Synthesis and Photophysical Evaluation of Polarity Sensitive Push-pull Isoquinolines and their alkynyl precursors

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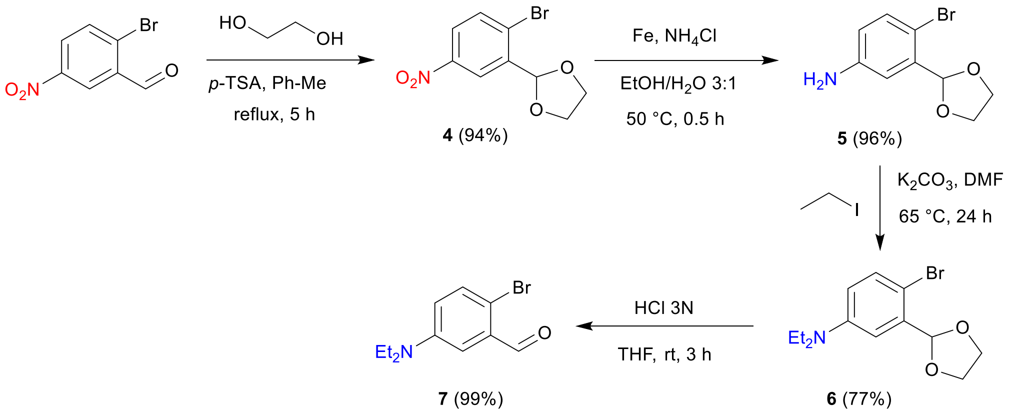
Supporting Information

*Preparation of 2-bromo-5-(diethylamino)benzaldehyde **7***



Scheme **S1**

2-(2-Bromo-5-nitrophenyl)-1,3-dioxolane **4**: A solution of 2-bromo-5-nitrobenzaldehyde (900 mg, 3.9 mmol), ethylene glycol (2.2 mL, 39 mmol) and *p*-TsOH (70 mg, 0.39 mmol) in toluene (25 mL) was refluxed for 5 h. After cooling at rt, the solution was diluted with EtOAc (25 mL) and washed with $NaHCO_3$ (20 mL). The organic layers were dried over Na_2SO_4 and the solvent was removed under reduced pressure. The crude pale yellow solid **4** (1.0 g, 94%) was sufficiently pure to be used for the next step without further purification. **^{1}H NMR** (300 MHz, $CDCl_3$) δ 8.44 (d, *J* = 2.8 Hz, 1H), 8.08 (dd, *J* = 8.7, 2.8 Hz, 1H), 7.75 (d, *J* = 8.7 Hz, 1H), 6.10 (s, 1H), 4.26 – 4.05 (m, 4H). NMR data are in agreement with those reported in the literature.[1]

4-Bromo-3-(1,3-dioxolan-2-yl)aniline **5**: A suspension of 2-(2-bromo-5-nitrophenyl)-1,3-dioxolane **4** (400 mg, 1.44 mmol), iron powder (408 mg, 7.28 mmol) and ammonium chloride (40 mg, 0.72 mmol) in 16 mL EtOH/H_2O (3:1) was heated at 80 °C for 1 h. The mixture was filtered through a thin pad od diatomite. The filtrate was extracted three times with EtOAc. The combined organic layers were washed with brine, dried over anhydrous Na_2SO_4. The solvent was evaporated at reduced pressure affording the product **5** (336 mg, 96%) as brown oil. It was used for the next step without further purification. **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.29 (d, *J* = 8.5 Hz, 1H), 6.93 (d, *J* = 2.9 Hz, 1H), 6.54 (dd, *J* = 8.5, 2.9 Hz, 1H), 6.00 (s, 1H), 4.21 – 4.00 (m, 4H), 3.73 (bs, 2H). **^{13}C NMR** (75 MHz, $CDCl_3$) δ 145.9 (C), 137.0 (C), 133.4 (CH), 117.3 (CH), 114.2 (CH), 110.5 (C), 102.6 (CH), 65.4 (2 × CH_2). **ESI(+)-MS**: m/z(%) = 244.13 (78) [^{79}Br MH]$^+$; 246.13 (76) [^{81}Br MH]$^+$ 266.09 (20) [^{79}Br M + Na]$^+$;

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[1] T. Kawabata, C. Jiang, K. Hayashi, K. Tsubaki, T. Yoshimura, S. Majumdar, T. Sasamori and N. Tokitoh, *J. Am. Chem. Soc.*, 2009, **131**, 54−55.

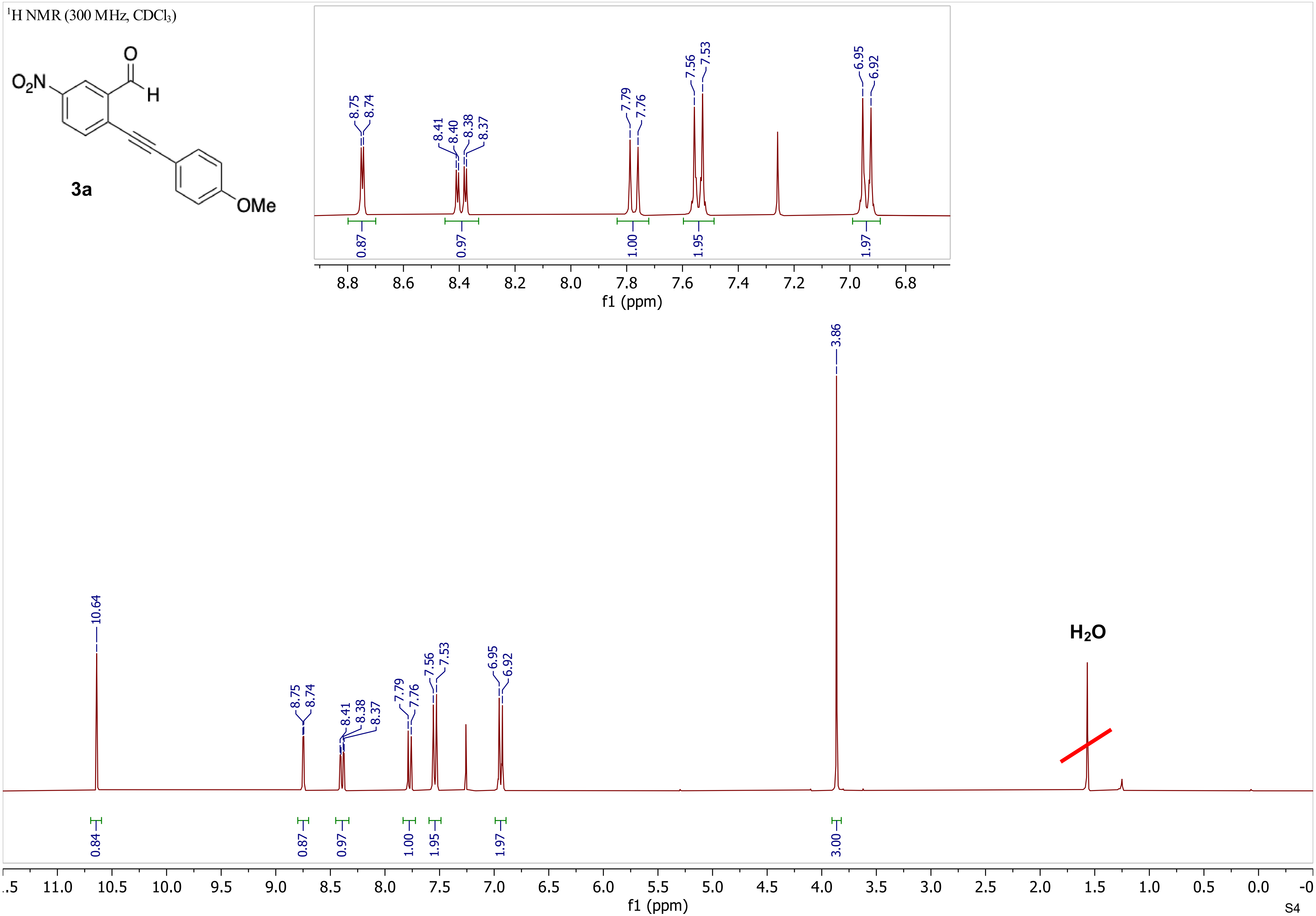
268.11 (22) [^{81}Br M + Na]$^+$. Calcd for $C_9H_{10}BrNO_2$ (244.09): C, 44.29; H, 4.13; N, 5.74; found: C, 44.12; H, 4.15; N, 5.73.

4-Bromo-3-(1,3-dioxolan-2-yl)-N,N-diethylaniline **6**: Under a nitrogen atmosphere, 4-bromo-3-(1,3-dioxolan-2-yl)aniline **5** (400 mg 1.46 mmol) was dissolved in 5 mL of dry DMF. To the reaction mixture, K_2CO_3 (303 mg 2.19 mmol) and iodoethane (956 mg, 6.13 mmol) were added. The reaction was stirred at 65 ° C for 24 h. The reaction was then stirred overnight until no more starting product was detected by TLC. A solution of brine was added (30 mL) and then extracted with EtOAc (3 × 10 mL). The organic phases were combined, dried over Na_2SO_4, and filtered. The solvent was removed at reduced pressure to afford product **6** (337 mg, 77%) as a brown oil. It was used directly for the next step without further purification. **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.32 (d, *J* = 8.9 Hz, 1H), 6.90 (d, *J* = 3.2 Hz, 1H), 6.53 (dd, *J* = 8.9, 3.2 Hz, 1H), 6.02 (s, 1H), 4.25 – 3.96 (m, 4H), 3.33 (q, *J* = 7.1 Hz, 4H), 1.14 (t, *J* = 7.1 Hz, 6H).

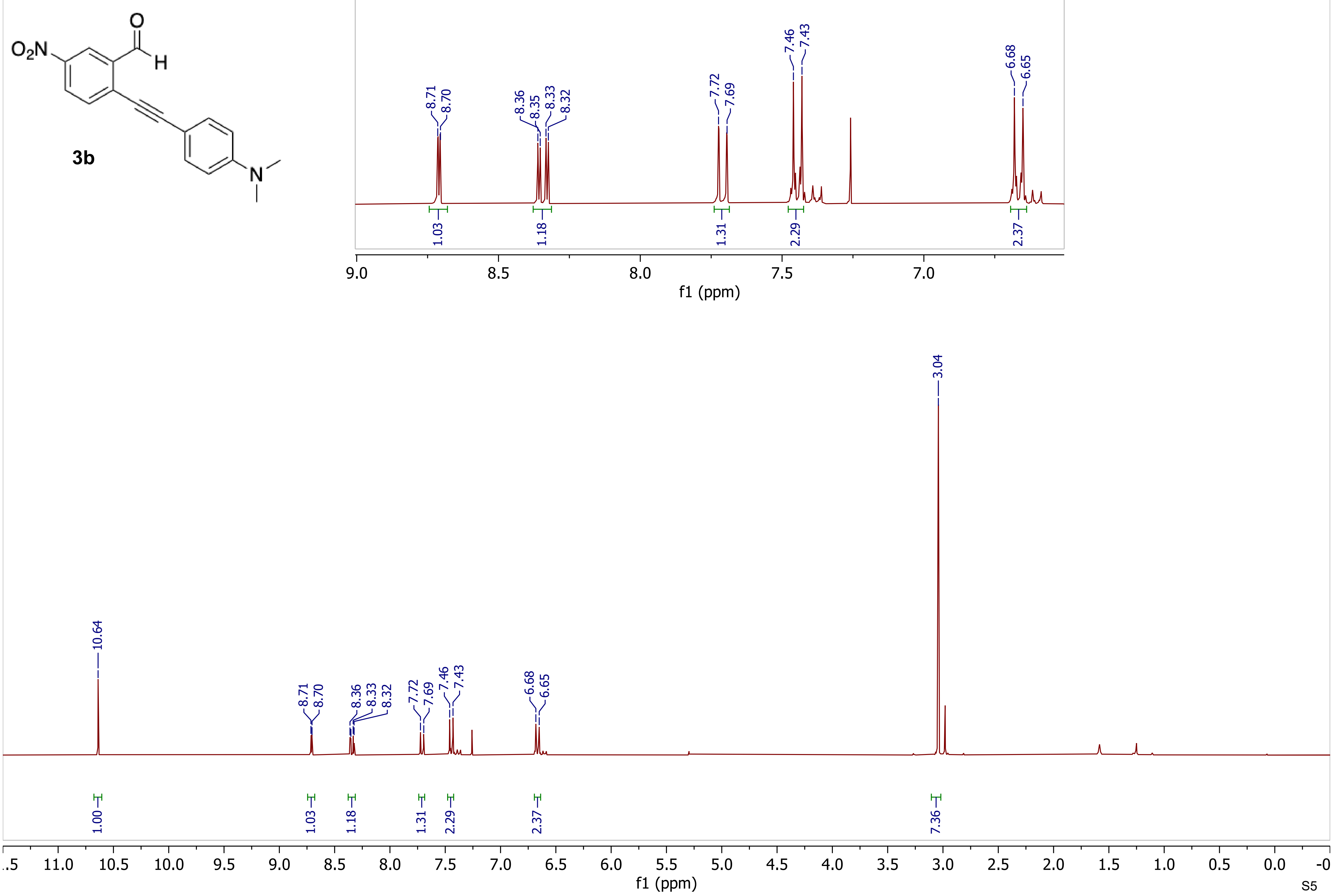
2-Bromo-5-(diethylamino)benzaldehyde **7**: To a solution of 4-bromo-3-(1,3-dioxolan-2-yl)-*N*,*N*-diethylaniline **6** (337 mg, 1.12 mmol) in 6 ml of THF, 6 mL of HCl 3N were added. The solution was stirred at rt overnight and then it was poured into $NaHCO_3$ saturated solution and extracted with DCM. The organic phases were combined, dried over Na_2SO_4, and filtered. The solvent was removed under reduced pressure to afford the 2-bromo-5-(diethylamino)benzaldehyde **7** (284 mg, 99%) as a brown oil, sufficiently pure to be used in the following Sonogashira coupling reactions without further purification.

^{1}H NMR (300 MHz, $CDCl_3$) δ 10.29 (s, 1H), 7.39 (d, *J* = 8.9 Hz, 1H), 7.15 (d, *J* = 3.4 Hz, 1H), 6.74 (dd, *J* = 8.9, 3.4 Hz, 1H), 3.36 (q, *J* = 7.1 Hz, 4H), 1.15 (t, *J* = 7.1 Hz, 6H). **^{13}C NMR** (75 MHz, CDCl3) δ 192.6 (CH), 147.2 (C), 134.1 (CH), 133.5 (C), 118.7 (CH), 111.7 (C), 111.6 (CH), 44.4 (2 × CH_2), 12.3 (2 × CH_3). **ESI(+)-MS**: m/z(%) = 256.14 (45) [^{79}Br MH]$^+$; 258.15 (40) [^{81}Br MH]$^+$; 288.16 (94) [^{79}Br MH + MeOH]$^+$; 290.14 (100) [^{81}Br MH + MeOH]$^+$. Calcd for $C_9H_{10}BrNO_2$ (256.14): C, 51.58; H, 5.51; N, 5.47; found: C, 51.69; H, 5.45; N, 5.55.

^1H NMR (300 MHz, $CDCl_3$)

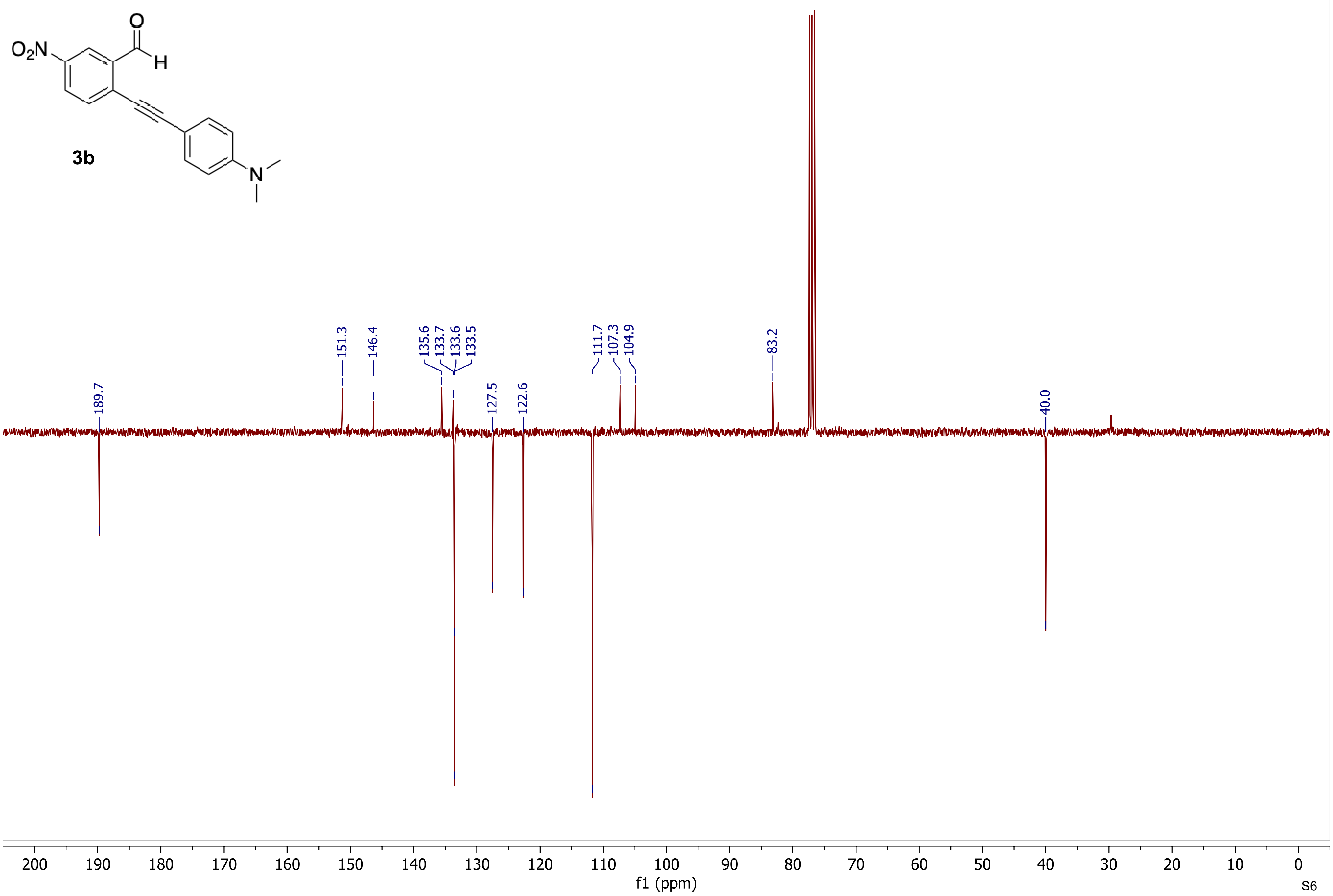


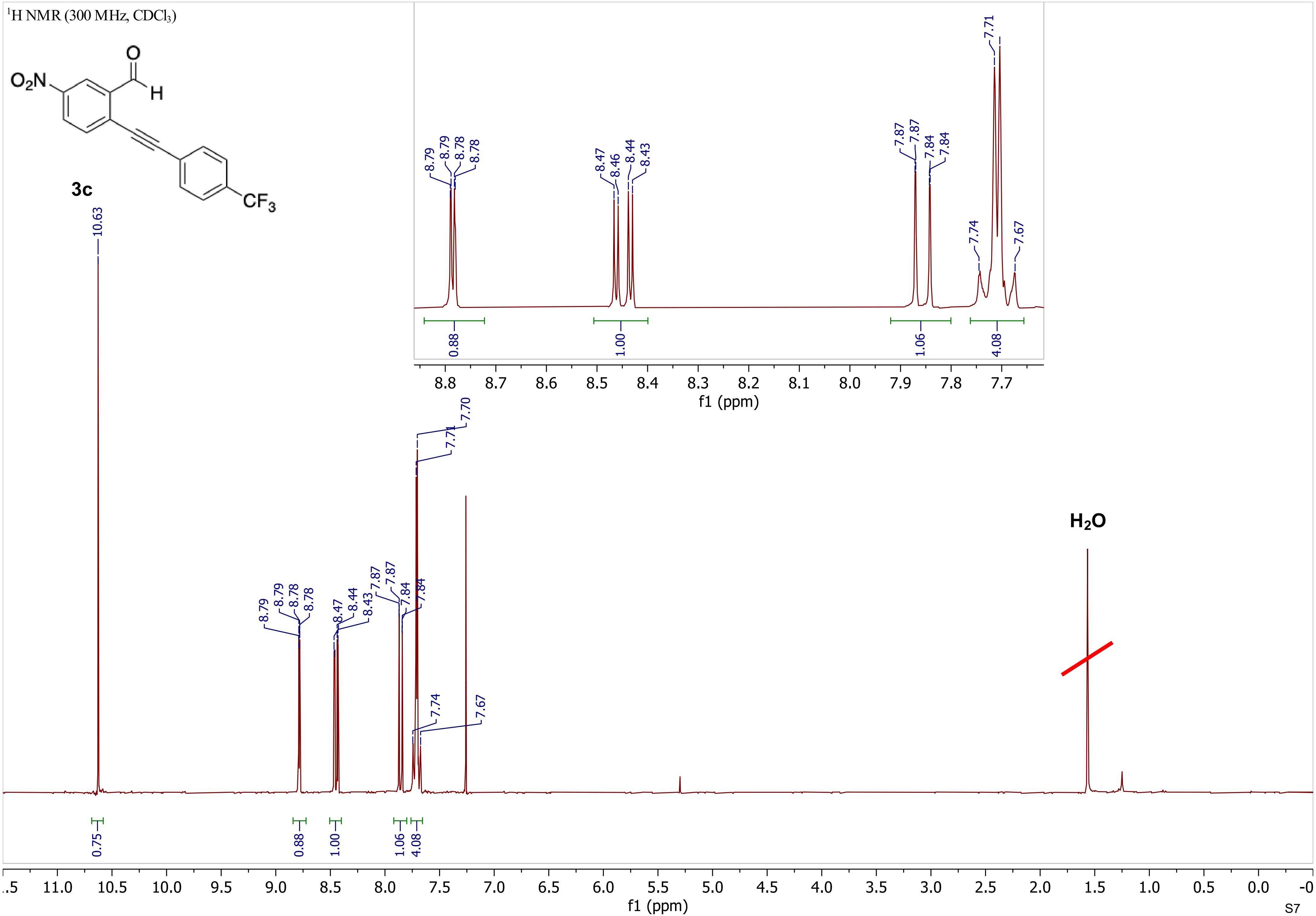
^{1}H NMR (300 MHz, $CDCl_3$)



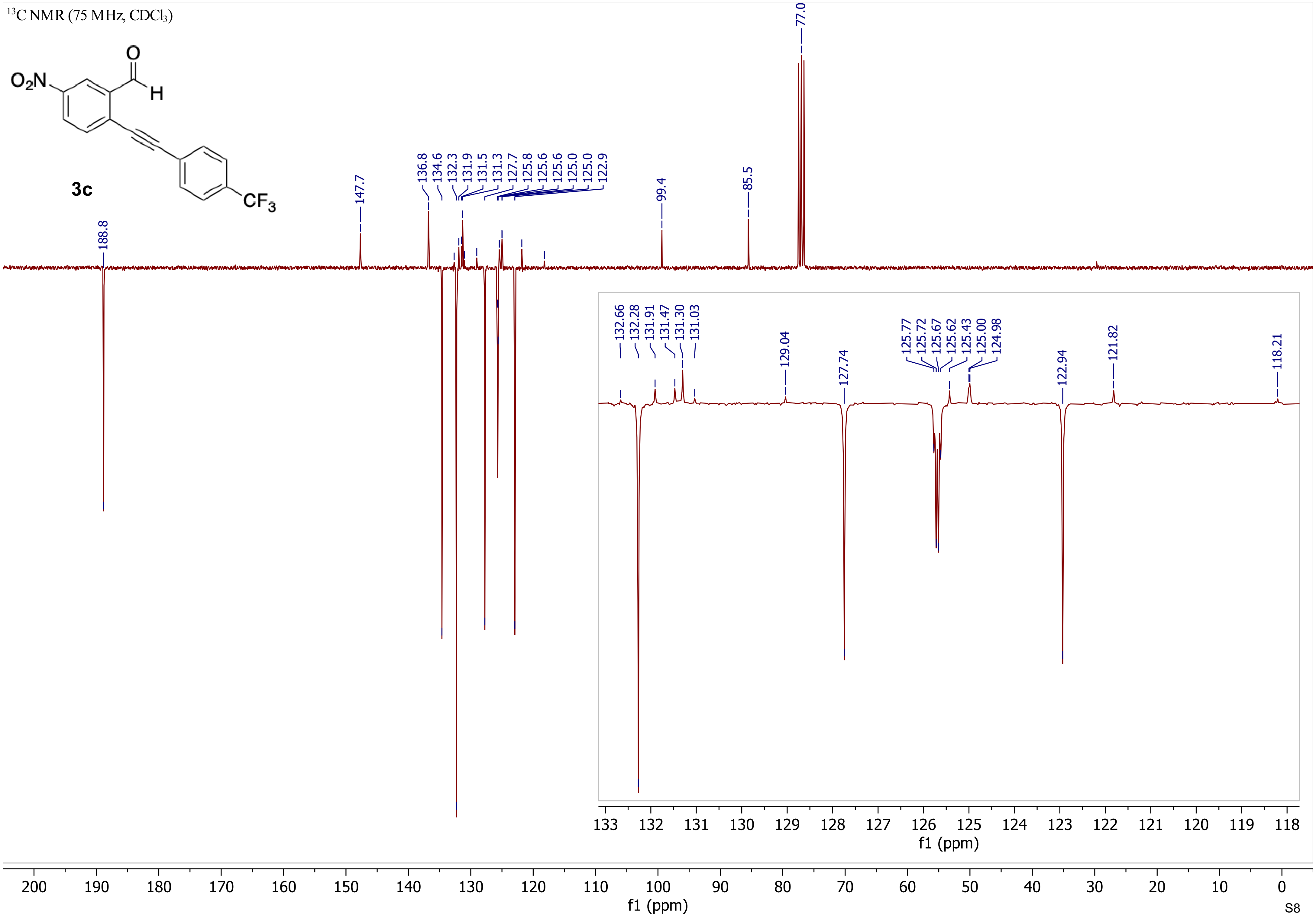
3b

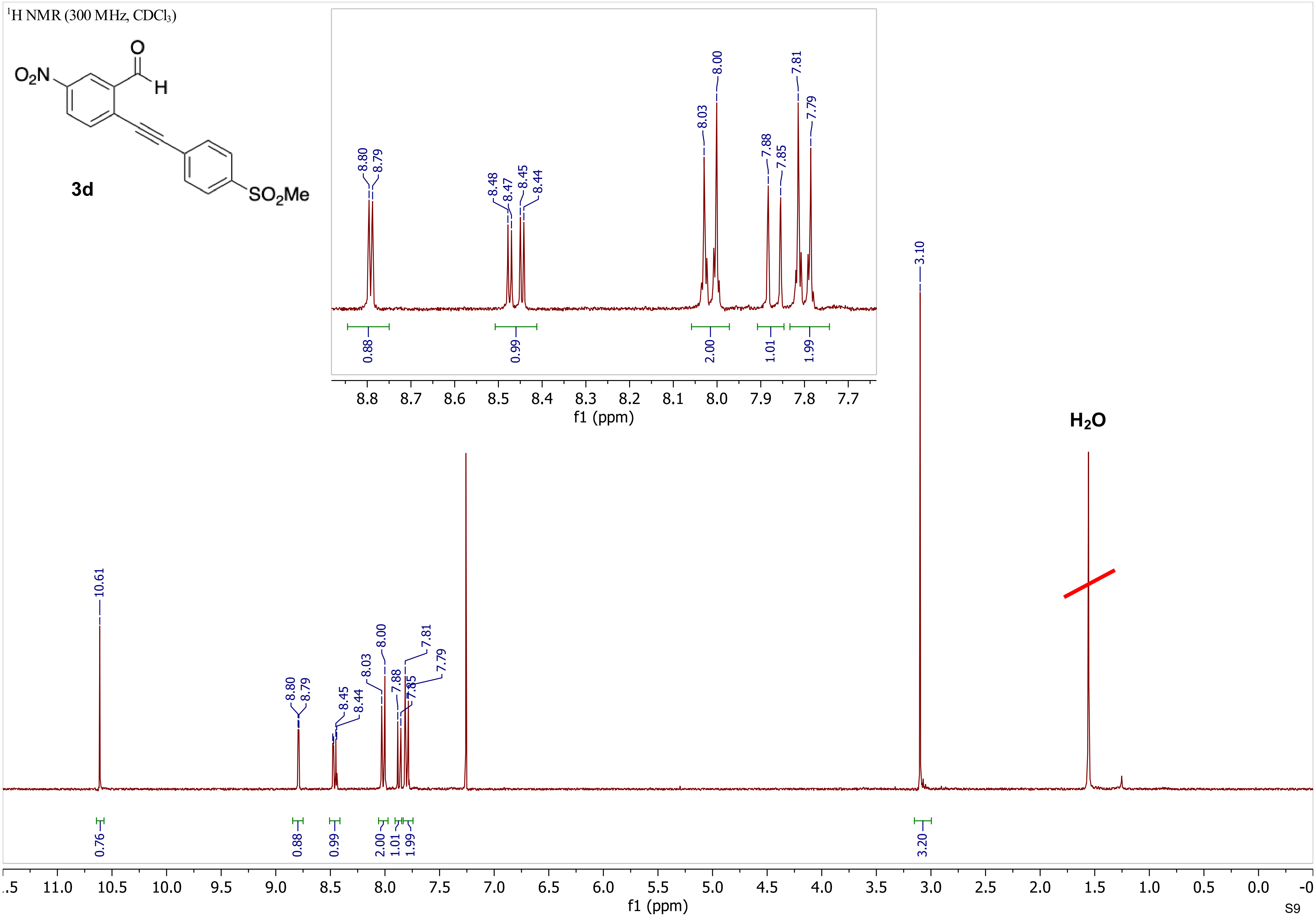
^{13}C NMR (75 MHz, CDCl$_3$)




^{1}H NMR (300 MHz, CDCl$_3$)
O_2N
O
H
CF_3
3c
10.63
8.79
8.79
8.78
8.78
8.47
8.46
8.44
8.43
7.87
7.87
7.84
7.84
7.71
7.70
7.74
7.67
H$_2$O
0.75
0.88
1.00
1.06
4.08
f1 (ppm)

^{13}C NMR (75 MHz, CDCl$_3$)

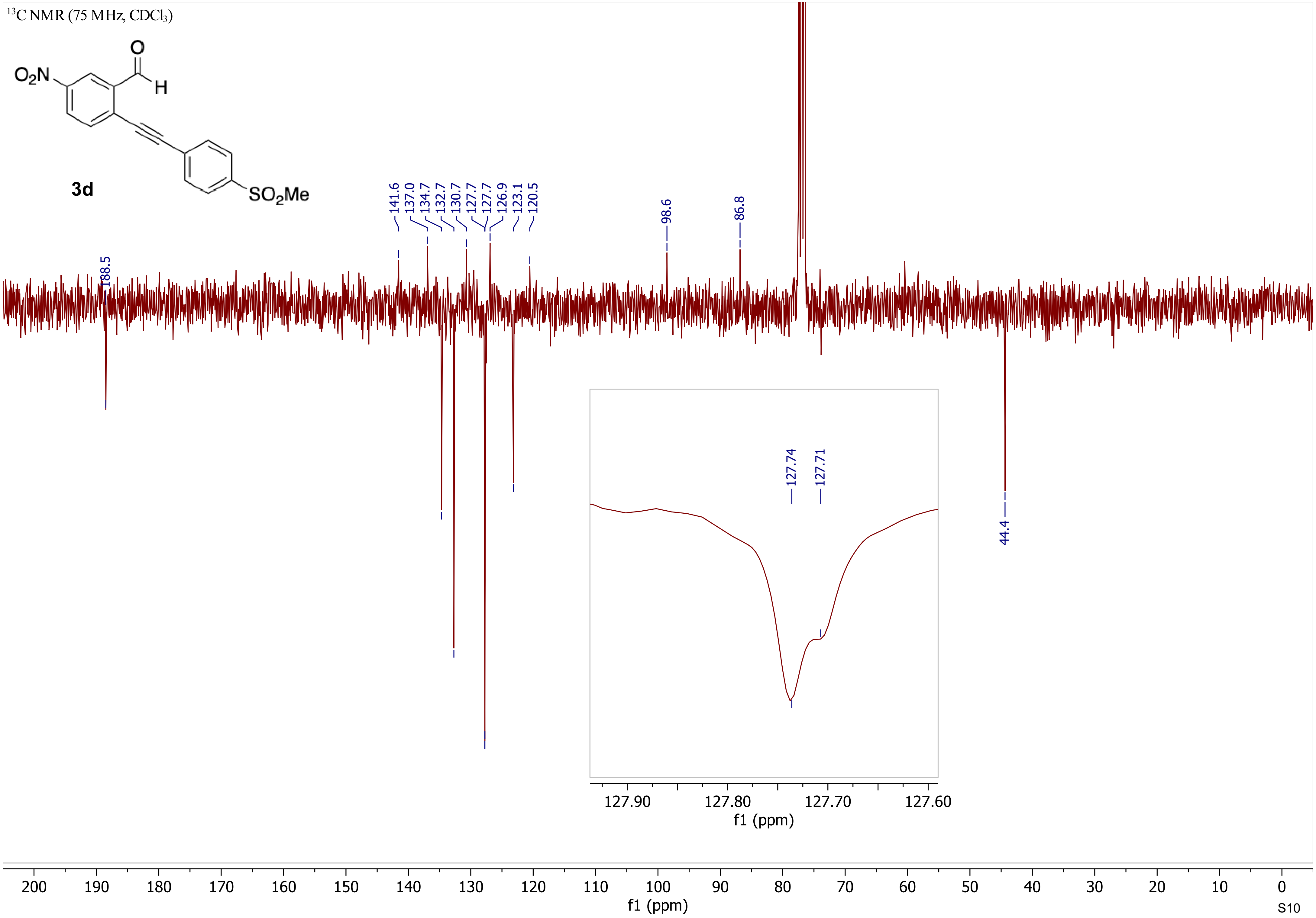




^{1}H NMR (300 MHz, $CDCl_3$)

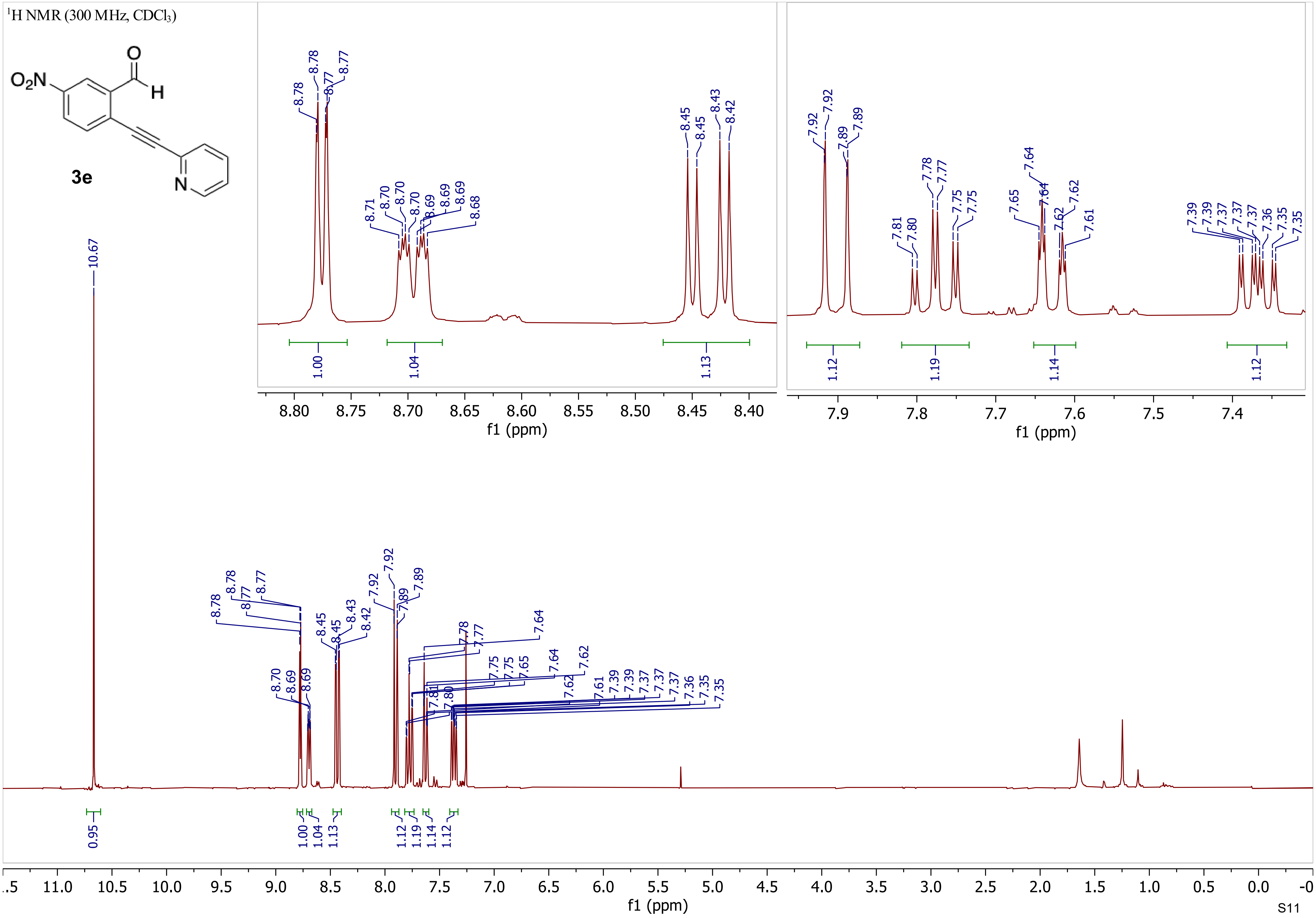
3d

^{13}C NMR (75 MHz, $CDCl_3$)

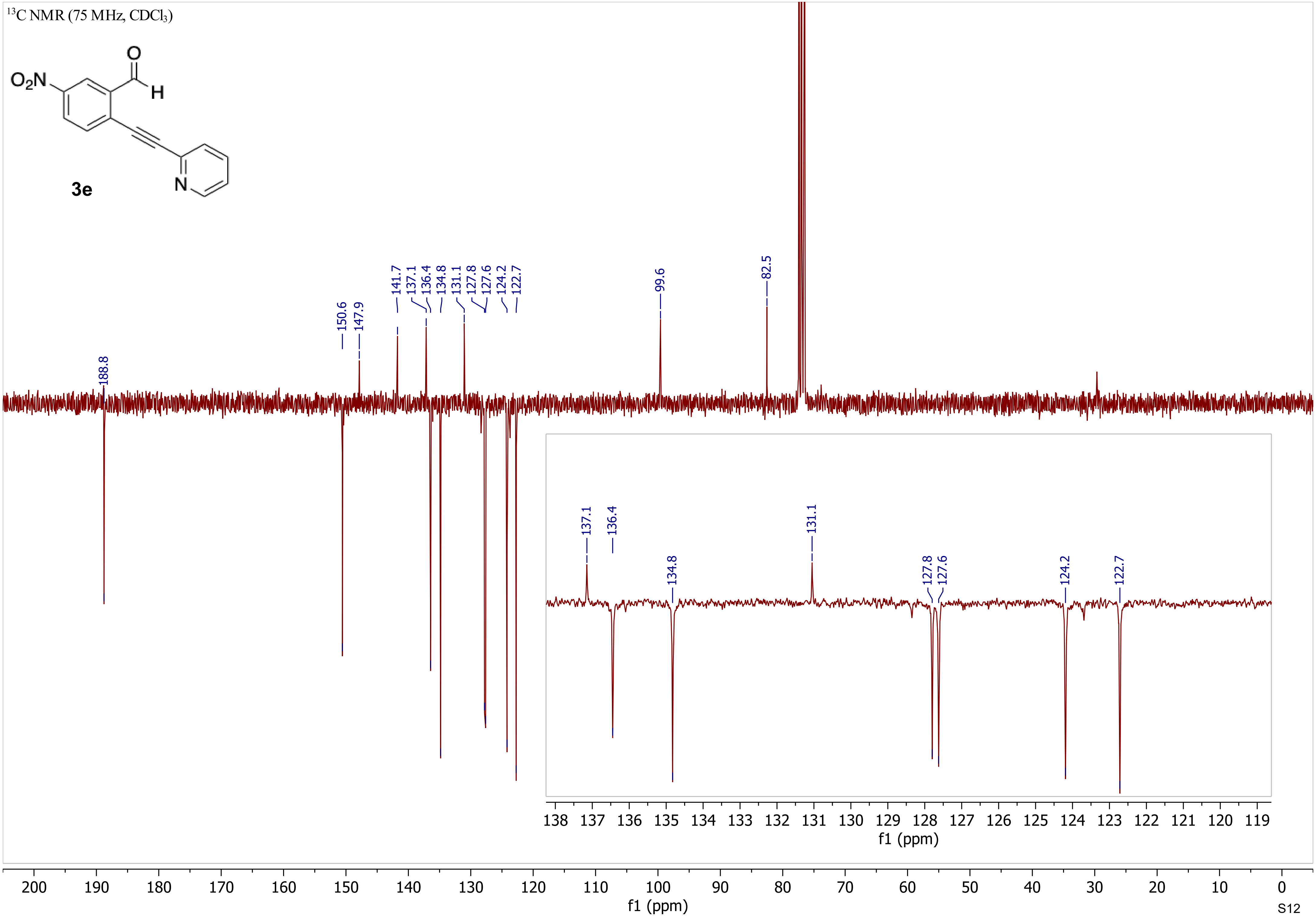


3d

^{1}H NMR (300 MHz, CDCl$_3$)



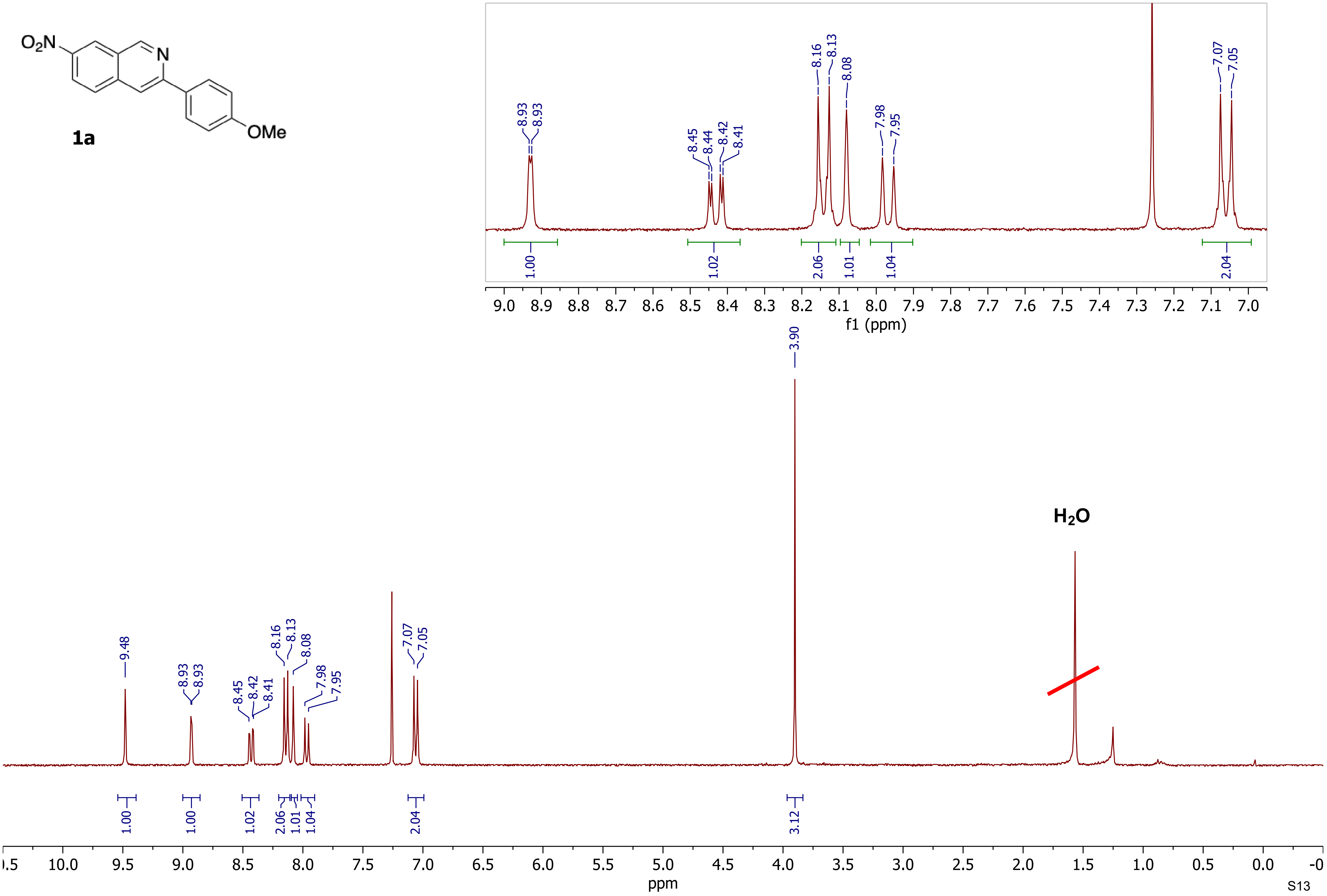
3e



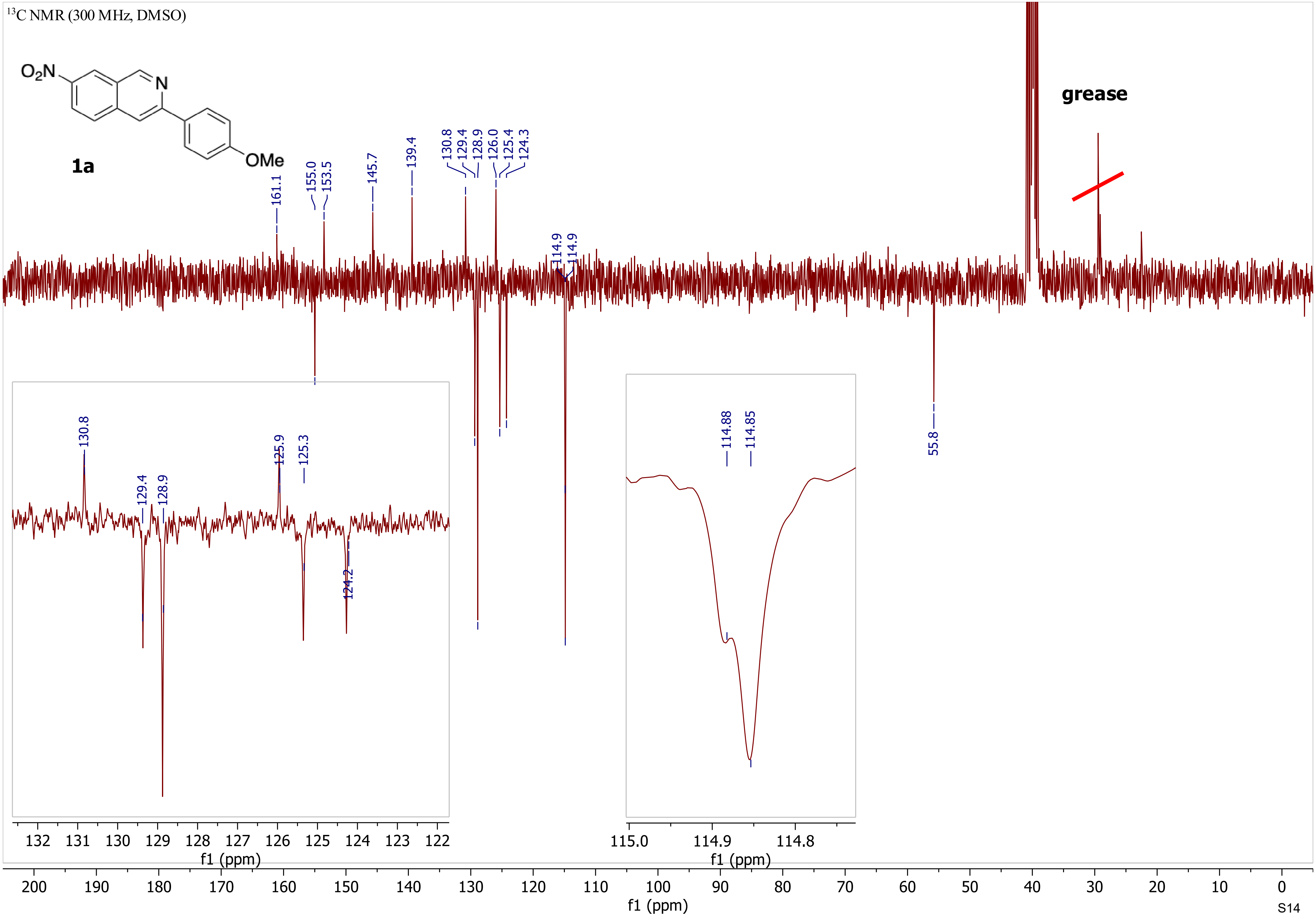
^{13}C NMR (75 MHz, CDCl$_3$)

3e

^{1}H NMR (300 MHz, $CDCl_3$)

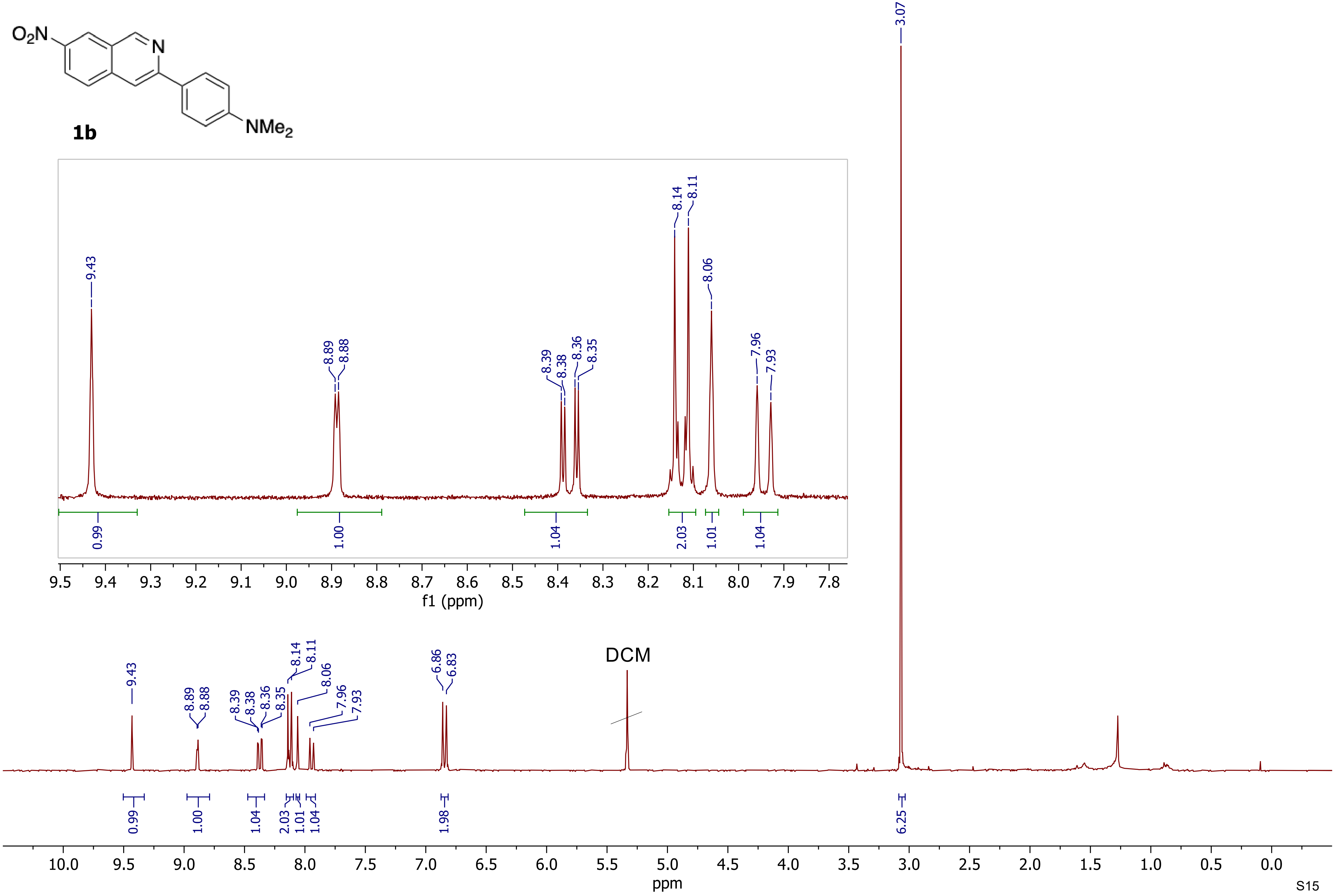


1a

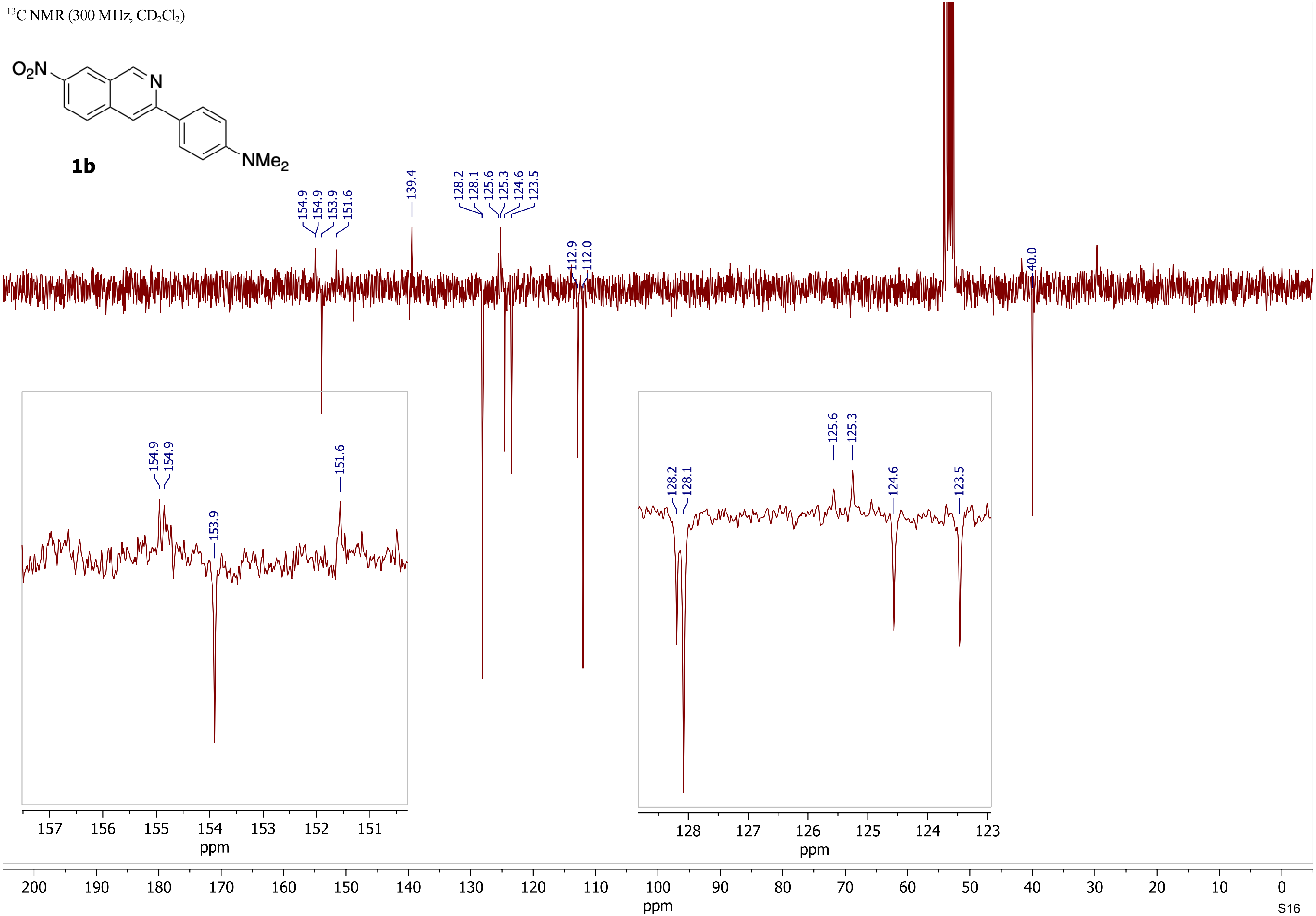

^{13}C NMR (300 MHz, DMSO)
O_2N
N
OMe
1a
grease
161.1
155.0
153.5
145.7
139.4
130.8
129.4
128.9
126.0
125.4
124.3
114.9
114.9
55.8
130.8
129.4
128.9
125.9
125.3
124.2
114.88
114.85
132 131 130 129 128 127 126 125 124 123 122
f1 (ppm)
115.0 114.9 114.8
f1 (ppm)
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

^{1}H NMR (300 MHz, CD_2Cl_2)

1b

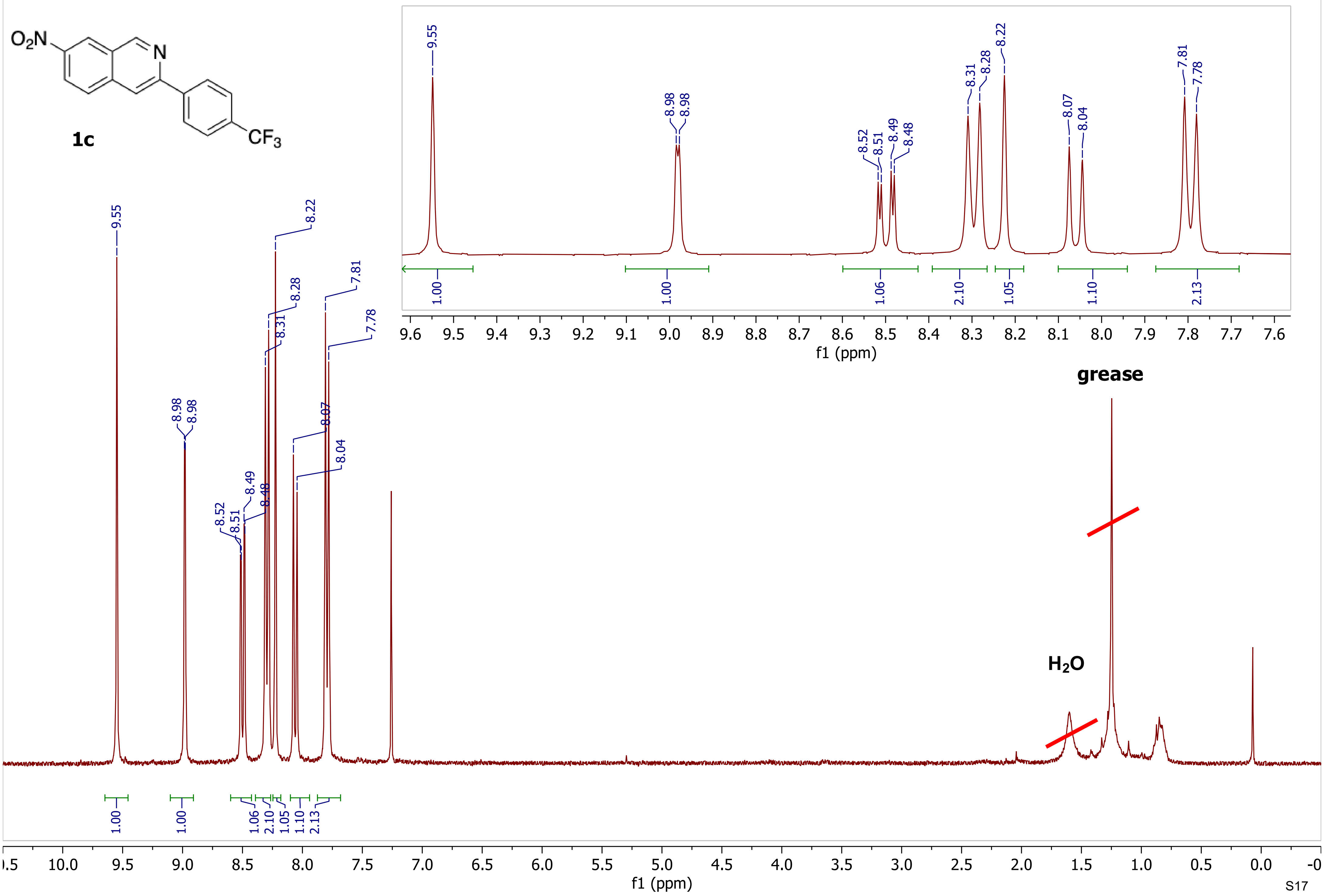


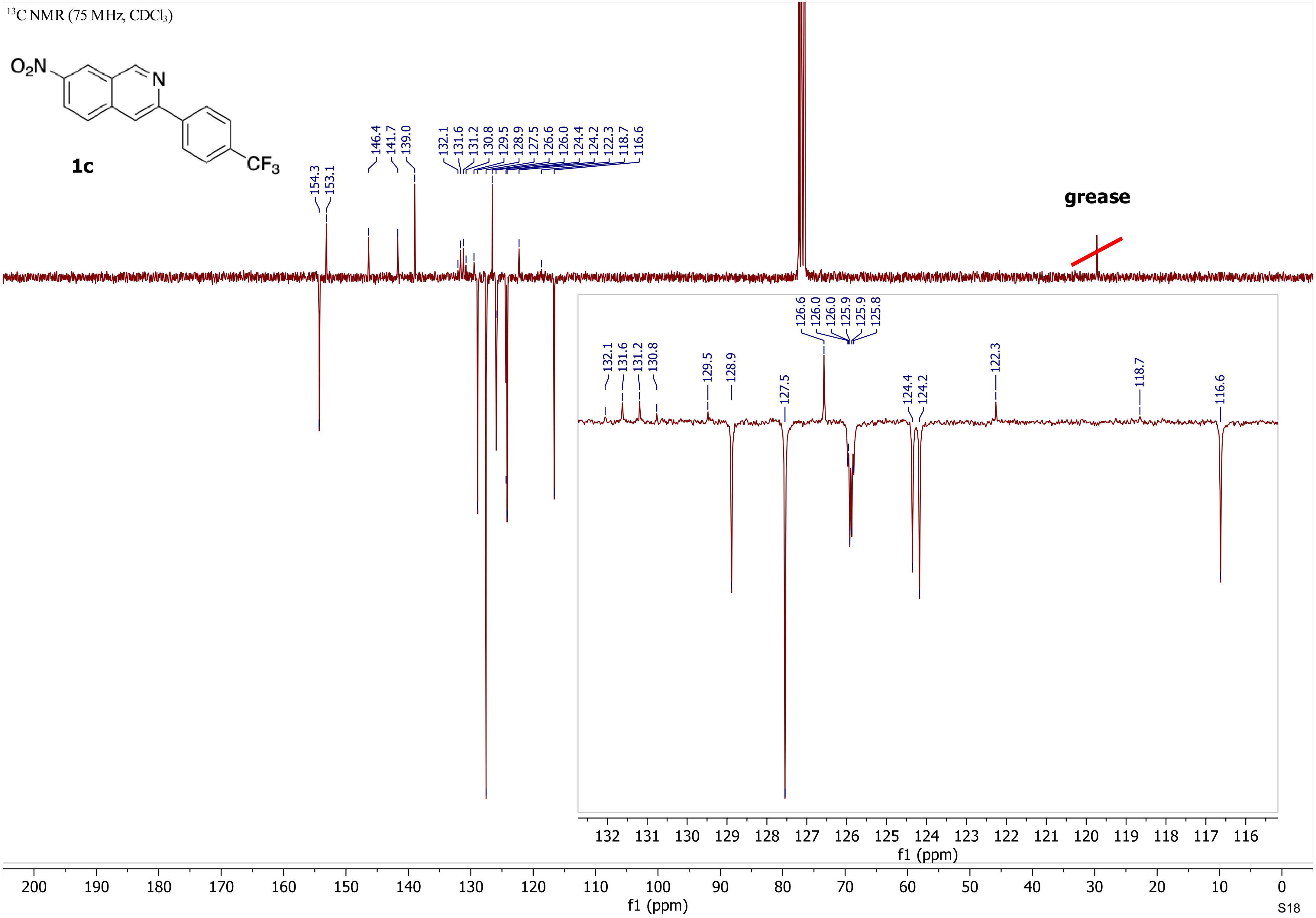
^{13}C NMR (300 MHz, CD_2Cl_2)



1b

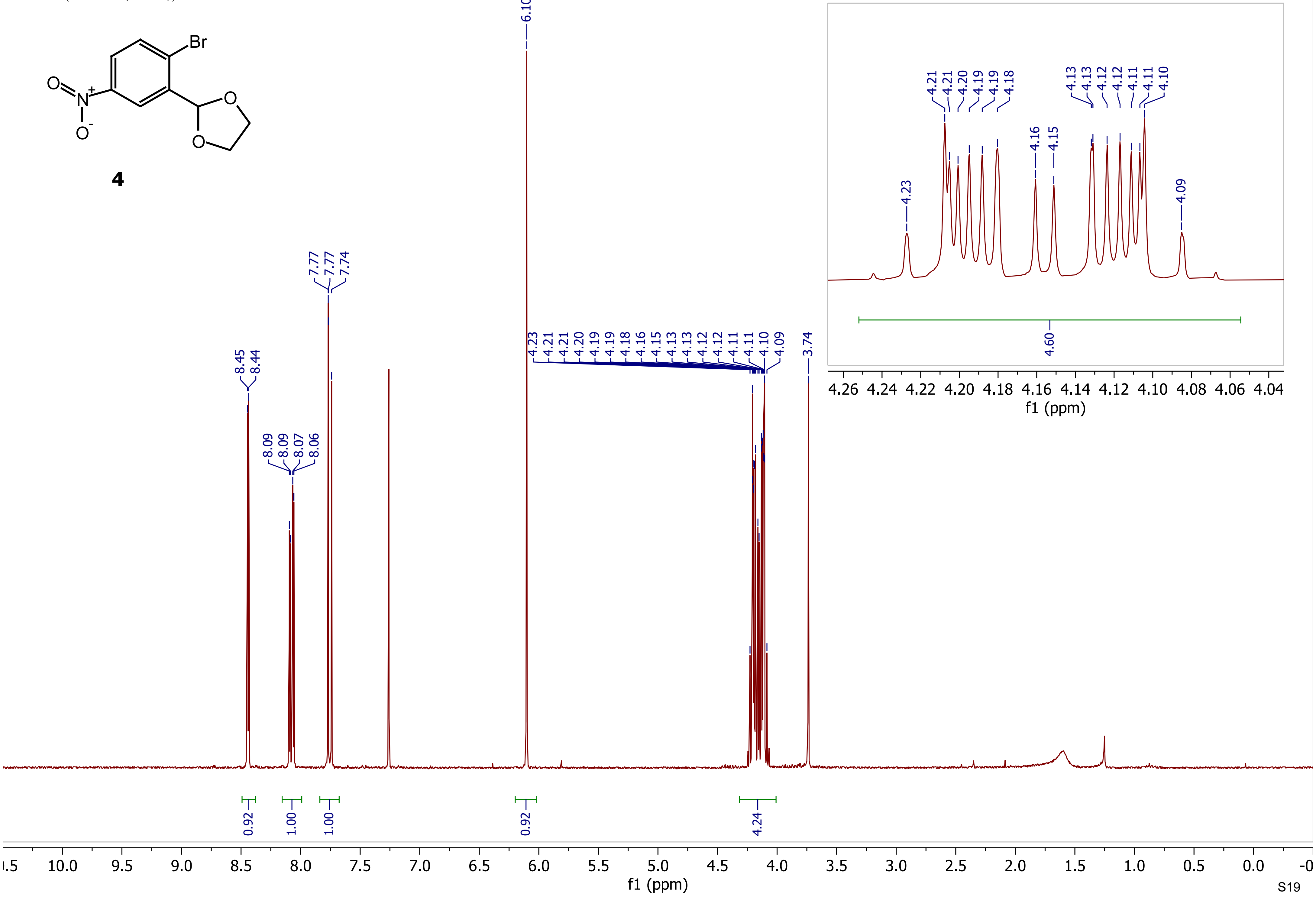
^{1}H NMR (300 MHz, $CDCl_3$)



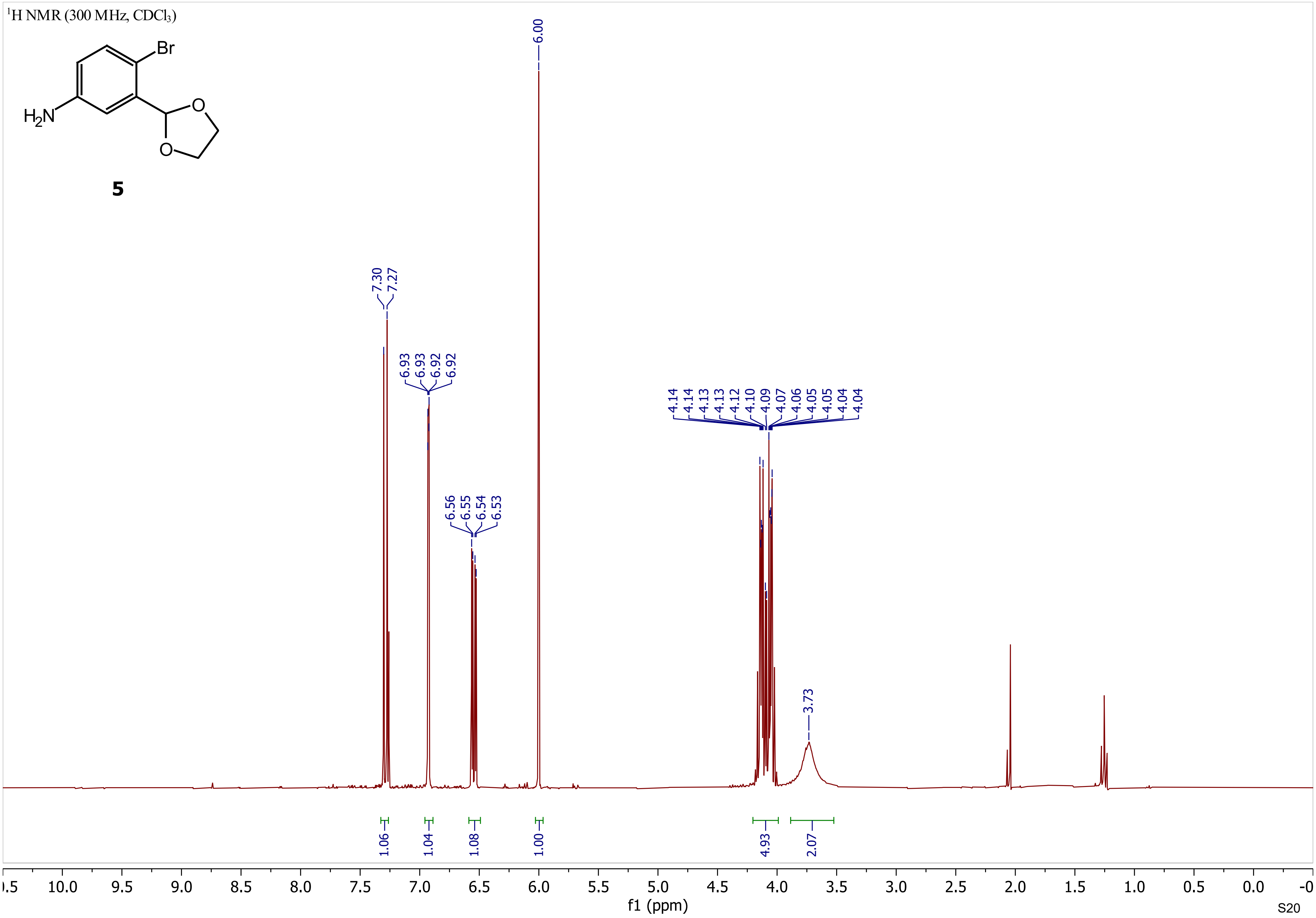

^{13}C NMR (75 MHz, CDCl$_3$)

1c

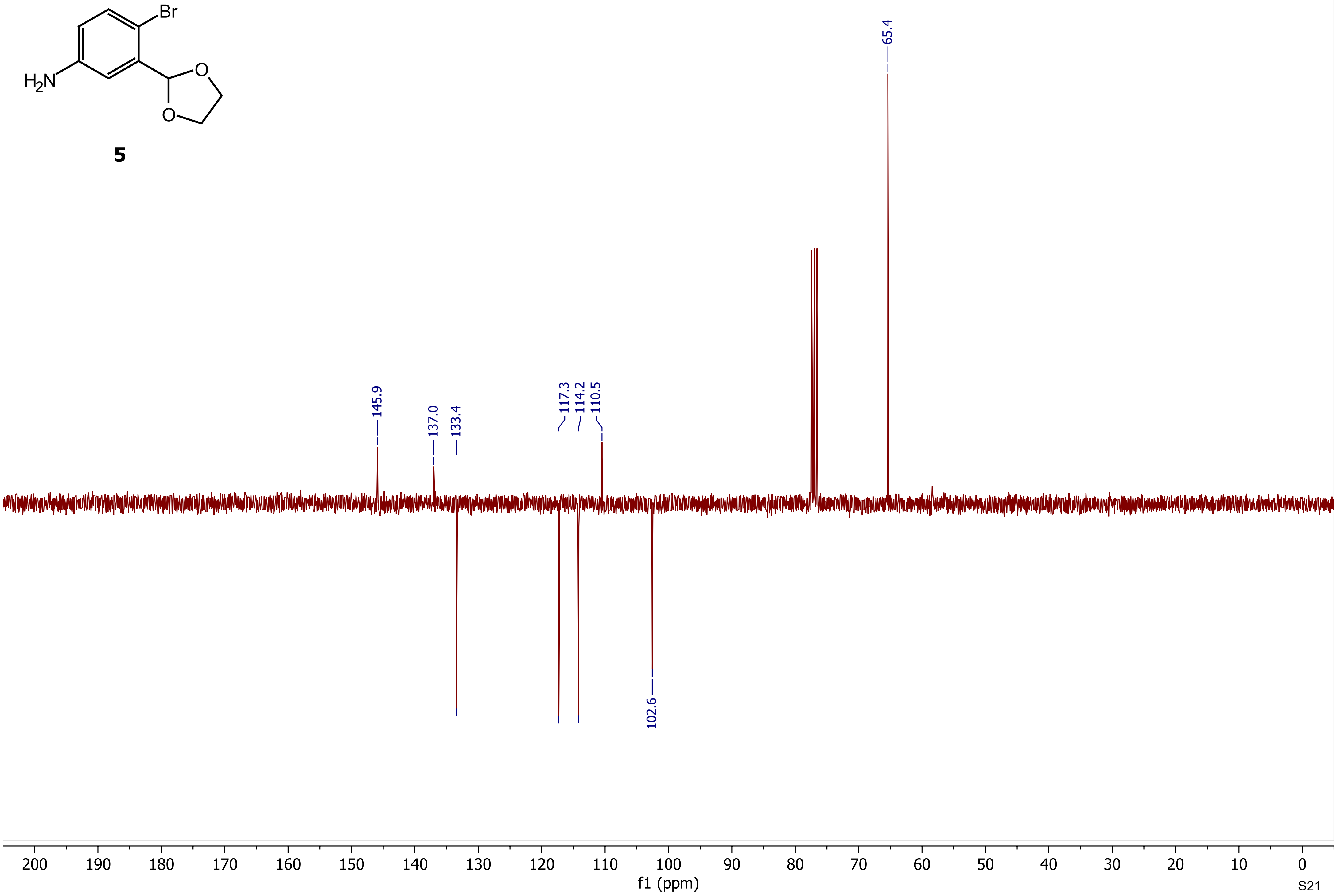
^{1}H NMR (300 MHz, CDCl$_3$)



^{1}H NMR (300 MHz, $CDCl_3$)

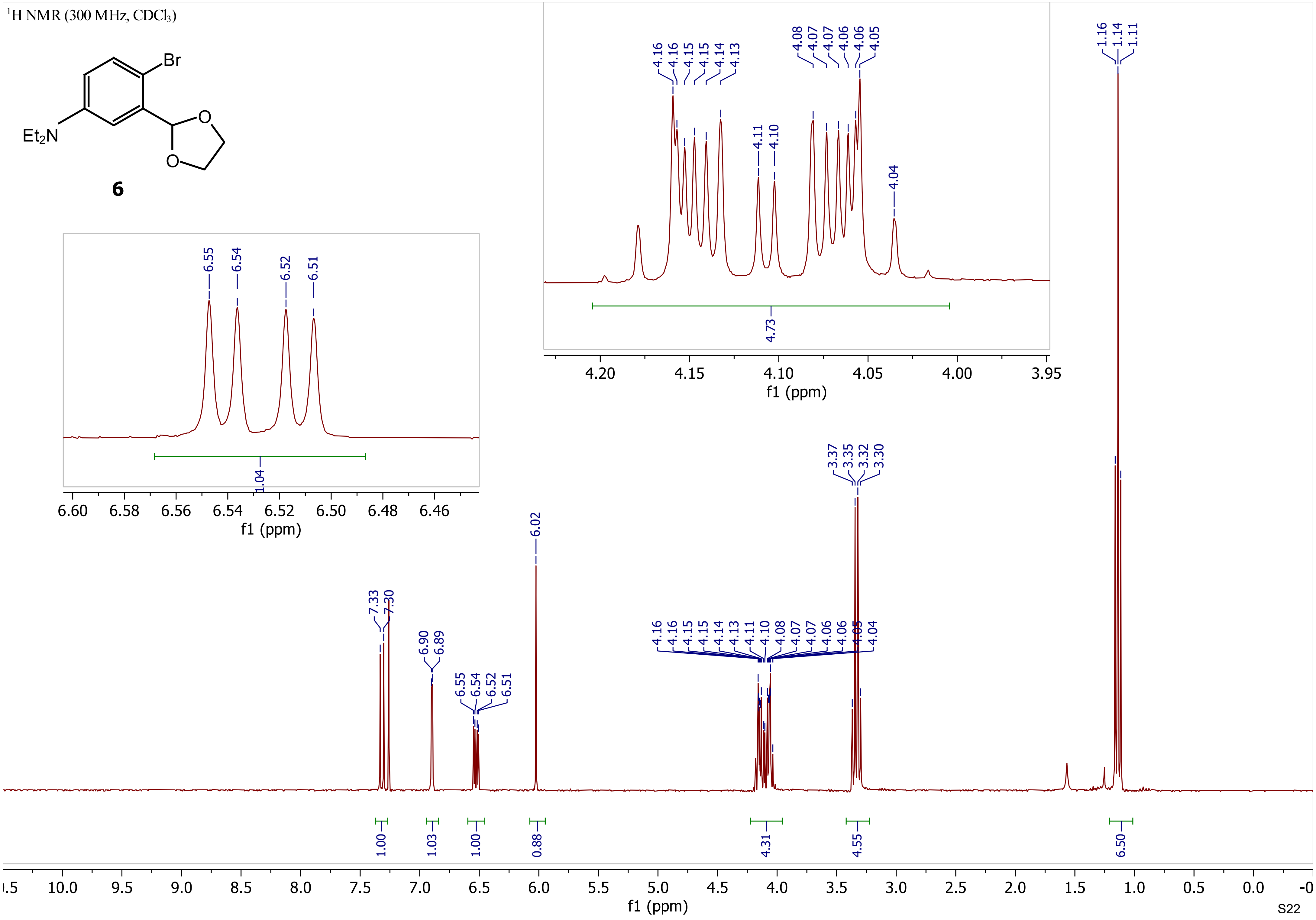


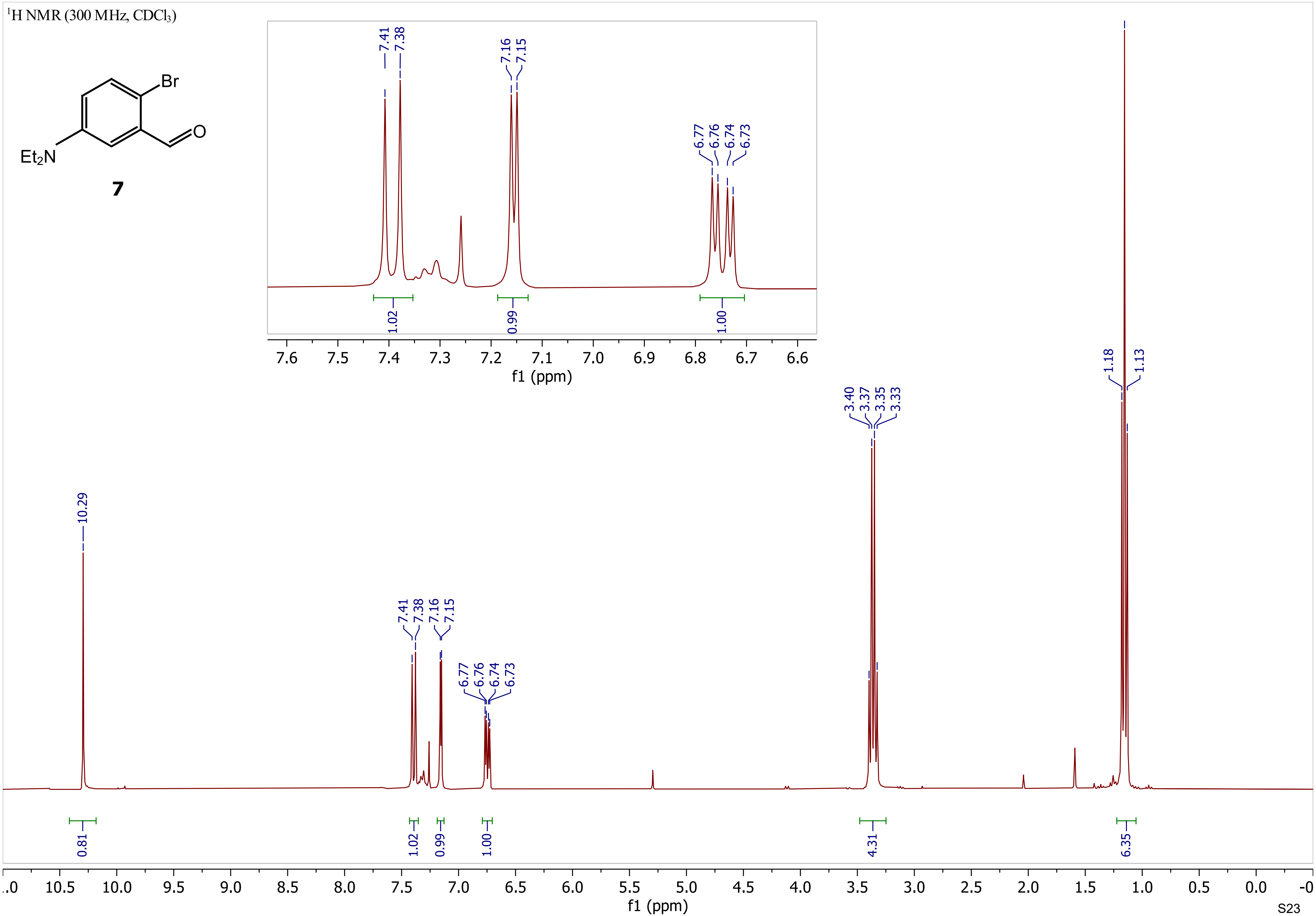
^{13}C NMR (75 MHz, CDCl$_3$)



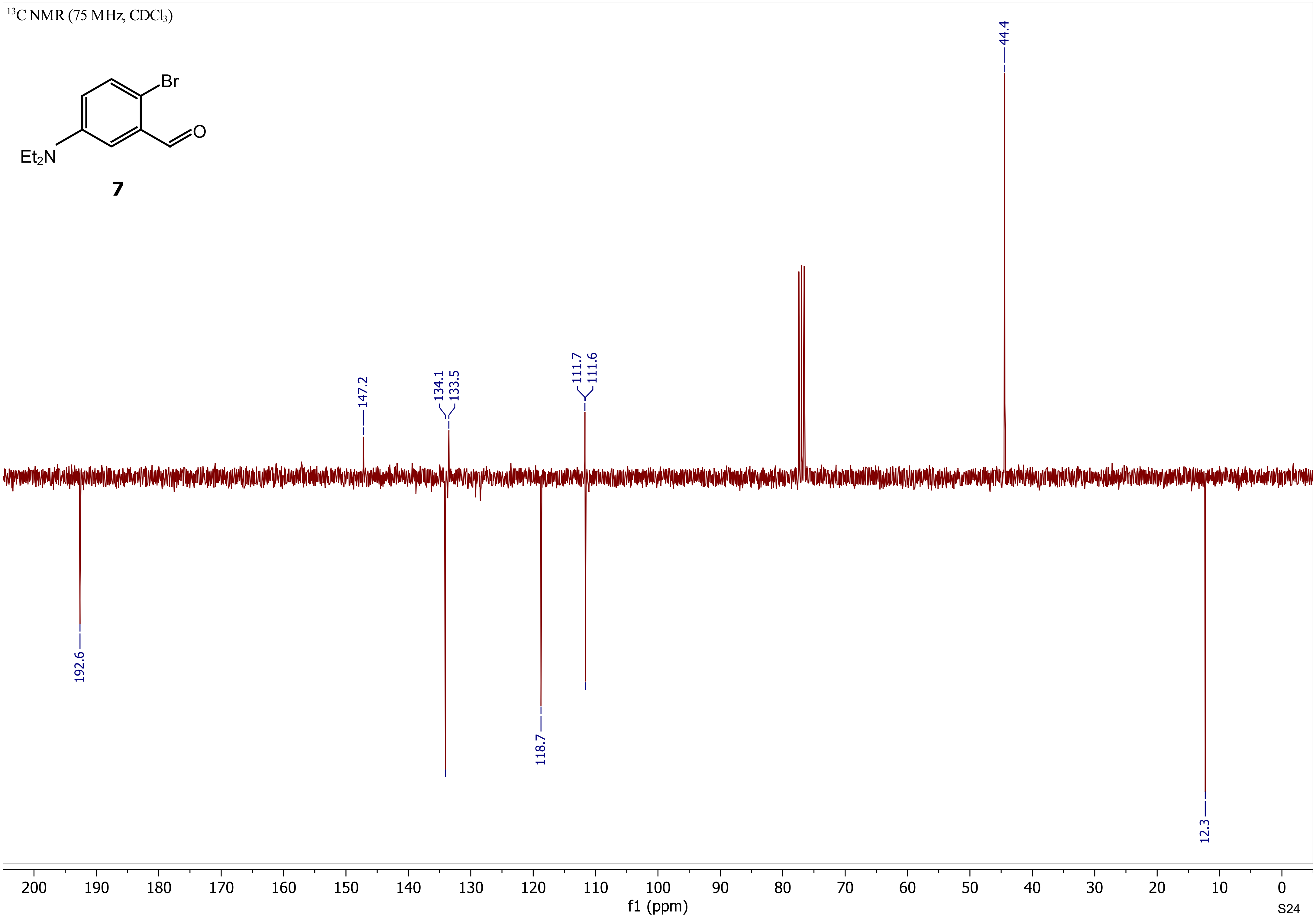
5

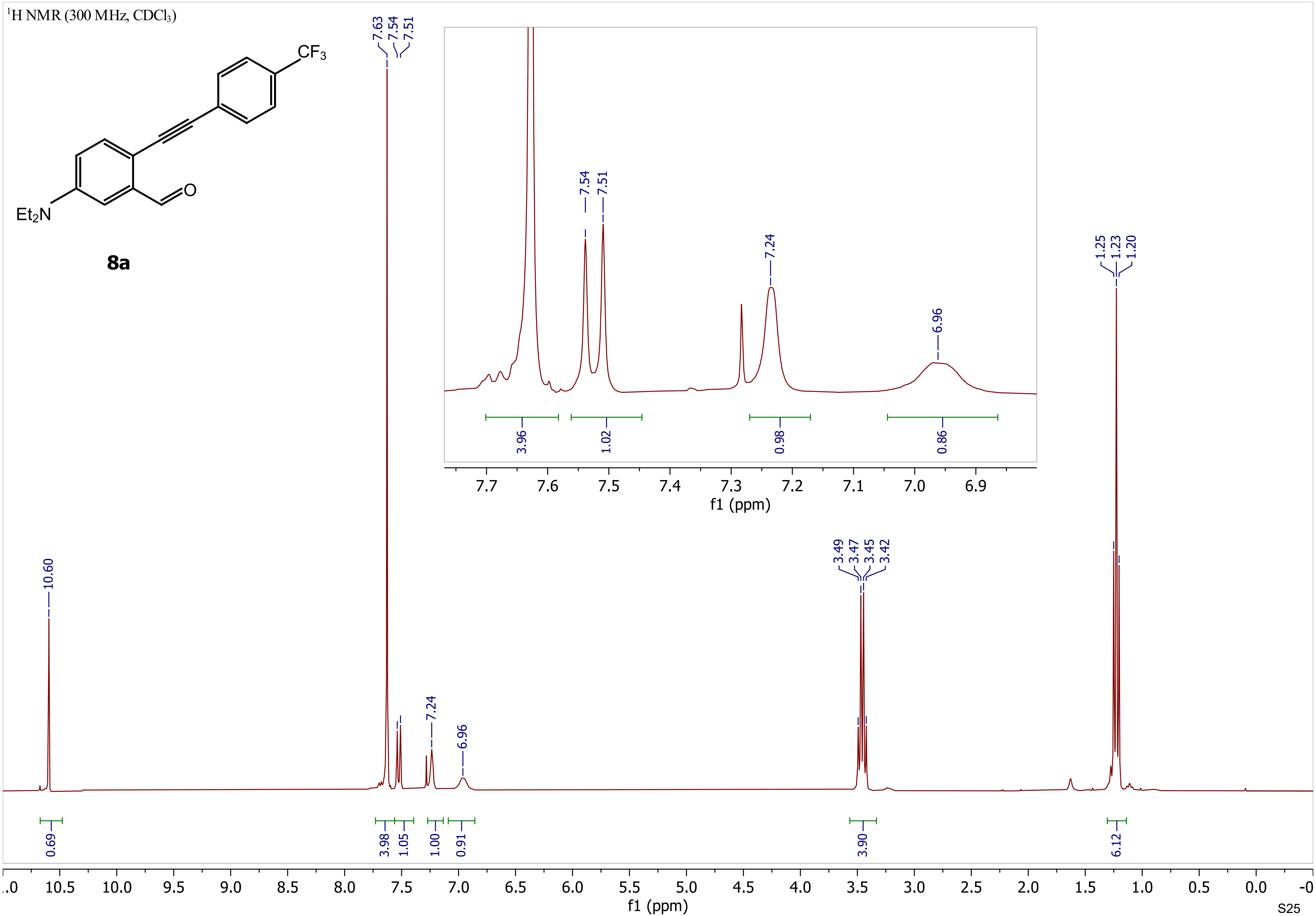
^{1}H NMR (300 MHz, CDCl$_3$)



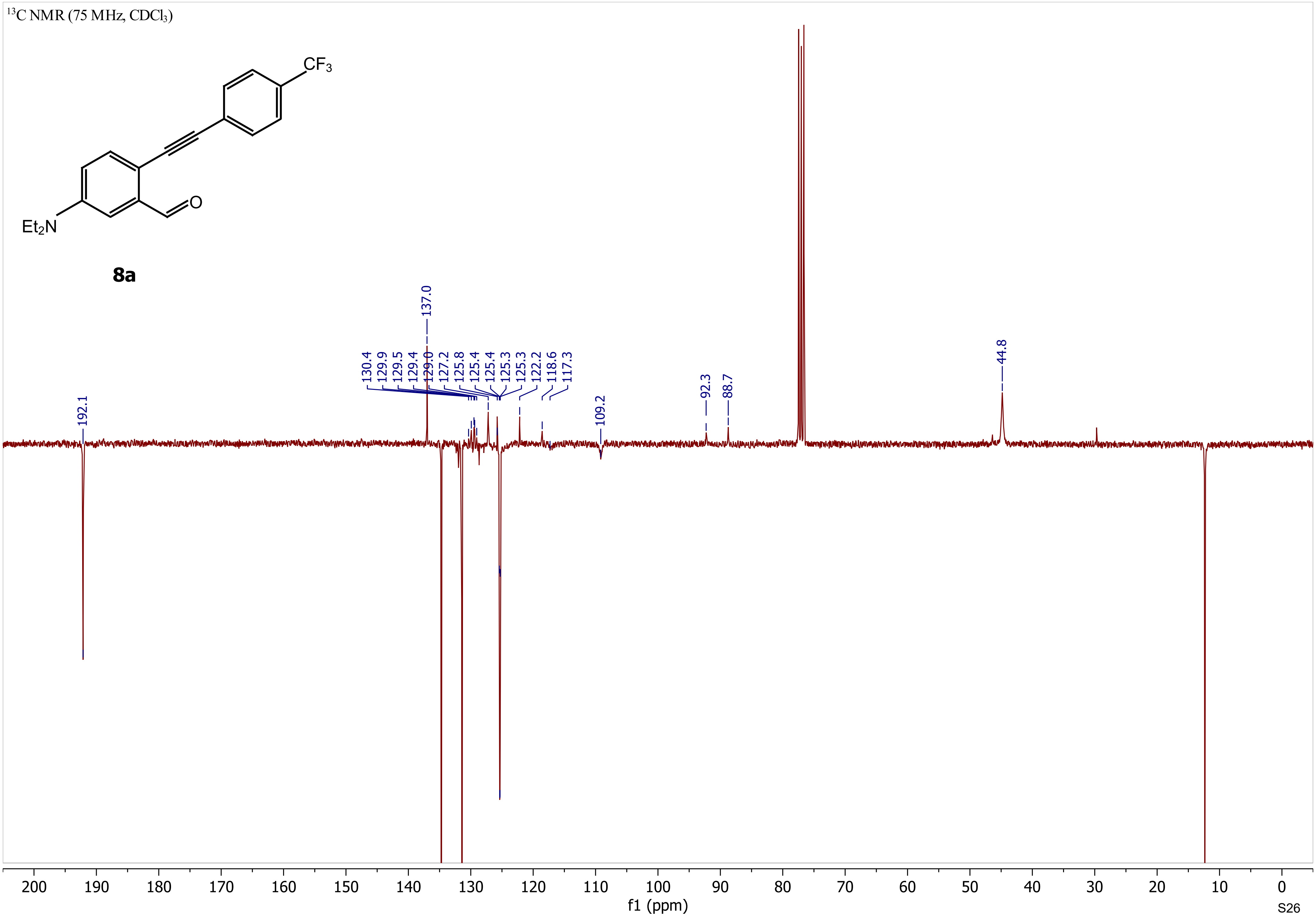

^{1}H NMR (300 MHz, $CDCl_3$)
Br
O
Et_2N
7
7.41
7.38
7.16
7.15
6.77
6.76
6.74
6.73
1.02
0.99
1.00
7.6
7.5
7.4
7.3
7.2
7.1
7.0
6.9
6.8
6.7
6.6
f1 (ppm)
10.29
3.40
3.37
3.35
3.33
1.18
1.13
0.81
1.02
0.99
1.00
4.31
6.35
.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0
f1 (ppm)

^{13}C NMR (75 MHz, $CDCl_3$)





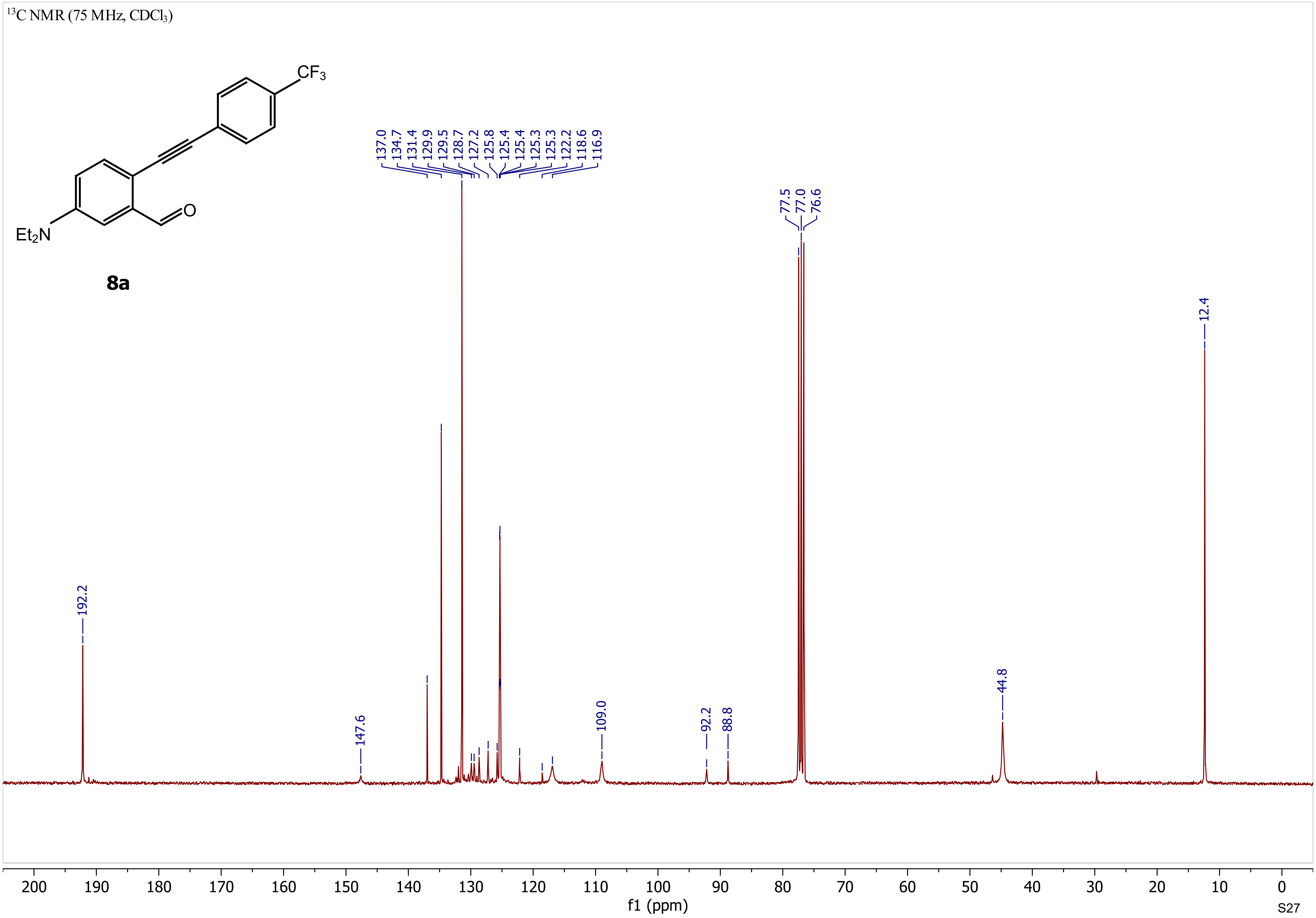
^{1}H NMR (300 MHz, CDCl$_3$)
CF$_3$
O
Et$_2$N
8a
10.60
7.63
7.54
7.51
7.24
6.96
3.49
3.47
3.45
3.42
1.25
1.23
1.20
0.69
3.98
1.05
1.00
0.91
3.90
6.12
3.96
1.02
0.98
0.86
f1 (ppm)



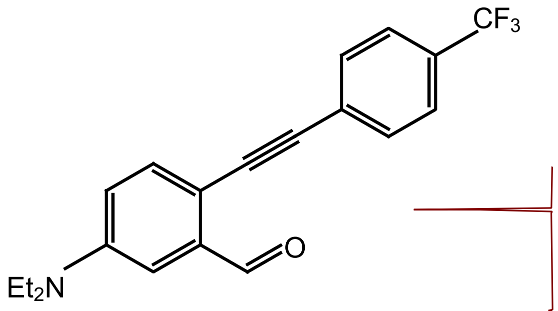
^{13}C NMR (75 MHz, CDCl$_3$)
CF$_3$
O
Et$_2$N
192.1
137.0
130.4
129.9
129.5
129.4
129.0
127.2
125.8
125.4
125.4
125.3
125.3
122.2
118.6
117.3
109.2
92.3
88.7
44.8
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

8a

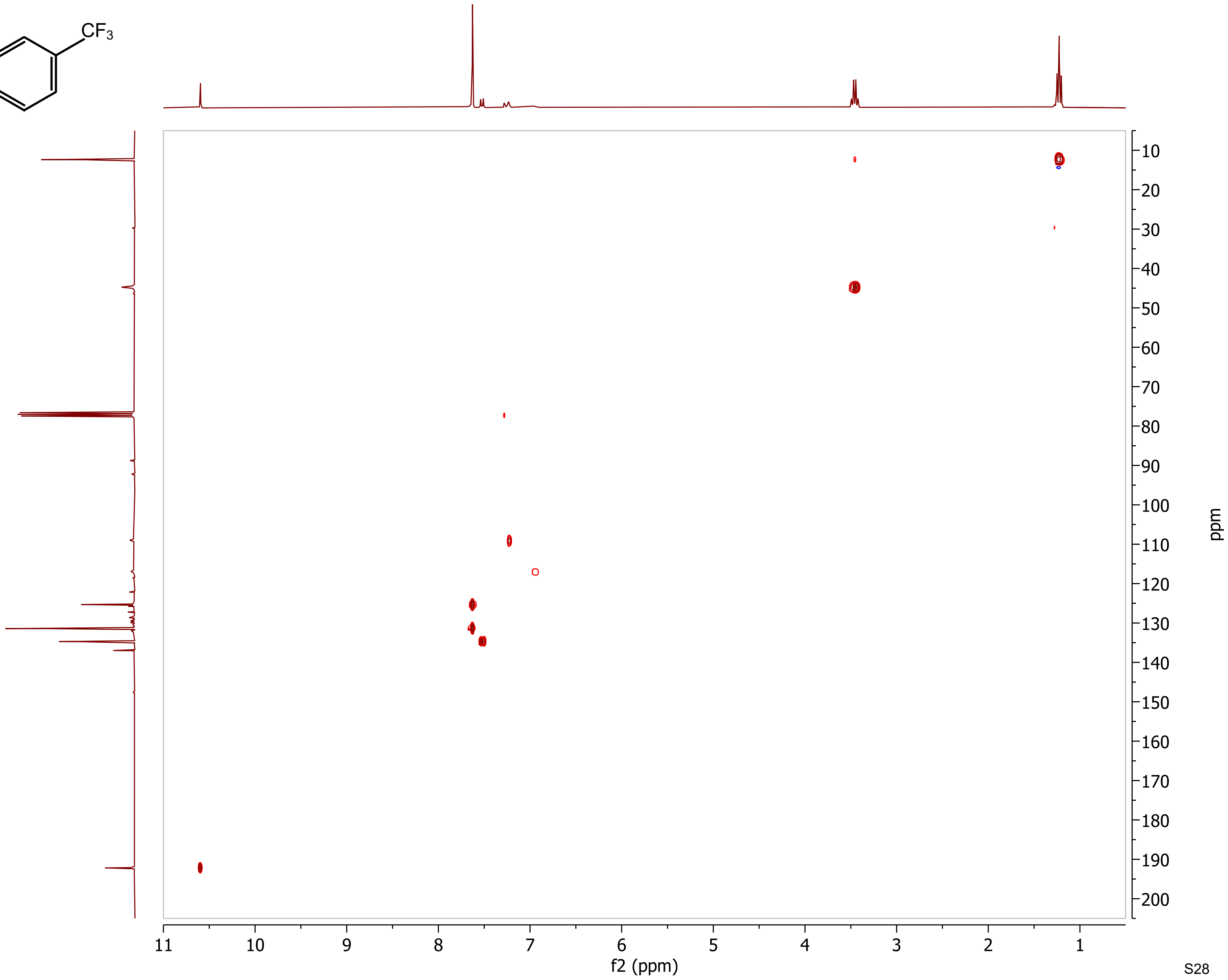
^{13}C NMR (75 MHz, CDCl$_3$)



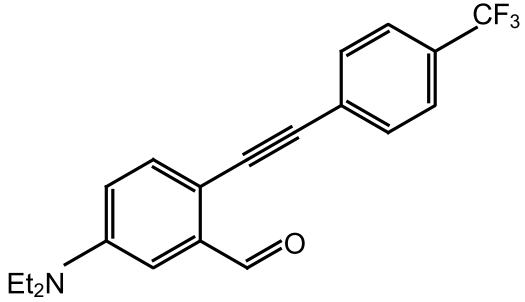
HSQC ($CDCl_3$)



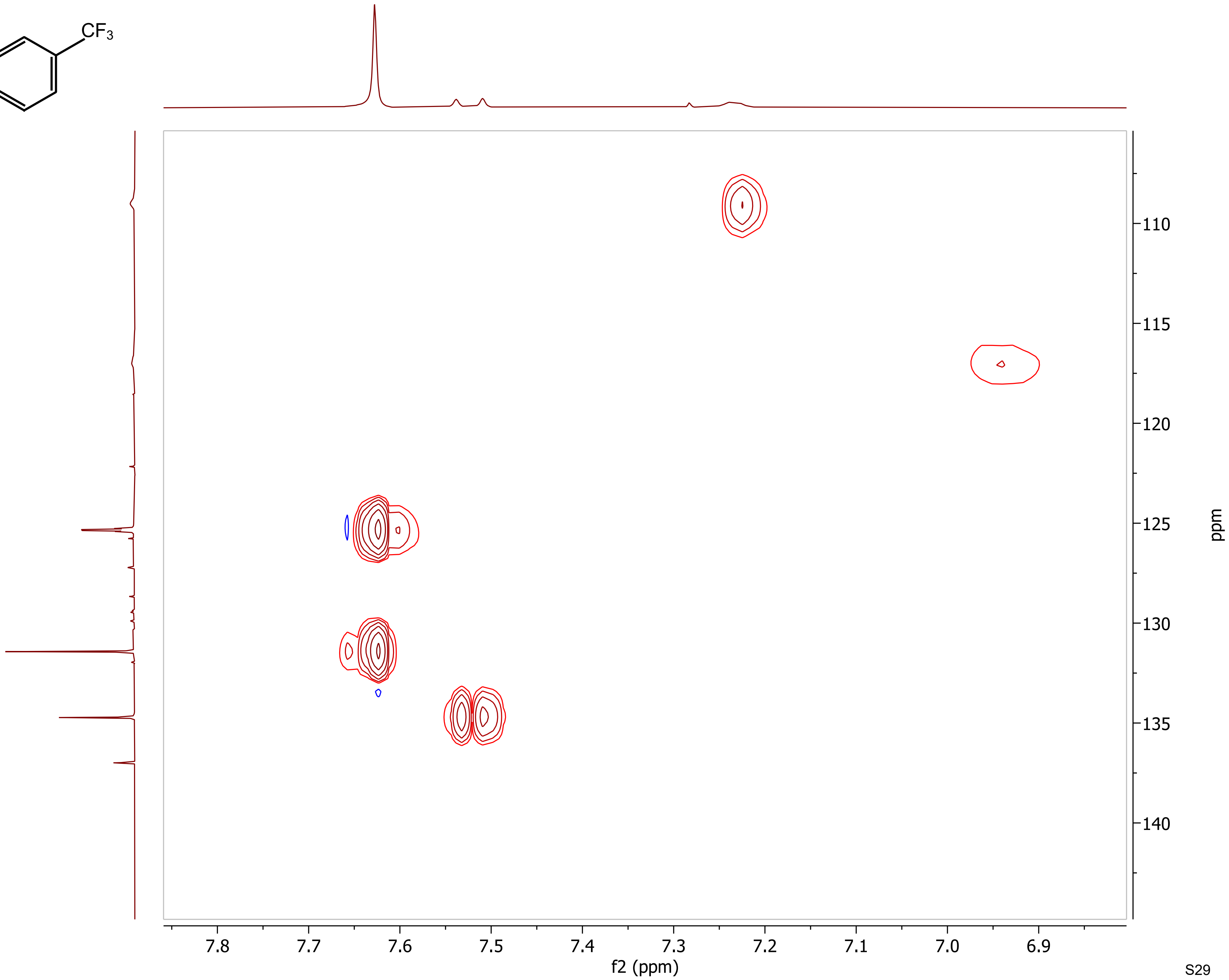
8a

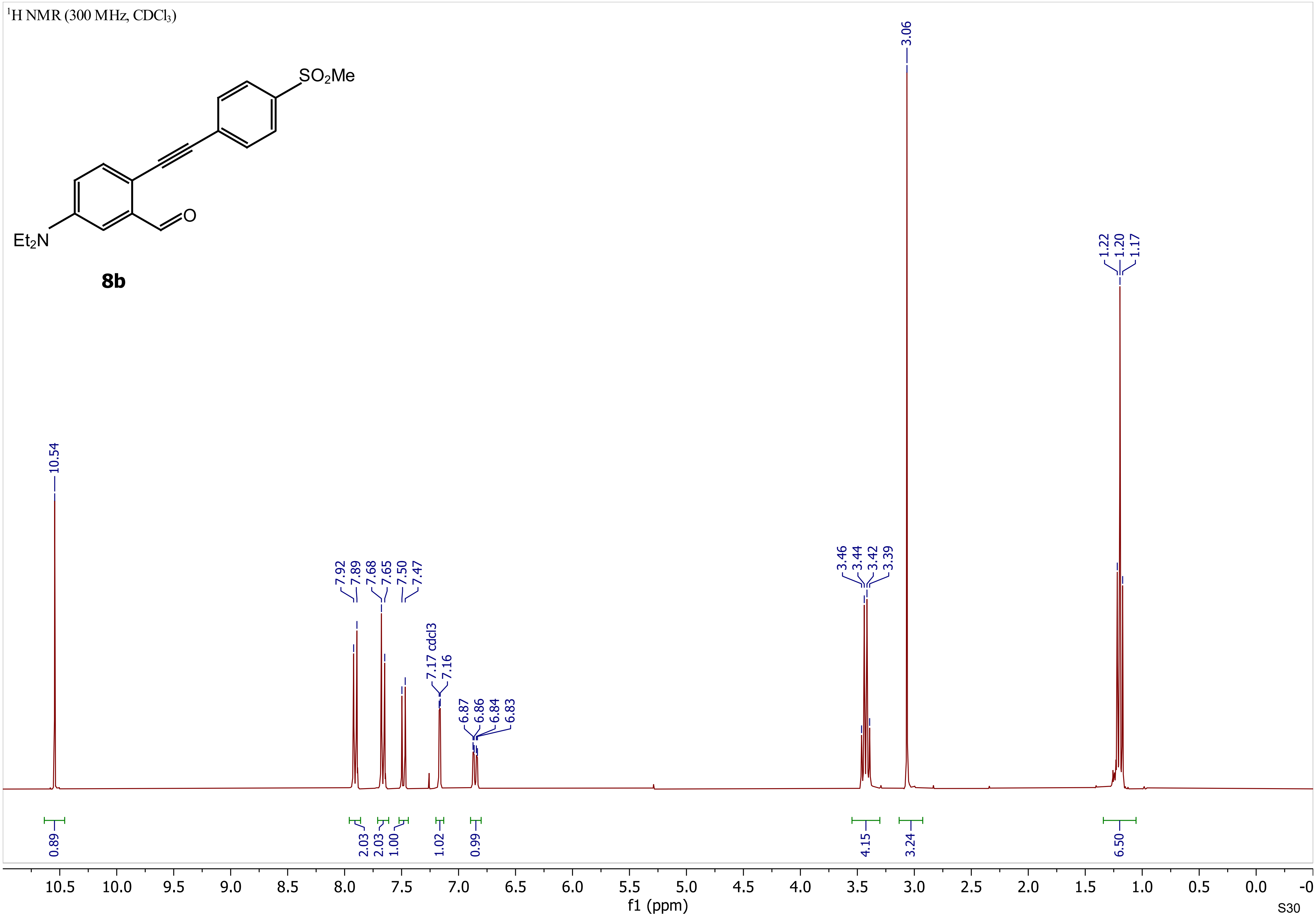


HSQC ($CDCl_3$)

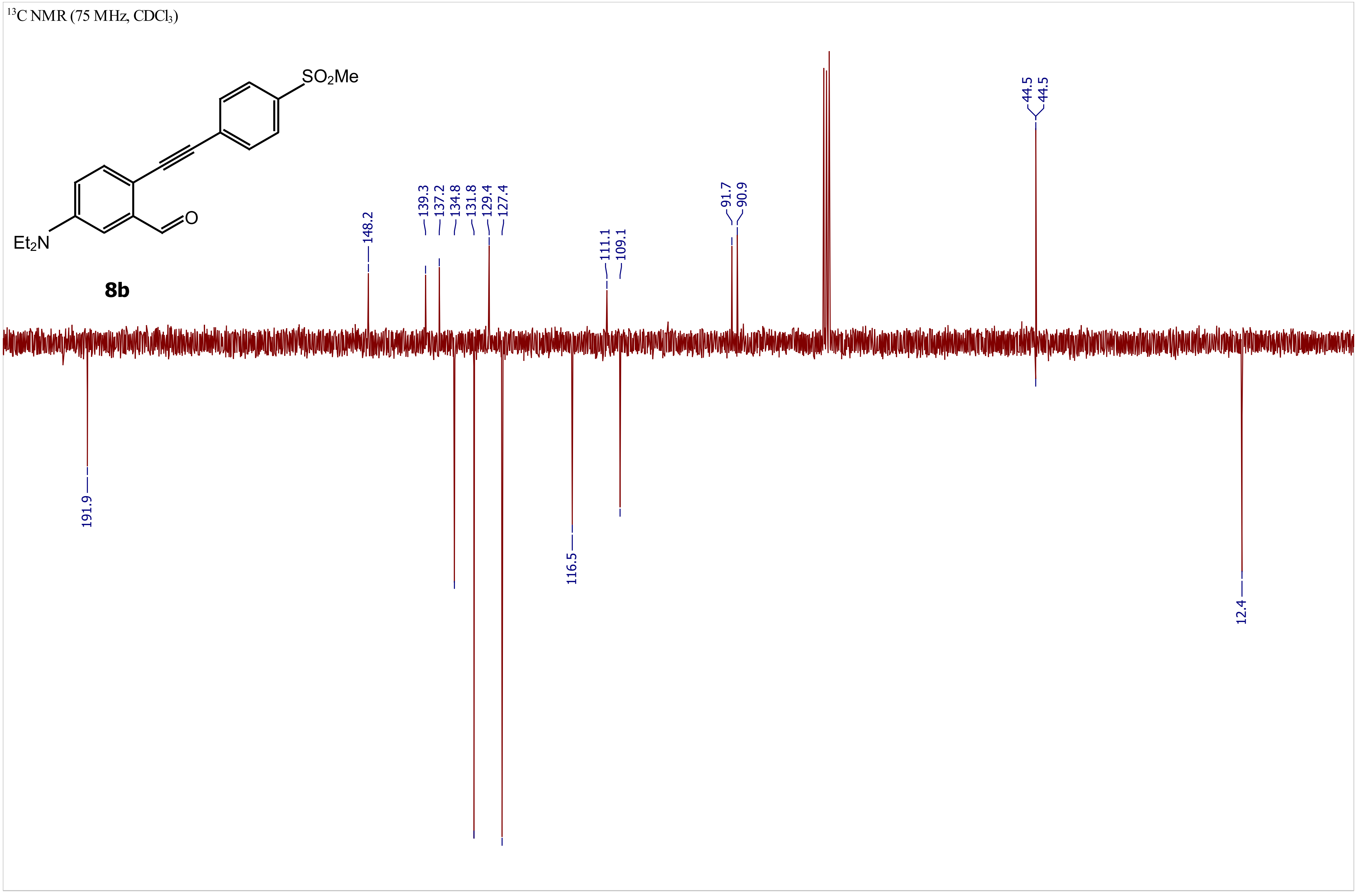


8a

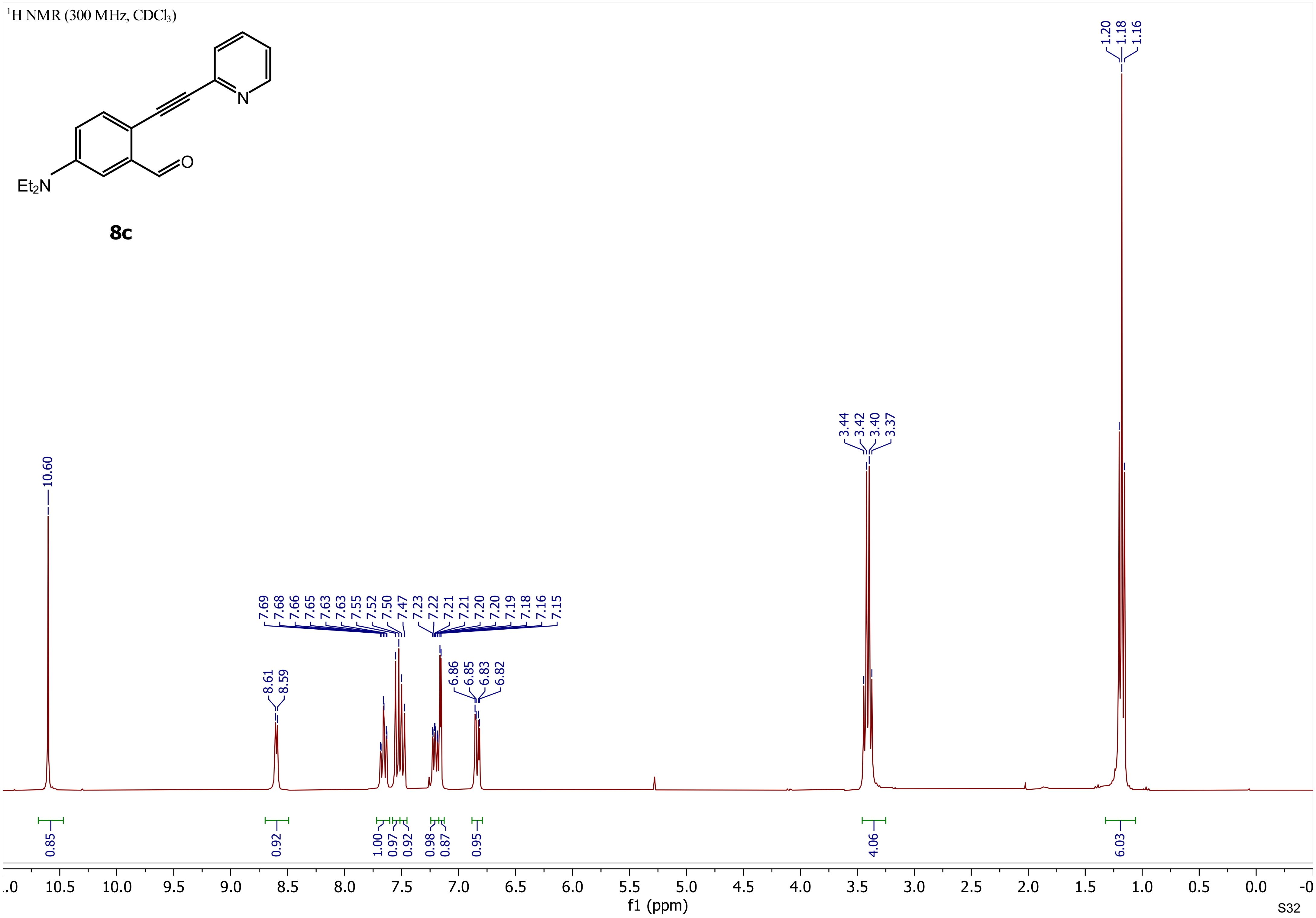



^{1}H NMR (300 MHz, CDCl$_3$)
SO$_2$Me
O
Et$_2$N
8b
10.54
7.92
7.89
7.68
7.65
7.50
7.47
7.17 cdcl3
7.16
6.87
6.86
6.84
6.83
3.46
3.44
3.42
3.39
3.06
1.22
1.20
1.17
0.89
2.03
2.03
1.00
1.02
0.99
4.15
3.24
6.50
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0
f1 (ppm)

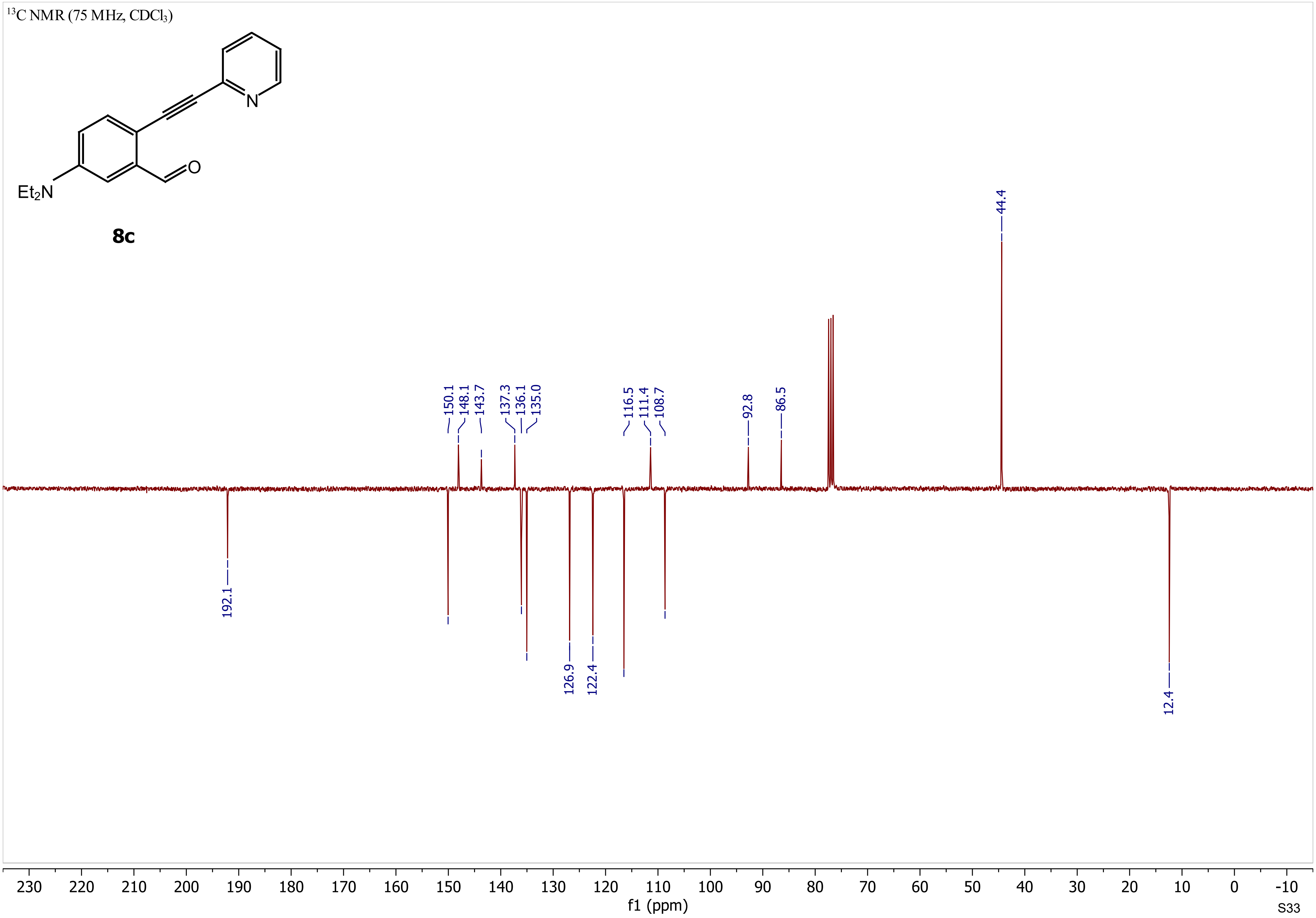
^{13}C NMR (75 MHz, $CDCl_3$)



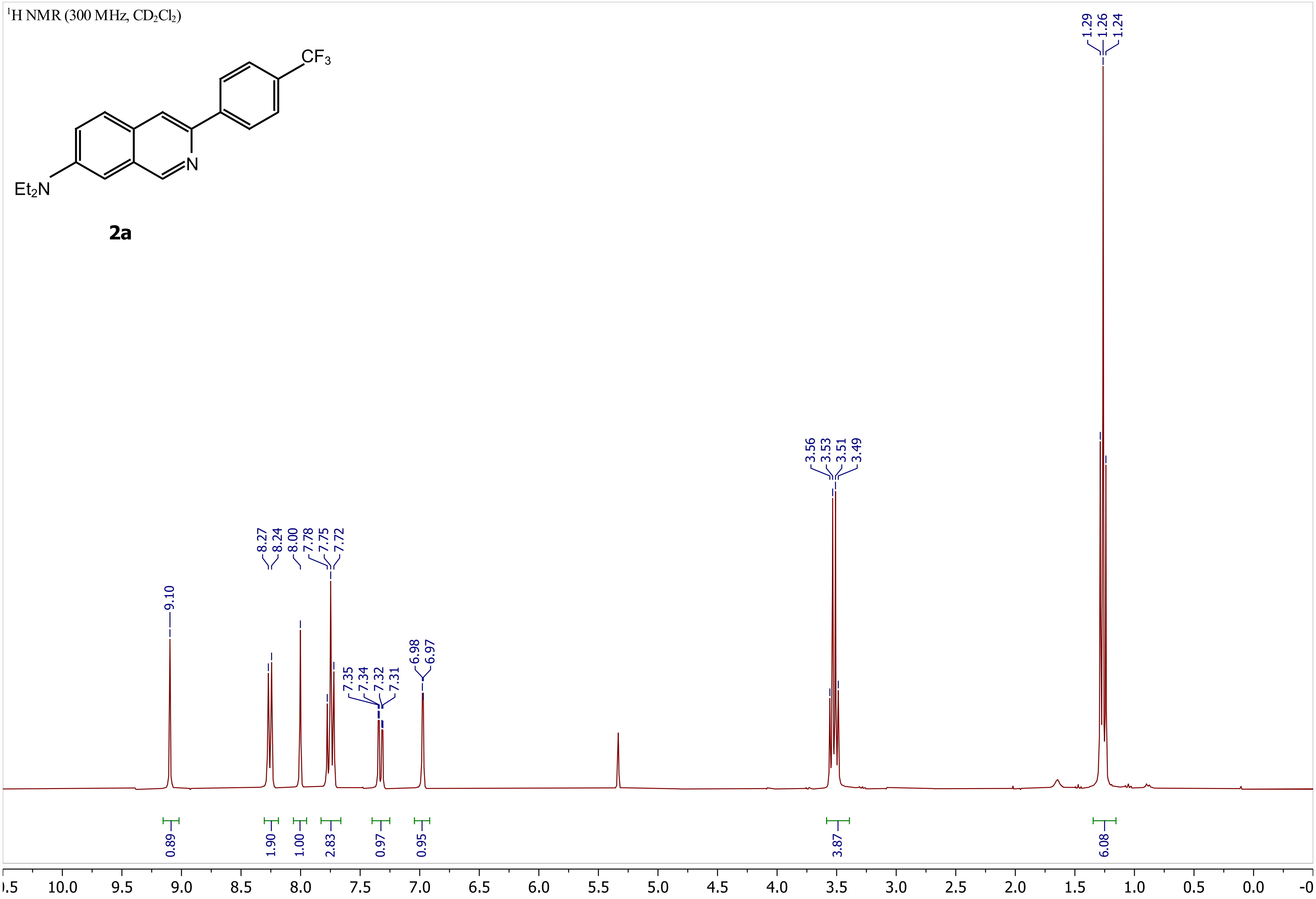
8b


^{1}H NMR (300 MHz, CDCl$_3$)
N
O
Et$_2$N
8c
10.60
8.61
8.59
7.69
7.68
7.66
7.65
7.63
7.63
7.55
7.52
7.50
7.47
7.23
7.22
7.21
7.21
7.20
7.20
7.19
7.18
7.16
7.15
6.86
6.85
6.83
6.82
3.44
3.42
3.40
3.37
1.20
1.18
1.16
0.85
0.92
1.00
0.97
0.92
0.98
0.87
0.95
4.06
6.03
.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0
f1 (ppm)

^{13}C NMR (75 MHz, CDCl$_3$)



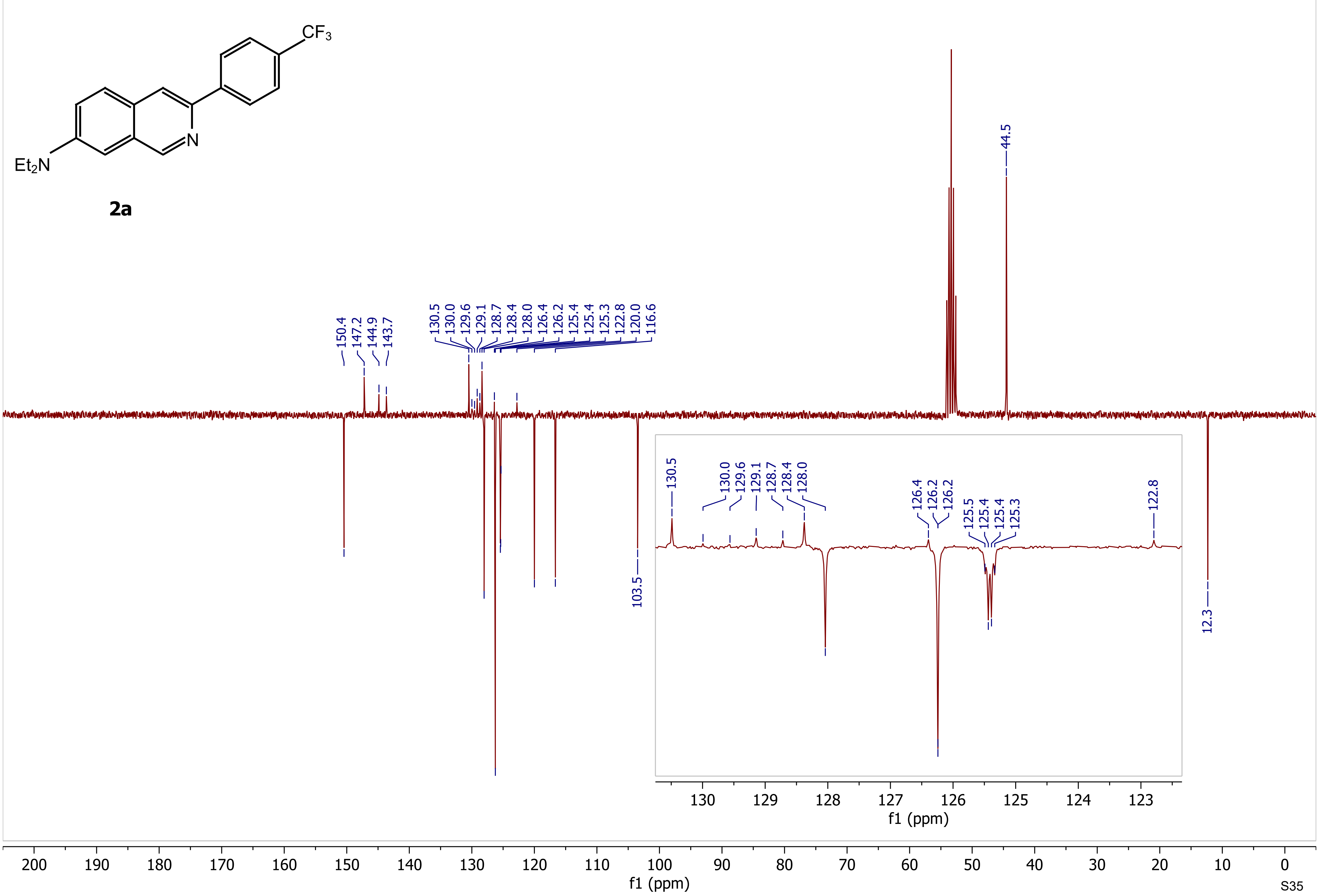
8c



^{1}H NMR (300 MHz, CD$_2$Cl$_2$)

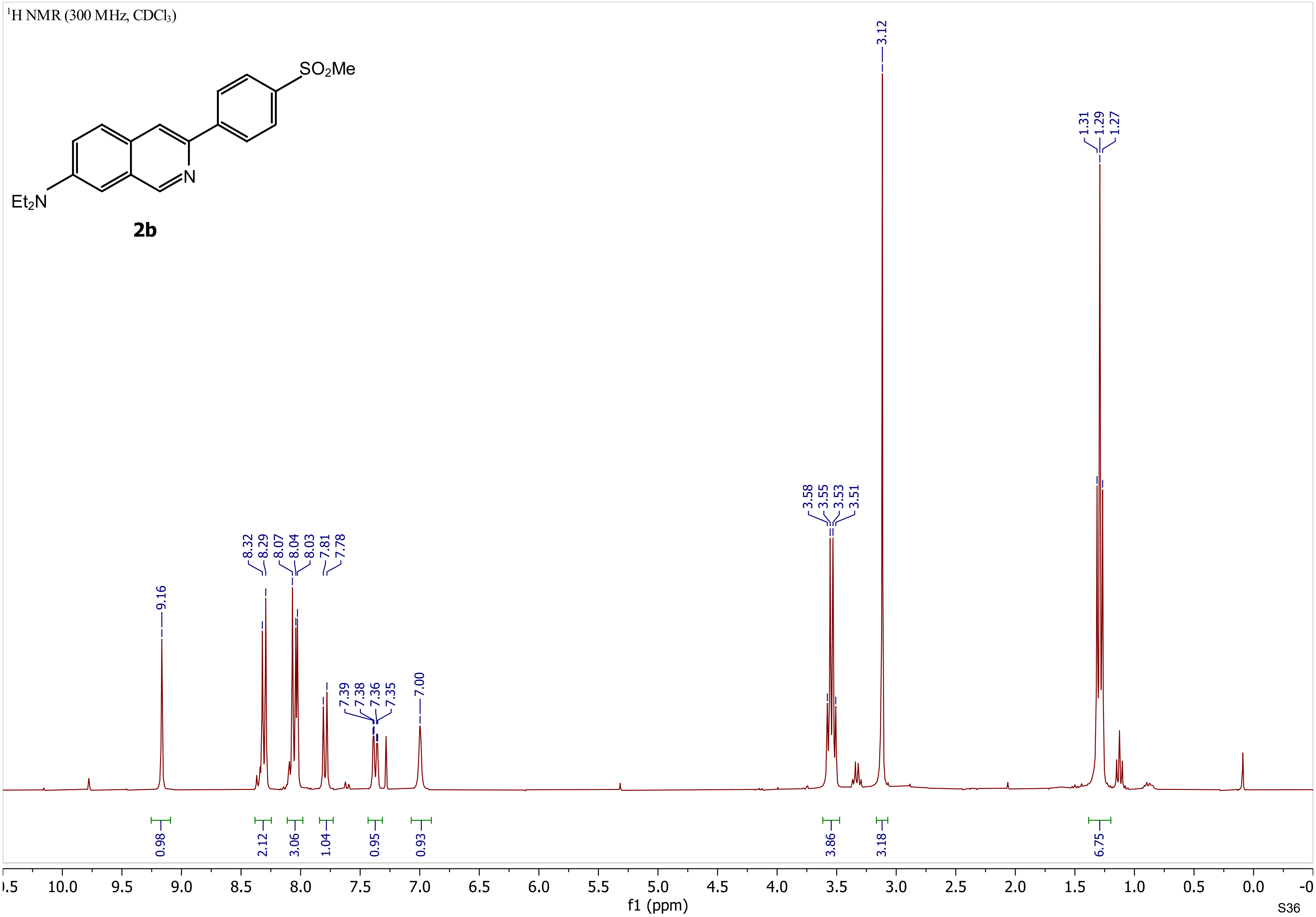
2a

13C NMR (75 MHz, CD_2Cl_2)



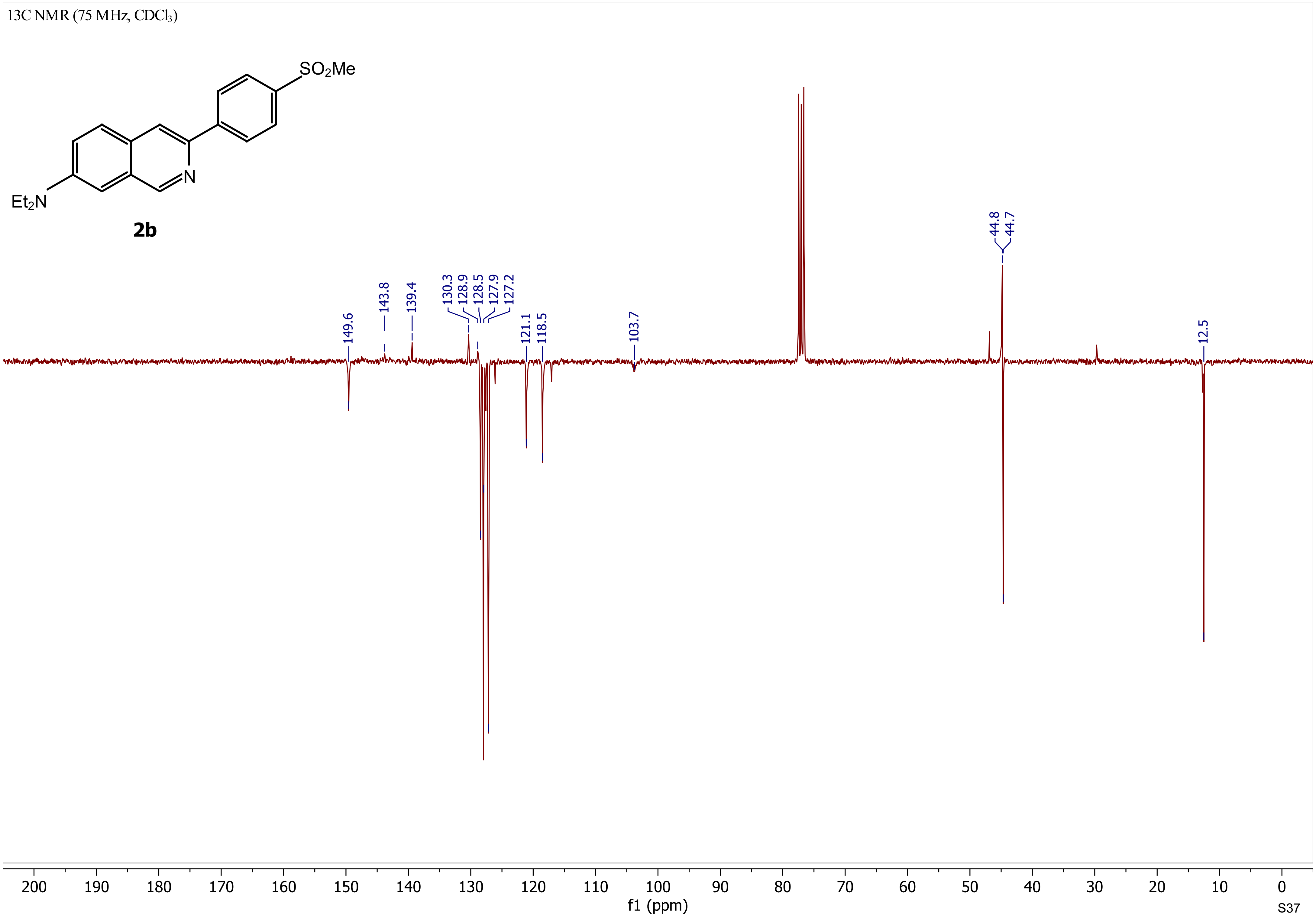
2a

^{1}H NMR (300 MHz, CDCl$_3$)



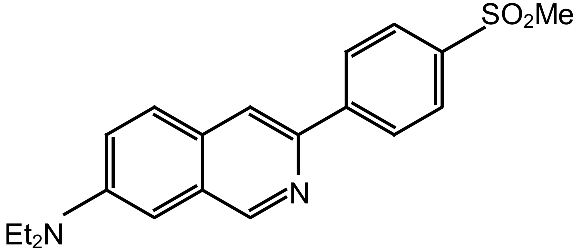
2b

13C NMR (75 MHz, $CDCl_3$)

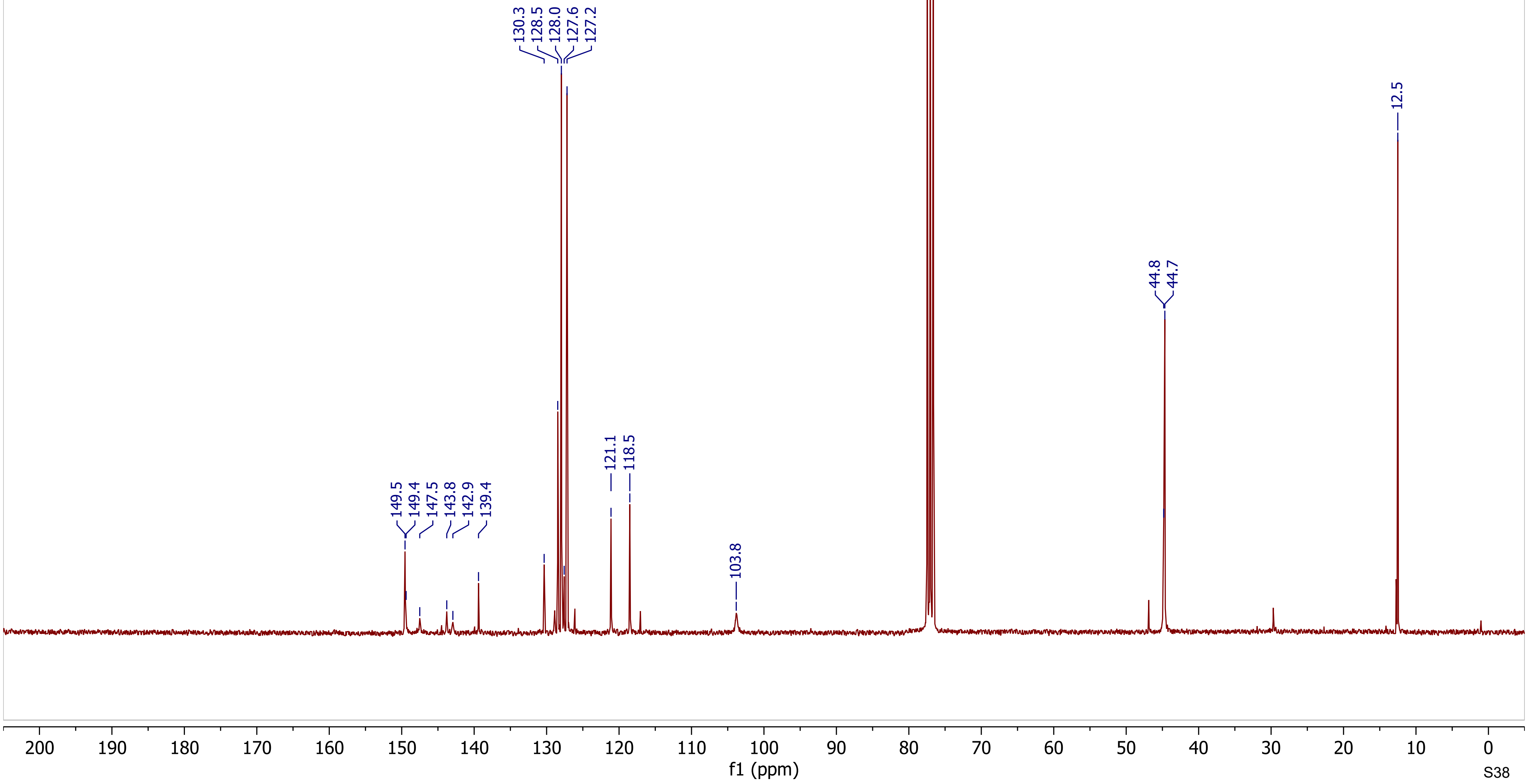


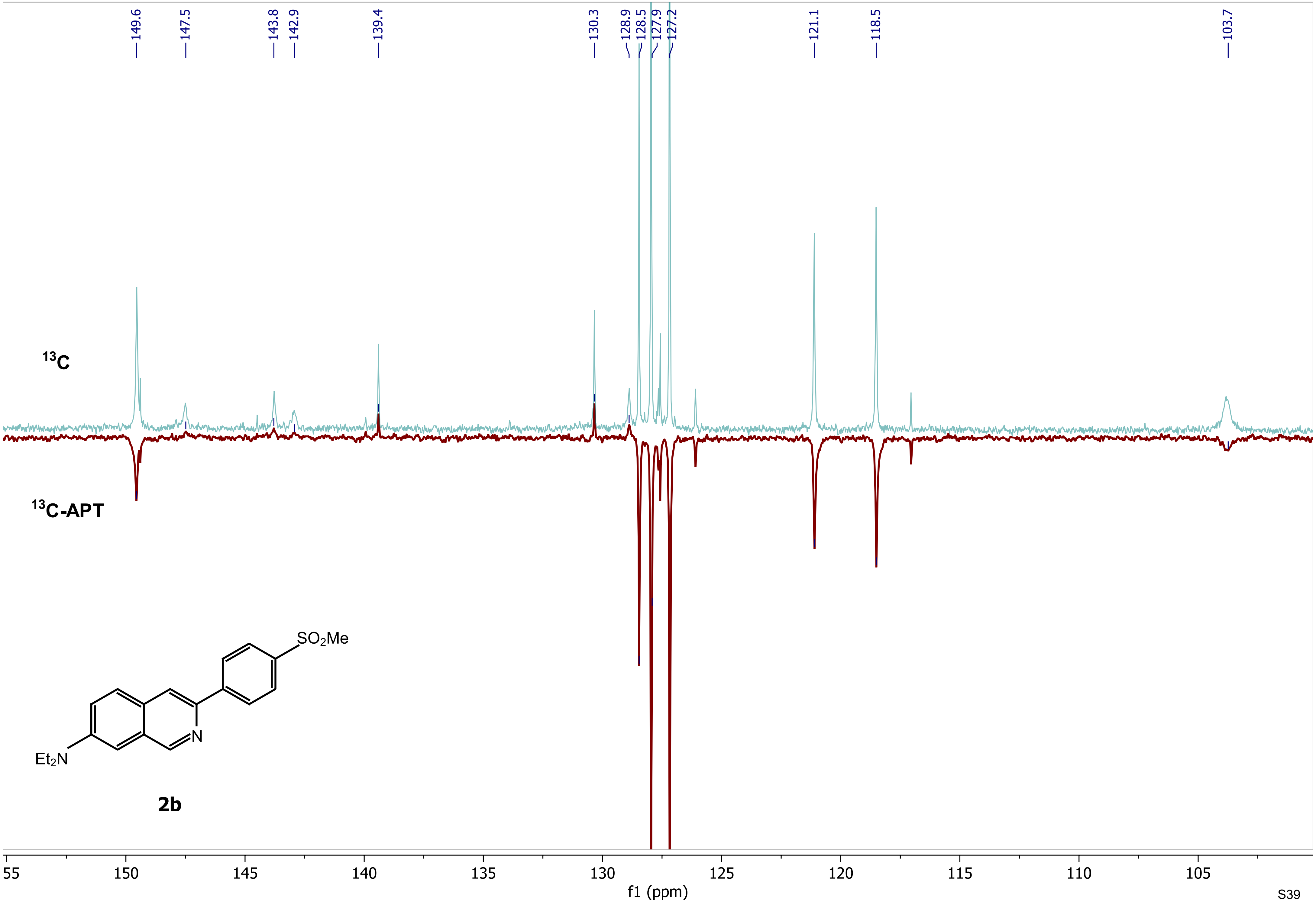
2b

13C NMR (75 MHz, $CDCl_3$)



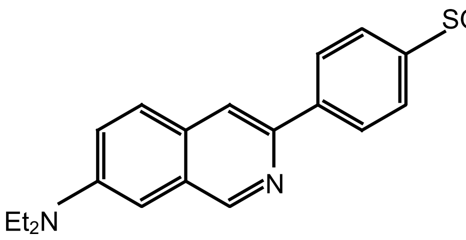
2b



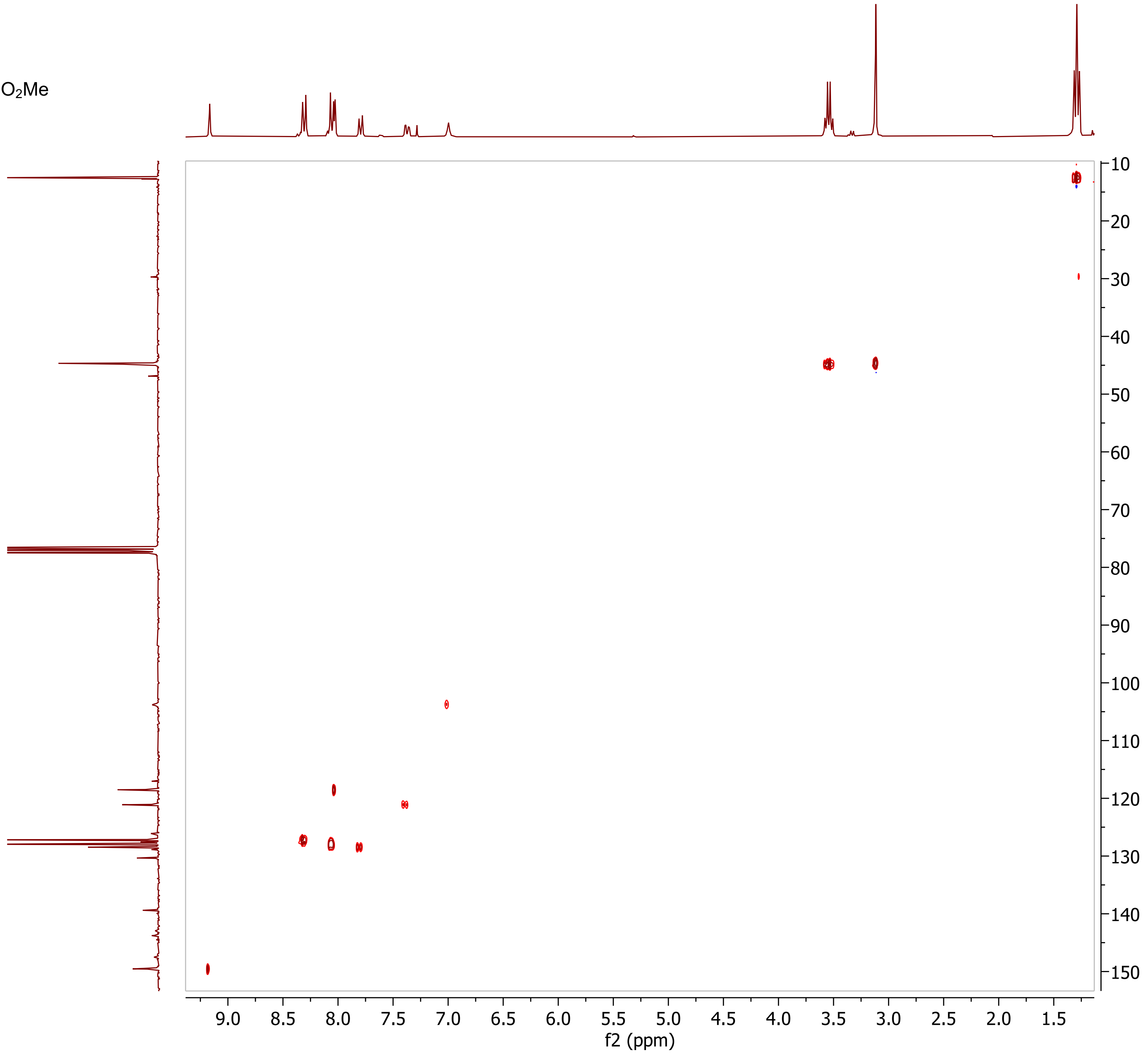

149.6
147.5
143.8
142.9
139.4
130.3
128.9
128.5
127.9
127.2
121.1
118.5
103.7
^{13}C
^{13}C-APT
SO$_2$Me
N
Et$_2$N
55
150
145
140
135
130
125
120
115
110
105
f1 (ppm)

2b

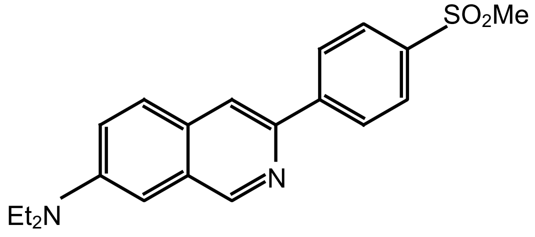
HSQC ($CDCl_3$)



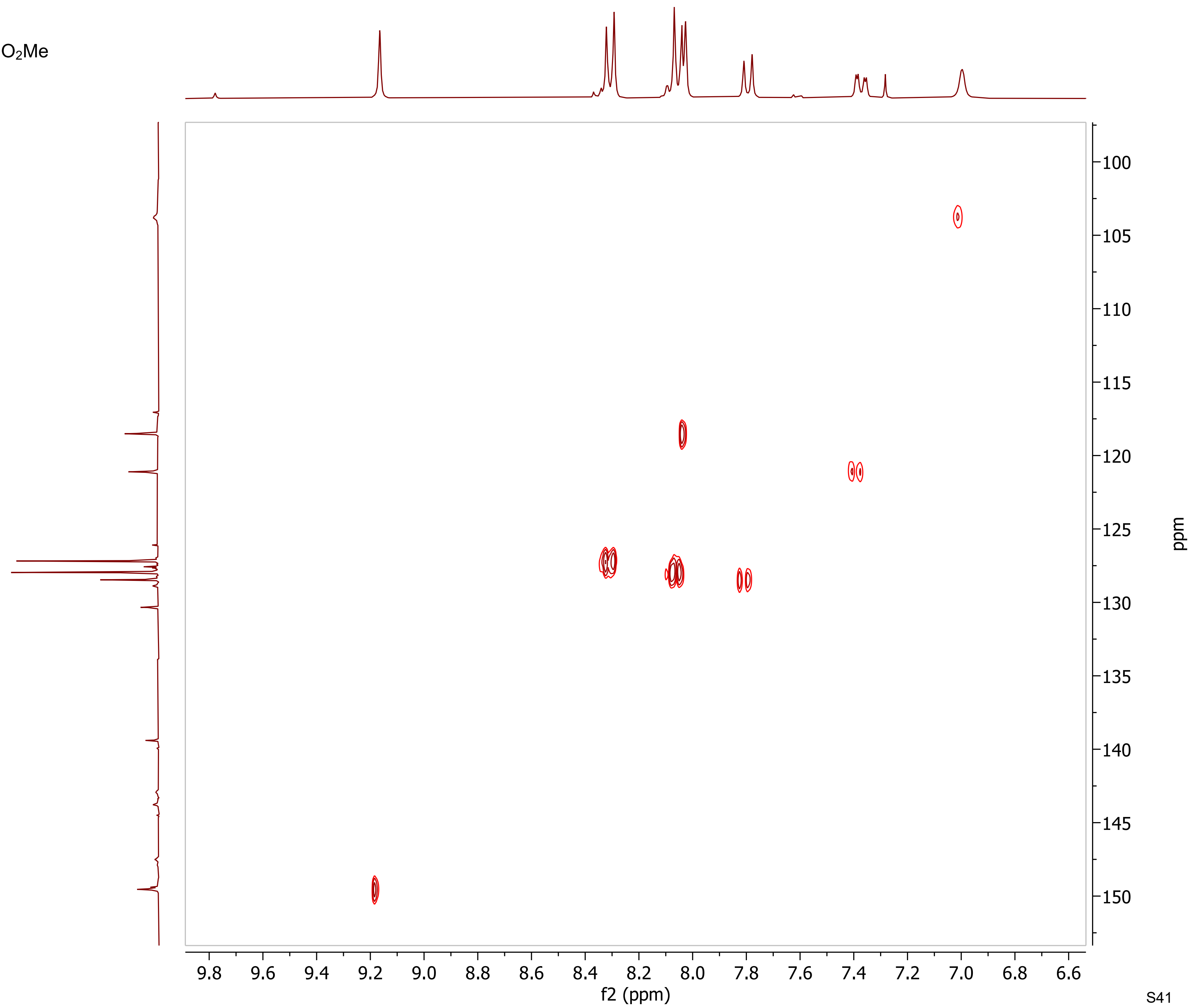
2b

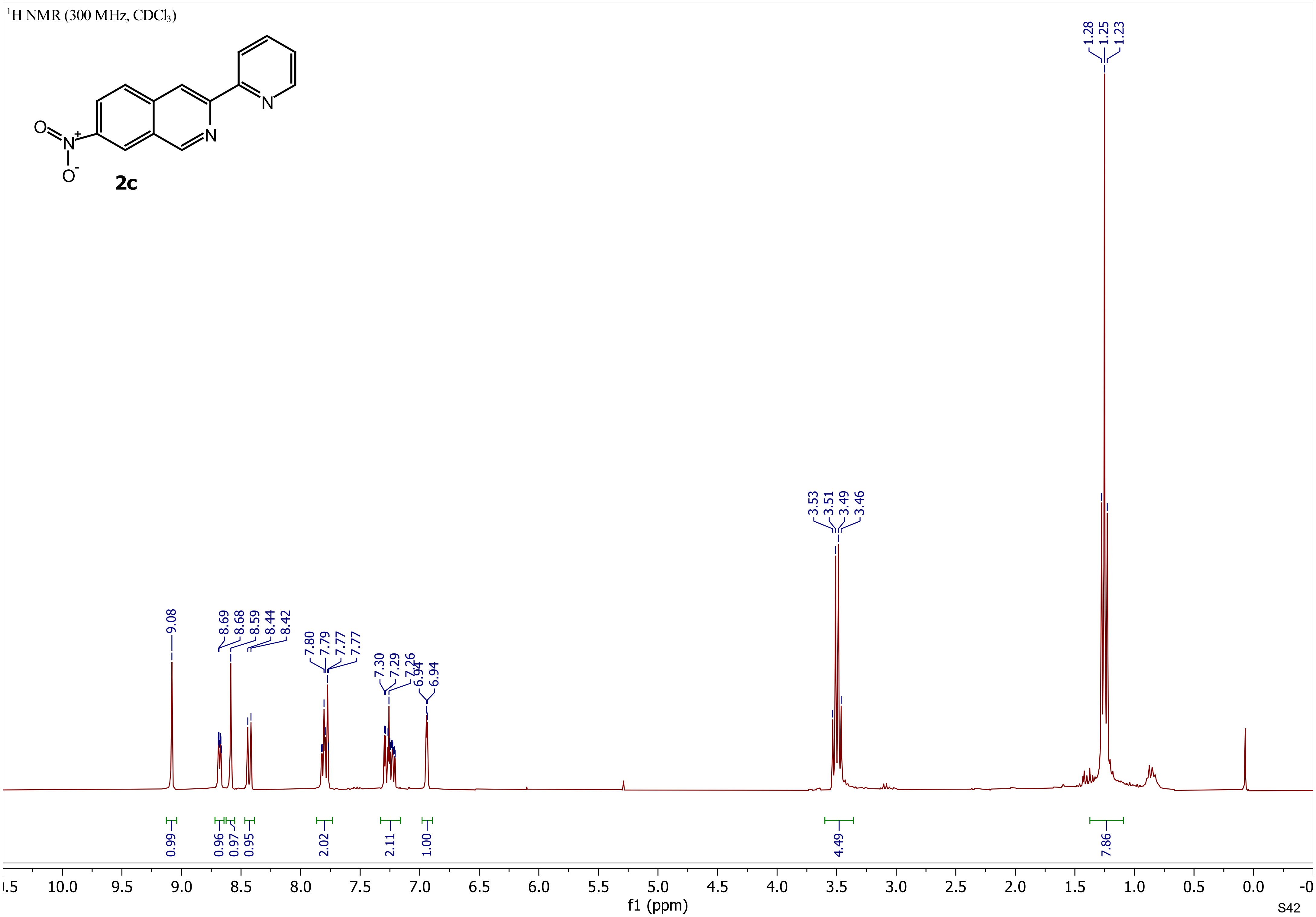


HSQC (CDCl$_3$)

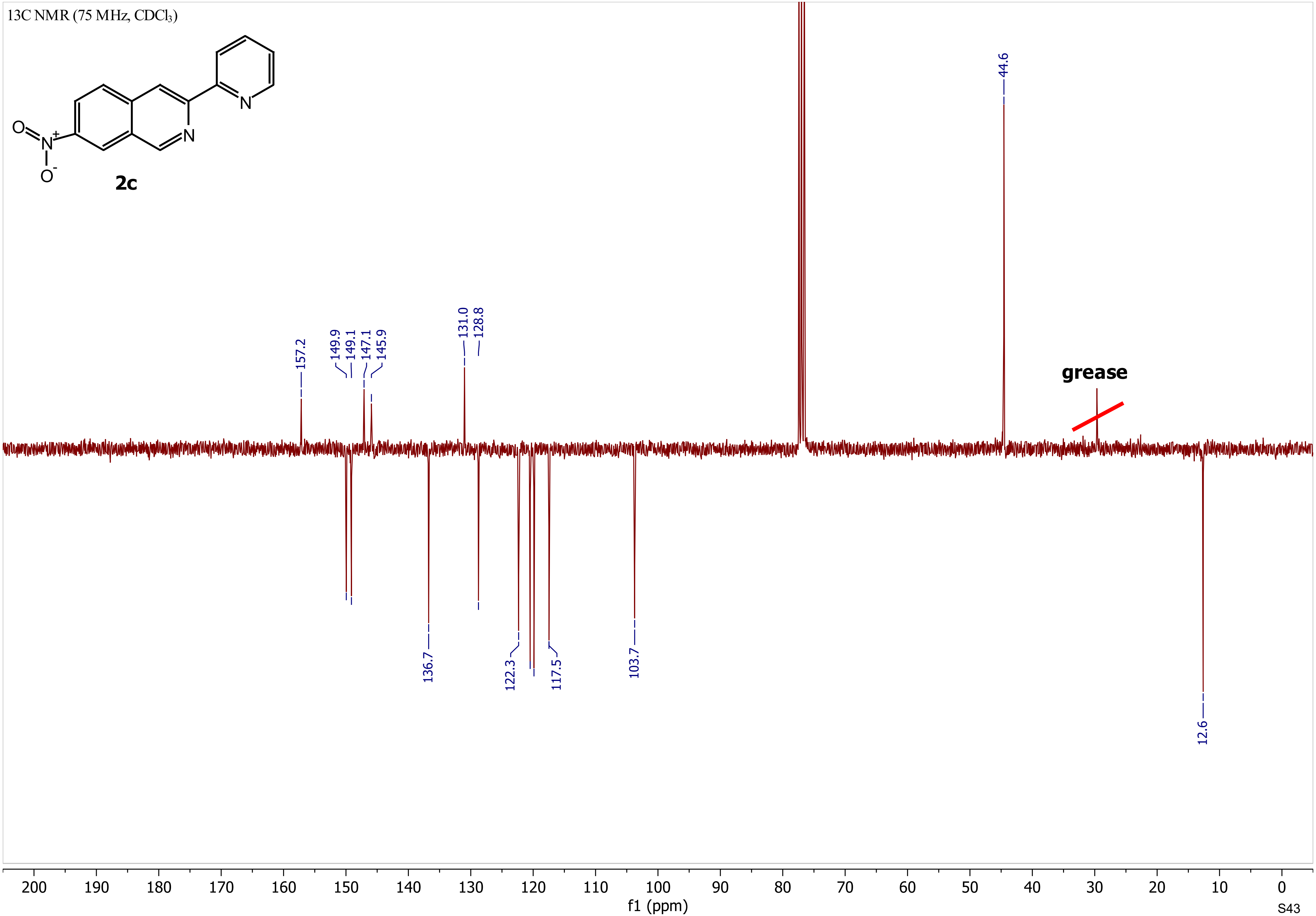


2b




^{1}H NMR (300 MHz, $CDCl_3$)
2c
9.08
8.69
8.68
8.59
8.44
8.42
7.80
7.79
7.77
7.77
7.30
7.29
7.26
6.94
6.94
3.53
3.51
3.49
3.46
1.28
1.25
1.23
0.99
0.96
0.97
0.95
2.02
2.11
1.00
4.49
7.86
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

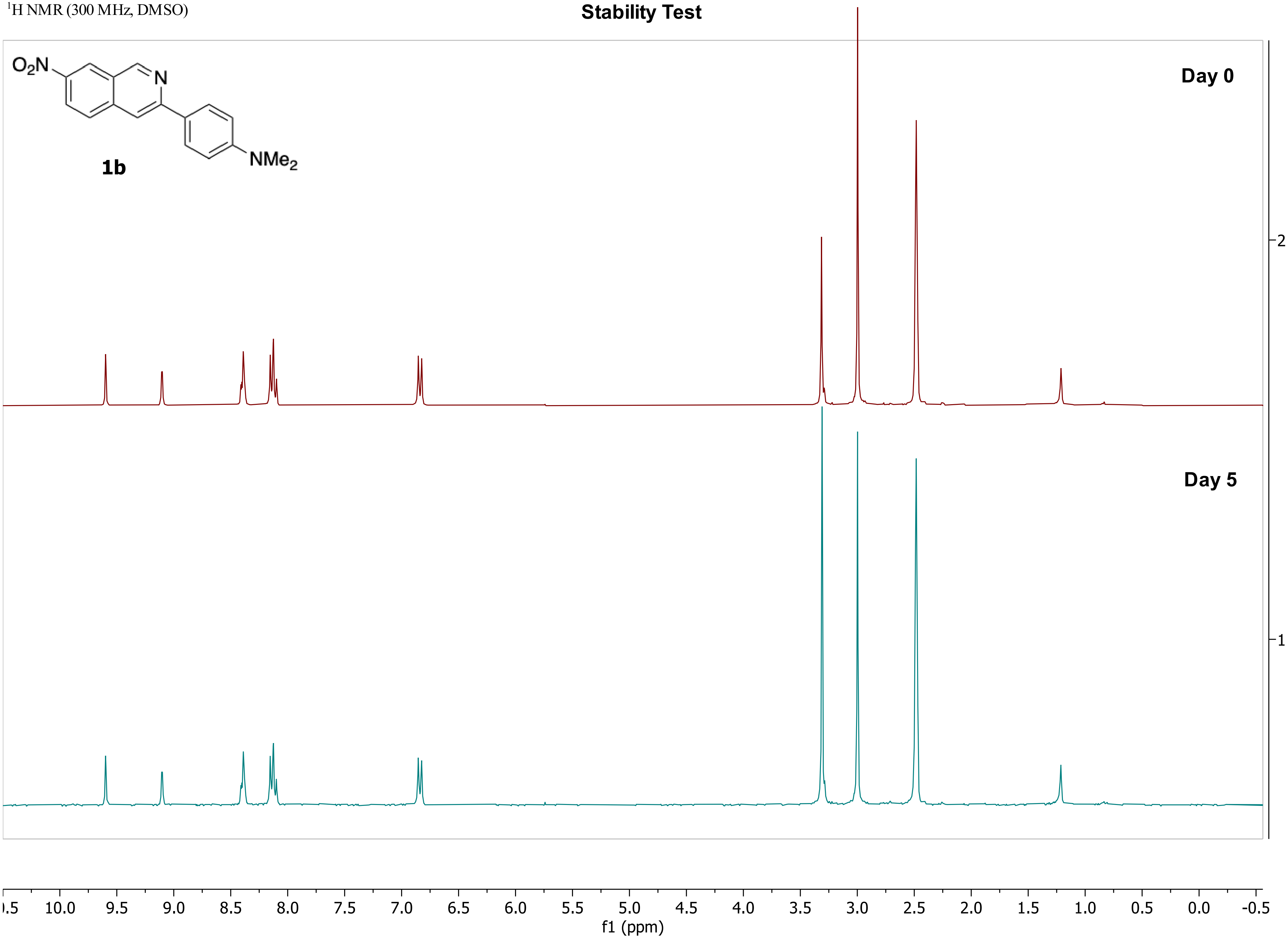
13C NMR (75 MHz, $CDCl_3$)



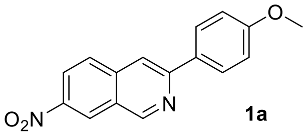
2c

^{1}H NMR (300 MHz, DMSO)

Stability Test

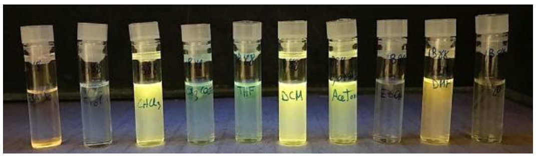


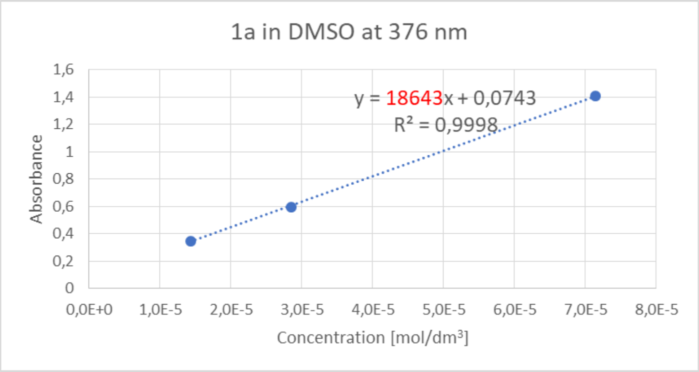
3-(4-methoxyphenyl)-7-nitroisoquinoline **1a**

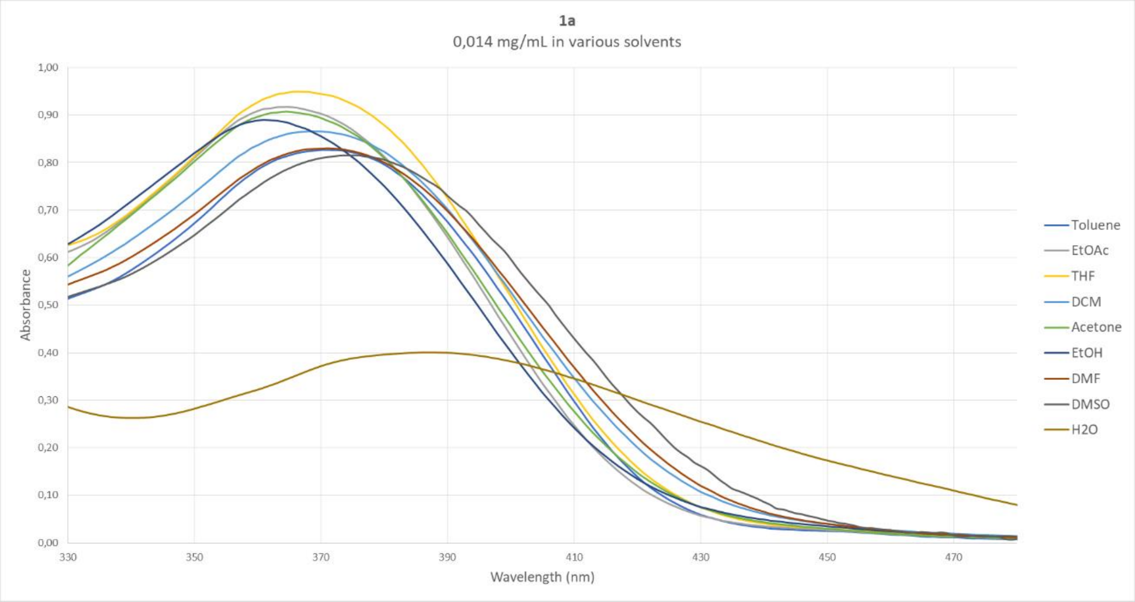


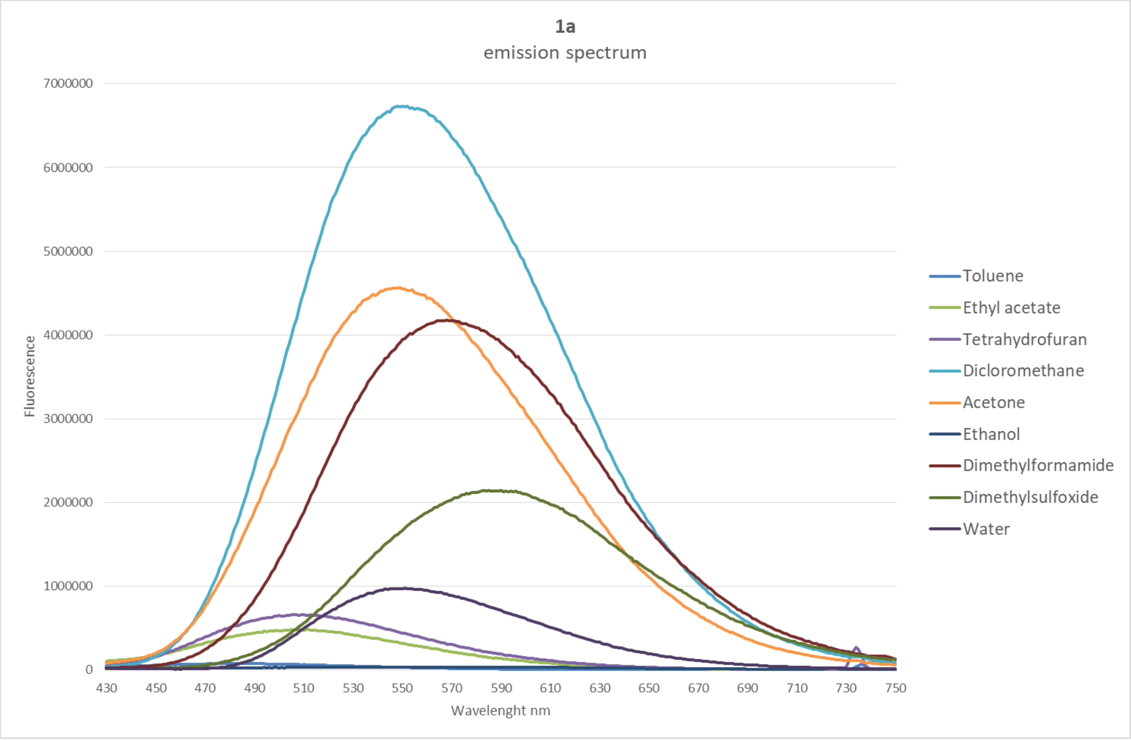
1a

365 nm lamp

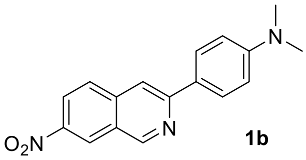



1a in DMSO at 376 nm


1a
0,014 mg/mL in various solvents

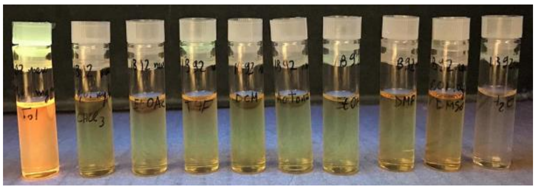

1a
emission spectrum

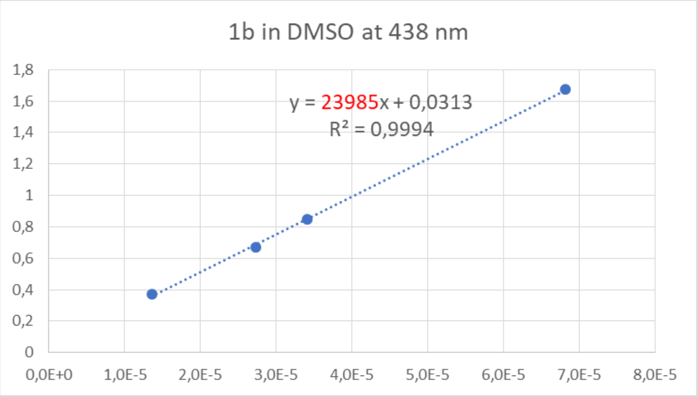
N,N-dimethyl-4-(7-nitroisoquinolin-3-yl)anilina **1b**

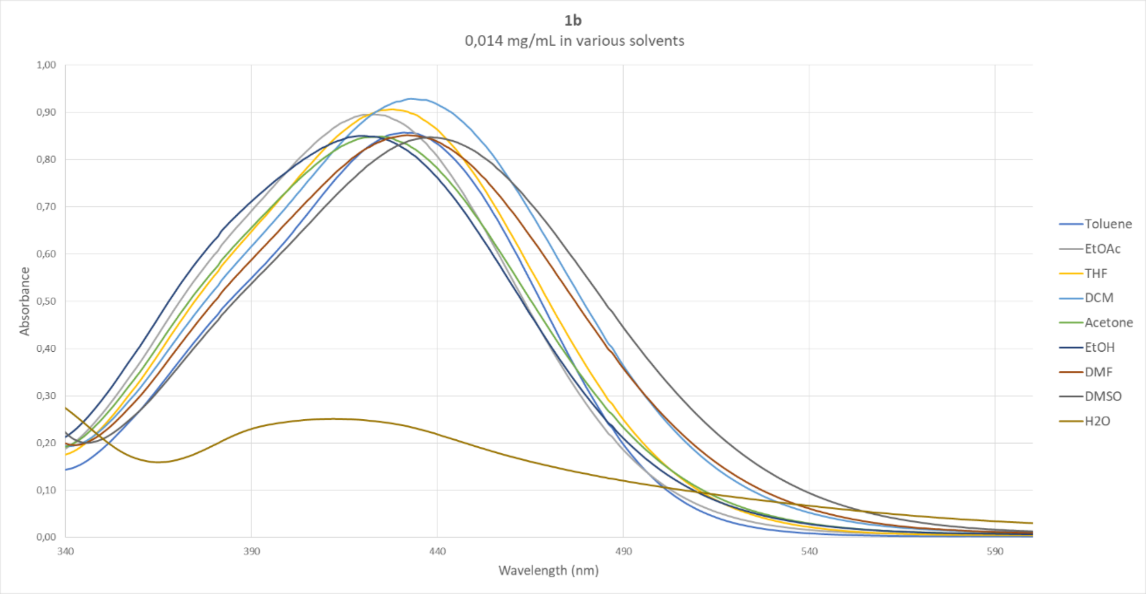


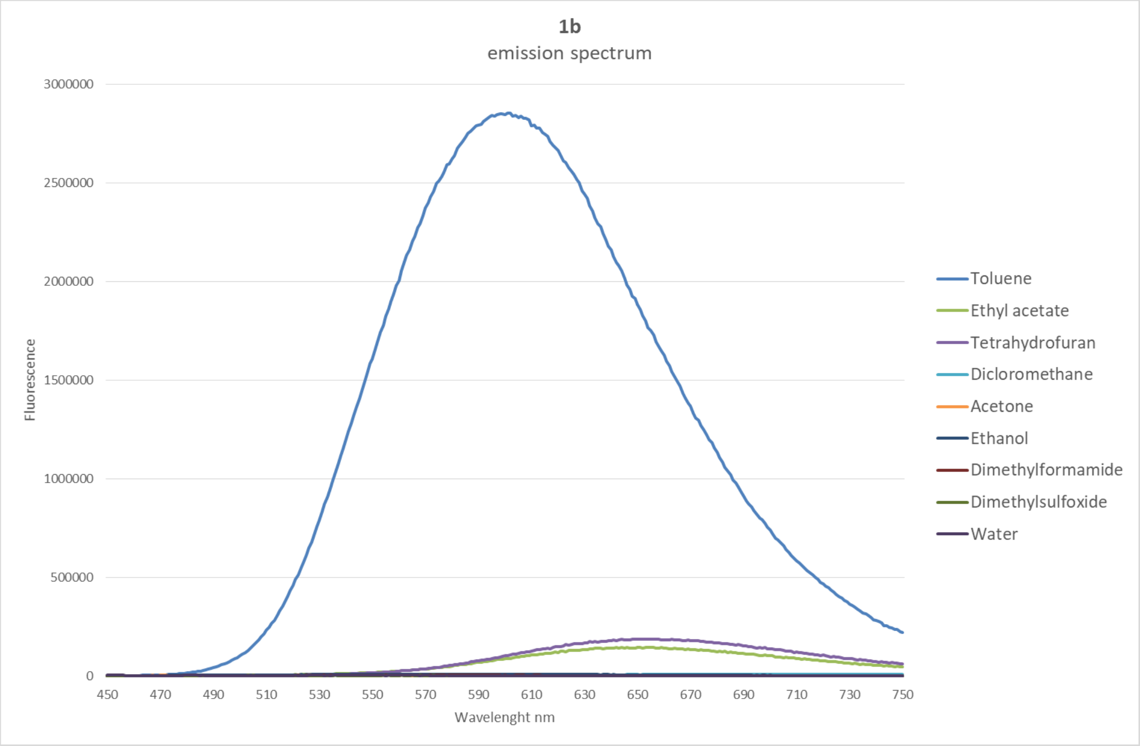
1b

365 nm lamp

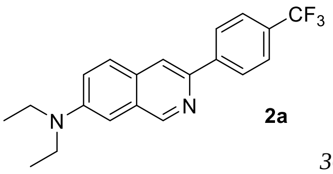




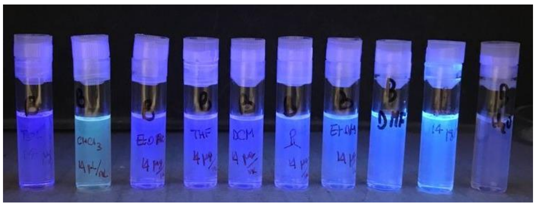


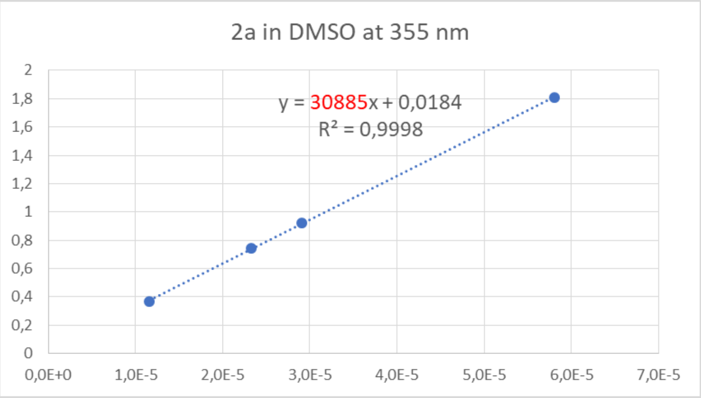


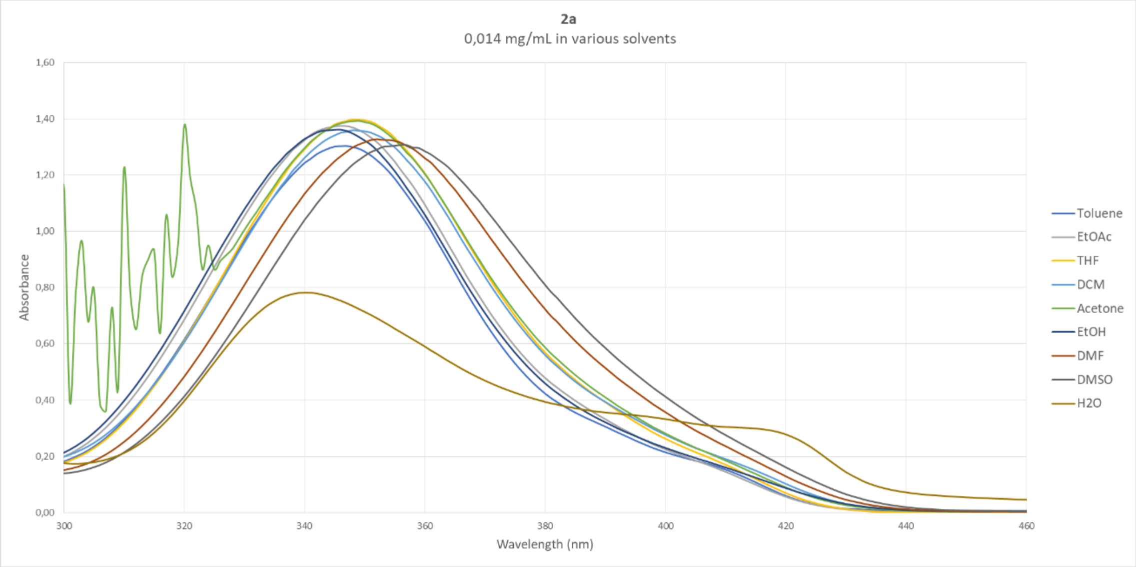
N,N-diethyl-3-(4-(trifluoromethyl)phenyl)isoquinolin-7-amine **2a**

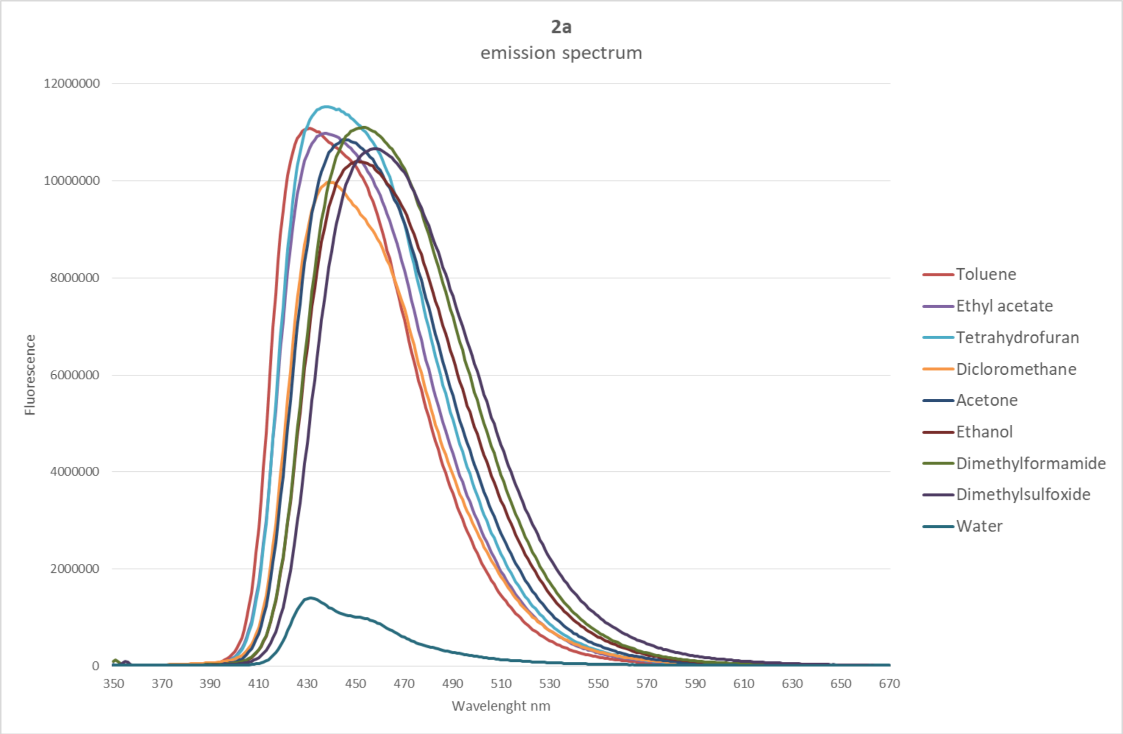


365 nm lamp

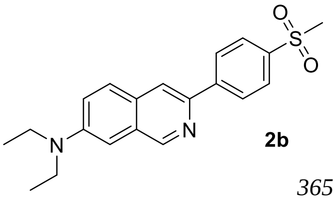






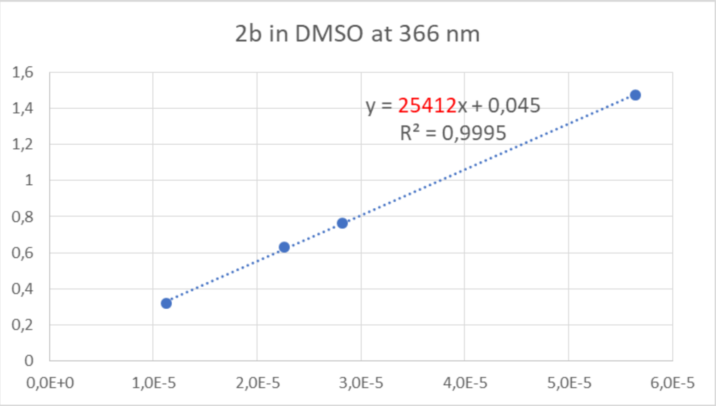


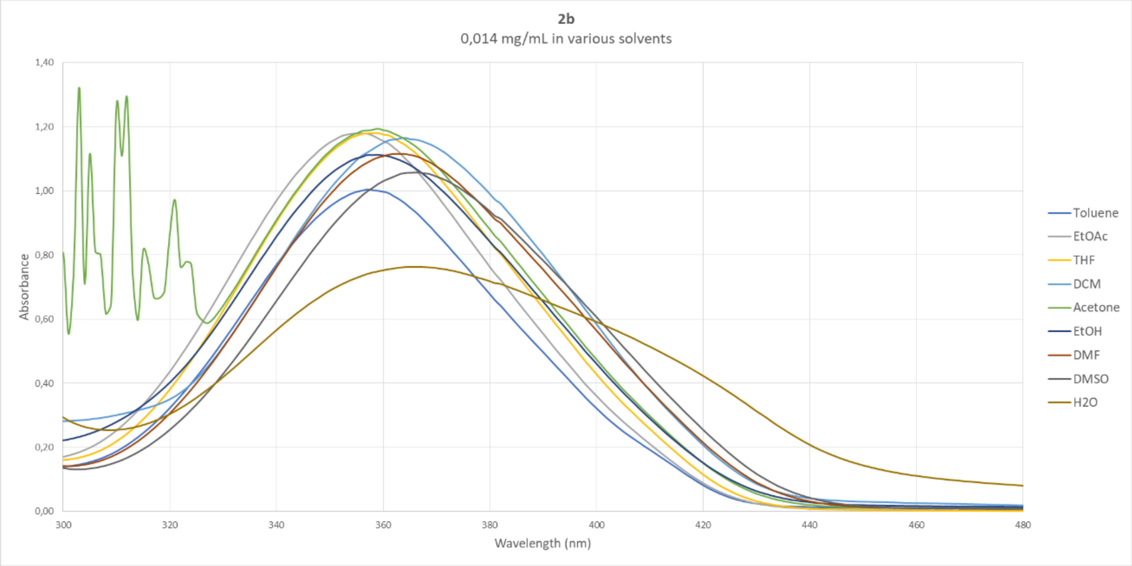
N,N-diethyl-3-(4-(methylsulfonyl)phenyl)isoquinolin-7-amine **2b**

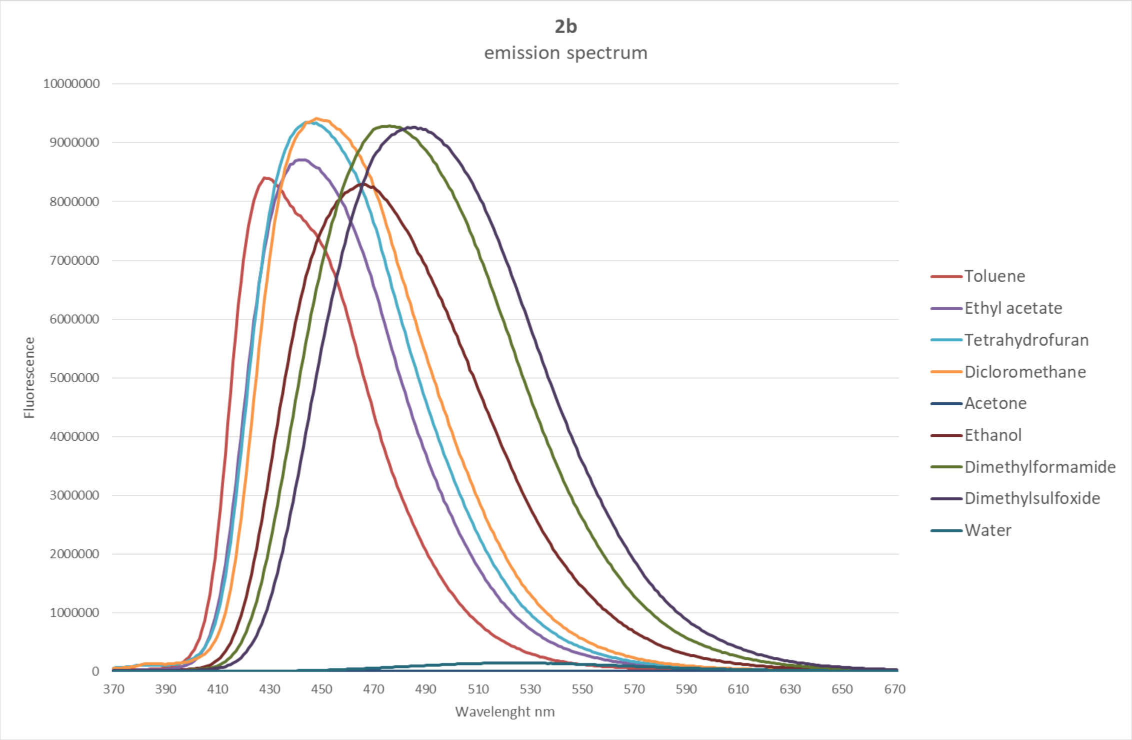


2b

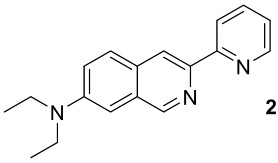
365 nm lamp





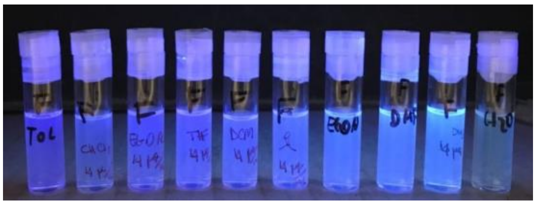


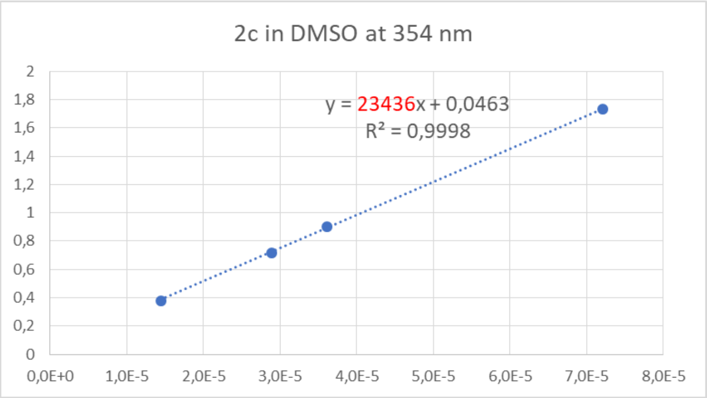
N,N-diethyl-3-(pyridin-2-yl)isoquinolin-7-amine **2c**

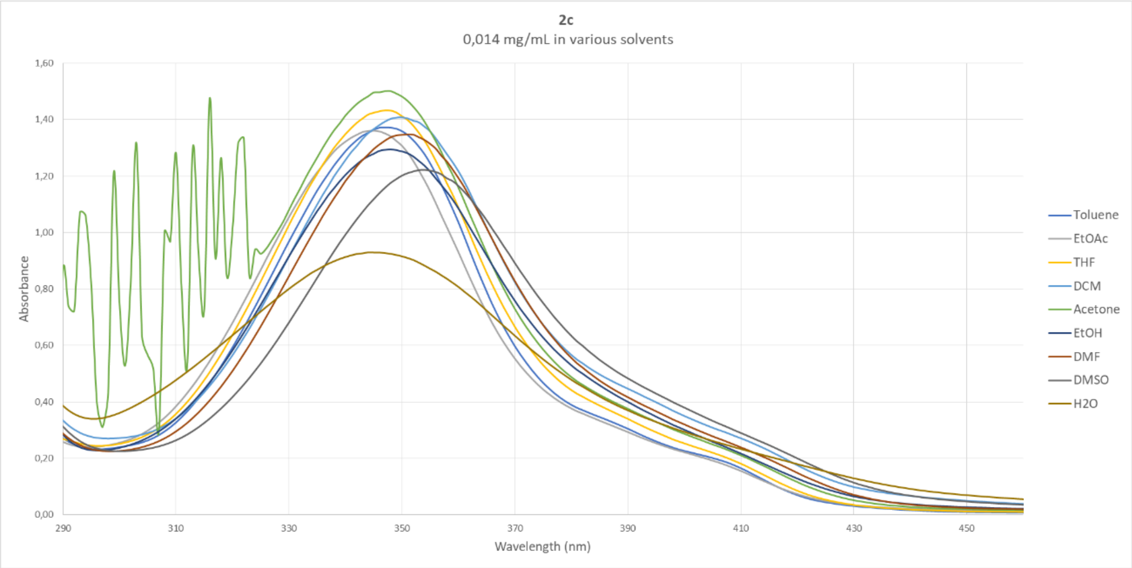


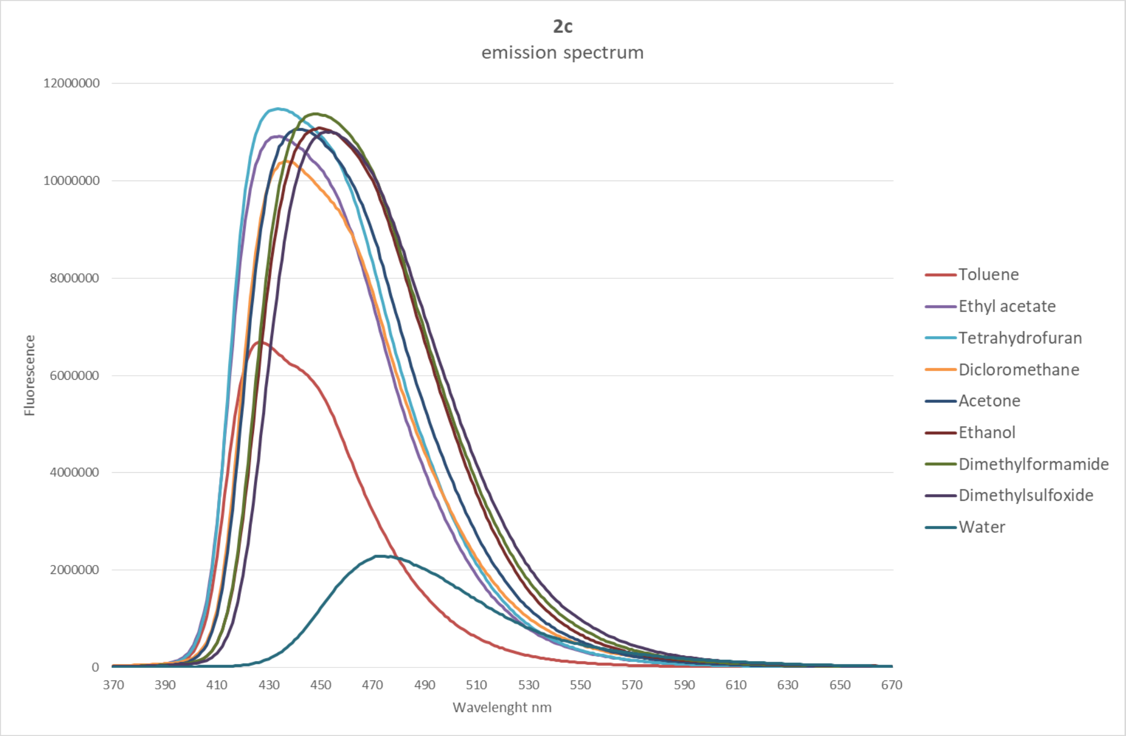
2c

365 nm lamp

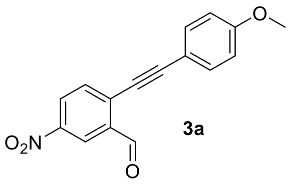




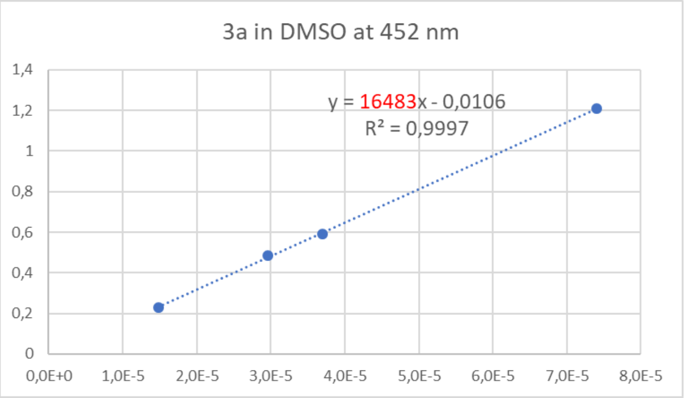


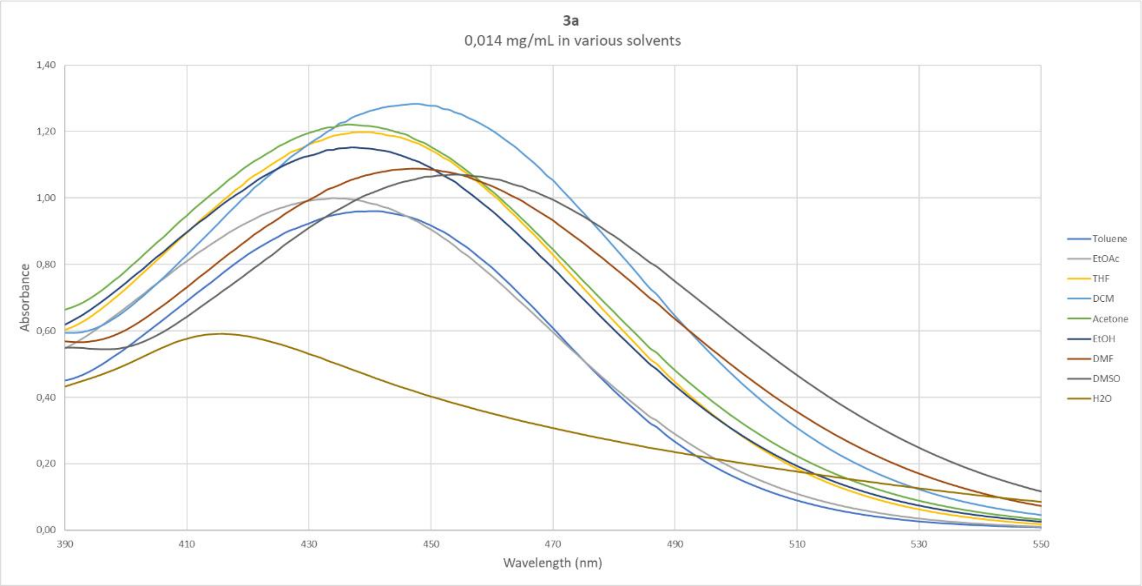


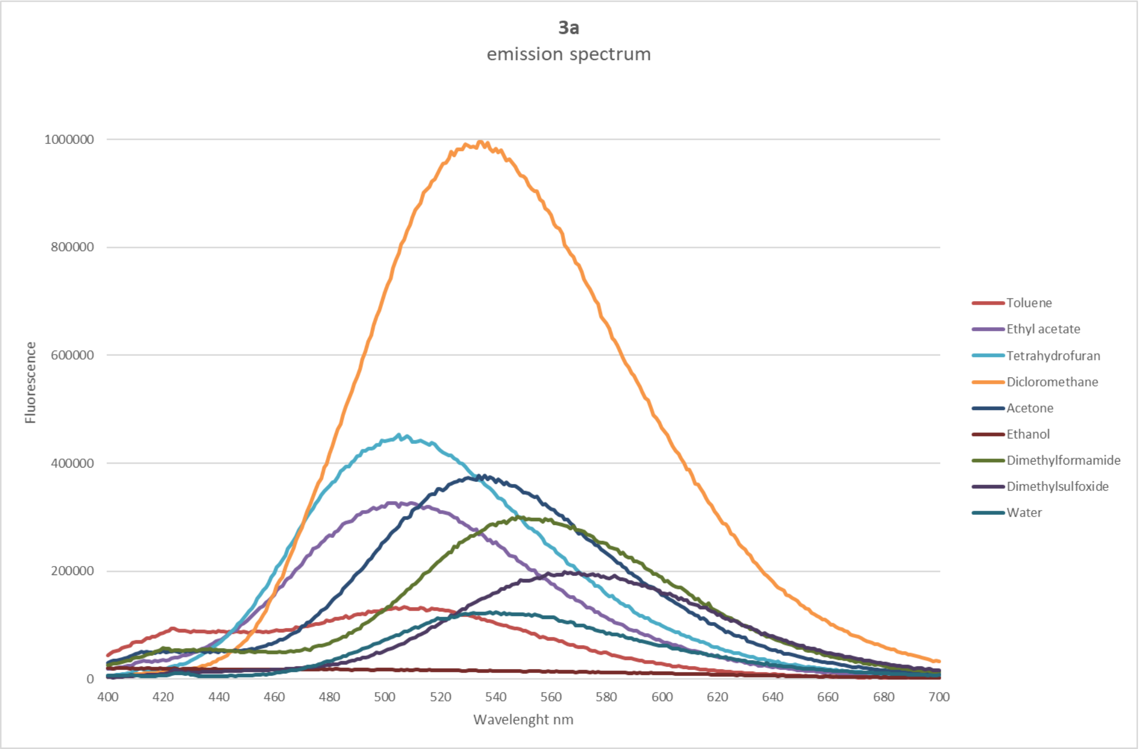
2-((4-Methoxyphenyl)ethynyl)-5-nitrobenzaldehyde **3a**



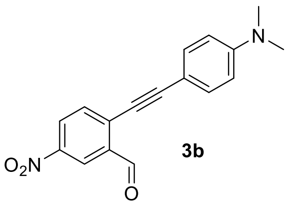
3a



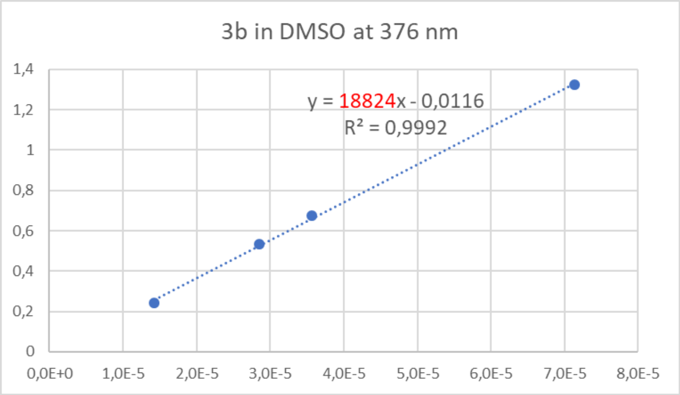


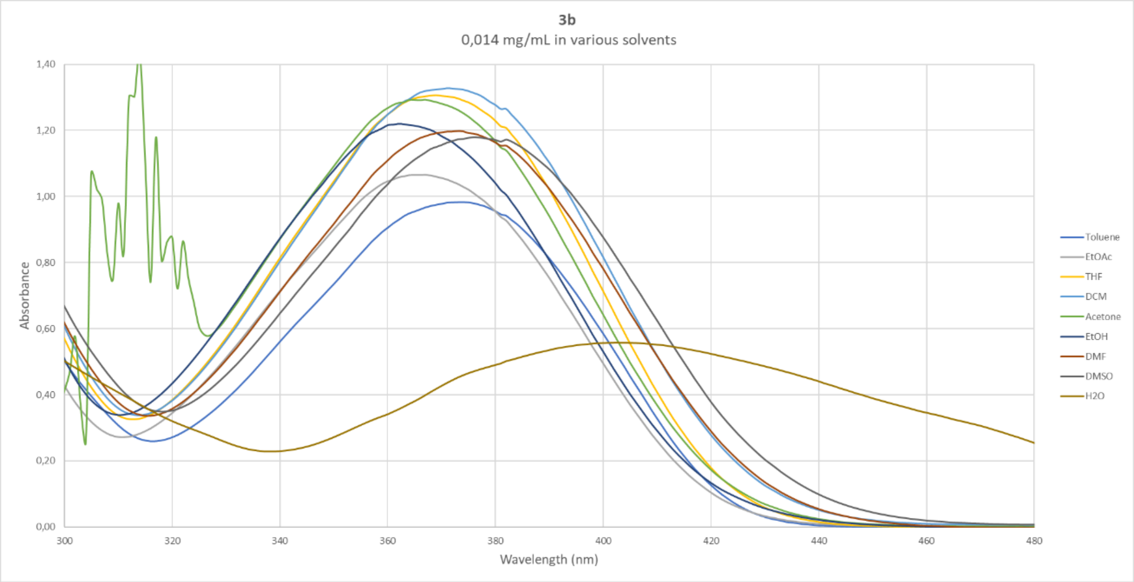


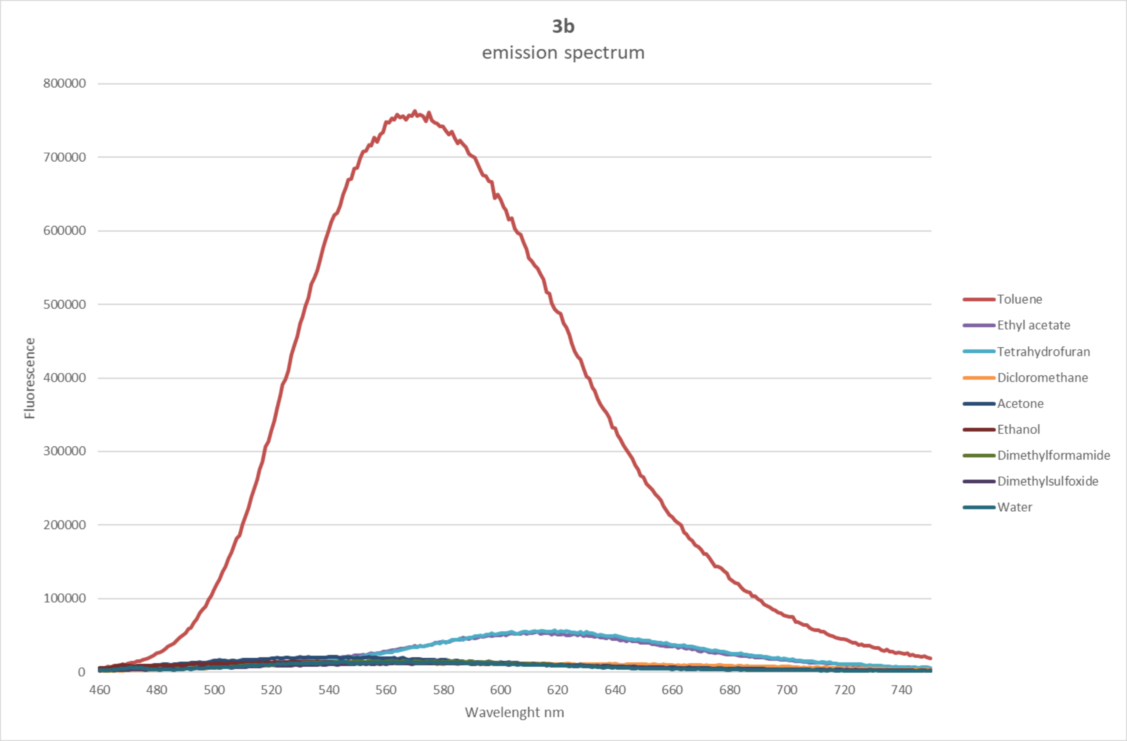
2-((4(Dimethylamino)phenyl)ethynyl)-5-nitrobenzaldehyde **3b**



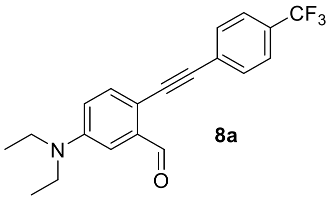
3b





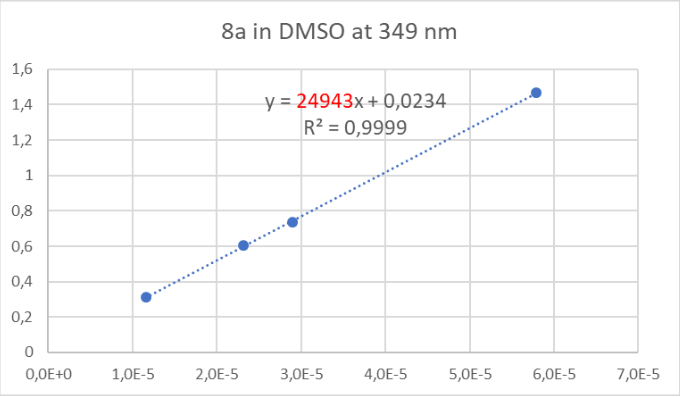


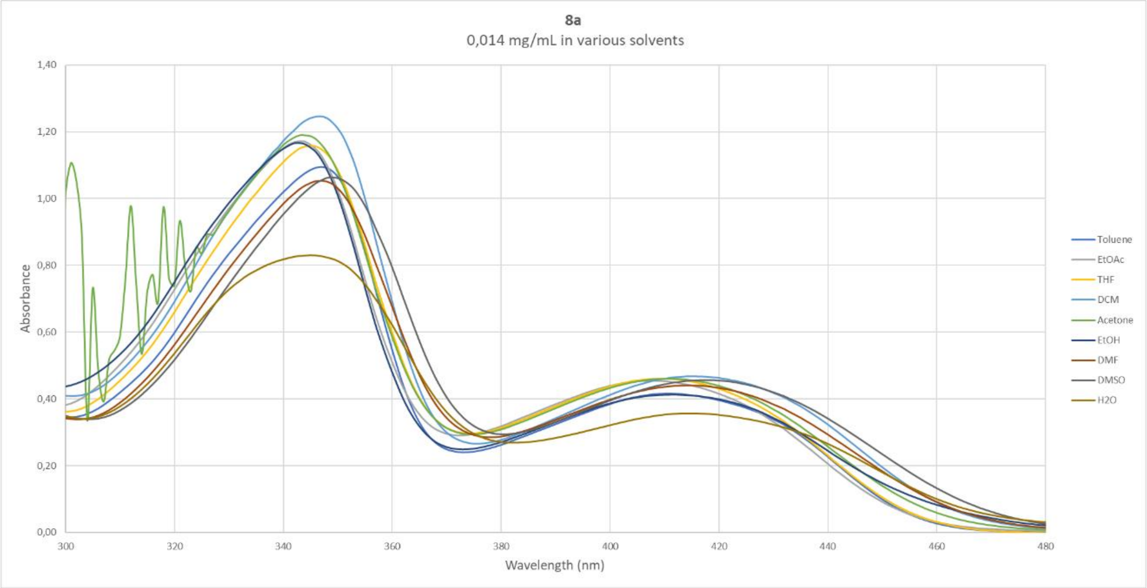
5-(Diethylamino)-2-((4-(trifluoromethyl)phenyl)ethynyl)benzaldehyde **8a**

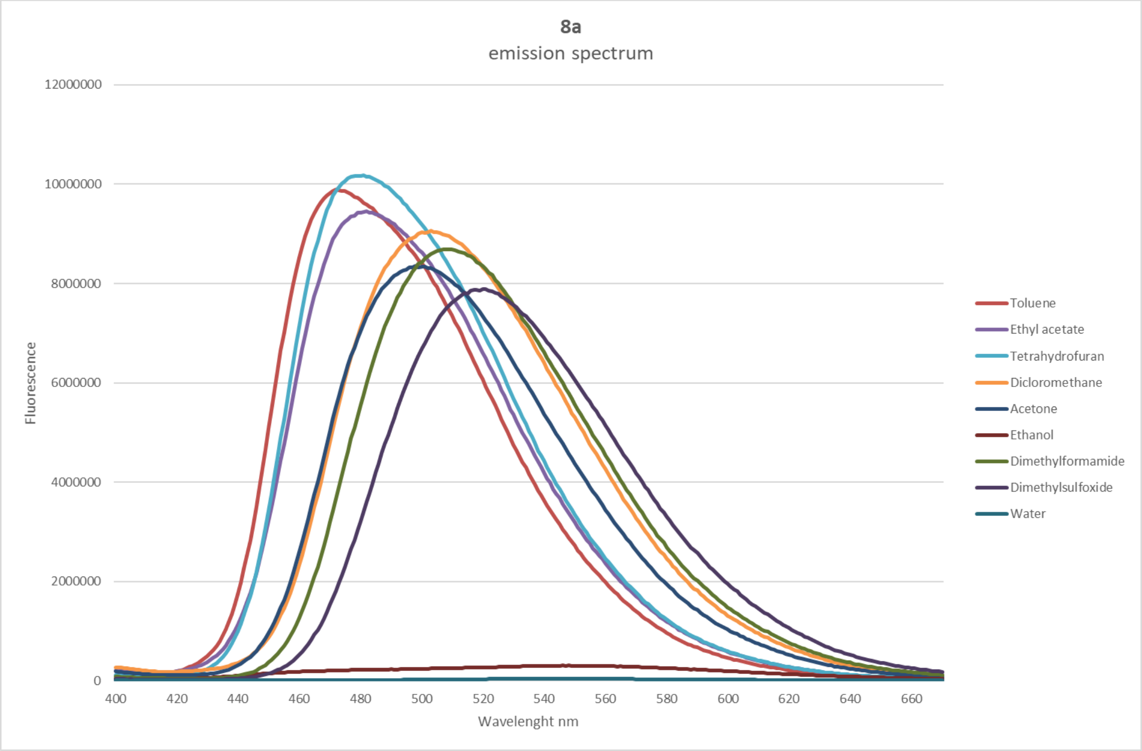


8a

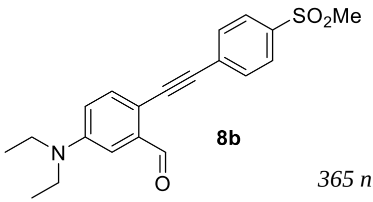
365 nm lamp





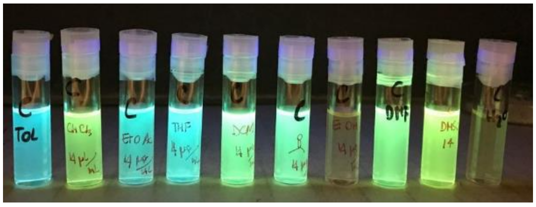


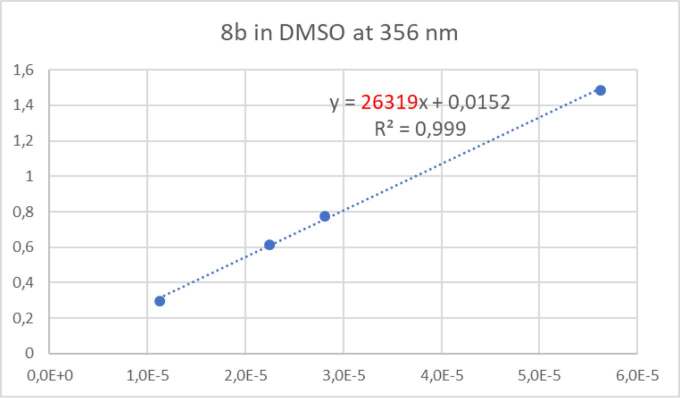
5-(Diethylamino)-2-((4-(methylsulfonyl)phenyl)ethynyl)benzaldehyde **8b**

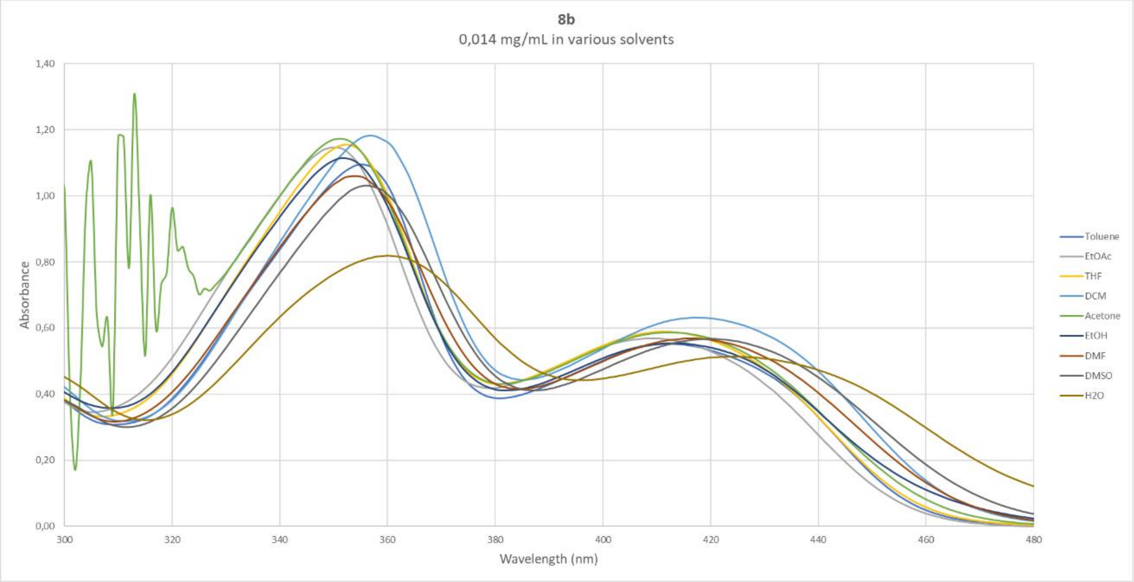


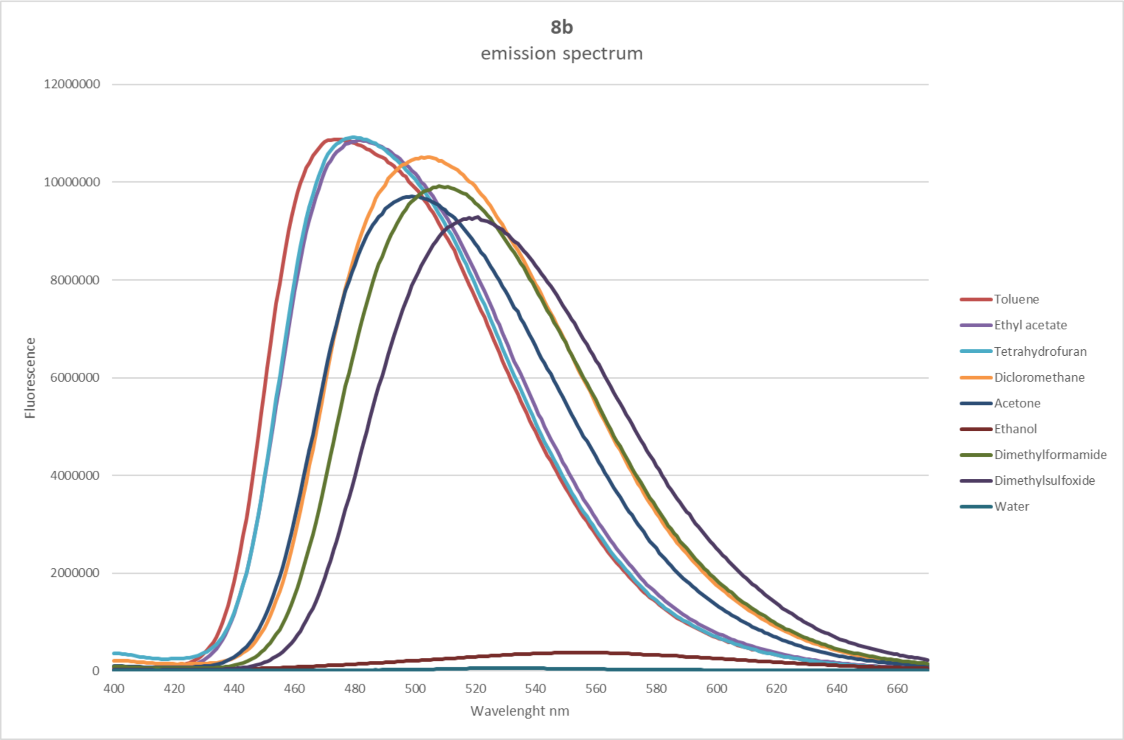
8b

365 nm lamp

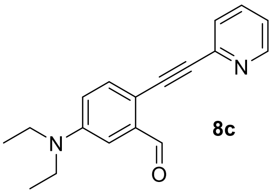






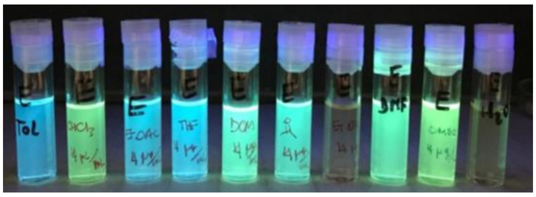


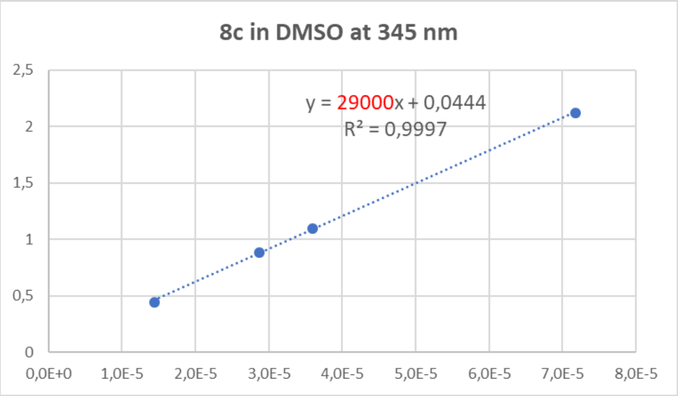
5-(Diethylamino)-2-(pyridin-2-ylethynyl)benzaldehyde **8c**

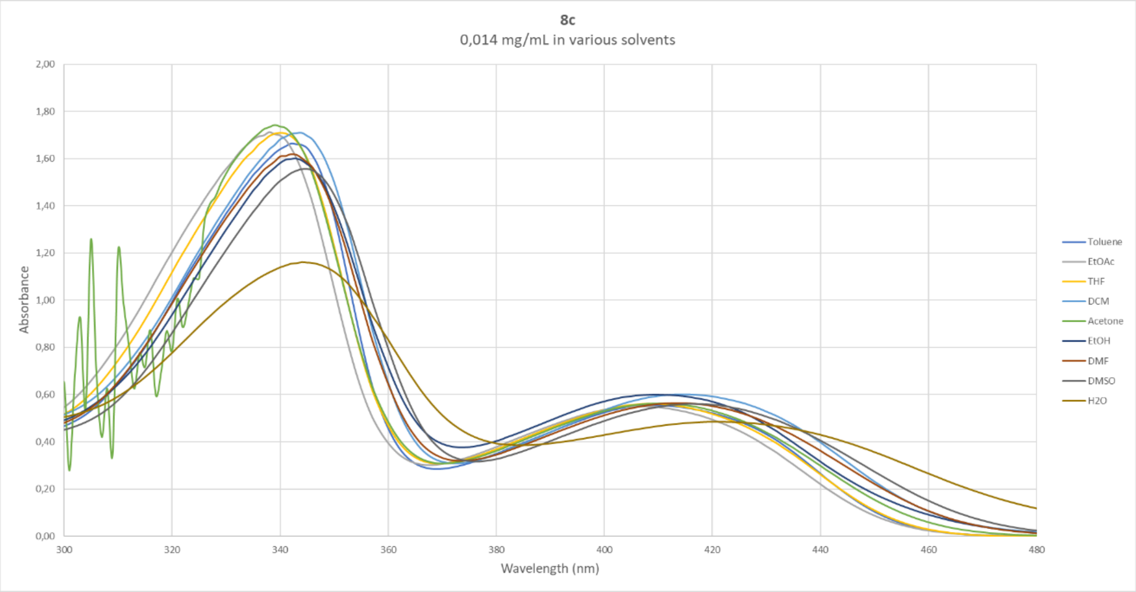


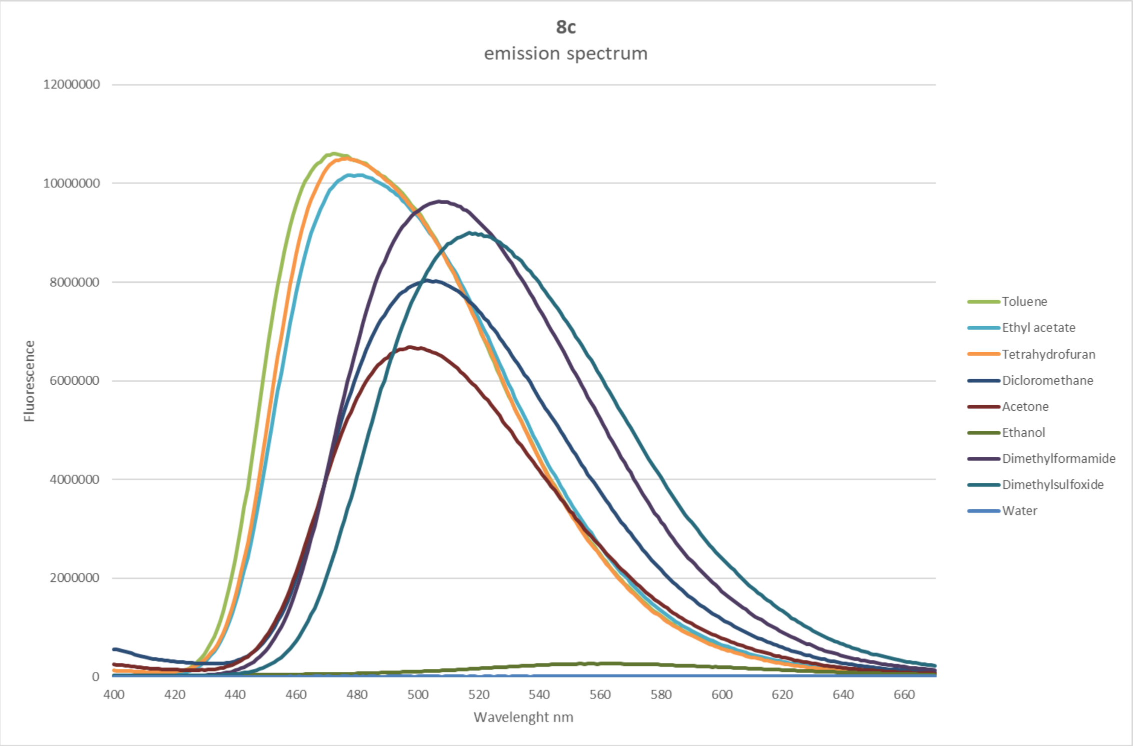
8c

365 nm lamp

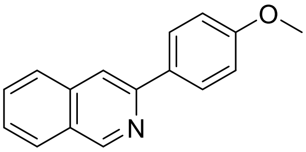


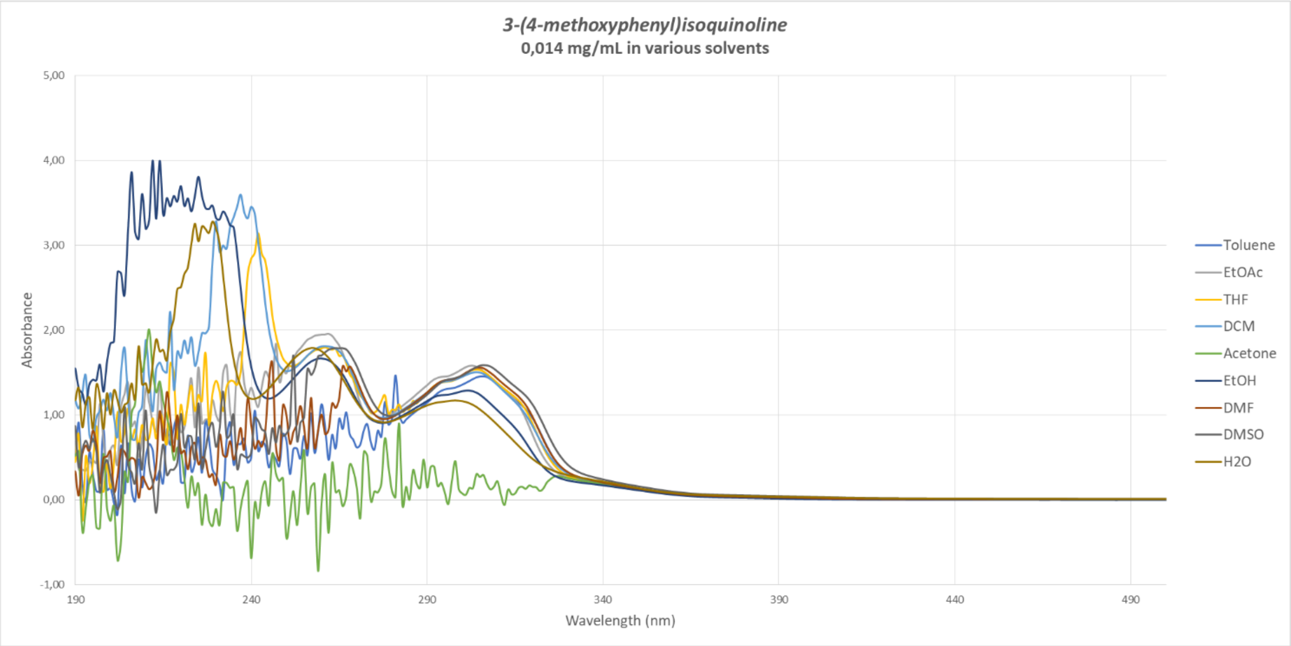




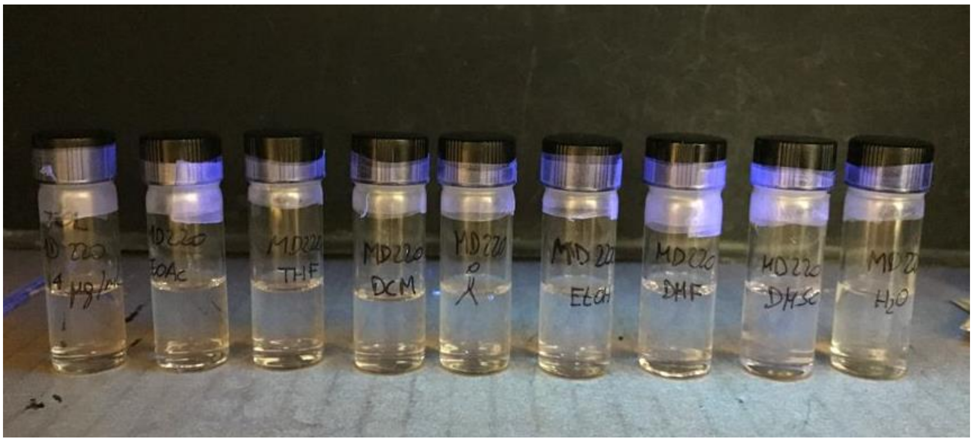


3-(4-Methoxyphenyl)isoquinoline





3-(4-Methoxyphenyl)isoquinoline solutions in 9 different solvents under a 254 nm lamp (same appearance under 365 nm lamp)



Absolute QY determination

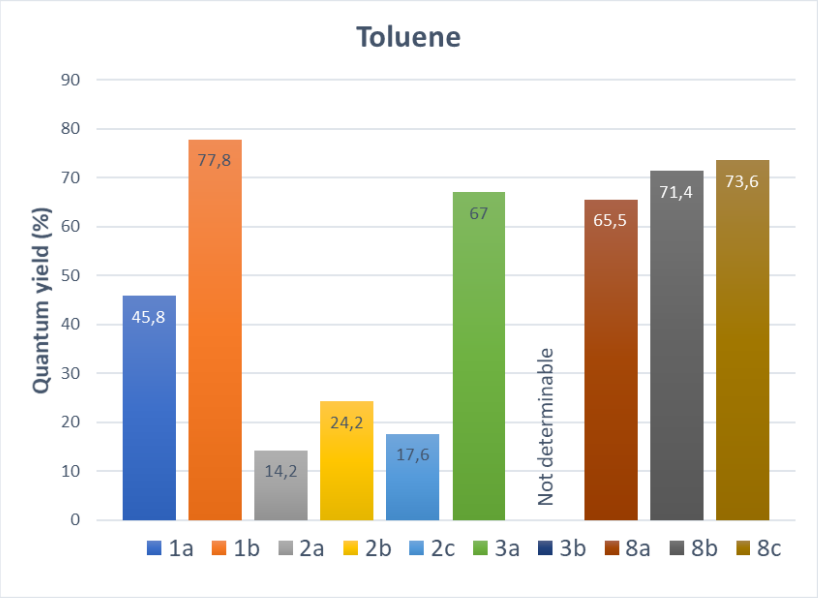
Absolute photoluminescence quantum yields were measured using a C11347 (Hamamatsu Photonics K.K). A description of the experimental setup and measurement method can be found in the article of K. Suzuki et al.[K. Suzuki, A. Kobayashi, S. Kaneko, K. Takehira, T. Yoshihara, H. Ishida, Y. Shiina, S. Oishic, S. Tobita, *Phys. Chem. Chem. Phys.*, **2009**, 11, 9850–9860]

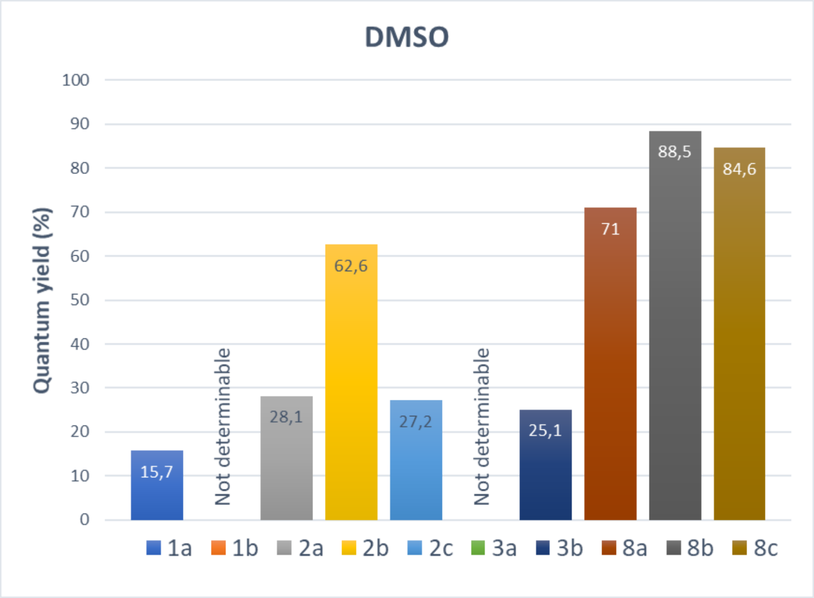
For any fixed excitation wavelength, the fluorescence quantum yield Φ is given by:

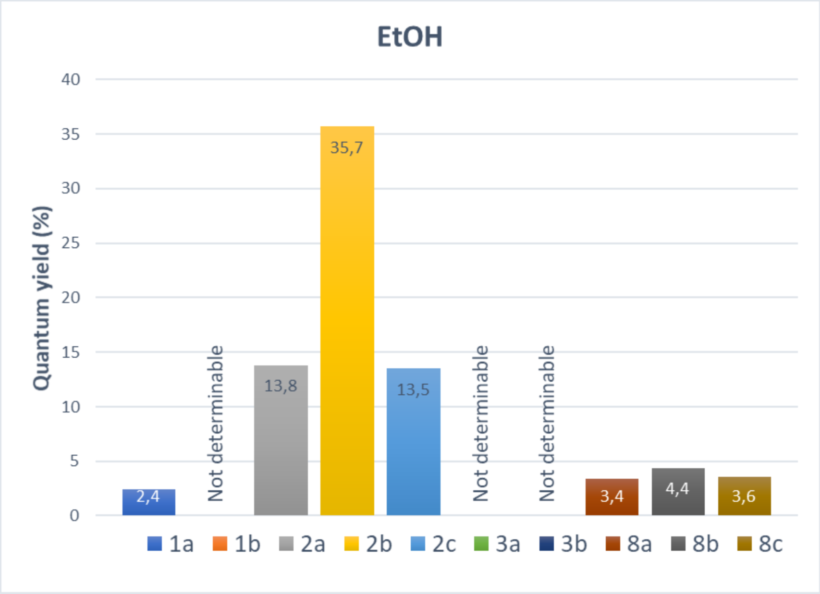
$$\Phi = \frac{\mathrm{PN(Em)}}{\mathrm{PN(Abs)}} = \frac{\int \frac{\lambda}{hc}\left[I_{em}^{sample}(\lambda) - I_{em}^{reference}(\lambda)\right] d\lambda}{\int \frac{\lambda}{hc}\left[I_{ex}^{reference}(\lambda) - I_{ex}^{sample}(\lambda)\right] d\lambda}$$

where PN(Em) is the number of photons emitted from a sample and PN(Abs) is the number of photons absorbed by a sample, λ is the wavelength, h is Planck's constant, c is the velocity of light, $I_{em}^{sample}(\lambda)$ and $I_{em}^{reference}(\lambda)$ are the photoluminescence intensities with and without a sample, respectively, $I_{ex}^{sample}(\lambda)$ and $I_{ex}^{reference}(\lambda)$ are the integrated intensities of the excitation light with and without a sample, respectively. PN(Em) is calculated in the wavelength interval [λ_i, λ_f], where λ_i is taken 10 nm below the excitation wavelength, while λ_f is the upper end wavelength in the emission spectrum.

	Solvent		
	Toluene	**DMSO**	**EtOH**
Compound	Quantum Yield (%)	Quantum Yield (%)	Quantum Yield (%)
1a	45,8	15,7	2,4
1b	77,8	not determinable	not determinable
2a	14,2	28,1	13,8
2b	24,2	62,6	35,7
2c	17,6	27,2	13,5
3a	67	not determinable	not determinable
3b	not determinable	25,1	not determinable
8a	65,5	71	3,4
8b	71,4	88,5	4,4
8c	73,6	84,6	3,6


Toluene
Quantum yield (%)
0
10
20
30
40
50
60
70
80
90
45,8
77,8
14,2
24,2
17,6
67
Not determinable
65,5
71,4
73,6
1a
1b
2a
2b
2c
3a
3b
8a
8b
8c


DMSO
Quantum yield (%)
0
10
20
30
40
50
60
70
80
90
100
15,7
Not determinable
28,1
62,6
27,2
Not determinable
25,1
71
88,5
84,6
1a
1b
2a
2b
2c
3a
3b
8a
8b
8c


EtOH
Quantum yield (%)
0
5
10
15
20
25
30
35
40
2,4
Not determinable
13,8
35,7
13,5
Not determinable
Not determinable
3,4
4,4
3,6
1a
1b
2a
2b
2c
3a
3b
8a
8b
8c