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Asymmetric Construction of Quaternary α-Nitro Amides by Palladium-Catalyzed C(sp^3)–H Arylation

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General Methods

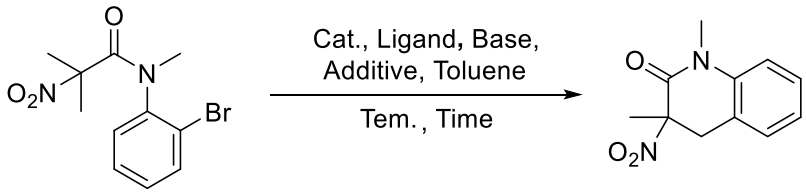
All air- and moisture-sensitive manipulations were carried out with standard Schlenk techniques under nitrogen or in a glove box under nitrogen. ^{1}H, ^{13}C and ^{31}P NMR spectra were recorded on a Varian instrument (400 MHz and 100 MHz) or Bruker AVANCE 600 (600 MHz and 150 MHz). ^{1}H, ^{13}C NMR chemical shifts are reported vs tetramethylsilane signal or residual protio solvent signals.

Toluene, *t*-AmOH, DMF, and dichloroethane were distilled over CaH_2 under nitrogen. 1,4-dioxane was distilled over sodium benzophenone ketyl under nitrogen.

The ligands **L5-L9** and **A6-A9** were synthesized following the literature procedures.[1] N-protected anilines were prepared according to the literature procedures.[2] All other chemicals were used as obtained from the suppliers (Aldrich, Alfa, J&K, and Chemical Reagent Companies of China) .

Optimization of Reaction Condition

***Table S1*. Initial Screening of Conditions[a]**



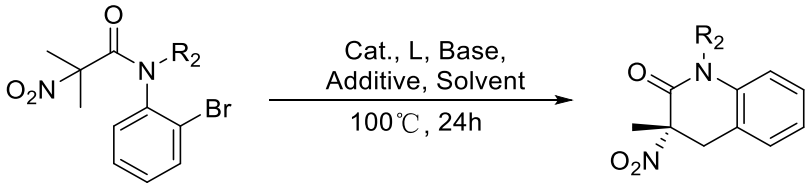
1a **2b**

Entry	Cat.	Base	**Ligand**	Additive	Solvent	Temp.(°C)	Time(h)	Yield[b]
1	$Pd(OAc)_2$	K_2CO_3	**PPh_3**	PivOH	Toluene	100	12	10%
2	$Pd(OAc)_2$	K_2CO_3	-	PivOH	Toluene	100	12	N.R.
3	$Pd(OAc)_2$	K_2CO_3	**PPh_3**	PivOH	Toluene	120	12	8%
4	$Pd(OAc)_2$	K_2CO_3	**PPh_3**	PivOH	Toluene	70	12	N.R.
5	$Pd(OAc)_2$	K_2CO_3	**PPh_3**	PivOH	Toluene	80	12	N.R.
6	$Pd(OAc)_2$	Na_2CO_3	**PPh_3**	PivOH	Toluene	100	12	10%
7	$Pd(OAc)_2$	$NaHCO_3$	**PPh_3**	PivOH	Toluene	100	12	10%
8	$Pd(OAc)_2$	CH_3COOK	**PPh_3**	PivOH	Toluene	100	12	9%
9	$Pd(OAc)_2$	K_3PO_4	**PPh_3**	PivOH	Toluene	100	12	16%
10	$Pd(OAc)_2$	K_2HPO_4	**PPh_3**	PivOH	Toluene	100	12	10%

11	$Pd(OAc)_2$	Cs_2CO_3	**PPh_3**	PivOH	Toluene	100	12	N.R.
12	$Pd(OAc)_2$	K_2CO_3	**$PCy_3(HBF_4)$**	PivOH	Toluene	100	12	47%
13	$Pd(OAc)_2$	K_2CO_3	**$PCy_3(HBF_4)$**	AdCOOH	Toluene	100	12	67%
14	$Pd(OAc)_2$	K_2CO_3	**$PCy_3(HBF_4)$**	AdCOOH	Toluene	100	24	73%
15[c]	**$Pd(OAc)_2$**	**K_2CO_3**	**$PCy_3(HBF_4)$**	**AdCOOH**	**Toluene**	**100**	**24**	**81%**
16[c]	$Pd_2(dba)_3$	K_2CO_3	**$PCy_3(HBF_4)$**	AdCOOH	Toluene	100	24	65%

[a]Reaction conditions unless otherwise noted: **1** (0.10 mmol), catalyst (0.005 mmol), phosphorus ligand (0.01 mmol), base (0.15 mmol), additive (0.03 mmol), solvent (1 mL), 100 ℃, under N_2 for 12 h. [b]Isolated yields. [c]catalyst (0.01 mmol), phosphorus ligand (0.02 mmol). N.R.= no reaction. N.P.= no product.

***Table S2*. Further Optimization of Reaction Conditions[a]**



1a R_2=Me
1b R_2=PMB

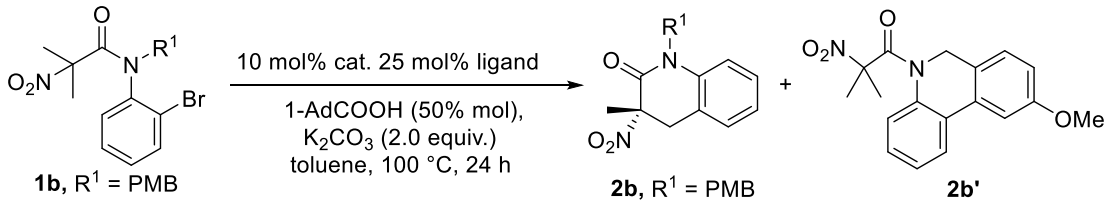
2a R_2=Me
2b R_2=PMB

Entry	Catalyst	Base	**Ligand**	Additive	Solvent	Yield[b]	*Ee*(%)[d]
1	$Pd(OAc)_2$	K_2CO_3	**L9**	AdCOOH (0.4 equiv.)	Toluene	50%[c]	93
2	$Pd(OAc)_2$	K_2CO_3	**L9**	AdCOOH (0.5 equiv.)	Toluene	60%[c]	93
3	$Pd(OAc)_2$	K_2CO_3	**L9**	AdCOOH (0.7 equiv.)	Toluene	55%[c]	93
4	$Pd(OAc)_2$	K_2CO_3	**L9**	AdCOOH (1 equiv.)	Toluene	50%[c]	93
5	$Pd(OAc)_2$	K_2CO_3	**L9**	AdCOOH (2 equiv.)	Toluene	40%[c]	93
6	$Pd(OAc)_2$	K_2CO_3	**L9**	PivOH (0.5 equiv.)	Toluene	35%[c]	90
7	$Pd(OAc)_2$	K_2CO_3 (1 equiv.)	**L9**	AdCOOH (0.5 equiv.)	Toluene	60%	93
8	$Pd(OAc)_2$	K_2CO_3 (2 equiv.)	**L9**	AdCOOH (0.5 equiv.)	Toluene	70%[c]	93
9	$Pd(OAc)_2$	K_2CO_3 (3 equiv.)	**L9**	AdCOOH (0.5 equiv.)	Toluene	58%	93
10	$Pd(Cp)(C_3H_5)$ (10 mol%)	K_2CO_3 (2 equiv.)	**L9**	AdCOOH (0.5 equiv.)	Toluene	68%	93
11	$Pd(Cp)(PhC_3H_4)$ (10 mol%)	K_2CO_3 (2 equiv.)	**L9**	AdCOOH (0.5 equiv.)	Toluene	27%	93

12	**Pd(Cp)(C_3H_5) (10 mol%)**	**K_2CO_3 (2 equiv.)**	**L9 (25 mmol%)**	**AdCOOH (0.5 equiv.)**	**Toluene**	**70%**	**93**
13[e]	**Pd(Cp)(C_3H_5) (10%)**	**K_2CO_3 (2 equiv.)**	**L9 (25 mmol%)**	**AdCOOH (0.5 equiv.)**	**Toluene**	**85%**	**98**
14[e]	Pd(Cp)(C_3H_5) (10%)	K_2CO_3 (2 equiv.)	**L9** (25 mmol%)	AdCOOH (0.5 equiv.)	1,4-Dioxane	40%[c]	98
15[e]	Pd(Cp)(C_3H_5) (10%)	K_2CO_3 (2 equiv.)	**L9** (25 mmol%)	AdCOOH (0.5 equiv.)	DMF	N.P.	-
16[e]	Pd(Cp)(C_3H_5) (10%)	K_2CO_3 (2 equiv.)	**L9** (25 mmol%)	AdCOOH (0.5 equiv.)	*t*-AmOH	60%[c]	98

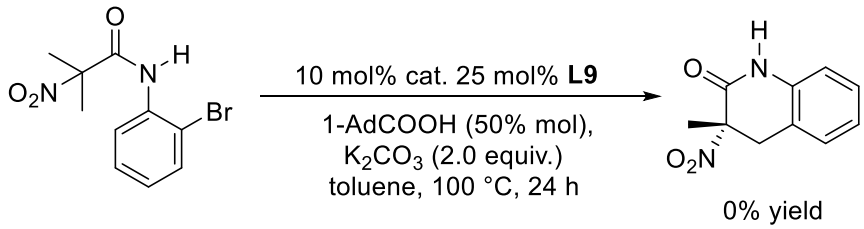
[a]Reaction conditions unless otherwise noted: **1a** (0.1 mmol), catalyst (0.005 mmol), phosphorus ligand (0.01 mmol), base (0.15 mmol), additive (0.03 mmol), solvent (1 mL), 100 °C, under N_2 atmosphere for 24 h. [b]Isolated yields. [c]Yield was determined by ^{1}H NMR using CH_2Br_2 as the internal standard. [d]The ***ee*** was determined by chiral HPLC with a chiral HPLC. [e]**1b** (0.1 mmol), Catalyst (0.01 mmol), Ligands (0.025 mmol), K_2CO_3 (0.2 mmol), AdCOOH (0.05 mmol), 0.1M with N_2 atmosphere at 100℃ for 24 h.

Isolation of product 2b' via C(sp^2)-H activation pathway



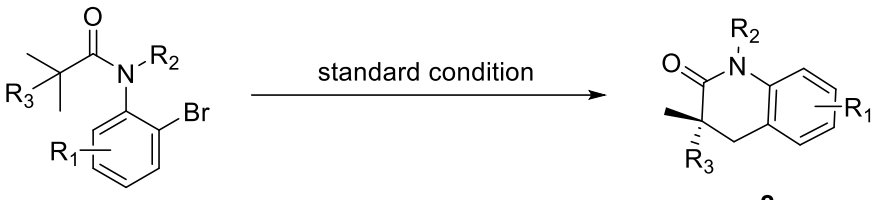
10 mol% $Pd(OAc)_2$, 25 mol% PCy_3:	35% yield	43% yield
10 mol% Pd(Cp)(C_3H_5), 25 mol% PCy_3:	30% yield	35% yield
10 mol% Pd(Cp)(C_3H_5), 25 mol% (*R*,*R*)-**L9**:	85% yield	8% yield

Examination of NH substrate under the optimal reaction conditions.



Experimental Details and Characterization Data

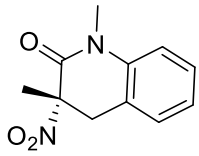
1、General Procedure for the Enantioselective Pd-Catalyzed Arylation:



1 **2**

To a 10 mL Schlenk type sealed tube equipped with a magnetic stirring bar, was added substrate **1** (0.10 mmol), PdCp(C_3H_5) (10 mol%), **L** (25 mol%), K_2CO_3 (0.20 mmol), AdCOOH (50 mol%) and toluene (1 mL) under N_2 atmosphere. The tube was capped, and heated to 100 °C for 24 h. Then, the reaction mixture was cooled to room temperature, filtered through a pad of Celite, evaporated under vacumm. The residue was purified by chromatography column on silica gel to afford the desired products **2**.

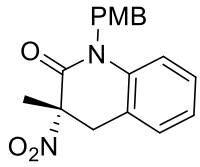
2、Characterization Data of products 2:



2a

White solid. 70% yield. The ***ee*** was determined on a Daicel Chiralpak ID column with hexane/2-propanol = 90/10, flow = 1.0 mL/min. Retention times: 13.2 min [(*S*)-enantiomer], 15.0 min [(*R*)-enantiomer]. 93% ***ee***. $[\alpha]^{20}_{D}$ = +73.0 (*c* 0.100, CH_2Cl_2), The absolute configuration was assigned by analogy with compound **2k**. Mp: 55.7-57.4 °C.

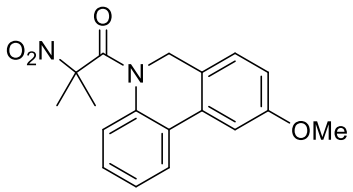
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.31 (t, *J* = 7.6 Hz, 1H), 7.17 (d, *J* = 7.6 Hz, 1H), 7.05 (ddd, *J* = 14.2, 8.2, 2.0 Hz, 2H), 3.79 (d, *J* = 16.4 Hz, 1H), 3.45 (s, 3H), 3.15 (d, *J* = 16.4 Hz, 1H), 1.85 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 163.49, 138.77, 128.69, 128.40, 123.91, 121.11, 115.14, 88.12, 37.96, 30.66, 21.79. HRMS (ESI) calcd for $C_{11}H_{13}N_2O_3$ $(M+H)^+$: 221.0921, found: 221.0928.



2b

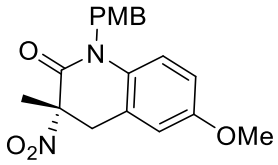
White solid. 85% yield. The ***ee*** was determined on a Daicel Chiralpak ID column with hexane/2-propanol = 90/10, flow = 1.0 mL/min. Retention times: 29.4 min [(*S*)-enantiomer], 36.8 min [(*R*)-enantiomer]. 98% ***ee***. $[\alpha]^{20}_{D}$ = +69.0 (*c* 0.100, CH_2Cl_2), The absolute configuration was assigned by analogy with compound **2k**. Mp: 60.5-61.3 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.26-7.21 (m, 2H), 7.20-7.14 (m, 2H), 7.02 (td, *J* = 7.6, 1.2 Hz, 1H), 6.97 (dd, *J* = 8.4, 0.8 Hz, 1H), 6.90-6.85 (m, 2H), 5.42 (d, *J* = 16.0 Hz, 1H), 4.89 (d, *J* = 16.0 Hz, 1H), 3.83 (d, *J* = 16.4 Hz, 1H), 3.78 (s, 3H), 3.22 (d, *J* = 16.4 Hz, 1H), 1.94 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 163.51, 158.88, 138.46, 128.66, 128.44, 128.15, 127.65, 124.01, 121.31, 116.09, 114.31, 88.18, 55.24, 47.30, 38.05, 22.13. HRMS (ESI) calcd for $C_{18}H_{19}N_2O_4$ $(M+H)^+$: 327.1339, found: 327.1356.



2b'

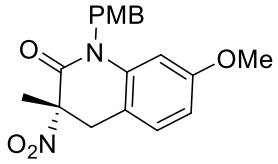
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.80-7.71 (m, 1H), 7.65 (d, *J* = 7. 2 Hz, 1H), 7.38-7.27 (m, 3H), 7.12 (d, *J* = 8.4, 1H), 6.85 (dd, *J* = 8.4, 2.8 Hz, 1H), 4.40 (s, 2H), 3.87 (s, 3H), 1.86 (s, 6H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 163.48, 160.13, 137.14, 136.99, 133.10, 129.88, 128.11, 128.05, 126.89, 126.39, 125.78, 125.68, 125.27, 124.44, 124.34, 113.41, 109.55, 109.45, 90.05, 55.63, 55.50, 48.18, 26.25. HRMS (ESI) calcd for $C_{18}H_{18}N_2NaO_4$ $(M+Na)^+$: 349.1159, found: 349.1165.



2c

White solid. 71% yield. The ***ee*** was determined on a Daicel Chiralpak ID column with hexane/2-propanol = 70/30, flow = 1.0 mL/min. Retention times: 15.5 min [(*S*)-enantiomer], 19.6 min [(*R*)-enantiomer]. 95% ***ee***. $[\alpha]^{20}_{D}$ = +355 (*c* 0.100, CH_2Cl_2), The absolute configuration w as assigned by analogy with compound **2k**. Mp: 99.9-102.3 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.24-7.19 (m, 2H), 6.89-6.84 (m, 3H), 6.72-6.65 (m, 2H), 5.39 (d, *J* = 15.6 Hz, 1H), 4.84 (d, *J* = 16.0 Hz, 1H), 3.77 (d, *J* = 16.4 Hz, 1H), 3.77 (s, 3H), 3.73 (s, 3H), 3.18 (d, *J* = 16.4 Hz, 1H), 1.92 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 163.08, 158.83, 155.95, 131.80, 128.26, 127.65, 122.74, 117.22, 114.28, 114.25, 113.36, 88.21, 55.47, 55.25, 47.36, 38.19, 22.16. HRMS (ESI) calcd for $C_{19}H_{21}N_2O_5$ $(M+H)^+$: 357.1445, found: 357.1432.

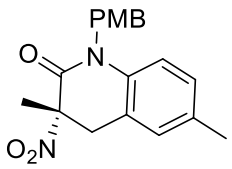


2d

White solid. 77% yield. The ***ee*** was determined on a Daicel Chiralpak AD-H column with hexane/2-propanol = 85/15, flow = 1.0 mL/min. Retention times: 26.5 min [(*R*)-enantiomer], 31.5 min [(*S*)-enantiomer]. 97% ***ee***. $[\alpha]^{20}_{D}$ = +103 (*c* 0.100, CH_2Cl_2), The absolute configuration was assigned by analogy with compound **2k**. Mp: 119.9-122.1 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.24 (d, *J* = 7.6 Hz, 2H), 7.05 (d, *J* = 8.0 Hz, 1H), 6.86 (d, *J* = 8.0 Hz, 2H), 6.54-6.52 (m, 2H), 5.39 (d, *J* = 16.0 Hz, 1H), 4.85 (d, *J* = 15.6 Hz, 1H), 3.77 (s, 3H), 3.74 (d, *J* = 16.4 Hz, 1H), 3.65 (s, 3H), 3.14 (d, *J* = 16.4 Hz, 1H), 1.91 (s, 3H). ^{13}C NMR (151 MHz, $CDCl_3$) δ 163.73, 159.86, 158.91, 139.51, 129.13,

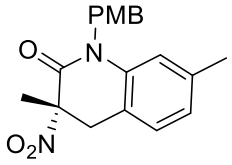
128.21, 127.76, 114.36, 113.37, 108.35, 103.50, 88.45, 55.33, 55.27, 47.43, 37.44, 22.15. HRMS (ESI) calcd for $C_{19}H_{20}N_2NaO_5$ $(M+Na)^+$: 379.1264, found: 379.1259.



2e

White solid. 70% yield. The ***ee*** was determined on a Daicel Chiralpak ID column with hexane/2-propanol = 90/10, flow = 1.0 mL/min. Retention times: 24.5 min [(*S*)-enantiomer], 31.9 min [(*R*)-enantiomer]. 95% ***ee***. $[\alpha]^{20}_D$ = +86.2 (*c* 0.100, CH_2Cl_2), The absolute configuration was assigned by analogy with compound **2k**. Mp: 64.5-66.8 °C.

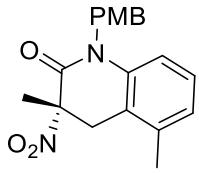
^{1}H NMR (600 MHz, $CDCl_3$) δ 7.23 (d, *J* = 8.4 Hz, 2H), 6.96 (d, *J* = 9.0 Hz, 2H), 6.87 (d, *J* = 8.4 Hz, 2H), 6.85 (d, *J* = 7.8 Hz, 1H), 5.38 (d, *J* = 15.6 Hz, 1H), 4.88 (d, *J* = 16.2 Hz, 1H), 3.77 (d, *J* = 16.2 Hz, 1H), 3.77 (s, 3H), 3.18 (d, *J* = 16.2 Hz, 1H), 2.25 (s, 3H), 1.92 (s, 3H). ^{13}C NMR (151 MHz, $CDCl_3$) δ 163.43, 158.86, 136.01, 133.77, 129.14, 129.09, 128.30, 127.70, 121.16, 116.00, 114.29, 88.34, 55.27, 47.22, 38.08, 22.16, 20.55. HRMS (ESI) calcd for $C_{19}H_{21}N_2O_4$ $(M+H)^+$: 341.1496, found: 341.1510.



2f

White solid. 78% yield. The ***ee*** was determined on a Daicel Chiralpak ID column with hexane/2-propanol = 90/10, flow = 1.0 mL/min. Retention times: 26.4 min [(*S*)-enantiomer], 31.4 min [(*R*)-enantiomer]. 98% ***ee***. $[\alpha]^{20}_D$ = +220 (*c* 0.0500, CH_2Cl_2), The absolute configuration was assigned by analogy with compound **2k**. Mp: 86.9-89.4 °C.

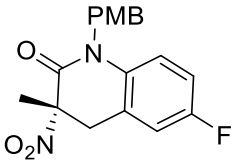
^{1}H NMR (600 MHz, $CDCl_3$) δ 7.24 (d, *J* = 7.8 Hz, 2H), 7.04 (d, *J* = 7.2 Hz, 1H), 6.88 (d, *J* = 8.4 Hz, 2H), 6.83 (d, *J* = 7.2 Hz, 1H), 6.79 (s, 1H), 5.39 (d, *J* = 16.2 Hz, 1H), 4.88 (d, *J* = 16.2 Hz, 1H), 3.78 (s, 3H), 3.77 (d, *J* = 16.8 Hz, 1H), 3.17 (d, *J* = 16.8Hz, 1H), 2.23 (s, 3H), 1.92 (s, 3H). ^{13}C NMR (151 MHz, $CDCl_3$) δ 163.64, 158.86, 138.69, 138.41, 128.33, 128.28, 127.69, 124.75, 118.34, 116.77, 114.31, 88.37, 55.27, 47.32, 37.76, 22.13, 21.54. HRMS (ESI) calcd for $C_{19}H_{21}N_2O_4$ $(M+H)^+$: 341.1496, found: 341.1511.



2g

White solid. 30% yield. The ***ee*** was determined on a Daicel Chiralpak ID column with hexane/2-propanol = 90/10, flow = 1.0 mL/min. Retention times: 26.0 min [(*S*)-enantiomer], 34.2 min [(*R*)-enantiomer]. 97% ***ee***. $[\alpha]^{20}_{D}$ = +140 (*c* 0.0500, CH_2Cl_2), The absolute configuration was assigned by analogy with compound **2k**. Mp: 102.5-103.7 °C.

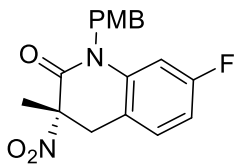
^{1}H NMR (600 MHz, $CDCl_3$) δ 7.23 (d, *J* = 7.2 Hz, 2H), 7.05 (t, *J* = 6.6 Hz, 1H), 6.93-6.85 (m, 3H), 6.83 (d, *J* = 7.8 Hz, 1H), 5.44 (d, *J* = 15.6 Hz, 1H), 4.85 (d, *J* = 15.6 Hz, 1H), 3.92 (d, *J* = 16.8 Hz, 1H), 3.78 (s, 3H), 3.04 (d, *J* = 16.2 Hz, 1H), 2.33 (s, 3H), 1.96 (s, 3H). ^{13}C NMR (151 MHz, $CDCl_3$) δ 163.31, 158.84, 138.67, 136.28, 128.36, 128.08, 127.65, 126.04, 120.08, 114.30, 114.26, 87.94, 55.27, 47.62, 34.37, 22.46, 19.50. HRMS (ESI) calcd for $C_{19}H_{21}N_2O_4$ $(M+H)^+$: 341.1496, found: 341.1516.



2h

White solid. 81% yield. The ***ee*** was determined on a Daicel Chiralpak ID column with hexane/2-propanol = 90/10, flow = 1.0 mL/min. Retention times: 28.7 min [(*S*)-enantiomer], 36.4 min [(*R*)-enantiomer]. 98% ***ee***. $[\alpha]^{20}_{D}$ = +168 (*c* 0.0500, CH_2Cl_2), The absolute configuration was assigned by analogy with compound **2k**. Mp: 118.7-122.4 °C.

^{1}H NMR (600 MHz, $CDCl_3$) δ 7.22 (d, *J* = 8.4 Hz, 2H), 6.94-6.84 (m, 5H), 5.43 (d, *J* = 16.2 Hz, 1H), 4.84 (d, *J* = 16.2 Hz, 1H), 3.79 (d, *J* = 16.8 Hz, 1H), 3.78 (s, 3H), 3.21 (d, *J* = 16.2 Hz, 1H), 1.94 (s, 3H). ^{13}C NMR (151 MHz, $CDCl_3$) δ 163.11, 158.99, 158.85 (d, J_{CF} = 245.2 Hz), 134.69 (d, J_{CF} = 2.6 Hz), 127.85, 127.63, 123.35 (d, J_{CF} = 8.0 Hz), 117.61 (d, J_{CF} = 8.0 Hz), 115.54 (d, J_{CF} = 23.6 Hz), 115.27 (d, J_{CF} = 22.6 Hz), 114.42, 87.84, 55.28, 47.57, 37.86, 22.20. ^{19}F NMR (565 MHz, $CDCl_3$) δ -118.34. HRMS (ESI) calcd for $C_{18}H_{17}FN_2NaO_4$ $(M+Na)^+$: 367.1065, found: 367.1089.

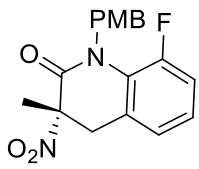


2i

White solid. 74% yield. The ***ee*** was determined on a Daicel Chiralpak ID column with hexane/2-propanol = 90/10, flow = 1.0 mL/min. Retention times: 19.1 min [(*S*)-enantiomer], 25.0 min [(*R*)-enantiomer]. 98% ***ee***. $[\alpha]^{20}_{D}$ = +132 (*c* 0.100, CH_2Cl_2), The absolute configuration was assigned by analogy with compound **2k**. Mp: 134.7-138.6 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.25-7.19 (m, 2H), 7.11 (d, *J* = 7.6 Hz, 1H), 6.91-6.85 (m, 2H), 6.74-6.67 (m, 2H), 5.40 (d, *J* = 16.0 Hz, 1H), 4.82 (d, *J* = 16.0 Hz, 1H), 3.78 (s, 3H), 3.17 (d, *J* = 16.4 Hz, 1H), 3.17 (d, *J* = 16.4 Hz, 1H), 1.93 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 163.38, 162.59 (d, J_{CF} = 247.0 Hz), 159.02, 139.86 (d, J_{CF} = 10.4 Hz), 129.60 (d, J_{CF} = 9.4 Hz), 127.68, 127.51, 116.86 (d, J_{CF} = 3.3 Hz), 114.44, 110.56 (d, J_{CF} = 21.8 Hz), 104.23 (d, J_{CF} = 27.3 Hz), 88.01, 55.25, 47.46, 37.43, 22.14.

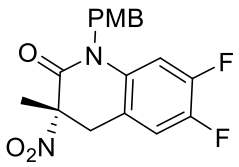
^{19}F NMR (565 MHz, $CDCl_3$) δ -111.37. HRMS (ESI) calcd for $C_{18}H_{17}FN_2NaO_4$ $(M+Na)^+$: 367.1065, found: 367.1053.



2j

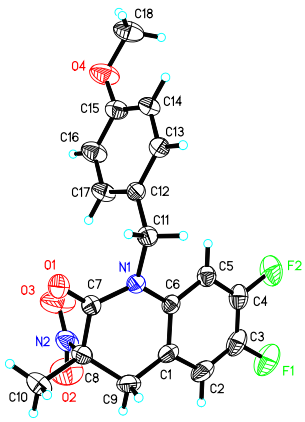
White solid. 64% yield. The ***ee*** was determined on a Daicel Chiralpak ID column with hexane/2-propanol = 90/10, flow = 1.0 mL/min. Retention times: 17.6 min [(*S*)-enantiomer], 21.8 min [(*R*)-enantiomer]. 97% ***ee***. $[\alpha]^{20}_D$ = +106 (*c* 0.0500, CH_2Cl_2), The absolute configuration was assigned by analogy with compound **2k**. Mp: 137.9-139.5 °C.

^{1}H NMR (600 MHz, $CDCl_3$) δ 7.16 (d, *J* = 8.4 Hz, 2H), 7.03-6.93 (m, 3H), 6.81-6.78 (m, 2H), 5.34 (d, *J* = 15.0 Hz, 1H), 5.18 (d, *J* = 15.6 Hz, 1H), 3.75 (d, *J* = 16.8 Hz, 1H), 3.75 (s, 3H), 3.13 (d, *J* = 16.2 Hz, 1H), 1.90 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 163.92, 158.80, 151.83 (d, J_{CF} = 251.2 Hz), 128.74, 128.30 (d, J_{CF} = 1.5 Hz), 125.94, 125.85 (d, J_{CF} = 2.2 Hz), 125.67 (d, J_{CF} = 8.7 Hz), 124.14 (d, J_{CF} = 3.2 Hz), 117.07 (d, J_{CF} = 22.3 Hz), 113.88, 88.28, 55.16, 48.41 (d, J_{CF} = 11.6 Hz), 38.12 (d, J_{CF} = 2.3 Hz), 21.95. ^{19}F NMR (565 MHz, $CDCl_3$) δ -118.60. HRMS (ESI) calcd for $C_{18}H_{17}FN_2NaO_4$ $(M+Na)^+$: 367.1065, found: 367.1051.



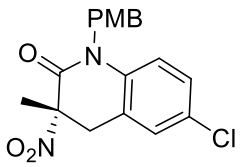
2k

≡



White solid. 83% yield. The ***ee*** was determined on a Daicel Chiralpak ID column with hexane/2-propanol = 90/10, flow = 1.0 mL/min. Retention times: 16.5 min [(*S*)-enantiomer], 20.4 min [(*R*)-enantiomer]. 97% ***ee***. $[\alpha]^{20}_{D}$ = +71.0 (*c* 0.100, CH_2Cl_2), The absolute configuration was assigned by analogy with compound **2k**. Mp: 182.3-183.7 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.25-7.19 (m, 2H), 7.00 (t, *J* = 8.8 Hz, 1H), 6.92-6.86 (m, 2H), 6.81 (dd, *J* = 12.0, 6.8 Hz, 1H), 5.41 (d, *J* = 16.0 Hz, 1H), 4.78 (d, *J* = 16.0 Hz, 1H), 3.79 (s, 3H), 3.74 (d, *J* = 16.4 Hz, 1H), 3.18 (d, *J* = 16.4 Hz, 1H), 1.94 (s, 3H). ^{13}C NMR (151 MHz, $CDCl_3$) δ 163.00, 159.15, 149.79 (dd, J_{CF} = 248.2, 13.4 Hz), 146.29 (dd, J_{CF} = 247.3, 12.8 Hz), 135.03 (dd, J_{CF} = 8.0, 2.9 Hz), 127.66, 127.26, 117.64 (dd, J_{CF} = 5.7, 3.9 Hz), 117.22 (d, J_{CF} = 19.0 Hz), 114.55, 106.30 (d, J_{CF} = 22.5 Hz), 87.75, 55.28, 47.67, 37.23, 22.16. ^{19}F NMR (565 MHz, $CDCl_3$) δ -135.58 (dt, *J* = 20.9, 10.2 Hz), -142.63 (dt, *J* = 21.5, 8.5 Hz). HRMS (ESI) calcd for $C_{18}H_{16}F_2N_2NaO_4$ $(M+Na)^+$: 385.0970, found: 385.0957.

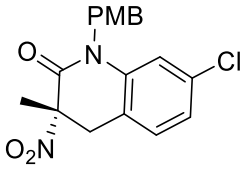


2l

White solid. 71% yield. The ***ee*** was determined on a Daicel Chiralpak ID column with hexane/2-propanol = 90/10, flow = 1.0 mL/min. Retention times: 23.0 min [(*S*)-enantiomer], 28.4 min [(*R*)-enantiomer]. 95% ***ee***. $[\alpha]^{20}_{D}$ = +190 (*c* 0.0300, CH_2Cl_2), The absolute configuration was assigned by analogy with compound **2k**. Mp: 69.5-71.4 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.24-7.18 (m, 2H), 7.18-7.11 (m, 2H), 6.92-6.85 (m, 3H), 5.42 (d, *J* = 16.0 Hz, 1H), 4.85 (d, *J* = 16.0 Hz, 1H), 3.79 (d, *J* = 16.4 Hz, 1H), 3.78 (s, 3H), 3.20 (d, *J* = 16.4 Hz, 1H), 1.94 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 163.13, 158.98, 137.04, 129.28, 128.64, 128.37, 127.63, 127.61, 122.99, 117.39,

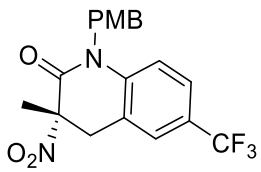
114.39, 87.75, 55.26, 47.37, 37.68, 22.17. HRMS (ESI) calcd for $C_{18}H_{17}ClN_2NaO_4$ $(M+Na)^+$: 383.0769, found: 383.0770.



2m

White solid. 86% yield. The ***ee*** was determined on a Daicel Chiralpak ID column with hexane/2-propanol = 90/10, flow = 1.0 mL/min. Retention times: 22.1 min [(*S*)-enantiomer], 26.6 min [(*R*)-enantiomer]. 98% ***ee***. $[\alpha]^{20}_D$ = +167 (*c* 0.100, CH_2Cl_2), The absolute configuration was assigned by analogy with compound **2k**. Mp: 117.5-120.7 °C.

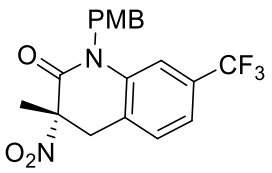
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.26-7.21 (m, 2H), 7.10 (d, *J* = 8.0 Hz, 1H), 7.03-6.96 (m, 2H), 6.92-6.87 (m, 2H), 5.39 (d, *J* = 15.6 Hz, 1H), 4.86 (d, *J* = 15.6 Hz, 1H), 3.79 (d, *J* = 16.8 Hz , 1H), 3.79 (s, 3H), 3.18 (d, *J* = 16.8 Hz, 1H), 1.94 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 163.29, 159.02, 139.56, 134.39, 129.43, 127.70, 127.45, 123.97, 119.69, 116.45, 114.44, 87.85, 55.26, 47.39, 37.52, 22.13. HRMS (ESI) calcd for $C_{18}H_{18}ClN_2O_4$ $(M+H)^+$: 361.0950, found: 361.0954.



2n

White solid. 50% yield. The ***ee*** was determined on a Daicel Chiralpak ID column with hexane/2-propanol = 90/10, flow = 1.0 mL/min. Retention times: 13.3 min [(*S*)-enantiomer], 17.0 min [(*R*)-enantiomer]. 88% ***ee***. $[\alpha]^{20}_D$ = +167 (*c* 0.0300, CH_2Cl_2), The absolute configuration was assigned by analogy with compound **2k**. Mp: 127.8-132.2 °C.

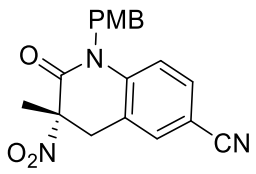
^{1}H NMR (600 MHz, $CDCl_3$) δ 7.44 (d, *J* = 7.8 Hz, 1H), 7.44 (s, 1H), 7.23 (d, *J* = 8.4 Hz, 2H), 7.07 (d, *J* = 8.4 Hz, 1H), 6.89 (d, *J* = 8.4 Hz, 2H), 5.47 (d, *J* = 15.6 Hz, 1H), 4.90 (d, *J* = 16.2 Hz, 1H), 3.88 (d, *J* = 16.8 Hz, 1H), 3.79 (s, 3H), 3.28 (d, *J* = 16.8 Hz, 1H), 1.97 (s, 3H). ^{13}C NMR (151 MHz, $CDCl_3$) δ 163.39, 159.11, 141.32, 127.65, 127.38, 126.08 (q, J_{CF} = 33.2 Hz), 126.01 (q, J_{CF} = 3.8 Hz), 125.50 (q, J_{CF} = 3.8 Hz), 123.63 (q, J_{CF} = 271.6 Hz), 121.82, 116.26, 114.49, 87.67, 55.29, 47.43, 37.82, 22.21. ^{19}F NMR (565 MHz, $CDCl_3$)) δ -62.29. HRMS (ESI) calcd for $C_{19}H_{17}F_3N_2NaO_4$ $(M+Na)^+$: 417.1033, found: 417.1024.



2o

White solid. 51% yield. The ***ee*** was determined on a Daicel Chiralpak ID column with hexane/2-propanol = 90/10, flow = 1.0 mL/min. Retention times: 12.0 min [(*S*)-enantiomer], 13.6 min [(*R*)-enantiomer]. 97% ***ee***. $[\alpha]^{20}_{D}$ = +112 (*c* 0.0400, CH_2Cl_2), The absolute configuration was assigned by analogy with compound **2k**. Mp: 104.3-105.6 °C.

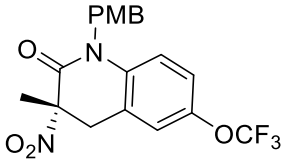
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.30 (s, 1H), 7.29 (s, 1H), 7.26-7.22 (m, 3H), 6.91-6.86 (m, 2H), 5.42 (d, *J* = 15.6 Hz, 1H), 4.94 (d, *J* = 16.0 Hz, 1H), 3.89 (d, *J* = 16.4 Hz, 1H), 3.79 (s, 3H), 3.26 (d, *J* = 16.8 Hz, 1H), 1.96 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 163.22, 159.10, 138.91, 131.12 (d, J_{CF} =33.0 Hz), 129.01, 127.91, 127.30, 125.08 (q, J_{CF} = 1.2 Hz), 123.41 (q, J_{CF} = 274.0 Hz), 120.74 (q, J_{CF} = 3.7 Hz), 114.45, 112.92 (q, J_{CF} = 3.8 Hz), 87.61, 55.24, 47.31, 37.77, 22.16. ^{19}F NMR (565 MHz, $CDCl_3$) δ -62.90. HRMS (ESI) calcd for $C_{19}H_{17}F_3N_2NaO_4$ $(M+Na)^+$: 417.1033, found: 417.1022.



2p

White solid. 30% yield. The ***ee*** was determined on a Daicel Chiralpak ID column with hexane/2-propanol = 80/20, flow = 1.0 mL/min. Retention times: 30.0 min [(*S*)-enantiomer], 34.3 min [(*R*)-enantiomer]. 96% ***ee***. $[\alpha]^{20}_{D}$ = +142 (*c* 0.100, CH_2Cl_2), The absolute configuration was assigned by analogy with compound **2k**. Mp: 139.5-142.3 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.50-7.45 (m, 2H), 7.23-7.18 (m, 2H), 7.06 (d, *J* = 9.2 Hz, 1H), 6.91-6.86 (m, 2H), 5.48 (d, *J* = 16.0 Hz, 1H), 4.87 (d, *J* = 16.0 Hz, 1H), 3.85 (d, *J* = 16.8 Hz, 1H), 3.79 (s, 3H), 3.27 (d, *J* = 16.8 Hz, 1H), 1.98 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 163.19, 159.17, 142.12, 132.94, 131.91, 127.59, 126.96, 122.38, 117.92, 116.67, 114.54, 107.45, 87.37, 55.27, 47.44, 37.48, 22.18. HRMS (ESI) calcd for $C_{19}H_{17}N_3NaO_4$ $(M+Na)^+$: 374.1111, found: 374.1094.

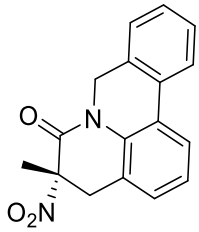


2q

White solid. 84% yield. The ***ee*** was determined on a Daicel Chiralpak ID column with hexane/2-propanol = 90/10, flow = 1.0 mL/min. Retention times: 12.5 min [(*S*)-enantiomer], 15.4 min [(*R*)-enantiomer]. 96% ***ee***. $[\alpha]^{20}_{D}$ = +253 (*c* 0.0300, CH_2Cl_2), The absolute configuration was assigned by analogy with compound **2k**. Mp: 65.3-66.9 °C.

^{1}H NMR (600 MHz, $CDCl_3$) δ 7.23 (d, *J* = 8.4 Hz, 2H), 7.06 (s, 1H), 7.03 (d, *J* = 9.6 Hz, 1H), 6.98 (d, *J* = 9.0 Hz, 1H), 6.89 (d, *J* = 7.8 Hz, 2H), 5.45 (d, *J* = 16.2 Hz, 1H), 4.83 (d, *J* = 15.6 Hz, 1H), 3.82 (d, *J* = 16.8 Hz, 1H), 3.78 (s, 3H), 3.24 (d, *J* = 16.8 Hz, 1H), 1.95 (s, 3H). ^{13}C NMR (151 MHz, $CDCl_3$) δ 163.18, 159.07, 144.97, 137.12,

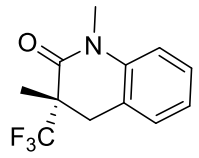
128.01, 127.63, 123.06, 121.18, 120.34 (q, J_{CF} = 257.8 Hz), 117.29, 114.47, 114.28, 87.70, 55.28, 47.57, 37.78, 22.21. ^{19}F NMR (565 MHz, $CDCl_3$) δ -58.11. HRMS (ESI) calcd for $C_{19}H_{17}F_3N_2NaO_5$ $(M+Na)^+$: 433.0982, found: 433.0988.



2r

White solid. 50% yield. The ***ee*** was determined on a Daicel Chiralpak ID column with hexane/2-propanol = 90/10, flow = 1.0 mL/min. Retention times: 18.5 min [(*R*)-enantiomer], 29.7 min [(*S*)-enantiomer]. 90% ***ee***. $[\alpha]^{20}_D$ = +60.0 (*c* 0.100, CH_2Cl_2), The absolute configuration was assigned by analogy with compound **2k**. Mp: 100-102.3 °C.

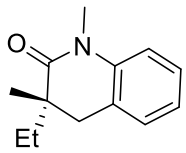
^{1}H NMR (600 MHz, $CDCl_3$) δ 7.78-7.73 (m, 2H), 7.38 (t, *J* = 7.8 Hz, 1H), 7.33 (t, *J* = 7.8 Hz, 1H), 7.28 (d, *J* = 7.8 Hz, 1H), 7.16 (d, *J* = 4.8 Hz, 2H), 5.39 (d, *J* = 16.2 Hz, 1H), 4.83 (d, *J* = 16.2 Hz, 1H), 3.89 (d, *J* = 16.2 Hz, 1H), 3.20 (d, *J* = 16.2 Hz, 1H), 1.89 (s, 3H). ^{13}C NMR (151 MHz, $CDCl_3$) δ 162.32, 133.35, 130.46, 129.52, 128.57, 128.38, 127.97, 126.74, 124.76, 124.17, 123.17, 123.14, 121.60, 87.90, 43.84, 37.55, 21.81. HRMS (ESI) calcd for $C_{17}H_{14}N_2NaO_3$ $(M+Na)^+$: 317.0897, found: 317.0897.



2s

White solid. 60% yield. The ***ee*** was determined on a Daicel Chiralcel OD-H column with hexane/2-propanol = 90/10, flow = 1.0 mL/min. Retention times: 6.7 min [(*S*)-enantiomer], 7.6 min [(*R*)-enantiomer]. 62% ***ee***. $[\alpha]^{20}_D$ = +50.0 (*c* 0.100, CH_2Cl_2), The absolute configuration was assigned by analogy with compound **2k**. Mp: 100-102.3 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.31 (t, *J* = 7.6 Hz, 1H), 7.20 (d, *J* = 7.6 Hz, 1H), 7.08 (t, *J* = 7.2 Hz, 1H), 7.00 (d, *J* = 8.0 Hz, 1H), 3.40 (s, 3H), 3.33 (d, *J* = 15.6 Hz, 1H), 2.87 (d, *J* = 15.6 Hz, 1H), 1.33 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 166.91, 139.02, 128.53, 128.04, 126.40 (q, J_{CF} = 283.8 Hz), 123.51, 121.86, 114.45, 47.12 (q, J_{CF} = 25.1 Hz), 32.83 (q, J_{CF} = 2.3 Hz), 30.12, 16.81 (q, J_{CF} = 2.2 Hz). ^{19}F NMR (565 MHz, $CDCl_3$) δ -74.21. HRMS (ESI) calcd for $C_{12}H_{13}F_3NO$ $(M+H)^+$: 244.0944, found: 244.0932.

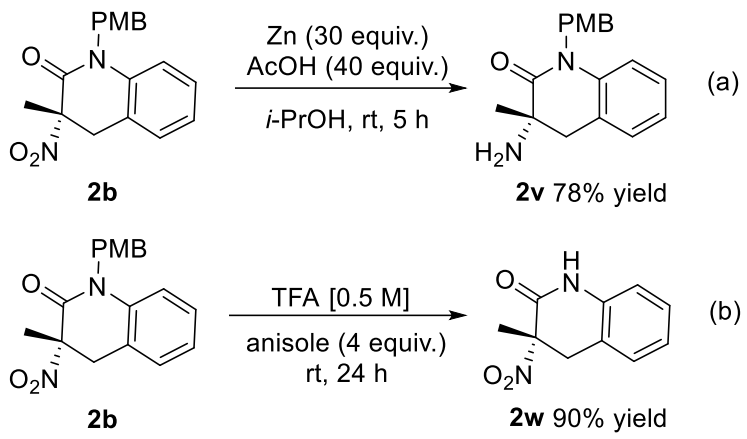


2u

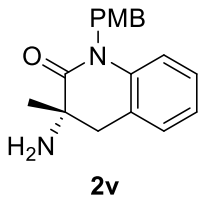
White solid. 80% yield at the temperature of 160 °C, while it is no reaction at 120 °C. The ***ee*** was determined on a Daicel Chiralcel OZ-3 column with hexane/2-propanol = 95/5, flow = 1.0 mL/min. Retention times: 6.9 min [(*R*)-enantiomer], 7.7 min [(*S*)-enantiomer]. 52% ***ee***. $[\alpha]^{20}_{D}$ = +143 (*c* 0.0300, CH_2Cl_2), The absolute configuration was assigned by analogy with compound **2k**. Mp: 100-102.3 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.25 (t, *J* = 7.6 Hz, 1H), 7.14 (d, *J* = 7.2 Hz, 1H), 7.01 (t, *J* = 7.6 Hz, 1H), 6.95 (d, *J* = 8.4 Hz, 1H), 3.36 (s, 3H), 2.77 (q, *J* = 15.6 Hz, 2H), 1.54-1.46 (m, 2H), 1.15 (s, 3H), 0.86 (t, *J* = 7.6 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 174.94, 140.03, 128.23, 127.19, 124.92, 122.61, 113.94, 40.66, 37.10, 29.90, 29.05, 21.92, 8.35. HRMS (ESI) calcd for $C_{13}H_{18}NO$ $(M+H)^+$: 204.1383, found: 204.1403.

3、Product transformation.



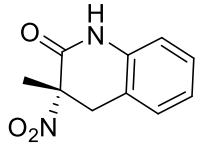
Activated Zn (18 mmol) was added to a solution of **2b** (0.6 mmol) in isopropyl alcohol [0.1 M], and then AcOH (24 mmol) was slowly added (within 10 min). The reaction was stirred at room temperature for 5 h. The reaction mixture was filtered through a pad of Celite and washed with ethyl acetate, the filtrate was washed twice with Na_2CO_3 (saturated aqueous), and the aqueous layer was extracted with ethyl acetate. The organic phases were combined, dried over anhydrous sodium sulfate and concentrated in vacuo. The residue was purified by silica gel column chromatography to afford the amine **2v**.



White solid. 78% yield. $[\alpha]^{20}_{D}$ = +47.0 (*c* 0.100, CH_2Cl_2), The absolute configuration was assigned by analogy with compound **2k**.

^{1}H NMR (600 MHz, $CDCl_3$) δ 7.20-7.09 (m, 4H), 7.02-6.96 (m, 1H), 6.92-6.88 (m, 1H), 6.87-6.81 (m, 2H), 5.30 (d, *J* = 15.6 Hz, 1H), 4.90 (d, *J* = 16.2 Hz, 1H), 3.76 (s, 3H), 3.03 (d, *J* = 15.6 Hz, 1H), 2.91 (d, *J* = 15.6 Hz, 1H), 2.00 (s, 2H), 1.27 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 175.28, 158.67, 139.01, 128.93, 128.80, 127.60, 127.45, 124.26, 123.17, 115.20, 114.20, 55.23, 53.00, 46.29, 40.09, 24.65. HRMS (ESI) calcd for $C_{18}H_{20}N_2NaO_2$ $(M+Na)^+$: 319.1417, found: 319.1413.

2b was weighed into a vial equipped with a magnetic stir bar, sealed with a rubber septum. The vial was put under vacuum and then backfilled with nitrogen. Anisole (4 equiv.) and TFA (0.05 M) were added. The reaction was stirred for 24 hours at room temperature and evaporated under vacuum. The residue was purified by silica gel column chromatography to afford the amine **2w**.

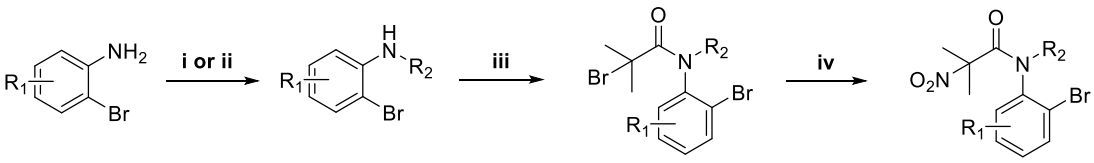


2w

White solid. 90% yield. $[\alpha]^{20}_{D}$ = +93.0 (*c* 0.100, CH_2Cl_2), The absolute configuration was assigned by analogy with compound **2k**.

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.82 (s, 1H), 7.25 (t, *J* = 7.2 Hz, 1H), 7.18 (d, *J* = 7.6 Hz, 1H), 7.06 (td, *J* = 7.6, 1.2 Hz, 1H), 6.88 (d, *J* = 8.0 Hz, 1H), 3.88 (d, *J* = 16.8 Hz, 1H), 3.19 (d, *J* = 16.4 Hz, 1H), 1.89 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 164.41, 135.39, 128.71, 128.38, 124.19, 119.63, 115.83, 87.91, 38.28, 21.31. HRMS (ESI) calcd for $C_{10}H_{11}N_2O_3$ $(M+H)^+$: 207.0764, found: 207.0752.

4、General procedure for the synthesis of substrates in Table 2:



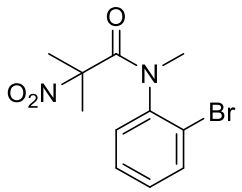
i: To a 50-mL oven-dried flask with a magnetic stirring bar, arylamine **I** (10.0 mmol) and paraformaldehyde (15.0 mmol) was dissolved in CH_3OH (20.0 mL), and CH_3ONa (50 mmol) was added over 5 min. After stirring at room temperature overnight, $NaBH_4$ (11.0 mmol) was added. The mixture was refluxed for 2 to5 h, and then the residue was quenched with NH_4Cl 50 mL (saturated aqueous). The aqueous phase was extracted with ethyl acetate (25.0 mL X 2). The combined organic phase was dried with anhydrous Na_2SO_4, the crude product was purified by column chromatography (silica gel, petroleum ether : ethyl acetate = 20:1) to obtain **IIa**.

ii: A mixture of **I** (7.35 mmol), K_2CO_3 (7.38 mmol), KI (7.35 mmol), and 4-methoxybenzyl bromide (10 mmol) in dry DMF (10 mL) was stirred at RT for 12 hours and then diluted with AcOEt. The organic layer was washed sequentially with H_2O and saturated NaCl solution and dried over anhydrous $MgSO_4$. Then the solvent was removed. The residue was purified by a column chromatography to obtain **IIb-IIq**.

iii: To a solution of **II** (21.5 mmol) and K_2CO_3 (21.7 mmol) in CH_2Cl_2 (35 mL) was added α-bromoisobutyryl bromide (22.6 mmol), dropwise. The reaction mixture was stirred overnight. The solution was filtered and the solvent was removed under vacuum, and the residue was partitioned between ethyl acetate and water. The ethyl acetate fraction was dried with $MgSO_4$, then evaporated. The residue was filtered over a short silica gel column with ethyl acetate to afford **III** for the next step without further purification.

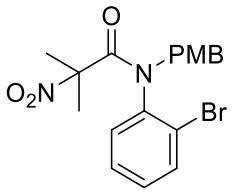
iv: III (5.03 mmol) was added to $NaNO_2$ (50 mmol) and DMF (40 mL). The reaction mixture was heated to 60 °C and stirred for 24 hours. After cooling to room temperature, the solution was filtered and washed with water and brine and then dried with Na_2SO_4. Removal of solvent furnished the crude product, which was purified by column chromatography on silica gel to afford **1a-1q**.

5、Characterization Data of Substrates in Table 2:



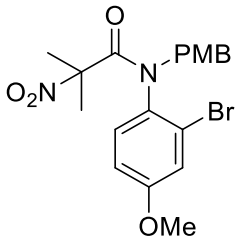
1a

White solid. 60% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.66 (dd, *J* = 8.0, 1.6 Hz, 1H), 7.36 (t, *J* = 7.6 Hz, 1H), 7.31-7.22 (m, 2H), 3.25 (s, 3H), 1.77 (s, 3H), 1.48 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 165.96, 140.35, 133.92, 130.78, 130.65, 129.14, 124.31, 90.28, 39.37, 28.21, 23.35. HRMS (ESI) calcd for $C_{11}H_{14}BrN_2O_3$ $(M+H)^+$: 310.0182, found: 301.0196.



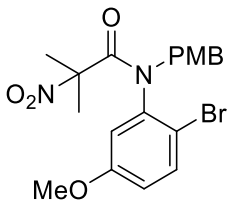
1b

White solid. 58% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.66 (d, *J* = 8.0 Hz, 1H), 7.21 (t, *J* = 7.2 Hz, 1H), 7.15-7.05 (m, 3H), 6.79 (d, *J* = 8.8 Hz, 2H), 6.65 (d, *J* = 7.6 Hz, 1H), 5.79 (d, *J* = 14.0 Hz, 1H), 3.84 (d, *J* = 14.4 Hz, 1H), 3.78 (s, 3H), 1.78 (s, 3H), 1.47 (s, 3H). ^{13}C NMR (151 MHz, $CDCl_3$) δ 165.85, 159.13, 140.37, 138.31, 131.35, 130.45, 129.90, 128.19, 127.51, 127.16, 113.75, 90.52, 55.20, 53.58, 28.36, 23.83, 23.24. HRMS (ESI) calcd for $C_{18}H_{19}BrN_2NaO_4$ $(M+Na)^+$: 429.0420, found: 429.0439.



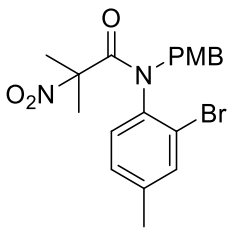
1c

White solid. 57% yield. ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.17 (s, 1H), 7.09 (d, *J* = 7.8 Hz, 2H), 6.79 (d, *J* = 7.8 Hz, 2H), 6.59 (dd, *J* = 8.4, 2.4 Hz, 1H), 6.51 (d, *J* = 9.0 Hz, 1H), 5.76 (d, *J* = 14.4 Hz, 1H), 3.81 (d, *J* = 10.8 Hz, 1H), 3.78 (s, 3H), 3.77 (s, 3H), 1.79 (s, 3H), 1.50 (s, 3H). ^{13}C NMR (151 MHz, $CDCl_3$) δ 166.33, 160.11, 159.13, 133.06, 130.47, 130.33, 128.15, 125.32, 119.13, 113.78, 113.30, 90.29, 55.70, 55.20, 53.65, 28.56, 23.21. HRMS (ESI) calcd for $C_{19}H_{22}BrN_2O_5$ $(M+H)^+$: 437.0707, found: 437.0715.



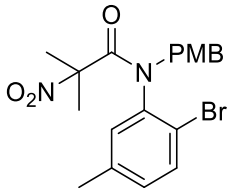
1d

White solid. 58% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.49 (d, *J* = 8.8 Hz, 1H), 7.12 (d, *J* = 8.4 Hz, 2H), 6.81 (d, *J* = 8.4 Hz, 2H), 6.76 (dd, *J* = 8.8, 3.2 Hz, 1H), 6.15 (d, *J* = 2.8 Hz, 1H), 5.78 (d, *J* = 14.4 Hz, 1H), 3.84 (d, *J* = 14.0 Hz, 1H), 3.78 (s, 3H), 3.53 (s, 3H), 1.81 (s, 3H), 1.47 (s, 3H). ^{13}C NMR (151 MHz, $CDCl_3$) δ 165.84, 159.43, 159.40, 138.78, 133.98, 130.72, 128.26, 117.79, 117.61, 114.82, 114.01, 90.60, 55.79, 55.46, 53.63, 28.92, 23.01. HRMS (ESI) calcd for $C_{19}H_{22}BrN_2O_5$ $(M+H)^+$: 437.0707, found: 437.0722.



1e

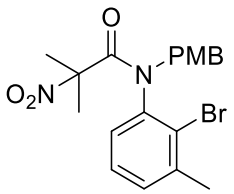
White solid. 62% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.47 (s, 1H), 7.10 (d, *J* = 8.4 Hz, 2H), 6.89 (d, *J* = 8.0 Hz, 1H), 6.79 (d, *J* = 8.4 Hz, 2H), 6.51 (d, *J* = 8.0 Hz, 1H), 5.77 (d, *J* = 14.4 Hz, 1H), 3.80 (d, *J* = 14.8 Hz, 1H), 3.78 (s, 3H), 2.31 (s, 3H), 1.78 (s, 3H), 1.48 (s, 3H). ^{13}C NMR (151 MHz, $CDCl_3$) δ 166.02, 159.13, 141.19, 135.25, 134.20, 132.17, 130.45, 129.02, 128.11, 124.34, 113.76, 90.38, 55.19, 53.57, 28.46, 23.22, 20.86. HRMS (ESI) calcd for $C_{19}H_{22}BrN_2O_4$ $(M+H)^+$: 421.0757, found: 421.0779.



1f

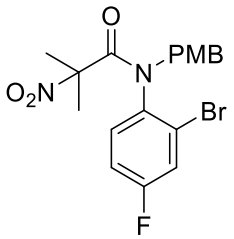
White solid. 64% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.51 (d, *J* = 8.4 Hz, 1H), 7.11 (d, *J* = 8.4 Hz, 2H), 7.01 (d, *J* = 7.6 Hz, 1H), 6.80 (d, *J* = 8.4 Hz, 2H), 6.46 (s, 1H), 5.74 (d, *J* = 14.4 Hz, 1H), 3.85 (d, *J* = 14.4 Hz, 1H), 3.79 (s, 3H), 2.12 (s, 3H), 1.78 (s, 3H), 1.44 (s, 3H). ^{13}C NMR (151 MHz, $CDCl_3$) δ 165.81, 159.13, 138.88, 137.72,

133.31, 133.27, 131.16, 130.40, 128.07, 121.04, 113.74, 90.40, 55.24, 53.64, 28.53, 23.01, 20.63. HRMS (ESI) calcd for $C_{19}H_{22}BrN_2O_4$ $(M+H)^+$: 421.0757, found: 421.0775.



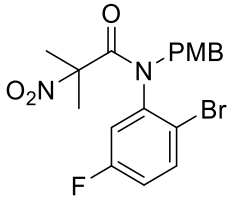
1g

White solid. 63% yield. ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.22 (d, *J* = 7.2 Hz, 1H), 7.11 (d, *J* = 7.8 Hz, 2H), 7.00 (t, *J* = 7.8 Hz, 1H), 6.79 (d, *J* = 7.8 Hz, 2H), 6.49 (d, *J* = 7.8 Hz, 1H), 5.79 (d, *J* = 13.8 Hz, 1H), 3.81 (d, *J* = 14.4 Hz, 1H), 3.78 (s, 3H), 2.47 (s, 3H), 1.76 (s, 3H), 1.44 (s, 3H). ^{13}C NMR (151 MHz, $CDCl_3$) δ 165.85, 159.13, 140.37, 138.31, 131.35, 130.45, 129.90, 128.19, 127.51, 127.16, 113.75, 90.52, 55.20, 53.58, 28.36, 23.83, 23.24. HRMS (ESI) calcd for $C_{19}H_{22}BrN_2O_4$ $(M+H)^+$: 421.0757, found: 421.0777.



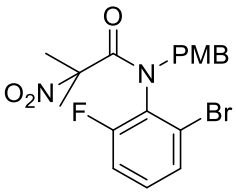
1h

White solid. 55% yield. ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.40 (d, *J* = 7.2 Hz, 1H), 7.07 (d, *J* = 7.8 Hz, 2H), 6.83-6.77 (m, 3H), 6.59 (t, *J* = 7.2 Hz, 1H), 5.79 (d, *J* = 14.4 Hz, 1H), 3.79 (d, *J* = 10.2 Hz, 1H), 3.78 (s, 3H), 1.81 (s, 3H), 1.50 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 165.92, 161.89 (d, J_{CF} = 256.2 Hz), 159.24, 134.05 (d, J_{CF} = 4.2 Hz), 133.79 (d, J_{CF} = 9.1 Hz), 130.47, 127.63, 125.51 (d, J_{CF} = 6.8 Hz), 121.09 (d, J_{CF} = 25.8 Hz), 115.39 (d, J_{CF} = 22.1 Hz), 113.85, 90.15, 55.19, 53.40, 28.56, 23.14. ^{19}F NMR (565 MHz, $CDCl_3$) δ -108.42. HRMS (ESI) calcd for $C_{19}H_{19}BrFN_2O_4$ $(M+H)^+$: 425.0507, found: 425.0523.



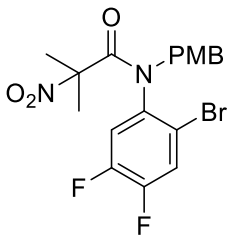
1i

White solid. 50% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.61 (dd, J = 9.2, 5.6 Hz, 1H), 7.08 (d, J = 8.0 Hz, 2H), 6.96 (ddd, J = 8.8, 7.2, 3.2 Hz, 1H), 6.81 (d, J = 8.8 Hz, 2H), 6.42 (dd, J = 8.8, 2.8 Hz, 1H), 5.76 (d, J = 11.6 Hz, 1H), 3.85 (d, J = 13.6 Hz, 1H), 3.78 (s, 3H), 1.81 (s, 3H), 1.51 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 165.60, 161.37 (d, J_{CF} = 252.8 Hz), 159.31, 139.22 (d, J_{CF} = 8.8 Hz), 134.42 (d, J_{CF} = 8.9 Hz), 130.35, 127.40 (d, J_{CF} = 2.3 Hz), 120.33 (d, J_{CF} = 24.6 Hz), 119.34, 117.95 (d, J_{CF} = 22.3 Hz), 113.93, 90.31, 55.18, 53.38, 28.30, 23.20. ^{19}F NMR (565 MHz, $CDCl_3$) δ -111.03. HRMS (ESI) calcd for $C_{19}H_{19}BrFN_2O_4$ $(M+H)^+$: 425.0507, found: 425.0519.



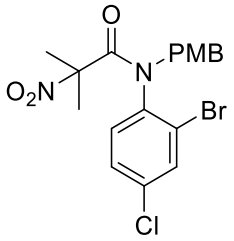
1j

White solid. A mixture of atropisomers. 49% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.47-7.42 (m, 1H), 7.25-7.18 (m, 1H), 7.08 (d, J = 8.4 Hz, 2H), 6.96 (dd, J = 8.4, 1.2 Hz, 1H), 6.73 (d, J = 8.8 Hz, 2H), 5.44 (d, J = 14.0 Hz, 1H), 4.20 (d, J = 14.4 Hz, 1H), 3.76 (s, 3H), 1.66 (s, 3H), 1.64 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 167.19, 159.78 (d, J_{CF} = 256.1 Hz), 159.35, 131.67 (d, J_{CF} = 9.1 Hz), 131.15, 130.10 (d, J_{CF} = 8.7 Hz), 129.35 (d, J_{CF} = 3.5 Hz), 126.90, 115.87 (d, J_{CF} = 21.8 Hz), 115.24 (d, J_{CF} = 21.6 Hz), 113.49, 91.69, 55.13, 53.81, 25.60 (d, J_{CF} = 1.8 Hz), 25.45 (d, J_{CF} = 1.5 Hz). ^{19}F NMR (565 MHz, $CDCl_3$) δ -109.39. HRMS (ESI) calcd for $C_{19}H_{19}BrFN_2O_4$ $(M+H)^+$: 425.0507, found: 425.0510.



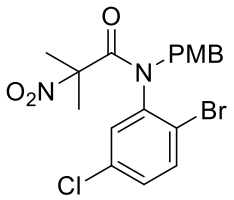
1k

White solid. 56% yield. ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.54-7.42 (m, 1H), 7.06 (s, 2H), 6.82 (s, 2H), 6.51 (s, 1H), 5.78 (s, 1H), 3.79 (s, 4H), 1.83 (s, 3H), 1.53 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 165.72, 159.42, 150.17 (dd, J_{CF} = 258.2, 11.0 Hz), 148.94 (dd, J_{CF} = 255.3, 12.9 Hz), 134.26 (dd, J_{CF} = 5.0, 2.3 Hz), 130.37, 127.13 (d, J_{CF} = 2.0 Hz), 122.06 (d, J_{CF} = 20.64 Hz), 121.68 (d, J_{CF} = 20.7 Hz), 119.34, 114.03, 90.10, 55.21, 53.35, 28.44, 23.21. ^{19}F NMR (565 MHz, $CDCl_3$) δ -131.46, -133.85. HRMS (ESI) calcd for $C_{18}H_{17}BrF_2N_2NaO_4$ $(M+Na)^+$: 465.0232, found: 465.0248.



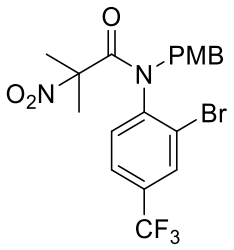
1l

White solid. 60% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.66 (d, J = 2.4 Hz, 1H), 7.14-7.00 (m, 3H), 6.79 (d, J = 8.4 Hz, 2H), 6.54 (d, J = 8.4 Hz, 1H), 5.79 (d, J = 14.4 Hz, 1H), 3.80 (s, 1H), 3.78 (s, 3H), 1.81 (s, 3H), 1.50 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 165.73, 159.30, 136.56, 135.86, 133.46, 133.31, 130.47, 128.53, 127.53, 125.39, 113.88, 90.20, 55.18, 53.34, 28.47, 23.19. ^{19}F NMR (565 MHz, $CDCl_3$) δ -62.81. HRMS (ESI) calcd for $C_{18}H_{18}BrClN_2NaO_4$ $(M+Na)^+$: 463.0031, found: 463.0044.



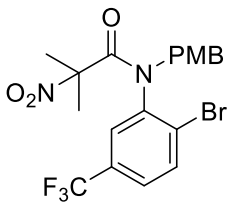
1m

White solid. 62% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.57 (d, *J* = 8.4 Hz, 1H), 7.19 (dd, *J* = 8.8, 2.4 Hz, 1H), 7.07 (d, *J* = 8.0 Hz, 2H), 6.81 (d, *J* = 8.8 Hz, 2H), 6.65 (s, 1H), 5.72 (s, 1H), 3.86 (s, 1H), 3.78 (s, 3H), 1.80 (s, 3H), 1.51 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 165.69, 159.38, 139.11, 134.33, 133.88, 132.77, 130.60, 130.41, 127.30, 122.76, 113.95, 90.35, 55.22, 53.47, 28.07, 23.47. HRMS (ESI) calcd for $C_{18}H_{18}BrClN_2NaO_4$ $(M+Na)^+$: 463.0031, found: 463.0045.



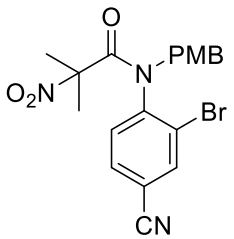
1n

White solid. 54% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.92 (s, 1H), 7.36 (ddd, *J* = 8.0, 2.4, 0.8 Hz, 1H), 7.07 (d, *J* = 8.0 Hz, 2H), 6.80 (d, *J* = 8.4 Hz, 2H), 6.75 (d, *J* = 8.0 Hz, 1H), 5.83 (d, *J* = 11.6 Hz, 1H), 3.82 (d, *J* = 11.6 Hz, 1H), 3.78 (s, 3H), 1.83 (s, 3H), 1.49 (s, 3H). ^{13}C NMR (151 MHz, $CDCl_3$) δ 165.49, 159.43, 141.42, 133.16, 132.47 (q, J_{CF} = 33.8 Hz), 130.87 (q, J_{CF} = 4.1 Hz), 130.47, 127.30 (q, J_{CF} = 5.9 Hz), 125.40, 125.28, 122.57 (q, J_{CF} = 273.3 Hz), 113.95, 90.25, 55.16, 53.32, 28.34, 23.22. HRMS (ESI) calcd for $C_{19}H_{19}BrF_3N_2O_4$ $(M+H)^+$: 475.0475, found: 475.0479.



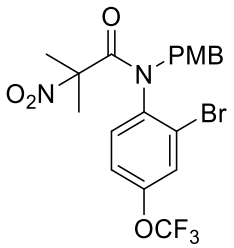
1o

White solid. 50% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.78 (d, *J* = 8.4 Hz, 1H), 7.44 (d, *J* = 8.4 Hz, 1H), 7.02 (d, *J* = 8.0 Hz, 2H), 6.78 (d, *J* = 8.8 Hz, 3H), 5.78 (s, 1H), 3.91 (s, 1H), 3.77 (s, 3H), 1.80 (s, 3H), 1.52 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 165.68, 159.54, 138.52, 134.36, 130.70 (q, J_{CF} = 31.7 Hz), 130.55, 130.33 (q, J_{CF} = 3.1 Hz), 129.04, 127.02 (q, J_{CF} = 4.7 Hz), 126.74, 122.67 (q, J_{CF} = 274.6 Hz), 113.96, 90.22, 55.21, 53.22, 28.03, 23.54. ^{19}F NMR (565 MHz, $CDCl_3$) δ -63.29. HRMS (ESI) calcd for $C_{19}H_{18}BrF_3N_2NaO_4$ $(M+Na)^+$: 497.0294, found: 497.0309.



1p

White solid. 45% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.95 (s, 1H), 7.39 (d, *J* = 8.4 Hz, 1H), 7.03 (d, *J* = 8.0 Hz, 2H), 6.78 (d, *J* = 8.0 Hz, 2H), 6.72 (d, *J* = 8.0 Hz, 1H), 5.81 (s, 1H), 3.87 (s, 1H), 3.78 (s, 3H), 1.84 (s, 3H), 1.51 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 165.29, 159.47, 142.27, 136.94, 133.43, 131.85, 130.49, 126.85, 125.68, 116.23, 114.52, 114.00, 90.11, 55.20, 53.14, 28.33, 23.27. HRMS (ESI) calcd for $C_{19}H_{18}BrN_3NaO_4$ $(M+Na)^+$: 454.0373, found: 454.0393.

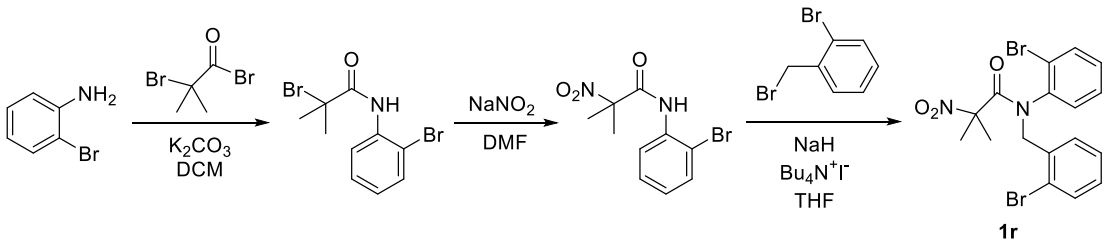


1q

White solid. 60% yield. ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.53 (s, 1H), 7.08 (d, *J* = 8.4 Hz, 2H), 6.96 (d, *J* = 8.4 Hz, 1H), 6.80 (d, *J* = 8.4 Hz, 2H), 6.65 (d, *J* = 8.4 Hz, 1H), 5.80 (d, *J* = 12.0 Hz, 1H), 3.80 (d, *J* = 12.0 Hz, 1H), 3.78 (s, 3H), 1.81 (s, 3H), 1.49 (s, 3H). ^{13}C NMR (151 MHz, $CDCl_3$) δ 165.79, 159.36, 149.25, 136.44, 133.64, 130.46,

127.49, 125.73, 122.70, 120.13, 120.12 (q, J_{CF} = 259.7 Hz), 113.92, 90.20, 55.19, 53.41, 28.47, 23.20. ^{19}F NMR (565 MHz, $CDCl_3$) δ -57.97. HRMS (ESI) calcd for $C_{19}H_{19}BrF_3N_2O_5$ $(M+H)^+$: 491.0424, found: 491.0430.

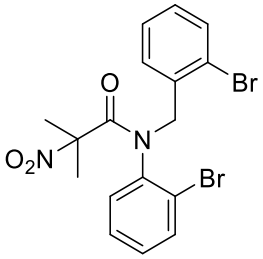
6、Synthetic procedure and Characterization Data of substrate 1r in Scheme 1:



To a solution of 2-bromoaniline (5.85 mmol) and K_2CO_3 (5.85 mmol) in CH_2Cl_2 (10 mL) was added α-bromoisobutyryl bromide (7.02 mmol). The reaction mixture was stirred overnight. The solution was filtered and the solvent was removed under vacuum, and the residue was partitioned between ethyl acetate and water. The ethyl acetate fraction was dried with $MgSO_4$, then evaporated to afford the crude bromoamide that was used without purification.

Bromoamide was added to $NaNO_2$ (117 mmol) and DMF (40 mL). The reaction mixture was heated to 60 °C and stirred for 24 hours. After cooling to room temperature, the solution was filtered and washed with water and brine and then dried with Na_2SO_4. Removal of solvent furnished the crude product, which gone through a rapid column chromatography purification on silica gel to afford a α-nitroamide.

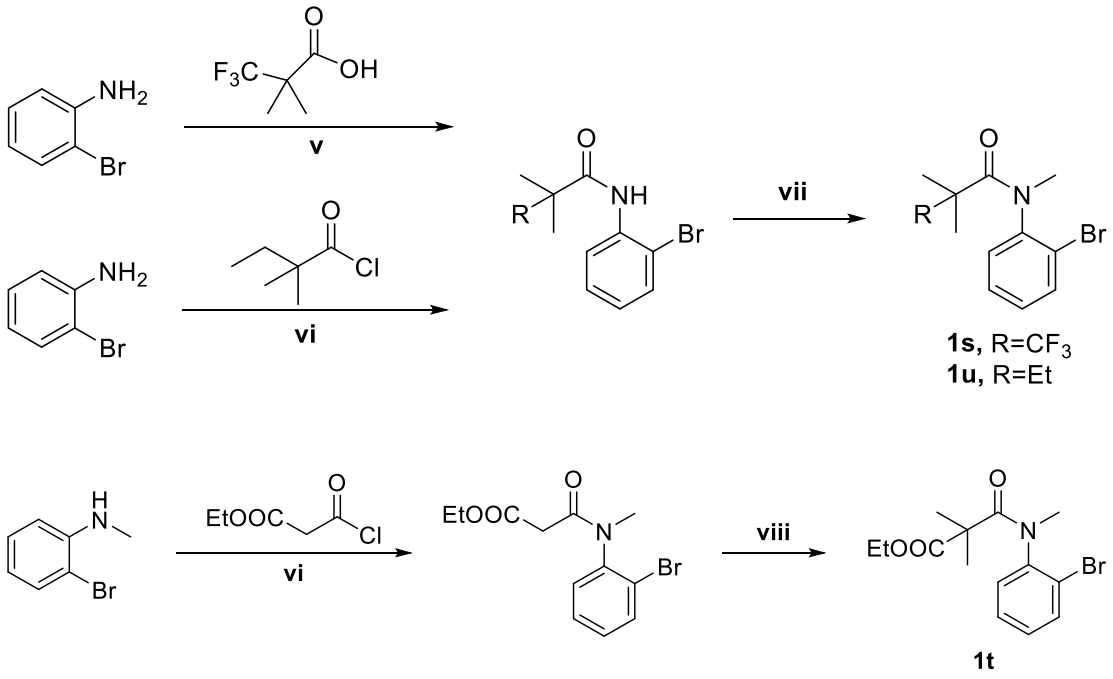
α-Nitroamide, tetra-n-butylammonium iodide (1.17 mmol) was dissolved in dry THF (30 mL) and place under N_2 and cooled to 0℃. NaH (8.37 mmol) was added portionwise and the resulting mixture was stirred until bubbling had ceased. 2-Bromobenzyl bromide (7.02 mmol) was added slowly and resulting mixture was allowed to warm to rt until completed. The reaction was quenched with ammonium chloride and the mixture was extracted with DCM twice. The organic phase was dried over $MgSO_4$ and concentrated under vacuum. The crude mixture was purified by column chromatography on silica gel to afford **1r** (45% yield).



1r

White solid. 45% yield. ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.65 (d, *J* = 8.4 Hz, 1H), 7.50 (d, *J* = 7.8 Hz, 1H), 7.44 (d, *J* = 7.8 Hz, 1H), 7.29 (t, *J* = 7.2 Hz, 1H), 7.20 (t, *J* = 7.2 Hz, 1H), 7.10 (t, *J* = 7.2 Hz, 2H), 6.79 (d, *J* = 7.8 Hz, 1H), 5.79 (d, *J* = 15.0 Hz, 1H), 4.37 (d, *J* = 15.0 Hz, 1H), 1.82 (s, 3H), 1.50 (s, 3H). ^{13}C NMR (151 MHz, $CDCl_3$) δ 166.00, 137.72, 135.09, 133.83, 132.65, 132.28, 130.78, 130.63, 129.29, 128.58, 127.76, 125.24, 124.37, 90.34, 53.21, 28.65, 23.06. HRMS (ESI) calcd for $C_{17}H_{16}Br_2N_2NaO_3$ $(M+Na)^+$: 476.9420, found: 476.9409.

7、Synthetic procedure and Characterization Data of substrate 1s-1u in Scheme 3:

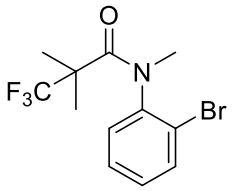


v: To a stirred solution of acid (6.14 mmol) in DCM (10 mL) were added $(COCl)_2$ (11.16 mmol) and DMF (3 drop) at 0°C, and the reaction mixture was stirred at 0°C for 2 h. Then, the reaction mixture was concentrated under vacuum, and to the residue were added DCM (10 mL) and aniline (5.85 mmol), and the reaction mixture was stirred at room temperature for 12 h. Next, to the reaction mixture was added saturated aqueous NH_4Cl solution. The aqueous layer was extracted with DCM, and the combined organic layer was washed with 2 M HCl, saturated aqueous $NaHCO_3$ solution, brine, dried over Na_2SO_4, and evaporated to afford the crude amide that was used without purification.

vi: To a solution of aniline and Et_3N (2 equiv.) in DCM (35 mL) was added acid chloride (1.2 equiv.), dropwise. The reaction mixture was stirred overnight. The solution was filtered and the solvent was removed under vacuum, and the residue was partitioned between ethyl acetate and water. The ethyl acetate fraction was dried with $MgSO_4$, then evaporated. The residue was purified by column chromatography to afford corresponding amide.

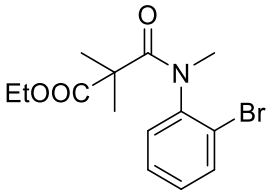
vii: amide was dissolved in dry THF (30 mL) and place under N_2 and cooled to 0°C. NaH (1.5 equiv.) was added portionwise and the resulting mixture was stirred until bubbling had ceased. MeI (1.5 equiv.) was added slowly and resulting mixture was allowed to warm to rt until completed. The reaction was quenched with ammonium chloride and the mixture was extracted with DCM twice. Combined the organic layer, dried over $MgSO_4$ and concentrated under vacuum. The crude mixture was purified by column chromatography on silica gel to afford **1s** and **1u**.

vii: The reaction process is similar to **vii** with 2.5 equiv. NaH and 2.5 equiv. MeI.



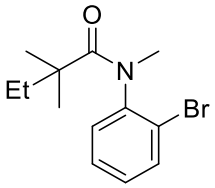
1u

White solid. 50% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.67 (d, *J* = 7.6 Hz, 1H), 7.40 (t, *J* = 7.2 Hz, 1H), 7.34 (d, *J* = 7.6 Hz, 1H), 7.27 (t, *J* = 7.2 Hz, 1H), 3.21 (s, 3H), 1.35 (s, 3H), 1.04 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 168.99, 142.96, 133.77, 130.46, 130.00, 128.61, 126.84 (q, J_{CF} = 284.6 Hz), 123.85, 50.42 (q, J_{CF} = 25.1 Hz), 40.07, 21.56, 20.09. ^{19}F NMR (565 MHz, $CDCl_3$) δ -73.99. HRMS (ESI) calcd for $C_{12}H_{14}BrF_3NO$ $(M+H)^+$: 324.0205, found: 324.0232.



1v

Two isomers. Faint yellow oil. 70% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.65 (d, *J* = 8.0 Hz, 1H), 7.39-7.30 (m, 1H), 7.27-7.16 (m, 2H), 4.30 (s, 1H), 3.98 (s, 1H), 3.20 (s, 3H), 1.59-1.14 (m, 9H). ^{13}C NMR (151 MHz, $CDCl_3$) δ 174.59, 173.78, 171.44, 143.15, 141.59, 133.85, 133.57, 131.06, 130.07, 129.17, 128.73, 128.26, 124.60, 122.28, 61.47, 61.01, 50.47, 49.03, 38.84, 37.59, 26.54, 24.69, 22.94, 22.76, 14.22, 13.92. HRMS (ESI) calcd for $C_{14}H_{19}BrNO_3$ $(M+H)^+$: 328.0543, found: 328.0565.



1w

White solid. 50% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.65 (d, *J* = 8.0 Hz, 1H), 7.35 (t, *J* = 7.6 Hz, 1H), 7.27 (d, *J* = 7.6 Hz, 1H), 7.22 (t, *J* = 7.6 Hz, 1H), 3.18 (s, 3H), 1.73-1.63 (m, 1H), 1.48-1.34 (m, 1H), 0.96 (d, *J* = 7.2 Hz, 6H), 0.90 (t, *J* = 7.2 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 176.98, 144.10, 133.67, 130.35, 129.36, 128.21, 124.10, 44.70, 39.36, 35.56, 26.58, 25.93, 9.58. HRMS (ESI) calcd for $C_{13}H_{19}BrNO$

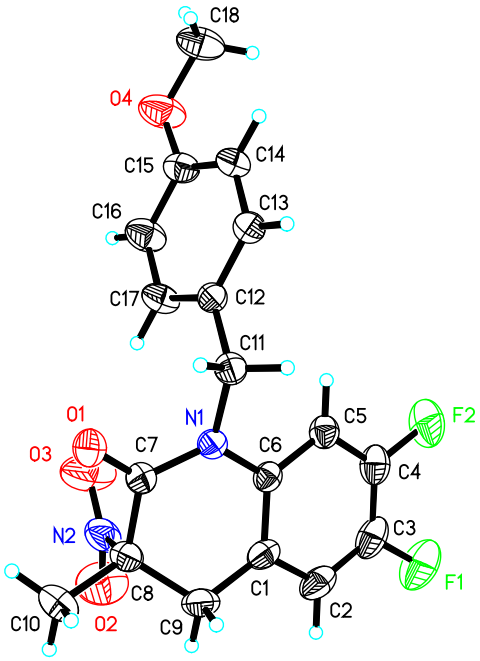
$(M+H)^+$: 284.0645, found: 284.0667.

References

1: (a) A. Alexakis, J. Burton, J. Vastra, C. Benhaim, X. Fournioux, A. Heuvel, J. M. Levêque, F. Mazé, S. Rosset, *Eur. J. Org. Chem.* **2000**, 4011. (b) M. D. K. Boele, P. C. J. Kamer, M. Lutz, A. L.Spek, J. G. Vries, P. W. N. M. Leeuwen, G. P. F. Strijdonck, *Chem. Eur. J.* **2004**, *10*, 6232. (c) A. R. Woodward, H. E. Burks, L. M. Chan, J. P. Morken, *Org. Lett.* **2005**, *7*, 24.

2: (a) X.-B. Wang, K.-Y. Dong, B. Yan, C. Zhang, L.-H. Qiu, X.-F. Xu, *RSC Adv.*, **2016**, *6*, 70221. (b) T.-J. Huang, Ch.-L. Yang, Y.-C. Kuo, Y.-C. Chang, L.-M. Yang, B.-H. Chou, S.-J. Lin, *Bioorganic & Medicinal Chemistry*, **2015**, *23*, 720. (c) M. J. Leonard, P. G. McKay, A. R. Lingham, *RSC Adv.*, **2015**, *5*, 76401. (d) M. Uchiyama, Y. Matsumoto, S. Nakamura, T. Ohwada, N. Kobayashi, N. Yamashita, A. Matsumiya, T. Sakamoto, *J. Am. Chem. Soc.* **2004**, *126*, 8755.

X-ray Structure of 2k

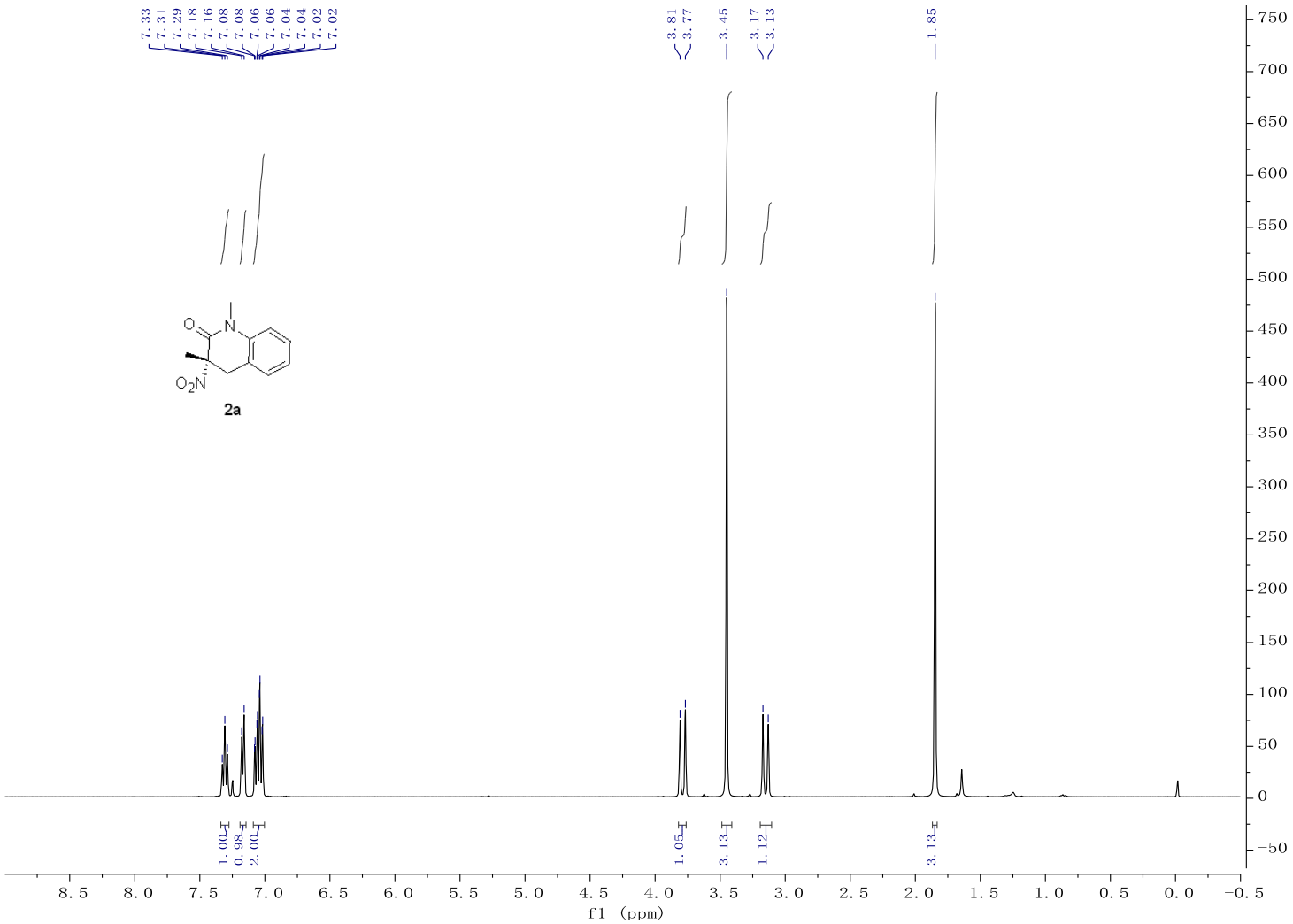


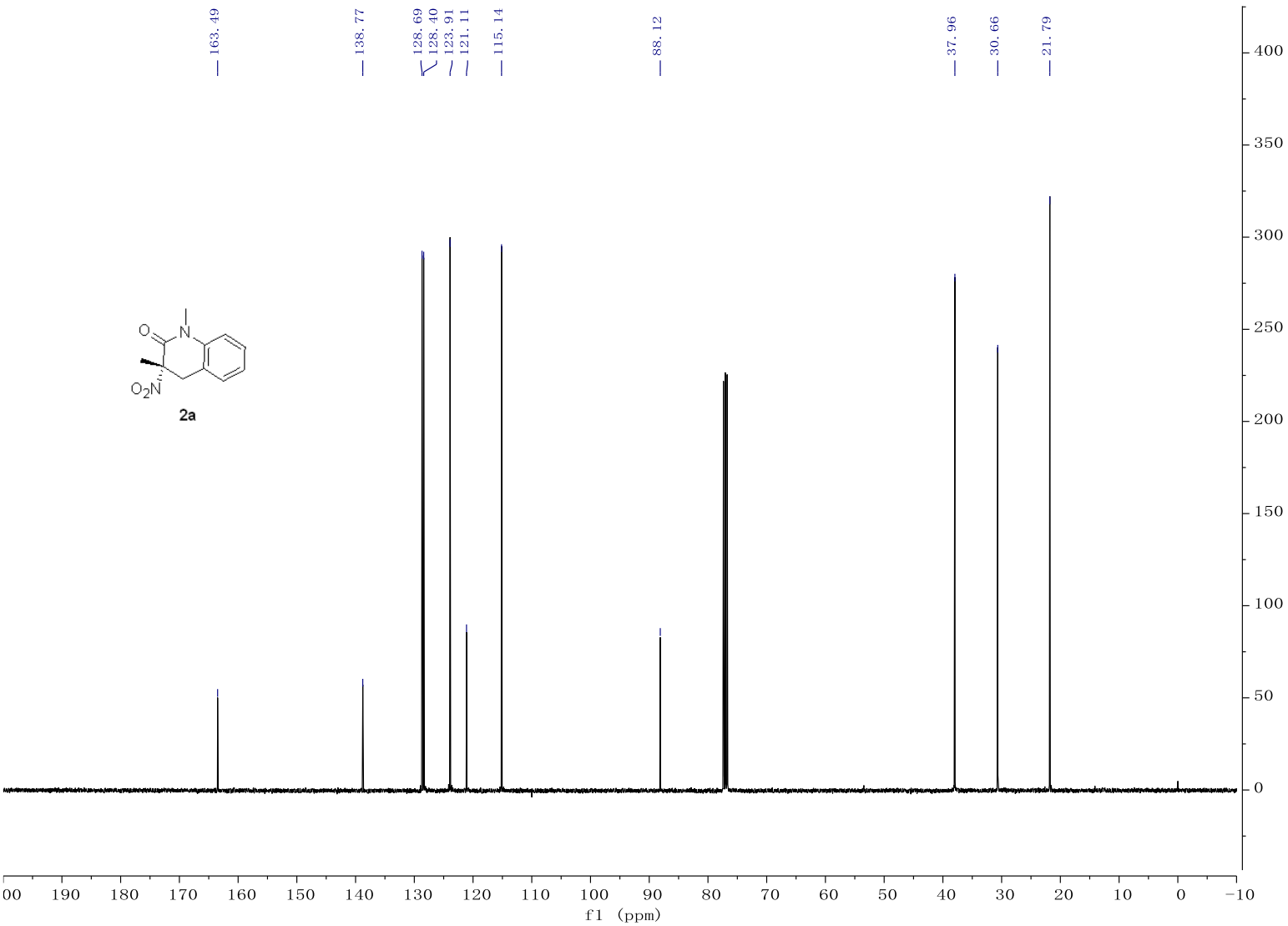
Crystal data and structure refinement for 2k.

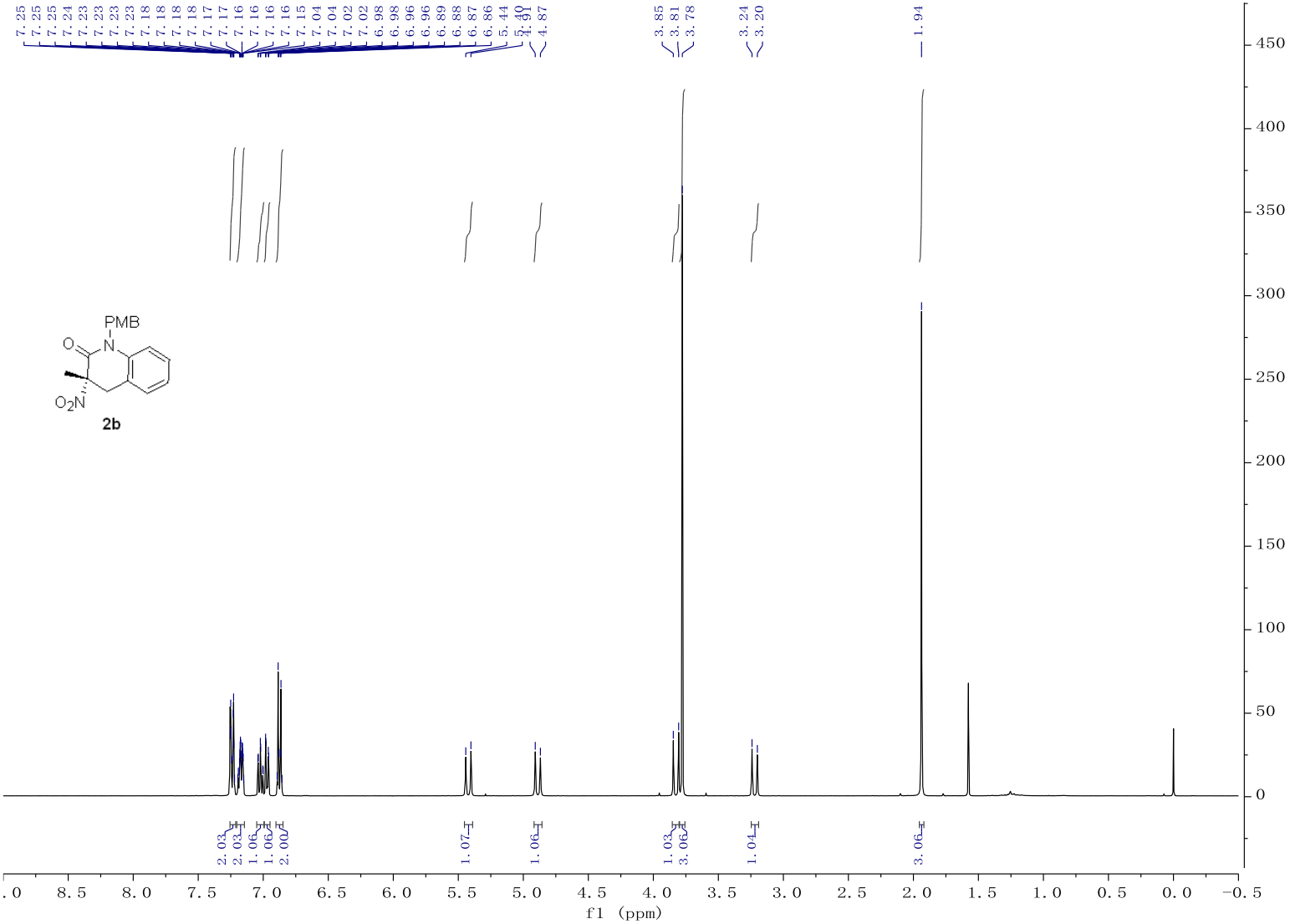
Identification code	cu_dm18070_0m	
Empirical formula	$C_{18}H_{16}F_2N_2O_4$	
Formula weight	362.33	
Temperature	296(2) K	
Wavelength	1.54178 Å	
Crystal system	Orthorhombic	
Space group	P 21 21 21	
Unit cell dimensions	a = 9.05270(10) Å	α = 90°.
	b = 10.53670(10) Å	β = 90°.
	c = 17.9083(2) Å	γ = 90°.
Volume	1708.19(3) $Å^3$	
Z	4	
Density (calculated)	1.409 Mg/m^3	

Absorption coefficient	0.980 mm^{-1}
F(000)	752
Crystal size	0.200 x 0.150 x 0.100 mm^3
Theta range for data collection	4.870 to 67.455°.
Index ranges	-8<=h<=10, -12<=k<=12, -21<=l<=21
Reflections collected	17068
Independent reflections	2979 [R(int) = 0.0377]
Completeness to theta = 67.679°	96.5 %
Absorption correction	Semi-empirical from equivalents
Max. and min. transmission	0.7532 and 0.6362
Refinement method	Full-matrix least-squares on F^2
Data / restraints / parameters	2979 / 0 / 238
Goodness-of-fit on F^2	1.066
Final R indices [I>2sigma(I)]	R1 = 0.0351, wR2 = 0.1024
R indices (all data)	R1 = 0.0370, wR2 = 0.1050
Absolute structure parameter	0.01(6)
Extinction coefficient	0.0159(13)
Largest diff. peak and hole	0.177 and -0.158 e.$Å^{-3}$

NMR spectra


7.33
7.31
7.29
7.18
7.16
7.08
7.08
7.06
7.06
7.04
7.04
7.02
7.02
3.81
3.77
3.45
3.17
3.13
1.85
O
N
O2N
2a
1.00
0.98
2.00
1.05
3.13
1.12
3.13
f1 (ppm)


163.49
138.77
128.69
128.40
123.91
121.11
115.14
88.12
37.96
30.66
21.79
2a
f1 (ppm)


PMB
O
N
O2N
2b
7.25
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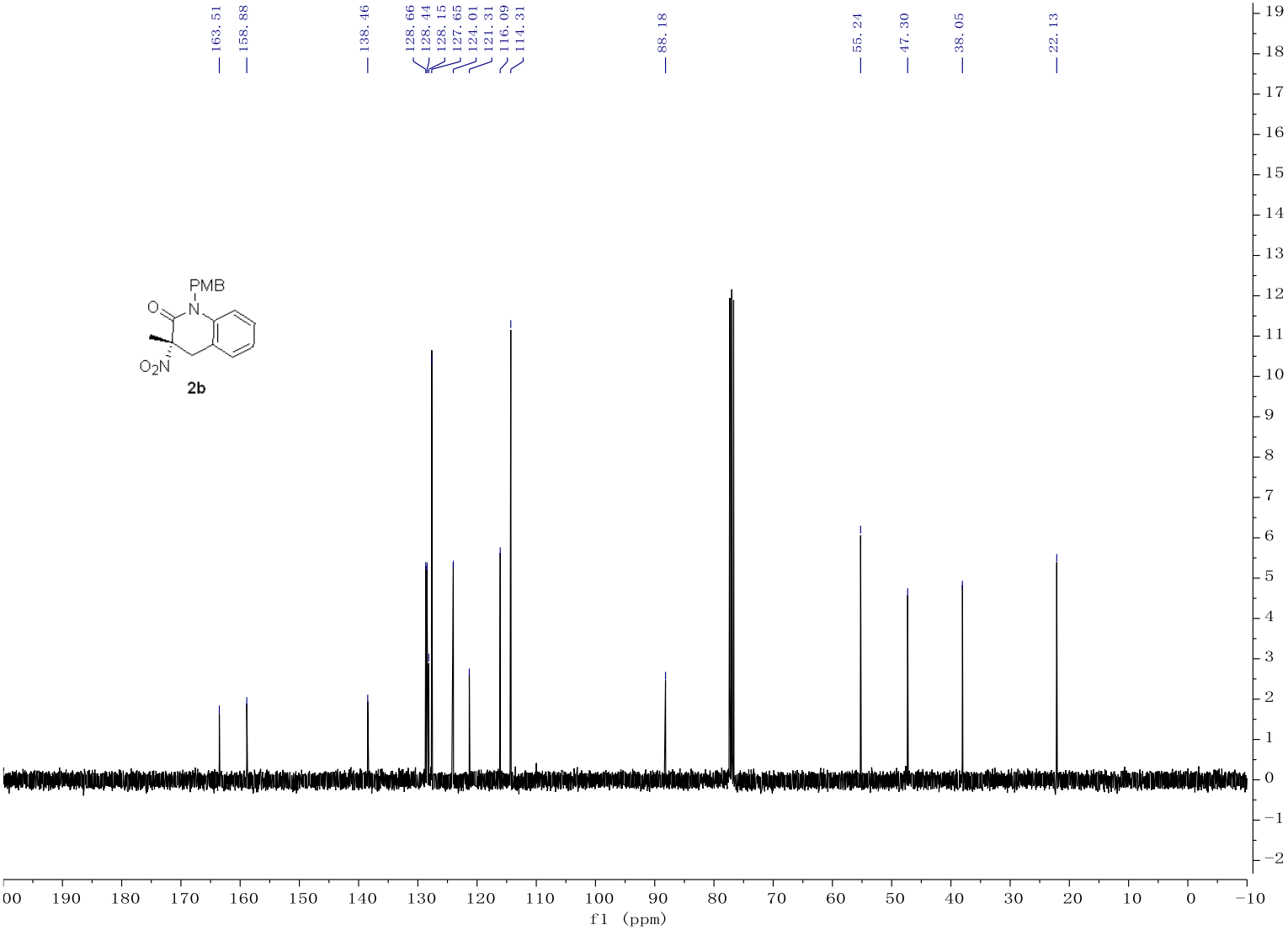
3.81
3.78
3.24
3.20
1.94
2.03
2.03
1.06
1.06
2.00
1.07
1.06
1.03
3.06
1.04
3.06
f1 (ppm)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128.66
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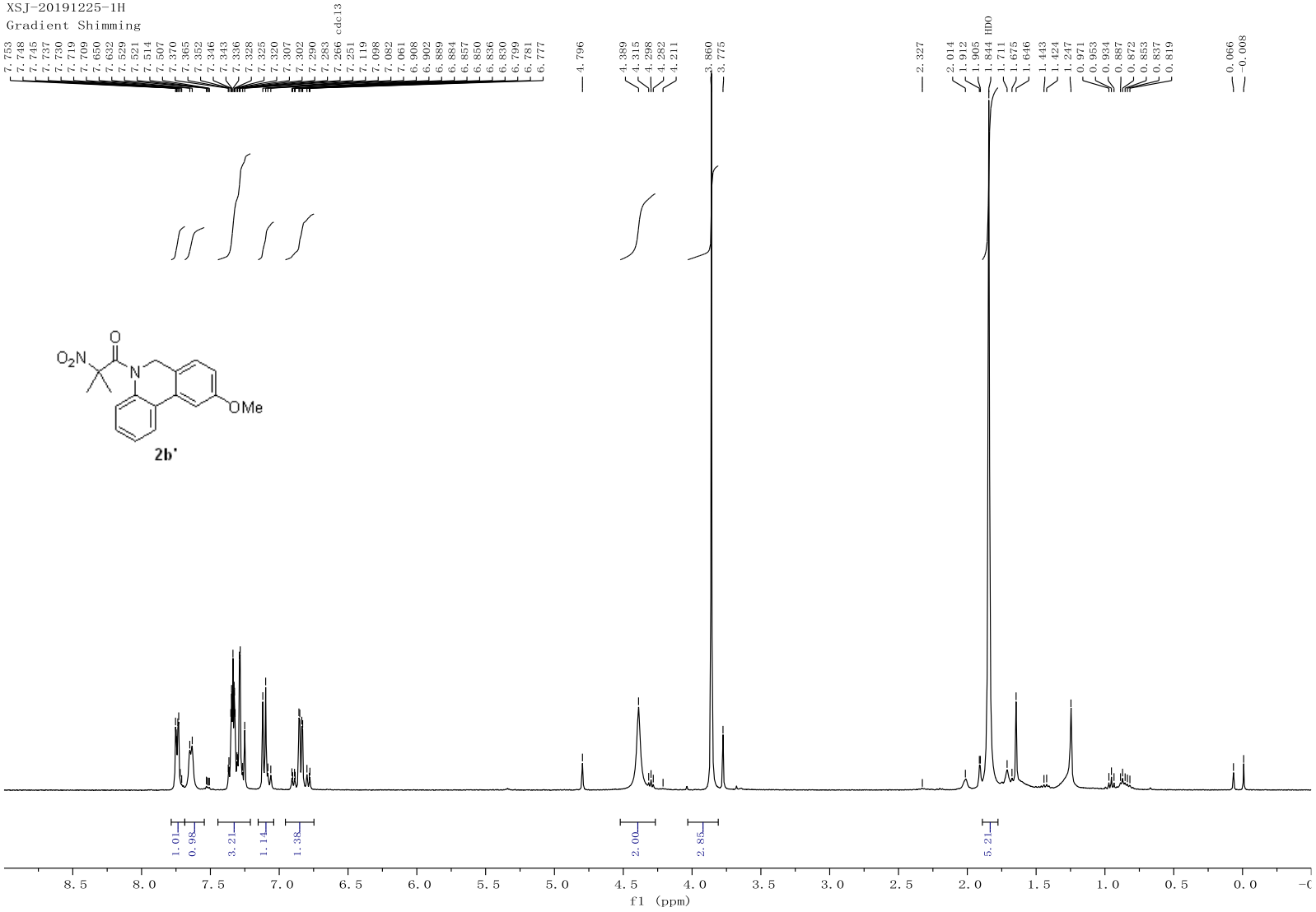
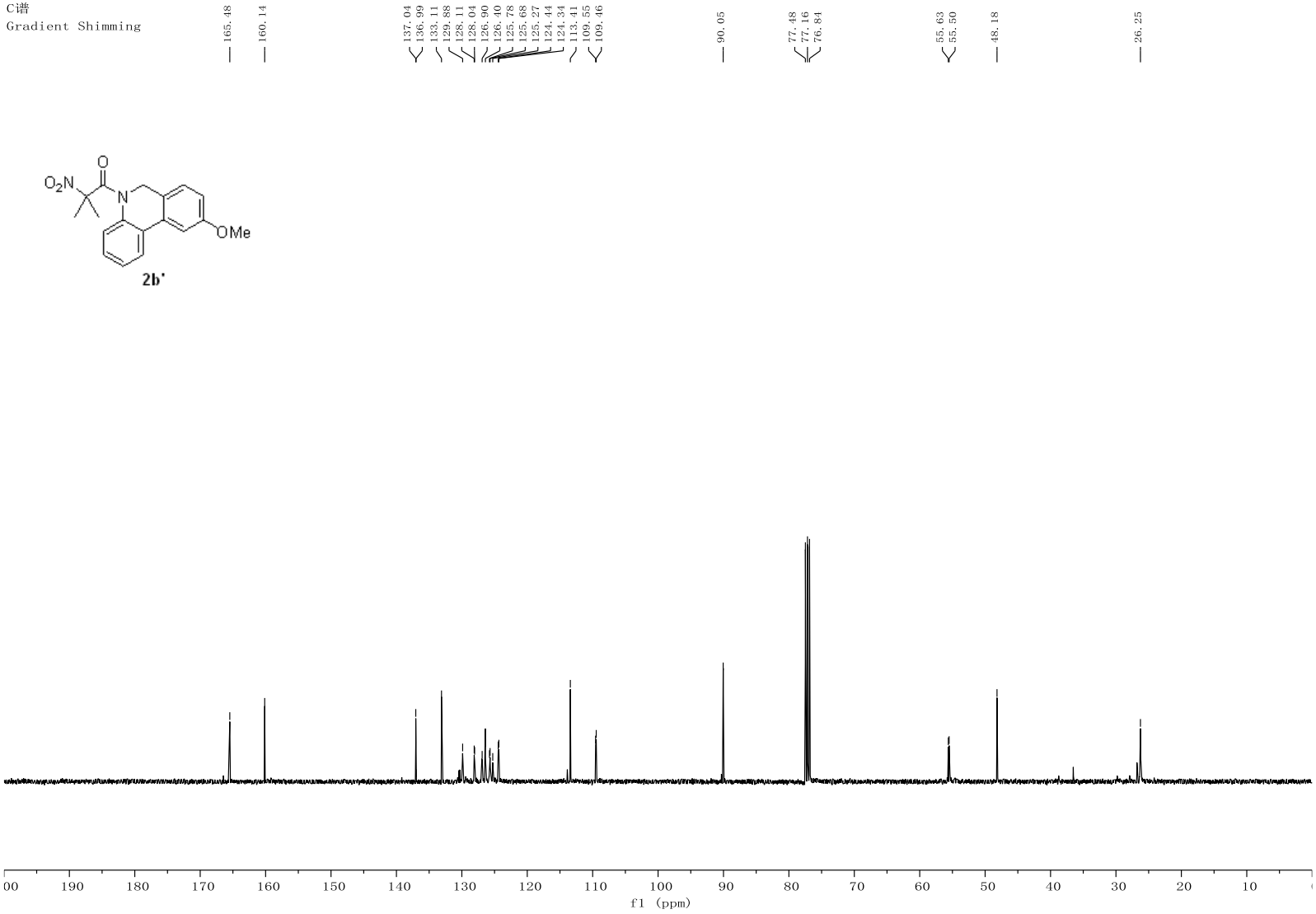
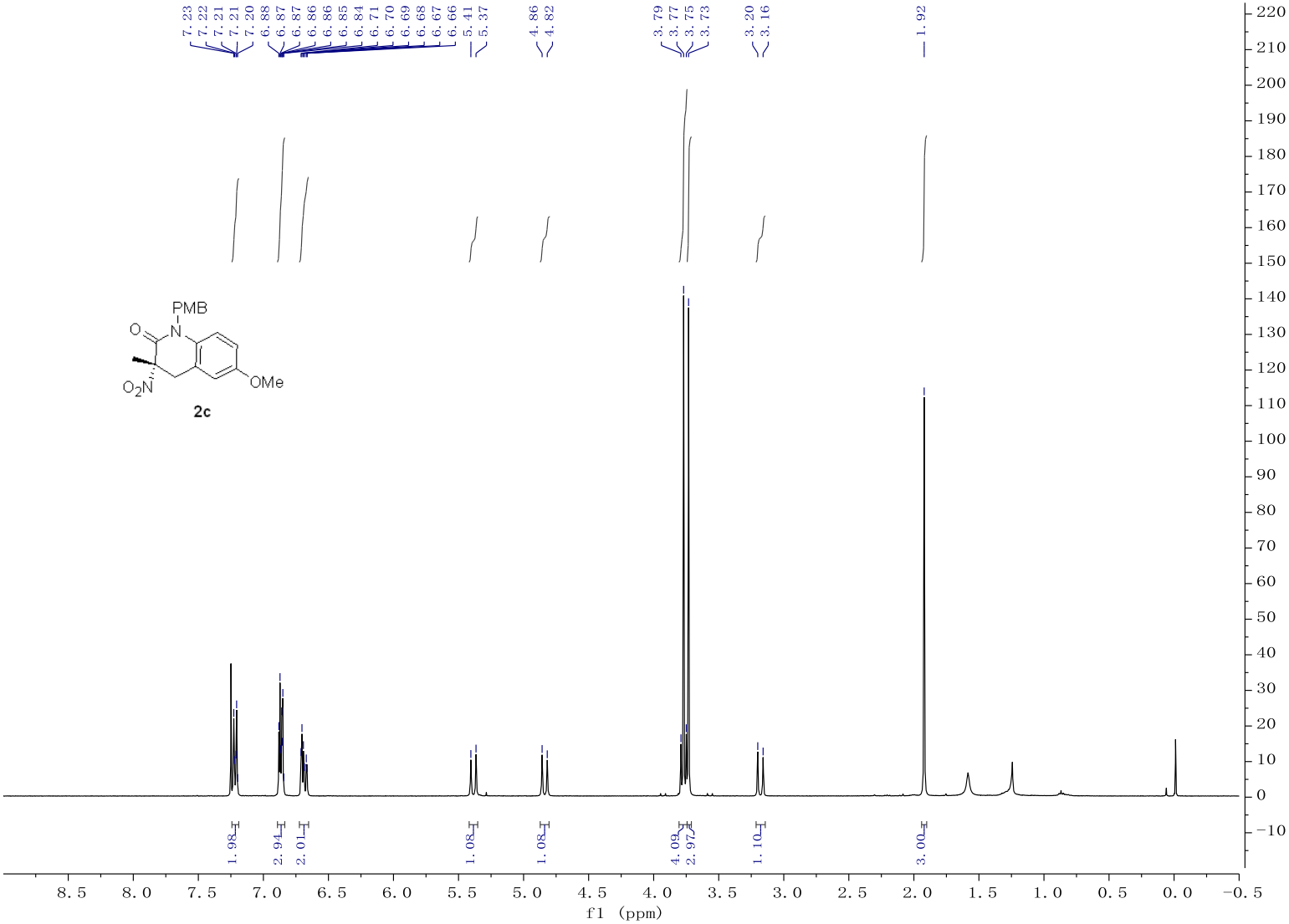
128.15
127.65
124.01
121.31
116.09
114.31
88.18
55.24
47.30
38.05
22.13
PMB
O
N
O2N
2b
f1 (ppm)


XSJ-20191225-1H
Gradient Shimming
cdcl3
HDO
2b'
f1 (ppm)

C谱
Gradient Shimming

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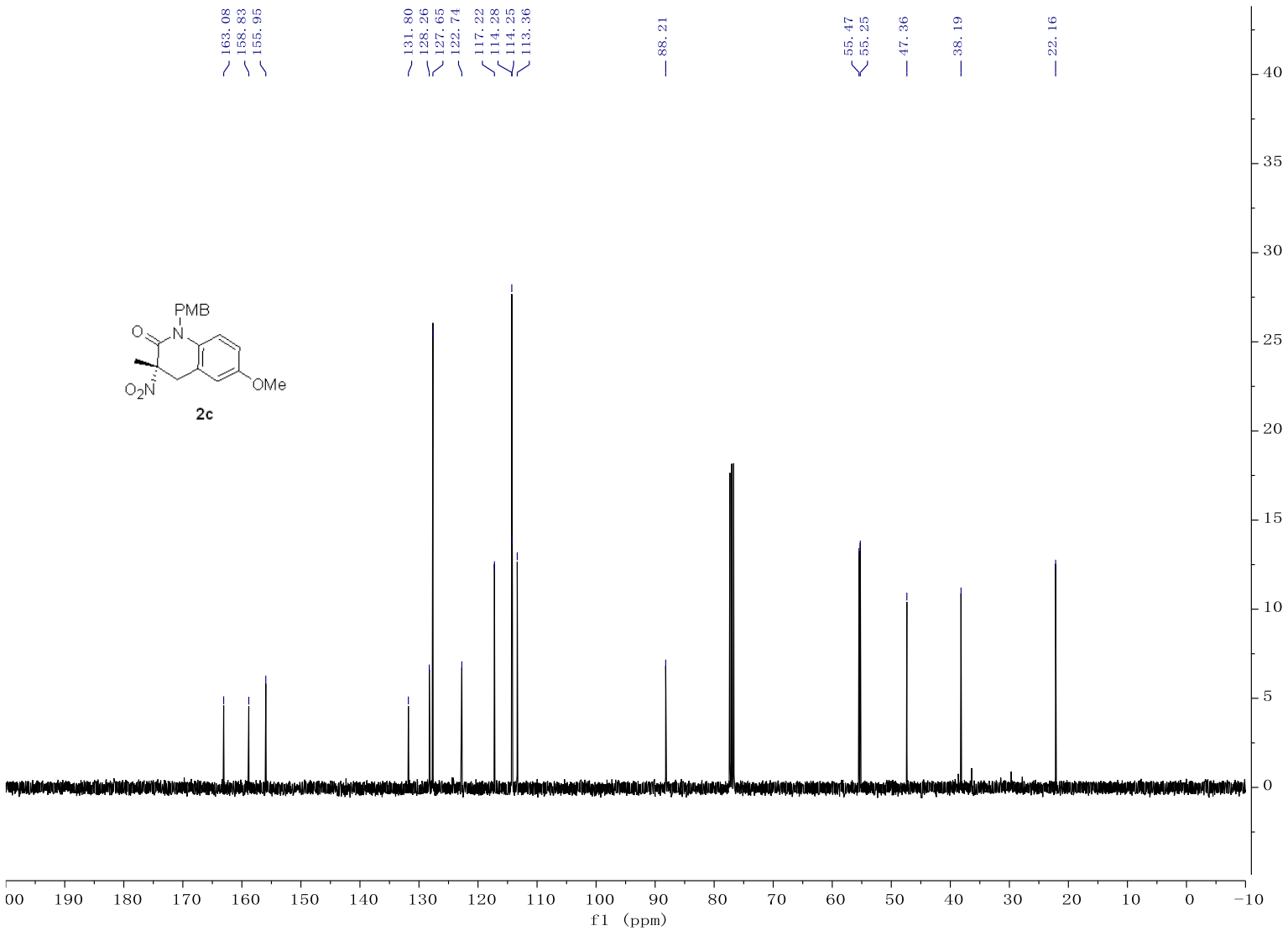
7.21
7.21
7.20
6.88
6.87
6.87
6.86
6.86
6.85
6.84
6.71
6.70
6.69
6.68
6.67
6.66
5.41
5.37
4.86
4.82
3.79
3.77
3.75
3.73
3.20
3.16
1.92
PMB
O
N
O2N
OMe
2c
1.98
2.94
2.01
1.08
1.08
4.09
2.97
1.10
3.00
f1 (ppm)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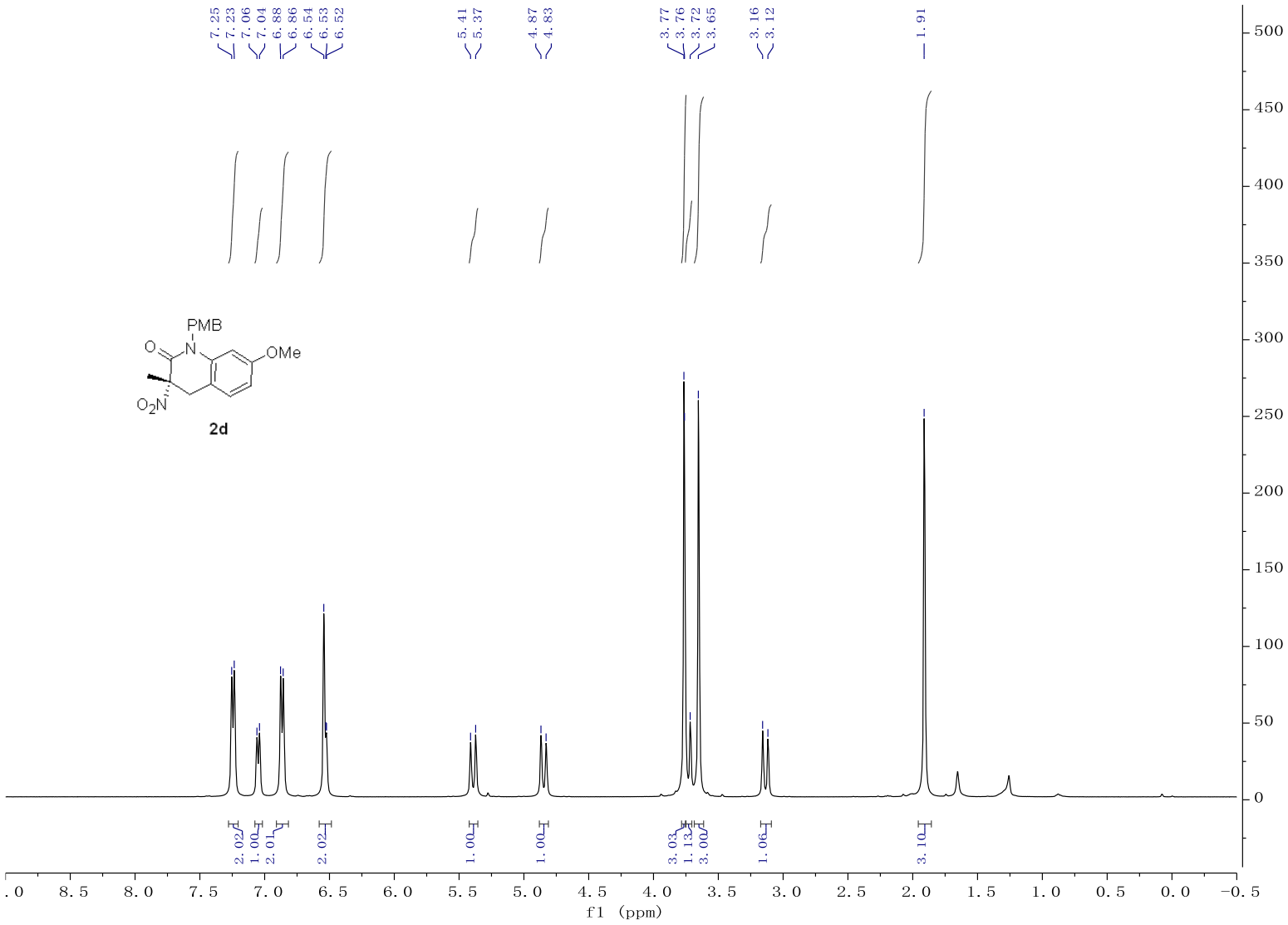
127.65
122.74
117.22
114.28
114.25
113.36
88.21
55.47
55.25
47.36
38.19
22.16
PMB
O
N
O2N
OMe
2c
f1 (ppm)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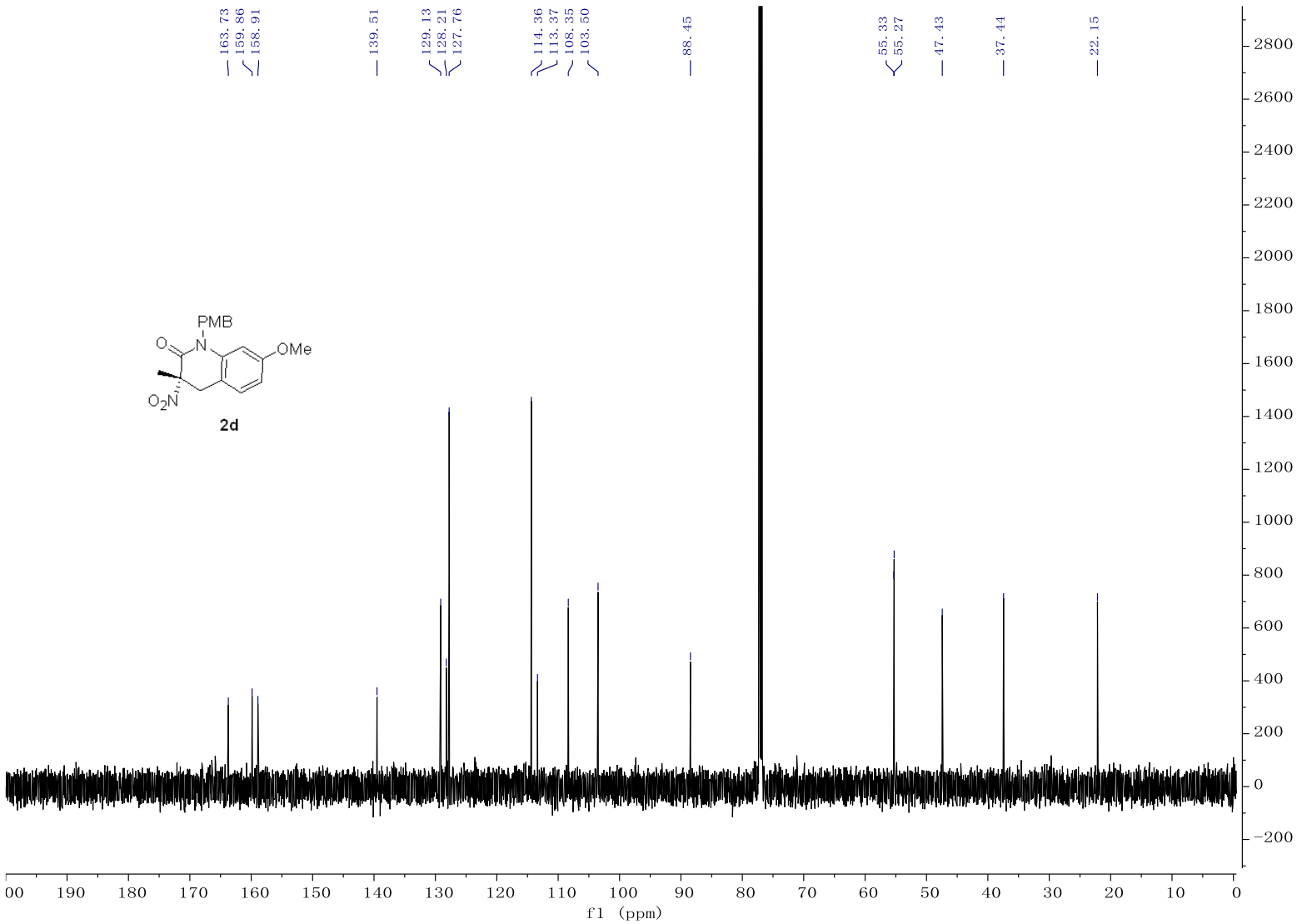
6.86
6.54
6.53
6.52
5.41
5.37
4.87
4.83
3.77
3.76
3.72
3.65
3.16
3.12
1.91
PMB
O
N
OMe
O2N
2d
2.02
1.00
2.01
2.02
1.00
1.00
3.03
1.13
3.00
1.06
3.10
f1 (ppm)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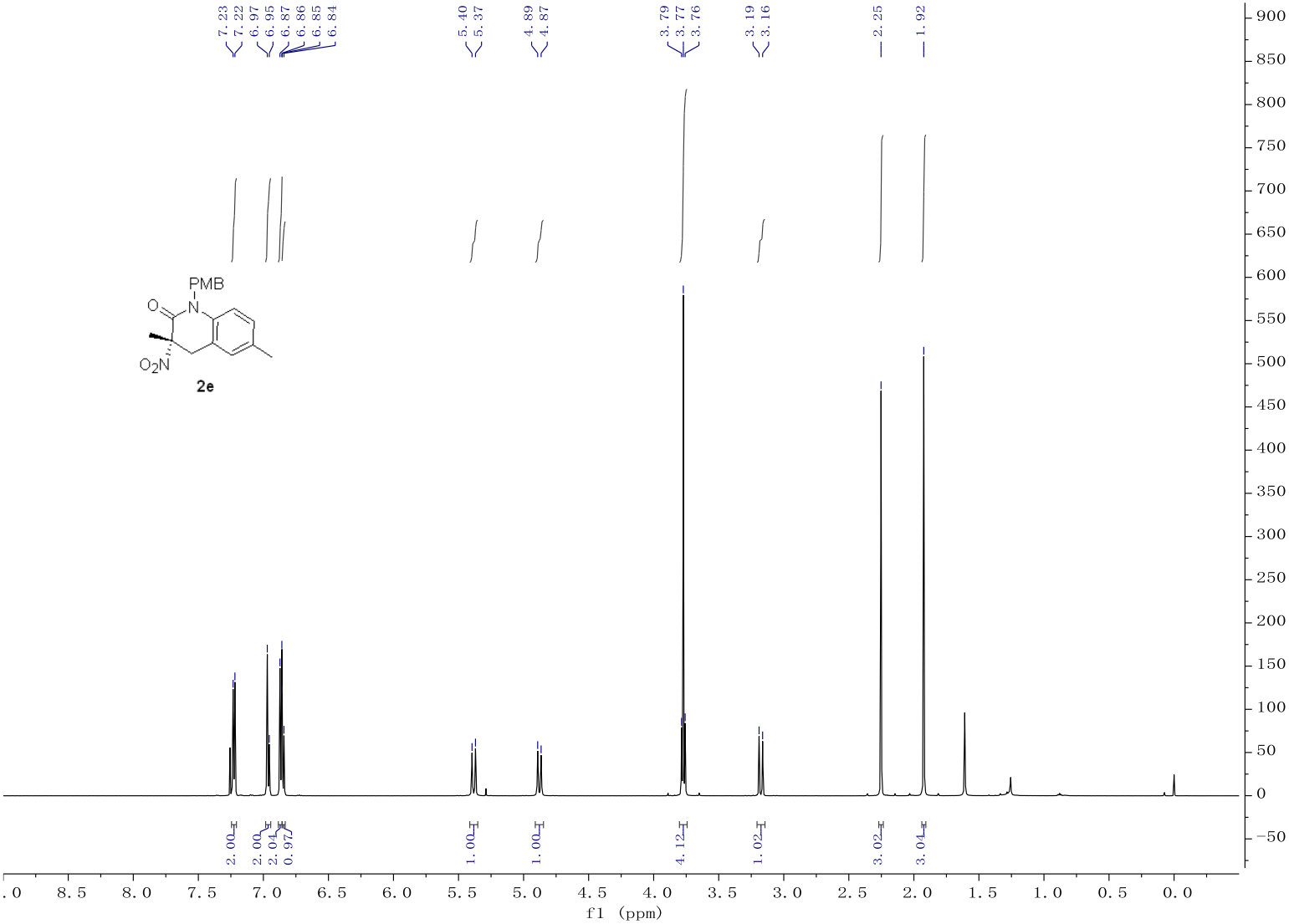
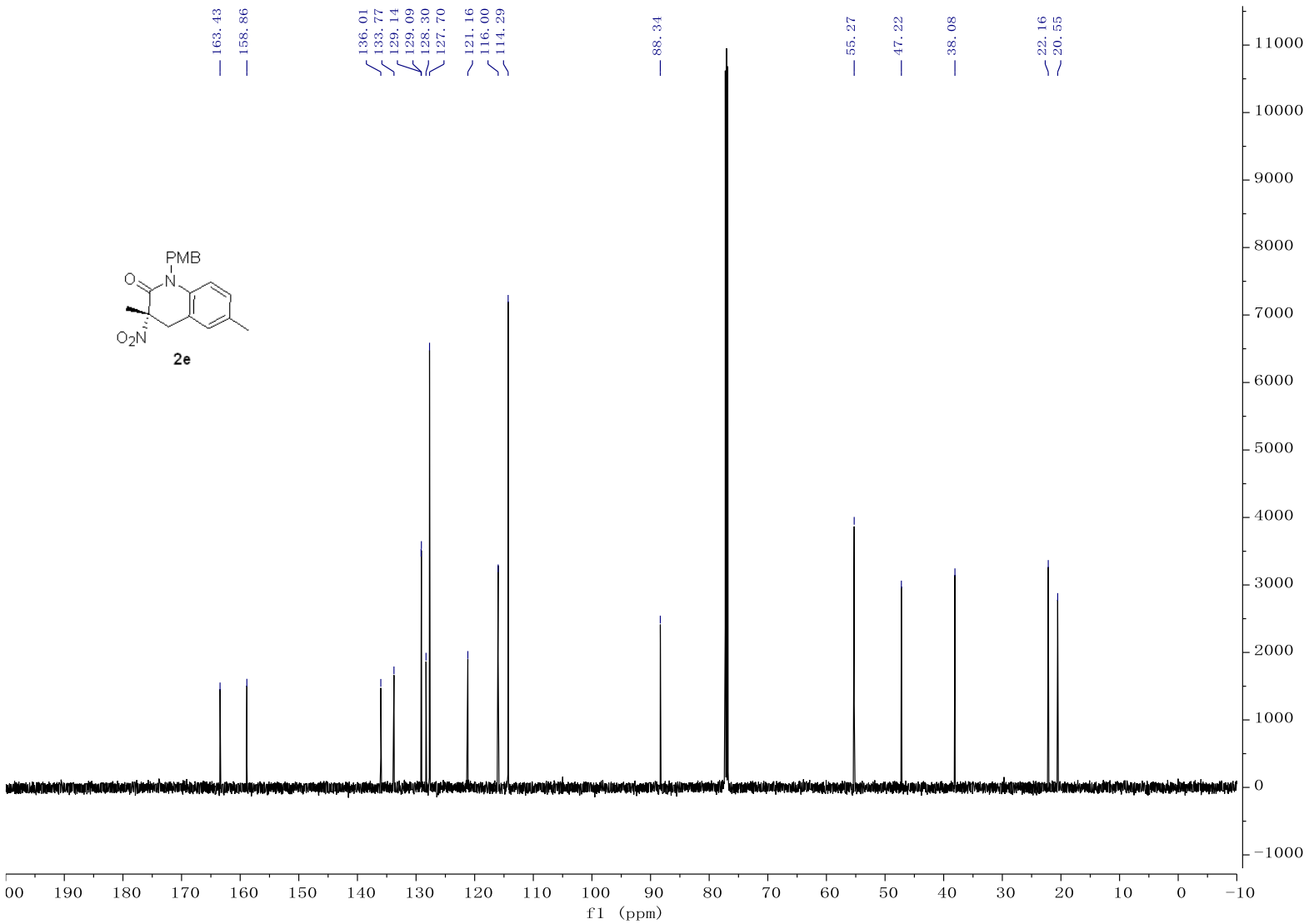
129.13
128.21
127.76
114.36
113.37
108.35
103.50
88.45
55.33
55.27
47.43
37.44
22.15
PMB
O
N
OMe
O_2N
2d
f1 (ppm)


7.23
7.22
6.97
6.95
6.87
6.86
6.85
6.84
5.40
5.37
4.89
4.87
3.79
3.77
3.76
3.19
3.16
2.25
1.92
PMB
O
N
O2N
2e
2.00
2.00
2.04
0.97
1.00
1.00
4.12
1.02
3.02
3.04
f1 (ppm)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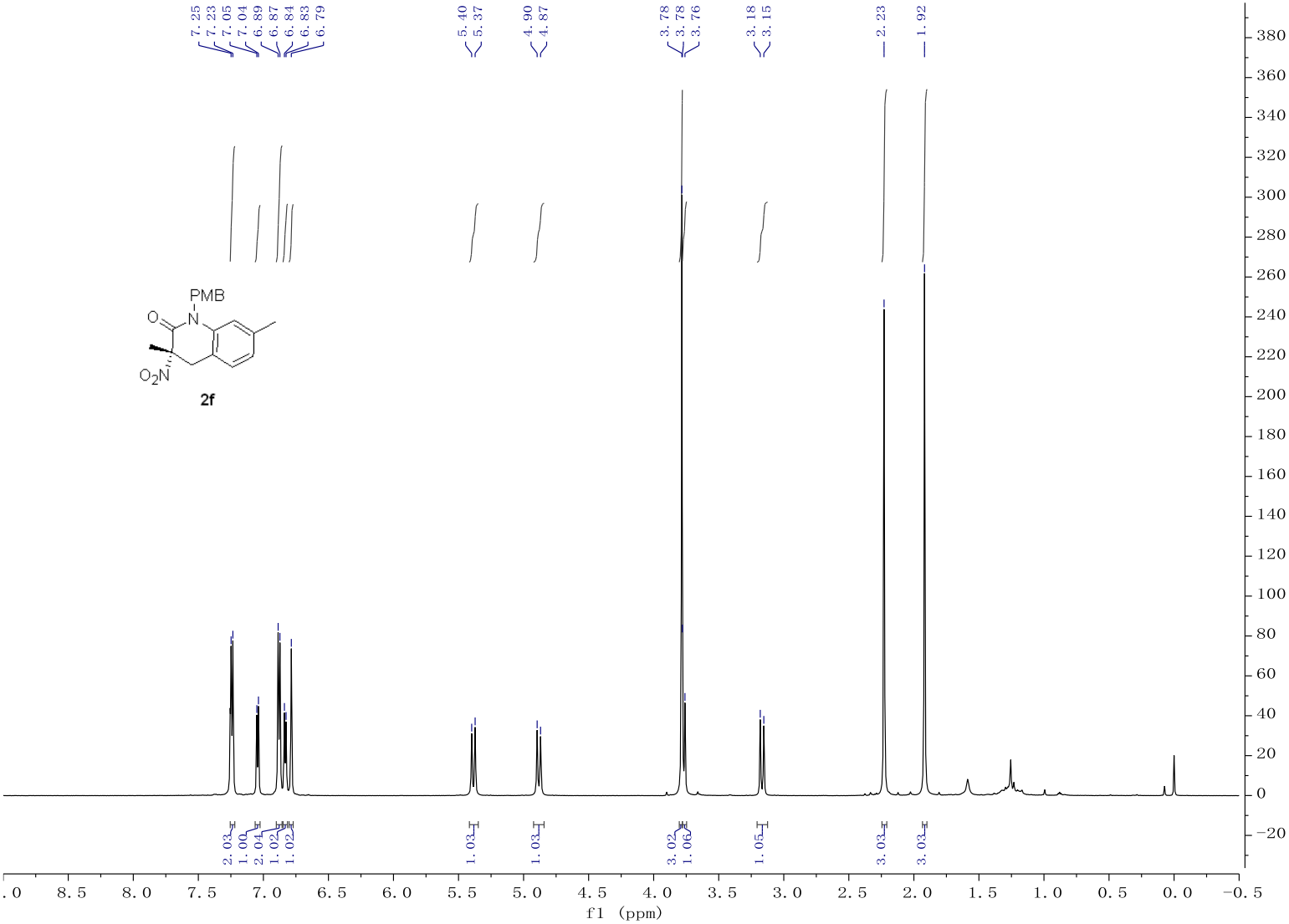
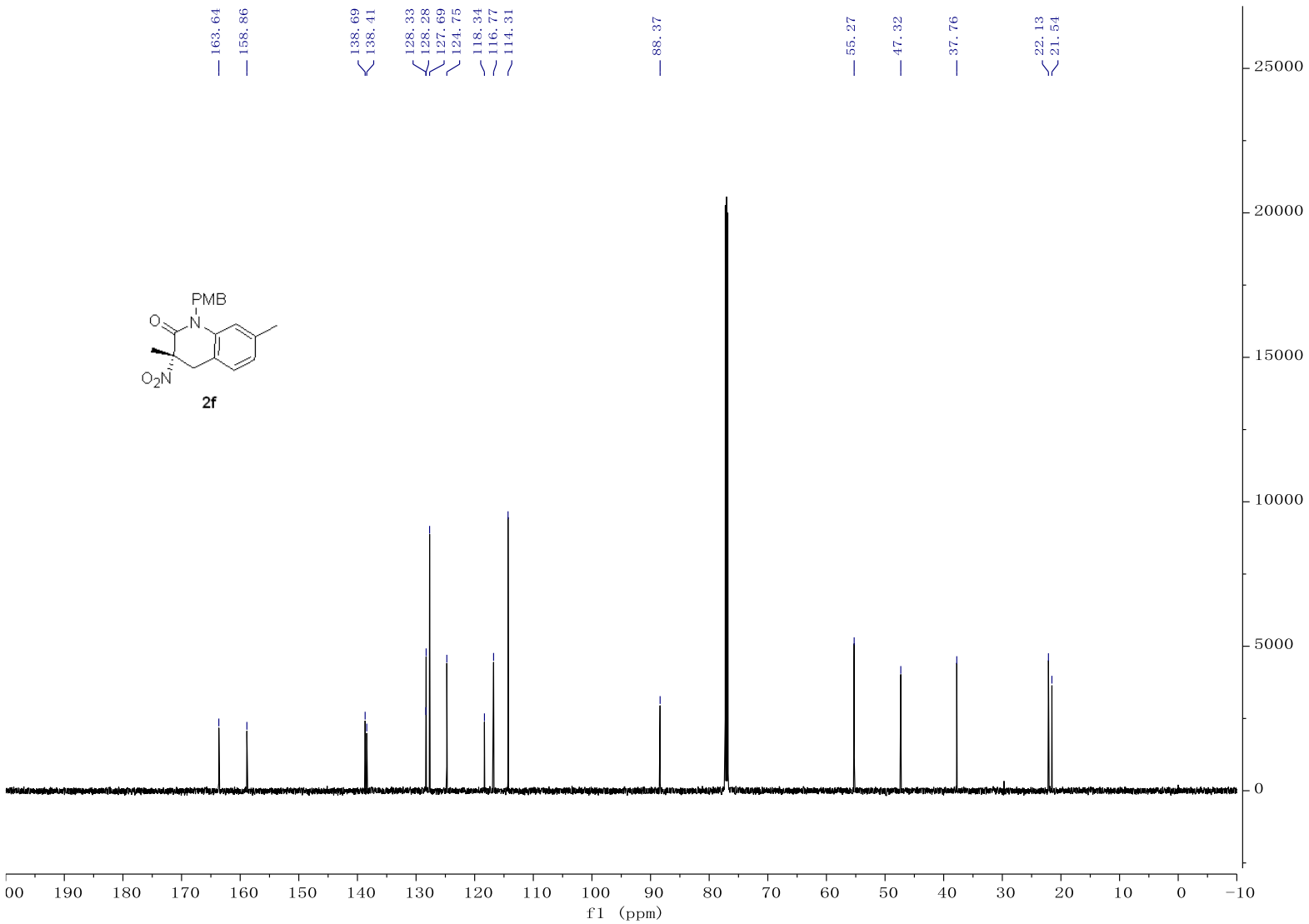
158.86
136.01
133.77
129.14
129.09
128.30
127.70
121.16
116.00
114.29
88.34
55.27
47.22
38.08
22.16
20.55
PMB
O
N
O_2N
2e
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
−1000
00 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10
f1 (ppm)


7.25
7.23
7.05
7.04
6.89
6.87
6.84
6.83
6.79
5.40
5.37
4.90
4.87
3.78
3.78
3.76
3.18
3.15
2.23
1.92
PMB
O
N
O2N
2f
2.03
1.00
2.04
1.02
1.02
1.03
1.03
3.02
1.06
1.05
3.03
3.03
f1 (ppm)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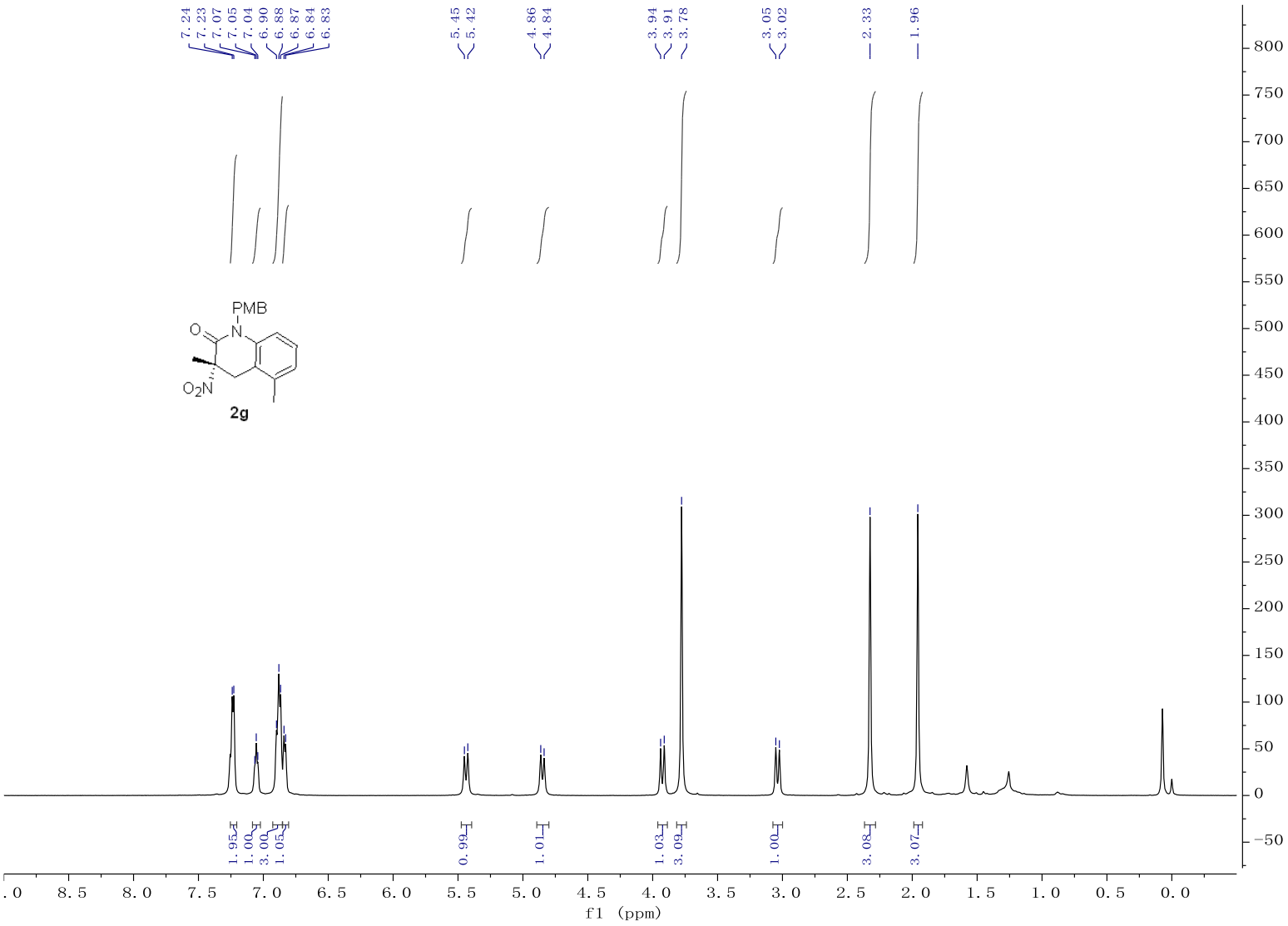
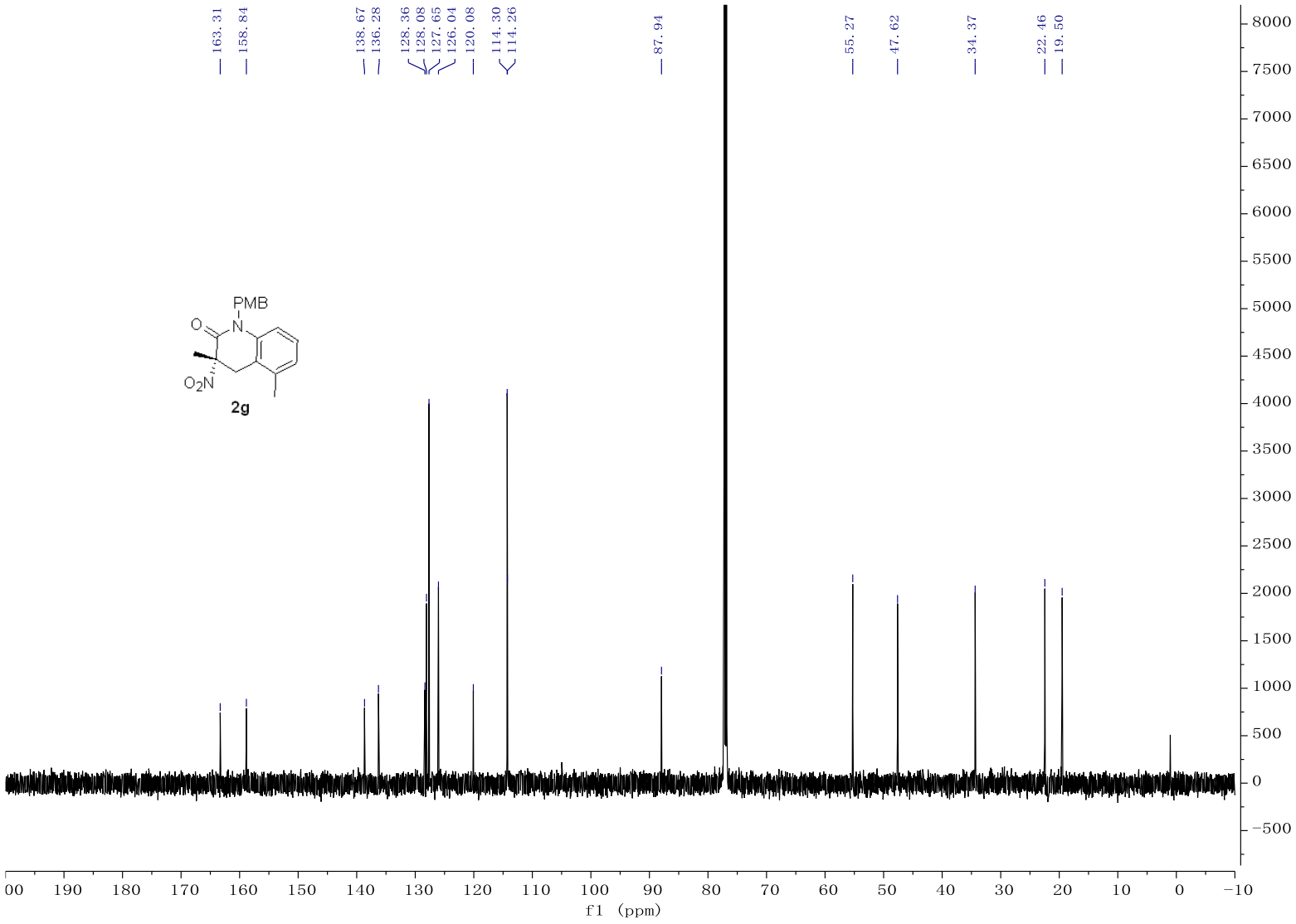
128.28
127.69
124.75
118.34
116.77
114.31
88.37
55.27
47.32
37.76
22.13
21.54
PMB
O
N
O2N
2f
25000
20000
15000
10000
5000
0
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10
f1 (ppm)


7.24
7.23
7.07
7.05
7.04
6.90
6.88
6.87
6.84
6.83
5.45
5.42
4.86
4.84
3.94
3.91
3.78
3.05
3.02
2.33
1.96
PMB
O
N
O2N
2g
1.95
1.00
3.00
1.05
0.99
1.01
1.03
3.09
1.00
3.08
3.07
f1 (ppm)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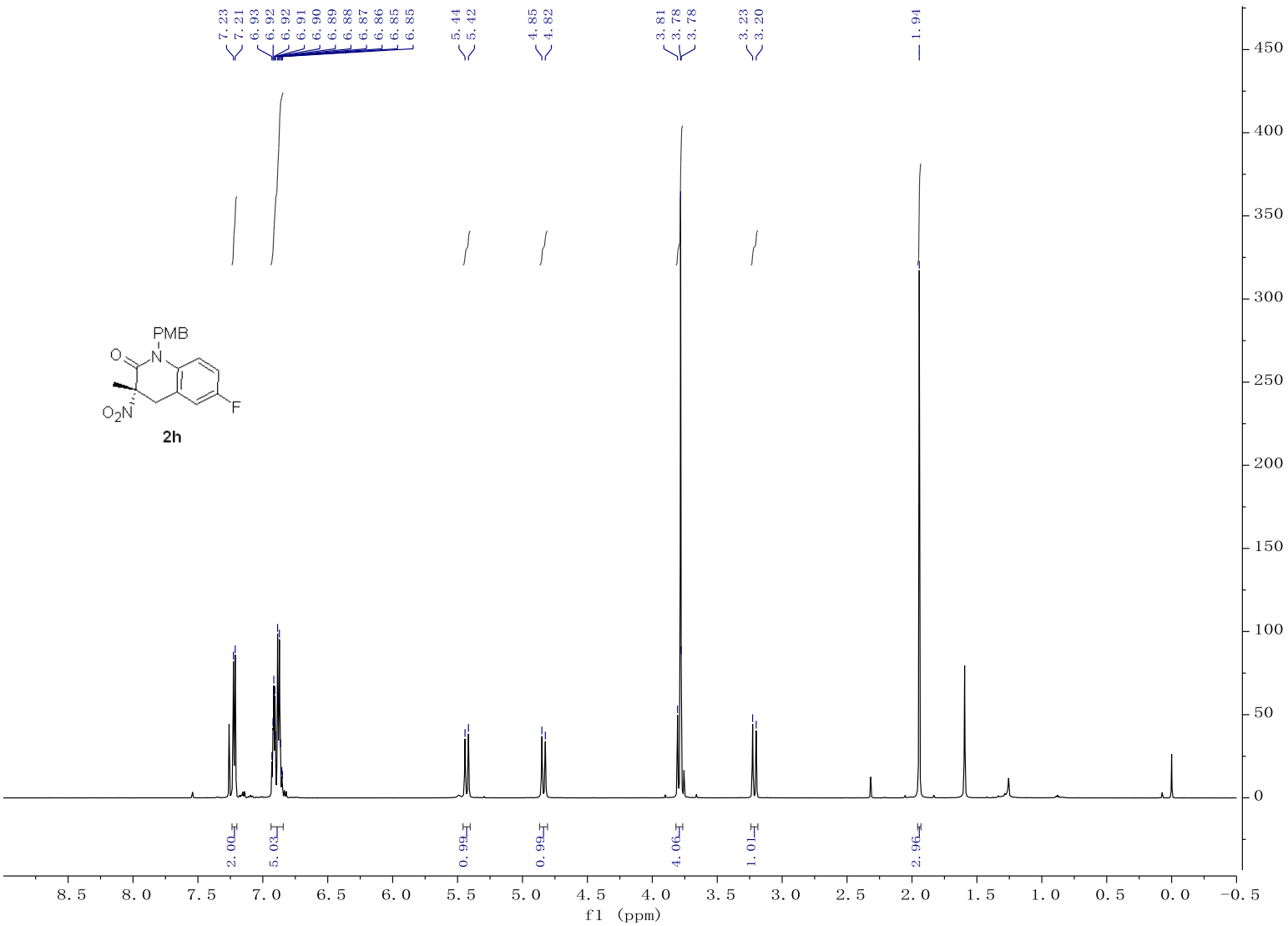
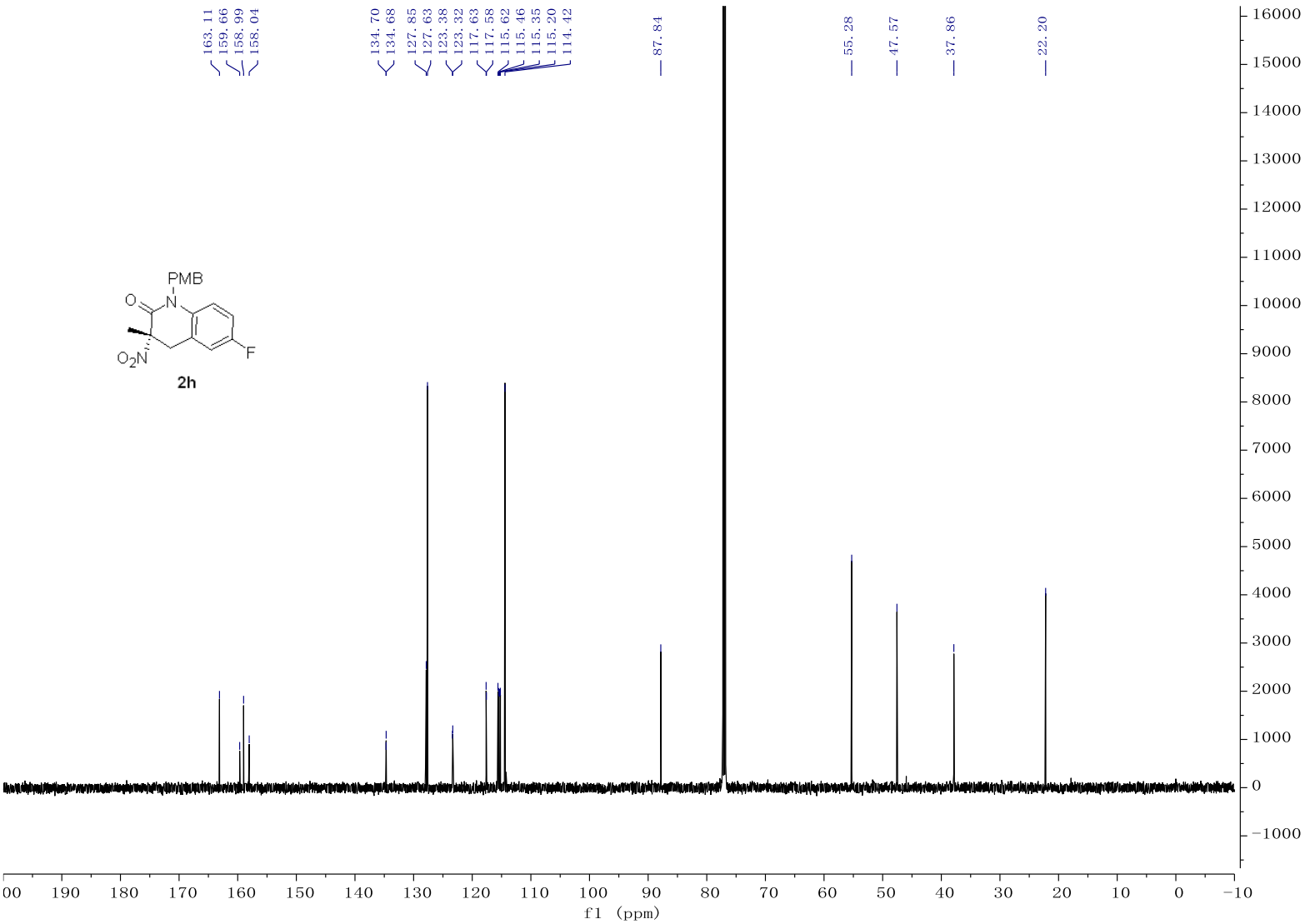
158.84
138.67
136.28
128.36
128.08
127.65
126.04
120.08
114.30
114.26
87.94
55.27
47.62
34.37
22.46
19.50
PMB
O
N
O2N
2g
f1 (ppm)


7.23
7.21
6.93
6.92
6.92
6.91
6.90
6.89
6.88
6.87
6.86
6.85
6.85
5.44
5.42
4.85
4.82
3.81
3.78
3.78
3.23
3.20
1.94
PMB
O
N
O2N
F
2h
2.00
5.03
0.99
0.99
4.06
1.01
2.96
f1 (ppm)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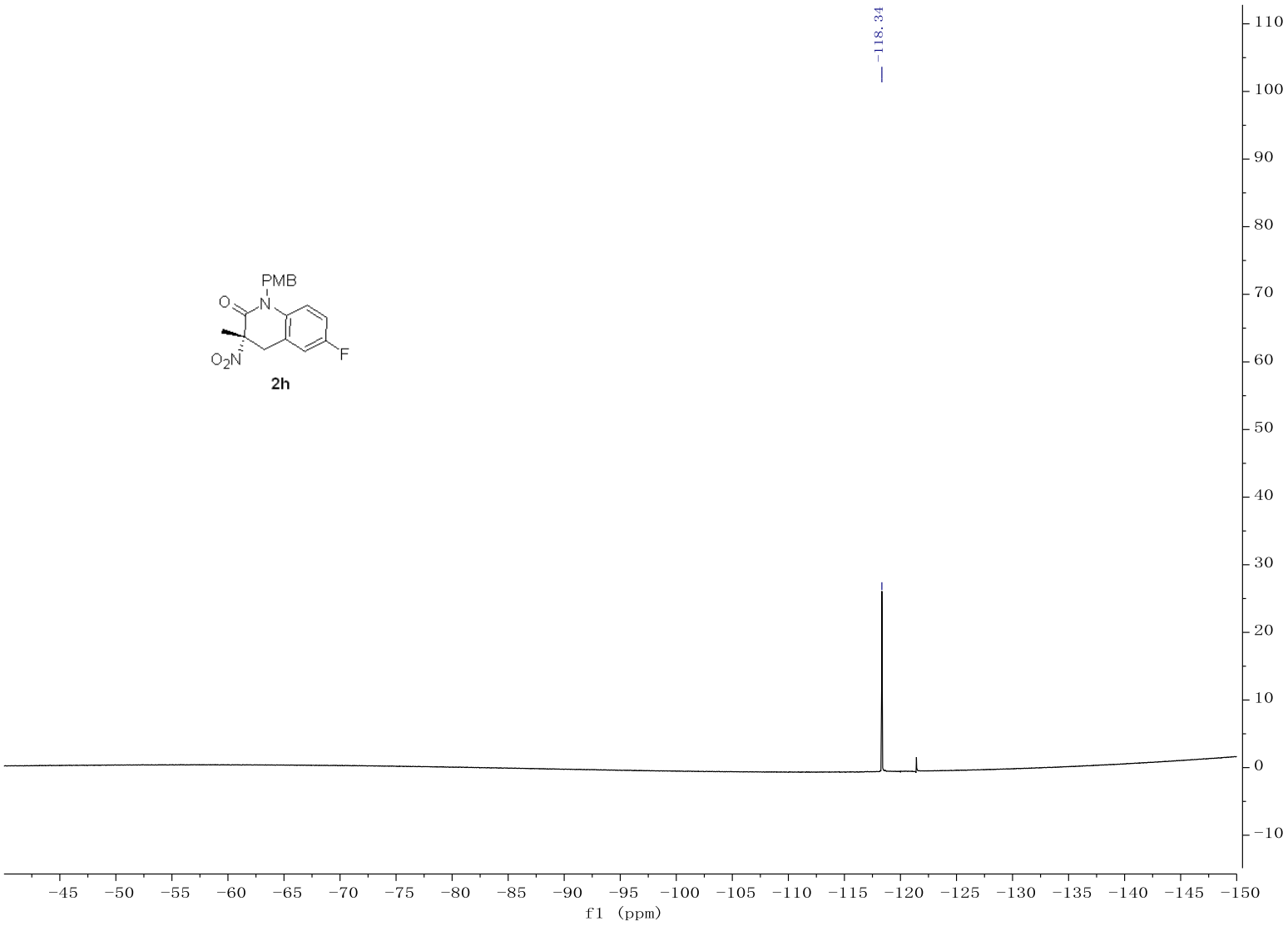
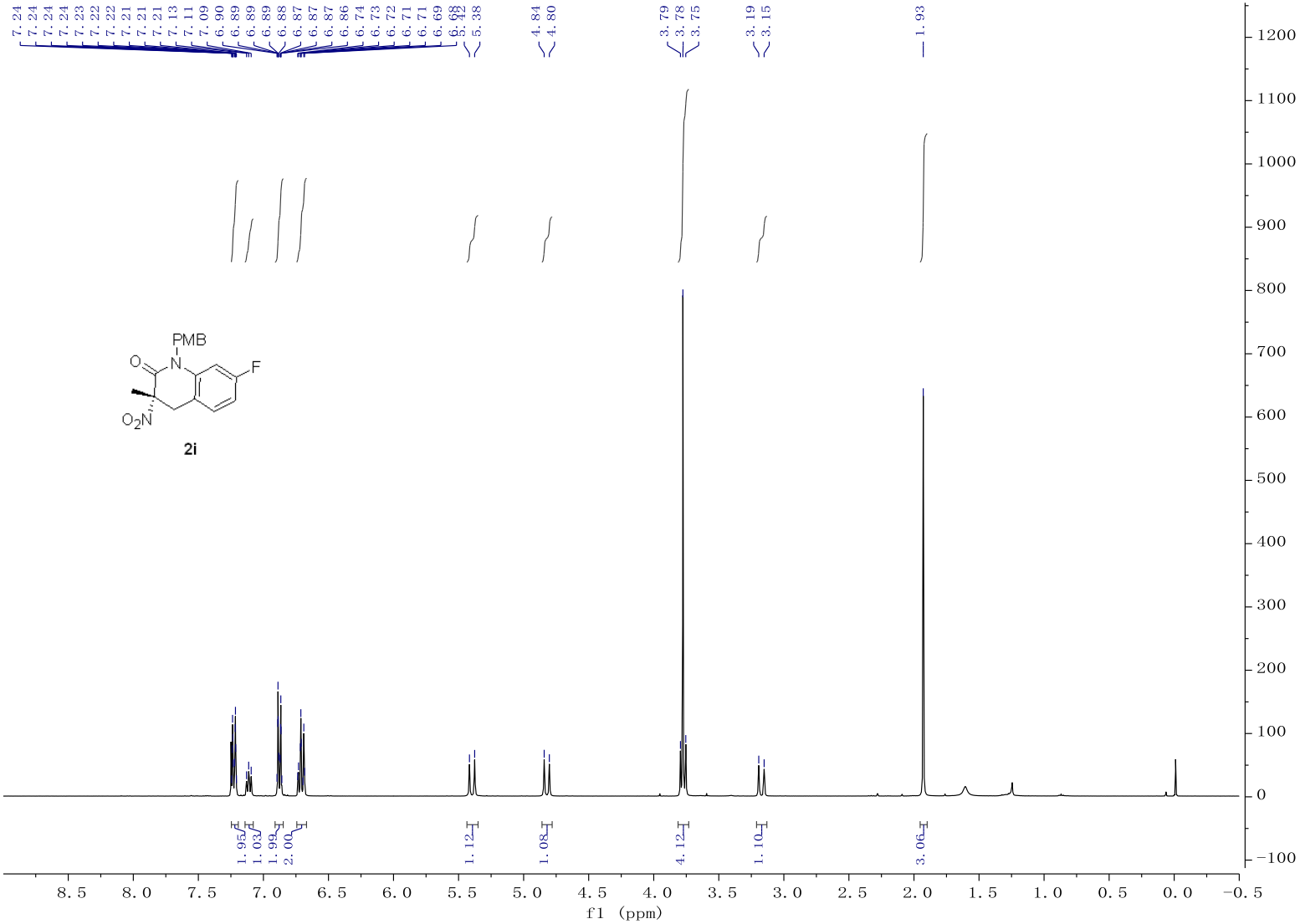
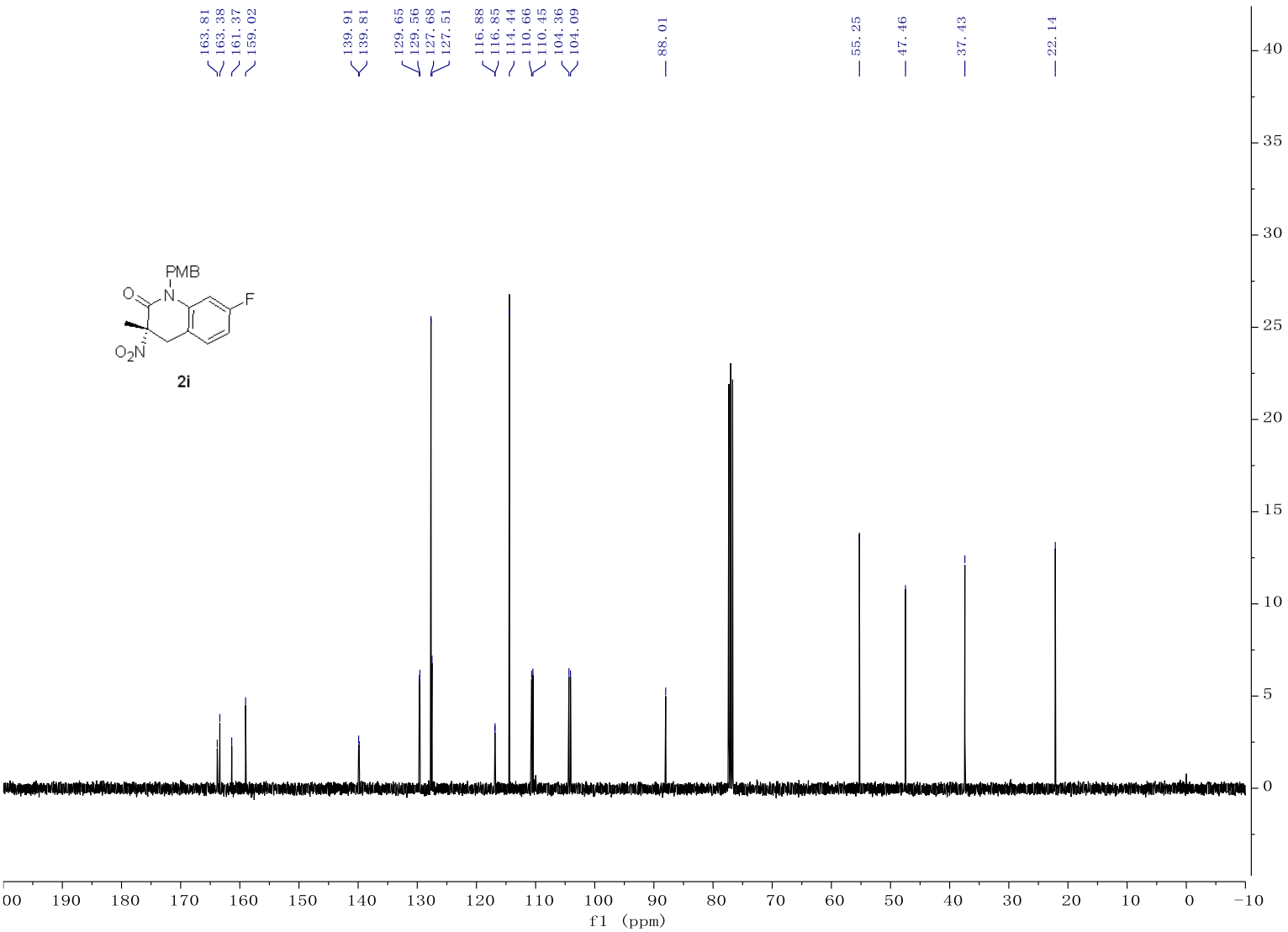
159.66
158.99
158.04
134.70
134.68
127.85
127.63
123.38
123.32
117.63
117.58
115.62
115.46
115.35
115.20
114.42
87.84
55.28
47.57
37.86
22.20
PMB
O
N
O2N
F
2h
f1 (ppm)


PMB
O
N
O2N
F
2h
−118.34
110
100
90
80
70
60
50
40
30
20
10
0
−10
−45 −50 −55 −60 −65 −70 −75 −80 −85 −90 −95 −100 −105 −110 −115 −120 −125 −130 −135 −140 −145 −150
f1 (ppm)


7.24
7.24
7.24
7.24
7.23
7.22
7.22
7.21
7.21
7.21
7.13
7.11
7.09
6.90
6.89
6.89
6.89
6.88
6.87
6.87
6.87
6.86
6.74
6.73
6.72
6.71
6.71
6.69
5.38
4.84
4.80
3.79
3.78
3.75
3.19
3.15
1.93
PMB
O
N
F
O2N
2i
1.95
1.03
1.99
2.00
1.12
1.08
4.12
1.10
3.06
f1 (ppm)


163.81
163.38
161.37
159.02
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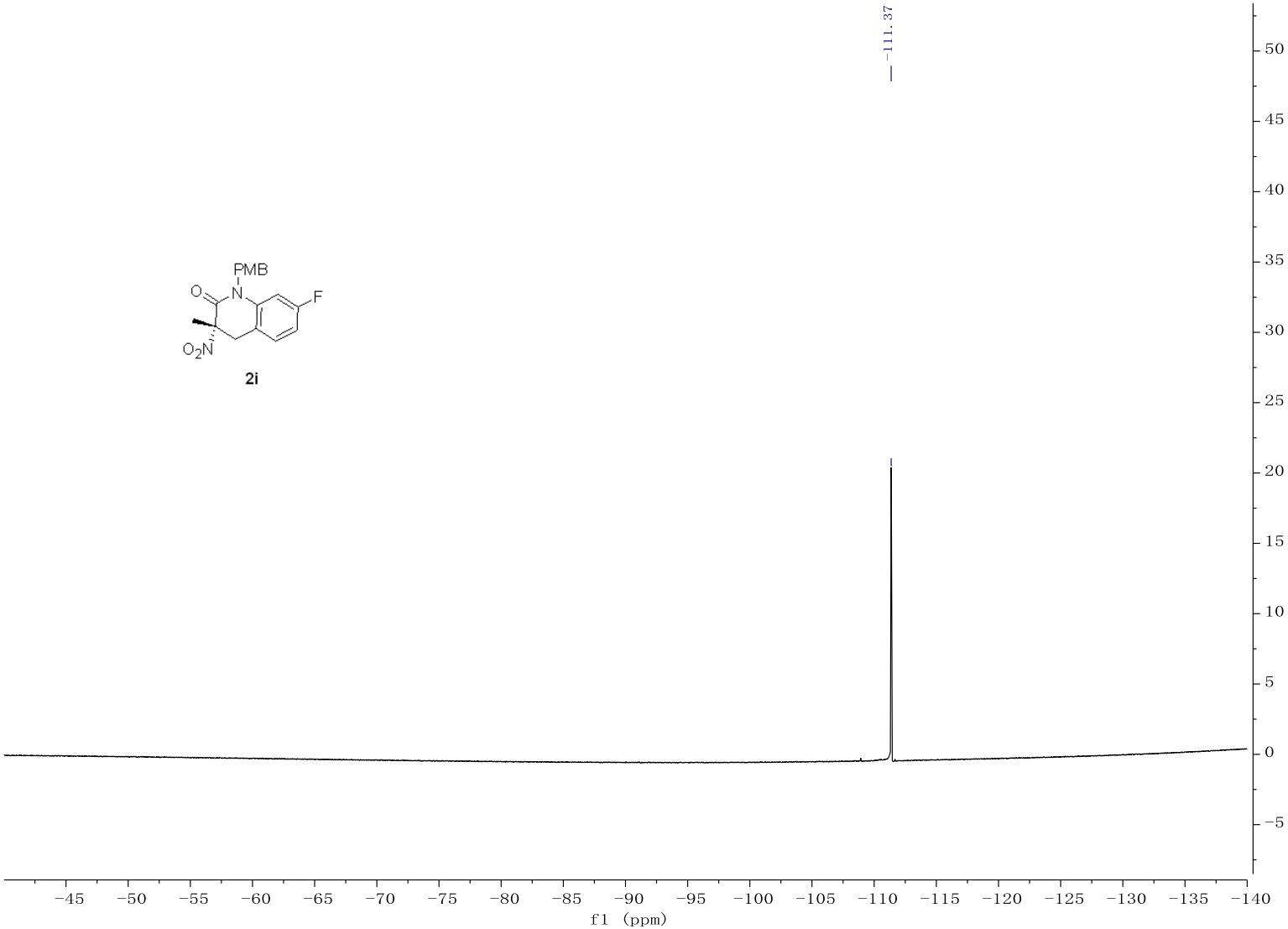
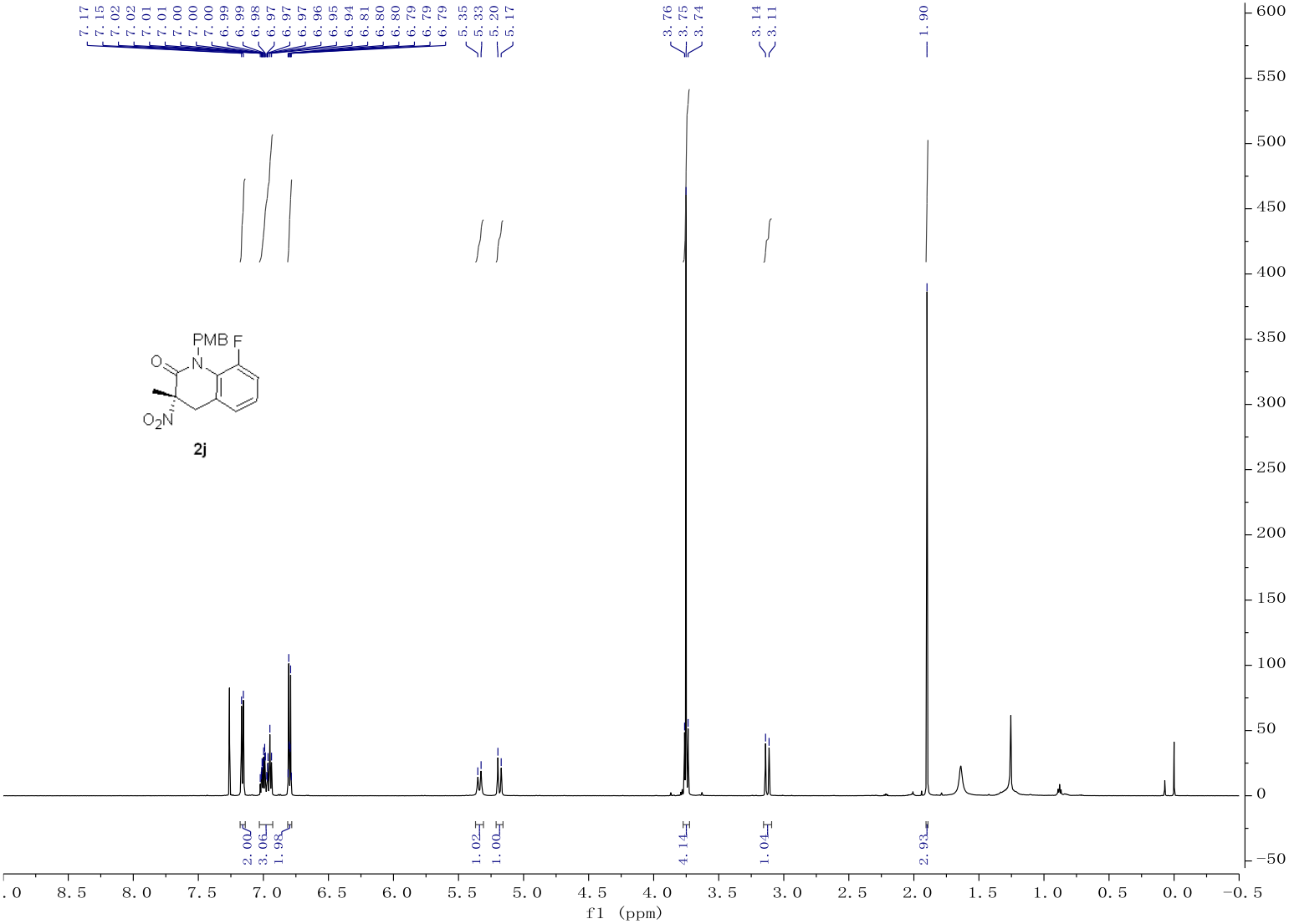
139.81
129.65
129.56
127.68
127.51
116.88
116.85
114.44
110.66
110.45
104.36
104.09
88.01
55.25
47.46
37.43
22.14
PMB
O
N
F
O_2N
2i
f1 (ppm)

PMB
O
N
F
O2N

2i


−111.37
50
45
40
35
30
25
20
15
10
5
0
−5
−45 −50 −55 −60 −65 −70 −75 −80 −85 −90 −95 −100 −105 −110 −115 −120 −125 −130 −135 −140
f1 (ppm)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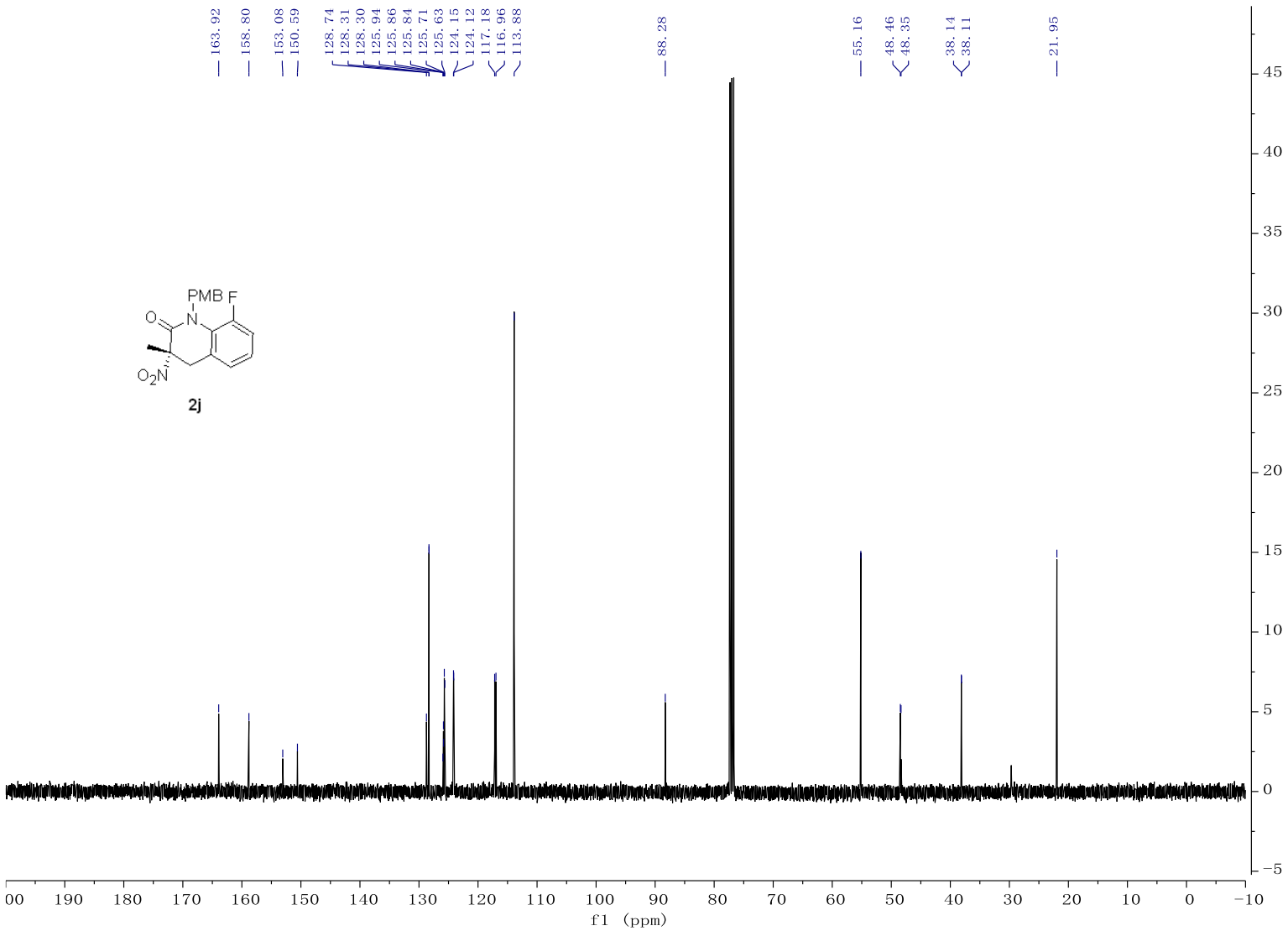
7.15
7.02
7.02
7.01
7.01
7.00
7.00
7.00
6.99
6.99
6.98
6.97
6.97
6.97
6.96
6.95
6.94
6.81
6.80
6.80
6.79
6.79
6.79
5.35
5.33
5.20
5.17
3.76
3.75
3.74
3.14
3.11
1.90
PMB F
O
N
O2N
2j
2.00
3.06
1.98
1.02
1.00
4.14
1.04
2.93
f1 (ppm)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128.31
128.30
125.94
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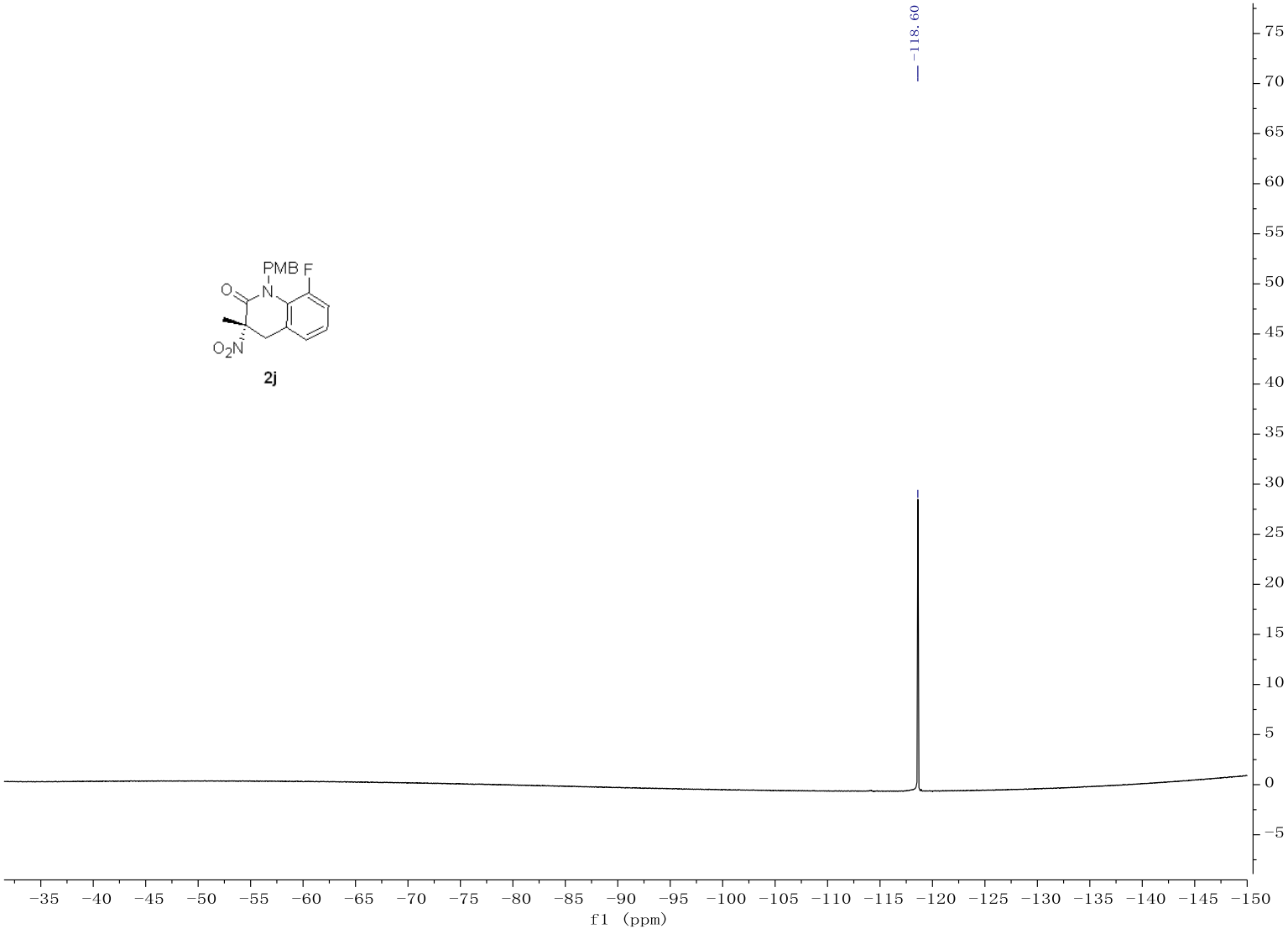
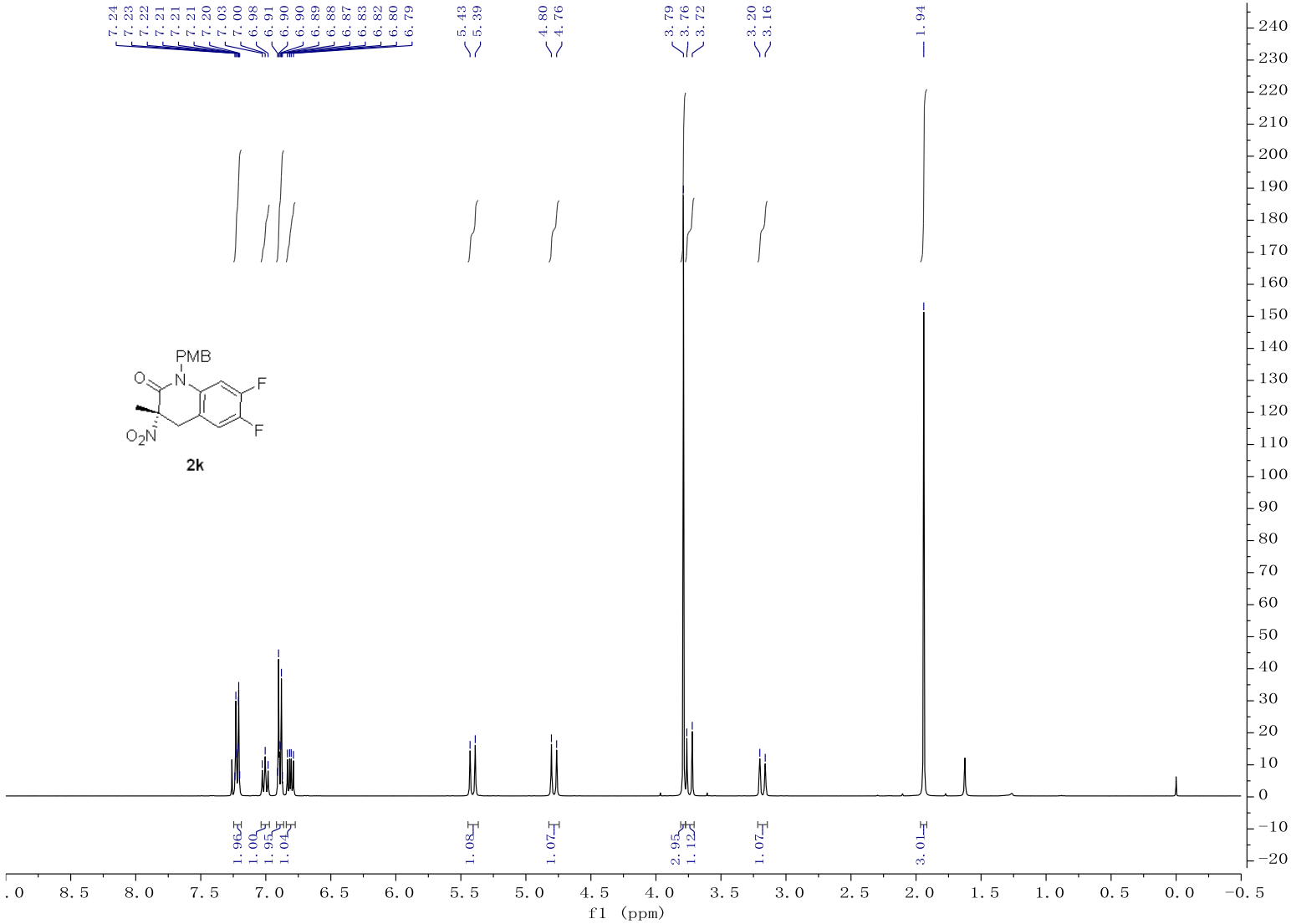
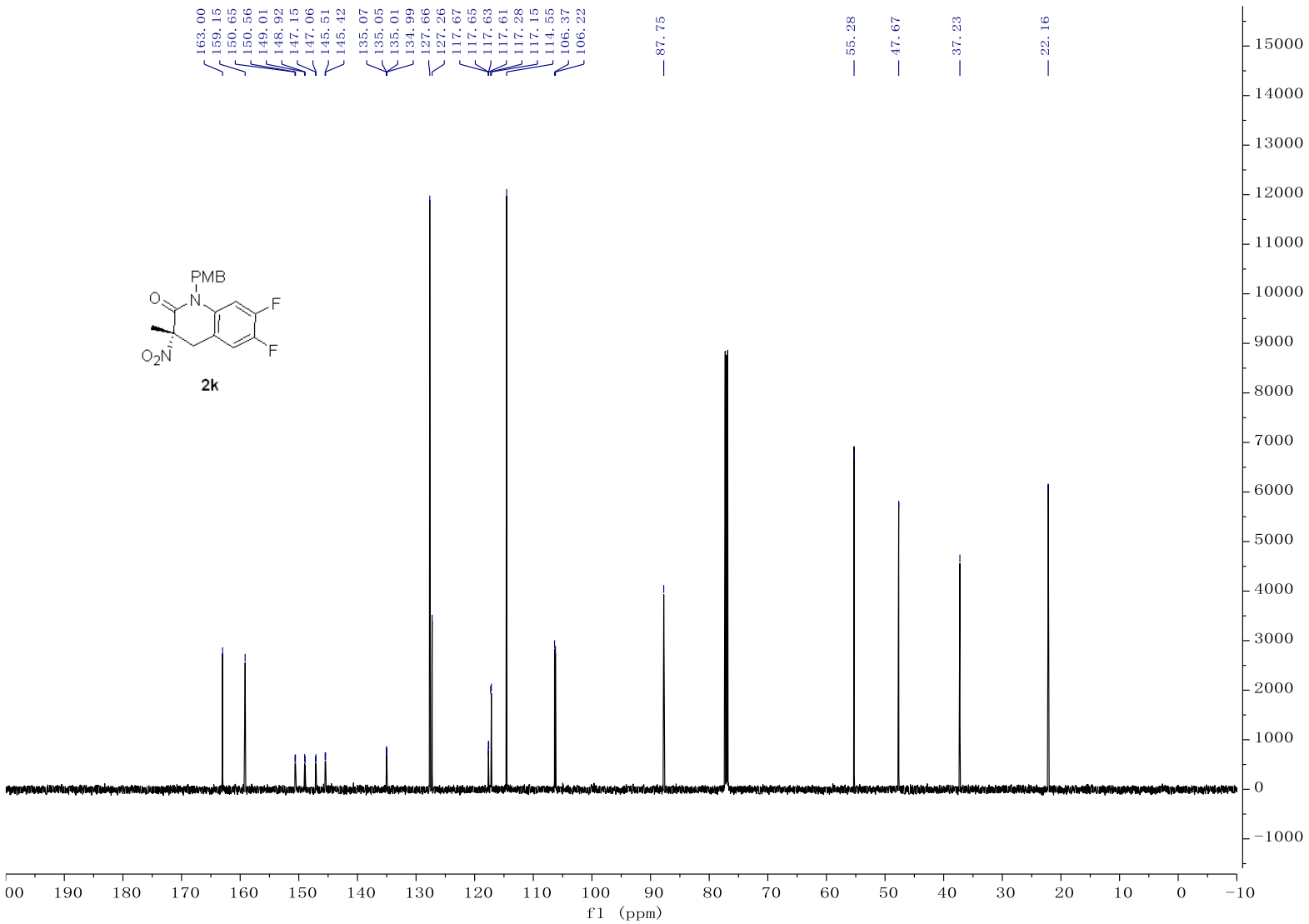
125.84
125.71
125.63
124.15
124.12
117.18
116.96
113.88
88.28
55.16
48.46
48.35
38.14
38.11
21.95
PMB
F
O
N
O2N
2j
f1 (ppm)

PMB
F
O
N
O2N

2j


−118.60
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
−5
−35 −40 −45 −50 −55 −60 −65 −70 −75 −80 −85 −90 −95 −100 −105 −110 −115 −120 −125 −130 −135 −140 −145 −150
f1 (ppm)


7.24
7.23
7.22
7.21
7.21
7.21
7.20
7.03
7.00
6.98
6.91
6.90
6.90
6.89
6.88
6.87
6.83
6.82
6.80
6.79
5.43
5.39
4.80
4.76
3.79
3.76
3.72
3.20
3.16
1.94
PMB
O
N
F
F
O2N
2k
1.96
1.00
1.95
1.04
1.08
1.07
2.95
1.12
1.07
3.01
f1 (ppm)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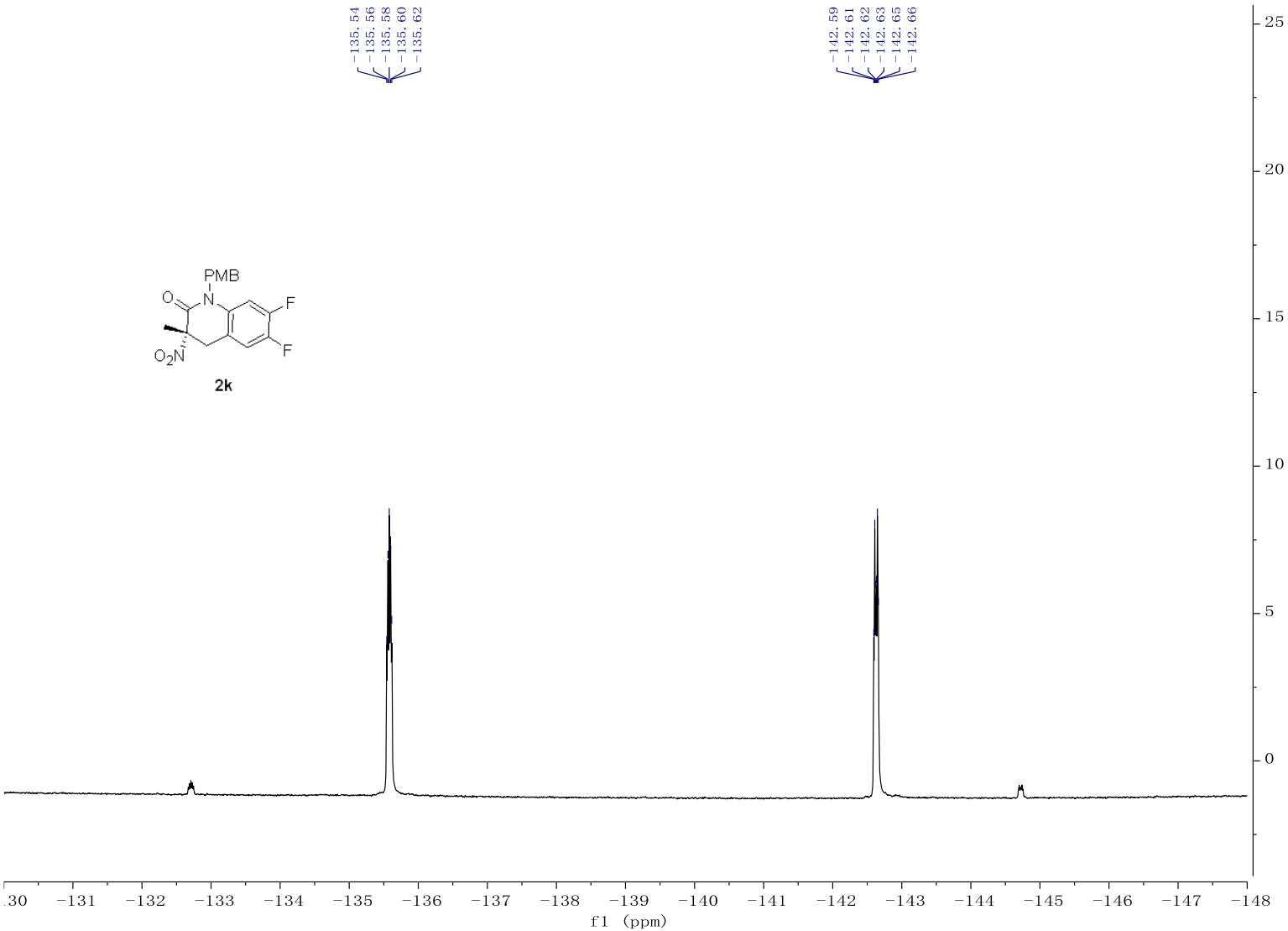
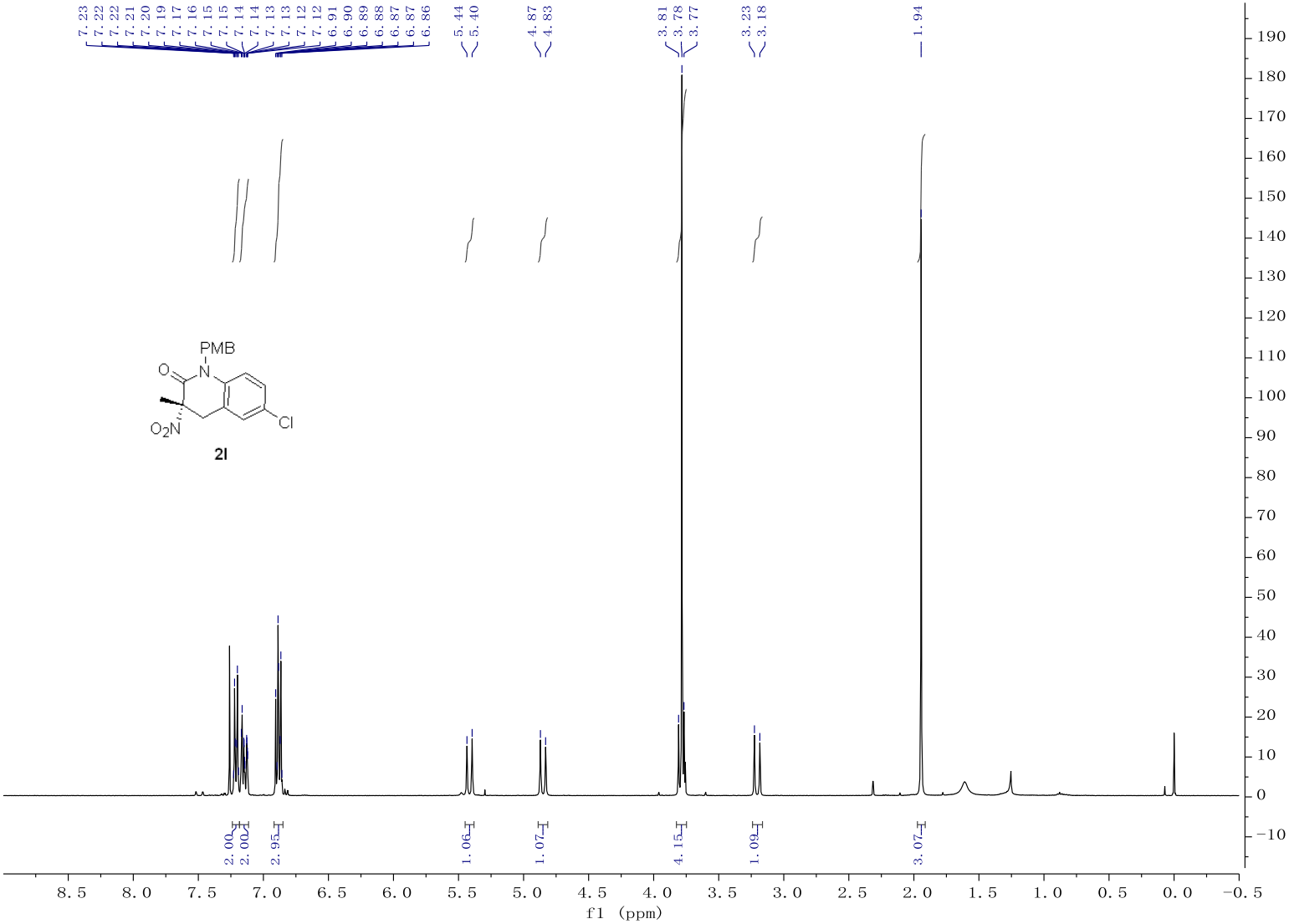
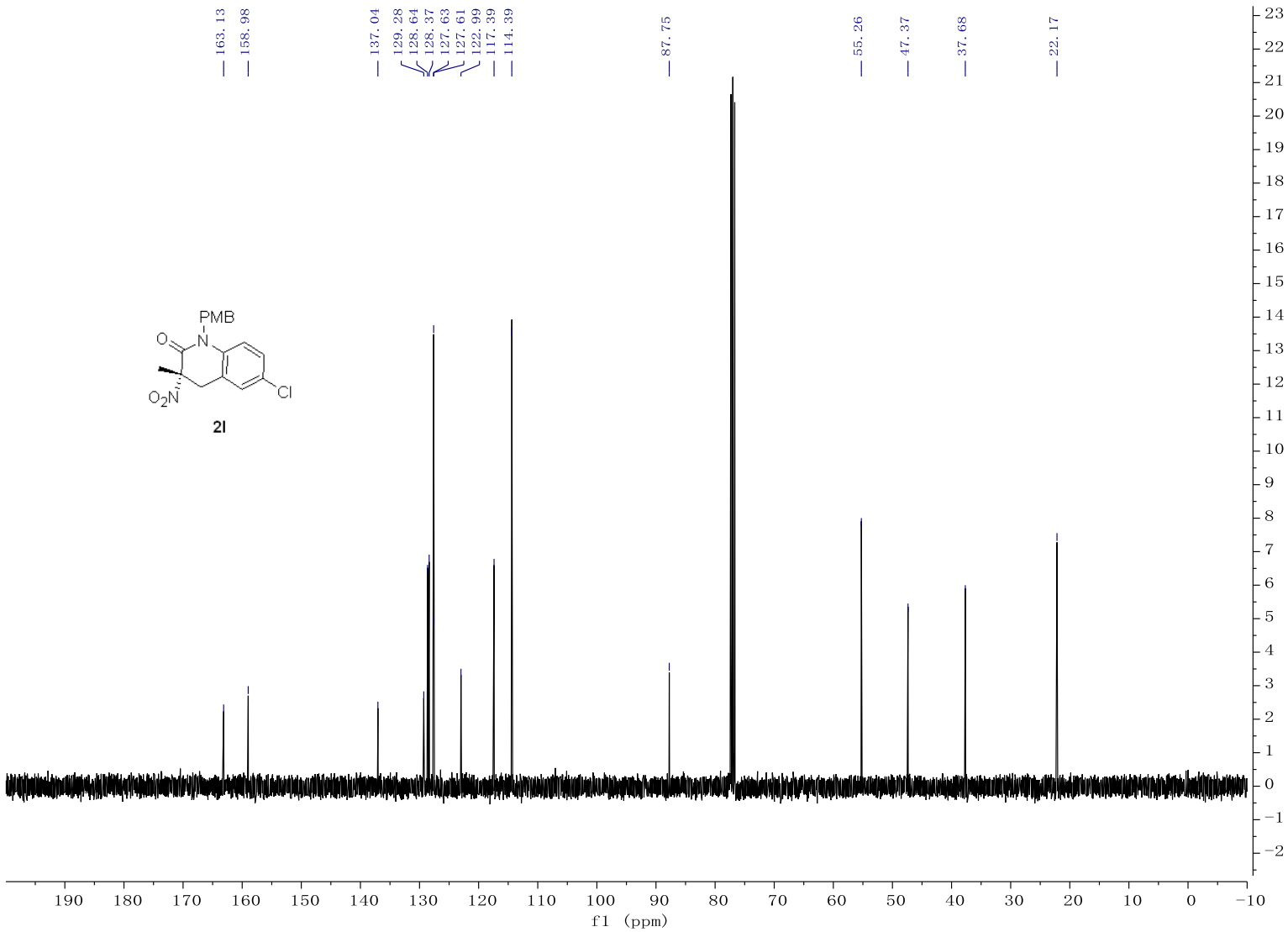
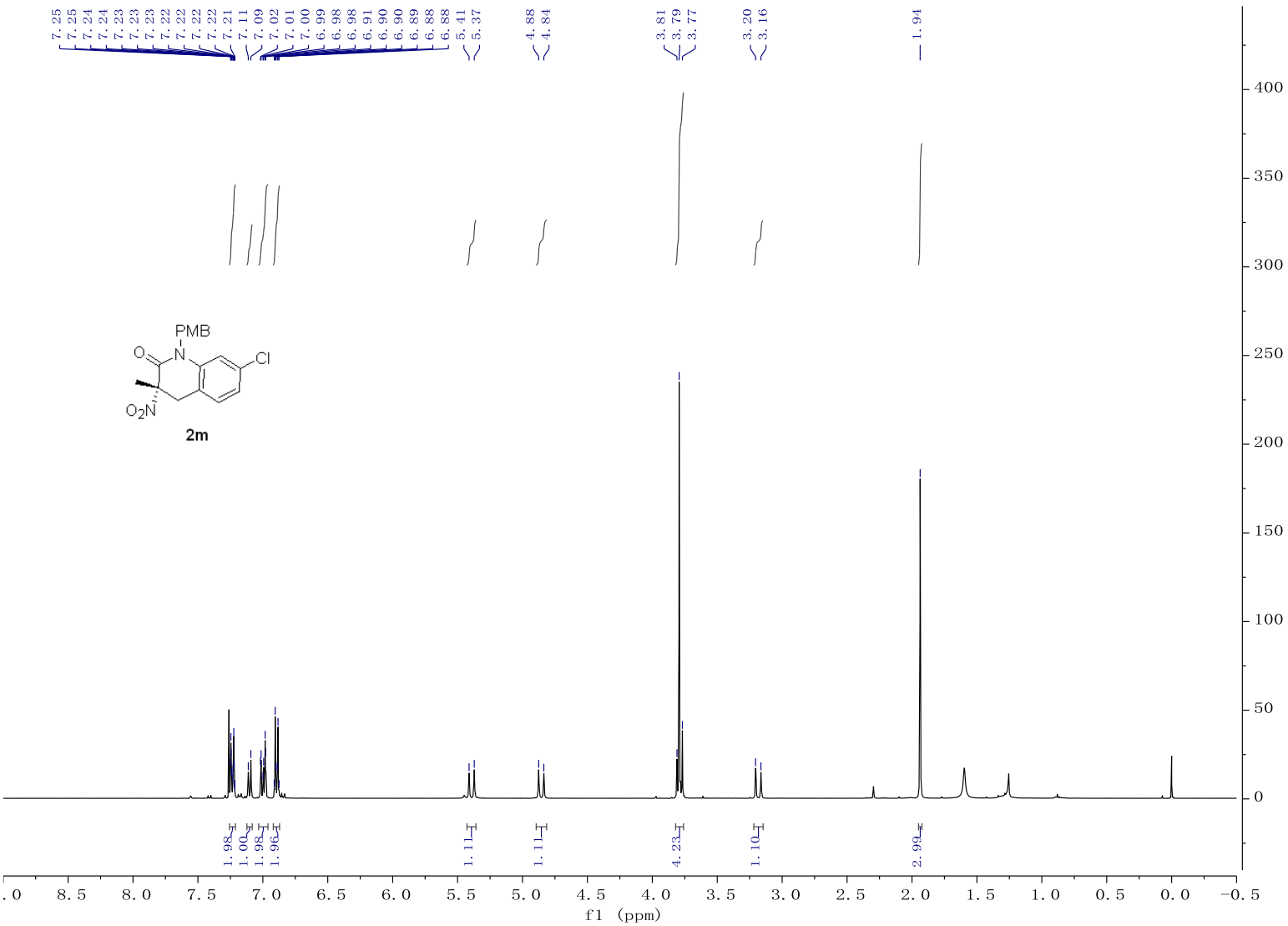
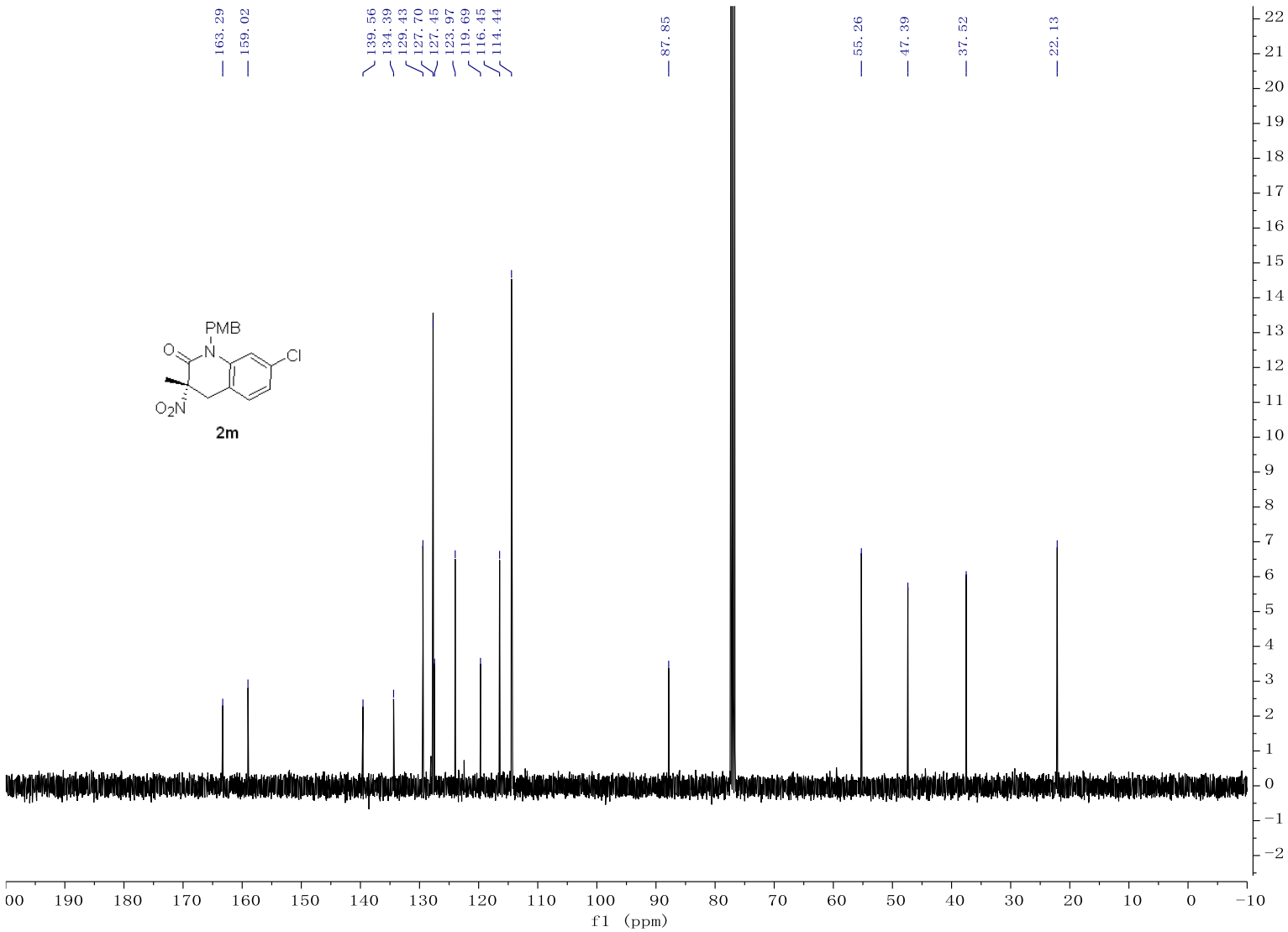
159.15
150.65
150.56
149.01
148.92
147.15
147.06
145.51
145.42
135.07
135.05
135.01
134.99
127.66
127.26
117.67
117.65
117.63
117.61
117.28
117.15
114.55
106.37
106.22
87.75
55.28
47.67
37.23
22.16
PMB
O
N
F
F
O2N
2k
f1 (ppm)

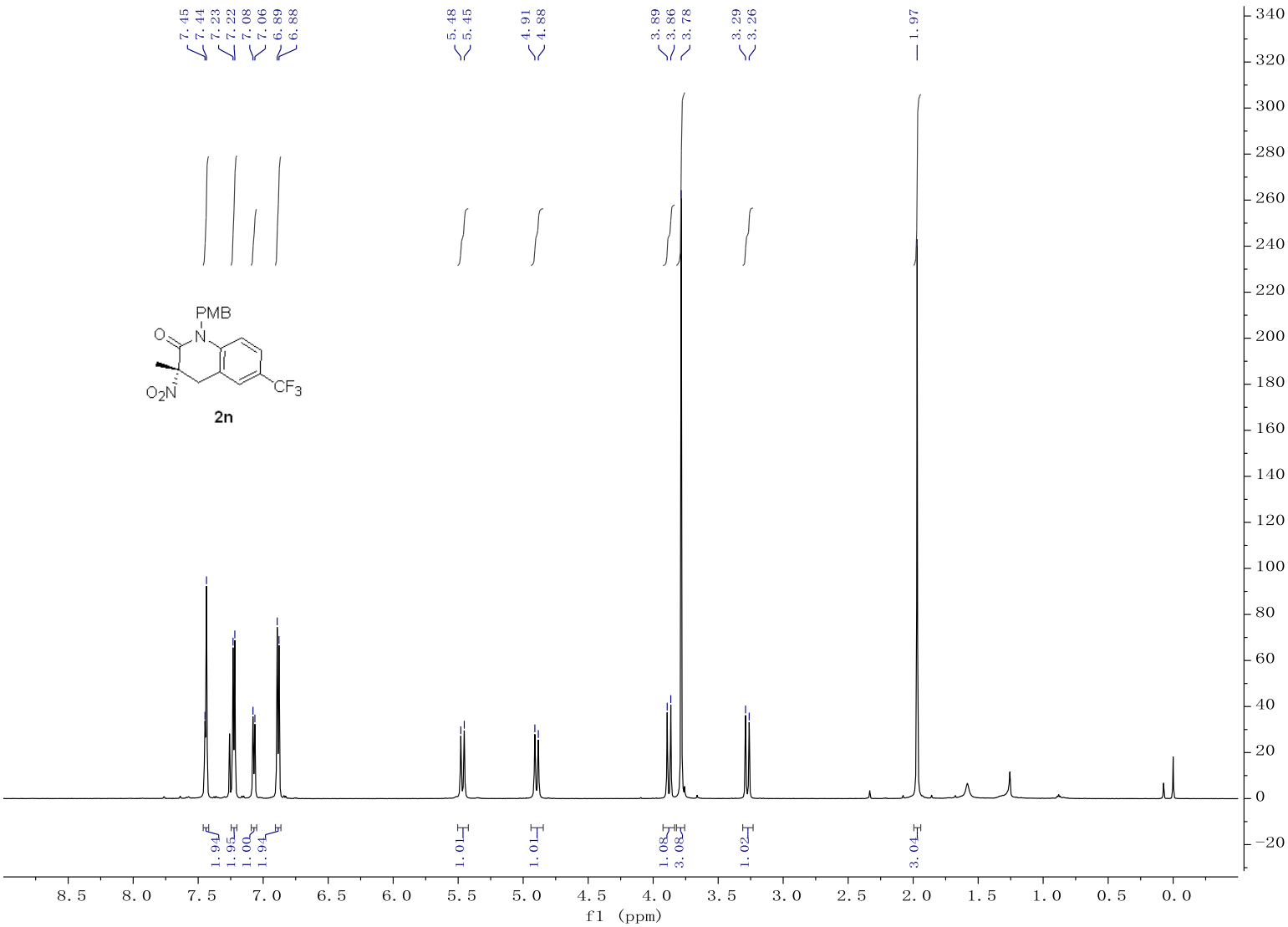

-135.54
-135.56
-135.58
-135.60
-135.62
-142.59
-142.61
-142.62
-142.63
-142.65
-142.66
PMB
O
N
F
F
O_2N
2k
25
20
15
10
5
0
-130
-131
-132
-133
-134
-135
-136
-137
-138
-139
-140
-141
-142
-143
-144
-145
-146
-147
-148
f1 (ppm)

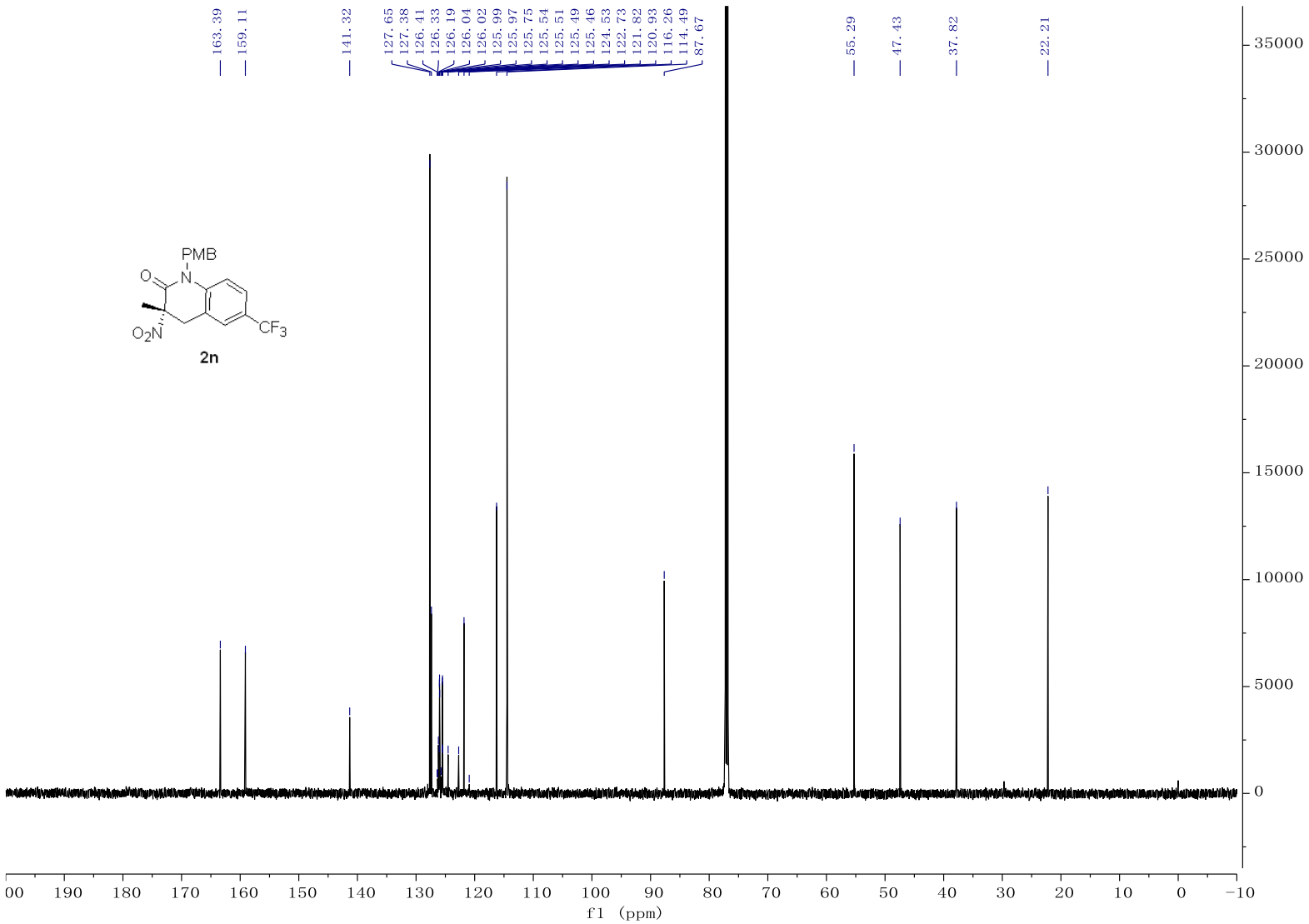

7.23
7.22
7.22
7.21
7.20
7.19
7.17
7.16
7.15
7.15
7.14
7.14
7.13
7.13
7.12
7.12
6.91
6.90
6.89
6.88
6.87
6.87
6.86
5.44
5.40
4.87
4.83
3.81
3.78
3.77
3.23
3.18
1.94
PMB
O
N
O2N
Cl
2l
2.00
2.00
2.95
1.06
1.07
4.15
1.09
3.07
f1 (ppm)

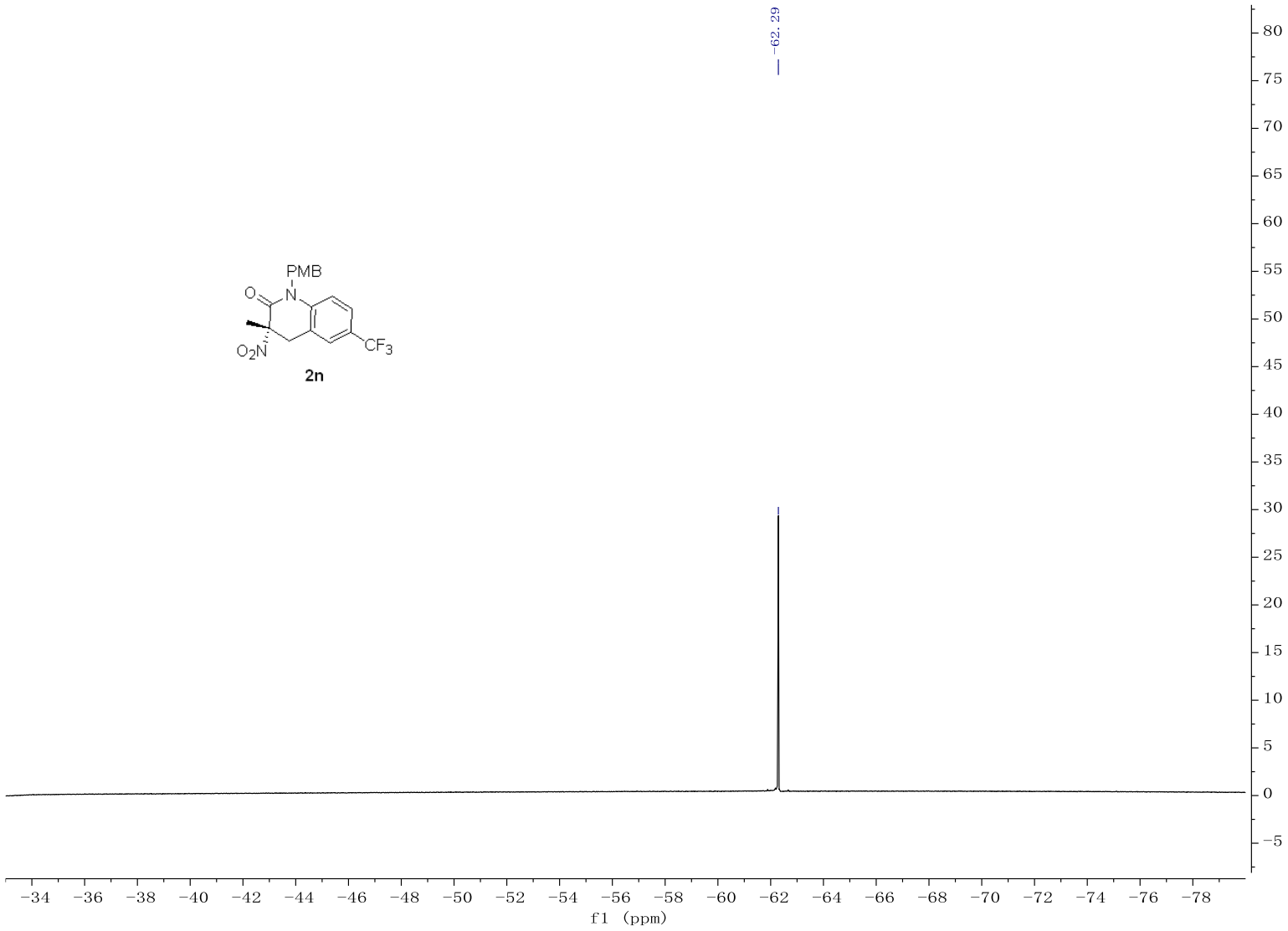

163.13
158.98
137.04
129.28
128.64
128.37
127.63
127.61
122.99
117.39
114.39
87.75
55.26
47.37
37.68
22.17
PMB
O
N
O2N
Cl
2l
f1 (ppm)

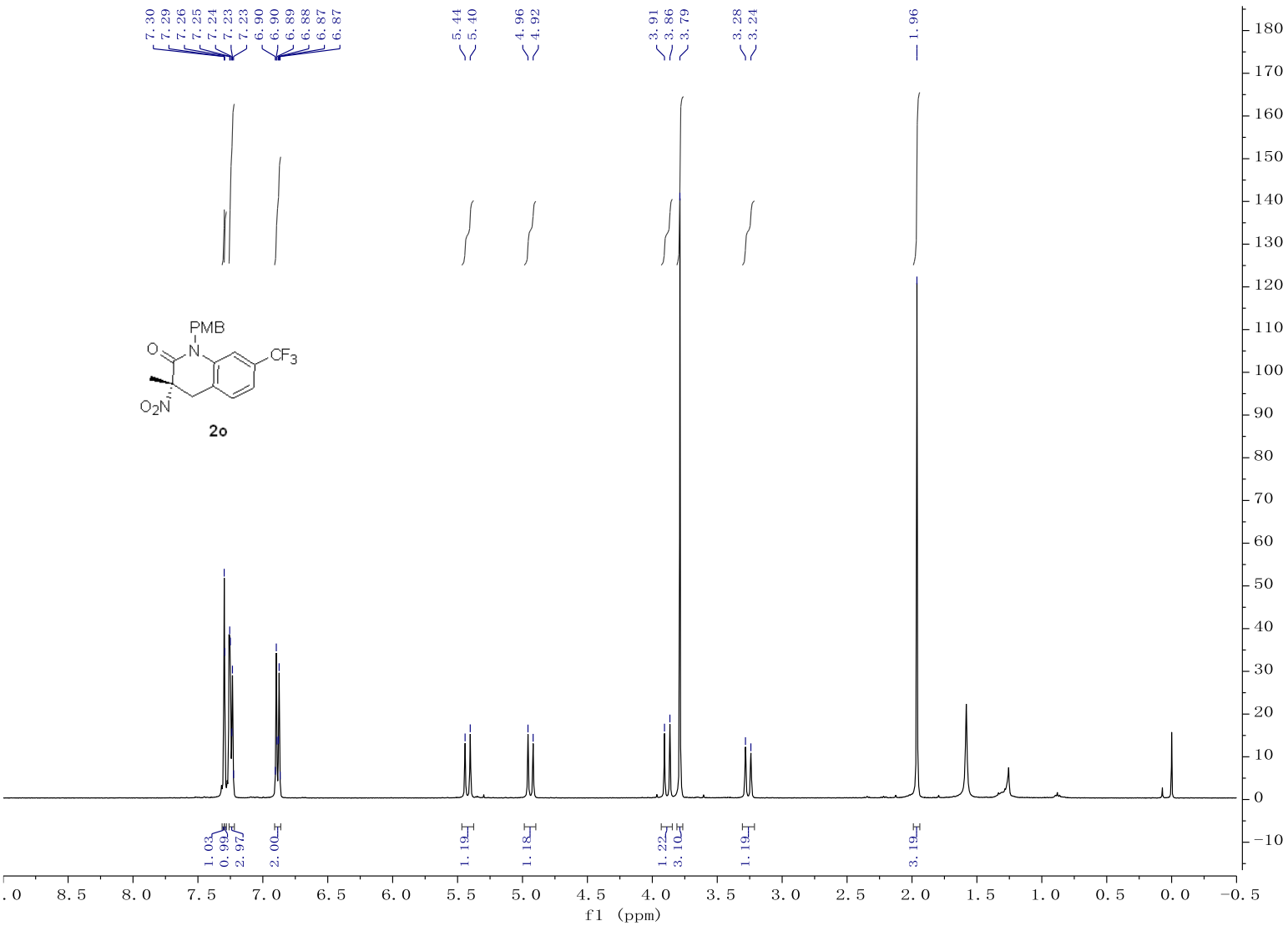

7.25
7.25
7.24
7.24
7.23
7.23
7.23
7.22
7.22
7.22
7.22
7.21
7.11
7.09
7.02
7.01
7.00
6.99
6.98
6.98
6.91
6.90
6.90
6.89
6.88
6.88
5.41
5.37
4.88
4.84
3.81
3.79
3.77
3.20
3.16
1.94
PMB
O
N
Cl
O2N
2m
1.98
1.00
1.98
1.96
1.11
1.11
4.23
1.10
2.99
f1 (ppm)

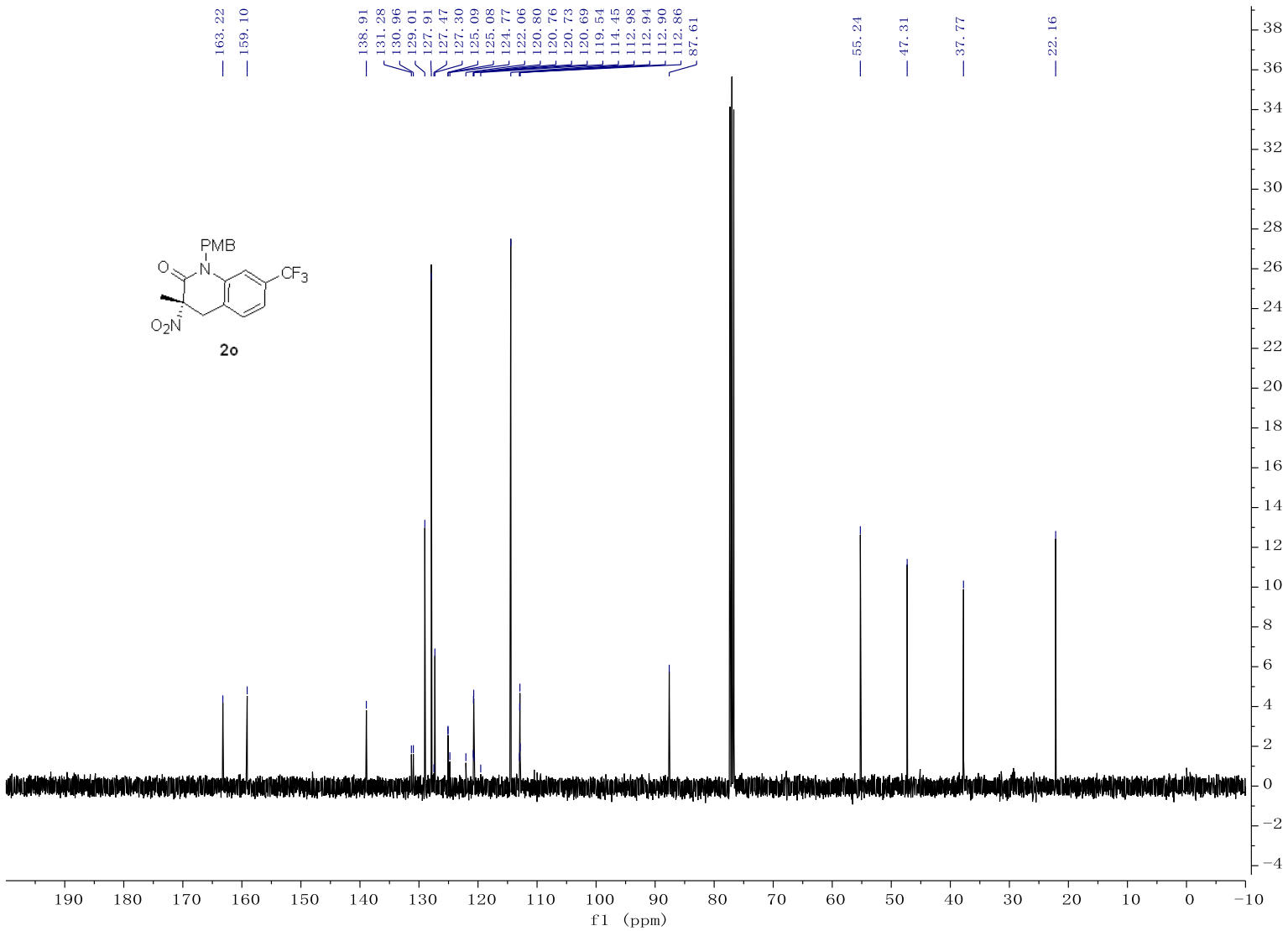

163.29
159.02
139.56
134.39
129.43
127.70
127.45
123.97
119.69
116.45
114.44
87.85
55.26
47.39
37.52
22.13
PMB
O
N
Cl
O2N
2m
f1 (ppm)

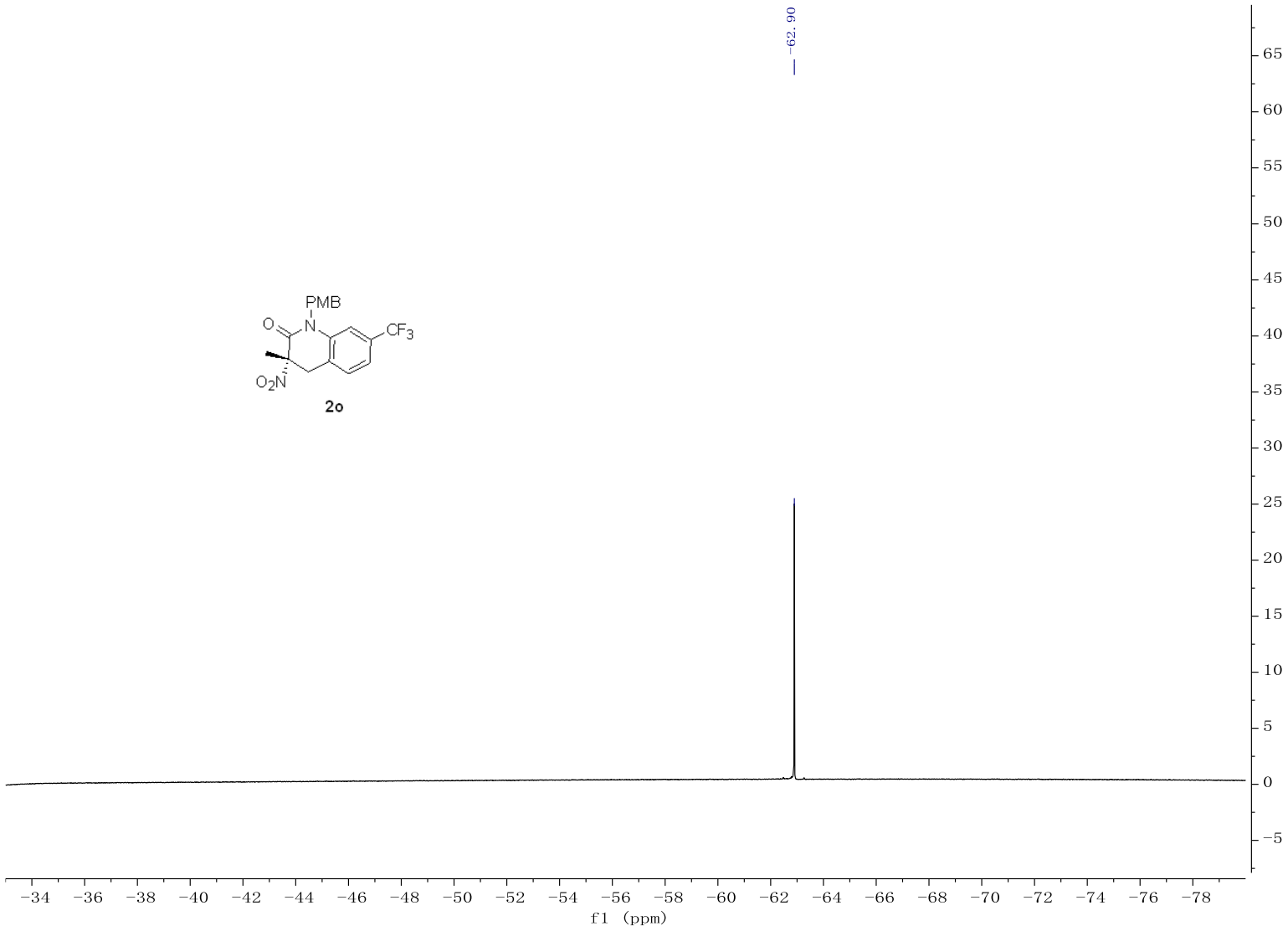

7.45
7.44
7.23
7.22
7.08
7.06
6.89
6.88
5.48
5.45
4.91
4.88
3.89
3.86
3.78
3.29
3.26
1.97
PMB
O
N
O2N
CF3
2n
1.94
1.95
1.00
1.94
1.01
1.01
1.08
3.08
1.02
3.04
f1 (ppm)

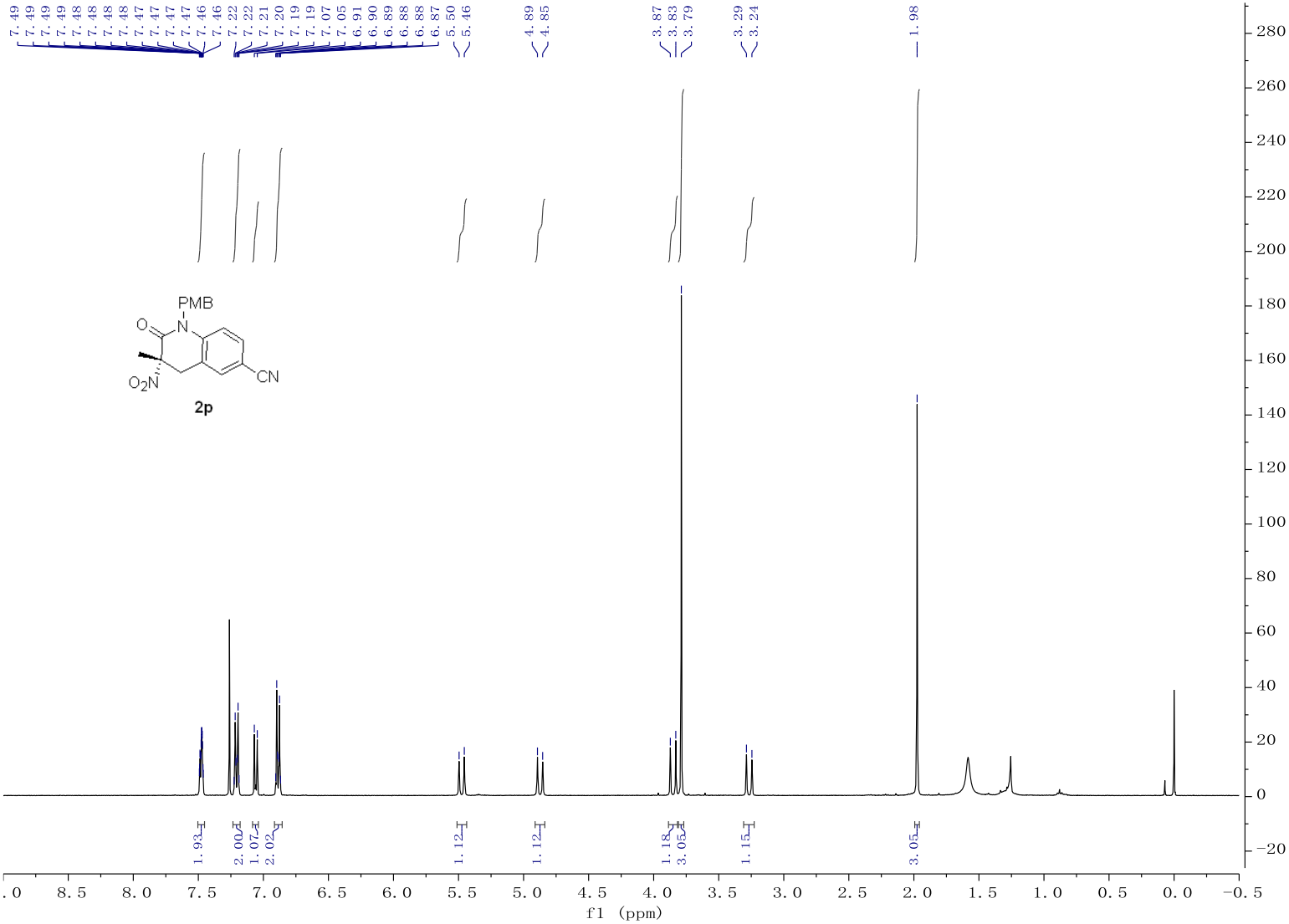

163.39
159.11
141.32
127.65
127.38
126.41
126.33
126.19
126.04
126.02
125.99
125.97
125.75
125.54
125.51
125.49
125.46
124.53
122.73
121.82
120.93
116.26
114.49
87.67
55.29
47.43
37.82
22.21
PMB
O
N
O2N
CF3
2n
35000
30000
25000
20000
15000
10000
5000
0
00 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10
f1 (ppm)

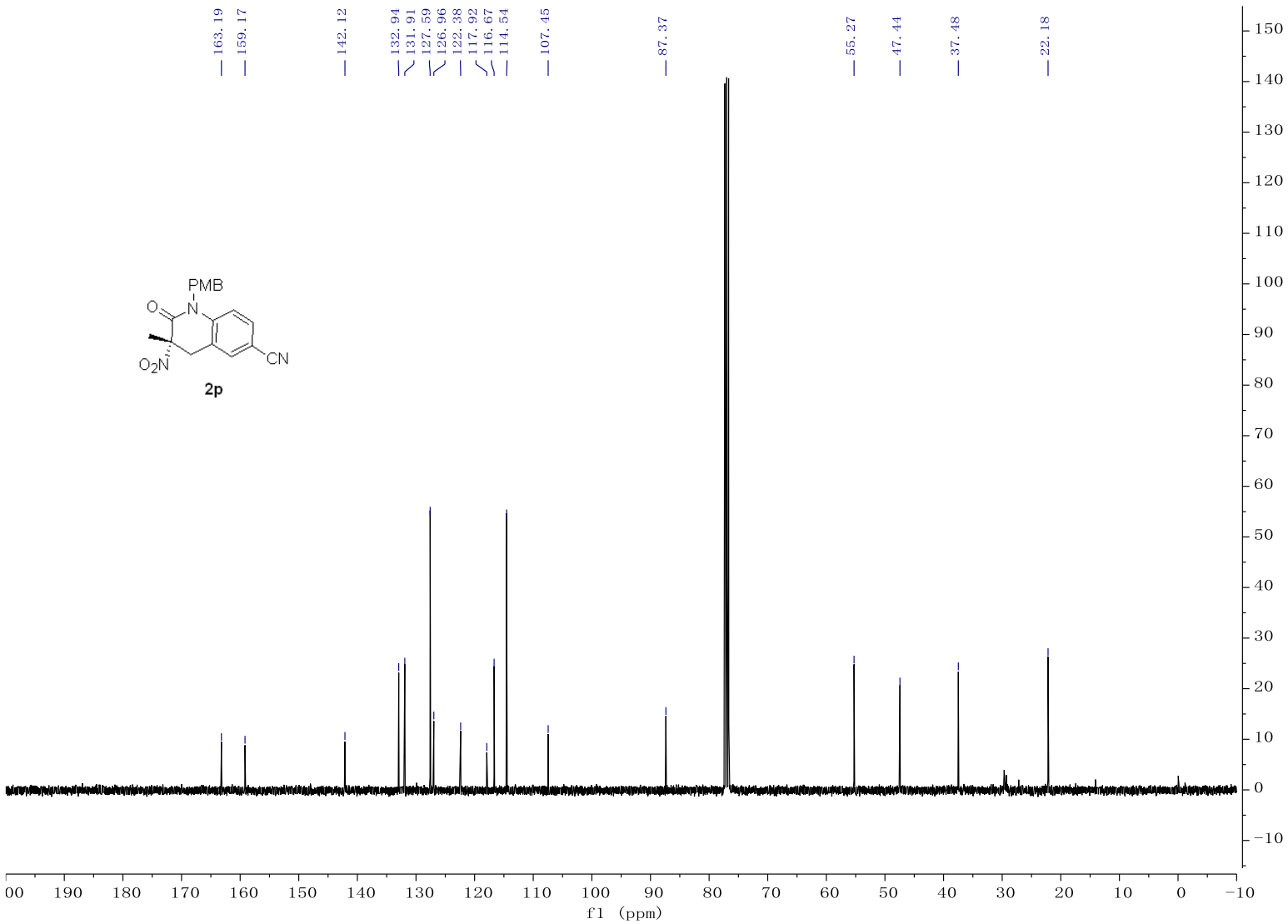

PMB
O
N
O2N
CF3
2n
−62.29
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
−5
−34 −36 −38 −40 −42 −44 −46 −48 −50 −52 −54 −56 −58 −60 −62 −64 −66 −68 −70 −72 −74 −76 −78
f1 (ppm)

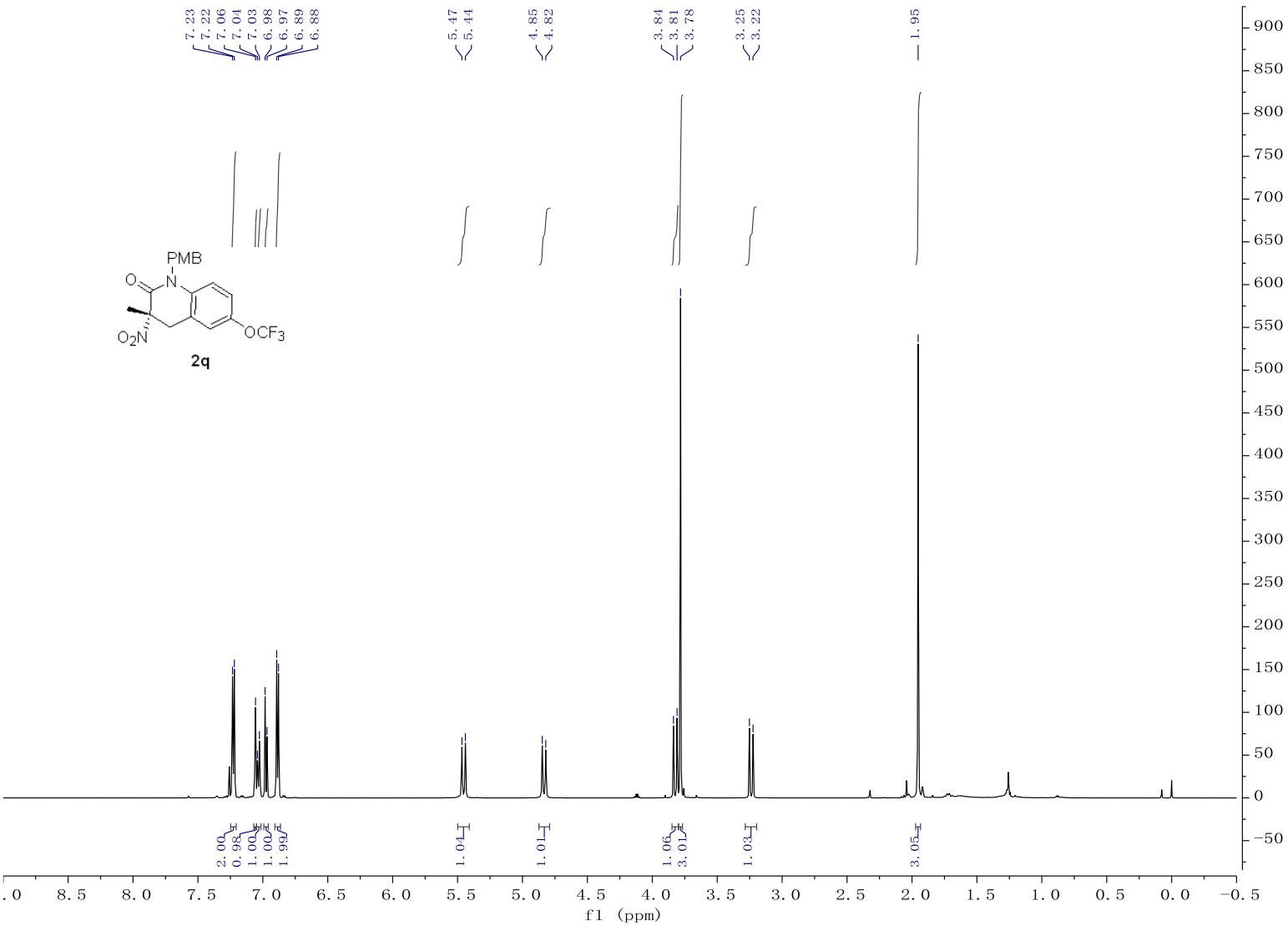

7.30
7.29
7.26
7.25
7.24
7.23
7.23
6.90
6.90
6.89
6.88
6.87
6.87
5.44
5.40
4.96
4.92
3.91
3.86
3.79
3.28
3.24
1.96
PMB
O
N
CF3
O2N
2o
1.03
0.99
2.97
2.00
1.19
1.18
1.22
3.10
1.19
3.19
f1 (ppm)

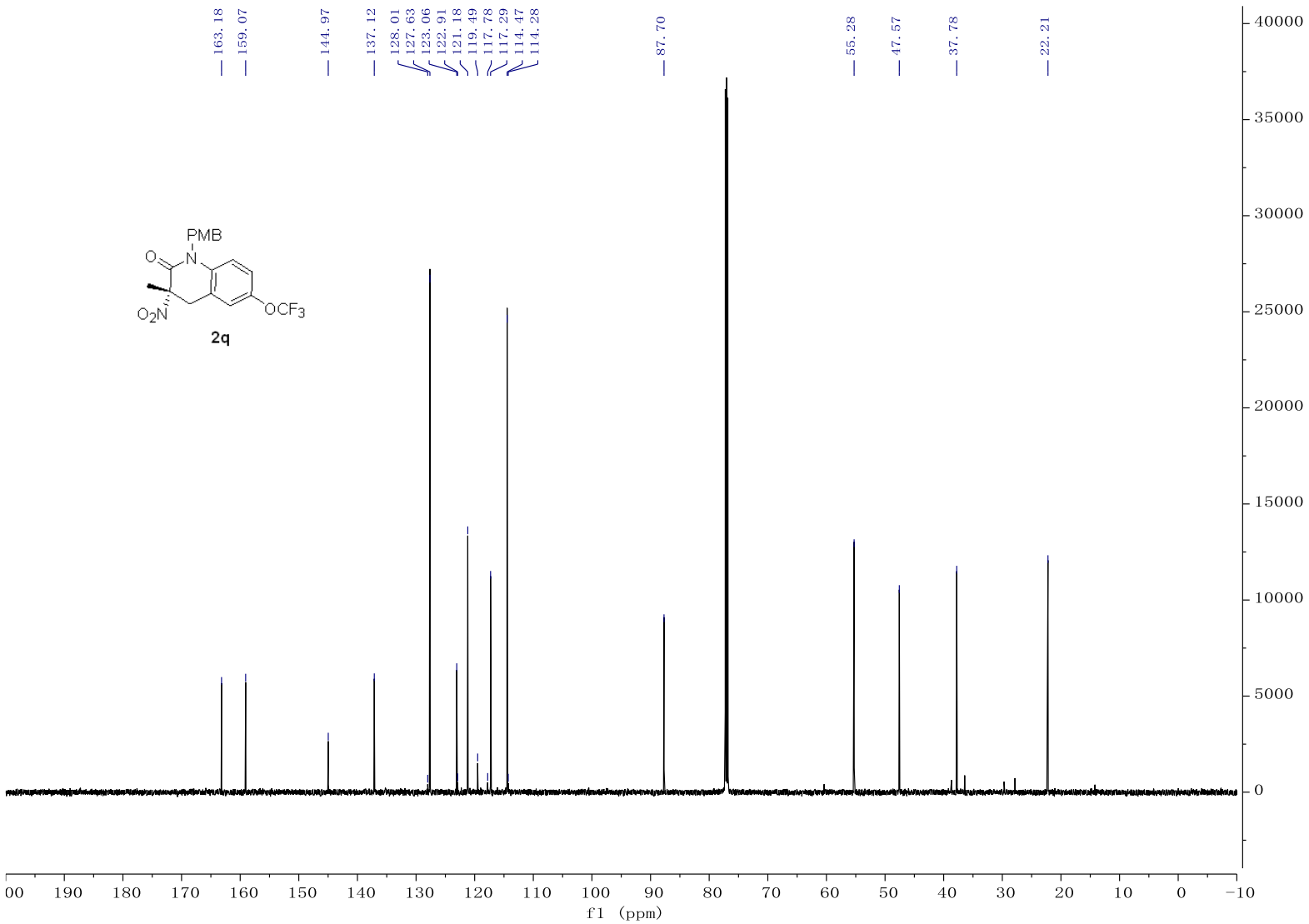

163.22
159.10
138.91
131.28
130.96
129.01
127.91
127.47
127.30
125.09
125.08
124.77
122.06
120.80
120.76
120.73
120.69
119.54
114.45
112.98
112.94
112.90
112.86
87.61
55.24
47.31
37.77
22.16
PMB
N
O
CF3
O2N
2o
f1 (ppm)


PMB
O
N
CF3
O2N
2o
−62.90
65
60
55
50
45
40
35
30
25
20
15
10
5
0
−5
−34 −36 −38 −40 −42 −44 −46 −48 −50 −52 −54 −56 −58 −60 −62 −64 −66 −68 −70 −72 −74 −76 −78
f1 (ppm)

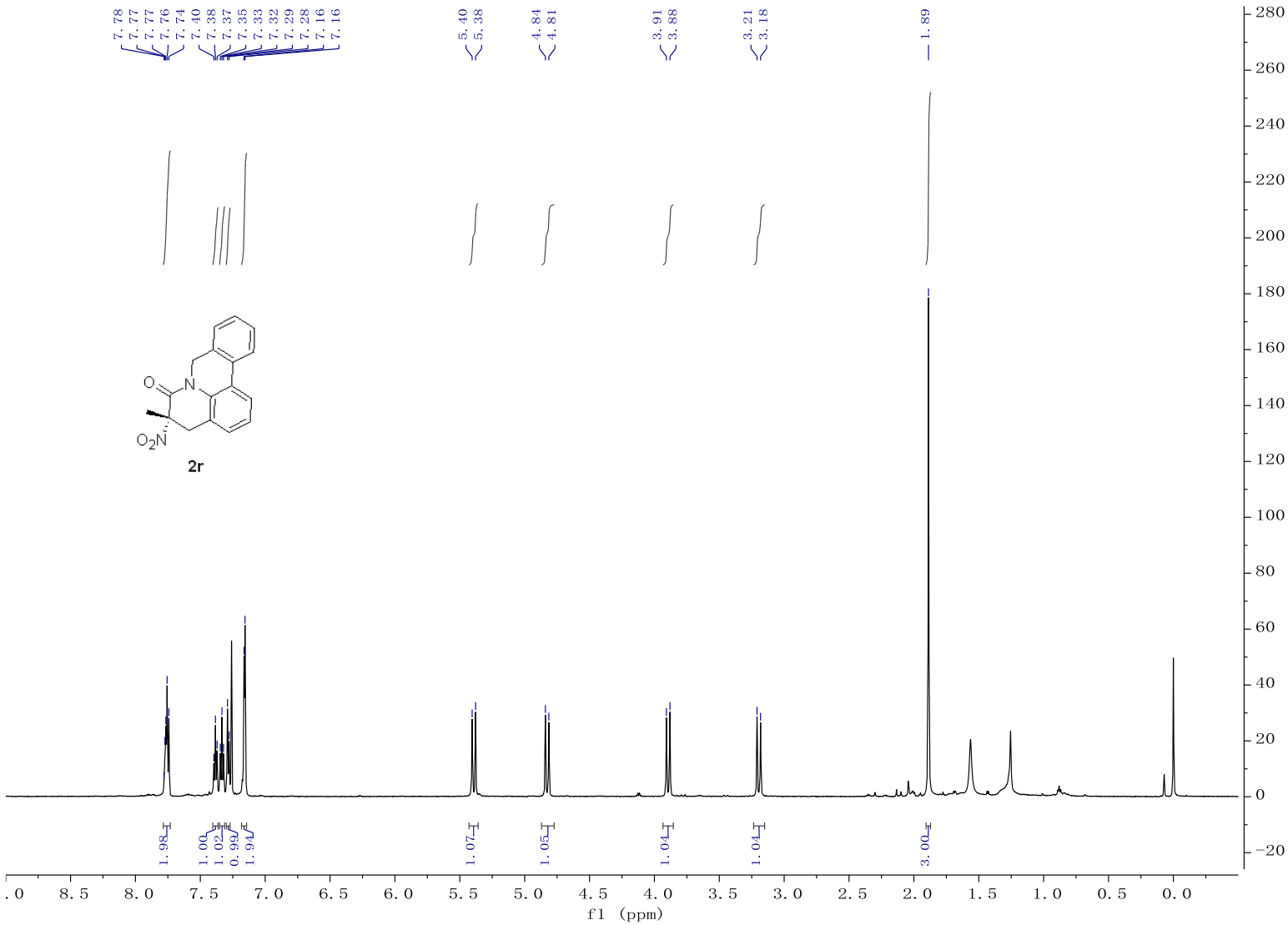

7.49
7.49
7.49
7.49
7.48
7.48
7.48
7.48
7.47
7.47
7.47
7.47
7.47
7.46
7.46
7.22
7.22
7.21
7.20
7.19
7.19
7.07
7.05
6.91
6.90
6.89
6.88
6.88
6.87
5.50
5.46
4.89
4.85
3.87
3.83
3.79
3.29
3.24
1.98
PMB
O
N
O2N
CN
2p
1.93
2.00
1.07
2.02
1.12
1.12
1.18
3.05
1.15
3.05
f1 (ppm)

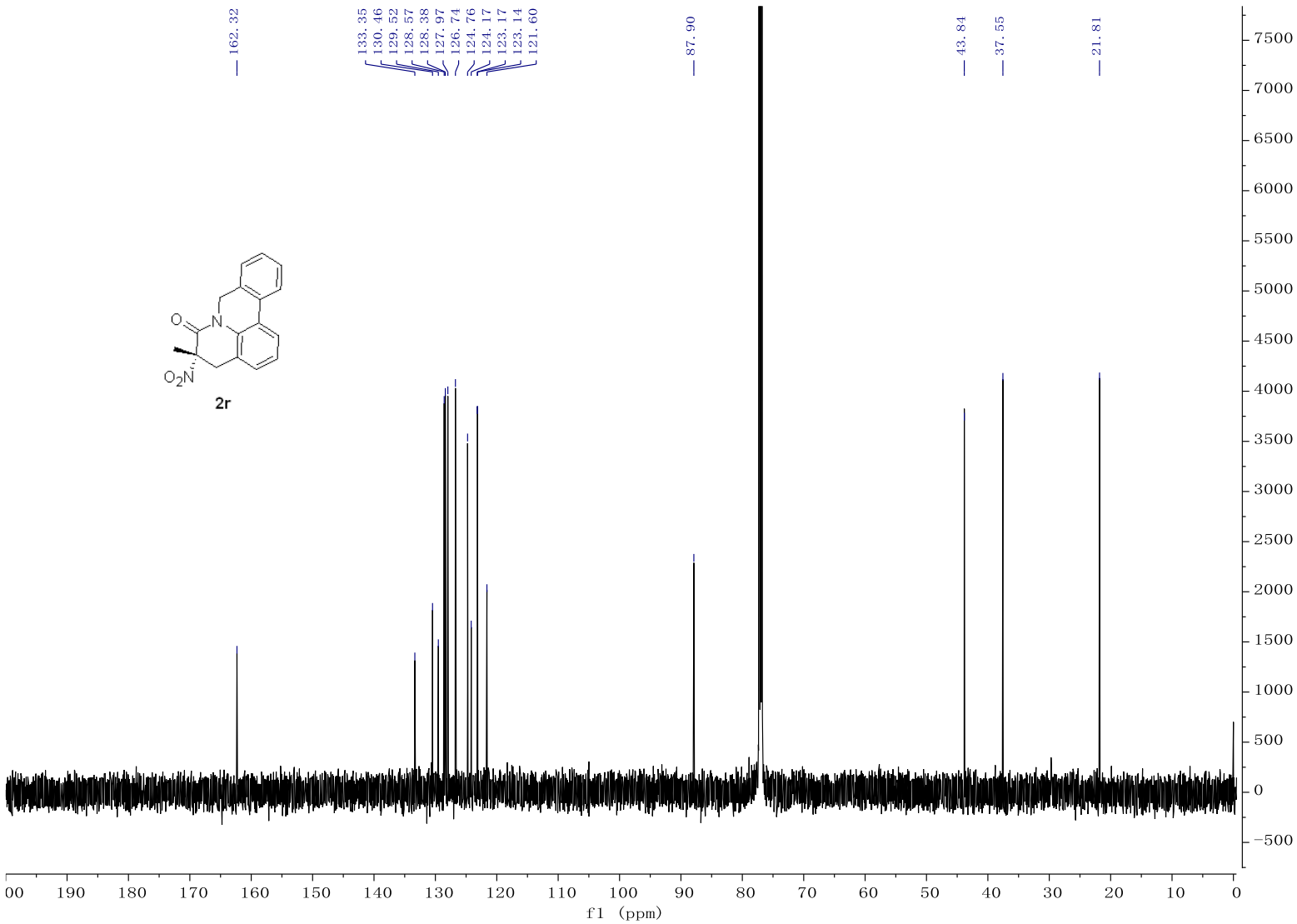

163.19
159.17
142.12
132.94
131.91
127.59
126.96
122.38
117.92
116.67
114.54
107.45
87.37
55.27
47.44
37.48
22.18
PMB
O
N
O2N
CN
2p
f1 (ppm)

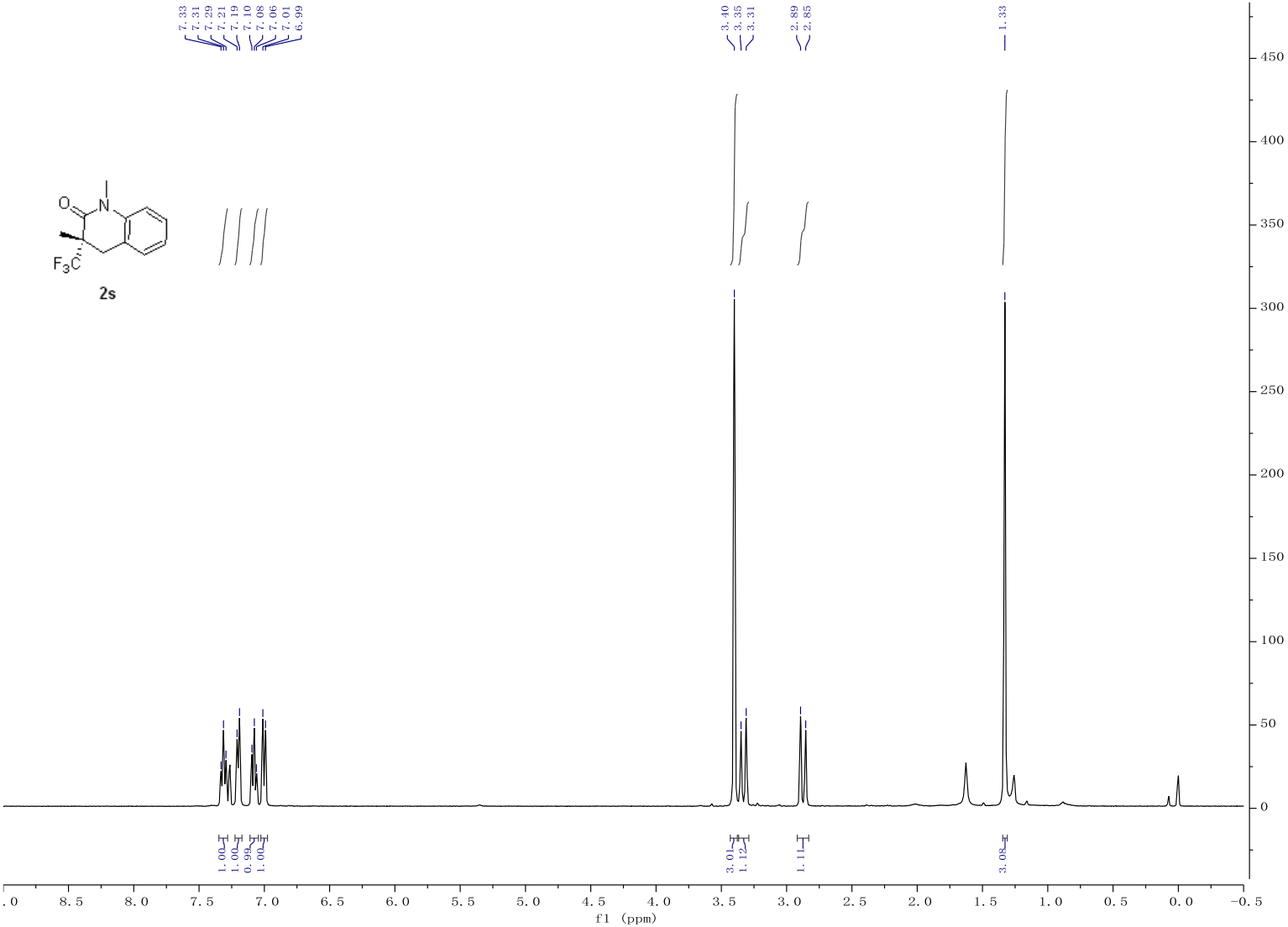

7.23
7.22
7.06
7.04
7.03
6.98
6.97
6.89
6.88
5.47
5.44
4.85
4.82
3.84
3.81
3.78
3.25
3.22
1.95
PMB
O
N
O2N
OCF3
2q
2.00
0.98
1.00
1.00
1.99
1.04
1.01
1.06
3.01
1.03
3.05
f1 (ppm)

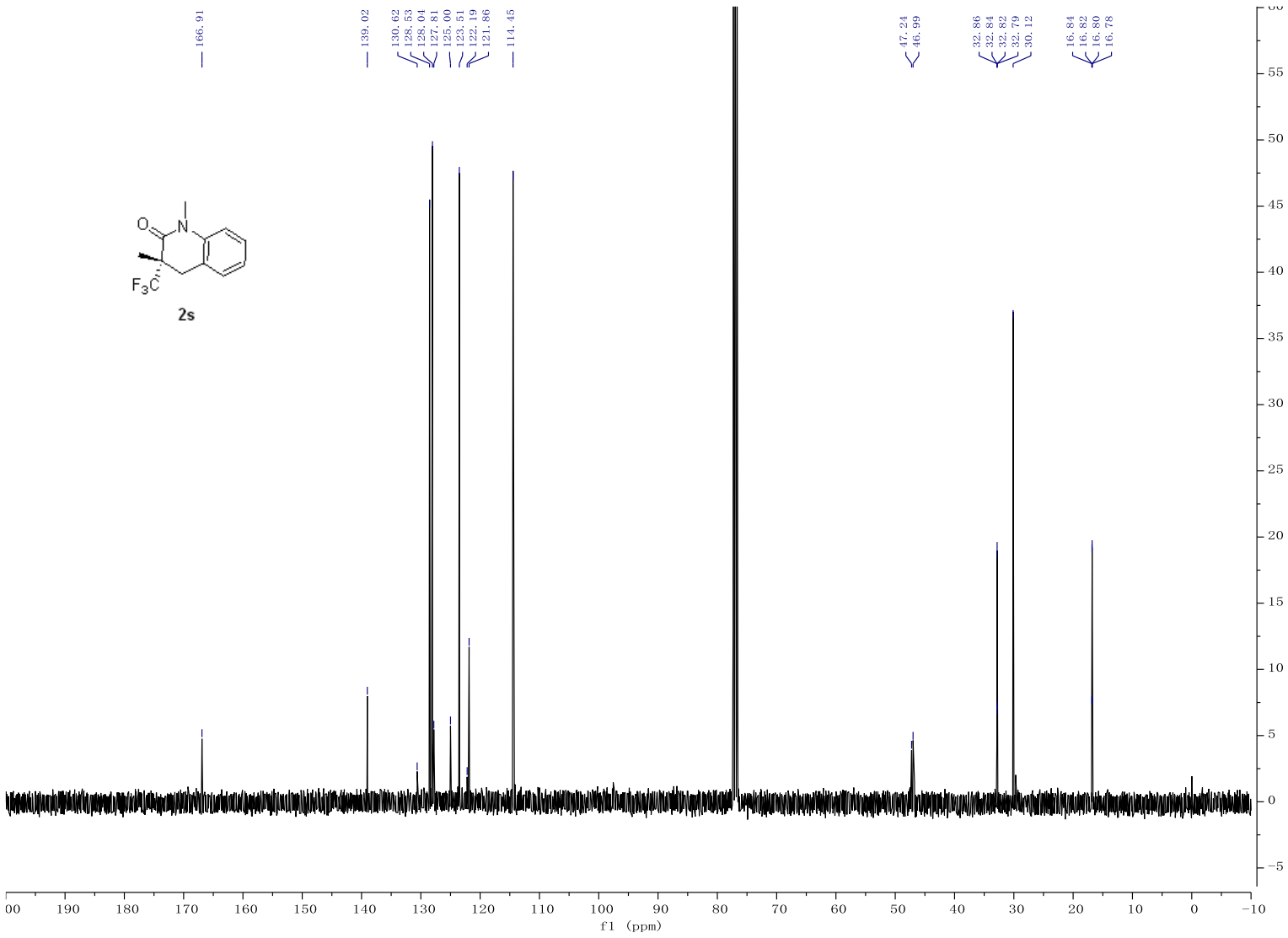

163.18
159.07
144.97
137.12
128.01
127.63
123.06
122.91
121.18
119.49
117.78
117.29
114.47
114.28
87.70
55.28
47.57
37.78
22.21
PMB
O
N
O2N
OCF3
2q
40000
35000
30000
25000
20000
15000
10000
5000
0
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
f1 (ppm)

PMB
O
N
O2N
OCF3
2q
−58.11
550
500
450
400
350
300
250
200
150
100
50
0
−50
−32 −34 −36 −38 −40 −42 −44 −46 −48 −50 −52 −54 −56 −58 −60 −62 −64 −66 −68 −70 −72 −74 −76 −78
f1 (ppm)

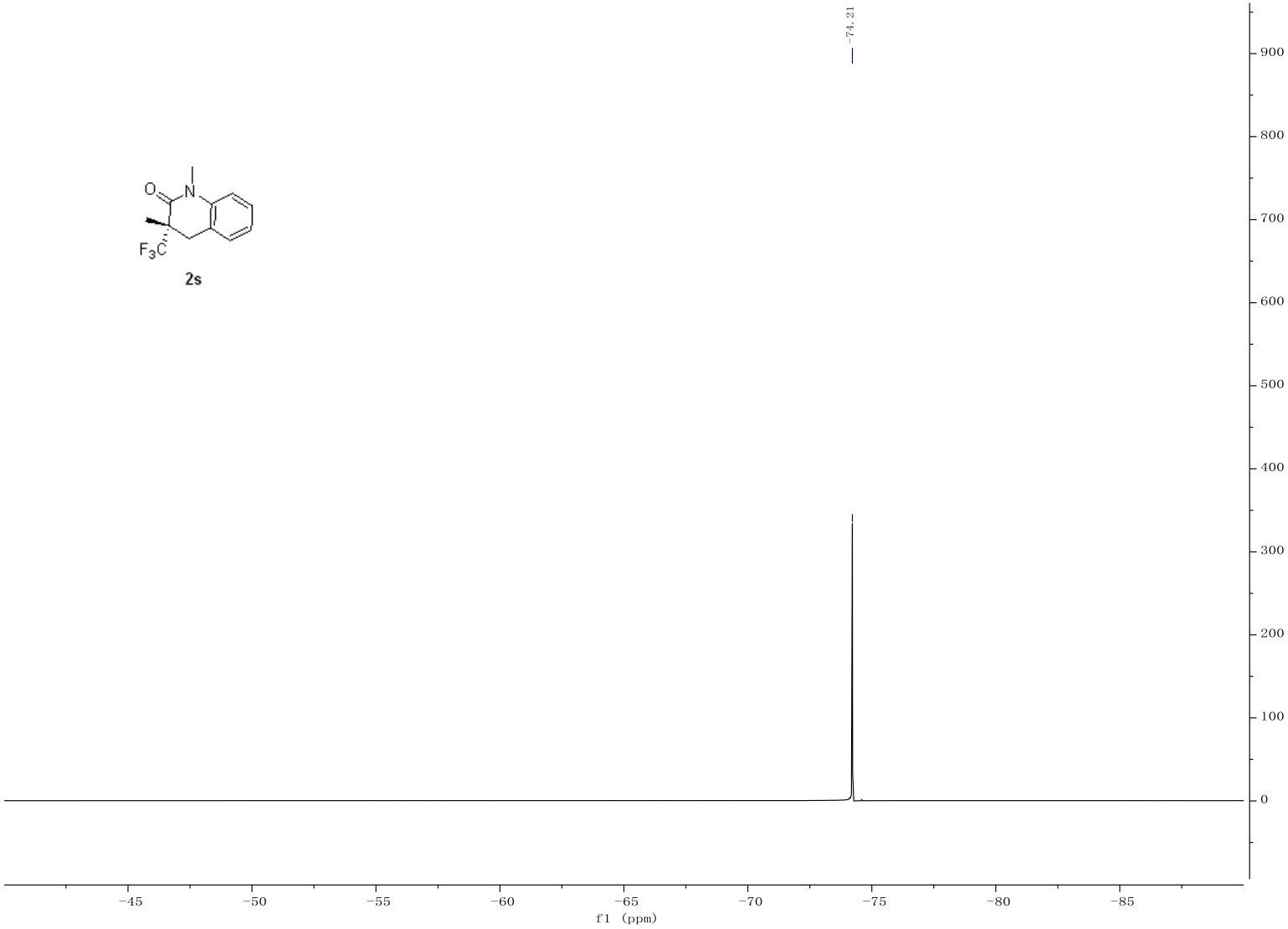

7.78
7.77
7.77
7.76
7.74
7.40
7.38
7.37
7.35
7.33
7.32
7.29
7.28
7.16
7.16
5.40
5.38
4.84
4.81
3.91
3.88
3.21
3.18
1.89
O
N
O_2N
2r
1.98
1.00
1.02
0.99
1.94
1.07
1.05
1.04
1.04
3.00
f1 (ppm)

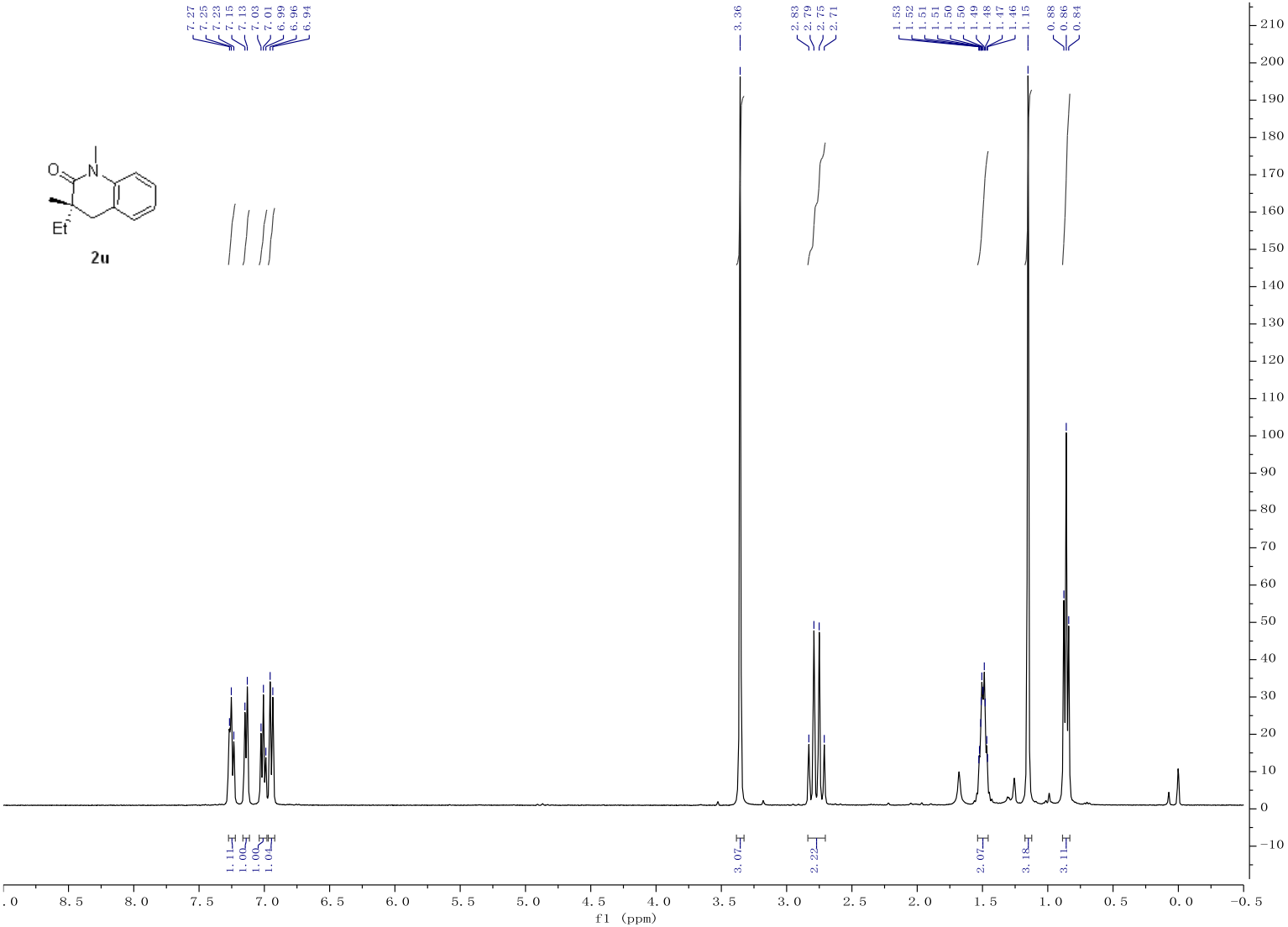

162.32
133.35
130.46
129.52
128.57
128.38
127.97
126.74
124.76
124.17
123.17
123.14
121.60
87.90
43.84
37.55
21.81
O
N
O_2N
2r
f1 (ppm)

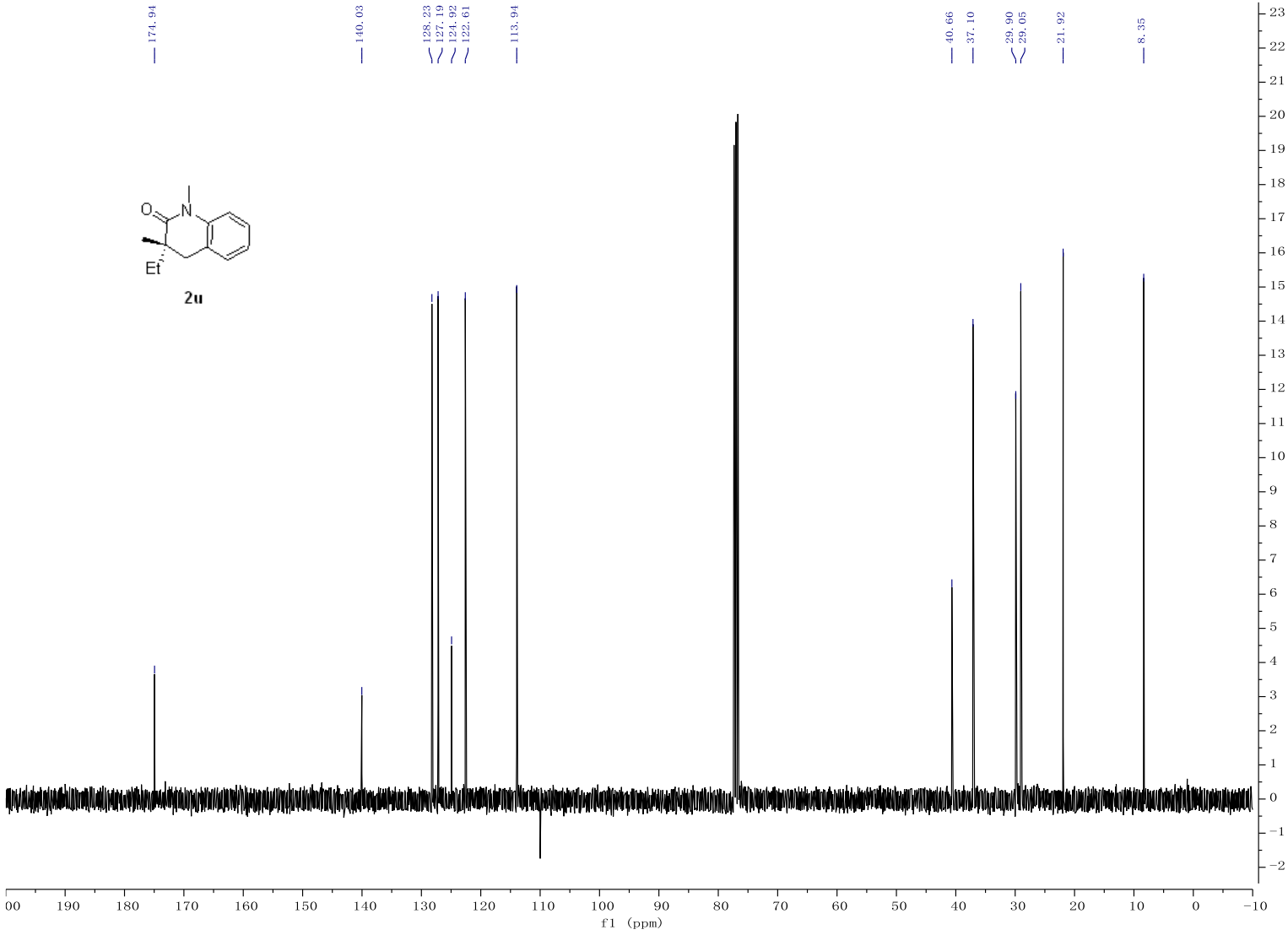

7.33
7.31
7.29
7.21
7.19
7.10
7.08
7.06
7.01
6.99
3.40
3.35
3.31
2.89
2.85
1.33
O
N
F3C
2s
1.00
1.00
0.99
1.00
3.01
1.12
1.11
3.08
f1 (ppm)

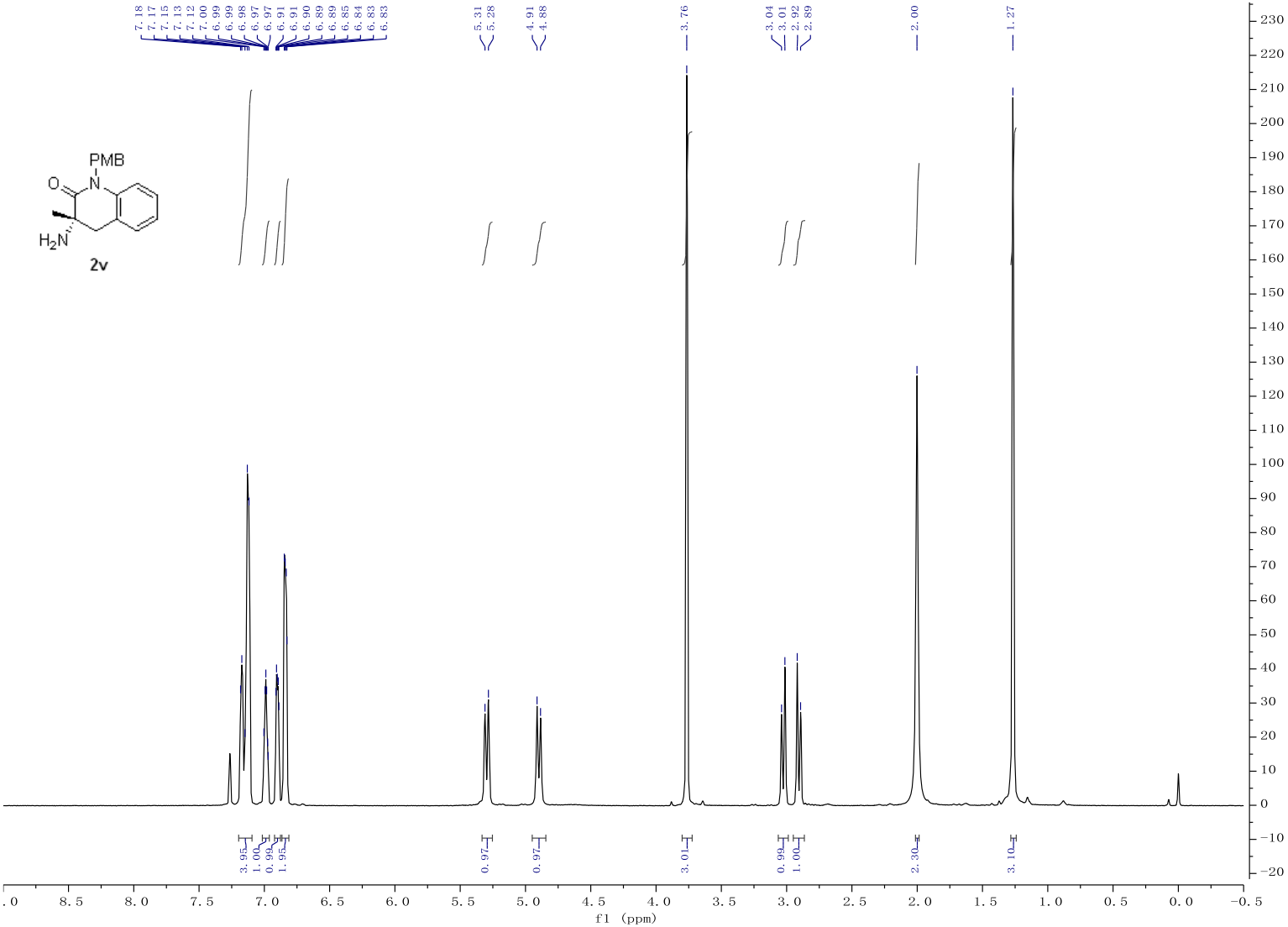

166.91
139.02
130.62
128.53
128.04
127.81
125.00
123.51
122.19
121.86
114.45
47.24
46.99
32.86
32.84
32.82
32.79
30.12
16.84
16.82
16.80
16.78
O
N
F3C
2s
f1 (ppm)

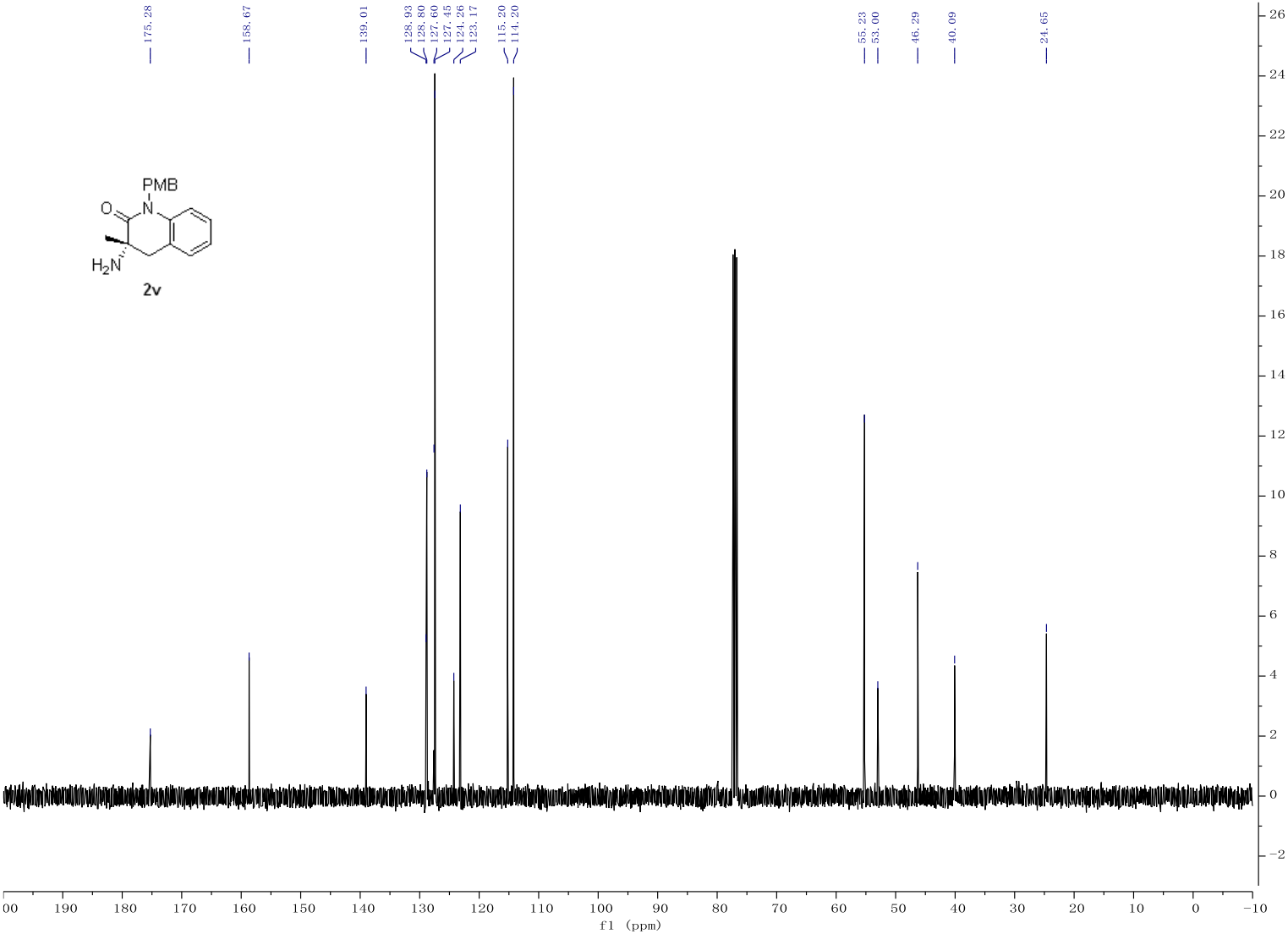
2s


-74.21
900
800
700
600
500
400
300
200
100
0
-45
-50
-55
-60
-65
-70
-75
-80
-85
f1 (ppm)


7.27
7.25
7.23
7.15
7.13
7.03
7.01
6.99
6.96
6.94
3.36
2.83
2.79
2.75
2.71
1.53
1.52
1.51
1.51
1.50
1.50
1.49
1.48
1.47
1.46
1.15
0.88
0.86
0.84
O
N
Et
2u
1.11
1.00
1.00
1.04
3.07
2.22
2.07
3.18
3.11
f1 (ppm)


174.94
140.03
128.23
127.19
124.92
122.61
113.94
40.66
37.10
29.90
29.05
21.92
8.35
O
N
Et
2u
f1 (ppm)


PMB
O
N
H2N
2v
7.18
7.17
7.15
7.13
7.12
7.00
6.99
6.99
6.98
6.97
6.97
6.91
6.91
6.90
6.89
6.89
6.85
6.84
6.83
6.83
5.31
5.28
4.91
4.88
3.76
3.04
3.01
2.92
2.89
2.00
1.27
3.95
1.00
0.99
1.95
0.97
0.97
3.01
0.99
1.00
2.30
3.10
f1 (ppm)


175.28
158.67
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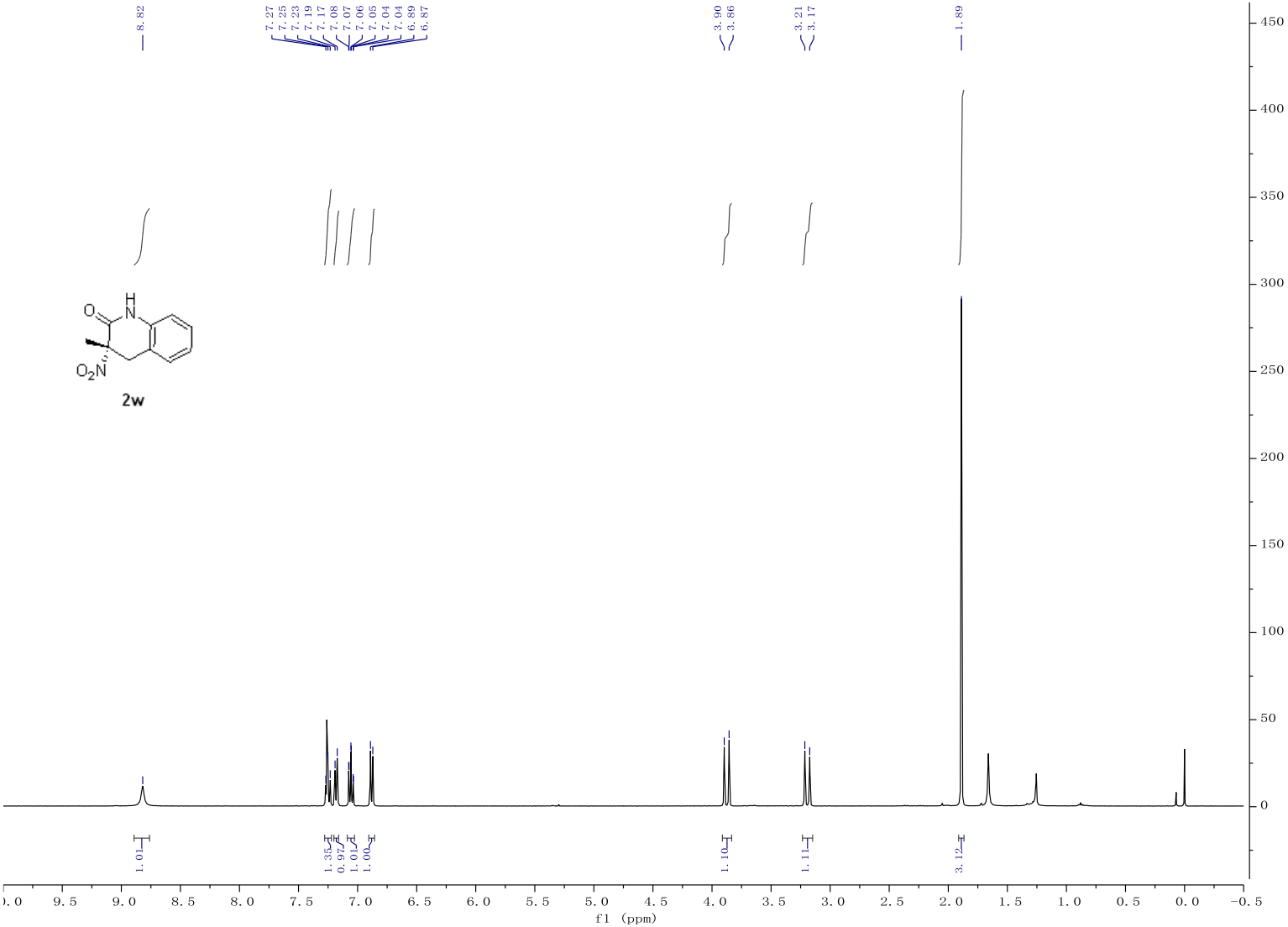
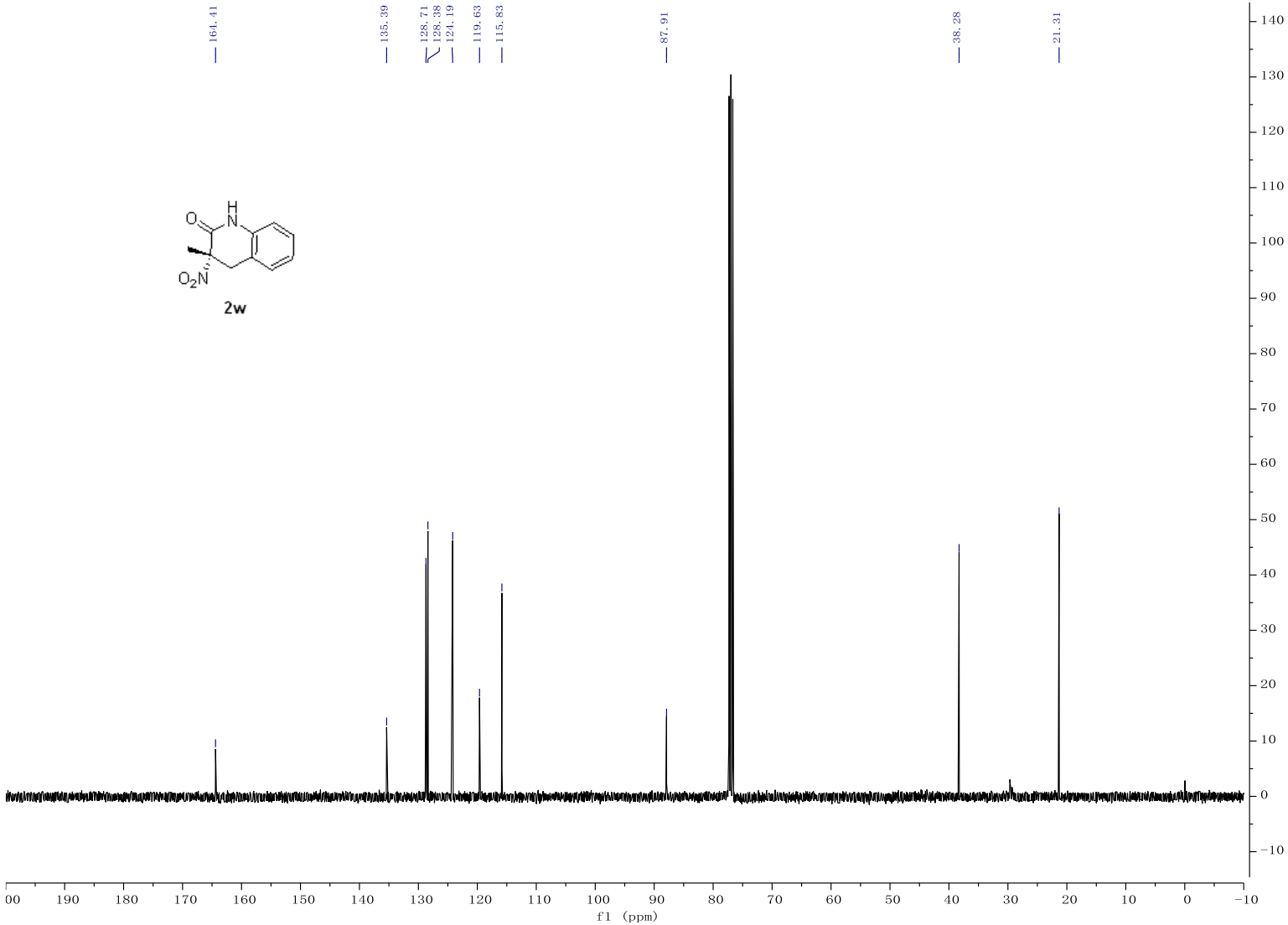
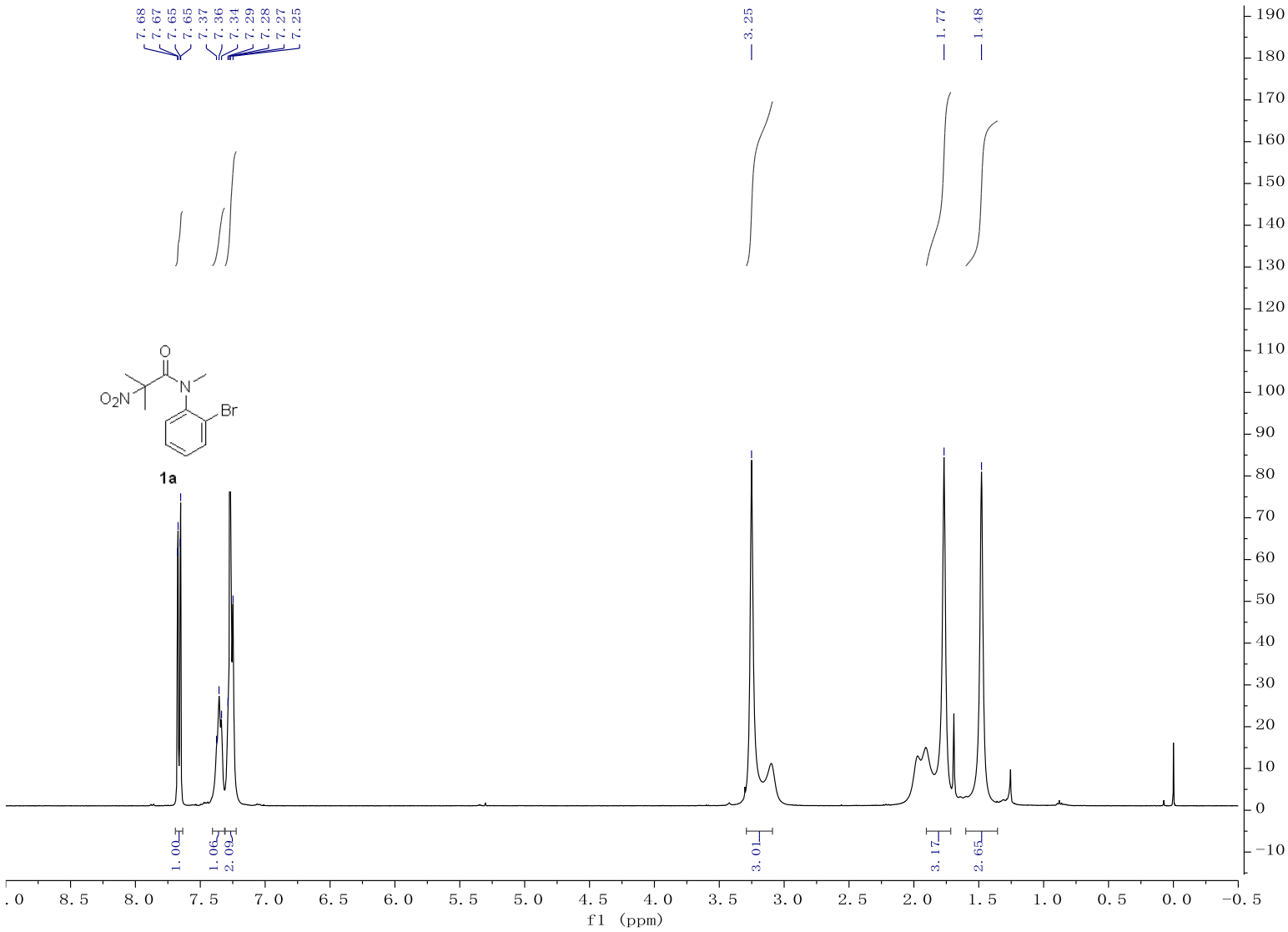
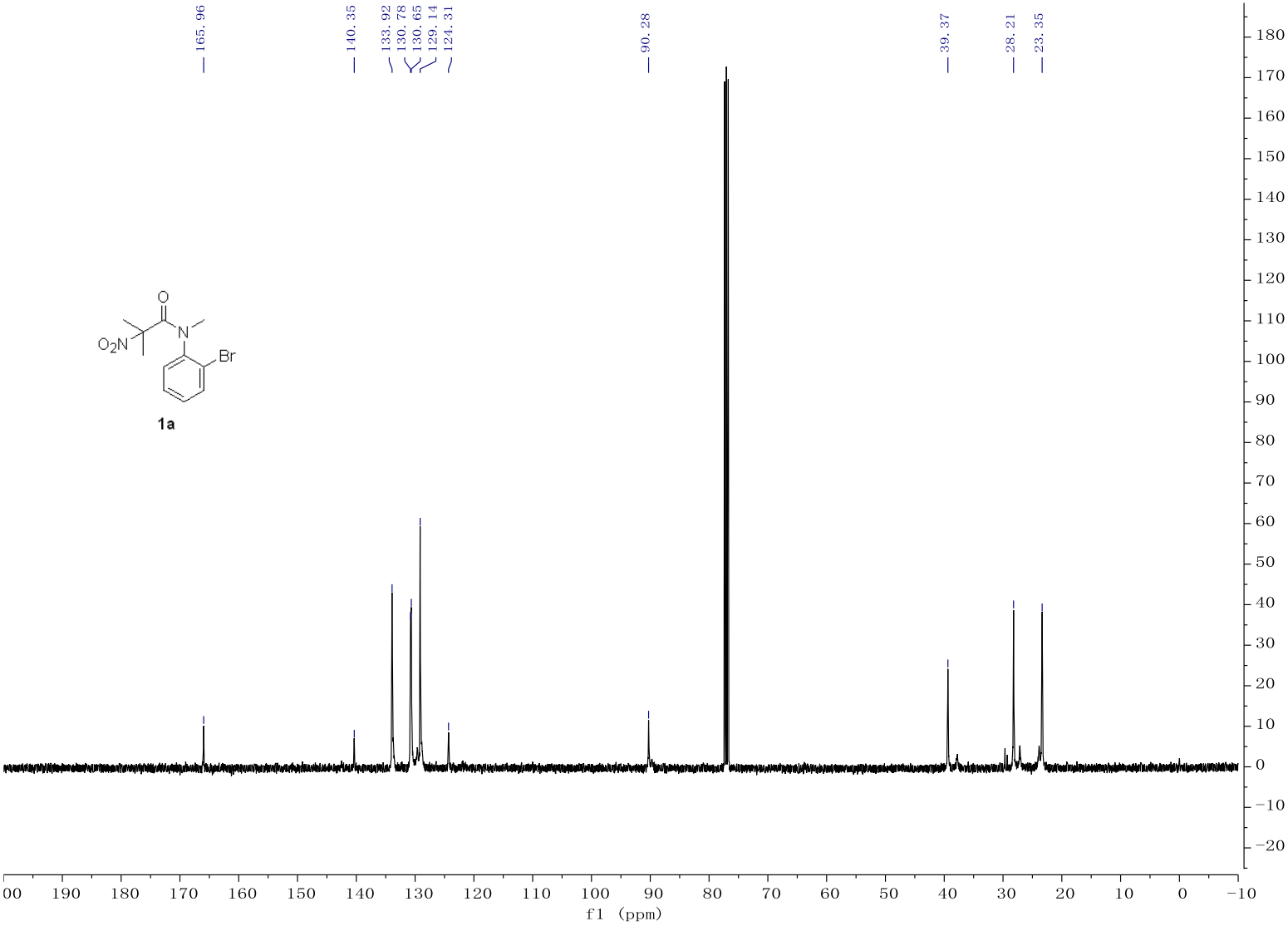
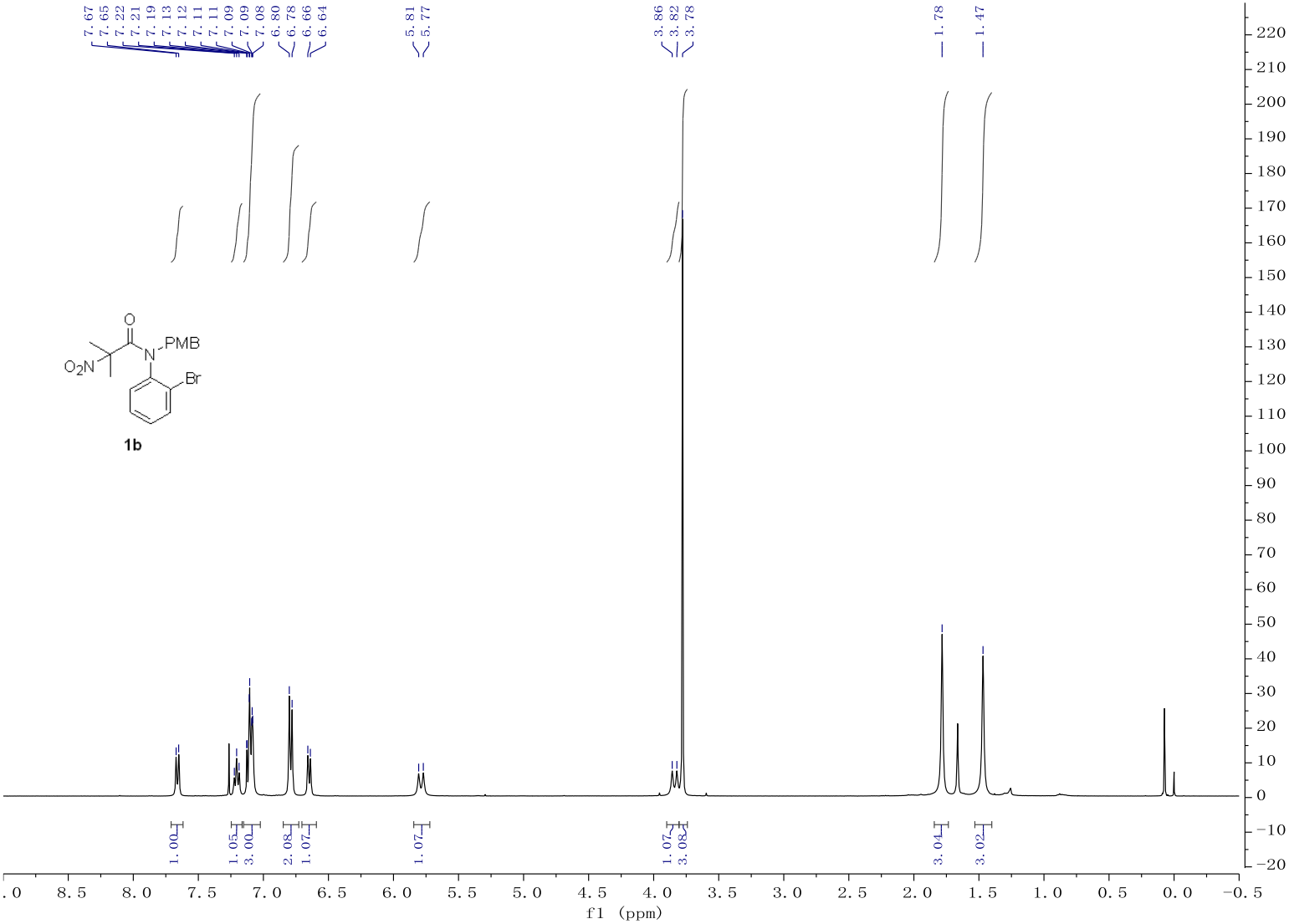
128.93
128.80
127.60
127.45
124.26
123.17
115.20
114.20
55.23
53.00
46.29
40.09
24.65
PMB
O
N
H2N
2v
f1 (ppm)

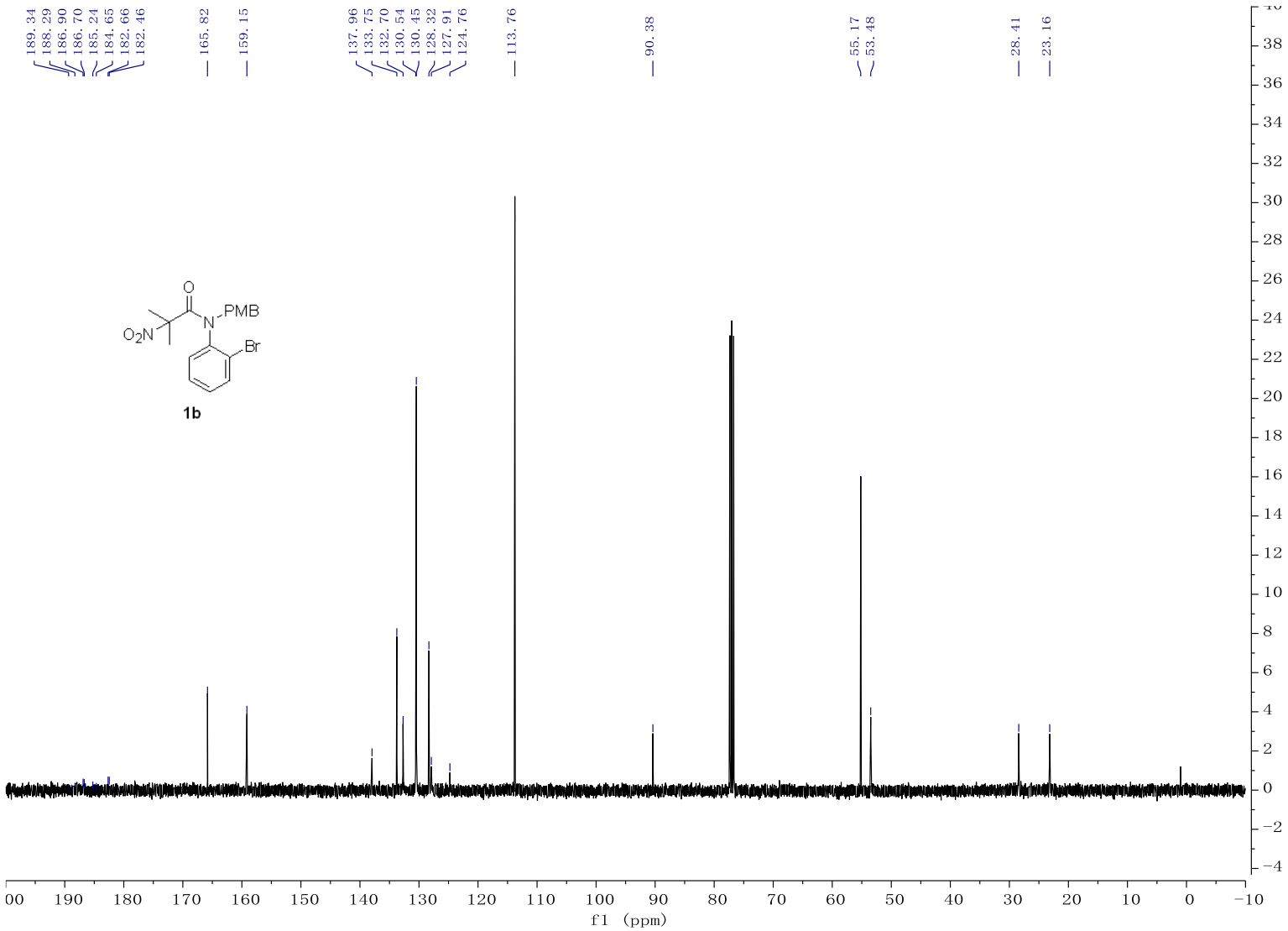

8.82
7.27
7.25
7.23
7.19
7.17
7.08
7.07
7.06
7.05
7.04
7.04
6.89
6.87
3.90
3.86
3.21
3.17
1.89
O
H
N
O_2N
2w
1.01
1.35
0.97
1.01
1.00
1.10
1.11
3.12
f1 (ppm)


164.41
135.39
128.71
128.38
124.19
119.63
115.83
87.91
38.28
21.31
O
H
N
O_2N
2w
f1 (ppm)


7.68
7.67
7.65
7.65
7.37
7.36
7.34
7.29
7.28
7.27
7.25
3.25
1.77
1.48
O
N
O_2N
Br
1a
1.00
1.06
2.09
3.01
3.17
2.65
f1 (ppm)


165.96
140.35
133.92
130.78
130.65
129.14
124.31
90.28
39.37
28.21
23.35
O
N
O2N
Br
1a
f1 (ppm)


7.67
7.65
7.22
7.21
7.19
7.13
7.12
7.11
7.11
7.09
7.09
7.08
6.80
6.78
6.66
6.64
5.81
5.77
3.86
3.82
3.78
1.78
1.47
O
N
PMB
O_2N
Br
1b
1.00
1.05
3.00
2.08
1.07
1.07
1.07
3.08
3.04
3.02
f1 (ppm)


189.34
188.29
186.90
186.70
185.24
184.65
182.66
182.46
165.82
159.15
137.96
133.75
132.70
130.54
130.45
128.32
127.91
124.76
113.76
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55.17
53.48
28.41
23.16
O
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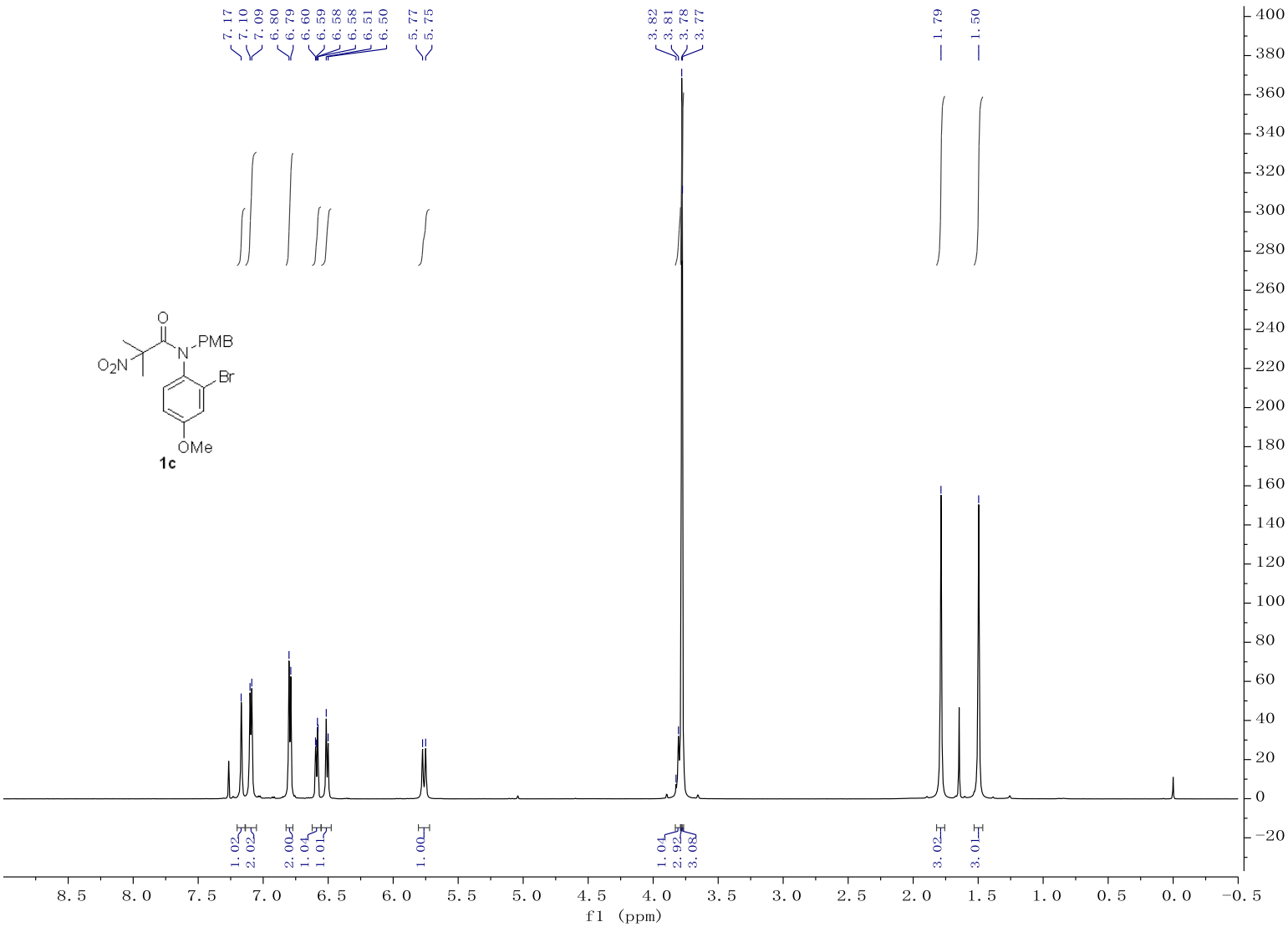
PMB
O_2N
Br
1b
f1 (ppm)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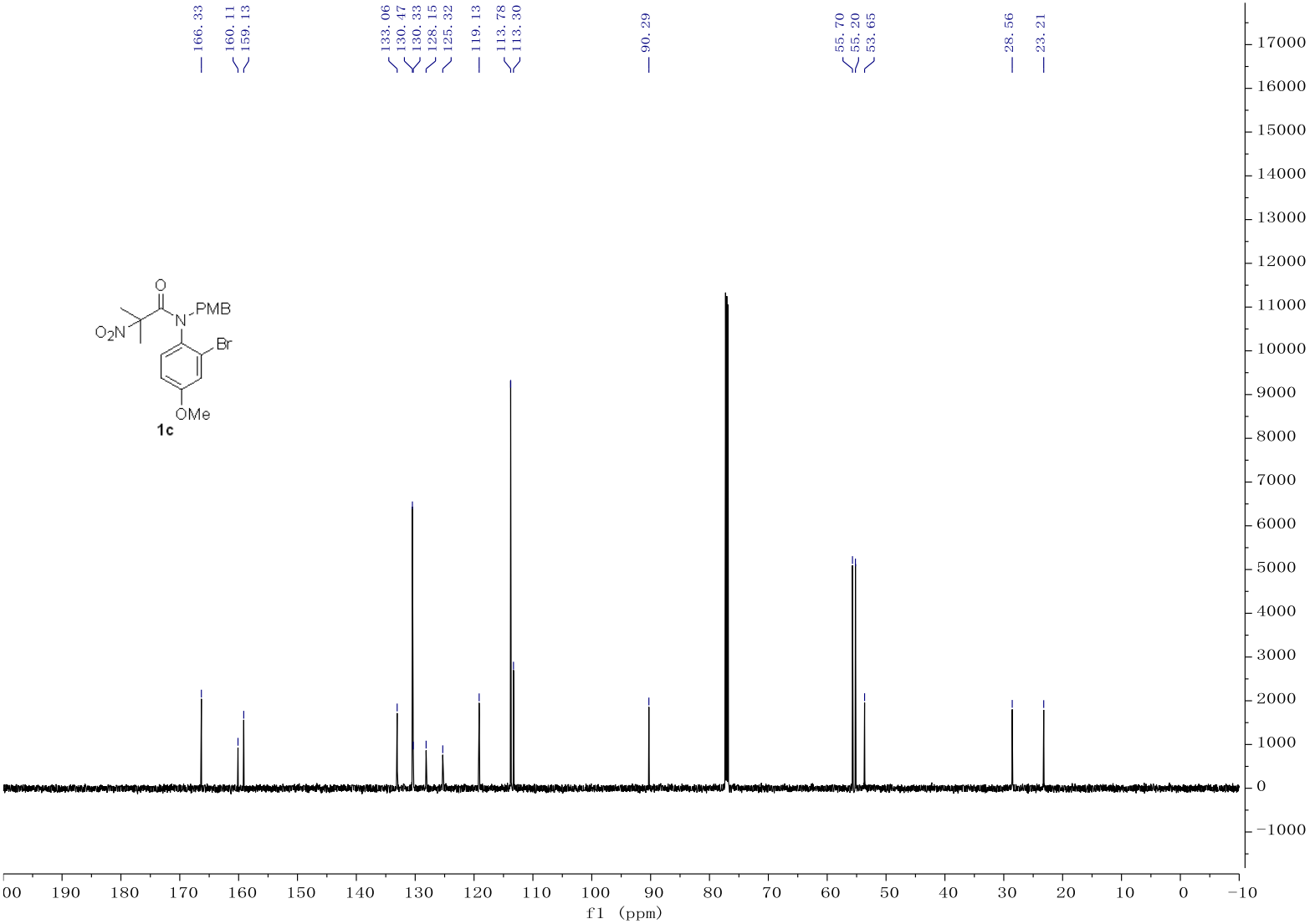
6.80
6.79
6.60
6.59
6.58
6.58
6.51
6.50
5.77
5.75
3.82
3.81
3.78
3.77
1.79
1.50
O
N
PMB
O_2N
Br
OMe
1c
1.02
2.02
2.00
1.04
1.01
1.00
1.04
2.92
3.08
3.02
3.01
f1 (ppm)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133.06
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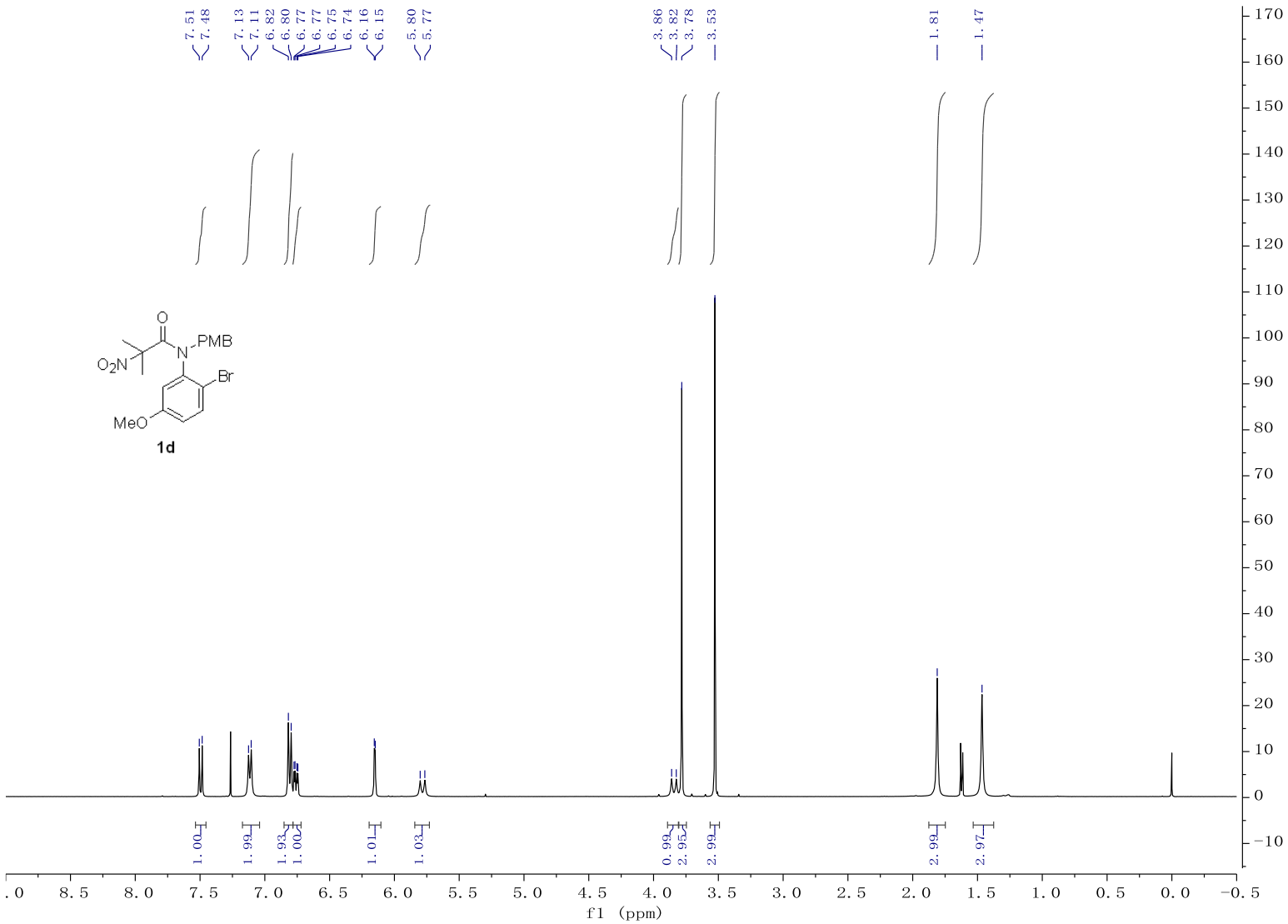
130.33
128.15
125.32
119.13
113.78
113.30
90.29
55.70
55.20
53.65
28.56
23.21
O
N
PMB
O_2N
Br
OMe
1c
f1 (ppm)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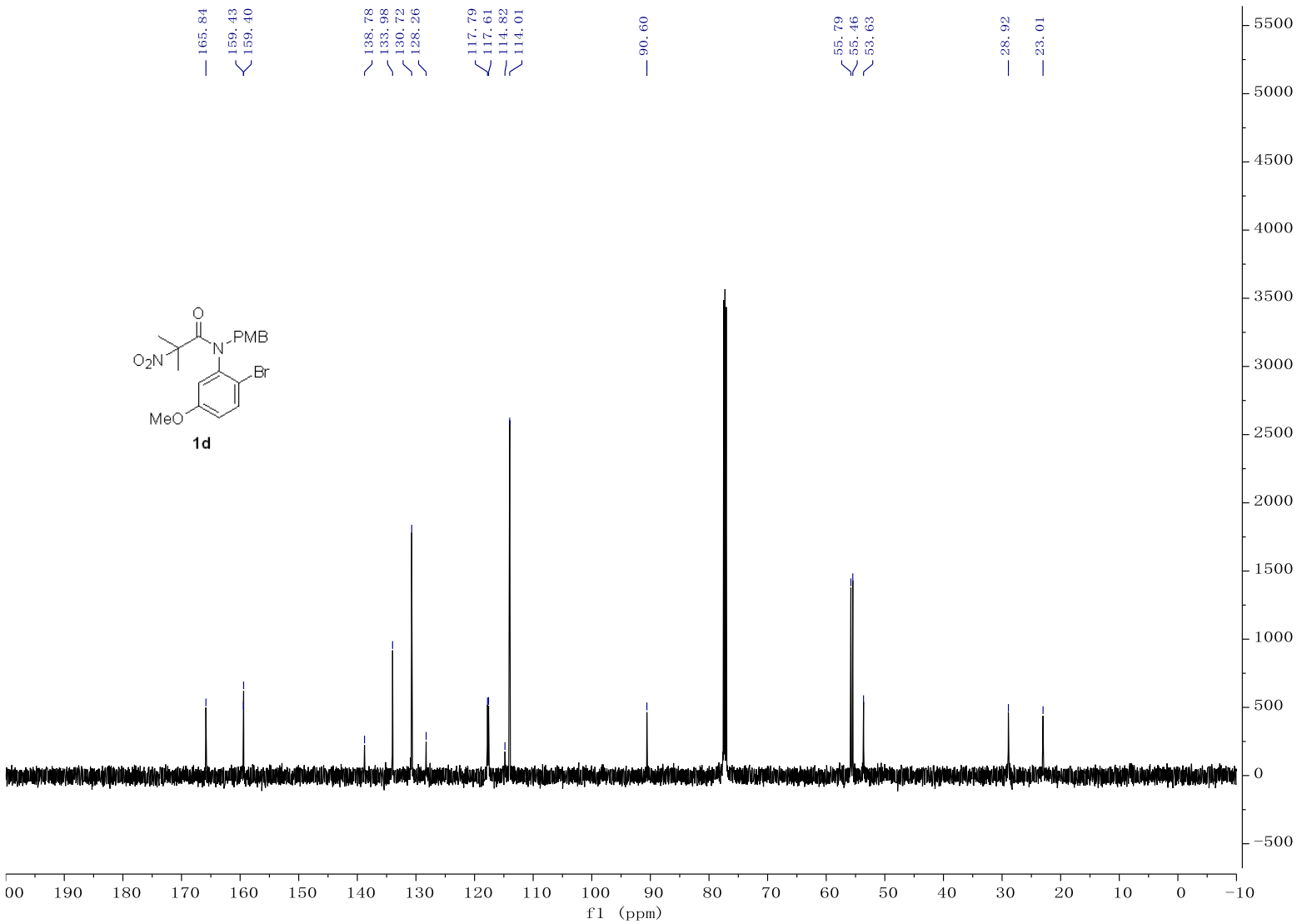
7.13
7.11
6.82
6.80
6.77
6.77
6.75
6.74
6.16
6.15
5.80
5.77
3.86
3.82
3.78
3.53
1.81
1.47
O
N
PMB
O_2N
Br
MeO
1d
1.00
1.99
1.93
1.00
1.01
1.03
0.99
2.95
2.99
2.99
2.97
f1 (ppm)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130.72
128.26
117.79
117.61
114.82
114.01
90.60
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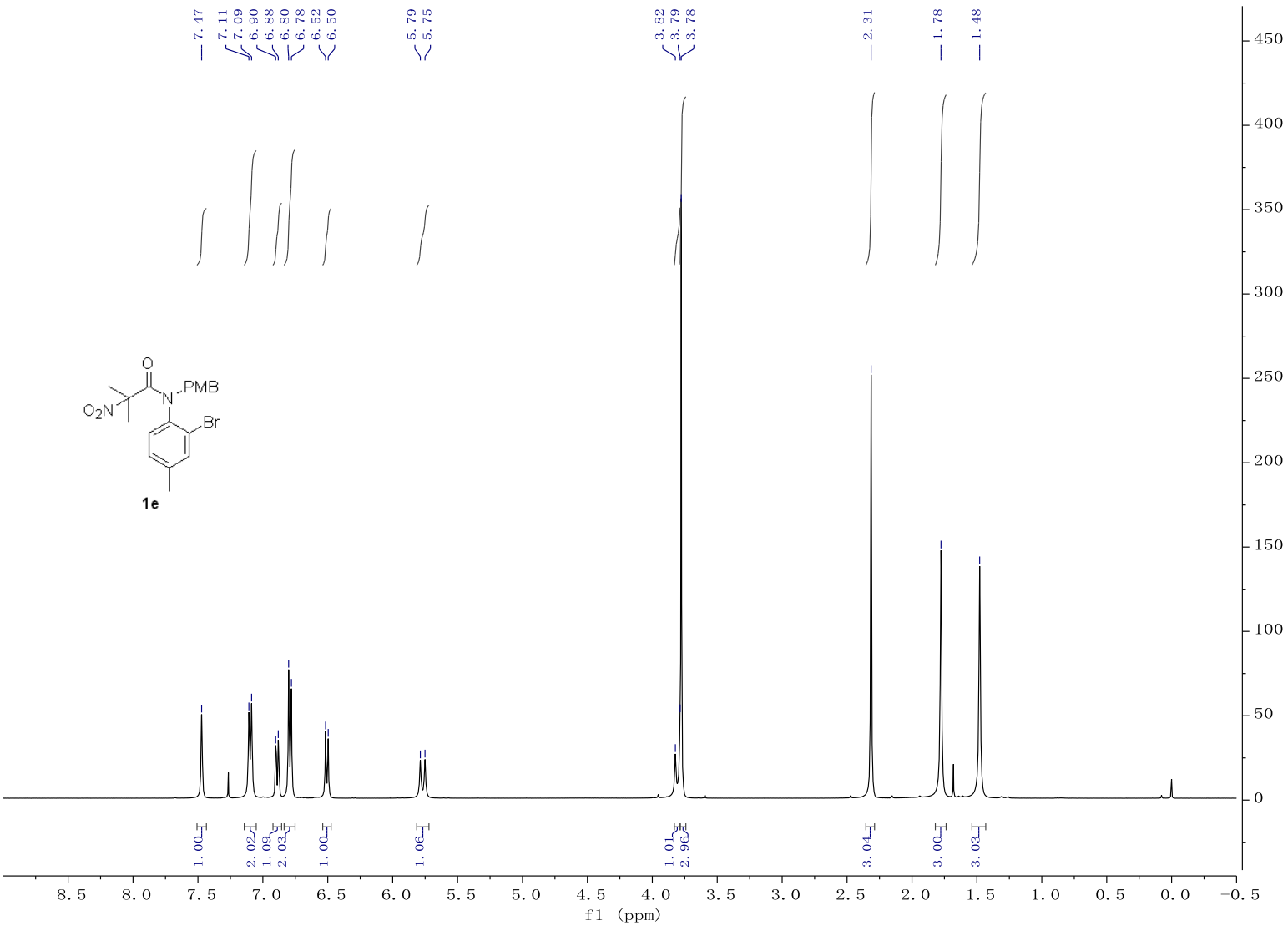
53.63
28.92
23.01
O
PMB
N
O_2N
Br
MeO
1d
f1 (ppm)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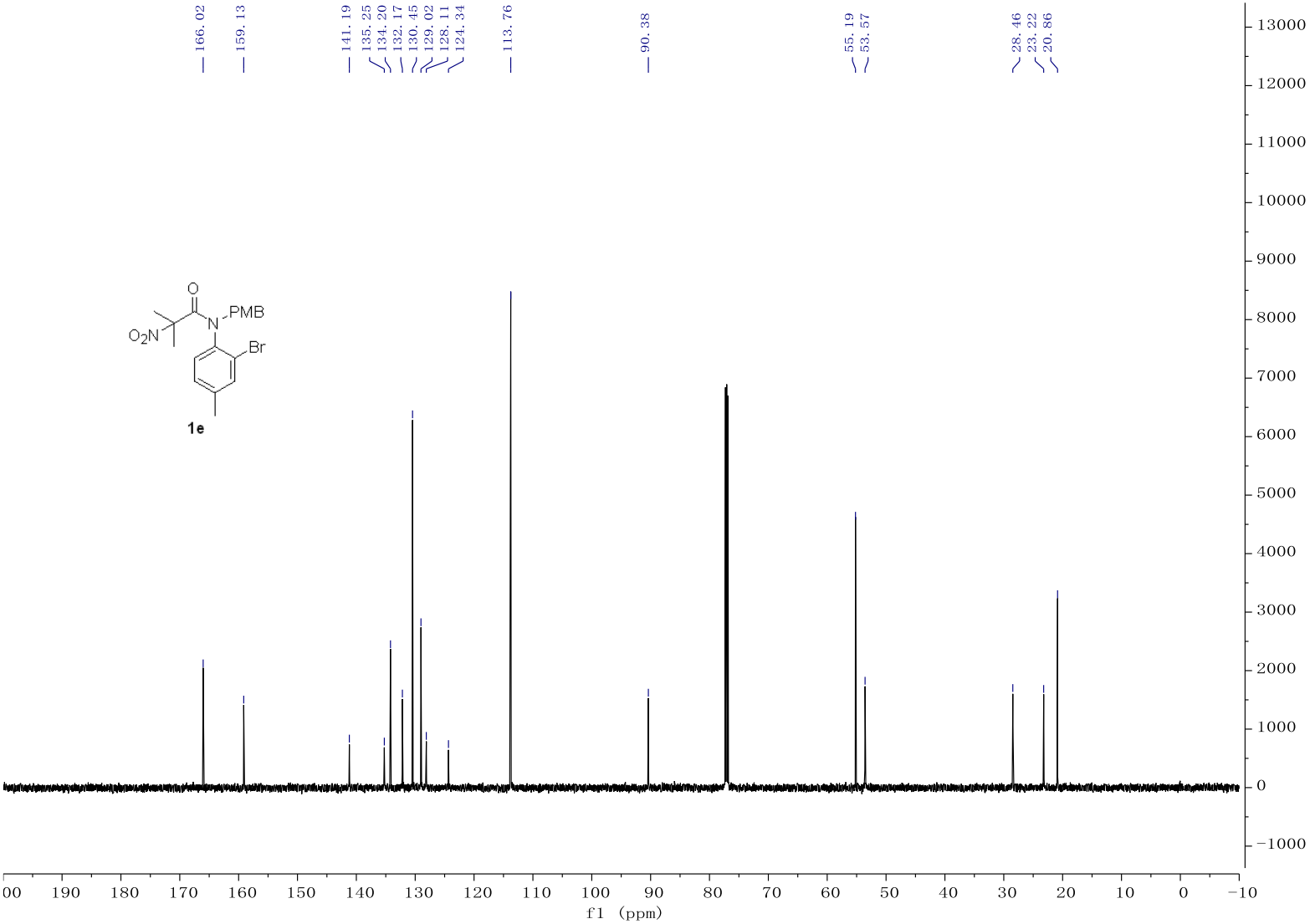
6.80
6.78
6.52
6.50
5.79
5.75
3.82
3.79
3.78
2.31
1.78
1.48
O
N
PMB
O2N
Br
1e
1.00
2.02
1.09
2.03
1.00
1.06
1.01
2.96
3.04
3.00
3.03
f1 (ppm)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132.17
130.45
129.02
128.11
124.34
113.76
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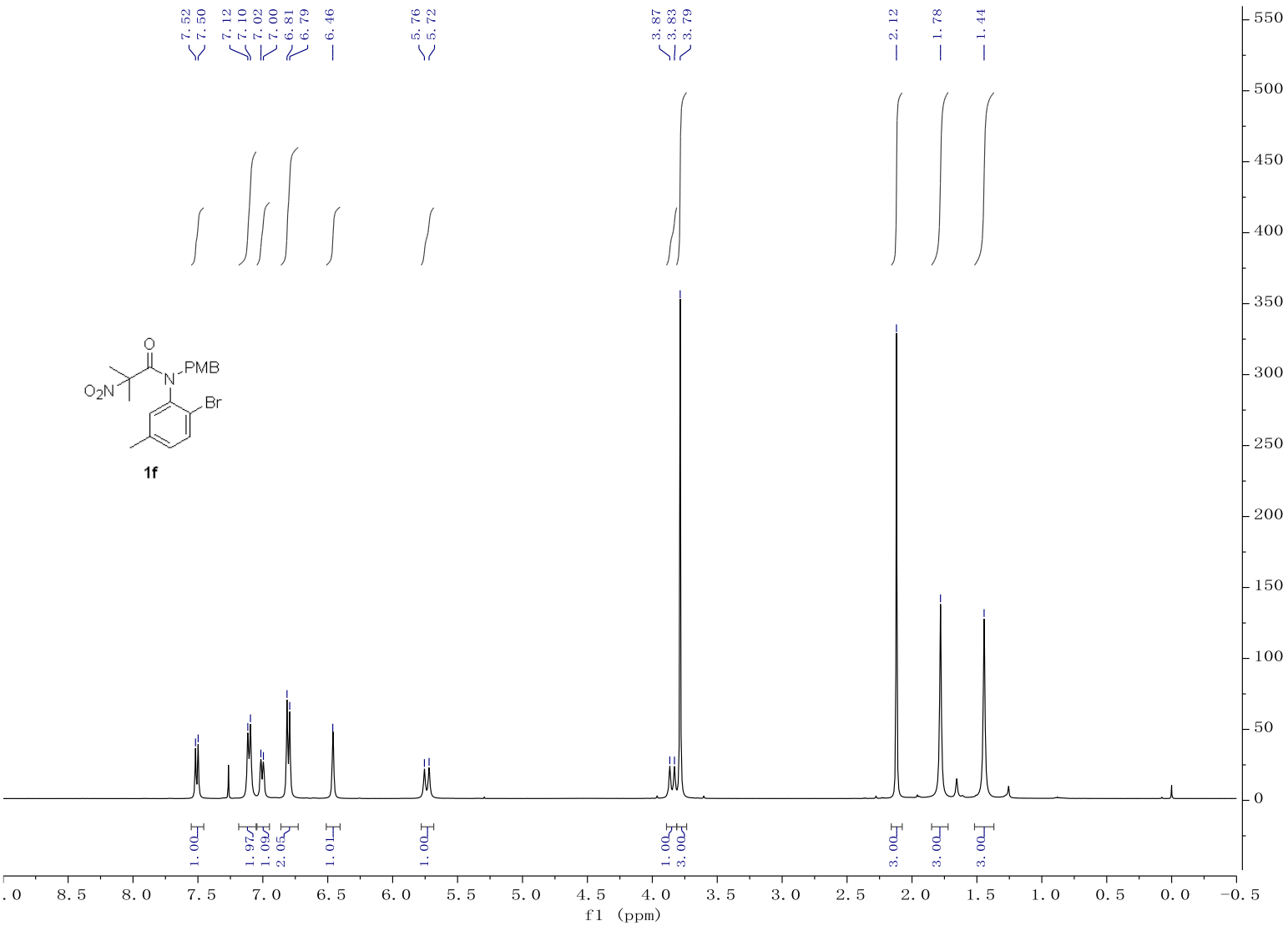
53.57
28.46
23.22
20.86
O
N
PMB
O_2N
Br
1e
f1 (ppm)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7.00
6.81
6.79
6.46
5.76
5.72
3.87
3.83
3.79
2.12
1.78
1.44
O
N
PMB
O_2N
Br
1f
1.00
1.97
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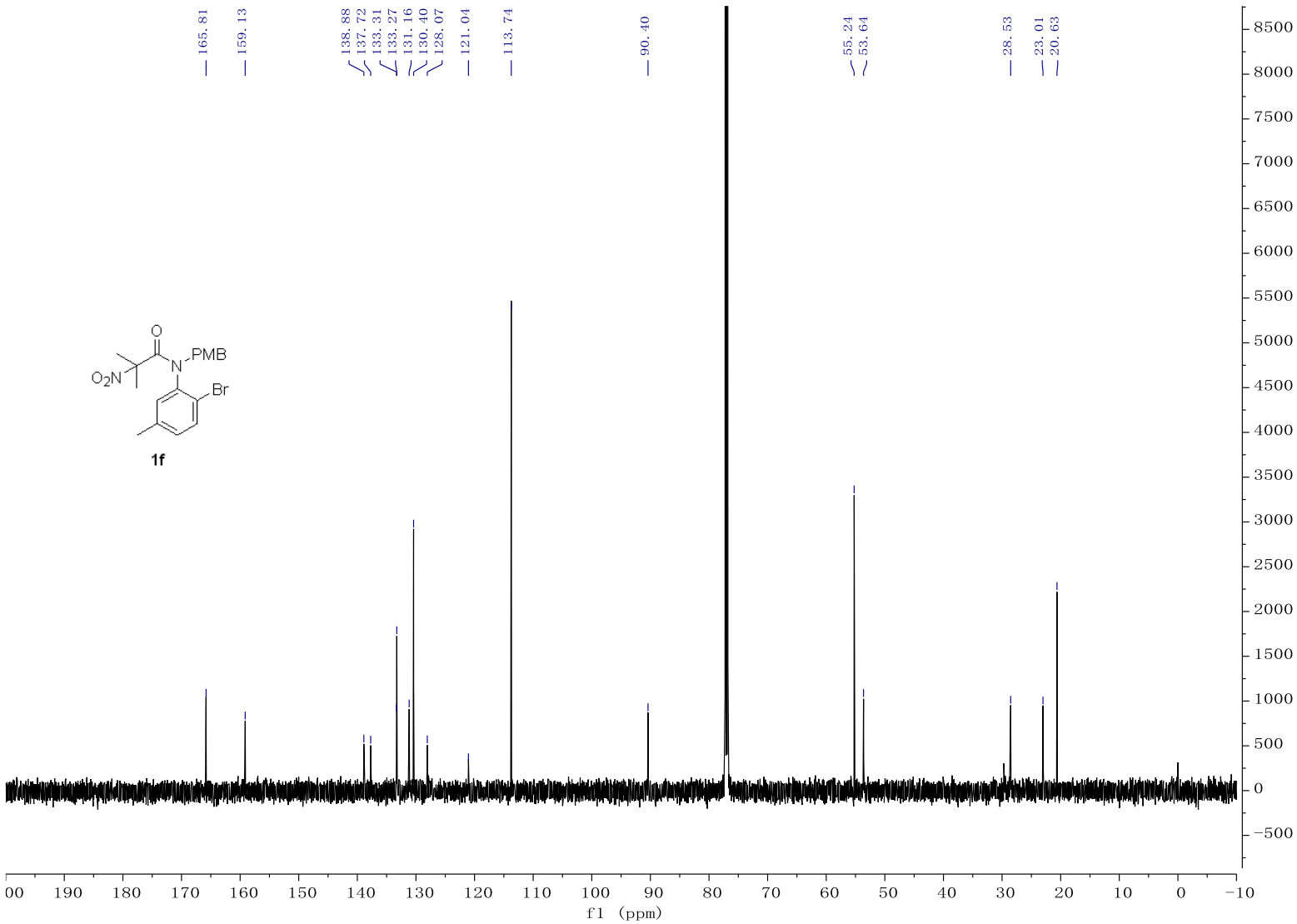
2.05
1.01
1.00
1.00
3.00
3.00
3.00
3.00
f1 (ppm)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159.13
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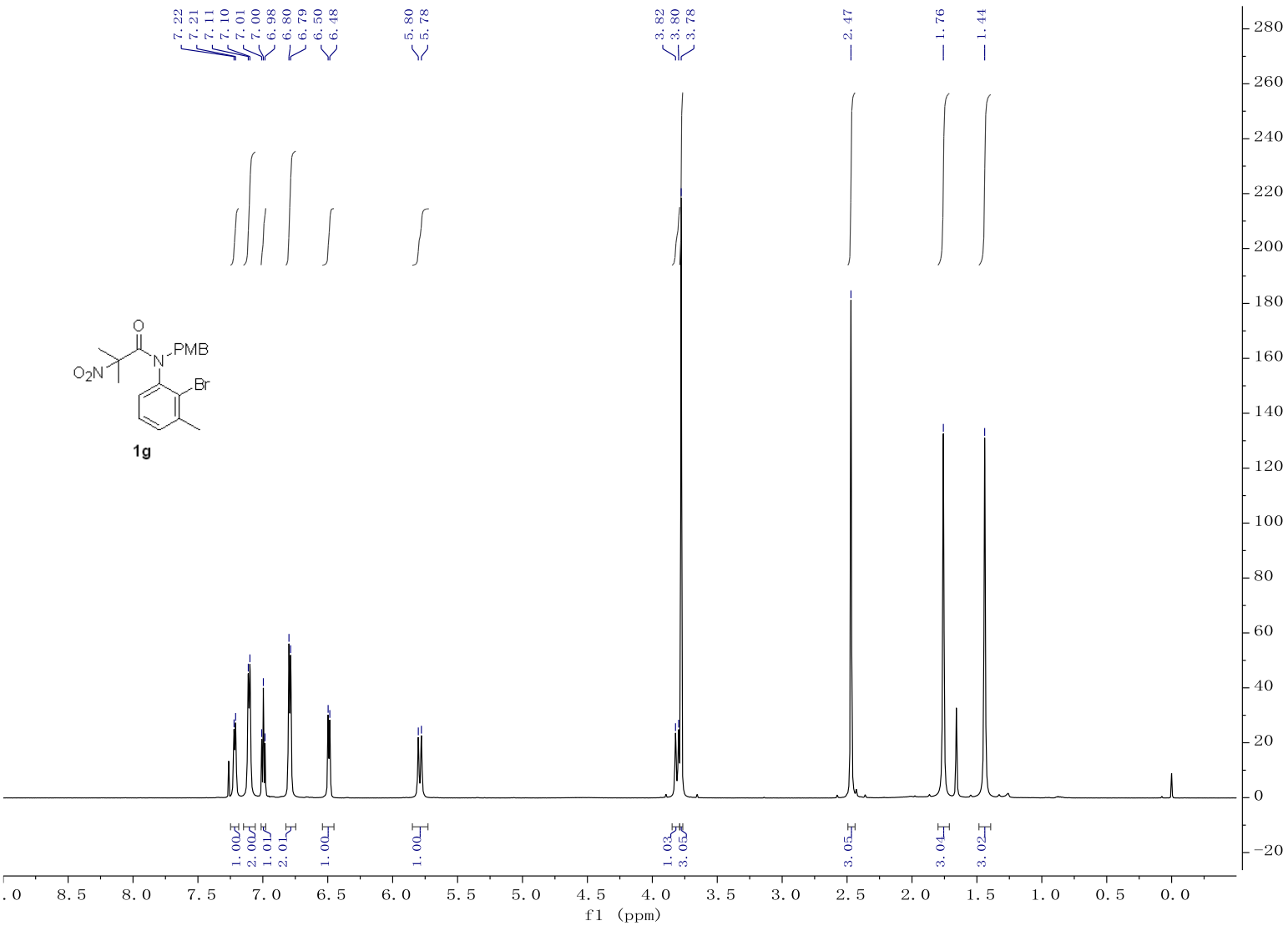
137.72
133.31
133.27
131.16
130.40
128.07
121.04
113.74
90.40
55.24
53.64
28.53
23.01
20.63
O
N
PMB
O_2N
Br
1f
f1 (ppm)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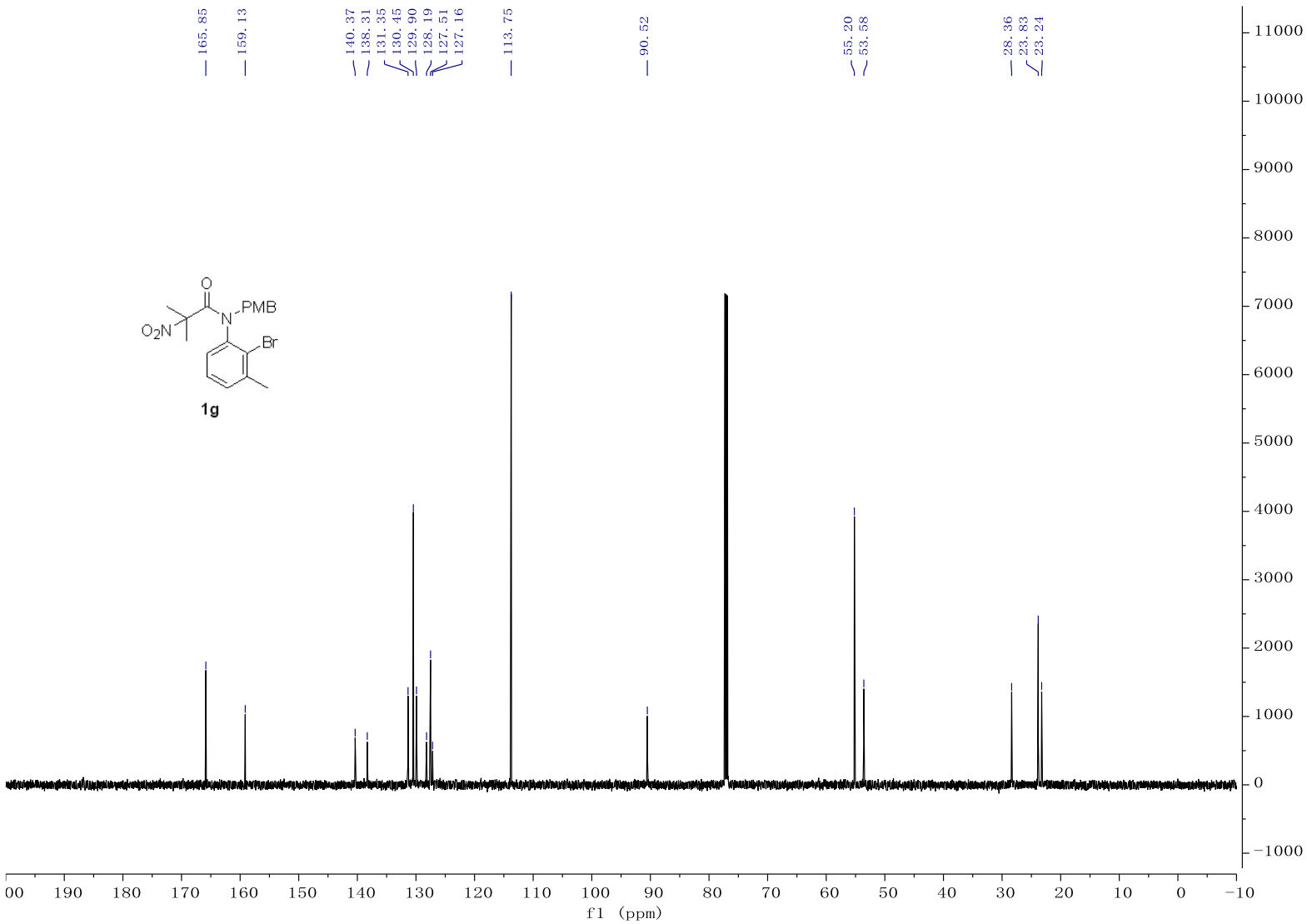
7.21
7.11
7.10
7.01
7.00
6.98
6.80
6.79
6.50
6.48
5.80
5.78
3.82
3.80
3.78
2.47
1.76
1.44
O
N
PMB
O2N
Br
1g
1.00
2.00
1.01
2.01
1.00
1.00
1.03
3.05
3.05
3.04
3.02
f1 (ppm)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159.13
140.37
138.31
131.35
130.45
129.90
128.19
127.51
127.16
113.75
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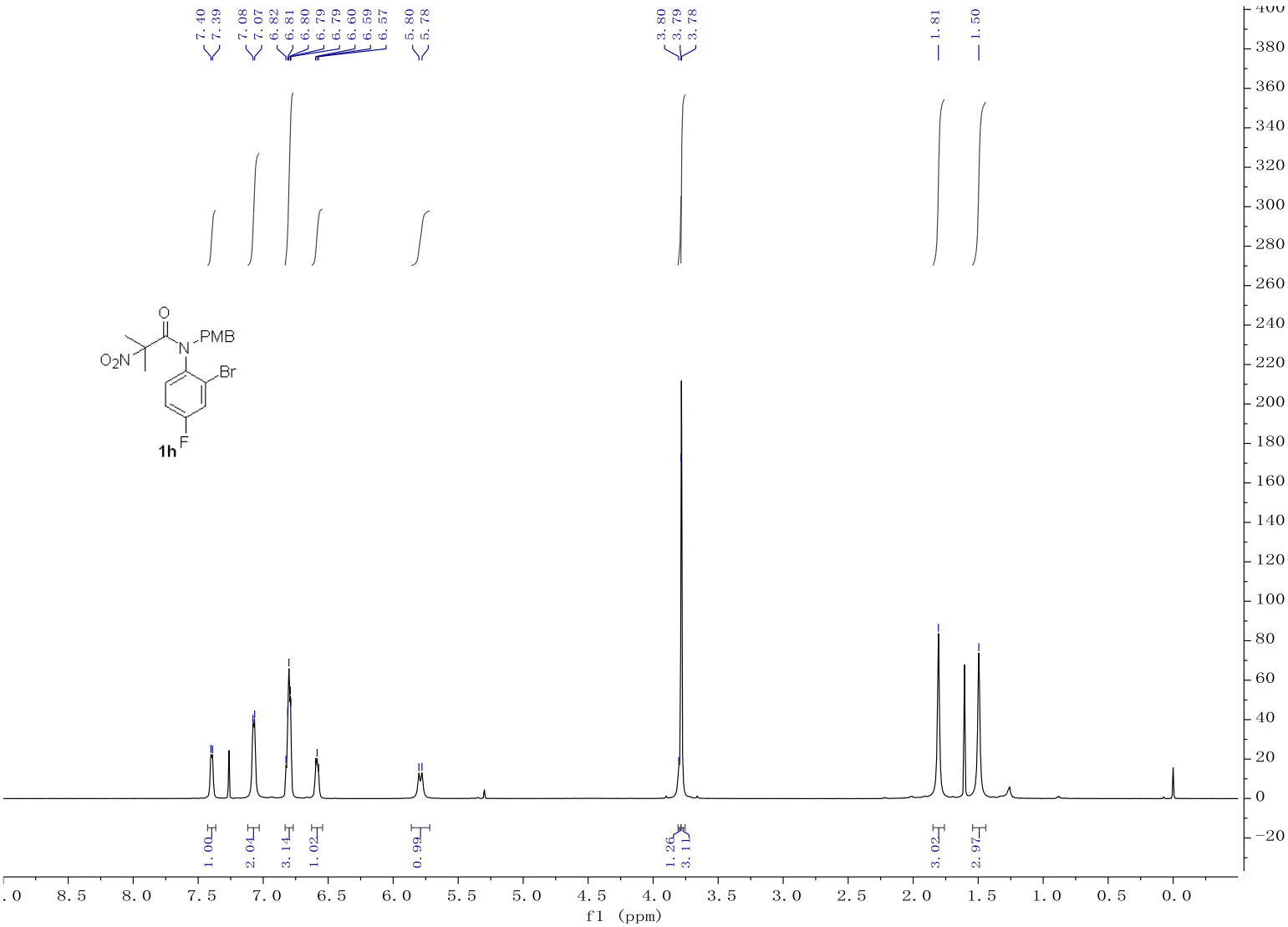
55.20
53.58
28.36
23.83
23.24
O
PMB
N
O_2N
Br
1g
f1 (ppm)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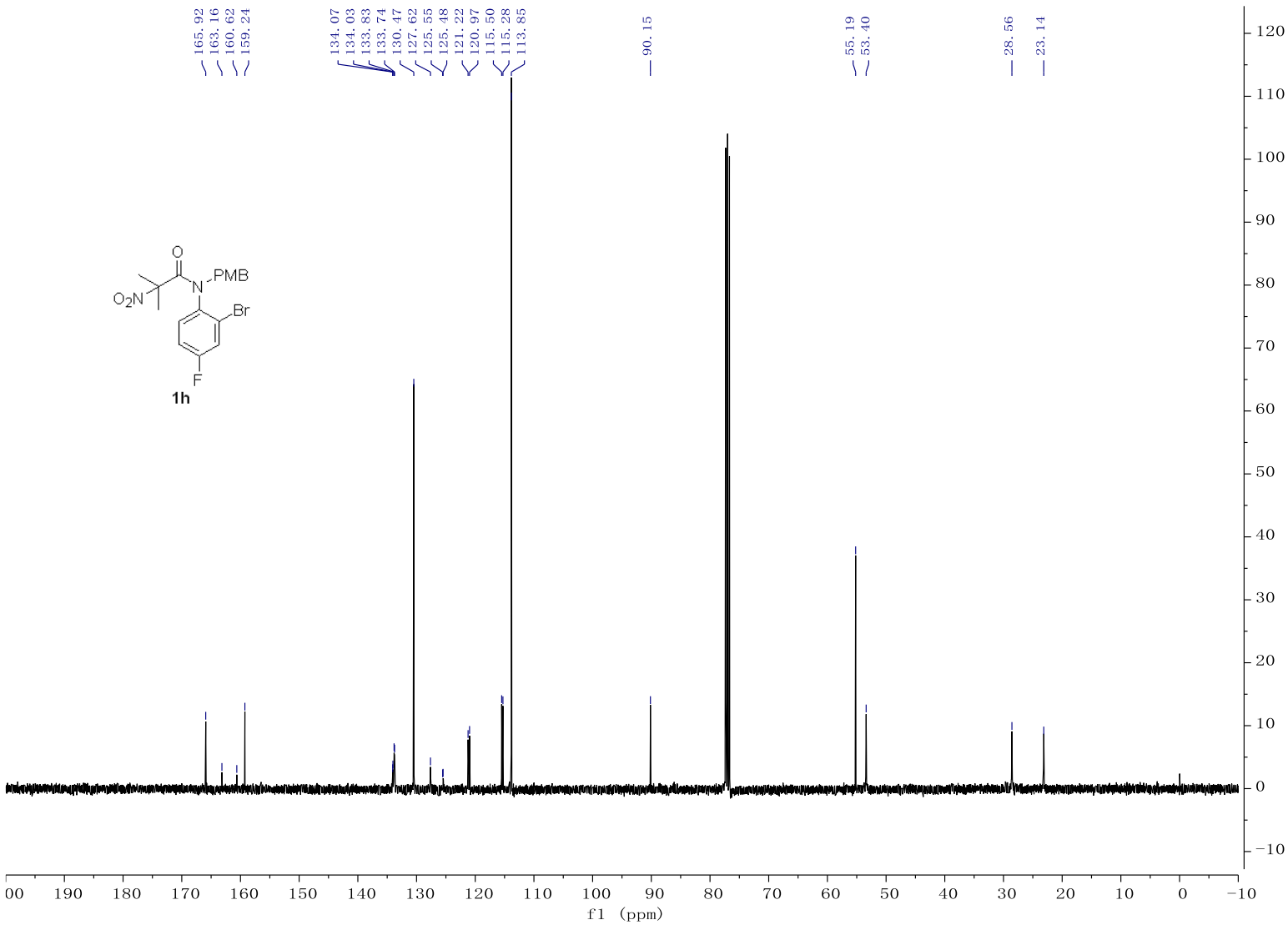
7.39
7.08
7.07
6.82
6.81
6.80
6.79
6.79
6.60
6.59
6.57
5.80
5.78
3.80
3.79
3.78
1.81
1.50
O
N
PMB
O_2N
Br
F
1h
1.00
2.04
3.14
1.02
0.99
1.26
3.11
3.02
2.97
f1 (ppm)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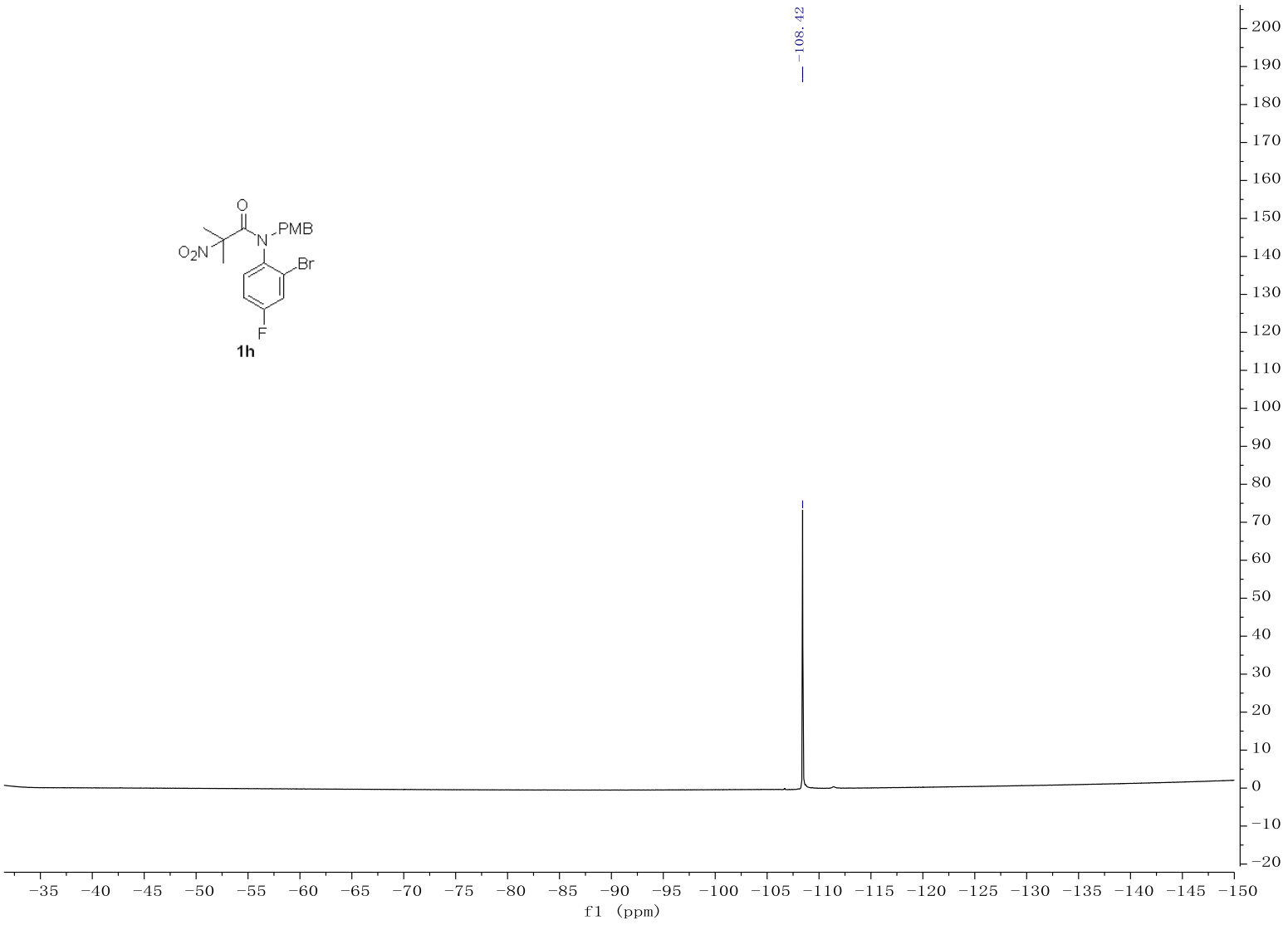
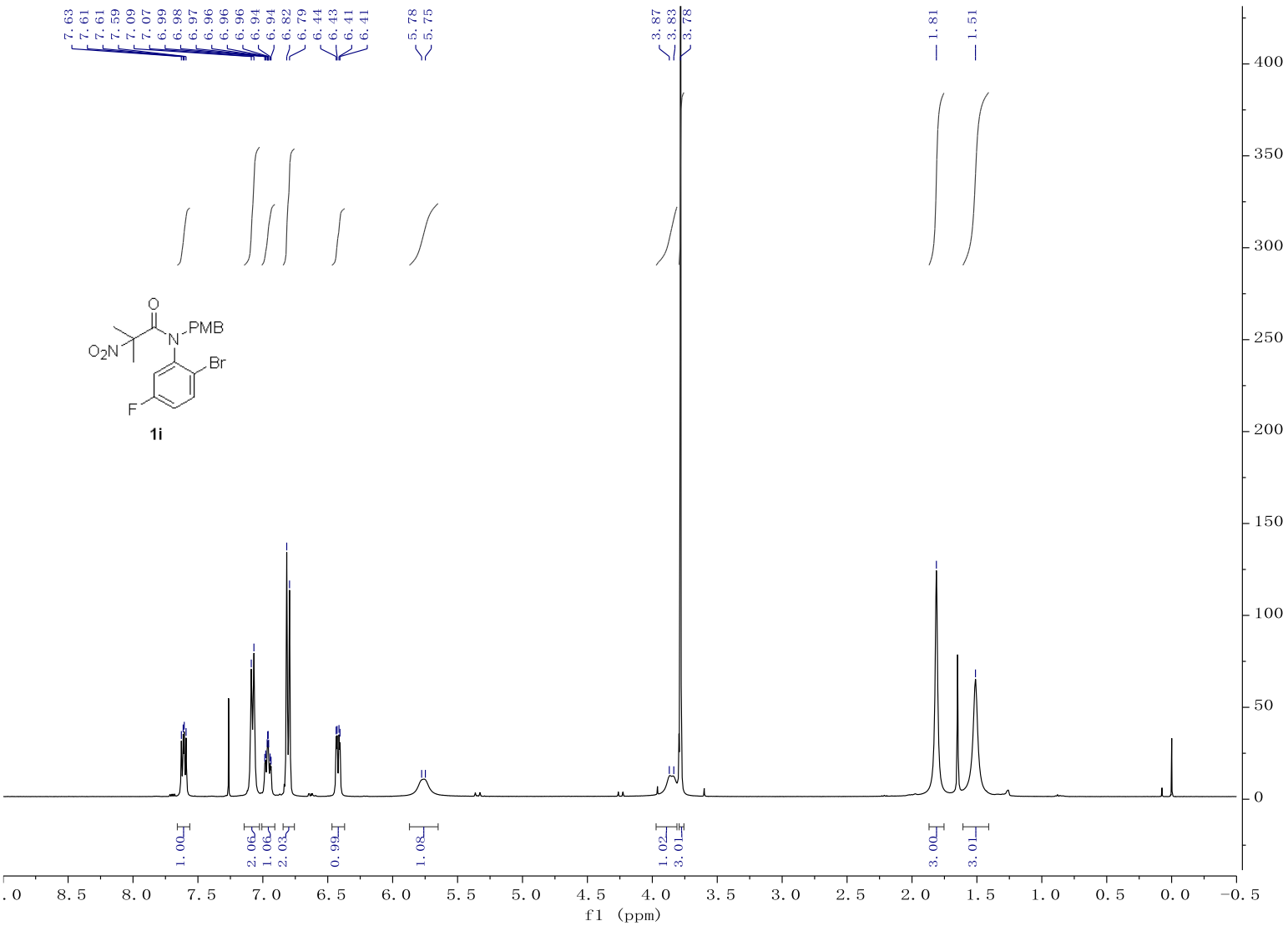
159.24
134.07
134.03
133.83
133.74
130.47
127.62
125.55
125.48
121.22
120.97
115.50
115.28
113.85
90.15
55.19
53.40
28.56
23.14
O
N
PMB
O_2N
Br
F
1h
f1 (ppm)


O
N
PMB
O_2N
Br
F
1h
−108.42
f1 (ppm)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7.61
7.59
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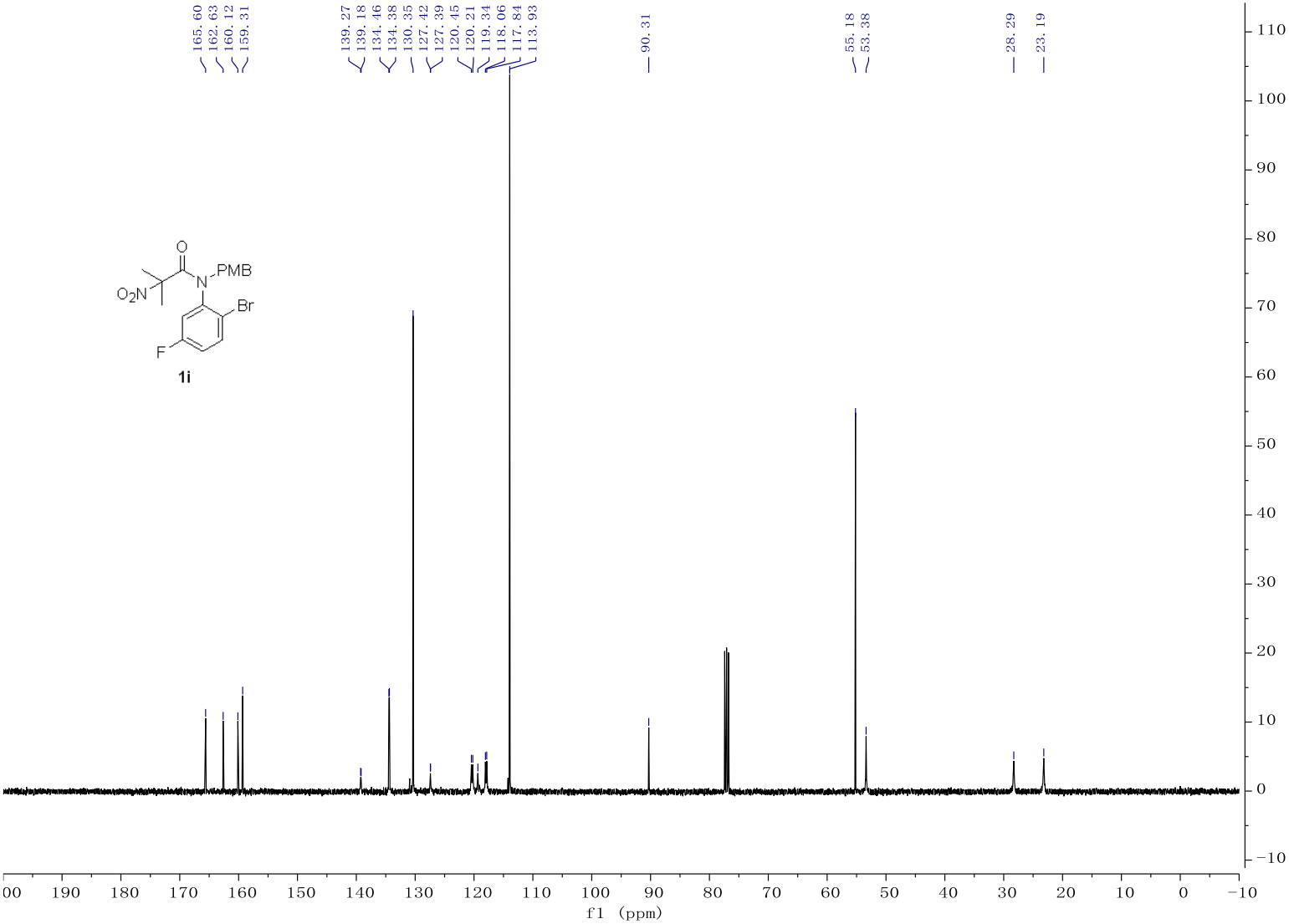
7.07
6.99
6.98
6.97
6.96
6.96
6.96
6.94
6.94
6.82
6.79
6.44
6.43
6.41
6.41
5.78
5.75
3.87
3.83
3.78
1.81
1.51
O
N
PMB
O_2N
Br
F
1i
1.00
2.06
1.06
2.03
0.99
1.08
1.02
3.01
3.00
3.01
f1 (ppm)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139.18
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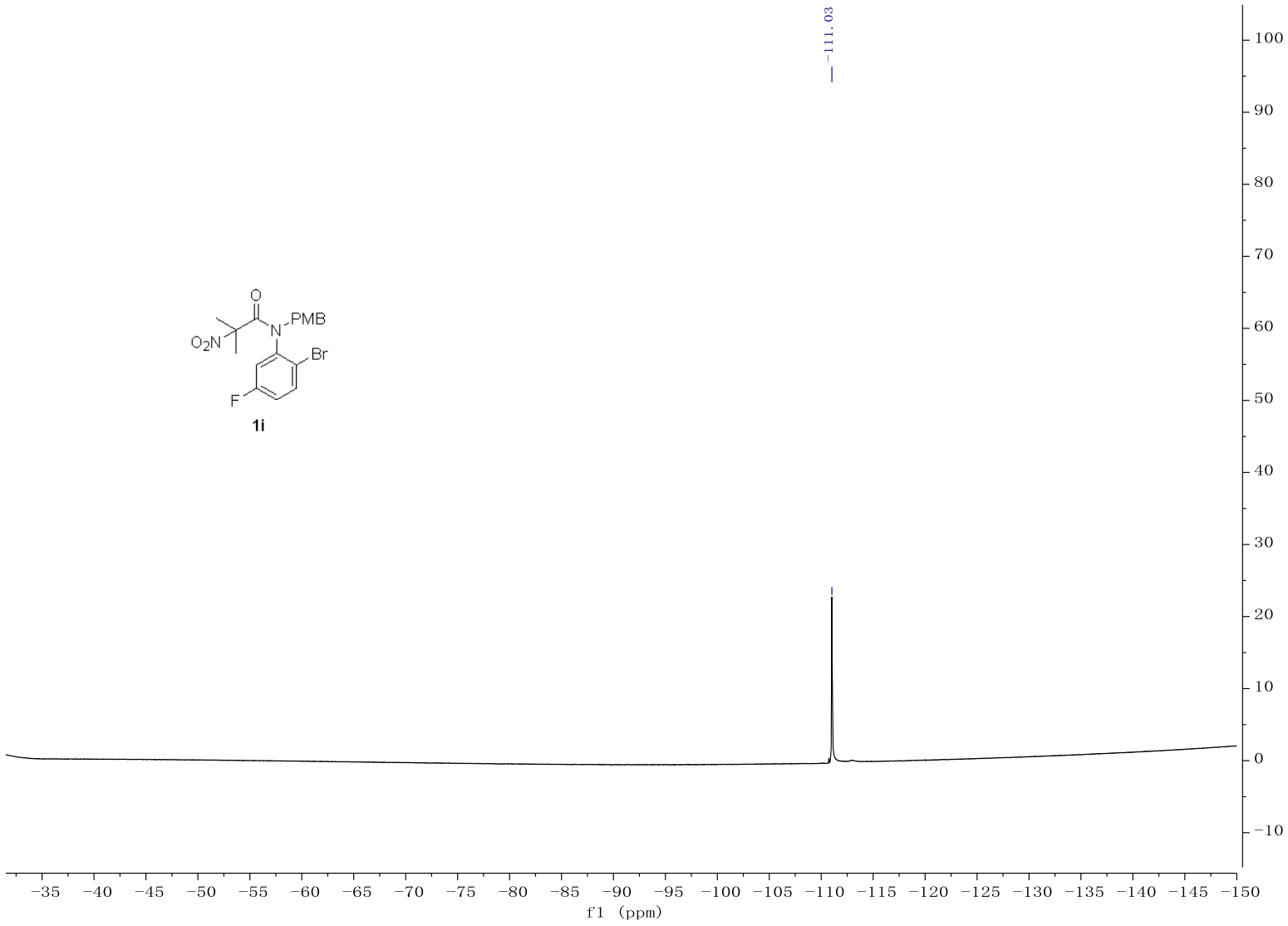
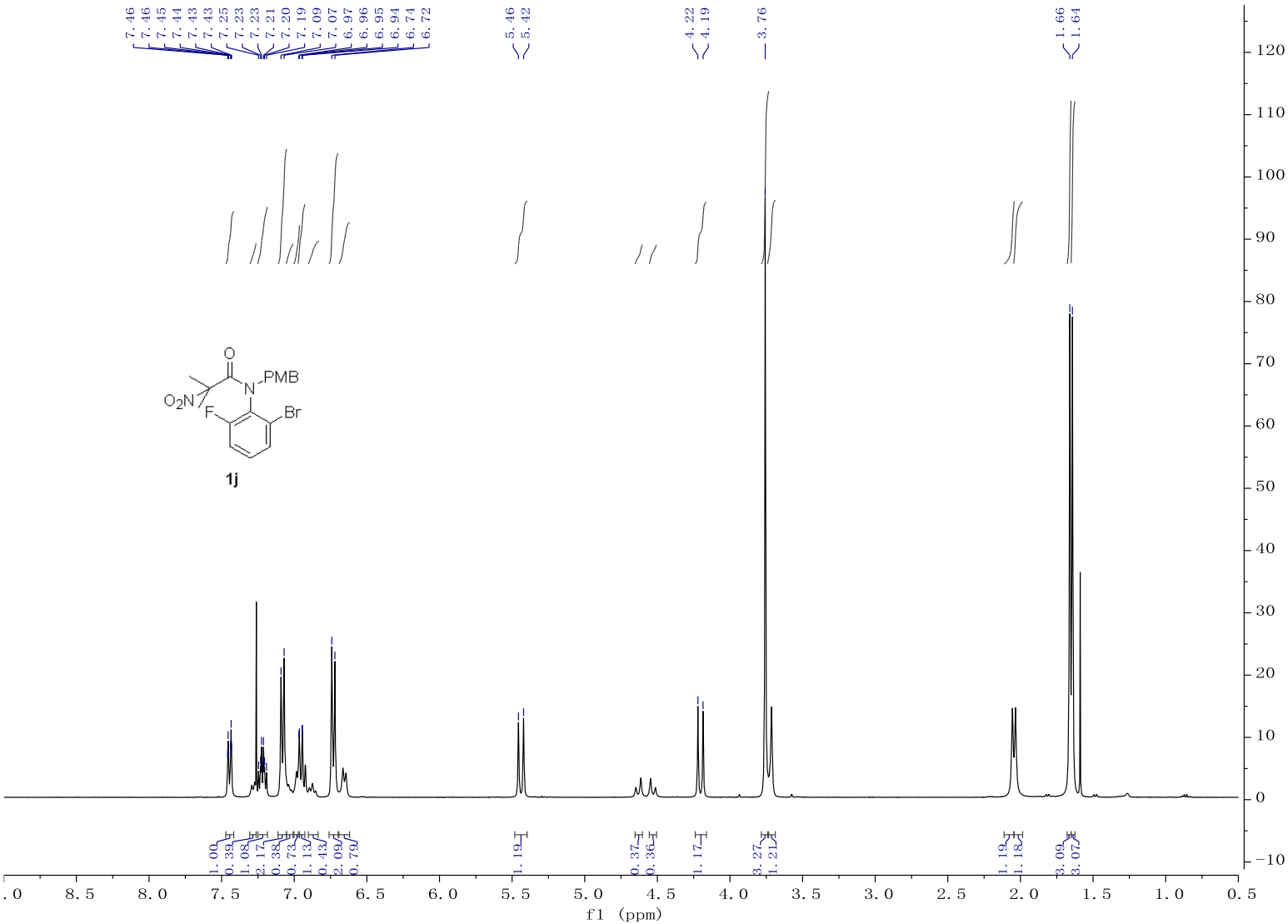
134.38
130.35
127.42
127.39
120.45
120.21
119.34
118.06
117.84
113.93
90.31
55.18
53.38
28.29
23.19
O
N
PMB
O_2N
Br
F
1i
f1 (ppm)


−111.03
O
PMB
N
O2N
Br
F
1i
100
90
80
70
60
50
40
30
20
10
0
−10
−35 −40 −45 −50 −55 −60 −65 −70 −75 −80 −85 −90 −95 −100 −105 −110 −115 −120 −125 −130 −135 −140 −145 −150
f1 (ppm)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7.46
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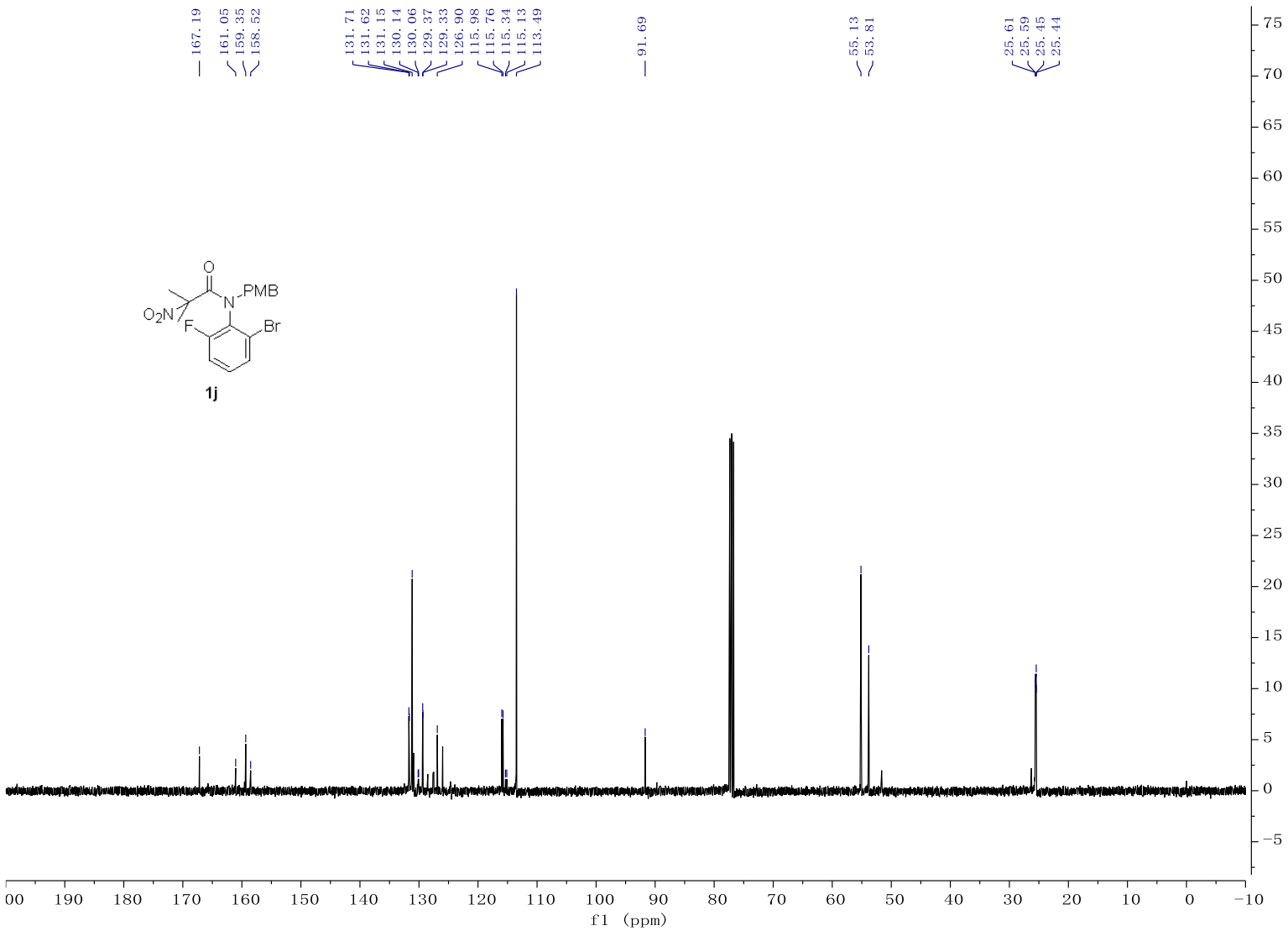
7.43
7.25
7.23
7.23
7.21
7.20
7.19
7.09
7.07
6.97
6.96
6.95
6.94
6.74
6.72
5.46
5.42
4.22
4.19
3.76
1.66
1.64
O
N
PMB
O_2N
F
Br
1j
f1 (ppm)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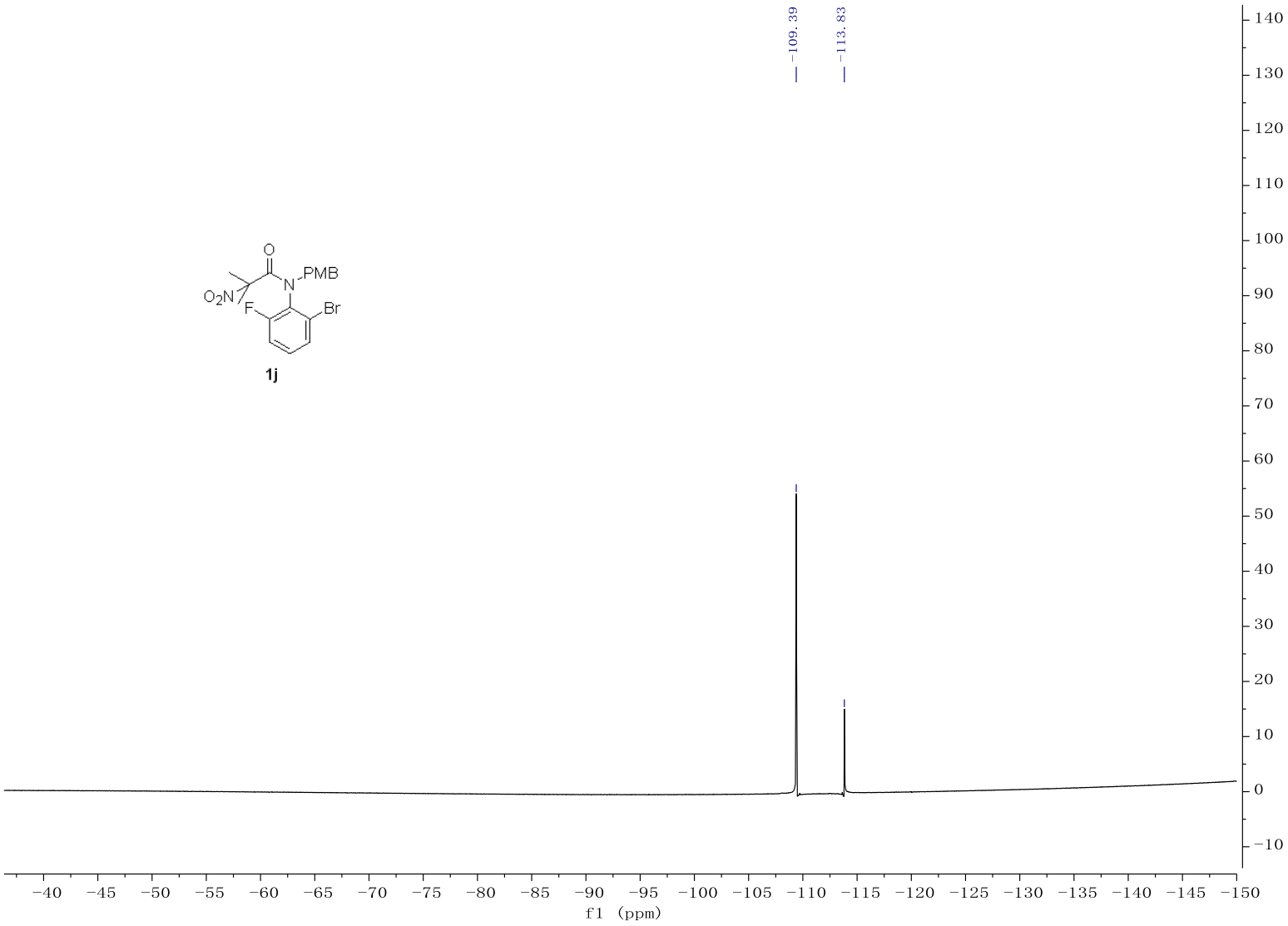
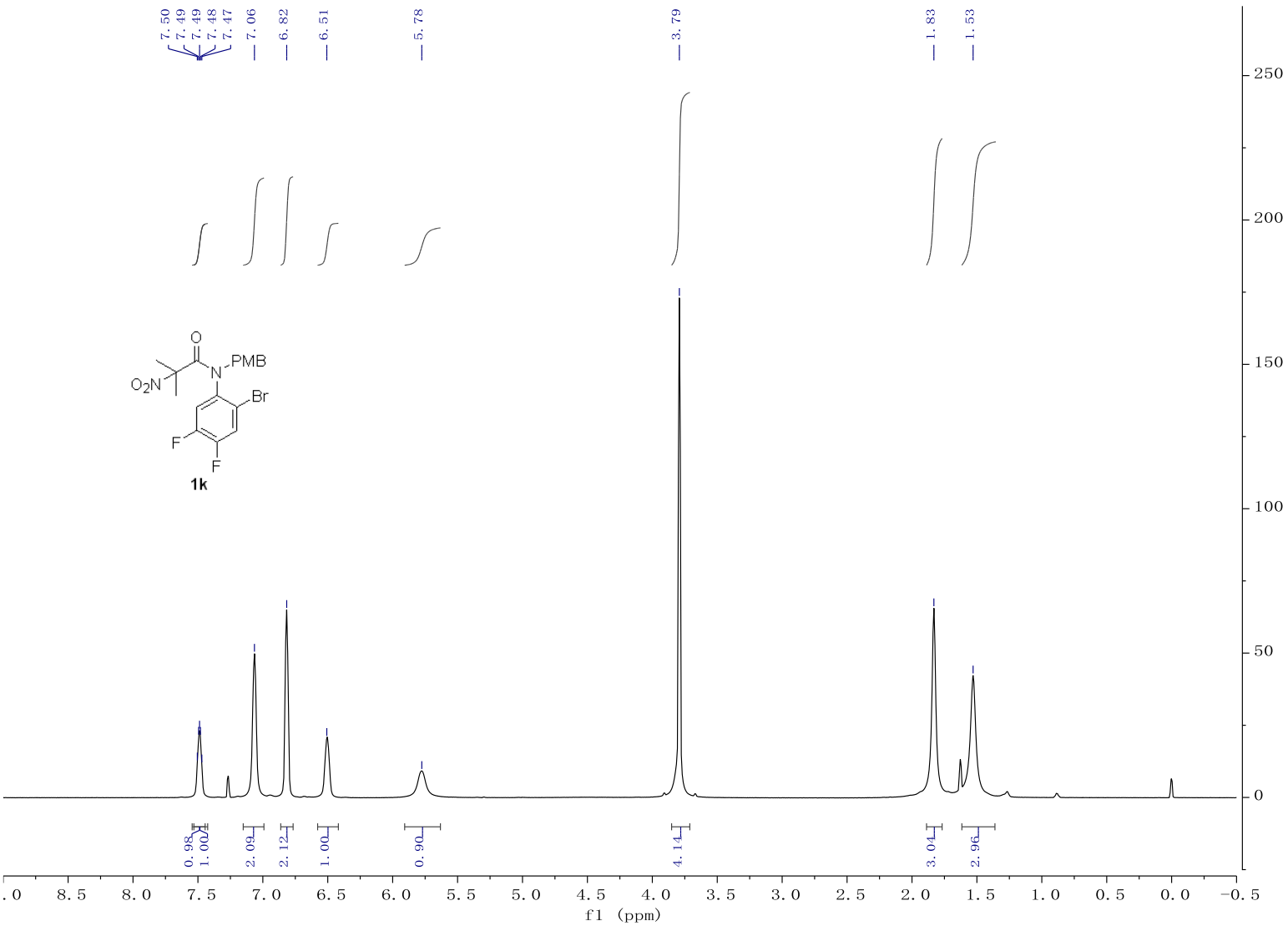
130.14
130.06
129.37
129.33
126.90
115.98
115.76
115.34
115.13
113.49
91.69
55.13
53.81
25.61
25.59
25.45
25.44
O
N
PMB
O_2N
F
Br
1j
f1 (ppm)


O
N
PMB
O_2N
F
Br
1j
−109.39
−113.83
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
−40 −45 −50 −55 −60 −65 −70 −75 −80 −85 −90 −95 −100 −105 −110 −115 −120 −125 −130 −135 −140 −145 −150
f1 (ppm)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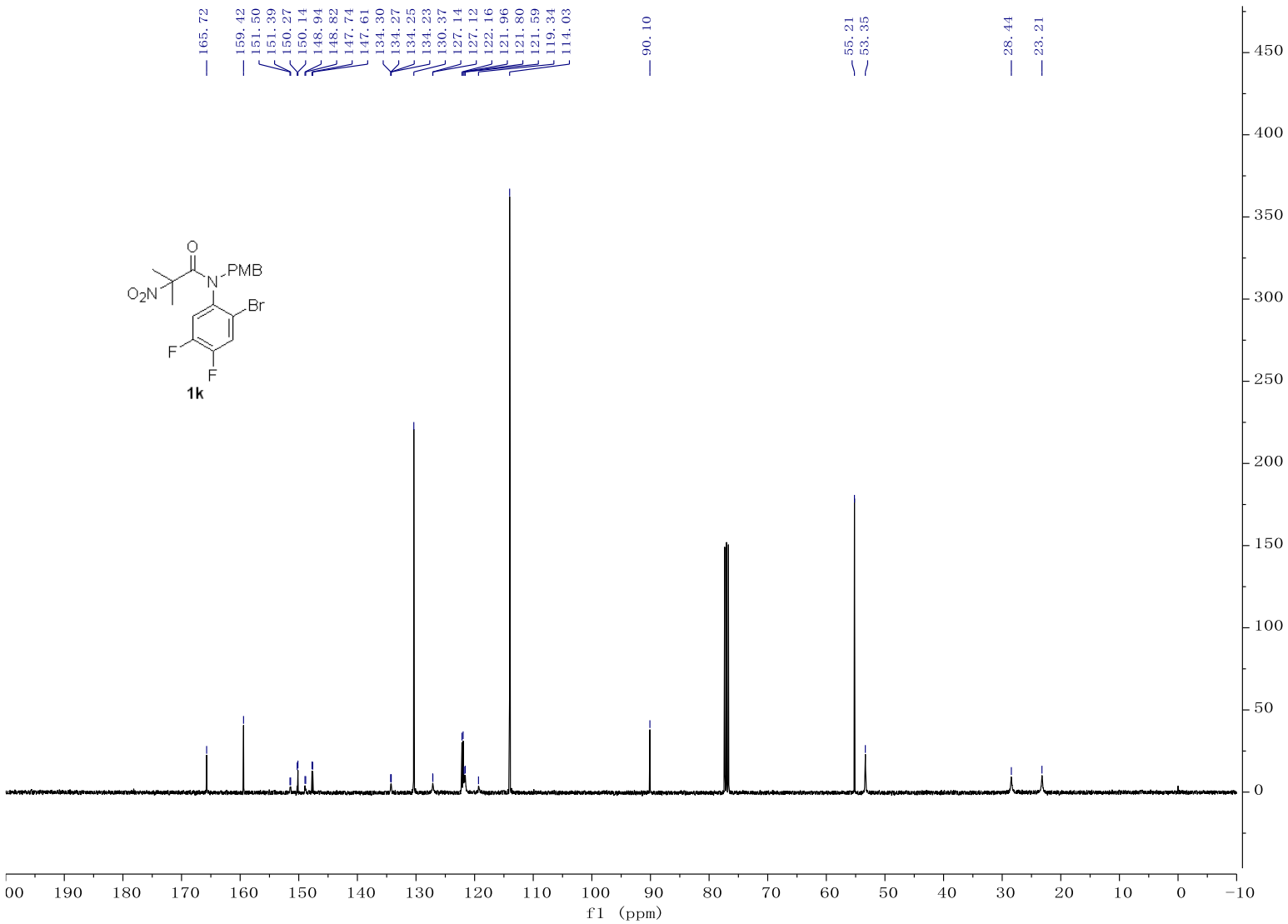
7.49
7.49
7.48
7.47
7.06
6.82
6.51
5.78
3.79
1.83
1.53
O
N
PMB
O2N
Br
F
F
1k
0.98
1.00
2.09
2.12
1.00
0.90
4.14
3.04
2.96
f1 (ppm)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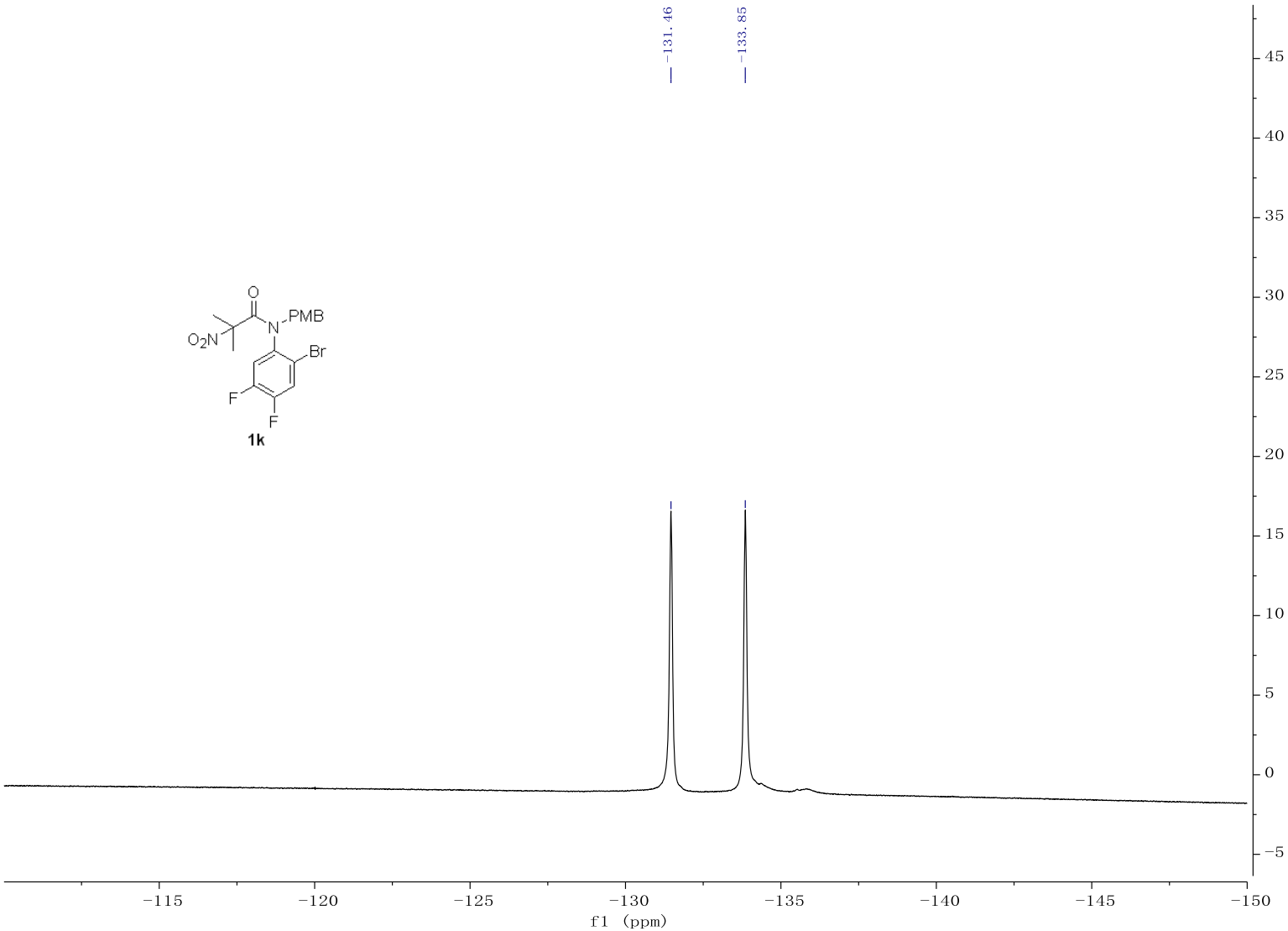
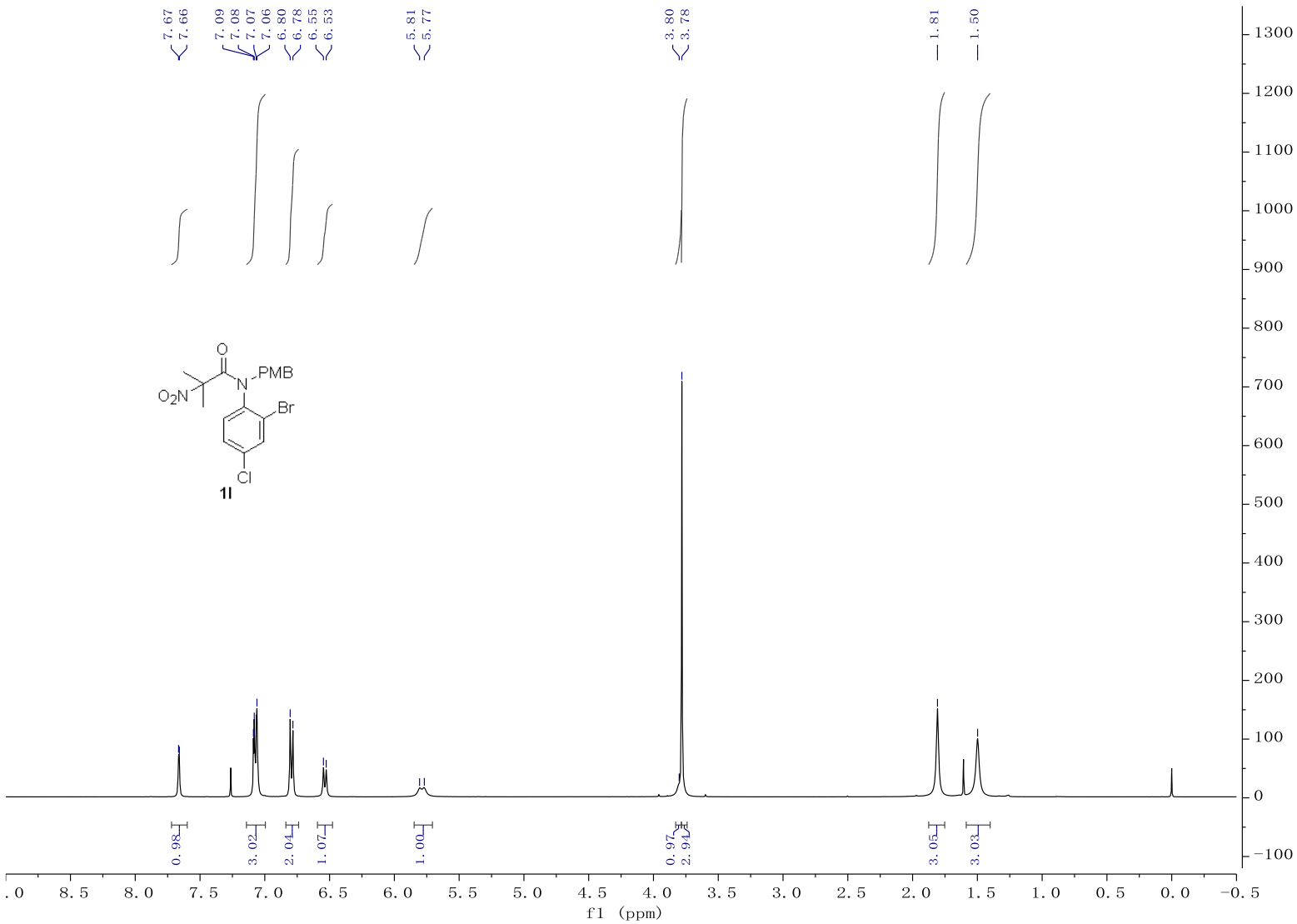
150.14
148.94
148.82
147.74
147.61
134.30
134.27
134.25
134.23
130.37
127.14
127.12
122.16
121.96
121.80
121.59
119.34
114.03
90.10
55.21
53.35
28.44
23.21
O
N
PMB
O_2N
Br
F
F
1k
f1 (ppm)


−131.46
−133.85
O
N
PMB
O2N
Br
F
F
1k
45
40
35
30
25
20
15
10
5
0
−5
−115
−120
−125
−130
−135
−140
−145
−150
f1 (ppm)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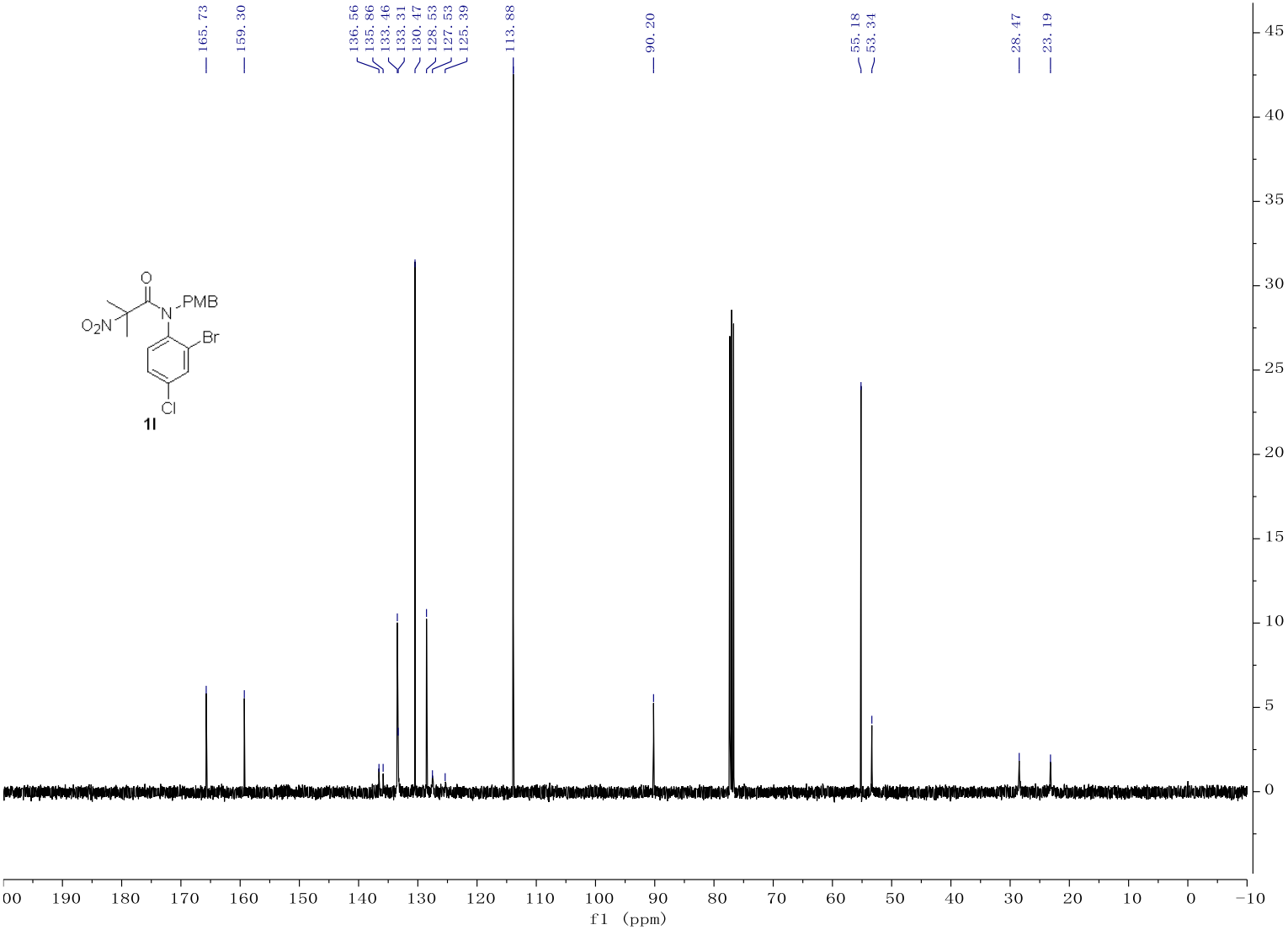
7.06
6.80
6.78
6.55
6.53
5.81
5.77
3.80
3.78
1.81
1.50
O
PMB
N
O_2N
Br
Cl
1l
0.98
3.02
2.04
1.07
1.00
0.97
2.94
3.05
3.03
f1 (ppm)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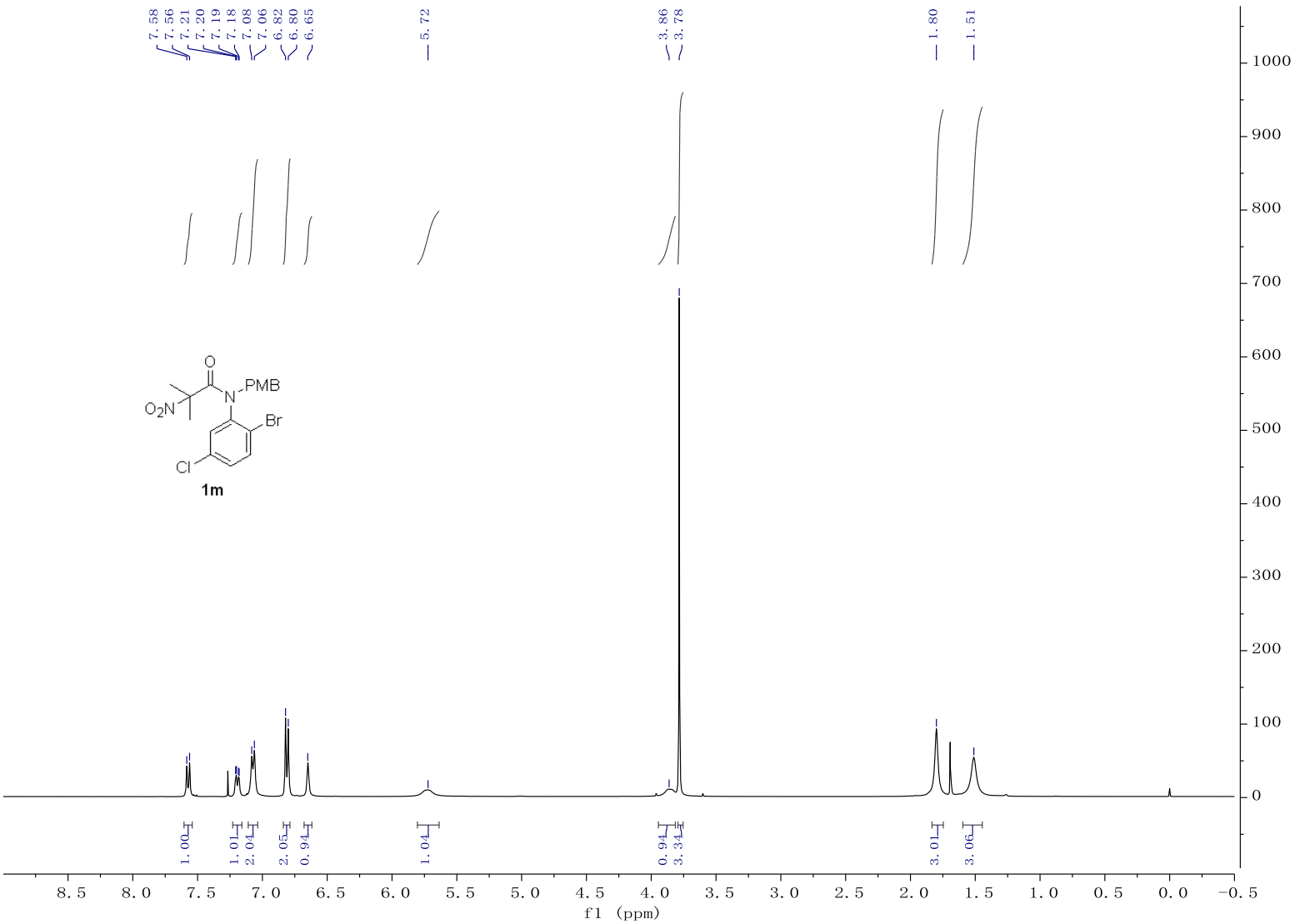
159.30
136.56
135.86
133.46
133.31
130.47
128.53
127.53
125.39
113.88
90.20
55.18
53.34
28.47
23.19
O
PMB
N
O_2N
Br
Cl
1l
f1 (ppm)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7.56
7.21
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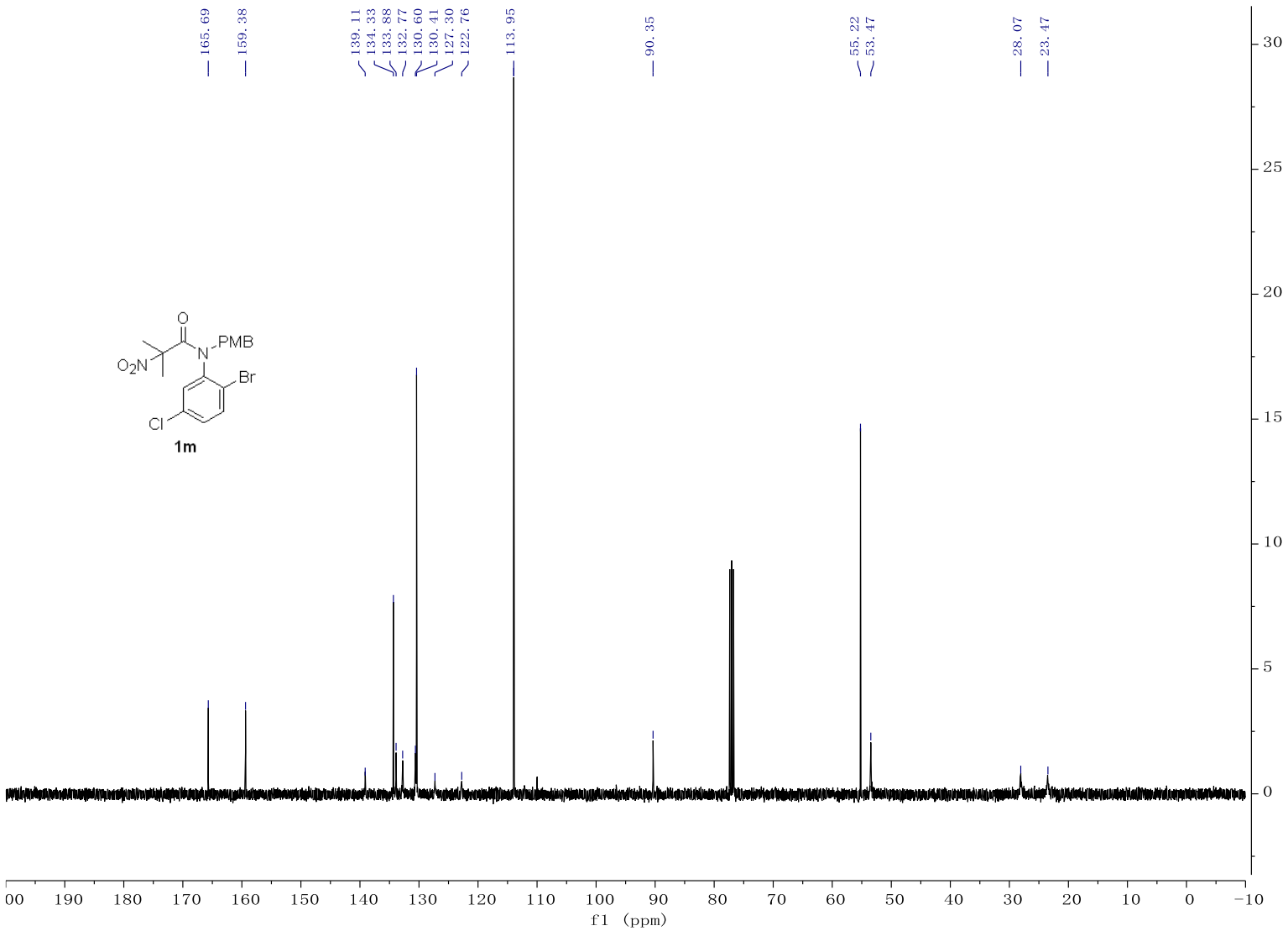
7.19
7.18
7.08
7.06
6.82
6.80
6.65
5.72
3.86
3.78
1.80
1.51
O
N
PMB
O2N
Br
Cl
1m
1.00
1.01
2.04
2.05
0.94
1.04
0.94
3.34
3.01
3.06
f1 (ppm)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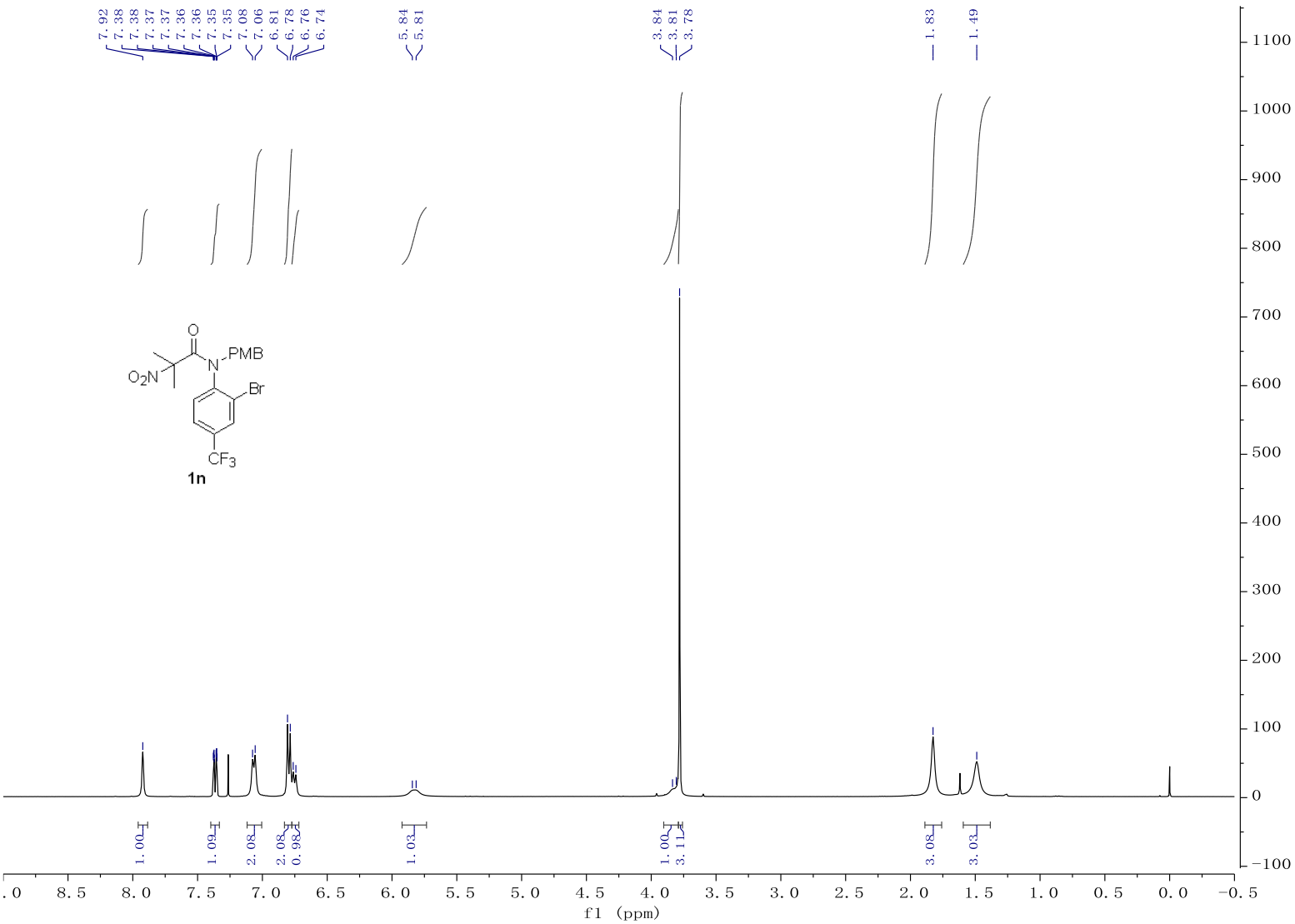
133.88
132.77
130.60
130.41
127.30
122.76
113.95
90.35
55.22
53.47
28.07
23.47
O
N
PMB
O_2N
Br
Cl
1m
f1 (ppm)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7.36
7.35
7.35
7.08
7.06
6.81
6.78
6.76
6.74
5.84
5.81
3.84
3.81
3.78
1.83
1.49
O
PMB
N
O_2N
Br
CF_3
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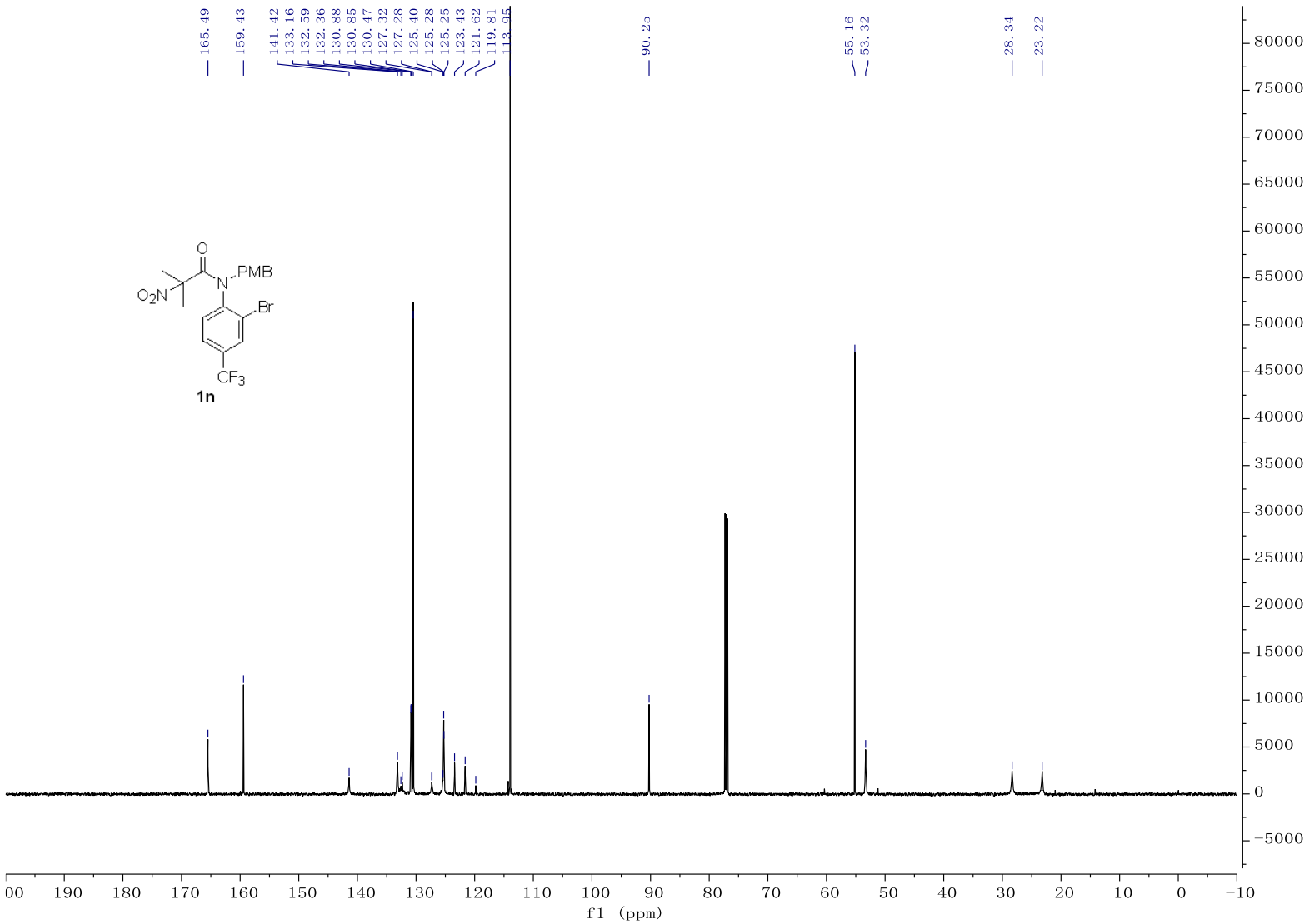
2.08
2.08
0.98
1.03
1.00
3.11
3.08
3.03
f1 (ppm)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127.28
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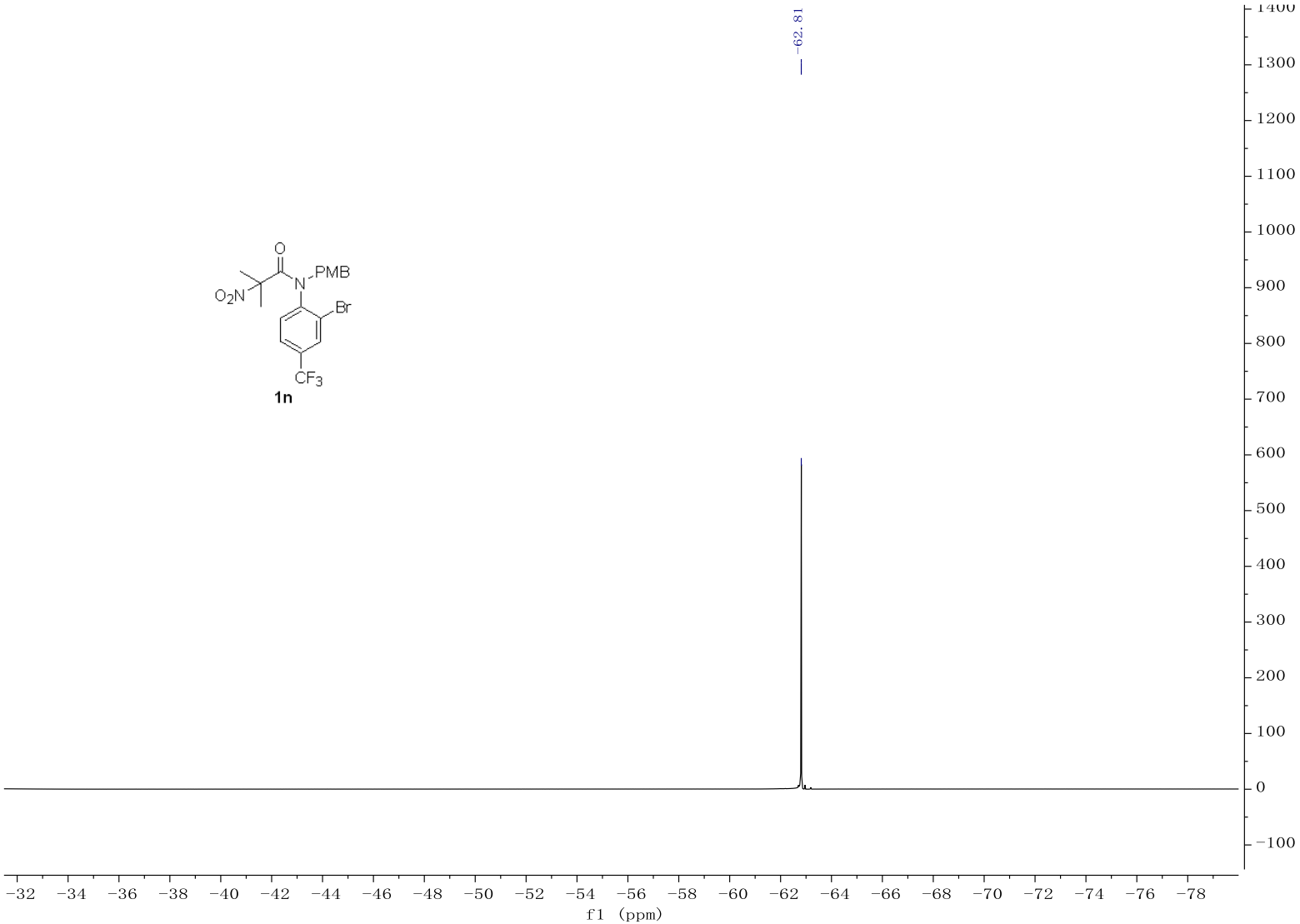
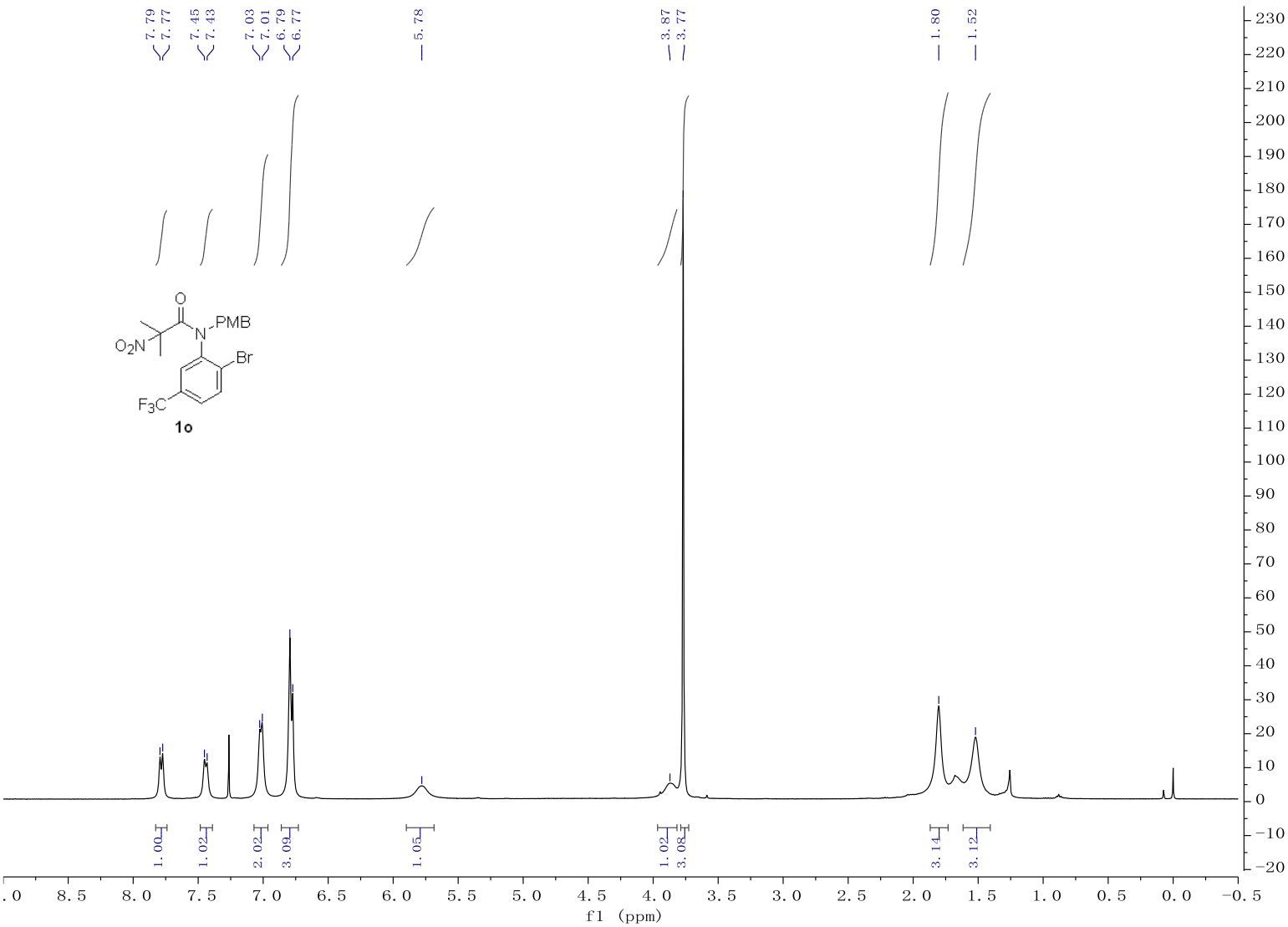
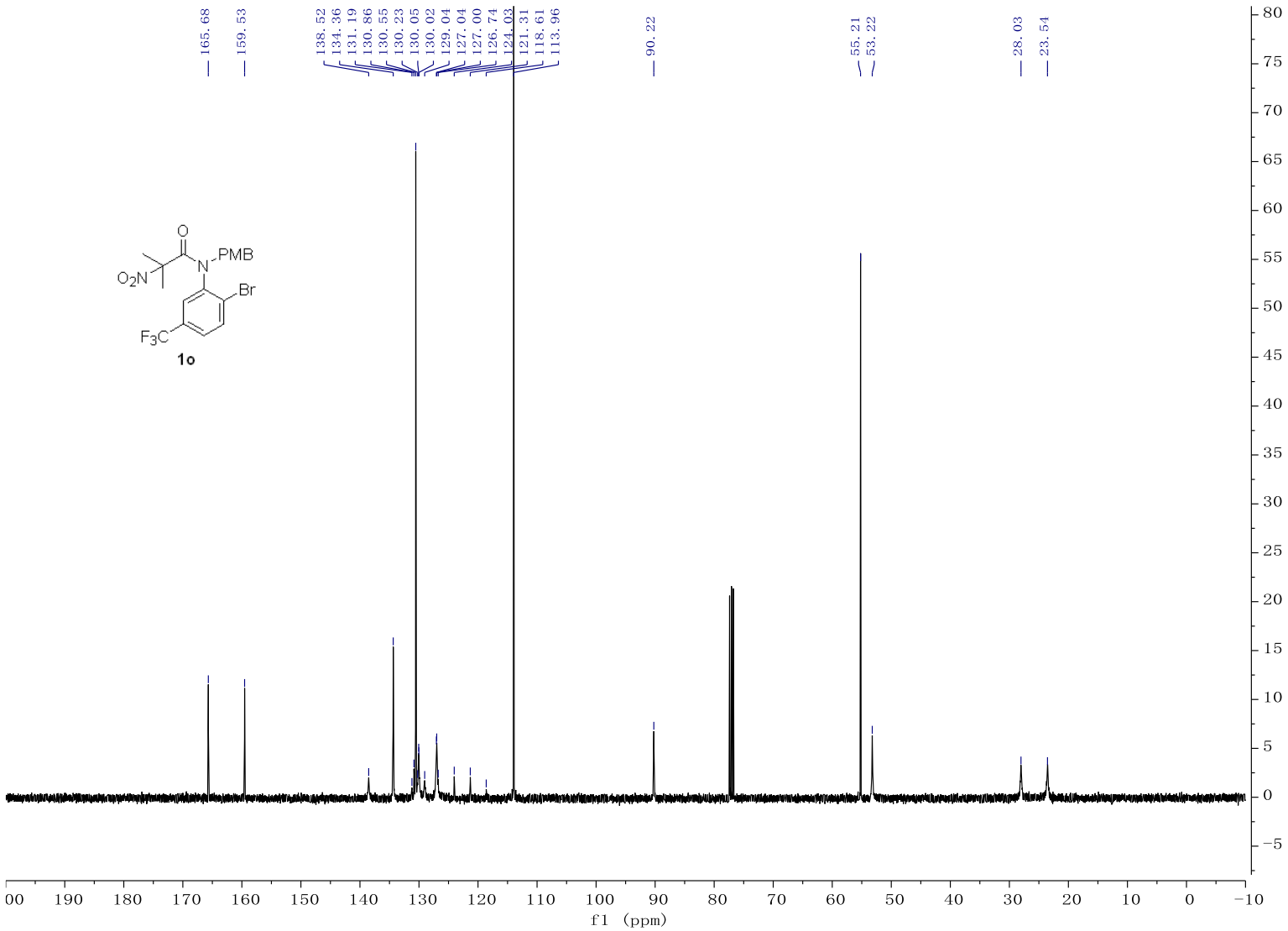
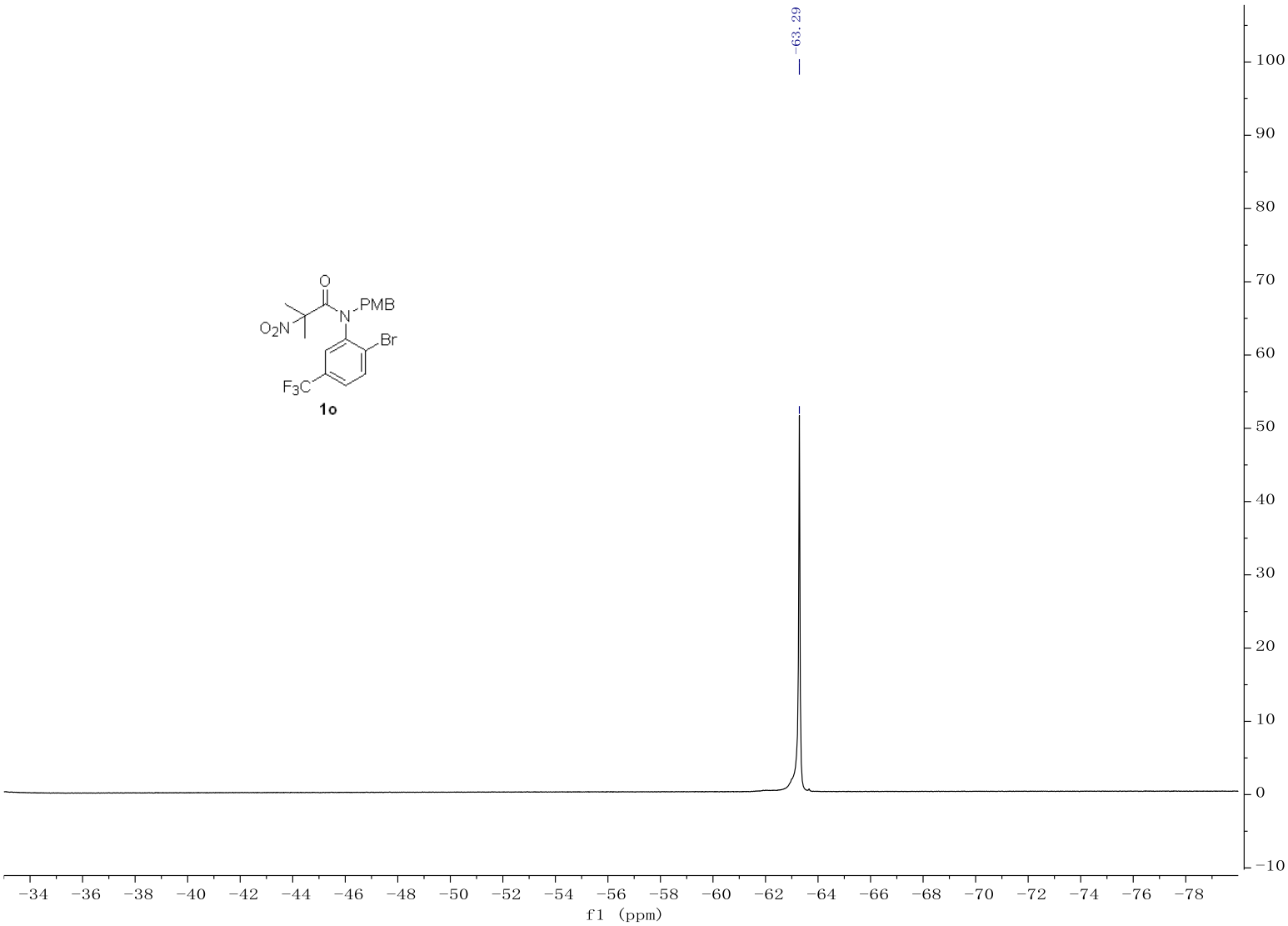
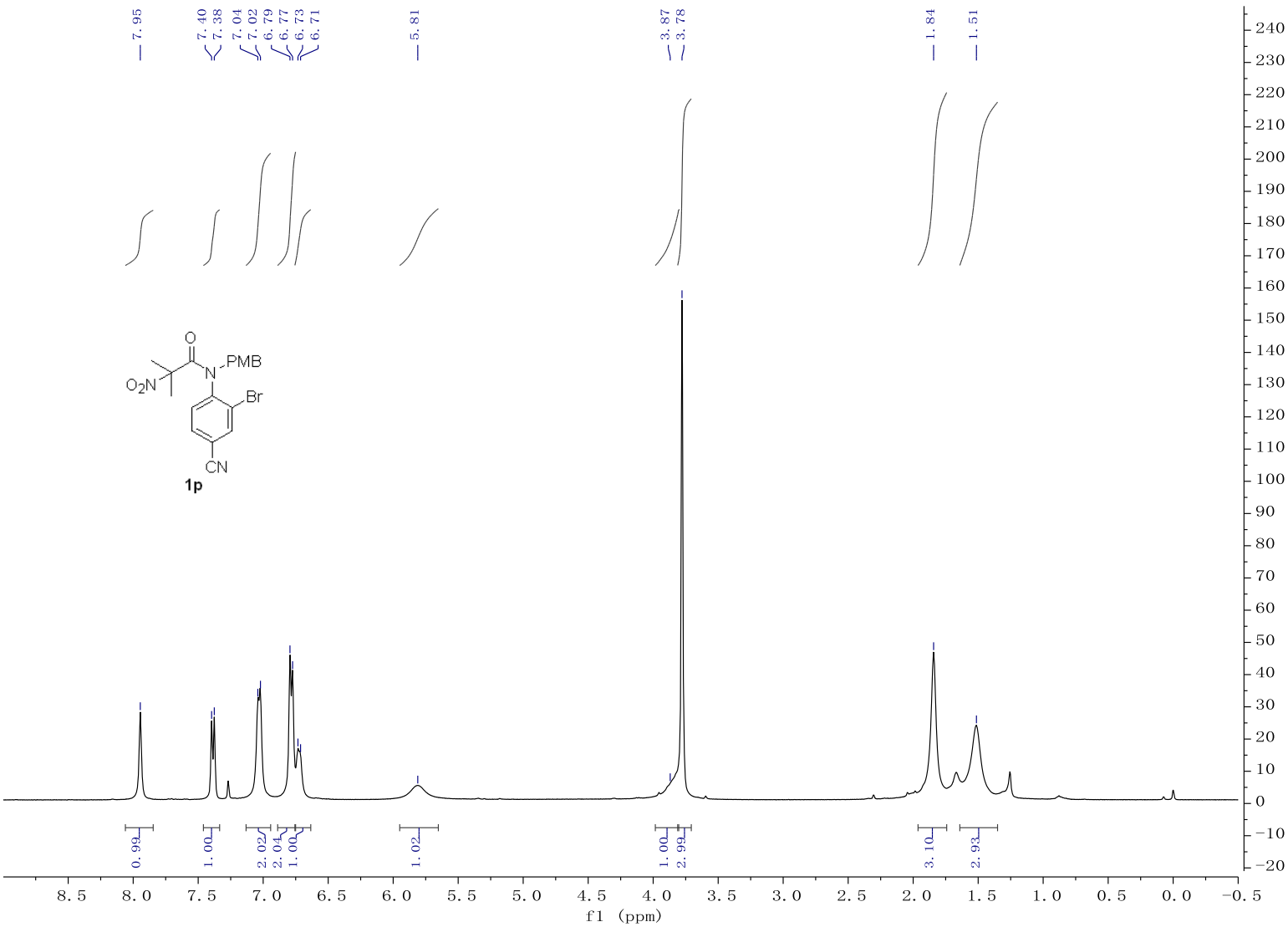
125.28
125.25
123.43
121.62
119.81
113.95
90.25
55.16
53.32
28.34
23.22
O
N
PMB
O_2N
Br
CF_3
1n
f1 (ppm)

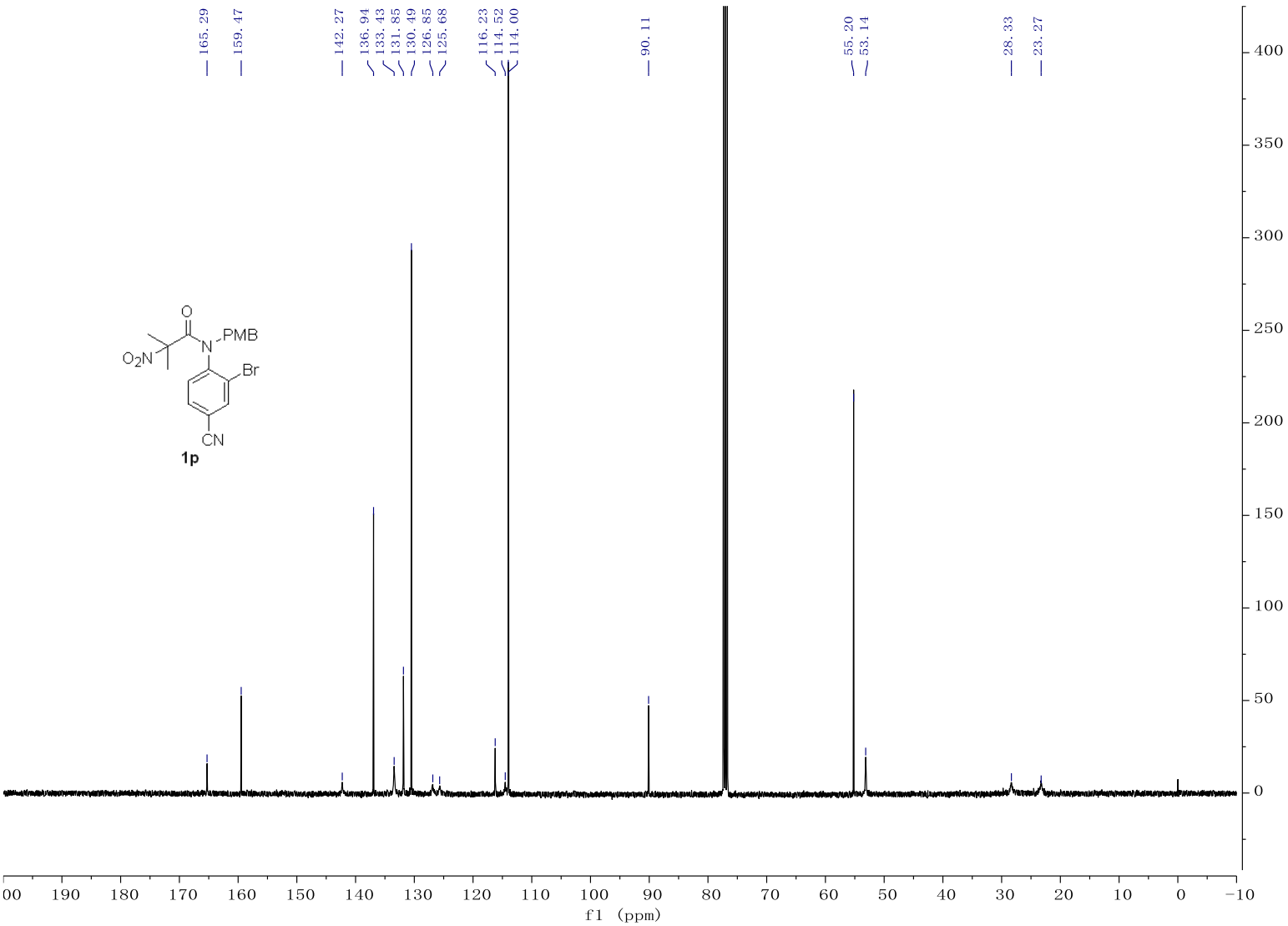

−62.81
O
N
PMB
O2N
Br
CF3
1n
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
−100
−32 −34 −36 −38 −40 −42 −44 −46 −48 −50 −52 −54 −56 −58 −60 −62 −64 −66 −68 −70 −72 −74 −76 −78
f1 (ppm)

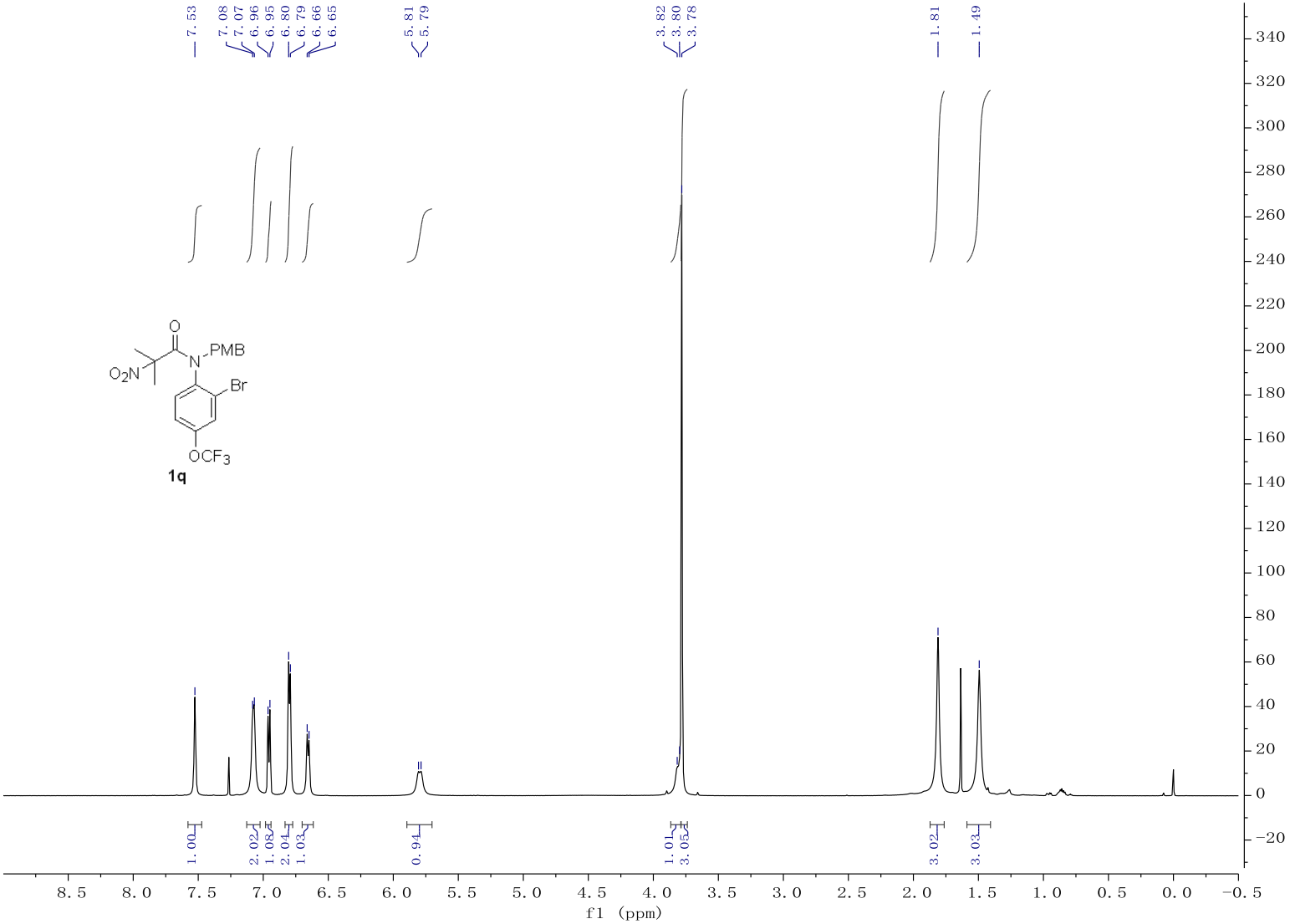

7.79
7.77
7.45
7.43
7.03
7.01
6.79
6.77
5.78
3.87
3.77
1.80
1.52
O
N
PMB
O_2N
Br
F_3C
1o
1.00
1.02
2.02
3.09
1.05
1.02
3.08
3.14
3.12
f1 (ppm)

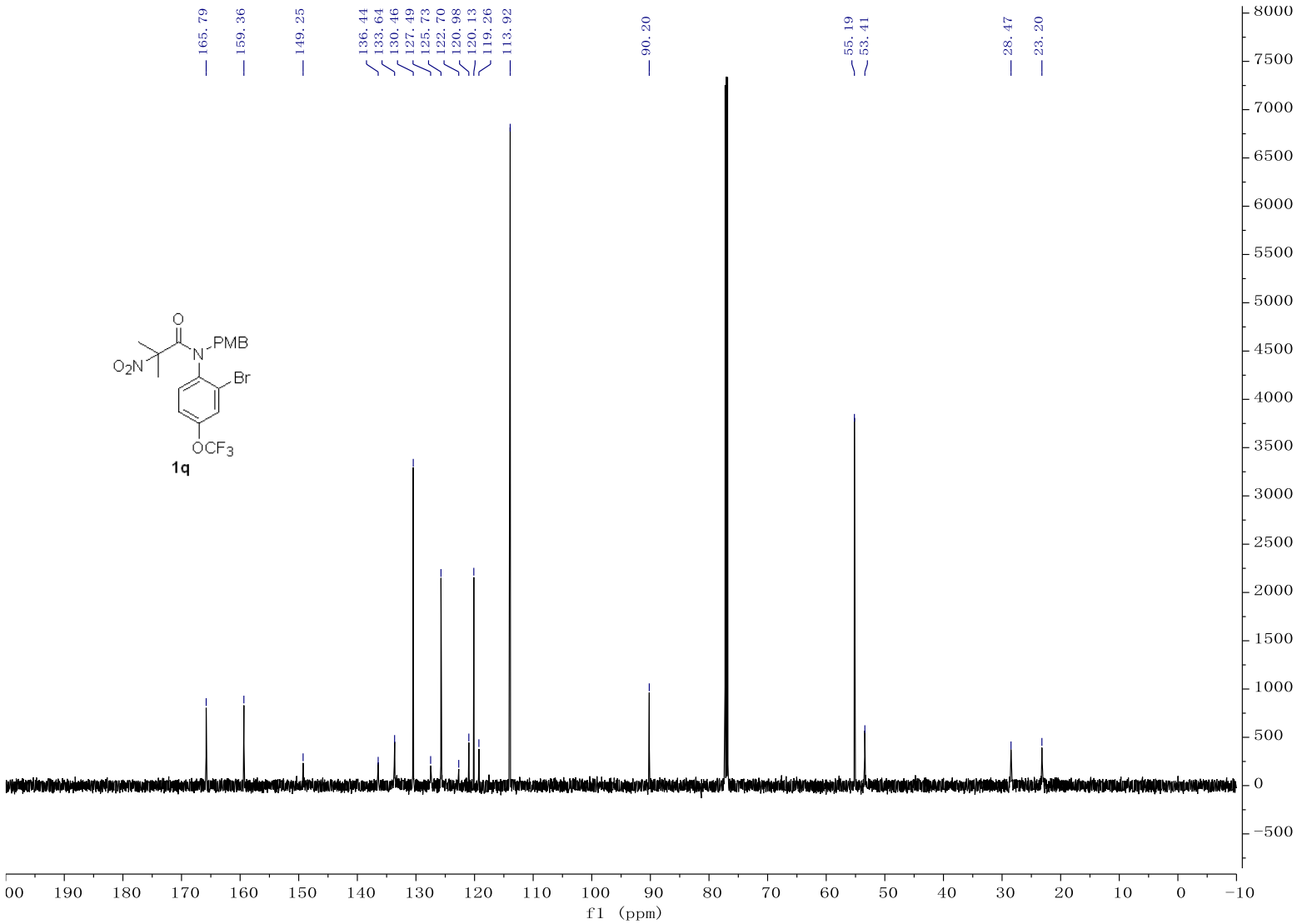

165.68
159.53
138.52
134.36
131.19
130.86
130.55
130.23
130.05
130.02
129.04
127.04
127.00
126.74
124.03
121.31
118.61
113.96
90.22
55.21
53.22
28.03
23.54
O
N
PMB
O_2N
Br
F_3C
1o
f1 (ppm)

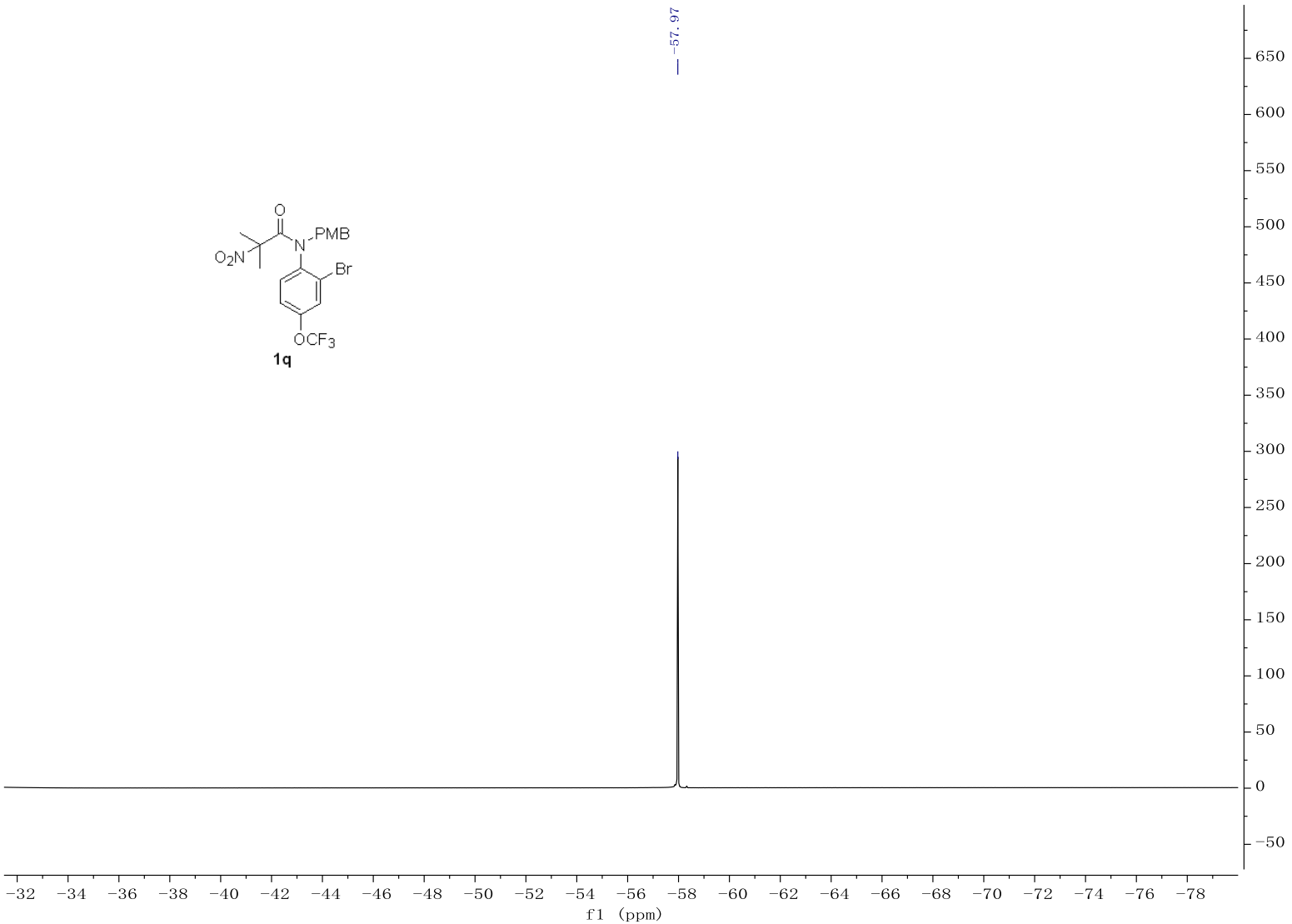

−63.29
O
PMB
N
O_2N
Br
F_3C
1o
100
90
80
70
60
50
40
30
20
10
0
−10
−34 −36 −38 −40 −42 −44 −46 −48 −50 −52 −54 −56 −58 −60 −62 −64 −66 −68 −70 −72 −74 −76 −78
f1 (ppm)

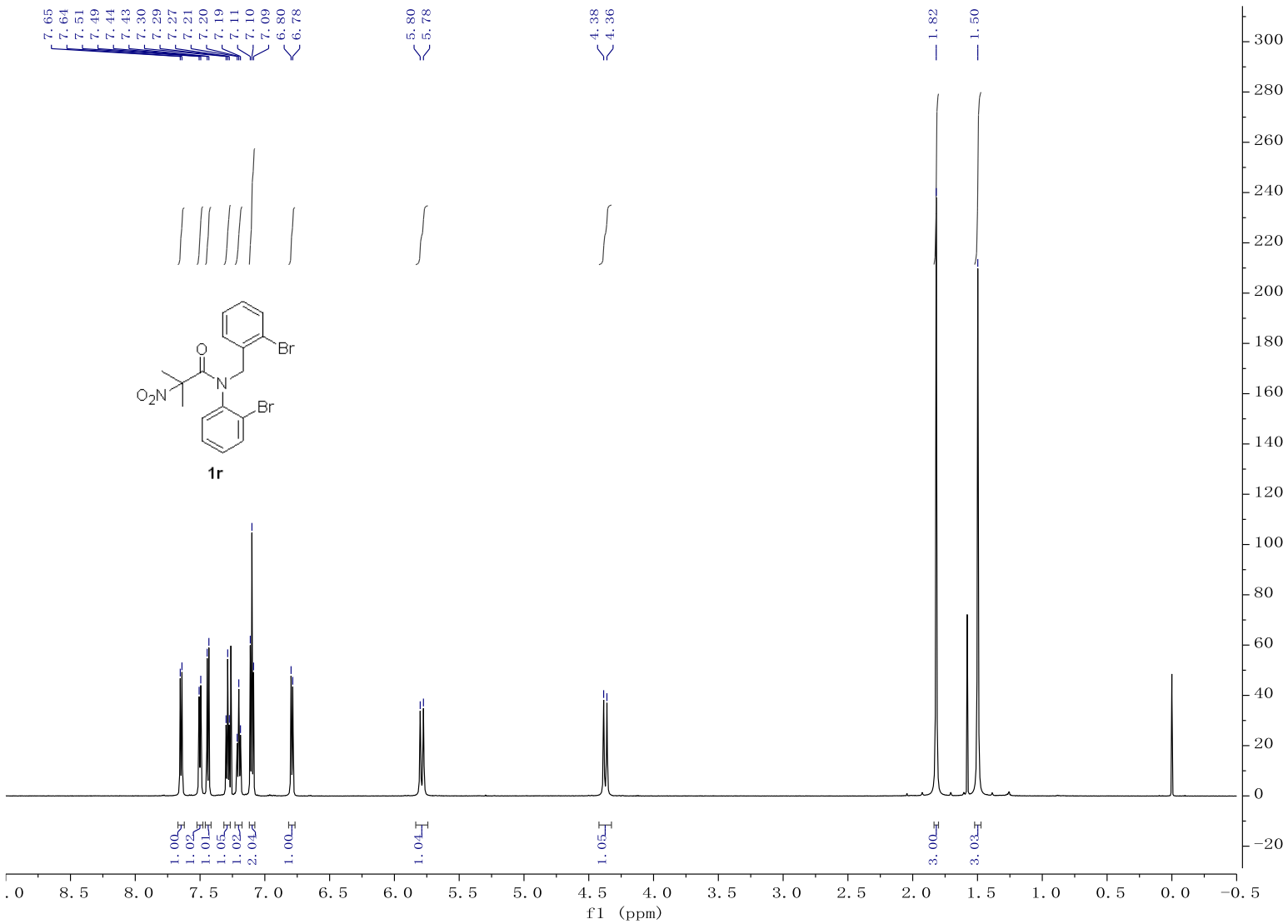

7.95
7.40
7.38
7.04
7.02
6.79
6.77
6.73
6.71
5.81
3.87
3.78
1.84
1.51
O
N
PMB
O_2N
Br
CN
1p
0.99
1.00
2.02
2.04
1.00
1.02
1.00
2.94
3.10
2.93
f1 (ppm)

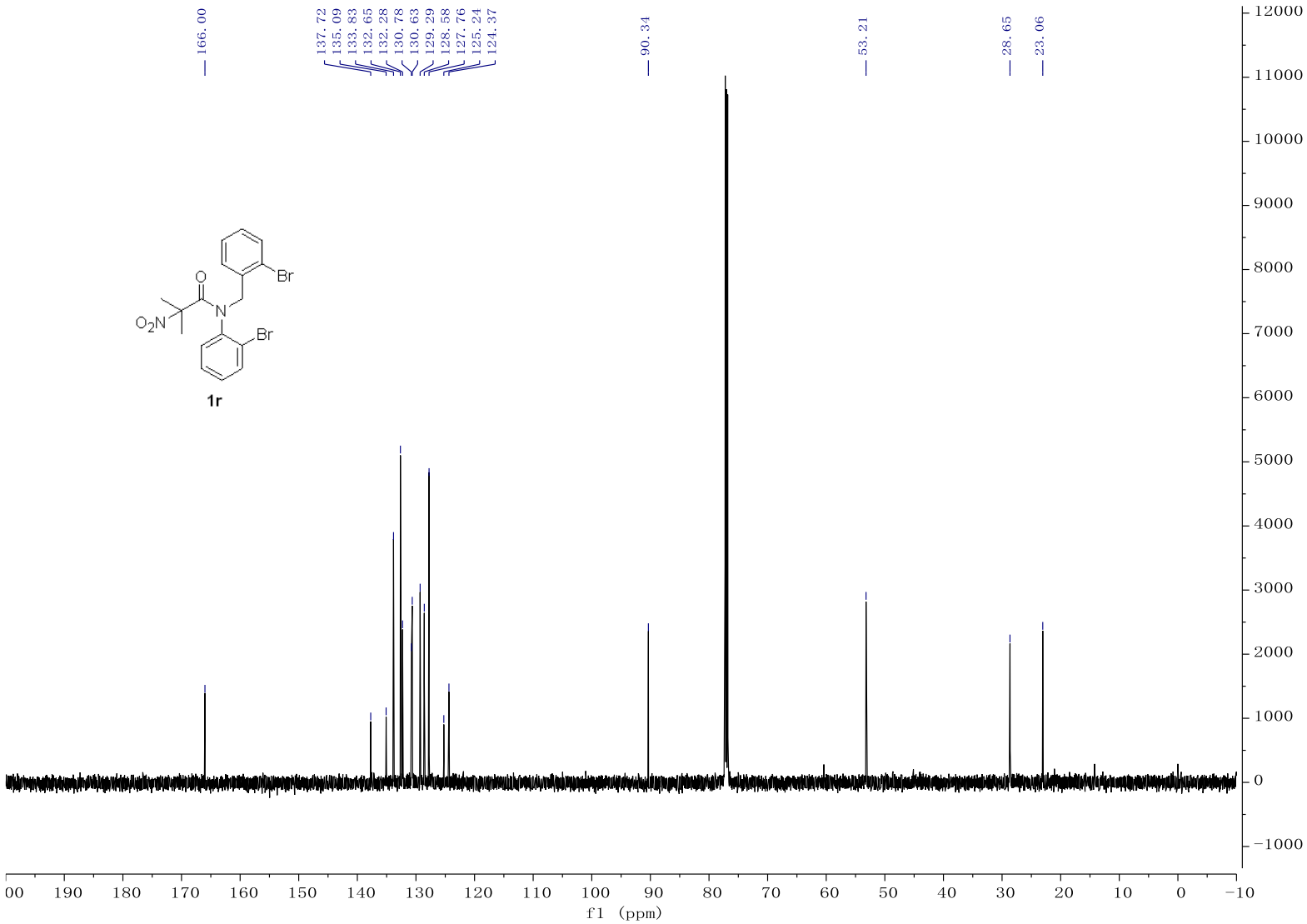

165.29
159.47
142.27
136.94
133.43
131.85
130.49
126.85
125.68
116.23
114.52
114.00
90.11
55.20
53.14
28.33
23.27
O
N
PMB
O_2N
Br
CN
1p
f1 (ppm)

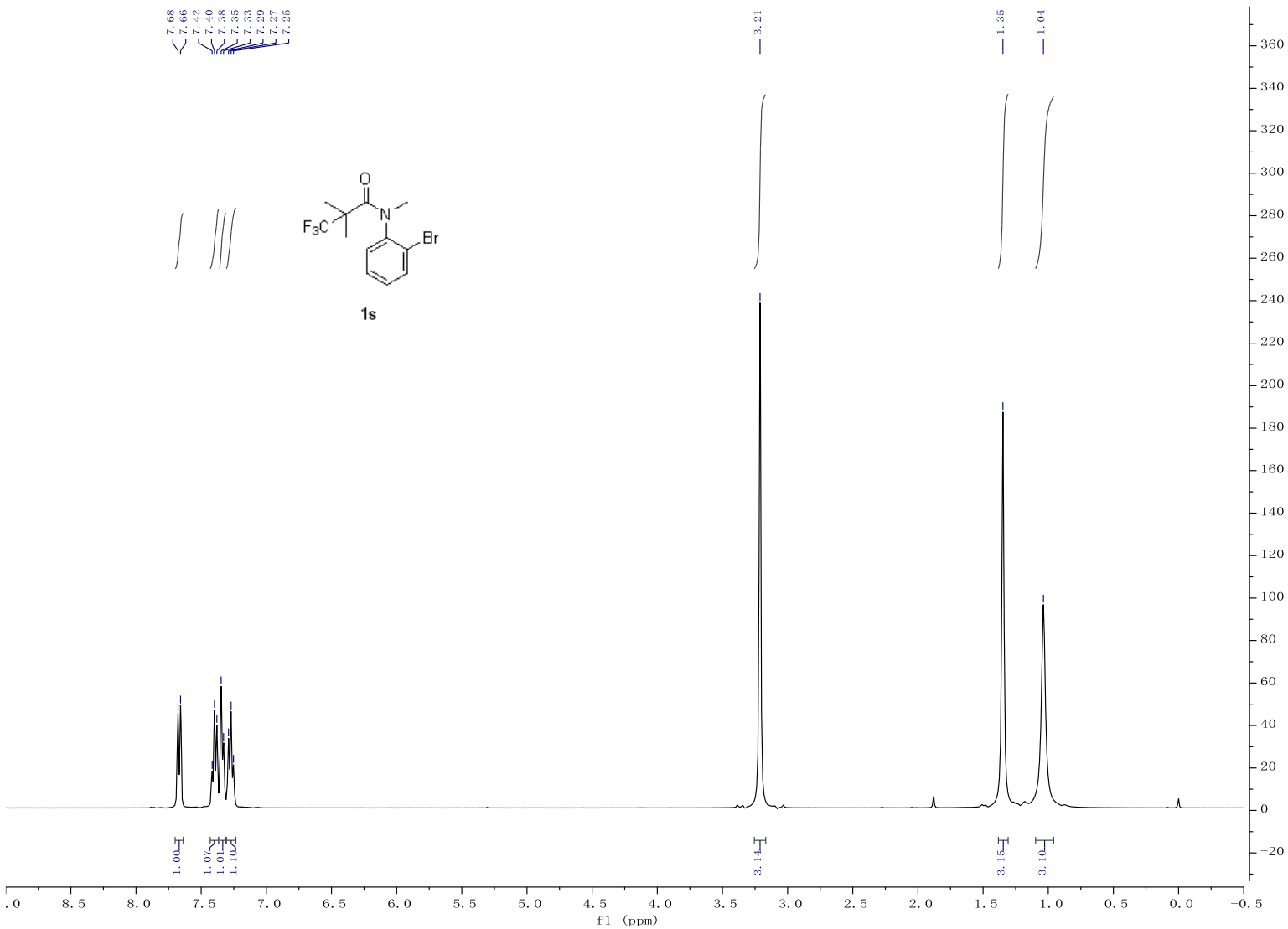

7.53
7.08
7.07
6.96
6.95
6.80
6.79
6.66
6.65
5.81
5.79
3.82
3.80
3.78
1.81
1.49
1.00
2.02
1.08
2.04
1.03
0.94
1.01
3.05
3.02
3.03
O
N
PMB
O_2N
Br
OCF_3
1q
f1 (ppm)

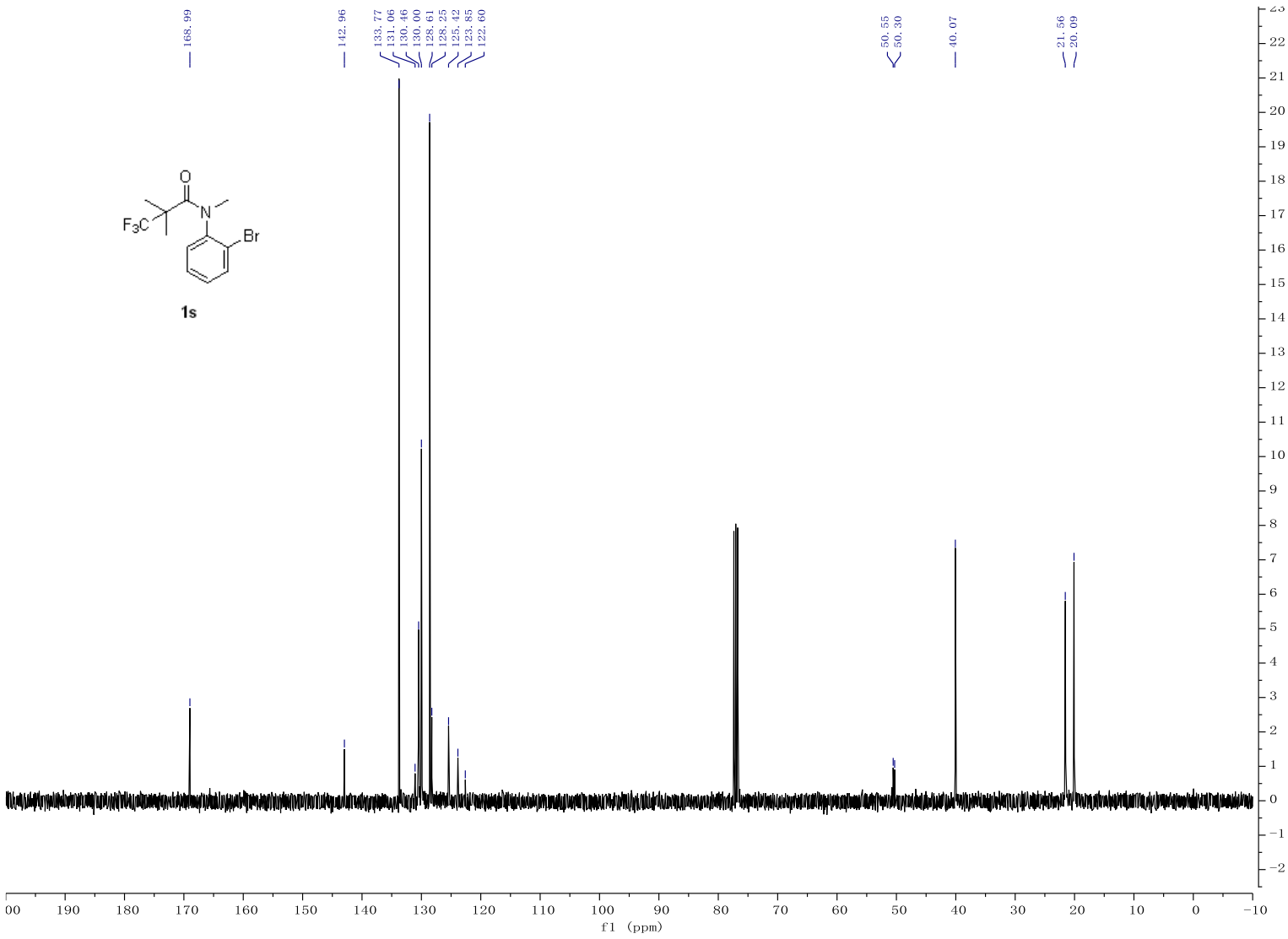

165.79
159.36
149.25
136.44
133.64
130.46
127.49
125.73
122.70
120.98
120.13
119.26
113.92
90.20
55.19
53.41
28.47
23.20
O
N
PMB
O_2N
Br
OCF_3
1q
f1 (ppm)

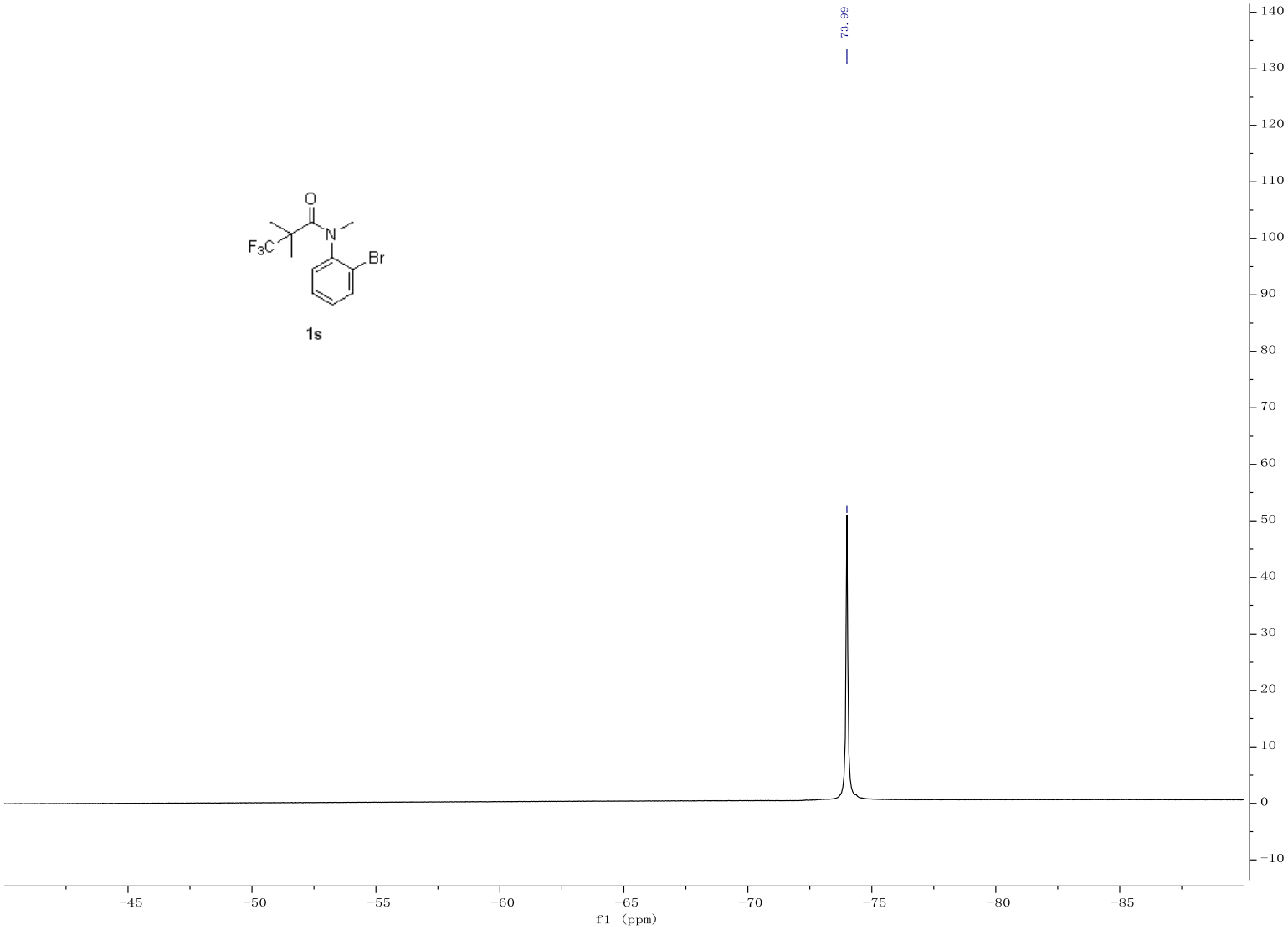

-57.97
O
N
PMB
O_2N
Br
OCF_3
1q
650
600
550
500
450
400
350
300
250
200
150
100
50
0
-50
-32 -34 -36 -38 -40 -42 -44 -46 -48 -50 -52 -54 -56 -58 -60 -62 -64 -66 -68 -70 -72 -74 -76 -78
f1 (ppm)

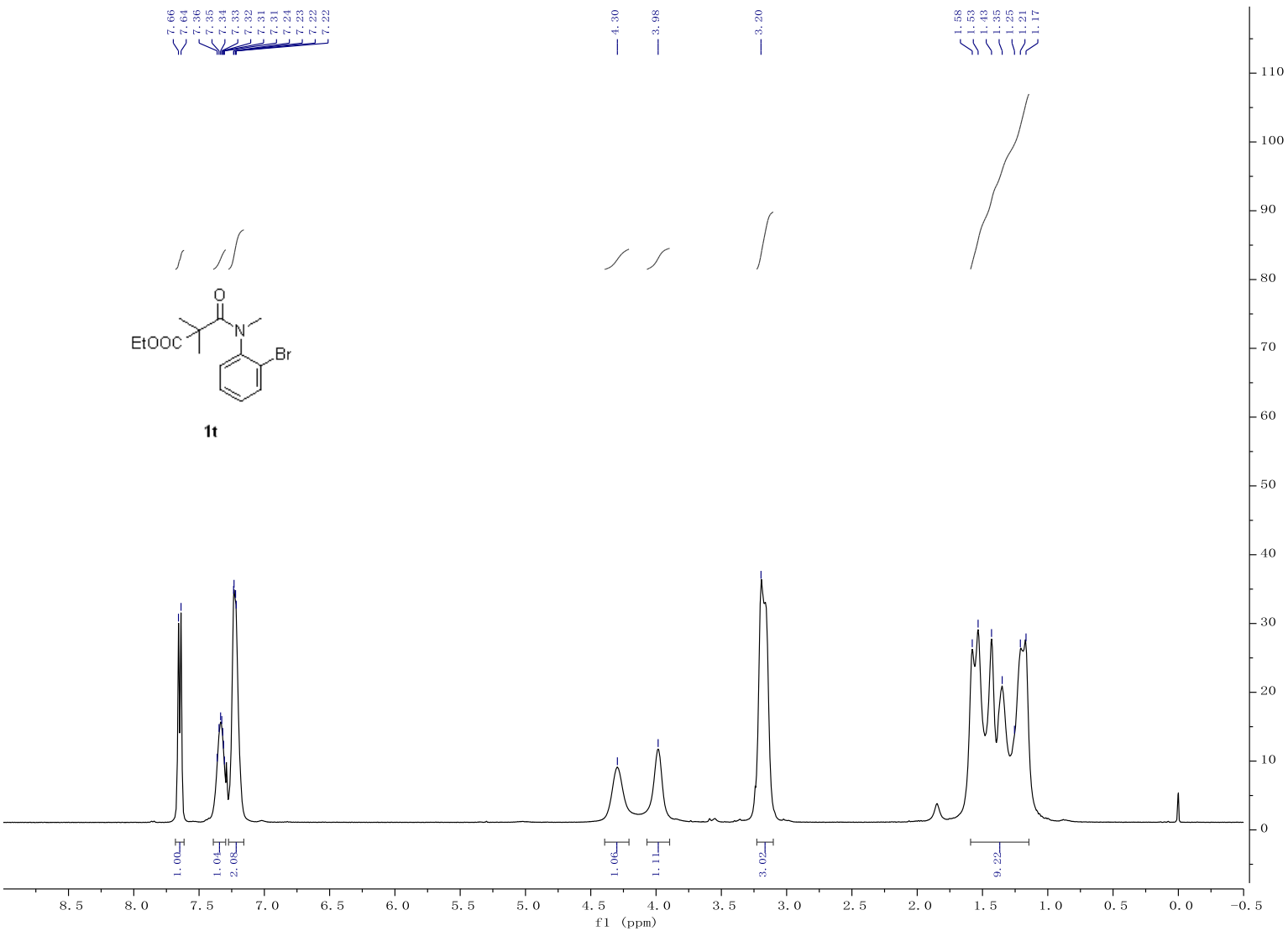

7.65
7.64
7.51
7.49
7.44
7.43
7.30
7.29
7.27
7.21
7.20
7.19
7.11
7.10
7.09
6.80
6.78
5.80
5.78
4.38
4.36
1.82
1.50
Br
Br
O
N
O_2N
1r
1.00
1.02
1.01
1.05
1.02
2.04
1.00
1.04
1.05
3.00
3.03
f1 (ppm)

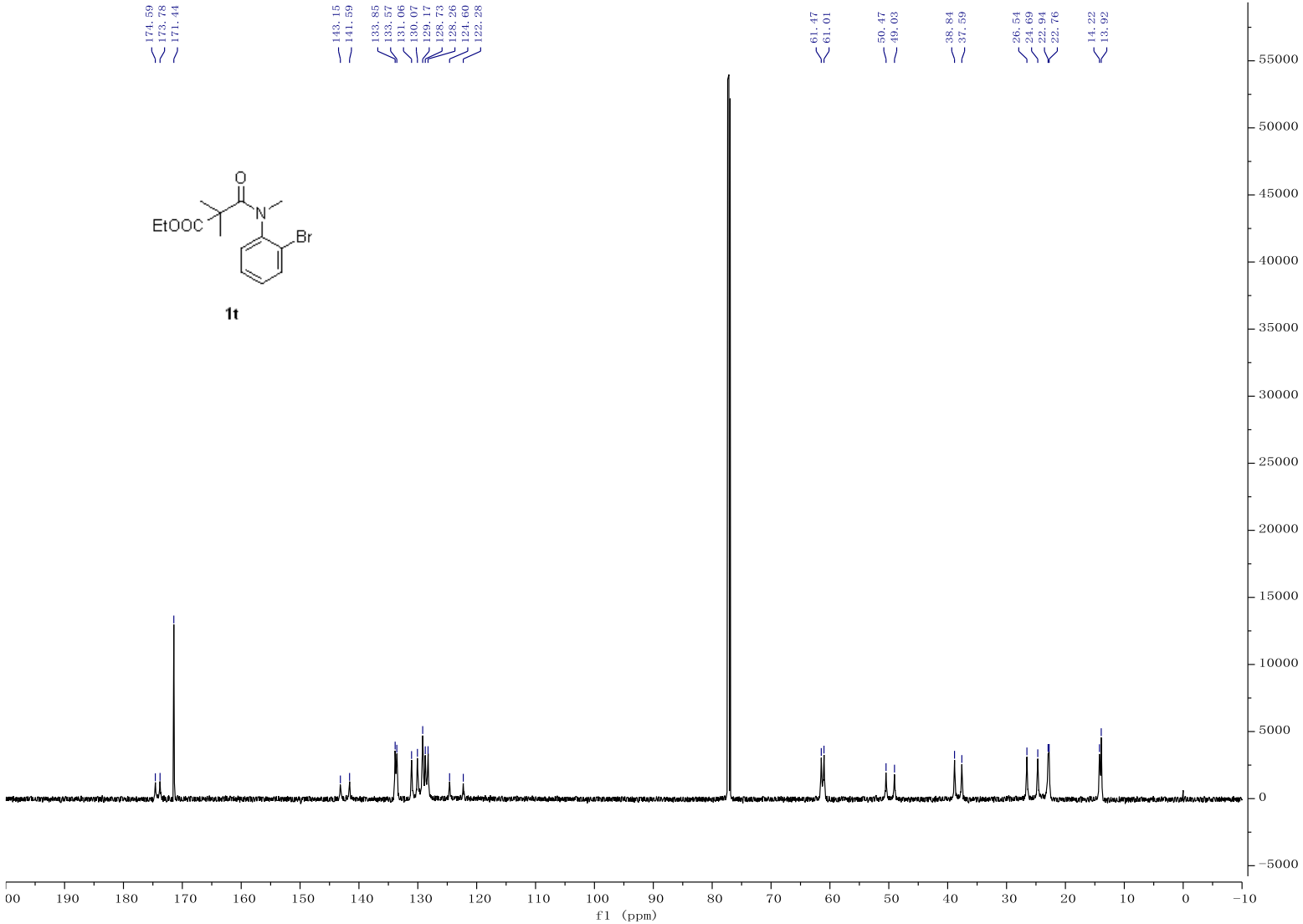

166.00
137.72
135.09
133.83
132.65
132.28
130.78
130.63
129.29
128.58
127.76
125.24
124.37
90.34
53.21
28.65
23.06
Br
Br
O
N
O_2N
1r
f1 (ppm)

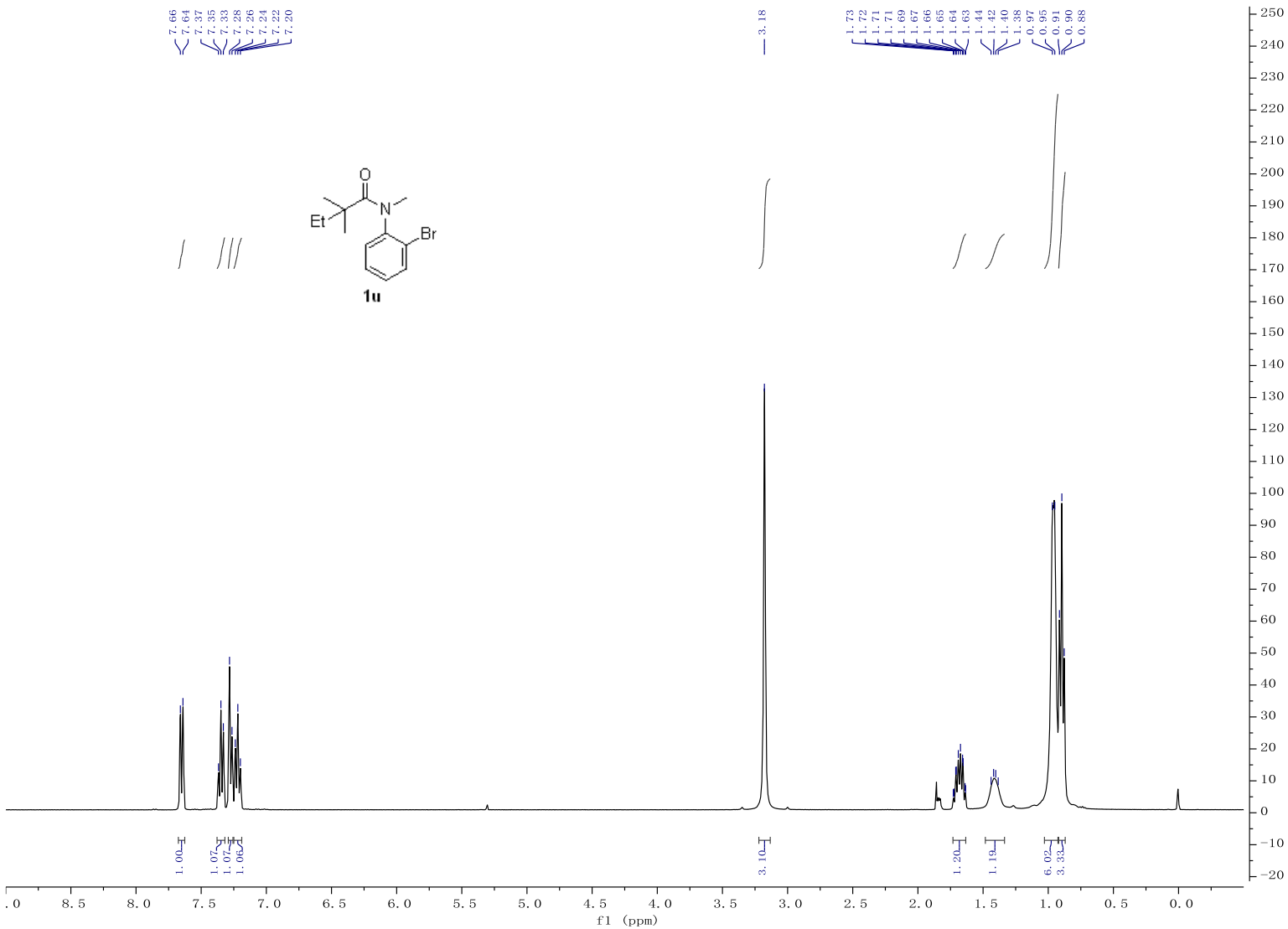

7.68
7.66
7.42
7.40
7.38
7.35
7.33
7.29
7.27
7.25
3.21
1.35
1.04
O
N
F3C
Br
1s
1.00
1.07
1.01
1.10
3.14
3.15
3.10
f1 (ppm)

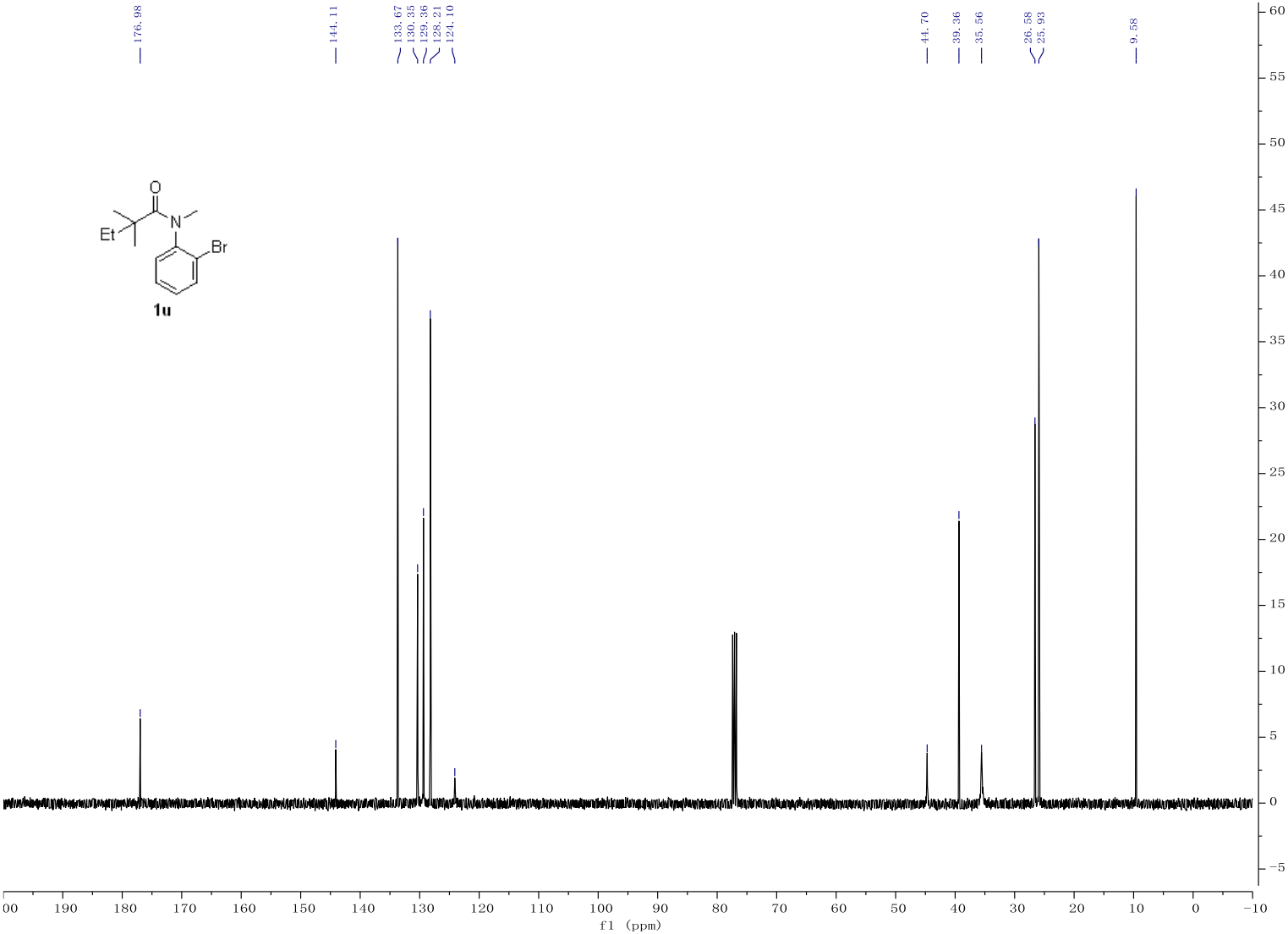

168.99
142.96
133.77
131.06
130.46
130.00
128.61
128.25
125.42
123.85
122.60
50.55
50.30
40.07
21.56
20.09
O
N
F3C
Br
1s
f1 (ppm)


O
N
F3C
Br
1s
-73.99
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
-45
-50
-55
-60
-65
-70
-75
-80
-85
f1 (ppm)

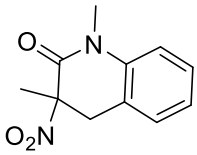

7.66
7.64
7.36
7.35
7.34
7.33
7.32
7.31
7.31
7.24
7.23
7.22
7.22
4.30
3.98
3.20
1.58
1.53
1.43
1.35
1.25
1.21
1.17
EtOOC
O
N
Br
1t
1.00
1.04
2.08
1.06
1.11
3.02
9.22
f1 (ppm)


174.59
173.78
171.44
143.15
141.59
133.85
133.57
131.06
130.07
129.17
128.73
128.26
124.60
122.28
61.47
61.01
50.47
49.03
38.84
37.59
26.54
24.69
22.94
22.76
14.22
13.92
EtOOC
O
N
Br
1t
55000
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
−5000
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
f1 (ppm)


7.66
7.64
7.37
7.35
7.33
7.28
7.26
7.24
7.22
7.20
3.18
1.73
1.72
1.71
1.71
1.69
1.67
1.66
1.65
1.64
1.63
1.44
1.42
1.40
1.38
0.97
0.95
0.91
0.90
0.88
O
N
Et
Br
1u
1.00
1.07
1.07
1.06
3.10
1.20
1.19
6.02
3.33
f1 (ppm)

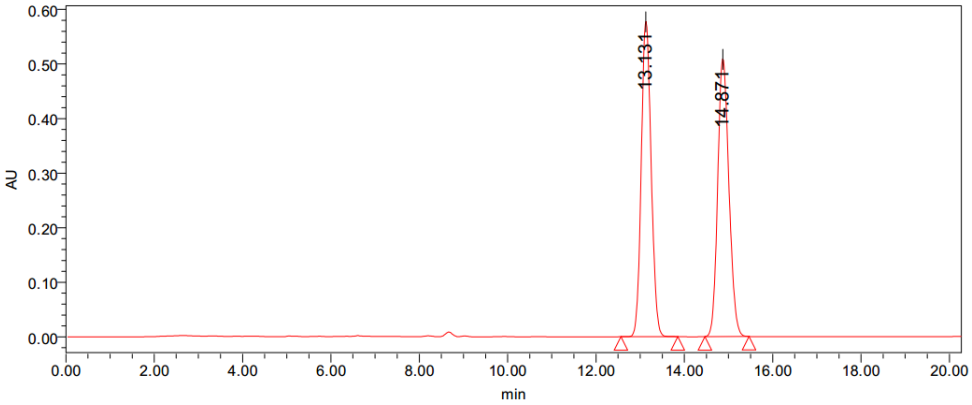

176.98
144.11
133.67
130.35
129.36
128.21
124.10
44.70
39.36
35.56
26.58
25.93
9.58
O
N
Et
Br
1u
f1 (ppm)

HPLC Charts

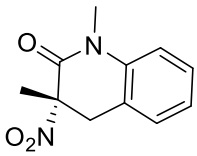


Rac-**2a**

CHROMATOGRAM

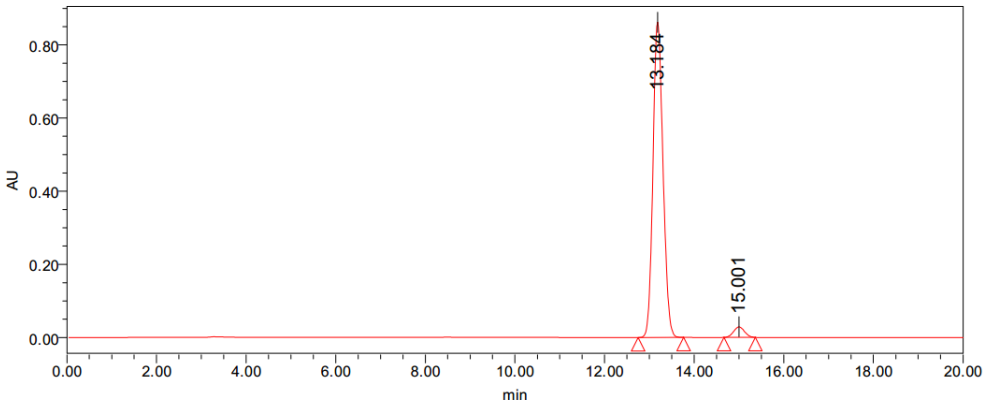


	Rt(min)	Area	% Area
1	13.131	8963434	49.95
2	14.871	8980779	50.05

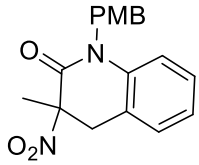


(*S*)-**2a**

CHROMATOGRAM

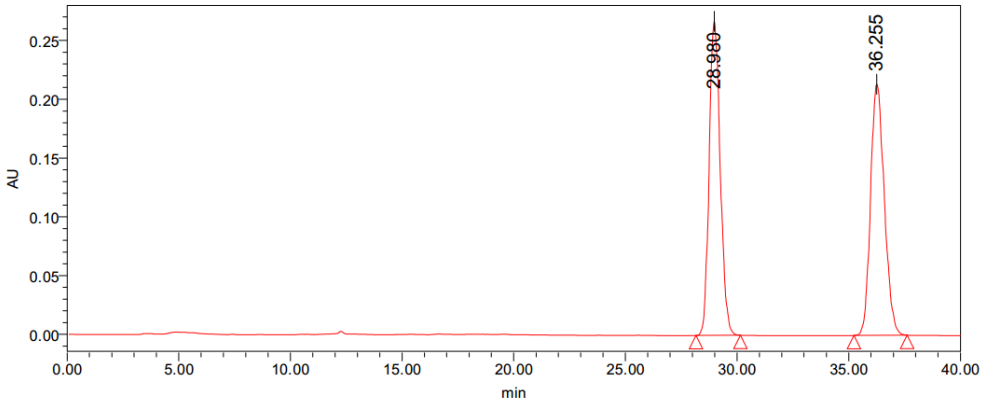


	Rt(min)	Area	% Area
1	13.184	13393103	96.52
2	15.001	483380	3.48

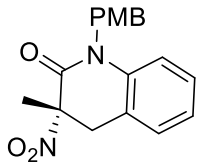


Rac-**2b**

CHROMATOGRAM

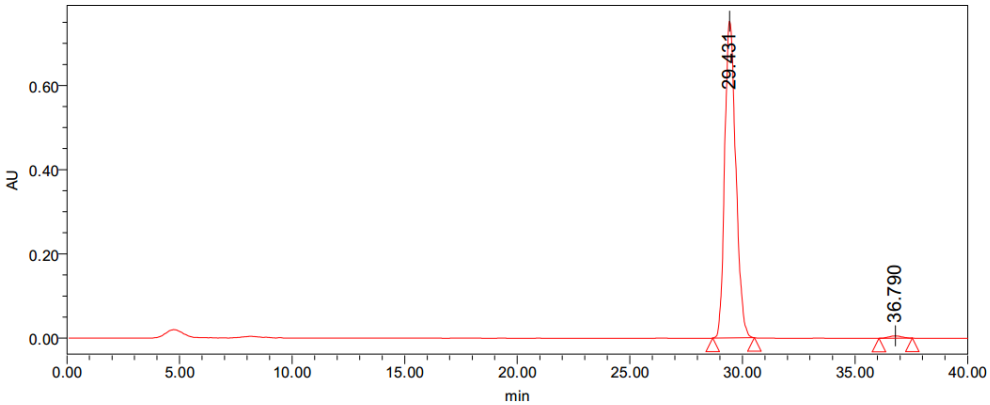


	Rt(min)	Area	% Area
1	28.980	9165561	50.05
2	36.255	9148600	49.95

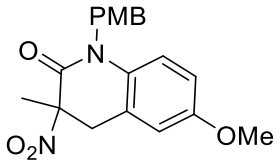


(*S*)-**2b**

CHROMATOGRAM

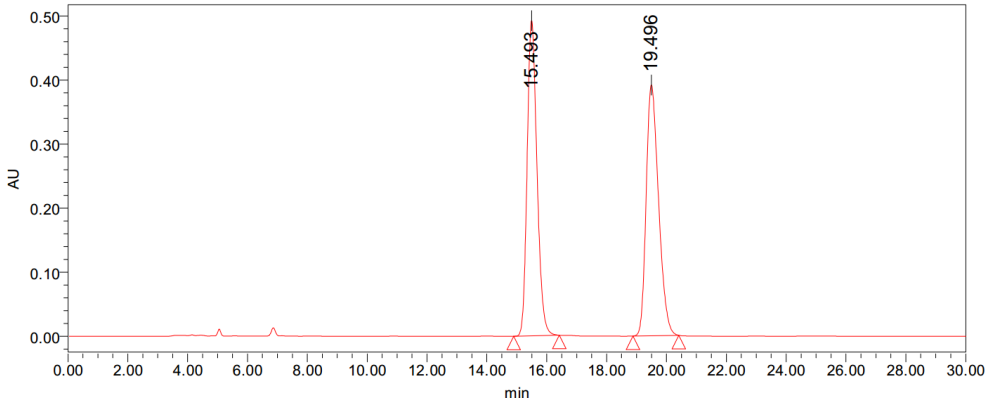


	Rt(min)	Area	% Area
1	29.431	25701070	99.15
2	36.790	219086	0.85

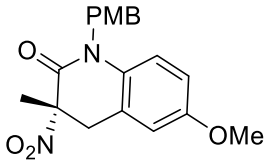


Rac-**2c**

CHROMATOGRAM

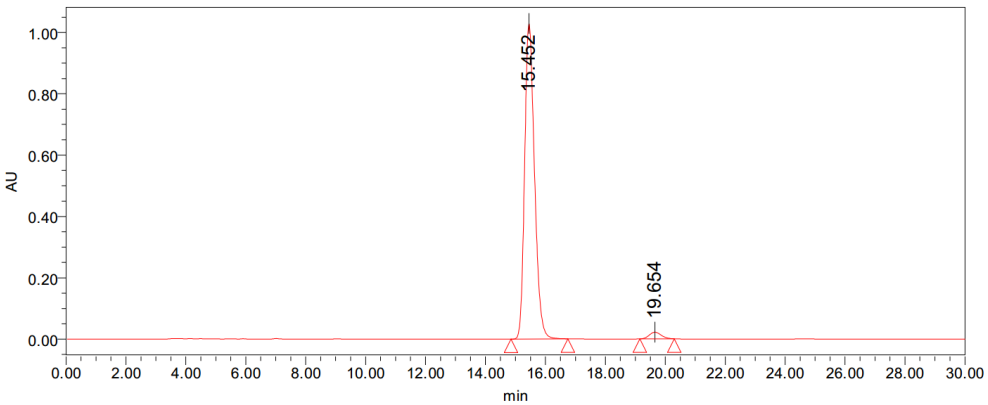


	Rt(min)	Area	% Area
1	15.493	11237191	49.99
2	19.496	11242864	50.01

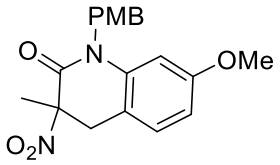


(*S*)-**2c**

CHROMATOGRAM

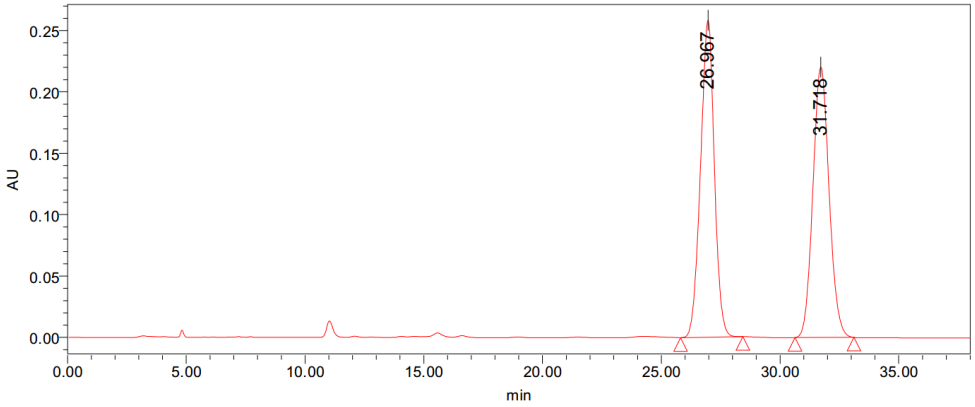


	Rt(min)	Area	% Area
1	15.452	23463578	97.46
2	19.654	610617	2.54

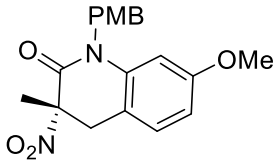


Rac-**2d**

CHROMATOGRAM

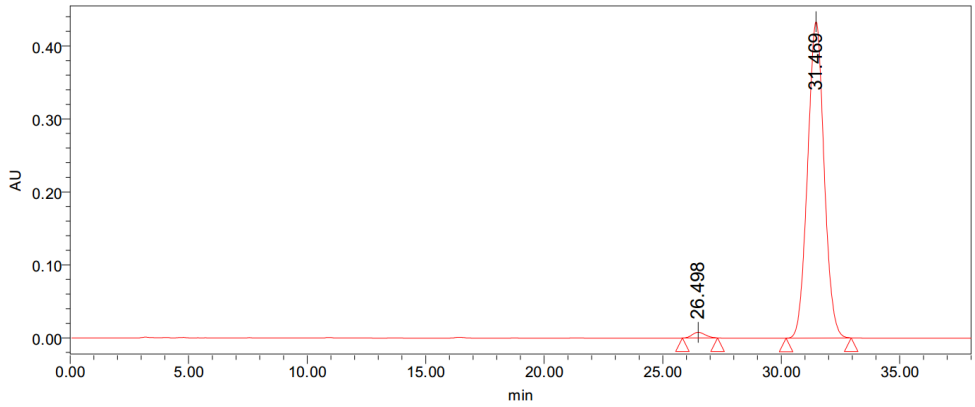


	Rt(min)	Area	% Area
1	26.967	10432951	49.98
2	31.718	10440584	50.02

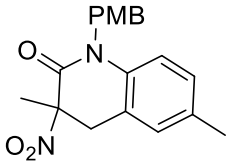


(*S*)-**2d**

CHROMATOGRAM

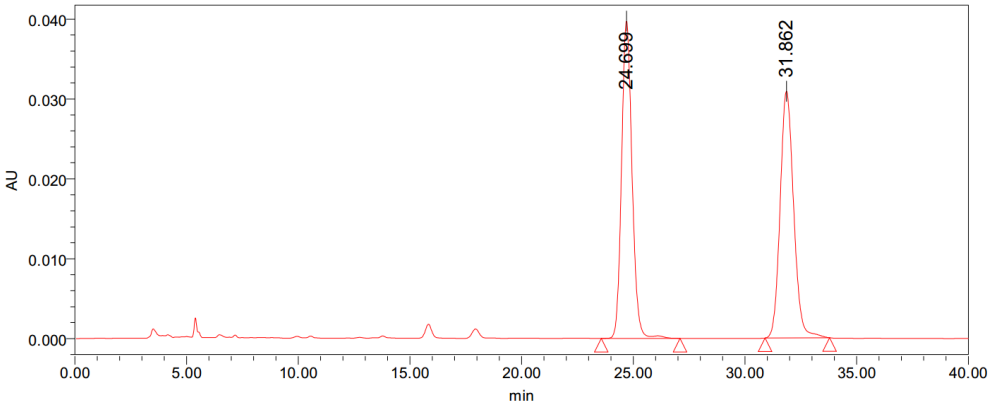


	Rt(min)	Area	% Area
1	26.498	298605	1.40
2	31.469	20964183	98.60

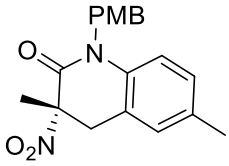


Rac-**2e**

CHROMATOGRAM

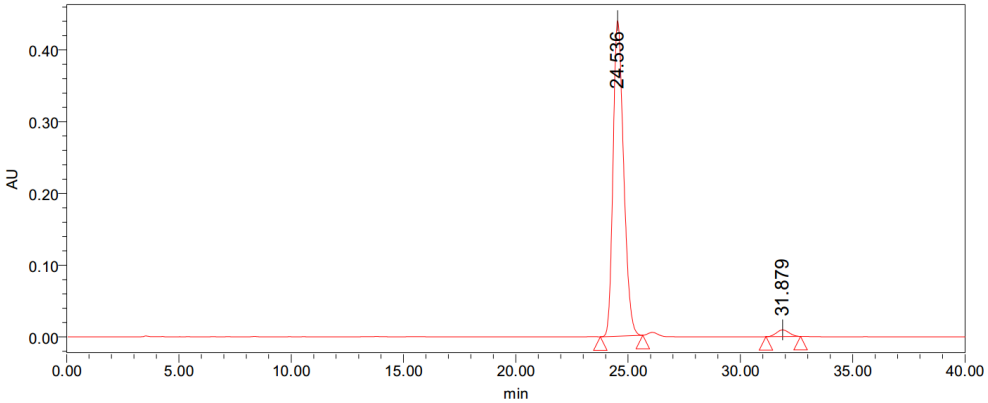


	Rt(min)	Area	% Area
1	24.699	1293993	49.93
2	31.862	1297813	50.07

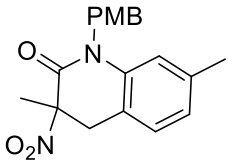


(*S*)-**2e**

CHROMATOGRAM

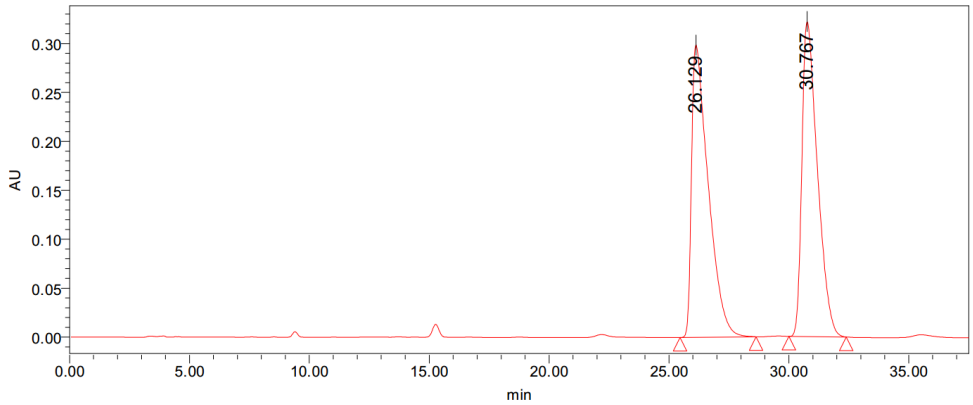


	Rt(min)	Area	% Area
1	24.536	14363833	97.53
2	31.879	364377	2.47

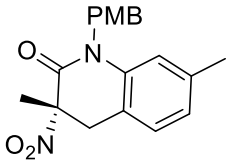


Rac-**2f**

CHROMATOGRAM

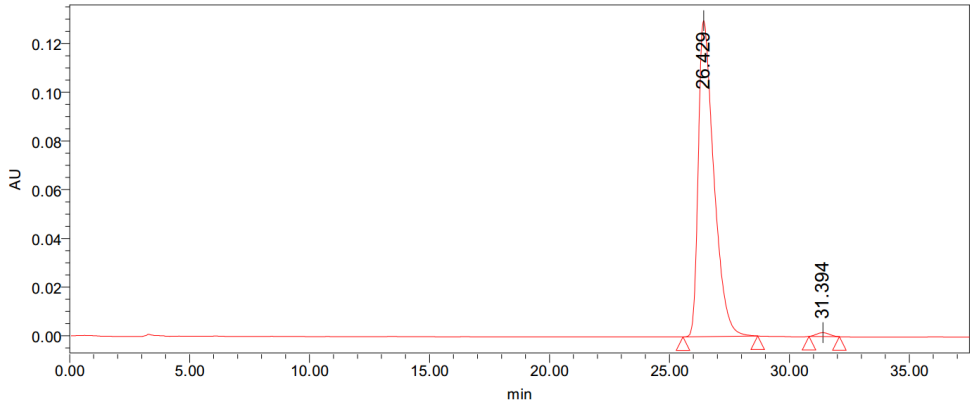


	Rt(min)	Area	% Area
1	26.129	14455294	49.98
2	30.767	14468726	50.02

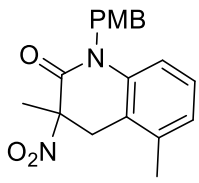


(*S*)-**2f**

CHROMATOGRAM

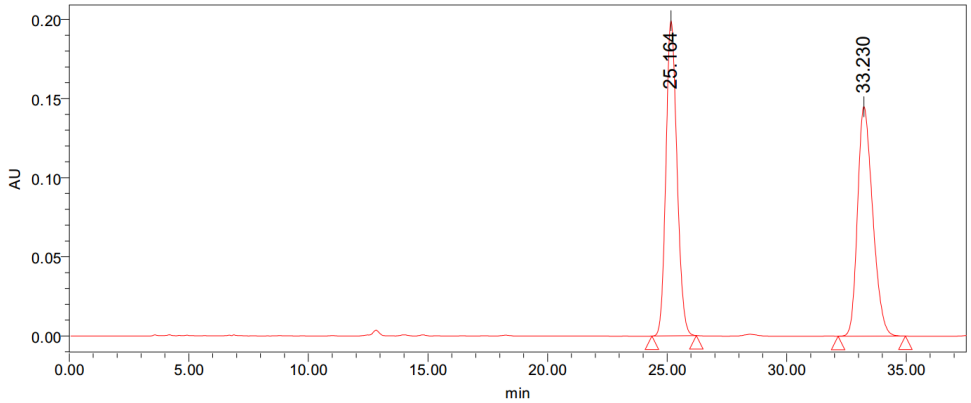


	Rt(min)	Area	% Area
1	26.429	5831155	98.98
2	31.394	60001	1.02

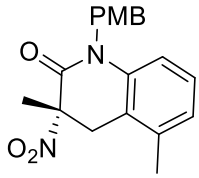


Rac-**2g**

CHROMATOGRAM

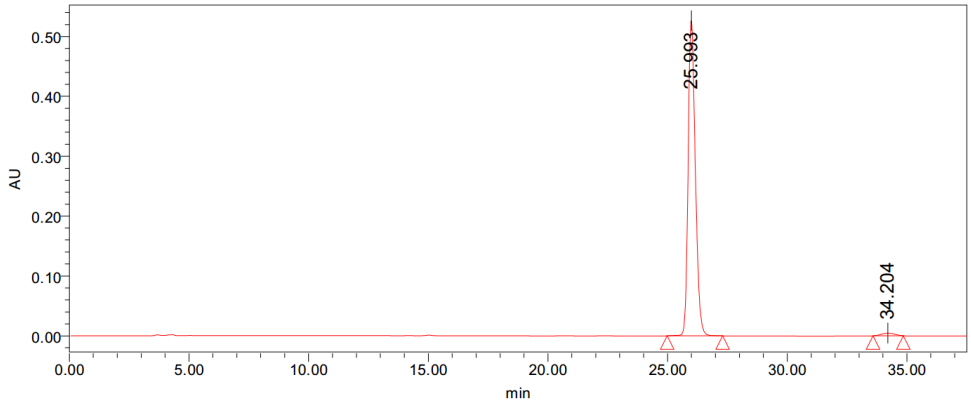


	Rt(min)	Area	% Area
1	25.164	6382739	50.04
2	33.230	6371841	49.96

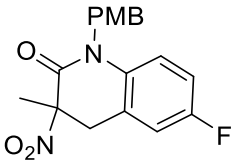


(*S*)-**2g**

CHROMATOGRAM

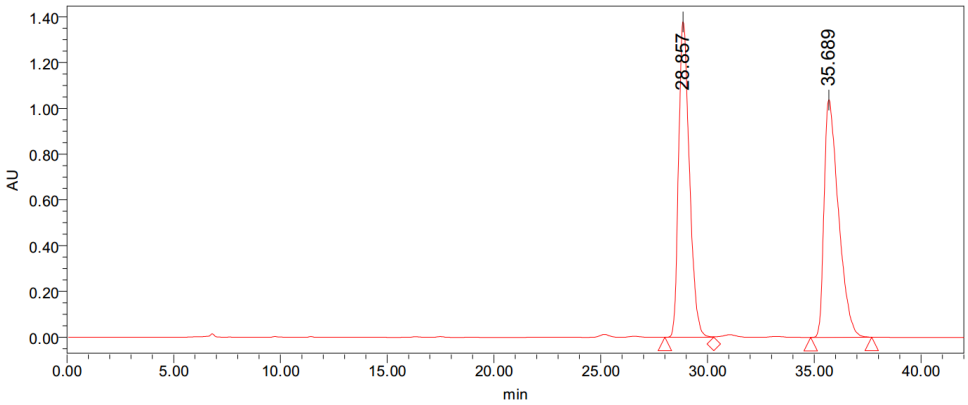


	Rt(min)	Area	% Area
1	25.993	11048136	98.49
2	34.204	169707	1.51

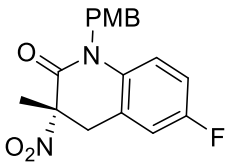


Rac-**2h**

CHROMATOGRAM

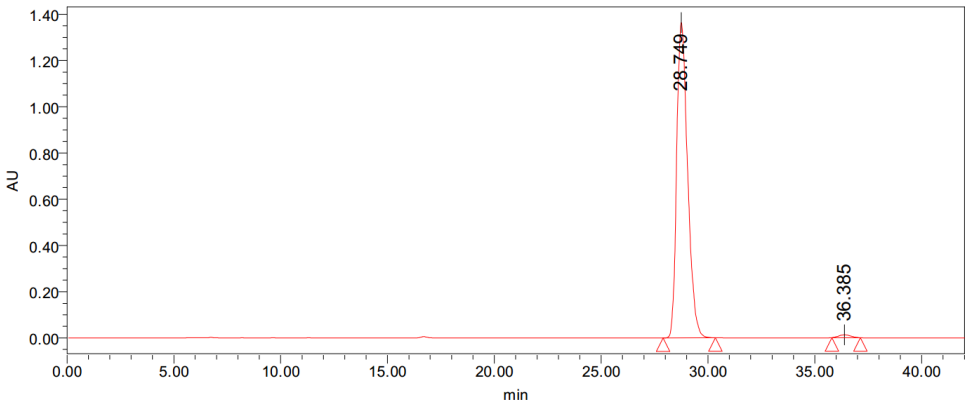


	Rt(min)	Area	% Area
1	28.857	48499444	50.00
2	35.689	48508625	50.00

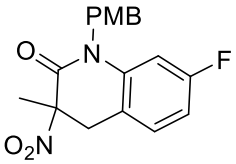


(*S*)-**2h**

CHROMATOGRAM

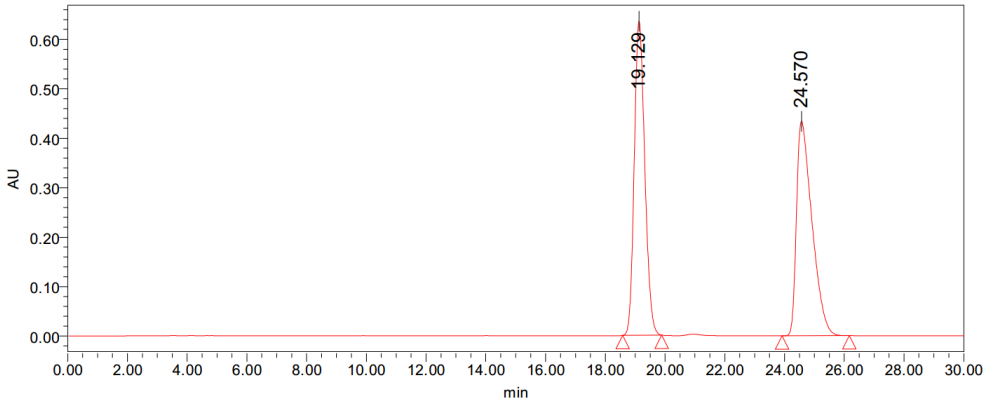


	Rt(min)	Area	% Area
1	28.749	48385250	99.00
2	36.385	487548	1.00

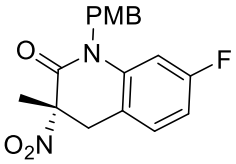


Rac-**2i**

CHROMATOGRAM

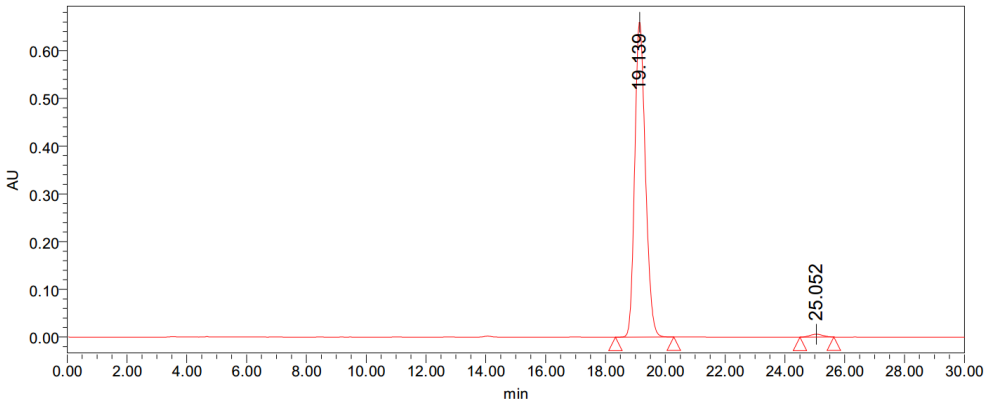


	Rt(min)	Area	% Area
1	19.129	15550798	49.94
2	24.570	15590514	50.06

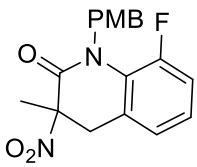


(*S*)-**2i**

CHROMATOGRAM

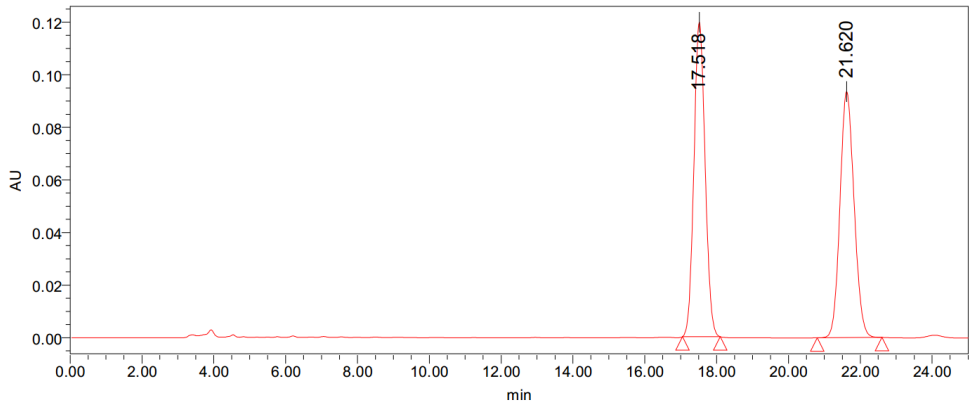


	Rt(min)	Area	% Area
1	19.139	16343063	98.89
2	25.052	183505	1.11

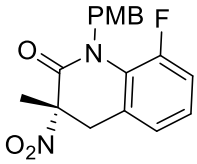


Rac-**2j**

CHROMATOGRAM

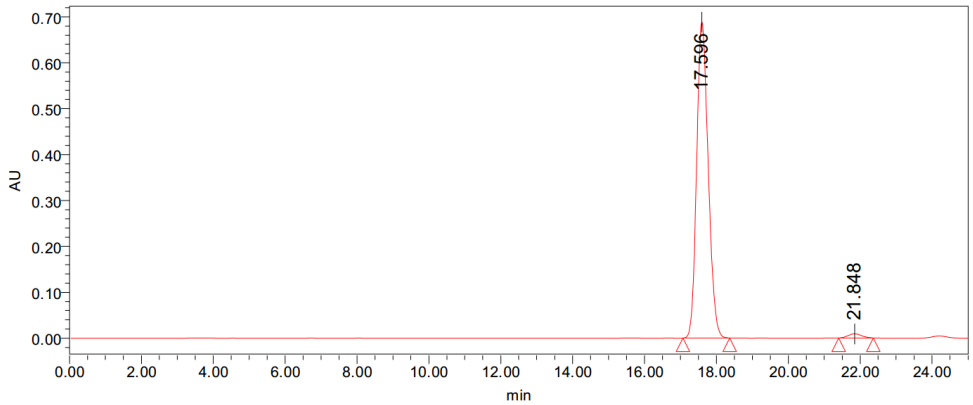


	Rt(min)	Area	% Area
1	17.518	2592850	50.41
2	21.620	2551048	49.59

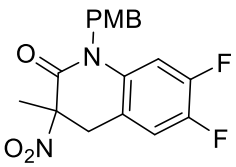


(*S*)-**2j**

CHROMATOGRAM

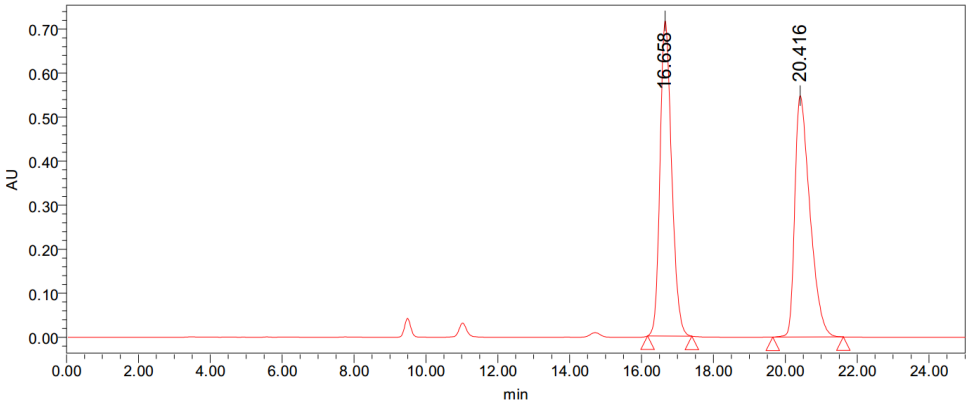


	Rt(min)	Area	% Area
1	17.596	15332908	98.49
2	21.848	234757	1.51

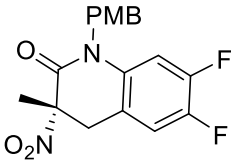


Rac-**2k**

CHROMATOGRAM

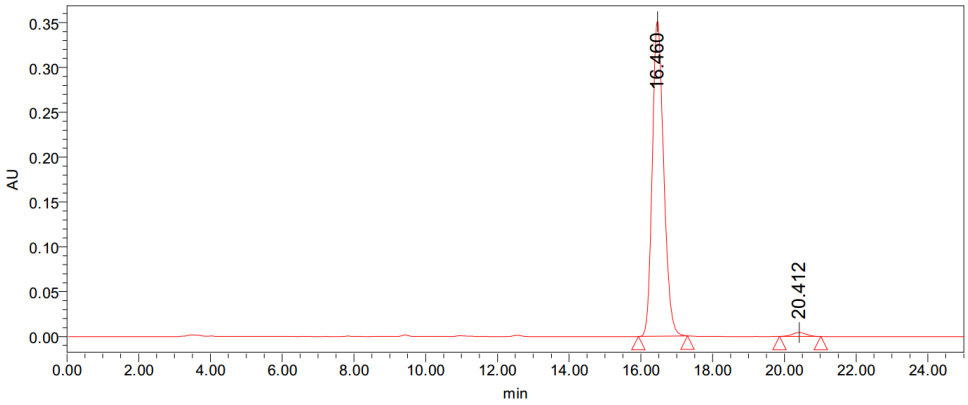


	Rt(min)	Area	% Area
1	16.658	16054619	50.09
2	20.416	15999391	49.91

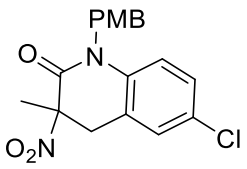


(*S*)-**2k**

CHROMATOGRAM

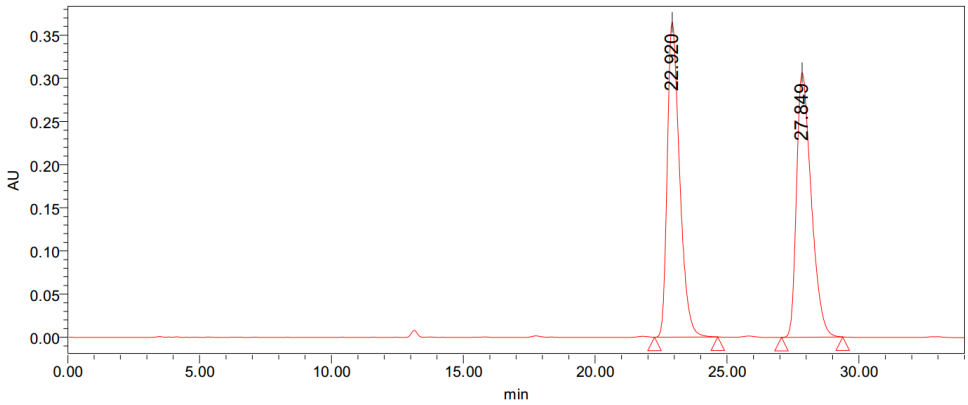


	Rt(min)	Area	% Area
1	16.460	7764022	98.53
2	20.412	115736	1.47

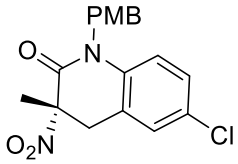


Rac-**2l**

CHROMATOGRAM

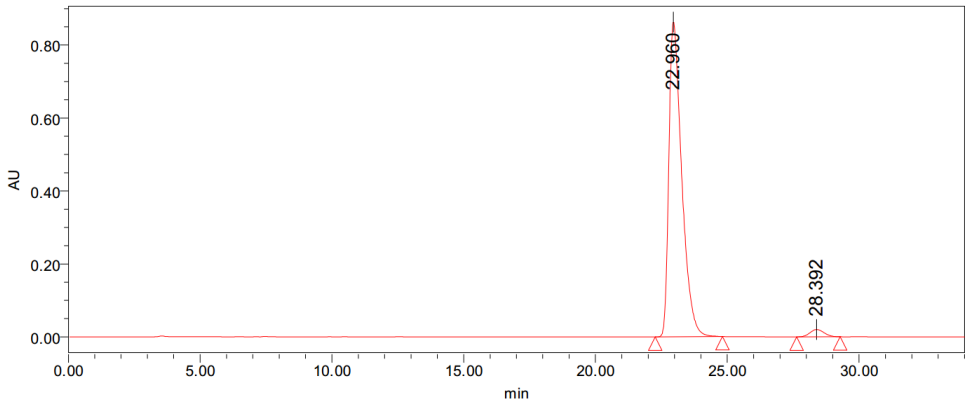


	Rt(min)	Area	% Area
1	22.920	11878774	50.01
2	27.849	11875387	49.99

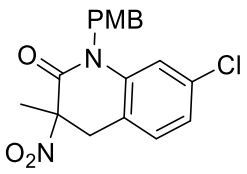


(*S*)-**2l**

CHROMATOGRAM

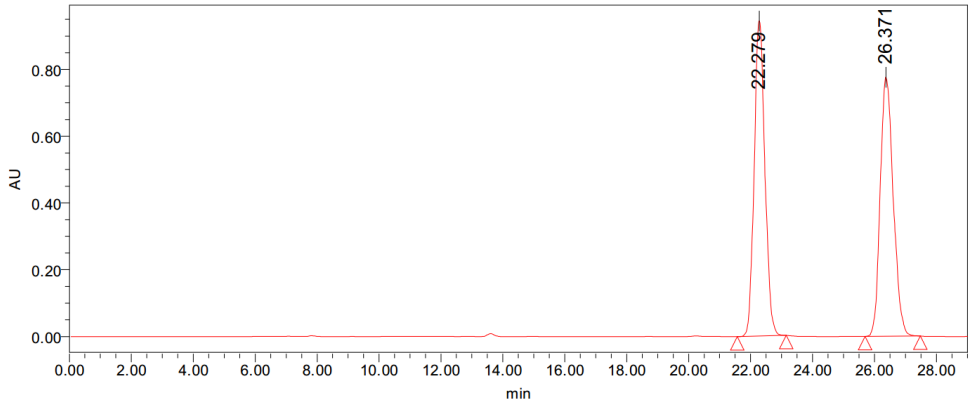


	Rt(min)	Area	% Area
1	22.960	29251780	97.48
2	28.392	754716	2.52

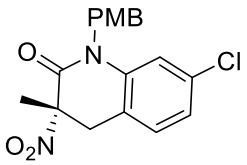


Rac-**2m**

CHROMATOGRAM

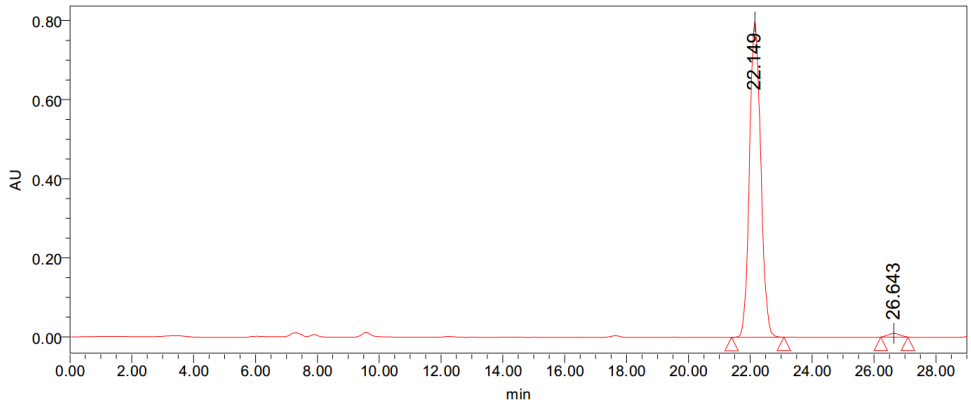


	Rt(min)	Area	% Area
1	22.279	22677735	50.00
2	26.371	22681427	50.00

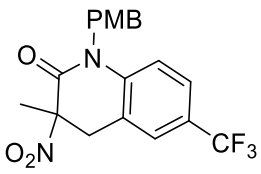


(*S*)-**2m**

CHROMATOGRAM

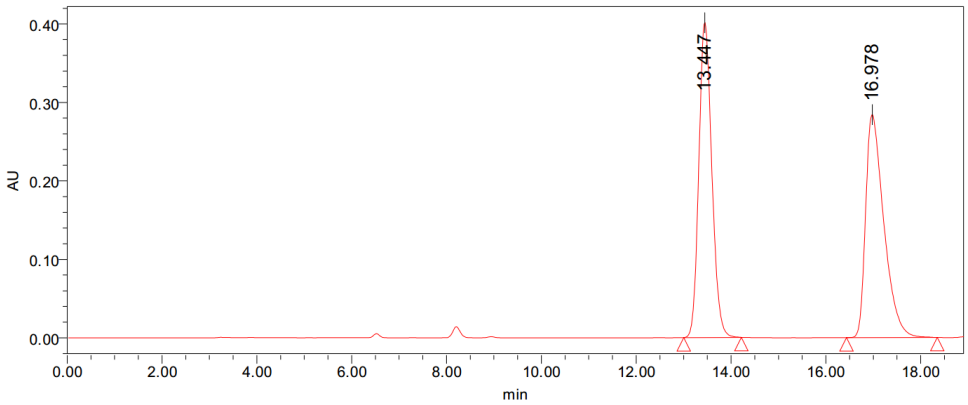


	Rt(min)	Area	% Area
1	22.149	20094656	98.83
2	26.643	238038	1.17

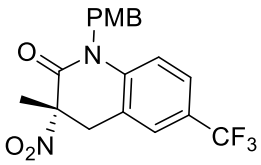


Rac-**2n**

CHROMATOGRAM

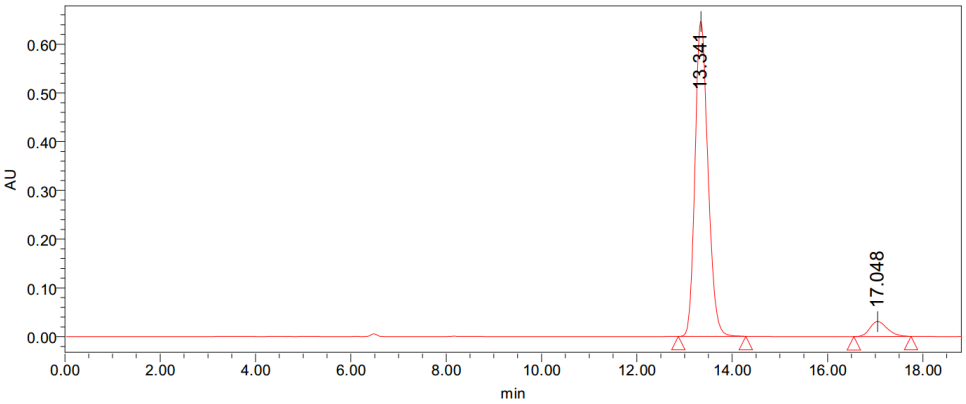


	Rt(min)	Area	% Area
1	13.447	7613994	50.16
2	16.978	7566583	49.84

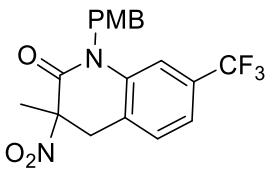


(*S*)-**2n**

CHROMATOGRAM

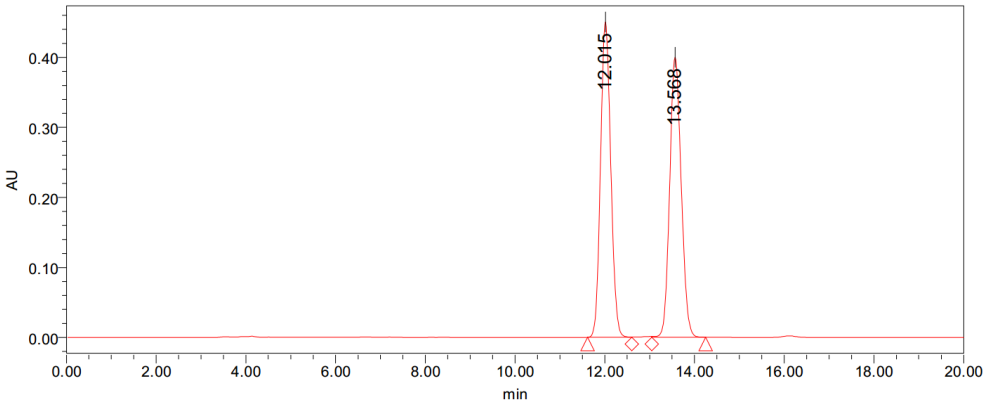


	Rt(min)	Area	% Area
1	13.341	12183240	94.04
2	17.048	772352	5.96

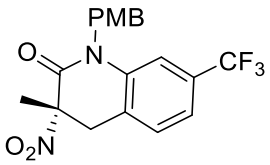


Rac-**2o**

CHROMATOGRAM

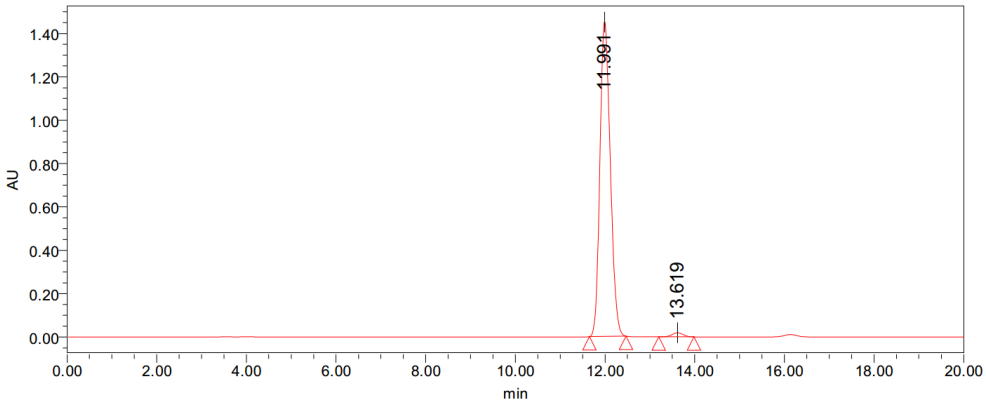


	Rt(min)	Area	% Area
1	12.015	7126878	50.03
2	13.568	7118463	49.97

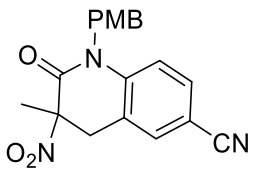


(*S*)-**2o**

CHROMATOGRAM

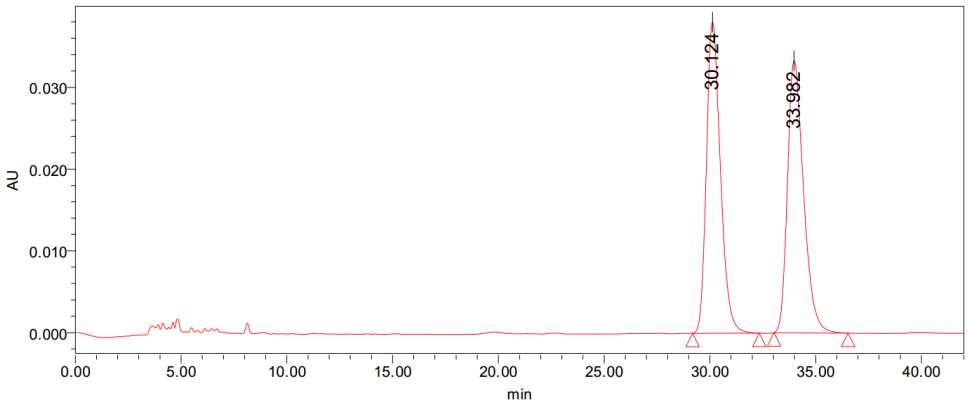


	Rt(min)	Area	% Area
1	11.991	23270446	98.64
2	13.619	319770	1.36

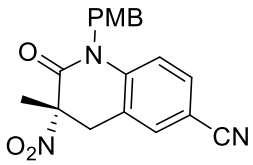


Rac-**2p**

CHROMATOGRAM

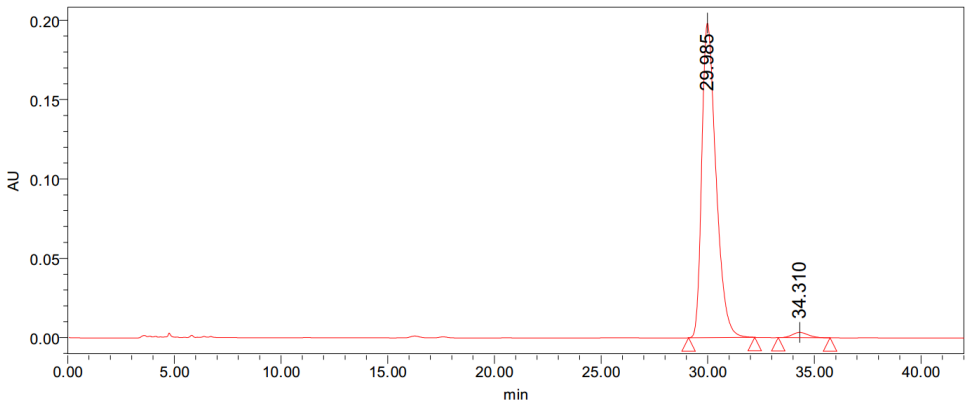


	Rt(min)	Area	% Area
1	30.124	1755171	49.95
2	33.982	1758791	50.05

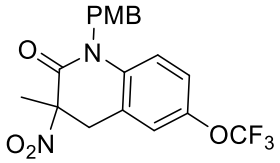


(*S*)-**2p**

CHROMATOGRAM

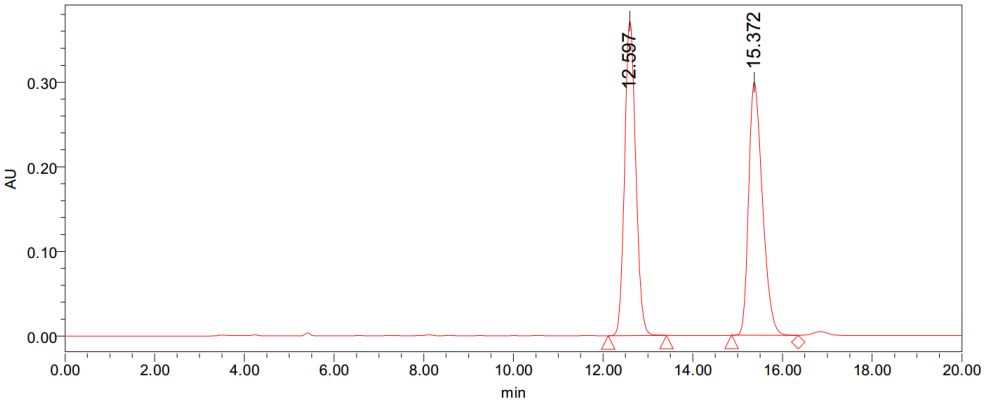


	Rt(min)	Area	% Area
1	29.985	9143185	98.12
2	34.310	174948	1.88

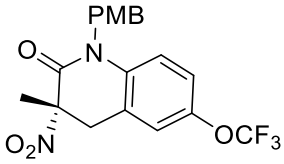


Rac-**2q**

CHROMATOGRAM

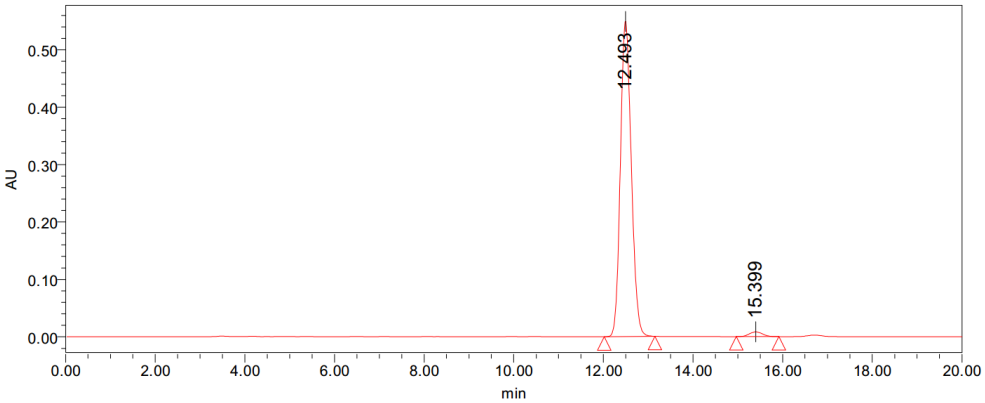


	Rt(min)	Area	% Area
1	12.597	6388780	50.00
2	15.372	6388345	50.00

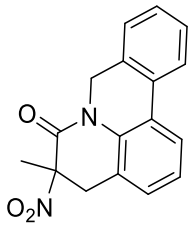


(*S*)-**2q**

CHROMATOGRAM

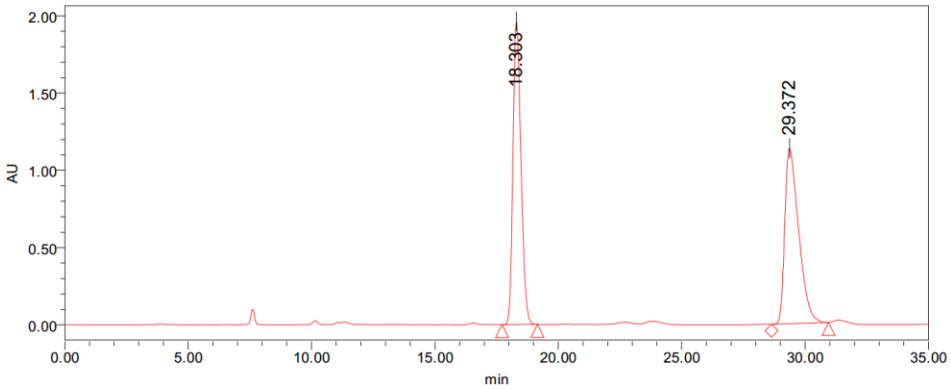


	Rt(min)	Area	% Area
1	12.493	9253036	98.13
2	15.399	175895	1.87

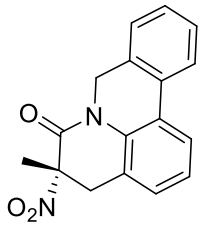


Rac-**2r**

CHROMATOGRAM

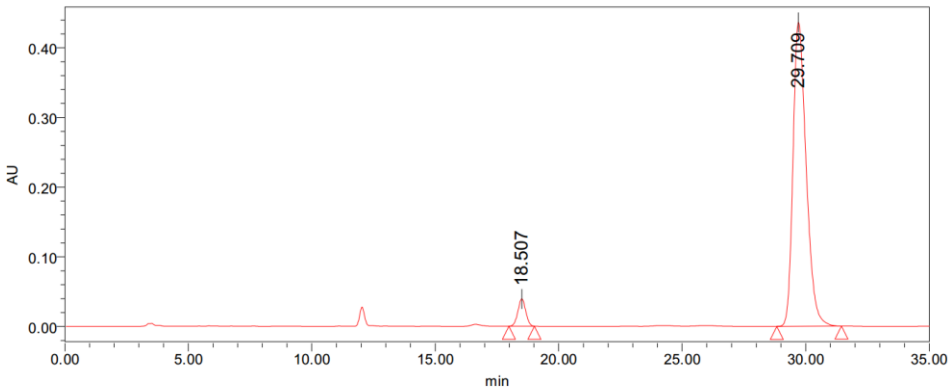


	Rt(min)	Area	% Area
1	18.303	44244221	50.00
2	29.372	44244581	50.00

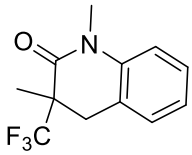


(*S*)-**2r**

CHROMATOGRAM

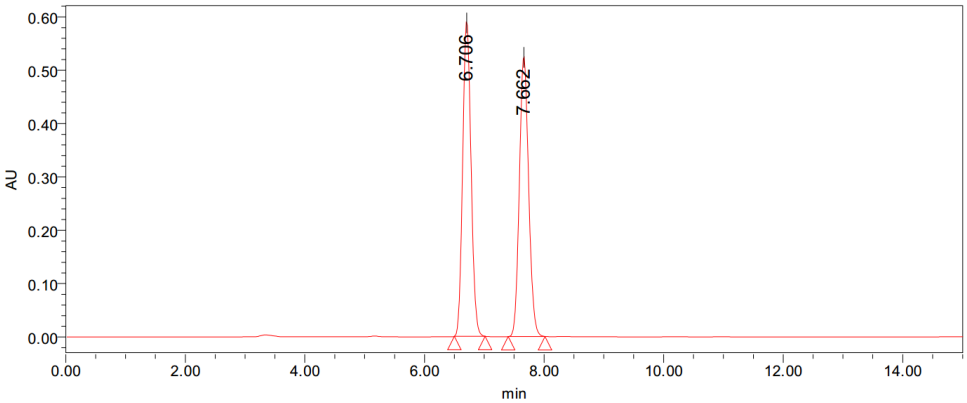


	Rt(min)	Area	% Area
1	18.507	872895	5.13
2	29.709	16144294	94.87

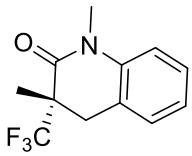


Rac-**2s**

CHROMATOGRAM

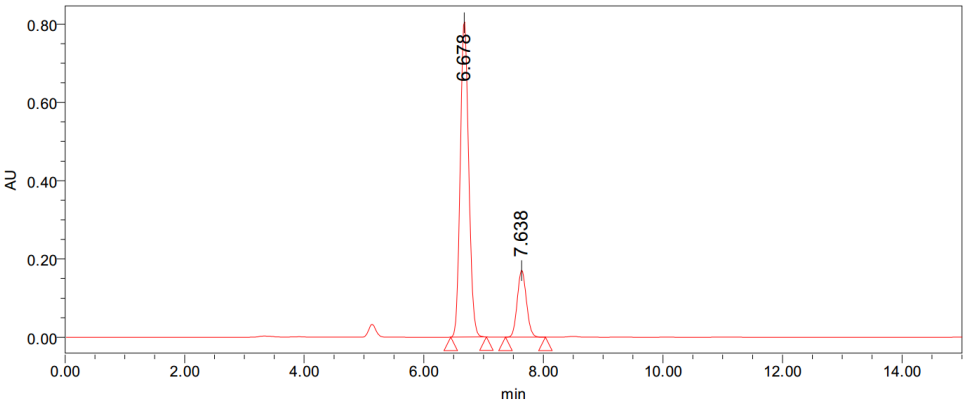


	Rt(min)	Area	% Area
1	6.706	5688937	50.09
2	7.662	5669142	49.91

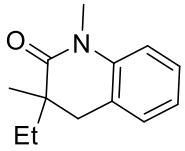


(*S*)-**2s**

CHROMATOGRAM

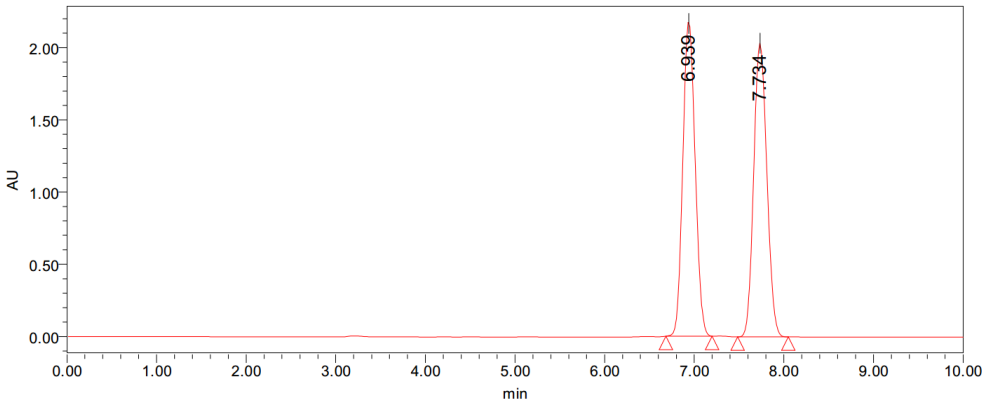


	Rt(min)	Area	% Area
1	6.678	7834471	81.19
2	7.638	1814560	18.81

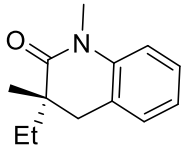


Rac-**2u**

CHROMATOGRAM

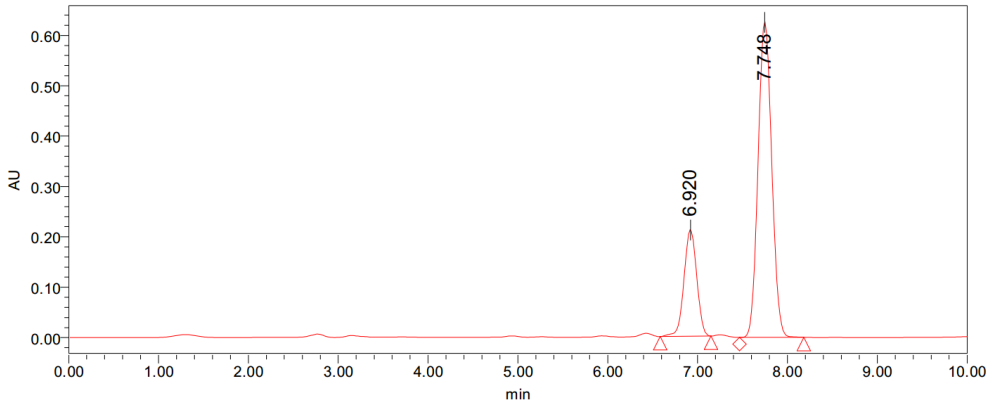


	Rt(min)	Area	% Area
1	6.939	20791723	50.02
2	7.734	20776363	49.98



2u

CHROMATOGRAM



	Rt(min)	Area	% Area
1	6.920	2087688	24.00
2	7.748	6611804	76.00