

Supporting Information

Phosphoric Acid-Catalyzed Asymmetric N-propargylation of Pyridazinones and 2-Pyridones

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Table of Contents

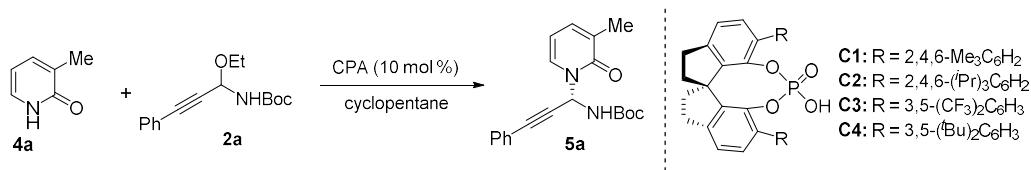
1. General information
2. Preparation of substrates
3. Optimization of the reaction conditions for **5**
4. General procedure for Scheme 2
5. General procedure for Scheme 3
6. Control experiments for Scheme 4
7. X-ray crystallographic data of **5f**
8. References
9. NMR and HPLC Spectra of compounds

General information

All of the reactions were carried out in flame-dried tubes under an argon atmosphere. Solvents were dried prior to use. Commercially obtained reagents were used as received. Analytical thin layer chromatography (TLC) was carried out using pre-coated (0.20 mm thickness) silica gel plates with F₂₅₄ indicator. For column chromatography, 200-300 mesh silica gel was used. ¹H NMR spectra were recorded on Bruker 300 MHz, or 400 MHz spectrometer in CDCl₃ or DMSO-d₆. ¹³C NMR spectra were recorded on Bruker 75 MHz, or 100 MHz spectrometer in CDCl₃ or DMSO-d₆. ¹⁹F NMR spectra were recorded on Bruker 376 MHz spectrometer in CDCl₃ or DMSO-d₆. Data for ¹H NMR spectra were reported relative to tetramethylsilane (TMS) as an internal standard (0 ppm) and were reported as follows: chemical shift (δ ppm), multiplicity, coupling constant (Hz) and integration. Multiplicities are denoted as follows: s = singlet, d = doublet, t = triplet, q = quartet, dd = doublet of doublets, td = triplet of doublets, and m = multiplet. Data for ¹³C NMR spectra were reported relative to CDCl₃ as an internal standard (77.16 ppm) and were reported in terms of chemical shift (δ ppm). High resolution mass spectra (HRMS) were performed on Agilent 6540 Q-TOF or Agilent 6230A TOF mass spectrometer (ESI). Melting points were uncorrected and determined on a SGW X-4B melting point apparatus. Enantiomeric excess (ee) values were determined by chiral HPLC analysis on Daicel Chiralpak IA, IC, OD-H, AS-H, ID column. Optical rotations were determined on a Shanghai Shenguang® polarimeter and reported as follows: $[\alpha]_D^T$ (c: g/100 mL, solvent).

All of the CPA were known compounds and were purchased from Daicel Chiral Technologies (China) Co., Ltd. All of the Pyridazinones **1** and Pyridones **4** were known compounds and were purchased from Aladdin, Bide pharm and Energy Chemical. All of the C-alkynyl N,O-acetals **2** were known and prepared according to the literature procedures.¹

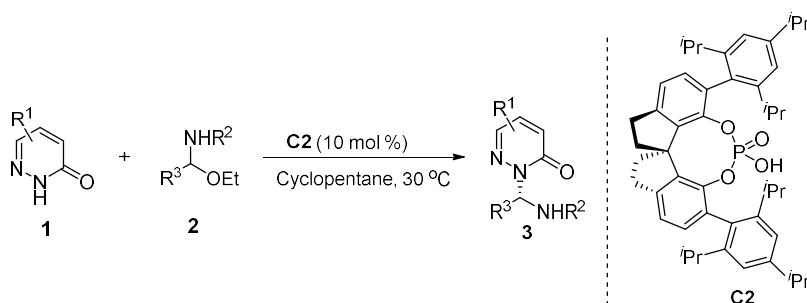
Optimization of the reaction conditions for 5^a



entry	CPA	solvent	1a:2a	t (°C)	yield (%) ^b	ee (%) ^c
1	C1	cyclopentane	1:4	30	23	0
2	C2	cyclopentane	1:4	30	83	83
3	C3	cyclopentane	1:4	30	<5	0
4	C4	cyclopentane	1:4	30	23	26
5	C2	DCM	1:4	30	56	76
6	C2	DCE	1:4	30	43	70
7	C2	Et ₂ O	1:4	30	32	72
8	C2	MeCN	1:4	30	27	60
9	C2	Hexane	1:4	30	16	86
10	C2	PhMe	1:4	30	68	78
11	C2	THF	1:4	30	61	78
12	C2	cyclohexane	1:4	30	72	82
13	C2	cyclopentane	1:4	25	79	88
14	C2	cyclopentane	1:4	20	58	90
15	C2	cyclopentane	1:4	10	<10	94
16	C2	cyclopentane	1:4	0	<5	94
17 ^d	C2	Cyclopentane	1:4	25	79	88
18 ^e	C2	cyclopentane	1:4	25	78	93
19 ^f	C2	cyclopentane	1:4	25	78	88
20 ^{e,g}	C2	cyclopentane	1:4	25	35	93

^aReaction conditions: **1a** (0.1 mmol), **2a** (0.4 mmol), catalyst (10 mol %) in solvent (2 mL) under Ar. The reaction was stirred at 25 °C for 24 h. ^bIsolated yield. ^cee was determined by chiral HPLC analysis. ^d3ÅMS (50 mg) was added. ^e4ÅMS (50 mg) was added. ^f5ÅMS (50 mg) was added. ^g5 mol % of **C2** was used.

General procedure for Scheme 2

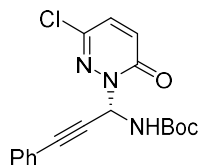


To a 10 mL of dry Schlenk tube were added **C2** (7.2 mg, 0.01 mmol, 10 mol %), **1** (0.1 mmol, 1.0 equiv) and **2** (0.4 mmol, 4.0 equiv), then Cyclopentane (2 mL) was added under argon atmosphere. The resulting mixture was stirred at 30 °C for 24 hours. The reaction mixture was concentrated

under vacuum; the crude residue was purified by silica gel column chromatography (eluent: petroleum ether/EtOAc = 10:1-3:1) to give **3**.

[Note: racemic samples were prepared by using BNDHP instead of **C2**.]

***tert*-Butyl (*S*)-(1-(3-chloro-6-oxopyridazin-1(6*H*)-yl)-3-phenylprop-2-yn-1-yl)carbamate (**3a**)**



Prepared from 6-chloropyridazin-3(2*H*)-one (13.0 mg, 0.1 mmol, 1.0 equiv) and *tert*-butyl (1-ethoxy-3-phenylprop-2-yn-1-yl)carbamate (110.0 mg, 0.4 mmol, 4.0 equiv) according to the general procedure in the presence of **C2** (7.2 mg, 0.01 mmol, 10 mol %), purified by silica gel column chromatography (petroleum ether/ EtOAc = 10:1 to 3:1) and was obtained as a white solid (31.6 mg, 88%), mp: 159-161 °C.

R_f (Petroleum ether/ EtOAc = 3:1) = 0.3.

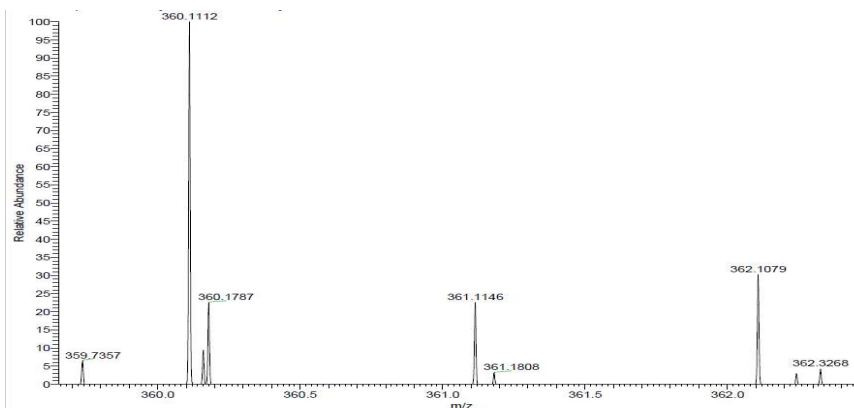
HPLC (IC, *n*-hexane/*i*-PrOH = 50/50, flow rate = 1.0 mL/min, I = 215 nm) *t_R* = 8.84 min (major), 10.79 min (minor), 94% ee.

[α]_D²⁵: +29.76 (c = 0.25, CH₂Cl₂).

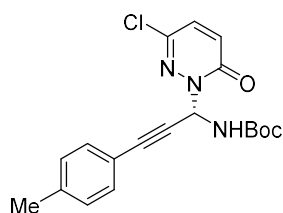
¹H NMR (400 MHz, CDCl₃) δ 7.46-7.39 (m, 2H), 7.37-7.22 (m, 4H), 7.16 (d, *J* = 9.6 Hz, 1H), 6.93 (d, *J* = 9.6 Hz, 1H), 6.23 (s, 1H), 1.45 (s, 9H).

¹³C NMR (100 MHz, CDCl₃) δ 157.6, 153.5, 138.1, 134.2, 132.8, 132.1, 129.2, 128.4, 121.4, 85.1, 82.8, 81.3, 59.0, 28.3.

HRMS (ESI) *m/z*: [M+H]⁺ Calcd for C₁₈H₁₉ClN₃O₃ 360.1109; Found 360.1112.



***tert*-Butyl (*S*)-(1-(3-chloro-6-oxopyridazin-1(6*H*)-yl)-3-(*p*-tolyl)prop-2-yn-1-yl)carbamate (**3b**)**



Prepared from 6-chloropyridazin-3(2*H*)-one (13.0 mg, 0.1 mmol, 1.0 equiv) and *tert*-butyl (1-ethoxy-3-(*p*-tolyl)prop-2-yn-1-yl)carbamate (115.7 mg, 0.4 mmol, 4.0 equiv) according to the general procedure in the presence of **C2** (7.2 mg, 0.01 mmol, 10 mol %), purified by silica gel

column chromatography (petroleum ether/ EtOAc = 10:1 to 3:1) and was obtained as a white solid (34.7 mg, 93%), mp: 177-179 °C.

R_f (Petroleum ether/ EtOAc = 3:1) = 0.3.

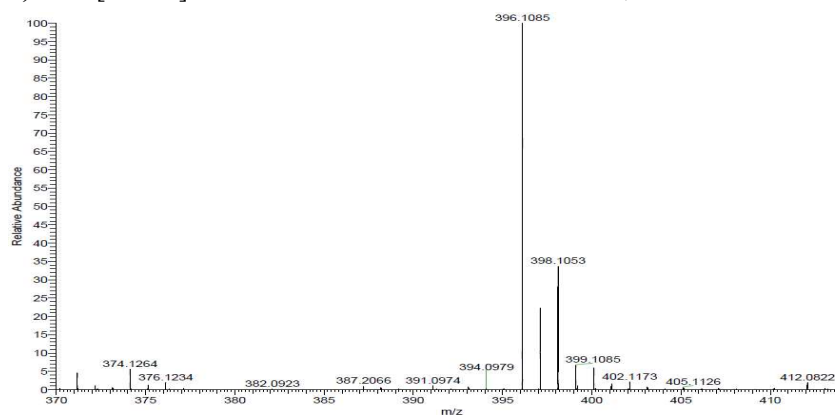
HPLC (IC, *n*-hexane/*i*-PrOH = 60/40, flow rate = 1.0 mL/min, I = 215 nm) t_R = 11.07 min (major), 14.23 min (minor), 96% ee.

$[\alpha]_D^{25}$: +8.96 (c = 0.25, CH₂Cl₂).

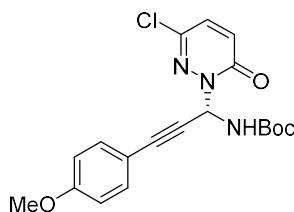
¹H NMR (400 MHz, CDCl₃) δ 7.35-7.30 (m, 2H), 7.25 (d, *J* = 9.6 Hz, 1H), 7.16 (d, *J* = 9.6 Hz, 1H), 7.10 (d, *J* = 7.6 Hz, 2H), 6.92 (d, *J* = 9.6 Hz, 1H), 6.19 (s, 1H), 2.33 (s, 3H), 1.45 (s, 9H).

¹³C NMR (100 MHz, CDCl₃) δ 157.6, 153.5, 139.5, 138.0, 134.2, 132.8, 132.0, 129.2, 118.3, 85.3, 82.1, 81.3, 59.1, 28.3, 21.6.

HRMS (ESI) *m/z*: [M+Na]⁺ Calcd for C₁₉H₂₀ClN₃NaO₃ 396.1085; Found 396.1085.



***tert*-Butyl (S)-(1-(3-chloro-6-oxopyridazin-1(6H)-yl)-3-(4-methoxyphenyl)prop-2-yn-1-yl)carbamate (3c)**



Prepared from 6-chloropyridazin-3(2H)-one (13.0 mg, 0.1 mmol, 1.0 equiv) and *tert*-butyl (1-ethoxy-3-(4-methoxyphenyl)prop-2-yn-1-yl)carbamate (122.1 mg, 0.4 mmol, 4.0 equiv) according to the general procedure in the presence of **C2** (7.2 mg, 0.01 mmol, 10 mol %), purified by silica gel column chromatography (petroleum ether/ EtOAc = 10:1 to 2:1) and was obtained as a white solid (34.6 mg, 89%), mp: 135-137 °C.

R_f (Petroleum ether/ EtOAc = 3:1) = 0.1.

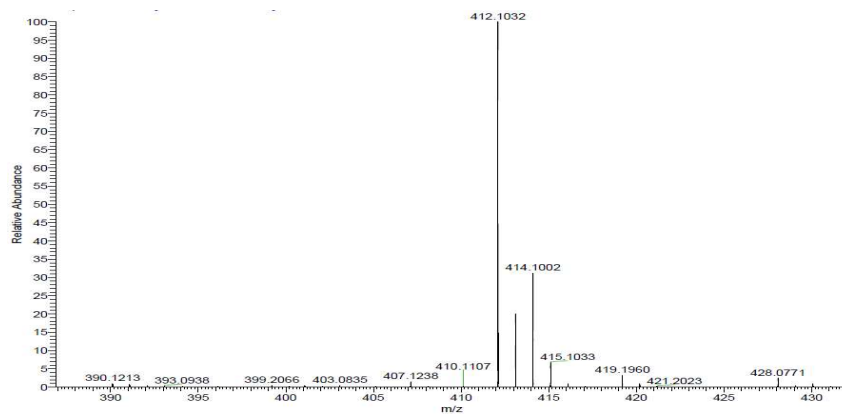
HPLC (IC, *n*-hexane/*i*-PrOH = 50/50, flow rate = 2.0 mL/min, I = 215 nm) t_R = 9.08 min (major), 13.13 min (minor), 90% ee.

$[\alpha]_D^{25}$: +35.68 (c = 0.25, CH₂Cl₂).

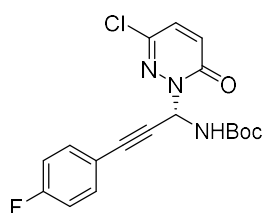
¹H NMR (400 MHz, CDCl₃) δ 7.40-7.32 (m, 2H), 7.25 (d, *J* = 9.6 Hz, 1H), 7.16 (d, *J* = 9.6 Hz, 1H), 6.92 (d, *J* = 9.6 Hz, 1H), 6.85-6.78 (m, 2H), 6.25 (s, 1H), 3.79 (s, 3H), 1.45 (s, 9H).

¹³C NMR (100 MHz, CDCl₃) δ 160.3, 157.6, 153.6, 138.0, 134.2, 133.6, 132.8, 114.0, 113.4, 85.2, 81.5, 81.2, 59.1, 55.4, 28.3.

HRMS (ESI) *m/z*: [M+Na]⁺ Calcd for C₁₉H₂₀ClN₃NaO₄ 412.1035; Found 412.1032.



***tert*-Butyl (S)-(1-(3-chloro-6-oxopyridazin-1(6H)-yl)-3-(4-fluorophenyl)prop-2-yn-1-yl)carbamate (3d)**



Prepared from 6-chloropyridazin-3(2H)-one (13.0 mg, 0.1 mmol, 1.0 equiv) and *tert*-butyl (1-ethoxy-3-(4-fluorophenyl)prop-2-yn-1-yl)carbamate (117.2 mg, 0.4 mmol, 4.0 equiv) according to the general procedure in the presence of **C2** (7.2 mg, 0.01 mmol, 10 mol %), purified by silica gel column chromatography (petroleum ether/ EtOAc = 10:1 to 3:1) and was obtained as a white solid (27.5 mg, 73%), mp: 139-141 °C.

R_f (Petroleum ether/ EtOAc = 3:1) = 0.3.

HPLC (IC, *n*-hexane/*i*-PrOH = 70/30, flow rate = 1.0 mL/min, I = 215 nm) t_R = 12.70 min (major), 14.04 min (minor), 92% ee.

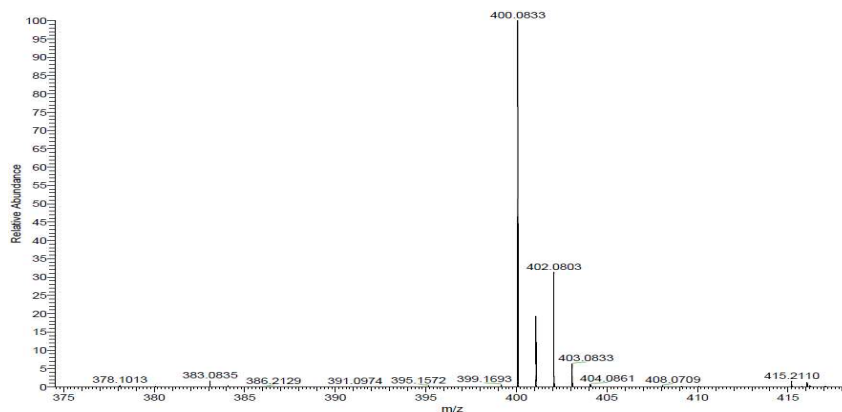
$[\alpha]_D^{25}$: +24.32 (c = 0.25, CH₂Cl₂).

¹H NMR (400 MHz, CDCl₃) δ 7.47-7.38 (m, 2H), 7.24 (d, *J* = 9.6 Hz, 1H), 7.19 (d, *J* = 9.6 Hz, 1H), 7.04-6.97 (m, 2H), 6.94 (d, *J* = 9.6 Hz, 1H), 6.20 (s, 1H), 1.45 (s, 9H).

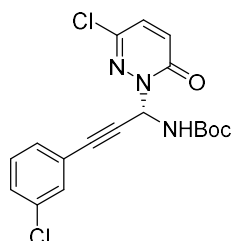
¹³C NMR (100 MHz, CDCl₃) δ 163.0 (d, *J* = 250.0 Hz), 157.6, 153.5, 138.1, 134.3, 134.1 (d, *J* = 9.0 Hz), 132.8, 117.5 (d, *J* = 3.0 Hz), 115.8 (d, *J* = 22.0 Hz), 84.1, 82.5, 81.4, 59.1, 28.3.

¹⁹F NMR (376 MHz, CDCl₃) δ -109.2 (s).

HRMS (ESI) *m/z*: [M+Na]⁺ Calcd for C₁₈H₁₇ClFN₃NaO₃ 400.0835; Found 400.0833.



***tert*-Butyl (S)-(1-(3-chloro-6-oxopyridazin-1(6H)-yl)-3-(3-chlorophenyl)prop-2-yn-1-yl)carbamate (3e)**



Prepared from 6-chloropyridazin-3(2H)-one (13.0 mg, 0.1 mmol, 1.0 equiv) and *tert*-butyl (3-(3-chlorophenyl)-1-ethoxyprop-2-yn-1-yl)carbamate (123.6 mg, 0.4 mmol, 4.0 equiv) according to the general procedure in the presence of **C2** (7.2 mg, 0.01 mmol, 10 mol %), purified by silica gel column chromatography (petroleum ether/ EtOAc = 10:1 to 3:1) and was obtained as a white solid (18.5 mg, 47%), mp: 139-141 °C.

R_f (Petroleum ether/ EtOAc = 3:1) = 0.4.

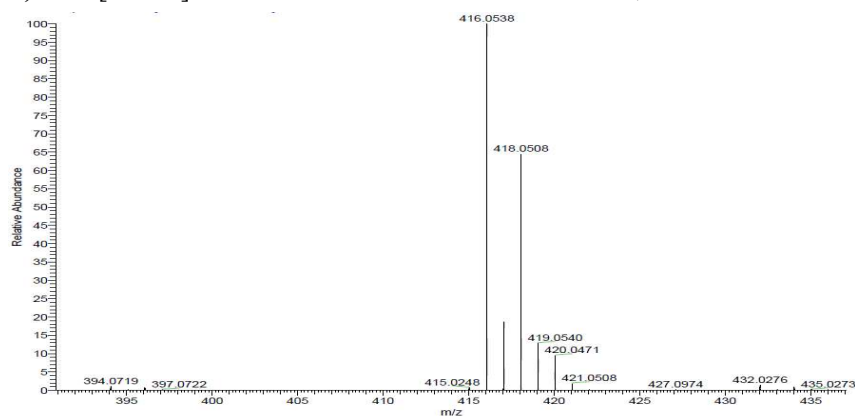
HPLC (IA, *n*-hexane/*i*-PrOH = 90/10, flow rate = 1.0 mL/min, I = 215 nm) t_R = 13.56 min (minor), 15.50 min (major), 92% ee.

$[\alpha]_D^{25}$: +17.60 (c = 0.10, CH₂Cl₂).

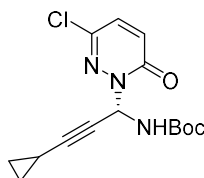
¹H NMR (400 MHz, CDCl₃) δ 7.43 (t, J = 1.6 Hz, 1H), 7.34-7.30 (m, 2H), 7.26-7.21 (m, 2H), 7.19 (d, J = 9.6 Hz, 1H), 6.94 (d, J = 9.6 Hz, 1H), 6.14 (s, 1H), 1.45 (s, 9H).

¹³C NMR (100 MHz, CDCl₃) δ 157.6, 153.4, 138.1, 134.3, 134.2, 132.8, 131.9, 130.2, 129.6, 129.5, 123.0, 83.8, 83.6, 81.4, 59.0, 28.2.

HRMS (ESI) m/z : [M+Na]⁺ Calcd for C₁₈H₁₇Cl₂N₃NaO₃ 416.0539; Found 416.0538.



***tert*-Butyl (S)-(1-(3-chloro-6-oxopyridazin-1(6H)-yl)-3-cyclopropylprop-2-yn-1-yl)carbamate (3f)**



Prepared from 6-chloropyridazin-3(2H)-one (13.0 mg, 0.1 mmol, 1.0 equiv) and *tert*-butyl (3-cyclopropyl-1-ethoxyprop-2-yn-1-yl)carbamate (95.7 mg, 0.4 mmol, 4.0 equiv) according to the general procedure in the presence of **C2** (7.2 mg, 0.01 mmol, 10 mol %), purified by silica gel column chromatography (petroleum ether/ EtOAc = 10:1 to 3:1) and was obtained as a white solid

(29.7 mg, 92%), mp: 149-151 °C.

R_f (Petroleum ether/ EtOAc = 3:1) = 0.2.

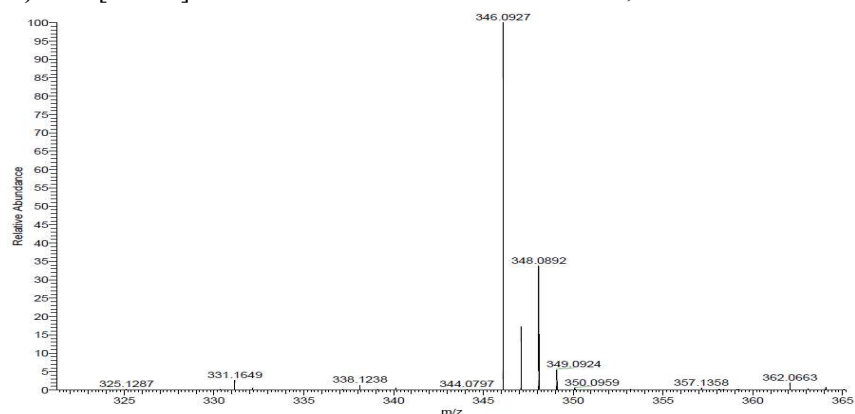
HPLC (IC, *n*-hexane/*i*-PrOH = 50/50, flow rate = 2.0 mL/min, I = 215 nm) t_R = 6.57 min (major), 9.72 min (minor), 80% ee.

$[\alpha]_D^{25}$: +18.88 (c = 0.25, CH₂Cl₂).

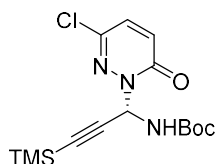
¹H NMR (400 MHz, CDCl₃) δ 7.17 (d, *J* = 9.6 Hz, 1H), 6.95 (dd, *J* = 9.2, 1.6 Hz, 1H), 6.91 (d, *J* = 9.6 Hz, 1H), 6.02 (s, 1H), 1.42 (s, 9H), 1.31-1.14 (m, 1H), 0.82-0.74 (m, 2H), 0.74-0.67 (m, 2H).

¹³C NMR (100 MHz, CDCl₃) δ 157.6, 153.4, 137.8, 134.1, 132.8, 89.4, 81.1, 69.1, 58.8, 28.3, 8.4, 8.3, -0.6.

HRMS (ESI) m/z: [M+Na]⁺ Calcd for C₁₅H₁₈ClN₃NaO₃ 346.0929; Found 346.0927.



tert-Butyl (S)-(1-(3-chloro-6-oxopyridazin-1(6H)-yl)-3-(trimethylsilyl)prop-2-yn-1-yl)carbamate (3g)



Prepared from 6-chloropyridazin-3(2H)-one (13.0 mg, 0.1 mmol, 1.0 equiv) and *tert*-butyl (1-ethoxy-3-(trimethylsilyl)prop-2-yn-1-yl)carbamate (108.5 mg, 0.4 mmol, 4.0 equiv) according to the general procedure in the presence of **C2** (7.2 mg, 0.01 mmol, 10 mol %), purified by silica gel column chromatography (petroleum ether/ EtOAc = 10:1 to 3:1) and was obtained as a white solid (20.6 mg, 58%), mp: 169-171 °C.

R_f (Petroleum ether/ EtOAc = 3:1) = 0.3.

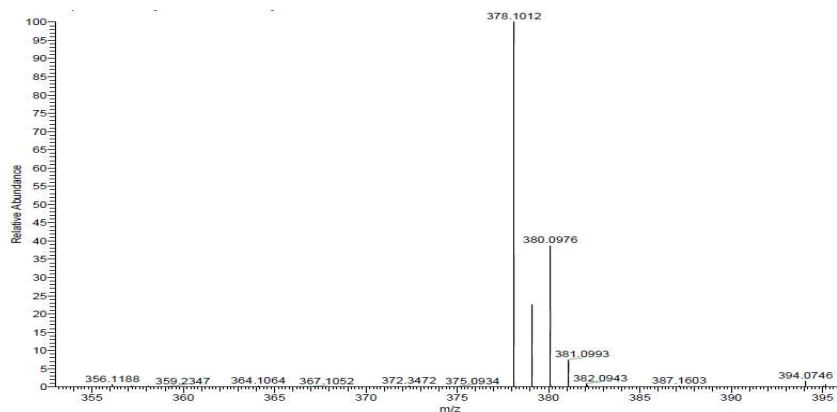
HPLC (IC, *n*-hexane/*i*-PrOH = 70/30, flow rate = 1.0 mL/min, I = 215 nm) t_R = 6.86 min (major), 8.21 min (minor), 90% ee.

$[\alpha]_D^{25}$: +4.00 (c = 0.15, CH₂Cl₂).

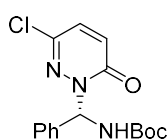
¹H NMR (400 MHz, CDCl₃) δ 7.18 (d, *J* = 9.6 Hz, 1H), 7.01 (d, *J* = 10.0 Hz, 1H), 6.92 (d, *J* = 9.6 Hz, 1H), 6.04 (s, 1H), 1.43 (s, 9H), 0.16 (s, 9H).

¹³C NMR (100 MHz, CDCl₃) δ 157.5, 153.5, 137.9, 134.2, 132.8, 97.9, 90.8, 81.3, 58.7, 28.3, -0.3.

HRMS (ESI) m/z: [M+Na]⁺ Calcd for C₁₅H₂₂ClN₃NaO₃Si 378.1011; Found 378.1012.



***tert*-Butyl (*S*)-((3-chloro-6-oxopyridazin-1(6H)-yl)(phenyl)methyl)carbamate (**3h**)**



Prepared from 6-chloropyridazin-3(2H)-one (13.0 mg, 0.1 mmol, 1.0 equiv) and *tert*-butyl (ethoxy(phenyl)methyl)carbamate (100.5 mg, 0.4 mmol, 4.0 equiv) according to the general procedure in the presence of **C2** (7.2 mg, 0.01 mmol, 10 mol %), purified by silica gel column chromatography (petroleum ether/ EtOAc = 10:1 to 3:1) and was obtained as a white solid (10.1 mg, 30%), mp: 154-156 °C.

R_f (Petroleum ether/ EtOAc = 3:1) = 0.3.

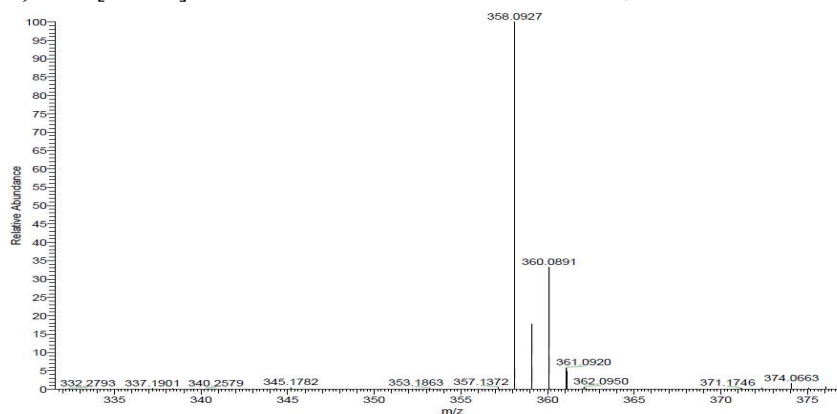
HPLC (OD-H, *n*-hexane/*i*-PrOH = 80/20, flow rate = 2.0 mL/min, I = 215 nm) t_R = 8.89 min (major), 10.11 min (minor), 24% ee.

$[\alpha]_D^{25}$: +9.80 (*c* = 0.1, CH₂Cl₂).

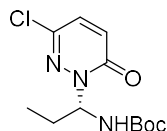
¹H NMR (400 MHz, CDCl₃) δ 7.43 (d, *J* = 10.0 Hz, 1H), 7.40-7.29 (m, 5H), 7.16 (d, *J* = 9.6 Hz, 1H), 6.89 (d, *J* = 9.6 Hz, 1H), 6.16 (s, 1H), 1.46 (s, 9H).

¹³C NMR (100 MHz, CDCl₃) δ 158.3, 154.3, 137.9, 136.6, 133.8, 132.6, 128.8, 126.3, 80.9, 68.3, 28.3.

HRMS (ESI) *m/z*: [M+Na]⁺ Calcd for C₁₆H₁₈ClN₃NaO₃ 358.0929; Found 358.0927.



***tert*-Butyl (*S*)-((1-(3-chloro-6-oxopyridazin-1(6H)-yl)propyl)carbamate (**3i**)**



Prepared from 6-chloropyridazin-3(2H)-one (13.0 mg, 0.1 mmol, 1.0 equiv) and *tert*-butyl (1-ethoxypropyl)carbamate (81.3 mg, 0.4 mmol, 4.0 equiv) according to the general procedure in the presence of **C2** (7.2 mg, 0.01 mmol, 10 mol %), purified by silica gel column chromatography (petroleum ether/ EtOAc = 10:1 to 3:1) and was obtained as a white solid (13.2 mg, 46%), mp: 135-137 °C.

R_f (Petroleum ether/EtOAc = 3:1) = 0.3.

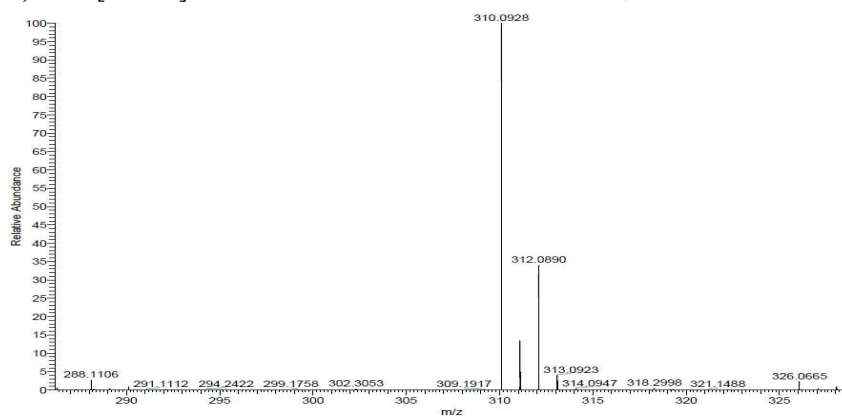
HPLC (OD-H, *n*-hexane/*i*-PrOH = 80/20, flow rate = 1.0 mL/min, I = 215 nm) t_R = 6.49 min (major), 7.76 min (minor), 70% ee.

$[\alpha]_D^{25}$: +12.00 (c = 0.1, CH₂Cl₂).

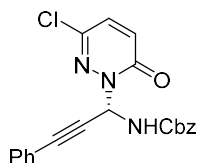
¹H NMR (400 MHz, CDCl₃) δ 7.16 (d, *J* = 9.6 Hz, 1H), 6.90 (d, *J* = 9.6 Hz, 1H), 6.35-6.18 (m, 1H), 5.65 (s, 1H), 2.02-1.79 (m, 2H), 1.42 (s, 9H), 0.95 (t, *J* = 7.6 Hz, 3H).

¹³C NMR (100 MHz, CDCl₃) δ 158.5, 154.4, 137.6, 133.5, 132.6, 80.5, 68.0, 28.3, 27.2, 9.7.

HRMS (ESI) *m/z*: [M+Na]⁺ Calcd for C₁₂H₁₈ClN₃NaO₃ 310.0929; Found 310.0928.



Benzyl (*S*)-(1-(3-chloro-6-oxopyridazin-1(6H)-yl)-3-phenylprop-2-yn-1-yl)carbamate (**3j**)



Prepared from 6-chloropyridazin-3(2H)-one (13.0 mg, 0.1 mmol, 1.0 equiv) and benzyl (1-ethoxy-3-phenylprop-2-yn-1-yl)carbamate (123.6 mg, 0.4 mmol, 4.0 equiv) according to the general procedure in the presence of **C2** (7.2 mg, 0.01 mmol, 10 mol %), purified by silica gel column chromatography (petroleum ether/ EtOAc c = 10:1 to 3:1) and was obtained as a white solid (16.1 mg, 41%), mp: 136-138 °C.

R_f (Petroleum ether/ EtOAc = 5:1) = 0.3.

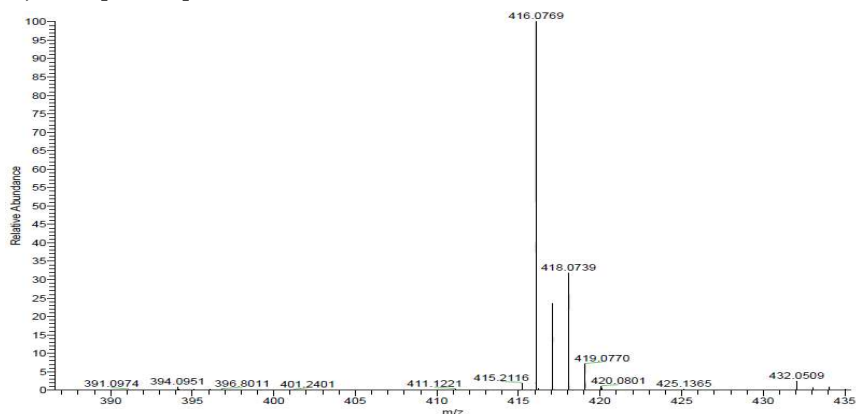
HPLC (IA, *n*-hexane/*i*-PrOH = 80/20, flow rate = 2.0 mL/min, I = 215 nm) t_R = 6.12 min (minor), 8.54 min (major), 92% ee.

$[\alpha]_D^{25}$: +13.12 (c = 0.25, CH₂Cl₂).

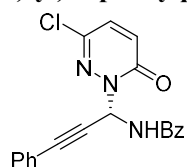
¹H NMR (400 MHz, CDCl₃) δ 7.45-7.38 (m, 2H), 7.37-7.22 (m, 9H), 7.11 (d, *J* = 9.6 Hz, 1H), 6.90 (d, *J* = 9.6 Hz, 1H), 6.57 (d, *J* = 7.2 Hz, 1H), 5.18 (d, *J* = 12.0 Hz, 1H), 5.08 (d, *J* = 12.0 Hz, 1H).

^{13}C NMR (100 MHz, CDCl_3) δ 157.6, 154.5, 138.3, 135.8, 134.3, 132.8, 132.1, 129.4, 128.7, 128.5, 128.4, 121.3, 85.5, 82.3, 67.7, 59.4.

HRMS (ESI) m/z : $[\text{M}+\text{Na}]^+$ Calcd for $\text{C}_{21}\text{H}_{16}\text{ClN}_3\text{NaO}_3$ 416.0772; Found 416.0769.



(S)-N-(1-(3-chloro-6-oxopyridazin-1(6H)-yl)-3-phenylprop-2-yn-1-yl)benzamide (3k)



Prepared from 6-chloropyridazin-3(2H)-one (13.0 mg, 0.1 mmol, 1.0 equiv) and N-(1-ethoxy-3-phenylprop-2-yn-1-yl)benzamide (111.6 mg, 0.4 mmol, 4.0 equiv) according to the general procedure in the presence of **C2** (7.2 mg, 0.01 mmol, 10 mol %), purified by silica gel column chromatography (petroleum ether/ EtOAc = 10:1 to 3:1) and was obtained as a white solid (18.5 mg, 51%), mp: 196-198 °C.

R_f (Petroleum ether/ EtOAc = 3:1) = 0.2.

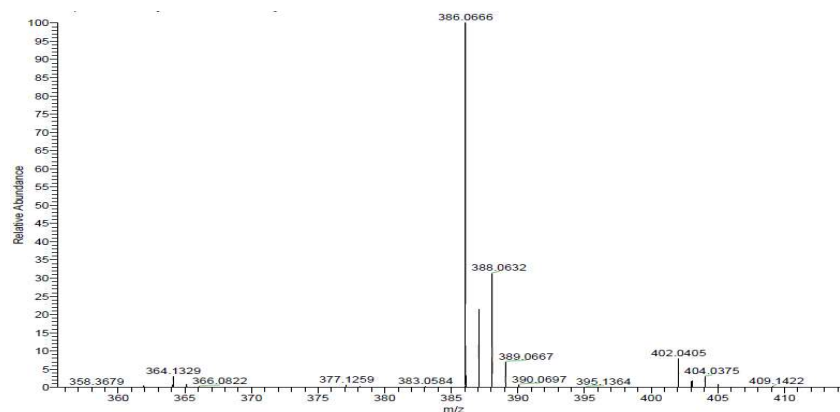
HPLC (IC, *n*-hexane/*i*-PrOH = 40/60, flow rate = 3.0 mL/min, I = 215 nm) t_R = 14.07 min (major), 20.97 min (minor), 88% ee.

$[\alpha]_D^{25}$: +8.53 (c = 0.15, CH_2Cl_2).

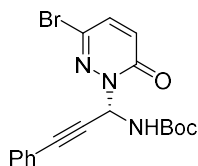
^1H NMR (400 MHz, CDCl_3) δ 7.98 (d, J = 8.8 Hz, 1H), 7.89 (d, J = 7.2 Hz, 2H), 7.70 (d, J = 8.8 Hz, 1H), 7.53 (t, J = 7.6 Hz, 1H), 7.48-7.39 (m, 4H), 7.37-7.24 (m, 3H), 7.14 (d, J = 10.0 Hz, 1H), 6.96 (d, J = 10.0 Hz, 1H).

^{13}C NMR (100 MHz, CDCl_3) δ 165.9, 157.9, 138.2, 134.3, 132.9, 132.7, 132.5, 132.1, 129.3, 128.7, 128.4, 127.6, 121.2, 85.5, 82.5, 58.4.

HRMS (ESI) m/z : $[\text{M}+\text{Na}]^+$ Calcd for $\text{C}_{20}\text{H}_{14}\text{ClN}_3\text{NaO}_2$ 386.0667; Found 386.0666.



***tert*-Butyl (*S*)-(1-(3-bromo-6-oxopyridazin-1(6H)-yl)-3-phenylprop-2-yn-1-yl)carbamate (**3l**)**



Prepared from 6-bromopyridazin-3(2H)-one (17.4 mg, 0.1 mmol, 1.0 equiv) and *tert*-butyl (1-ethoxy-3-phenylprop-2-yn-1-yl)carbamate (110.0 mg, 0.4 mmol, 4.0 equiv) according to the general procedure in the presence of **C2** (7.2 mg, 0.01 mmol, 10 mol %), purified by silica gel column chromatography (petroleum ether/ EtOAc = 10:1 to 3:1) and was obtained as a white solid (32.7mg, 81%), mp: 162-164 °C.

R_f (Petroleum ether/ EtOAc = 3:1) = 0.3.

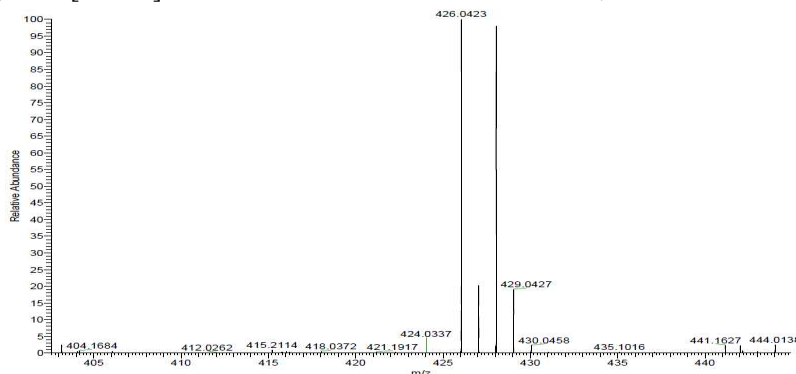
HPLC (IC, *n*-hexane/*i*-PrOH = 50/50, flow rate = 1.0 mL/min, I = 215 nm) *t_R* = 9.48 min (major), 11.97 min (minor), 94% ee.

[α]_D²⁵: +22.16 (c = 0.25, CH₂Cl₂).

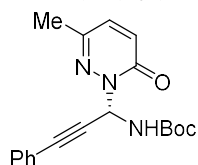
¹H NMR (400 MHz, CDCl₃) δ 7.46-7.41 (m, 2H), 7.36-7.20 (m, 5H), 6.83 (d, *J* = 9.6 Hz, 1H), 6.25 (s, 1H), 1.45 (s, 9H).

¹³C NMR (100 MHz, CDCl₃) δ 157.6, 153.5, 136.9, 132.5, 132.1, 129.2, 128.4, 127.0, 121.4, 85.1, 82.8, 81.3, 59.2, 28.3.

HRMS (ESI) *m/z*: [M+Na]⁺ Calcd for C₁₈H₁₈BrN₃NaO₃ 426.0424; Found 426.0423.



***tert*-Butyl (*S*)-(1-(3-methyl-6-oxopyridazin-1(6H)-yl)-3-phenylprop-2-yn-1-yl)carbamate (**3m**)**



Prepared from *tert*-butyl 6-methylpyridazin-3(2H)-one (11.0 mg, 0.1 mmol, 1.0 equiv) and *tert*-butyl (1-ethoxy-3-phenylprop-2-yn-1-yl)carbamate (110.0 mg, 0.4 mmol, 4.0 equiv) according to the general procedure in the presence of **C2** (7.2 mg, 0.01 mmol, 10 mol %), purified by silica gel column chromatography (petroleum ether/ EtOAc = 10:1 to 2:1) and was obtained as a white solid (7.5 mg, 22%), mp: 163-165 °C.

R_f (Petroleum ether/ EtOAc = 2:1) = 0.2.

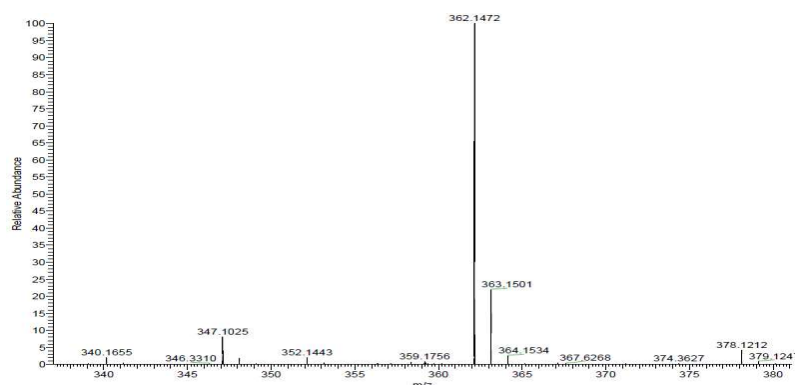
HPLC (IA, *n*-hexane/*i*-PrOH = 70/30, flow rate = 1.0 mL/min, I = 215 nm) *t_R* = 6.06 min (minor), 7.16 min (major), 92% ee.

[α]_D²⁵: +81.52 (c = 0.25, CH₂Cl₂).

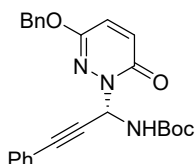
¹H NMR (400 MHz, CDCl₃) δ 7.48-7.38 (m, 2H), 7.36-7.26 (m, 3H), 7.25-7.12 (m, 1H), 7.08 (d, *J* = 9.6 Hz, 1H), 6.87 (d, *J* = 9.6 Hz, 1H), 6.33 (s, 1H), 2.36 (s, 3H), 1.45 (s, 9H).

^{13}C NMR (100 MHz, CDCl_3) δ 158.5, 153.7, 144.7, 133.8, 132.0, 130.6, 128.9, 128.2, 121.7, 84.2, 83.6, 80.9, 59.9, 28.3, 20.9.

HRMS (ESI) m/z : $[\text{M}+\text{Na}]^+$ Calcd for $\text{C}_{19}\text{H}_{21}\text{N}_3\text{NaO}_3$ 362.1475; Found 362.1472.



***tert*-Butyl (*S*)-(1-(3-(benzyloxy)-6-oxopyridazin-1(6H)-yl)-3-phenylprop-2-yn-1-yl)carbamate (3n)**



Prepared from 6-(benzyloxy)pyridazin-3(2H)-one (20.2 mg, 0.1 mmol, 1.0 equiv) and *tert*-butyl (1-ethoxy-3-phenylprop-2-yn-1-yl)carbamate (110.0 mg, 0.4 mmol, 4.0 equiv) according to the general procedure in the presence of **C2** (7.2 mg, 0.01 mmol, 10 mol %), purified by silica gel column chromatography (petroleum ether/ EtOAc = 10:1 to 2:1) and was obtained as colorless oil (28.9 mg, 67%).

R_f (Petroleum ether/ EtOAc = 3:1) = 0.1.

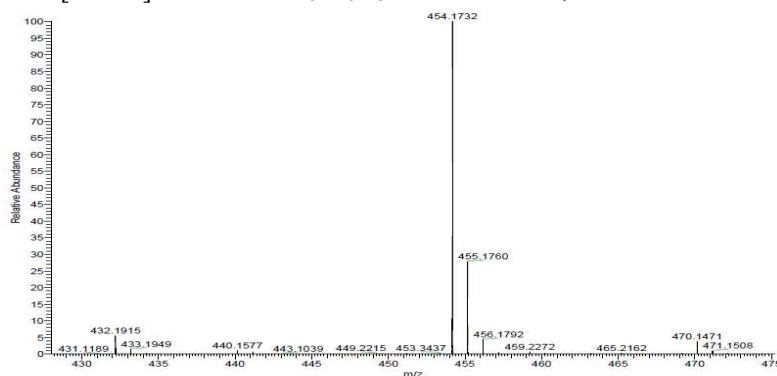
HPLC (IC, *n*-hexane/*i*-PrOH = 70/30, flow rate = 1.0 mL/min, I = 215 nm) t_R = 21.16 min (major), 24.15 min (minor), 94% ee.

$[\alpha]_D^{25}$: +23.92 (c = 0.25, CH_2Cl_2).

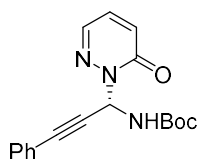
^1H NMR (400 MHz, CDCl_3) δ 7.49-7.40 (m, 4H), δ 7.40-7.27 (m, 6H), 7.22 (s, 1H), 6.96 (d, J = 10.0 Hz, 1H), 6.91 (d, J = 10.0 Hz, 1H), 6.19 (s, 1H), 5.27 (d, J = 12.0 Hz, 1H), 5.21 (d, J = 12.0 Hz, 1H), 1.46 (s, 9H).

^{13}C NMR (100 MHz, CDCl_3) δ 157.9, 153.7, 152.4, 135.9, 133.6, 132.1, 129.0, 128.7, 128.5, 128.4, 127.5, 121.8, 84.4, 83.6, 81.0, 69.3, 58.9, 28.4.

HRMS (ESI) m/z : $[\text{M}+\text{Na}]^+$ Calcd for $\text{C}_{25}\text{H}_{25}\text{N}_3\text{NaO}_4$ 454.1737; Found 454.1732.



***tert*-Butyl (S)-(1-(6-oxopyridazin-1(6H)-yl)-3-phenylprop-2-yn-1-yl)carbamate (3o)**



Prepared from pyridazin-3(2H)-one (9.6 mg, 0.1 mmol, 1.0 equiv) and *tert*-butyl (1-ethoxy-3-phenylprop-2-yn-1-yl)carbamate (110.0 mg, 0.4 mmol, 4.0 equiv) according to the general procedure in the presence of **C2** (7.2 mg, 0.01 mmol, 10 mol %), purified by silica gel column chromatography (petroleum ether/ EtOAc = 10:1 to 2:1) and was obtained as a white solid (13.3 mg, 41%), mp: 164-166 °C.

R_f (Petroleum ether/ EtOAc = 2:1) = 0.2.

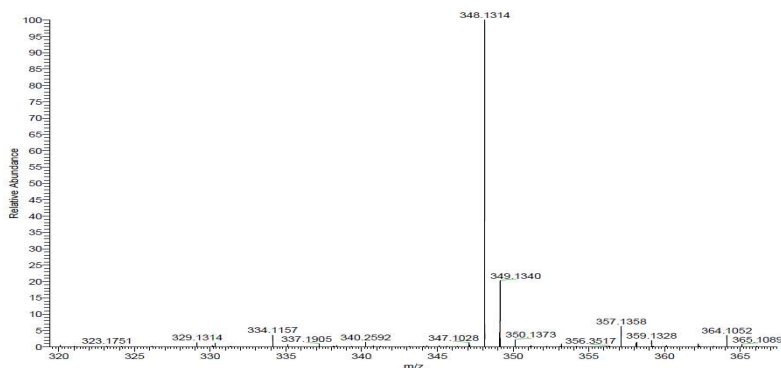
HPLC (IA, *n*-hexane/*i*-PrOH = 80/20, flow rate = 1.0 mL/min, I = 215 nm) *t_R* = 17.64 min (minor), 20.11 min (major), 94% ee.

[α]_D²⁵: +46.72 (c = 0.25, CH₂Cl₂).

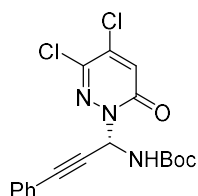
¹H NMR (400 MHz, CDCl₃) δ 7.81 (dd, *J* = 3.6, 1.6 Hz, 1H), 7.48-7.38 (m, 2H), 7.36-7.25 (m, 4H), 7.19 (dd, *J* = 9.2, 3.6 Hz, 1H), 6.95 (dd, *J* = 9.2, 1.6 Hz, 1H), 6.30 (s, 1H), 1.44 (s, 9H).

¹³C NMR (100 MHz, CDCl₃) δ 159.2, 153.7, 136.5, 132.1, 131.7, 130.9, 129.1, 128.3, 121.6, 84.7, 83.2, 81.1, 60.0, 28.3.

HRMS (ESI) *m/z*: [M+Na]⁺ Calcd for C₁₈H₁₉N₃NaO₃ 348.1319; Found 348.1314.



***tert*-Butyl (S)-(1-(3,4-dichloro-6-oxopyridazin-1(6H)-yl)-3-phenylprop-2-yn-1-yl)carbamate (3p)**



Prepared from 5,6-dichloropyridazin-3(2H)-one (16.4 mg, 0.1 mmol, 1.0 equiv) and *tert*-butyl (1-ethoxy-3-phenylprop-2-yn-1-yl)carbamate (110.0 mg, 0.4 mmol, 4.0 equiv) according to the general procedure in the presence of **C2** (7.2 mg, 0.01 mmol, 10 mol %), purified by silica gel column chromatography (petroleum ether/ EtOAc = 30:1 to 10:1) and was obtained as a white solid (36.2 mg, 92%), mp: 191-193 °C.

R_f (Petroleum ether/ EtOAc = 10:1) = 0.3.

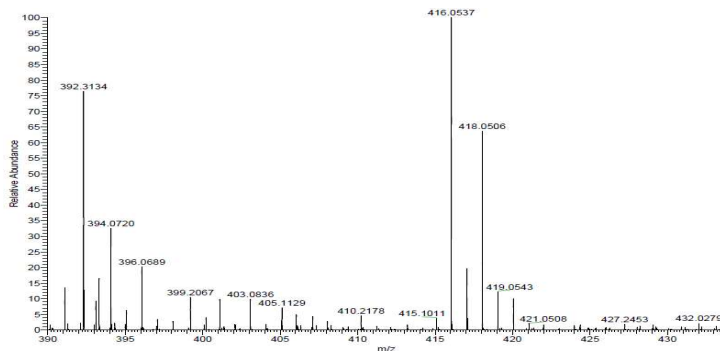
HPLC (OD-H, *n*-hexane/*i*-PrOH = 80/20, flow rate = 1.0 mL/min, I = 215 nm) *t_R* = 6.73 min (minor), 8.85 min (major), 86% ee.

[α]_D²⁵: +30.13 (c = 0.15, CH₂Cl₂).

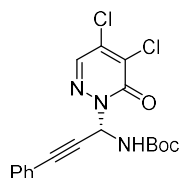
¹H NMR (400 MHz, CDCl₃) δ 7.48-7.38 (m, 2H), 7.38-7.27 (m, 3H), 7.24 (d, *J* = 9.6 Hz, 1H), 7.11 (s, 1H), 6.15 (s, 1H), 1.46 (s, 9H).

¹³C NMR (100 MHz, CDCl₃) δ 157.0, 153.4, 140.1, 137.0, 132.0, 130.1, 129.3, 128.4, 121.1, 85.4, 82.3, 81.5, 59.1, 28.2.

HRMS (ESI) *m/z*: [M+Na]⁺ Calcd for C₁₈H₁₇Cl₂N₃NaO₃ 416.0539; Found 416.0537.



***tert*-Butyl (S)-(1-(4,5-dichloro-6-oxopyridazin-1(6H)-yl)-3-phenylprop-2-yn-1-yl)carbamate (3q)**



Prepared from 4,5-dichloropyridazin-3(2H)-one (16.4 mg, 0.1 mmol, 1.0 equiv) and *tert*-butyl (1-ethoxy-3-phenylprop-2-yn-1-yl)carbamate (110.0 mg, 0.4 mmol, 4.0 equiv) according to the general procedure in the presence of **C2** (7.2 mg, 0.01 mmol, 10 mol %), purified by silica gel column chromatography (petroleum ether/ EtOAc = 20:1 to 5:1) and was obtained as a colorless oil (19.7 mg, 50%).

R_f (Petroleum ether/ EtOAc = 5:1) = 0.5.

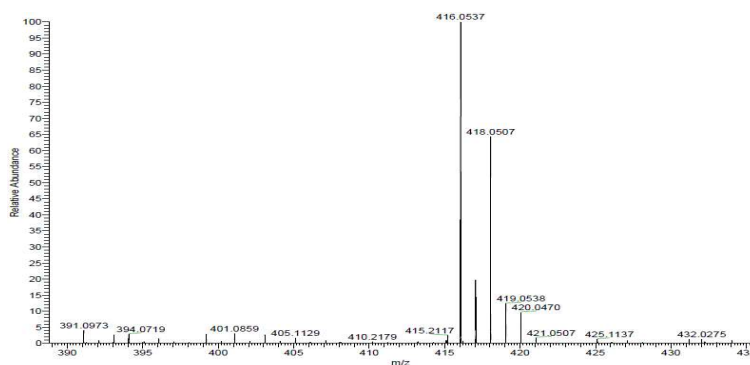
HPLC (IC, *n*-hexane/*i*-PrOH = 50/50, flow rate = 1.0 mL/min, I = 215 nm) t_R = 6.11 min (major), 7.62 min (minor), 88% ee.

[α]_D²⁵: +59.60 (c = 0.25, CH₂Cl₂).

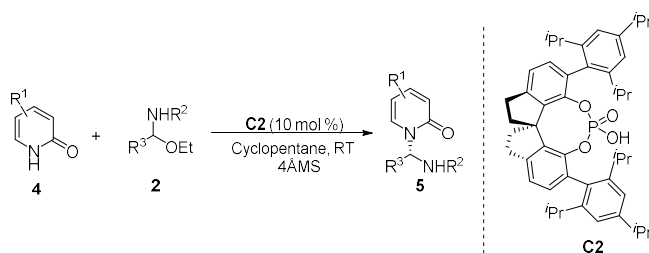
¹H NMR (400 MHz, CDCl₃) δ 7.83 (s, 1H), 7.47-7.38 (m, 2H), 7.38-7.27 (m, 3H), 7.25-7.17 (m, 1H), 6.24 (s, 1H), 1.45 (s, 9H).

¹³C NMR (100 MHz, CDCl₃) δ 155.4, 153.6, 137.0, 136.1, 135.0, 132.1, 129.3, 128.4, 121.2, 85.5, 82.1, 81.5, 61.3, 28.3.

HRMS (ESI) *m/z*: [M+Na]⁺ Calcd for C₁₈H₁₇Cl₂N₃NaO₃ 416.0539; Found 416.0537.



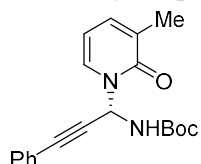
General procedure for Scheme 3



To a 10 mL of dry Schlenk tube were added **C2** (7.2 mg, 0.01 mmol, 10 mol %), 4ÅMS (50 mg), **4** (0.1 mmol, 1.0 equiv) and **2** (0.4 mmol, 4.0 equiv), then Cyclopentane (2 mL) was added under argon atmosphere. The resulting mixture was stirred at RT for 24 hours. The reaction mixture was concentrated under vacuum; the crude residue was purified by silica gel column chromatography (eluent: petroleum ether/EtOAc = 10:1-3:1) to give **5**.

[Note: racemic samples were prepared by using BNDHP instead of **C2**.]

tert-Butyl (*S*)-(1-(3-methyl-2-oxopyridin-1(2H)-yl)-3-phenylprop-2-yn-1-yl)carbamate (**5a**)



Prepared from 3-methylpyridin-2(1H)-one (10.9 mg, 0.1 mmol, 1.0 equiv) and *tert*-butyl (1-ethoxy-3-phenylprop-2-yn-1-yl)carbamate (110.0 mg, 0.4 mmol, 4.0 equiv) according to the general procedure in the presence of **C2** (7.2 mg, 0.01 mmol, 10 mol %), purified by silica gel column chromatography (petroleum ether/ EtOAc = 10:1 to 3:1) and was obtained as a white solid (26.4 mg, 78%), mp: 90-92 °C.

R_f (Petroleum ether/ EtOAc = 3:1) = 0.5.

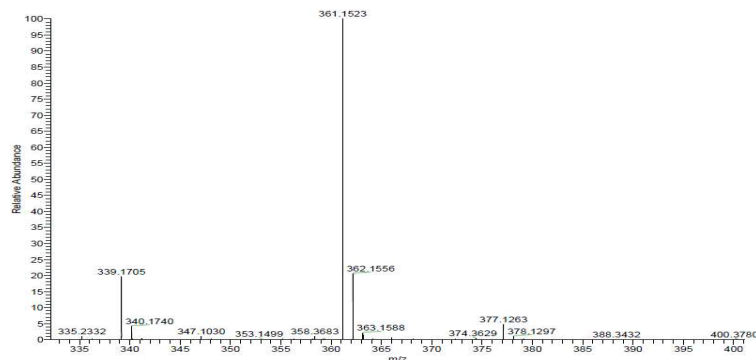
HPLC (IC, *n*-hexane/*i*-PrOH = 70/30, flow rate = 1.0 mL/min, I = 215 nm) t_R = 10.73 min (minor), 12.67 min (major), 93% ee.

$[\alpha]_D^{25}$: -35.12 (c = 0.25, CH₂Cl₂).

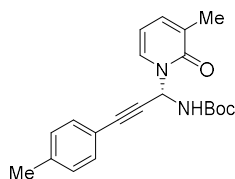
¹H NMR (400 MHz, CDCl₃) δ 7.51 (d, *J* = 6.4 Hz, 1H), 7.44 (d, *J* = 7.2 Hz, 2H), 7.36-7.25 (m, 3H), 7.20 (d, *J* = 6.4 Hz, 1H), 6.76 (s, 1H), 6.61 (s, 1H), 6.13 (t, *J* = 6.8 Hz, 1H), 2.17 (s, 3H), 1.43 (s, 9H).

¹³C NMR (100 MHz, CDCl₃) δ 162.3, 154.0, 137.2, 133.4, 132.0, 130.4, 129.0, 128.3, 121.6, 105.6, 85.0, 83.1, 81.0, 59.3, 28.2, 17.0.

HRMS (ESI) m/z: [M+Na]⁺ Calcd for C₂₀H₂₂N₂NaO₃ 361.1523; Found 361.1523.



***tert*-Butyl (*S*)-1-(3-methyl-2-oxopyridin-1(2H)-yl)-3-(*p*-tolyl)prop-2-yn-1-yl)carbamate (**5b**)**



Prepared from 3-methylpyridin-2(1H)-one (10.9 mg, 0.1 mmol, 1.0 equiv) and *tert*-butyl (1-ethoxy-3-(*p*-tolyl)prop-2-yn-1-yl)carbamate (115.7 mg, 0.4 mmol, 4.0 equiv) according to the general procedure in the presence of **C2** (7.2 mg, 0.01 mmol, 10 mol %), purified by silica gel column chromatography (petroleum ether/ EtOAc = 10:1 to 3:1) and was obtained as a white solid (27.5 mg, 78%), mp: 153-155 °C.

R_f (Petroleum ether/ EtOAc = 3:1) = 0.4.

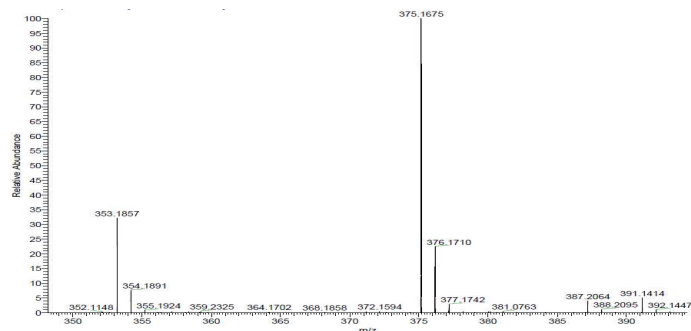
HPLC (IC, *n*-hexane/*i*-PrOH = 80/20, flow rate = 2.0 mL/min, I = 215 nm) *t_R* = 9.46 min (minor), 12.13 min (major), 92% ee.

[α]_D²⁵: +2.00 (c = 0.25, CH₂Cl₂).

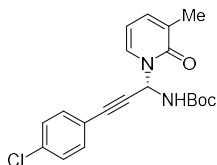
¹H NMR (400 MHz, CDCl₃) δ 7.50 (d, *J* = 6.4 Hz, 1H), 7.33 (d, *J* = 7.6 Hz, 2H), 7.23-7.15 (m, 1H), 7.09 (d, *J* = 7.6 Hz, 2H), 6.75 (s, 1H), 6.54 (s, 1H), 6.12 (t, *J* = 6.8 Hz, 1H), 2.33 (s, 3H), 2.16 (s, 3H), 1.42 (s, 9H).

¹³C NMR (100 MHz, CDCl₃) δ 162.2, 154.0, 139.2, 137.2, 133.3, 131.9, 130.4, 129.0, 118.5, 105.6, 85.2, 82.4, 81.0, 59.4, 28.2, 21.5, 17.0.

HRMS (ESI) *m/z*: [M+Na]⁺ Calcd for C₂₁H₂₄N₂NaO₃ 375.1679; Found 375.1675.



***tert*-Butyl (*S*)-1-(3-(4-chlorophenyl)-1-(3-methyl-2-oxopyridin-1(2H)-yl)prop-2-yn-1-yl)carbamate (**5c**)**



Prepared from 3-methylpyridin-2(1H)-one (10.9 mg, 0.1 mmol, 1.0 equiv) and *tert*-butyl (3-(4-chlorophenyl)-1-ethoxyprop-2-yn-1-yl)carbamate (123.6 mg, 0.4 mmol, 4.0 equiv) according to the general procedure in the presence of **C2** (7.2 mg, 0.01 mmol, 10 mol %), purified by silica gel column chromatography (petroleum ether/ EtOAc = 10:1 to 3:1) and was obtained as a white solid (23.8 mg, 64%), mp: 173-175 °C.

R_f (Petroleum ether/ EtOAc = 3:1) = 0.4.

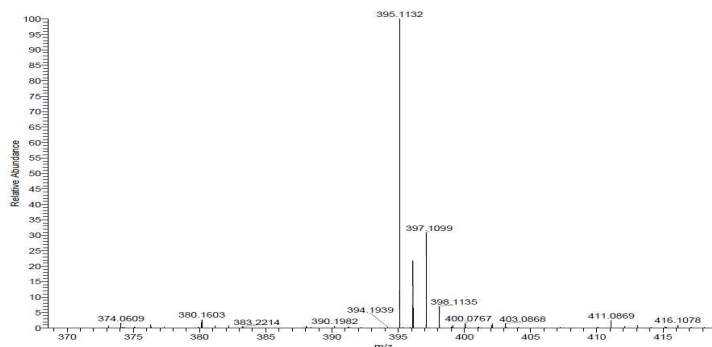
HPLC (IA, *n*-hexane/*i*-PrOH = 70/30, flow rate = 1.0 mL/min, I = 215 nm) *t_R* = 5.56 min (major), 6.10 min (minor), 82% ee.

[α]_D²⁵: -12.43 (c = 0.25, CH₂Cl₂).

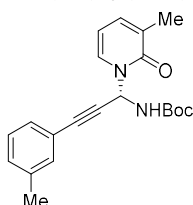
¹H NMR (400 MHz, DMSO-d₆) δ 8.84 (d, *J* = 7.6 Hz, 1H), 7.71 (d, *J* = 6.4 Hz, 1H), 7.55-7.43 (m, 4H), 7.39-7.27 (m, 2H), 6.30 (t, *J* = 6.8 Hz, 1H), 2.02 (s, 3H), 1.39 (s, 9H).

¹³C NMR (100 MHz, DMSO-d₆) δ 165.7, 158.9, 142.3, 139.4, 138.7, 136.4, 134.2, 133.6, 124.9, 111.3, 91.2, 87.9, 85.1, 58.3, 33.2, 22.1.

HRMS (ESI) *m/z*: [M+Na]⁺ Calcd for C₂₀H₂₁ClN₂NaO₃ 395.1133; Found 395.1132.



***tert*-Butyl (*S*)-(1-(3-methyl-2-oxopyridin-1(2H)-yl)-3-(*m*-tolyl)prop-2-yn-1-yl)carbamate (**5d**)**



Prepared from 3-methylpyridin-2(1H)-one (10.9 mg, 0.1 mmol, 1.0 equiv) and *tert*-butyl (1-ethoxy-3-(*m*-tolyl)prop-2-yn-1-yl)carbamate (115.7 mg, 0.4 mmol, 4.0 equiv) according to the general procedure in the presence of **C2** (7.2 mg, 0.01 mmol, 10 mol %), purified by silica gel column chromatography (petroleum ether/ EtOAc = 10:1 to 3:1) and was obtained as a white solid (31.0 mg, 88%), mp: 148-150 °C.

R_f (Petroleum ether/ EtOAc = 3:1) = 0.4.

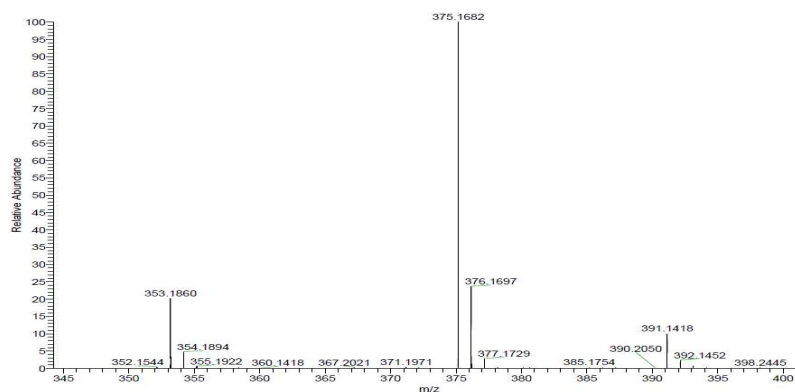
HPLC (IC, *n*-hexane/*i*-PrOH = 70/30, flow rate = 1.0 mL/min, I = 215 nm) *t_R* = 14.09 min (minor), 16.42 min (major), 90% ee.

[α]_D²⁵: -16.64 (c = 0.25, CH₂Cl₂).

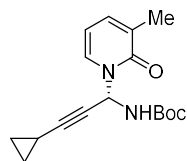
¹H NMR (400 MHz, CDCl₃) δ 7.52 (d, *J* = 6.4 Hz, 1H), 7.27-7.06 (m, 5H), 6.76 (s, 1H), 6.66 (s, 1H), 6.12 (t, *J* = 6.8 Hz, 1H), 2.29 (s, 3H), 2.16 (s, 3H), 1.43 (s, 9H).

¹³C NMR (100 MHz, CDCl₃) δ 162.2, 154.0, 137.9, 137.2, 133.4, 132.6, 130.2, 129.8, 129.0, 128.1, 121.4, 105.7, 85.2, 82.9, 80.9, 59.0, 28.2, 21.2, 17.1.

HRMS (ESI) *m/z*: [M+Na]⁺ Calcd for C₂₁H₂₄N₂NaO₃ 375.1679; Found 375.1682.



***tert*-Butyl (S)-(3-cyclopropyl-1-(3-methyl-2-oxopyridin-1(2H)-yl)prop-2-yn-1-yl)carbamate (5e)**



Prepared from 3-methylpyridin-2(1H)-one (10.9 mg, 0.1 mmol, 1.0 equiv) and *tert*-butyl (3-cyclopropyl-1-ethoxyprop-2-yn-1-yl)carbamate (95.7 mg, 0.4 mmol, 4.0 equiv) according to the general procedure in the presence of **C2** (7.2 mg, 0.01 mmol, 10 mol %), purified by silica gel column chromatography (petroleum ether/ EtOAc = 10:1 to 3:1) and was obtained as a white solid (26.3 mg, 87%), mp: 176-178 °C.

R_f (Petroleum ether/ EtOAc = 3:1) = 0.3.

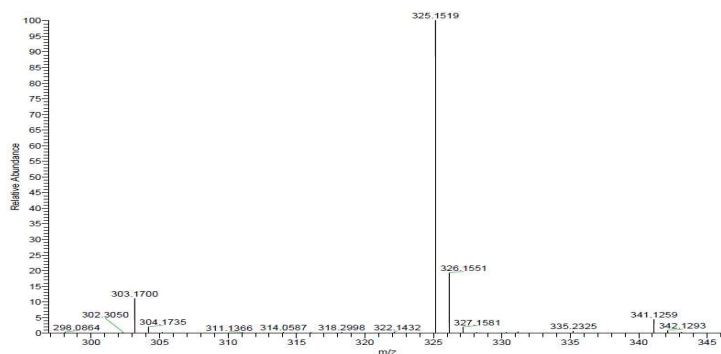
HPLC (IC, *n*-hexane/*i*-PrOH = 50/50, flow rate = 2.0 mL/min, I = 215 nm) t_R = 6.70 min (minor), 11.15 min (major), 94% ee.

$[\alpha]_D^{25}$: -44.80 (c = 0.25, CH₂Cl₂).

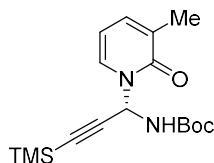
¹H NMR (400 MHz, CDCl₃) δ 7.39 (dd, J = 6.8, 1.2 Hz, 1H), 7.22-7.12 (m, 1H), 6.46 (s, 1H), 6.32 (s, 1H), 6.10 (t, J = 6.8 Hz, 1H), 2.15 (s, 3H), 1.40 (s, 9H), 1.31-1.22 (m, 1H), 0.82-0.73 (m, 2H), 0.73-0.66 (m, 2H).

¹³C NMR (100 MHz, CDCl₃) δ 162.7, 154.5, 137.6, 133.9, 130.8, 106.0, 89.7, 81.4, 70.0, 59.6, 28.8, 17.6, 8.9, 8.8, 0.0.

HRMS (ESI) m/z : [M+Na]⁺ Calcd for C₁₇H₂₂N₂NaO₃ 325.1523; Found 325.1519.



***tert*-Butyl (S)-(1-(3-methyl-2-oxopyridin-1(2H)-yl)-3-(trimethylsilyl)prop-2-yn-1-yl)carbamate (5f)**



Prepared from 3-methylpyridin-2(1H)-one (10.9 mg, 0.1 mmol, 1.0 equiv) and *tert*-butyl (1-ethoxy-3-(trimethylsilyl)prop-2-yn-1-yl)carbamate (108.5 mg, 0.4 mmol, 4.0 equiv) according to the general procedure in the presence of **C2** (7.2 mg, 0.01 mmol, 10 mol %), purified by silica gel column chromatography (petroleum ether/ EtOAc = 10:1 to 3:1) and was obtained as a white solid (27.1 mg, 81%), mp: 165-167 °C.

R_f (Petroleum ether/ EtOAc = 3:1) = 0.5.

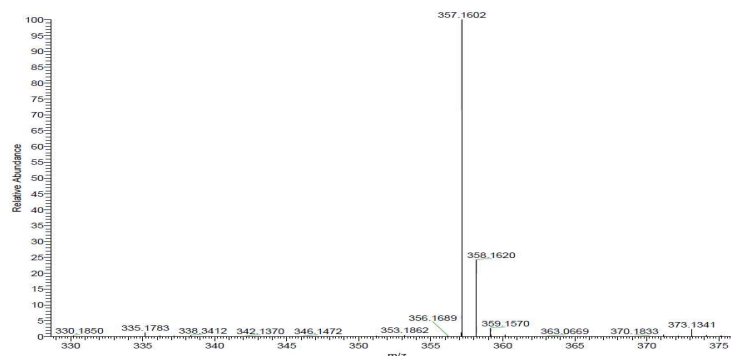
HPLC (IC, *n*-hexane/*i*-PrOH = 80/20, flow rate = 1.0 mL/min, I = 215 nm) t_R = 7.24 min (minor), 9.87 min (major), 89% ee.

$[\alpha]_D^{25}$: -37.04 ($c = 0.25$, CH_2Cl_2).

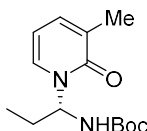
$^1\text{H NMR}$ (400 MHz, CDCl_3) δ 7.43 (d, $J = 6.0$ Hz, 1H), 7.22-7.16 (m, 1H), 6.58 (s, 1H), 6.27 (s, 1H), 6.11 (t, $J = 6.8$ Hz, 1H), 2.15 (s, 3H), 1.41 (s, 9H), 0.17 (s, 9H).

$^{13}\text{C NMR}$ (100 MHz, CDCl_3) δ 162.4, 154.2, 137.4, 133.5, 130.5, 105.9, 98.9, 91.0, 81.3, 58.5, 28.6, 17.5, 0.0.

HRMS (ESI) m/z : $[\text{M}+\text{Na}]^+$ Calcd for $\text{C}_{17}\text{H}_{26}\text{N}_2\text{NaO}_3\text{Si}$ 357.1605, Found 357.1602.



tert-Butyl (*S*)-(1-(3-methyl-2-oxopyridin-1(2H)-yl)propyl)carbamate (**5g**)



Prepared from 3-methylpyridin-2(1H)-one (10.9 mg, 0.1 mmol, 1.0 equiv) and *tert*-butyl (1-ethoxypropyl)carbamate (81.3 mg, 0.4 mmol, 4.0 equiv) according to the general procedure in the presence of **C2** (7.2 mg, 0.01 mmol, 10 mol %), purified by silica gel column chromatography (petroleum ether/ EtOAc = 10:1 to 3:1) and was obtained as a white solid (5.6 mg, 21%), mp: 144-146 °C.

R_f (Petroleum ether/ EtOAc = 3:1) = 0.3.

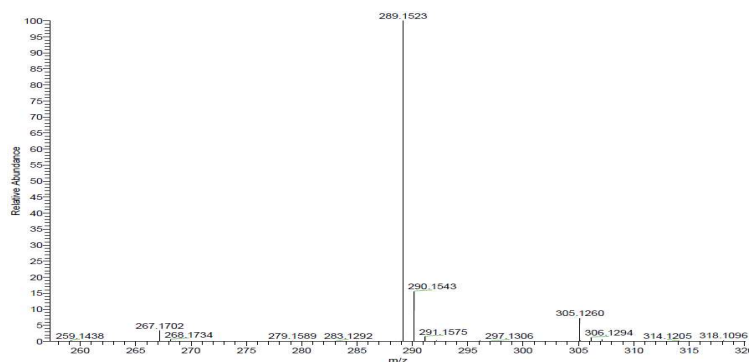
HPLC (IC, *n*-hexane/*i*-PrOH = 70/30, flow rate = 2.0 mL/min, I = 215 nm) t_R = 3.46 min (major), 4.33 min (minor), 66% ee.

$[\alpha]_D^{25}$: +70.80 ($c = 0.05$, CH_2Cl_2).

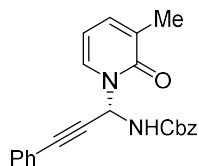
$^1\text{H NMR}$ (400 MHz, CDCl_3) δ 7.21 (d, $J = 6.8$ Hz, 1H), 7.16 (d, $J = 6.8$ Hz, 1H), 6.46 (d, $J = 7.2$ Hz, 1H), 6.09 (t, $J = 6.8$ Hz, 1H), 5.36 (d, $J = 5.6$ Hz, 1H), 2.38-2.18 (m, 1H), 2.13 (s, 3H), 2.11-1.95 (m, 1H), 1.41 (s, 9H), 0.88 (t, $J = 7.2$ Hz, 3H).

$^{13}\text{C NMR}$ (100 MHz, CDCl_3) δ 163.2, 155.0, 137.0, 134.9, 130.5, 105.4, 80.1, 73.4, 28.2, 26.1, 16.9, 10.4.

HRMS (ESI) m/z : $[\text{M}+\text{Na}]^+$ Calcd for $\text{C}_{14}\text{H}_{22}\text{N}_2\text{NaO}_3$ 289.1523; Found 289.1523.



Benzyl (*S*)-1-(3-methyl-2-oxopyridin-1(2H)-yl)-3-phenylprop-2-yn-1-yl)carbamate (**5h**)



Prepared from 3-methylpyridin-2(1H)-one (10.9 mg, 0.1 mmol, 1.0 equiv) and benzyl (1-ethoxy-3-phenylprop-2-yn-1-yl)carbamate (123.6 mg, 0.4 mmol, 4.0 equiv) according to the general procedure in the presence of **C2** (7.2 mg, 0.01 mmol, 10 mol %), purified by silica gel column chromatography (petroleum ether/ EtOAc = 10:1 to 3:1) and was obtained as colorless oil (16.0 mg, 43%).

R_f (Petroleum ether/ EtOAc = 3:1) = 0.3.

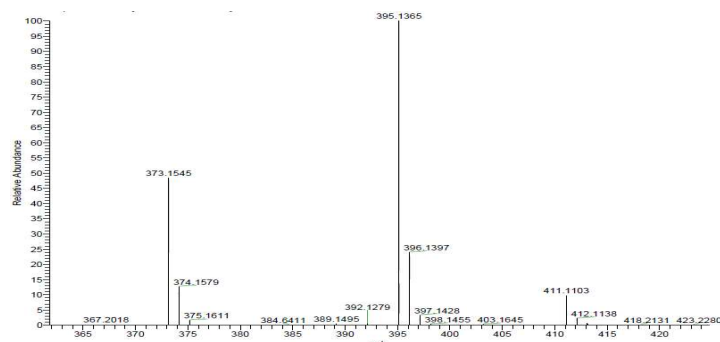
HPLC (IA, *n*-hexane/*i*-PrOH = 70/30, flow rate = 1.0 mL/min, I = 215 nm) t_R = 7.35 min (minor), 8.02 min (major), 76% ee.

$[\alpha]_D^{25}$: -27.69 (c = 0.15, CH₂Cl₂).

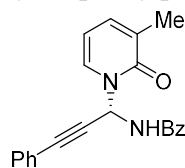
¹H NMR (400 MHz, CDCl₃) δ 7.56 (d, J = 6.4 Hz, 1H), 7.46-7.40 (m, 2H), 7.38-7.25 (m, 8H), 7.20 (d, J = 6.0 Hz, 1H), 6.88 (s, 1H), 6.81 (s, 1H), 6.12 (t, J = 6.8 Hz, 1H), 5.14 (d, J = 12.0 Hz, 1H), 5.06 (d, J = 12.0 Hz, 1H), 2.15 (s, 3H).

¹³C NMR (100 MHz, CDCl₃) δ 162.2, 155.0, 137.4, 135.8, 133.5, 132.0, 130.4, 129.1, 128.5, 128.31, 128.27, 128.2, 121.5, 105.8, 85.6, 82.7, 67.4, 59.2, 17.1.

HRMS (ESI) m/z : [M+Na]⁺ Calcd for C₂₃H₂₀N₂NaO₃ 395.1366; Found 395.1365.



(*S*)-N-(1-(3-methyl-2-oxopyridin-1(2H)-yl)-3-phenylprop-2-yn-1-yl)benzamide (**5i**)



Prepared from 3-methylpyridin-2(1H)-one (10.9 mg, 0.1 mmol, 1.0 equiv) and N-(1-ethoxy-3-phenylprop-2-yn-1-yl)benzamide (111.6 mg, 0.4 mmol, 4.0 equiv) according to the general procedure in the presence of **C2** (7.2 mg, 0.01 mmol, 10 mol %), purified by silica gel column chromatography (petroleum ether/ EtOAc = 10:1 to 3:1) and was obtained as a white solid (28.1 mg, 82%), mp: 193-195 °C.

R_f (Petroleum ether/ EtOAc = 3:1) = 0.2.

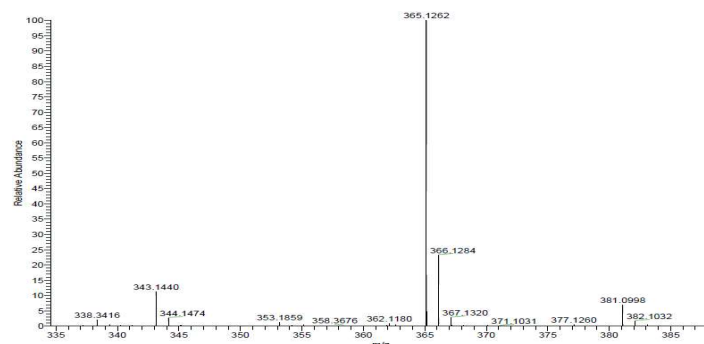
HPLC (IA, *n*-hexane/*i*-PrOH = 90/10, flow rate = 1.0 mL/min, I = 215 nm) t_R = 13.53 min (minor), 14.87 min (major), 54% ee.

$[\alpha]_D^{25}$: +5.36 (c = 0.25, CH₂Cl₂).

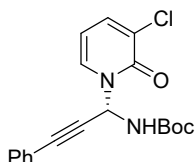
¹H NMR (400 MHz, CDCl₃) δ 8.69 (d, *J* = 8.4 Hz, 1H), 7.93-7.79 (m, 2H), 7.66 (d, *J* = 6.4 Hz, 1H), 7.51-7.36 (m, 5H), 7.34-7.24 (m, 3H), 7.20 (d, *J* = 6.4 Hz, 1H), 7.11 (d, *J* = 8.4 Hz, 1H), 6.14 (t, *J* = 6.8 Hz, 1H), 2.13 (s, 3H).

¹³C NMR (100 MHz, CDCl₃) δ 166.4, 162.6, 137.6, 134.5, 132.8, 132.3, 132.1, 130.6, 129.0, 128.6, 128.3, 127.6, 121.6, 105.8, 85.2, 82.9, 59.1, 16.9.

HRMS (ESI) *m/z*: [M+Na]⁺ Calcd for C₂₂H₁₈N₂NaO₂ 365.1260; Found 365.1262.



***tert*-Butyl (S)-(1-(3-chloro-2-oxopyridin-1(2H)-yl)-3-phenylprop-2-yn-1-yl)carbamate (5j)**



Prepared from 3-chloropyridin-2(1H)-one (12.9 mg, 0.1 mmol, 1.0 equiv) and *tert*-butyl (1-ethoxy-3-phenylprop-2-yn-1-yl)carbamate (110.0 mg, 0.4 mmol, 4.0 equiv) according to the general procedure in the presence of **C2** (7.2 mg, 0.01 mmol, 10 mol %), purified by silica gel column chromatography (petroleum ether/ EtOAc = 10:1 to 3:1) and was obtained as a white solid (22.9 mg, 64%), mp: 189-191 °C.

R_f (Petroleum ether/ EtOAc = 3:1) = 0.4.

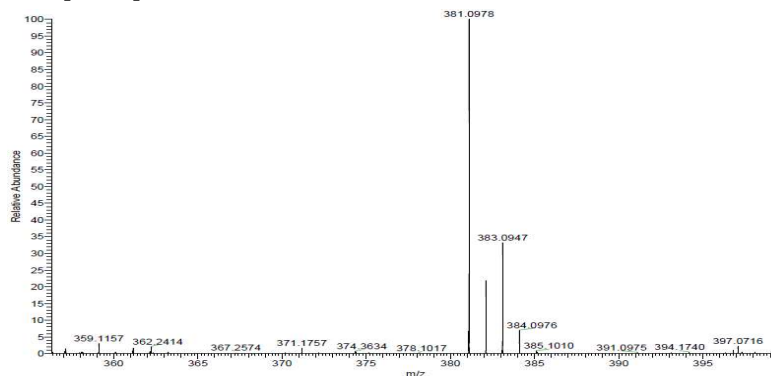
HPLC (IC, *n*-hexane/*i*-PrOH = 90/10, flow rate = 2.0 mL/min, I = 215 nm) *t_R* = 13.93 min (minor), 16.17 min (major), 76% ee.

[α]_D²⁵: -16.88 (c = 0.25, CH₂Cl₂).

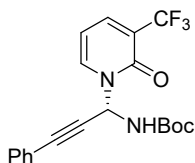
¹H NMR (400 MHz, CDCl₃) δ 7.70-7.59 (m, 1H), 7.54 (dd, *J* = 7.2, 2.0 Hz, 1H), 7.48-7.40 (m, 2H), 7.37-7.26 (m, 3H), 6.72 (s, 1H), 6.57 (s, 1H), 6.18 (t, *J* = 7.2 Hz, 1H), 1.43 (s, 9H).

¹³C NMR (100 MHz, CDCl₃) δ 158.2, 153.9, 138.1, 134.9, 132.0, 129.2, 128.3, 126.6, 121.3, 105.3, 85.7, 82.1, 81.3, 60.3, 28.2.

HRMS (ESI) *m/z*: [M+H]⁺ Calcd for C₁₉H₁₉ClN₂NaO₃ 381.0976; Found 381.0978.



***tert*-Butyl (S)-(1-(2-oxo-3-(trifluoromethyl)pyridin-1(2H)-yl)-3-phenylprop-2-yn-1-yl)carbamate (5k)**



Prepared from 3-(trifluoromethyl)pyridin-2(1H)-one (16.3 mg, 0.1 mmol, 1.0 equiv) and *tert*-butyl (1-ethoxy-3-phenylprop-2-yn-1-yl)carbamate (110.0 mg, 0.4 mmol, 4.0 equiv) according to the general procedure in the presence of **C2** (7.2 mg, 0.01 mmol, 10 mol %), purified by silica gel column chromatography (petroleum ether/ EtOAc = 10:1 to 3:1) and was obtained as colorless oil (23.5 mg, 60%).

R_f (Petroleum ether/ EtOAc = 3:1) = 0.5.

HPLC (IE, *n*-hexane/*i*-PrOH = 80/20, flow rate = 1.0 mL/min, I = 215 nm) *t_R* = 9.89 min (major), 11.96 min (minor), 72% ee.

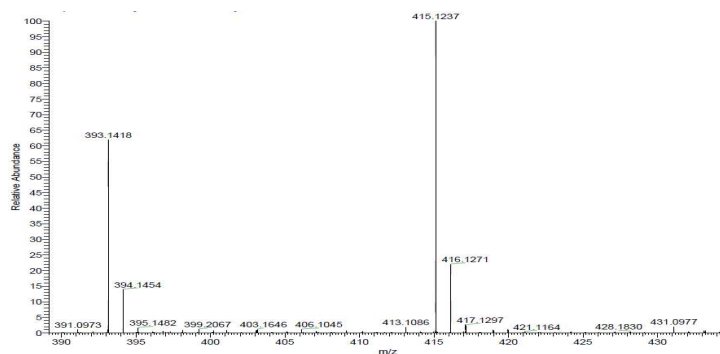
[α]_D²⁵: -6.08 (c = 0.25, CH₂Cl₂).

¹H NMR (400 MHz, CDCl₃) δ 8.06 (d, *J* = 6.8 Hz, 1H), 7.74 (d, *J* = 6.8 Hz, 1H), 7.45-7.39 (m, 2H), 7.37-7.25 (m, 3H), 6.81 (s, 2H), 6.28 (t, *J* = 6.8 Hz, 1H), 1.43 (s, 9H).

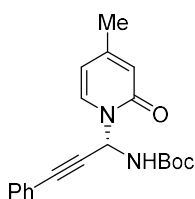
¹³C NMR (75 MHz, DMSO-*d*₆) δ 156.6, 154.1, 140.9 (q, *J* = 4.5 Hz), 139.4, 132.2, 130.0, 129.2, 123.3 (q, *J* = 270.0 Hz), 121.0, 118.6 (q, *J* = 30.0 Hz), 105.6, 85.1, 84.2, 80.6, 54.4, 28.3.

¹⁹F NMR (376 MHz, DMSO-*D*₆) δ -70.2.

HRMS (ESI) *m/z*: [M+Na]⁺ Calcd for C₂₀H₁₉F₃N₂NaO₃ 415.1240; Found 415.1237.



***tert*-Butyl (S)-(1-(4-methyl-2-oxopyridin-1(2H)-yl)-3-phenylprop-2-yn-1-yl)carbamate (5l)**



Prepared from 4-methylpyridin-2(1H)-one (10.9 mg, 0.1 mmol, 1.0 equiv) and *tert*-butyl (1-ethoxy-3-phenylprop-2-yn-1-yl)carbamate (110.0 mg, 0.4 mmol, 4.0 equiv) according to the general procedure in the presence of **C2** (7.2 mg, 0.01 mmol, 10 mol %), purified by silica gel column chromatography (petroleum ether/ EtOAc = 10:1 to 3:1) and was obtained as a white solid (20.3 mg, 60%), mp: 213-215 °C.

R_f (Petroleum ether/ EtOAc = 3:1) = 0.2.

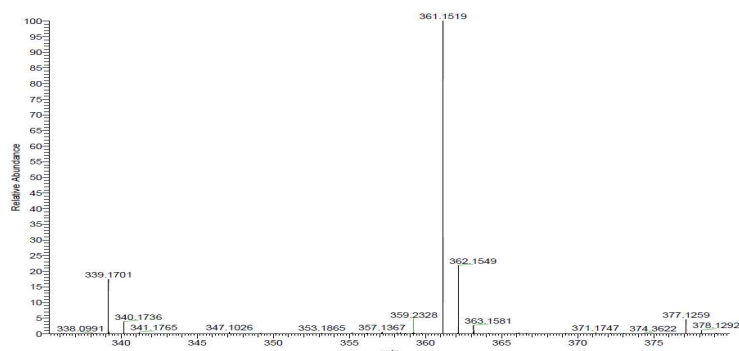
HPLC (IC, *n*-hexane/*i*-PrOH = 50/50, flow rate = 1.0 mL/min, I = 215 nm) *t_R* = 7.84 min (minor), 9.89 min (major), 83% ee.

$[\alpha]_{\text{D}}^{25}$: +8.24 (c = 0.25, CH₂Cl₂).

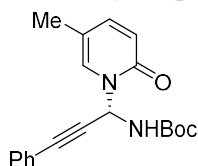
¹H NMR (400 MHz, CDCl₃) δ 7.51 (d, *J* = 6.8 Hz, 1H), 7.47-7.42 (m, 2H), 7.37-7.26 (m, 3H), 6.67 (s, 1H), 6.53 (s, 1H), 6.37 (s, 1H), 6.04 (dd, *J* = 7.2, 2.0 Hz, 1H), 2.17 (s, 3H), 1.43 (s, 9H).

¹³C NMR (100 MHz, CDCl₃) δ 161.9, 154.0, 151.9, 134.9, 132.0, 129.0, 128.3, 121.6, 119.8, 108.6, 85.2, 82.9, 81.0, 58.9, 28.3, 21.4.

HRMS (ESI) *m/z*: [M+Na]⁺ Calcd for C₂₀H₂₂N₂NaO₃ 361.1523; Found 361.1519.



***tert*-Butyl (*S*)-(1-(5-methyl-2-oxopyridin-1(2H)-yl)-3-phenylprop-2-yn-1-yl)carbamate (5m)**



Prepared from 5-methylpyridin-2(1H)-one (10.9 mg, 0.1 mmol, 1.0 equiv) and *tert*-butyl (1-ethoxy-3-phenylprop-2-yn-1-yl)carbamate (110.0 mg, 0.4 mmol, 4.0 equiv) according to the general procedure in the presence of **C2** (7.2 mg, 0.01 mmol, 10 mol %), purified by silica gel column chromatography (petroleum ether/ EtOAc = 10:1 to 3:1) and was obtained as a white solid (30.8 mg, 91%), mp: 176-178 °C.

R_f (Petroleum ether/ EtOAc = 3:1) = 0.2.

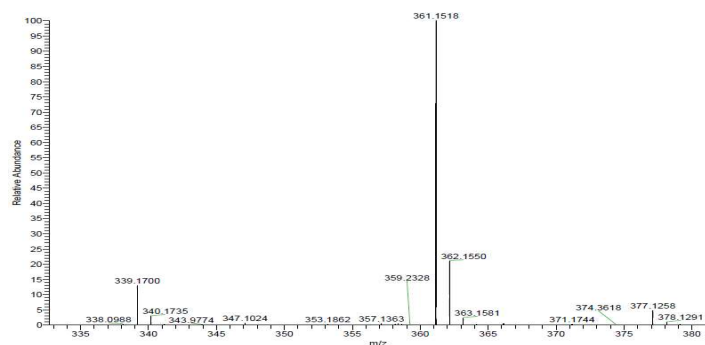
HPLC (AS-H, *n*-hexane/*i*-PrOH = 90/10, flow rate = 1.0 mL/min, I = 215 nm) *t_R* = 7.74 min (major), 10.97 min (minor), 88% ee.

$[\alpha]_{\text{D}}^{25}$: +5.44 (c = 0.25, CH₂Cl₂).

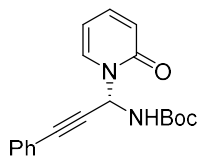
¹H NMR (400 MHz, CDCl₃) δ 7.47-7.41 (m, 2H), 7.37-7.25 (m, 4H), 7.20 (dd, *J* = 9.2, 2.4 Hz, 1H), 6.65 (s, 2H), 6.53 (d, *J* = 9.2 Hz, 1H), 2.09 (s, 3H), 1.43 (s, 9H).

¹³C NMR (100 MHz, CDCl₃) δ 161.2, 154.0, 142.8, 133.3, 132.0, 129.0, 128.3, 121.6, 121.1, 115.1, 84.9, 83.2, 81.0, 59.2, 28.3, 17.2.

HRMS (ESI) *m/z*: [M+Na]⁺ Calcd for C₂₀H₂₂N₂NaO₃ 361.1523, Found 361.1518.



***tert*-Butyl (*S*)-(1-(2-oxopyridin-1(2H)-yl)-3-phenylprop-2-yn-1-yl)carbamate (**5n**)**



Prepared from pyridin-2(1H)-one (9.5 mg, 0.1 mmol, 1.0 equiv) and *tert*-butyl (1-ethoxy-3-phenylprop-2-yn-1-yl)carbamate (110.0 mg, 0.4 mmol, 4.0 equiv) according to the general procedure in the presence of **C2** (7.2 mg, 0.01 mmol, 10 mol %), purified by silica gel column chromatography (petroleum ether/ EtOAc = 10:1 to 3:1) and was obtained as a white solid (28.2 mg, 87%), mp: 188-190 °C.

R_f (Petroleum ether/ EtOAc = 3:1) = 0.2.

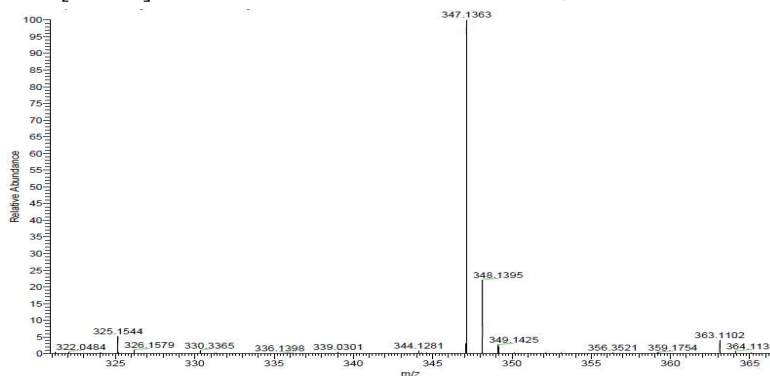
HPLC (IC, *n*-hexane/*i*-PrOH = 80/20, flow rate = 1.2 mL/min, I = 215 nm) *t_R* = 17.46 min (minor), 19.19 min (major), 82% ee.

[α]_D²⁵: +26.16 (c = 0.25, CH₂Cl₂).

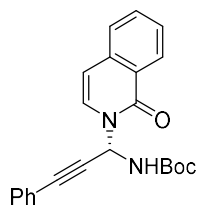
¹H NMR (400 MHz, CDCl₃) δ 7.64 (dd, *J* = 6.8, 1.6 Hz, 1H), 7.48-7.40 (m, 2H), 7.39-7.27 (m, 4H), 6.72 (s, 1H), 6.58 (dd, *J* = 9.2, 0.4 Hz, 2H), 6.20 (td, *J* = 6.8, 1.2 Hz, 1H), 1.43 (s, 9H).

¹³C NMR (100 MHz, CDCl₃) δ 161.9, 153.9, 140.1, 136.0, 132.0, 129.1, 128.3, 121.53, 121.47, 105.9, 85.3, 82.7, 81.1, 59.4, 28.2.

HRMS (ESI) *m/z*: [M+Na]⁺ Calcd for C₁₉H₂₀N₂NaO₃ 347.1366; Found 347.1363.



***tert*-Butyl (*S*)-(1-(1-oxoisoquinolin-2(1H)-yl)-3-phenylprop-2-yn-1-yl)carbamate (**5o**)**



Prepared from isoquinolin-1(2H)-one (14.5 mg, 0.1 mmol, 1.0 equiv) and *tert*-butyl (1-ethoxy-3-phenylprop-2-yn-1-yl)carbamate (110.0 mg, 0.4 mmol, 4.0 equiv) according to the general procedure in the presence of **C2** (7.2 mg, 0.01 mmol, 10 mol %), purified by silica gel column chromatography (petroleum ether/ EtOAc = 20:1 to 5:1) and was obtained as colorless oil (10.1 mg, 27%).

R_f (Petroleum ether/ EtOAc = 5:1) = 0.3.

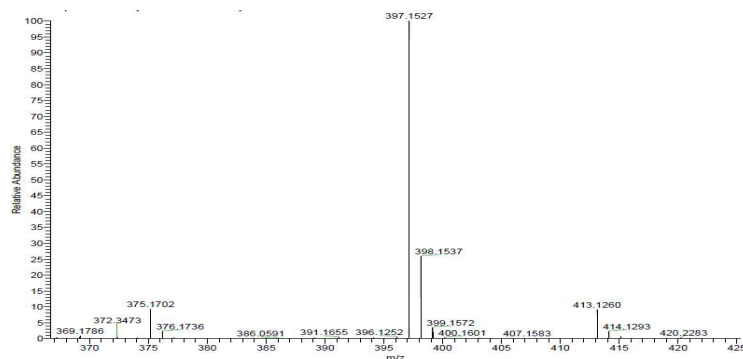
HPLC (ID, *n*-hexane/*i*-PrOH = 60/40, flow rate = 1.0 mL/min, I = 215 nm) *t_R* = 9.90 min (major), 12.20 min (minor), 96% ee.

[α]_D²⁵: -8.40 (c = 0.1, CH₂Cl₂).

¹H NMR (400 MHz, CDCl₃) δ 8.48-8.41 (m, 1H), 7.69-7.57 (m, 1H), 7.55-7.37 (m, 5H), 7.36-7.25 (m, 3H), 6.89 (s, 1H), 6.54 (d, *J* = 7.6 Hz, 1H), 6.45 (s, 1H), 1.42 (s, 9H).

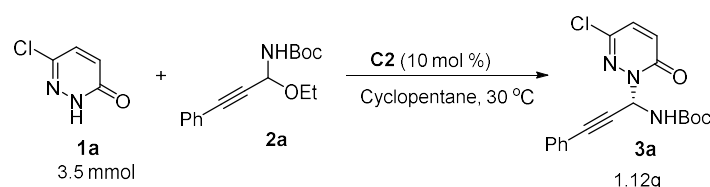
¹³C NMR (100 MHz, CDCl₃) δ 161.5, 154.1, 137.0, 132.6, 132.0, 129.7, 129.0, 128.3, 128.0, 127.0, 126.4, 126.0, 121.6, 106.4, 84.8, 83.3, 80.8, 58.5, 28.3.

HRMS (ESI) *m/z*: [M+Na]⁺ Calcd for C₂₃H₂₂N₂NaO₃ 397.1523; Found 397.1527.



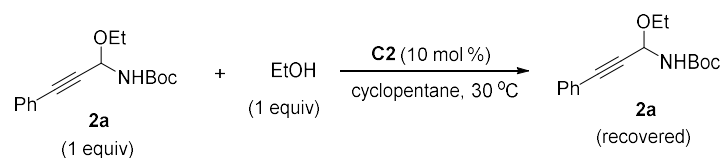
Control Experiments for Scheme 4

Gram-scale reaction



To a 100 mL of dry three-neck flask were added **C2** (251.6 mg, 0.35 mmol, 10 mol %), **1a** (455 mg, 3.5 mmol, 1.0 equiv) and **2a** (3.85 g, 14 mmol, 4.0 equiv), then Cyclopentane (50 mL) was added under argon atmosphere. The resulting mixture was stirred at 30 °C for 24 hours. The reaction mixture was concentrated under vacuum; the crude residue was purified by silica gel column chromatography (eluent: petroleum ether/EtOAc = 10:1-3:1) to give **3a** (1.12 g, 89 %, 94% ee).

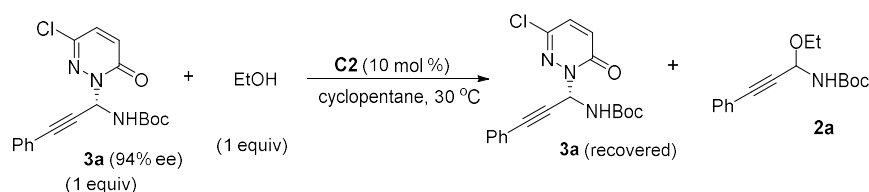
Scheme 4a



To a 10 mL of dry schlenk tube were added **2a** (13.8 mg, 0.05 mmol, 1.0 equiv) and EtOH (2.3 mg, 0.05 mmol, 1.0 equiv), then Cyclopentane (1 mL) was added under argon atmosphere. The resulting mixture was stirred at 30 °C. After a period of time, the reaction solution was monitored and the ee values were determined by HPLC.

entry	t (h)	ee of recovered 2a (%)
1	1	0
2	3	0
3	6	0
4	12	0
5	24	0

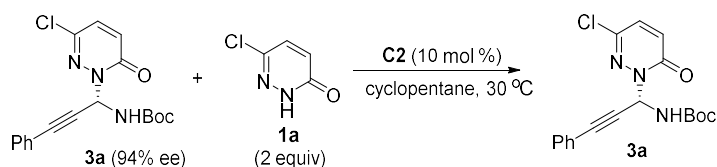
Scheme 4b



To a 10 mL of dry schlenk tube were added **3a** (18.0 mg, 0.05 mmol, 1.0 equiv), EtOH (2.3 mg, 0.05 mmol, 1.0 equiv) and **C2** (3.6 mg, 0.005 mmol, 10 mol %), then Cyclopentane (1 mL) was added under argon atmosphere. The resulting mixture was stirred at 30 °C. After a period of time, the reaction solution was monitored and the ee values were determined by HPLC.

Entry	t (h)	ee of recovered 3a (%)	yield of 2a (%)	ee of 2a (%)
1	6	94	<5	0
2	12	94	6	0
3	18	92	8	0
4	24	92	17	0
5	48	92	22	0

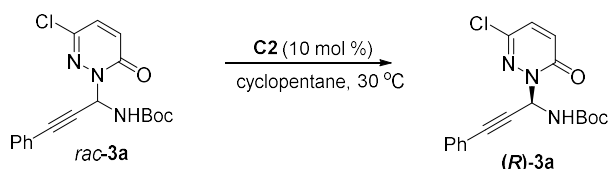
Scheme 4c



To a 10 mL of dry schlenk tube were added **3a** (18.0 mg, 0.05 mmol, 1.0 equiv), **1a** (13.0 mg, 0.1 mmol, 2.0 equiv) and **C2** (3.6 mg, 0.005 mmol, 10 mol %), then Cyclopentane (1 mL) was added under argon atmosphere. The resulting mixture was stirred at 30 °C. After a period of time, the reaction solution was monitored and the ee values were determined by HPLC.

entry	t (h)	ee of 3a
1	6	94
2	12	94
3	18	92
4	24	92
5	48	92
6	96	92

Scheme 4d



To a 10 mL of dry schlenk tube were added *rac*-**3a** (18.0 mg, 0.05 mmol, 1.0 equiv) and **C2** (3.6 mg, 0.005 mmol, 10 mol %), then Cyclopentane (1 mL) was added under argon atmosphere. The resulting mixture was stirred at 30 °C. After a period of time, the reaction solution was monitored and the ee values were determined by HPLC.

entry	t (h)	ee of (<i>R</i>)- 3a
1	6	-6
2	12	-6
3	18	-10
4	24	-10
5	48	-15

X-ray crystallographic data of **5f**

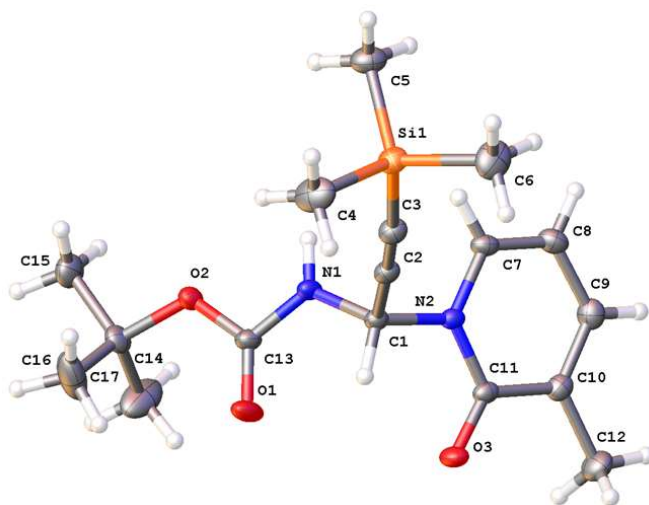
The crystal structures have been deposited at the Cambridge Crystallographic Data Centre. CCDC 2268745 (**5f**) contains the supplementary crystallographic data for this paper. These data can be obtained free of charge via the internet at www.ccdc.cam.ac.uk/data-request/cif.

The measurements were taken in a Bruker D8 Venture diffractometer. The data were integrated by Bruker D8 with multi-scan absorption corrections. The structure solution and refinement were processed by SHELXL.

X-ray crystallographic data for **5f**

Method of crystallization: A solution of **5f** in dichloromethane and petroleum ether was evaporated the solvent slowly at room temperature.

Crystal data and structure for **5f**



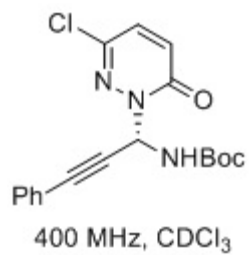
X-ray structure of **5f**. Thermal ellipsoids are shown at the 50% level.

Empirical formula	C ₁₇ H ₂₆ N ₂ O ₃ Si	
Formula weight	334.49	
Temperature	213.00 K	
Wavelength	1.34139 Å	
Crystal system	Monoclinic	
Space group	P 1 21 1	
Unit cell dimensions	a = 9.3045(2) Å	$\alpha = 90^\circ$
	b = 11.4846(2) Å	$\beta = 115.1230(10)^\circ$

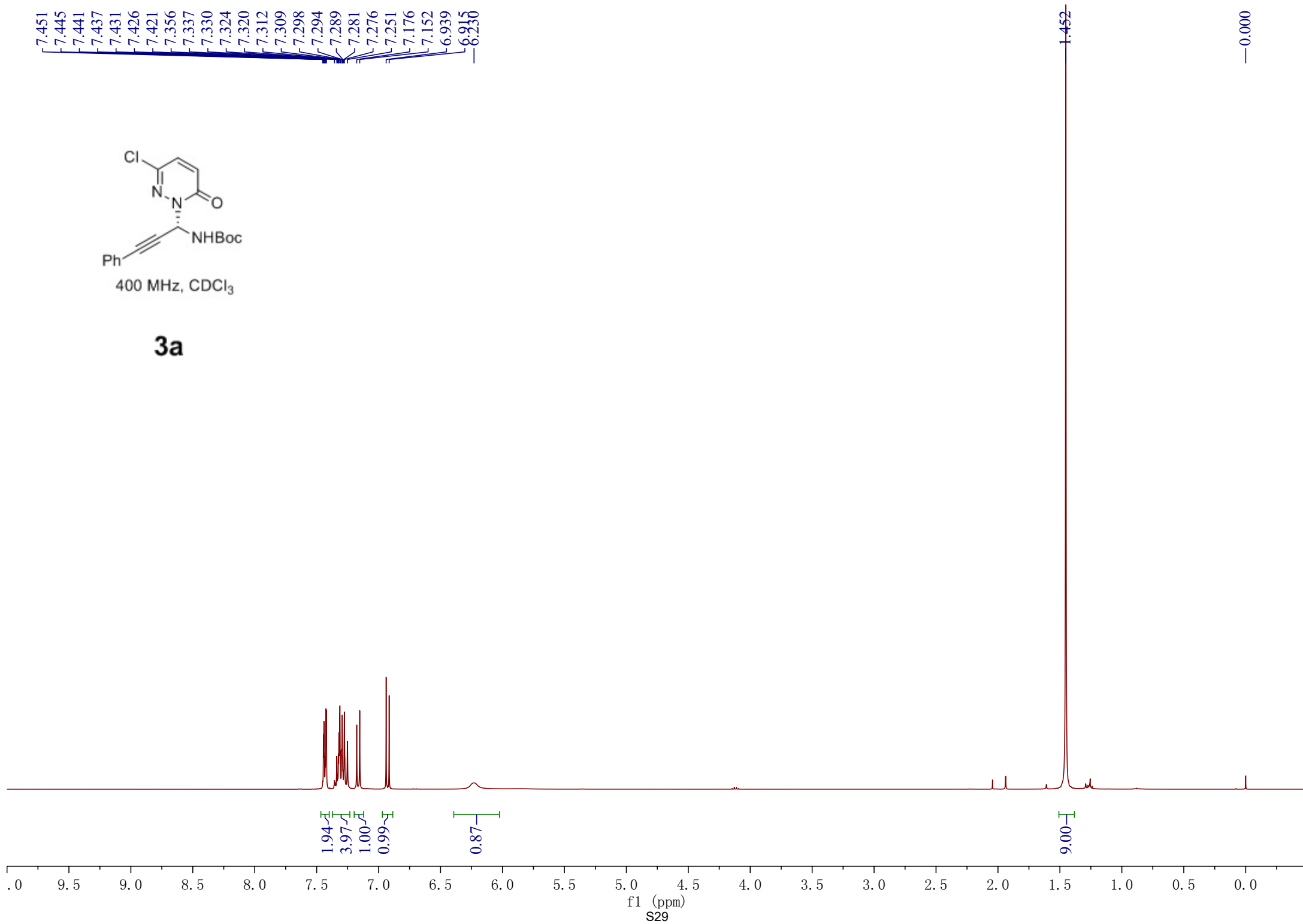
	$c = 10.1085(2) \text{ \AA}$	$\gamma = 90^\circ$
Volume	$977.99(3) \text{ \AA}^3$	
Z	2	
Density (calculated)	1.136 Mg/m^3	
Absorption coefficient	0.764 mm^{-1}	
F(000)	360	
Crystal size	$0.07 \times 0.07 \times 0.05 \text{ mm}^3$	
θ range for data collection	4.203 to 54.886°	
Index ranges	$-11 \leq h \leq 11, -13 \leq k \leq 13, -12 \leq l \leq 12$	
Reflections collected	11863	
Independent reflections	3679 ($R_{\text{int}} = 0.0473$)	
Completeness to $\theta = 25.242^\circ$	99.7 %	
Max. and min. transmission	0.7508 and 0.5632	
Data / restraints / parameters	3679 / 1 / 215	
Goodness-of-fit on F^2	1.052	
Final R indices [$I > 2\sigma(I)$]	$R_1 = 0.0351, wR_2 = 0.0804$	
R indices (all data)	$R_1 = 0.0336, wR_2 = 0.0819$	
Largest diff. peak and hole	0.134 and $-0.202 \text{ e.\AA}^{-3}$	
Flack parameter	0.049(17)	

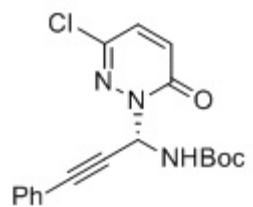
References

- [1] (a) Wang, Y.; Wang, S.; Shan, W.; Shao, Z. *Nat. Commun.* **2020**, *11*, 226. (b) Sun, Z.; Chen, L.; Qiu, K.; Liu, B.; Li, H.; Yu, F. *Chem. Commun.*, **2022**, 58, 3035-3038. (c) Ma, X.-Y.; Zhang, C.-F.; Hu, X.; Zou, W.; Li, Y. *Tetrahedron*, **2020**, *76*, 131085.



3a





100 MHz, CDCl₃

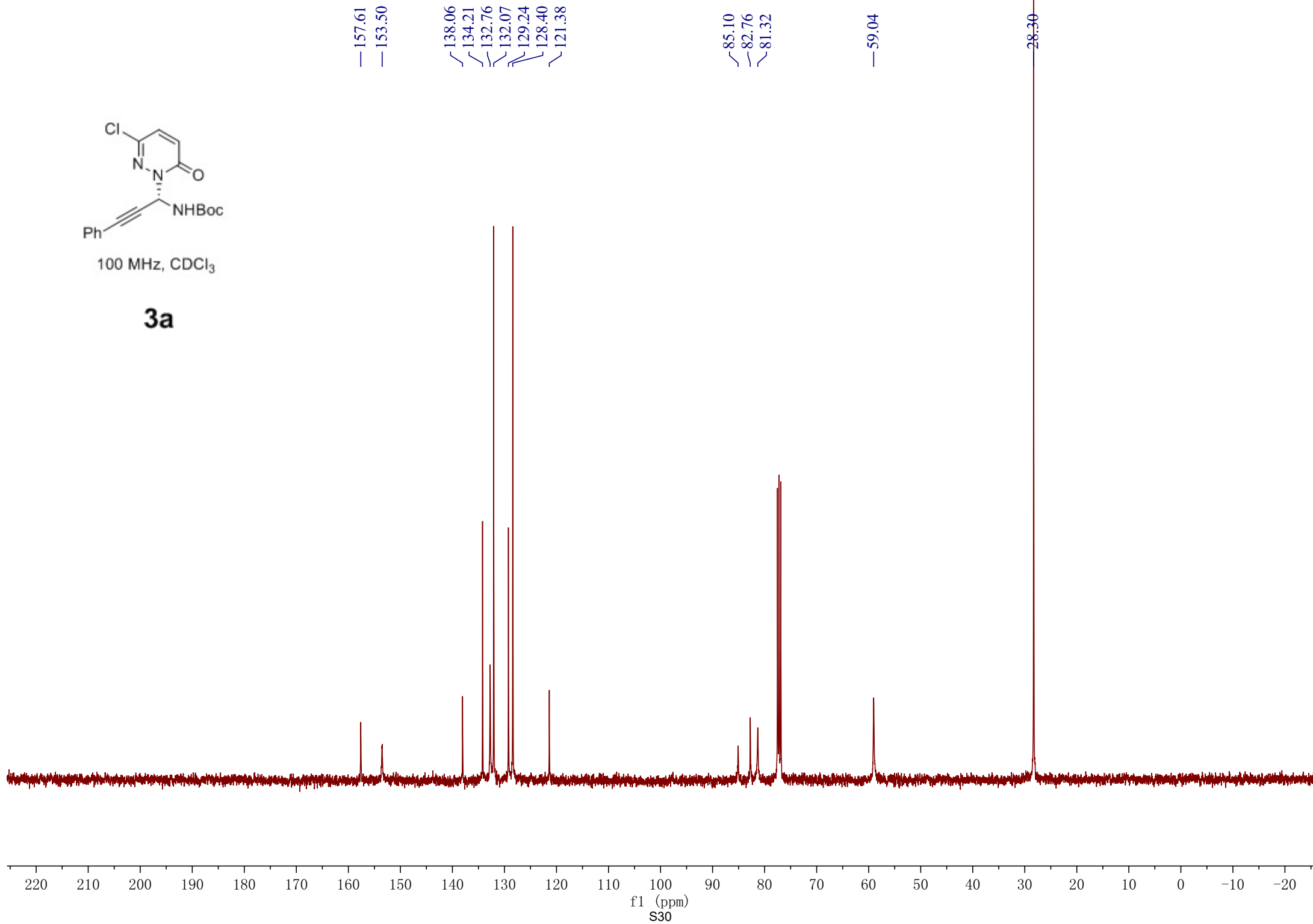
3a

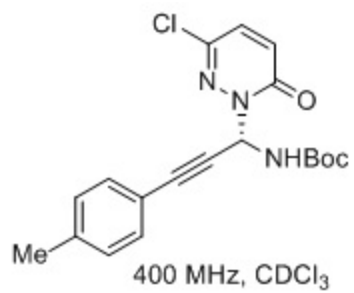
157.61
153.50
138.06
134.21
132.76
132.07
129.24
128.40
121.38

85.10
82.76
81.32

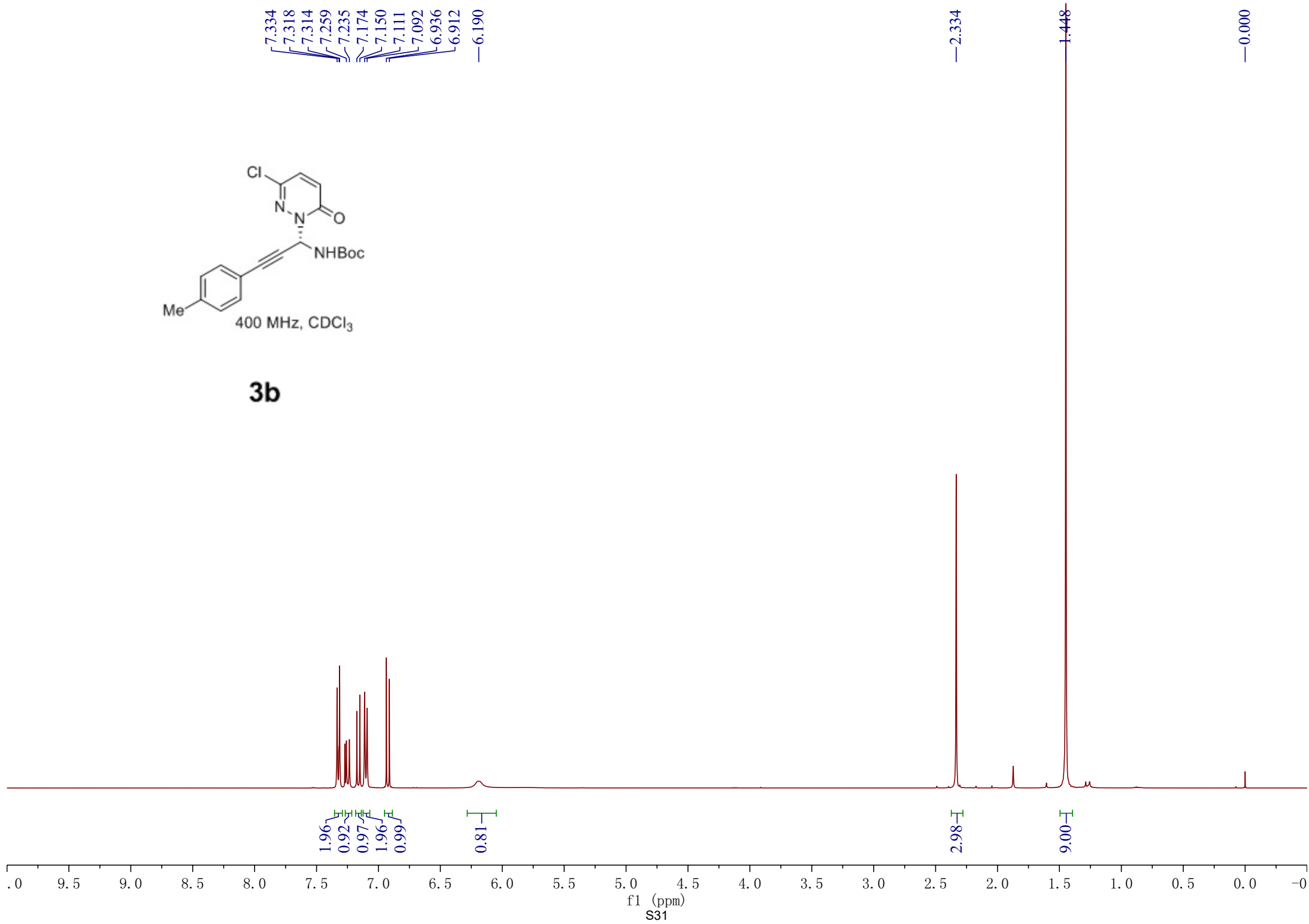
59.04

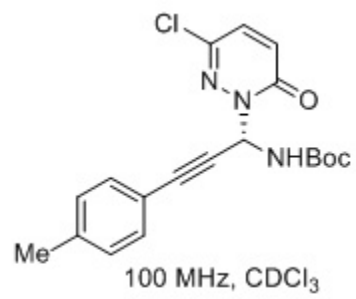
28.30



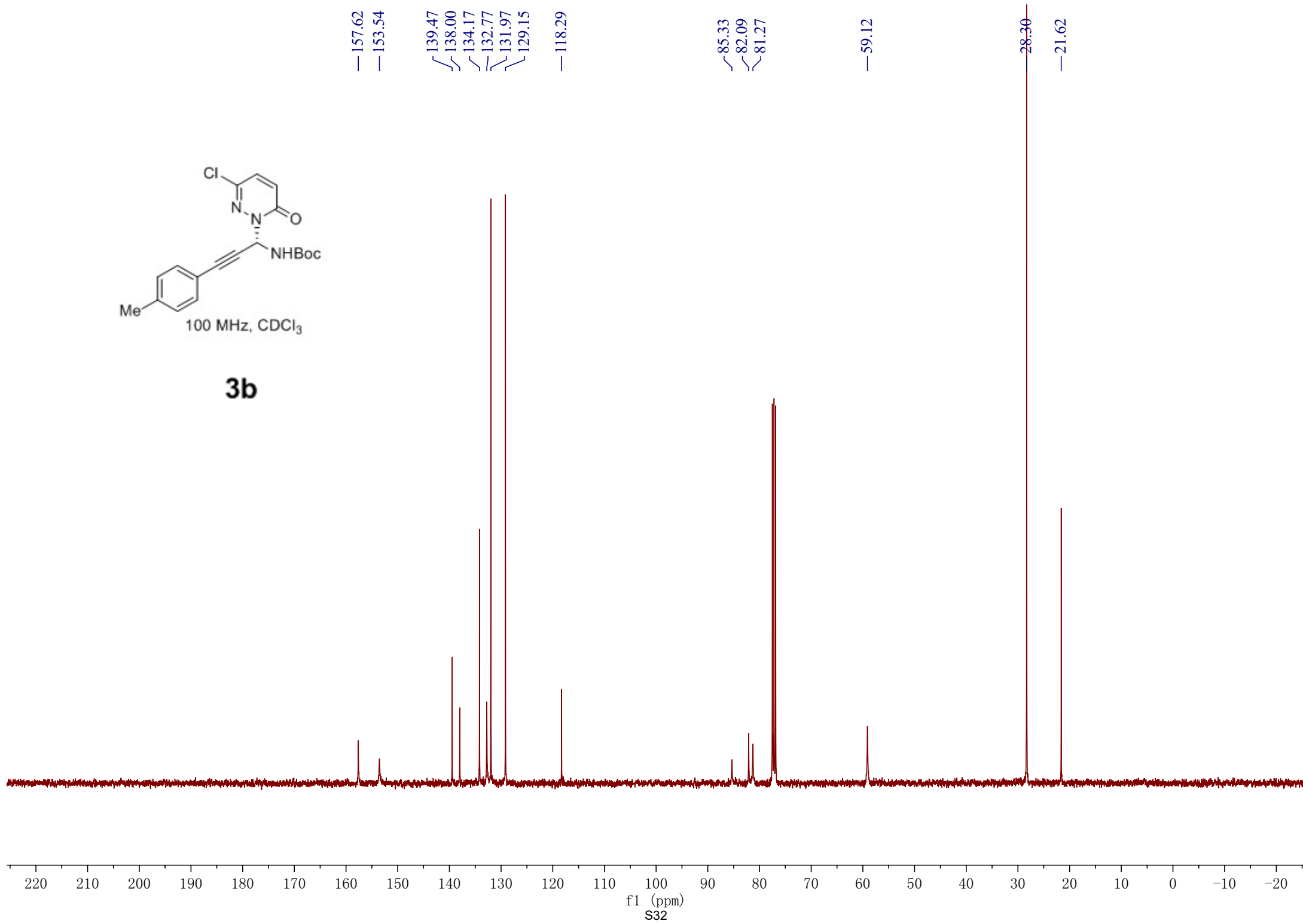


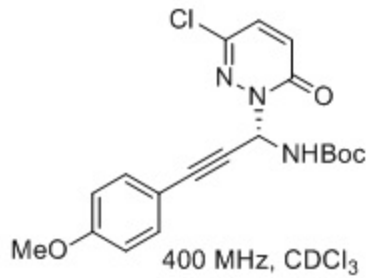
3b



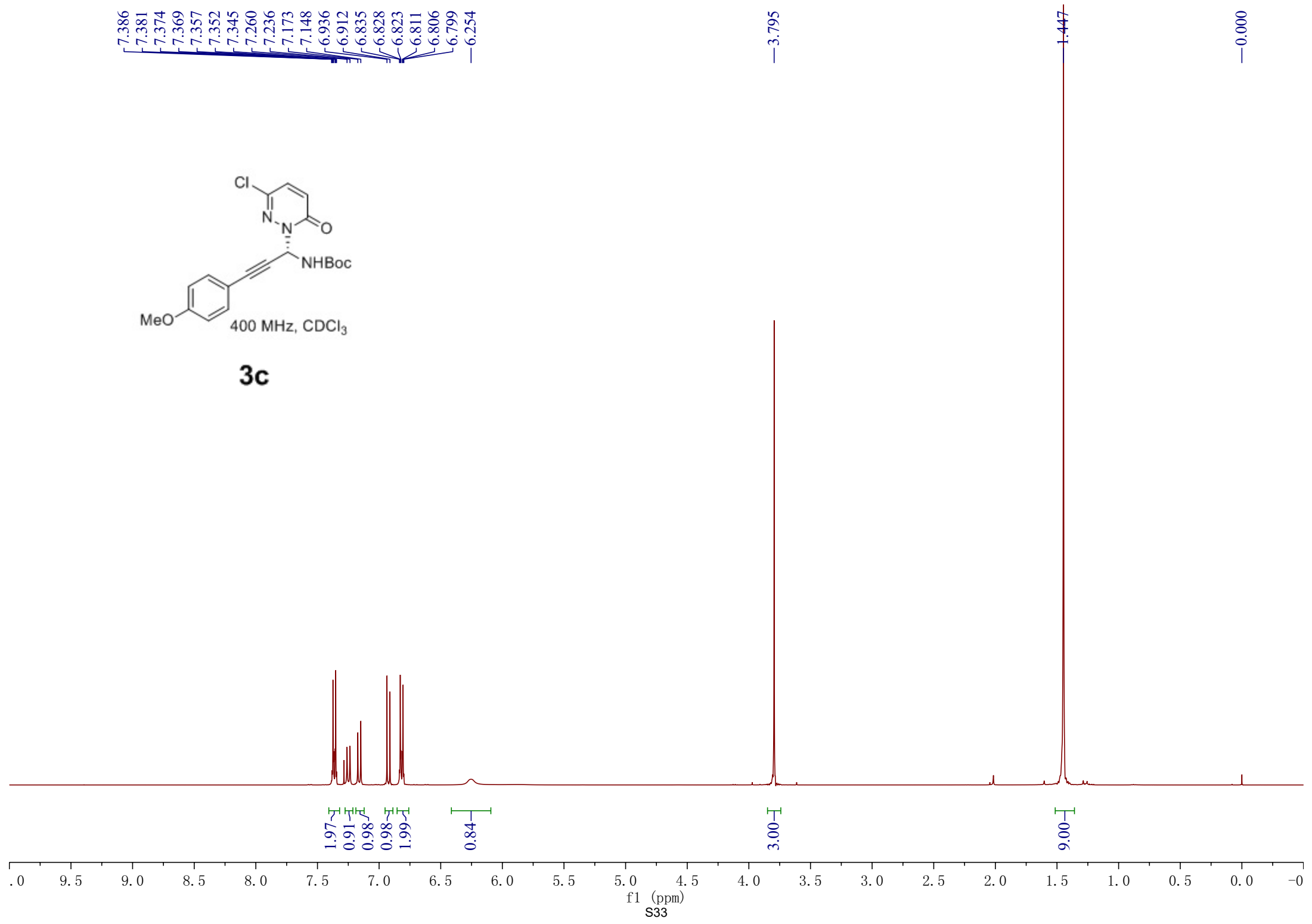


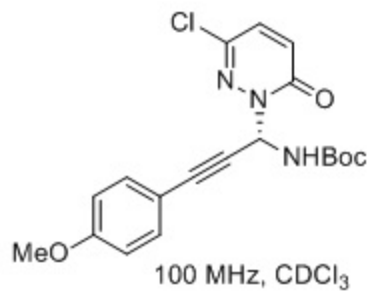
3b





3c





3c

160.26
157.62
153.57

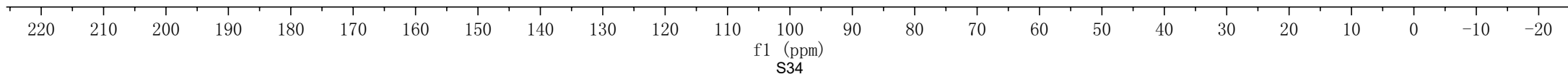
137.98
134.16
133.61
132.76

114.02
113.37

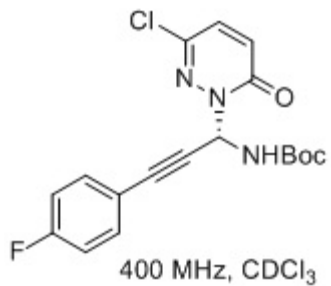
85.22
81.48
81.23

59.14
55.37

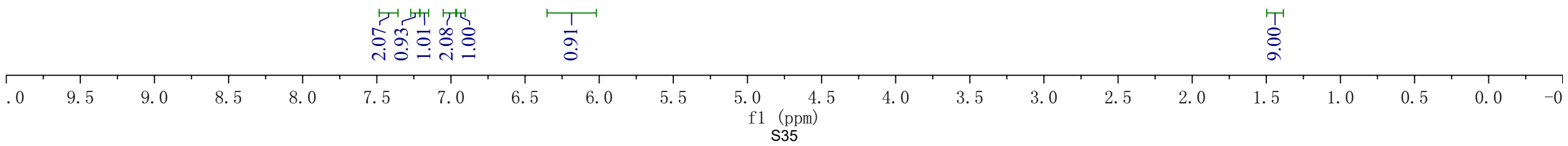
28.29



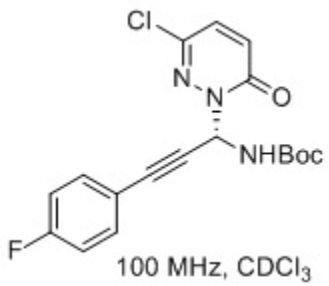
7.451
7.444
7.438
7.430
7.425
7.422
7.414
7.408
7.401
7.250
7.226
7.197
7.173
7.029
7.022
7.017
7.005
7.000
6.996
6.990
6.984
6.979
6.972
6.953
6.929
— 6.198



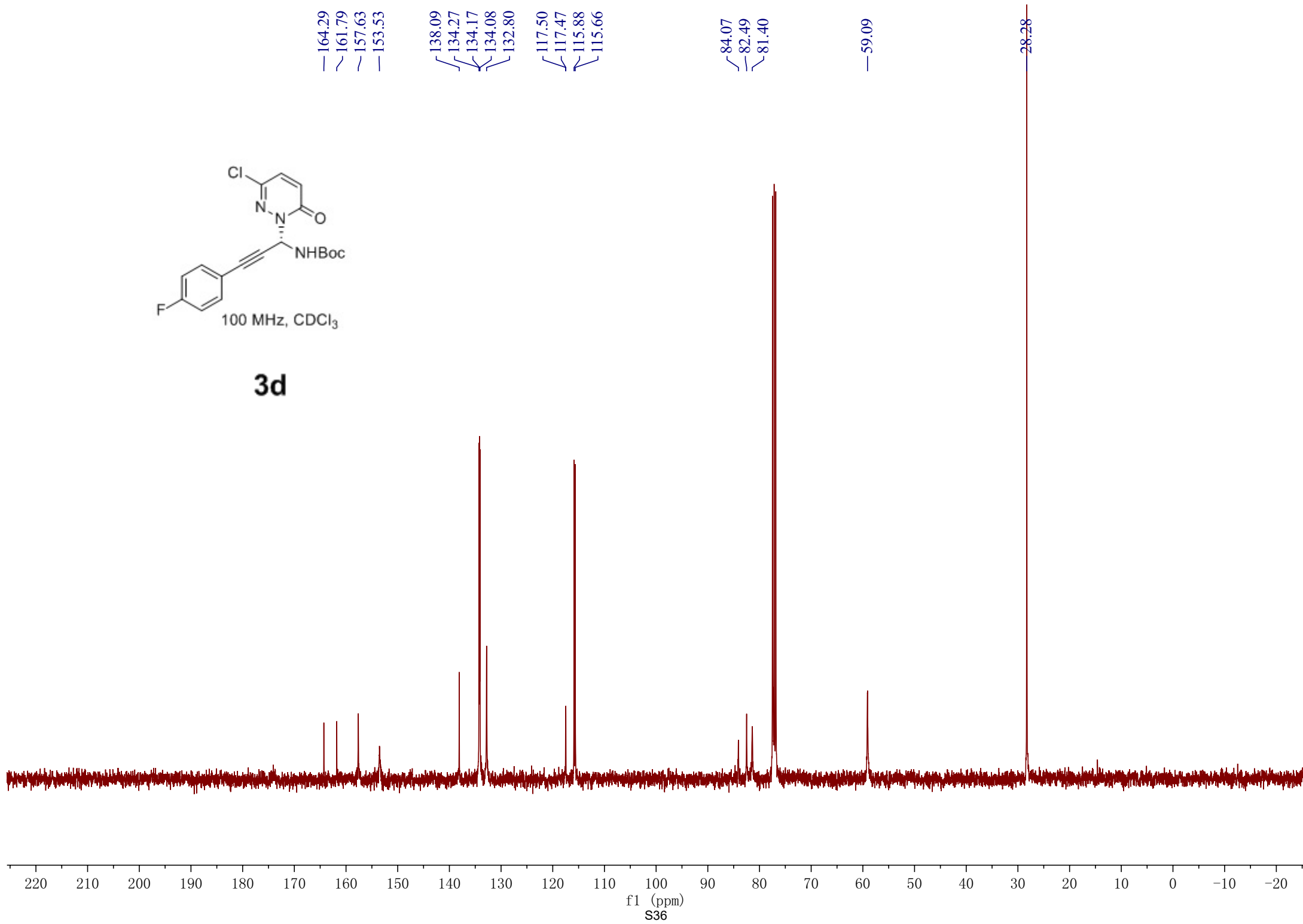
3d

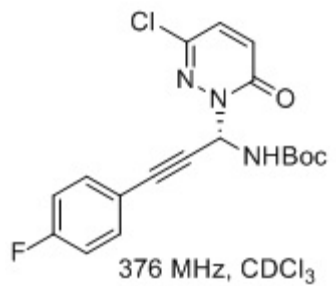


— 0.000

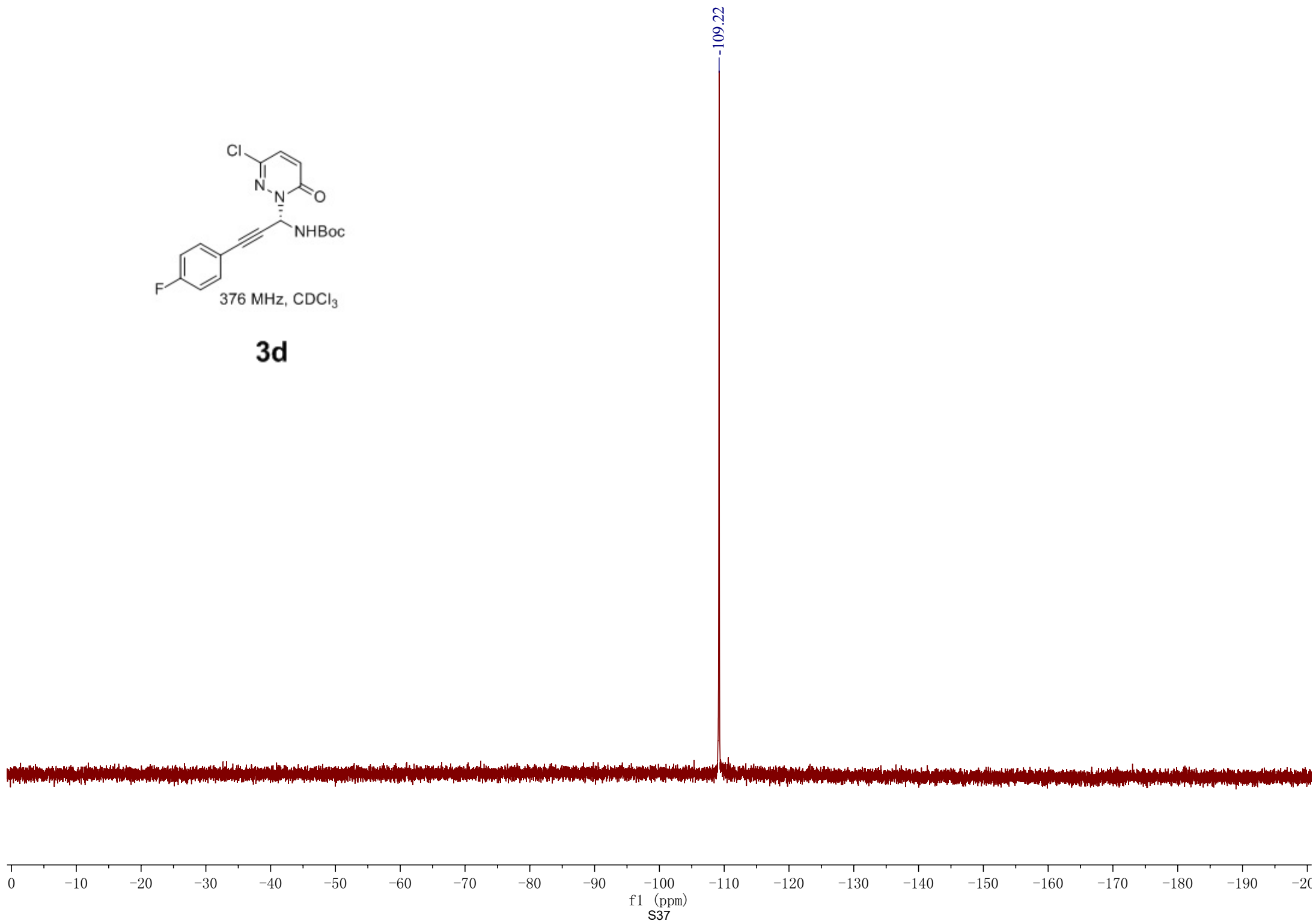


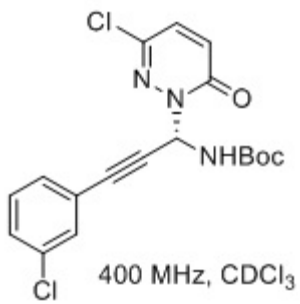
3d





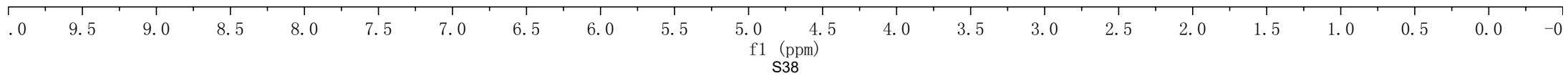
3d





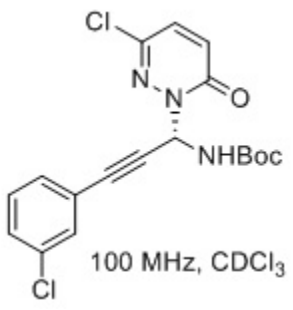
3e

7.438
7.434
7.430
7.335
7.332
7.329
7.327
7.313
7.311
7.308
7.257
7.242
7.236
7.218
7.198
7.174
6.948
6.924
— 6.136



1.454

— 0.000



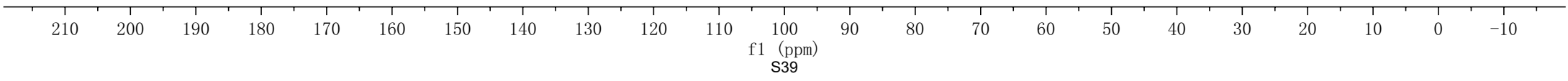
3e

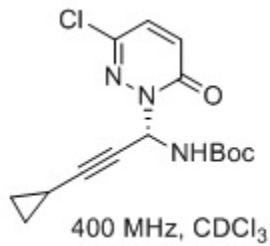
— 157.55
— 153.38
138.11
134.28
134.20
132.75
131.90
130.16
129.62
129.50
123.02

83.79
83.56
81.43

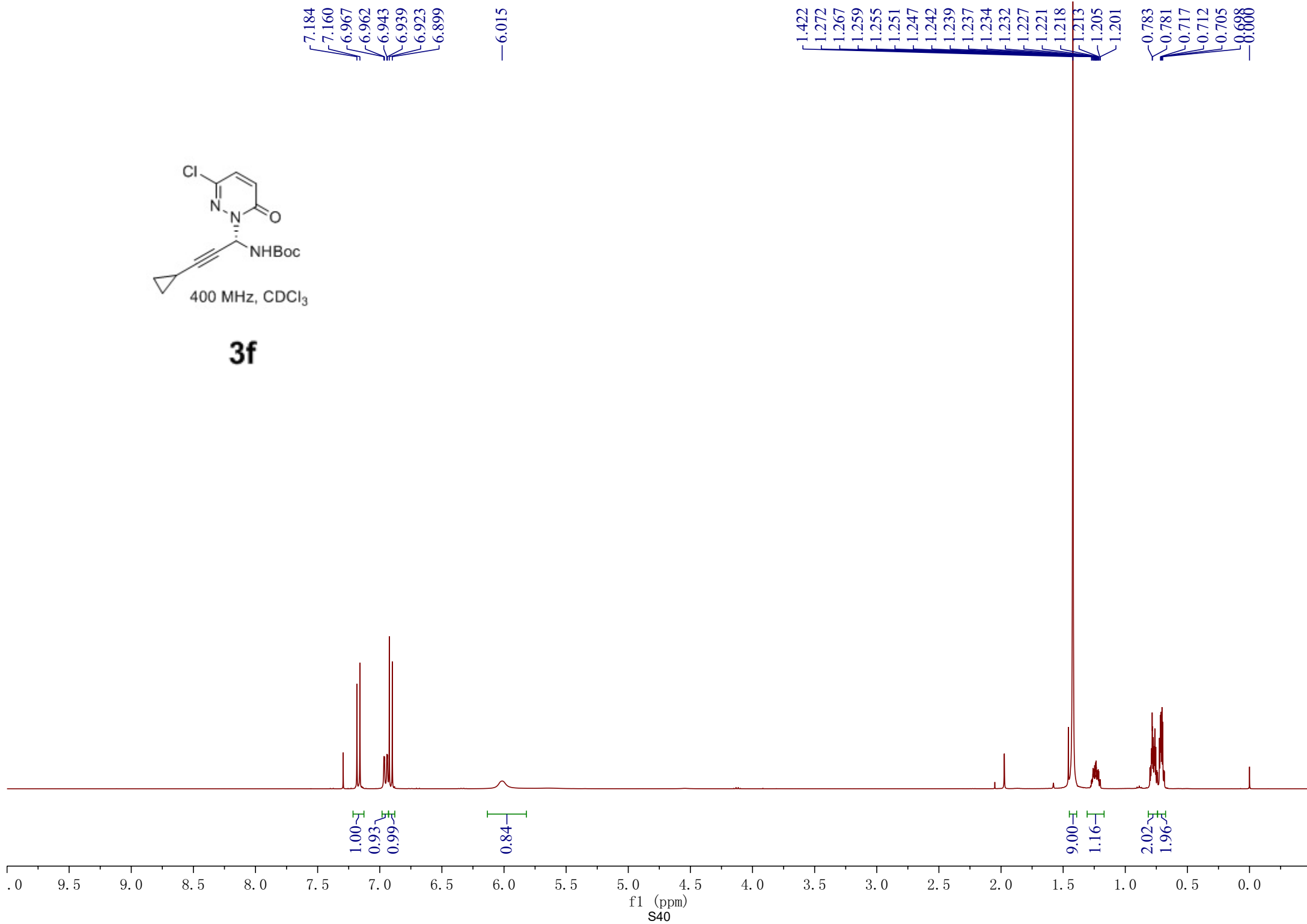
— 59.02

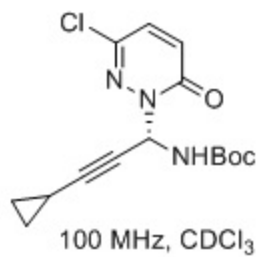
— 28.23



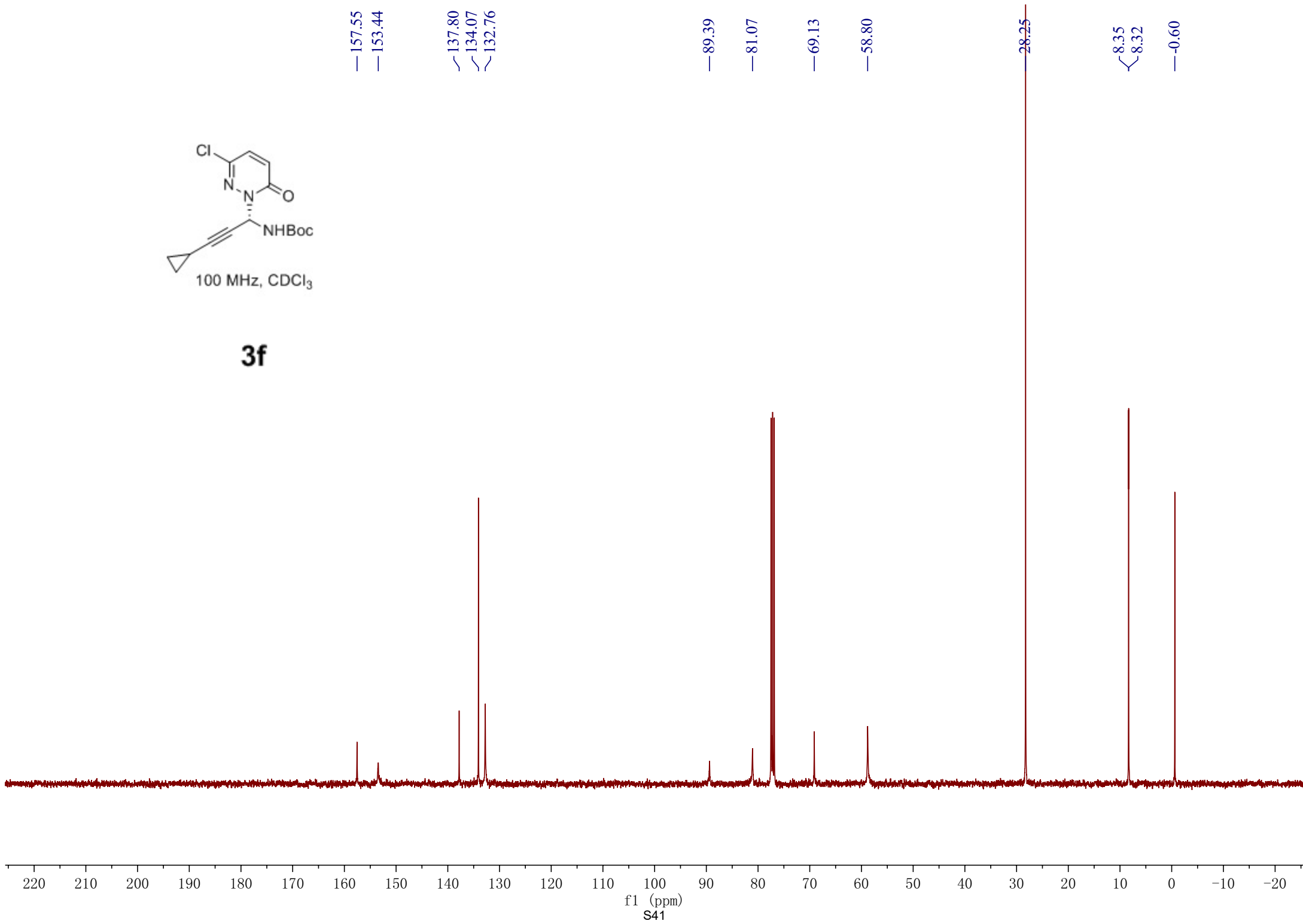


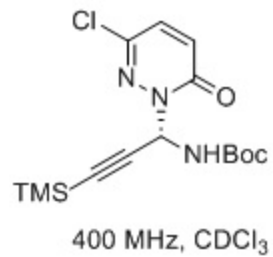
3f





3f





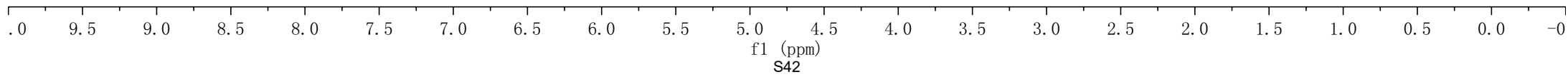
3g

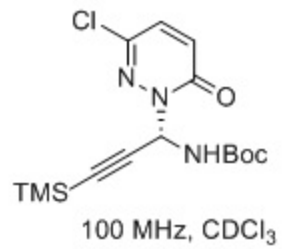
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7.023
6.998
6.930
6.906

6.043

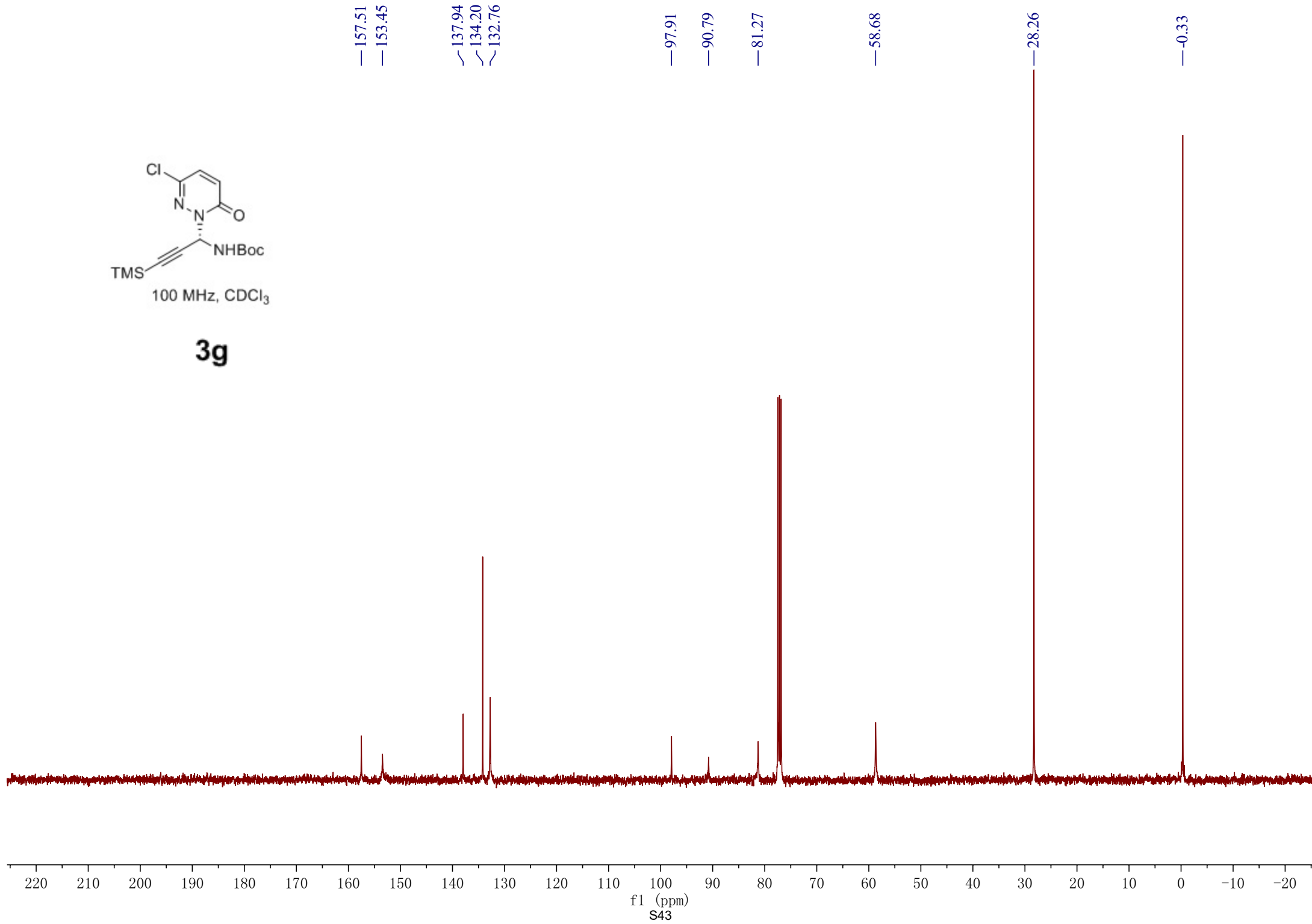
1.431

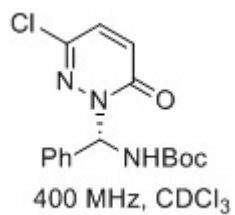
0.164





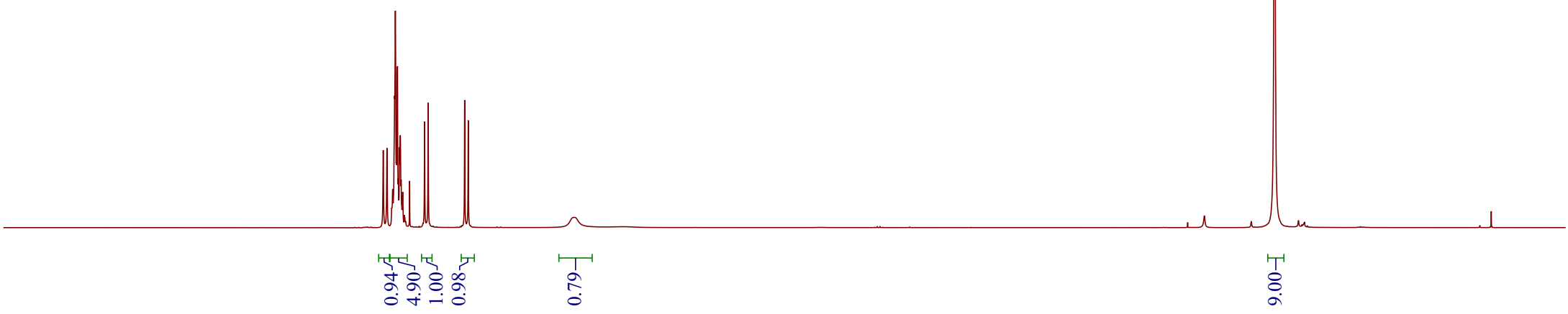
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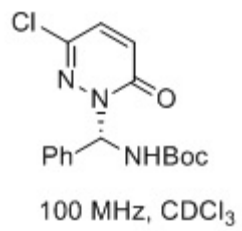


3h

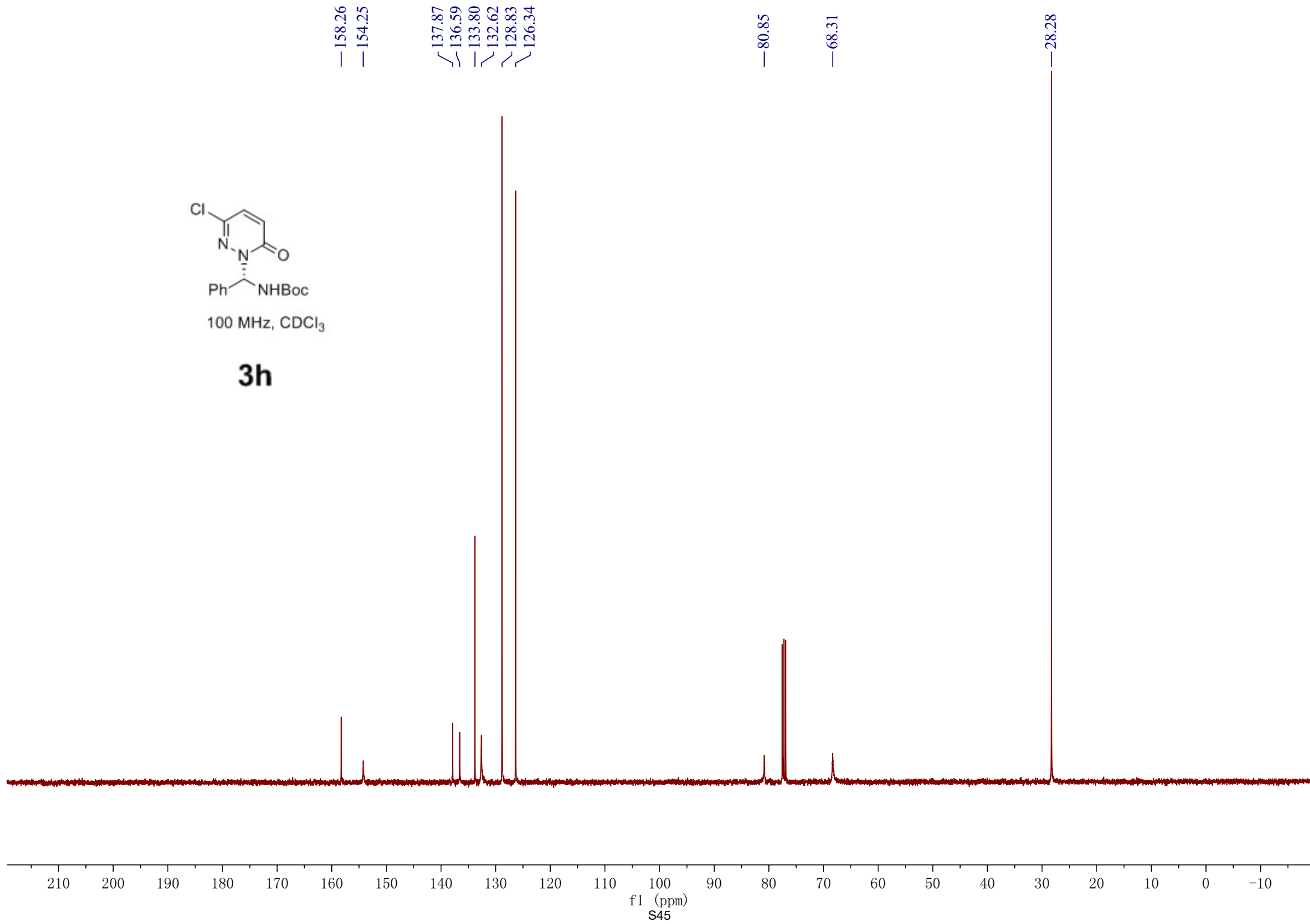
7.447
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7.370
7.365
7.359
7.351
7.345
7.338
7.332
7.327
7.316
7.305
7.302
7.169
7.145
6.900
6.875
— 6.163

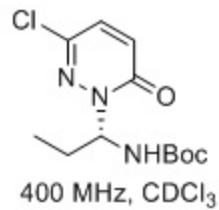


— 0.000

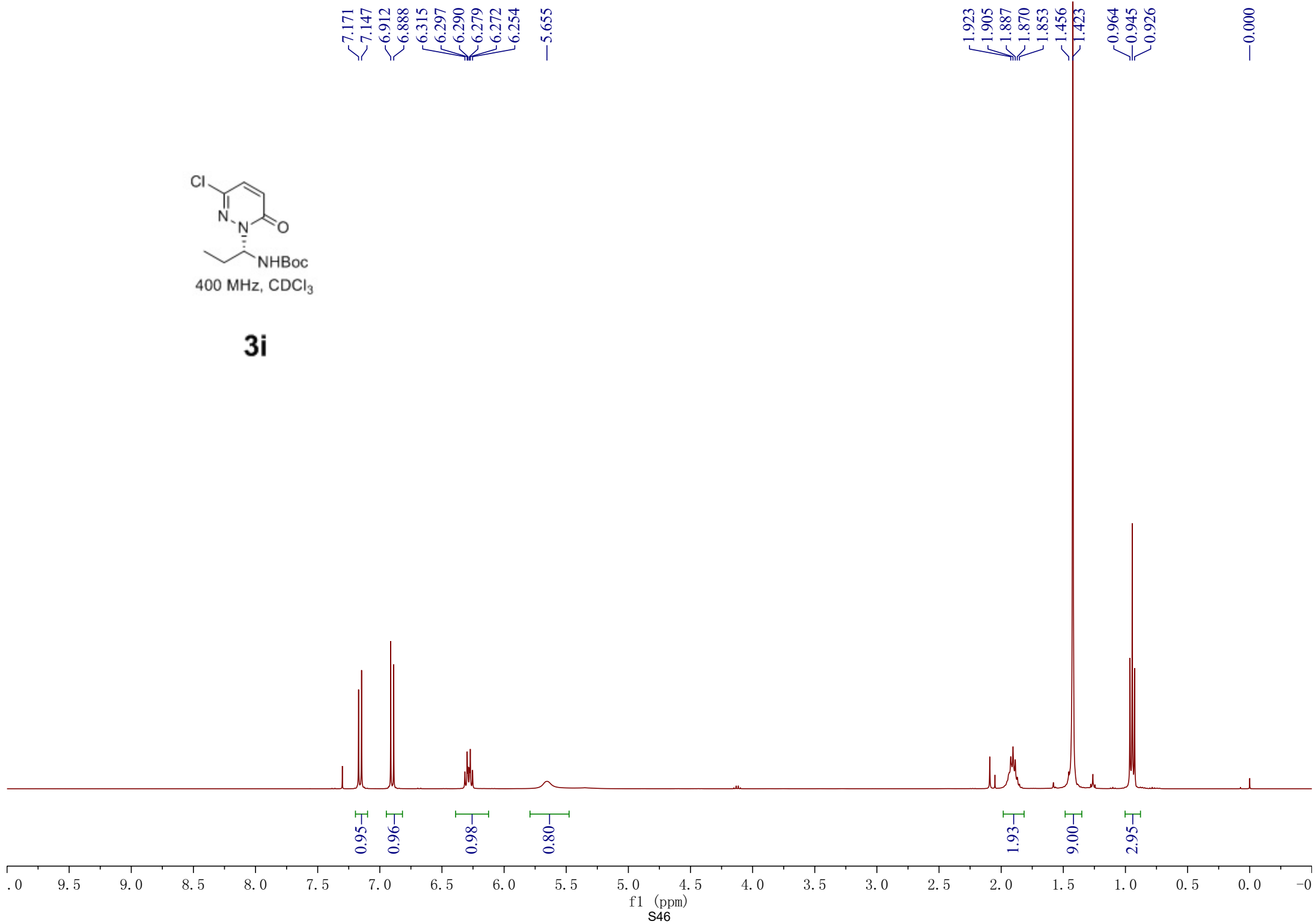


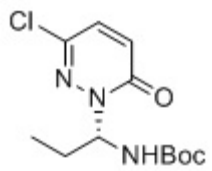
3h





3i





100 MHz, CDCl₃

3i

— 158.46
— 154.38

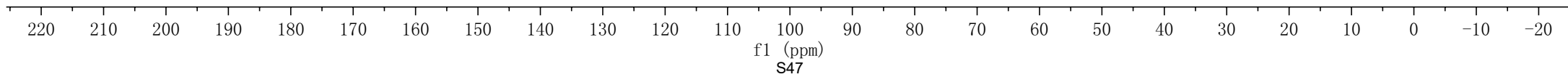
~ 137.63
~ 133.50
~ 132.56

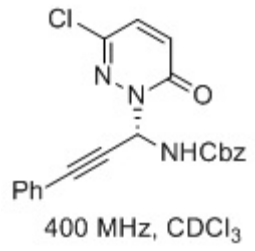
— 80.50

— 68.04

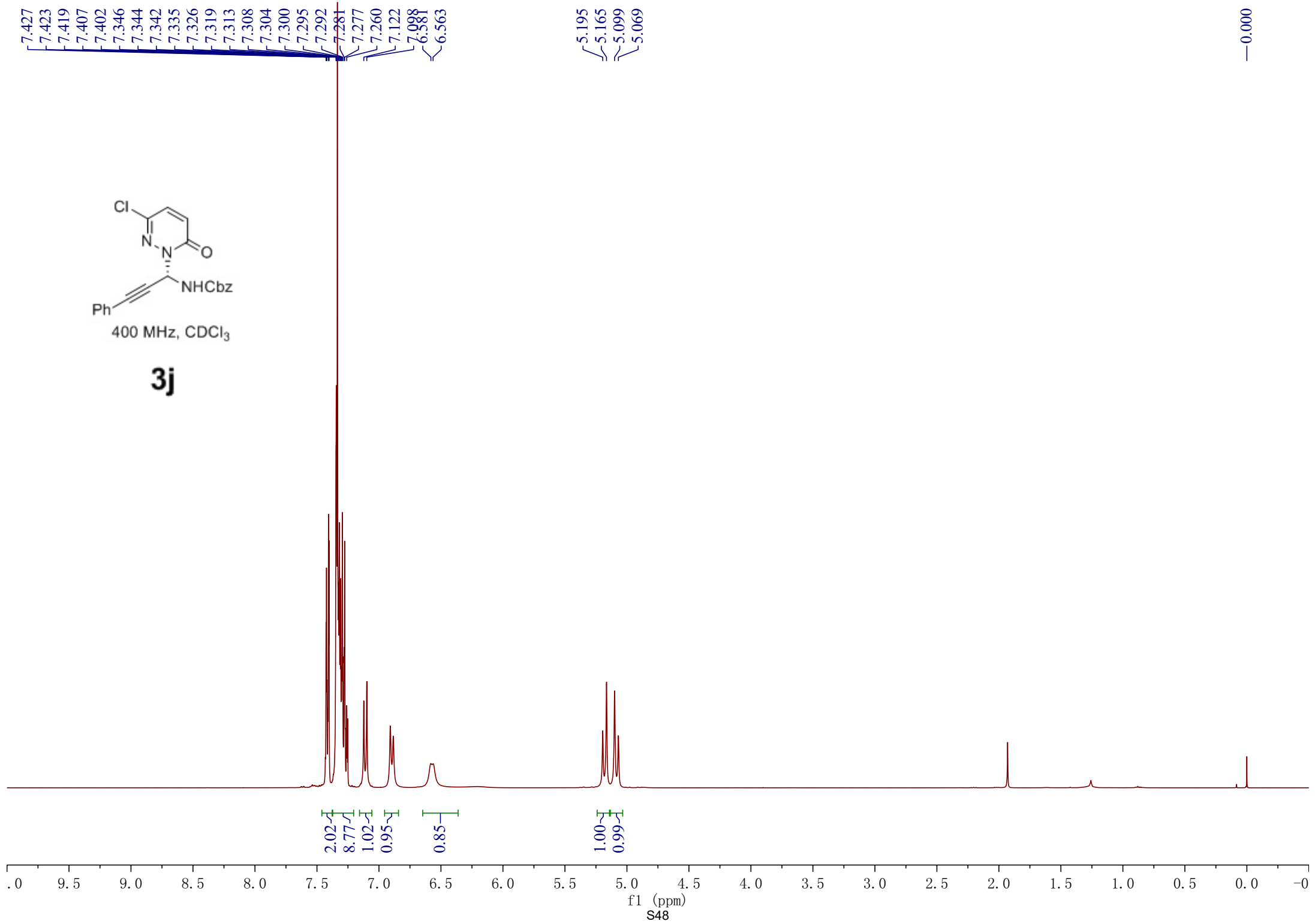
~ 28.30
~ 27.15

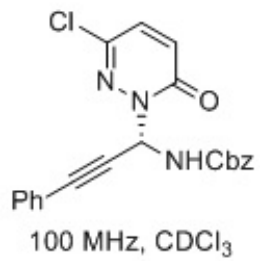
— 9.69



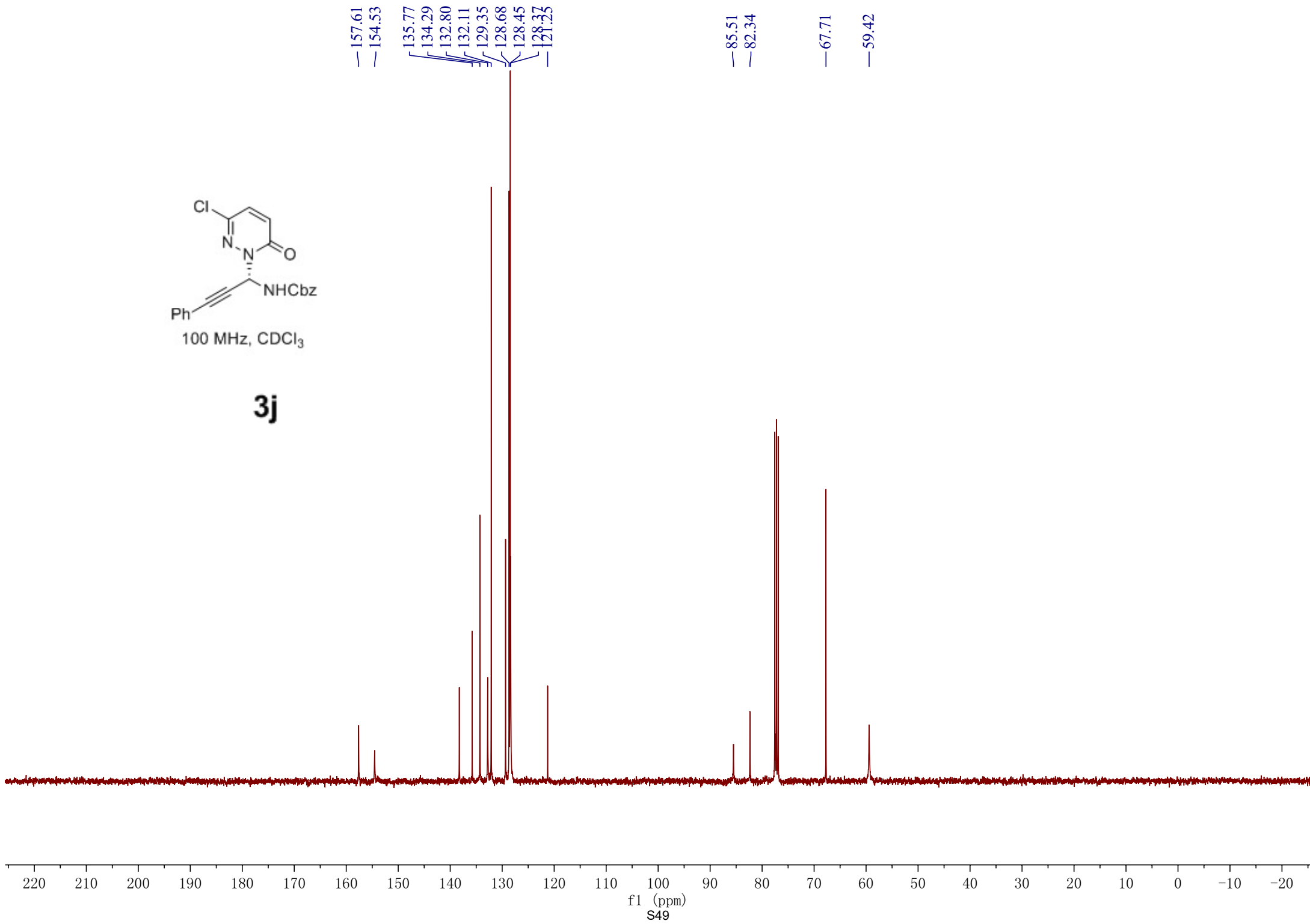


3j

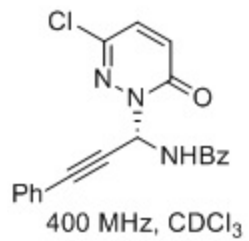




3j



7.993
7.970
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7.876
7.707
7.685
7.545
7.527
7.508
7.457
7.454
7.441
7.438
7.434
7.423
7.356
7.353
7.347
7.338
7.331
7.320
7.316
7.309
7.290
7.273
7.269
7.243
7.149
7.124
6.970
6.945



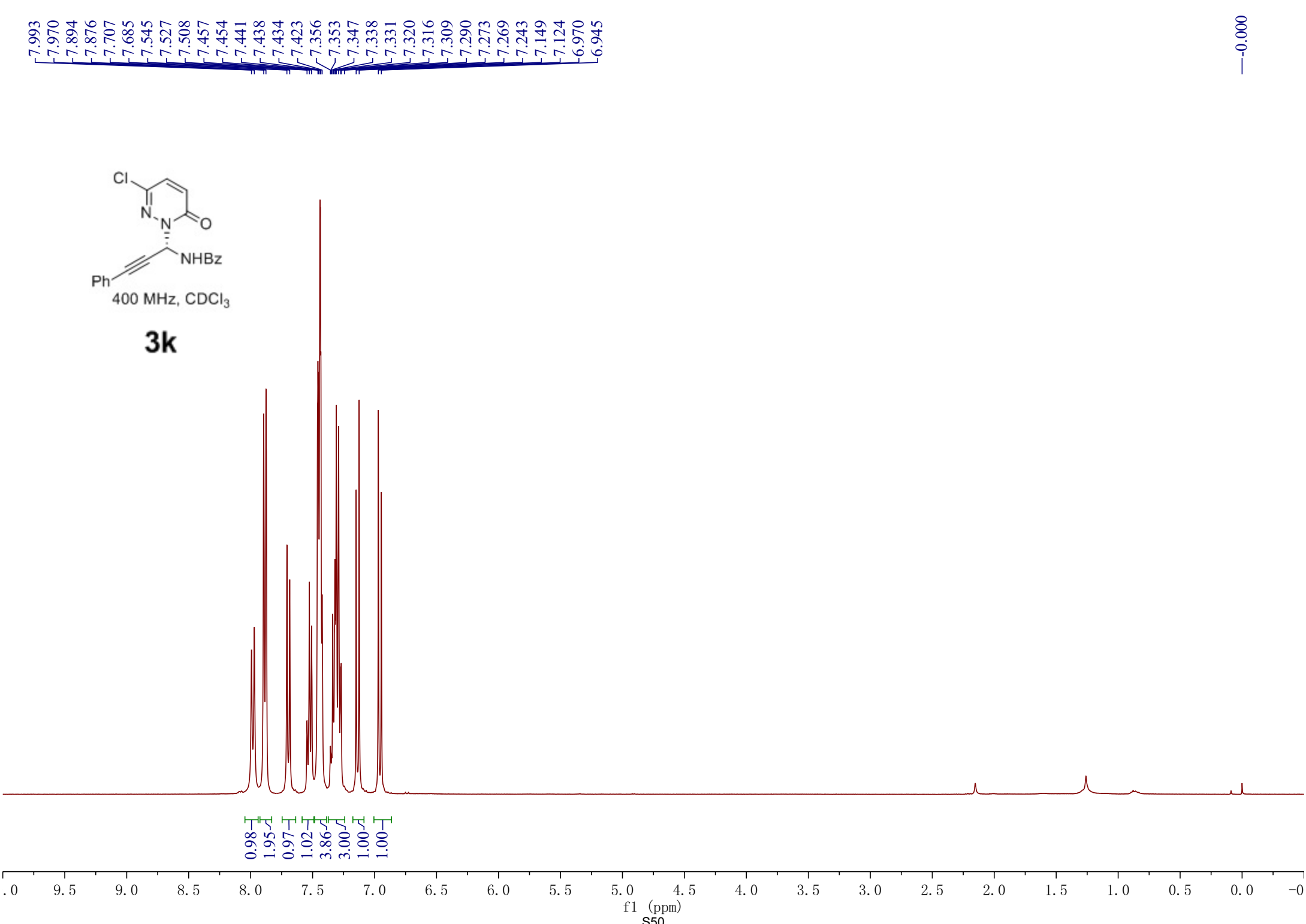
3k

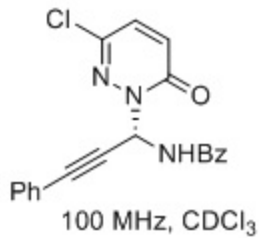
0.98
1.95
0.97
1.02
3.86
3.00
1.00
1.00

0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0

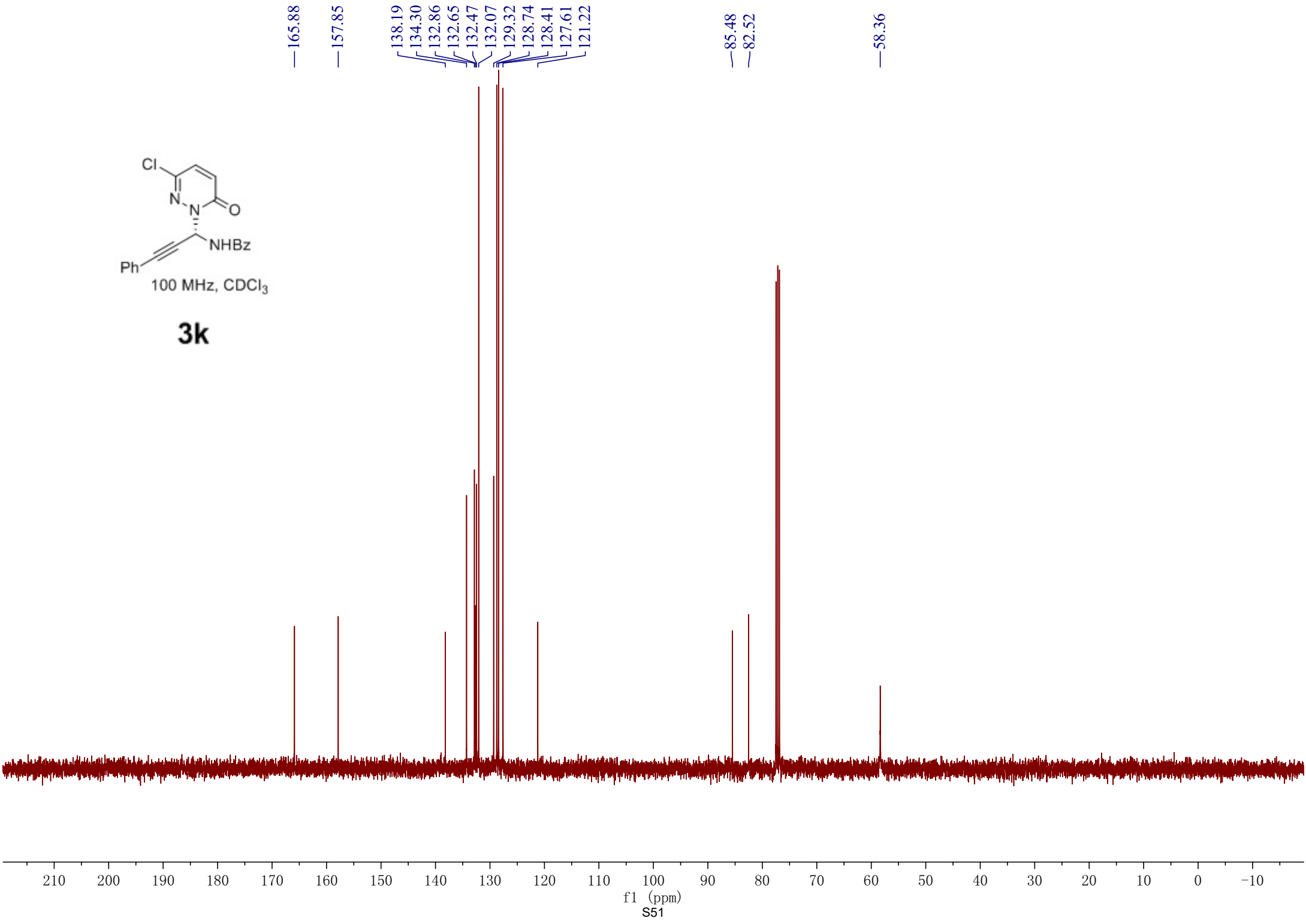
f1 (ppm)
S50

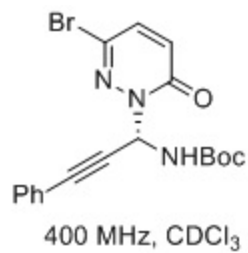
-0.000



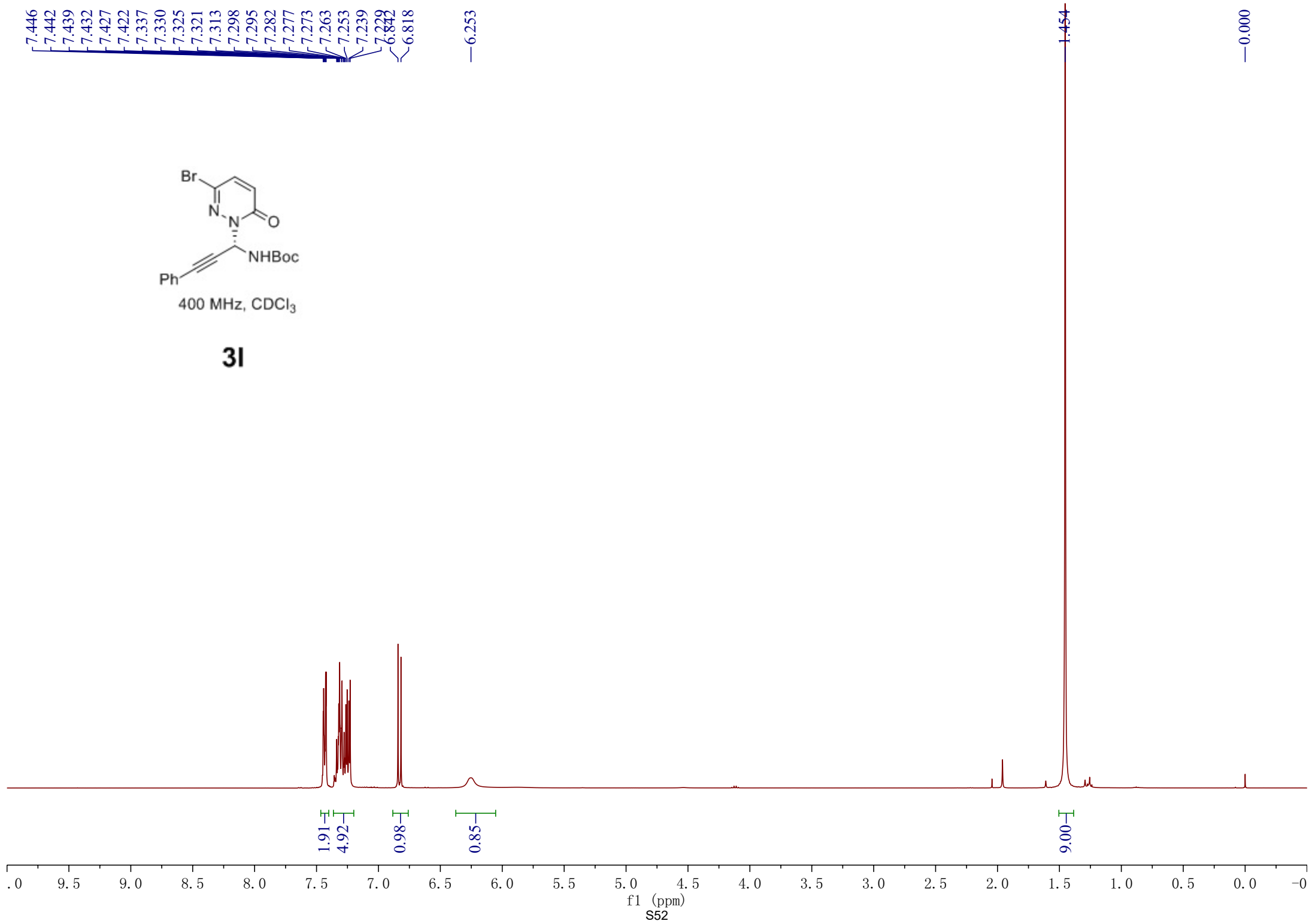


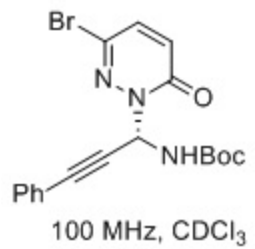
3k



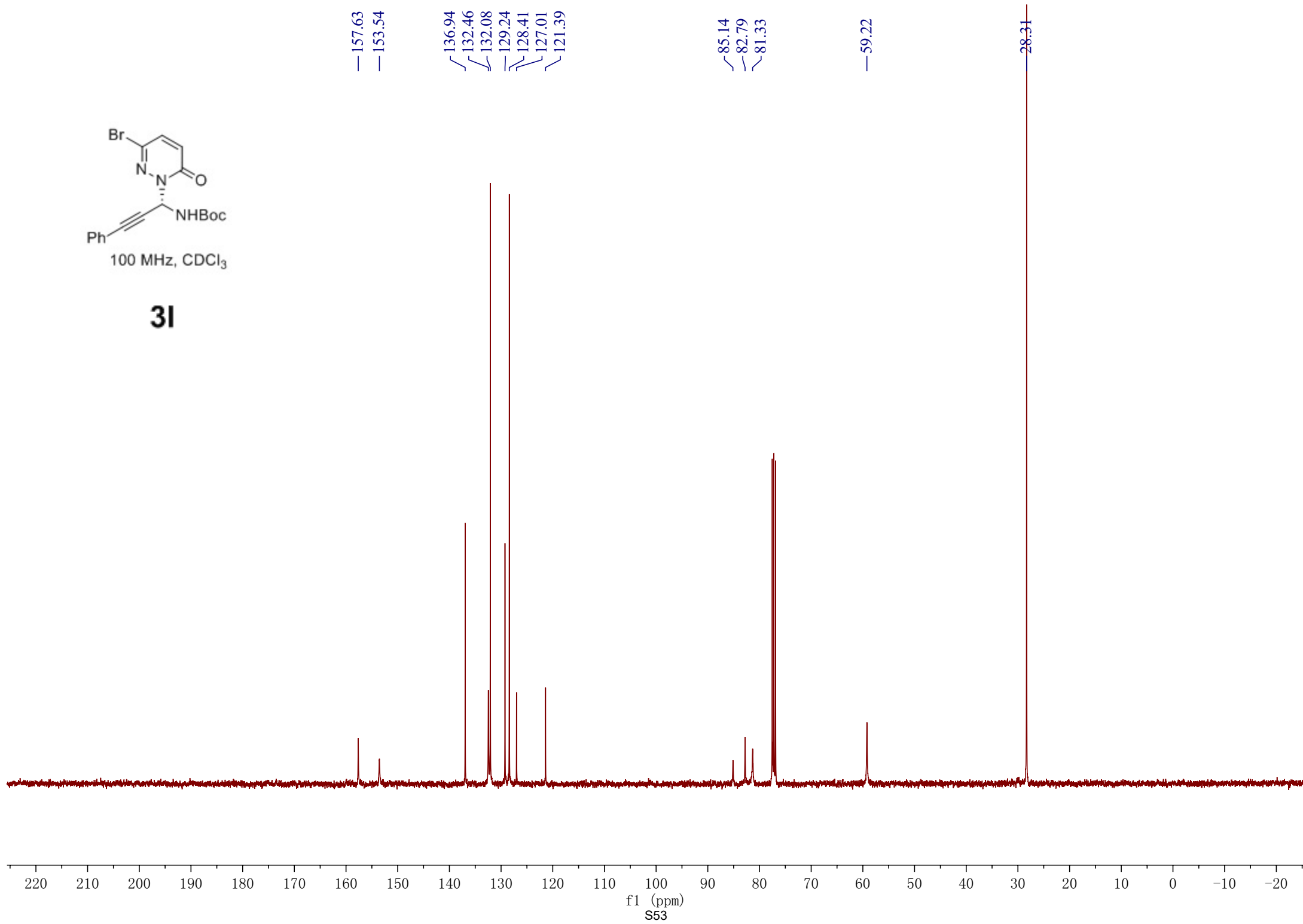


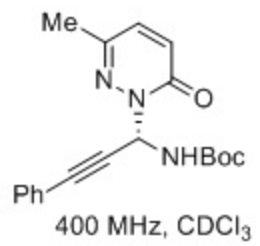
3I



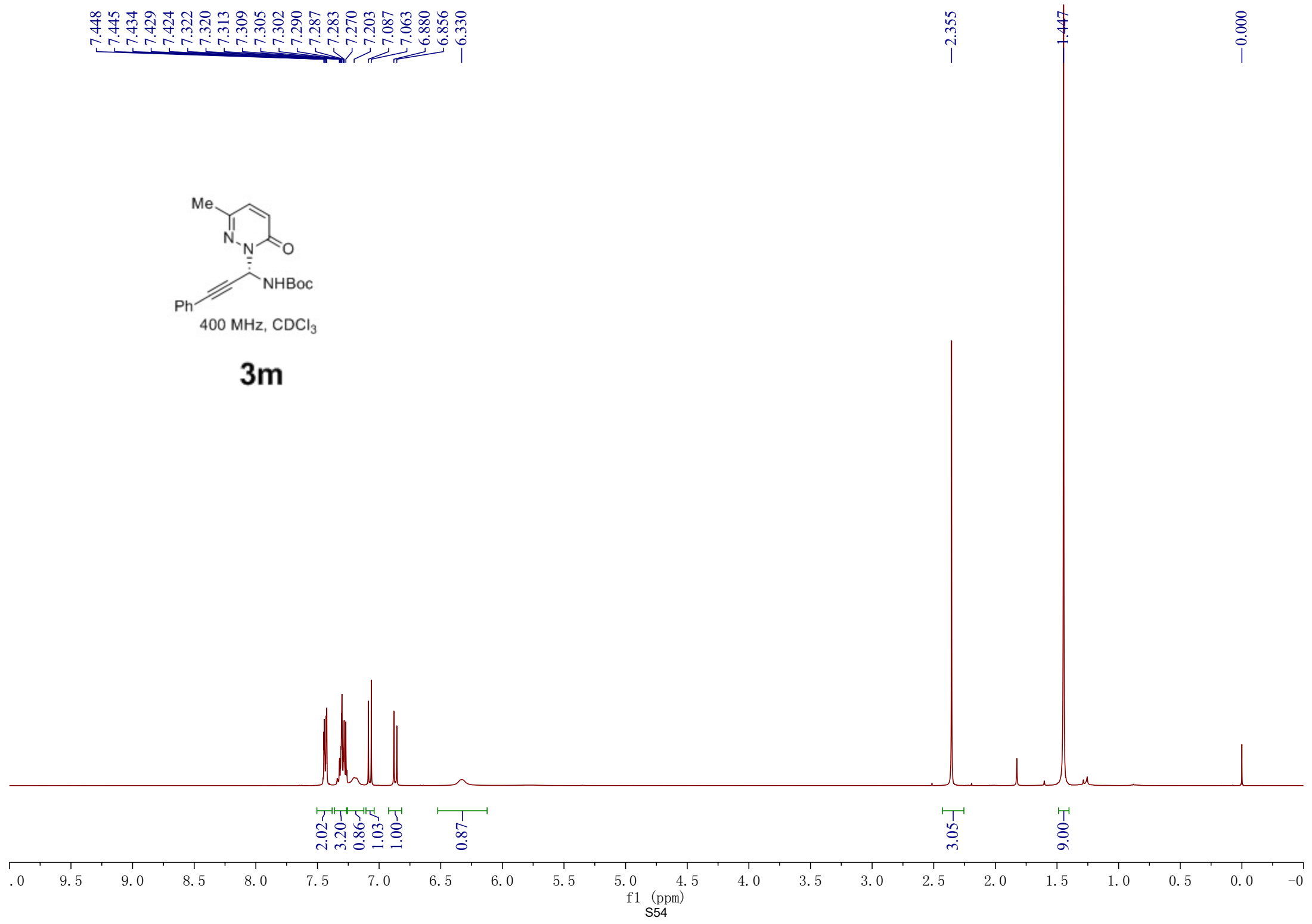


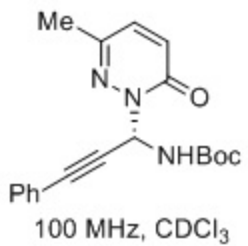
31





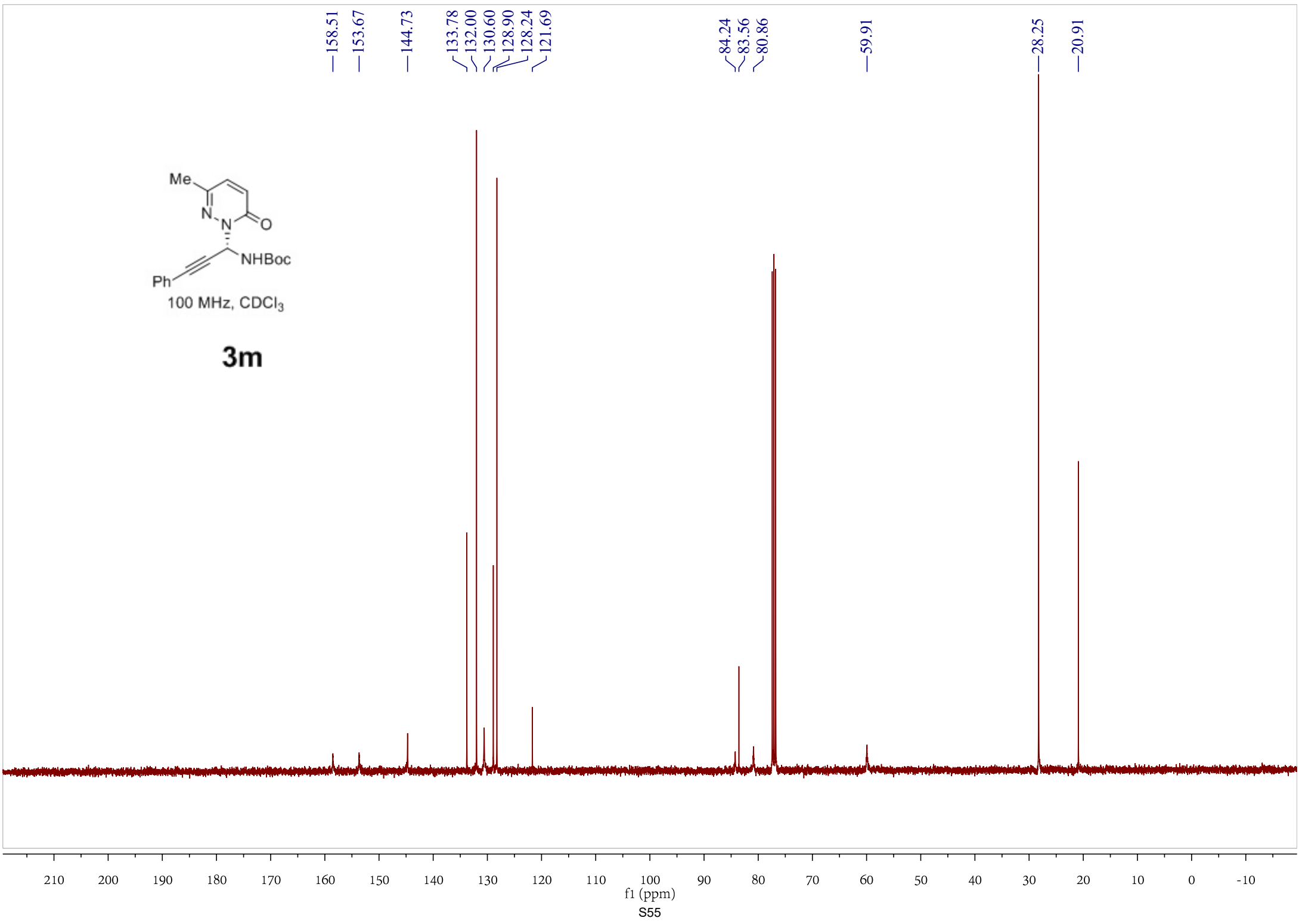
3m

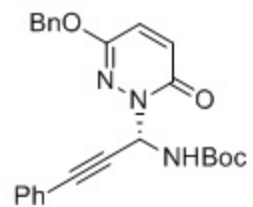




3m

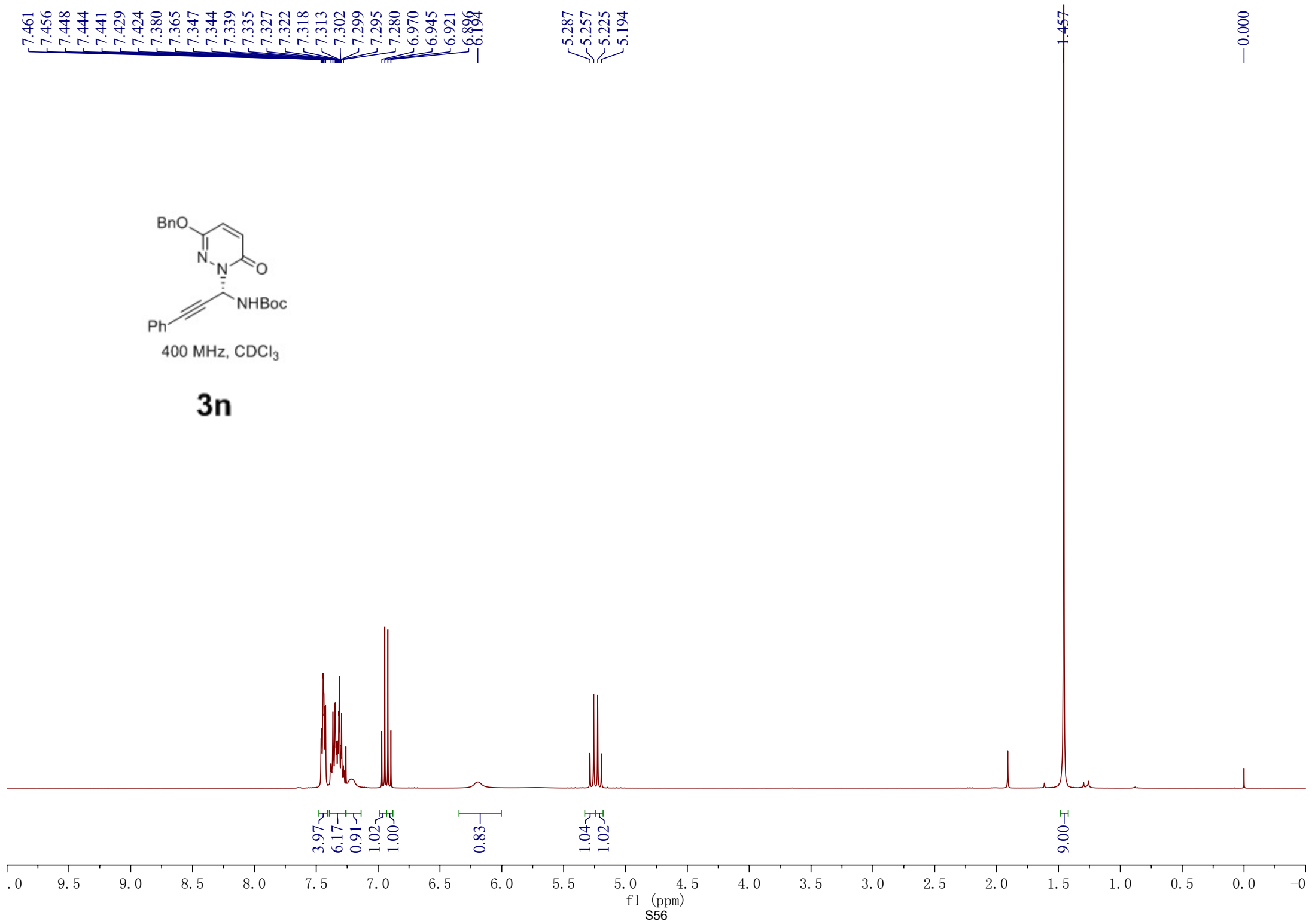
- 158.51
- 153.67
- 144.73
- 133.78
- 132.00
- 130.60
- 128.90
- 128.24
- 121.69
- 84.24
- 83.56
- 80.86
- 59.91
- 28.25
- 20.91

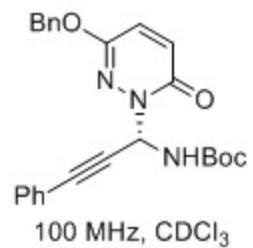




400 MHz, CDCl₃

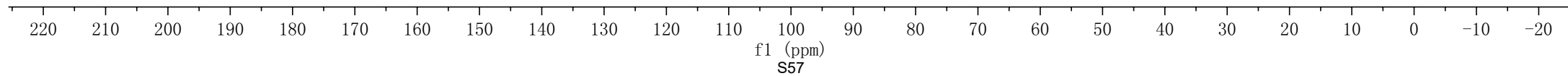
3n

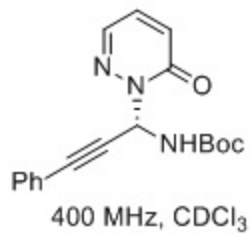




3n

157.86
153.68
152.44
135.87
133.60
132.08
129.04
128.71
128.52
128.38
127.48
121.76
84.40
83.64
81.03
69.25
58.93
28.36



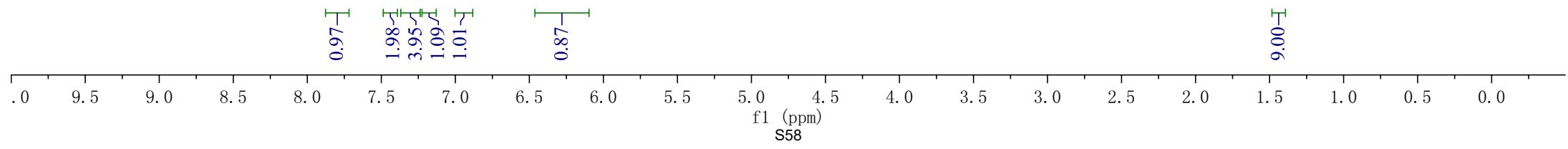


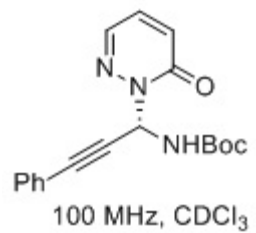
3o

7.821
7.817
7.812
7.808
7.441
7.425
7.421
7.309
7.304
7.303
7.284
6.958
6.301

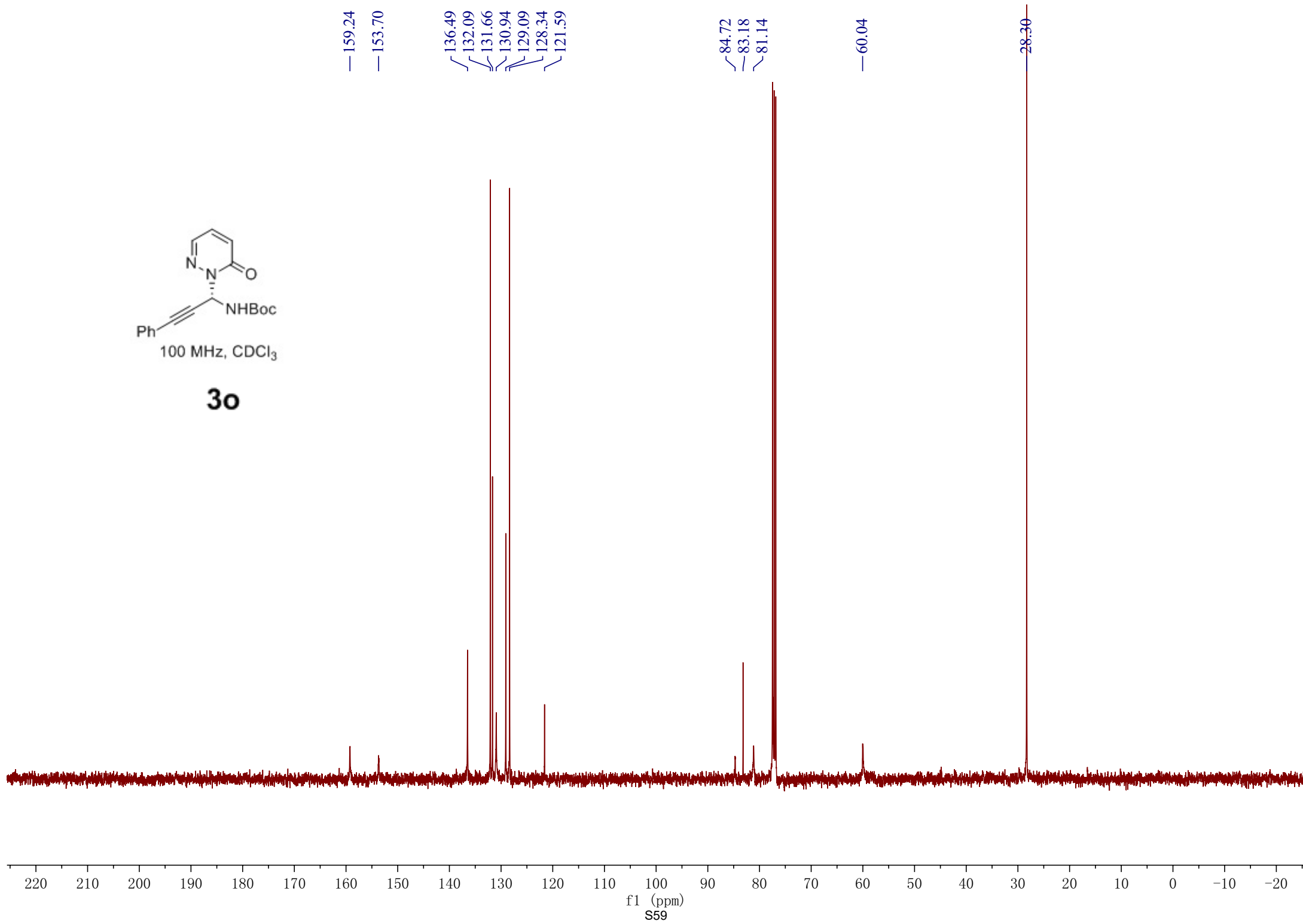
1.442

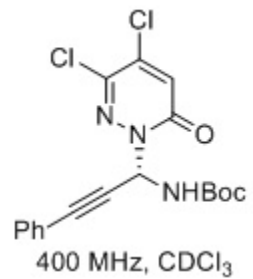
0.000



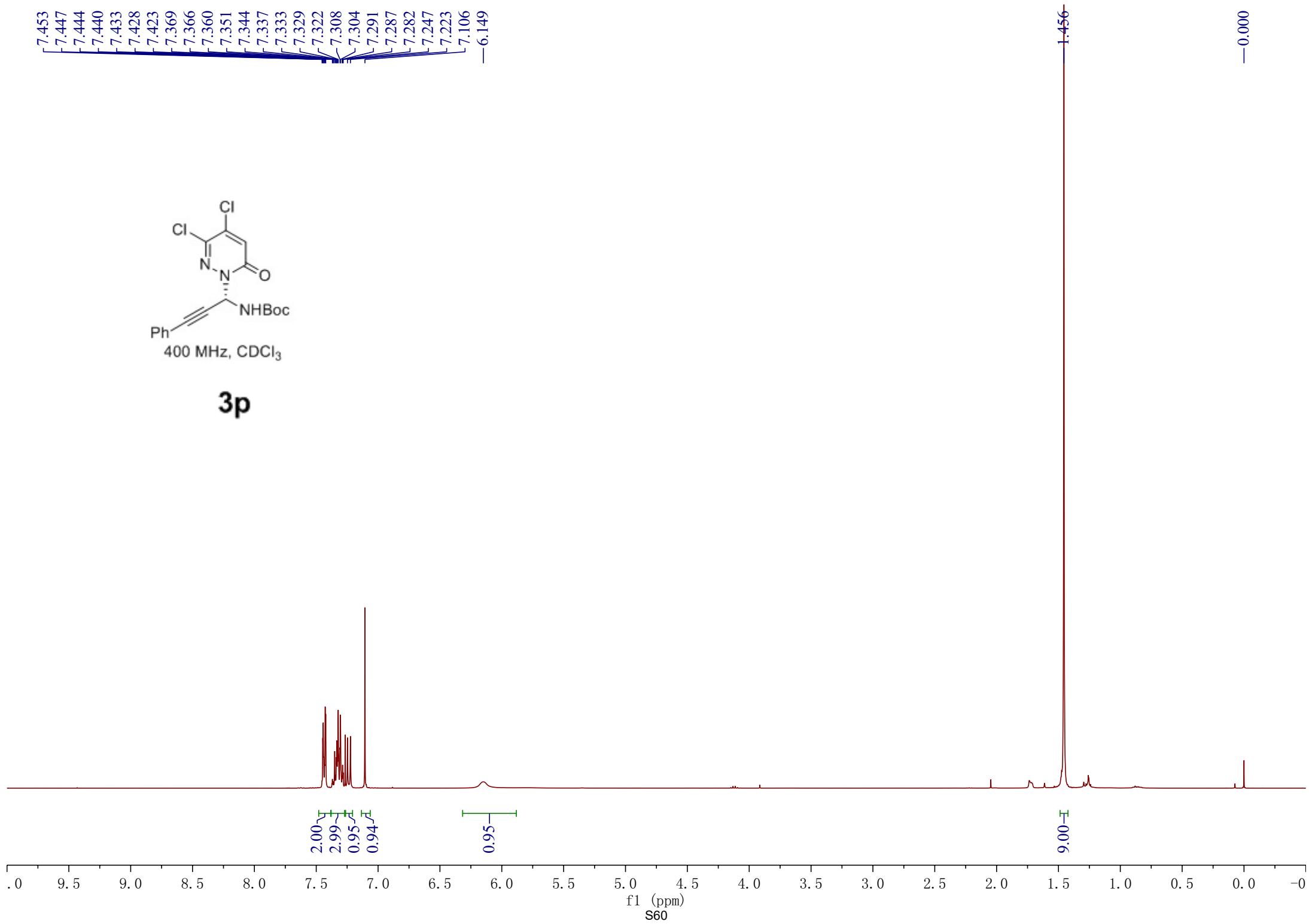


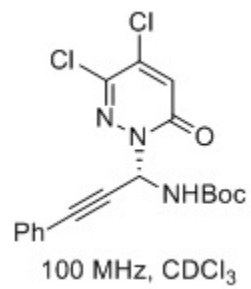
3o



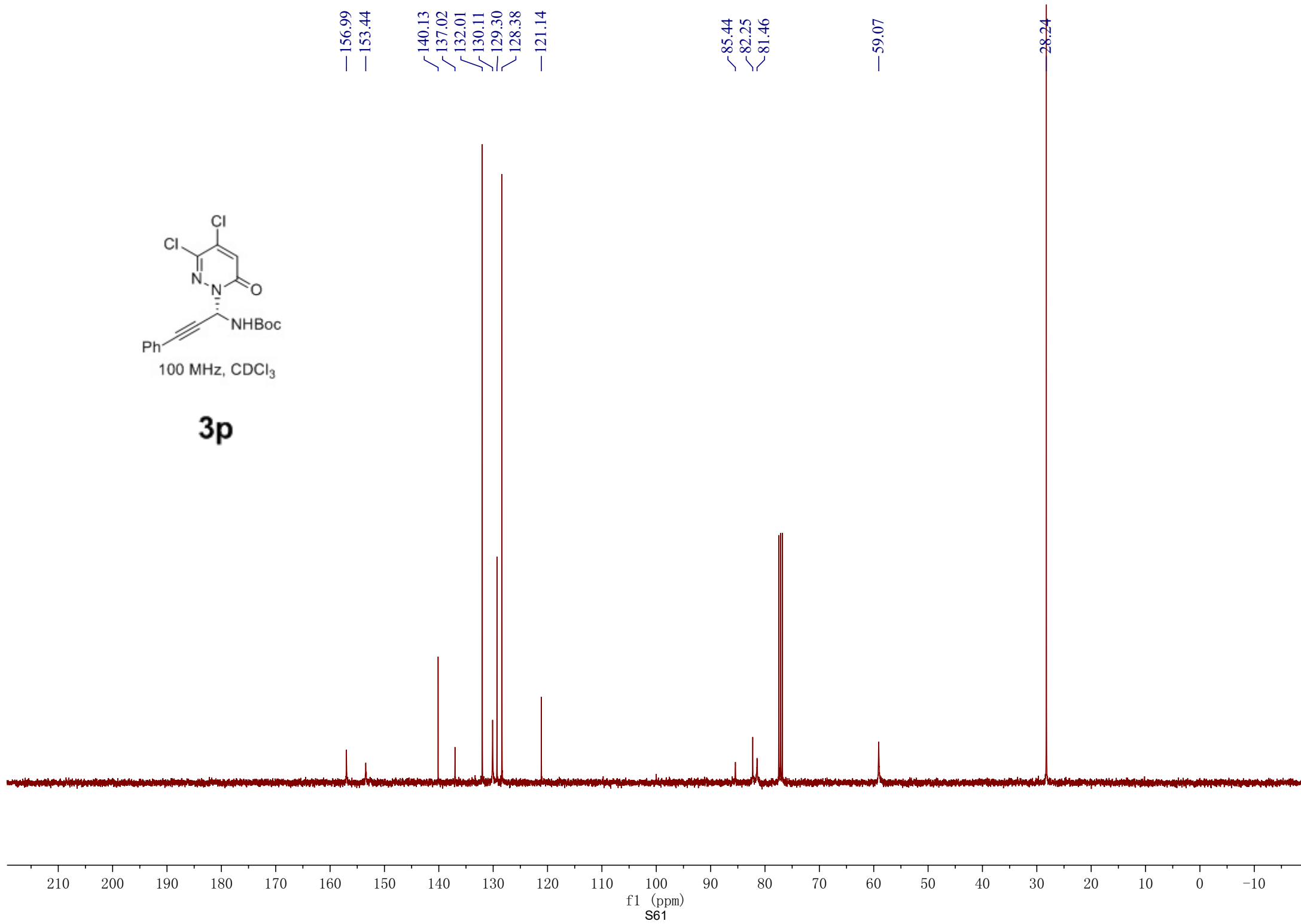


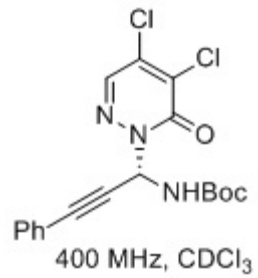
3p



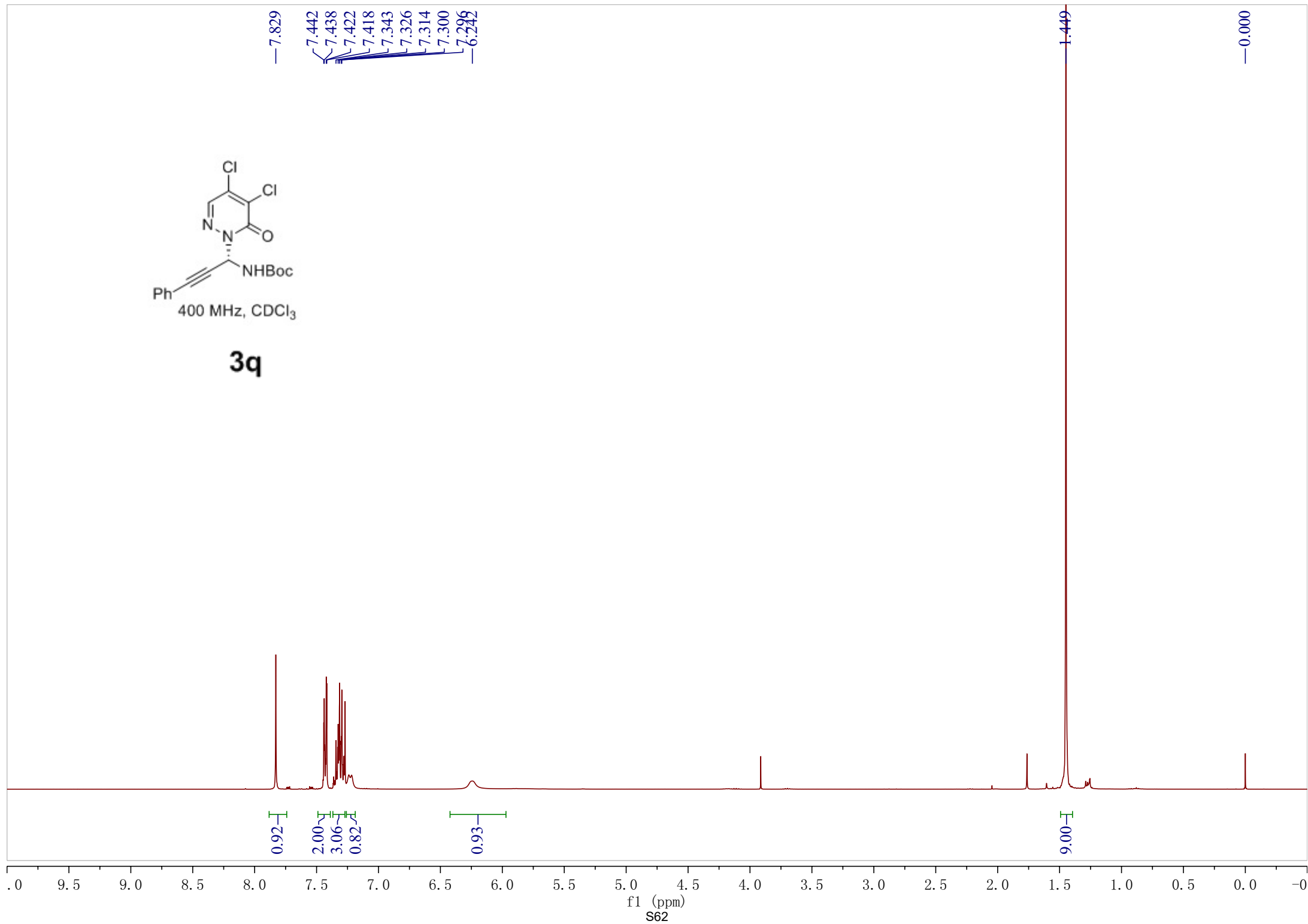


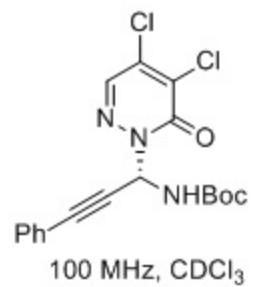
3p





3q





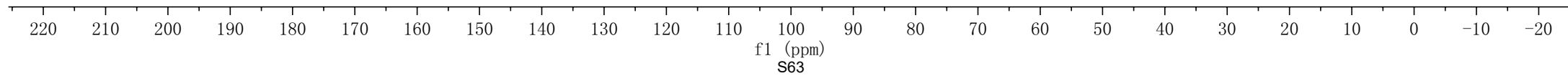
3q

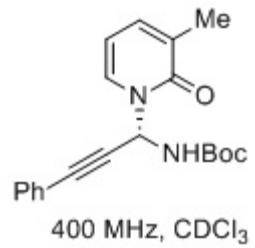
155.36
153.55
136.99
136.07
134.95
132.09
129.33
128.41
121.20

85.54
82.14
81.54

61.29

28.29





5a

7.520
7.504
7.445
7.427
7.343
7.325
7.303
7.285
7.271
7.210
7.194
6.757
6.612
6.144
6.127
6.110

2.166

1.428

0.000

9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0

f1 (ppm)
S64

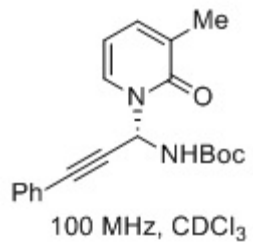
0.96
1.97
3.12
1.01

0.96
0.86

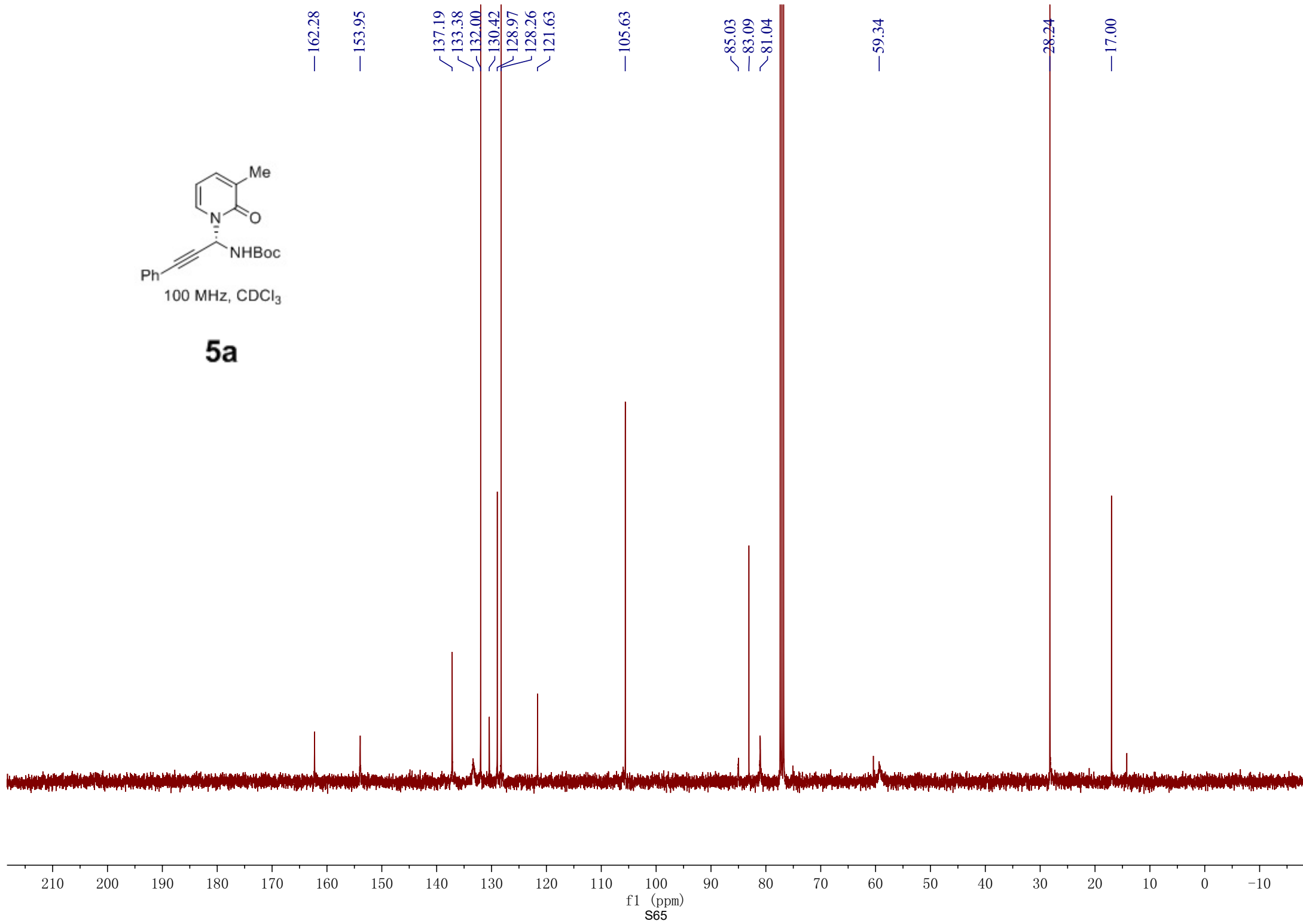
1.02

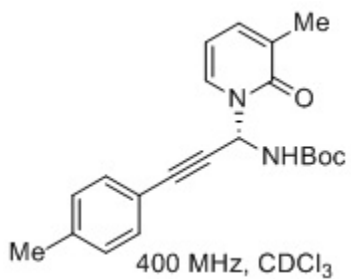
3.00

9.14



5a





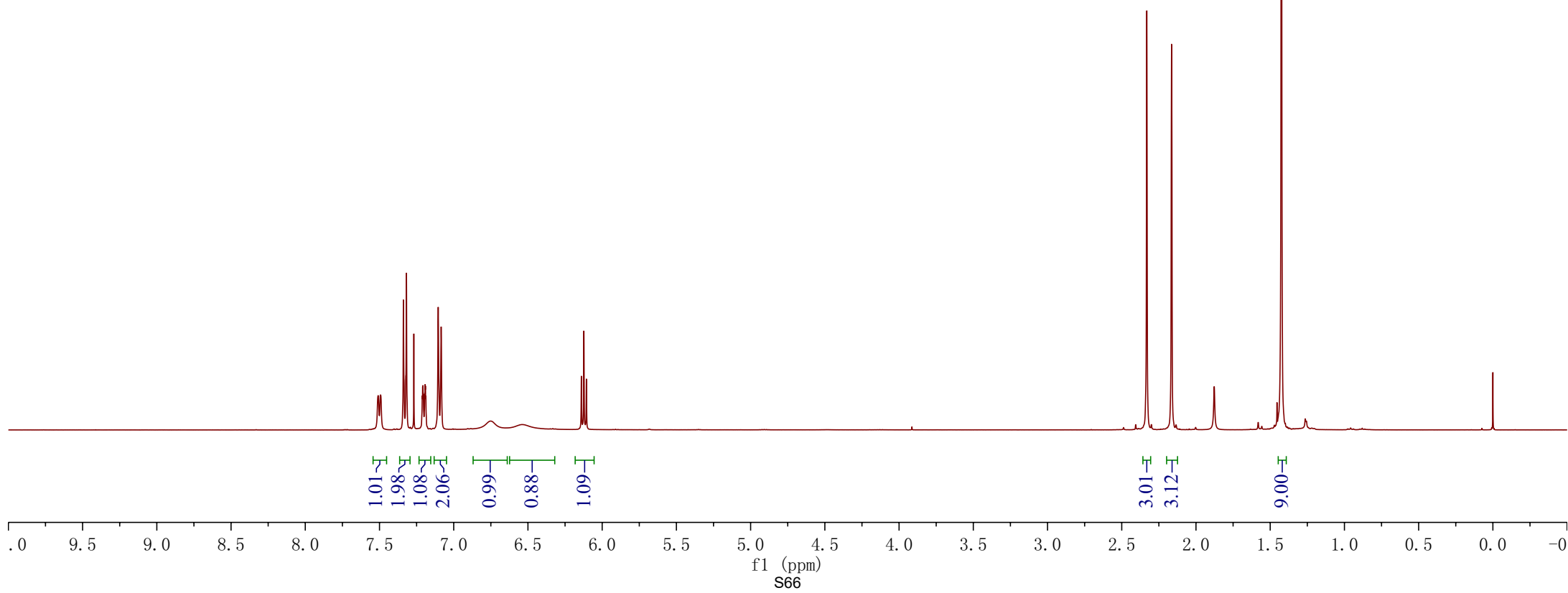
5b

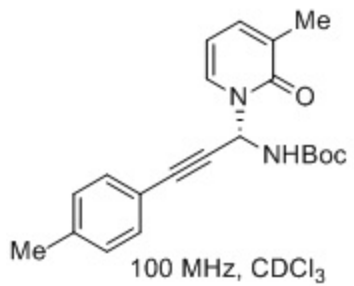
7.509
7.493
7.339
7.319
7.212
7.209
7.207
7.204
7.195
7.193
7.191
7.188
7.104
7.085
6.753
6.537
6.140
6.123
6.106

2.331
2.164

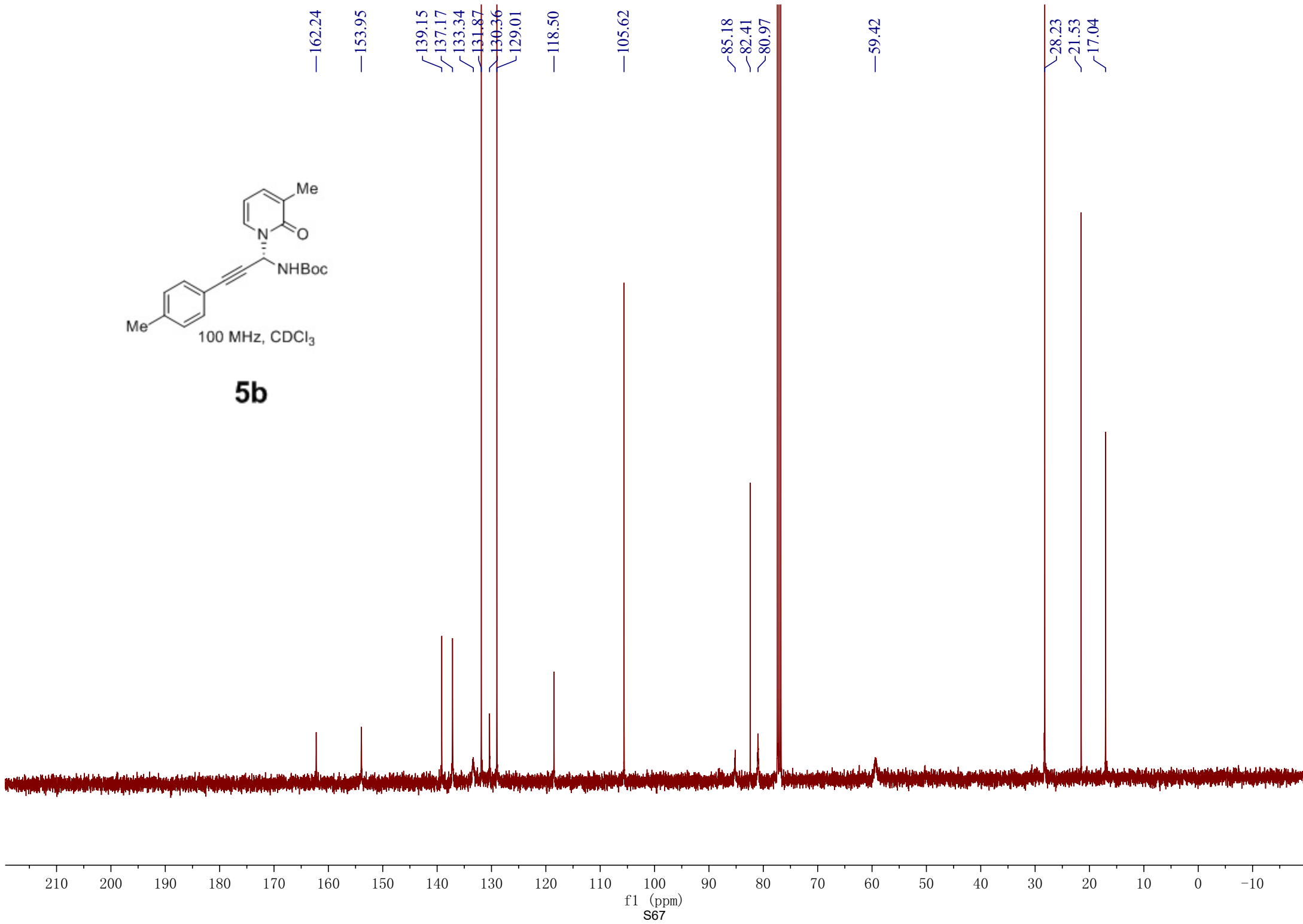
1.424

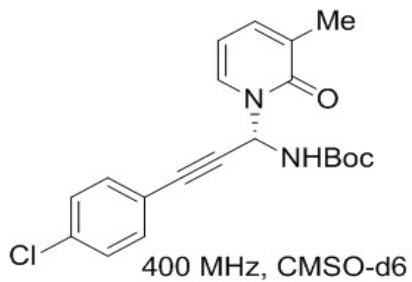
0.000



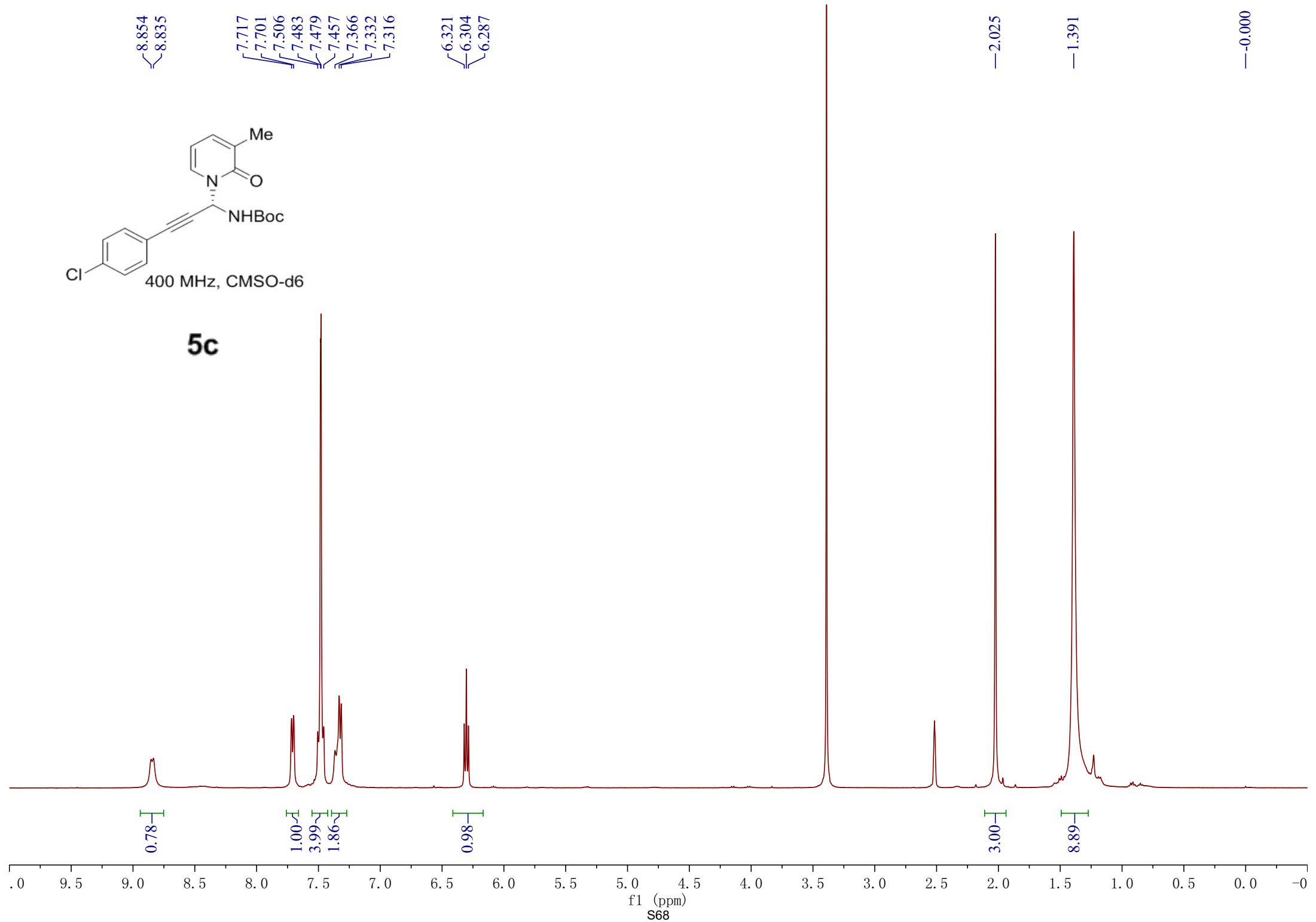


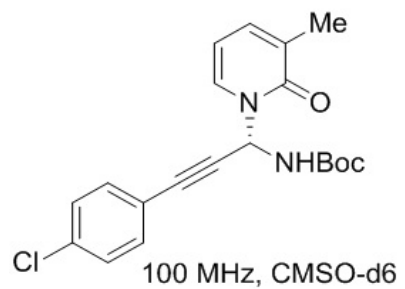
5b



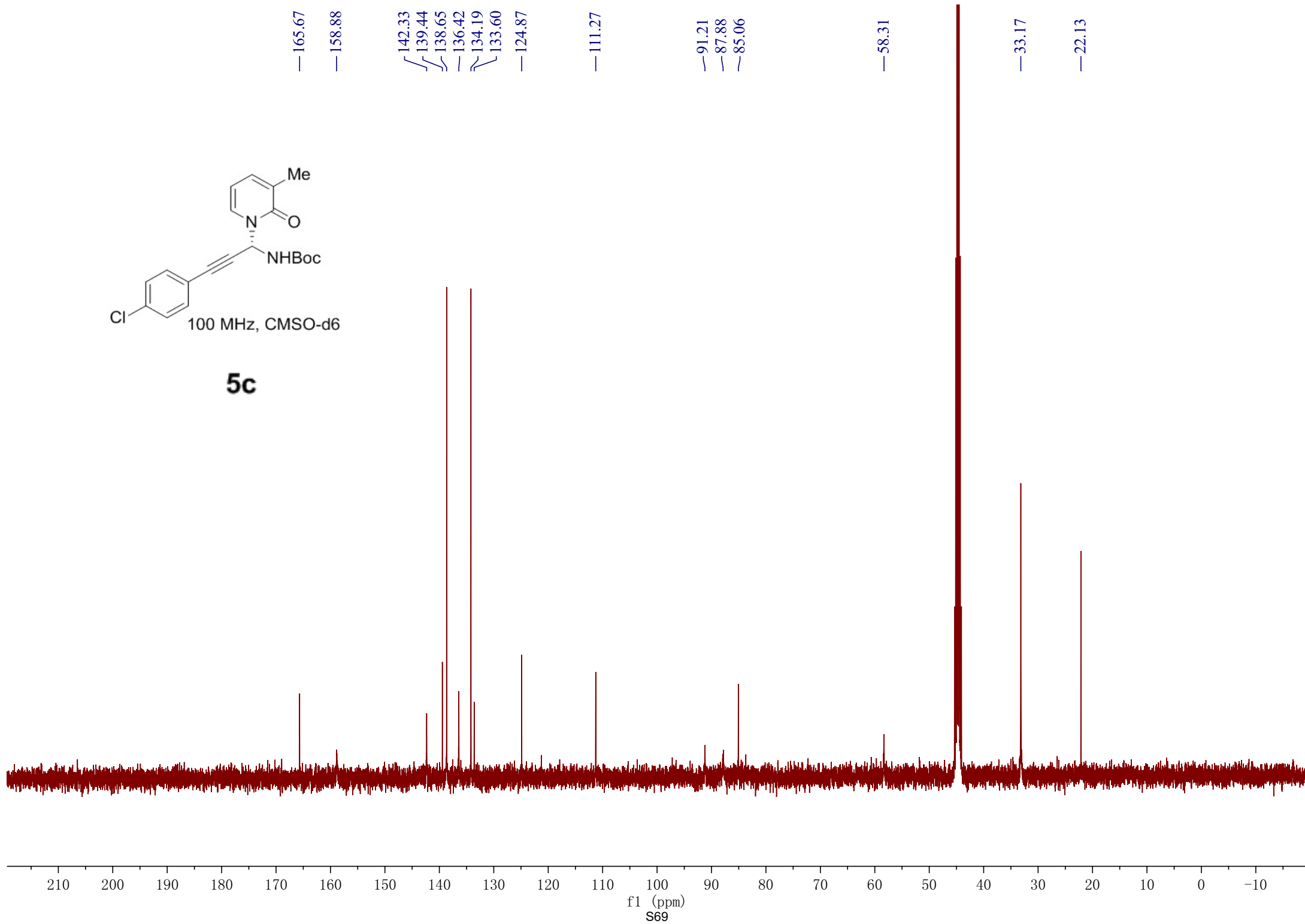


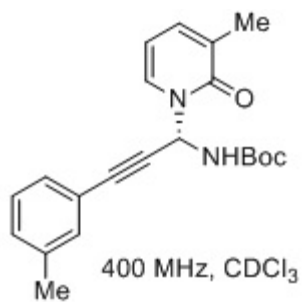
5c





5c





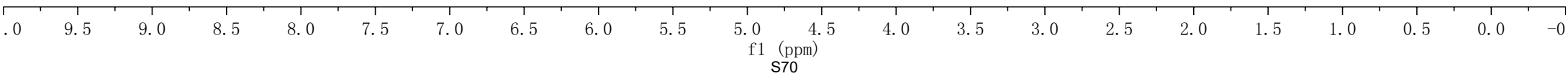
5d

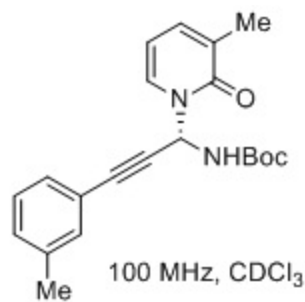
7.529
7.513
7.259
7.241
7.223
7.201
7.188
7.170
7.151
7.134
7.115
6.756
6.655
6.137
6.120
6.103

2.293
2.165

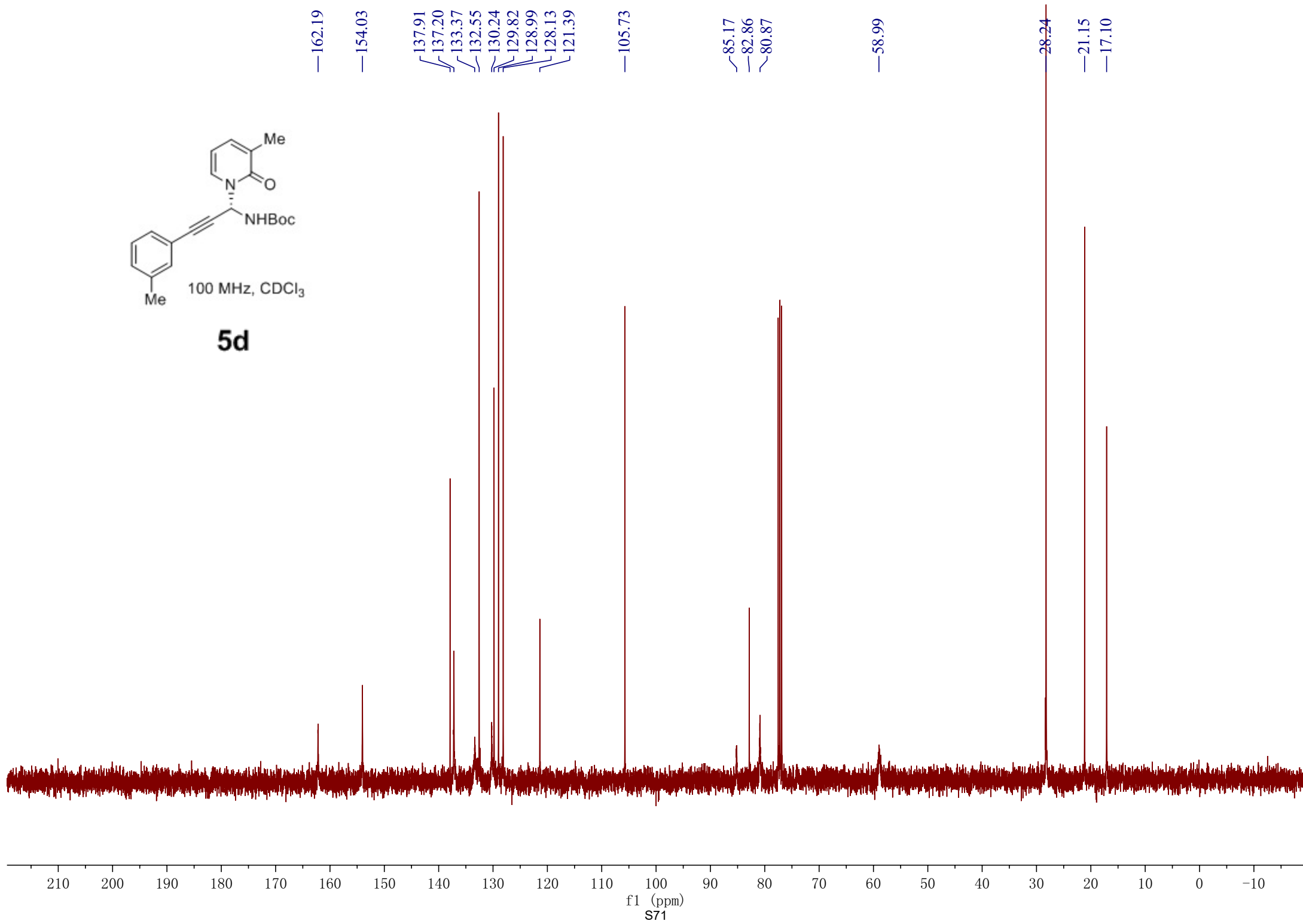
1.426

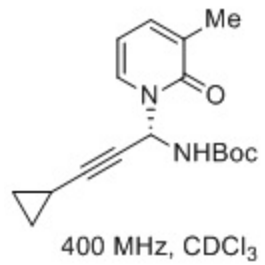
0.000



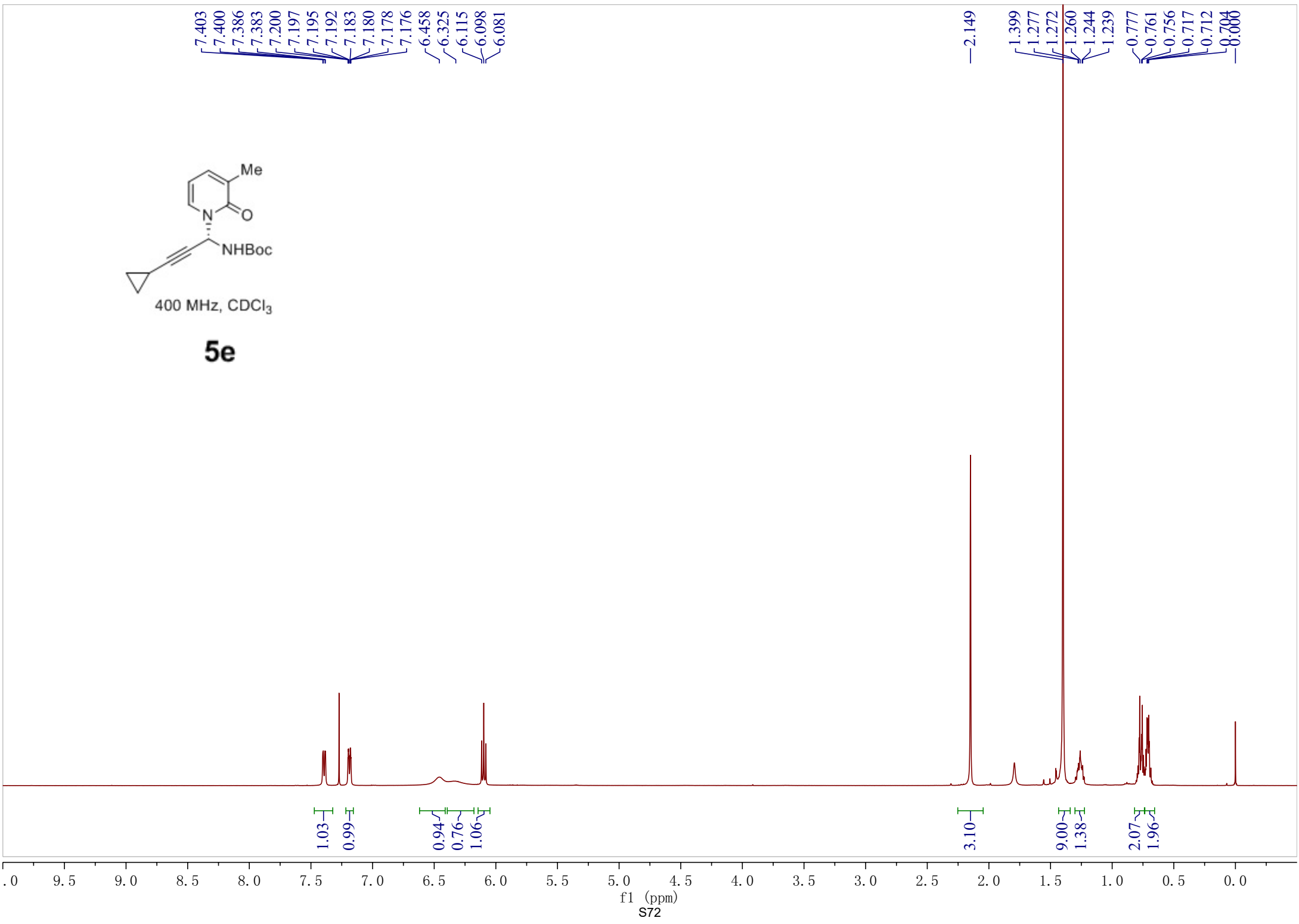


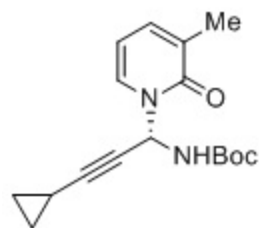
5d





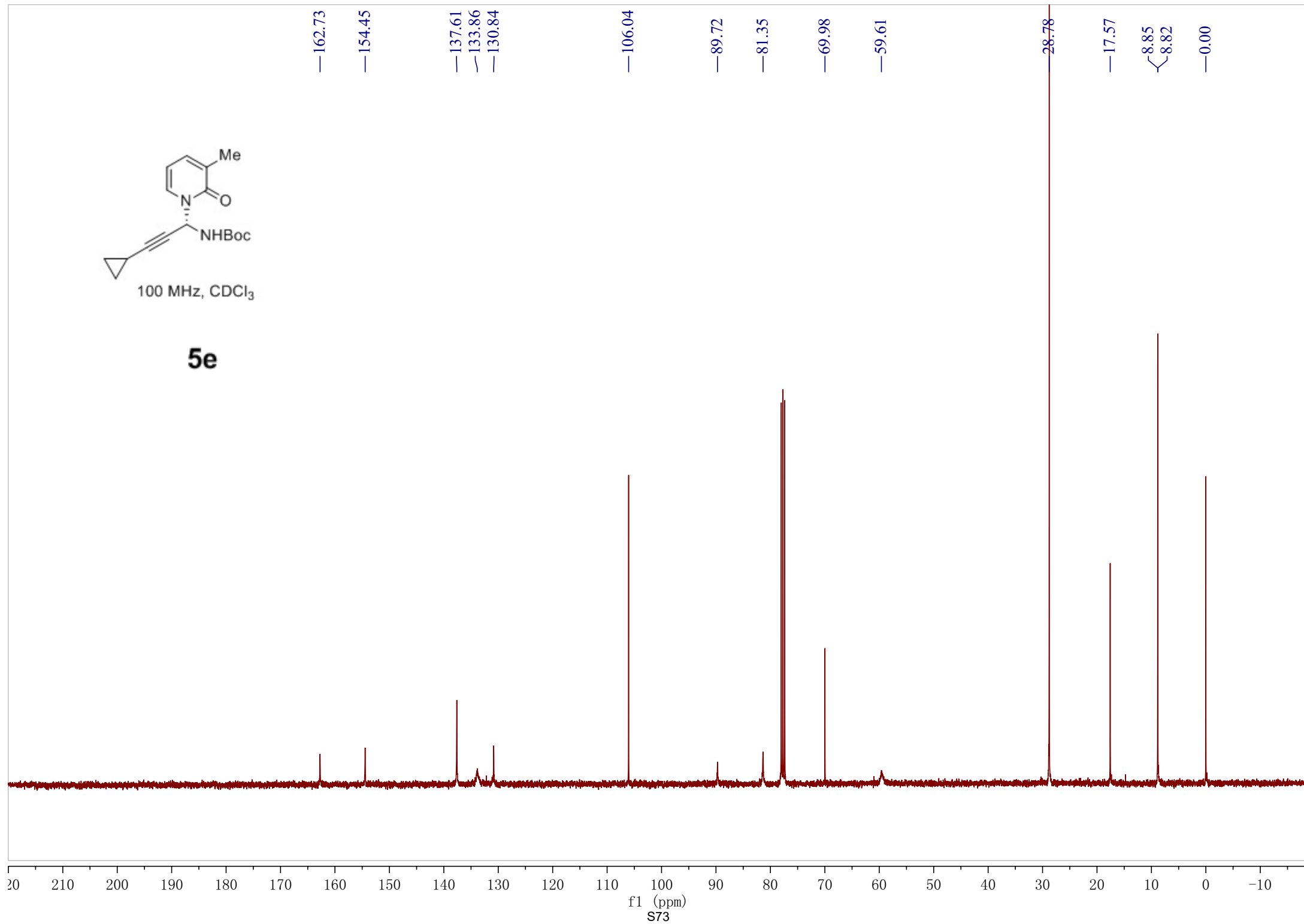
5e

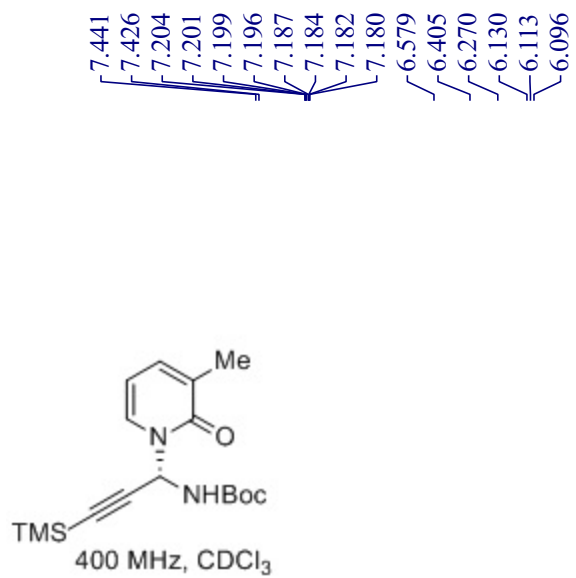




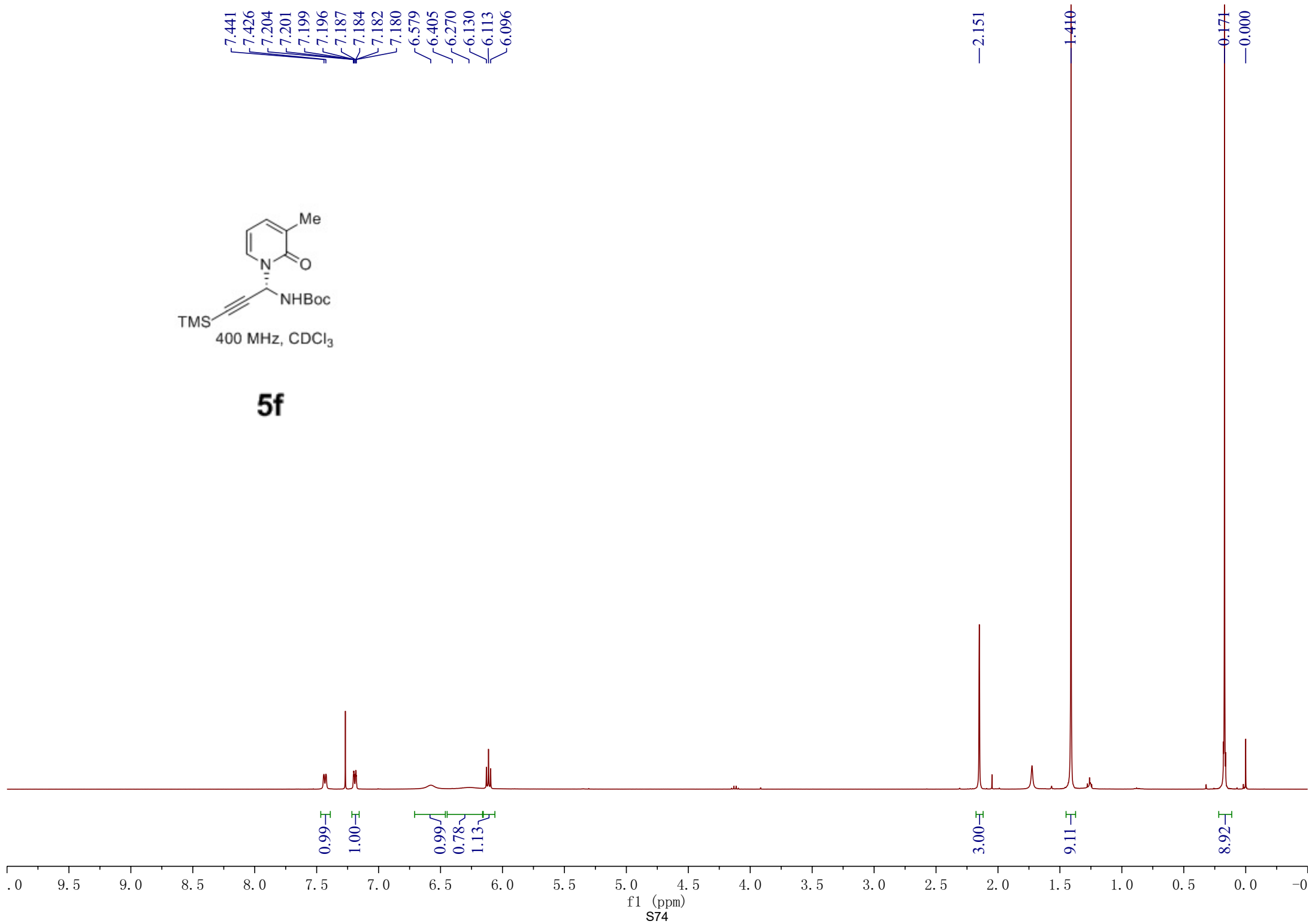
100 MHz, CDCl₃

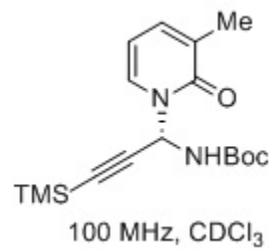
5e



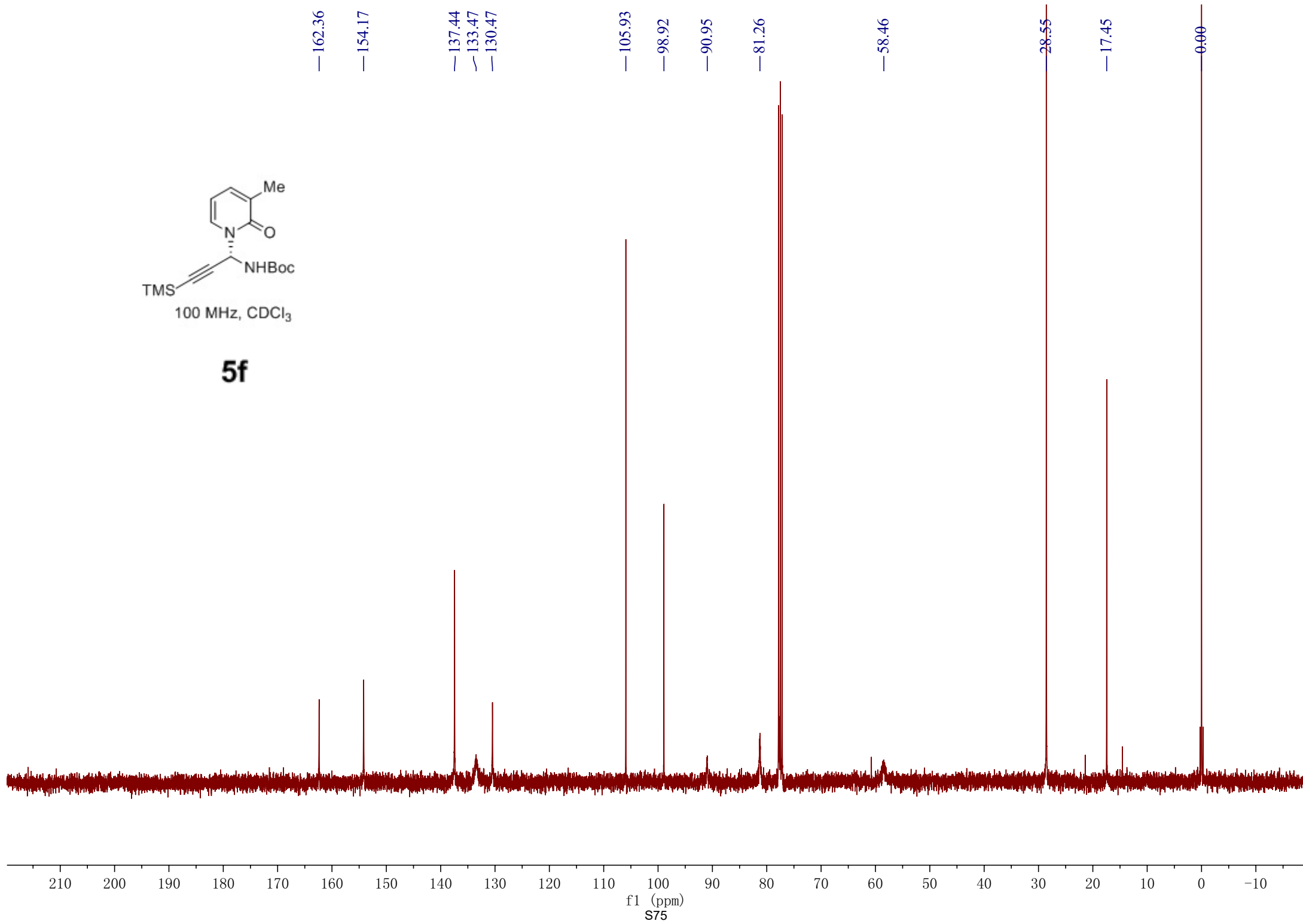


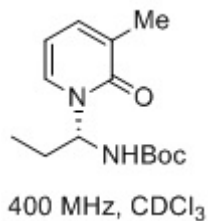
5f



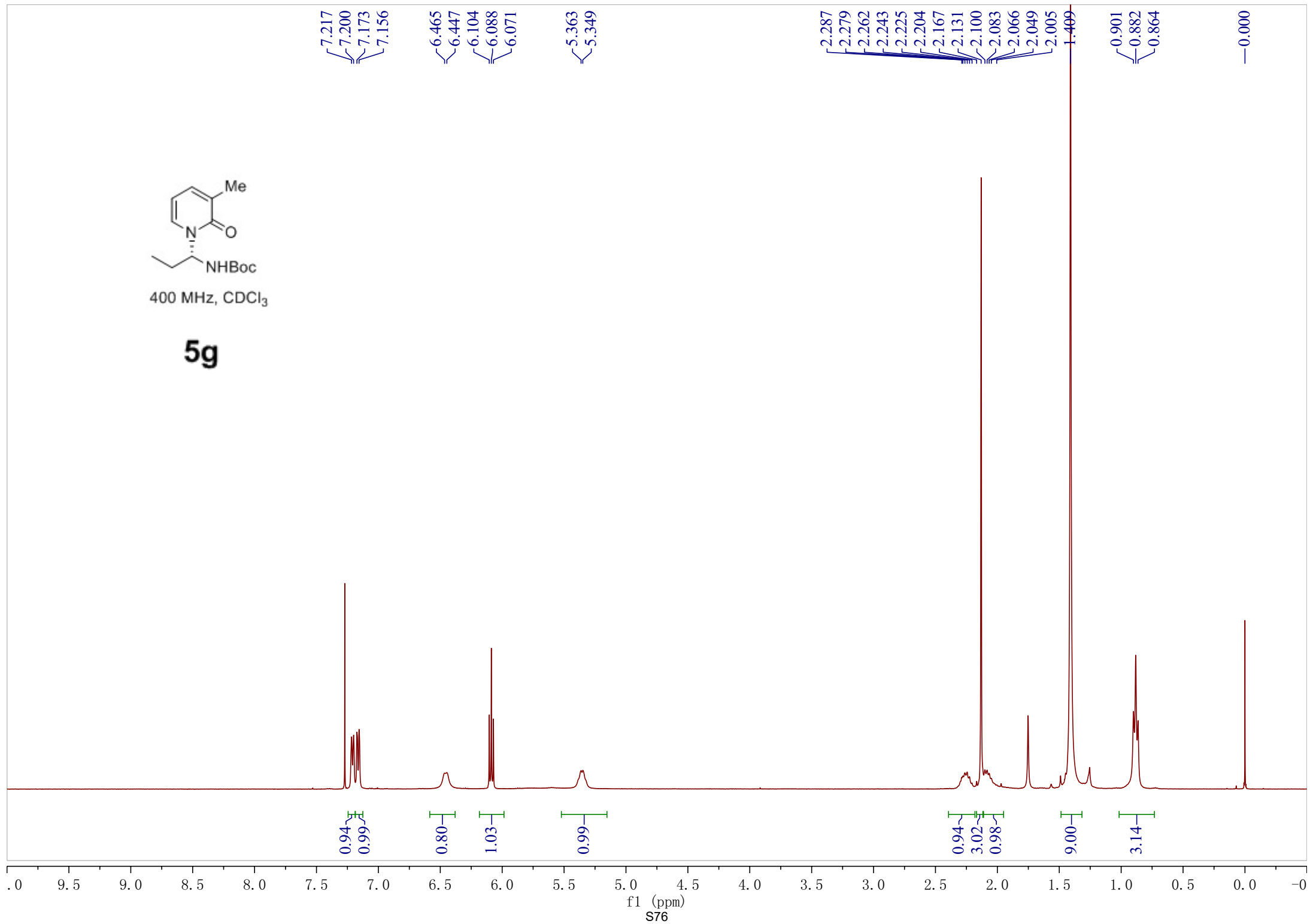


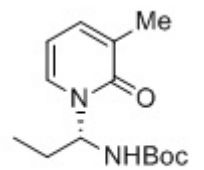
5f





5g





100 MHz, CDCl₃

5g

—163.22

—155.00

—137.02

—134.89

—130.50

—105.37

—80.12

—73.38

—28.24

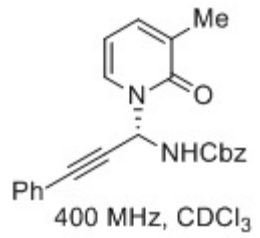
—26.08

—16.87

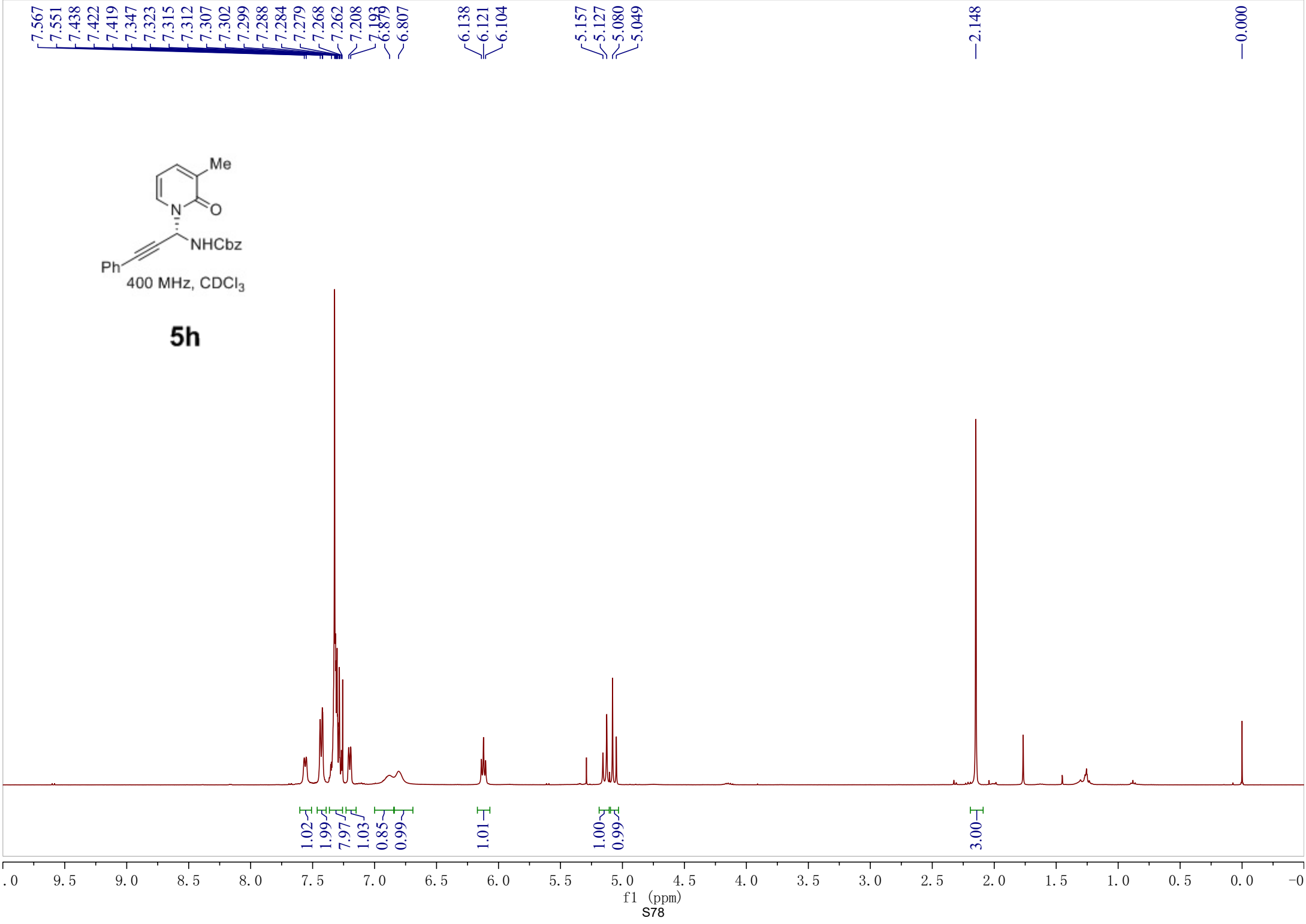
—10.35

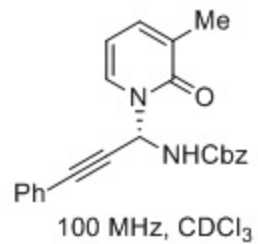
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10

f1 (ppm)
S77

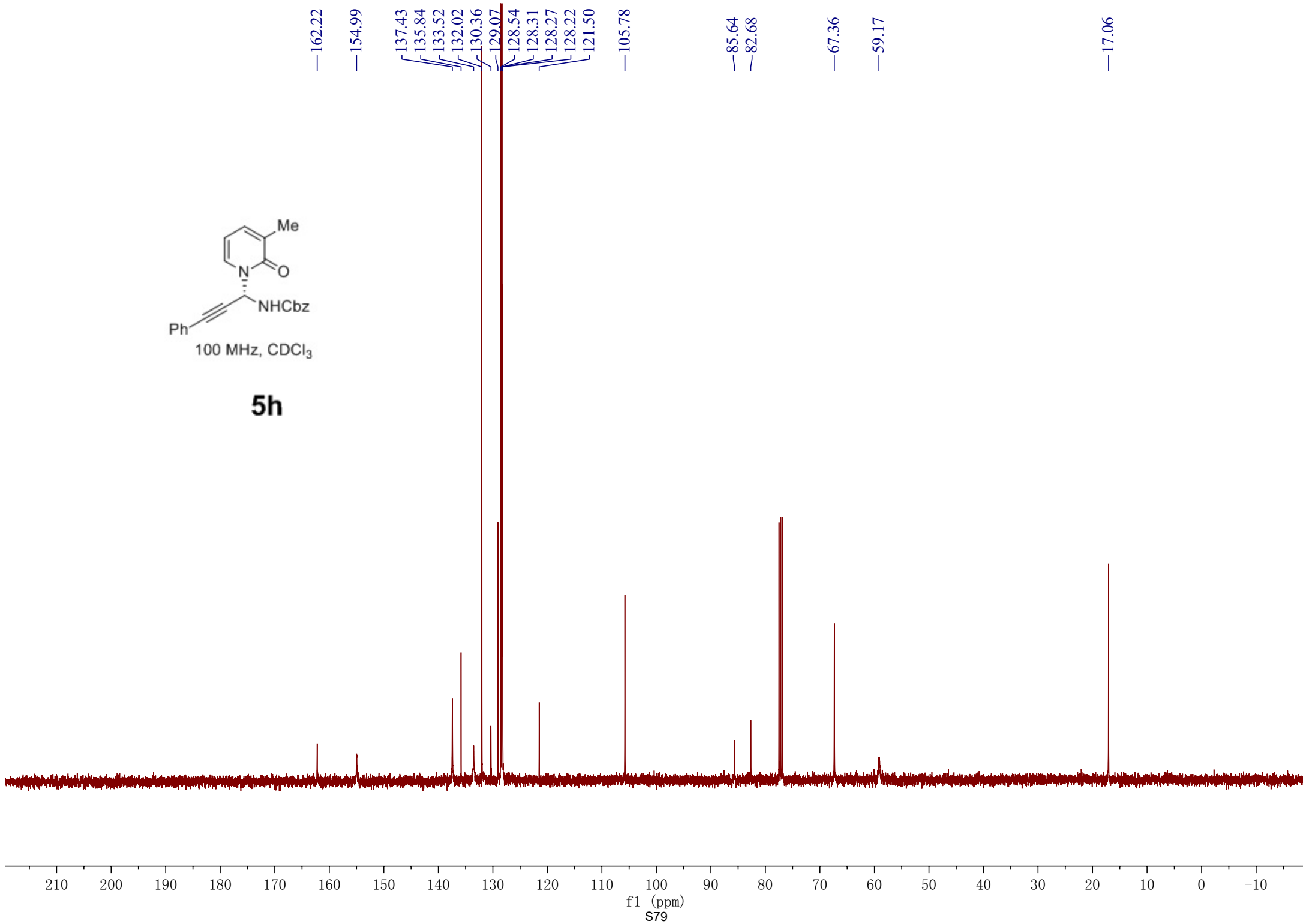


5h

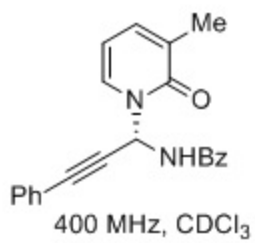




5h



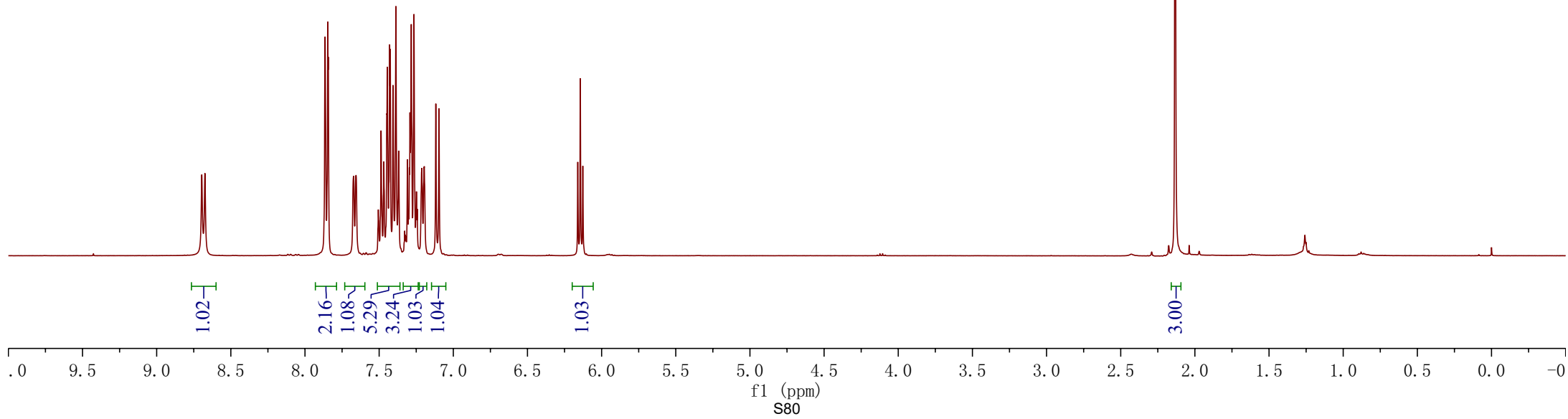
8.696
8.675
7.864
7.846
7.843
7.449
7.445
7.429
7.425
7.407
7.387
7.292
7.283
7.265
7.118
7.097
6.161
6.144
6.127

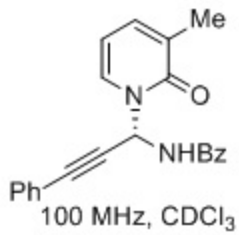


5i

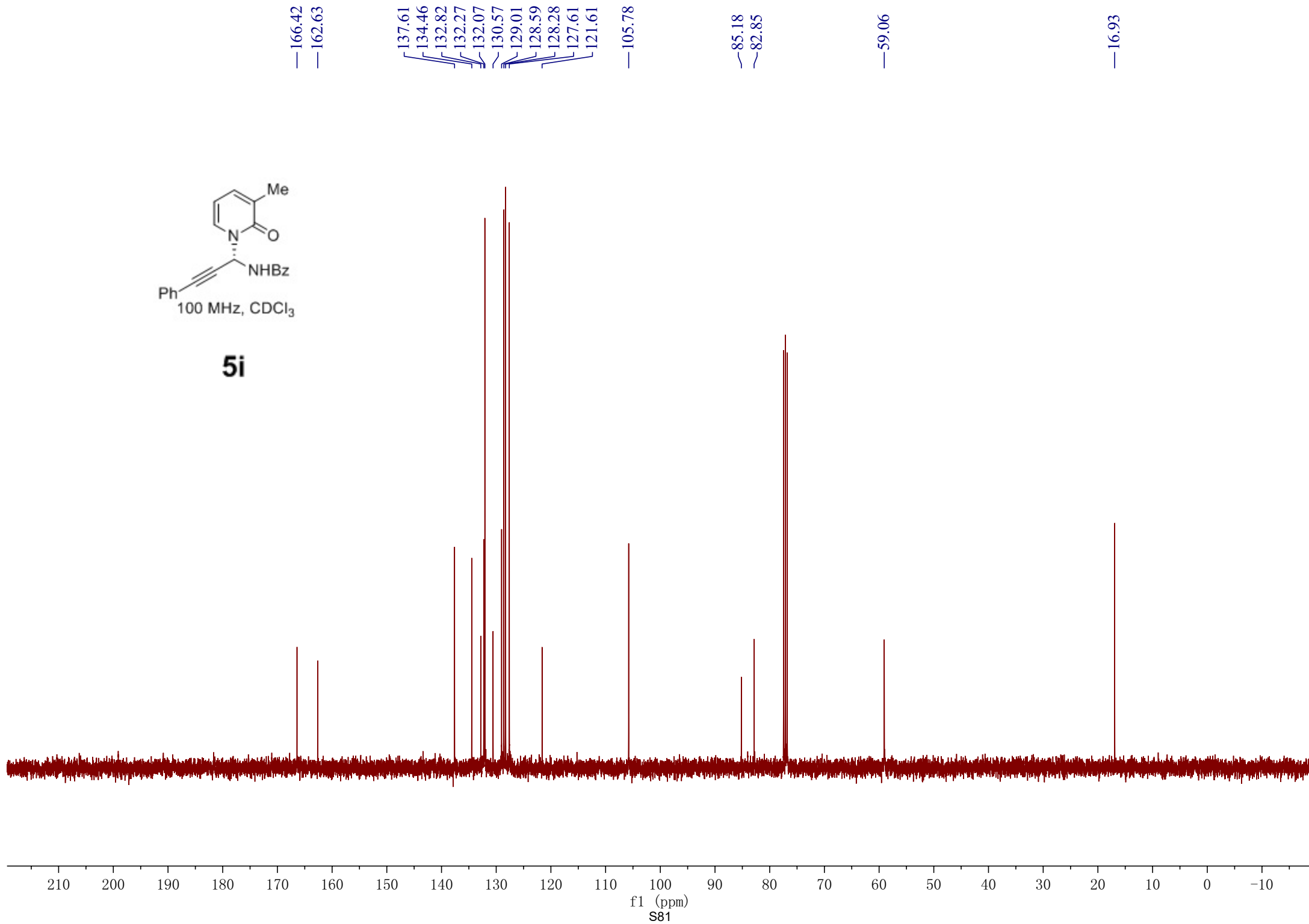
2.133

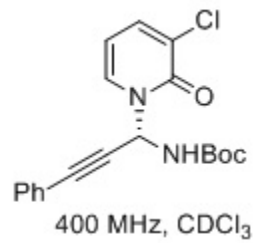
0.000



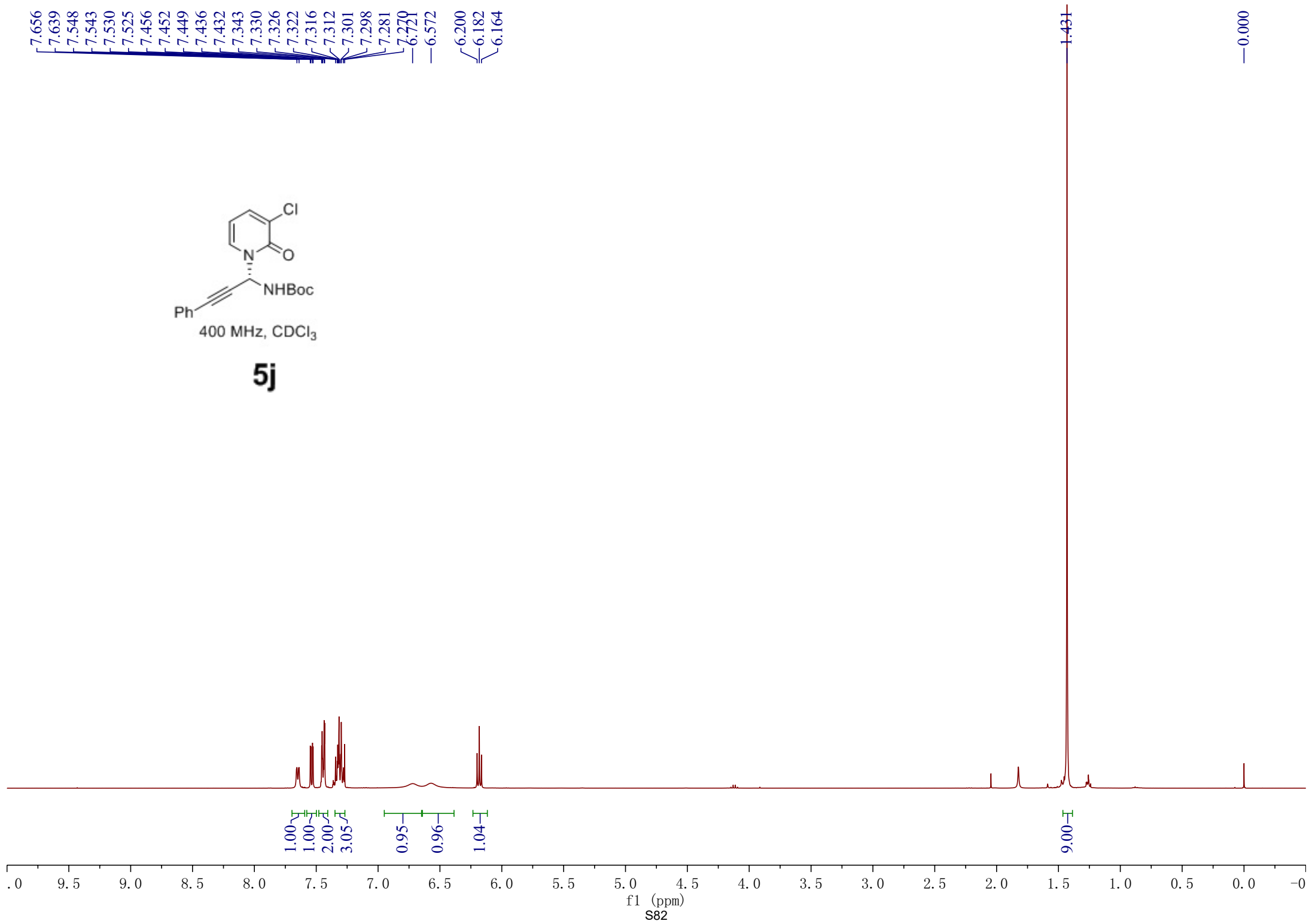


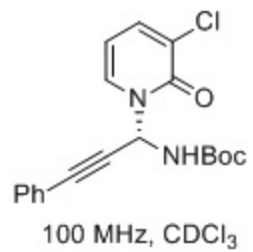
5i



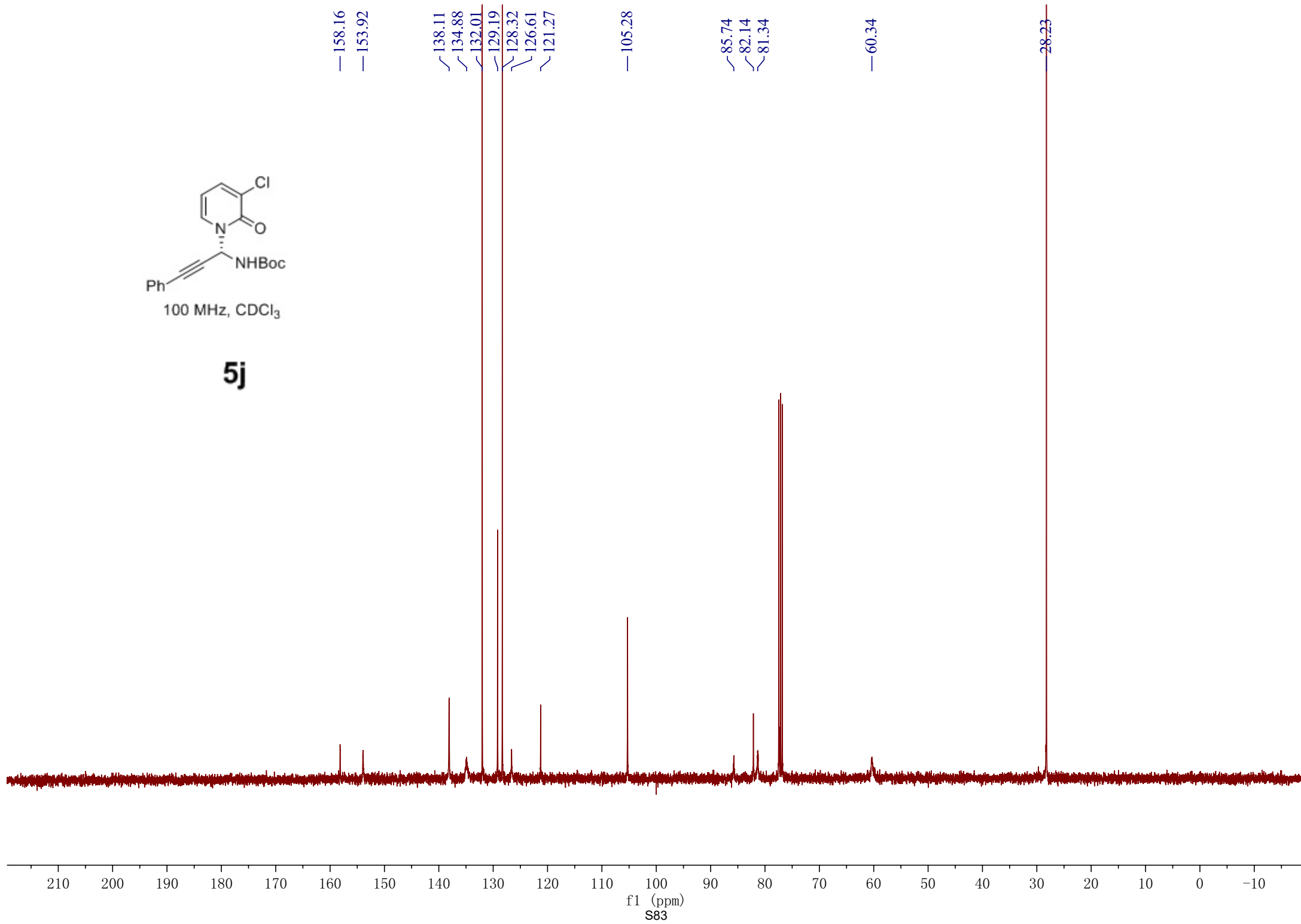


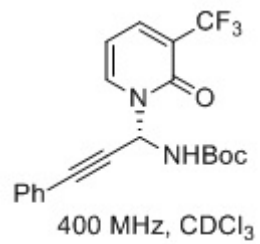
5j





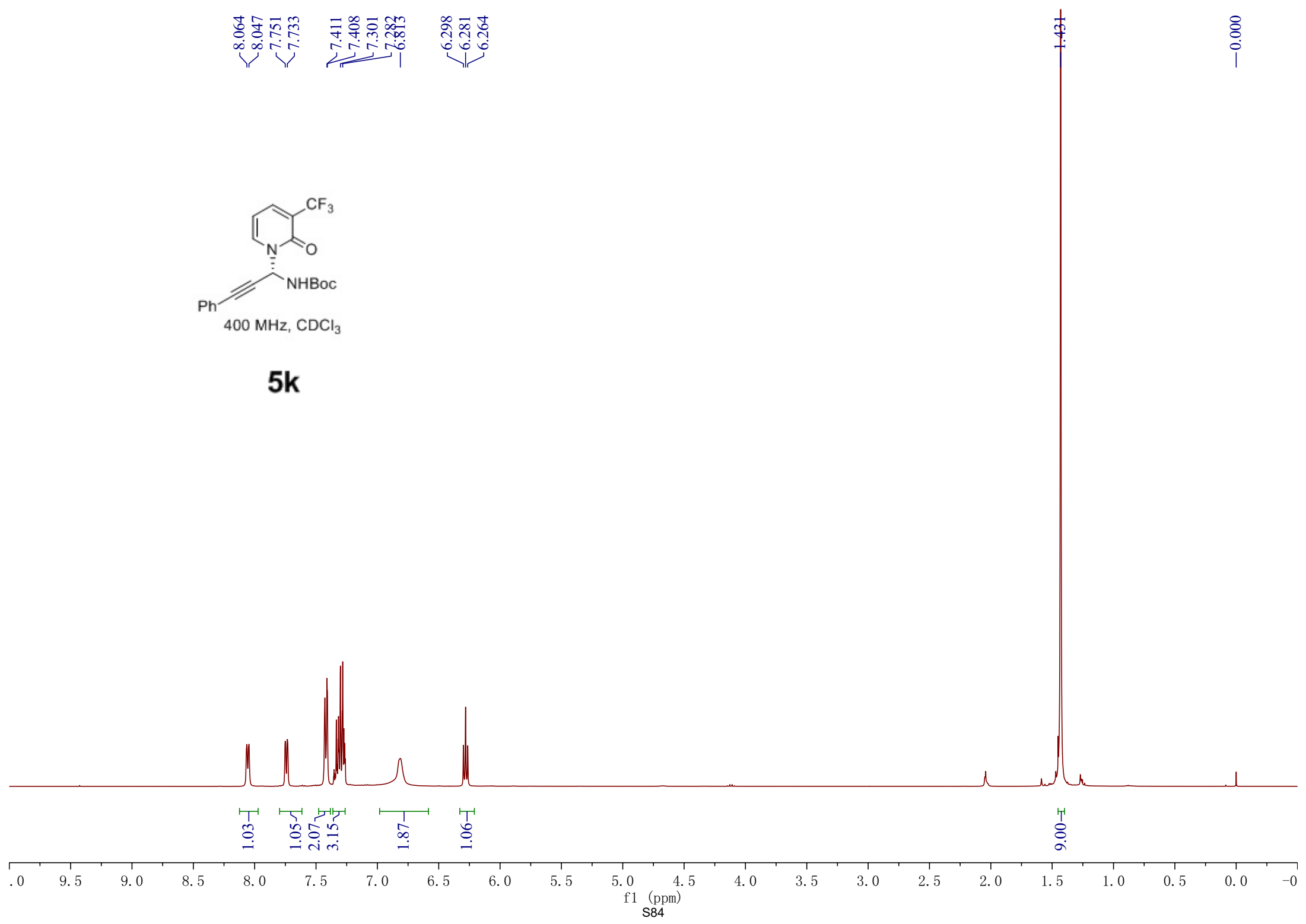
5j

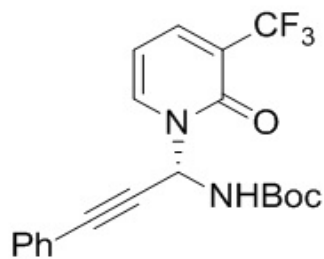




5k

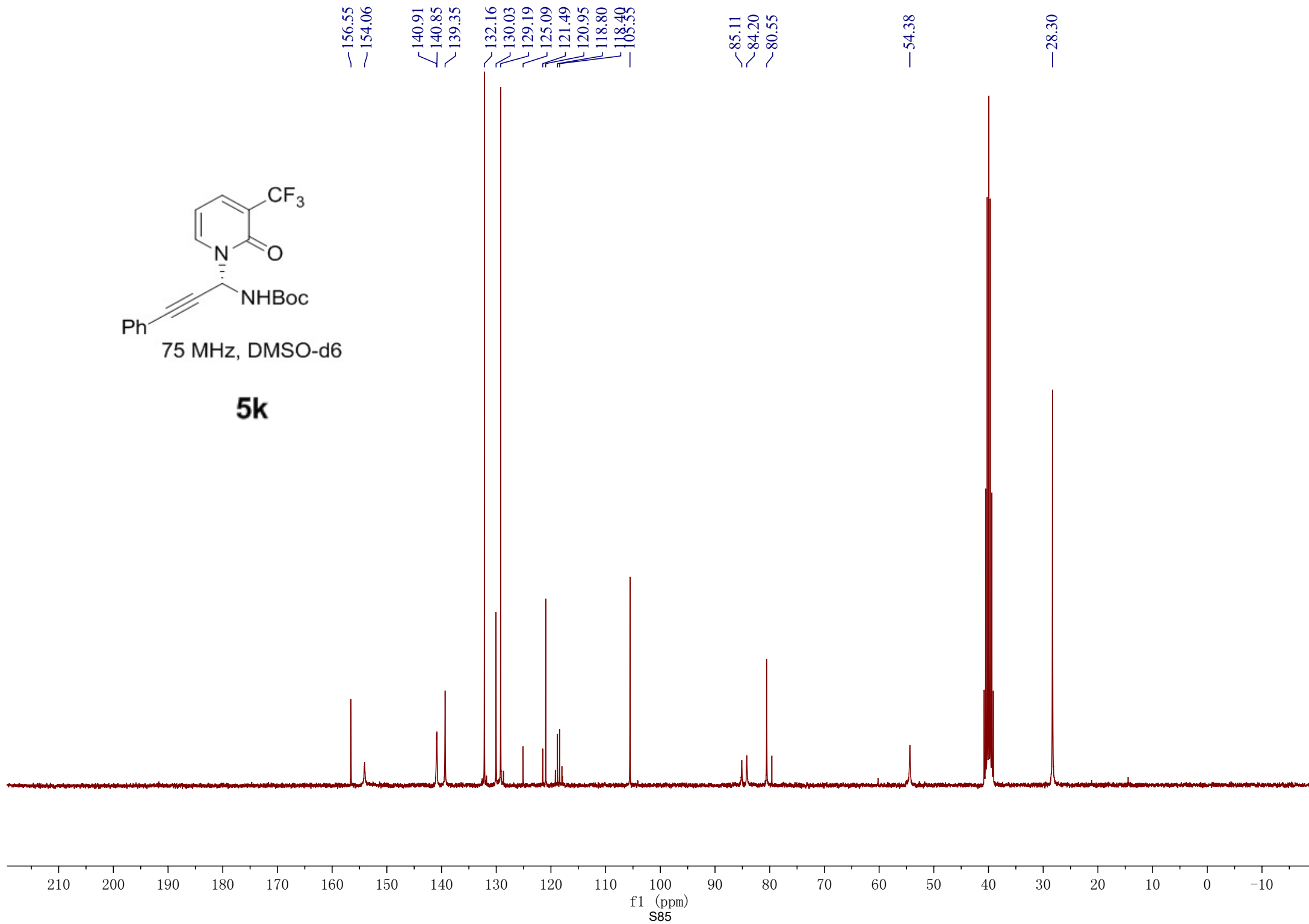
8.064
8.047
7.751
7.733
7.411
7.408
7.301
7.282
6.813
6.298
6.281
6.264
-0.000

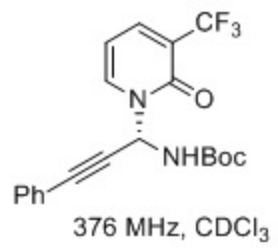




75 MHz, DMSO-d6

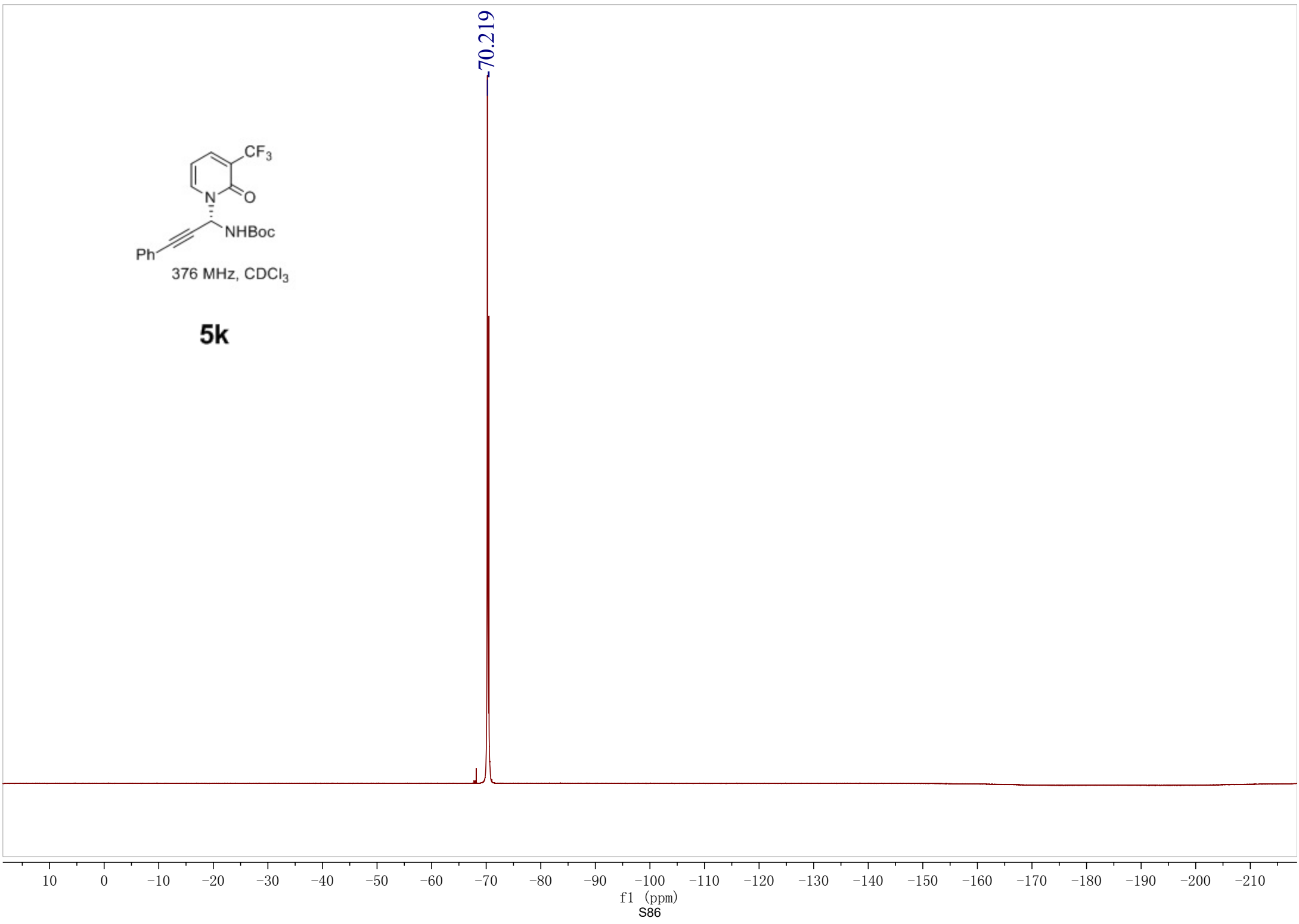
5k

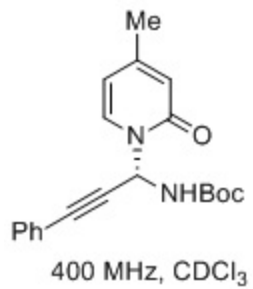




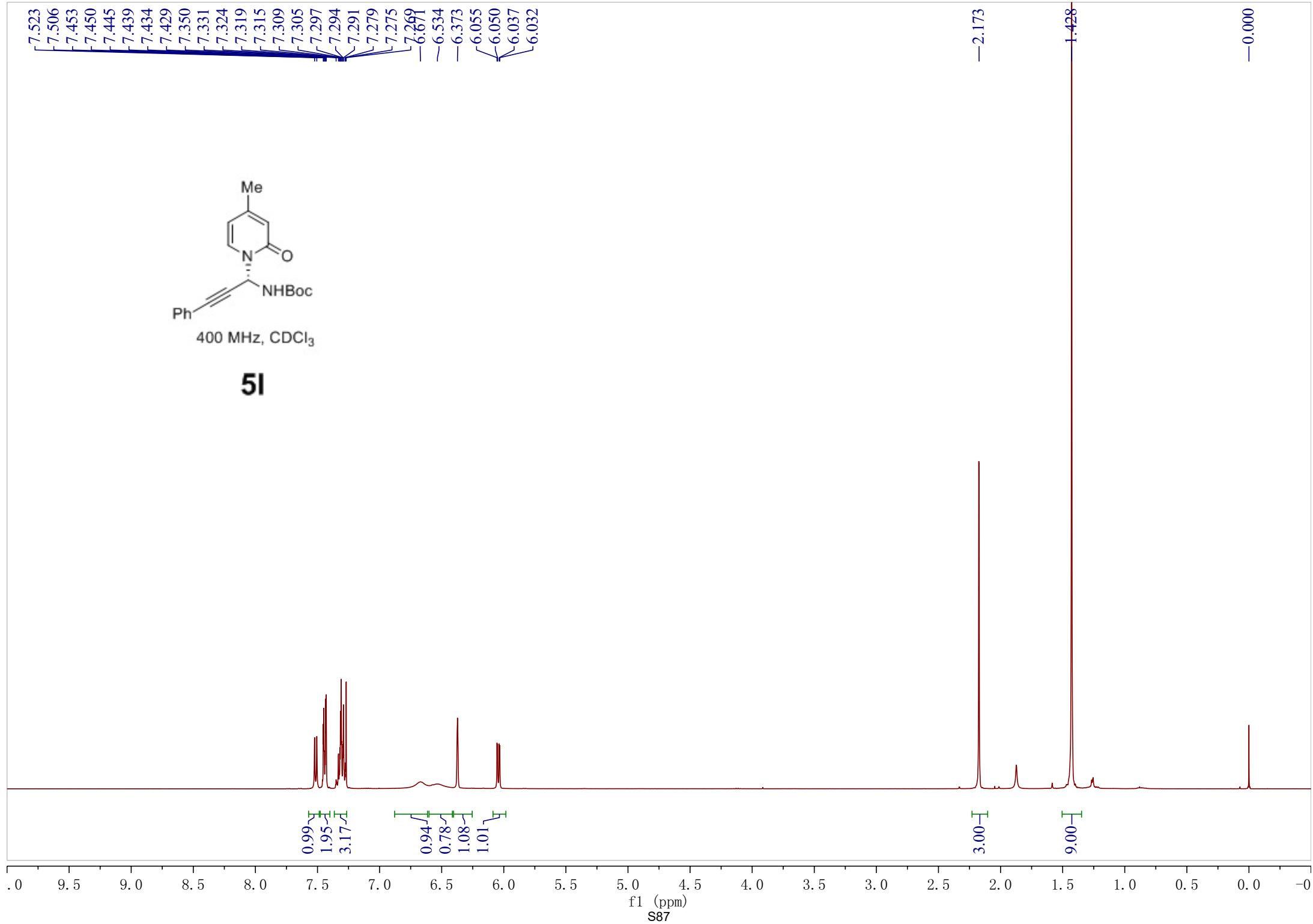
5k

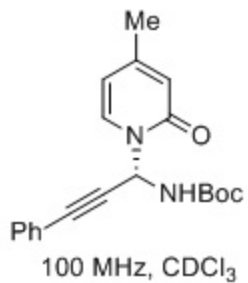
70.219



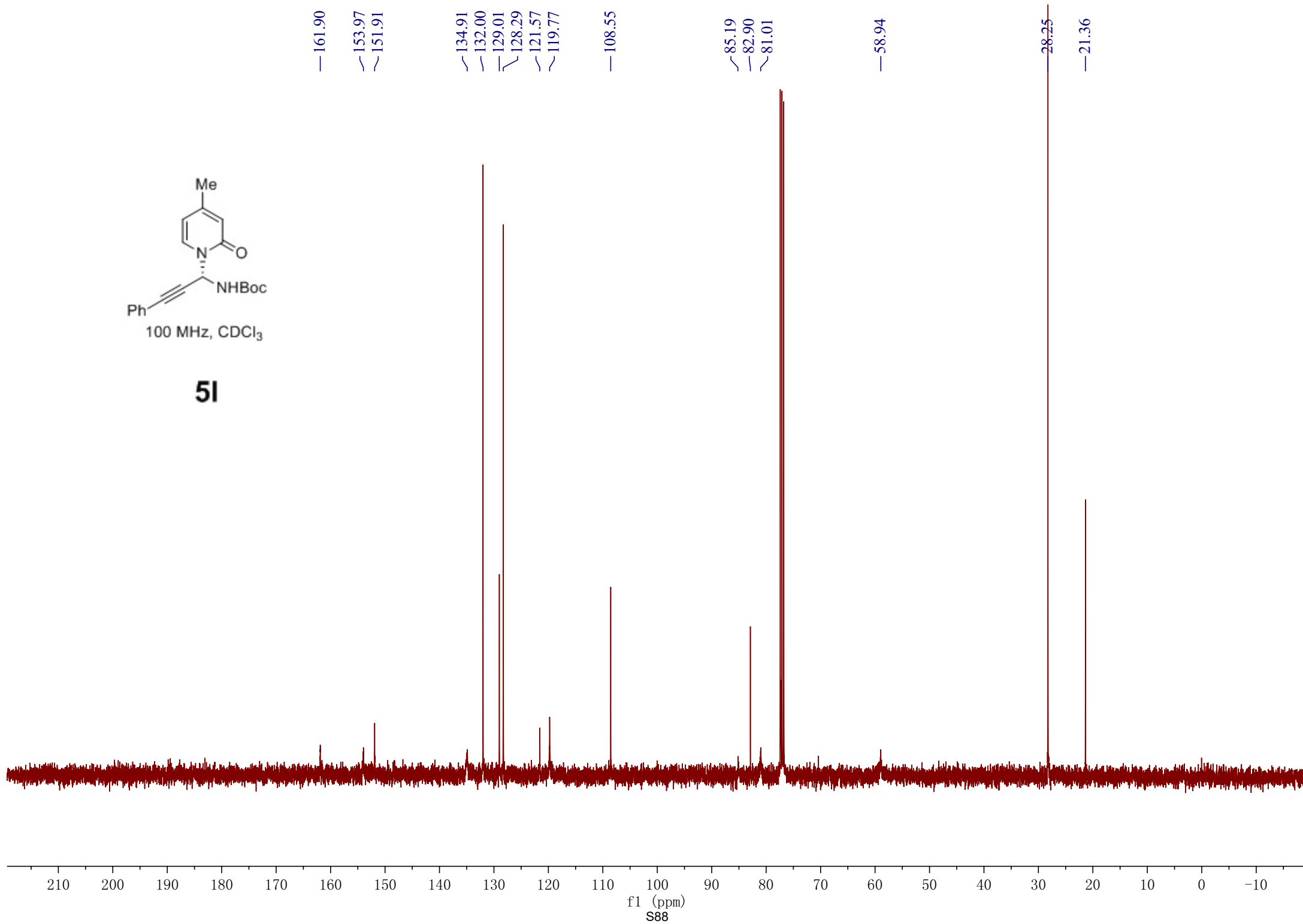


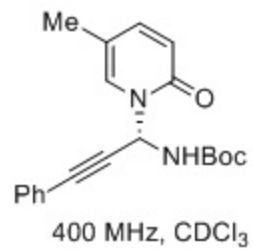
5I



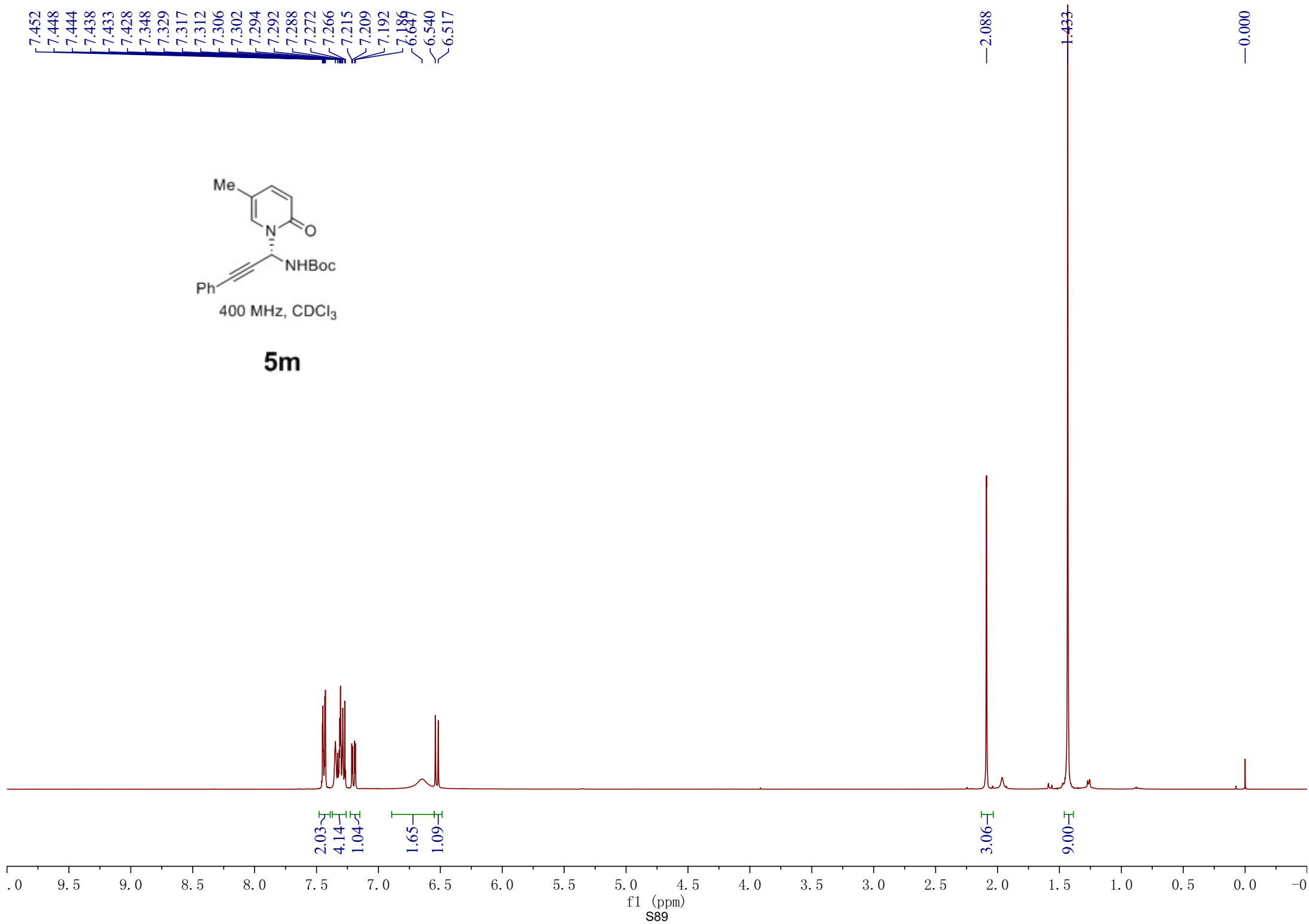


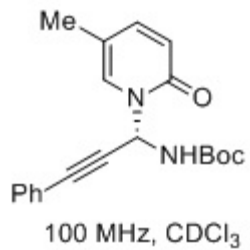
51



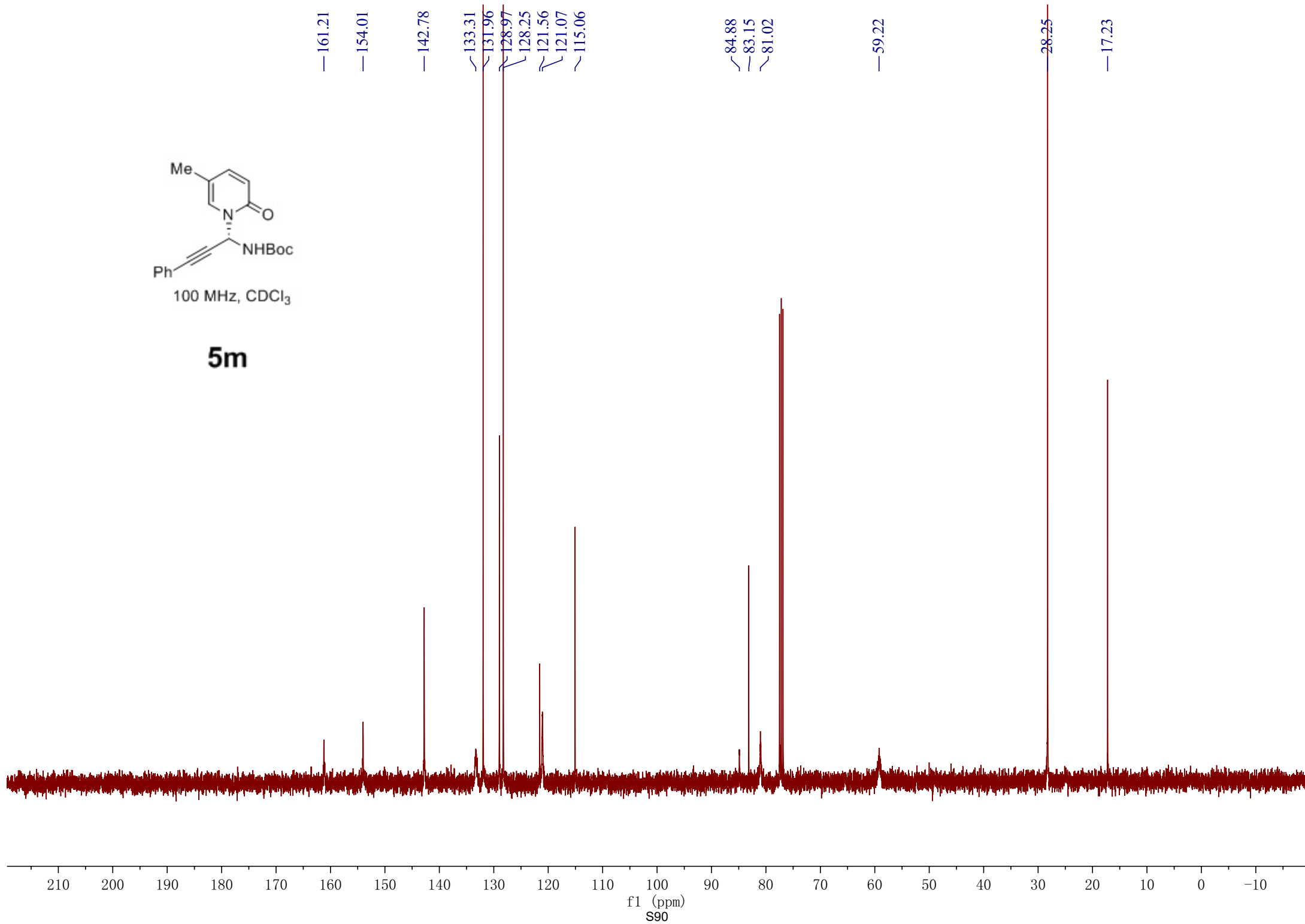


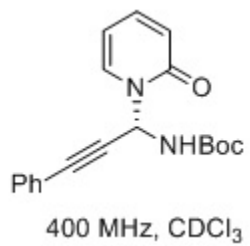
5m



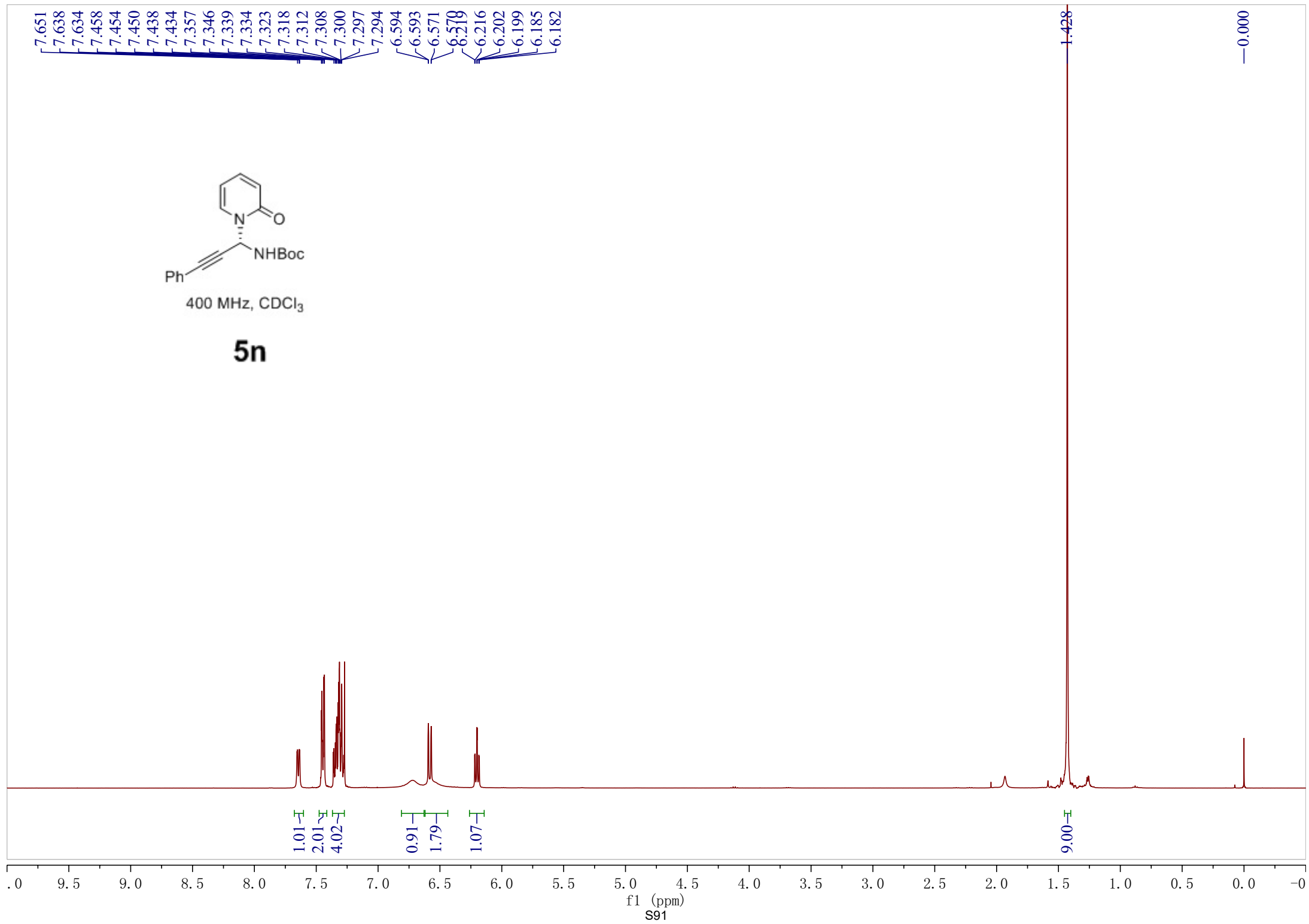


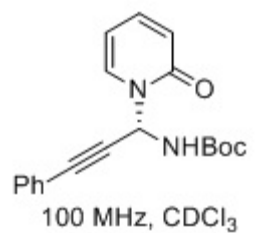
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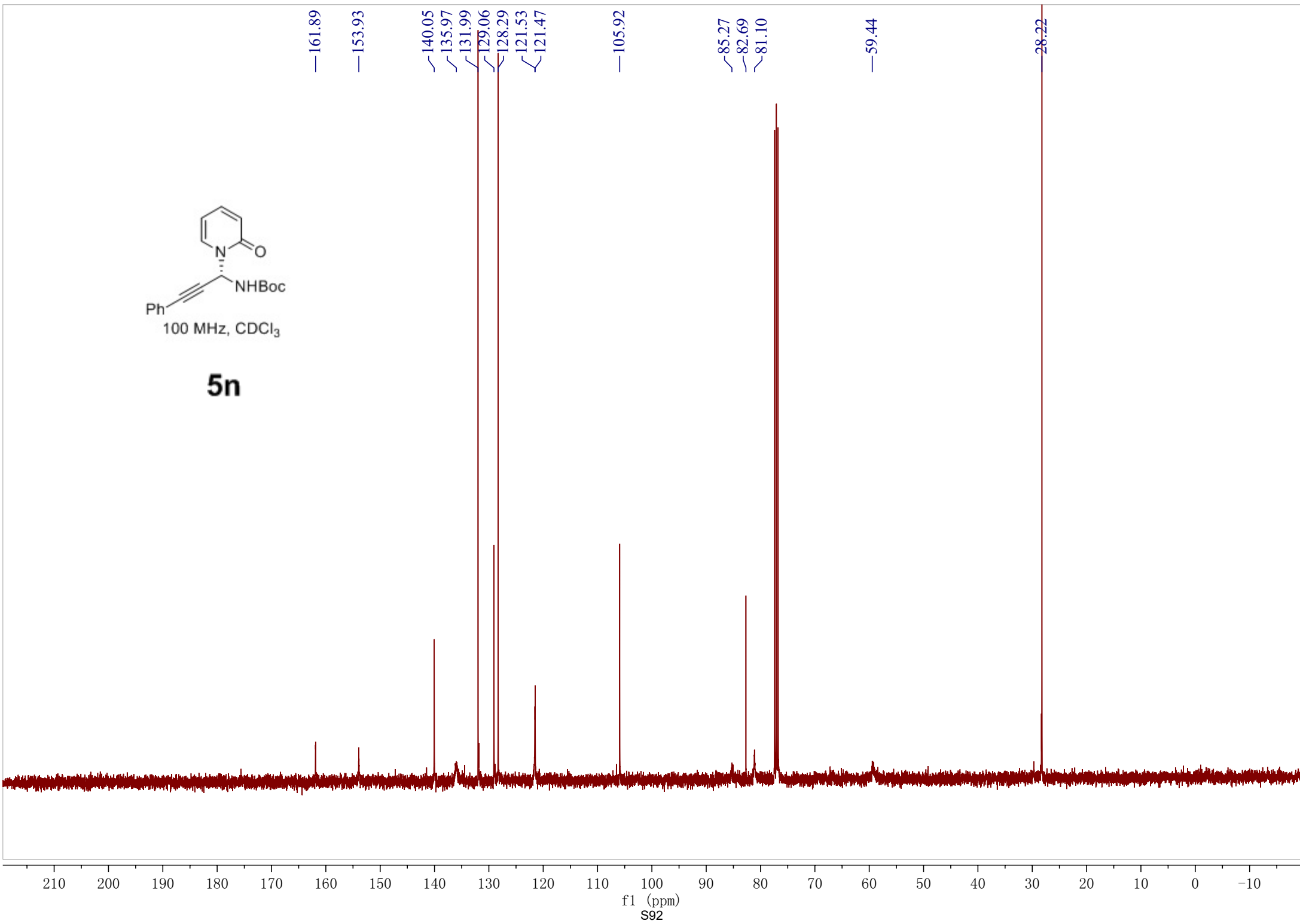


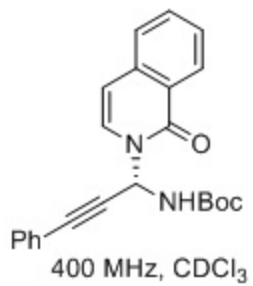
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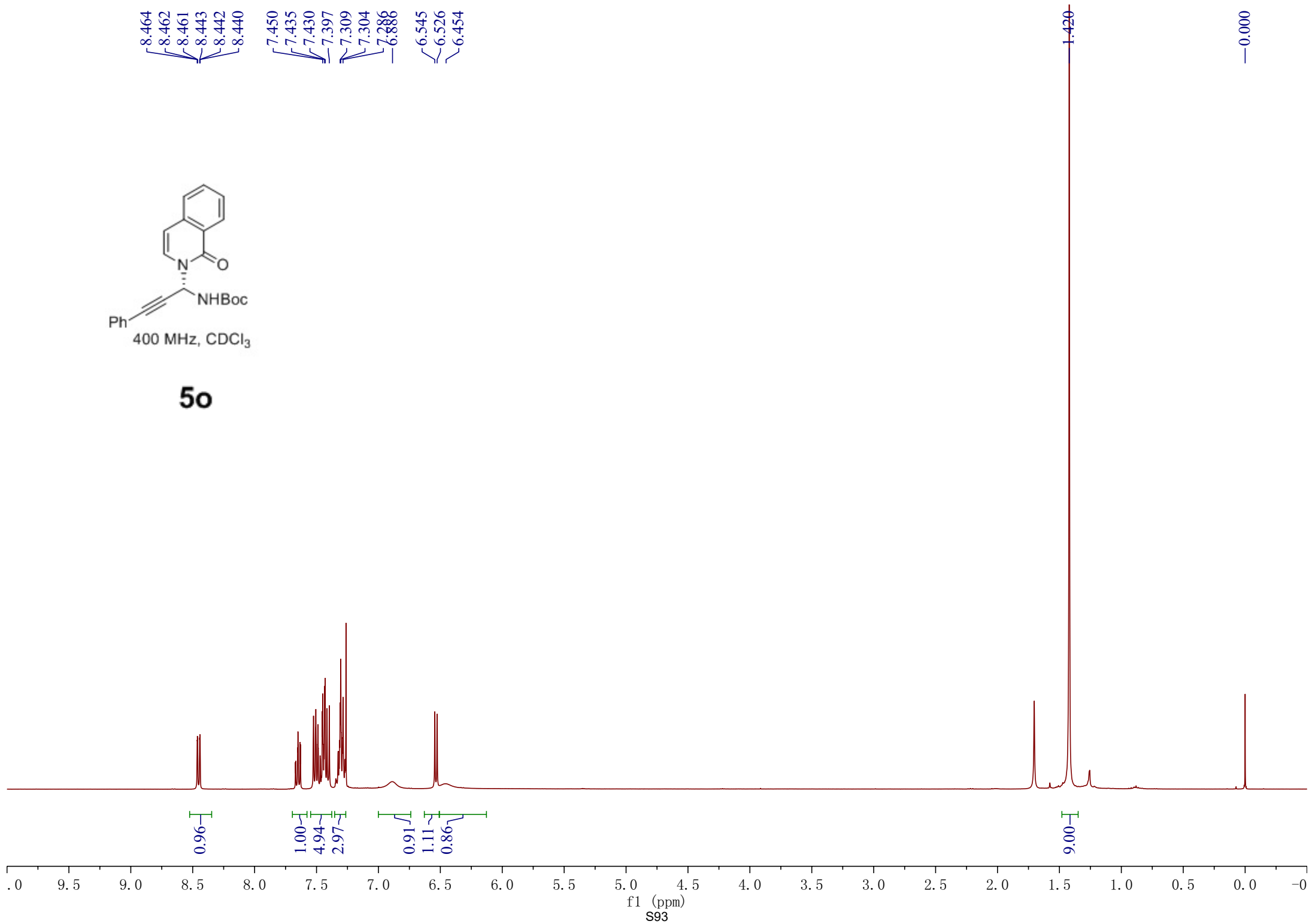
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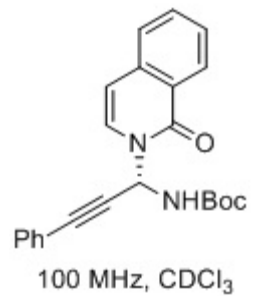




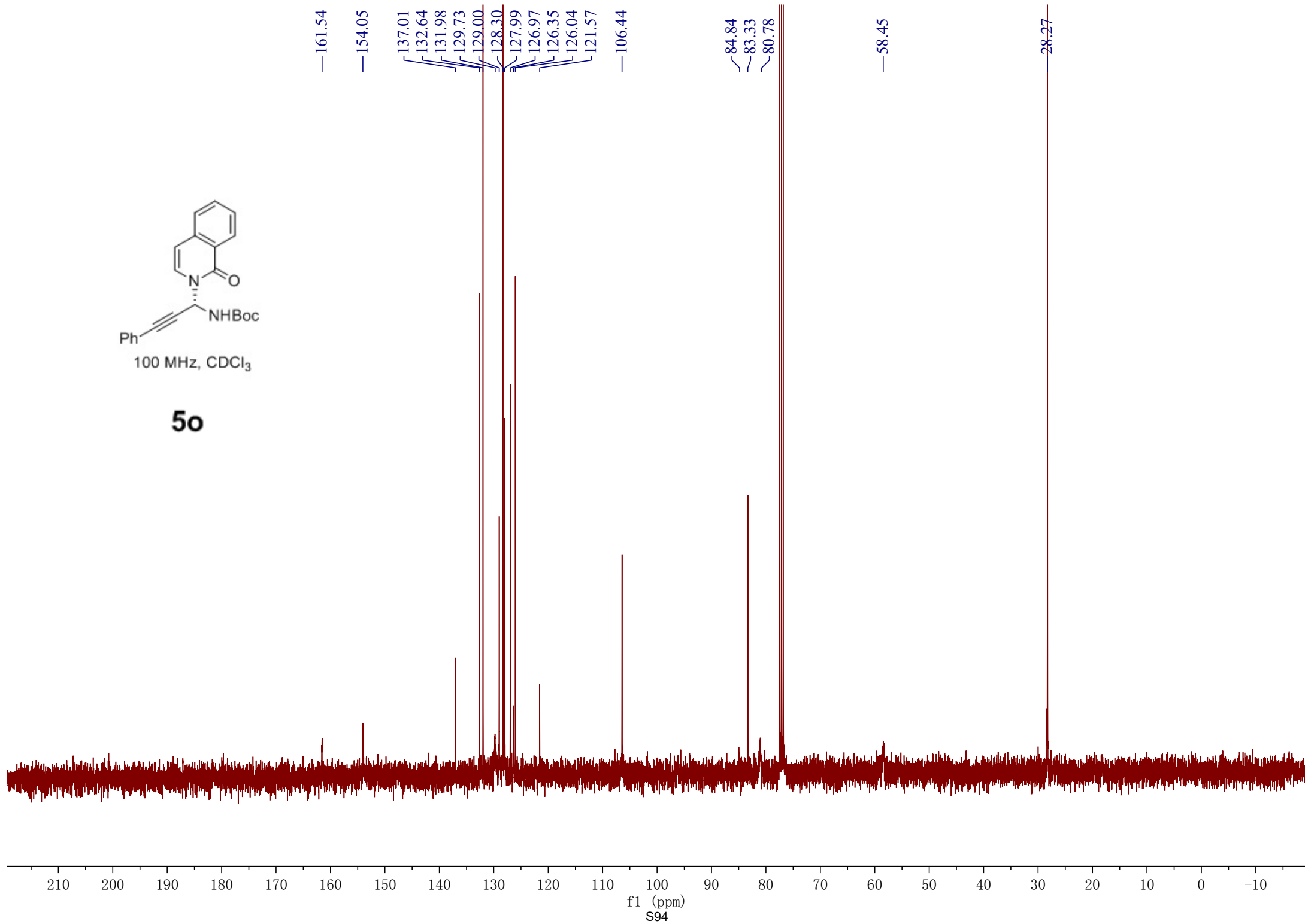
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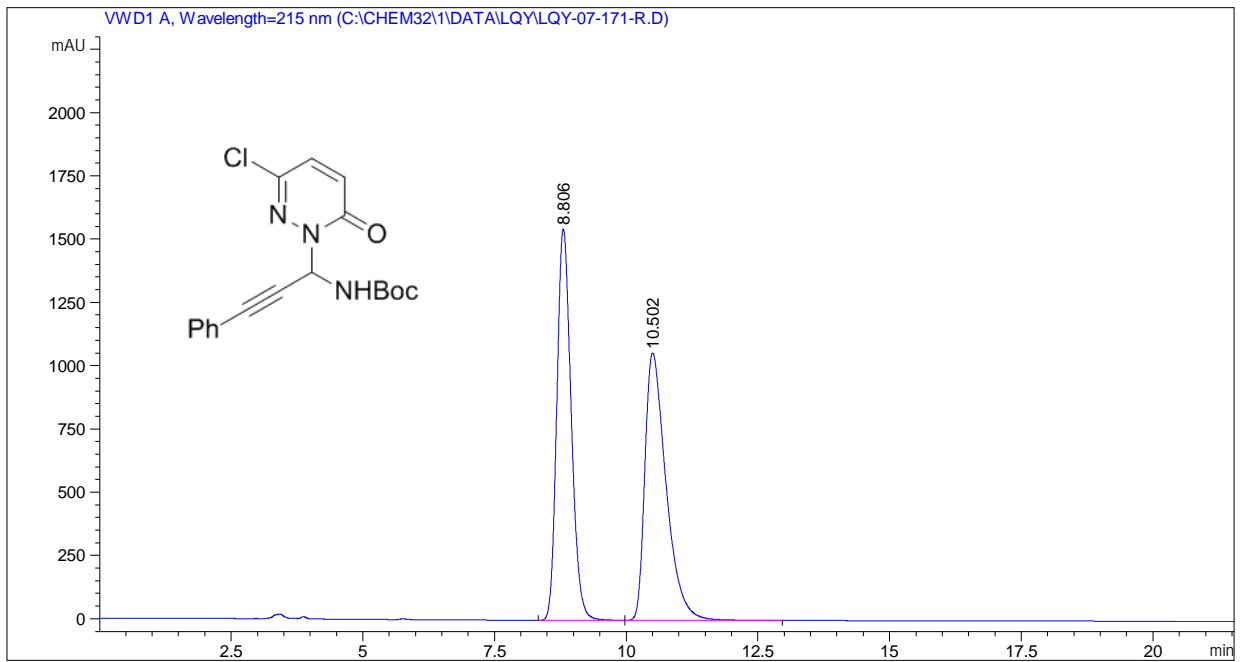
8.464
8.462
8.461
8.443
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7.309
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7.286
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6.545
6.526
6.454



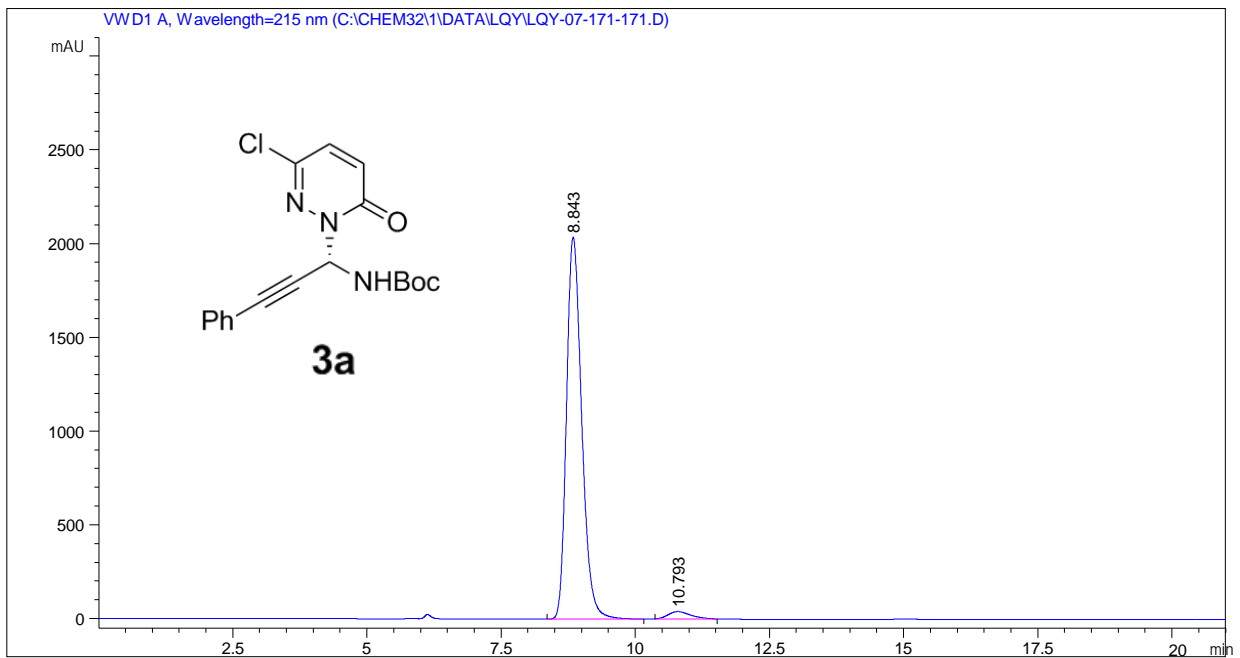


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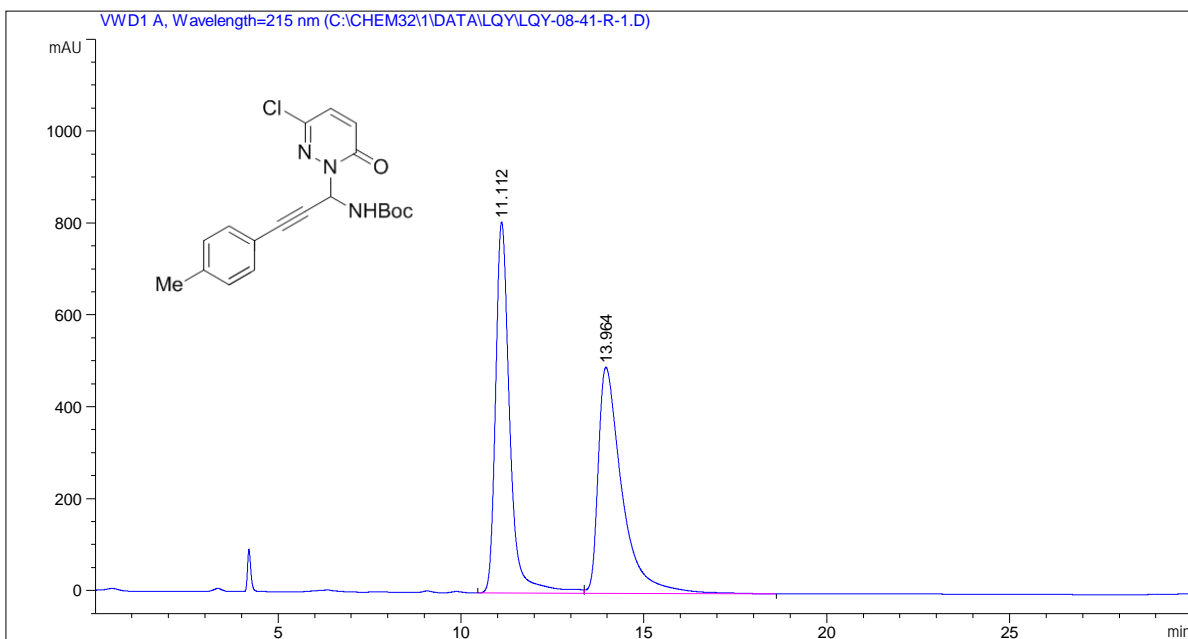




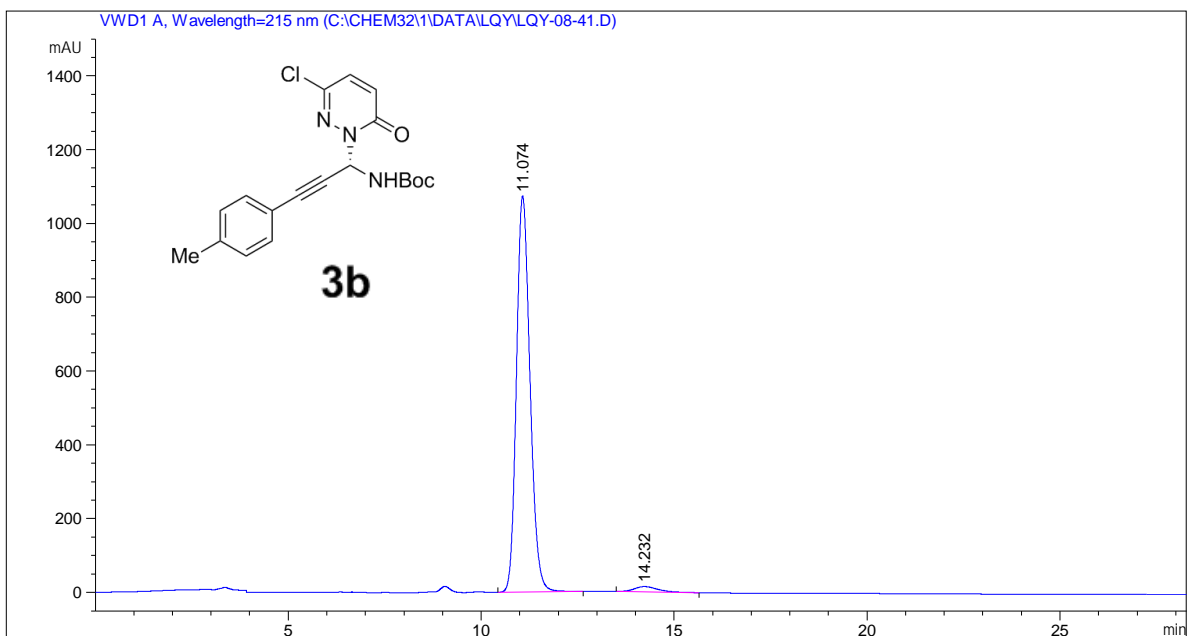
#	[min]	[min]	[mAU*s]	[mAU]	%	
1	8.806	BB	0.2934	2.92104e4	1545.91370	49.7149
2	10.502	BB	0.4243	2.95454e4	1056.23389	50.2851



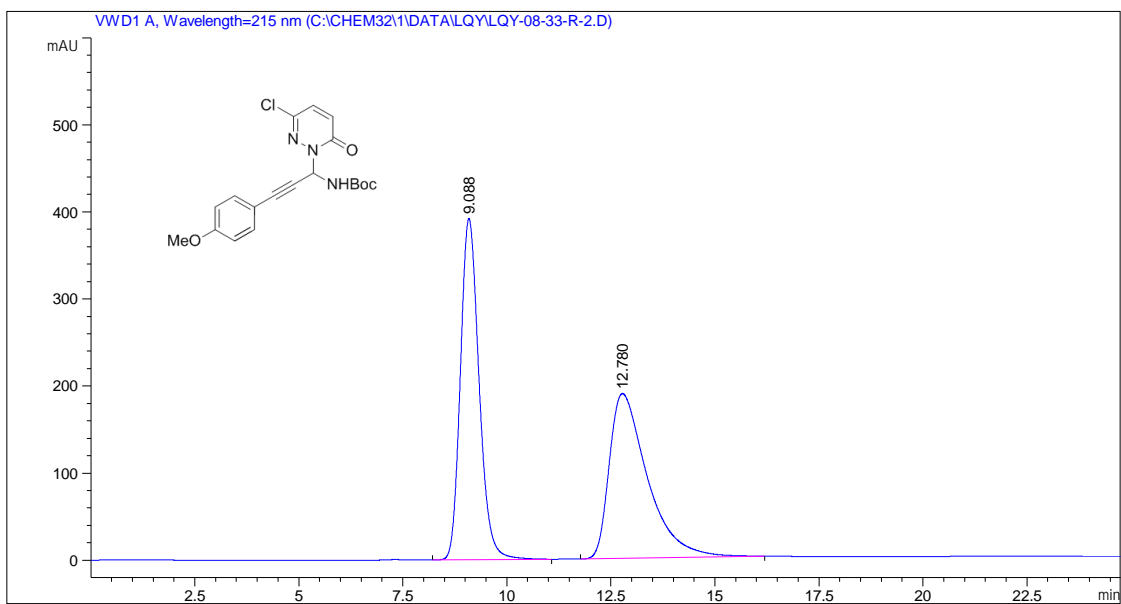
#	[min]	[min]	[mAU*s]	[mAU]	%	
1	8.843	MM	0.3287	4.01724e4	2036.99768	97.1887
2	10.793	MM	0.4896	1162.04663	39.55899	2.8113



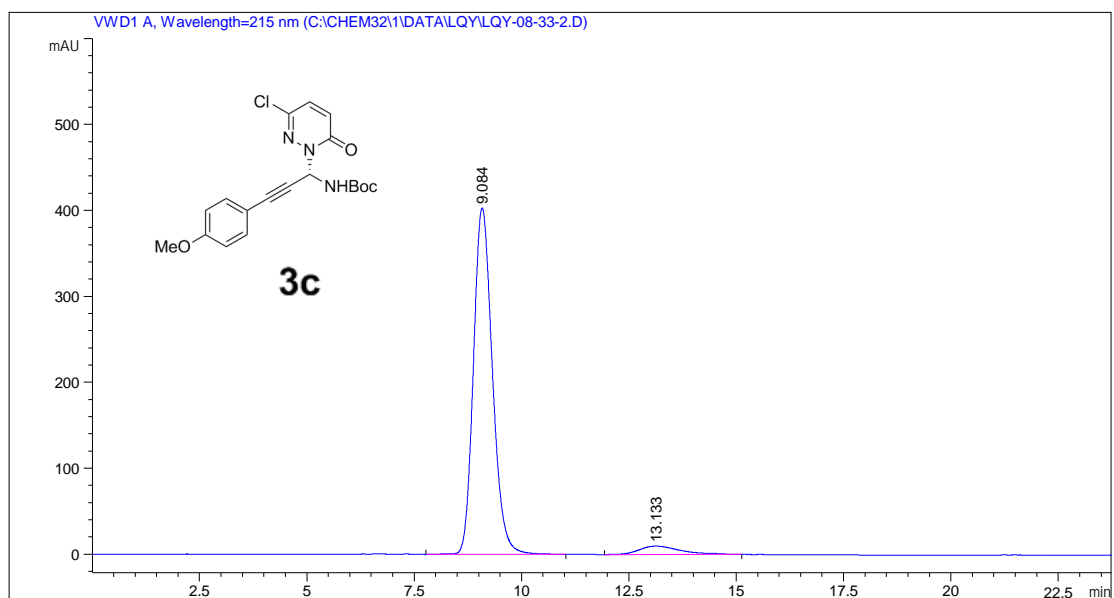
#	[min]	[min]	[mAU*s]	[mAU]	%	
1	11.112	BV R	0.4083	2.18504e4	807.78693	49.6470
2	13.964	VB	0.6655	2.21611e4	491.99591	50.3530



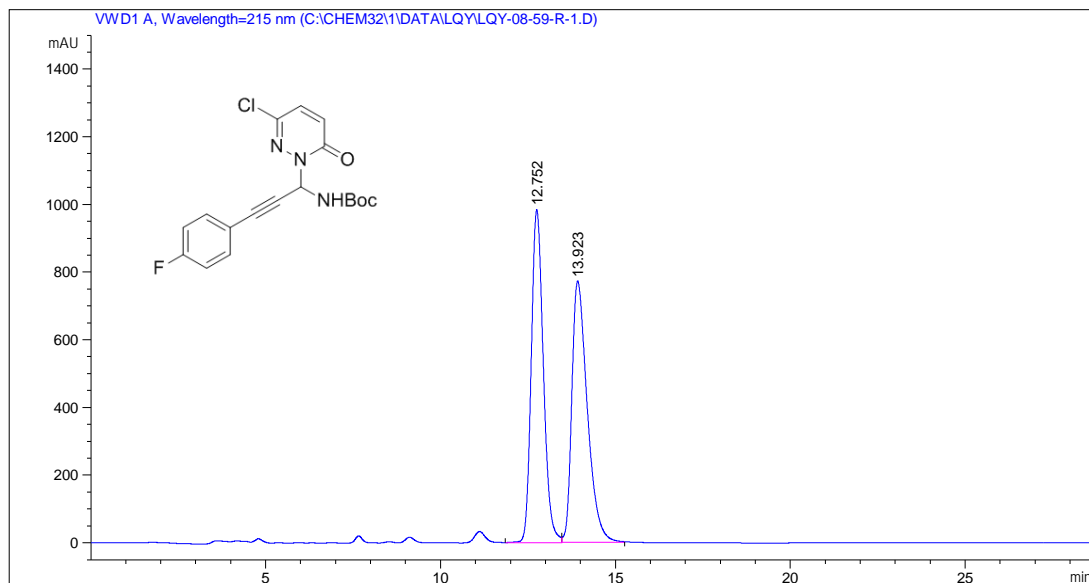
#	[min]	[min]	[mAU*s]	[mAU]	%	
1	11.074	BB	0.3775	2.61821e4	1073.79468	97.7482
2	14.232	BB	0.6489	603.15656	14.24609	2.2518



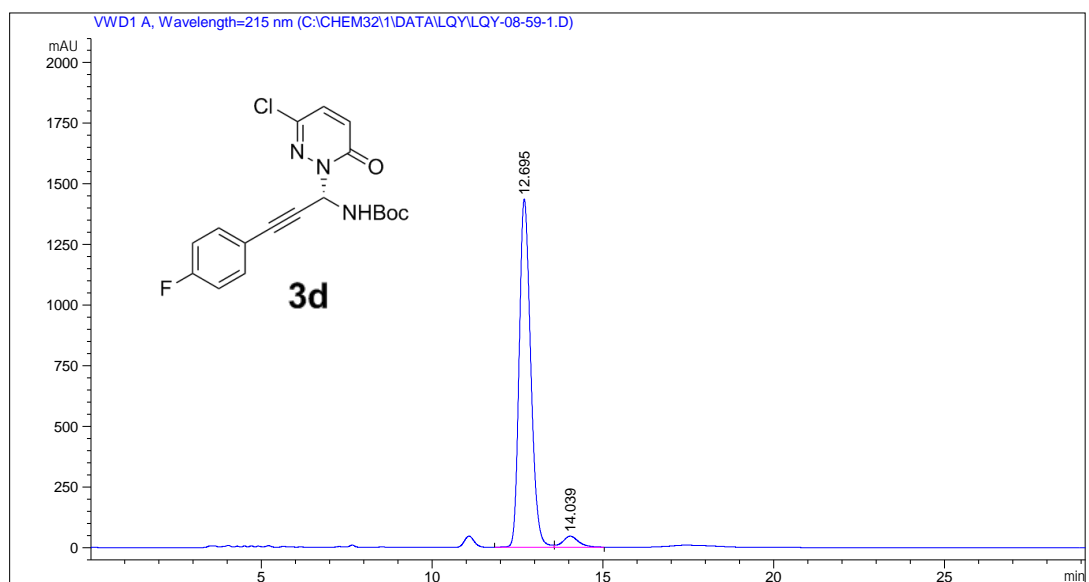
#	[min]	[min]	[mAU*s]	[mAU]	%	
1	9.088	BB	0.4817	1.22173e4	391.94629	50.2893
2	12.780	BB	0.9601	1.20768e4	189.36020	49.7107



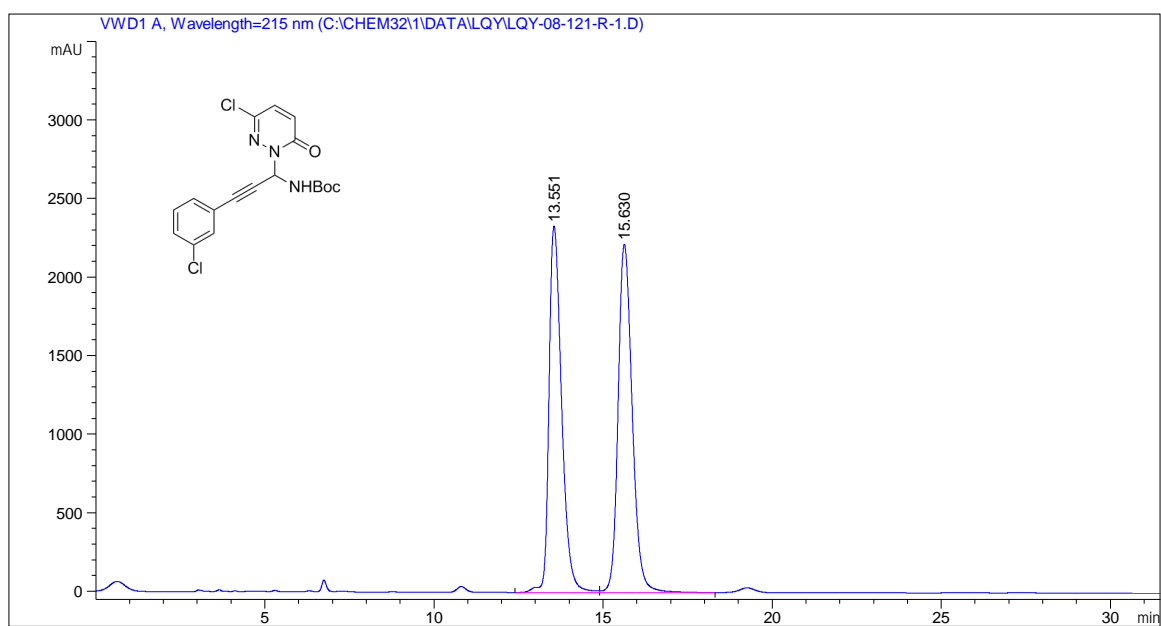
#	[min]	[min]	[mAU*s]	[mAU]	%	
1	9.084	BB	0.4753	1.23838e4	403.28482	94.9234
2	13.133	BB	0.9599	662.29431	9.81979	5.0766



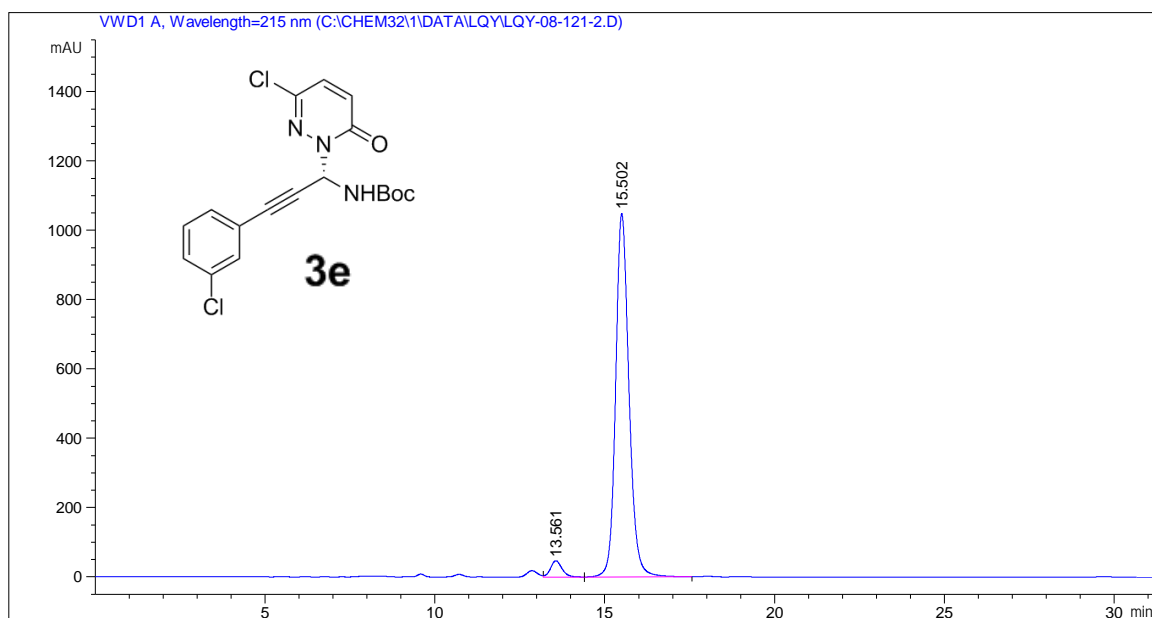
#	[min]	[min]	[mAU*s]	[mAU]	%
1	12.752	0.3719	2.37278e4	985.34229	49.9988
2	13.923	0.5121	2.37289e4	772.22656	50.0012



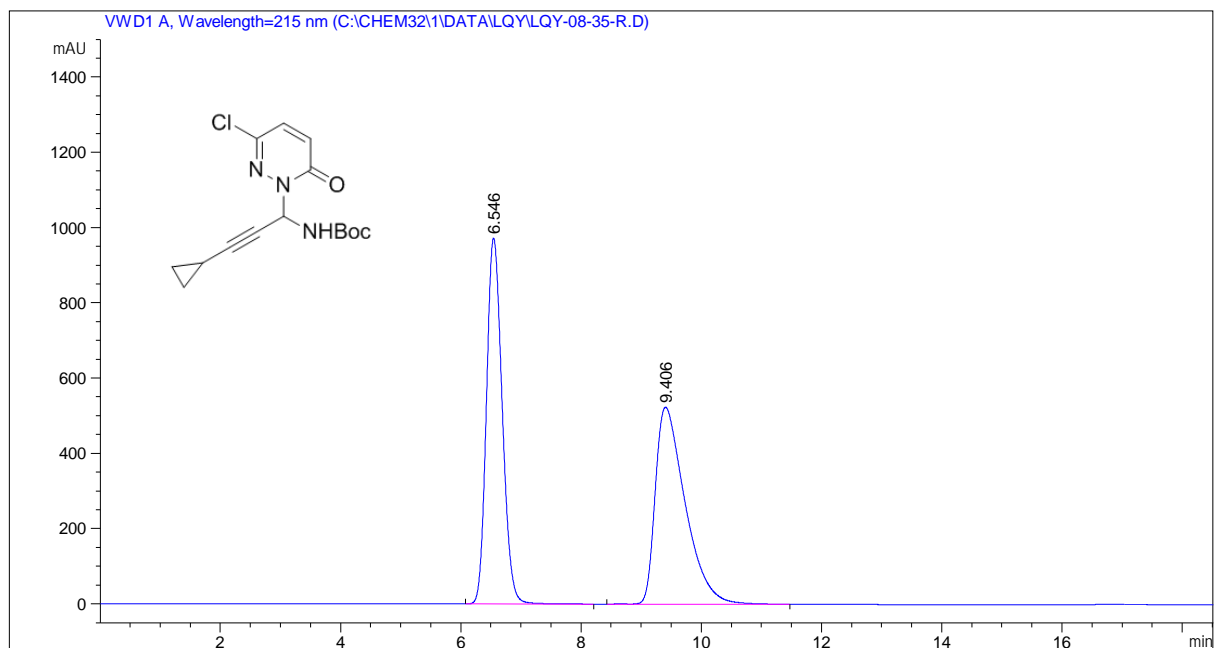
#	[min]	[min]	[mAU*s]	[mAU]	%
1	12.695	0.3900	3.36248e4	1437.00769	95.6994
2	14.039	0.5489	1511.06738	45.88544	4.3006



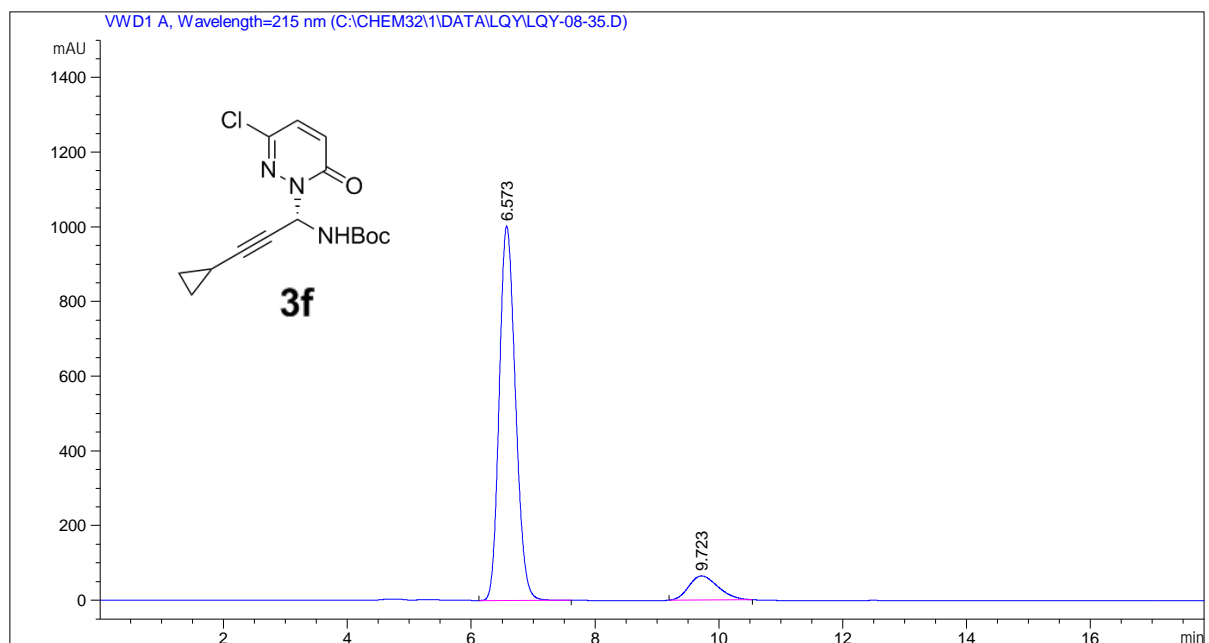
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	13.551	VV R	0.3982	6.05814e4	2331.77954	48.5467
2	15.630	VB	0.4480	6.42085e4	2216.45508	51.4533



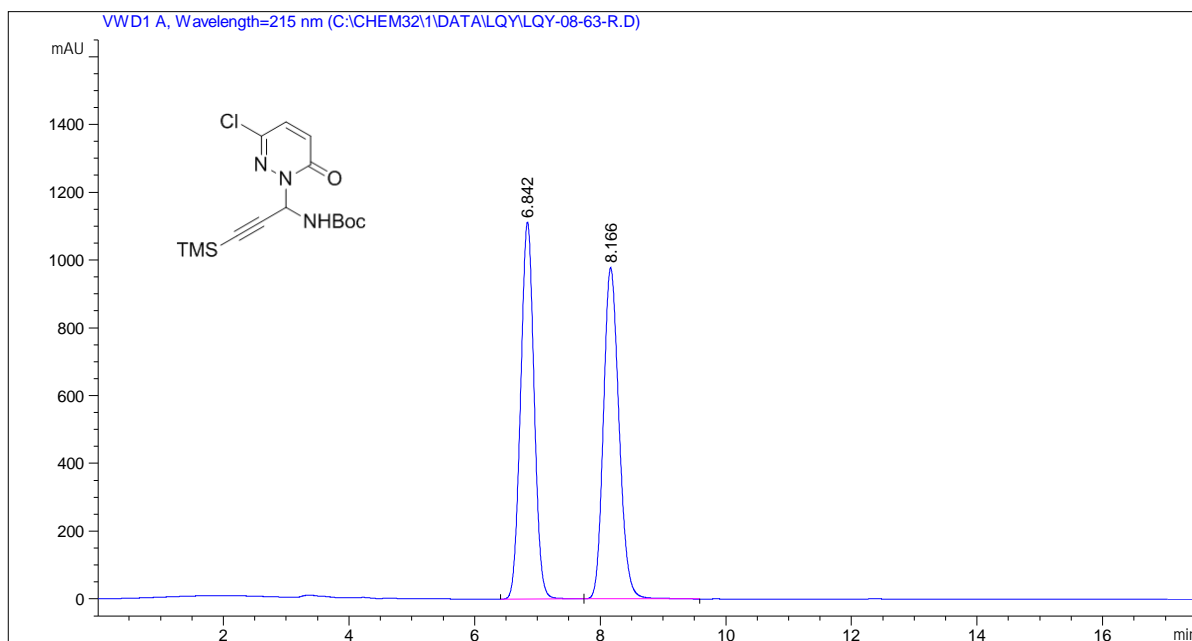
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	13.561	VB	0.3563	1101.51282	47.19630	3.7118
2	15.502	BB	0.4159	2.85748e4	1048.71362	96.2882



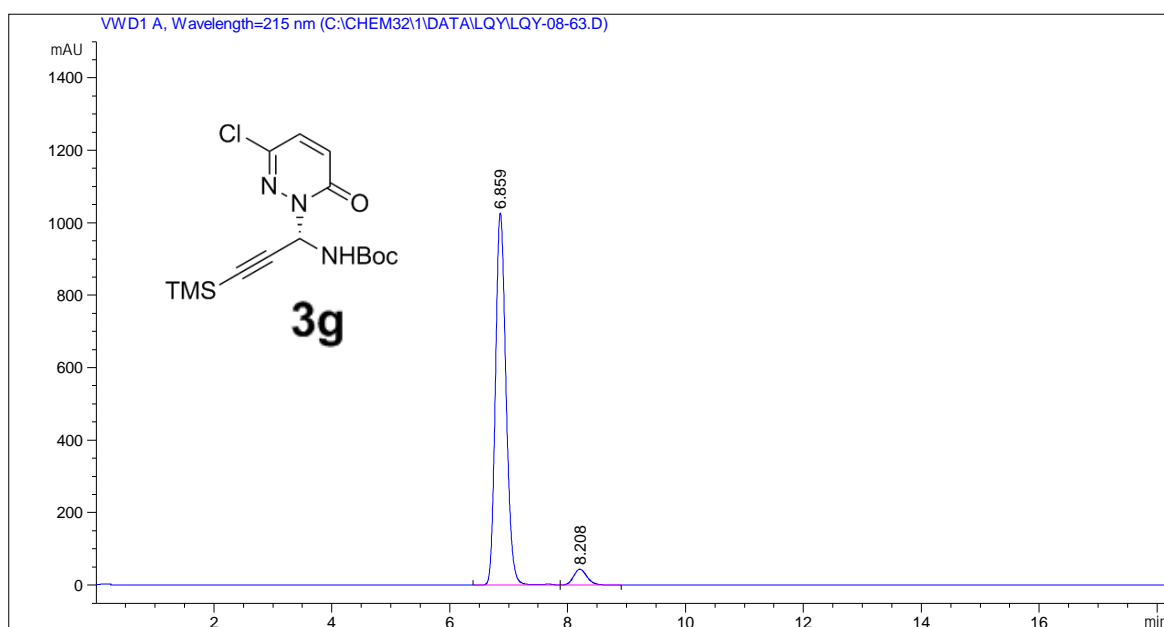
#	[min]	[min]	[mAU*s]	[mAU]	%	
1	6.546	BB	0.2839	1.76657e4	972.57458	49.5176
2	9.406	VB R	0.5205	1.80099e4	523.37500	50.4824



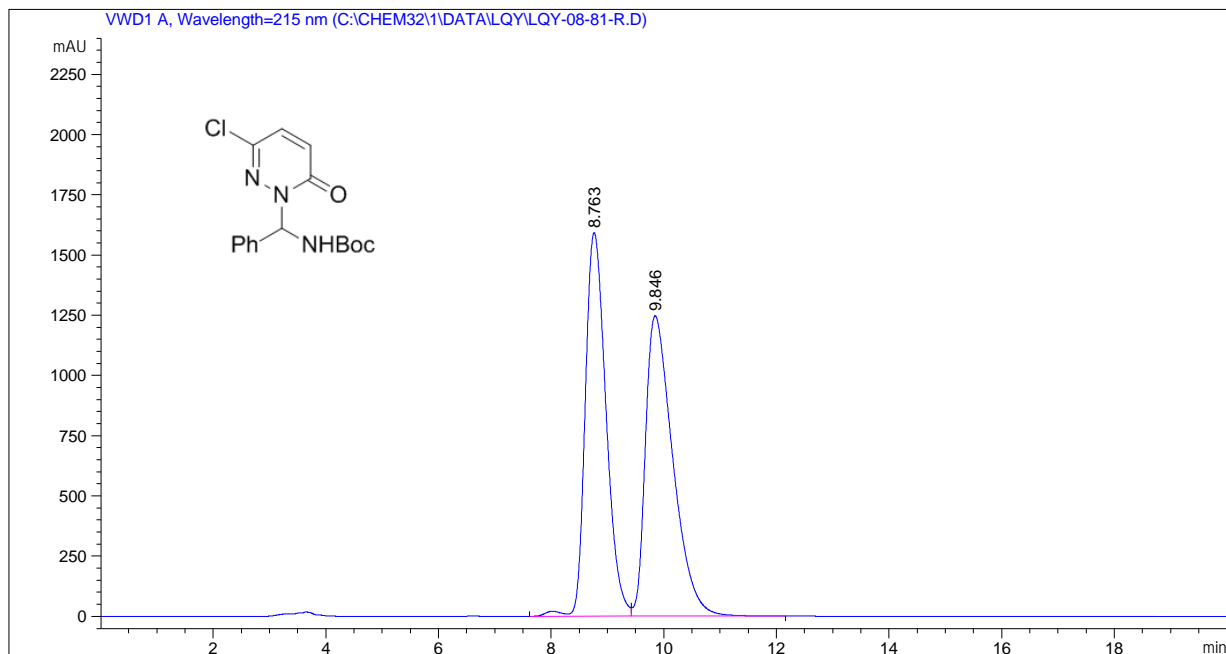
#	[min]	[min]	[mAU*s]	[mAU]	%	
1	6.573	BB	0.2841	1.82249e4	1002.47131	89.4876
2	9.723	MM	0.5513	2140.93506	64.72498	10.5124



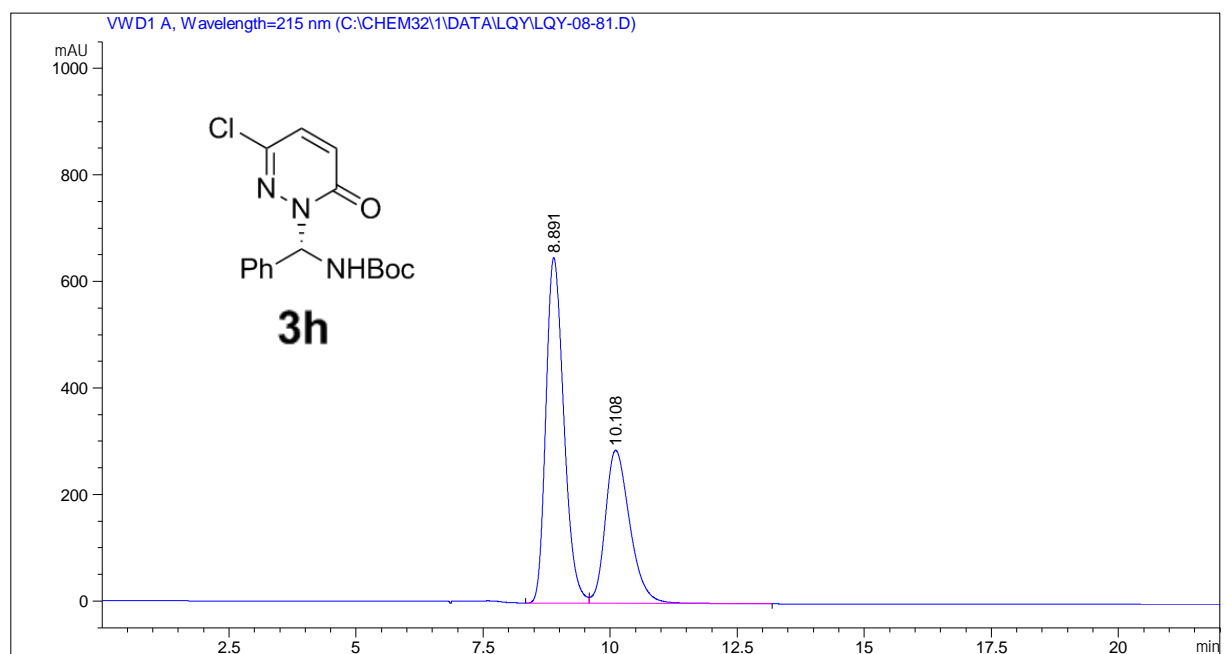
#	[min]	[min]	[mAU*s]	[mAU]	%	
1	6.842	BB	0.2322	1.66073e4	1112.35486	49.6510
2	8.166	BB	0.2670	1.68408e4	977.25244	50.3490



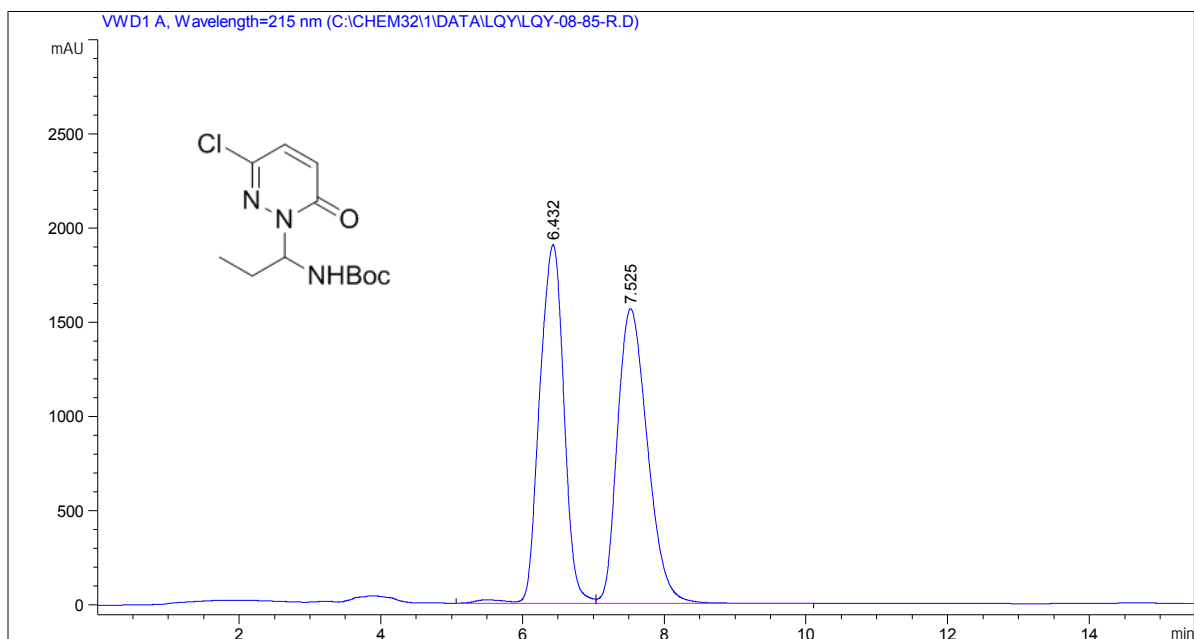
#	[min]	[min]	[mAU*s]	[mAU]	%	
1	6.859	BV R	0.1930	1.27776e4	1026.81482	94.8457
2	8.208	VB	0.2457	694.38489	43.62417	5.1543



#	[min]	[min]	[mAU*s]	[mAU]	%	
1	8.763	VR	0.3982	4.08560e4	1592.40771	49.2159
2	9.846	VB	0.5173	4.21579e4	1247.26355	50.7841

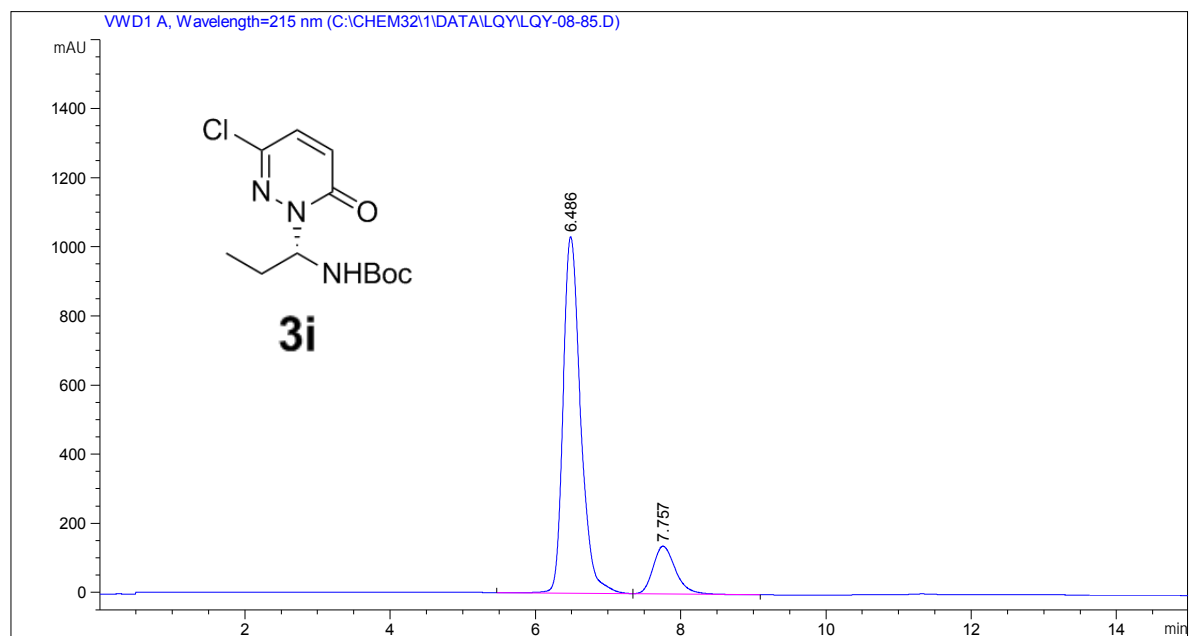


#	[min]	[min]	[mAU*s]	[mAU]	%	
1	8.891	BV	0.3809	1.59569e4	648.88745	62.2837
2	10.108	VB	0.5151	9662.78125	287.51392	37.7163



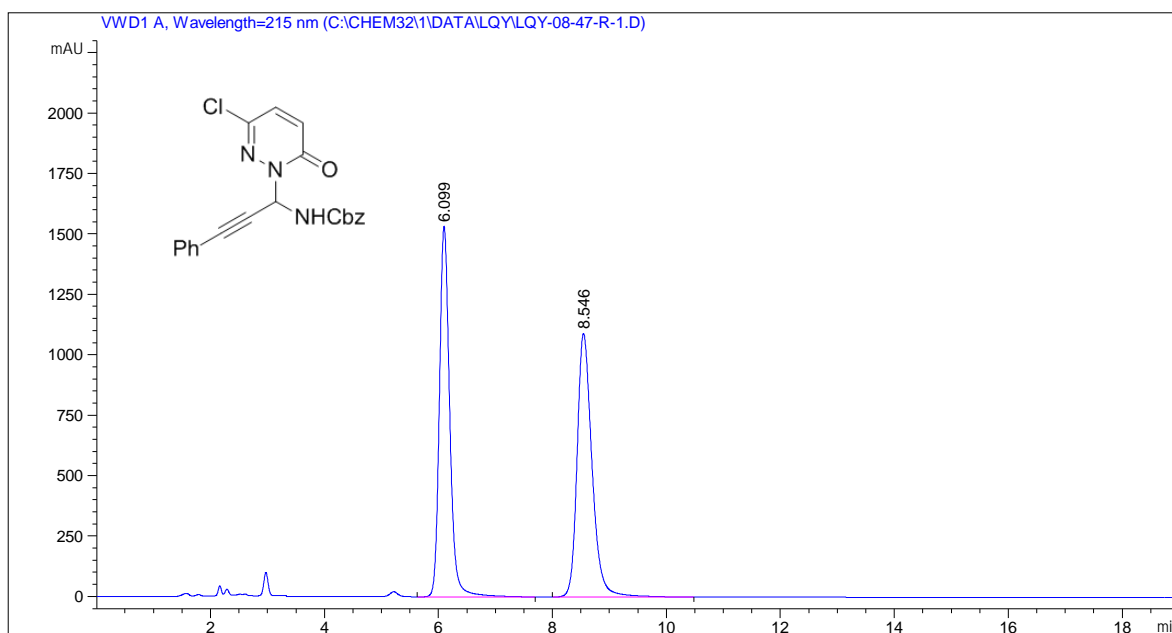
DYU FYhH] aY HndY K] Xh\ . . . 5f YU <Y] [\h 5f YU

#	[mi n]	[mi n]	[mAU*s]	[mAU]	%	
1	6.432	VV R	0.3888	4.53167e4	1901.92883	49.6298
2	7.525	VB	0.4674	4.59928e4	1562.36353	50.3702

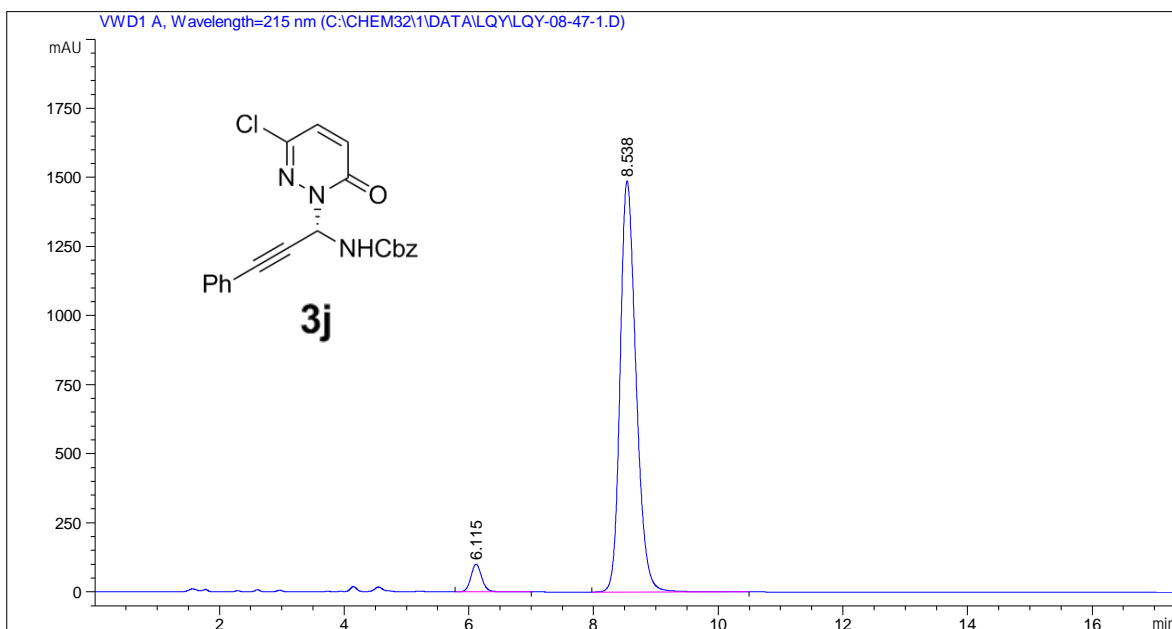


DYU FYhH] aY HndY K] Xh\ . . . 5f YU <Y] [\h 5f YU

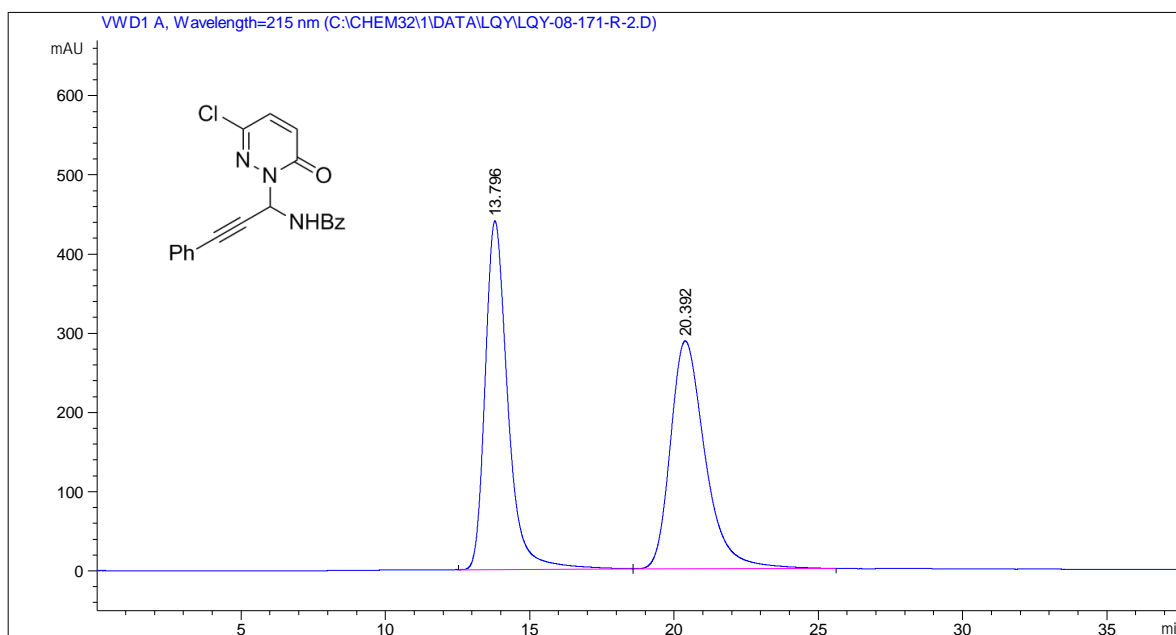
#	[mi n]	[mi n]	[mAU*s]	[mAU]	%	
1	6.486	VV R	0.2543	1.72738e4	1031.92419	85.2559
2	7.757	VB	0.3314	2987.31543	138.64326	14.7441



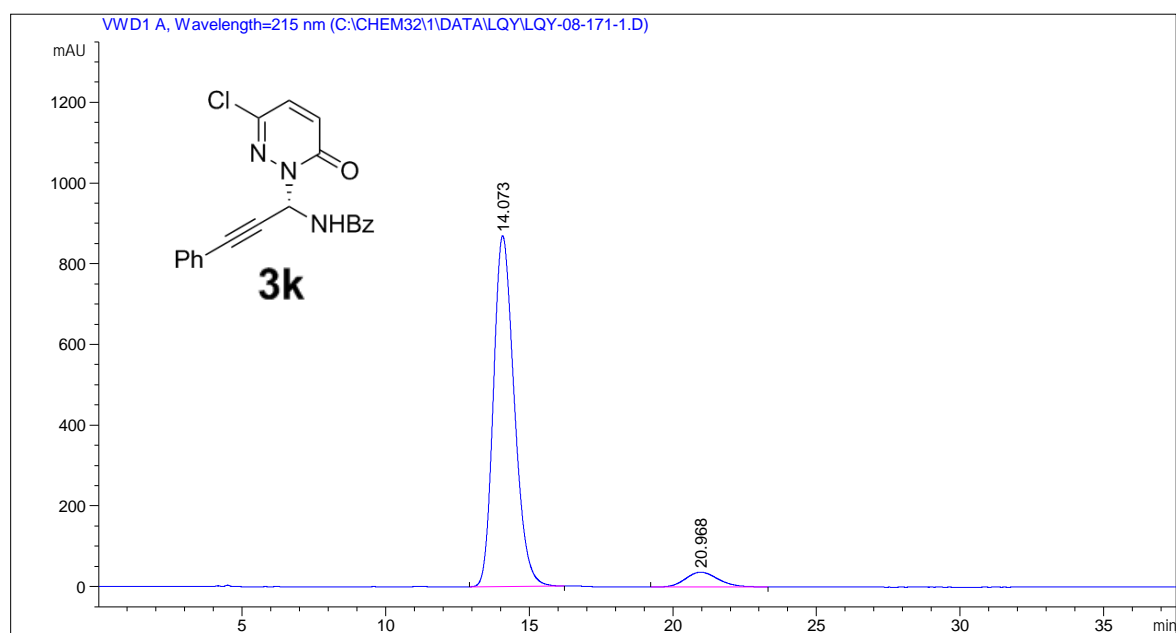
#	[min]	[min]	[mAU*s]	[mAU]	%	
1	6.099	BB	0.1927	1.92867e4	1533.41492	49.3974
2	8.546	BB	0.2765	1.97573e4	1089.68945	50.6026



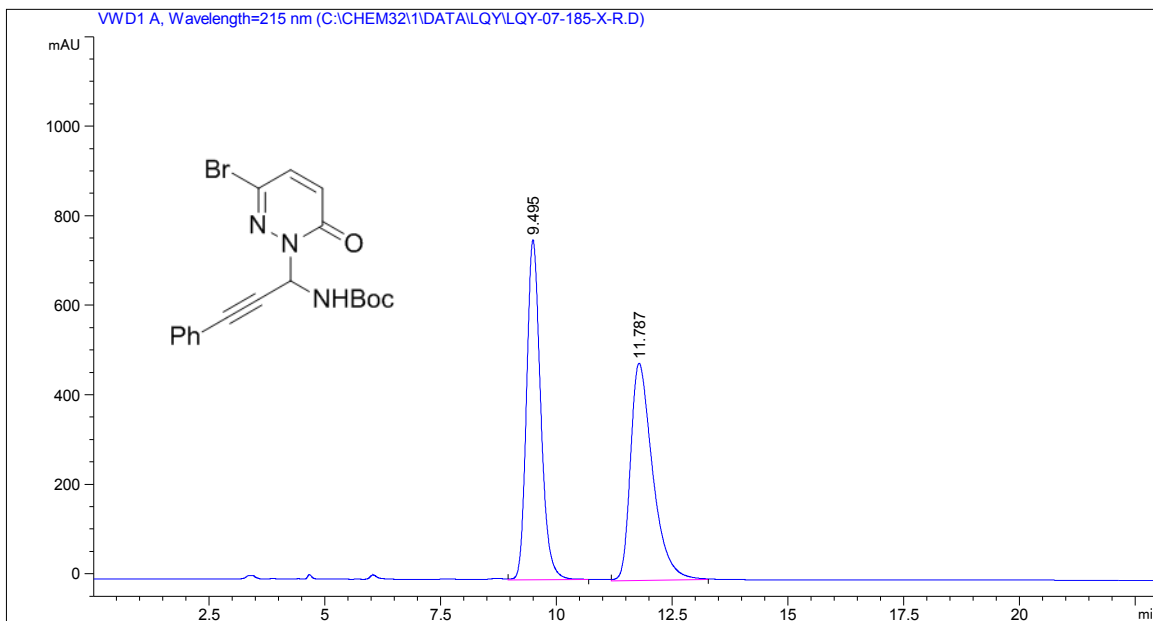
#	[min]	[min]	[mAU*s]	[mAU]	%	
1	6.115	BB	0.1861	1214.56812	100.40508	4.3998
2	8.538	BB	0.2720	2.63904e4	1487.71179	95.6002



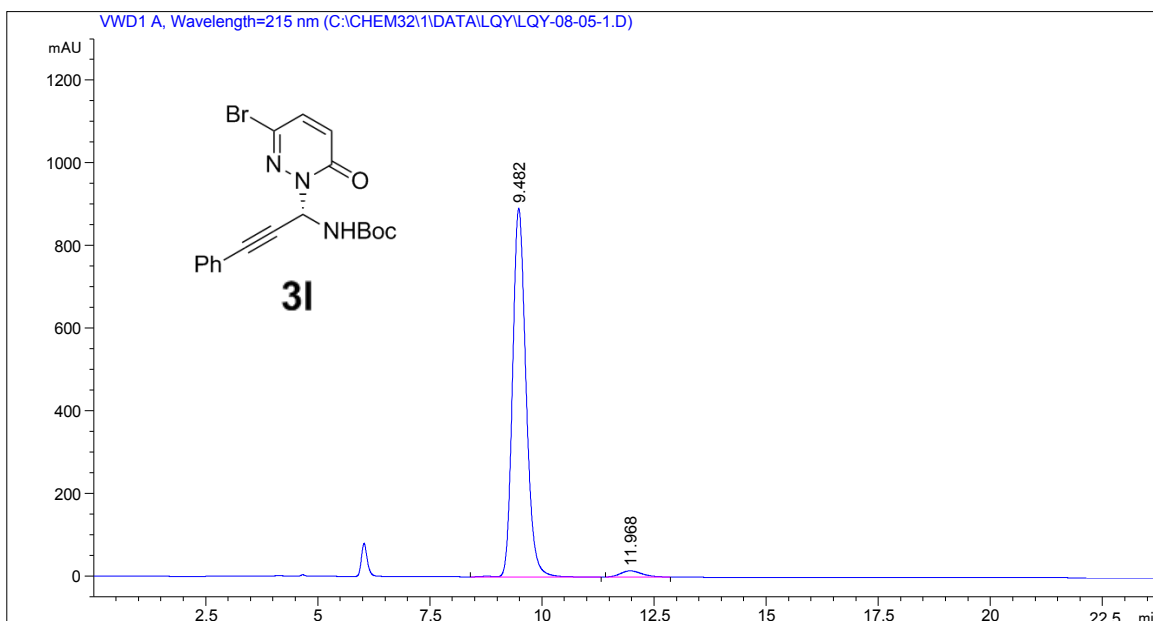
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	13.796	BB	0.8311	2.40085e4	440.35574	49.9961
2	20.392	BB	1.2674	2.40122e4	287.49829	50.0039



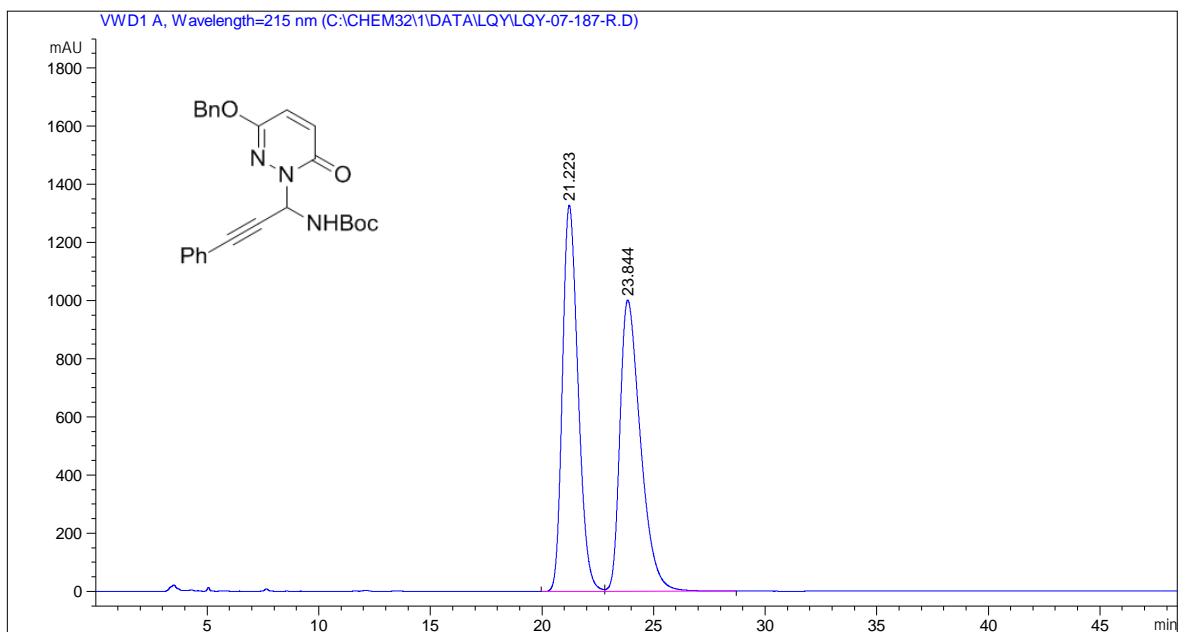
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	14.073	BB	0.7816	4.37153e4	869.48621	93.7963
2	20.968	BB	1.1839	2891.34961	36.74792	6.2037



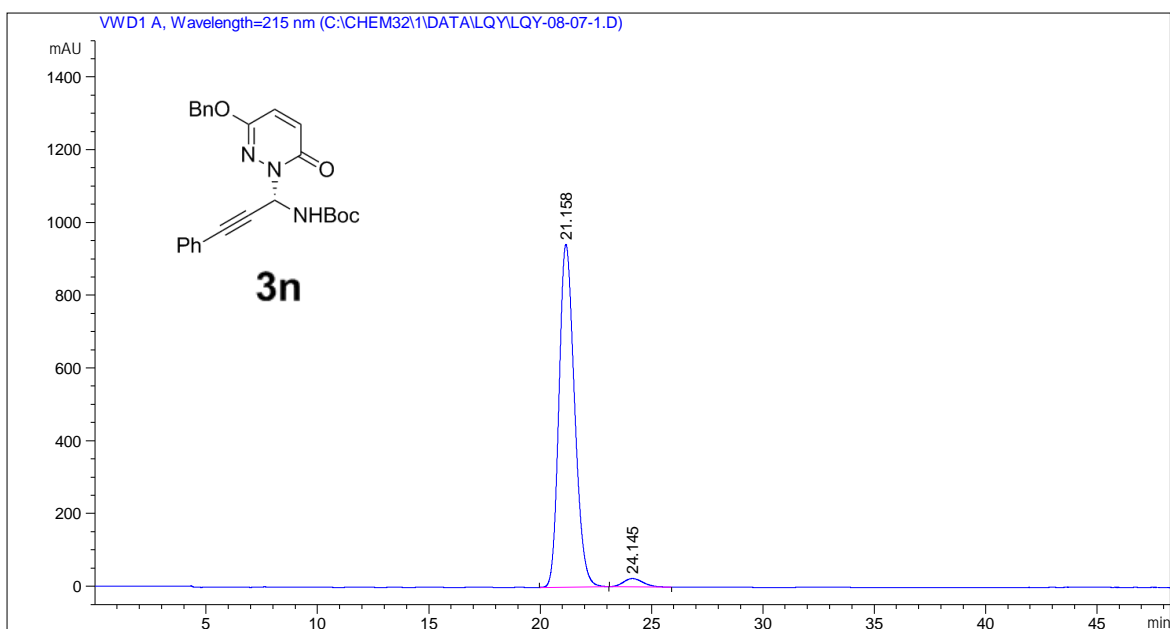
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	9.495	MM	0.3519	1.60500e4	760.16357	49.8748
2	11.787	MM	0.5537	1.61305e4	485.56241	50.1252



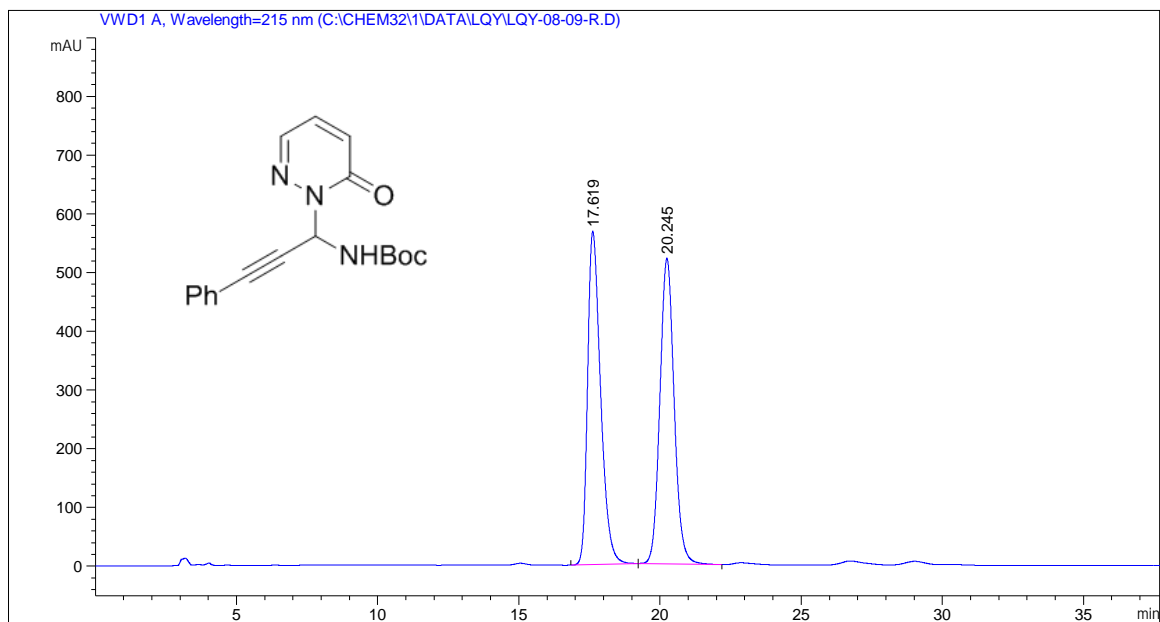
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	9.482	VB R	0.3206	1.85629e4	892.58099	97.1696
2	11.968	MM	0.5823	540.70605	15.47744	2.8304



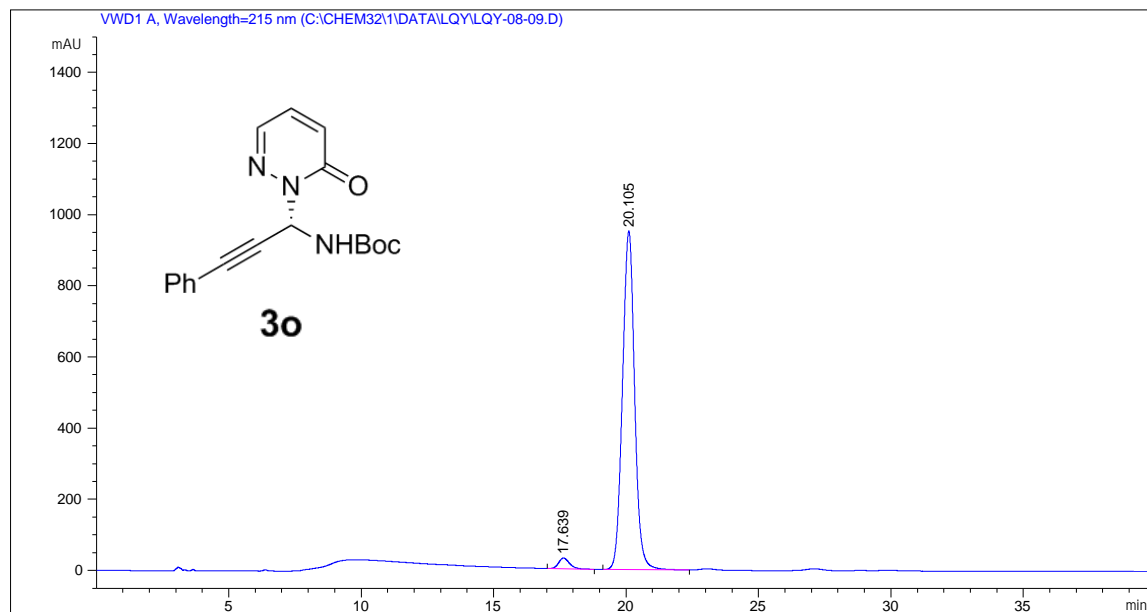
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	21.223	BV	0.7520	6.44654e4	1328.69922	50.1330
2	23.844	VB	0.9757	6.41235e4	1001.86029	49.8670



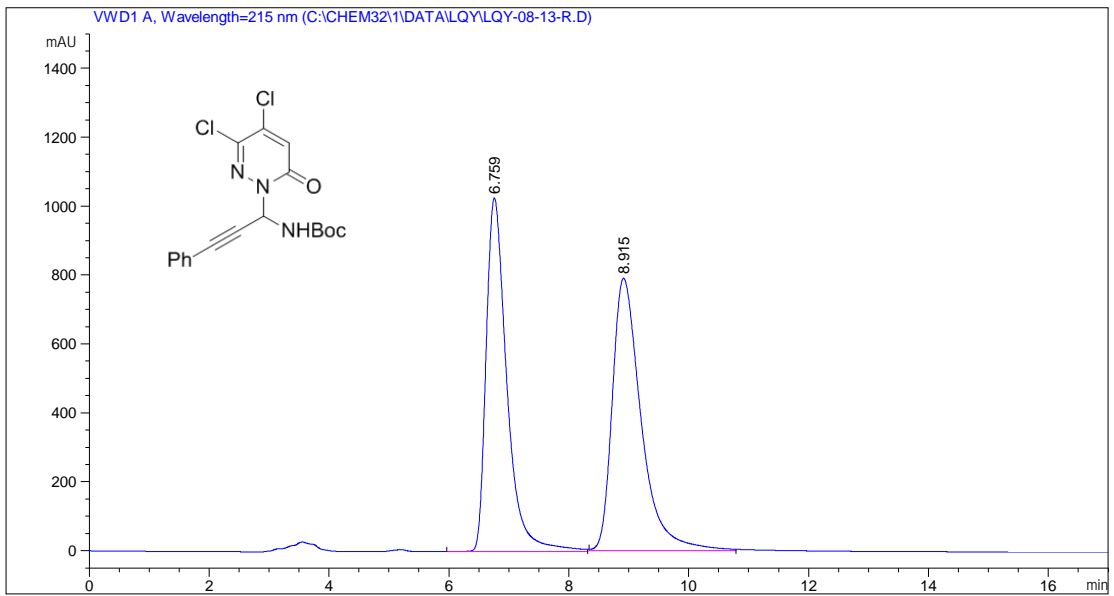
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	21.158	BB	0.7504	4.56736e4	942.41882	97.0787
2	24.145	BB	0.9230	1374.42297	22.71358	2.9213



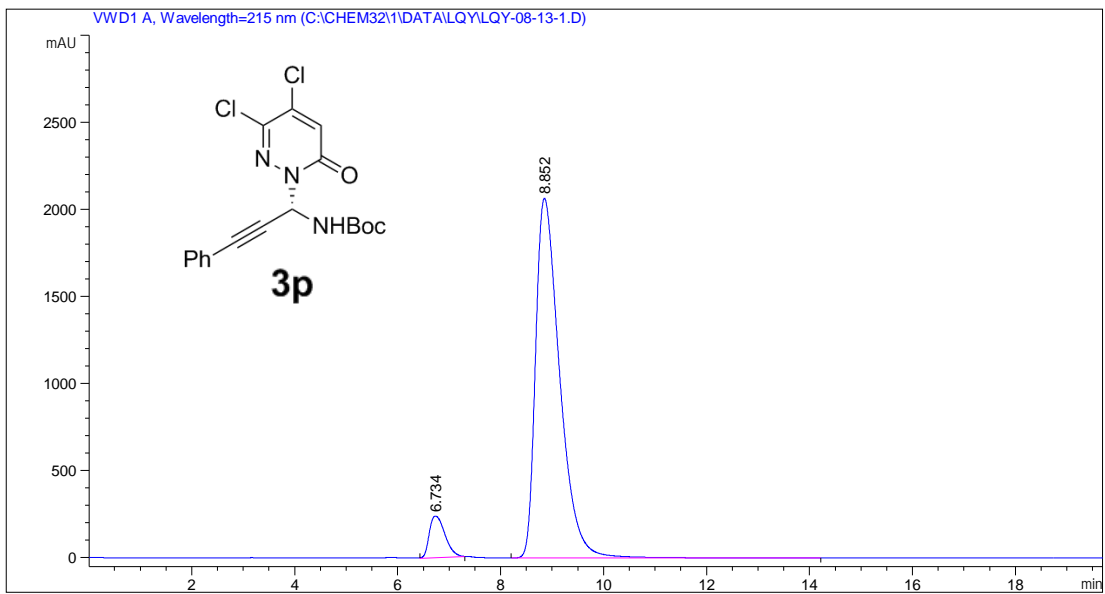
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	17.619	BB	0.4874	1.81186e4	567.64630	49.8163
2	20.245	BB	0.5433	1.82523e4	520.20465	50.1837



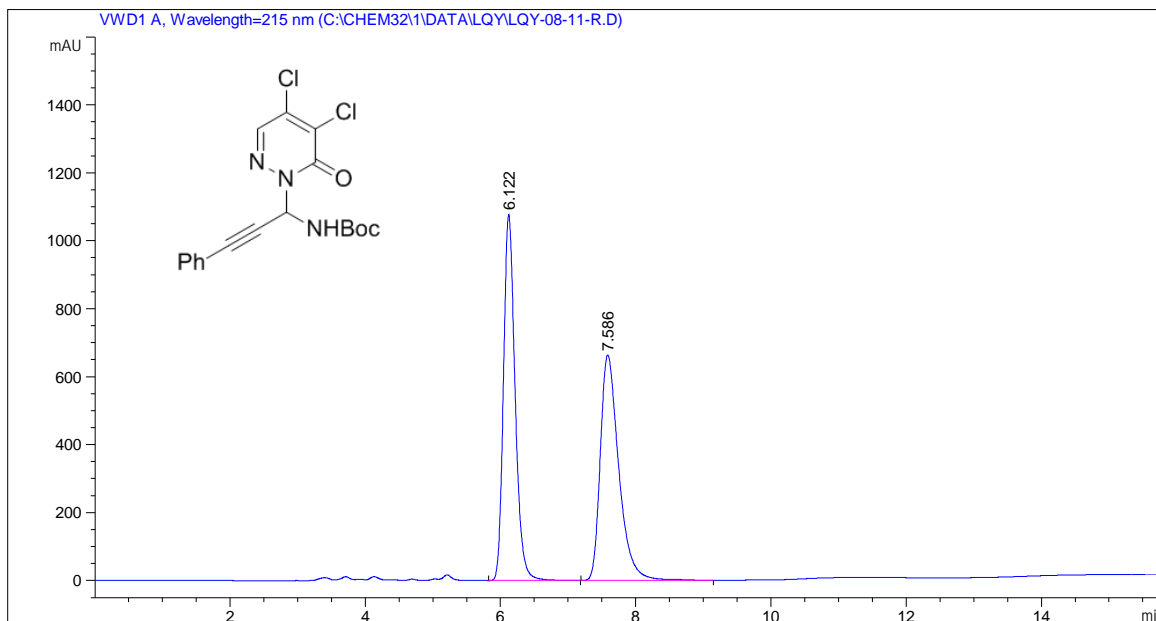
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	17.639	BB	0.4345	861.66656	30.23155	2.7676
2	20.105	BB	0.4942	3.02721e4	951.46997	97.2324



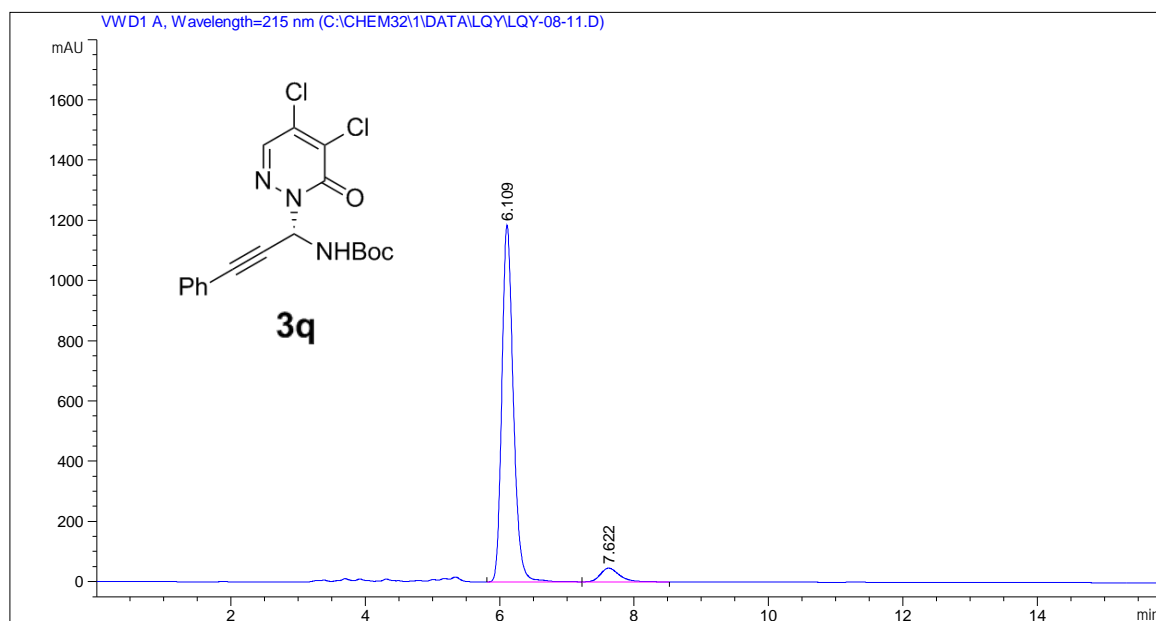
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	6.759	BV	0.3671	2.46307e4	1025.82715	48.2583
2	8.915	MM	0.5570	2.64085e4	790.22650	51.7417



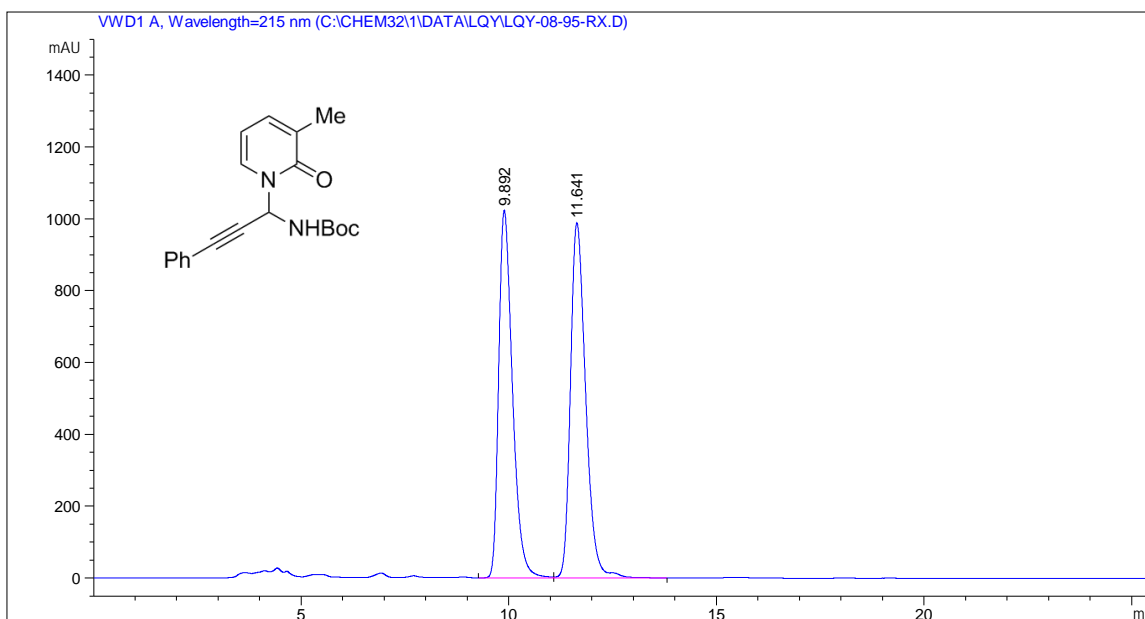
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	6.734	MM	0.3537	5093.09863	239.99750	7.0609
2	8.852	BB	0.4958	6.70378e4	2064.76172	92.9391



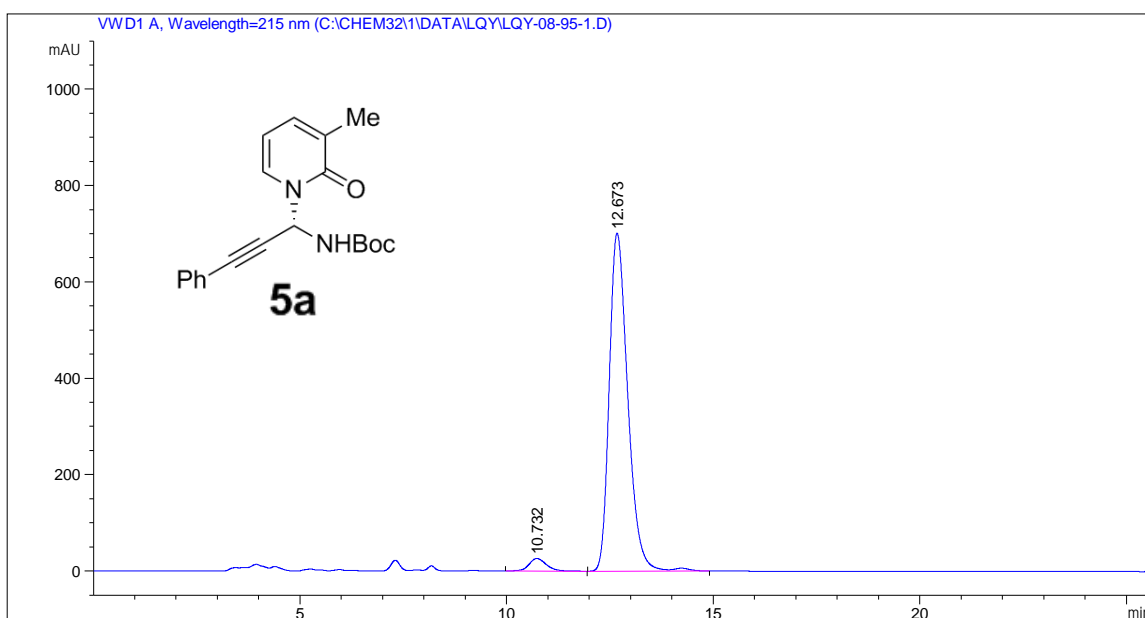
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	6.122	BB	0.1823	1.28656e4	1077.32642	50.5592
2	7.586	BV R	0.2883	1.25810e4	663.24408	49.4408



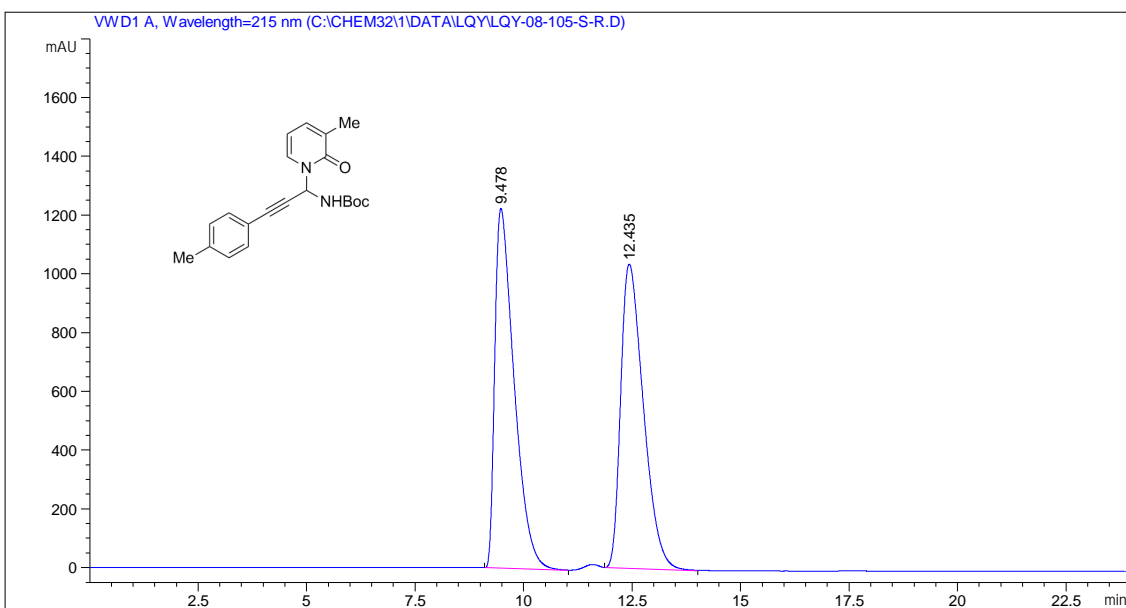
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	6.109	BV	0.1820	1.40047e4	1184.01758	93.9780
2	7.622	VB	0.3002	897.40613	45.47625	6.0220



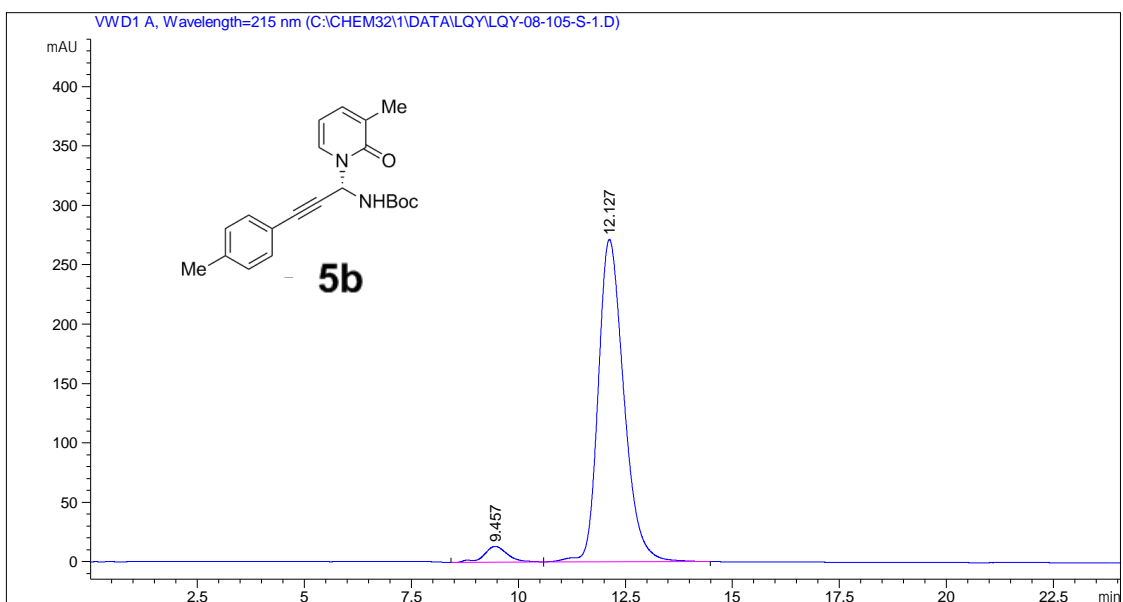
#	[min]	[min]	[mAU*s]	[mAU]	%	
1	9.892	BV	0.3536	2.35565e4	1023.03162	48.3775
2	11.641	VV R	0.3889	2.51366e4	988.15271	51.6225



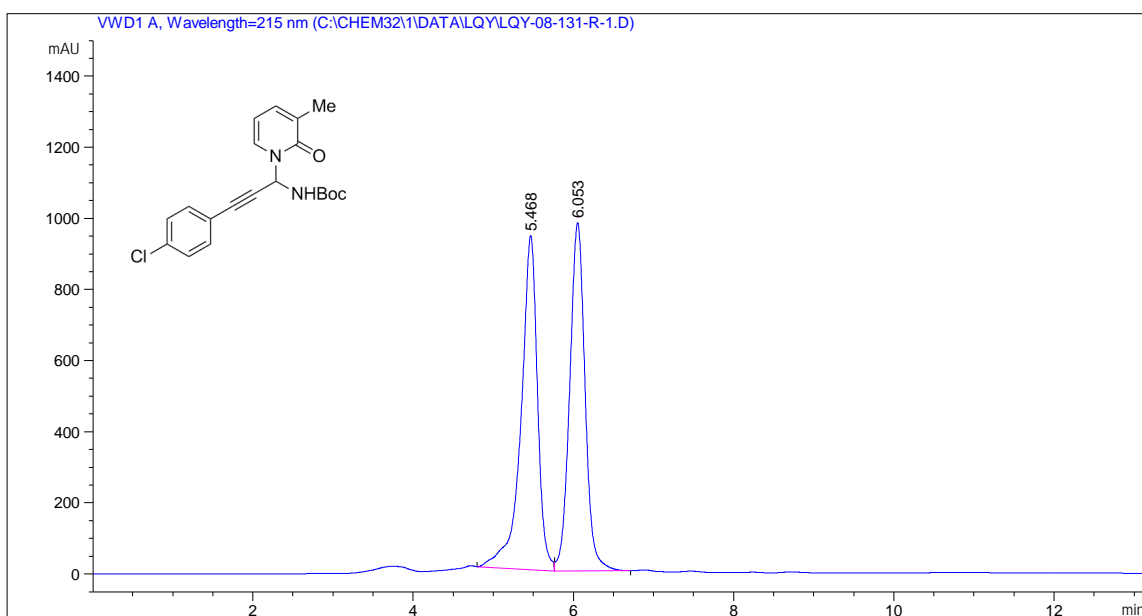
#	[min]	[min]	[mAU*s]	[mAU]	%	
1	10.732	BB	0.4510	780.96393	26.33418	3.4528
2	12.673	BV R	0.4752	2.18376e4	701.65155	96.5472



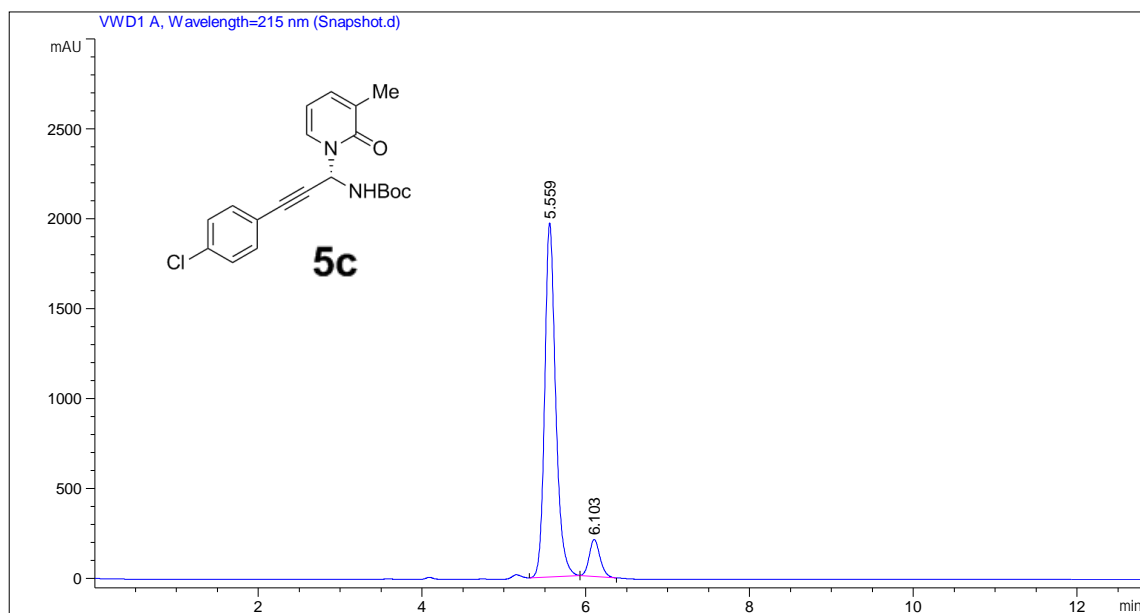
#	[min]	[min]	[mAU*s]	[mAU]	%	
1	9.478	BB	0.4710	3.77713e4	1223.91370	50.0738
2	12.435	MM	0.6061	3.76599e4	1035.52917	49.9262



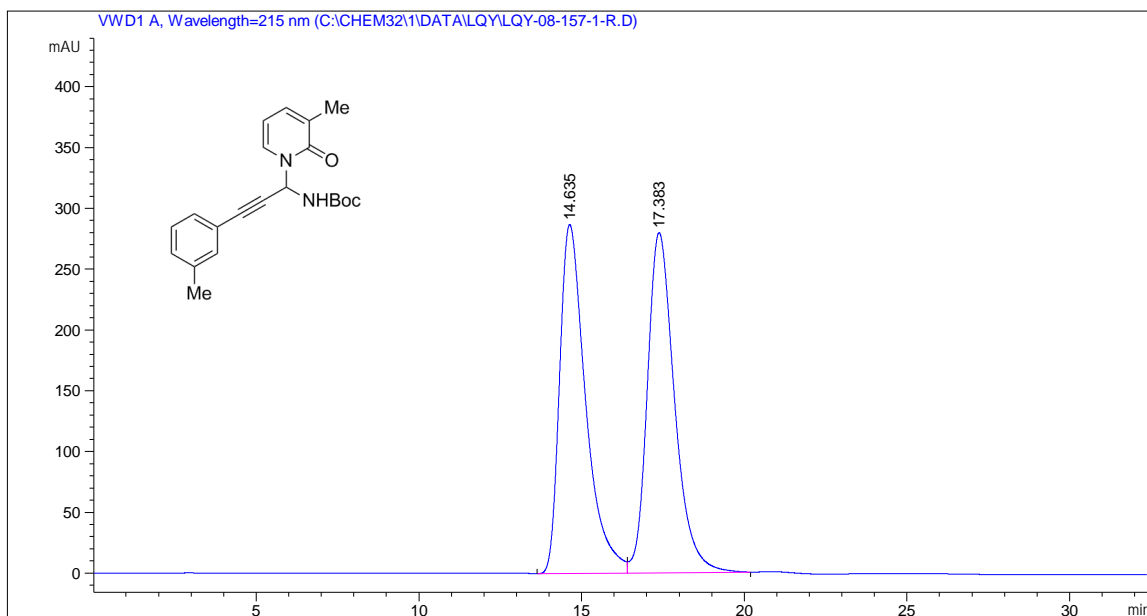
#	[min]	[min]	[mAU*s]	[mAU]	%	
1	9.457	VB R	0.5679	505.45255	13.31378	4.2992
2	12.127	BB	0.6398	1.12516e4	271.30576	95.7008



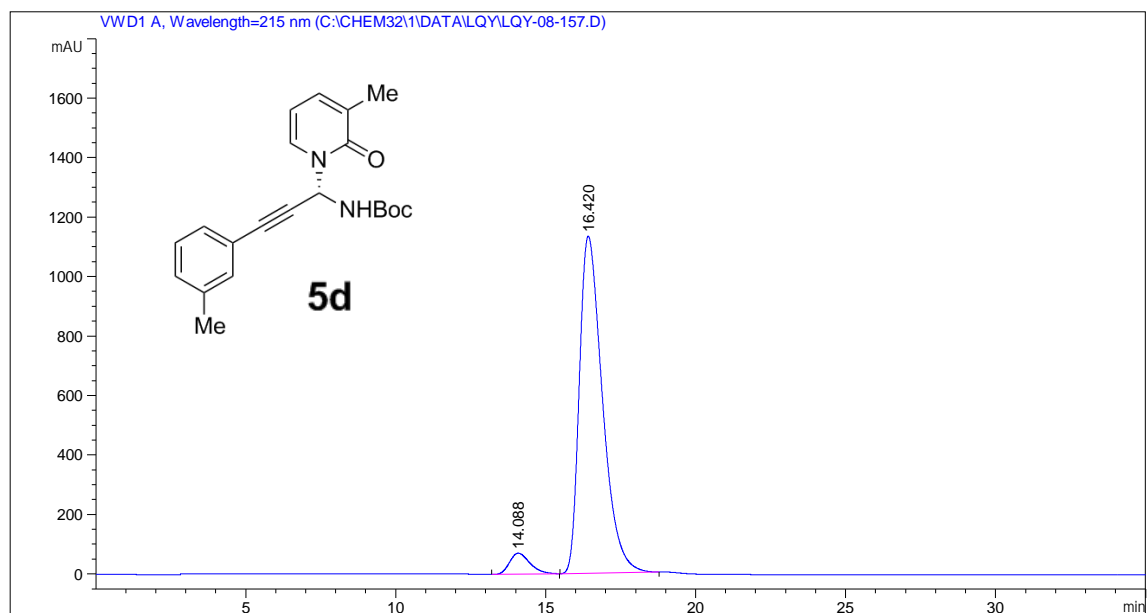
#	[min]	[min]	[mAU*s]	[mAU]	%	
1	5.468	MM	0.2397	1.35316e4	940.80920	50.8477
2	6.053	VB	0.2038	1.30805e4	979.35138	49.1523



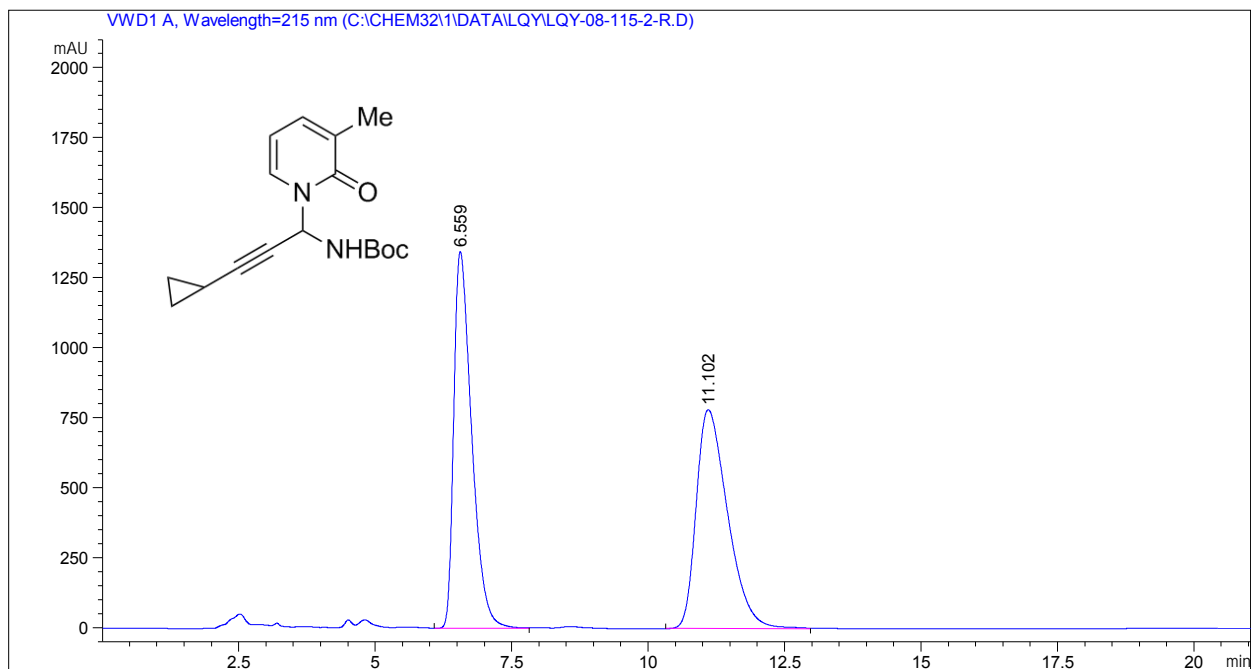
#	[min]	[min]	[mAU*s]	[mAU]	%	
1	5.559	MM	0.1549	1.82867e4	1967.73901	90.6805
2	6.103	MM	0.1521	1879.38477	205.95634	9.3195



#	[min]	[min]	[mAU*s]	[mAU]	%	
1	14.635	BV	0.8388	1.59665e4	287.09940	49.5697
2	17.383	VB	0.8883	1.62437e4	279.80981	50.4303

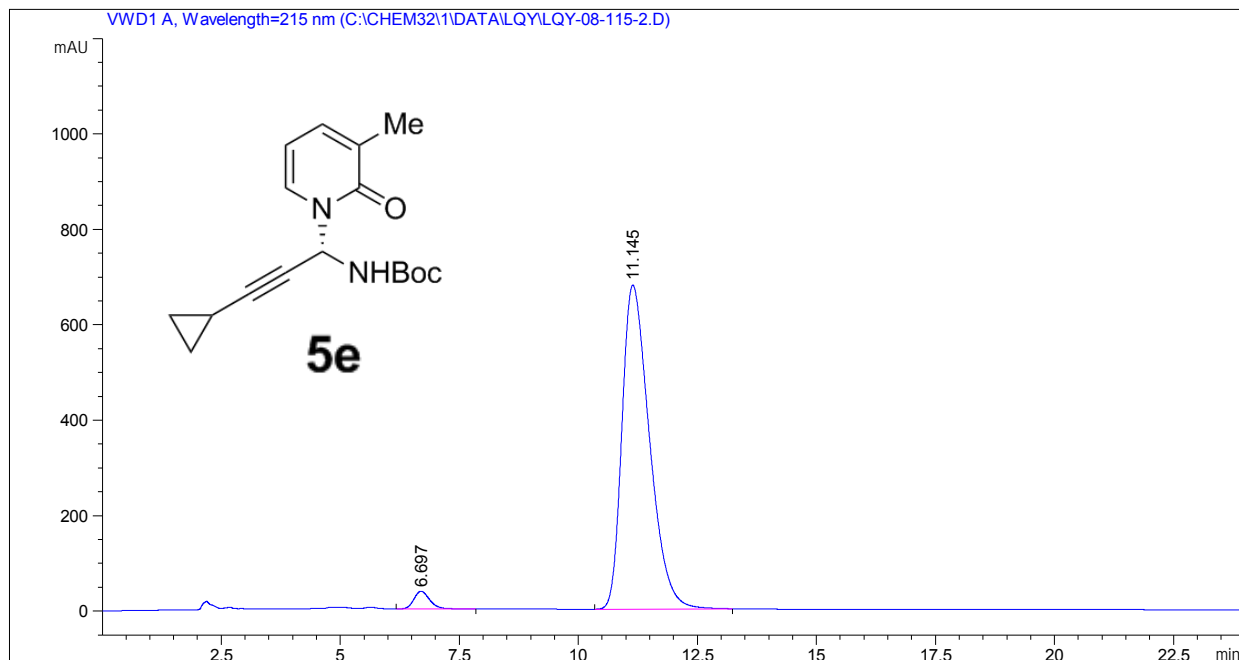


#	[min]	[min]	[mAU*s]	[mAU]	%	
1	14.088	BB	0.7265	3357.64209	70.77703	5.2640
2	16.420	BB	0.8240	6.04279e4	1133.43201	94.7360



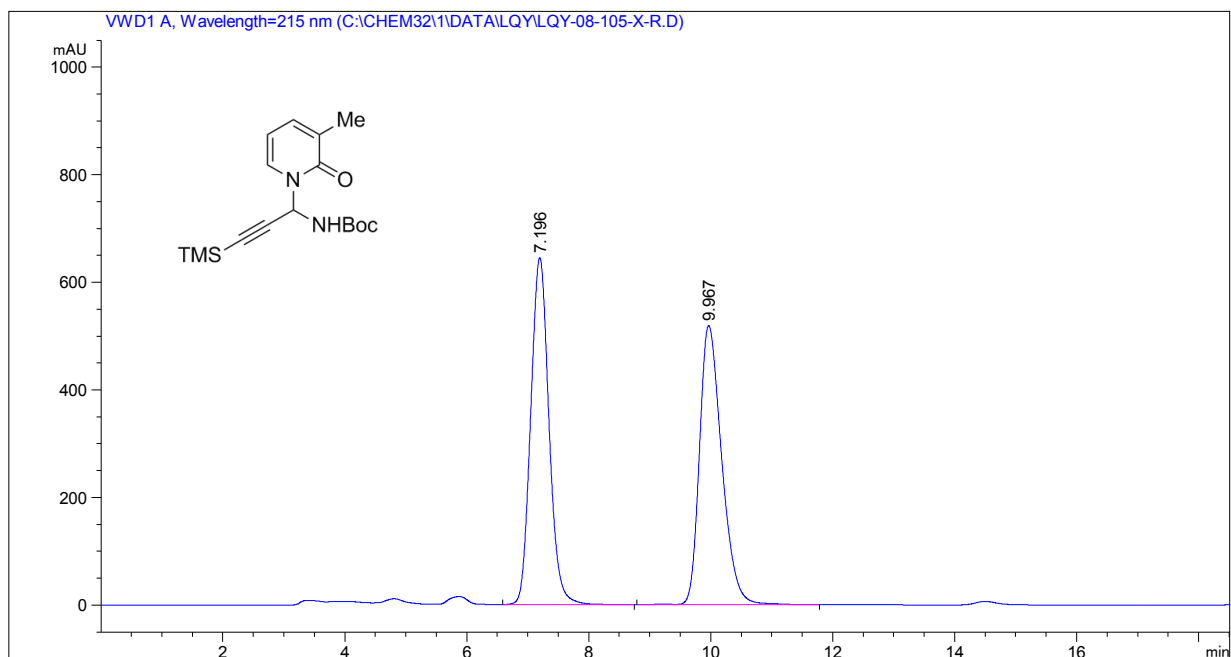
DYU_FYhH aY HndY K] Xh\ 5fYU <Y] [\h 5fYU

#	[min]	[min]	[mAU*s]	[mAU]	%
1	6.559 MM	0.3800	3.06810e4	1345.70300	49.4692
2	11.102 MM	0.6680	3.13394e4	781.96362	50.5308

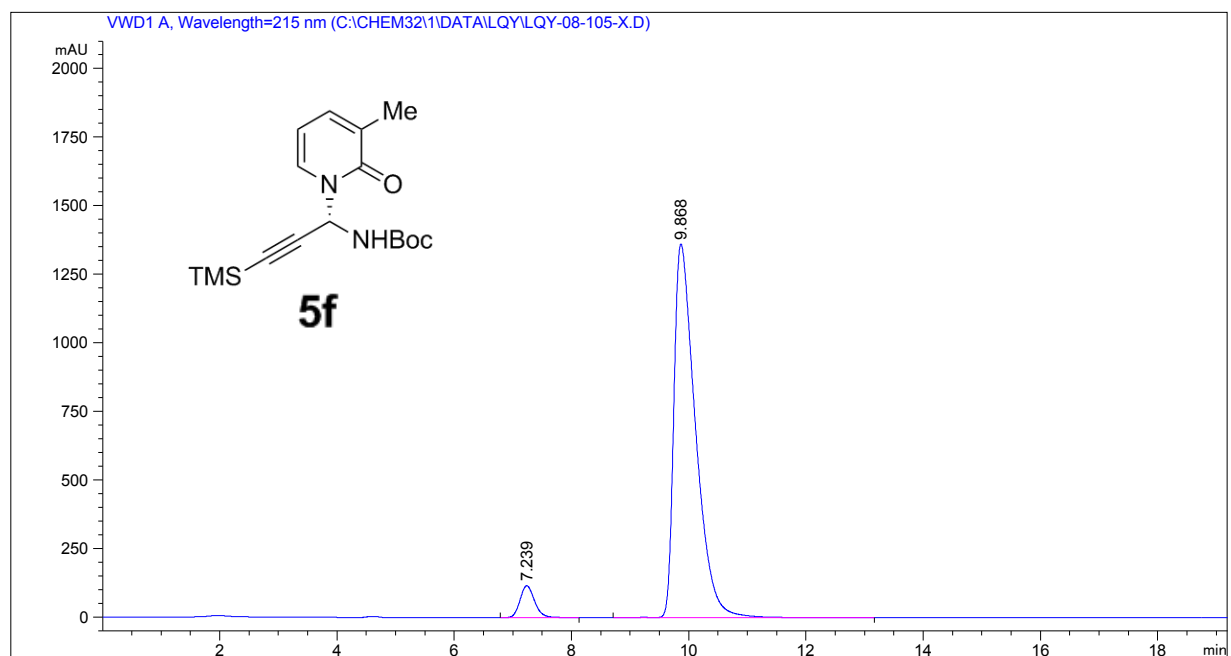


DYU_FYhH aY HndY K] Xh\ 5fYU <Y] [\h 5fYU

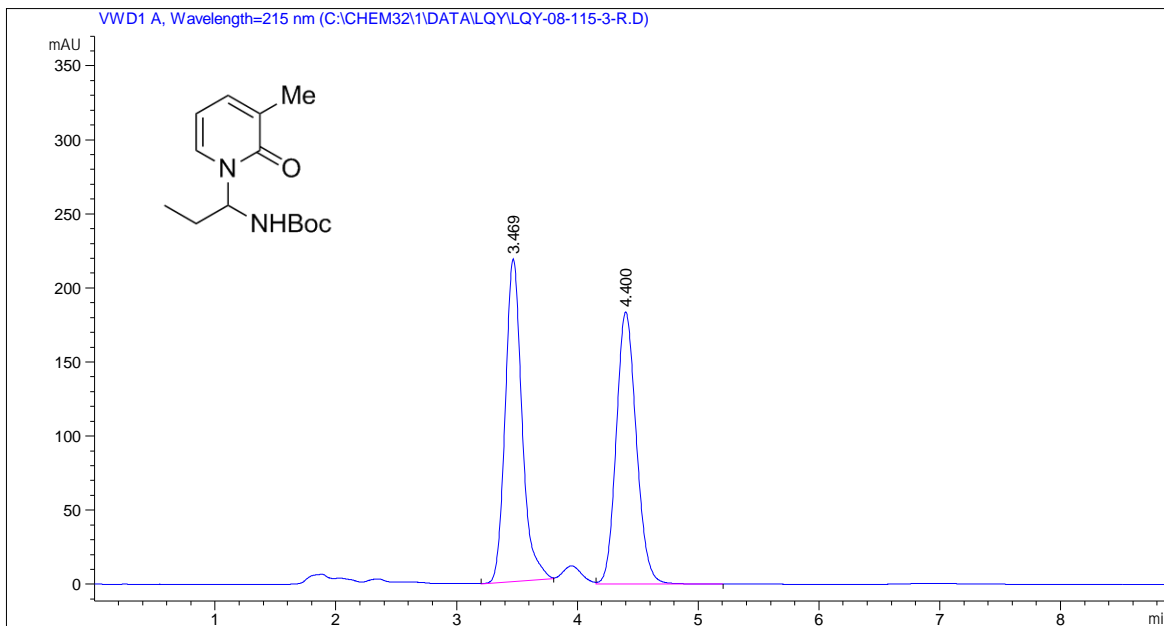
#	[min]	[min]	[mAU*s]	[mAU]	%
1	6.697 BB	0.3521	845.15936	36.91849	2.9985
2	11.145 MM	0.6703	2.73409e4	679.79895	97.0015



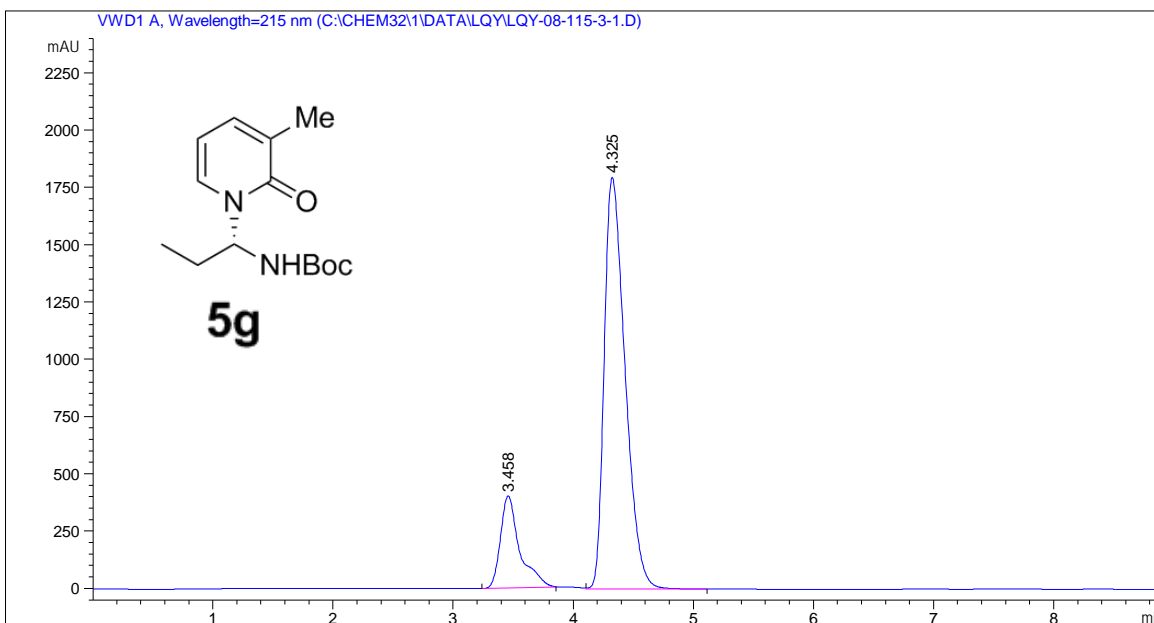
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.196	BB	0.3241	1.33883e4	645.15979	50.4298
2	9.967	VB R	0.3889	1.31600e4	518.94922	49.5702



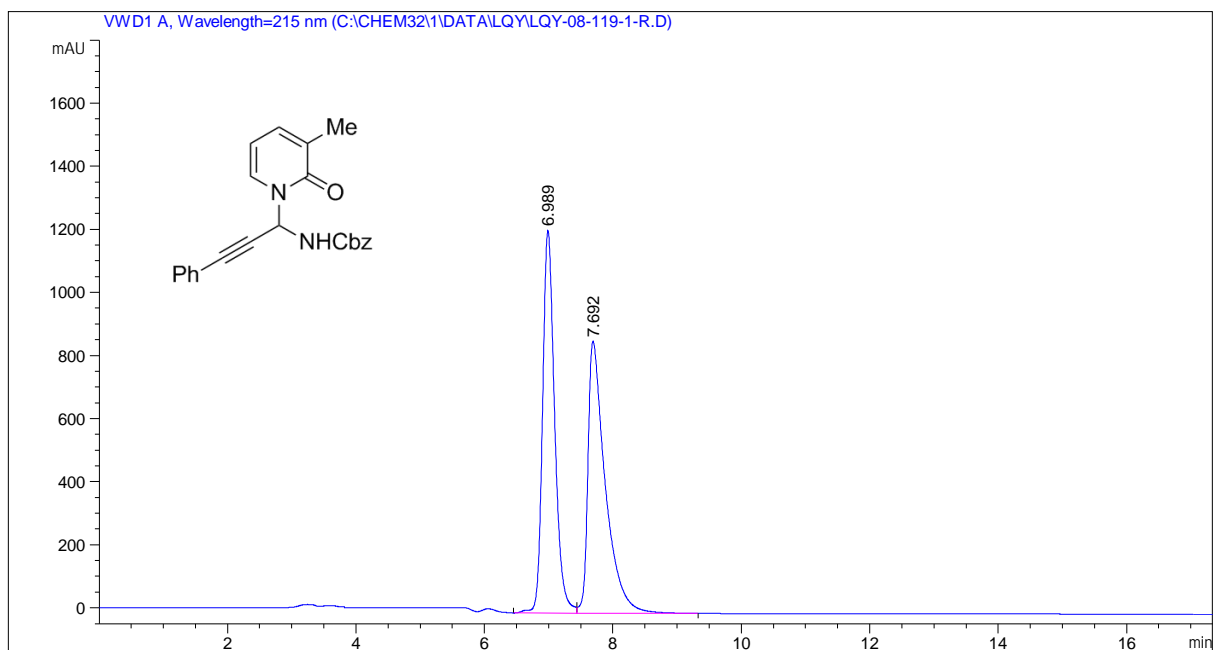
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.239	BB	0.2658	2017.70862	116.66652	5.4800
2	9.868	VB R	0.3848	3.48019e4	1363.39001	94.5200



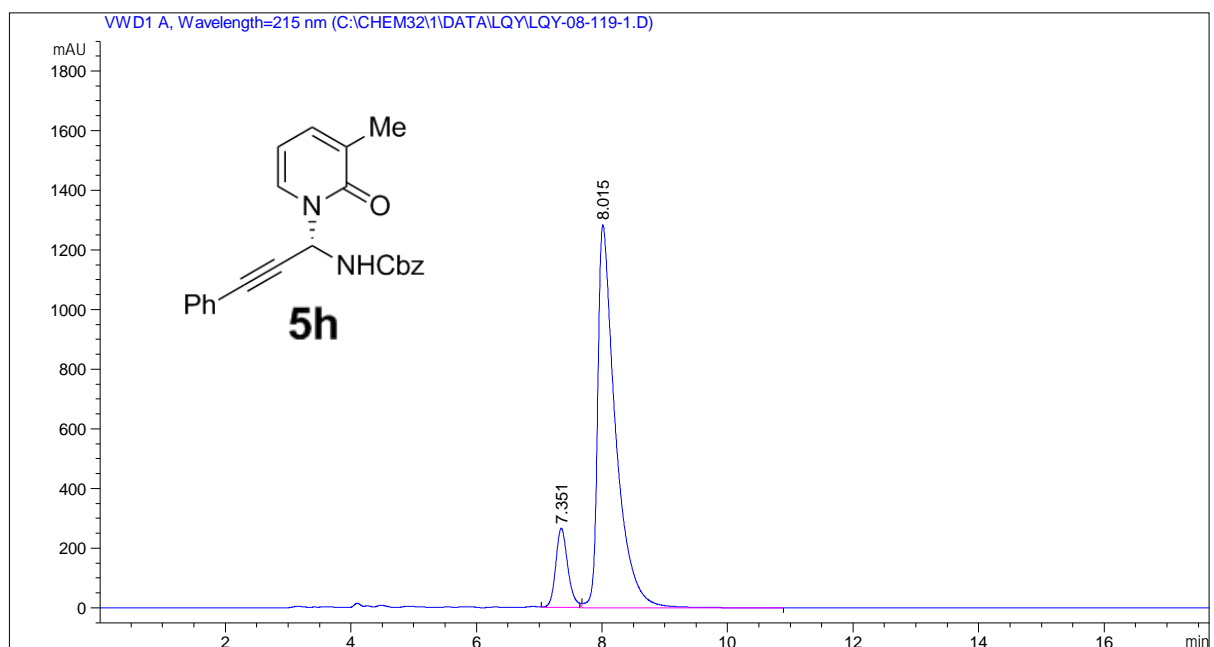
#	[min]	[min]	[mAU*s]	[mAU]	%	
1	3.469	MM	0.1609	2105.23413	218.04080	49.8684
2	4.400	VB	0.1785	2116.34814	183.53882	50.1316



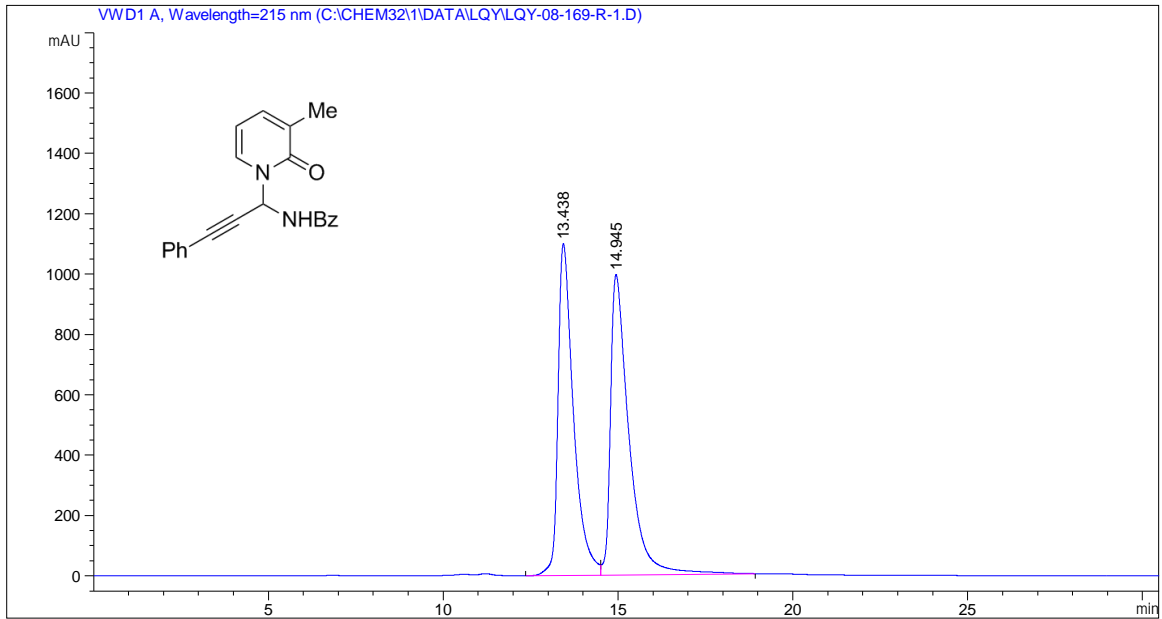
#	[min]	[min]	[mAU*s]	[mAU]	%	
1	3.458	MM	0.1845	4438.65137	400.91919	17.0290
2	4.325	VB	0.1856	2.16266e4	1794.70776	82.9710



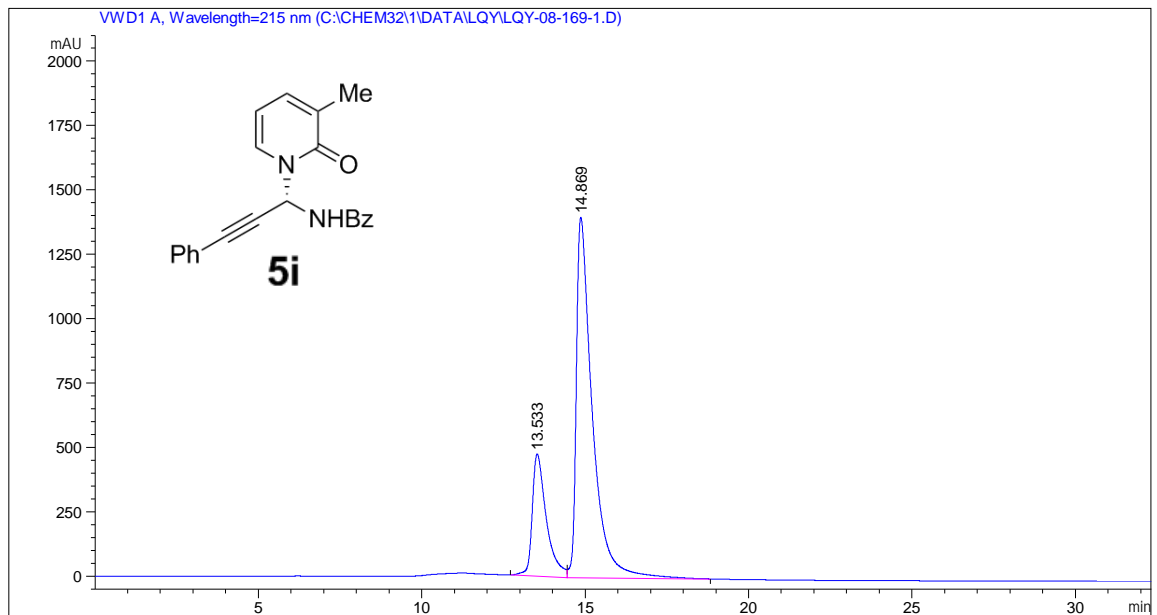
#	[min]	[min]	[mAU*s]	[mAU]	%	
1	6.989	VR	0.1989	1.58923e4	1212.43835	49.5567
2	7.692	VB	0.2708	1.61766e4	862.37329	50.4433



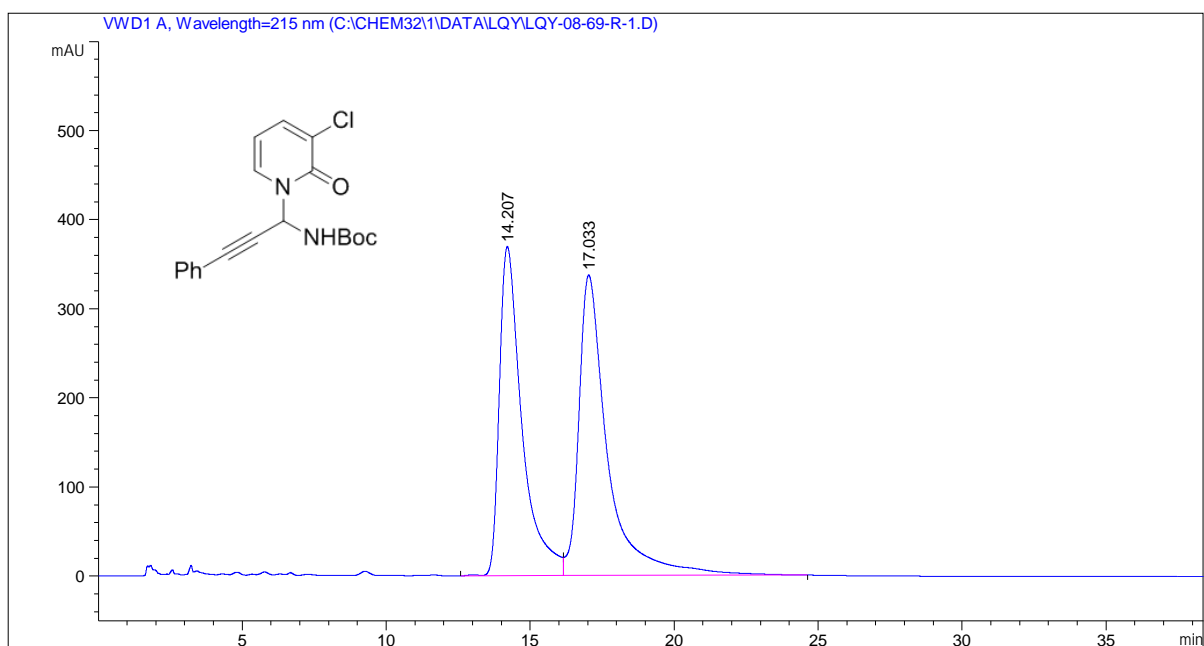
#	[min]	[min]	[mAU*s]	[mAU]	%	
1	7.351	MM	0.2226	3554.34644	266.09863	12.3308
2	8.015	VB	0.2827	2.52707e4	1283.75549	87.6692



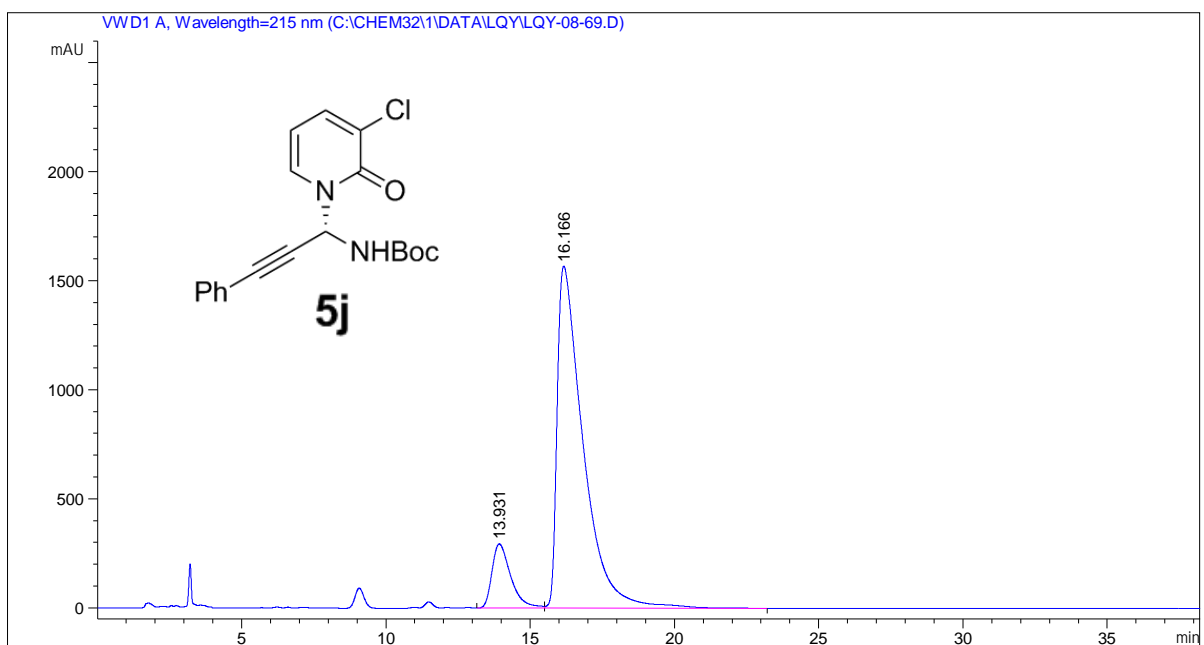
#	[min]	[min]	[mAU*s]	[mAU]	%	
1	13.438	MM	0.5133	3.38782e4	1099.95325	48.0874
2	14.945	MM	0.6125	3.65731e4	995.24701	51.9126



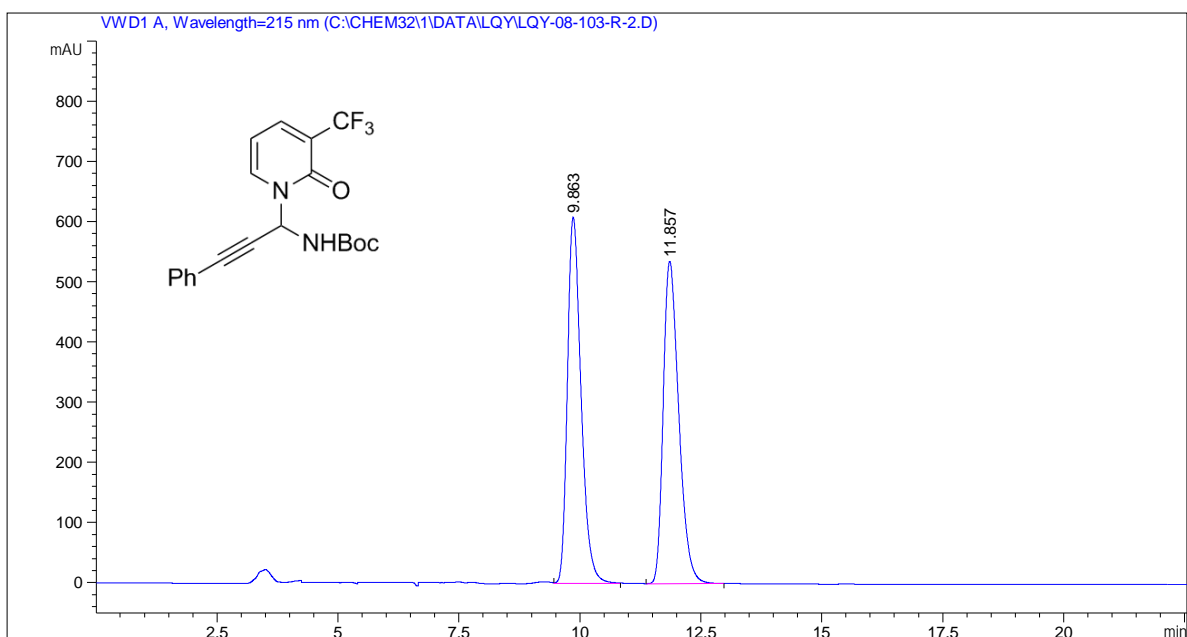
#	[min]	[min]	[mAU*s]	[mAU]	%	
1	13.533	MM	0.5022	1.43179e4	475.13943	23.0375
2	14.869	MM	0.5692	4.78327e4	1400.56360	76.9625



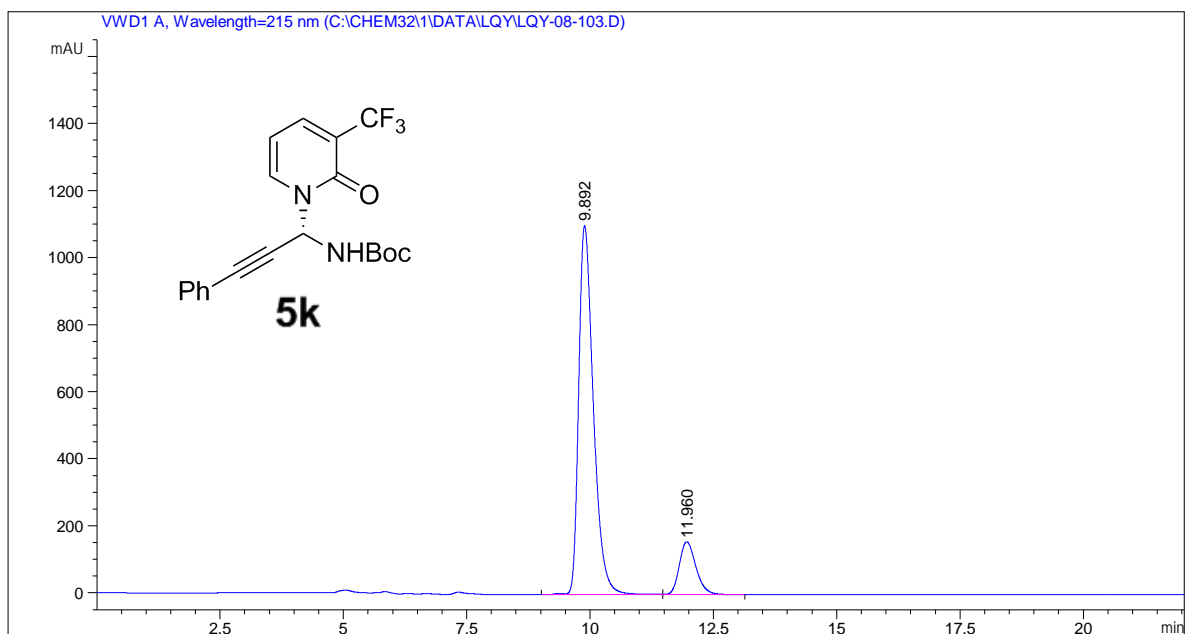
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	14.207	VV R	0.7978	2.02276e4	369.42578	46.3217
2	17.033	VB	0.9899	2.34400e4	337.23438	53.6783



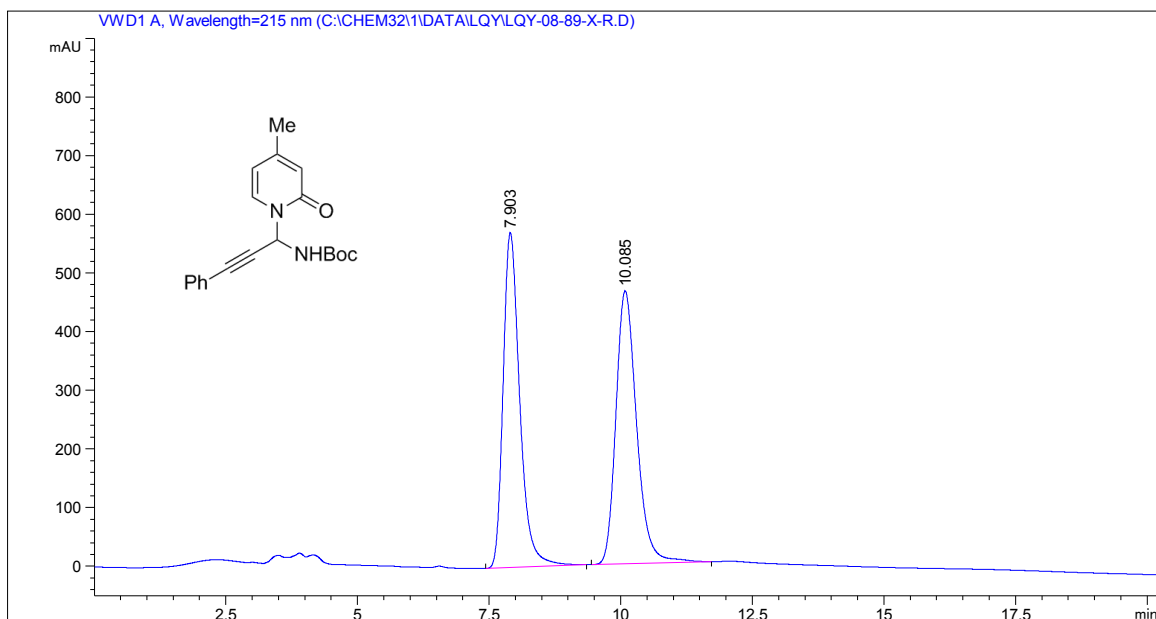
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	13.931	BV	0.6961	1.33869e4	294.64618	12.0267
2	16.166	VB	0.9071	9.79231e4	1569.15857	87.9733



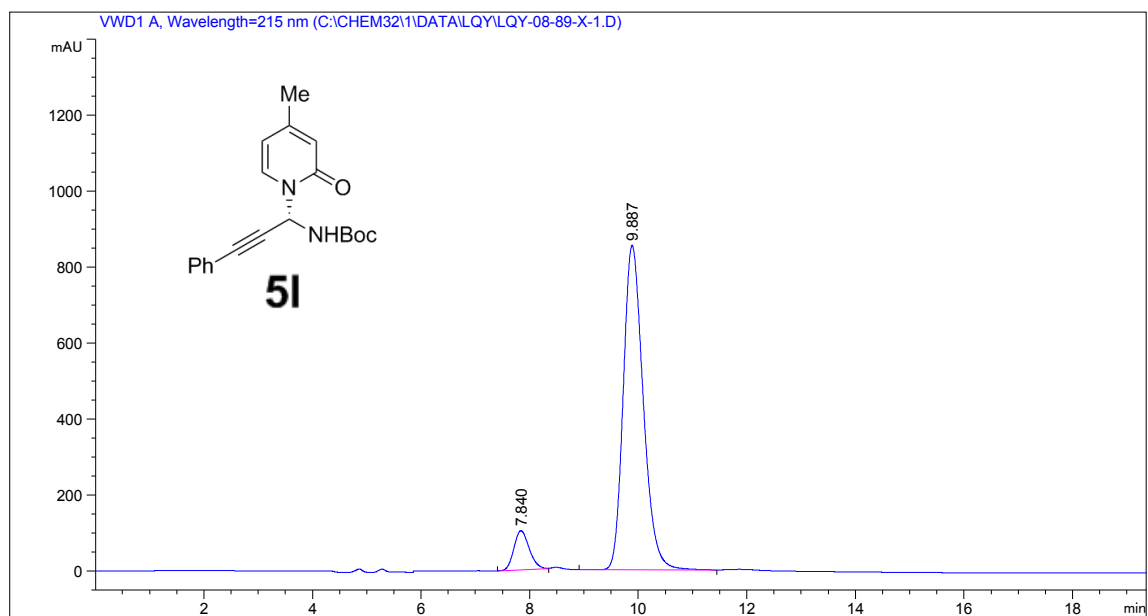
#	[min]	[min]	[mAU*s]	[mAU]	%
1	9.863 MM	0.3271	1.19437e4	608.49042	49.9623
2	11.857 BB	0.3446	1.19617e4	535.50598	50.0377



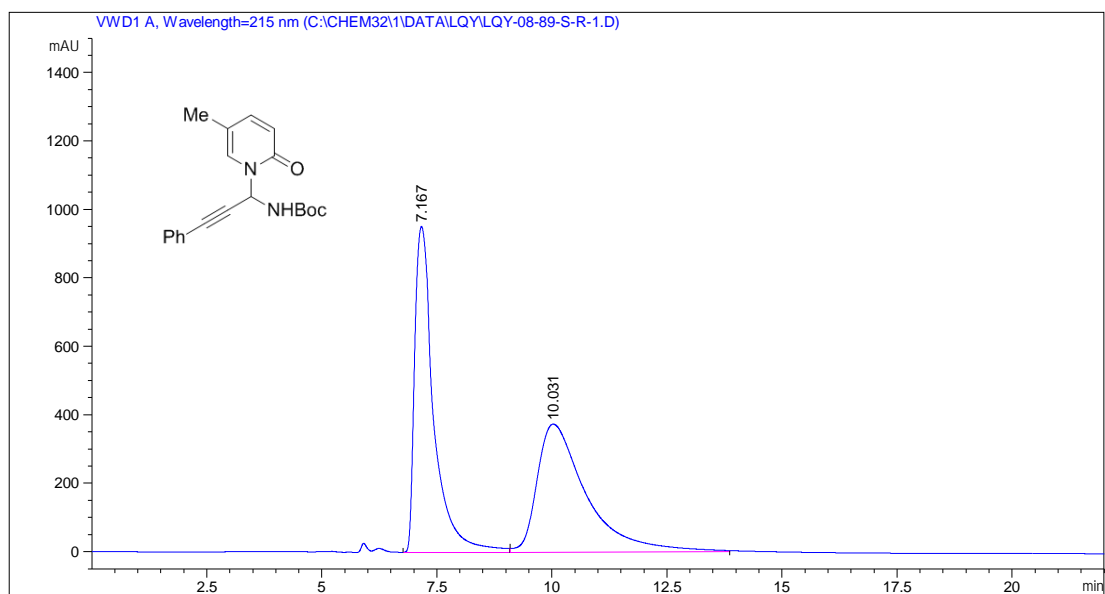
#	[min]	[min]	[mAU*s]	[mAU]	%
1	9.892 VV R	0.3170	2.27945e4	1100.88086	86.0349
2	11.960 VB	0.3606	3699.98804	157.78110	13.9651



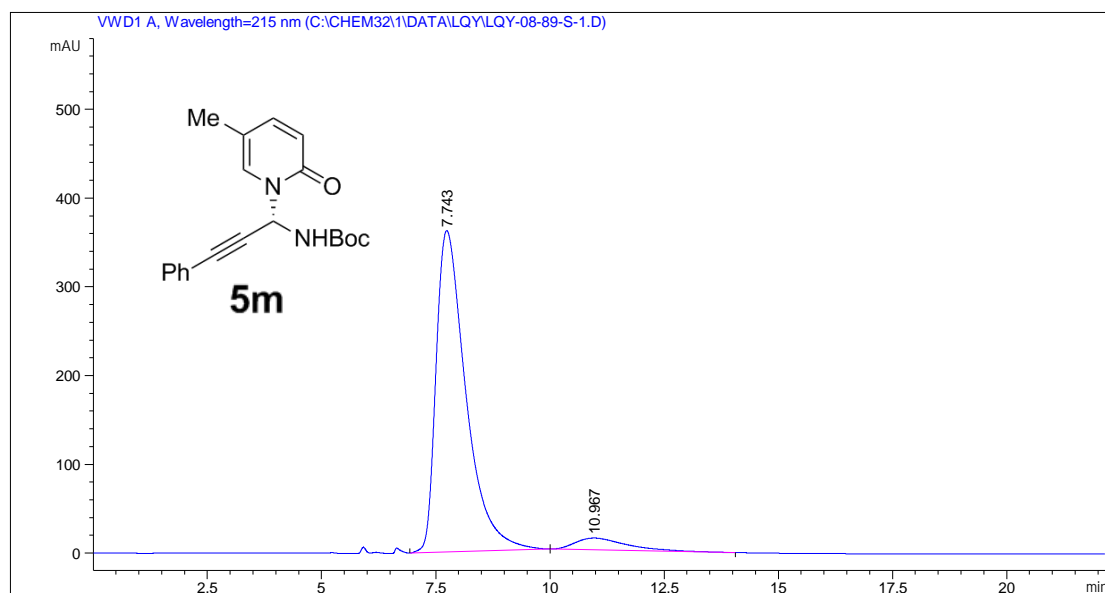
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.903	BB	0.3352	1.25375e4	570.89581	49.6493
2	10.085	BB	0.4199	1.27146e4	465.19318	50.3507



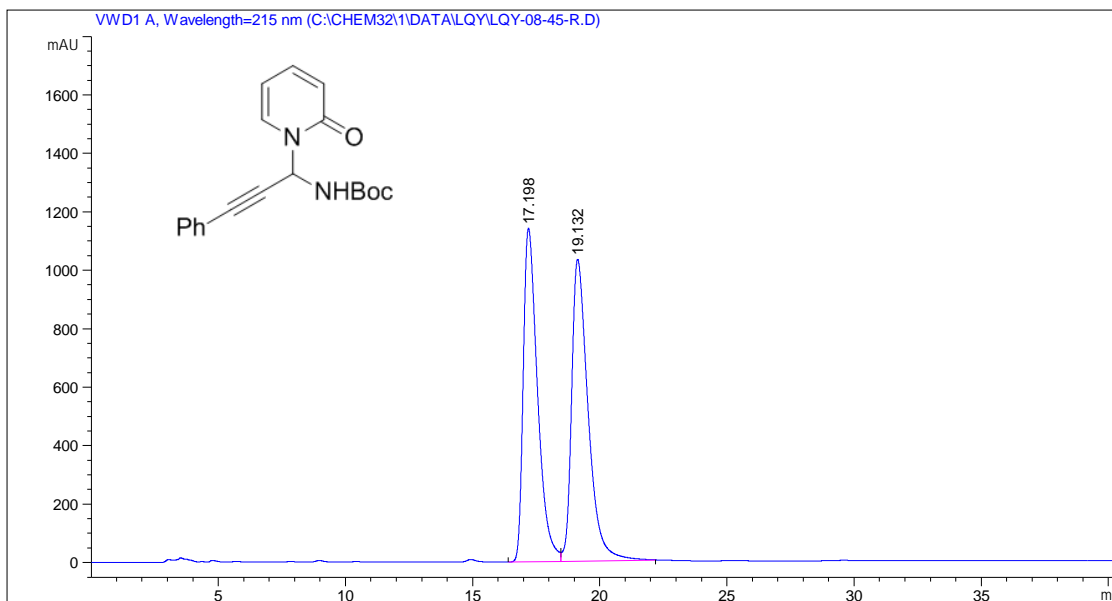
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.840	MM	0.3291	2046.23303	103.63663	8.5911
2	9.887	VB R	0.3935	2.17718e4	853.83411	91.4089



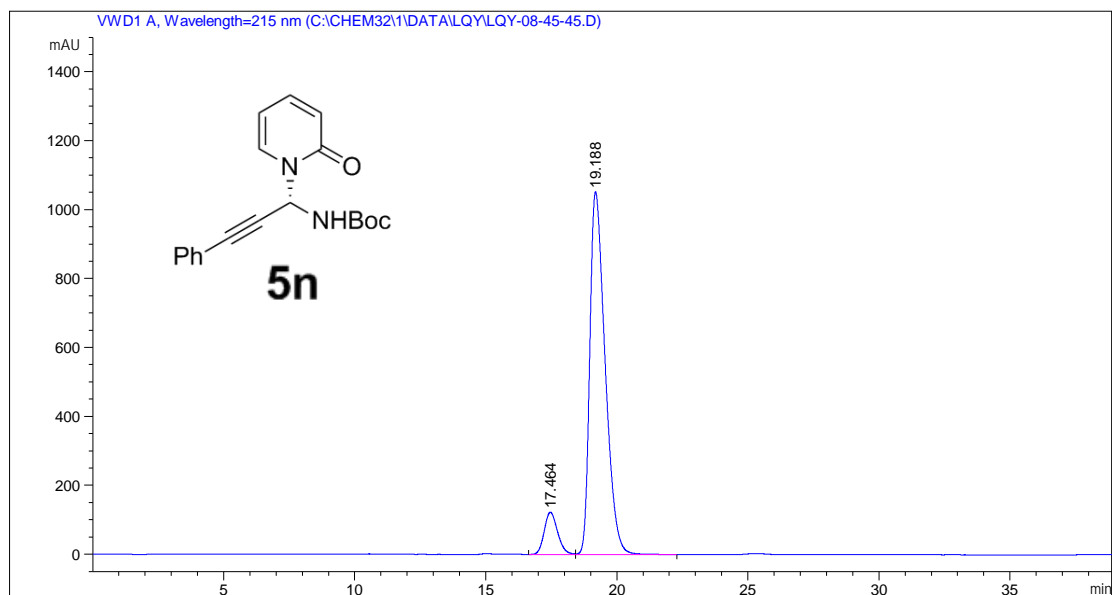
#	[min]	[min]	[mAU*s]	[mAU]	%	
1	7.167	BV	0.4341	2.75061e4	952.08728	49.7177
2	10.031	MM	1.2391	2.78185e4	374.17365	50.2823



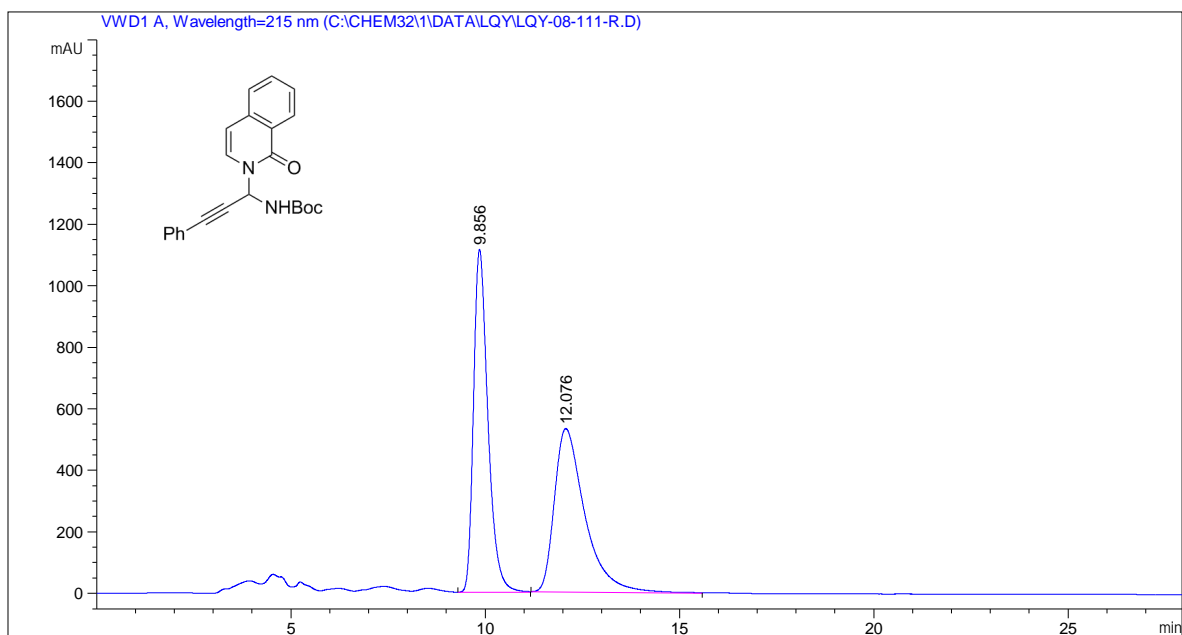
#	[min]	[min]	[mAU*s]	[mAU]	%	
1	7.743	BB	0.6900	1.64497e4	362.12421	93.9783
2	10.967	BB	1.1497	1054.02502	13.34138	6.0217



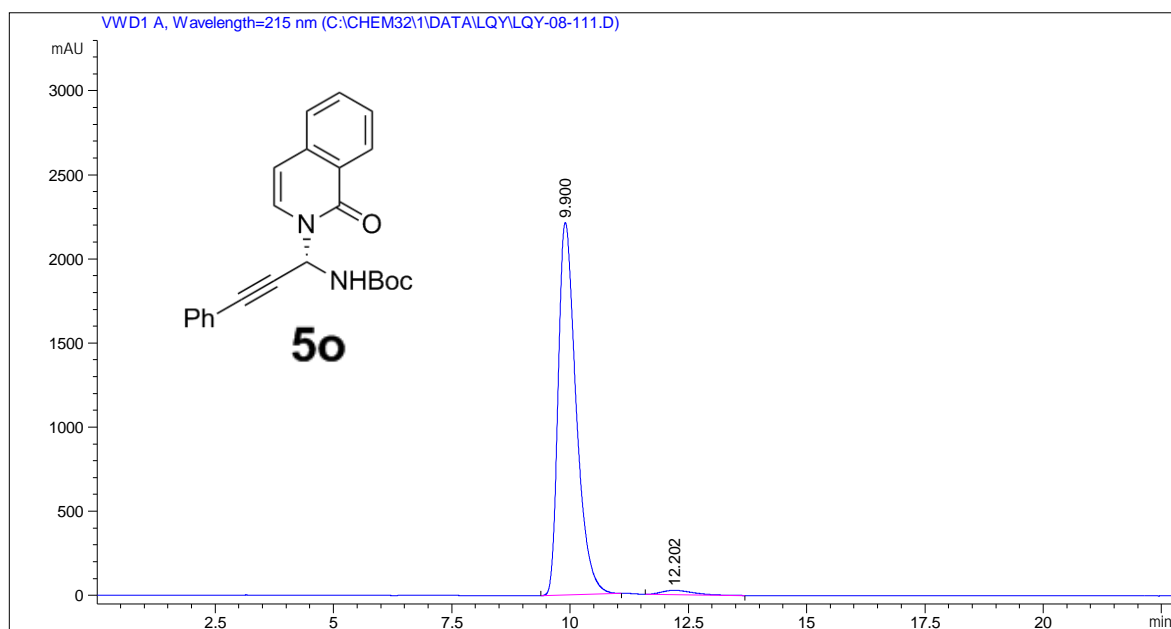
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	17.198	BV	0.5926	4.46036e4	1142.12146	48.8387
2	19.132	MM	0.7535	4.67247e4	1033.51782	51.1613



Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	17.464	BV	0.5475	4334.63232	122.59177	9.2154
2	19.188	VB	0.6185	4.27024e4	1052.22437	90.7846



Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	9.856	BV	0.3930	2.87715e4	1115.11047	49.8483
2	12.076	MM	0.9080	2.89466e4	531.31116	50.1517



Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	9.900	BB	0.4011	5.83087e4	2214.91919	98.0437
2	12.202	BB	0.7001	1163.45093	25.75040	1.9563