Supporting Information

Iron Porphyrin-Catalyzed Insertion Reaction of *N*-Tosylhydrazone-Derived Carbenes into X-H (X = Si, Sn, Ge) Bonds

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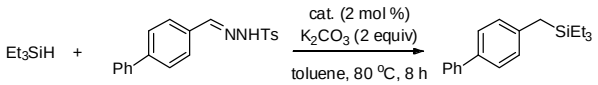
1. General Information

All reagents purchased from commercial sources were used as received. The solvents toluene, THF and 1,4-dioxane were distilled from sodium. The silica gel for column chromatography was supplied as 300-400 mesh from Haiyang Chemicals (Qingdao, China). The ^{1}H and ^{13}C NMR spectra were recorded on a Varian Inova,spectrometer and are referenced to the residual solvent signals (7.26 ppm for ^{1}H and 77.16 ppm for ^{13}C in $CDCl_3$). Multiplicity was indicated as follows: s (singlet), d (doublet), t (triplet), q (quartet), m (multiplet), dd (doublet of doublet), br s (broad singlet). Coupling constants were reported in Hertz (Hz). The MS spectra were recorded on Agilent Technologies 5973N. High resolution mass spectra (HRMS) were recorded on Agilent Technologies 6224 by using ESI method or Waters Micromass GCT Premier by using EI method. GC analysis was performed with Shimadzu GC-2010 plus. Microwave reactions were performed with CEM Discover SP microwave synthesizer. *N*-Tosylhydrazones[1] and metal porphyrin catalysts[2] were prepared according to the known procedures.

2. Screen of metal complexes

Table S1. Screen of the catalysts[a]



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

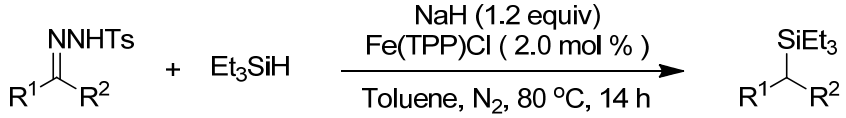
entry	catalyst	yield[b] (%)
1	$Cu(OTf)_2$	25
2	$CuCl_2$	32
3	CuI	16
4	CuBr	16
5	Rh(TPFPP)Cl	ND
6	Rh(TPP)Cl	50
7	Rh(TPP)Me	ND
8	Co(TPP)	32
9	Co(TTP)	20
10	Co(TPFPP)	ND
11	Fe(TPFPP)Cl	ND
12	Fe(TPP)Cl	62
13	Fe(TTP)Cl	30

14	Fe(*p*-ClTPP)Cl	ND
15	Fe(TPP)Cl	76[c,d]

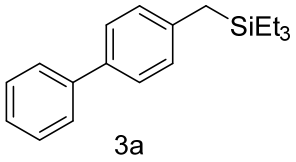
[a]Unless otherwise specified, reaction conditions: **1a** (0.2 mmol), **2a** (0.4 mmol, 2 equiv), cat. (2 mol%) and K_2CO_3 (0.4 mmol, 2 equiv) were reacted in toluene (2 mL) at 80 °C for 8 hours. [b]GC yield. [c]Reactions were done at 80 °C for 14 h. [d]Isolated yield.

3. Synthesis and Analytical Data of compounds

The Fe(TPP)Cl catalyzed carbene insertion reaction into Et_3SiH was performed according to the general procedure given below:



General procedure: To a flame-dried sealed tube were added *N*-tosylhydrazone (0.2 mmol, 1.0 equiv), NaH (9.6 mg, 60 wt%, 0.24 mmol, 1.2 equiv), Fe(TPP)Cl (2.86 mg, 4.0 μmol, 0.02 equiv), triethylsilane (64 μl, 0.4 mmol, 2.0 equiv) and dry toluene (2.0 mL, 0.1 M) under Ar atmosphere. Then the tube was sealed and heated at 80 °C for additional 14 h. The reaction was monitored by TLC. When the reaction was completed, the crude reaction mixture was purified by flash column chromatography on silica gel (eluting with petroleum ether) to afford product as a colorless oil.



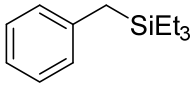
3a

3a ([1,1'-biphenyl]-4-ylmethyl)triethylsilane:

Colorless oil. 51 mg, Yield: 90 %

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.62 (d, *J* = 8.0 Hz, 2H), 7.52 – 7.36 (m, 4H), δ 7.36 – 7.29 (m, 1H), 7.12 (d, *J* = 8.0 Hz, 2H), 2.18 (s, 2H), 0.98 (t, *J* = 8.0 Hz, 9H), 0.58 (q, *J* = 8.0 Hz, 6H).

EI-MS m/z (relative intensity): 282 (M+, 32), 115 (100), 87 (82), 168 (47), 167 (38), 59 (25), 165 (24), 57 (23). The spectroscopic data were identical in all respects to those previously reported[3].



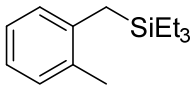
3b

3b benzyltriethylsilane:

Colorless oil. 30 mg, Yield: 72 %

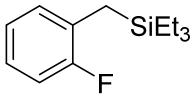
^{1}H NMR (400 MHz, $CDCl_3$): δ 7.21 (t, *J* = 7.5 Hz, 2H), 7.08 (d, *J* = 7.5 Hz, 1H), 7.03 (d, *J* = 7.5 Hz, 2H), 2.11 (s, 2H), 0.93 (t, *J* = 8.0 Hz, 9H), 0.53 (q, *J* = 8.0 Hz, 6H) .

EI-MS m/z (relative intensity): 206 (M^+, 19.5), 115 (100), 87 (93), 121 (8021), 59 (26), 179 (25), 180 (23), 178 (13). The spectroscopic data were identical in all respects to those previously reported.[3]



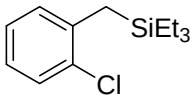
3c

3c triethyl(2-methylbenzyl)silane:
Colorless oil. 38 mg, Yield: 86 %
^{1}H NMR (400 MHz, $CDCl_3$): δ 7.15 – 7.03 (m, 2H), 7.03 – 6.96 (m, 2H), 2.27 (s, 3H), 2.12 (s, 2H), 0.93 (t, *J* = 8.0 Hz, 9H), 0.56 (q, *J* = 8.0 Hz, 6H).
^{13}C NMR (100 MHz, $CDCl_3$): δ 139.3, 134.7, 130.2, 128.9, 125.8, 124.1, 20.5, 18.7, 7.5, 3.7.
HRMS(EI) m/z calcd. for C14H24Si $[M]^+$ 220.1647, found 220.1651.



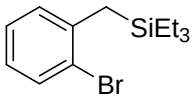
3d

3d triethyl(2-fluorobenzyl)silane:
Colorless oil. 21 mg, Yield: 46 %
^{1}H NMR (400 MHz, $CDCl_3$): δ 7.10 – 6.92 (m, 4H), 2.11 (d, *J* = 2.1 Hz, 2H), 0.94 (t, *J* = 8.0 Hz, 9H), 0.55 (q, *J* = 8.0 Hz, 6H).
^{19}F NMR (376 MHz, $CDCl_3$): δ -117.07 – -117.35 (m).
^{13}C NMR (100 MHz, $CDCl_3$): δ 160.5 (d, *J* = 242.3 Hz), 130.5 (d, *J* = 5.1 Hz), 127.9 (d, *J* = 17.1 Hz), 125.5 (d, *J* = 7.7 Hz), 123.8 (d, *J* = 3.4 Hz), 115.1 (d, *J* = 22.5 Hz), 14.4 (d, *J* = 2.5 Hz), 7.3 , 3.3 .
HRMS(EI) m/z calcd. for C13H21FSi $[M]^+$ 224.1397, found 224.1404.



3e

3e (2-chlorobenzyl)triethylsilane:
Colorless oil. 34 mg, Yield: 71 %
^{1}H NMR (400 MHz, $CDCl_3$): δ 7.30 (d, *J* = 6.6 Hz, 1H), 7.14 – 7.05 (m, 2H), 7.03 – 6.96 (m, 1H)., 2.30 (s, 2H), 0.92 (t, *J* = 8.0 Hz, 9H), 0.57 (q, *J* = 8.0 Hz, 6H).
^{13}C NMR (100 MHz, CDCl3): δ 139.3, 132.8, 130.0, 129.5, 126.5, 125.3, 19.5, 7.5, 3.6.
EI-MS m/z (relative intensity): 240 (M^+, 1.62), 87 (100), 115 (79), 211 (67), 59 (30), 213 (25), 91 (18), 93 (14). The spectroscopic data were identical in all respects to those previously reported[3].



3f

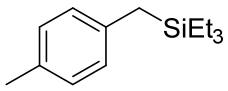
3f (2-bromobenzyl)triethylsilane:

Colorless oil. 31 mg, Yield: 54 %

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.49 (dd, *J* = 8.0, 1.4 Hz, 1H), 7.15 (td, *J* = 7.4, 1.3 Hz, 1H), 7.08 (dd, *J* = 7.7, 1.9 Hz, 1H), 6.96 – 6.88 (m, 1H), 2.34 (s, 2H), 0.92 (t, *J* = 8.0 Hz, 9H), 0.59 (q, *J* = 8.0 Hz, 6H).

^{13}C NMR (100 MHz, CDCl3): δ 141.1, 132.8, 129.8, 127.2, 125.6, 123.7, 22.2, 7.4, 3.6.

HRMS(EI) m/z calcd. for C13H21SiBr $[M]^+$ 284.0596, found 284.0602.



3g

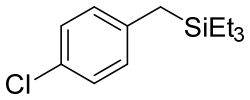
3g triethyl(4-methylbenzyl)silane:

Colorless oil. 23 mg, Yield: 52 %

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.03 (d, *J* = 7.6 Hz, 2H), 6.93 (d, *J* = 7.6 Hz, 2H), 2.30 (s, 3H), 2.07 (s, 2H), 0.94 (t, *J* = 8.0 Hz, 9H), 0.52 (q, *J* = 8.0 Hz, 6H).

^{13}C NMR (100 MHz, $CDCl_3$): δ 137.4, 133.2, 129.0, 128.1, 21.1, 21.0, 7.5, 3.1.

HRMS(EI) m/z calcd. for C14H24Si $[M]^+$ 220.1647, found 220.1650.



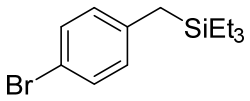
3h

3h (4-chlorobenzyl)triethylsilane:

Colorless oil. 47 mg, Yield: 97 %

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.17 (d, *J* = 8.5 Hz, 2H), 6.94 (d, *J* = 8.5 Hz, 2H), 2.07 (s, 2H), 0.92 (t, J = 8.0 Hz, 9H), 0.51 (q, *J* = 8.0 Hz, 6H).

EI-MS m/z (relative intensity): 240 (M^+, 12.2), 115 (100), 87 (90), 59 (24), 155 (14), 213 (25), 91 (18), 93 (14). The spectroscopic data were identical in all respects to those previously reported[3].



3i

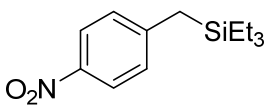
3i (4-bromobenzyl)triethylsilane:

Colorless oil. 47 mg, Yield: 83 %

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.31 (d, *J* = 8.5 Hz, 1H), 6.88 (d, *J* = 8.5 Hz, 1H), 2.05 (s, 1H), 0.91 (t, *J* = 8.0 Hz, 5H), 0.50 (q, *J* = 8.0 Hz, 4H).

^{13}C NMR (100 MHz, $CDCl_3$): δ 139.9, 131.3, 129.9, 117.4, 21.4, 7.4, 3.0.

HRMS(EI) m/z calcd. for C13H21SiBr $[M]^+$ 284.0596, found 284.0599.



3j

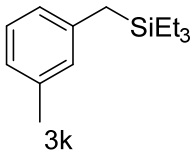
3j triethyl(4-nitrobenzyl)silane:

Colorless oil. 42 mg, Yield: 83 %

^{1}H NMR (400 MHz, $CDCl_3$): δ 8.07 (d, *J* = 8.7 Hz, 2H), 7.13 (d, *J* = 8.7 Hz, 2H), 2.25 (s, 2H), 0.92 (t, *J* = 8.0 Hz, 9H), 0.52 (q, *J* = 8.0 Hz, 6H).

^{13}C NMR (100 MHz, $CDCl_3$): δ 150.2, 144.9, 128.5, 123.8, 23.3, 7.3, 3.0.

HRMS(EI) m/z calcd. for C13H21NO2Si $[M]^+$ 251.1342, found 251.1343.



3k

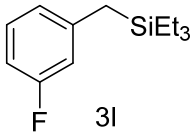
3k triethyl(3-methylbenzyl)silane:

Colorless oil. 36 mg, Yield: 81 %

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.11 (t, *J* = 7.4 Hz, 1H), 6.92 – 6.79 (m, 3H), 2.32 (s, 3H), 2.08 (s, 2H), 0.95 (t, *J* = 8.0 Hz, 9H), 0.53 (q, *J* = 8.0 Hz, 6H).

^{13}C NMR (100 MHz, $CDCl_3$): δ 140.7 , 137.7 , 129.1 , 128.1 , 125.3 , 124.7 , 21.6 , 21.6 , 7.4 , 3.2 .

HRMS(EI) m/z calcd. for C14H24Si $[M]^+$ 220.1647, found 220.1642.



3l

3l triethyl(3-fluorobenzyl)silane:

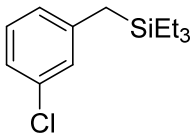
Colorless oil. 26 mg, Yield: 58 %

^{1}H NMR (400 MHz, $CDCl_3$): δ 6.98 – 6.84 (m, 4H), 2.06 (s, 2H), 0.92 (t, *J* = 8.0 Hz, 9H), 0.51 (q, *J* = 8.0 Hz, 6H).

^{19}F NMR (376 MHz, $CDCl_3$): δ -120.56 –-120.69 (m).

^{13}C NMR (100 MHz, $CDCl_3$): δ 160.3 (d, *J* = 241.2 Hz), 136.2 (d, *J* = 3.1 Hz), 129.2 (d, *J* = 7.7 Hz), 115.0 (d, *J* = 21.0 Hz), 20.8, 7.4 , 3.1 .

HRMS(EI) m/z calcd. for C13H21FSi $[M]^+$ 224.1367, found 224.1400.



3m

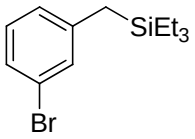
3m (3-chlorobenzyl)triethylsilane:

Colorless oil. 39 mg, Yield: 81 %

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.13 (t, *J* = 7.7 Hz, 1H), 7.07 – 6.97 (m, 2H), 6.89 (d, *J* = 7.7, 1H), 2.08 (s, 2H), 0.93 (t, *J* = 8.0 Hz, 9H), 0.52 (q, *J* = 8.0 Hz, 6H).

^{13}C NMR (100 MHz, $CDCl_3$): δ 143.1 , 134.0 , 129.5 , 128.1 , 126.4 , 124.1 , 21.8 , 7.4 , 3.1 .

HRMS(EI) m/z calcd. for C13H21SiCl $[M]^+$ 240.1101, found 240.1104.



3n

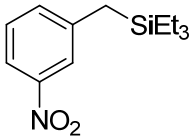
3n (3-bromobenzyl)triethylsilane:

Colorless oil. 40 mg, Yield: 71 %

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.22 – 7.14 (m, 2H), 7.07 (t, *J* = 7.7 Hz, 1H), δ 6.94 (d, *J* = 7.7 Hz, 1H)., 2.07 (s, 2H), 0.93 (t, *J* = 8.0 Hz, 9H), 0.52 (q, *J* = 8.0 Hz, 6H).

^{13}C NMR (100 MHz, $CDCl_3$): δ 143.5 , 131.0 , 129.8 , 127.0 , 126.8 , 122.4 , 21.8 , 7.4 , 3.1 .

HRM (EI) m/z calcd. for C13H21SiBr $[M]^+$ 284.0596, found 284.0604.



3o

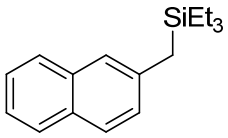
3o triethyl(3-nitrobenzyl)silane:

Colorless oil. 44 mg, Yield: 88 %

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.92 (d, *J* = 7.7 Hz, 1H), 7.87 (s, 1H), 7.39 – 7.29 (m, 2H), 2.22 (s, 2H), 0.92 (t, *J* = 8.0 Hz, 9H), 0.52 (q, *J* = 8.0 Hz, 6H).

^{13}C NMR (100 MHz, $CDCl_3$): δ 148.4 , 143.3 , 134.3 , 129.0 , 122.6 , 119.2 , 22.2 , 7.3 , 3.0 .

HRMS(EI) m/z calcd. for C13H21NO2Si $[M]^+$ 251.1342, found 251.1346.



3p

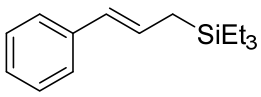
3p triethyl(naphthalen-2-ylmethyl)silane:

Colorless oil. 39 mg, Yield: 76 %

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.79 (d, *J* = 7.7 Hz, 1H), 7.73 (t, *J* = 8.1 Hz, 2H), 7.48 – 7.34 (m, 3H), 7.21 (dd, *J* = 8.1, 1.7 Hz, 1H), 2.29 (s, 2H), 0.97 (t, *J* = 8.0 Hz, 9H), 0.56 (q, *J* = 8.0 Hz, 6H).

^{13}C NMR (100 MHz, CDCl3): δ 138.6 , 134.0 , 131.0 , 128.1 , 127.7 , 127.6 , 127.1 , 125.9 , 125.3 , 124.4 , 22.1 , 7.5 , 3.2 .

HRMS(EI) m/z calcd. for C14H24Si $[M]^+$ 256.1647, found 256.1656.



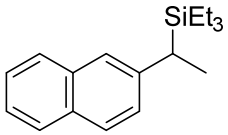
3q

3q cinnamyltriethylsilane:

Colorless oil. 13 mg, Yield: 28 %

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.31-7.23 (m, 4H), 7.18-7.10 (m, 1H), 6.28-6.20 (m, 2H), 1.70 (dd, *J* = 5.0, 2.0 Hz, 2H), 0.96 (t, *J* = 8.0 Hz, 9H), 0.57 (q, *J* = 8.0 Hz, 6H);

EI-MS m/z (relative intensity): 232 (M^+, 18.67), 115 (100), 87 (97), 59 (33), 116 (15), 117(11), 88 (10), 57 (10).The spectroscopic data were identical in all respects to those previously reported[3].



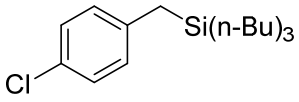
3r

3r triethyl(1-(naphthalen-2-yl)ethyl)silane:

Colorless oil. 14 mg, Yield: 26 %

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.81 – 7.69 (m, 3H), 7.49 (s, 1H), 7.43 (t, *J* = 7.5 Hz, 1H), 7.37 (t, *J* = 7.5 Hz, 1H), 7.25 (dd, *J* = 8.0, 1.0 Hz, 1H), 2.49 (q, *J* = 7.5 Hz, 1H), 1.48 (d, *J* = 7.5 Hz, 3H), 0.91 (t, *J* = 8.0 Hz, 9H), 0.55 (q, *J* = 8.0 Hz, 6H).

EI-MS m/z (relative intensity): 270 (M^+, 21), 115 (100), 87 (87.5), 59 (30), 57(24), 155(21.35), 55 (16), 154 (15).The spectroscopic data were identical in all respects to those previously reported[3].



4a

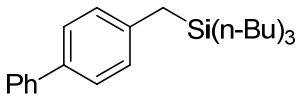
4a tributyl(4-chlorobenzyl)silane:

Colorless oil. 51 mg, Yield: 78 %

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.15 (d, *J* = 8.4 Hz, 2H), 6.90 (d, *J* = 8.4 Hz, 2H), 2.04 (s, 2H), 1.37 – 1.14 (m, 12H), 0.86 (t, *J* = 7.1 Hz, 9H), 0.52 – 0.42 (m, 6H).

^{13}C NMR (100 MHz, $CDCl_3$): δ 139.4, 129.5, 129.4, 128.3, 26.9, 26.1, 22.3, 13.9, 11.7.

EI-MS m/z (relative intensity): 324 (M^+, 2), 143 (100), 199 (54), 59 (46), 87(34), 101(31), 155 (19), 91 (15). The spectroscopic data were identical in all respects to those previously reported[3].



4b

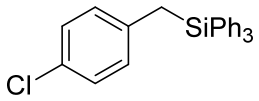
4b ([1,1'-biphenyl]-4-ylmethyl)tributylsilane:

Colorless oil. 50 mg, Yield: 68 %

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.62 (d, *J* = 8.2 Hz, 2H), 7.54 – 7.38 (m, 4H), 7.37 – 7.29 (m, 1H), 7.11 (d, *J* = 8.2 Hz, 1H), 2.17 (s, 2H), 1.37-0.94 (m, 12H), 0.92 (t, *J* = 7.0 Hz, 9H), 0.62 – 0.50 (m, 6H).

^{13}C NMR (100 MHz, $CDCl_3$): δ 141.4, 140.2, 136.8, 128.8, 128.6, 126.9, 126.9, 126.8, 26.9, 26.1, 22.5, 13.9, 11.9.

HRMS(EI) m/z calcd. for C25H38Si $[M]^+$ 366.2743, found 366.2738.



4c

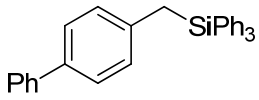
4c (4-chlorobenzyl)triphenylsilane:

White solid. m.p. 166-167 ^{o}C. 23 mg, Yield: 30 %

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.47 – 7.37 (m, 9H), 7.38 – 7.32 (m, 6H), 7.04 (d, *J* = 8.4 Hz, 2H), 6.76 (d, *J* = 8.4 Hz, 2H), 2.90 (s, 2H).

^{13}C NMR (100 MHz, $CDCl_3$): δ 137.0, 136.1, 133.9, 130.5, 130.3, 129.8, 128.2, 128.0, 23.1.

EI-MS m/z (relative intensity): 384 (M^+, 2), 259 (100), 181 (89), 260 (30), 53(30), 182(70), 84 (25), 183 (15). The spectroscopic data were identical in all respects to those previously reported[3].



4d

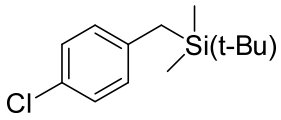
4d ([1,1'-biphenyl]-4-ylmethyl)triphenylsilane:

White solid. m.p. 146-148 ^{o}C . 70 mg, Yield: 82 %

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.56 (d, *J* = 8.0 Hz, 2H), 7.48 – 7.30 (m, 20H), 6.94 (d, *J* = 8.0 Hz, 2H), 2.99 (s, 2H).

^{13}C NMR (100 MHz, $CDCl_3$): δ 141.0, 137.5, 137.2, 136.0, 134.1, 129.6, 129.6, 128.6, 127.8, 126.8, 126.7, 126.6, 23.2.

HRMS(EI) m/z calcd. for C31H26Si $[M]^+$ 426.1804, found 426.1802.



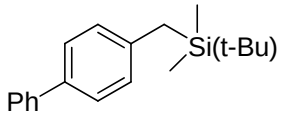
4e

4e tert-butyl(4-chlorobenzyl)dimethylsilane:

Colorless oil. 11 mg, Yield: 23 %

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.17 (d, *J* = 8.4 Hz, 2H), 6.93 (d, *J* = 8.4 Hz, 2H), 2.06 (s, 2H), 0.90 (s, 9H), -0.12 (s, 6H).

EI-MS m/z (relative intensity): 240(M^+,15), 73(100), 115 (87), 87 (26), 59(22), 183(21), 105 (19), 155 (18).The spectroscopic data were identical in all respects to those previously reported[3].



4f

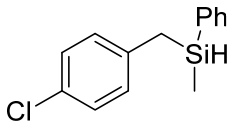
4f ([1,1'-biphenyl]-4-ylmethyl)(tert-butyl)dimethylsilane:

Colorless oil. 23 mg, Yield: 40 %

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.60 (d, *J* = 8.0 Hz, 2H), 7.51 – 7.37 (m, 4H), 7.36 – 7.27 (m, 1H), 7.10 (d, *J* = 8.0 Hz, 2H), 2.15 (s, 2H), 0.95 (s, 9H), -0.05 (s, 6H).

^{13}C NMR (100 MHz, $CDCl_3$): δ 141.3, 140.1, 136.8, 128.8, 128.6, 127.0, 126.9, 126.9, 26.7, 22.4, 16.9, -6.4.

HRMS(EI) m/z calcd. for C19H26Si $[M]^+$ 282.1804, found 282.1809.



4g

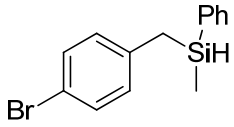
4g (4-chlorobenzyl)(methyl)(phenyl)silane:

Colorless oil. 31 mg, Yield: 63 %

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.49 – 7.42 (m, 2H), 7.40-7.33 (m, , 3H), 7.16 (d, *J* = 8.0 Hz, 2H), 6.91 (d, *J* = 8.0 Hz, 2H), 4.43 (q, *J* = 3.7 Hz, 1H), 2.45 – 2.22 (m, 2H), 0.31 (d, *J* = 3.7Hz, 3H).

^{13}C NMR (100 MHz, $CDCl_3$): δ 137.9, 135.1, 134.5, 130.2, 129.7, 129.7, 128.5, 128.1, 23.2, -6.1.

HRMS(EI) m/z calcd. for C14H15ClSi $[M]^+$ 246.0632, found 246.0629.



4h

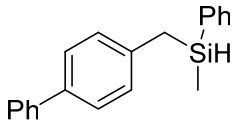
4h (4-bromobenzyl)(methyl)(phenyl)silane:

Colorless oil. 30 mg, Yield: 51 %

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.46 (d, *J* = 8.5 Hz, 2H), 7.43 – 7.28 (m, 5H), 6.87 (d, *J* = 8.5 Hz, 2H), 4.44 (q, *J* = 3.5 Hz, 1H), 2.46 – 2.21 (m, 2H), 0.32 (d, *J* = 3.5 Hz, 3H).

^{13}C NMR (100 MHz, $CDCl_3$): δ 138.4, 135.1, 134.5, 131.4, 130.2, 129.8, 128.1, 118.1, 23.3, -6.1.

HRMS(EI) m/z calcd. for C14H15BrSi $[M]^+$ 290.0126, found 290.0136.



4i

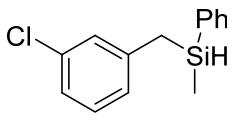
4i ([1,1'-biphenyl]-4-ylmethyl)(methyl)(phenyl)silane:

White solid. m.p. 42-44 ^oC . 43 mg, Yield: 75 %

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.61 (d, *J* = 7.8 Hz, 2H), 7.53 (d, *J* = 7.6 Hz, 2H), 7.54-7.32 (m, 8H), 7.11 (d, *J* = 7.8 Hz, 2H), 4.51 (q, *J* = 3.7 Hz, 1H), 2.57 – 2.35 (m, 2H), 0.38 (d, *J* = 3.7 Hz, 3H).

^{13}C NMR (100 MHz, $CDCl_3$): δ 141.2, 138.6, 137.4, 135.6, 134.6, 129.6, 128.9, 128.8, 128.0, 127.1, 127.0, 126.9, 23.4, -6.0.

HRMS(EI) m/z calcd. for C20H20Si $[M]^+$ 288.1334, found 288.1337.

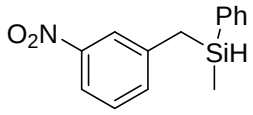


4j

4j (3-chlorobenzyl)(methyl)(phenyl)silane:

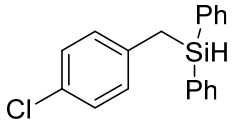
Colorless oil. 31 mg, Yield: 63 %

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.46 (d, *J* = 7.8 Hz, 2H), 7.43 – 7.30 (m, 3H), 7.16 – 7.03 (m, 2H), 7.00 (s, 1H), 6.89 – 6.82 (m, 1H), 4.44 (q, *J* = 6.4, 5.0 Hz, 1H), 2.44 – 2.22 (m, 2H), 0.35 – 0.29 (m, 3H).
^{13}C NMR (100 MHz, $CDCl_3$): δ 141.6, 135.0, 134.5, 134.1, 129.8, 129.6, 128.4, 128.1, 126.6, 124.7, 23.7, -6.1.
HRMS(EI) m/z calcd. for C14H15ClSi $[M]^+$ 246.0632, found 246.0639.



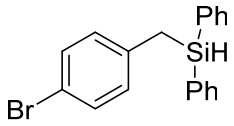
4k

4k methyl(3-nitrobenzyl)(phenyl)silane:
Colorless oil. 30 mg, Yield: 58 %
^{1}H NMR (400 MHz, $CDCl_3$): δ 7.93 (d, *J* = 8.2 Hz, 1H), 7.84 (s, 1H), 7.47 – 7.30 (m, 5H), 7.29 – 7.23 (m, 2H), 4.47 (q, *J* = 3.7 Hz, 1H), 2.56 – 2.39 (m, 2H), 0.35 (d, *J* = 3.7 Hz, 3H).
^{13}C NMR (100 MHz, $CDCl_3$): δ 148.2, 141.6, 134.4, 134.3, 134.1, 129.9, 129.0, 128.0, 122.8, 119.6, 23.9, -6.3.
HRMS(EI) m/z calcd. for C14H15NO2Si $[M]^+$ 257.0872, found 257.0876.



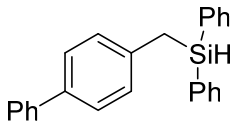
4l

4l (4-chlorobenzyl)diphenylsilane:
White solid. m.p. 80-82 ^{o}C . 27 mg, Yield: 44 %
^{1}H NMR (400 MHz, $CDCl_3$): δ 7.54 – 7.48 (m, 4H), 7.46 – 7.33 (m, 6H), 7.14 (d, *J* = 8.4 Hz, 2H), 6.92 (d, *J* = 8.4 Hz, 2H), 4.94 (t, *J* = 3.7 Hz, 1H), 2.67 (d, *J* = 3.7 Hz, 2H).
^{13}C NMR (100 MHz, $CDCl_3$): δ 142.9, 137.3, 135.3, 133.2, 130.4, 130.0, 128.5, 128.2, 22.0.
HRMS(EI) m/z calcd. for C19H17ClSi $[M]^+$ 308.0788, found 308.0787.



4m

4m (4-bromobenzyl)diphenylsilane:
White solid. m.p. 85-87 ^{o}C . 36 mg, Yield: 51 %
^{1}H NMR (400 MHz, $CDCl_3$): δ 7.51 – 7.44 (m, 4H)., 7.44 – 7.29 (m, 6H), 7.25 (d, *J* = 8.1 Hz, 2H), 6.84 (d, *J* = 8.1 Hz, 2H), 4.91 (t, *J* = 3.5 Hz, 1H), 2.62 (d, *J* = 3.5 Hz, 2H).
^{13}C NMR (100 MHz, $CDCl_3$): δ 137.8, 135.3, 133.2, 131.4, 130.5, 130.0, 128.2, 118.3, 22.1.
HRMS(EI) m/z calcd. for C19H17BrSi $[M]^+$ 352.0283, found 352.0293.



4n

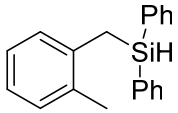
4n ([1,1'-biphenyl]-4-ylmethyl)diphenylsilane:

White solid. m.p. 110-111 ^{o}C . 27 mg, Yield: 39 %

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.63 – 7.52 (m, 6H), 7.50 – 7.30 (m, 11H),δ 7.11 (d, *J* = 8.2 Hz, 1H)., 5.03 (t, *J* = 3.8 Hz, 1H), 2.77 (d, *J* = 3.8 Hz, 2H).

^{13}C NMR (100 MHz, $CDCl_3$): δ 141.0, 138.2, 137.7, 135.3, 131.7, 129.8, 128.7, 128.7, 128.0, 127.2, 126.9, 126.8, 19.8.

HRMS(EI) m/z calcd. for C25H22Si $[M]^+$ 350.1491, found 350.1490.



4o

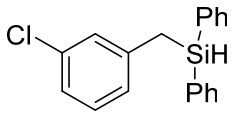
4o (2-methylbenzyl)diphenylsilane:

Colorless oil. 35 mg, Yield: 62 %

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.54 – 7.44 (m, 4H), 7.45 – 7.30 (m, 6H), 7.11 – 6.85 (m, 4H), 4.91 (t, *J* = 3.7 Hz, 1H), 2.66 (d, *J* = 3.7 Hz, 2H), 2.13 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$): δ 140.1, 137.1, 135.4, 133.8, 130.2, 129.9, 129.3, 128.1, 125.9, 124.9, 20.3, 19.9.

HRMS(EI) m/z calcd. for C20H20Si $[M]^+$ 288.1334, found 288.1342.



4p

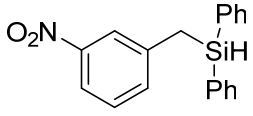
4p (3-chlorobenzyl)diphenylsilane:

Colorless oil. 33 mg, Yield: 54 %

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.55 – 7.47 (m, 4H), 7.46 – 7.33 (m, 6H), 7.11 – 7.03 (m, 2H), 7.00 (s, 1H), 6.90 – 6.82 (m, 1H), 4.96 (t, *J* = 3.5 Hz, 1H), 2.67 (d, *J* = 3.5 Hz, 2H).

^{13}C NMR (100 MHz, $CDCl_3$): δ 140.9, 135.3, 134.1, 133.1, 130.1, 129.5, 128.8, 128.2, 126.9, 124.9, 22.4.

HRMS(EI) m/z calcd. for C19H17ClSi $[M]^+$ 308.0788, found 308.0790.



4q

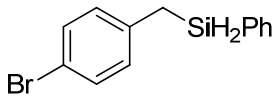
4q (3-nitrobenzyl)diphenylsilane:

Colorless oil. 20 mg, Yield: 31 %

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.96 – 7.87 (m, 1H), 7.83 (s, 1H), 7.54 – 7.27 (m, 12H), 4.95 (s, 1H), 2.78 (s, 2H).

^{13}C NMR (100 MHz, $CDCl_3$): δ 148.3, 141.2, 135.3, 134.8, 132.4, 130.3, 129.1, 128.3, 123.4, 119.9, 22.8.

HRMS(EI) m/z calcd. for C19H17NO2Si $[M]^+$ 319.1029, found 319.1037.



4r

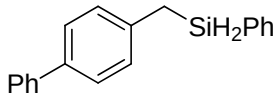
4r (4-bromobenzyl)(phenyl)silane:

Colorless oil. 13 mg, Yield: 24 %

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.47 (d, *J* = 8.4 Hz, 2H), 7.43 – 7.28 (m, 5H), 6.94 (d, *J* = 8.4 Hz, 2H), 4.39 (t, *J* = 3.3 Hz, 2H), 2.42 (t, *J* = 3.3 Hz, 2H).

^{13}C NMR (100 MHz, $CDCl_3$): δ 140.1, 138.2, 135.4, 131.6, 130.2, 130.1, 128.2, 118.5, 19.9.

HRMS(EI) m/z calcd. for C13H13BrSi $[M]^+$ 275.9970, found 275.9976.



4s

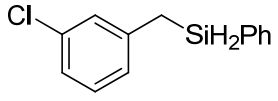
4s ([1,1'-biphenyl]-4-ylmethyl)(phenyl)silane:

Colorless oil. 13 mg, Yield: 24 %

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.63 – 7.56 (m, 2H), δ 7.56 – 7.51 (m, 2H), δ 7.48 (d, *J* = 8.2 Hz, 2H)., 7.46 – 7.39 (m, 3H), 7.39 – 7.29 (m, 3H), 7.17 (d, *J* = 8.2 Hz, 2H), 4.46 (t, *J* = 3.9 Hz, 2H), 2.53 (t, *J* = 3.9 Hz, 2H).

^{13}C NMR (100 MHz, $CDCl_3$): δ 141.2, 138.4, 137.8, 135.4, 131.8, 130.0, 128.9, 128.8, 128.2, 127.3, 127.1, 127.0, 19.9.

HRMS(EI) m/z calcd. for C19H18Si $[M]^+$ 274.1178, found 274.1182.



4t

4t (3-chlorobenzyl)(phenyl)silane:

Colorless oil. 12 mg, Yield: 26 %

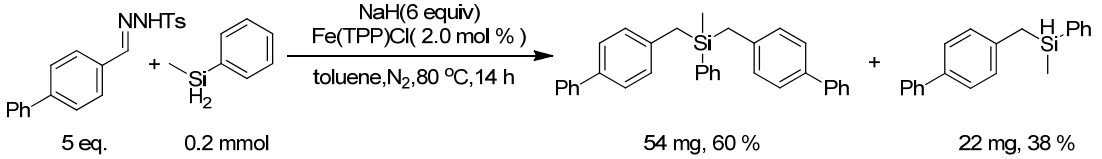
^{1}H NMR (400 MHz, $CDCl_3$): δ 7.53 – 7.45 (m, 2H), 7.44 – 7.32 (m, 3H), 7.22 – 7.08 (m, 2H), 7.07 (s, 1H), 6.94 (d, *J* = 7.0 Hz, 1H), 4.41 (t, *J* = 4.0 Hz, 2H), 2.44 (t, *J* = 4.0 Hz, 2H).

^{13}C NMR (100 MHz, $CDCl_3$): δ 141.3, 135.7, 135.4, 134.3, 130.1, 129.8, 128.4, 128.2, 126.6, 125.1, 20.2.

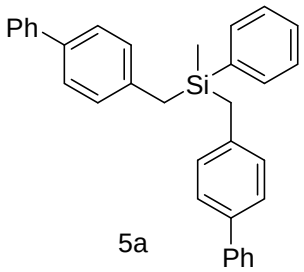
HRMS(EI) m/z calcd. for C13H13ClSi $[M]^+$ 232.0475, found 232.0472.

Fe(TPP)Cl catalyzed double Si-H insertion reaction:

a) One-pot double insertion of secondary Si-H bonds



To a flame-dried sealed tube were added *N*-tosylhydrazone (1 mmol, 5 equiv), NaH (48.mg, 60 wt%, 1.2 mmol, 6 equiv) , Fe(TPP)Cl (2.86 mg, 4 μmol, 0.02 equiv) and dry Toluene (2.0 mL, 0.1 M) inside a glove box. Then, methylphenylsilane (24.5 mg, 0.2 mmol, 1.0 equiv) was added and the tube was sealed and heated at 80 °C for additional 14 h. The reaction was monitored by TLC. When the reaction was completed, the crude reaction mixture was allowed to reach room temperature, and filtered through a short pad of silica gel with EtOAc as an eluent. The filtrate was evaporated under reduced pressure to leave a crude mixture, which was purified by column chromatography on silica gel (eluting with petroleum ether) to afford product.



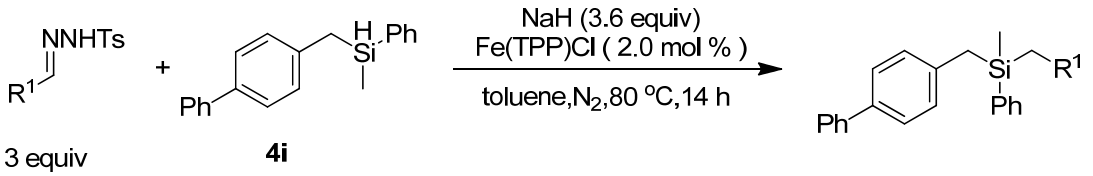
5a bis([1,1'-biphenyl]-4-ylmethyl)(methyl)(phenyl)silane. : Colorless oil. 54 mg, Yield: 60 %

^{1}H NMR (400 MHz, $CDCl_3$) : δ 7.64 (d, *J* = 7.3 Hz, 4H), 7.48 (q, *J* = 7.3 Hz, 10H), 7.39 (dt, *J* = 15.0, 7.3 Hz, 5H), δ 2.57 – 2.43 (m, 4H)., 0.33 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) : δ 141.2 , 138.4 , 137.2 , 136.5 , 134.4 , 129.5 , 129.1 , 128.8 , 127.9, 126.9 , 126.9 , 23.9 , -5.6 .

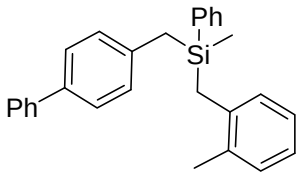
HRMS (ESI) m/z calcd. for C33H34NSi $[M+NH_4]^+$ 472.2461, found 472.2455.

b) Second step insertion of **4i**:



To a flame-dried sealed tube were added *N*-tosylhydrazone (0.6 mmol, 3 equiv), NaH (28.8 mg, 60 wt%, 0.69 mmol, 3.6 equiv) , Fe(TPP)Cl (2.86 mg, 4. μmol, 0.02 equiv), **4i** ([1,1'-biphenyl]-4-ylmethyl)(methyl)(phenyl)silane (57.7 mg, 0.2 mmol, 1.0 equiv) and dry toluene (2.0 mL, 0.1 M) under Ar atmosphere. Then the tube was sealed and heated at 80 °C for additional

14 h. The reaction was monitored by TLC. When the reaction was completed, the crude reaction mixture was purified by column chromatography on silica gel (eluting with petroleum ether) to afford product.



5b

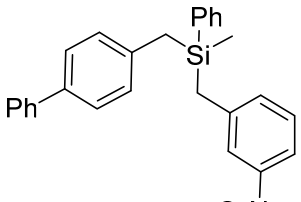
5b ([1,1'-biphenyl]-4-ylmethyl)(methyl)(2-methylbenzyl)(phenyl)silane:

Colorless oil. 39 mg, Yield: 50 %

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.60 (d, *J* = 7.5 Hz, 2H), 7.48 – 7.40 (m, 7H), 7.40 – 7.30 (m, 3H), 7.13 – 6.97 (m, 5H), 6.93 (dd, *J* = 6.9, 2.0 Hz, 1H), 2.55 – 2.38 (m, 4H), 2.04 (s, 3H), 0.24 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$): δ 141.1, 138.3, 137.6, 137.1, 136.8, 135.1, 134.1, 130.2, 129.3, 128.9, 128.9, 128.7, 127.7, 126.8, 126.8, 125.7, 124.5, 24.0, 21.1, 20.2, -5.7.

HRMS(EI) m/z calcd. for C28H28Si $[M]^+$ 392.1960, found 392.1957.



5c

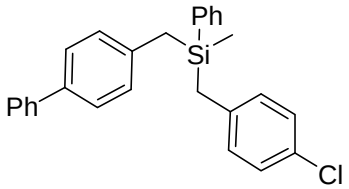
5c ([1,1'-biphenyl]-4-ylmethyl)(methyl)(3-nitrobenzyl)(phenyl)silane:

Colorless oil. 76 mg, Yield: 90 %

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.93 – 7.85 (m, 1H), 7.70 (s, 1H), 7.60 – 7.53 (m, 2H), 7.47 – 7.19 (m, 11H), 7.10 (d, *J* = 7.7 Hz, 1H), 6.99 (d, *J* = 8.2 Hz, 2H), 2.53 – 2.35 (m, 4H), 0.26 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$): δ148.2, 141.6, 141.0, 137.7, 137.6, 135.2, 134.6, 134.2, 129.9, 129.0, 129.0, 128.8, 128.1, 127.1, 127.1, 126.9, 123.1, 119.6, 24.6, 23.7, -5.8.

HRMS(ESI) m/z calcd. for C27H29N2O2Si $[M+NH_4]^+$ 441.1998, found 441.1991.



5d

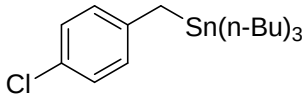
5d ([1,1'-biphenyl]-4-ylmethyl)(4-chlorobenzyl)(methyl)(phenyl)silane:

White solid. m.p.54-56 ^{o}C . 53 mg, Yield: 64 %

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.60 (d, *J* = 8.0 Hz, 2H), 7.49 – 7.29 (m, 10H), 7.14 (d, *J* = 8.4 Hz, 2H), 7.00 (d, *J* = 8.0 Hz, 2H), 6.82 (d, *J* = 8.4 Hz, 2H), 2.49 – 2.29 (m, 4H), 0.25 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$): δ 141.1, 138.2, 137.7, 137.3, 136.0, 134.3, 130.0, 129.8, 129.6, 129.0, 128.8, 128.3, 127.9, 127.0, 126.9, 23.8, 23.7, -5.8.

HRMS(EI) m/z calcd. for C27H25ClSi $[M]^+$ 412.1414, found 412.1408.



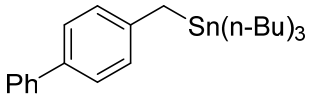
7a

7a tributyl(4-chlorobenzyl)stannane :

Colorless oil. 65 mg, Yield: 85 %

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.12 (d, *J* = 8.4 Hz, 2H), 6.90 (d, *J* = 8.4 Hz, 2H), 2.26 (t, J_{Sn-H} = 56 Hz, 2H), 1.47 – 1.34 (m, 6H), 1.31 – 1.20 (m, 6H), 0.87 (t, *J* = 7.3 Hz, 9H), 0.80 (t, *J* = 8.0 Hz, 6H).

EI-MS m/z (relative intensity): 414(M+,1), 177(100), 179 (97), 235 (70), 175(67), 291(55), 233 (55), 289 (44).The spectroscopic data were identical in all respects to those previously reported[3].



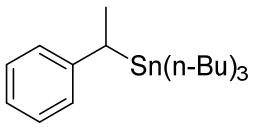
7b

7b ([1,1'-biphenyl]-4-ylmethyl)tributylstannane:

Colorless oil. 62 mg, Yield: 80 %

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.58 (d, *J* = 8.3 Hz, 2H), 7.45 – 7.39 (m, 4H), 7.33 – 7.26 (m, 1H), 7.06 (d, *J* = 8.3 Hz, 2H), 2.35(t, J_{Sn-H} = 28 Hz, 2H), 1.52 – 1.37 (m, 6H), 1.36 – 1.19 (m, 6H), 0.92 – 0.80 (m, 15H).

EI-MS m/z (relative intensity): 457(M^+,1), 167(100), 179 (66), 177 (60), 291(60), 235(59), 289 (55), 287 (46).The spectroscopic data were identical in all respects to those previously reported[3].



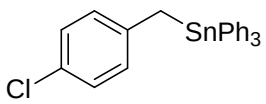
7c

7c tributyl(1-phenylethyl)stannane:

Colorless oil. 24 mg, Yield: 30 %

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.21 (t, *J* = 7.2 Hz, 2H), 7.04 (d, *J* = 7.2 Hz, 2H), 7.00 (t, *J* = 7.2 Hz, 1H), 2.71 (q, *J* = 7.8 Hz,1H), 1.58 (d, *J* = 7. 8Hz, 3H), 1.45 – 1.32 (m, 6H), 1.32 – 1.17 (m, 6H), 0.86 (t, *J* = 7.8 Hz,9H), 0.82 – 0.74 (m, 6H).

EI-MS m/z (relative intensity): 474(M^+,2), 351(100), 197 (46), 125 (26), 89(22), 350(42), 195 (35), 89 (11).The spectroscopic data were identical in all respects to those previously reported[3].



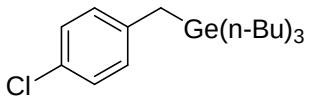
7d

7d (4-chlorobenzyl)triphenylstannane:

Colorless oil. 68 mg, Yield: 72 %

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.47 – 7.32 (m, 15H), 7.11 (d, *J* = 8.4 Hz, 2H), 6.97 (d, *J* = 8.4 Hz, 2H), 2.95 (t, J_{Sn-H} = 66 Hz, 2H).

EI-MS m/z (relative intensity): 396(M^+,1), 179(100), 177 (92), 105 (64), 175(61), 235(57), 291 (44), 233 (43).The spectroscopic data were identical in all respects to those previously reported[3].



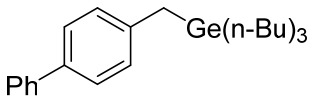
7e

7e tributyl(4-chlorobenzyl)germane:

Colorless oil. 73 mg, Yield: 99 %

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.15 (d, *J* = 8.4 Hz, 2H), 6.91 (d, *J* = 8.4 Hz, 2H), 2.17 (s, 2H), 1.32 – 1.24 (m, 12H), 0.87 (t, *J* = 6.9 Hz, 9H), 0.74 – 0.62 (m, 6H).

EI-MS m/z (relative intensity): 370(M^+,1), 189(100), 133 (74), 89 (28), 55(26), 245(36), 187 (75), 89 (38). The spectroscopic data were identical in all respects to those previously reported[3].



7f

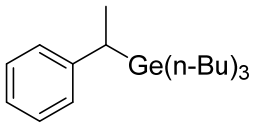
7f ([1,1'-biphenyl]-4-ylmethyl)tributylgermane:

Colorless oil. 73 mg, Yield: 89 %

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.64 (d, *J* = 8.1 Hz, 2H), 7.54 – 7.42 (m, 4H), 7.39 – 7.31 (m, 1H), 7.13 (d, *J* = 8.1 Hz, 2H), 2.32 (s, 2H), 1.43 – 1.29 (m, 12H), 0.94 (t, *J* = 6.9 Hz, 9H), 0.83 – 0.75 (m, 6H).

^{13}C NMR (100 MHz, $CDCl_3$): δ 141.4, 141.2, 136.6, 128.8, 128.3, 126.9, 126.9, 126.8, 27.4, 26.7, 22.02, 13.9, 12.4.

HRMS(EI) m/z calcd. for C25H38^{70}Ge $[M]^+$ 408.2216, found 408.2211.



7g

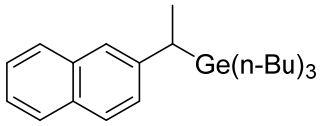
7g tributyl(1-phenylethyl)germane:

Colorless oil. 31 mg, Yield: 44 %

^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.24 – 7.20 (m, 2H), 7.09 – 7.01 (m, 3H), 2.49 (q, *J* = 7.5 Hz, 1H), 1.42 (d, *J* = 7.5 Hz, 3H), 1.33 – 1.16 (m, 10H), 0.85 (t, *J* = 6.8 Hz, 9H), 0.72 – 0.62 (m, 6H).

^{13}C NMR (101 MHz, Chloroform-*d*) δ 147.2 , 128.1 , 126.6 , 124.1 , 28.6 , 27.5 , 26.9 , 16.2 , 13.9 , 11.3 .

HRMS(EI) m/z calcd. for C20H36^{70}Ge $[M]^+$ 346.2060, found 346.2057,.



7h

7h tributyl(1-(naphthalen-2-yl)ethyl)germane:

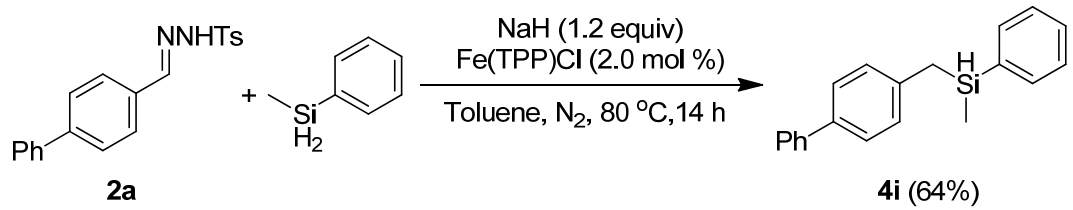
Colorless oil. 35 mg, Yield: 44 %

^{1}H NMR (400 MHz, $CDCl_3$) : δ 7.79 – 7.66 (m, 3H), 7.46 (s, 1H), 7.41 (t, *J* = 7.4 Hz, 1H), 7.35 (t, *J* = 7.4 Hz, 1H), 7.26 – 7.18 (m, 1H), 2.67 (q, *J* = 7.5 Hz, 1H), 1.52 (d, *J* = 7.5 Hz, 3H), 1.31 – 1.19 (m, 12H), 0.88 – 0.78 (m, 9H), 0.76 – 0.62 (m, 6H).

^{13}C NMR (100 MHz, $CDCl_3$) : δ 145.0 , 133.9 , 131.3 , 127.6 , 127.4 , 127.3 , 126.8 , 125.8 , 124.4 , 123.6 , 28.9 , 27.5 , 26.8 , 16.3 , 13.9 , 11.4 .

HRMS(EI) m/z calcd. for C24H38^{70}Ge $[M]^+$ 396.2216, found 396.2206,.

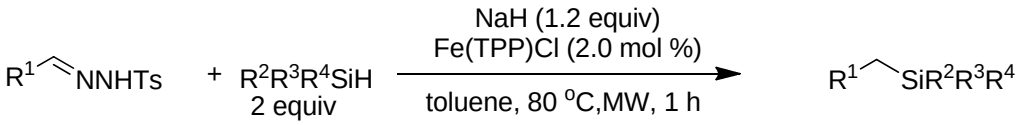
Fe(TPP)Cl catalyzed gram scale reaction:



2a **4i** (64%)

To a flame-dried sealed tube were added **2a** (1.0 g, 2.85 mmol, 1.0 equiv), NaH (137 mg, 60 wt%, 3.42 mmol, 1.2 equiv), Fe(TPP)Cl (40 mg, 0.02 equiv), methylphenylsilane (697mg, 5.71 mmol, 2.0 equiv) and dry Toluene (30 mL) under Ar atmosphere. Then the tube was sealed and heated at 80 °C for additional 14 h. The reaction was monitored by TLC. When the reaction was completed, the crude reaction mixture was purified by column chromatography on silica gel (eluting with petroleum ether) to afford product **4i** (444 mg, 64%)

Fe(TPP)Cl catalyzed Si-H insertion under microwave irradiation:



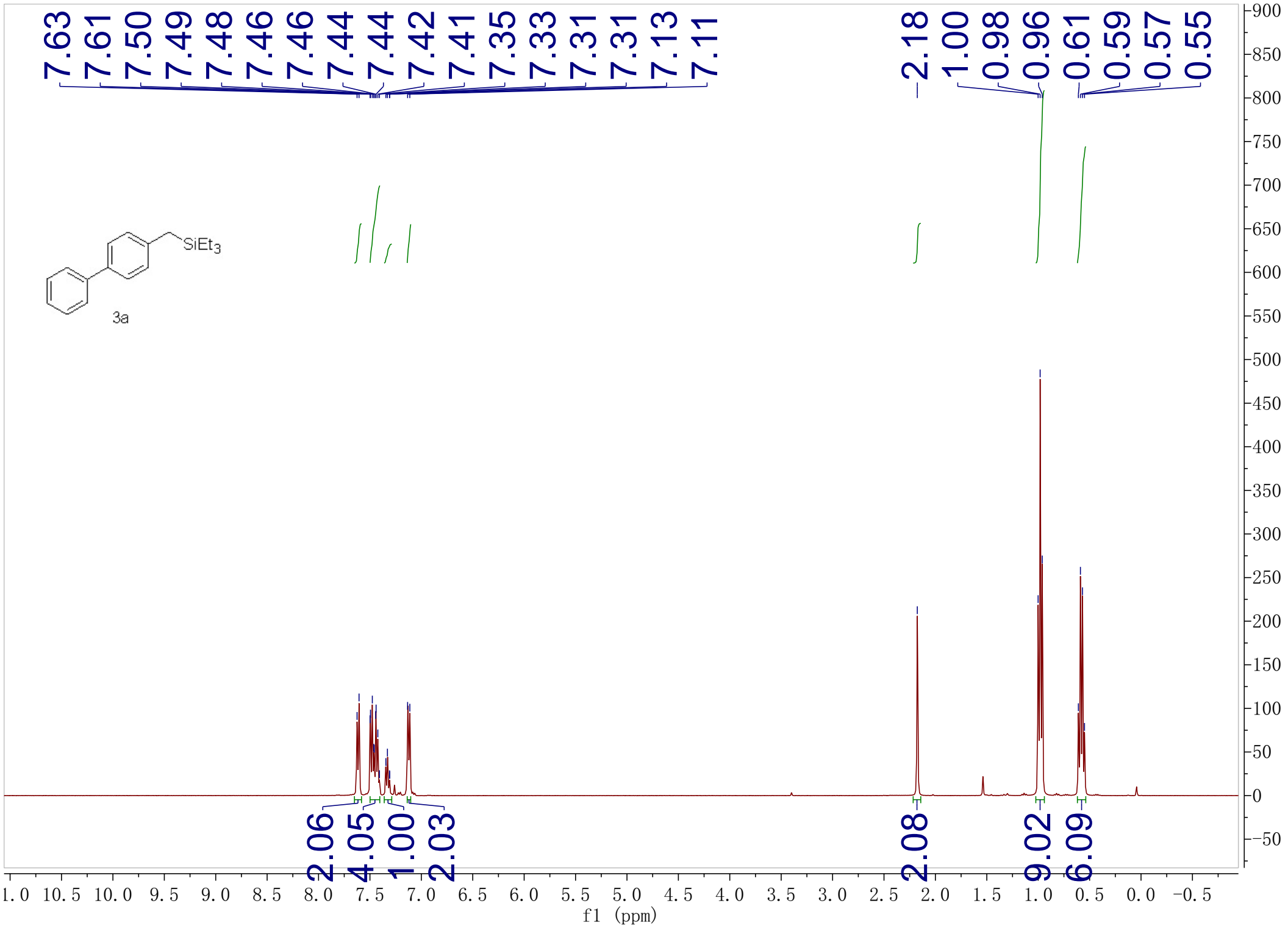
To a tube equipped with rubber stopper were added *N*-tosylhydrazone (0.2 mmol, 1.0 equiv), NaH (9.6 mg, 60 wt%, 0.24 mmol, 1.2 equiv), Fe(TPP)Cl (2.86 mg, 4.0 μmol, 0.02 equiv), silane (0.4 mmol, 2.0 equiv) and toluene (2.0 mL, 0.1 M) under air atmosphere. Then the tube was sealed and placed in Discover SP microwave synthesizer and reacted at 80 °C for 1 h. After completion the reaction was allowed to cool to room temperature and the crude reaction mixture was purified by column chromatography on silica gel (eluting with petroleum ether) to afford the insertion product.

4. References and Notes

[1] Creary, X.; Tam, W. W.; Albizati, K. F.; Stevens, R. V. *Org. Synth.* **1986**, *64*, 207.

[2] (a) Adler, A. D.; Longo, F. R.; Finarelli, J. D.; Goldmacher, J.; Assour, J.; Korsakoff, L. *J. Org. Chem.* **1967**, *32*, 476. (b) Fleischer, E. B.; Palmer, J. M.; Srivastava, T. S.; Chatterjee, A. *J. Am. Chem. Soc.* **1971**, *93*, 3162

[3] Liu, Z.; Li, Q.; Yang, Y.; Bi, X. *Chem. Commun.* **2017**, *53*, 2503.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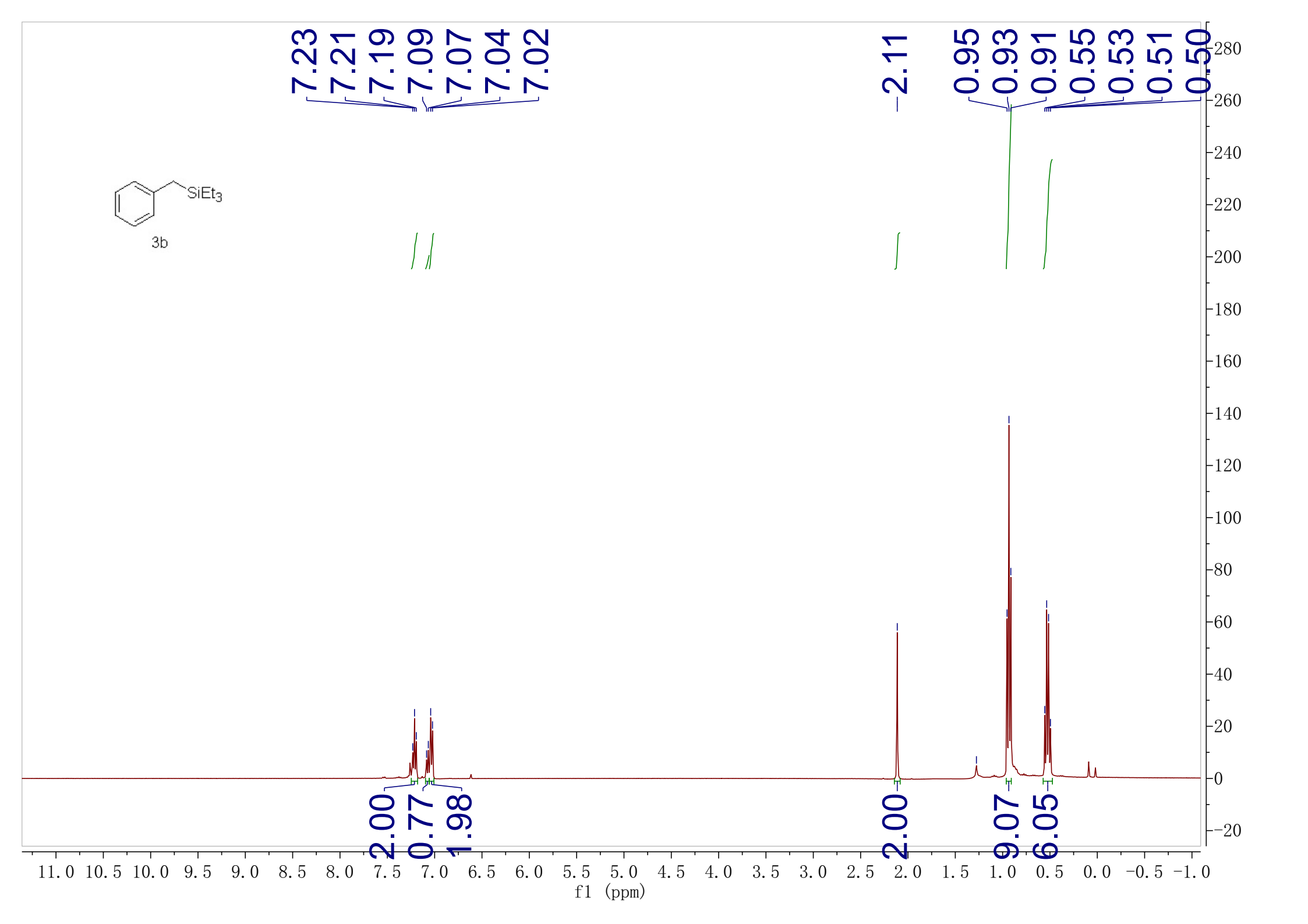
7.61
7.50
7.49
7.48
7.46
7.46
7.44
7.44
7.42
7.41
7.35
7.33
7.31
7.31
7.13
7.11
2.18
1.00
0.98
0.96
0.61
0.59
0.57
0.55
SiEt3
3a
2.06
4.05
1.00
2.03
2.08
9.02
6.09
f1 (ppm)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7.07
7.04
7.02
2.11
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0.93
0.91
0.55
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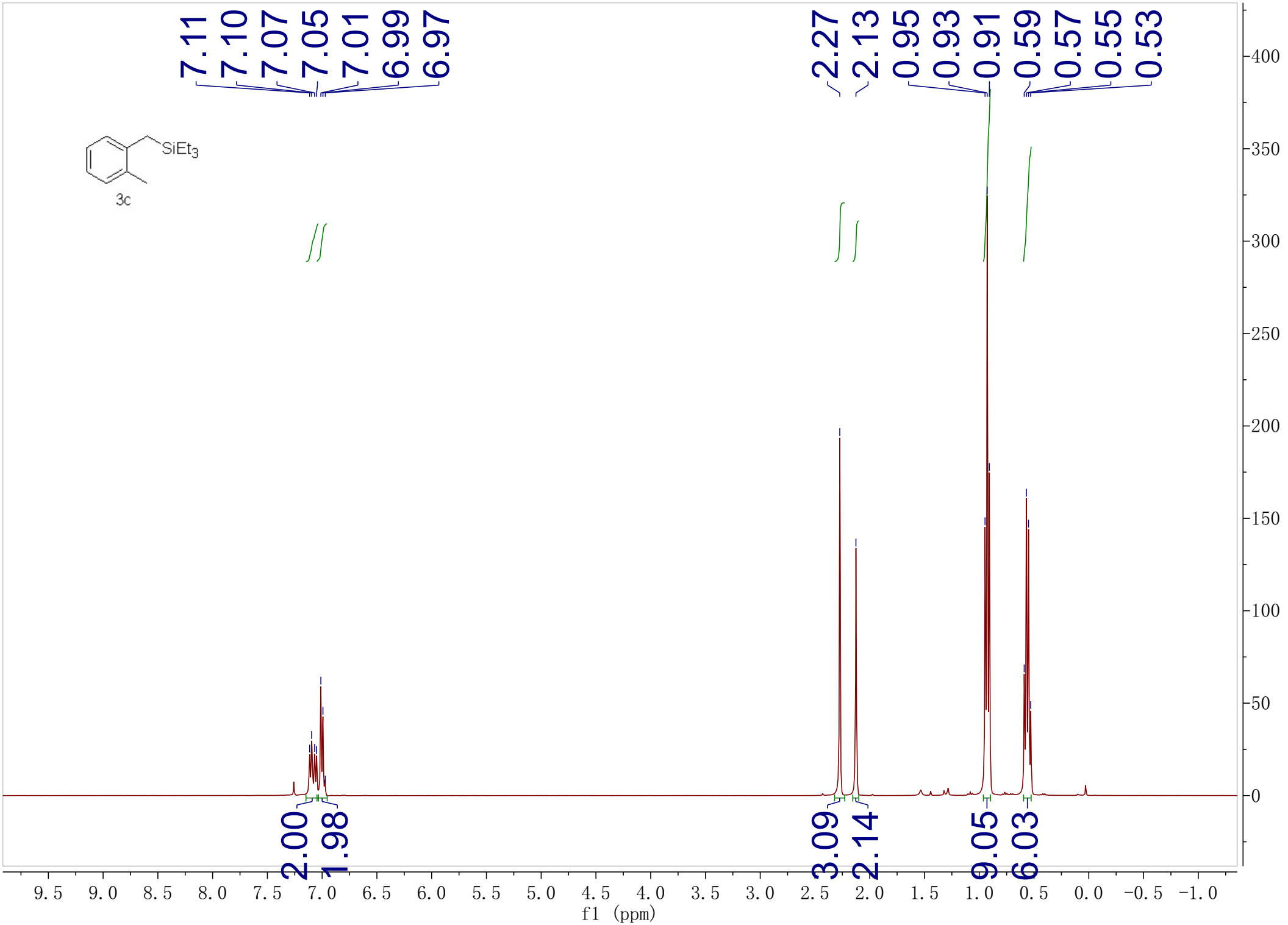
0.51
0.50
SiEt3
3b
2.00
0.77
1.98
2.00
9.07
6.05
f1 (ppm)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0.91
0.59
0.57
0.55
0.53
SiEt3
3c
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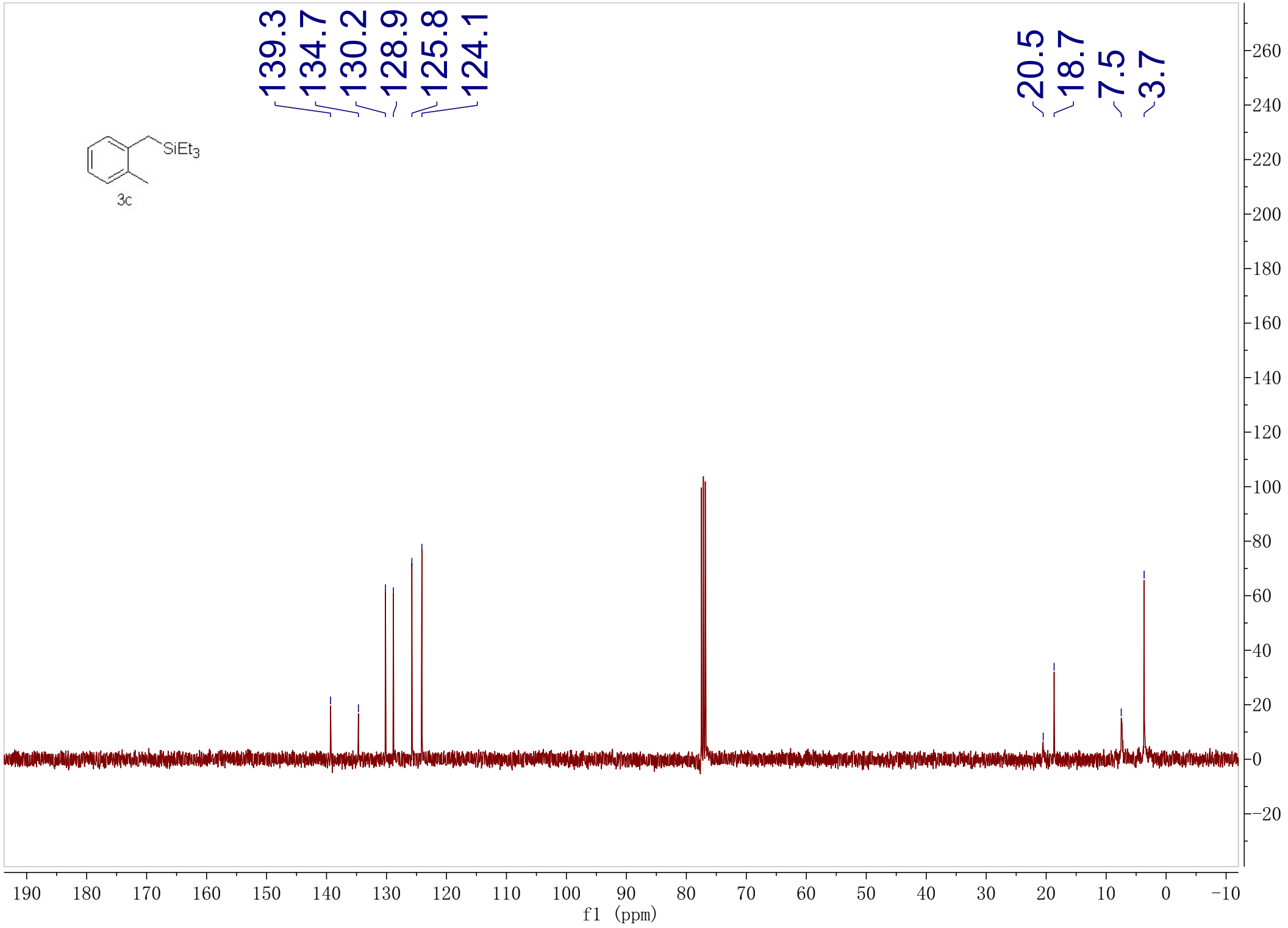
3.09
2.14
9.05
6.03
f1 (ppm)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134.7
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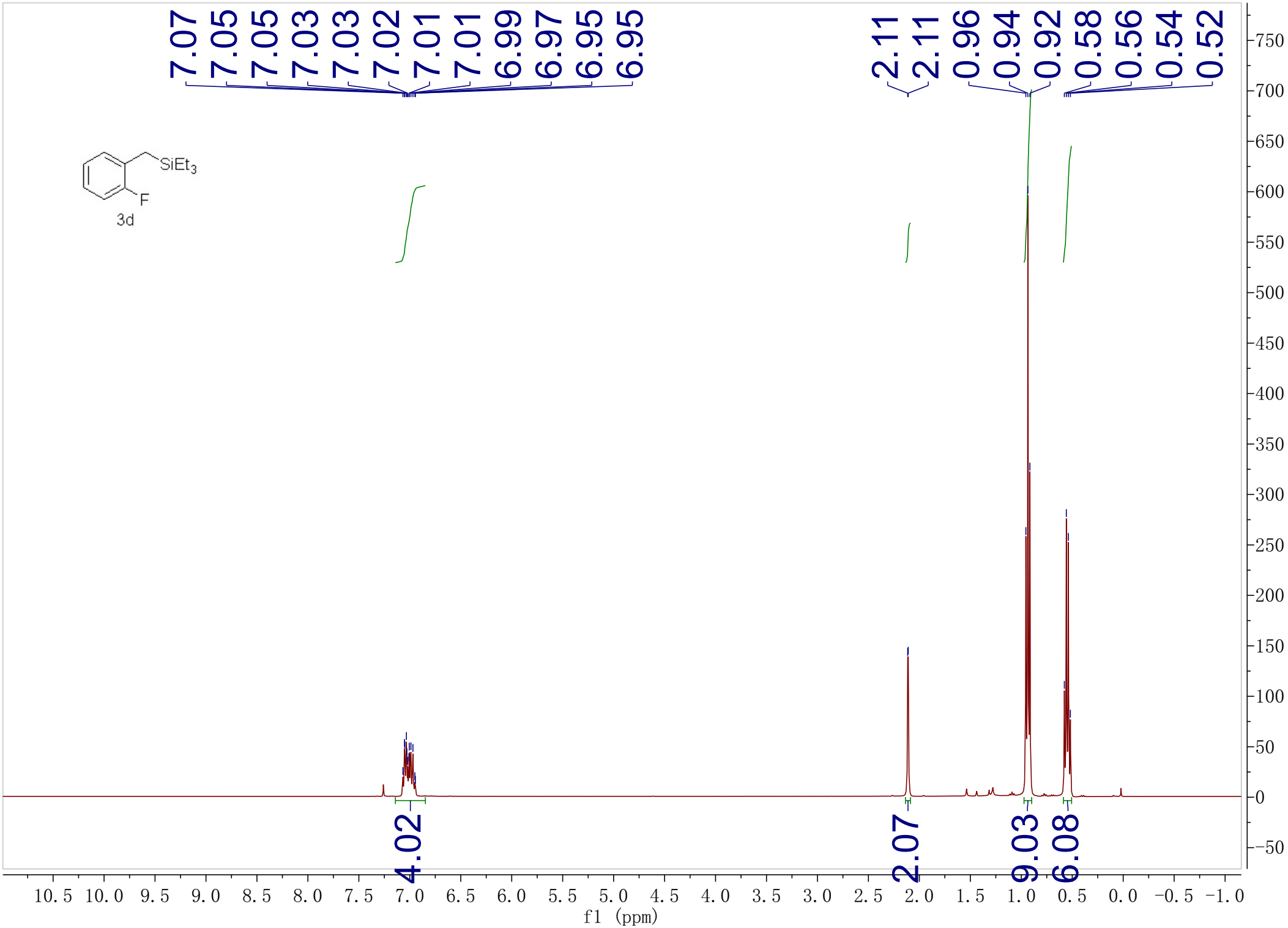
20.5
18.7
7.5
3.7
SiEt3
3c
f1 (ppm)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7.05
7.05
7.03
7.03
7.02
7.01
7.01
6.99
6.97
6.95
6.95
2.11
2.11
0.96
0.94
0.92
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0.54
0.52
SiEt3
F
3d
4.02
2.07
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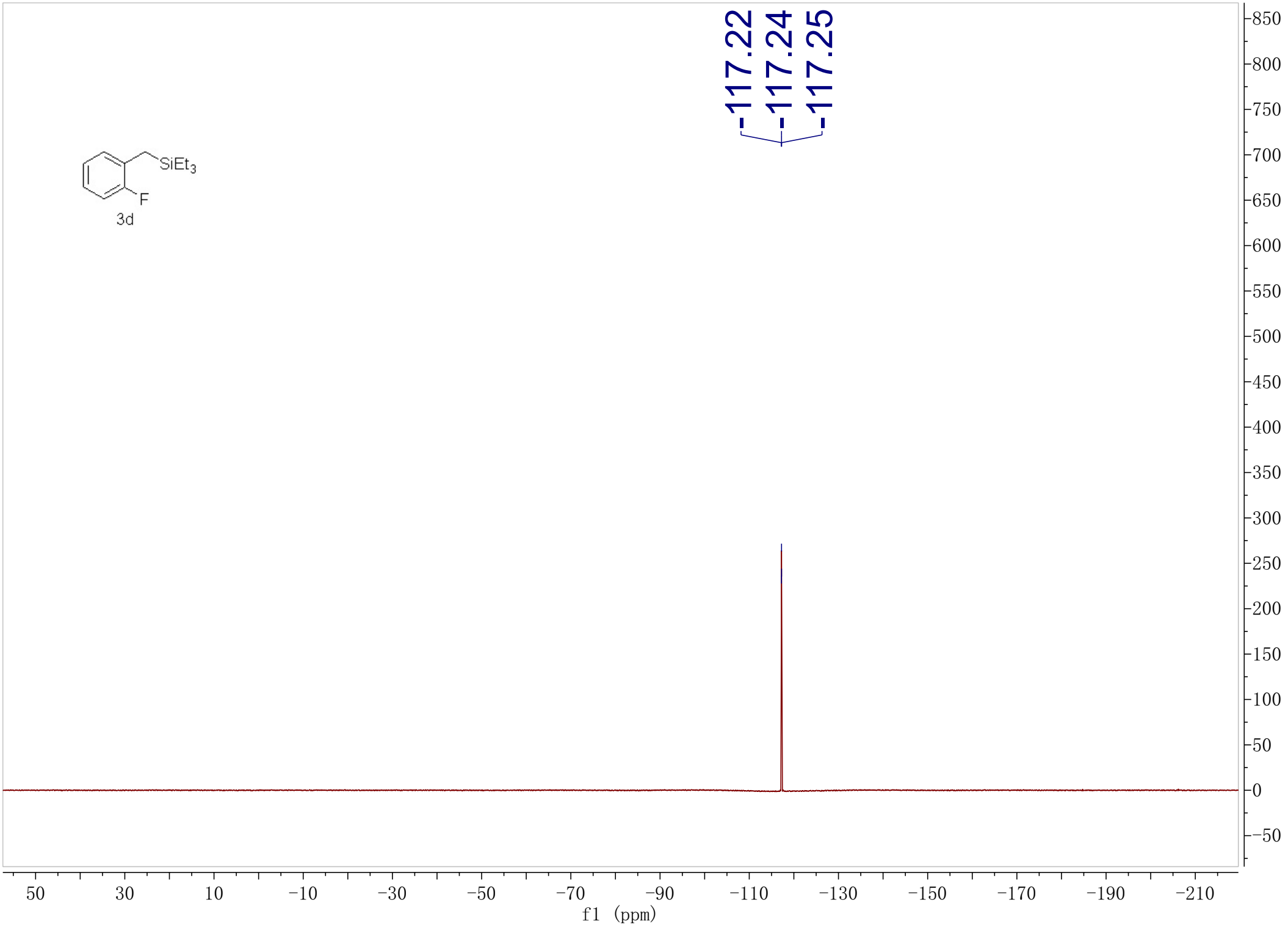
6.08
f1 (ppm)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SiEt3
F
3d
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800
750
700
650
600
550
500
450
400
350
300
250
200
150
100
50
0
-50
50
30
10
-10
-30
-50
-70
-90
-110
-130
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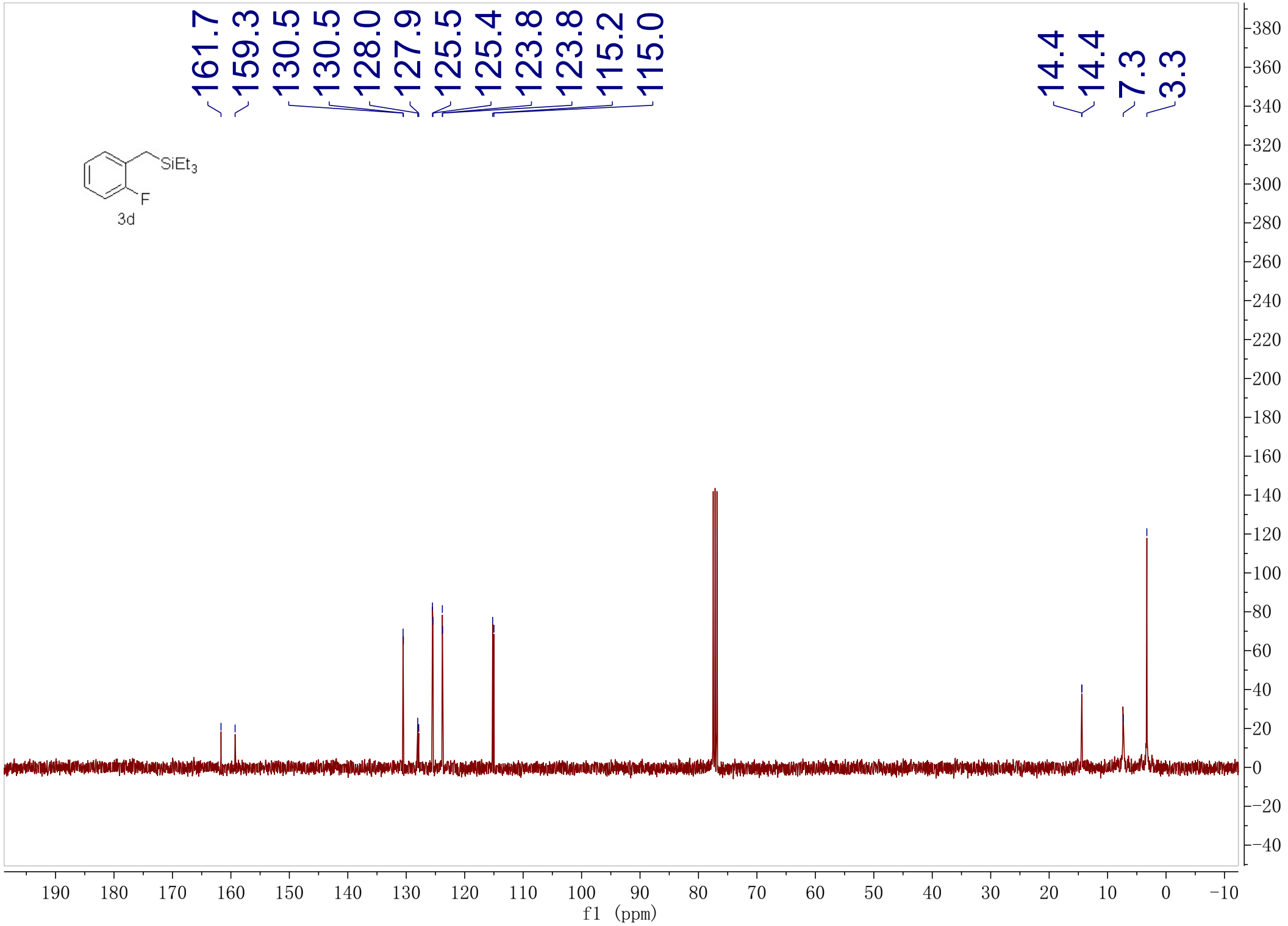
f1 (ppm)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159.3
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130.5
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125.4
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115.0
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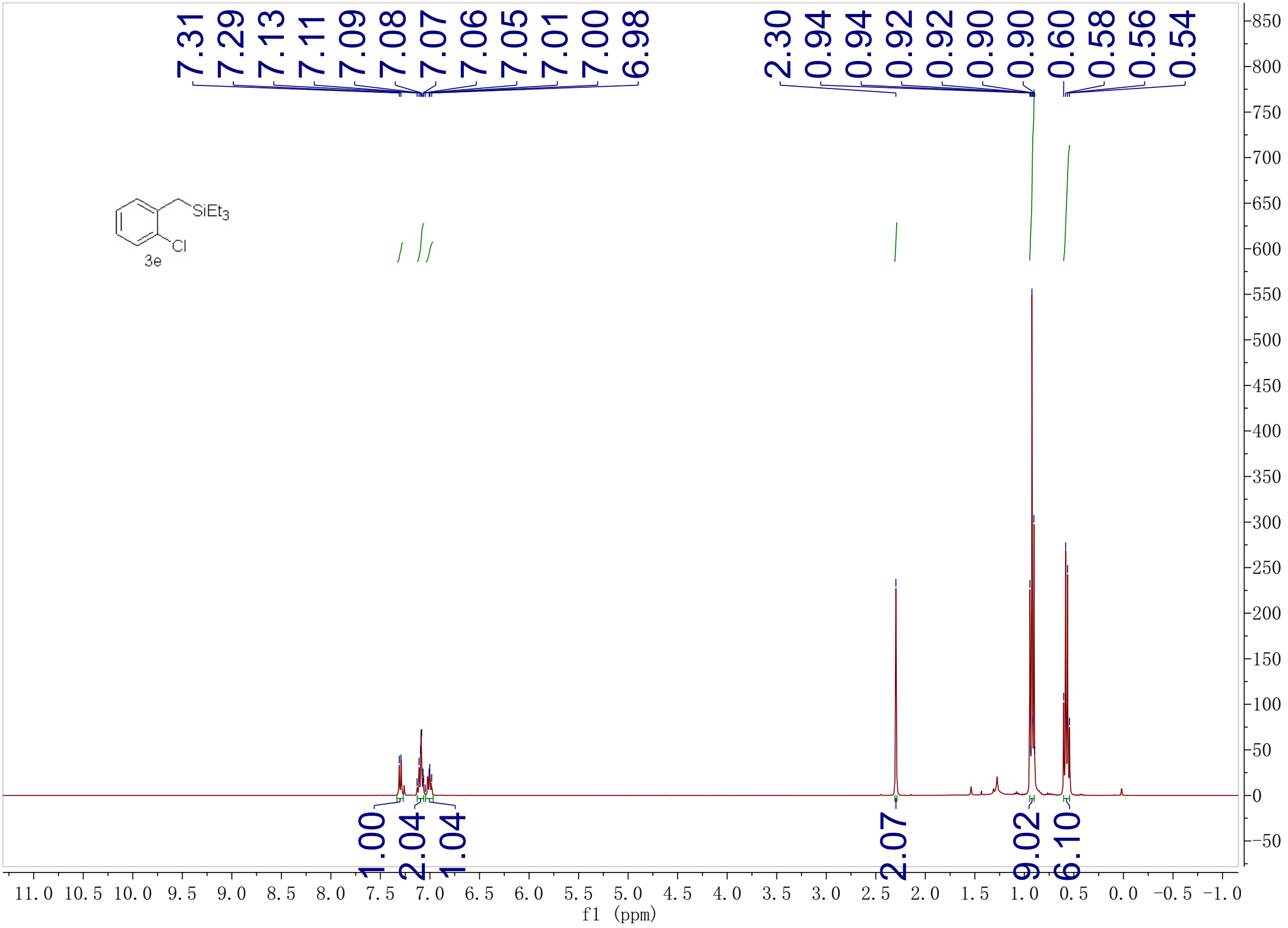
7.3
3.3
SiEt3
F
3d
f1 (ppm)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7.29
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7.11
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7.07
7.06
7.05
7.01
7.00
6.98
2.30
0.94
0.94
0.92
0.92
0.90
0.90
0.60
0.58
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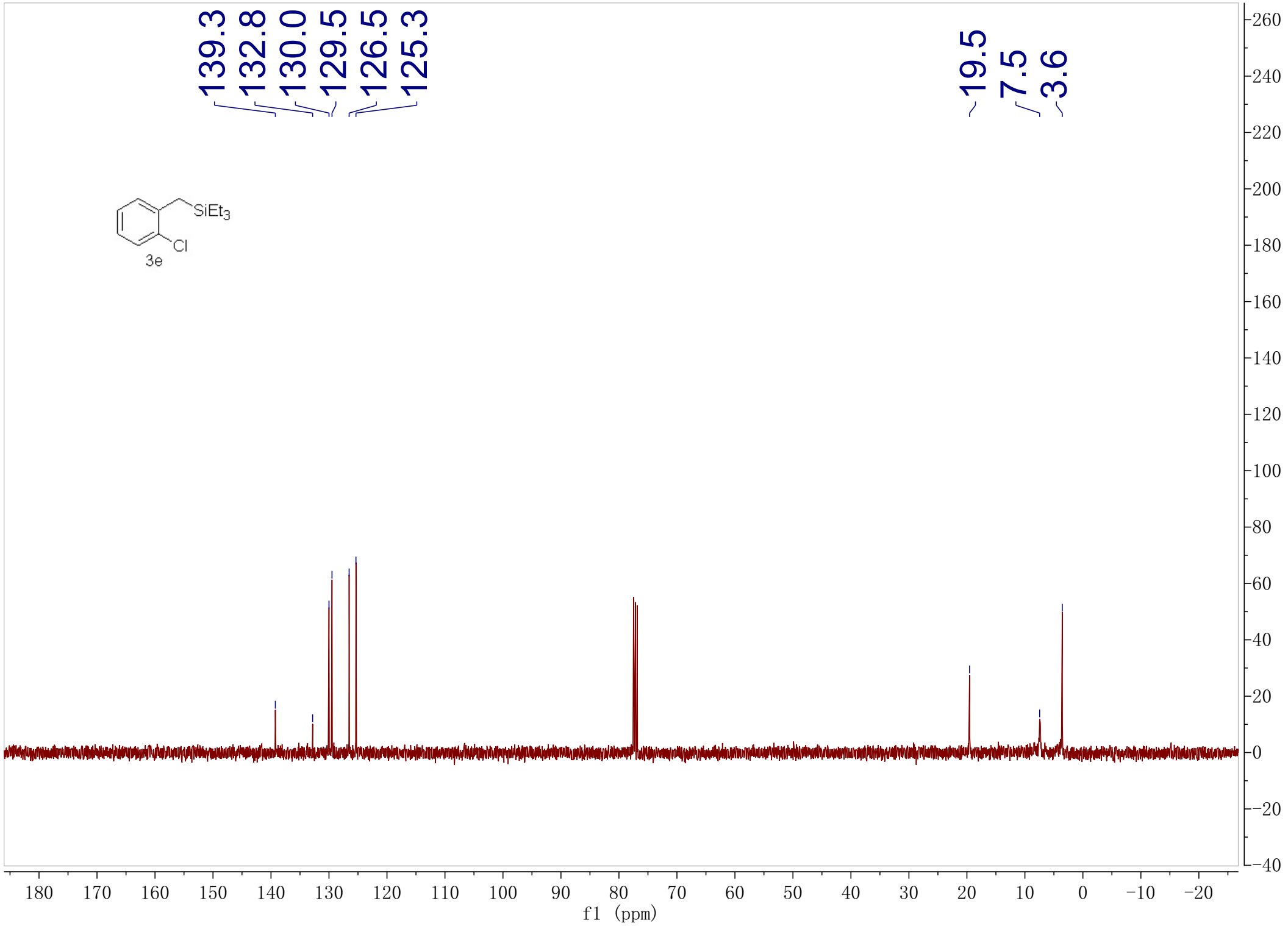
SiEt3
Cl
3e
1.00
2.04
1.04
2.07
9.02
6.10
f1 (ppm)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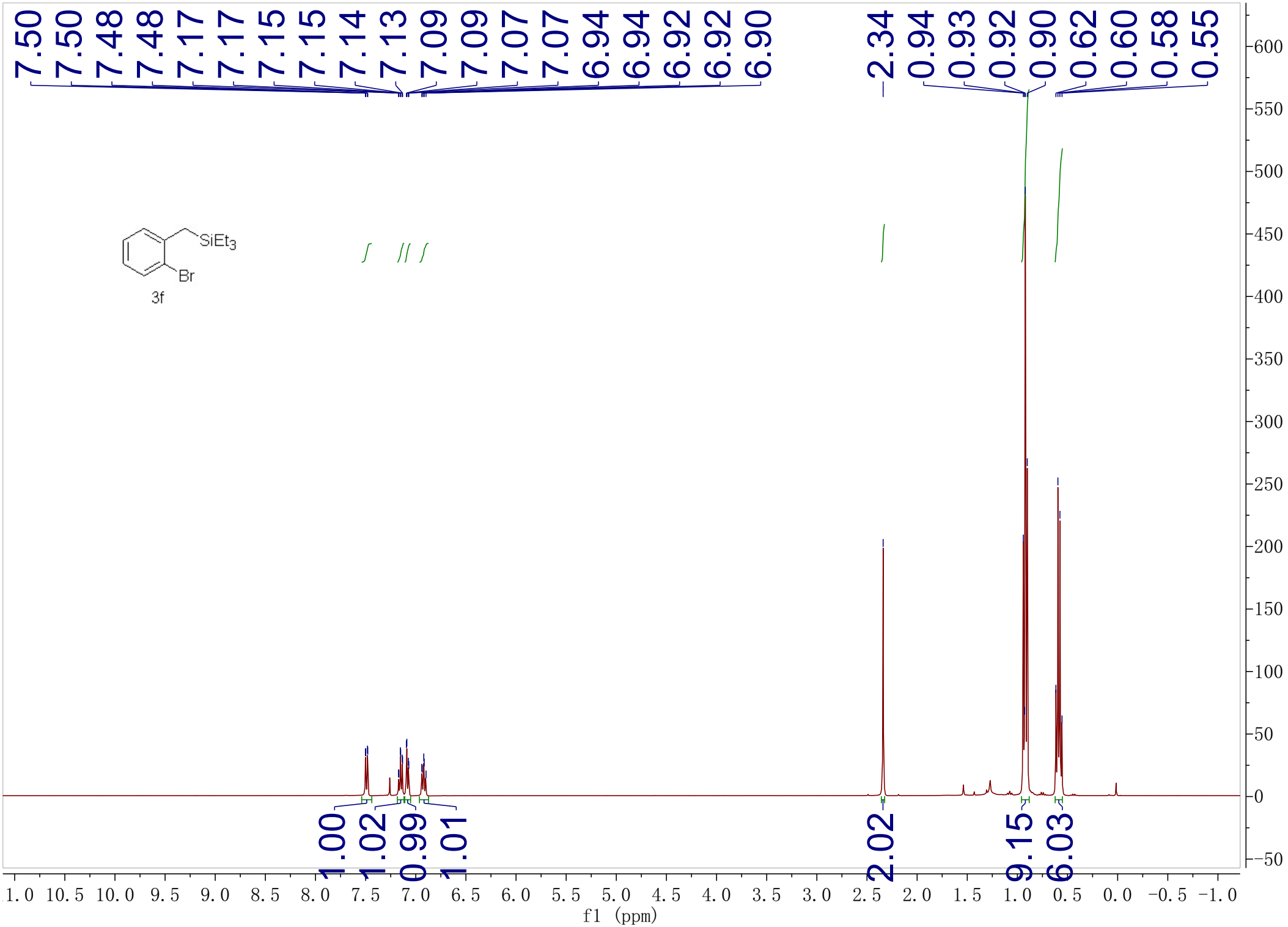
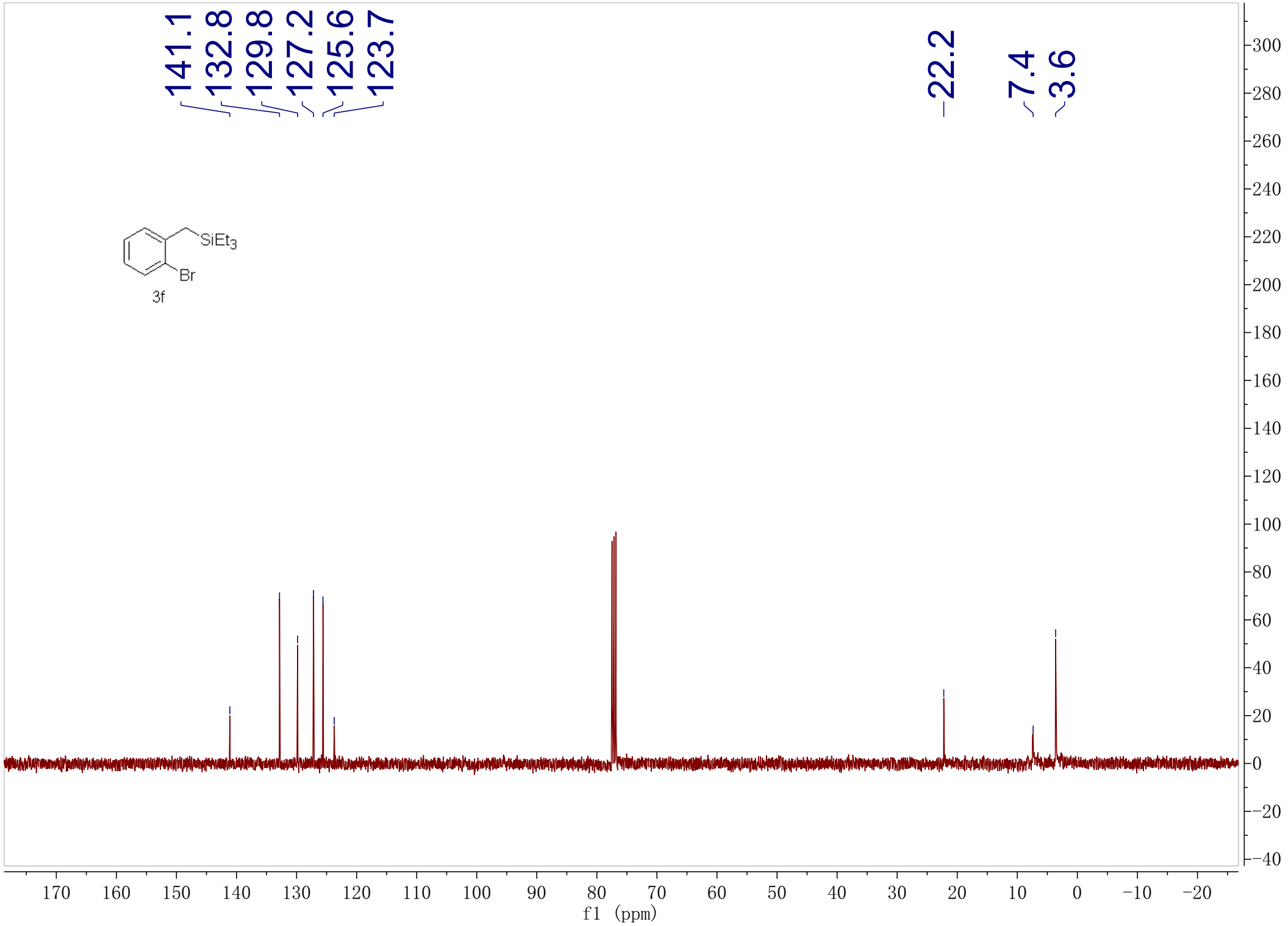
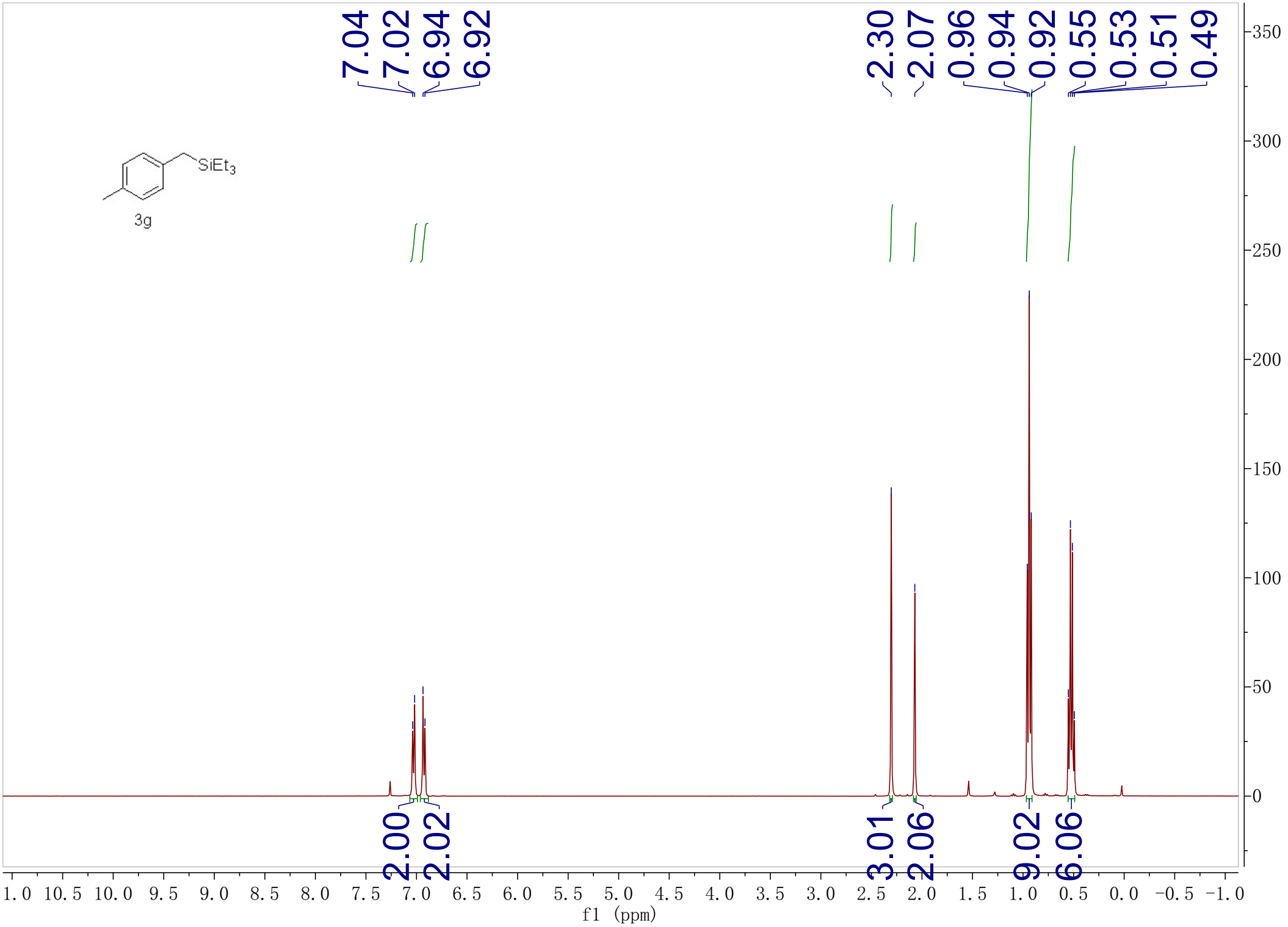
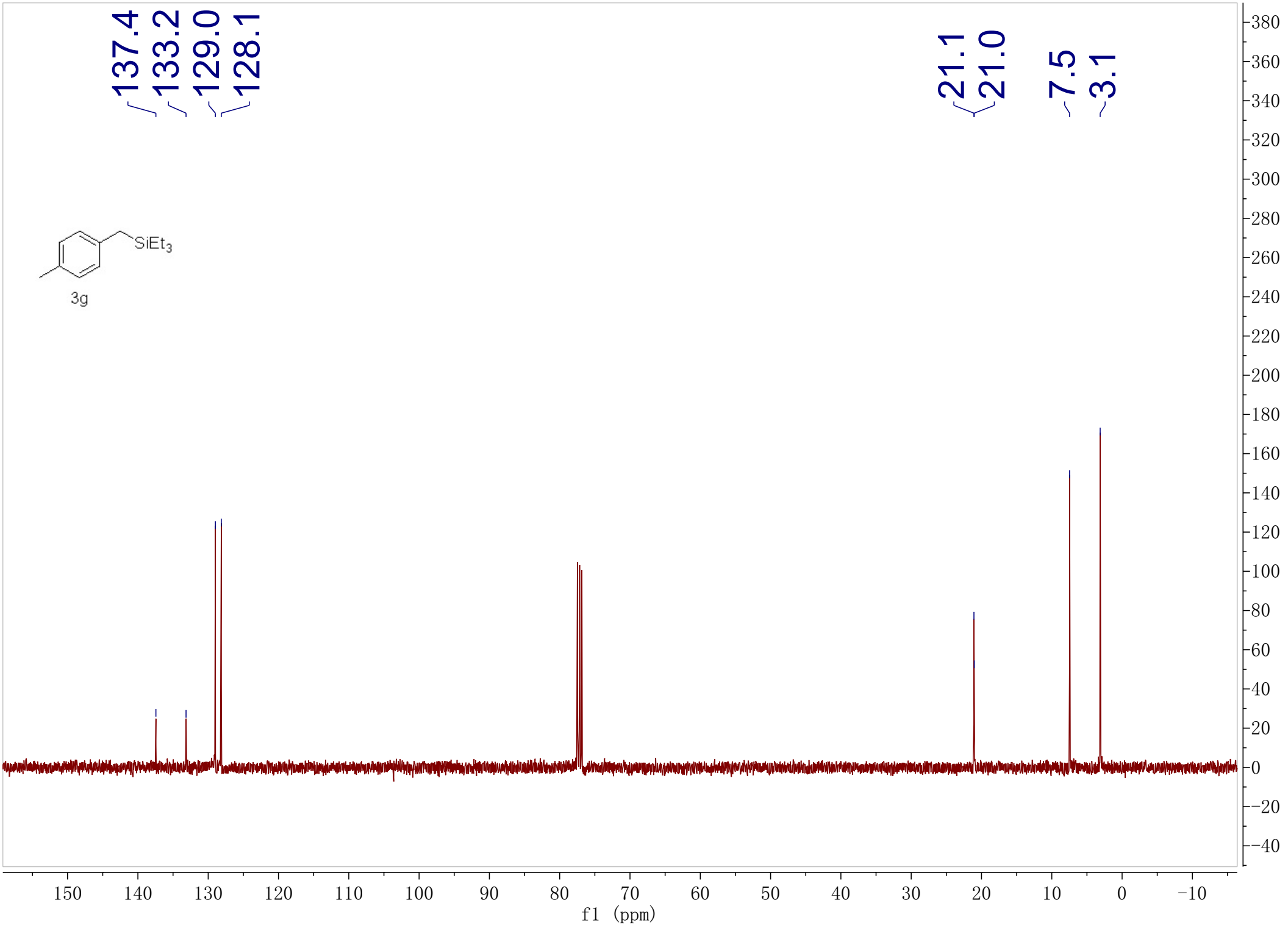
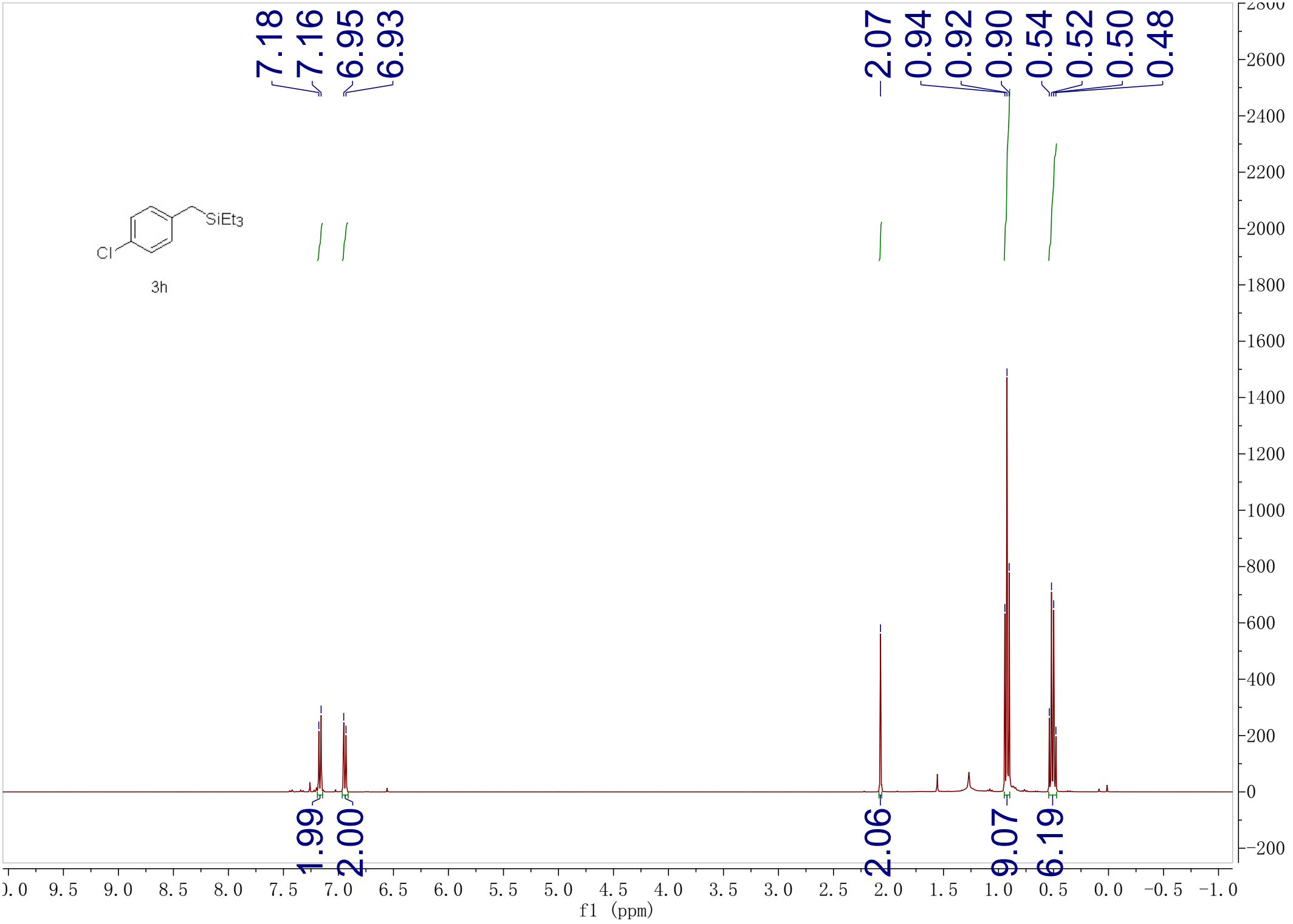
132.8
130.0
129.5
126.5
125.3
19.5
7.5
3.6
SiEt3
Cl
3e
260
240
220
200
180
160
140
120
100
80
60
40
20
0
−20
−40
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
−20
f1 (ppm)

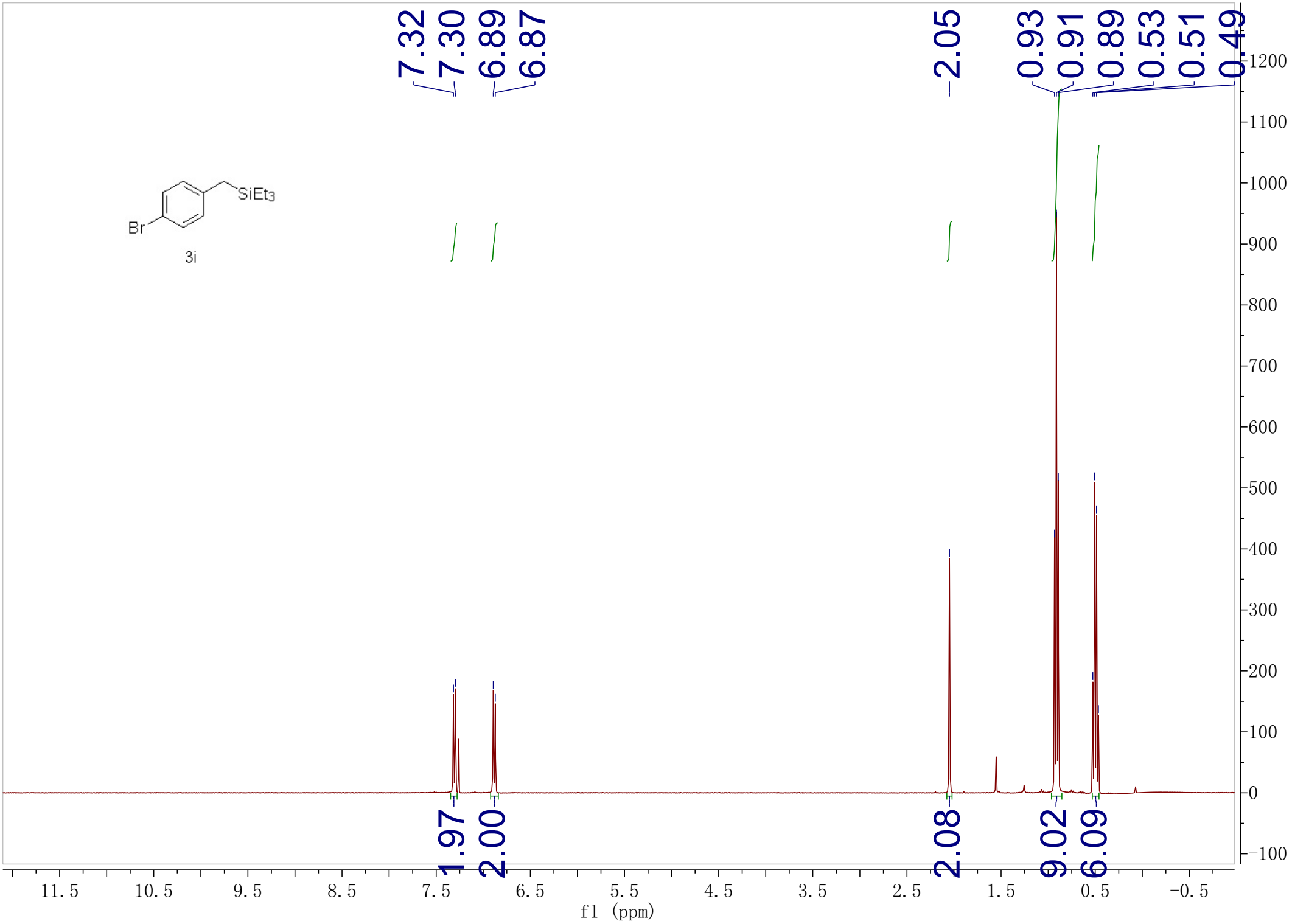

7.50
7.50
7.48
7.48
7.17
7.17
7.15
7.15
7.14
7.13
7.09
7.09
7.07
7.07
6.94
6.94
6.92
6.92
6.90
2.34
0.94
0.93
0.92
0.90
0.62
0.60
0.58
0.55
SiEt3
Br
3f
1.00
1.02
0.99
1.01
2.02
9.15
6.03
f1 (ppm)

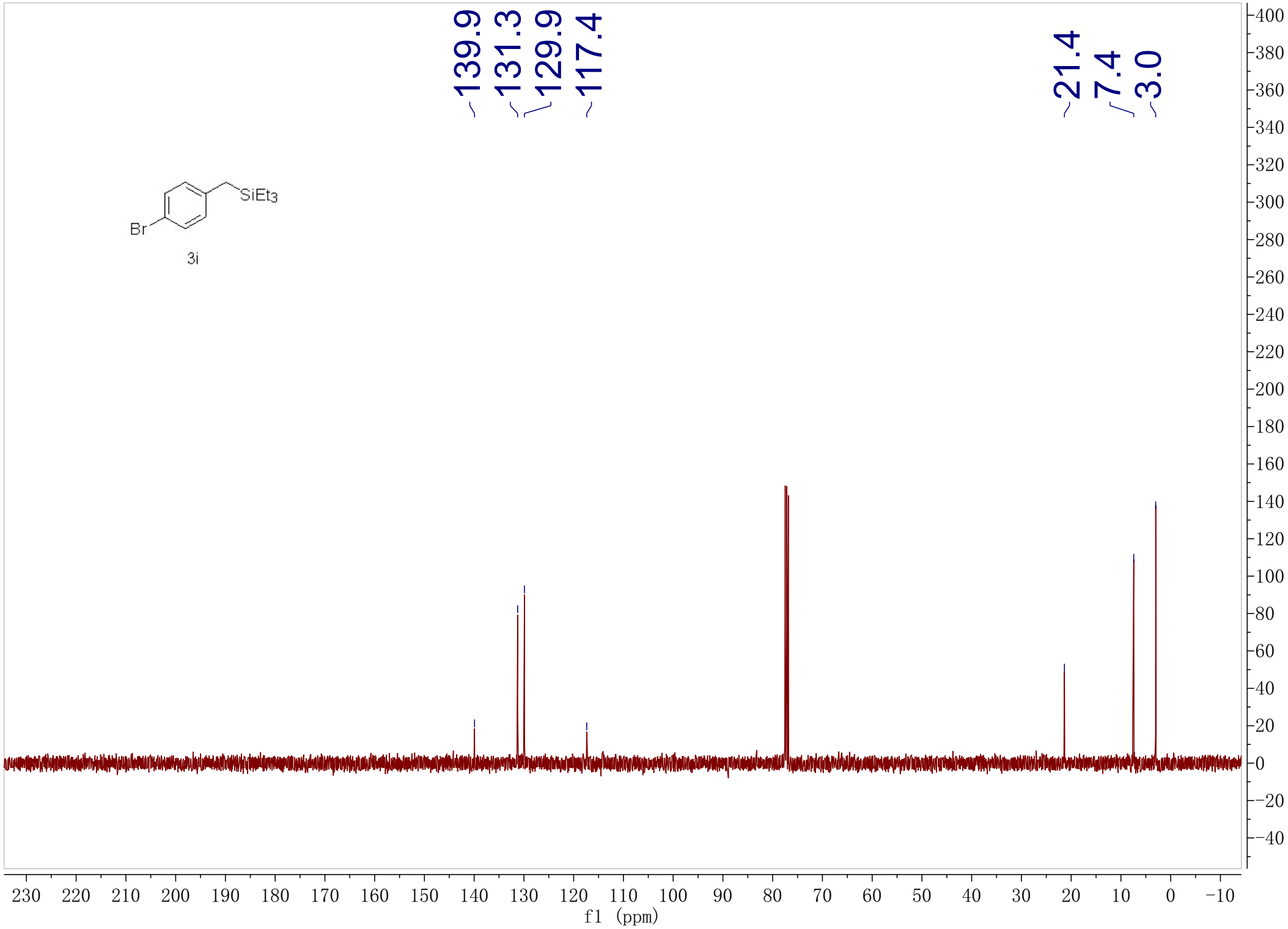

141.1
132.8
129.8
127.2
125.6
123.7
22.2
7.4
3.6
SiEt3
Br
3f
f1 (ppm)

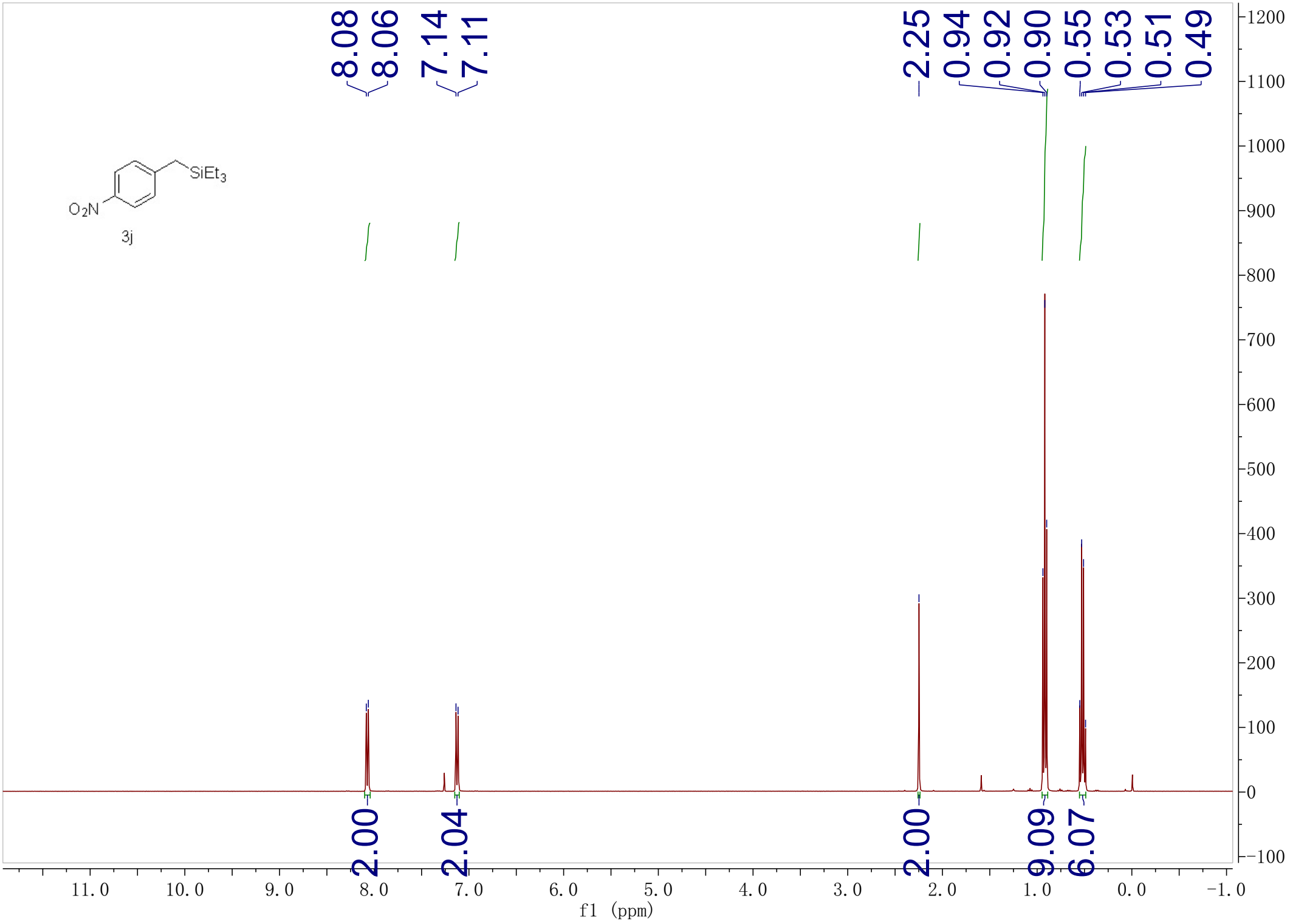

7.04
7.02
6.94
6.92
2.30
2.07
0.96
0.94
0.92
0.55
0.53
0.51
0.49
SiEt3
3g
2.00
2.02
3.01
2.06
9.02
6.06
f1 (ppm)

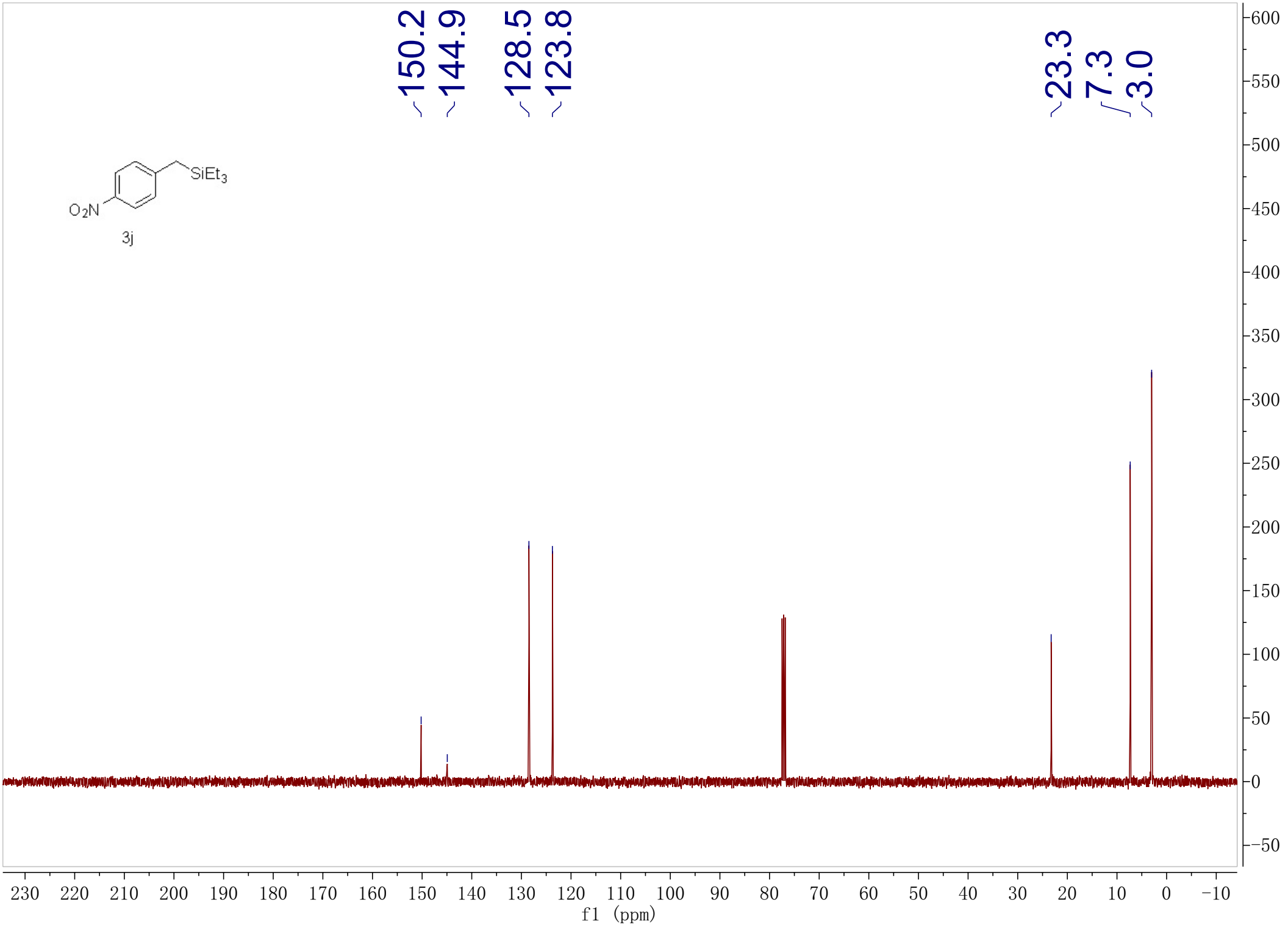

137.4
133.2
129.0
128.1
21.1
21.0
7.5
3.1
SiEt3
3g
f1 (ppm)

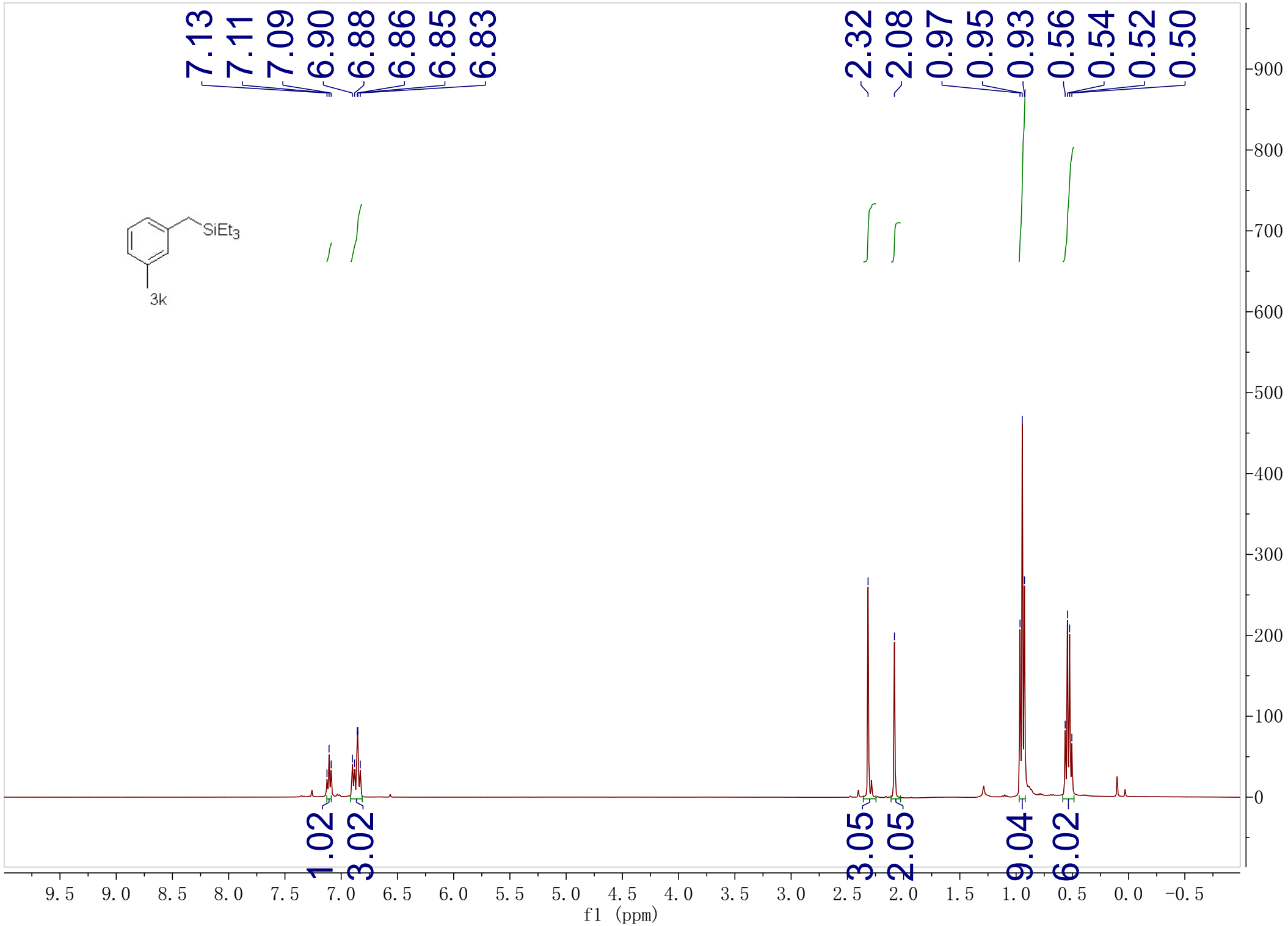

7.18
7.16
6.95
6.93
2.07
0.94
0.92
0.90
0.54
0.52
0.50
0.48
SiEt3
Cl
3h
1.99
2.00
2.06
9.07
6.19
f1 (ppm)

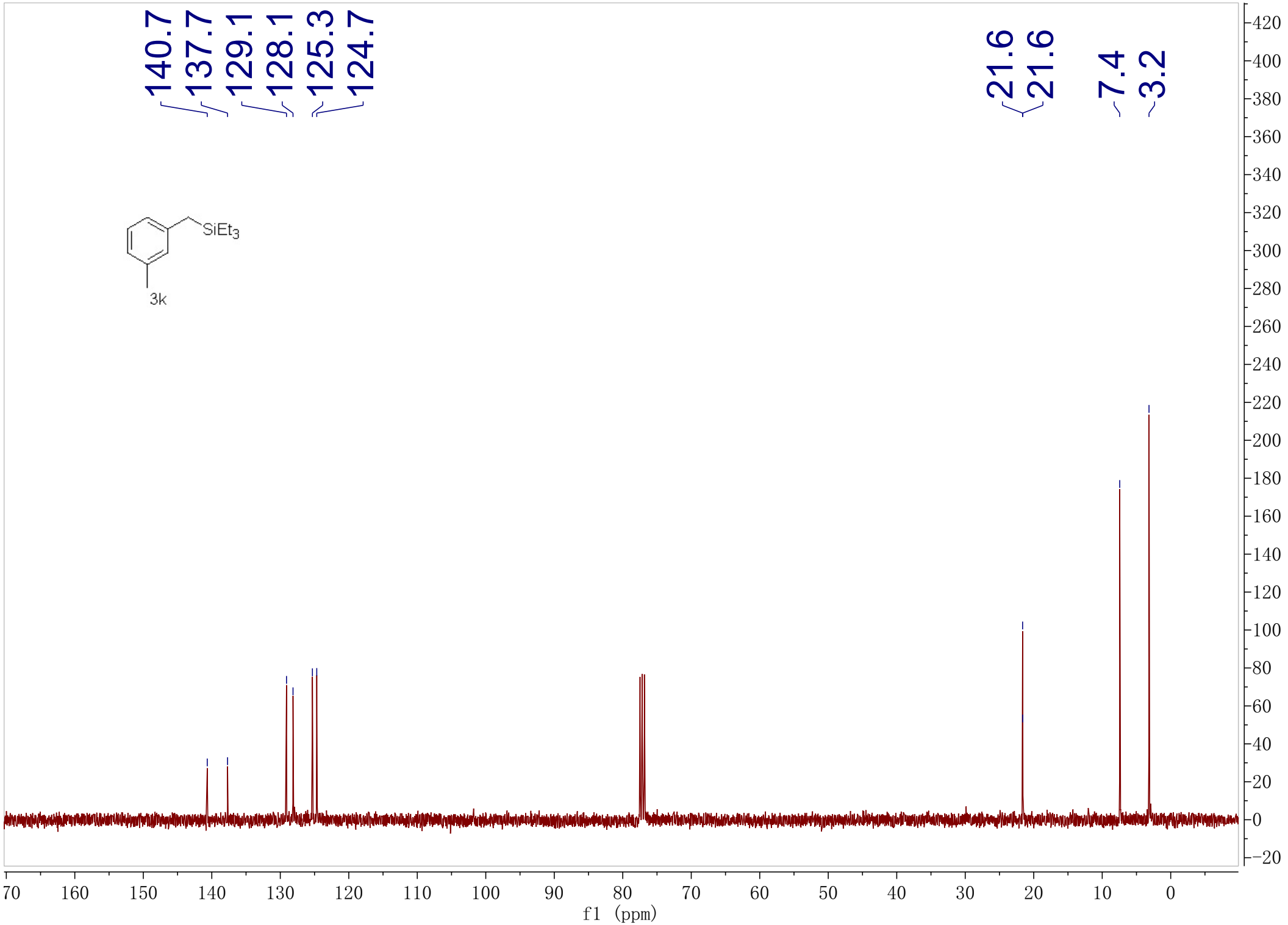

7.32
7.30
6.89
6.87
2.05
0.93
0.91
0.89
0.53
0.51
0.49
SiEt3
Br
3i
1.97
2.00
2.08
9.02
6.09
f1 (ppm)

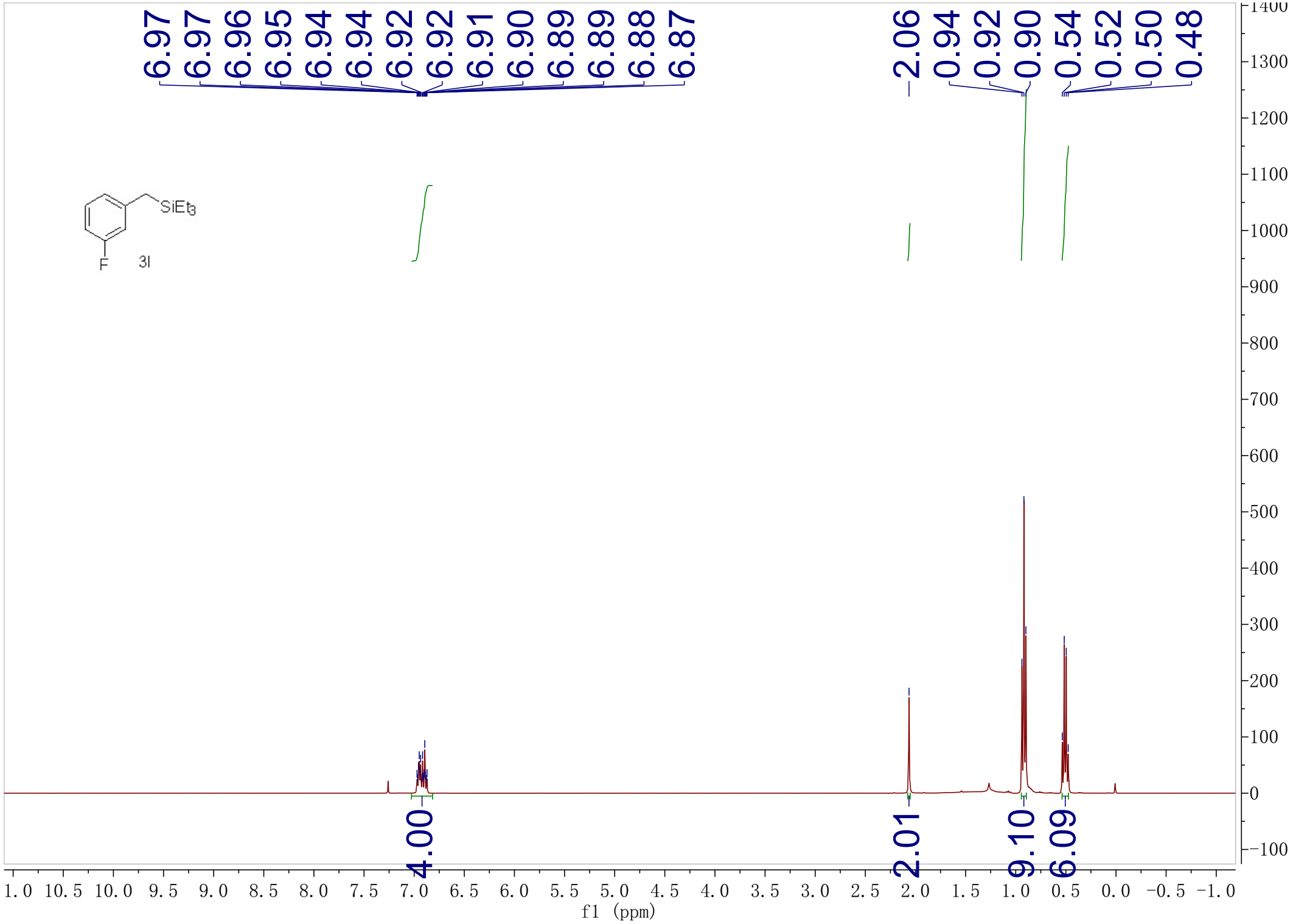

139.9
131.3
129.9
117.4
21.4
7.4
3.0
SiEt3
Br
3i
f1 (ppm)

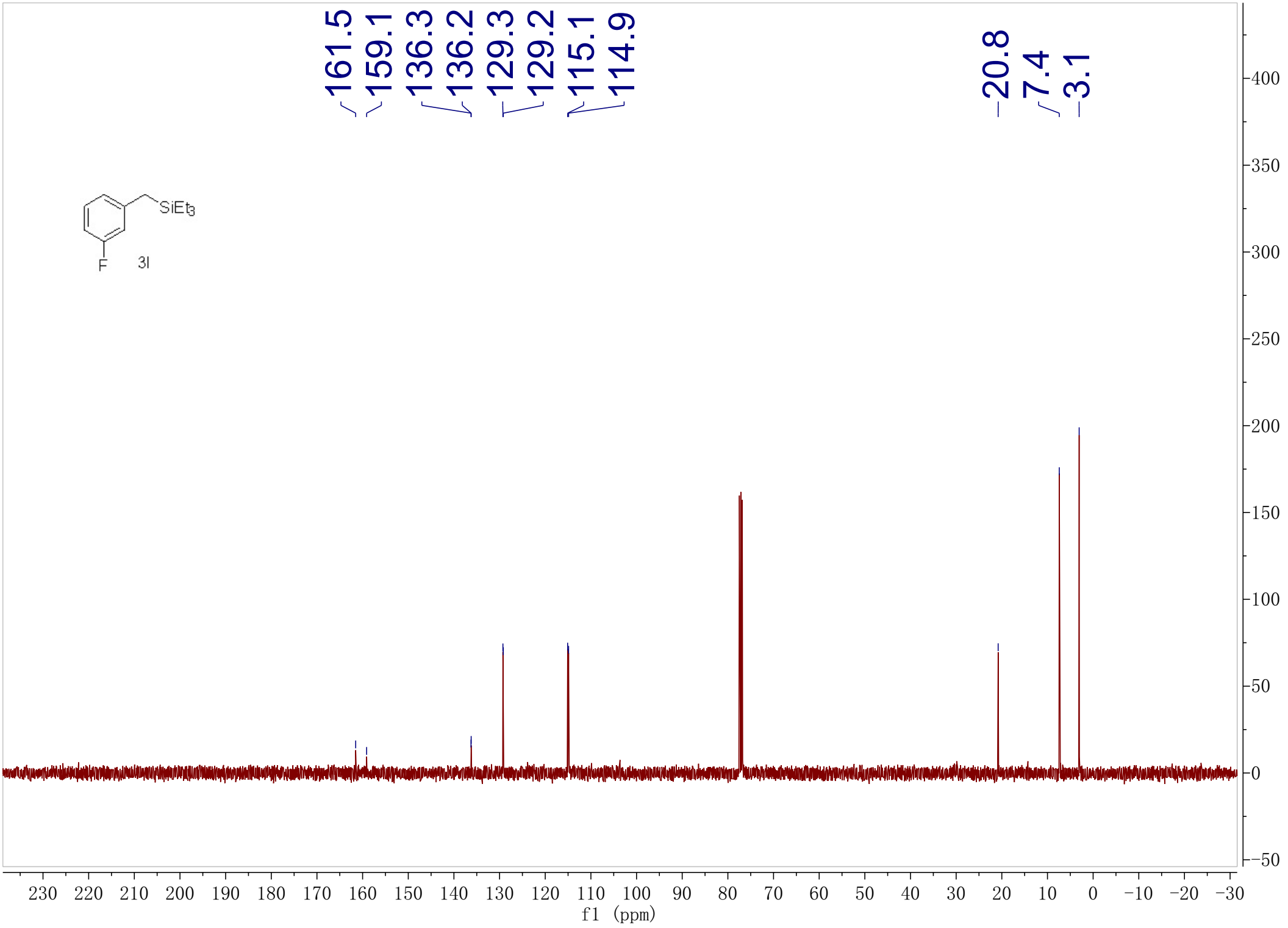

8.08
8.06
7.14
7.11
2.25
0.94
0.92
0.90
0.55
0.53
0.51
0.49
SiEt3
O2N
3j
2.00
2.04
2.00
9.09
6.07
f1 (ppm)

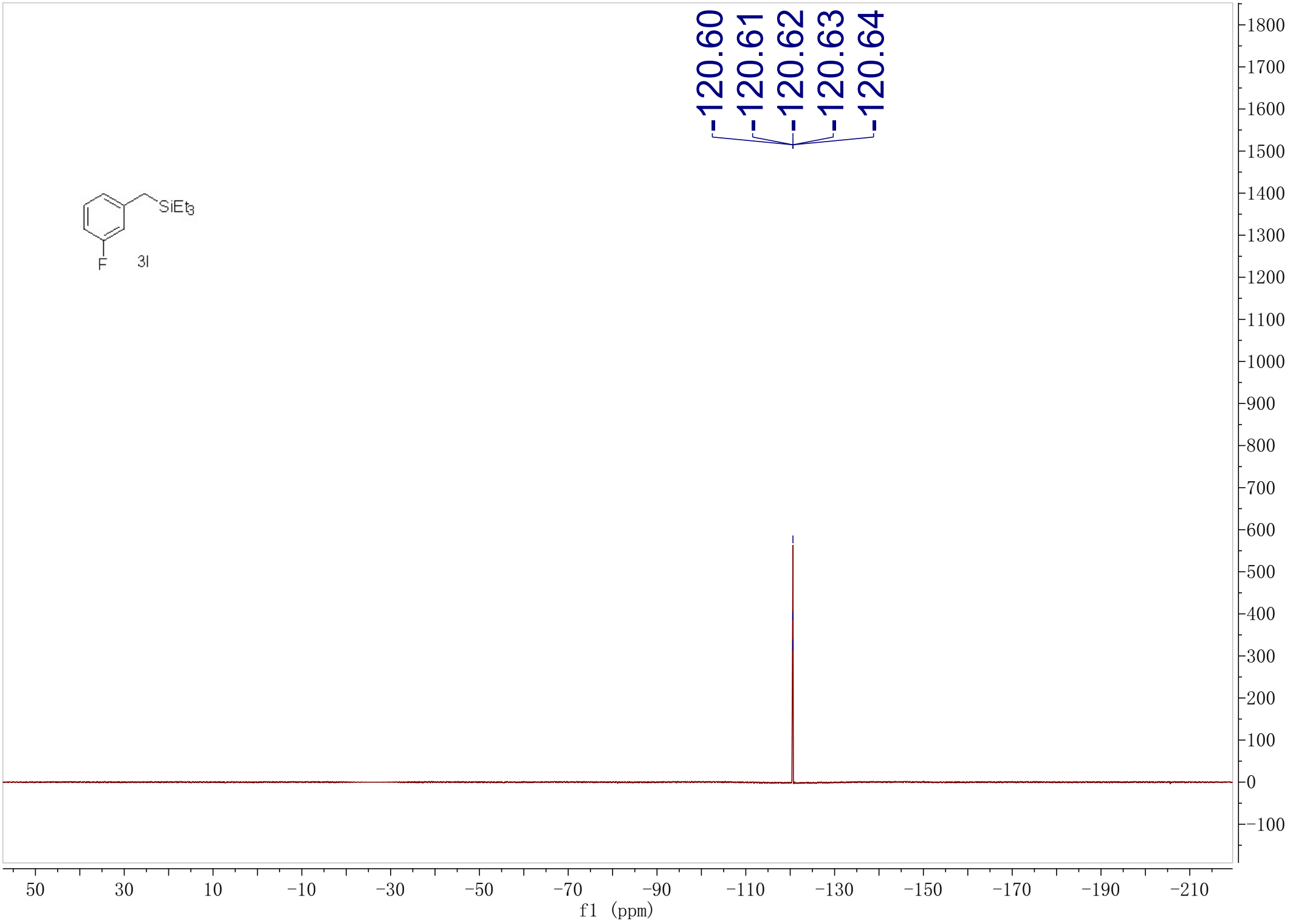

150.2
144.9
128.5
123.8
23.3
7.3
3.0
SiEt3
O2N
3j
600
550
500
450
400
350
300
250
200
150
100
50
0
−50
230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10
f1 (ppm)

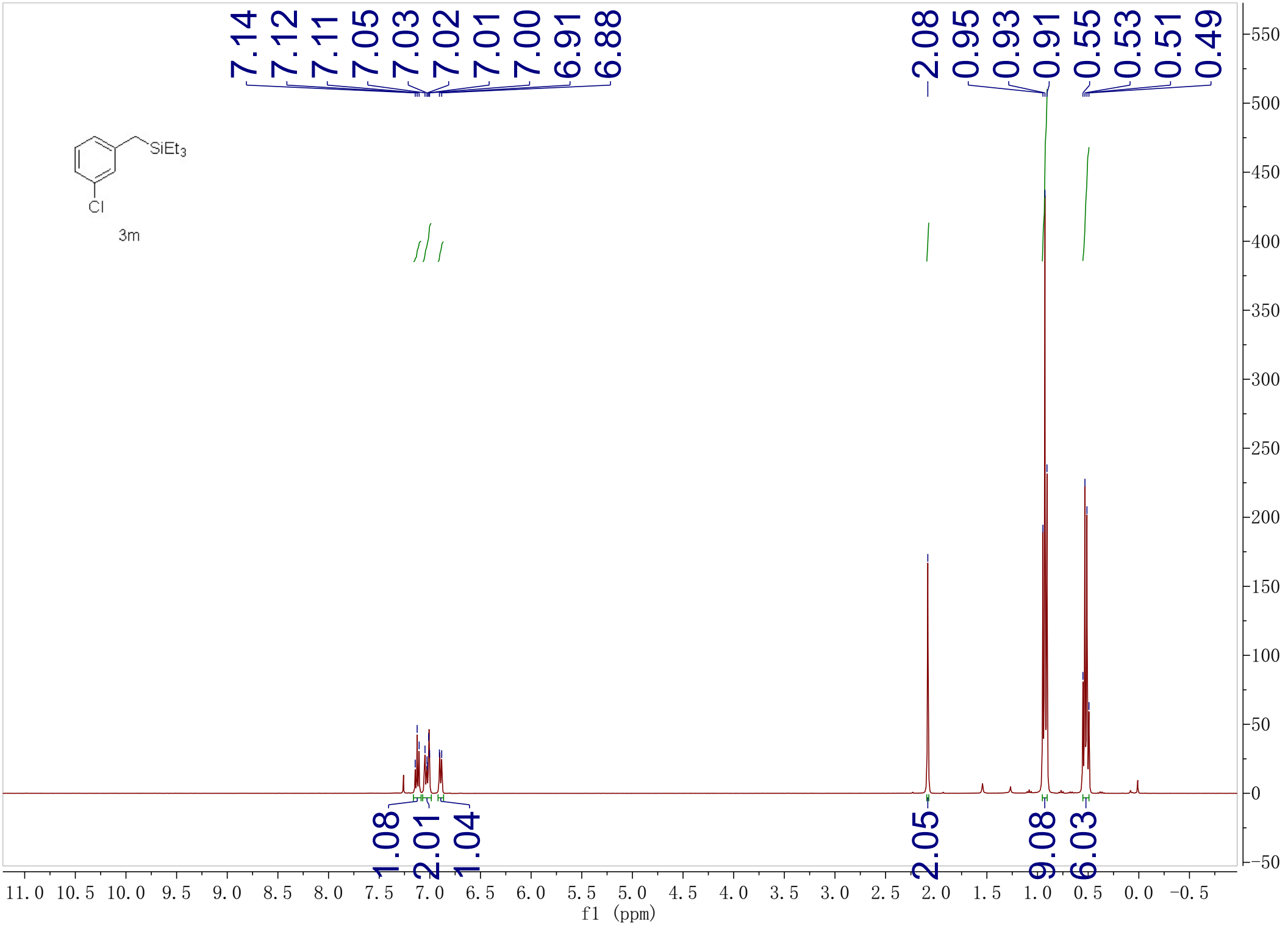

7.13
7.11
7.09
6.90
6.88
6.86
6.85
6.83
2.32
2.08
0.97
0.95
0.93
0.56
0.54
0.52
0.50
SiEt3
3k
1.02
3.02
3.05
2.05
9.04
6.02
f1 (ppm)

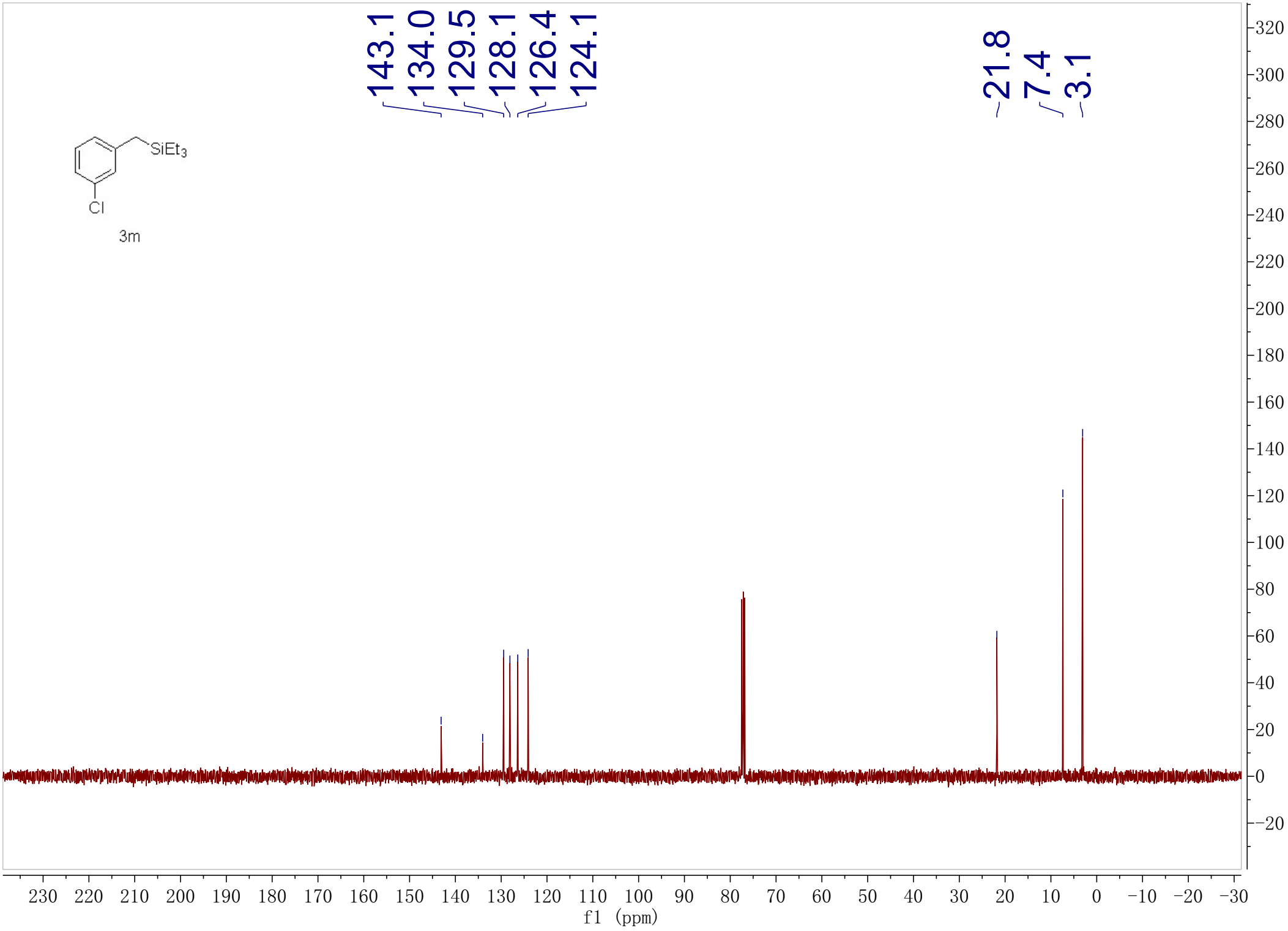

140.7
137.7
129.1
128.1
125.3
124.7
21.6
21.6
7.4
3.2
SiEt3
3k
f1 (ppm)

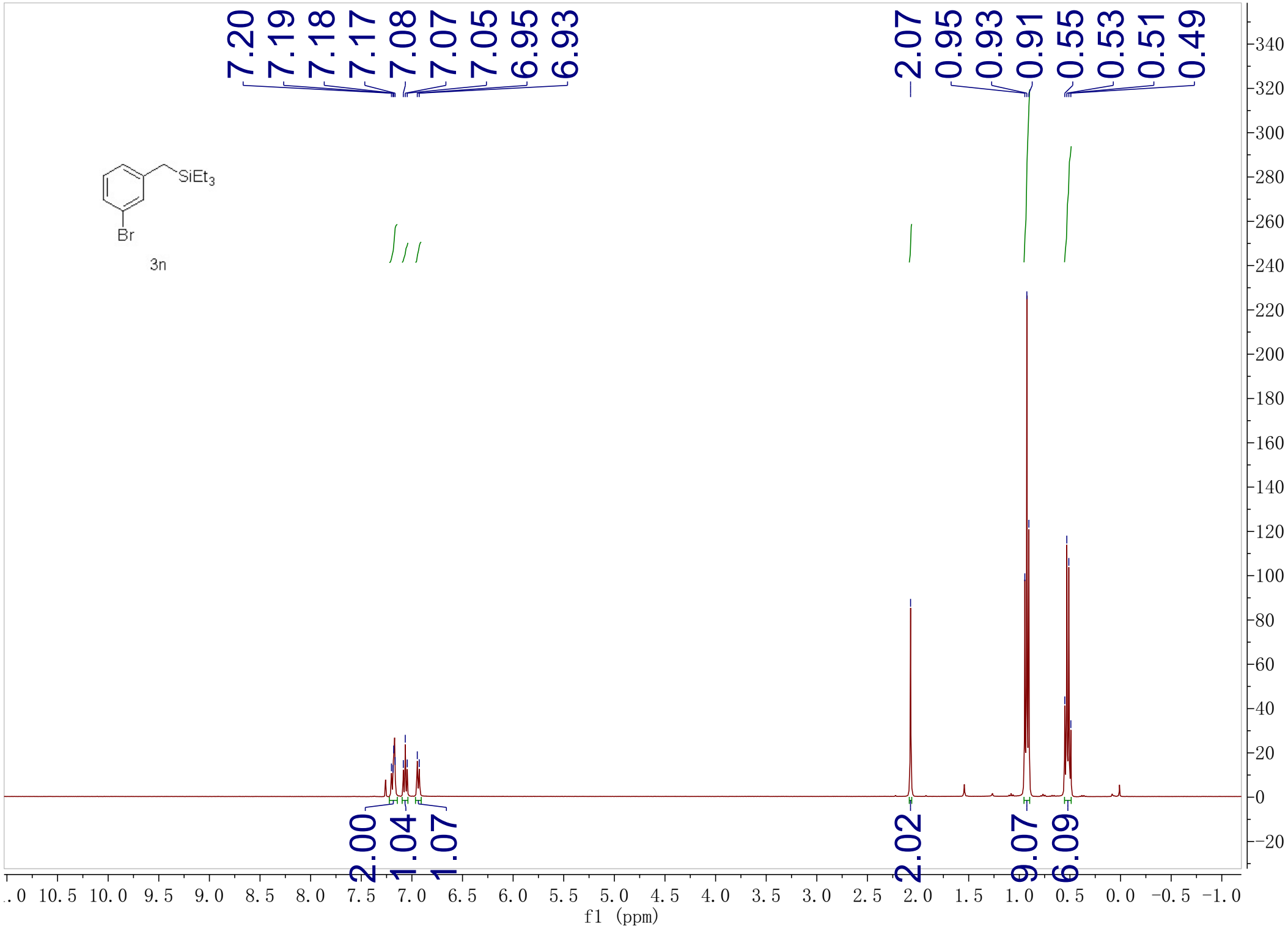

6.97
6.97
6.96
6.95
6.94
6.94
6.92
6.92
6.91
6.90
6.89
6.89
6.88
6.87
2.06
0.94
0.92
0.90
0.54
0.52
0.50
0.48
SiEt3
F
3l
4.00
2.01
9.10
6.09
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
−100
1.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 −0.5 −1.0
f1 (ppm)

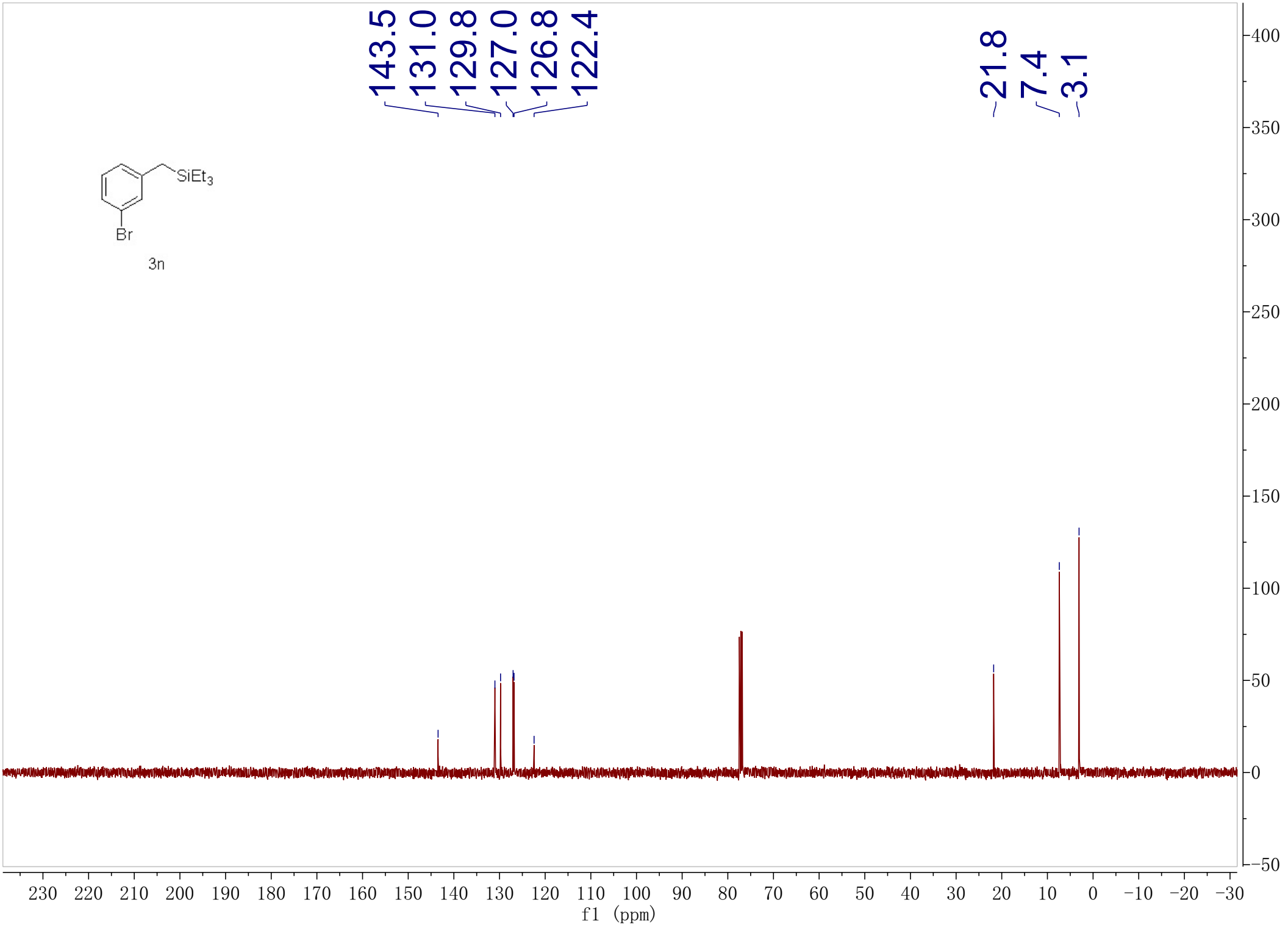

161.5
159.1
136.3
136.2
129.3
129.2
115.1
114.9
20.8
7.4
3.1
SiEt3
F
3l
400
350
300
250
200
150
100
50
0
-50
230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10 -20 -30
f1 (ppm)

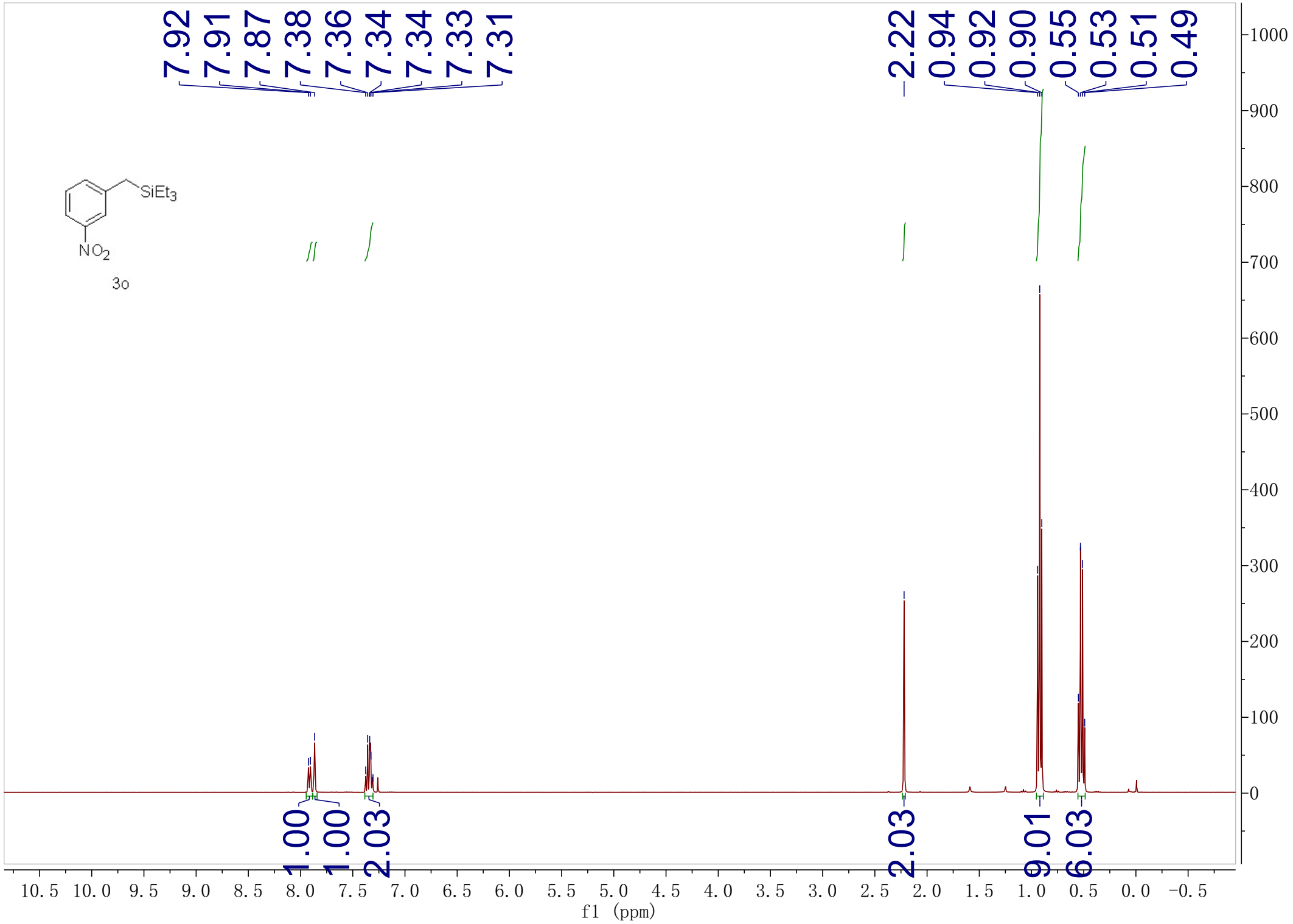

120.60
120.61
120.62
120.63
120.64
SiEt3
F
3l
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
−100
50
30
10
−10
−30
−50
−70
−90
−110
−130
−150
−170
−190
−210
f1 (ppm)

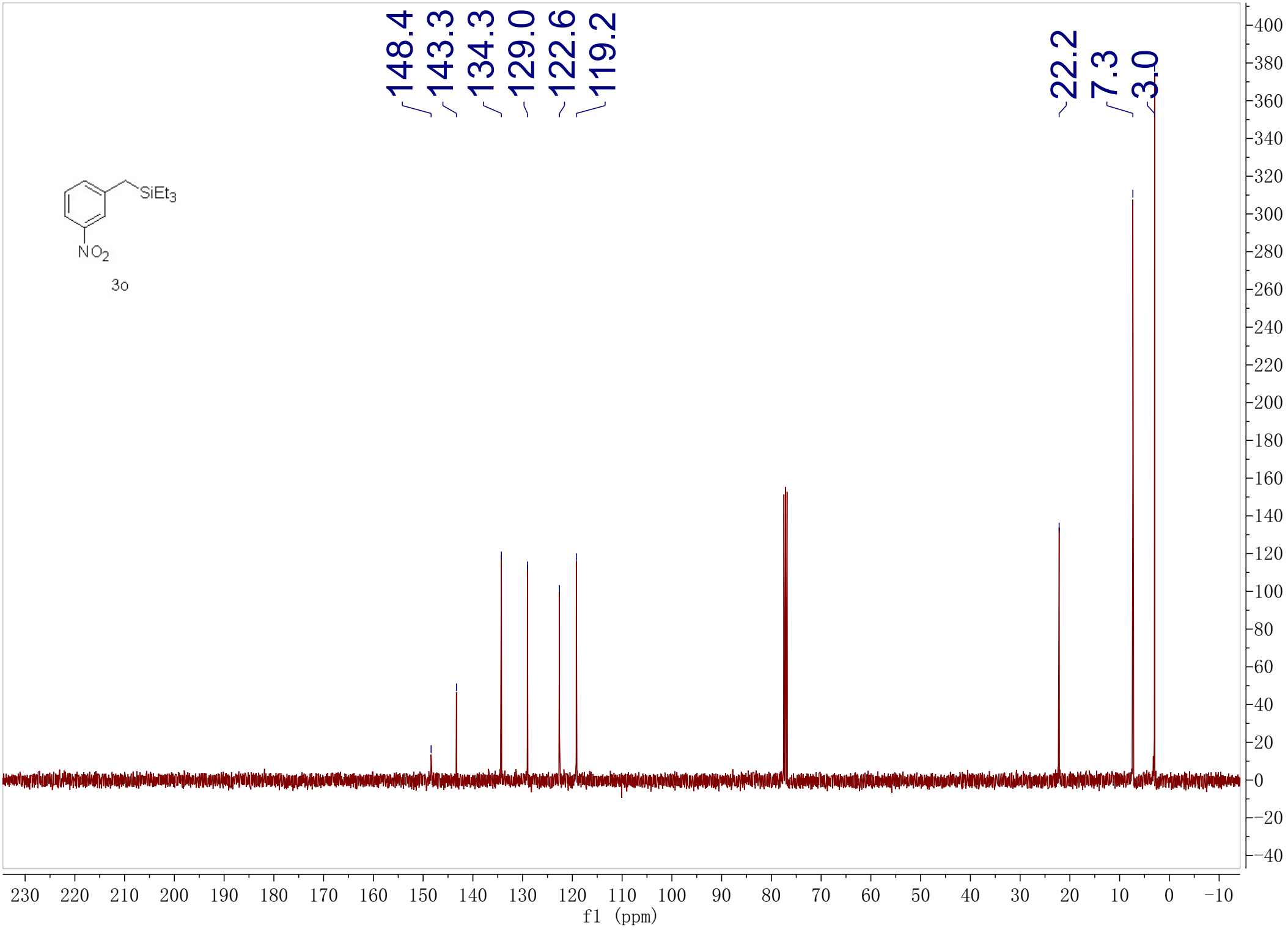

7.14
7.12
7.11
7.05
7.03
7.02
7.01
7.00
6.91
6.88
2.08
0.95
0.93
0.91
0.55
0.53
0.51
0.49
SiEt3
Cl
3m
1.08
2.01
1.04
2.05
9.08
6.03
f1 (ppm)

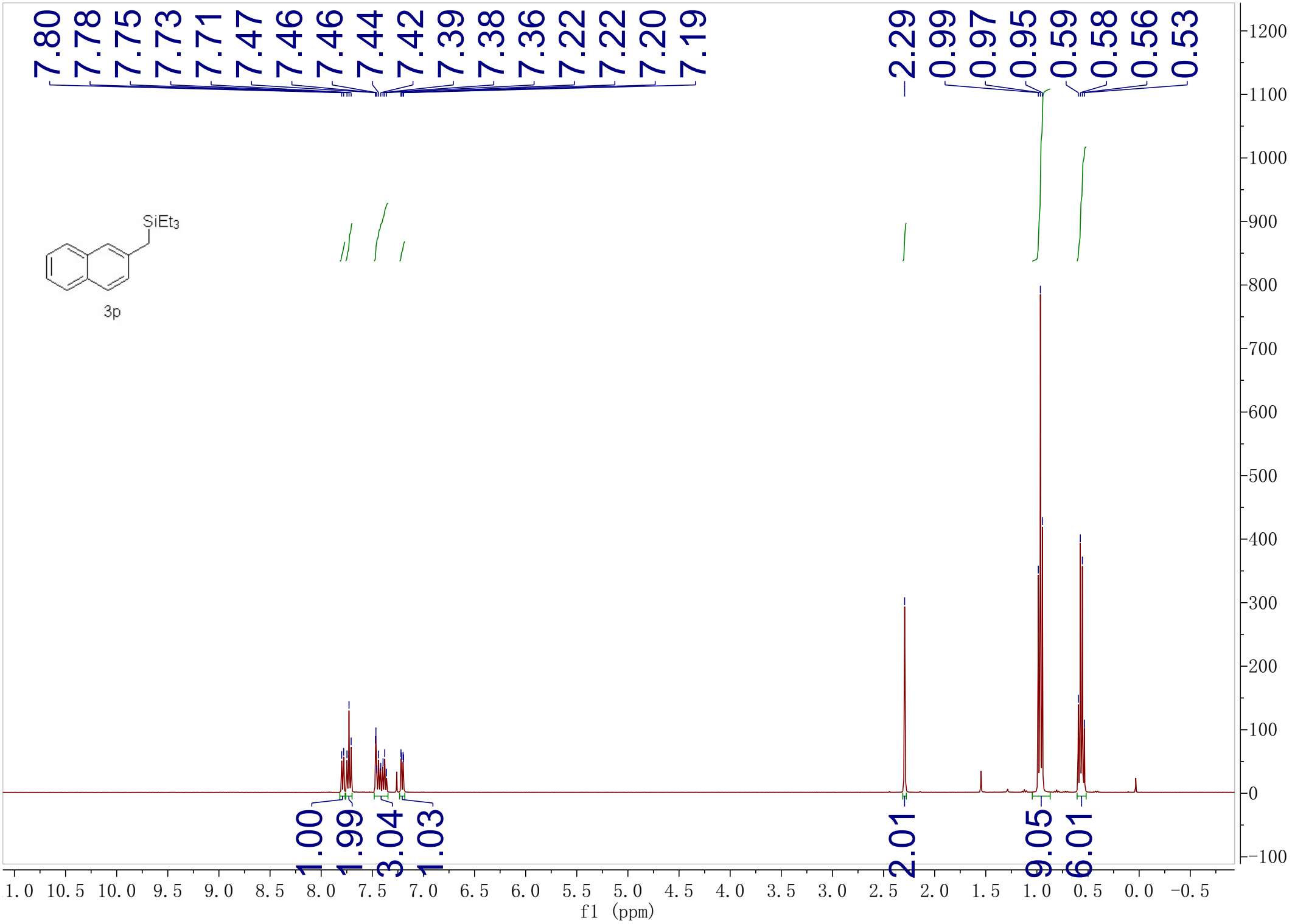

143.1
134.0
129.5
128.1
126.4
124.1
21.8
7.4
3.1
SiEt3
Cl
3m
320
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
−20
230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10 −20 −30
f1 (ppm)

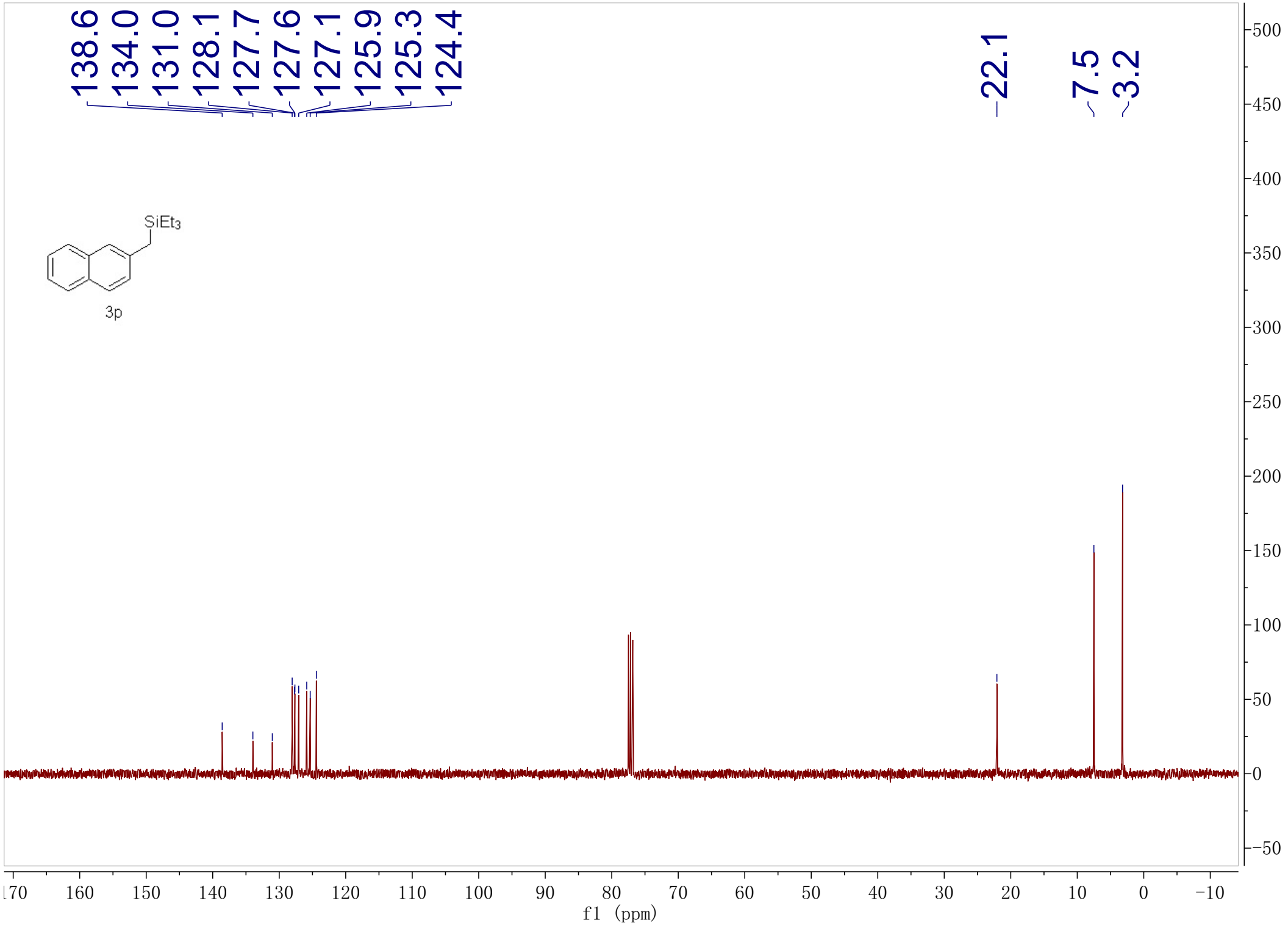

7.20
7.19
7.18
7.17
7.08
7.07
7.05
6.95
6.93
2.07
0.95
0.93
0.91
0.55
0.53
0.51
0.49
SiEt3
Br
3n
2.00
1.04
1.07
2.02
9.07
6.09
f1 (ppm)

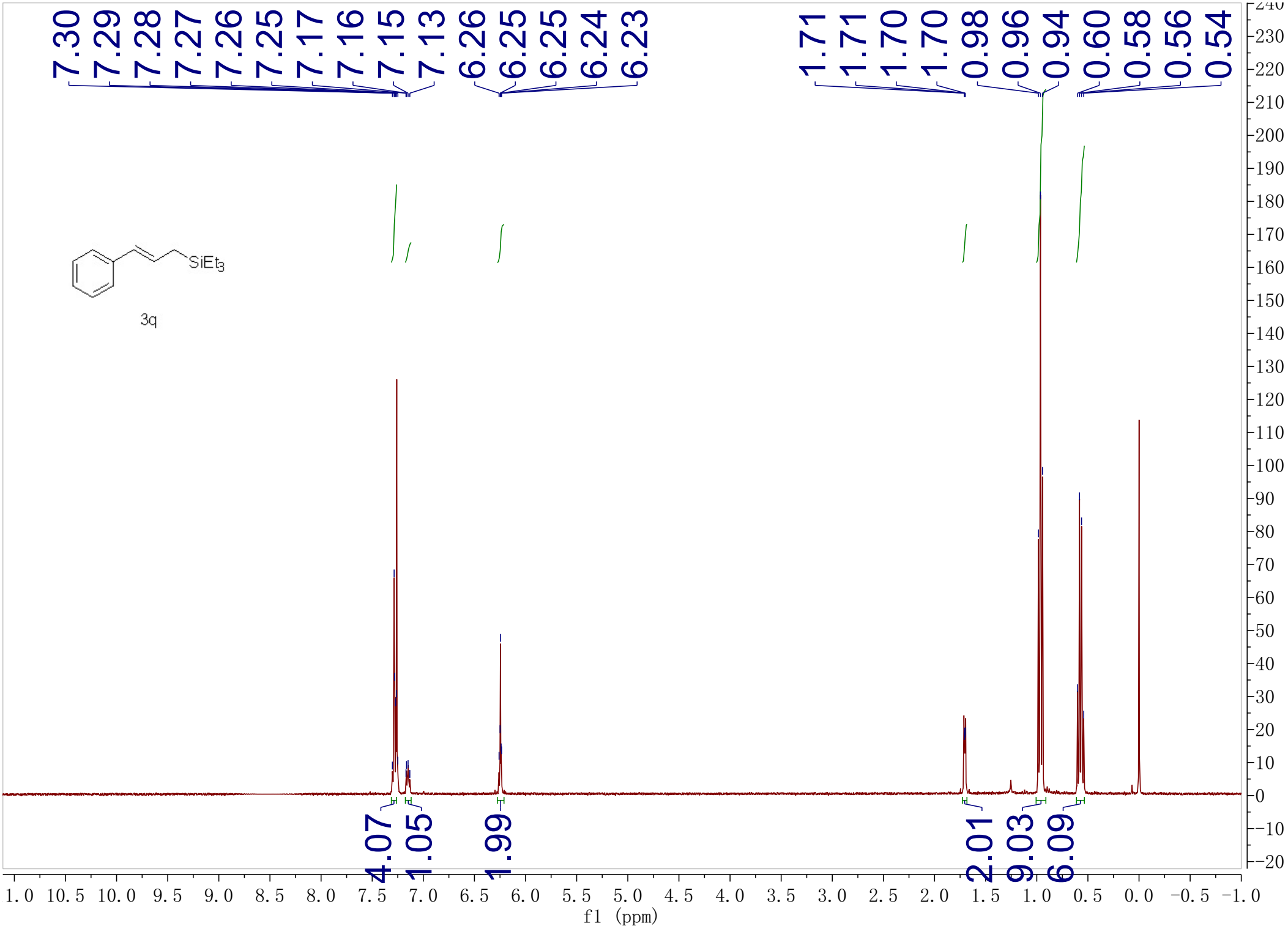

143.5
131.0
129.8
127.0
126.8
122.4
21.8
7.4
3.1
SiEt3
Br
3n
400
350
300
250
200
150
100
50
0
−50
230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10 −20 −30
f1 (ppm)

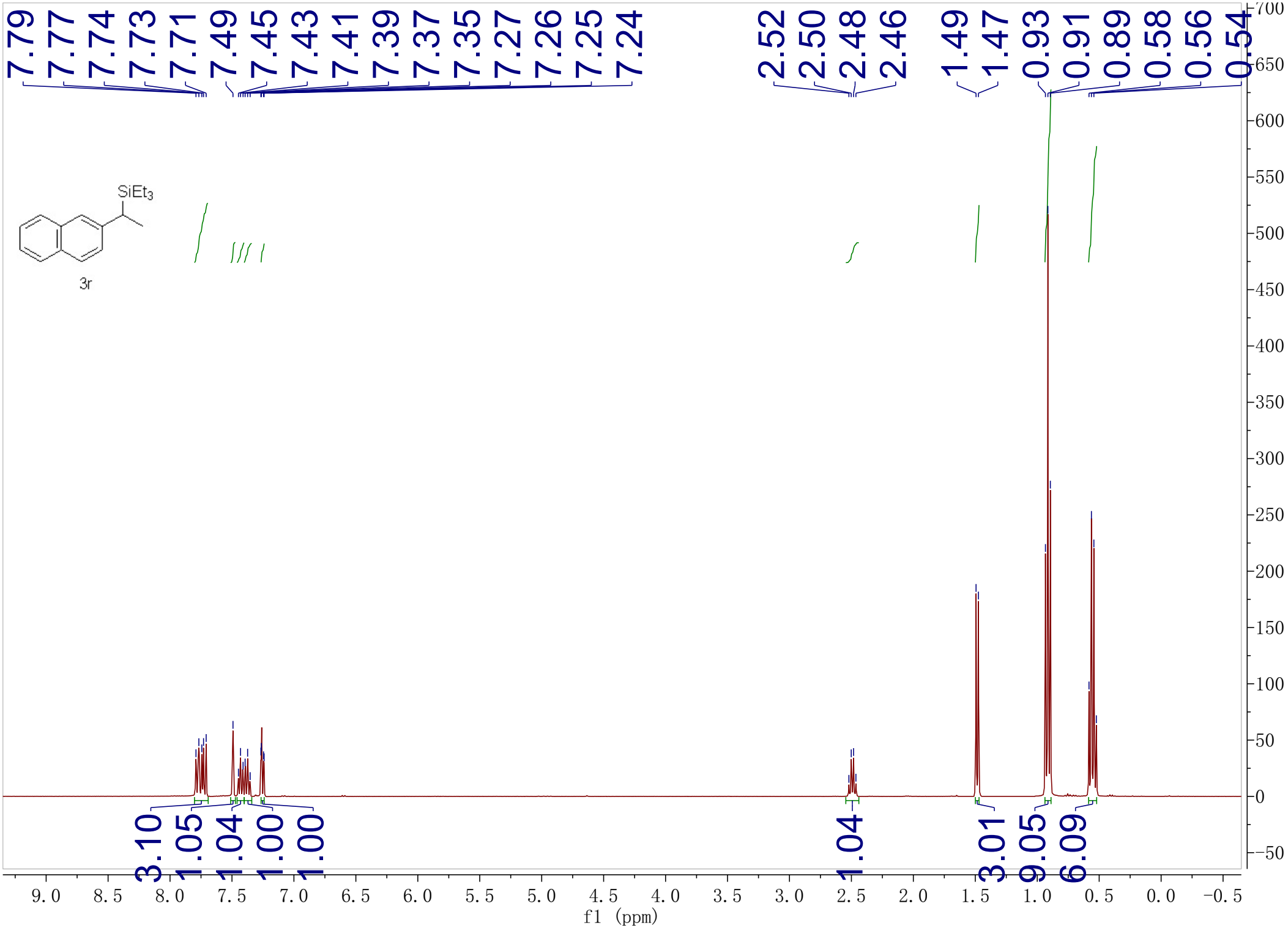

7.92
7.91
7.87
7.38
7.36
7.34
7.34
7.33
7.31
2.22
0.94
0.92
0.90
0.55
0.53
0.51
0.49
SiEt3
NO2
3o
1.00
1.00
2.03
2.03
9.01
6.03
1000
900
800
700
600
500
400
300
200
100
0
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

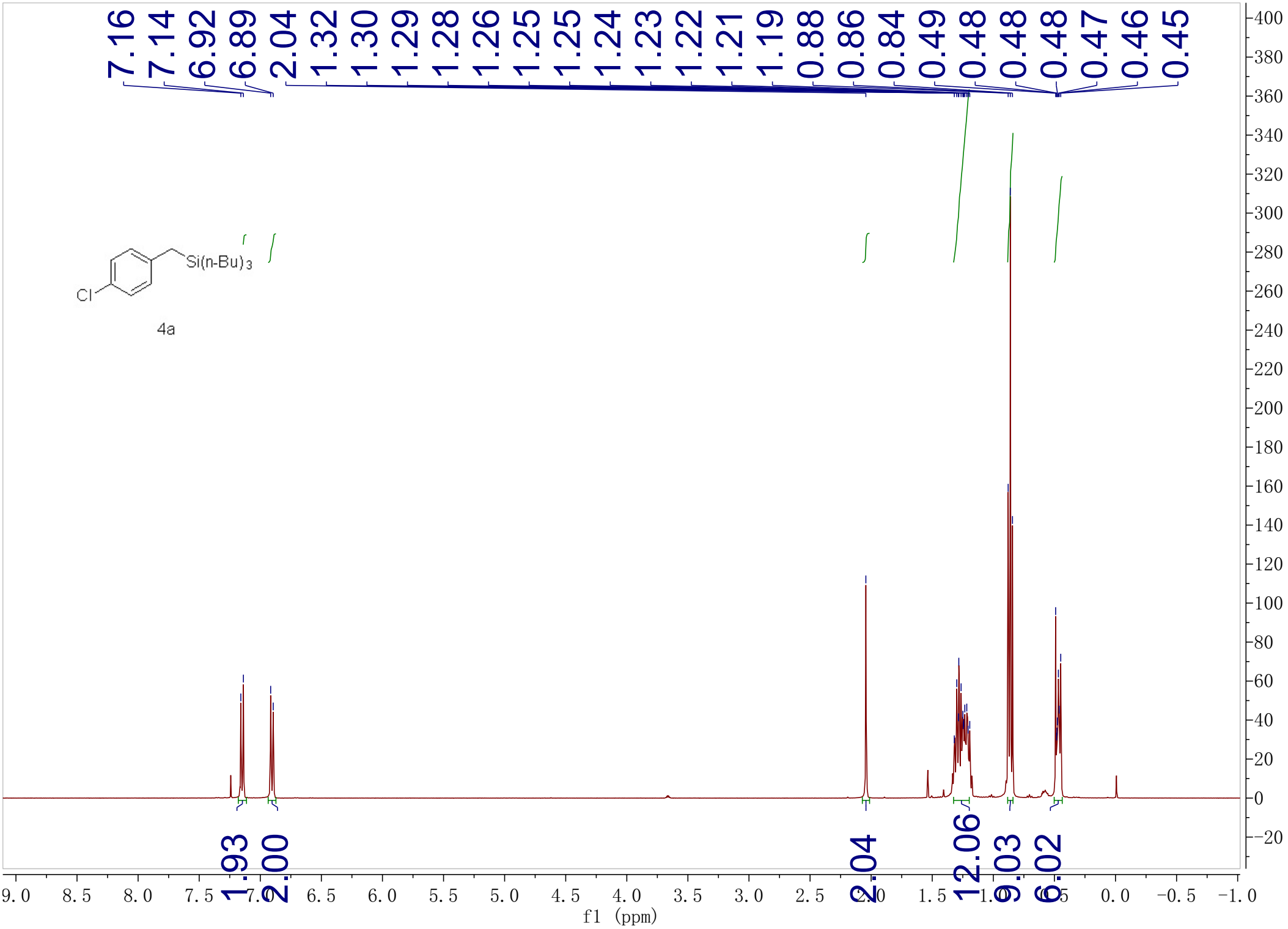

148.4
143.3
134.3
129.0
122.6
119.2
22.2
7.3
3.0
SiEt3
NO2
3o
f1 (ppm)

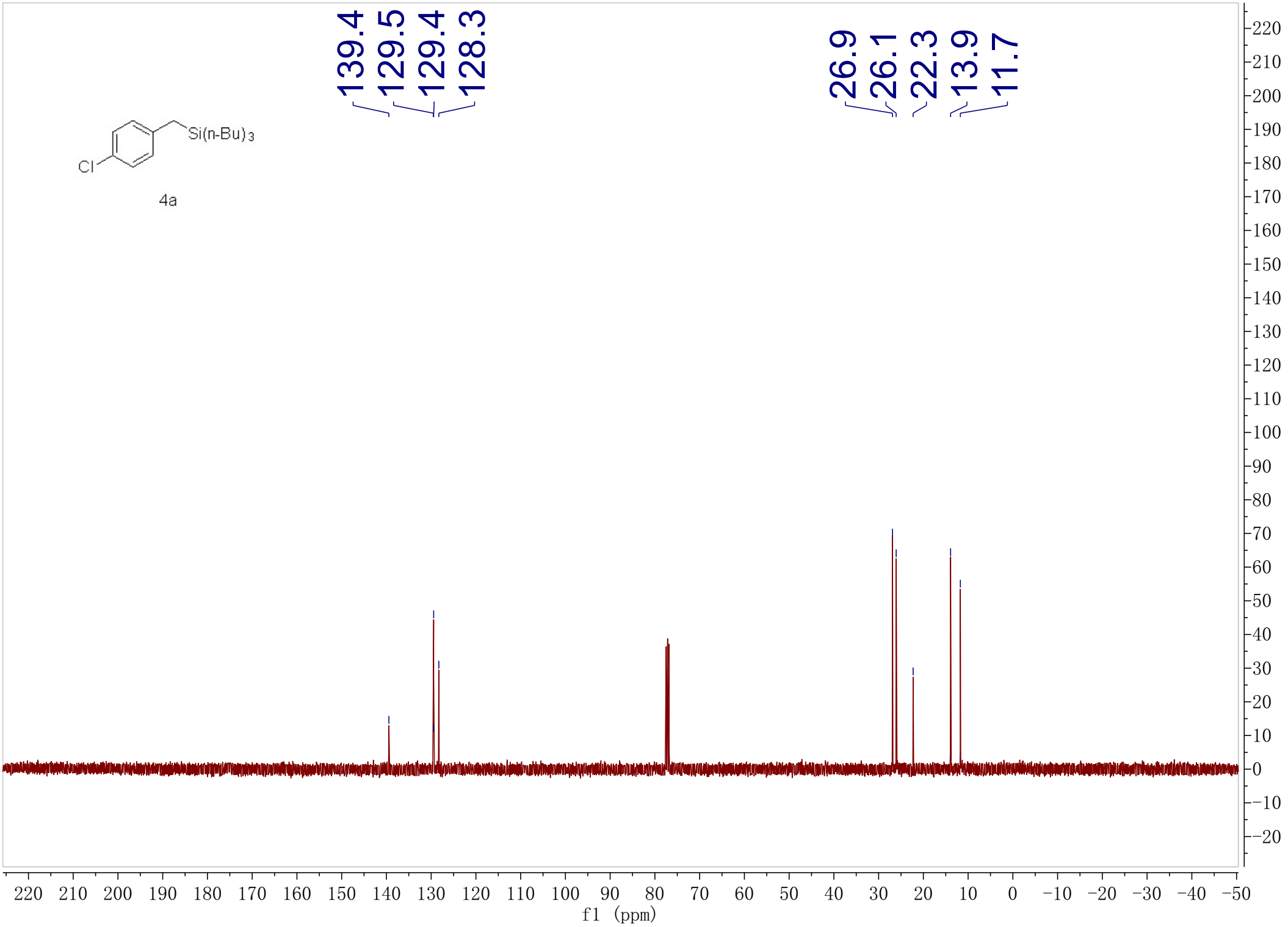

7.80
7.78
7.75
7.73
7.71
7.47
7.46
7.46
7.44
7.42
7.39
7.38
7.36
7.22
7.22
7.20
7.19
2.29
0.99
0.97
0.95
0.59
0.58
0.56
0.53
SiEt3
3p
1.00
1.99
3.04
1.03
2.01
9.05
6.01
f1 (ppm)

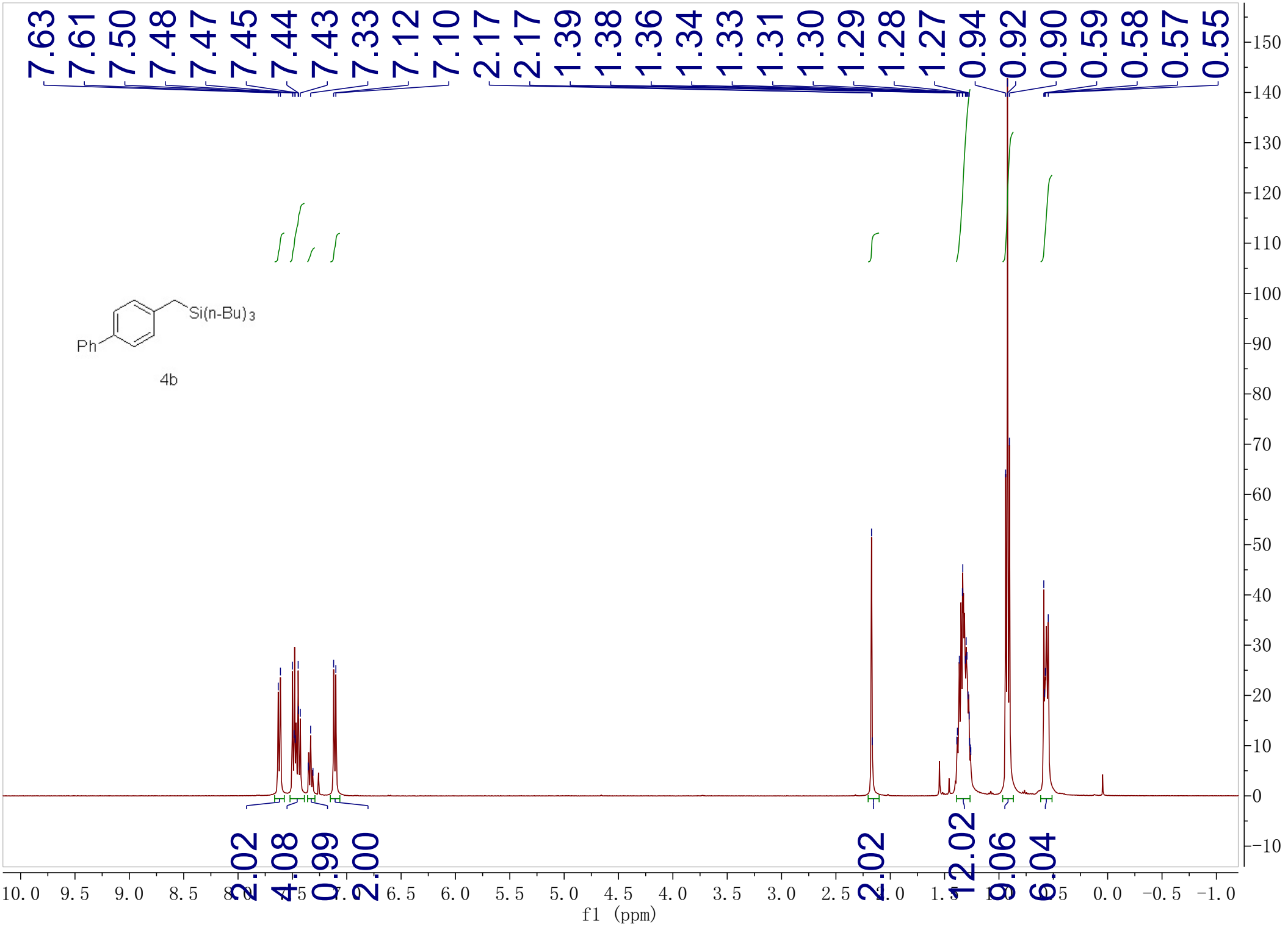

138.6
134.0
131.0
128.1
127.7
127.6
127.1
125.9
125.3
124.4
22.1
7.5
3.2
SiEt3
3p
f1 (ppm)

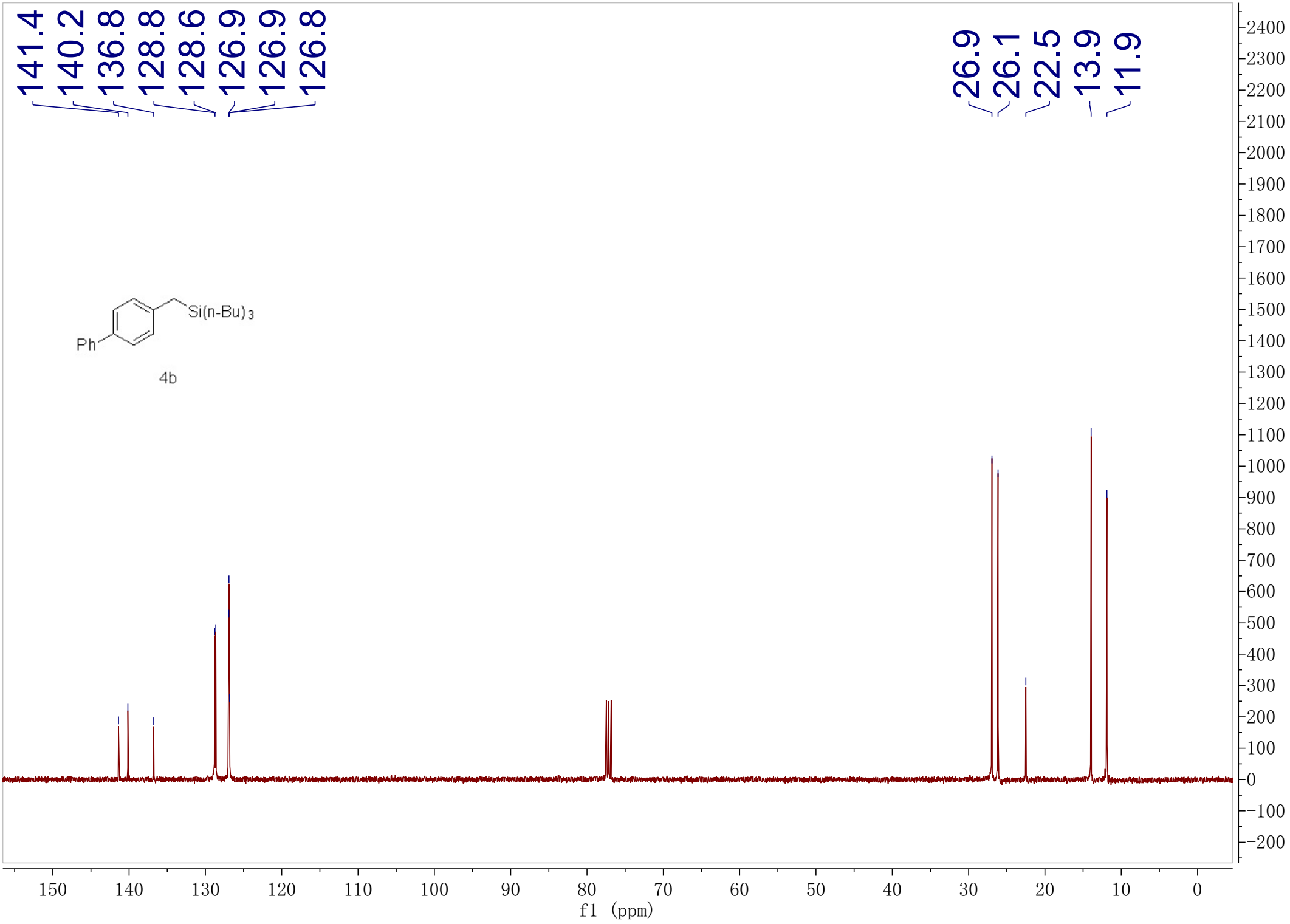

7.30
7.29
7.28
7.27
7.26
7.25
7.17
7.16
7.15
7.13
6.26
6.25
6.25
6.24
6.23
1.71
1.71
1.70
1.70
0.98
0.96
0.94
0.60
0.58
0.56
0.54
SiEt3
3q
4.07
1.05
1.99
2.01
9.03
6.09
f1 (ppm)

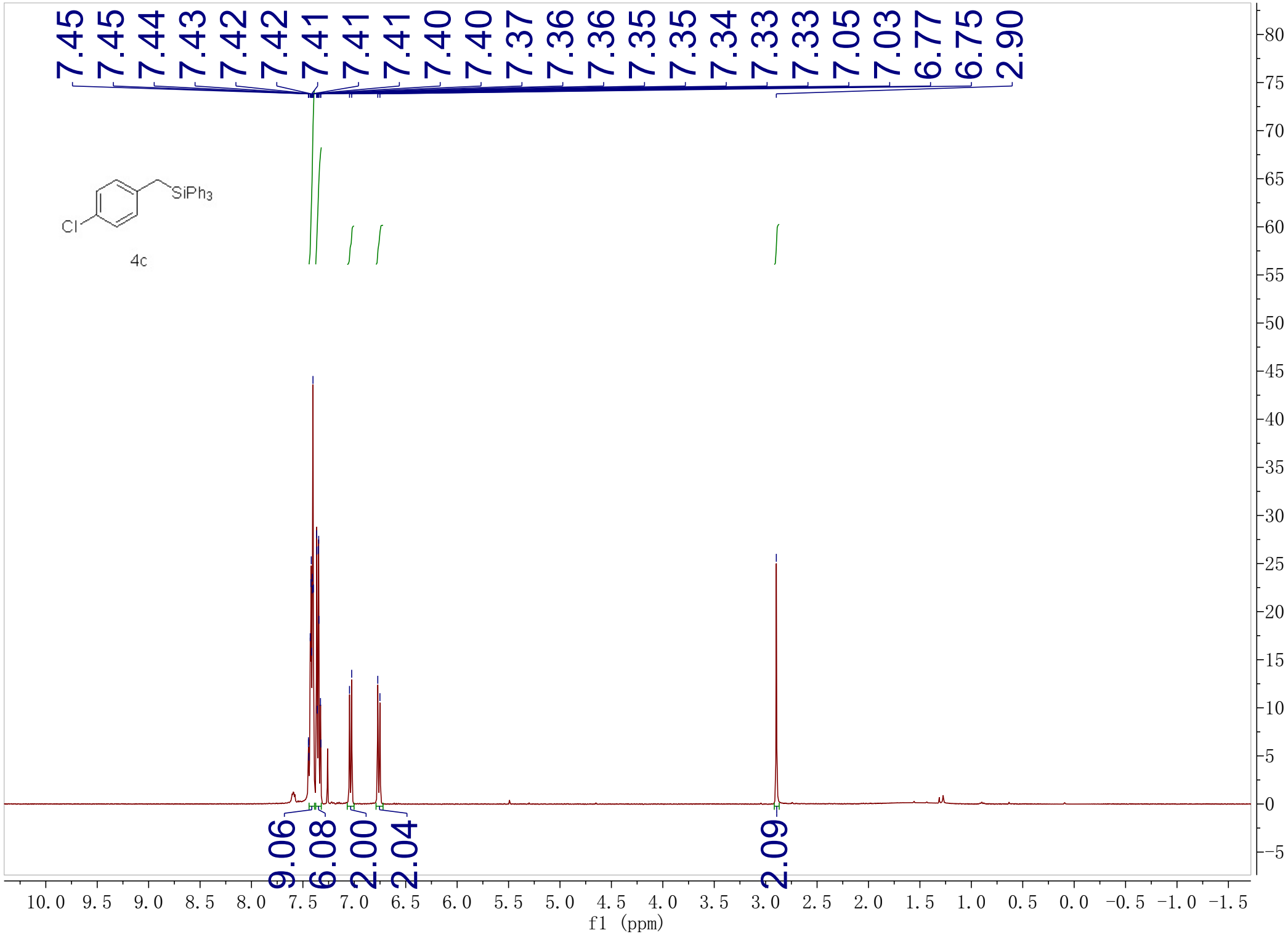

7.79
7.77
7.74
7.73
7.71
7.49
7.45
7.43
7.41
7.39
7.37
7.35
7.27
7.26
7.25
7.24
2.52
2.50
2.48
2.46
1.49
1.47
0.93
0.91
0.89
0.58
0.56
0.54
SiEt3
3r
3.10
1.05
1.04
1.00
1.00
1.04
3.01
9.05
6.09
f1 (ppm)

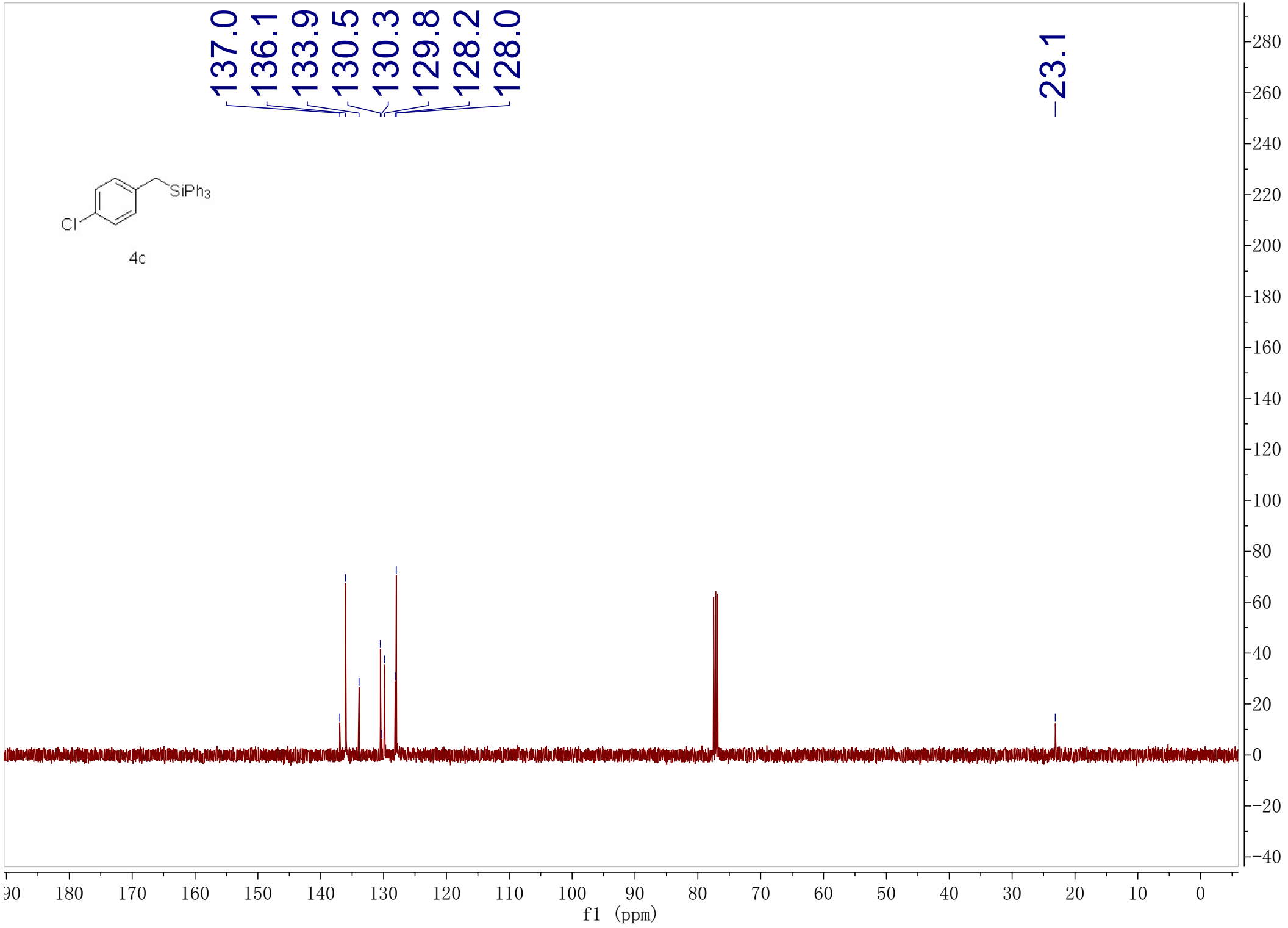

7.16
7.14
6.92
6.89
2.04
1.32
1.30
1.29
1.28
1.26
1.25
1.25
1.24
1.23
1.22
1.21
1.19
0.88
0.86
0.84
0.49
0.48
0.48
0.48
0.47
0.46
0.45
Si(n-Bu)3
Cl
4a
1.93
2.00
2.04
12.06
9.03
6.02
f1 (ppm)

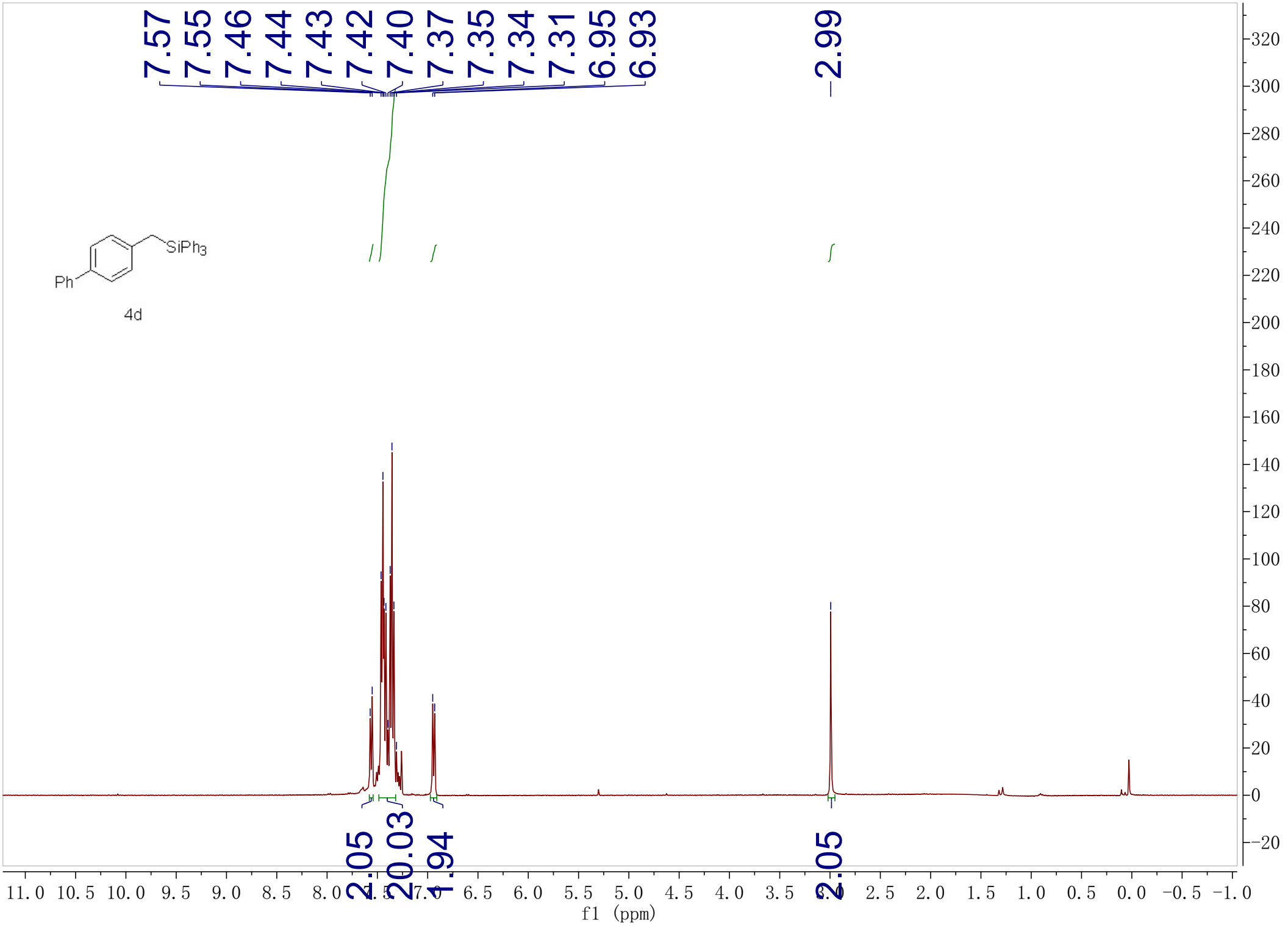

139.4
129.5
129.4
128.3
26.9
26.1
22.3
13.9
11.7
Si(n-Bu)3
Cl
4a
f1 (ppm)


7.63
7.61
7.50
7.48
7.47
7.45
7.44
7.43
7.33
7.12
7.10
2.17
2.17
1.39
1.38
1.36
1.34
1.33
1.31
1.30
1.29
1.28
1.27
0.94
0.92
0.90
0.59
0.58
0.57
0.55
Si(n-Bu)3
Ph
4b
2.02
4.08
0.99
2.00
2.02
12.02
9.06
6.04
f1 (ppm)


141.4
140.2
136.8
128.8
128.6
126.9
126.9
126.8
26.9
26.1
22.5
13.9
11.9
Si(n-Bu)3
Ph
4b
2400
2300
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
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


7.45
7.45
7.44
7.43
7.42
7.42
7.41
7.41
7.41
7.40
7.40
7.37
7.36
7.36
7.35
7.35
7.34
7.33
7.33
7.05
7.03
6.77
6.75
2.90
SiPh3
Cl
4c
9.06
6.08
2.00
2.04
2.09
f1 (ppm)


137.0
136.1
133.9
130.5
130.3
129.8
128.2
128.0
-23.1
SiPh3
Cl
4c
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
90
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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7.37
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7.34
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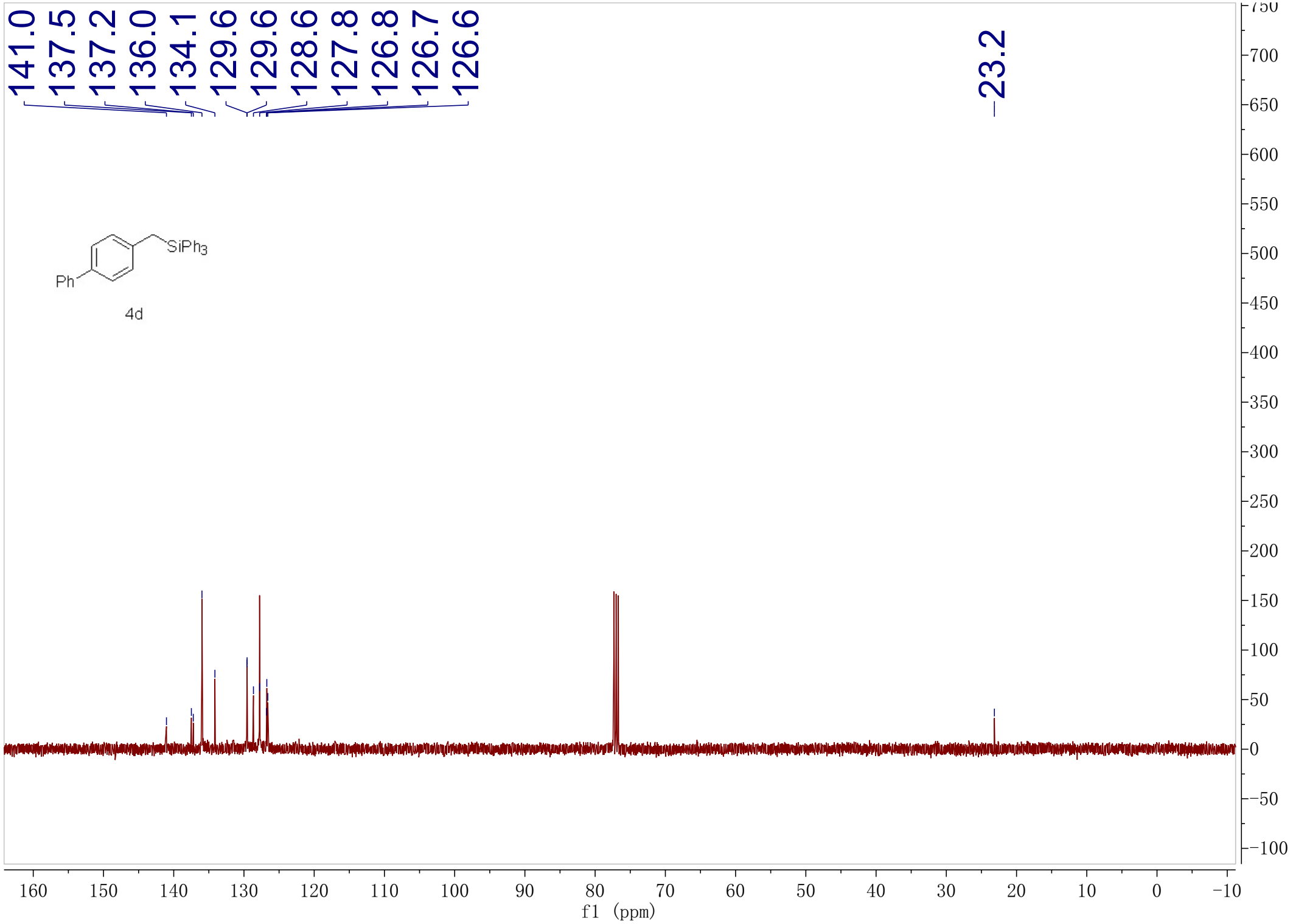
6.93
2.99
SiPh3
Ph
4d
2.05
20.03
1.94
2.05
f1 (ppm)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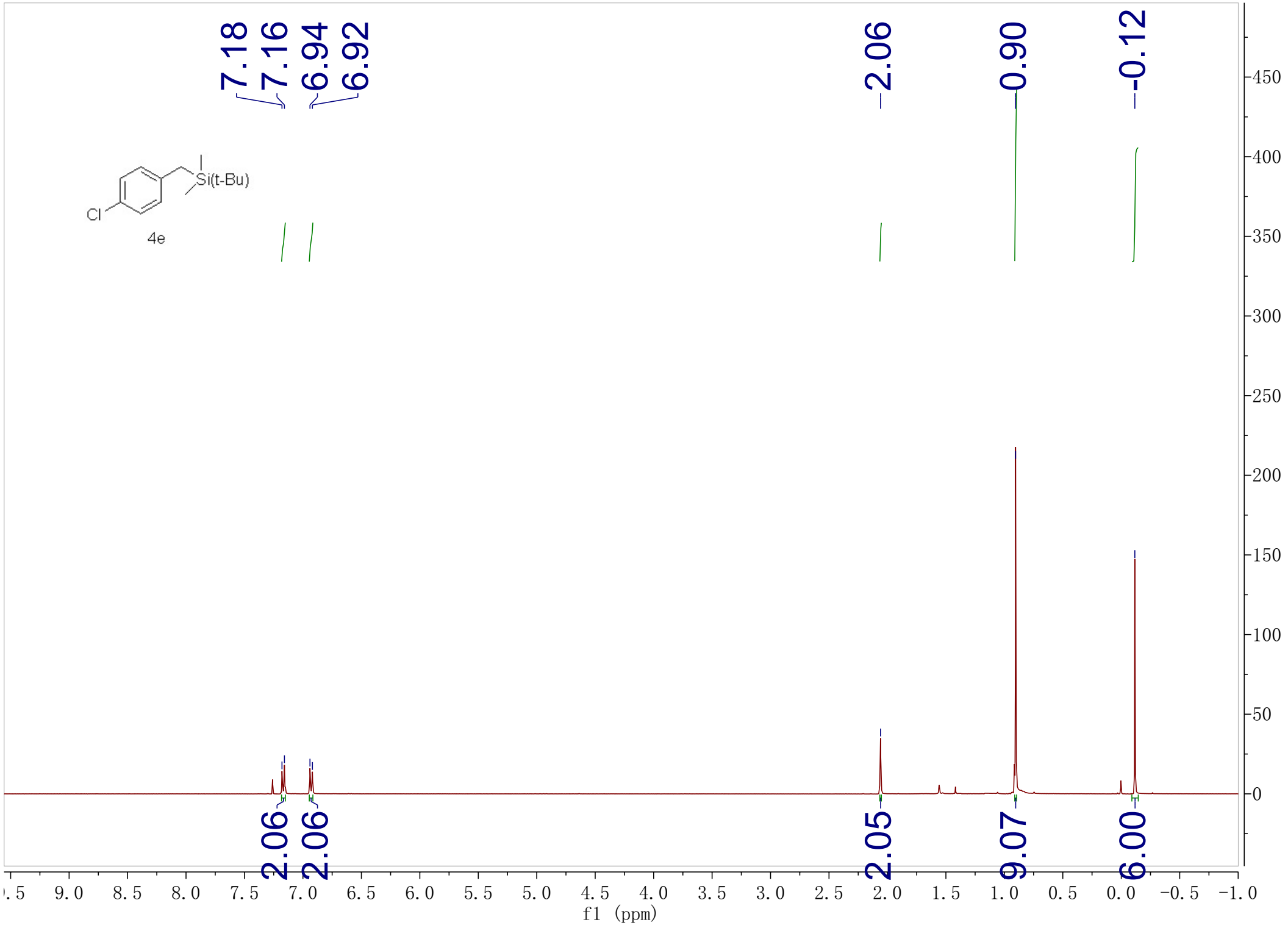
126.7
126.6
23.2
SiPh3
Ph
4d
f1 (ppm)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6.92
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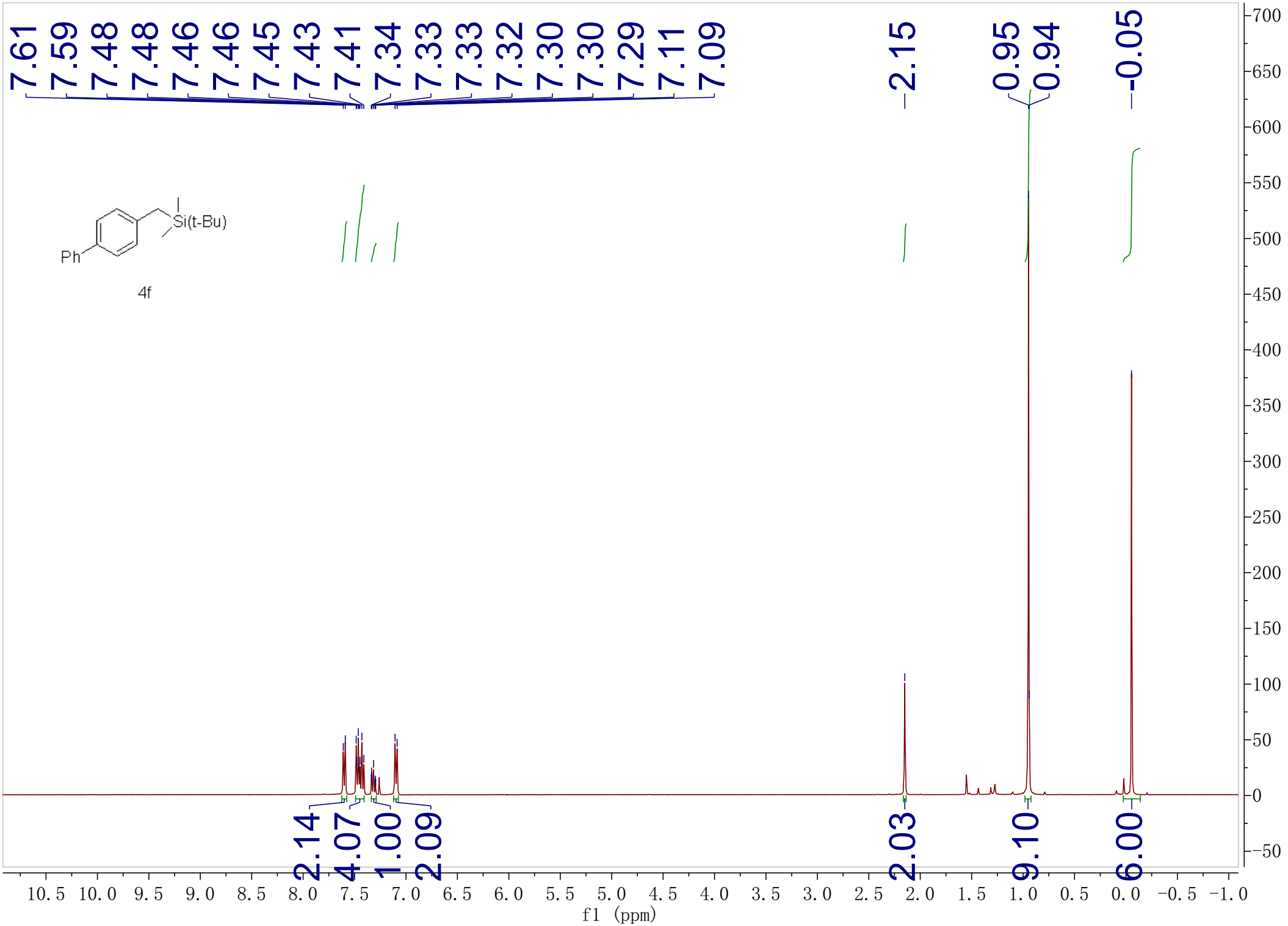
Si(t-Bu)
Cl
4e
2.06
2.06
2.05
9.07
6.00
f1 (ppm)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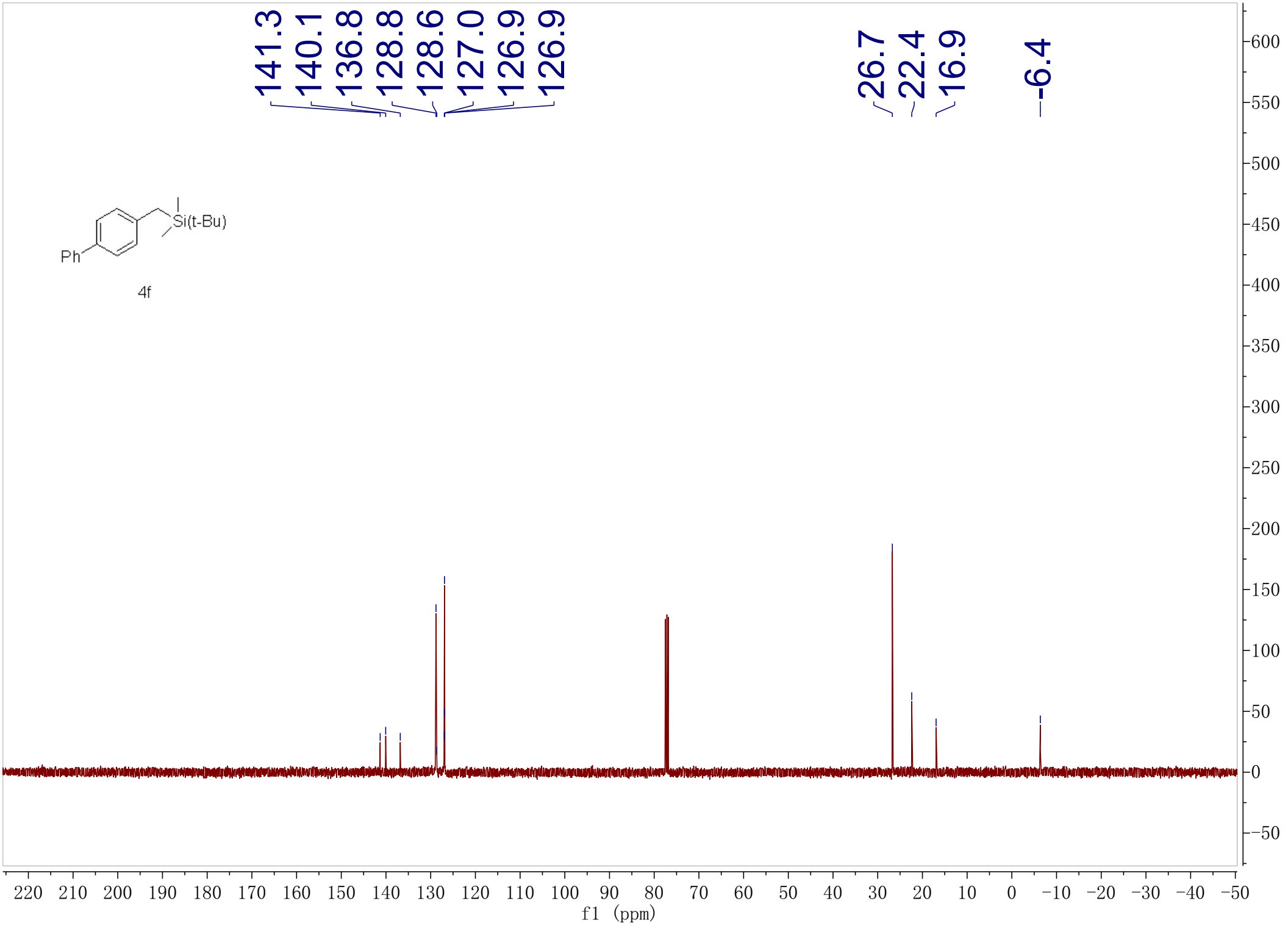
7.32
7.30
7.30
7.29
7.11
7.09
2.15
0.95
0.94
-0.05
Si(t-Bu)
Ph
4f
2.14
4.07
1.00
2.09
2.03
9.10
6.00
f1 (ppm)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126.9
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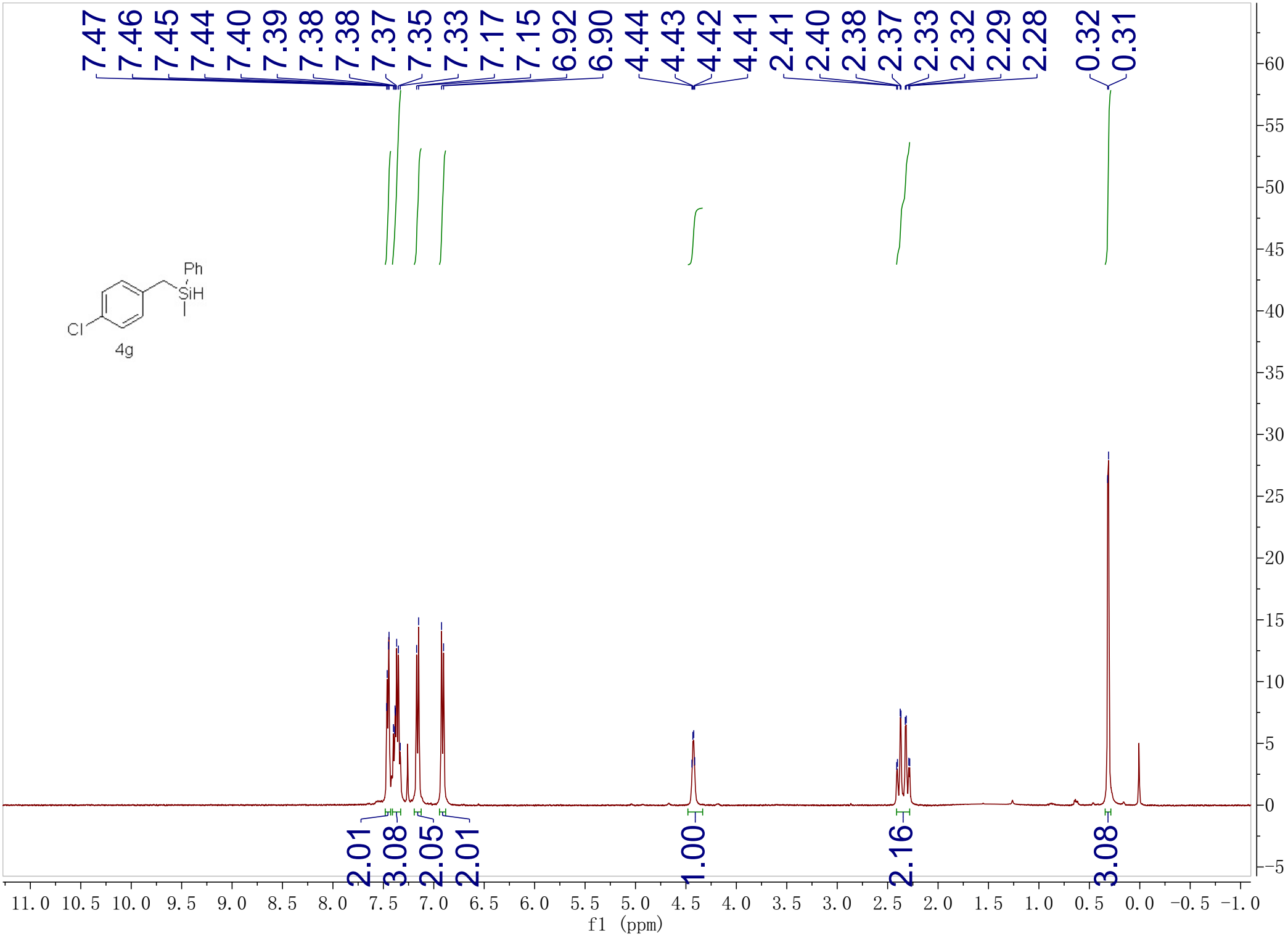
22.4
16.9
-6.4
Si(t-Bu)
Ph
4f
f1 (ppm)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7.44
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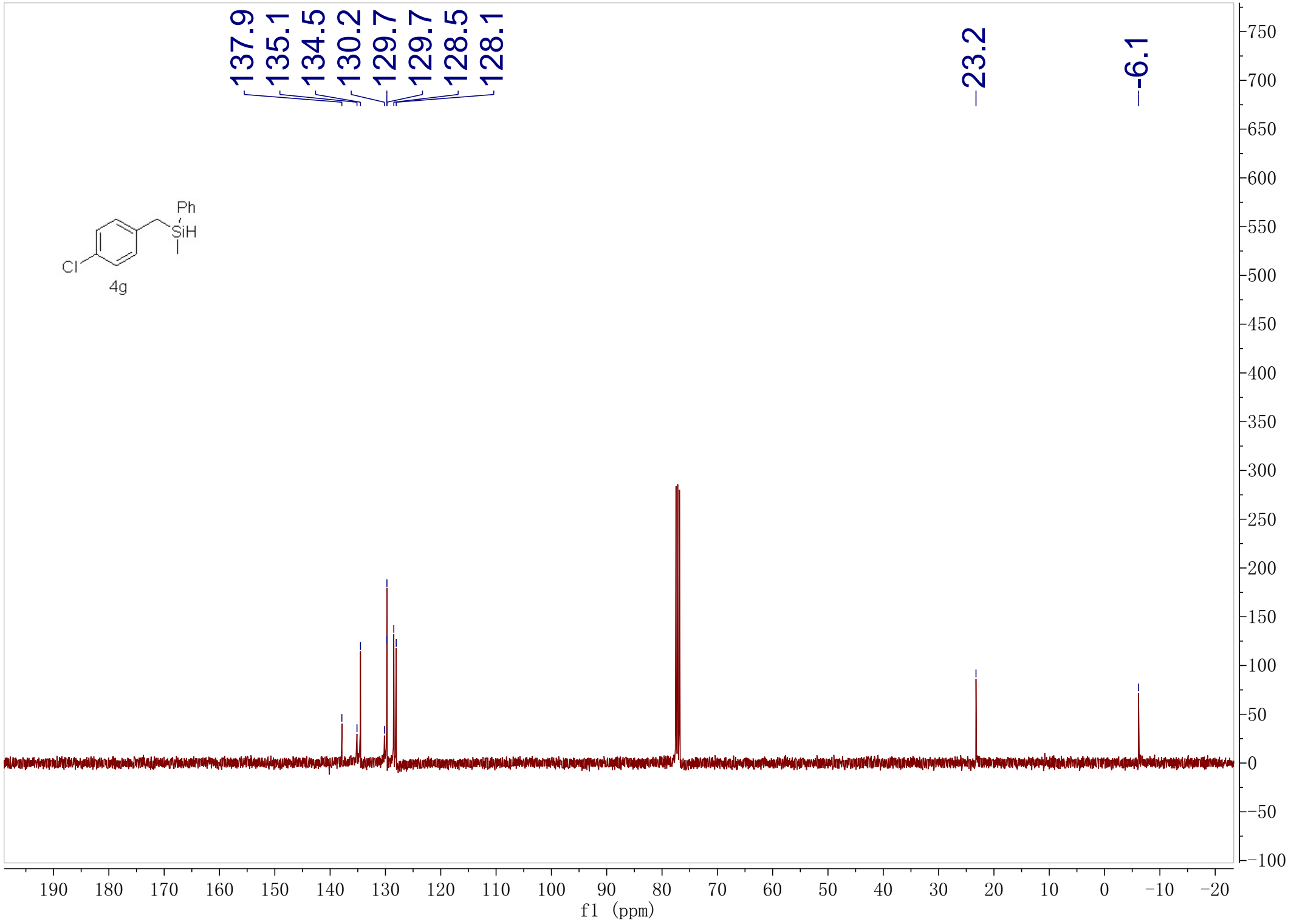
7.38
7.38
7.37
7.35
7.33
7.17
7.15
6.92
6.90
4.44
4.43
4.42
4.41
2.41
2.40
2.38
2.37
2.33
2.32
2.29
2.28
0.32
0.31
Ph
SiH
Cl
4g
2.01
3.08
2.05
2.01
1.00
2.16
3.08
f1 (ppm)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-6.1
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SiH
Cl
4g
750
700
650
600
550
500
450
400
350
300
250
200
150
100
50
0
-50
-100
190
180
170
160
150
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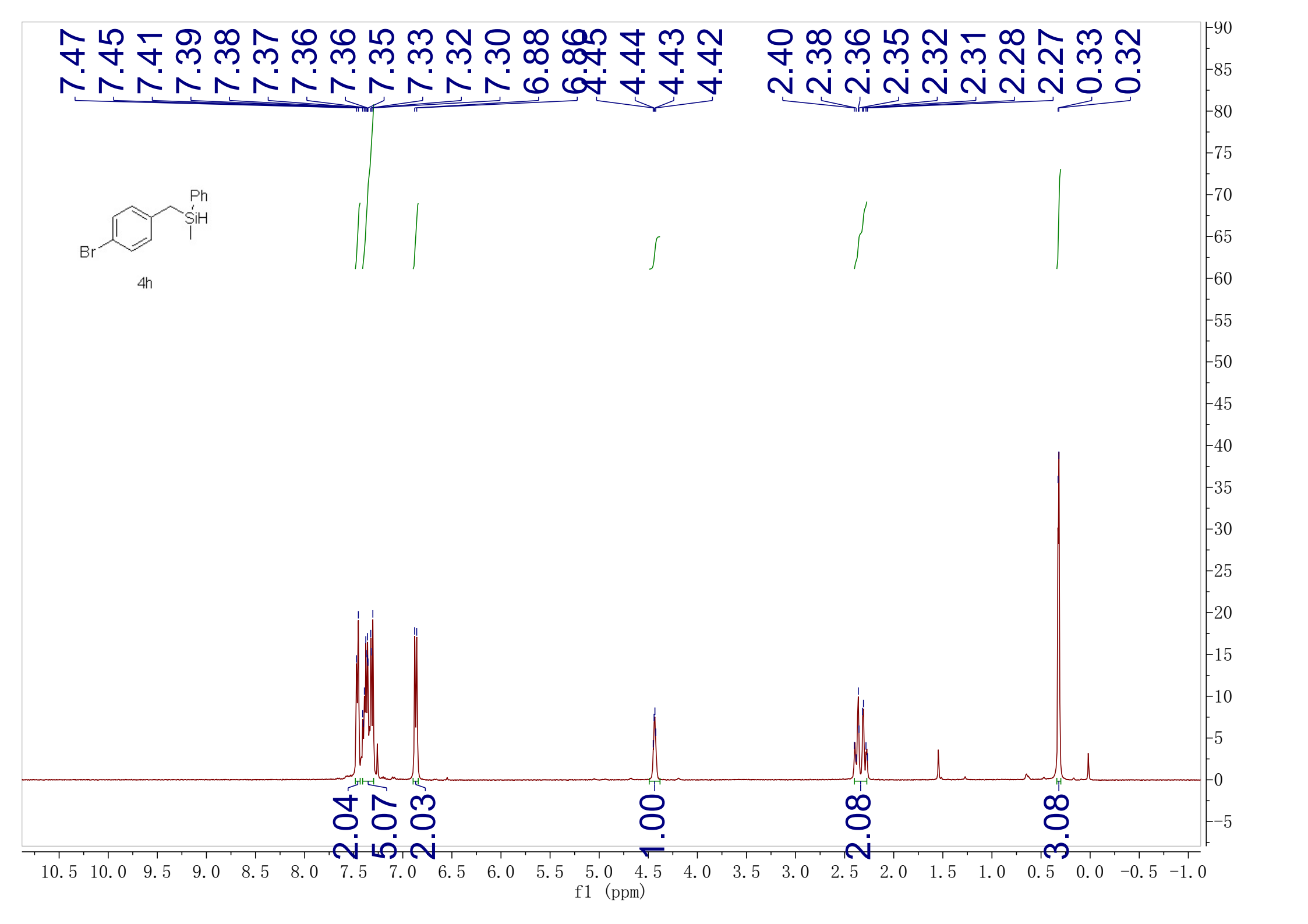
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
-20
f1 (ppm)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7.36
7.36
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7.33
7.32
7.30
6.88
6.86
6.85
4.44
4.43
4.42
2.40
2.38
2.36
2.35
2.32
2.31
2.28
2.27
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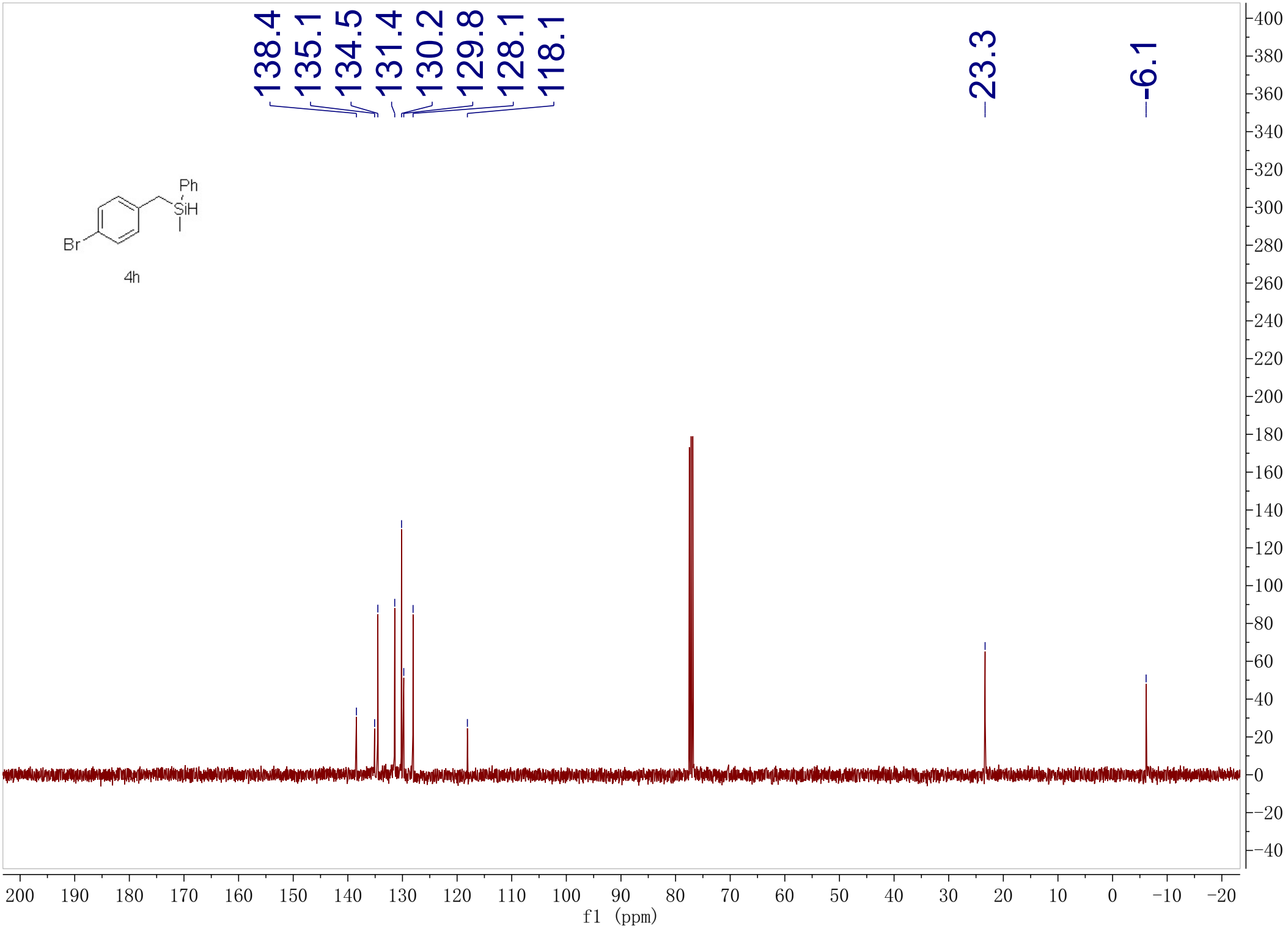
0.32
Ph
SiH
Br
4h
2.04
5.07
2.03
1.00
2.08
3.08
f1 (ppm)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135.1
134.5
131.4
130.2
129.8
128.1
118.1
23.3
-6.1
Ph
SiH
Br
4h
400
380
360
340
320
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
200
190
180
170
160
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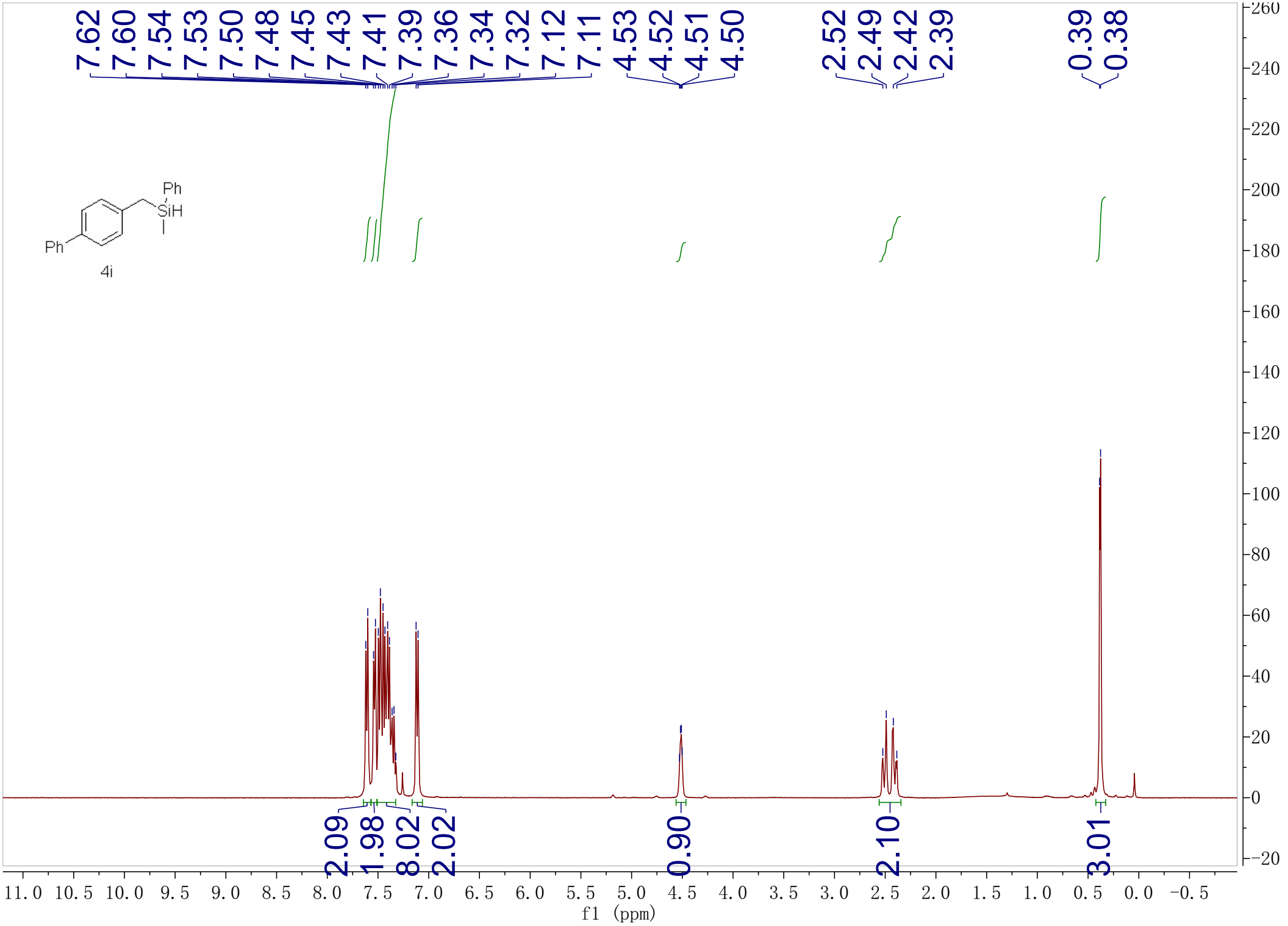
100
90
80
70
60
50
40
30
20
10
0
-10
-20
f1 (ppm)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7.45
7.43
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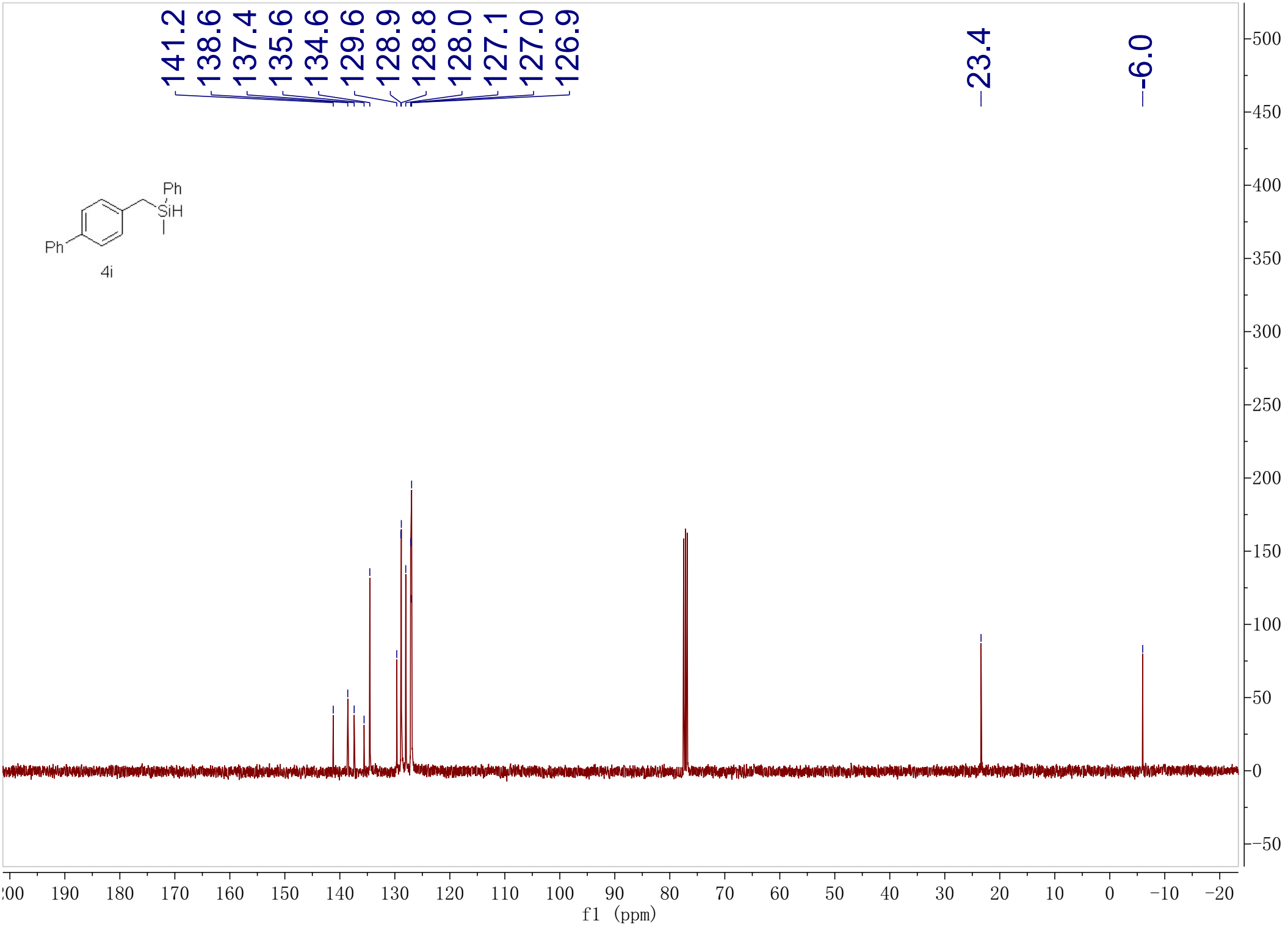
7.39
7.36
7.34
7.32
7.12
7.11
4.53
4.52
4.51
4.50
2.52
2.49
2.42
2.39
0.39
0.38
Ph
SiH
Ph
4i
2.09
1.98
8.02
2.02
0.90
2.10
3.01
f1 (ppm)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135.6
134.6
129.6
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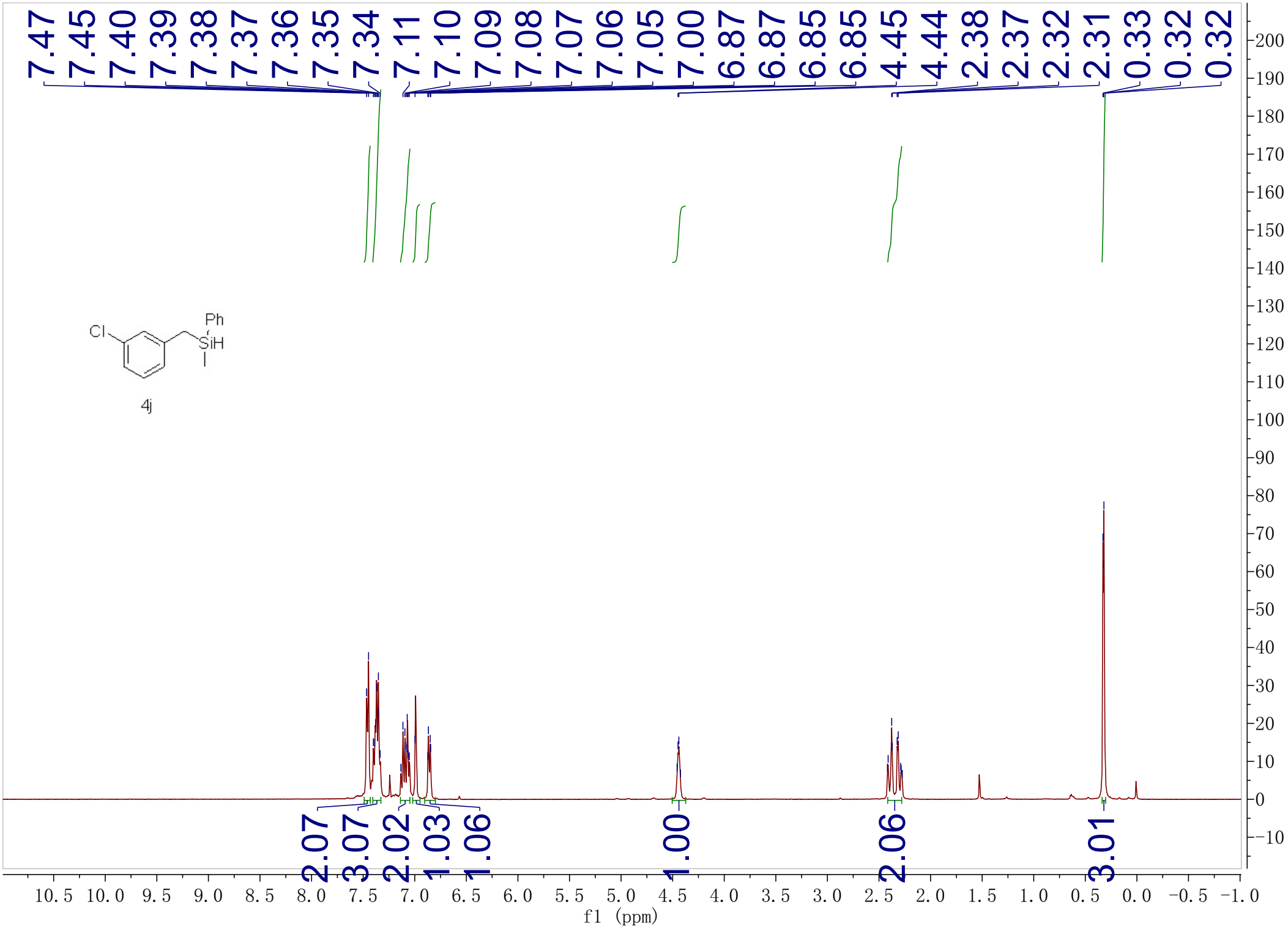
128.8
128.0
127.1
127.0
126.9
-23.4
-6.0
Ph
SiH
Ph
4i
f1 (ppm)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7.38
7.37
7.36
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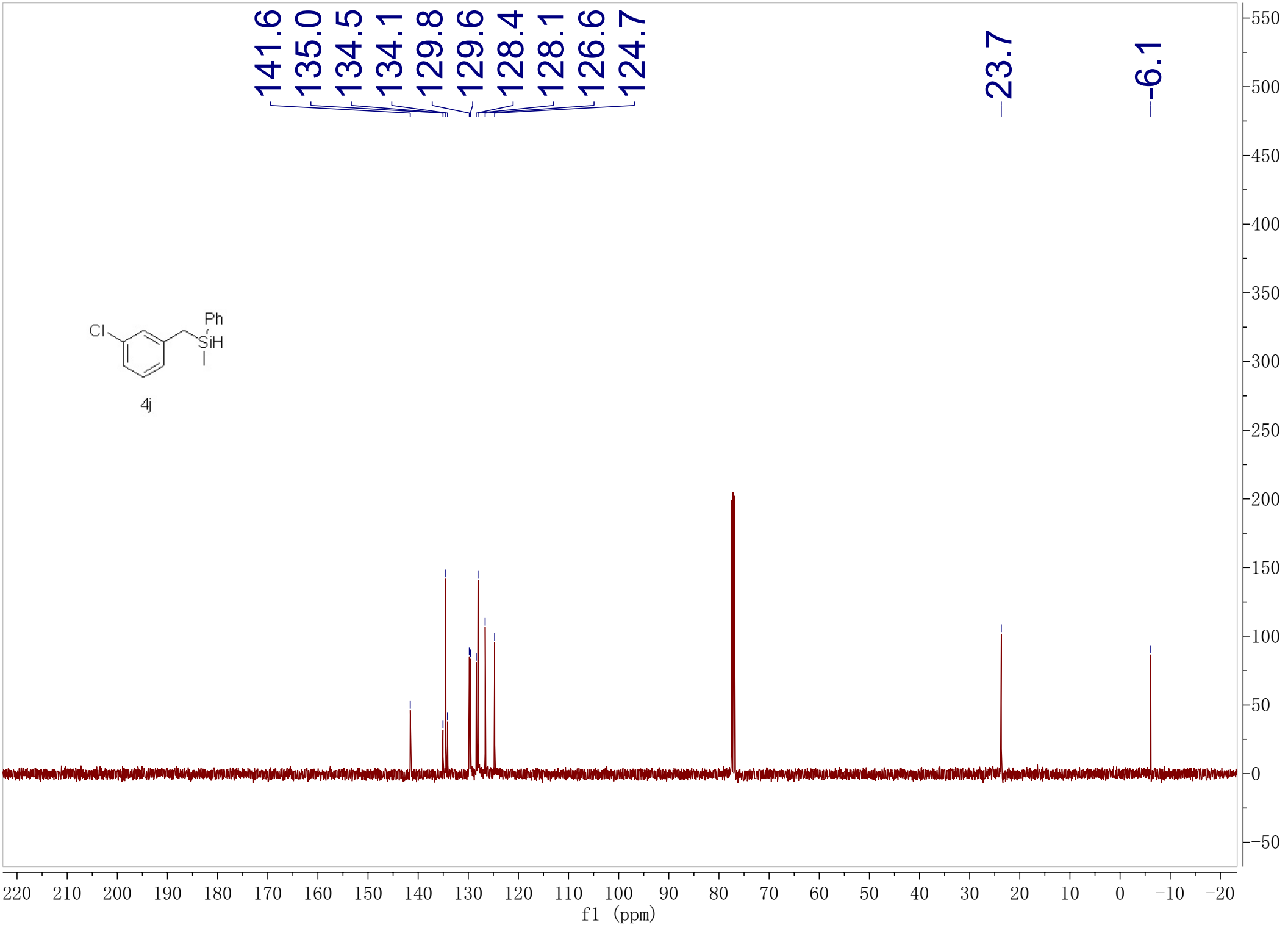
7.34
7.11
7.10
7.09
7.08
7.07
7.06
7.05
7.00
6.87
6.87
6.85
6.85
4.45
4.44
2.38
2.37
2.32
2.31
0.33
0.32
0.32
Cl
Ph
SiH
4j
2.07
3.07
2.02
1.03
1.06
1.00
2.06
3.01
f1 (ppm)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134.1
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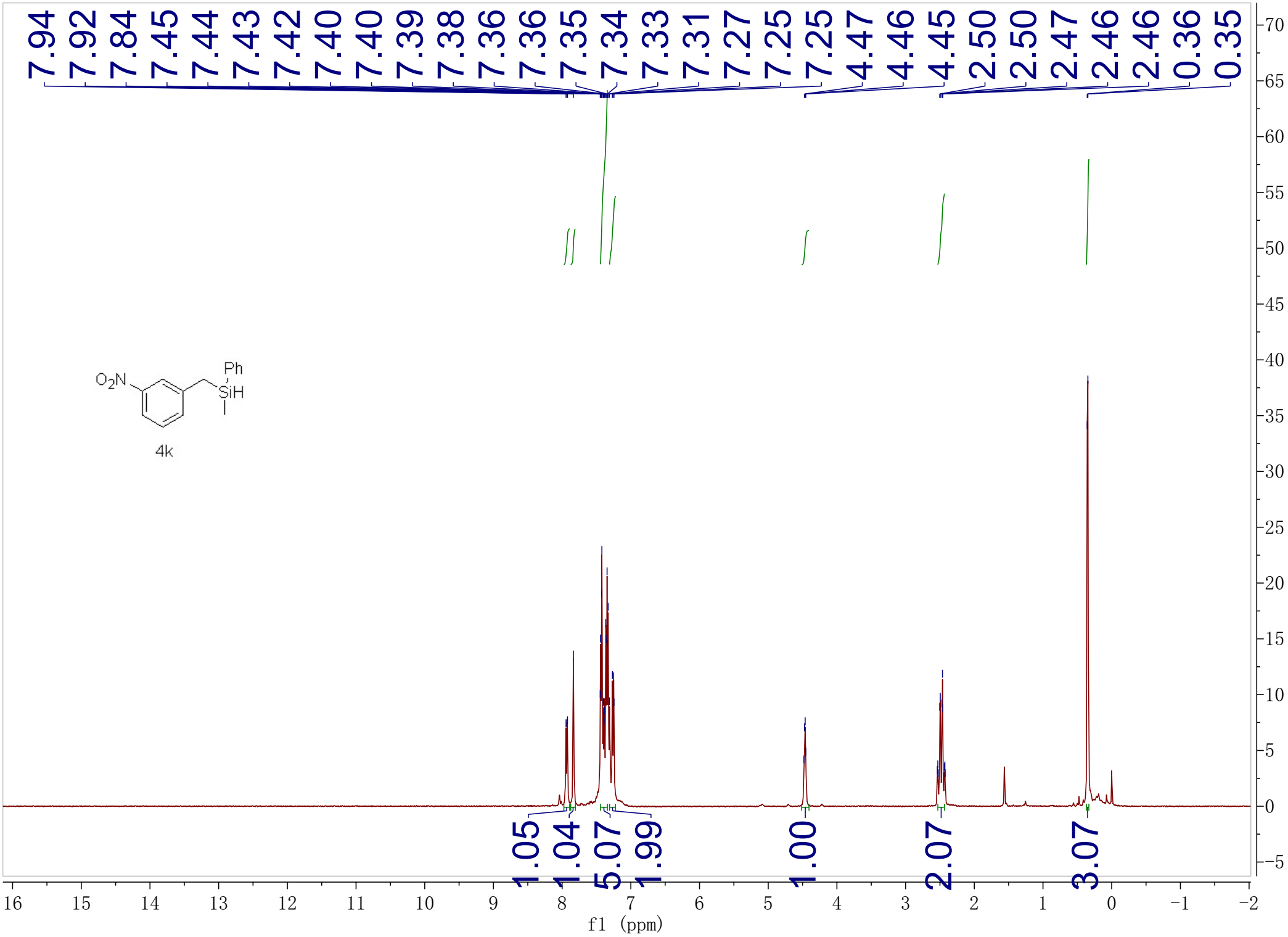
128.1
126.6
124.7
-23.7
-6.1
Cl
Ph
SiH
4j
f1 (ppm)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7.40
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7.38
7.36
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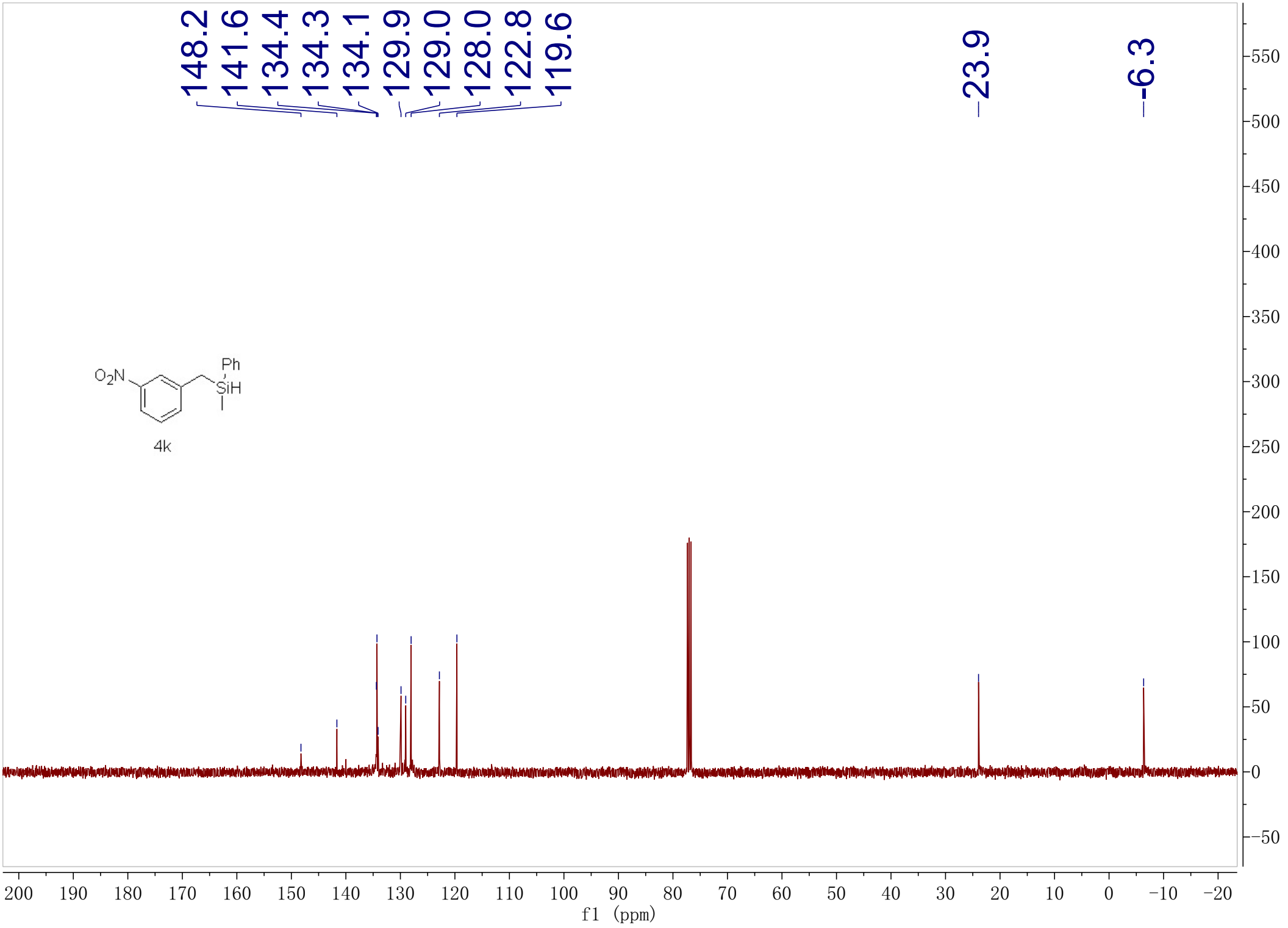
7.35
7.34
7.33
7.31
7.27
7.25
7.25
4.47
4.46
4.45
2.50
2.50
2.47
2.46
2.46
0.36
0.35
O2N
Ph
SiH
4k
1.05
1.04
5.07
1.99
1.00
2.07
3.07
f1 (ppm)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134.1
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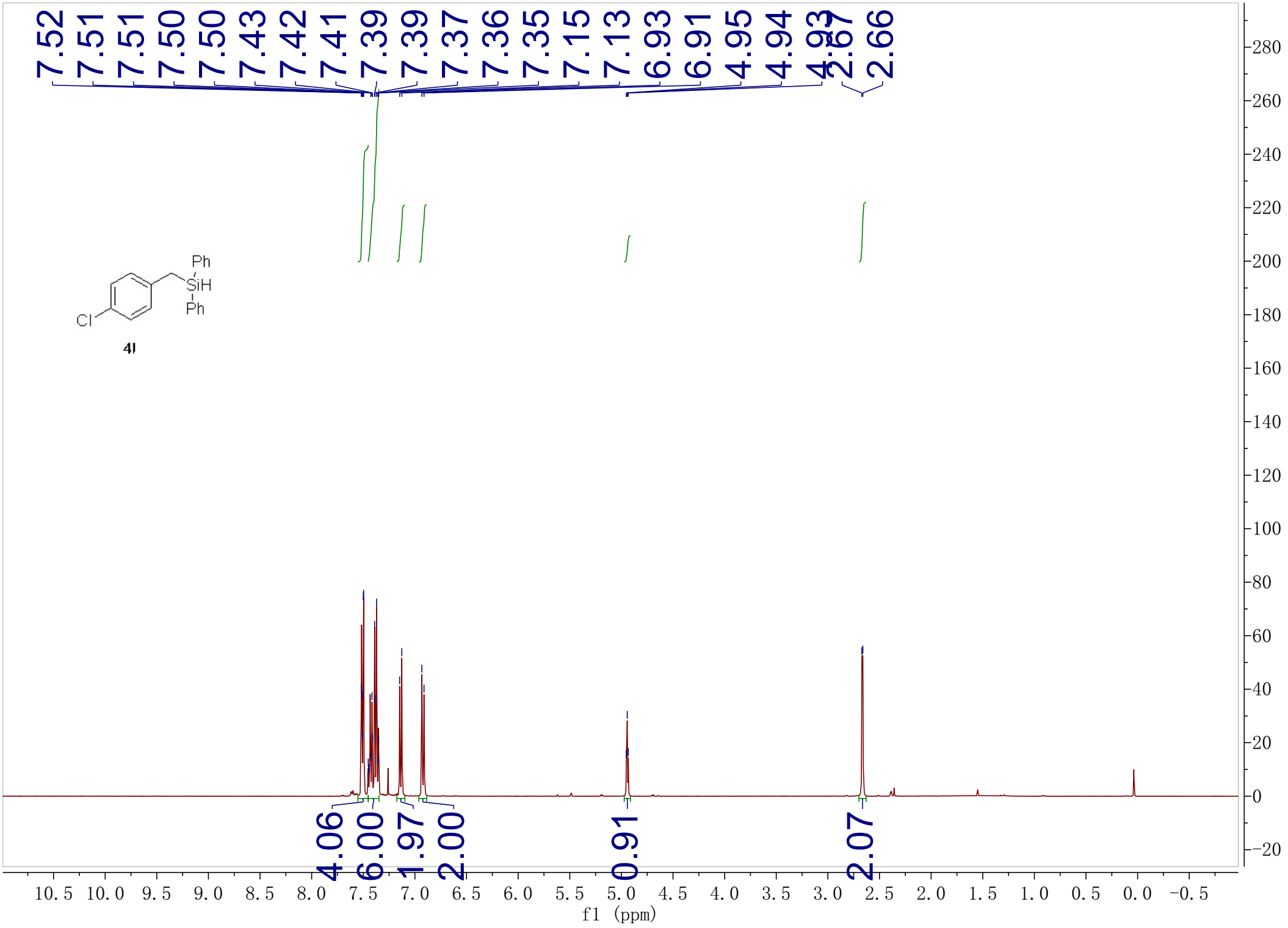
129.0
128.0
122.8
119.6
-23.9
-6.3
O2N
Ph
SiH
4k
550
500
450
400
350
300
250
200
150
100
50
0
-50
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10 -20
f1 (ppm)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7.39
7.37
7.36
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7.15
7.13
6.93
6.91
4.95
4.94
4.93
2.67
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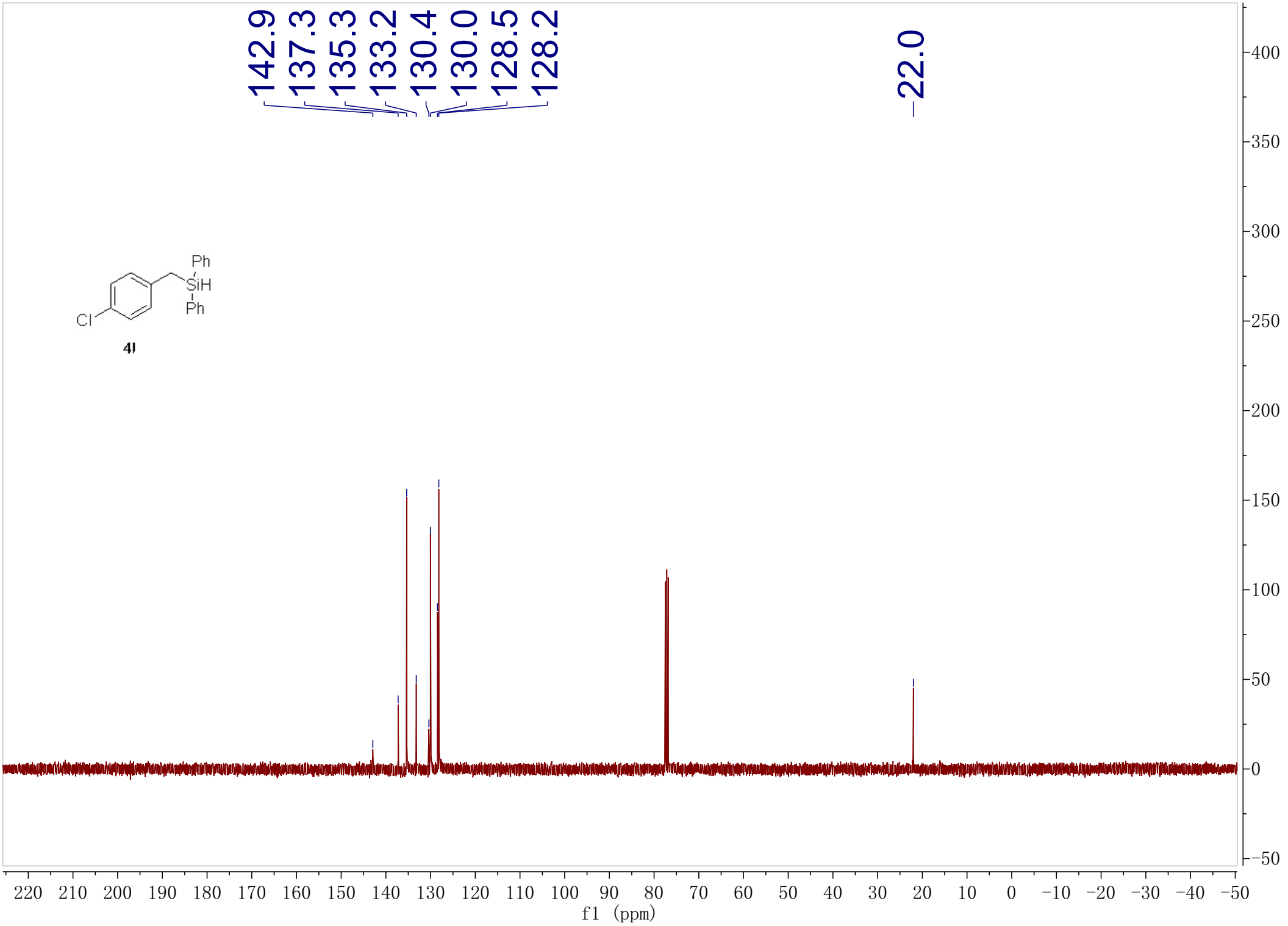
SiH
Ph
Cl
4l
4.06
6.00
1.97
2.00
0.91
2.07
f1 (ppm)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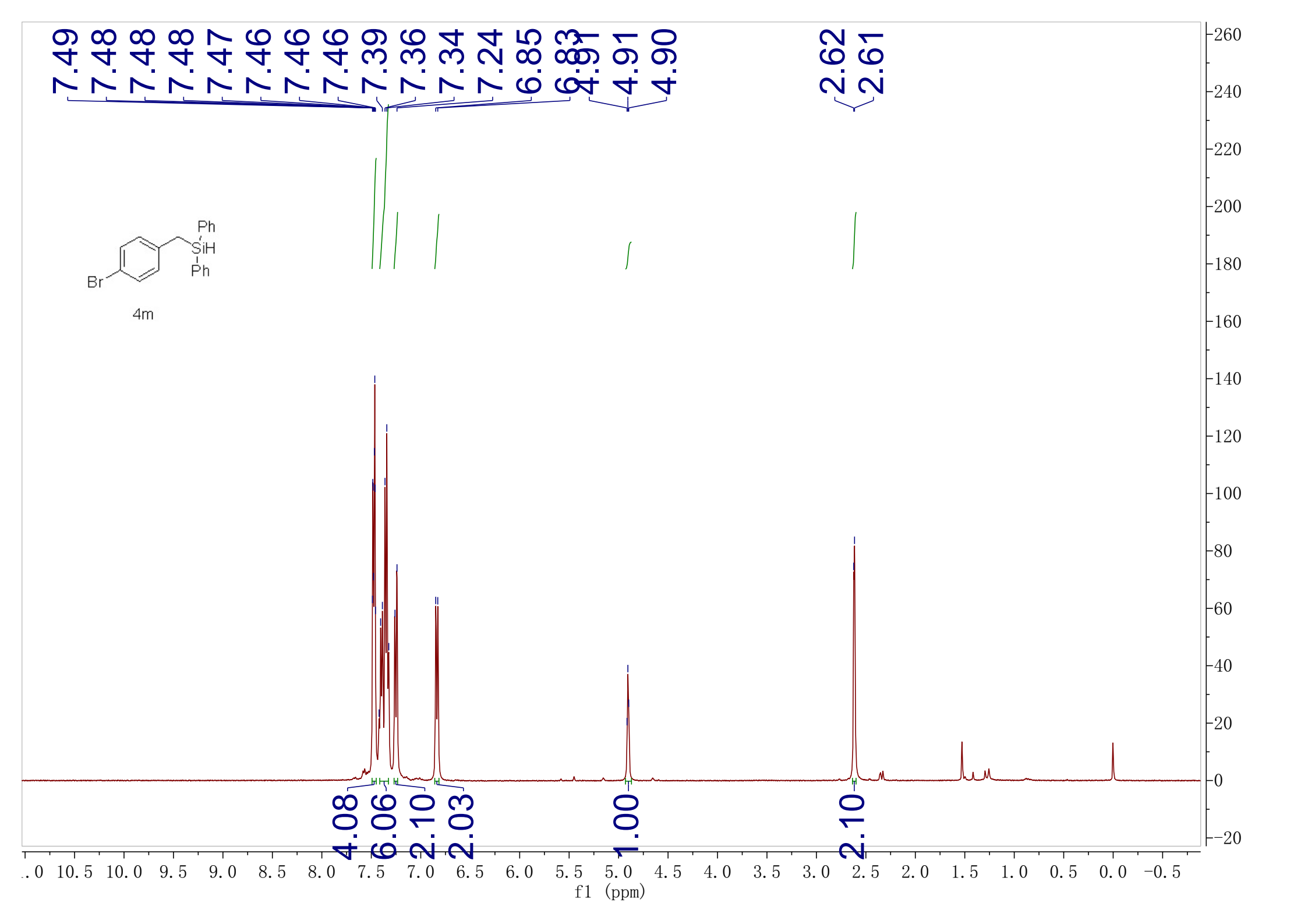
137.3
135.3
133.2
130.4
130.0
128.5
128.2
22.0
Ph
SiH
Ph
Cl
4l
400
350
300
250
200
150
100
50
0
−50
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10 −20 −30 −40 −50
f1 (ppm)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7.36
7.34
7.24
6.85
6.83
4.91
4.91
4.90
2.62
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Ph
Br
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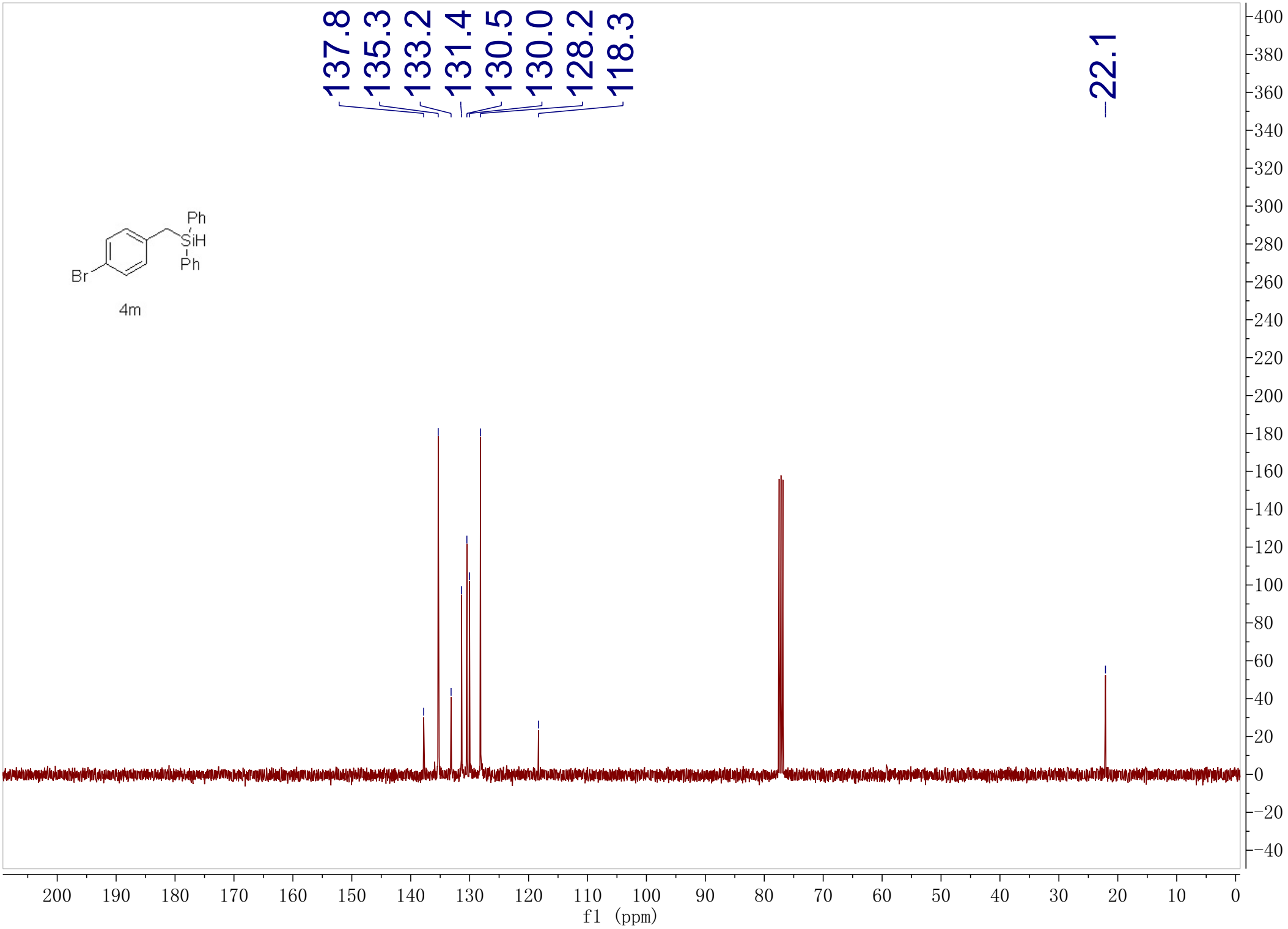
4.08
6.06
2.10
2.03
1.00
2.10
f1 (ppm)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128.2
118.3
-22.1
Ph
SiH
Ph
Br
4m
400
380
360
340
320
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
200
190
180
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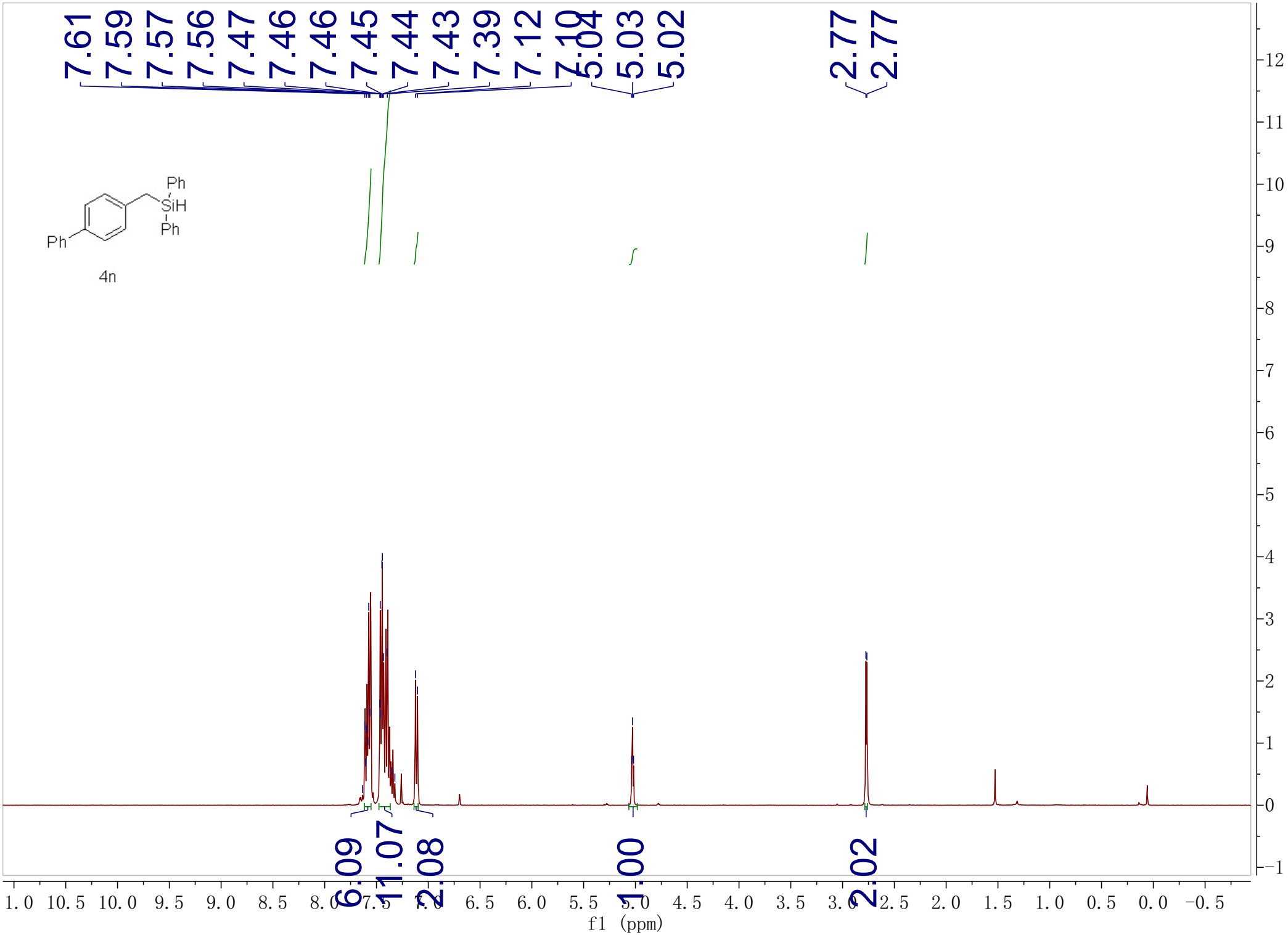
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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7.44
7.43
7.39
7.12
7.10
5.04
5.03
5.02
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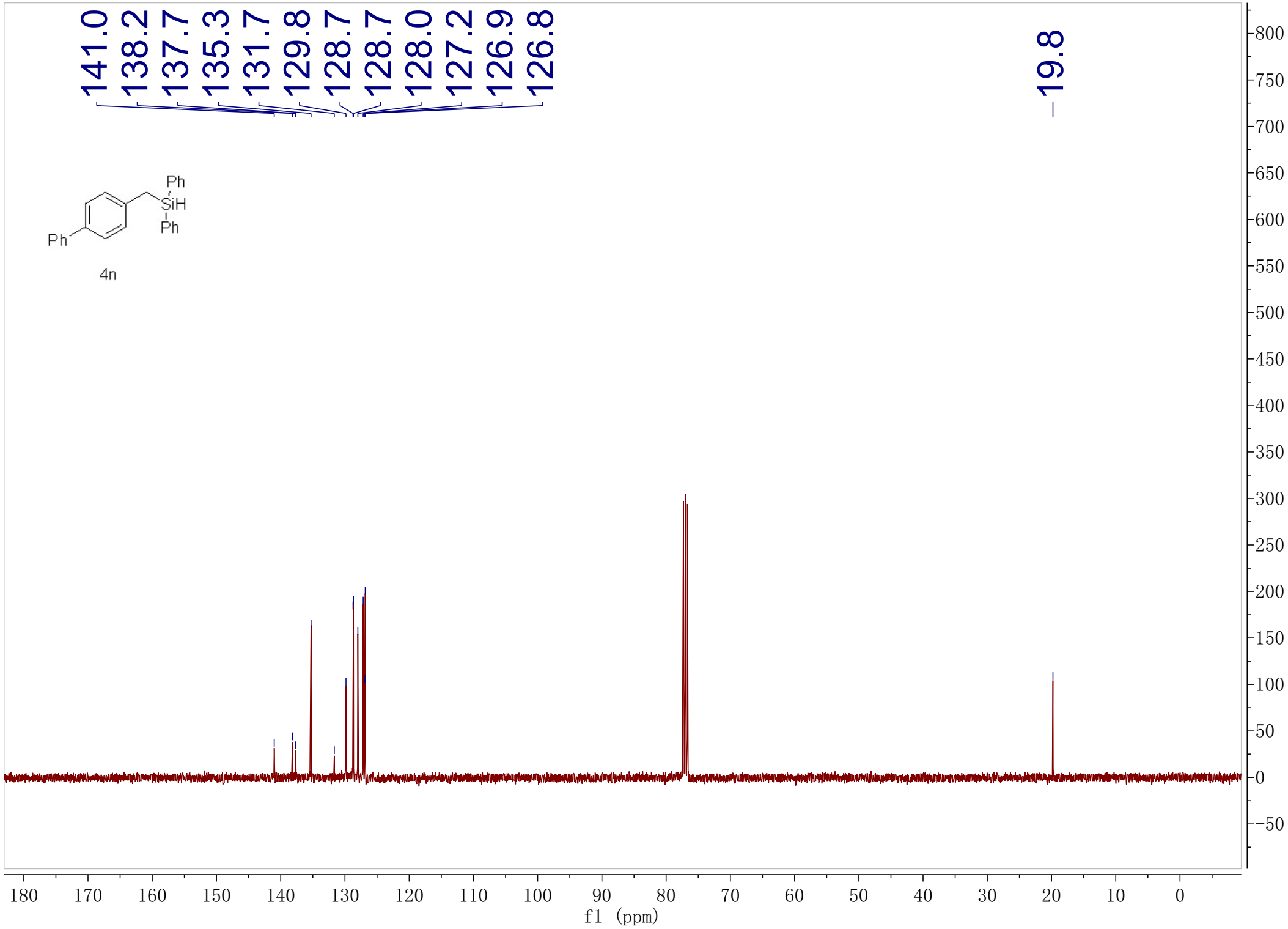
2.77
Ph
SiH
Ph
Ph
4n
6.09
11.07
2.08
1.00
2.02
f1 (ppm)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127.2
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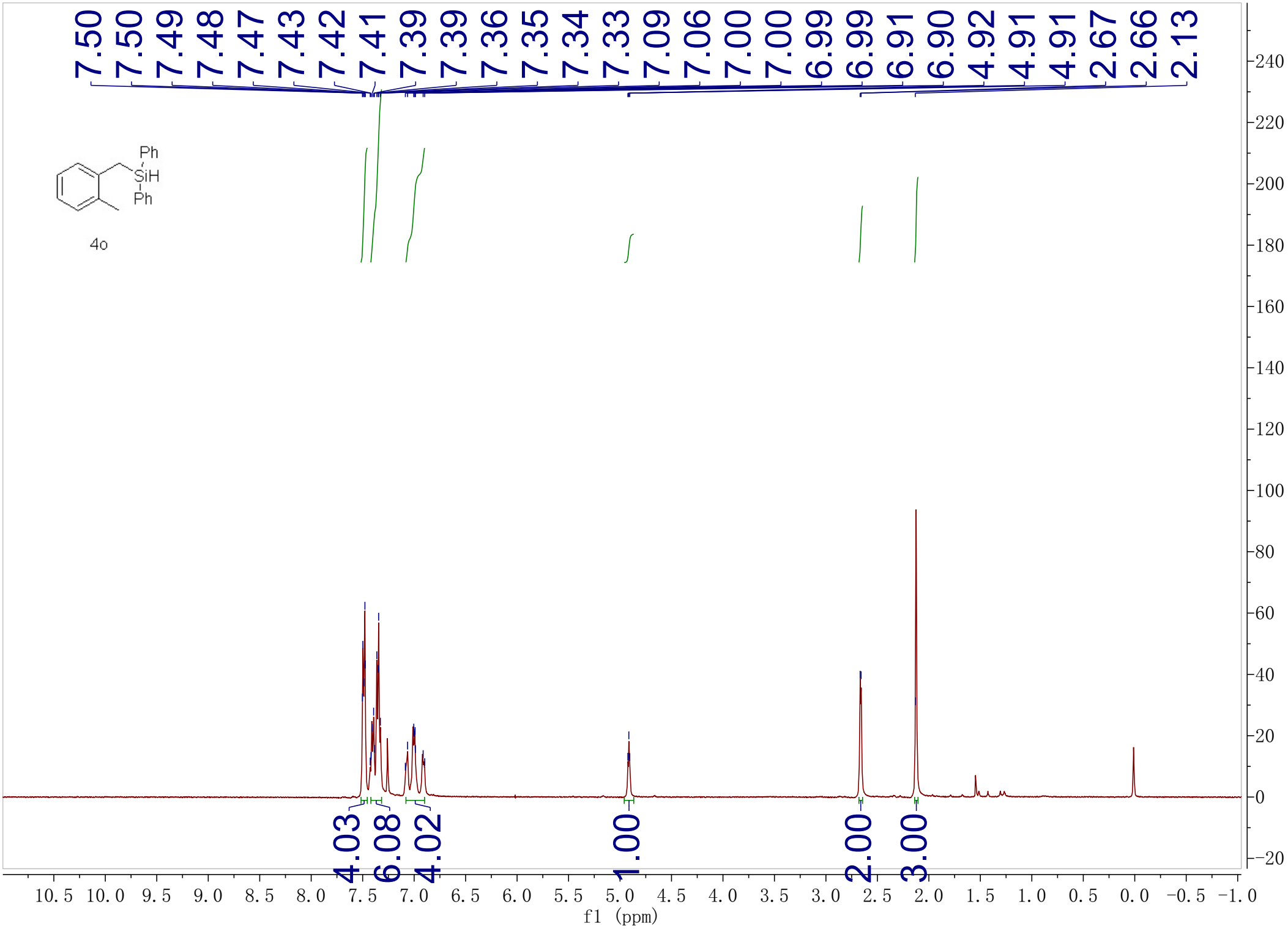
126.8
19.8
Ph
SiH
Ph
Ph
4n
f1 (ppm)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7.34
7.33
7.09
7.06
7.00
7.00
6.99
6.99
6.91
6.90
4.92
4.91
4.91
2.67
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2.13
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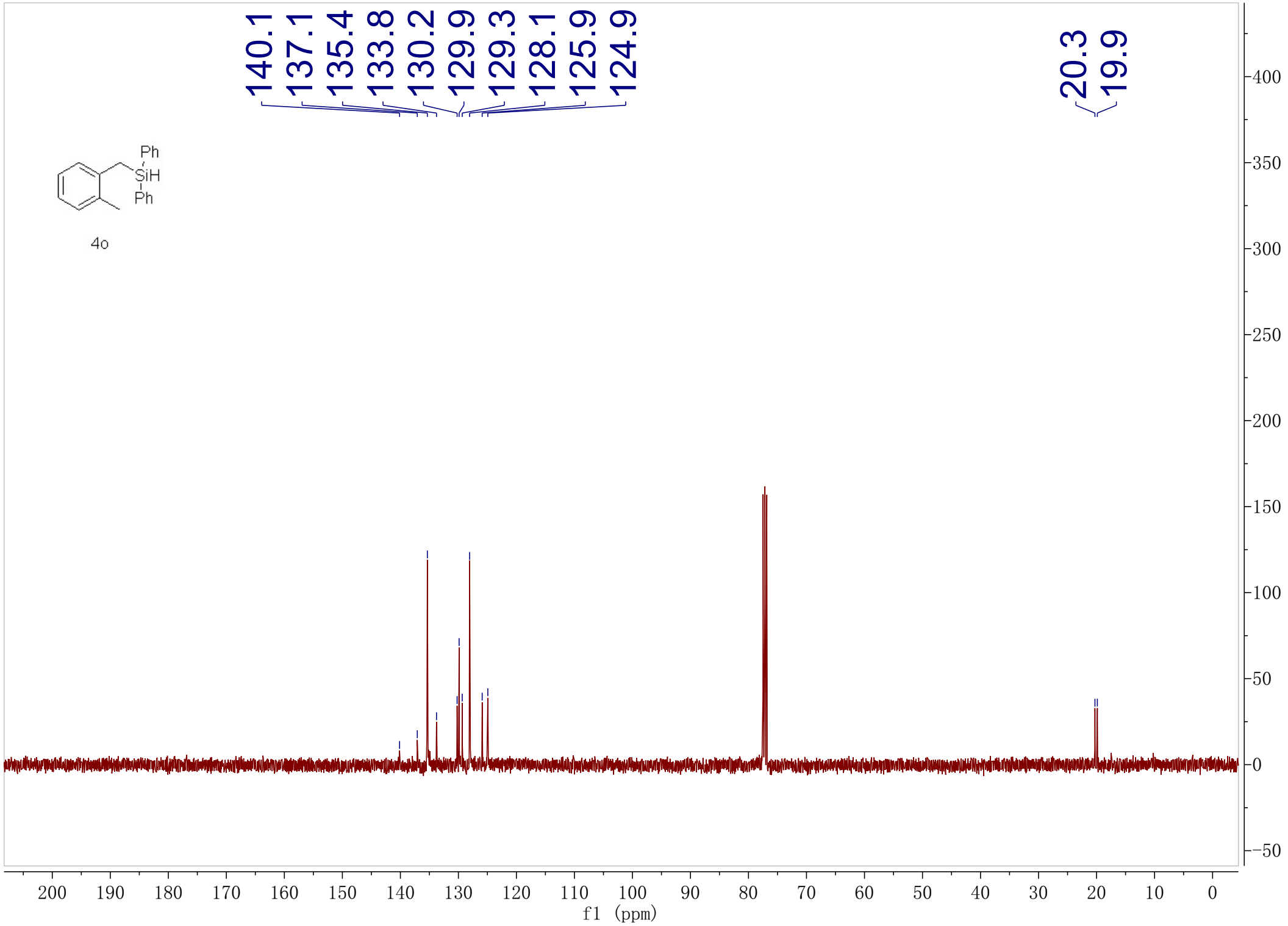
SiH
Ph
4o
4.03
6.08
4.02
1.00
2.00
3.00
f1 (ppm)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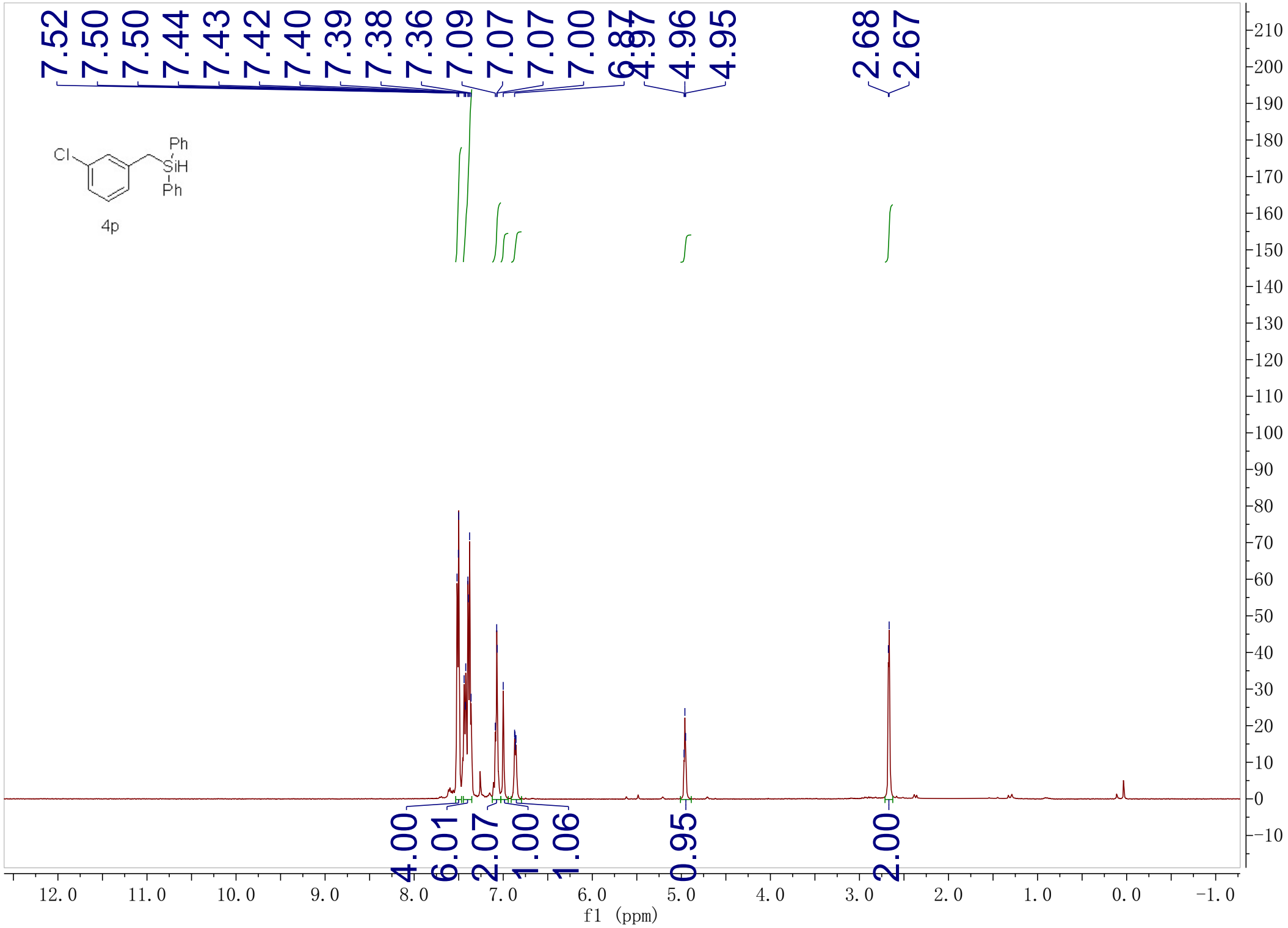
129.9
129.3
128.1
125.9
124.9
20.3
19.9
Ph
SiH
Ph
4o
400
350
300
250
200
150
100
50
0
−50
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)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7.42
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7.39
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7.36
7.09
7.07
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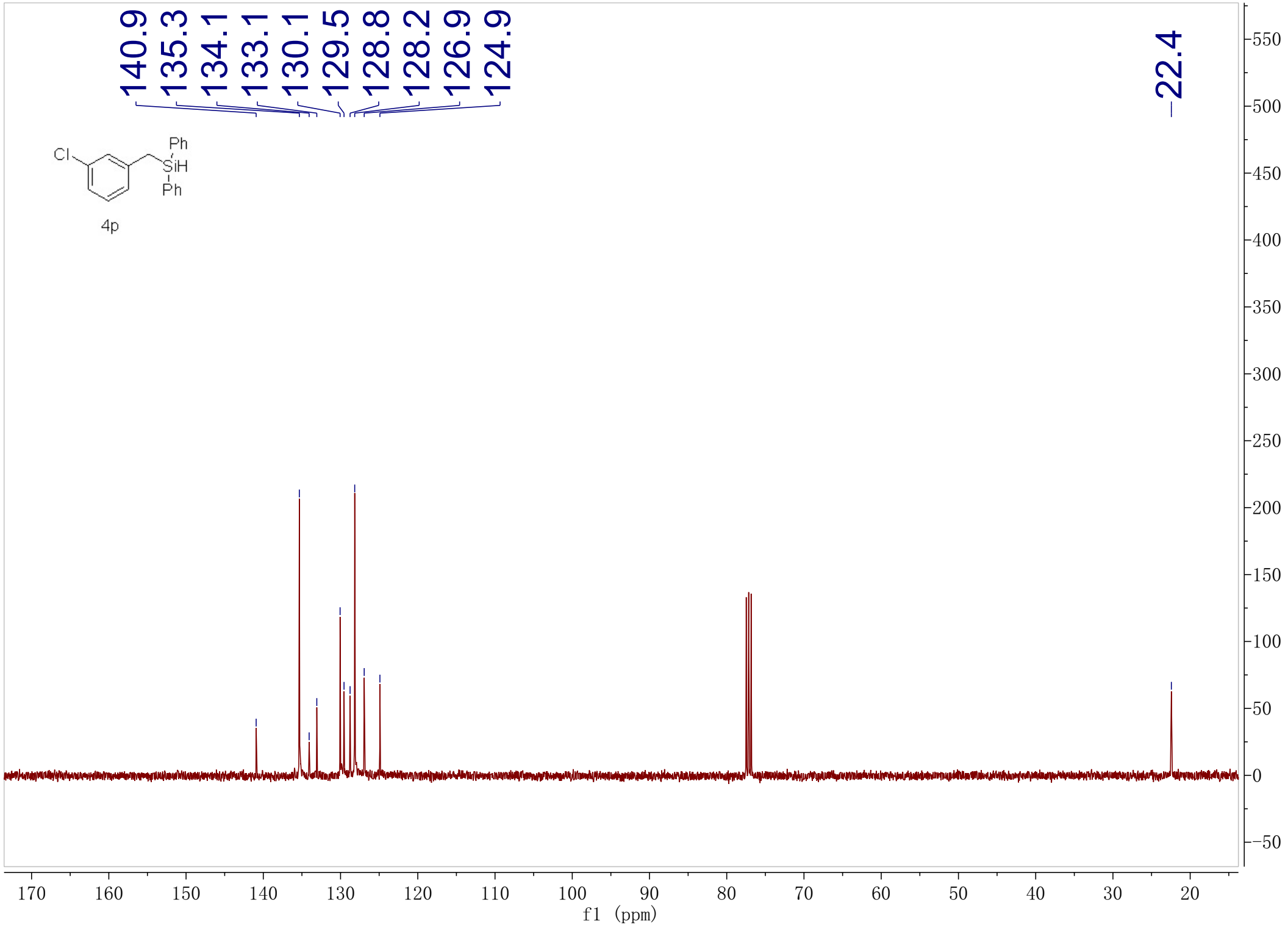
7.00
6.87
4.97
4.96
4.95
2.68
2.67
Cl
Ph
SiH
Ph
4p
4.00
6.01
2.07
1.00
1.06
0.95
2.00
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
f1 (ppm)
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10


140.9
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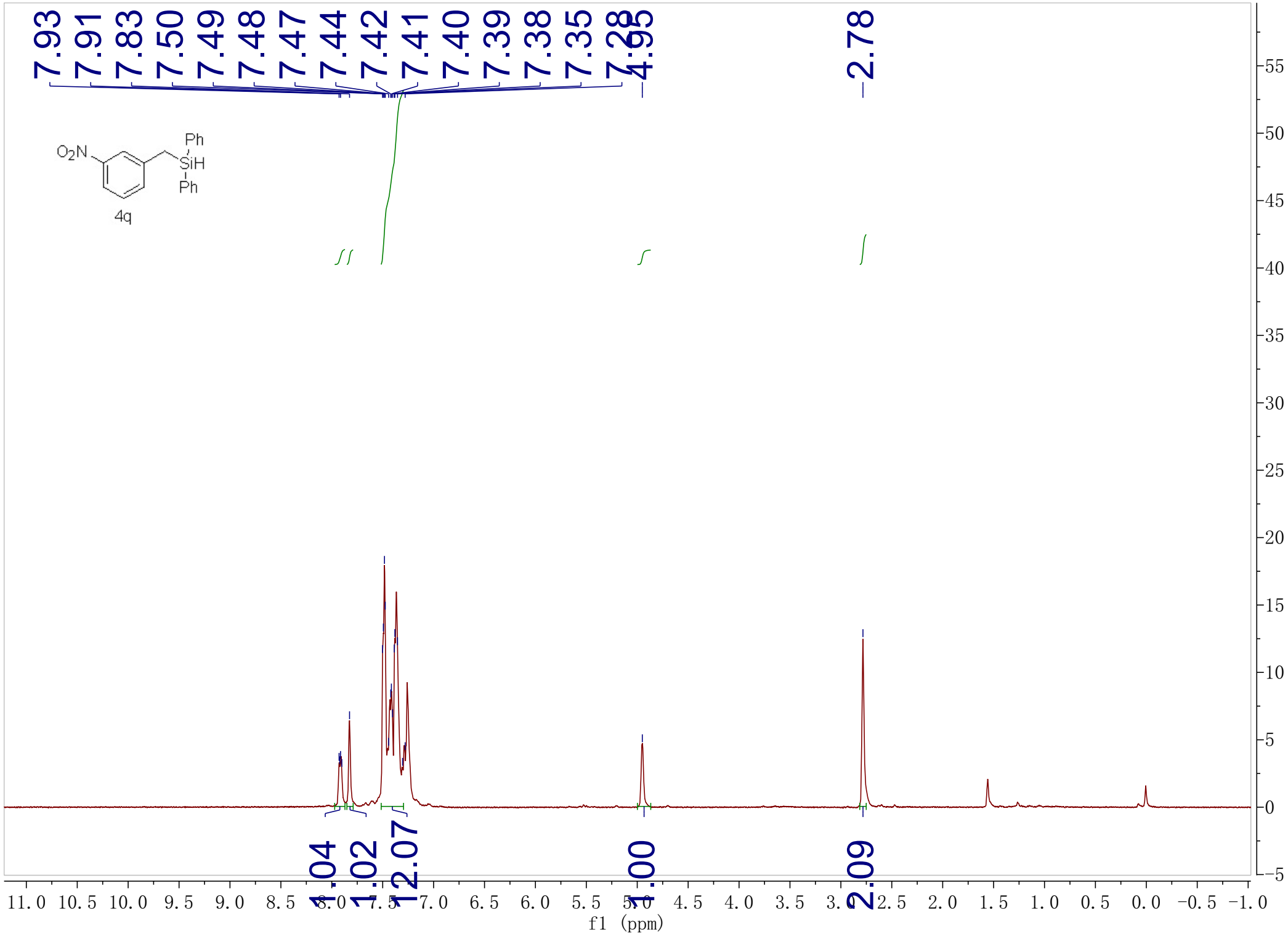
134.1
133.1
130.1
129.5
128.8
128.2
126.9
124.9
-22.4
Cl
Ph
SiH
Ph
4p
550
500
450
400
350
300
250
200
150
100
50
0
-50
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
f1 (ppm)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7.41
7.40
7.39
7.38
7.35
7.28
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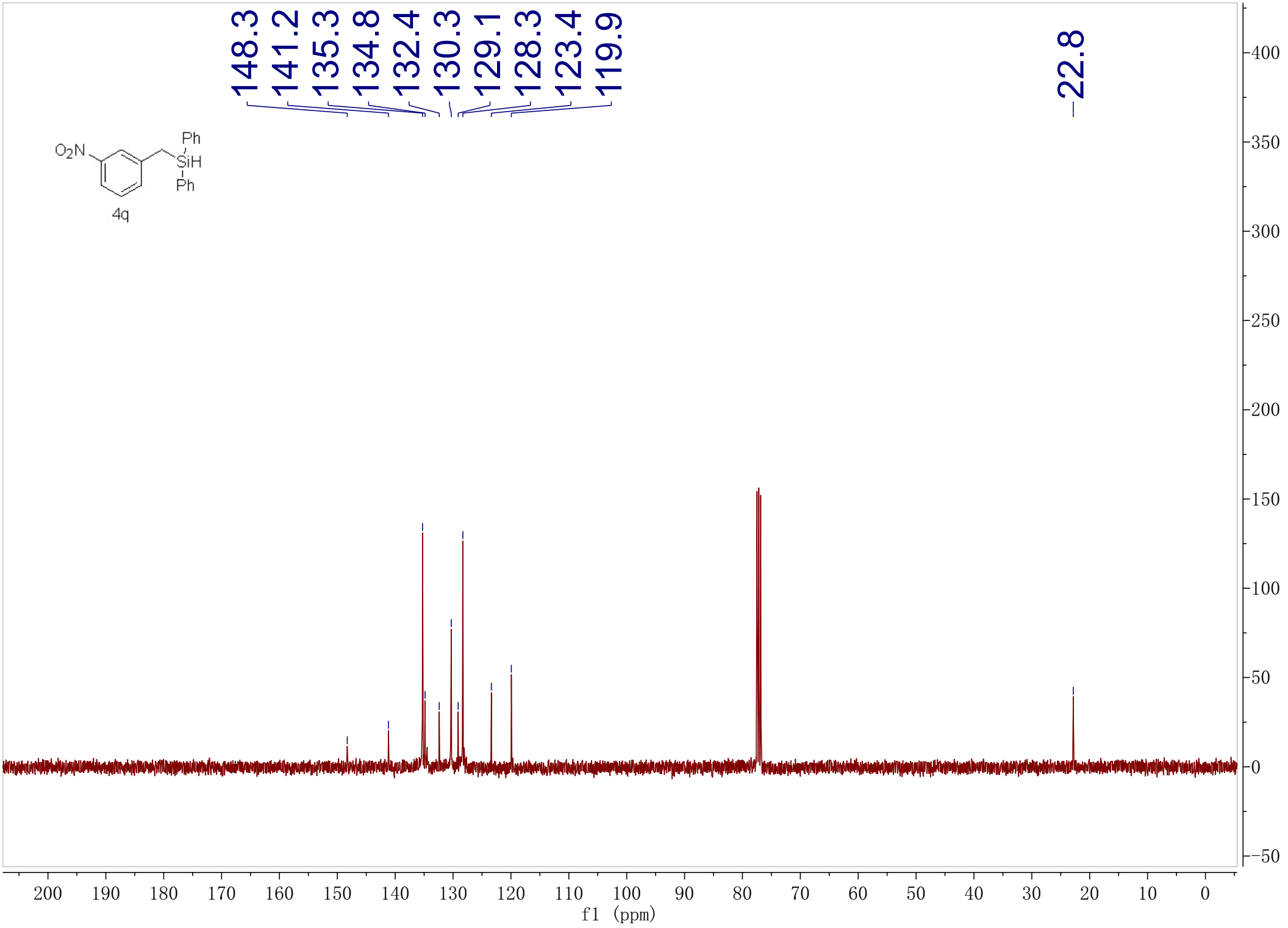
2.78
O2N
Ph
SiH
Ph
4q
1.04
1.02
2.07
1.00
2.09
f1 (ppm)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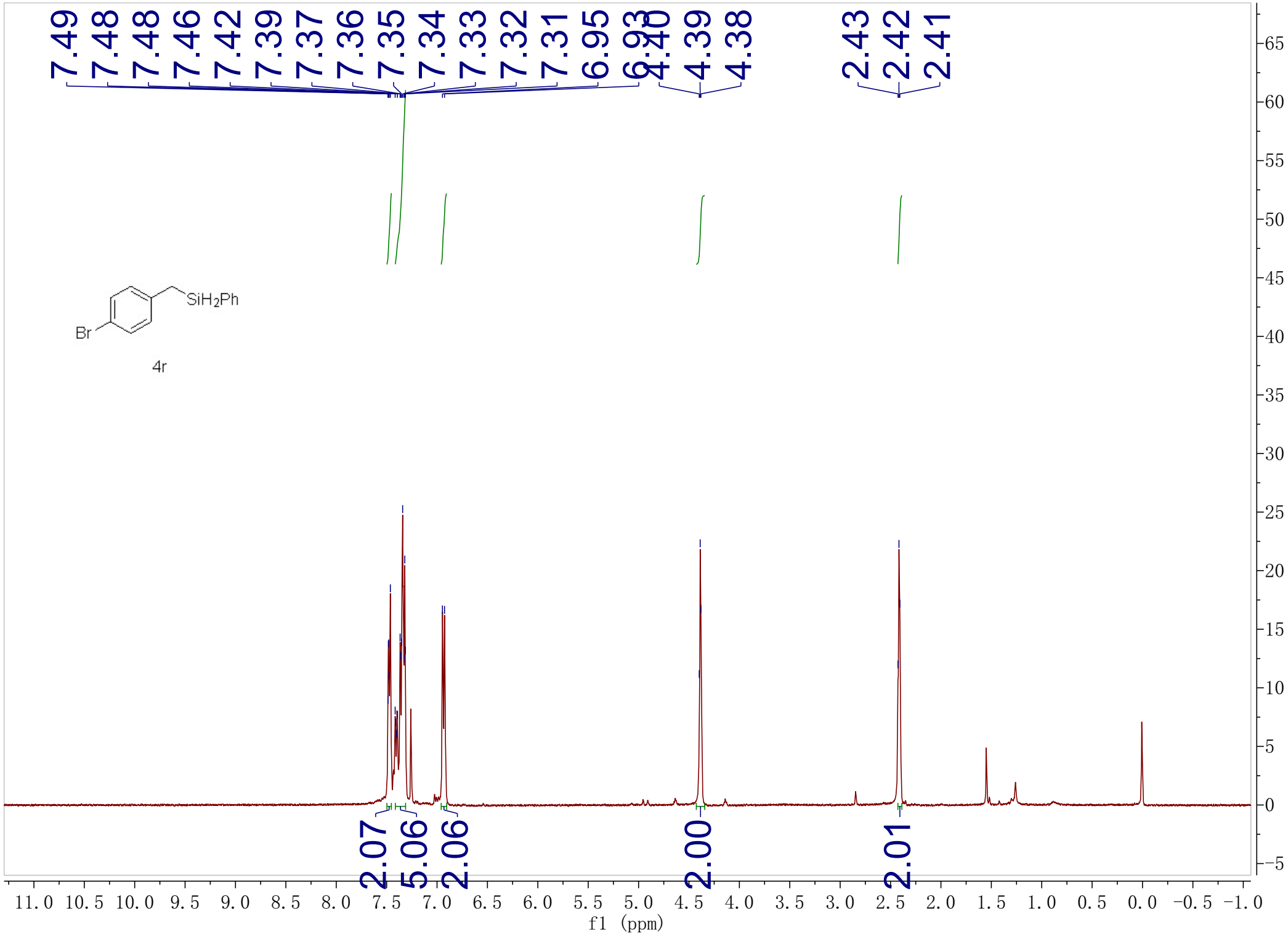
129.1
128.3
123.4
119.9
22.8
O2N
Ph
SiH
Ph
4q
400
350
300
250
200
150
100
50
0
-50
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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7.46
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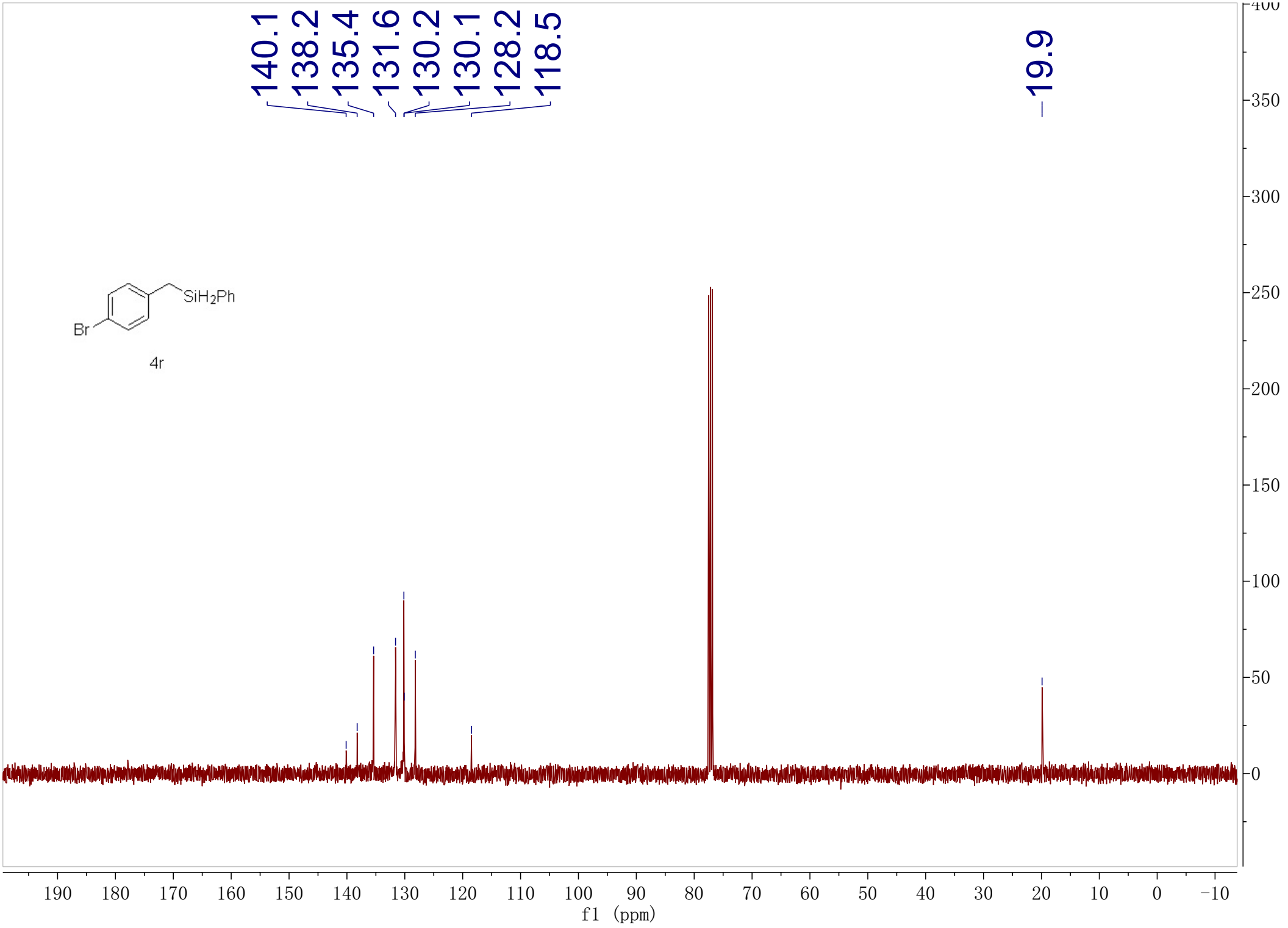
7.33
7.32
7.31
6.95
6.93
4.40
4.39
4.38
2.43
2.42
2.41
SiH2Ph
Br
4r
2.07
5.06
2.06
2.00
2.01
f1 (ppm)


140.1
138.2
135.4
131.6
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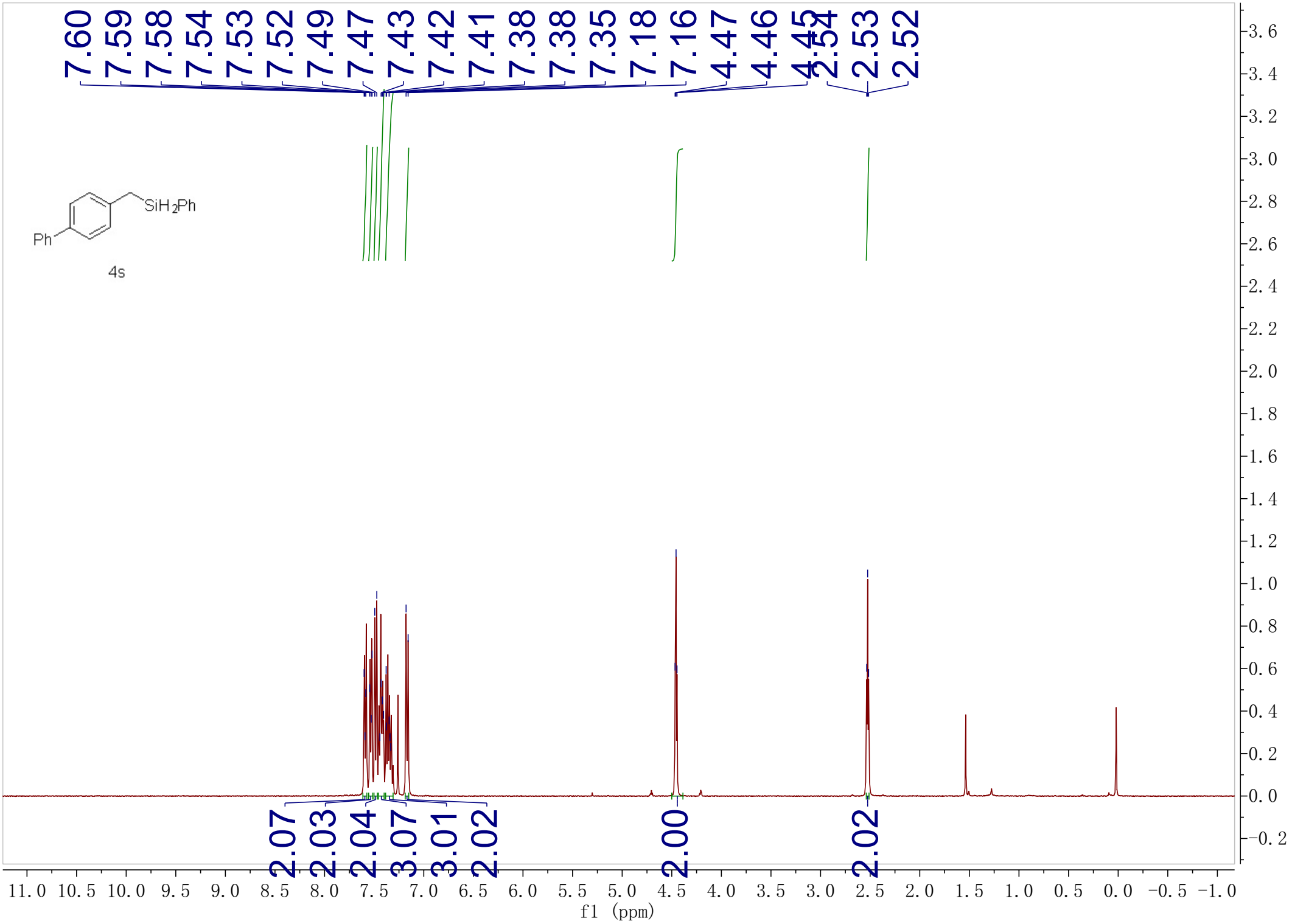
118.5
19.9
SiH2Ph
Br
4r
f1 (ppm)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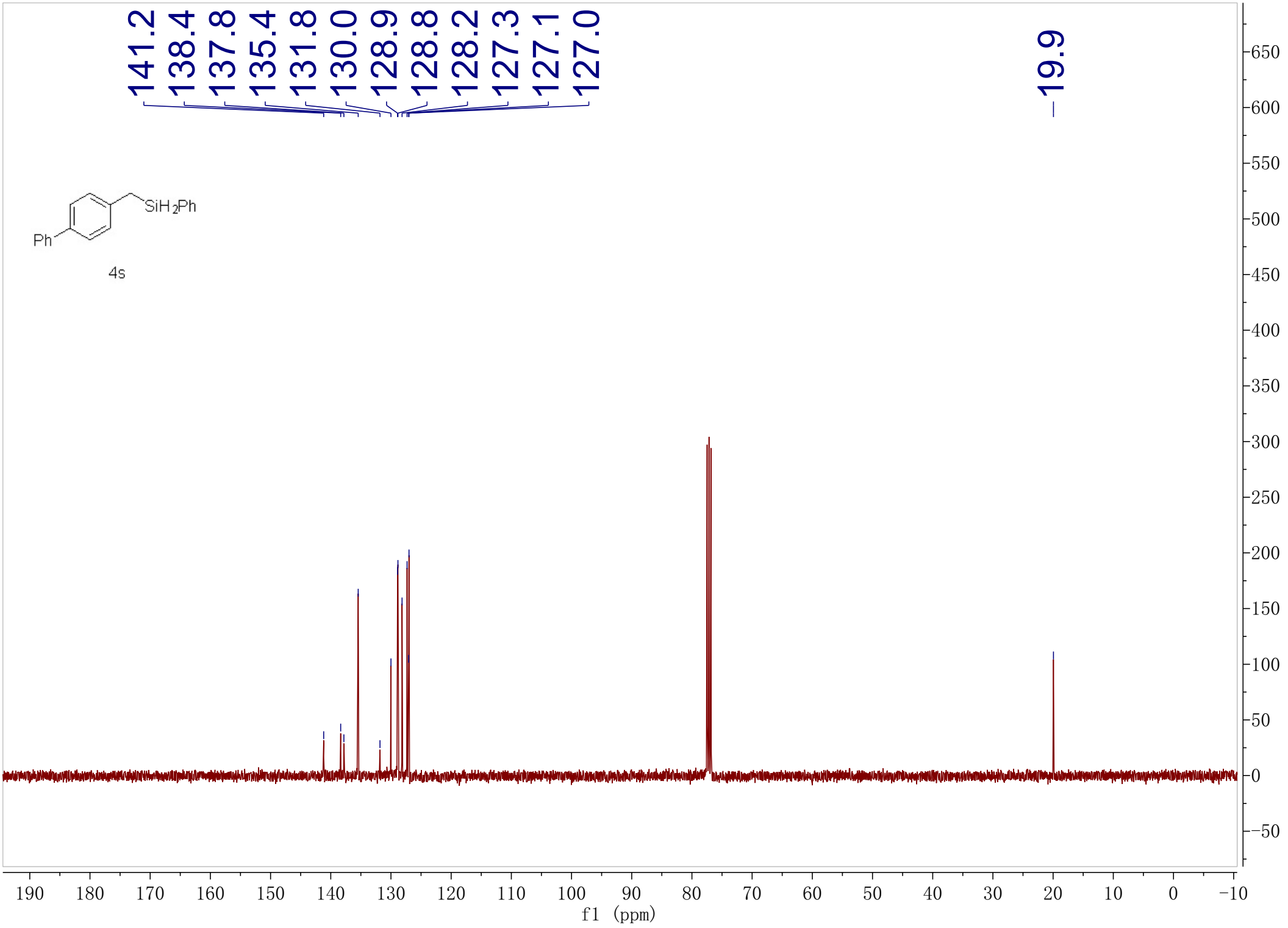
7.47
7.43
7.42
7.41
7.38
7.38
7.35
7.18
7.16
4.47
4.46
4.45
2.54
2.53
2.52
SiH2Ph
Ph
4s
2.07
2.03
2.04
3.07
3.01
2.02
2.00
2.02
f1 (ppm)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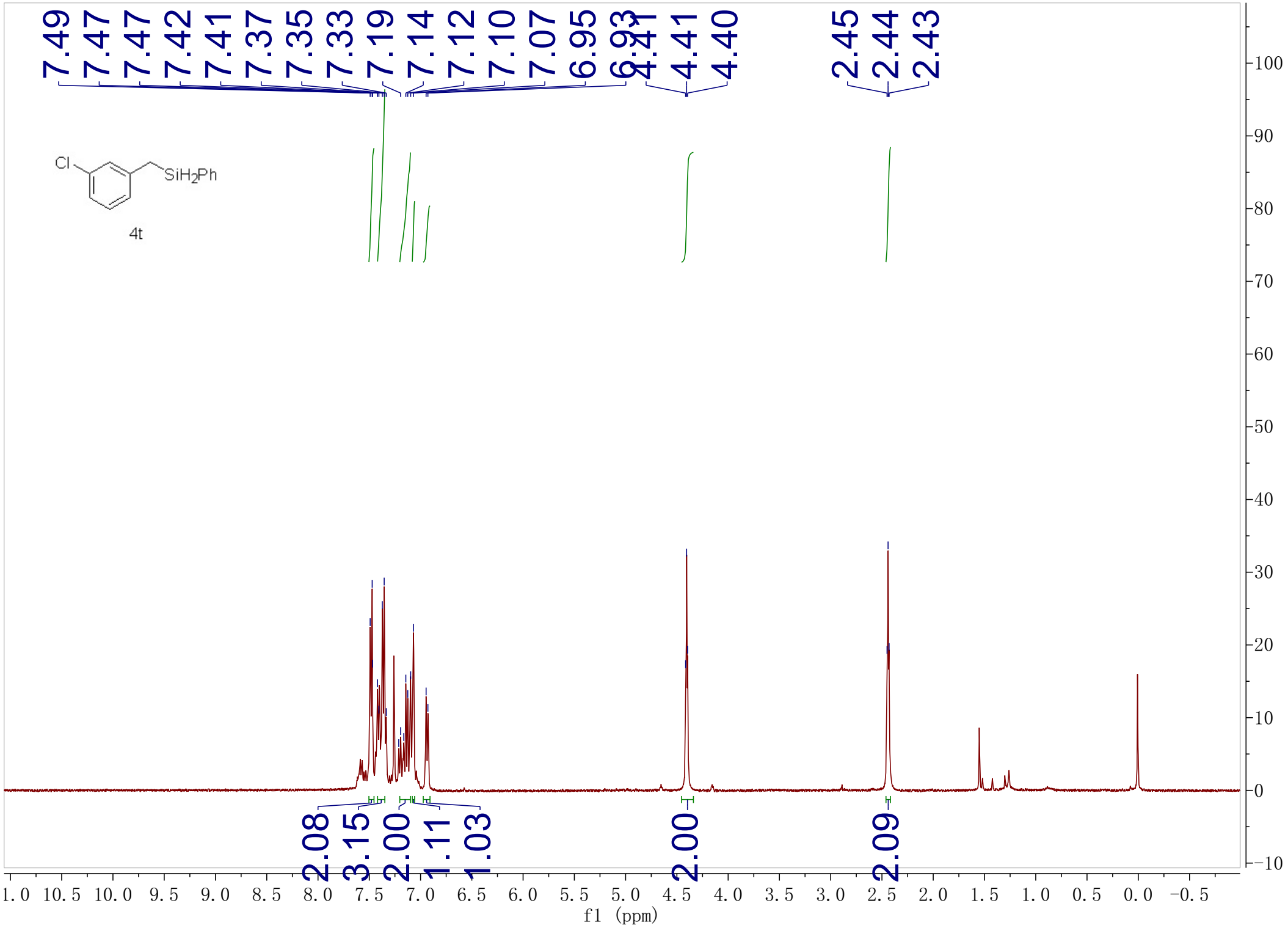
138.4
137.8
135.4
131.8
130.0
128.9
128.8
128.2
127.3
127.1
127.0
19.9
SiH2Ph
Ph
4s
650
600
550
500
450
400
350
300
250
200
150
100
50
0
−50
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
f1 (ppm)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7.47
7.47
7.42
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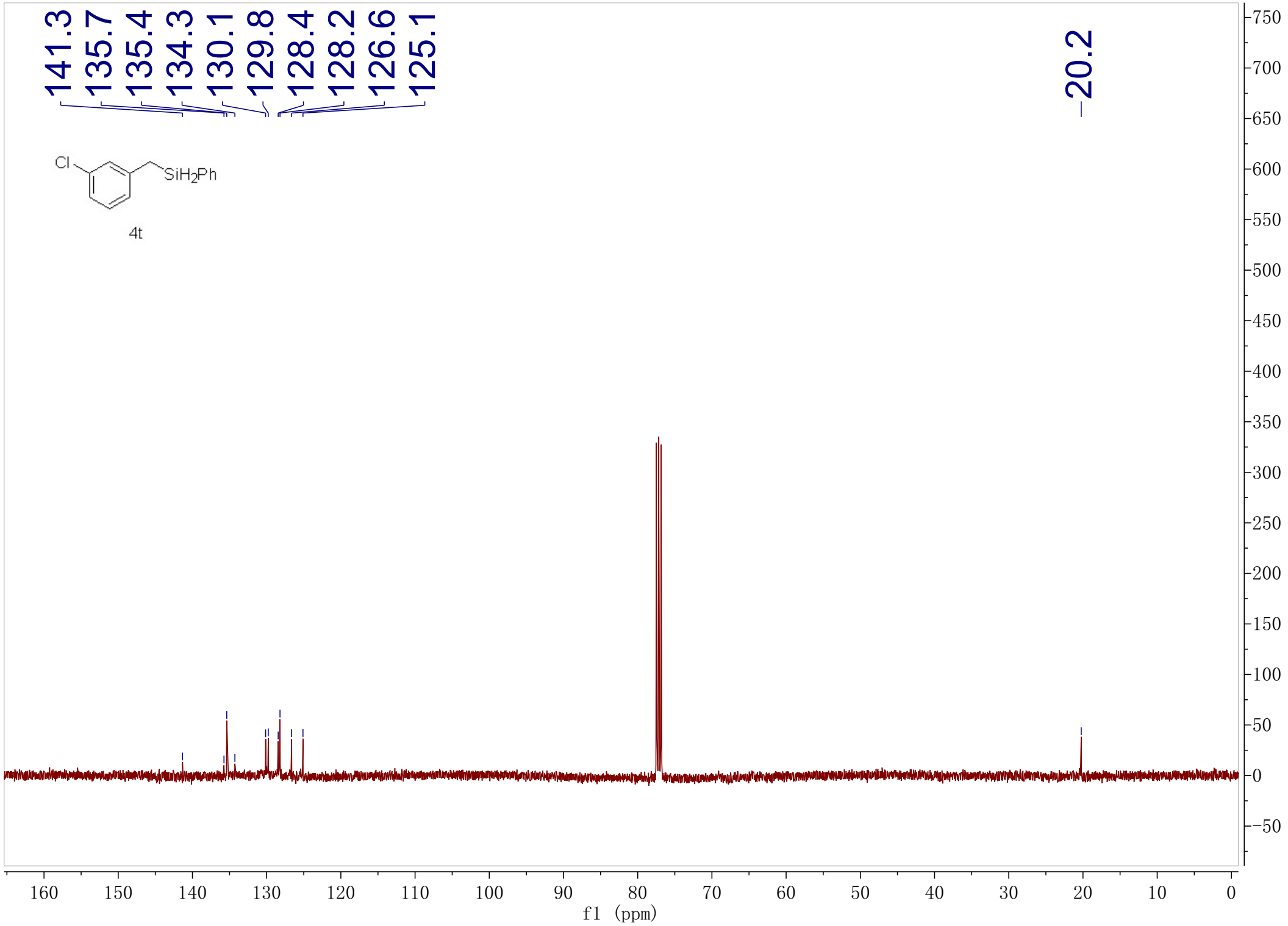
7.37
7.35
7.33
7.19
7.14
7.12
7.10
7.07
6.95
6.93
4.41
4.40
2.45
2.44
2.43
Cl
SiH2Ph
4t
2.08
3.15
2.00
1.11
1.03
2.00
2.09
f1 (ppm)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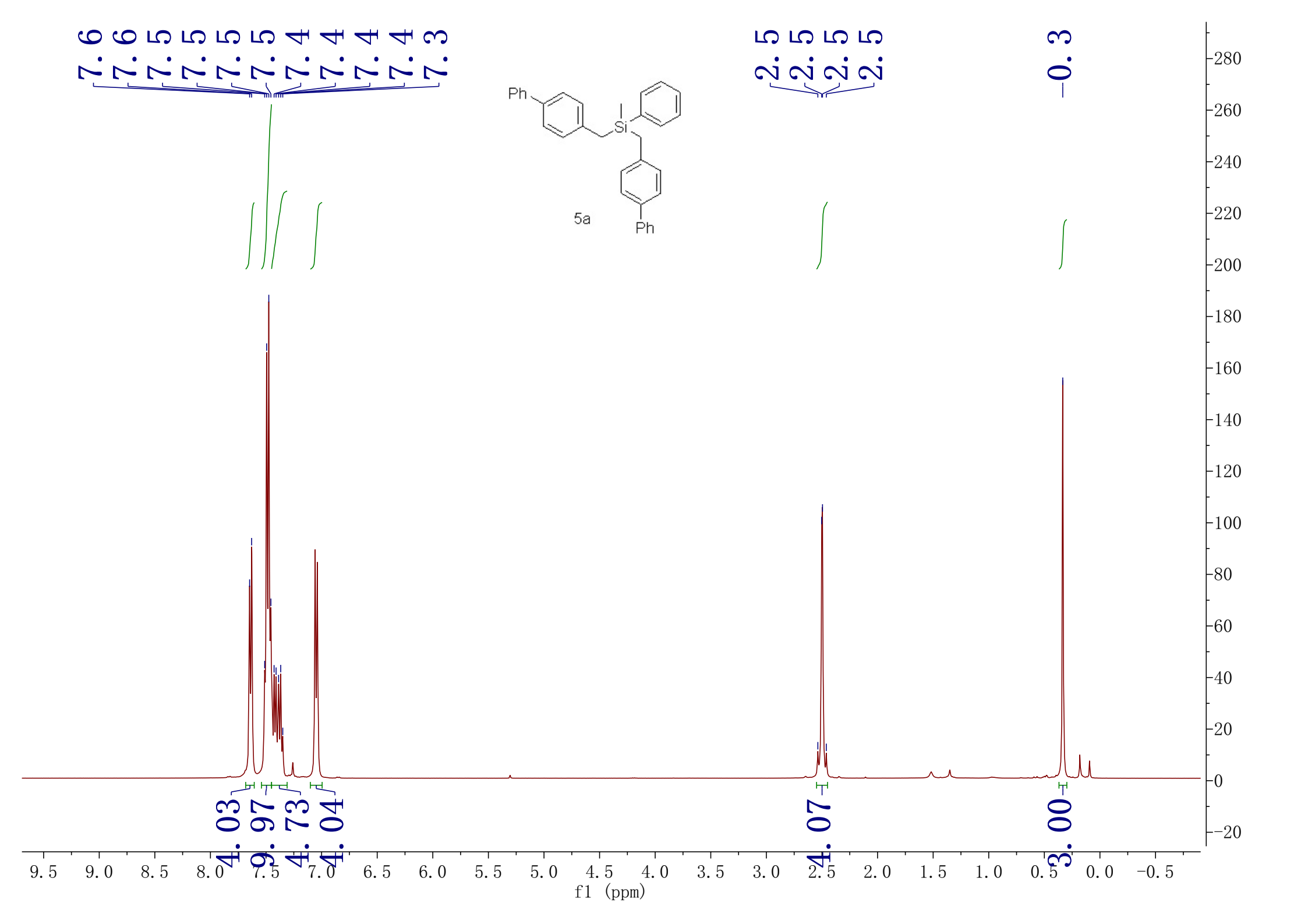
135.7
135.4
134.3
130.1
129.8
128.4
128.2
126.6
125.1
-20.2
Cl
SiH2Ph
4t
750
700
650
600
550
500
450
400
350
300
250
200
150
100
50
0
-50
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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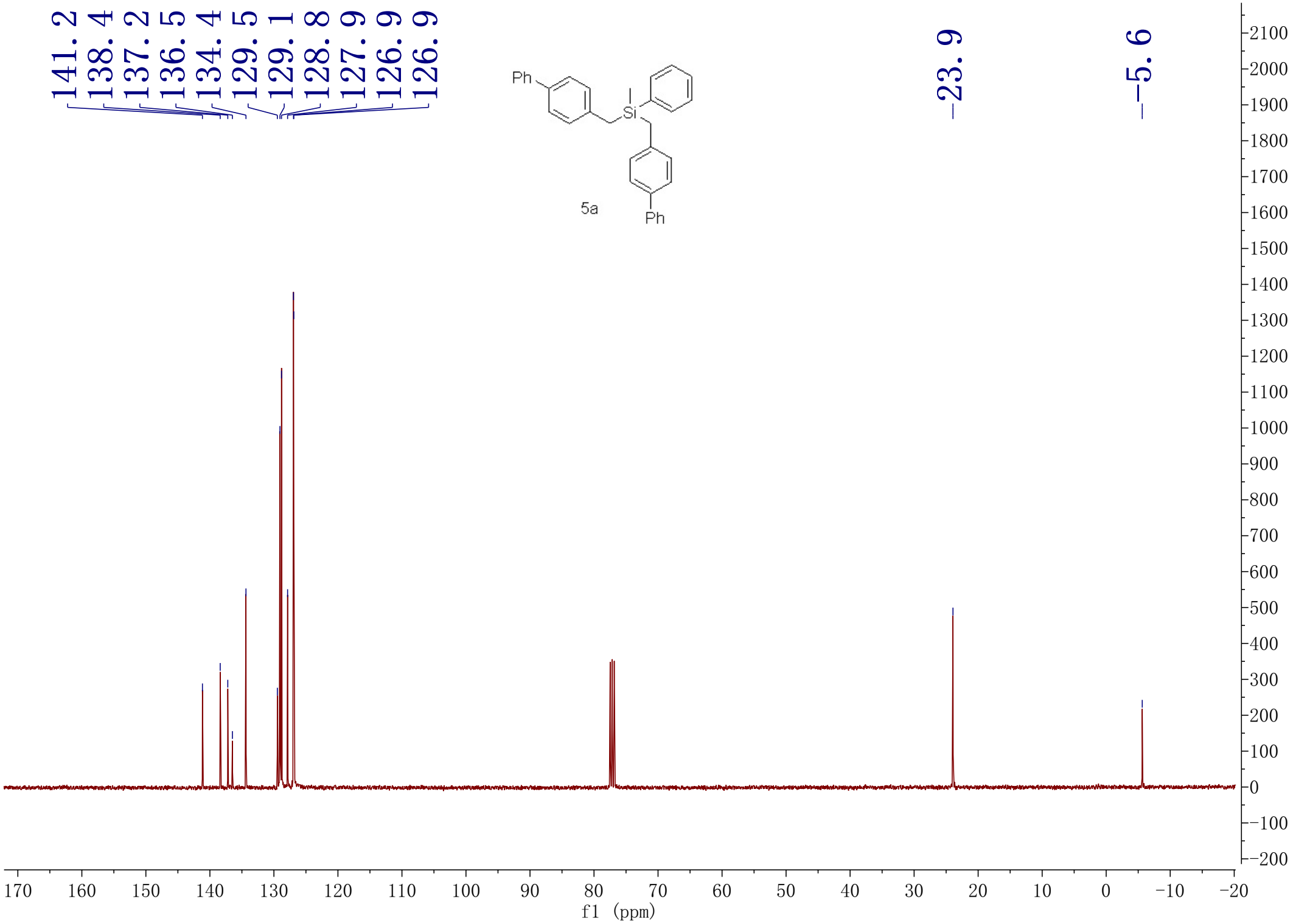
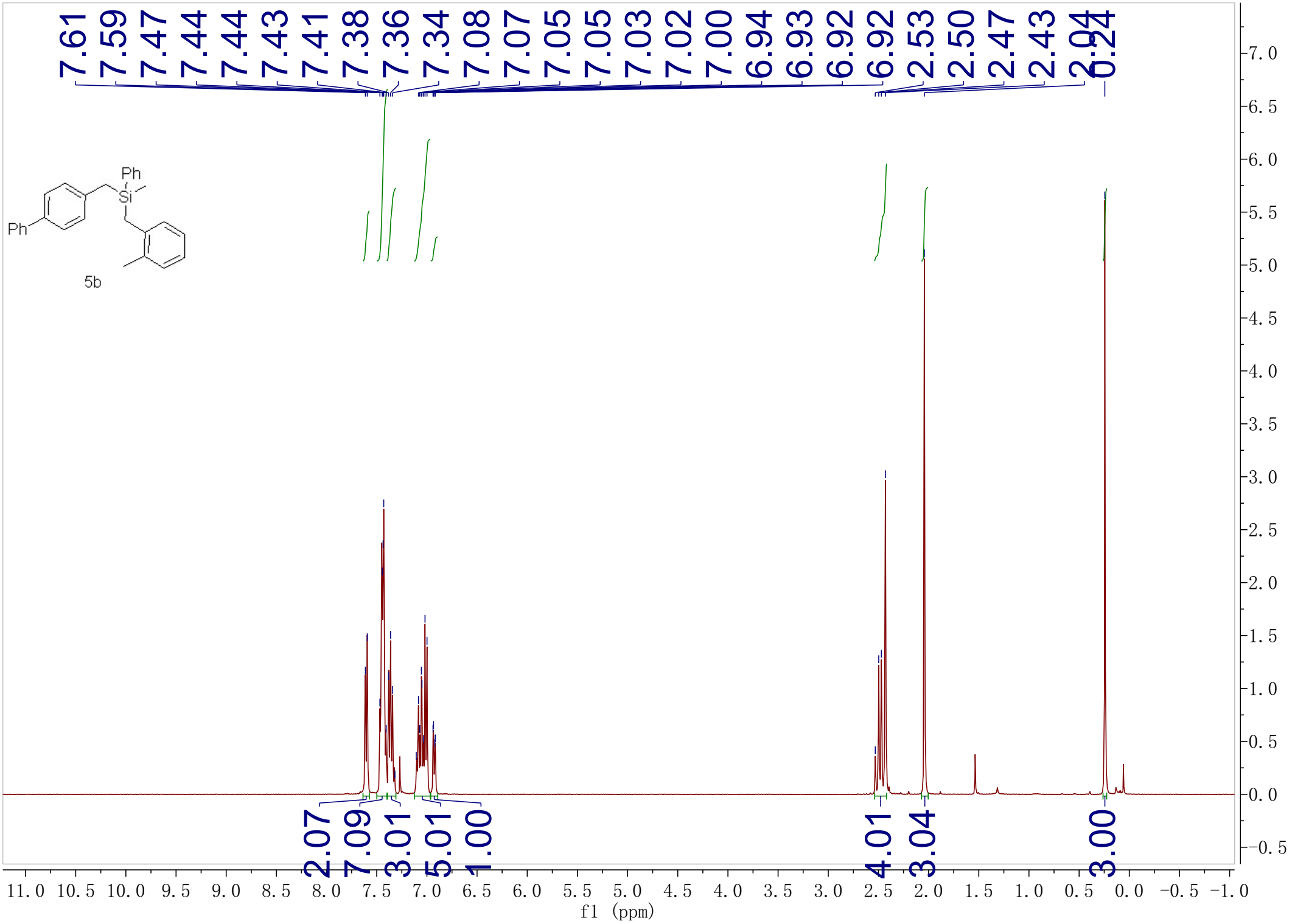
7.65
7.55
7.55
7.55
7.54
7.44
7.44
7.44
7.43
2.55
2.55
2.55
2.55
-0.03
Ph
Si
Ph
5a
4.03
9.97
4.73
4.04
4.07
3.00
f1 (ppm)


141.2
138.4
137.2
136.5
134.4
129.5
129.1
128.8
127.9
126.9
126.9
-23.9
-5.6
Ph
Si
Ph
5a
f1 (ppm)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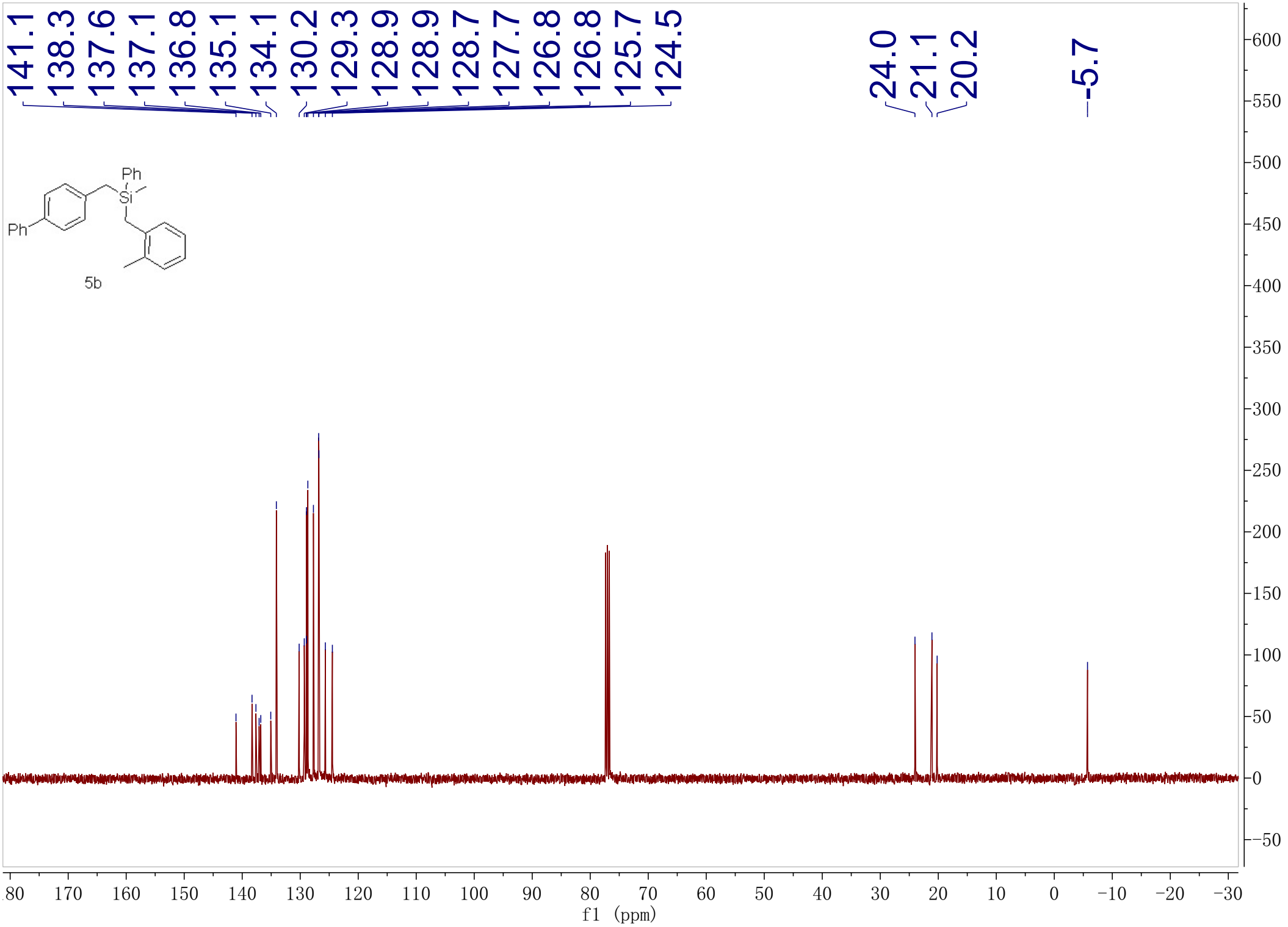
7.59
7.47
7.44
7.44
7.43
7.41
7.38
7.36
7.34
7.08
7.07
7.05
7.05
7.03
7.02
7.00
6.94
6.93
6.92
6.92
2.53
2.50
2.47
2.43
0.24
Ph
Si
Ph
5b
2.07
7.09
3.01
5.01
1.00
4.01
3.04
3.00
f1 (ppm)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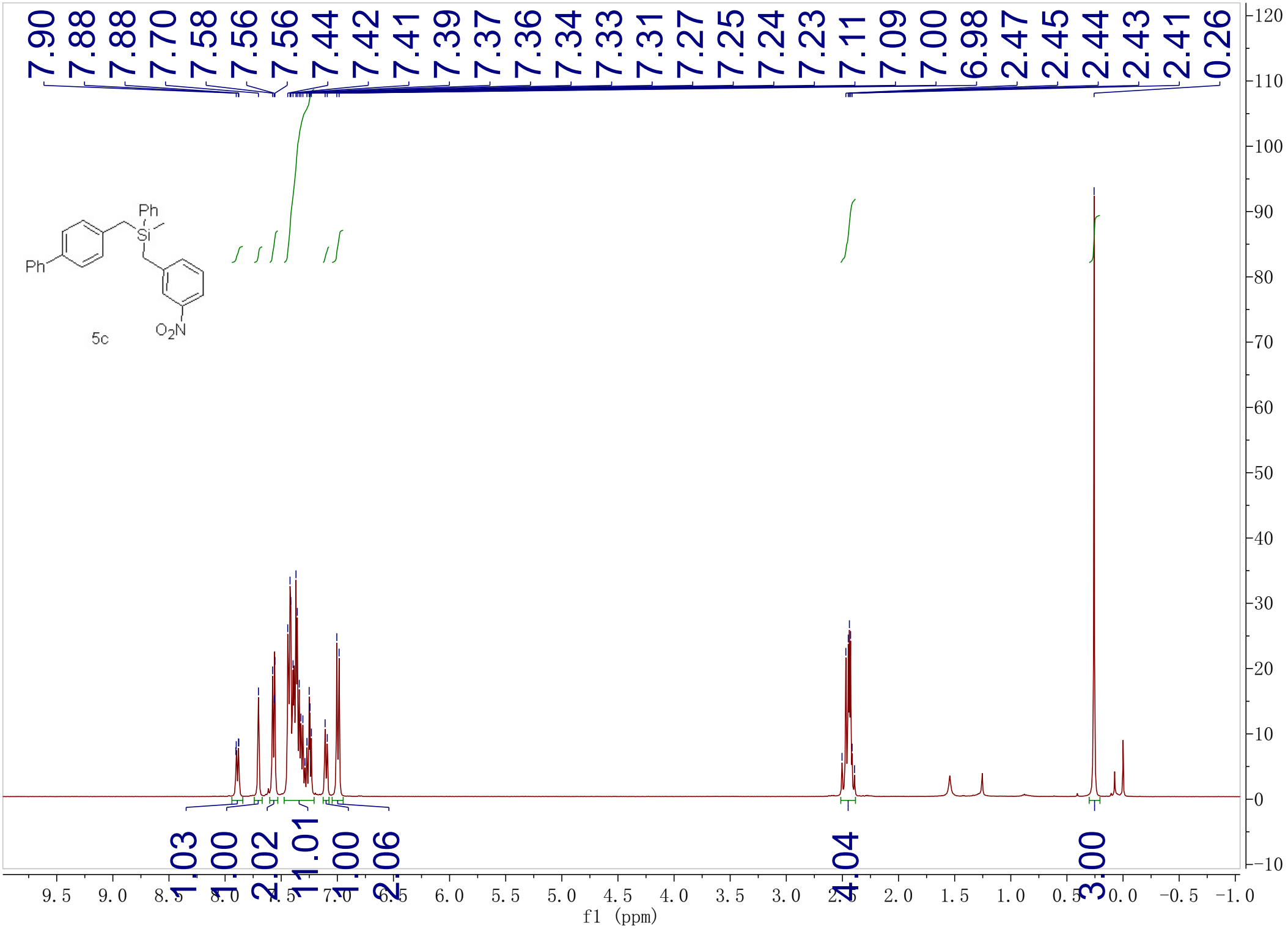
138.3
137.6
137.1
136.8
135.1
134.1
130.2
129.3
128.9
128.9
128.7
127.7
126.8
126.8
125.7
124.5
24.0
21.1
20.2
-5.7
Ph
Si
Ph
5b
600
550
500
450
400
350
300
250
200
150
100
50
0
-50
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
f1 (ppm)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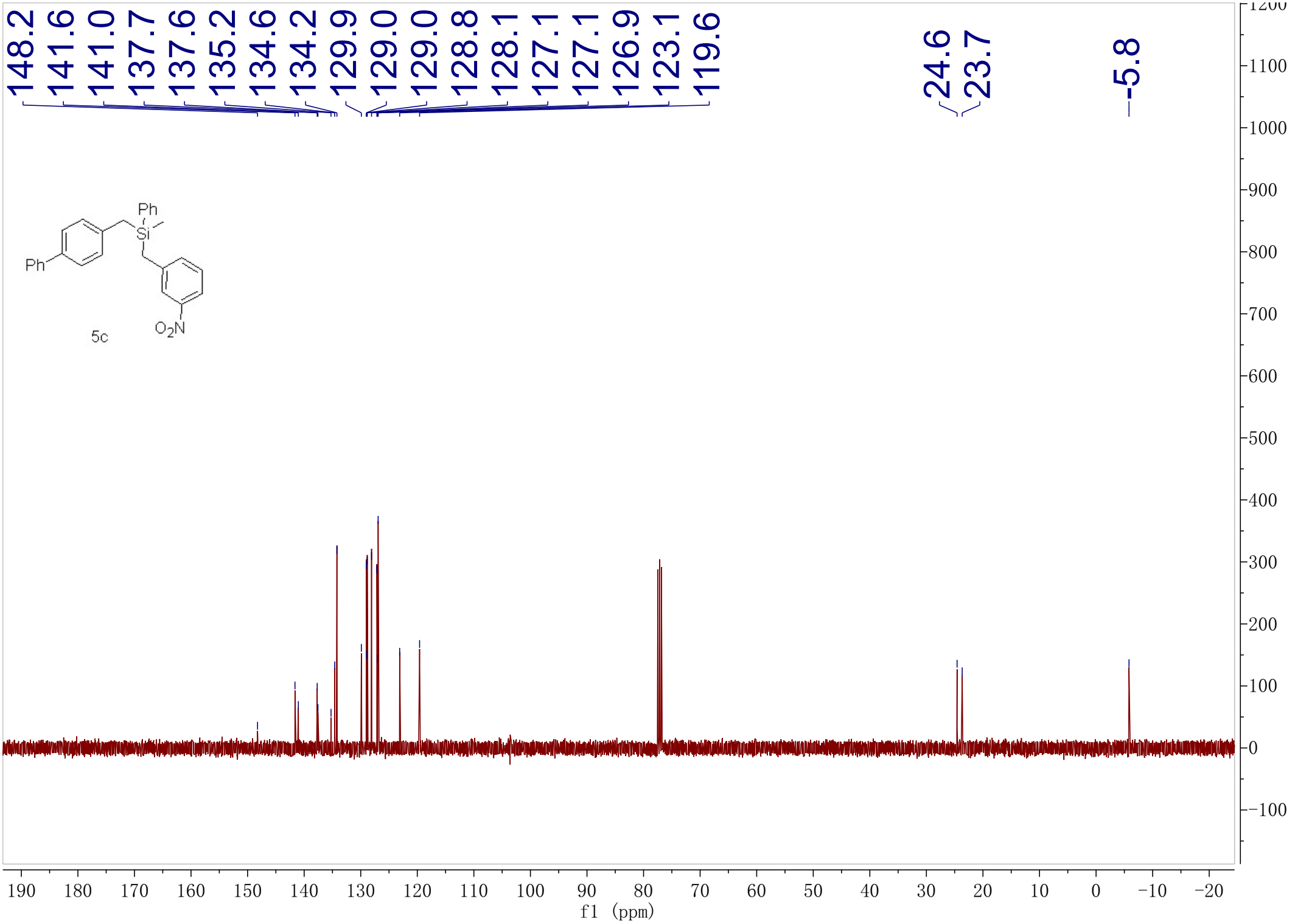
7.88
7.88
7.70
7.58
7.56
7.56
7.44
7.42
7.41
7.39
7.37
7.36
7.34
7.33
7.31
7.27
7.25
7.24
7.23
7.11
7.09
7.00
6.98
2.47
2.45
2.44
2.43
2.41
0.26
Ph
Si
Ph
O2N
5c
1.03
1.00
2.02
11.01
1.00
2.06
4.04
3.00
f1 (ppm)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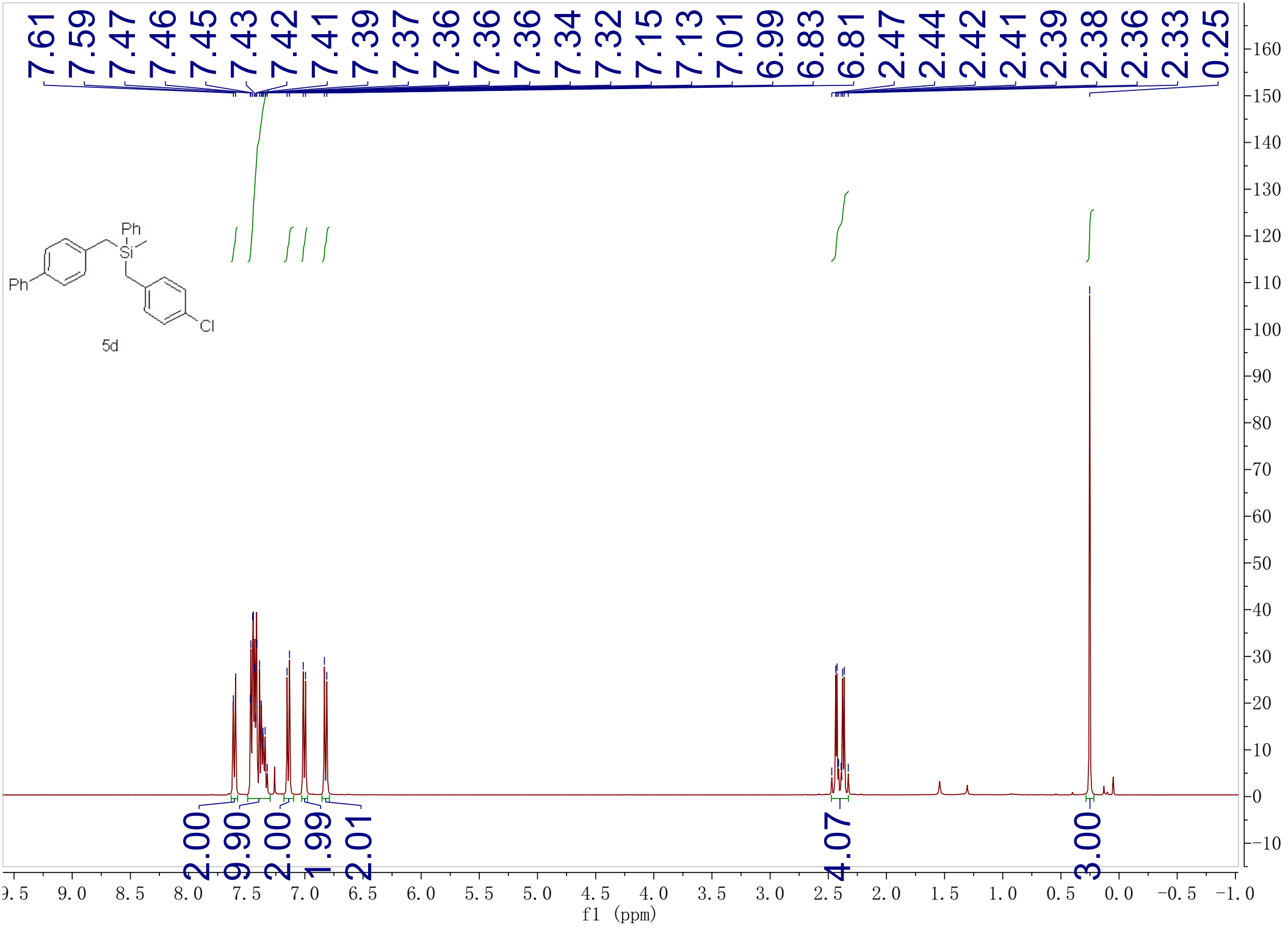
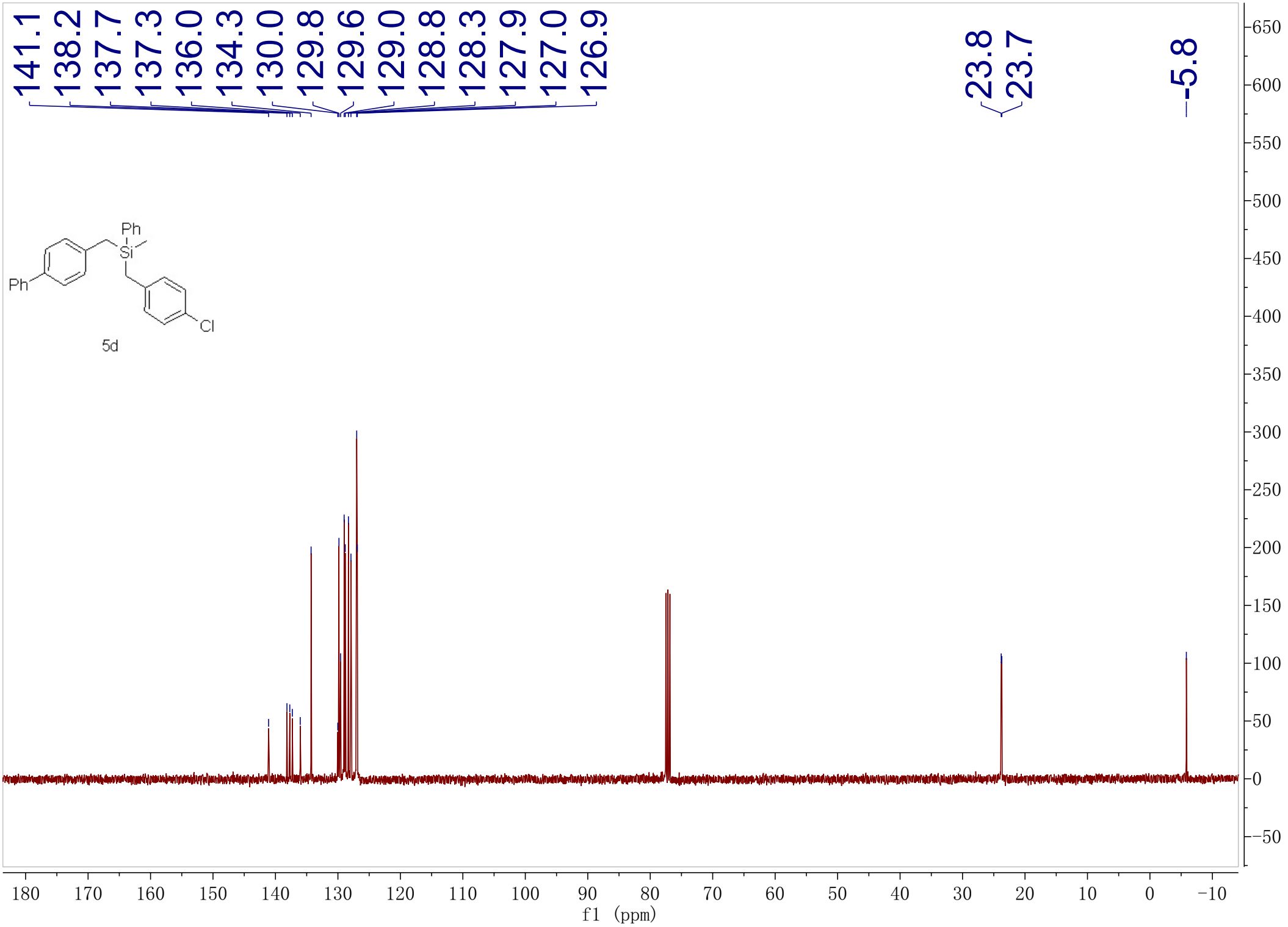
137.7
137.6
135.2
134.6
134.2
129.9
129.0
129.0
128.8
128.1
127.1
127.1
126.9
123.1
119.6
24.6
23.7
-5.8
Ph
Si
Ph
O2N
5c
f1 (ppm)


7.61
7.59
7.47
7.46
7.45
7.43
7.42
7.41
7.39
7.37
7.36
7.36
7.36
7.34
7.32
7.15
7.13
7.01
6.99
6.83
6.81
2.47
2.44
2.42
2.41
2.39
2.38
2.36
2.33
0.25
Ph
Si
Ph
Cl
5d
2.00
9.90
2.00
1.99
2.01
4.07
3.00
f1 (ppm)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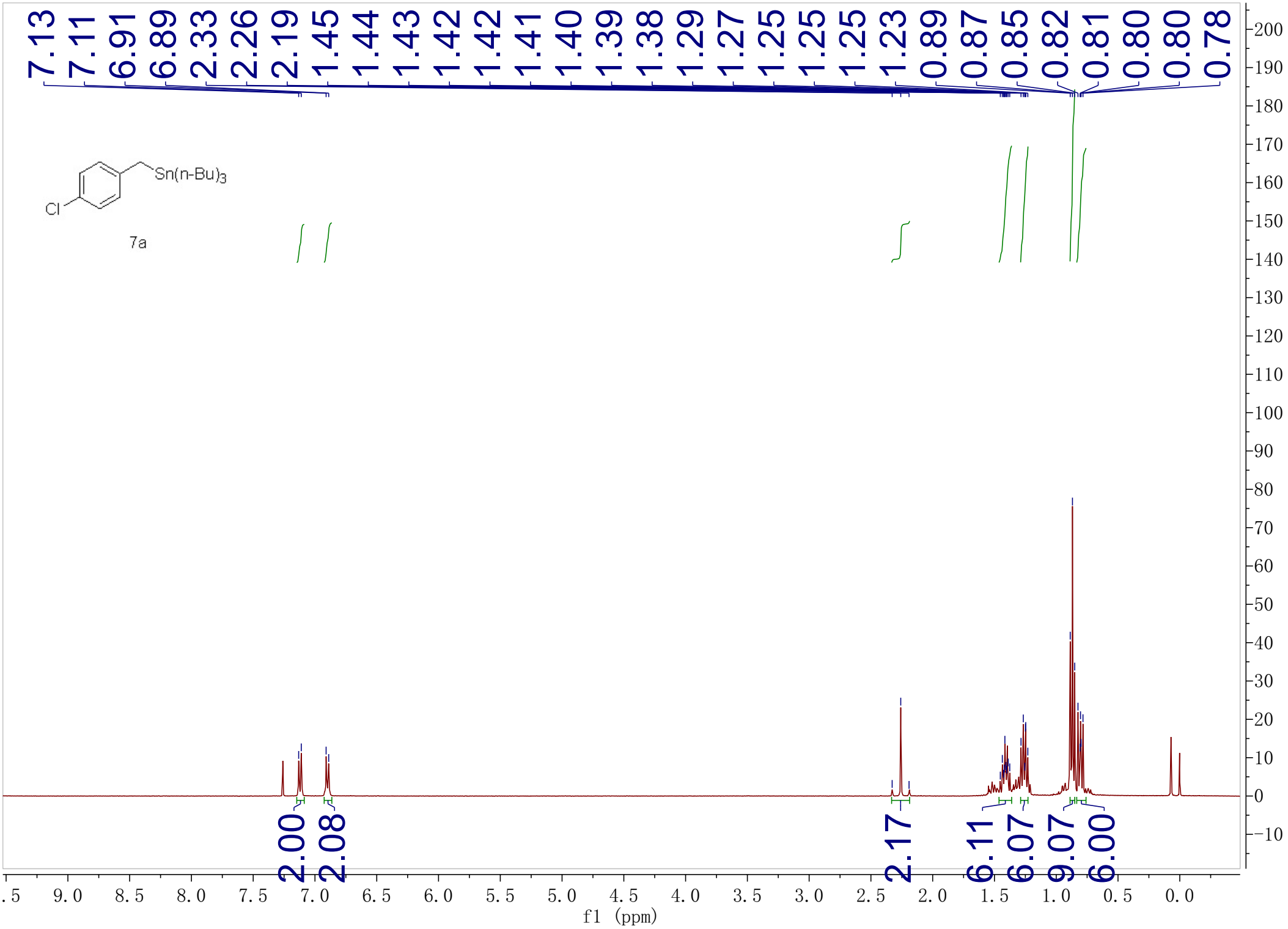
138.2
137.7
137.3
136.0
134.3
130.0
129.8
129.6
129.0
128.8
128.3
127.9
127.0
126.9
23.8
23.7
-5.8
Ph
Si
Ph
Cl
5d
650
600
550
500
450
400
350
300
250
200
150
100
50
0
-50
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)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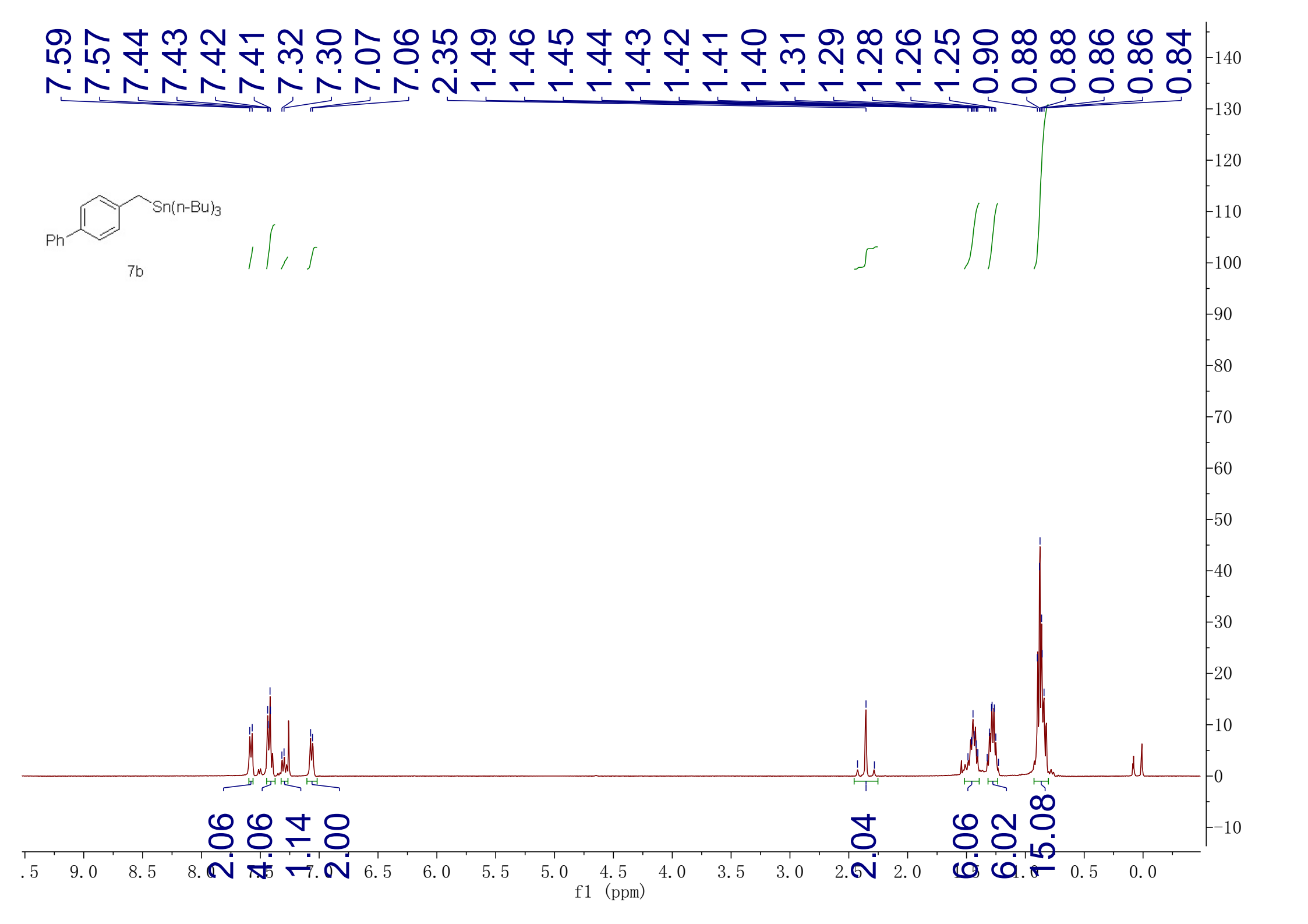
7.11
6.91
6.89
2.33
2.26
2.19
1.45
1.44
1.43
1.42
1.42
1.41
1.40
1.39
1.38
1.29
1.27
1.25
1.25
1.25
1.23
0.89
0.87
0.85
0.82
0.81
0.80
0.80
0.78
Sn(n-Bu)3
Cl
7a
2.00
2.08
2.17
6.11
6.07
9.07
6.00
f1 (ppm)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7.57
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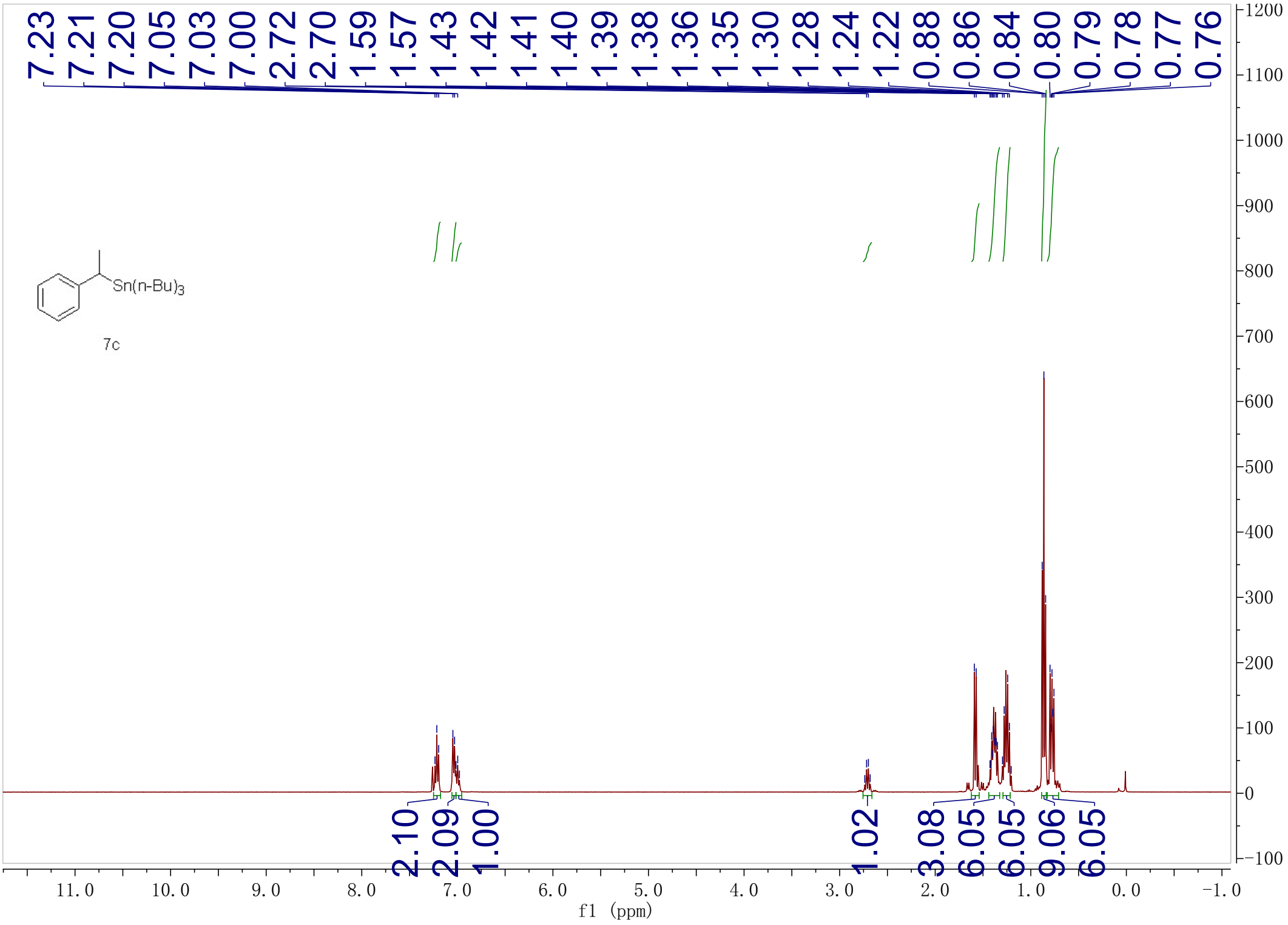
7.43
7.42
7.41
7.32
7.30
7.07
7.06
2.35
1.49
1.46
1.45
1.44
1.43
1.42
1.41
1.40
1.31
1.29
1.28
1.26
1.25
0.90
0.88
0.88
0.86
0.86
0.84
Sn(n-Bu)3
Ph
7b
2.06
4.06
1.14
2.00
2.04
6.06
6.02
15.08
f1 (ppm)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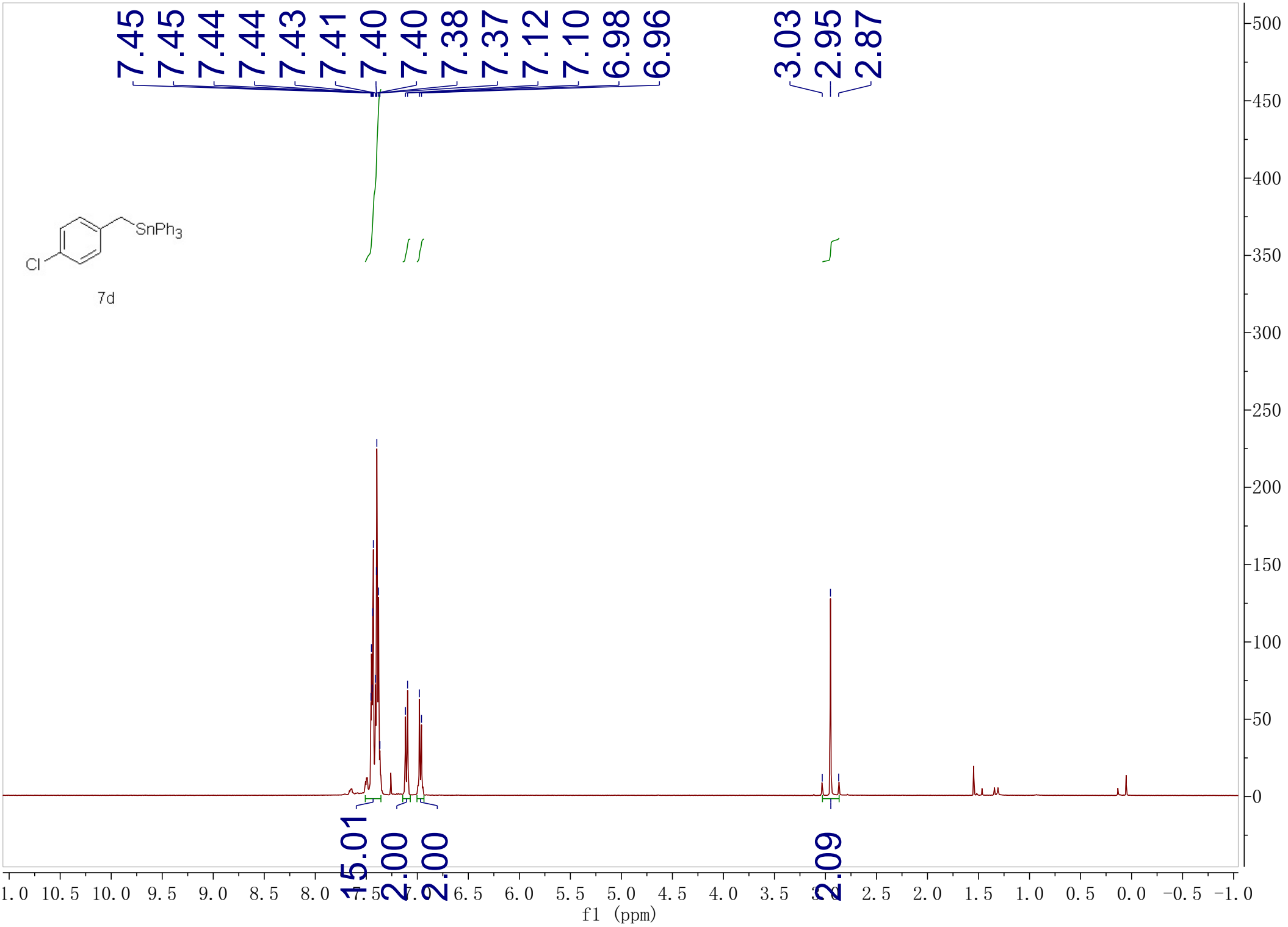
7.20
7.05
7.03
7.00
2.72
2.70
1.59
1.57
1.43
1.42
1.41
1.40
1.39
1.38
1.36
1.35
1.30
1.28
1.24
1.22
0.88
0.86
0.84
0.80
0.79
0.78
0.77
0.76
Sn(n-Bu)3
7c
2.10
2.09
1.00
1.02
3.08
6.05
6.05
9.06
6.05
f1 (ppm)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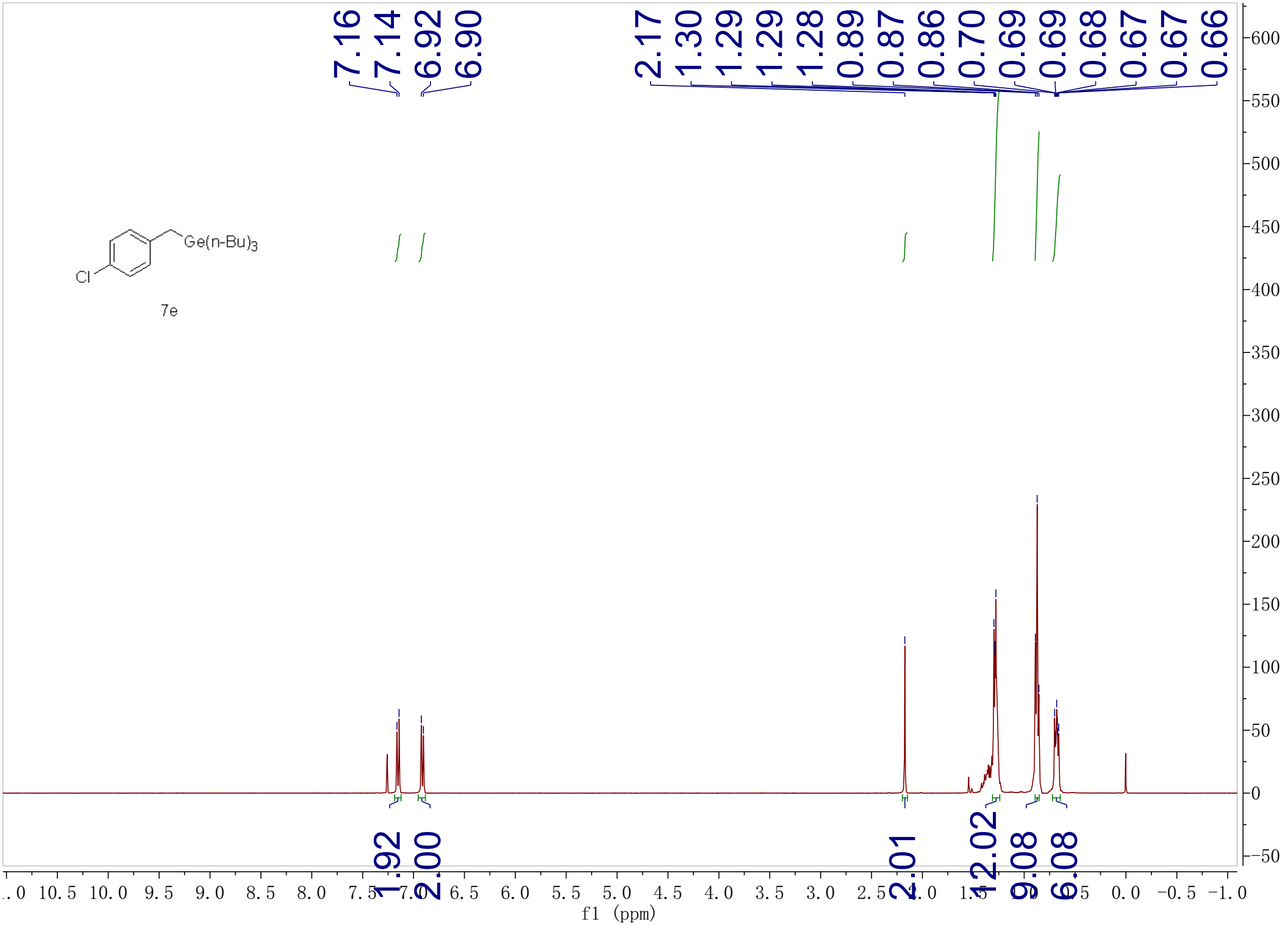
7.44
7.43
7.41
7.40
7.40
7.38
7.37
7.12
7.10
6.98
6.96
3.03
2.95
2.87
SnPh3
Cl
7d
15.01
2.00
2.00
2.09
f1 (ppm)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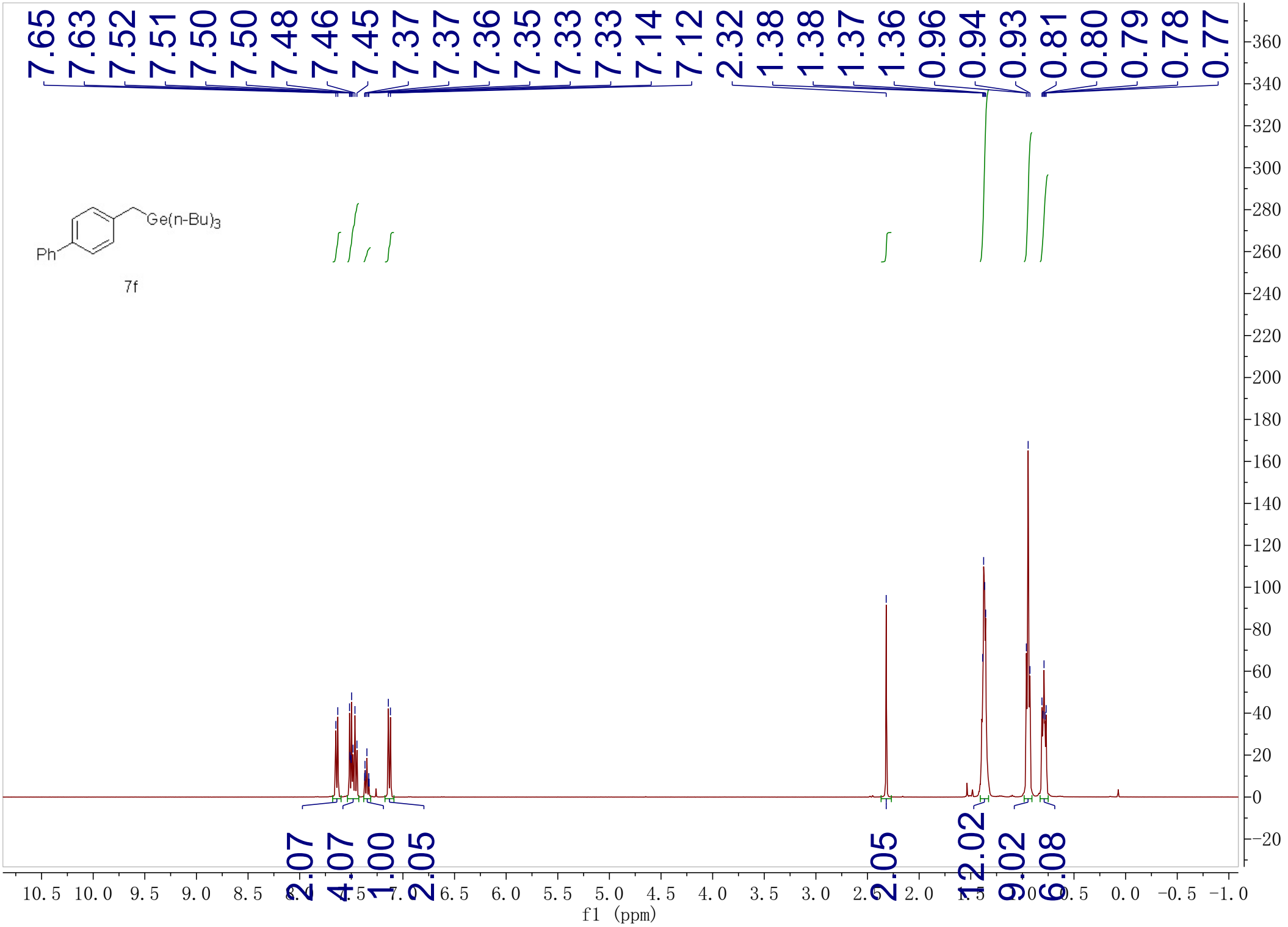
6.90
2.17
1.30
1.29
1.29
1.28
0.89
0.87
0.86
0.70
0.69
0.69
0.68
0.67
0.67
0.66
Ge(n-Bu)3
Cl
7e
1.92
2.00
2.01
12.02
9.08
6.08
f1 (ppm)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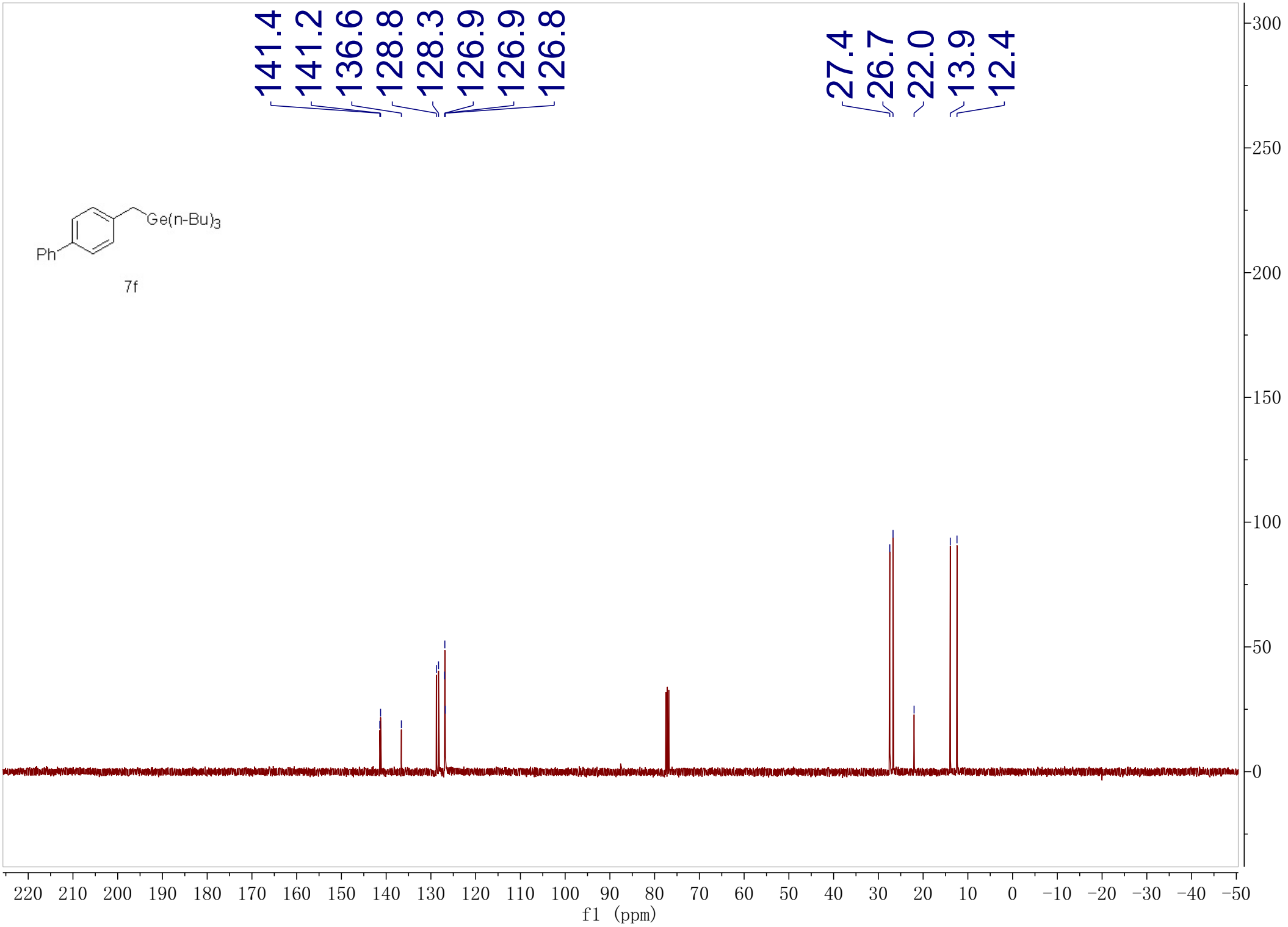
7.48
7.46
7.45
7.37
7.37
7.36
7.35
7.33
7.33
7.14
7.12
2.32
1.38
1.38
1.37
1.36
0.96
0.94
0.93
0.81
0.80
0.79
0.78
0.77
Ge(n-Bu)3
Ph
7f
2.07
4.07
1.00
2.05
2.05
12.02
9.02
6.08
f1 (ppm)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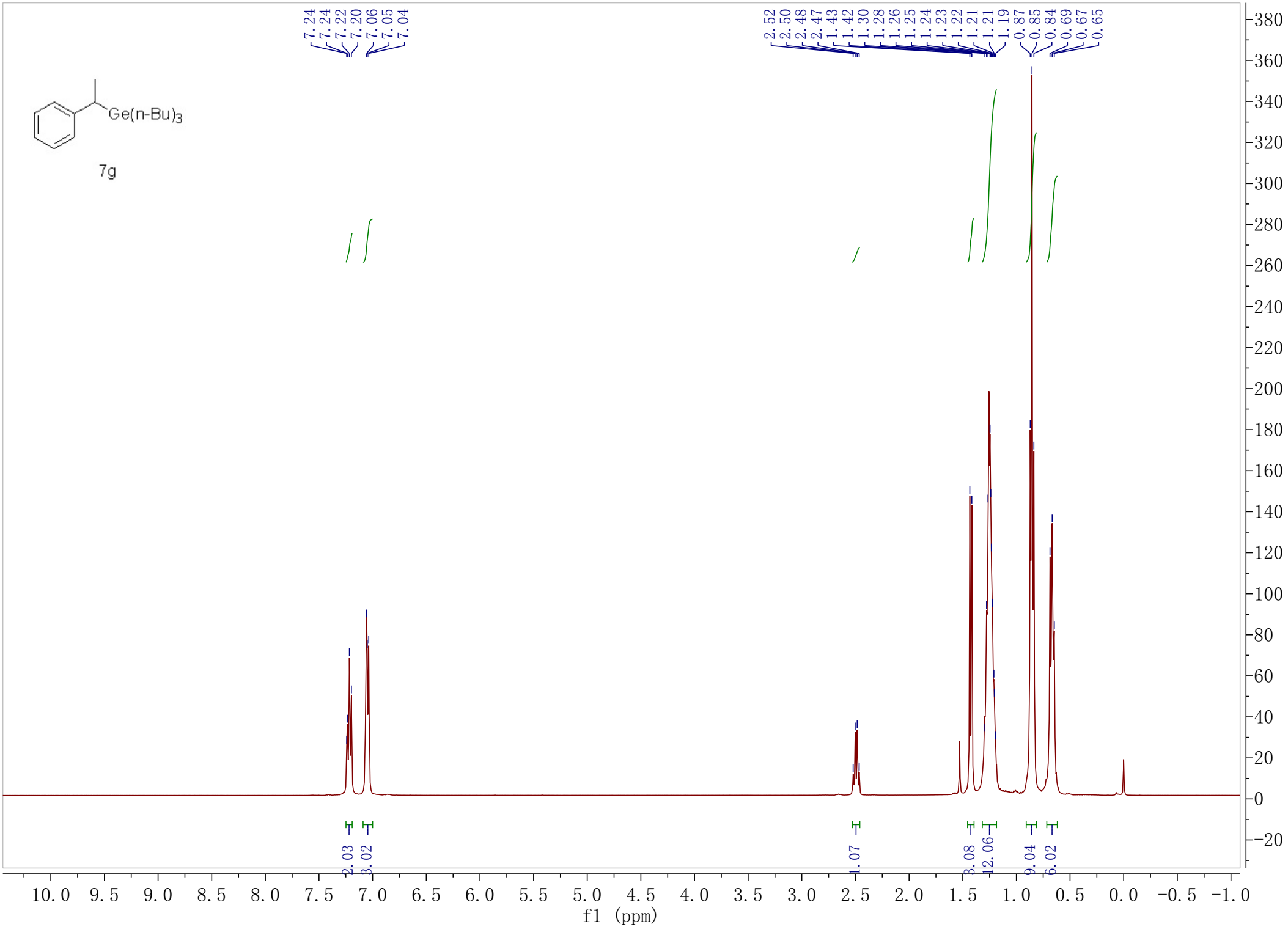
141.2
136.6
128.8
128.3
126.9
126.9
126.8
27.4
26.7
22.0
13.9
12.4
Ge(n-Bu)3
Ph
7f
300
250
200
150
100
50
0
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10 -20 -30 -40 -50
f1 (ppm)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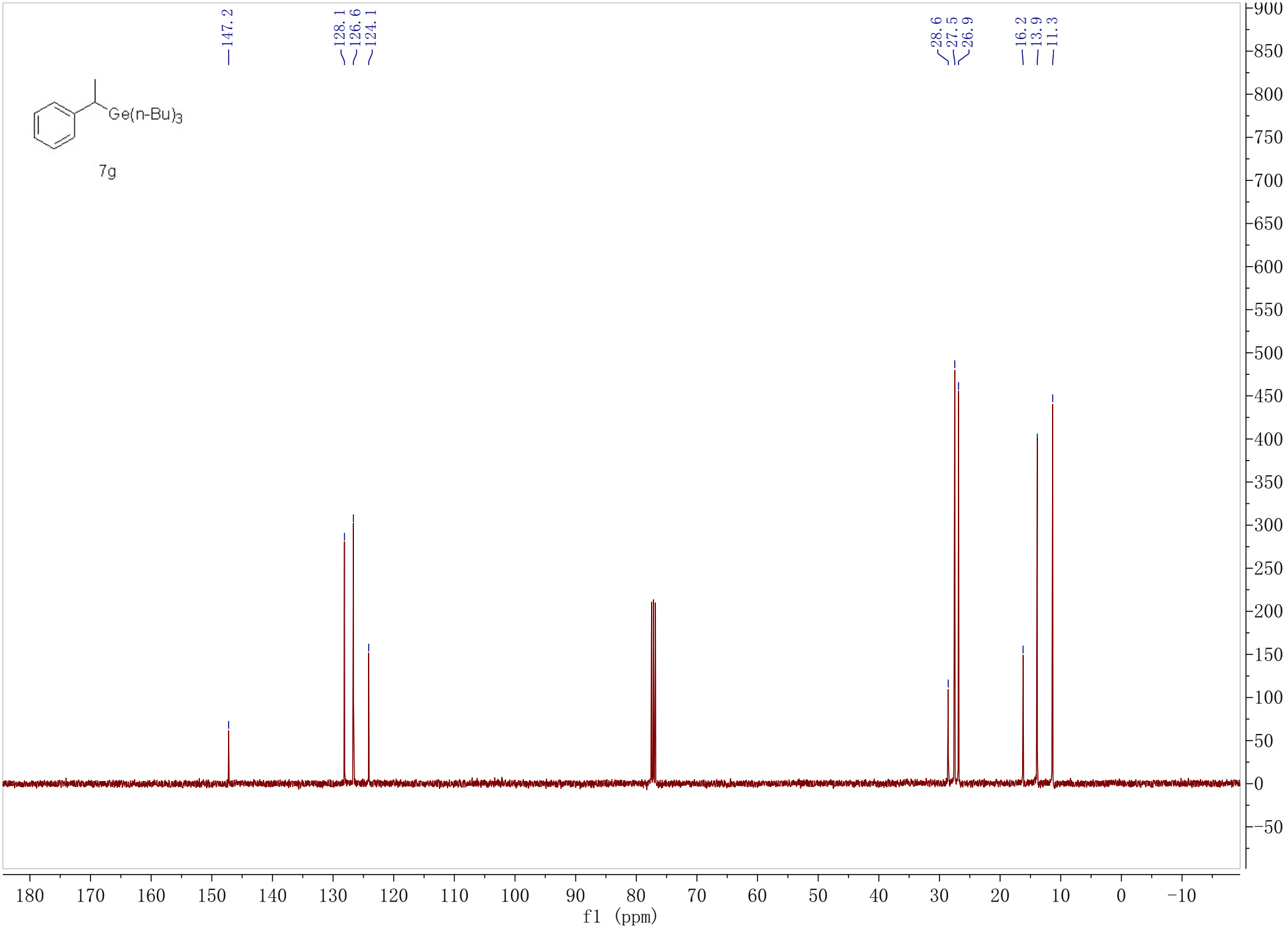
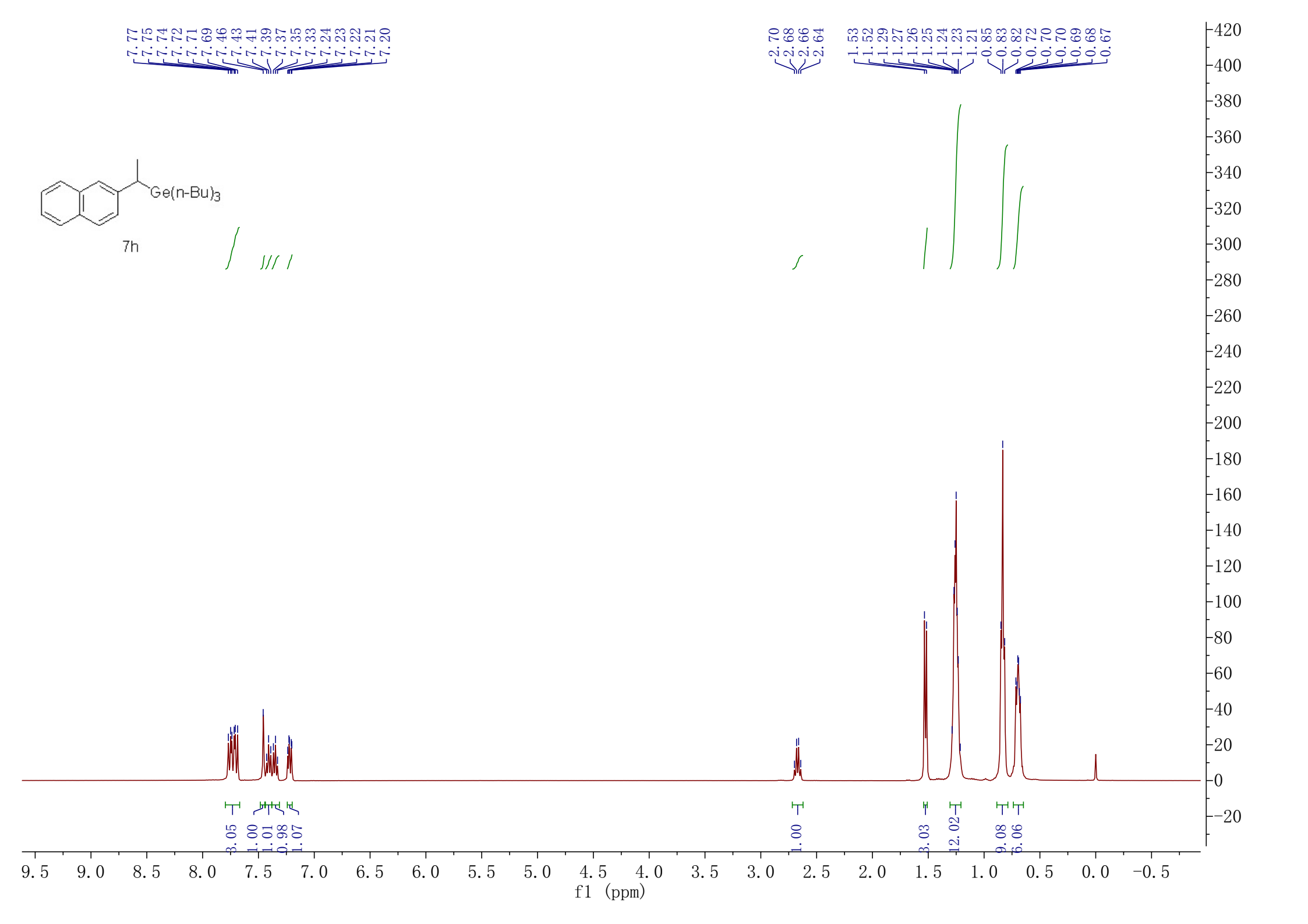
7.24
7.22
7.20
7.06
7.05
7.04
2.52
2.50
2.48
2.47
1.43
1.42
1.30
1.28
1.26
1.25
1.24
1.23
1.22
1.21
1.21
1.19
0.87
0.85
0.84
0.69
0.67
0.65
Ge(n-Bu)3
7g
2.03
3.02
1.07
3.08
12.06
9.04
6.02
f1 (ppm)


147.2
128.1
126.6
124.1
28.6
27.5
26.9
16.2
13.9
11.3
Ge(n-Bu)3
7g
f1 (ppm)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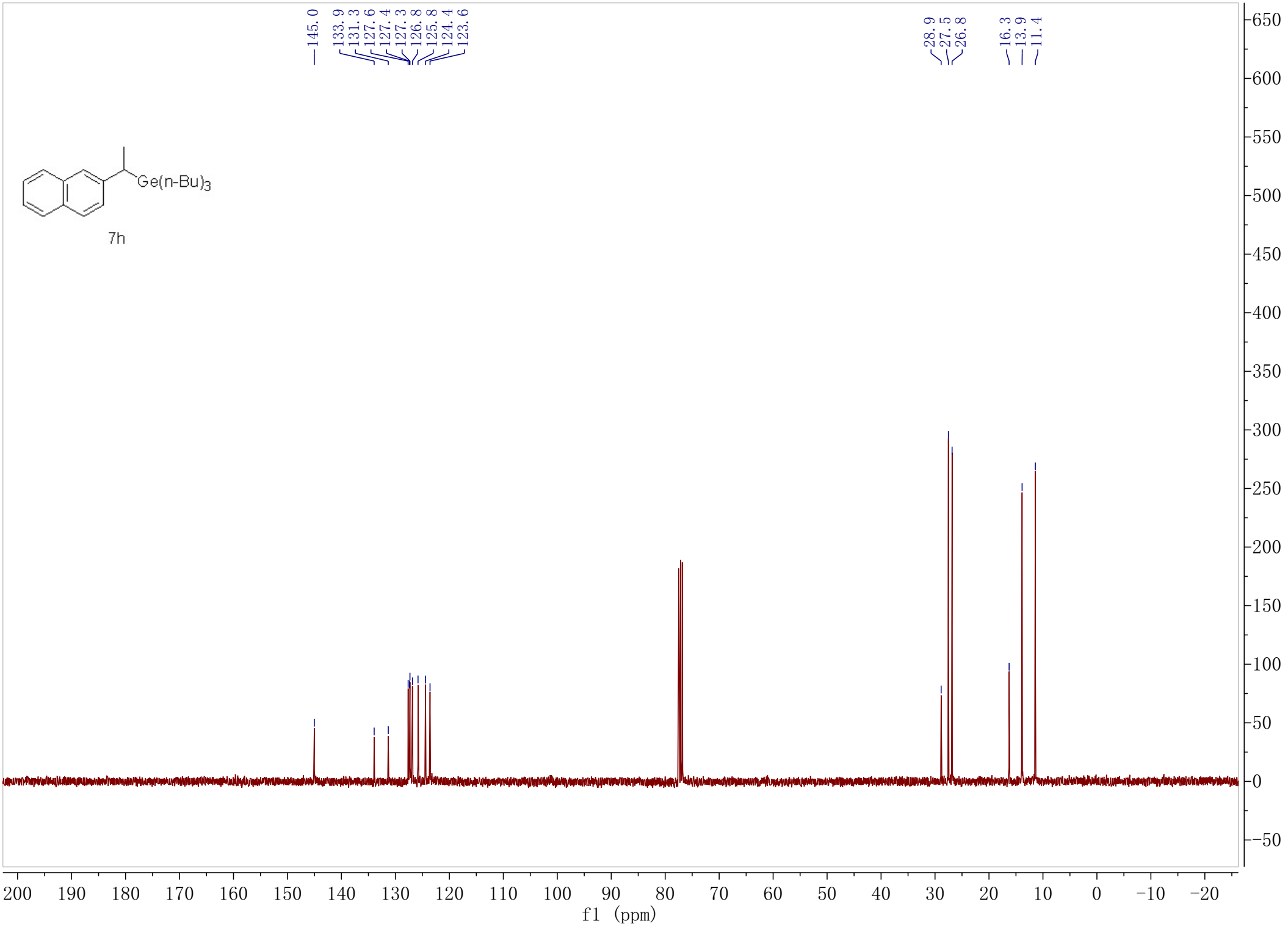
7.69
7.46
7.43
7.41
7.39
7.37
7.35
7.33
7.24
7.23
7.22
7.21
7.20
2.70
2.68
2.66
2.64
1.53
1.52
1.29
1.27
1.26
1.25
1.24
1.23
1.21
0.85
0.83
0.82
0.72
0.70
0.70
0.69
0.68
0.67
Ge(n-Bu)3
7h
3.05
1.00
1.01
0.98
1.07
1.00
3.03
12.02
9.08
6.06
f1 (ppm)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133.9
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127.4
127.3
126.8
125.8
124.4
123.6
28.9
27.5
26.8
16.3
13.9
11.4
Ge(n-Bu)3
7h
f1 (ppm)