Radical-mediated Sulfonylative/Thiolative Cyclization of Biaryl Enones to Phenanthrone Derivatives

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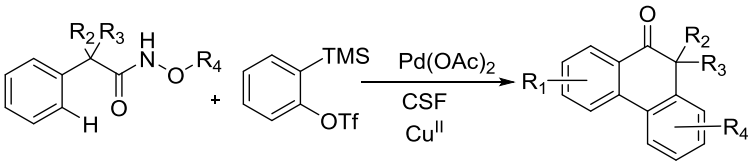
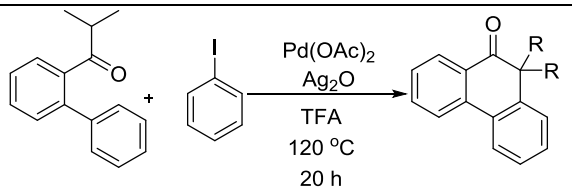
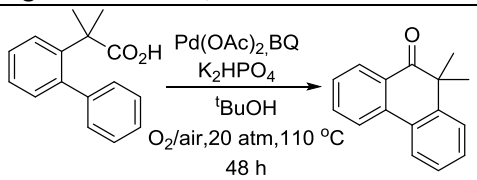
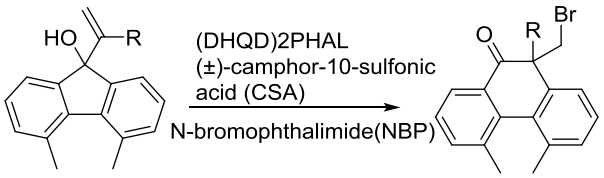
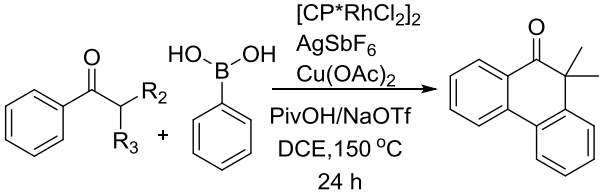
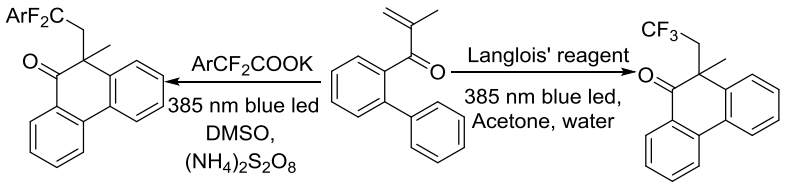
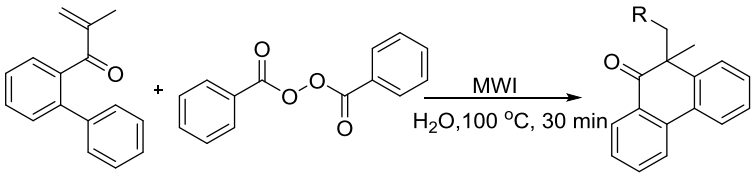
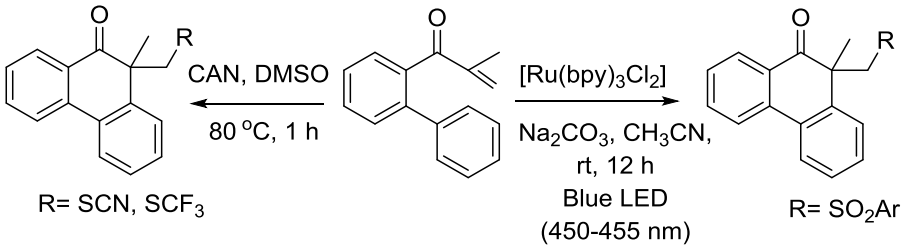
Table of Contents

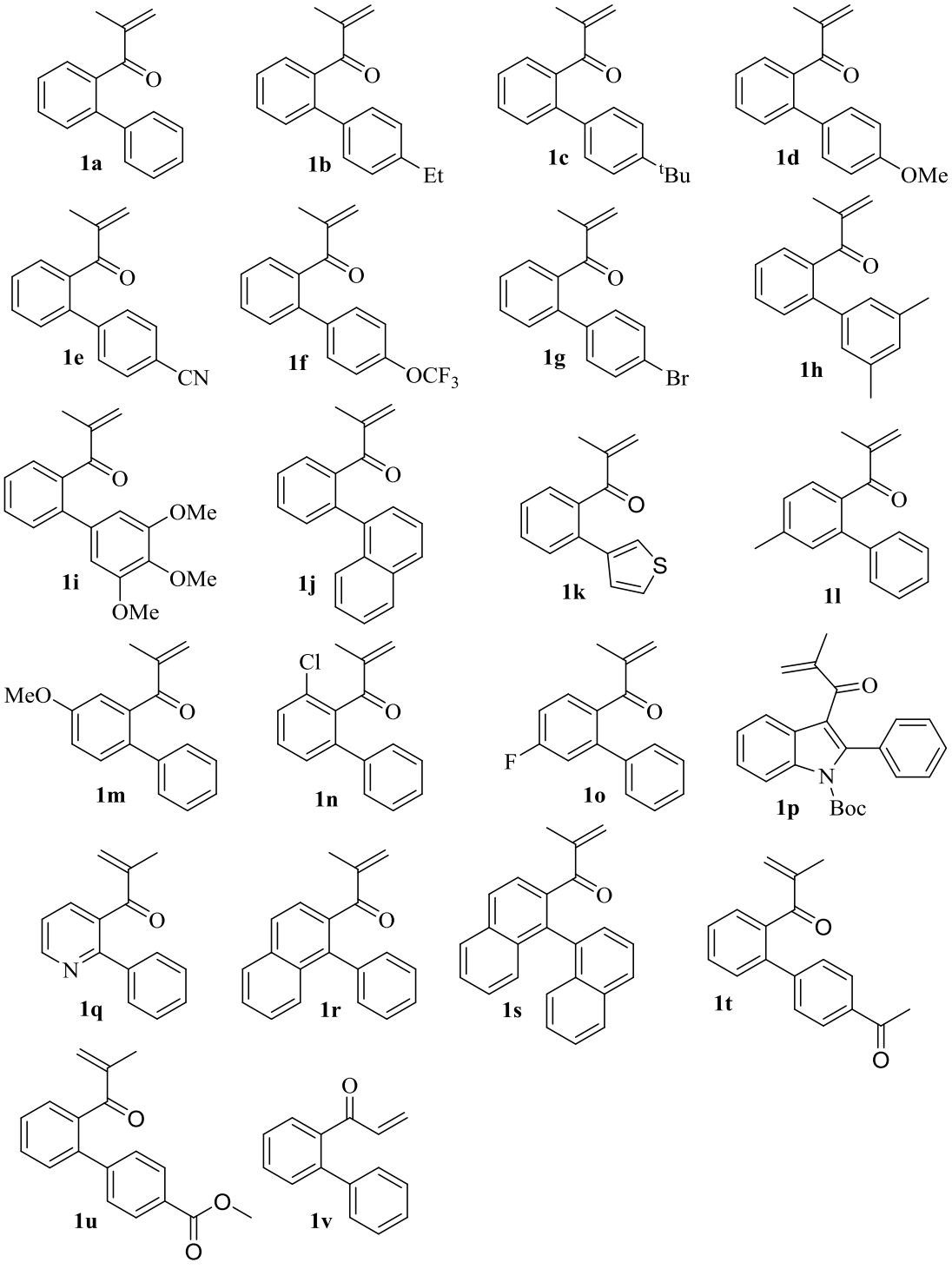
Table S1: Comparison table between literature approaches for the synthesis of phenanthrone derivatives and this strategy

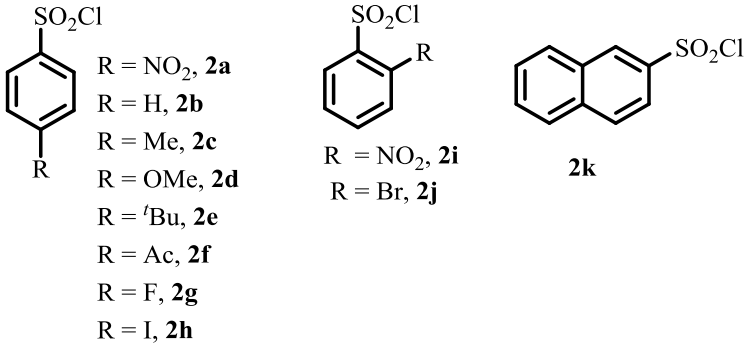
Reaction and reference	Remarks
Previous Approaches:	
 Z. Chen, B. Tang & Co-workers, *Org. Lett.* 2022, **24**, 2087–2092	R_2, R_3 = alkyl or cycloalkyl -Cu-salts needed along with the metal catalyst & -Reaction proceeds at higher temperature
 C. -H. Cheng & Co-workers, *J. Am. Chem. Soc.* 2010, **132**, 8569–8571	R = Me, cycloalkyl It requires metal catalyst along with the oxidant at higher temperatures.
 J. -Q. You & Co-workers, *J. Am. Chem. Soc*., 2008, **130**, 17676–17677	R = Me Metal catalyst along with the oxidant in Oxygen atmosphere is obligatory, also higher temperatures and long-time span for the reaction to proceed.
 Y. -Y. Yeung & Co-workers, *ACS Catal.* 2017, **7**, 4435–4440	R = Me,Aryl, Naphthyl Substituted 9-fluorenones are needed to prepare the starting materials
 Z. Bin, J. You & Co-workers, *Chem. Sci.*, 2023, **14**, 5125-5131	R_2, R_3= Me, Aryl and cyclo alkyl Oxidant, metal catalyst as well as additives are needed

 P. Li &Co-workers,Asian *J. Org. Chem.*, 2022, **11**, e202200269	Langlois' reagent in presence of molecular oxygen (O2) in air is essential
 P. Li &Co-workers, *Org. Biomol. Chem.*, 2023,**21**, 4018-4021	R= alkyl, aryl Microwave accelerated transformation at higher temperature
THIS WORK:	
	-Oxidant at 80 °C -Photocatalyst at Room temperature Unprecedented Thiofunctionalized phenanthrones

2. Structures of starting materials 1 and 2

All the Starting materials (**1a, 1c, 1d, 1g, 1j,1u,1v**)[8(a,b),17] were prepared based on literature reports, and the spectral data was compared.





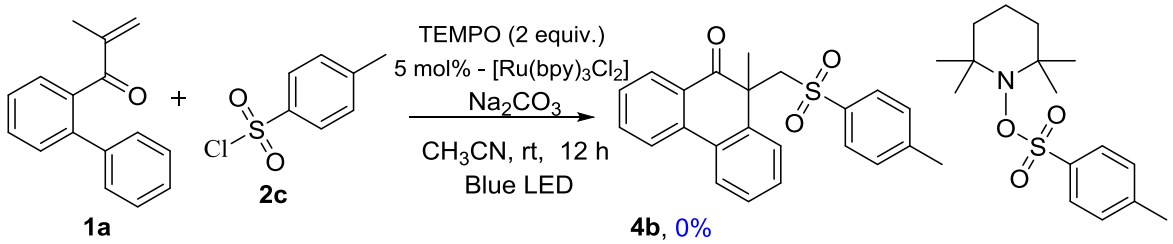
- **Visual representation of the reaction set-up:**

Figure S1: Blue LED reactor with magnetic stirring plate

3. Control experiments:

A. Radical trapping reaction with 2,2,6,6-tetramethylpiperidin-1-yl)oxidanyl (TEMPO):

Biaryl enone (0.3 mmol), 4-nitro benzenesulfonyl chloride (0.6 mmol), $Ru(bpy)_3Cl_2$ (5 mol %), Na_2CO_3 (0.3 mmol), 2,2,6,6-tetramethylpiperidin-1-yl) oxidanyl (TEMPO) (0.6 mmol) were taken in a reaction vial and solvent anhydrous CH_3CN was added. The reaction mixture was stirred under blue LED at room temperature and the progress of the reaction was monitored by TLC and found that the reaction inhibited.

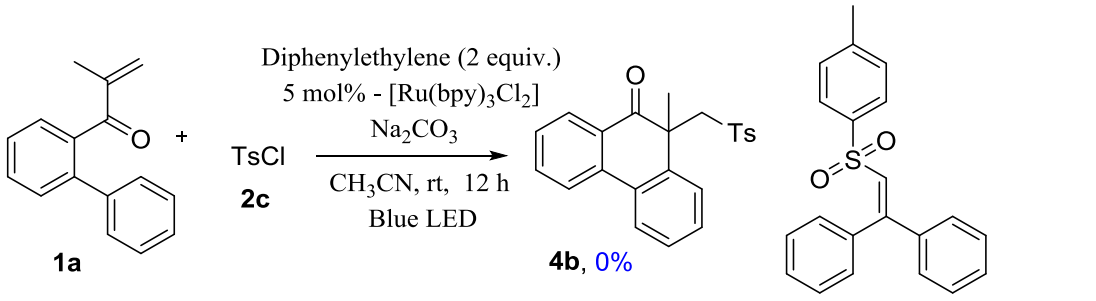


HRMS found for $C_{16}H_{26}NO_3S$:312.1265
Calculated : 312.1633

B. Radical trapping reaction with 1,1-Diphenyl ethylene:

Biaryl enone (0.3 mmol), 4-nitro benzenesulfonyl chloride (0.6 mmol), $Ru(bpy)_3Cl_2$ (5 mol %), Na_2CO_3 (0.3 mmol), 1,1-Diphenyl ethylene (0.6 mmol) were taken in a reaction vial and solvent anhydrous CH_3CN was added. The reaction mixture was stirred under blue LED at

room temperature and the progress of the reaction was monitored by TLC was found to be inhibited.



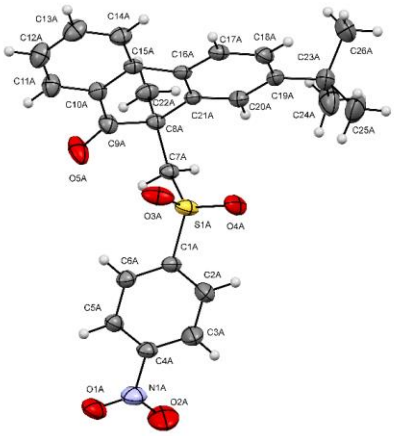
Diphenylethylene-tosyl adduct, **Y**
HRMS found for $C_{21}H_{19}SO_2$: 335.10971
Calculated: 335.11058

4. X-ray Crystallography:

X-ray data for the compounds KB11 and KB328 were collected at room temperature on a Bruker D8 QUEST instrument with an IμS Mo microsource (λ = 0.7107 A) and a PHOTON-III detector. The raw data frames were reduced and corrected for absorption effects using the Bruker Apex 3 software suite programs [1]. The structure was solved using intrinsic phasing method [2] and further refined with the SHELXL [2] program and expanded using Fourier techniques. Anisotropic displacement parameters were included for all non-hydrogen atoms. The atoms C24A/C25A/C26A/O4A and C3B/N1B/C24B/ C25B/C26B of KB11 were disordered over two positions and their site occupation factors were refined into 0.724(5)/0.276(5) and 0.538(6)/0.462(6), respectively. All C bound H atoms were positioned geometrically and treated as riding on their parent C atoms [C-H = 0.93-0.97 Å, and Uiso(H) = 1.5Ueq(C) for methyl H or 1.2Ueq(C) for other H atoms].

A. Crystal structure determination of 3c:

Crystal Data for $C_{26}H_{25}NO_5S$ (M =463.53 g/mol): triclinic, space group P-1 (no. 2), a = 9.7342(7) Å, b = 12.3271(9) Å, c = 21.0097(15) Å, α = 98.273(2)°, β = 95.450(2)°, γ = 104.946(2)°, V = 2387.3(3) Å^3, Z = 4, T = 294.15 K, μ(MoKα) = 0.172 mm^{-1}, *Dcalc* = 1.290 g/cm^3, 43584 reflections measured (3.956° ≤ 2Θ ≤ 52.784°), 9745 unique (R_{int} = 0.0672, R_{sigma} = 0.0703) which were used in all calculations. The final R_1 was 0.0641 (I > 2σ(I)) and wR_2 was 0.1715 (all data). **CCDC 2278957** deposition numbers contains the supplementary crystallographic data for this paper which can be obtained free of charge at https://www.ccdc.cam.ac.uk/structures/.



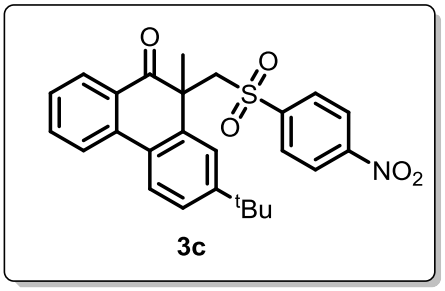
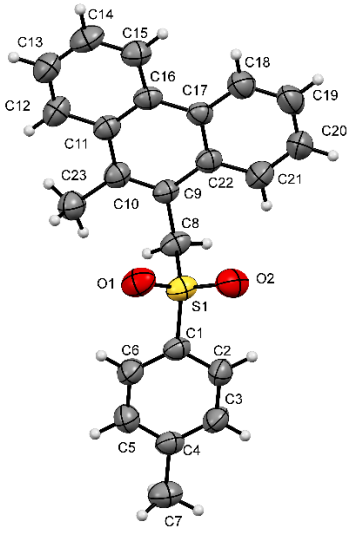


Figure S2: ORTEP diagram of compound **3c** with the atom-numbering. Displacement ellipsoids are drawn at the 30% probability level and H atoms are shown as small spheres of arbitrary radius. Only molecule A was shown for a better view. The minor disordered atom components were omitted for clarity

B. Crystal structure determination of 9:

Crystal Data for $C_{23}H_{20}O_2S$ (M =360.480 g/mol): monoclinic, space group $P2_1/c$ (no. 14), a = 14.441(4) Å, b = 4.9171(15) Å, c = 25.385(7) Å, β = 103.485(9)°, V = 1752.9(9) Å^3, Z = 4, T = 294.15 K, μ(Mo Kα) = 0.199 mm^{-1}, $Dcalc$ = 1.366 g/cm^3, 18591 reflections measured (4.88° ≤ 2Θ ≤ 52.48°), 3520 unique (R_{int} = 0.1265, R_{sigma} = 0.1348) which were used in all calculations. The final R_1 was 0.0774 (I>2σ(I)) and wR_2 was 0.2415 (all data). **CCDC 2278958** deposition numbers contains the supplementary crystallographic data for this paper which can be obtained free of charge at https://www.ccdc.cam.ac.uk/structures/.



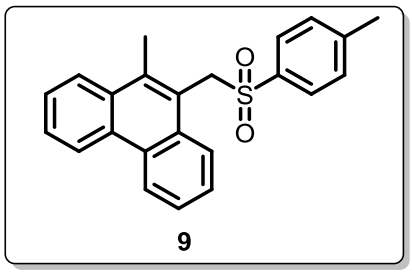


Figure S3: ORTEP diagram of compound **9** with the atom-numbering. Displacement ellipsoids are drawn at the 30% probability level and H atoms are shown as small spheres of arbitrary radius.

5. Electrochemical studies:

Cyclic voltammetry experiments of **1d** and **2a** were carried out on a PC-controlled CH instruments model CHI 620C electrochemical analyser in acetonitrile at a scan rate of 200 mV/s using 0.1 mM concentration of tetrabutylammonium hexafluorophosphate (NBu_4PF_6) as supporting electrolyte. The working electrode is glassy carbon, saturated calomel electrode (SCE) is reference electrode, and platinum wire is auxiliary electrode. Then, the spectro electrochemistry of both the substrates was measured using this cyclic voltammetric technique and evaluated the maximum oxidation and reduction potentials of the individual substrates. Substrate **1d** shows oxidation potentials at 1.82 V, 1.57 V and reduction potentials at −1.46 V, −1.21 V. whereas **2a** shows the oxidation potential at 1.01 V, 1.79 V and reduction potentials at −1.21 V, −1.09 V.

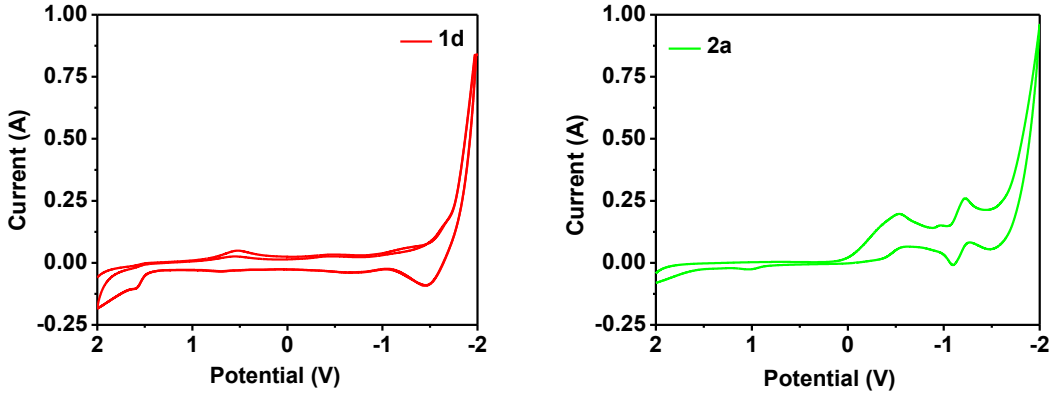


Fig. S4: (a) Cyclic voltammogram of **1d** recorded using tetrabutylammonium hexafluorophosphate (NBu_4PF_6) as supporting electrolyte. (b) Cyclic voltammogram of **1d** and **2a** in CH_3CN recorded using tetrabutylammonium hexafluorophosphate (NBu_4PF_6) as supporting electrolyte.

6. Stern-Volmer Quenching Experiment:

All spectroscopic measurements were carried out in TECAN Infinite M200 PRO spectrophotometer. The excitation of $Ru(bpy)_3Cl_2$ catalyst at 455 nm and emission was recorded from 500 nm to 750 nm. The substrate 4-nitrobenzene sulfonyl chloride (**2a**) was serially diluted (200 mM- 1.5625 mM) in degassed acetonitrile. The photocatalyst concentration at 10 mM in degassed acetonitrile was incubated with serially diluted 4-nitrobenzene sulfonyl chloride and the corresponding fluorescence was recorded. The experiments were performed in replicates. The Stern Volmer graph was plotted in Graph Pad Prism 8.0.2 software by using values at the emission maxima of 620 nm. Stern Volmer constant (K_{SV}) was calculated to be $3.18 \times 10^{-2}\ M^{-1}$.

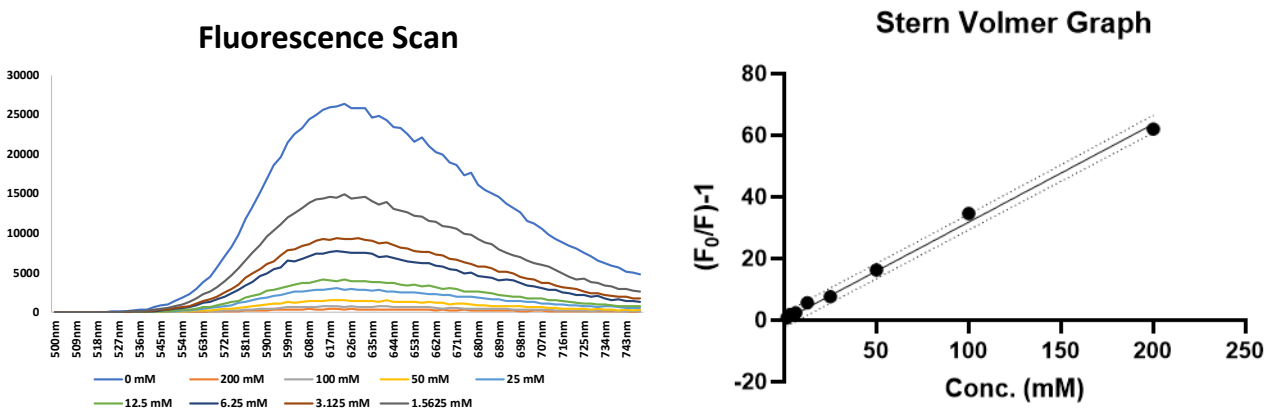


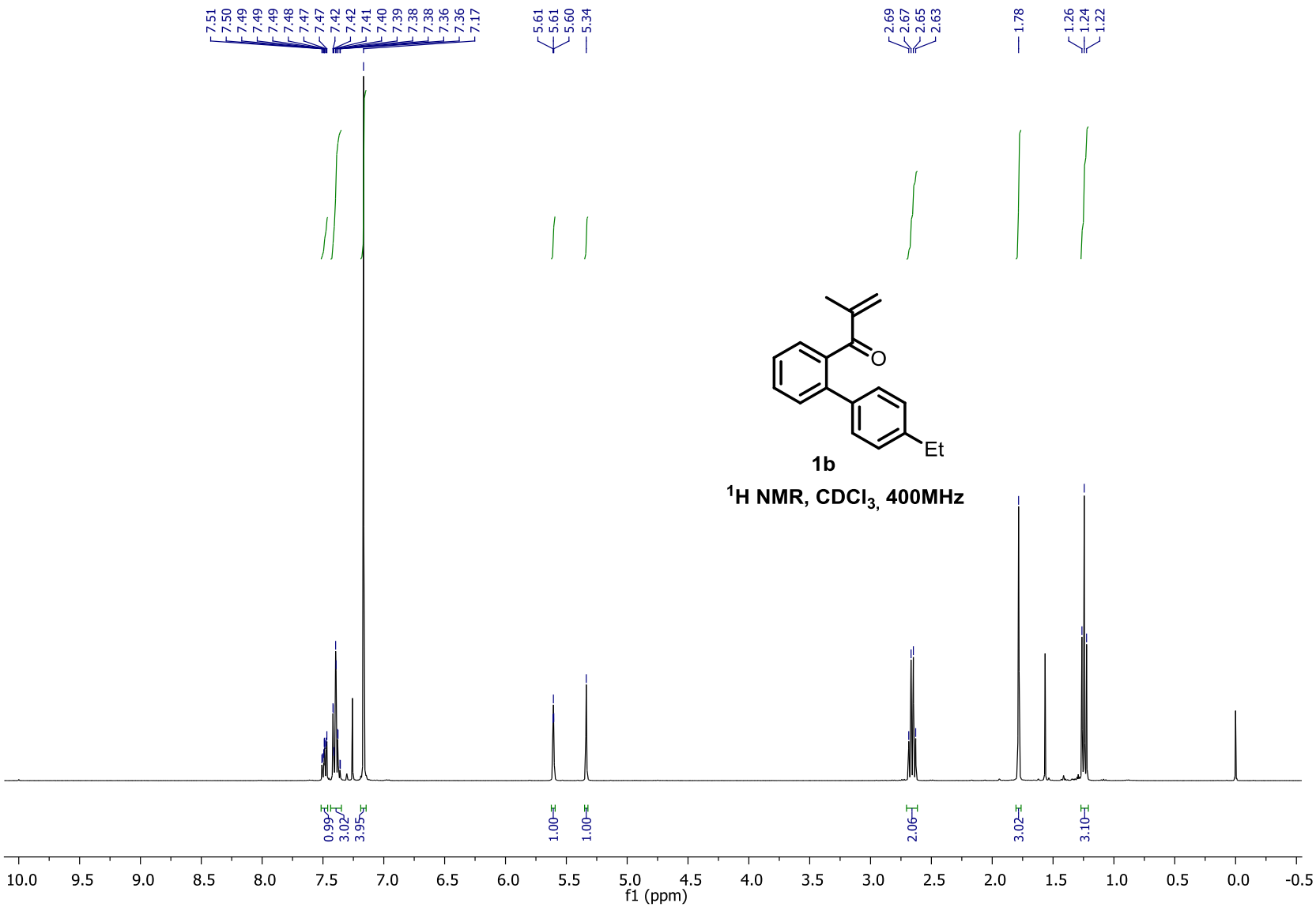
Fig. S5: (a) Fluorescence spectrum showing quenching of $[Ru(bpy)_3]^{2+}$ (Ex = 455 nm, Em = 620 nm) with increasing concentrations of 4-nitrobenzenesulfonyl chloride (0- 200 mM); (b) Corresponding Stern–Volmer plot.

7. References:

1. (a) X. Yang, J. Liu, Y. Gao, L. Wang, Y. Zhang, and P. Li, Asian J. Org. Chem. 2022, 11, e202200269 (b) X. Yang, G.Zhang, J. Zhou, C. Zhou, L. Wang and P. Li, *Org. Biomol. Chem.*, 2023, 21**,** 4018-4021.

2. Bruker (2016). APEX3, SAINT and SADABS. Bruker AXS, Inc., Madison, Wisconsin, USA.

3. Sheldrick G. M. (2015).ActaCrystallogr C71: 3-8.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5.60
5.34
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2.67
2.65
2.63
1.78
1.26
1.24
1.22
O
Et
1b
^{1}H NMR, CDCl$_3$, 400MHz
0.99
3.02
3.95
1.00
1.00
2.06
3.02
3.10
10.0
9.5
9.0
8.5
8.0
7.5
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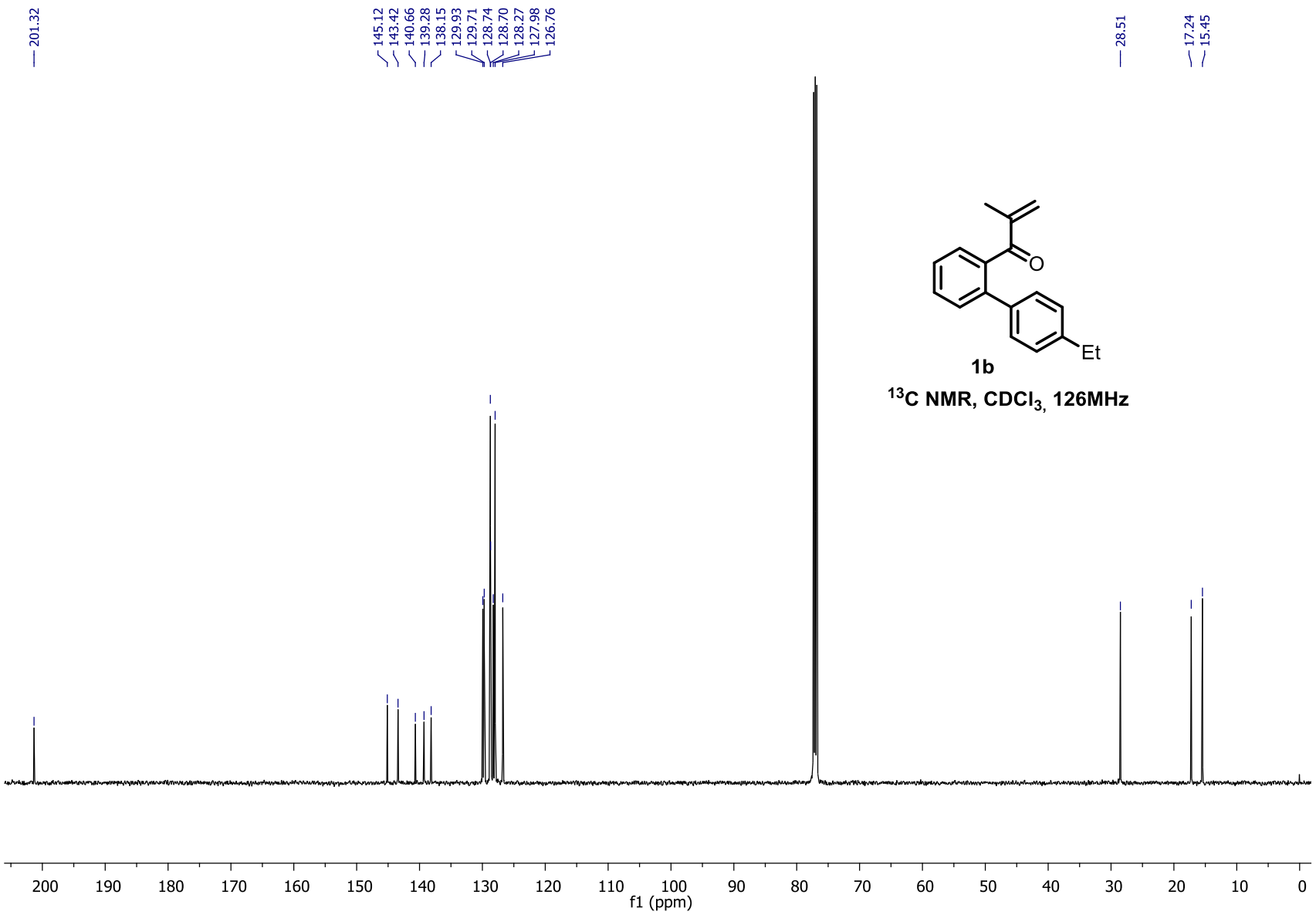
f1 (ppm)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129.71
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126.76
28.51
17.24
15.45
O
Et
1b
13C NMR, CDCl3, 126MHz
200
190
180
170
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70
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50
40
30
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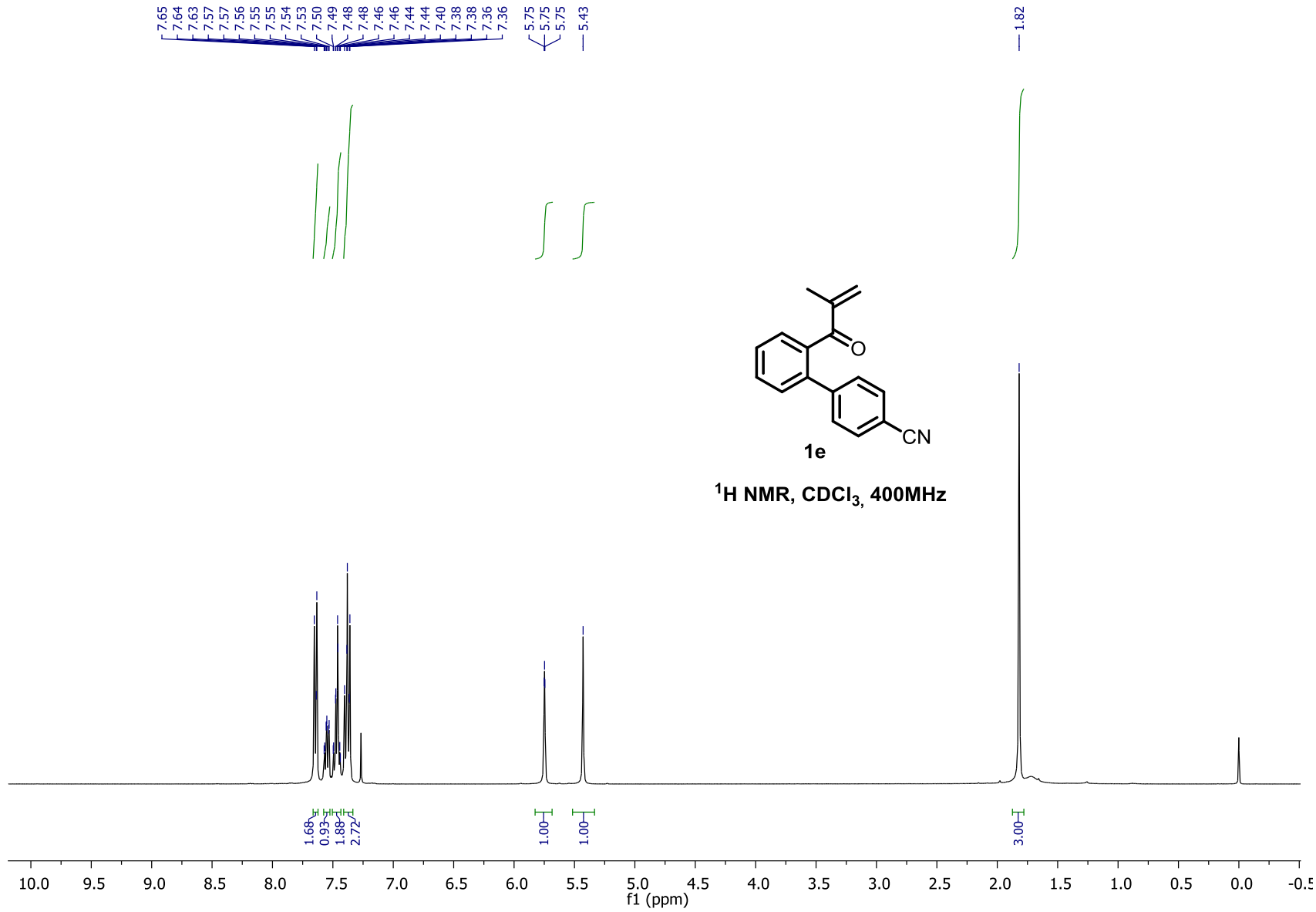
10
0
f1 (ppm)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5.75
5.75
5.43
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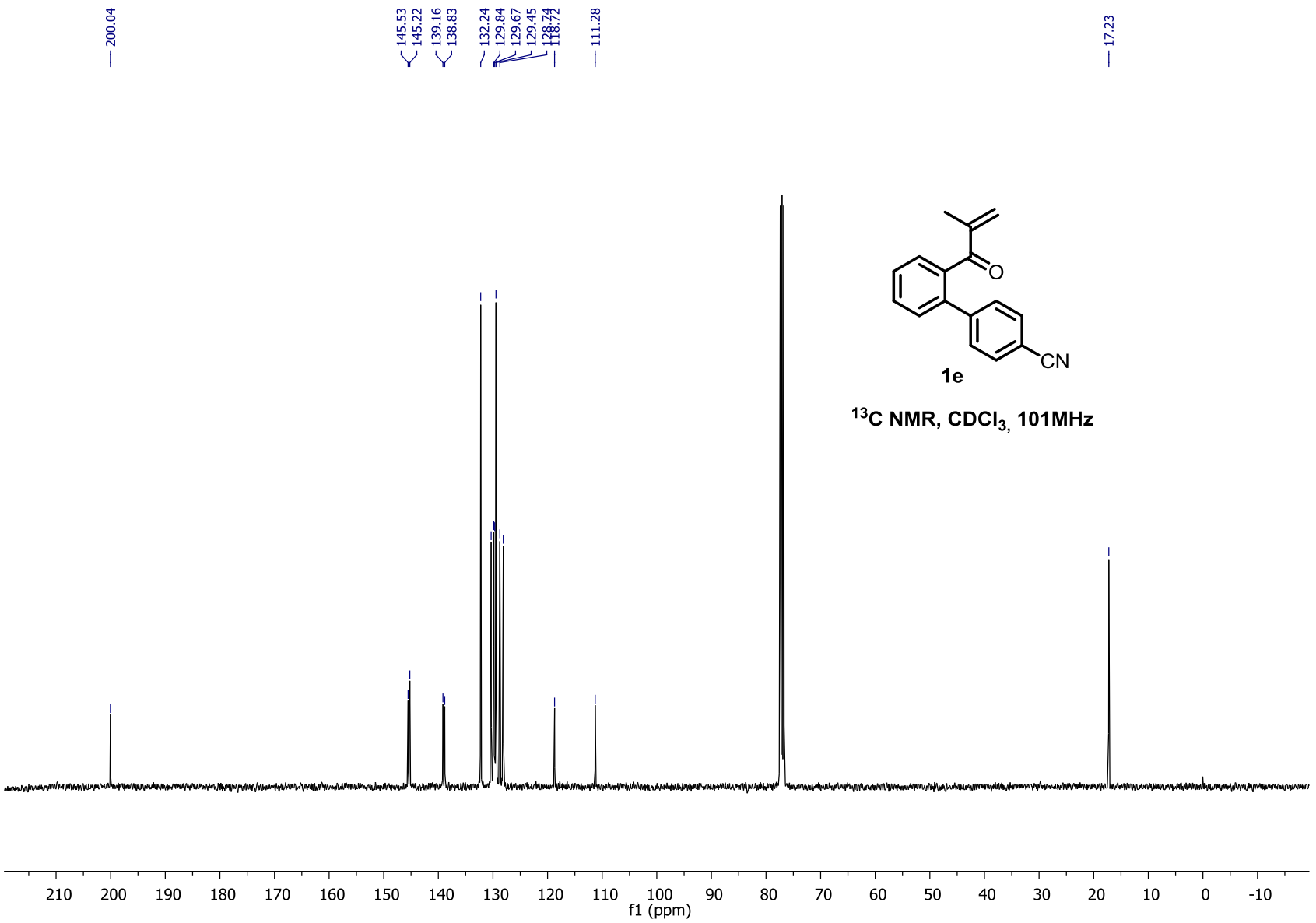
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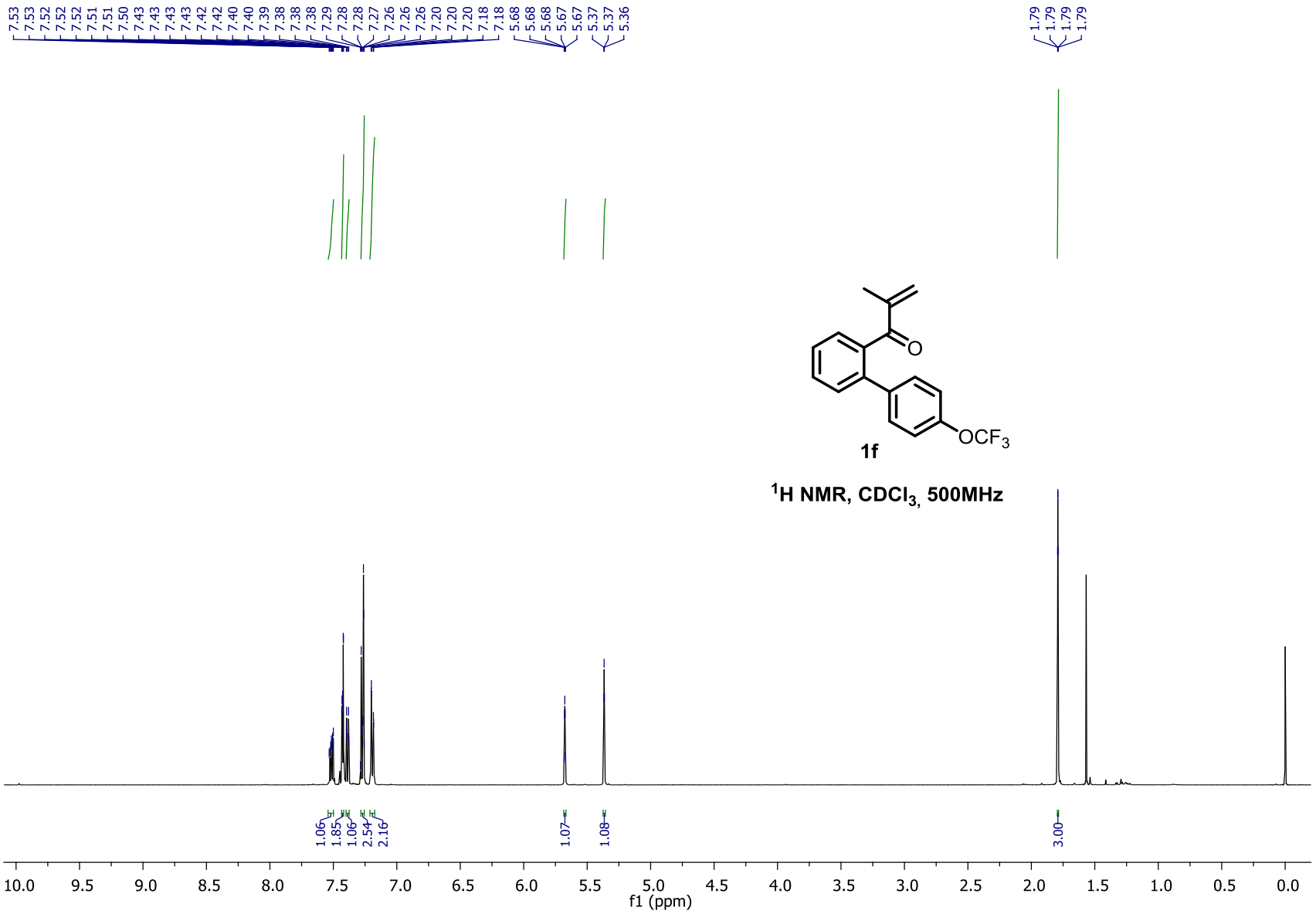
f1 (ppm)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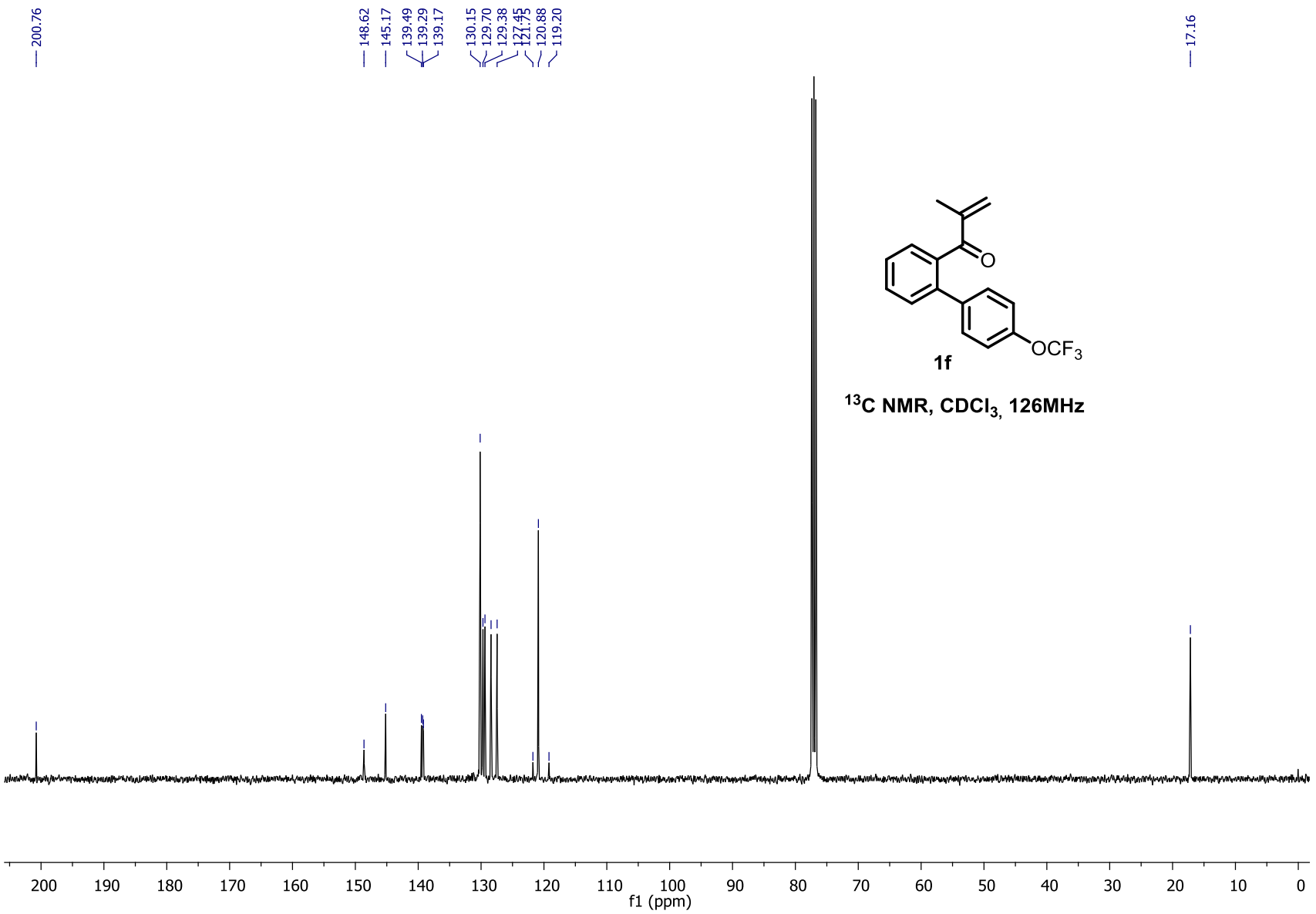
f1 (ppm)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OCF3
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190
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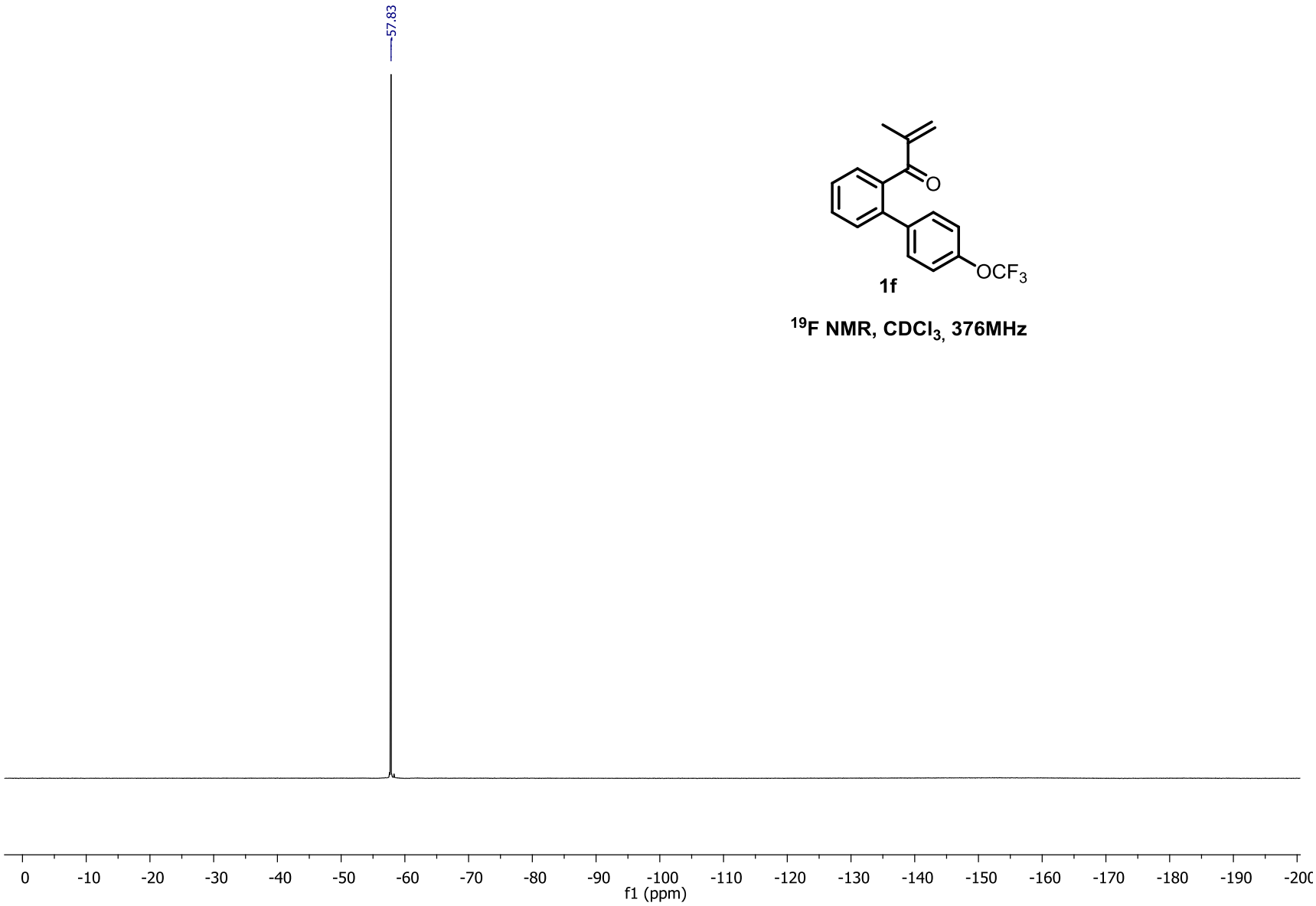
f1 (ppm)



1f

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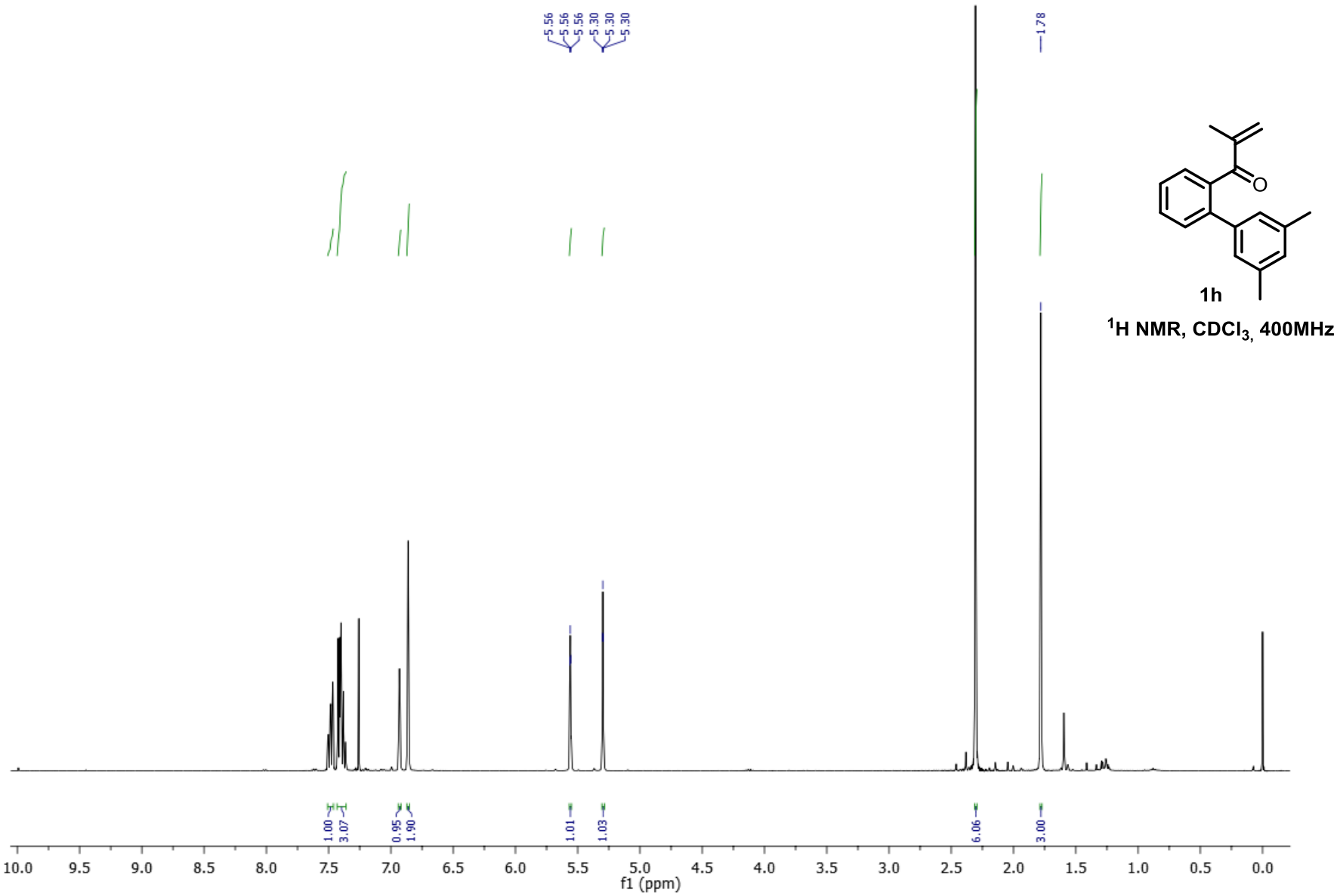
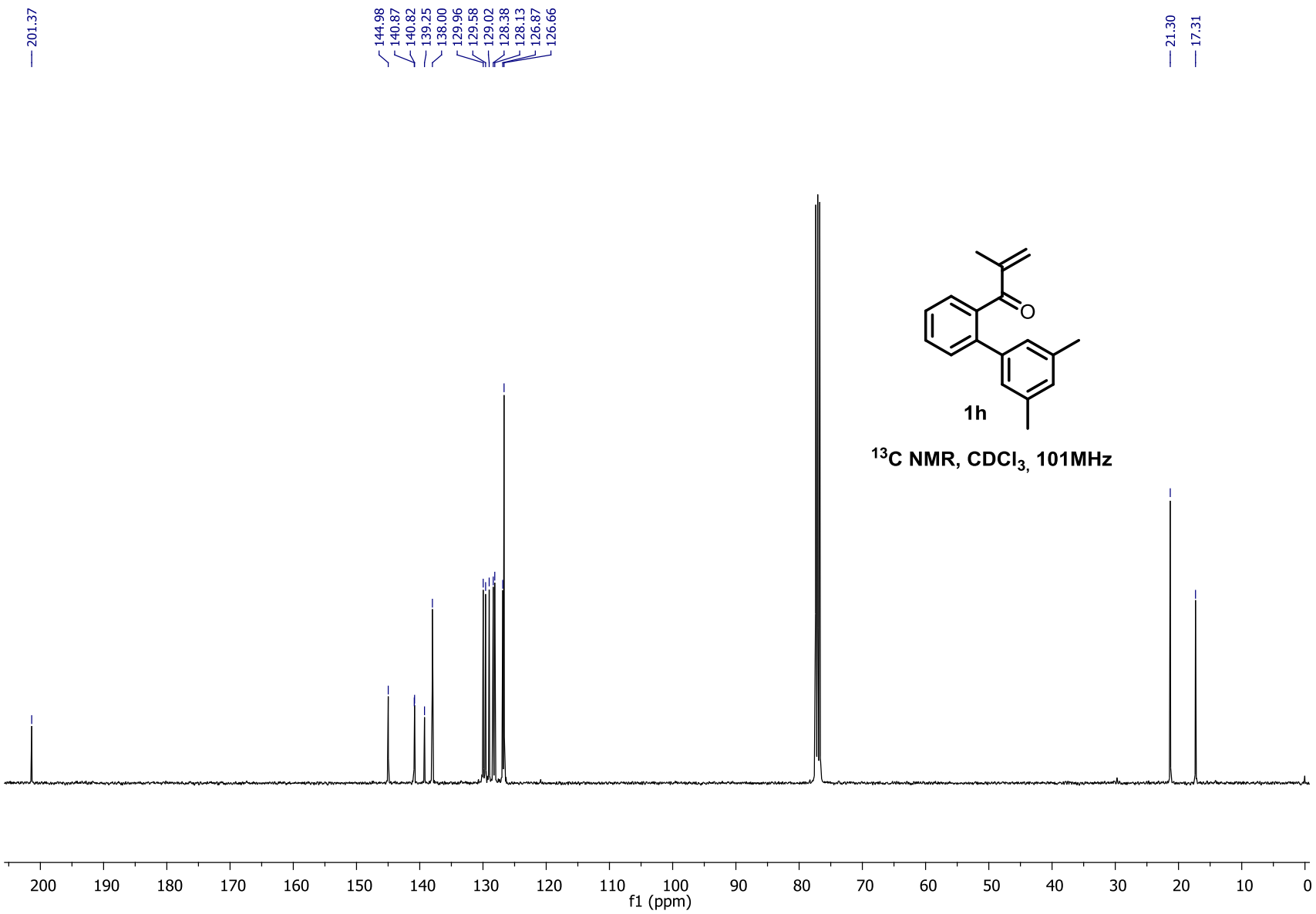


1h

^{1}H NMR, $CDCl_3$, 400MHz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129.58
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21.30
17.31
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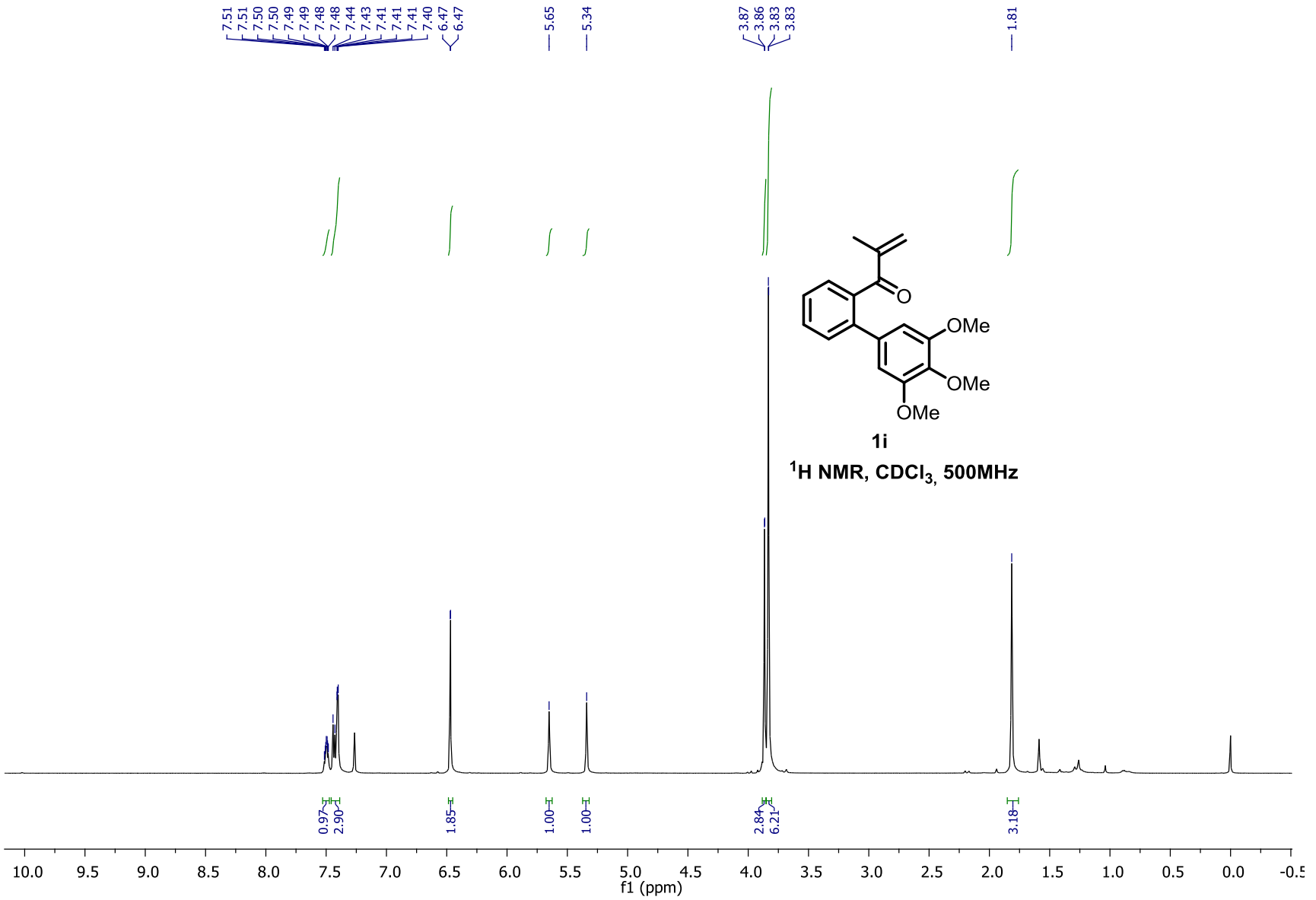
f1 (ppm)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7.40
6.47
6.47
5.65
5.34
3.87
3.86
3.83
3.83
1.81
OMe
OMe
OMe
1i
1H NMR, CDCl3, 500MHz
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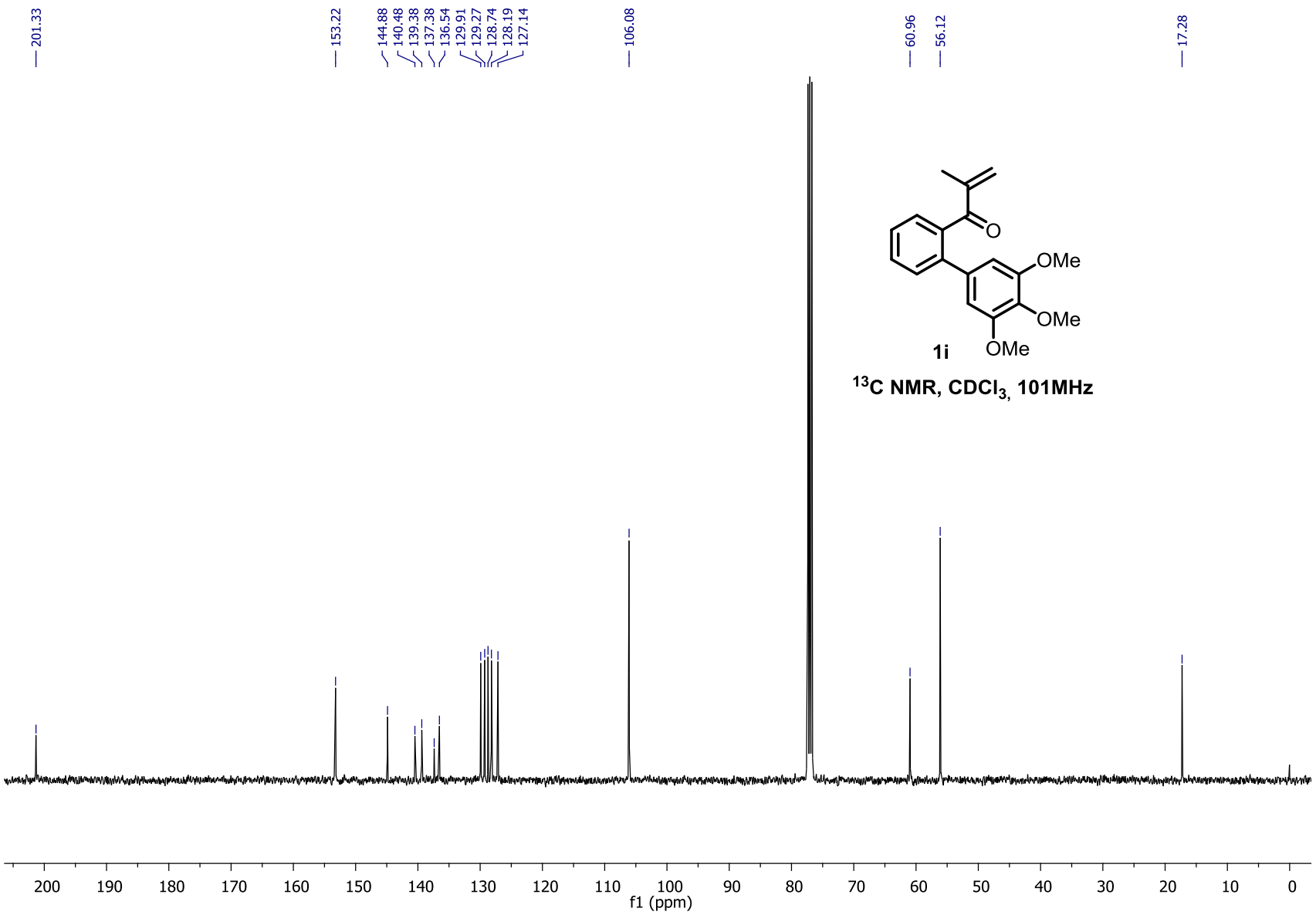
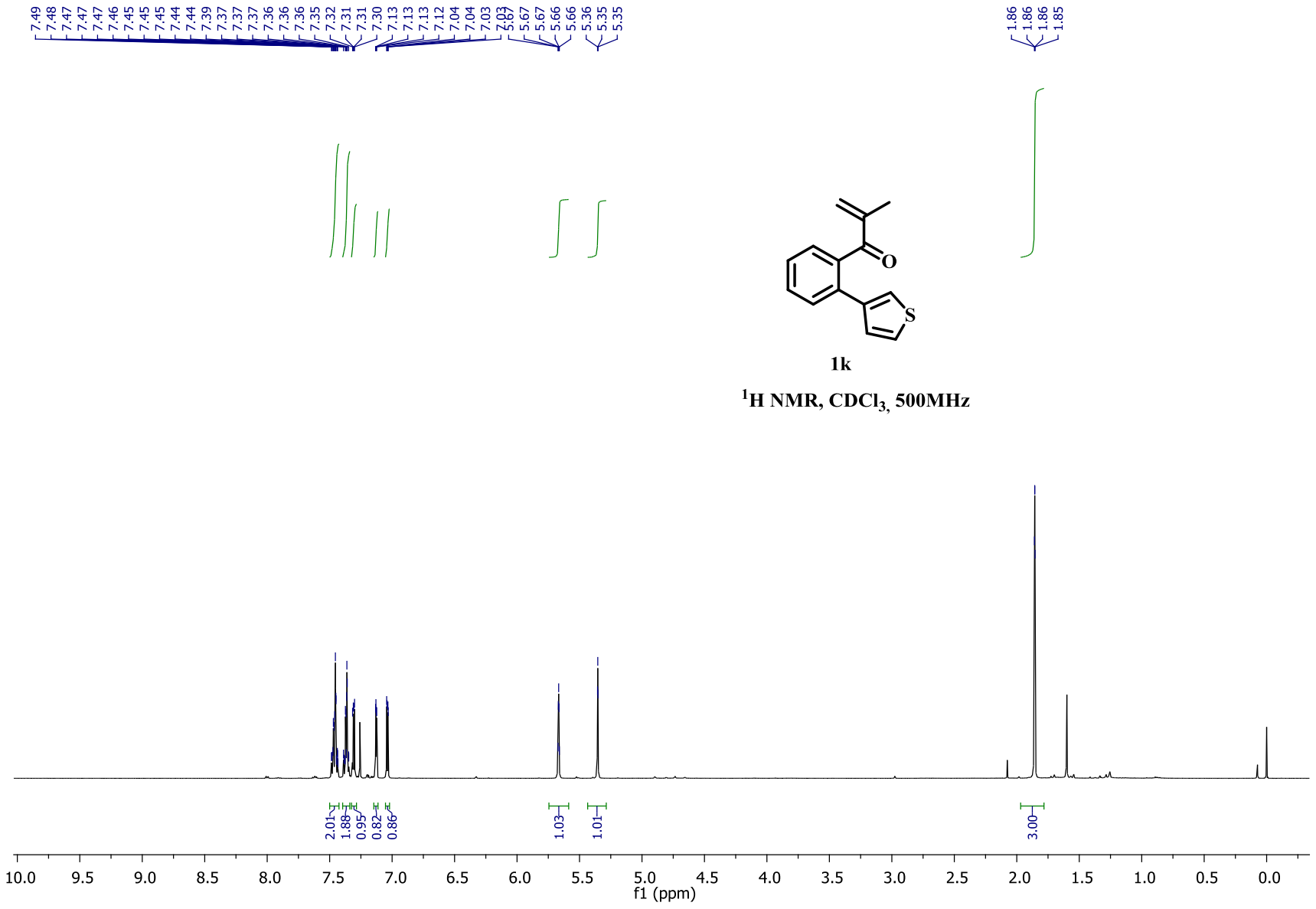
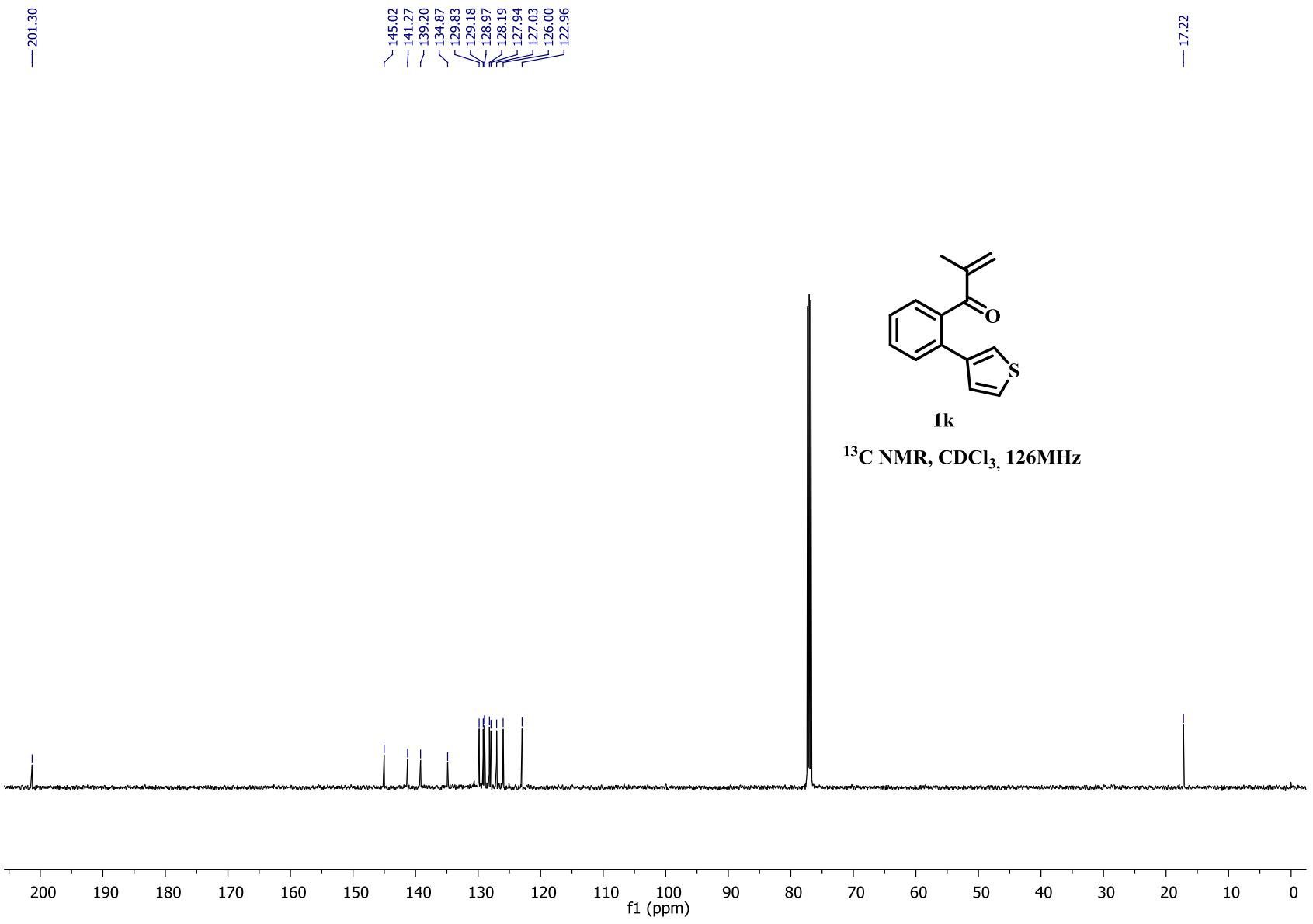
2.90
1.85
1.00
1.00
2.84
6.21
3.18
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


201.33
153.22
144.88
140.48
139.38
137.38
136.54
129.91
129.27
128.74
128.19
127.14
106.08
60.96
56.12
17.28
O
OMe
OMe
OMe
1i
^{13}C NMR, CDCl$_3$, 101MHz
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)



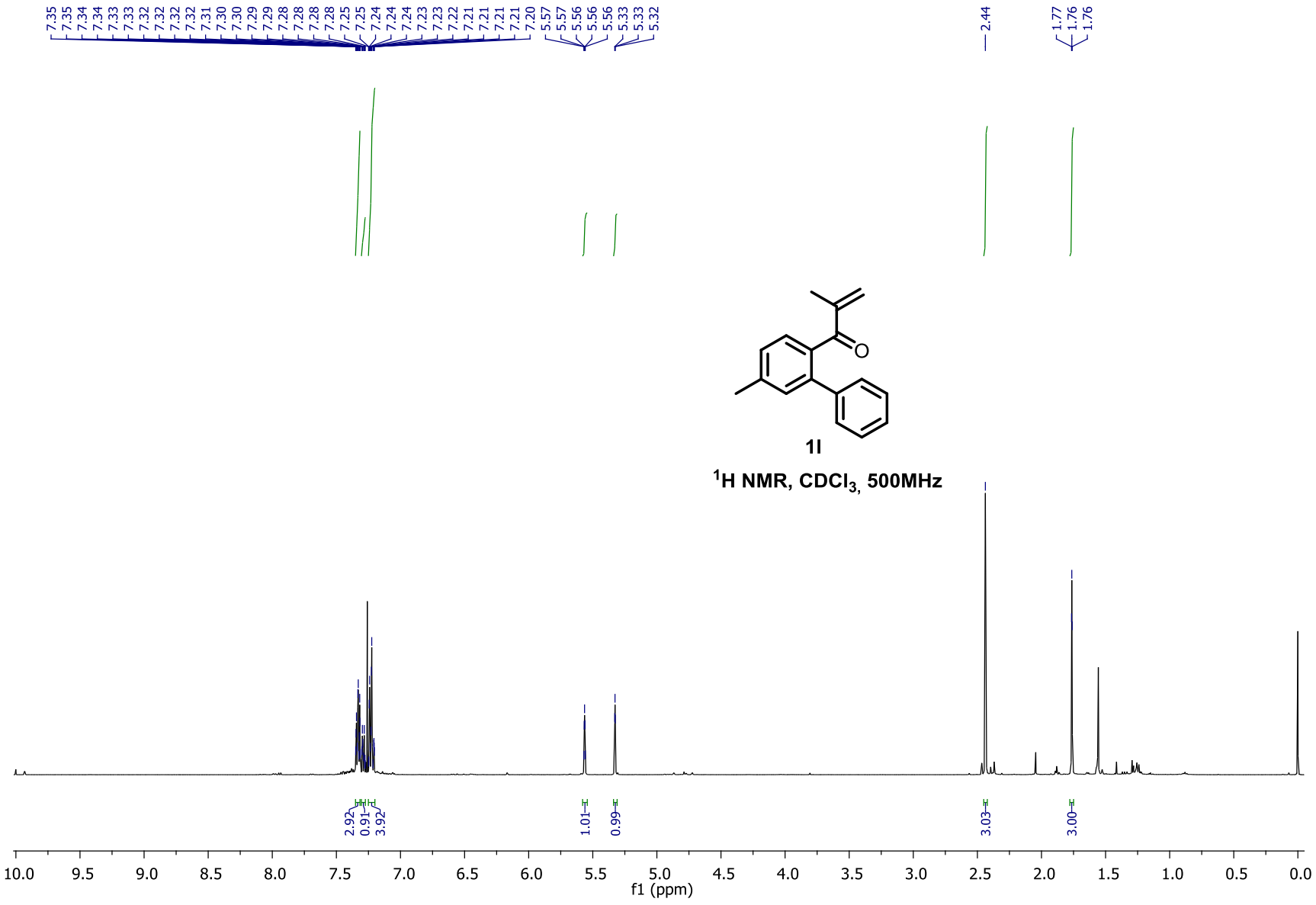
1k

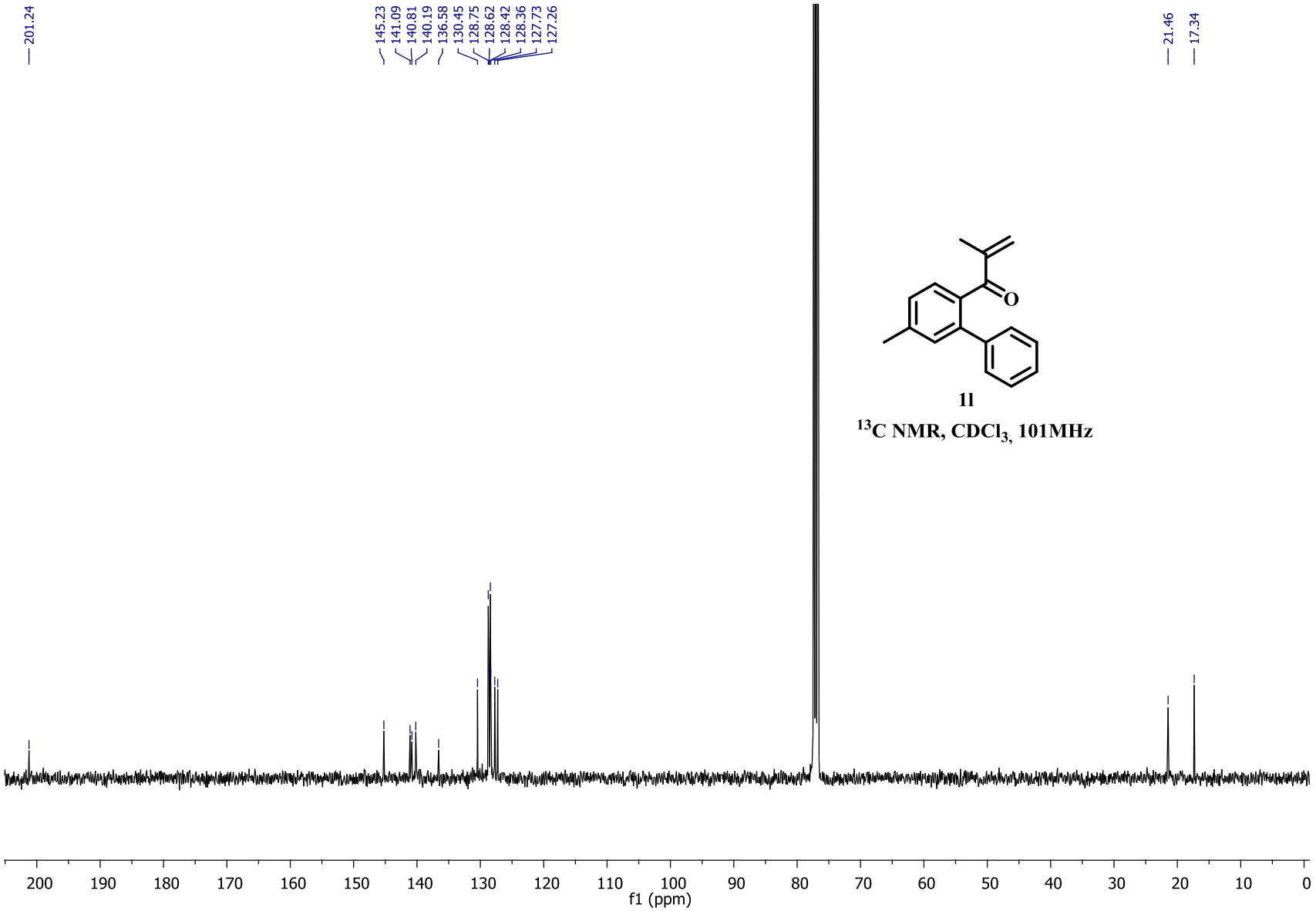
^{1}H NMR, $CDCl_3$, 500MHz



1k

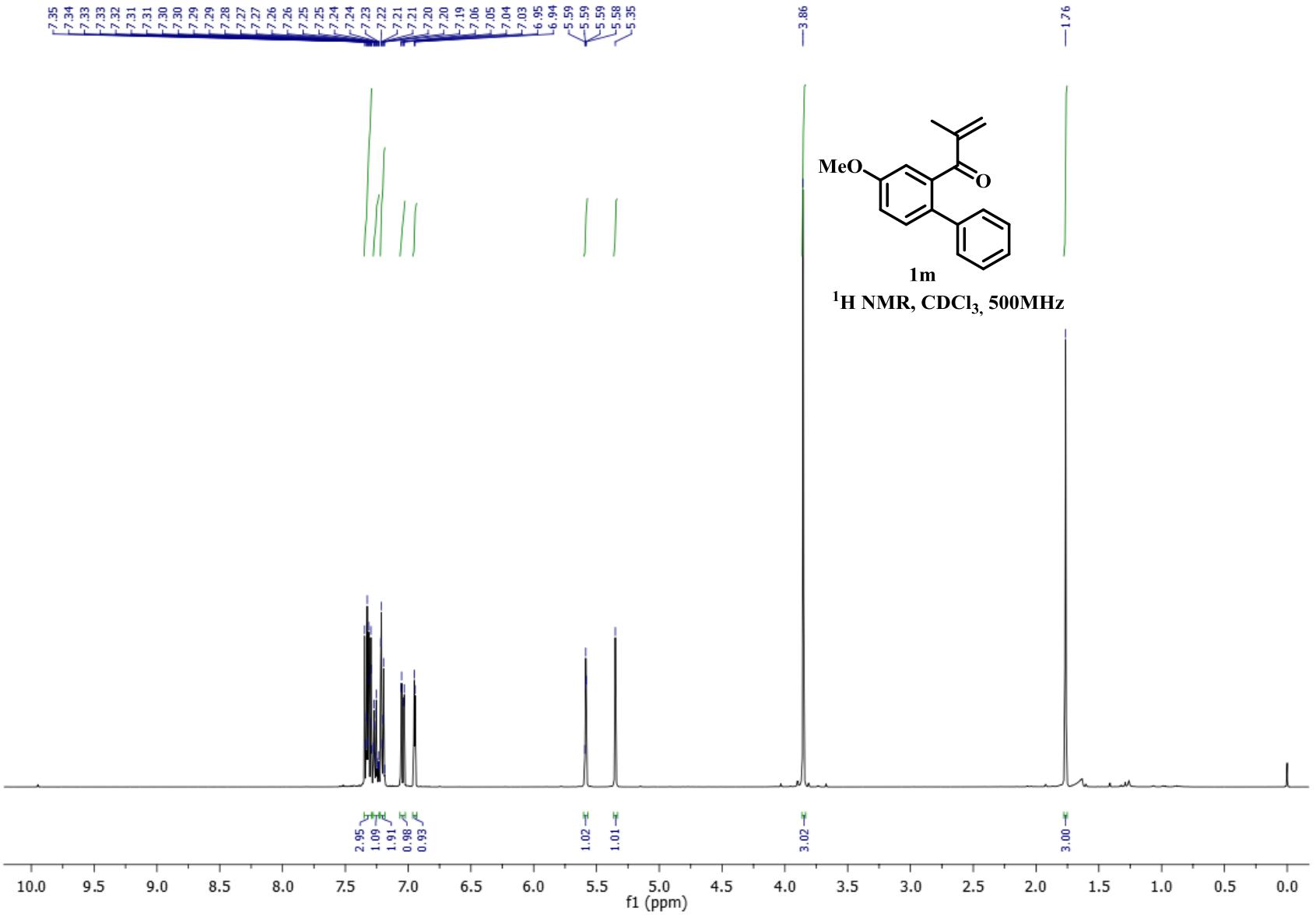
^{13}C NMR, $CDCl_3$, 126MHz

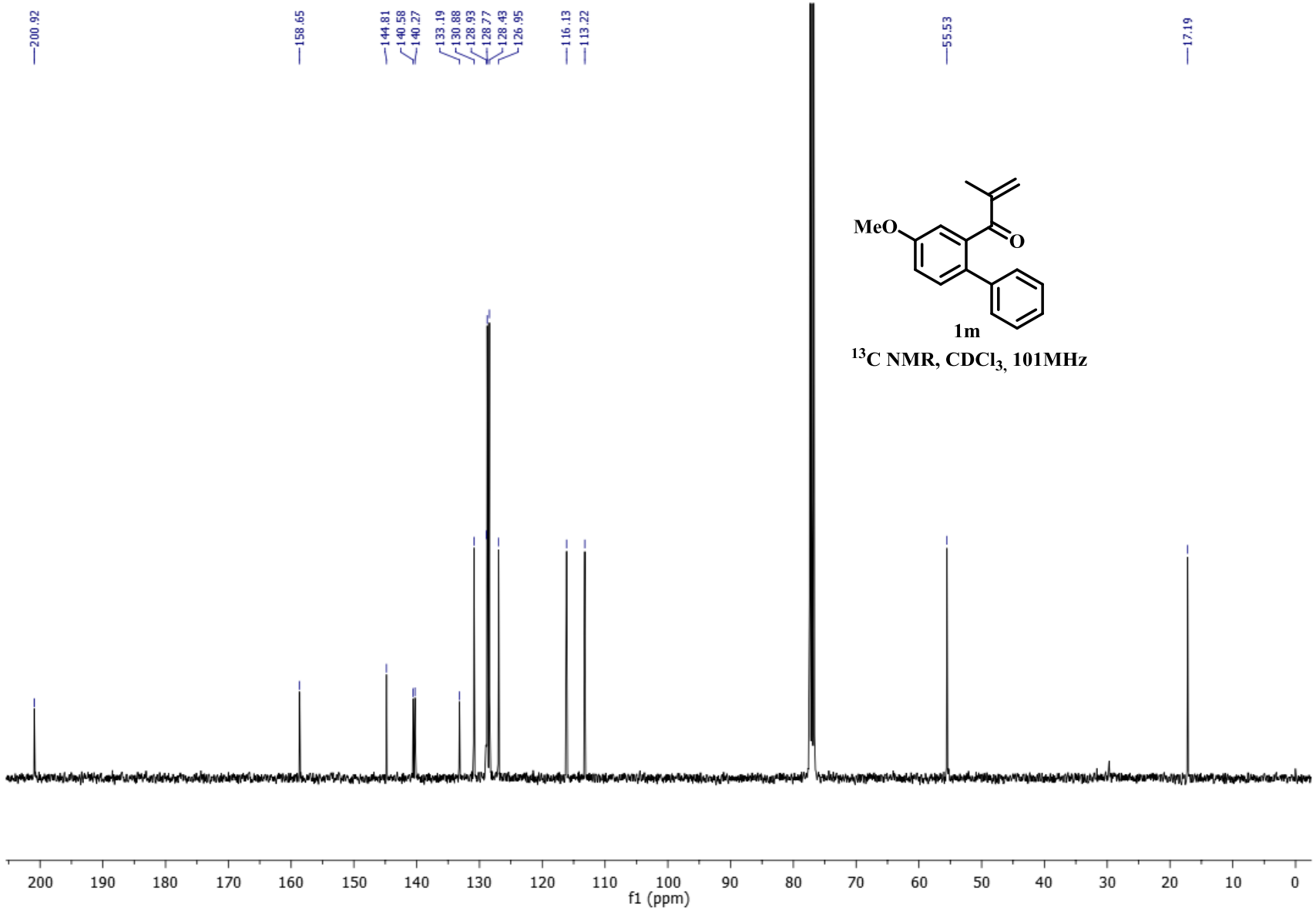

7.35
7.35
7.34
7.34
7.33
7.33
7.32
7.32
7.32
7.32
7.31
7.30
7.30
7.29
7.29
7.28
7.28
7.28
7.28
7.25
7.25
7.24
7.24
7.24
7.23
7.23
7.22
7.21
7.21
7.21
7.21
7.20
5.57
5.57
5.56
5.56
5.56
5.33
5.33
5.32
2.44
1.77
1.76
1.76
O
1l
^{1}H NMR, CDCl$_3$, 500MHz
2.92
0.91
3.92
1.01
0.99
3.03
3.00
10.0
9.5
9.0
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)

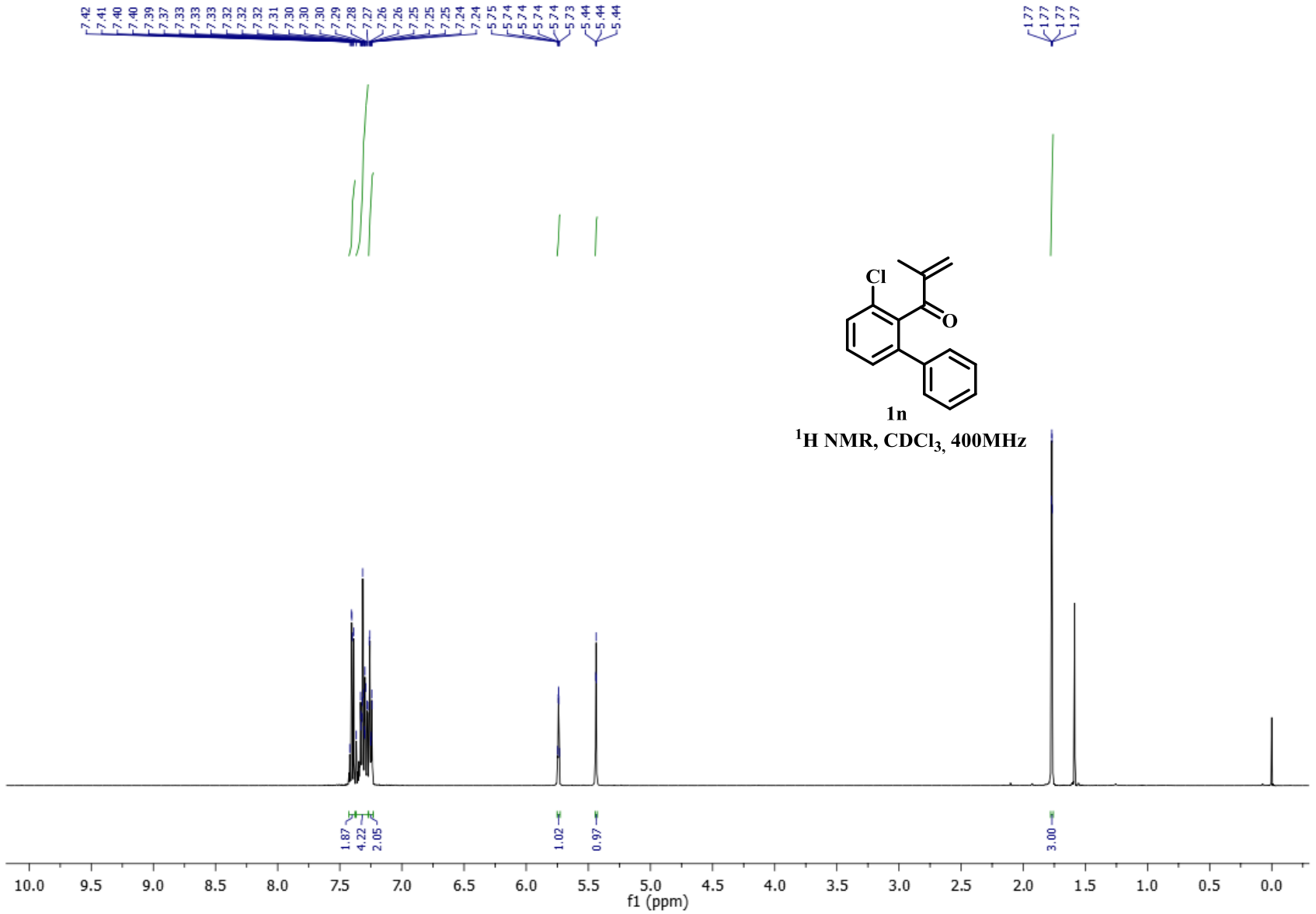


1l

^{13}C NMR, $CDCl_3$, 101MHz

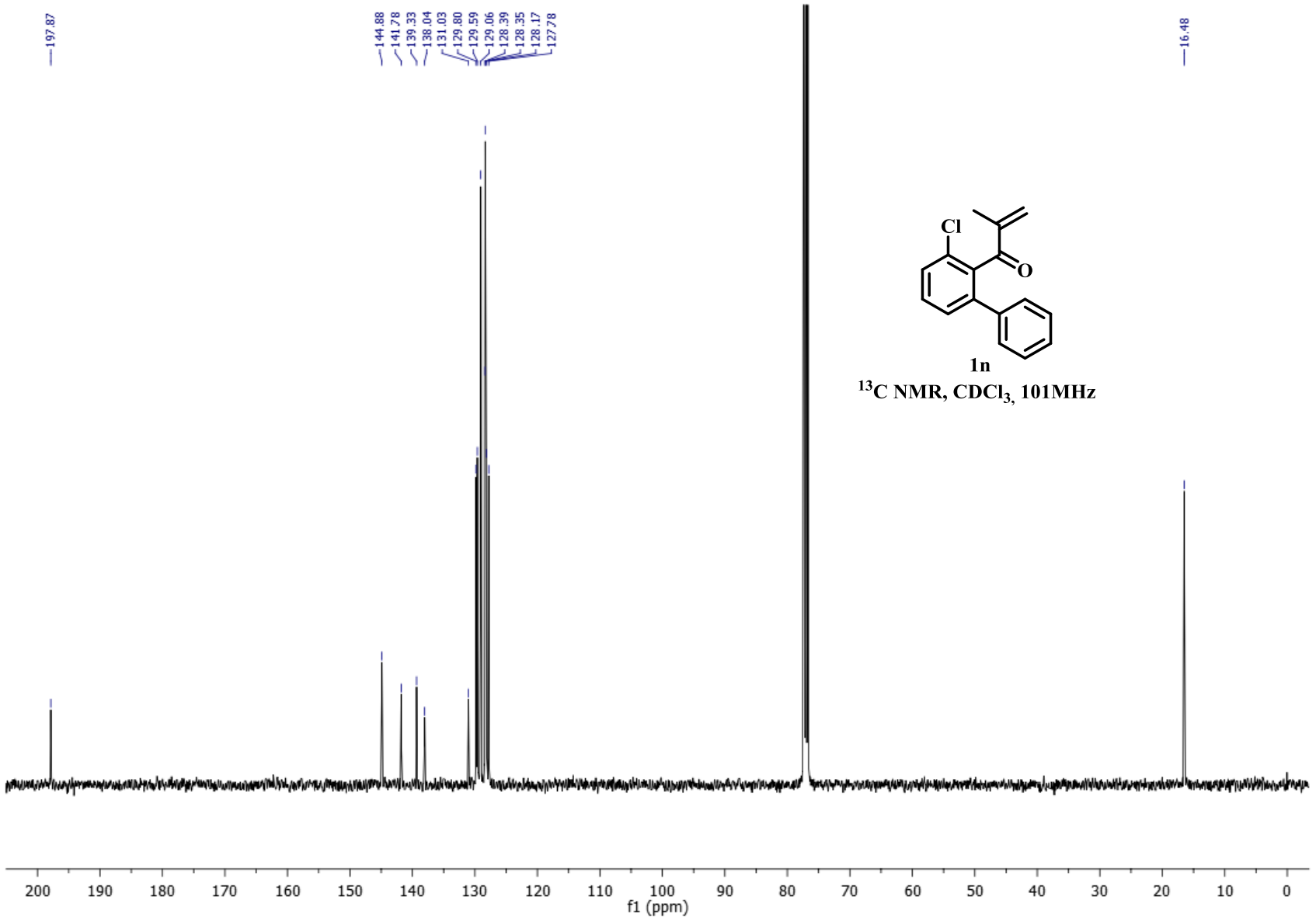

MeO
O
1m
^{1}H NMR, $CDCl_3$, 500MHz
f1 (ppm)


200.92
158.65
144.81
140.58
140.27
133.19
130.88
128.93
128.77
128.43
126.95
116.13
113.22
55.53
17.19
MeO
O
1m
^{13}C NMR, CDCl$_3$, 101MHz
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)



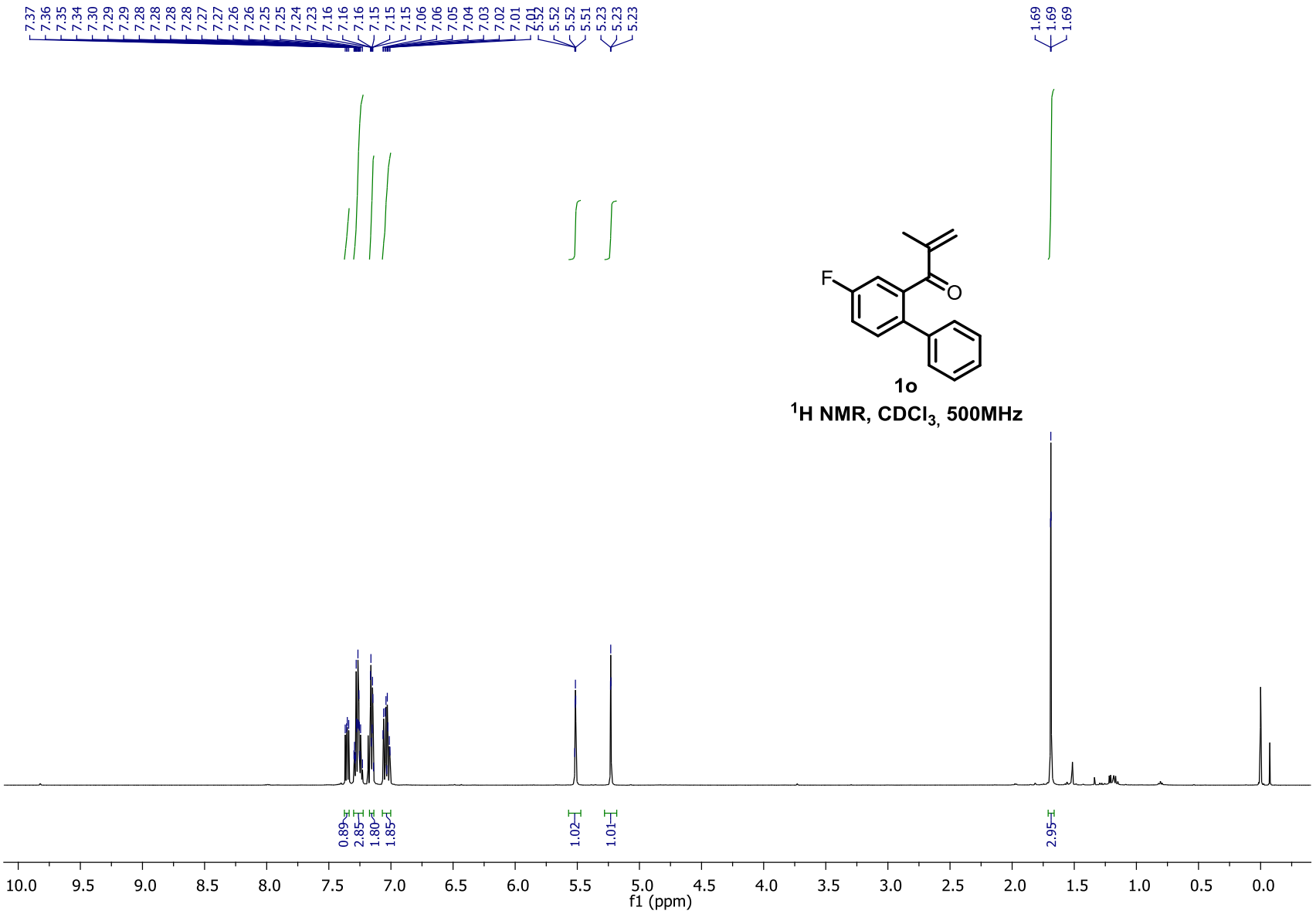
1n

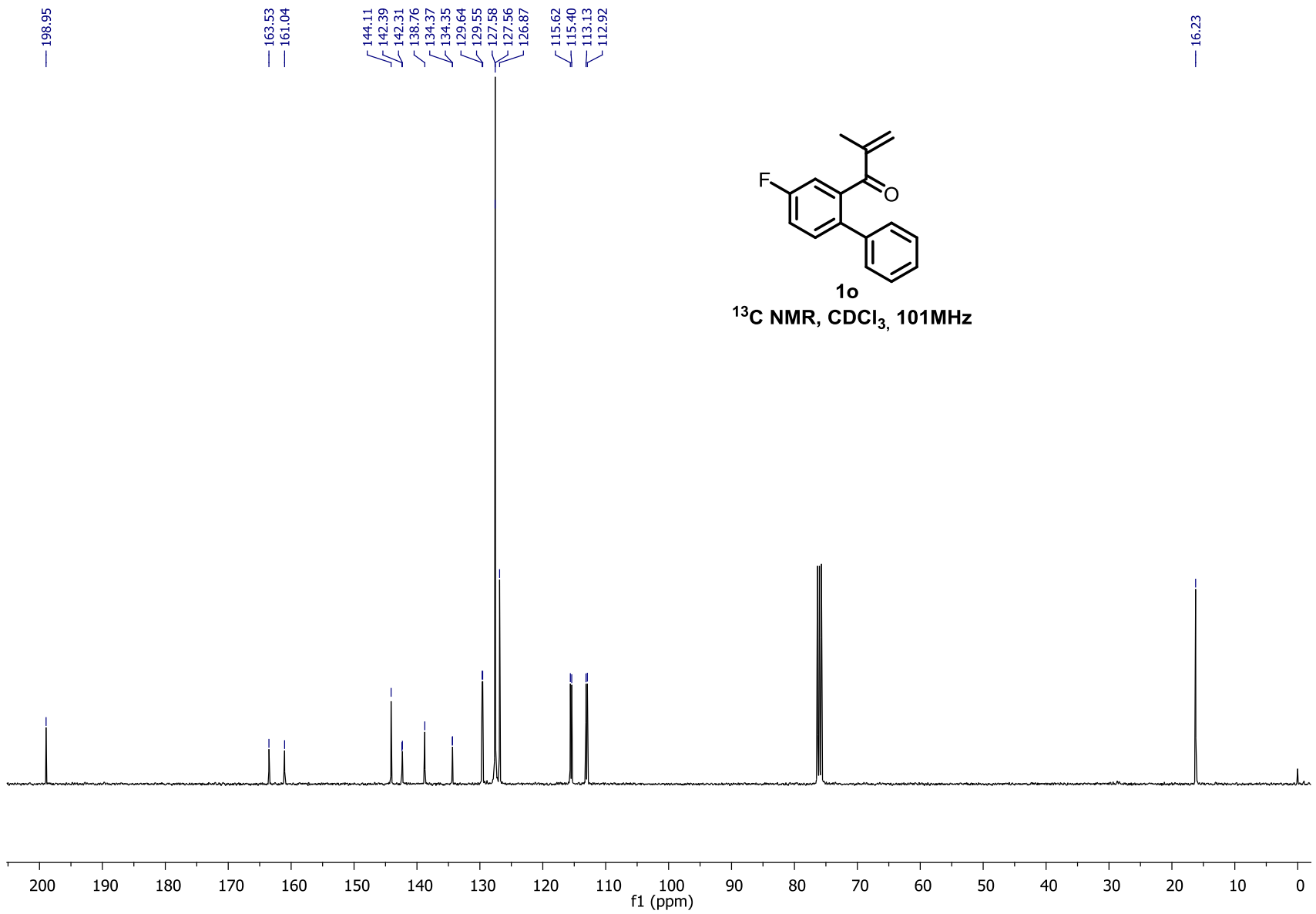
^{1}H NMR, $CDCl_3$, 400MHz

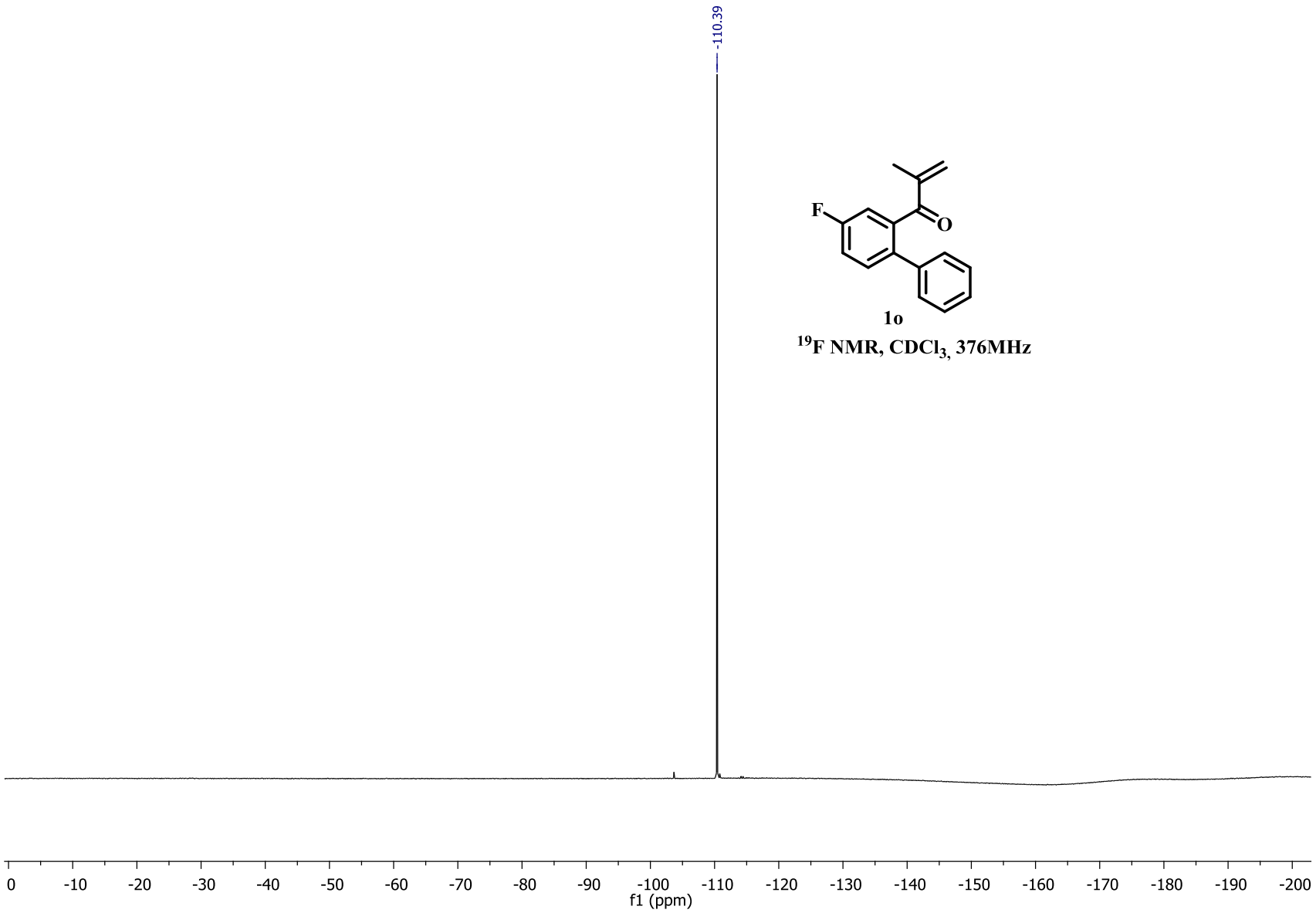


1n

^{13}C NMR, $CDCl_3$, 101MHz

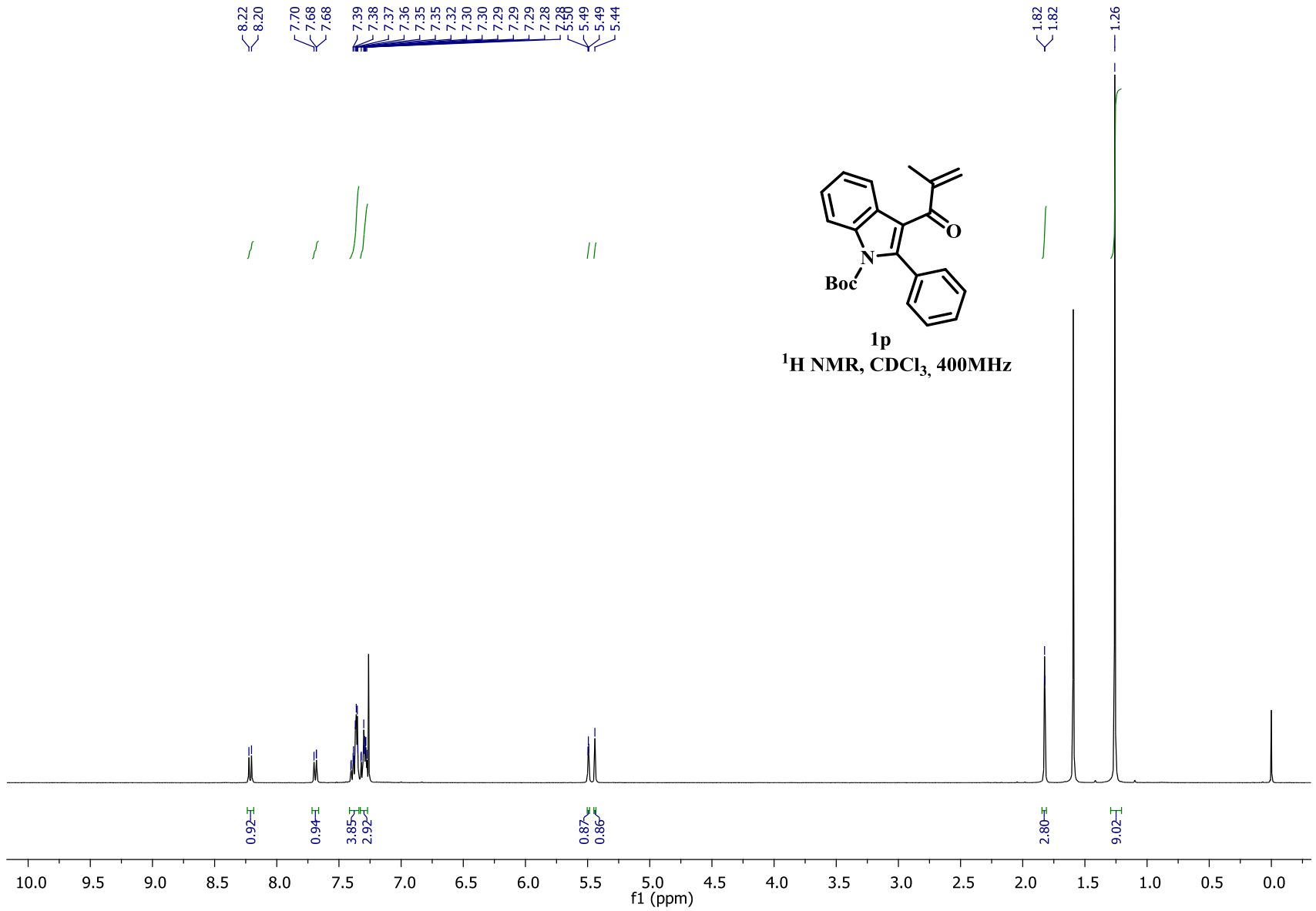

7.37
7.36
7.35
7.34
7.30
7.29
7.29
7.28
7.28
7.28
7.28
7.27
7.27
7.26
7.26
7.25
7.25
7.24
7.23
7.16
7.16
7.15
7.15
7.15
7.06
7.06
7.05
7.04
7.03
7.02
7.01
7.01
5.52
5.52
5.52
5.51
5.23
5.23
5.23
1.69
1.69
1.69
F
O
1o
1H NMR, CDCl3, 500MHz
0.89
2.85
1.80
1.85
1.02
1.01
2.95
10.0
9.5
9.0
8.5
8.0
7.5
7.0
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)


198.95
163.53
161.04
144.11
142.39
142.31
138.76
134.37
134.35
129.64
129.55
127.58
127.56
126.87
115.62
115.40
113.13
112.92
16.23
F
O
1o
13C NMR, CDCl3, 101MHz
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)



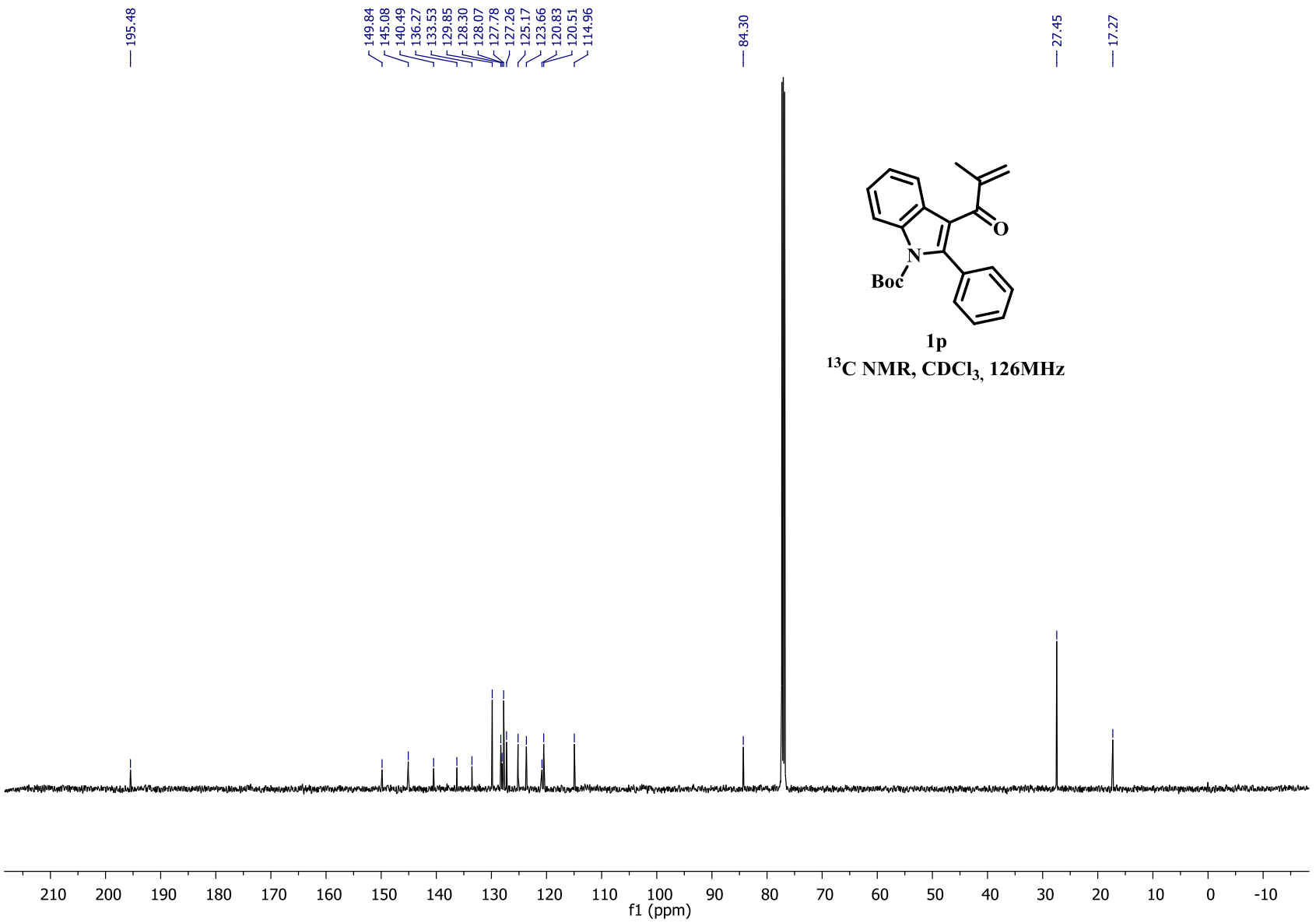
1o

^{19}F NMR, $CDCl_3$, 376MHz



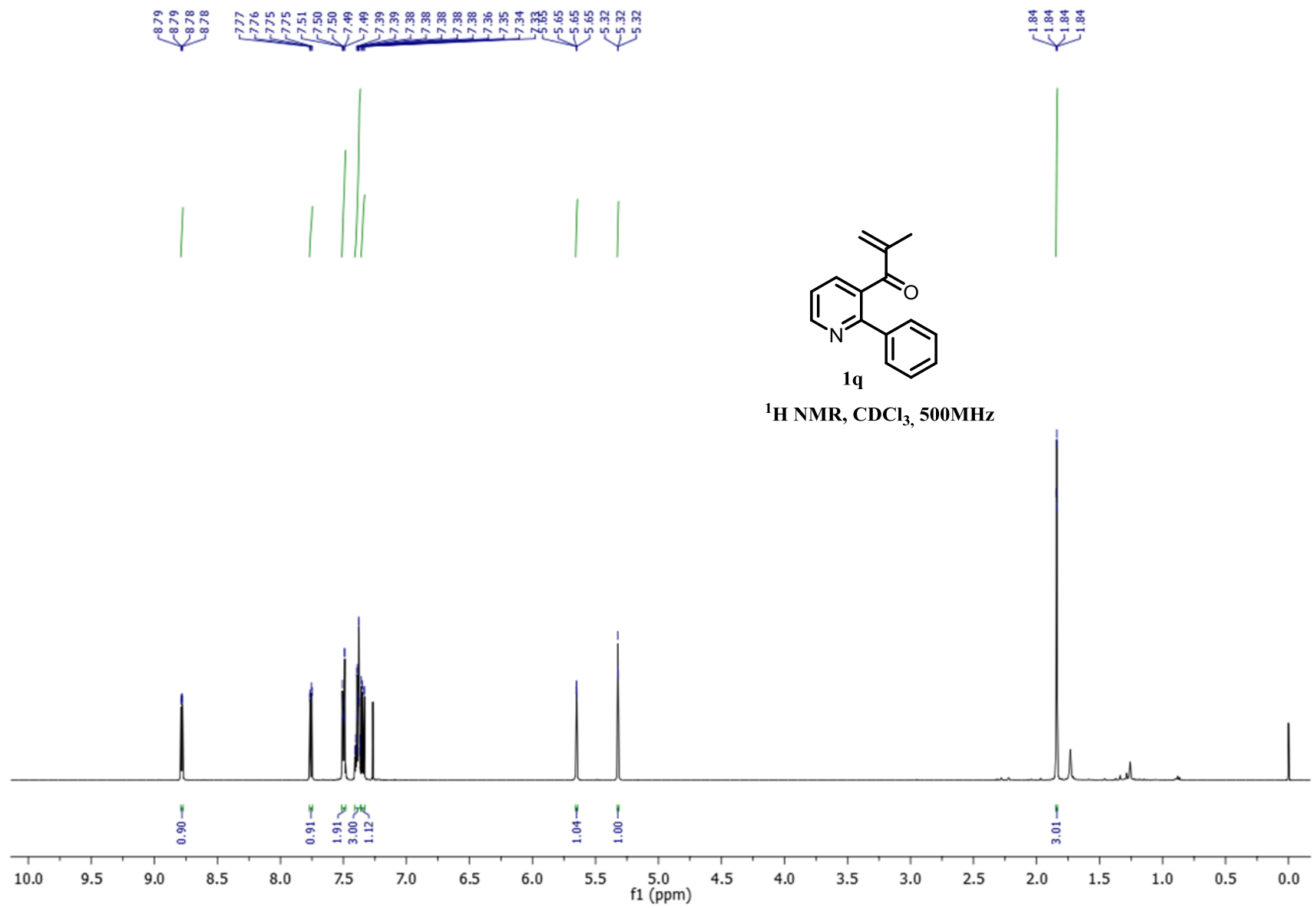
1p

^{1}H NMR, $CDCl_3$, 400MHz



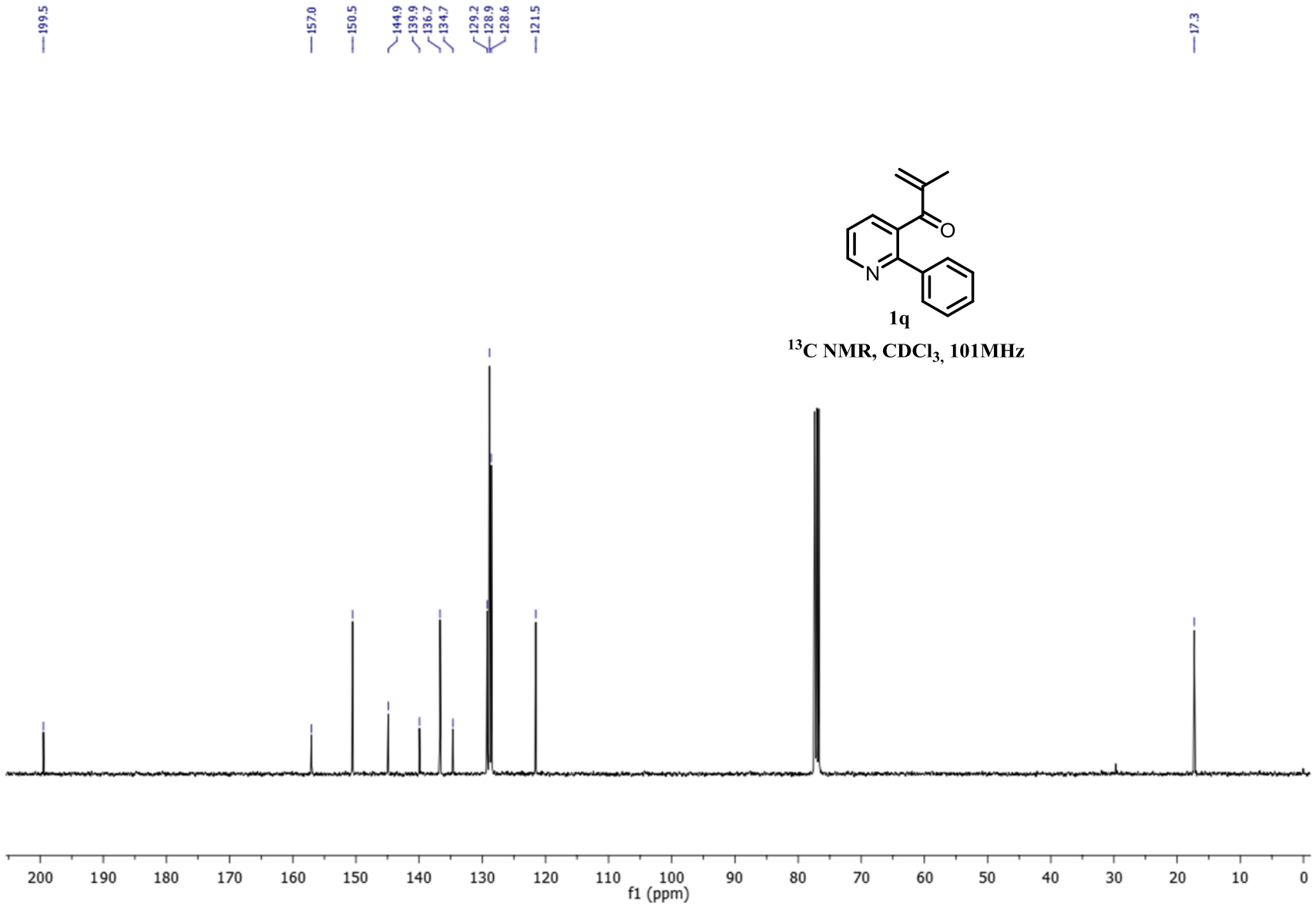
1p

^{13}C NMR, $CDCl_3$, 126MHz



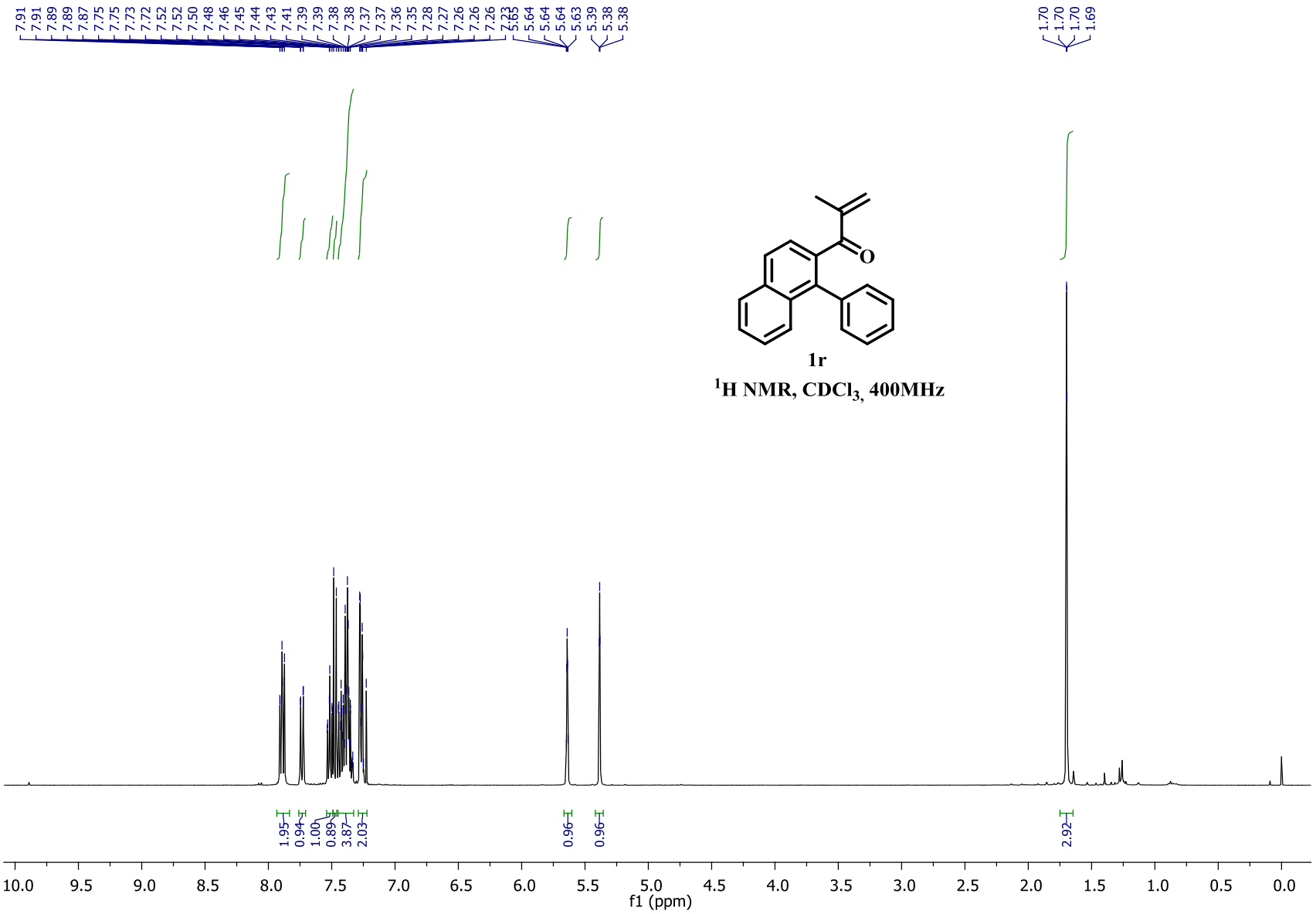
1q

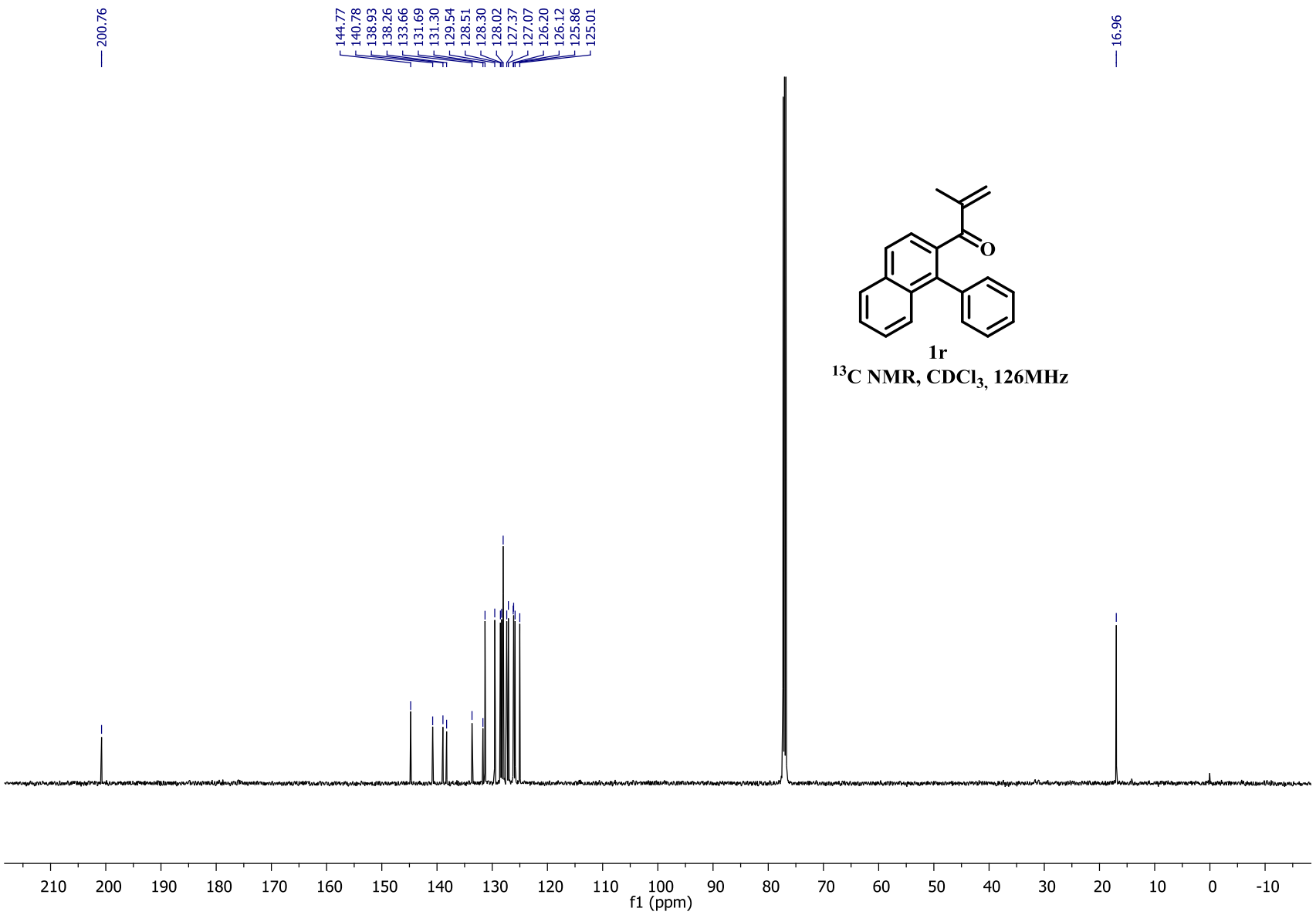
^{1}H NMR, $CDCl_3$, 500MHz

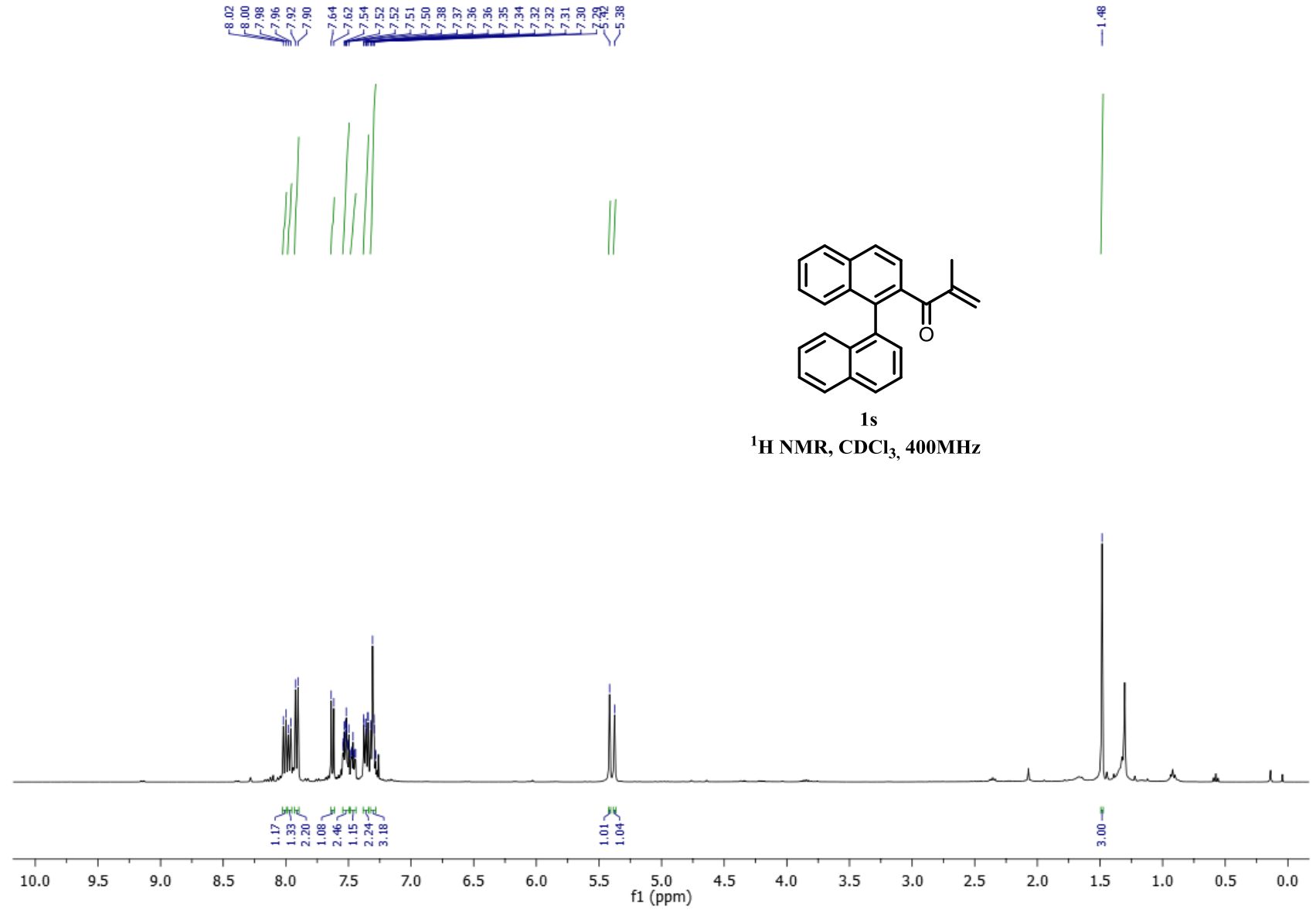


1q

^{13}C NMR, $CDCl_3$, 101MHz

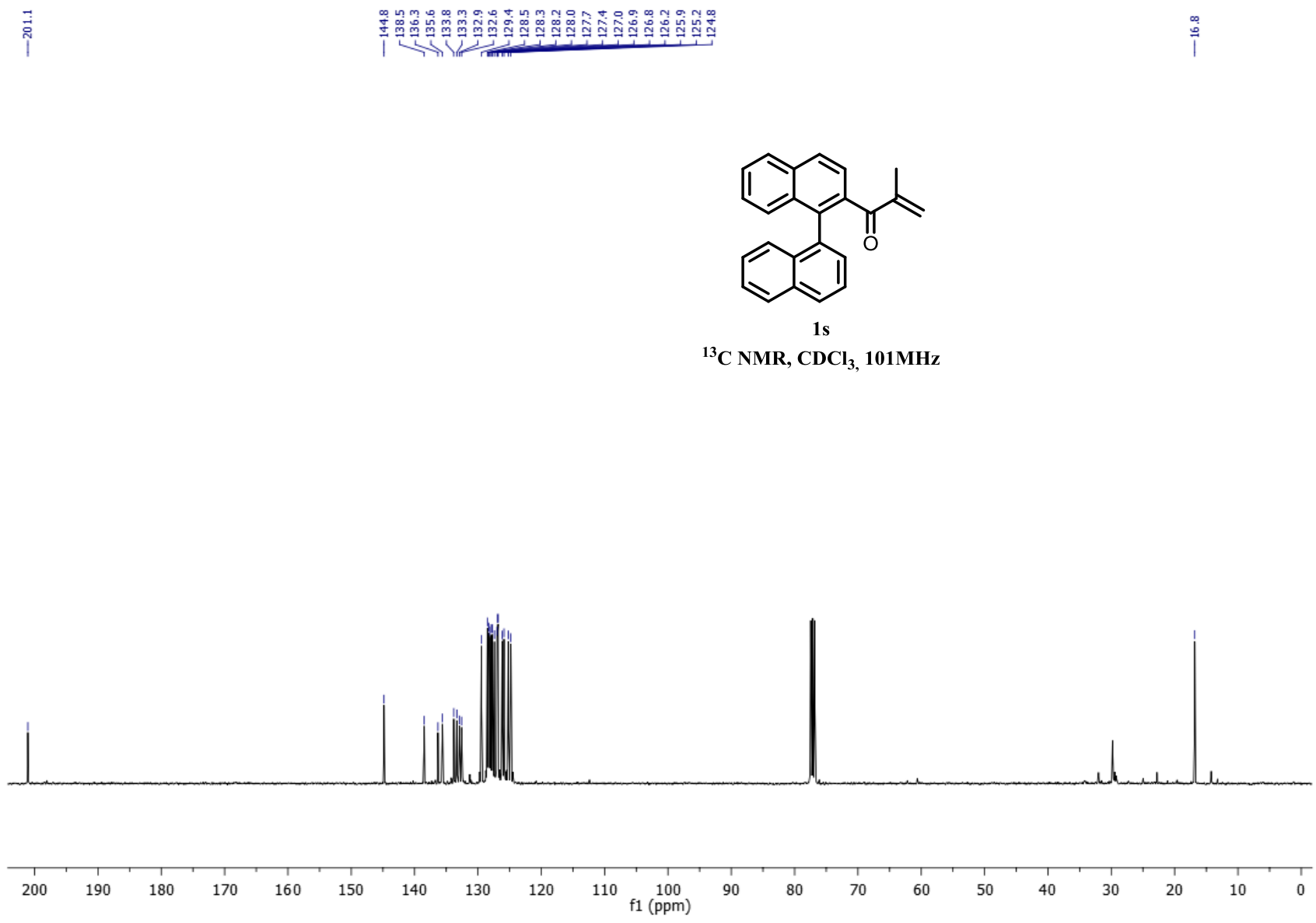

7.91
7.91
7.89
7.89
7.87
7.75
7.75
7.73
7.72
7.52
7.52
7.50
7.48
7.46
7.45
7.44
7.43
7.41
7.39
7.39
7.38
7.38
7.37
7.37
7.36
7.35
7.28
7.27
7.26
7.26
7.26
5.64
5.64
5.63
5.39
5.38
5.38
1.70
1.70
1.70
1.69
O
1r
1H NMR, CDCl3, 400MHz
1.95
0.94
1.00
0.89
3.87
2.03
0.96
0.96
2.92
10.0
9.5
9.0
8.5
8.0
7.5
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)


200.76
144.77
140.78
138.93
138.26
133.66
131.69
131.30
129.54
128.51
128.30
128.02
127.37
127.07
126.20
126.12
125.86
125.01
16.96
O
1r
13C NMR, CDCl3, 126MHz
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)



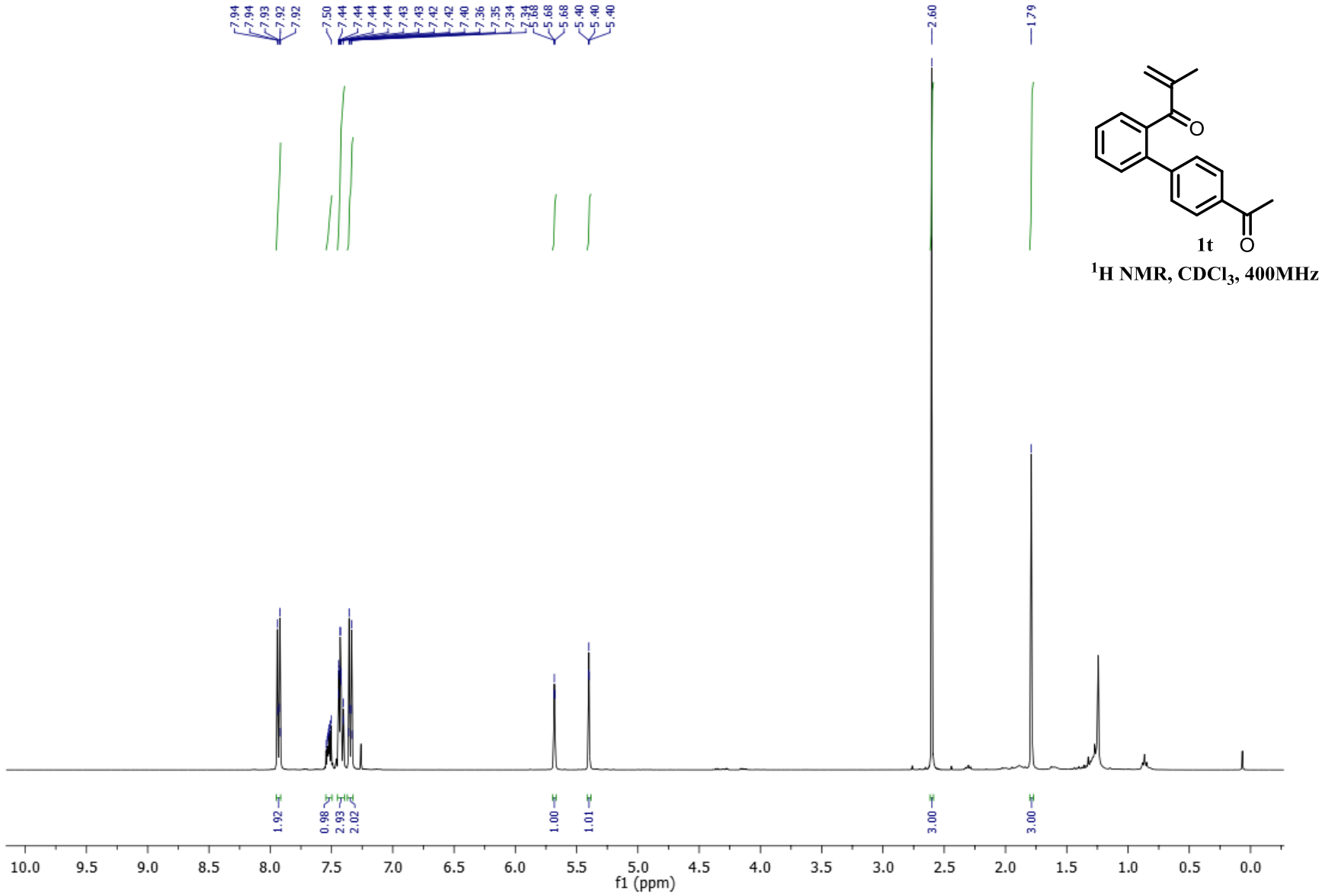
1s

^{1}H NMR, $CDCl_3$, 400MHz



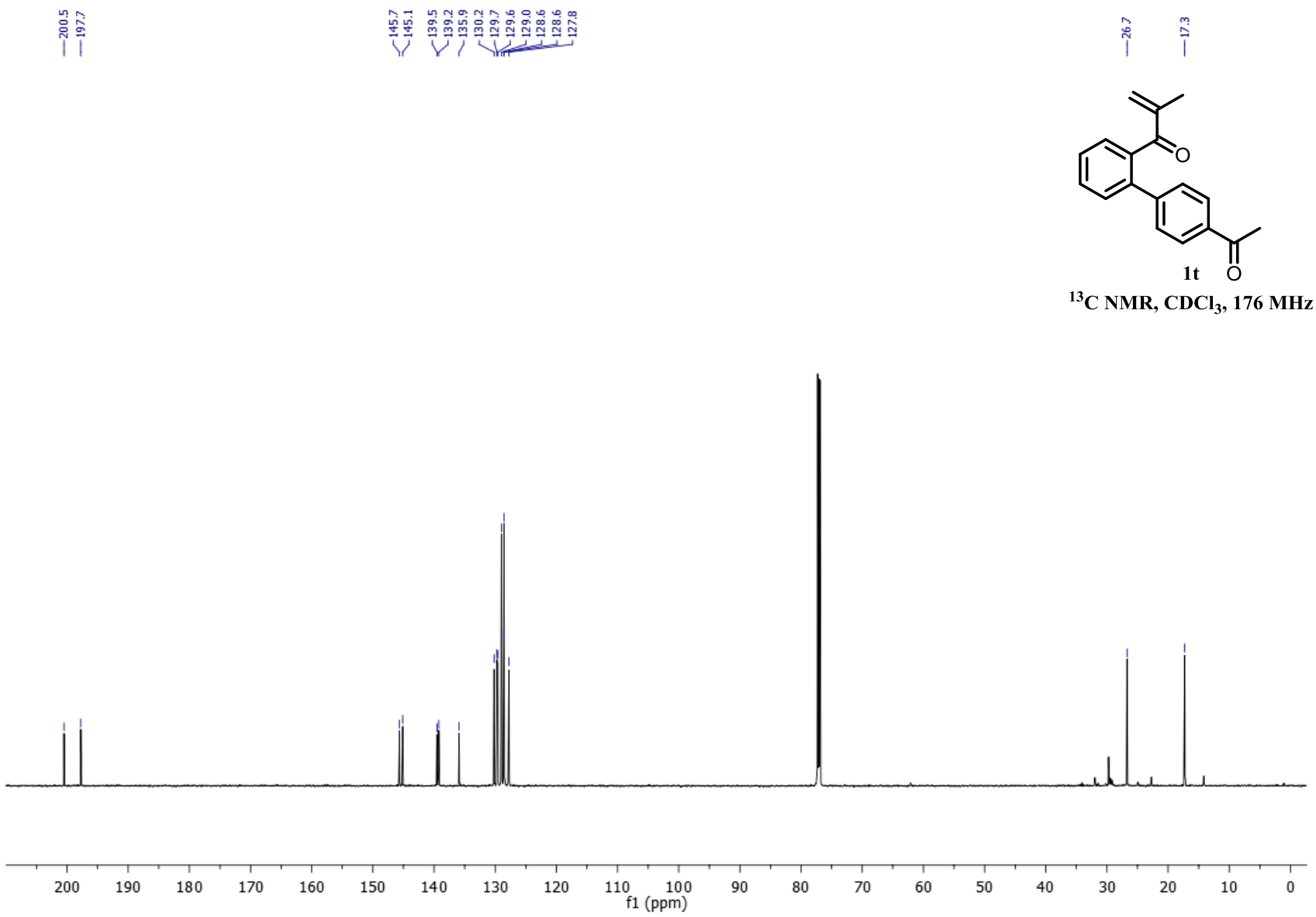
1s

^{13}C NMR, $CDCl_3$, 101MHz



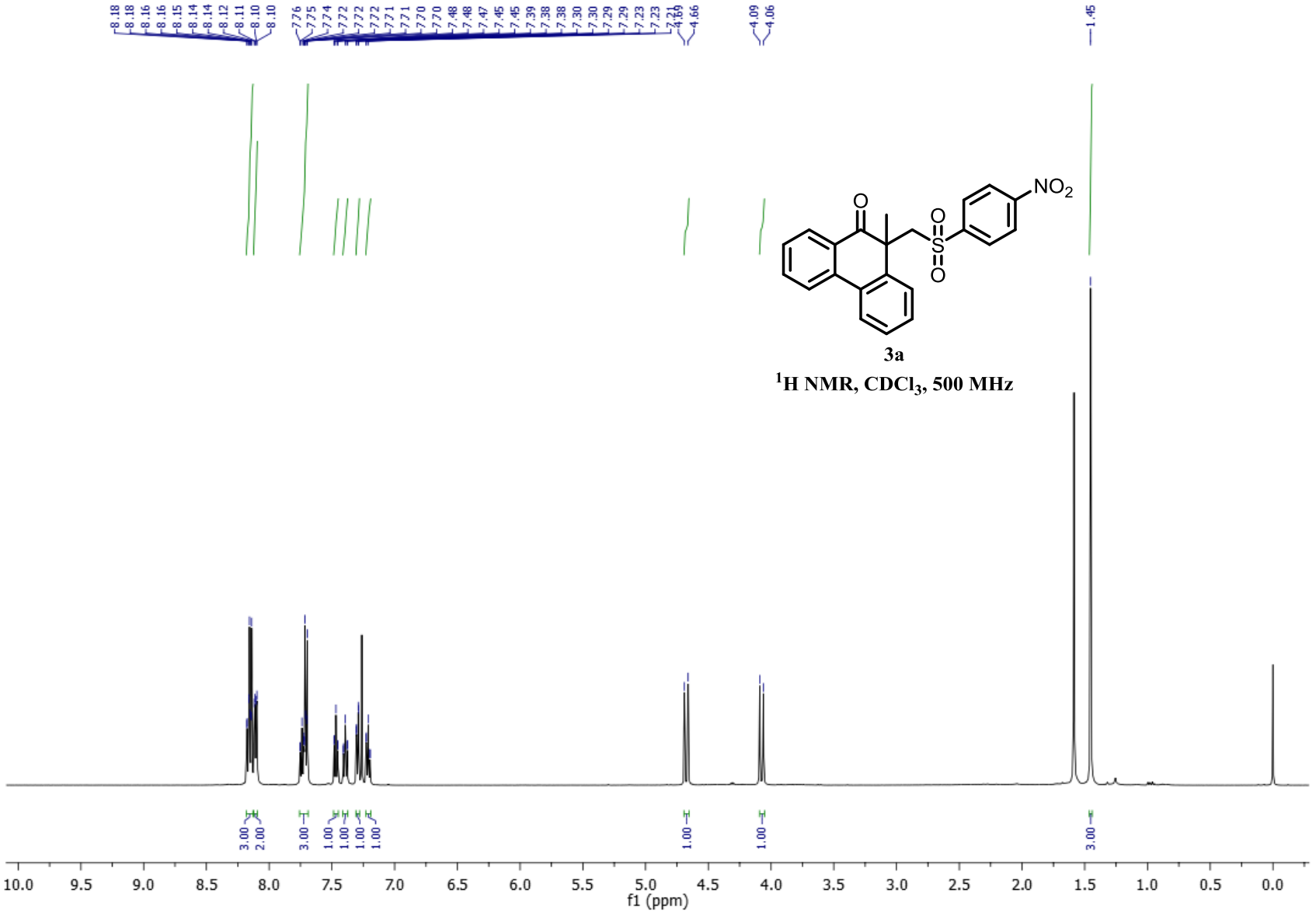
1t

^{1}H NMR, $CDCl_3$, 400MHz



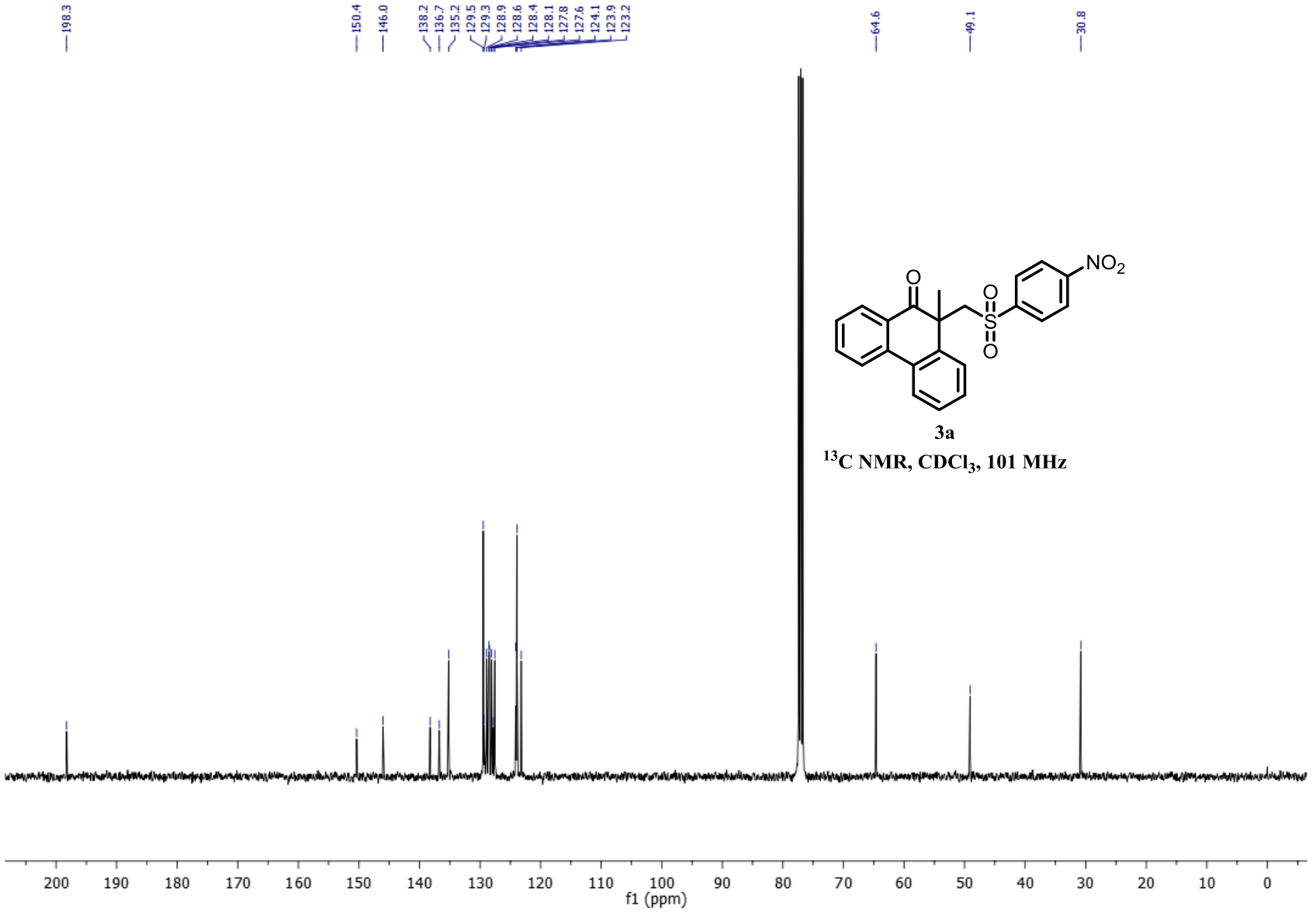
1t

^{13}C NMR, $CDCl_3$, 176 MHz



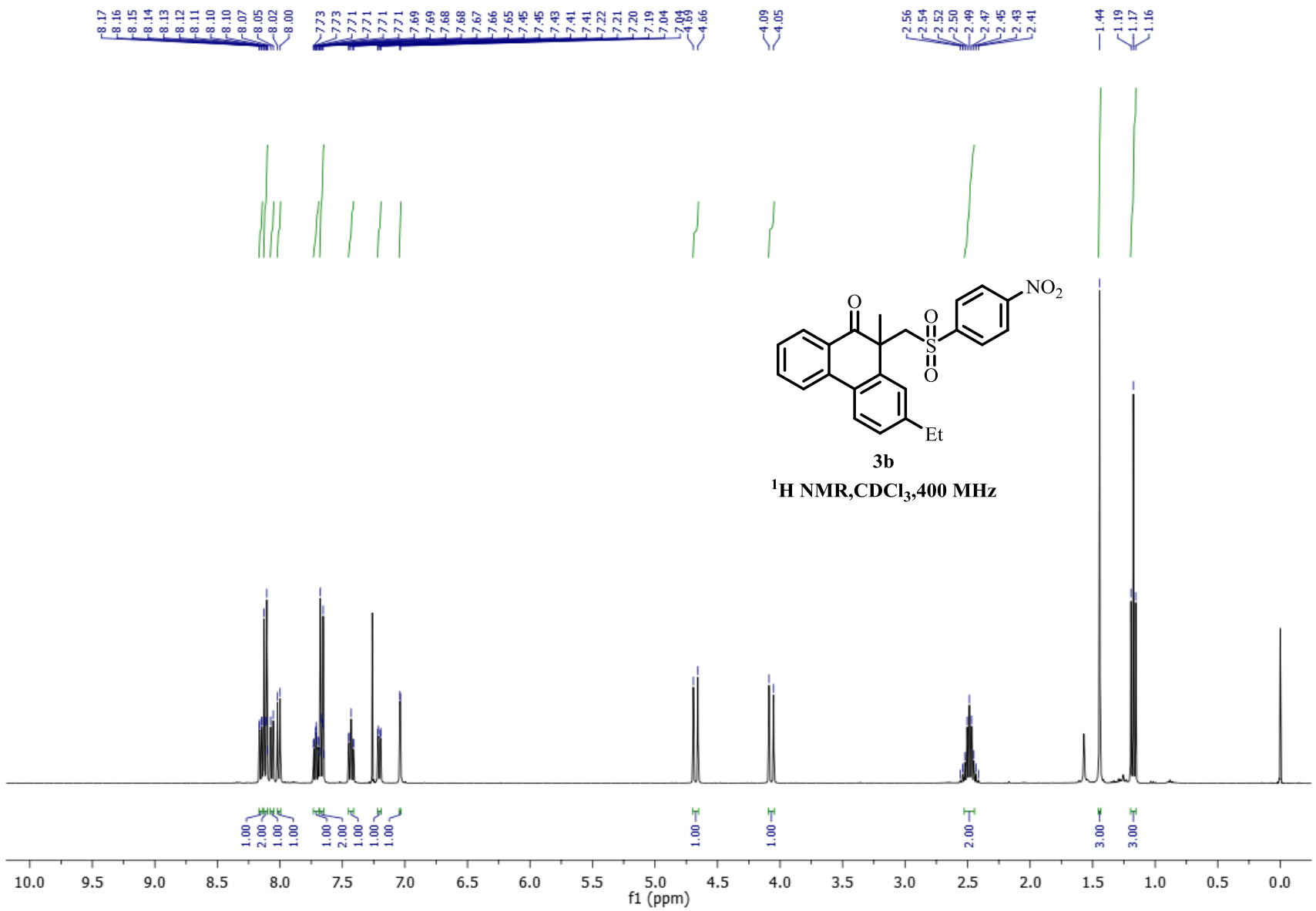
3a

^{1}H NMR, $CDCl_3$, 500 MHz



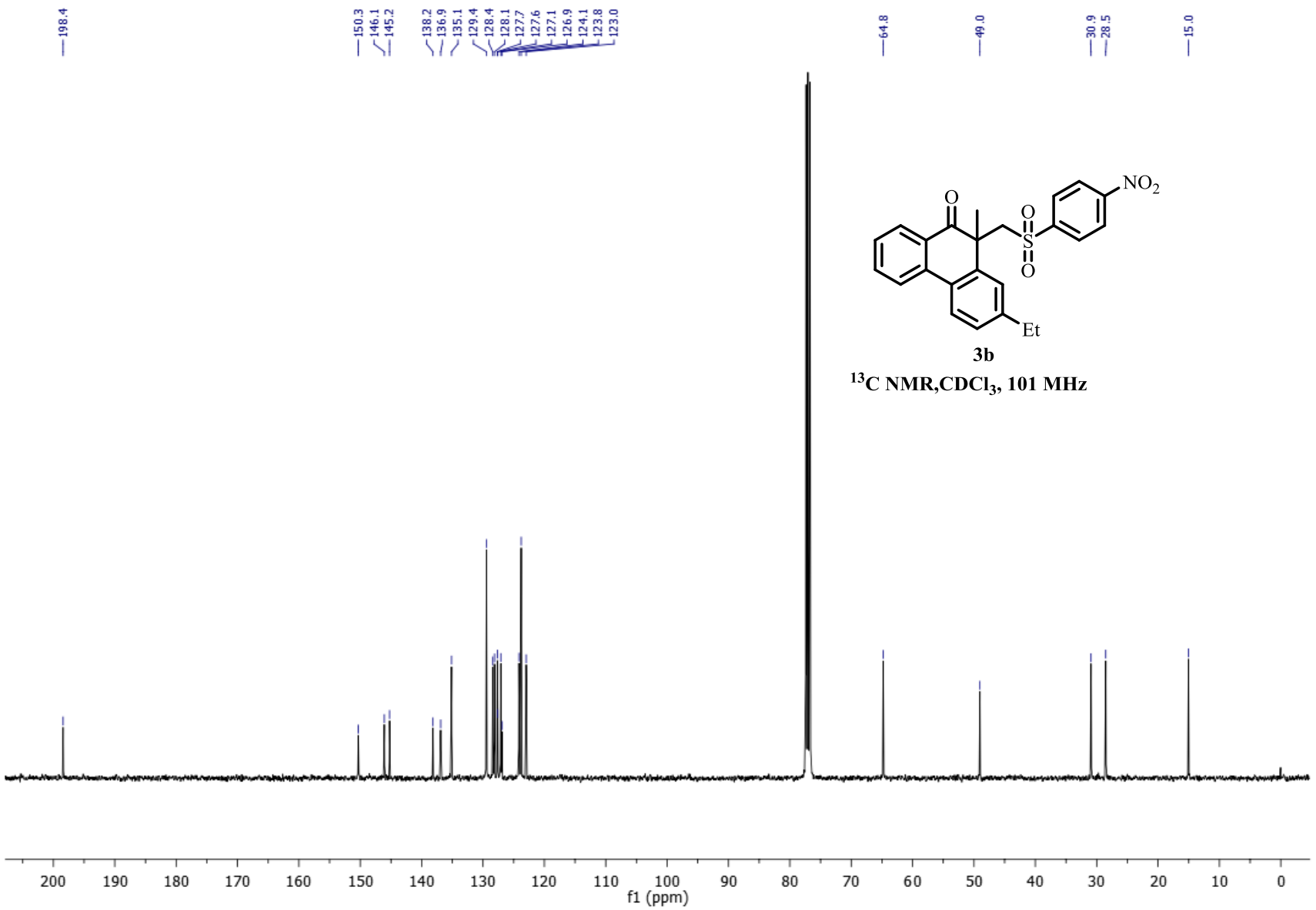
3a

^{13}C NMR, $CDCl_3$, 101 MHz



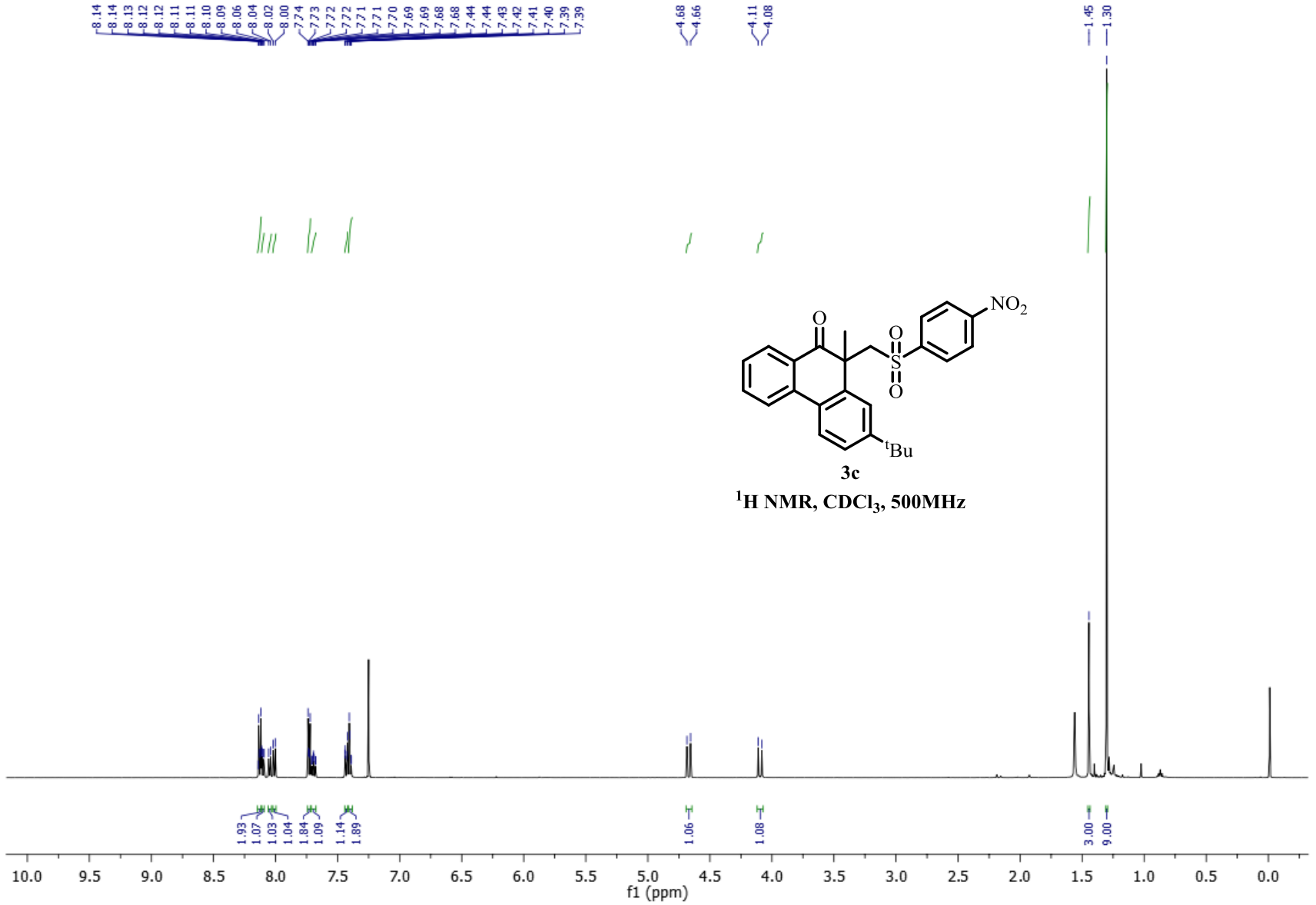
3b

^{1}H NMR,$CDCl_3$,400 MHz



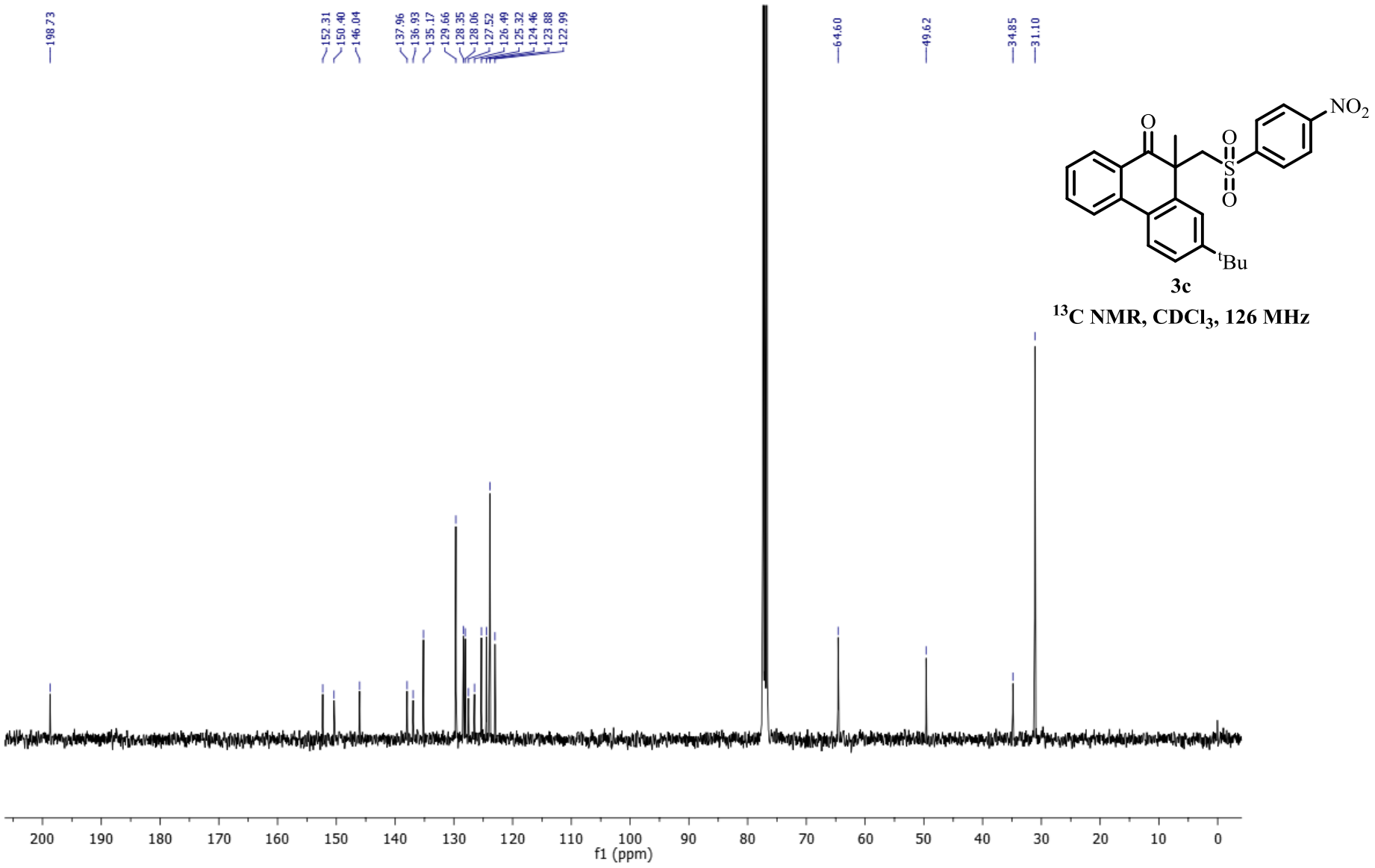
3b

^{13}C NMR,$CDCl_3$, 101 MHz



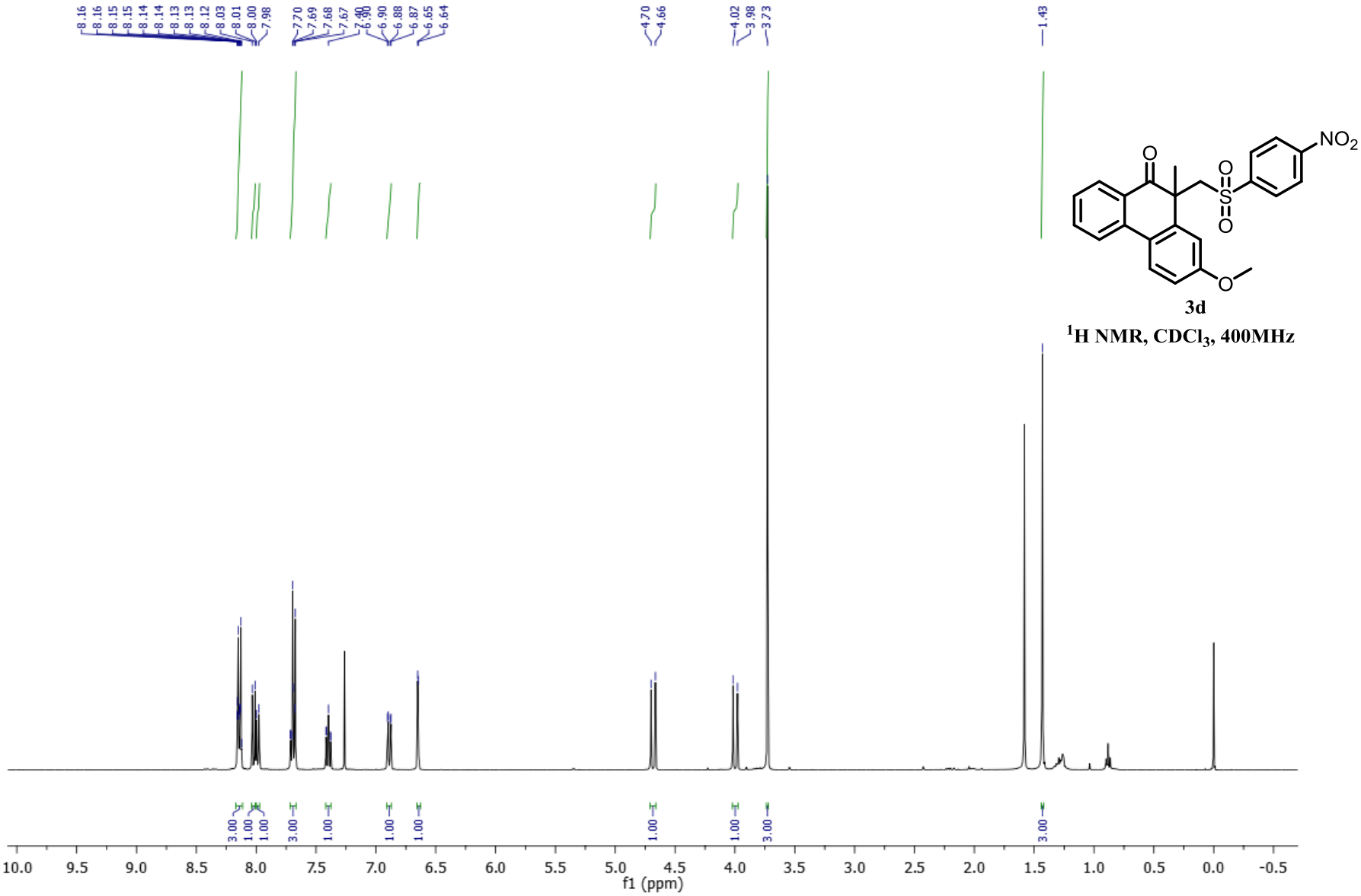
3c

^{1}H NMR, $CDCl_3$, 500MHz



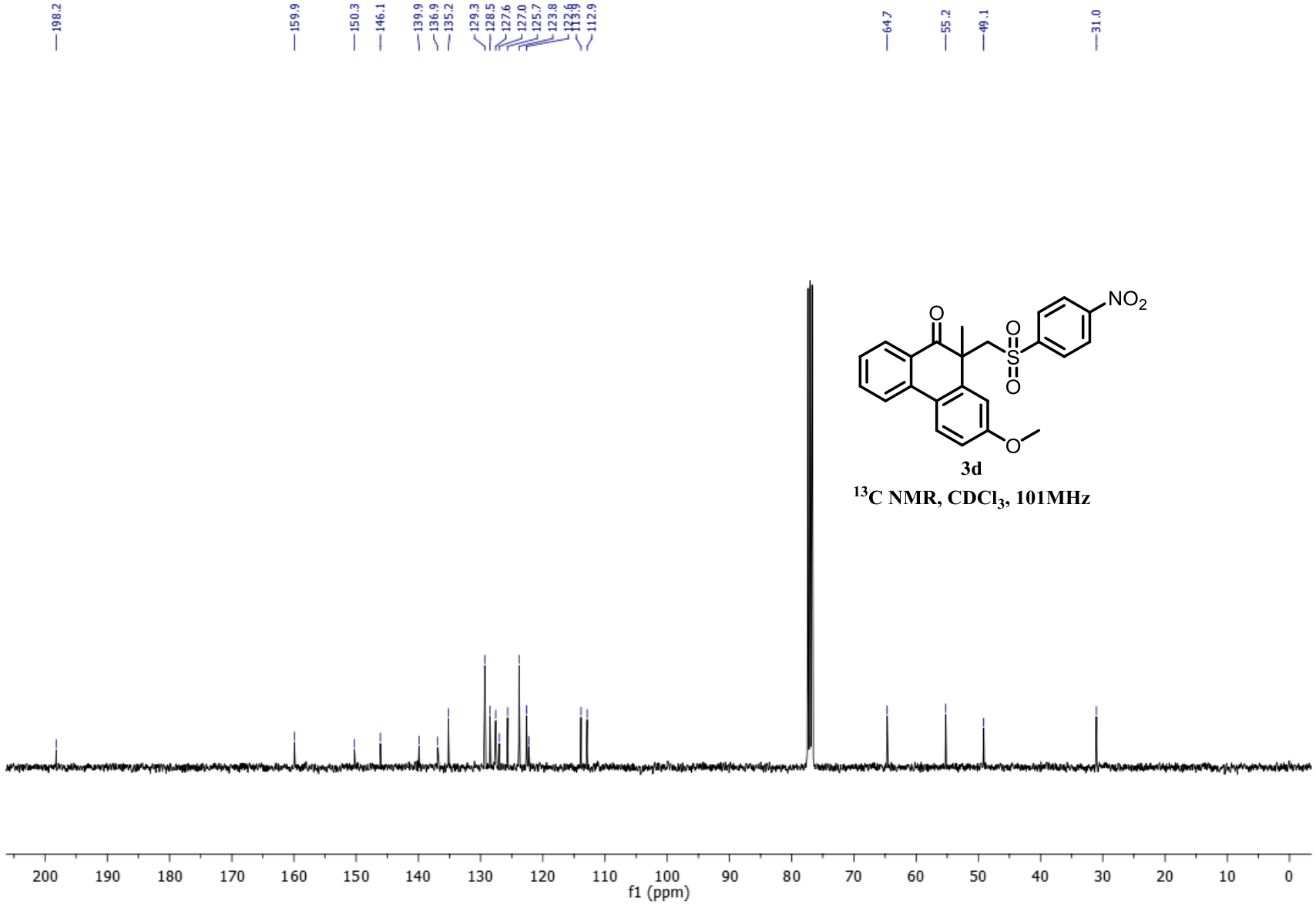
3c

^{13}C NMR, $CDCl_3$, 126 MHz



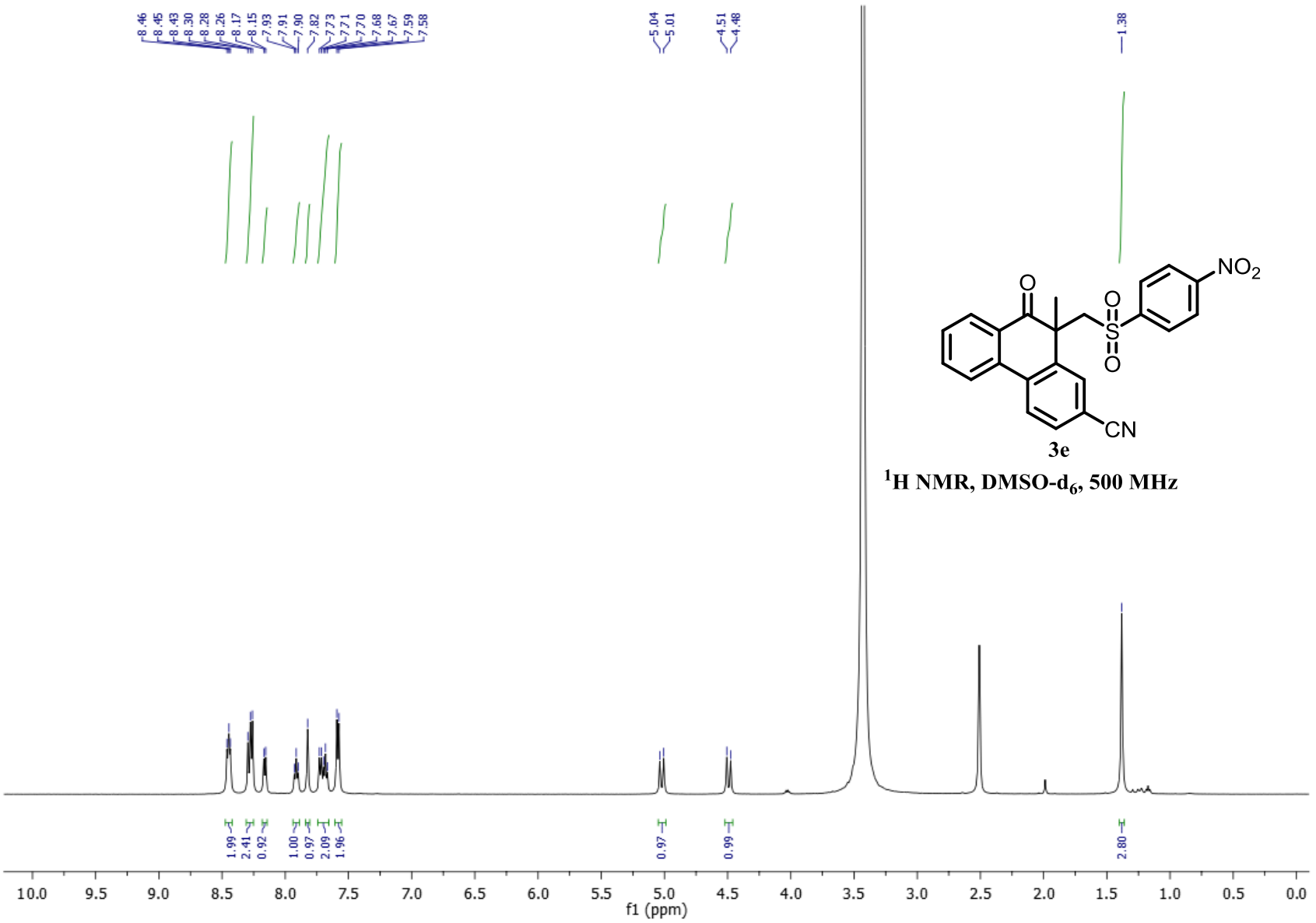
3d

^{1}H NMR, $CDCl_3$, 400MHz



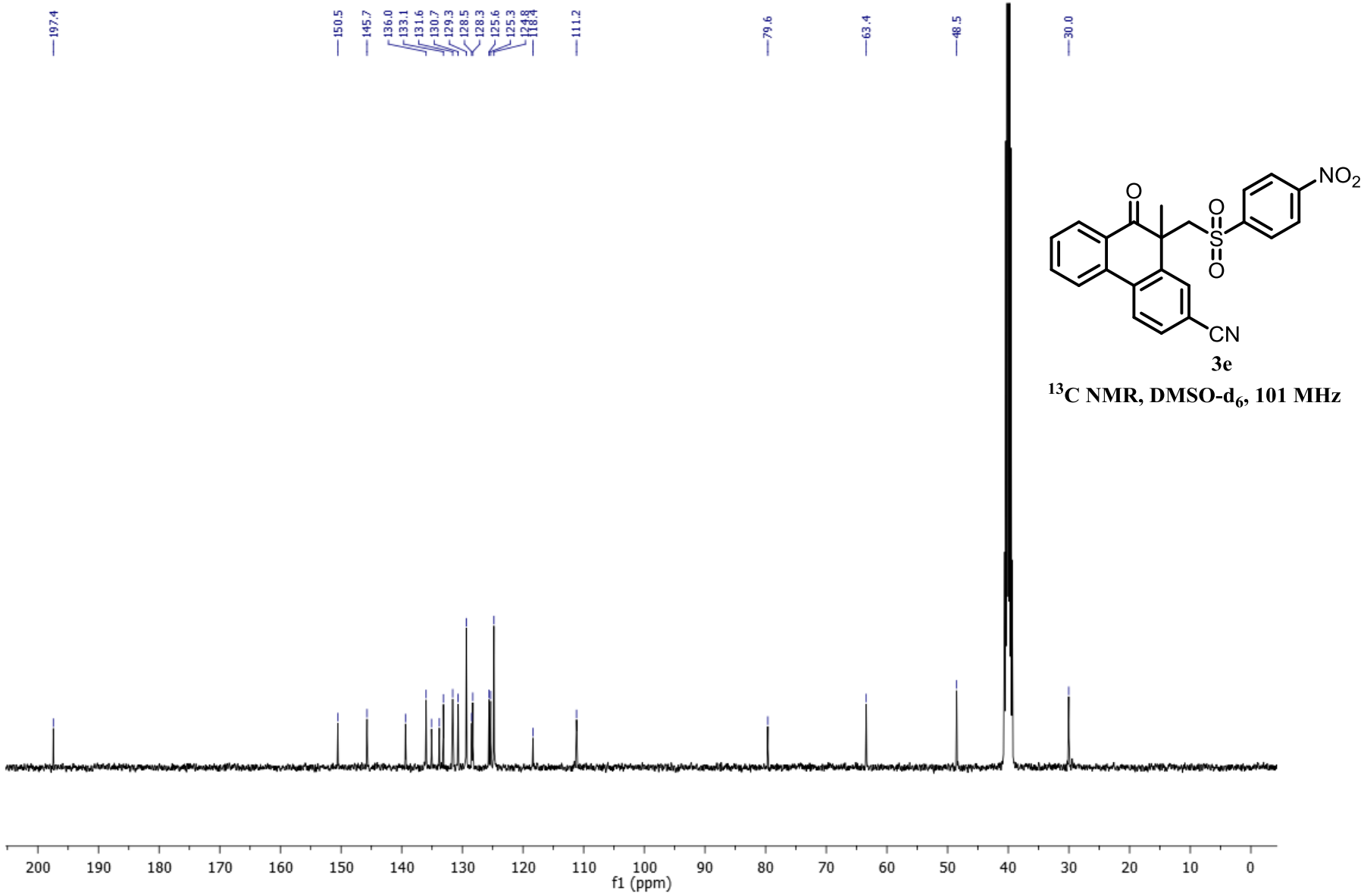
3d

^{13}C NMR, $CDCl_3$, 101MHz



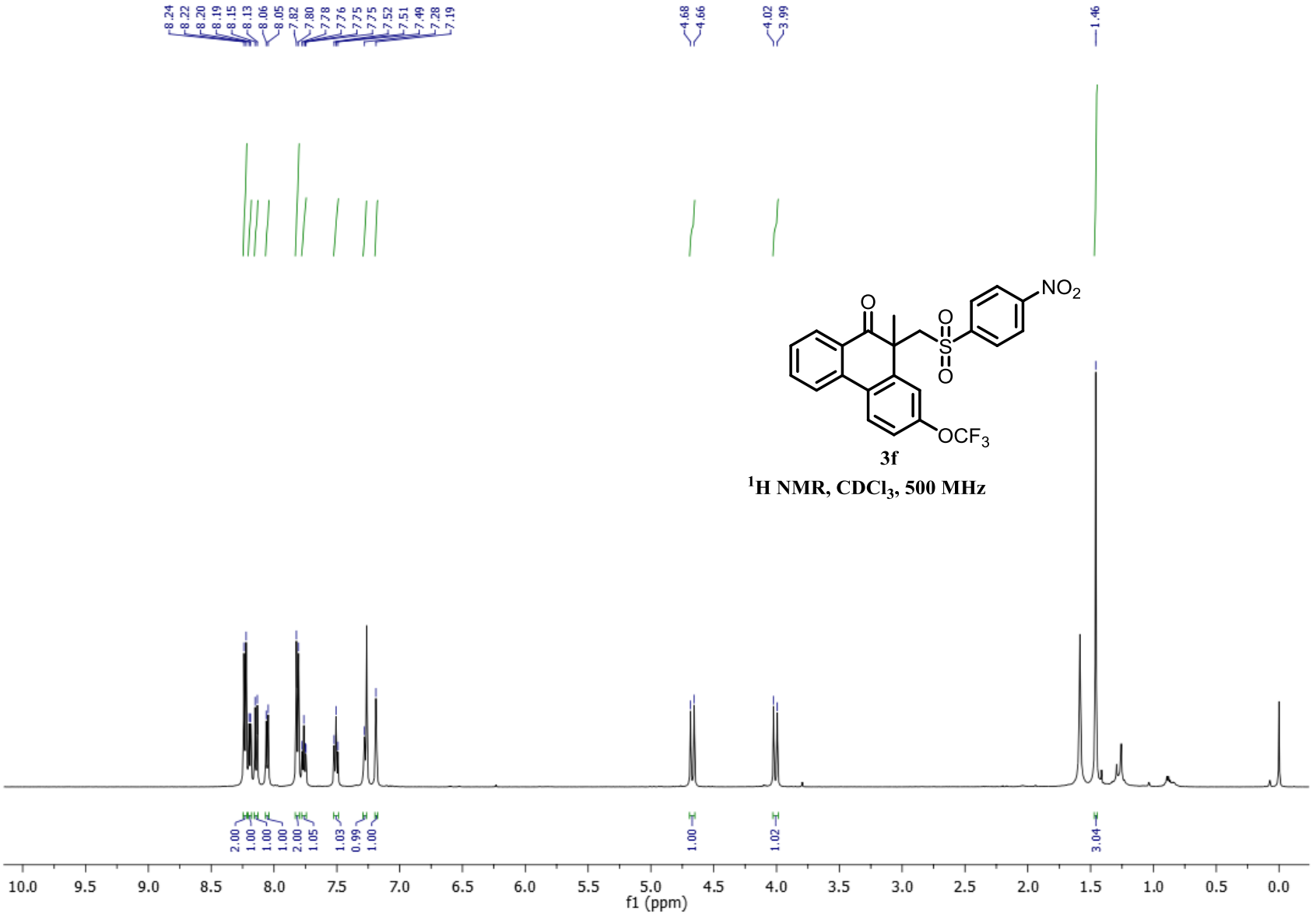
3e

^{1}H NMR, DMSO-d_6, 500 MHz



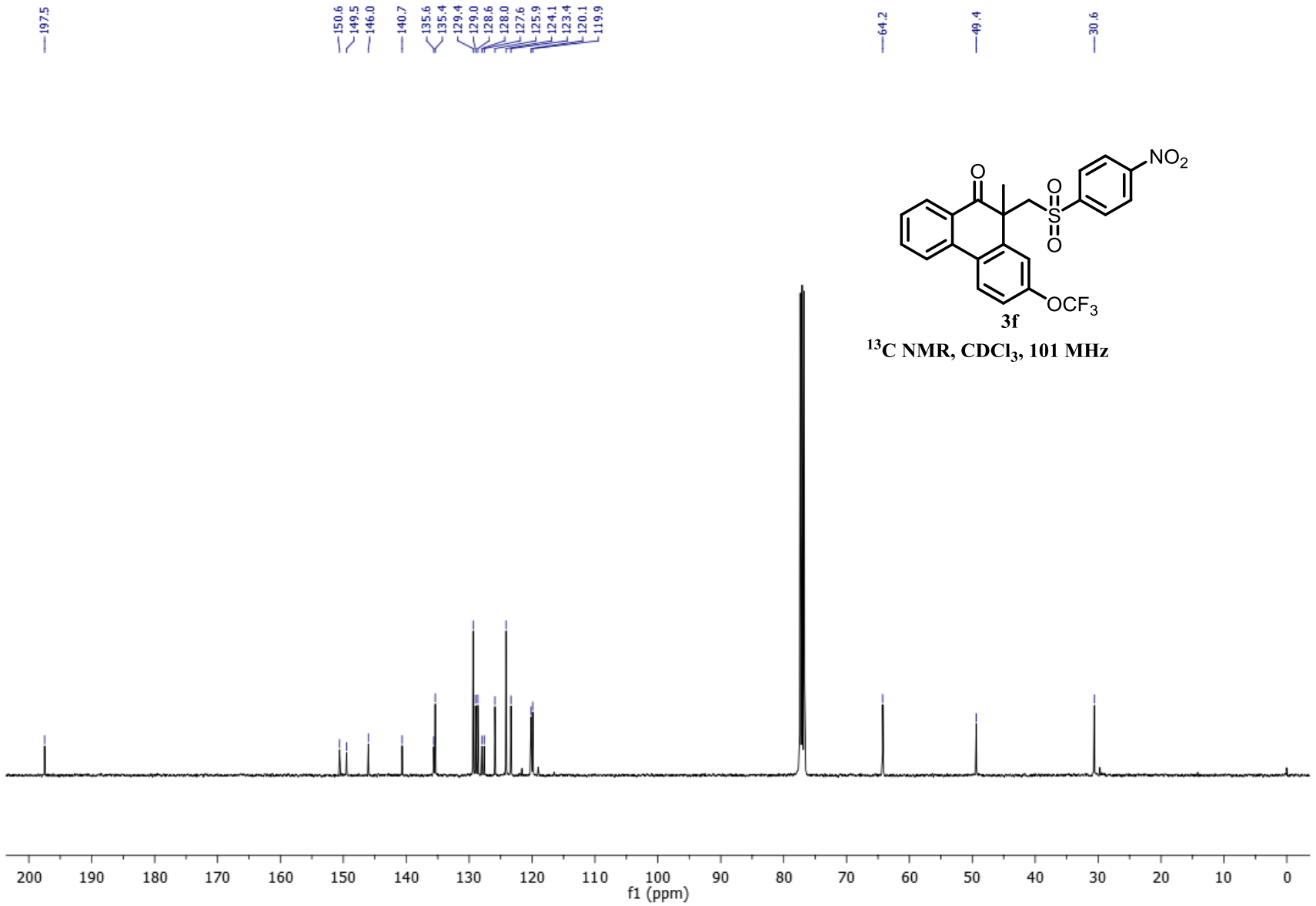
3e

^{13}C NMR, DMSO-d_6, 101 MHz



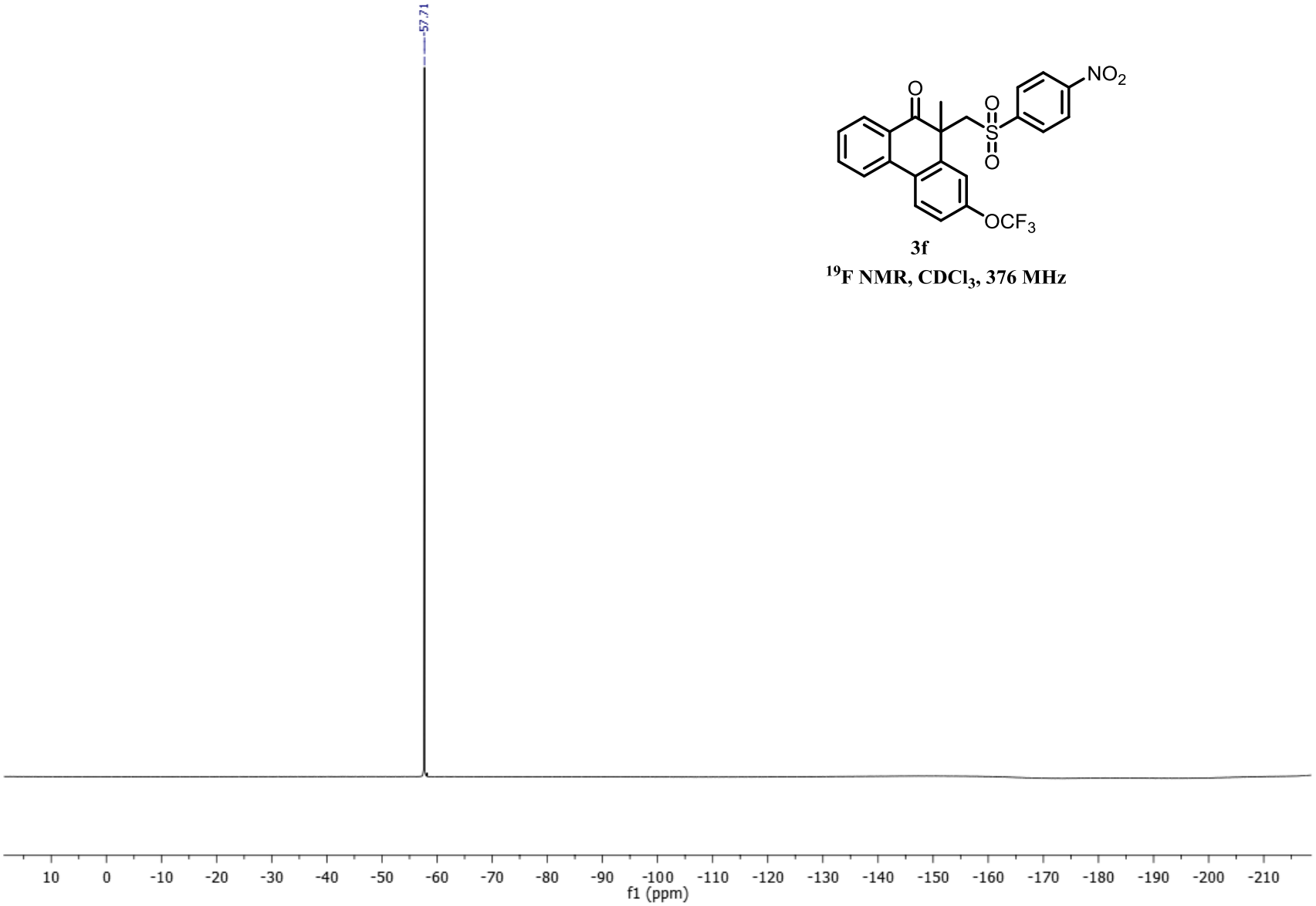
3f

^{1}H NMR, $CDCl_3$, 500 MHz



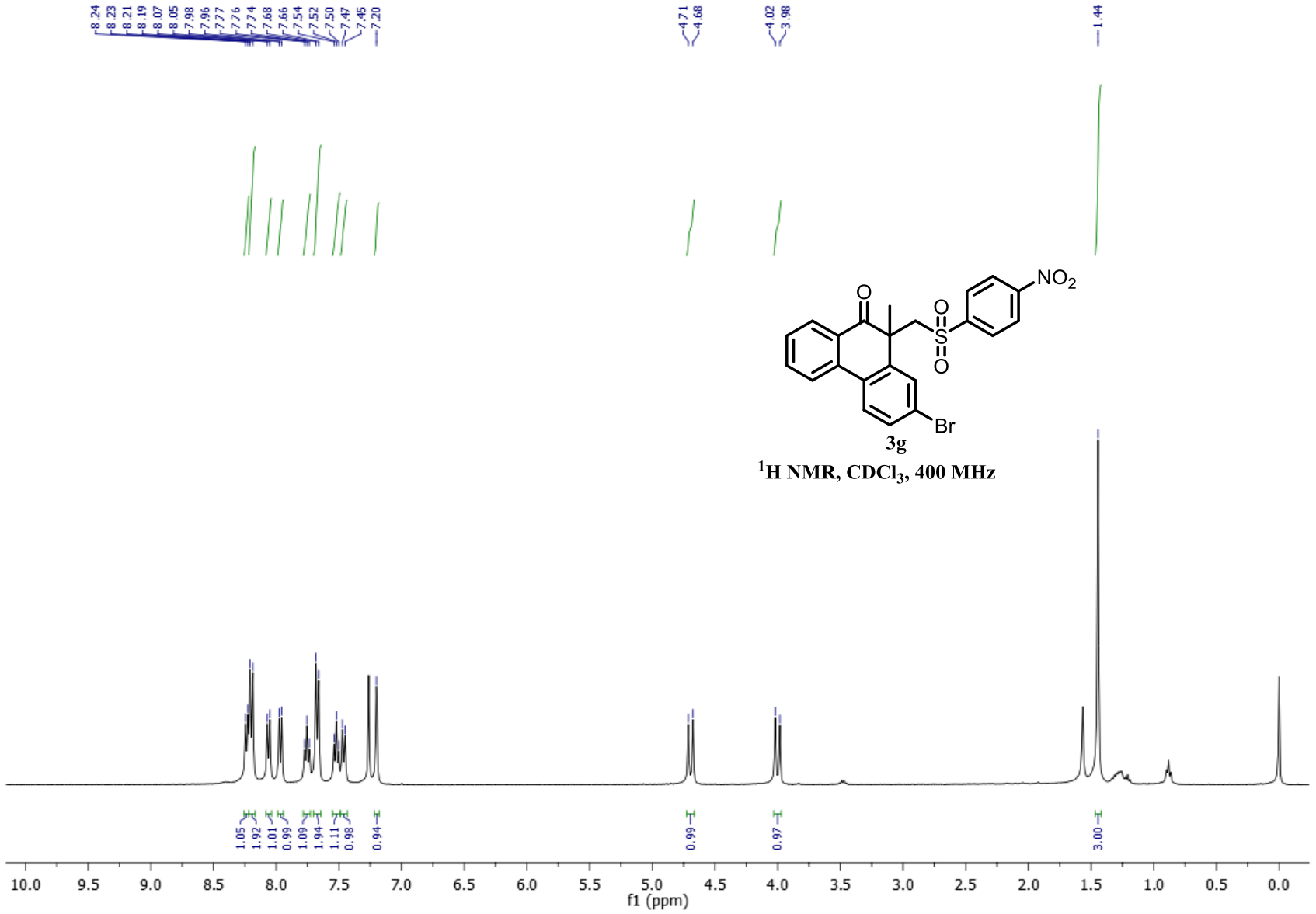
3f

^{13}C NMR, $CDCl_3$, 101 MHz



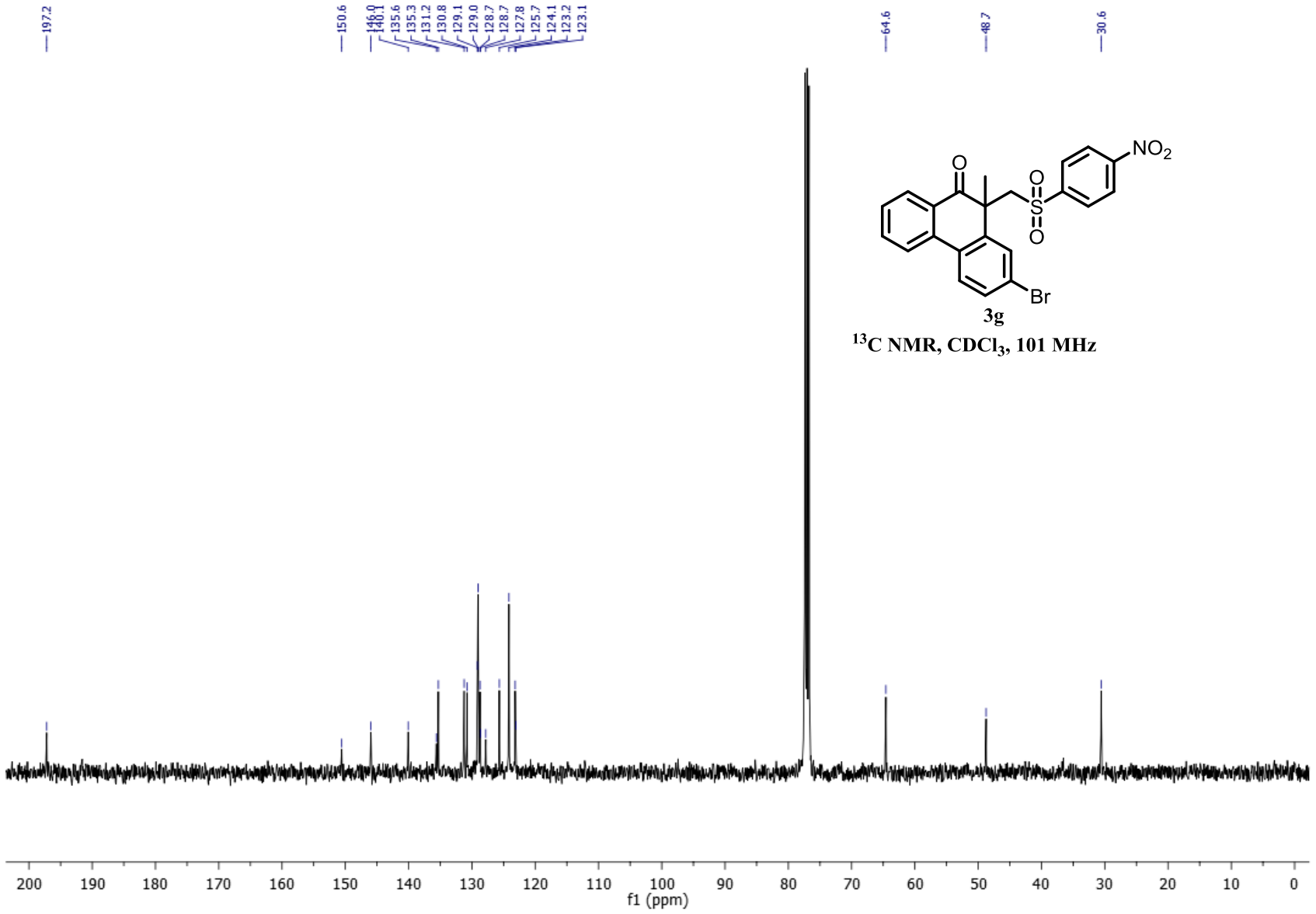
3f

^{19}F NMR, $CDCl_3$, 376 MHz



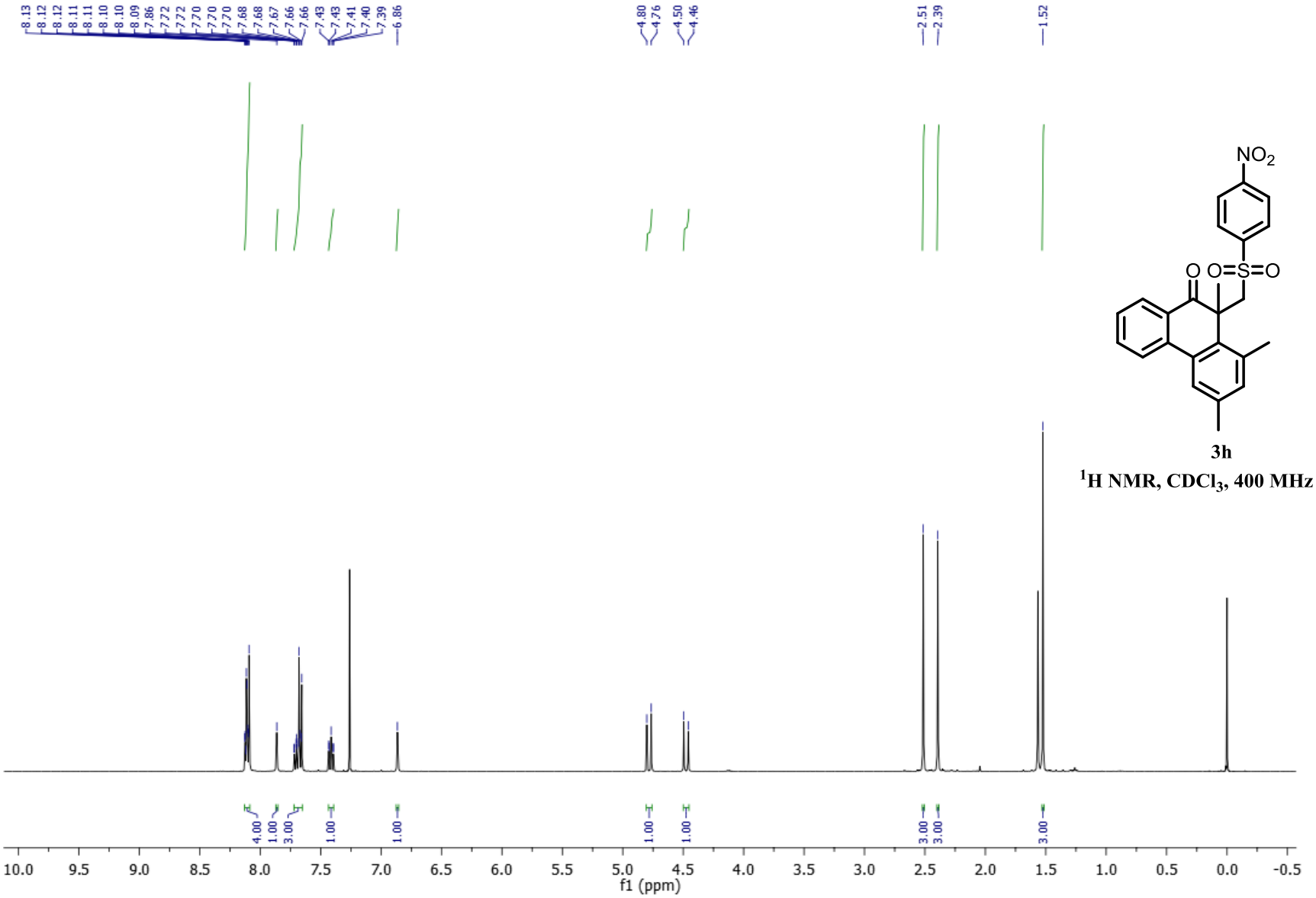
3g

^{1}H NMR, $CDCl_3$, 400 MHz



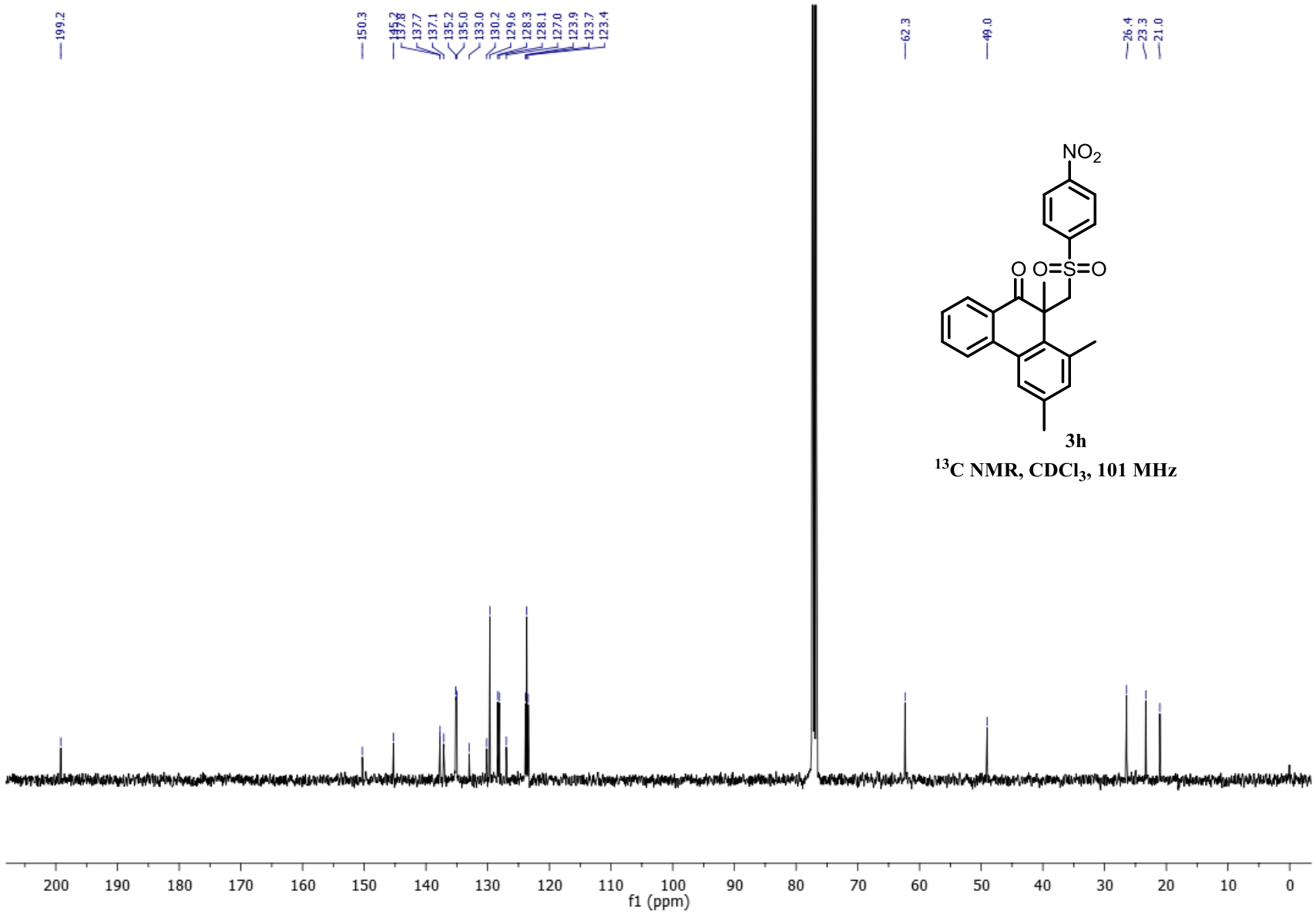
3g

^{13}C NMR, $CDCl_3$, 101 MHz



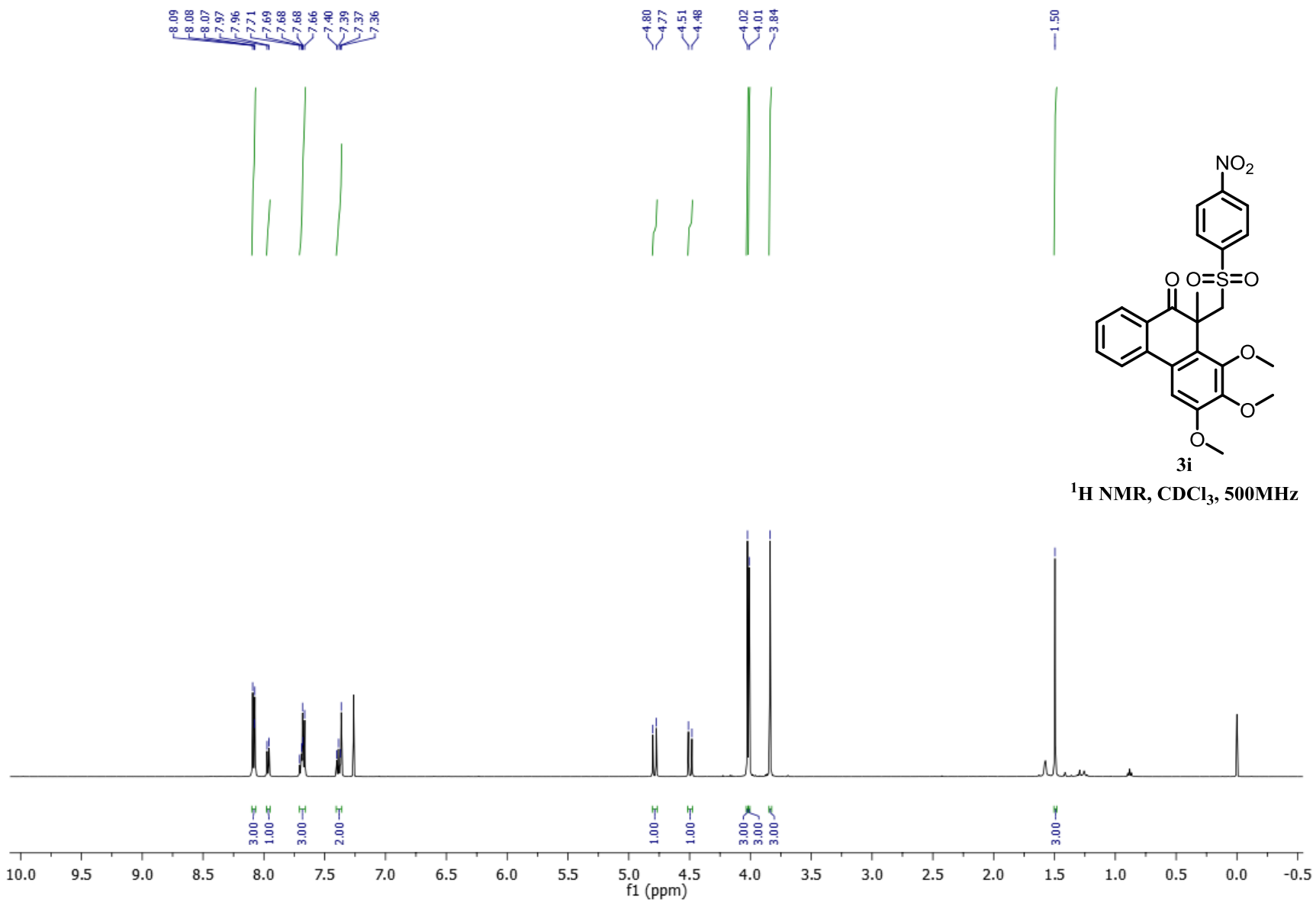
3h

^{1}H NMR, $CDCl_3$, 400 MHz



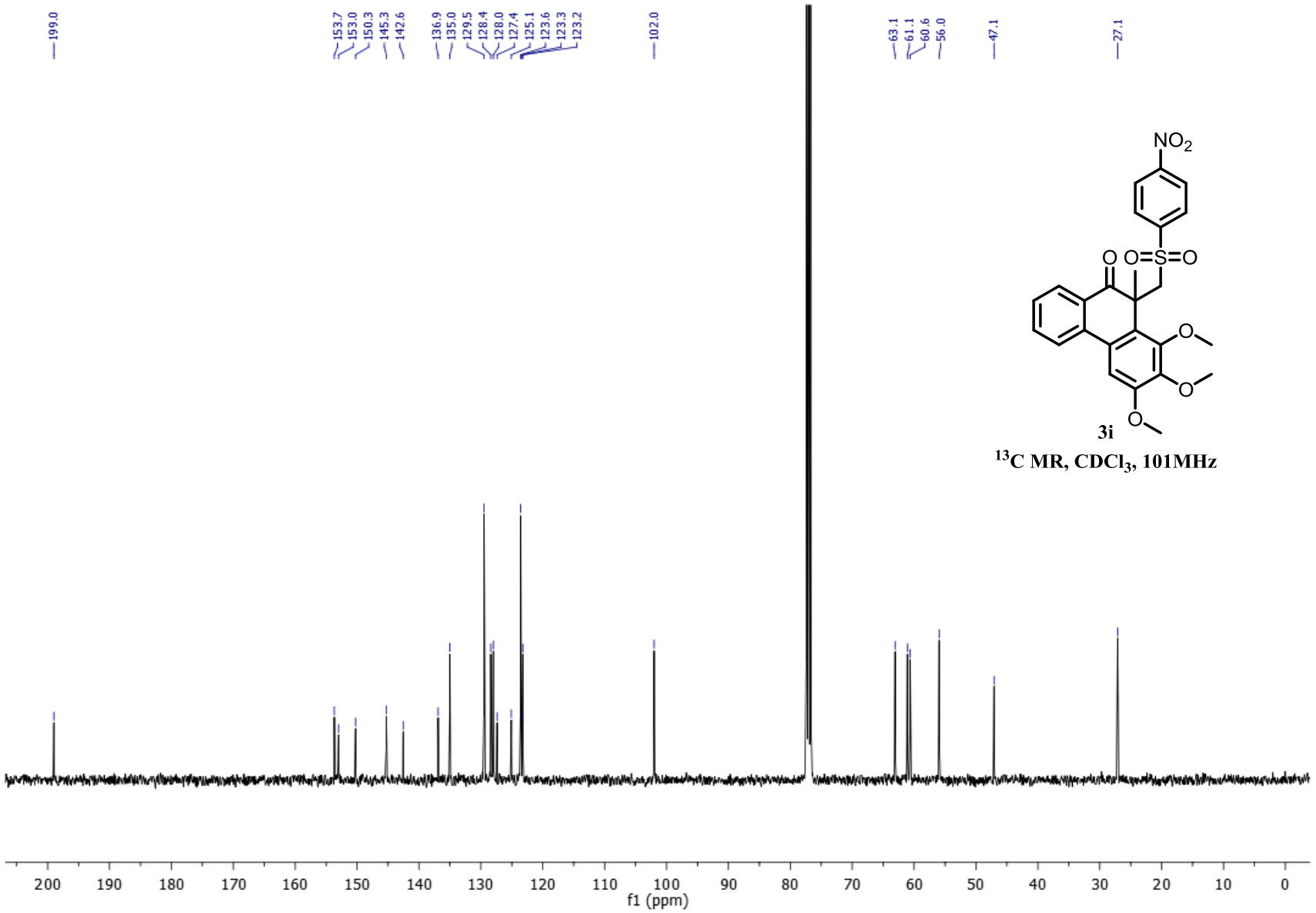
3h

^{13}C NMR, $CDCl_3$, 101 MHz



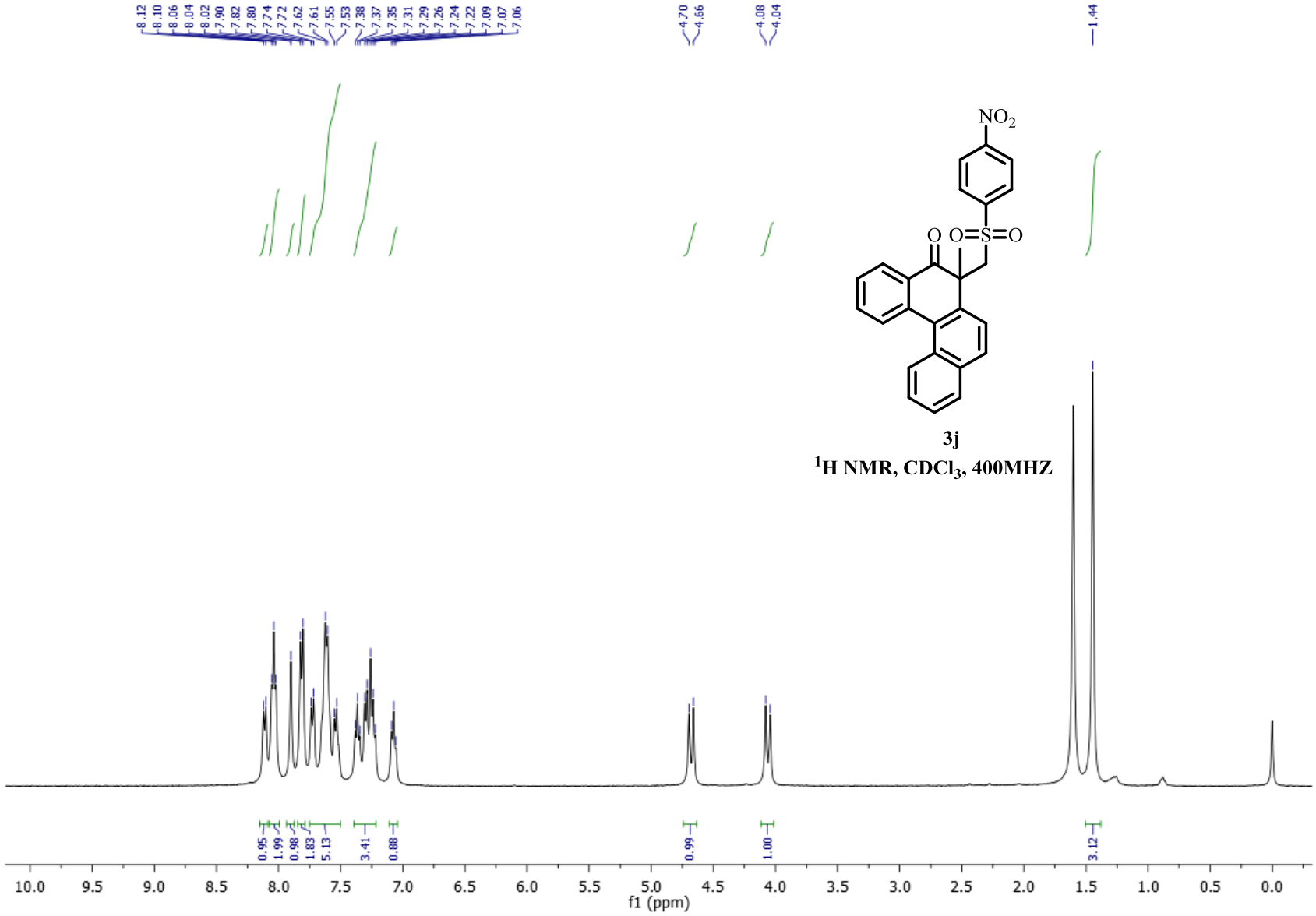
3i

^{1}H NMR, $CDCl_3$, 500MHz



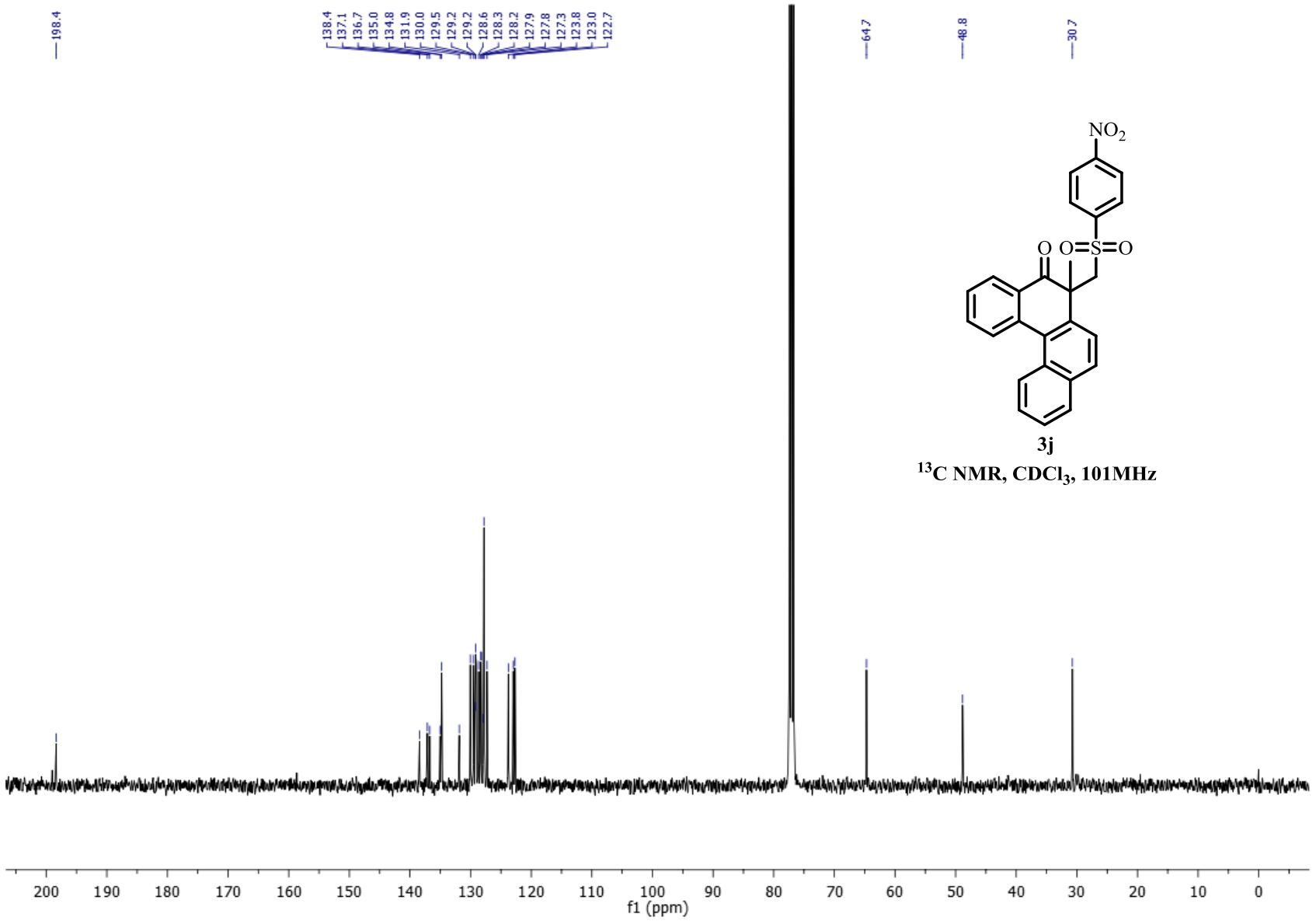
3i

^{13}C MR, $CDCl_3$, 101MHz



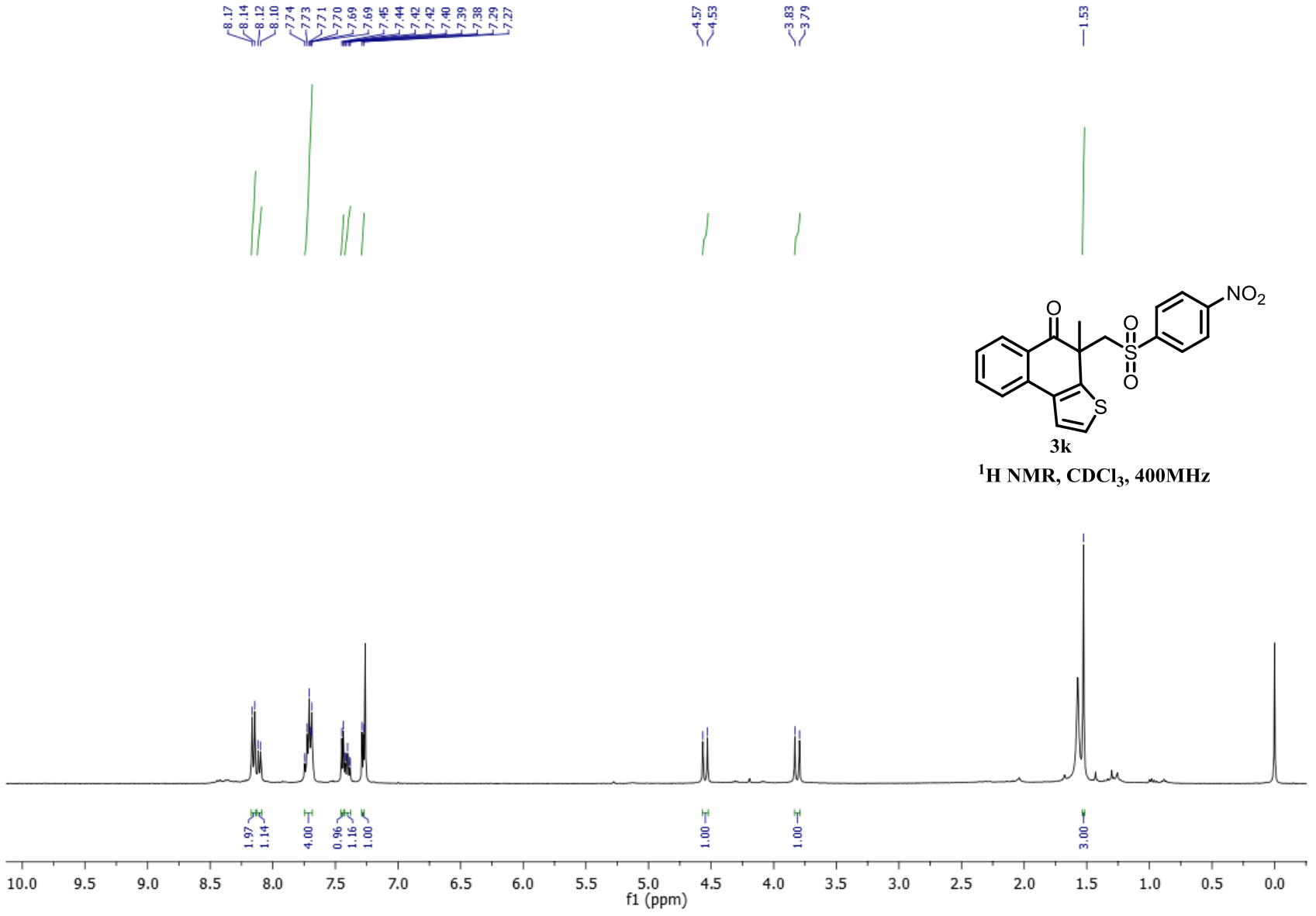
3j

^{1}H NMR, $CDCl_3$, 400MHZ



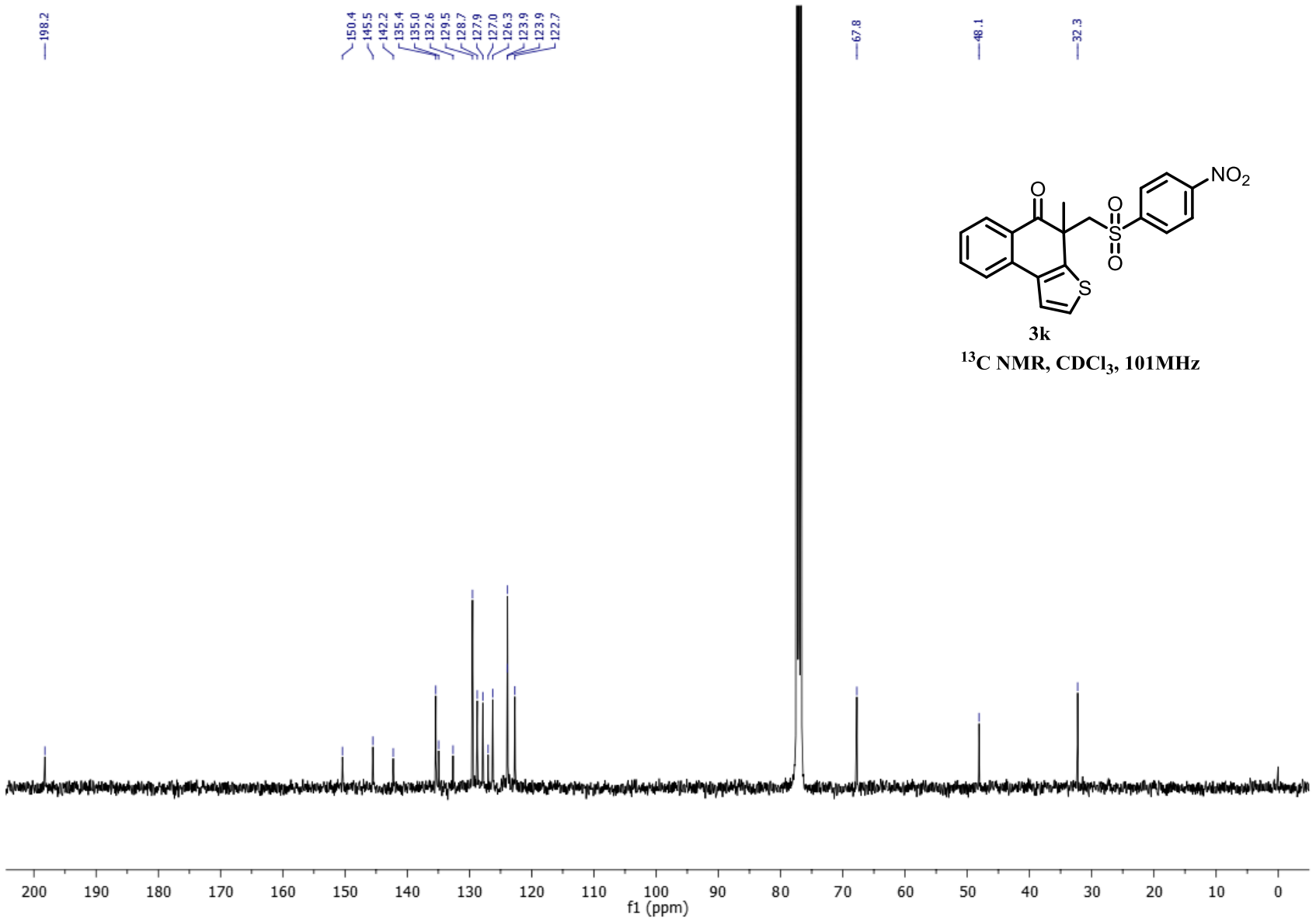
3j

^{13}C NMR, $CDCl_3$, 101MHz



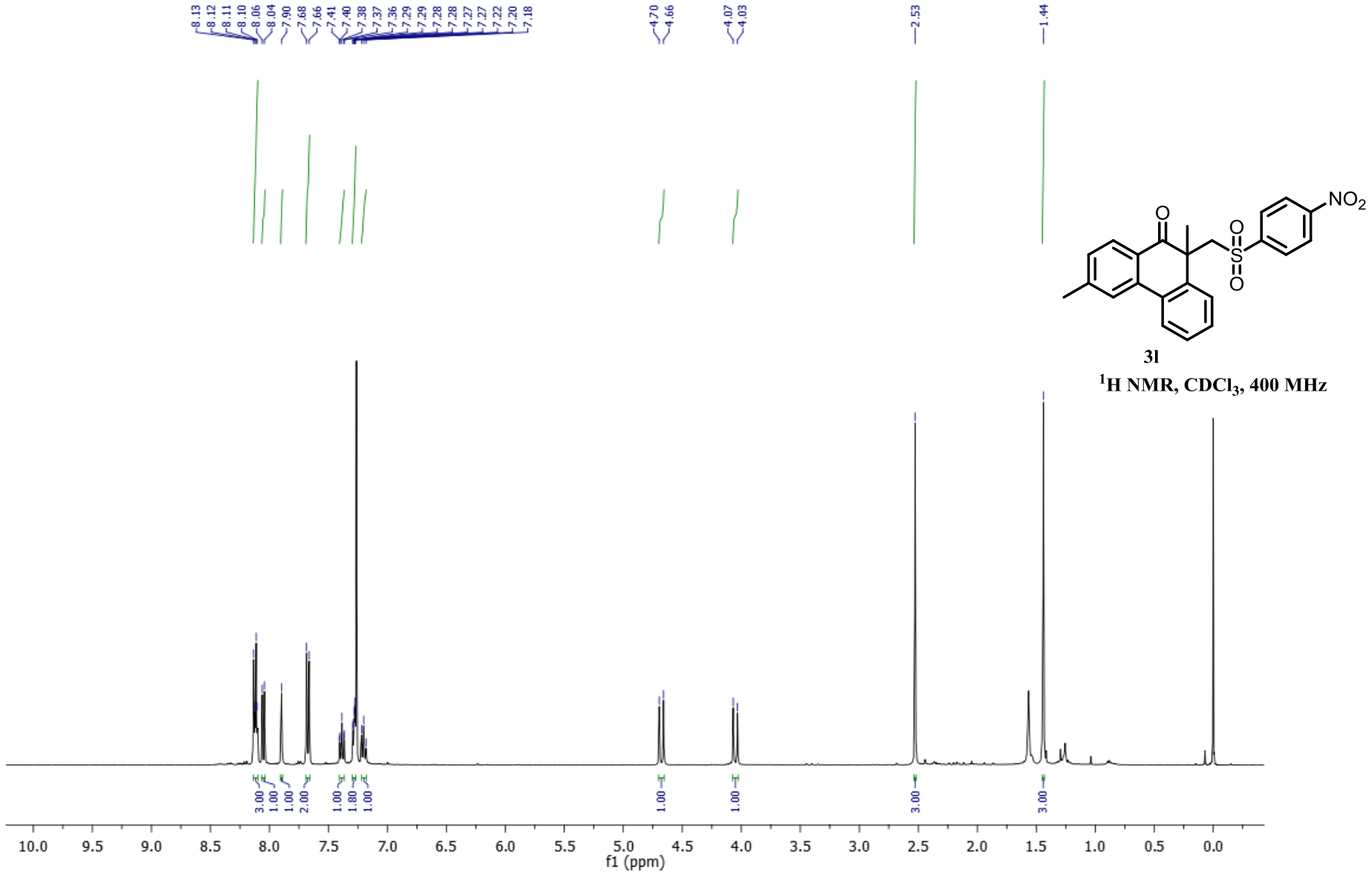
3k

^{1}H NMR, $CDCl_3$, 400MHz



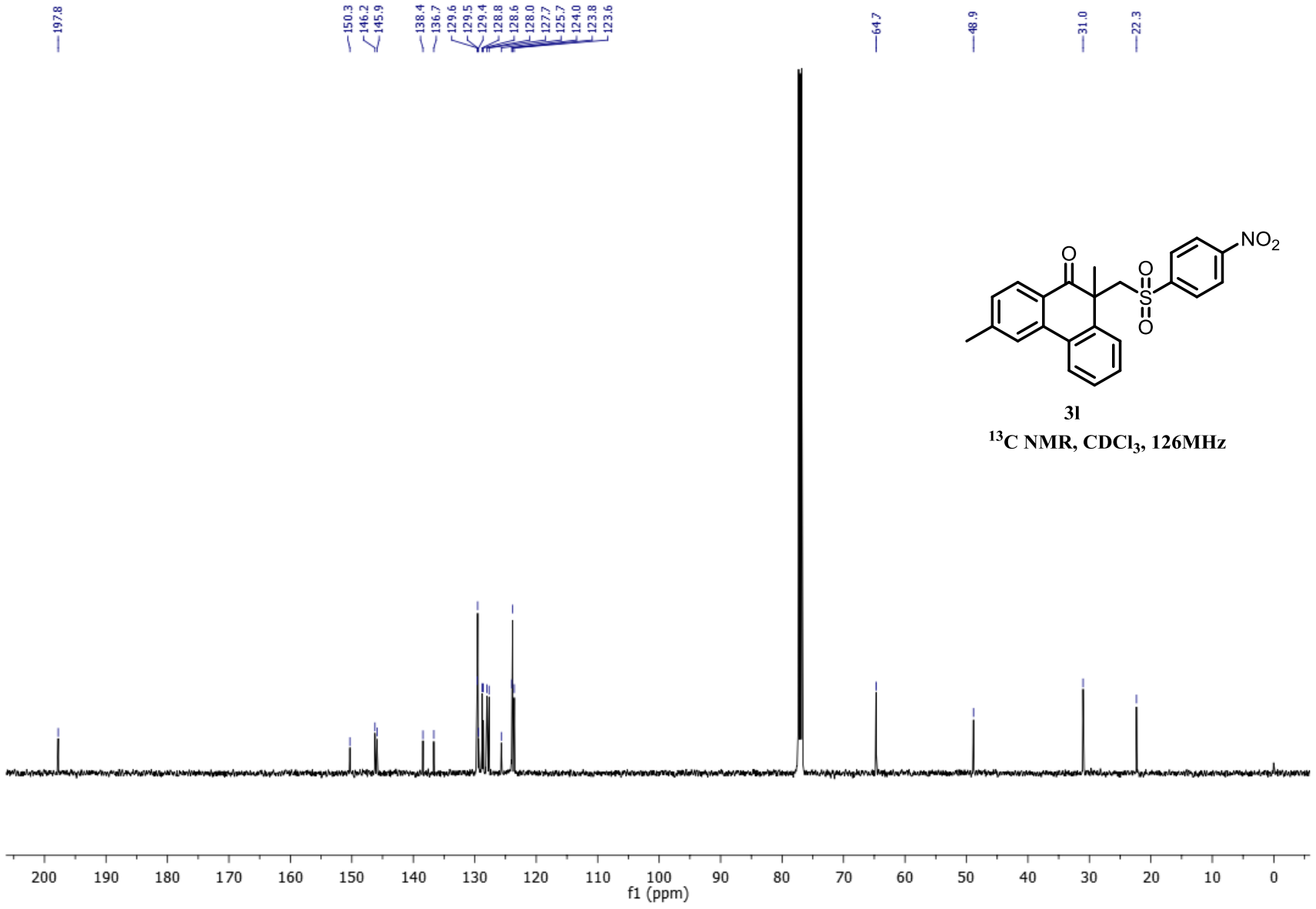
3k

^{13}C NMR, $CDCl_3$, 101MHz



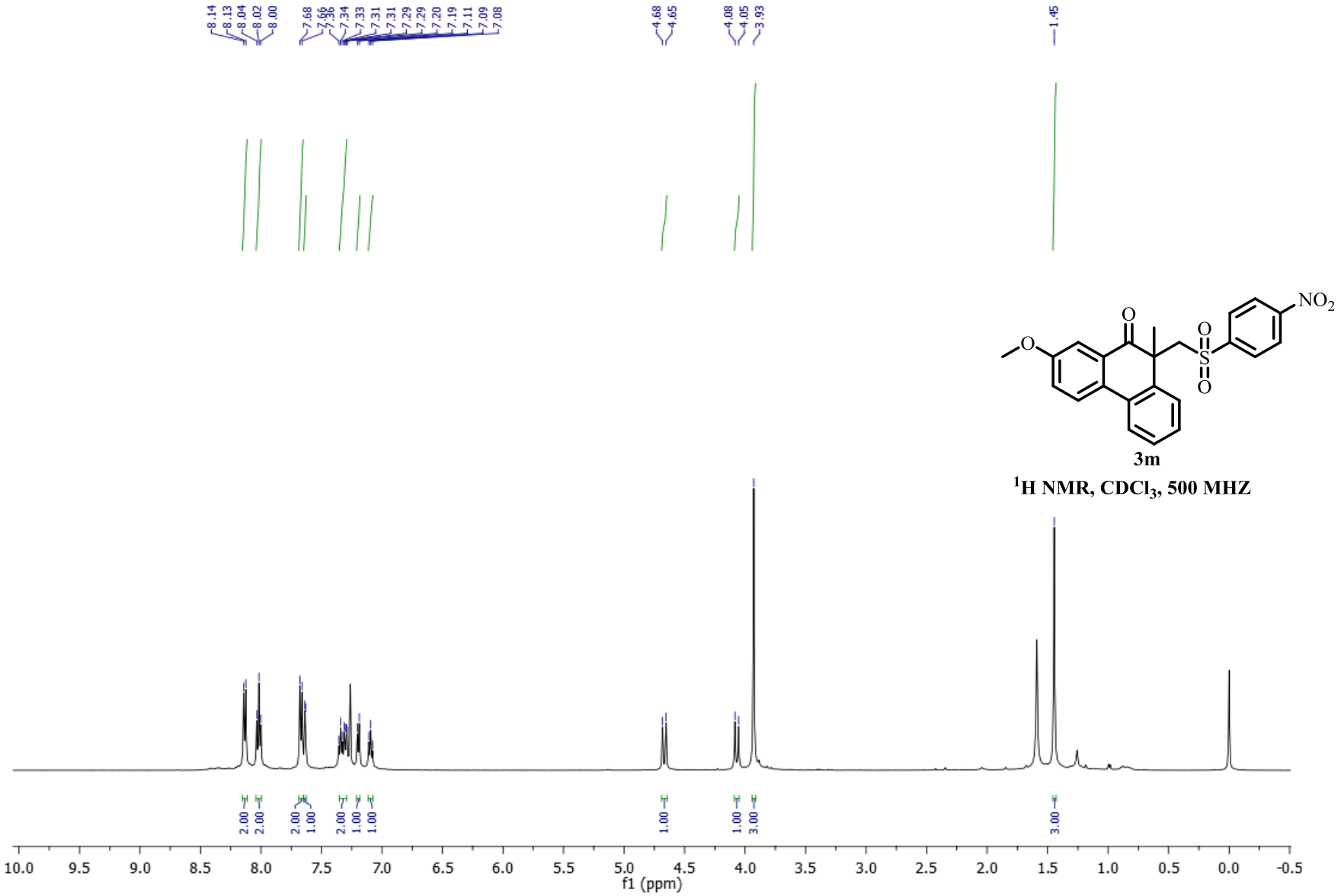
3l

^{1}H NMR, $CDCl_3$, 400 MHz



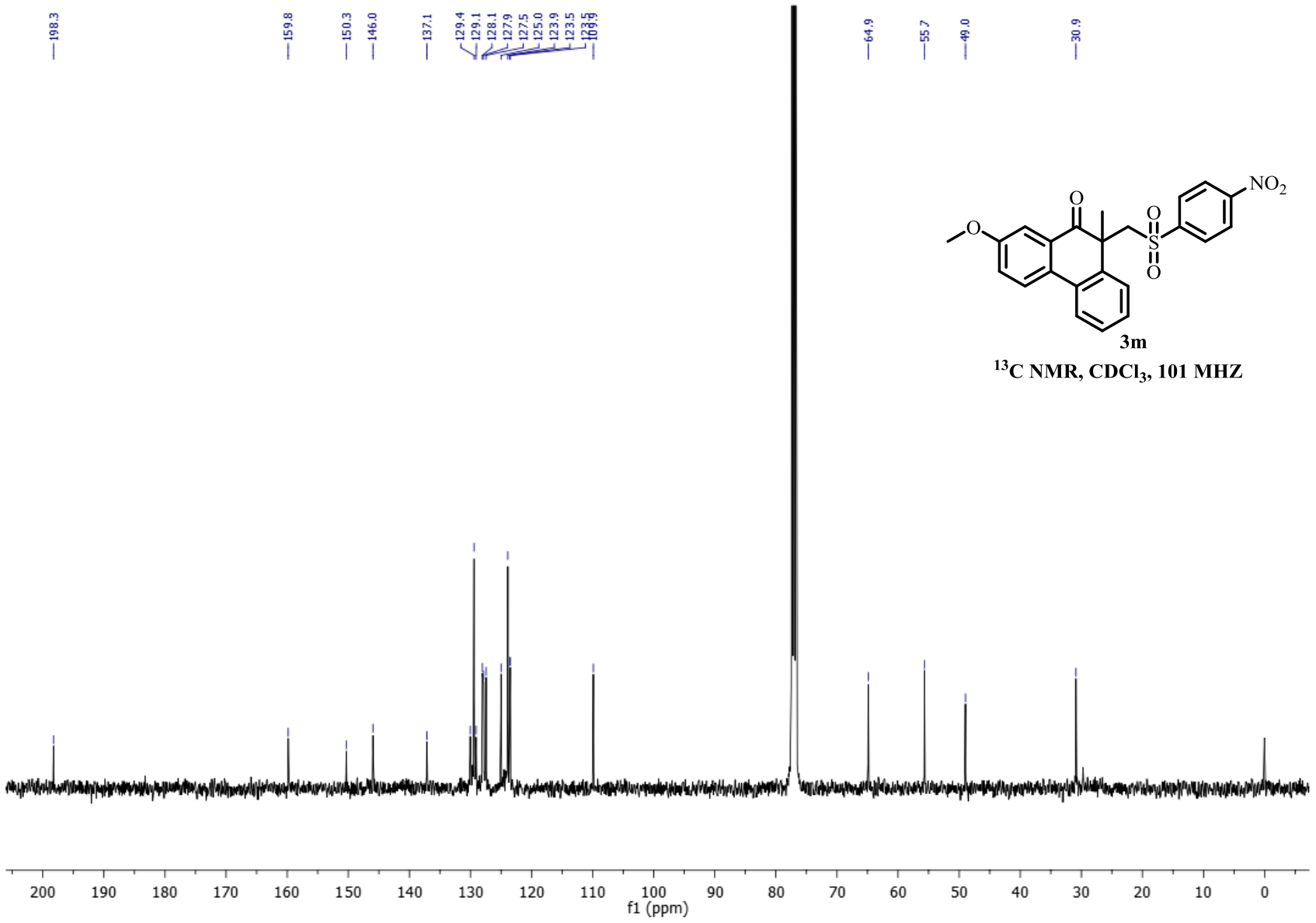
3l

^{13}C NMR, $CDCl_3$, 126MHz



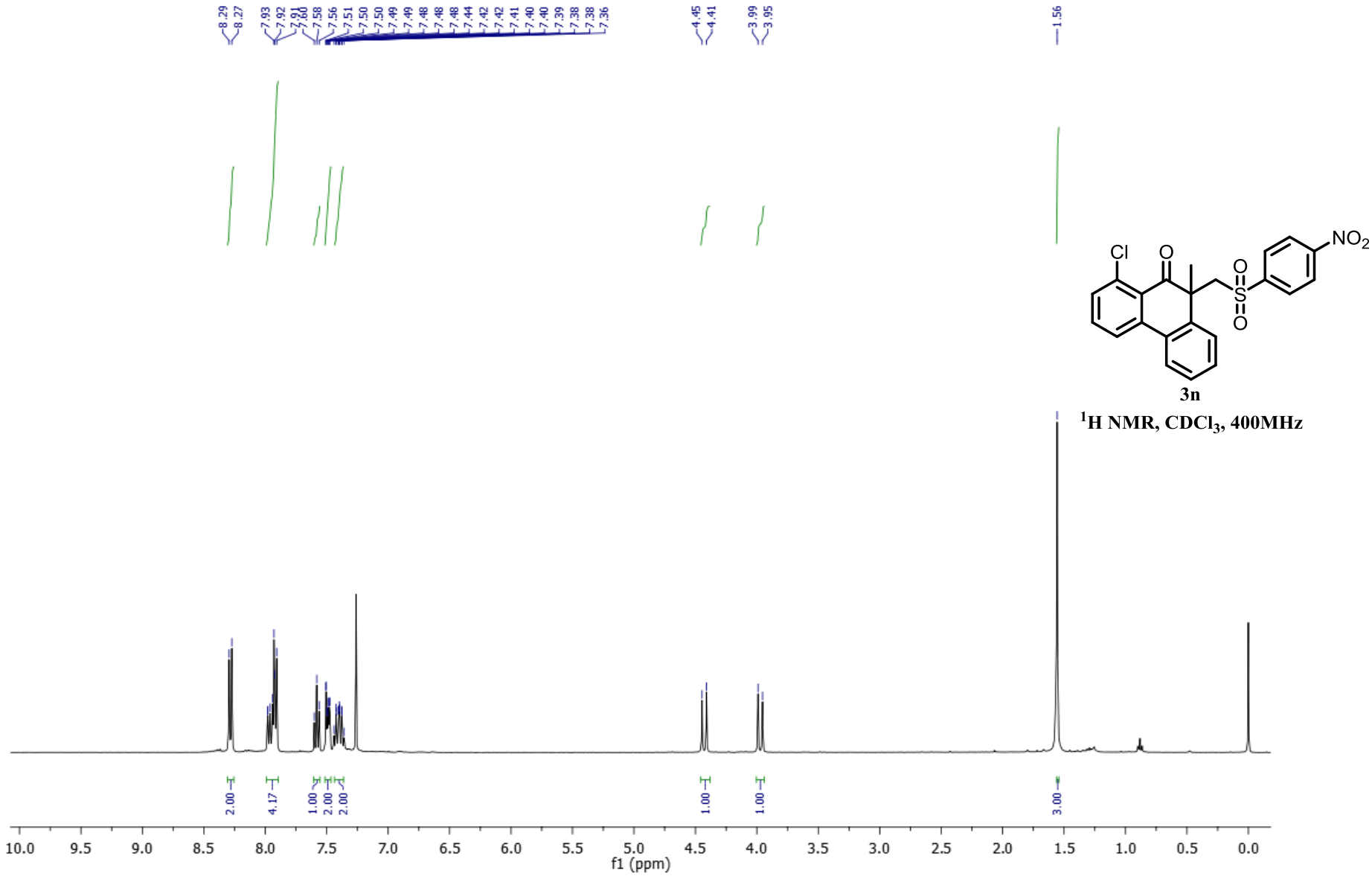
3m

^{1}H NMR, $CDCl_3$, 500 MHZ



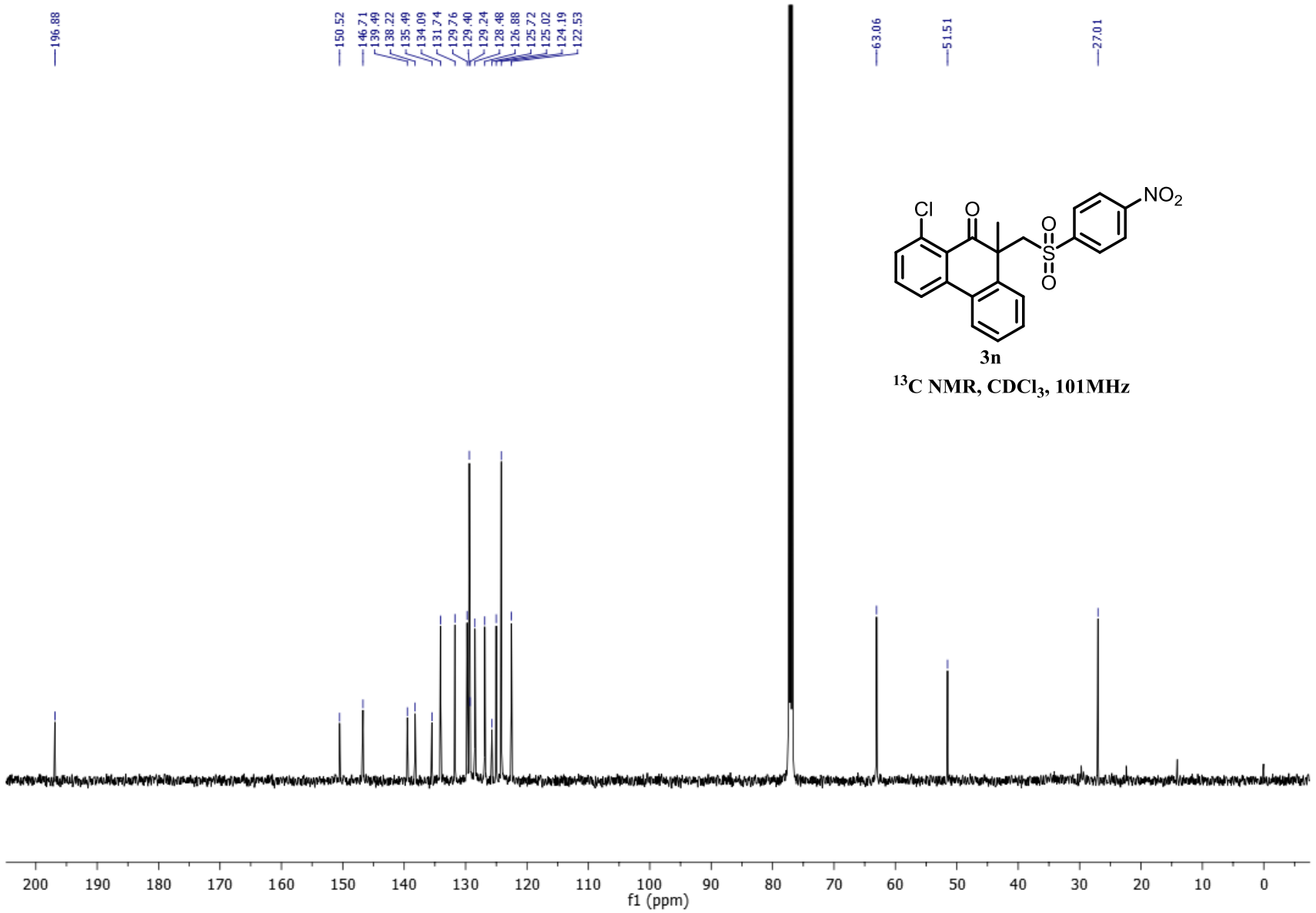
3m

^{13}C NMR, $CDCl_3$, 101 MHZ



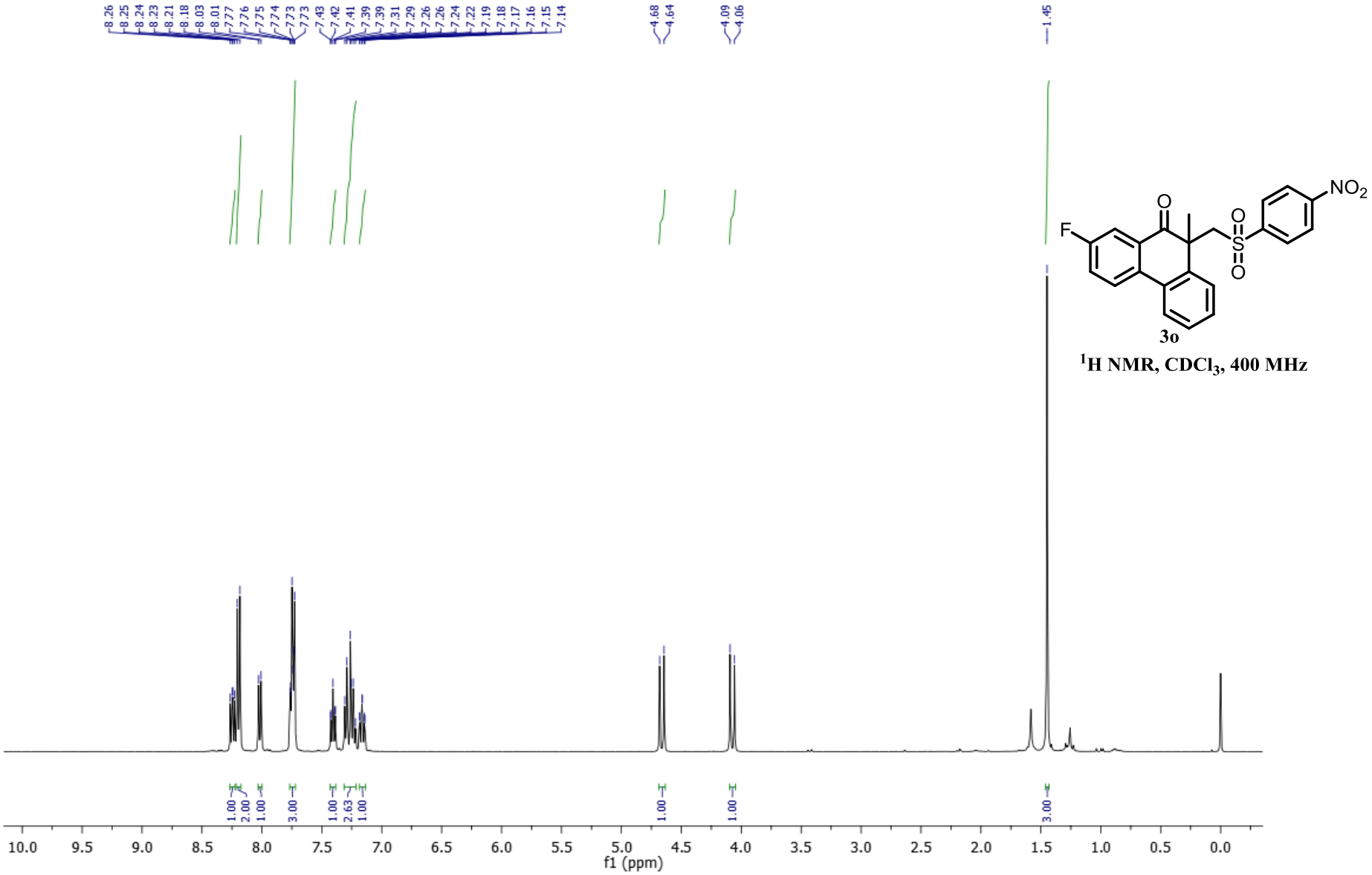
3n

^{1}H NMR, $CDCl_3$, 400MHz



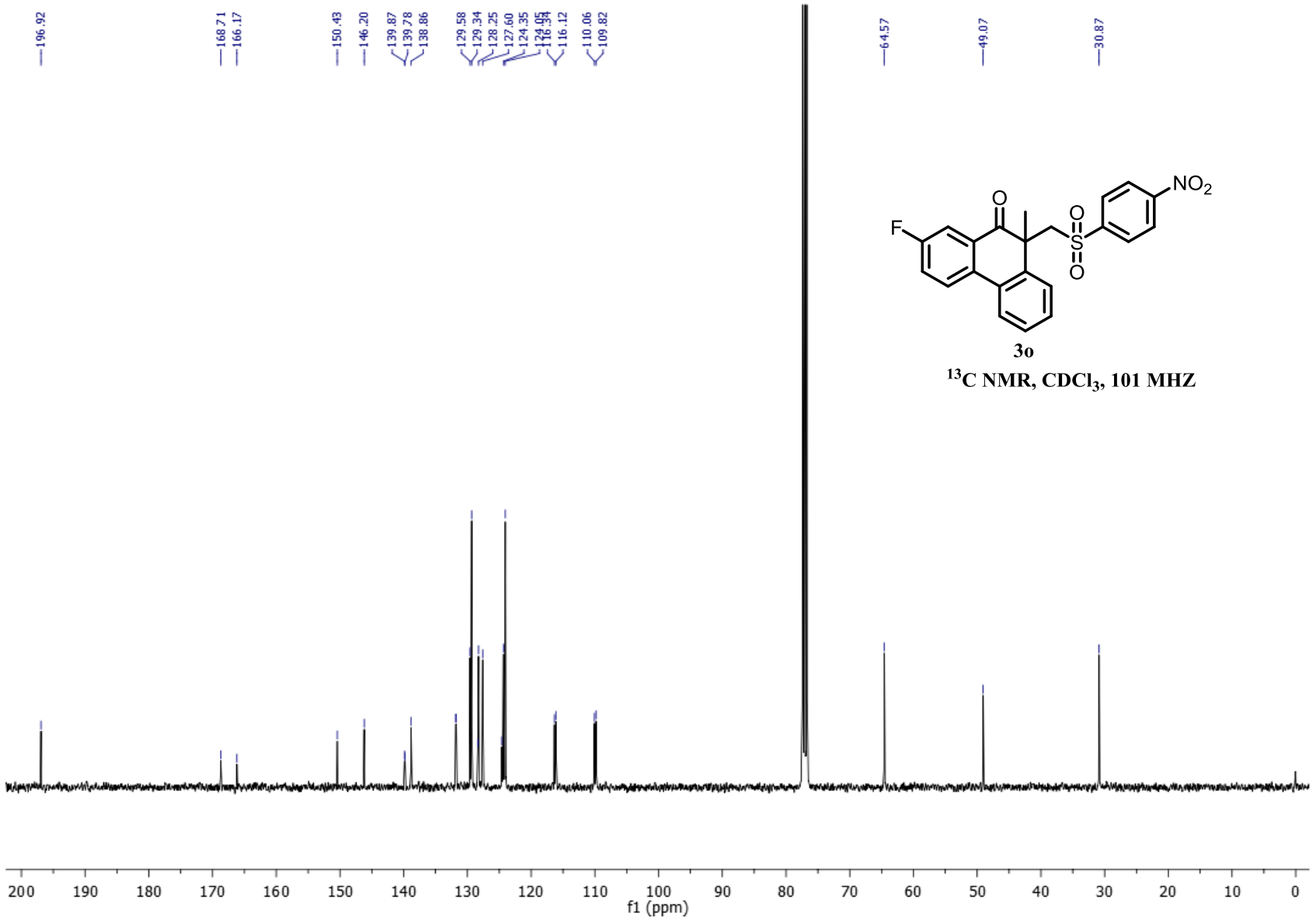
3n

^{13}C NMR, $CDCl_3$, 101MHz



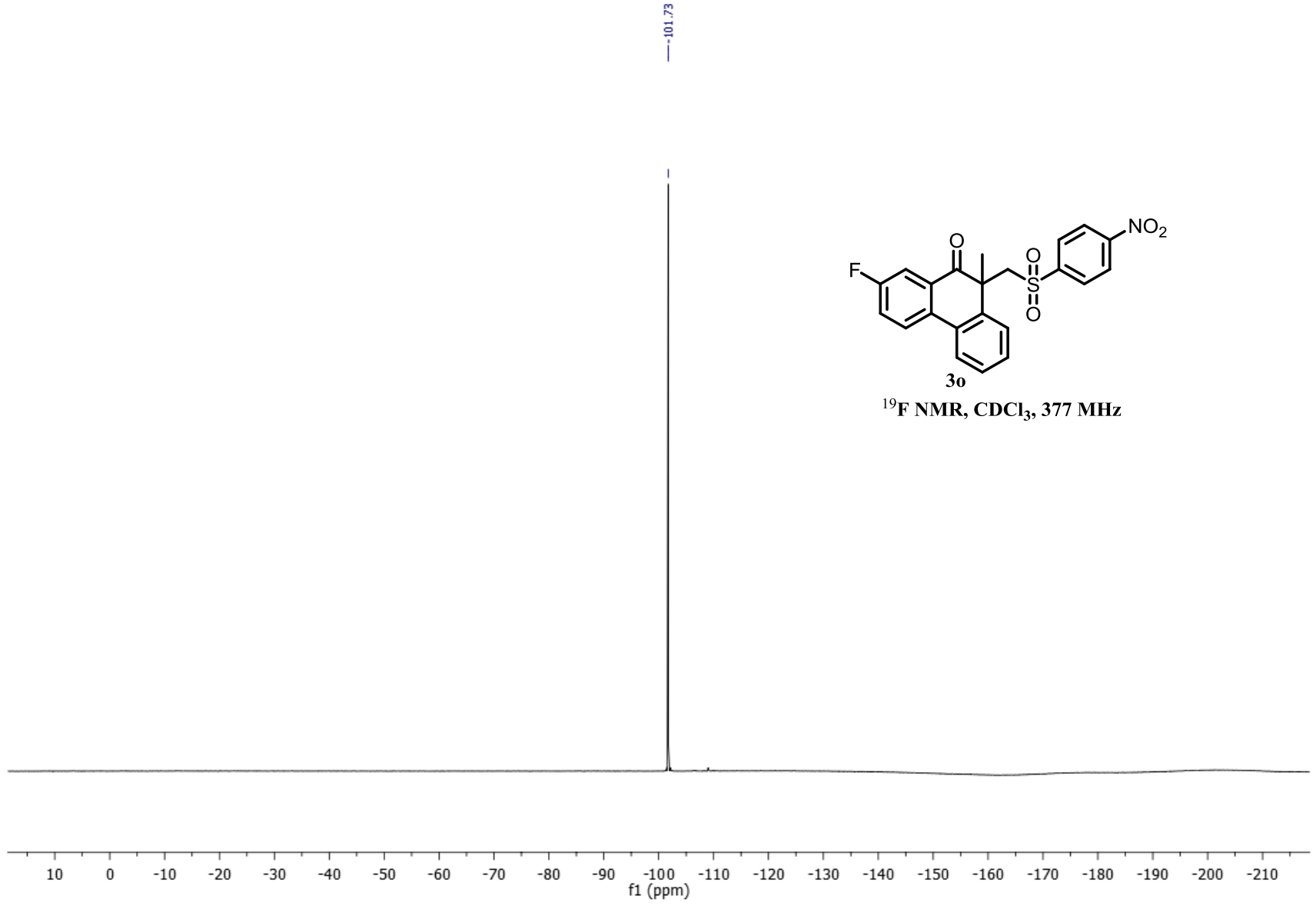
3o

^{1}H NMR, $CDCl_3$, 400 MHz



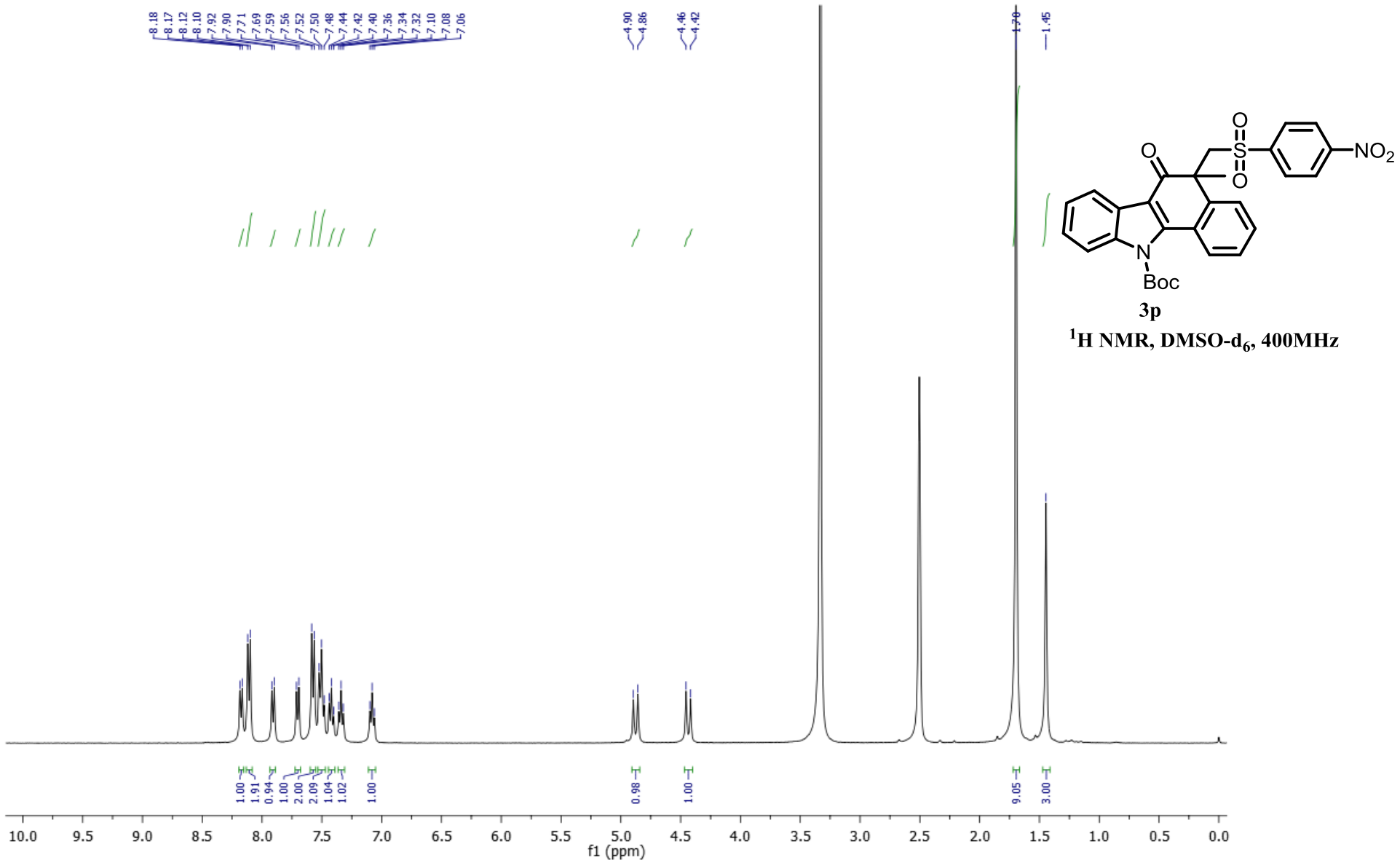
3o

^{13}C NMR, $CDCl_3$, 101 MHZ



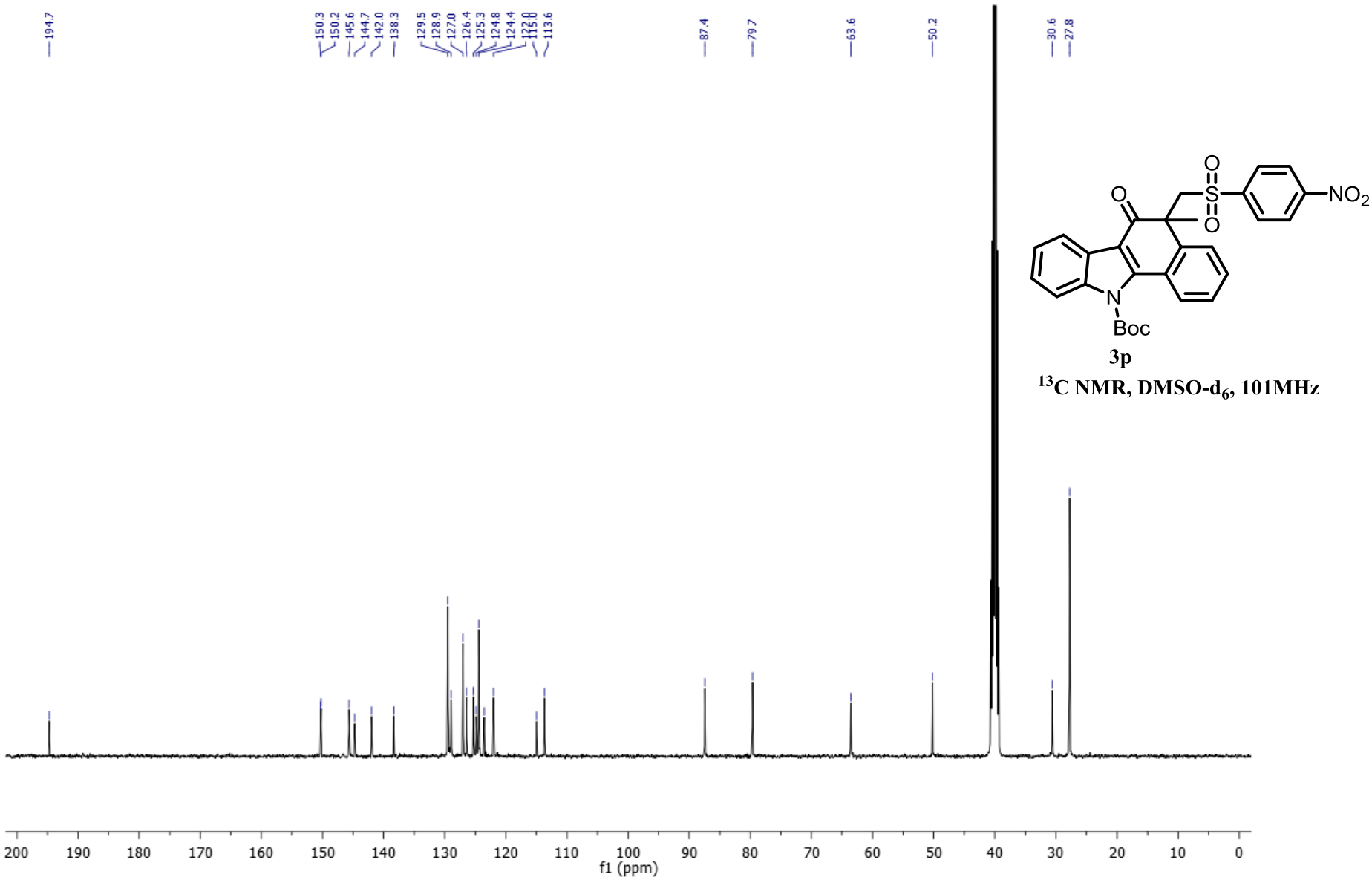
3o

^{19}F NMR, $CDCl_3$, 377 MHz



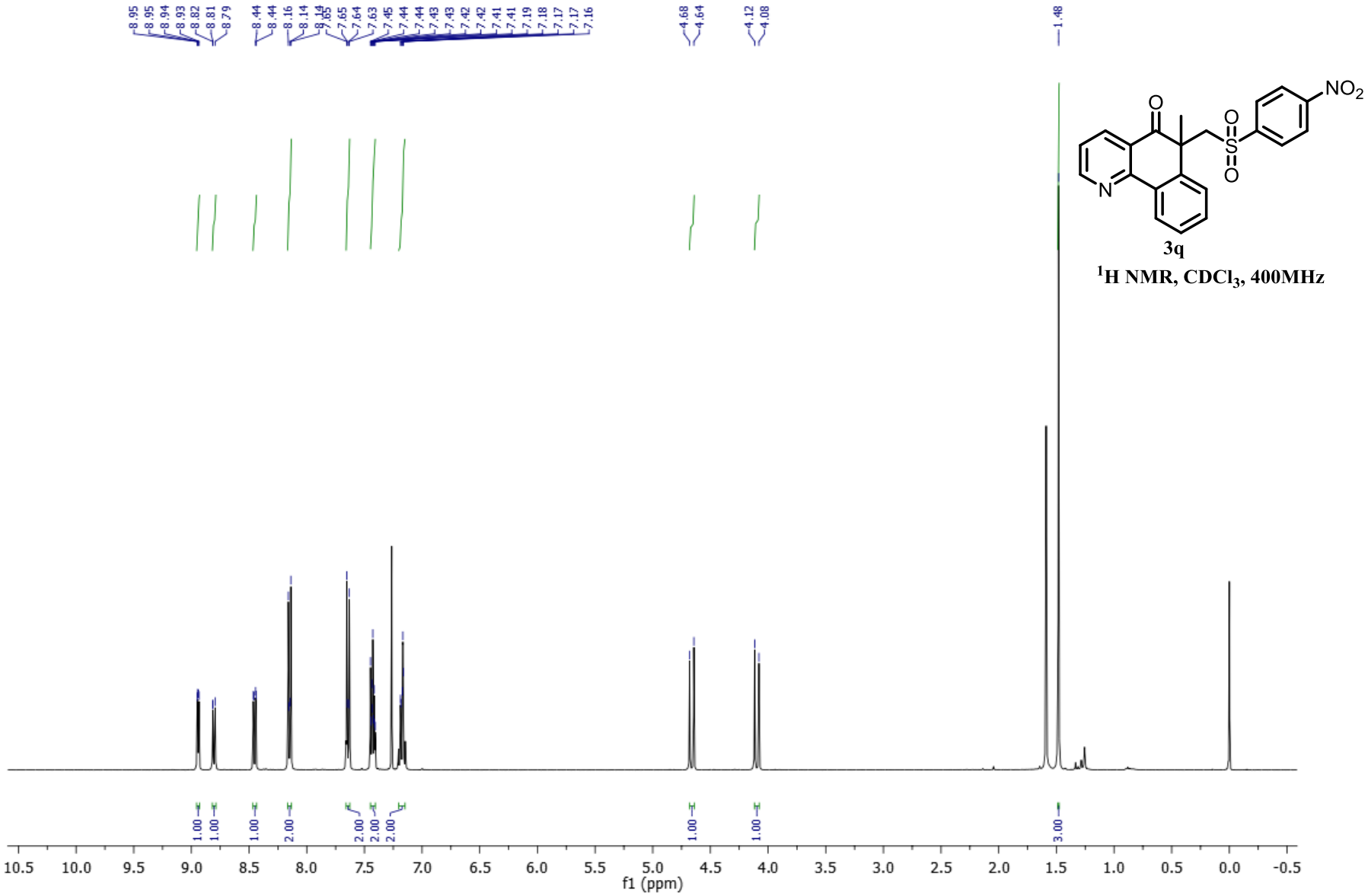
3p

^{1}H NMR, DMSO-d_6, 400MHz



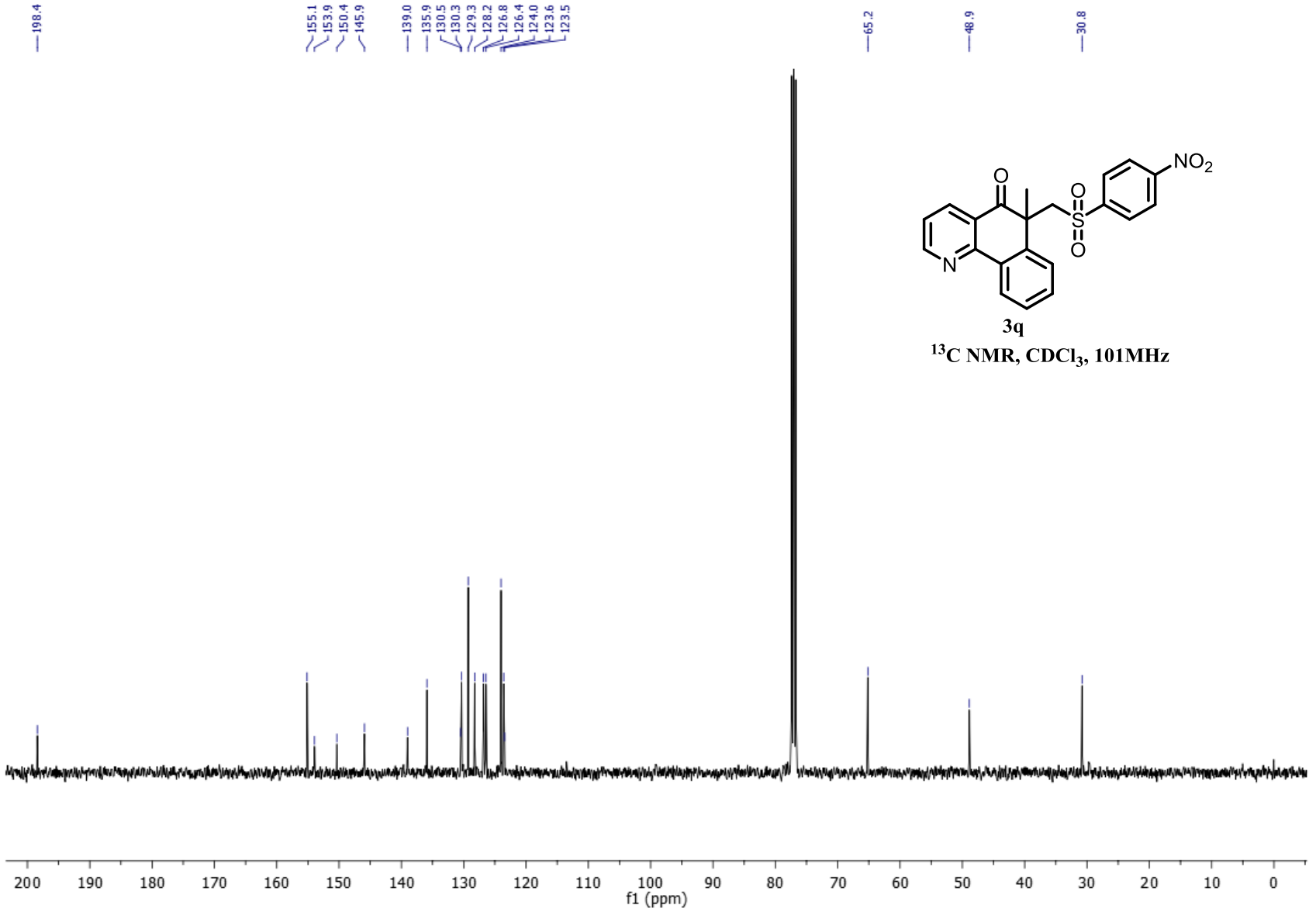
3p

^{13}C NMR, DMSO-d$_6$, 101MHz



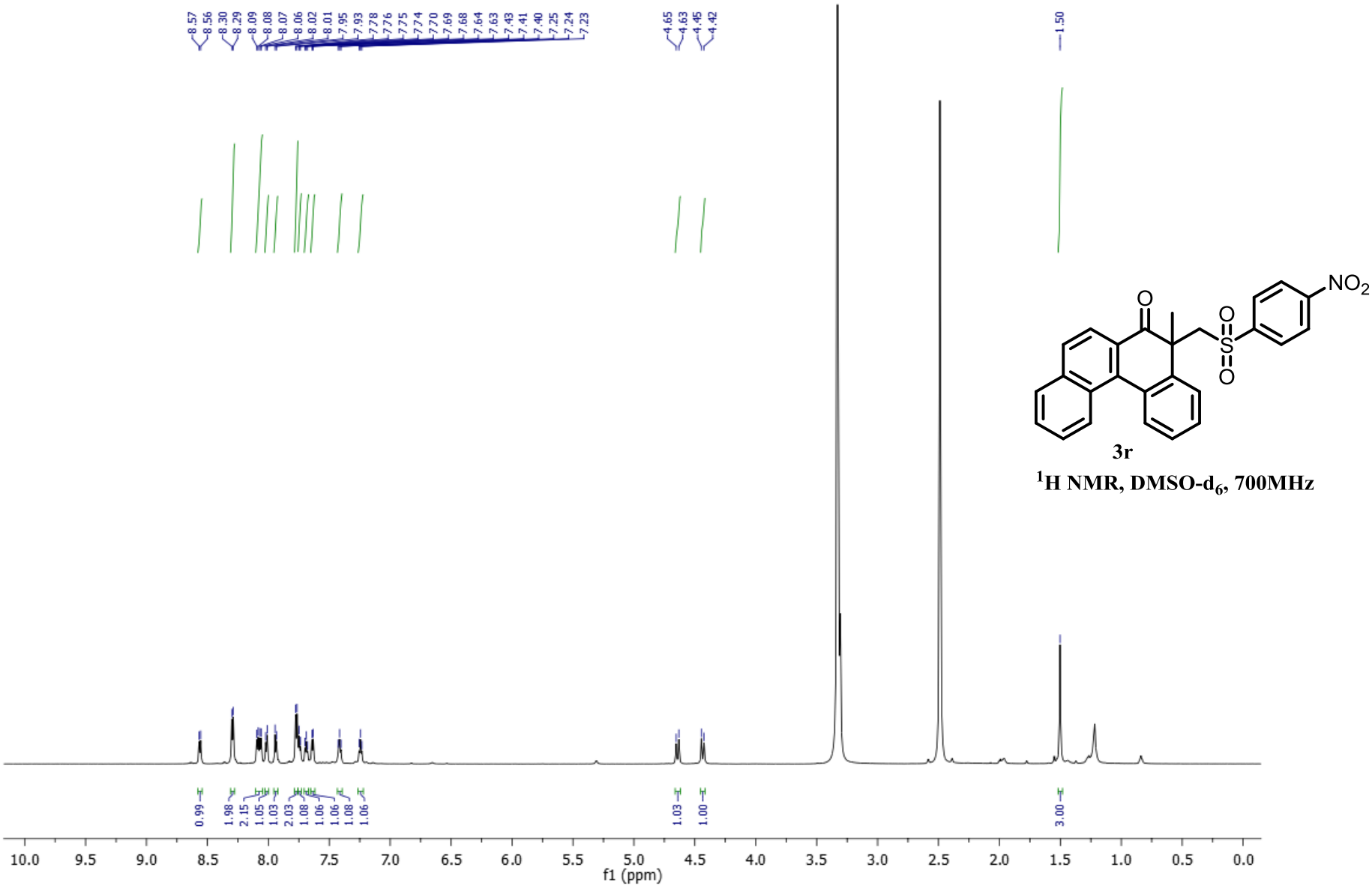
3q

^{1}H NMR, $CDCl_3$, 400MHz



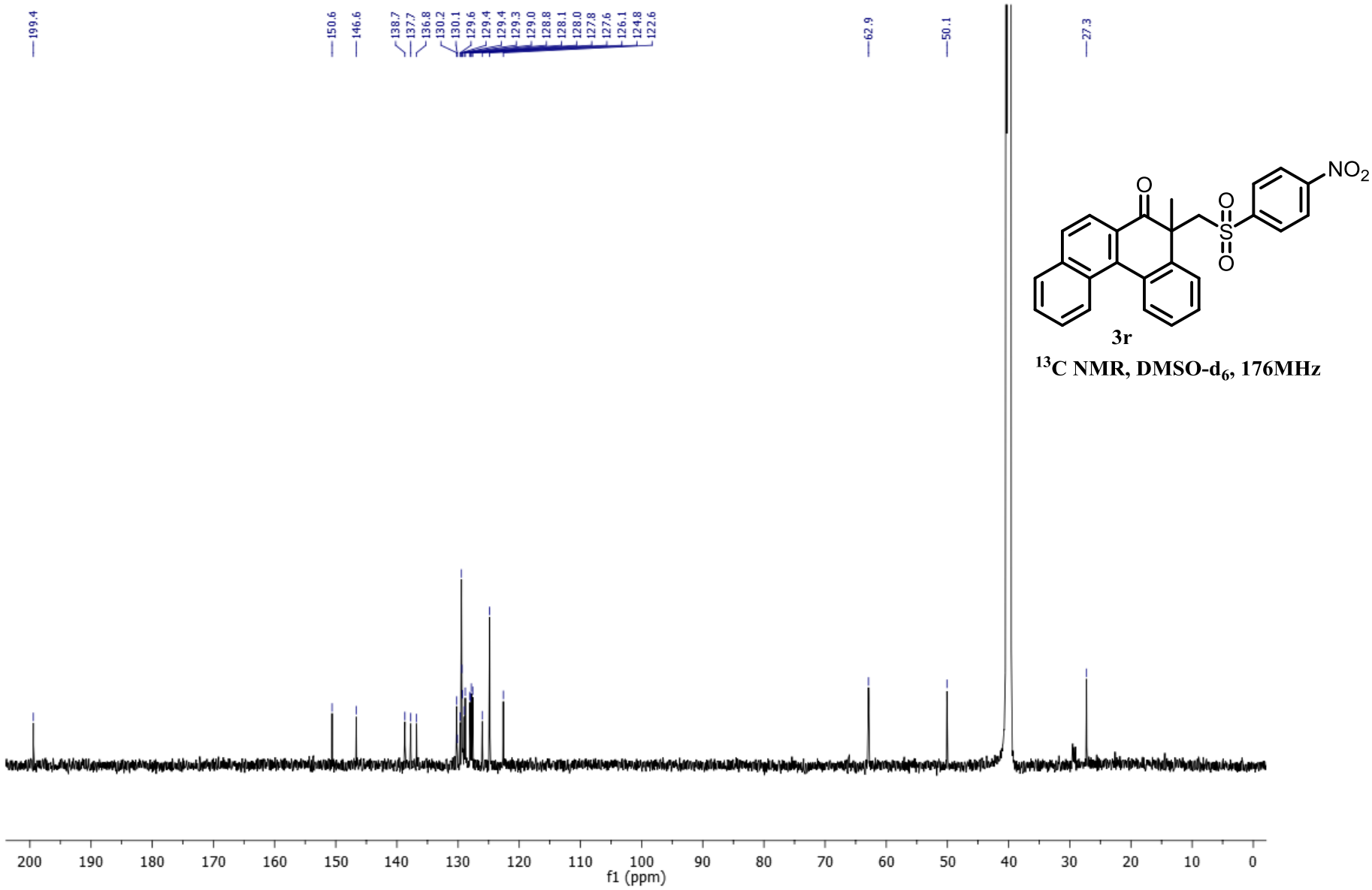
3q

^{13}C NMR, $CDCl_3$, 101MHz



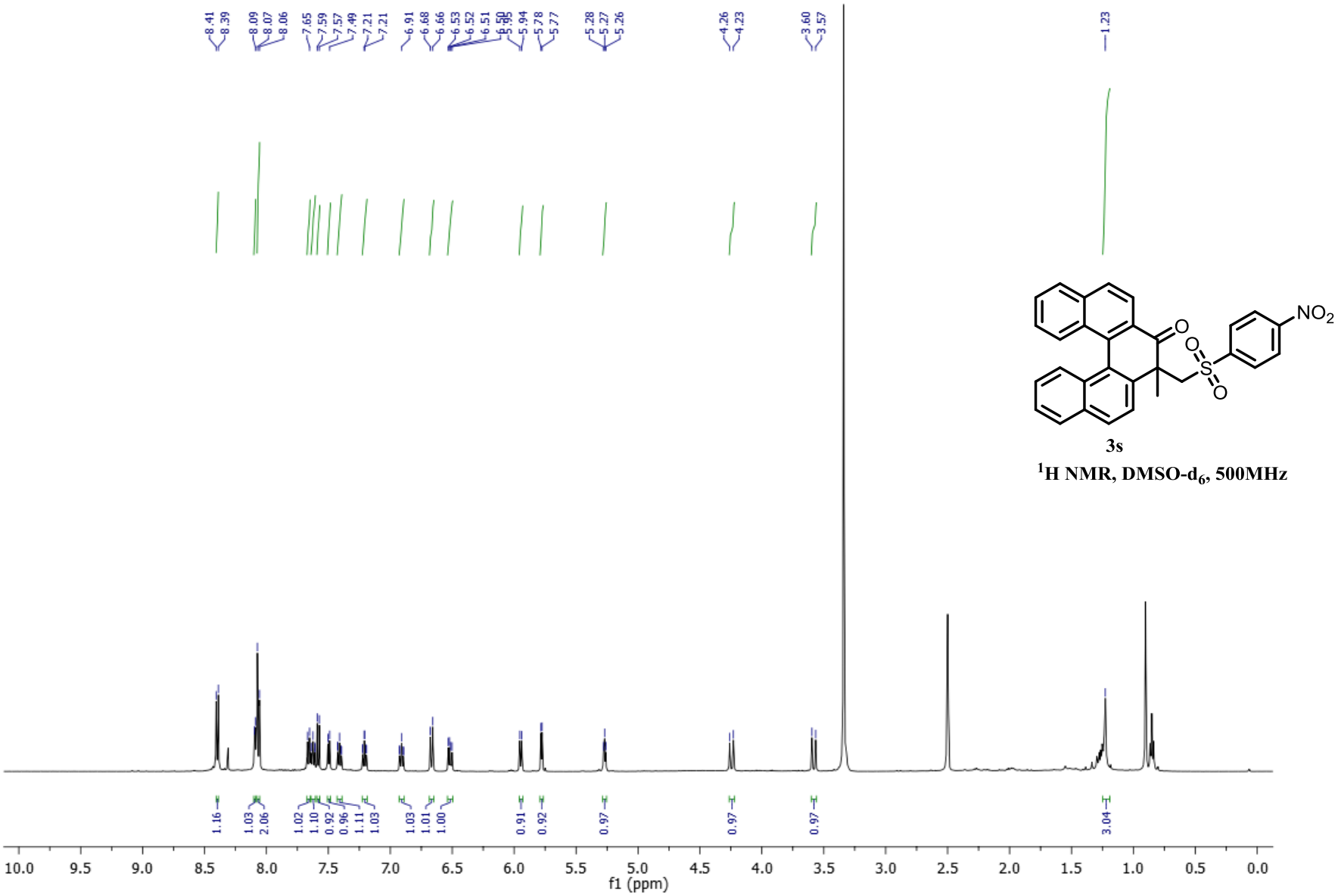
3r

^{1}H NMR, DMSO-d$_6$, 700MHz



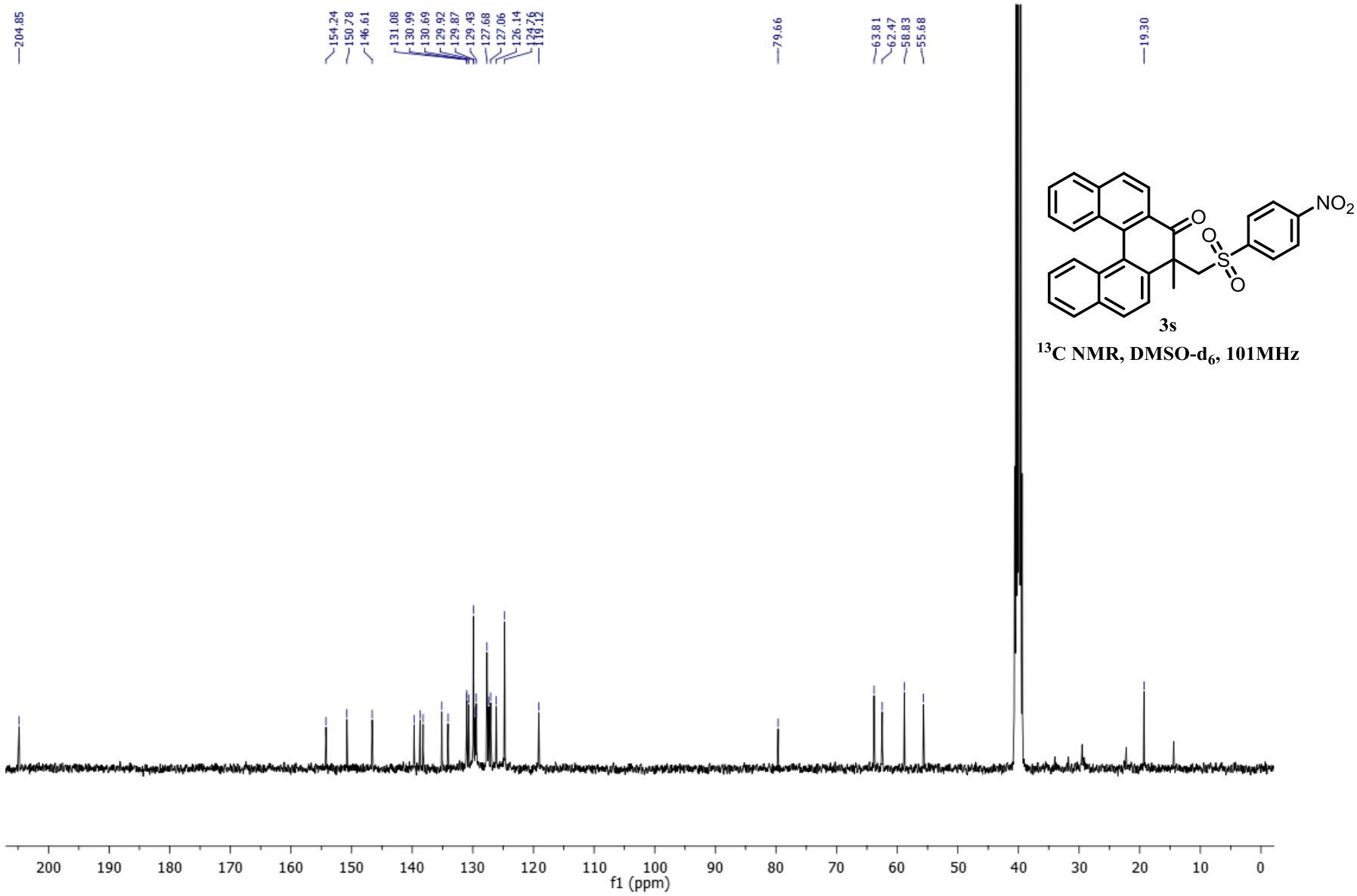
3r

^{13}C NMR, DMSO-d$_6$, 176MHz



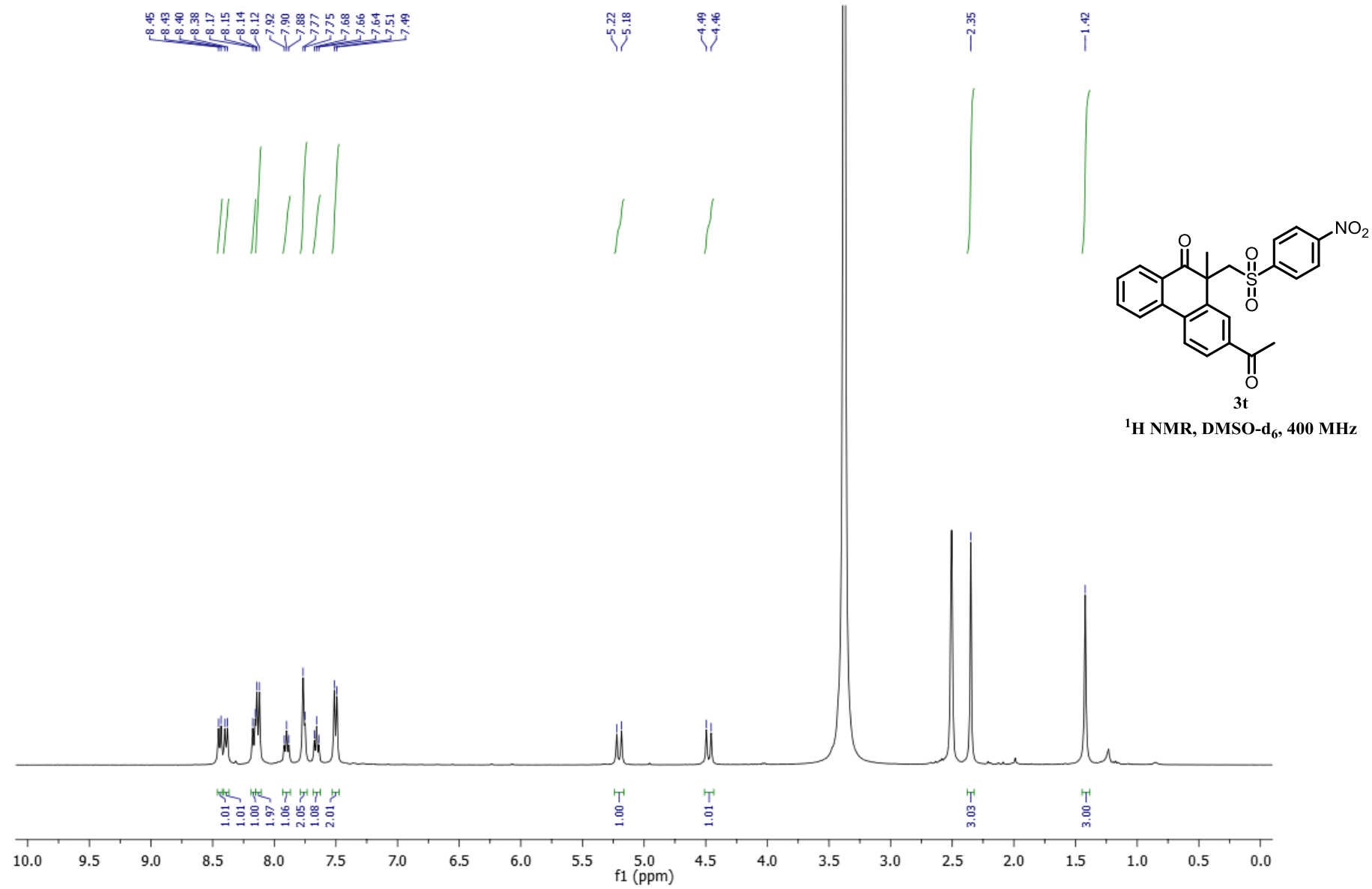
3s

^{1}H NMR, DMSO-d$_6$, 500MHz



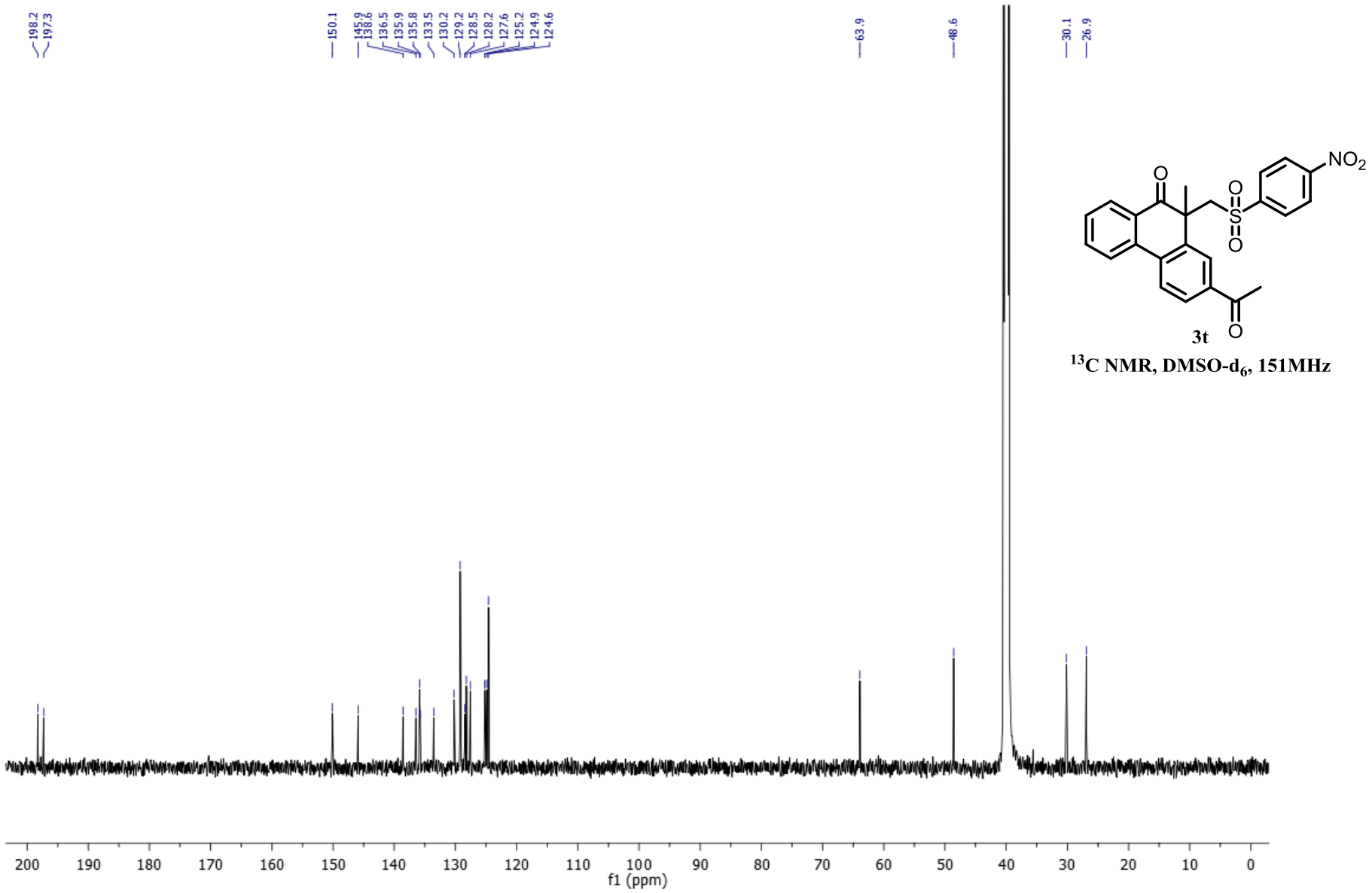
3s

^{13}C NMR, DMSO-d$_6$, 101MHz



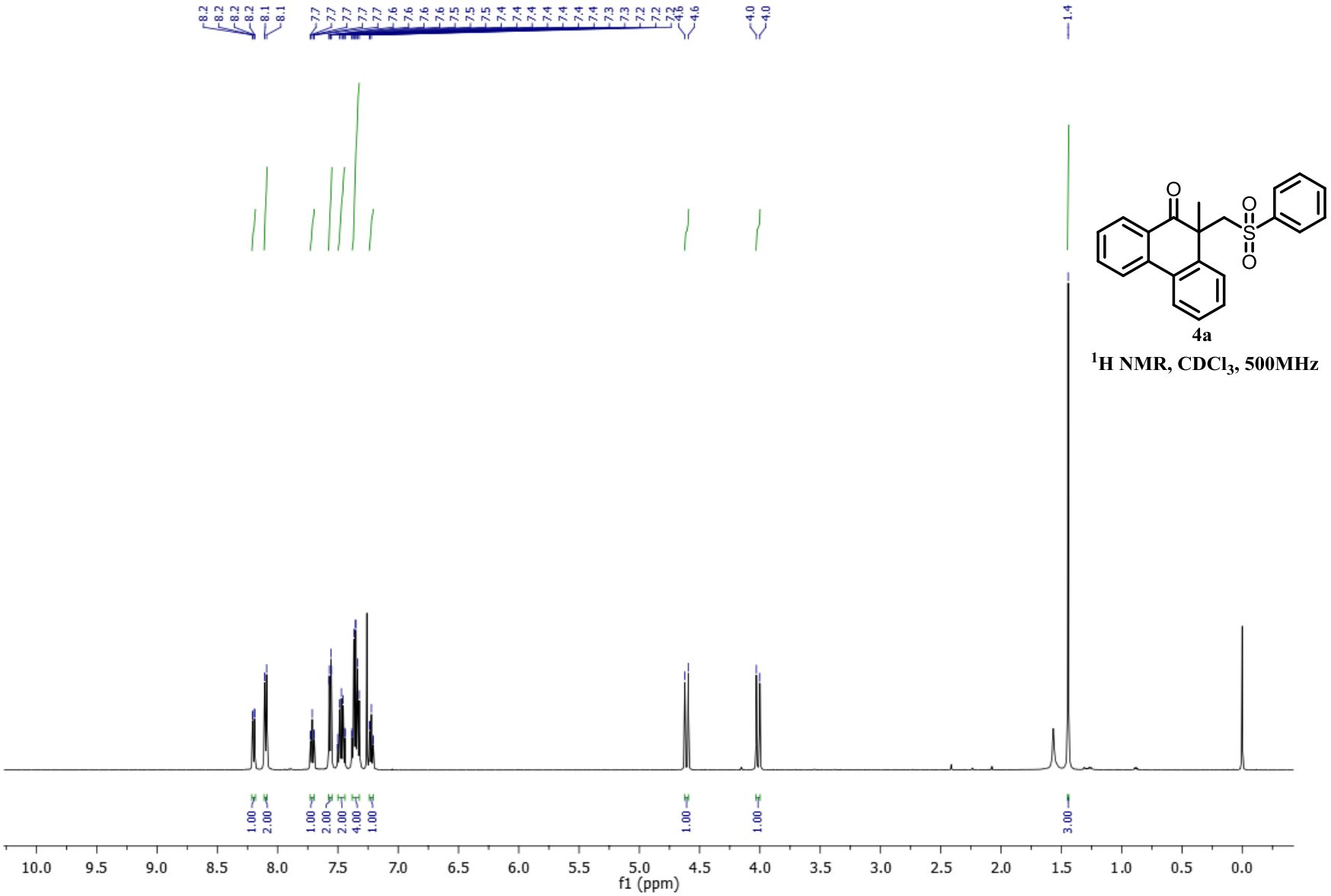
3t

^{1}H NMR, DMSO-d$_6$, 400 MHz



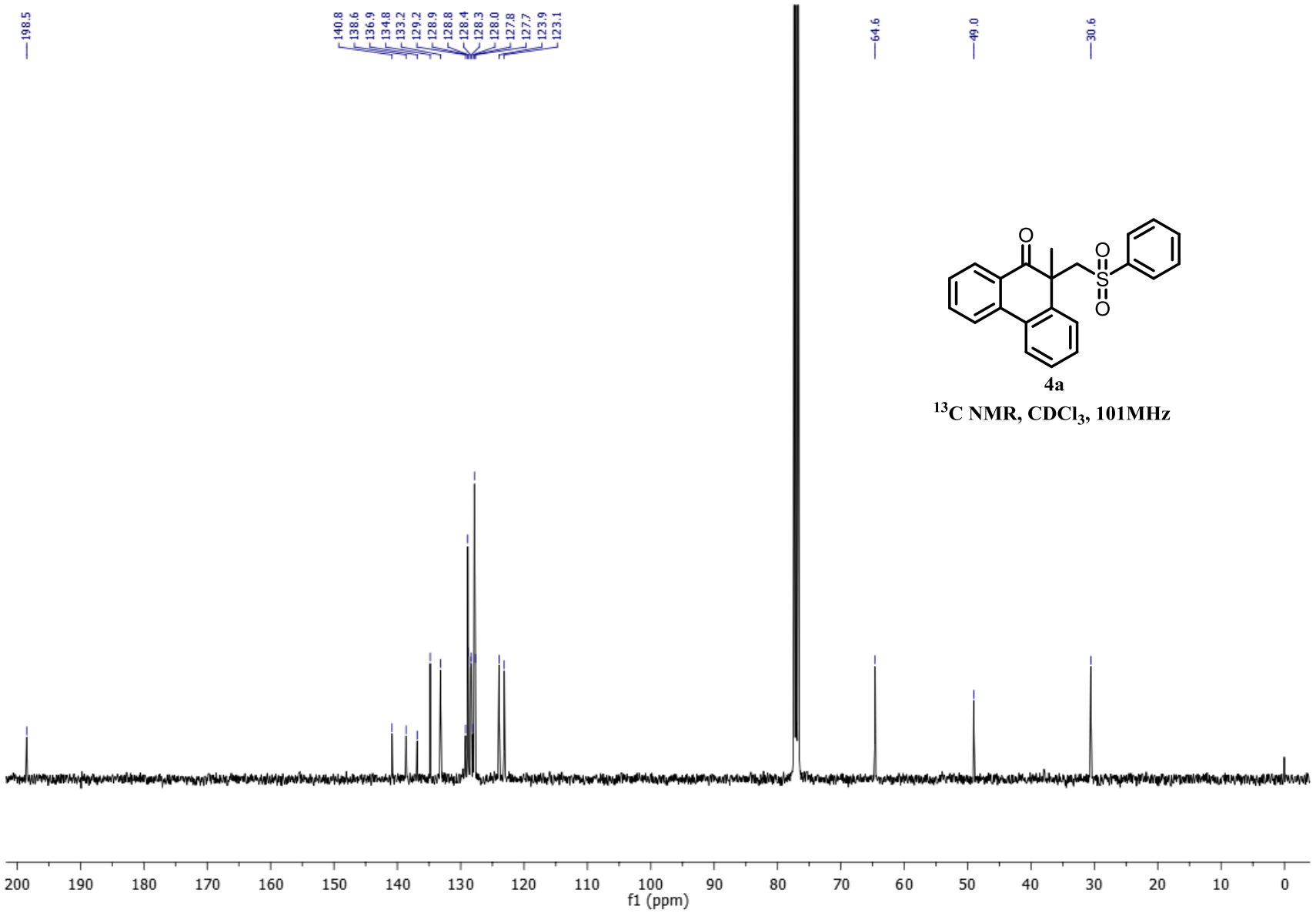
3t

^{13}C NMR, DMSO-d$_6$, 151MHz



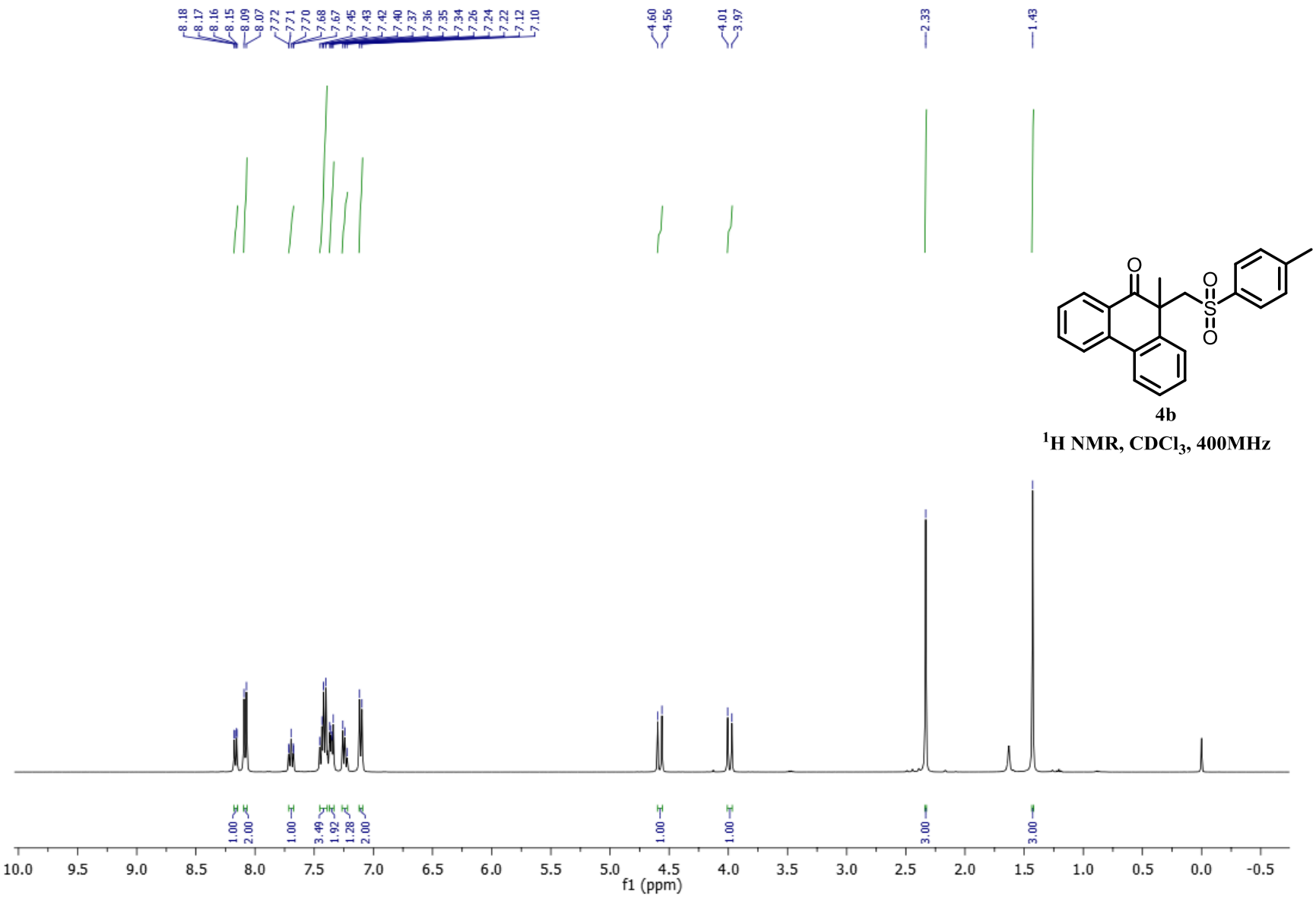
4a

^{1}H NMR, $CDCl_3$, 500MHz



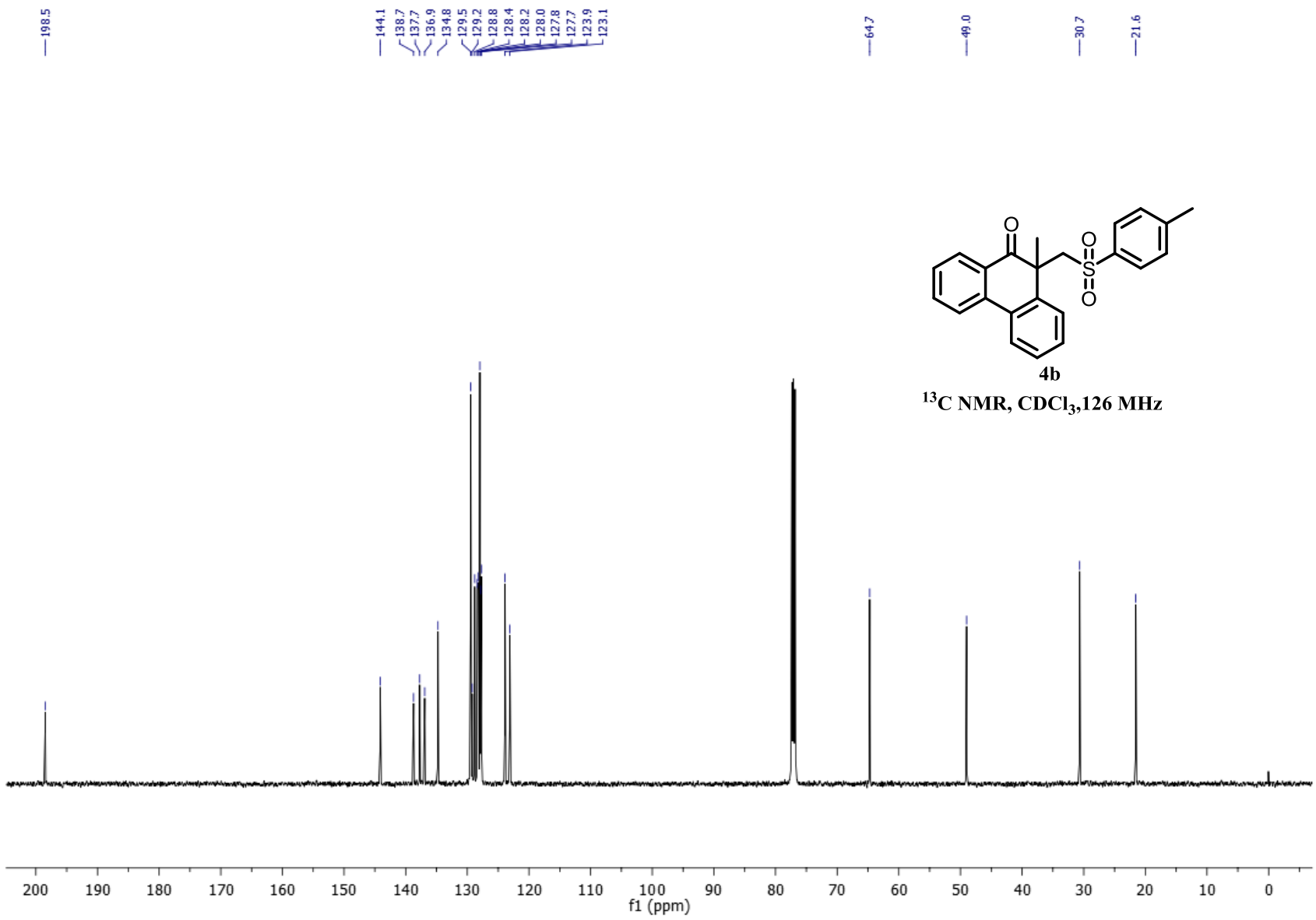
4a

^{13}C NMR, $CDCl_3$, 101MHz



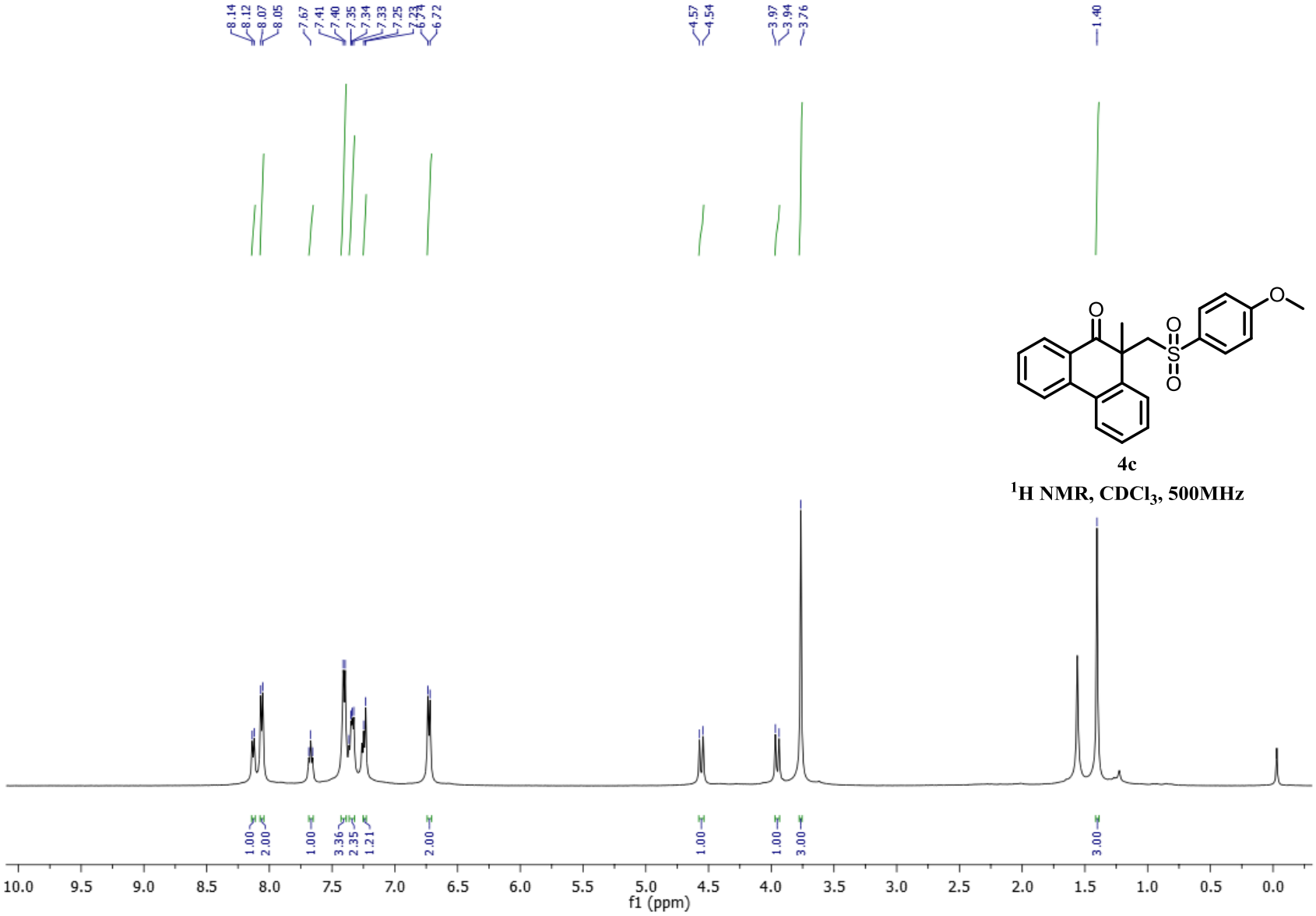
4b

^{1}H NMR, $CDCl_3$, 400MHz



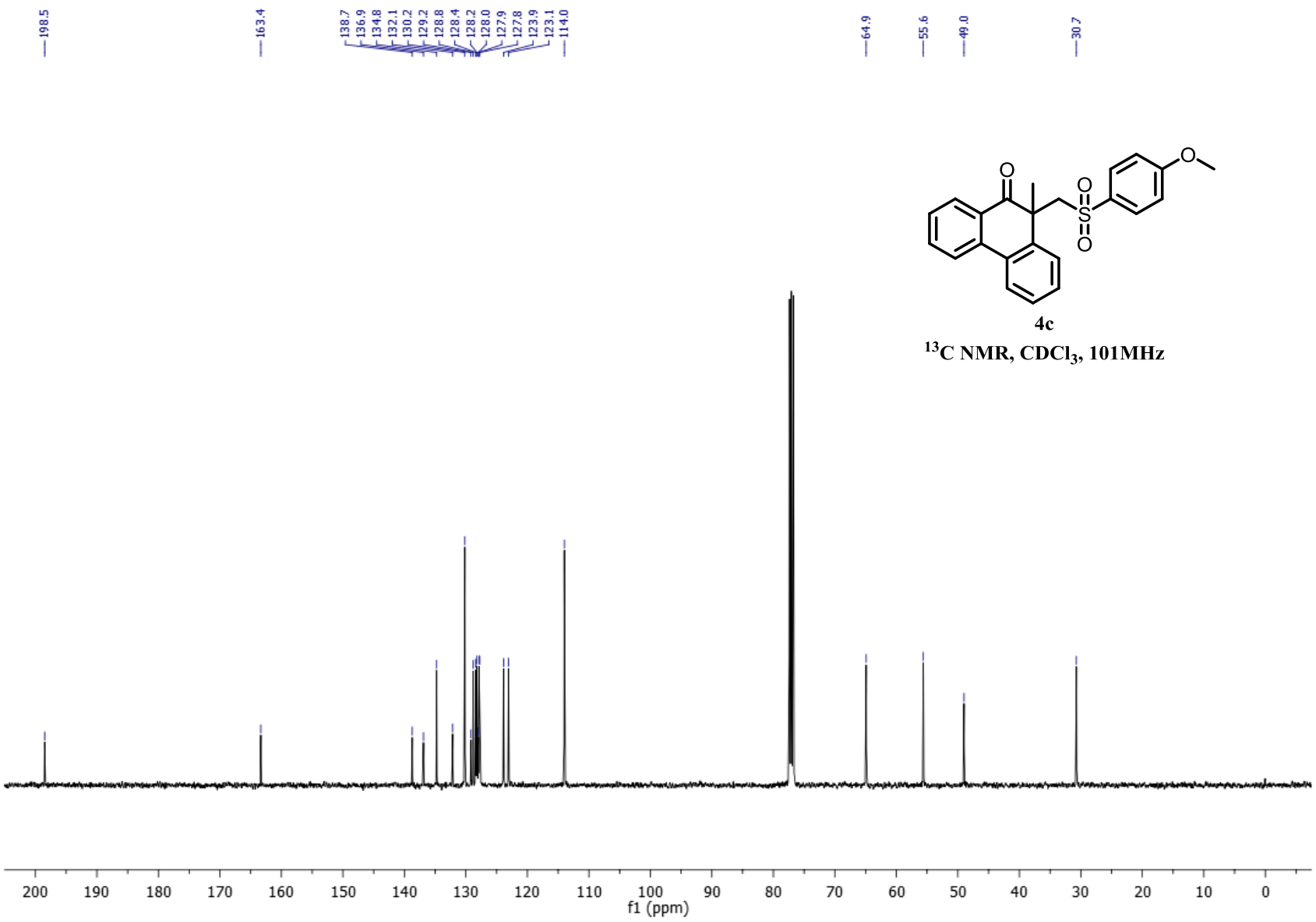
4b

^{13}C NMR, $CDCl_3$,126 MHz



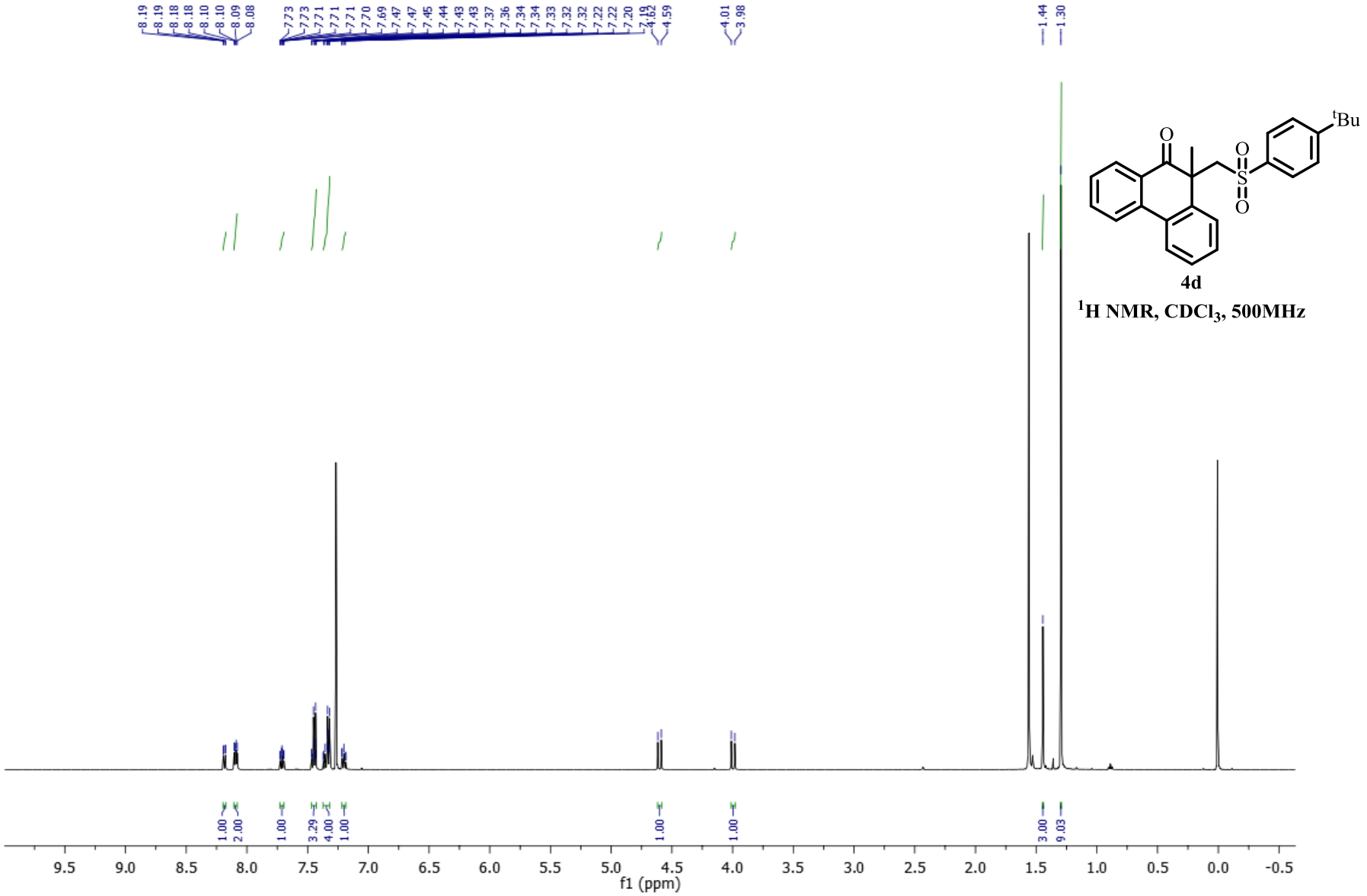
4c

^{1}H NMR, $CDCl_3$, 500MHz



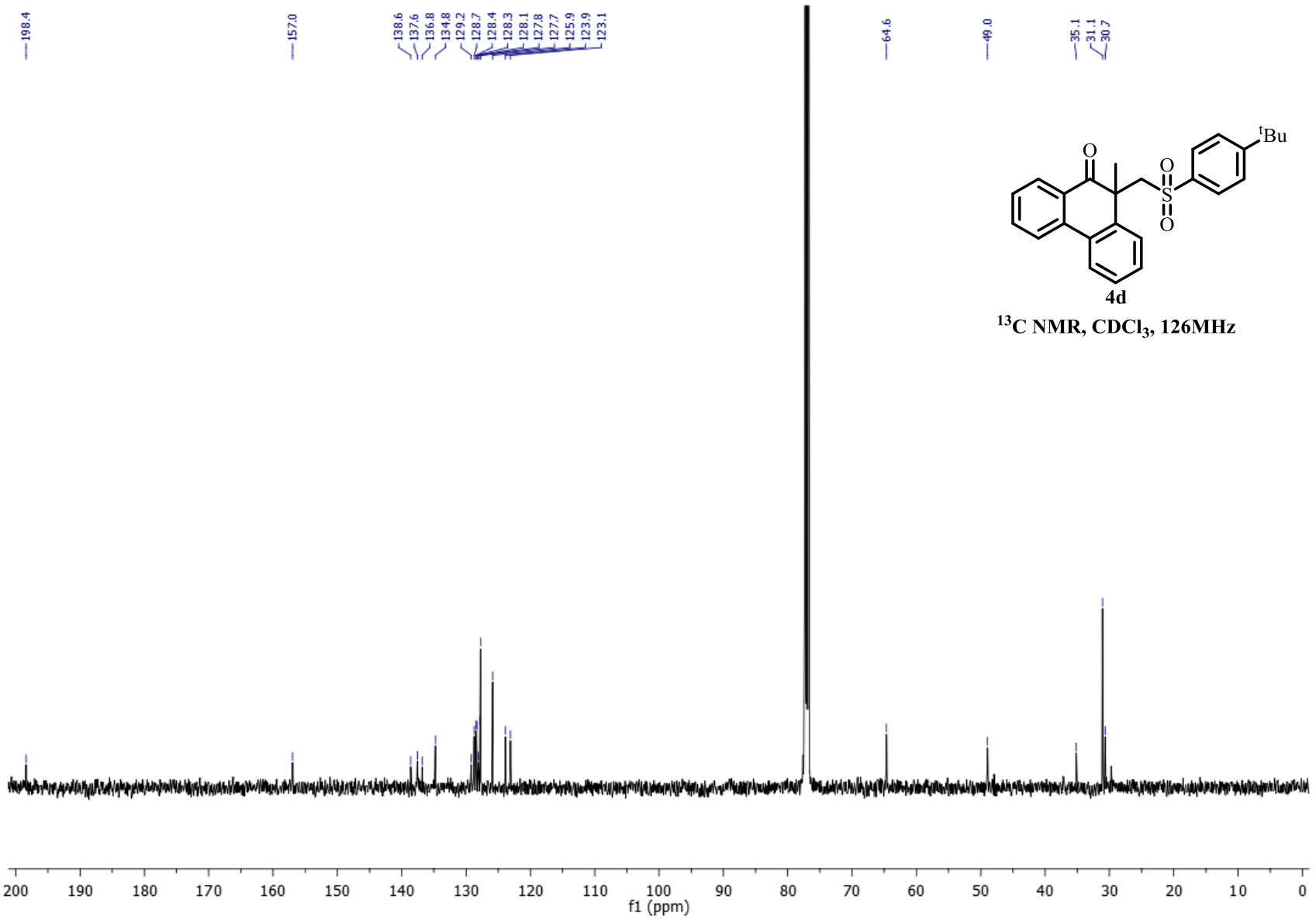
4c

^{13}C NMR, $CDCl_3$, 101MHz



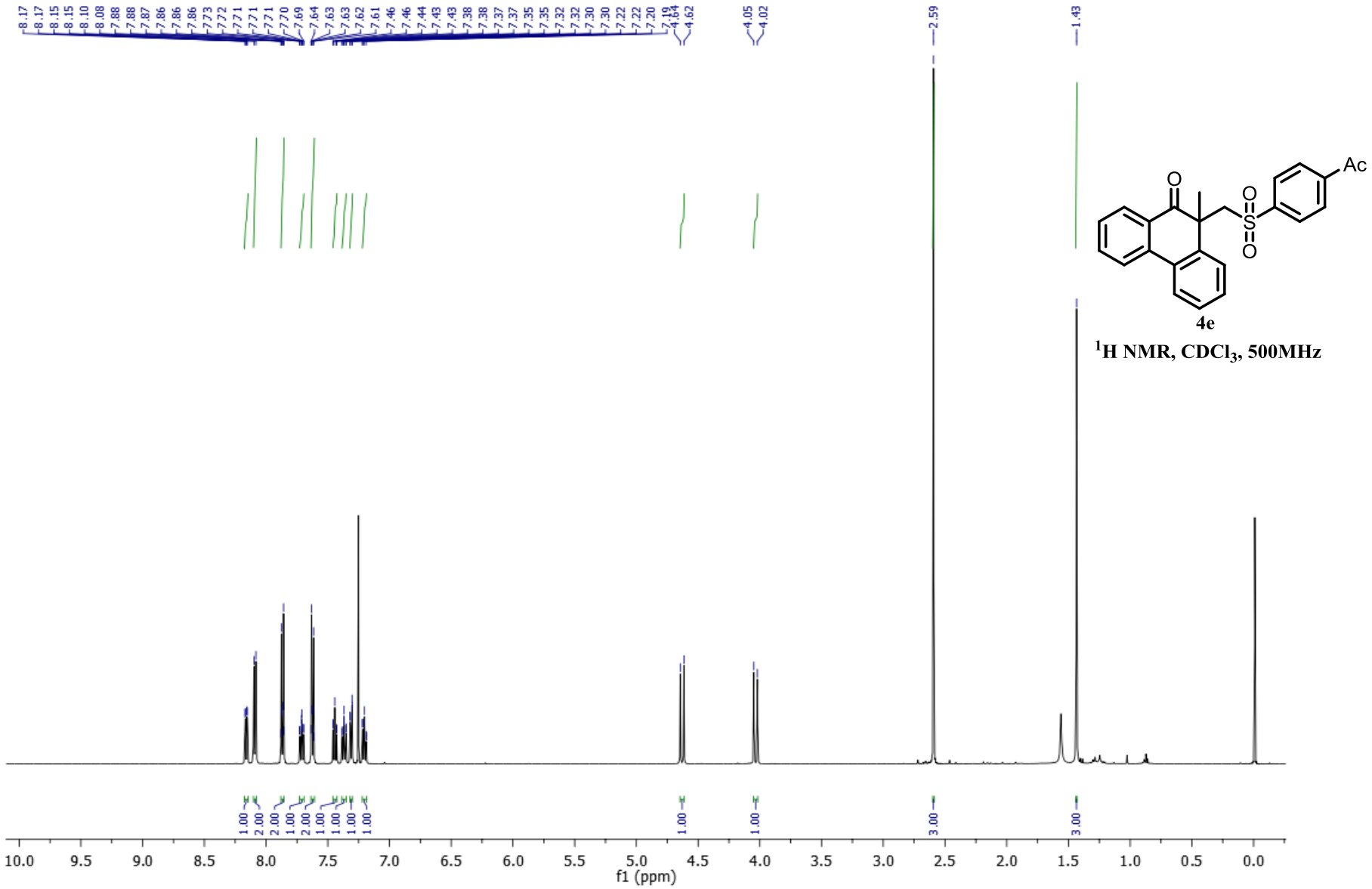
4d

^{1}H NMR, $CDCl_3$, 500MHz



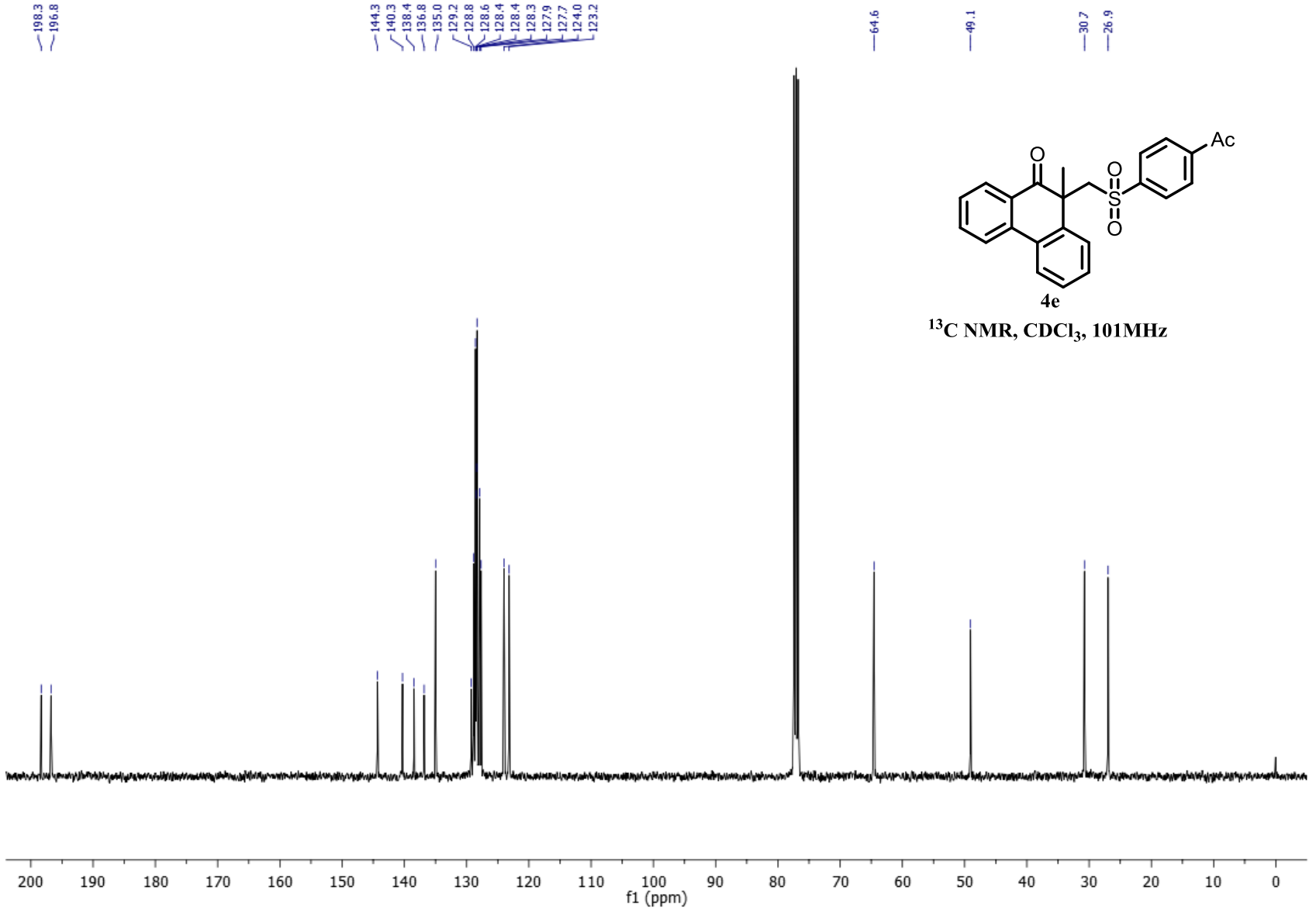
4d

^{13}C NMR, $CDCl_3$, 126MHz



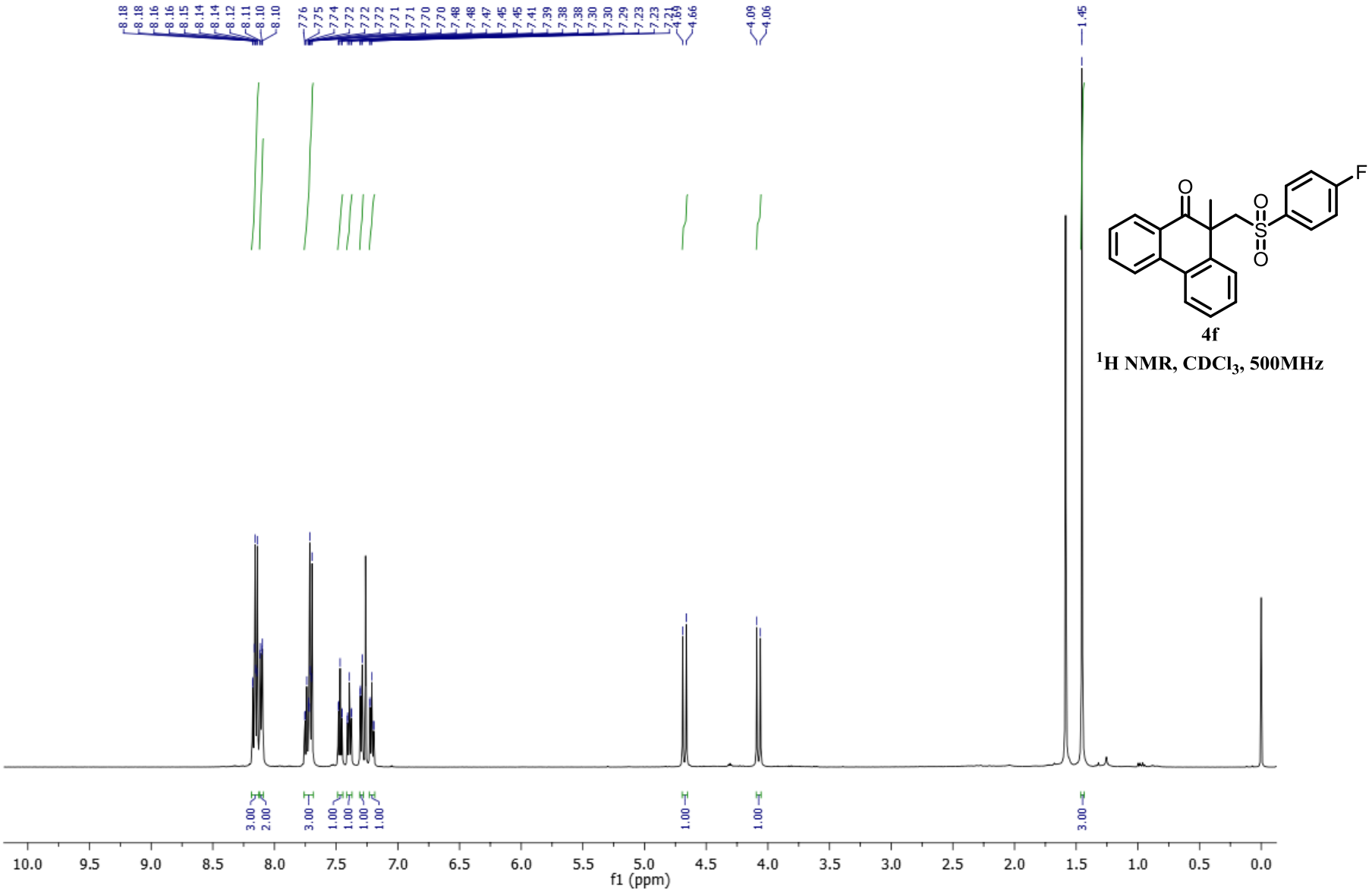
4e

^{1}H NMR, $CDCl_3$, 500MHz



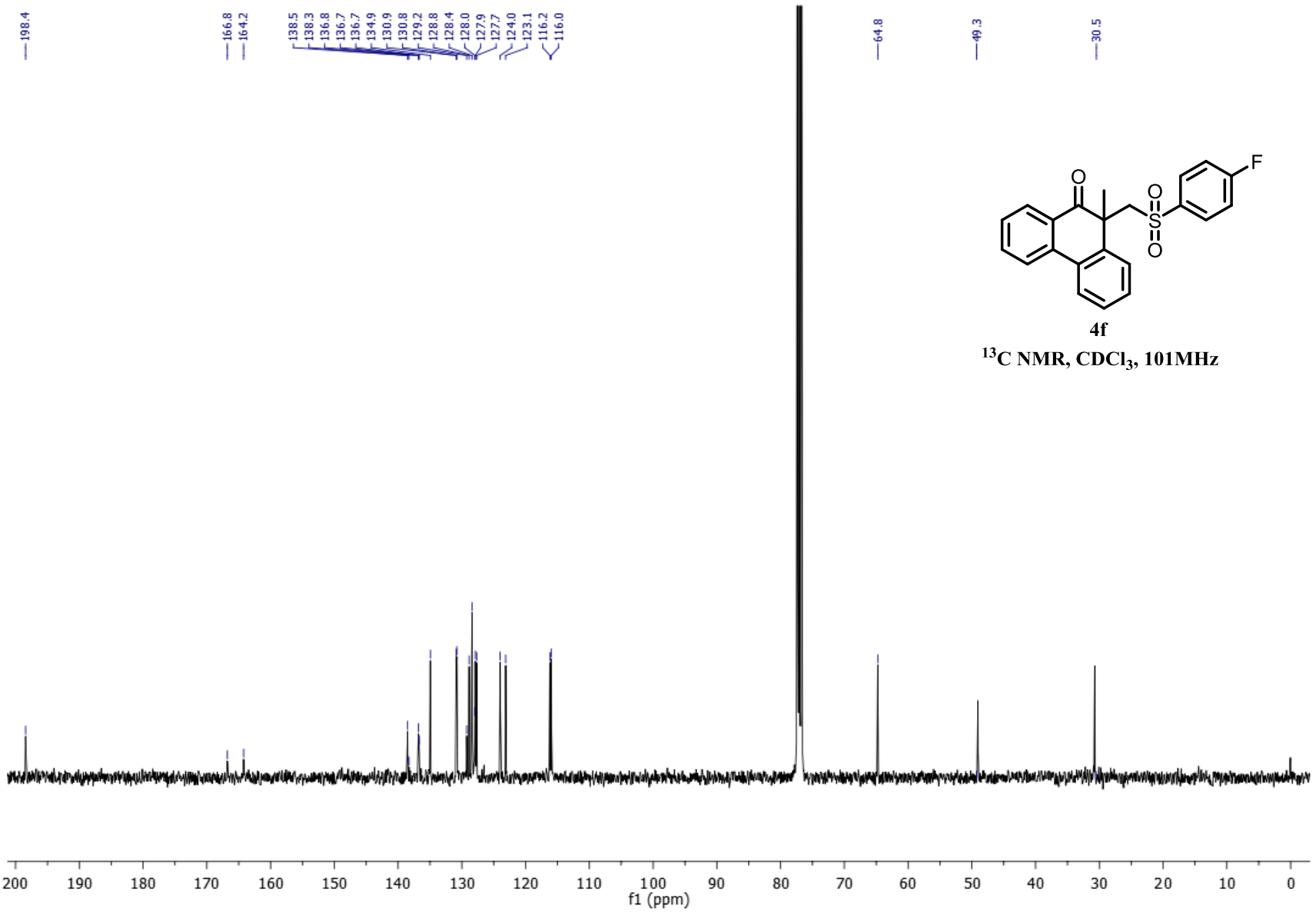
4e

^{13}C NMR, $CDCl_3$, 101MHz



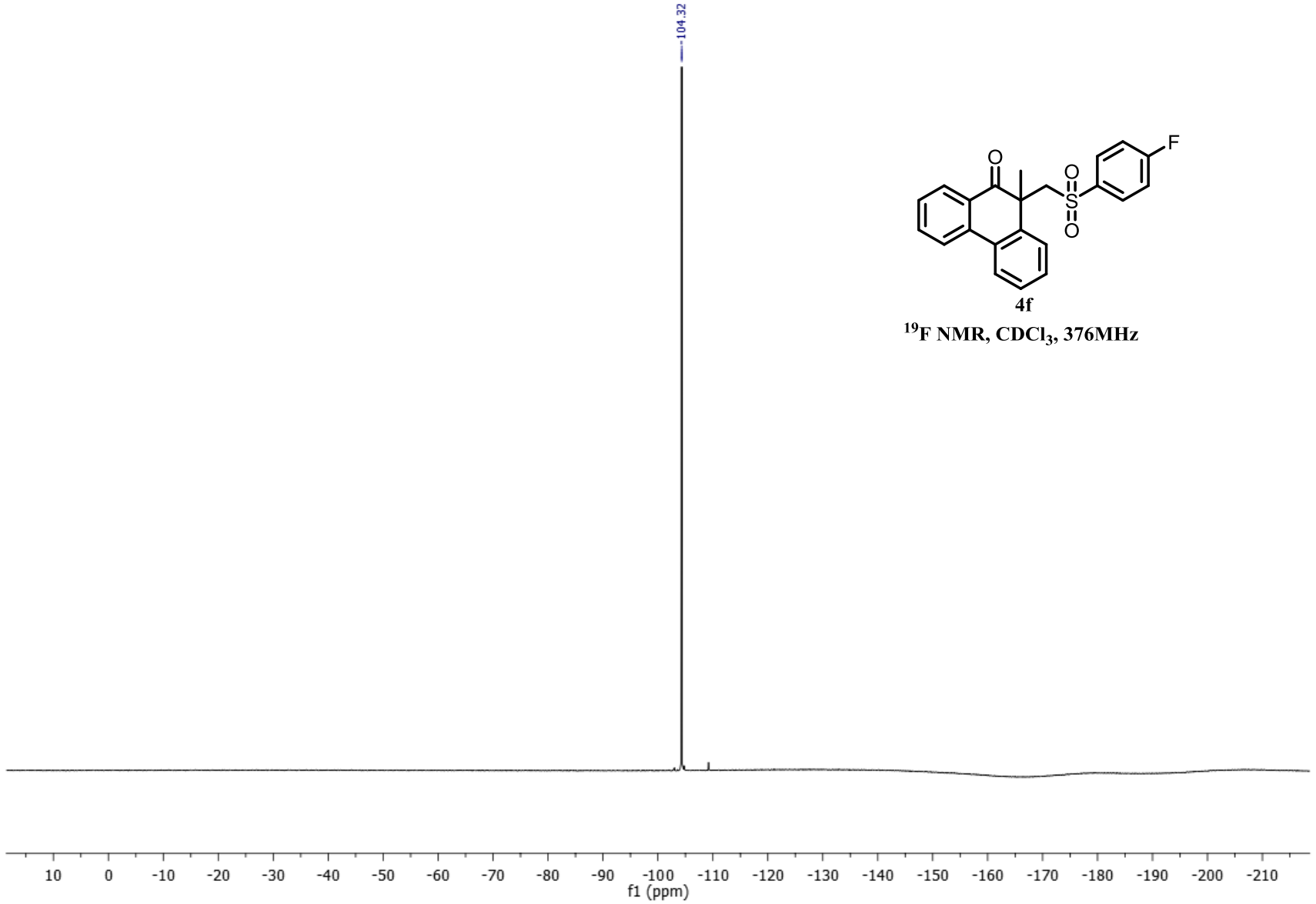
4f

^{1}H NMR, $CDCl_3$, 500MHz



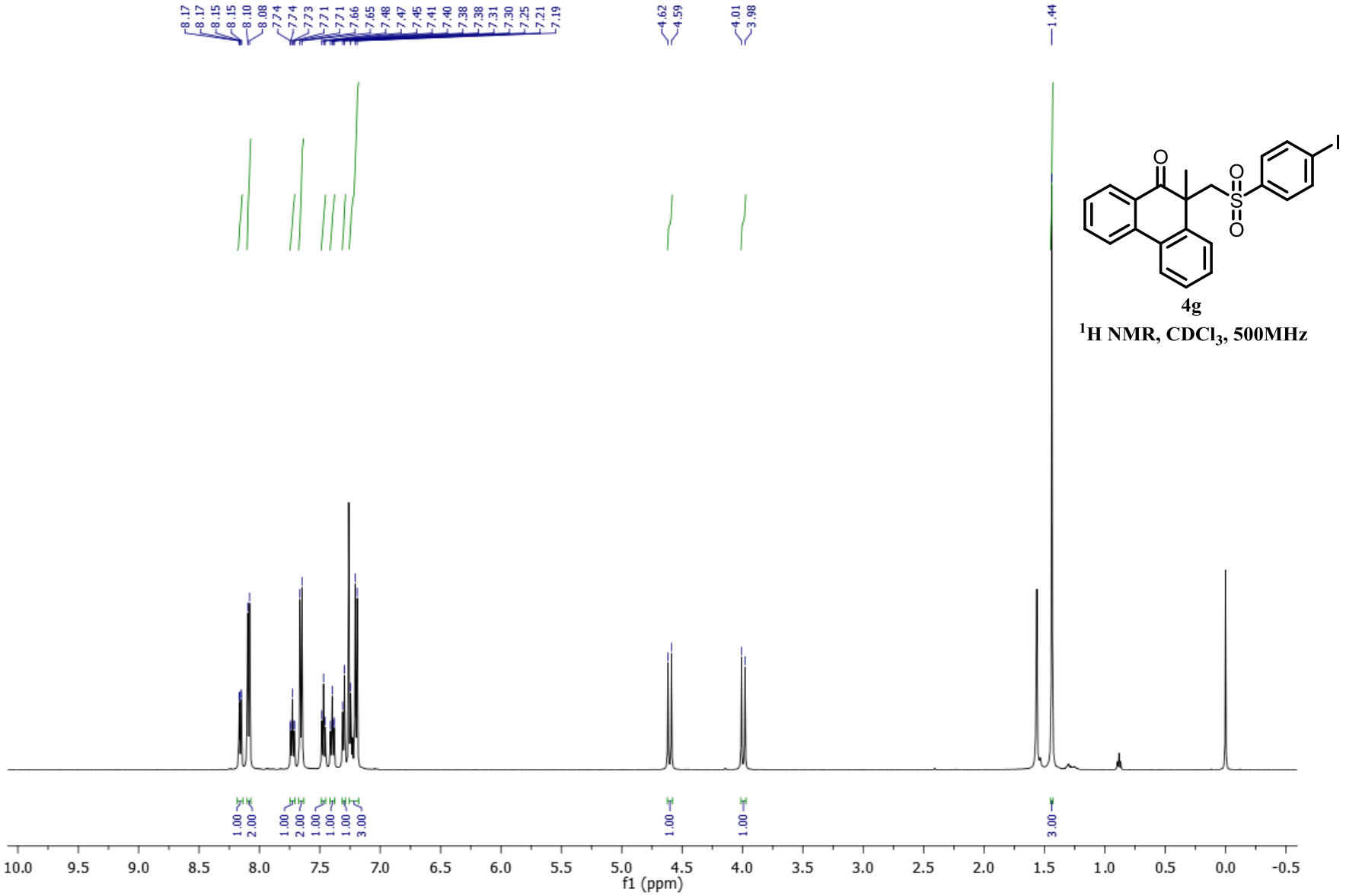
4f

^{13}C NMR, $CDCl_3$, 101MHz



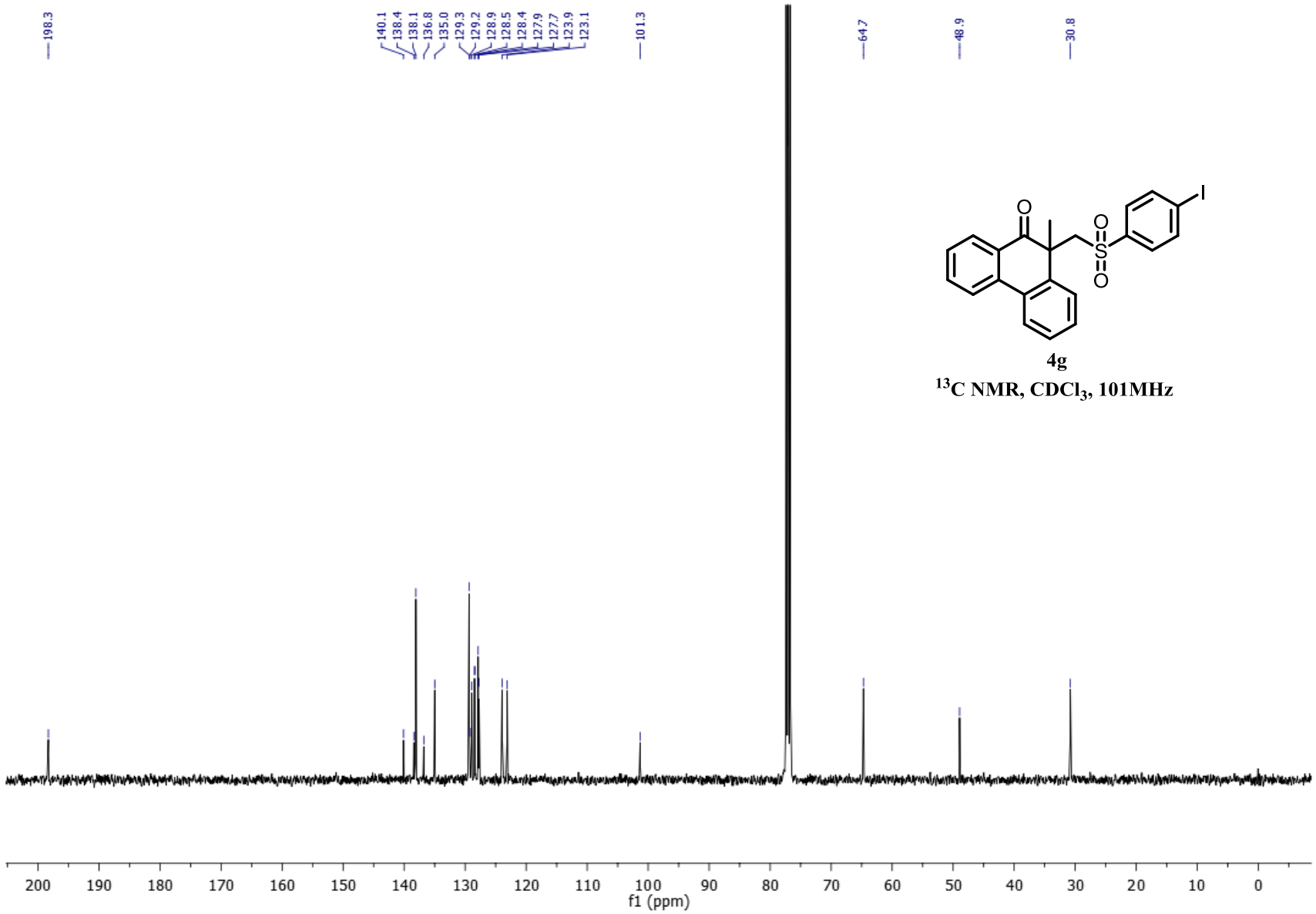
4f

^{19}F NMR, $CDCl_3$, 376MHz



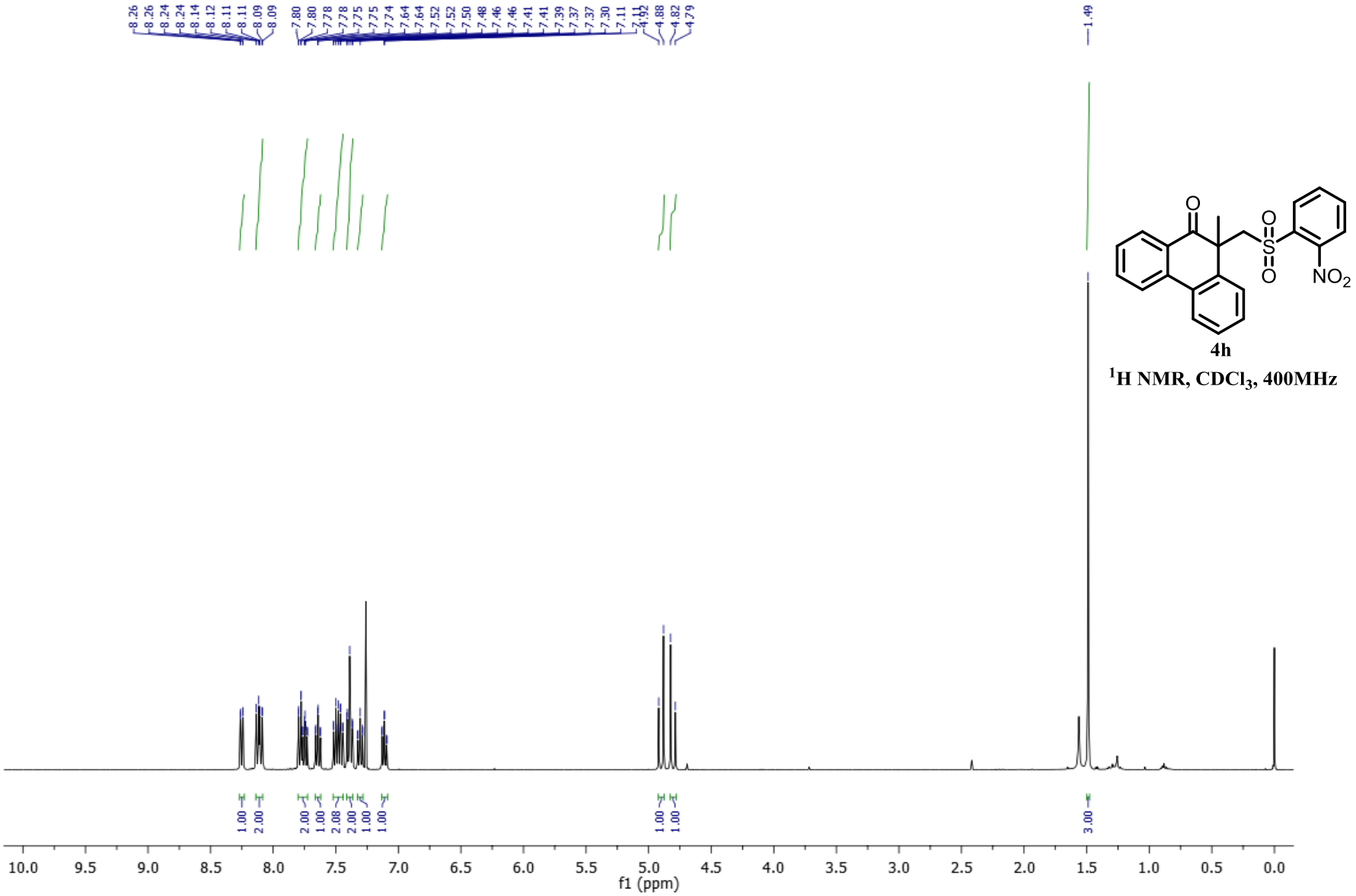
4g

^{1}H NMR, $CDCl_3$, 500MHz



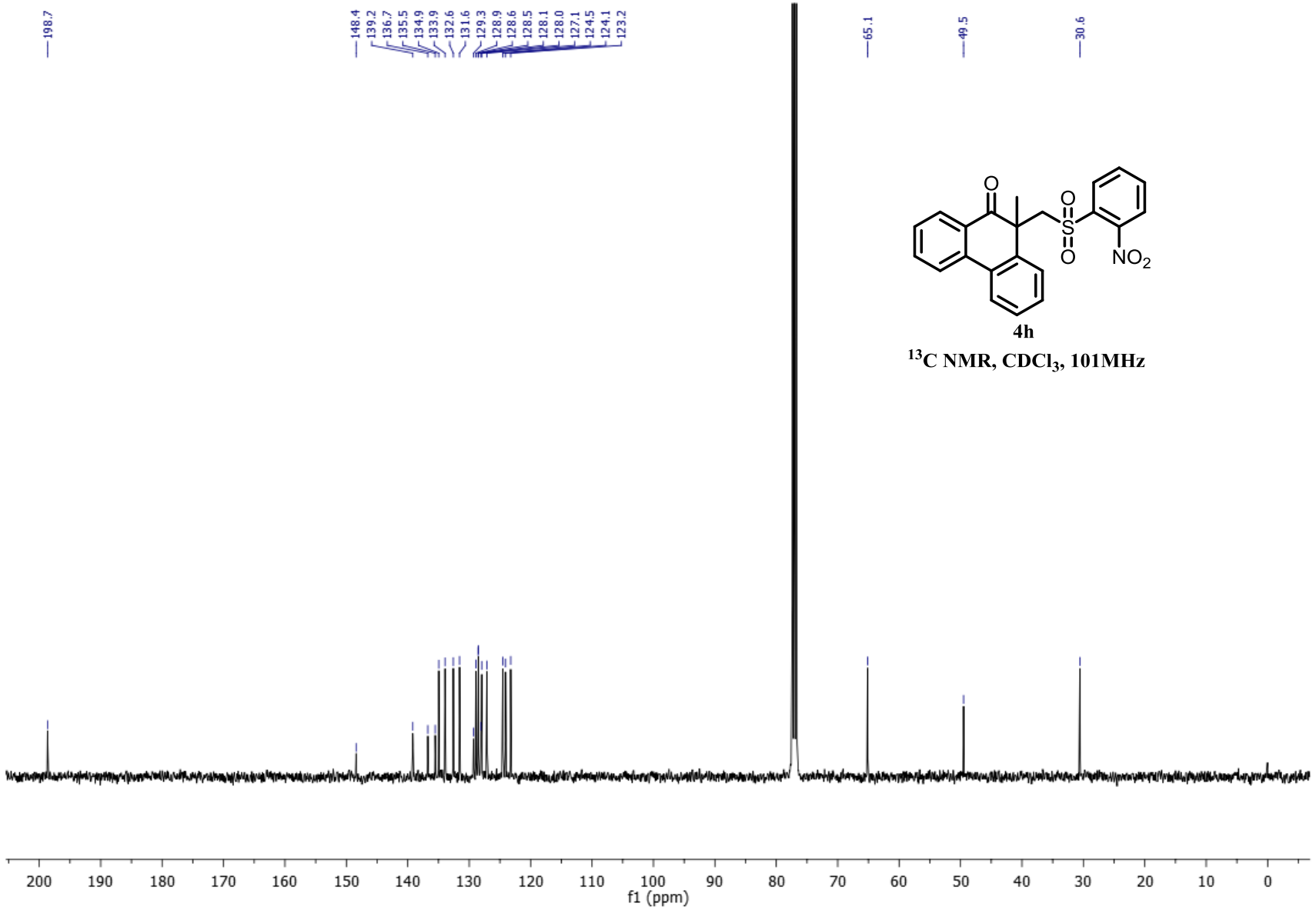
4g

^{13}C NMR, $CDCl_3$, 101MHz



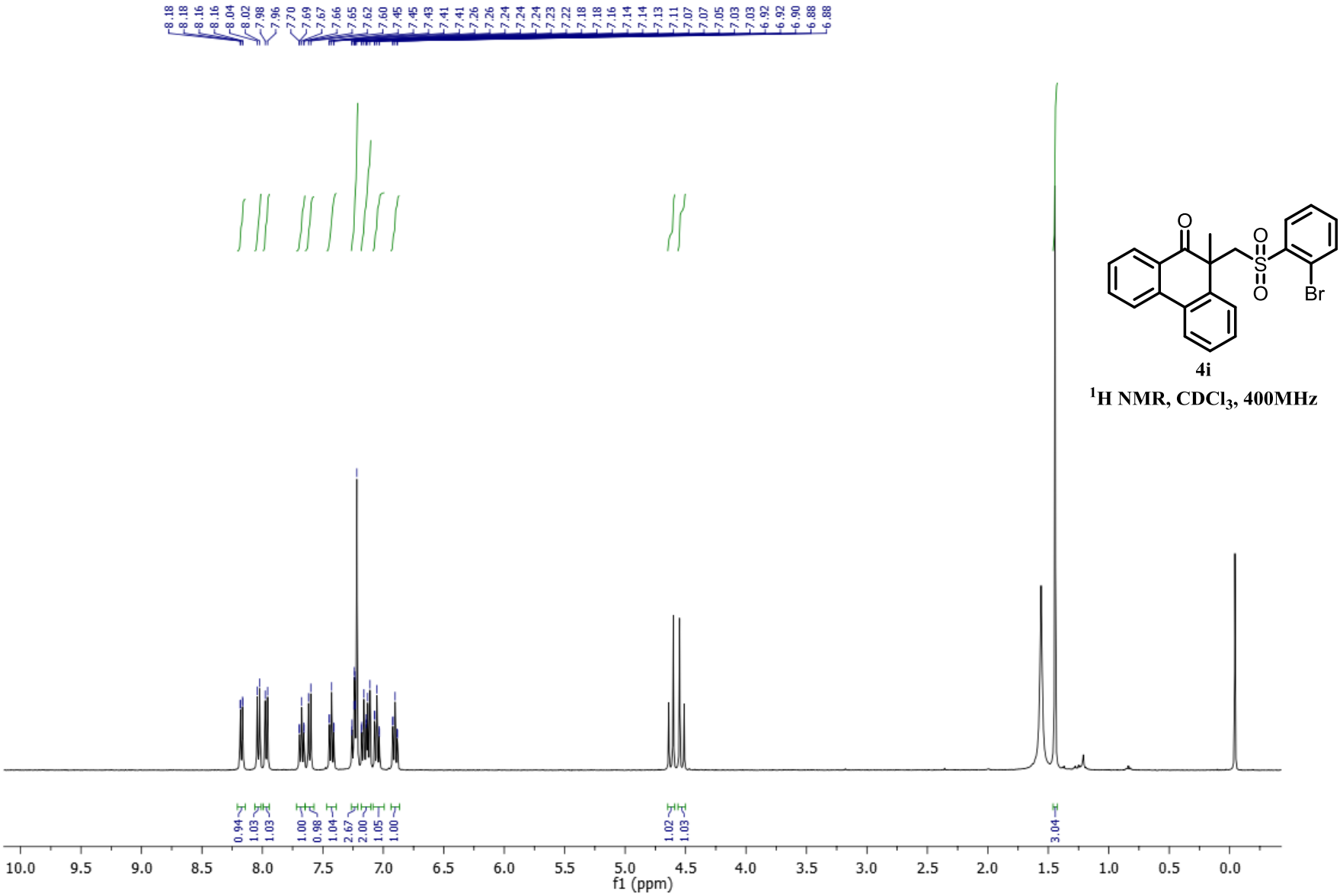
4h

^{1}H NMR, $CDCl_3$, 400MHz



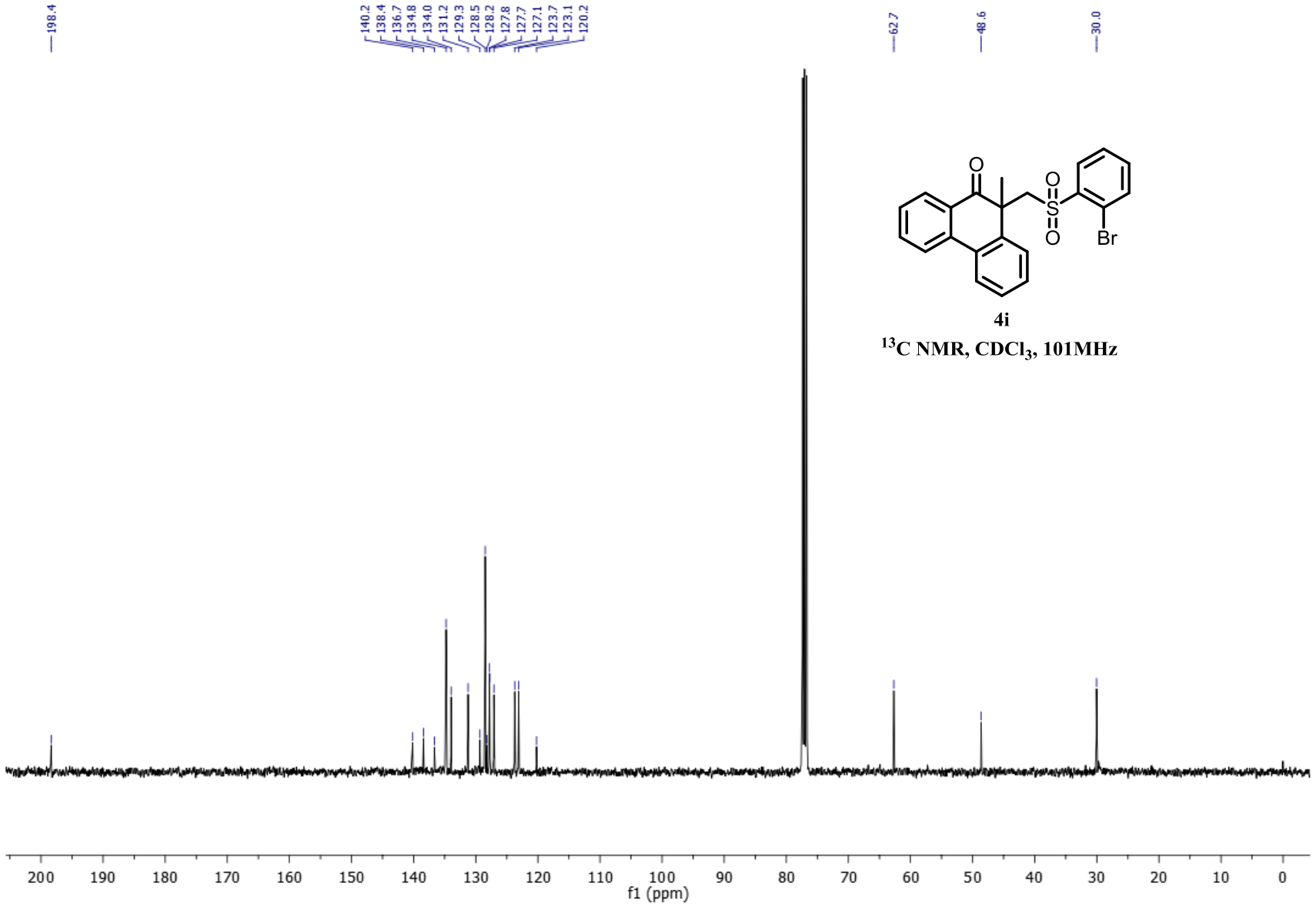
4h

^{13}C NMR, $CDCl_3$, 101MHz



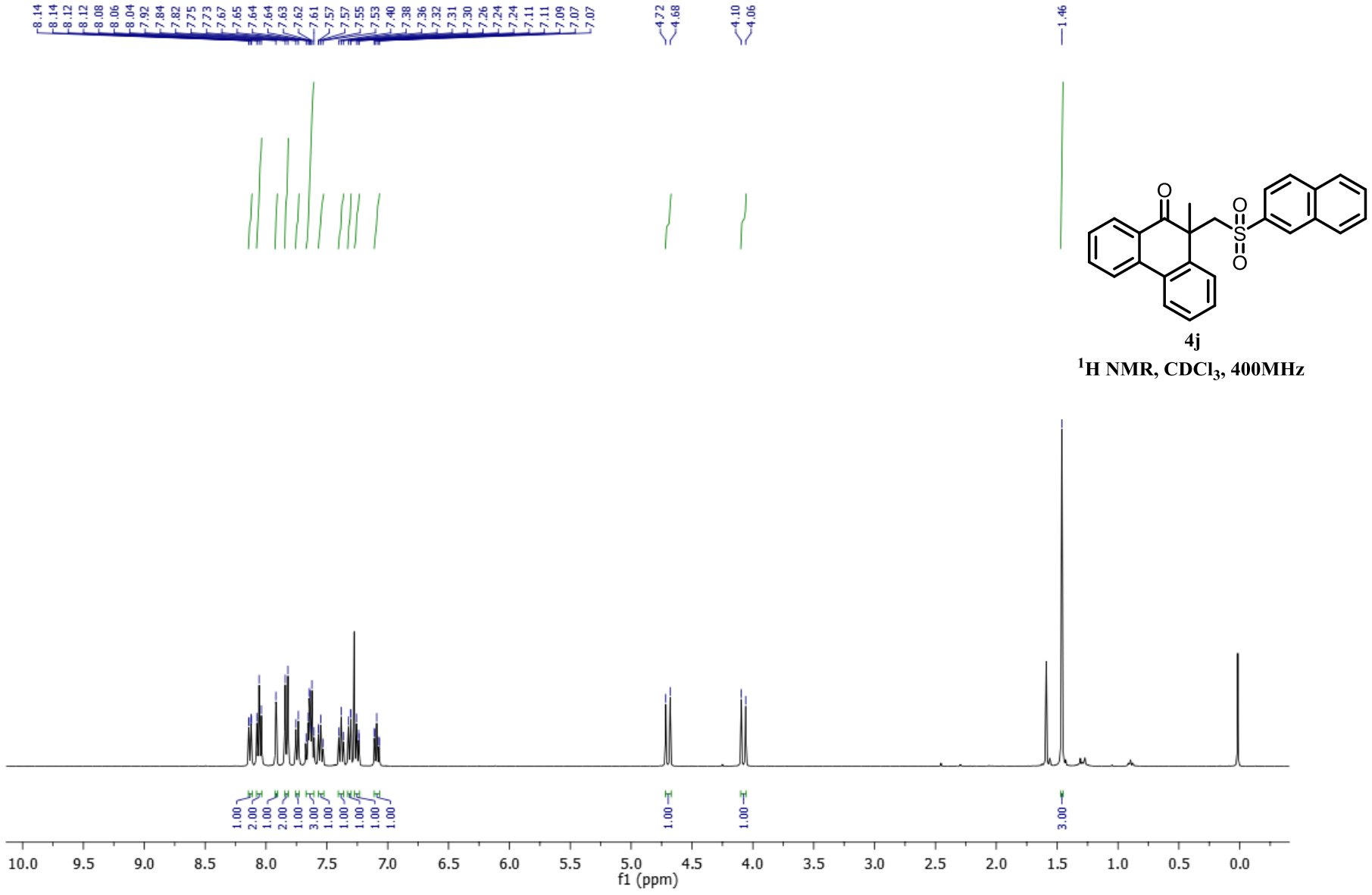
4i

^{1}H NMR, $CDCl_3$, 400MHz



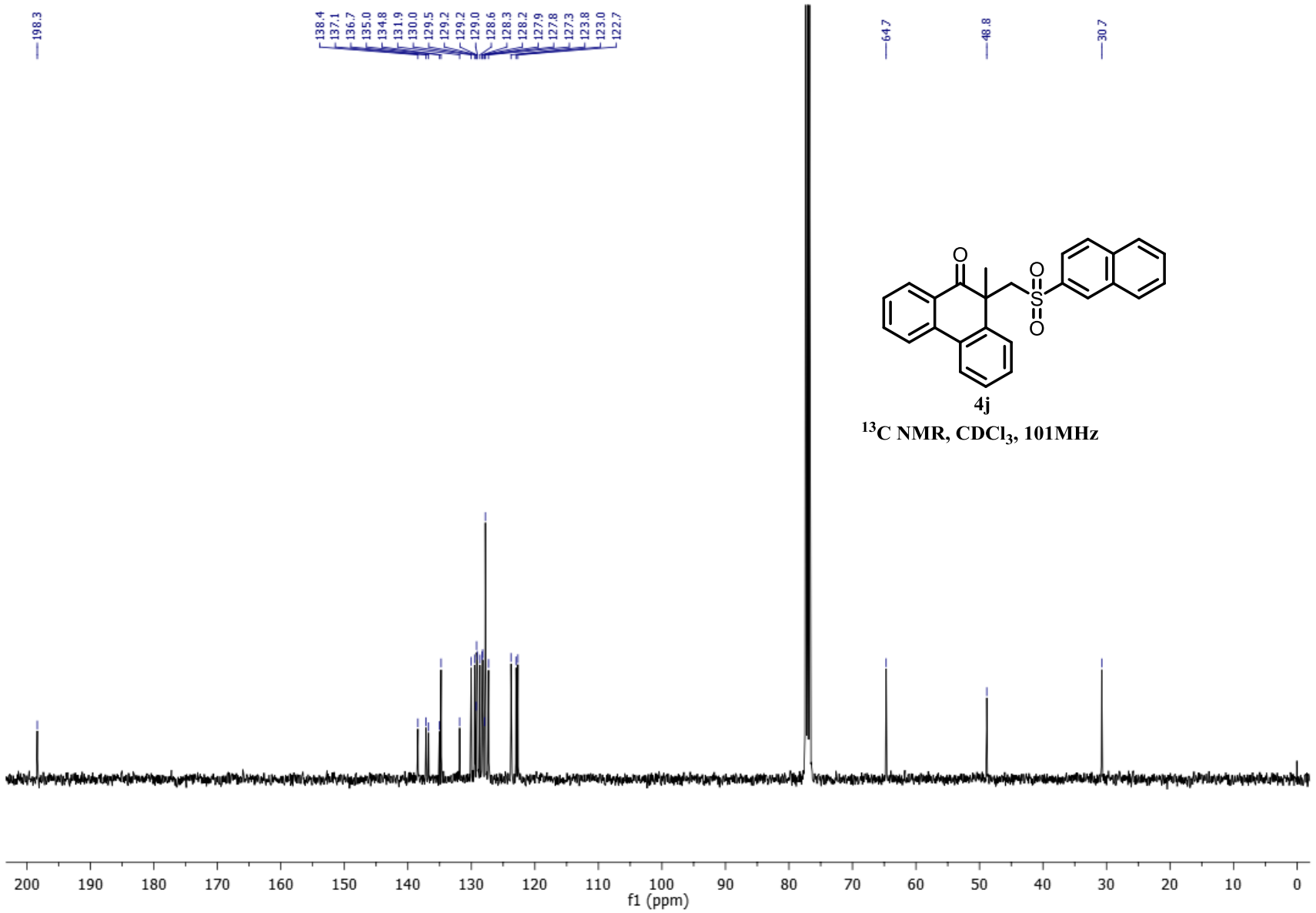
4i

^{13}C NMR, $CDCl_3$, 101MHz



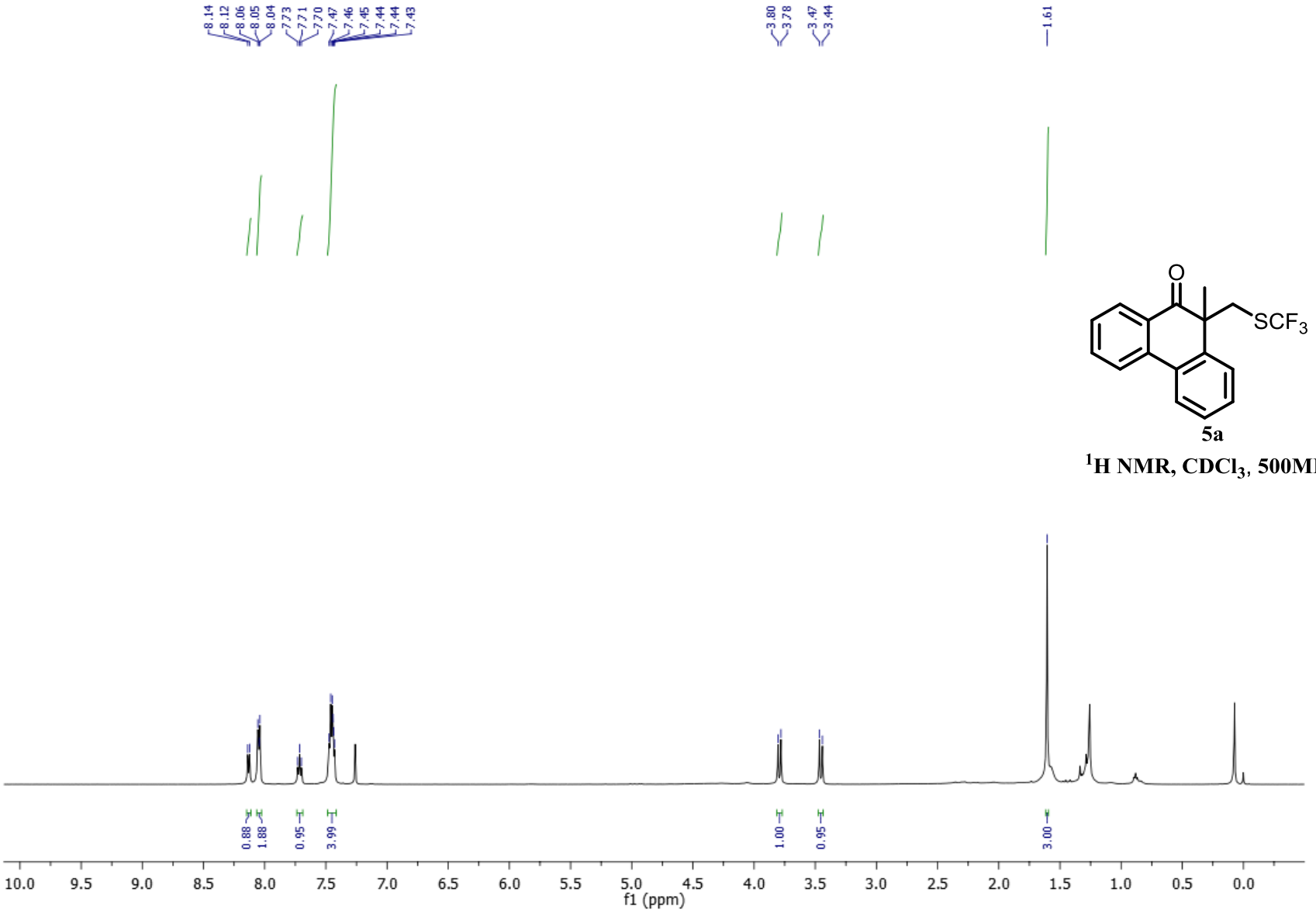
4j

^{1}H NMR, $CDCl_3$, 400MHz



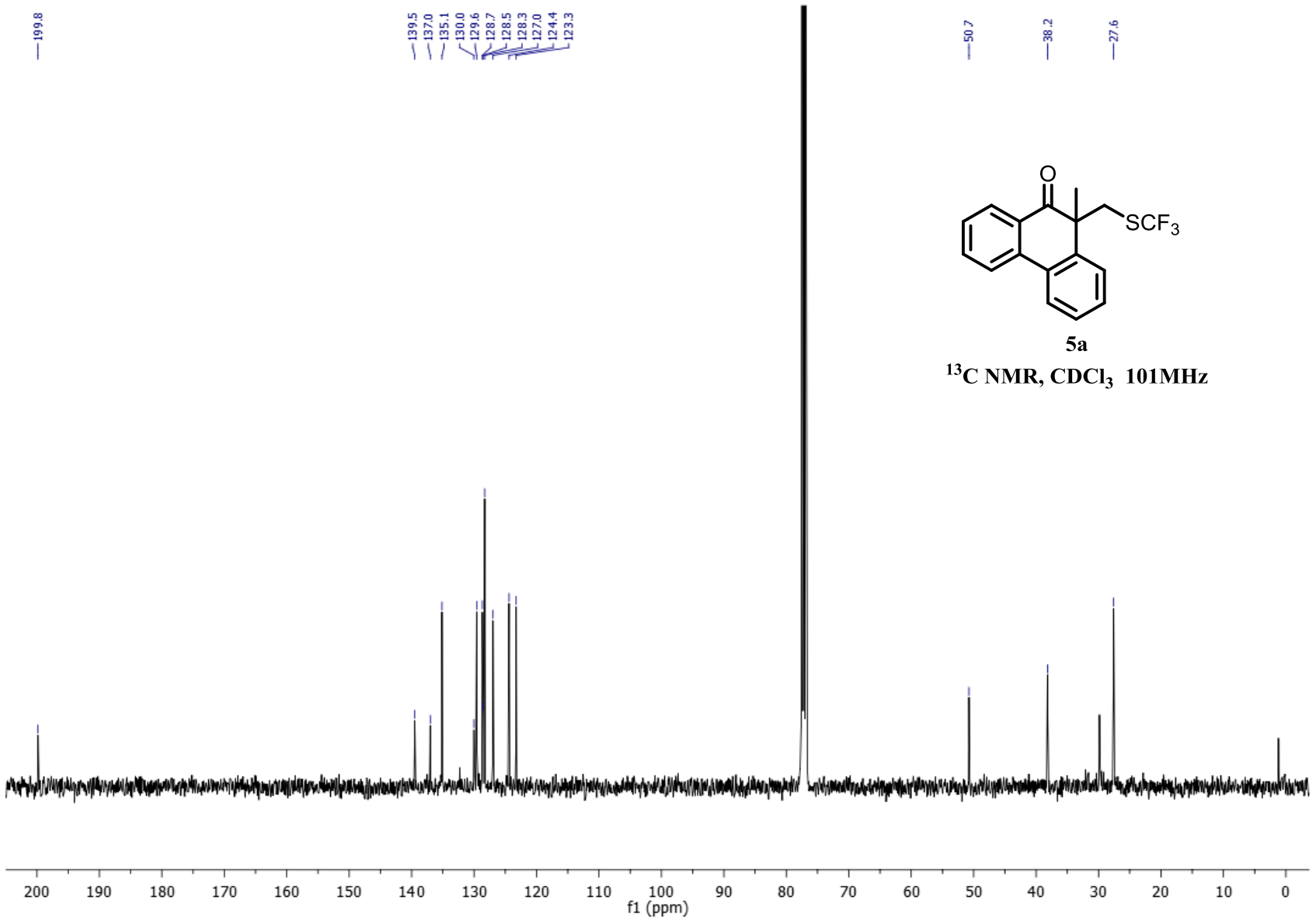
4j

^{13}C NMR, $CDCl_3$, 101MHz



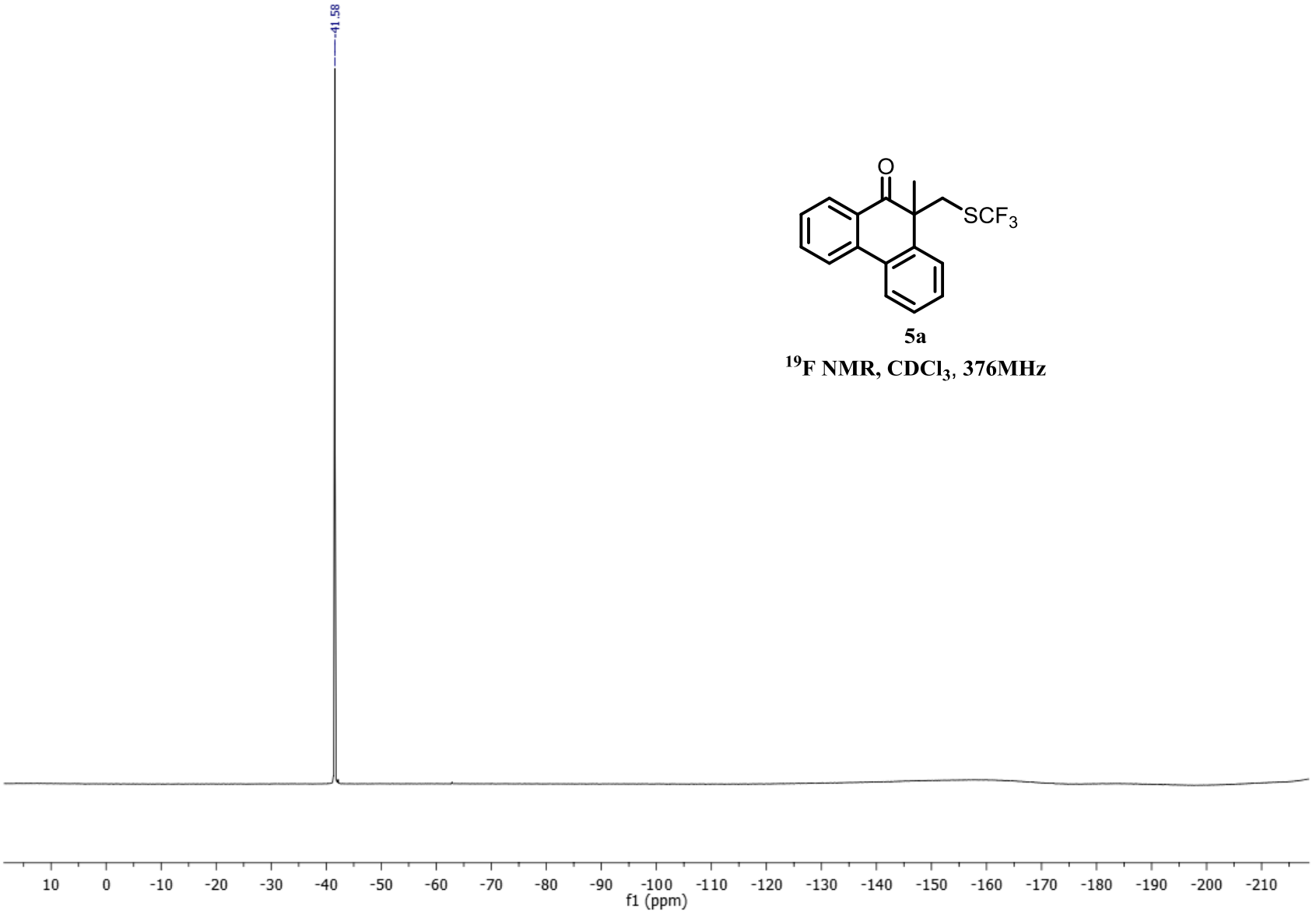
5a

^{1}H NMR, $CDCl_3$, 500MHz



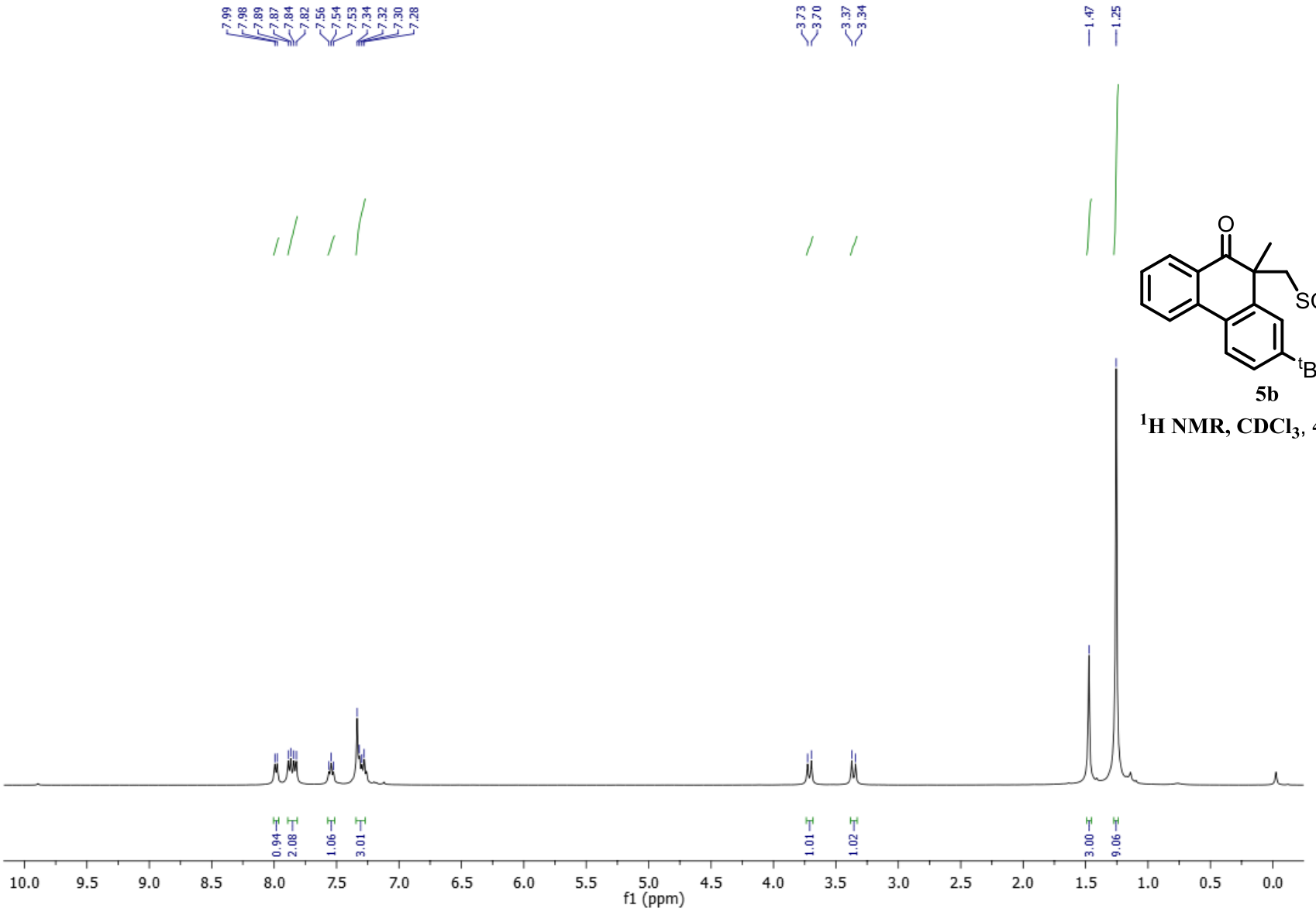
5a

^{13}C NMR, $CDCl_3$ 101MHz



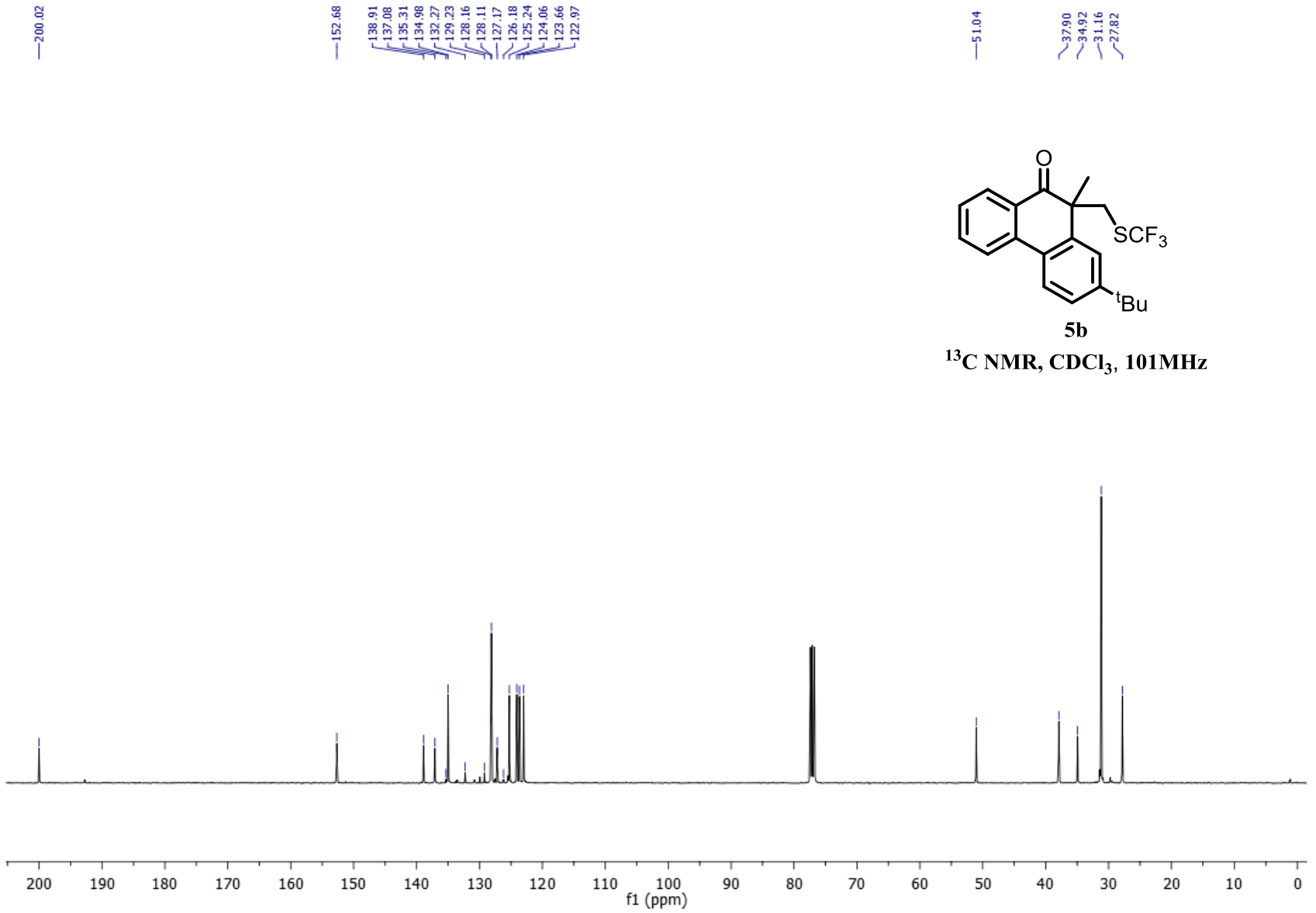
5a

^{19}F NMR, $CDCl_3$, 376MHz



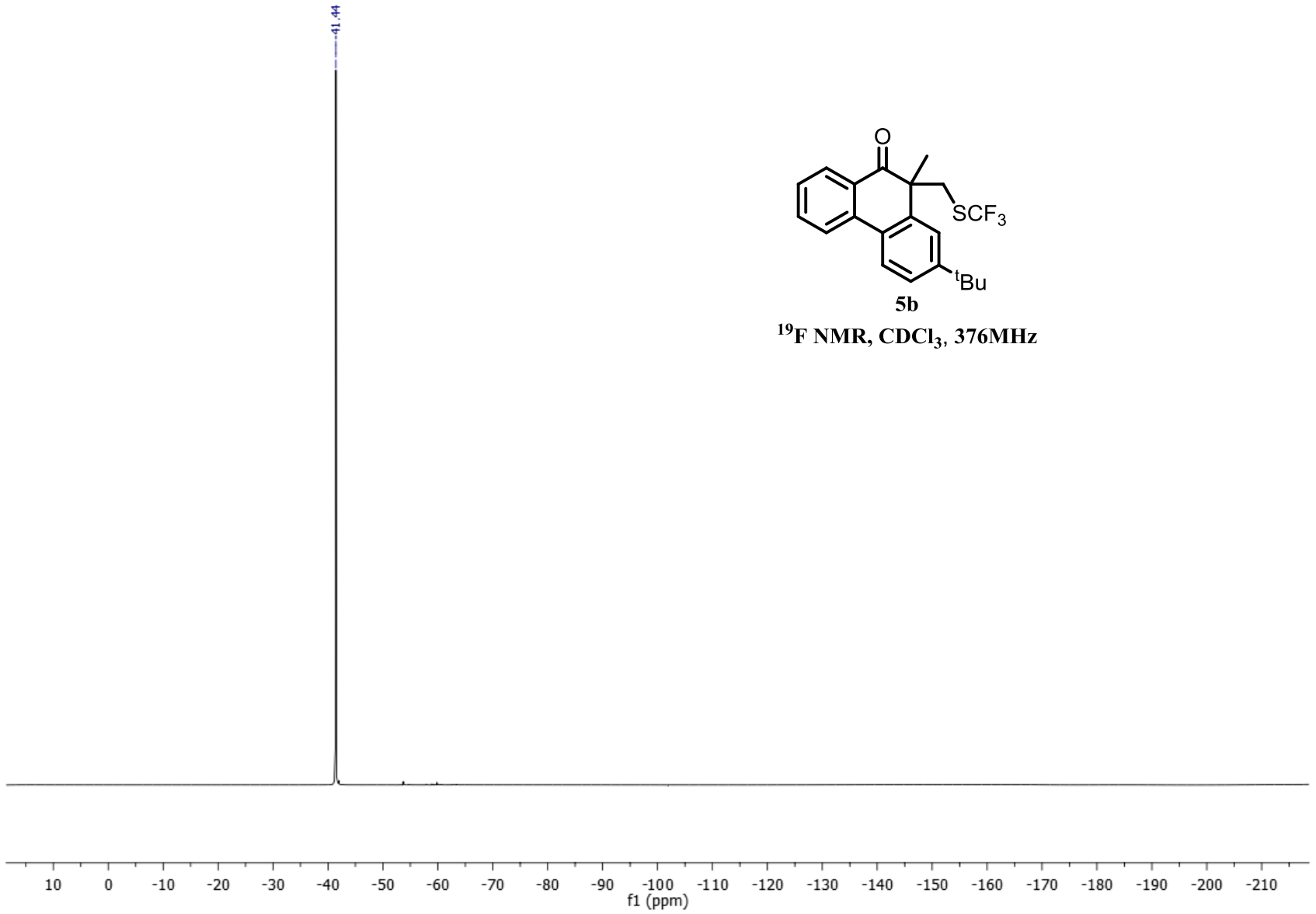
5b

^{1}H NMR, $CDCl_3$, 400MHz



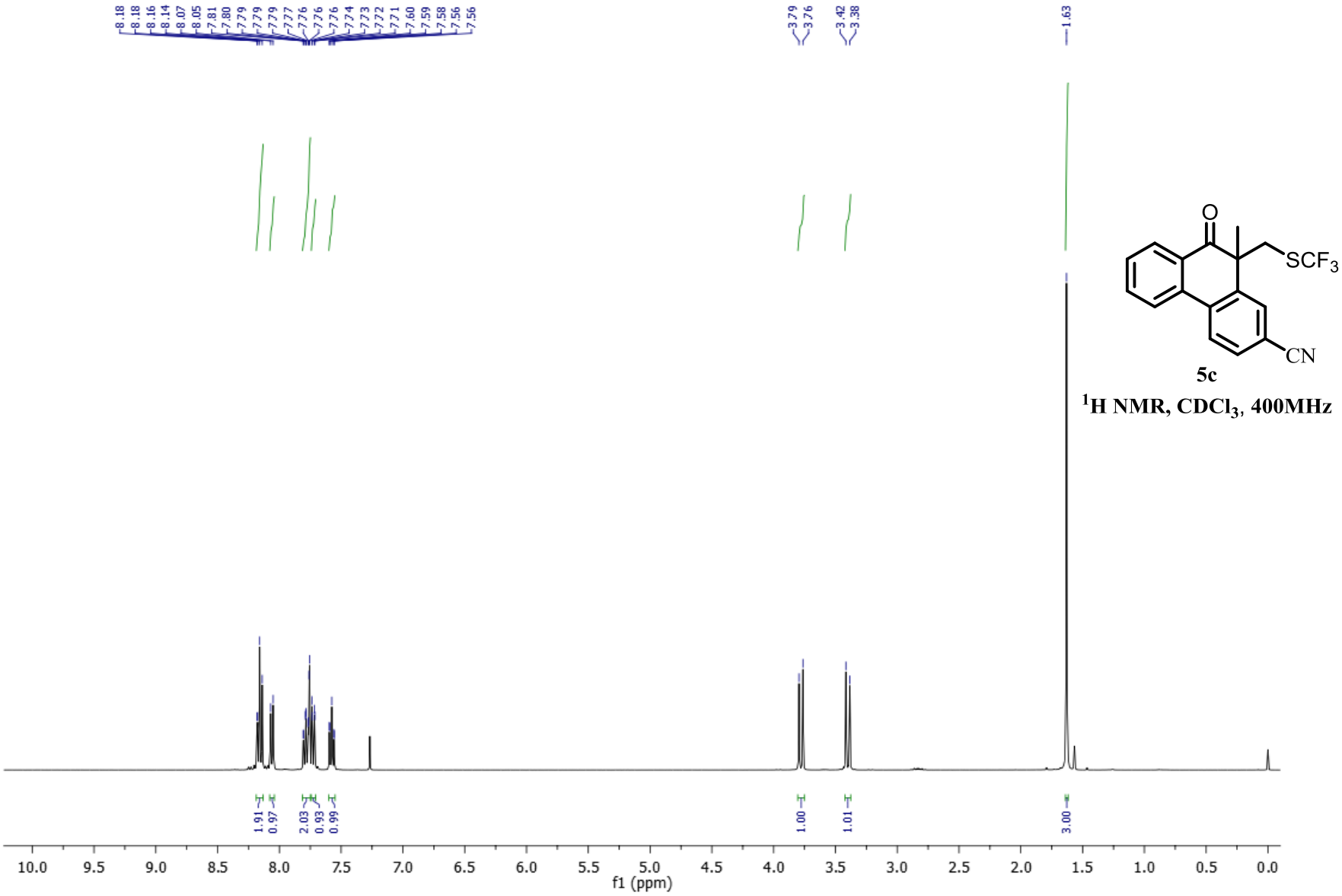
5b

^{13}C NMR, $CDCl_3$, 101MHz



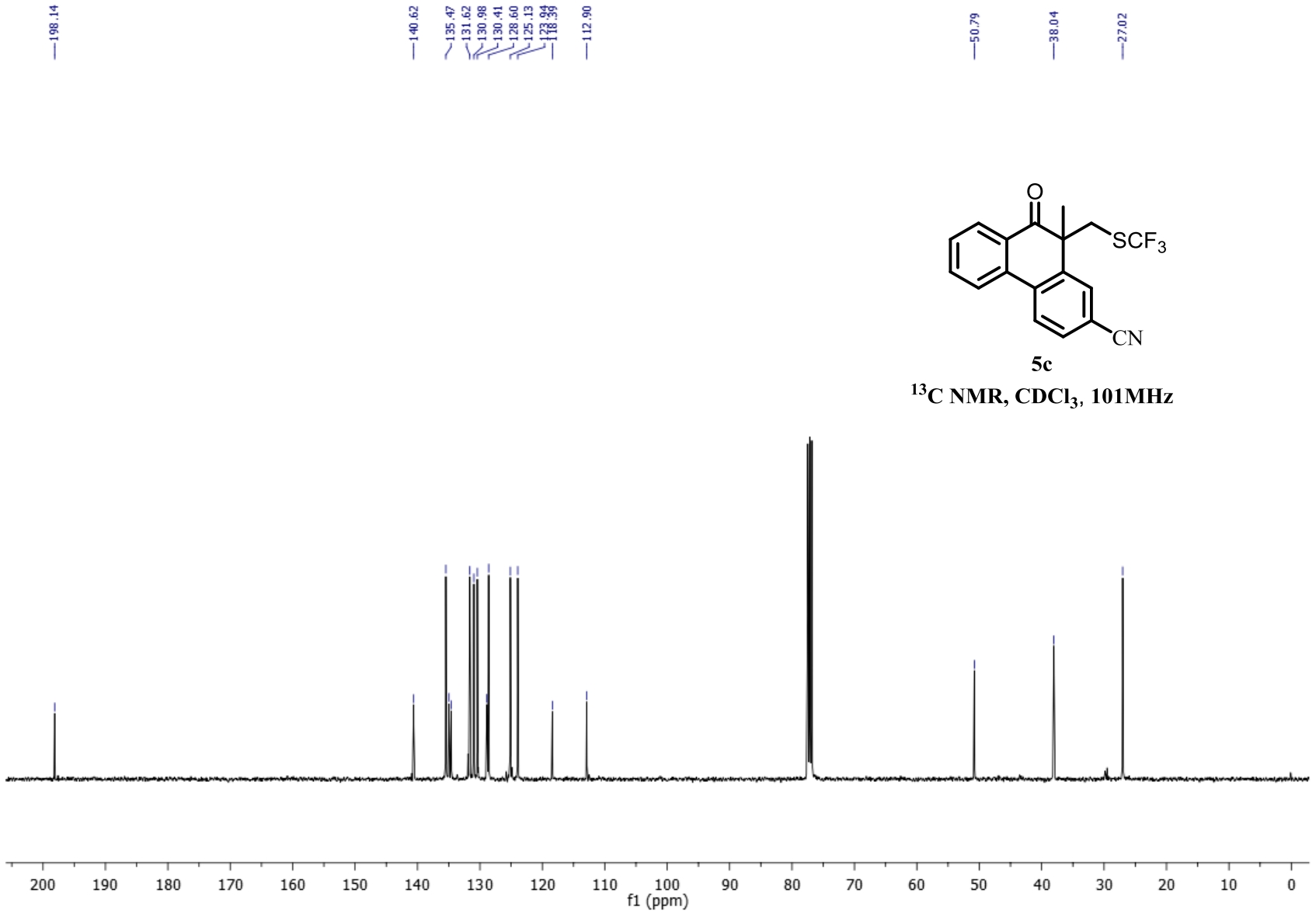
5b

^{19}F NMR, $CDCl_3$, 376MHz



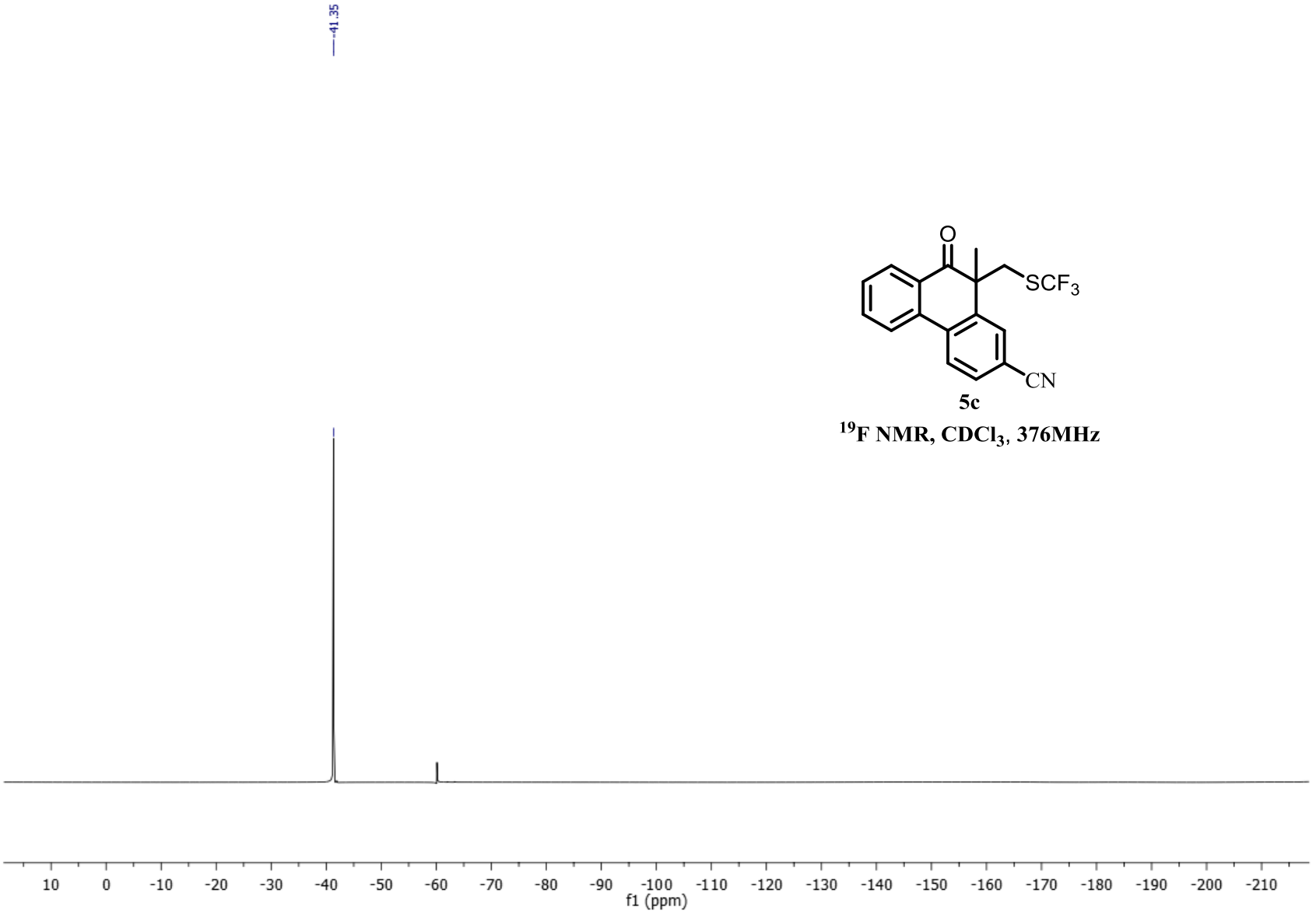
5c

^{1}H NMR, $CDCl_3$, 400MHz



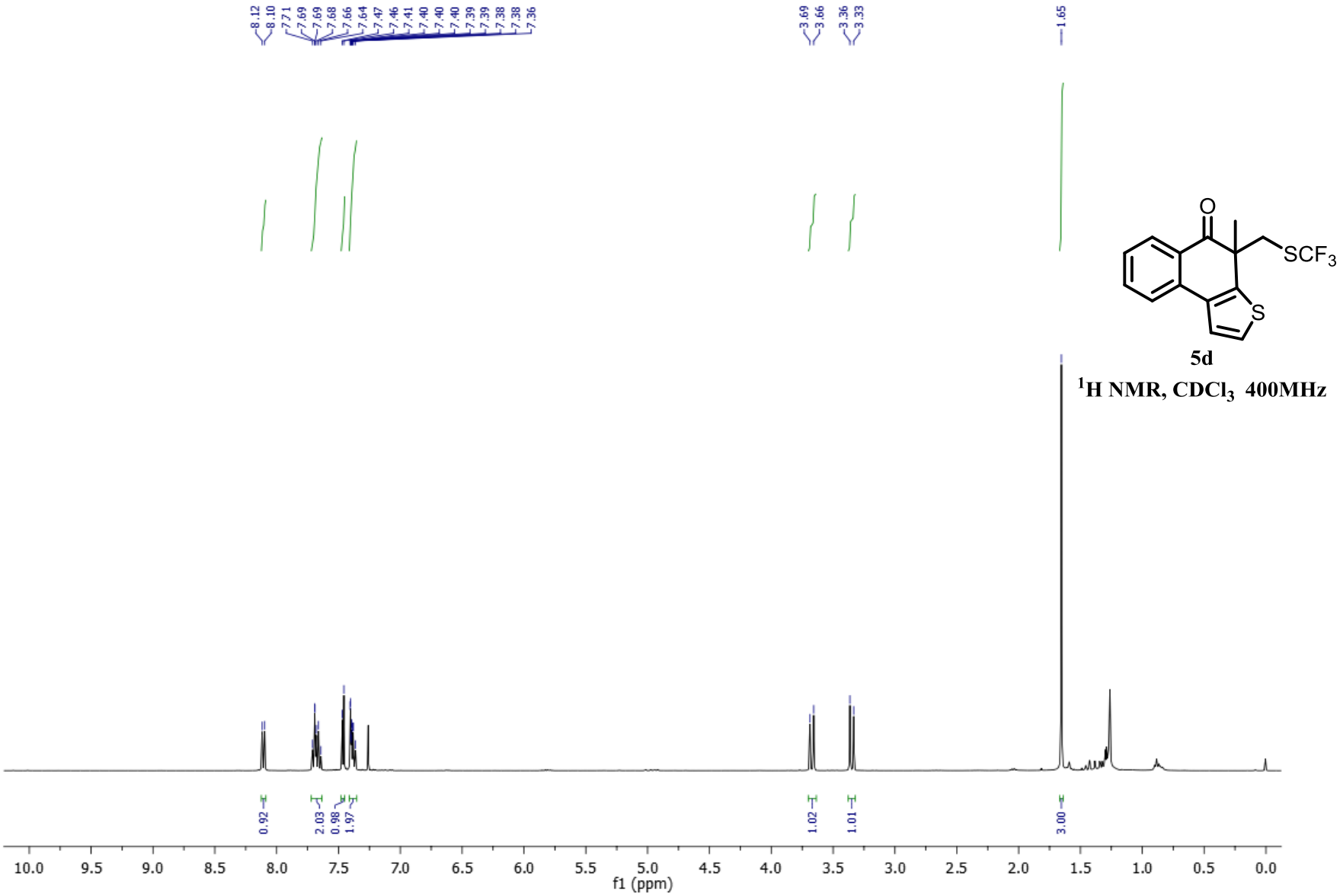
5c

^{13}C NMR, $CDCl_3$, 101MHz



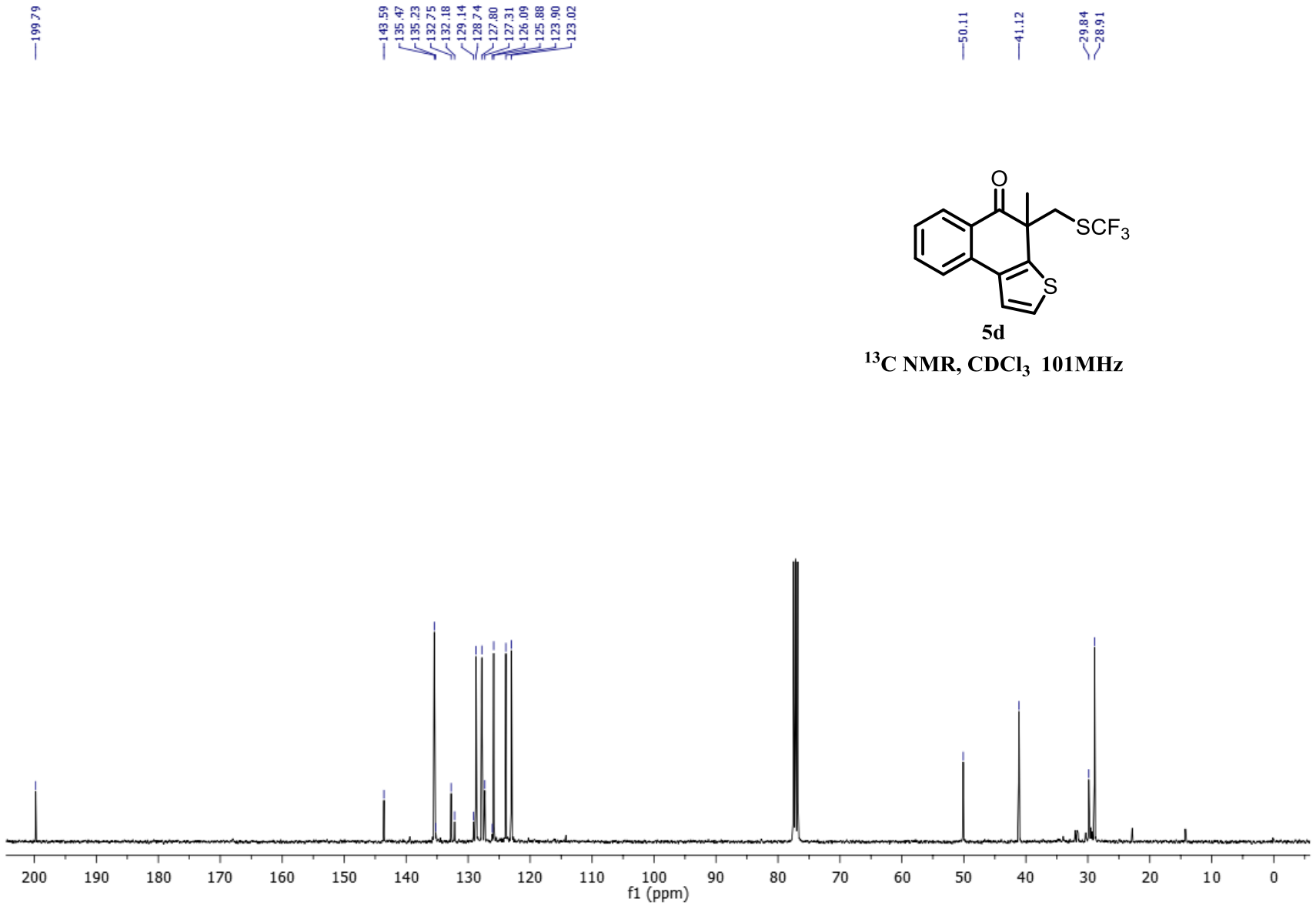
5c

^{19}F NMR, $CDCl_3$, 376MHz



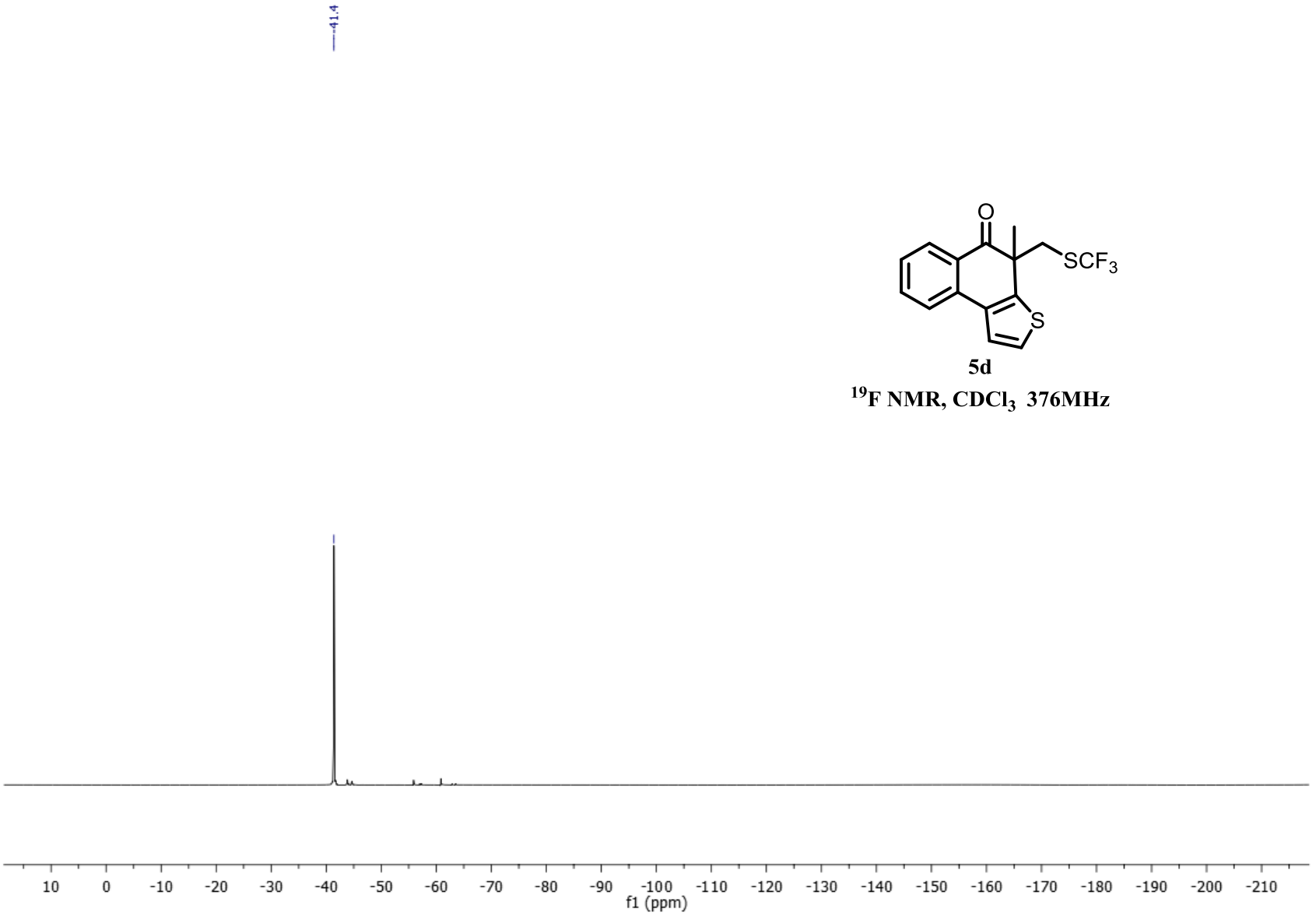
5d

^{1}H NMR, $CDCl_3$ 400MHz



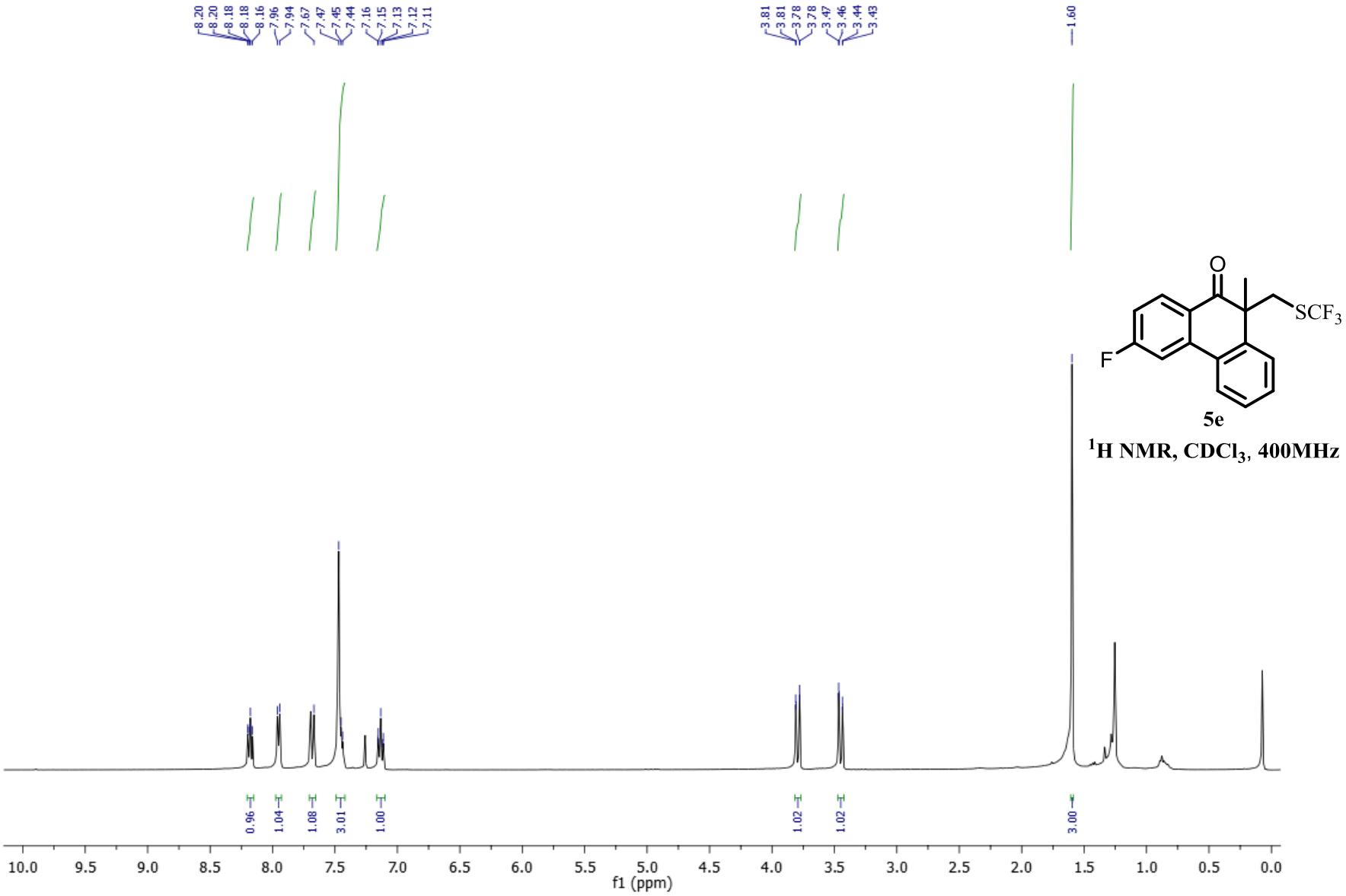
5d

^{13}C NMR, $CDCl_3$ 101MHz



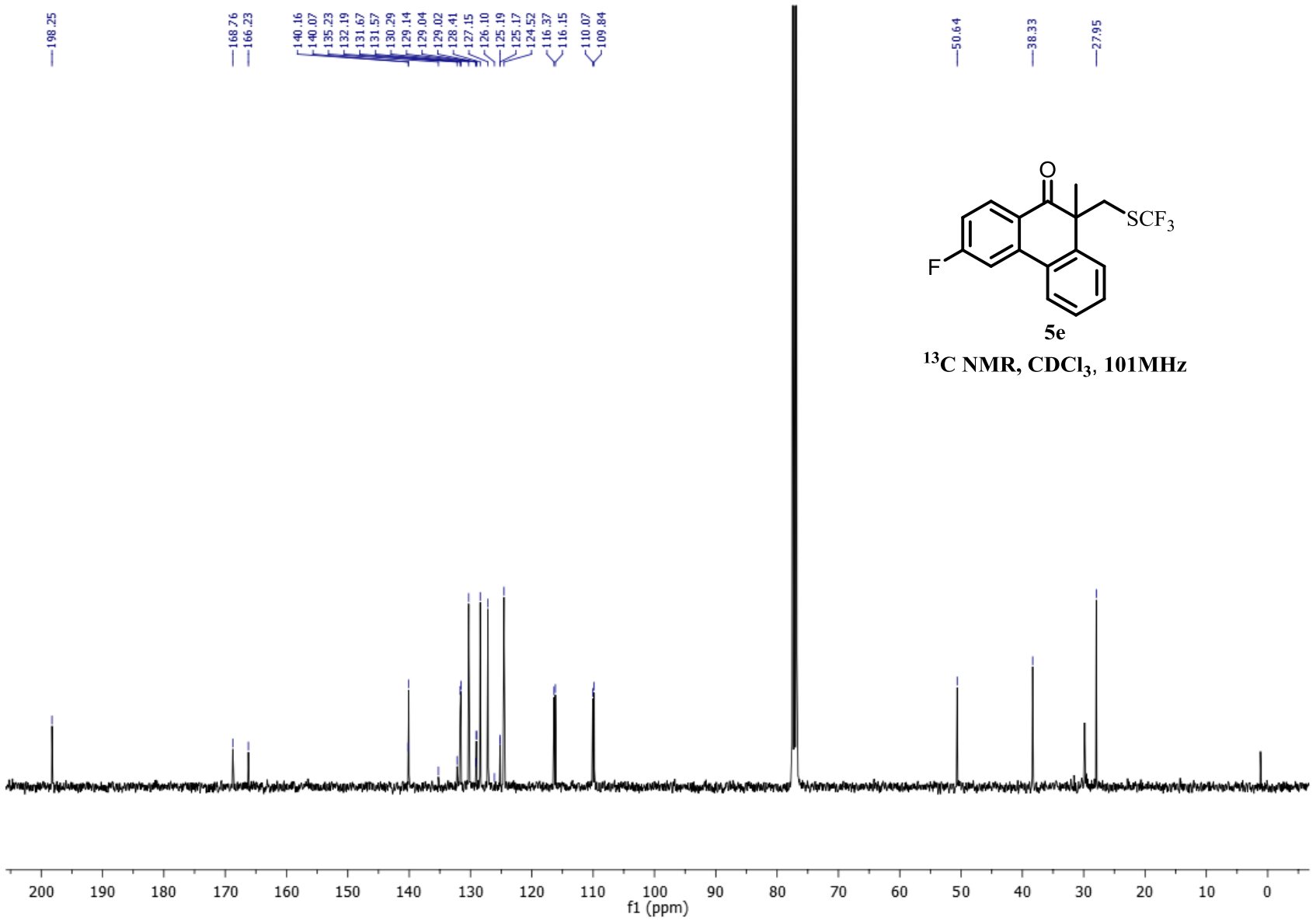
5d

^{19}F NMR, $CDCl_3$ 376MHz



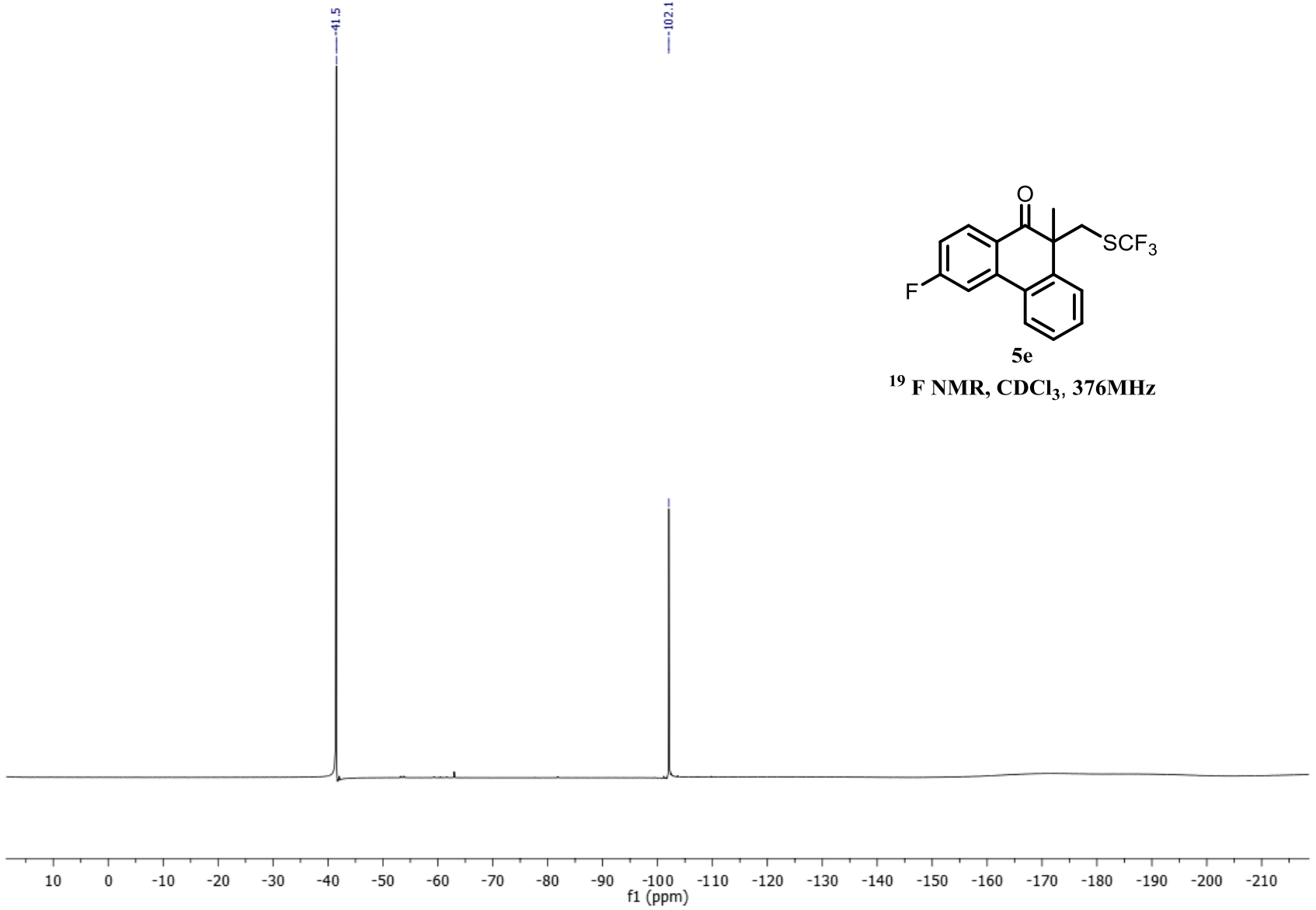
5e

^{1}H NMR, $CDCl_3$, 400MHz



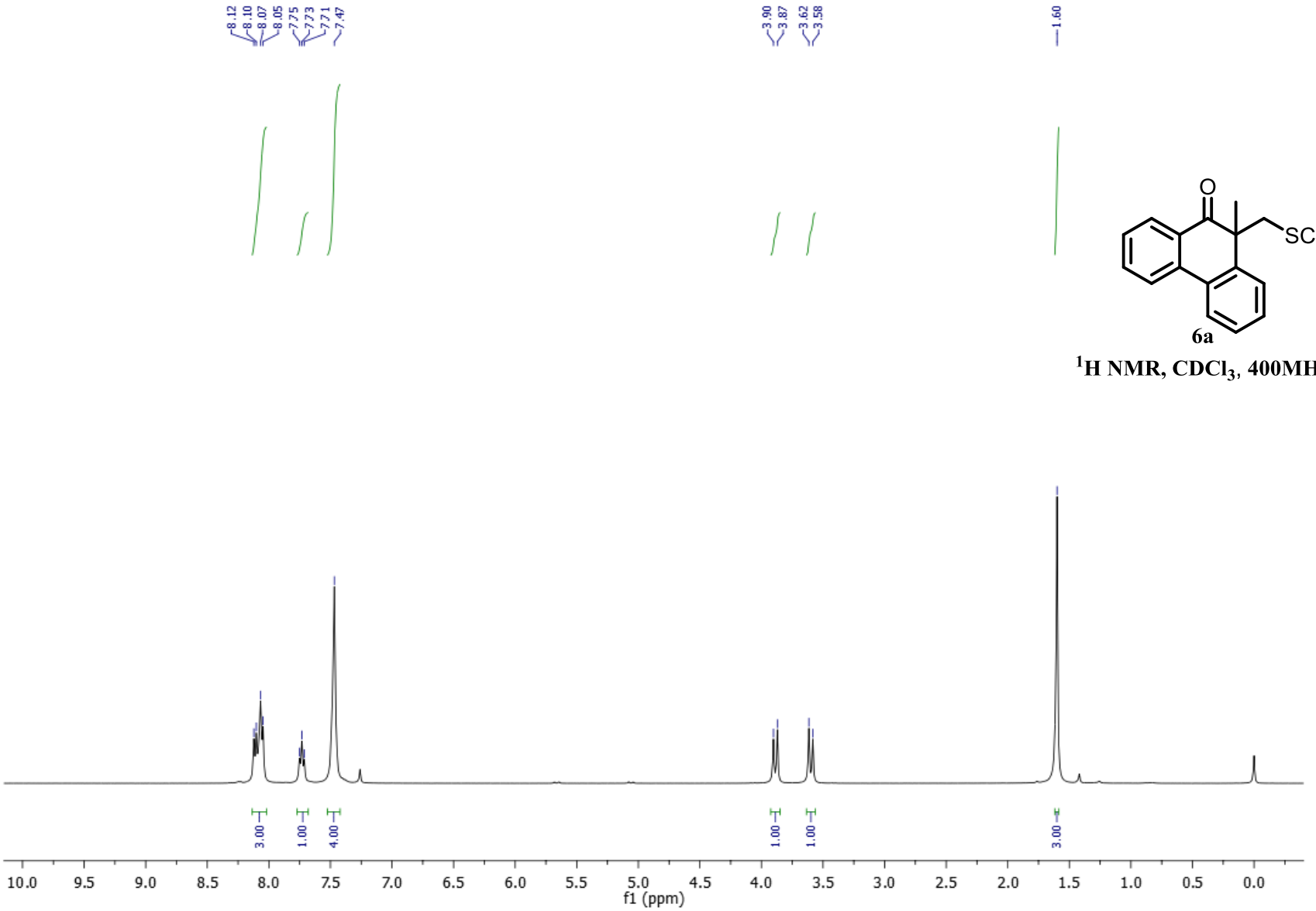
5e

^{13}C NMR, $CDCl_3$, 101MHz



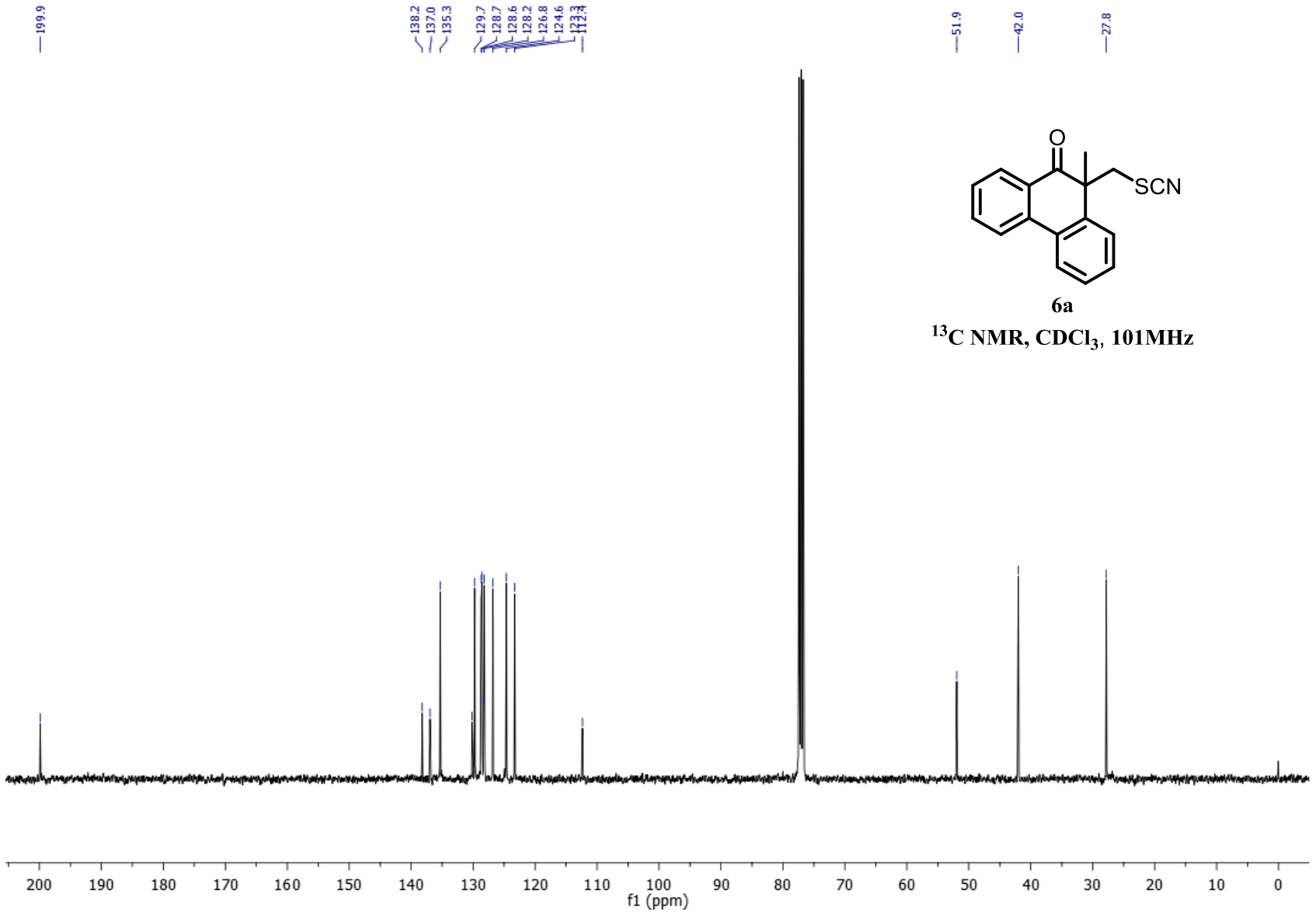
5e

^{19} F NMR, $CDCl_3$, 376MHz



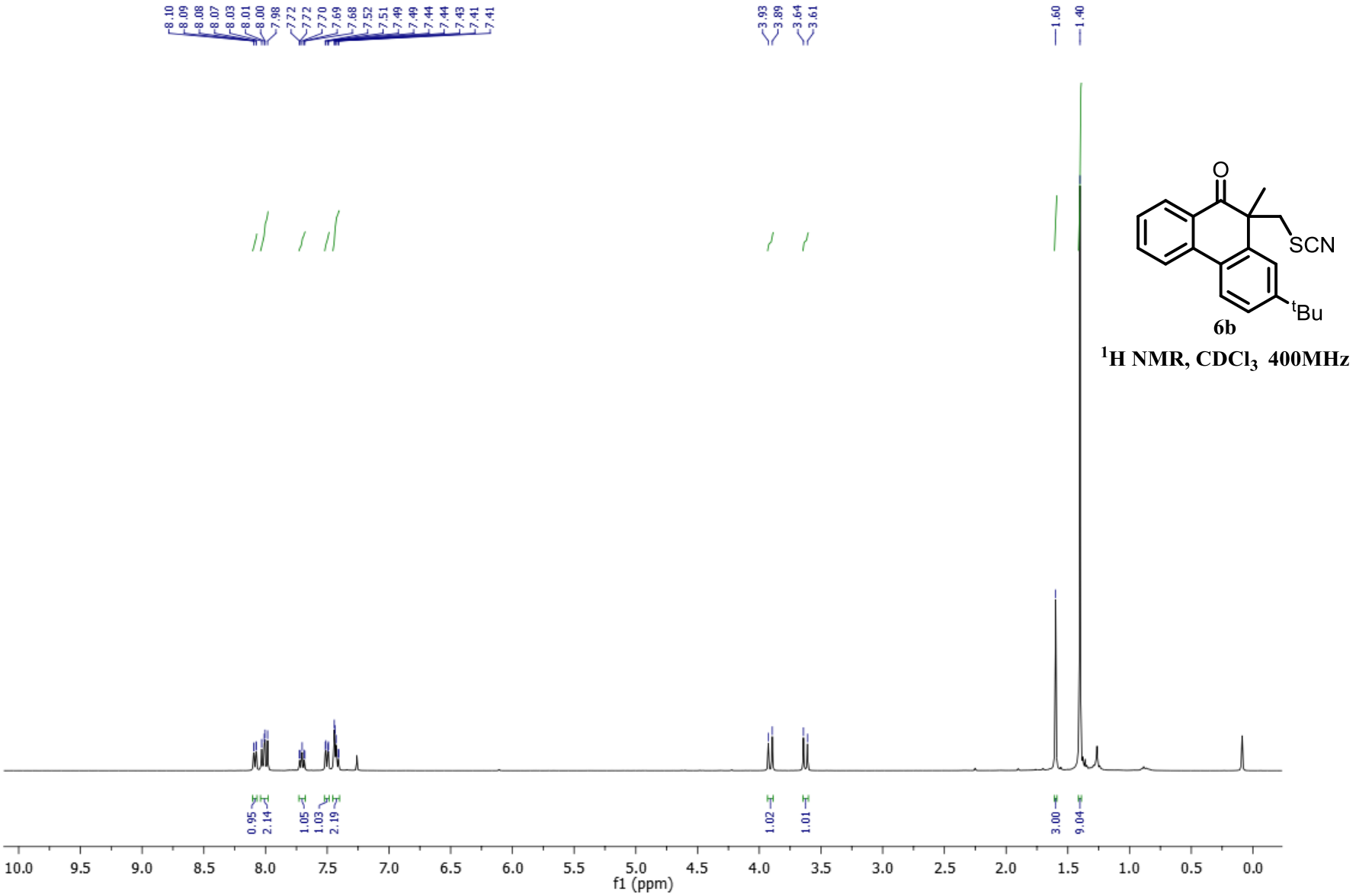
6a

^{1}H NMR, $CDCl_3$, 400MHz



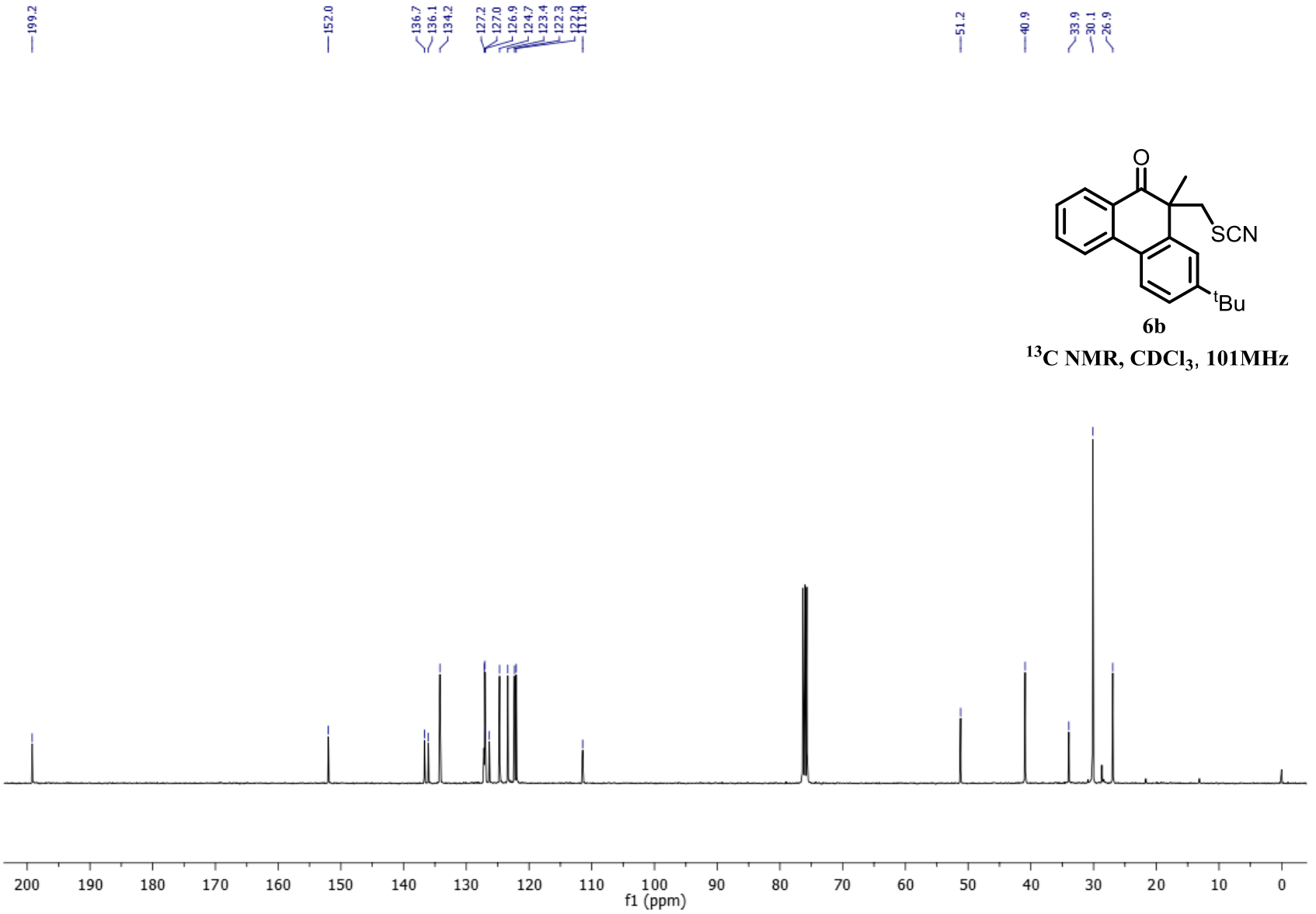
6a

^{13}C NMR, $CDCl_3$, 101MHz



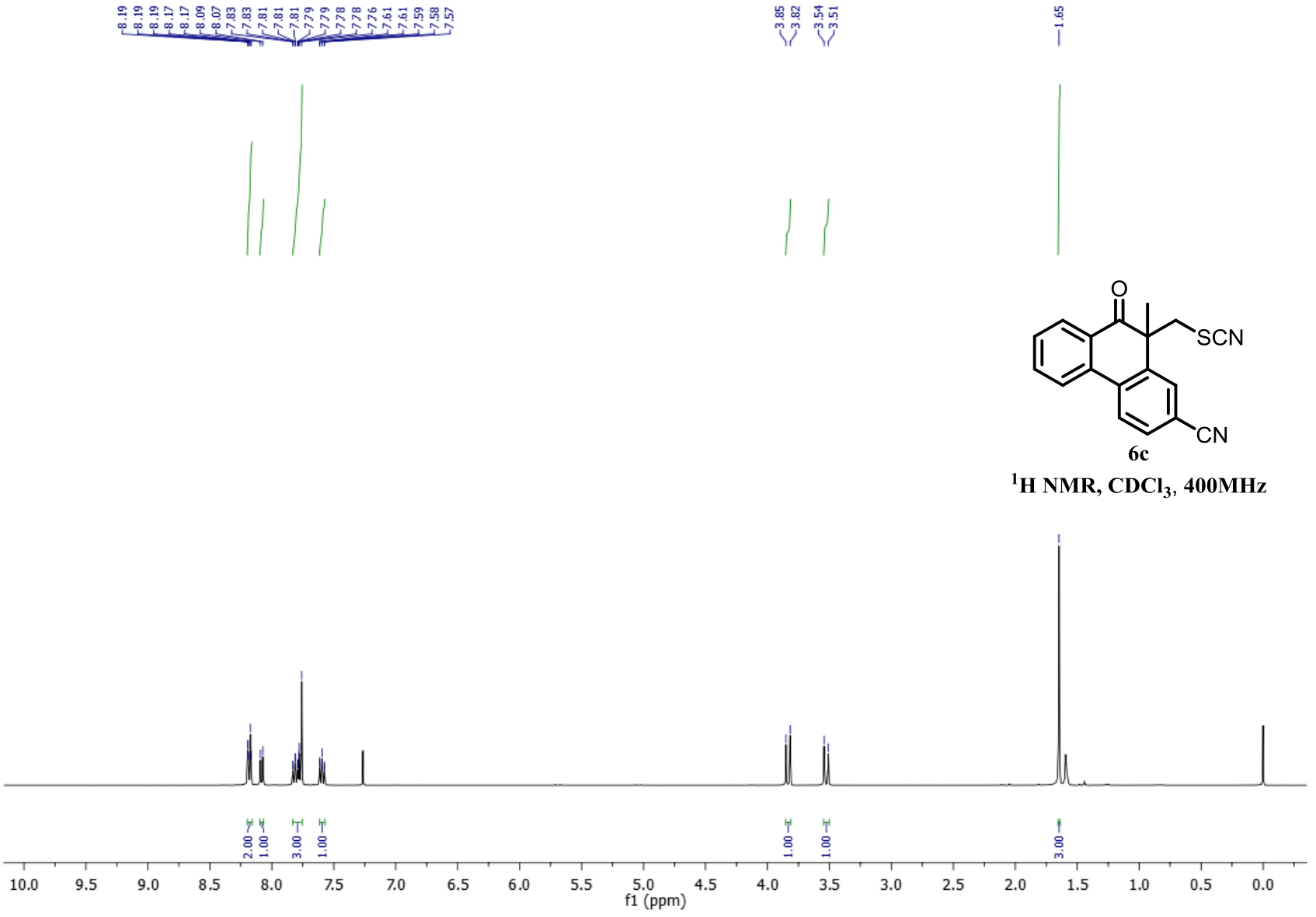
6b

^{1}H NMR, $CDCl_3$ 400MHz



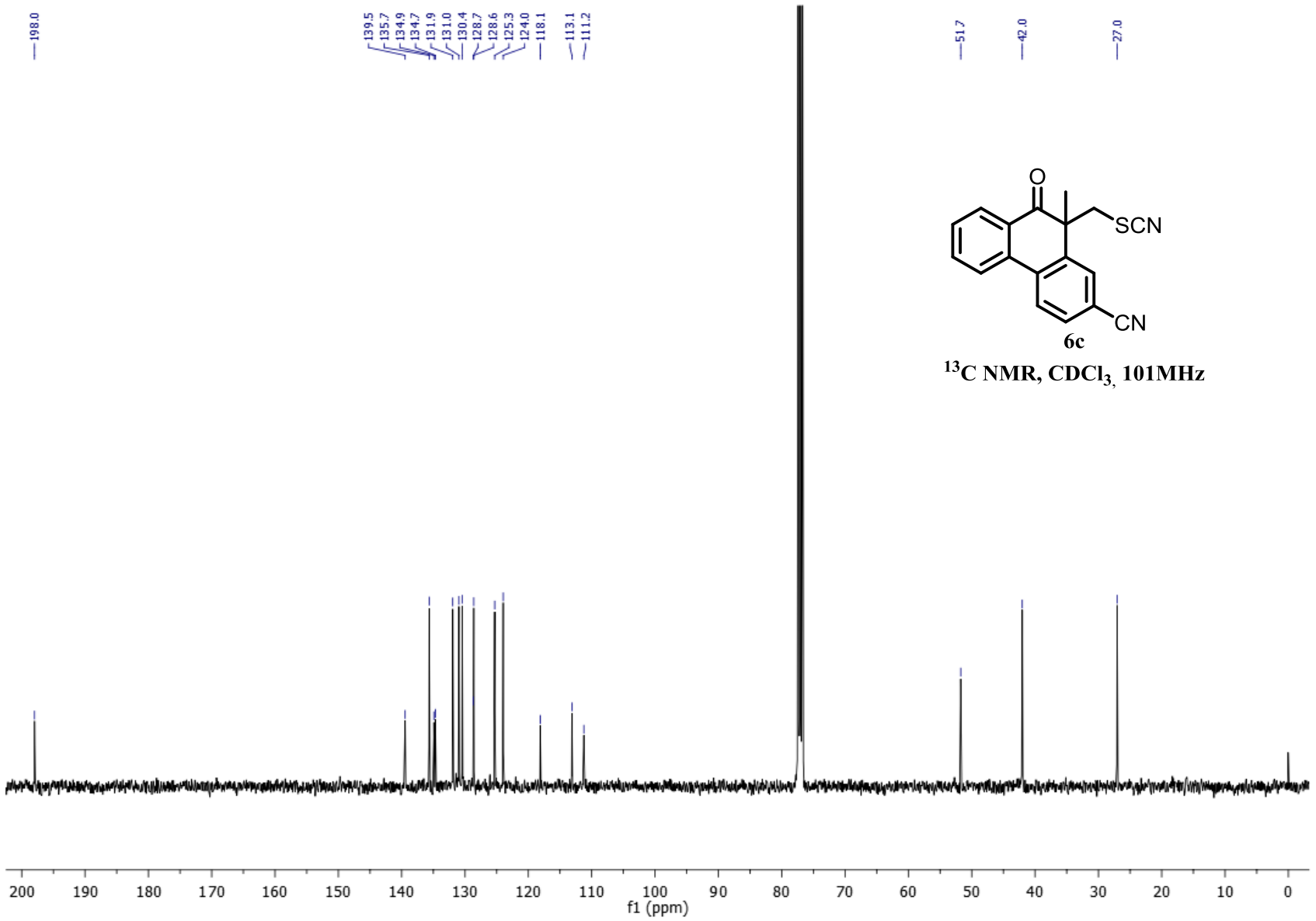
6b

^{13}C NMR, $CDCl_3$, 101MHz



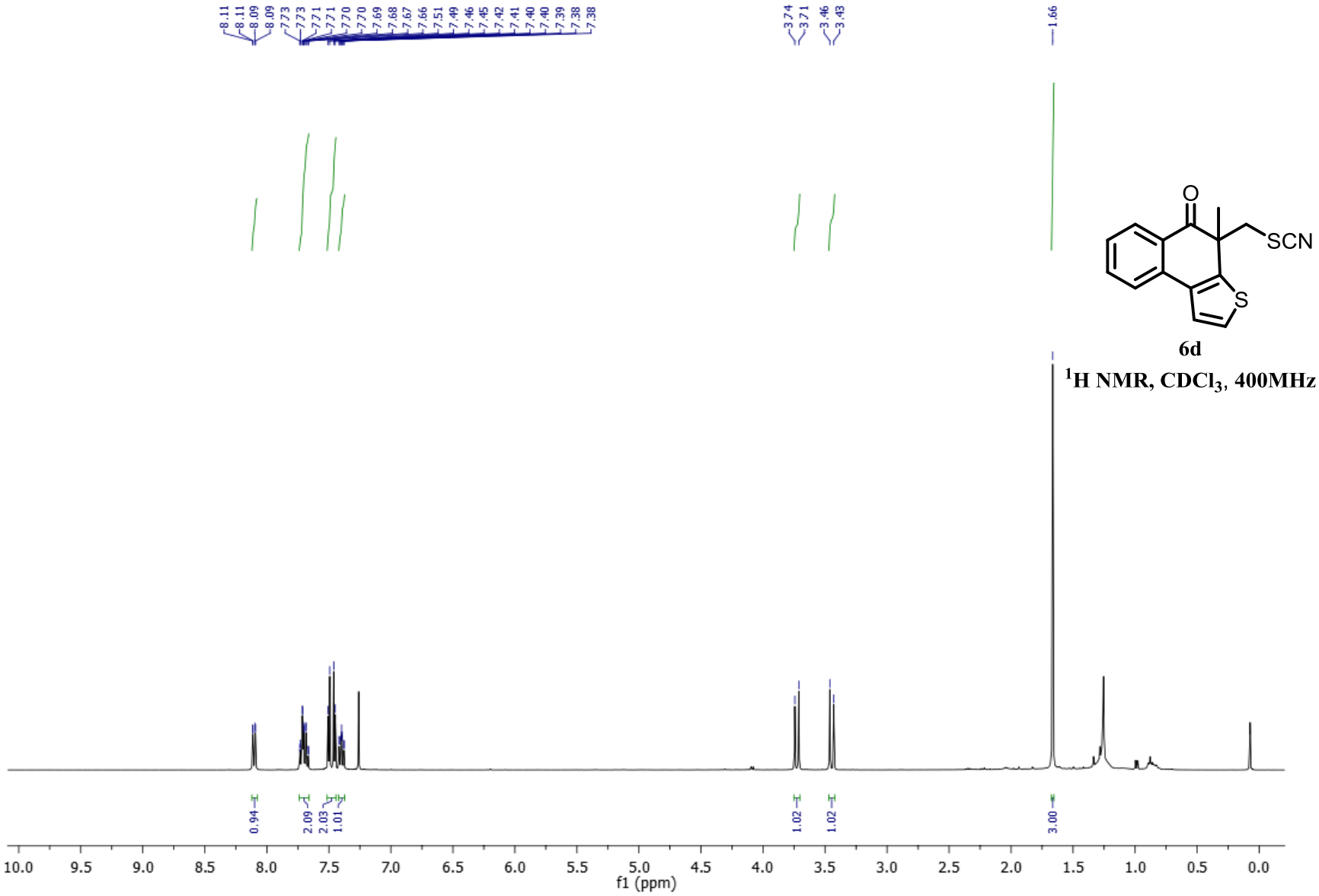
6c

^{1}H NMR, $CDCl_3$, 400MHz



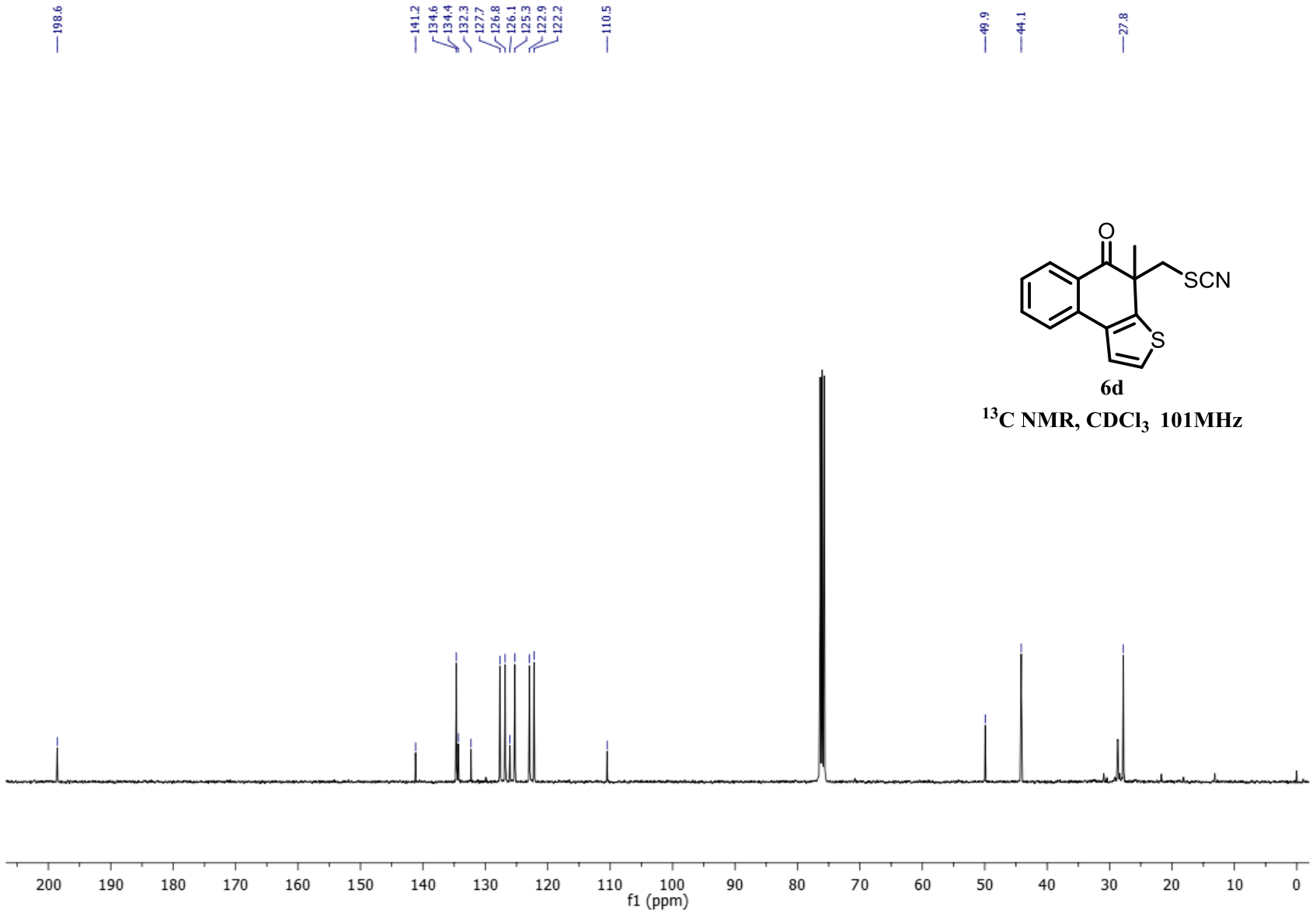
6c

^{13}C NMR, $CDCl_3$, 101MHz



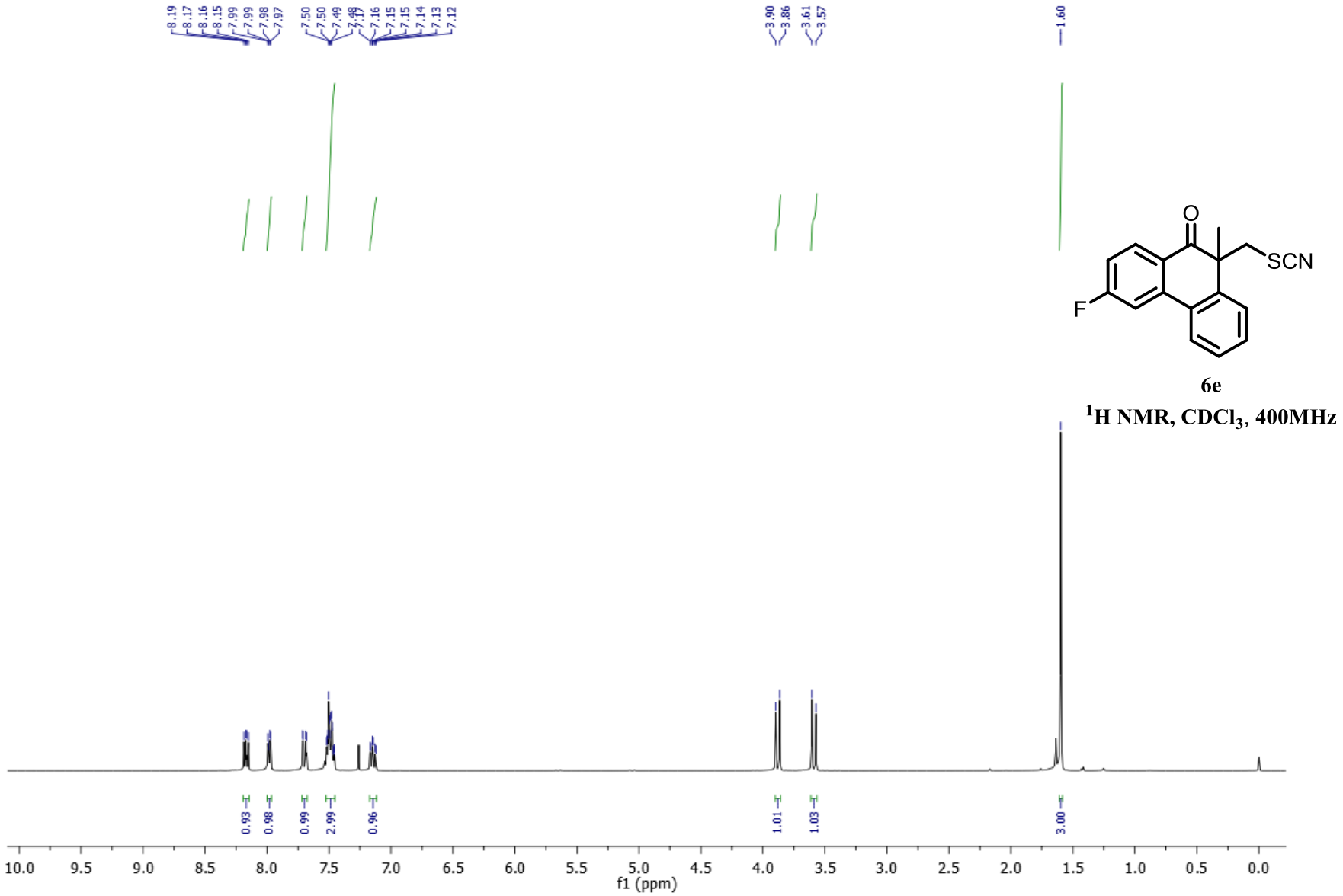
6d

^{1}H NMR, $CDCl_3$, 400MHz



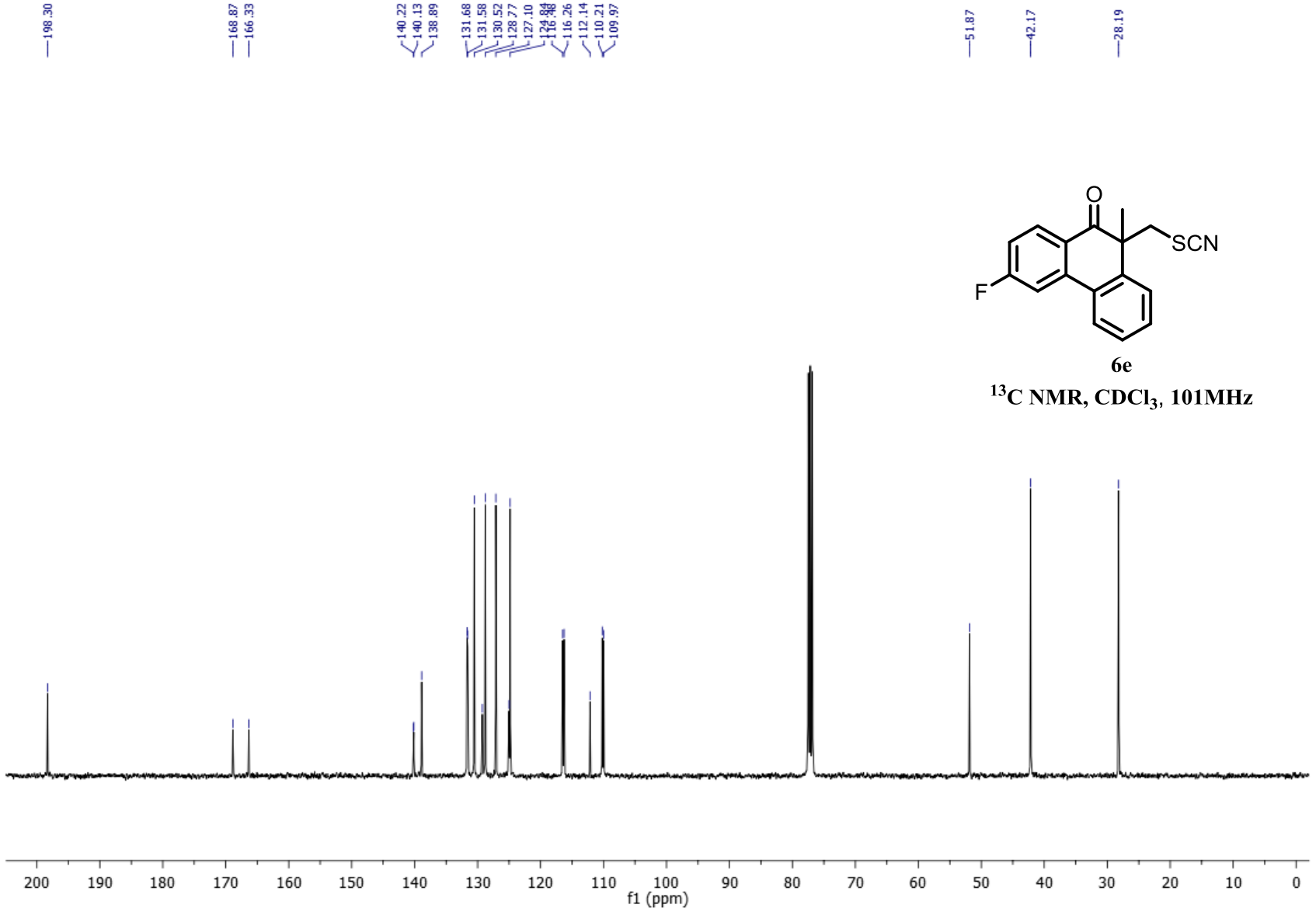
6d

^{13}C NMR, $CDCl_3$ 101MHz



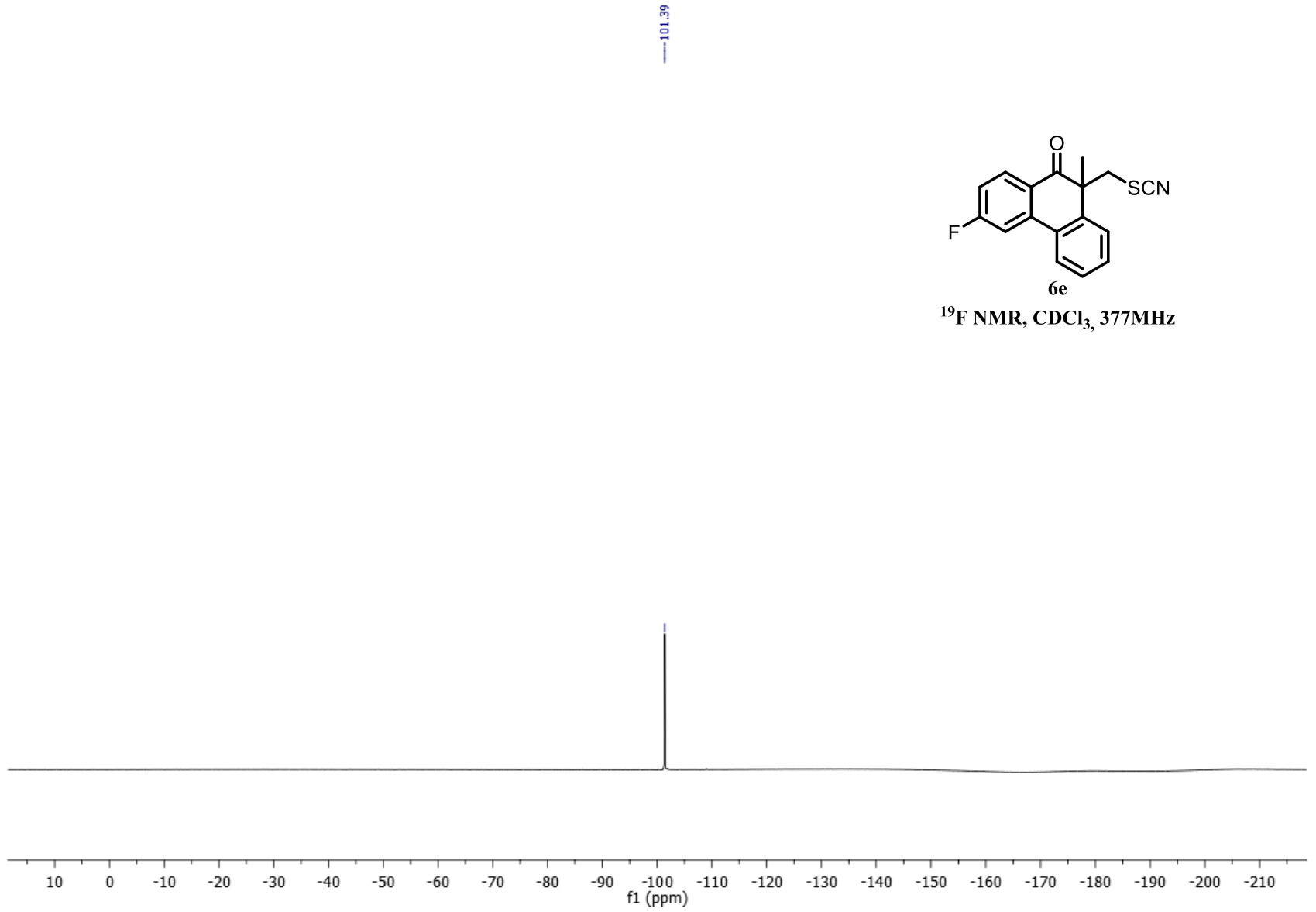
6e

^{1}H NMR, $CDCl_3$, 400MHz



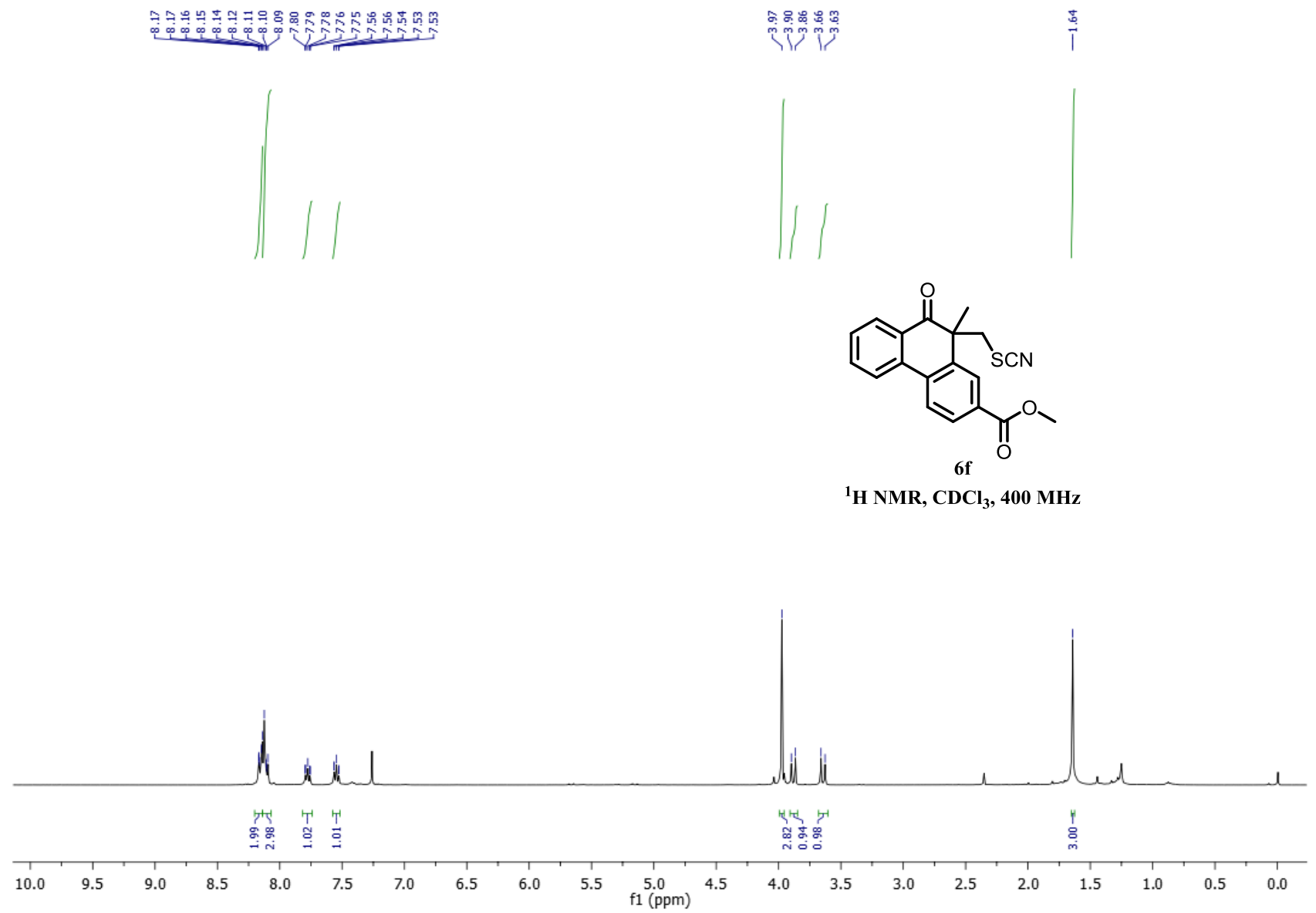
6e

^{13}C NMR, $CDCl_3$, 101MHz



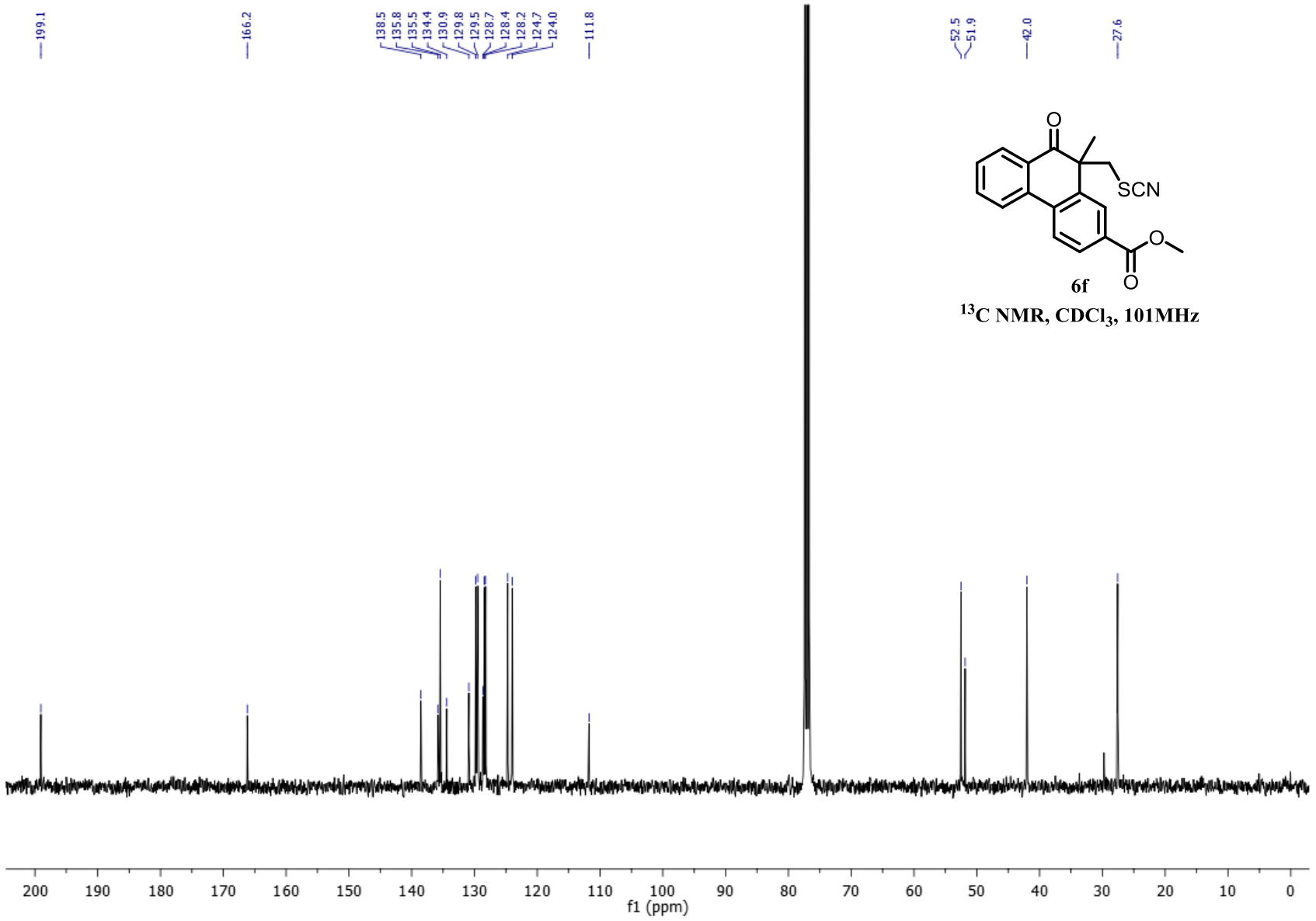
6e

^{19}F NMR, $CDCl_3$, 377MHz



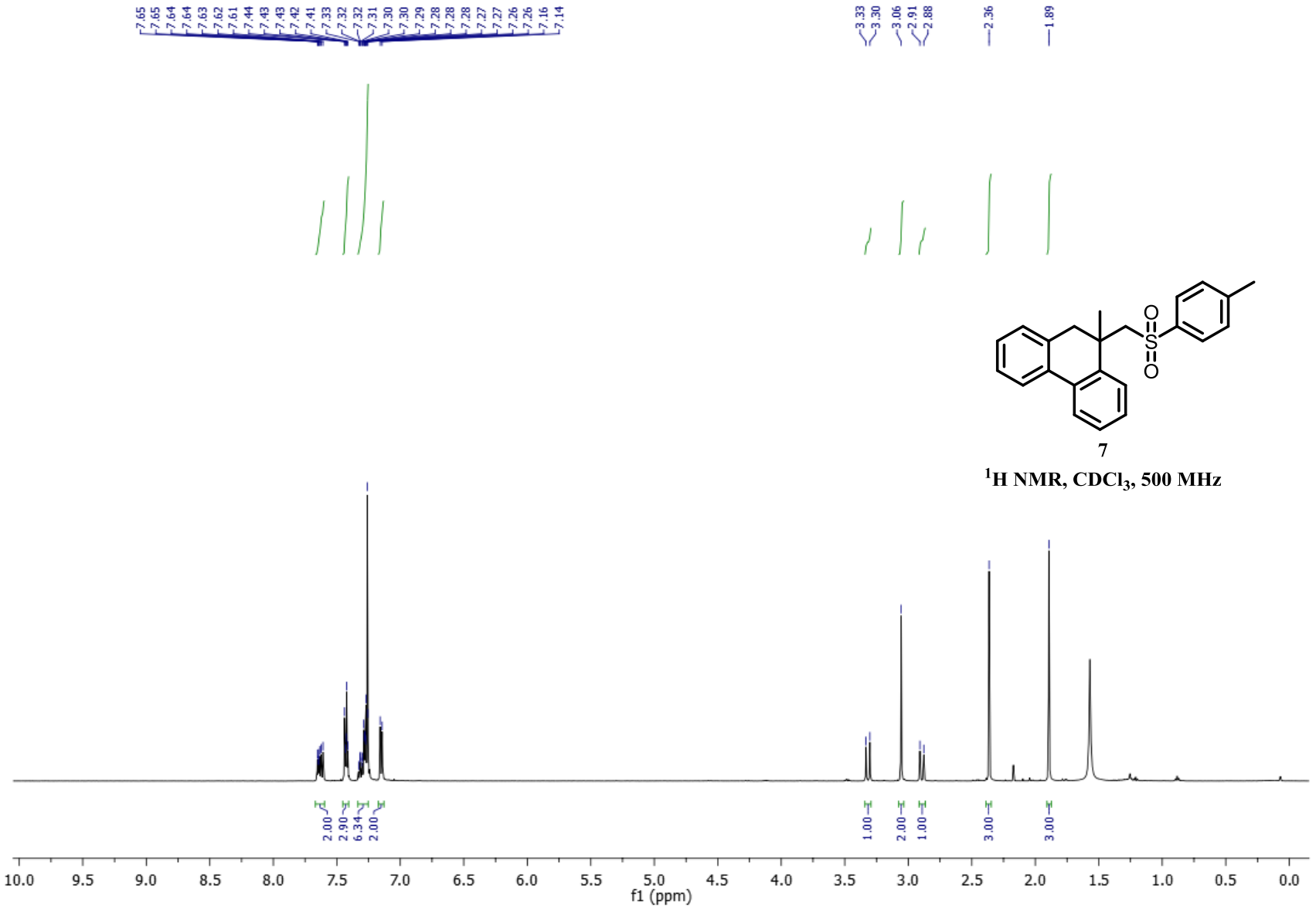
6f

^{1}H NMR, $CDCl_3$, 400 MHz



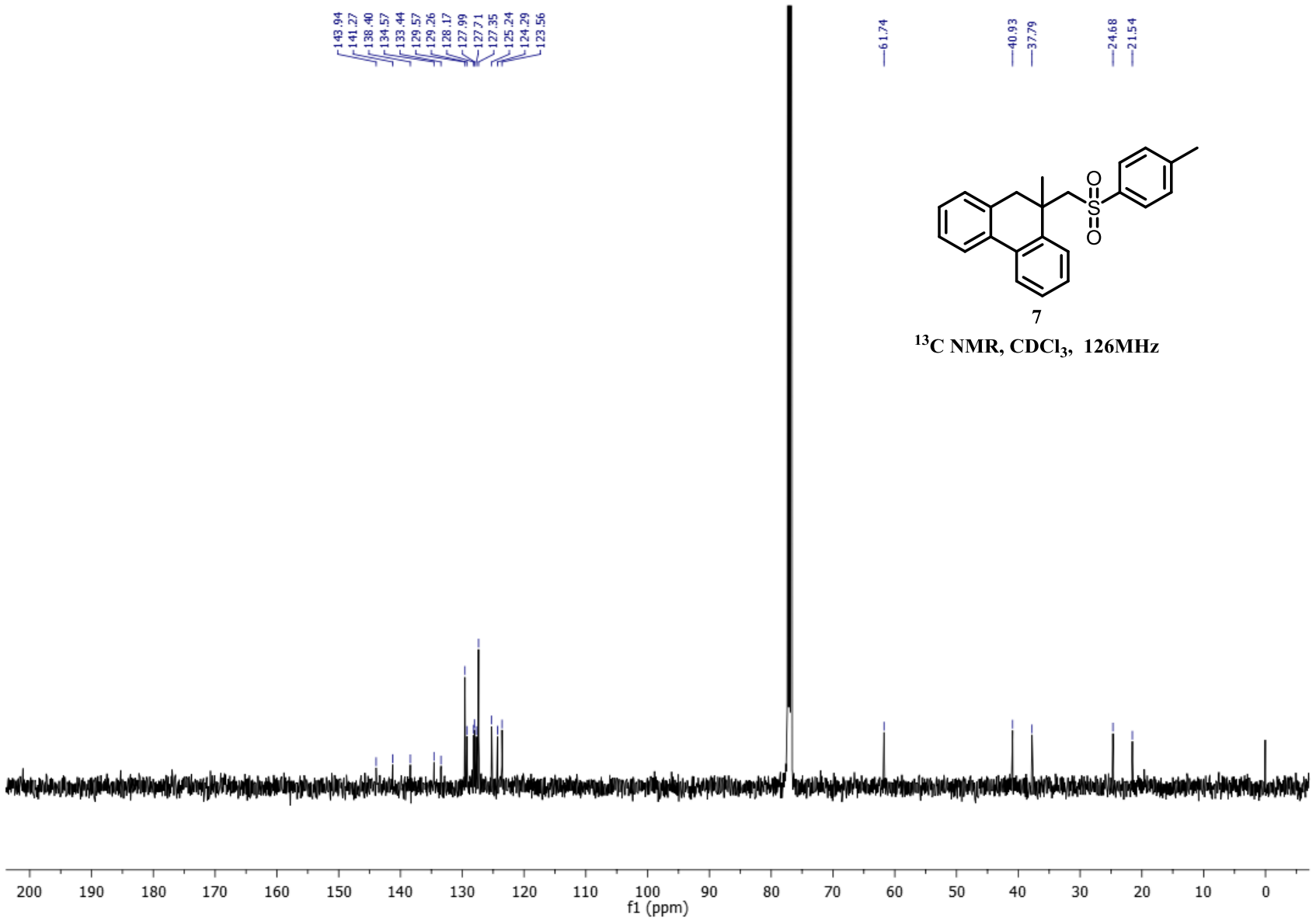
6f

^{13}C NMR, $CDCl_3$, 101MHz



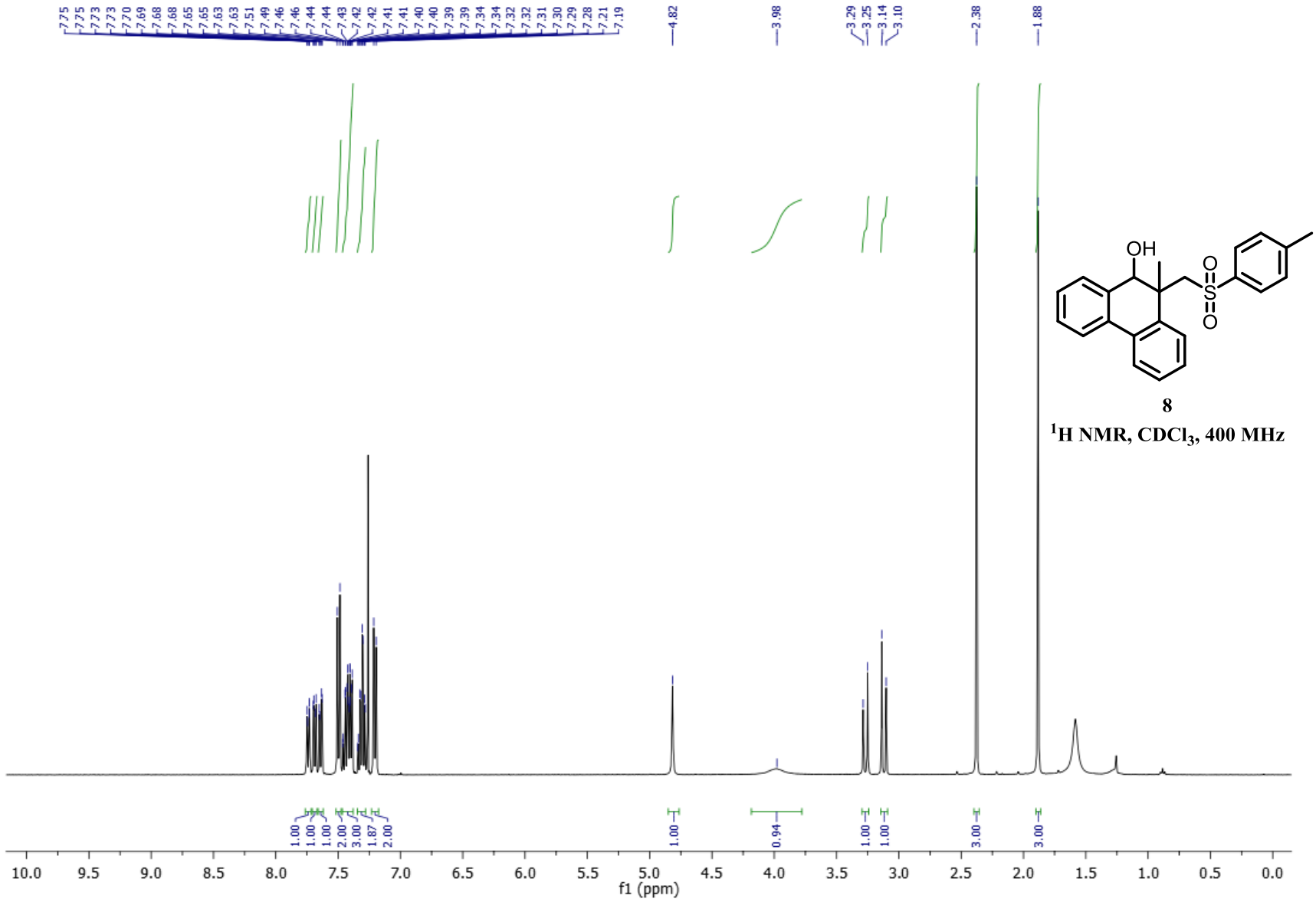
7

^{1}H NMR, $CDCl_3$, 500 MHz



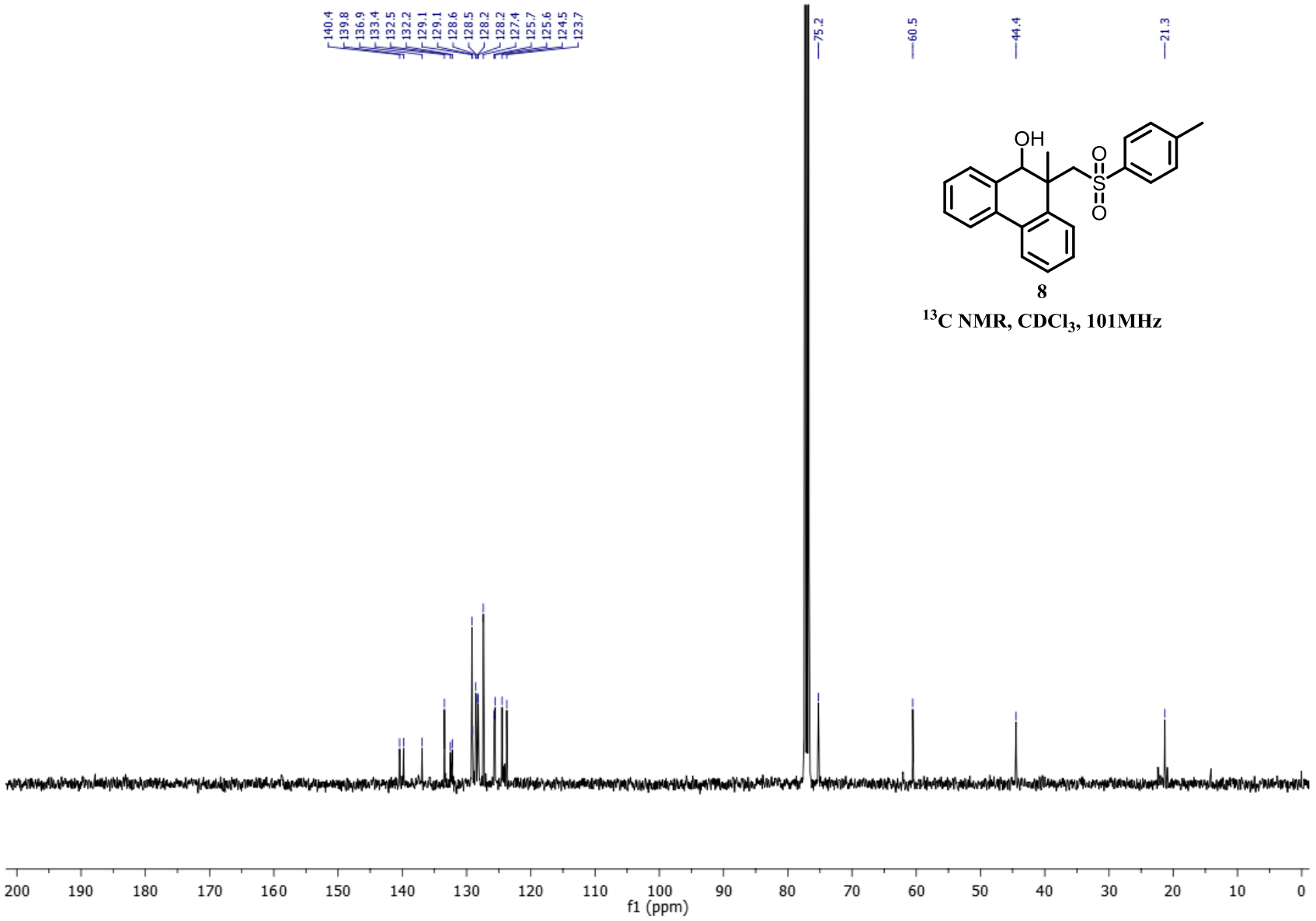
7

^{13}C NMR, $CDCl_3$, 126MHz



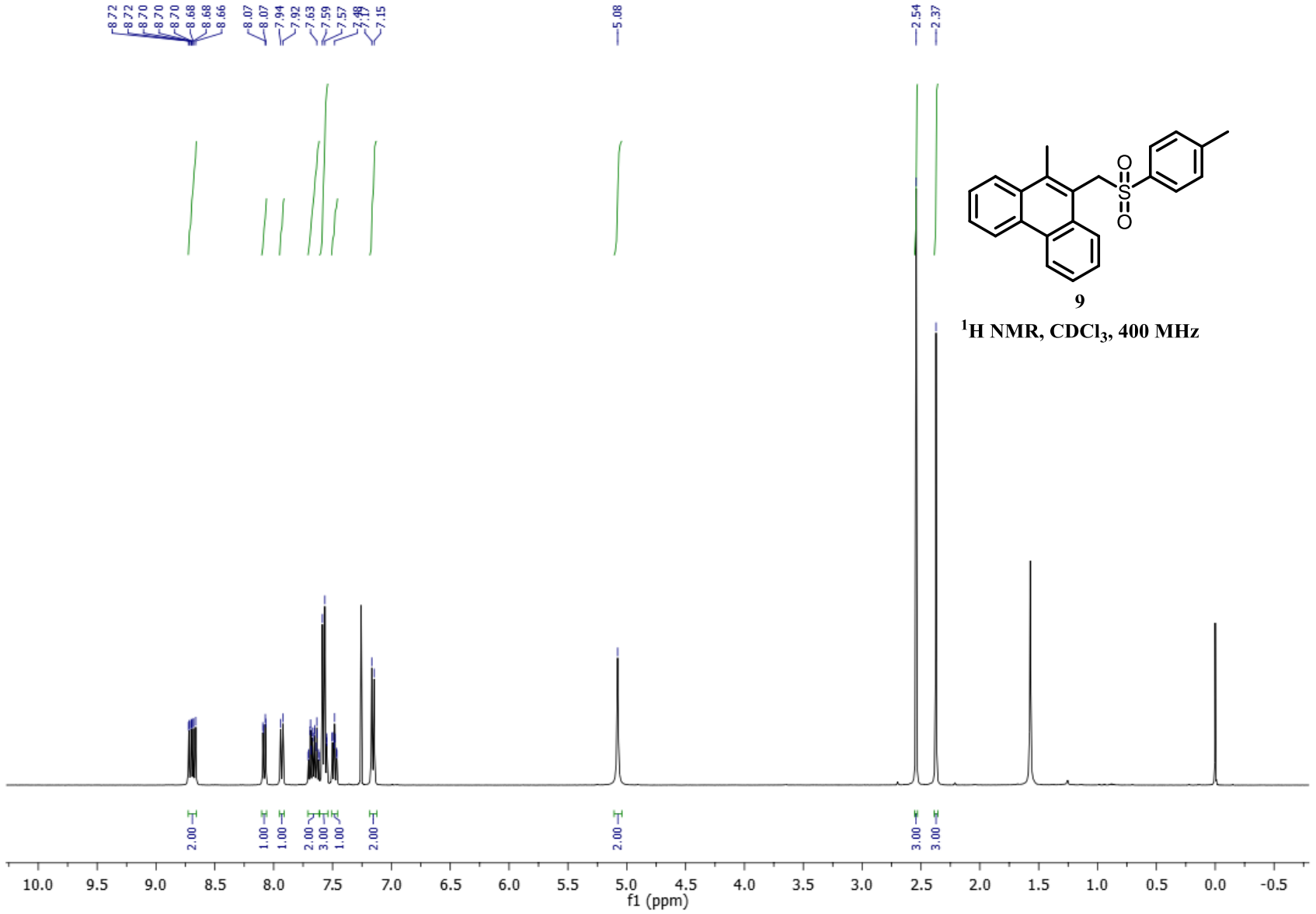
8

^{1}H NMR, $CDCl_3$, 400 MHz



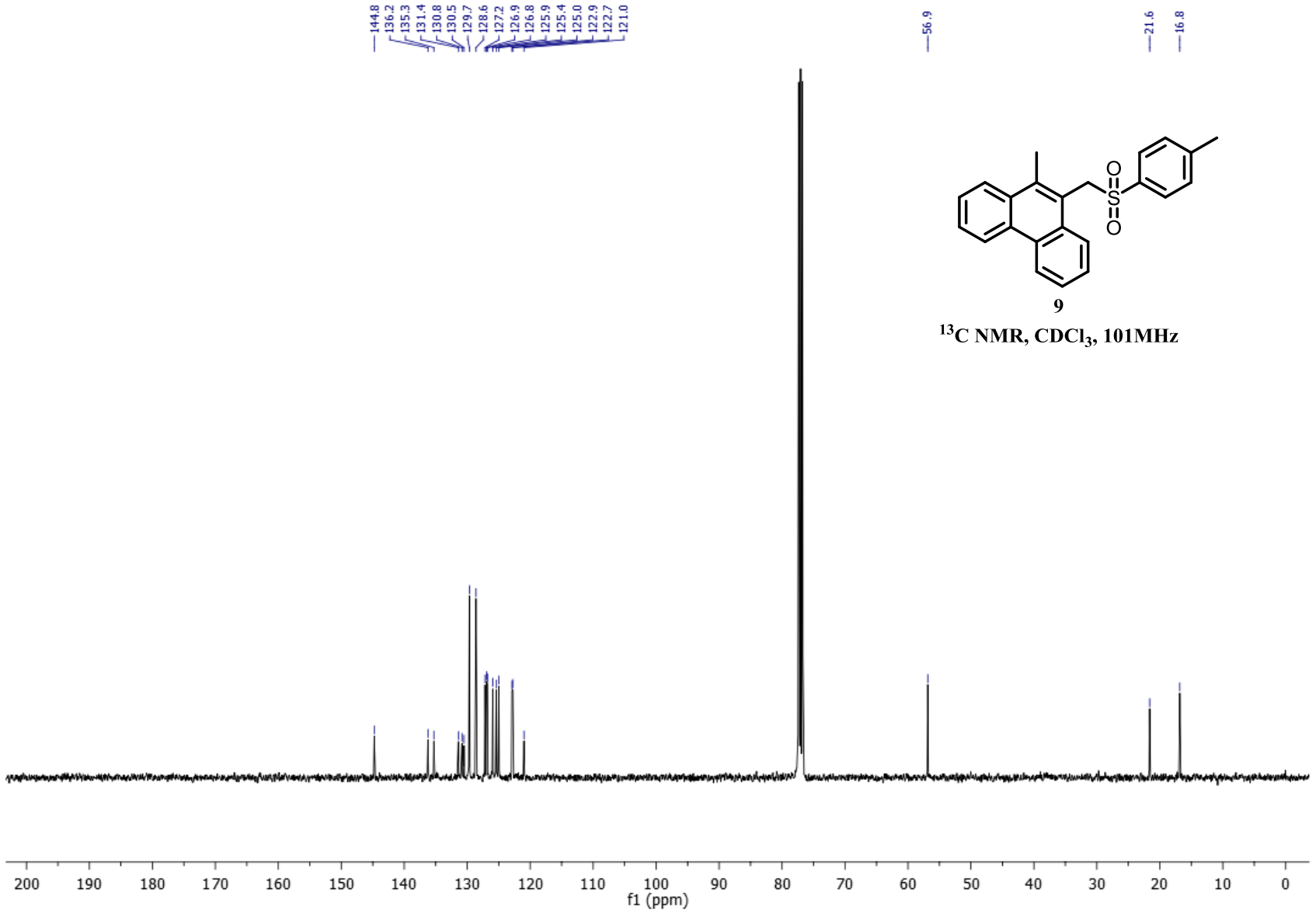
8

^{13}C NMR, $CDCl_3$, 101MHz



9

^{1}H NMR, $CDCl_3$, 400 MHz



9

^{13}C NMR, $CDCl_3$, 101MHz