

SUPPORTING INFORMATION

Diastereoselective Synthesis of Terminal Bromo-Substituted Propargylamines via Generation of Lithium Bromoacetylide and Addition to Chiral *N*-*tert*-Butanesulfinyl Aldimines

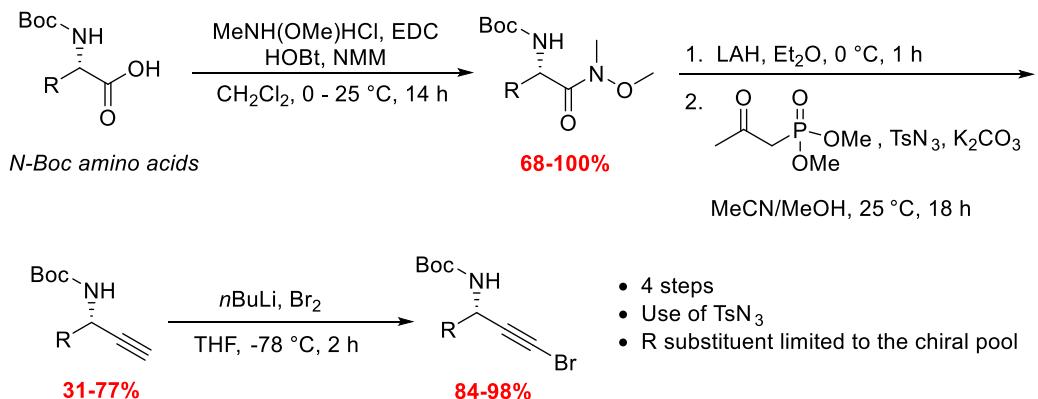
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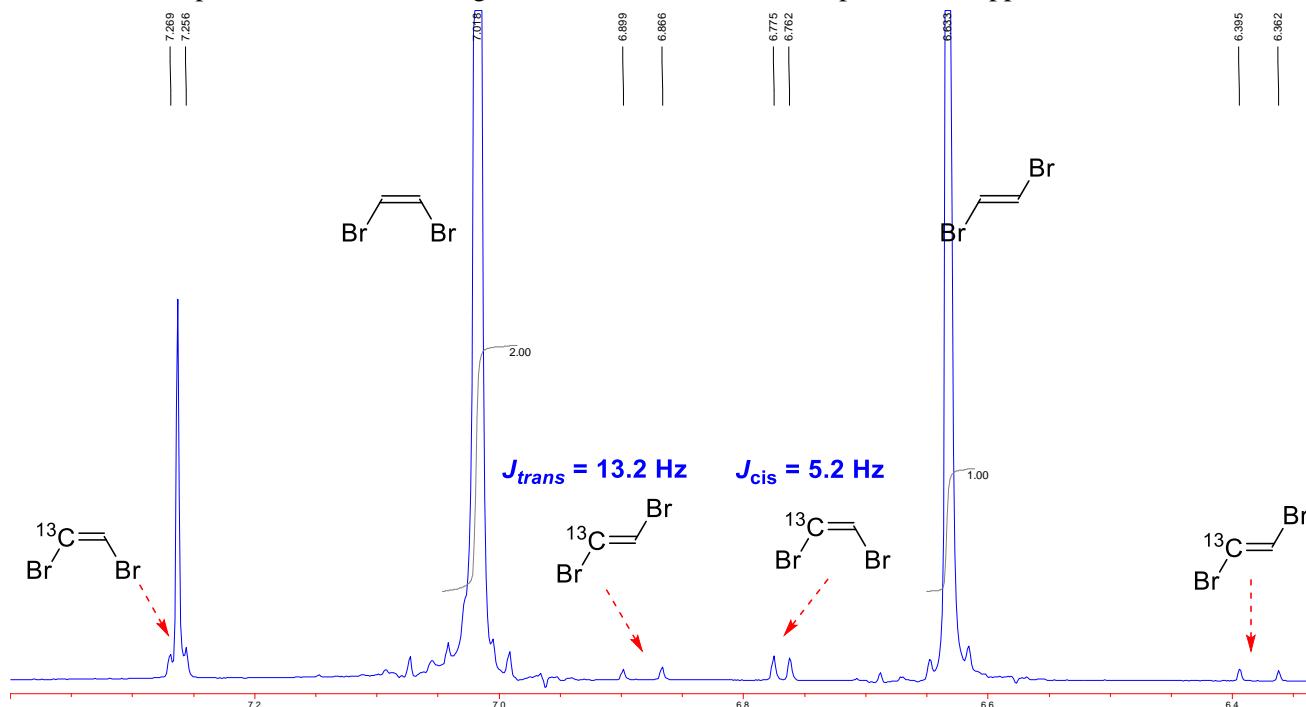
Scheme S1. Burgess and Coworkers' Four-Step Sequence to Prepare Chiral Terminal Bromo-Substituted Propargylamines¹



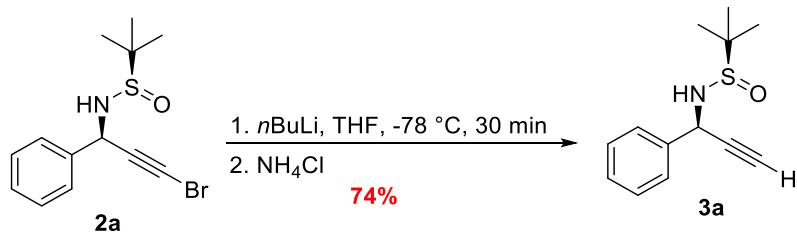
Burgess and coworkers employed the four-step sequence shown above to prepare chiral terminal bromo-substituted propargylamines.¹ Starting from *N*-Boc protected amino acids, Weinreb amide formation followed by LAH reduction produced the corresponding amino aldehyde. Ohira-Bestmann homologation produced the terminal alkyne which was then brominated via treatment with *n*BuLi and Br₂. In addition to the R group being limited to commercially available amino acids, this method also used TsN₃ which is unstable and can be an explosion liability.

Determination of *Cis/Trans* Ratio of Commercially Available 1,2-Dibromoethene

The *cis/trans* ratio of 1,2-dibromoethene was determined to be ~2:1 from integration of the corresponding *cis* and *trans* isomer peaks in the ¹H NMR spectrum. The assignment of the *cis* and *trans* isomer peaks was performed according to Bochet's method² which uses the coupling constants of the ¹³C satellite peaks to assign the signal as the *cis* (smaller coupling constant) or *trans* (larger coupling constant) isomer. The resonance at 7.02 ppm has ¹³C satellite peaks with a smaller coupling constant (*J* = 5.2 Hz) than the resonance at 6.63 (J = 13.2 for ¹³C satellite peaks). Thus the peak at 7.02 can be assigned as the *cis* isomer, and the peak at 6.63 ppm as the *trans* isomer.



Scheme S2. Conversion of **2a to **3a** to Confirm Absolute Stereochemistry of **2a****



Terminal bromo-substituted propargylamine **2a** was converted to terminal propargylamine **3a** by treatment with *n*BuLi (2.5 equiv) for 30 min at -78 °C to affect lithium-halogen exchange. Quenching with NH₄Cl (aqueous solution) protonated the terminal lithium acetylide to produce terminal propargylamine **3a** in 74% yield. Comparison of spectral data (¹H, ¹³C NMR) and the optical rotation to reported experimental data³ confirmed the stereochemical assignment of the amine stereocenter.

The stereochemistry produced in the reaction of lithium bromoacetylide with *N-t*-BS aldimines can be explained by the widely accepted chair transition state⁴ shown below. This transition state is common for the addition of organolithium reagents to Ellman *N-t*-BS imines.

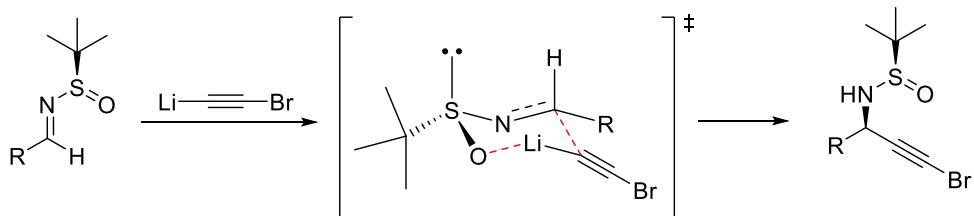


Figure S1. Putative chair transition state controlling stereoselectivity.

Discussion of Additional Reaction Optimization (Table S1)

Additional reaction optimization efforts for the addition of lithium bromoacetylide to *N-t*-BS aldimine **1a** are discussed below and shown in Table S1.

As shown in Table S1, while screening bases for the generation of lithium bromoacetylide from 1,2-dibromoethene we tested the use of alkyl lithiums (entries 1 and 2) and various solutions of metallated hexamethyldisilazane (entries 3-5). As observed in our previous work,³ use of MeLi (entry 1) and *n*BuLi (entry 2) both failed to produce the desired product. In the case of MeLi only methyl addition product **S1** was produced, and *n*BuLi produced only debromo-product **3a** in 24% yield and 4:1 dr. In contrast, use of LiHMDS proved more promising as LiHMDS (1.0 M in THF, entry 3) produced **2a** in a 68% yield and 9:1 dr and **3a** was formed in only 13% yield despite the presence of THF in the LiHMDS solution. In line with our other observations, the presence of THF in the LiHMDS solution promoted the complete consumption of starting material **1a**. Studies with NaHMDS (entry 4) and KHMDS (entry 5) demonstrated the importance of the Li counterion for the reaction, as Na and K counterions produced the desired product in little to no yield.

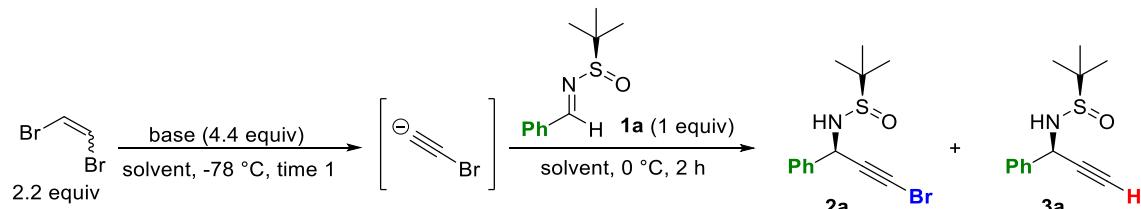
After having discovered that it could be beneficial in some cases to add aldimine **1a** immediately after addition of the base (i.e. elimination of the 30 min period to generate lithium bromoacetylide), we tested this protocol using MTBE as the reaction solvent and as the solvent for the LiHMDS solution as shown in entry 6.

Interestingly, in line with the result of entry 14 of Table 1 (which also used an LiHMDS solution in MTBE), this diminished the isolated yield of **2a** (compare Table S1, entry 6: 59% yield to Table 1, entry 13: 67% yield).

We also explored whether we could reduce the equivalents of 1,2-dibromoethene and base (entries 7 and 8), but this decreased the isolated yield. Decreasing the equivalents of 1,2-dibromoethene from 2.2 to 1.1 (entry 7) also lowered the diastereoselectivity ($dr = 15:1$), revealing that the amount of lithium bromoacetylide present in the reaction mixture impacts the diastereoselectivity of the reaction. Increasing the equivalents of 1,2-dibromethene to 1.65 restored the diastereoselectivity back to 20:1 (entry 8), although the yield was still diminished in comparison to the use of 2.2 equiv of 1,2-dibromoethene. Increasing to 3.0 equiv 1,2-dibromoethene and 6.0 equiv LiHMDS (entry 9) did not improve the reaction yield beyond what was achieved when 2.2 equiv 1,2-dibromoethene and 4.4 equiv LiHMDS were used.

Finally we probed the effect of reaction concentration and the order of reagent addition. Doubling the reaction concentration (entry 10) slightly decreased the yield (72%) and diastereoselectivity (19:1). Diluting the reaction concentration two-fold (entry 11) resulted in a slight decrease in yield (73%) and no change in diastereoselectivity (20:1). We then tested order of reagent addition, starting with aldimine **1a** in the round-bottom flask in order to avoid transfer of a solution of **1a** to the *in situ* generated lithium bromoacetylide. Addition of 1,2-dibromoethene followed by LiHMDS to aldimine **1a** dissolved in Et₂O (entry 12), and addition of LiHMDS followed by 1,2-dibromoethene to aldimine **1a** dissolved in Et₂O (entry 13) produced identical results, as both methods afforded slightly reduced diastereoselectivity ($dr = 17:1$) but had negligible effects on the isolated yield.

Table S1. Optimization of Solvent and Base for Generation and Addition of Lithium Bromoacetylide to Phenyl Imine **1a**

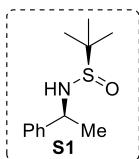


entry	solvent	base	equiv of 1,2-dibromoethene/base	time 1 (h)	yield 2a (%) ^b	unreacted 1a relative to 2a ^c	yield 3a (%) ^b	yield 2a + 3a (%)	dr of 2a ^d
1 ^e	Et ₂ O	MeLi (1.6 M in Et ₂ O)	2.2/4.4	0.5	--	--	--	--	--
2	Et ₂ O	nBuLi (2.5 M in hexanes)	2.2/4.4	0.5	--	--	24	24	4:1 ^f
3	Et ₂ O	LiHMDS (1.0 M in THF)	2.2/4.4	0.5	68	--	13	81	9:1
4 ^g	Et ₂ O	NaHMDS (1.0 M in THF)	2.2/4.4	0.5	15	--	22	37	16:1
5 ^g	Et ₂ O	KHMDS (0.5 M in toluene)	2.2/4.4	0.5	--	--	trace	trace	--
6	MTBE	LiHMDS (1.0 M in MTBE)	2.2/4.4	--	59	0.28	--	59	20:1
7	Et ₂ O	LiHMDS (1.0 M toluene)	1.1/2.2	--	68	0.11	--	68	15:1
8	Et ₂ O	LiHMDS (1.0 M in toluene)	1.65/3.3	--	68	0.07	--	68	20:1
9	Et ₂ O	LiHMDS (1.0 M in toluene)	3.0/6.0	--	76	0.11	--	76	20:1
10 ^h	Et ₂ O	LiHMDS (1.0 M in toluene)	2.2/4.4	--	72	0.14	--	72	19:1
11 ⁱ	Et ₂ O	LiHMDS (1.0 M in toluene)	2.2/4.4	--	73	0.11	--	73	20:1
12 ^j	Et ₂ O	LiHMDS (1.0 M toluene)	2.2/4.4	--	77	0.09	--	77	17:1
13 ^k	Et ₂ O	LiHMDS (1.0 M toluene)	2.2/4.4	--	77	0.09	--	77	17:1

^aReaction conditions: To a *cis/trans* mixture of 1,2-dibromoethene in solvent (2.0 mL) cooled to -78 °C was added a base and the reaction was stirred at -78 °C for 30 min for entries 1-5. In entries 6-13, the imine was added immediately following addition of the base. At -78 °C **1a** (0.5 mmol, 1 equiv) was added in solvent (3.0 mL) and the reaction was stirred at 0 °C for 2 h. ^bIsolated yield. ^cRelative amount of unreacted **1a** relative to **2a** was determined from the crude ¹H NMR spectrum. The propargylic proton of the major diastereomer of product **2a** (5.24 ppm, d) was set to an integration value of 1. The integration value for the aldimine H of starting material **1a** (8.59, s) was then obtained. Higher integration values for **1a** correspond to larger amounts of unreacted aldimine starting material relative to **2a**.

^dDiastereomeric ratio determined by analysis of crude ¹H NMR spectrum. ^eMethyl addition product **S1** was obtained in 89% yield. The diastereomeric ratio was determined to be 2.3:1 based on the masses of the recovered major (70.3 mg) and minor diastereomer (30.3 mg) which were separable by silica gel column chromatography. ^fDiastereomeric ratio of product **3a**.

^gSignificant decomposition and no starting material **1a** observed in crude ¹H NMR spectrum. ^h2-fold concentration: 1,2-dibromoethene dissolved in 1.0 mL of Et₂O, and imine **1a** added in 1.5 mL of Et₂O. ⁱ2-fold dilution: 1,2-dibromoethene dissolved in 4.0 mL of Et₂O, and imine **1a** added in 6 mL of Et₂O. ^jAlternate order of addition: To imine **1a** (0.5 mmol) dissolved in Et₂O (5.0 mL) and cooled to -78 °C was added 1,2-dibromoethene (1.1 mmol, 2.2 equiv), followed by the addition of LiHMDS (2.2 mmol, 4.4 equiv). The reaction was then stirred at 0 °C for 2 h. ^kAlternate order of addition: To imine **1a** (0.5 mmol) dissolved in Et₂O (5.0 mL) and cooled to -78 °C was added LiHMDS (2.2 mmol, 4.4 equiv), followed by the addition of 1,2-dibromoethene (1.1 mmol, 2.2 equiv). The reaction was then stirred at 0 °C for 2 h.



Addition of lithium bromoacetylide to *ortho*-methoxyphenyl aldimine **1f** produced a diastereomeric ratio of 5:1, which is significantly lower than the diastereomeric ratios of 16:1 and 19:1 observed for *meta*- and *para*-methoxyphenyl aldimines **1g** and **1h**. The lower diastereoselectivity could result from competitive coordination of lithium bromoacetylide by the *ortho*-methoxy group as shown in Figure S2. Notably, the *ortho*-methoxy groups makes possible bidentate coordination with the aldimine nitrogen atom. This coordination could compete with the coordination of lithium bromoacetylide by the sulfinamide oxygen atom in the chair transition state responsible for stereocontrol (see Figure S1) and thereby lower the diastereomeric ratio. A similar bidentate chelation hypothesis has been proposed for the diastereoselectivity observed in the addition of Grignard reagents to 2-pyridyl *N*-*t*-BS aldimines.⁵

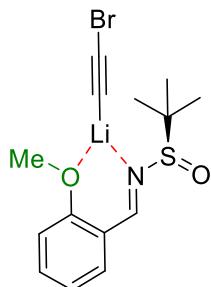
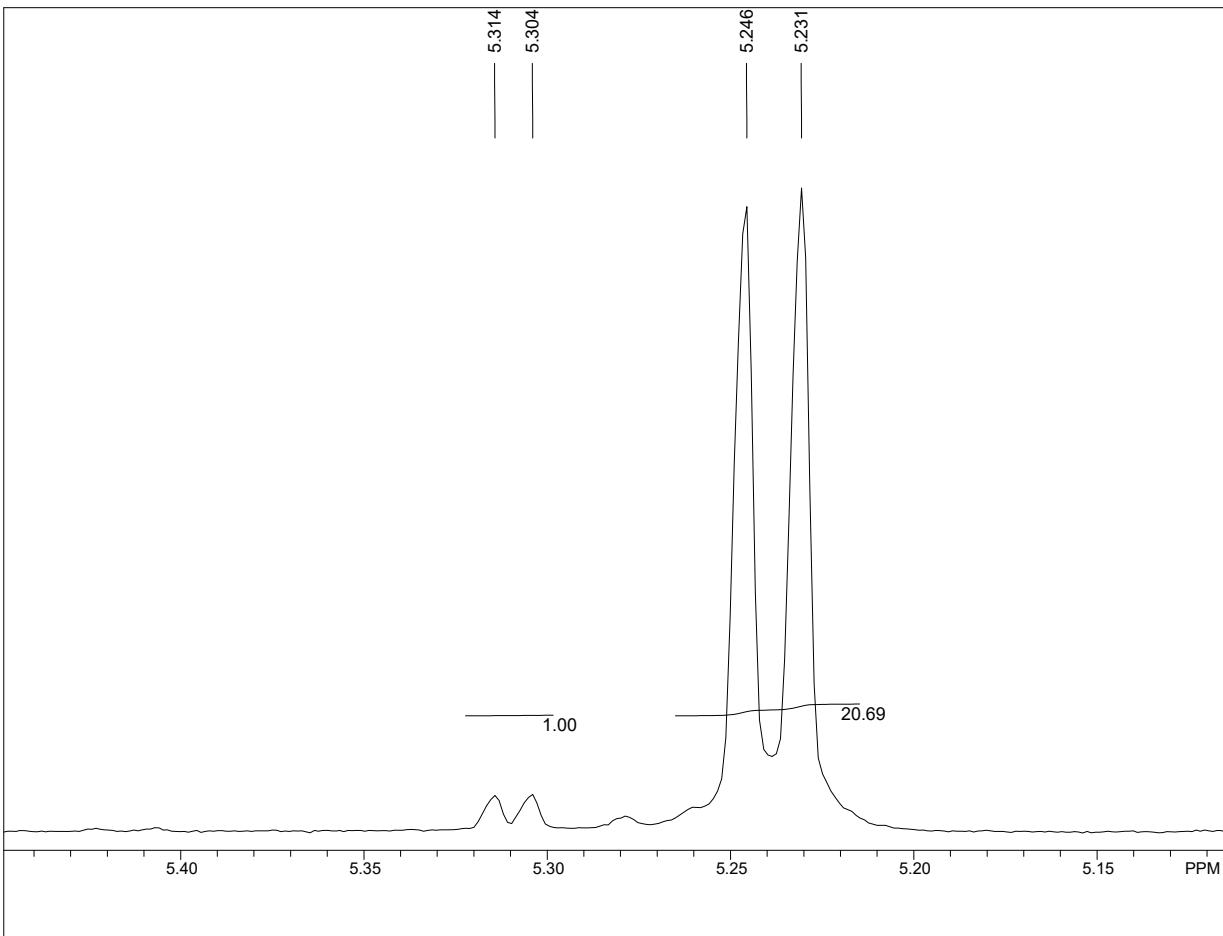
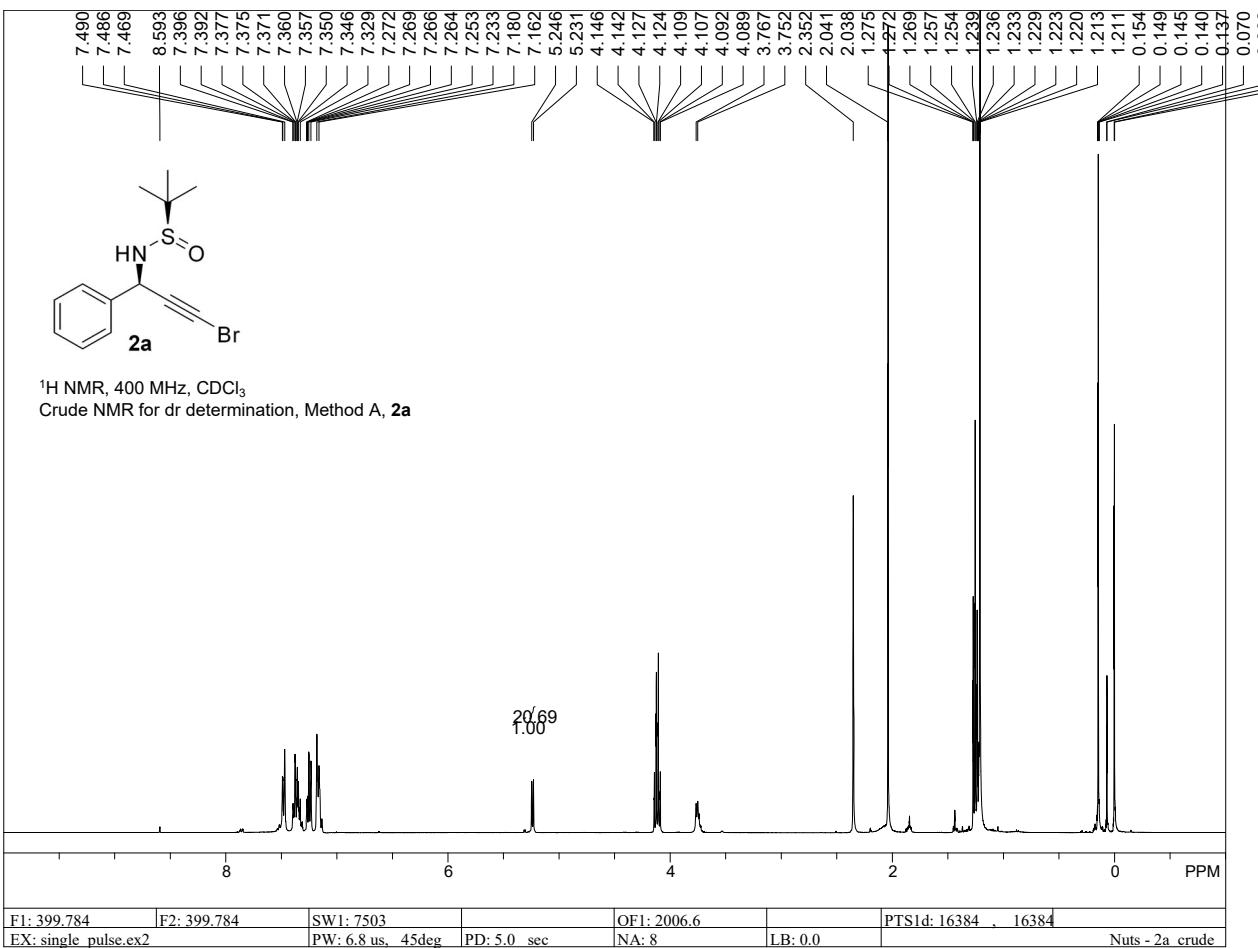


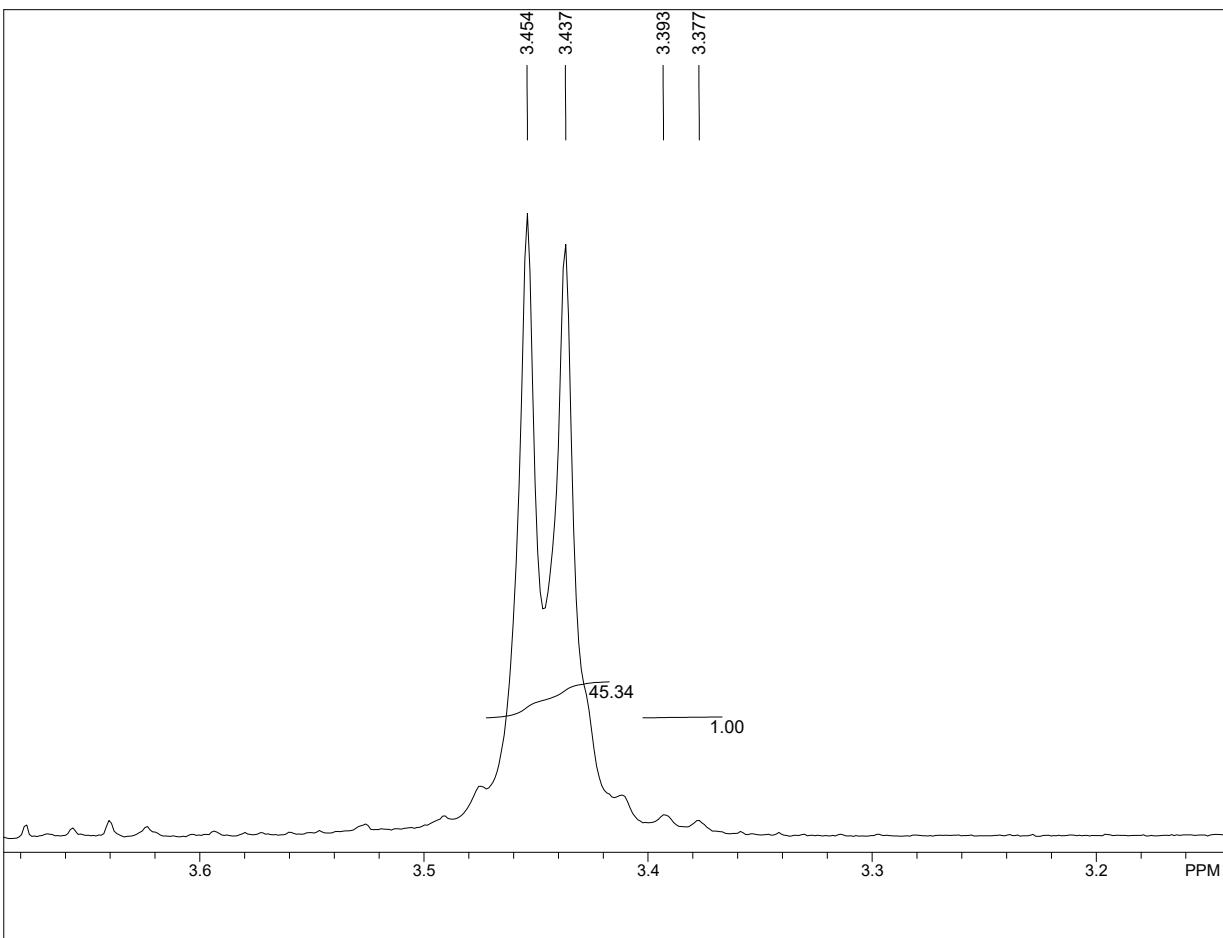
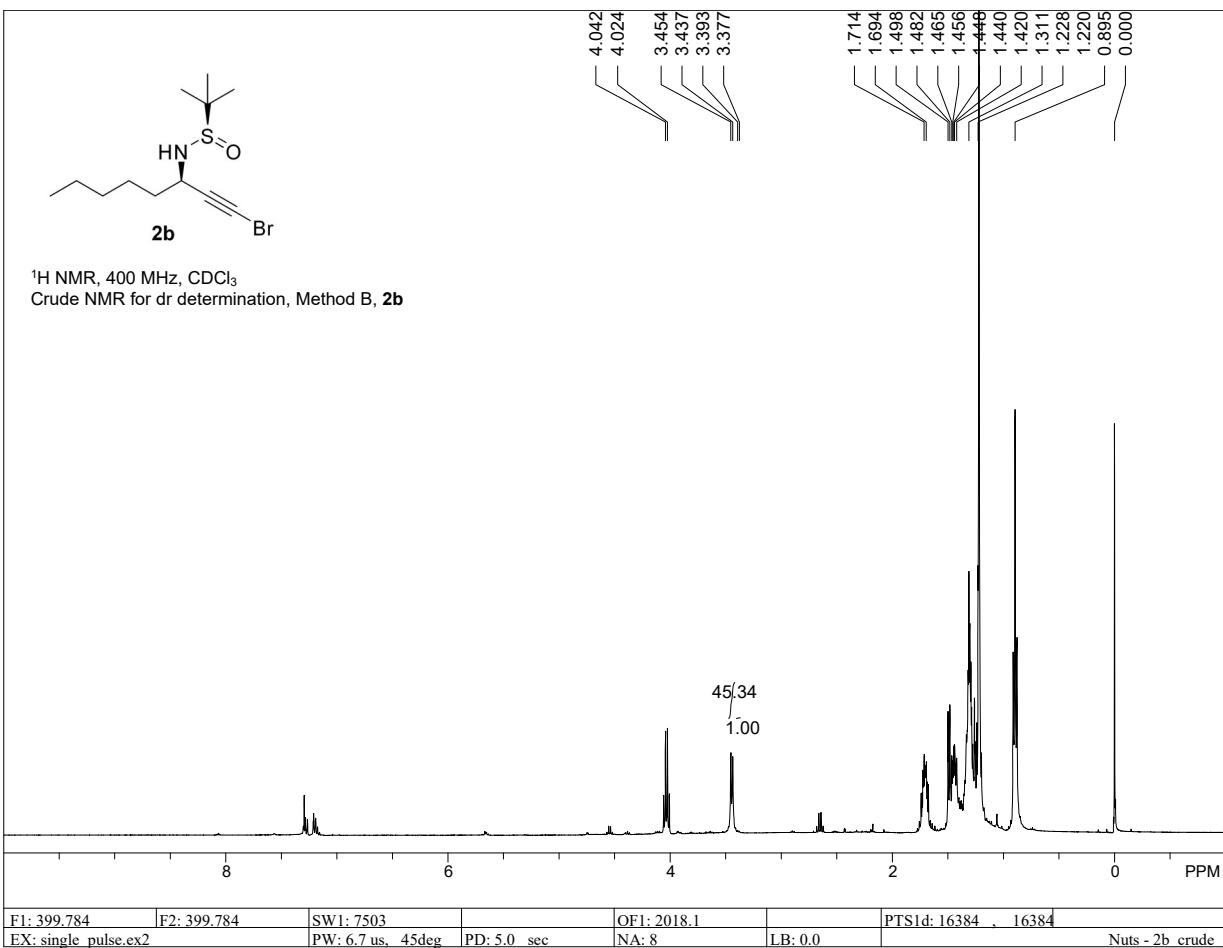
Figure S2. Hypothesis for decreased diastereoselectivity for 2-methoxyphenyl aldimine **1f**.

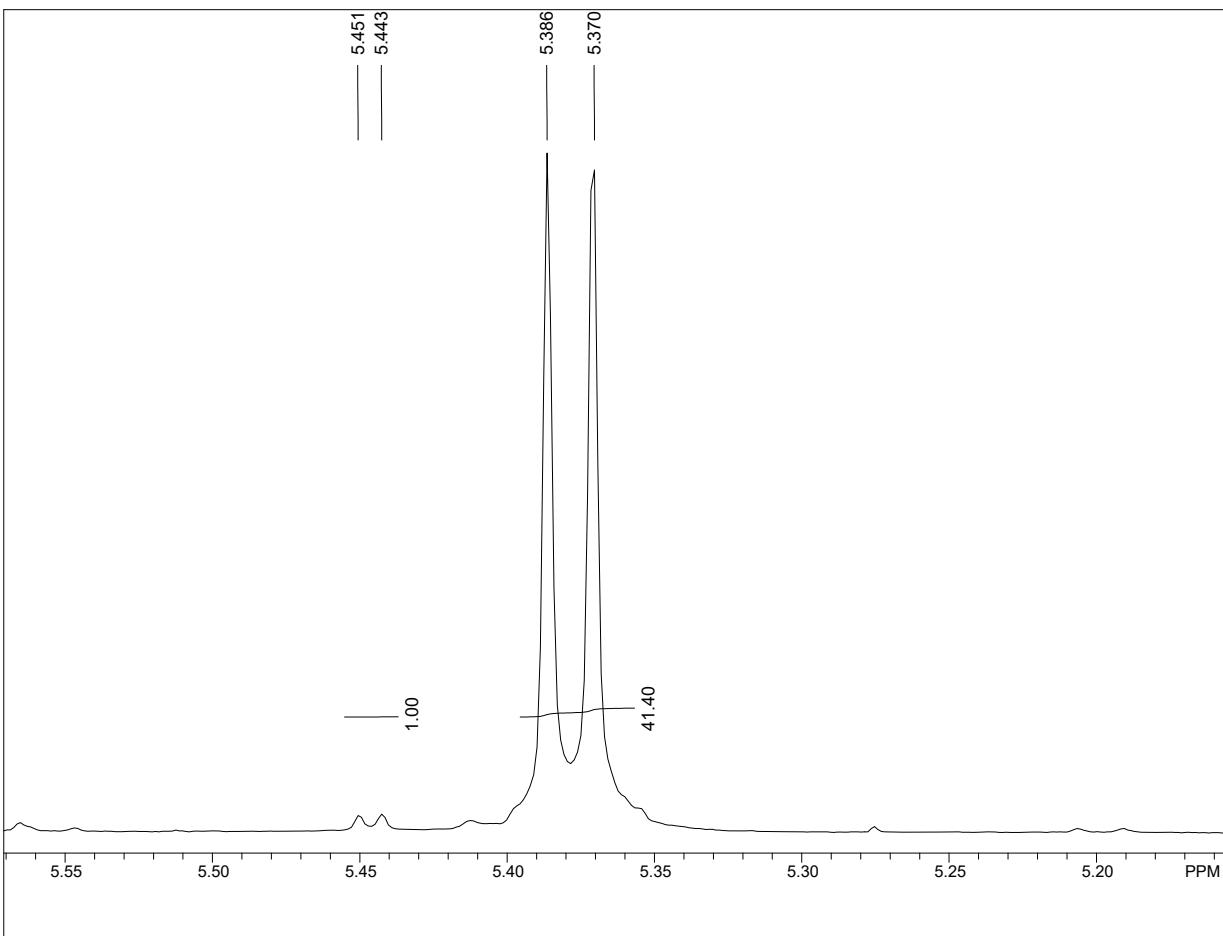
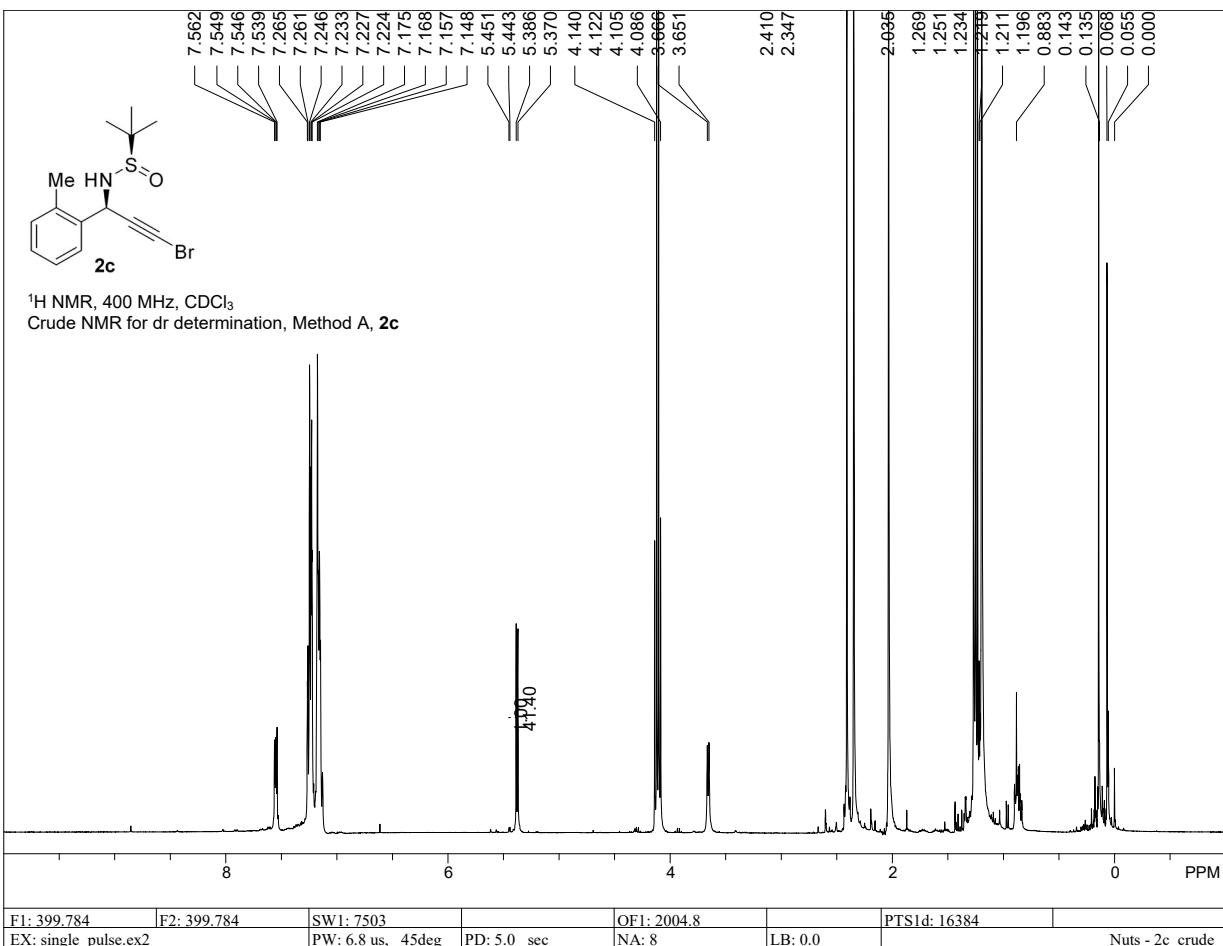
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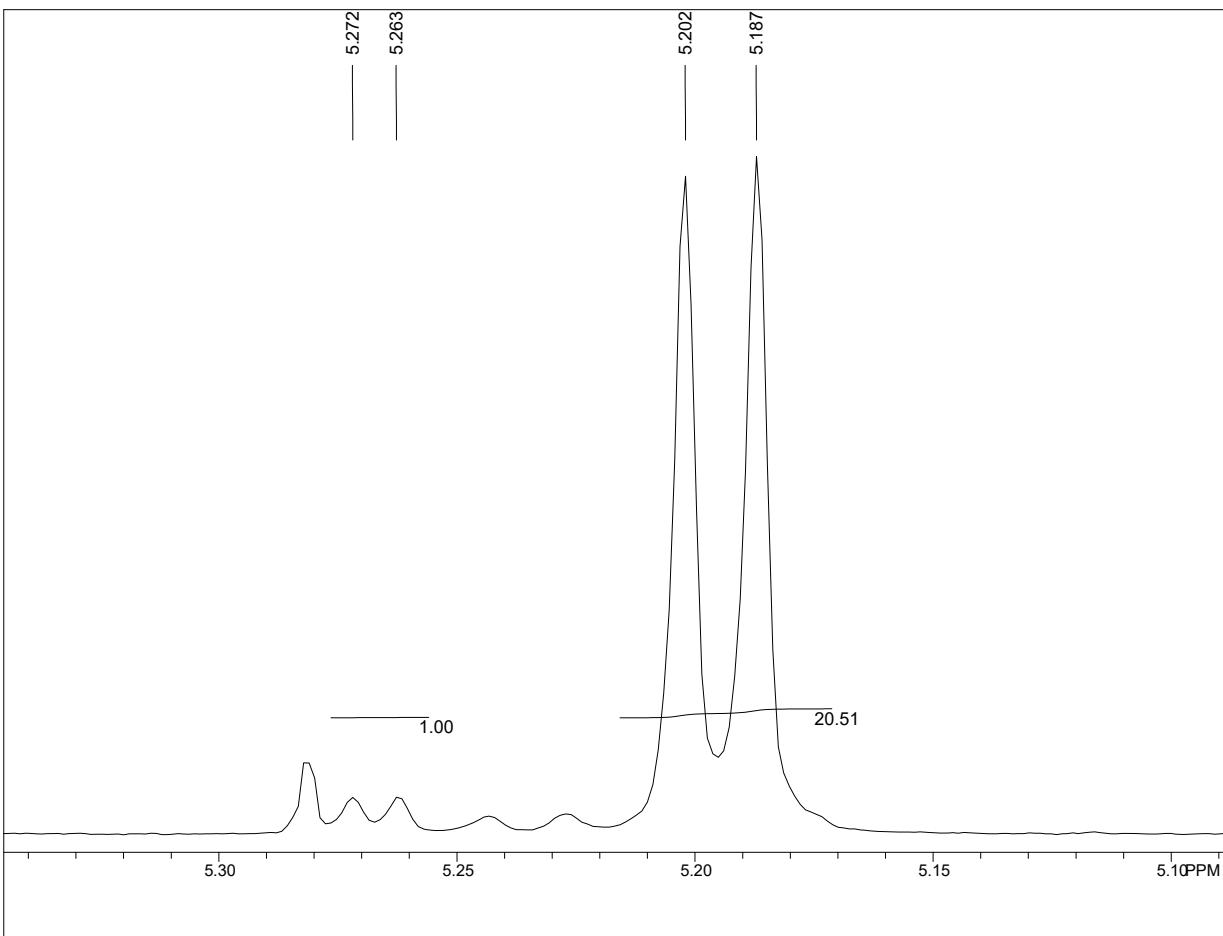
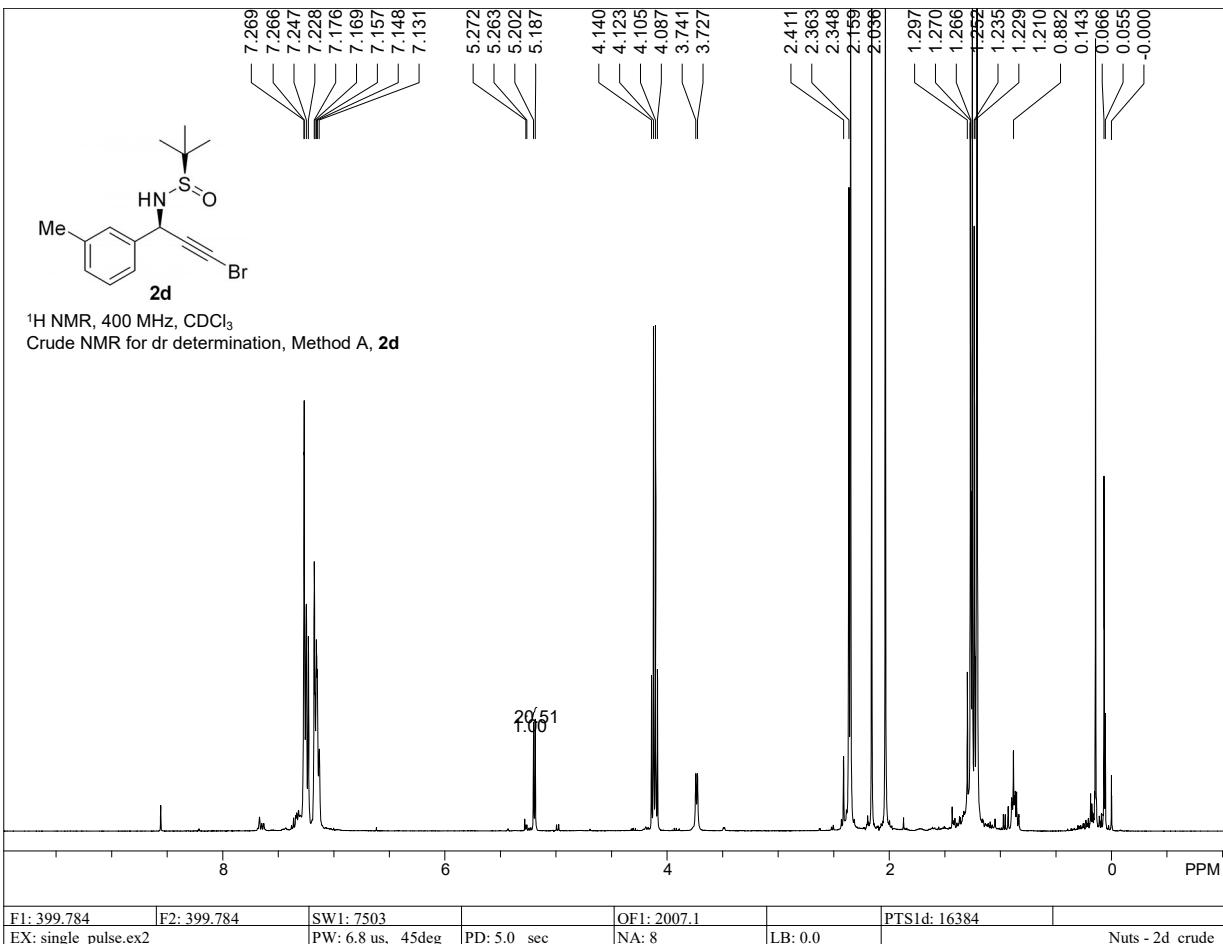
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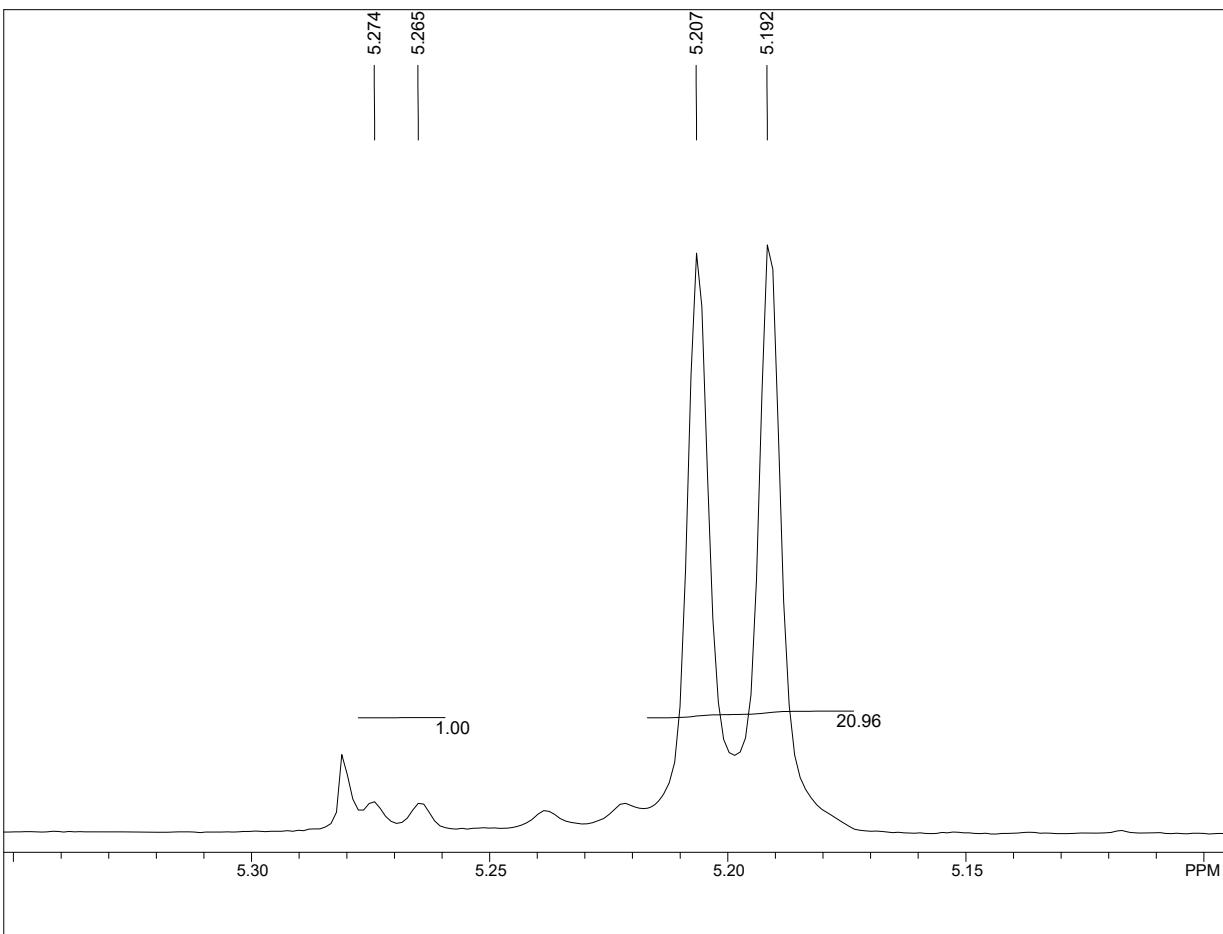
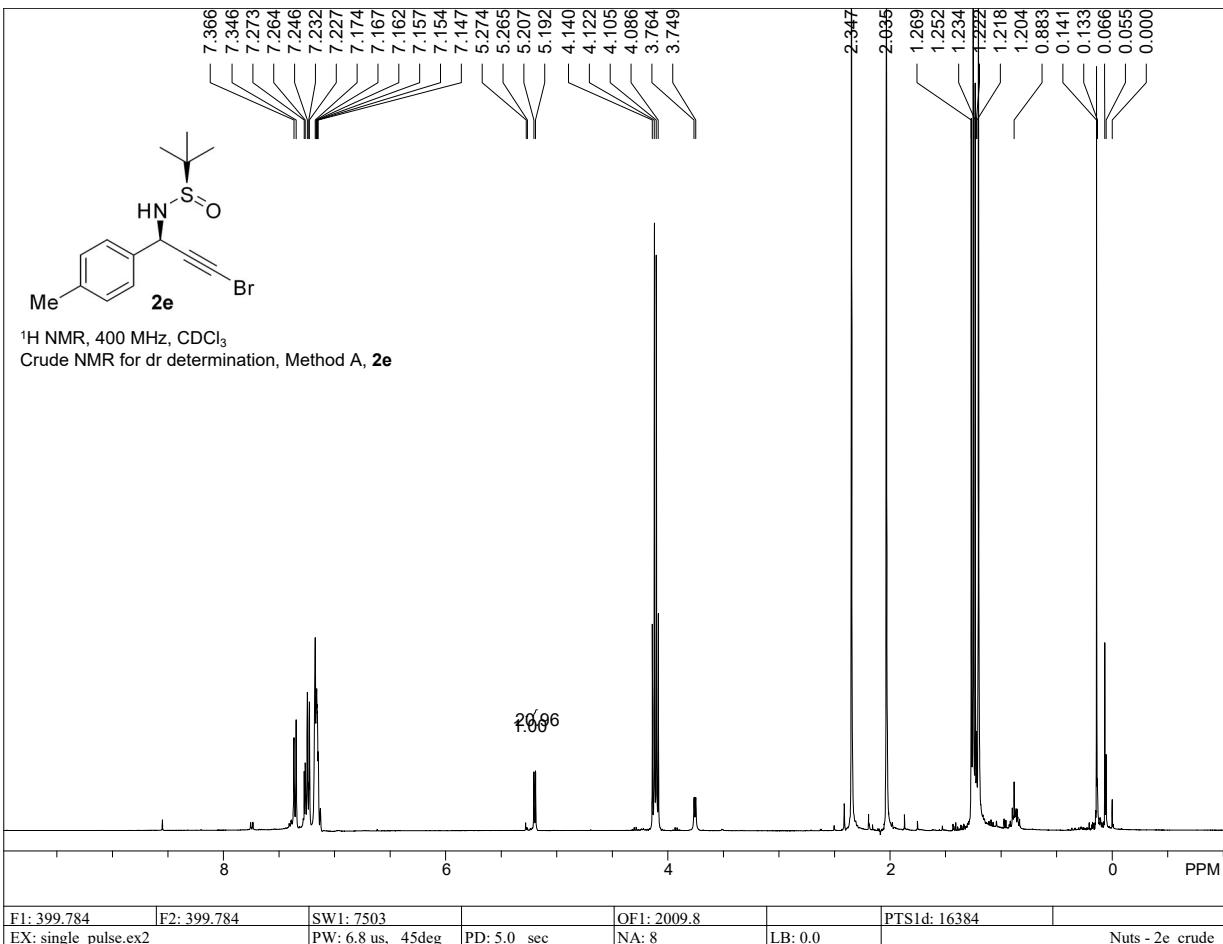
*Crude ^1H NMR Spectra for Determination of Diastereomeric Ratio for Compounds **2a-2ac***

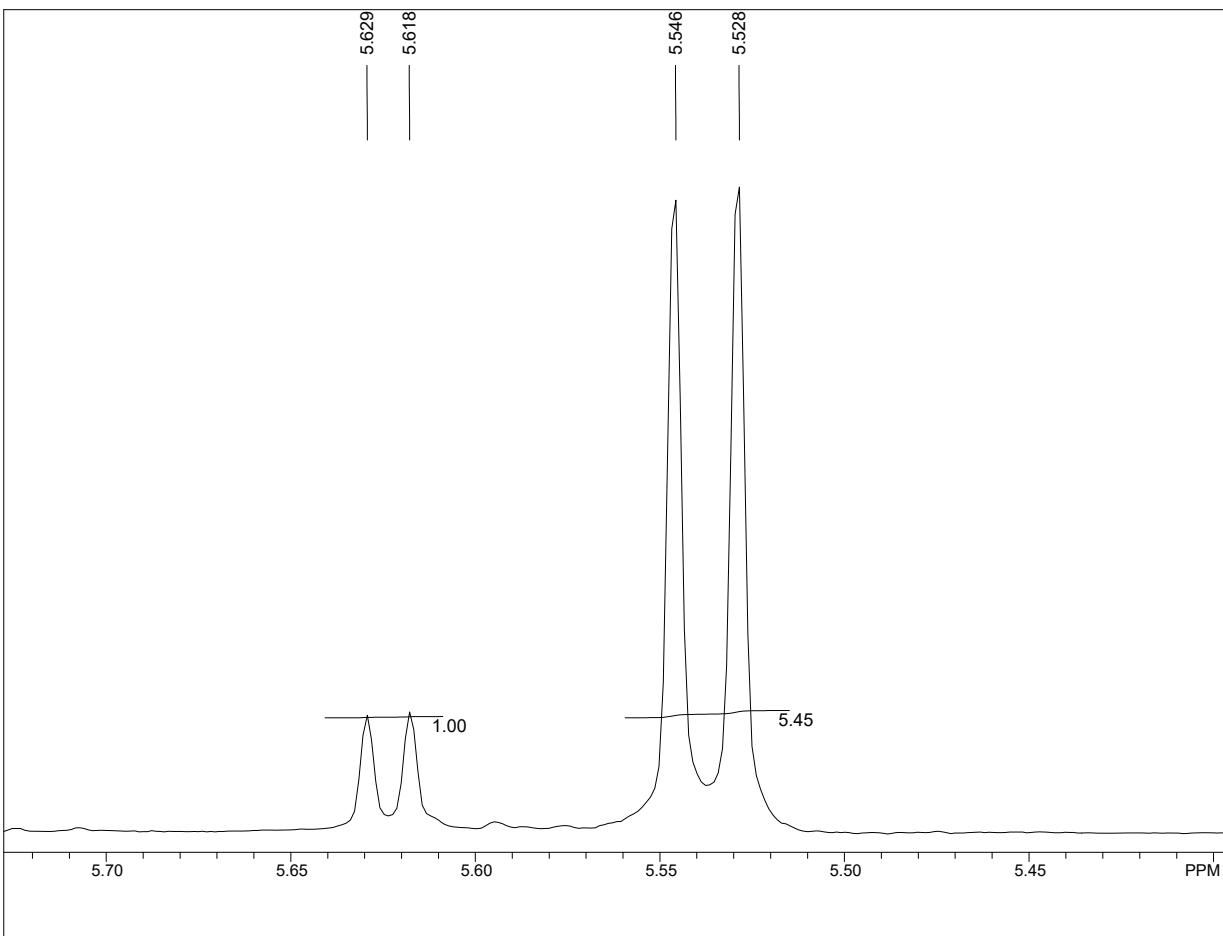
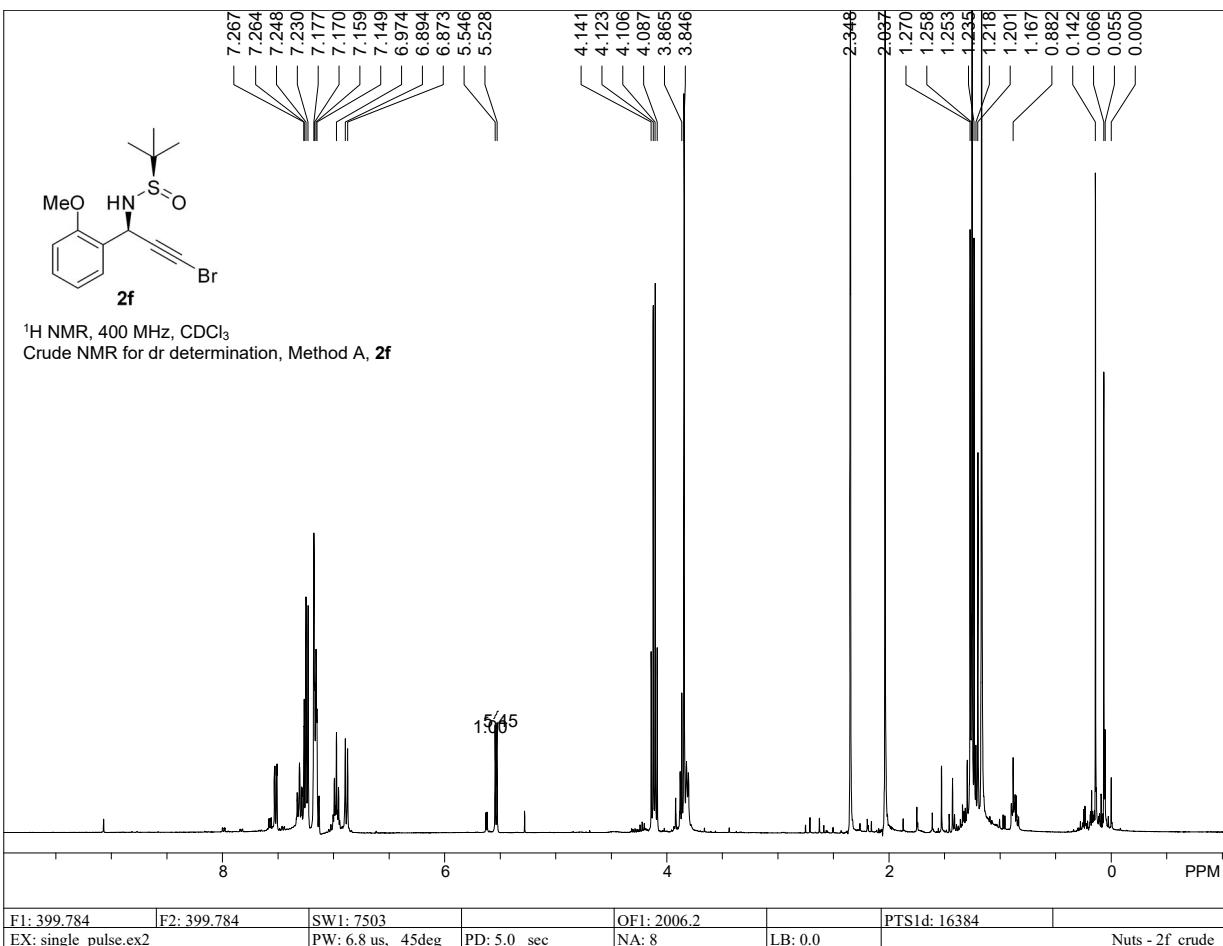


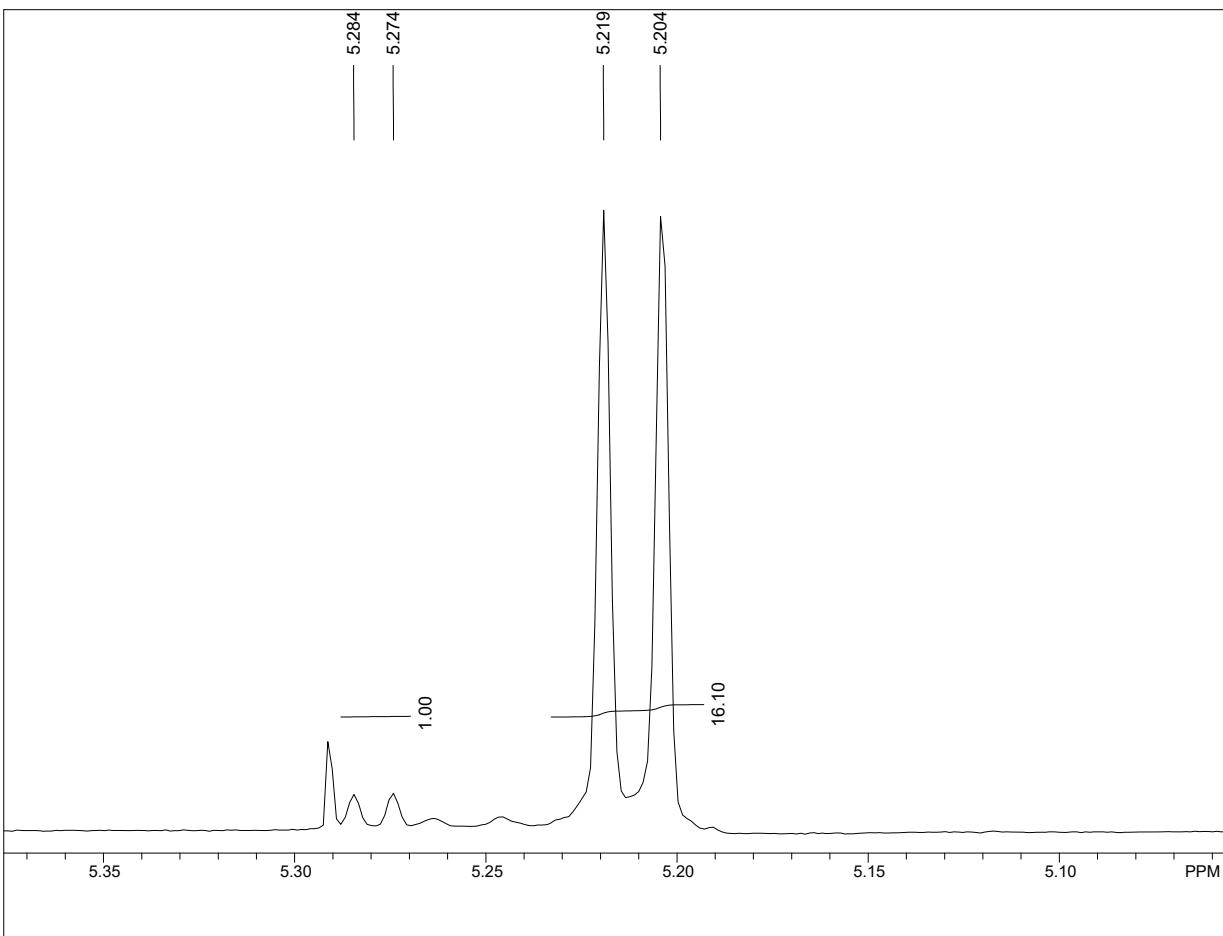
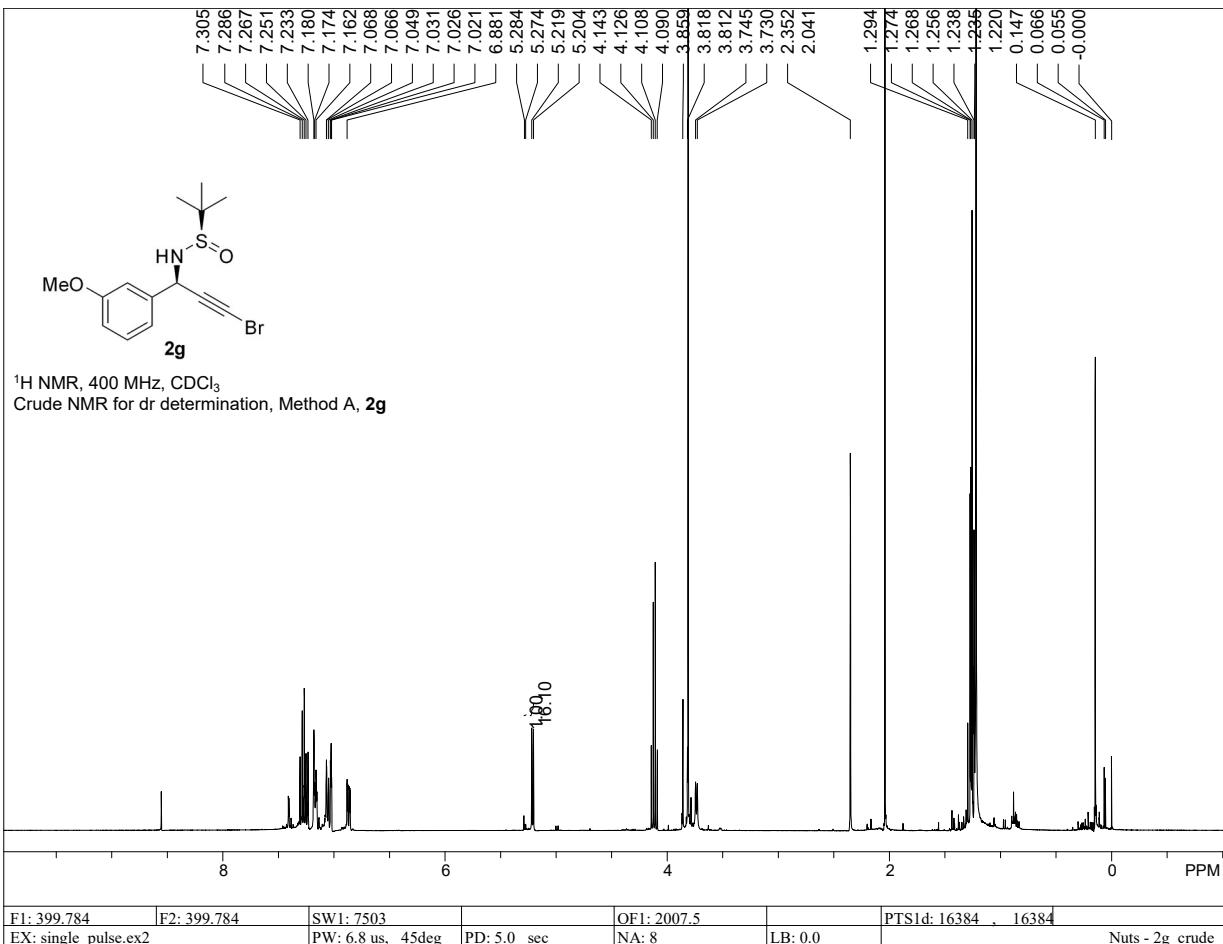


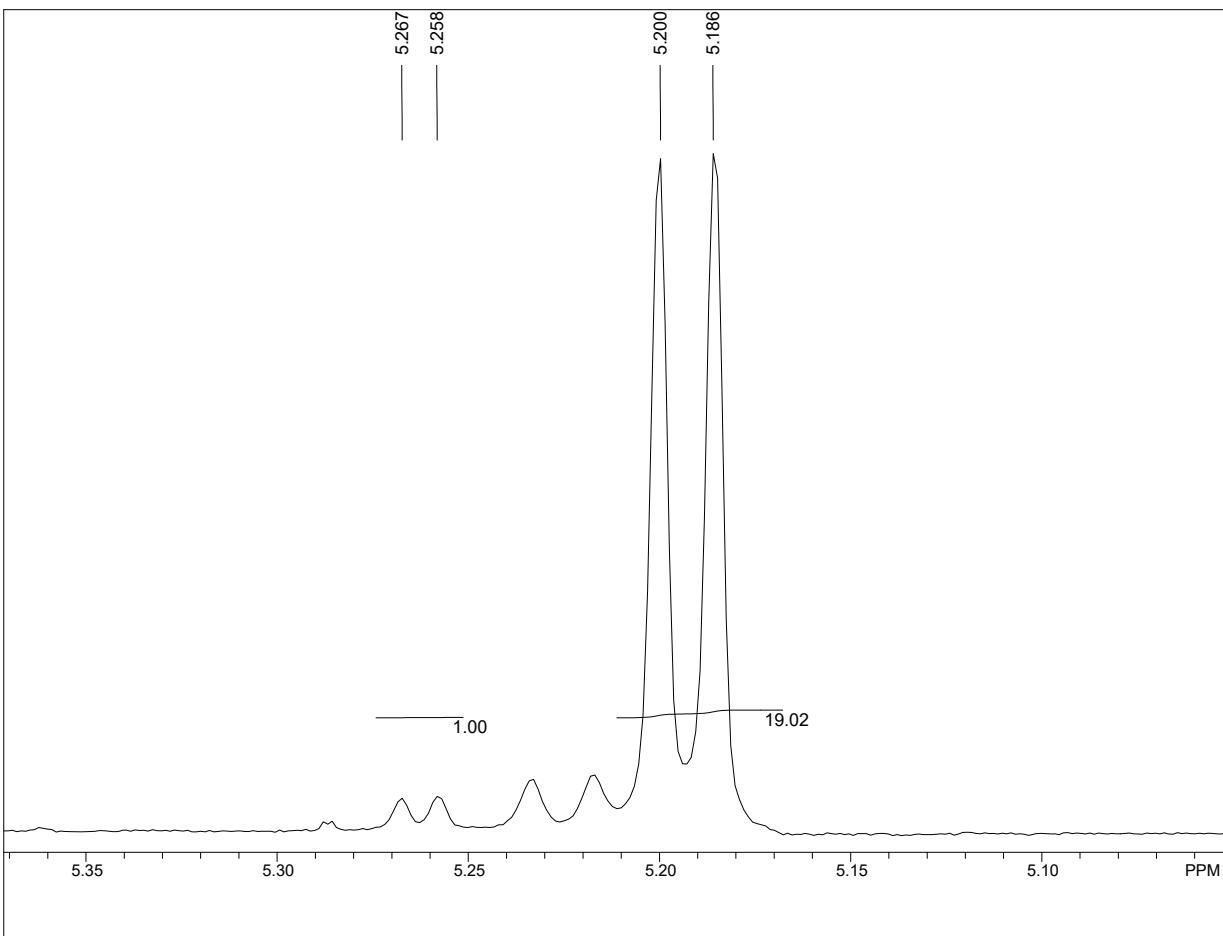
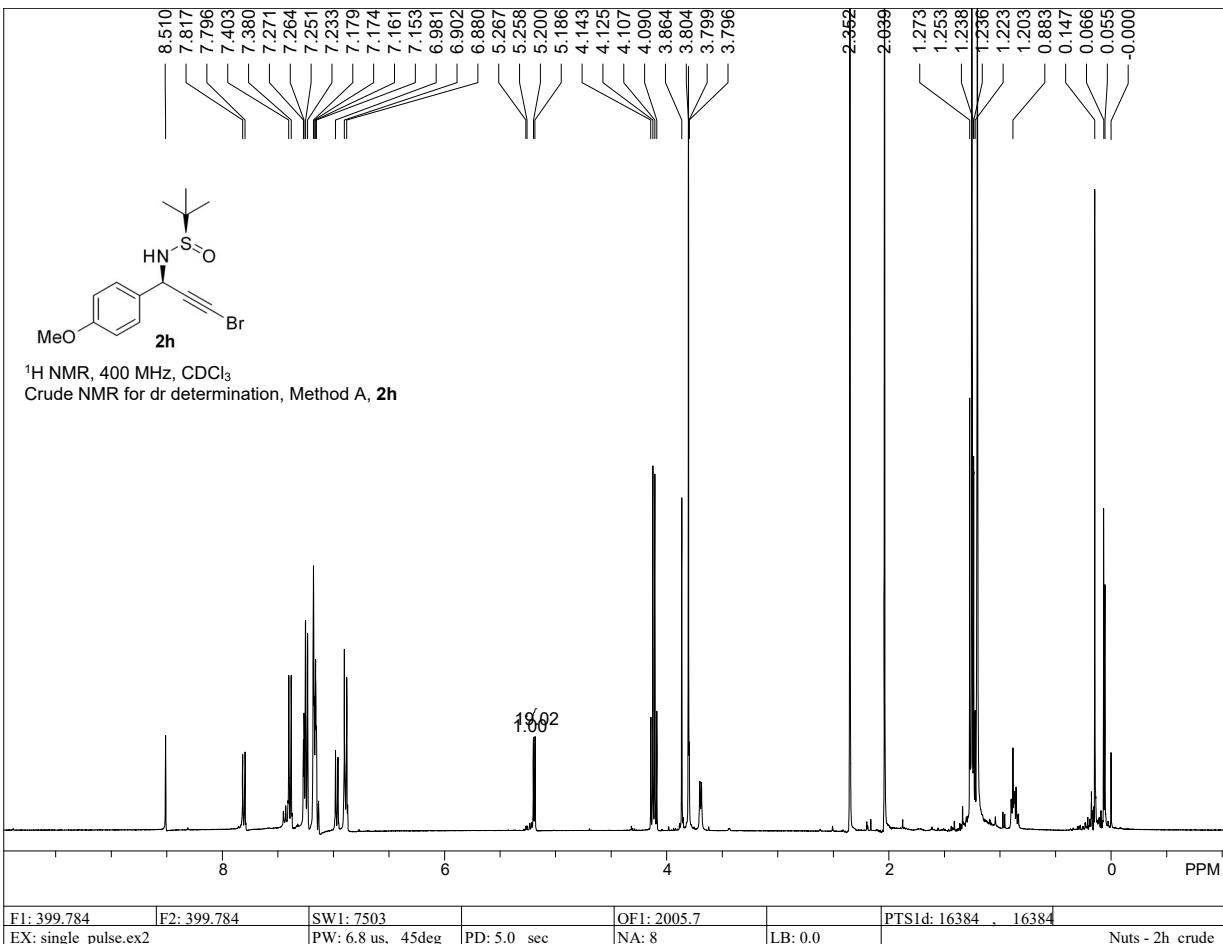


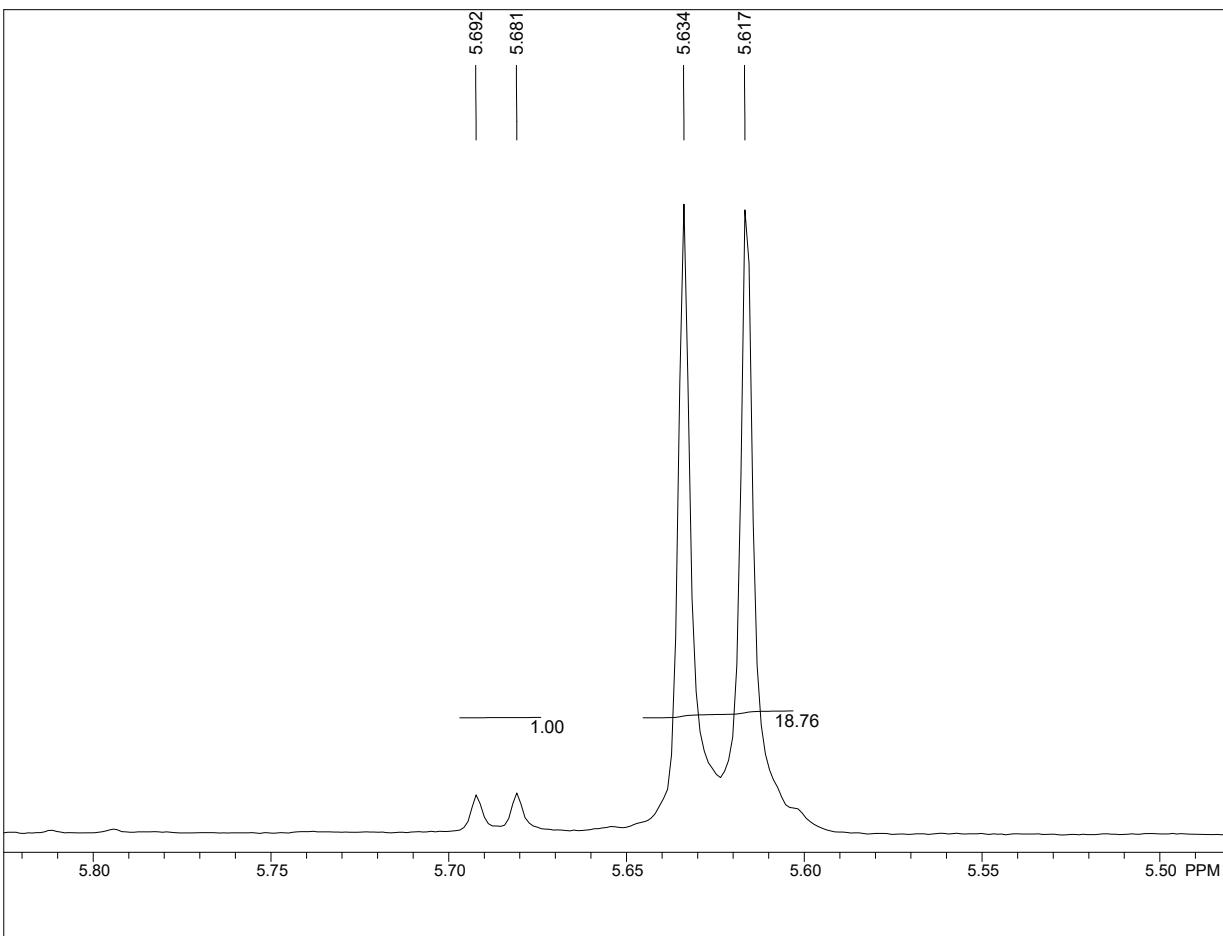
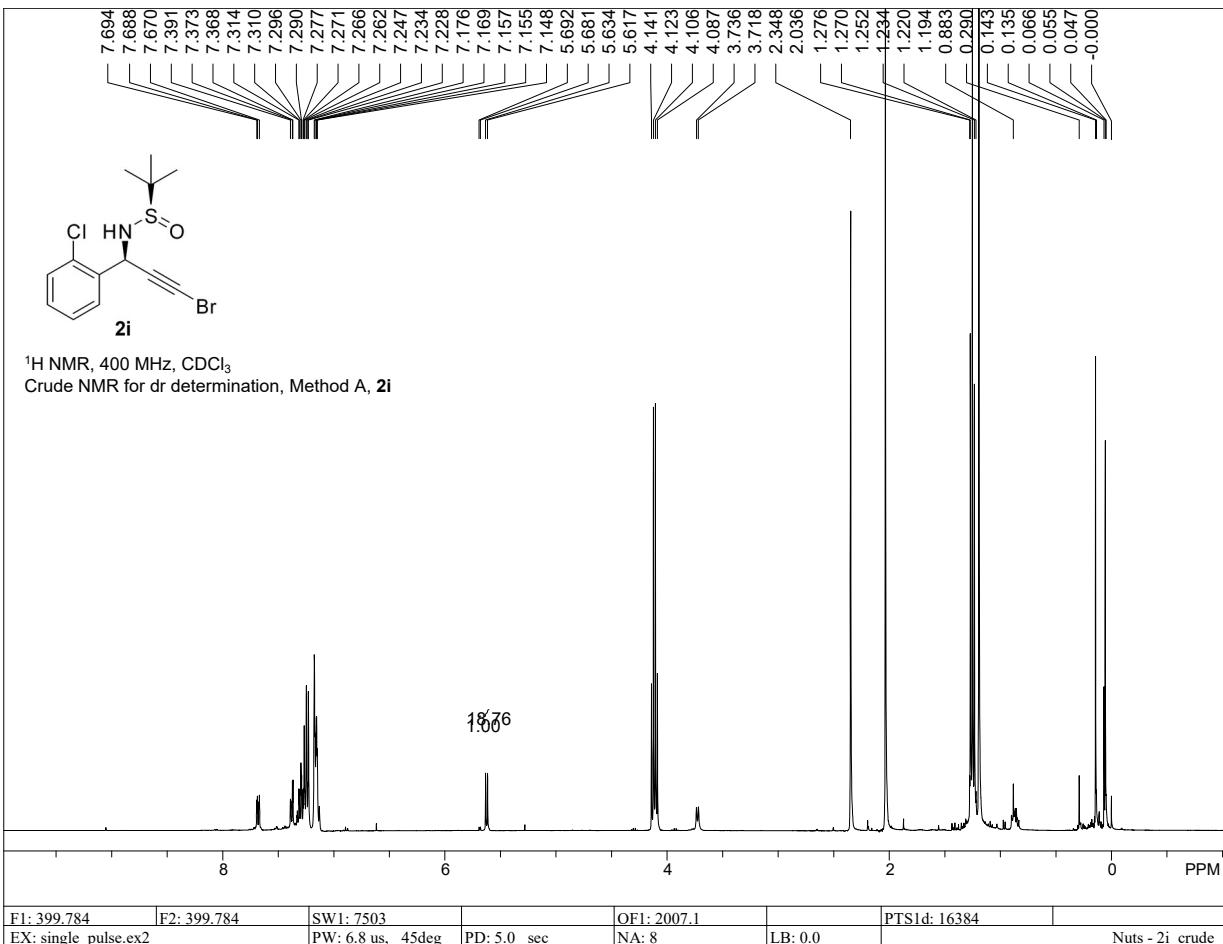


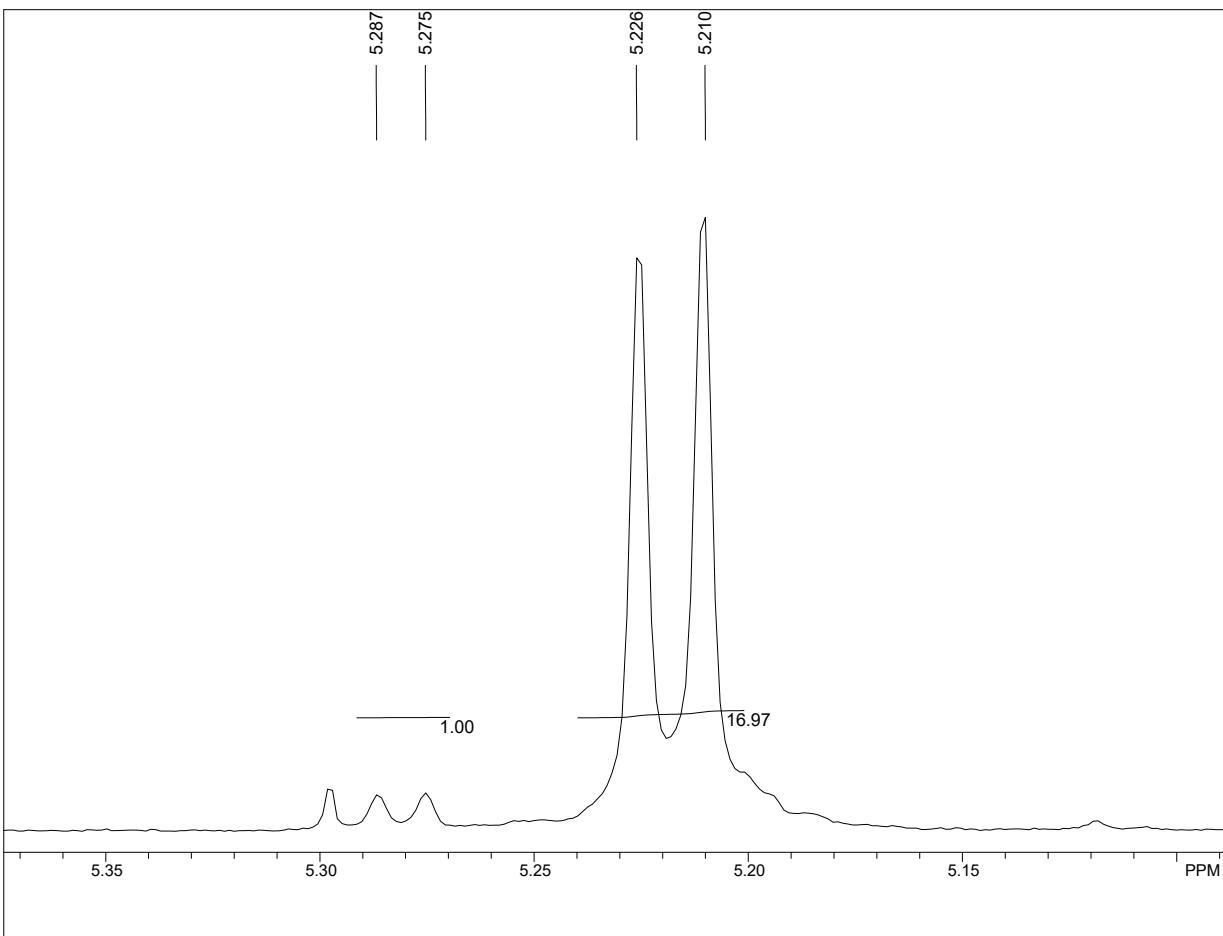
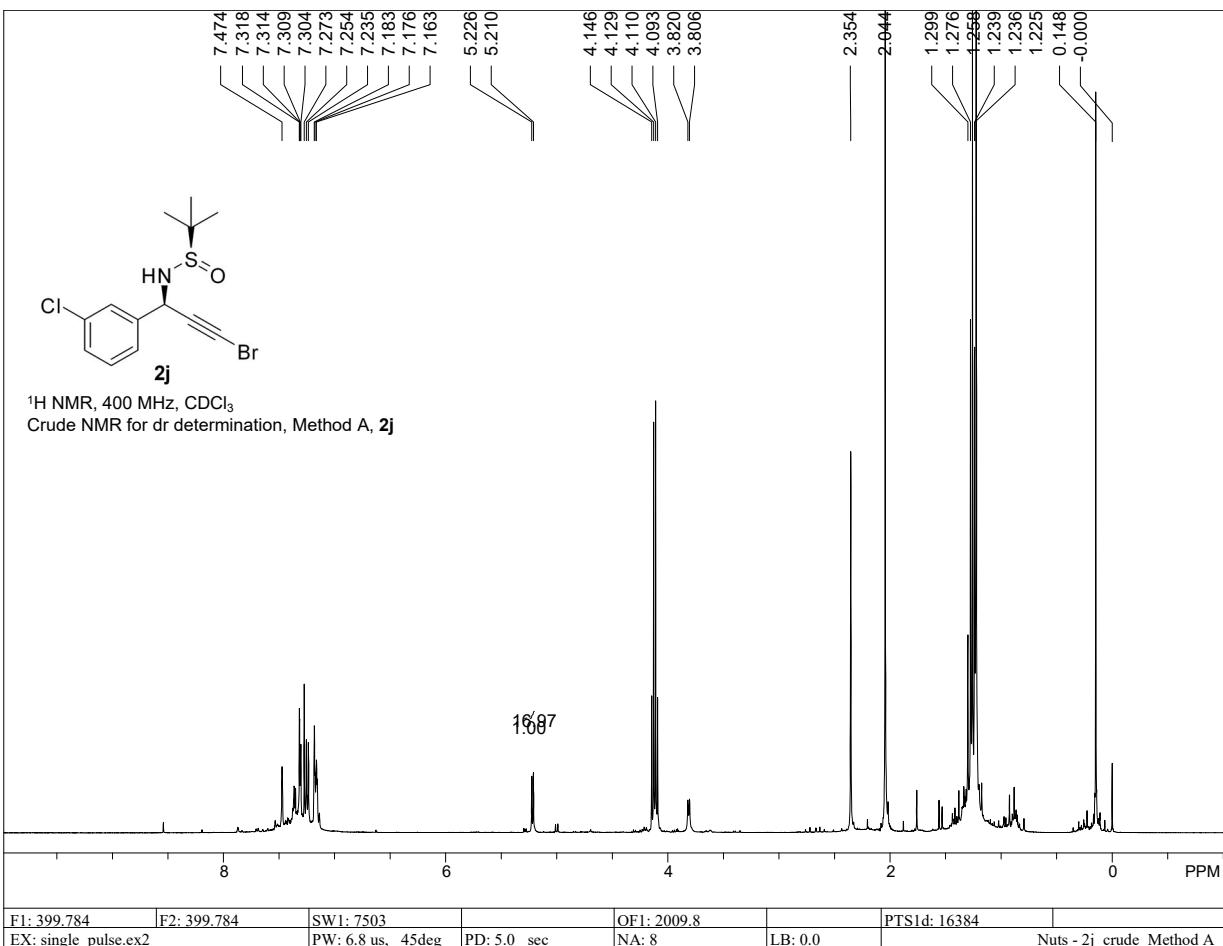


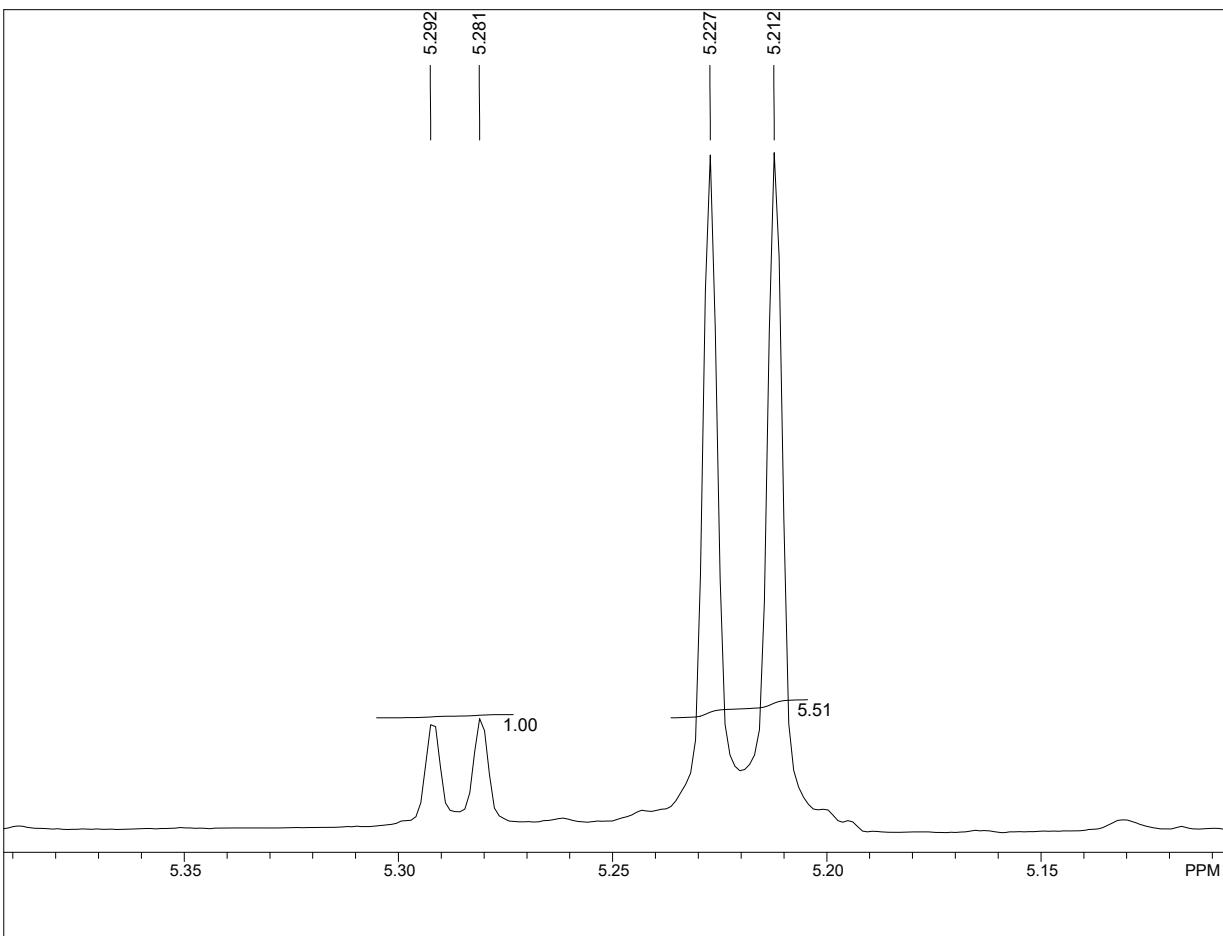
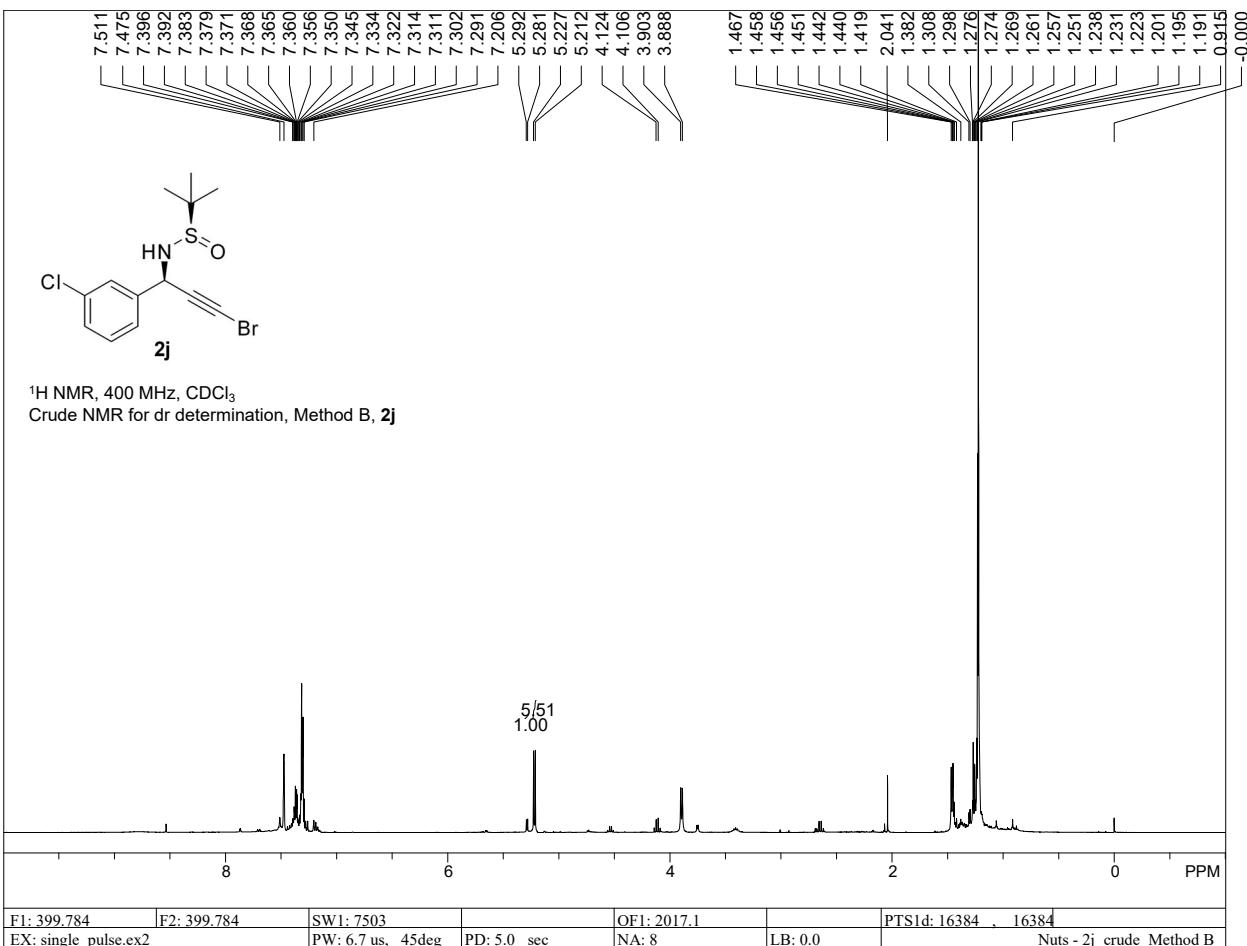


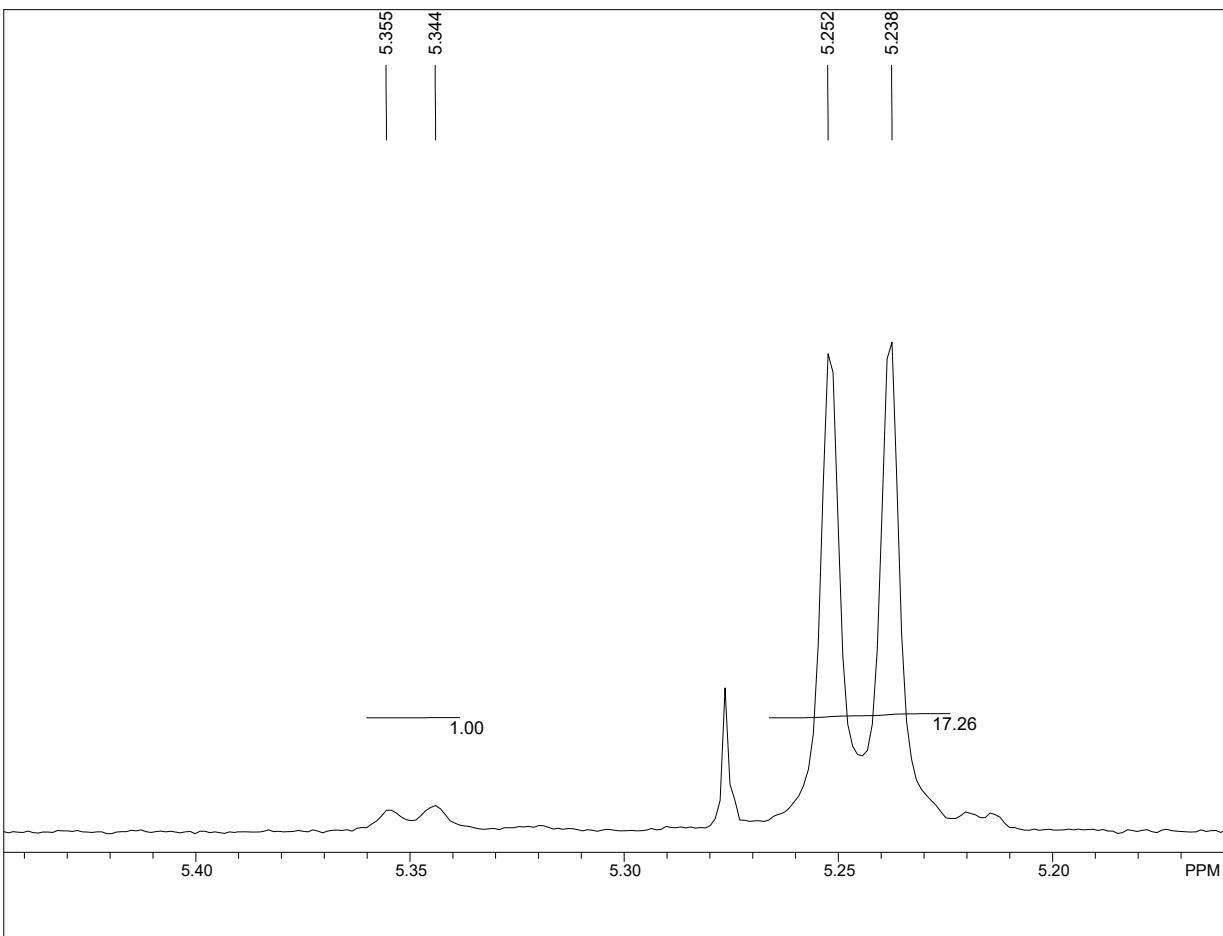
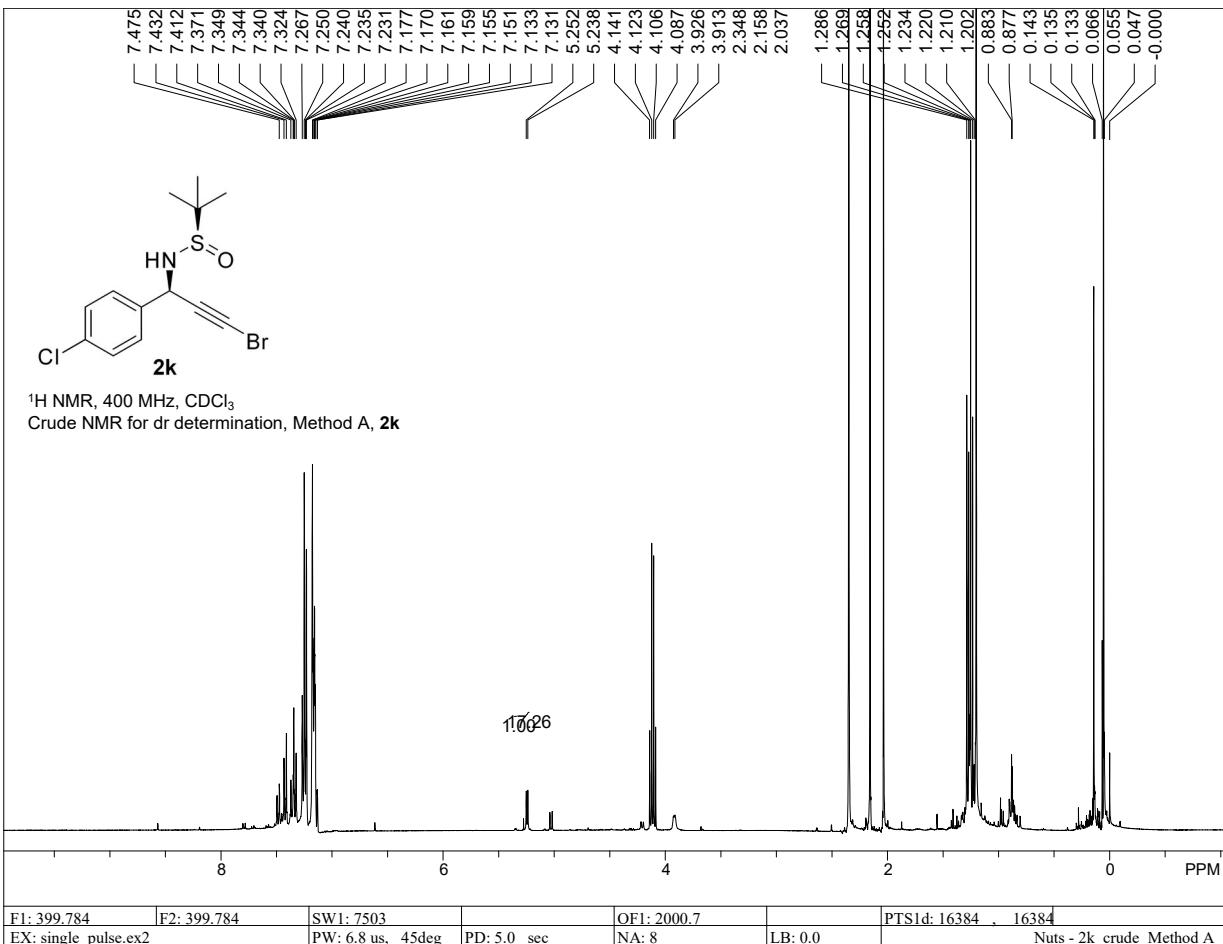


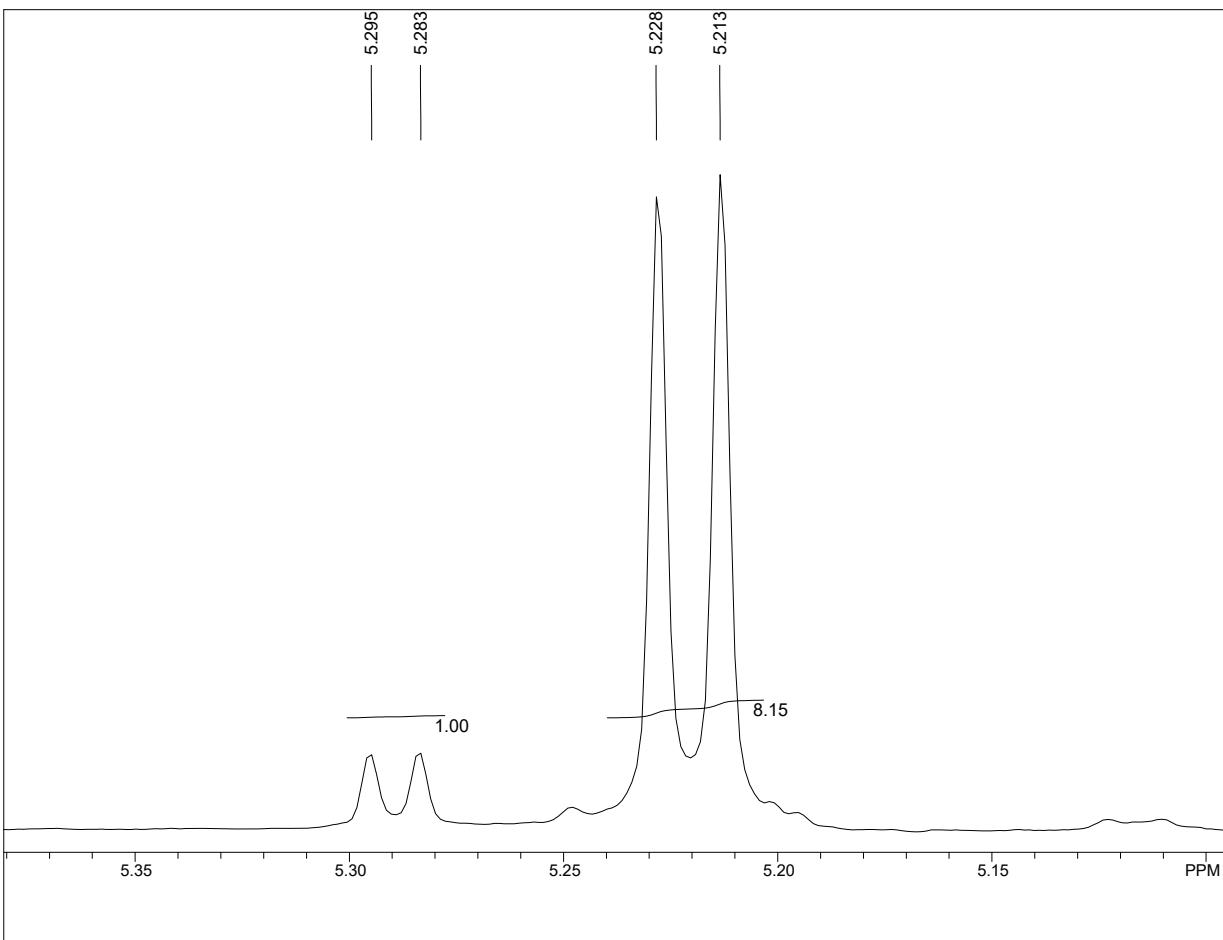
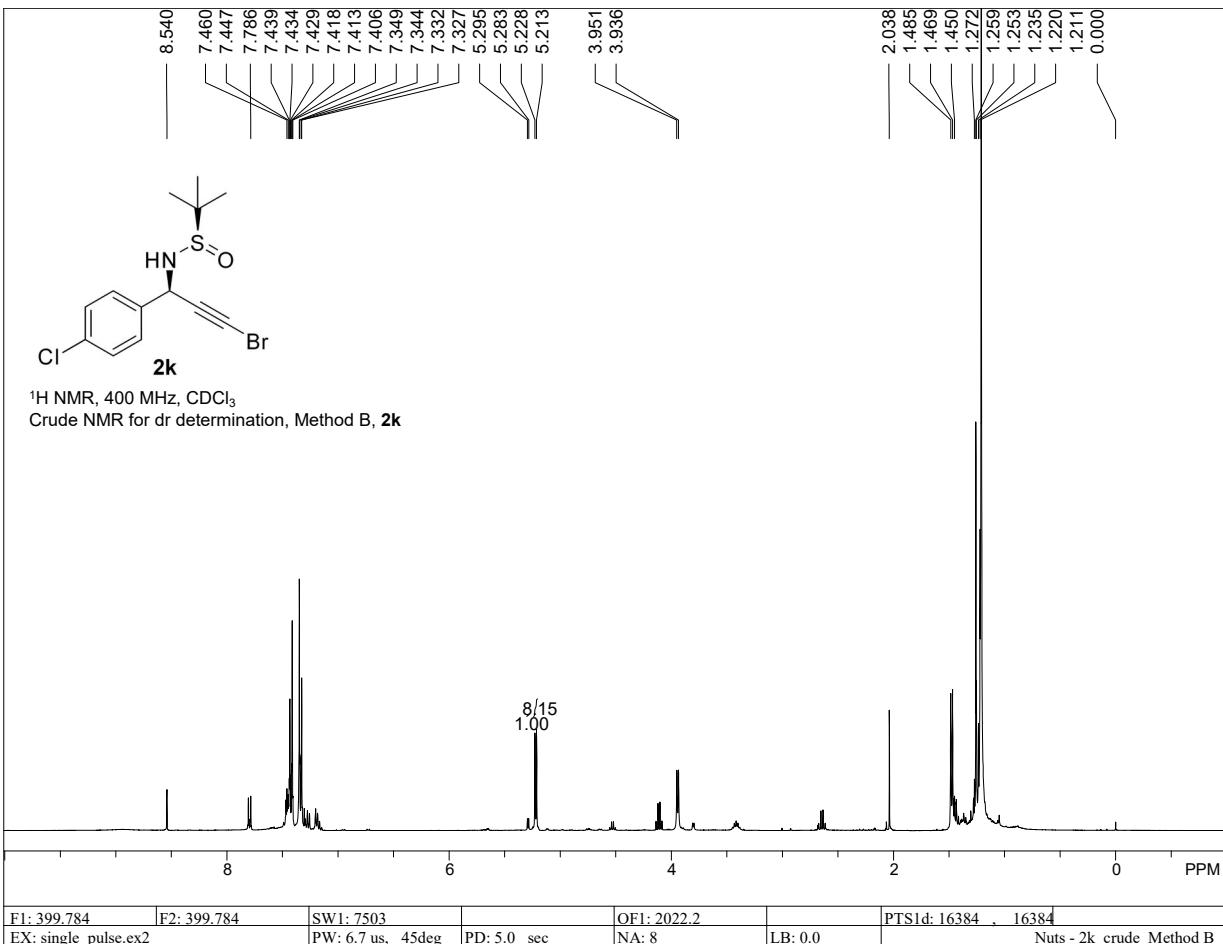


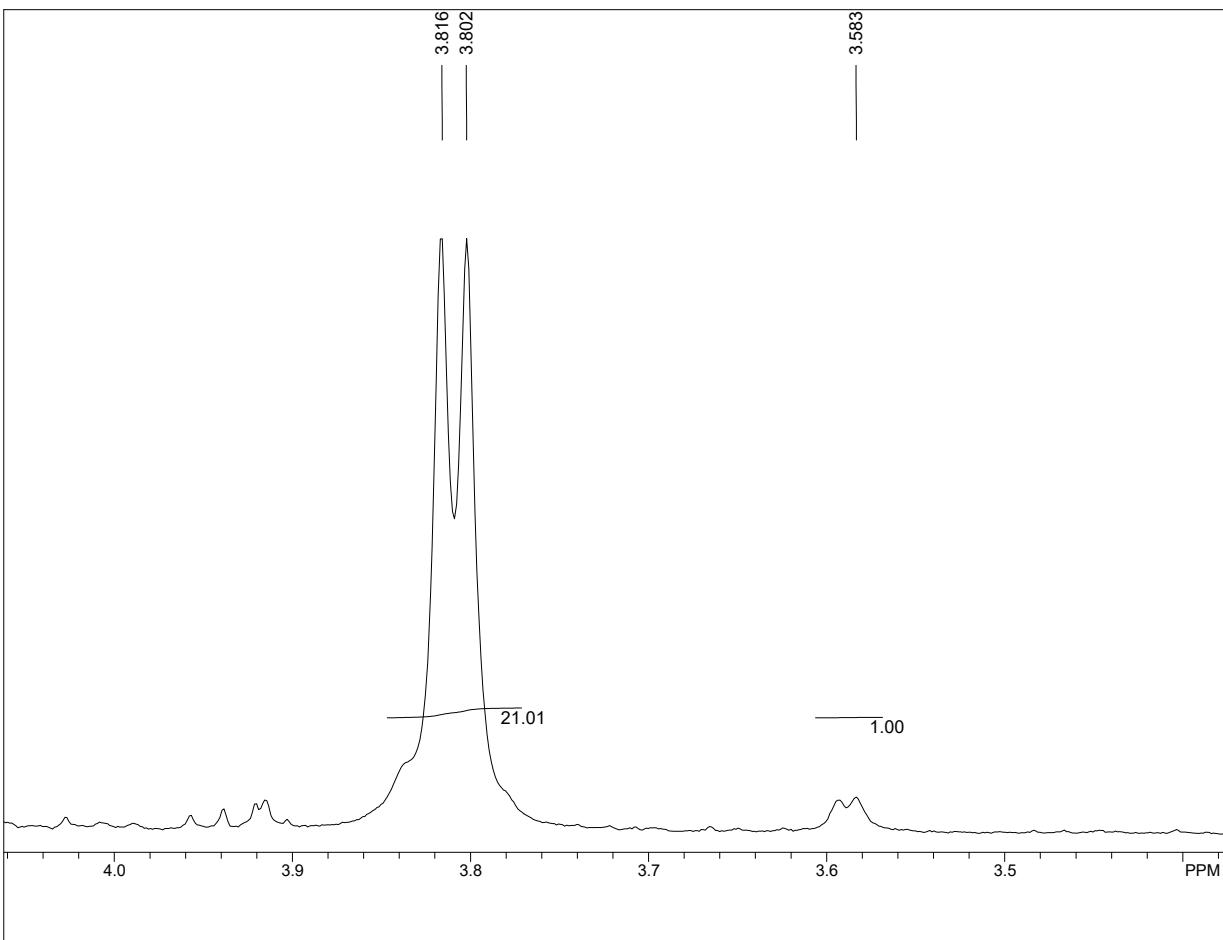
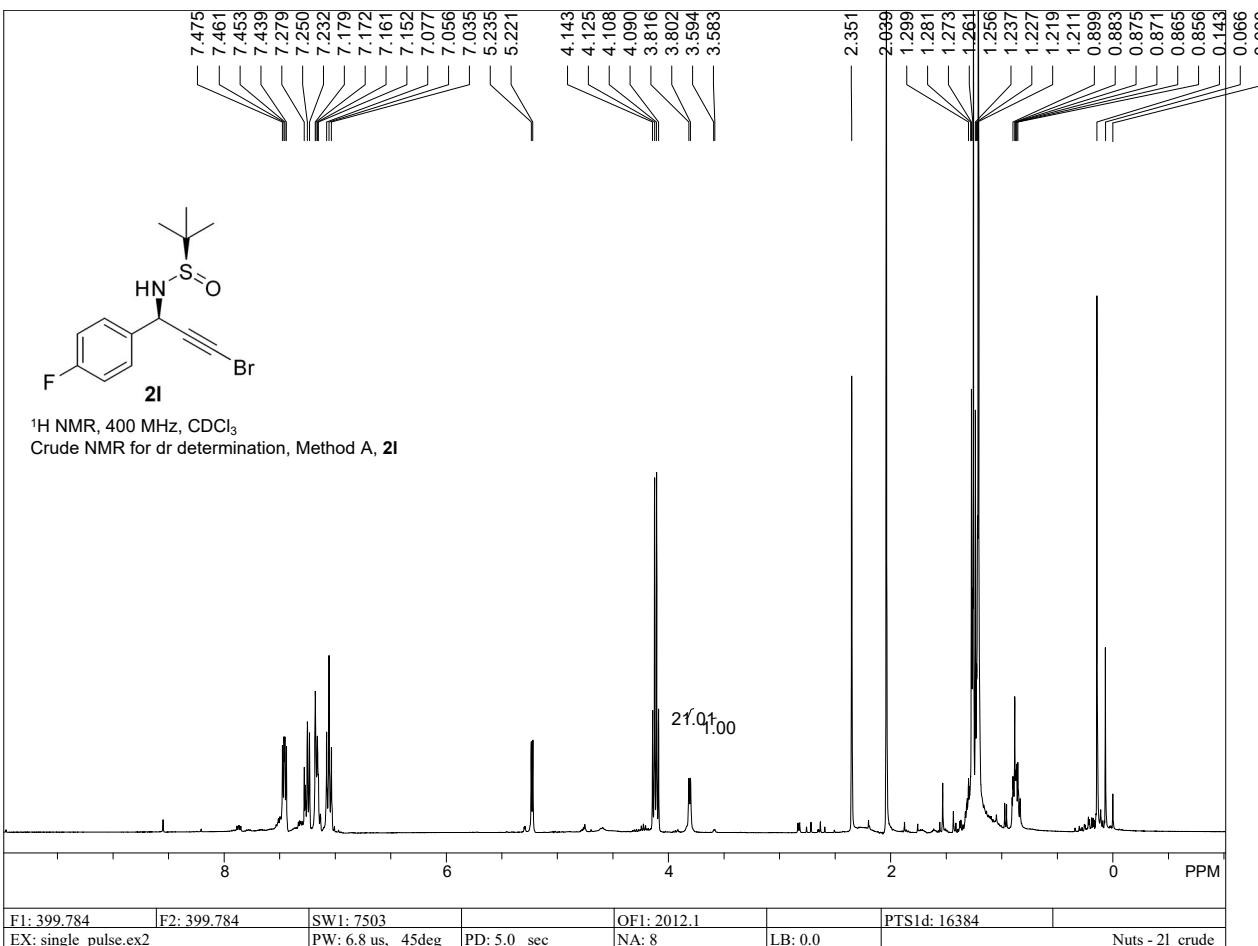


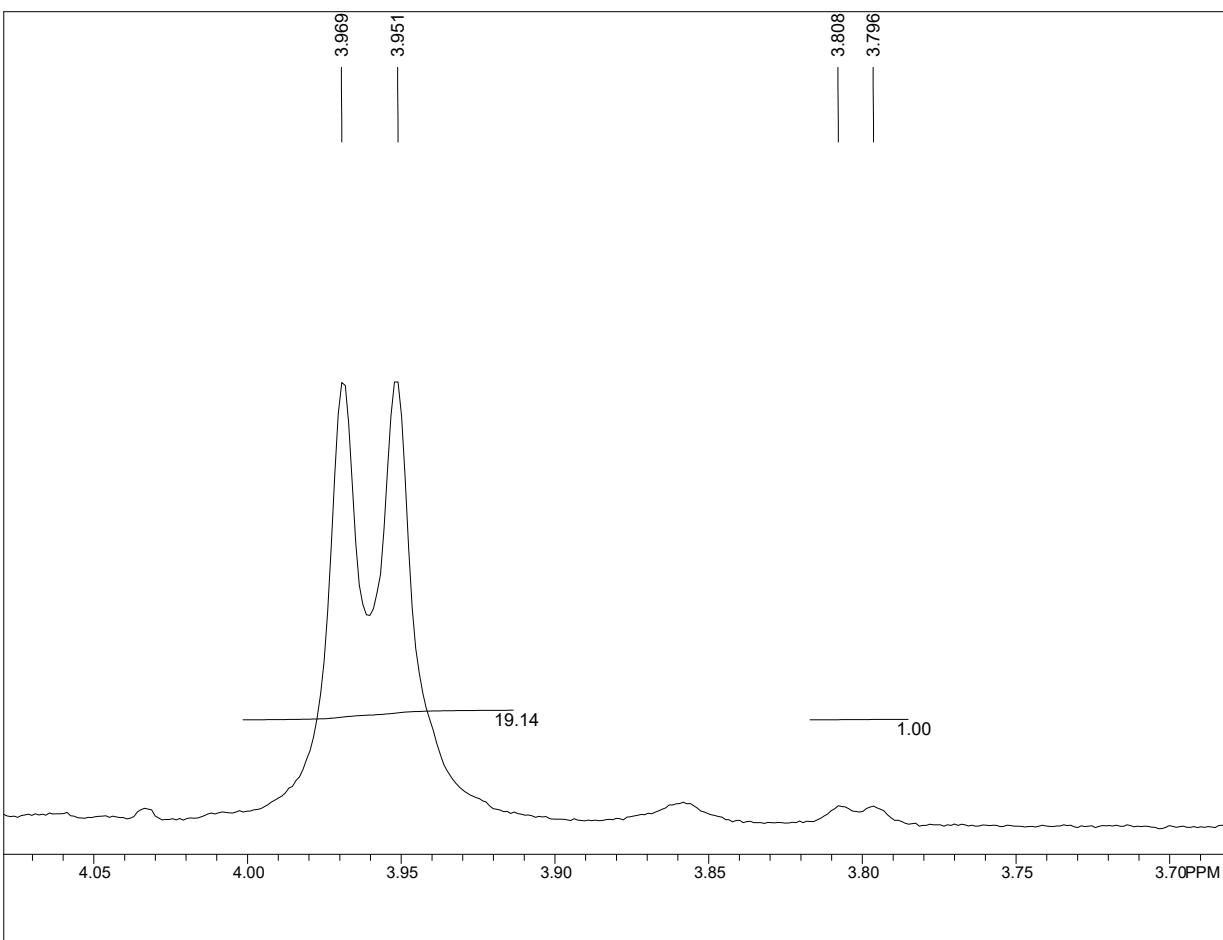
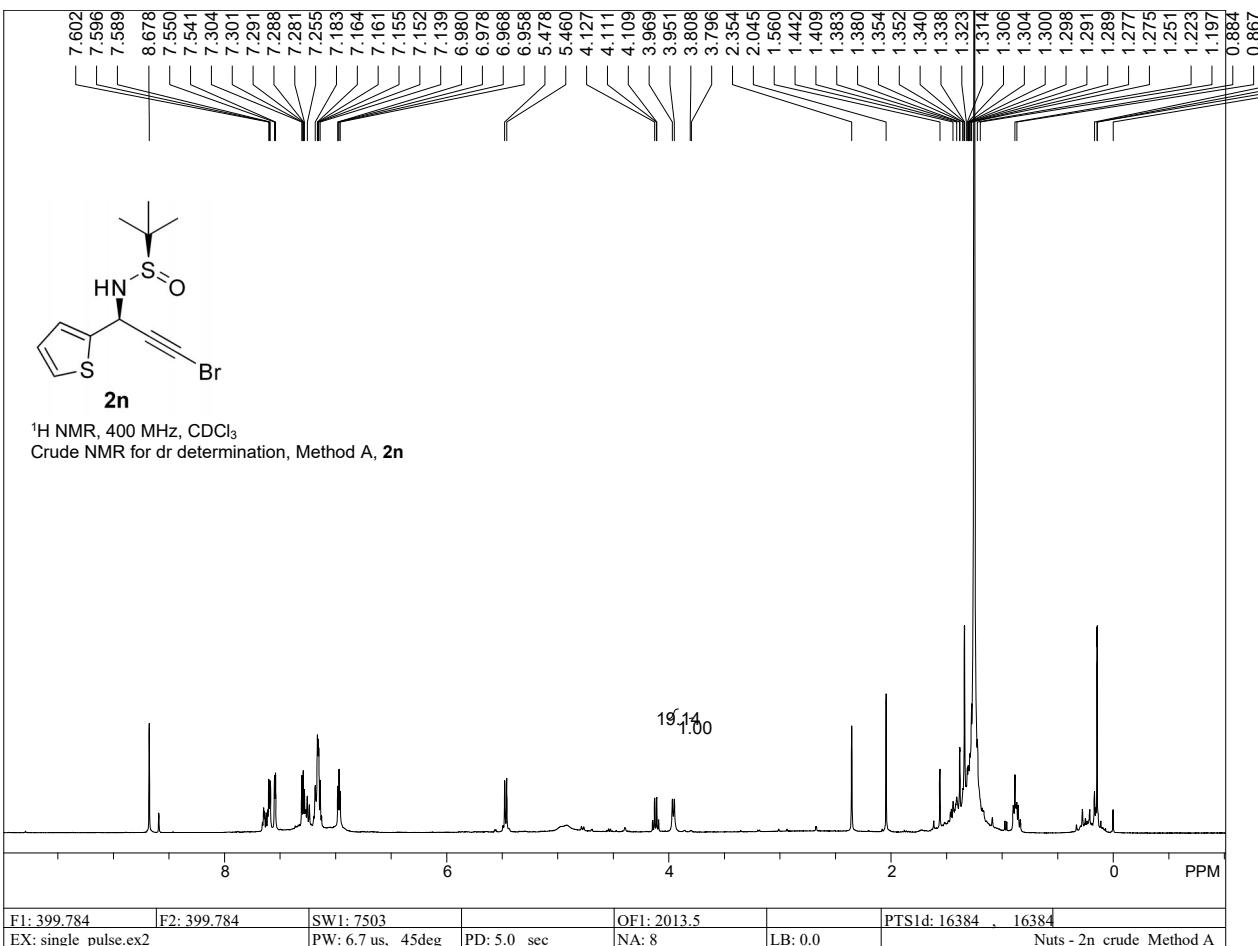


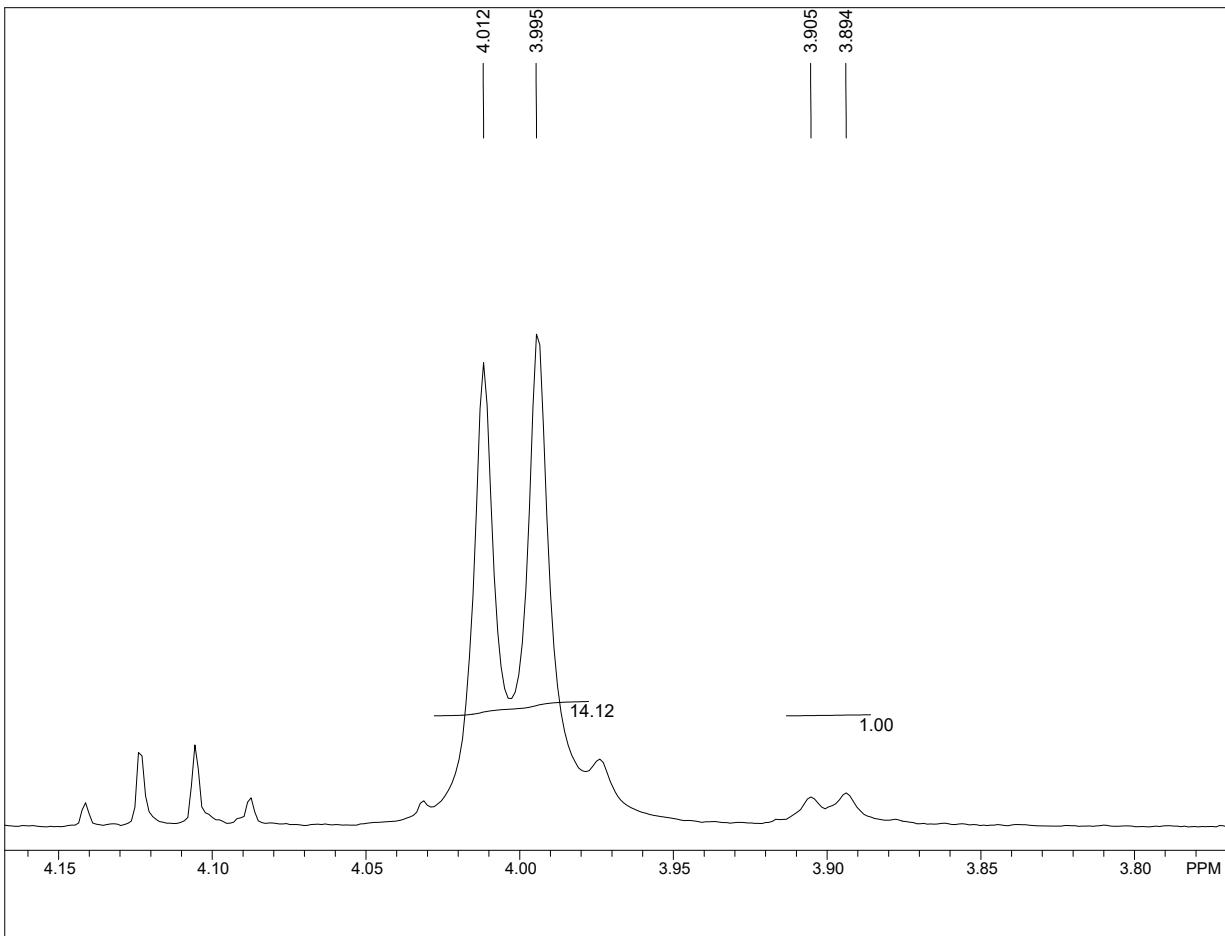
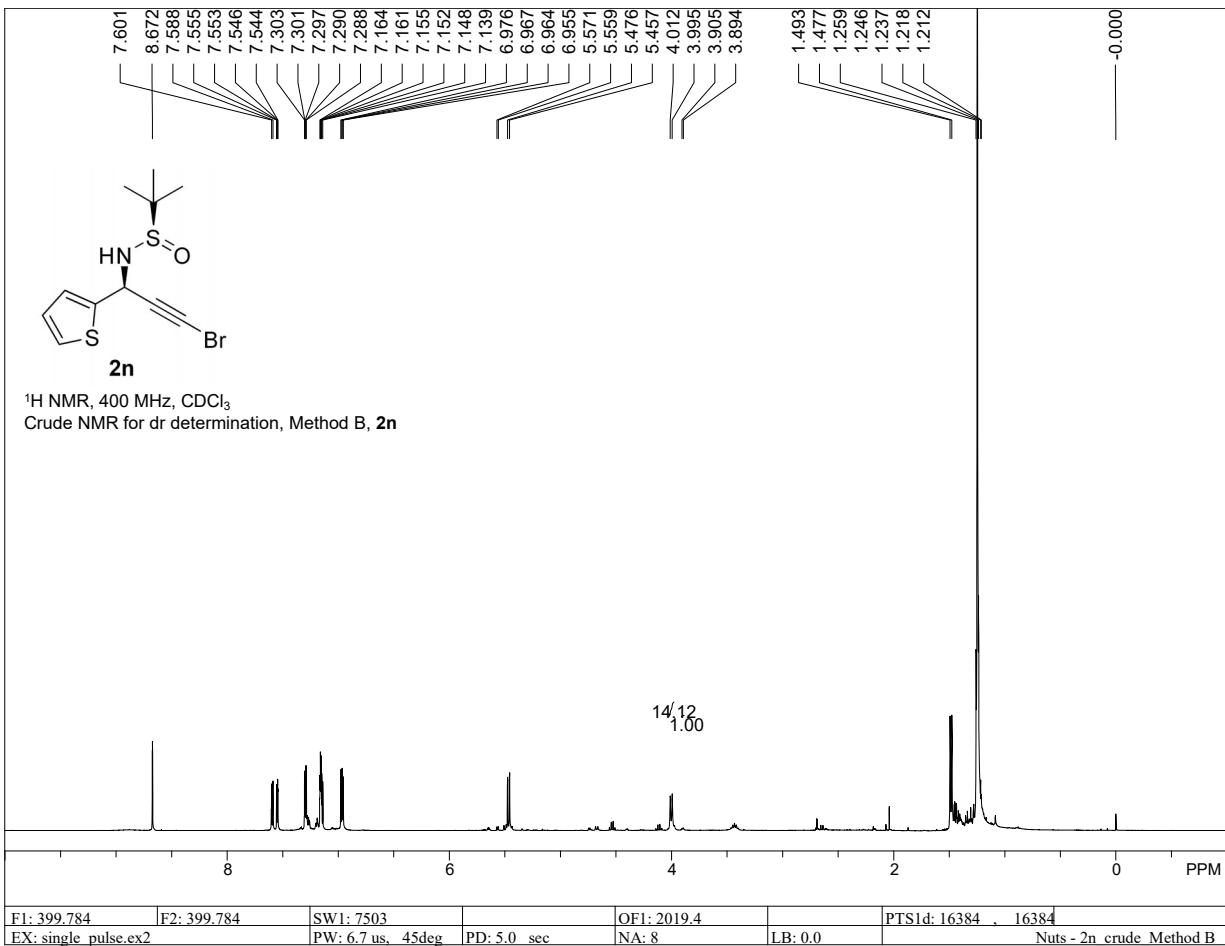


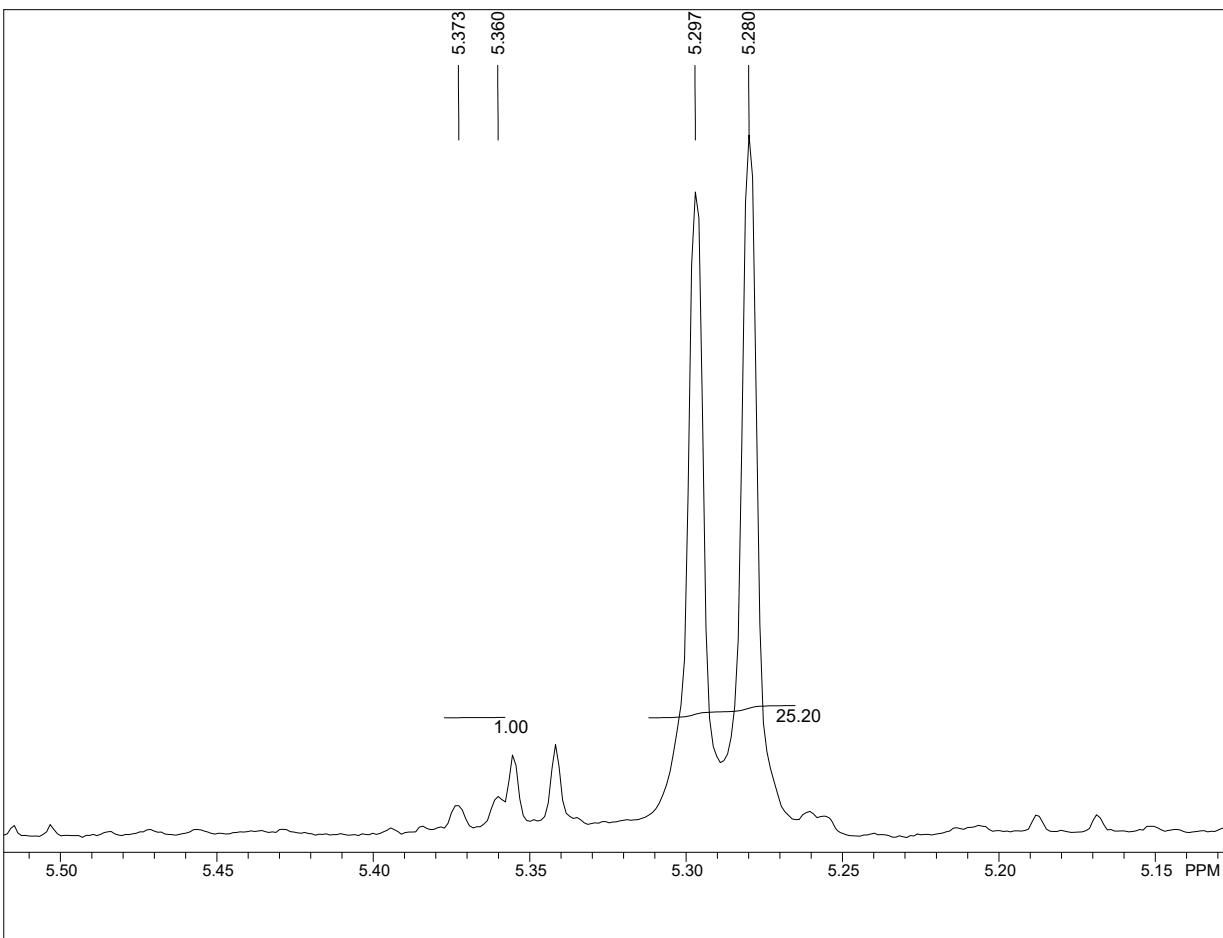
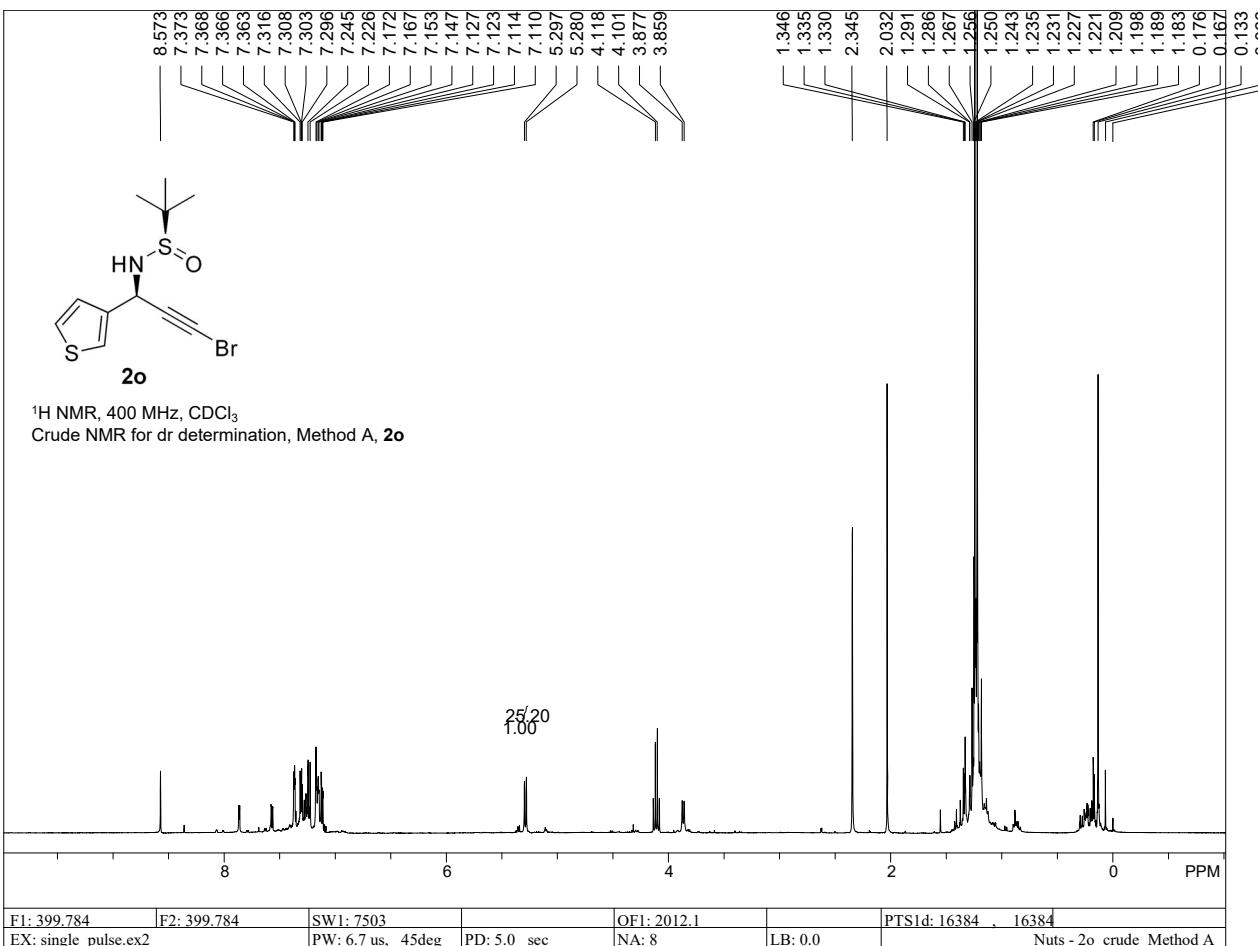


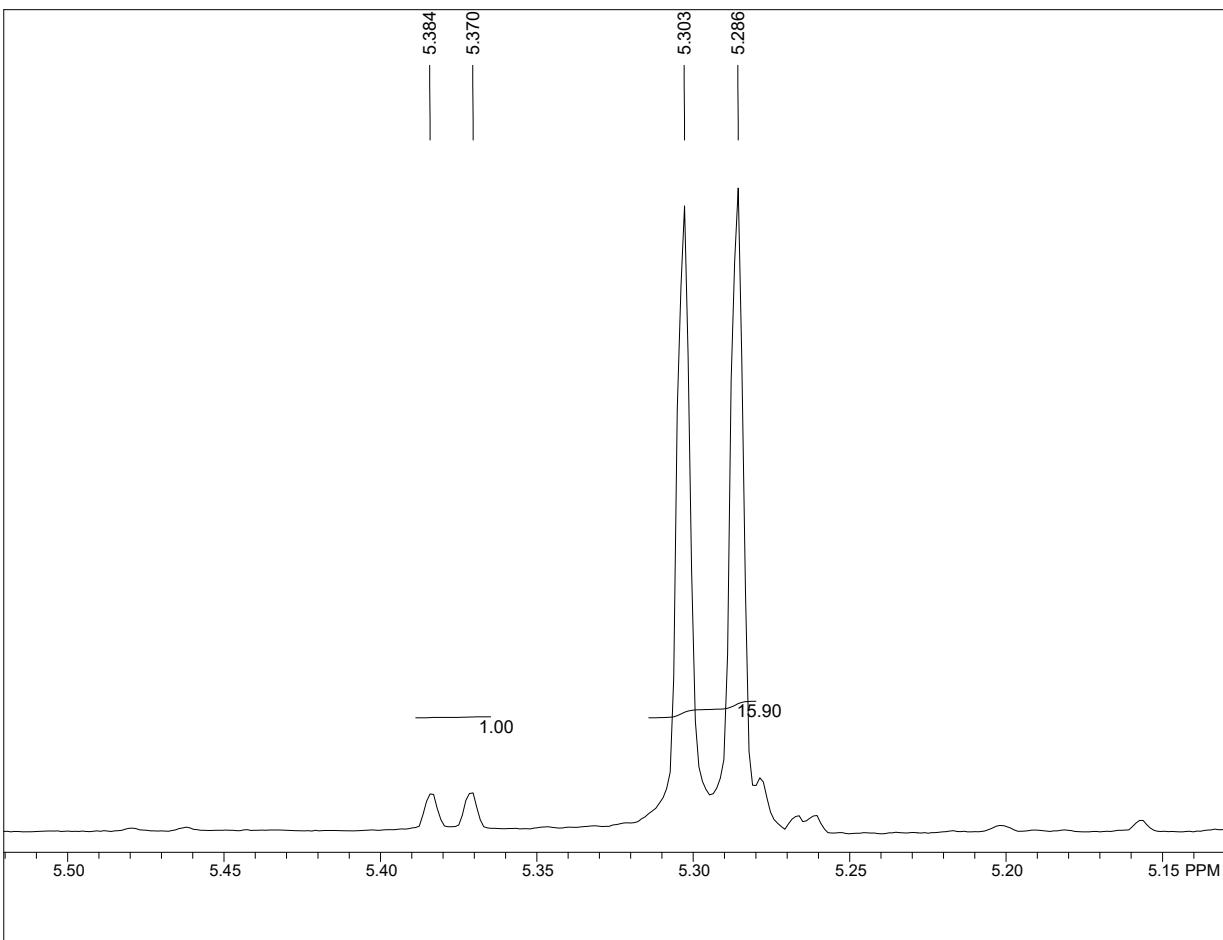
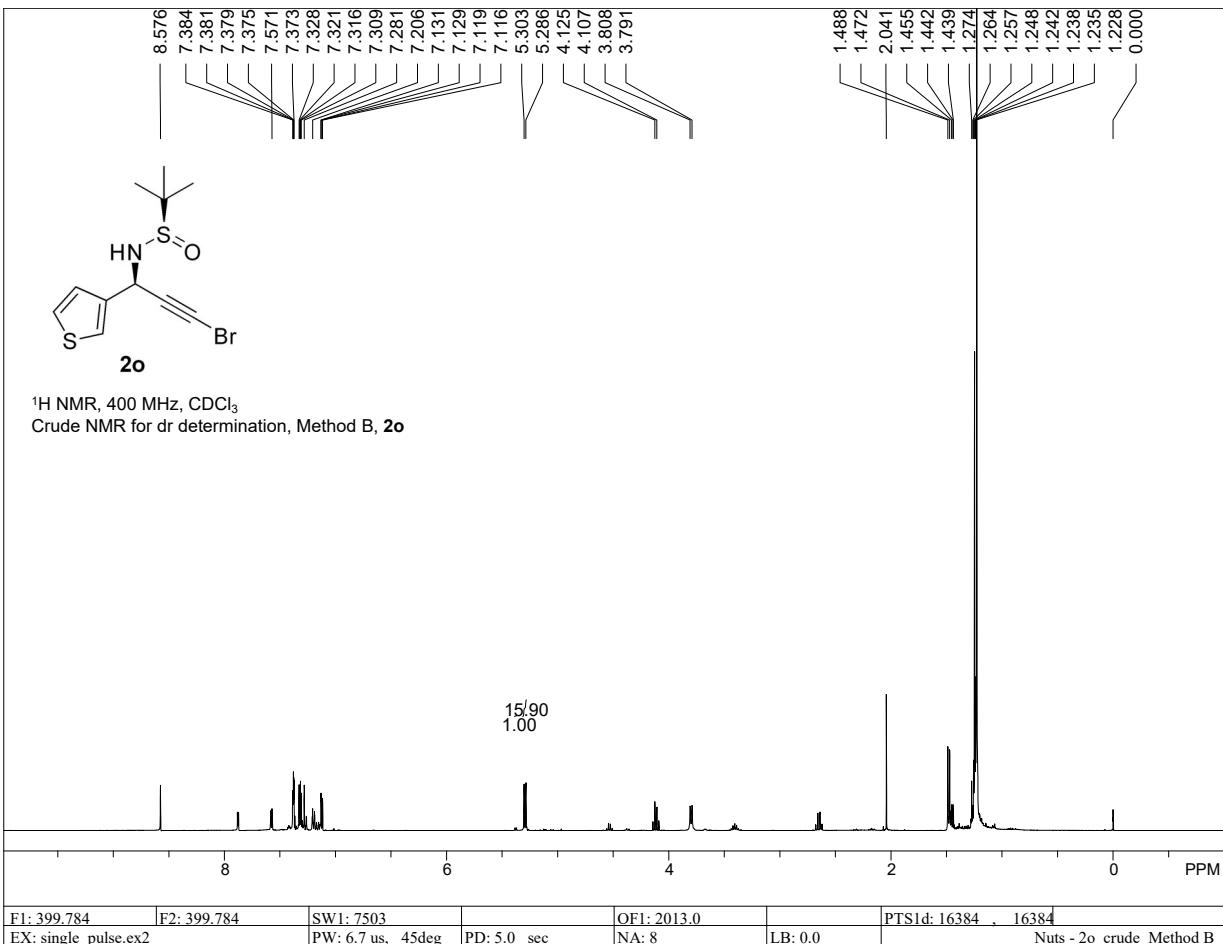


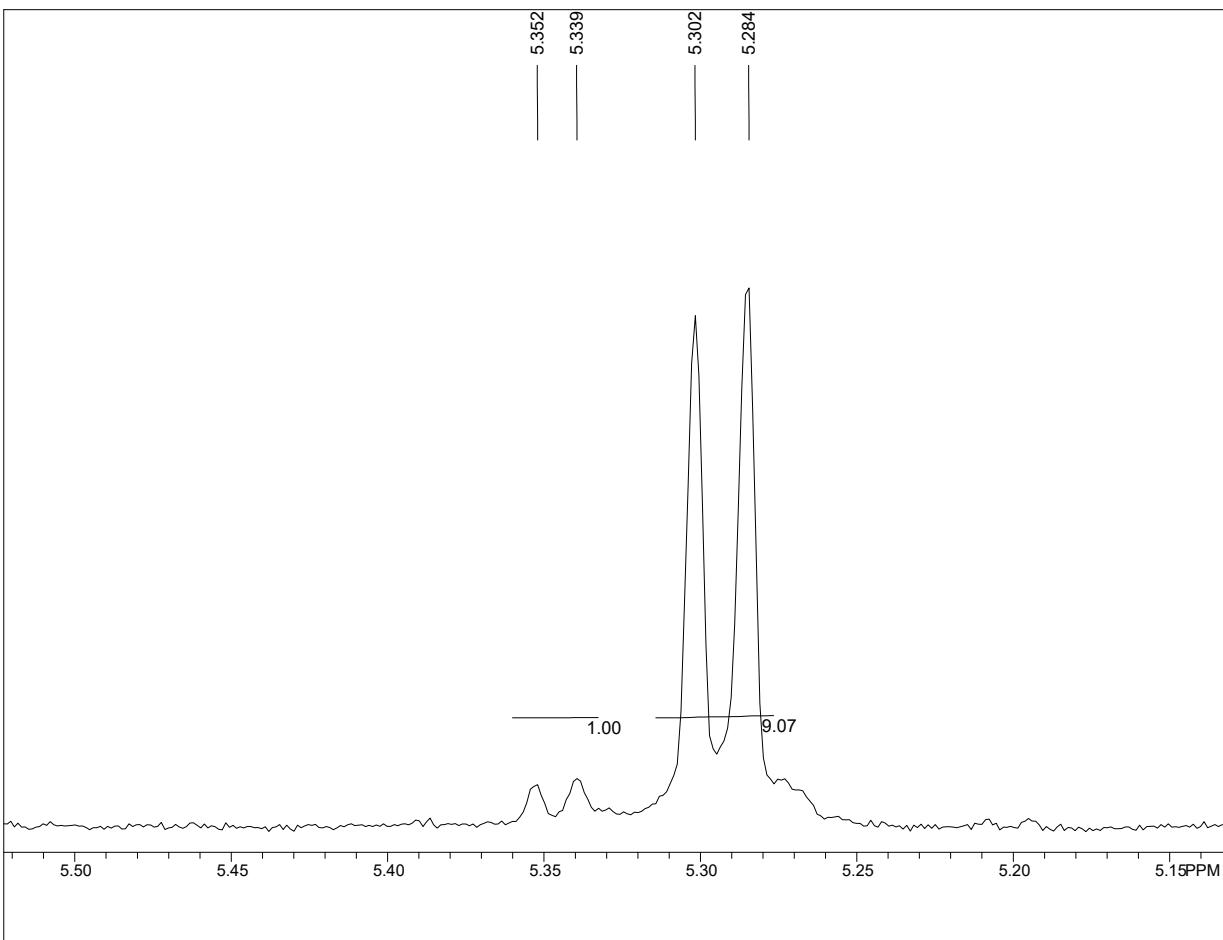
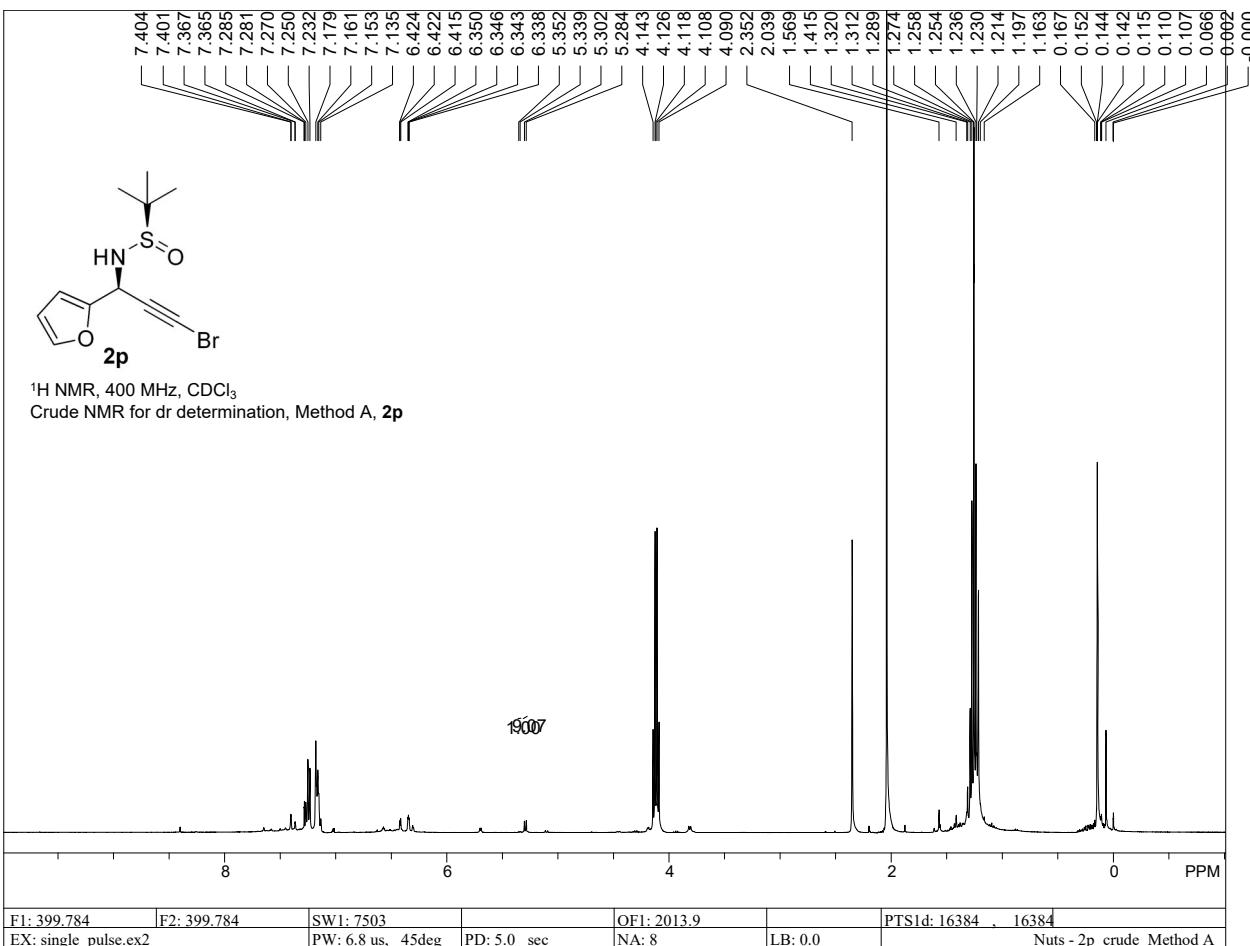


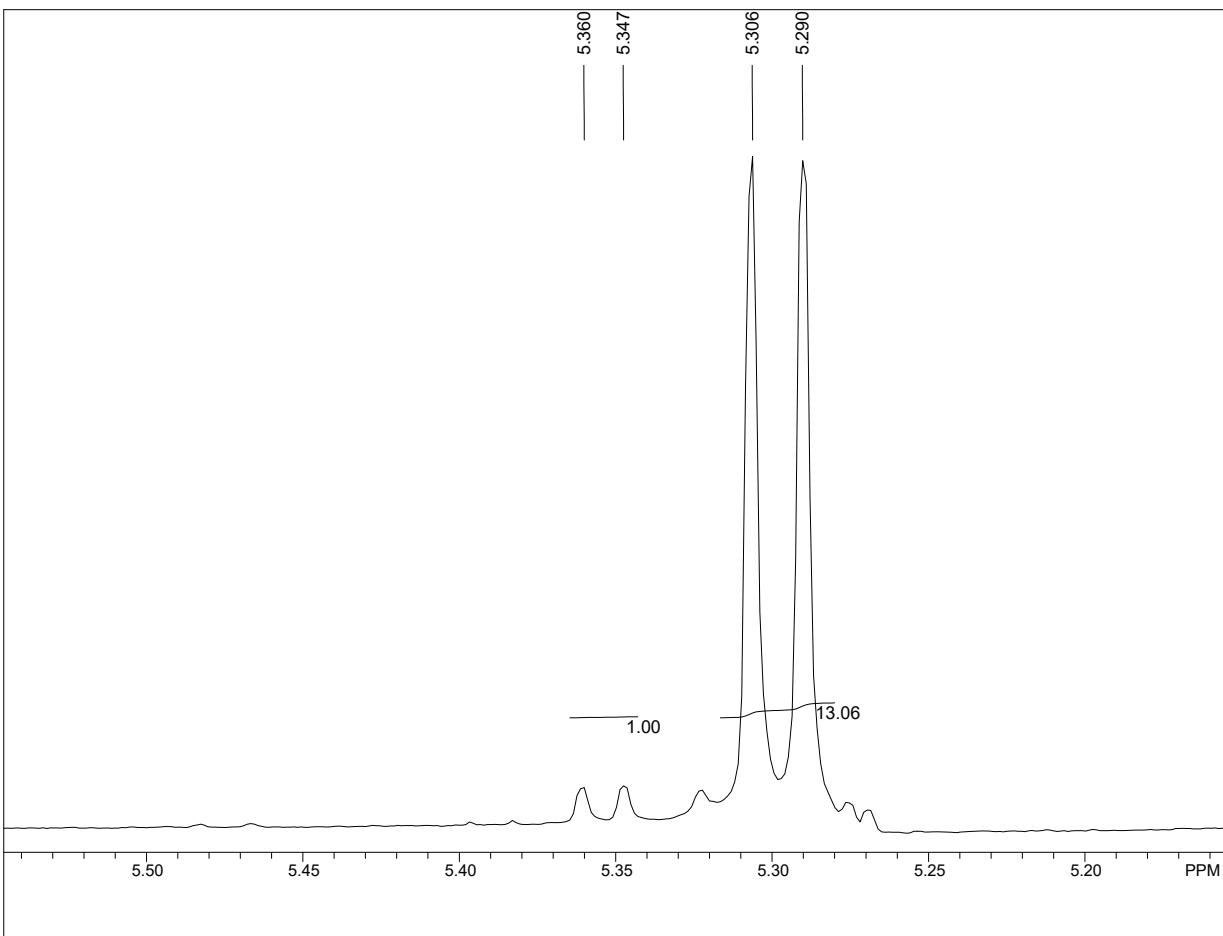
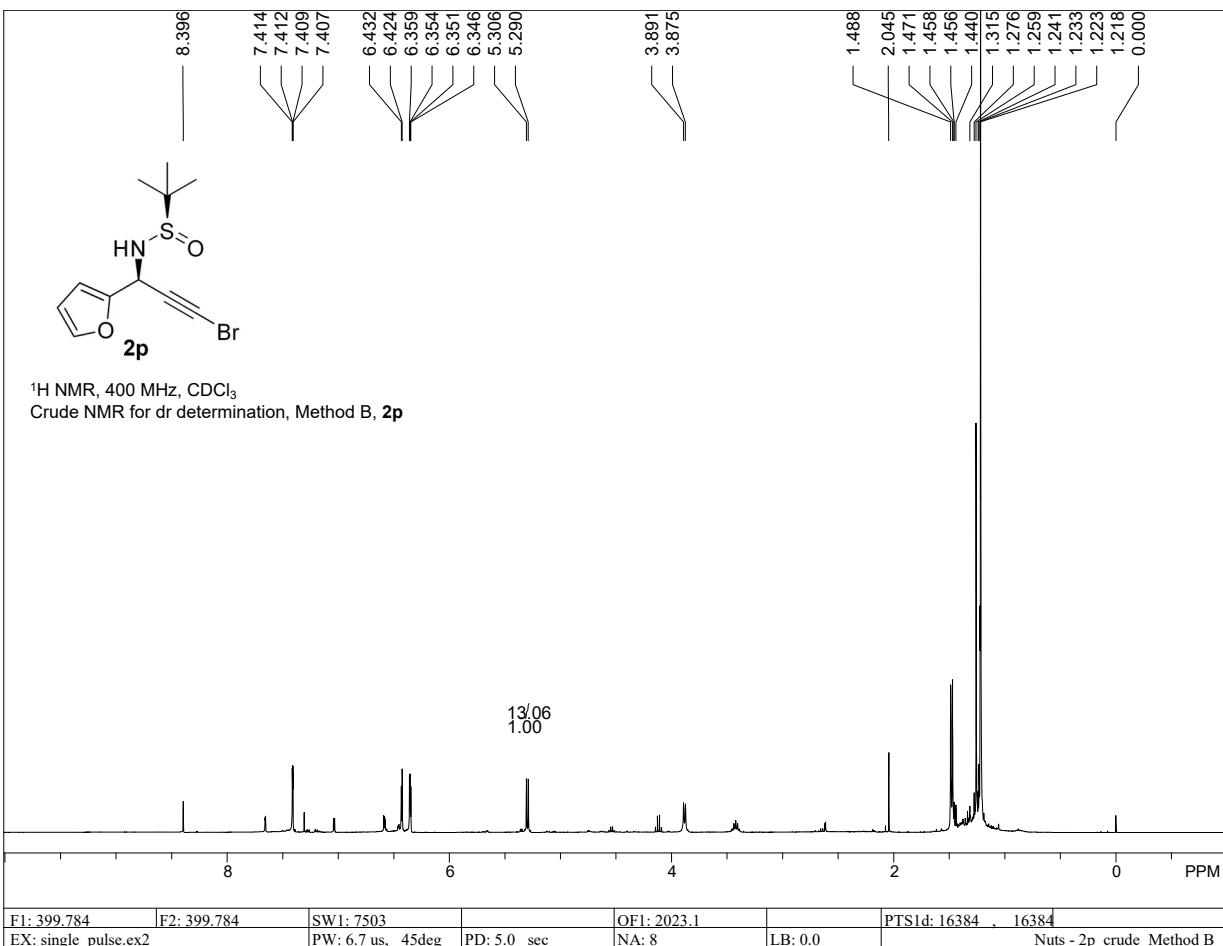


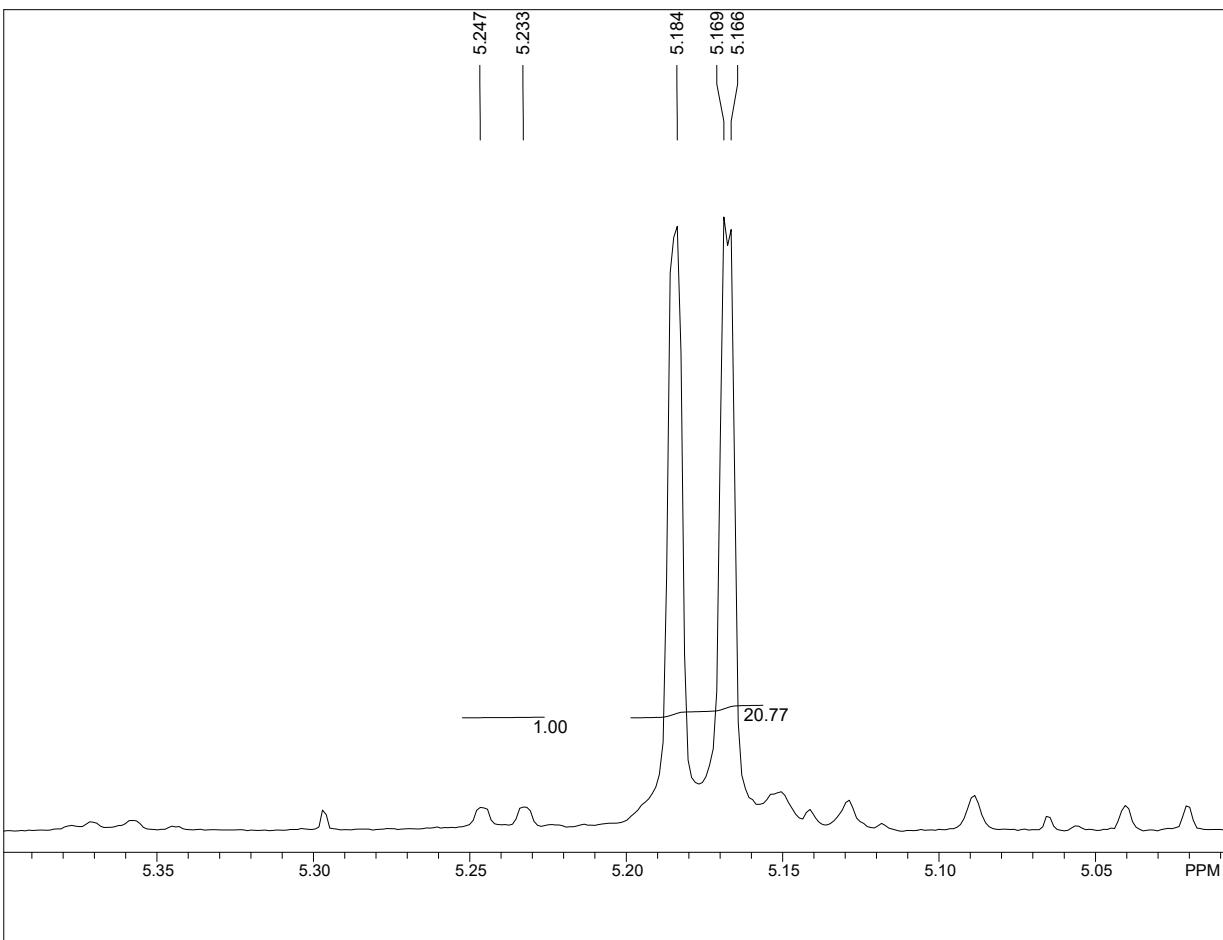
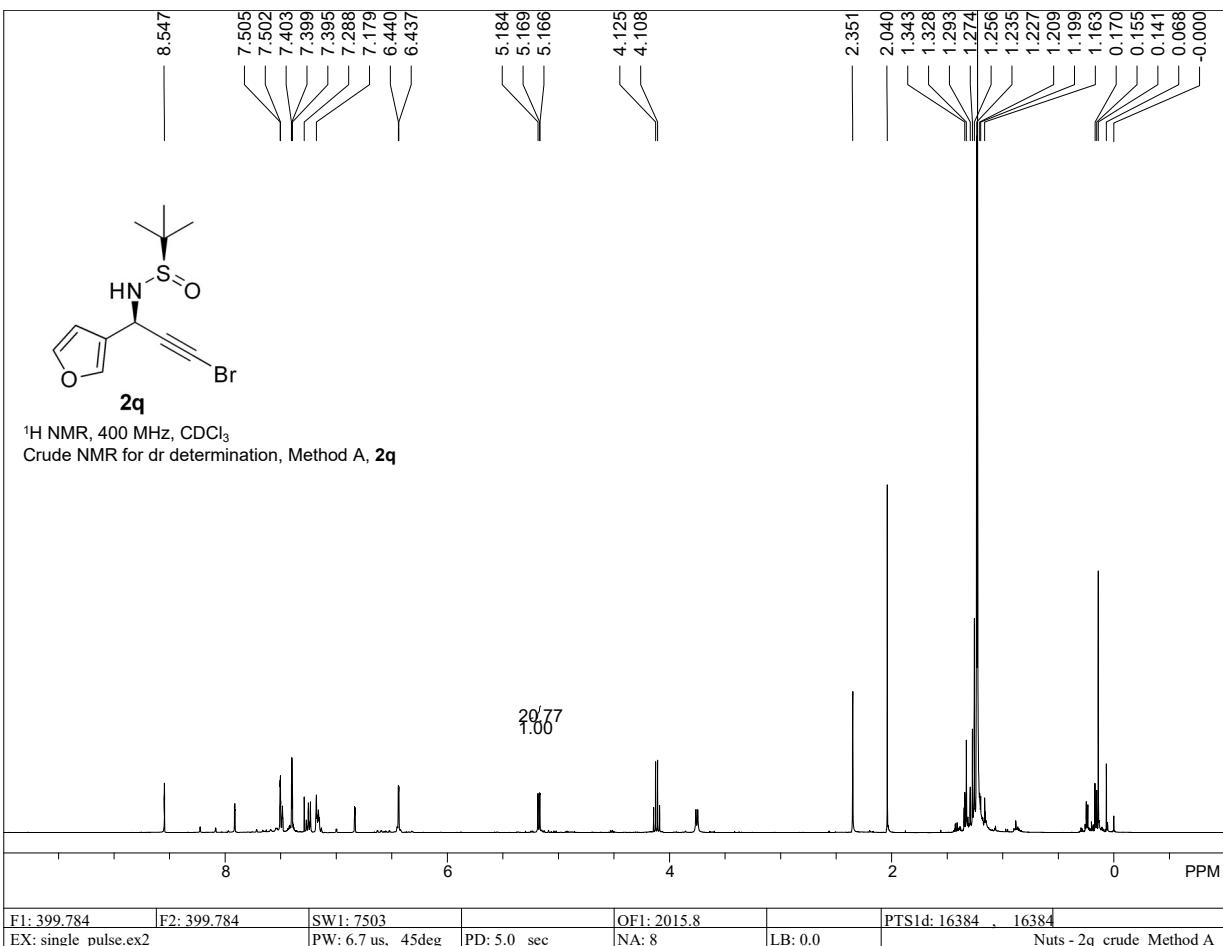


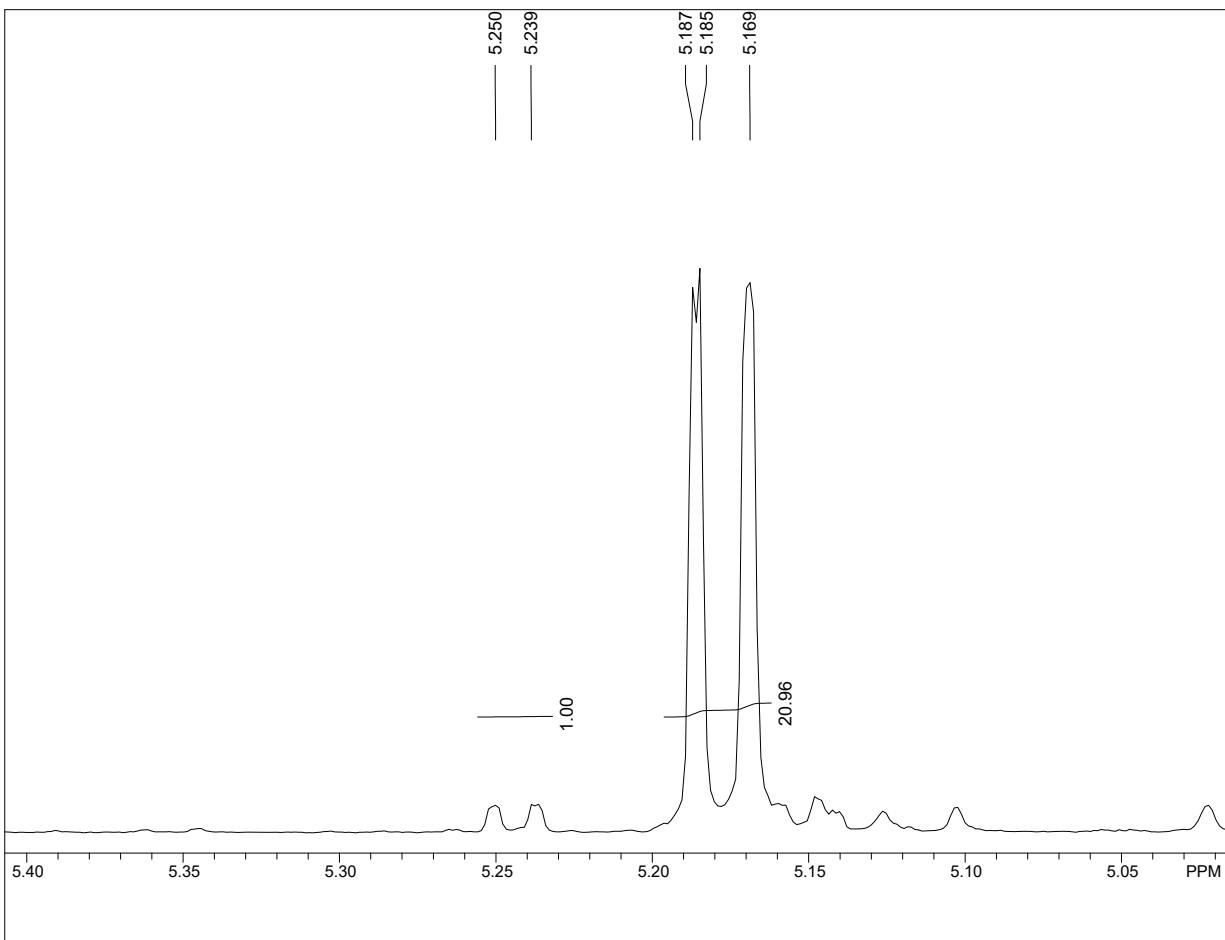
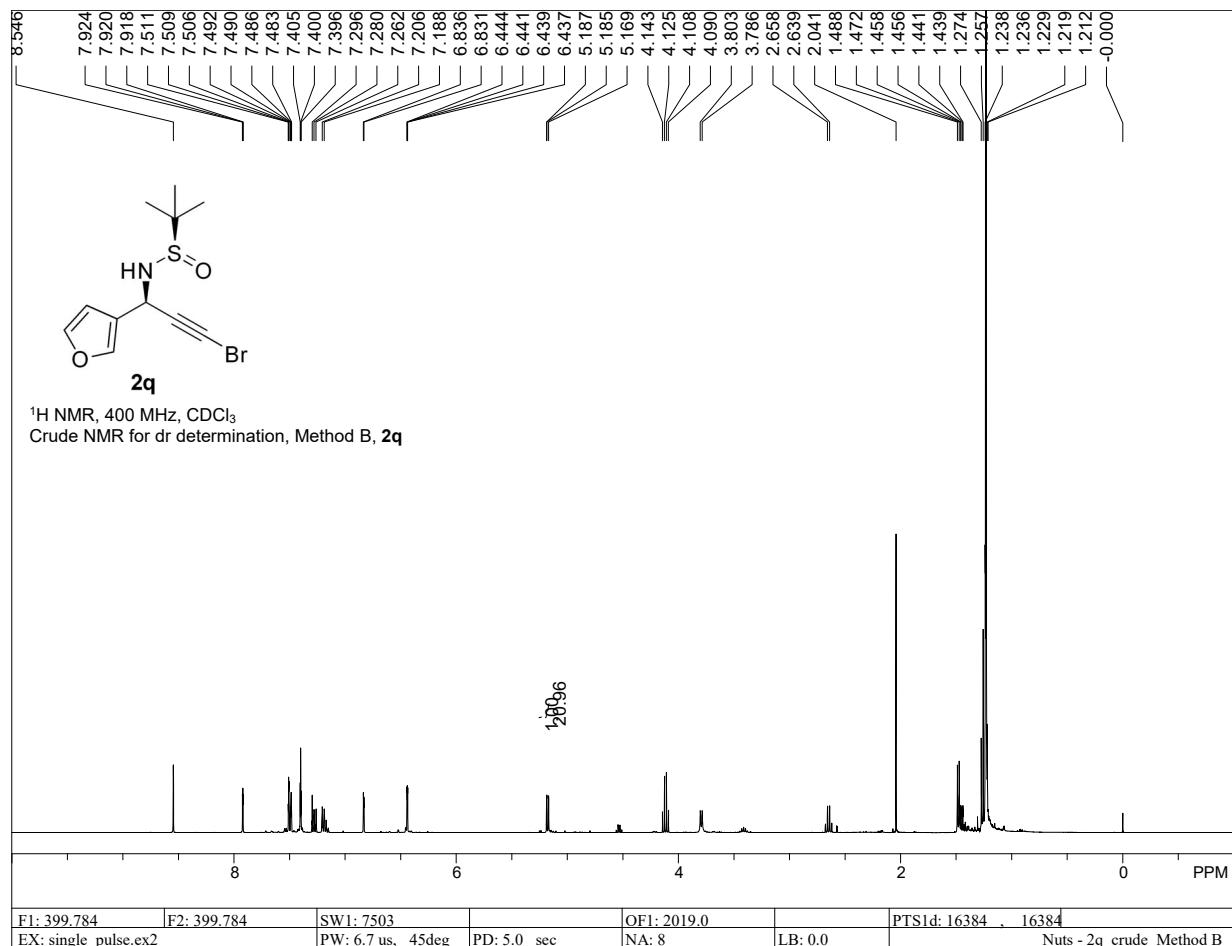


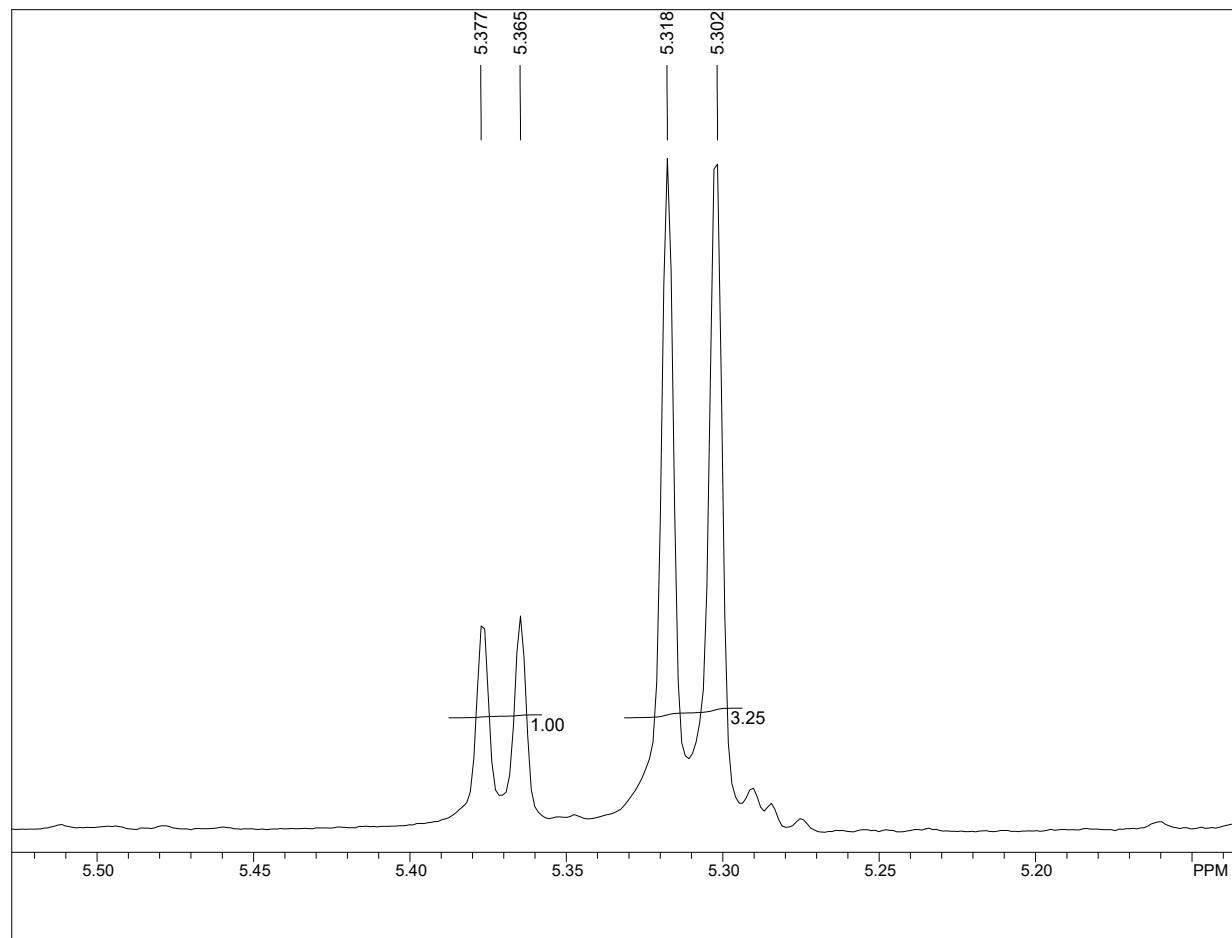
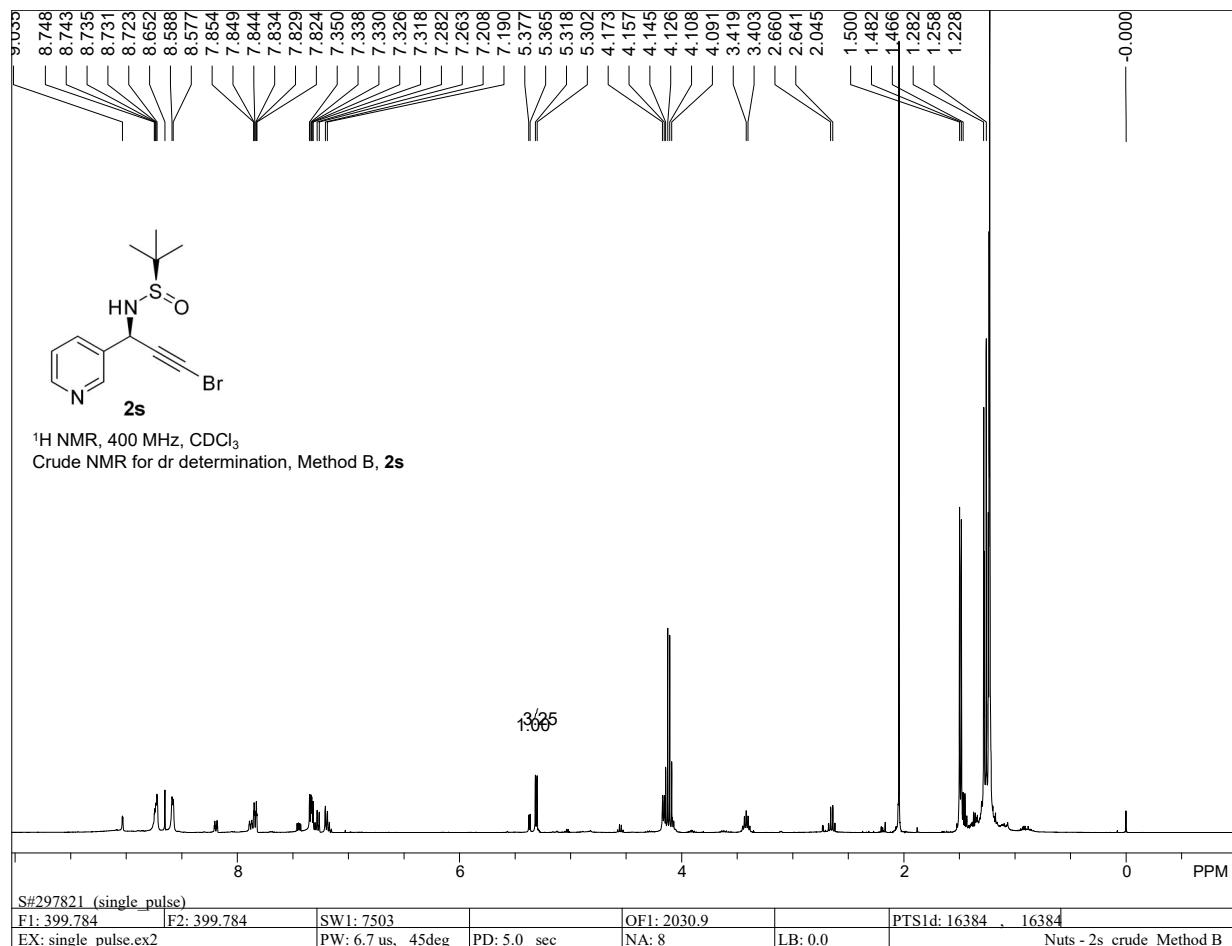


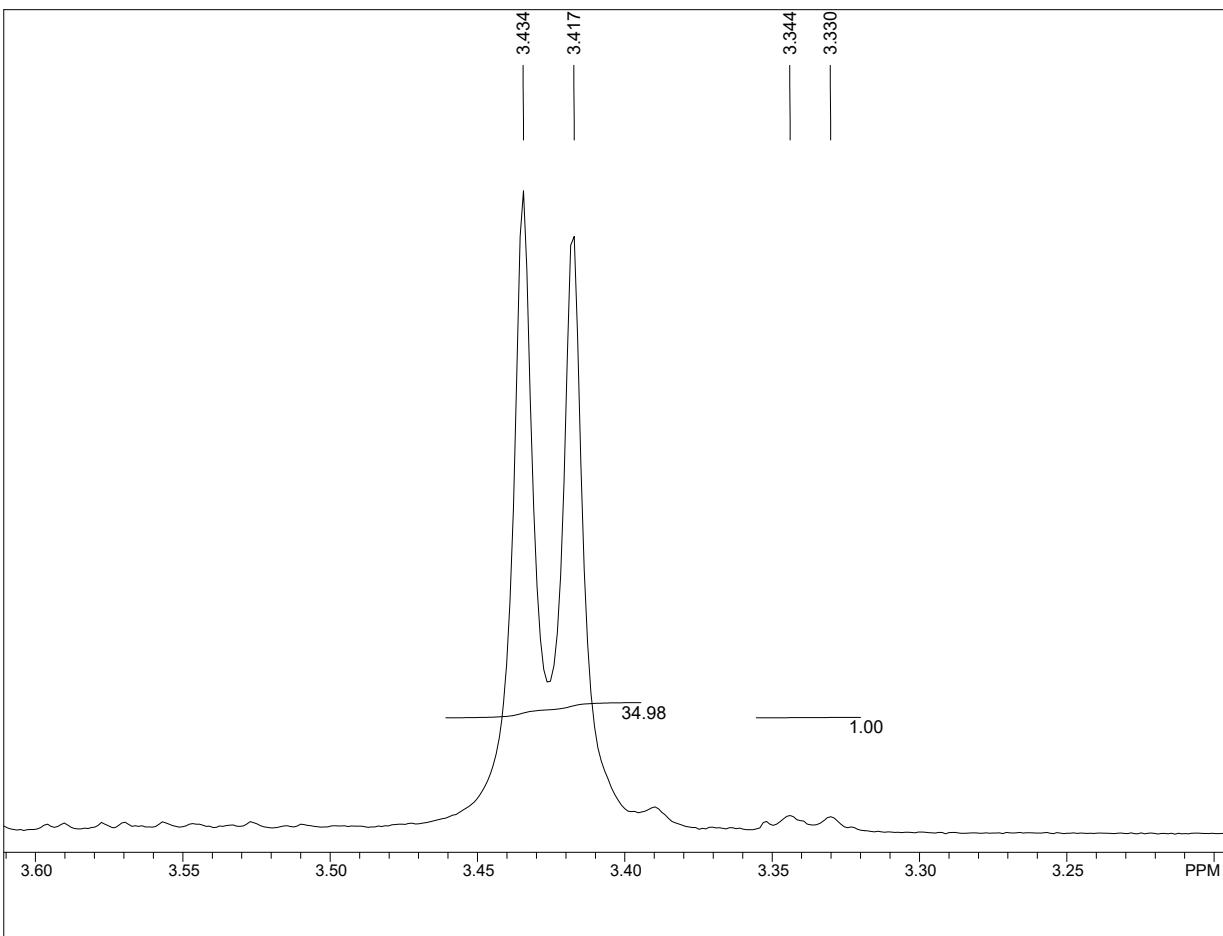
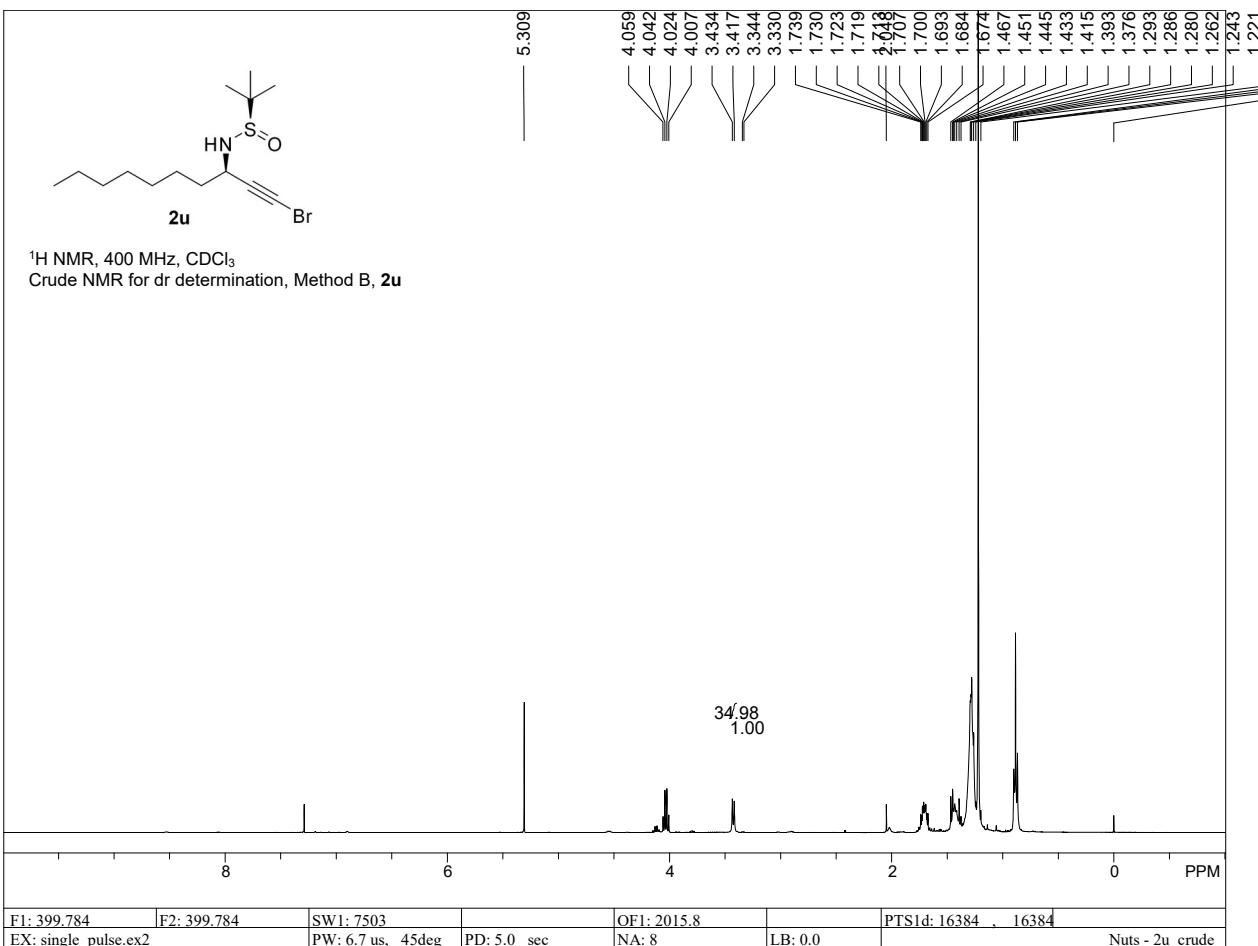


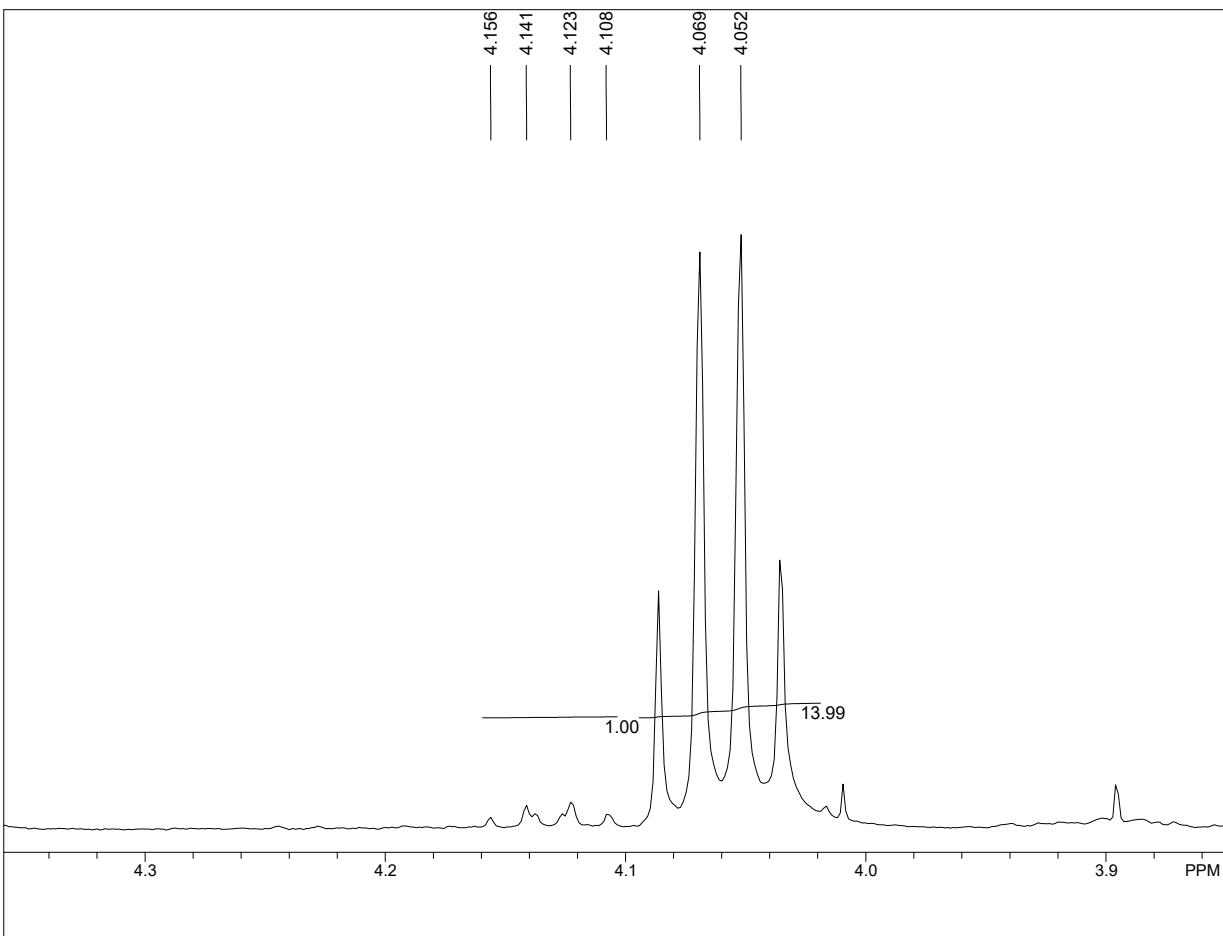
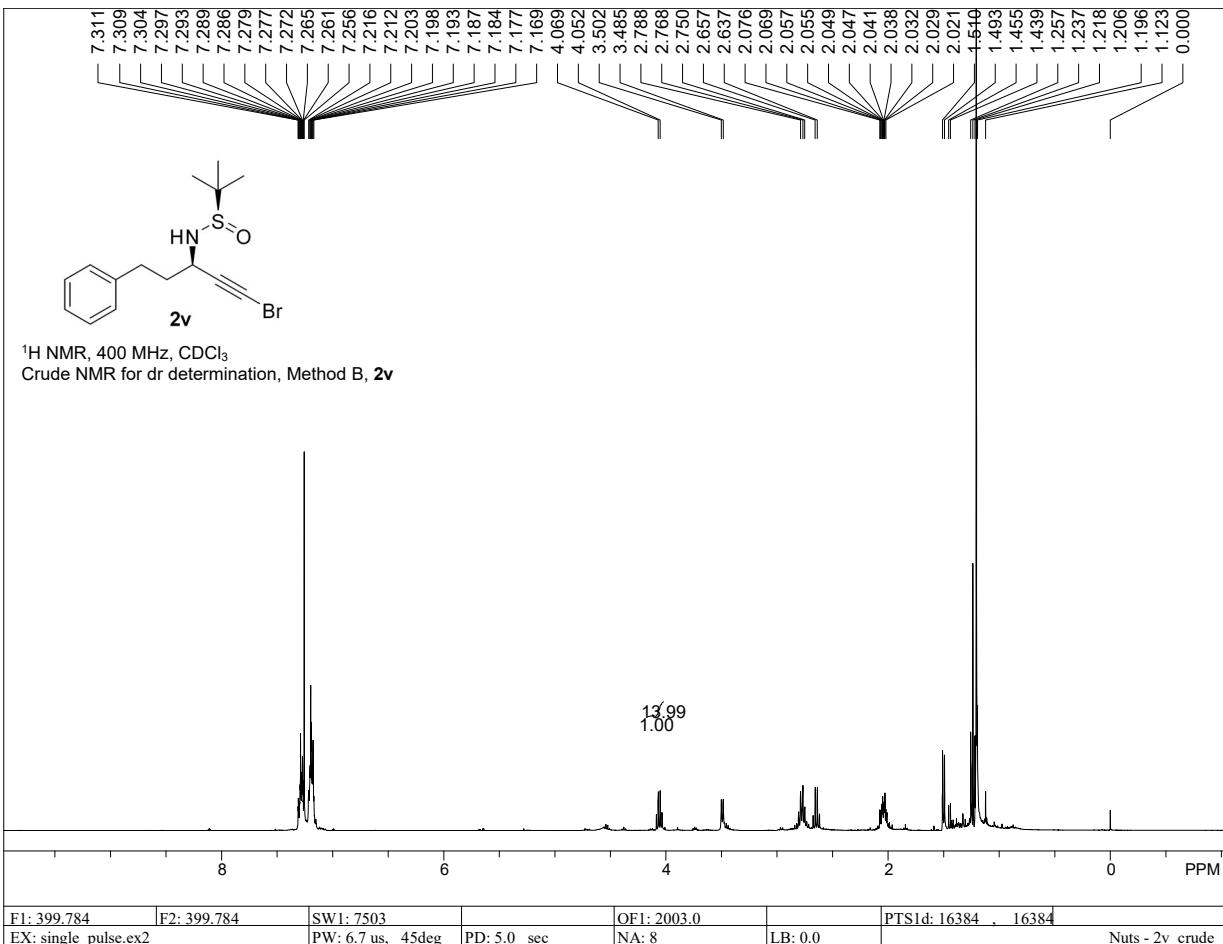


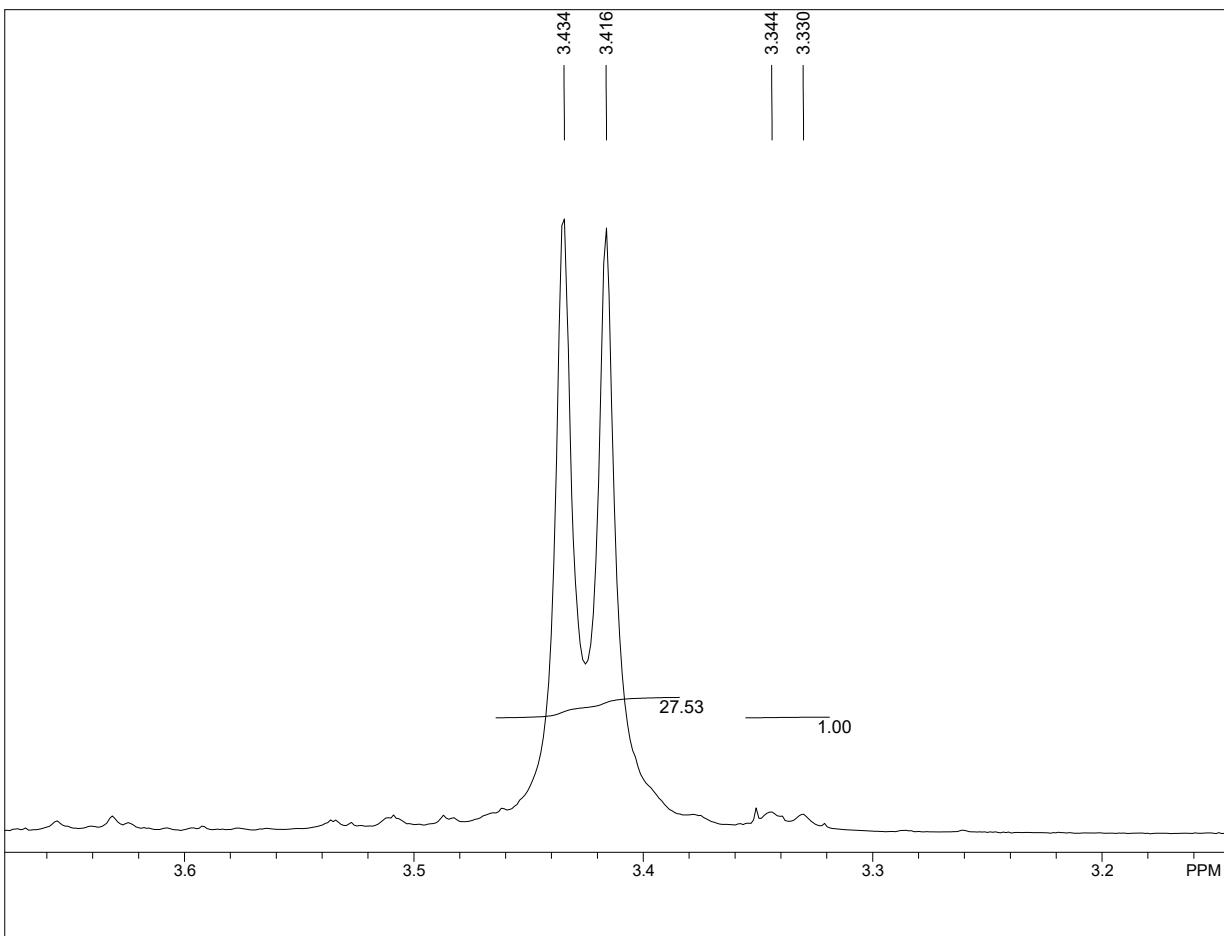
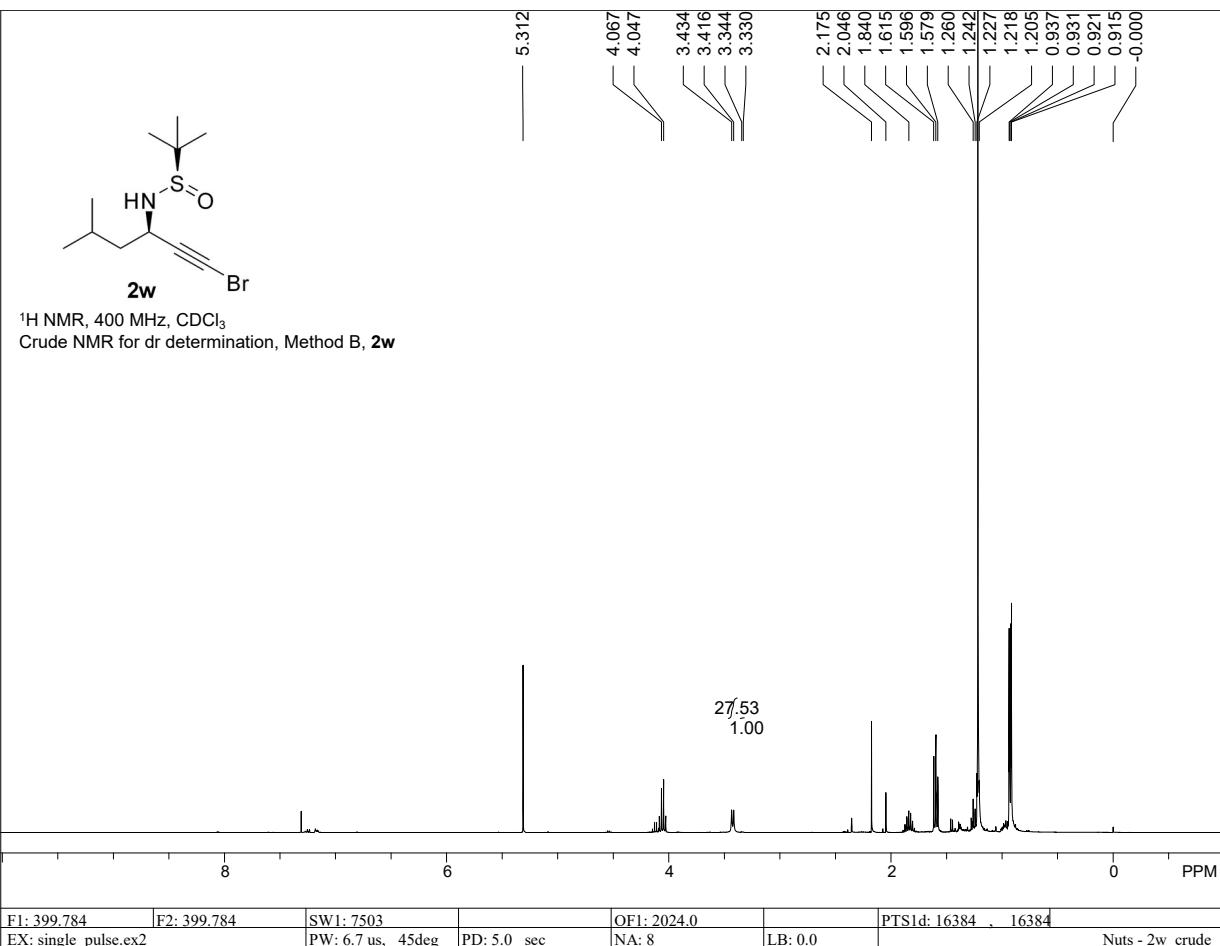


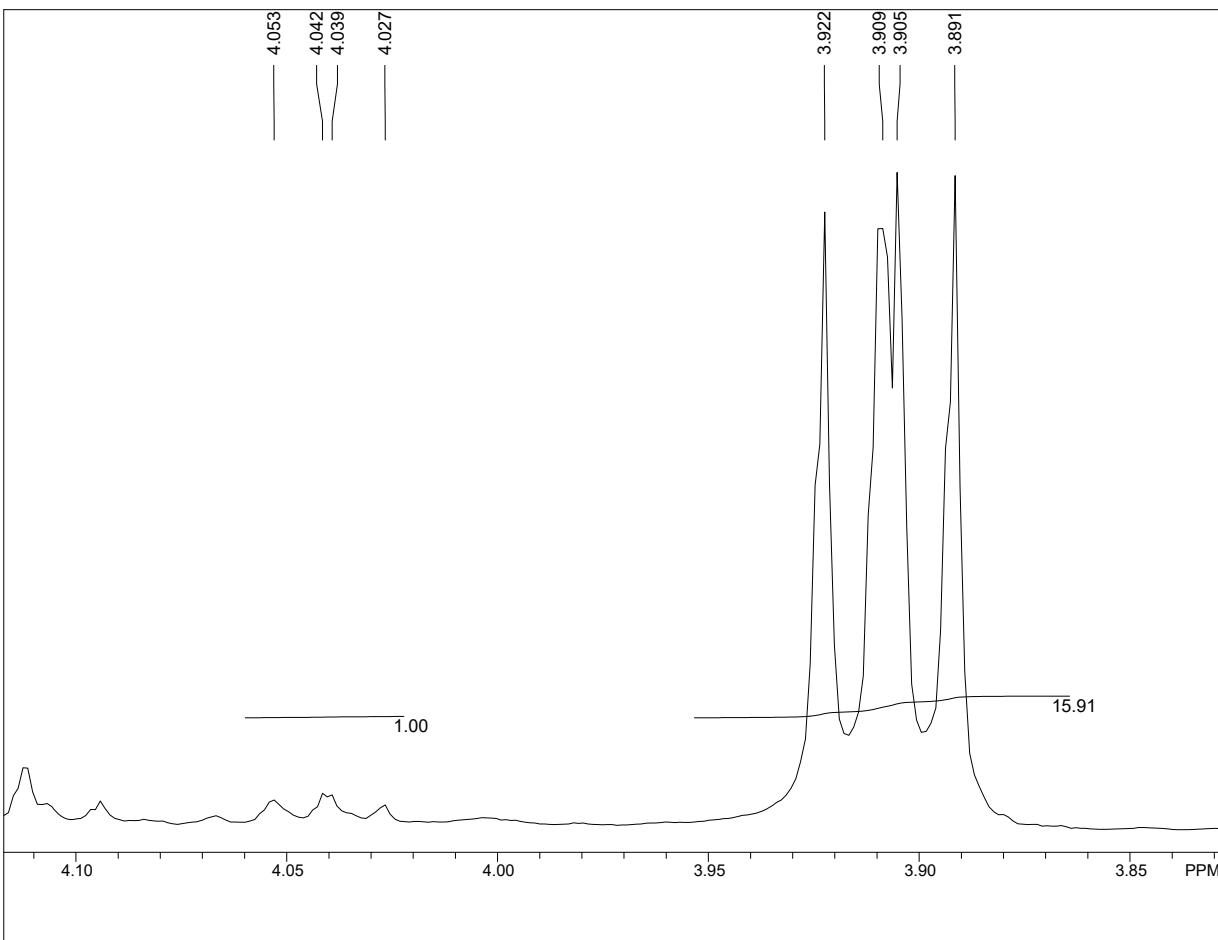
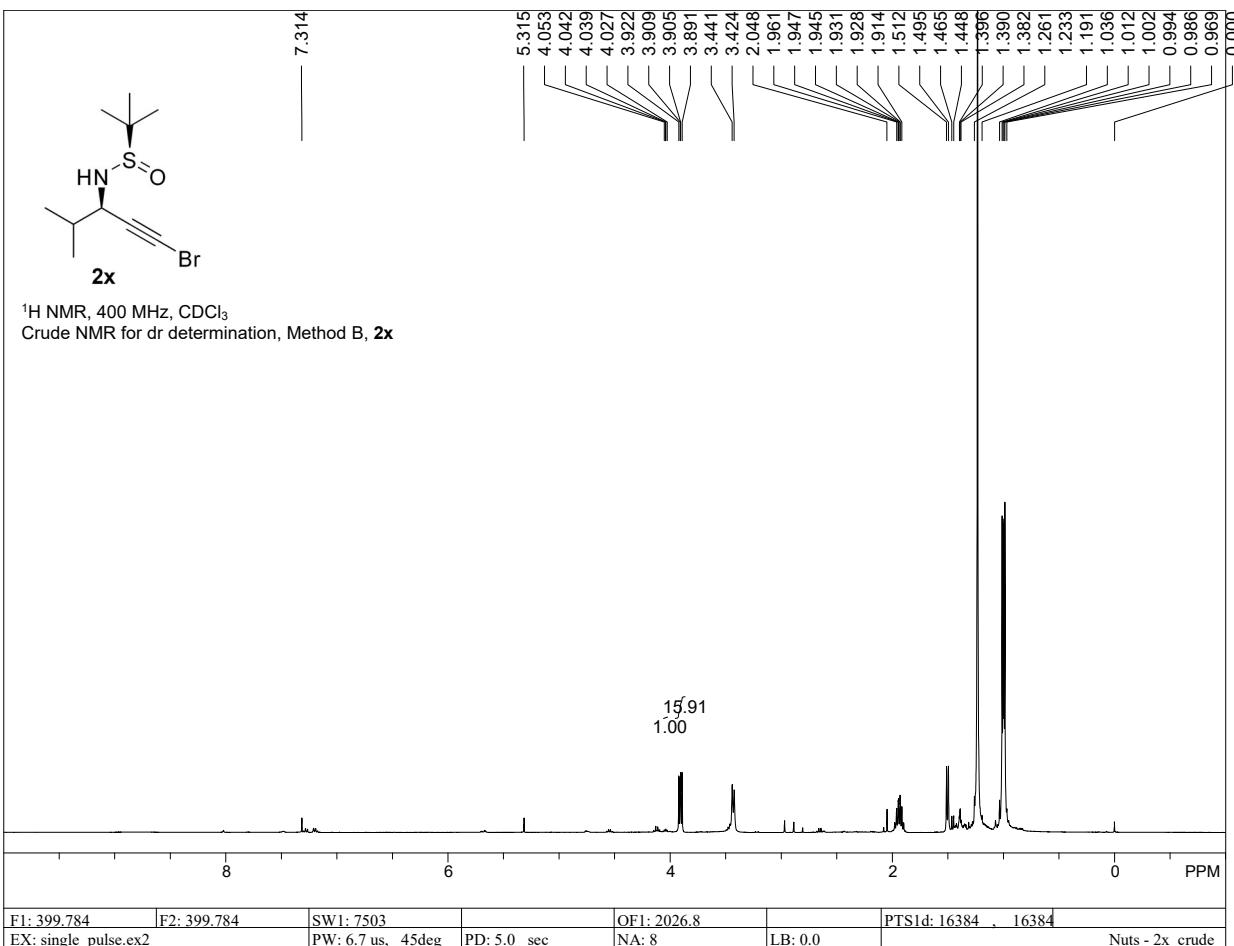


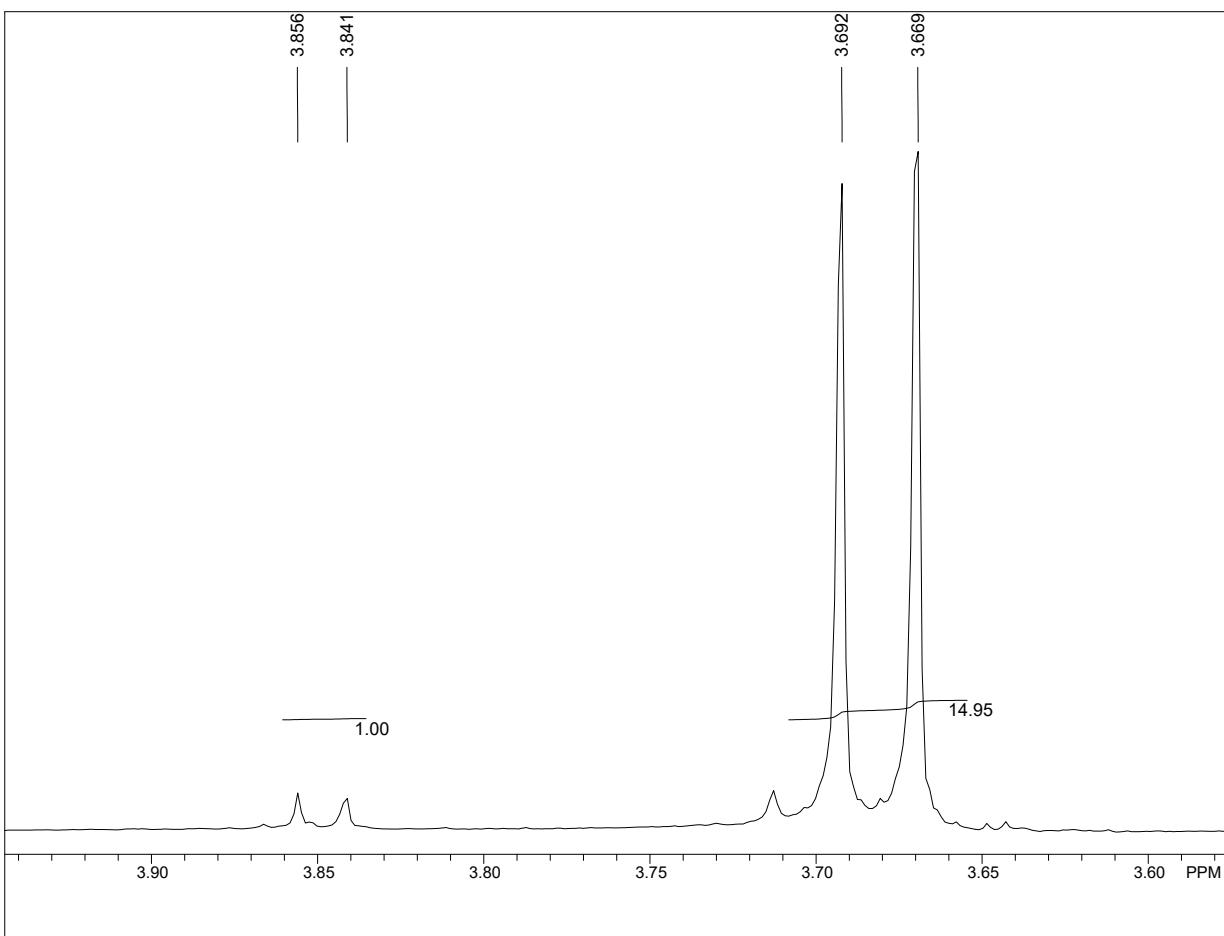
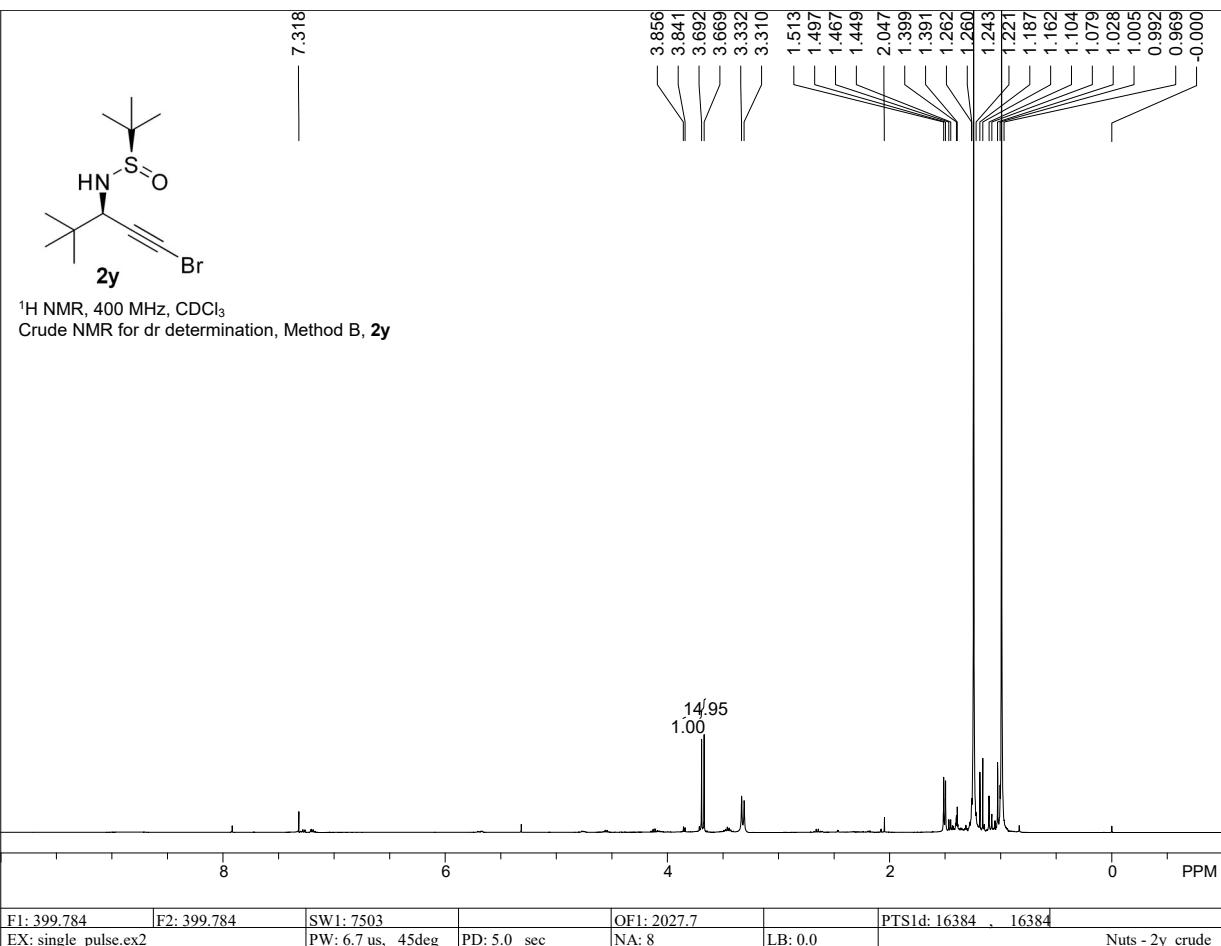


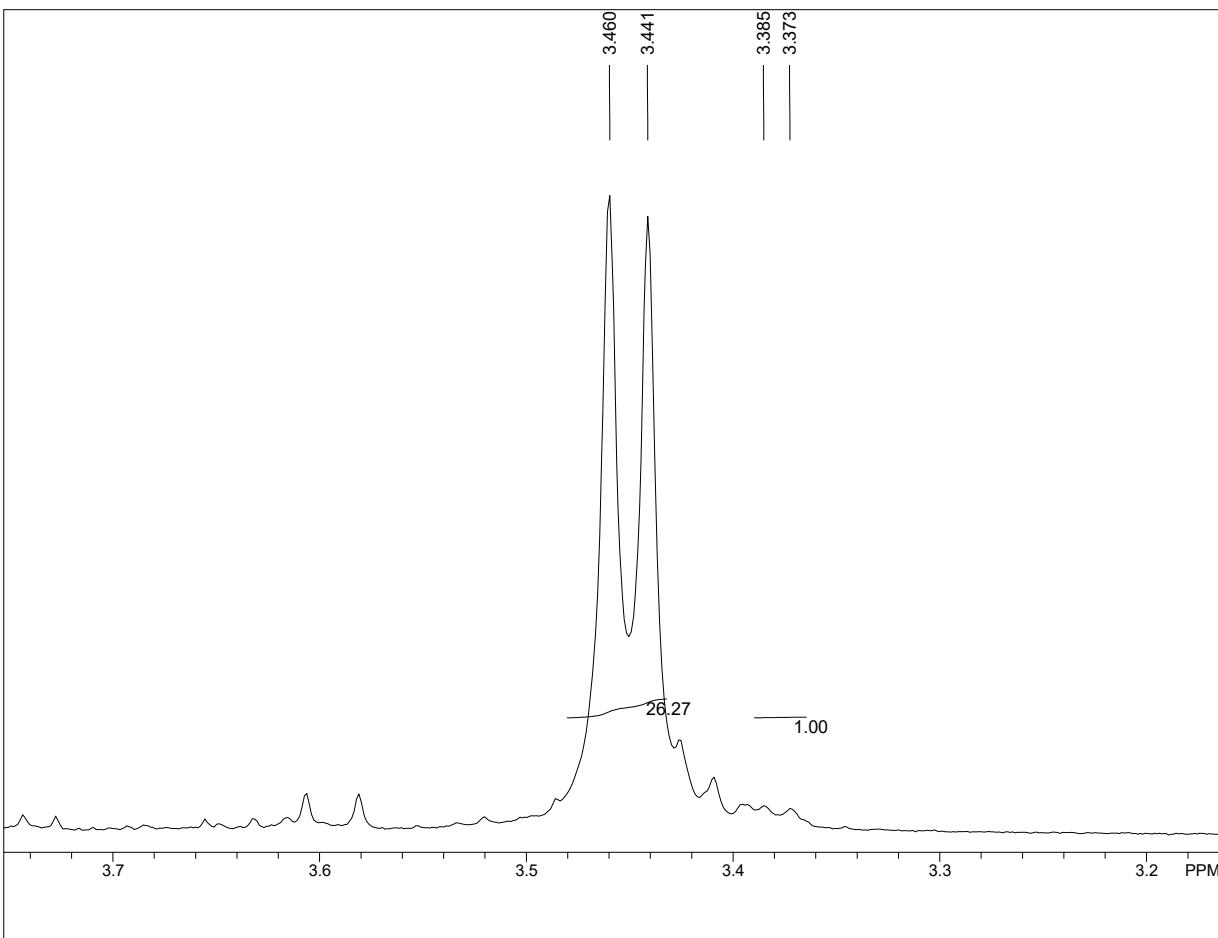
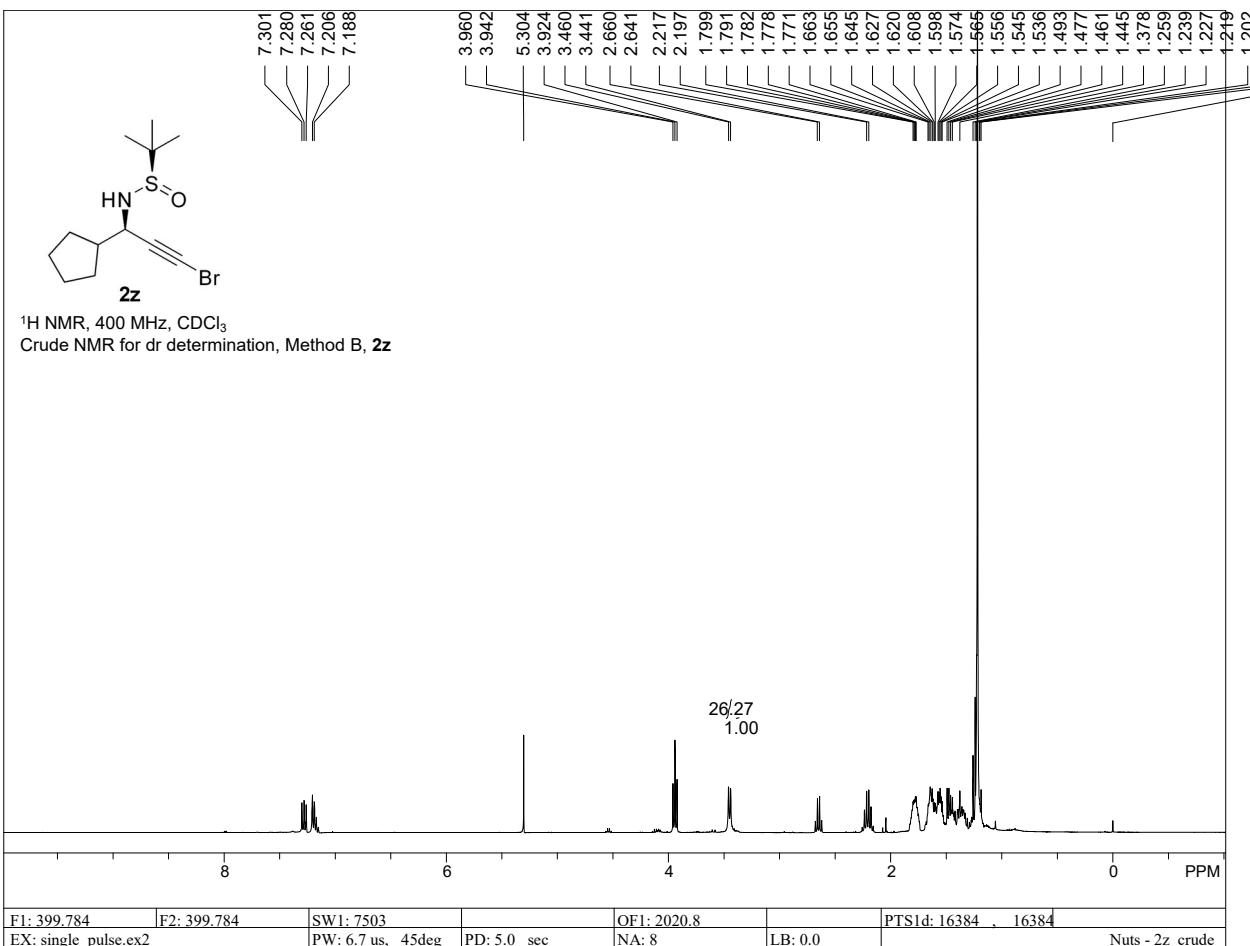


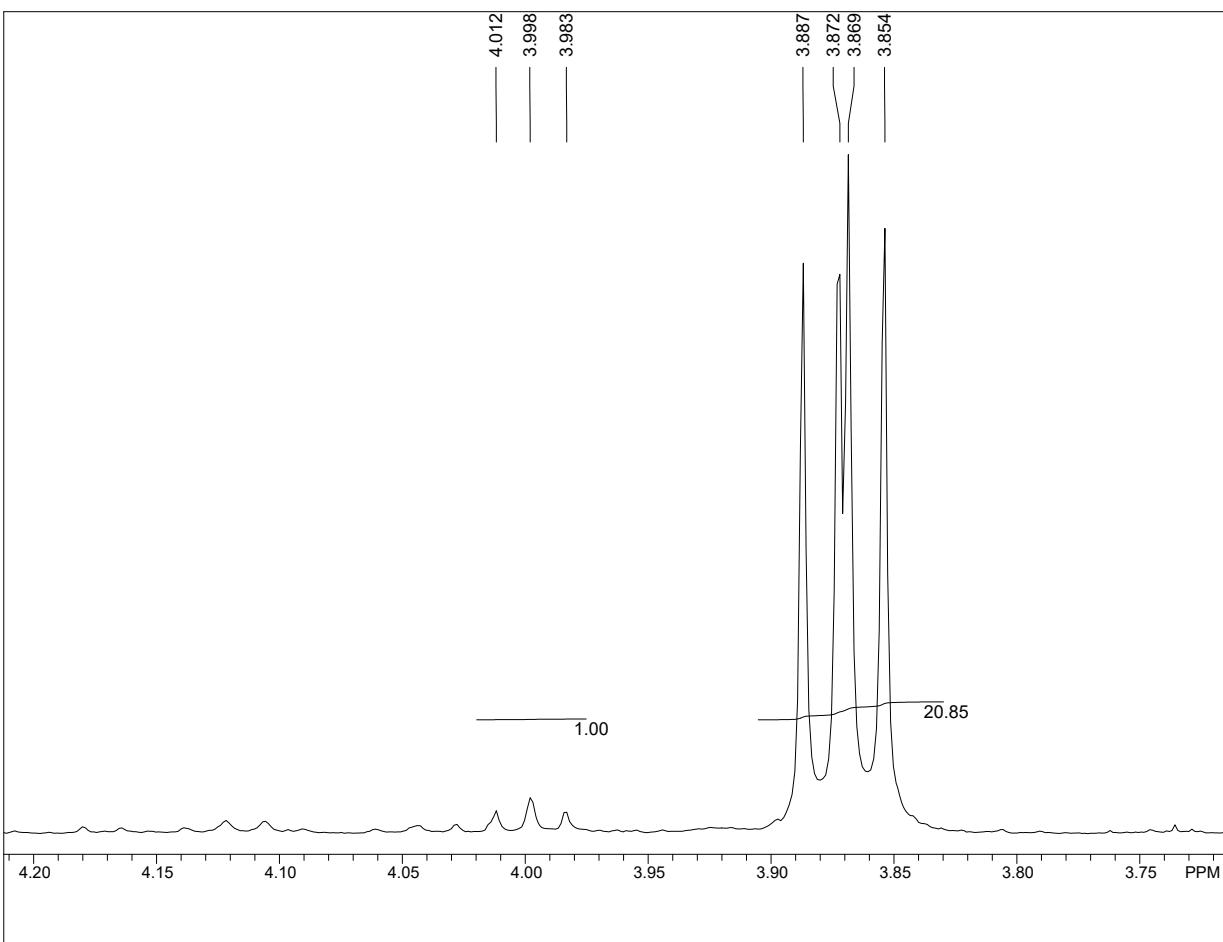
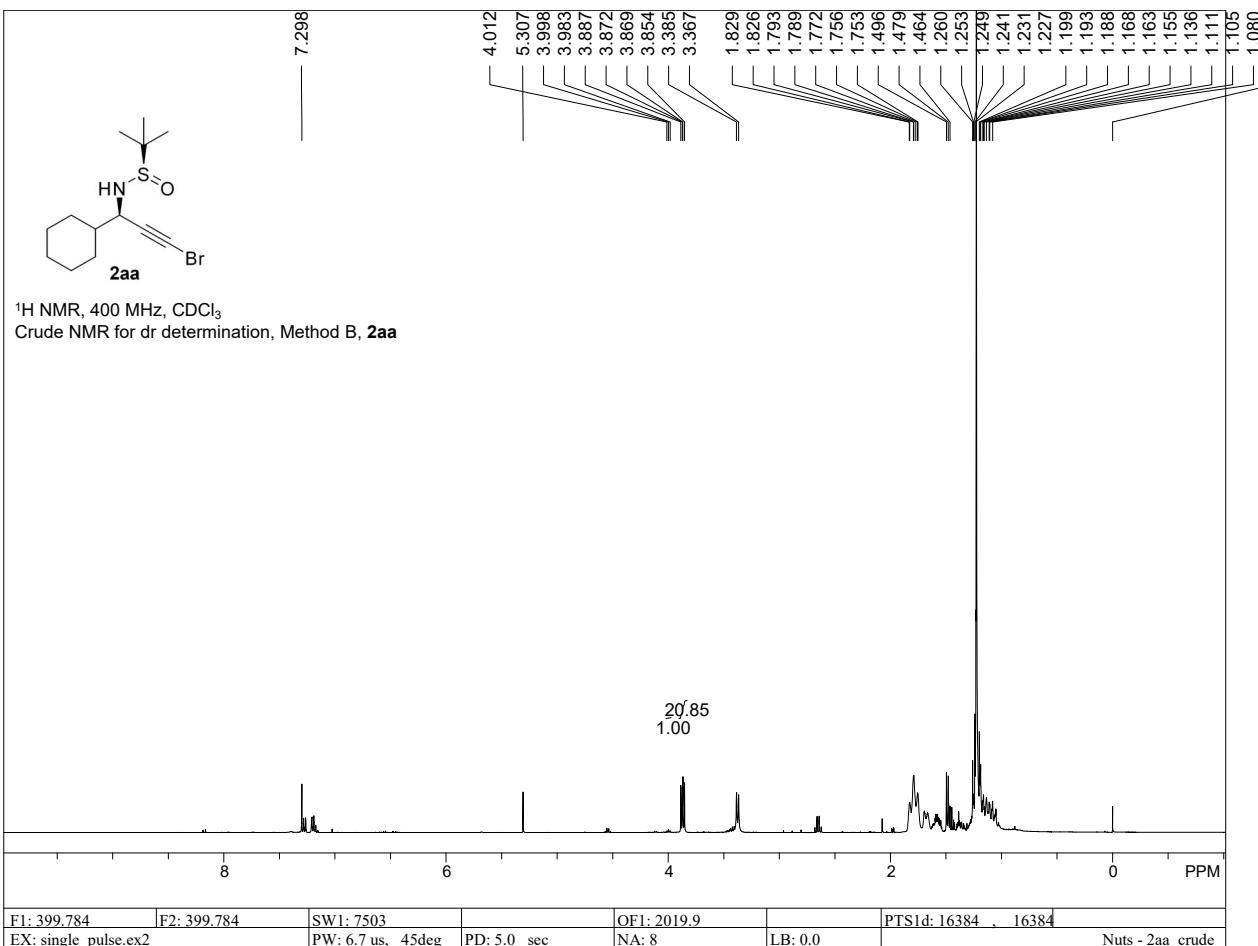


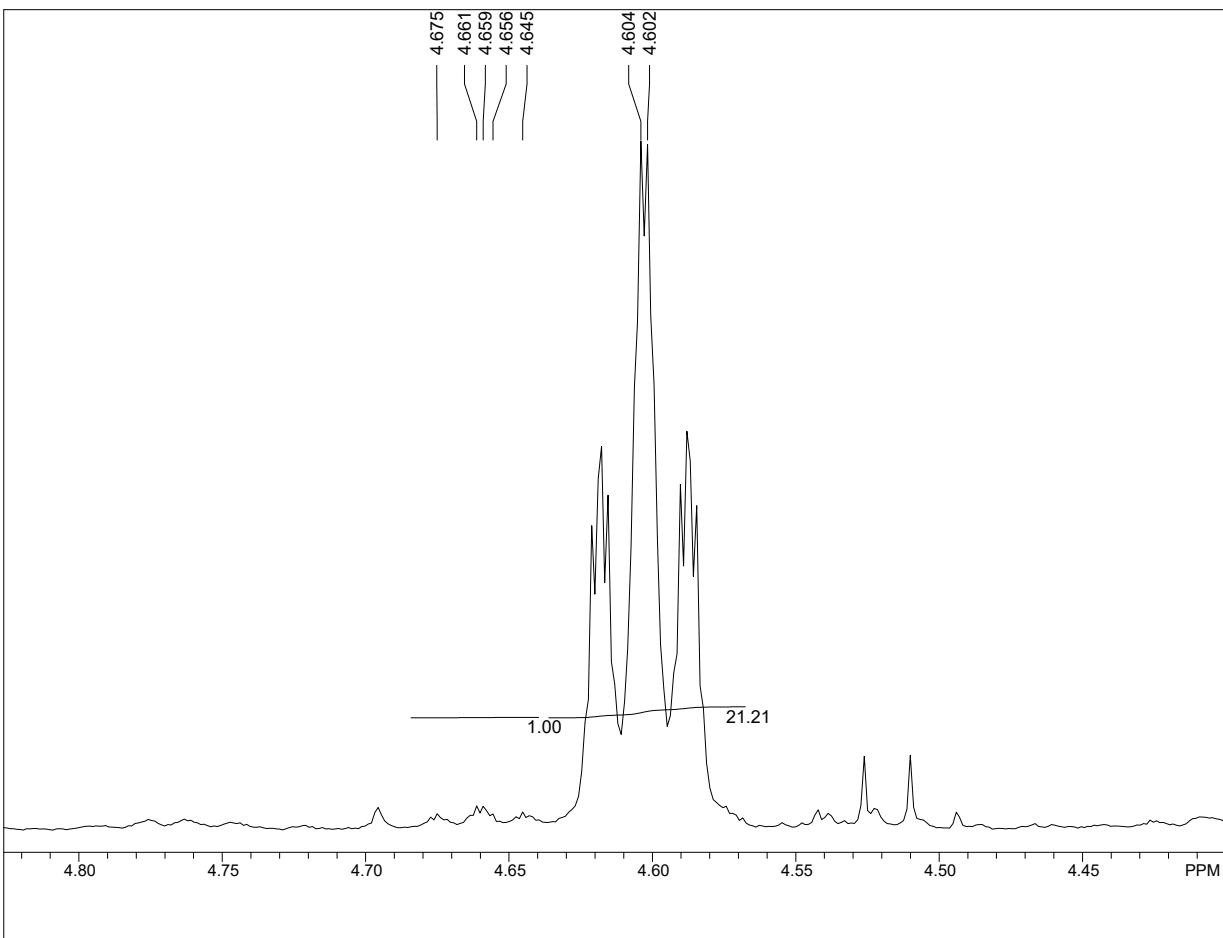
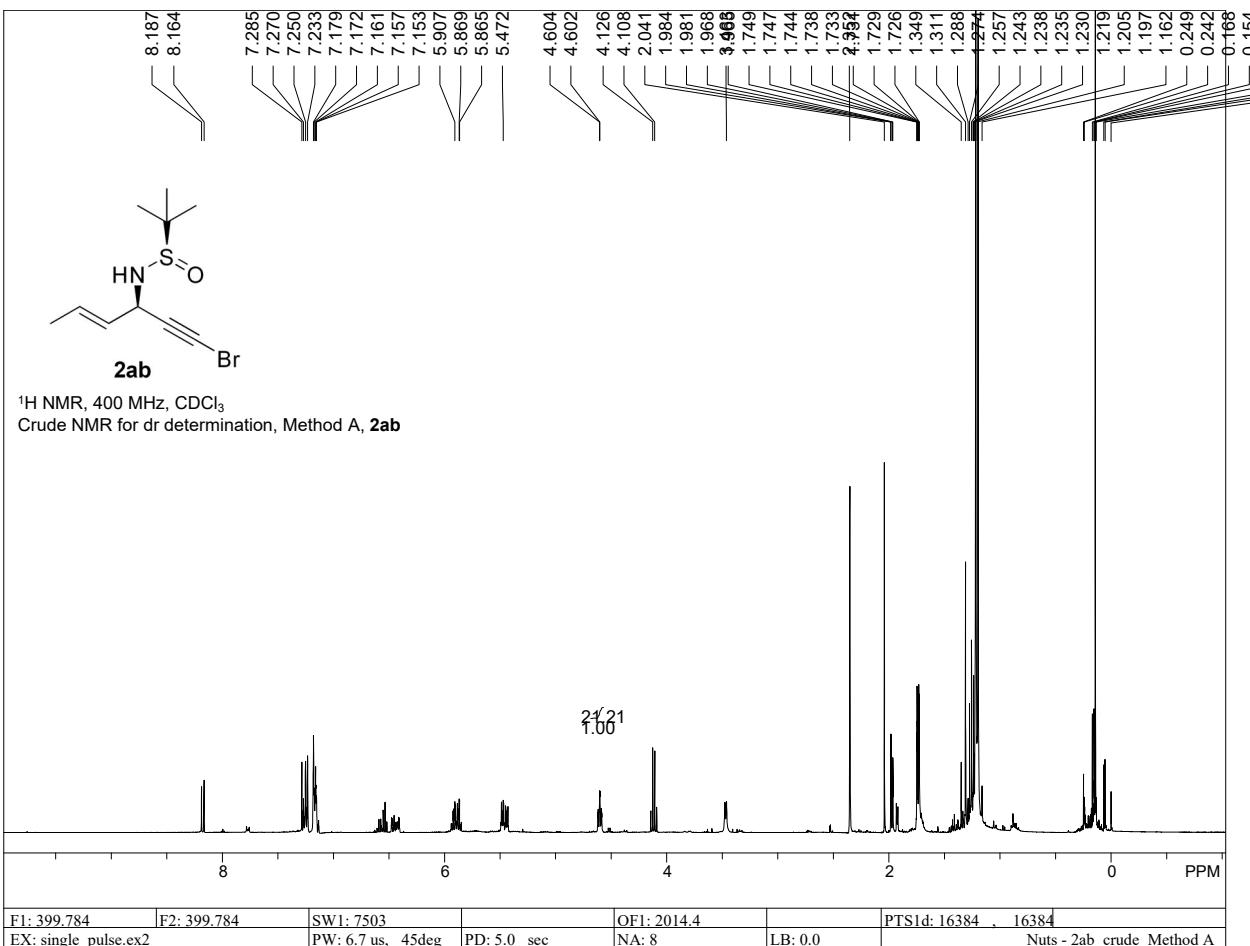


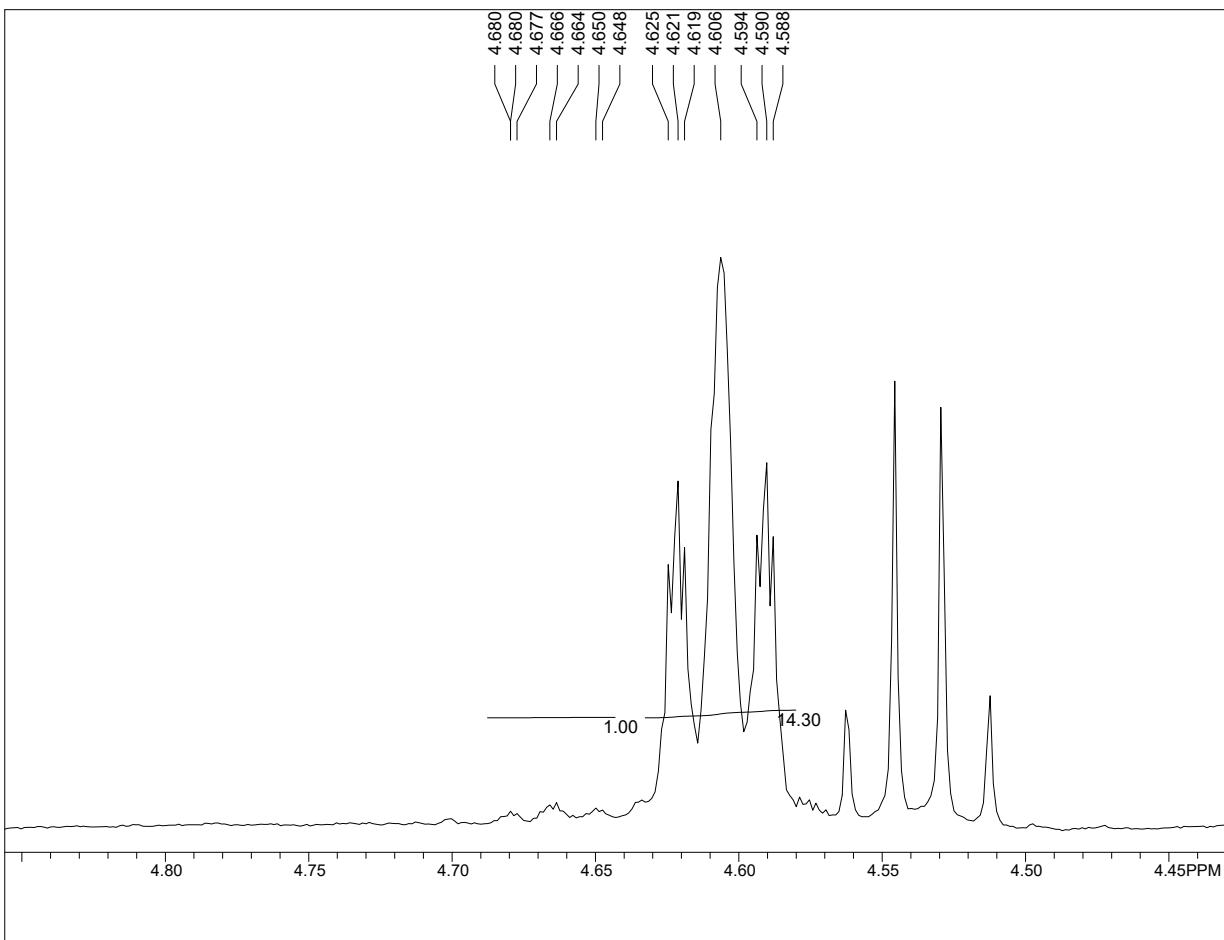
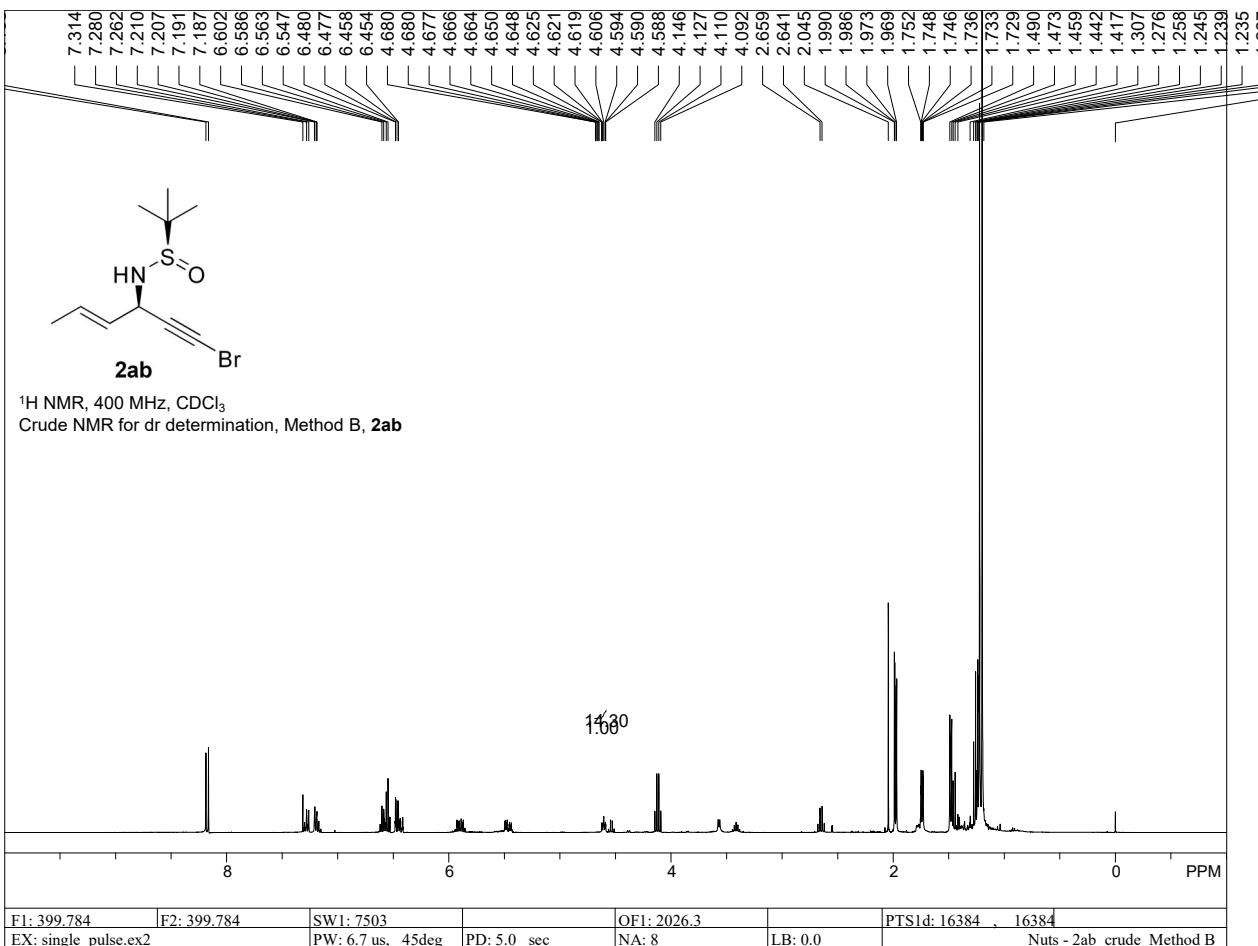


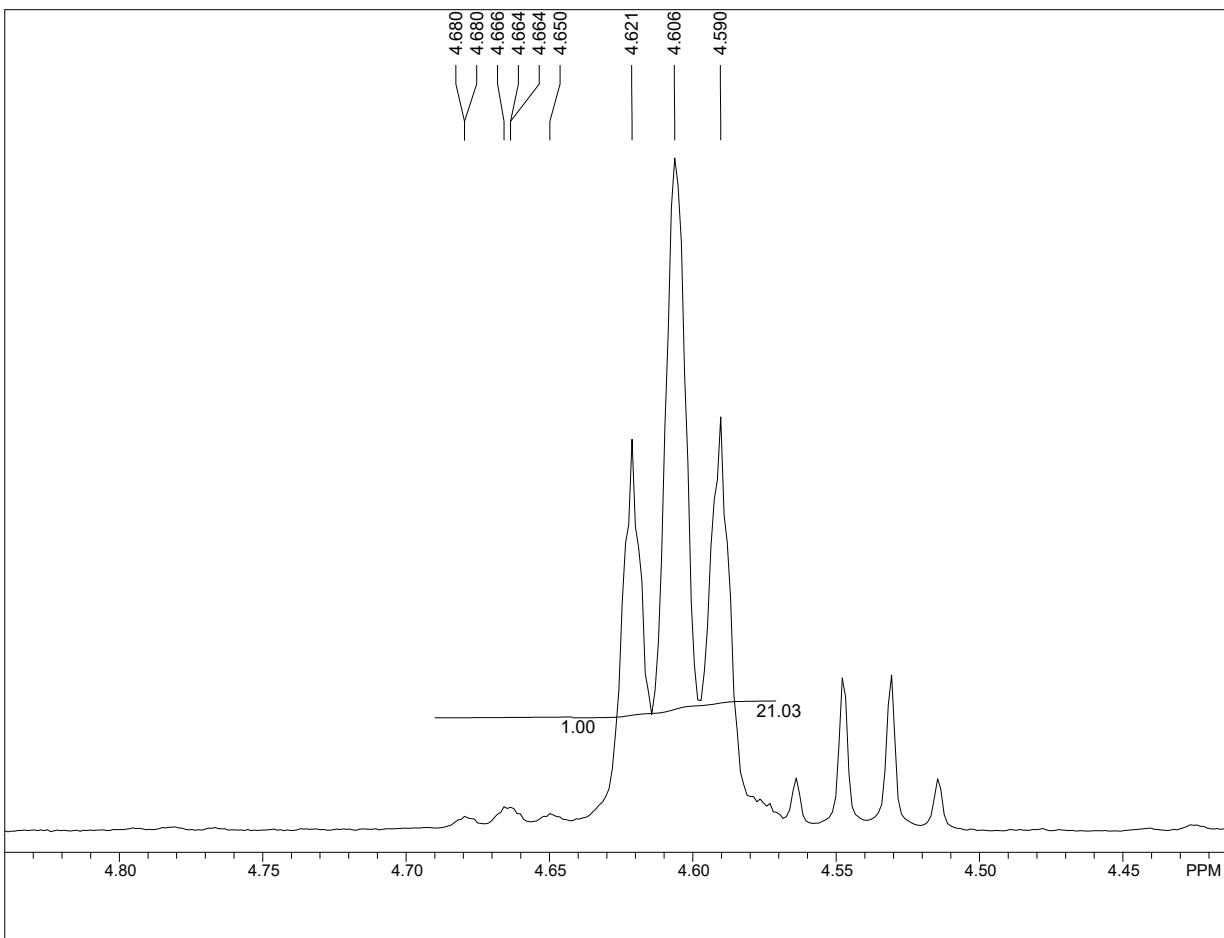
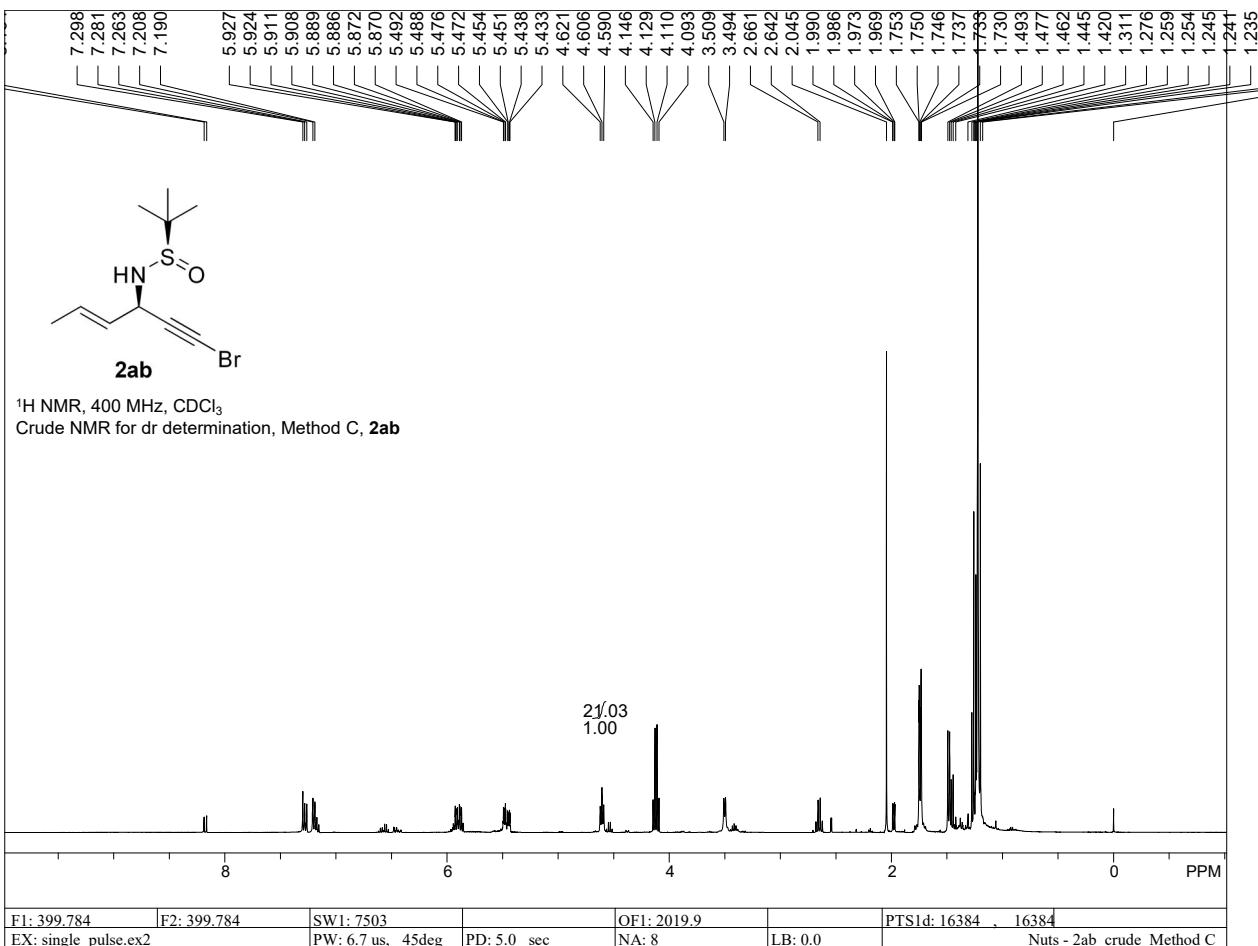


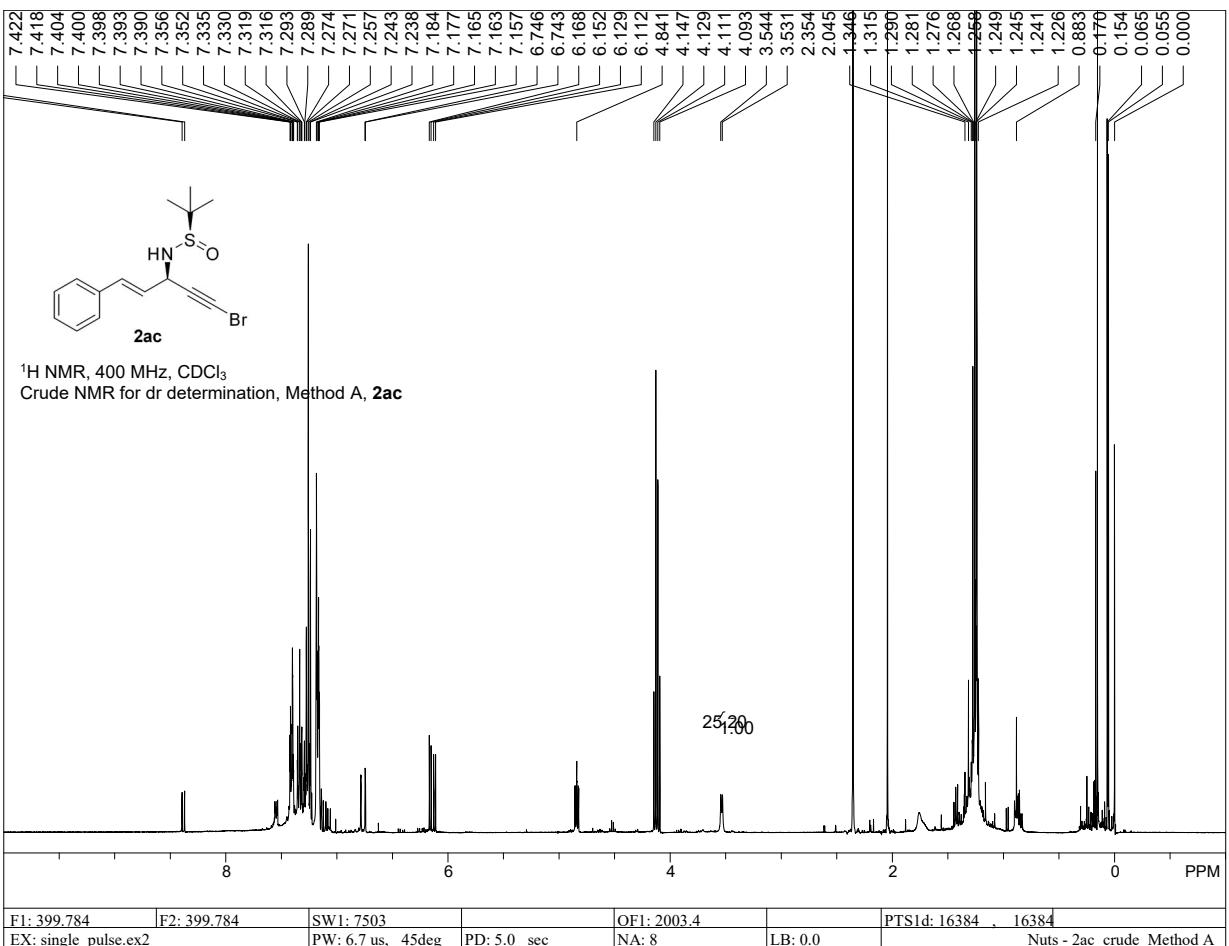


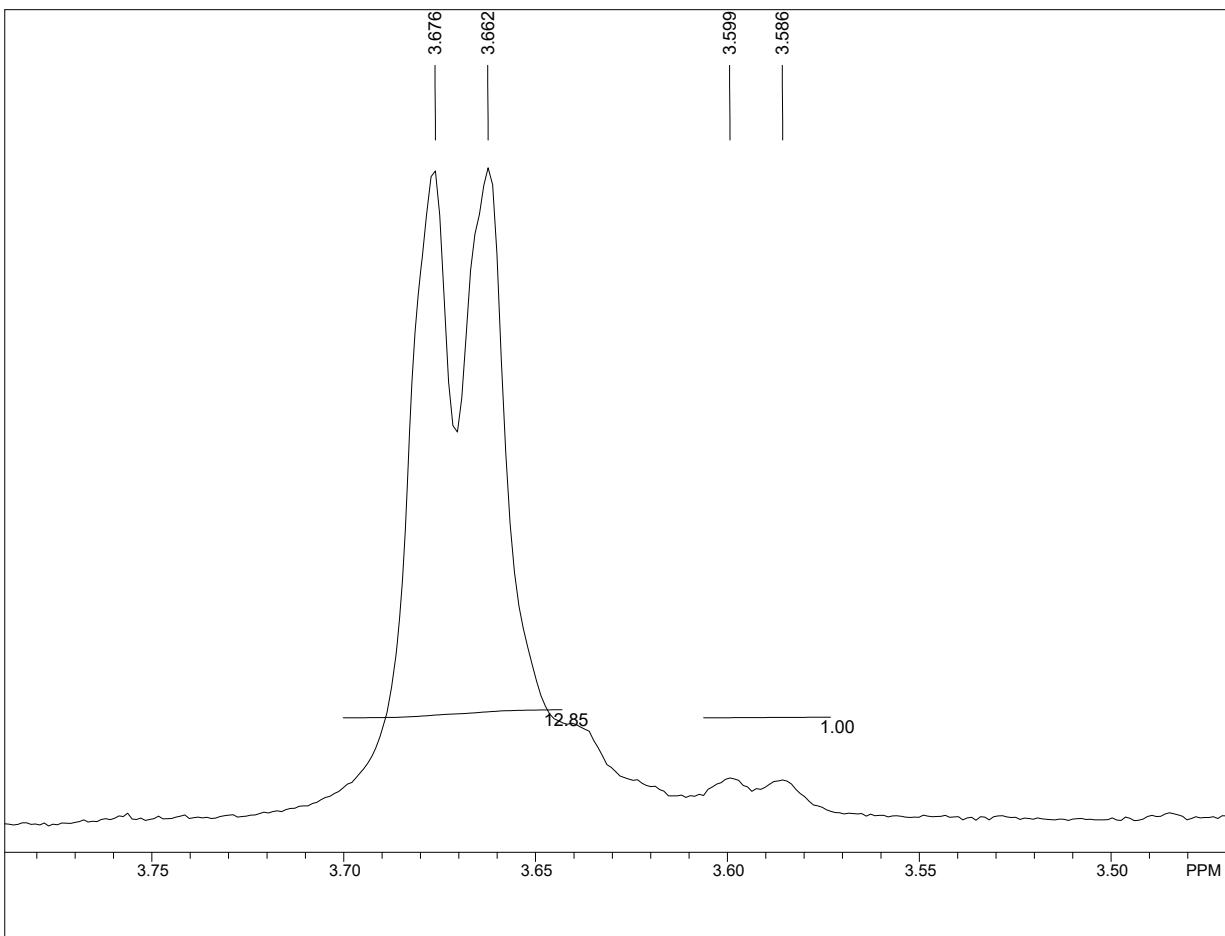
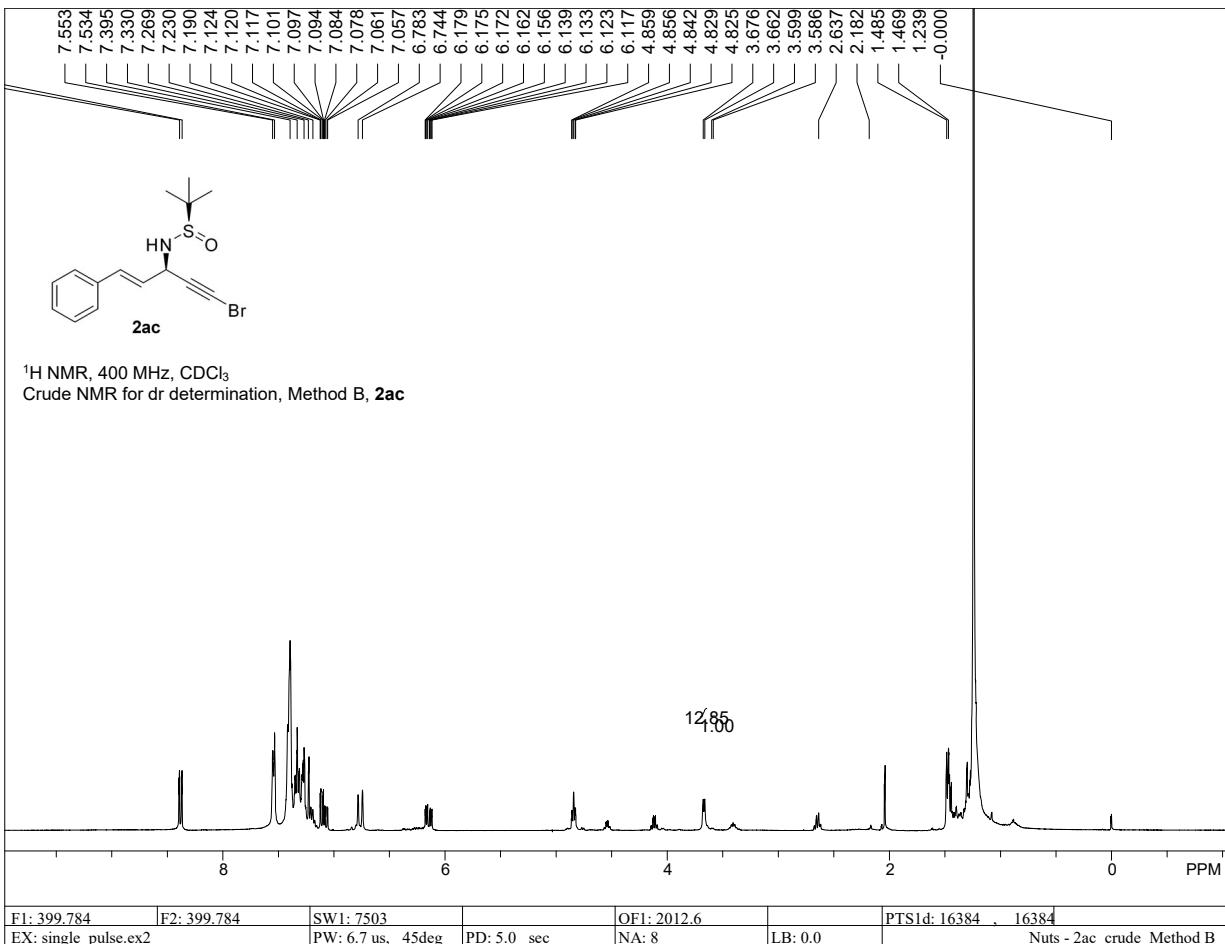


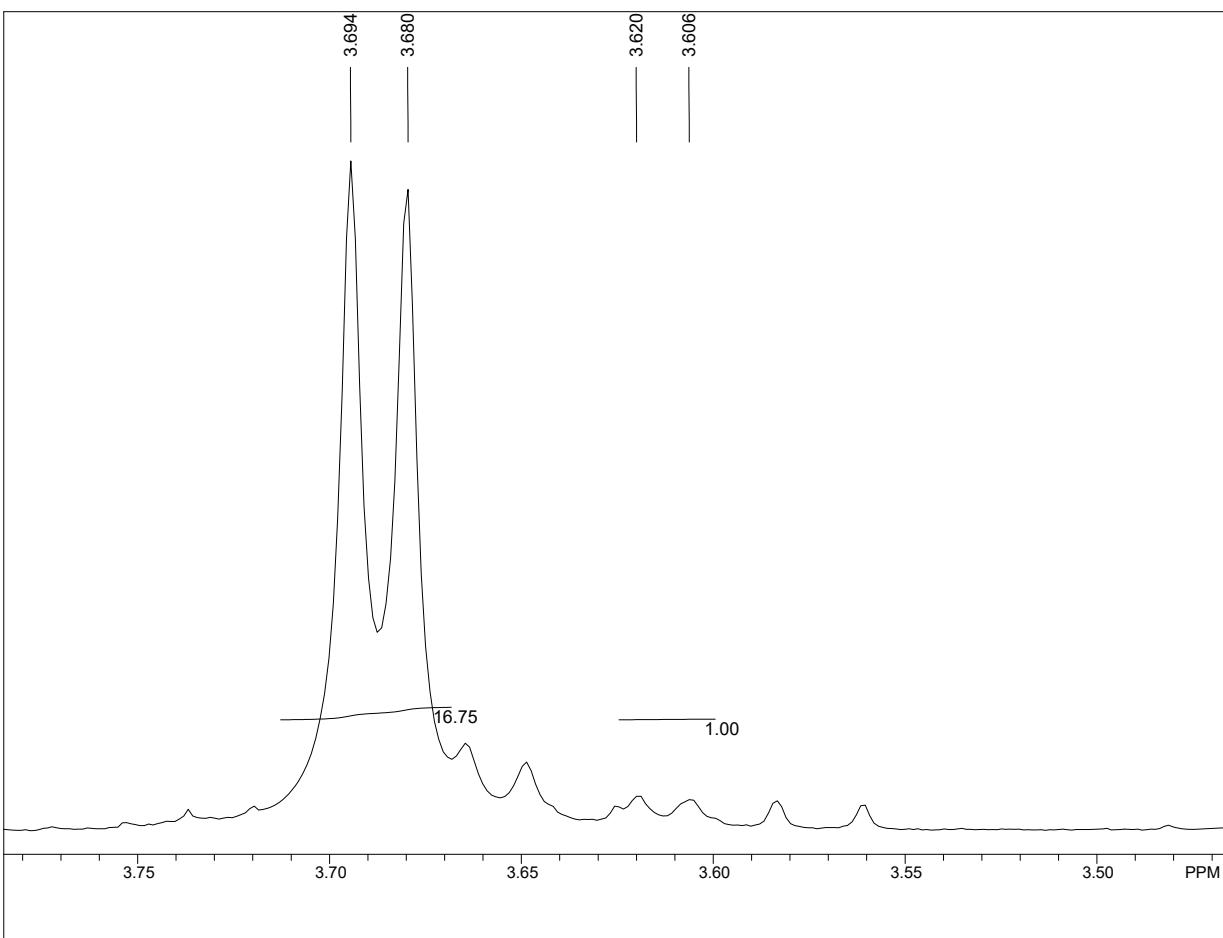
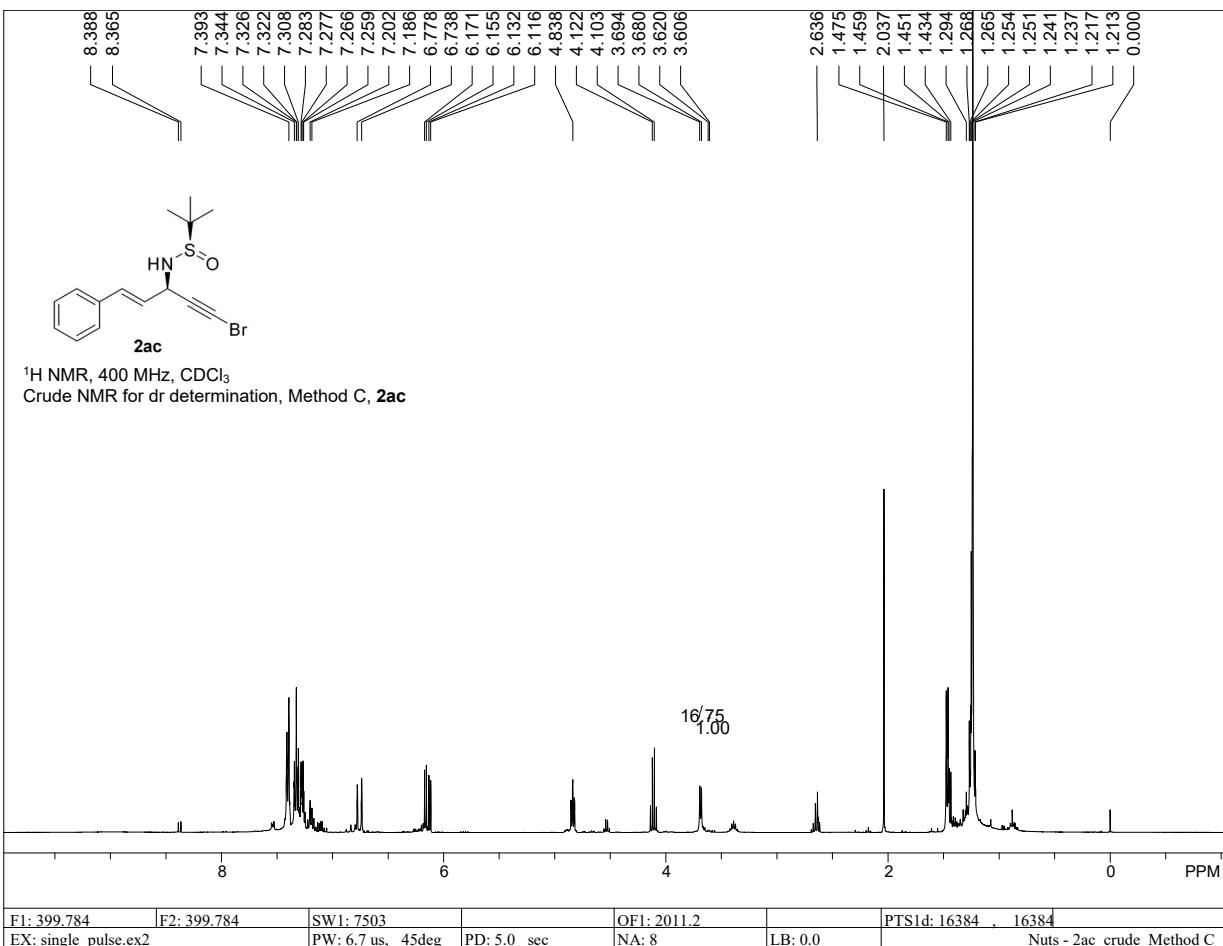




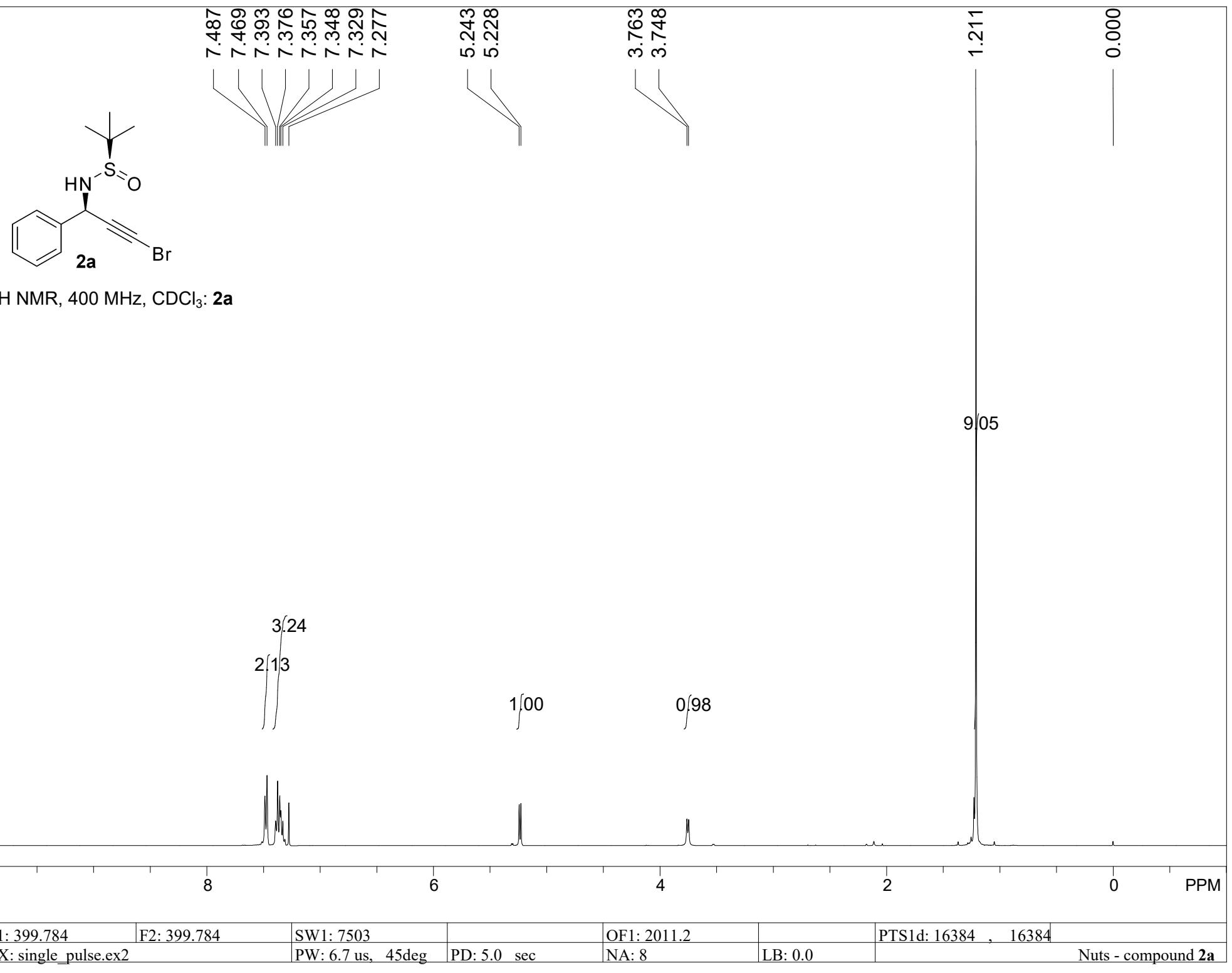


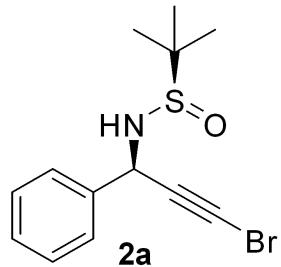




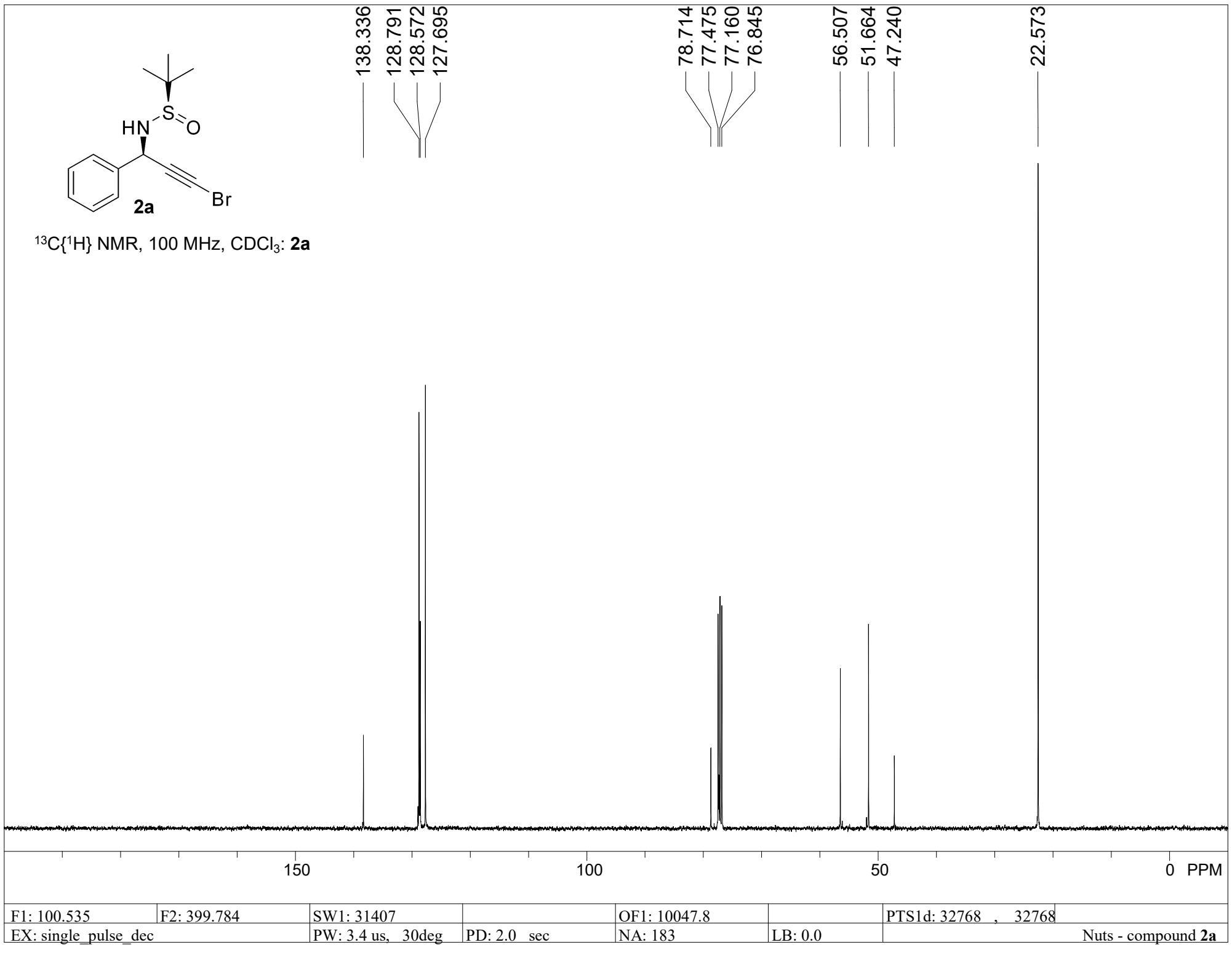


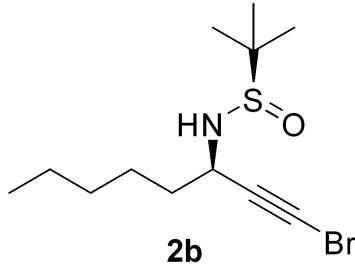
1H and $^{13}C\{^1H\}$ Spectra of Compounds **2a-2ac**, **3a** and **3b**, **4a** and **4b**, **5a** and **5b**, and **6**



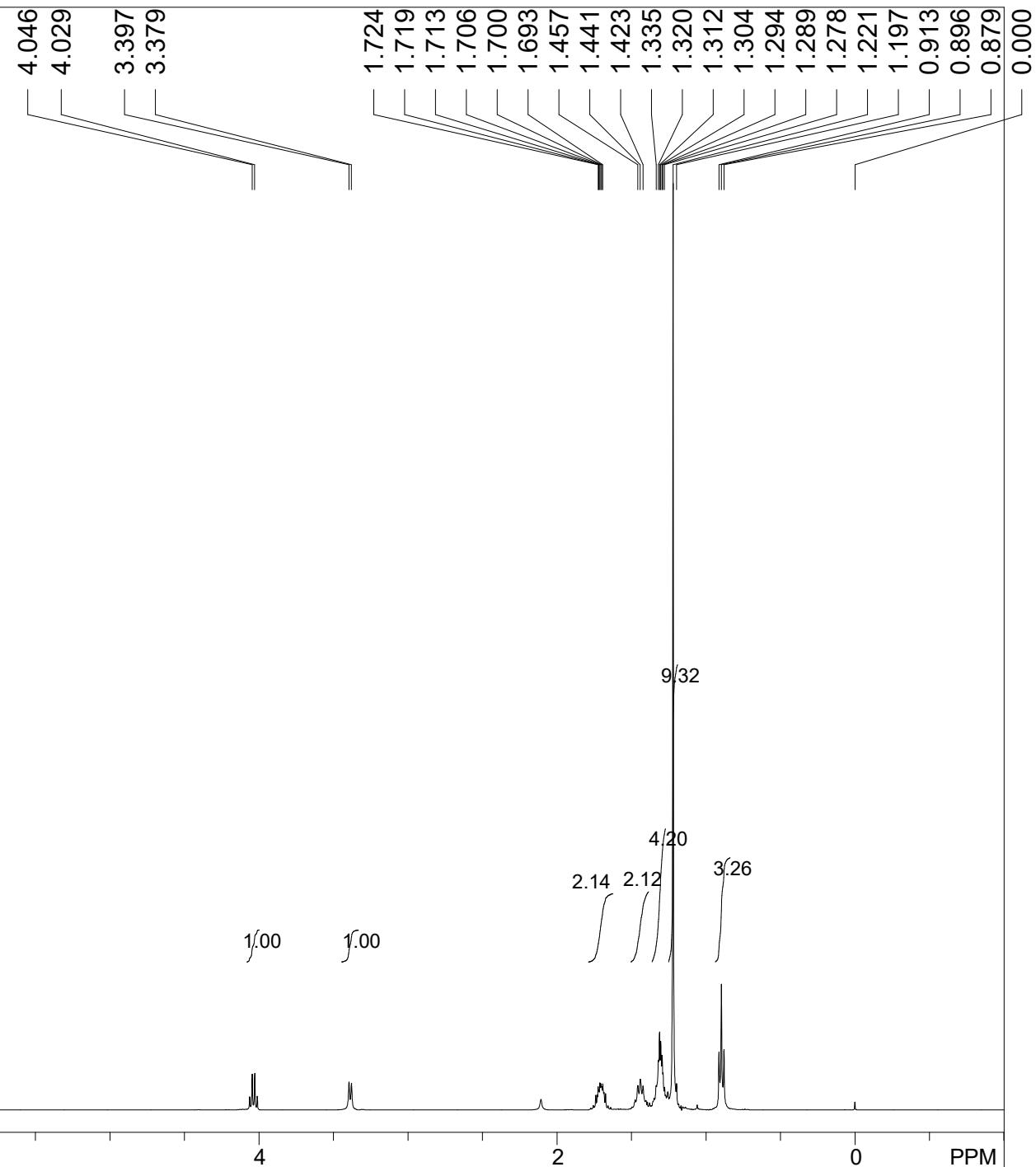


$^{13}\text{C}\{\text{H}\}$ NMR, 100 MHz, CDCl_3 : **2a**





¹H NMR, 400 MHz, CDCl₃: **2b**



F1: 399.784

F2: 399.784

SW1: 7503

OF1: 2019.9

PTS1d: 16384 , 16384

EX: single_pulse.ex2

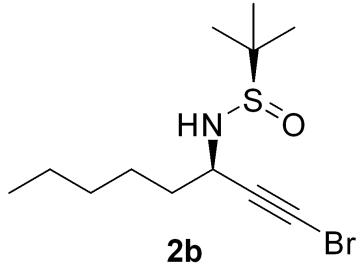
PW: 6.8 us, 45deg

PD: 5.0 sec

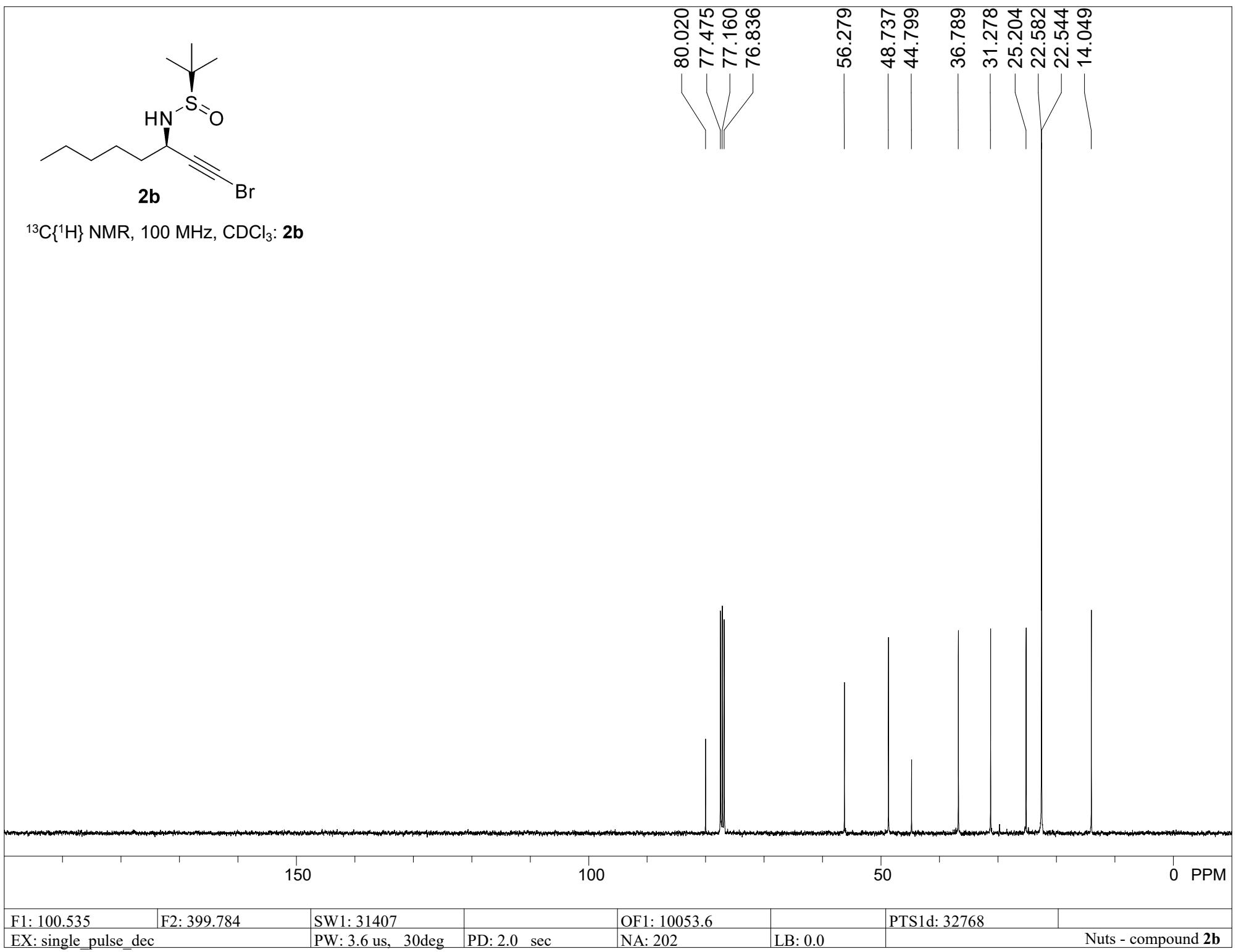
NA: 8

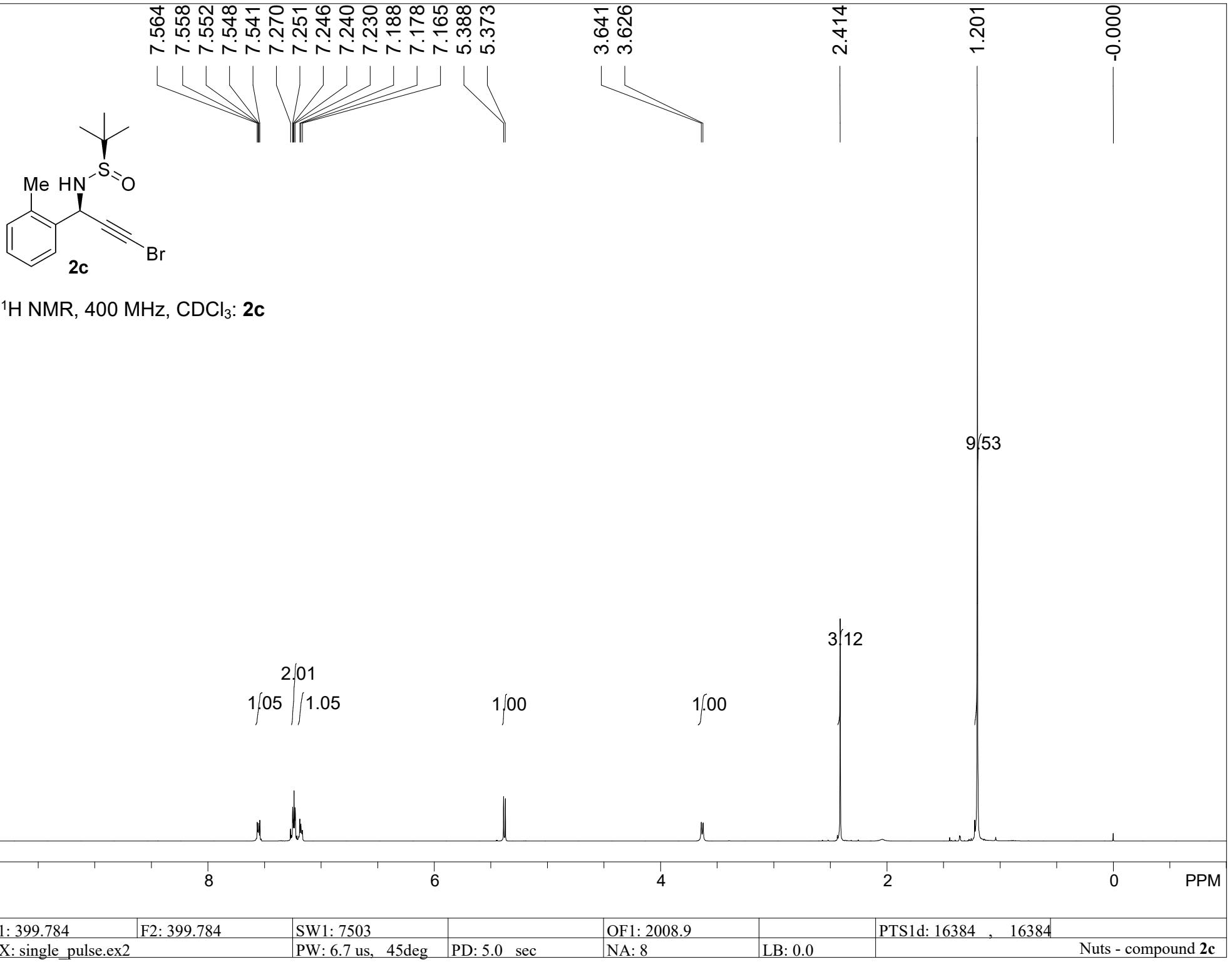
LB: 0.0

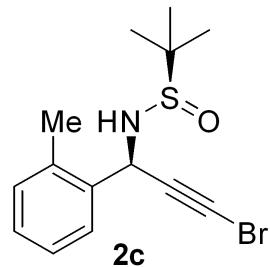
Nuts - compound **2b**



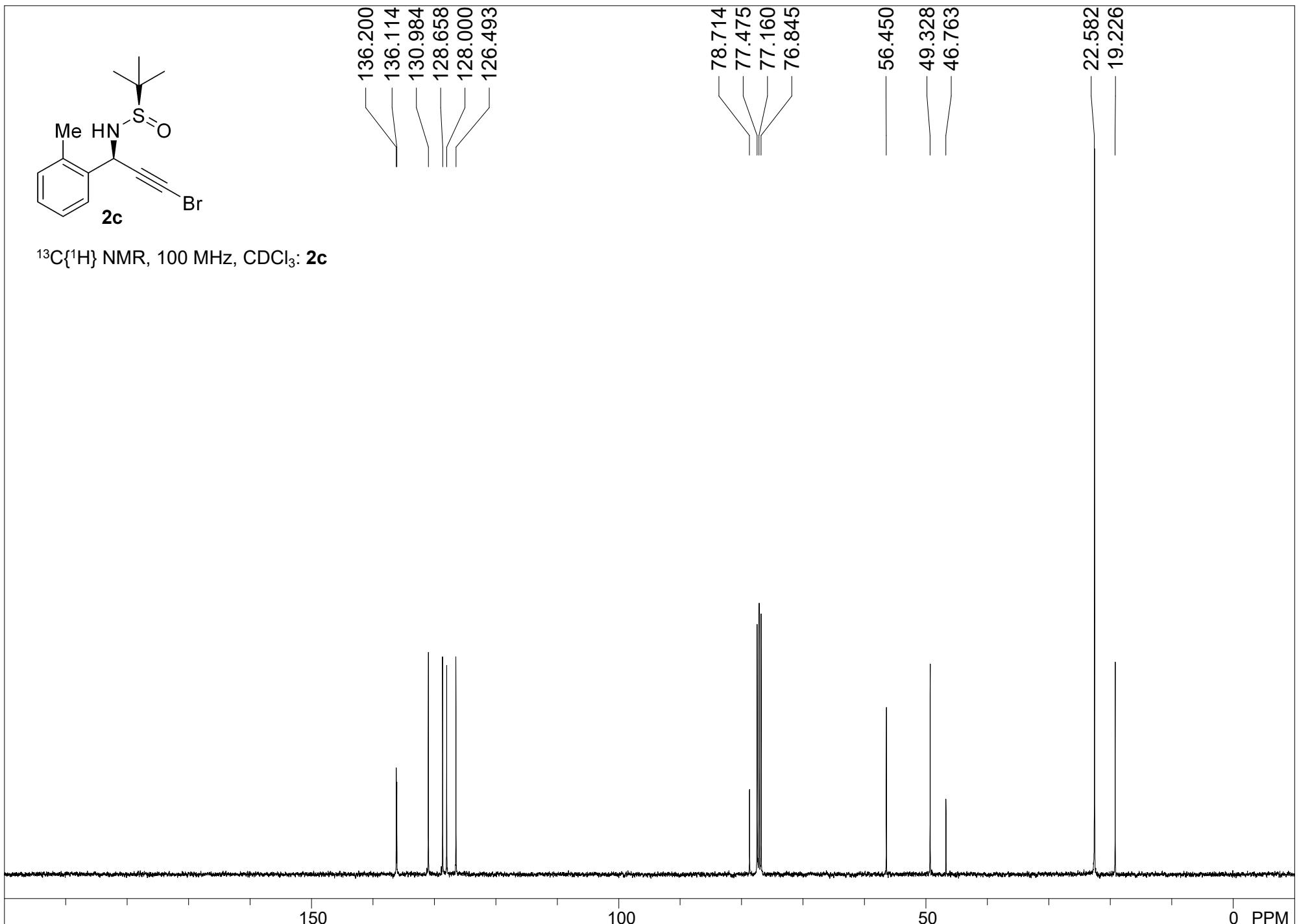
$^{13}\text{C}\{\text{H}\}$ NMR, 100 MHz, CDCl_3 : **2b**







$^{13}\text{C}\{\text{H}\}$ NMR, 100 MHz, CDCl_3 : **2c**



F1: 100.535
EX: single_pulse_dec

F2: 399.784

SW1: 31407

PW: 3.3 us, 30deg

OF1: 10050.7

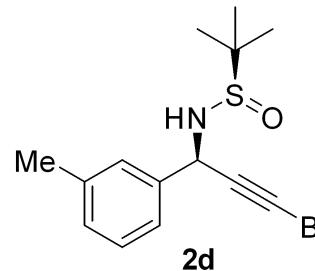
PD: 2.0 sec

NA: 219

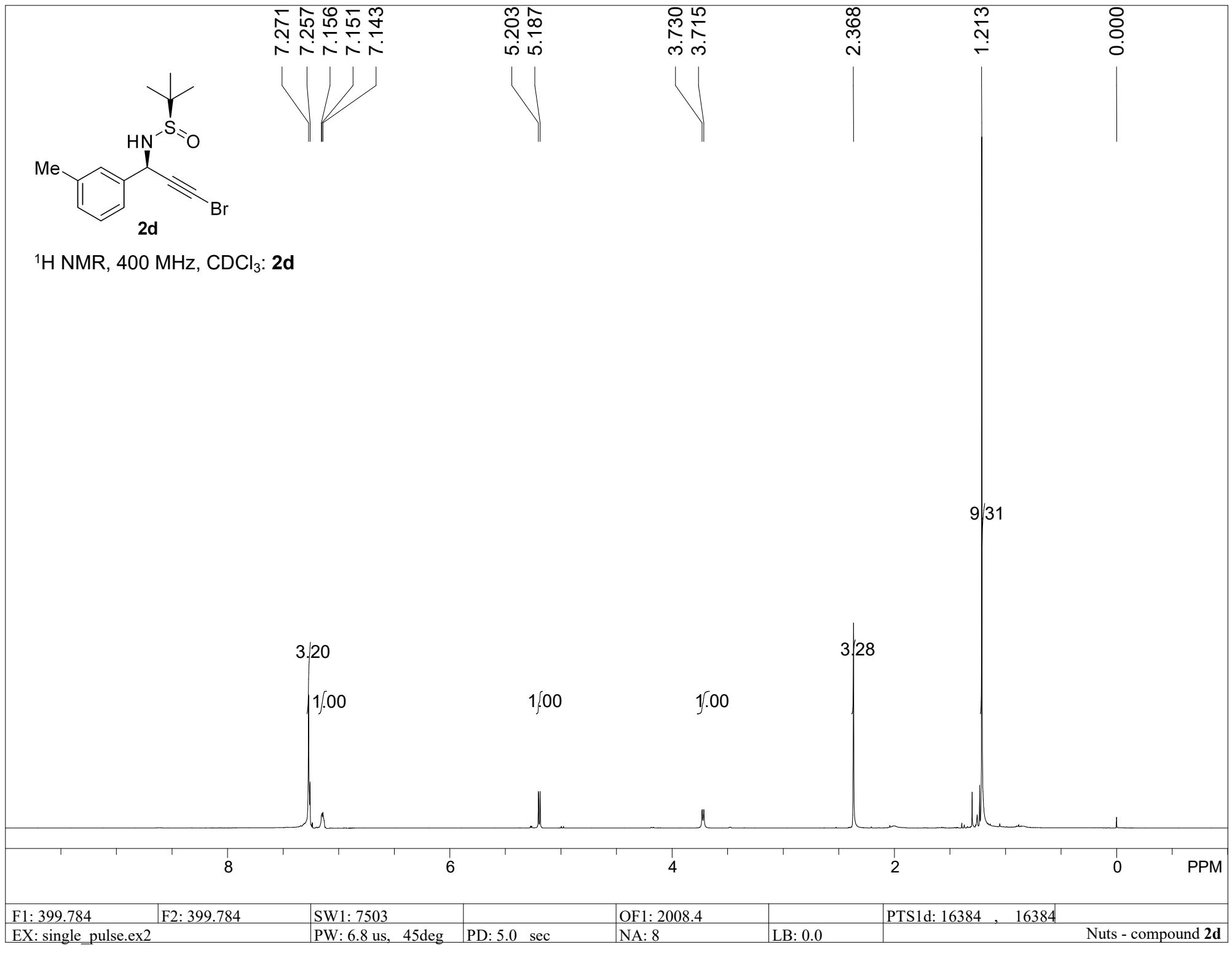
LB: 0.0

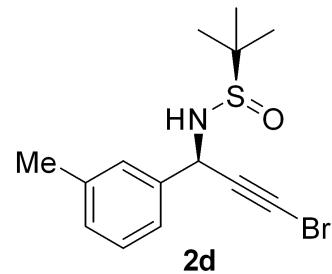
PTS1d: 16384, 32768

Nuts - compound **2c**

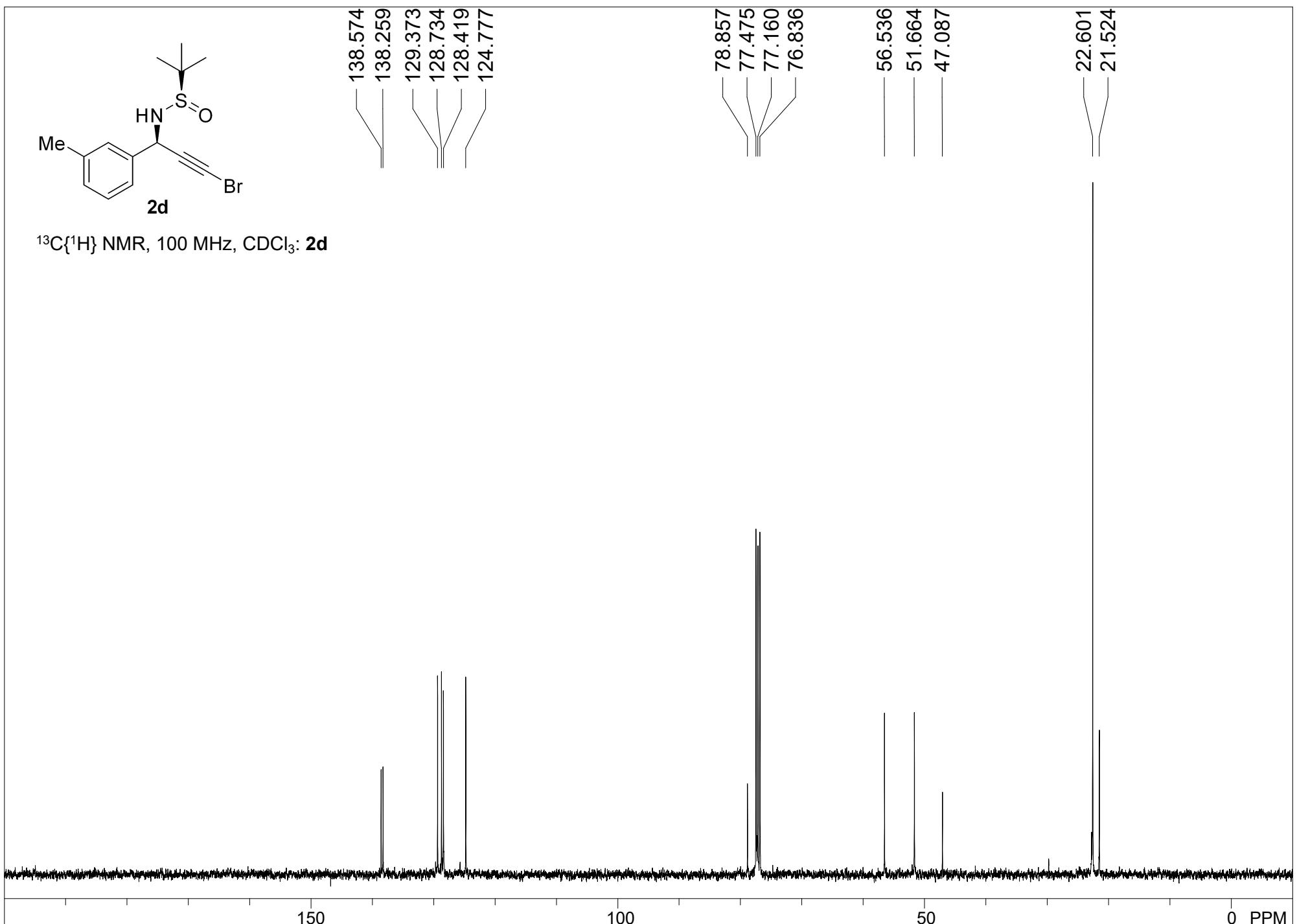


¹H NMR, 400 MHz, CDCl₃: **2d**

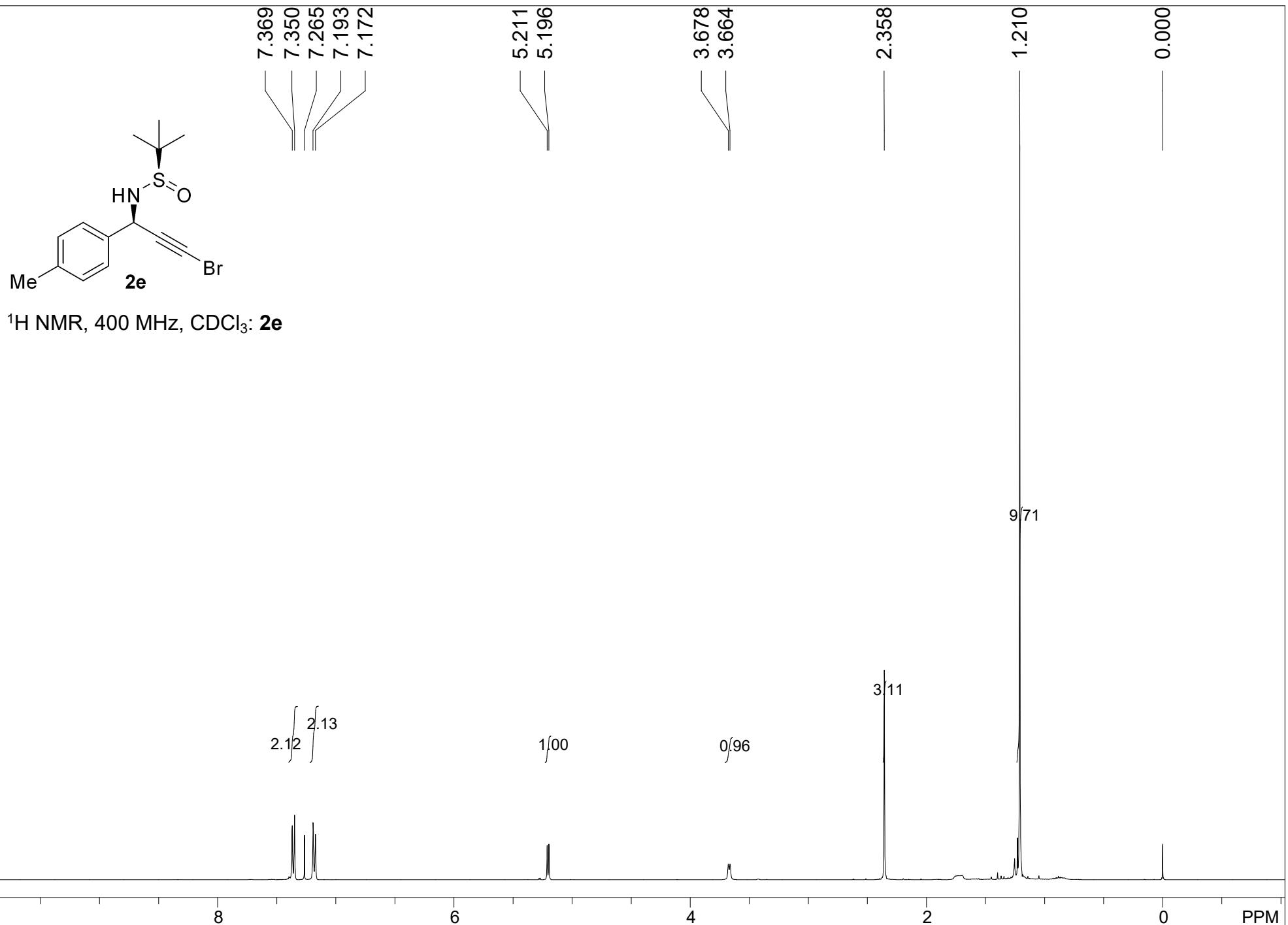




$^{13}\text{C}\{\text{H}\}$ NMR, 100 MHz, CDCl_3 : **2d**

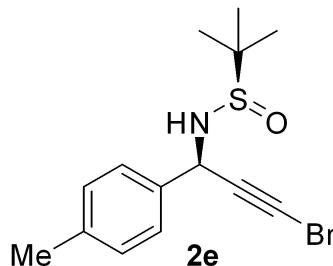


F1: 100.535	F2: 399.784	SW1: 31407		OF1: 10051.7		PTS1d: 32768	
EX: single_pulse_dec		PW: 3.6 us, 30deg	PD: 2.0 sec	NA: 95	LB: 0.0		Nuts - compound 2d

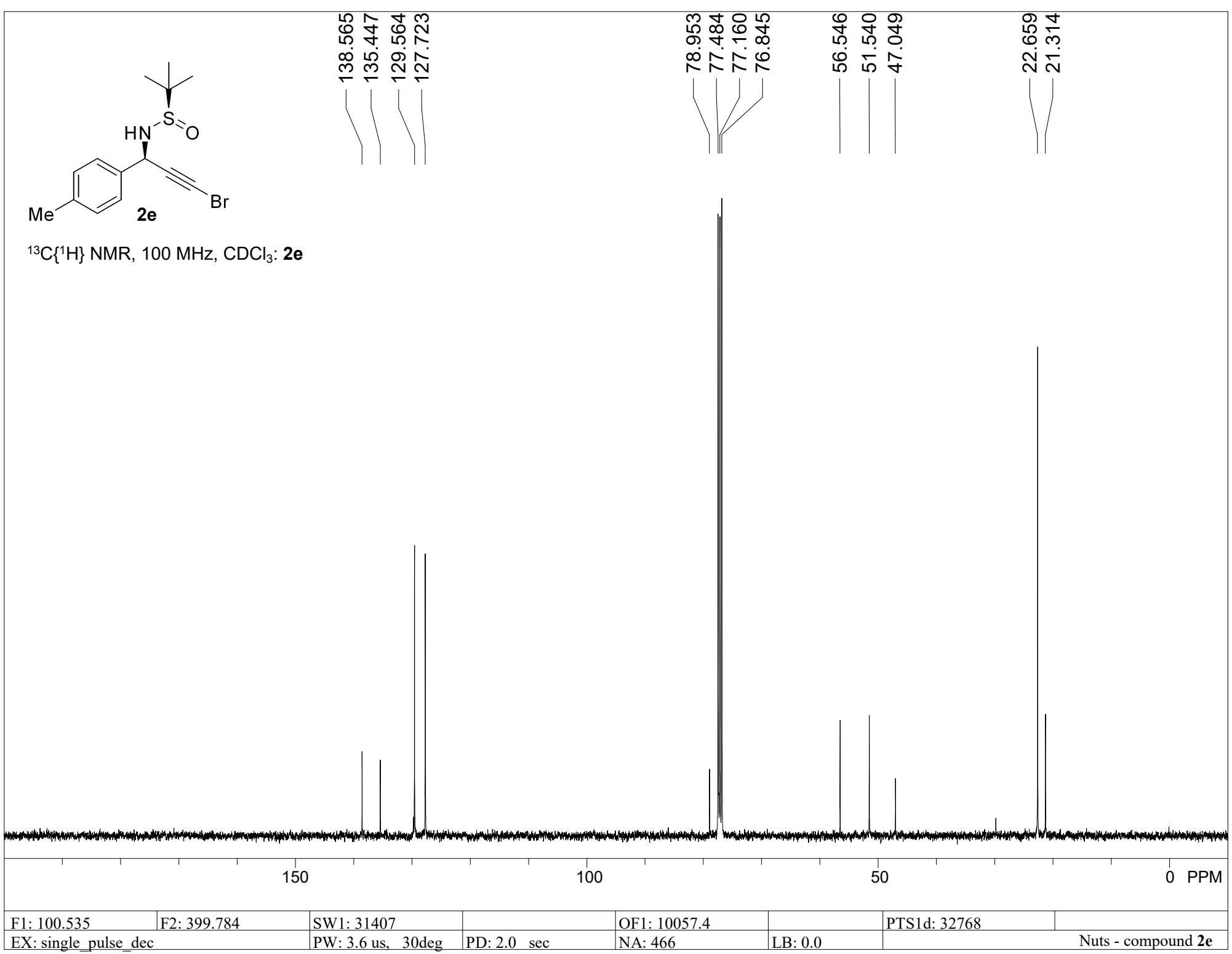


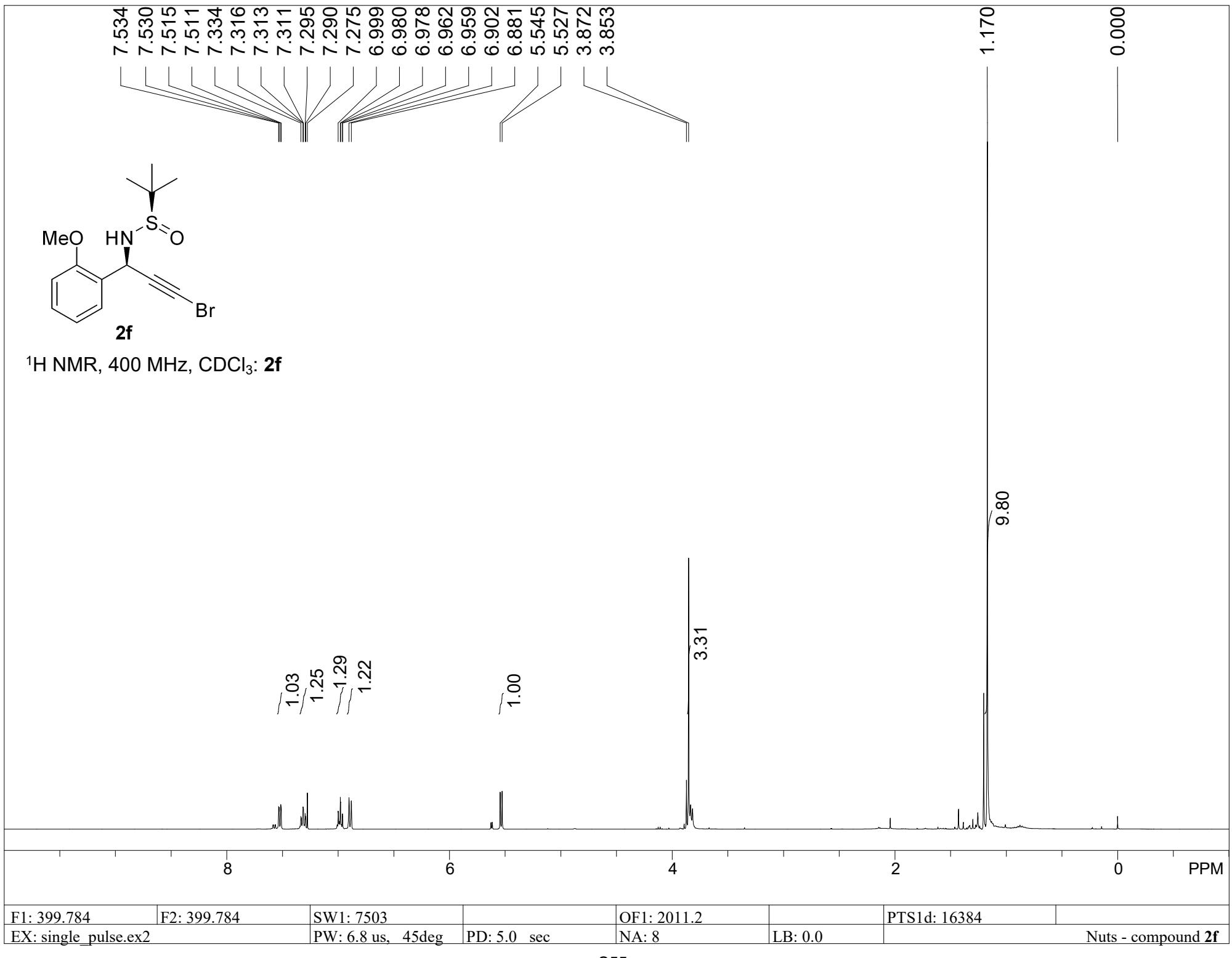
¹H NMR, 400 MHz, CDCl₃: **2e**

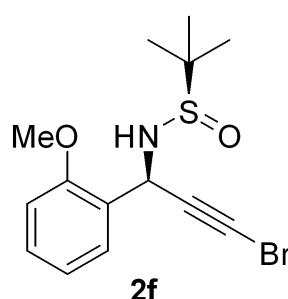
F1: 399.784	F2: 399.784	SW1: 7503		OF1: 2006.6		PTS1d: 16384	
EX: single_pulse.ex2		PW: 6.8 us, 45deg	PD: 5.0 sec	NA: 8	LB: 0.0		Nuts - compound 2e



$^{13}\text{C}\{\text{H}\}$ NMR, 100 MHz, CDCl_3 : **2e**







156.557

129.878
128.391
126.884
120.792

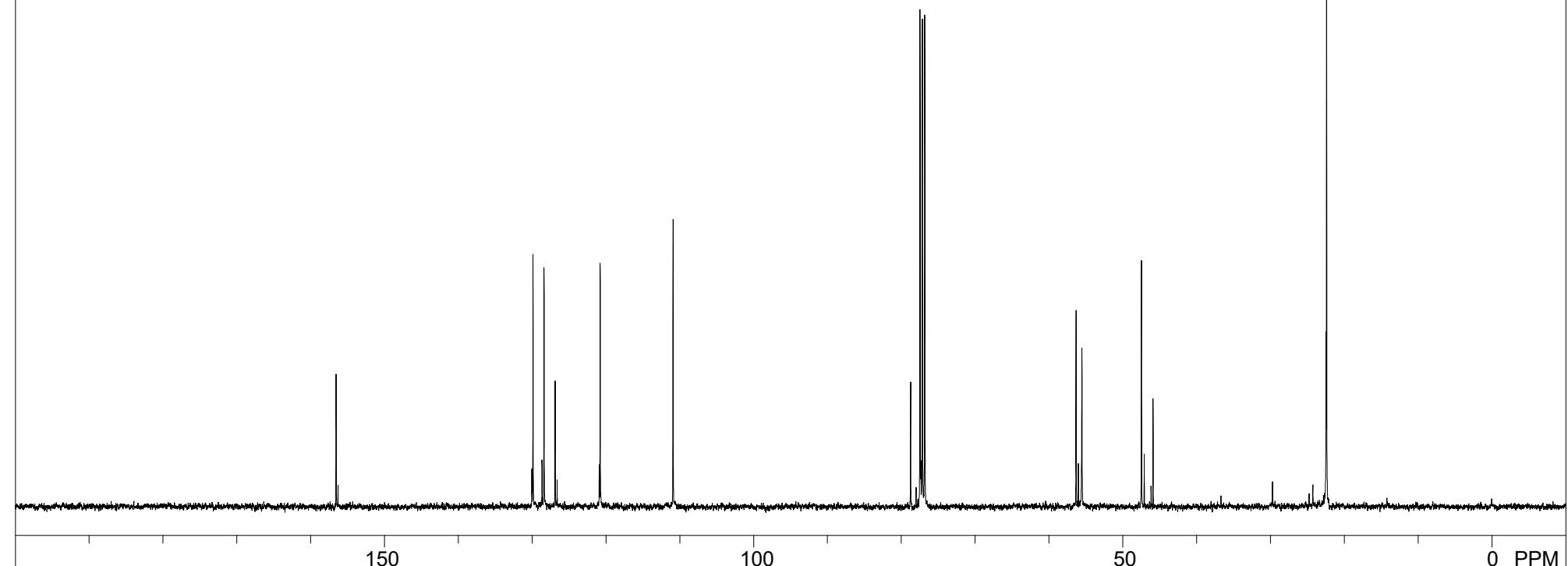
110.913

78.752
77.475
77.160
76.836

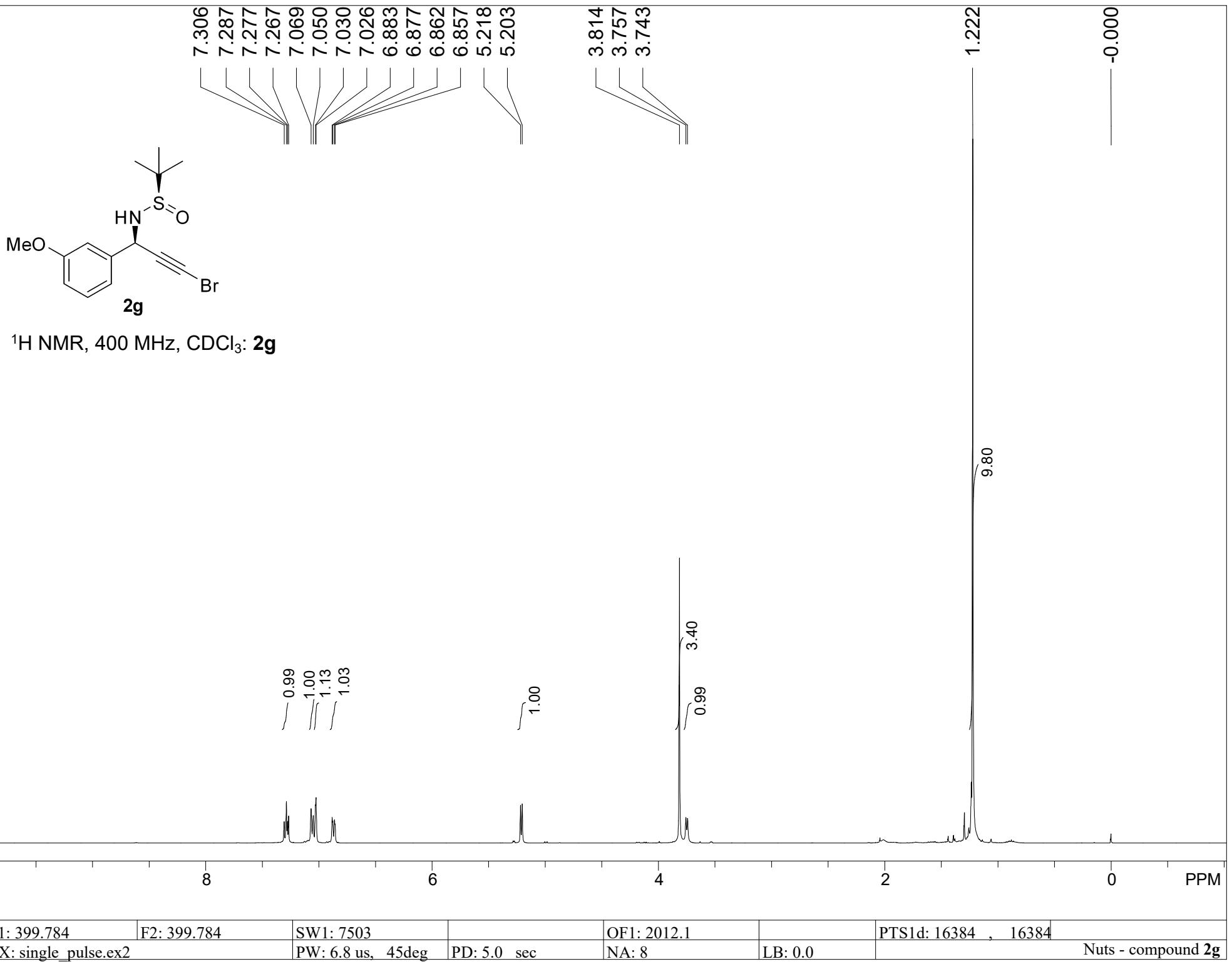
56.345
55.554
47.497
45.924

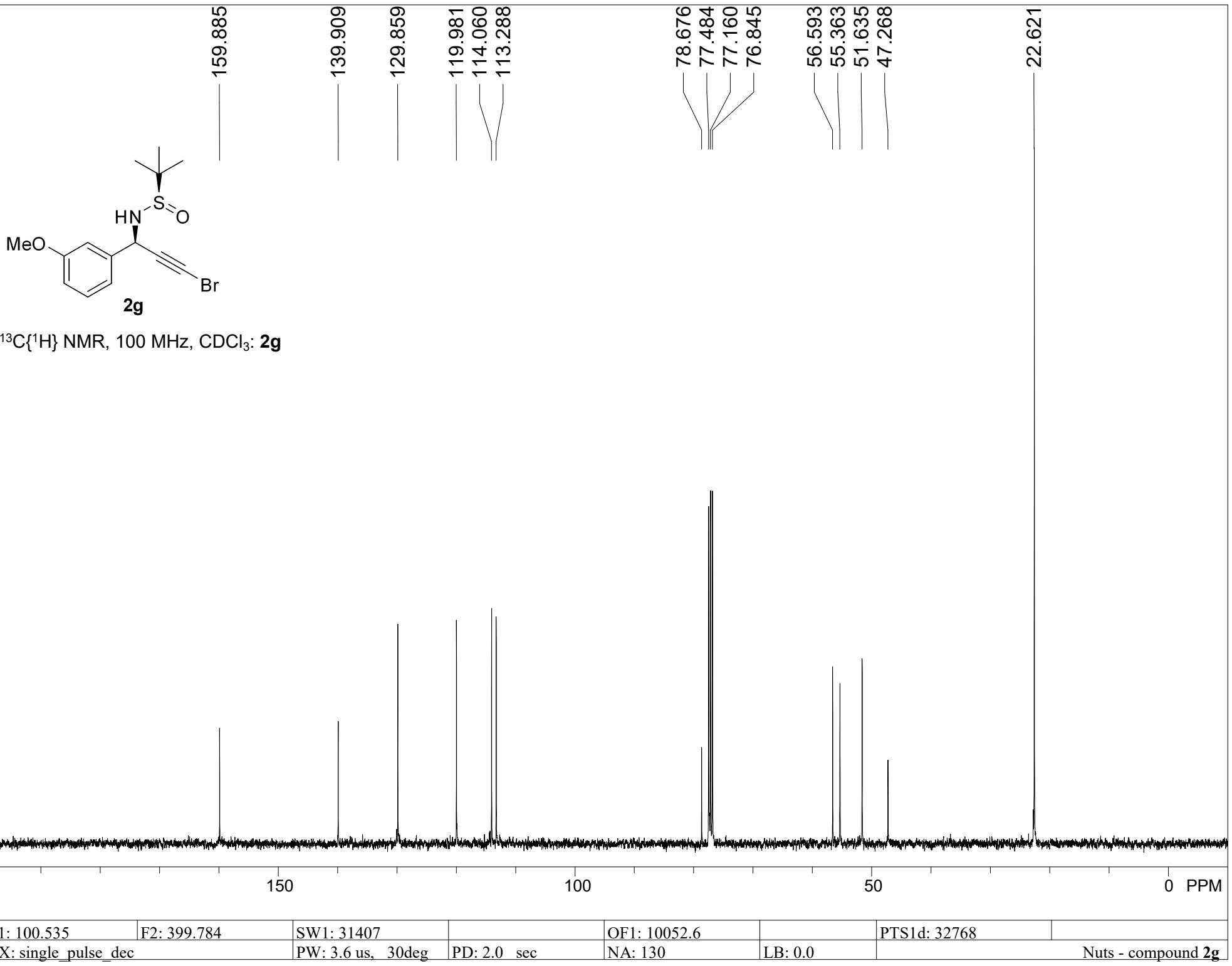
22.420

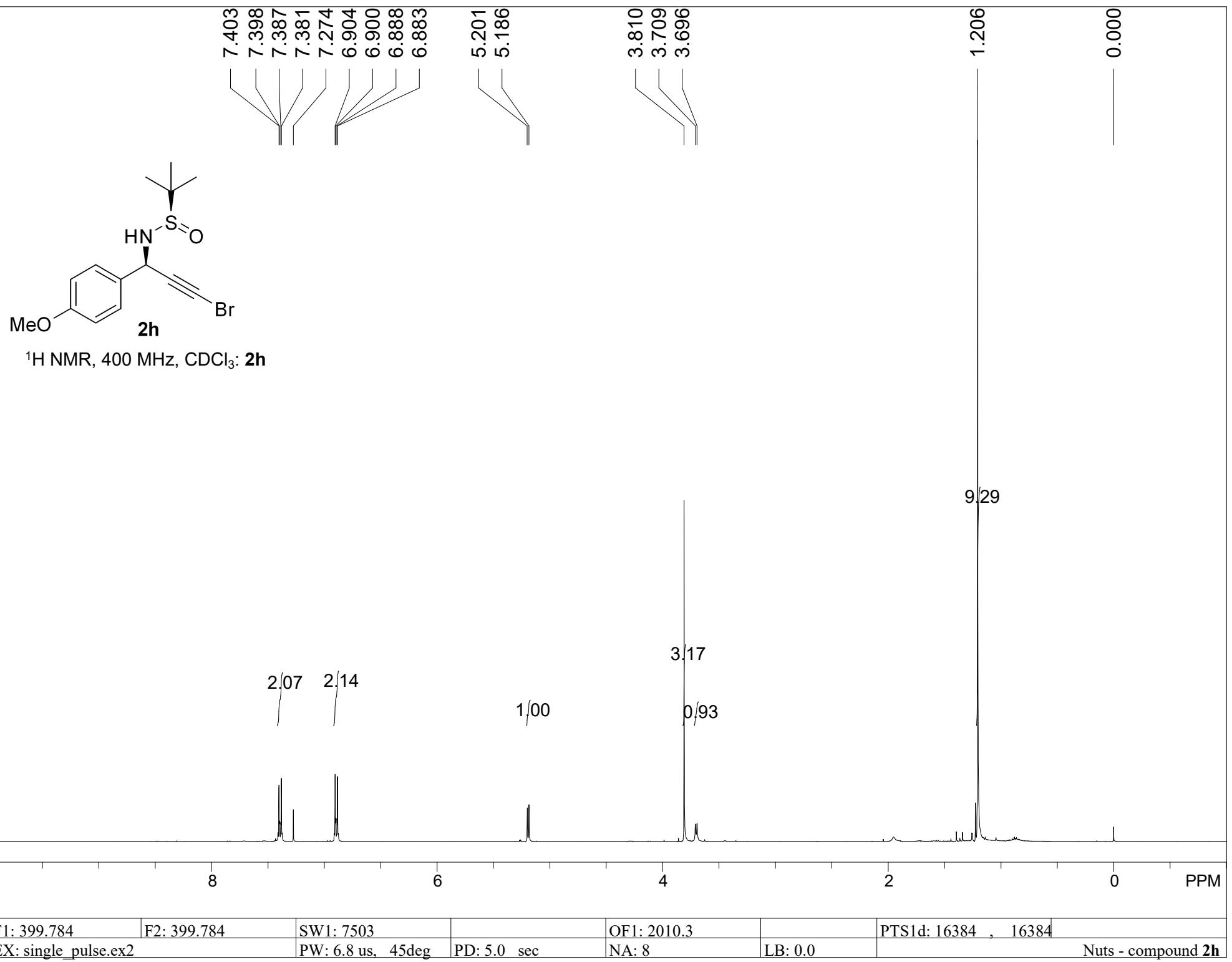
$^{13}\text{C}\{\text{H}\}$ NMR, 100 MHz, CDCl_3 : **2f**

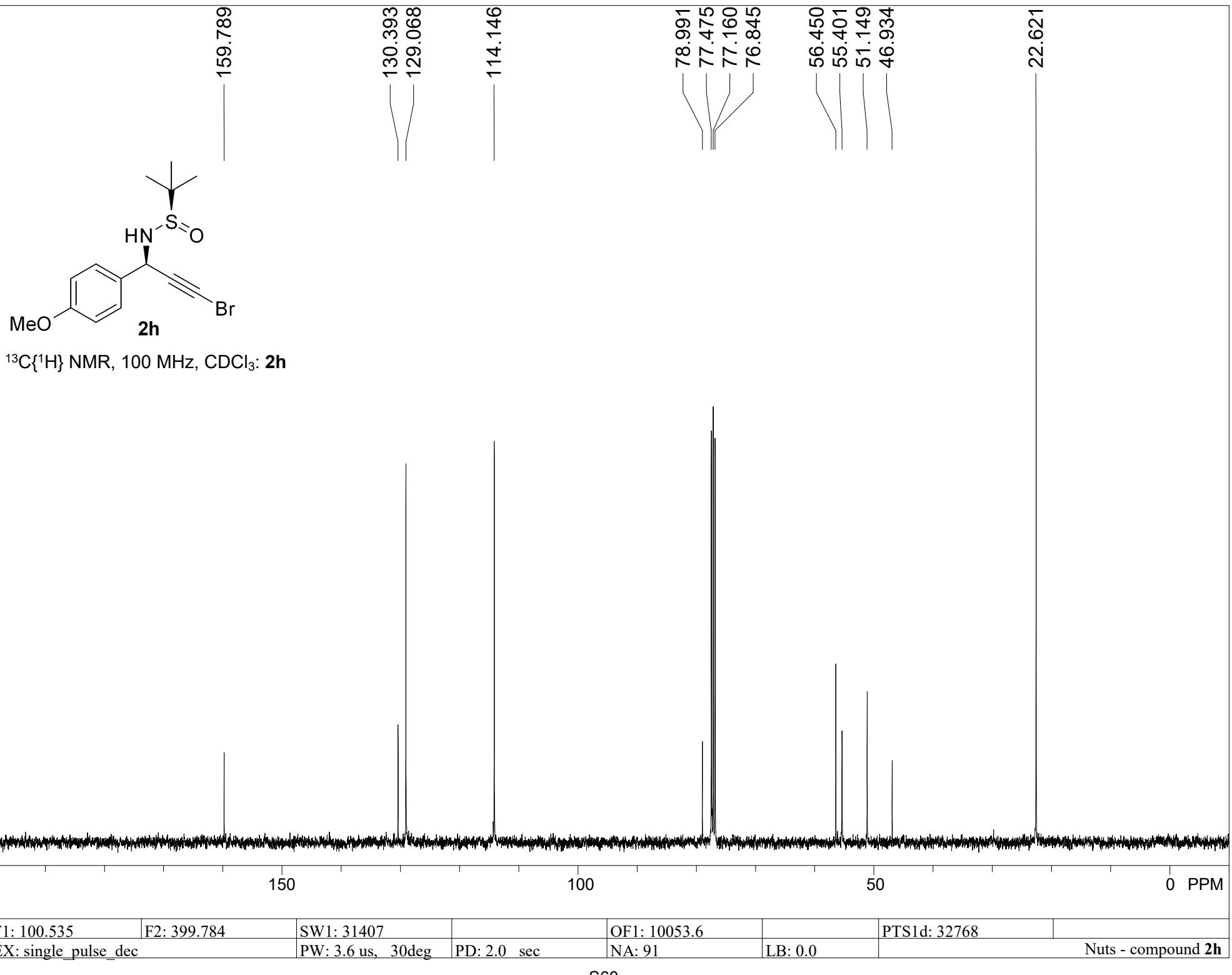


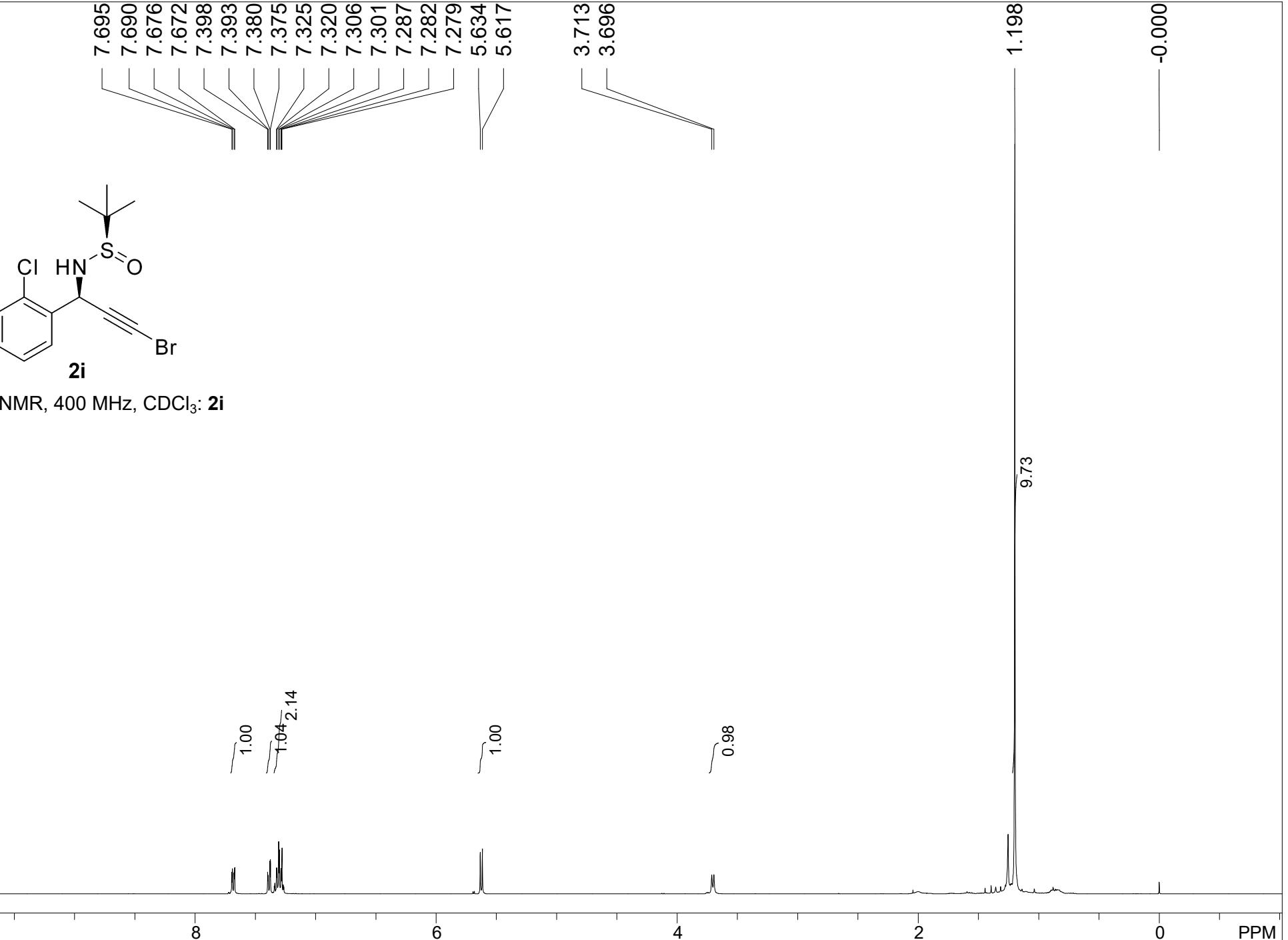
F1: 100.535	F2: 399.784	SW1: 31407		OF1: 10050.7		PTS1d: 32768	
EX: single_pulse_dec		PW: 3.6 us, 30deg	PD: 2.0 sec	NA: 414	LB: 0.0		Nuts - compound 2f





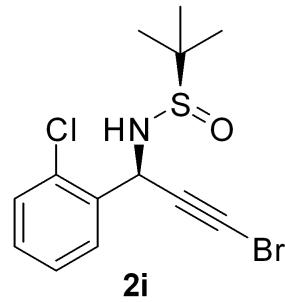




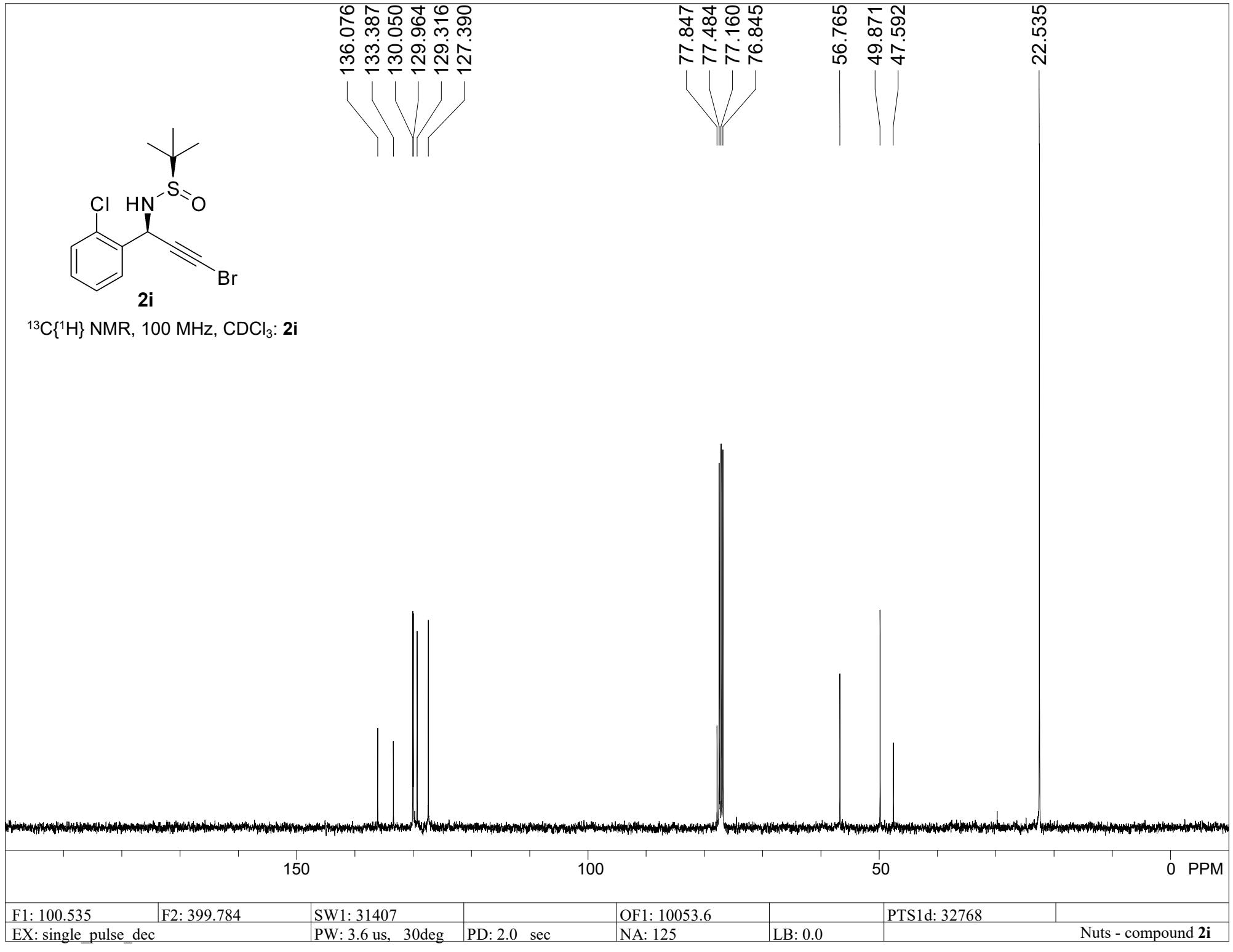


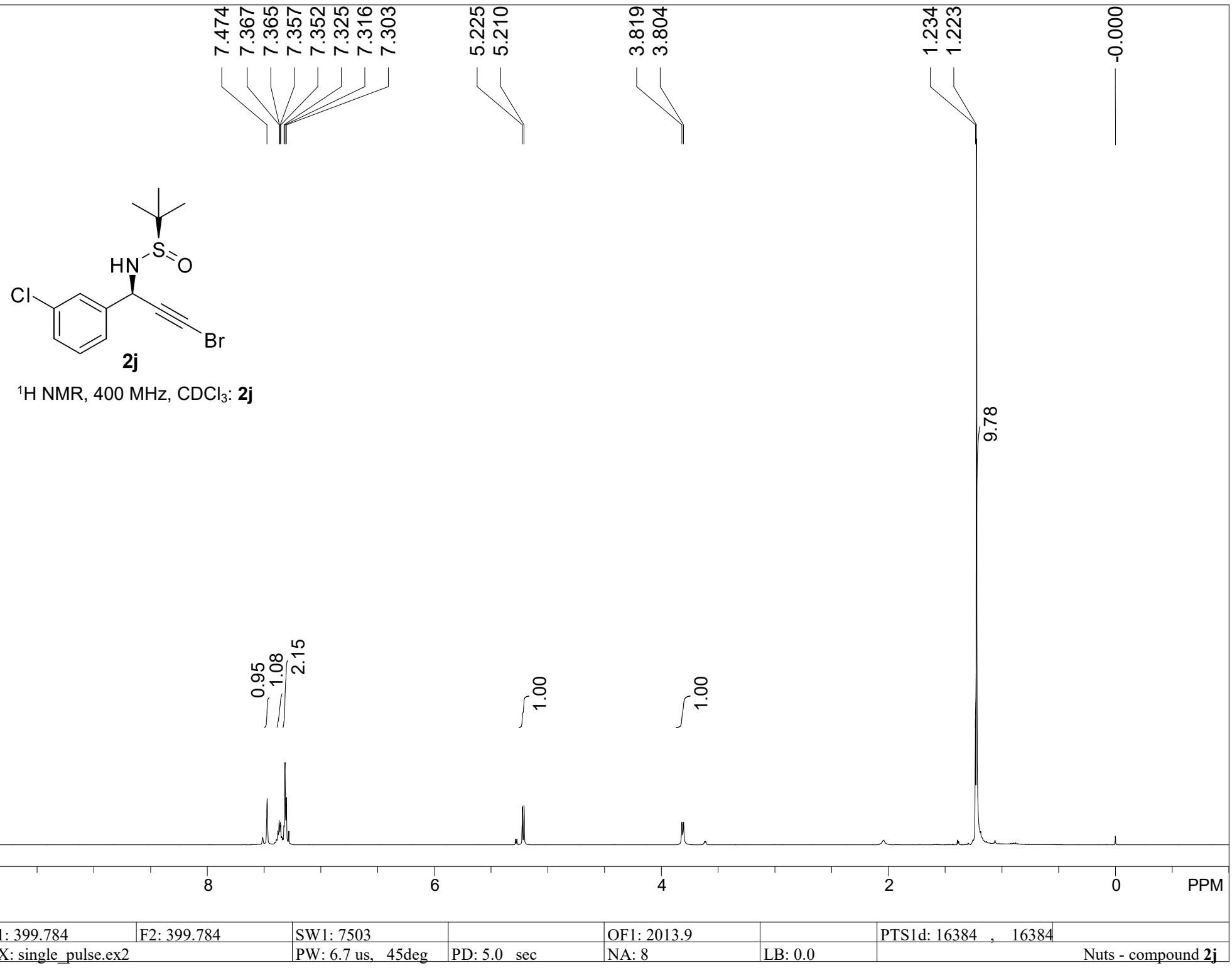
¹H NMR, 400 MHz, CDCl₃: **2i**

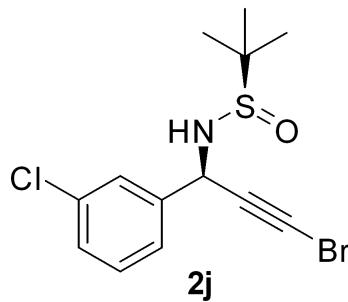
F1: 399.784	F2: 399.784	SW1: 7503		OF1: 2012.1		PTS1d: 16384	
EX: single_pulse.ex2		PW: 6.8 us, 45deg	PD: 5.0 sec	NA: 8	LB: 0.0		Nuts - compound 2i



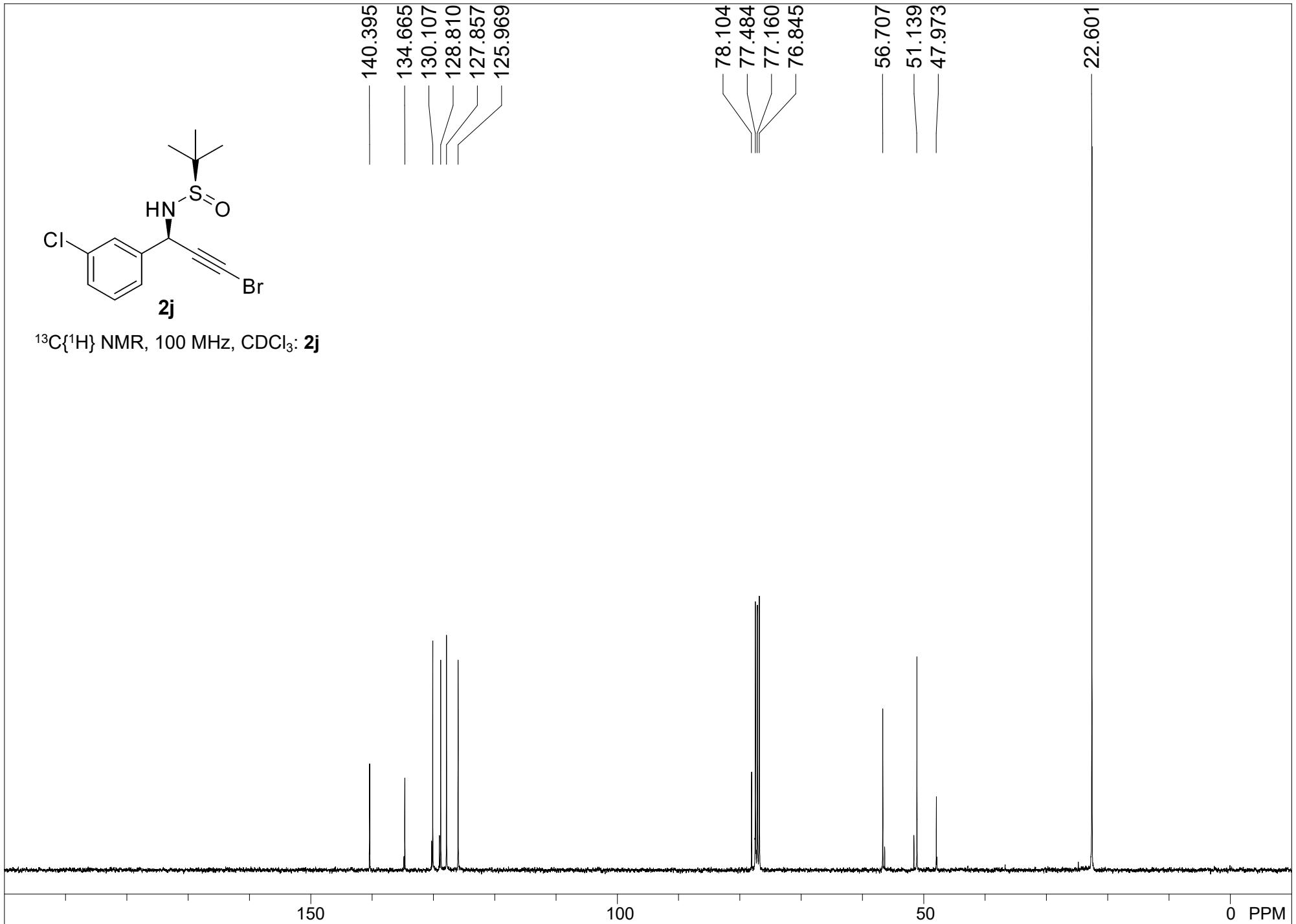
$^{13}\text{C}\{\text{H}\}$ NMR, 100 MHz, CDCl_3 : **2i**



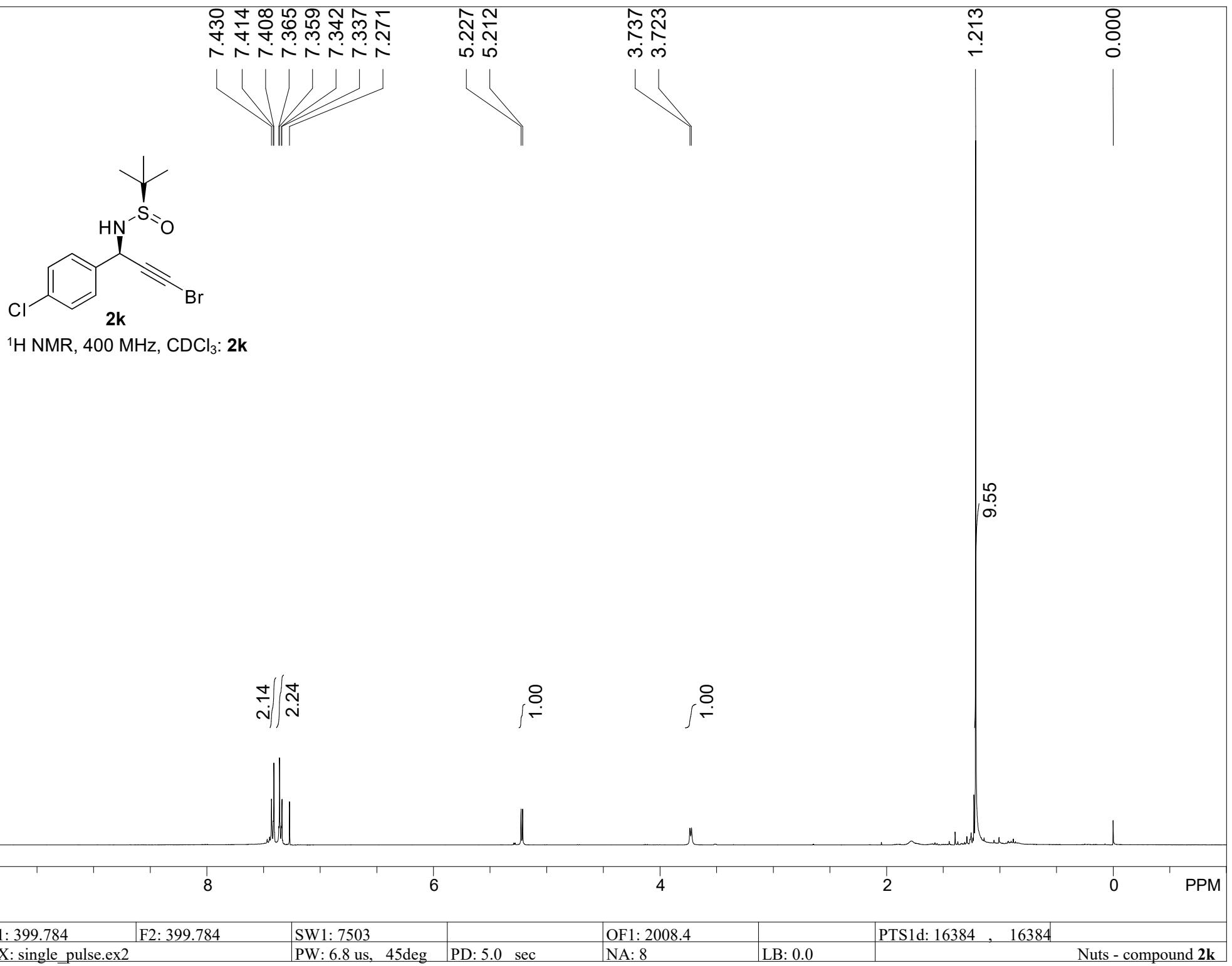


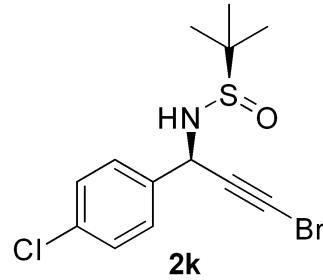


$^{13}\text{C}\{\text{H}\}$ NMR, 100 MHz, CDCl_3 : **2j**

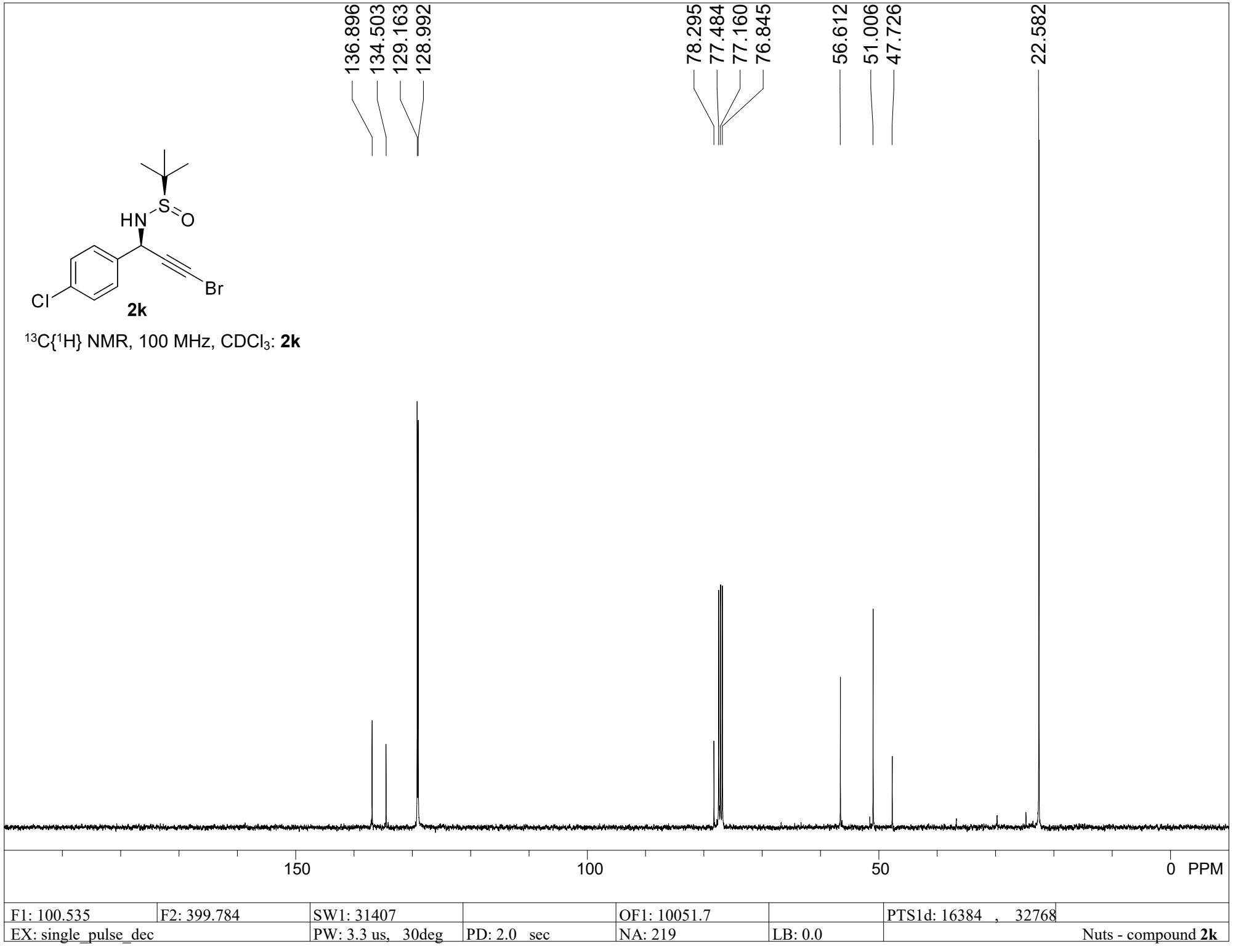


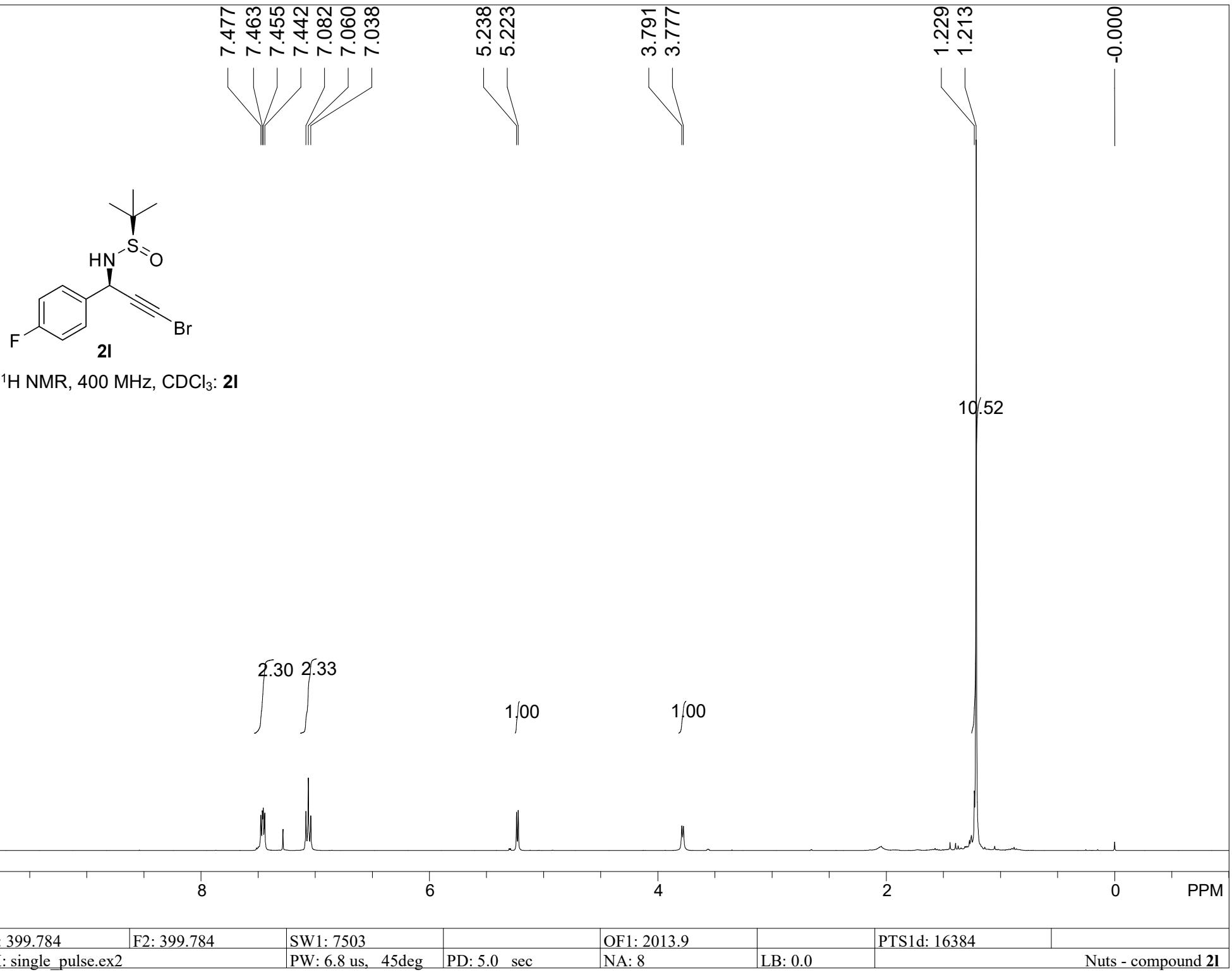
F1: 100.535	F2: 399.784	SW1: 31407		OF1: 10052.6		PTS1d: 16384 , 32768	
EX: single_pulse_dec		PW: 3.3 us, 30deg		PD: 2.0 sec	NA: 365	LB: 0.0	Nuts - compound 2j

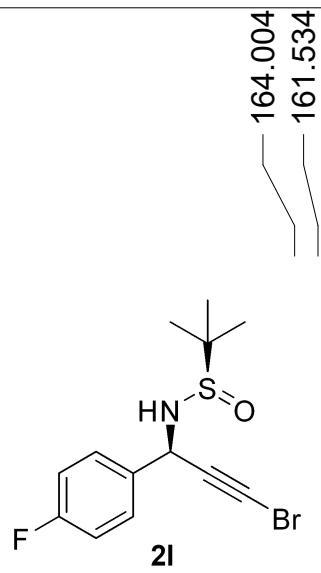




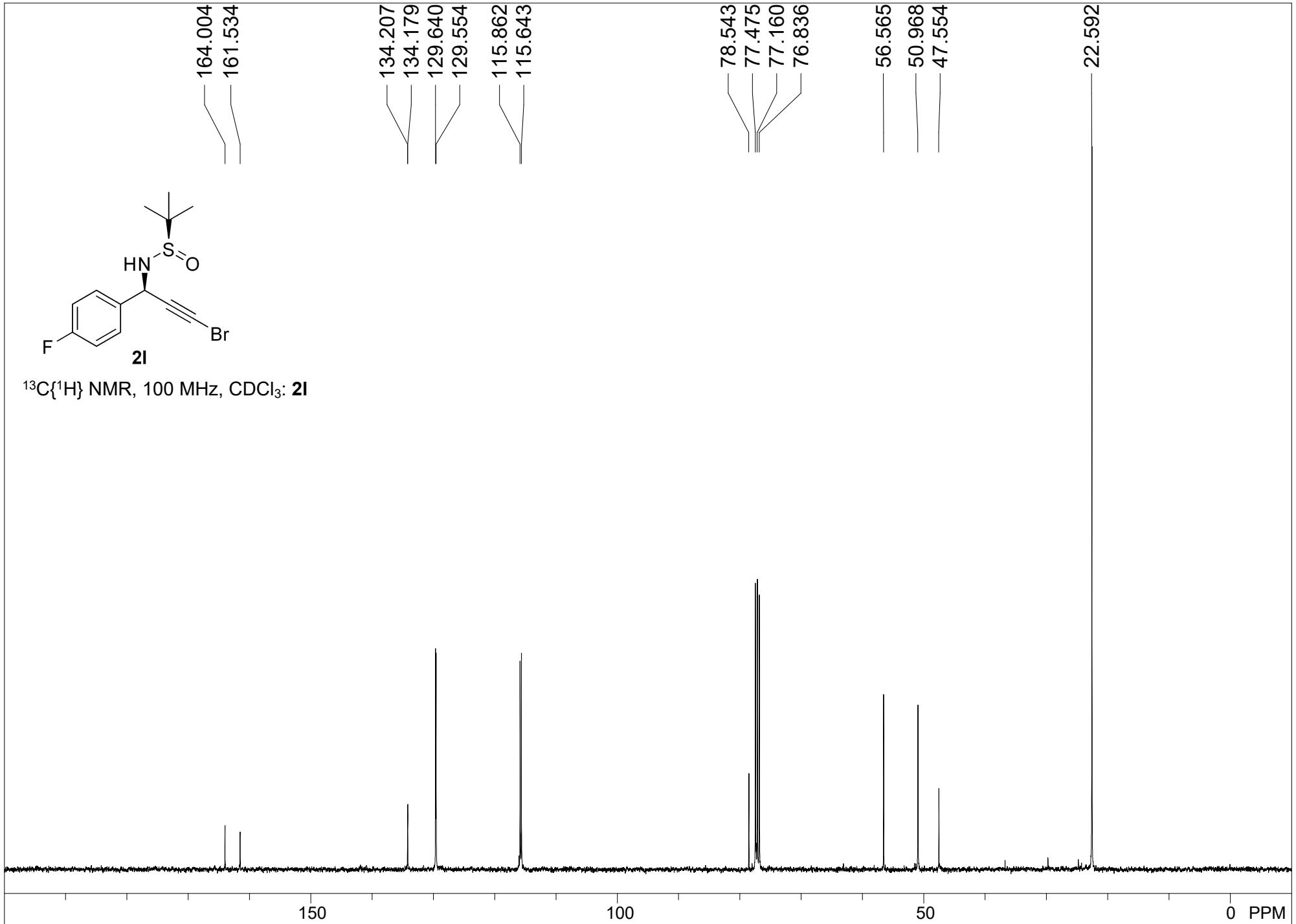
$^{13}\text{C}\{\text{H}\}$ NMR, 100 MHz, CDCl_3 : **2k**



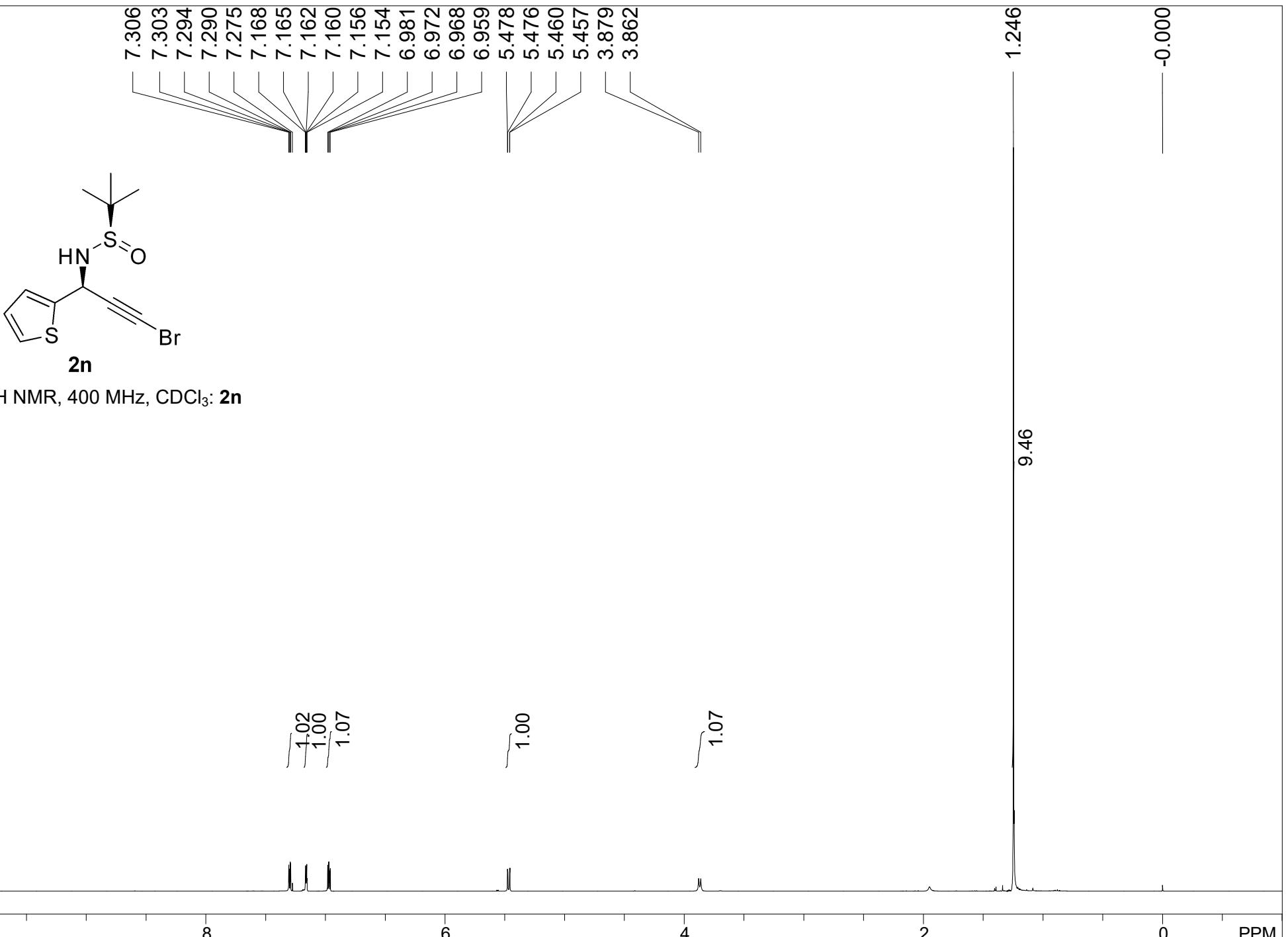




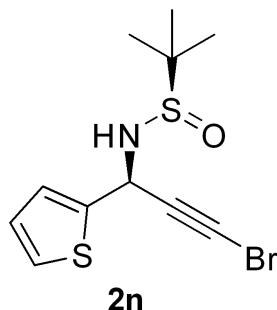
$^{13}\text{C}\{\text{H}\}$ NMR, 100 MHz, CDCl_3 : **2l**



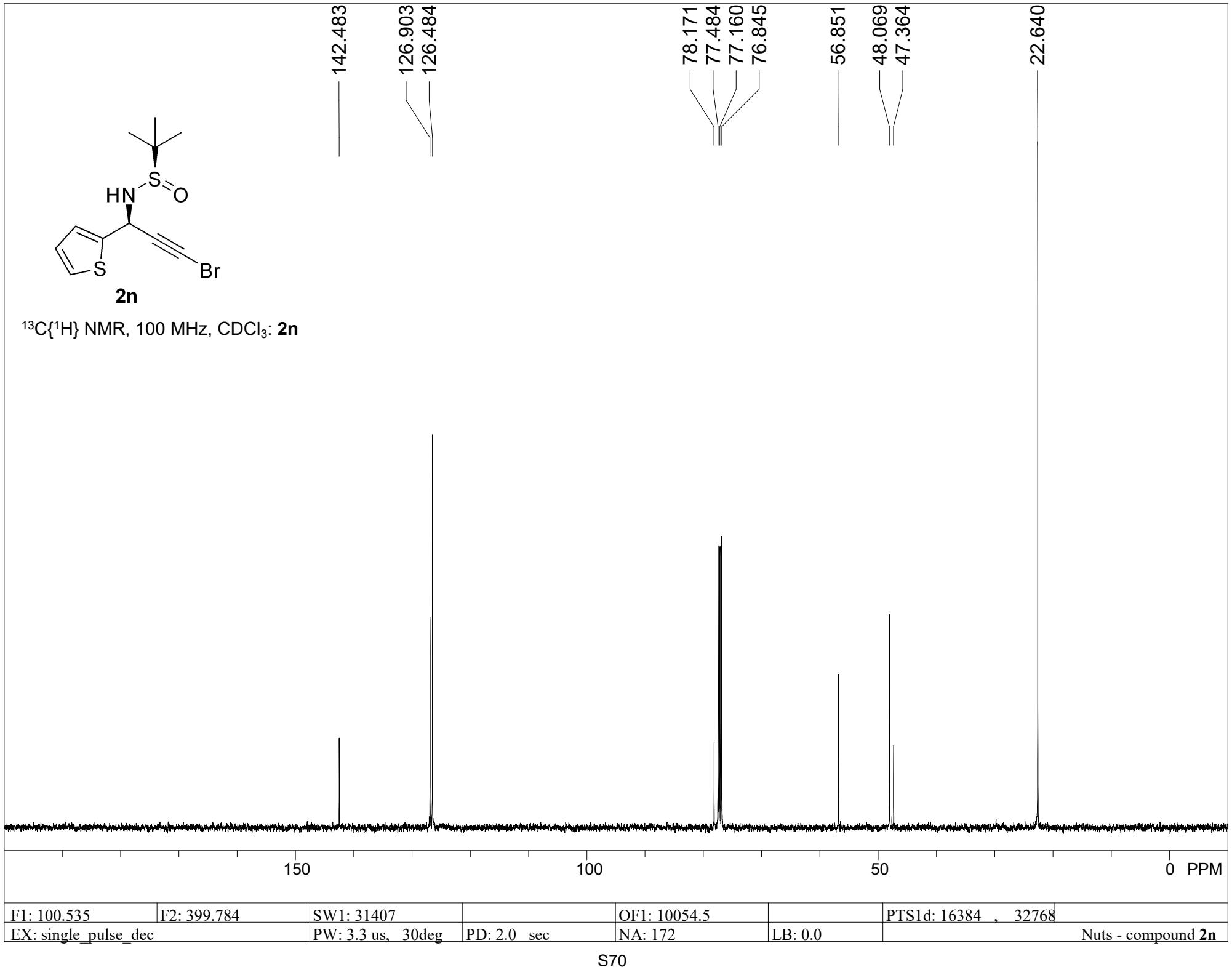
F1: 100.535	F2: 399.784	SW1: 31407		OF1: 10053.6		PTS1d: 32768	
EX: single_pulse_dec		PW: 3.6 us, 30deg	PD: 2.0 sec	NA: 384	LB: 0.0		Nuts - compound 2l

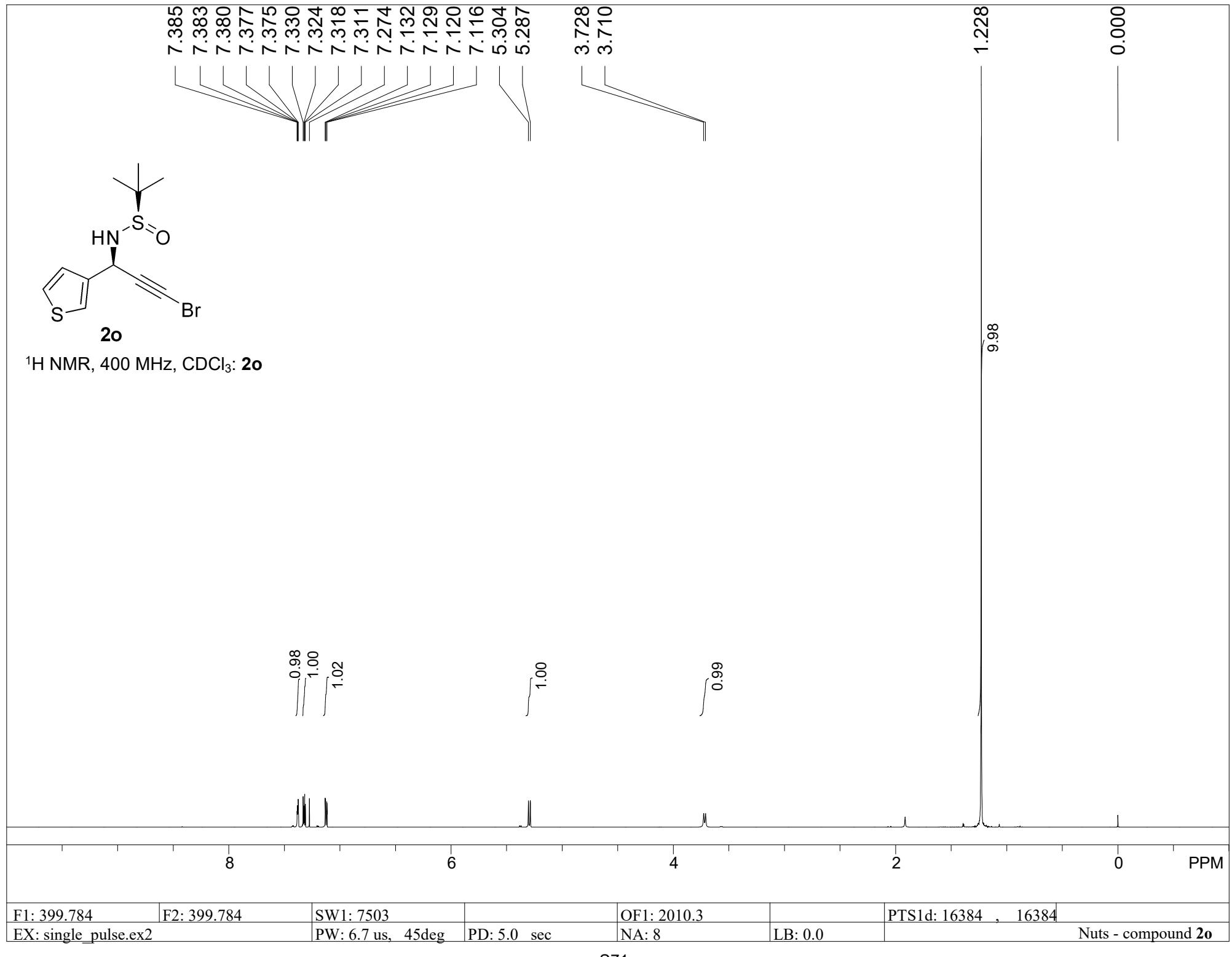


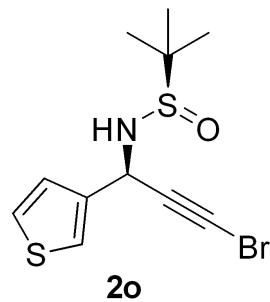
F1: 399.784	F2: 399.784	SW1: 7503		OF1: 2010.7		PTS1d: 16384 , 16384
EX: single_pulse.ex2		PW: 6.7 us, 45deg	PD: 5.0 sec	NA: 8	LB: 0.0	Nuts - compound 2n



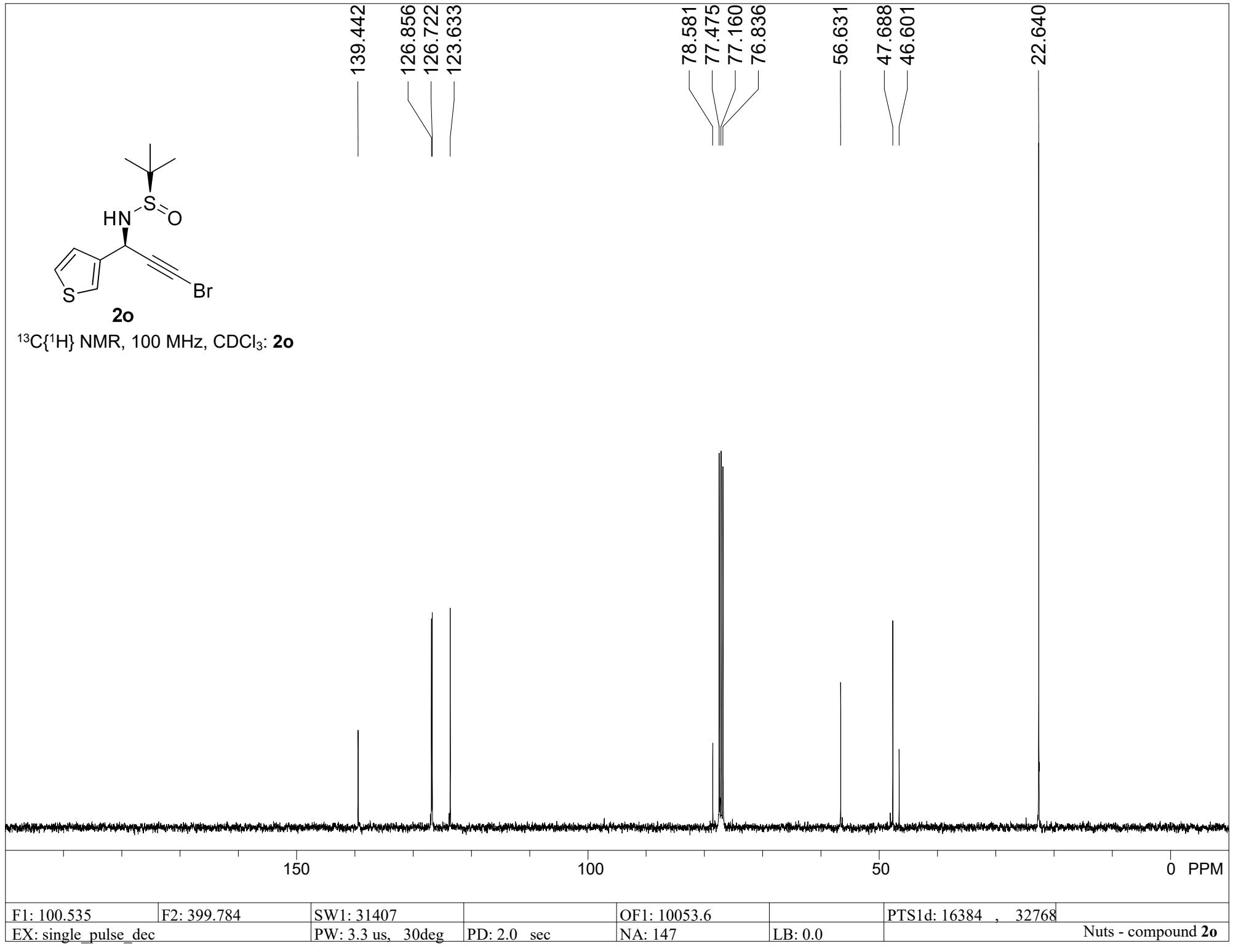
$^{13}\text{C}\{\text{H}\}$ NMR, 100 MHz, CDCl_3 : **2n**

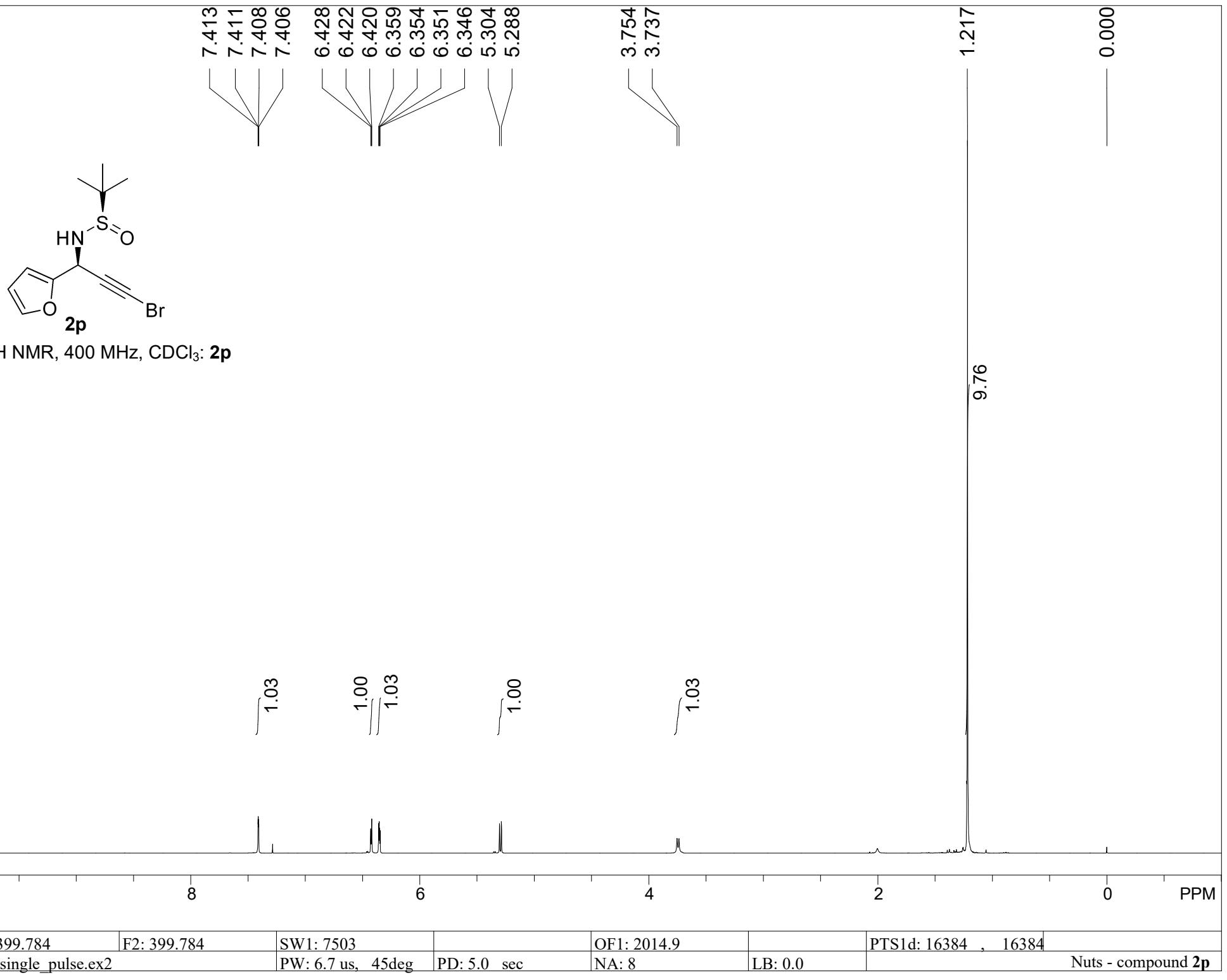


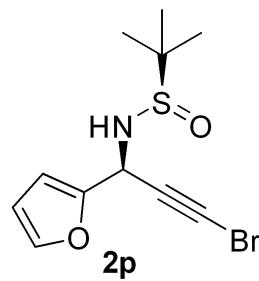




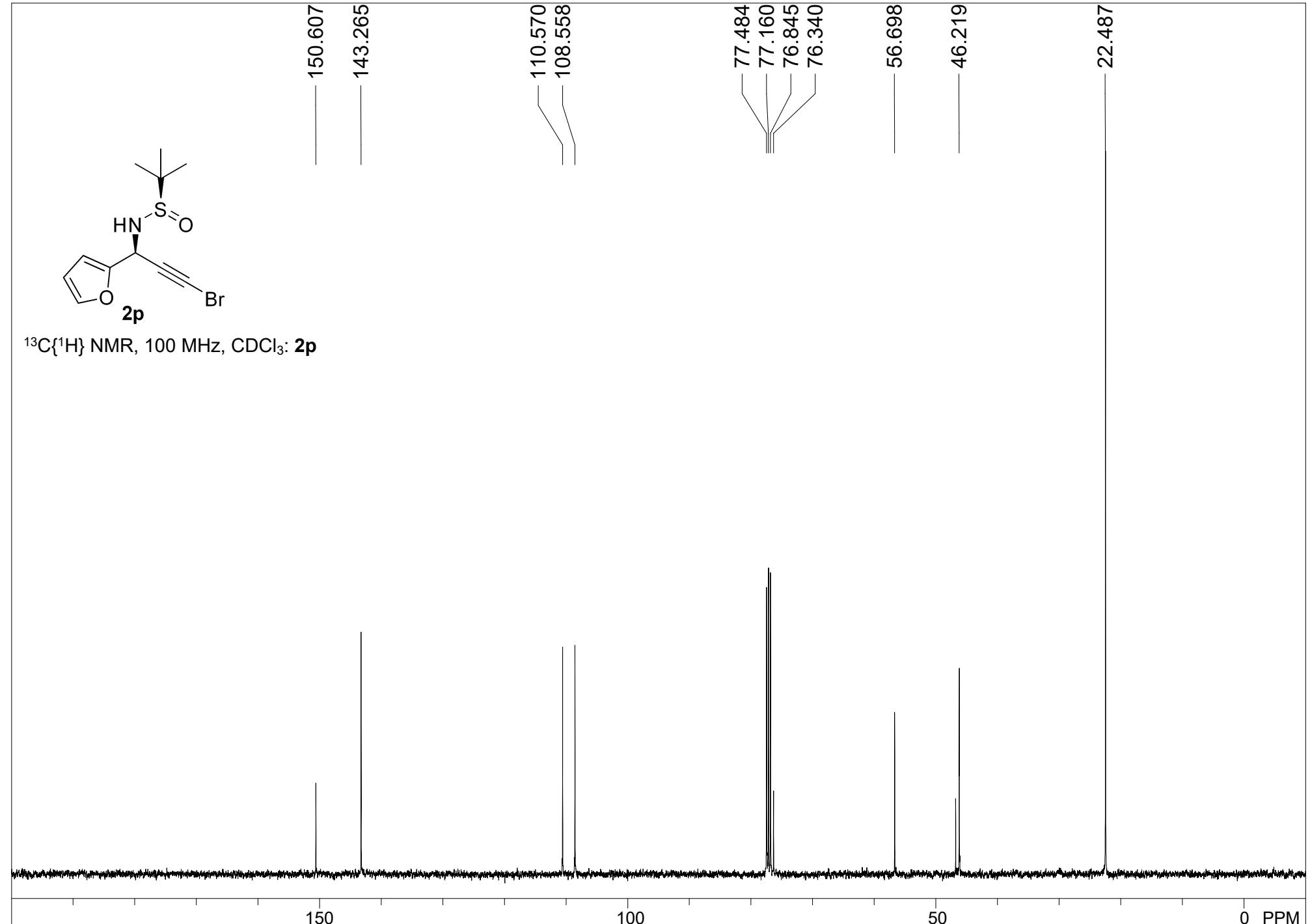
$^{13}\text{C}\{\text{H}\}$ NMR, 100 MHz, CDCl_3 : **2o**



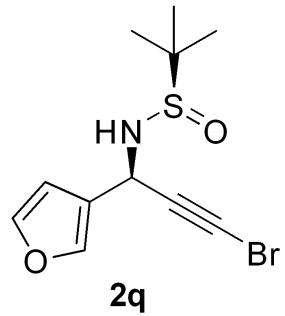




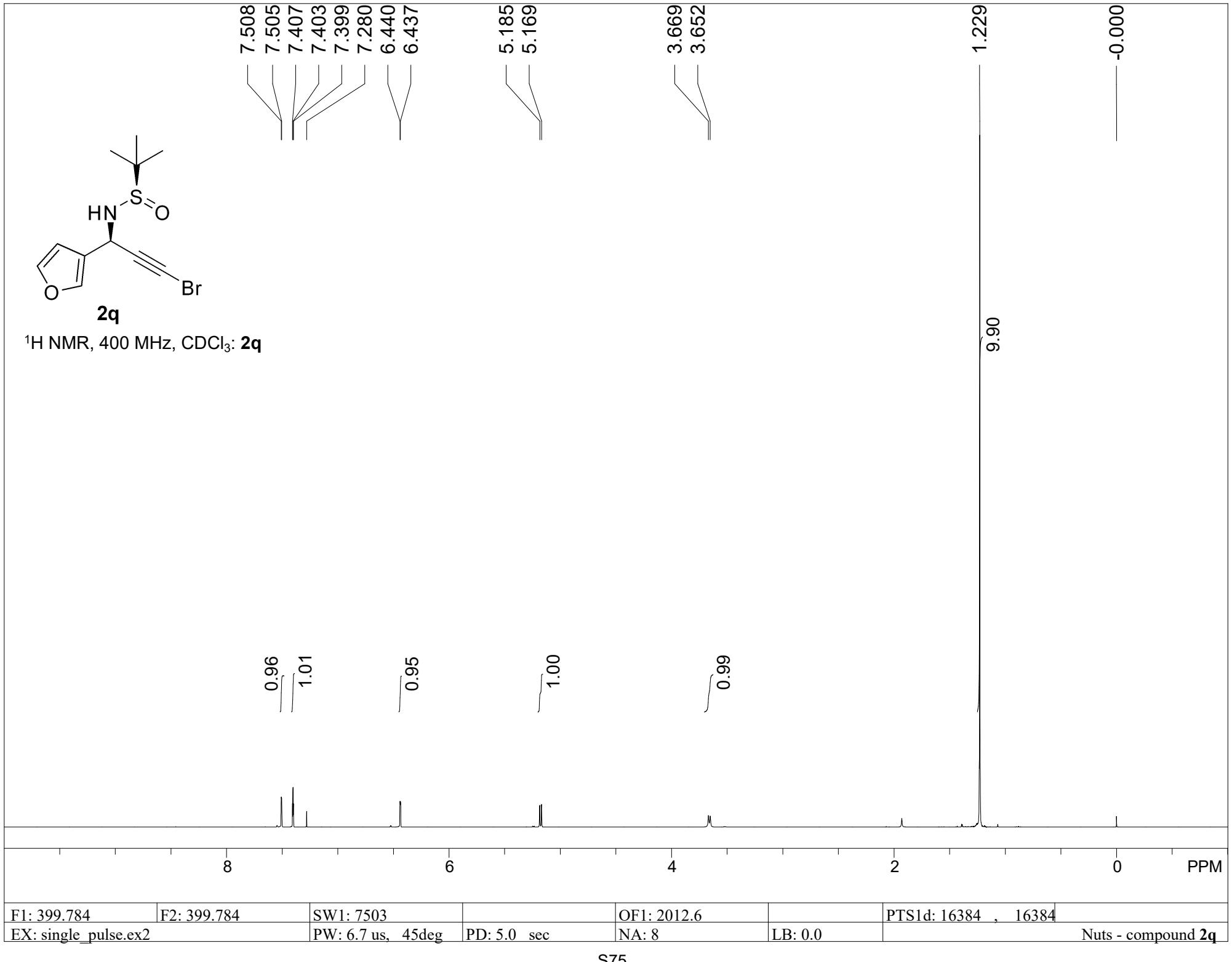
¹³C{¹H} NMR, 100 MHz, CDCl₃: **2p**

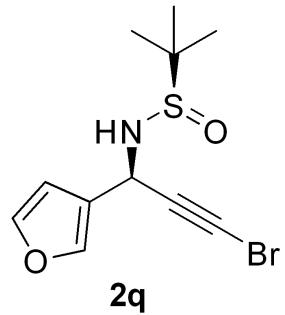


F1: 100.535	F2: 399.784	SW1: 31407		OF1: 10053.6		PTS1d: 32768 , 32768	
EX: single_pulse_dec		PW: 3.3 us, 30deg	PD: 2.0 sec	NA: 120	LB: 0.0		Nuts - compound 2p

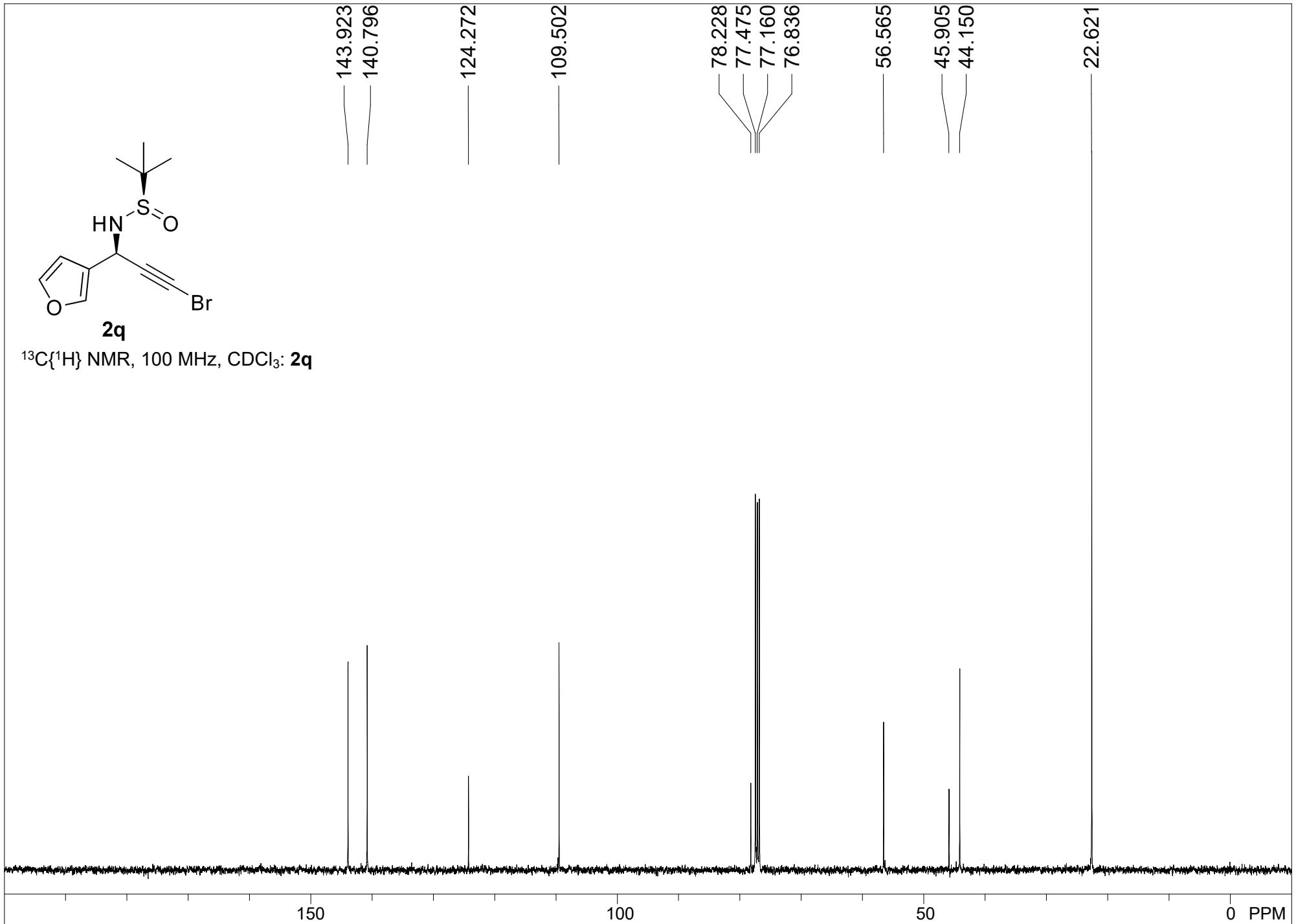


¹H NMR, 400 MHz, CDCl₃: **2q**





$^{13}\text{C}\{\text{H}\}$ NMR, 100 MHz, CDCl_3 : **2q**



F1: 100.535

F2: 399.784

SW1: 31407

PW: 3.3 us, 30deg

OF1: 10054.5

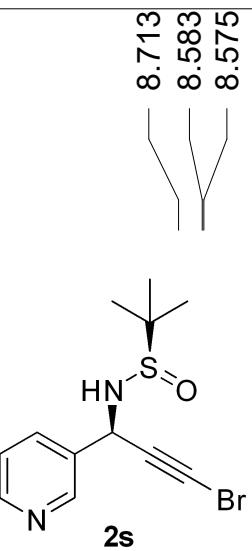
PD: 2.0 sec

PTS1d: 32768

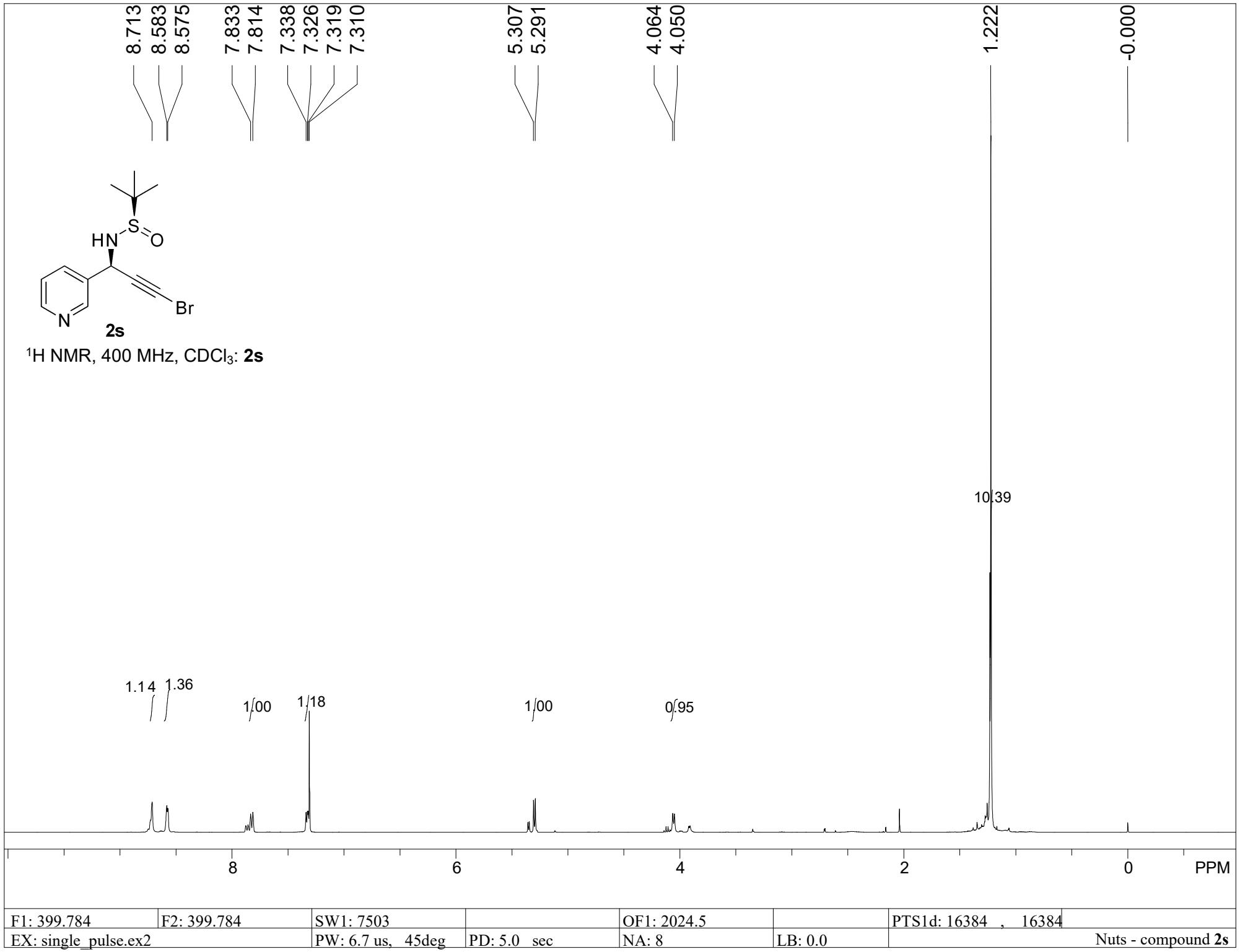
NA: 156

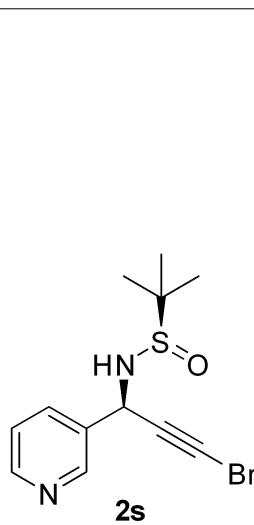
LB: 0.0

Nuts - compound **2q**

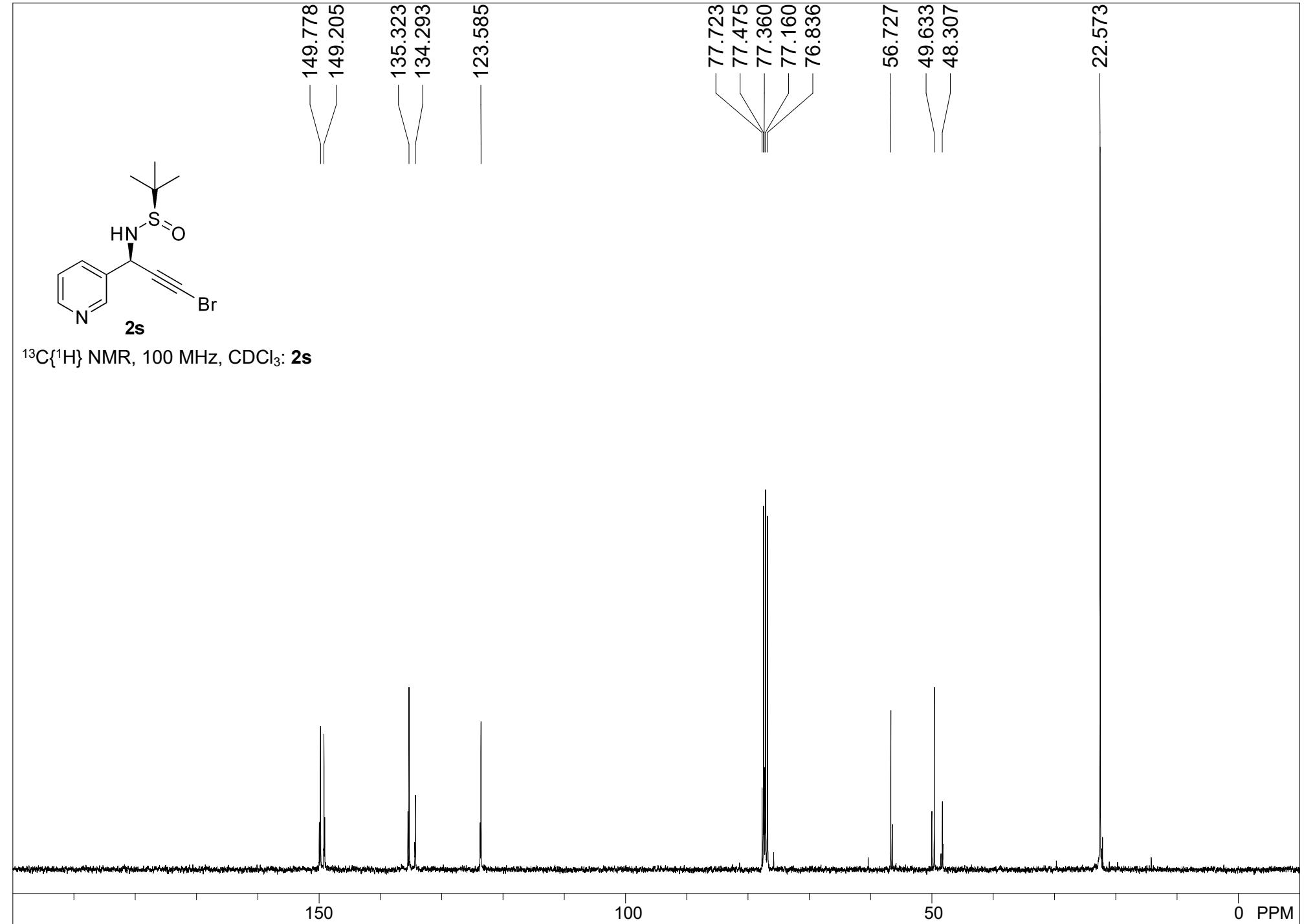


¹H NMR, 400 MHz, CDCl₃: **2s**

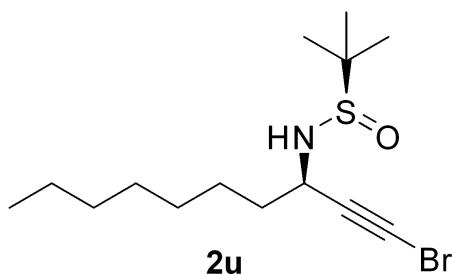




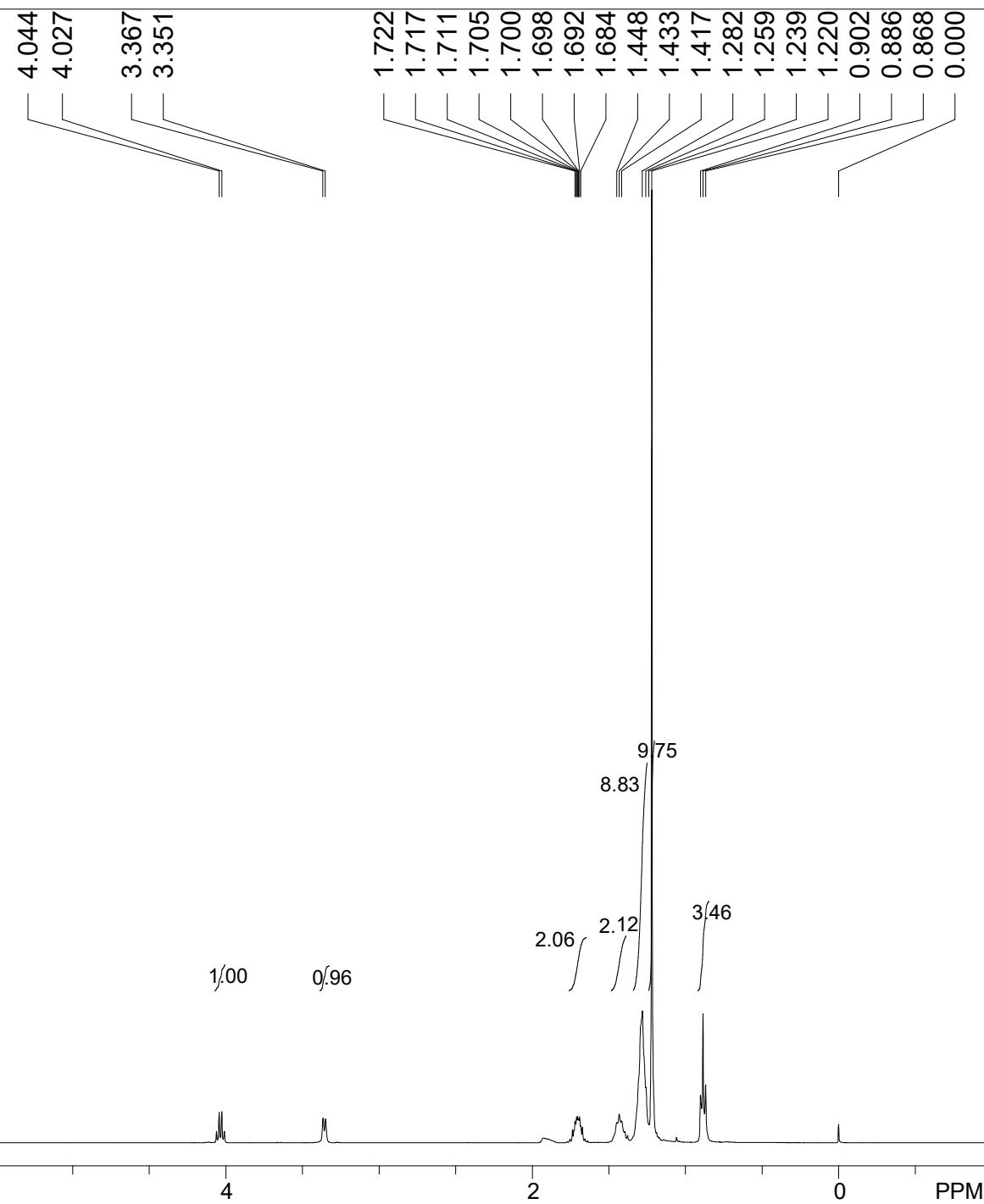
$^{13}\text{C}\{\text{H}\}$ NMR, 100 MHz, CDCl_3 : **2s**



F1: 100.535	F2: 399.784	SW1: 31407		OF1: 10051.7		PTS1d: 16384 , 32768	
EX: single_pulse_dec		PW: 3.3 us, 30deg	PD: 2.0 sec	NA: 286	LB: 0.0		Nuts - compound 2s



¹H NMR, 400 MHz, CDCl₃: **2u**



F1: 399.784

F2: 399.784

SW1: 7503

OF1: 2013.0

PTS1d: 16384 , 16384

EX: single_pulse.ex2

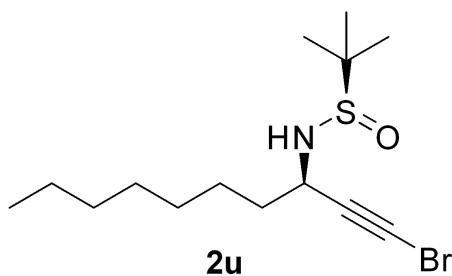
PW: 6.7 us, 45deg

PD: 5.0 sec

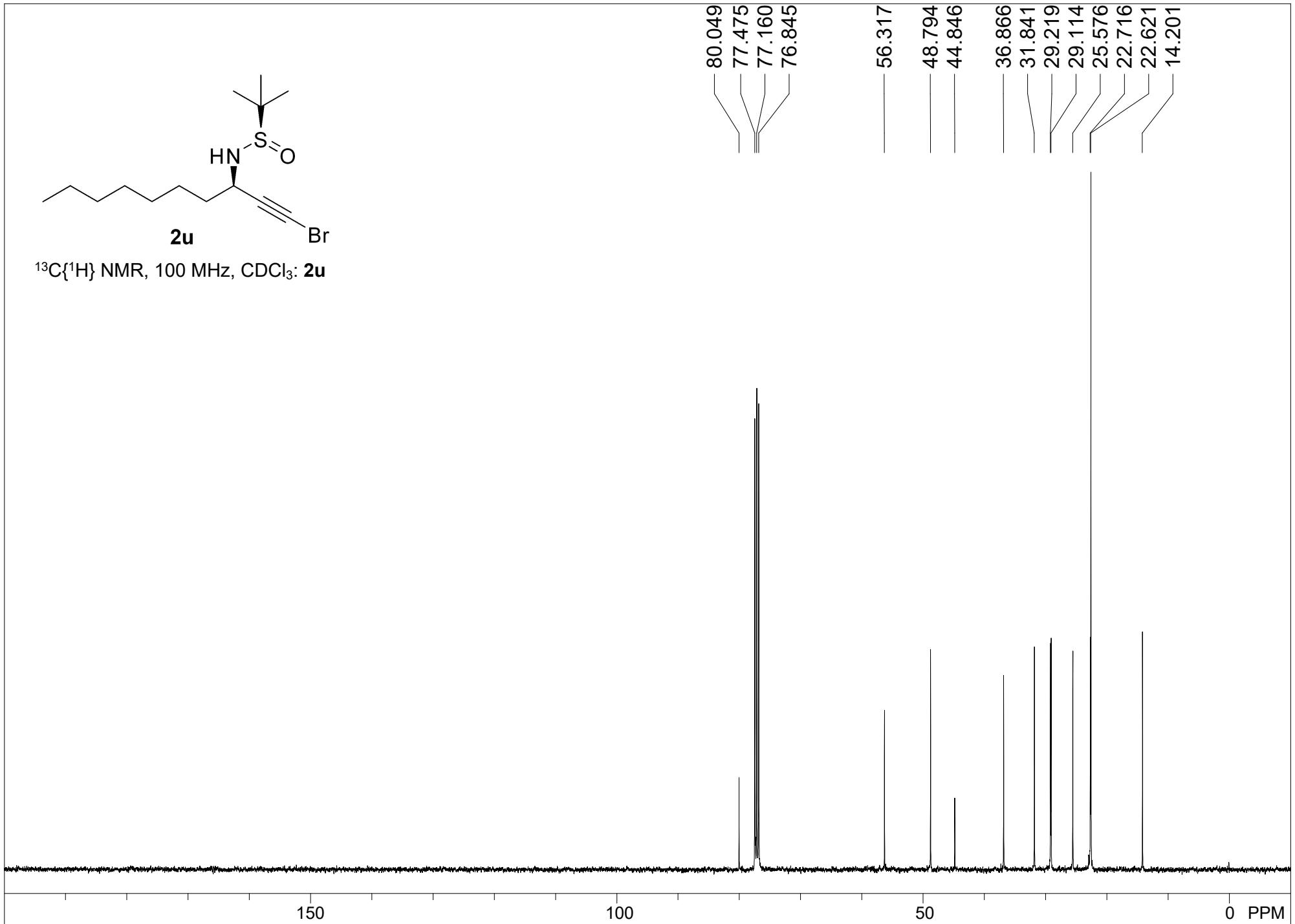
NA: 8

LB: 0.0

Nuts - compound **2u**



$^{13}\text{C}\{\text{H}\}$ NMR, 100 MHz, CDCl_3 : **2u**



F1: 100.535

F2: 399.784

SW1: 31407

100

EX: single_pulse_dec

PW: 3.3 us, 30deg

S80

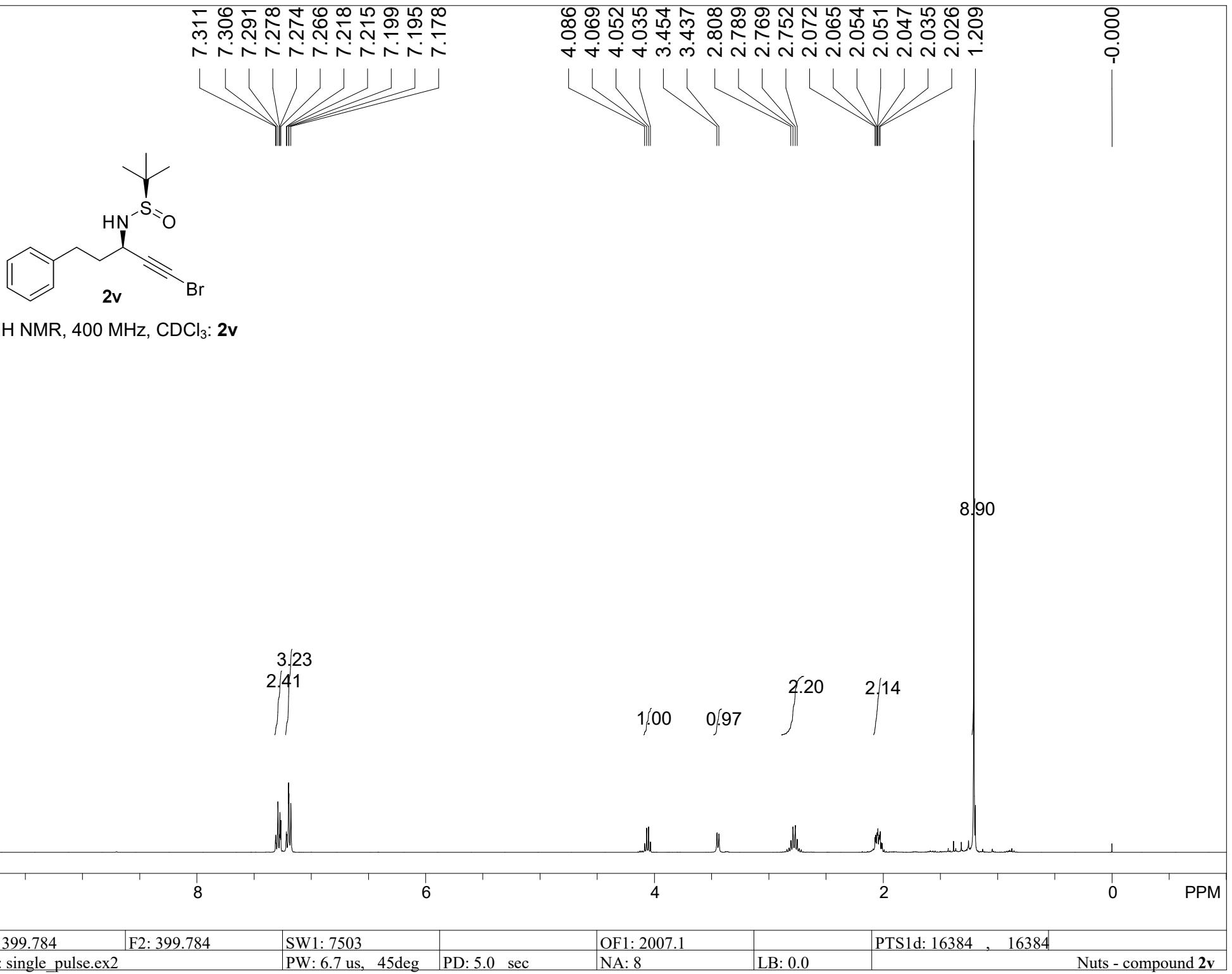
OF1: 10056.4

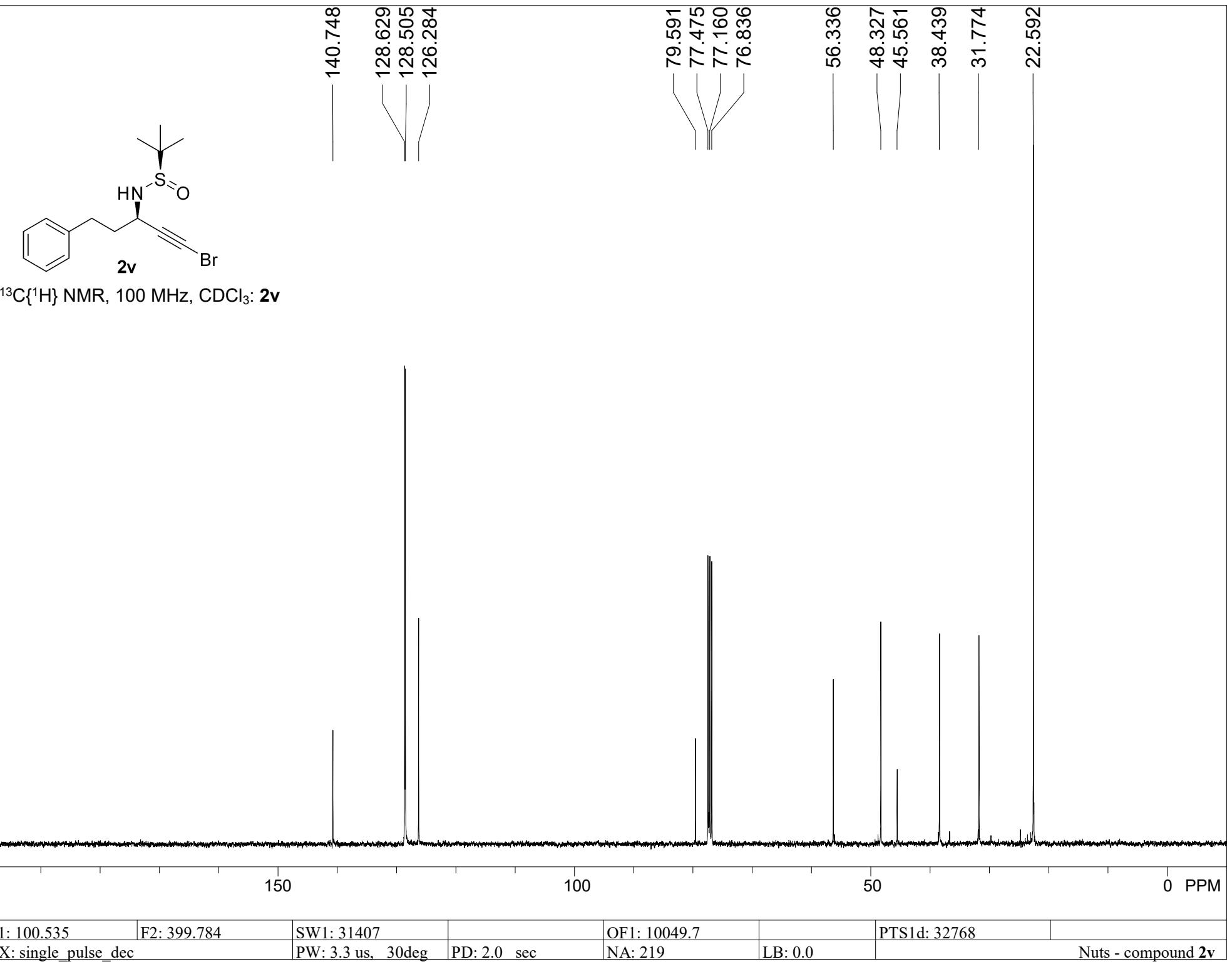
NA: 616

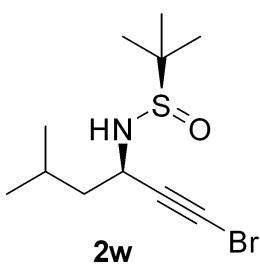
LB: 0.0

PTS1d: 16384 , 32768

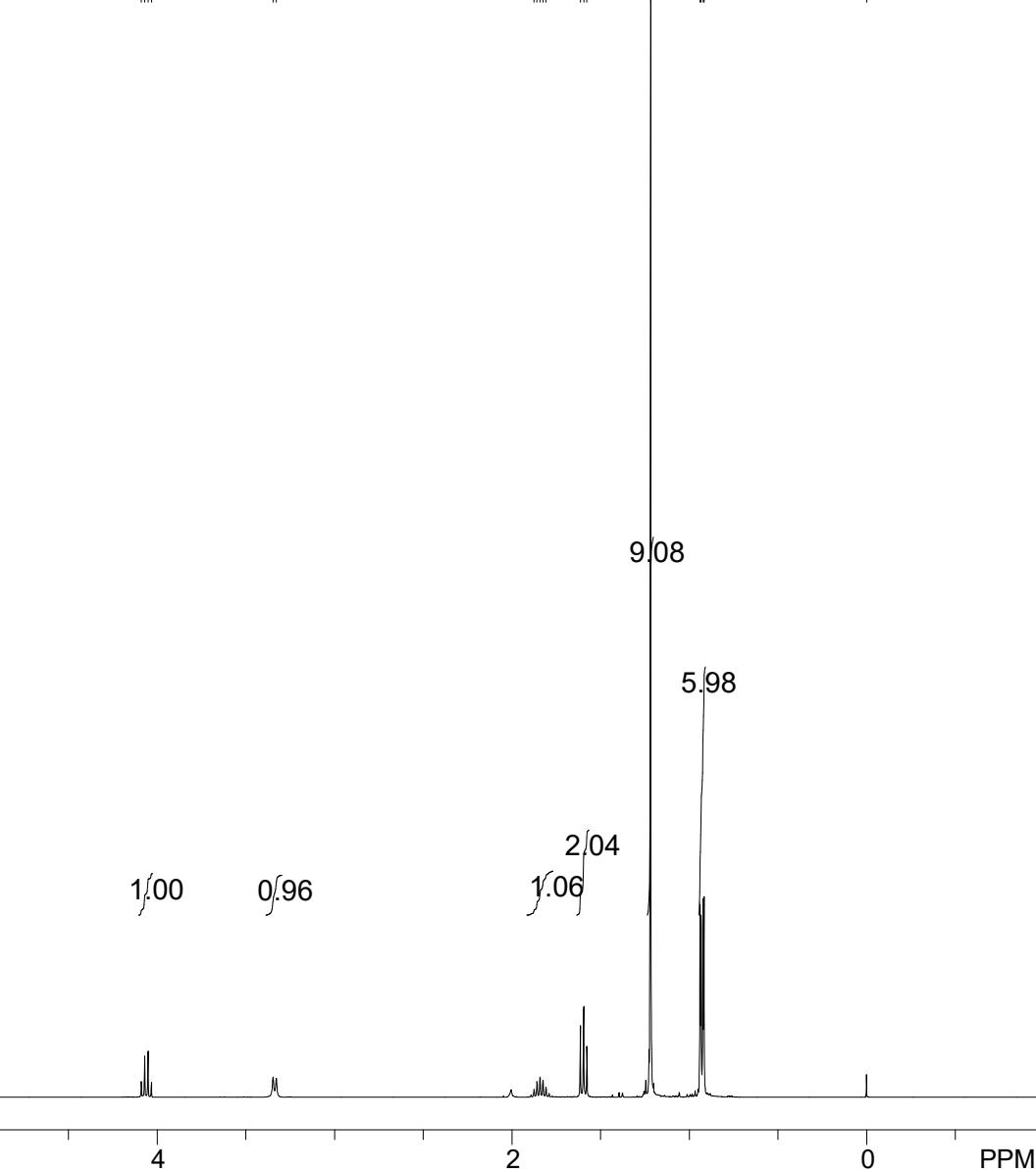
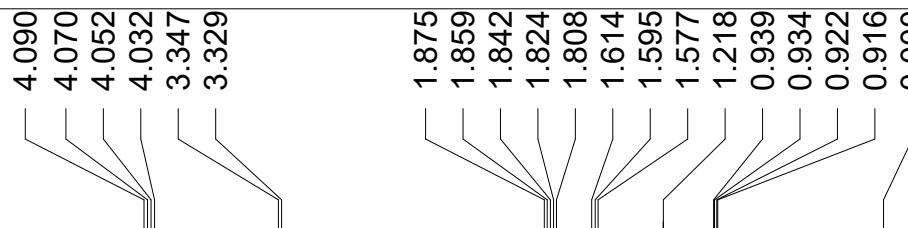
Nuts - compound **2u**







¹H NMR, 400 MHz, CDCl₃: **2w**



F1: 399.784
EX: single_pulse.ex2

F2: 399.784
PW: 6.7 us, 45deg

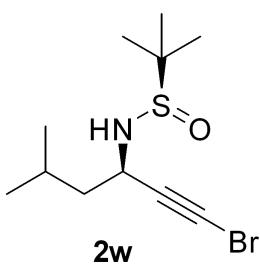
SW1: 7503
PD: 5.0 sec

OF1: 2016.7
NA: 8

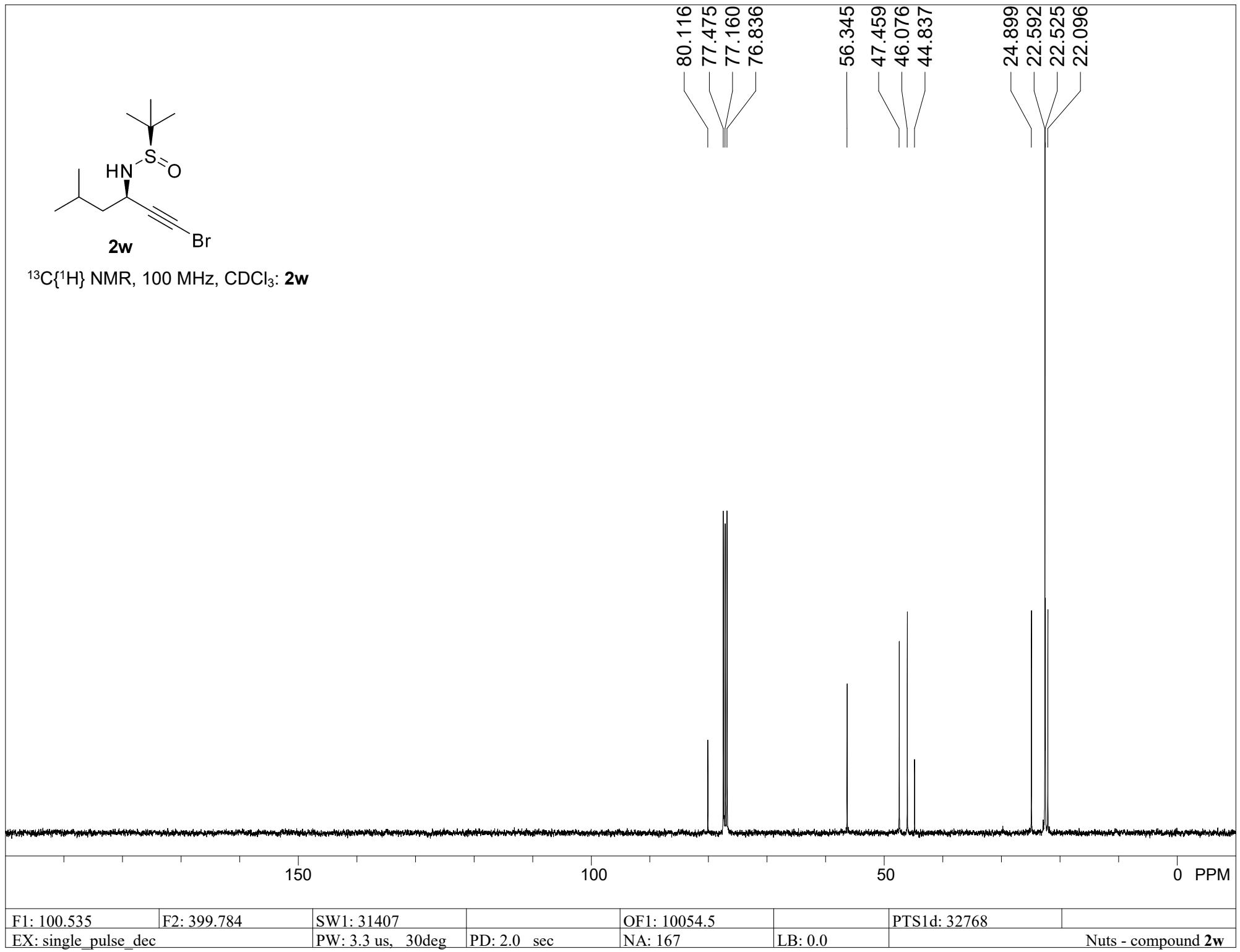
LB: 0.0

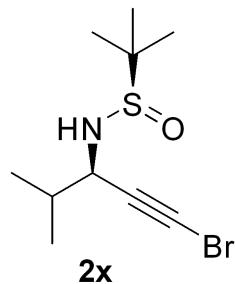
PTS1d: 16384 , 16384

Nuts - compound **2w**

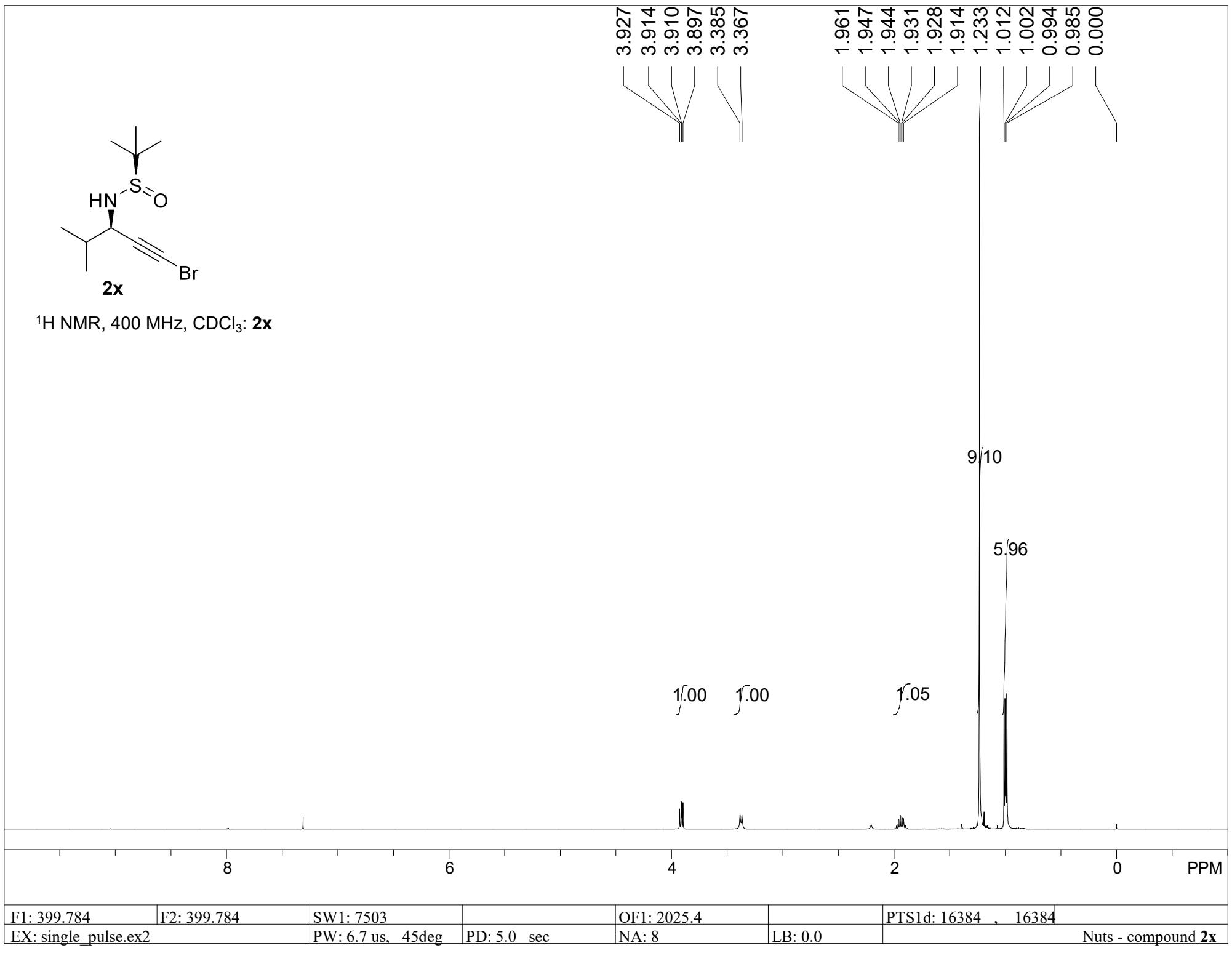


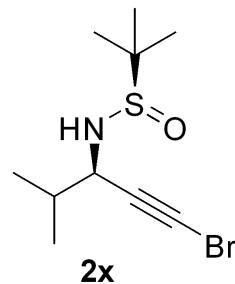
$^{13}\text{C}\{\text{H}\}$ NMR, 100 MHz, CDCl_3 : **2w**



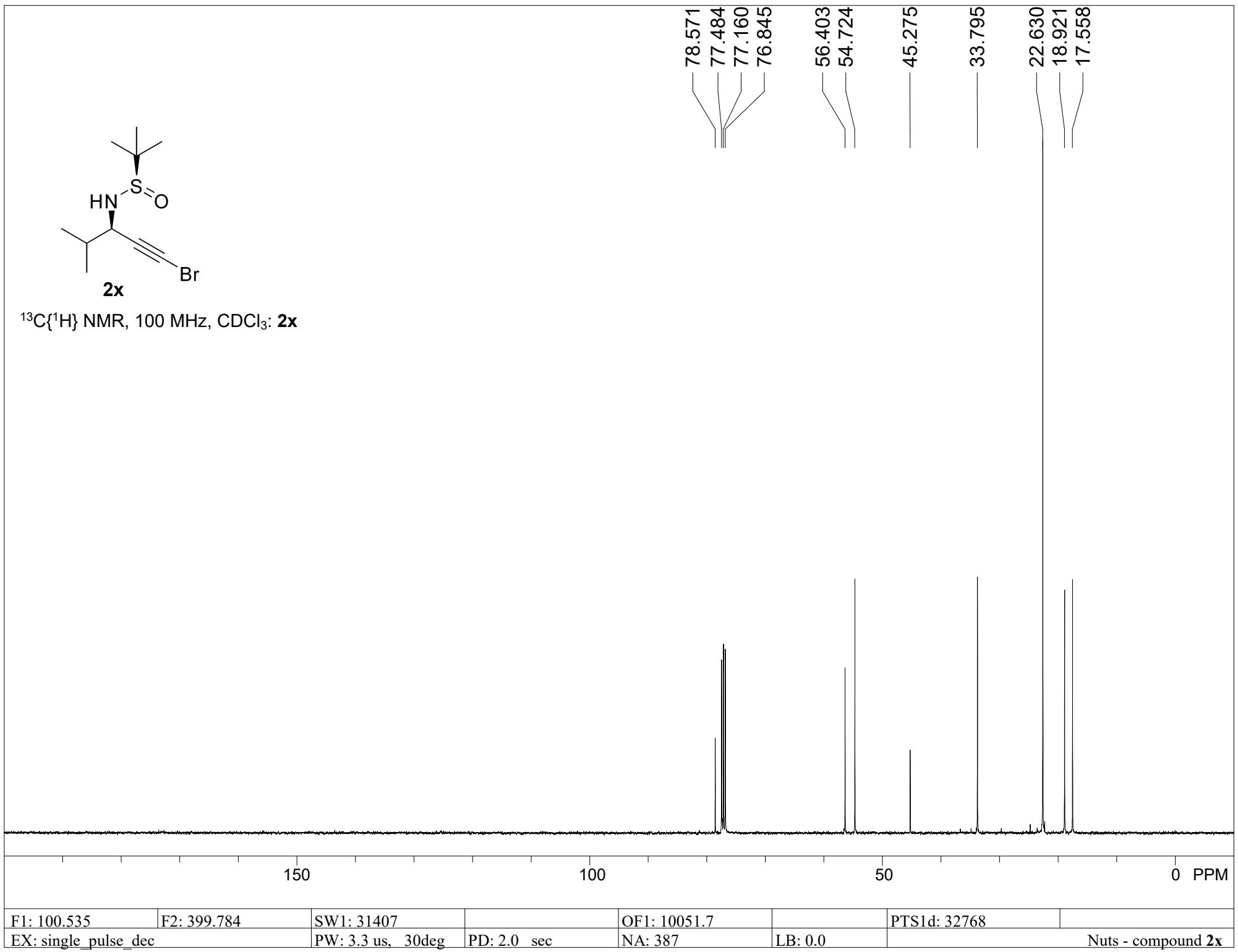


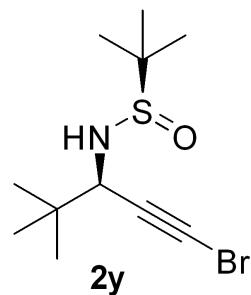
¹H NMR, 400 MHz, CDCl₃: **2x**



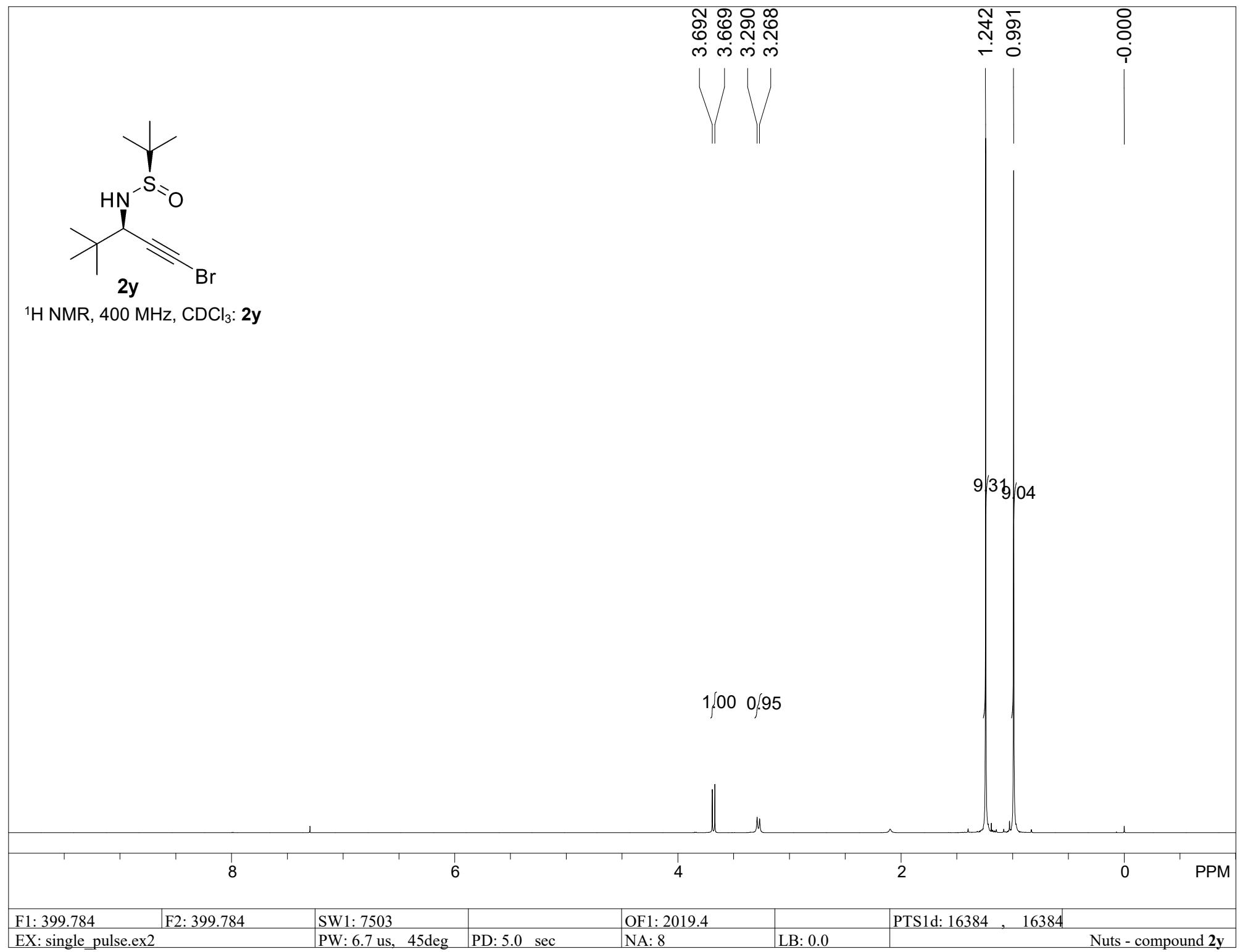


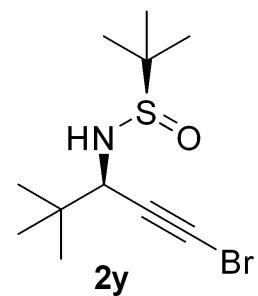
$^{13}\text{C}\{^1\text{H}\}$ NMR, 100 MHz, CDCl_3 : **2x**



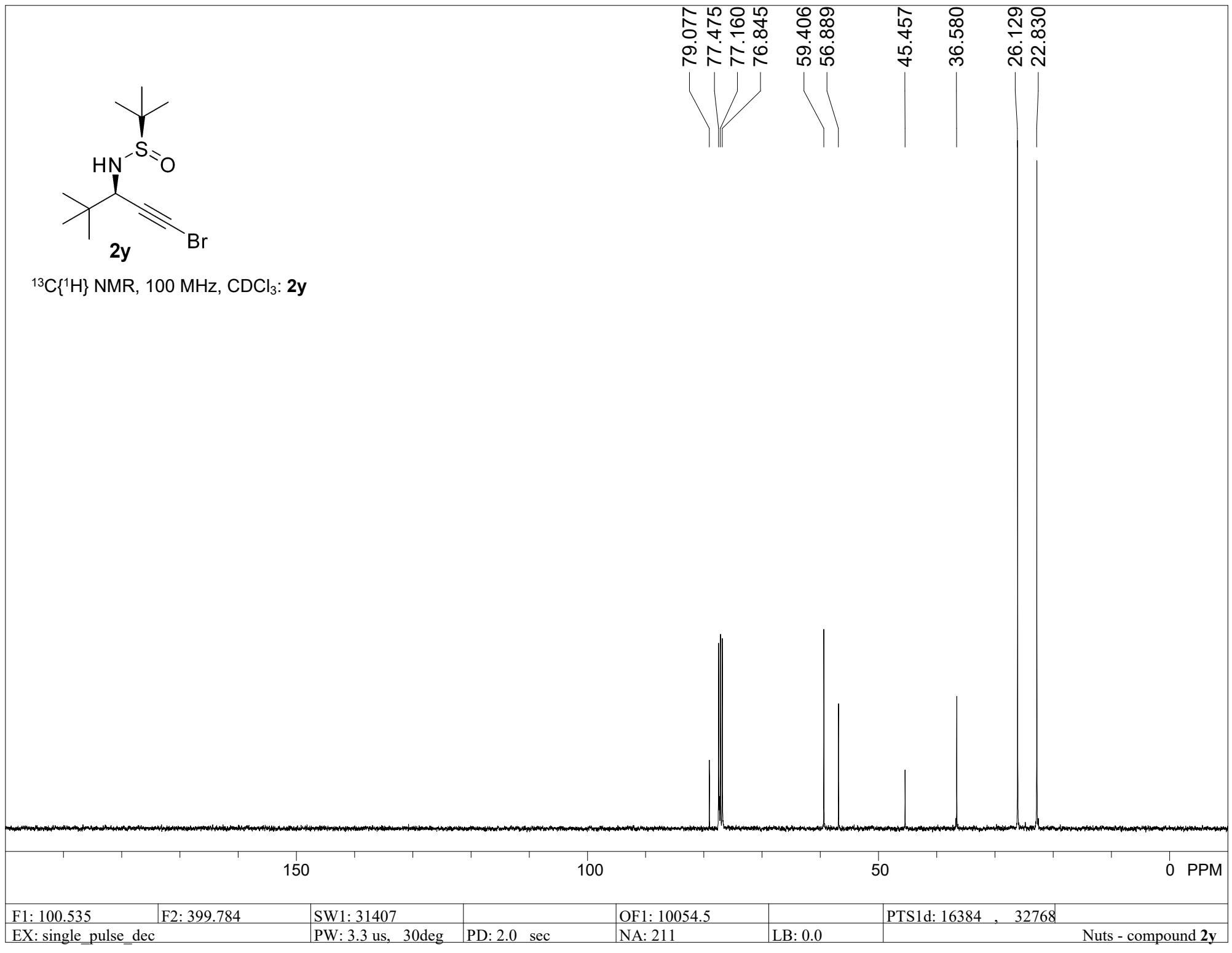


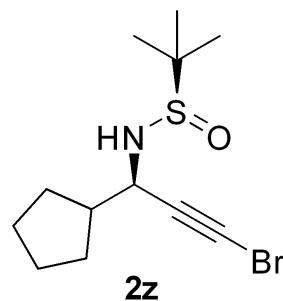
¹H NMR, 400 MHz, CDCl₃: **2y**



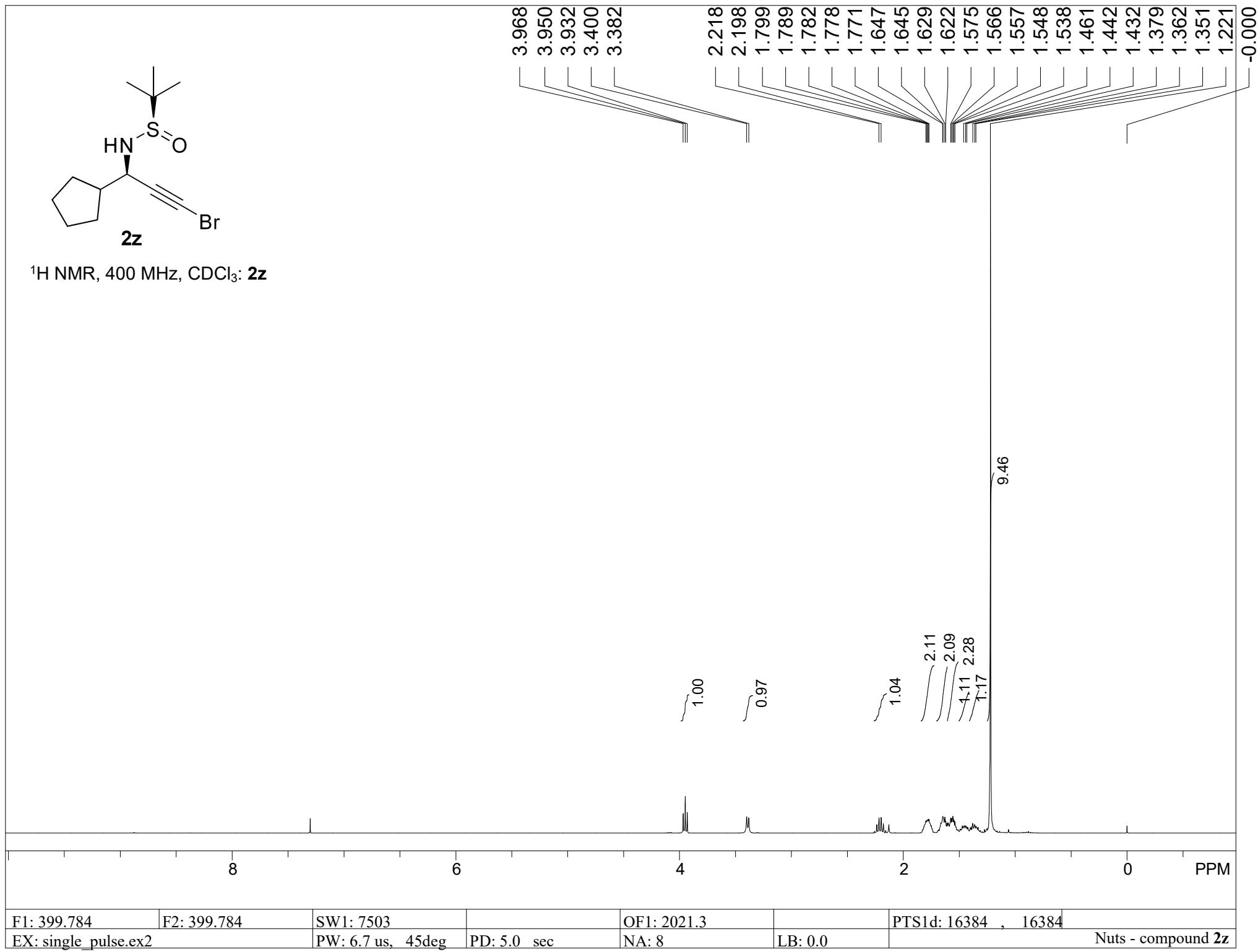


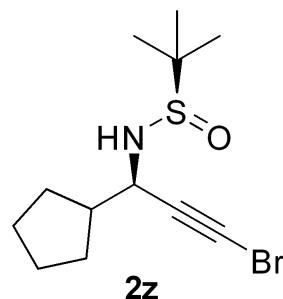
$^{13}\text{C}\{\text{H}\}$ NMR, 100 MHz, CDCl_3 : **2y**



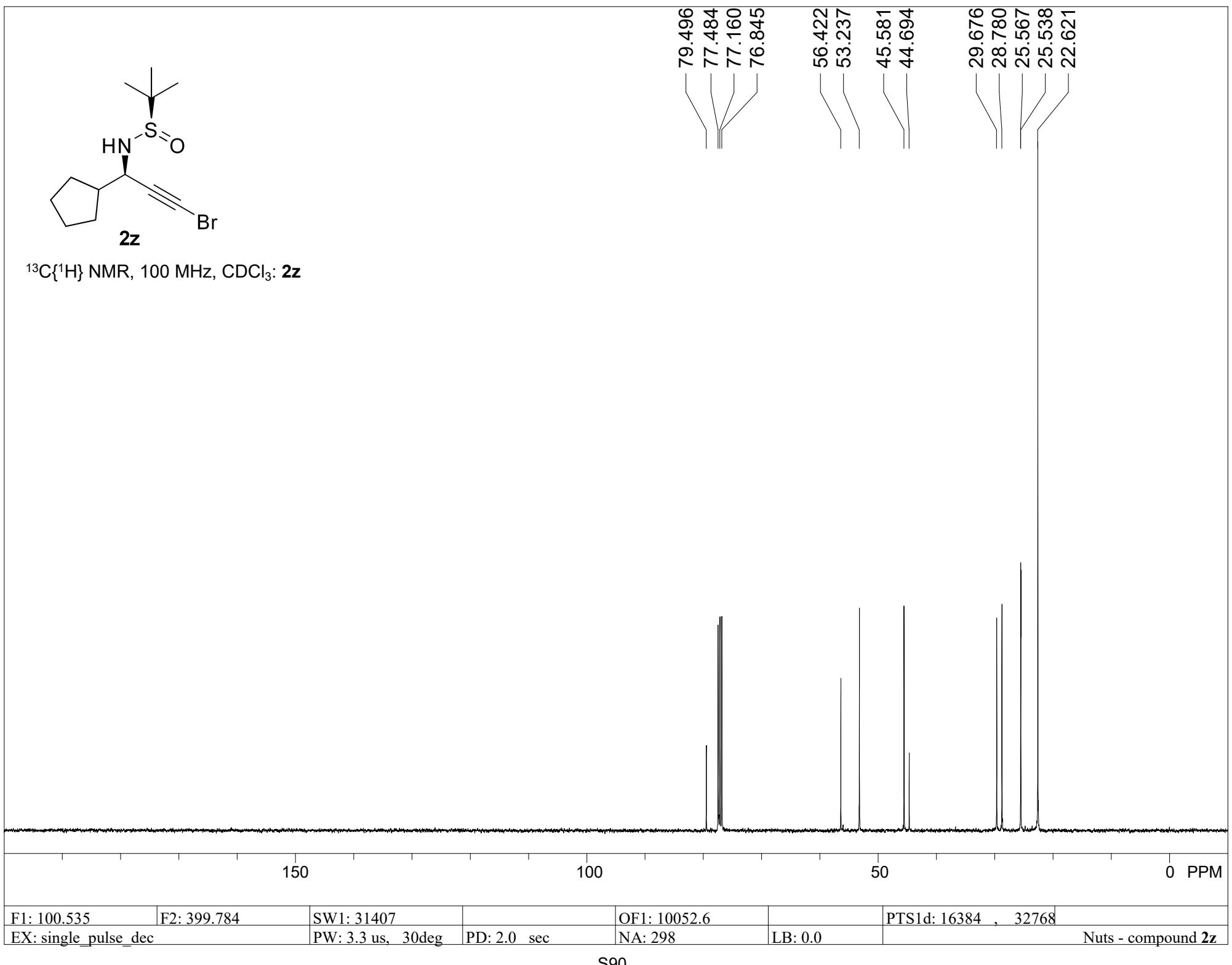


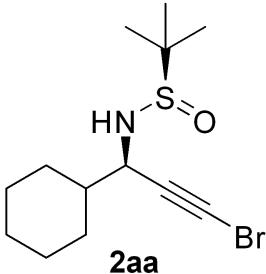
¹H NMR, 400 MHz, CDCl₃: **2z**



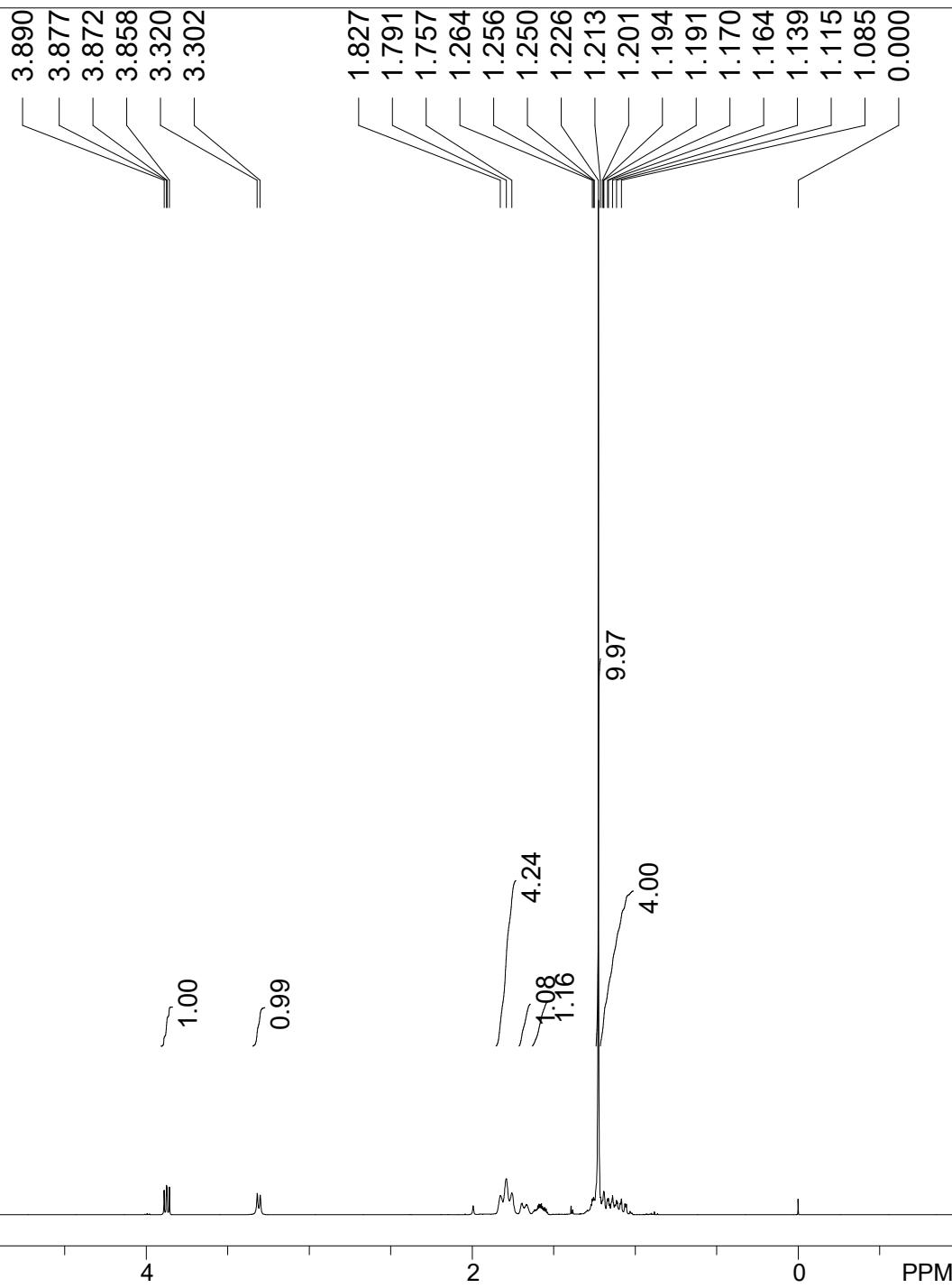


$^{13}\text{C}\{\text{H}\}$ NMR, 100 MHz, CDCl_3 : **2z**





¹H NMR, 400 MHz, CDCl₃: **2aa**



F1: 399.784
EX: single_pulse.ex2

F2: 399.784
PW: 6.7 us, 45deg

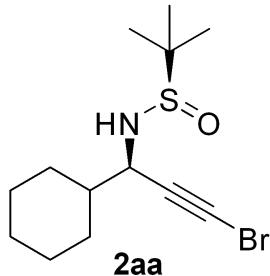
SW1: 7503
PD: 5.0 sec

OF1: 2016.7
NA: 8

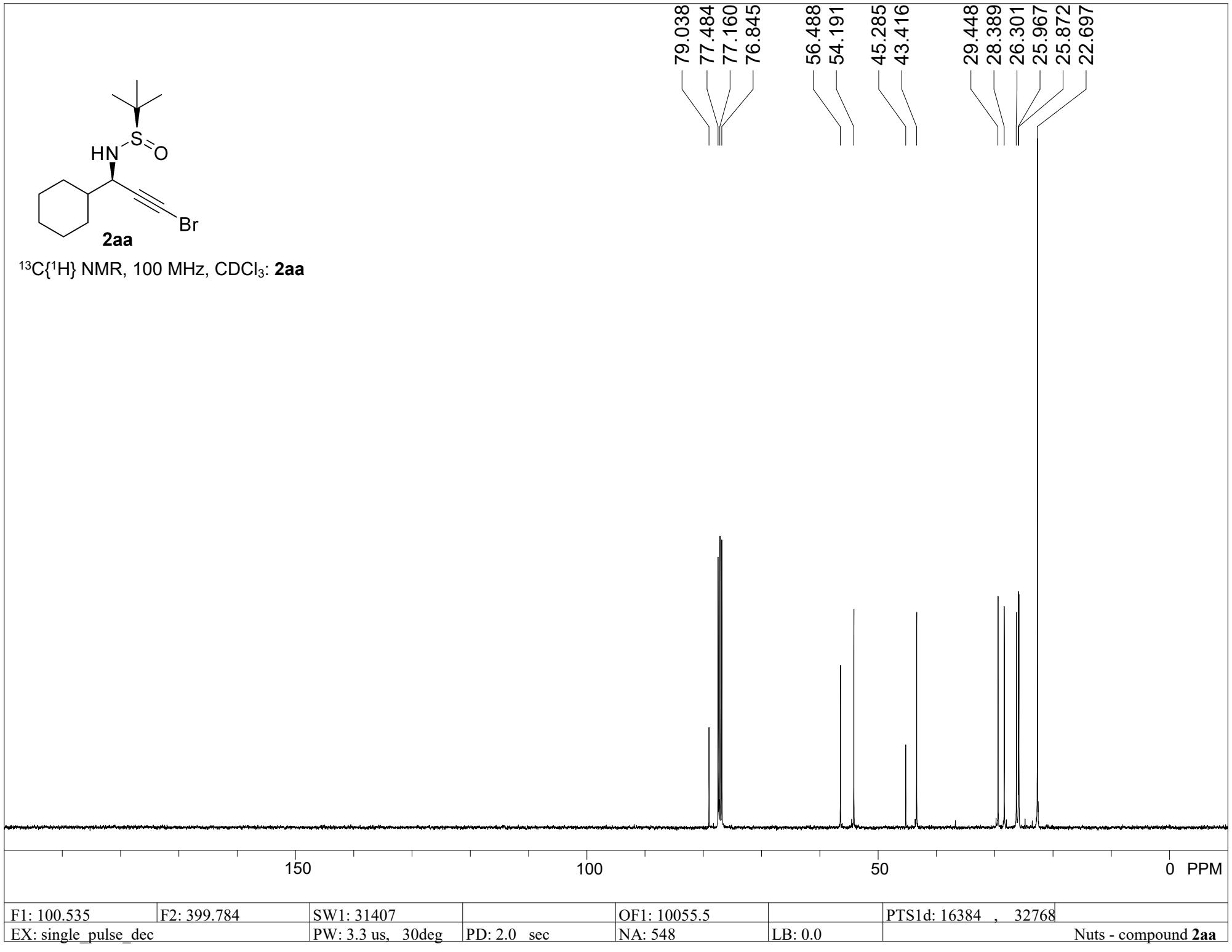
LB: 0.0

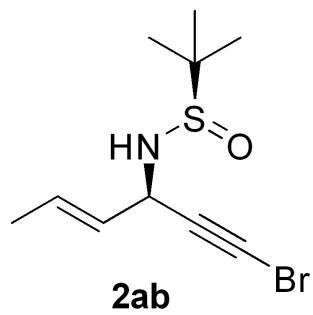
PTS1d: 16384 , 16384

Nuts - compound **2aa**

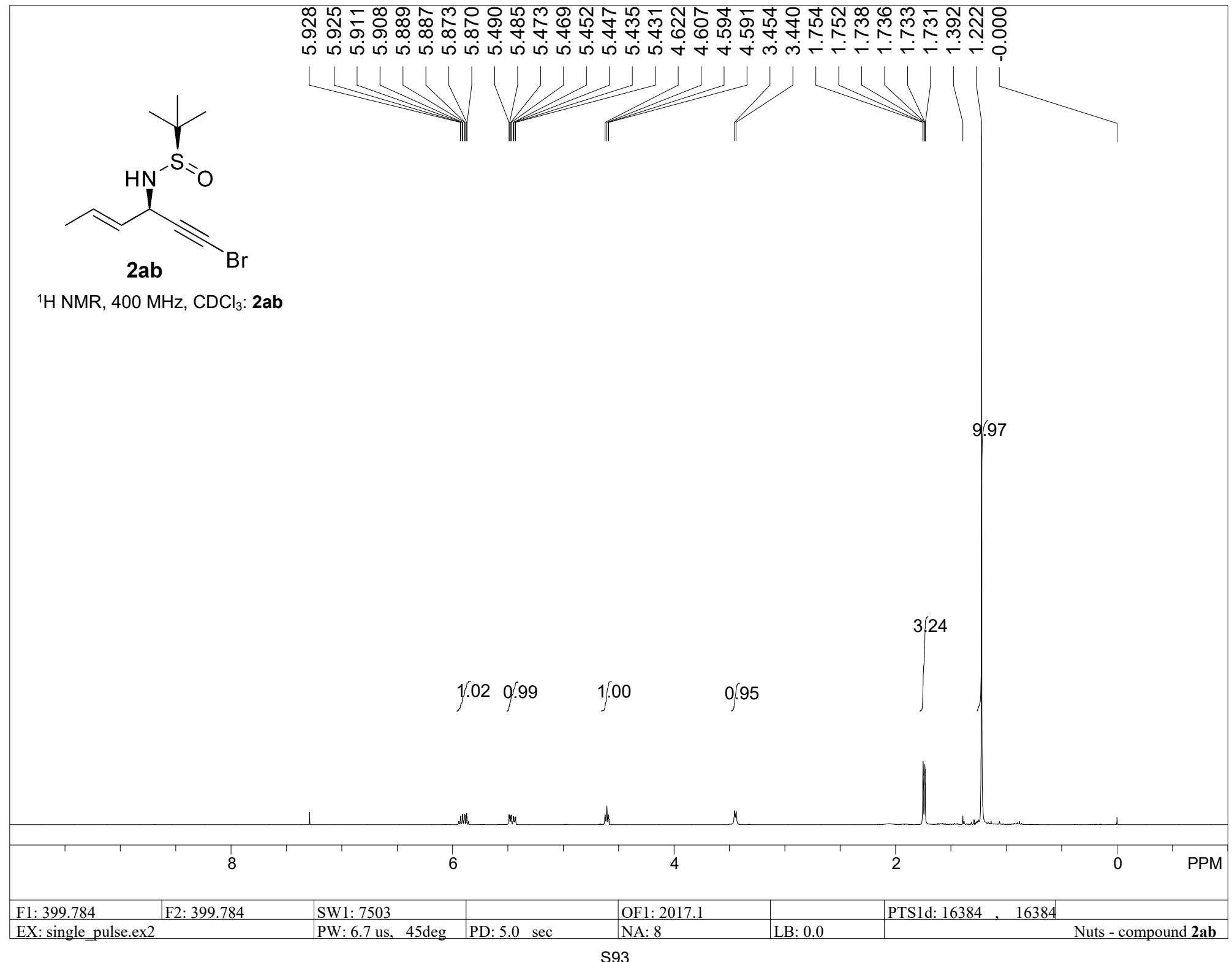


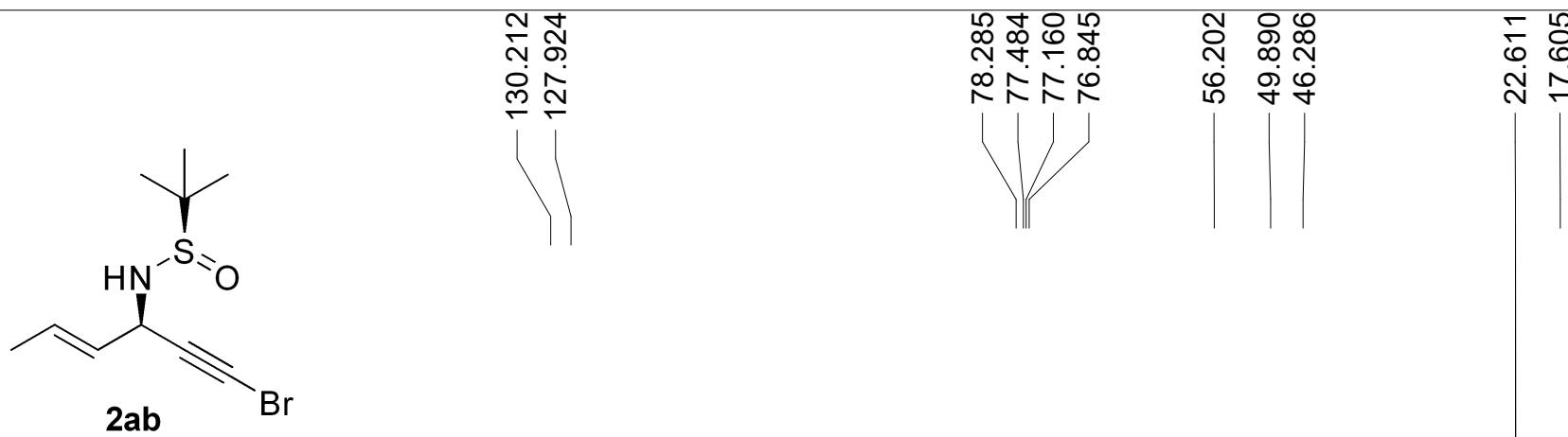
$^{13}\text{C}\{\text{H}\}$ NMR, 100 MHz, CDCl_3 : **2aa**



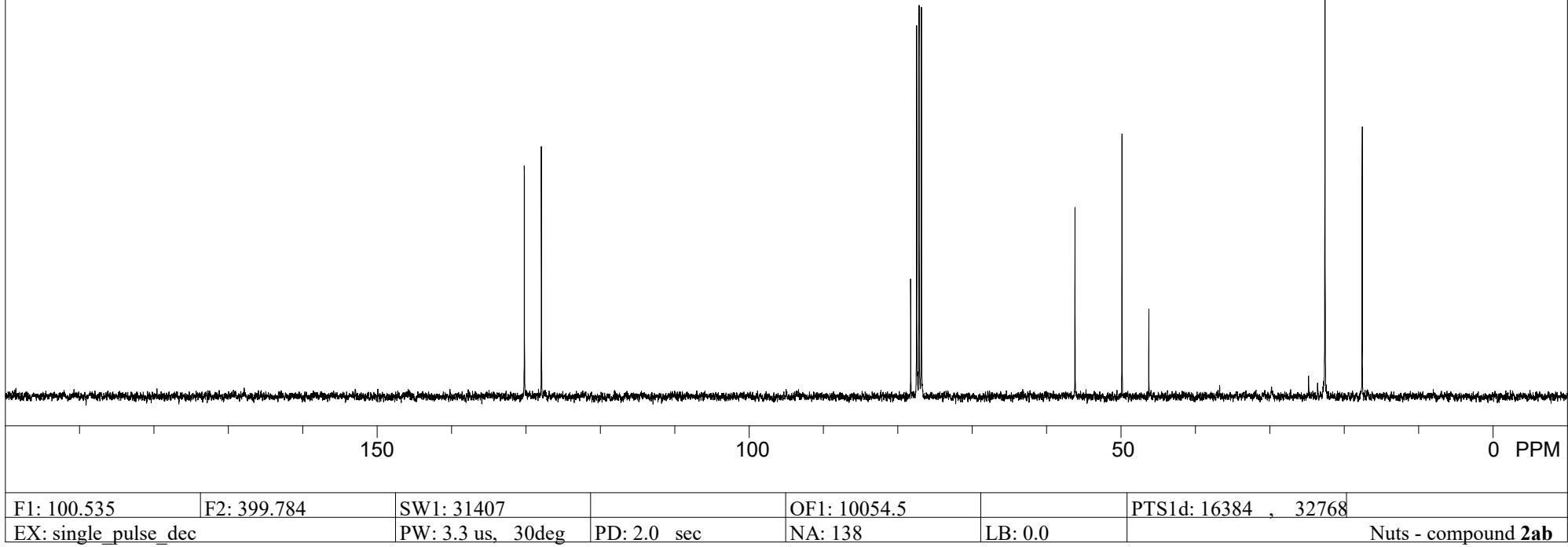


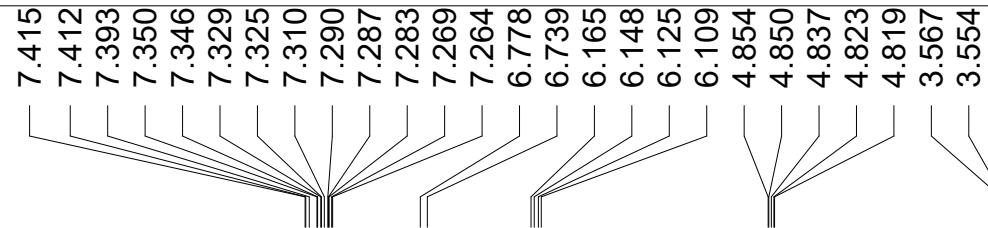
¹H NMR, 400 MHz, CDCl₃: **2ab**



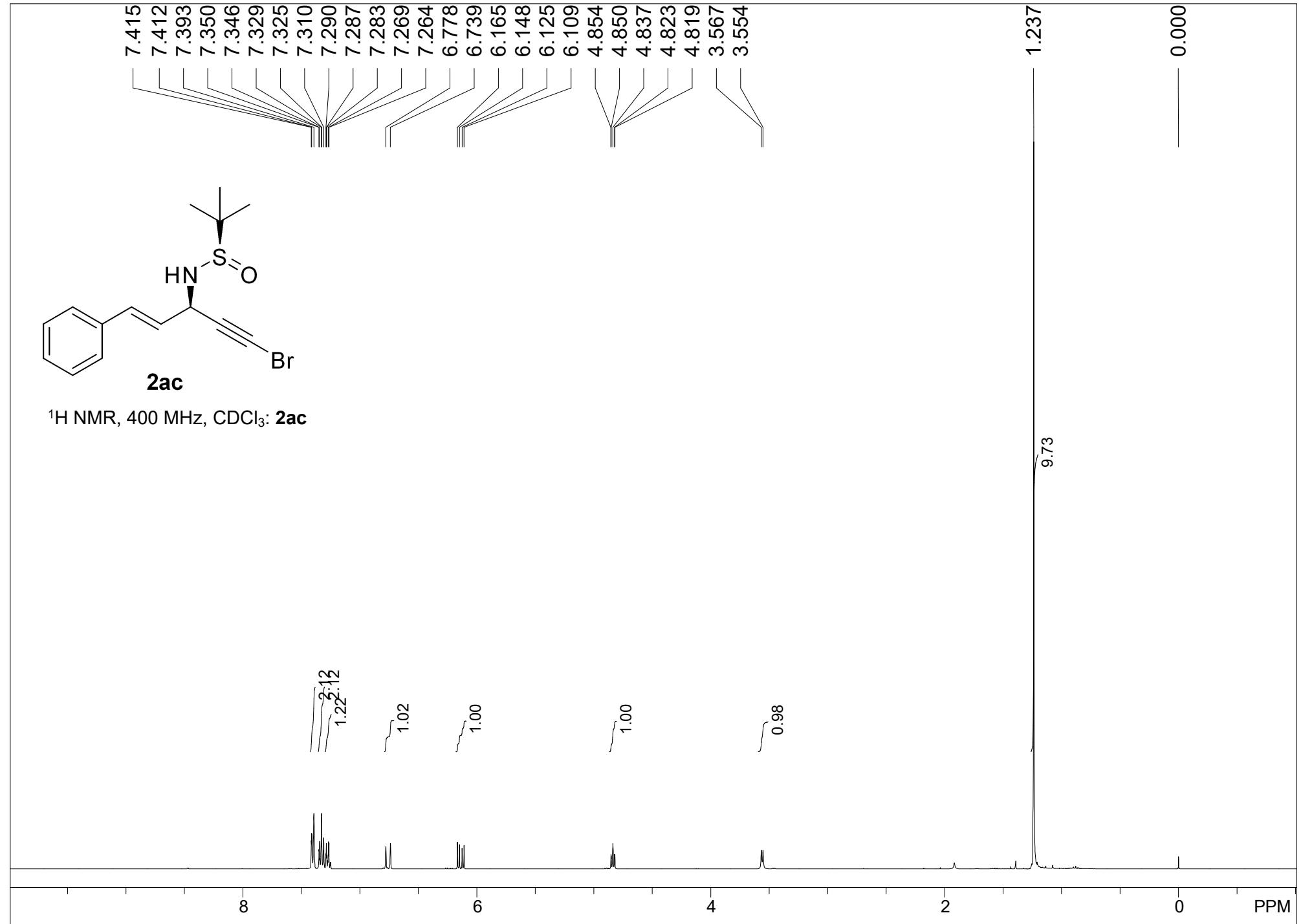


$^{13}\text{C}\{\text{H}\}$ NMR, 100 MHz, CDCl_3 : **2ab**





¹H NMR, 400 MHz, CDCl₃: **2ac**



F1: 399.784

F2: 399.784

SW1: 7503

OF1: 2006.6

PTS1d: 16384 , 16384

EX: single_pulse.ex2

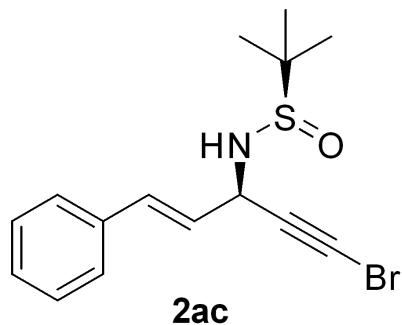
PW: 6.7 us, 45deg

PD: 5.0 sec

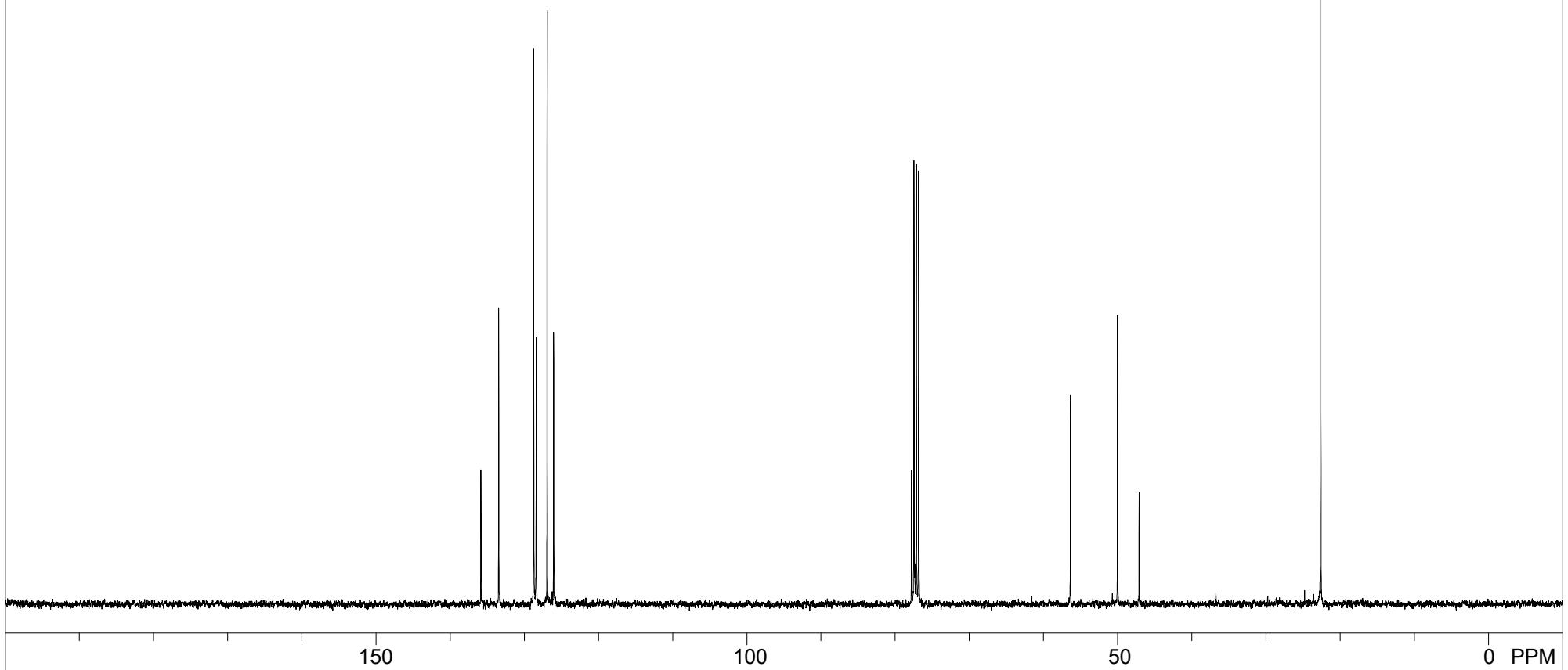
NA: 8

LB: 0.0

Nuts - compound **2ac**



$^{13}\text{C}\{\text{H}\}$ NMR, 100 MHz, CDCl_3 : **2ac**



F1: 100.535

F2: 399.784

SW1: 31407

OF1: 10053.6

PTS1d: 16384 , 32768

EX: single_pulse_dec

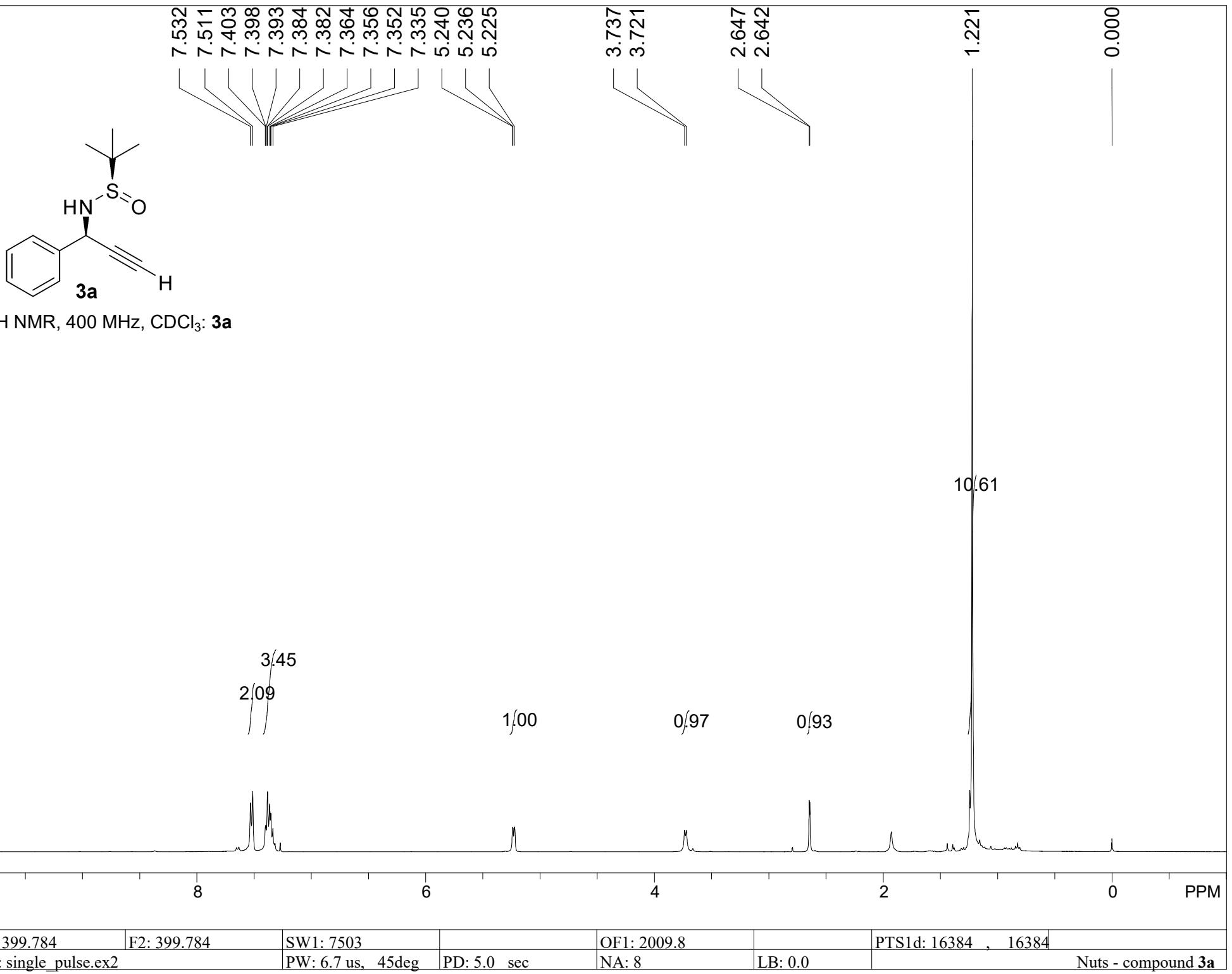
PW: 3.3 us, 30deg

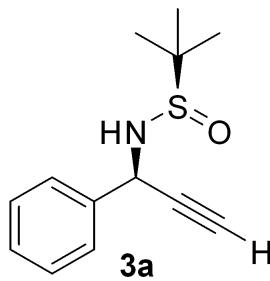
PD: 2.0 sec

NA: 309

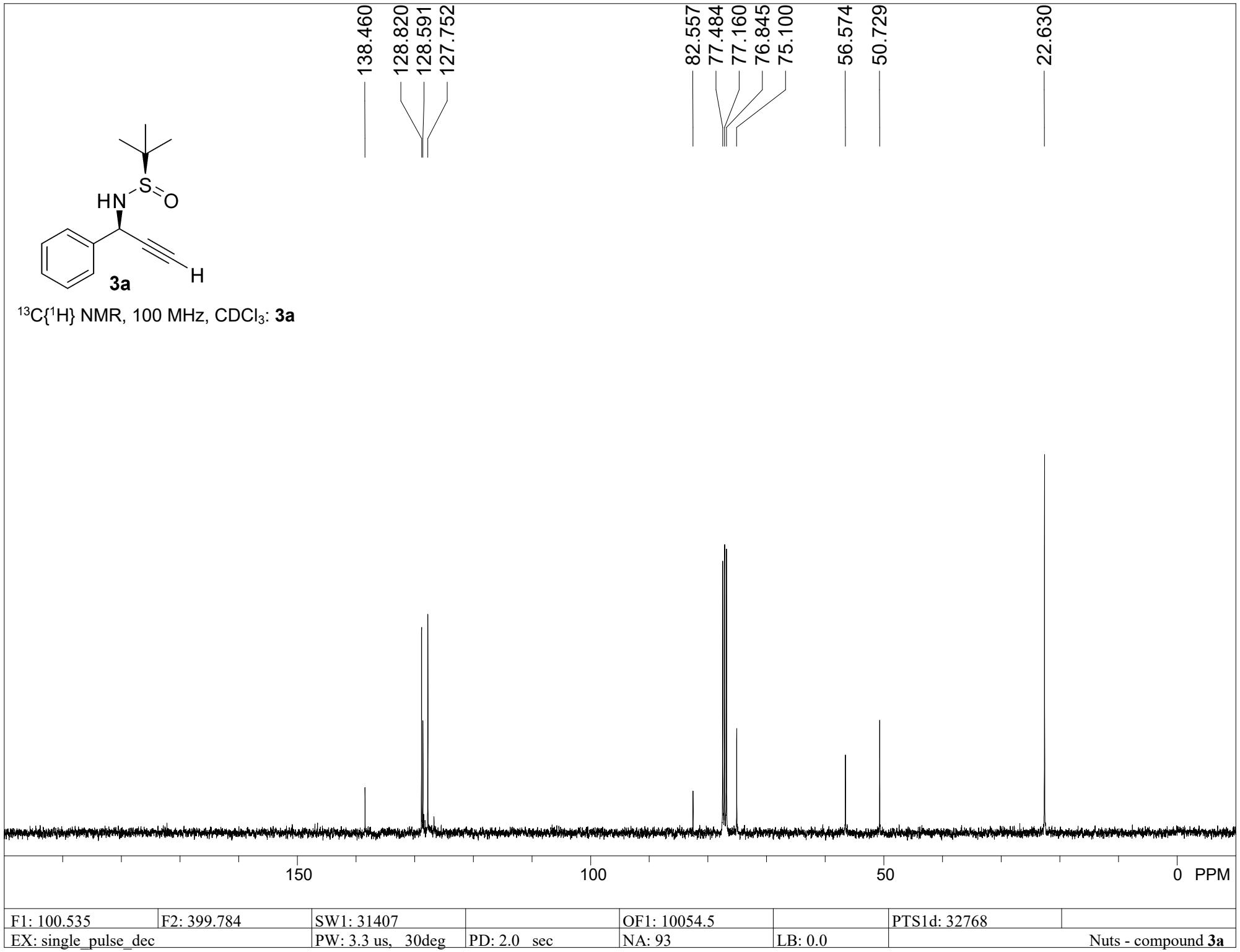
LB: 0.0

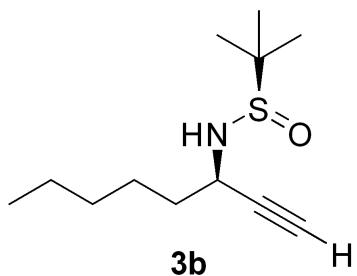
Nuts - compound **2ac**



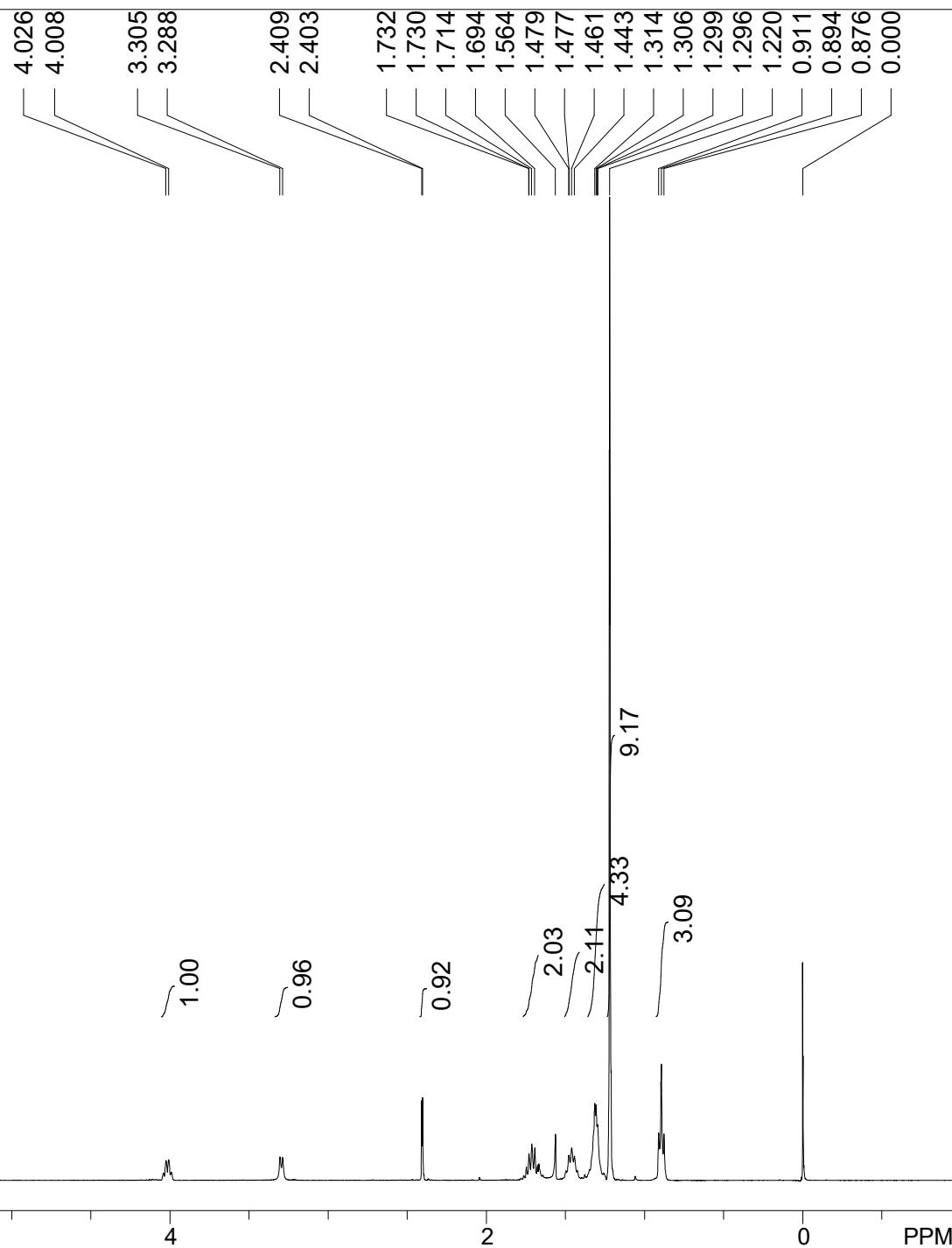


$^{13}\text{C}\{\text{H}\}$ NMR, 100 MHz, CDCl_3 : **3a**

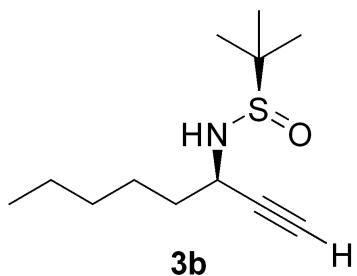




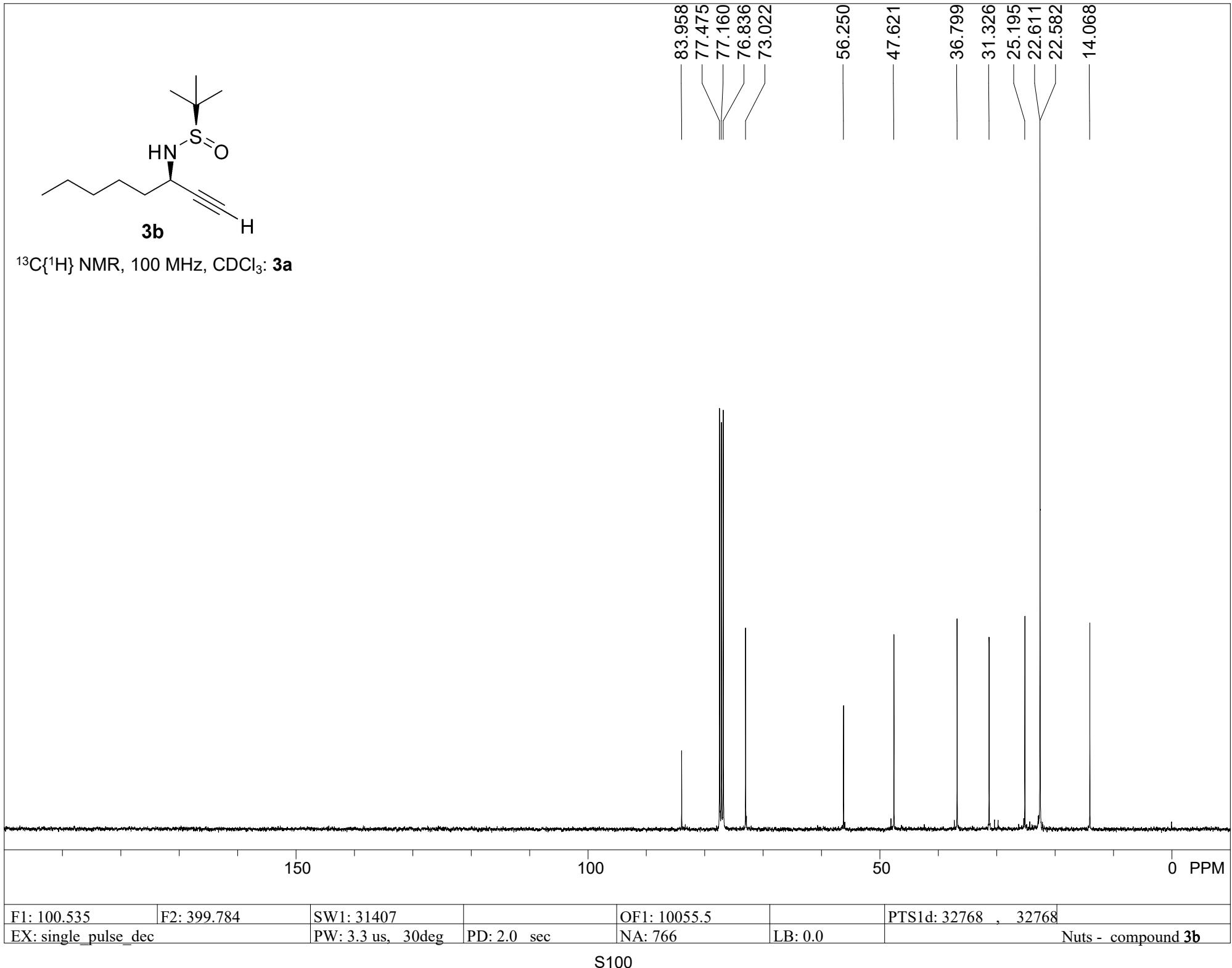
¹H NMR, 400 MHz, CDCl₃: **3b**



F1: 399.784	F2: 399.784	SW1: 7503		OF1: 2005.2		PTS1d: 16384 , 16384	
EX: single_pulse.ex2		PW: 6.7 us, 45deg	PD: 5.0 sec	NA: 8	LB: 0.0		Nuts - compound 3b



$^{13}\text{C}\{\text{H}\}$ NMR, 100 MHz, CDCl_3 : **3a**

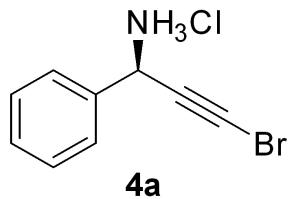


7.617
7.610
7.606
7.598
7.593
7.506
7.500
7.492
7.488

5.427

4.884

3.315
3.310
3.305



^1H NMR, 400 MHz, CD_3OD : **4a**

2.96

1.99

1.00

8

6

4

2

0

PPM

F1: 399.784

EX: single_pulse.ex2

F2: 399.784

SW1: 7503

PW: 6.7 us, 45deg

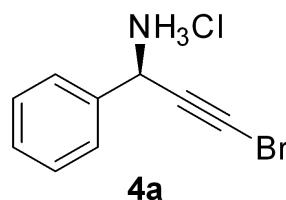
OF1: 2010.5

PD: 5.0 sec

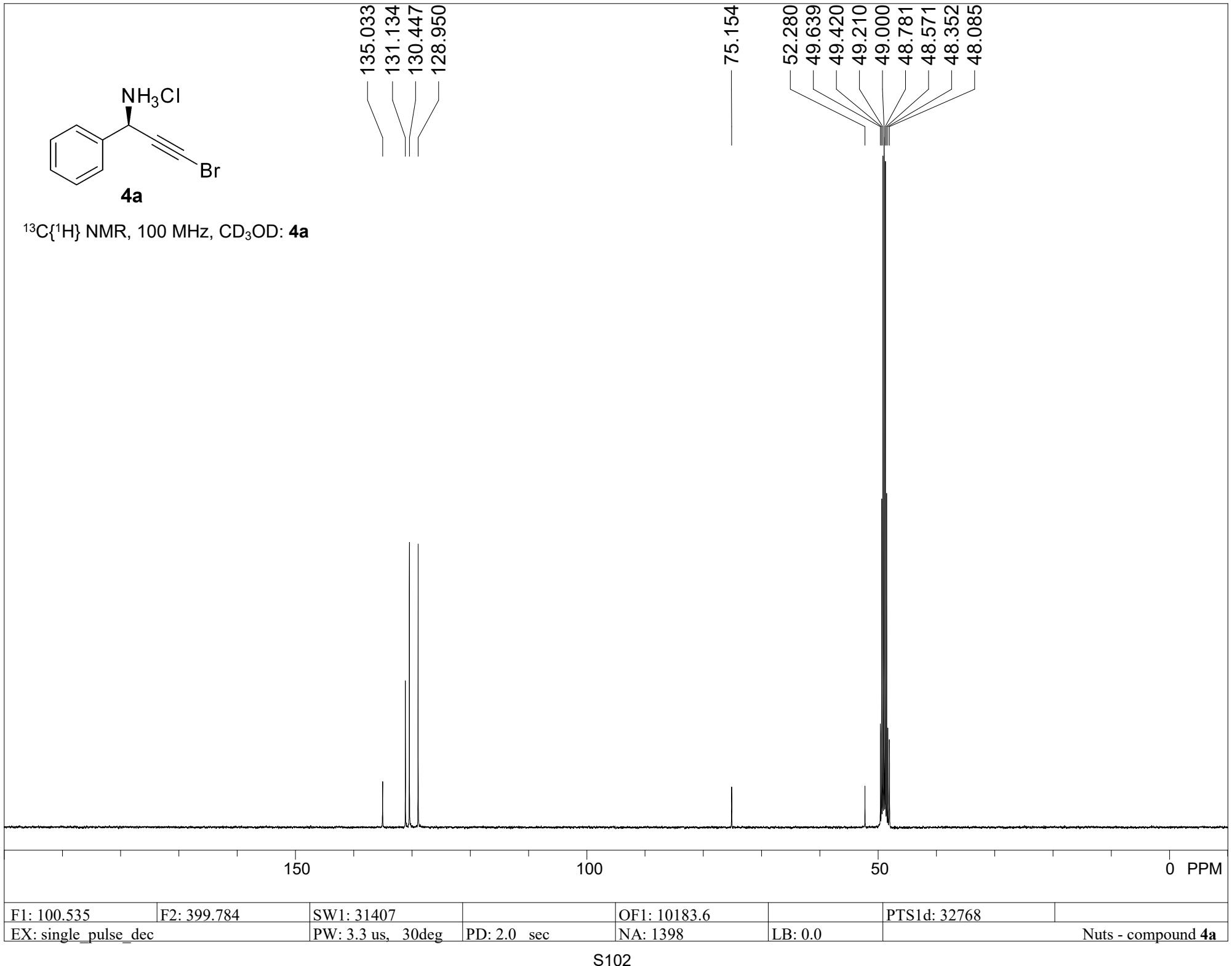
NA: 8

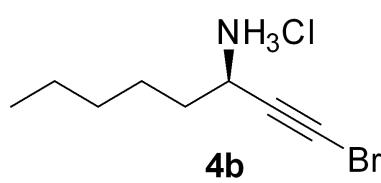
PTS1d: 16384 , 16384

Nuts - compound **4a**

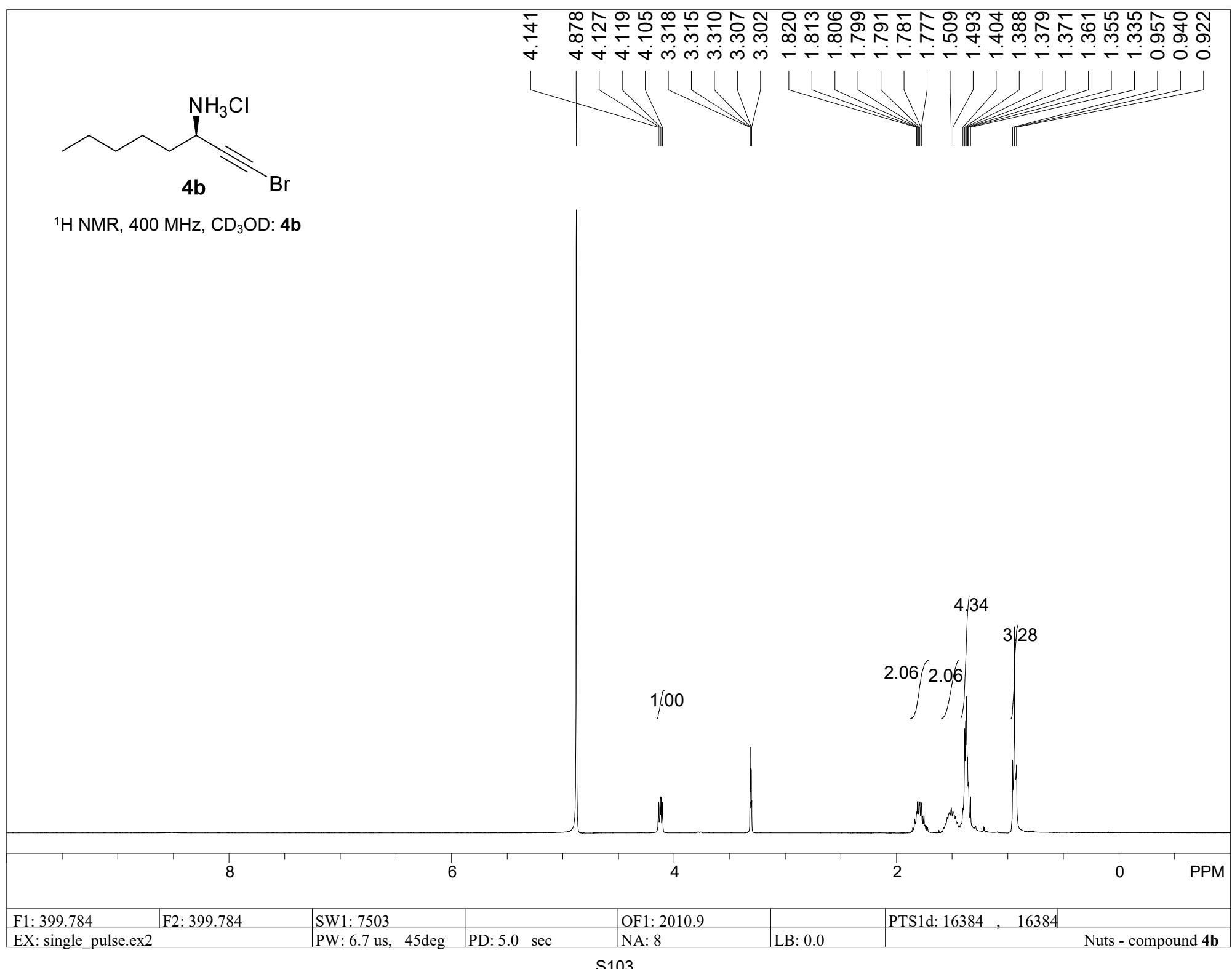


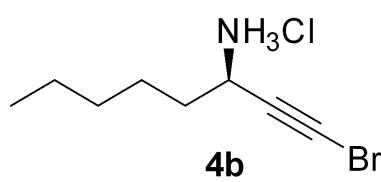
$^{13}\text{C}\{\text{H}\}$ NMR, 100 MHz, CD_3OD : **4a**



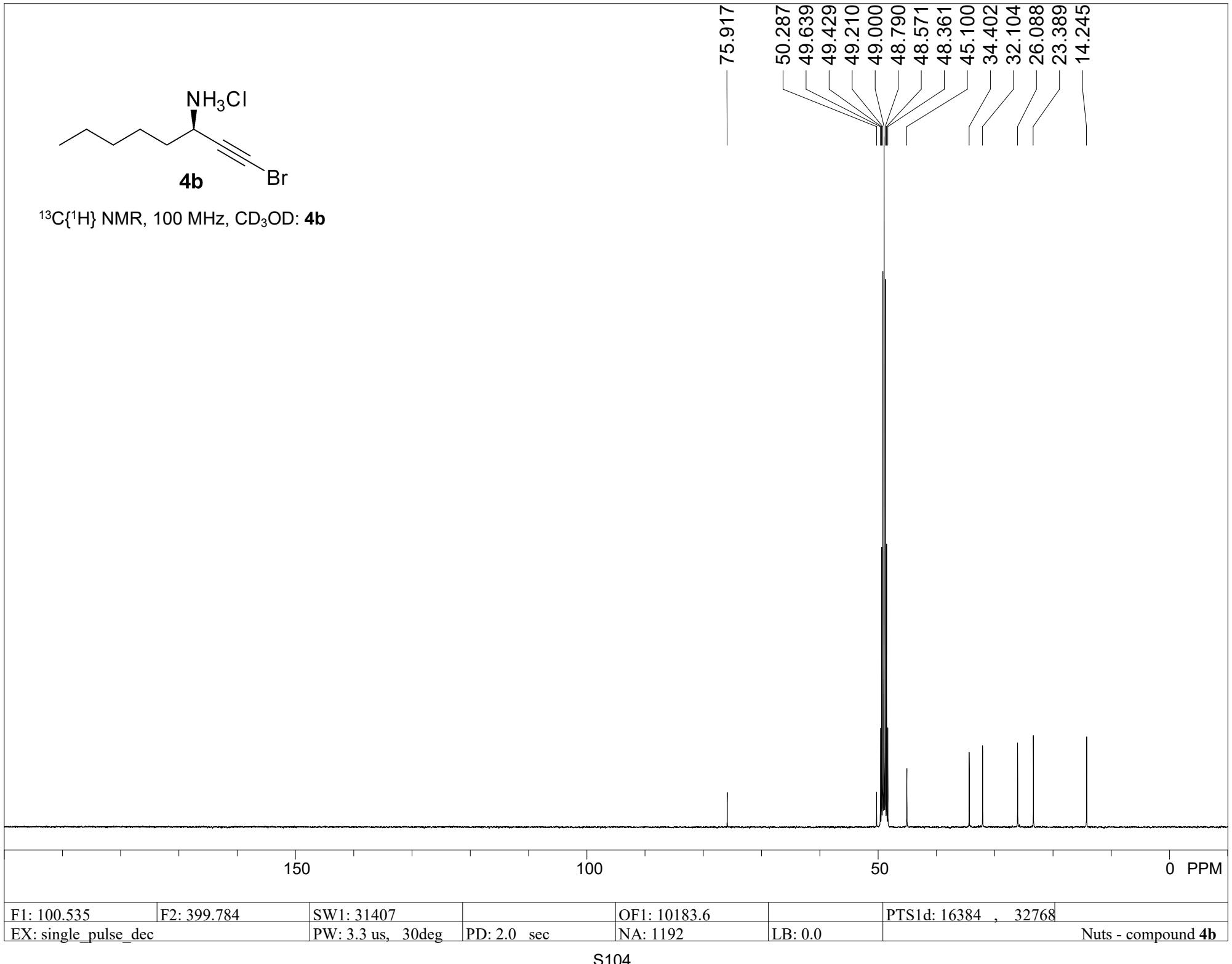


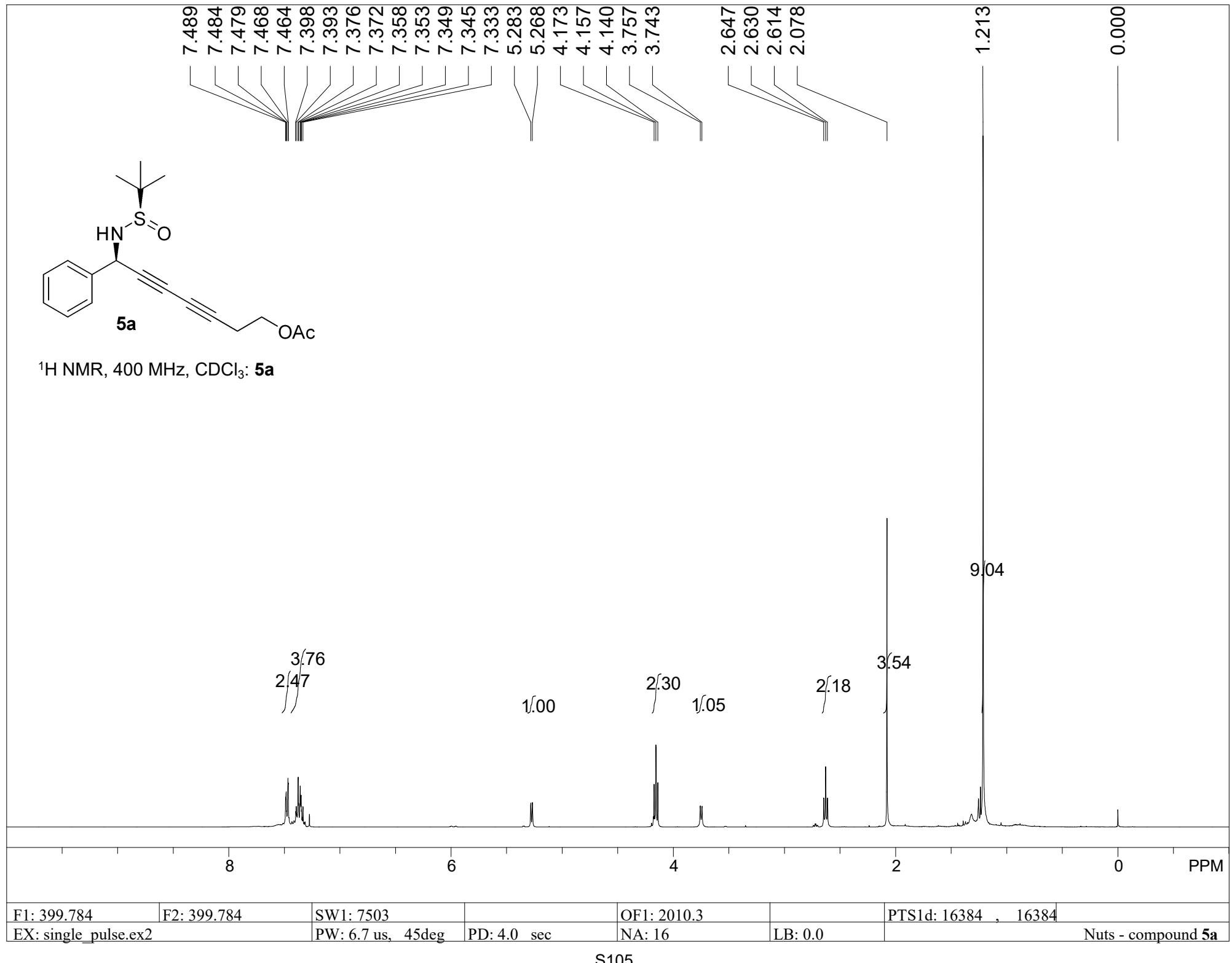
¹H NMR, 400 MHz, CD₃OD: **4b**

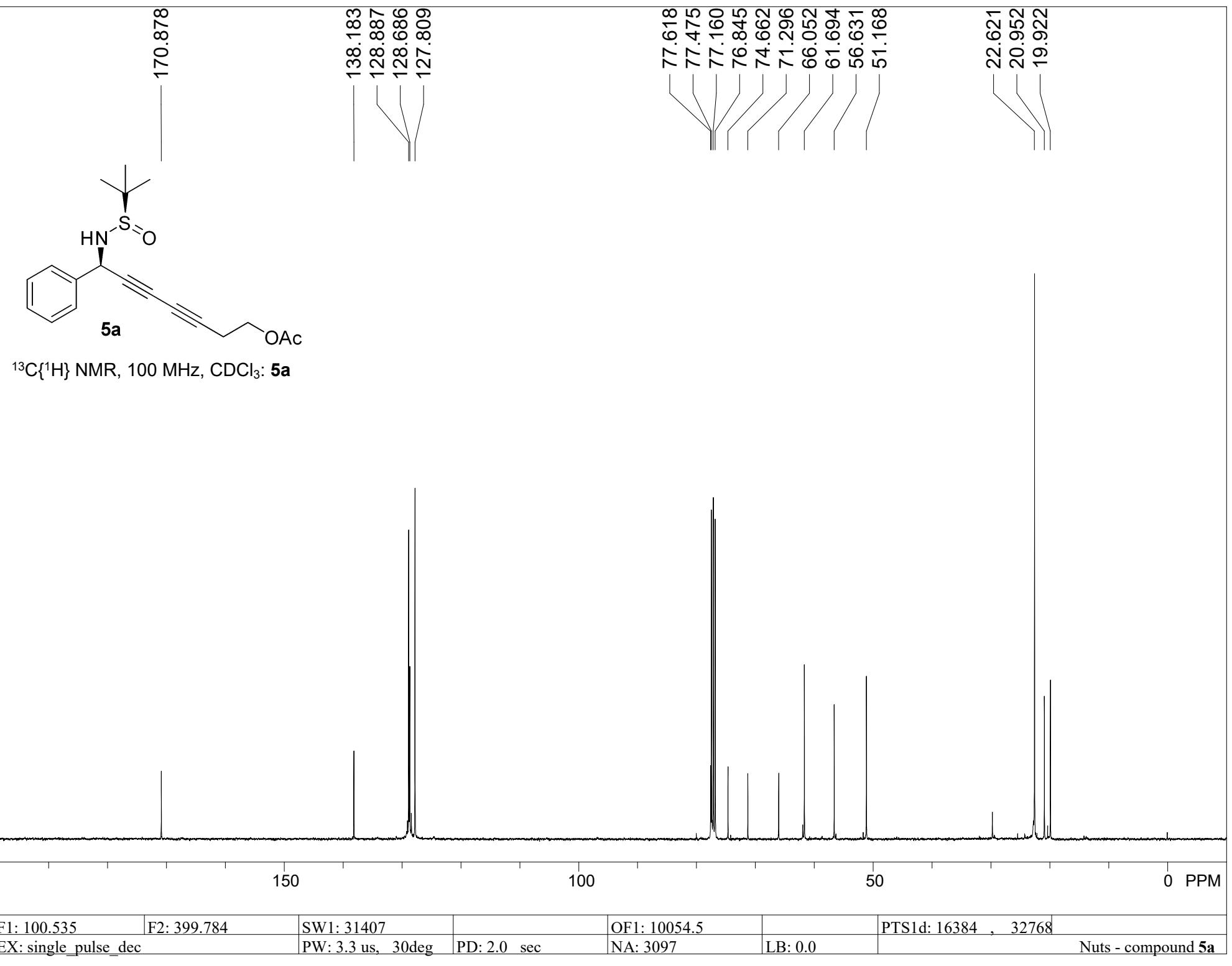


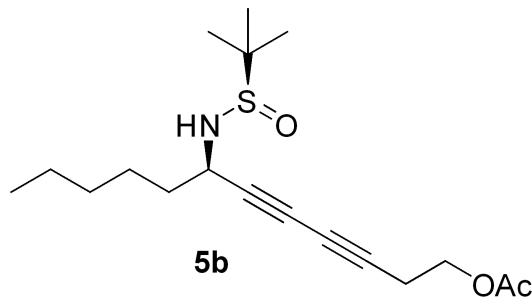


$^{13}\text{C}\{\text{H}\}$ NMR, 100 MHz, CD_3OD : **4b**

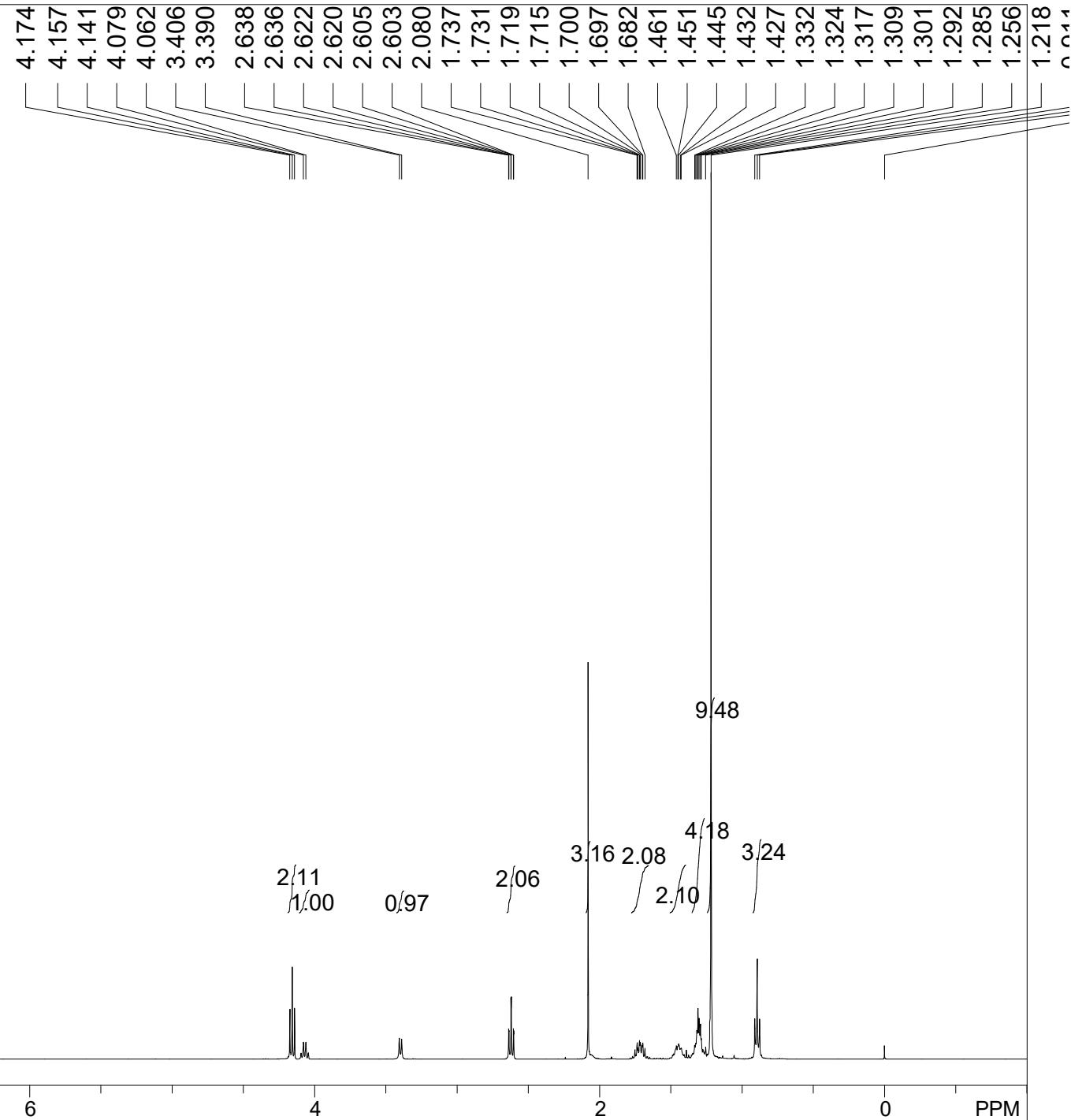








¹H NMR, 400 MHz, CDCl₃: **5b**



F1: 399.784

EX: single_pulse.ex2

SW1: 7503

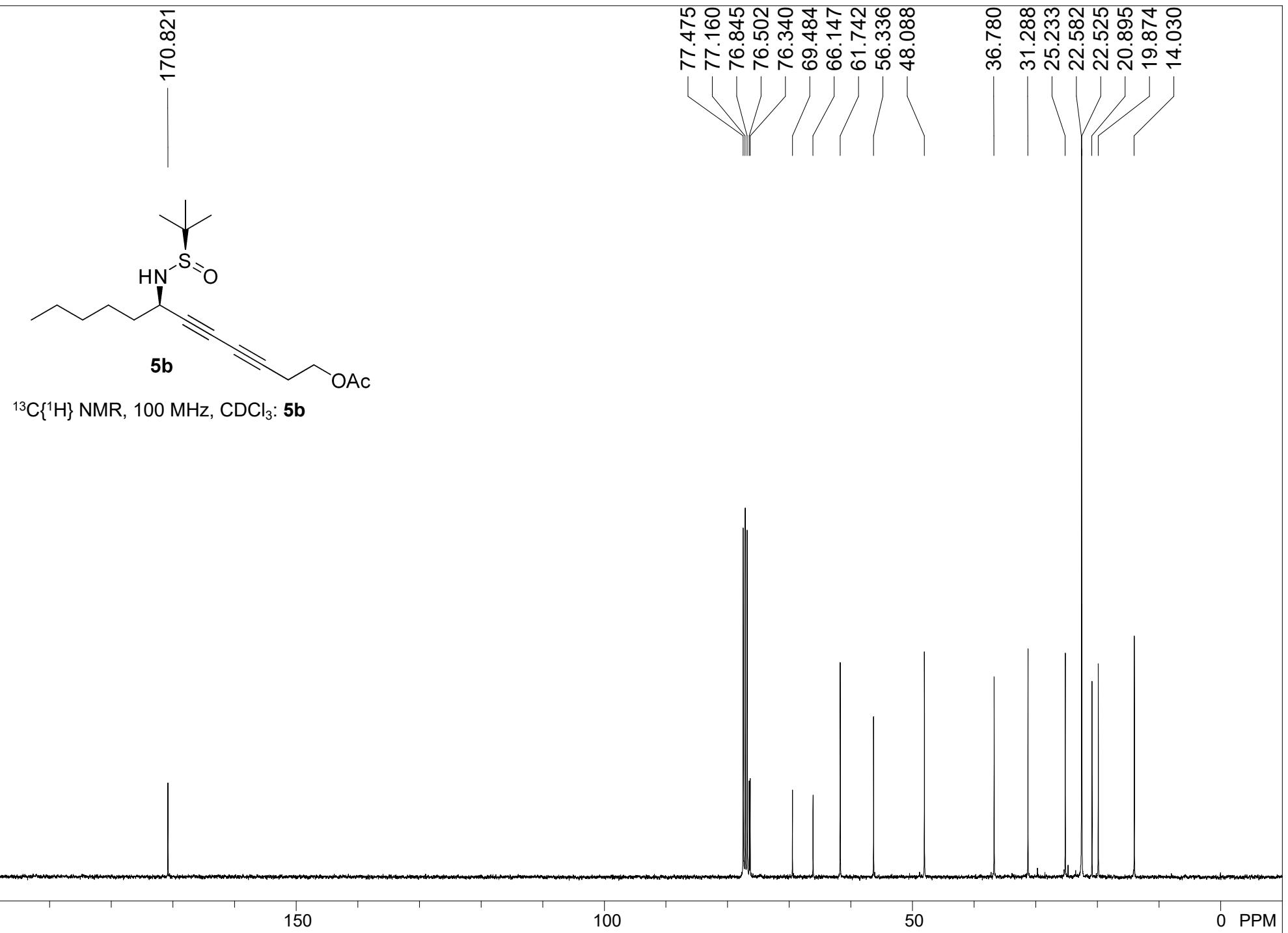
PW: 6.7 us, 45deg

OF1: 2020.4

NA: 8

PTS1d: 16384 , 16384

Nuts - compound **5b**



F1: 100.535 F2: 399.784

SW1: 31407

OF1: 10054.5

PTS1d: 16384 , 32768

EX: single_pulse_dec

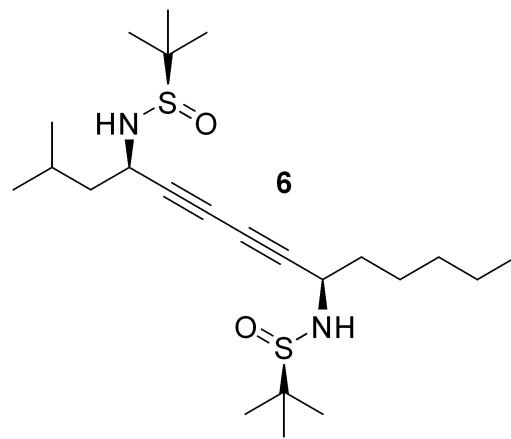
PW: 3.3 us, 30deg

PD: 2.0 sec

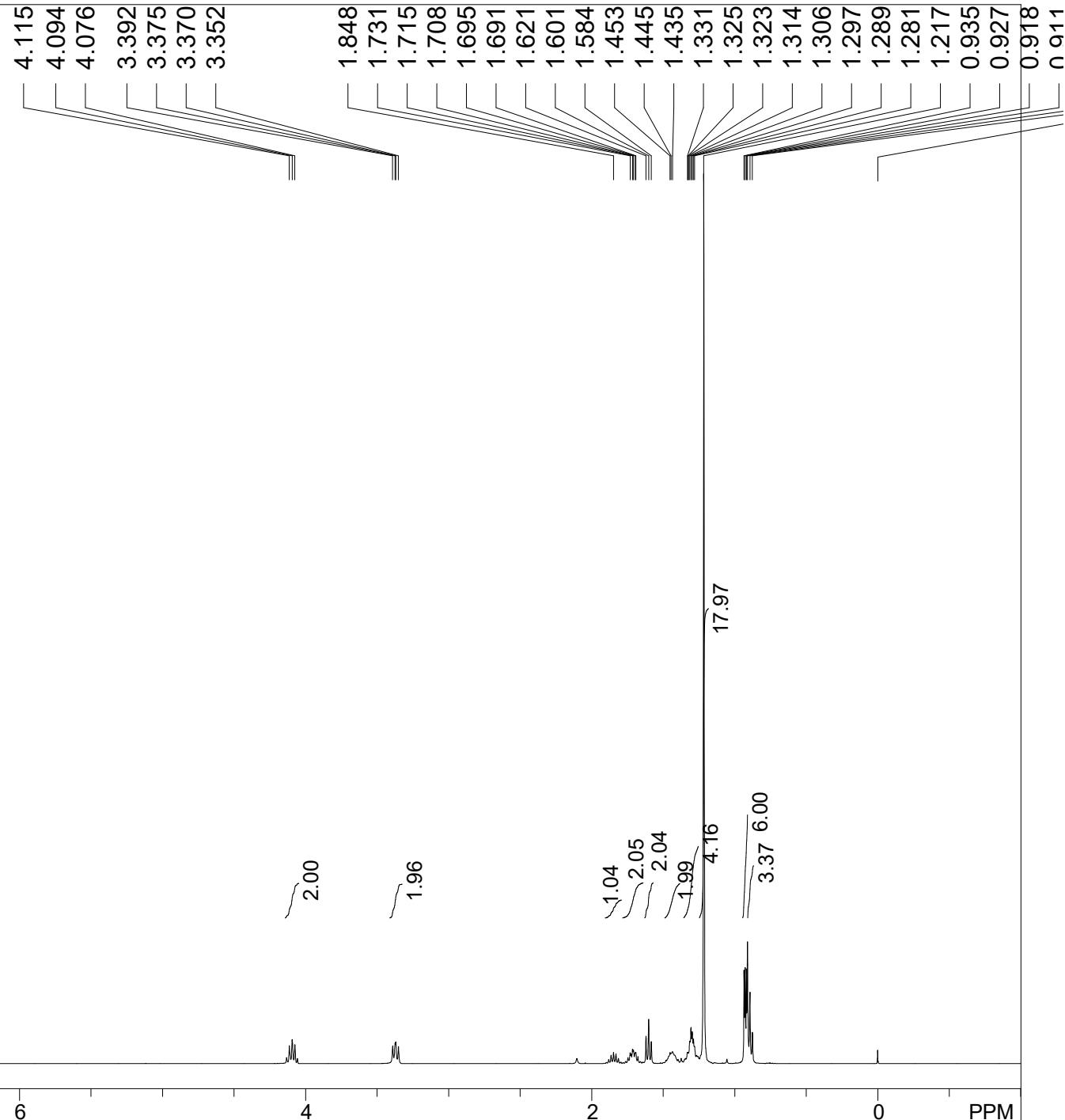
NA: 868

LB: 0.0

Nuts - compound **5b**



¹H NMR, 400 MHz, CDCl₃: **6**



F1: 399.784

F2: 399.784

SW1: 7503

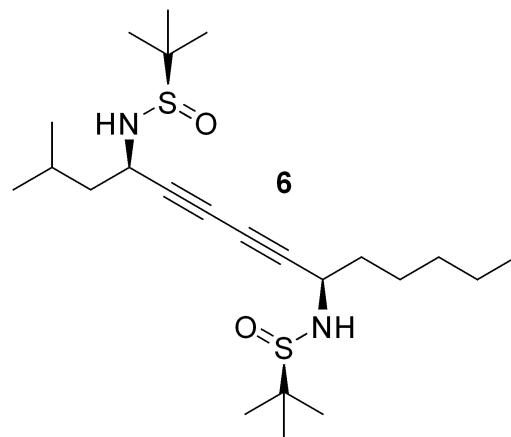
PW: 6.7 us, 45deg

OF1: 2019.0

NA: 8

PTS1d: 16384 , 16384

Nuts - compound **6**



$^{13}\text{C}\{\text{H}\}$ NMR, 100 MHz, CDCl_3 : **6**

79.115
79.086
77.484
77.160
76.845
69.084
56.403
56.345
48.050
46.791
45.981
36.684

31.307
25.204
24.918
22.611
22.535
22.029
14.058

150 100 50 0 PPM

F1: 100.535	F2: 399.784	SW1: 31407		OF1: 10055.5		PTS1d: 32768	
EX: single_pulse_dec		PW: 3.3 us, 30deg	PD: 2.0 sec	NA: 319	LB: 0.0		Nuts - compound 6