

(*E*)-2-(1,2-diphenylvinyl)quinoline (3ia):



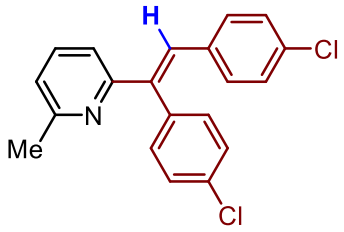
^{1}H NMR (500 MHz, $CDCl_3$) δ 8.17 (dd, *J* = 8.5, 1.1 Hz, 1H), 7.96 (t, *J* = 4.3 Hz, 2H), 7.76 – 7.68 (m, 2H), 7.51 – 7.46 (m, 1H), 7.43 – 7.35 (m, 3H), 7.30 (dd, *J* = 7.6, 1.9 Hz, 2H), 7.15 – 7.09 (m, 6H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 159.25, 148.08, 141.10, 139.32, 136.92, 136.09, 132.62, 130.49, 130.30, 129.75, 129.74, 129.13, 128.03, 127.81, 127.54, 127.49, 127.35, 126.29, 120.95. **HRMS** (ESI): *m/z* $[M + Na]^+$ calcd for $C_{23}H_{17}NNa$: 330.1259, found 330.1254.

(*E*)-2-(1,2-di-p-tolylvinyl)-6-methylpyridine (3ab):



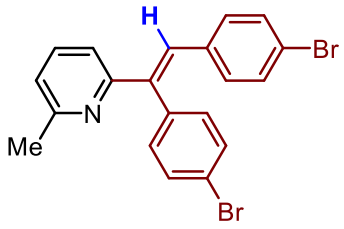
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.84 (s, 1H), 7.40 (t, *J* = 7.7 Hz, 1H), 7.21 (d, *J* = 7.8 Hz, 2H), 7.15 (d, *J* = 8.0 Hz, 2H), 7.03 – 6.90 (m, 5H), 6.72 (d, *J* = 7.9 Hz, 1H), 2.64 (s, 3H), 2.42 (s, 3H), 2.27 (s, 3H).**^{13}C NMR** (126 MHz, $CDCl_3$) δ 158.49, 157.80, 139.69, 137.05, 136.86, 136.56, 136.35, 134.28, 130.43, 130.17, 130.01, 129.68, 128.61, 121.39, 119.53, 24.88, 21.38, 21.24. **HRMS** (ESI): *m/z* $[M + H]^+$ calcd for $C_{22}H_{22}N$: 300.1752, found 300.1757.

(*E*)-2-(1,2-bis(4-chlorophenyl)vinyl)-6-methylpyridine (3ac):



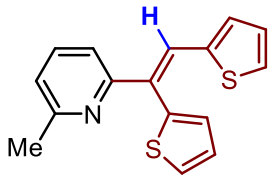
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.81 (s, 1H), 7.42 (t, *J* = 7.7 Hz, 1H), 7.38 – 7.34 (m, 2H), 7.18 – 7.14 (m, 2H), 7.12 – 7.08 (m, 2H), 7.03 (d, *J* = 7.6 Hz, 1H), 6.97 (d, *J* = 8.5 Hz, 2H), 6.68 (d, *J* = 7.8 Hz, 1H), 2.62 (s, 3H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 158.07, 157.29, 140.00, 137.34, 136.49, 135.12, 133.63, 132.92, 131.65, 131.06, 129.79, 129.26, 128.16, 121.95, 119.48 , 24.77. **HRMS** (ESI): *m/z* $[M + H]^+$ calcd for $C_{20}H_{16}Cl_2N$: 340.0660, found 340.0654.

(*E*)-2-(1,2-bis(4-bromophenyl)vinyl)-6-methylpyridine (3ad):



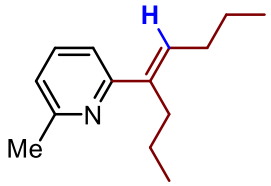
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.78 (s, 1H), 7.55 – 7.50 (m, 2H), 7.43 (t, *J* = 7.7 Hz, 1H), 7.30 – 7.26 (m, 2H), 7.12 – 7.09 (m, 2H), 7.05 (d, *J* = 7.5 Hz, 1H), 6.94 – 6.89 (m, 2H), 6.69 (d, *J* = 7.8 Hz, 1H), 2.62 (s, 3H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 158.15, 157.29, 140.20, 137.86, 136.55, 135.60, 132.26, 132.00, 131.39, 131.18, 129.88, 122.03, 121.87, 121.29, 119.56, 24.78. **HRMS** (ESI): *m/z* $[M + H]^+$ calcd for $C_{20}H_{16}Br_2N$: 427.9649, found 427.9650.

(*Z*)-2-(1,2-di(thiophen-2-yl)vinyl)-6-methylpyridine (3ae):



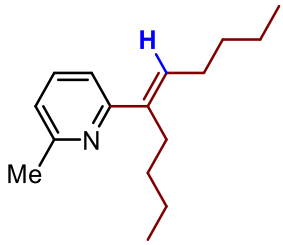
^{1}H NMR (500 MHz, $CDCl_3$) δ 8.40 (s, 1H), 7.56 (dd, *J* = 5.2, 1.2 Hz, 1H), 7.44 (t, *J* = 7.7 Hz, 1H), 7.23 – 7.15 (m, 3H), 7.03 (dd, *J* = 3.4, 1.2 Hz, 1H), 7.02 – 6.98 (m, 1H), 6.94 (dd, *J* = 5.1, 3.7 Hz, 1H), 6.82 (d, *J* = 7.8 Hz, 1H), 2.62 (s, 3H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 157.68, 156.64, 140.55, 138.46, 136.67, 131.20, 129.68, 129.01, 128.36, 127.98, 127.72, 127.14, 126.28, 121.54, 118.95, 24.76. **HRMS** (ESI): *m/z* $[M + H]^+$ calcd for $C_{16}H_{14}NS_2$:284.0568, found 284.0559.

(*E*)-2-methyl-6-(oct-4-en-4-yl)pyridine (3af):



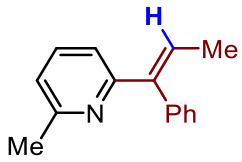
^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.48 (t, *J* = 7.7 Hz, 1H), 7.13 (d, *J* = 7.9 Hz, 1H), 6.95 (d, *J* = 7.6 Hz, 1H), 6.20 (t, *J* = 7.3 Hz, 1H), 2.59 (t, *J* = 7.8 Hz, 2H), 2.53 (s, 3H), 2.22 (q, *J* = 7.3 Hz, 2H), 1.50 (h, *J* = 7.4 Hz, 2H), 1.44 – 1.38 (m, 2H), 0.97 (t, *J* = 7.3 Hz, 3H), 0.90 (d, *J* = 7.2 Hz, 3H). **^{13}C NMR** (126 MHz, Chloroform-*d*) δ 159.53, 157.35, 139.91, 136.31, 131.75, 120.64, 117.31, 30.78, 30.38, 24.75, 22.86, 22.11, 14.16, 14.09. **HRMS** (ESI): *m/z* $[M + Na]^+$ calcd for $C_{14}H_{21}NNa$: 226.1572, found 226.1567.

(*E*)-2-(dec-5-en-5-yl)-6-methylpyridine (3ag):



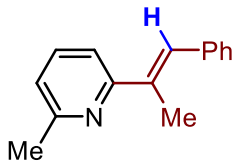
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.48 (t, *J* = 7.7 Hz, 1H), 7.13 (d, *J* = 7.8 Hz, 1H), 6.95 (d, *J* = 7.5 Hz, 1H), 6.20 (t, *J* = 7.3 Hz, 1H), 2.60 (t, *J* = 7.3 Hz, 2H), 2.53 (s, 3H), 2.24 (q, *J* = 7.4 Hz, 2H), 1.47 – 1.31 (m, 8H), 0.94 – 0.87 (m, 6H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 159.51, 157.34, 153.18, 136.31, 131.72, 120.62, 117.27, 31.86, 31.18, 28.34, 28.04, 24.73, 22.79, 22.58, 14.00, 13.96. **HRMS** (ESI): *m/z* $[M + Na]^+$ calcd for $C_{16}H_{25}NNa$: 254.1588, found 254.1580.

(*E*)-2-methyl-6-(1-phenylprop-1-en-1-yl)pyridine (3ah):



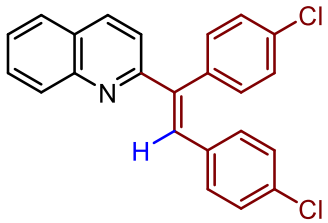
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.43 – 7.37 (m, 2H), 7.37 – 7.31 (m, 2H), 7.25 – 7.19 (m, 2H), 7.04 (q, *J* = 7.2 Hz, 1H), 6.96 (d, *J* = 7.6 Hz, 1H), 6.60 (d, *J* = 7.8 Hz, 1H), 2.59 (s, 3H), 1.76 (d, *J* = 7.2 Hz, 3H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 157.85, 157.66, 141.55, 138.96, 136.30, 130.06, 128.32, 127.85, 126.95, 121.08, 119.05, 24.79, 15.40. **HRMS** (ESI): m/z $[M+H]^+$ calcd for $C_{15}H_{16}N$：210.1283, found 210.1293.

(*E*)-2-methyl-6-(1-phenylprop-1-en-2-yl)pyridine (3ai):



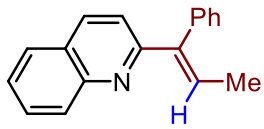
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.57 (t, *J* = 7.7 Hz, 1H), 7.47 (d, *J* = 1.5 Hz, 1H), 7.44 – 7.40 (m, 2H), 7.38 (t, *J* = 7.7 Hz, 2H), 7.32 (d, *J* = 7.8 Hz, 1H), 7.26 (s, 1H), 7.05 (d, *J* = 7.6 Hz, 1H), 2.60 (s, 3H), 2.35 (d, *J* = 1.4 Hz, 3H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 159.31, 157.55, 138.14, 136.57, 129.93, 129.37, 128.08, 126.68, 121.38, 117.17, 24.77, 15.95. **HRMS** (ESI): m/z $[M+H]^+$ calcd for $C_{15}H_{16}N$：210.1283, found 210.1293.

(*E*)-2-(1,2-bis(4-chlorophenyl)vinyl)quinoline (3ic):



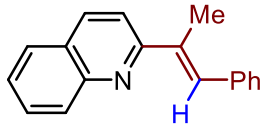
^{1}H NMR (500 MHz, $CDCl_3$) δ 8.14 (d, *J* = 8.6 Hz, 1H), 8.01 (d, *J* = 8.6 Hz, 1H), 7.86 (s, 1H), 7.80 – 7.69 (m, 2H), 7.54 – 7.49 (m, 1H), 7.41 – 7.36 (m, 2H), 7.24 – 7.19 (m, 2H), 7.18 – 7.12 (m, 2H), 7.07 (dd, *J* = 19.8, 8.5 Hz, 3H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 158.37, 147.93, 140.48, 137.20, 136.21, 135.00, 133.89, 133.34, 131.75, 131.63, 131.26, 129.82, 129.61, 129.38, 128.31, 127.41, 127.29, 126.44, 120.52. **HRMS** (ESI): *m/z* $[M + H]^+$ calcd for $C_{23}H_{16}Cl_2N$: 376.0660, found 376.0652.

(*E*)-2-(1-phenylprop-1-en-2-yl)quinoline (3ih):



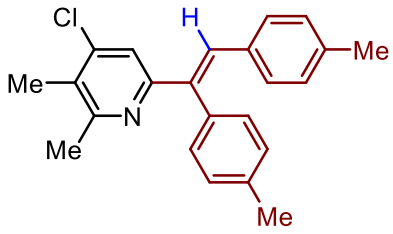
^{1}H NMR (500 MHz, $CDCl_3$) δ 8.16 (d, *J* = 8.5 Hz, 1H), 7.98 (d, *J* = 8.6 Hz, 1H), 7.75 (dd, *J* = 16.8, 7.6 Hz, 2H), 7.53 – 7.43 (m, 3H), 7.40 (d, *J* = 7.1 Hz, 1H), 7.32 (d, *J* = 7.7 Hz, 2H), 7.15 (d, *J* = 7.3 Hz, 1H), 7.07 (d, *J* = 8.6 Hz, 1H), 1.91 (d, *J* = 7.2 Hz, 3H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 159.00, 147.86, 142.06, 138.63, 135.82, 130.13, 129.97, 129.48, 129.40, 128.40, 127.30, 127.16, 127.03, 125.85, 120.75, 15.71. **HRMS** (ESI): *m/z* $[M + H]^+$ calcd for $C_{18}H_{16}N$: 246.1283, found 246.1275.

(*E*)-2-(1-phenylprop-1-en-1-yl)quinoline (3ii):



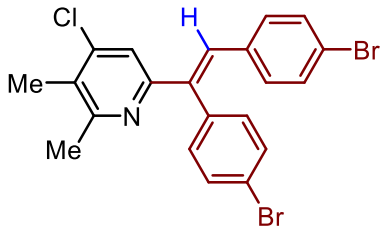
^{1}H NMR (500 MHz, $CDCl_3$) δ 8.17 – 8.10 (m, 2H), 7.81 (d, *J* = 8.1 Hz, 1H), 7.76 (d, *J* = 8.6 Hz, 1H), 7.71 (t, *J* = 7.7 Hz, 1H), 7.50 (t, *J* = 5.9 Hz, 4H), 7.42 (t, *J* = 7.5 Hz, 2H), 7.30 (t, *J* = 7.3 Hz, 1H), 2.53 (s, 3H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 160.13, 147.79, 137.90, 137.67, 136.15, 131.74, 129.61, 129.49, 129.46, 128.24, 127.35, 127.12, 127.05, 126.10, 118.73, 16.12. **HRMS** (ESI): *m/z* $[M + H]^+$ calcd for $C_{18}H_{16}N$: 246.1283, found 246.1275.

(*E*)-4-chloro-6-(1,2-di-p-tolylvinyl)-2,3-dimethylpyridine (3gb):



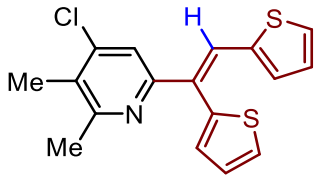
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.82 (s, 1H), 7.20 (d, *J* = 7.8 Hz, 2H), 7.12 – 7.08 (m, 2H), 6.94 (d, *J* = 1.6 Hz, 4H), 6.73 (s, 1H), 2.62 (d, *J* = 2.1 Hz, 3H), 2.41 (s, 3H), 2.33 (d, *J* = 2.0 Hz, 3H), 2.25 (d, *J* = 2.2 Hz, 3H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 157.84, 156.41, 144.16, 138.54, 137.24, 137.01, 135.82, 134.00, 130.60, 130.01, 129.95, 129.80, 128.61, 127.72, 120.64, 24.03, 21.36, 21.20, 15.39. **HRMS** (ESI): *m/z* $[M + H]^+$ calcd for $C_{23}H_{23}ClN$: 348.1519, found 348.1510.

(*E*)-6-(1,2-bis(4-bromophenyl)vinyl)-2,3-dimethylpyridine (3gd) :



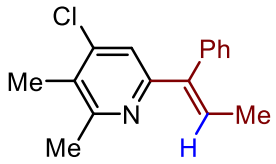
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.78 (s, 1H), 7.61 – 7.44 (m, 2H), 7.27 (dt, *J* = 4.7, 2.7 Hz, 2H), 7.15 – 7.01 (m, 2H), 6.89 (d, *J* = 8.5 Hz, 2H), 6.71 (s, 1H), 2.62 (s, 3H), 2.35 (s, 3H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 158.26, 155.20, 144.35, 139.10, 137.24, 135.35, 132.43, 131.89, 131.37, 131.23, 130.09, 128.59, 122.11, 121.47, 120.74, 23.99, 15.45. **HRMS** (ESI): *m/z* $[M + H]^+$ calcd for $C_{21}H_{17}Br_2ClN$:477.9396, found 477.9430.

(*Z*)-4-chloro-6-(1,2-di(thiophen-2-yl)vinyl)-2,3-dimethylpyridine (3ge):



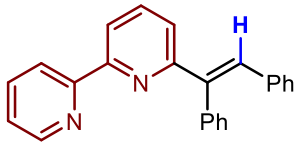
^{1}H NMR (500 MHz, $CDCl_3$) δ 8.37 (s, 1H), 7.57 (d, *J* = 5.1 Hz, 1H), 7.23 – 7.21 (m, 1H), 7.19 (d, *J* = 5.0 Hz, 1H), 7.16 (d, *J* = 3.6 Hz, 1H), 7.02 (d, *J* = 3.4 Hz, 1H), 6.94 (t, *J* = 4.5 Hz, 1H), 6.83 (s, 1H), 2.62 (s, 3H), 2.33 (s, 3H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 157.78, 154.68, 144.46, 140.33, 137.68, 131.35, 129.12, 128.62, 128.56, 128.11, 127.98, 127.94, 127.37, 126.32, 120.14, 24.01, 15.44. **HRMS** (ESI): *m/z* $[M + H]^+$ calcd for $C_{17}H_{15}ClNS_2$:332.0334, found 332.0344.

(*E*)-4-chloro-2,3-dimethyl-6-(1-phenylprop-1-en-1-yl)pyridine (3gh):



^{1}H NMR (500 MHz, $CDCl_3$) δ 7.41 (t, *J* = 7.4 Hz, 2H), 7.35 (d, *J* = 7.4 Hz, 1H), 7.23 – 7.12 (m, 2H), 7.02 (d, *J* = 7.2 Hz, 1H), 6.63 (s, 1H), 2.58 (s, 3H), 2.31 (s, 3H), 1.74 (d, *J* = 7.2 Hz, 3H). **^{13}C NMR** (500 MHz, $CDCl_3$) δ 157.79, 155.79, 144.10, 140.54, 138.30, 129.99, 128.47, 128.25, 127.45, 127.18, 120.25, 24.00, 15.42, 15.33. **HRMS** (ESI): *m/z* $[M + H]^+$ calcd for $C_{16}H_{17}ClN$: 258.1050, found 258.1059.

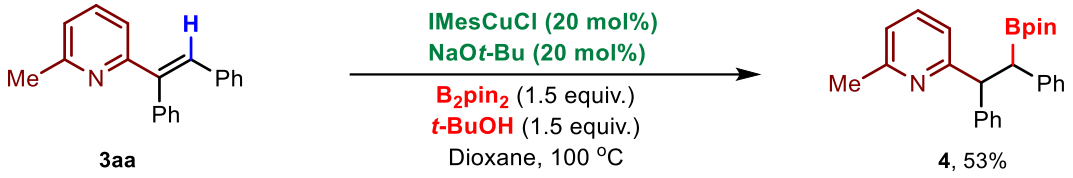
(*E*)-6-(1,2-diphenylvinyl)-2,2'-bipyridine (3ja):



^{1}H NMR (500 MHz, $CDCl_3$) δ 8.69 (ddd, *J* = 4.8, 1.8, 0.9 Hz, 1H), 8.61 (dt, *J* = 8.0, 0.9 Hz, 1H), 8.30 (dd, *J* = 7.8, 0.9 Hz, 1H), 8.08 (s, 1H), 7.85 (td, *J* = 7.7, 1.8 Hz, 1H), 7.67 (t, *J* = 7.8 Hz, 1H), 7.47 – 7.37 (m, 3H), 7.37 – 7.28 (m, 3H), 7.18 – 7.06 (m, 5H), 6.97 (dd, *J* = 7.8, 0.9 Hz, 1H).**^{13}C NMR** (126 MHz, $CDCl_3$) δ 157.79, 156.39, 155.22, 149.05, 140.47, 139.18, 137.24, 136.89, 136.85, 130.86, 130.30, 130.04, 128.99, 127.93, 127.58, 127.23, 123.71, 122.37, 121.27, 119.25. **HRMS** (ESI): *m/z* $[M + H]^+$ calcd for $C_{24}H_{19}N2$: 335.1548, found 335.1561.

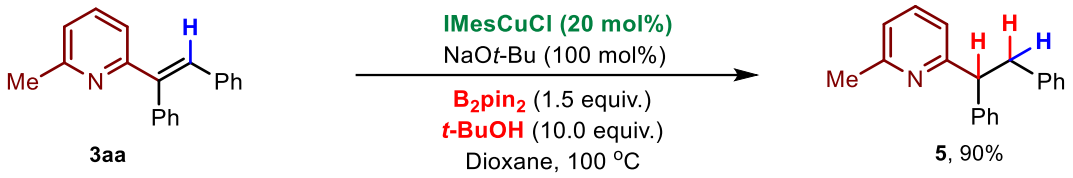
4. Further functionalization reactions

(*E*)-6-(1,2-diphenylprop-1-en-1-yl)-2,2'-bipyridine



To an oven-dried Schlenk tube equipped with a magnetic stir bar, IMesCuCl (0.06 mmol, 24.3 mg), $NaOBu^t$ (0.06 mmol, 5.8 mg), **3aa** (0.3 mmol, 81.4 mg) and B_2Pin_2 (0.45 mmol, 114.3 mg) were added. The tube was evacuated and backfilled with argon (this process was repeated three times). Under argon atmosphere, dioxane (1.5 mL) and *tert*-butanol (0.45 mmol, 42 μL) were added into the tube. The resulting mixture was stirred at 100 °C for 48 h. After cooling to room temperature, the organic phases were concentrated in vacuo and purified by column chromatography to obtain the product **4** (64 mg, 53%) as a white solid. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.63 – 7.58 (m, 2H), 7.24 (d, J = 7.4 Hz, 3H), 7.19 – 7.06 (m, 5H), 7.00 – 6.95 (m, 1H), 6.79 (d, J = 7.7 Hz, 1H), 6.69 (d, J = 7.6 Hz, 1H), 4.53 (d, J = 12.5 Hz, 1H), 3.66 (d, J = 12.5 Hz, 1H), 2.41 (s, 3H), 0.90 (d, J = 7.8 Hz, 12H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 161.78, 157.46, 144.03, 141.00, 135.91, 129.23, 128.78, 128.08, 127.89, 126.34, 125.10, 120.22, 119.59, 83.18, 56.27, 24.57, 24.42, 24.19. **HRMS** (ESI): m/z $[M + H]^+$ calcd for $C_{26}H_{31}BNO_2$: 400.2442, found 400.2483.

(*E*)-2-(1,2-diphenylvinyl)-6-methylpyridine

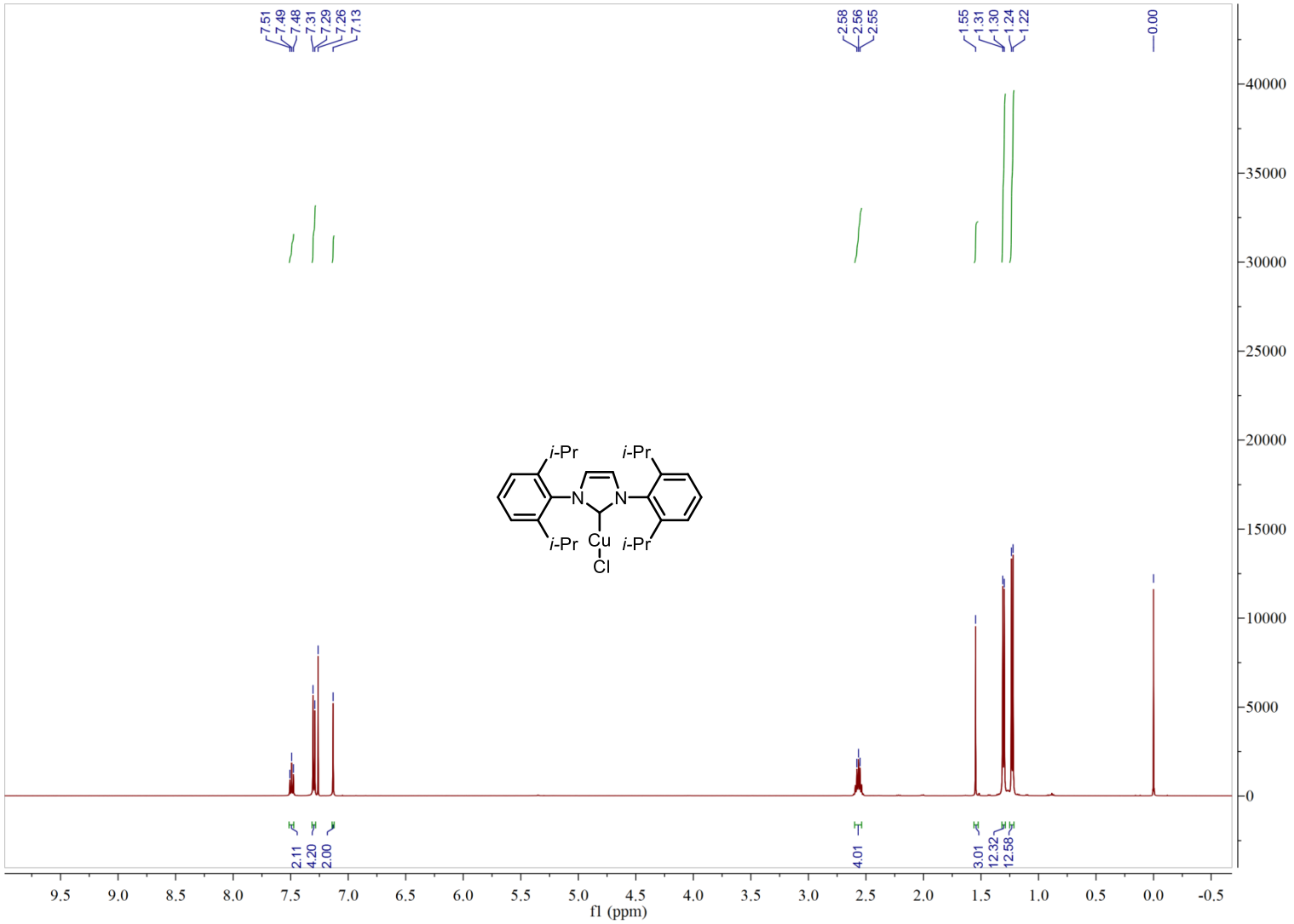


To an oven-dried Schlenk tube equipped with a magnetic stir bar, IMesCuCl (0.06 mmol, 24.3mg), $NaOBu^t$ (0.3 mmol, 28.8 mg), **3aa** (0.3 mmol, 81.4 mg) and B_2Pin_2 (0.45 mmol, 114.3 mg) were added. The tube was evacuated and backfilled with argon (this process was repeated three times). Under argon atmosphere, dioxane (1.5 mL) and *tert*-butanol (3.0 mmol, 286 μL) were added into the tube. The resulting mixture was stirred at 100 °C for 48 h. After cooling to room temperature, the organic phases were concentrated in vacuo and purified by column chromatography to obtain the product **5** (73.7 mg, 90%) as a transparent oily. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.37 – 7.30 (m, 3H), 7.22 (dd, J = 10.4, 4.8 Hz, 2H), 7.15 – 7.11 (m, 3H), 7.09 – 7.03 (m, 3H), 6.88 (d, J = 7.7 Hz, 2H), 4.33 (t, J = 7.8 Hz, 1H), 3.63 (dd, J = 13.7, 7.8 Hz, 1H), 3.30 (dd, J = 13.7, 7.8 Hz, 1H), 2.53 (s, 3H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 162.34, 157.78, 143.63, 140.67, 136.43, 129.20, 128.34, 128.31, 128.04, 126.37, 125.80, 120.81, 119.86, 55.52, 41.64, 24.75.

5. References

[1]. O. Santoro, A. Collado, A. M. Slawin, S. P. Nolan, C. S. Cazin, *Chem. Commun.*, 2013, **49**, 10483.

[2]. M. J. Mio, L. C. Kopel, J. B. Braun, T. L. Gadzikwa, K. L. Hull, R. G. Brisbois, C. J. Markworth, P. A. Grieco, *Org. Lett.*, 2002, **4**, 3199.


7.51
7.49
7.48
7.31
7.29
7.26
7.13
2.58
2.56
2.55
1.55
1.31
1.30
1.24
1.22
0.00
i-Pr
i-Pr
i-Pr
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Cl
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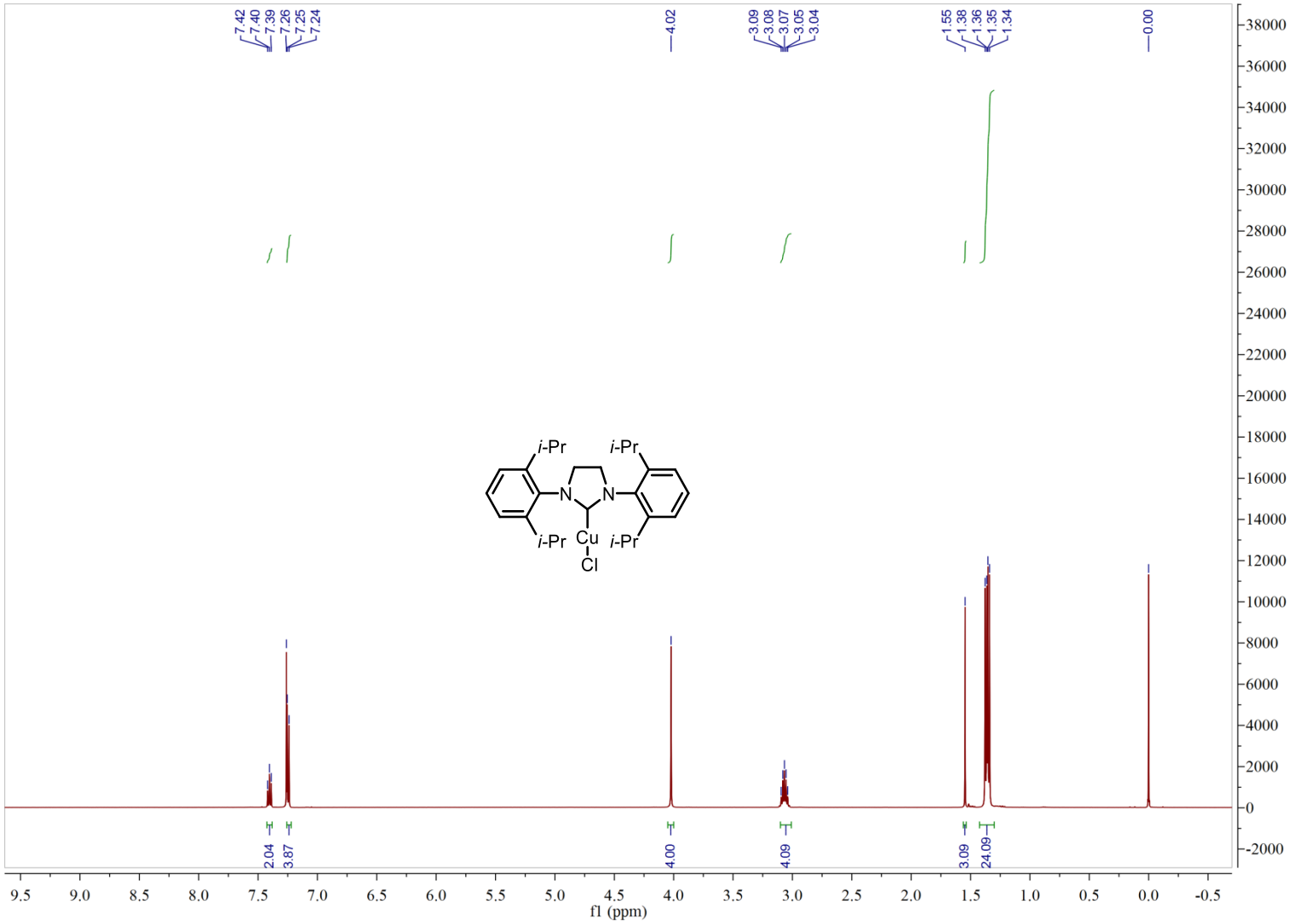
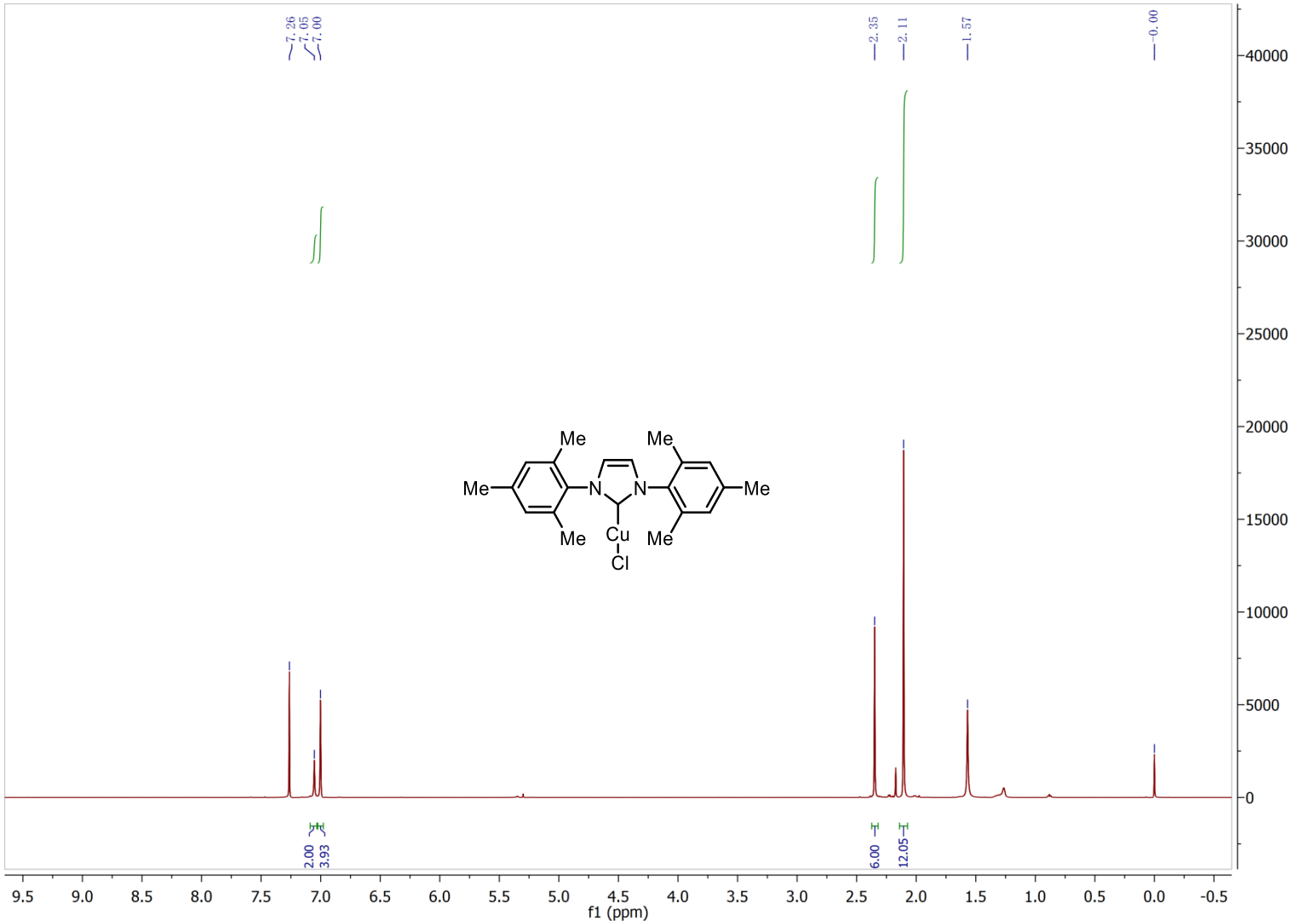
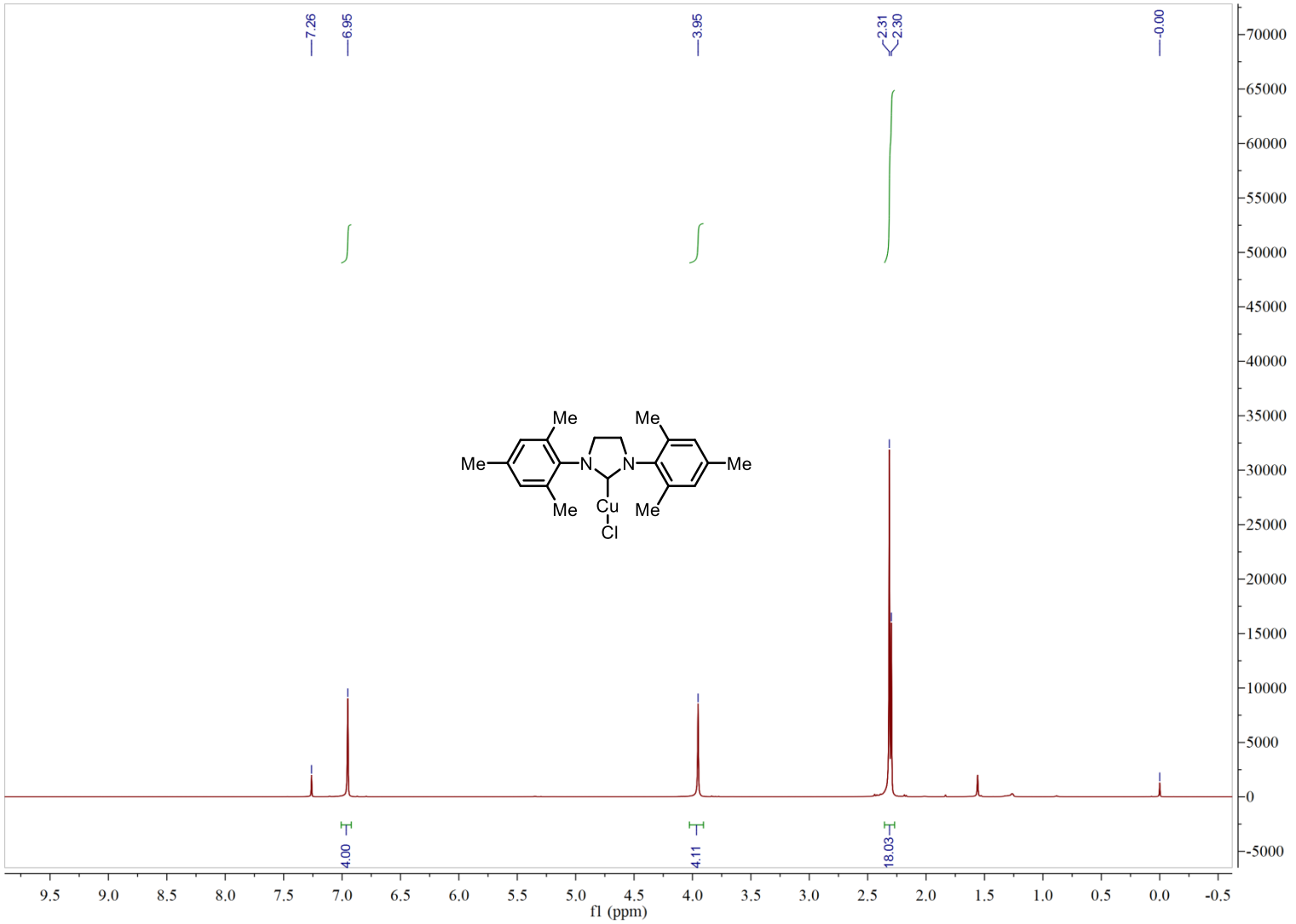
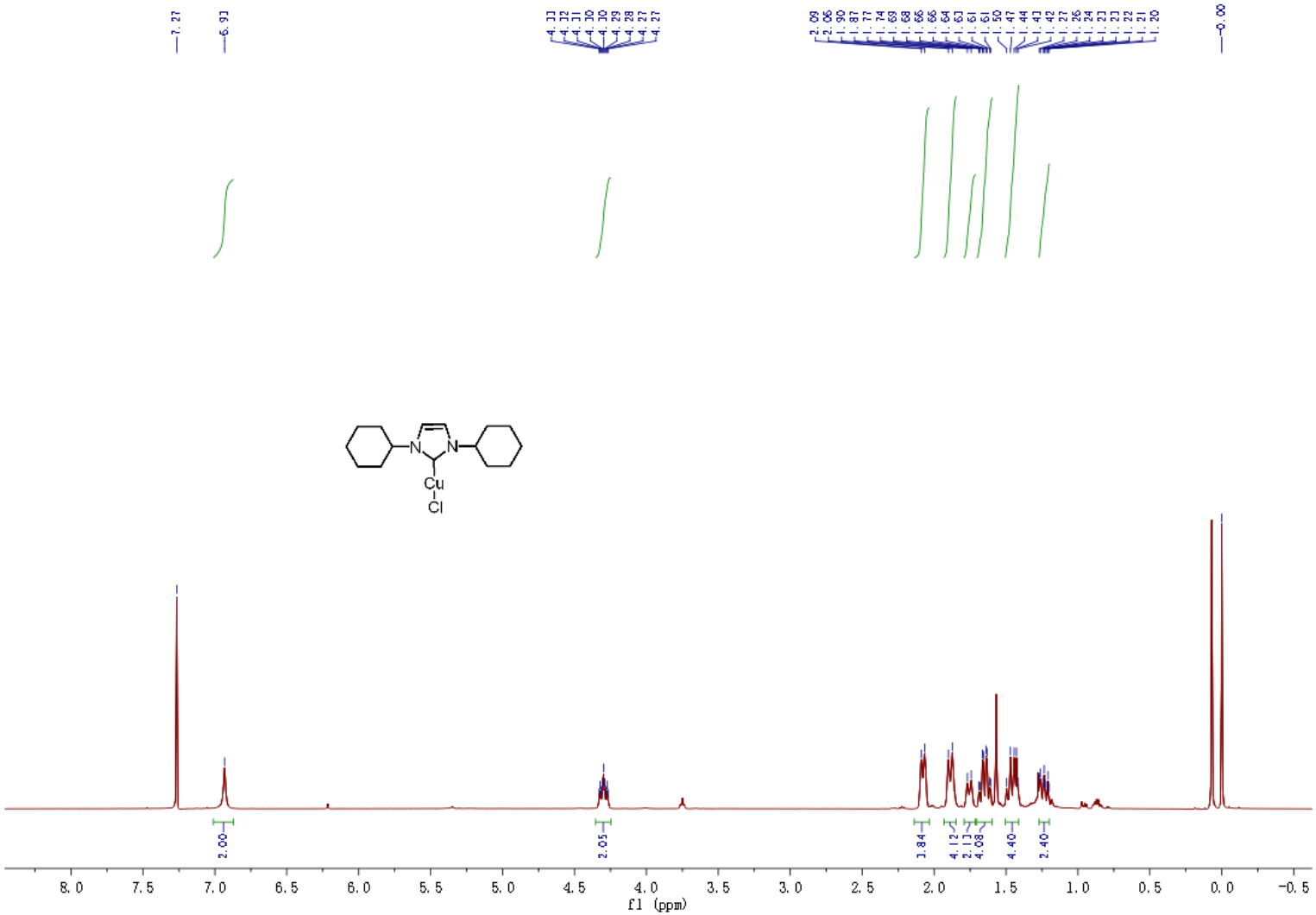
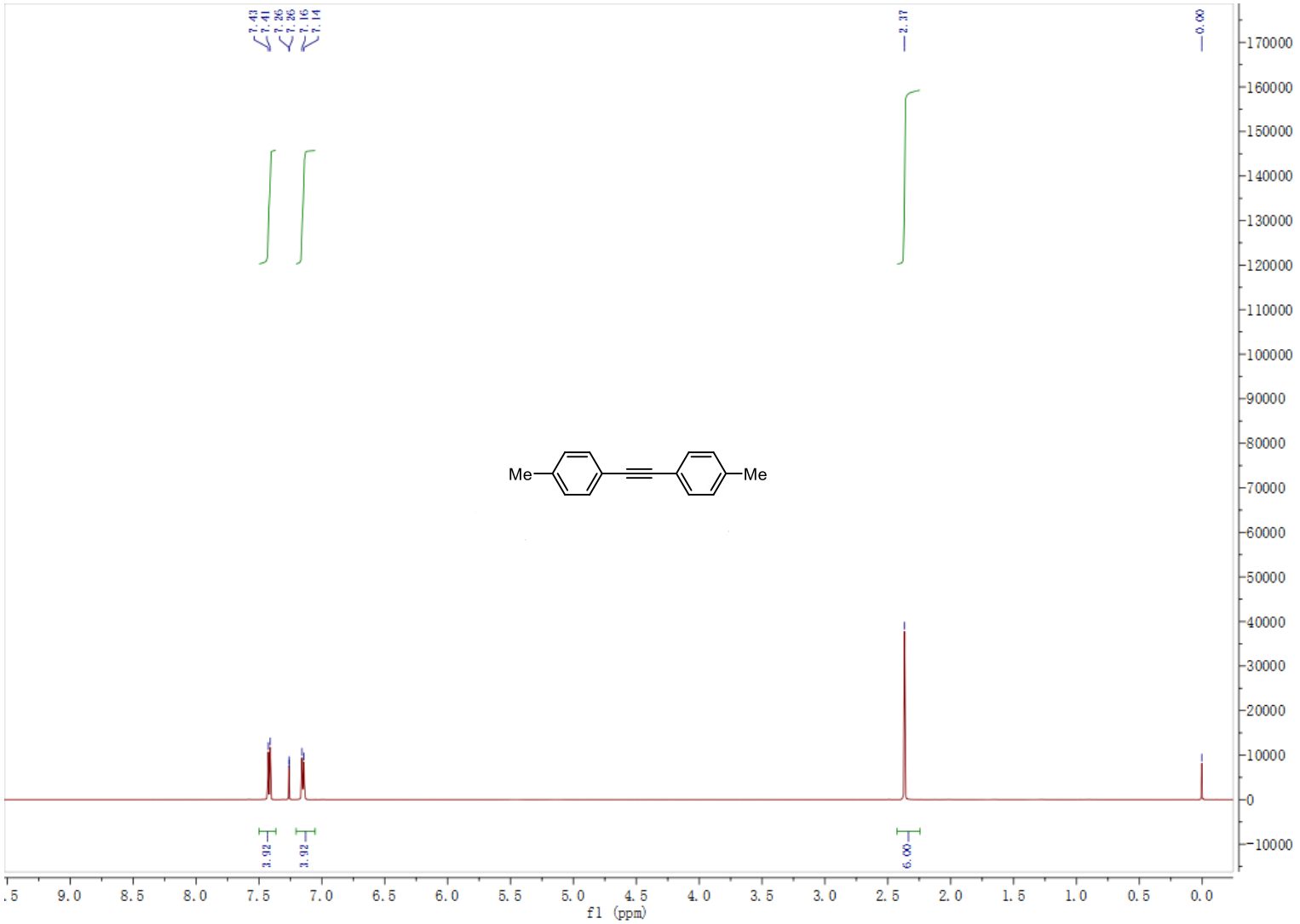
2.00
4.01
3.01
12.32
12.58
f1 (ppm)

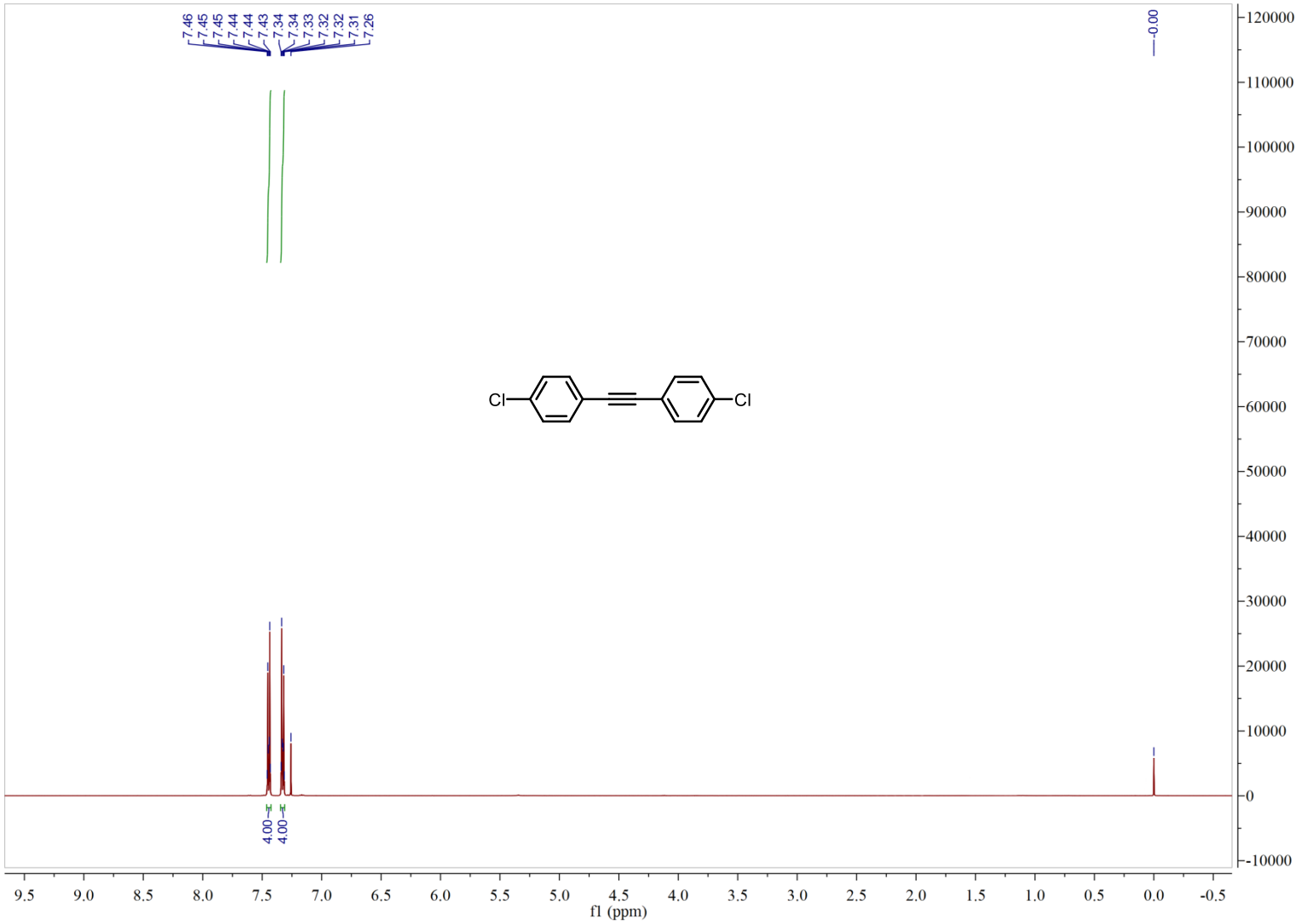

7.42
7.40
7.39
7.26
7.25
7.24
4.02
3.09
3.08
3.07
3.05
3.04
1.55
1.38
1.36
1.35
1.34
0.00
i-Pr
i-Pr
i-Pr
i-Pr
N
N
Cu
Cl
2.04
3.87
4.00
4.09
3.09
24.09
f1 (ppm)

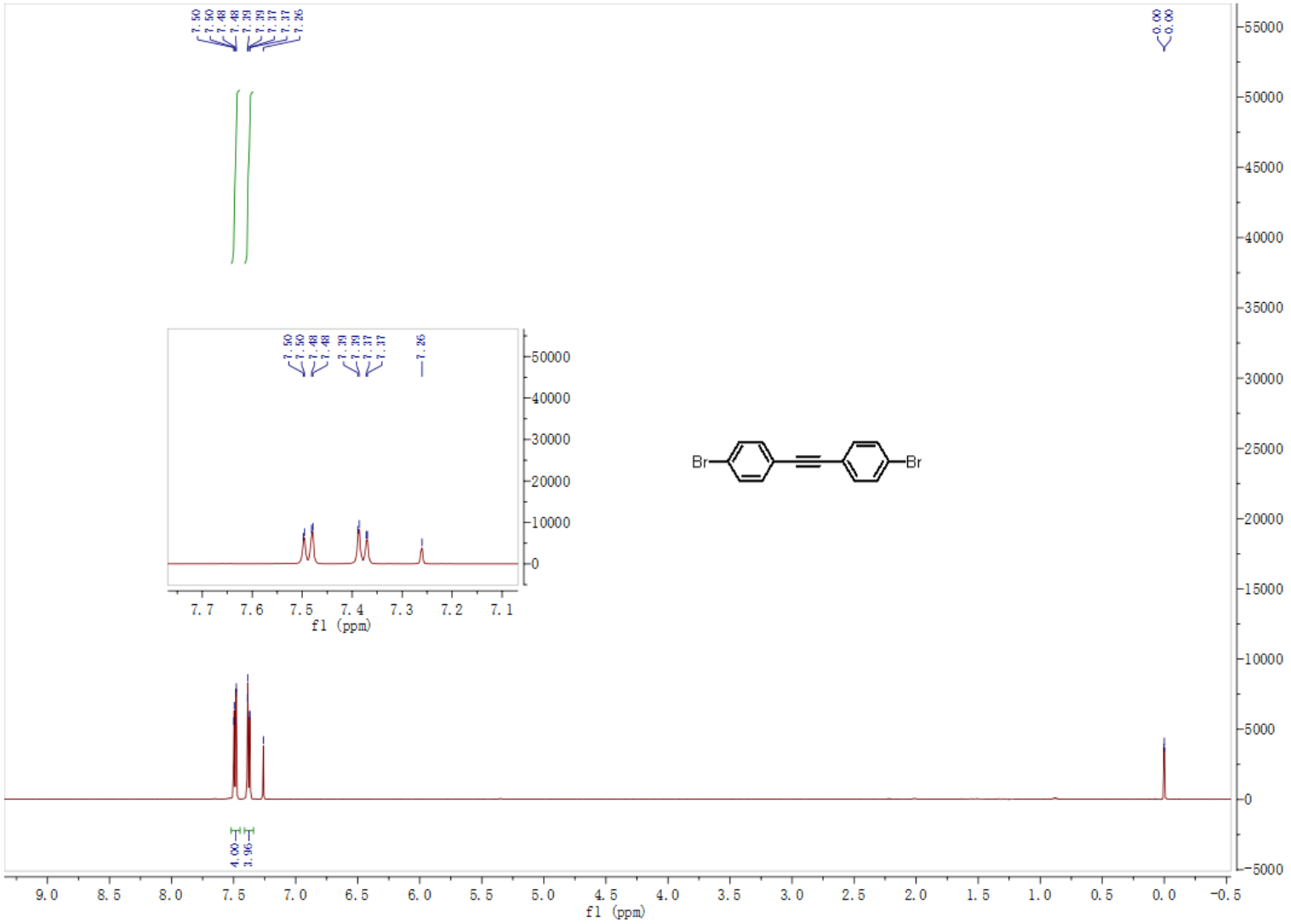

7.26
7.05
7.00
2.35
2.11
1.57
0.00
Me
Me
Me
Me
Me
Me
N
N
Cu
Cl
40000
35000
30000
25000
20000
15000
10000
5000
0
2.00
3.93
6.00
12.05
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

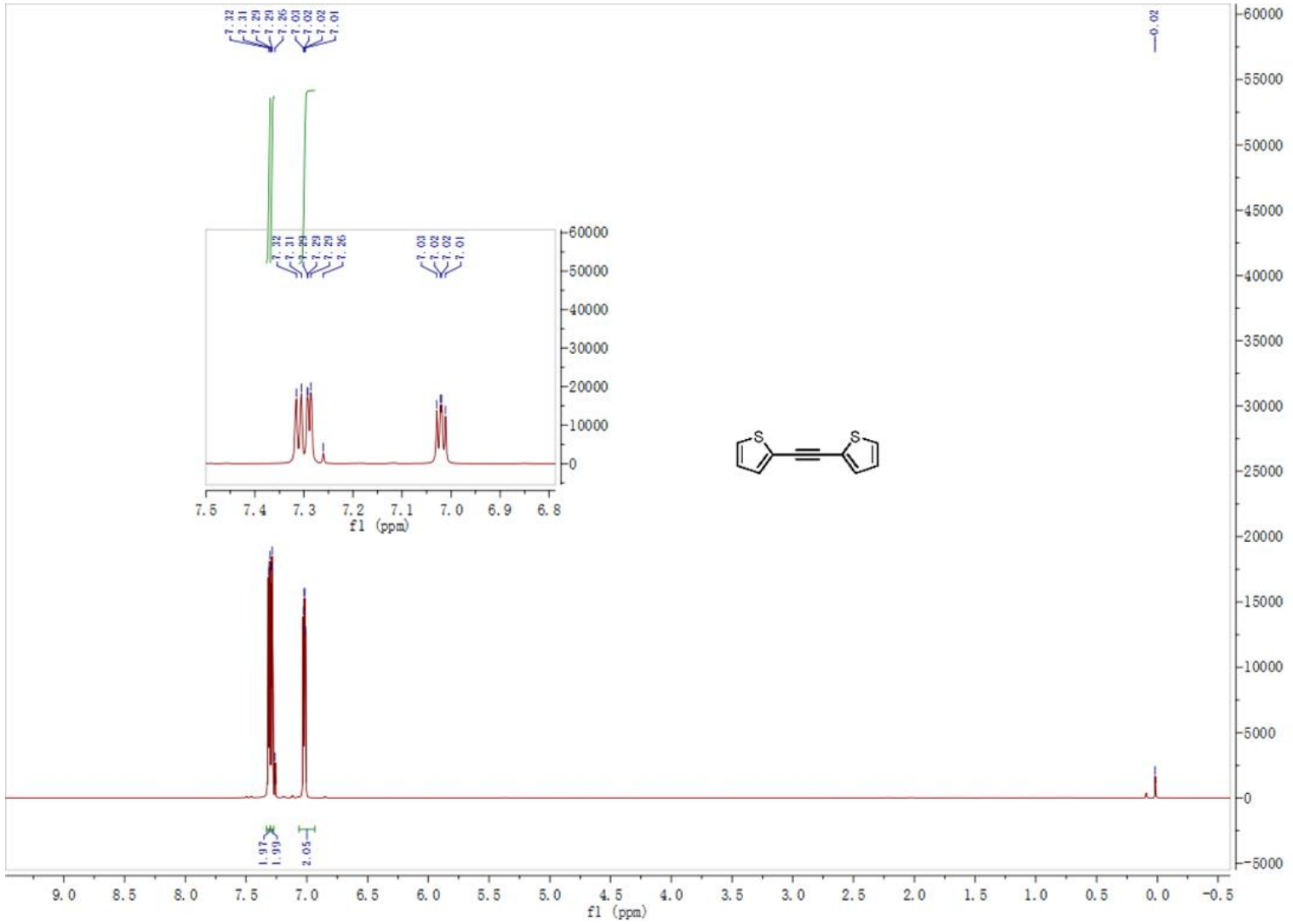

7.26
6.95
3.95
2.31
2.30
0.00
Me
Me
Me
Me
Me
Me
N
N
Cu
Cl
4.00
4.11
18.03
f1 (ppm)

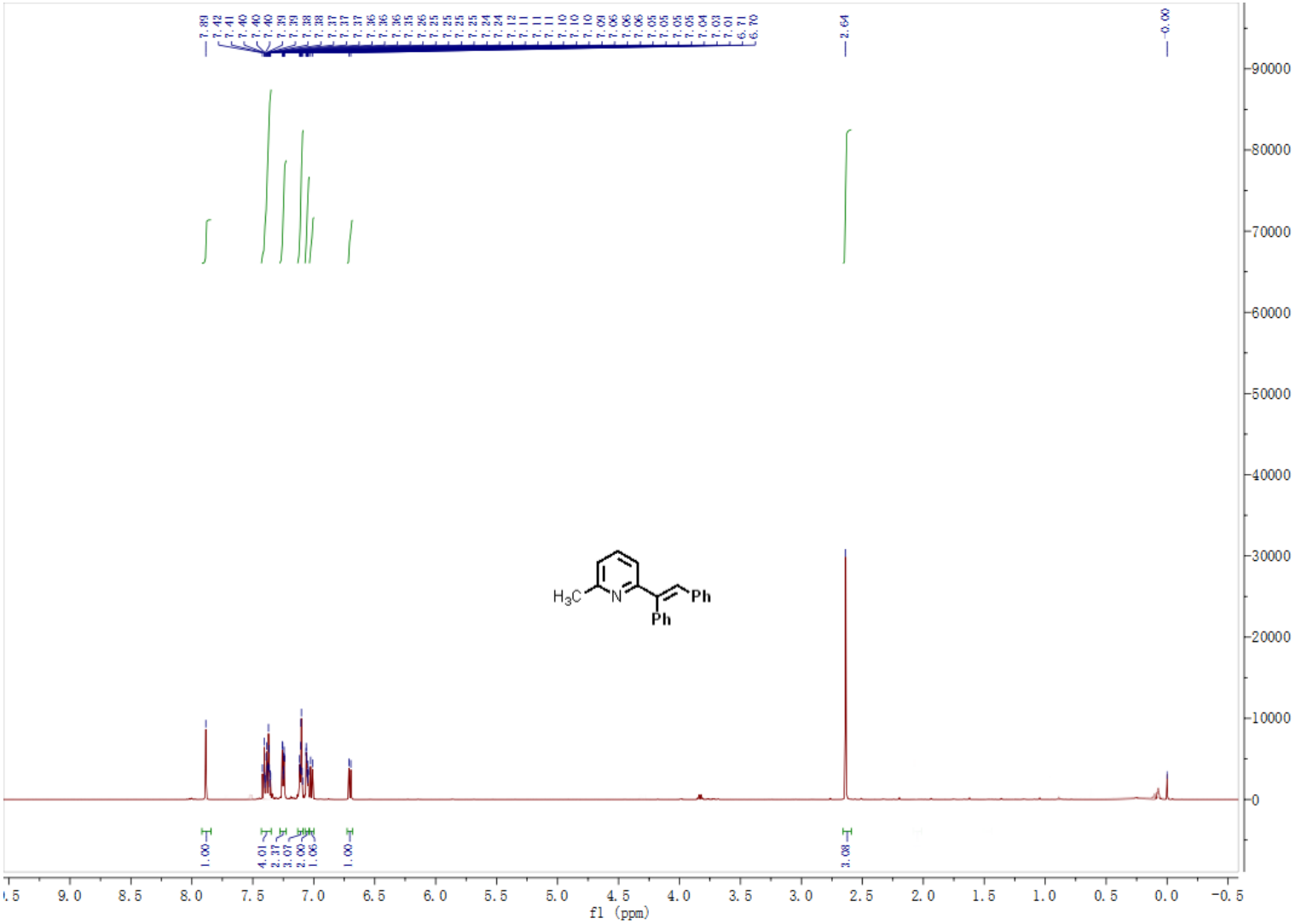

7.27
6.93
4.33
4.32
4.31
4.30
4.30
4.29
4.28
4.27
4.27
2.09
2.06
1.90
1.87
1.77
1.74
1.69
1.68
1.66
1.66
1.64
1.63
1.61
1.61
1.50
1.47
1.44
1.43
1.42
1.27
1.26
1.24
1.23
1.23
1.22
1.21
1.20
0.00
N
N
Cu
Cl
2.00
2.05
3.84
4.12
2.13
4.08
4.40
2.40
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

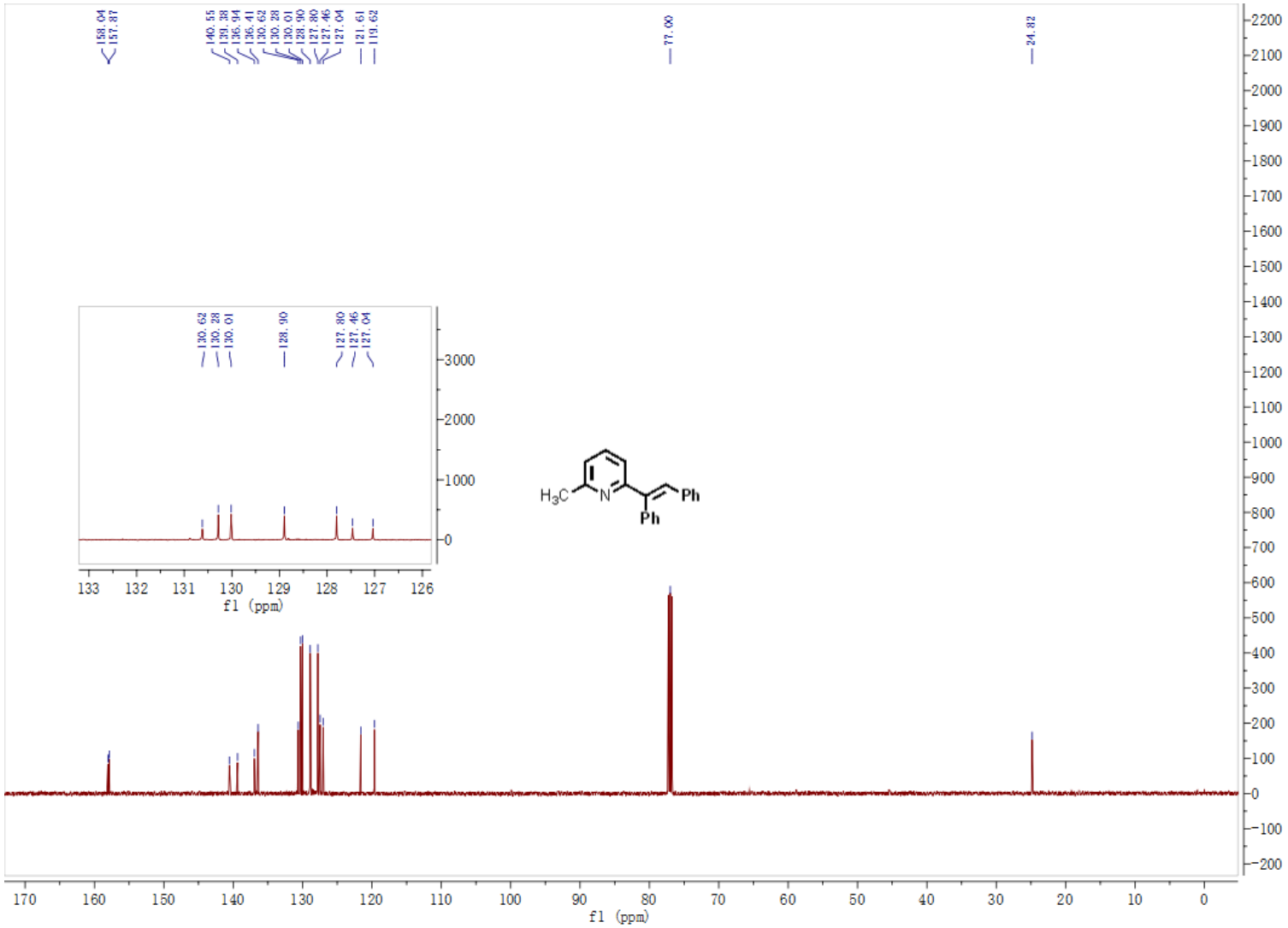

7.43
7.41
7.26
7.26
7.16
7.14
2.37
0.00
Me
Me
3.92
3.92
6.00
f1 (ppm)

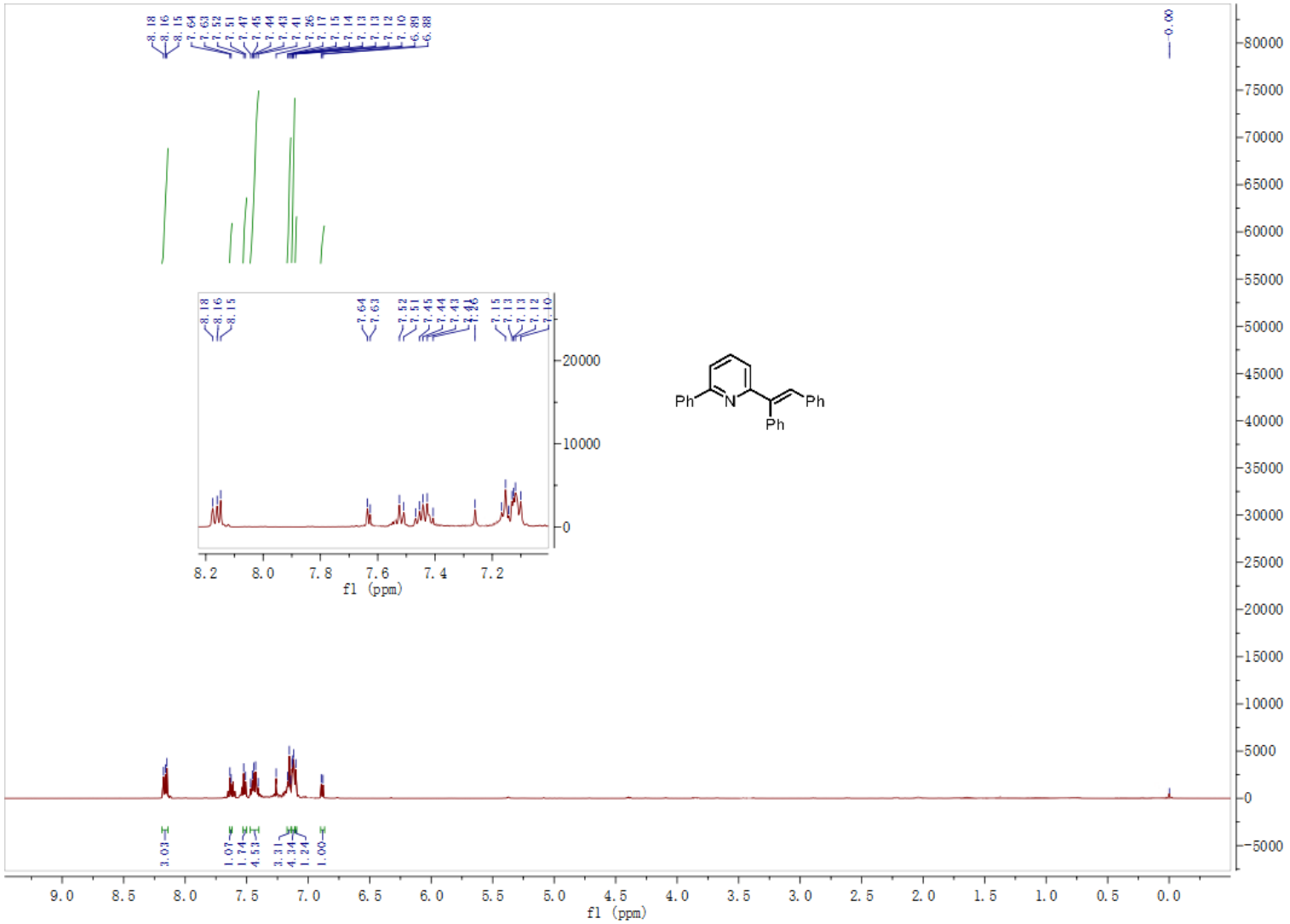

7.46
7.45
7.45
7.44
7.44
7.43
7.34
7.34
7.33
7.32
7.32
7.31
7.26
-0.00
Cl
Cl
4.00
4.00
120000
110000
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
-10000
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

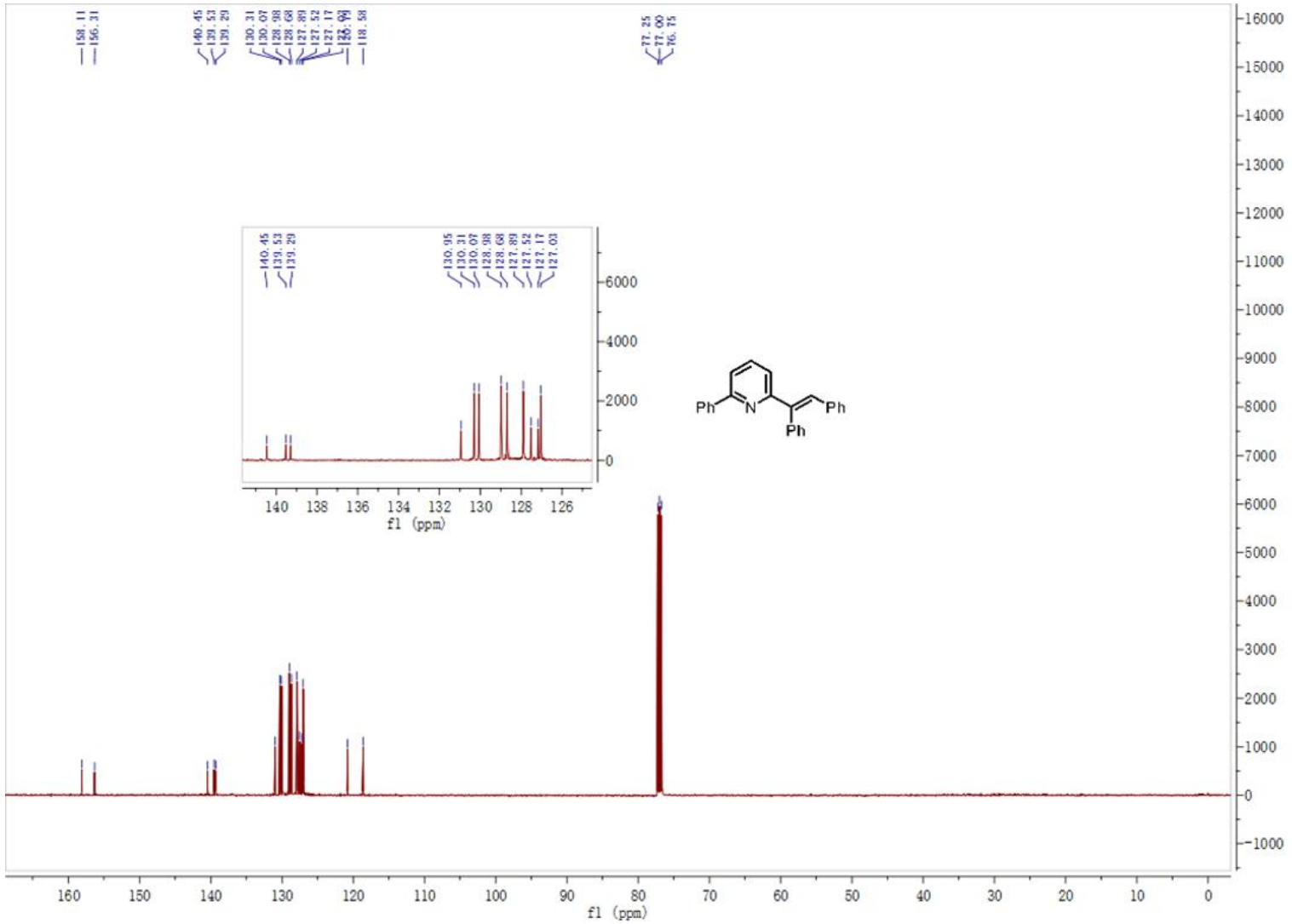

7.50
7.50
7.48
7.48
7.39
7.39
7.37
7.37
7.26
0.00
0.00
Br
Br
4.00
3.96
f1 (ppm)

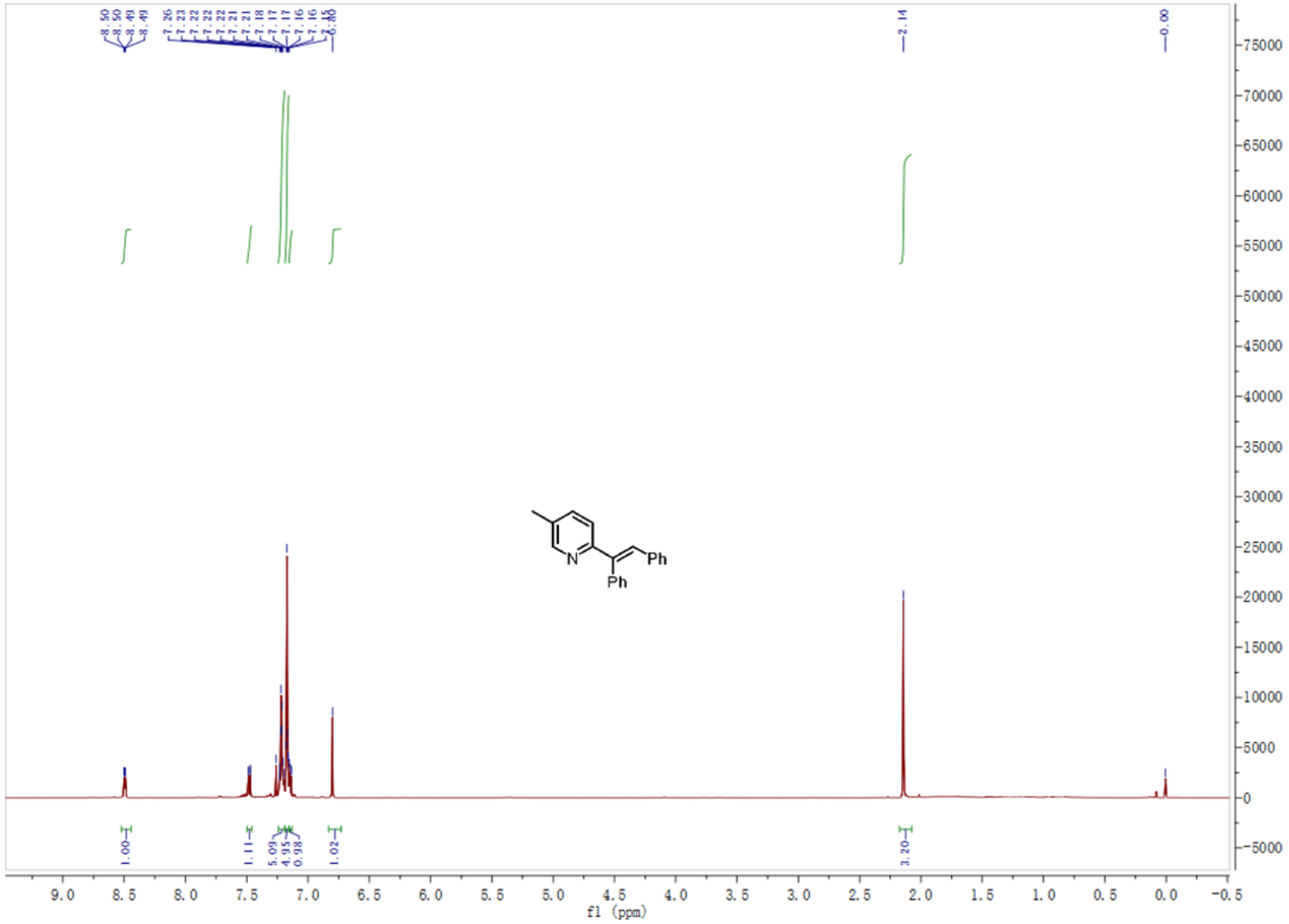

7.32
7.31
7.29
7.29
7.26
7.03
7.02
7.02
7.01
0.02
7.5 7.4 7.3 7.2 7.1 7.0 6.9 6.8
f1 (ppm)
1.97
1.99
2.05
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)
S
S

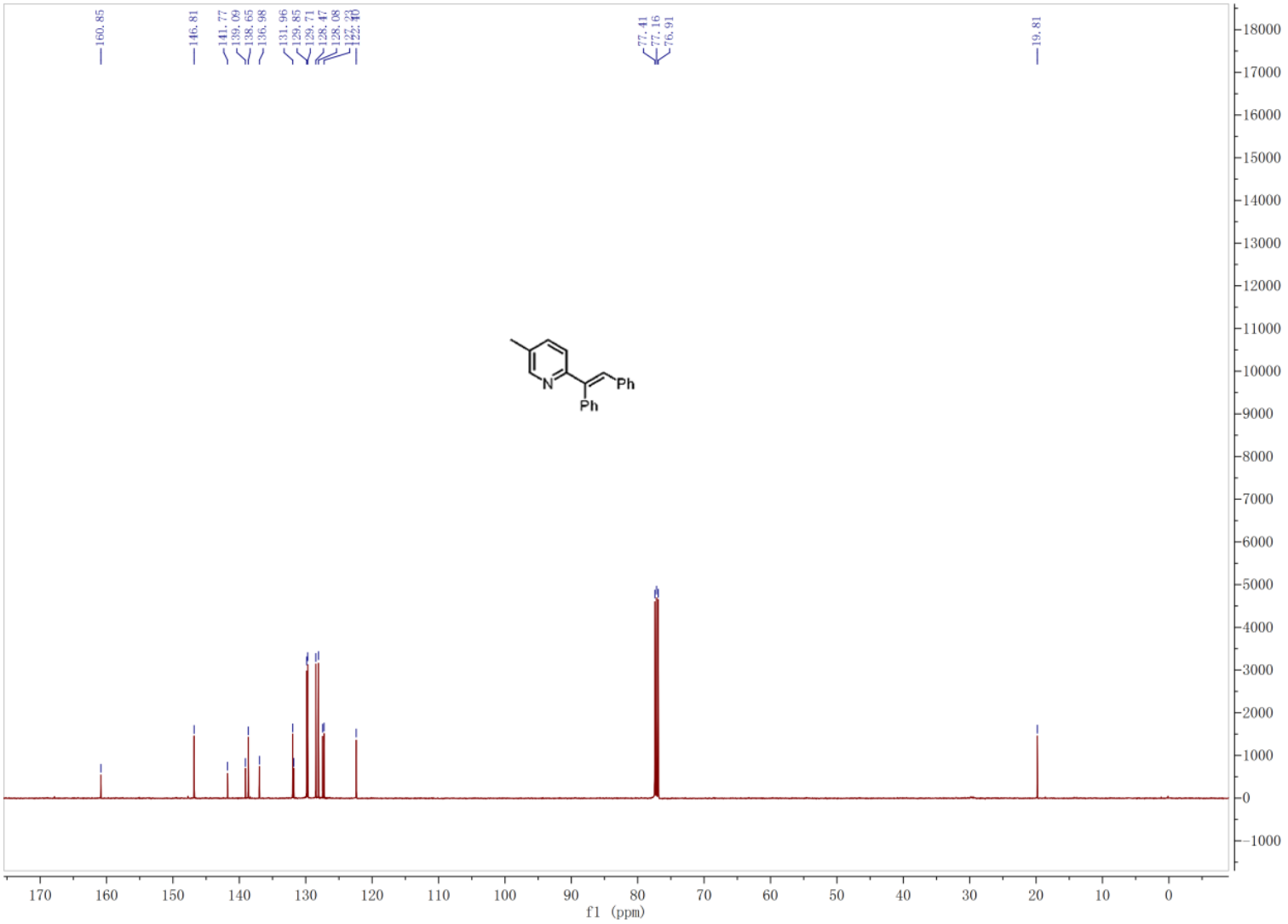

7.89
7.42
7.41
7.40
7.40
7.40
7.39
7.39
7.38
7.38
7.37
7.37
7.37
7.36
7.36
7.36
7.35
7.25
7.25
7.25
7.25
7.24
7.24
7.12
7.11
7.11
7.10
7.10
7.10
7.09
7.06
7.06
7.05
7.05
7.05
7.04
7.03
7.01
6.71
6.70
2.64
0.00
H3C
N
Ph
Ph
1.00
4.01
2.37
3.07
2.00
1.06
1.00
3.08
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

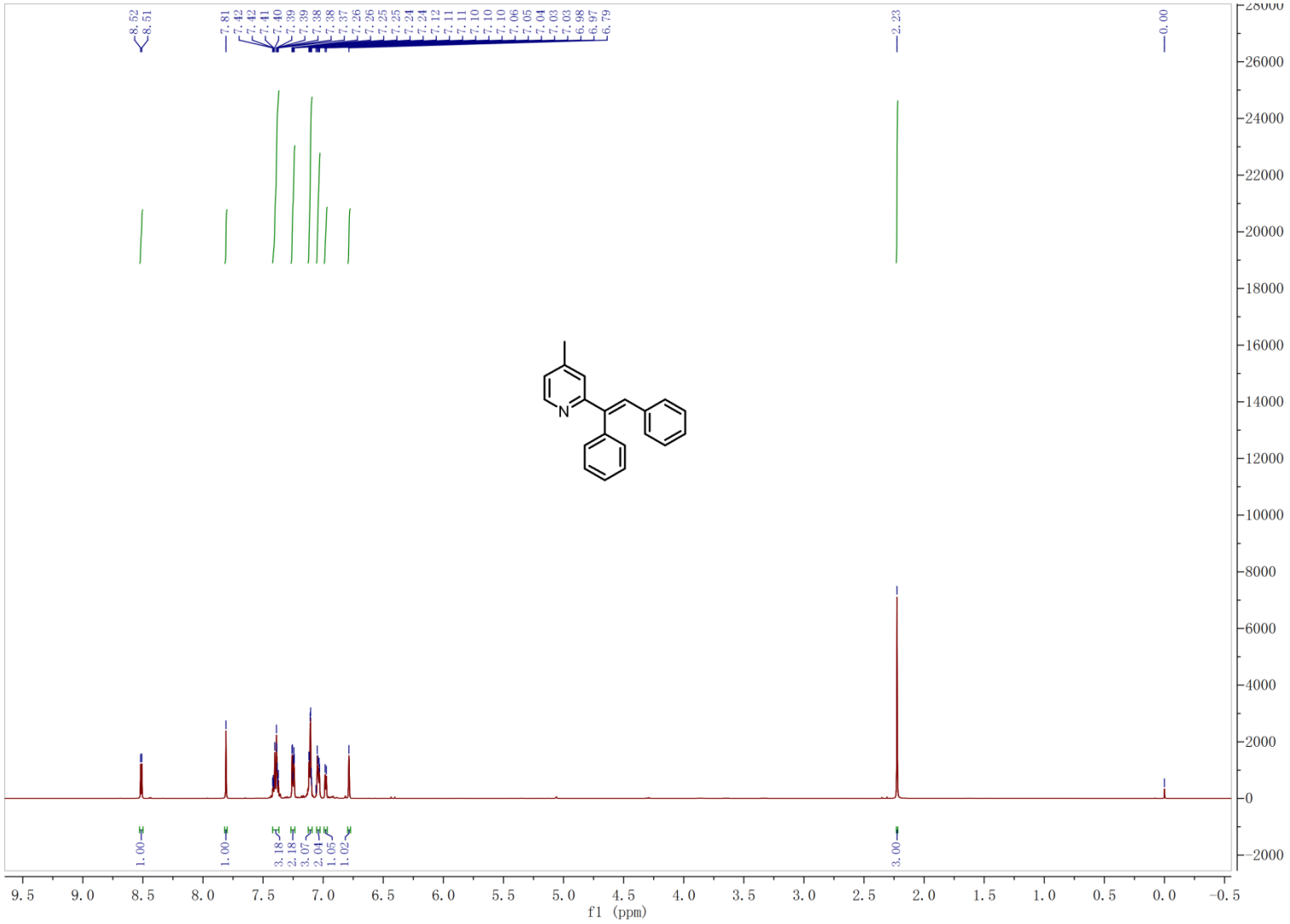

158.04
157.87
140.55
139.38
136.94
136.41
130.62
130.28
130.01
128.90
127.80
127.46
127.04
121.61
119.62
77.00
24.82
130.62
130.28
130.01
128.90
127.80
127.46
127.04
3000
2000
1000
0
133 132 131 130 129 128 127 126
f1 (ppm)
H3C
N
Ph
Ph
2200 2100 2000 1900 1800 1700 1600 1500 1400 1300 1200 1100 1000 900 800 700 600 500 400 300 200 100 0 -100 -200
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)


8.18
8.16
8.15
7.64
7.63
7.52
7.51
7.47
7.45
7.44
7.43
7.41
7.26
7.17
7.15
7.14
7.13
7.13
7.12
7.10
6.89
6.88
0.00
Ph
N
Ph
Ph
f1 (ppm)
f1 (ppm)
3.03
1.07
1.74
4.53
3.31
4.34
1.24
1.00


158.11
156.31
140.45
139.53
139.29
130.31
130.07
128.98
128.68
127.89
127.52
127.17
118.58
77.25
77.00
76.75
130.95
130.31
130.07
128.98
128.68
127.89
127.52
127.17
127.03
f1 (ppm)
Ph
N
Ph
Ph
f1 (ppm)


8.50
8.50
8.49
8.49
7.26
7.23
7.22
7.22
7.22
7.21
7.21
7.18
7.17
7.17
7.16
7.16
7.15
7.15
2.14
0.00
N
Ph
Ph
1.00
1.11
5.09
4.95
0.98
1.02
3.20
fl (ppm)


160.85
146.81
141.77
139.09
138.65
136.98
131.96
129.85
129.71
128.47
128.08
77.41
77.16
76.91
19.81
N
Ph
Ph
18000
17000
16000
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
−1000
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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8.51
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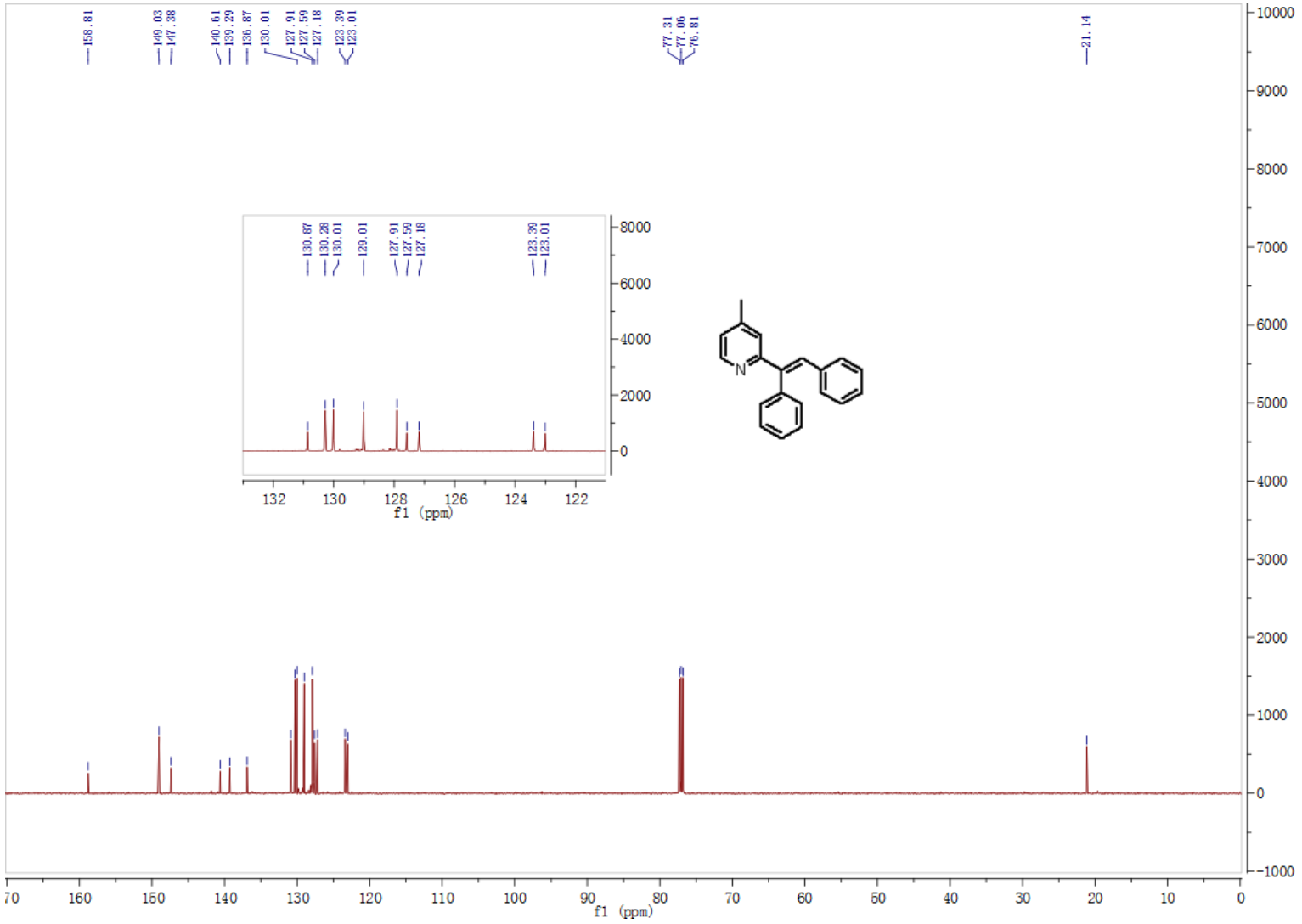
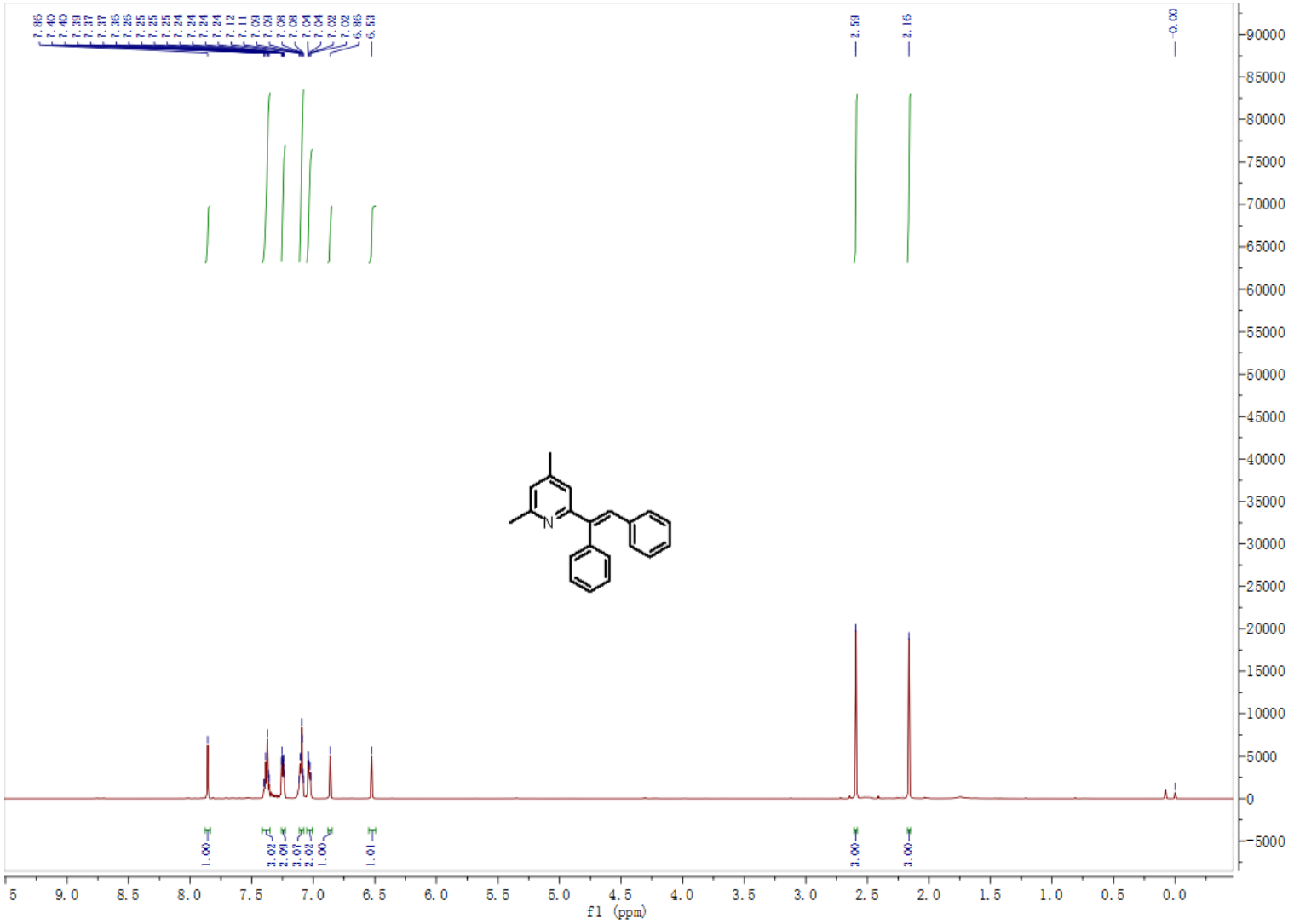
7.42
7.42
7.41
7.40
7.39
7.39
7.38
7.38
7.37
7.26
7.26
7.25
7.25
7.24
7.24
7.12
7.11
7.11
7.10
7.10
7.10
7.06
7.05
7.04
7.03
6.98
6.97
6.79
2.23
0.00
N
1.00
1.00
3.18
2.18
3.07
2.04
1.05
1.02
3.00
f1 (ppm)


158.81
149.03
147.38
140.61
139.29
136.87
130.01
127.91
127.59
127.18
123.39
123.01
77.31
77.06
76.81
21.14
130.87
130.28
130.01
129.01
127.91
127.59
127.18
123.39
123.01
f1 (ppm)
f1 (ppm)


7.86
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7.40
7.39
7.37
7.37
7.36
7.26
7.25
7.25
7.25
7.24
7.24
7.24
7.24
7.12
7.11
7.09
7.09
7.08
7.08
7.04
7.04
7.02
7.02
6.86
6.53
2.59
2.16
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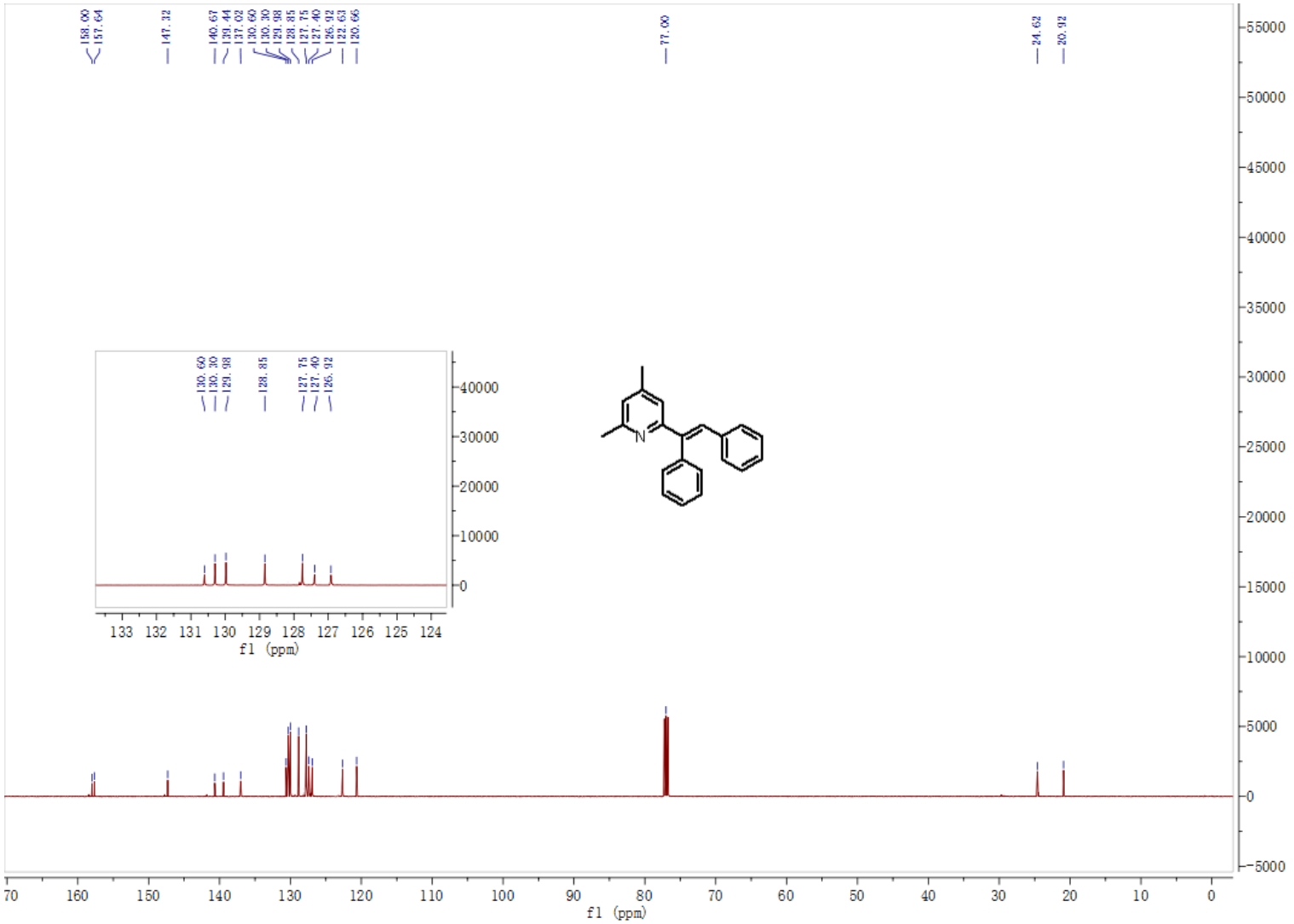
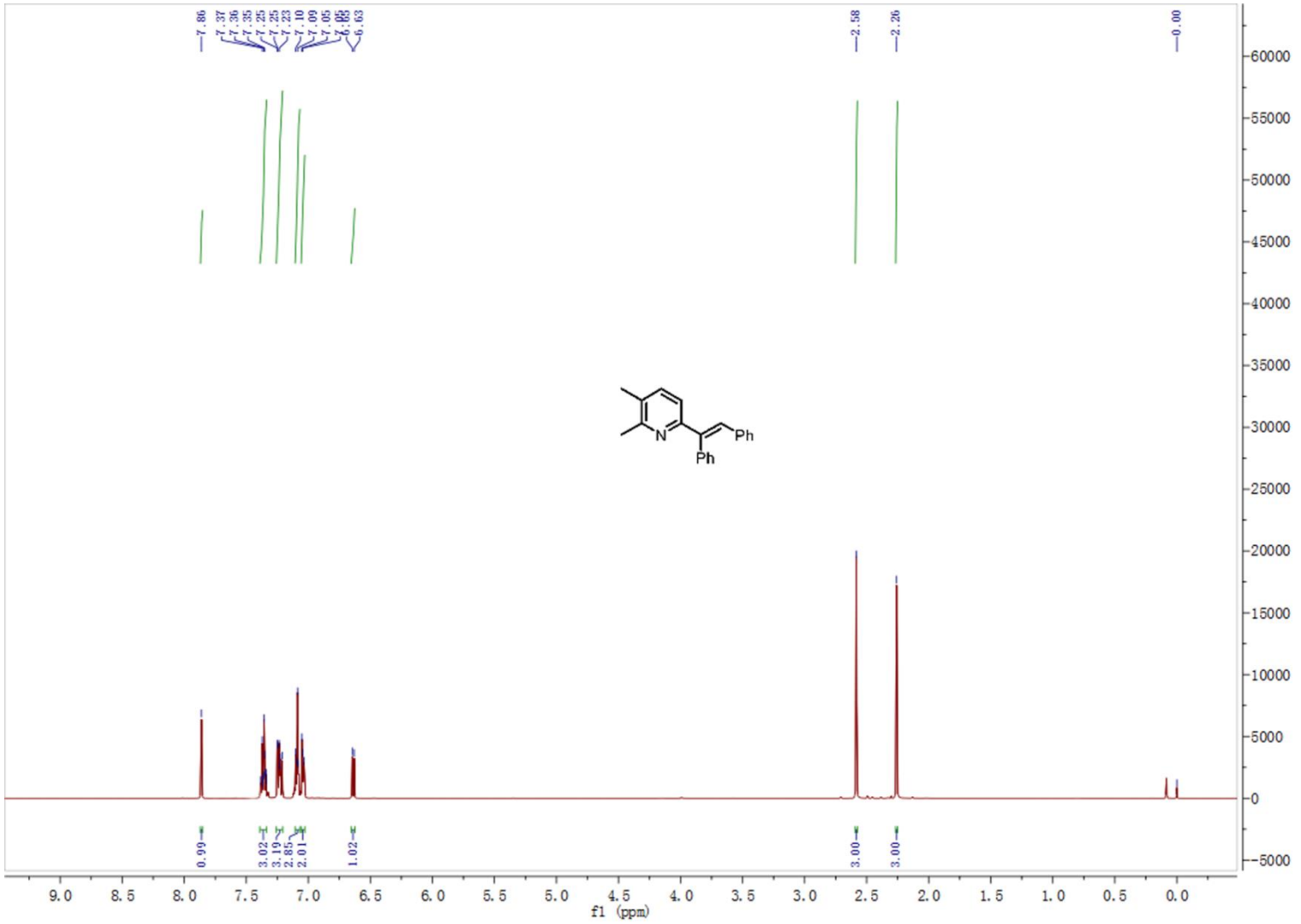
N
1.00
3.02
2.01
3.07
2.02
1.00
1.01
3.00
3.00
f1 (ppm)


158.00
157.64
147.32
140.67
139.44
137.02
130.60
130.30
129.98
128.85
127.75
127.40
126.92
122.63
120.66
77.00
24.62
20.92
55000
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
-5000
70 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)
130.60
130.30
129.98
128.85
127.75
127.40
126.92
40000
30000
20000
10000
0
133 132 131 130 129 128 127 126 125 124
f1 (ppm)
N


7.86
7.37
7.36
7.35
7.25
7.25
7.23
7.10
7.09
7.05
6.63
2.58
2.26
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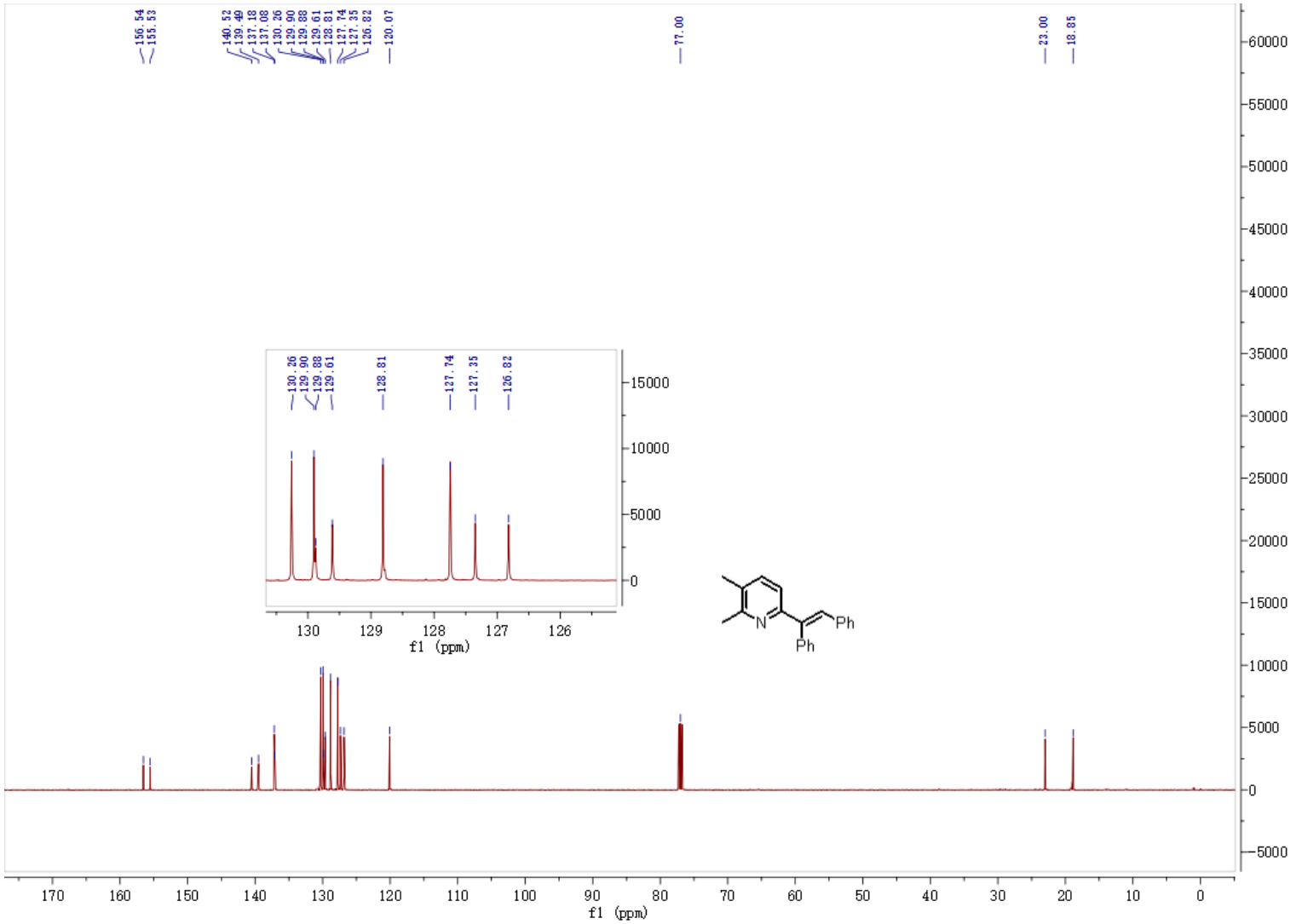
N
Ph
Ph
0.99
3.02
3.19
2.85
2.01
1.02
3.00
3.00
f1 (ppm)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155.53
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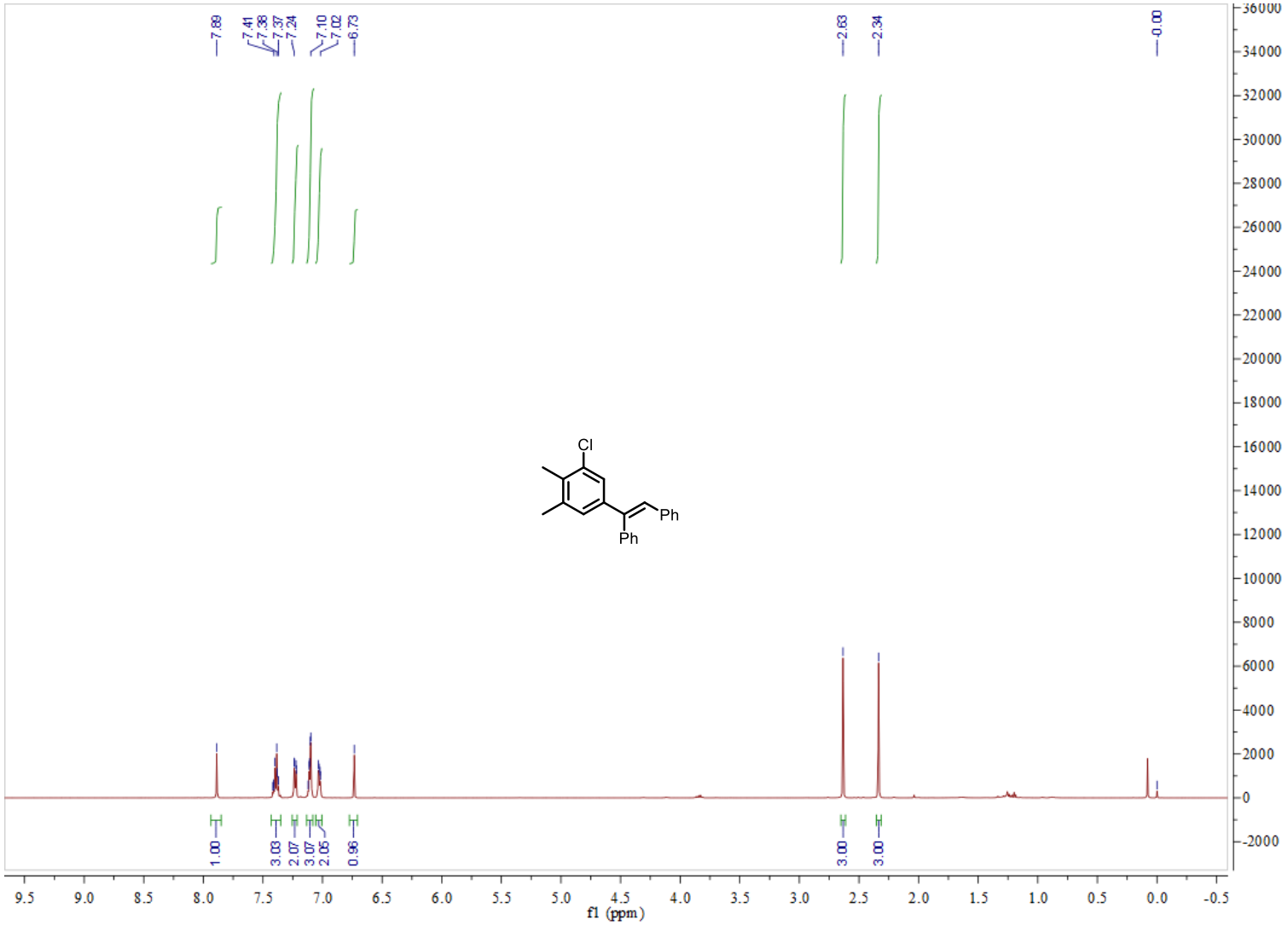
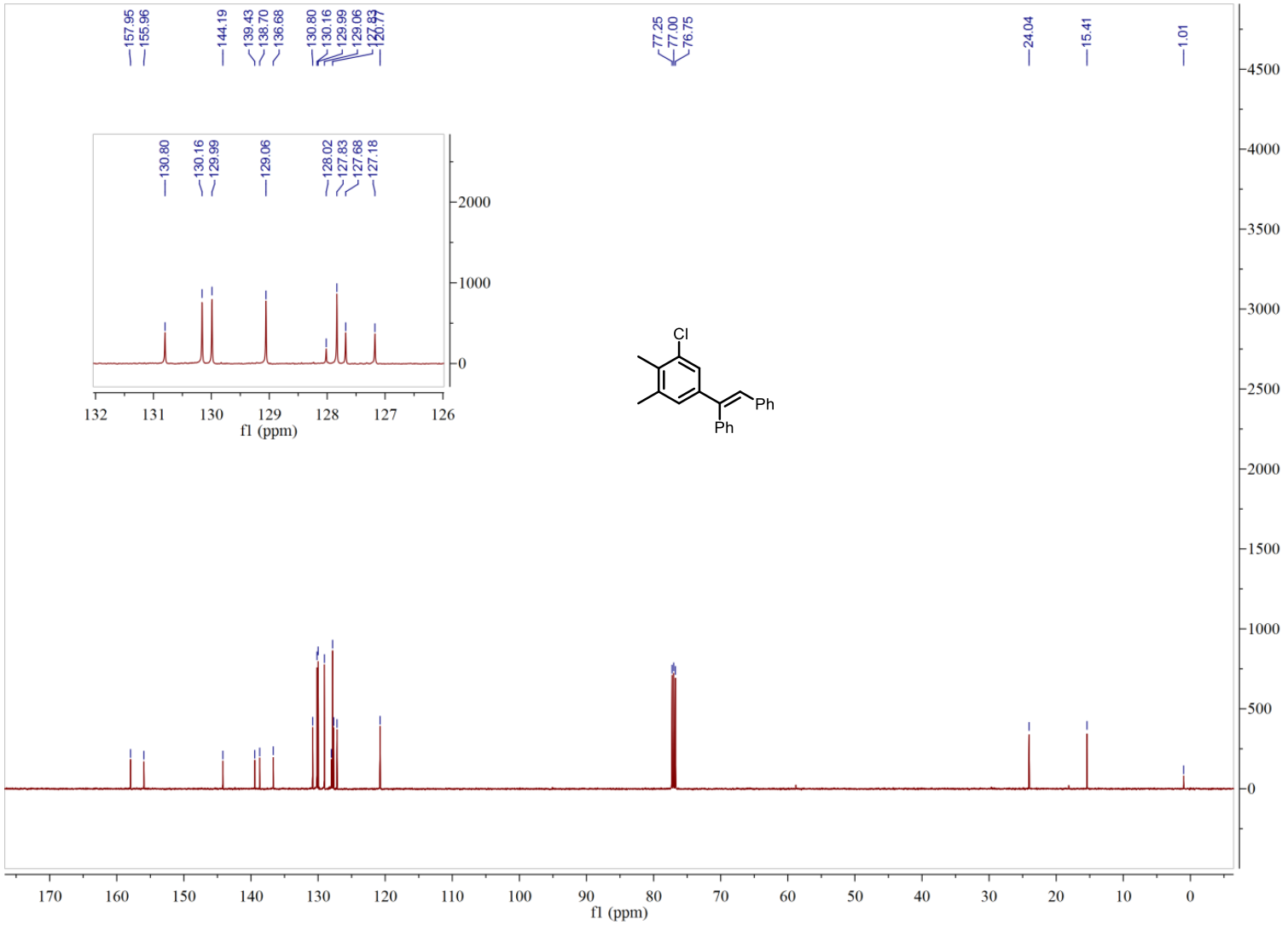
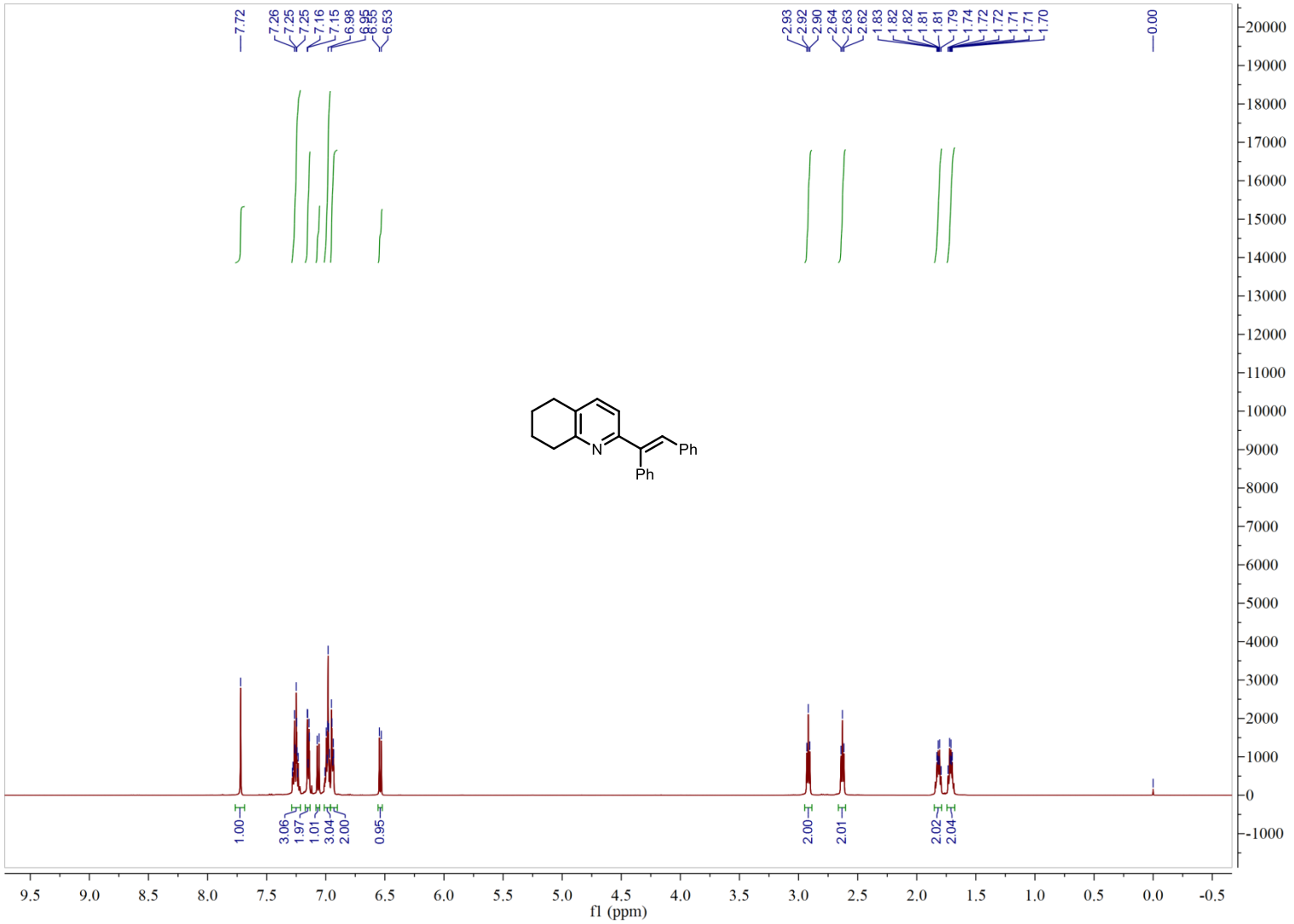
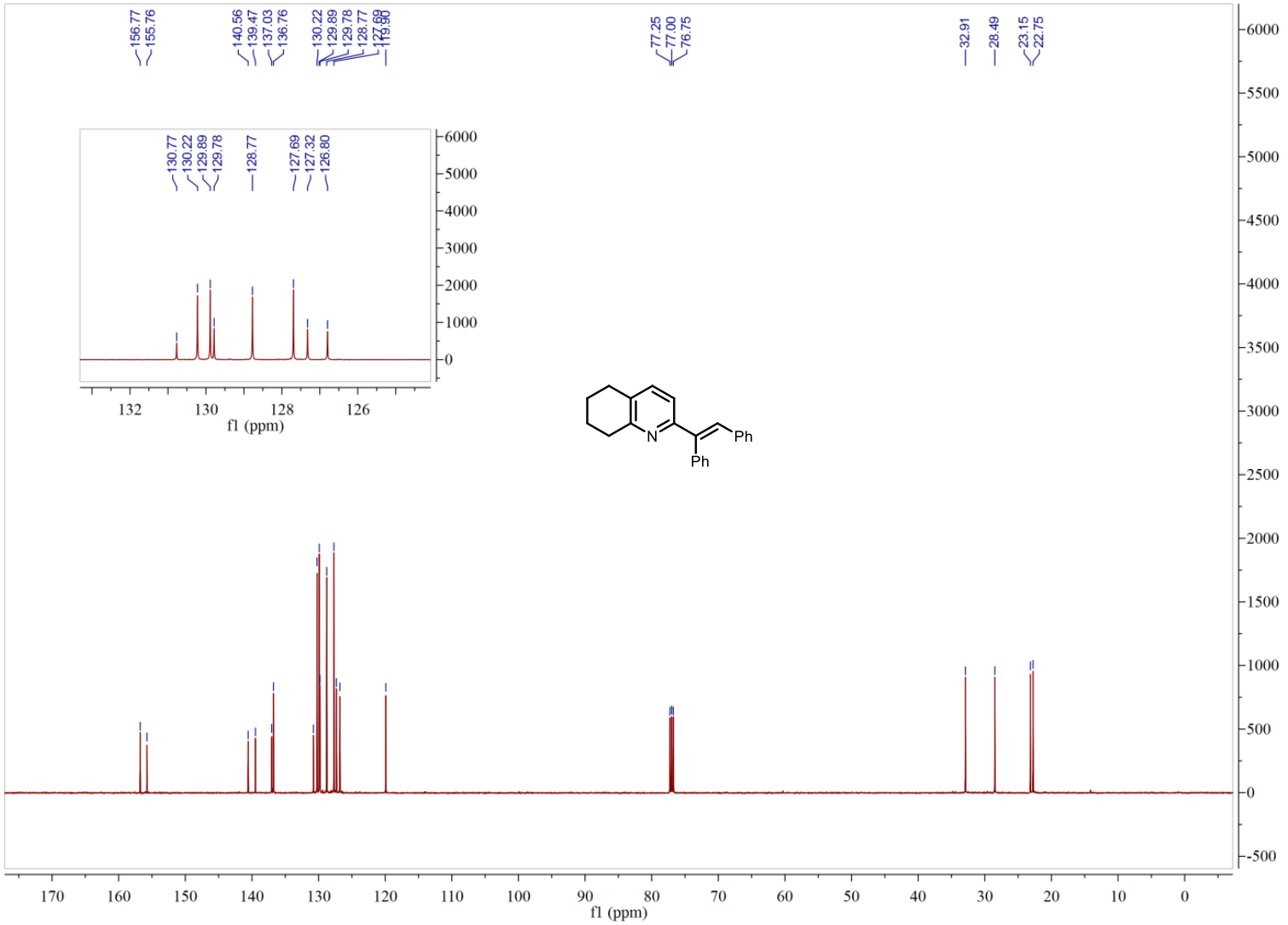
139.49
137.18
137.08
130.26
129.90
129.88
129.61
128.81
127.74
127.35
126.82
120.07
77.00
23.00
18.85
f1 (ppm)
Ph
Ph
N


7.89
7.41
7.38
7.37
7.24
7.10
7.02
6.73
2.63
2.34
0.00
Cl
Ph
Ph
1.00
3.03
2.07
3.07
2.05
0.96
3.00
3.00
f1 (ppm)


157.95
155.96
144.19
139.43
138.70
136.68
130.80
130.16
129.99
129.06
127.83
127.68
127.18
77.25
77.00
76.75
24.04
15.41
1.01
fl (ppm)
Cl
Ph
Ph


7.72
7.26
7.25
7.25
7.16
7.15
6.98
6.55
6.53
2.93
2.92
2.90
2.64
2.63
2.62
1.83
1.82
1.82
1.81
1.81
1.79
1.74
1.72
1.72
1.71
1.71
1.70
0.00
N
Ph
Ph
1.00
3.06
1.97
1.01
3.04
2.00
0.95
2.00
2.01
2.02
2.04
fl (ppm)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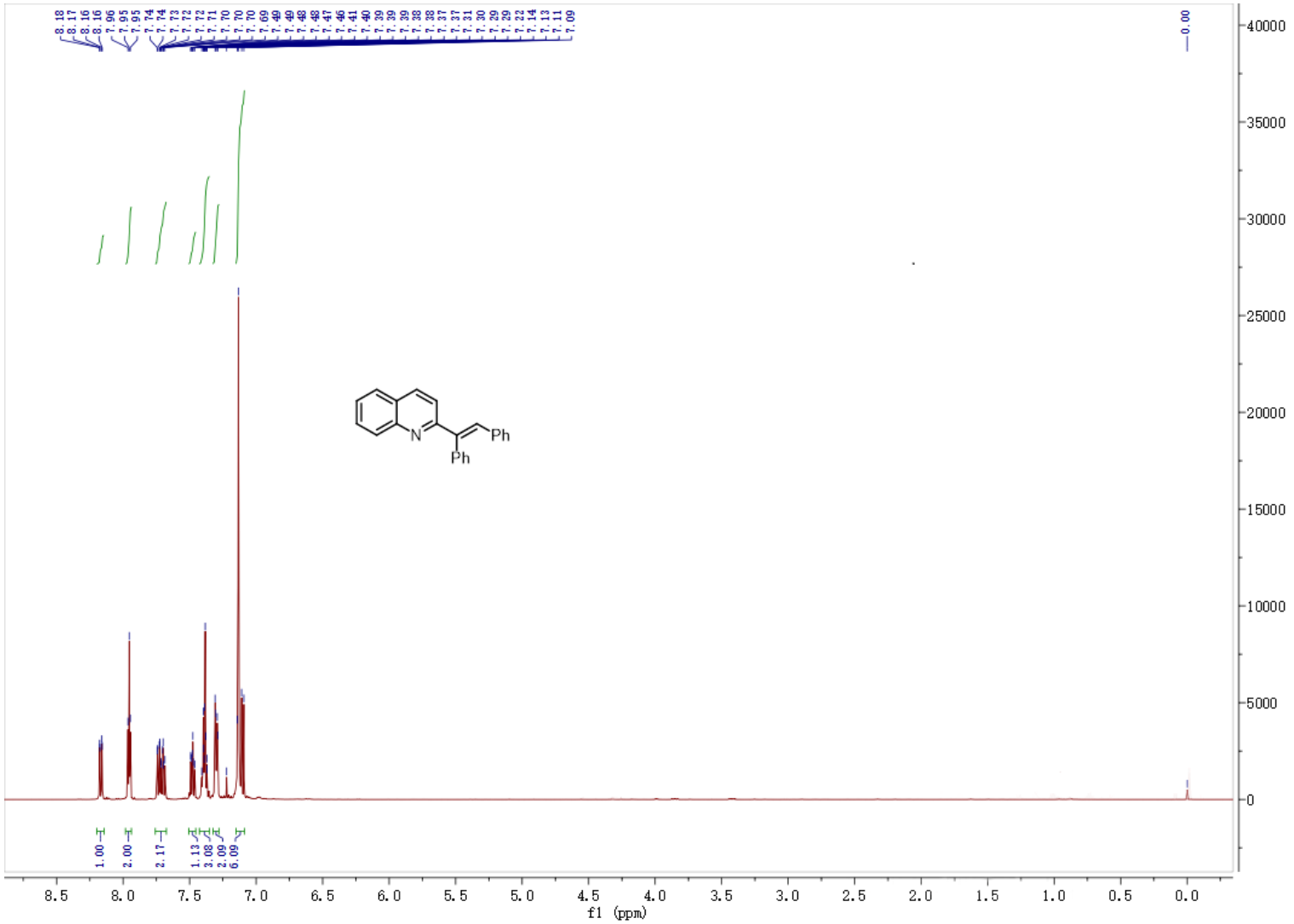
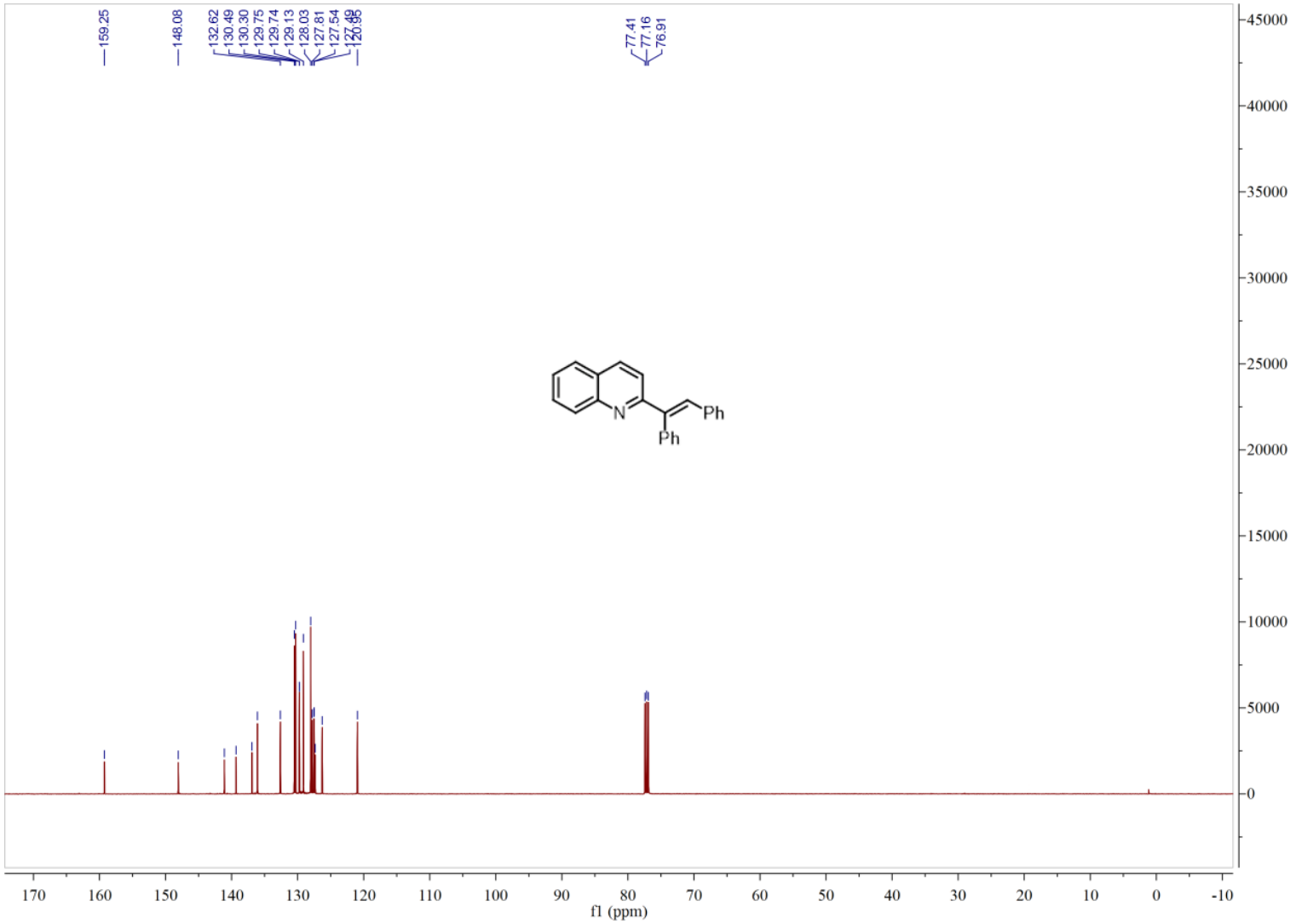
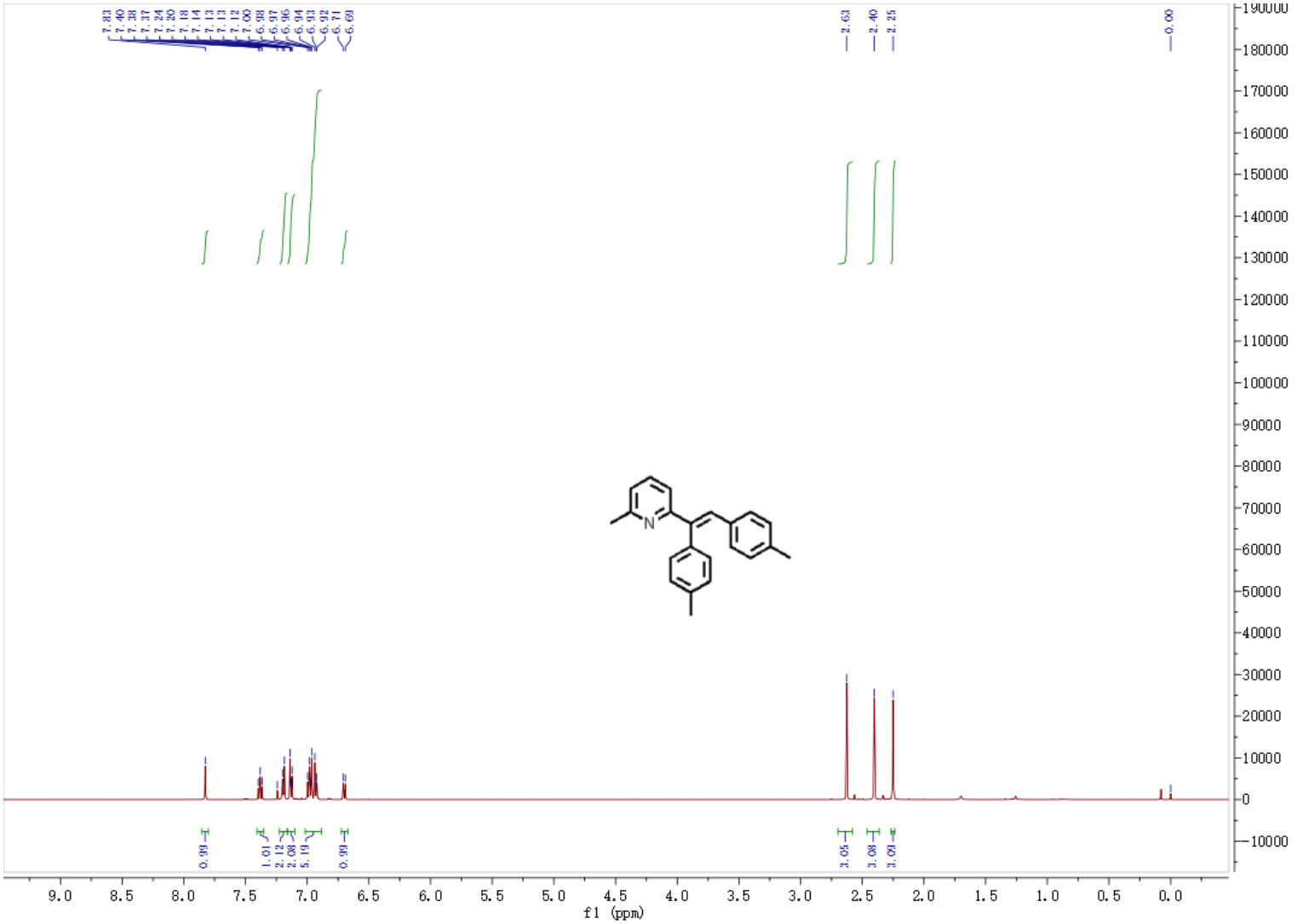
139.47
137.03
136.76
130.22
129.89
129.78
128.77
77.25
77.00
76.75
32.91
28.49
23.15
22.75
130.77
130.22
129.89
129.78
128.77
127.69
127.32
126.80
fl (ppm)
N
Ph
Ph
fl (ppm)


8.18
8.17
8.16
8.16
7.96
7.95
7.95
7.74
7.74
7.73
7.72
7.72
7.71
7.70
7.70
7.70
7.69
7.49
7.48
7.48
7.47
7.46
7.41
7.40
7.39
7.39
7.39
7.38
7.38
7.37
7.31
7.31
7.30
7.29
7.29
7.23
7.14
7.13
7.11
7.09
0.00
N
Ph
Ph
1.00
2.00
2.17
1.13
3.08
2.09
6.09
40000
35000
30000
25000
20000
15000
10000
5000
0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


159.25
148.08
132.62
130.49
130.30
129.75
129.74
129.13
128.03
127.81
127.54
77.41
77.16
76.91
N
Ph
Ph
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)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7.40
7.38
7.37
7.24
7.20
7.18
7.14
7.13
7.13
7.12
7.00
6.98
6.97
6.96
6.94
6.93
6.92
6.71
6.69
2.63
2.40
2.25
0.00
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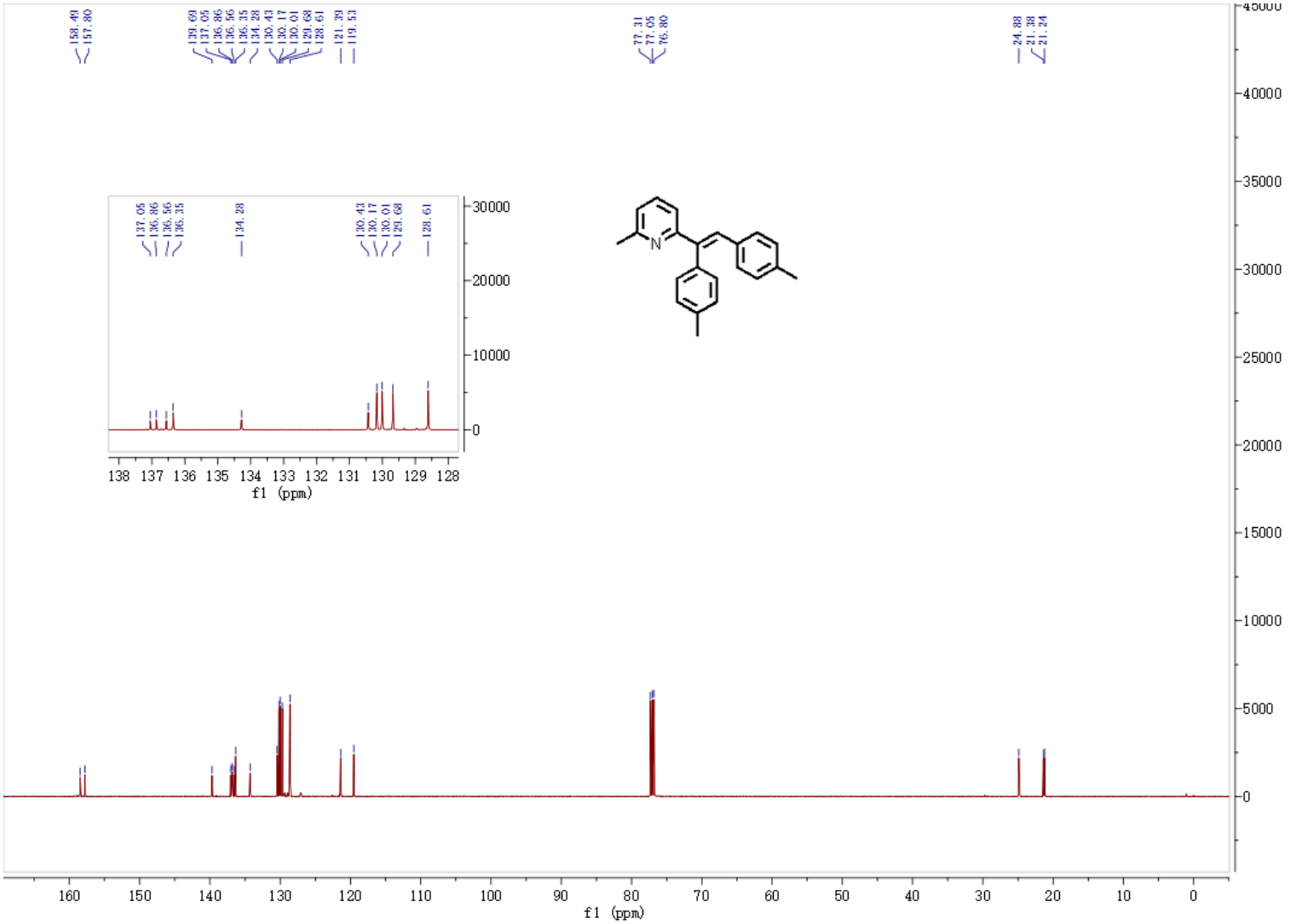
1.01
2.12
2.08
5.19
0.99
3.05
3.08
3.09
f1 (ppm)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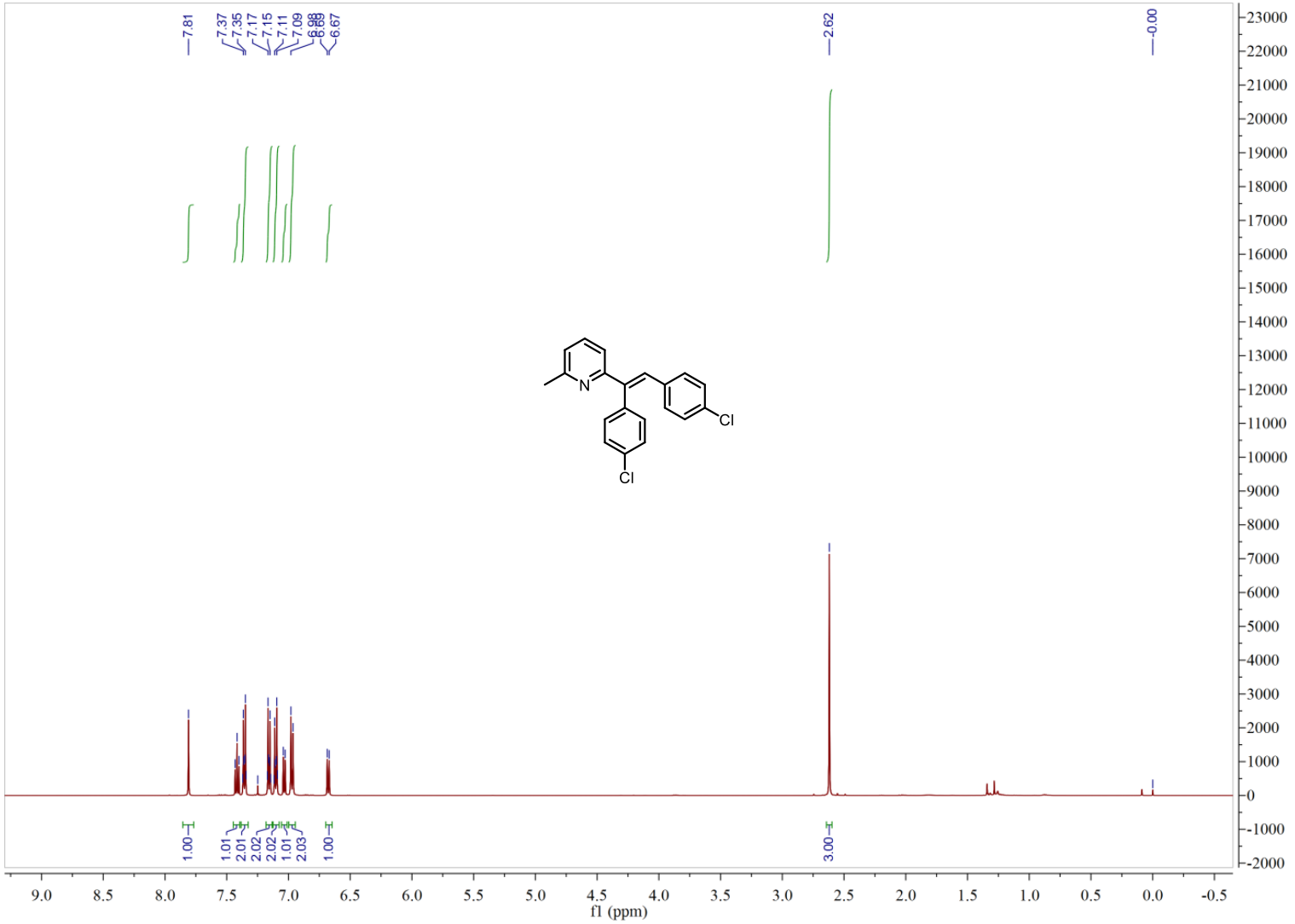
136.86
136.56
136.35
134.28
130.43
130.17
130.01
129.68
128.61
121.39
119.53
77.31
77.05
76.80
24.88
21.38
21.24
137.05
136.86
136.56
136.35
134.28
130.43
130.17
130.01
129.68
128.61
30000
20000
10000
0
138 137 136 135 134 133 132 131 130 129 128
f1 (ppm)
N
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)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7.37
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7.09
6.88
6.87
6.69
6.67
2.62
0.00
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Cl
Cl
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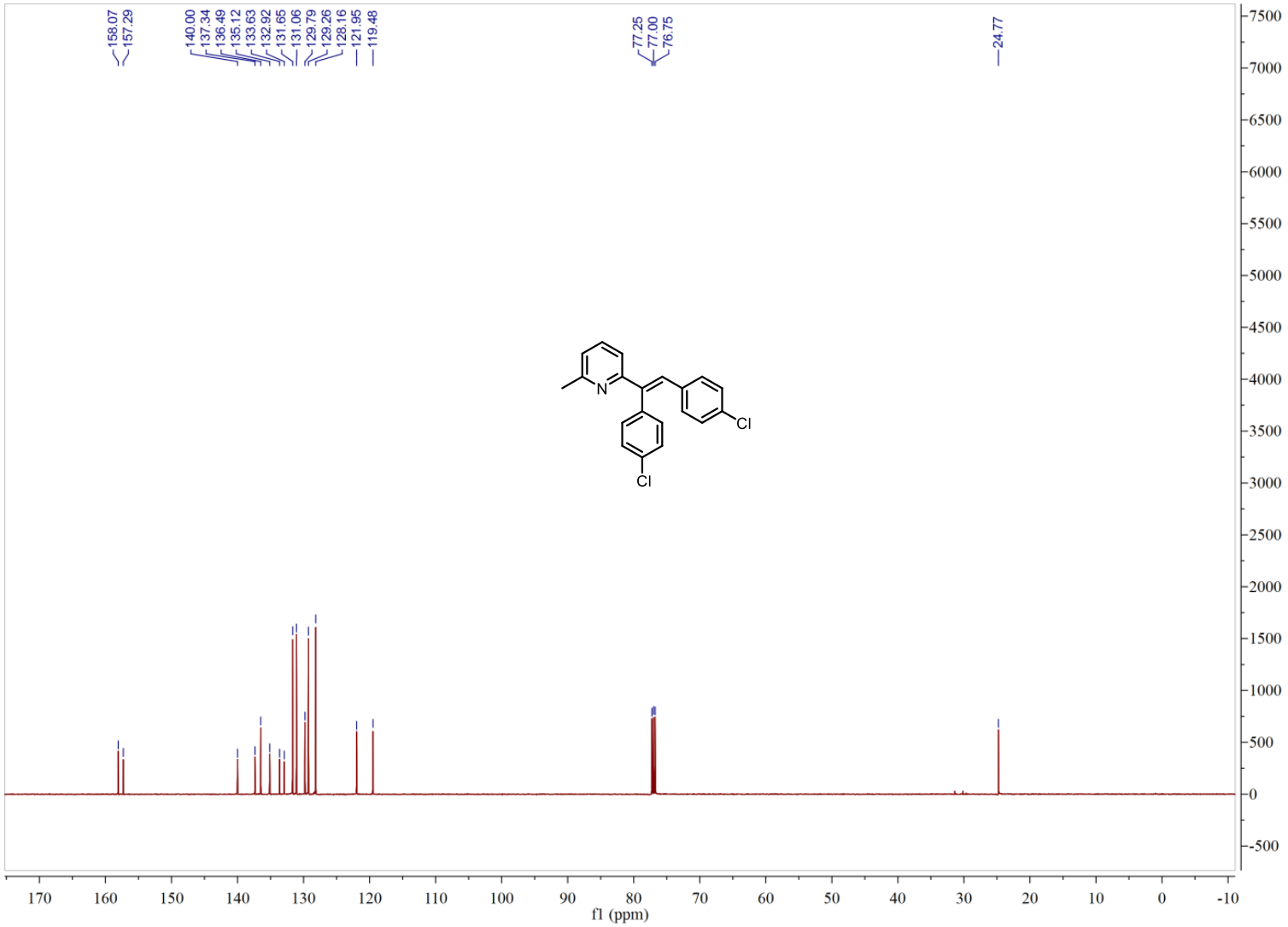
1.01
2.01
2.02
2.02
1.01
2.03
1.00
3.00
f1 (ppm)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129.26
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121.95
119.48
77.25
77.00
76.75
24.77
N
Cl
Cl
7500
7000
6500
6000
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
-500
170
160
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140
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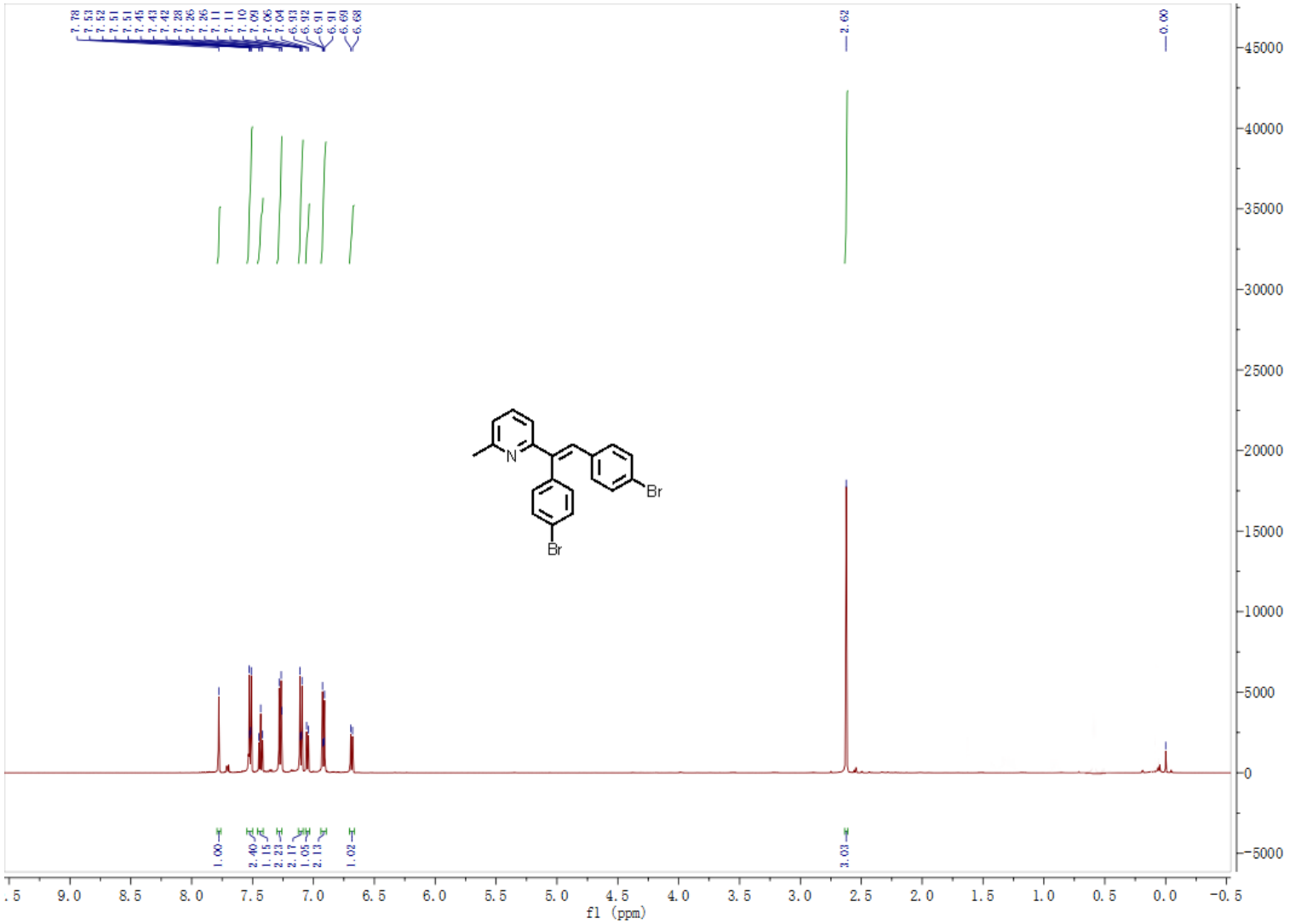
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)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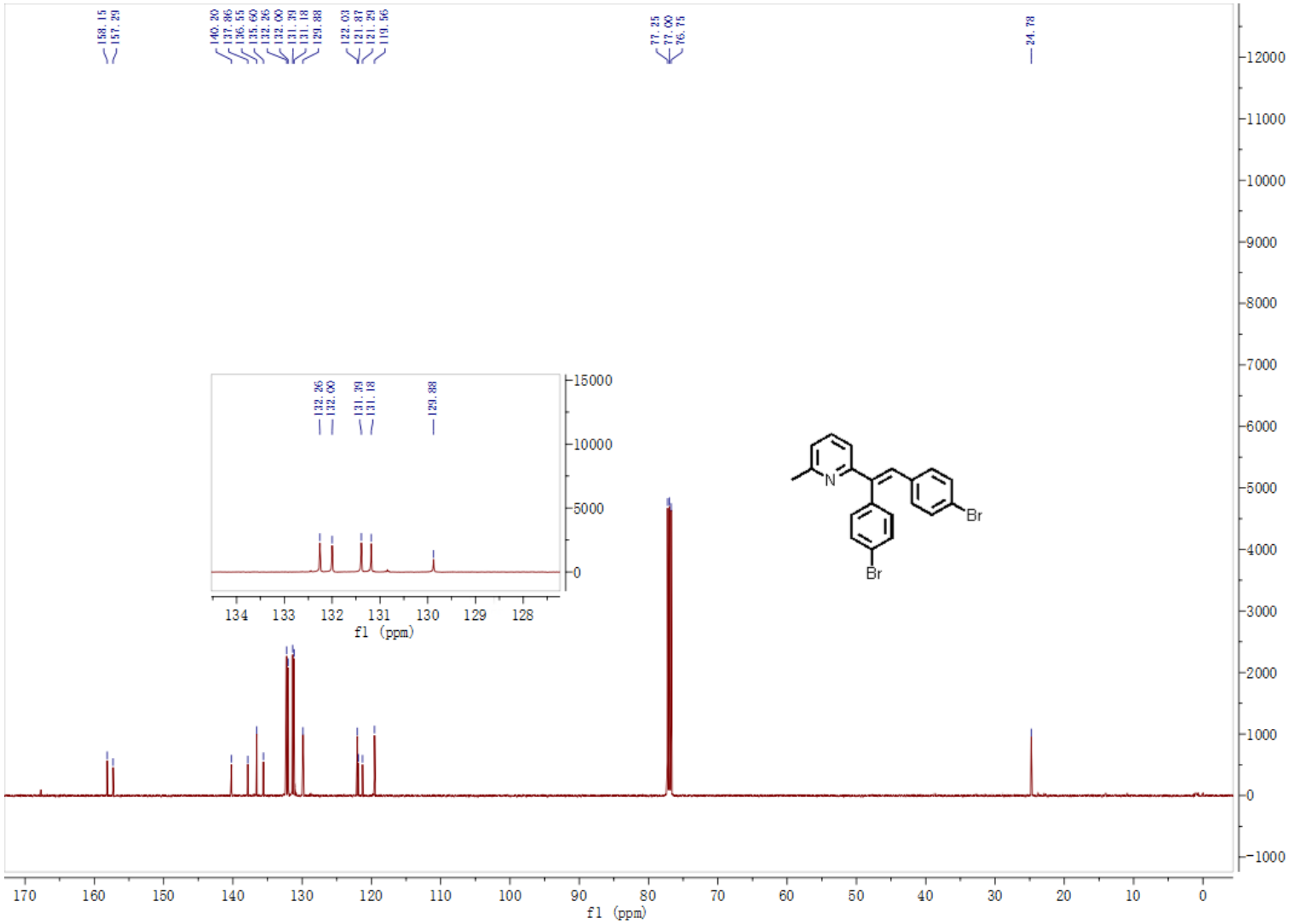
7.28
7.26
7.11
7.10
7.08
7.06
7.04
6.93
6.92
6.91
6.91
6.69
6.68
2.62
0.00
N
Br
Br
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
-5000
1.00
2.40
1.15
2.23
2.11
1.05
2.13
1.02
3.03
.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)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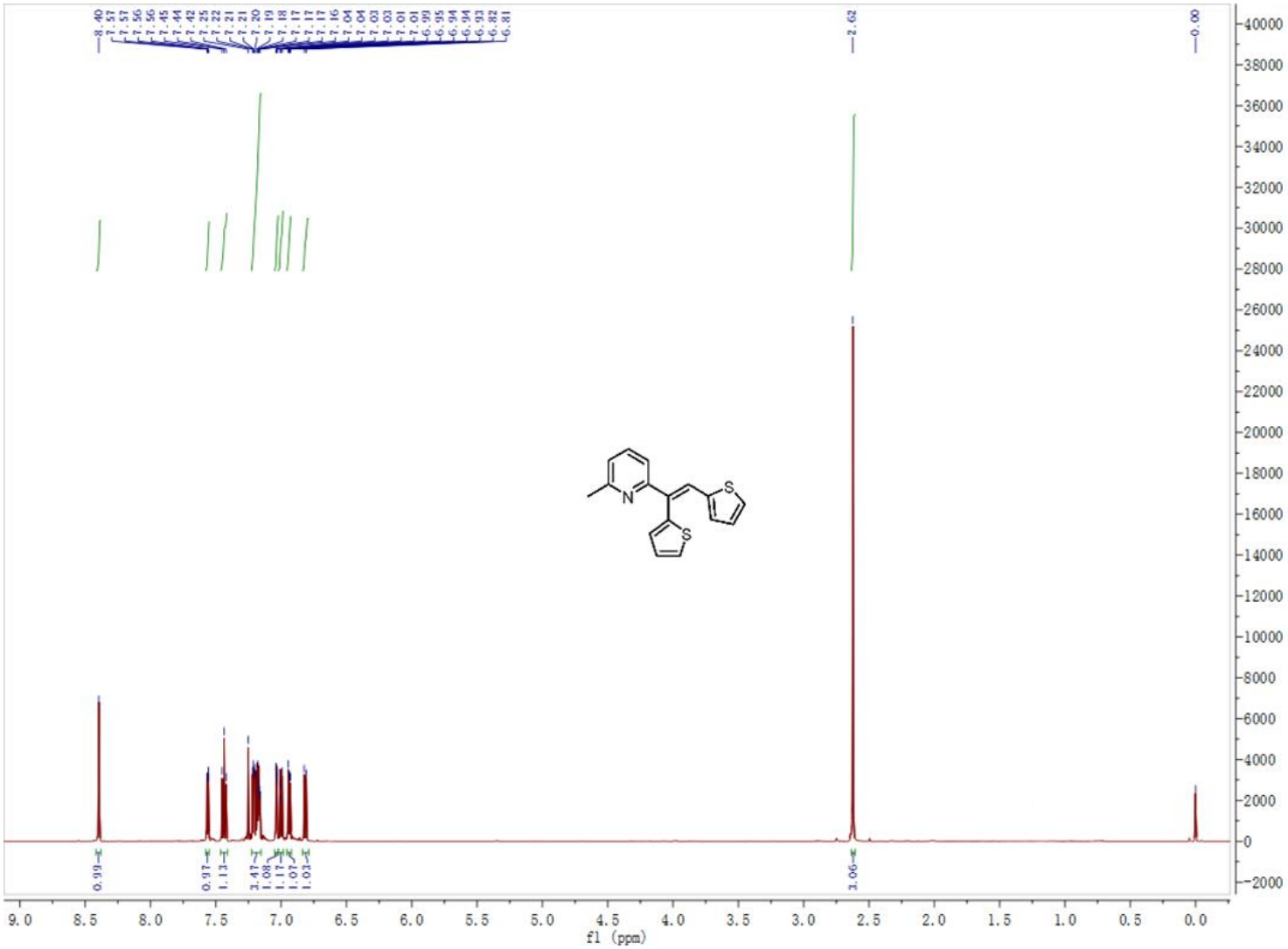
132.26
132.00
131.39
131.18
129.88
122.03
121.87
121.29
119.56
77.25
77.00
76.75
24.78
132.26
132.00
131.39
131.18
129.88
f1 (ppm)
f1 (ppm)
N
Br
Br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7.57
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7.44
7.42
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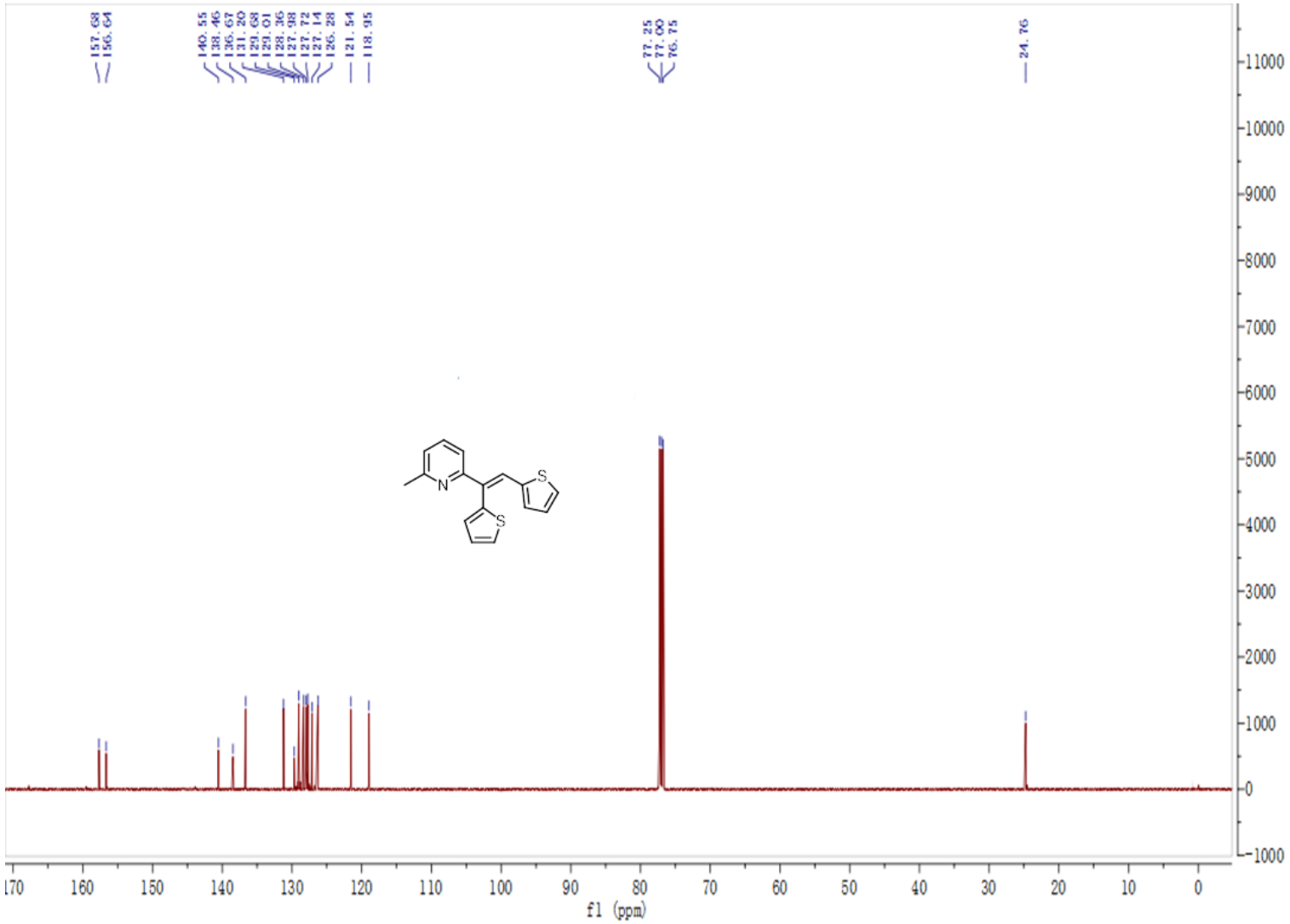
7.22
7.21
7.21
7.20
7.19
7.18
7.17
7.17
7.16
7.04
7.04
7.03
7.03
7.01
7.01
6.99
6.95
6.94
6.94
6.93
6.82
6.81
2.62
0.00
N
S
S
0.93
0.97
1.13
3.47
1.08
1.11
1.07
1.03
3.06
40000
38000
36000
34000
32000
30000
28000
26000
24000
22000
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
-2000
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)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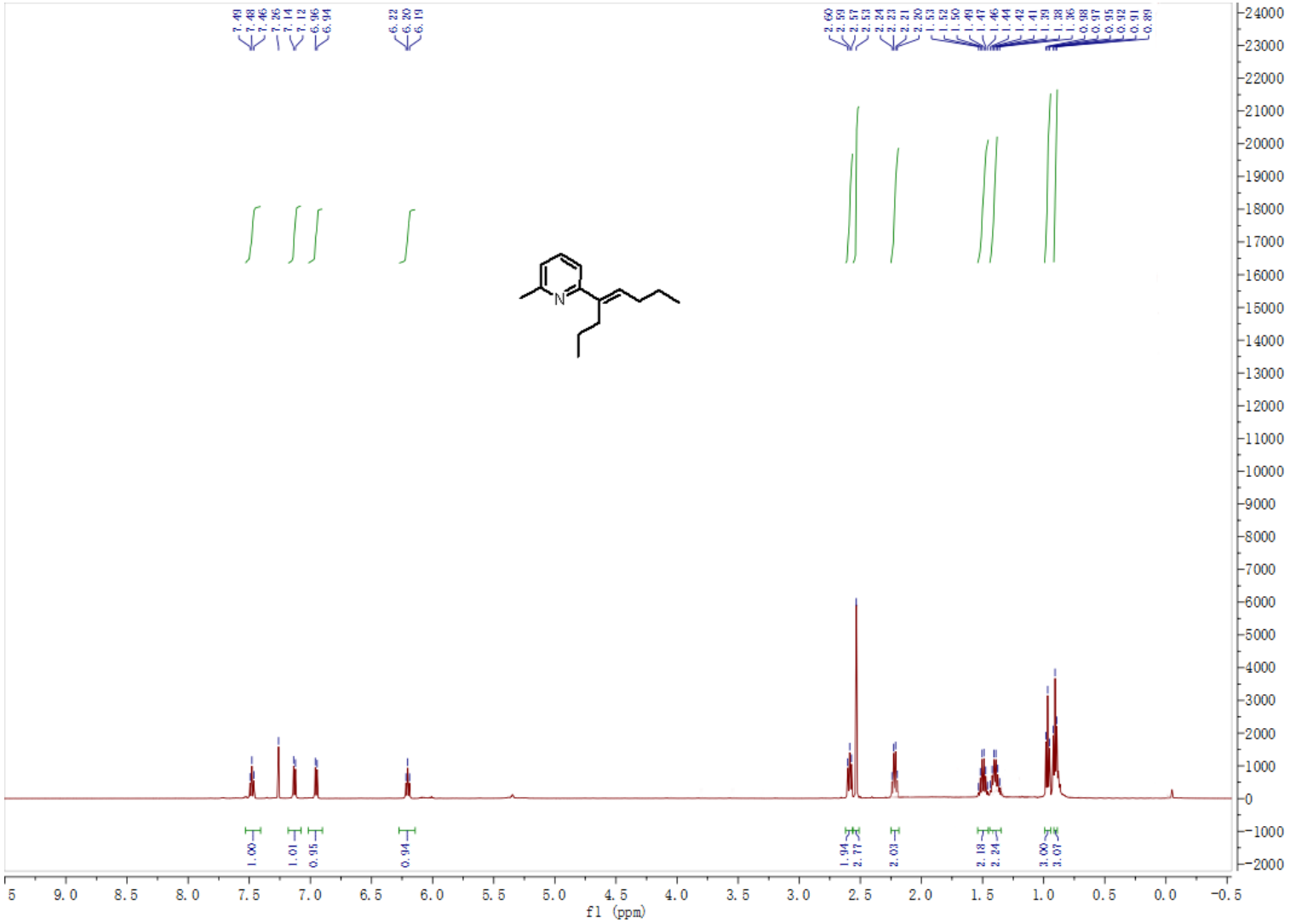
127.98
127.72
127.14
126.28
121.54
118.95
77.25
77.00
76.75
24.76
N
S
S
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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7.46
7.26
7.14
7.12
6.96
6.94
6.22
6.20
6.19
2.60
2.59
2.57
2.53
2.24
2.23
2.21
2.20
1.53
1.52
1.50
1.49
1.47
1.46
1.44
1.42
1.41
1.39
1.38
1.36
0.98
0.97
0.95
0.92
0.91
0.89
N
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1.01
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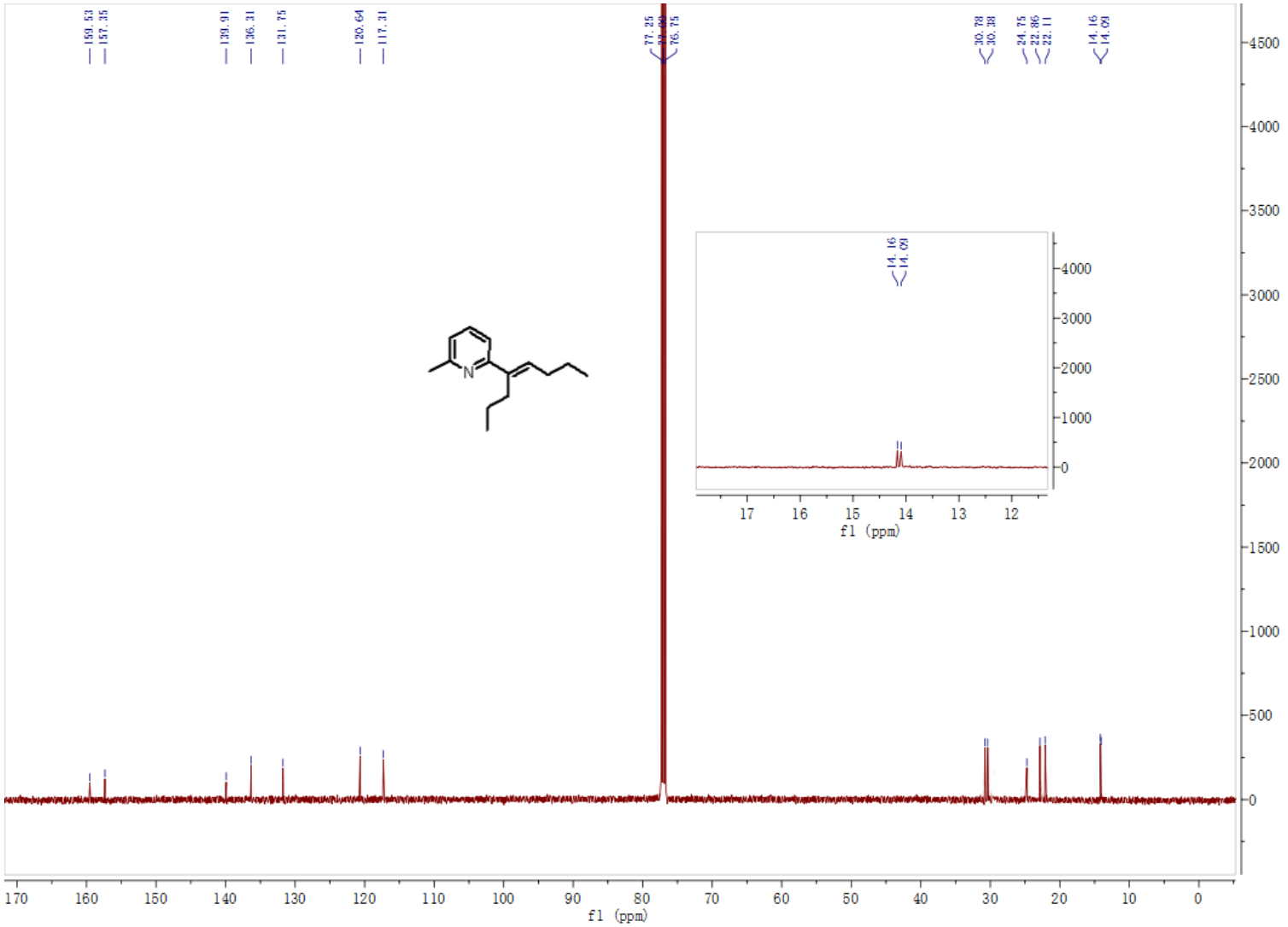
0.94
1.94
2.77
2.03
2.18
2.24
3.00
3.07
f1 (ppm)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136.31
131.75
120.64
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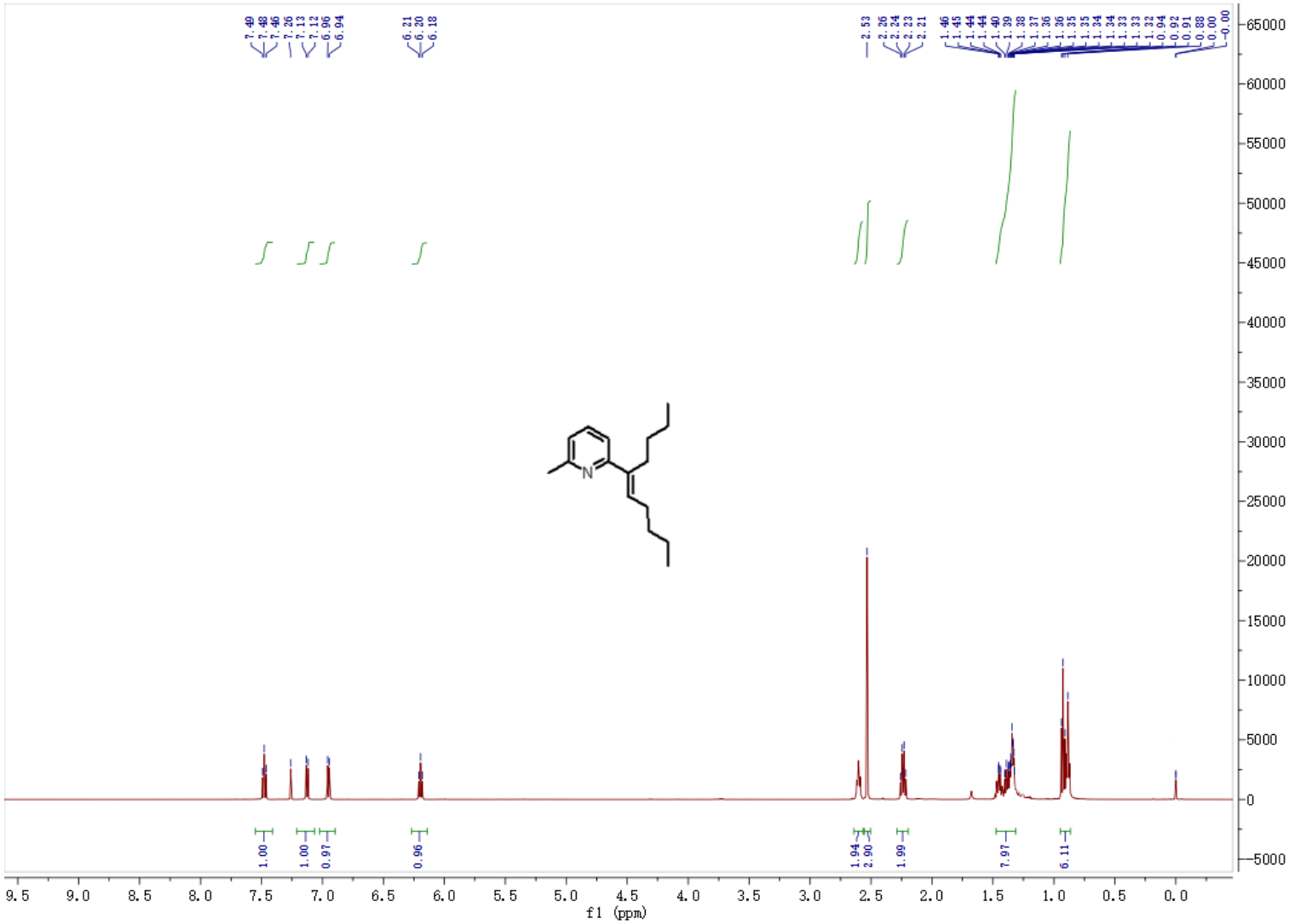
76.75
30.78
30.38
24.75
22.86
22.11
14.16
14.09
f1 (ppm)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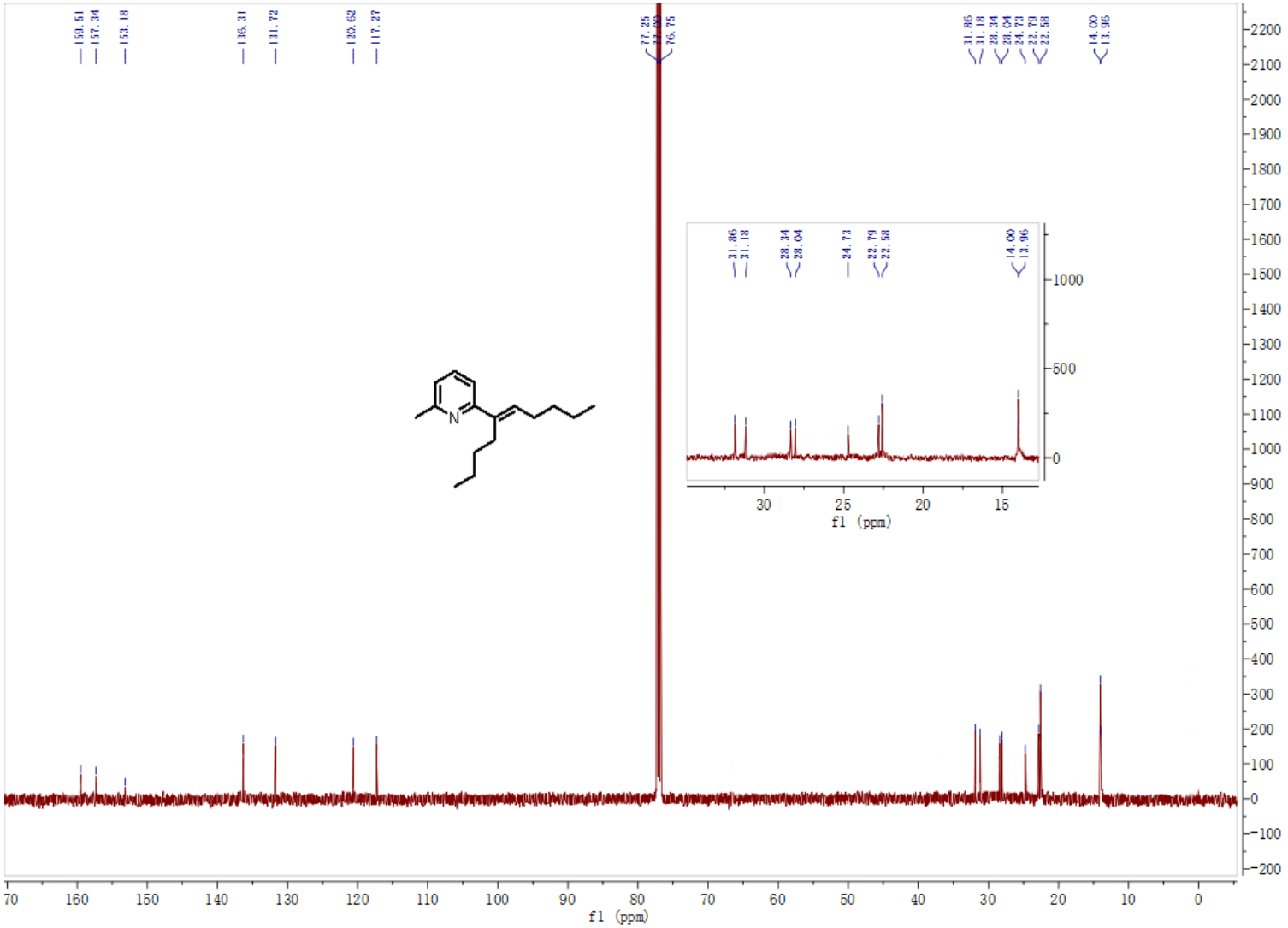
7.48
7.46
7.26
7.13
7.12
6.96
6.94
6.21
6.20
6.18
2.53
2.26
2.24
2.23
2.21
1.46
1.45
1.44
1.44
1.40
1.39
1.38
1.37
1.36
1.36
1.35
1.35
1.34
1.34
1.33
1.33
1.32
0.94
0.92
0.91
0.88
0.00
N
1.00
1.00
0.97
0.96
1.94
2.90
1.99
7.97
6.11
65000
60000
55000
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
-5000
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)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157.34
153.18
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77.25
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31.18
28.34
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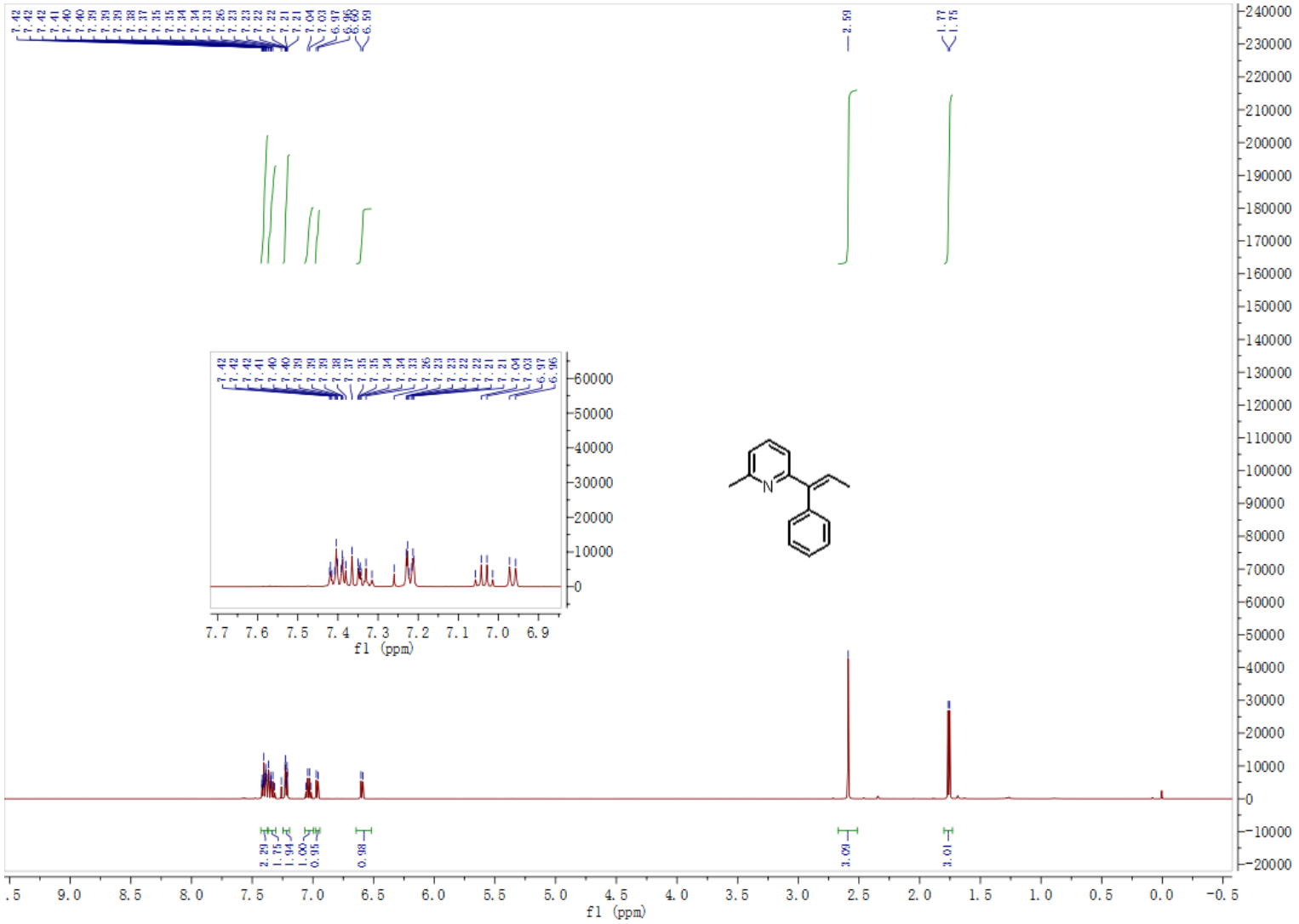
24.73
22.79
22.58
14.00
13.96
N
f1 (ppm)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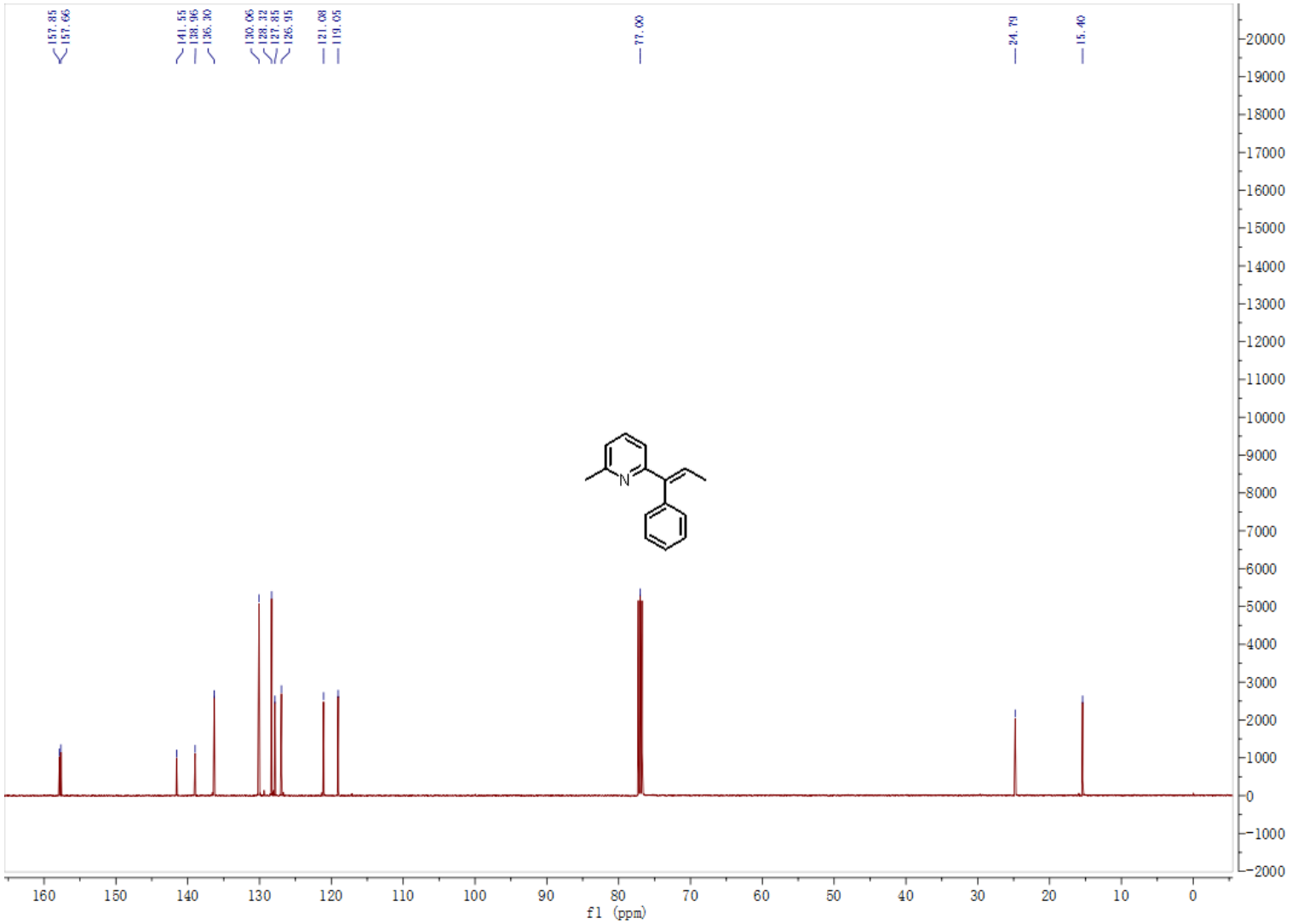
7.34
7.34
7.33
7.26
7.23
7.23
7.22
7.22
7.21
7.21
7.04
7.03
6.97
6.96
6.96
6.59
2.59
1.77
1.75
f1 (ppm)
2.29
1.75
1.94
1.00
0.95
0.98
3.09
3.01
f1 (ppm)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77.00
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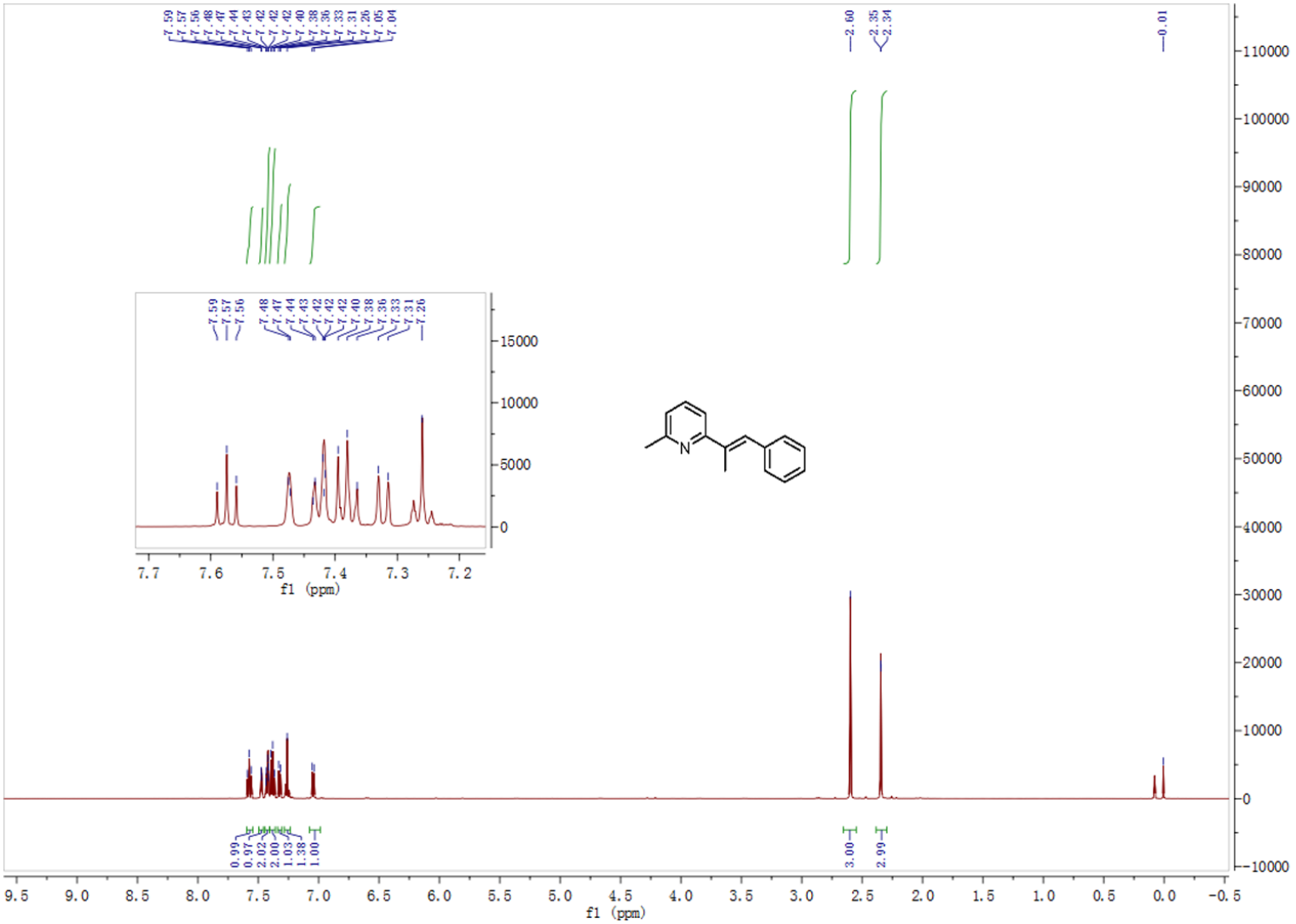
15.40
N
f1 (ppm)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7.40
7.38
7.36
7.33
7.31
7.26
7.05
7.04
2.60
2.35
2.34
0.01
15000
10000
5000
0
7.7
7.6
7.5
7.4
7.3
7.2
f1 (ppm)
N
110000
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
-10000
0.99
0.97
2.02
2.00
1.03
1.38
1.00
3.00
2.99
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
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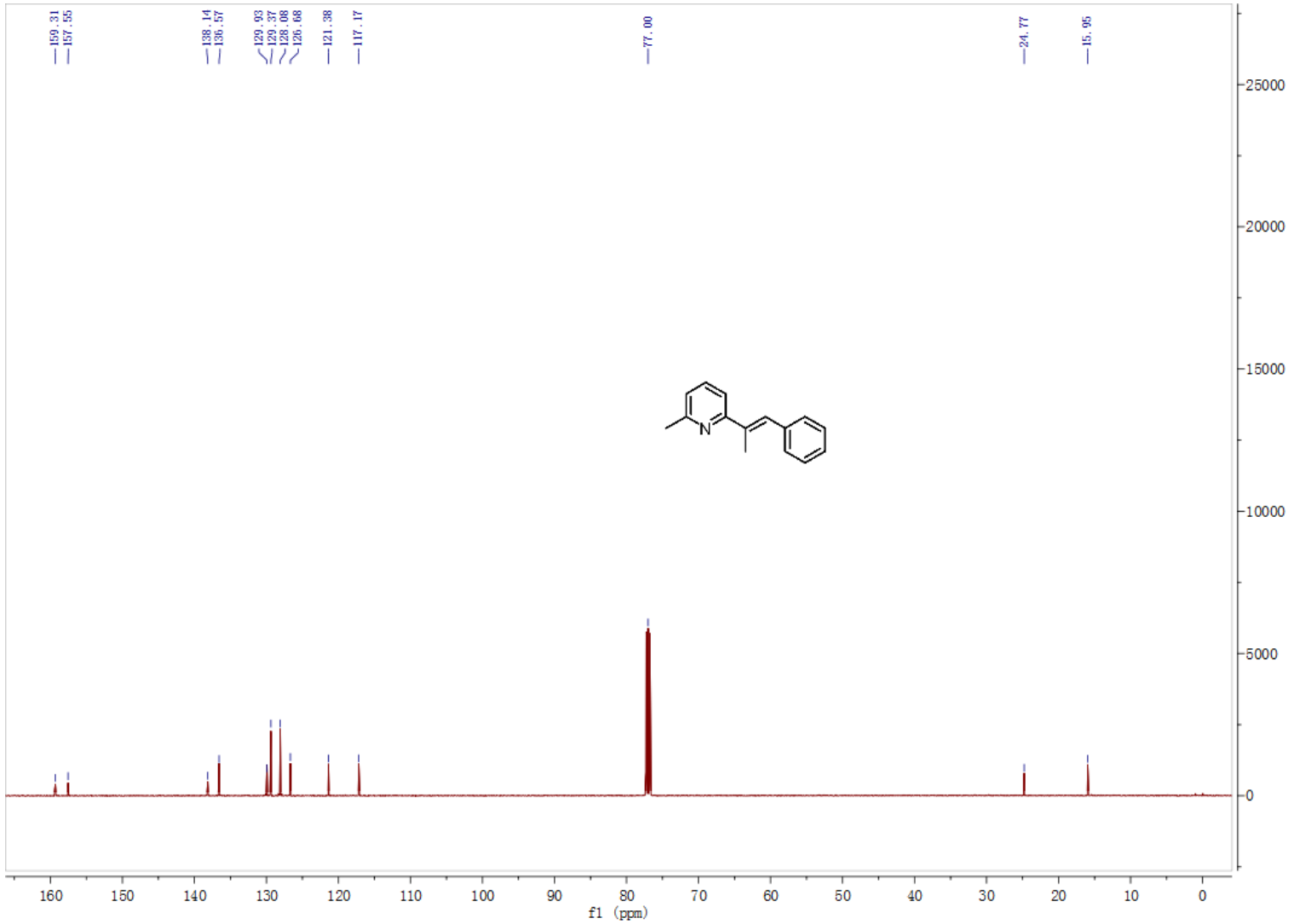
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)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136.57
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129.37
128.08
126.68
121.38
117.17
77.00
24.77
15.95
25000
20000
15000
10000
5000
0
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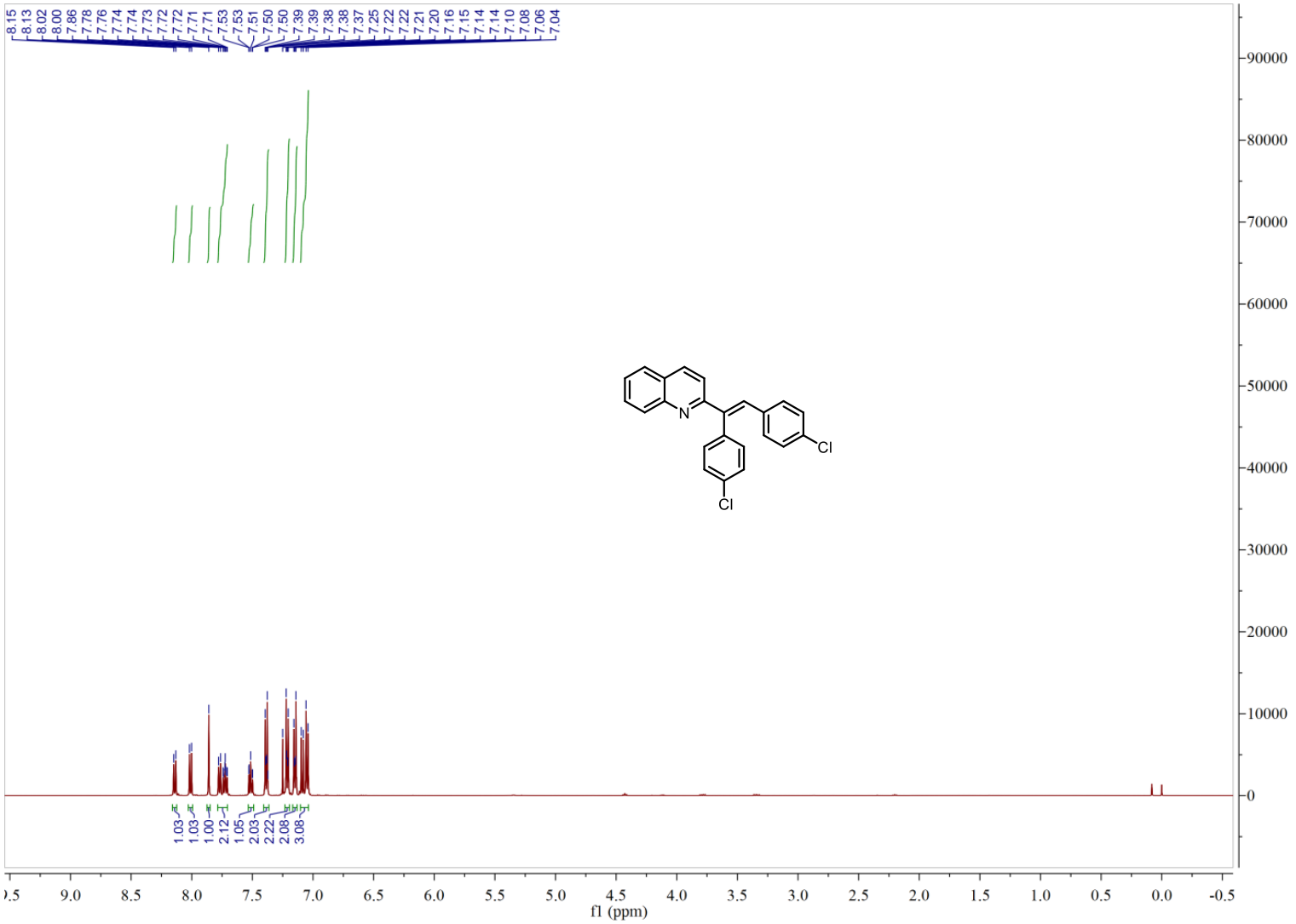
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)
N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7.74
7.73
7.72
7.72
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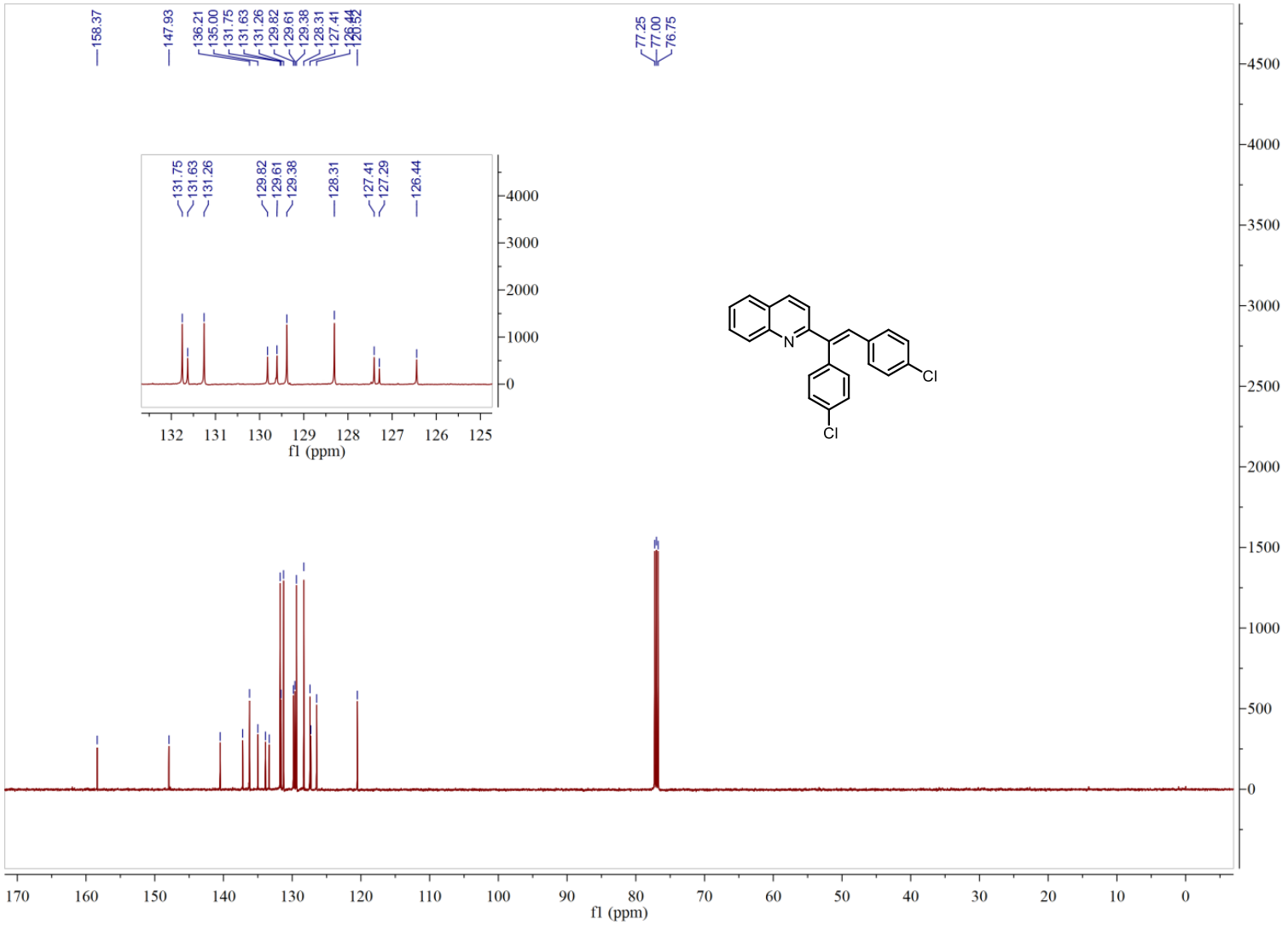
7.51
7.50
7.50
7.39
7.39
7.38
7.38
7.37
7.25
7.22
7.22
7.21
7.20
7.16
7.15
7.14
7.14
7.10
7.08
7.06
7.04
N
Cl
Cl
1.03
1.03
1.00
2.12
1.05
2.03
2.22
2.08
3.08
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)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126.44
77.25
77.00
76.75
131.75
131.63
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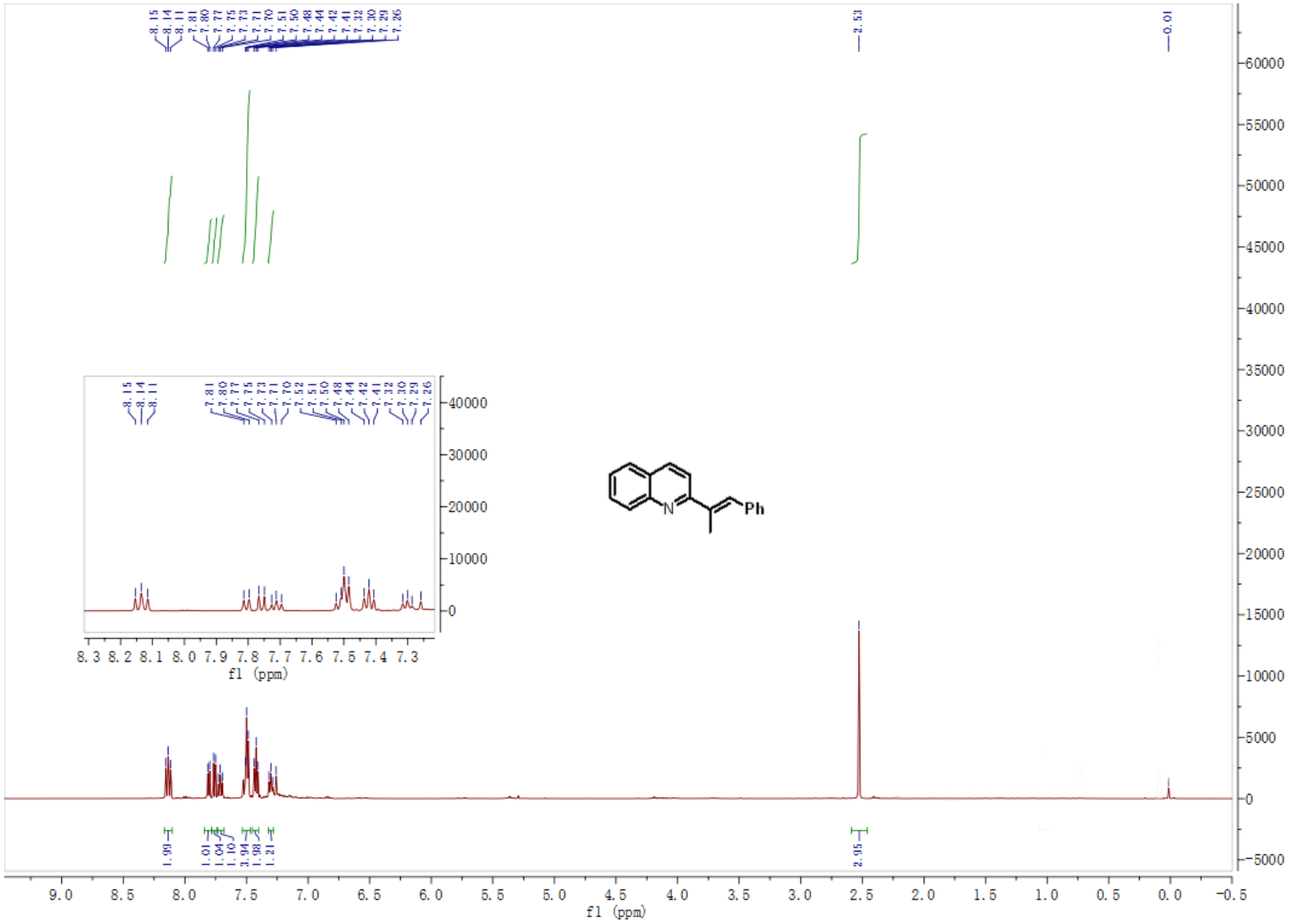
129.61
129.38
128.31
127.41
127.29
126.44
f1 (ppm)
f1 (ppm)
N
Cl
Cl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7.73
7.71
7.70
7.51
7.50
7.48
7.44
7.42
7.41
7.32
7.30
7.29
7.26
2.53
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Ph
N
f1 (ppm)
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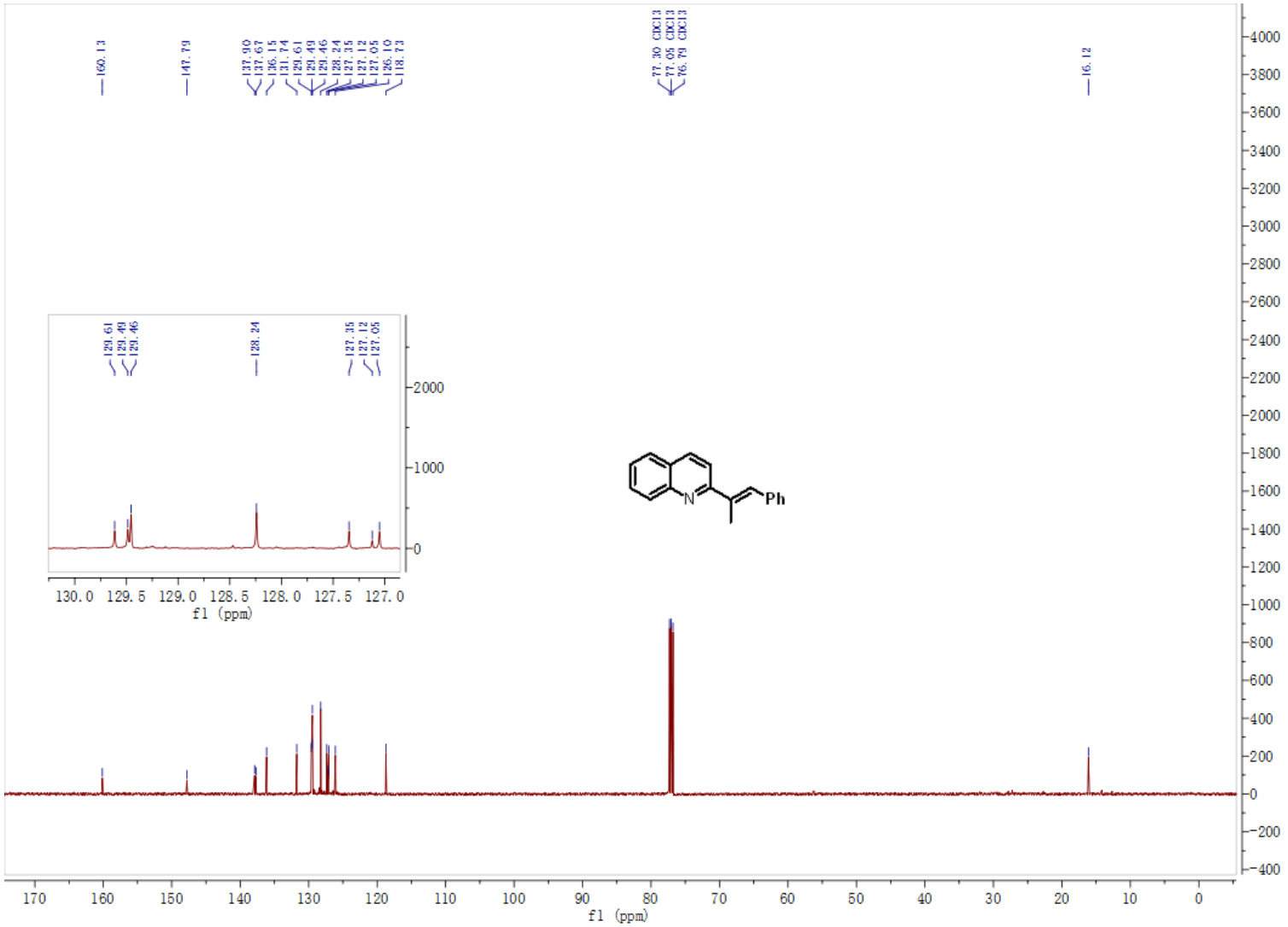
1.01
1.04
1.10
3.94
1.98
1.21
2.95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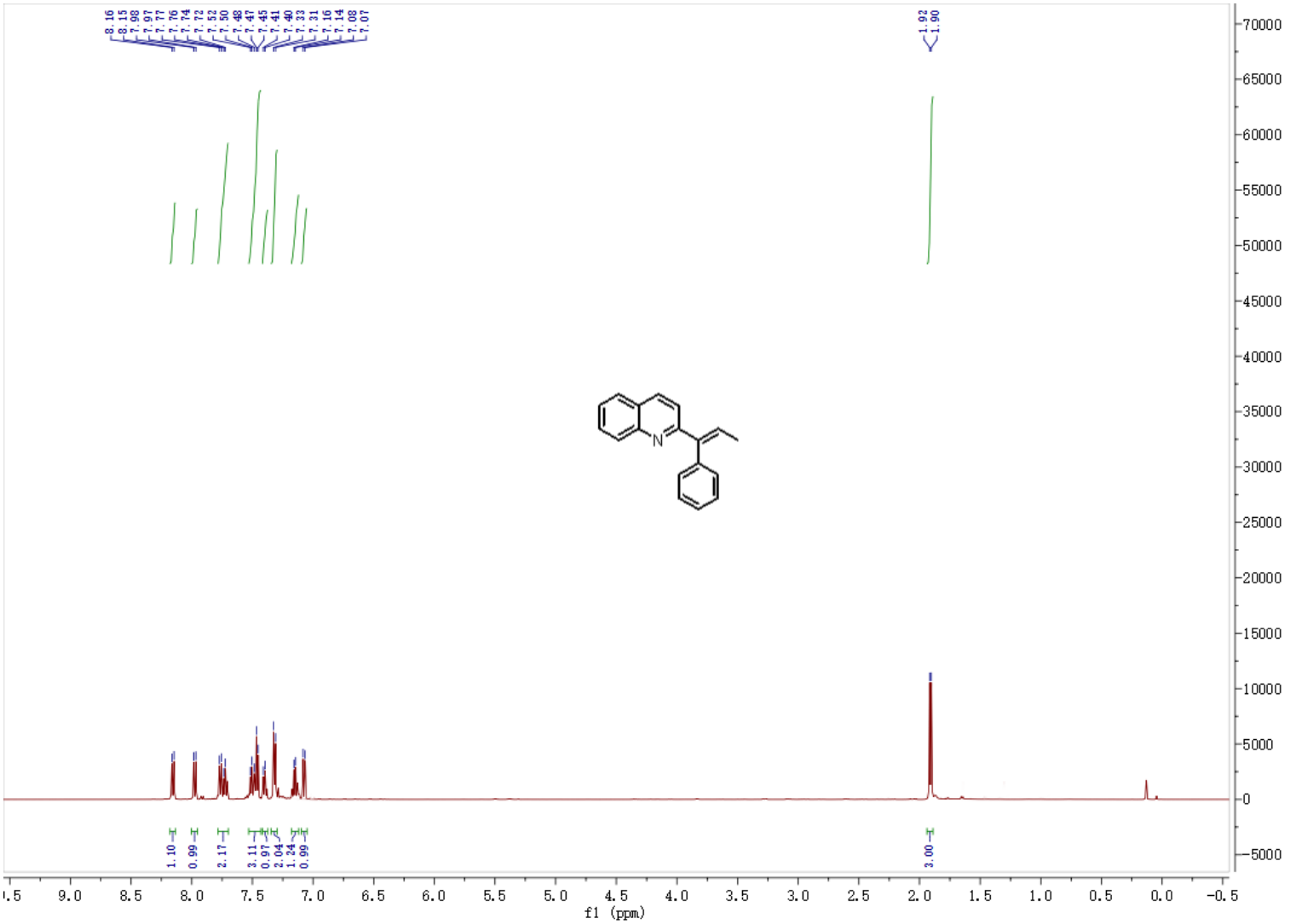
128.24
127.35
127.12
127.05
126.10
118.73
77.30 CDCl3
77.05 CDCl3
76.79 CDCl3
16.12
Ph
N
f1 (ppm)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7.76
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7.50
7.48
7.47
7.45
7.41
7.40
7.33
7.31
7.16
7.14
7.08
7.07
1.92
1.90
N
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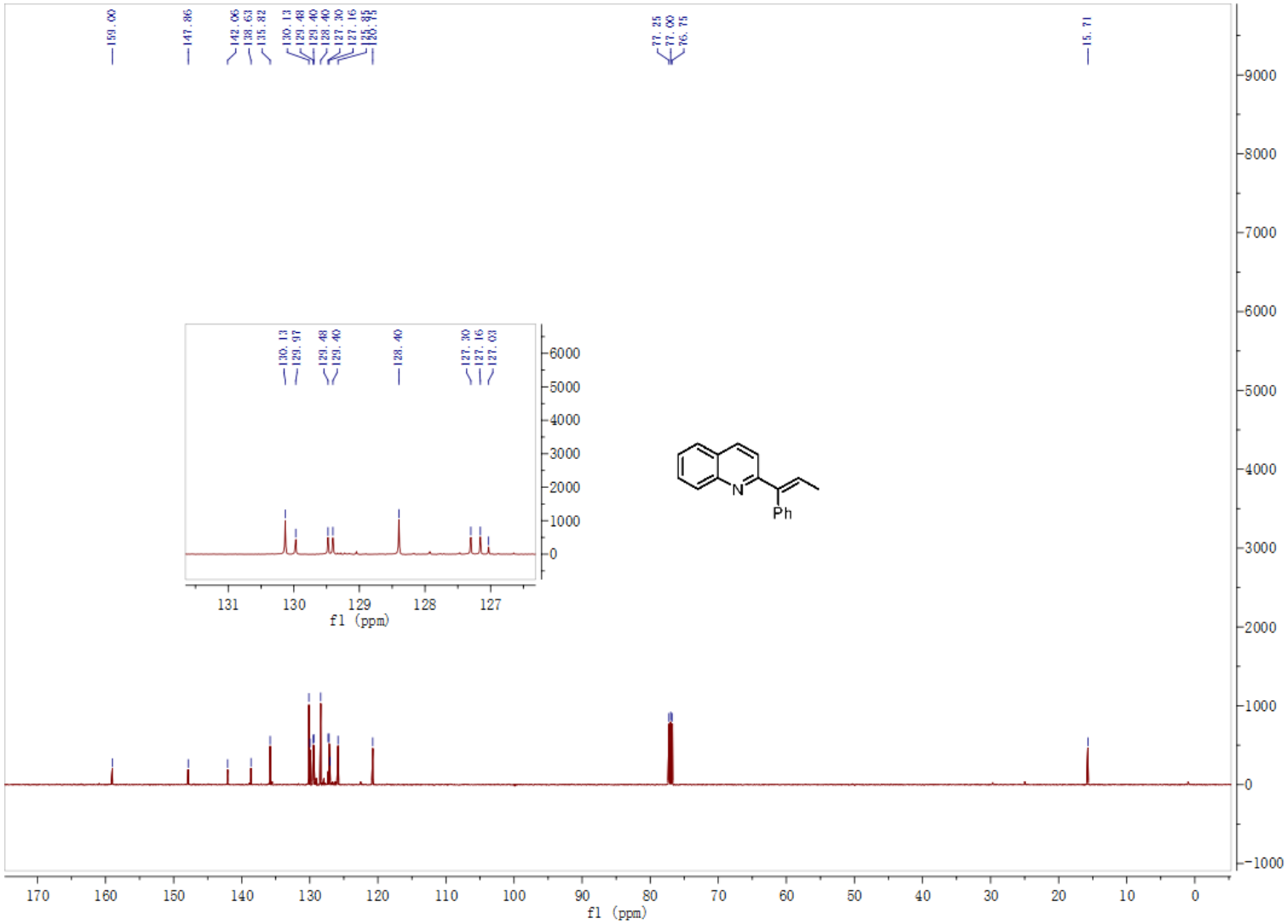
0.99
2.17
3.11
0.97
2.04
1.24
0.99
3.00
f1 (ppm)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130.13
129.48
129.40
128.40
127.30
127.16
125.95
120.78
77.25
77.00
76.75
15.71
130.13
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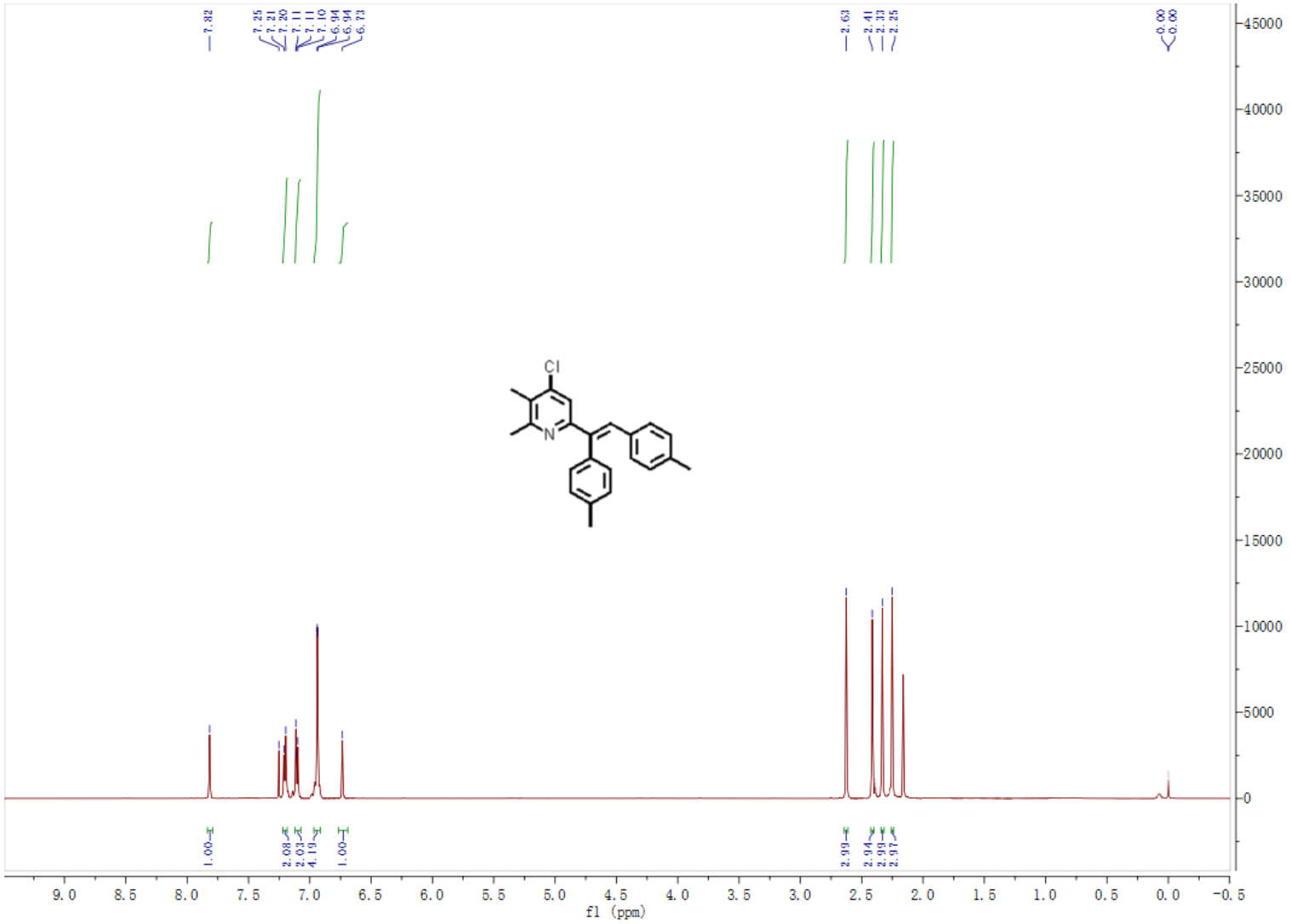
129.40
128.40
127.30
127.16
127.03
Ph
N
f1 (ppm)
f1 (ppm)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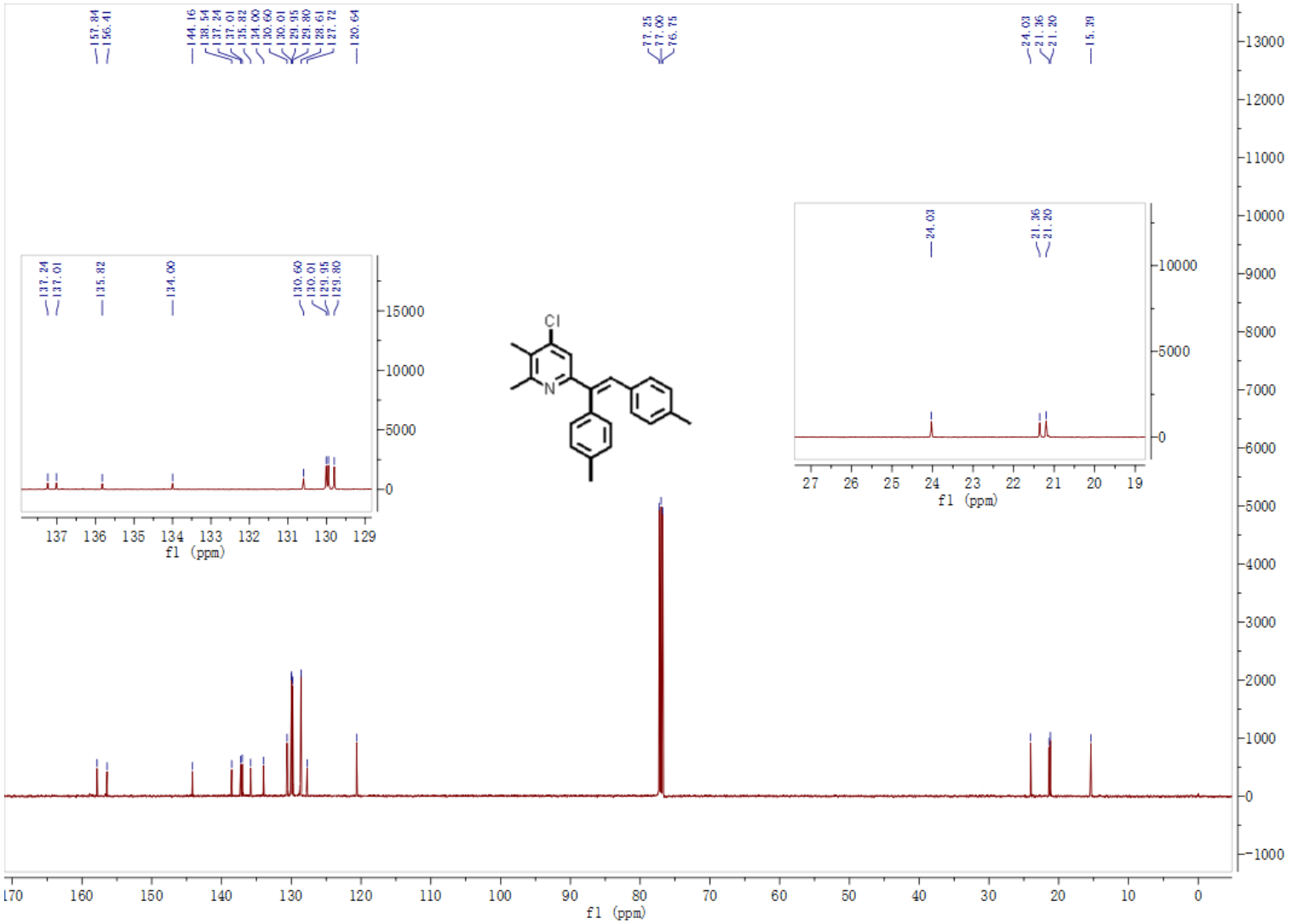
7.25
7.21
7.20
7.11
7.10
6.94
6.94
6.73
2.63
2.41
2.33
2.25
0.00
0.00
Cl
N
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
1.00
2.08
2.03
4.19
1.00
2.99
2.94
2.99
2.97
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)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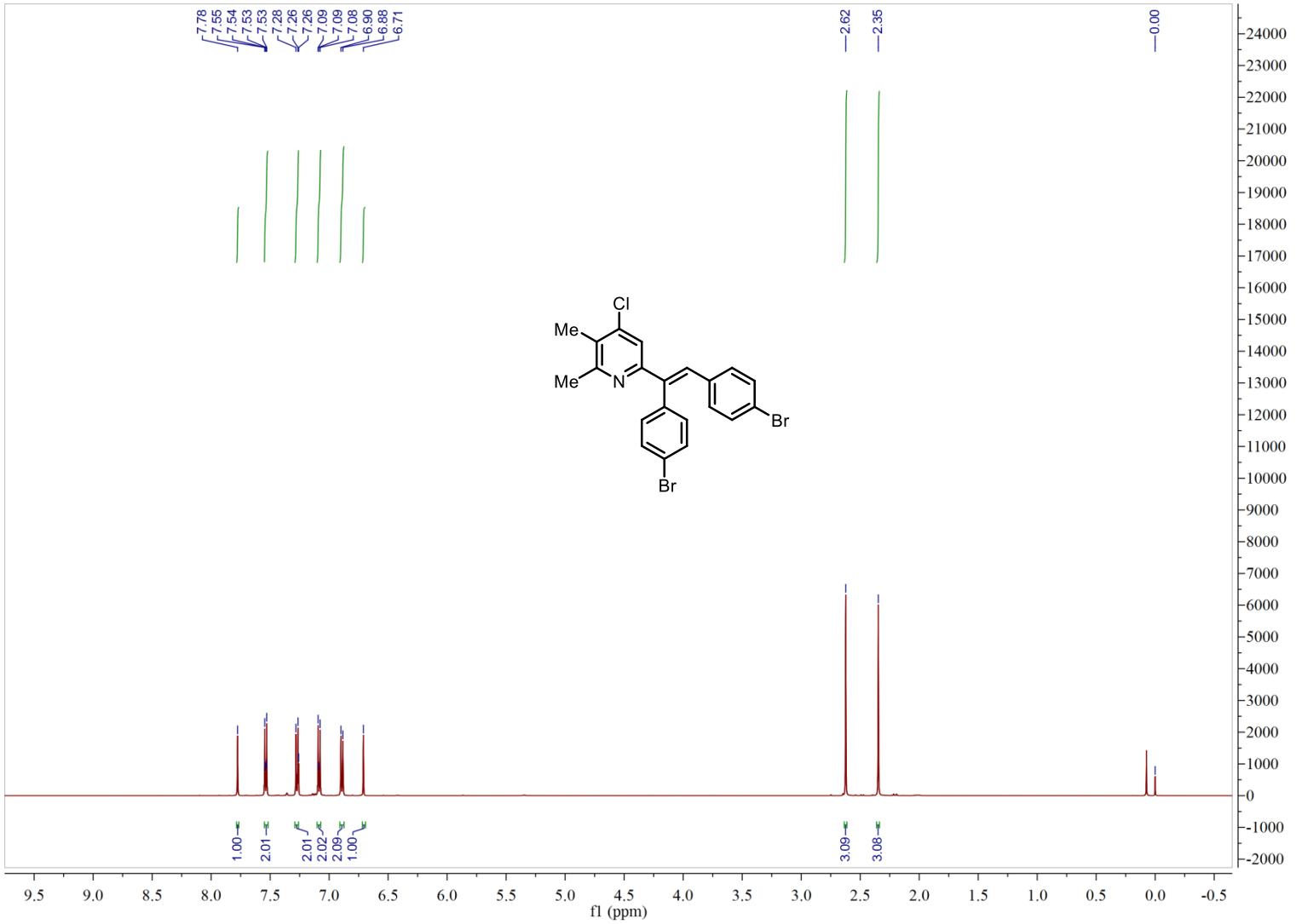
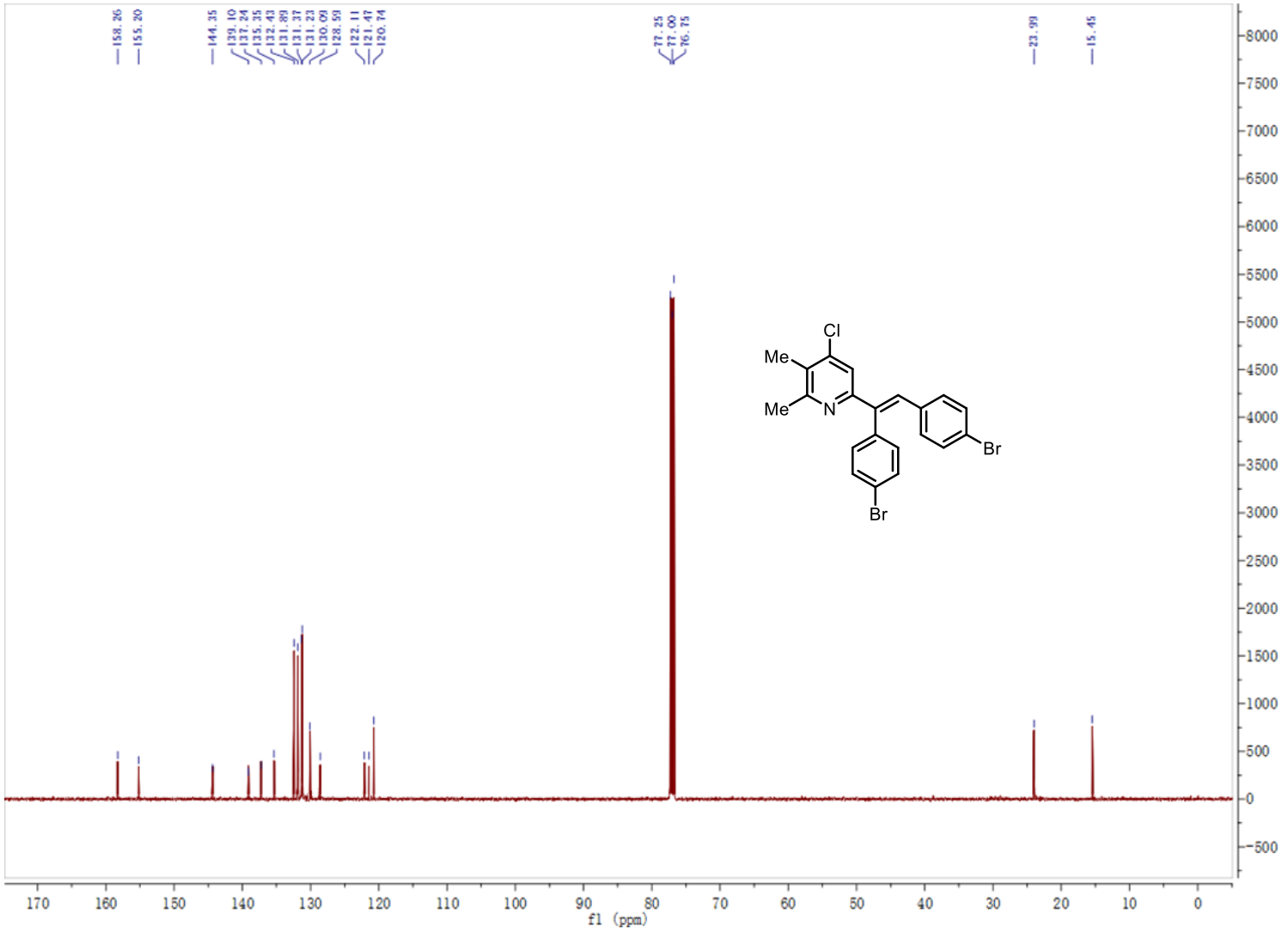
77.25
77.00
76.75
24.03
21.36
21.20
15.39
Cl
N
f1 (ppm)


7.78
7.55
7.54
7.53
7.53
7.28
7.26
7.26
7.09
7.09
7.08
6.90
6.88
6.71
2.62
2.35
0.00
Cl
Me
Me
N
Br
Br
1.00
2.01
2.01
2.02
2.09
1.00
3.09
3.08
f1 (ppm)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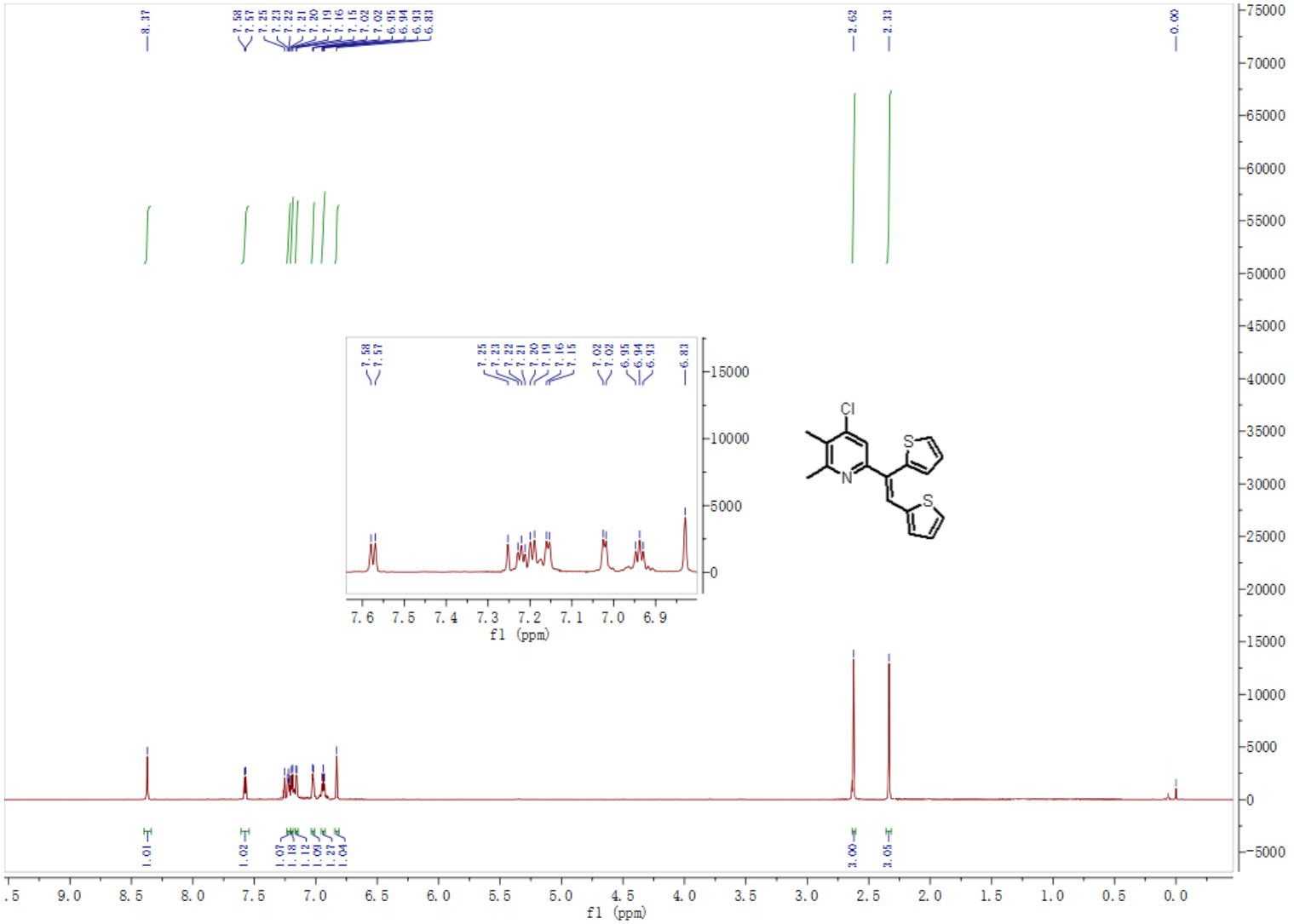
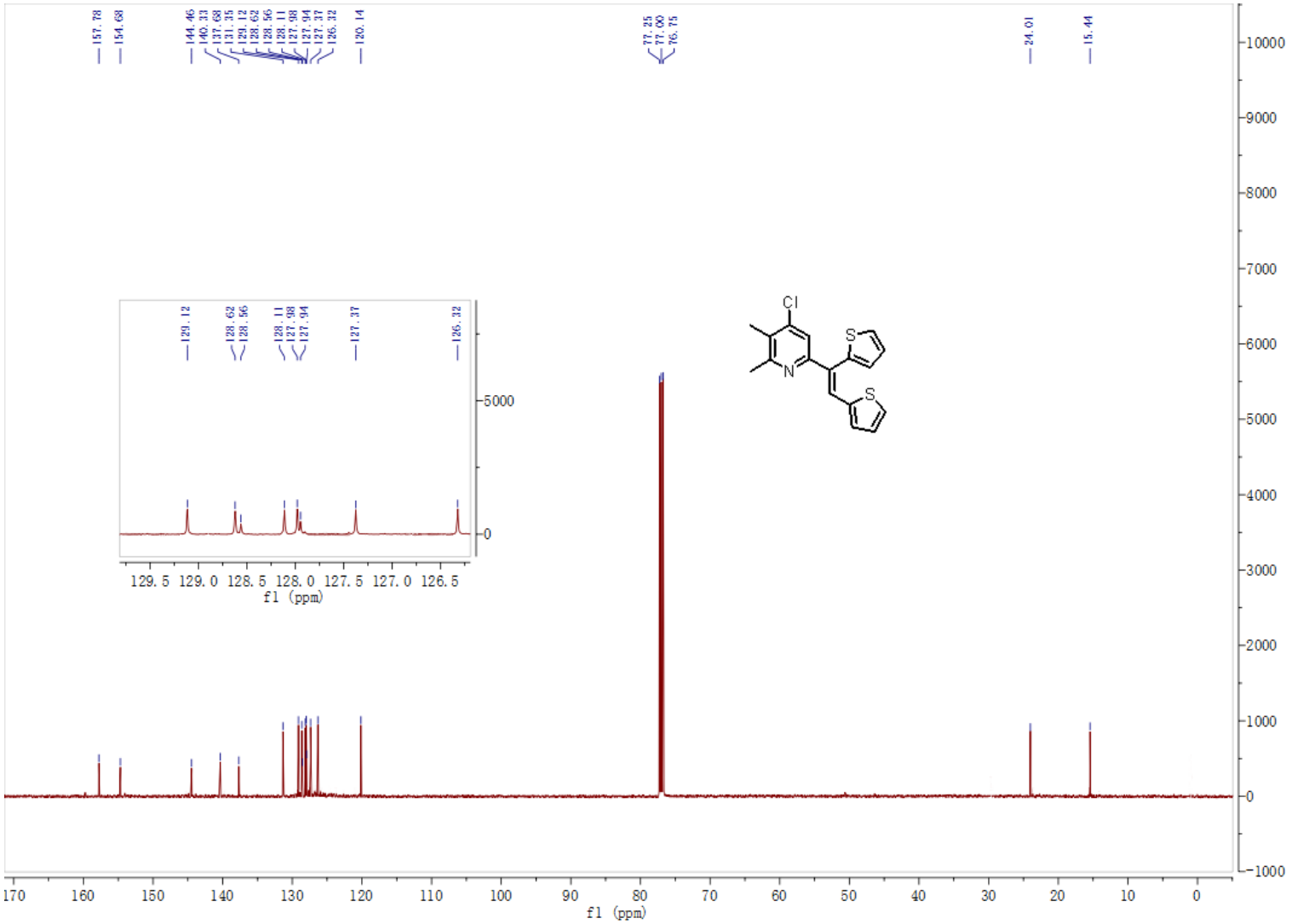
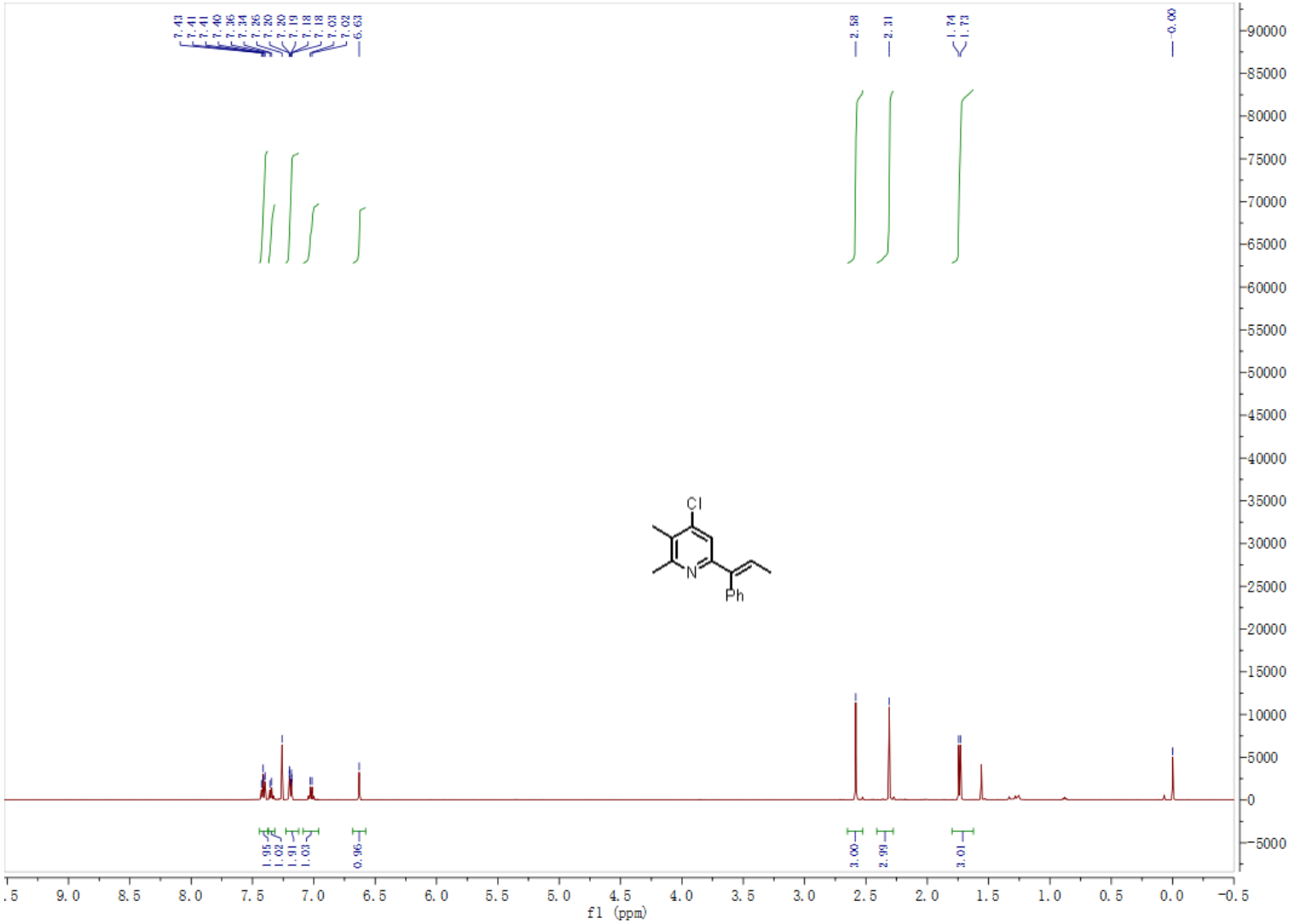
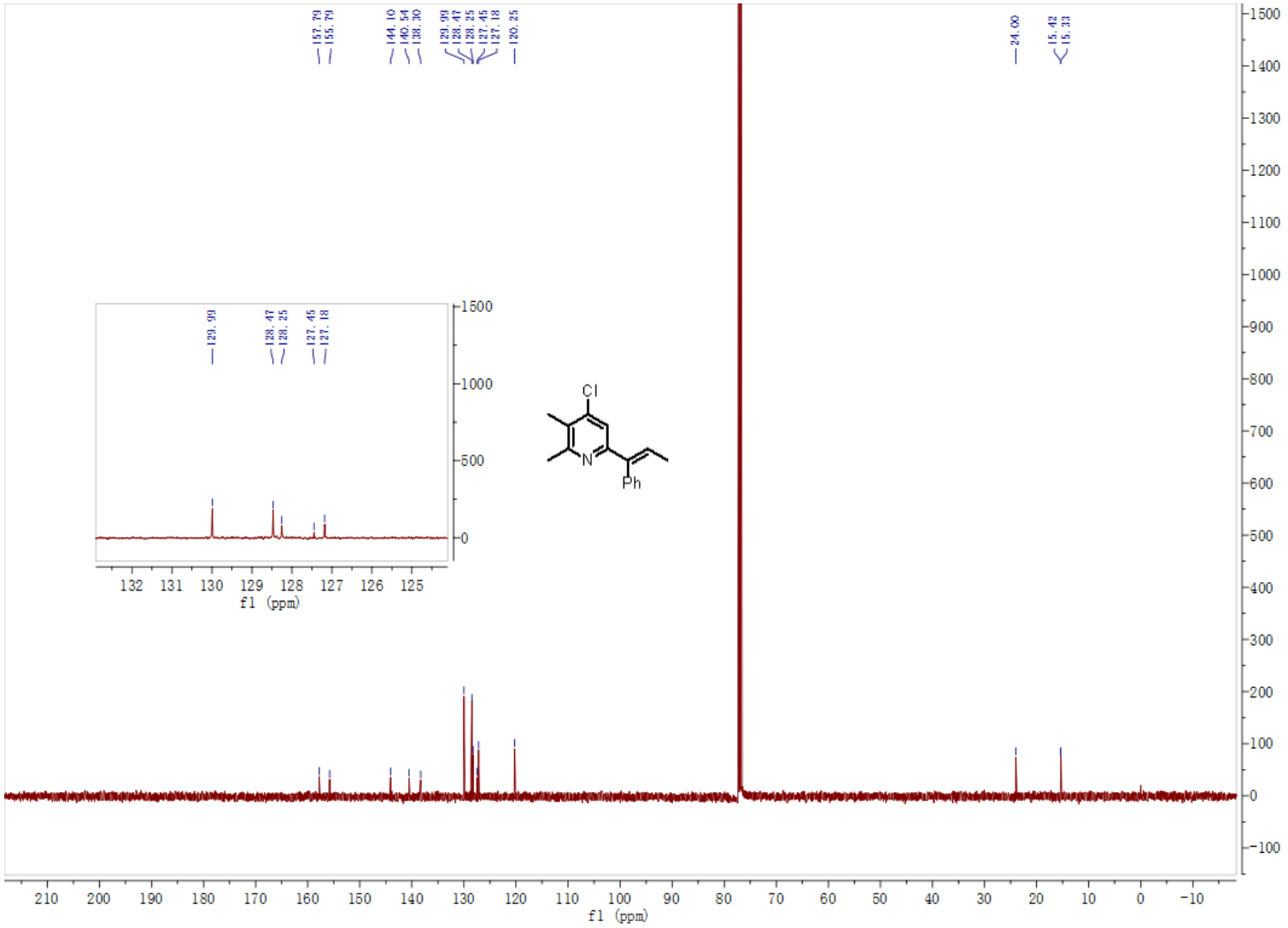
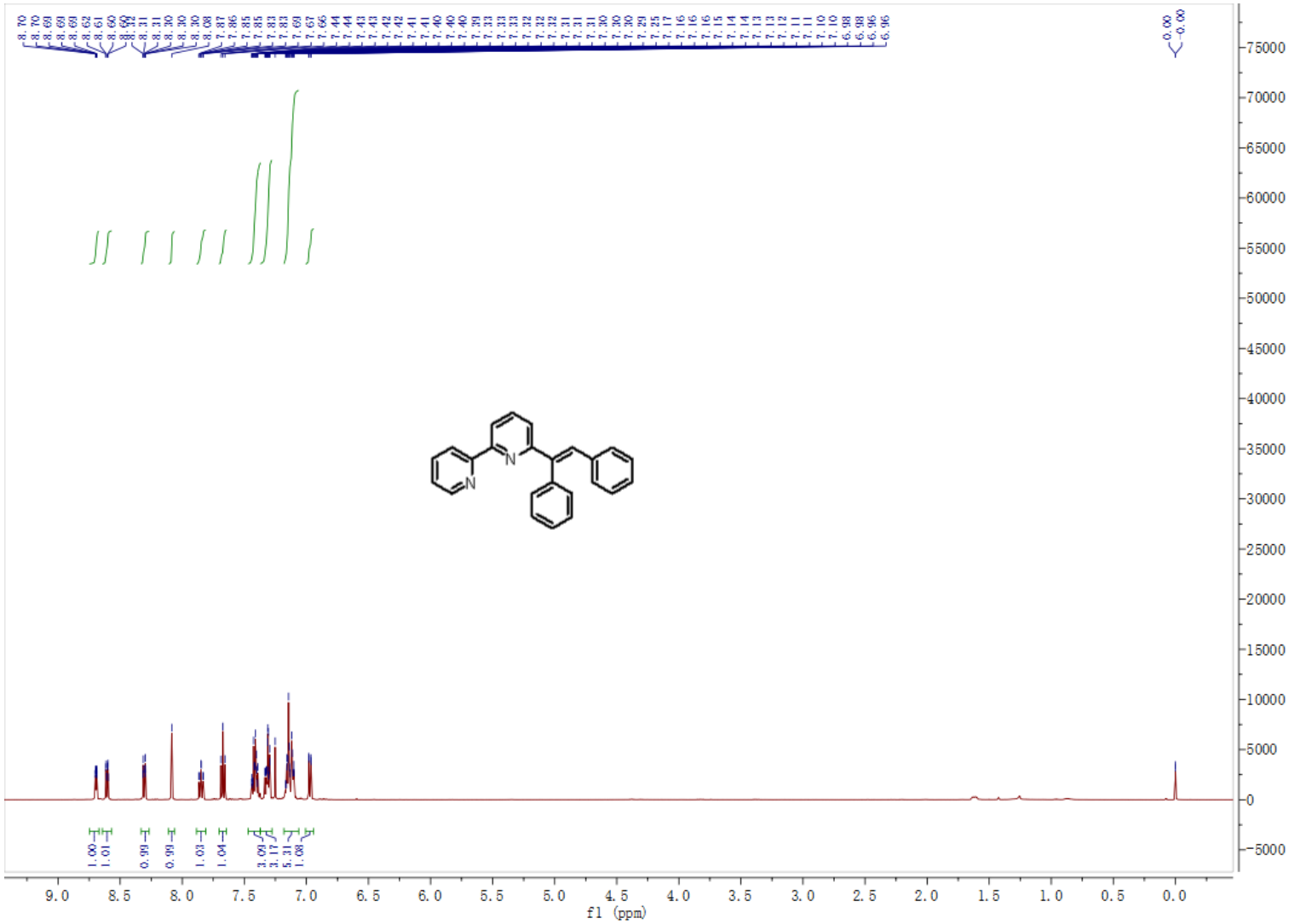
155.20
144.35
139.10
137.24
135.35
132.43
131.89
131.37
131.23
130.09
128.59
122.11
121.47
120.74
77.25
77.00
76.75
23.99
15.45
Cl
Me
Me
N
Br
Br
8000
7500
7000
6500
6000
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
-500
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

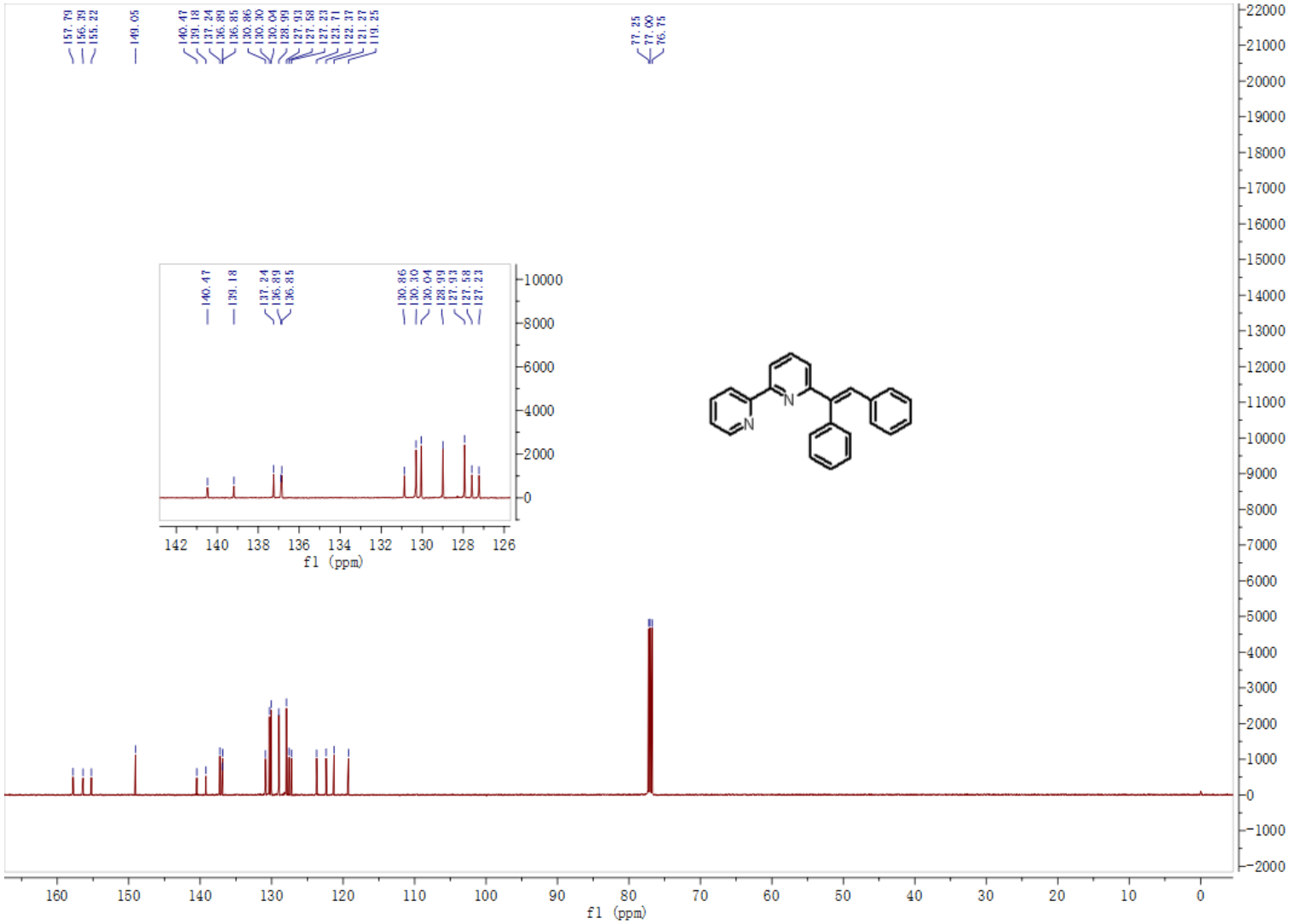

8.37
7.58
7.57
7.25
7.23
7.22
7.21
7.20
7.19
7.16
7.15
7.02
6.95
6.94
6.93
6.83
2.62
2.33
0.00
1.01
1.02
1.07
1.18
1.12
1.09
1.27
1.04
3.00
3.05
f1 (ppm)
Cl
N
S
S

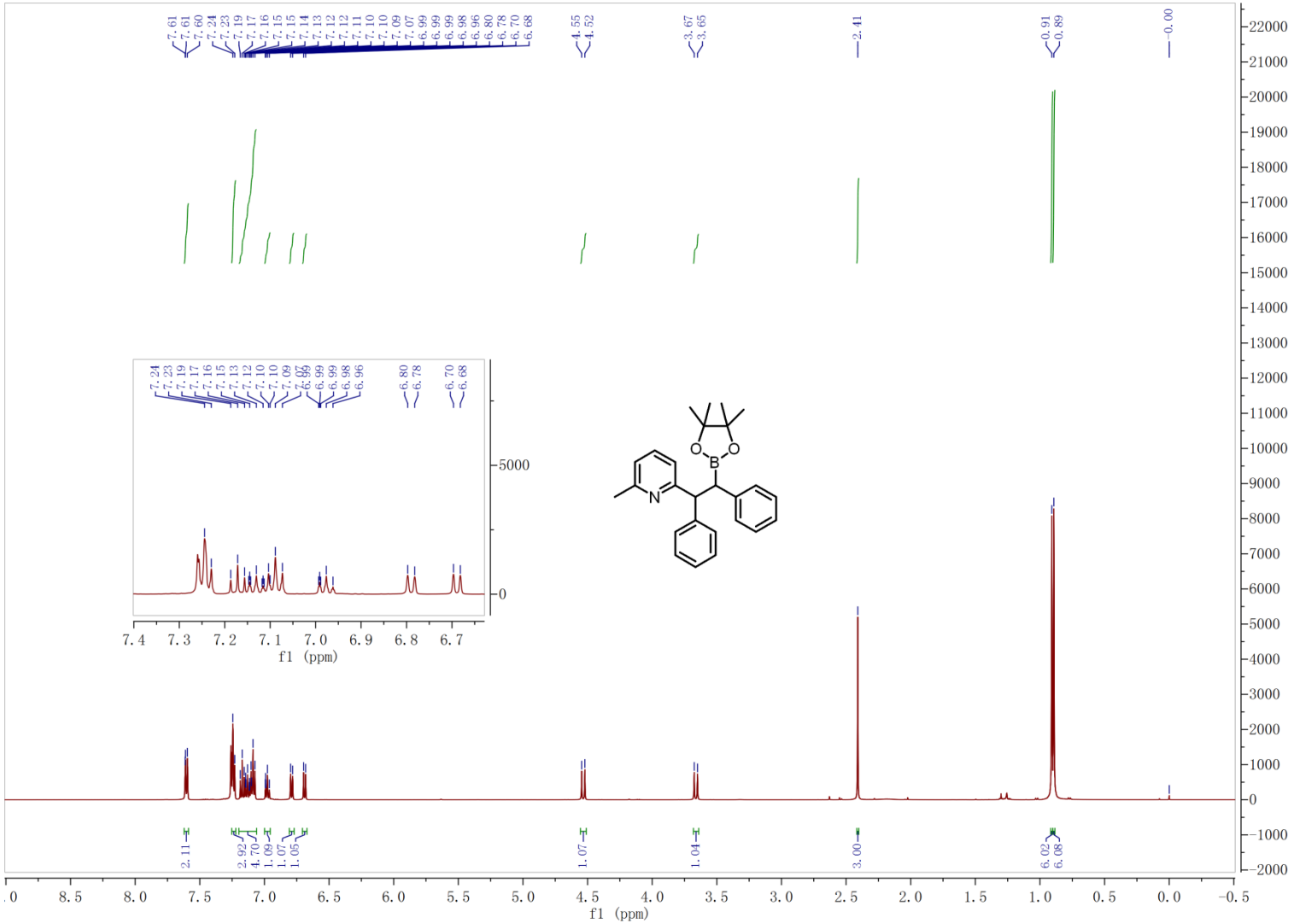

157.78
154.68
144.46
140.33
137.68
131.35
129.12
128.62
128.56
128.11
127.98
127.94
127.37
126.32
120.14
77.25
77.00
76.75
24.01
15.44
Cl
N
S
S
129.12
128.62
128.56
128.11
127.98
127.94
127.37
126.32
5000
0
129.5 129.0 128.5 128.0 127.5 127.0 126.5
f1 (ppm)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

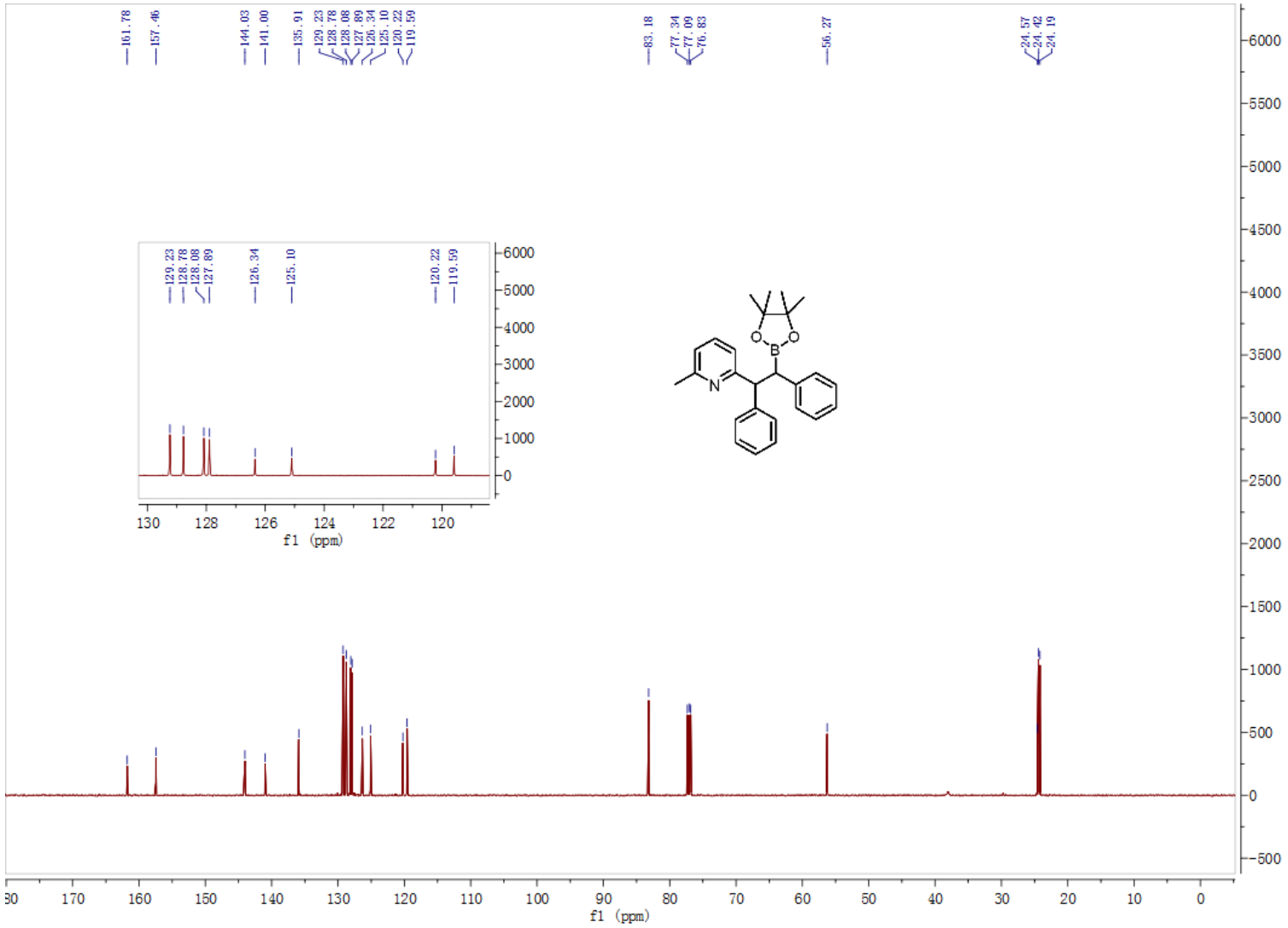

7.43
7.41
7.41
7.40
7.36
7.34
7.26
7.20
7.20
7.19
7.18
7.18
7.03
7.02
6.63
2.58
2.31
1.74
1.73
0.00
Cl
N
Ph
1.95
1.02
1.91
1.03
0.96
3.00
2.91
3.01
f1 (ppm)

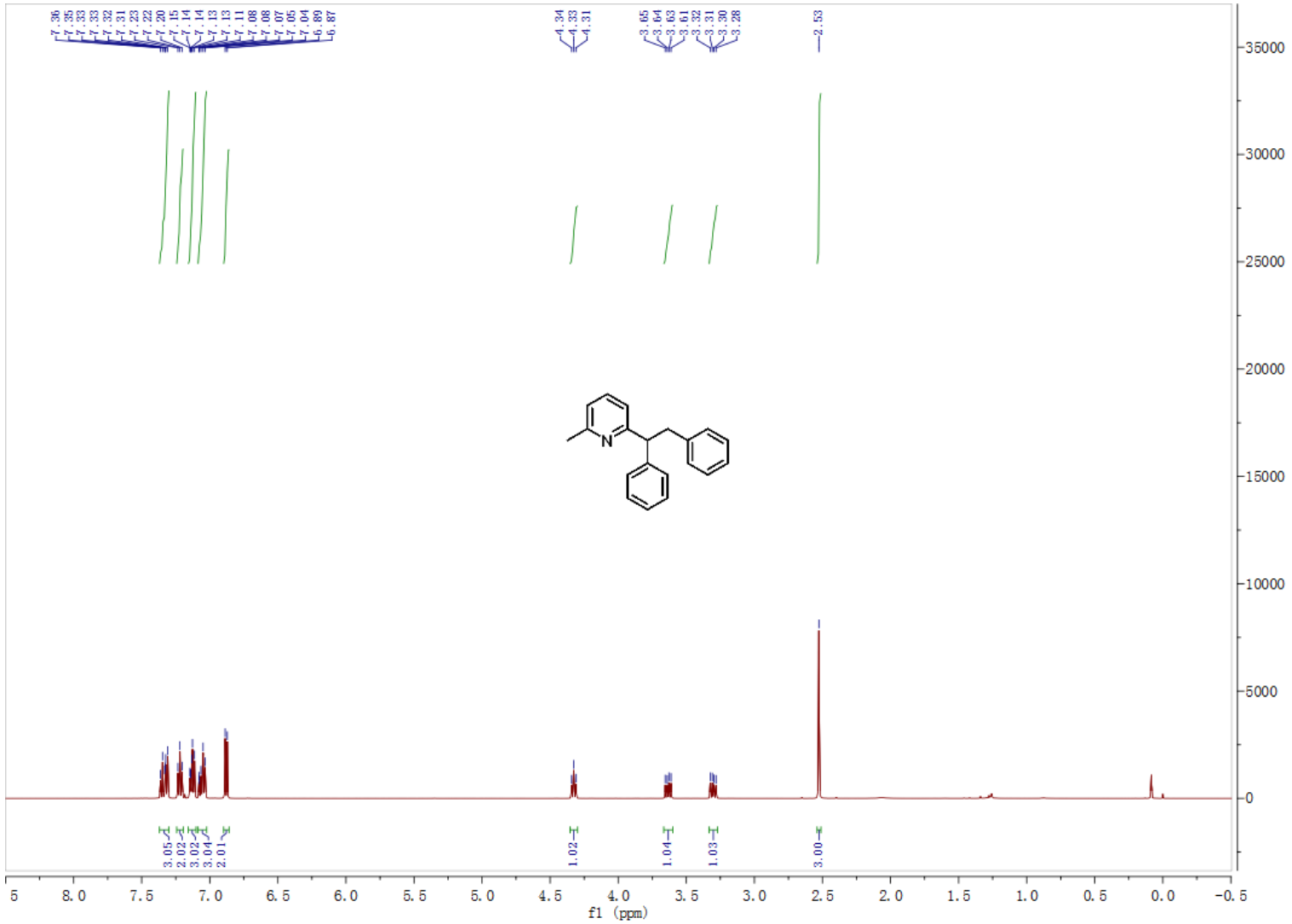

157.79
155.79
144.10
140.54
138.30
129.99
128.47
128.25
127.45
127.18
120.25
24.00
15.42
15.33
Cl
N
Ph
f1 (ppm)

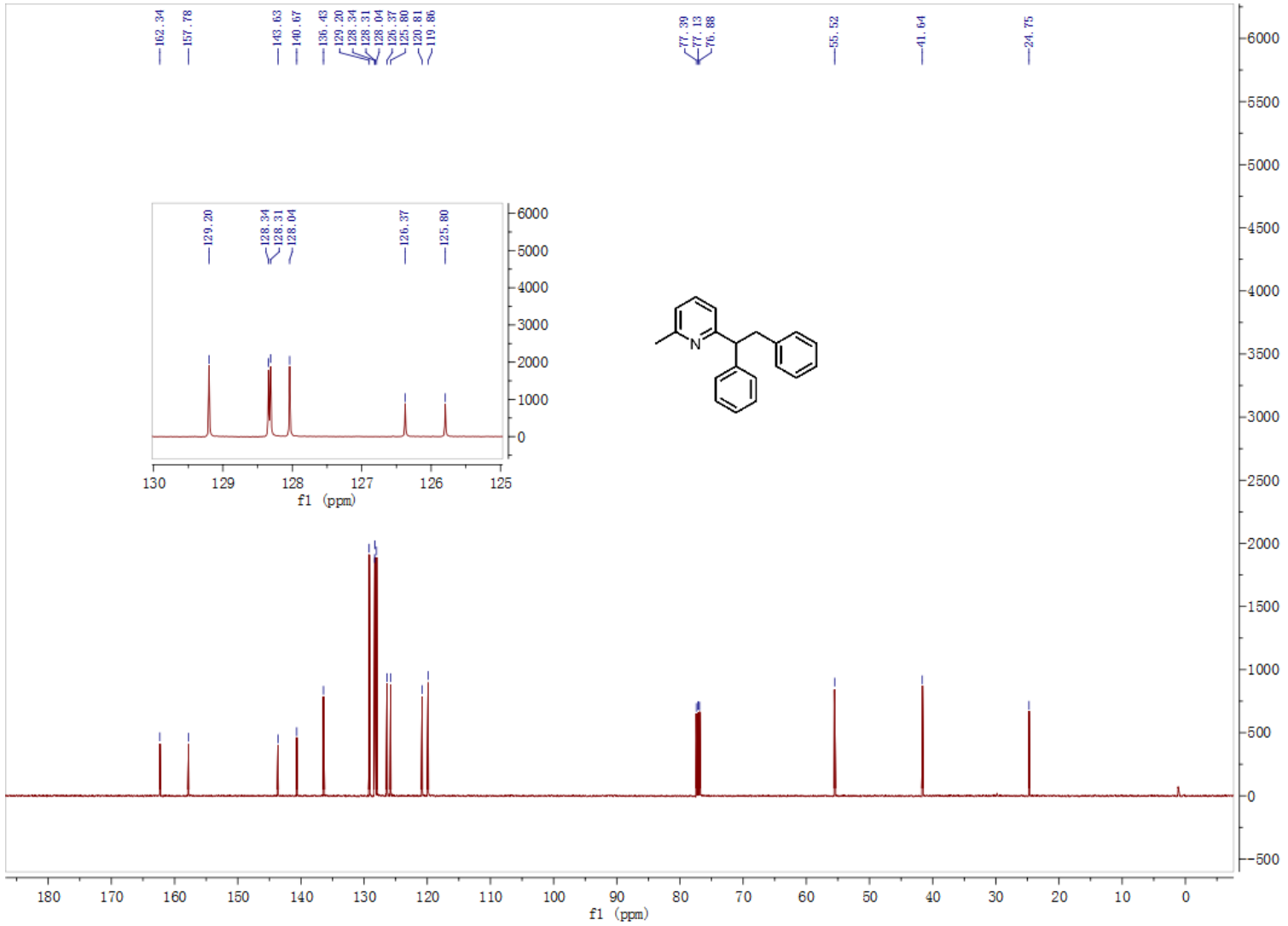

8.70
8.69
8.52
8.51
8.50
8.32
8.31
8.30
8.29
8.08
7.87
7.85
7.83
7.69
7.67
7.66
7.44
7.43
7.42
7.41
7.40
7.39
7.33
7.32
7.31
7.30
7.29
7.25
7.17
7.16
7.15
7.14
7.13
7.12
7.11
7.10
6.98
6.96
0.00
N
N
1.00
1.01
0.99
0.99
1.03
1.04
3.09
3.17
5.31
1.08
75000
70000
65000
60000
55000
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
-5000
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


157.79
156.39
155.22
149.05
140.47
139.18
137.24
136.89
136.85
130.86
130.30
130.04
128.99
127.93
127.58
127.23
123.71
122.37
121.27
119.25
77.25
77.00
76.75
f1 (ppm)
f1 (ppm)
N
N


7.61
7.61
7.60
7.24
7.23
7.19
7.17
7.16
7.15
7.15
7.14
7.13
7.12
7.12
7.11
7.10
7.10
7.09
7.07
6.99
6.99
6.98
6.96
6.80
6.78
6.70
6.68
4.55
4.52
3.67
3.65
2.41
0.91
0.89
0.00
5000
0
7.4
7.3
7.2
7.1
7.0
6.9
6.8
6.7
f1 (ppm)
O
B
O
N
2.11
2.92
4.70
1.09
1.07
1.05
1.07
1.04
3.00
6.02
6.08
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)


161.78
157.46
144.03
141.00
135.91
129.23
128.78
128.08
127.89
126.34
125.10
120.22
119.59
83.18
77.34
77.09
76.83
56.27
24.57
24.42
24.19
f1 (ppm)
f1 (ppm)


7.36
7.35
7.33
7.33
7.32
7.31
7.23
7.22
7.20
7.15
7.14
7.14
7.13
7.13
7.11
7.08
7.08
7.07
7.05
7.04
6.89
6.87
4.34
4.33
4.31
3.65
3.64
3.63
3.61
3.32
3.31
3.30
3.28
2.53
N
35000
30000
25000
20000
15000
10000
5000
0
3.05
2.02
3.02
3.04
2.01
1.02
1.04
1.03
3.00
5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)


162.34
157.78
143.63
140.67
136.43
129.20
128.34
128.31
128.04
126.37
125.80
120.81
119.86
77.39
77.13
76.88
55.52
41.64
24.75
f1 (ppm)
f1 (ppm)