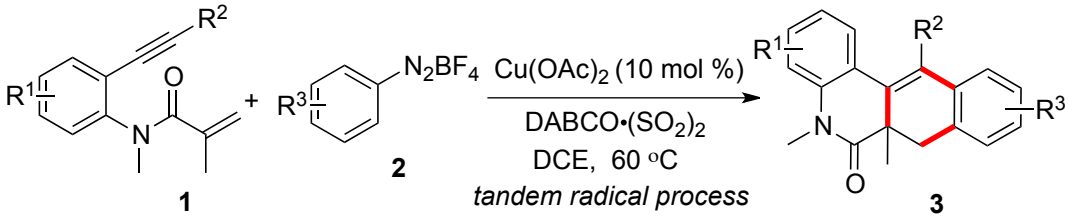
Electronic Supplementary Material (ESI) for Organic Chemistry Frontiers.

Supporting Information

General experimental methods:

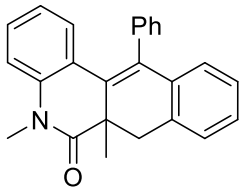
Unless otherwise stated, all commercial reagents were used as received. Flash column chromatography was performed using silica gel (60-Å pore size, 32–63µm, standard grade). Analytical thin–layer chromatography was performed using glass plates pre-coated with 0.25 mm 230–400 mesh silica gel impregnated with a fluorescent indicator (254 nm). Thin layer chromatography plates were visualized by exposure to ultraviolet light. Organic solutions were concentrated on rotary evaporators at ~20 Torr at 25–35°C. Nuclear magnetic resonance (NMR) spectra are recorded in parts per million from internal tetramethylsilane on the δ scale. ^{1}H and ^{13}C NMR spectra were recorded in $CDCl_3$ on a Bruker DRX-400 spectrometer operating at 400 MHz and 100 MHz, respectively. All chemical shift values are quoted in ppm and coupling constants quoted in Hz. High resolution mass spectrometry (HRMS) spectra were obtained on a micrOTOF II Instrument.

General experimental procedure for the radical cyclization of benzene-tethered 1,7-enynes **1** *with aryldiazonium tetrafluoroborates* **2** *in the presence of DABCO·(SO$_2$)$_2$*



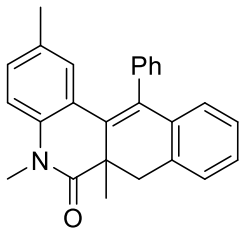
1 **2** **3**

Benzene-tethered 1,7-enyne **1** (0.2 mmol) was added to a mixture of aryldiazonium tetrafluoroborate **2** (0.3 mmol), DABCO·(SO$_2$)$_2$ (0.18 mmol), Cu(OAc)$_2$ (10 mol%) in DCE (2.0 mL). The mixture was stirred at 60°C for 4 hours. After completion of reaction as indicated by TLC, the solvent was evaporated. The residue was purified directly by flash column chromatography (EtOAc/*n*-hexane, 1:4) to give the desired product **3**.



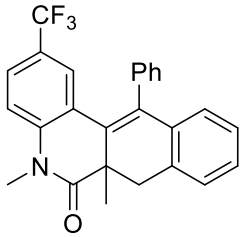
5,6a-dimethyl-12-phenyl-6a,7-dihydrobenzo[*j*]phenanthridin-6(5*H*)-one (**3a**)

Yield: 57%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.24 (s, 3H), 3.34 (d, *J* = 16.3 Hz, 1H), 3.41 (s, 3H), 3.48 (d, *J* = 16.3 Hz, 1H), 6.59 (t, *J* = 7.4 Hz, 1H), 6.80 (d, *J* = 7.1 Hz, 1H), 6.94 (d, *J* = 8.0 Hz, 1H), 7.08-7.11 (m, 3H), 7.16-7.20 (m, 1H), 7.25-7.29 (m, 3H), 7.34-7.41 (m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 22.6, 30.4, 37.9, 43.3, 114.2, 121.9, 123.1, 125.9, 126.4, 127.2, 127.6, 128.1, 128.5, 128.6, 130.7, 130.9, 132.2, 132.6, 134.2, 135.4, 138.8, 139.4, 174.1; HRMS (ESI) calcd for $C_{25}H_{21}NO$: ($M + H^+$) 352.1696, found: 352.1697.



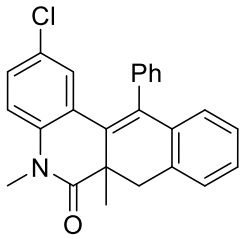
2,5,6a-trimethyl-12-phenyl-6a,7-dihydrobenzo[*j*]phenanthridin-6(5*H*)-one (**3b**)

Yield: 56%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.24 (s, 3H), 1.87 (s, 3H), 3.34 (d, *J* = 16.4 Hz, 1H), 3.38 (s, 3H), 3.46 (d, *J* = 16.3 Hz, 1H), 6.55 (s, 1H), 6.82 (d, *J* = 8.2 Hz, 1H), 6.89 (d, *J* = 8.1 Hz, 1H), 7.12 (t, *J* = 6.6 Hz, 2H), 7.16-7.20 (m, 1H), 7.25-7.29 (m, 3H), 7.35-7.42 (m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 20.3, 22.6, 30.3, 37.9, 43.3, 113.9, 122.7, 125.9, 126.4, 127.1, 127.5, 128.5, 128.6, 128.6, 130.9, 131.2, 131.6, 132.4, 132.7, 134.2, 135.2, 137.1, 139.1, 173.9; HRMS (ESI) calcd for $C_{26}H_{23}NO$: ($M + H^+$) 366.1852, found: 366.1850.



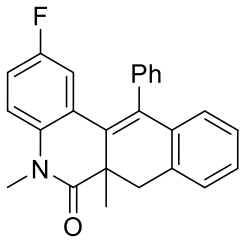
5,6a-dimethyl-12-phenyl-2-(trifluoromethyl)-6a,7-dihydrobenzo[*j*]phenanthridin-6(5*H*)-one (**3c**)

Yield: 71%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.27 (s, 3H), 3.36 (d, *J* = 16.4 Hz, 1H), 3.43 (s, 3H), 3.49 (d, *J* = 16.3 Hz, 1H), 7.01 (d, *J* = 8.5 Hz, 1H), 7.04 (s, 1H), 7.11-7.16 (m, 2H), 7.20-7.25 (m, 2H), 7.29-7.33 (m, 3H), 7.38-7.42 (m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 22.7, 30.5, 37.8, 43.2, 114.2, 123.2, 123.9, 124.7, 124.8, 126.3, 126.6, 127.7, 127.8, 127.9, 128.1, 128.6, 128.9, 130.5, 132.5, 133.6, 137.1, 137.8, 141.9, 174.2; HRMS (ESI) calcd for $C_{26}H_{20}F_3NO$: ($M + H^+$) 420.1570, found: 420.1561.



2-Chloro-5,6a-dimethyl-12-phenyl-6a,7-dihydrobenzo[*j*]phenanthridin-6(5*H*)-one (**3d**)

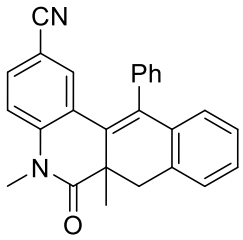
Yield: 66%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.24 (s, 3H), 3.34 (d, *J* = 16.4 Hz, 1H), 3.38 (s, 3H), 3.47 (d, *J* = 16.4 Hz, 1H), 6.71 (d, *J* = 2.2 Hz, 1H), 6.85 (d, *J* = 8.7 Hz, 1H), 7.04 (dd, J_1 = 8.7 Hz, J_2 = 2.3 Hz, 1H), 7.11 (d, *J* = 3.9 Hz, 2H), 7.18-7.29 (m, 4H), 7.40-7.44 (m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 22.7, 30.5, 37.8, 43.1, 115.3, 124.6, 126.2, 126.6, 127.4, 127.7, 127.8, 128.0, 128.5, 128.9, 130.5, 130.6, 130.8, 132.6, 133.7, 136.7, 138.0, 138.1, 173.8; HRMS (ESI) calcd for $C_{25}H_{20}NOCl$: ($M + H^+$) 386.1306, found: 386.1298.



2-Fluoro-5,6a-dimethyl-12-phenyl-6a,7-dihydrobenzo[*j*]phenanthridin-6(5*H*)-one (**3e**)

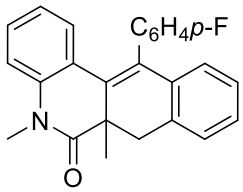
Yield: 58%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.24 (s, 3H), 3.34 (d, *J* = 16.4 Hz, 1H), 3.39 (s, 3H), 3.47 (d, *J* = 16.4 Hz, 1H), 6.47 (dd, J_1 = 11.0 Hz, J_2 = 2.7 Hz, 1H), 6.77-6.82 (m, 1H), 6.87 (dd, J_1 = 8.9 Hz, J_2 = 5.0 Hz, 1H), 7.08-7.13 (m, 2H), 7.18-7.40 (m, 4H), 7.37-7.43 (m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 22.7, 30.6, 37.8, 43.0, 114.6 (d, $^{2}J_{CF}$ = 22.9 Hz), 115.2 (d, $^{3}J_{CF}$ = 8.2 Hz), 117.2 (d, $^{2}J_{CF}$ = 25.4 Hz), 124.9 (d, $^{3}J_{CF}$ = 8.1 Hz), 126.2, 126.5,

127.7, 128.0, 128.5, 128.9, 130.5, 131.1, 132.7, 133.8, 135.8, 136.7, 138.2, 157.8 (d, $^{1}J_{CF}$ = 240.4 Hz), 173.6; HRMS (ESI) calcd for $C_{25}H_{20}NOF$: (M + H^{+}) 370.1602, found: 370.1608.



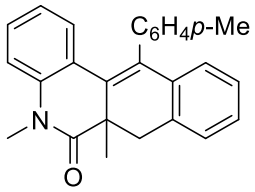
5,6a-dimethyl-6-oxo-12-phenyl-5,6,6a,7-tetrahydrobenzo[*j*]phenanthridine-2-carbonitrile (**3f**)

Yield: 50%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.25 (s, 3H), 3.34 (d, *J* = 16.4 Hz, 1H), 3.43 (s, 3H), 3.50 (d, *J* = 16.3 Hz, 1H), 6.99-7.01 (m, 2H), 7.13 (d, *J* = 3.7 Hz, 2H), 7.21-7.26 (m, 3H), 7.29 (d, *J* = 7.2 Hz, 1H), 7.36 (dd, J_1 = 8.5 Hz, J_2 = 1.5 Hz, 1H), 7.44 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 22.8, 30.5, 37.7, 43.1, 105.5, 114.7, 118.4, 123.9, 126.4, 126.7, 128.1, 128.4, 128.6, 129.1, 129.6, 130.4, 131.6, 132.4, 133.4, 134.4, 137.5, 137.8, 142.8, 174.1; HRMS (ESI) calcd for $C_{26}H_{20}N_2O$: (M + H^{+}) 377.1648, found: 377.1651.



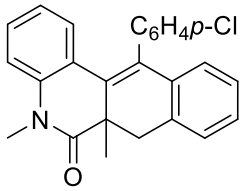
12-(4-Fluorophenyl)-5,6a-dimethyl-6a,7-dihydrobenzo[*j*]phenanthridin-6(5*H*)-one (**3g**)

Yield: 58%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.23 (s, 3H), 3.33 (d, *J* = 16.3 Hz, 1H), 3.41 (s, 3H), 3.48 (d, *J* = 16.3 Hz, 1H), 6.64 (t, *J* = 7.6 Hz, 1H), 6.76 (d, *J* = 7.2 Hz, 1H), 6.96 (d, *J* = 8.1 Hz, 1H), 7.03-7.14 (m, 5H), 7.17-7.30 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 22.7, 30.4, 37.8, 43.3, 114.3, 115.7 (d, $^{2}J_{CF}$ = 21.3 Hz), 122.1, 123.0, 125.7, 126.5, 127.8, 128.2, 128.6, 130.6, 132.4, 132.5, 132.6, 132.8, 134.0, 134.5 (d, $^{2}J_{CF}$ = 23.3 Hz), 139.5, 162.1 (d, $^{1}J_{CF}$ = 246.5 Hz), 173.9; HRMS (ESI) calcd for $C_{25}H_{20}NOF$: (M + H^{+}) 370.1602, found: 370.1610.



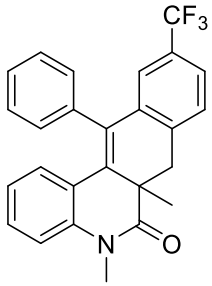
5,6a-dimethyl-12-(*p*-tolyl)-6a,7-dihydrobenzo[*j*]phenanthridin-6(5*H*)-one (**3h**)

Yield: 48%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.23 (s, 3H), 2.40 (s, 3H), 3.33 (d, *J* = 16.3 Hz, 1H), 3.41 (s, 3H), 3.46 (d, *J* = 16.3 Hz, 1H), 6.61 (t, *J* = 7.6 Hz, 1H), 6.65 (d, *J* = 7.9 Hz, 1H), 6.94 (d, *J* = 8.1 Hz, 1H), 7.11-7.21 (m, 8H), 7.26-7.28 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 21.3, 22.6, 30.3, 37.9, 43.3, 114.1, 122.0, 123.3, 125.9, 126.4, 127.5, 127.9, 128.4, 129.3, 130.6, 130.7, 132.0, 132.6, 134.4, 135.4, 135.7, 136.8, 139.4, 174.1; HRMS (ESI) calcd for $C_{26}H_{23}NO$: ($M + H^+$) 366.1852, found: 366.1848.



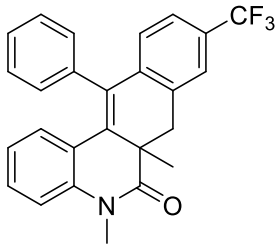
12-(4-Chlorophenyl)-5,6a-dimethyl-6a,7-dihydrobenzo[*j*]phenanthridin-6(5*H*)-one (**3i**)

Yield: 62%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.23 (s, 3H), 3.33 (d, *J* = 16.3 Hz, 1H), 3.40 (s, 3H), 3.48 (d, *J* = 16.3 Hz, 1H), 6.66 (t, *J* = 7.6 Hz, 1H), 6.79 (d, *J* = 7.9 Hz, 1H), 6.96 (d, *J* = 8.1 Hz, 1H), 7.01 (d, *J* = 7.8 Hz, 1H), 7.09-7.21 (m, 5H), 7.29 (d, *J* = 7.1 Hz, 1H), 7.37 (d, *J* = 7.8 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 22.7, 30.4, 37.8, 43.3, 114.3, 122.2, 122.9, 125.6, 126.5, 127.8, 128.3, 128.6, 128.9, 130.6, 132.3, 132.6, 132.8, 133.2, 133.8, 134.2, 137.3, 139.5, 173.9; HRMS (ESI) calcd for $C_{25}H_{20}NOCl$: ($M + H^+$) 386.1306, found: 386.1296.



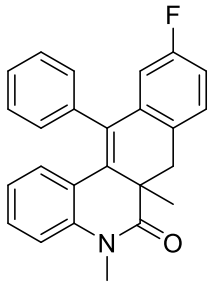
5,6a-dimethyl-12-phenyl-10-(trifluoromethyl)-6a,7-dihydrobenzo[*j*]phenanthridin-6(5*H*)-one (**3j**)

Yield: 24%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.26 (s, 3H), 3.39 (d, *J* = 19.8 Hz, 4H), 3.51 (d, *J* = 16.5 Hz, 1H), 6.61 (t, *J* = 7.5 Hz, 1H), 6.81 (d, *J* = 7.2 Hz, 1H), 6.97 (t, *J* = 8.1 Hz, 1H), 7.13 (t, *J* = 7.3 Hz, 1H), 7.18 (d, *J* = 8.2 Hz, 1H), 7.23-7.26 (m, 2H), 7.33 (d, *J* = 8.2 Hz, 1H), 7.37-7.43 (m, 3H), 7.52 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 22.9, 30.4, 37.6, 43.4, 114.3, 122.1, 122.6, 123.4, 125.0, 125.1, 125.9, 127.6, 128.7, 128.8, 128.9, 130.7, 130.8, 133.3, 134.3, 134.9, 137.4, 138.1, 139.5, 173.4; HRMS (ESI) calcd for $C_{26}H_{20}NOF_3$: ($M + H^+$) 420.1570, found: 420.1573.



5,6a-dimethyl-12-phenyl-9-(trifluoromethyl)-6a,7-dihydrobenzo[*j*]phenanthridin-6(5*H*)-one (**3j'**)

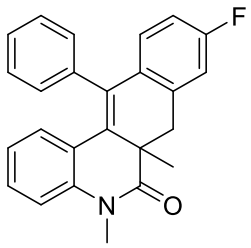
Yield: 26%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.24 (s, 3H), 3.40 (d, *J* = 15.1 Hz, 4H), 3.50 (d, *J* = 16.7 Hz, 1H), 6.61 (t, *J* = 7.5 Hz, 1H), 6.78 (d, *J* = 7.9 Hz, 1H), 6.96 (d, *J* = 8.1 Hz, 1H), 7.13 (t, *J* = 7.2 Hz, 1H), 7.26 (s, 2H), 7.35-7.44 (m, 6H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 22.8, 30.4, 37.8, 43.3, 114.3, 122.2, 122.3, 122.3, 122.7, 124.1, 124.2, 127.7, 128.6, 128.8, 128.9, 130.7, 130.7, 134.0, 134.3, 134.8, 136.5, 137.8, 139.5, 173.5; HRMS (ESI) calcd for $C_{26}H_{20}NOF_3$: ($M + H^+$) 420.1570, found: 420.1573.



10-fluoro-5,6a-dimethyl-12-phenyl-6a,7-dihydrobenzo[*j*]phenanthridin-6(5*H*)-one (**3k**)

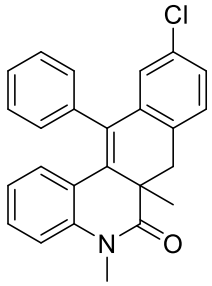
Yield: 28%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.23 (s, 3H), 3.32 (d, *J* = 16.2 Hz, 1H), 3.40 (d, *J* = 9.6 Hz, 4H), 6.60 (t, *J* = 7.6 Hz, 1H), 6.79-6.89 (m, 3H), 6.95 (d, *J* = 8.1 Hz, 1H), 7.11 (t, *J* = 7.2 Hz, 1H), 7.23 (dd, J_1 = 12.6 Hz, J_2 = 6.2 Hz, 3H), 7.36-7.42 (m, 3H); ^{13}C NMR

(100 MHz, $CDCl_3$) δ 22.6, 30.4, 37.1, 43.5, 112.9 (d, $^2J_{CF}$ = 23.9 Hz), 113.9 (d, $^2J_{CF}$ = 21.5 Hz), 114.2, 122.1, 122.7, 127.5, 128.0, 128.4, 128.8, 129.3, 129.5, 129.6, 130.7, 133.6, 134.6, 138.3, 139.5, 161.8 (d, $^1J_{CF}$ = 242.0 Hz), 173.8; HRMS (ESI) calcd for $C_{25}H_{20}NOF$: (M + H^+) 370.1602, found: 370.1608.



9-fluoro-5,6a-dimethyl-12-phenyl-6a,7-dihydrobenzo[*j*]phenanthridin-6(5*H*)-one (**3k'**)

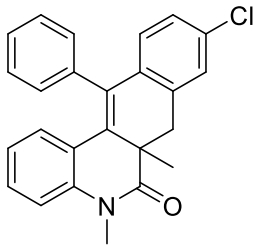
Yield: 42%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.24 (s, 3H), 3.31 (d, *J* = 16.5 Hz, 1H), 3.41 (s, 3H), 3.48 (d, *J* = 16.4 Hz, 1H), 6.59 (t, *J* = 7.6 Hz, 1H), 6.77 (d, *J* = 8.7 Hz, 2H), 6.95 (d, *J* = 8.0 Hz, 1H), 6.98-7.05 (m, 2H), 7.10 (t, *J* = 7.2 Hz, 1H), 7.23-7.26 (m, 2H), 7.35-7.41 (m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 22.8, 30.4, 37.9, 43.1, 112.9 (d, $^2J_{CF}$ = 21.0 Hz), 114.2, 115.4 (d, $^2J_{CF}$ = 21.8 Hz), 122.1, 123.0, 127.4, 127.8 (d, $^3J_{CF}$ = 8.1 Hz), 128.1, 128.7, 130.4, 130.6, 130.8, 131.3, 134.6, 135.2, 138.7, 139.3, 162.1 (d, $^1J_{CF}$ = 248.5 Hz), 173.8; HRMS (ESI) calcd for $C_{25}H_{20}NOF$: (M + H^+) 370.1602, found: 370.1611.



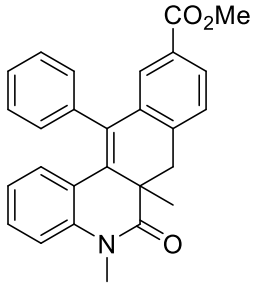
10-chloro-5,6a-dimethyl-12-phenyl-6a,7-dihydrobenzo[*j*]phenanthridin-6(5*H*)-one (**3l**)

Yield: 38%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.23 (s, 3H), 3.31 (d, *J* = 16.4 Hz, 1H), 3.40 (s, 3H), 3.41 (d, *J* = 16.0 Hz, 1H), 6.60 (t, *J* = 7.6 Hz, 1H), 6.78 (d, *J* = 7.1 Hz, 1H), 6.95 (d, *J* = 8.1 Hz, 1H), 7.07-7.16 (m, 3H), 7.20-7.25 (m, 3H), 7.37-7.43 (m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 22.7, 30.4, 37.3, 43.4, 114.3, 122.1, 122.7, 125.8, 127.4, 127.6, 128.5, 128.9, 129.7, 130.7, 130.9, 132.3, 133.8, 134.4, 135.9, 138.1, 139.5, 173.7; HRMS (ESI)

calcd for $C_{25}H_{20}NOCl$: (M + H^+) 386.1306, found: 386.1309.

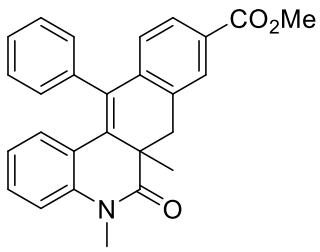


9-chloro-5,6a-dimethyl-12-phenyl-6a,7-dihydrobenzo[*j*]phenanthridin-6(5*H*)-one (**3l'**) Yield: 30%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.23 (s, 3H), 3.30 (d, *J* = 16.5 Hz, 1H), 3.41 (s, 3H), 3.46 (d, *J* = 16.5 Hz, 1H), 6.59 (t, *J* = 7.6 Hz, 1H), 6.77 (d, *J* = 7.3 Hz, 1H), 6.95 (d, *J* = 8.1 Hz, 1H), 7.00 (d, *J* = 8.5 Hz, 1H), 7.05 (d, *J* = 9.9 Hz, 1H), 7.11 (t, *J* = 7.3 Hz, 1H), 7.23-7.26 (m, 3H), 7.34-7.41 (m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 22.7, 30.4, 37.7, 43.3, 114.3, 122.1, 122.9, 126.5, 127.2, 127.4, 128.3, 128.8, 130.6, 130.7, 132.5, 132.8, 133.1, 134.5, 138.4, 139.4, 173.7; HRMS (ESI) calcd for $C_{25}H_{20}NOCl$: (M + H^+) 386.1306, found: 386.1304.



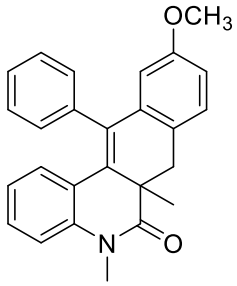
Methyl

5,6a-dimethyl-6-oxo-12-phenyl-5,6,6a,7-tetrahydrobenzo[*j*]phenanthridine-10-carboxylate (**3m**) Yield: 33%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.24 (s, 3H), 3.41 (s, 3H), 3.51 (d, *J* = 17.3 Hz, 1H), 3.99 (d, *J* = 19.2 Hz, 4H), 6.60 (t, *J* = 7.5 Hz, 1H), 6.79 (d, *J* = 7.6 Hz, 1H), 6.95 (d, *J* = 8.1 Hz, 1H), 7.12 (td, J_1 = 7.6 Hz, J_2 = 2.6 Hz, 2H), 7.23 (d, *J* = 7.5 Hz, 3H), 7.36-7.42 (m, 3H), 7.65 (d, *J* = 7.5 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 23.1, 30.4, 34.6, 43.0, 52.2, 114.2, 121.9, 122.8, 125.8, 127.4, 128.3, 128.7, 129.1, 129.2, 130.4, 130.9, 133.3, 133.4, 134.7, 135.3, 138.6, 139.5, 168.5, 173.6; HRMS (ESI) calcd for $C_{27}H_{23}NO_3$: (M + H^+) 410.1751, found: 410.1769.



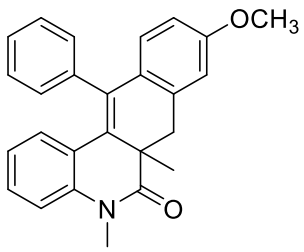
Methyl 5,6a-dimethyl-6-oxo-12-phenyl-5,6,6a,7-tetrahydrobenzo[*j*]phenanthridine-9-carboxylate (**3m'**)

Yield: 38%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.23 (s, 3H), 3.41 (d, *J* = 16.5 Hz, 1H), 3.43 (s, 3H), 3.50 (d, *J* = 16.6 Hz, 1H), 3.82 (s, 3H), 6.60 (t, *J* = 7.6 Hz, 1H), 6.79 (d, *J* = 7.1 Hz, 1H), 6.96 (d, *J* = 8.1 Hz, 1H), 7.11 (t, *J* = 7.1 Hz, 1H), 7.26 (s, 1H), 7.34-7.44 (m, 5H), 7.83-7.87 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 22.7, 30.4, 38.1, 43.3, 51.9, 114.3, 122.1, 122.8, 125.7, 126.8, 127.6, 127.9, 128.4, 128.6, 128.7, 128.9, 129.4, 130.8, 133.3, 134.4, 134.7, 138.1, 139.4, 167.0, 173.7; HRMS (ESI) calcd for $C_{27}H_{23}NO_3$: (M + H^+) 410.1751, found: 410.1760.



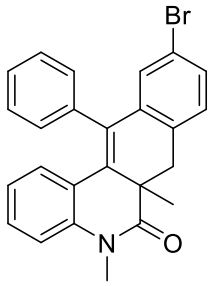
10-methoxy-5,6a-dimethyl-12-phenyl-6a,7-dihydrobenzo[*j*]phenanthridin-6(5*H*)-one (**3n**)

Yield: 28%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.23 (s, 3H), 3.28 (d, *J* = 16.1 Hz, 1H), 3.39 (d, *J* = 11.8 Hz, 4H), 3.68 (s, 3H), 6.59 (t, *J* = 7.6 Hz, 1H), 6.69 (d, *J* = 2.4 Hz, 1H), 6.74 (dd, J_1 = 8.1 Hz, J_1 = 2.5 Hz, 1H), 6.80 (d, *J* = 7.9 Hz, 1H), 6.94 (d, *J* = 8.1 Hz, 1H), 7.09 (t, *J* = 7.7 Hz, 1H), 7.19-7.25 (m, 3H), 7.33-7.40 (m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 22.5, 30.3, 37.1, 43.5, 55.2, 111.9, 112.9, 114.2, 121.9, 123.1, 124.8, 127.3, 128.1, 128.7, 129.2, 130.8, 131.1, 132.9, 135.2, 135.3, 138.7, 139.5, 158.3, 174.1; HRMS (ESI) calcd for $C_{26}H_{23}NO_2$: (M + H^+) 382.1802, found: 382.1811.



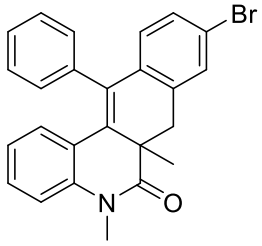
9-methoxy-5,6a-dimethyl-12-phenyl-6a,7-dihydrobenzo[*j*]phenanthridin-6(5*H*)-one (**3n'**)

Yield: 43%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.23 (s, 3H), 3.30 (d, *J* = 16.4 Hz, 1H), 3.40 (s, 3H), 3.47 (d, *J* = 16.3 Hz, 1H), 3.80 (s, 3H), 6.58 (t, *J* = 7.2 Hz, 1H), 6.62 (dd, J_1 = 8.7 Hz, J_1 = 2.5 Hz, 1H), 6.76 (d, *J* = 8.0 Hz, 1H), 6.85 (d, *J* = 2.1 Hz, 1H), 6.93 (d, *J* = 7.7 Hz, 1H), 6.99 (d, *J* = 8.7 Hz, 1H), 7.07 (t, *J* = 7.7 Hz, 1H), 7.19-7.25 (m, 2H), 7.33-7.40 (m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 22.8, 30.4, 38.4, 43.2, 55.3, 111.4, 114.2, 114.3, 122.0, 123.5, 127.2, 127.4, 127.5, 127.7, 128.7, 129.4, 130.5, 130.8, 134.6, 135.3, 139.1, 139.3, 159.2, 174.2; HRMS (ESI) calcd for $C_{26}H_{23}NO_2$: (M + H^+) 382.1802, found: 382.1810.



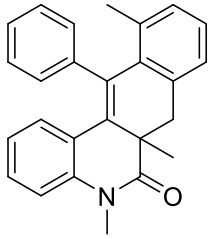
10-bromo-5,6a-dimethyl-12-phenyl-6a,7-dihydrobenzo[*j*]phenanthridin-6(5*H*)-one (**3o**)

Yield: 32%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.22 (s, 3H), 3.30 (d, *J* = 16.4 Hz, 1H), 3.39 (d, *J* = 13.7 Hz, 4H), 6.59 (t, *J* = 7.6 Hz, 1H), 6.77 (d, *J* = 7.8 Hz, 1H), 6.95 (d, *J* = 8.1 Hz, 1H), 7.11 (t, *J* = 7.7 Hz, 1H), 7.15 (d, *J* = 7.9 Hz, 1H), 7.21-7.25 (m, 3H), 7.30 (d, *J* = 7.9 Hz, 1H), 7.35-7.43 (m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 22.7, 30.4, 37.4, 43.4, 114.3, 120.4, 122.1, 122.7, 127.6, 128.5, 128.6, 128.9, 130.0, 130.3, 130.7, 131.4, 133.8, 134.3, 136.3, 138.0, 139.5, 173.7; HRMS (ESI) calcd for $C_{25}H_{20}NOBr$: (M + H^+) 430.0801, found: 430.0791.



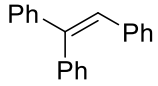
9-bromo-5,6a-dimethyl-12-phenyl-6a,7-dihydrobenzo[*j*]phenanthridin-6(5*H*)-one (**3o'**)

Yield: 20%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.23 (s, 3H), 3.30 (d, *J* = 16.5 Hz, 1H), 3.41 (s, 3H), 3.46 (d, *J* = 16.4 Hz, 1H), 6.59 (t, *J* = 7.6 Hz, 1H), 6.77 (d, *J* = 8.0 Hz, 1H), 6.94 (t, *J* = 7.6 Hz, 2H), 7.11 (t, *J* = 7.7 Hz, 1H), 7.20-7.22 (m, 3H), 7.36-7.42 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 22.7, 30.4, 37.6, 43.3, 114.3, 121.4, 122.1, 122.9, 127.4, 127.5, 128.3, 128.8, 129.5, 130.6, 130.7, 131.2, 132.7, 133.2, 134.5, 134.8, 138.3, 139.4, 173.6; HRMS (ESI) calcd for $C_{25}H_{20}NOBr$: ($M + H^+$) 430.0801, found: 430.0792.



5,6a,11-trimethyl-12-phenyl-6a,7-dihydrobenzo[*j*]phenanthridin-6(5*H*)-one (**3p**)

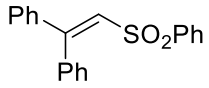
Yield: 43%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.24 (s, 3H), 2.42 (s, 3H), 3.32 (d, *J* = 16.8 Hz, 1H), 3.41 (s, 3H), 3.45 (d, *J* = 16.8 Hz, 1H), 6.59 (t, *J* = 7.6 Hz, 1H), 6.78 (d, *J* = 7.9 Hz, 1H), 6.93 (d, *J* = 6.7 Hz, 2H), 6.99 (d, *J* = 7.6 Hz, 1H), 7.06-7.11 (m, 2H), 7.24 (s, 2H), 7.31-7.39 (m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 19.8, 23.4, 30.4, 34.1, 43.1, 114.1, 121.9, 123.4, 124.3, 125.7, 127.1, 127.9, 128.6, 129.7, 130.5, 130.8, 130.9, 131.5, 133.9, 135.8, 135.9, 139.1, 139.3, 174.3; HRMS (ESI) calcd for $C_{26}H_{23}NO$: ($M + H^+$) 366.1852, found: 366.1866.



Ethene-1,1,2-triyltribenzene [1]

^{1}H NMR (400 MHz, $CDCl_3$) δ 6.97 (s, 1H), 7.03 (d, *J* = 6.9 Hz, 2H), 7.11-7.13 (m, 3H), 7.20-7.21 (m, 2H), 7.29-7.32 (m, 8H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 126.7, 127.4, 127.5,

127.6, 127.9, 128.1, 128.2, 128.6, 129.5, 130.4, 137.3, 140.4, 142.5, 143.4.



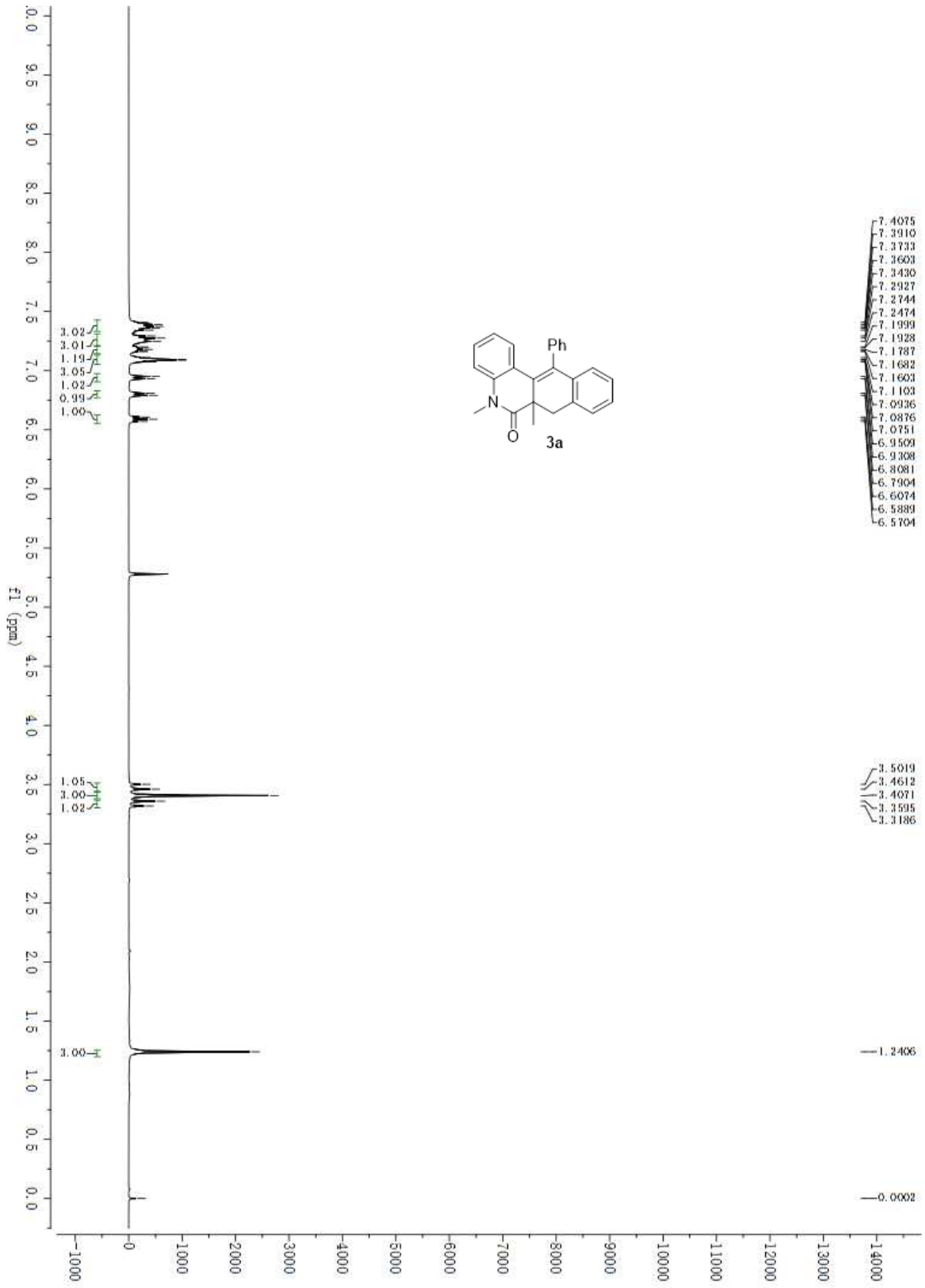
(2-(phenylsulfonyl)ethene-1,1-diyl)dibenzene [2]

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.03 (s, 1H), 7.08 (d, *J* = 7.3 Hz, 2H), 7.21 (d, *J* = 7.5 Hz, 2H), 7.26-7.36 (m, 8H), 7.48 (t, *J* = 7.4 Hz, 1H), 7.58 (t, *J* = 7.6 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 127.6, 127.8, 128.2, 128.5, 128.6, 128.7, 128.8, 129.7, 130.3, 132.8, 135.4, 139.1, 141.4, 155.2.

References:

1) B. J. Li, Y. Z. Li, X. Y. Lu, J. Lu, B. T. Guan, Z. J. Shi, *Angew. Chem., Int. Ed.* 2008, **120**, 10278.

2) G. A. Russell, P. Ngoviwatchai, H. Tashtoush, J. Hershberger, *Organometallics* 1987, **6**, 1414.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7.1603
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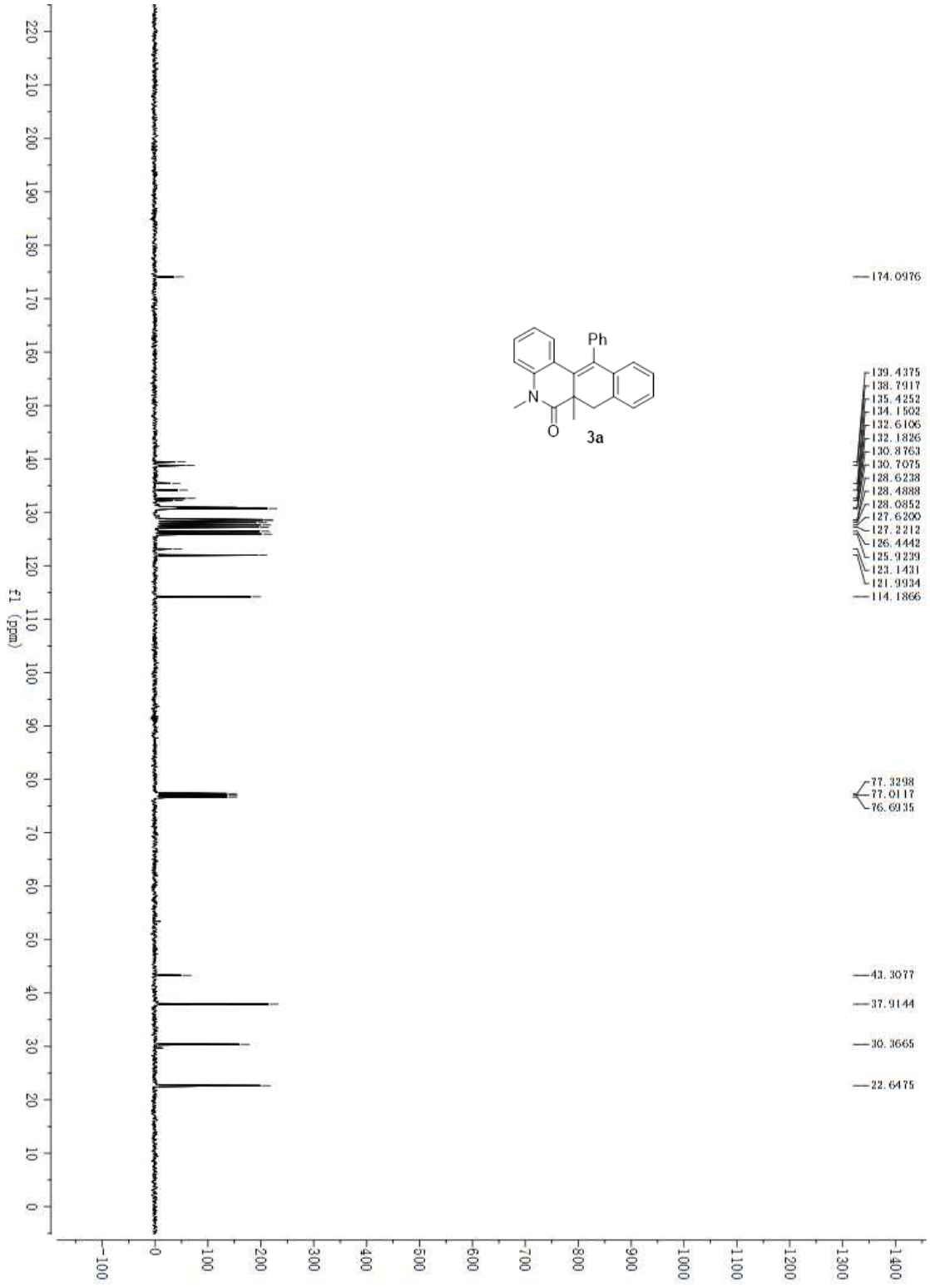
3.00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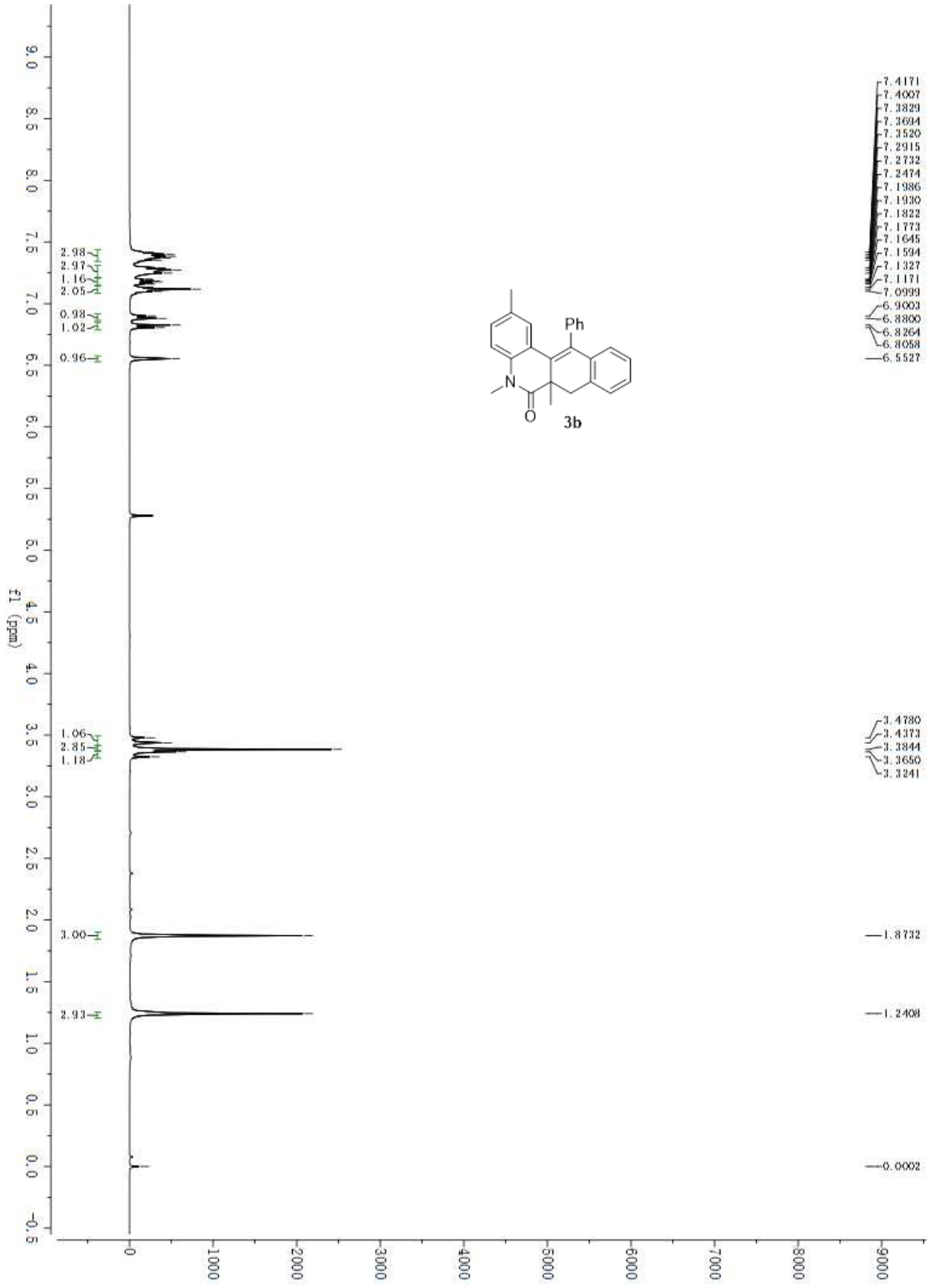
f1 (ppm)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3.4373
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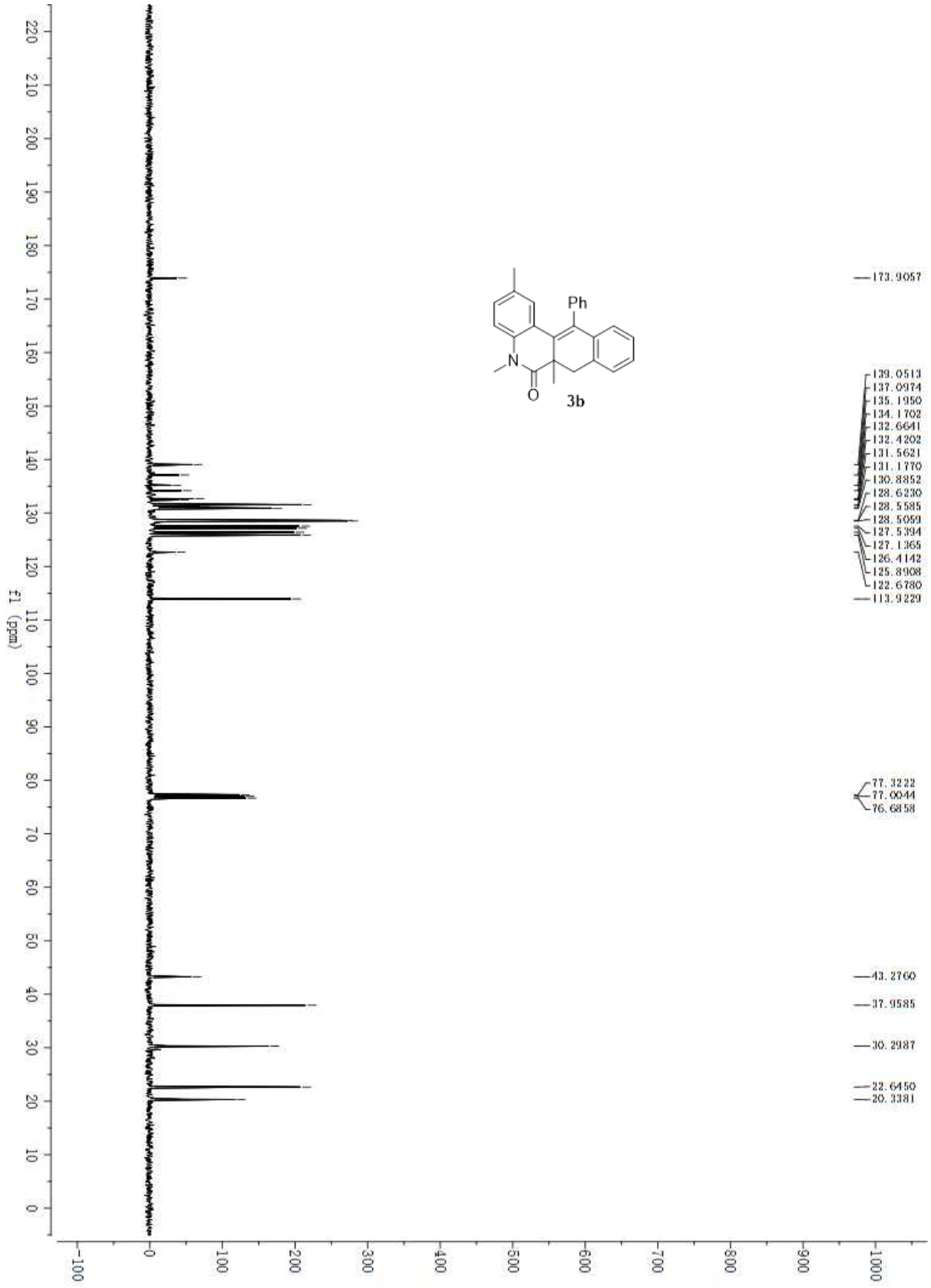
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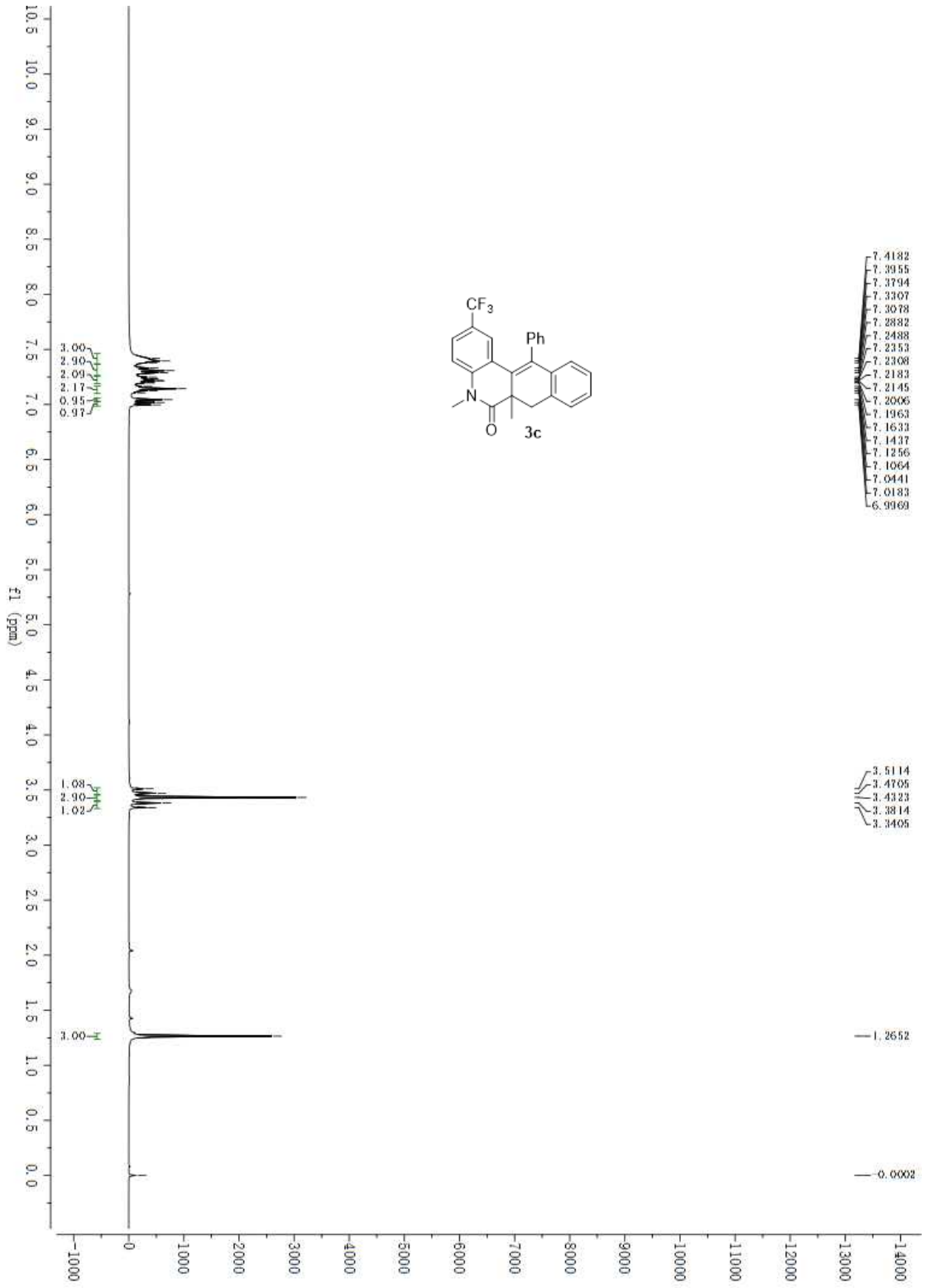
f1 (ppm)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2.90
1.02
3.00
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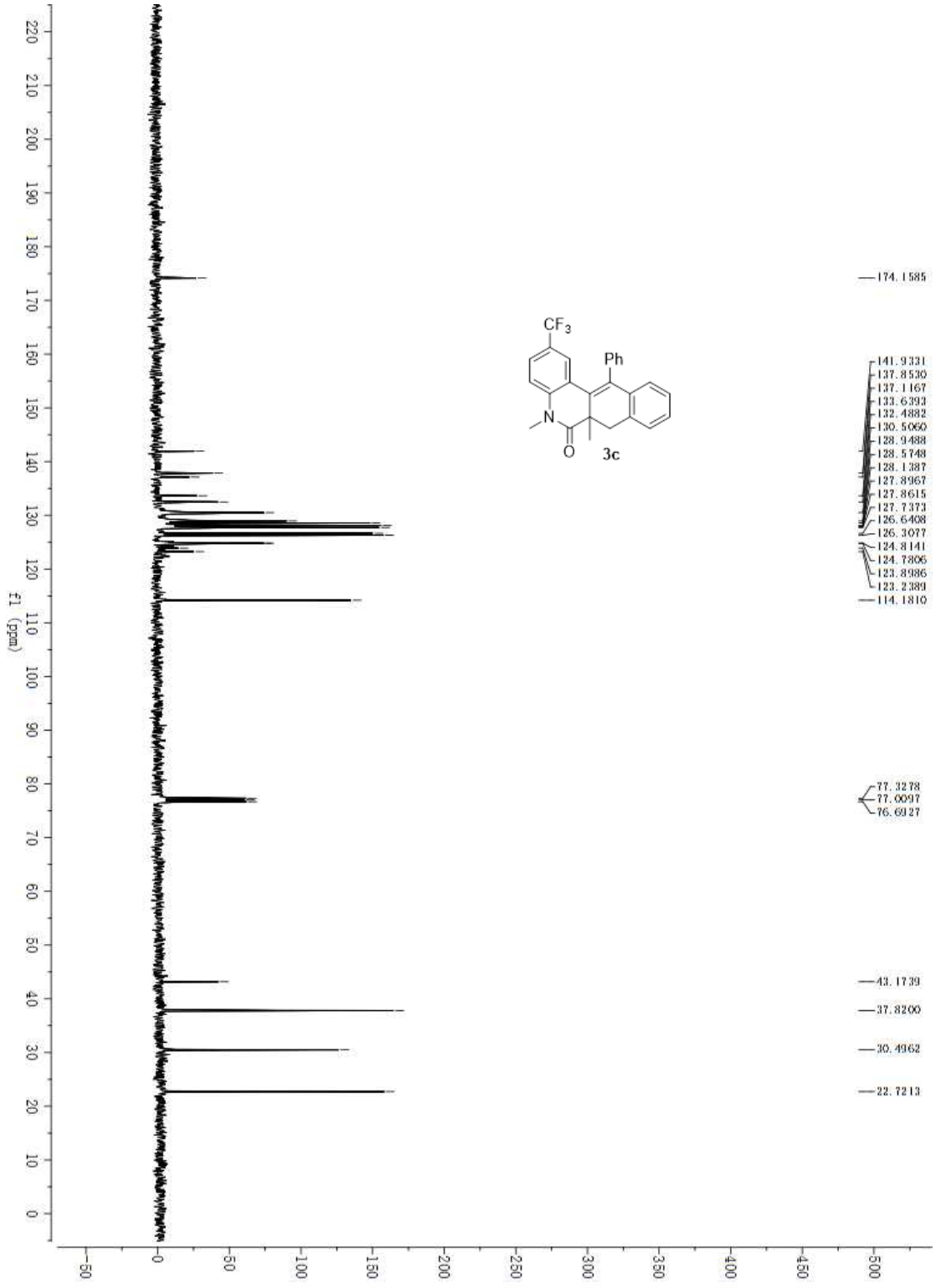
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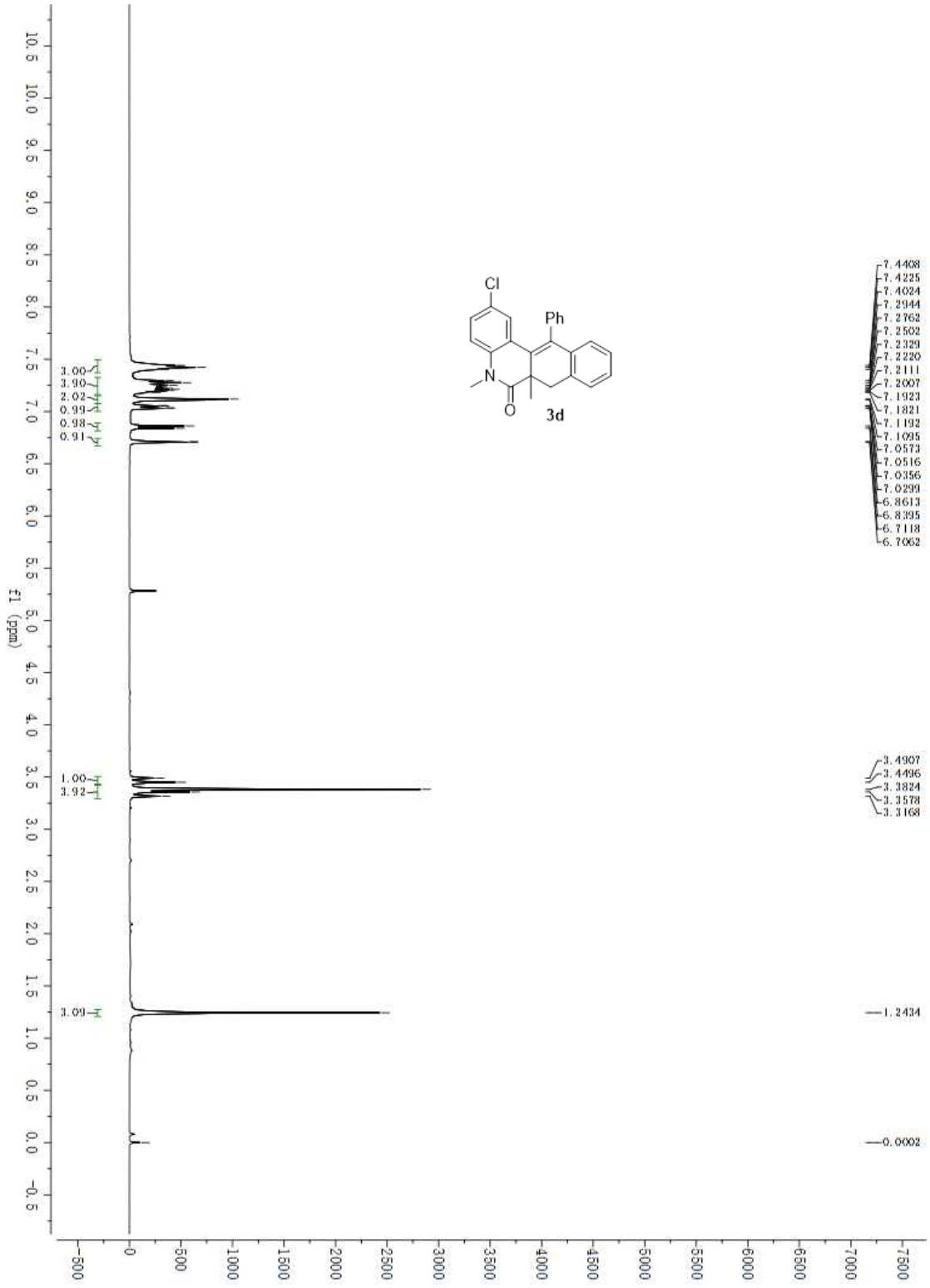
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6.7062
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3.3824
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3.3168
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2.02
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0.98
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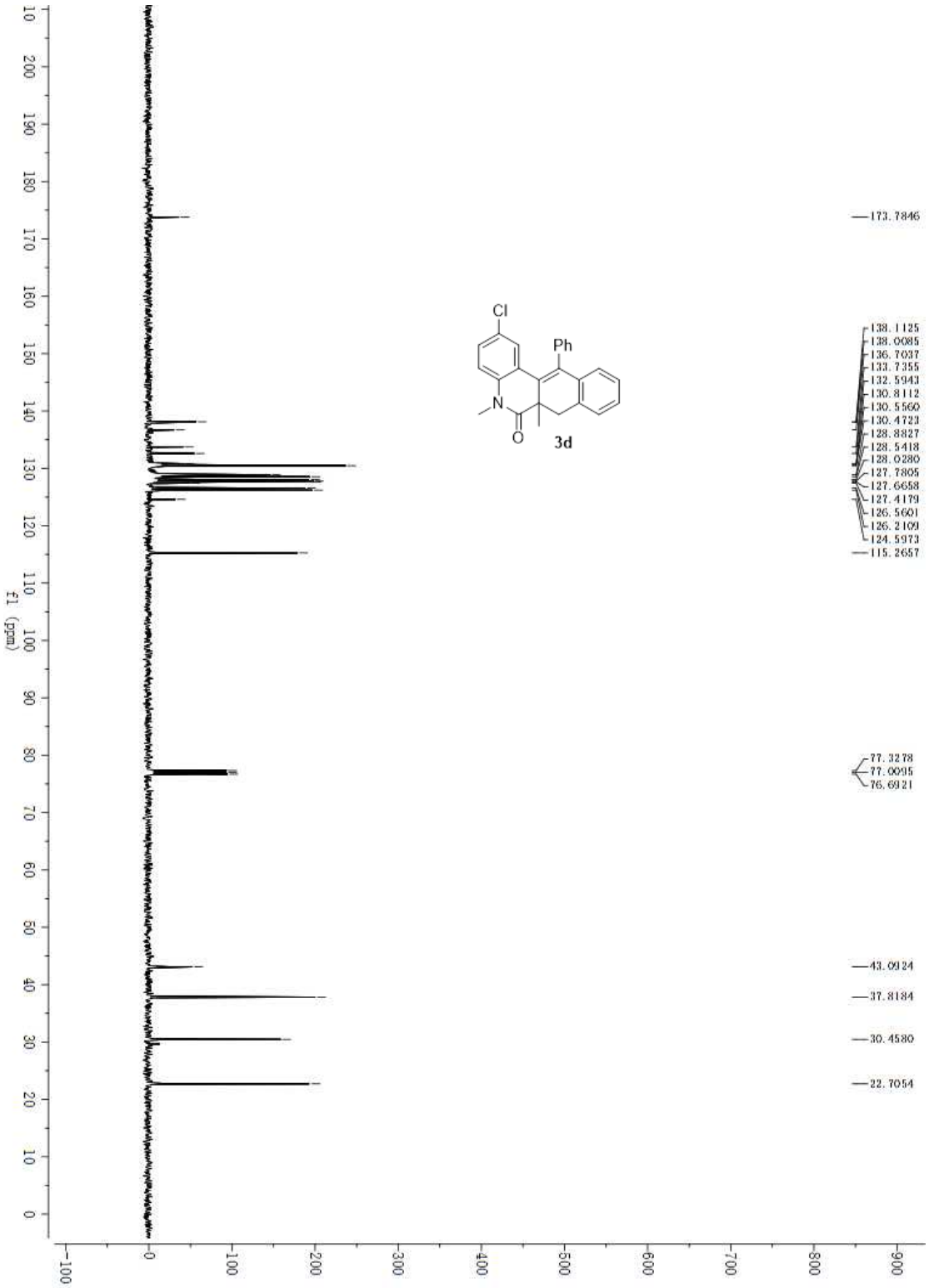
1.00
3.92
3.09
f1 (ppm)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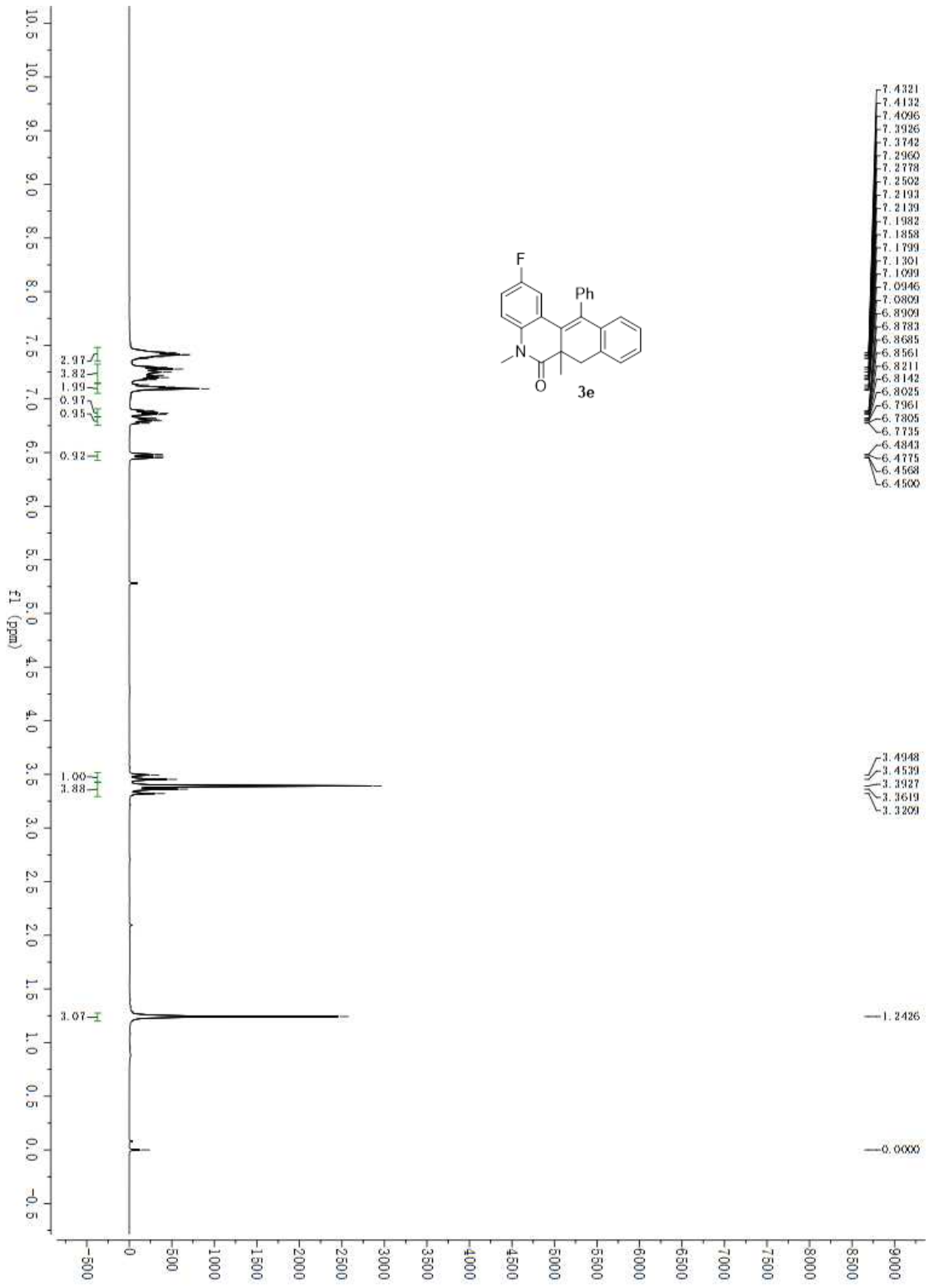
f1 (ppm)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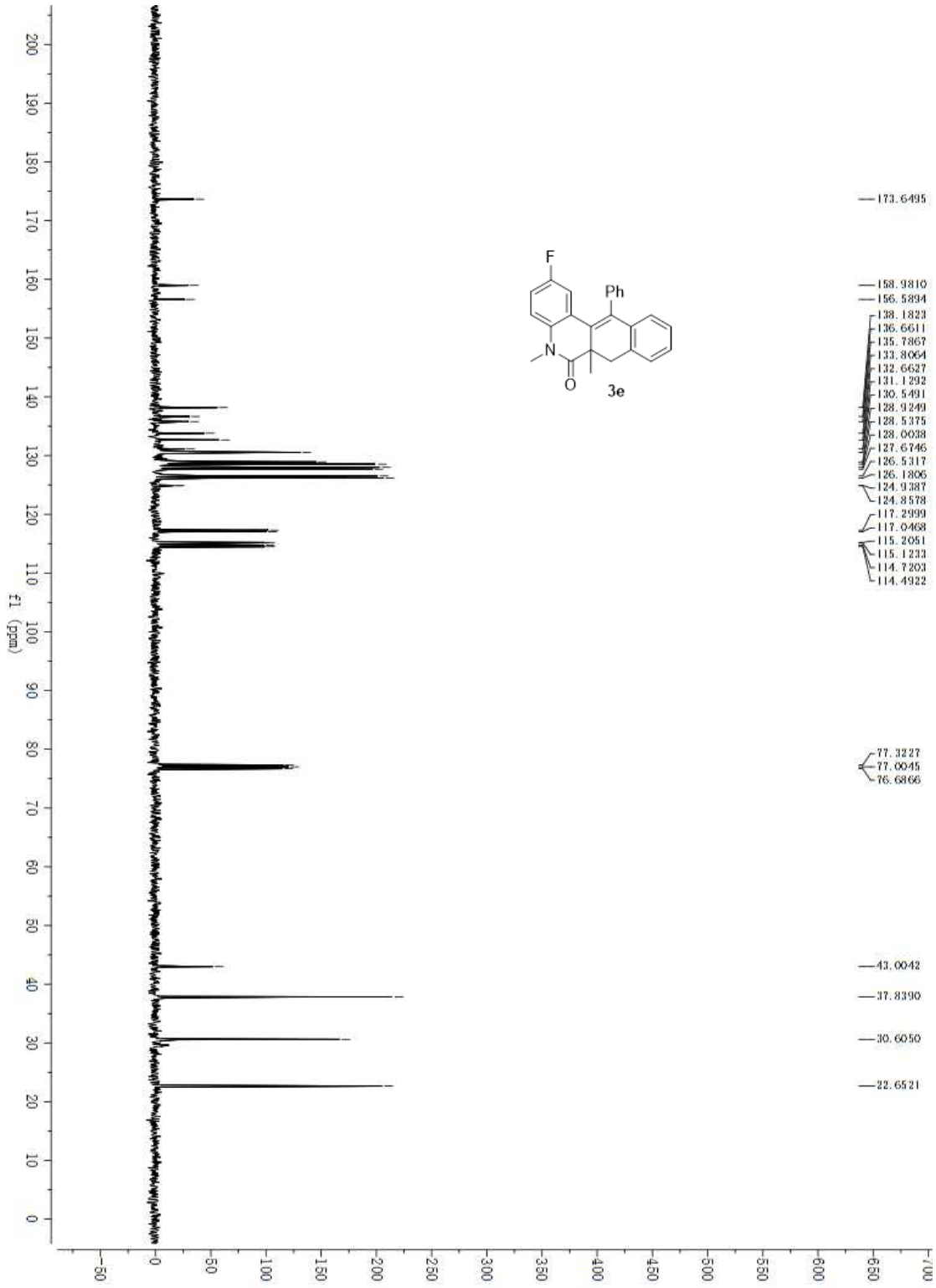
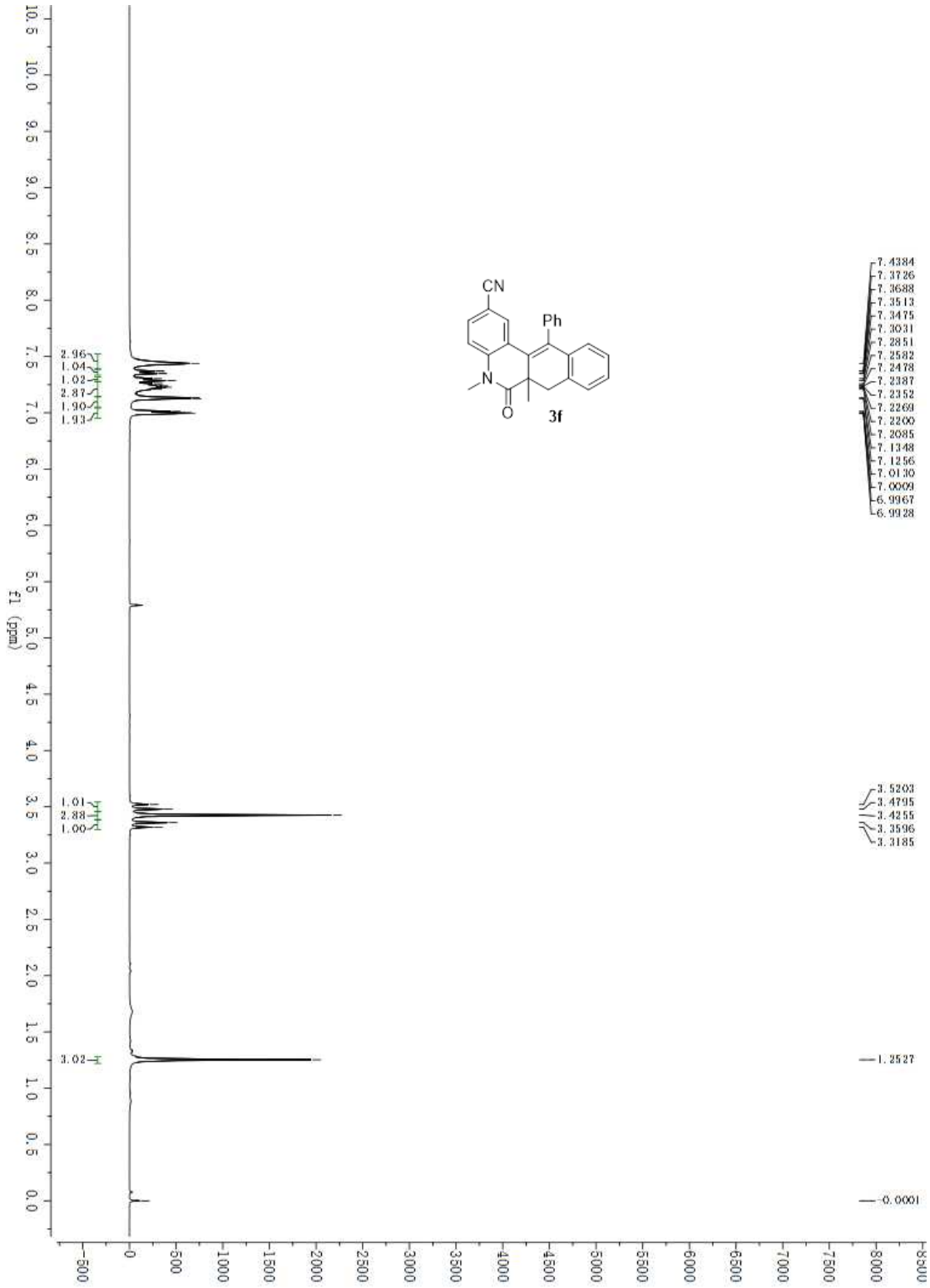
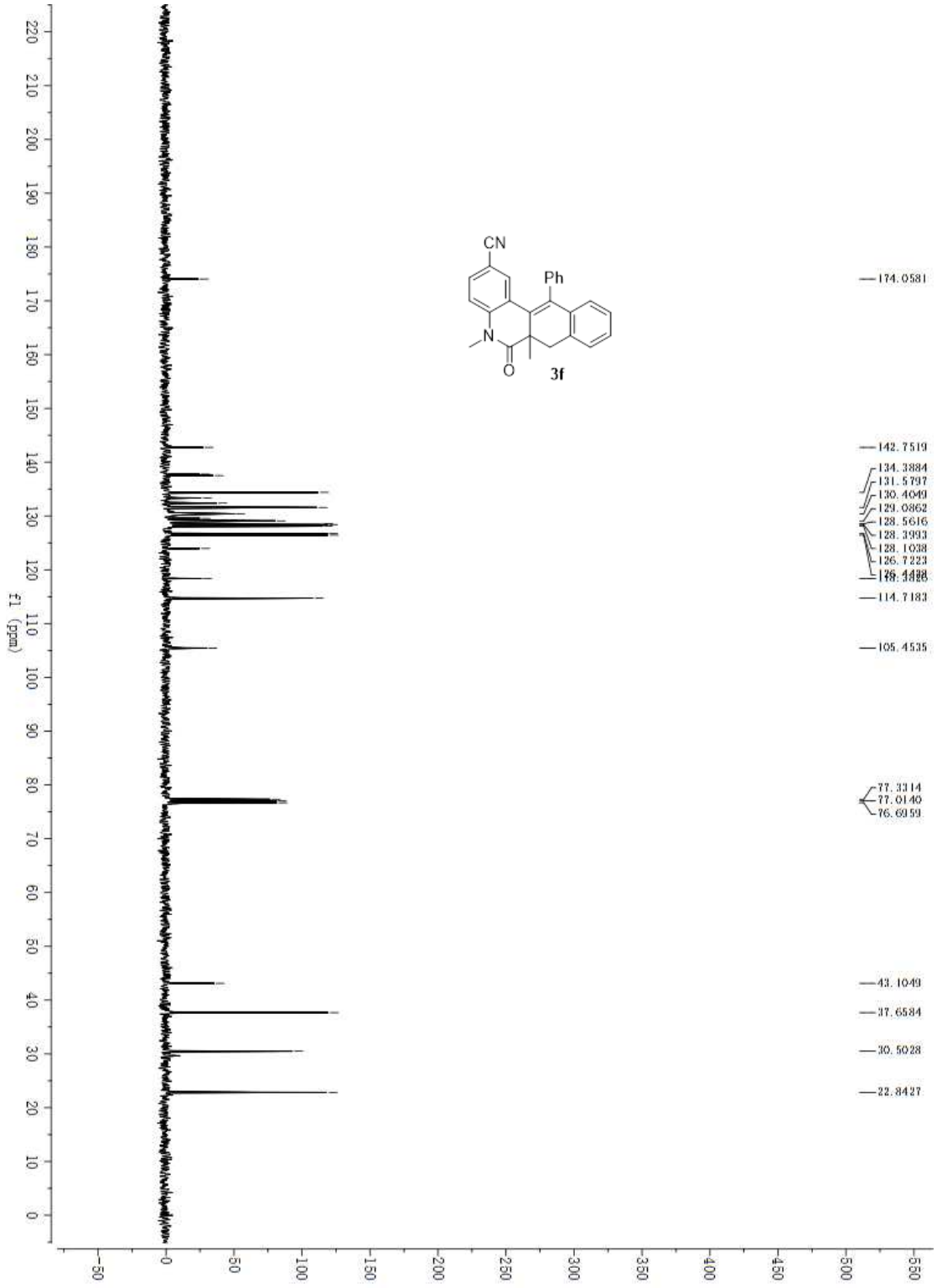
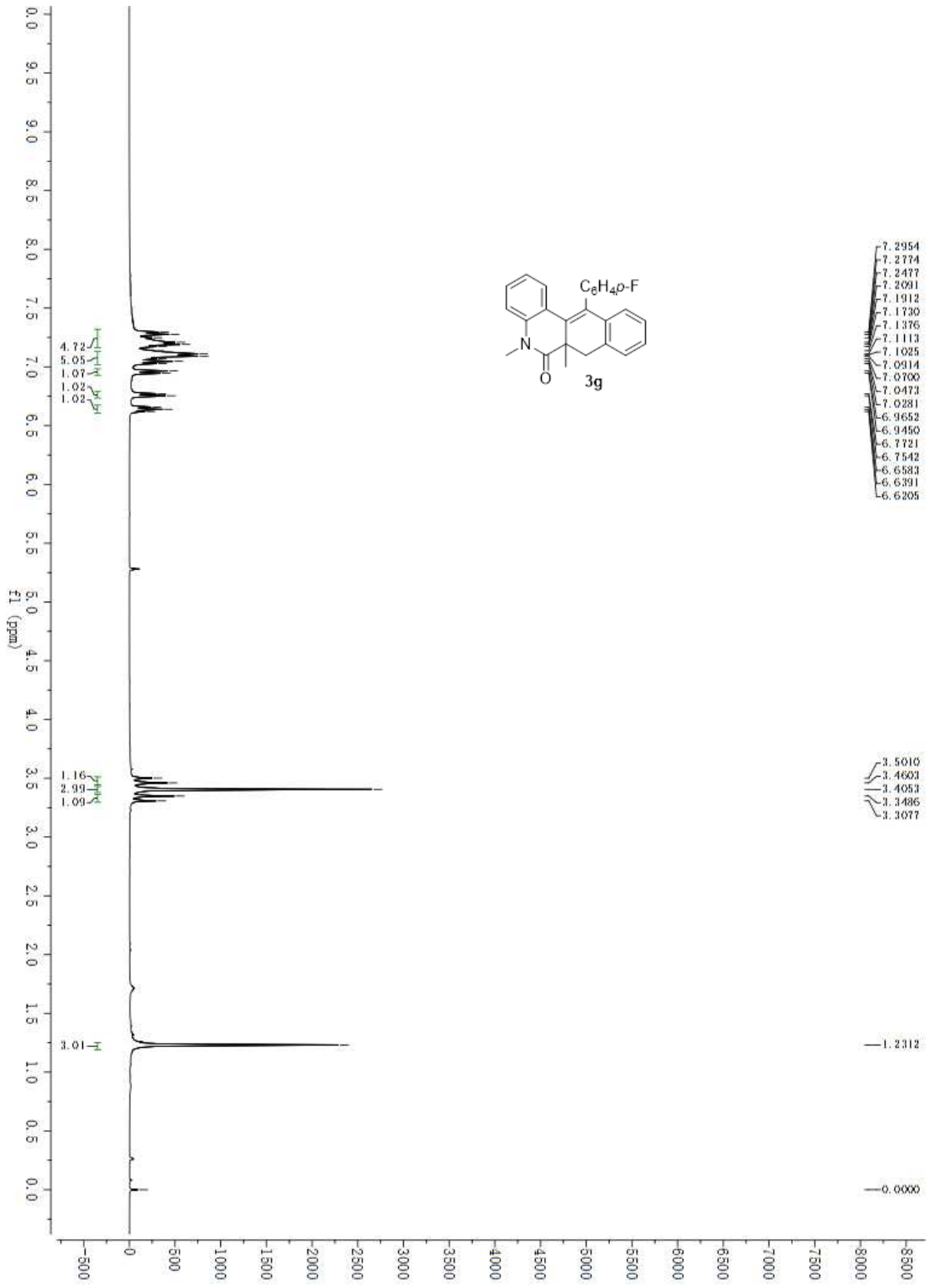
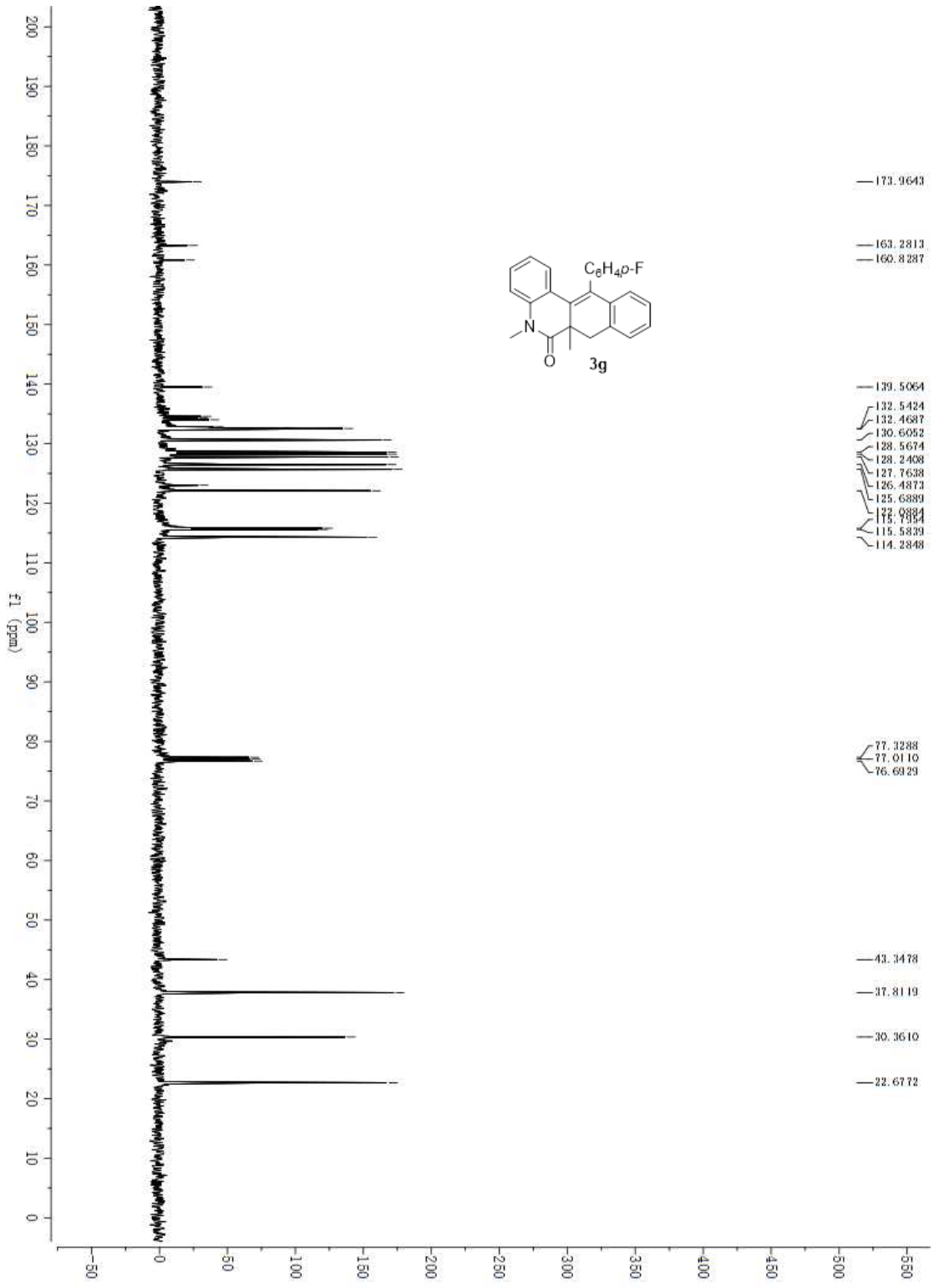
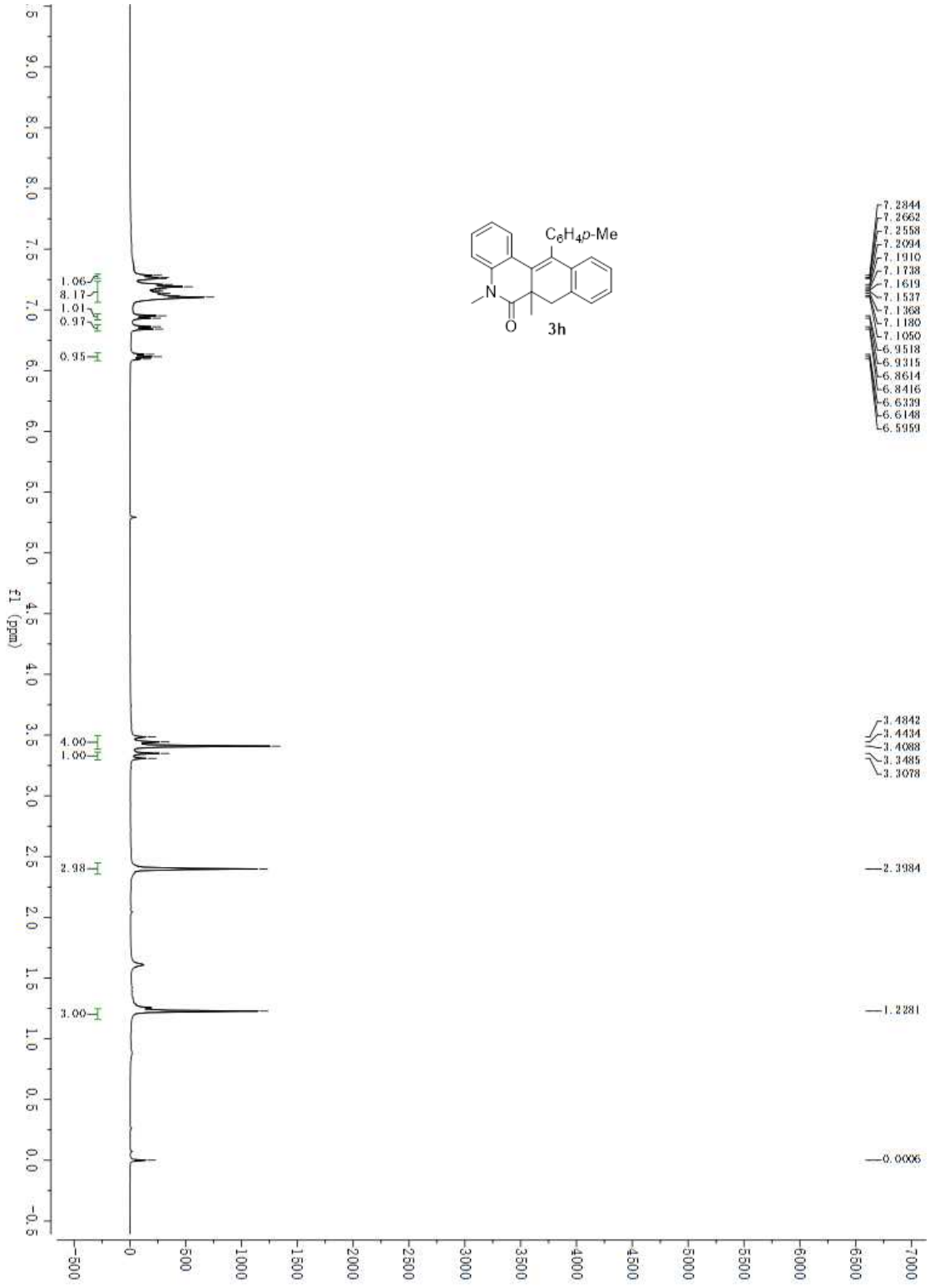

F
Ph
N
O
3e
173.6495
158.9810
156.5894
138.1823
136.6611
135.7867
133.8064
132.6627
131.1292
130.5491
128.9249
128.5375
128.0038
127.6746
126.5317
126.1806
124.9387
124.8578
117.2999
117.0468
115.2051
115.1233
114.7203
114.4922
77.3227
77.0045
76.6866
43.0042
37.8390
30.6050
22.6521
f1 (ppm)

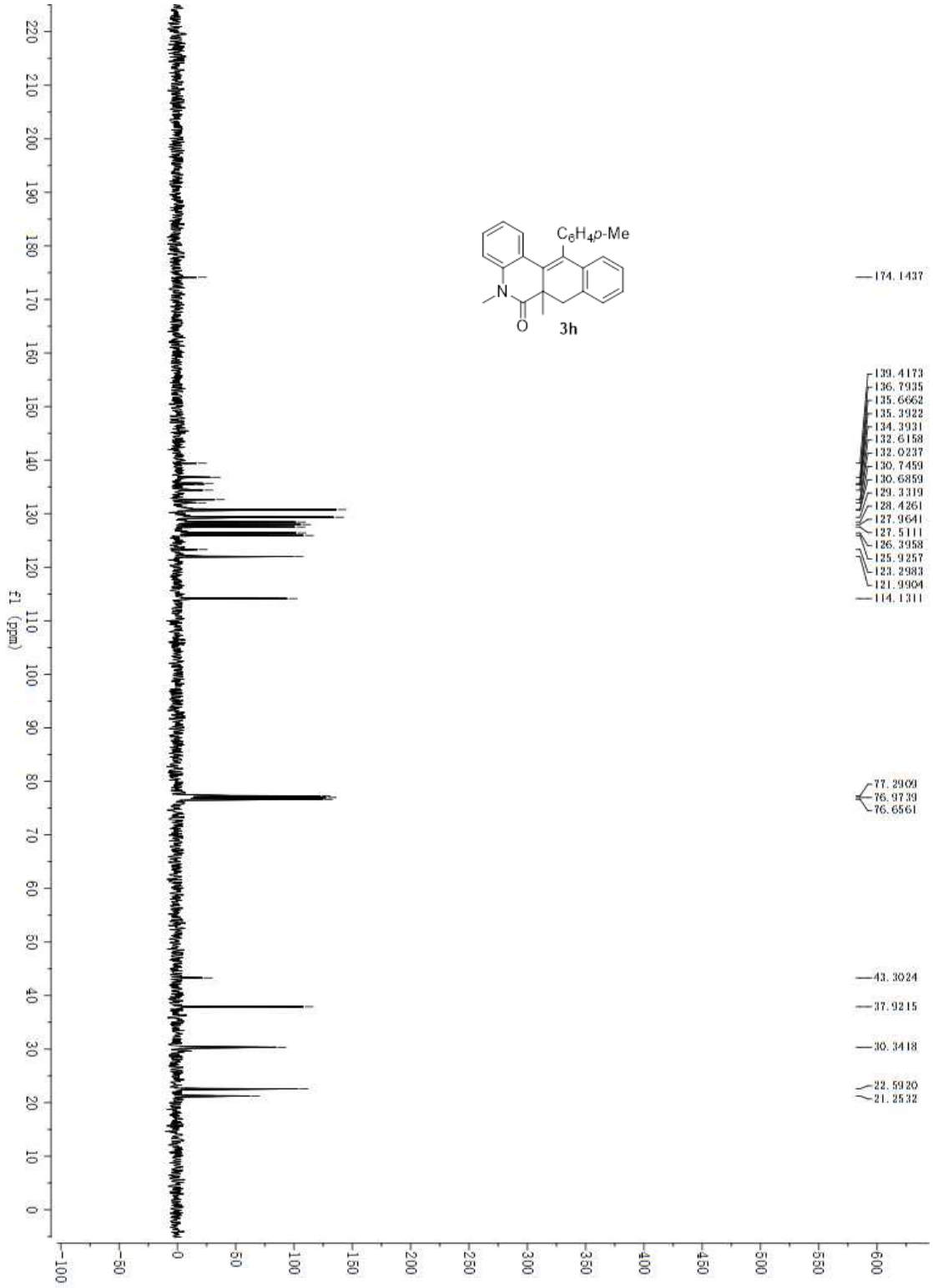

CN
Ph
N
O
3f
f1 (ppm)
2.96
1.04
1.02
2.87
1.90
1.93
1.01
2.88
1.00
3.02
7.4384
7.3726
7.3688
7.3513
7.3475
7.3031
7.2851
7.2582
7.2478
7.2387
7.2352
7.2269
7.2200
7.2085
7.1348
7.1256
7.0130
7.0009
6.9967
6.9928
3.5203
3.4795
3.4255
3.3596
3.3185
1.2527
0.0001

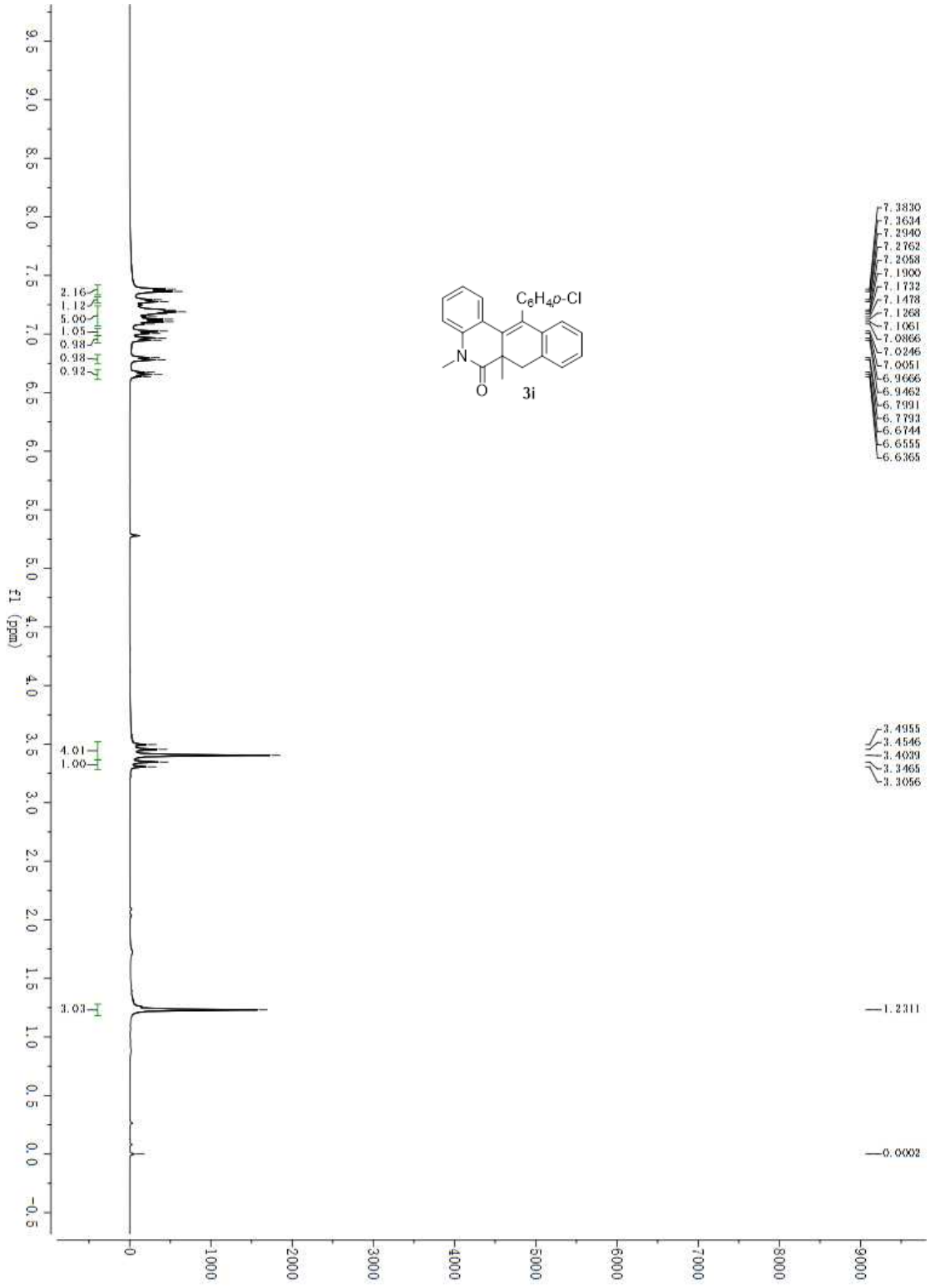

CN
Ph
N
O
3f
174.0581
142.7519
134.3884
131.5797
130.4049
129.0862
128.5616
128.3993
128.1038
126.7223
114.7183
105.4535
77.3314
77.0140
76.6959
43.1049
37.6584
30.5028
22.8427
f1 (ppm)

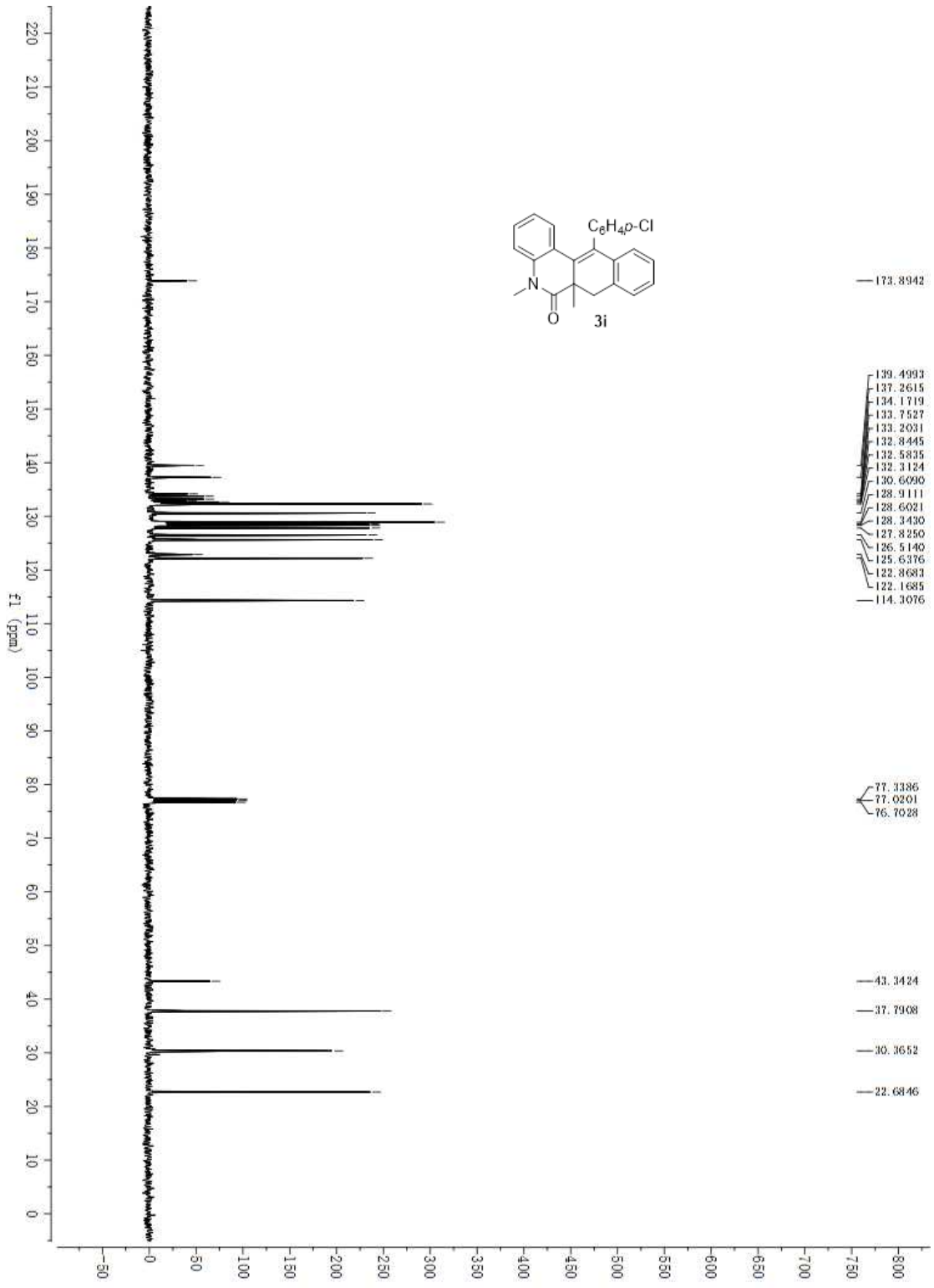

C6H4p-F
N
O
3g
f1 (ppm)
4.72
5.05
1.07
1.02
1.02
1.16
2.99
1.09
3.01
7.2954
7.2774
7.2477
7.2091
7.1912
7.1730
7.1376
7.1113
7.1025
7.0914
7.0700
7.0473
7.0281
6.9652
6.9450
6.7721
6.7542
6.6583
6.6391
6.6205
3.5010
3.4603
3.4053
3.3486
3.3077
1.2312
0.0000

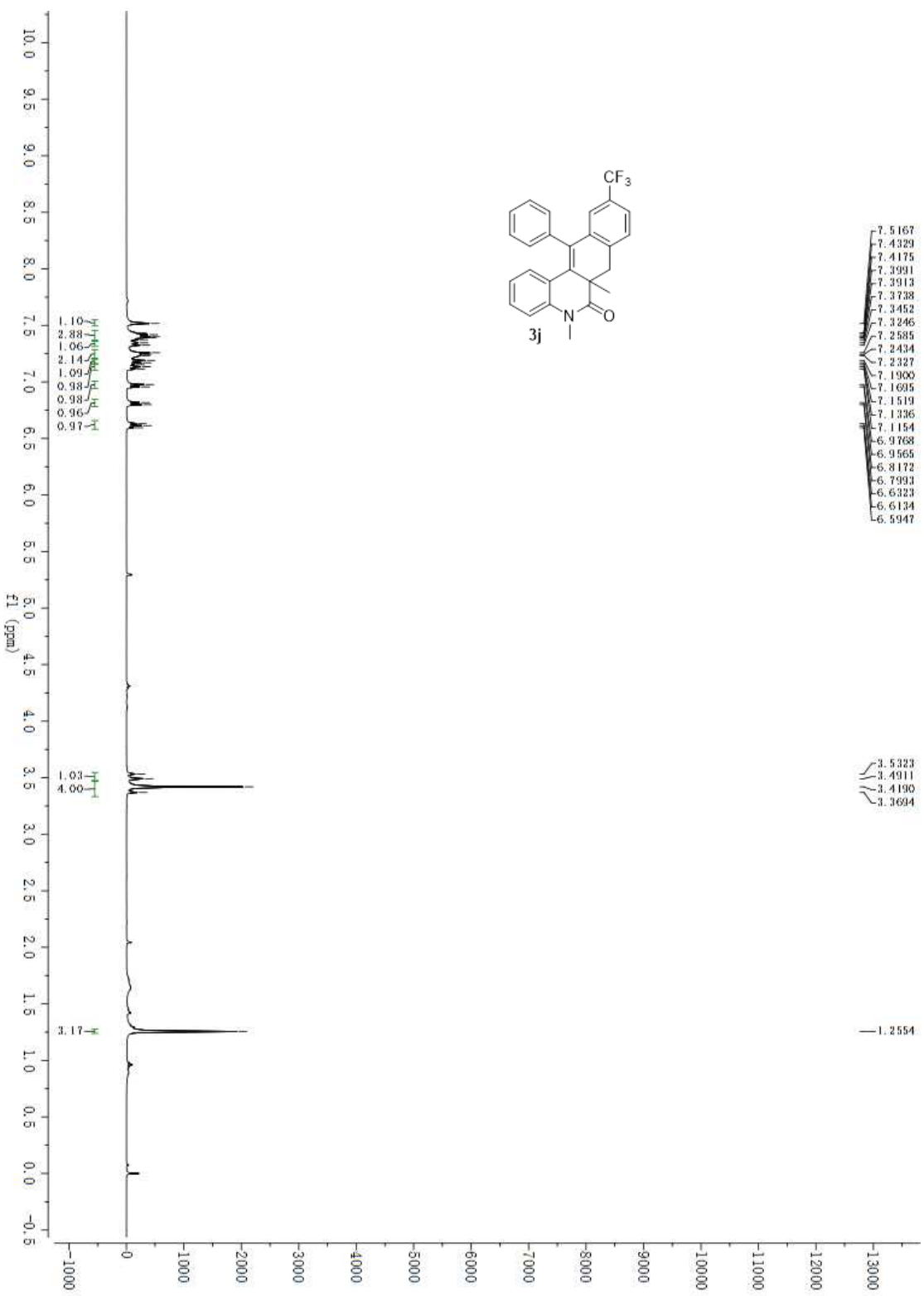

C6H4p-F
N
O
3g
f1 (ppm)
173.9643
163.2813
160.8287
139.5064
132.5424
132.4687
130.6052
128.5674
128.2408
127.7638
126.4873
125.6889
122.0884
115.7154
115.5839
114.2848
77.3288
77.0110
76.6929
43.3478
37.8119
30.3610
22.6772

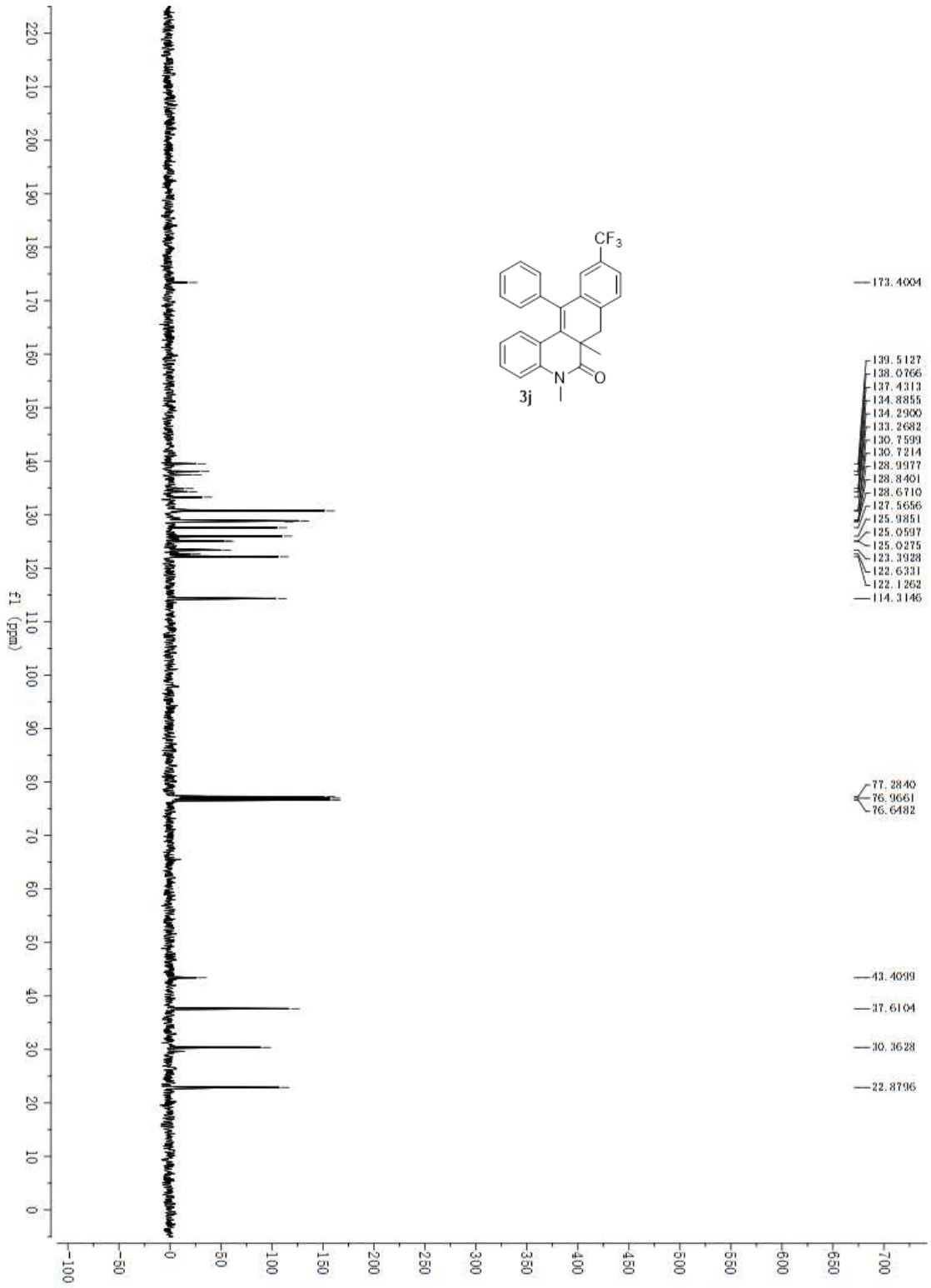

C6H4p-Me
N
O
3h
f1 (ppm)
1.06
8.17
1.01
0.97
0.95
4.00
1.00
2.98
3.00
7.2844
7.2662
7.2558
7.2094
7.1910
7.1738
7.1619
7.1537
7.1368
7.1180
7.1050
6.9518
6.9315
6.8614
6.8416
6.6339
6.6148
6.5959
3.4842
3.4434
3.4088
3.3485
3.3078
2.3984
1.2281
0.0006

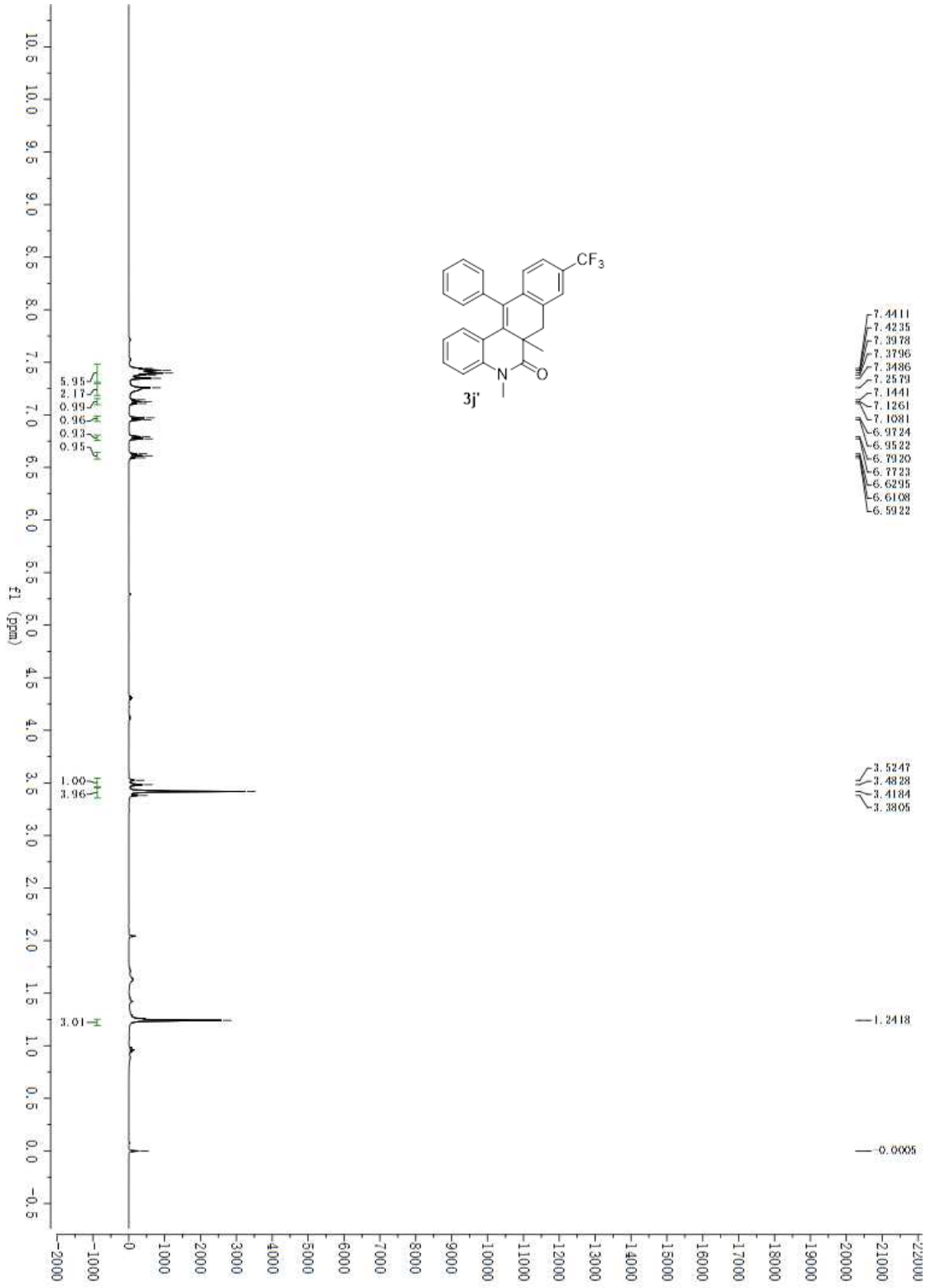

C6H4p-Me
N
O
3h
174.1437
139.4173
136.7935
135.6662
135.3922
134.3931
132.6158
132.0237
130.7459
130.6859
129.3319
128.4261
127.9641
127.5111
126.3958
125.9257
123.2983
121.9904
114.1311
77.2909
76.9739
76.6561
43.3024
37.9215
30.3418
22.5920
21.2532
f1 (ppm)

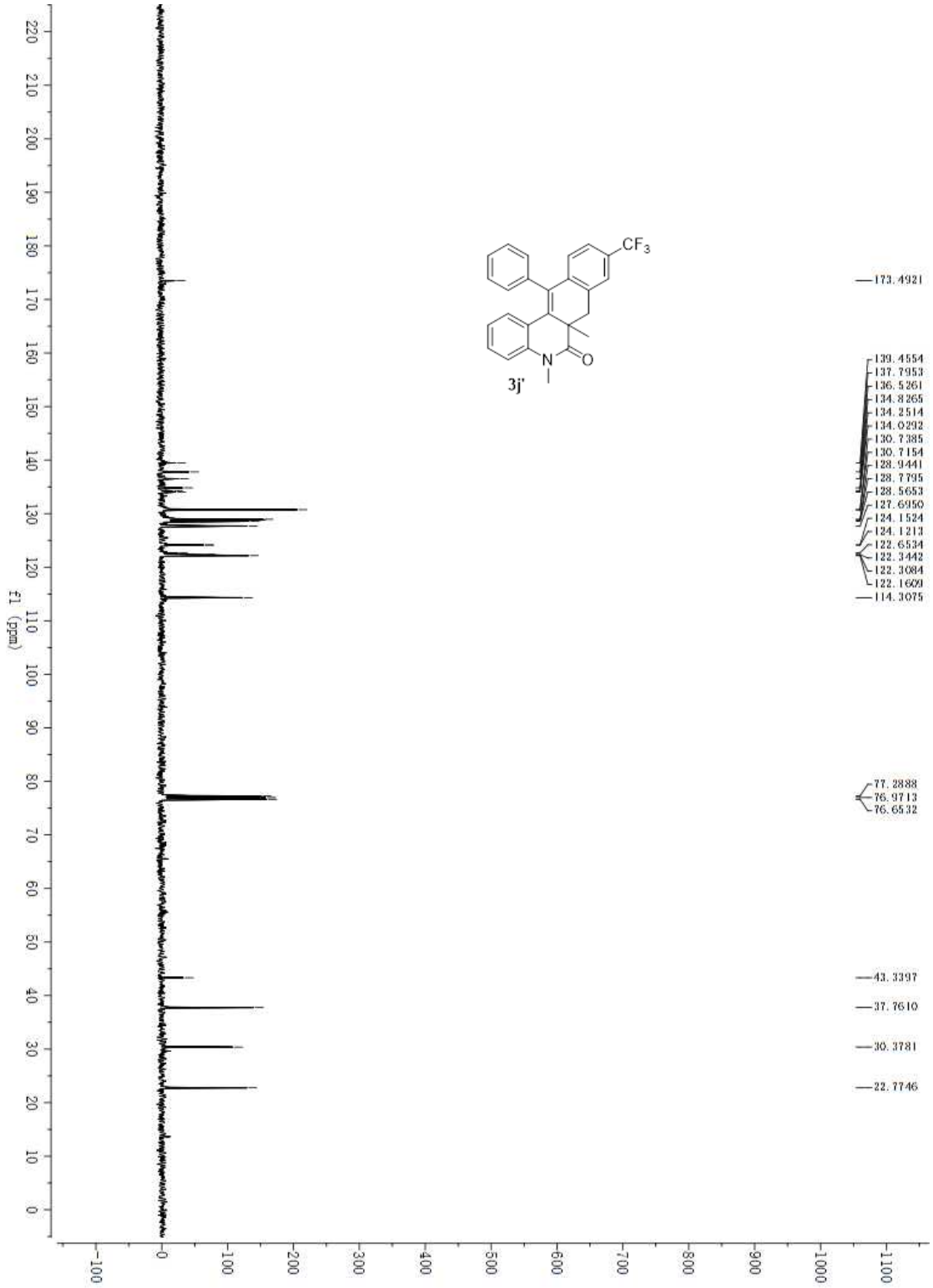

C6H4p-Cl
3i
f1 (ppm)
2.16
1.12
5.00
1.05
0.98
0.98
0.92
4.01
1.00
3.03
7.3830
7.3634
7.2940
7.2762
7.2058
7.1900
7.1732
7.1478
7.1268
7.1061
7.0866
7.0246
7.0051
6.9666
6.9462
6.7991
6.7793
6.6744
6.6555
6.6365
3.4955
3.4546
3.4039
3.3465
3.3056
1.2311
0.0002

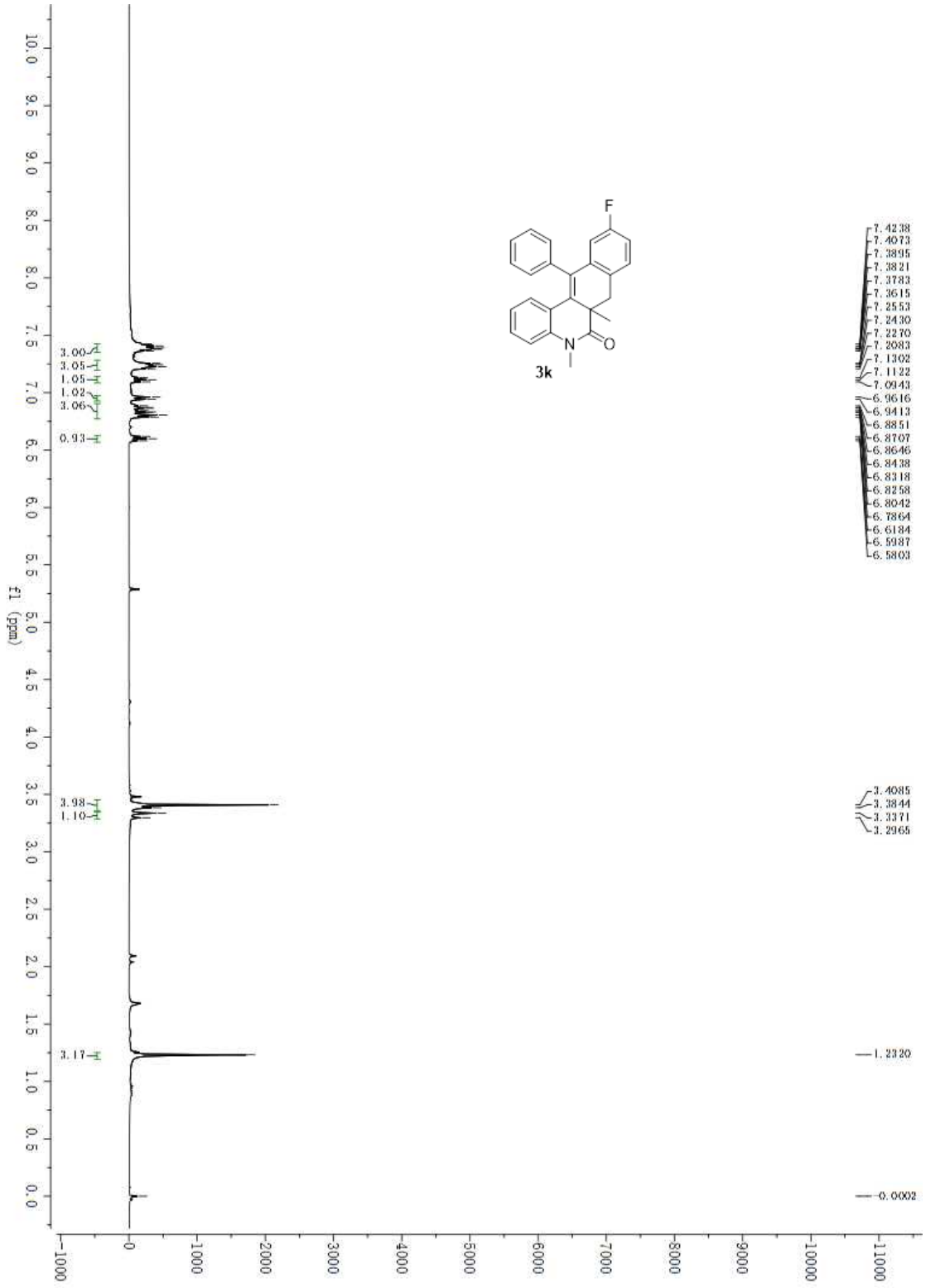

C6H4p-Cl
N
O
3i
173.8942
139.4993
137.2615
134.1719
133.7527
133.2031
132.8445
132.5835
132.3124
130.6090
128.9111
128.6021
128.3430
127.8250
126.5140
125.6376
122.8683
122.1685
114.3076
77.3386
77.0201
76.7028
43.3424
37.7908
30.3652
22.6846
f1 (ppm)

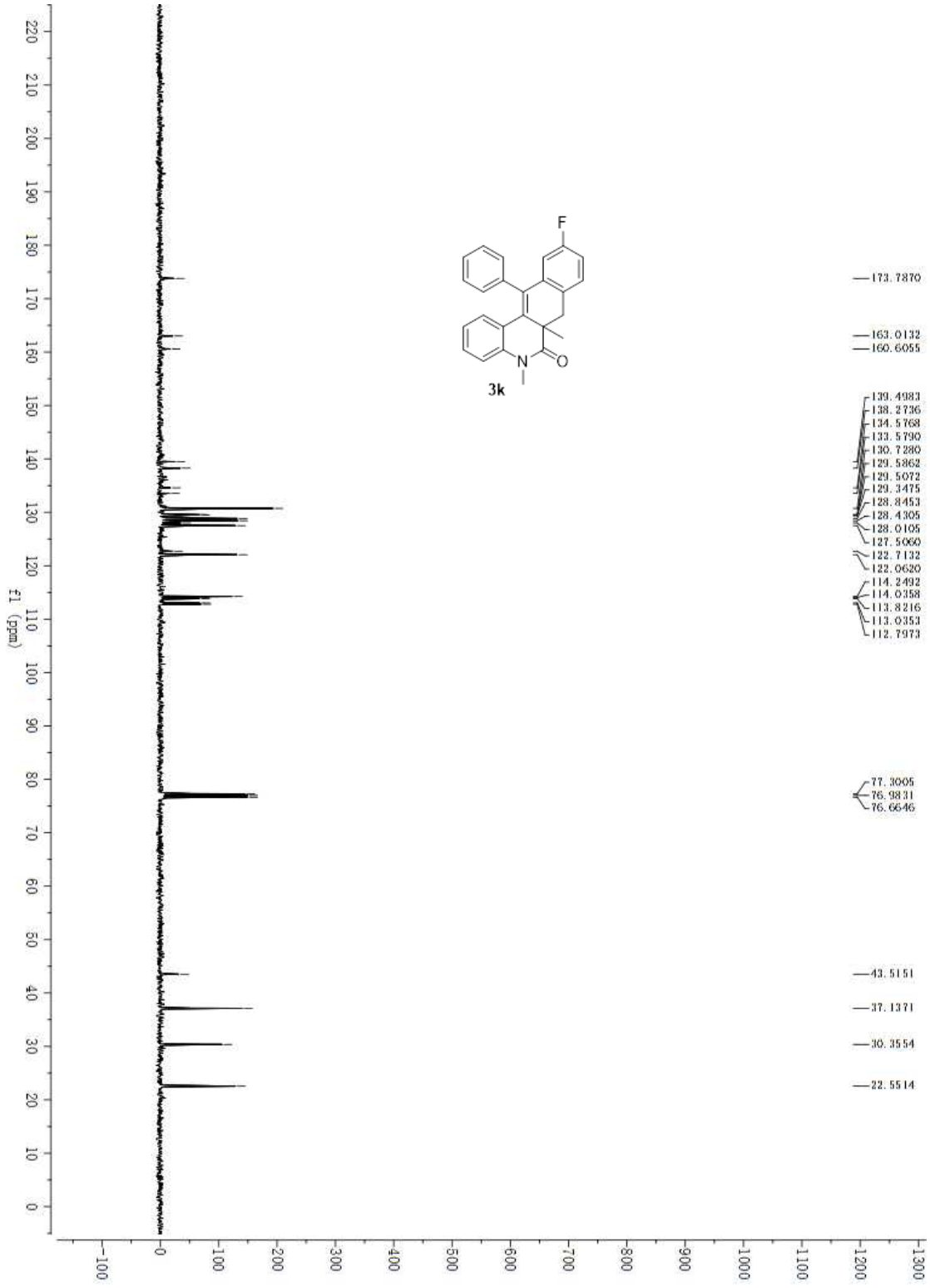

CF3
N
O
3j
7.5167
7.4329
7.4175
7.3991
7.3913
7.3738
7.3452
7.3246
7.2585
7.2434
7.2327
7.1900
7.1695
7.1519
7.1336
7.1154
6.9768
6.9565
6.8172
6.7993
6.6323
6.6134
6.5947
3.5323
3.4911
3.4190
3.3694
1.2554
1.10
2.88
1.06
2.14
1.09
0.98
0.98
0.96
0.97
1.03
4.00
3.17
f1 (ppm)

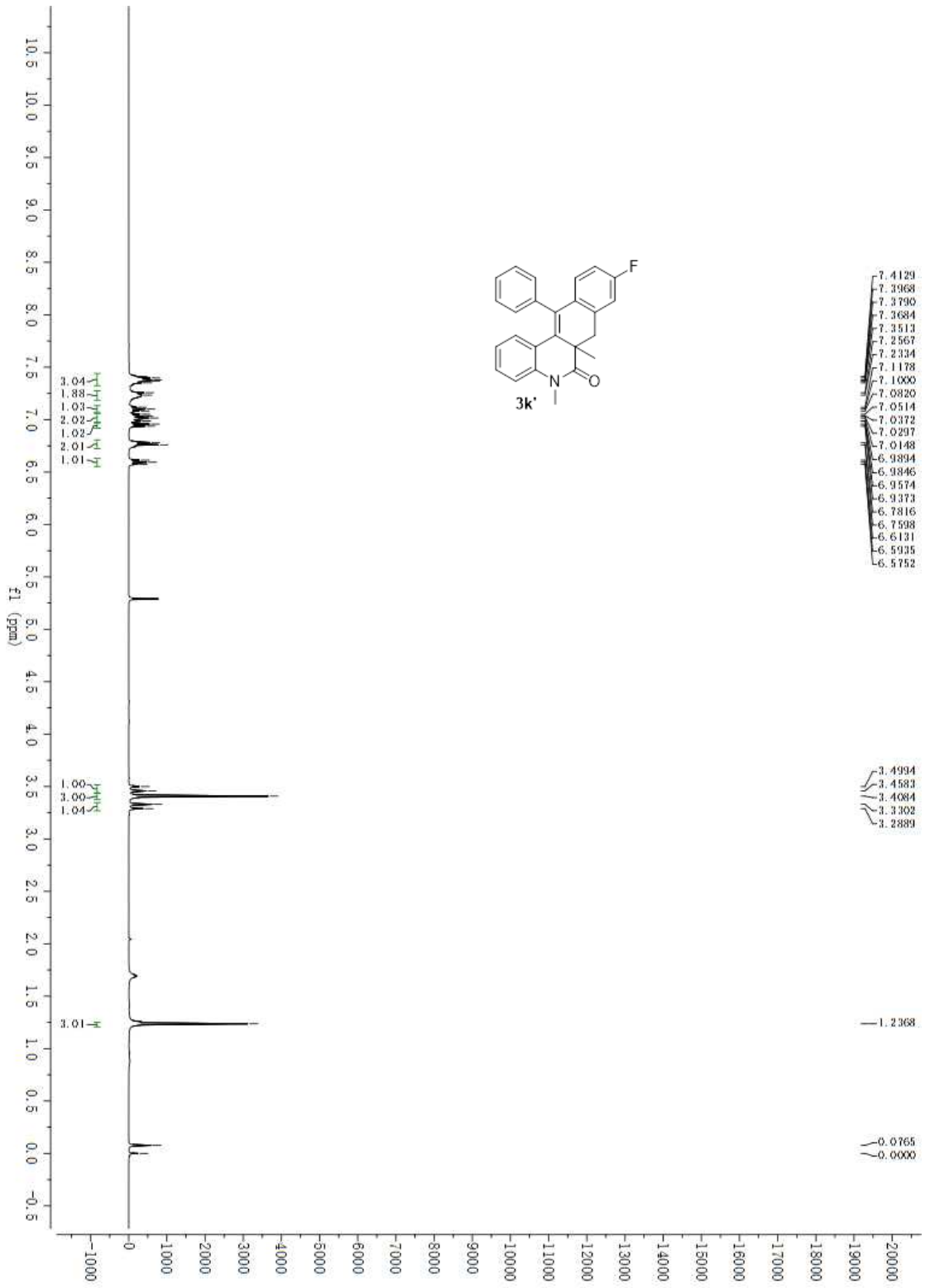

CF3
N
O
3j
173.4004
139.5127
138.0766
137.4313
134.8855
134.2900
133.2682
130.7593
130.7214
128.9977
128.8401
128.6710
127.5656
125.9851
125.0597
125.0275
123.3928
122.6331
122.1262
114.3146
77.2840
76.9661
76.6482
43.4099
37.6104
30.3628
22.8796
f1 (ppm)

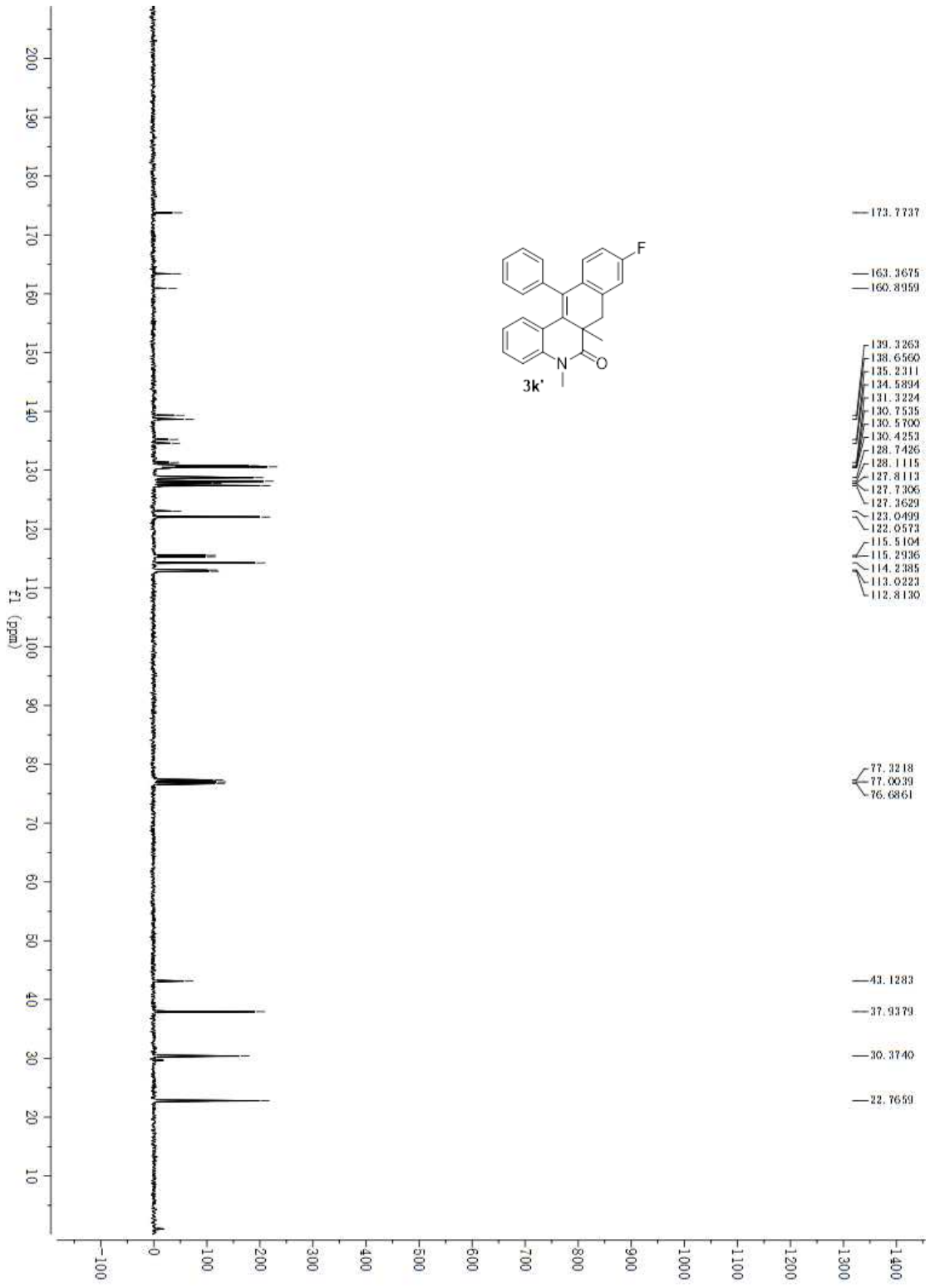

CF3
N
O
3j'
7.4411
7.4235
7.3978
7.3796
7.3486
7.2579
7.1441
7.1261
7.1081
6.9724
6.9522
6.7920
6.7723
6.6295
6.6108
6.5922
3.5247
3.4828
3.4184
3.3805
1.2418
0.0005
5.95
2.17
0.99
0.96
0.93
0.95
1.00
3.96
3.01
f1 (ppm)

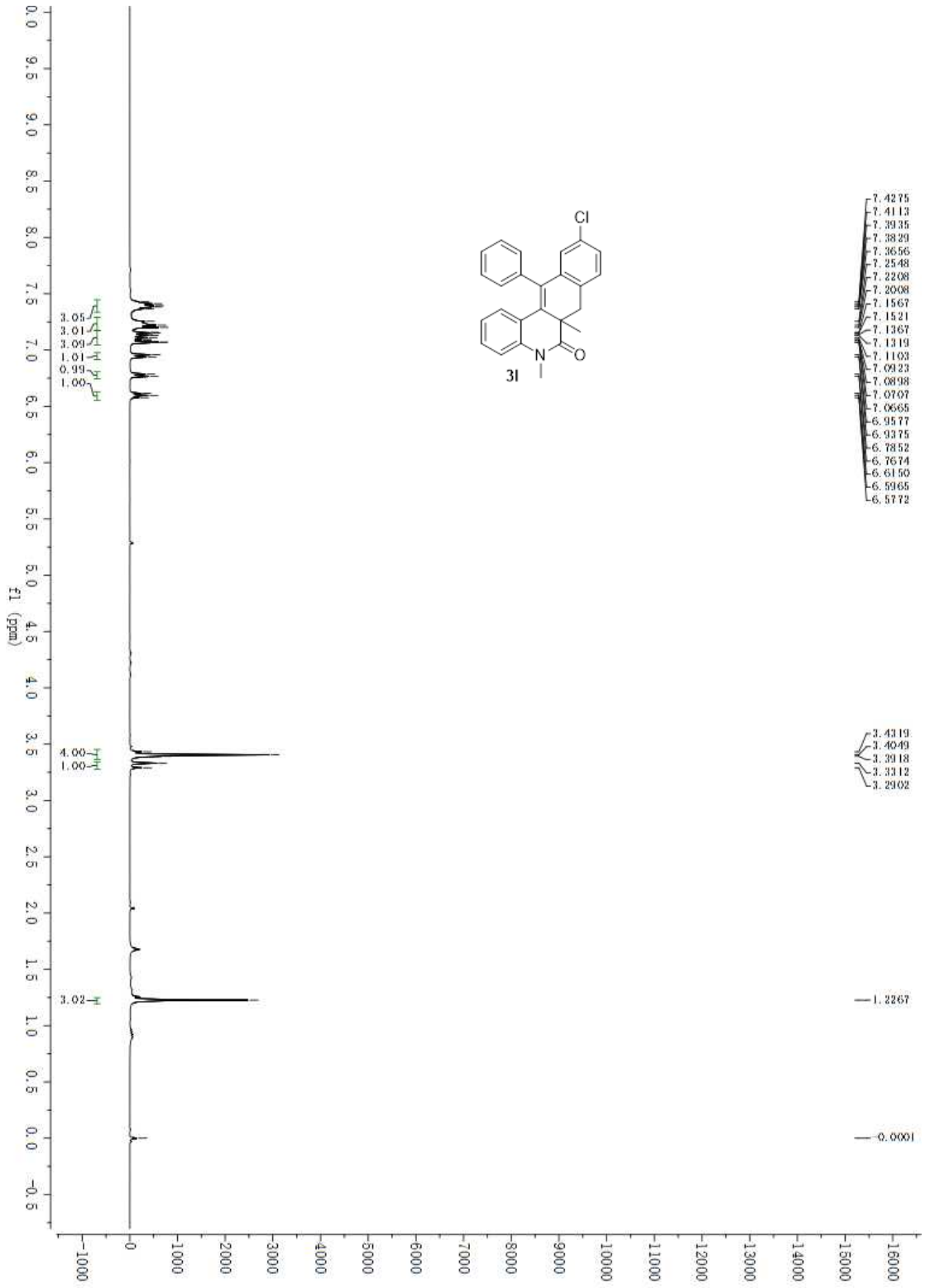

CF3
N
O
3j'
173.4921
139.4554
137.7953
136.5261
134.8265
134.2514
134.0292
130.7385
130.7154
128.9441
128.7795
128.5653
127.6950
124.1524
124.1213
122.6534
122.3442
122.3084
122.1609
114.3075
77.2888
76.9713
76.6532
43.3397
37.7610
30.3781
22.7746
f1 (ppm)

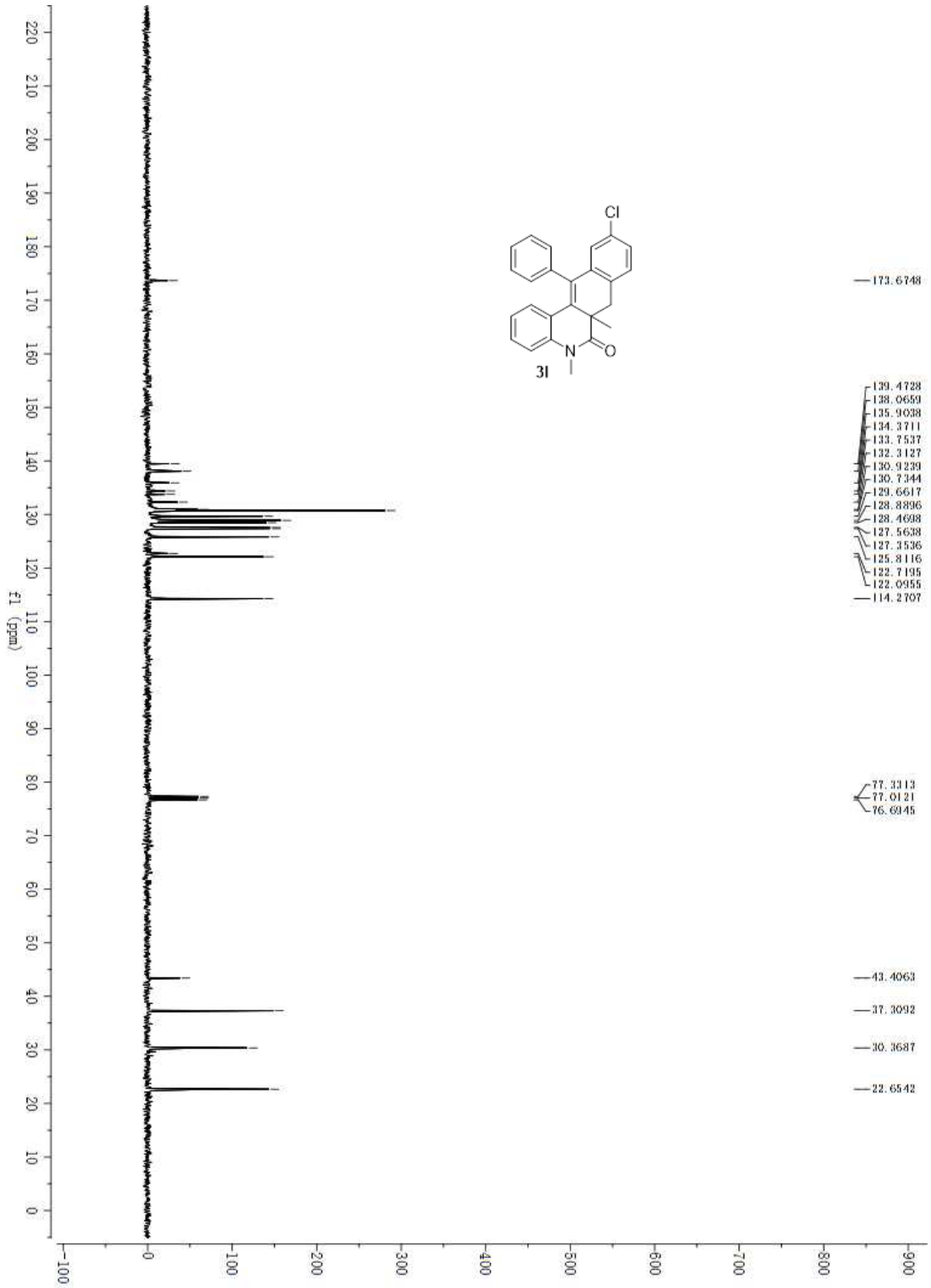

F
N
O
3k
7.4238
7.4073
7.3895
7.3821
7.3783
7.3615
7.2553
7.2430
7.2270
7.2083
7.1302
7.1122
7.0943
6.9616
6.9413
6.8851
6.8707
6.8646
6.8438
6.8318
6.8258
6.8042
6.7864
6.6184
6.5987
6.5803
3.4085
3.3844
3.3371
3.2965
1.2320
0.0002
3.00
3.05
1.05
1.02
3.06
0.93
3.98
1.10
3.17
f1 (ppm)

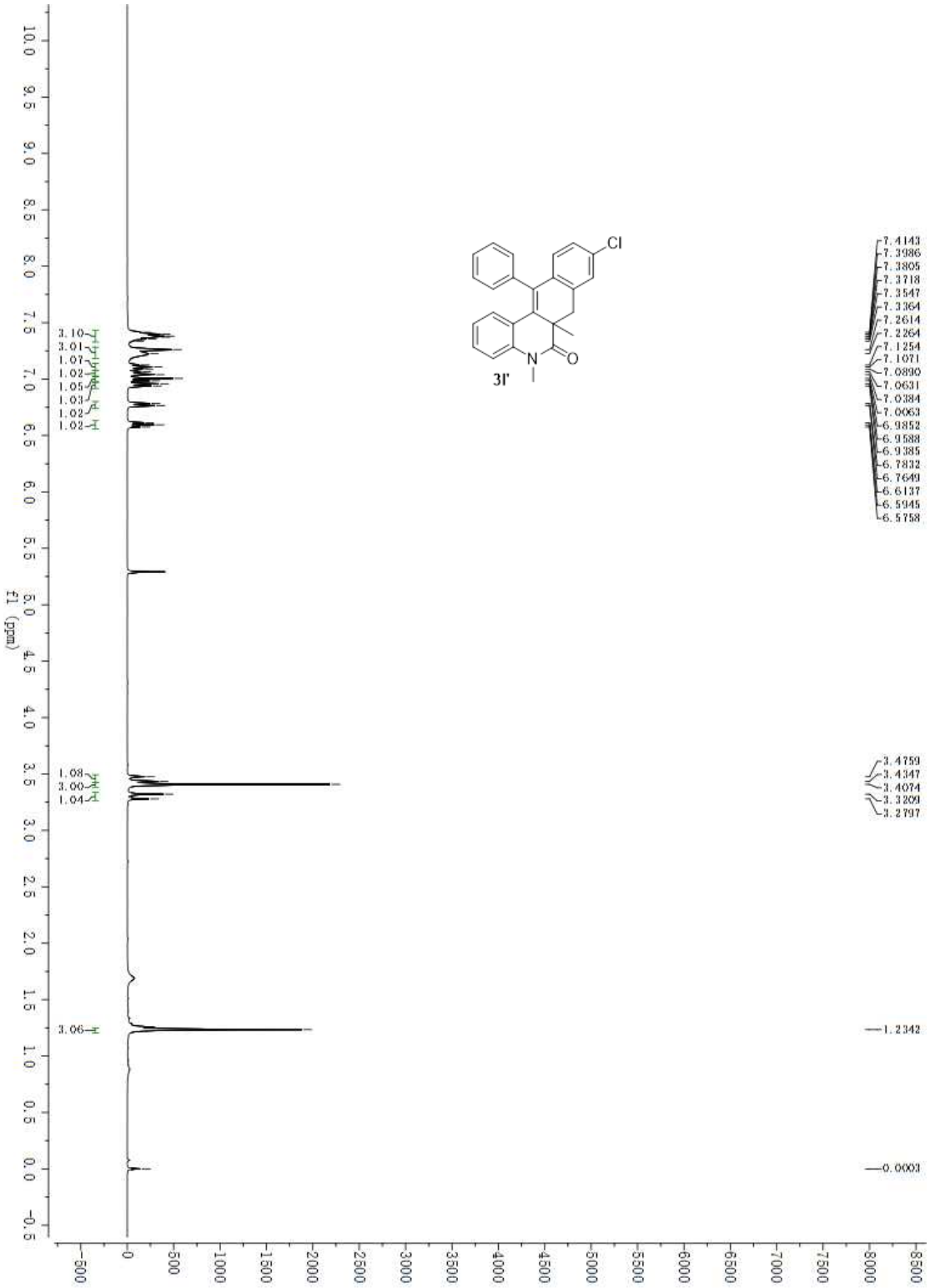

F
N
O
3k
173.7870
163.0132
160.6055
139.4983
138.2736
134.5768
133.5790
130.7280
129.5862
129.5072
129.3475
128.8453
128.4305
128.0105
127.5060
122.7132
122.0620
114.2492
114.0358
113.8216
113.0353
112.7973
77.3005
76.9831
76.6646
43.5151
37.1371
30.3554
22.5514
f1 (ppm)

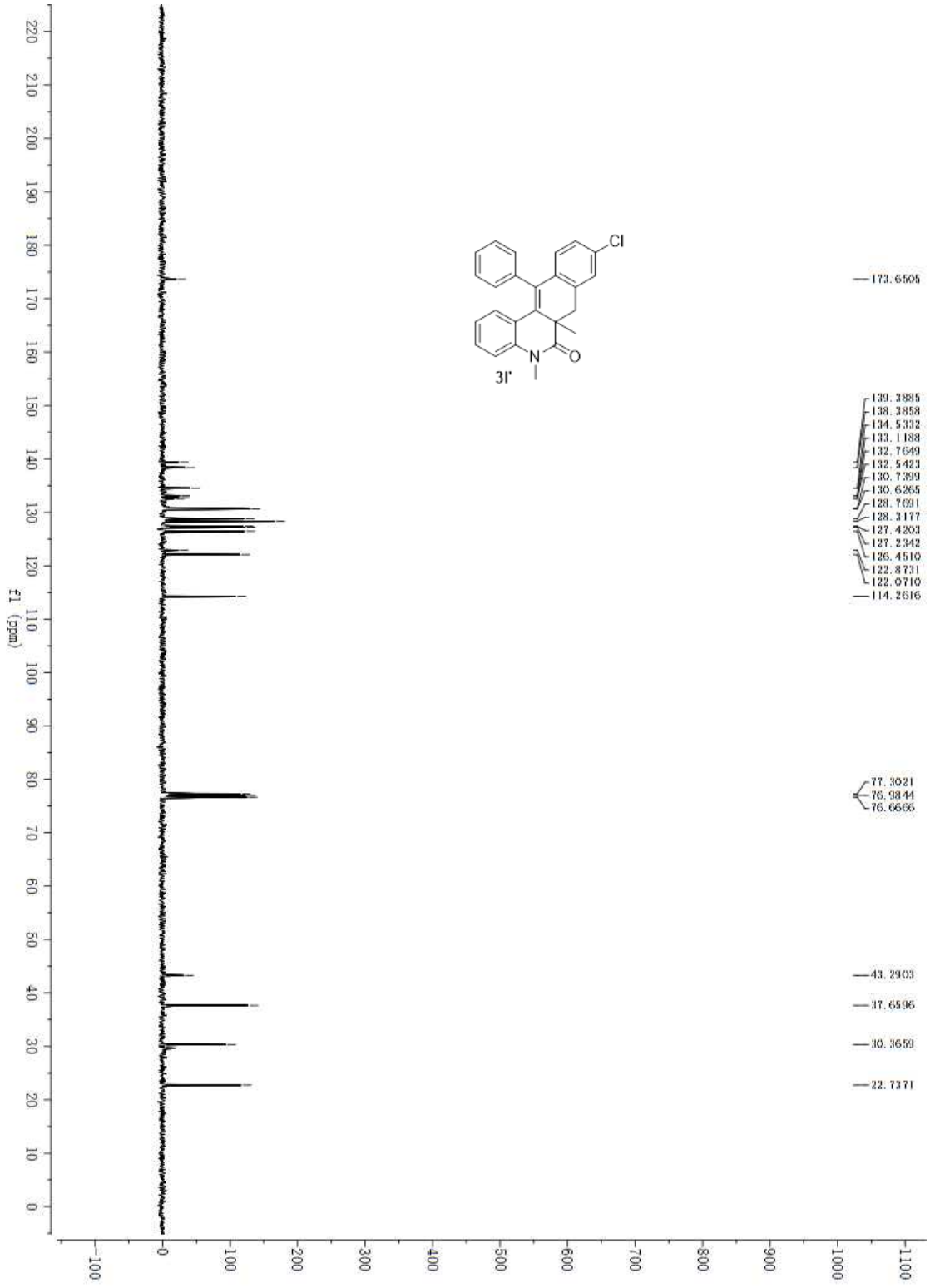

F
N
O
3k'
7.4129
7.3968
7.3790
7.3684
7.3513
7.2567
7.2334
7.1178
7.1000
7.0820
7.0514
7.0372
7.0297
7.0148
6.9894
6.9846
6.9574
6.9373
6.7816
6.7598
6.6131
6.5935
6.5752
3.4994
3.4583
3.4084
3.3302
3.2889
1.2368
0.0765
0.0000
3.04
1.88
1.03
2.02
1.02
2.01
1.01
1.00
3.00
1.04
3.01
f1 (ppm)

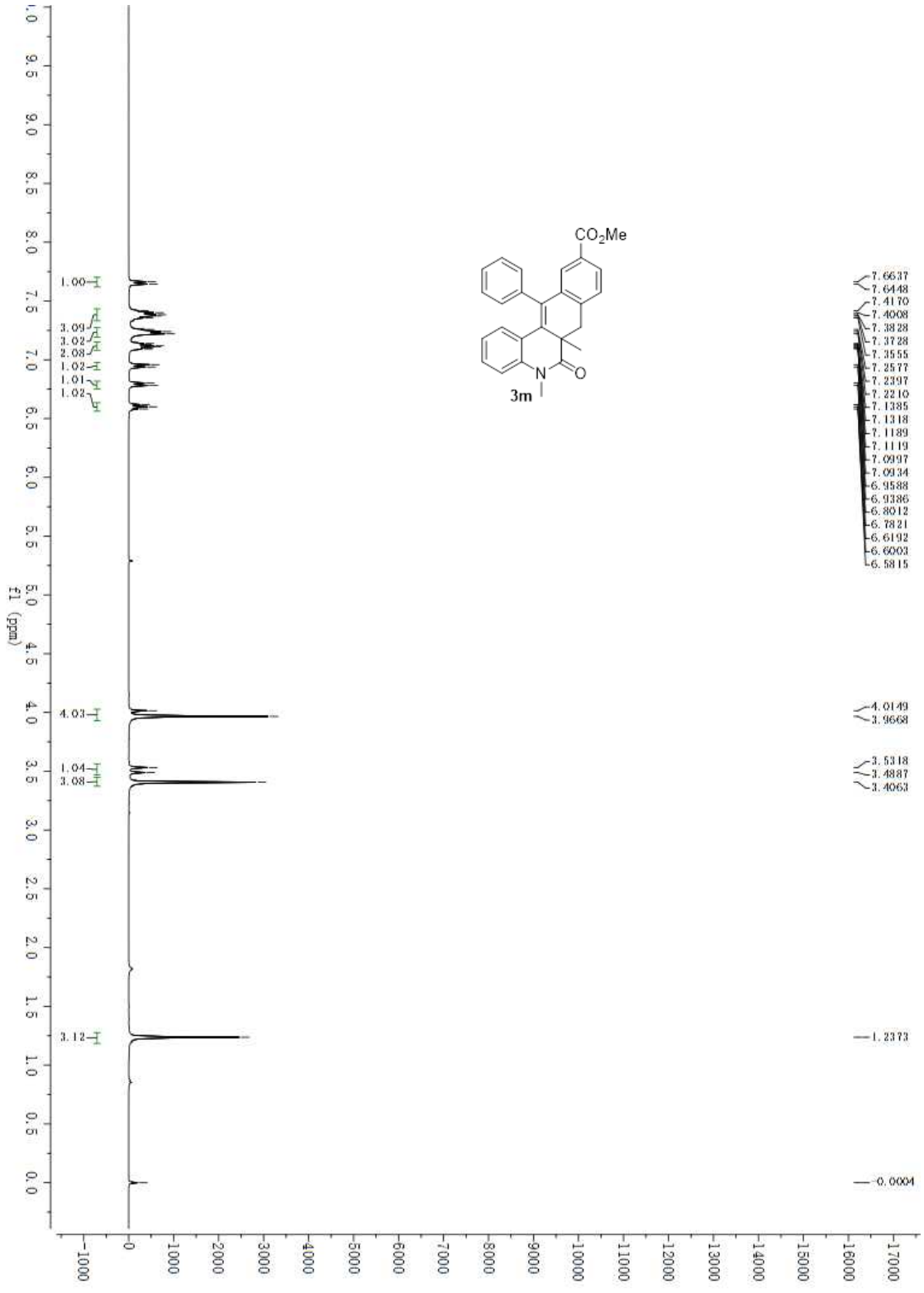

F
N
O
3k'
173.7737
163.3675
160.8959
139.3263
138.6560
135.2311
134.5894
131.3224
130.7535
130.5700
130.4253
128.7426
128.1115
127.8113
127.7306
127.3629
123.0499
122.0573
115.5104
115.2936
114.2385
113.0223
112.8130
77.3218
77.0039
76.6861
43.1283
37.9379
30.3740
22.7659
f1 (ppm)

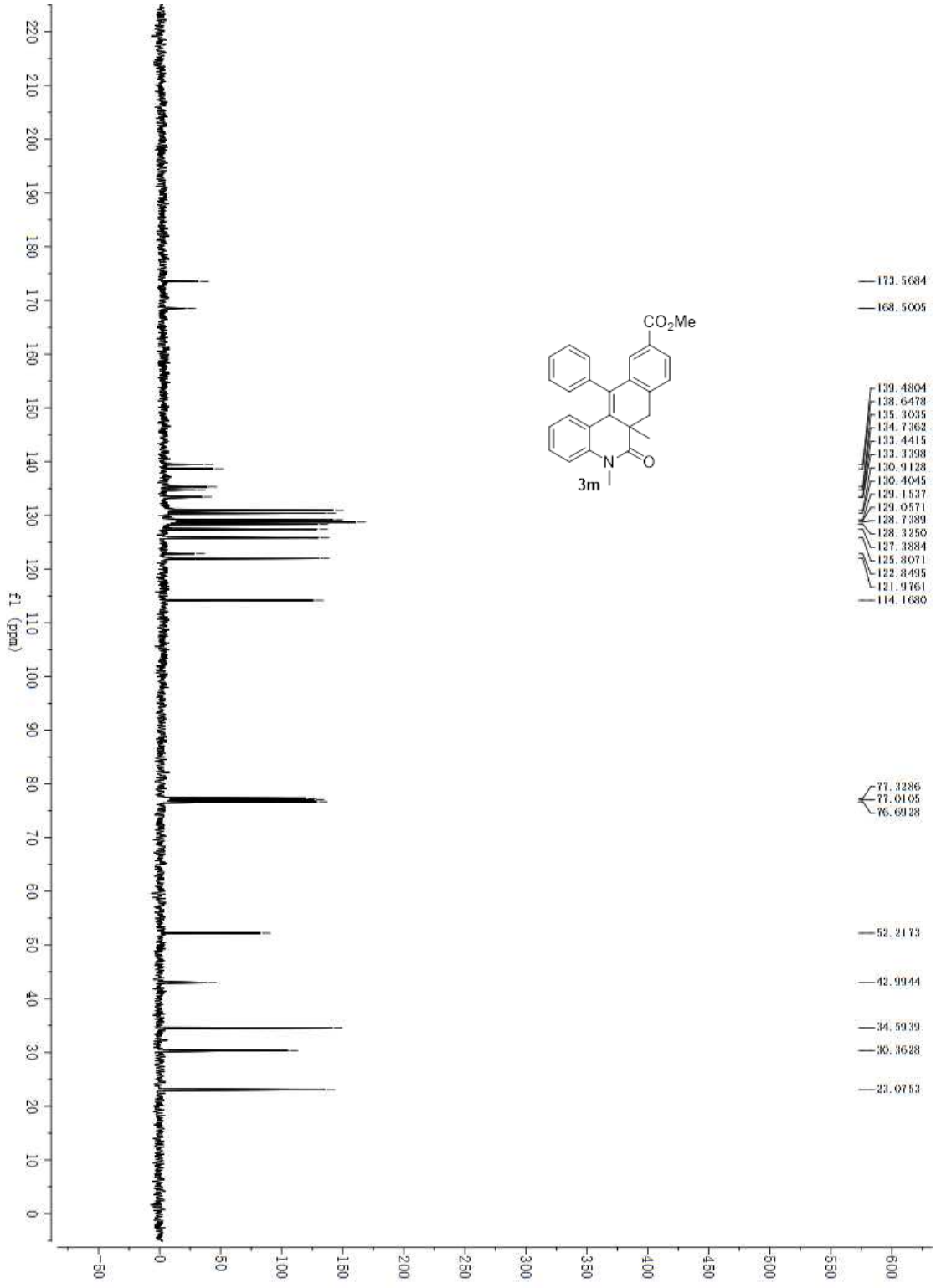

Cl
N
O
3l
7.4275
7.4113
7.3935
7.3829
7.3656
7.2548
7.2208
7.2008
7.1567
7.1521
7.1367
7.1319
7.1103
7.0923
7.0898
7.0707
7.0665
6.9577
6.9375
6.7852
6.7674
6.6150
6.5965
6.5772
3.4319
3.4049
3.3918
3.3312
3.2902
1.2267
0.0001
3.05
3.01
3.09
1.01
0.99
1.00
4.00
1.00
3.02
f1 (ppm)

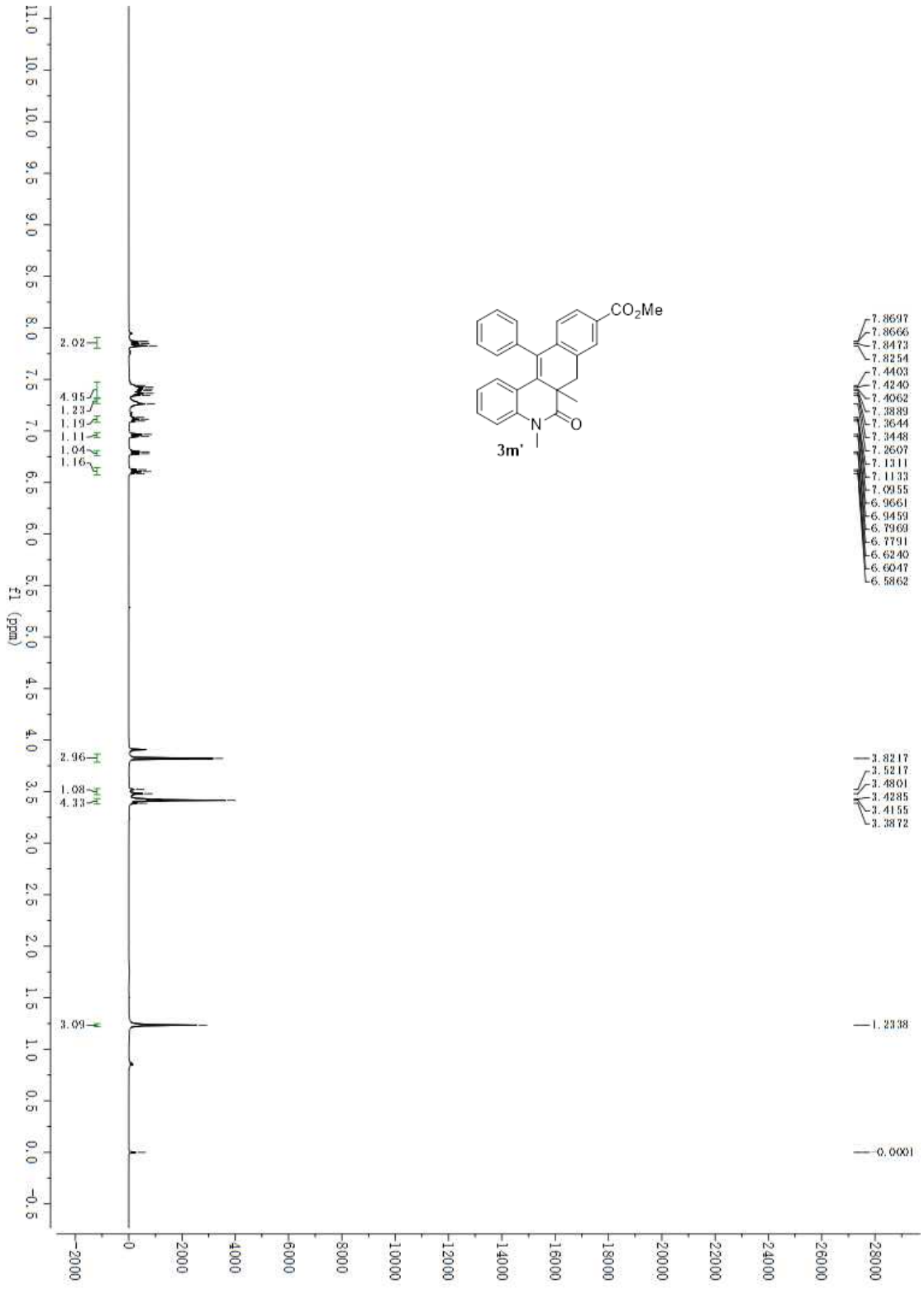

Cl
N
O
3l
173.6748
139.4728
138.0659
135.9038
134.3711
133.7537
132.3127
130.9239
130.7344
129.6617
128.8896
128.4698
127.5638
127.3536
125.8116
122.7195
122.0955
114.2707
77.3313
77.0121
76.6945
43.4063
37.3092
30.3687
22.6542
f1 (ppm)

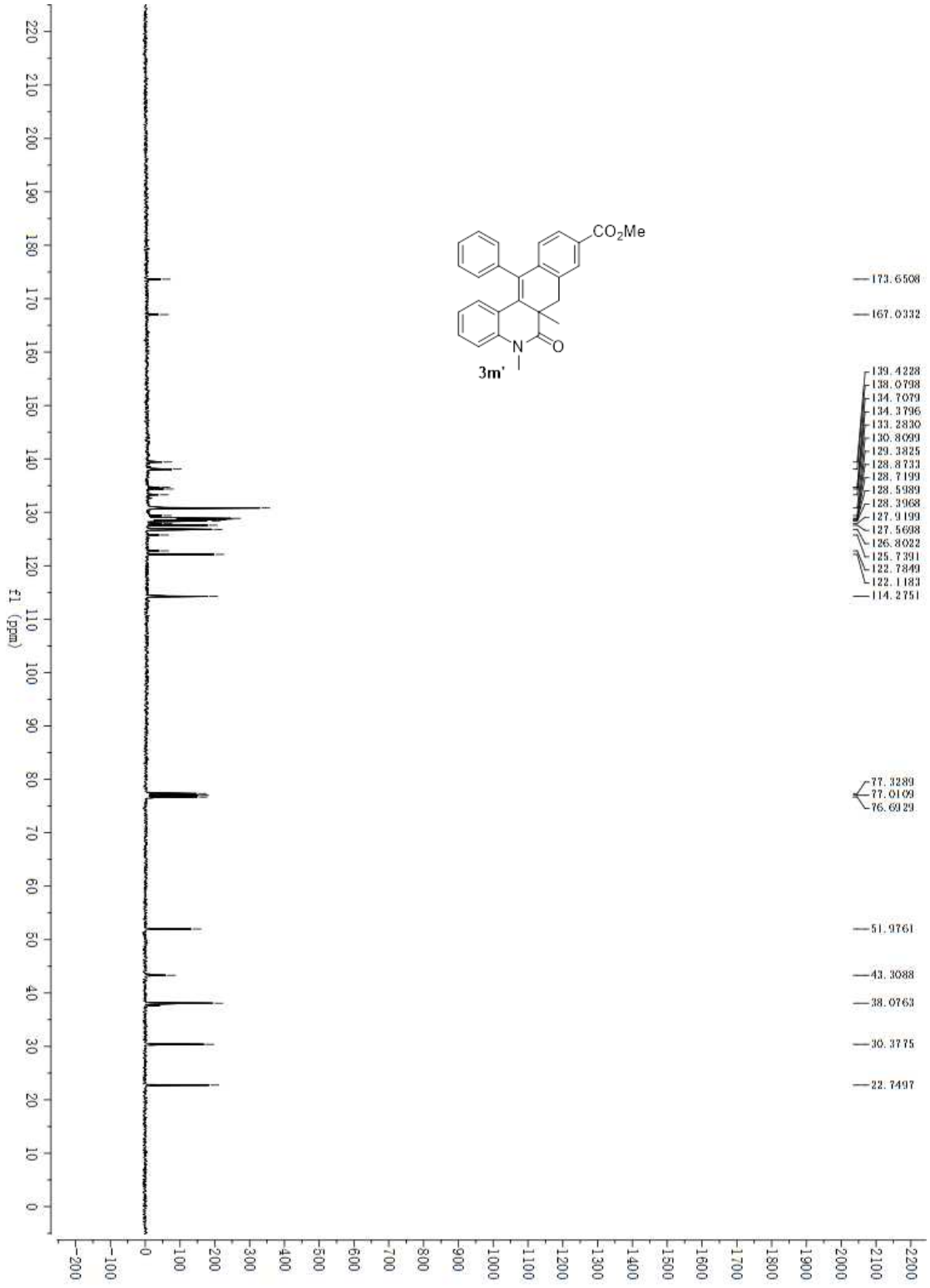

Cl
N
O
31'
f1 (ppm)
3.10
3.01
1.07
1.02
1.05
1.03
1.02
1.02
1.08
3.00
1.04
3.06
7.4143
7.3986
7.3805
7.3718
7.3547
7.3364
7.2614
7.2264
7.1254
7.1071
7.0890
7.0631
7.0384
7.0063
6.9852
6.9588
6.9385
6.7832
6.7649
6.6137
6.5945
6.5758
3.4759
3.4347
3.4074
3.3209
3.2797
1.2342
0.0000

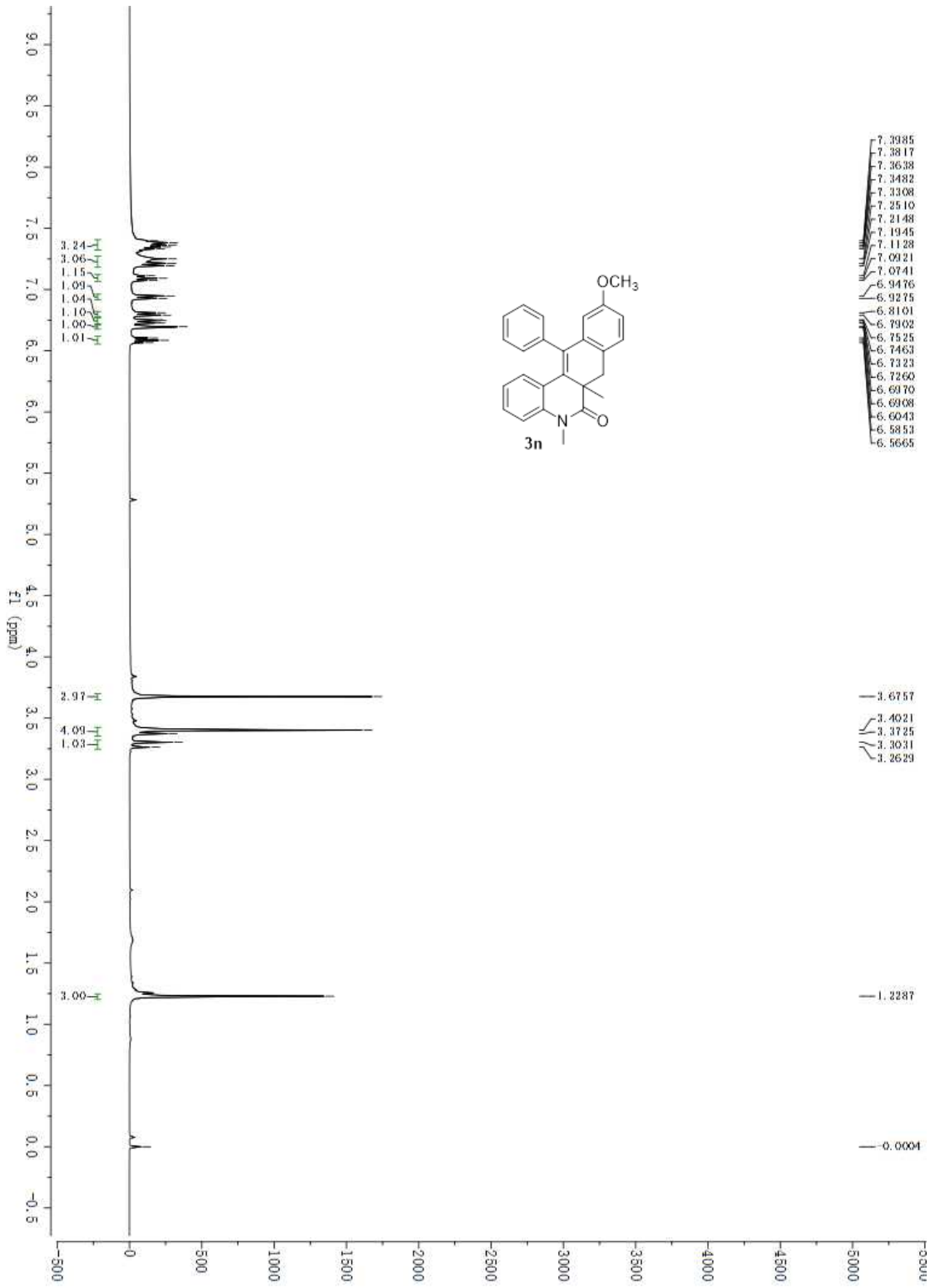

Cl
N
O
3l'
173.6505
139.3885
138.3858
134.5332
133.1188
132.7649
132.5423
130.7399
130.6265
128.7691
128.3177
127.4203
127.2342
126.4510
122.8731
122.0710
114.2616
77.3021
76.9844
76.6666
43.2903
37.6596
30.3659
22.7371
f1 (ppm)

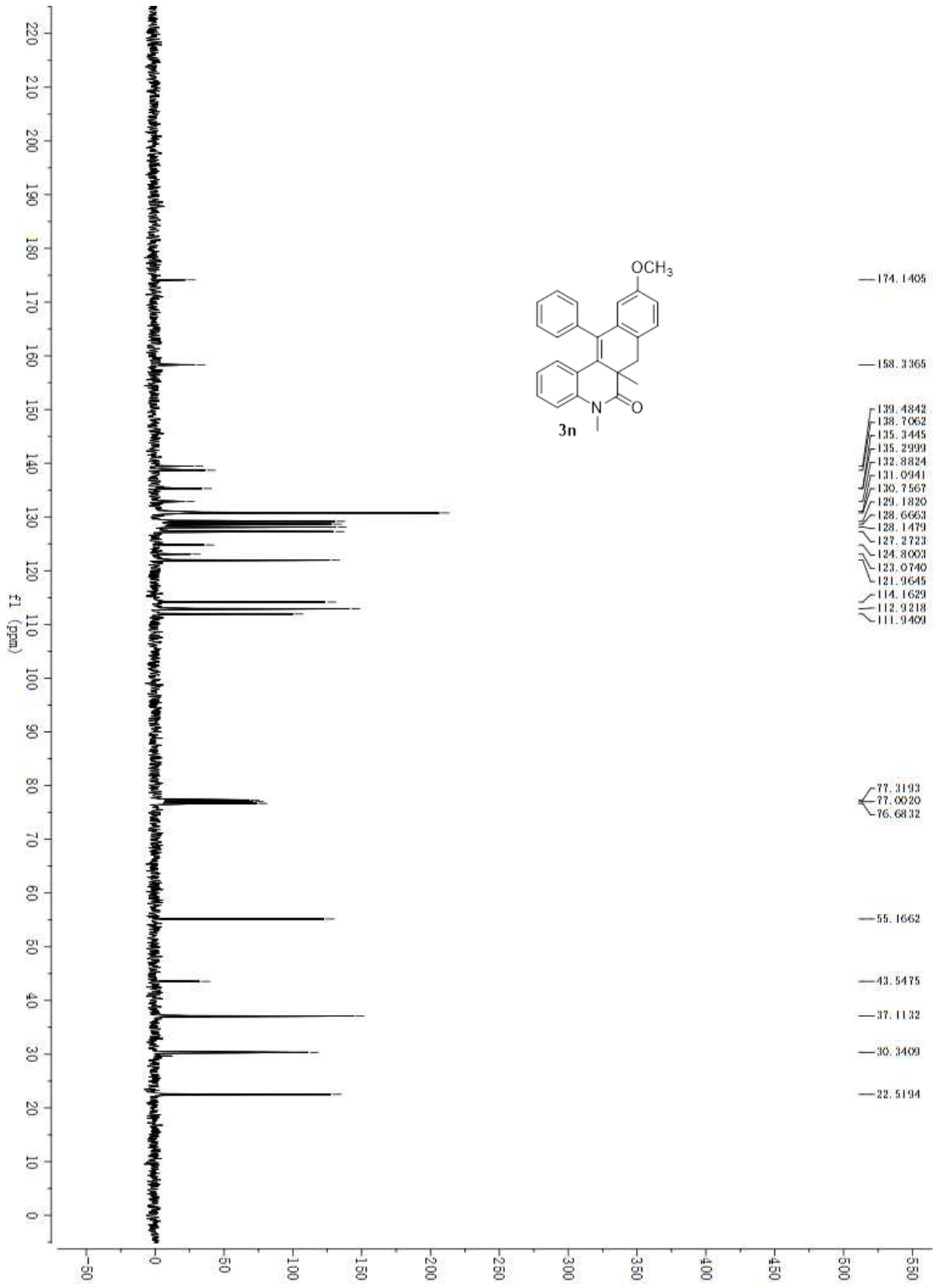

CO2Me
N
O
3m
7.6637
7.6448
7.4170
7.4008
7.3828
7.3728
7.3555
7.3577
7.2397
7.2210
7.1385
7.1318
7.1189
7.1119
7.0997
7.0934
6.9588
6.9386
6.8012
6.7821
6.6192
6.6003
6.5815
4.0149
3.9668
3.5318
3.4887
3.4063
1.2373
0.0004
1.00
3.09
3.02
2.08
1.02
1.01
1.02
4.03
1.04
3.08
3.12
f1 (ppm)

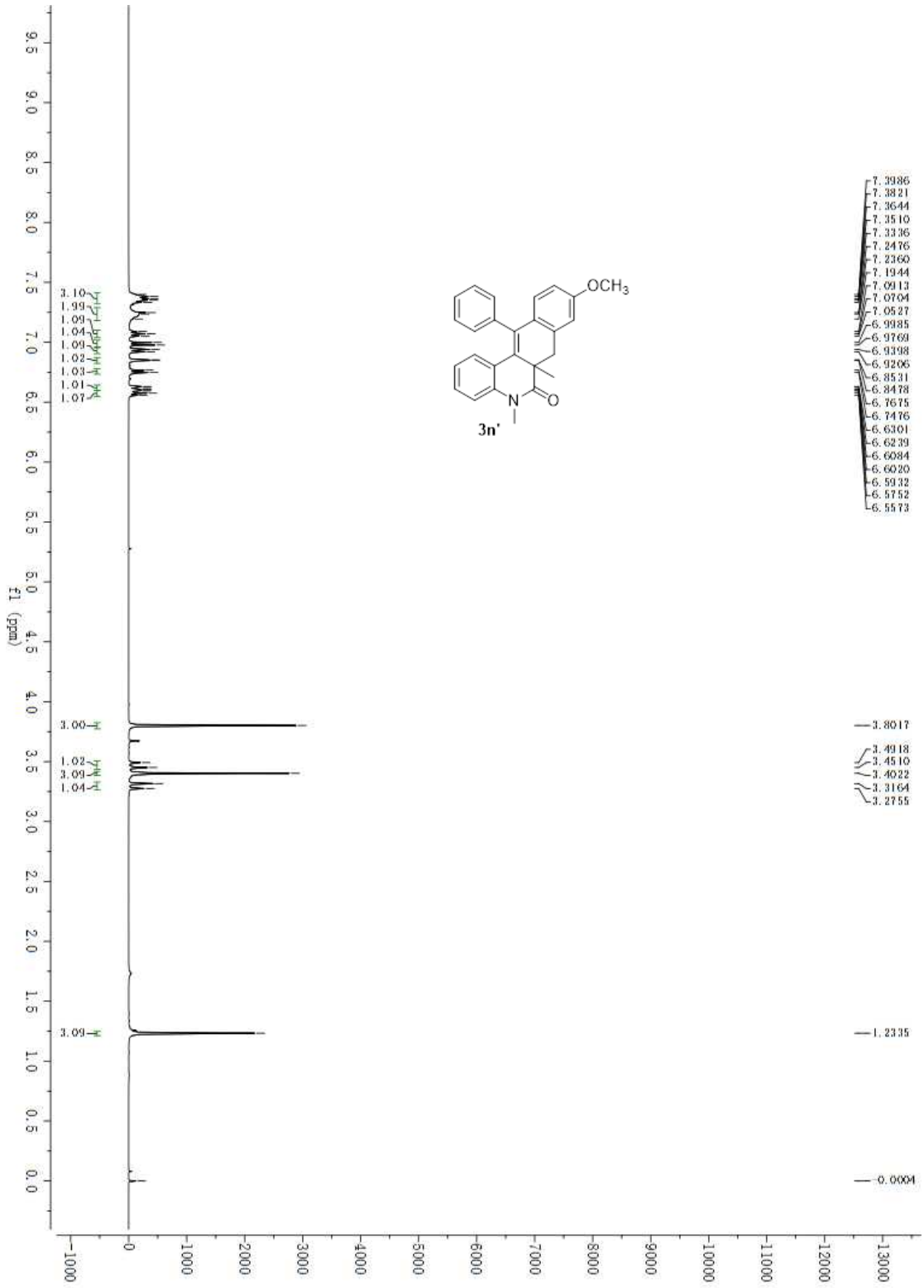

CO2Me
N
O
3m
173.5684
168.5005
139.4804
138.6478
135.3035
134.7362
133.4415
133.3398
130.9128
130.4045
129.1537
129.0571
128.7389
128.3250
127.3884
125.8071
122.8495
121.9761
114.1680
77.3286
77.0105
76.6928
52.2173
42.9944
34.5939
30.3628
23.0753
f1 (ppm)

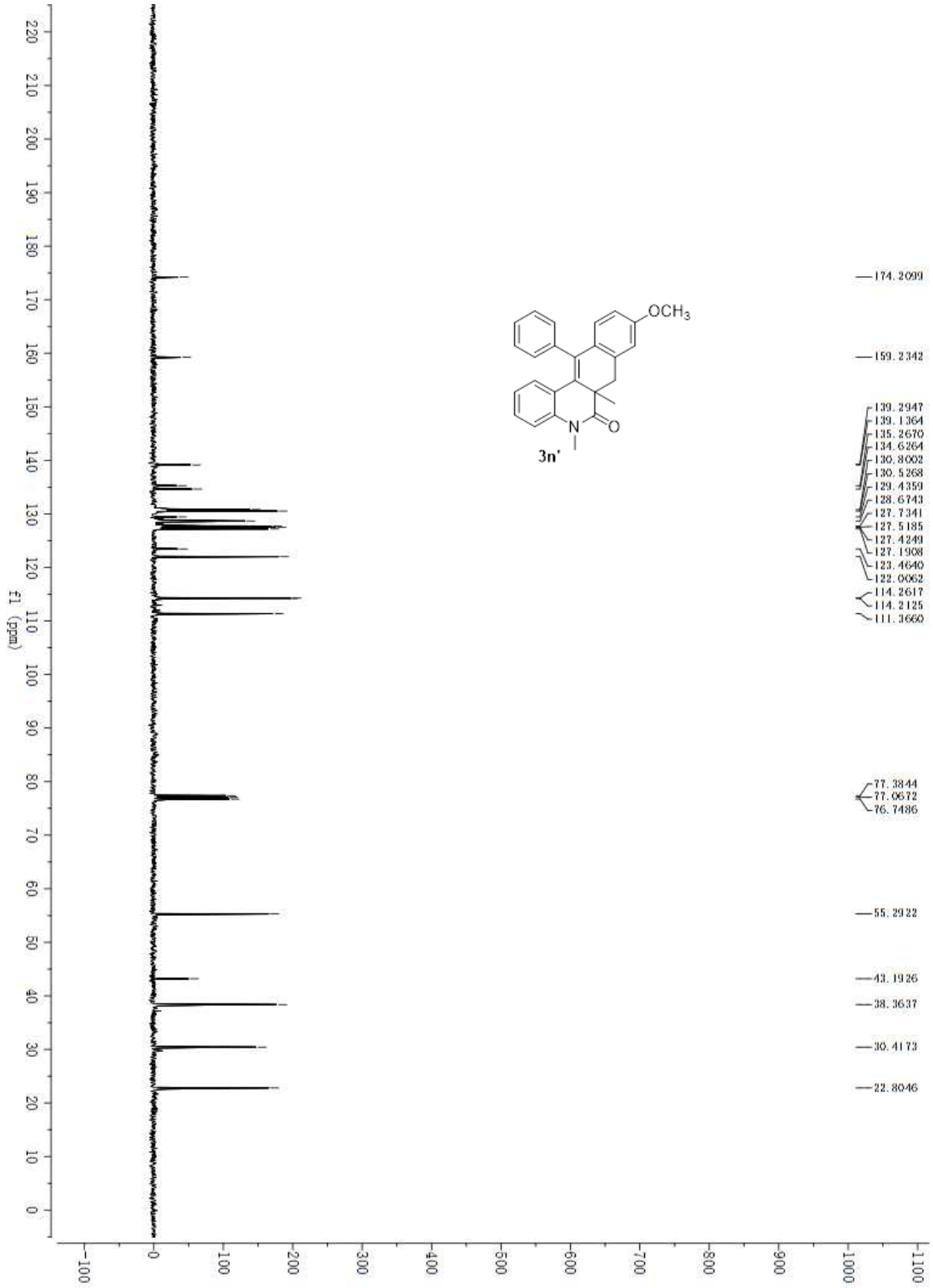

CO2Me
N
O
3m'
f1 (ppm)
2.02
4.95
1.23
1.19
1.11
1.04
1.16
2.96
1.08
4.33
3.09
7.8697
7.8666
7.8473
7.8254
7.4403
7.4240
7.4062
7.3889
7.3644
7.3448
7.2607
7.1311
7.1133
7.0955
6.9661
6.9459
6.7969
6.7791
6.6240
6.6047
6.5862
3.8217
3.5217
3.4801
3.4285
3.4155
3.3872
1.2338
0.0001

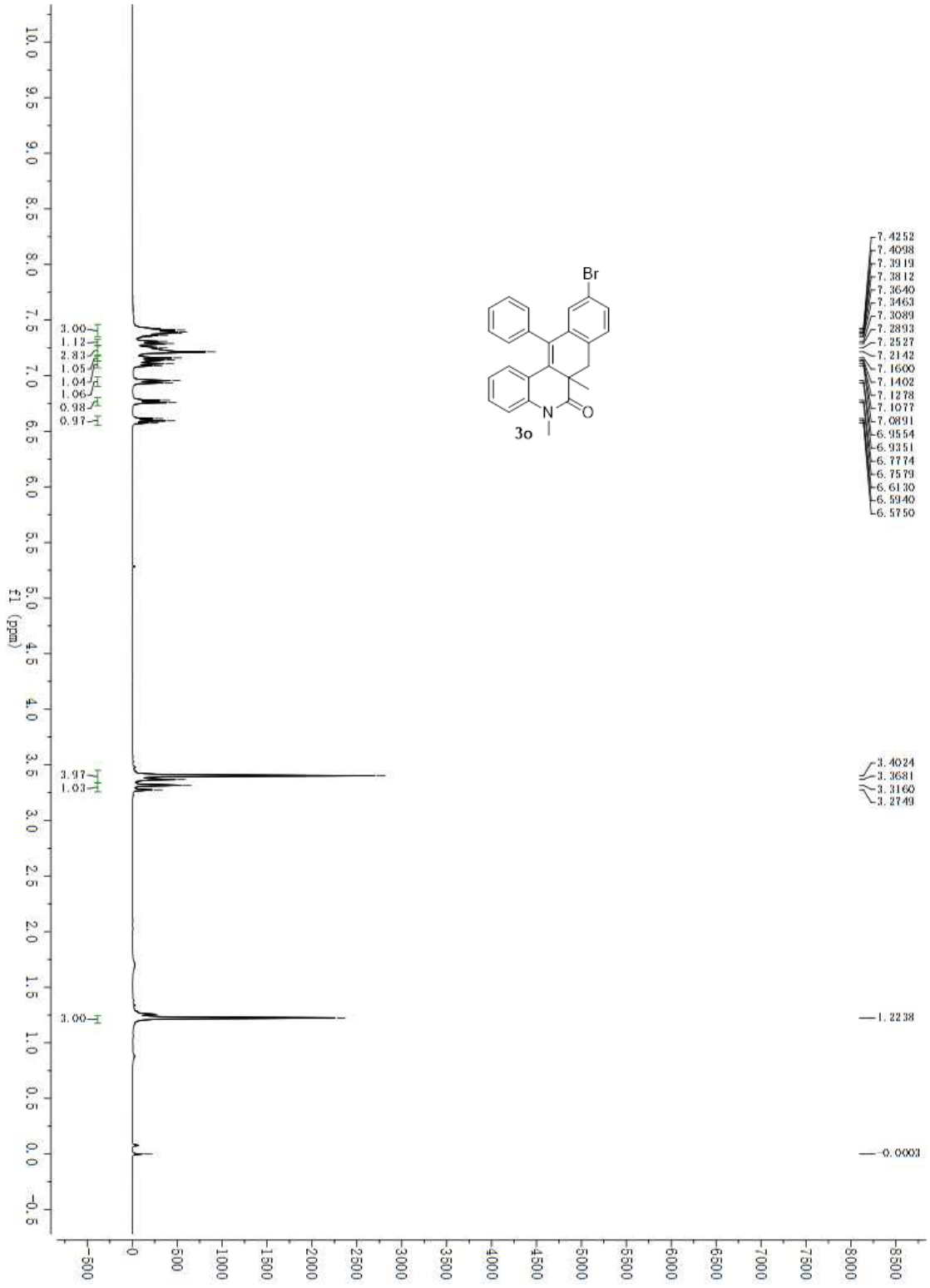

CO2Me
N
O
3m'
173.6508
167.0332
139.4228
138.0798
134.7079
134.3796
133.2830
130.8099
129.3825
128.8733
128.7199
128.5989
128.3968
127.9199
127.5698
126.8022
125.7391
122.7849
122.1183
114.2751
77.3289
77.0109
76.6929
51.9761
43.3088
38.0763
30.3775
22.7497
f1 (ppm)

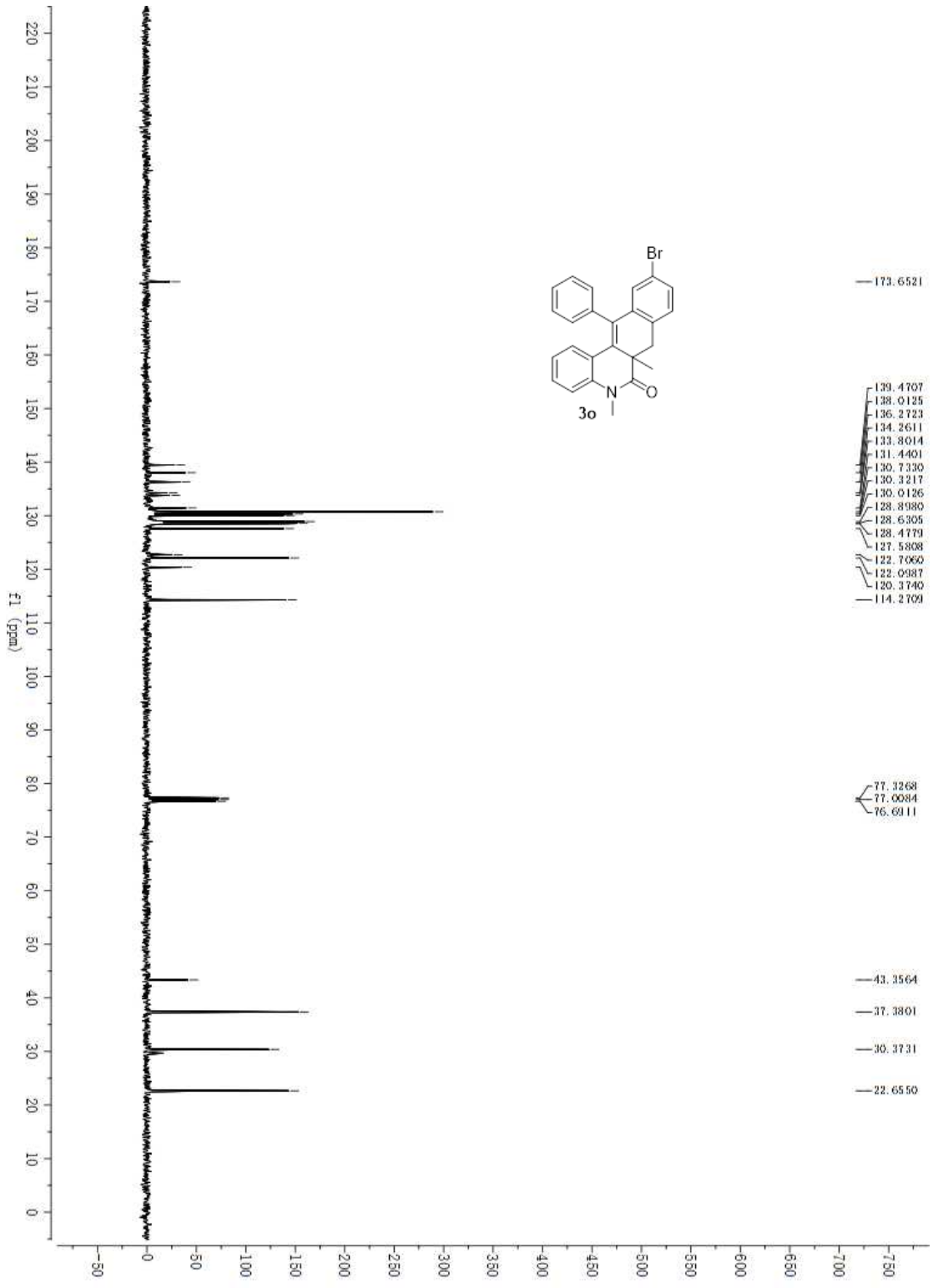

OCH3
N
O
3n
f1 (ppm)
3.24
3.06
1.15
1.09
1.04
1.10
1.00
1.01
2.97
4.09
1.03
3.00
7.3985
7.3817
7.3638
7.3482
7.3308
7.2510
7.2148
7.1945
7.1128
7.0921
7.0741
6.9476
6.9275
6.8101
6.7902
6.7525
6.7463
6.7323
6.7260
6.6970
6.6908
6.6043
6.5853
6.5665
3.6757
3.4021
3.3725
3.3031
3.2629
1.2287
0.0004

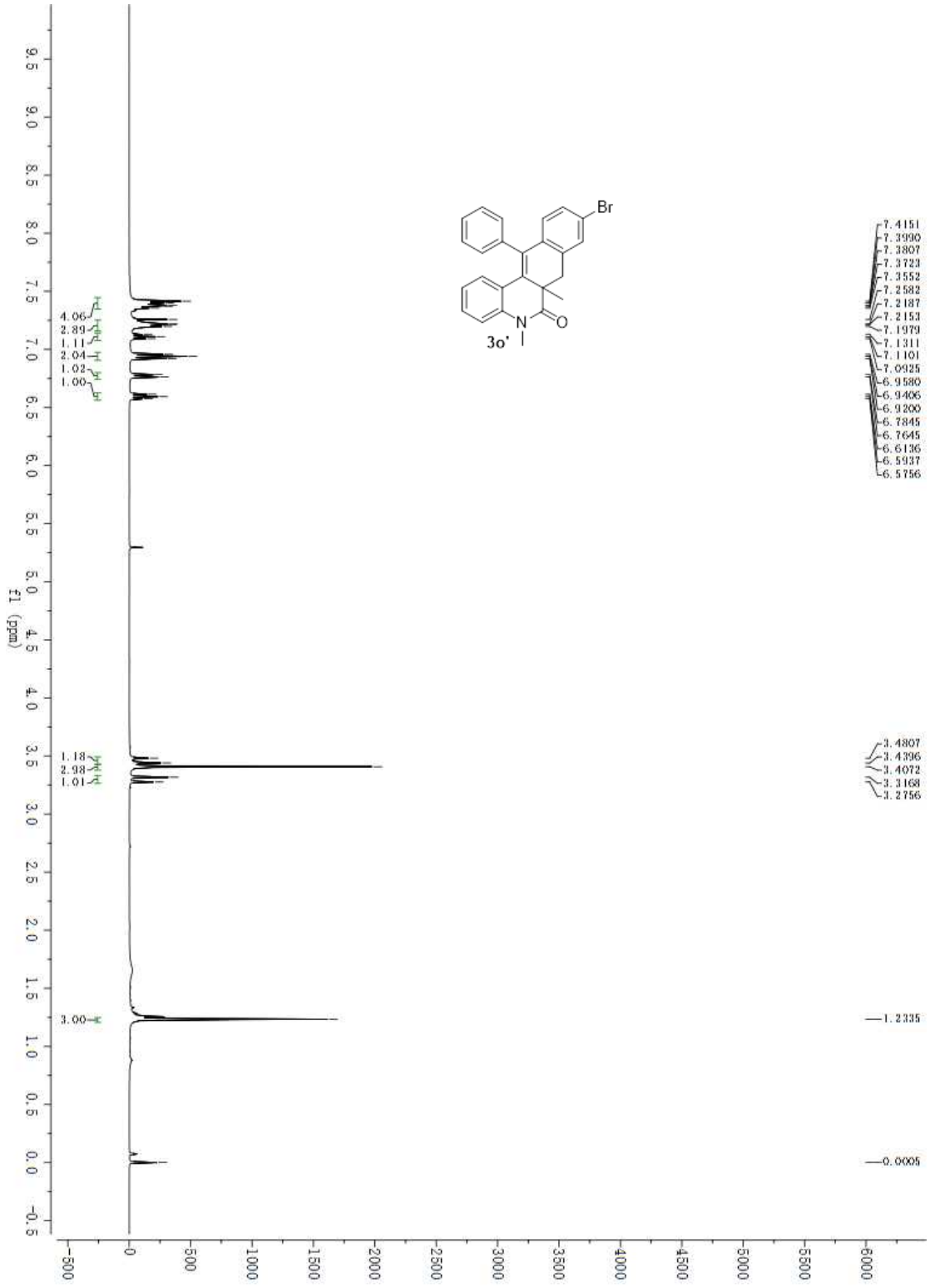

OCH3
N
O
3n
174.1405
158.3365
139.4842
138.7062
135.3445
135.2999
132.8824
131.0941
130.7567
129.1820
128.6663
128.1479
127.2723
124.8003
123.0740
121.9645
114.1629
112.9218
111.9409
77.3193
77.0020
76.6832
55.1662
43.5475
37.1132
30.3409
22.5194
f1 (ppm)

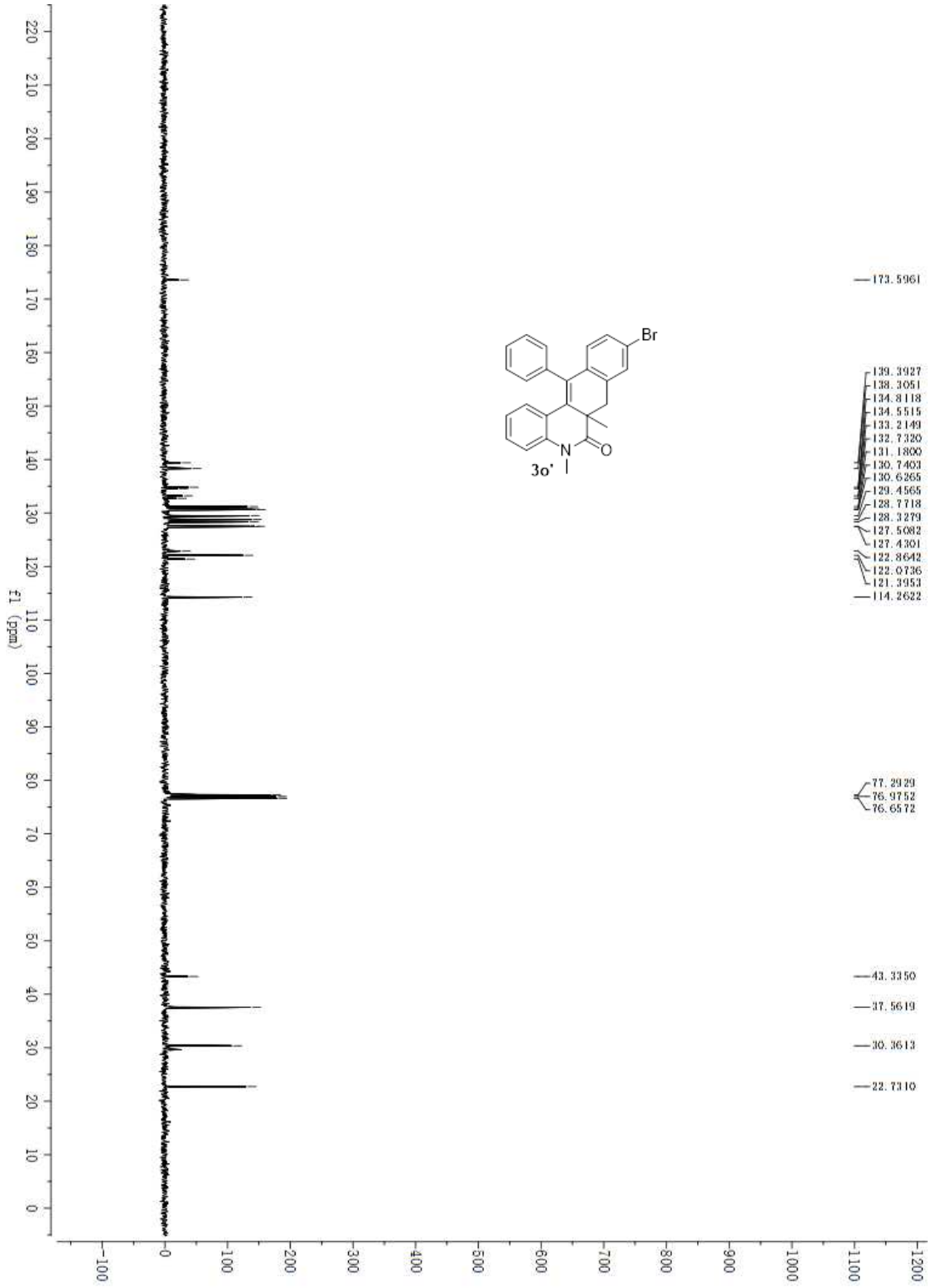

OCH3
N
O
3n'
f1 (ppm)
7.3986
7.3821
7.3644
7.3510
7.3336
7.2476
7.2360
7.1944
7.0913
7.0704
7.0527
6.9985
6.9769
6.9398
6.9206
6.8531
6.8478
6.7675
6.7476
6.6301
6.6239
6.6084
6.6020
6.5932
6.5752
6.5573
3.8017
3.4918
3.4510
3.4022
3.3164
3.2755
1.2335
0.0004
3.10
1.99
1.09
1.04
1.09
1.02
1.03
1.01
1.07
3.00
1.02
3.09
1.04
3.09

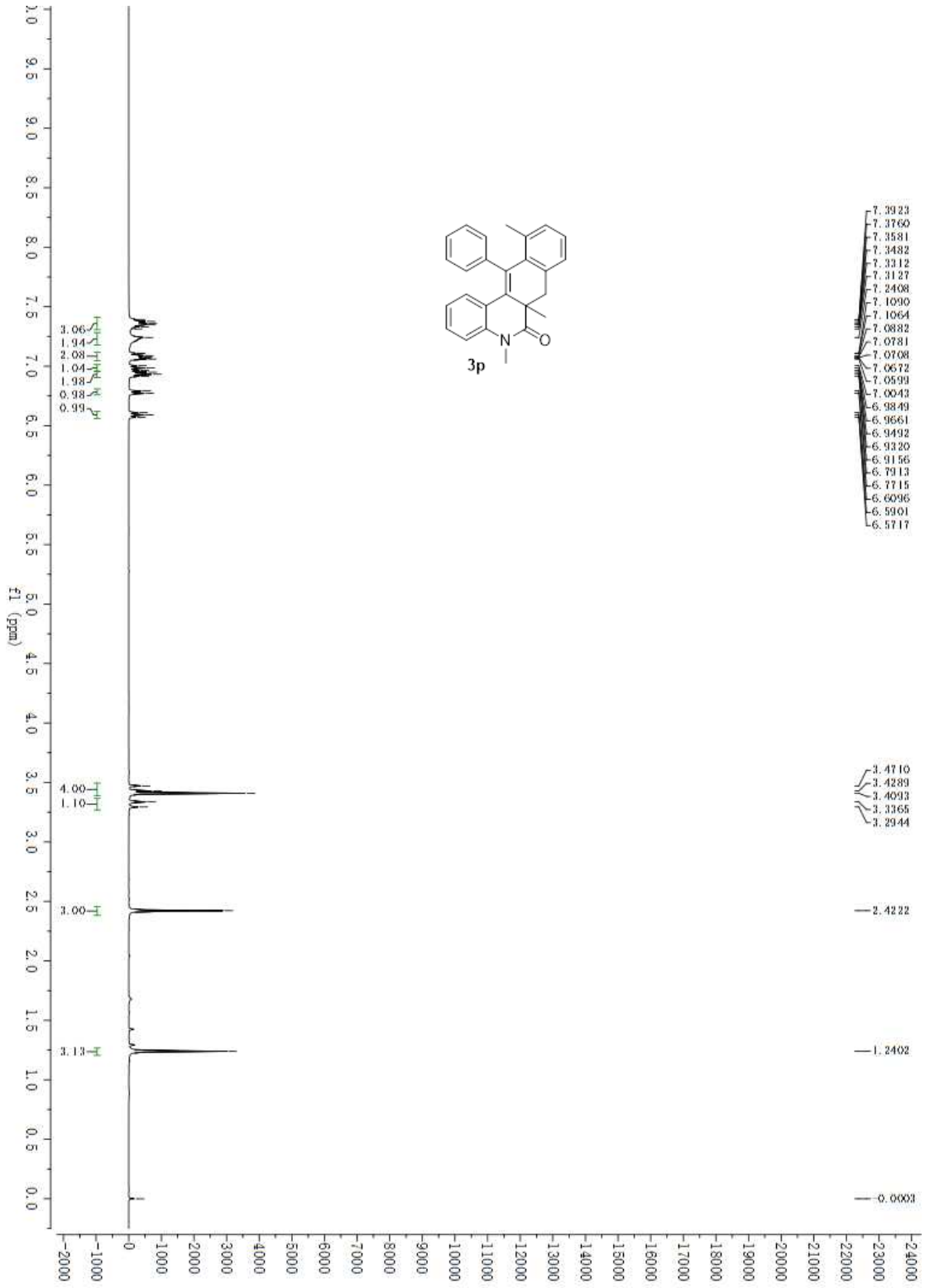

OCH3
N
O
3n'
174.2099
159.2342
139.2947
139.1364
135.2670
134.6264
130.8002
130.5268
129.4359
128.6743
127.7341
127.5185
127.4249
127.1908
123.4640
122.0062
114.2617
114.2125
111.3660
77.3844
77.0672
76.7486
55.2922
43.1926
38.3637
30.4173
22.8046
f1 (ppm)

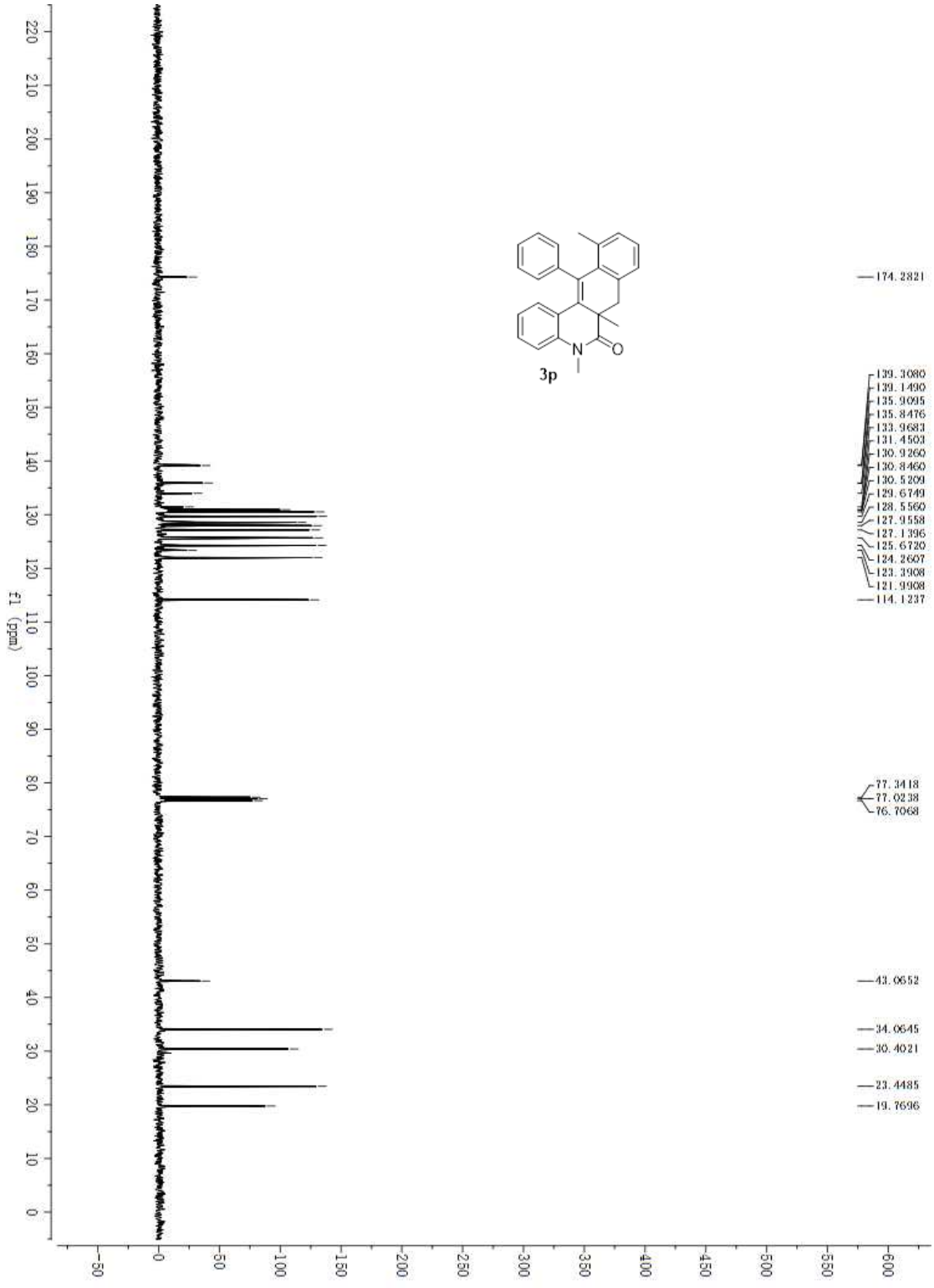

Br
N
O
3o
7.4252
7.4098
7.3919
7.3812
7.3640
7.3463
7.3089
7.2893
7.2527
7.2142
7.1600
7.1402
7.1278
7.1077
7.0891
6.9554
6.9351
6.7774
6.7579
6.6130
6.5940
6.5750
3.4024
3.3681
3.3160
3.2749
1.2238
0.0003
3.00
1.12
2.83
1.05
1.04
1.06
0.98
0.97
3.97
1.03
3.00
f1 (ppm)

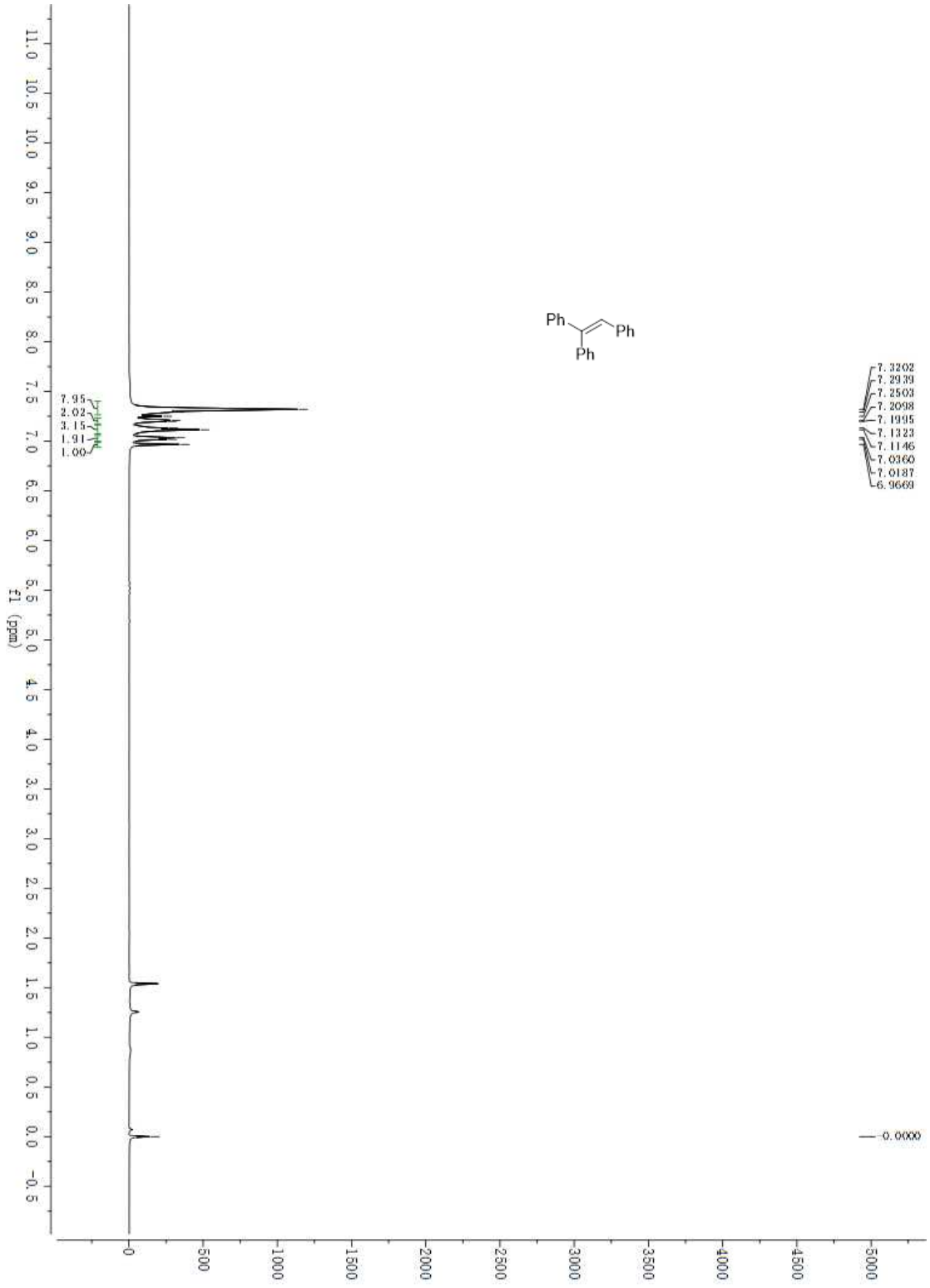

Br
N
O
3o
173.6521
139.4707
138.0125
136.2723
134.2611
133.8014
131.4401
130.7330
130.3217
130.0126
128.8980
128.6305
128.4779
127.5808
122.7060
122.0987
120.3740
114.2709
77.3268
77.0084
76.6911
43.3564
37.3801
30.3731
22.6550
f1 (ppm)

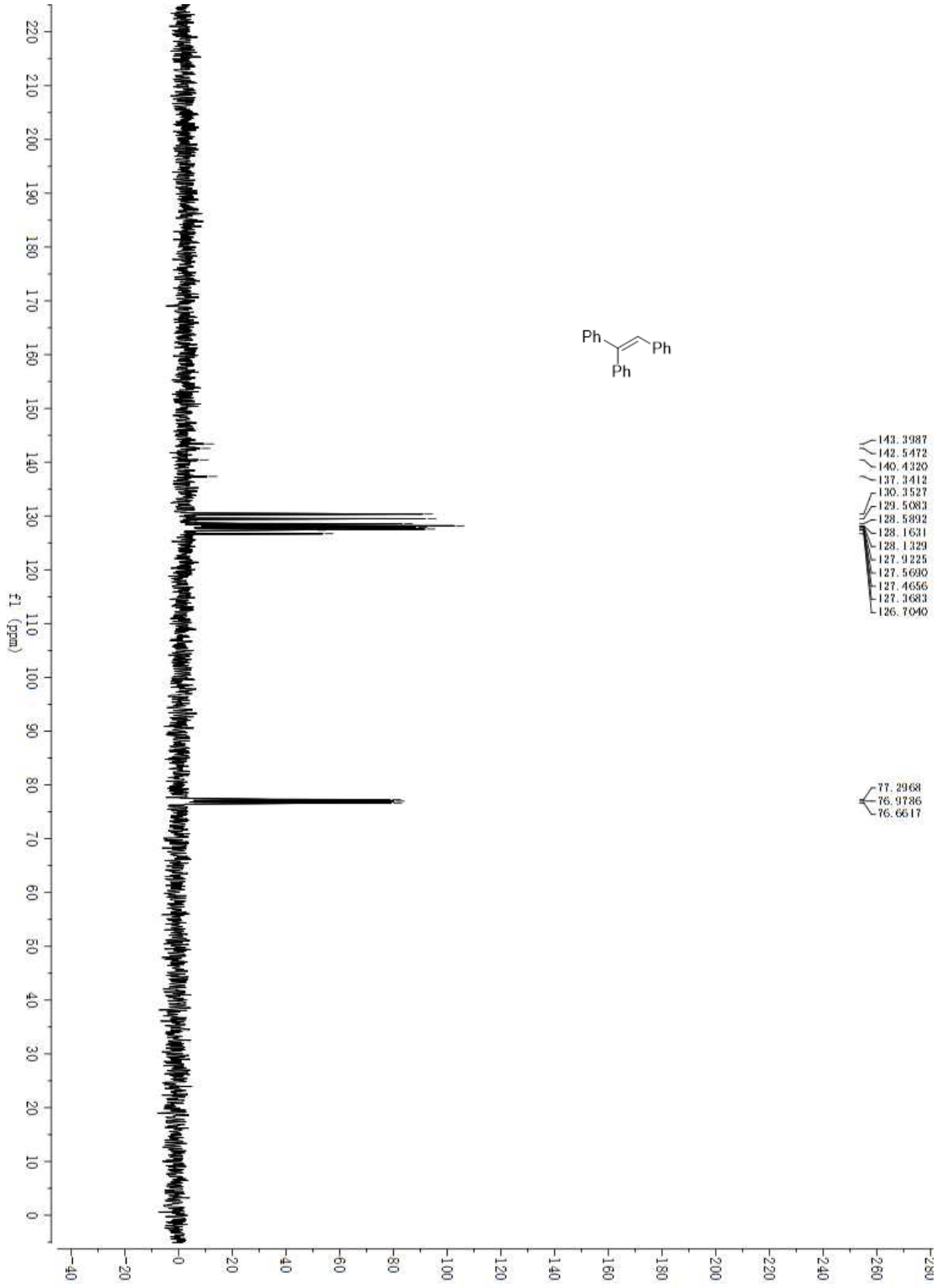

Br
N
O
3o'
7.4151
7.3990
7.3807
7.3723
7.3552
7.2582
7.2187
7.2153
7.1979
7.1311
7.1101
7.0925
6.9580
6.9406
6.9200
6.7845
6.7645
6.6136
6.5937
6.5756
3.4807
3.4396
3.4072
3.3168
3.2756
1.2335
0.0005
4.06
2.89
1.11
2.04
1.02
1.00
1.18
2.98
1.01
3.00
f1 (ppm)

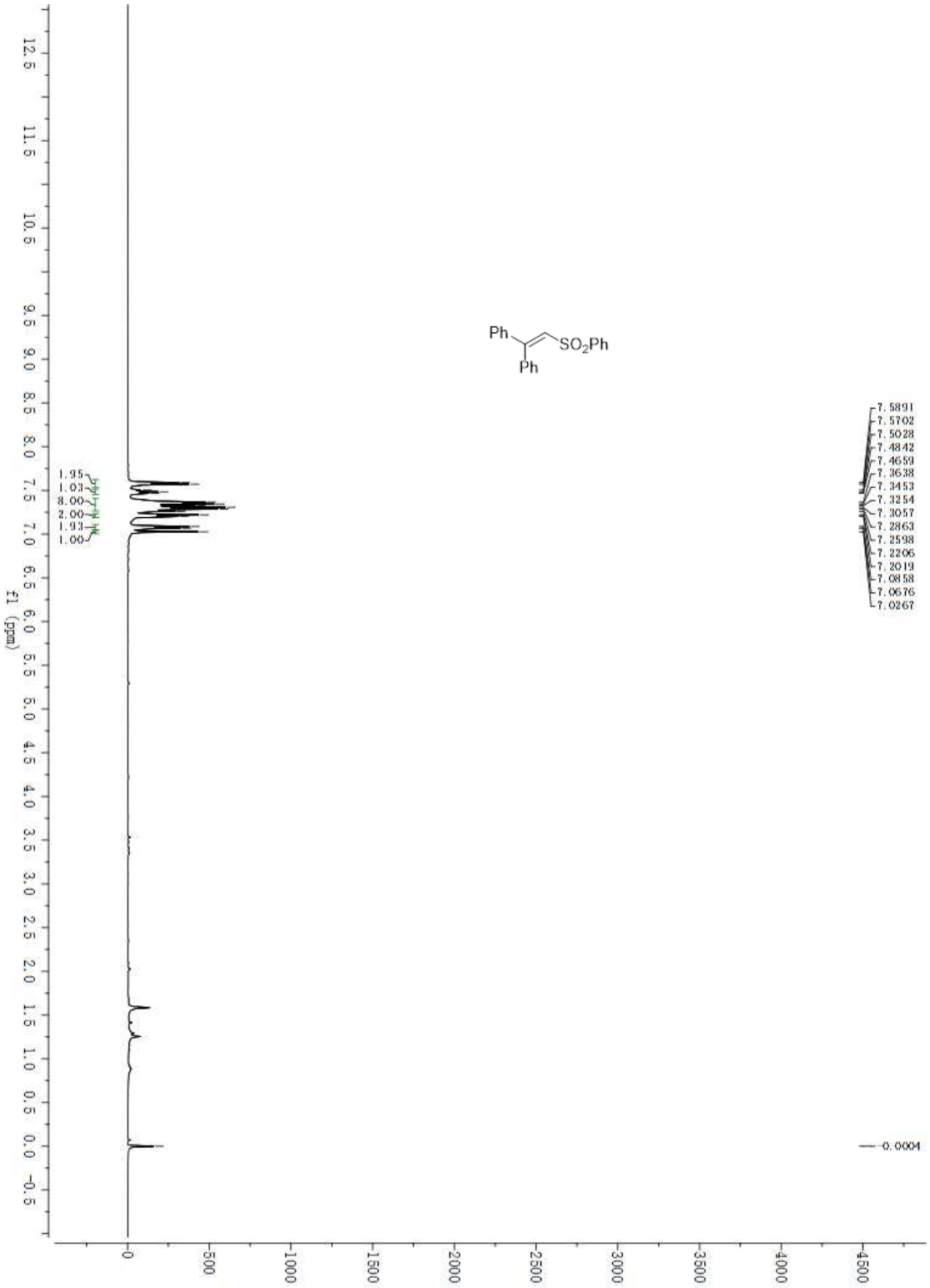

Br
N
O
3o'
173.5961
139.3927
138.3051
134.8118
134.5515
133.2149
132.7320
131.1800
130.7403
130.6265
129.4565
128.7718
128.3279
127.5082
127.4301
122.8642
122.0736
121.3953
114.2622
77.2929
76.9752
76.6572
43.3350
37.5619
30.3613
22.7310
f1 (ppm)


3p
f1 (ppm)
7.3923
7.3760
7.3581
7.3482
7.3312
7.3127
7.2408
7.1090
7.1064
7.0882
7.0781
7.0708
7.0672
7.0599
7.0043
6.9849
6.9661
6.9492
6.9320
6.9156
6.7913
6.7715
6.6096
6.5901
6.5717
3.4710
3.4289
3.4093
3.3365
3.2944
2.4222
1.2402
0.0003
3.06
1.94
2.08
1.04
1.98
0.98
0.99
4.00
1.10
3.00
3.13


3p
174.2821
139.3080
139.1490
135.9095
135.8476
133.9683
131.4503
130.9260
130.8460
130.5209
129.6749
128.5560
127.9558
127.1396
125.6720
124.2607
123.3908
121.9908
114.1237
77.3418
77.0238
76.7068
43.0652
34.0645
30.4021
23.4485
19.7696
f1 (ppm)


Ph
Ph
Ph
7.95
2.02
3.15
1.91
1.00
7.3202
7.2939
7.2503
7.2098
7.1995
7.1323
7.1146
7.0360
7.0187
6.9669
0.0000
f1 (ppm)


Ph
Ph
Ph
143.3987
142.5472
140.4320
137.3412
130.3527
129.5083
128.5892
128.1631
128.1329
127.9225
127.5690
127.4656
127.3683
126.7040
77.2968
76.9786
76.6617
f1 (ppm)


Ph
SO2Ph
Ph
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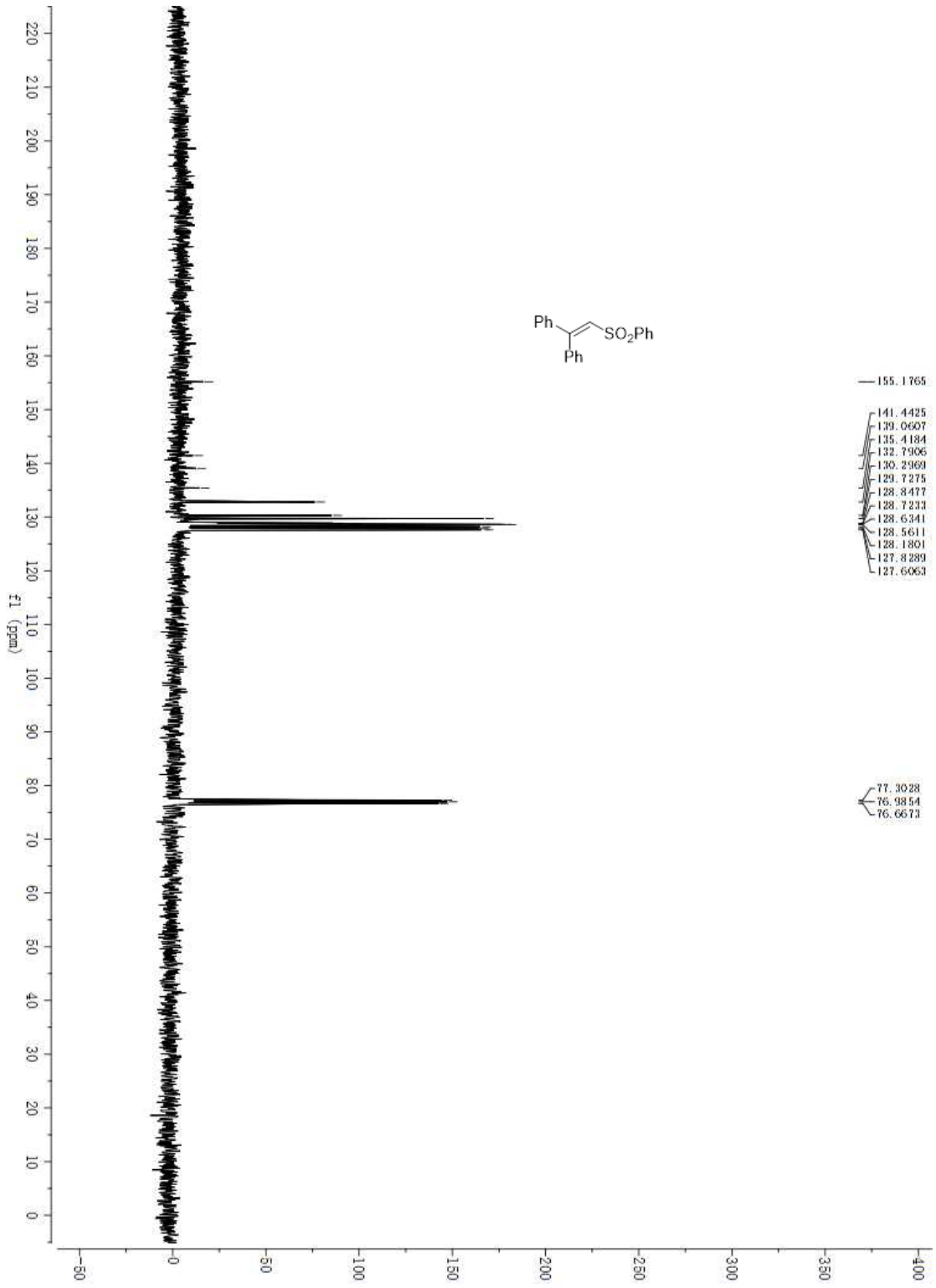
1.03
8.00
2.00
1.93
1.00
7.5891
7.5702
7.5028
7.4842
7.4659
7.3638
7.3453
7.3254
7.3057
7.2863
7.2598
7.2206
7.2019
7.0858
7.0676
7.0267
0.0004
f1 (ppm)


Ph
SO2Ph
Ph
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141.4425
139.0607
135.4184
132.7906
130.2969
129.7275
128.8477
128.7233
128.6341
128.5611
128.1801
127.8289
127.6063
77.3028
76.9854
76.6673
f1 (ppm)