SUPPORTING INFORMATION

Synthesis of Substituted 1,4-Dioxenes through O–H Insertion and Cyclization using Keto-Diazo Compounds

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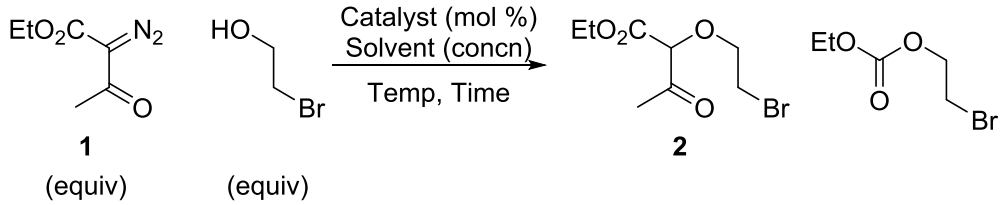
Optimization of the Metal-Catalyzed O–H Insertion Reaction using Diazo 1



1 (equiv) (equiv) **2**

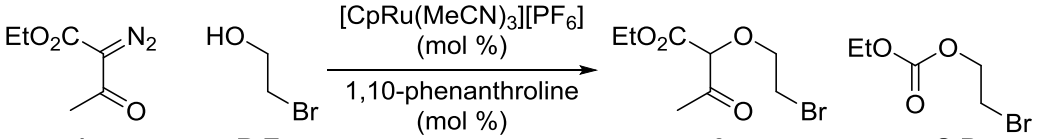
The following reaction variables were screened during the initial optimization (**Table S1**).

Catalyst (mol %)	$Rh_2(OAc)_4$ (0.5); $Rh_2(OCOCF_3)_4$ (0.5); CuBr (2.0); $Cu(OTf)_2$ (2.0)
Equiv of diazo **1**	1.0; 1.1; 1.5; 2.0; 3.0
Equiv of 2-bromoethanol	1.0; 1.1; 1.2; 1.5
Solvent (Concn / M)	PhH (0.1); PhMe (0.1); CH_2Cl_2 (0.1); $C_2H_4Cl_2$ (0.1/0.5)
Temp (°C)	25; 60; 80
Time (min)	20; 60; 90; 17 h

Initial attempts at O–H insertion of 2-bromoethanol with diazo **1** using $Rh_2(OAc)_4$ afforded the desired bromide **2** with variable yields (<5–39%) as well as the formation of a side product which proved inseparable. Attempts to reduce the formation of this side product (tentatively assigned as 2-bromoethyl ethyl carbonate from the crude ^{1}H NMR spectra) by changing multiple variables (**Table S1**) proved unsuccessful.

Therefore an alternative catalytic system using a ruthenium complex was examined.[1]

Selected optimization of reaction conditions using $[CpRu(MeCN)_3][PF_6]$ and 1,10-phenanthroline (**Table S2**).



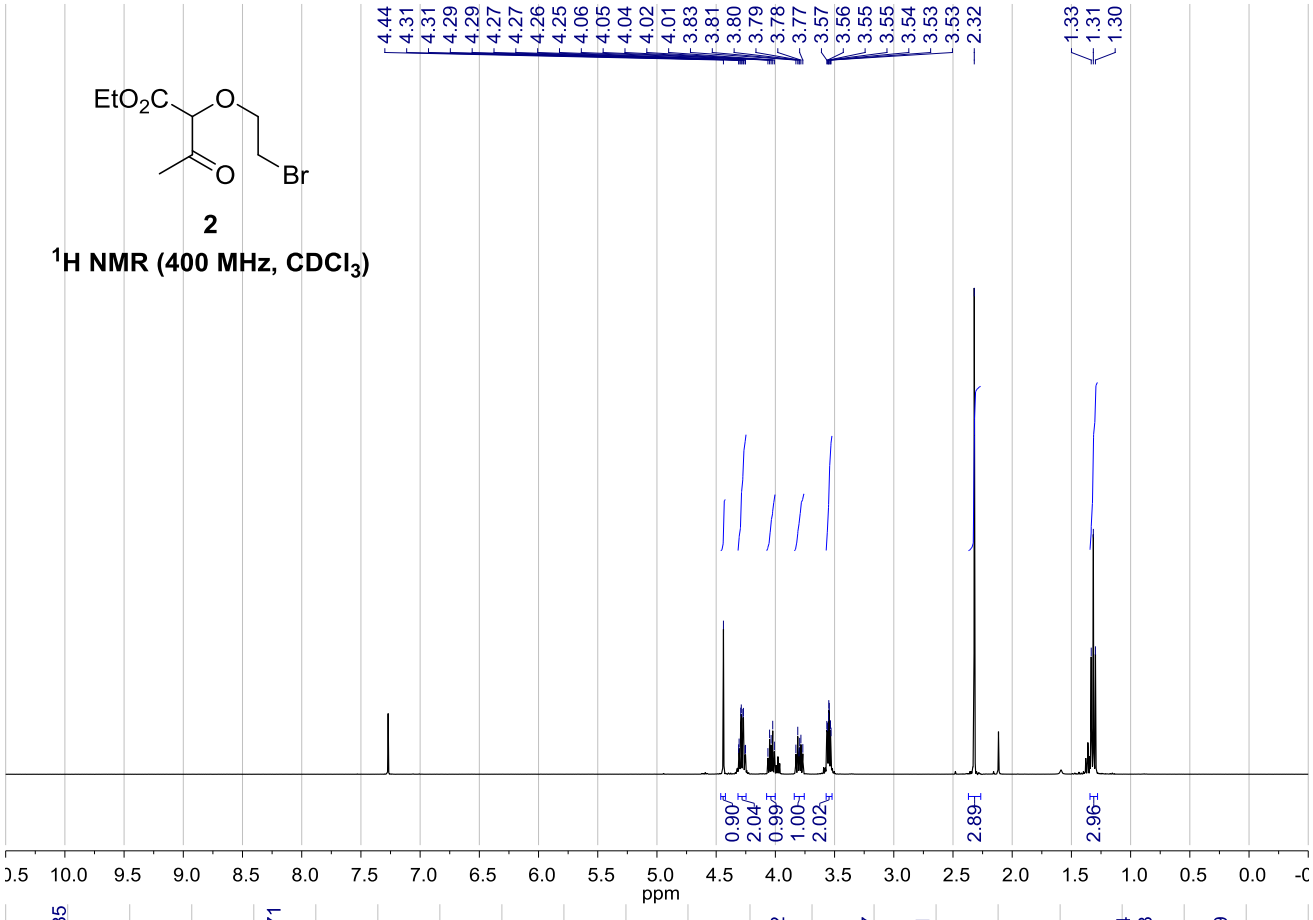
1 (equiv) **B.E.** (equiv) **2** **S.P.**

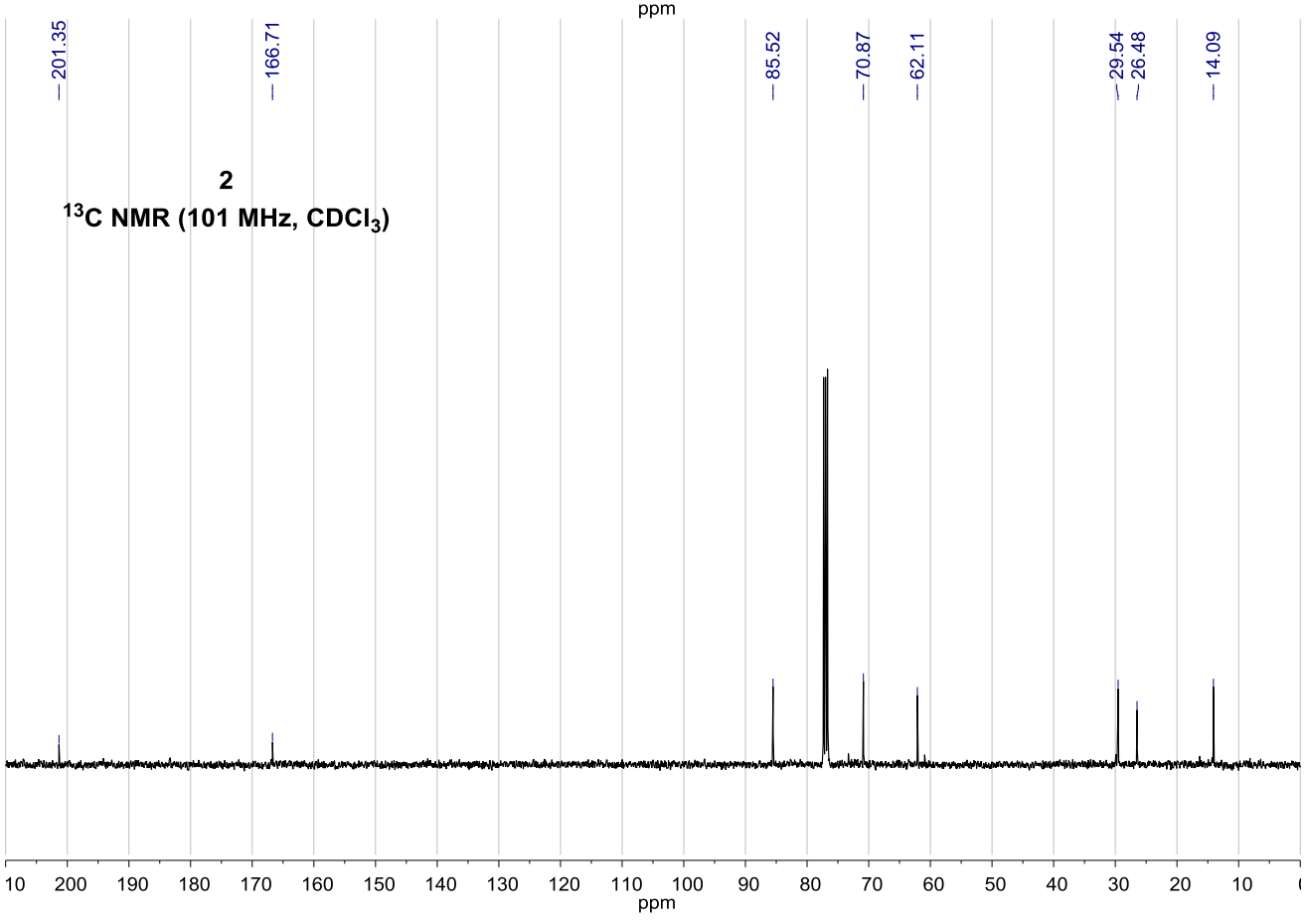
entry[a]	equiv of **1**	equiv of **B.E.**	concn (M)	cat. loading (mol %)	ligand loading (mol %)	Time (h)	Yield (%)[b] **2**	**S.P.**
1[c]	1.0	3.0	0.3	2.5	2.5	1	53	0
2	1.0	3.0	0.3	2.5	2.5	1	64	<2
3	1.0	10	0.3	2.5	2.5	1	30	0
4	3.0	1.0	0.3	2.5	2.5	1	78	0
5	1.2	1.0	0.3	2.5	2.5	1	78	0
6	1.2	1.0	0.5	2.5	2.5	1	82	<3
7	**1.2**	**1.0**	**0.5**	**0.5**	**0.5**	**1**	**78**	**<4**
8	1.2	1.0	0.5	0.5	-	1	35	16
9	1.2	1.0	0.5	0.5	1.0	1	4	0
10	1.2	1.0	0.5	-	-	1	0	0
11	1.2	1.0	0.5	-	0.5	1	0	0
12	1.2	1.0	0.5	0.5	0.5	1 h 30 min	76	<3
13[d]	1.2	1.0	0.5	0.5	0.5	1	72[e]	0
14[d]	**1.2**	**1.0**	**0.5**	**1.0**	**1.0**	**1**	**86[e]**	**0**

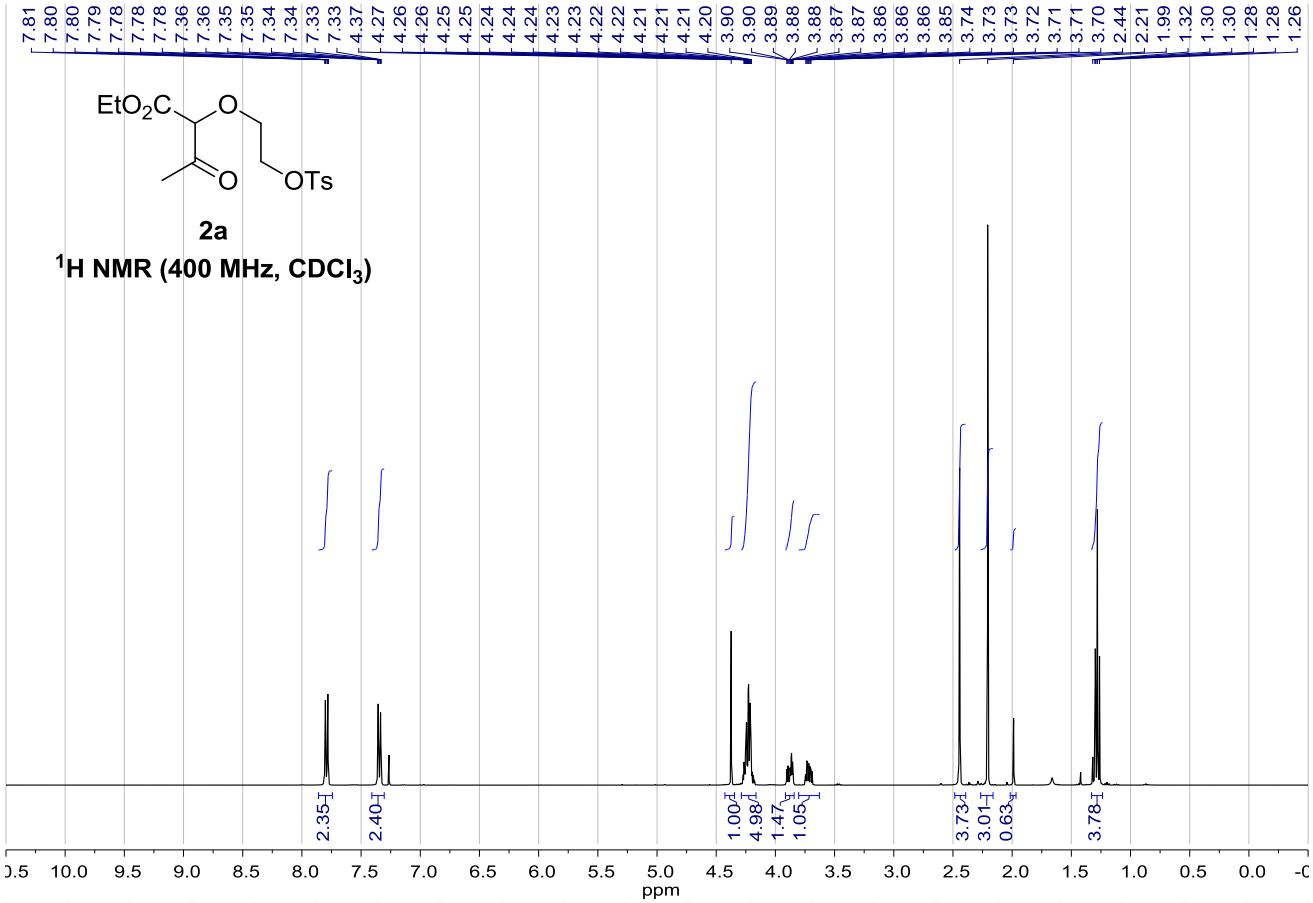
[a]0.2 mmol scale. [b]Yield determined by ^{1}H NMR with respect to an internal standard (1,3,5-trimethoxybenzene). [c]"Old" bottle of 2-bromoethanol used. Newly bought 2-bromoethanol used in subsequent reactions. [d]1.0 mmol scale. [e]Isolated yield.

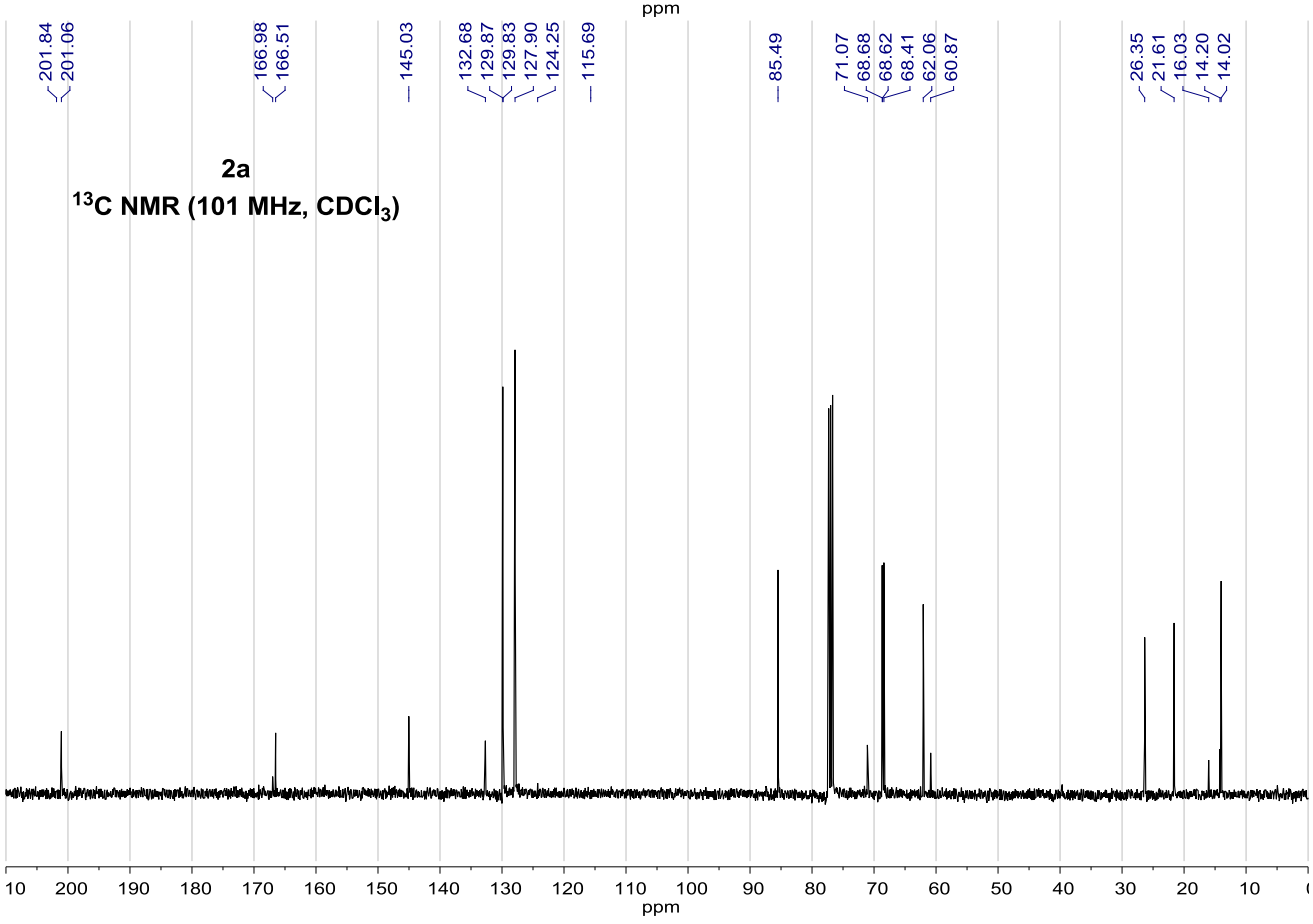
The initial attempt at the Ru-catalyzed O–H insertion used conditions based off those reported by Lacour and co-workers,[1] a promising yield of 53% of bromide **2** was observed *without* any formation of the side product. Lacour and co-workers noted that the use of anhydrous alcohols was essential for the Ru-catalyzed O–H insertion. Therefore, a fresh bottle of comerically available 2-bromoethanol was used and an increase in yield was observed (64%, entry 2). Subsequent reactions were conducted using the new 2-bromoethanol. Increasing the equiv of 2-bromoethanol decreased the yield of bromide **2** (entry 3), but higher yields were obtained when diazo **1** was in excess (entries 4 and 5), and the excess could be lowered to 1.2 equiv of diazo **1** without affecting the yield (entry 5). Increasing the concentration of the reaction increased the yield of **2** slightly (entry 6). Pleasingly, the catalyst and ligand loading could be significantly reduced to 0.5 mol % without affecting the yield (entry 7). However, when the reaction was conducted without any 1,10-phenanthroline (entry 8), the yield of **2** decreased and a significant amount of carbonate **S.P.** was observed. When an excess of 1,10-phenanthroline with respect to $[CpRu(MeCN)_3][PF_6]$ (2 equiv, entry 9), the reaction was not productive, presumably due to 1,10-phenanthroline completely complexing to the Ruthenium. When $[CpRu(MeCN)_3][PF_6]$ was absent (entries 10 and 11), no reaction was observed and excellent recovery of diazo **1** was observed. Increasing the reaction time did not improve the yield of **2** (entry 12). When the reaction was conducted on a preparative scale (1 mmol), slightly reduced isolated yields were observed (entry 13). The catalyst and ligand loading was increased to 1 mol % in order to ensure a perfect 1:1 ratio of catalyst:ligand (entry 14) and an excellent isolated yield of 86% was obtained.

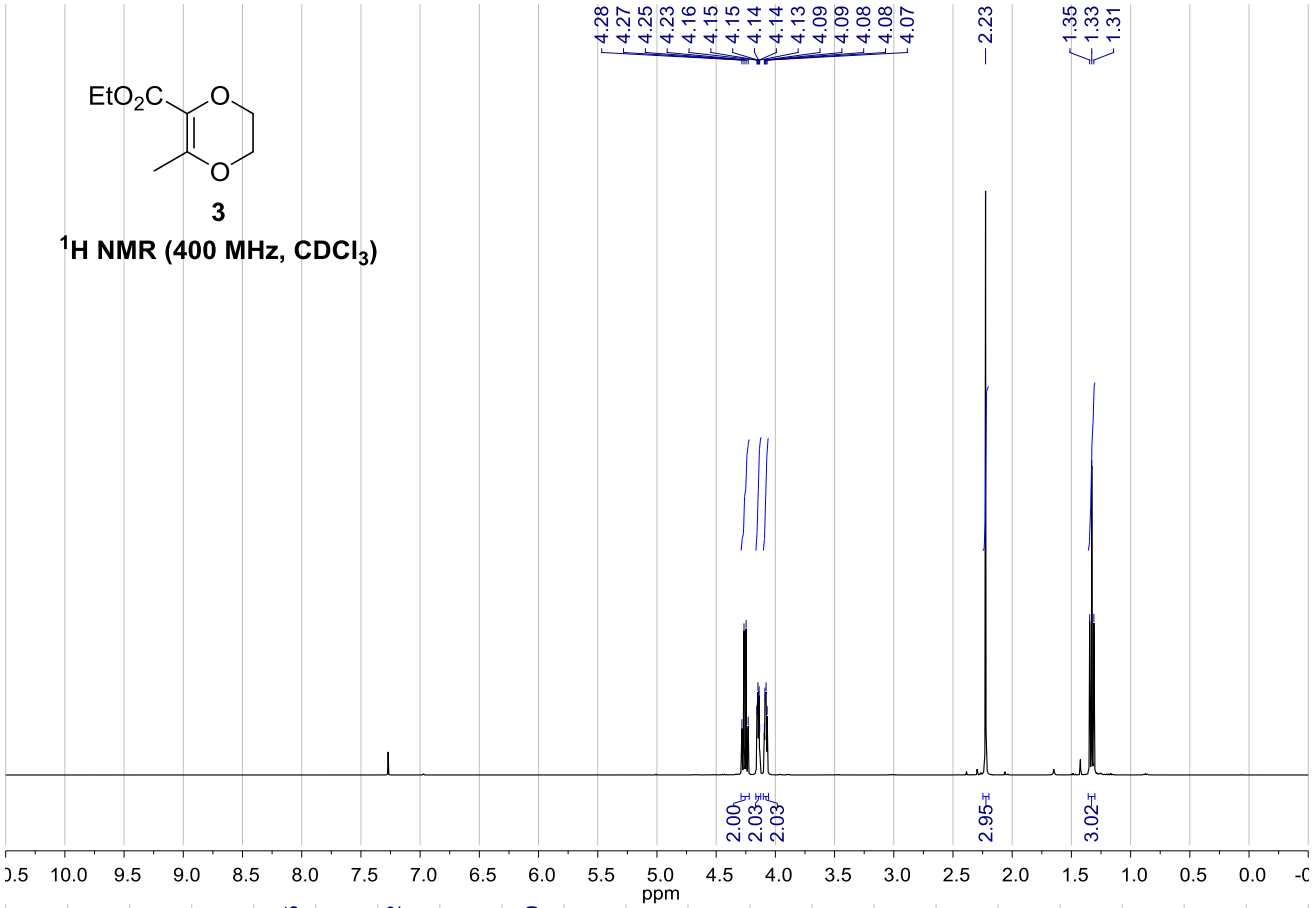
^{1}H and ^{13}C NMR Spectra of Selected Compounds


4.44
4.31
4.31
4.29
4.29
4.27
4.27
4.26
4.25
4.06
4.05
4.04
4.02
4.01
3.83
3.81
3.80
3.79
3.78
3.77
3.57
3.56
3.55
3.55
3.54
3.53
3.53
2.32
1.33
1.31
1.30
EtO2C
O
O
Br
2
1H NMR (400 MHz, CDCl3)
0.90
2.04
0.99
1.00
2.02
2.89
2.96
ppm


201.35
166.71
85.52
70.87
62.11
29.54
26.48
14.09
2
13C NMR (101 MHz, CDCl3)
ppm


EtO2C
O
O
OTs
2a
1H NMR (400 MHz, CDCl3)
ppm


2a
13C NMR (101 MHz, CDCl3)
ppm


EtO2C
O
O
3
1H NMR (400 MHz, CDCl3)
4.28
4.27
4.25
4.23
4.16
4.15
4.15
4.14
4.14
4.13
4.09
4.09
4.08
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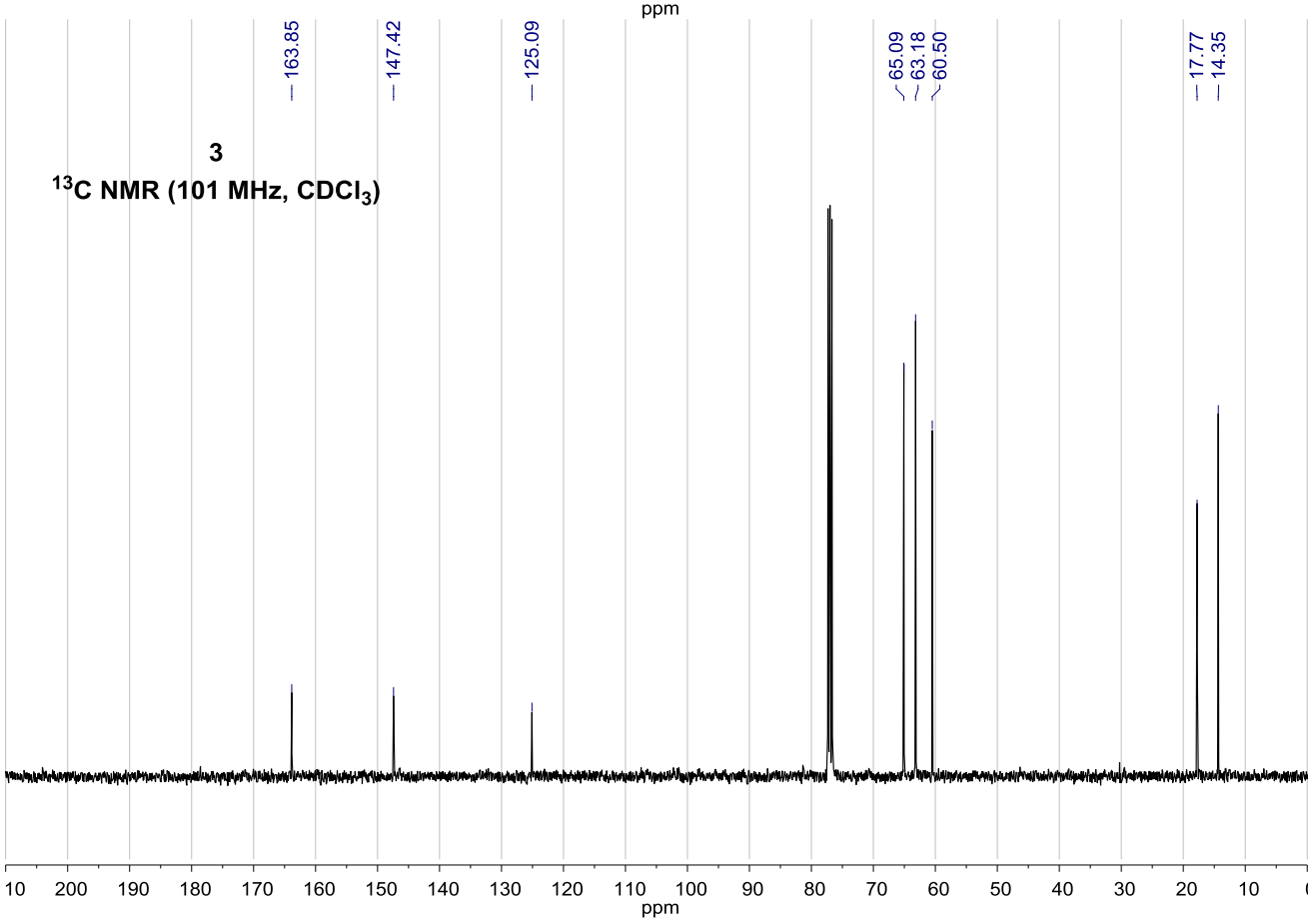
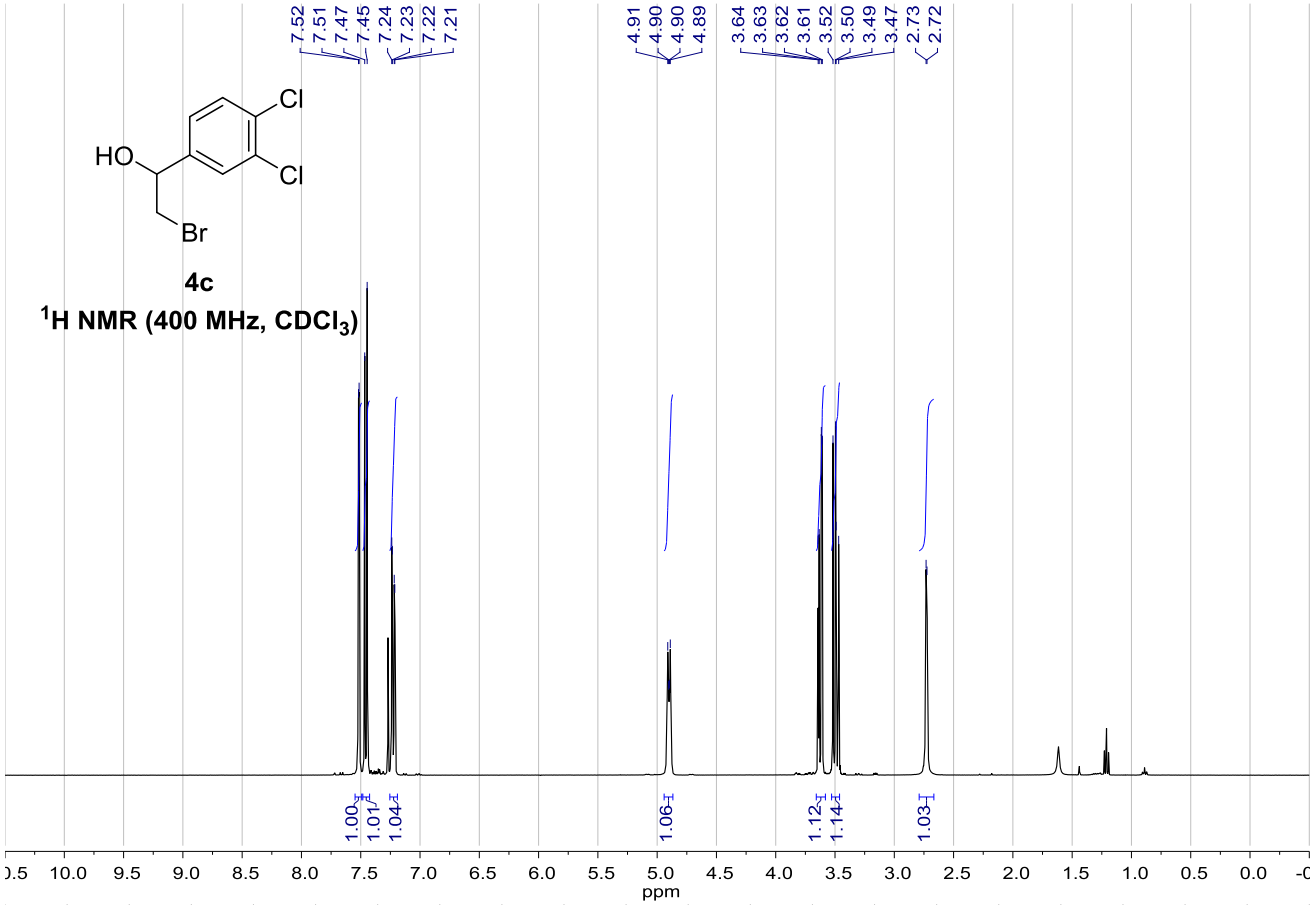
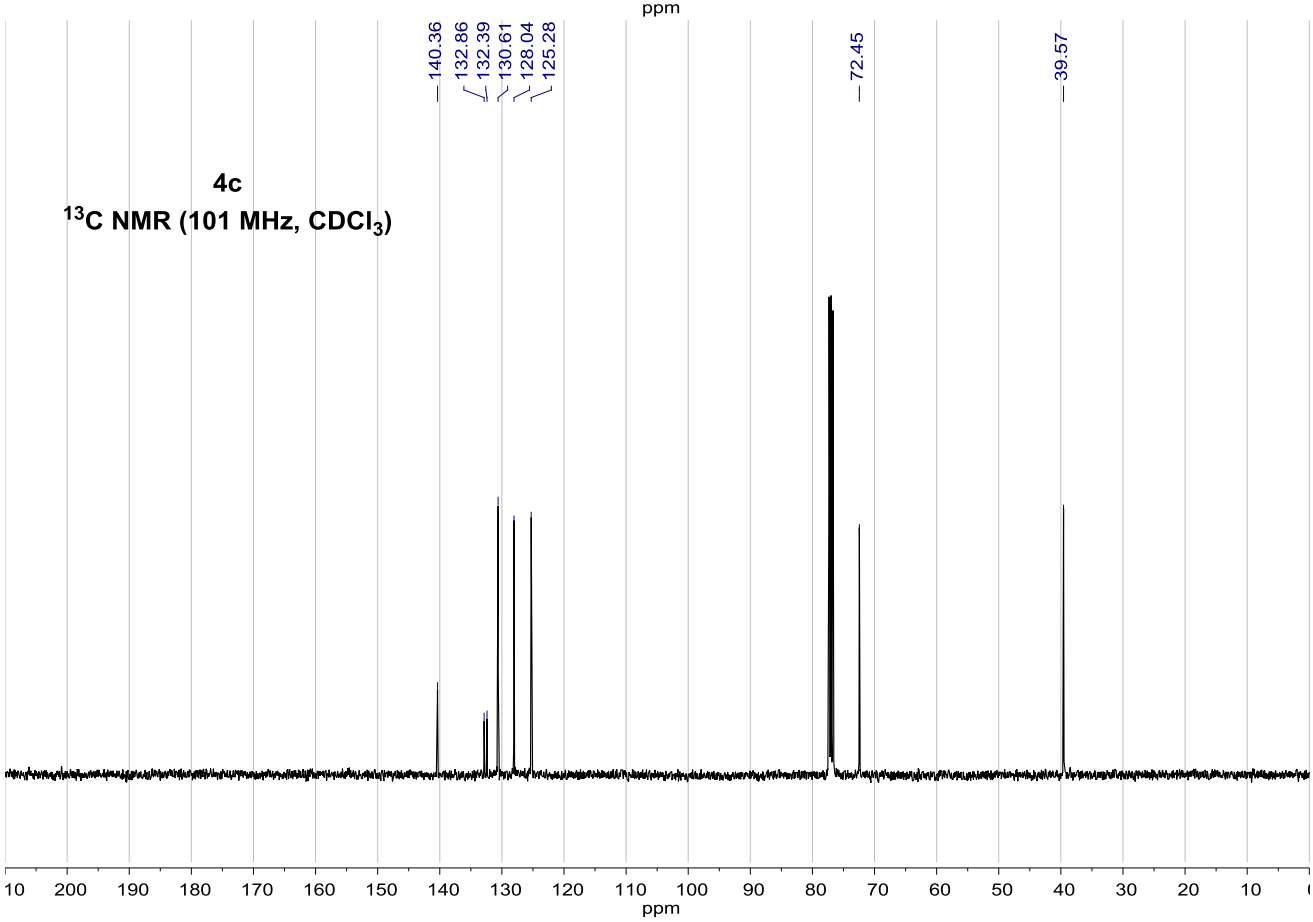
2.00
2.03
2.03
2.95
3.02
ppm


163.85
147.42
125.09
65.09
63.18
60.50
17.77
14.35
3
13C NMR (101 MHz, CDCl3)
ppm


7.52
7.51
7.47
7.45
7.24
7.23
7.22
7.21
4.91
4.90
4.90
4.89
3.64
3.63
3.62
3.61
3.52
3.50
3.49
3.47
2.73
2.72
Cl
HO
Cl
Br
4c
^{1}H NMR (400 MHz, CDCl$_3$)
1.00
1.01
1.04
1.06
1.12
1.14
1.03
ppm


140.36
132.86
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130.61
128.04
125.28
72.45
39.57
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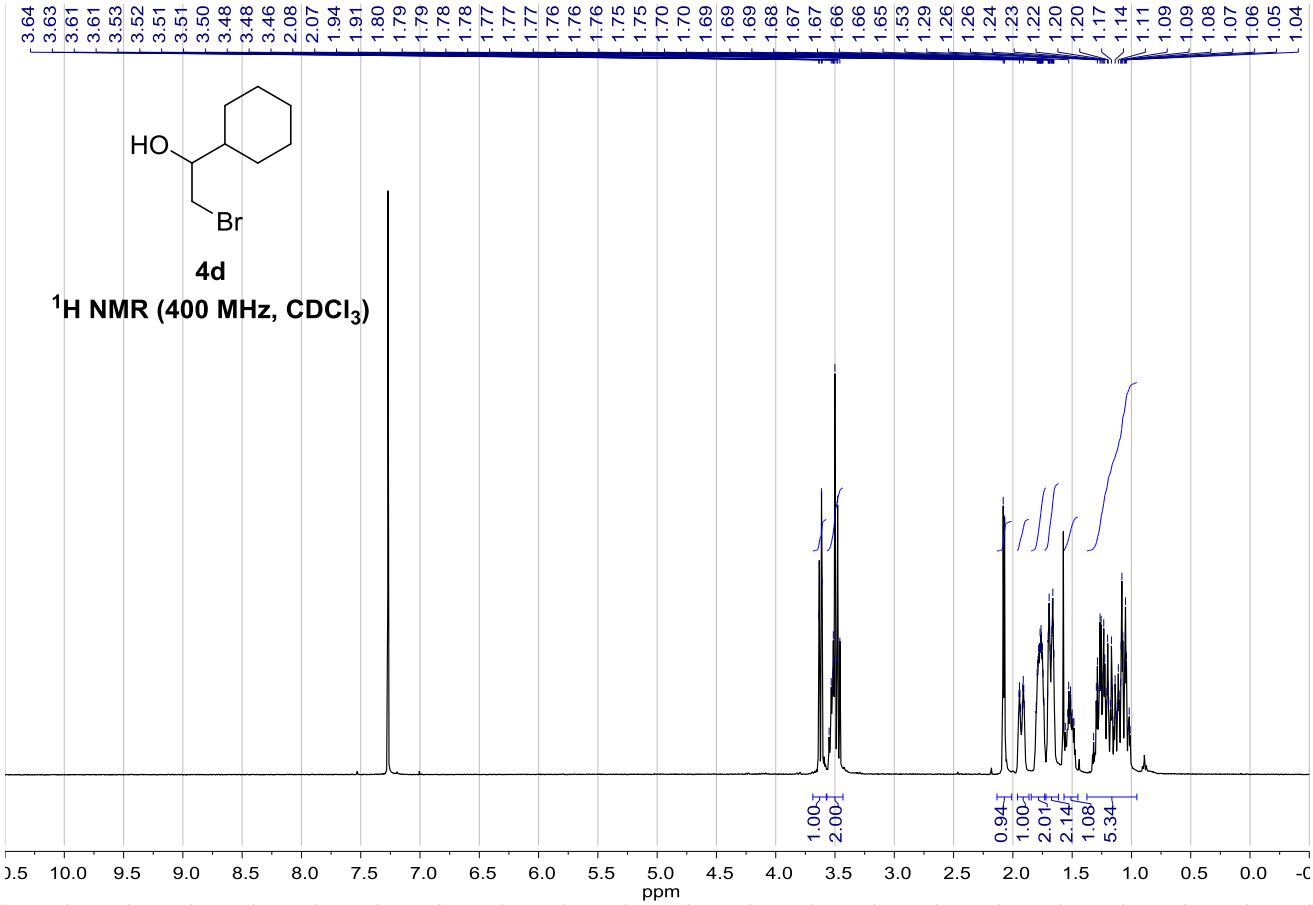
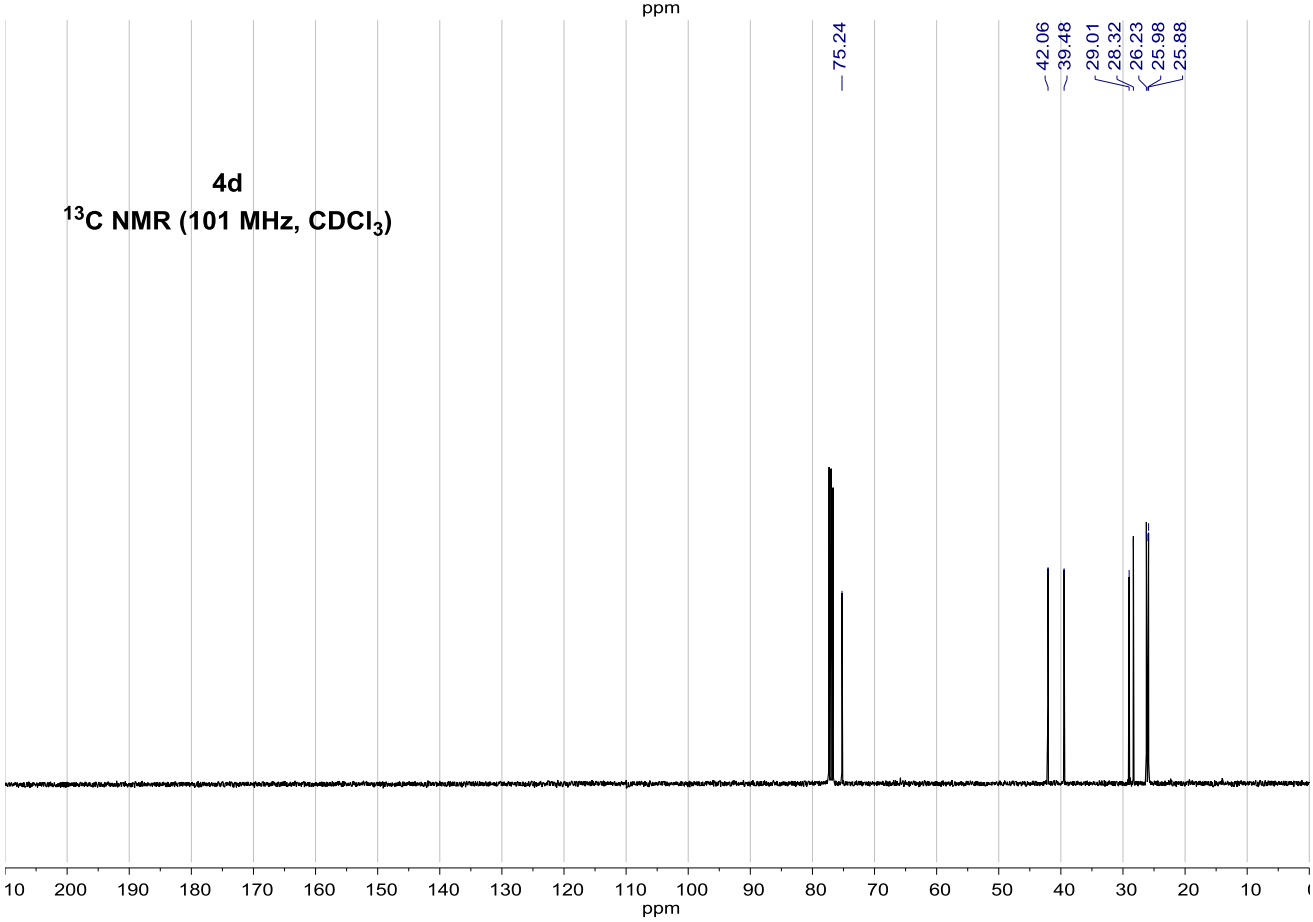
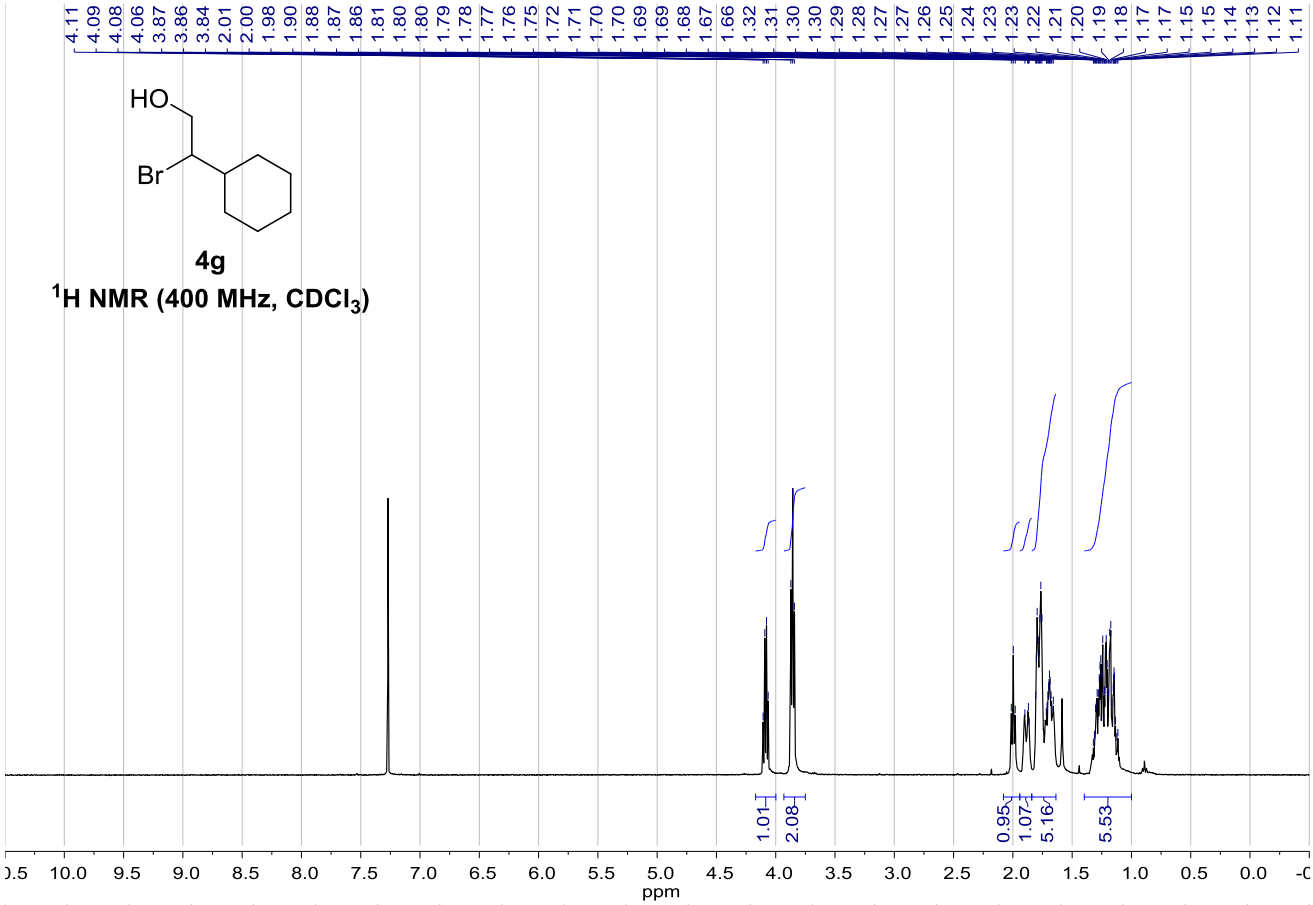
^{13}C NMR (101 MHz, CDCl$_3$)
ppm


HO
Br
4d
^{1}H NMR (400 MHz, CDCl$_3$)
ppm


4d
^{13}C NMR (101 MHz, CDCl$_3$)
ppm


HO
Br
4g
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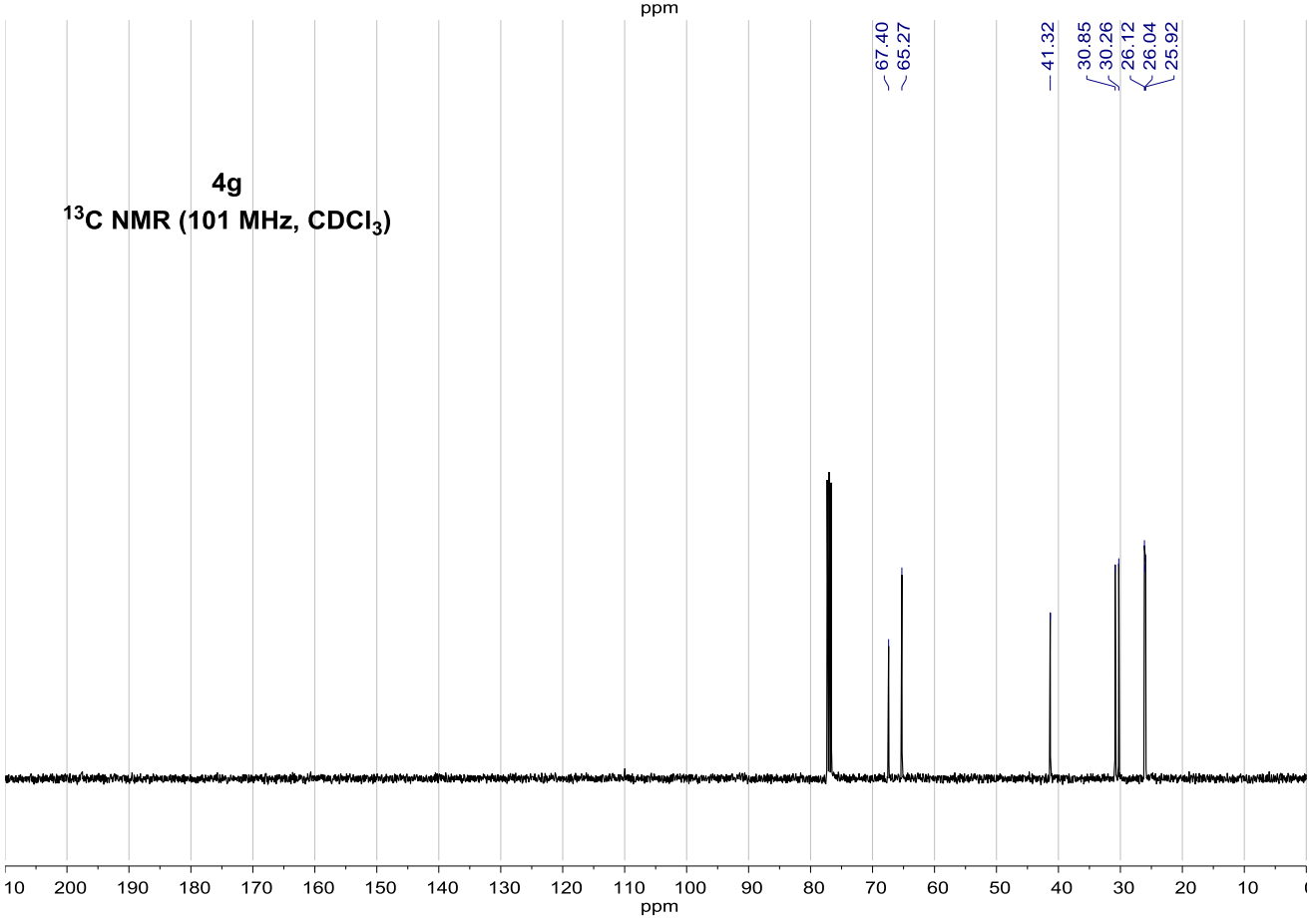
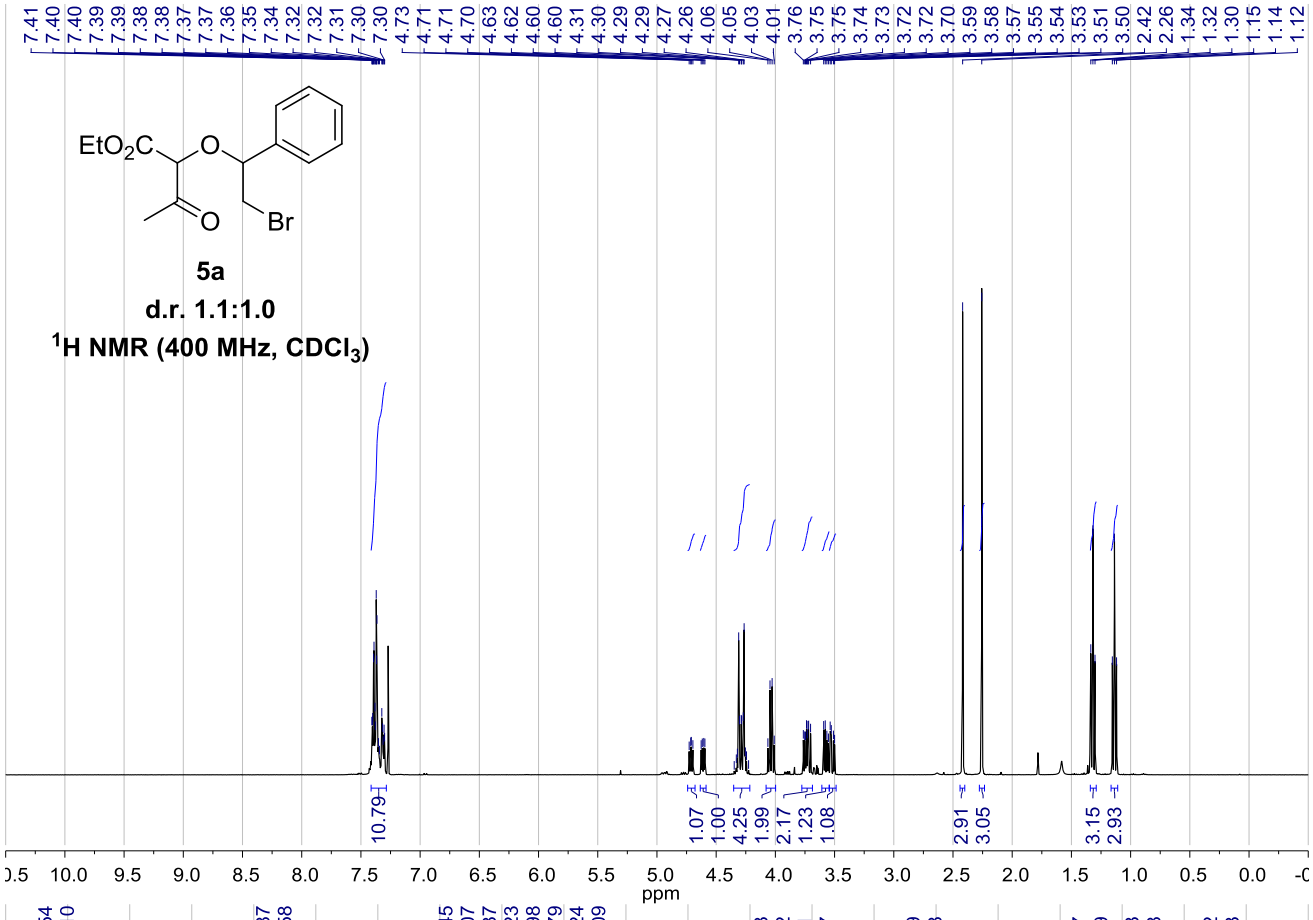
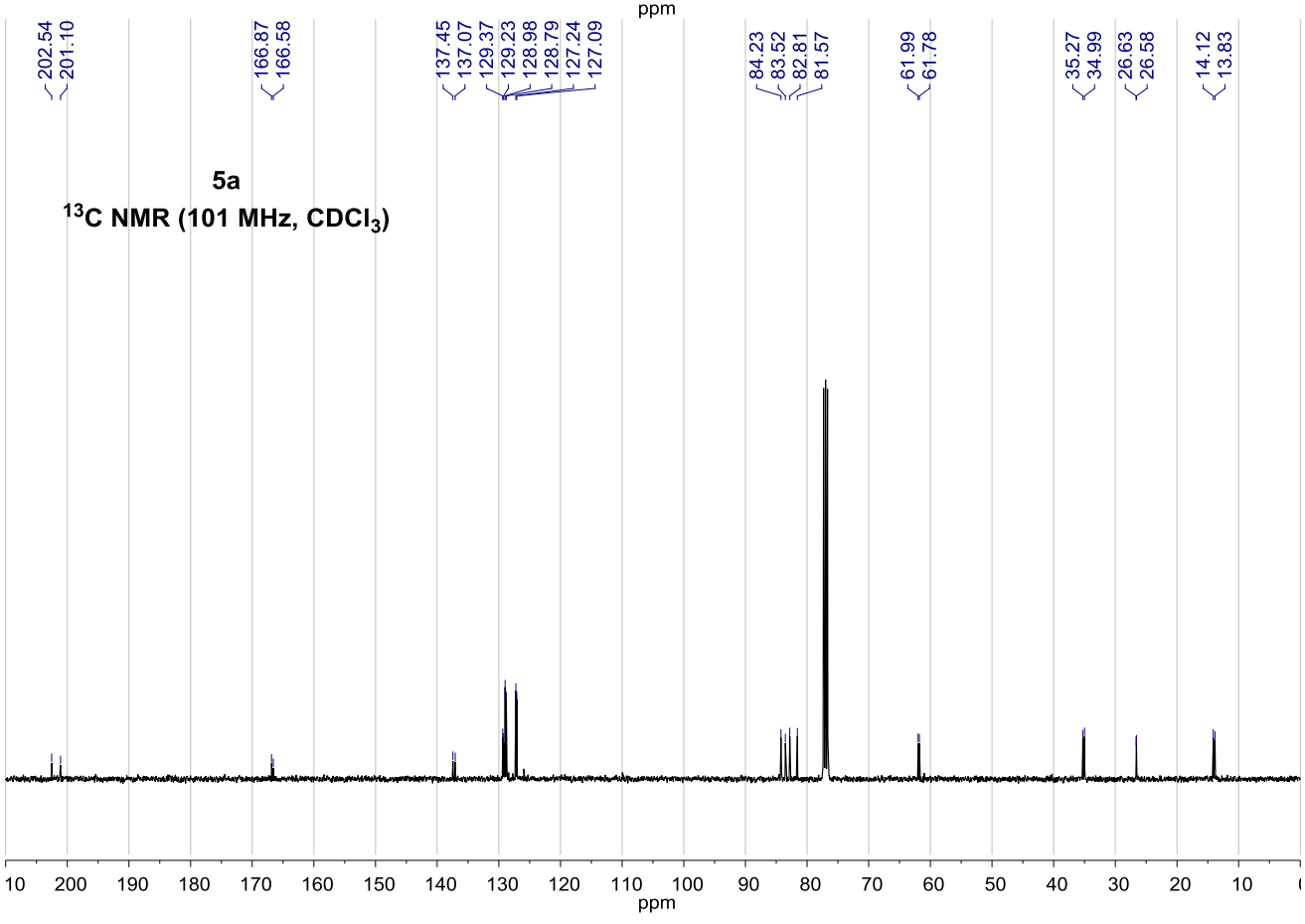
2.08
0.95
1.07
5.16
5.53
ppm


67.40
65.27
41.32
30.85
30.26
26.12
26.04
25.92
4g
^{13}C NMR (101 MHz, CDCl$_3$)
ppm


EtO2C
O
O
Br
5a
d.r. 1.1:1.0
1H NMR (400 MHz, CDCl3)
ppm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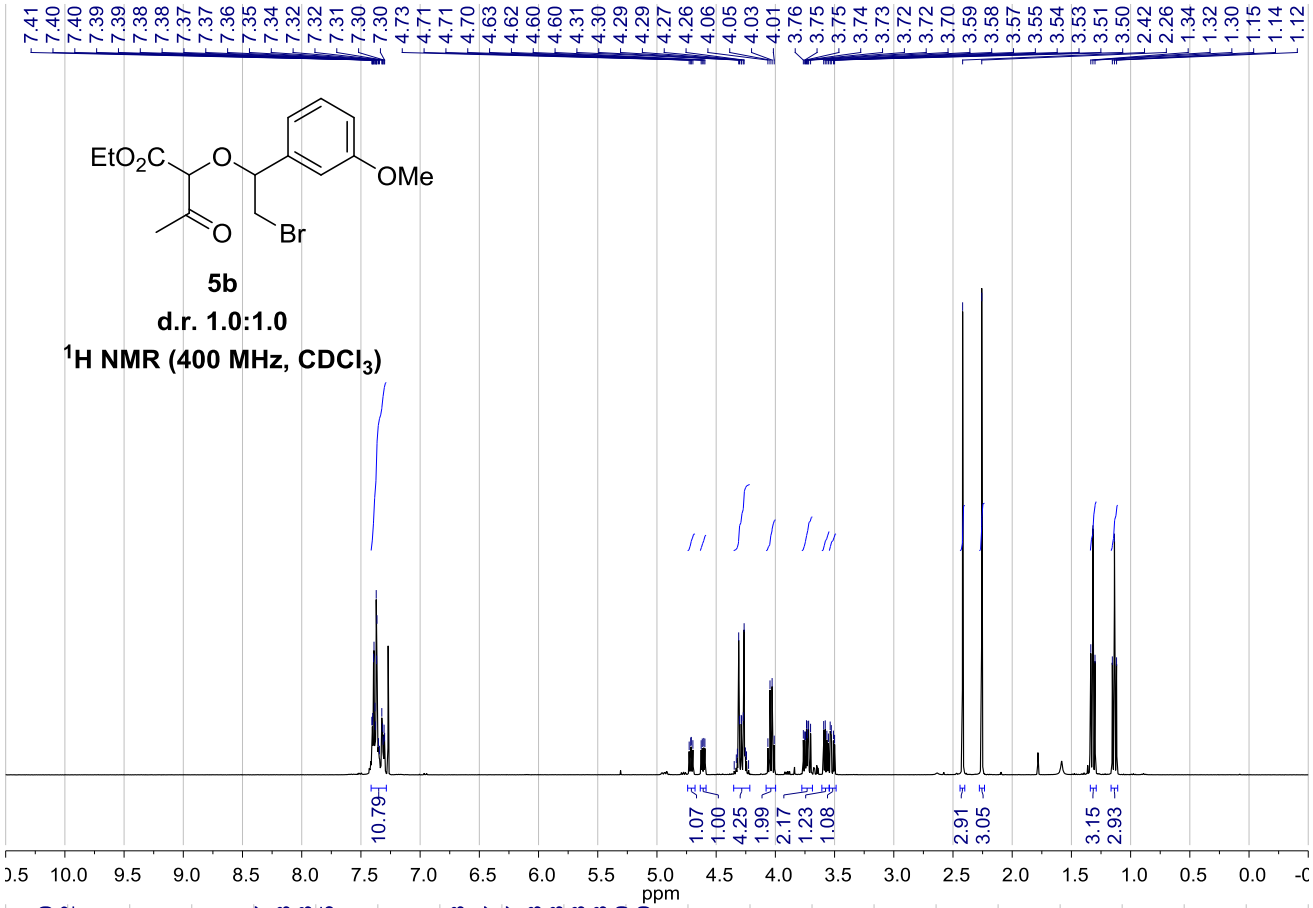
13C NMR (101 MHz, CDCl3)
ppm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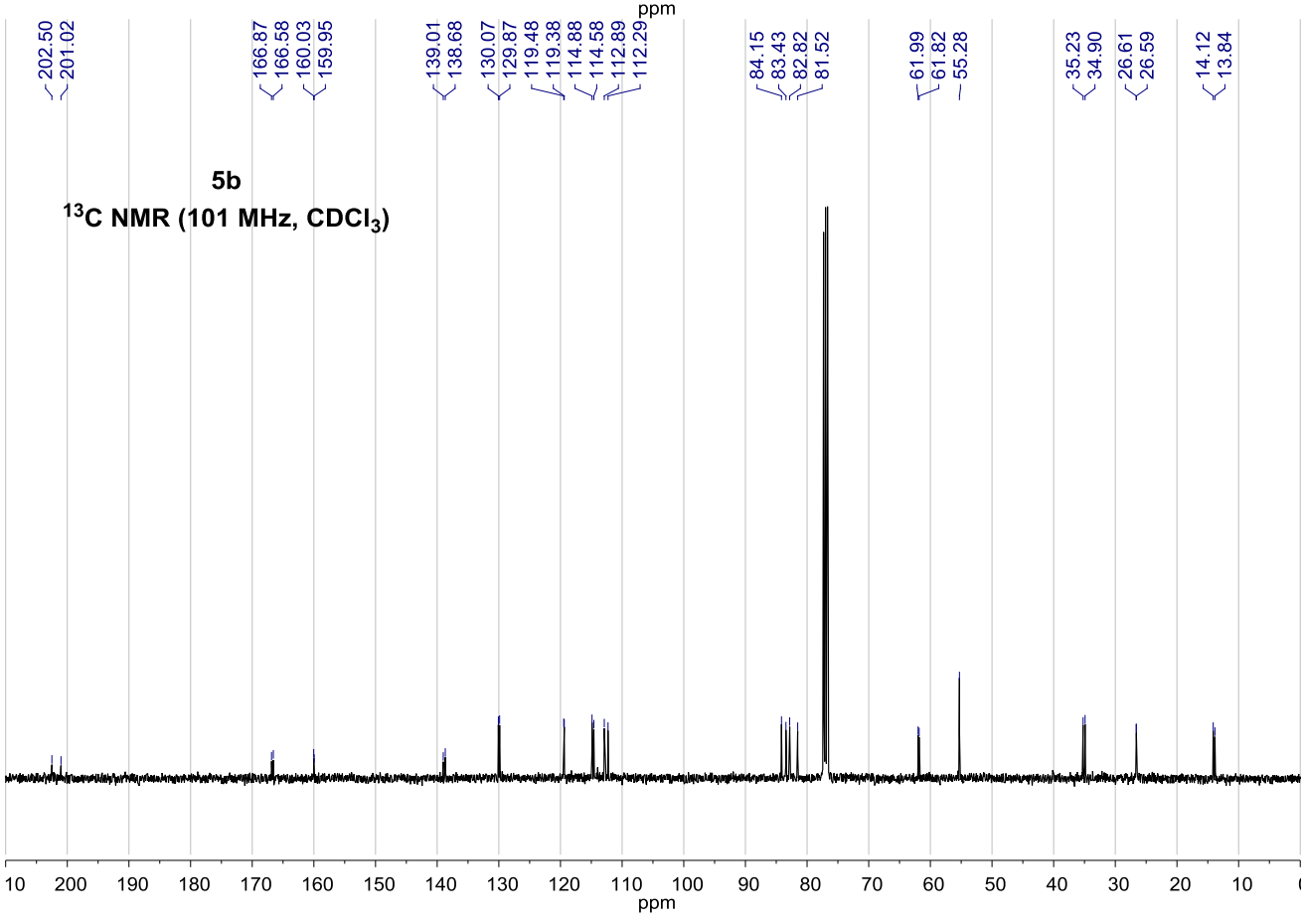
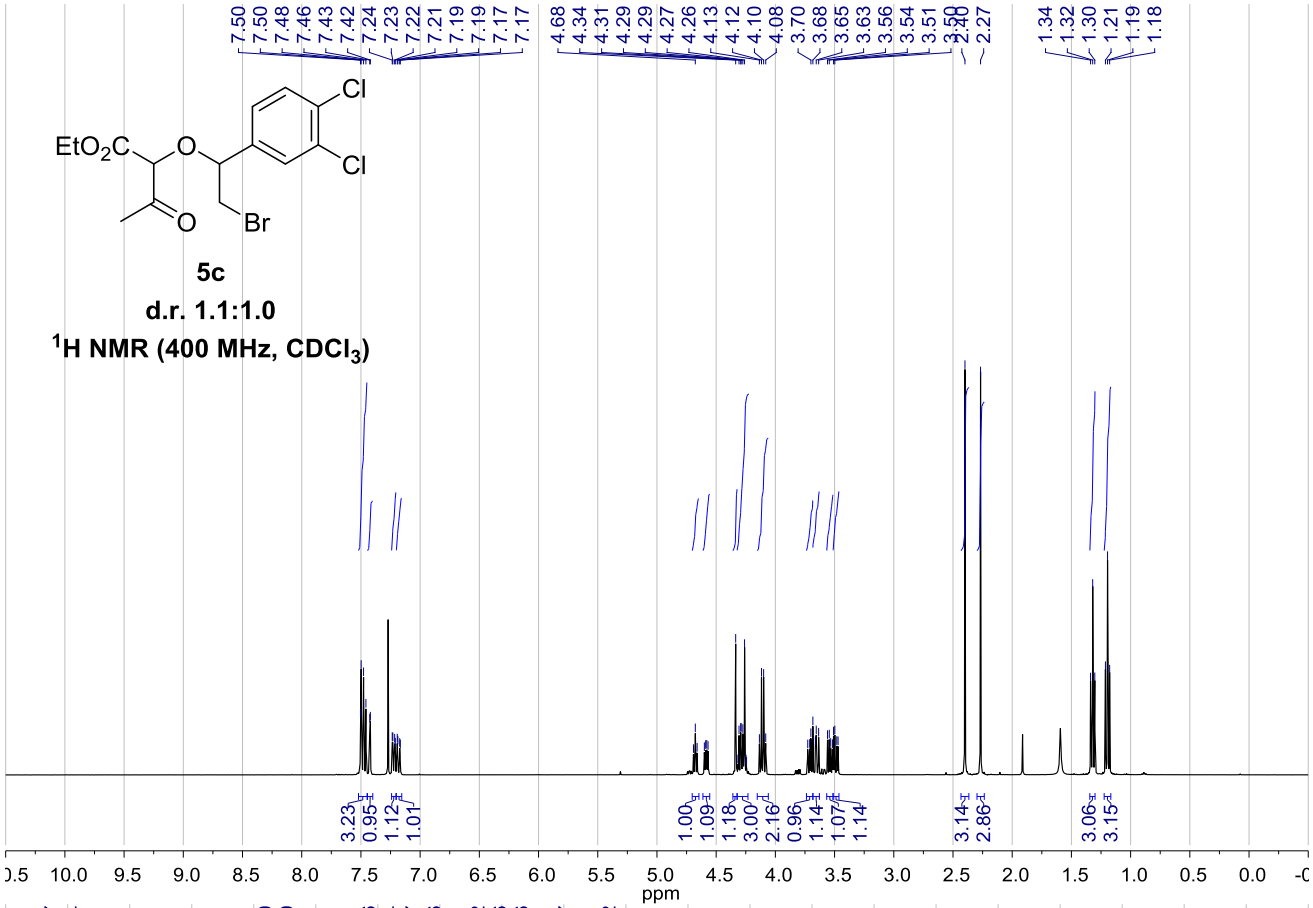
OMe
O
Br
5b
d.r. 1.0:1.0
1H NMR (400 MHz, CDCl3)
ppm


5b
13C NMR (101 MHz, CDCl3)
ppm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4.68 4.34 4.31 4.29 4.29 4.27 4.26 4.13 4.12 4.10 4.08
3.70 3.68 3.65 3.63 3.56 3.54 3.51 2.40 2.27
1.34 1.32 1.30 1.21 1.19 1.18
Cl
Cl
EtO2C
O
O
O
Br
5c
d.r. 1.1:1.0
1H NMR (400 MHz, CDCl3)
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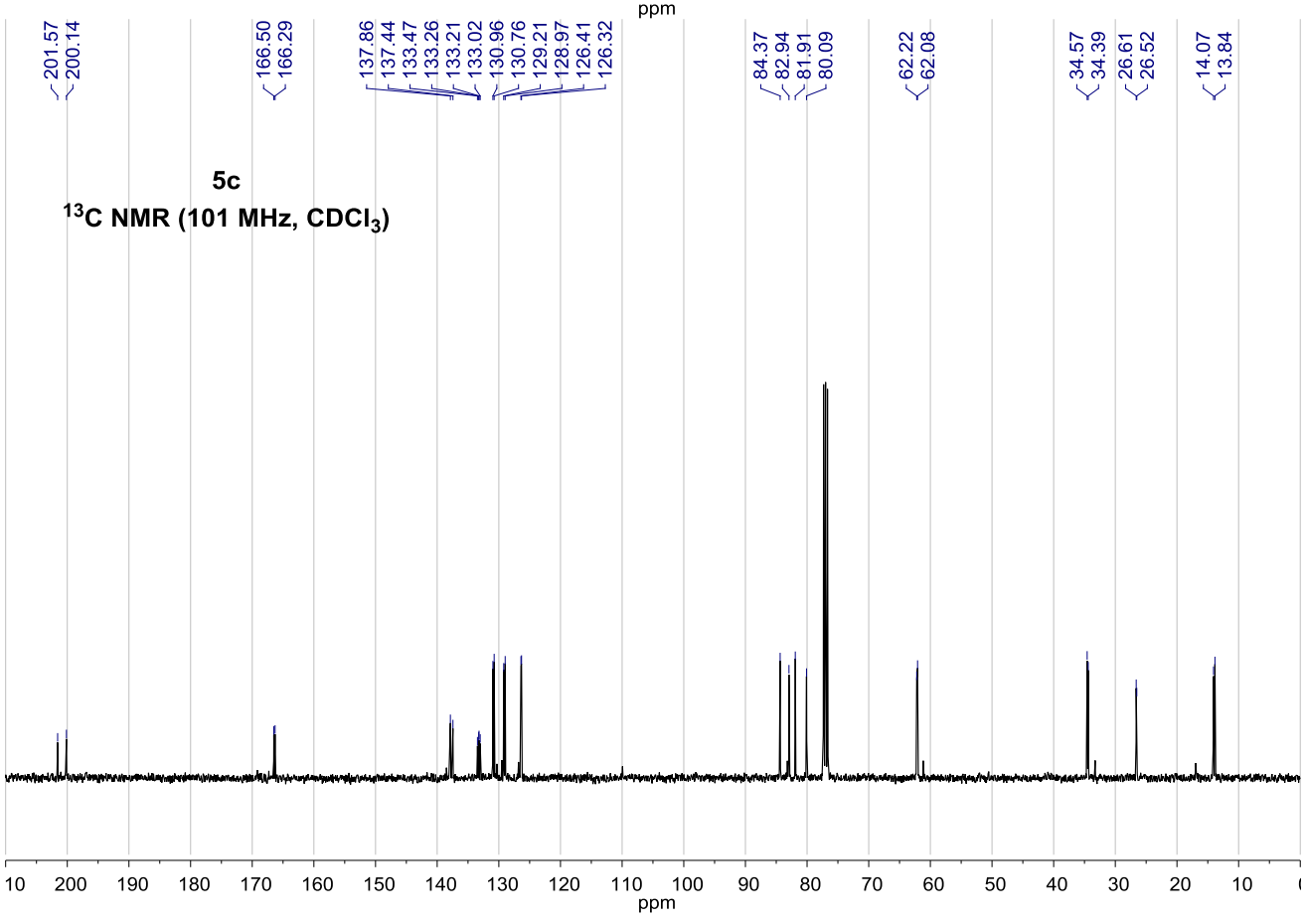
ppm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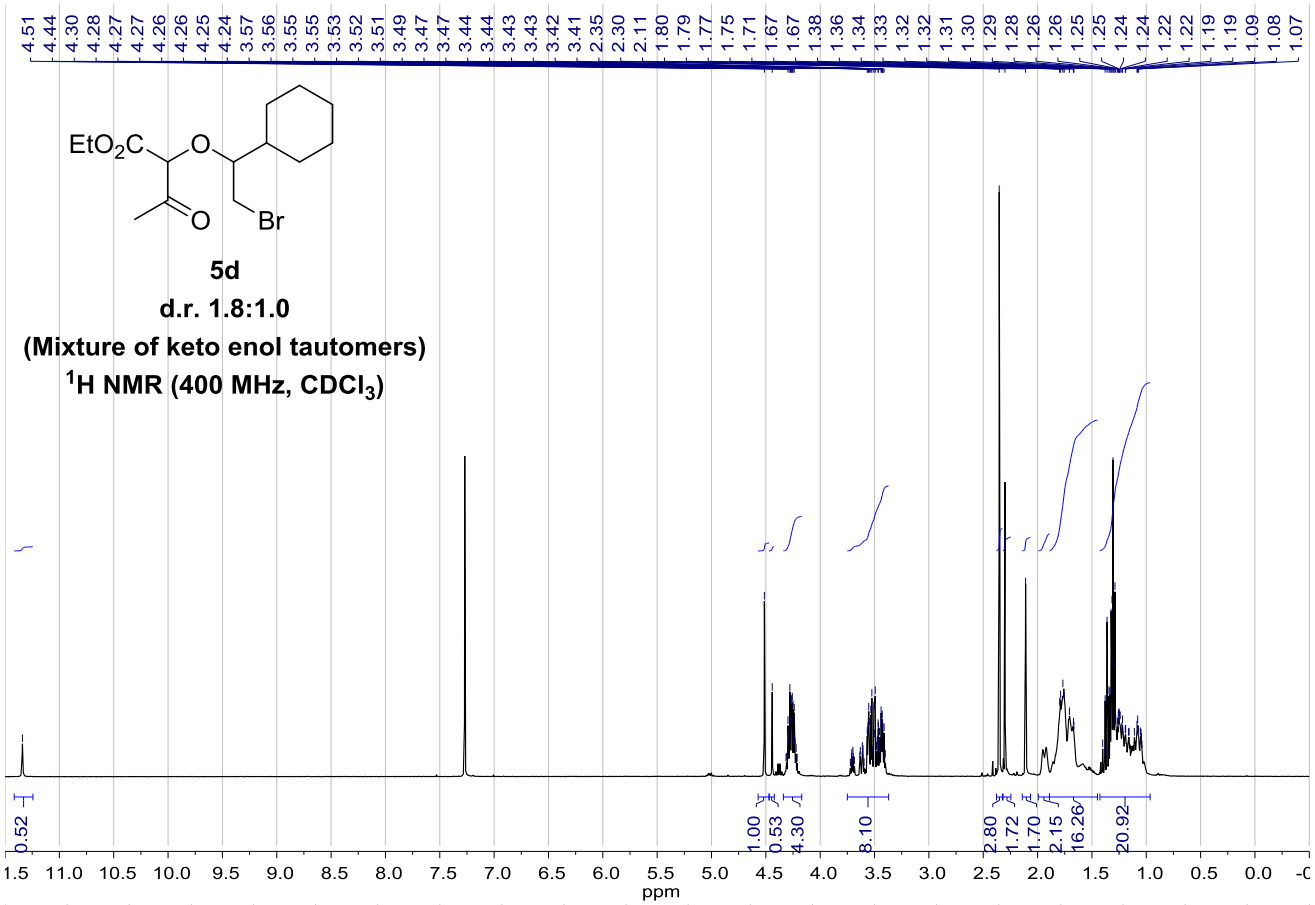
166.50 166.29
137.86 137.44 133.47 133.26 133.21 133.02 130.96 130.76 129.21 128.97 126.41 126.32
84.37 82.94 81.91 80.09
62.22 62.08
34.57 34.39
26.61 26.52
14.07 13.84
5c
13C NMR (101 MHz, CDCl3)
ppm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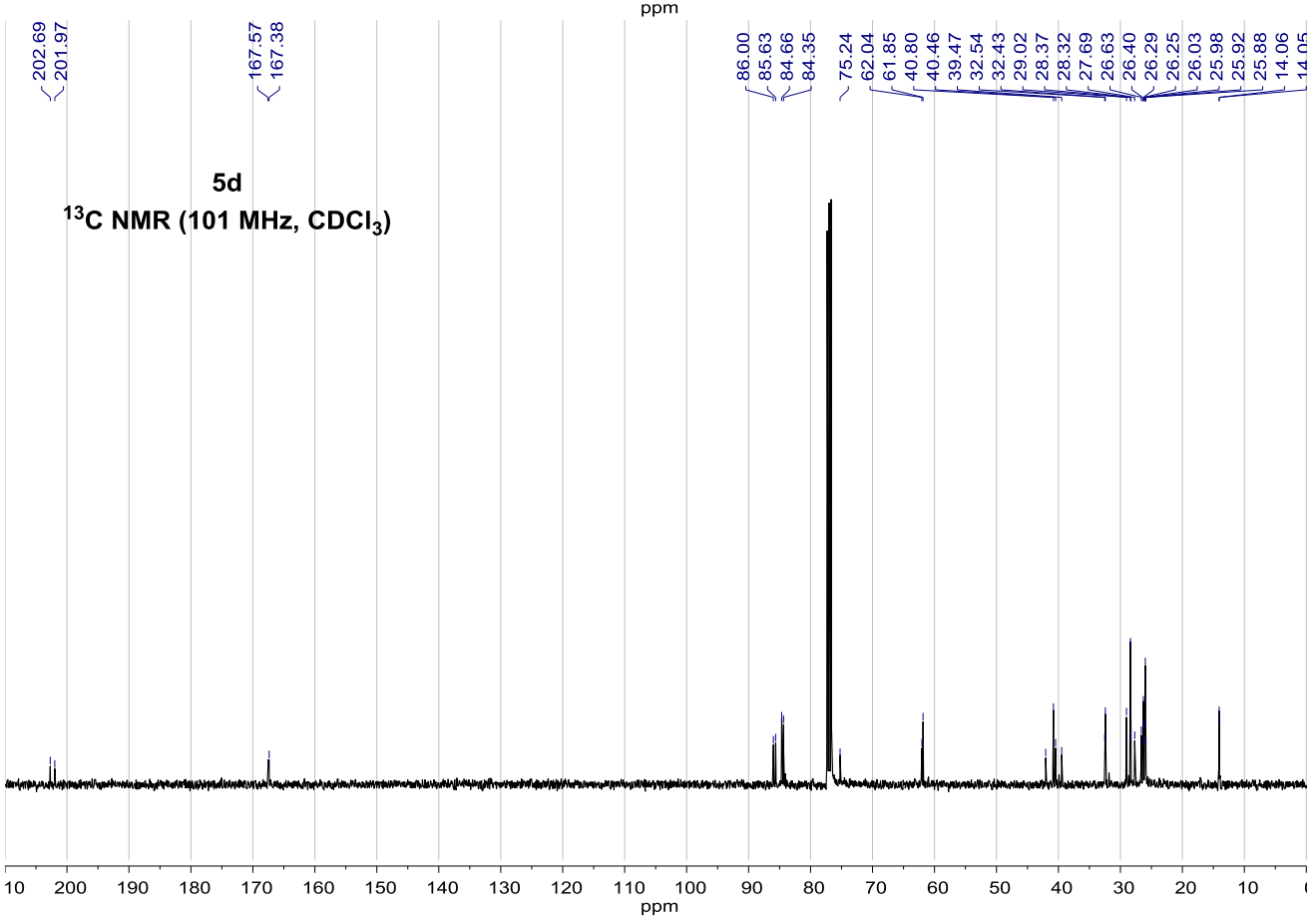
O
Br
5d
d.r. 1.8:1.0
(Mixture of keto enol tautomers)
1H NMR (400 MHz, CDCl3)
ppm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13C NMR (101 MHz, CDCl3)
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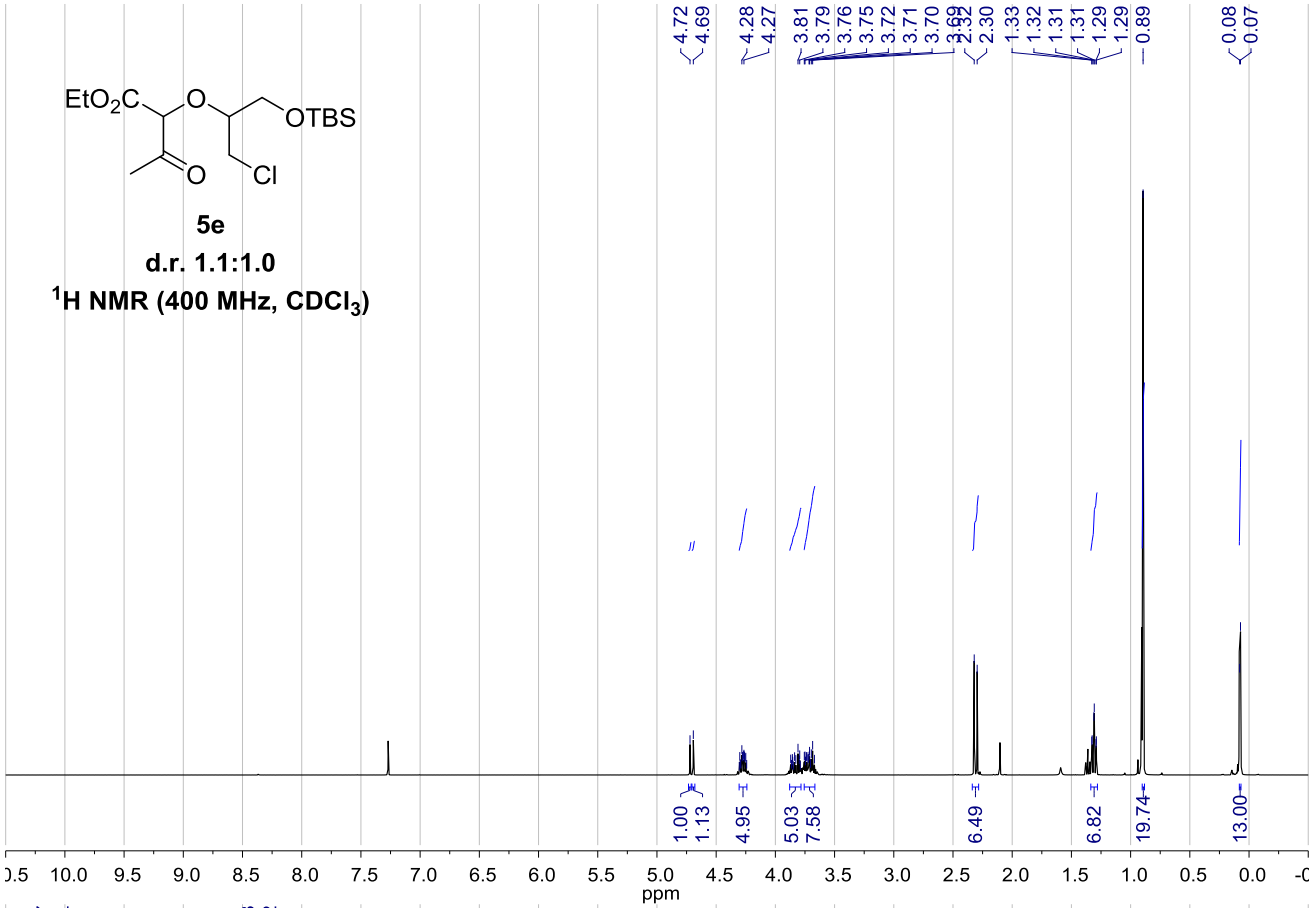
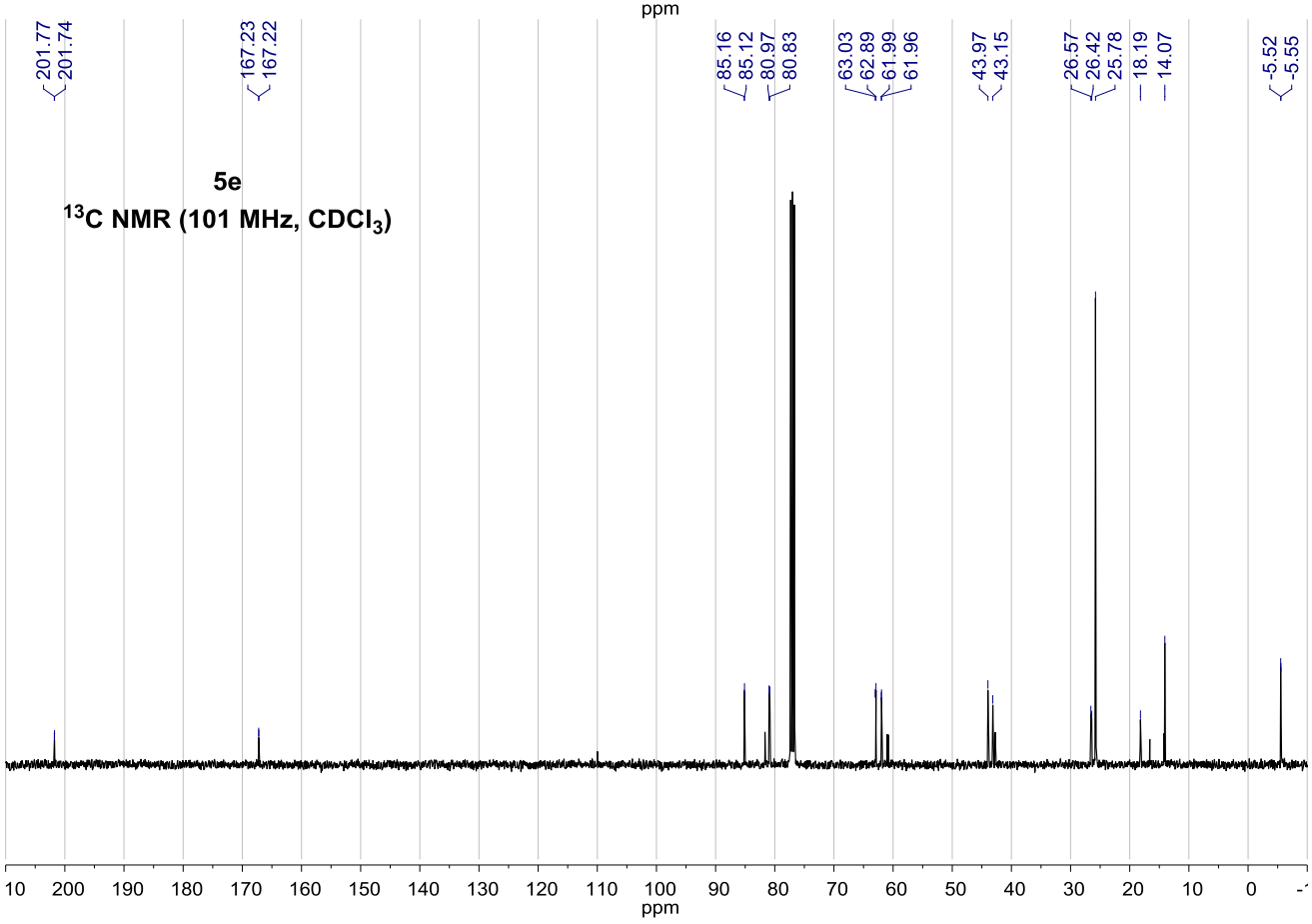
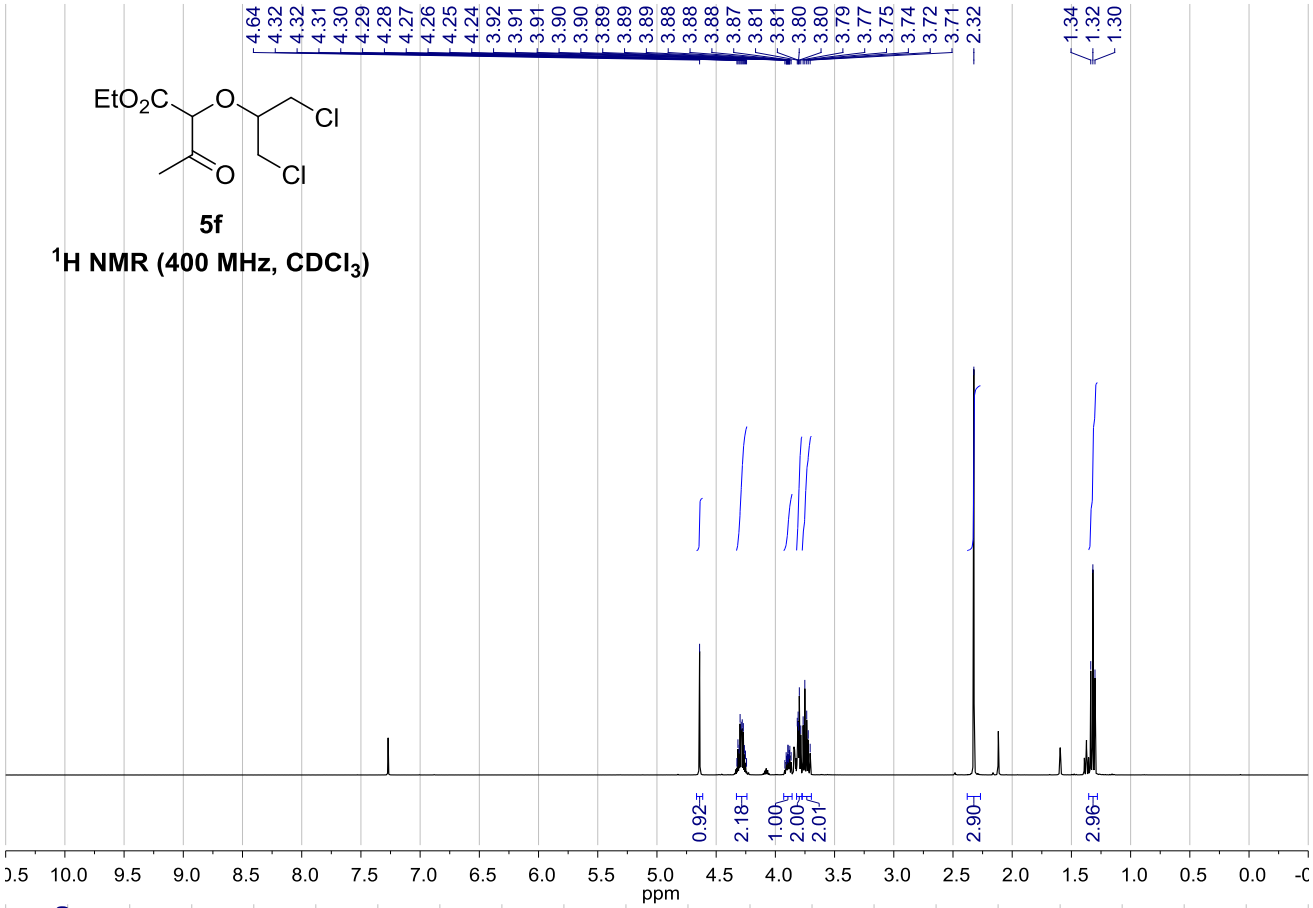
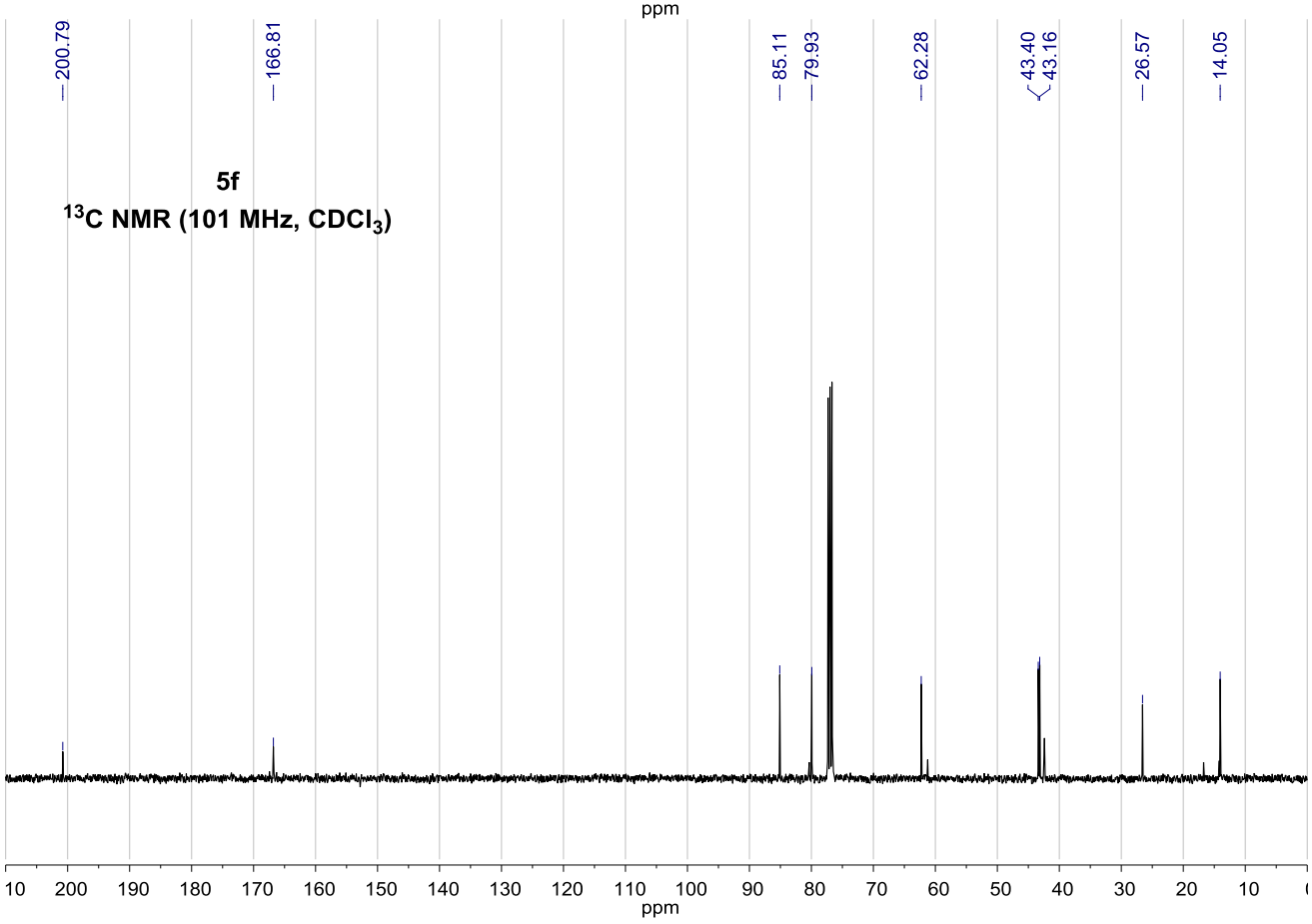
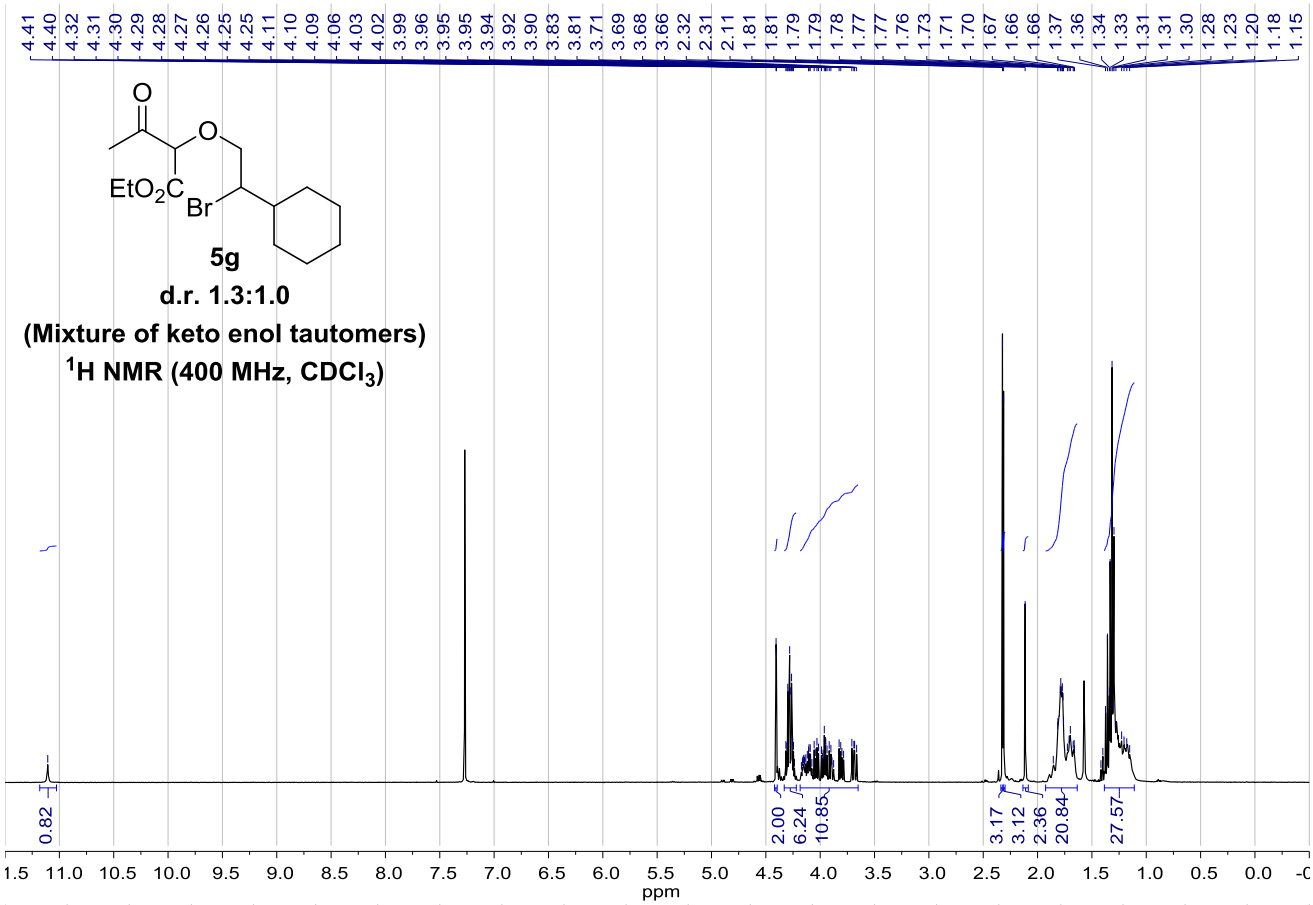
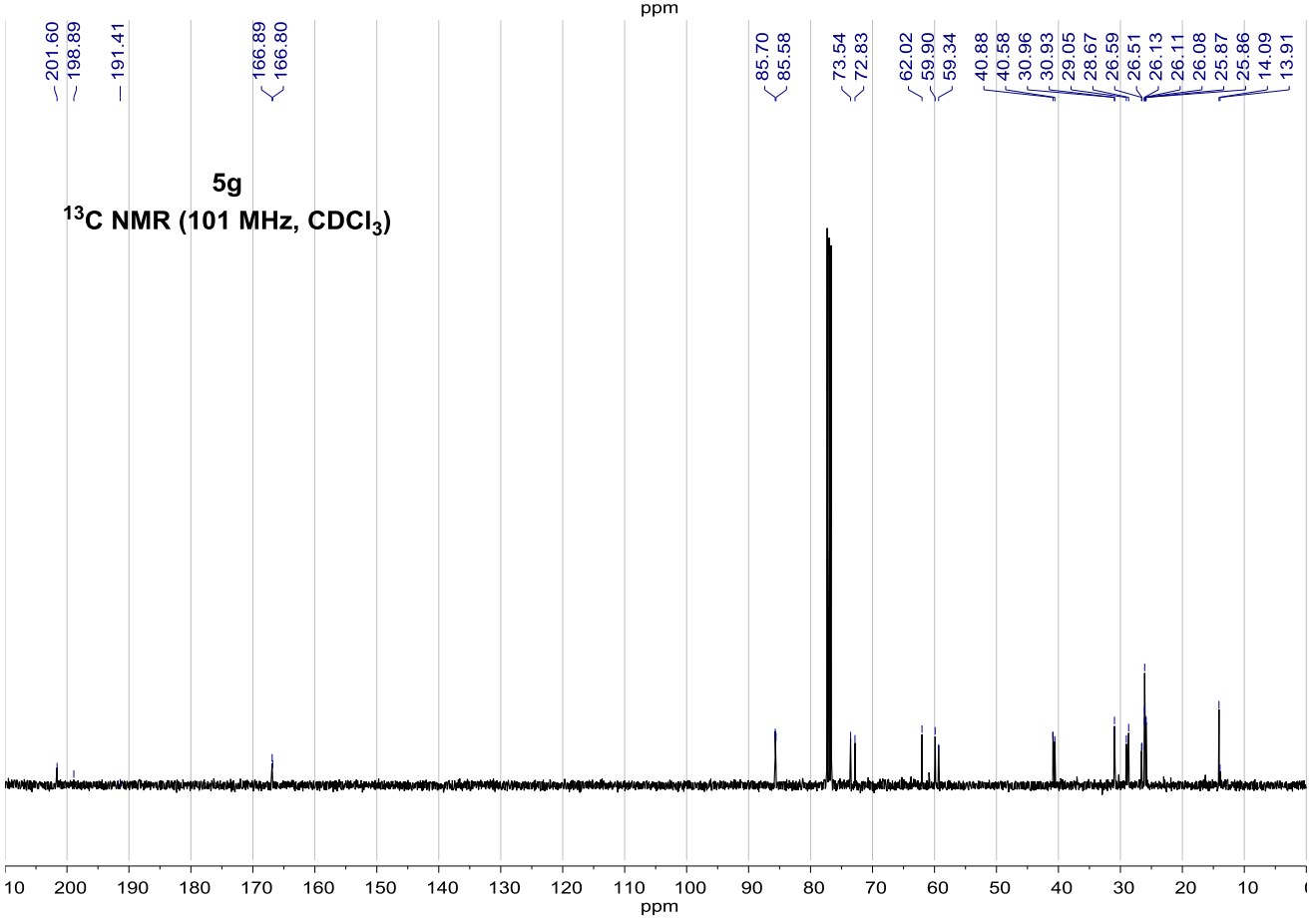

EtO2C
O
OTBS
O
Cl
5e
d.r. 1.1:1.0
1H NMR (400 MHz, CDCl3)
4.72
4.69
4.28
4.27
3.81
3.79
3.76
3.75
3.72
3.71
3.70
2.32
2.30
1.33
1.32
1.31
1.31
1.29
1.29
0.89
0.08
0.07
1.00
1.13
4.95
5.03
7.58
6.49
6.82
19.74
13.00
ppm

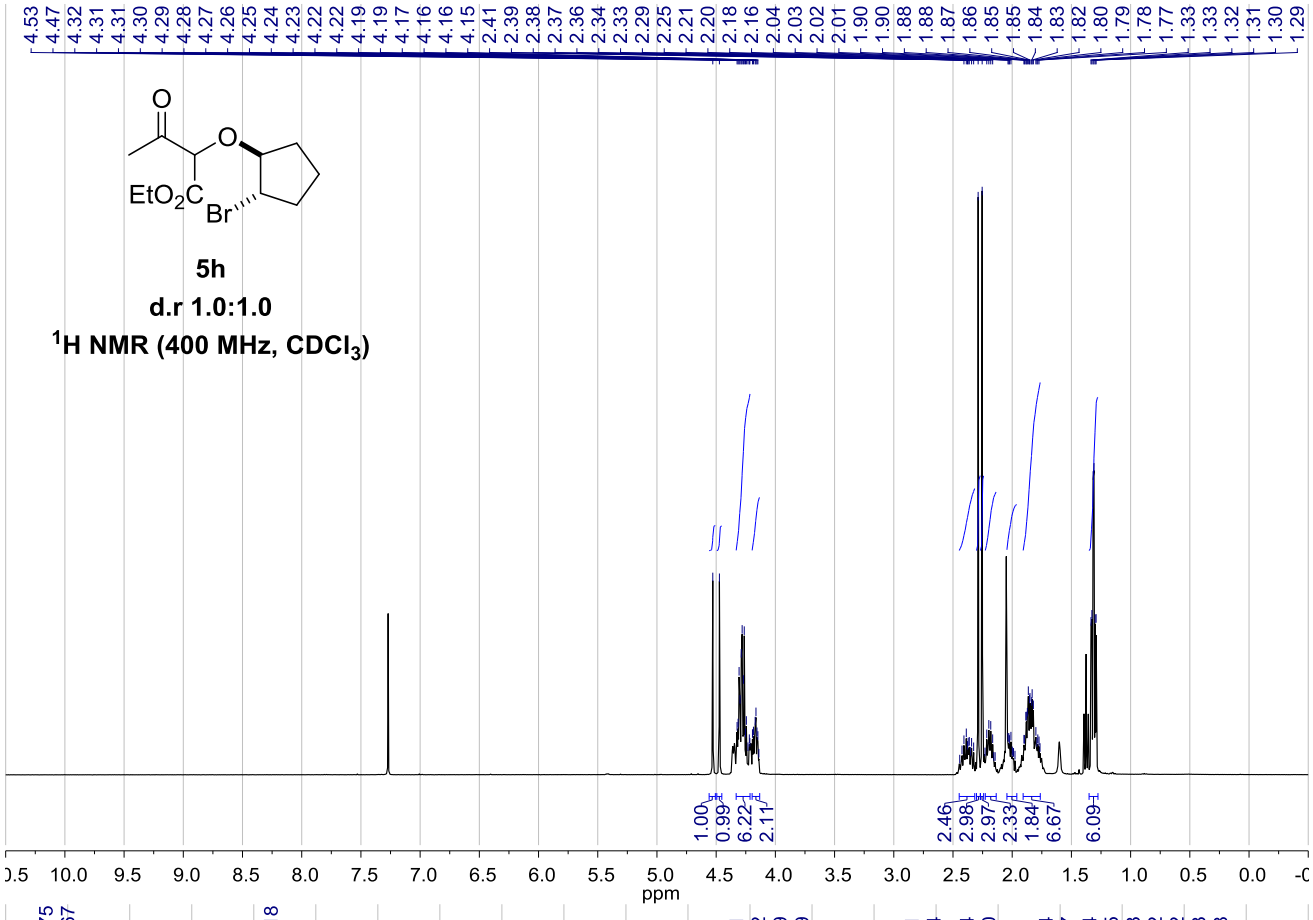

201.77
201.74
167.23
167.22
85.16
85.12
80.97
80.83
63.03
62.89
61.99
61.96
43.97
43.15
26.57
26.42
25.78
18.19
14.07
-5.52
-5.55
5e
13C NMR (101 MHz, CDCl3)
ppm

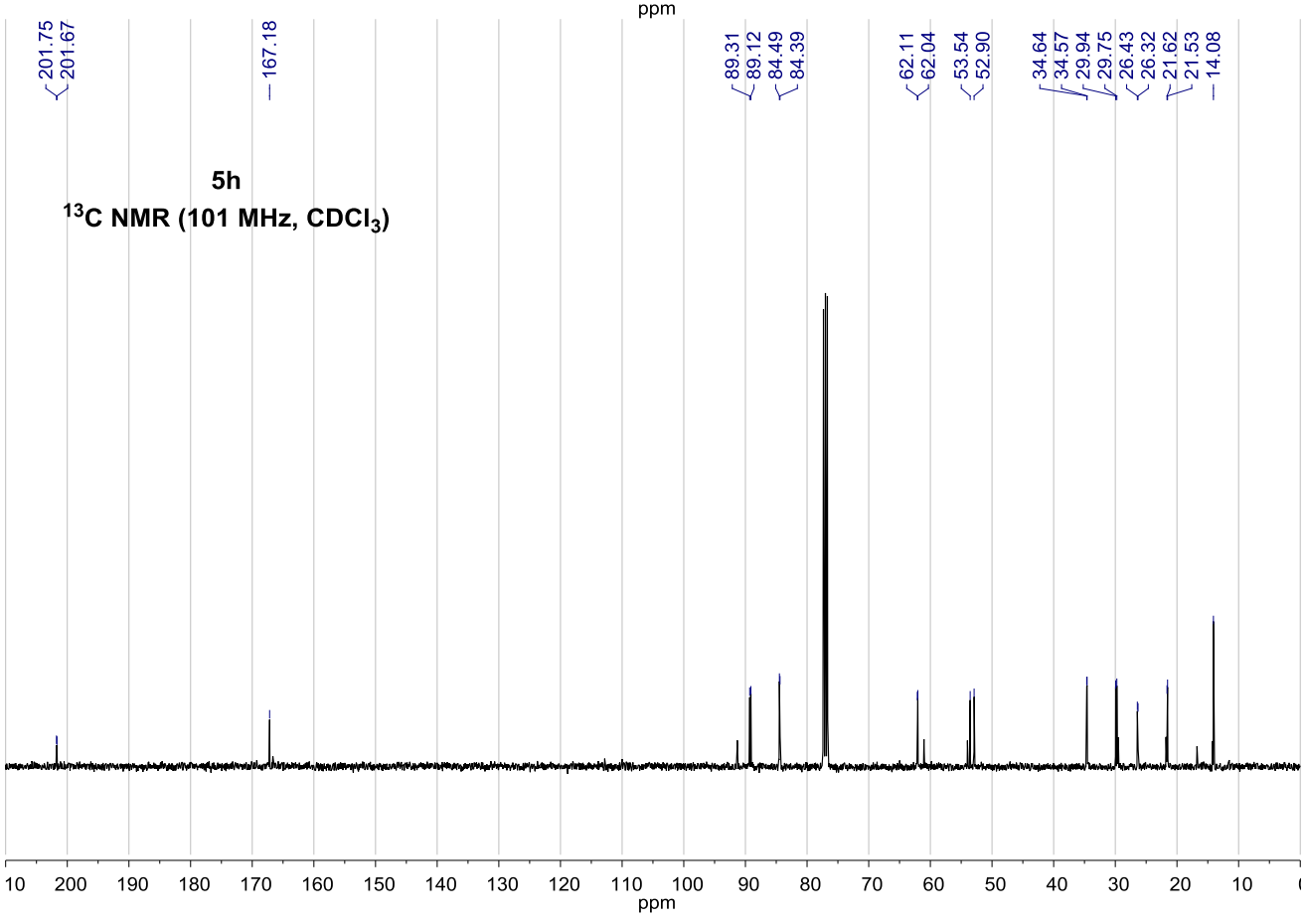

4.64 4.32 4.32 4.31 4.30 4.29 4.28 4.27 4.26 4.25 4.24 3.92 3.91 3.91 3.90 3.90 3.89 3.89 3.89 3.88 3.88 3.88 3.87 3.81 3.81 3.80 3.80 3.79 3.77 3.75 3.74 3.72 3.71 2.32 1.34 1.32 1.30
EtO2C O Cl O Cl
5f
1H NMR (400 MHz, CDCl3)
0.92 2.18 1.00 2.00 2.01 2.90 2.96
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
ppm

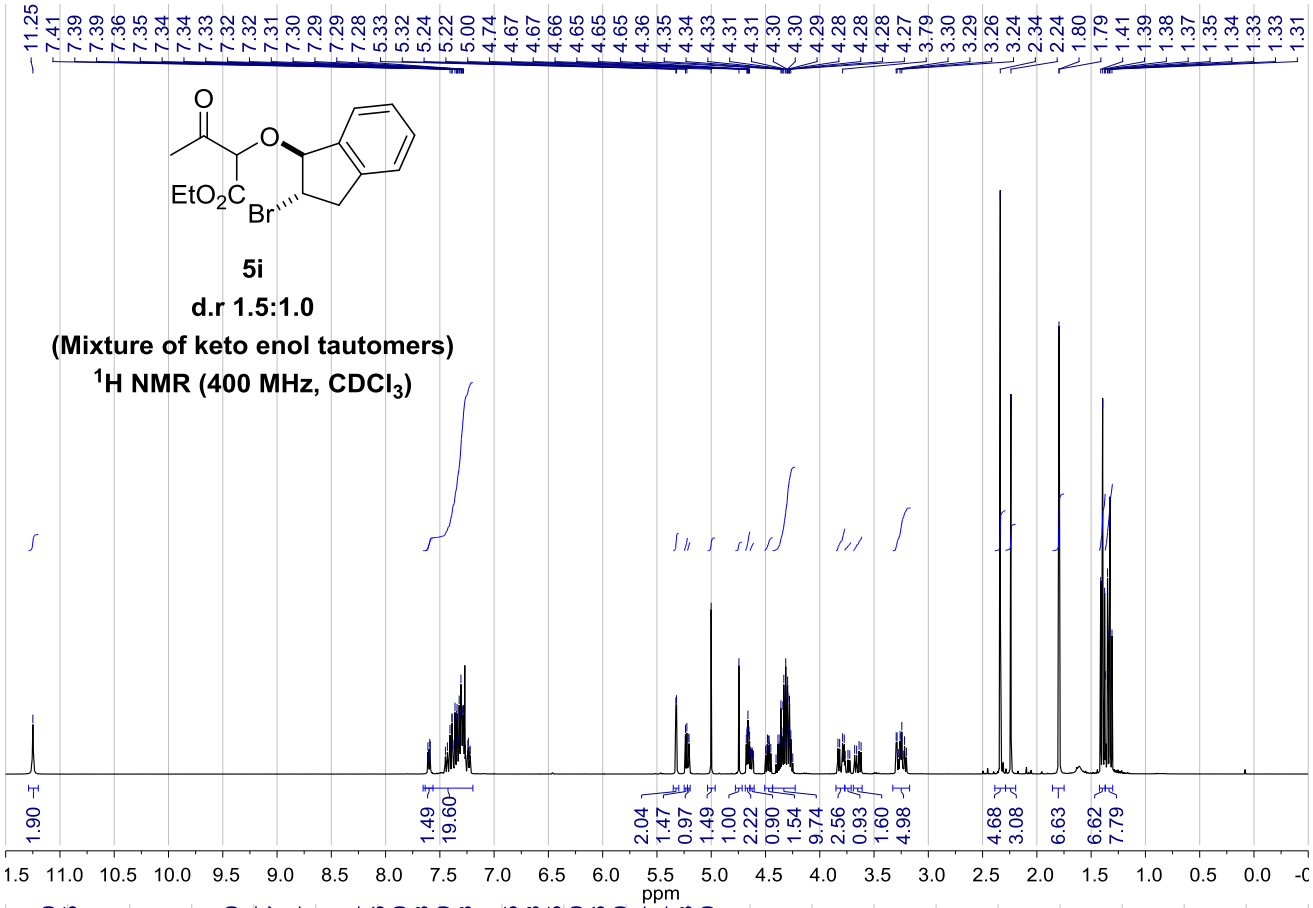

200.79 166.81 85.11 79.93 62.28 43.40 43.16 26.57 14.05
5f
13C NMR (101 MHz, CDCl3)
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10
ppm

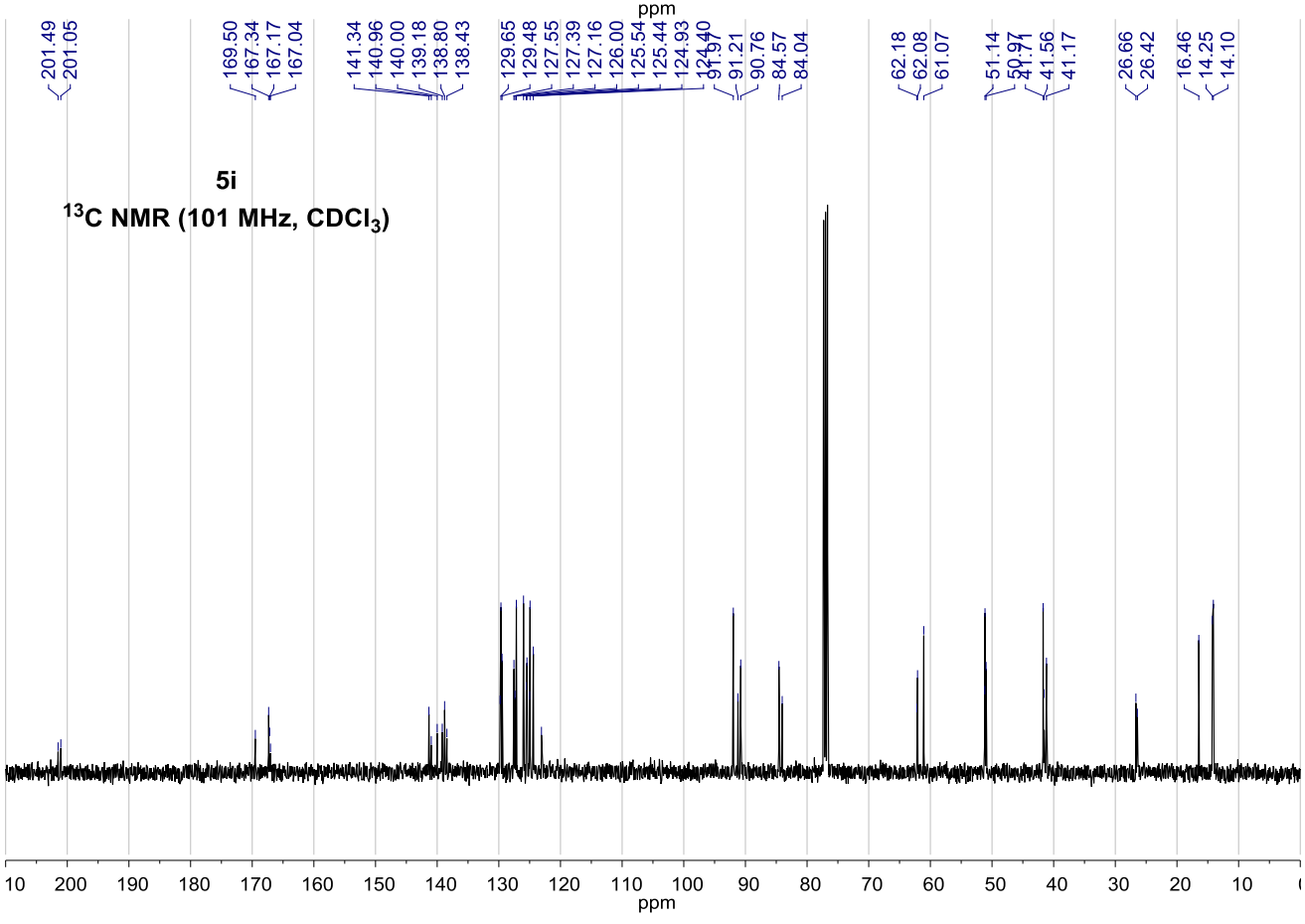

4.41 4.40 4.32 4.31 4.30 4.29 4.28 4.27 4.26 4.25 4.25 4.11 4.10 4.09 4.06 4.03 4.02 3.99 3.96 3.95 3.95 3.94 3.92 3.90 3.83 3.81 3.71 3.69 3.68 3.66 2.32 2.31 2.11 1.81 1.81 1.79 1.79 1.78 1.77 1.77 1.76 1.73 1.71 1.70 1.67 1.66 1.66 1.37 1.36 1.34 1.33 1.31 1.31 1.30 1.28 1.23 1.20 1.18 1.15
O
O
EtO2C
Br
5g
d.r. 1.3:1.0
(Mixture of keto enol tautomers)
1H NMR (400 MHz, CDCl3)
0.82
2.00
6.24
10.85
3.17
3.12
2.36
20.84
27.57
1.5 11.0 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
ppm

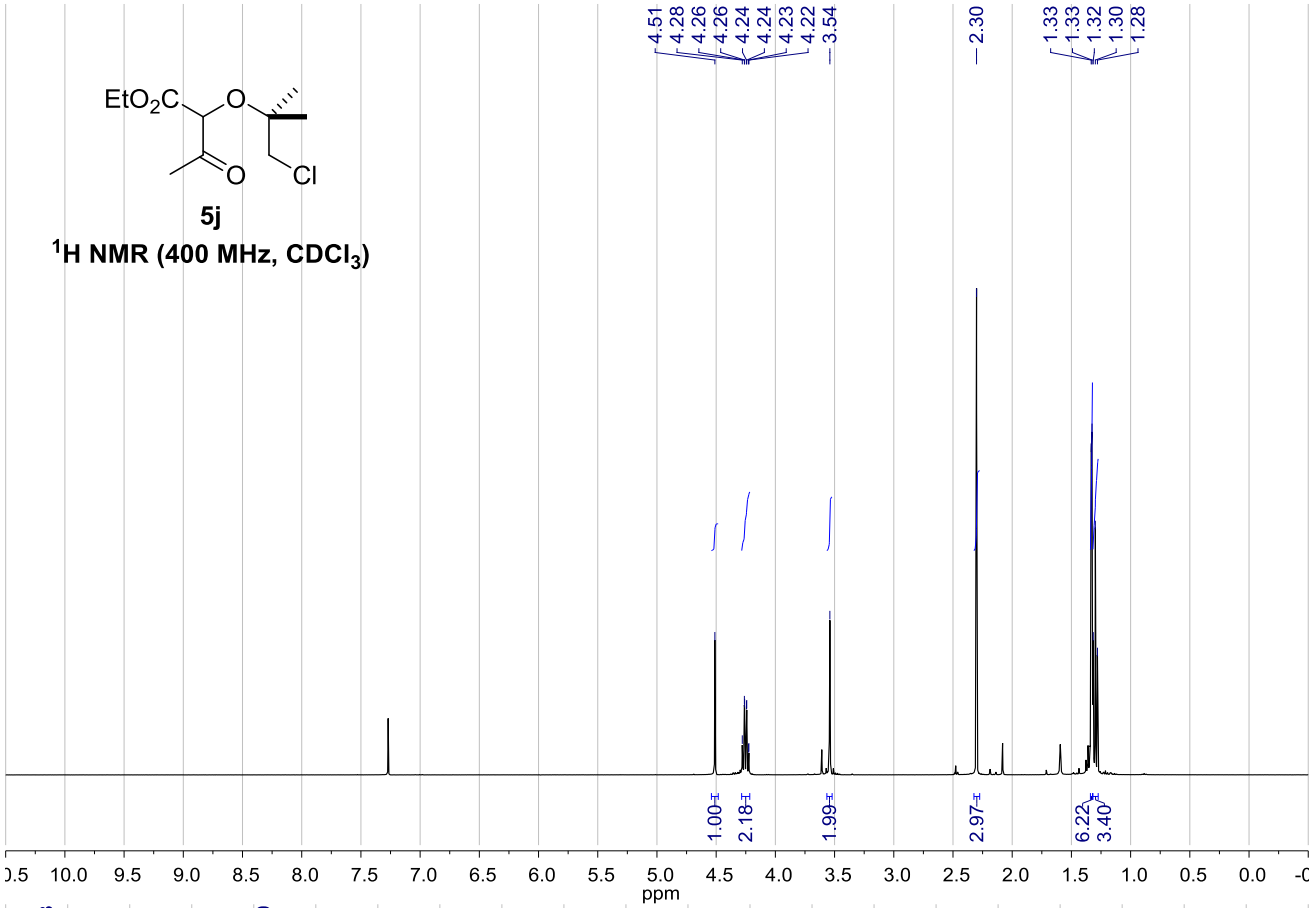

201.60
198.89
191.41
166.89
166.80
85.70
85.58
73.54
72.83
62.02
59.90
59.34
40.88
40.58
30.96
30.93
29.05
28.67
26.59
26.51
26.13
26.11
26.08
25.87
25.86
14.09
13.91
5g
13C NMR (101 MHz, CDCl3)
10 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10
ppm

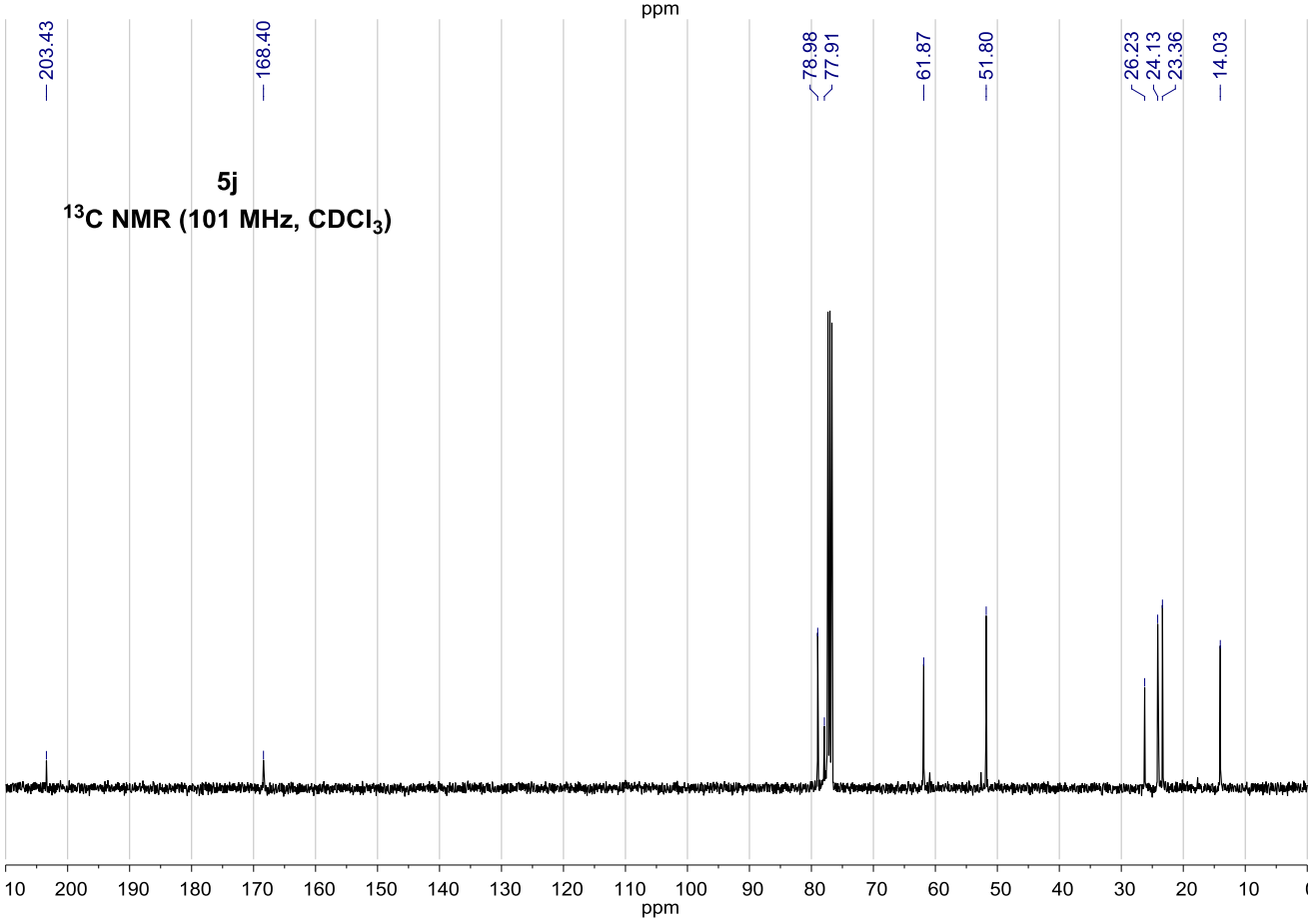

4.53 4.47 4.32 4.31 4.31 4.30 4.29 4.28 4.27 4.26 4.25 4.24 4.23 4.22 4.22 4.19 4.19 4.17 4.16 4.16 4.15 2.41 2.39 2.38 2.37 2.36 2.34 2.33 2.29 2.25 2.21 2.20 2.18 2.16 2.04 2.03 2.02 2.01 1.90 1.90 1.88 1.88 1.87 1.86 1.85 1.85 1.84 1.83 1.82 1.80 1.79 1.78 1.77 1.33 1.33 1.32 1.31 1.30 1.29
O
O
EtO2C
Br
5h
d.r 1.0:1.0
1H NMR (400 MHz, CDCl3)
1.00 0.99 6.22 2.11 2.46 2.98 2.97 2.33 1.84 6.67 6.09
ppm

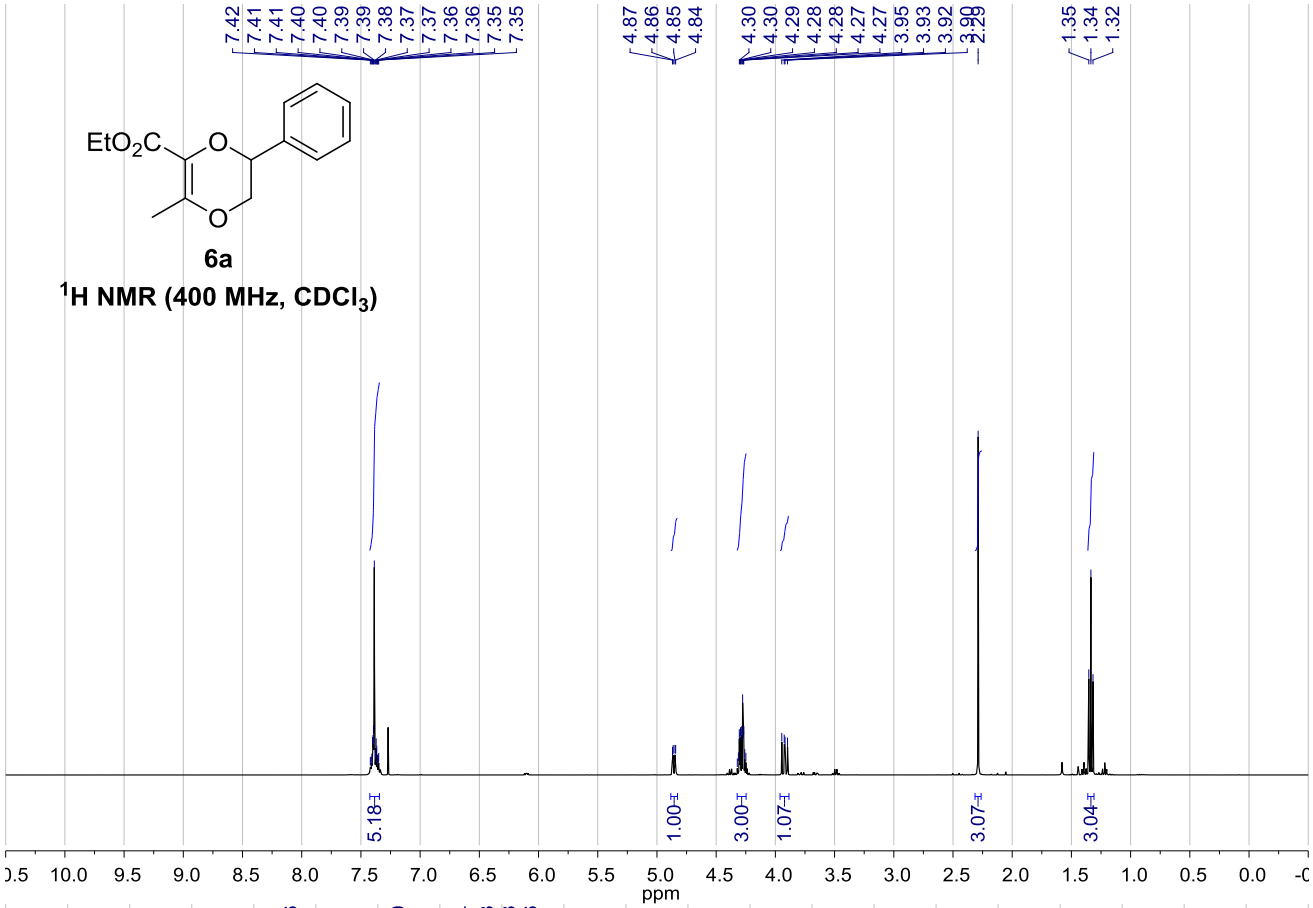

201.75 201.67 167.18 89.31 89.12 84.49 84.39 62.11 62.04 53.54 52.90 34.64 34.57 29.94 29.75 26.43 26.32 21.62 21.53 14.08
5h
13C NMR (101 MHz, CDCl3)
ppm

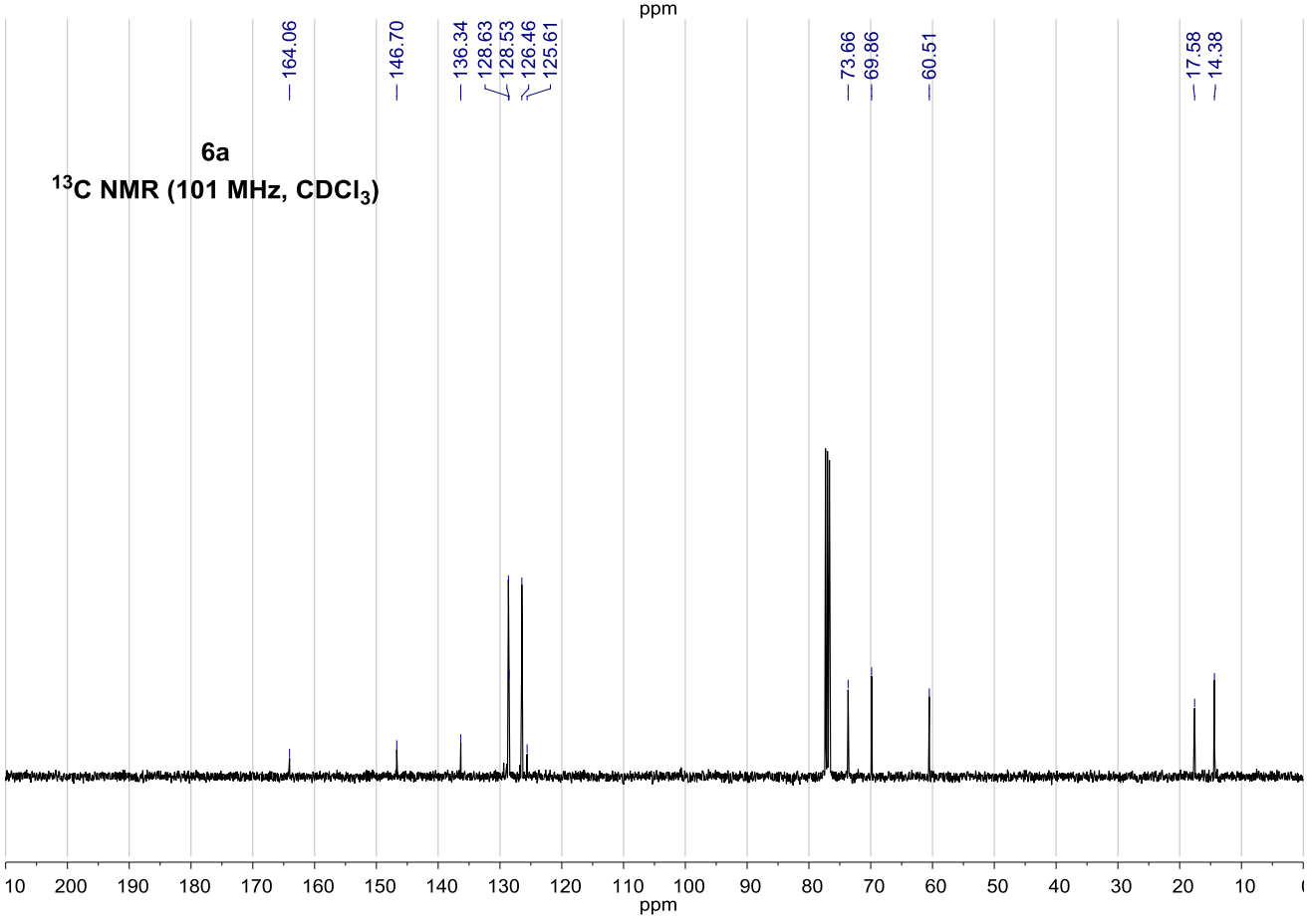

O
O
EtO2C
Br
5i
d.r 1.5:1.0
(Mixture of keto enol tautomers)
1H NMR (400 MHz, CDCl3)
ppm

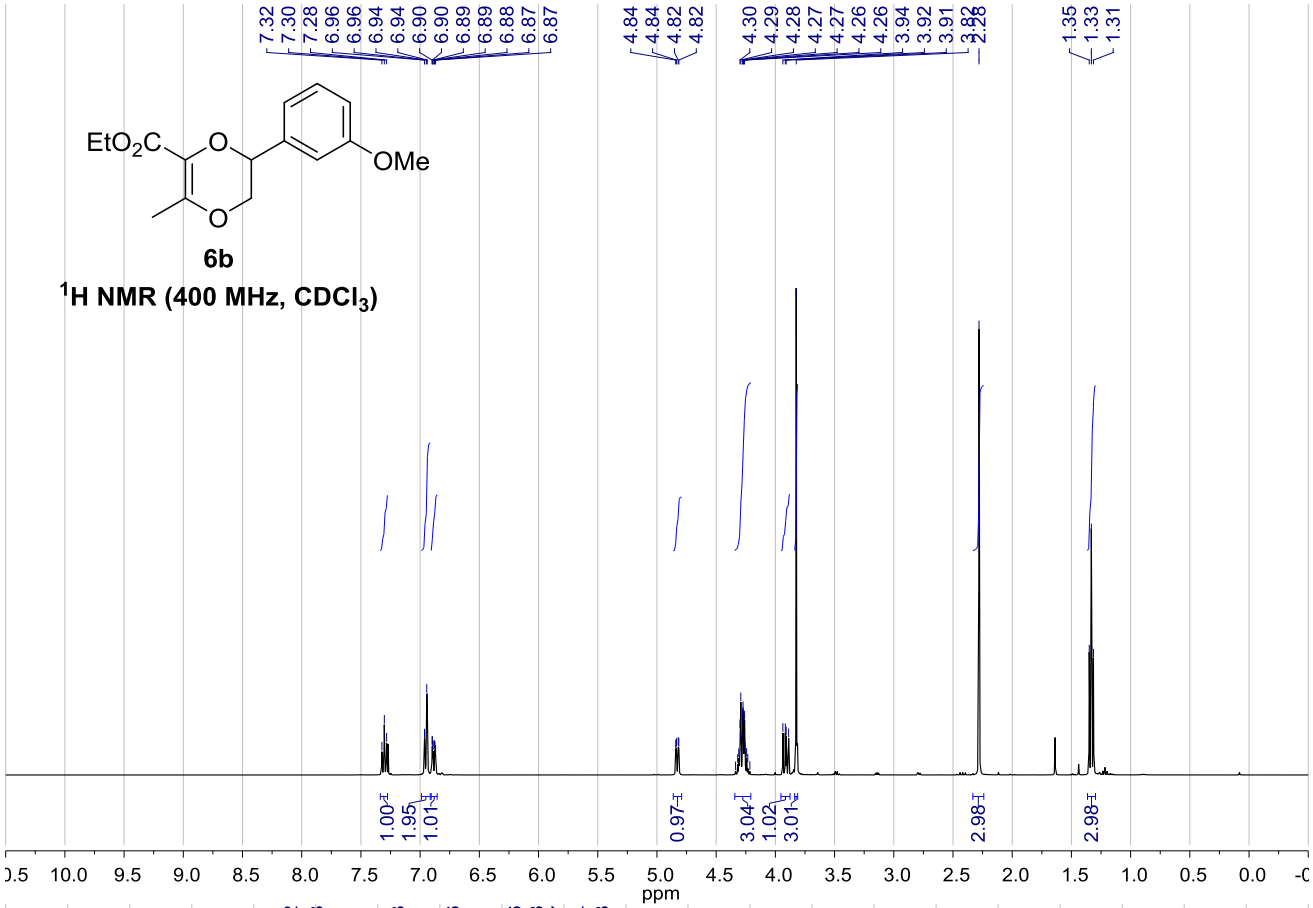

5i
13C NMR (101 MHz, CDCl3)
ppm

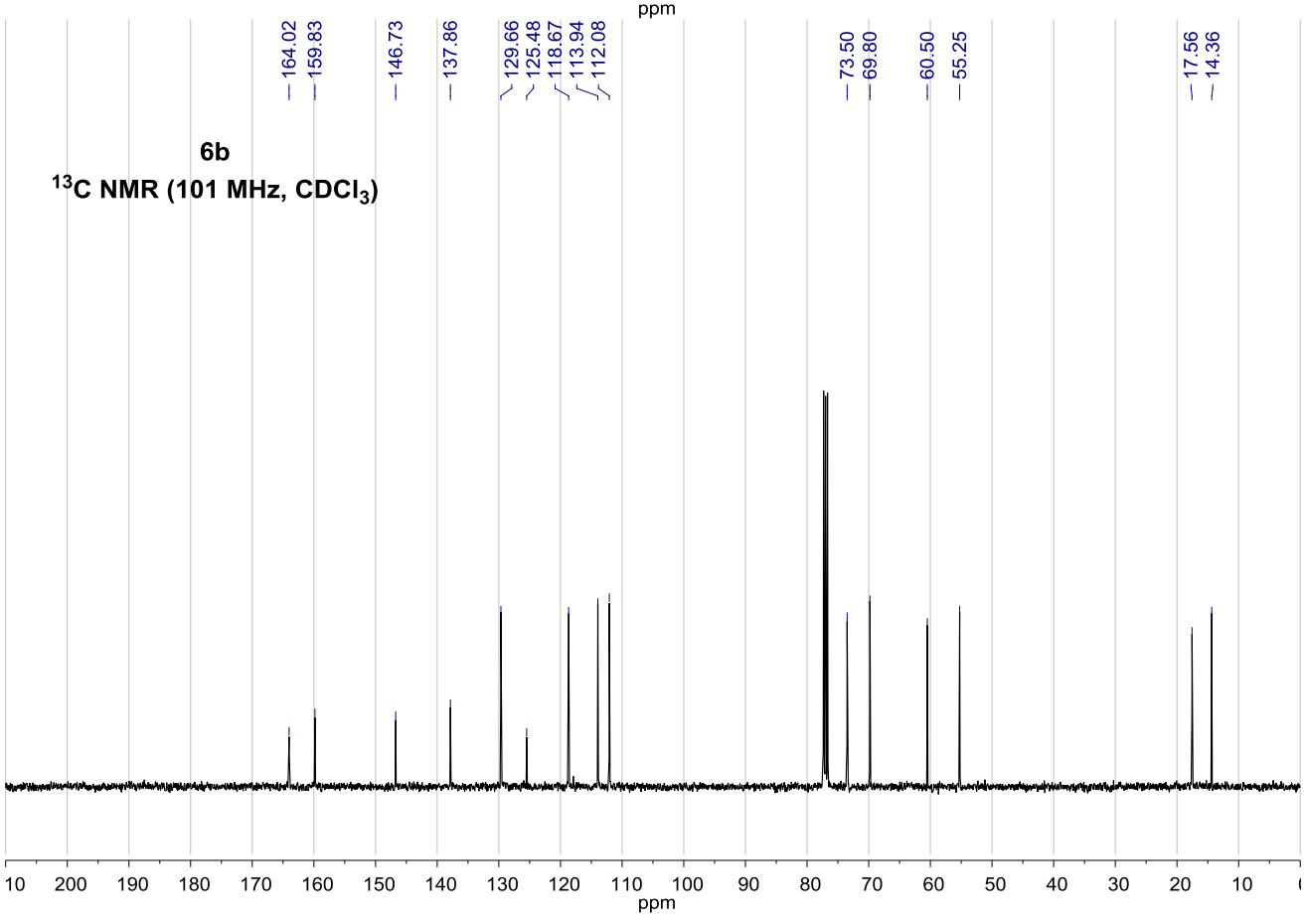

EtO2C
O
O
Cl
5j
1H NMR (400 MHz, CDCl3)
4.51
4.28
4.26
4.26
4.24
4.24
4.23
4.22
3.54
2.30
1.33
1.33
1.32
1.30
1.28
1.00
2.18
1.99
2.97
6.22
3.40
ppm

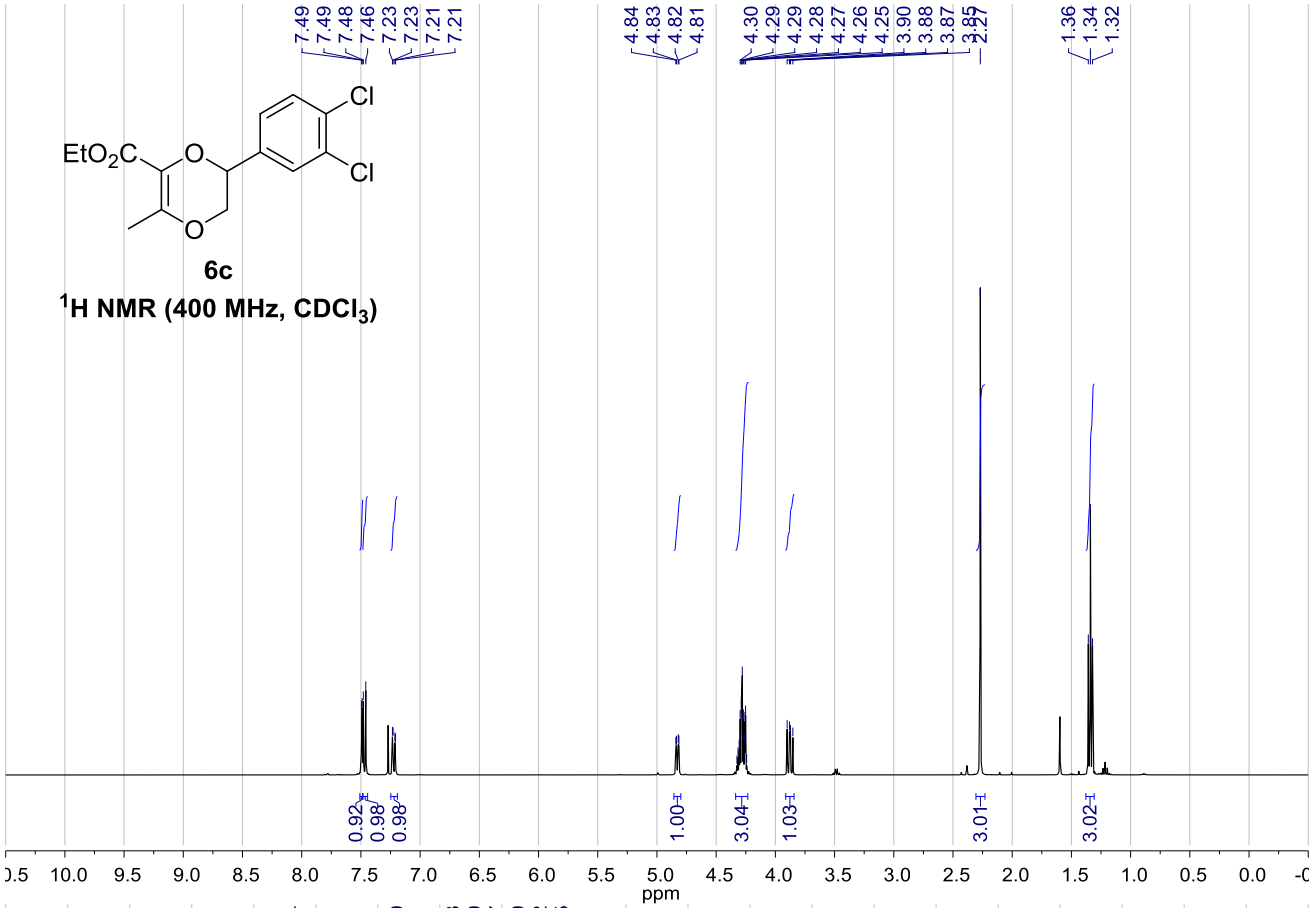

203.43
168.40
78.98
77.91
61.87
51.80
26.23
24.13
23.36
14.03
5j
13C NMR (101 MHz, CDCl3)
ppm

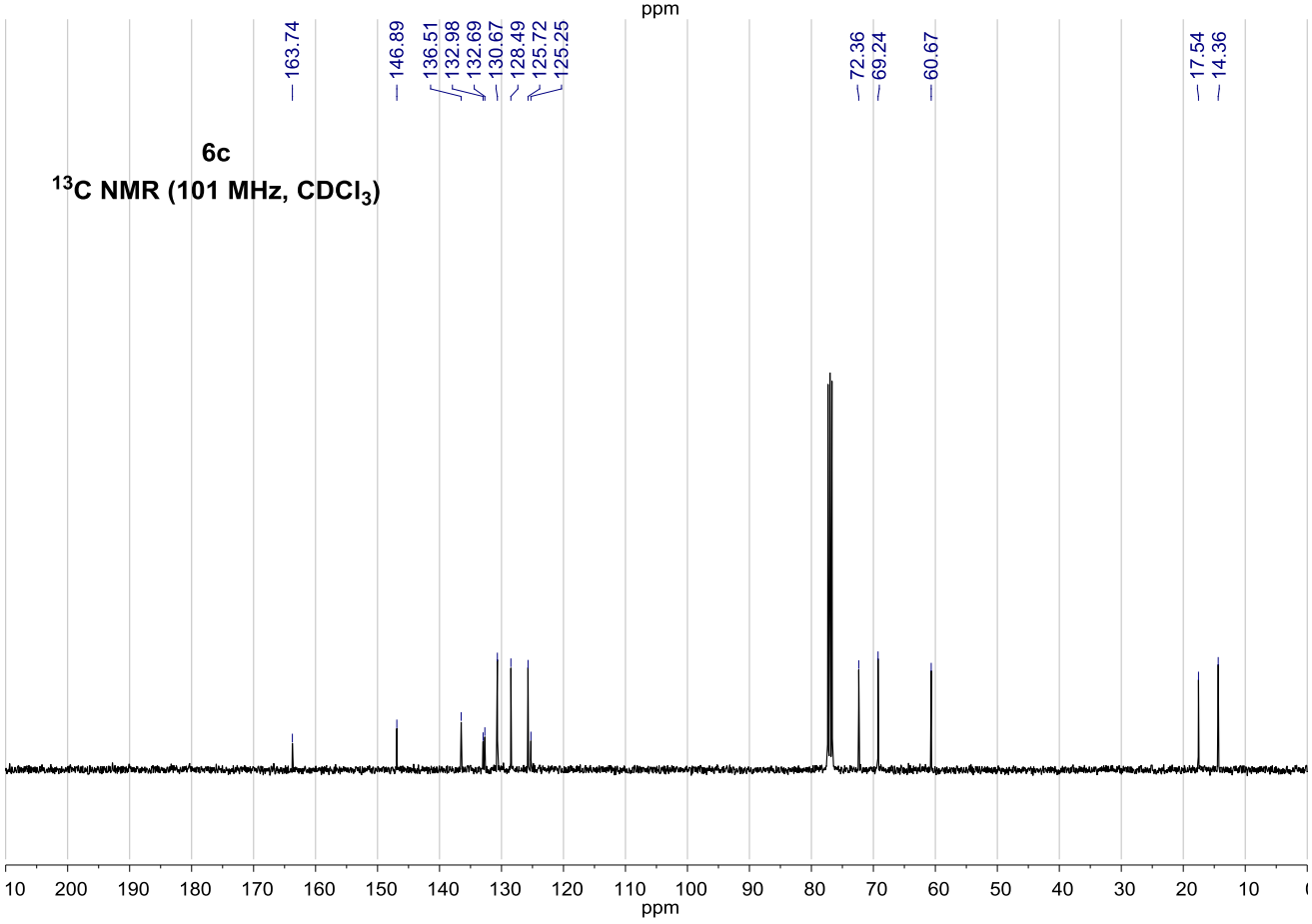

7.42
7.41
7.41
7.40
7.40
7.39
7.39
7.38
7.37
7.37
7.36
7.36
7.35
7.35
4.87
4.86
4.85
4.84
4.30
4.30
4.29
4.28
4.28
4.27
4.27
3.95
3.93
3.92
3.90
2.29
1.35
1.34
1.32
EtO2C
O
O
6a
1H NMR (400 MHz, CDCl3)
5.18
1.00
3.00
1.07
3.07
3.04
ppm

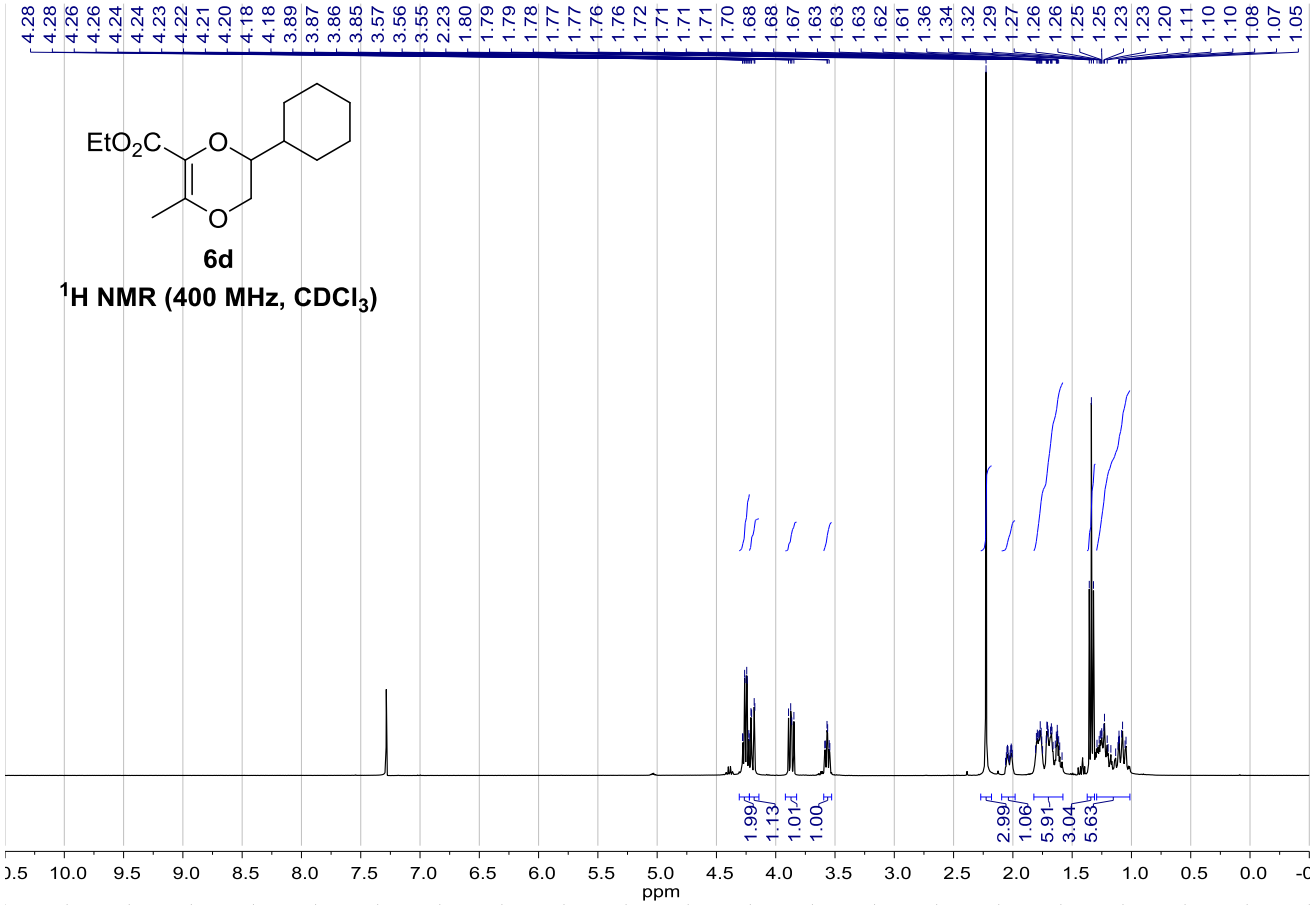

164.06
146.70
136.34
128.63
128.53
126.46
125.61
73.66
69.86
60.51
17.58
14.38
6a
13C NMR (101 MHz, CDCl3)
ppm

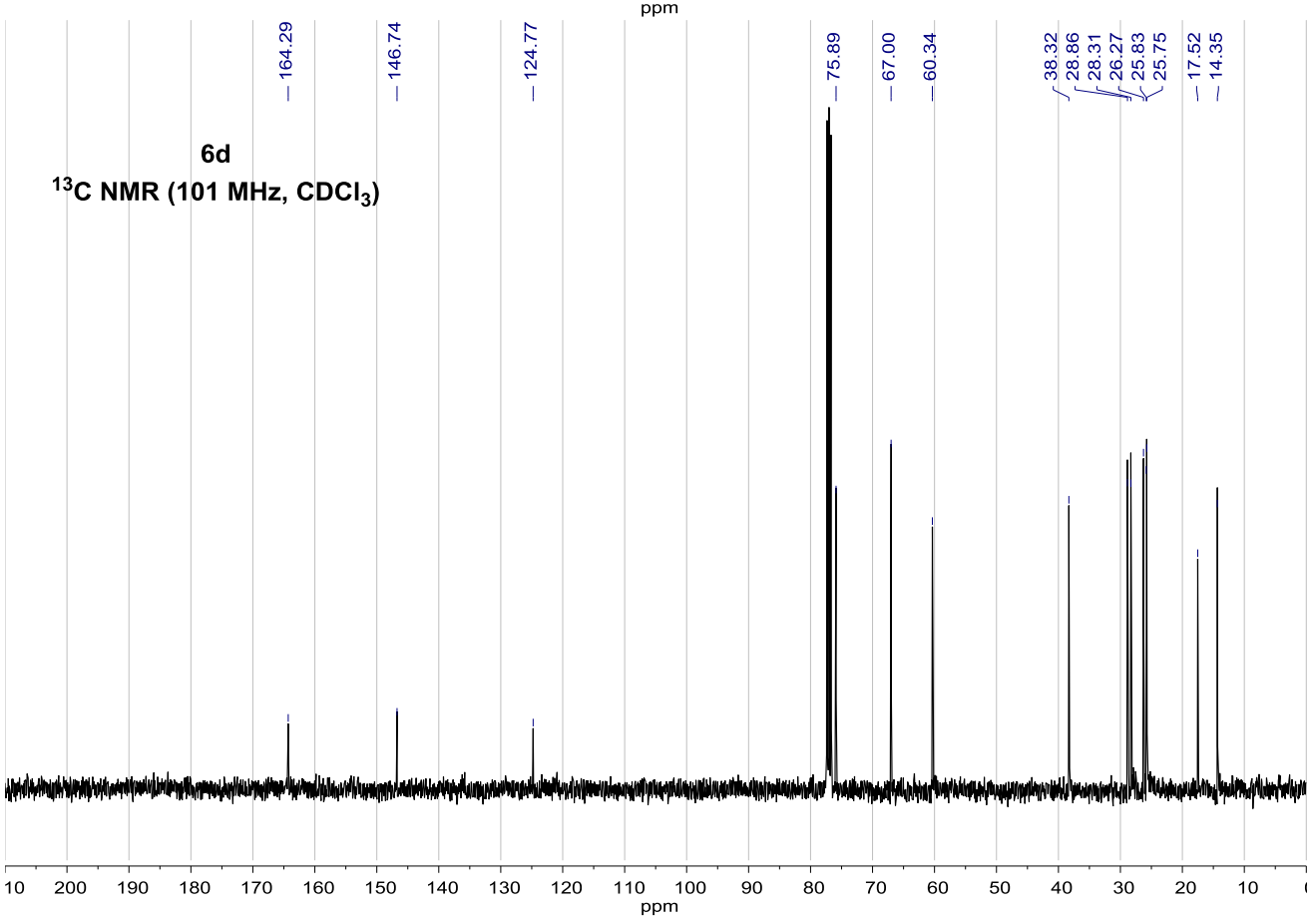

7.32
7.30
7.28
6.96
6.96
6.94
6.94
6.90
6.90
6.89
6.89
6.88
6.87
6.87
4.84
4.84
4.82
4.82
4.30
4.29
4.28
4.27
4.27
4.26
4.26
3.94
3.92
3.91
2.28
1.35
1.33
1.31
EtO2C
O
O
O
OMe
6b
1H NMR (400 MHz, CDCl3)
1.00
1.95
1.01
0.97
3.04
1.02
3.01
2.98
2.98
ppm

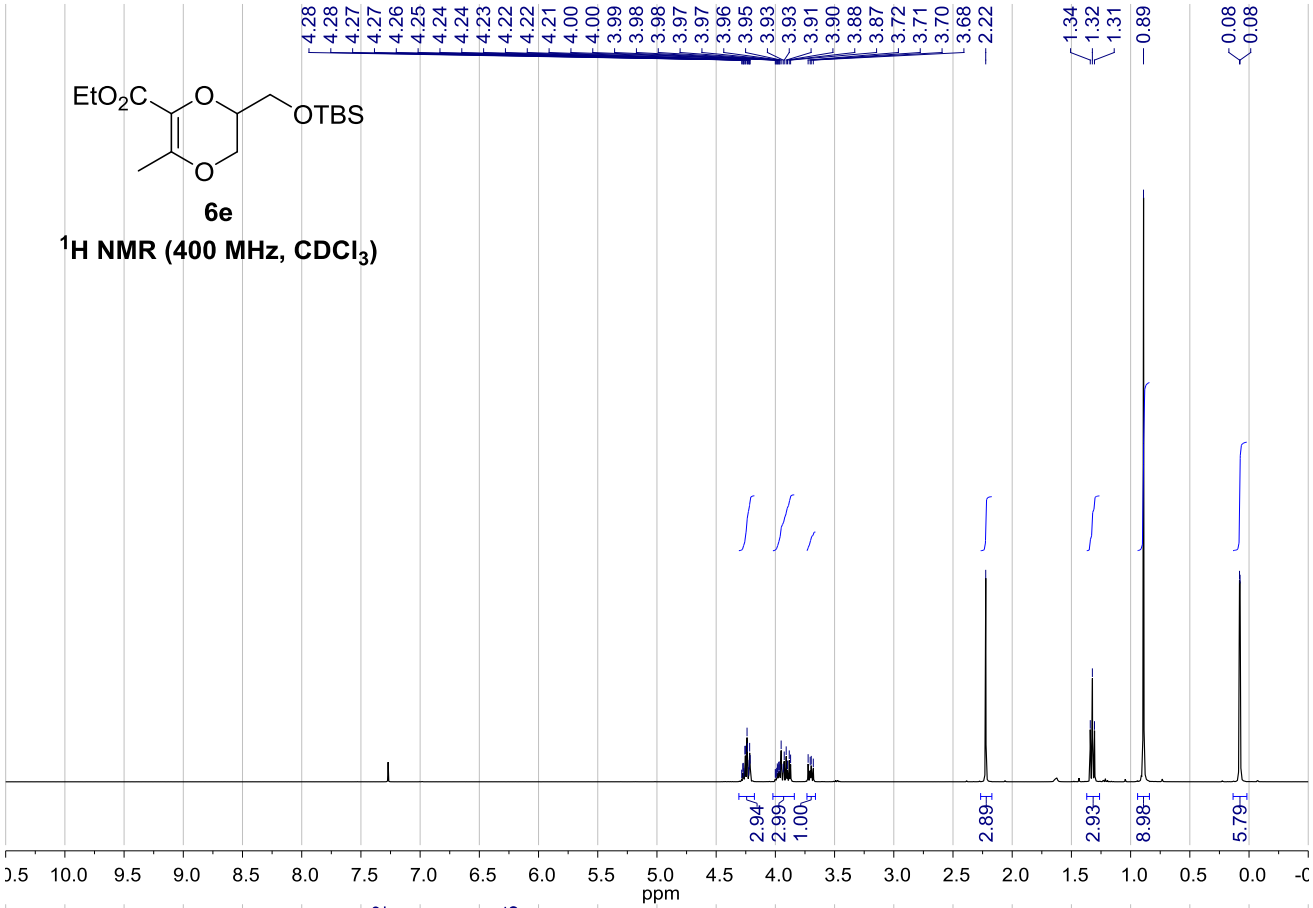

164.02
159.83
146.73
137.86
129.66
125.48
118.67
113.94
112.08
73.50
69.80
60.50
55.25
17.56
14.36
6b
13C NMR (101 MHz, CDCl3)
ppm

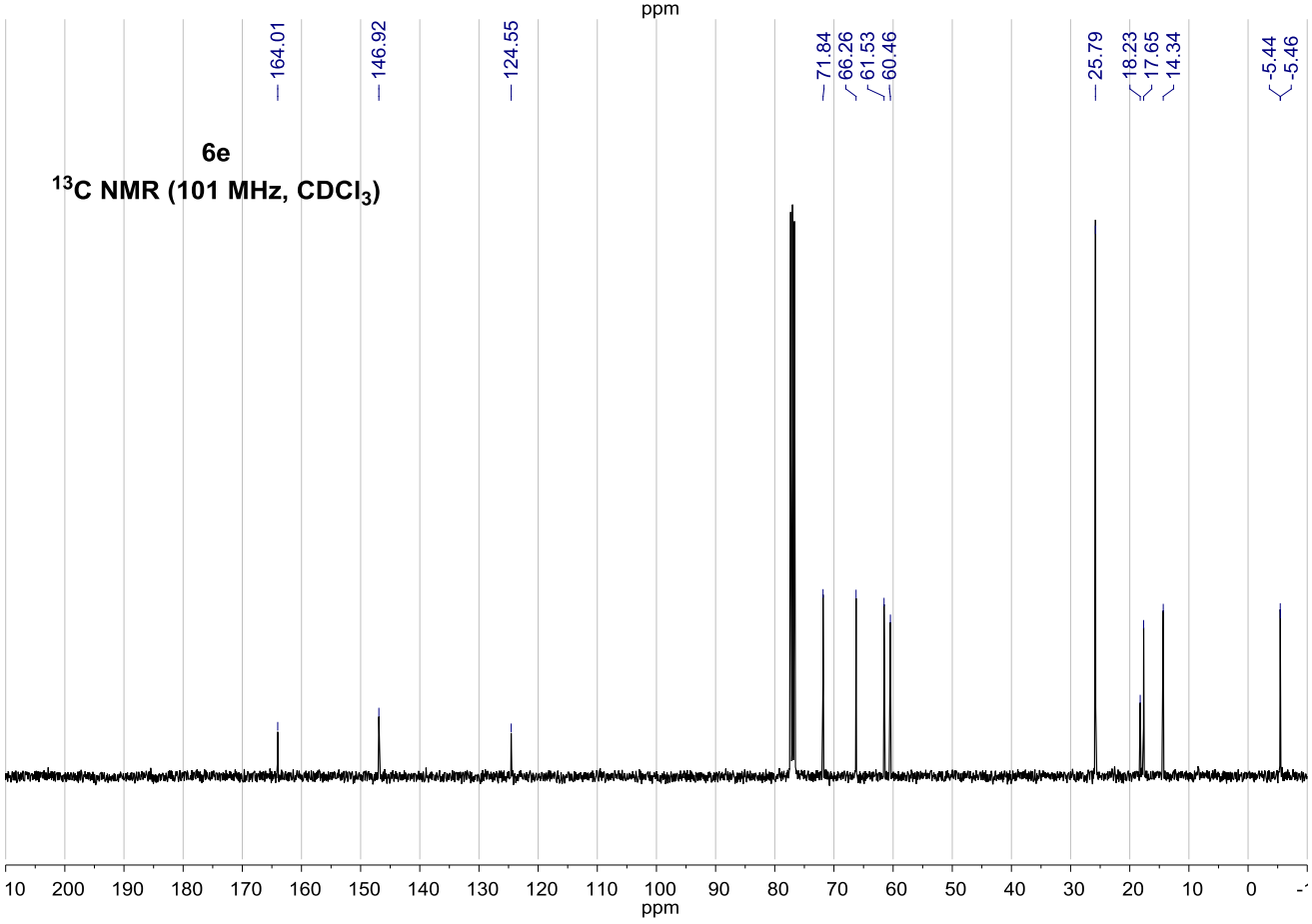

7.49
7.49
7.48
7.46
7.23
7.23
7.21
7.21
4.84
4.83
4.82
4.81
4.30
4.29
4.29
4.28
4.27
4.26
4.25
3.90
3.88
3.87
3.85
2.27
1.36
1.34
1.32
Cl
Cl
EtO2C
O
O
6c
1H NMR (400 MHz, CDCl3)
0.92
0.98
0.98
1.00
3.04
1.03
3.01
3.02
ppm

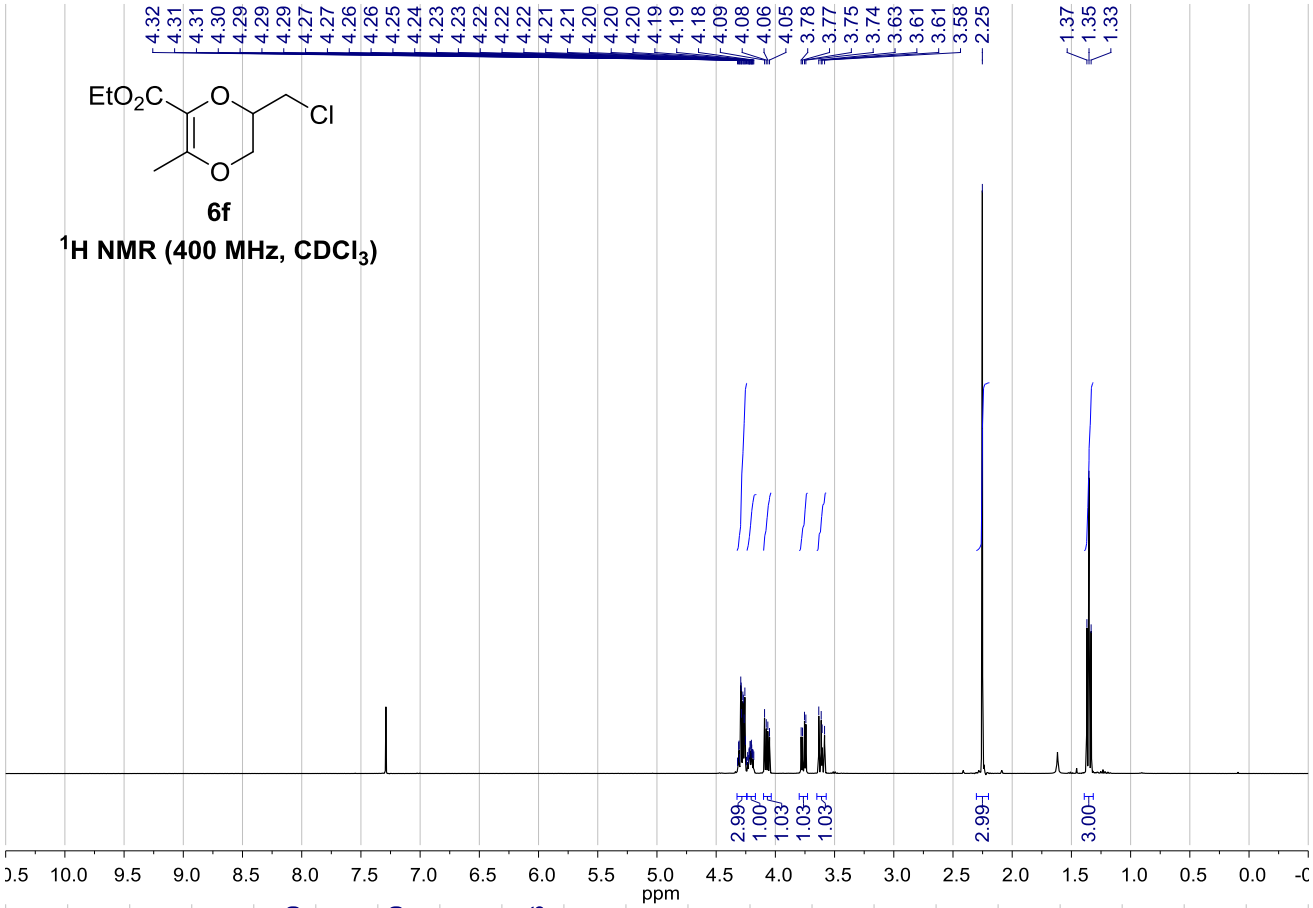

163.74
146.89
136.51
132.98
132.69
130.67
128.49
125.72
125.25
72.36
69.24
60.67
17.54
14.36
6c
13C NMR (101 MHz, CDCl3)
ppm

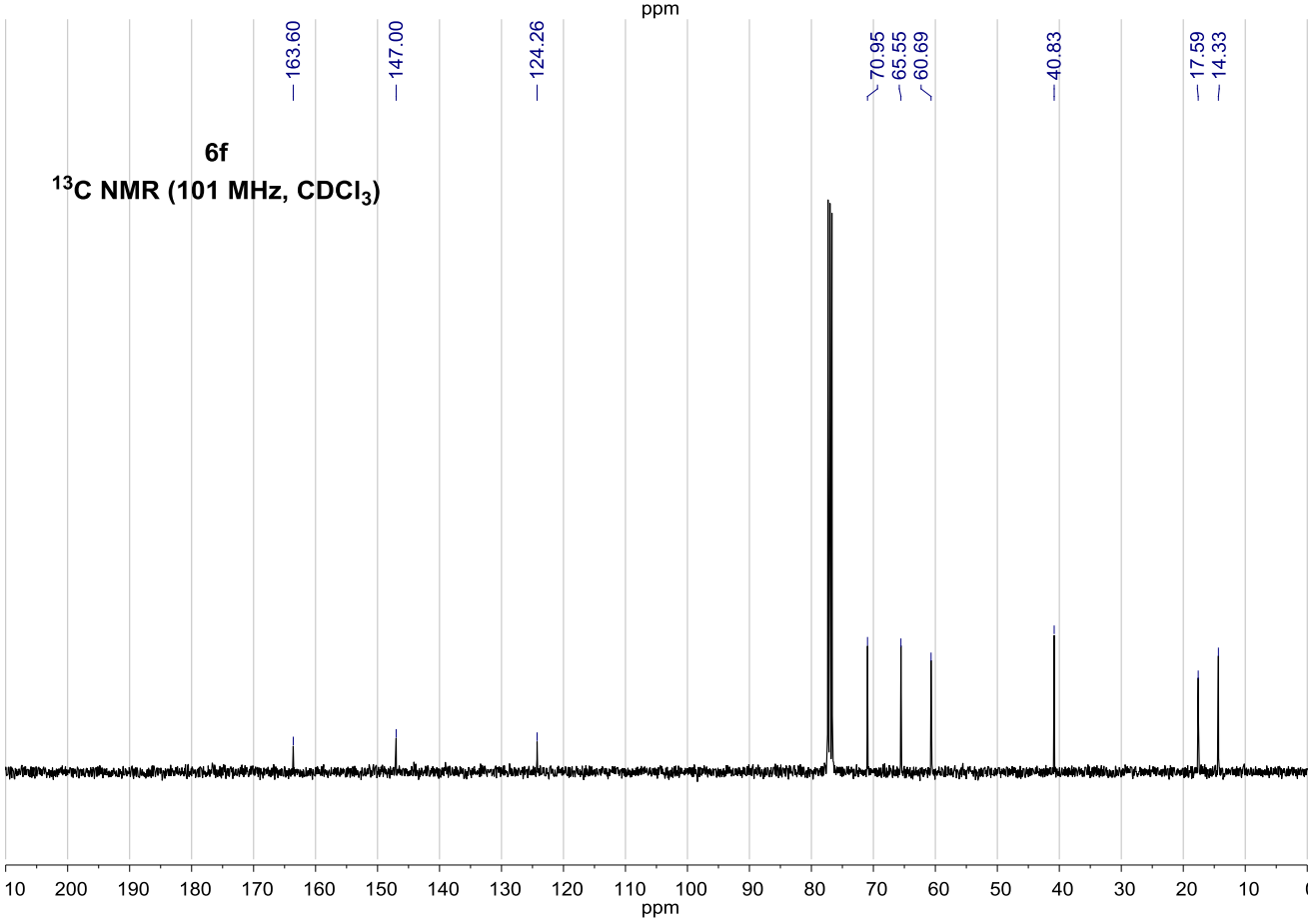

EtO2C
O
O
6d
1H NMR (400 MHz, CDCl3)
ppm

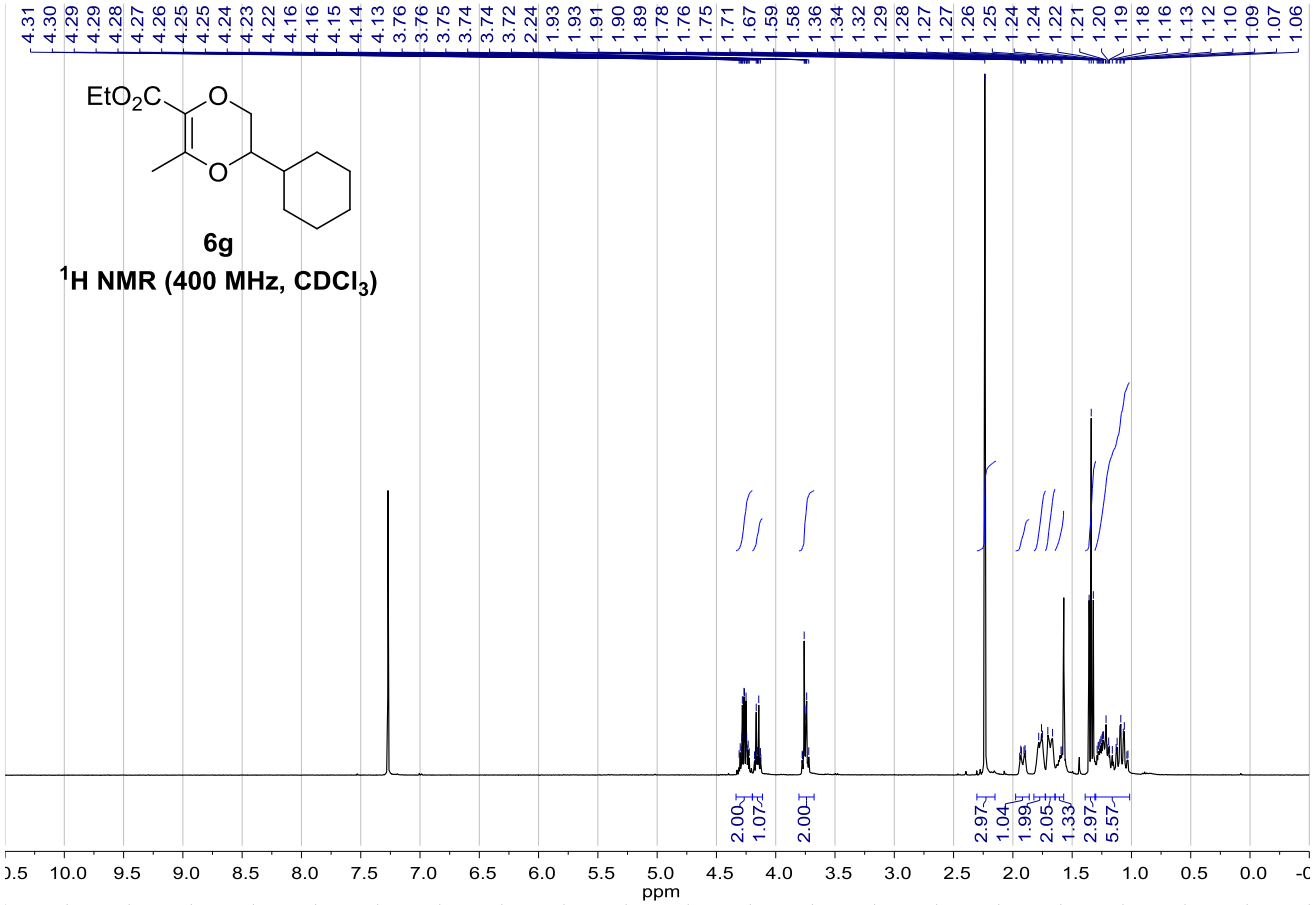

164.29
146.74
124.77
75.89
67.00
60.34
38.32
28.86
28.31
26.27
25.83
25.75
17.52
14.35
6d
13C NMR (101 MHz, CDCl3)
ppm

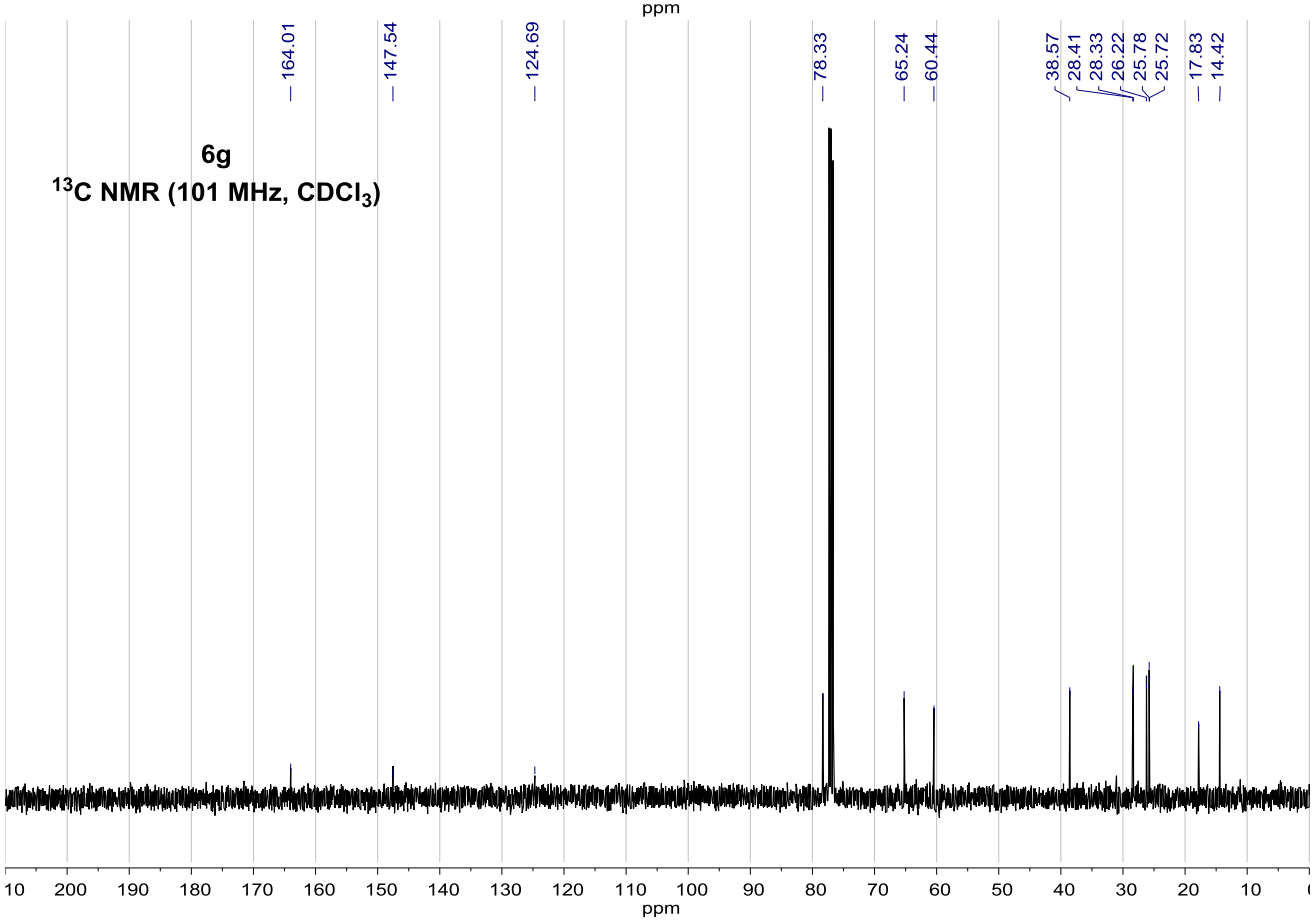

EtO2C
O
OTBS
O
6e
1H NMR (400 MHz, CDCl3)
4.28 4.28 4.27 4.27 4.26 4.25 4.24 4.24 4.23 4.22 4.22 4.21 4.00 4.00 3.99 3.98 3.98 3.97 3.97 3.96 3.95 3.93 3.93 3.91 3.90 3.88 3.87 3.72 3.71 3.70 3.68 2.22 1.34 1.32 1.31 0.89 0.08 0.08
2.94 2.99 1.00 2.89 2.93 8.98 5.79
ppm

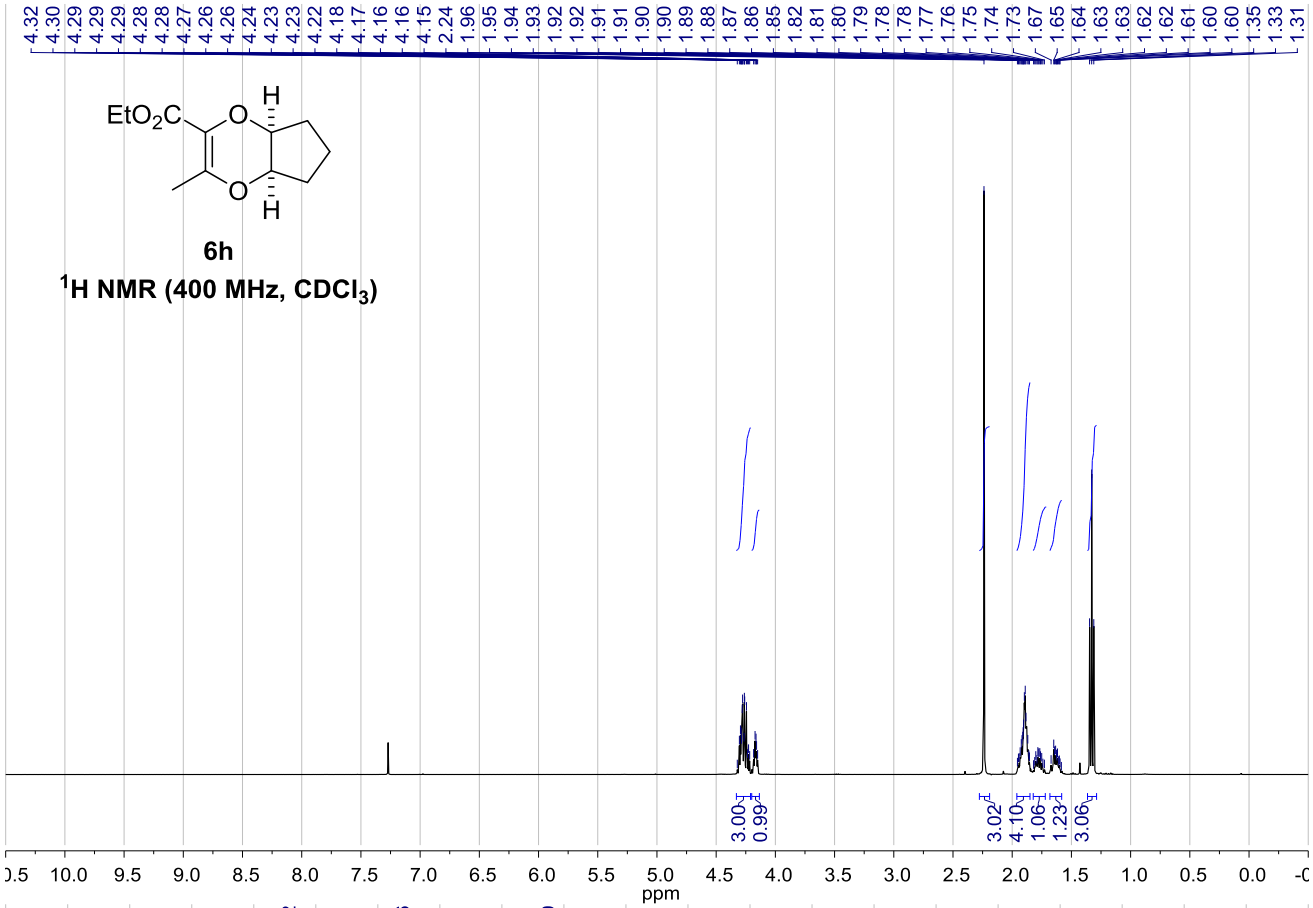

6e
13C NMR (101 MHz, CDCl3)
164.01 146.92 124.55 71.84 66.26 61.53 60.46 25.79 18.23 17.65 14.34 -5.44 -5.46
ppm

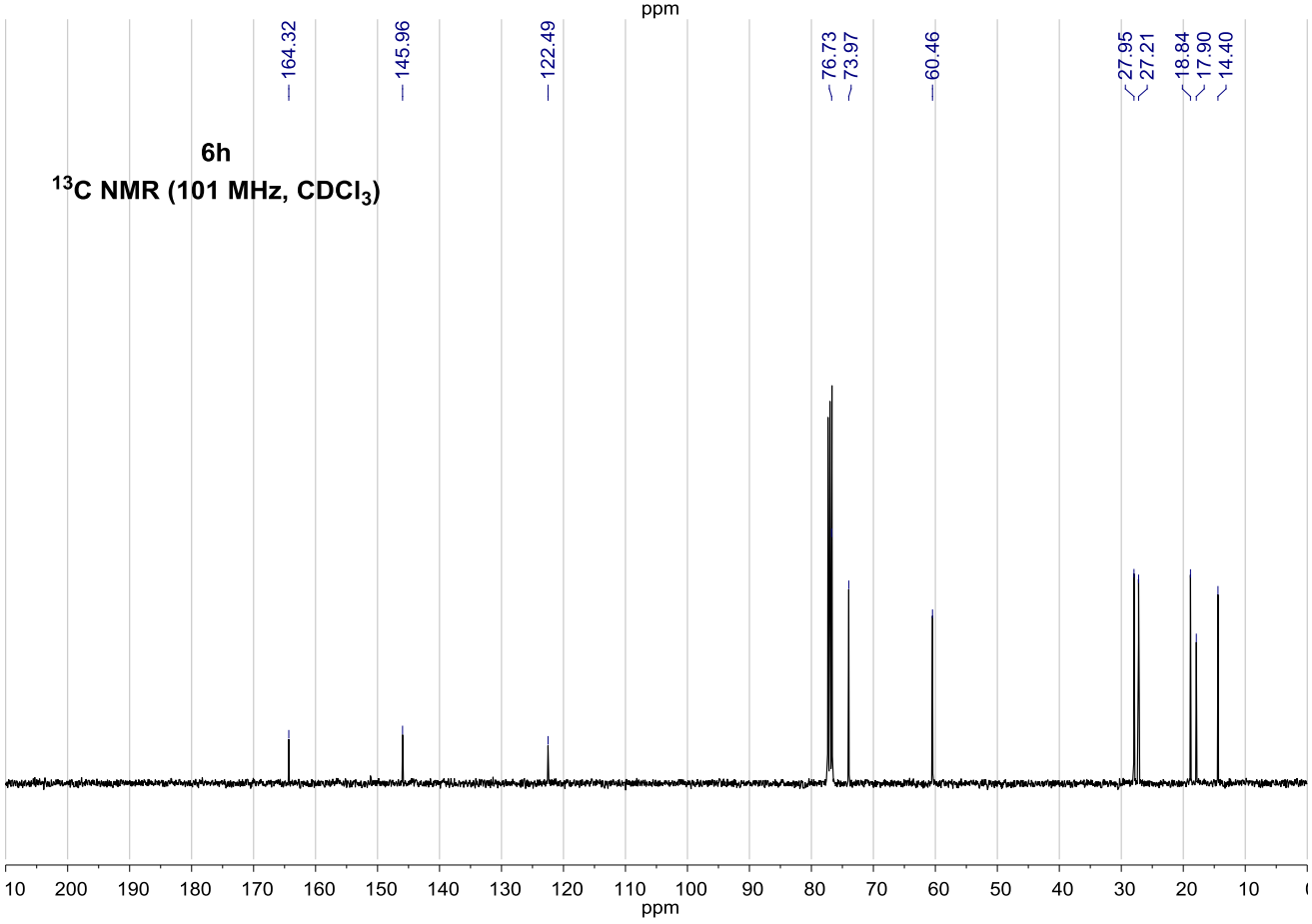

4.32 4.31 4.31 4.30 4.29 4.29 4.29 4.27 4.27 4.26 4.26 4.25 4.24 4.23 4.23 4.22 4.22 4.22 4.21 4.21 4.20 4.20 4.20 4.19 4.19 4.18 4.09 4.08 4.06 4.05 3.78 3.77 3.75 3.74 3.63 3.61 3.61 3.58 2.25 1.37 1.35 1.33
EtO2C
O
Cl
O
6f
1H NMR (400 MHz, CDCl3)
2.99 1.00 1.03 1.03 1.03 2.99 3.00
10.0 9.5 9.0 8.5 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
ppm

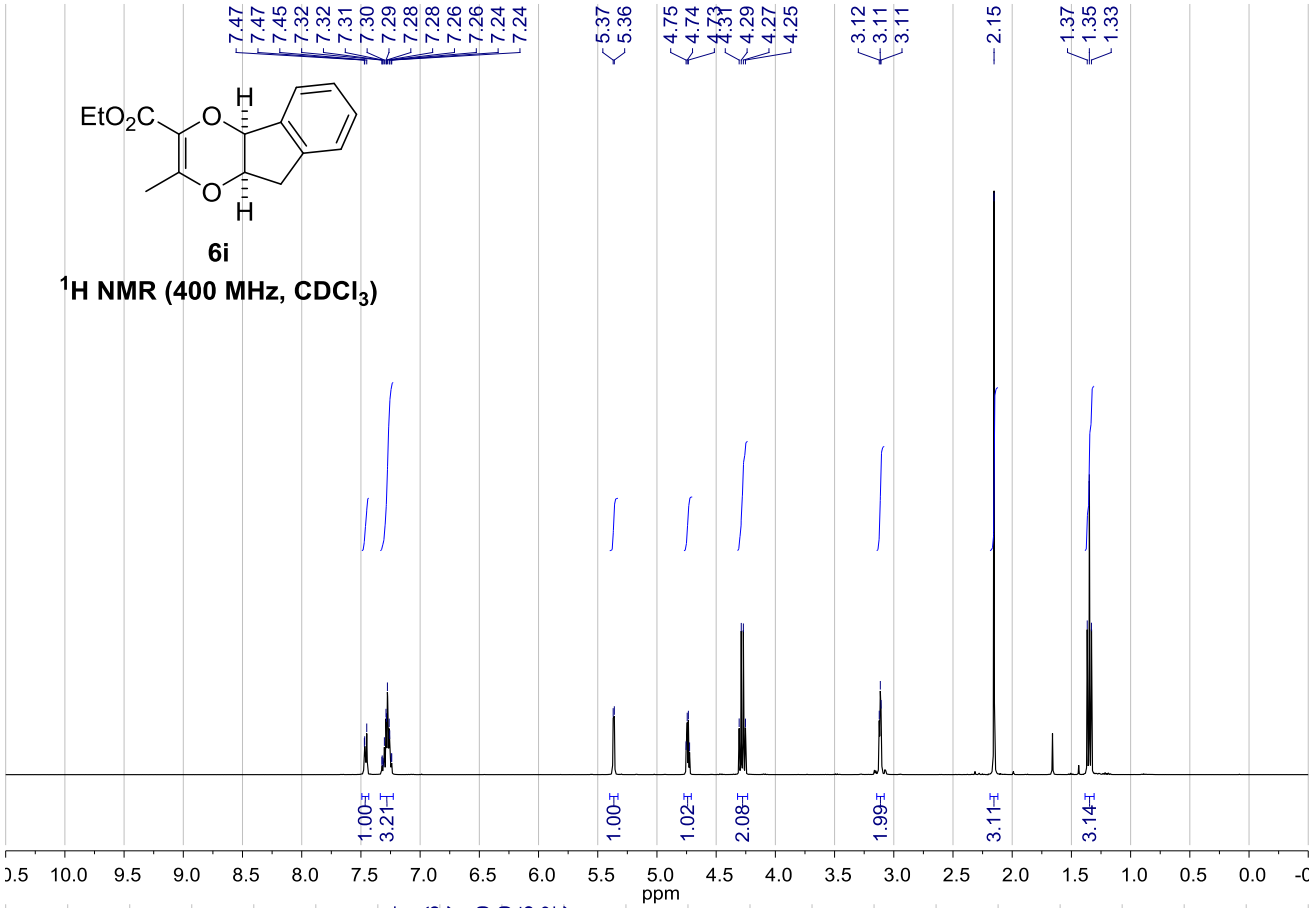

163.60 147.00 124.26 70.95 65.55 60.69 40.83 17.59 14.33
6f
13C NMR (101 MHz, CDCl3)
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10
ppm

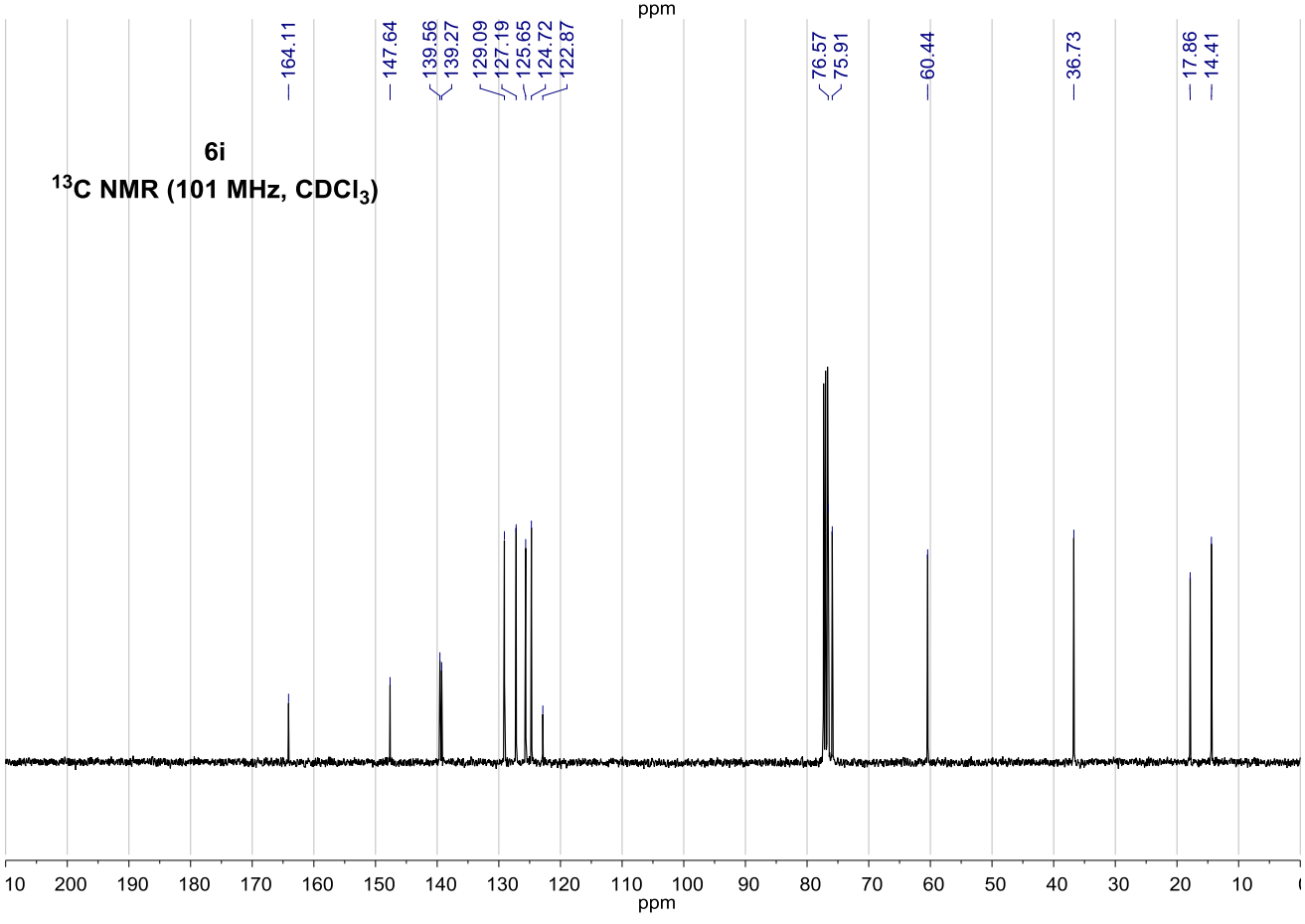

EtO2C
O
O
6g
1H NMR (400 MHz, CDCl3)
ppm

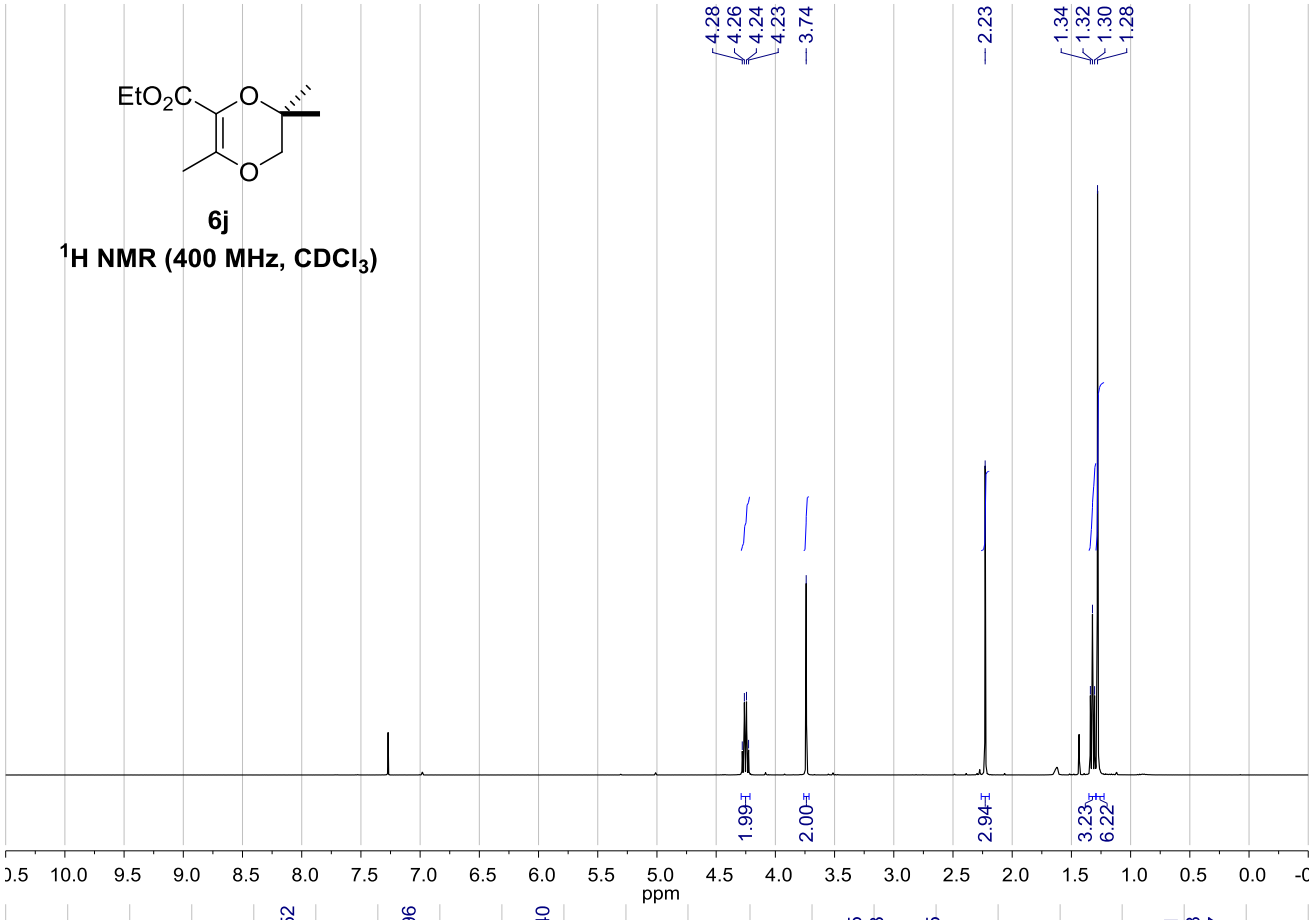

164.01
147.54
124.69
78.33
65.24
60.44
38.57
28.41
28.33
26.22
25.78
25.72
17.83
14.42
6g
13C NMR (101 MHz, CDCl3)
ppm

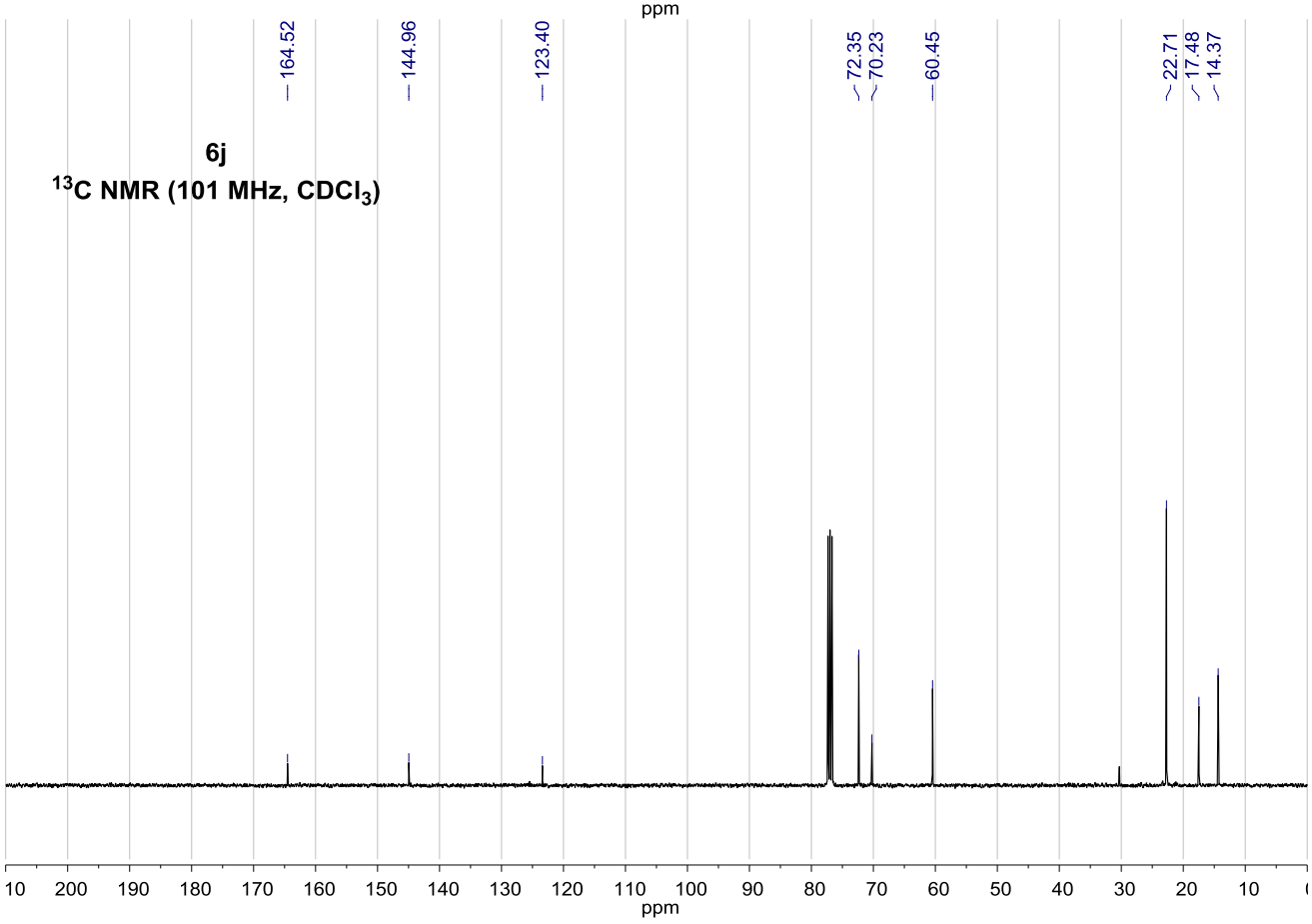

4.32 4.30 4.29 4.29 4.29 4.28 4.28 4.27 4.26 4.26 4.24 4.23 4.23 4.22 4.18 4.17 4.16 4.16 4.15 2.24 1.96 1.95 1.94 1.93 1.92 1.92 1.91 1.91 1.90 1.90 1.89 1.88 1.87 1.86 1.85 1.82 1.81 1.80 1.79 1.78 1.78 1.77 1.76 1.75 1.74 1.73 1.67 1.65 1.64 1.63 1.63 1.62 1.62 1.61 1.60 1.60 1.35 1.33 1.31
EtO2C
O
H
O
H
6h
1H NMR (400 MHz, CDCl3)
3.00 0.99 3.02 4.10 1.06 1.23 3.06
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
ppm

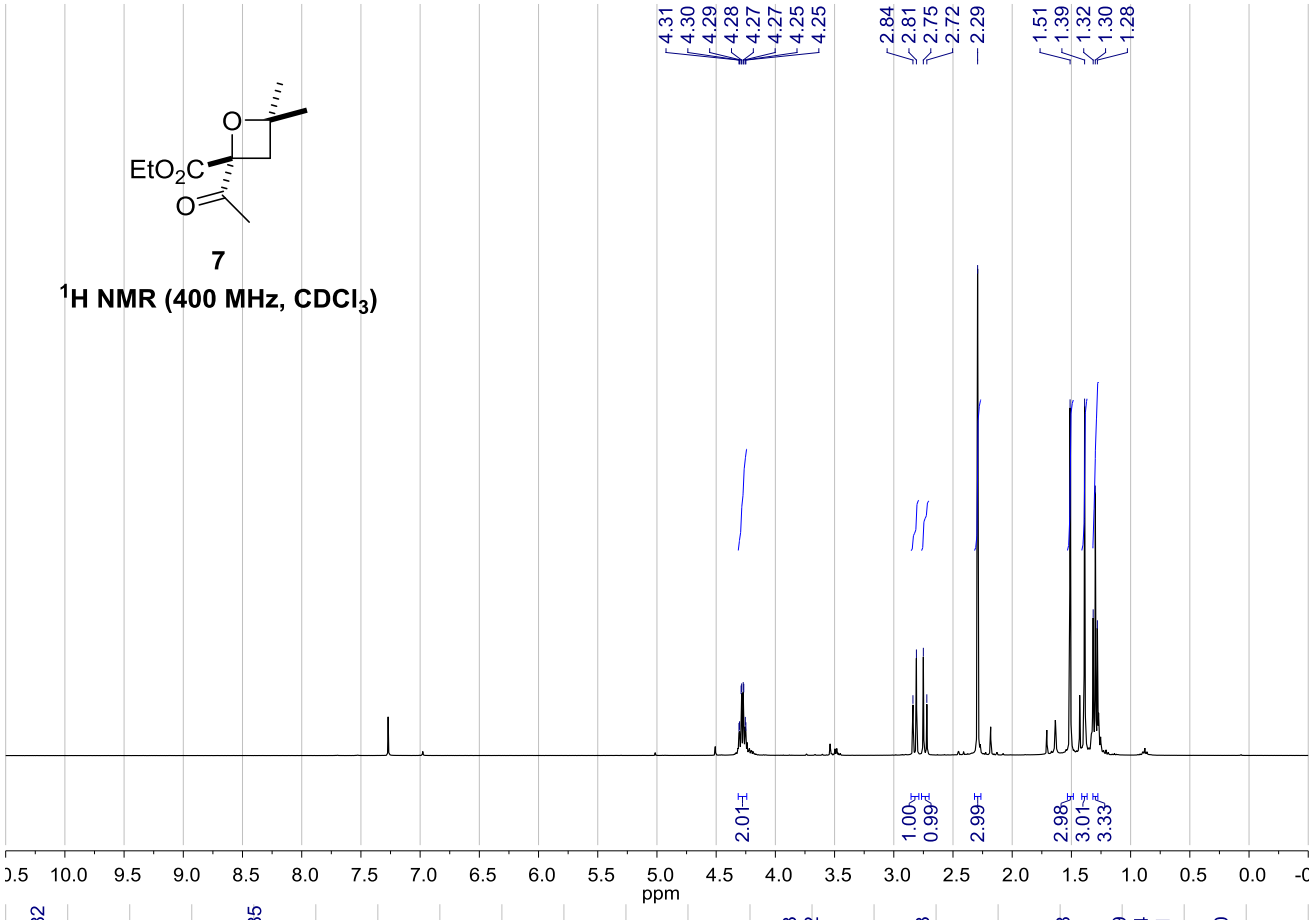

164.32
145.96
122.49
76.73
73.97
60.46
27.95
27.21
18.84
17.90
14.40
6h
13C NMR (101 MHz, CDCl3)
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10
ppm

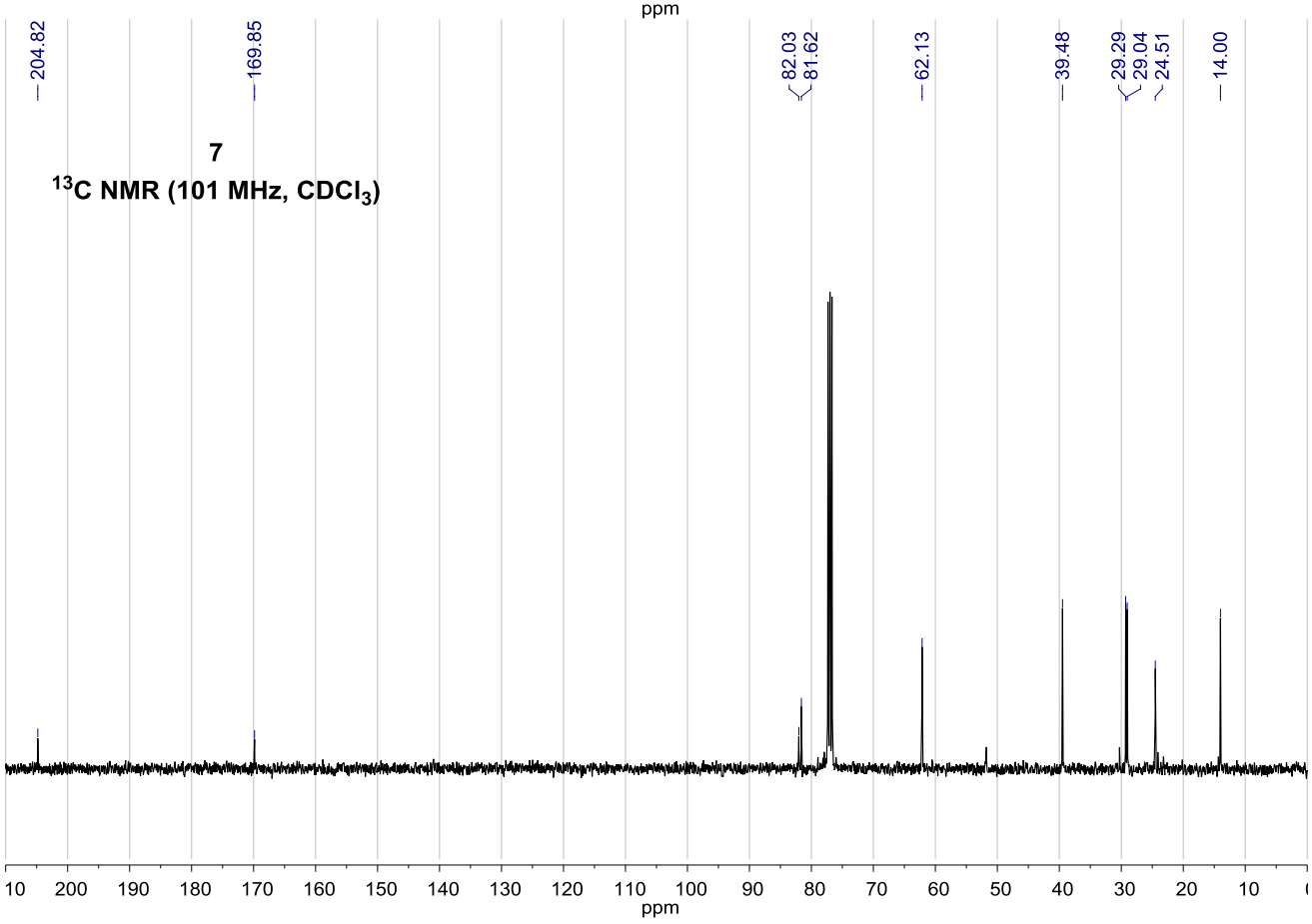

7.47
7.47
7.45
7.32
7.32
7.31
7.30
7.29
7.28
7.28
7.26
7.26
7.24
7.24
5.37
5.36
4.75
4.74
4.31
4.29
4.27
4.25
3.12
3.11
3.11
2.15
1.37
1.35
1.33
EtO2C
O
H
O
H
6i
1H NMR (400 MHz, CDCl3)
1.00
3.21
1.00
1.02
2.08
1.99
3.11
3.14
ppm

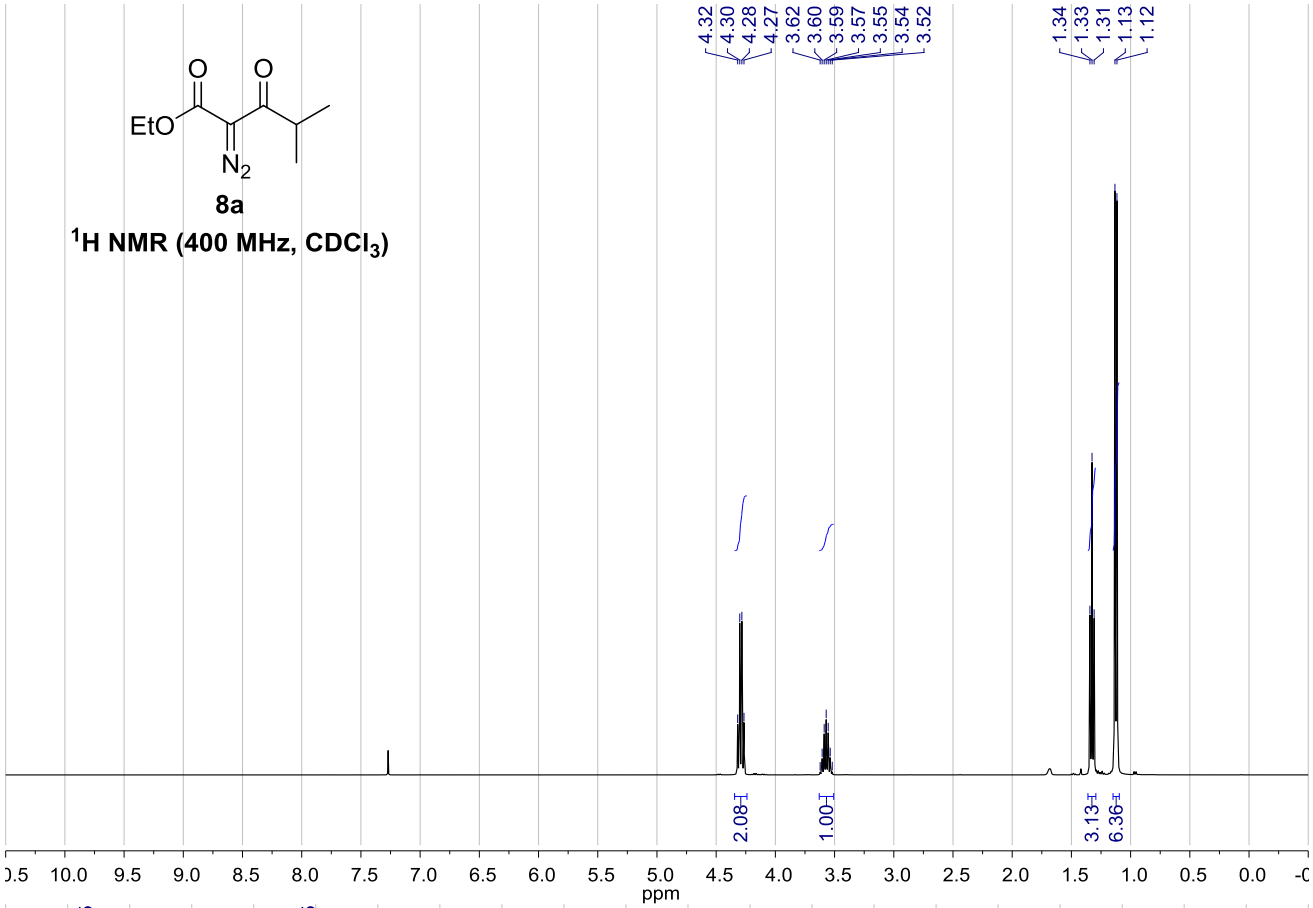

164.11
147.64
139.56
139.27
129.09
127.19
125.65
124.72
122.87
76.57
75.91
60.44
36.73
17.86
14.41
6i
13C NMR (101 MHz, CDCl3)
ppm

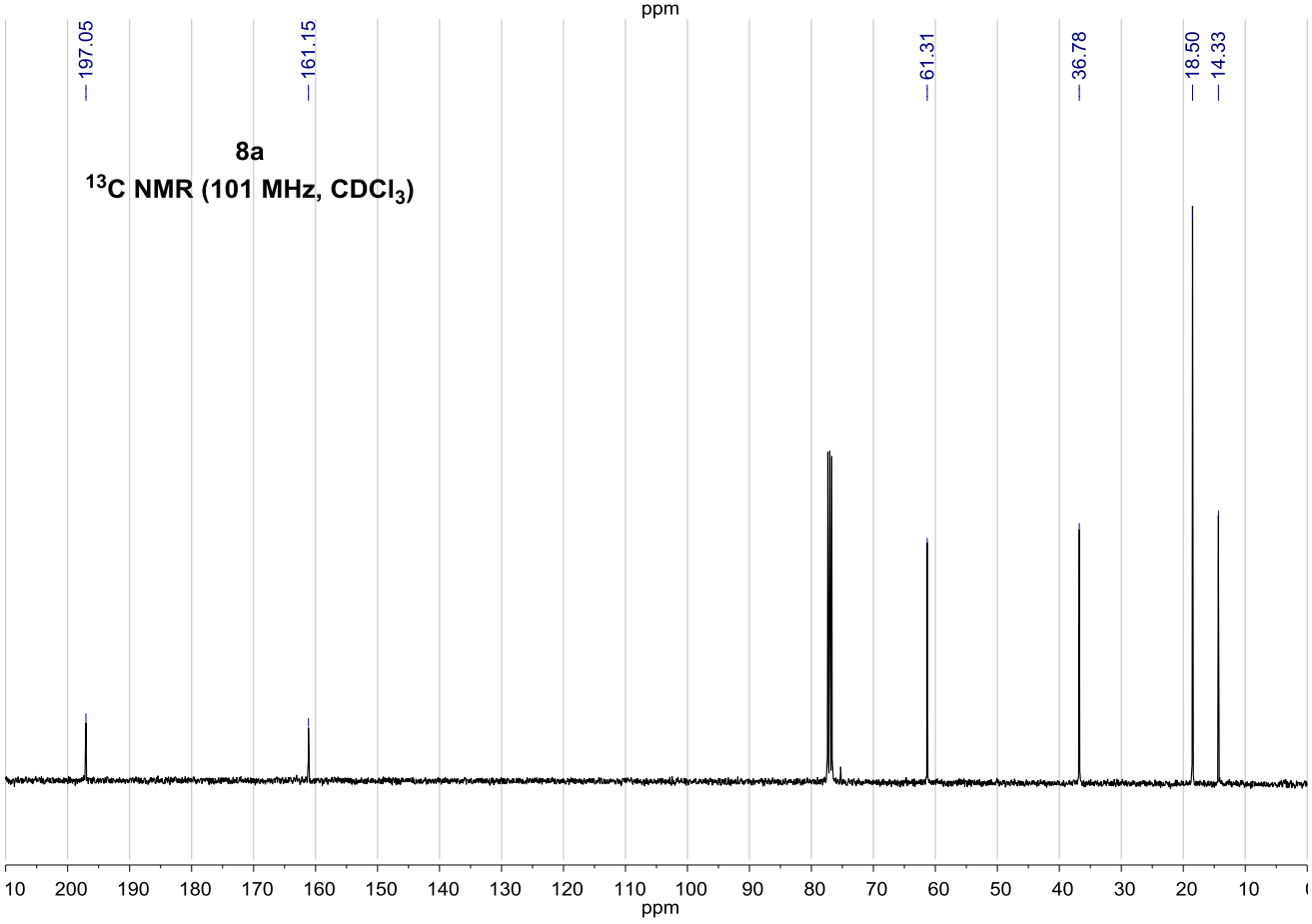

EtO2C
O
O
6j
1H NMR (400 MHz, CDCl3)
4.28
4.26
4.24
4.23
3.74
2.23
1.34
1.32
1.30
1.28
1.99
2.00
2.94
3.23
6.22
ppm

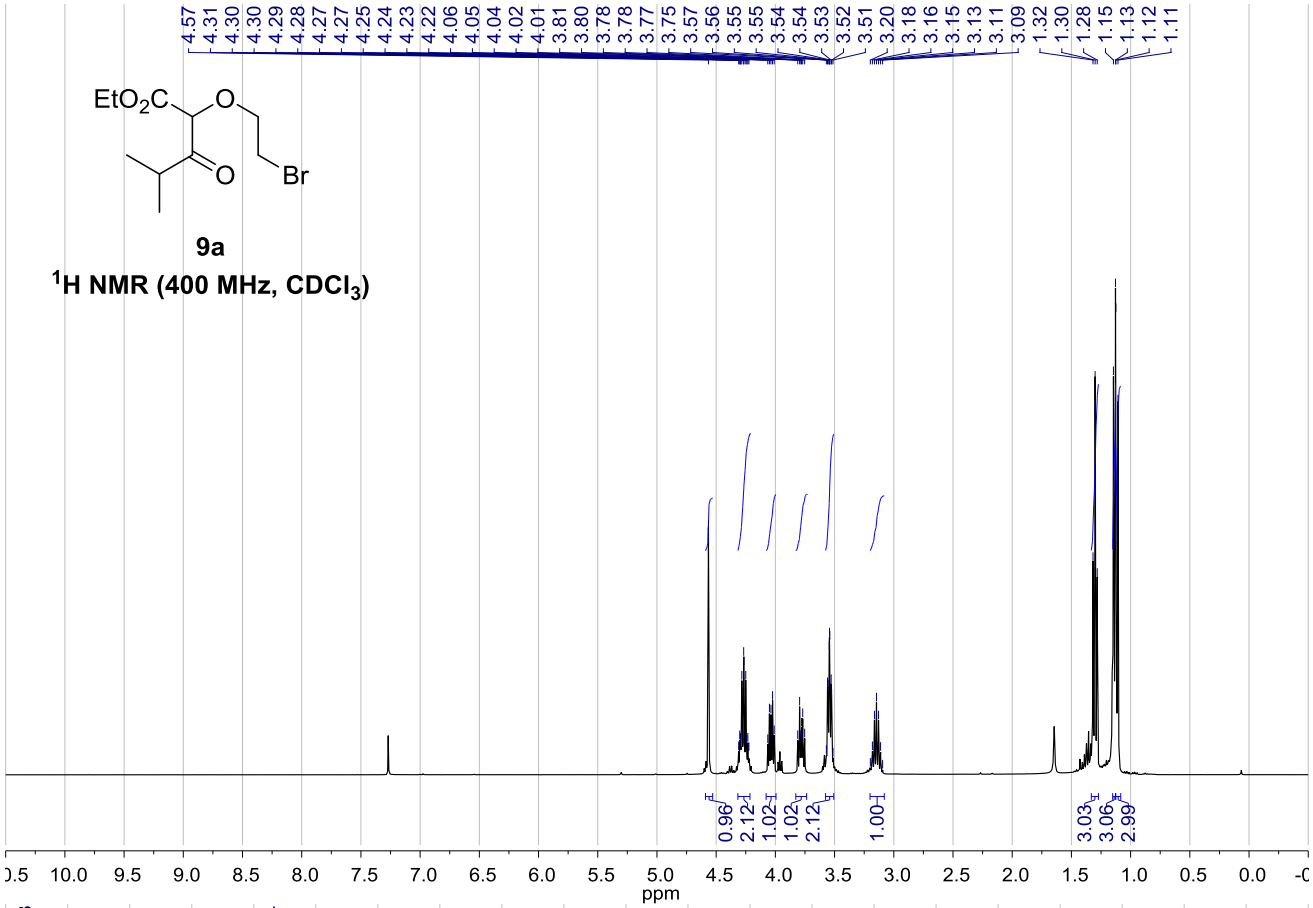

6j
13C NMR (101 MHz, CDCl3)
164.52
144.96
123.40
72.35
70.23
60.45
22.71
17.48
14.37
ppm

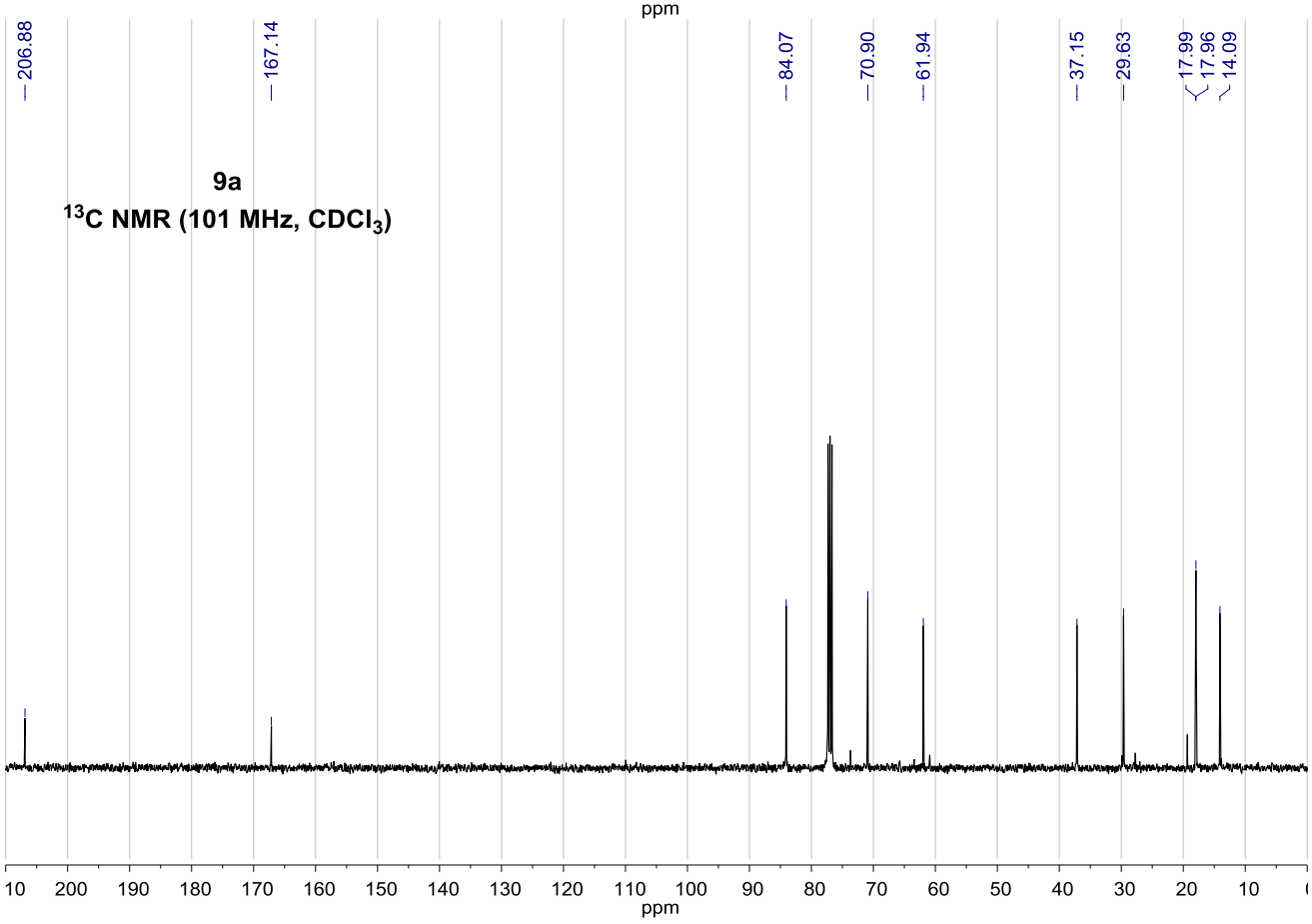

4.31
4.30
4.29
4.28
4.27
4.27
4.25
4.25
2.84
2.81
2.75
2.72
2.29
1.51
1.39
1.32
1.30
1.28
O
EtO2C
O
7
1H NMR (400 MHz, CDCl3)
2.01
1.00
0.99
2.99
2.98
3.01
3.33
ppm

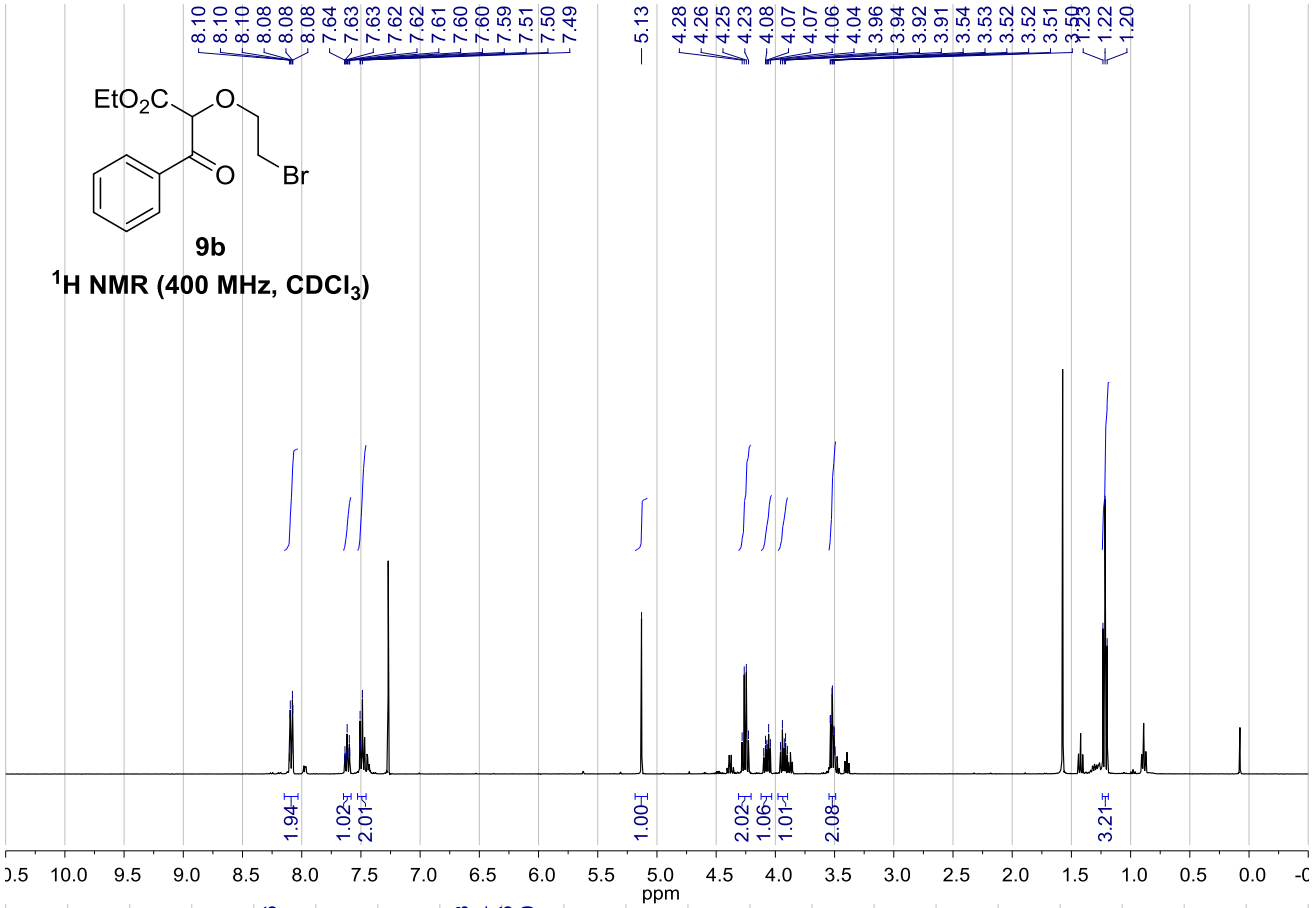

204.82
169.85
82.03
81.62
62.13
39.48
29.29
29.04
24.51
14.00
7
13C NMR (101 MHz, CDCl3)
ppm

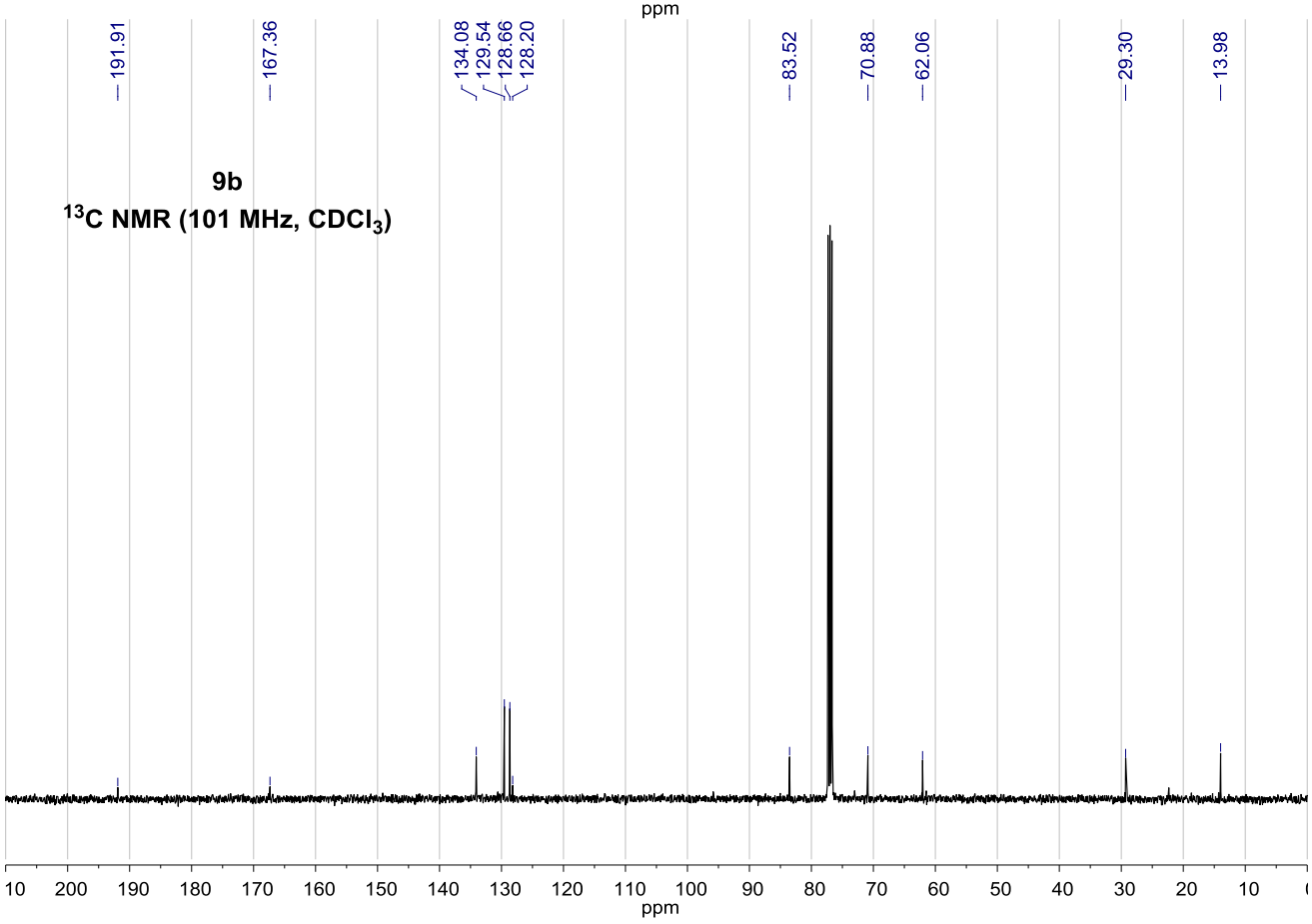

EtO
O
O
N2
8a
1H NMR (400 MHz, CDCl3)
4.32
4.30
4.28
4.27
3.62
3.60
3.59
3.57
3.55
3.54
3.52
1.34
1.33
1.31
1.13
1.12
2.08
1.00
3.13
6.36
ppm

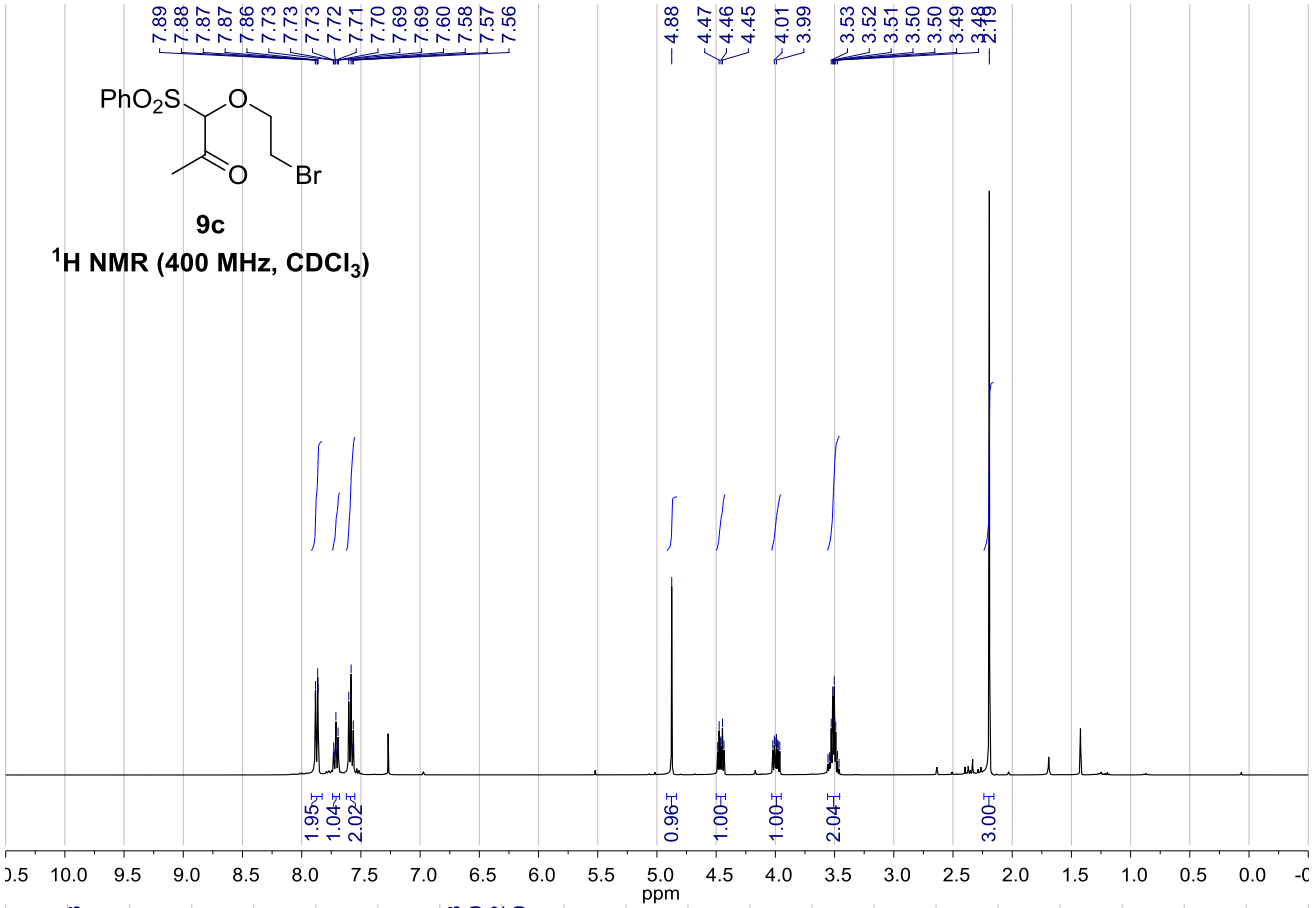

197.05
161.15
61.31
36.78
18.50
14.33
8a
13C NMR (101 MHz, CDCl3)
ppm

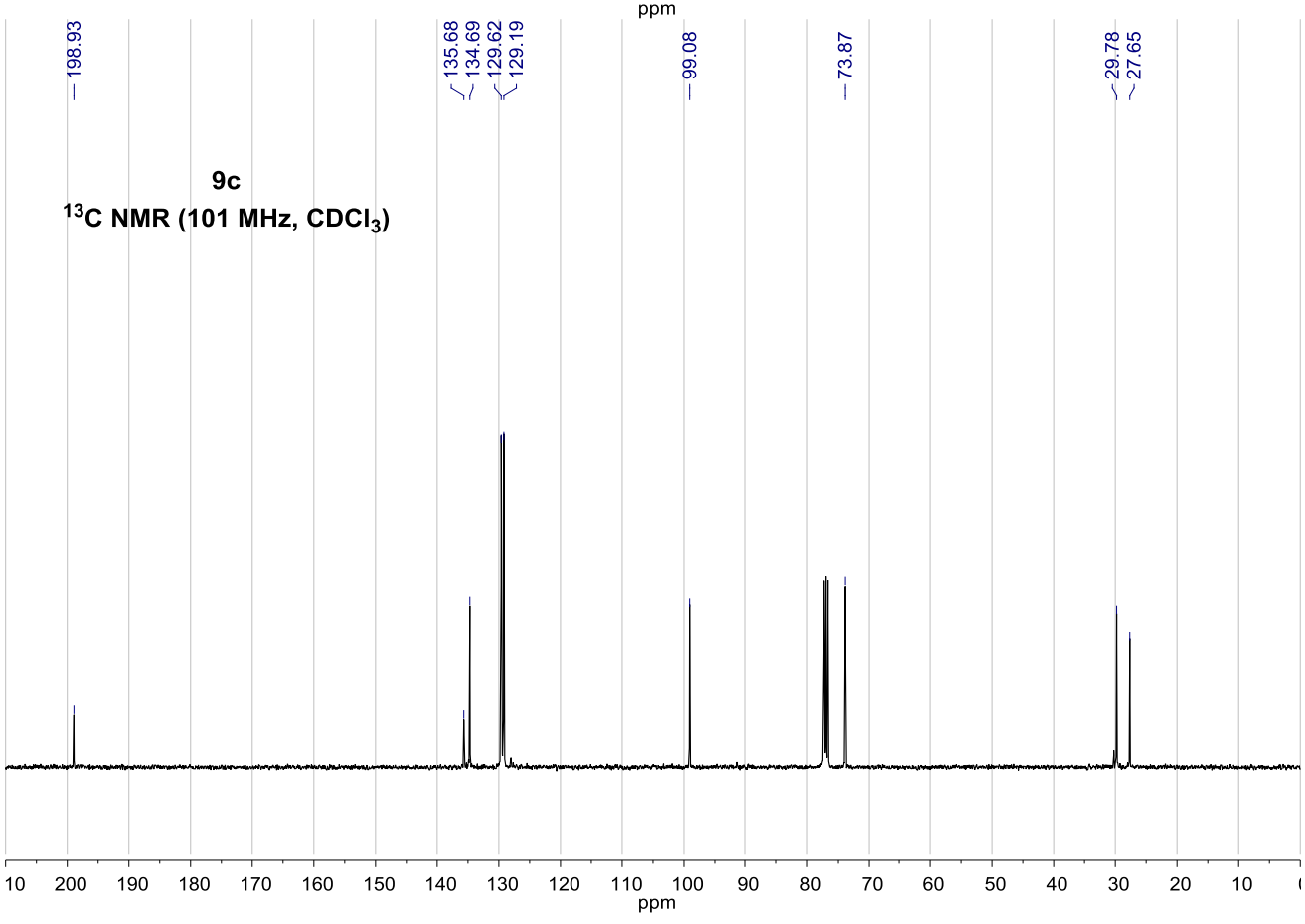

4.57 4.31 4.30 4.30 4.29 4.28 4.27 4.27 4.25 4.24 4.23 4.22 4.06 4.05 4.04 4.02 4.01 3.81 3.80 3.78 3.78 3.77 3.75 3.57 3.56 3.55 3.55 3.54 3.54 3.53 3.52 3.51 3.20 3.18 3.16 3.15 3.13 3.11 3.09 1.32 1.30 1.28 1.15 1.13 1.12 1.11
EtO2C
O
O
Br
9a
1H NMR (400 MHz, CDCl3)
0.96 2.12 1.02 2.12 1.00 3.03 3.06 2.99
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
ppm

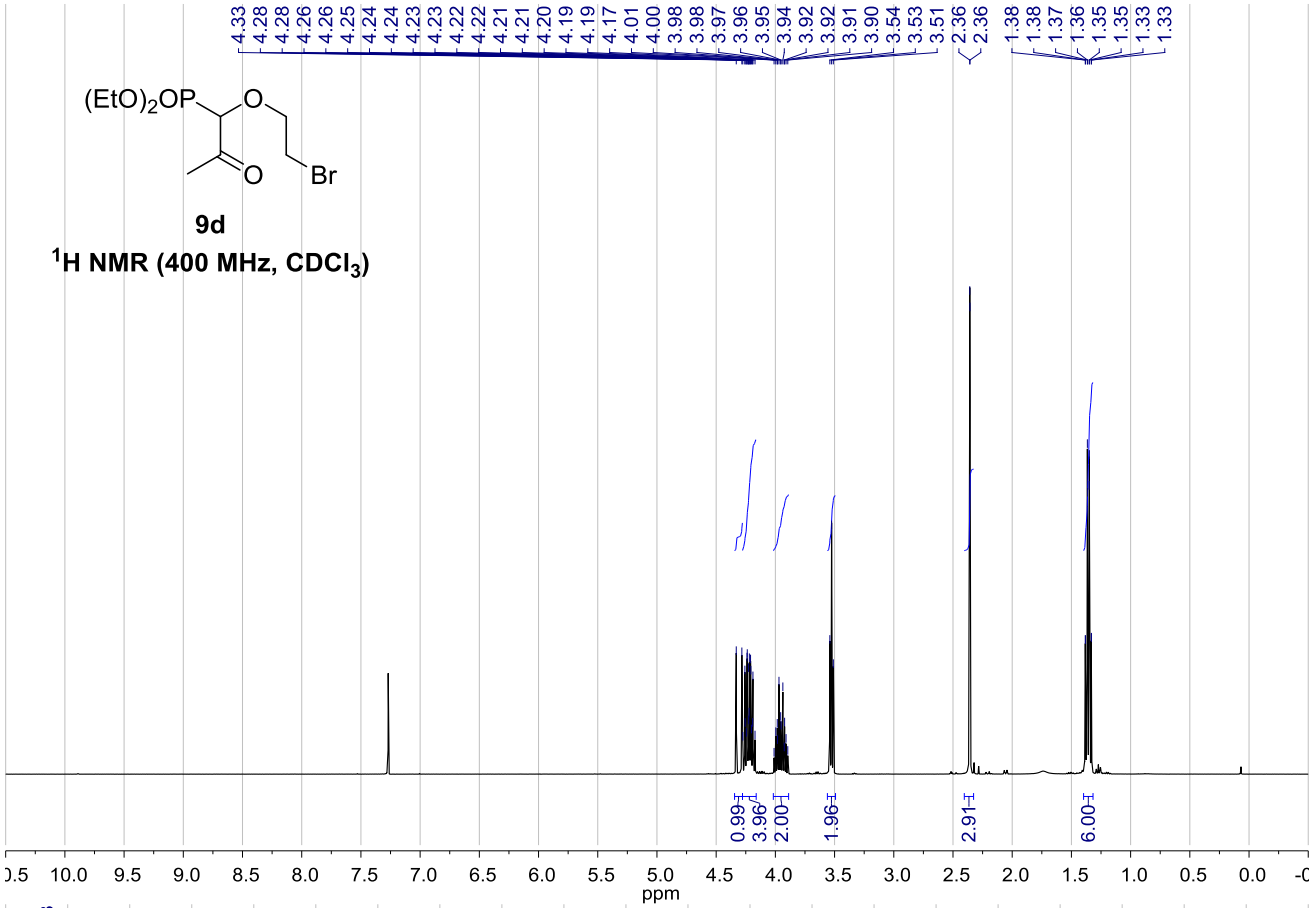

206.88
167.14
84.07
70.90
61.94
37.15
29.63
17.99
17.96
14.09
9a
13C NMR (101 MHz, CDCl3)
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10
ppm

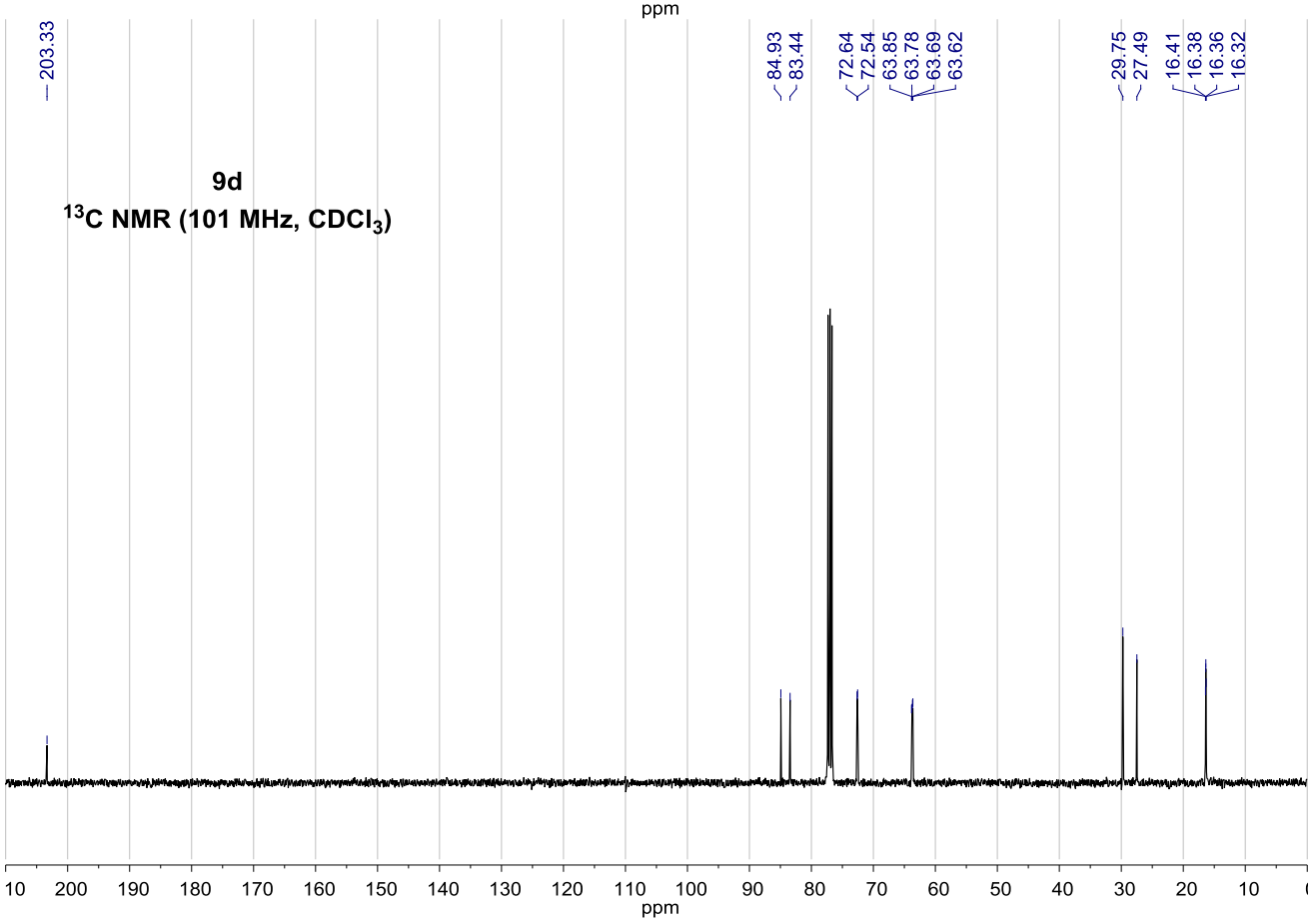

8.10
8.10
8.10
8.08
8.08
8.08
7.64
7.63
7.63
7.62
7.62
7.61
7.60
7.60
7.59
7.51
7.50
7.49
5.13
4.28
4.26
4.25
4.23
4.08
4.07
4.07
4.06
4.04
3.96
3.94
3.92
3.91
3.54
3.53
3.52
3.52
3.51
3.50
1.23
1.22
1.20
EtO2C
O
O
Br
9b
1H NMR (400 MHz, CDCl3)
1.94
1.02
2.01
1.00
2.02
1.06
1.01
2.08
3.21
ppm

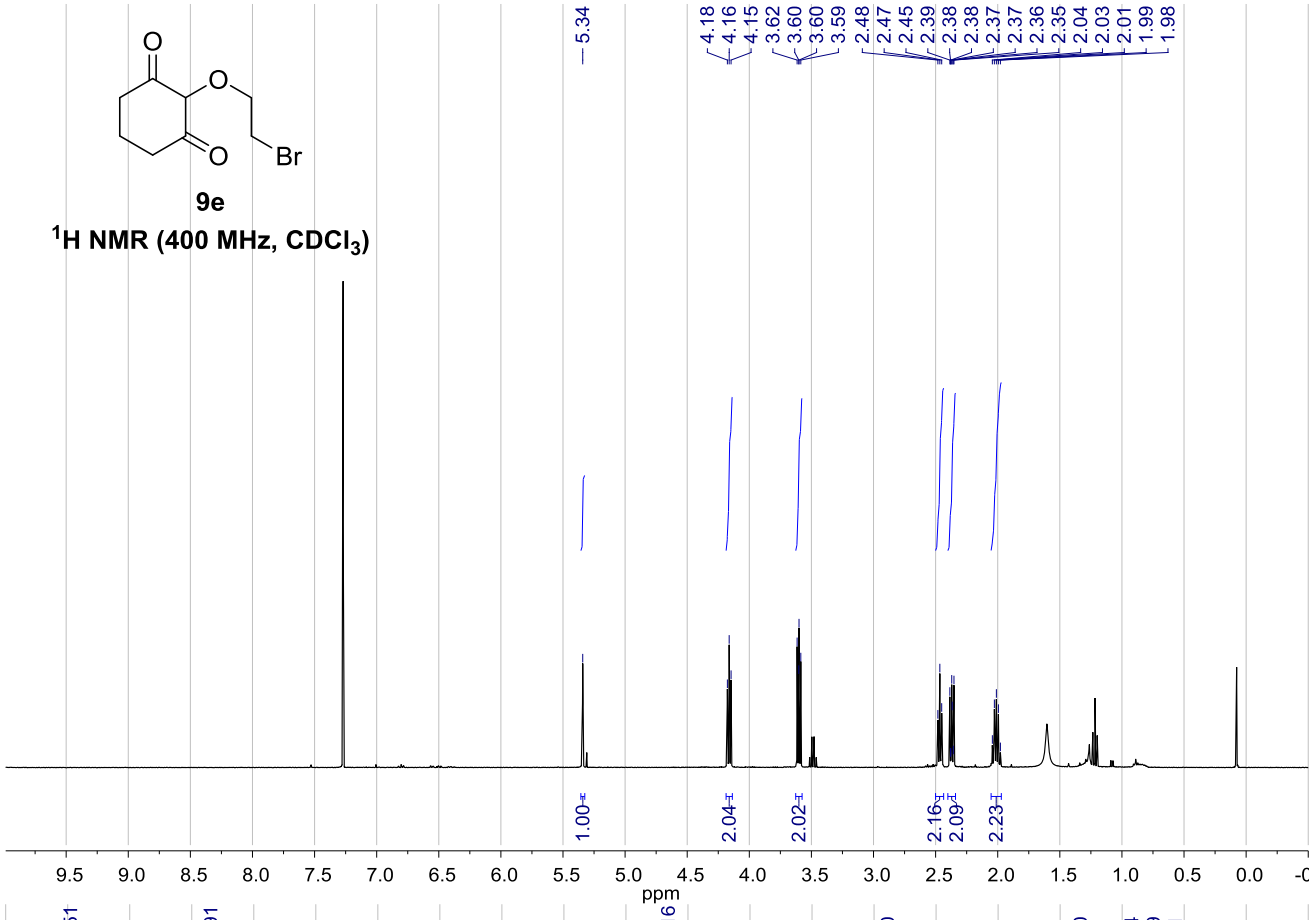

191.91
167.36
134.08
129.54
128.66
128.20
83.52
70.88
62.06
29.30
13.98
9b
13C NMR (101 MHz, CDCl3)
ppm

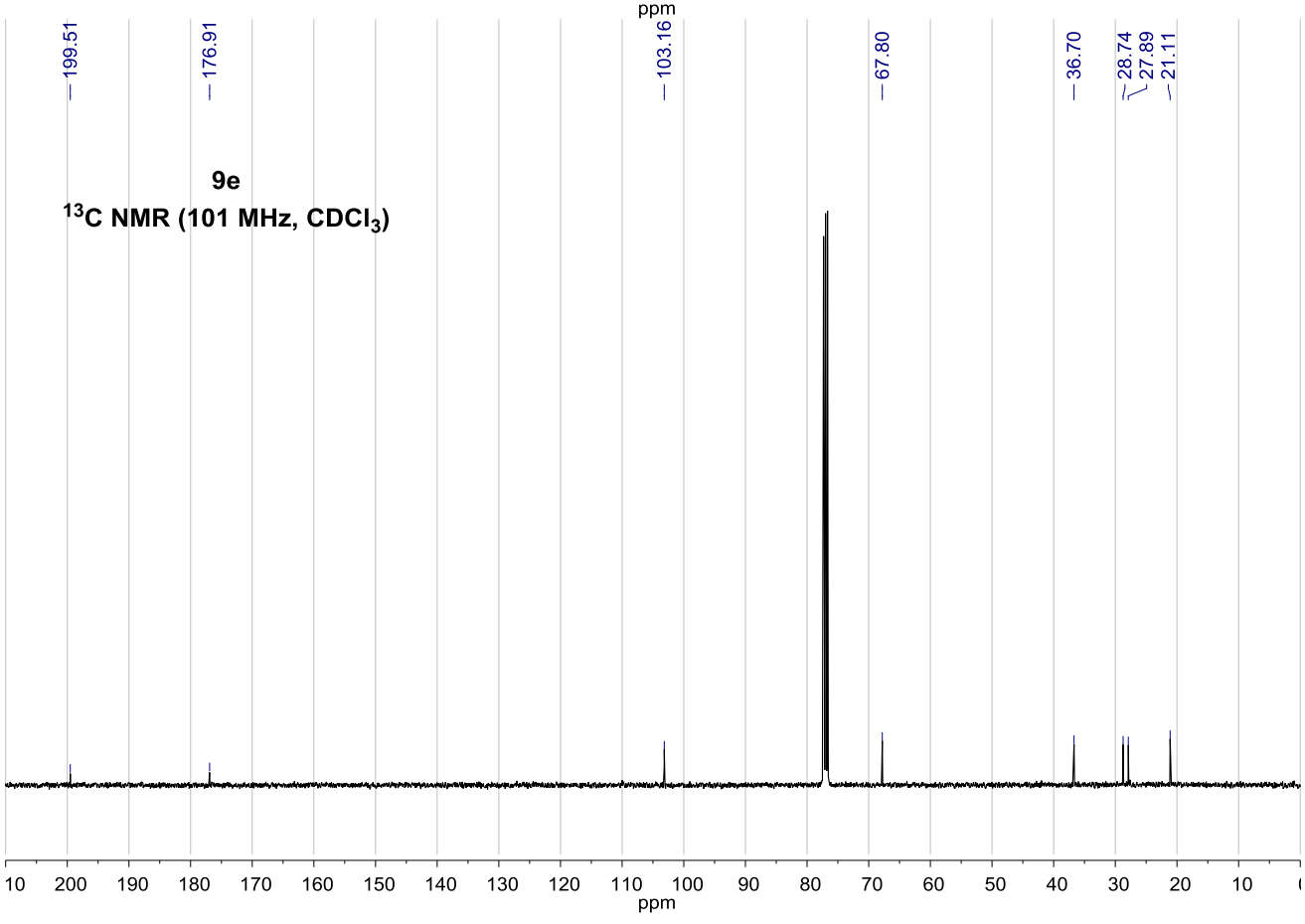

7.89
7.88
7.87
7.87
7.86
7.73
7.73
7.73
7.72
7.71
7.70
7.69
7.69
7.60
7.58
7.57
7.56
4.88
4.47
4.46
4.45
4.01
3.99
3.53
3.52
3.51
3.50
3.50
3.49
3.48
2.19
PhO2S
O
O
Br
9c
1H NMR (400 MHz, CDCl3)
1.95
1.04
2.02
0.96
1.00
1.00
2.04
3.00
ppm

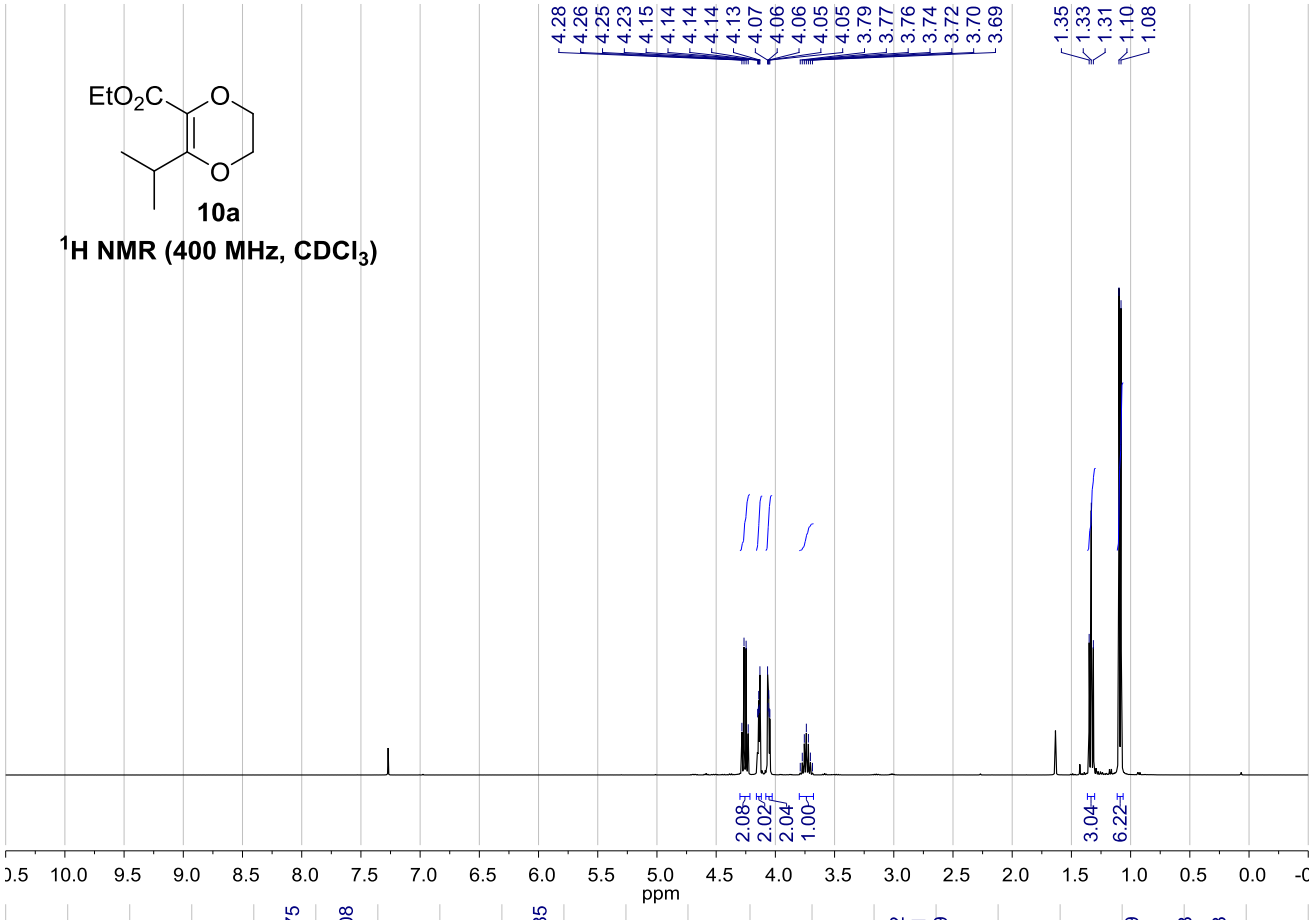

198.93
135.68
134.69
129.62
129.19
99.08
73.87
29.78
27.65
9c
13C NMR (101 MHz, CDCl3)
ppm

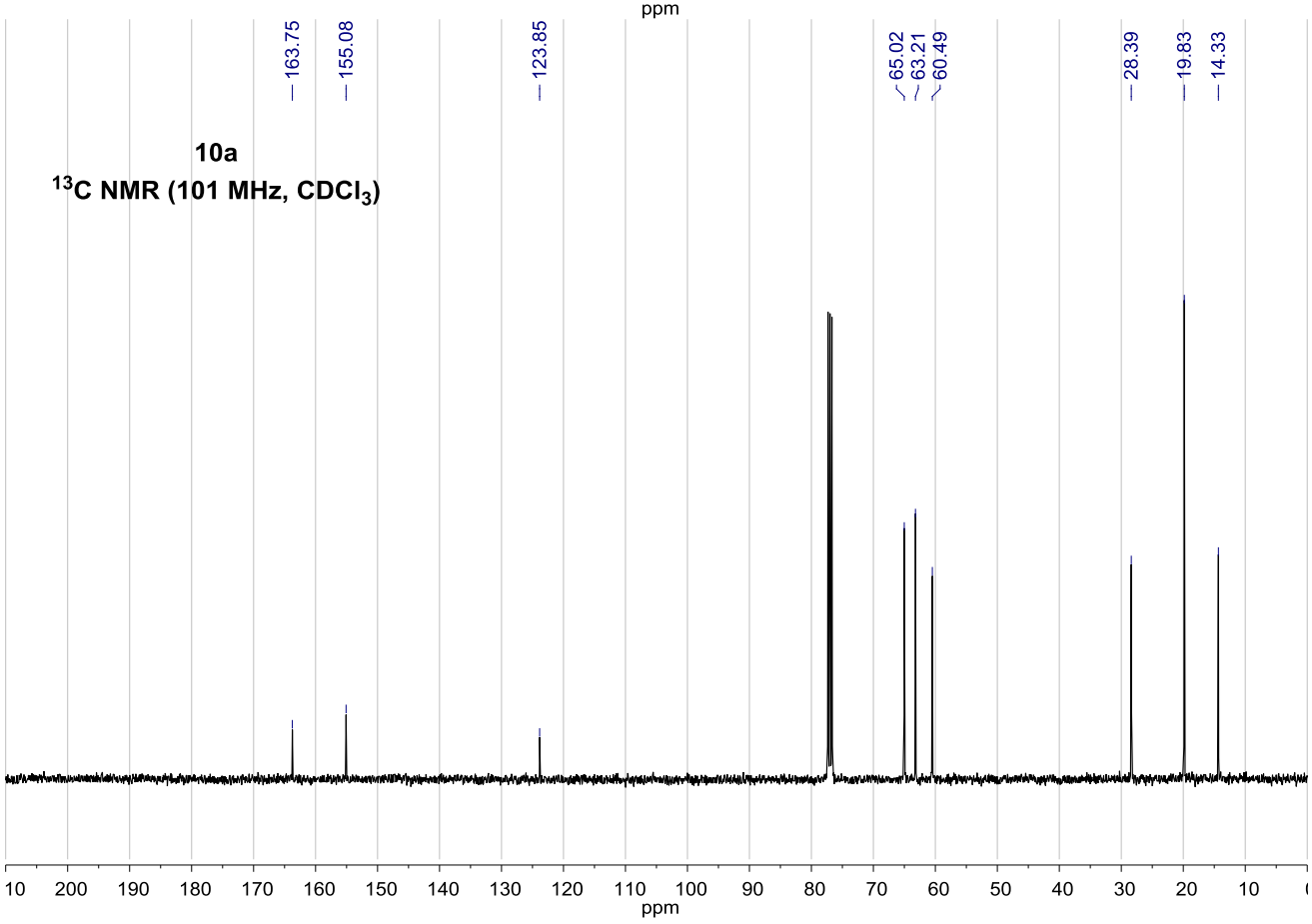

4.33 4.28 4.28 4.26 4.26 4.25 4.24 4.24 4.23 4.23 4.22 4.22 4.21 4.21 4.20 4.19 4.19 4.17 4.01 4.00 3.98 3.98 3.97 3.96 3.95 3.94 3.92 3.92 3.91 3.90 3.54 3.53 3.51 2.36 2.36 1.38 1.38 1.37 1.36 1.35 1.35 1.33 1.33
(EtO)2OP
O
O
Br
9d
1H NMR (400 MHz, CDCl3)
0.99 3.96 2.00 1.96 2.91 6.00
ppm

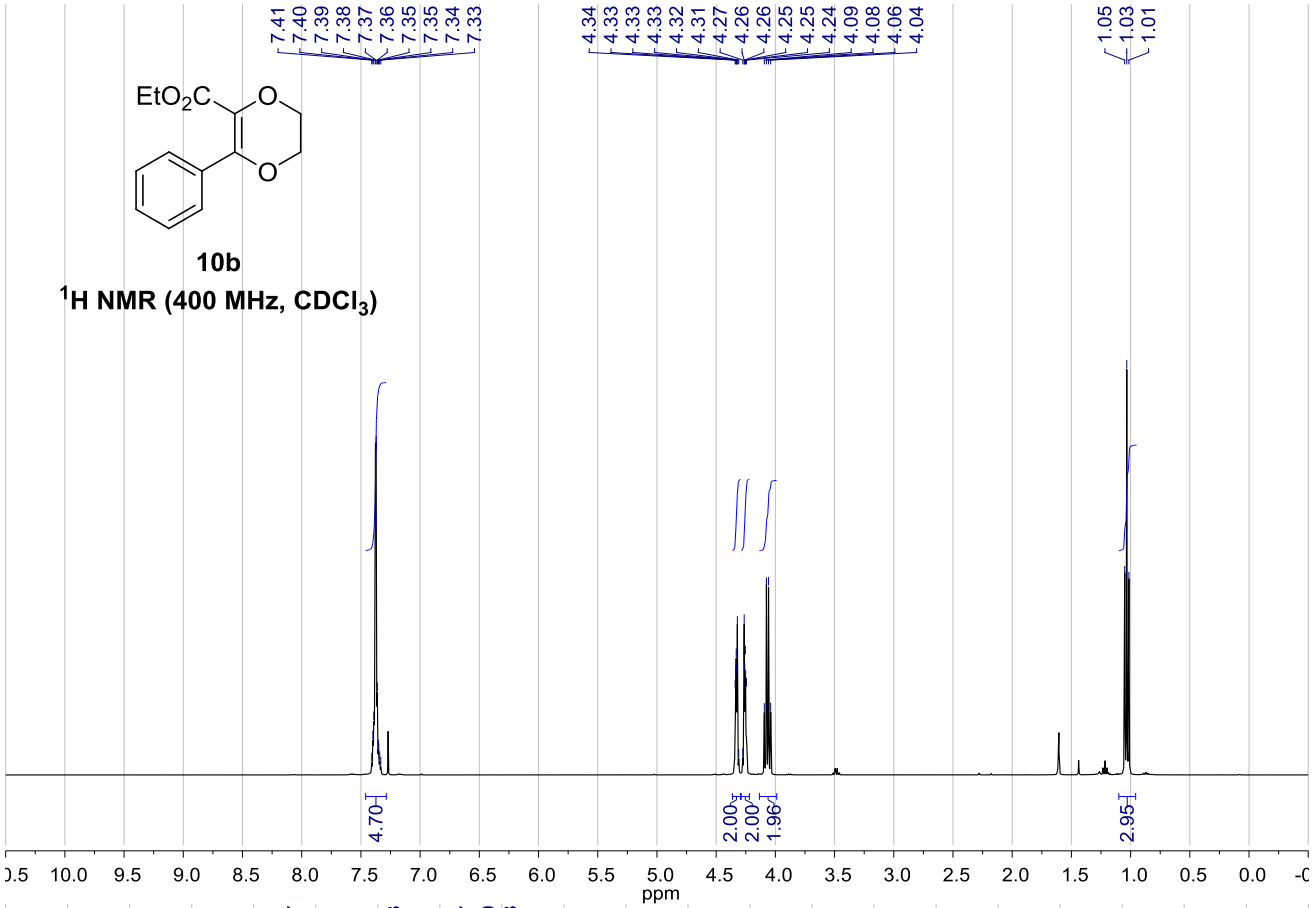

203.33
84.93 83.44 72.64 72.54 63.85 63.78 63.69 63.62 29.75 27.49 16.41 16.38 16.36 16.32
9d
13C NMR (101 MHz, CDCl3)
ppm


O
O
O
Br
9e
^{1}H NMR (400 MHz, $CDCl_3$)
5.34
4.18
4.16
4.15
3.62
3.60
3.60
3.59
2.48
2.47
2.45
2.39
2.38
2.38
2.37
2.37
2.36
2.35
2.04
2.03
2.01
1.99
1.98
1.00
2.04
2.02
2.16
2.09
2.23
ppm


199.51
176.91
103.16
67.80
36.70
28.74
27.89
21.11
9e
^{13}C NMR (101 MHz, $CDCl_3$)
ppm

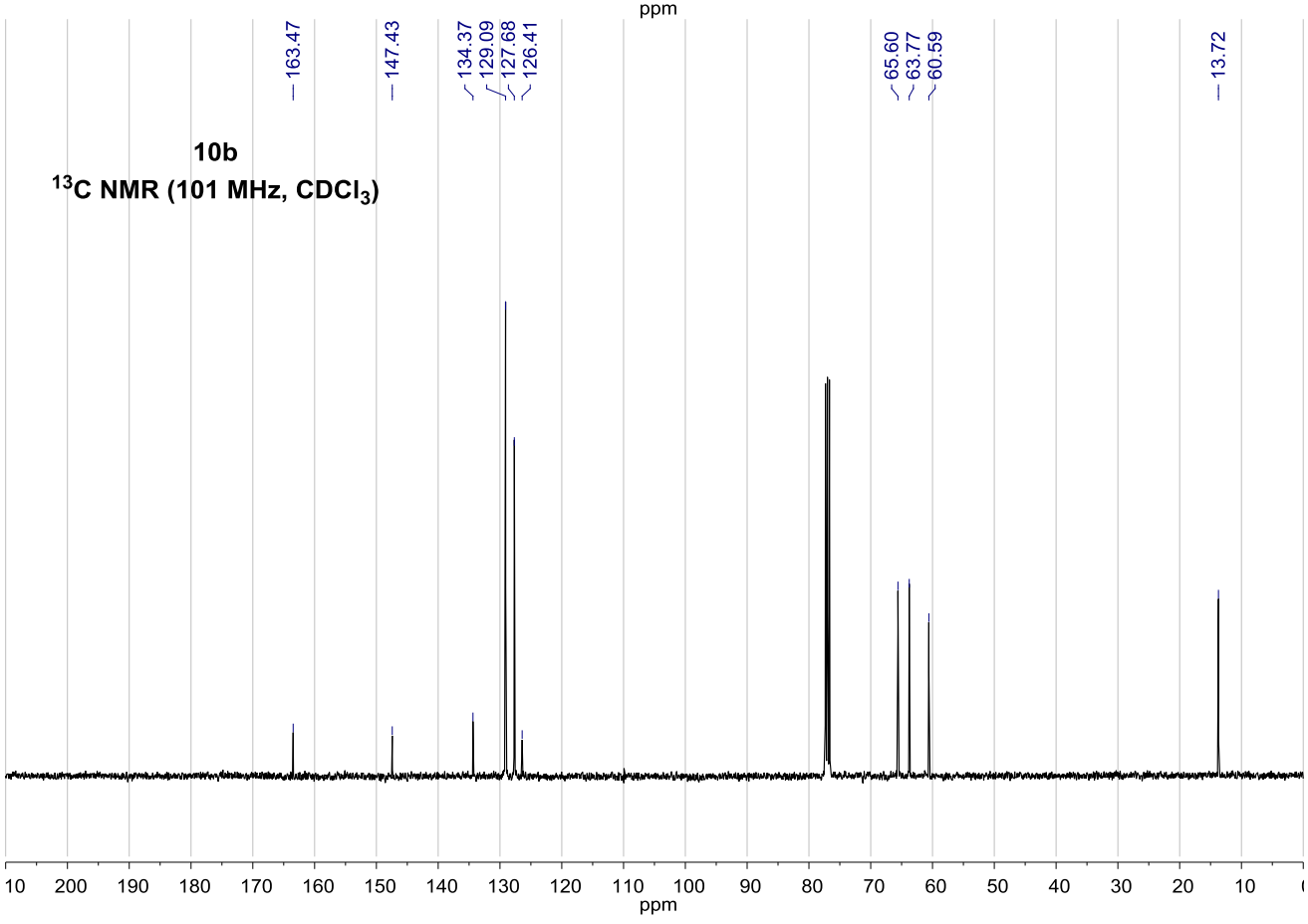

EtO2C
O
O
10a
1H NMR (400 MHz, CDCl3)
4.28
4.26
4.25
4.23
4.15
4.14
4.14
4.14
4.13
4.07
4.06
4.06
4.05
4.05
3.79
3.77
3.76
3.74
3.72
3.70
3.69
1.35
1.33
1.31
1.10
1.08
2.08
2.02
2.04
1.00
3.04
6.22
ppm


10a
13C NMR (101 MHz, CDCl3)
163.75
155.08
123.85
65.02
63.21
60.49
28.39
19.83
14.33
ppm



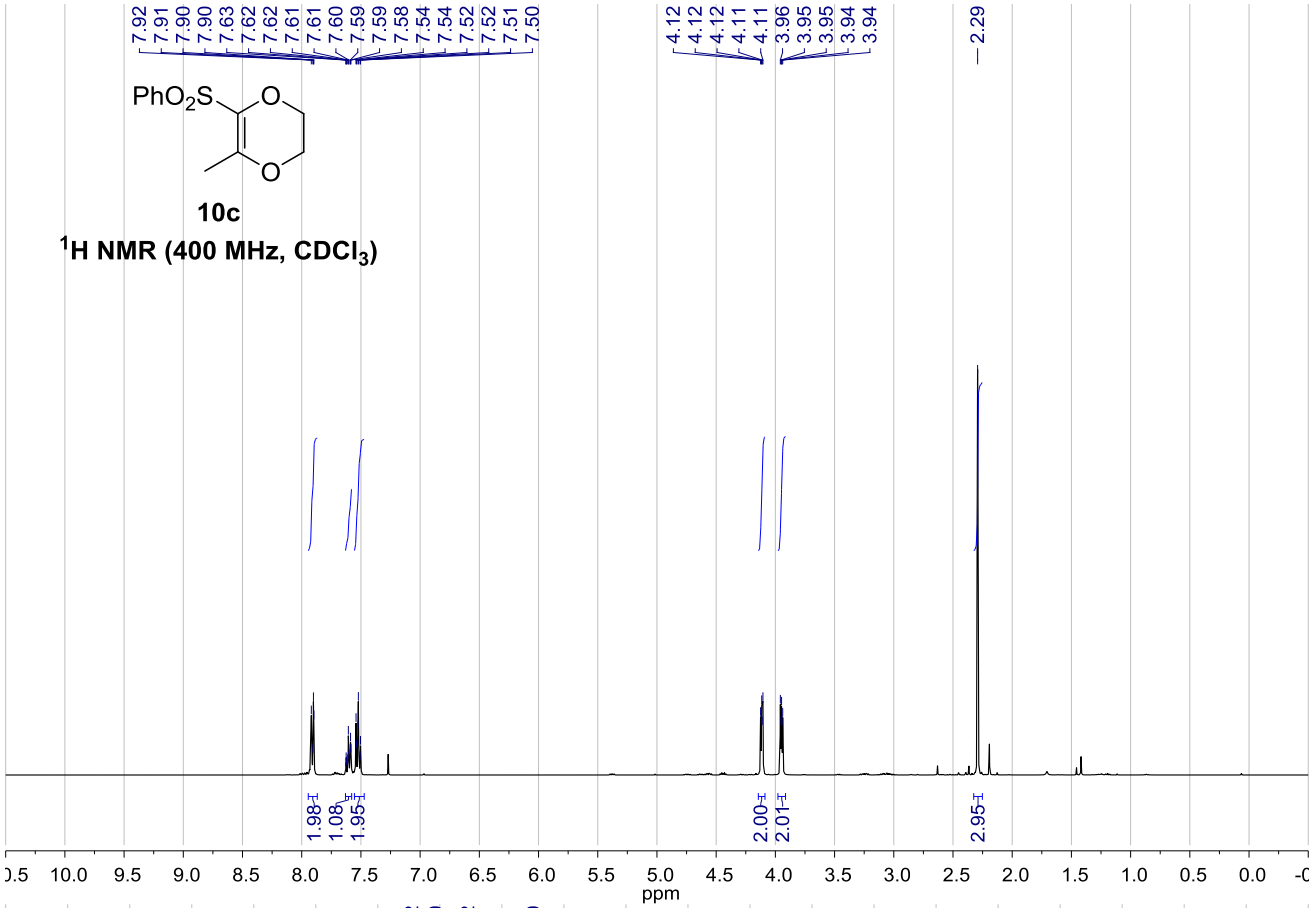
10b

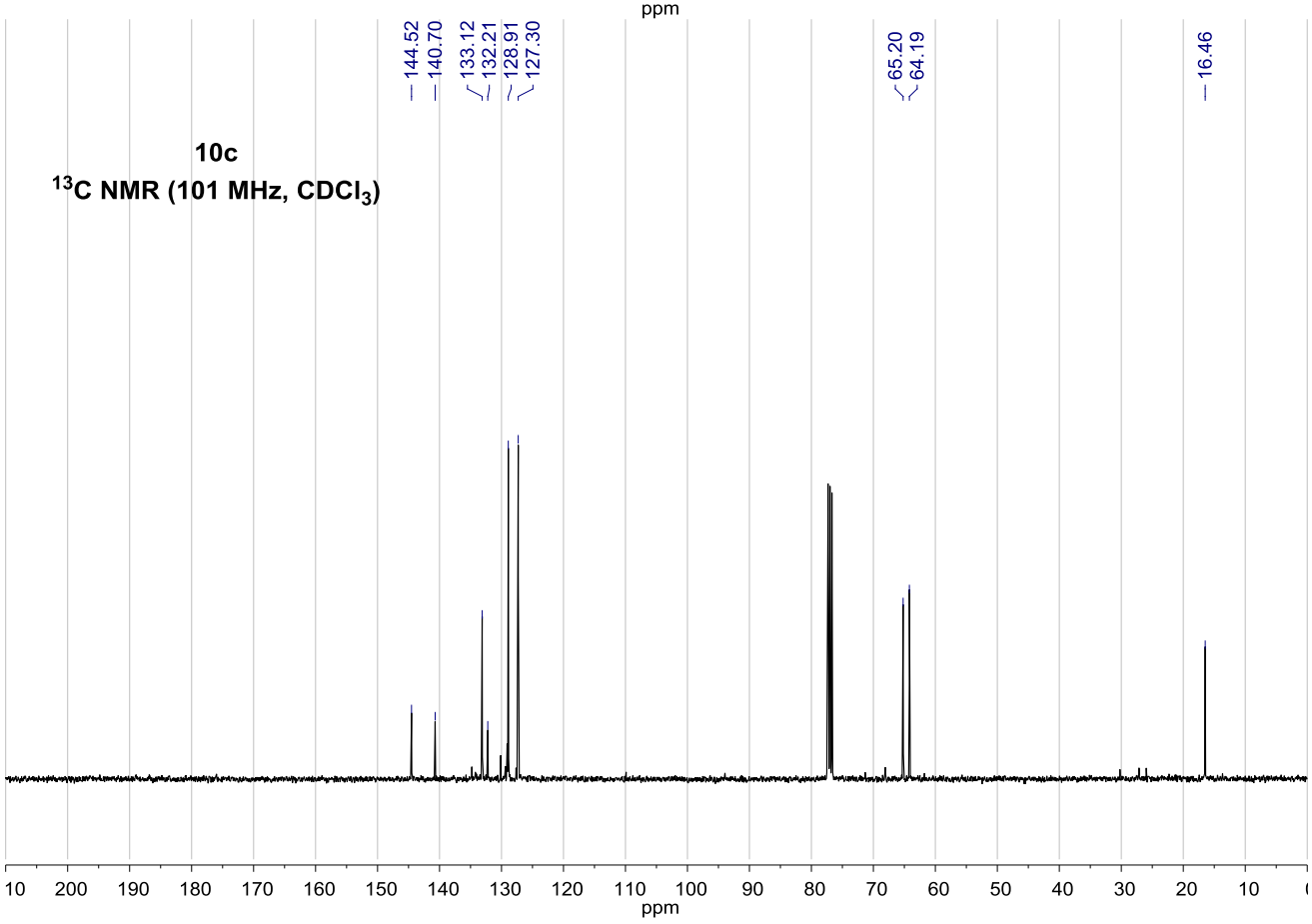
^{1}H NMR (400 MHz, $CDCl_3$)

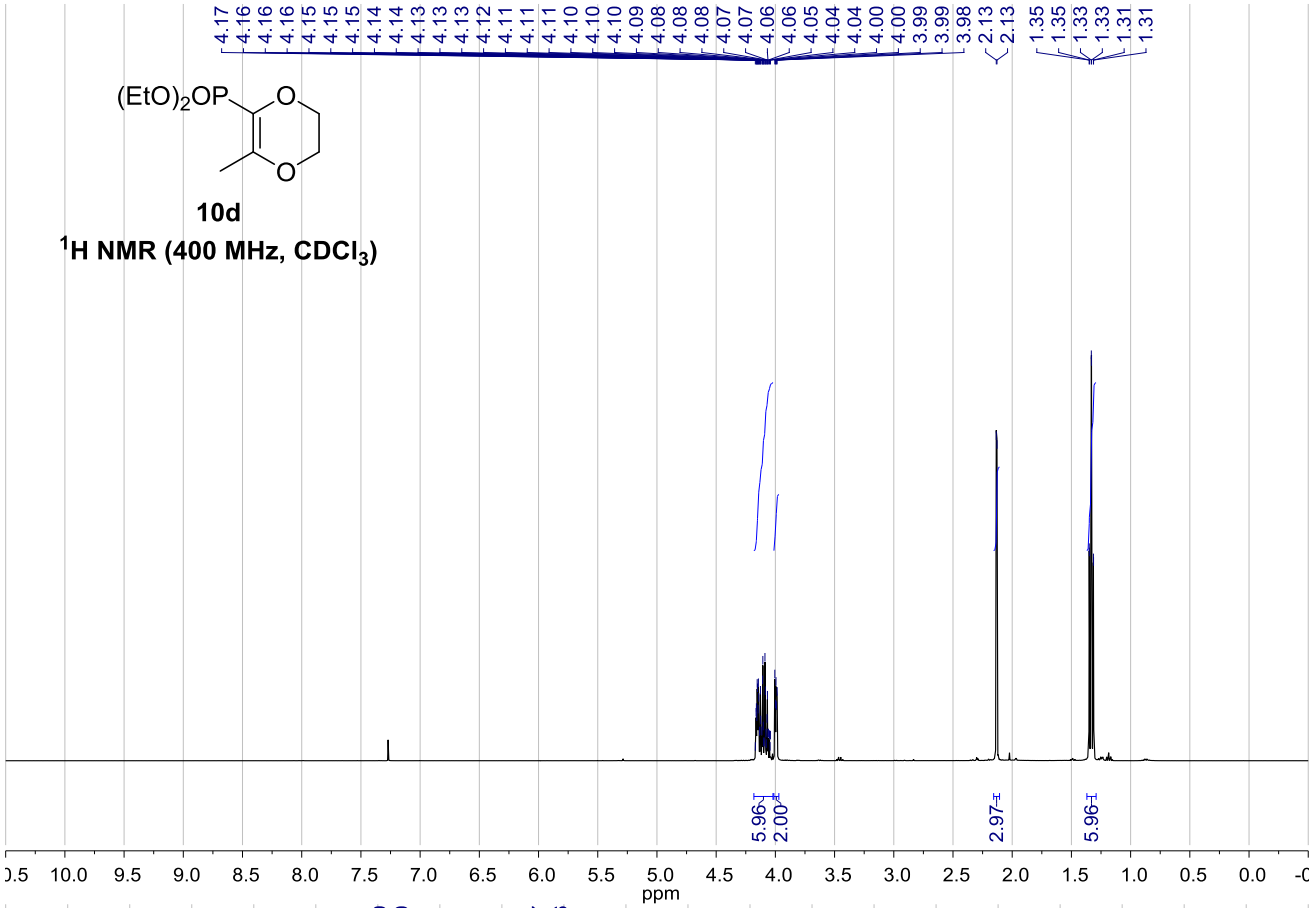


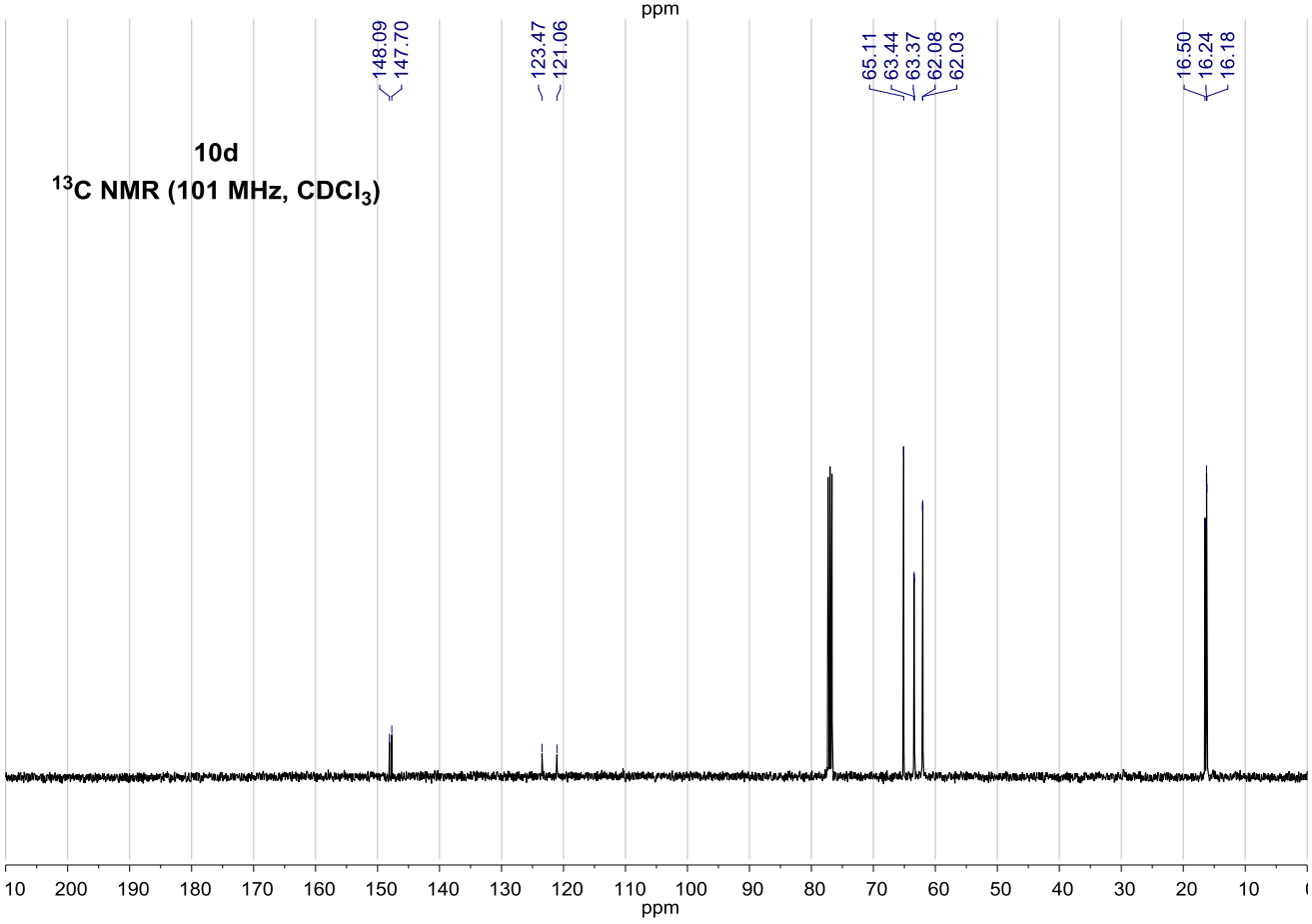
10b

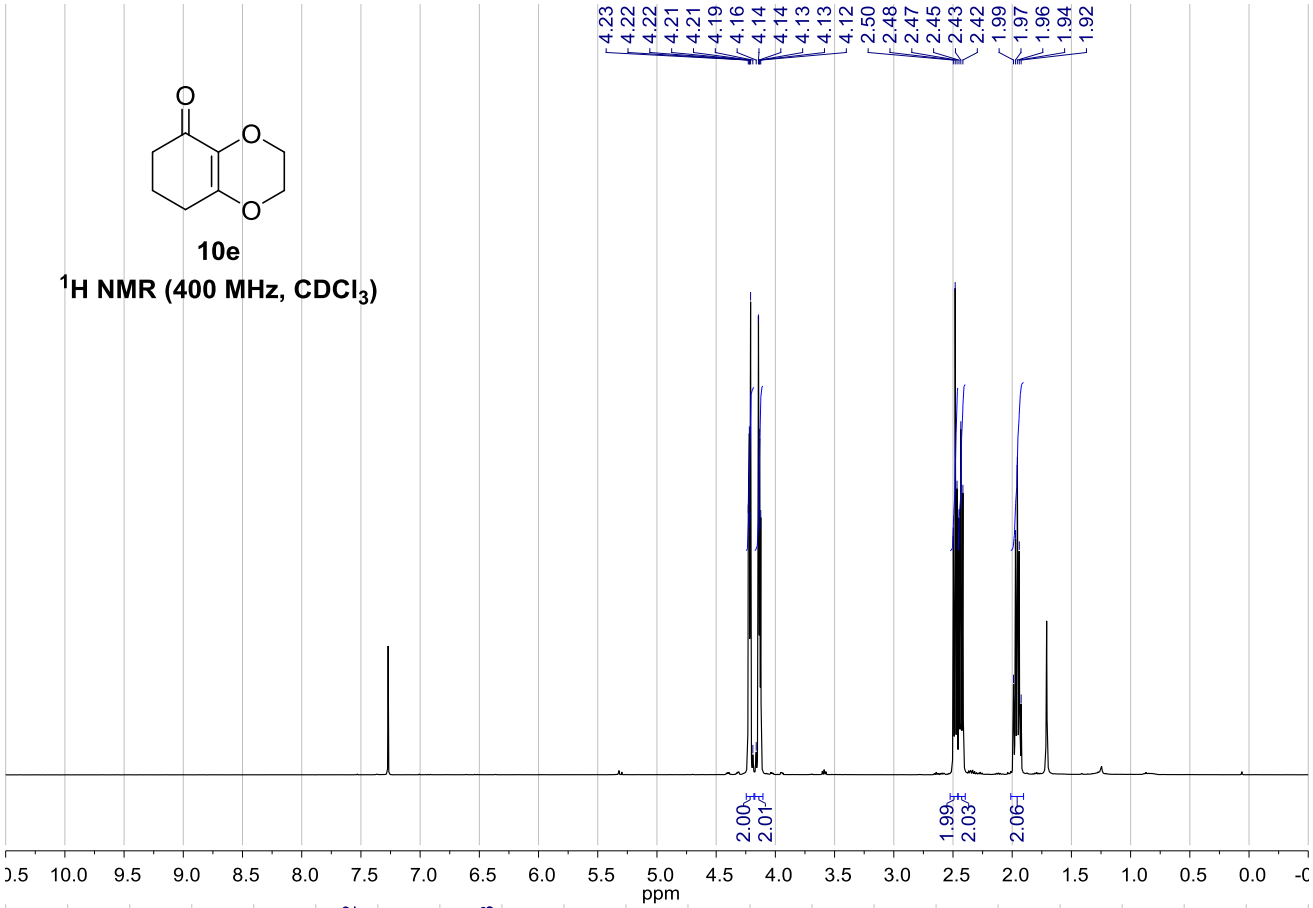
^{13}C NMR (101 MHz, $CDCl_3$)

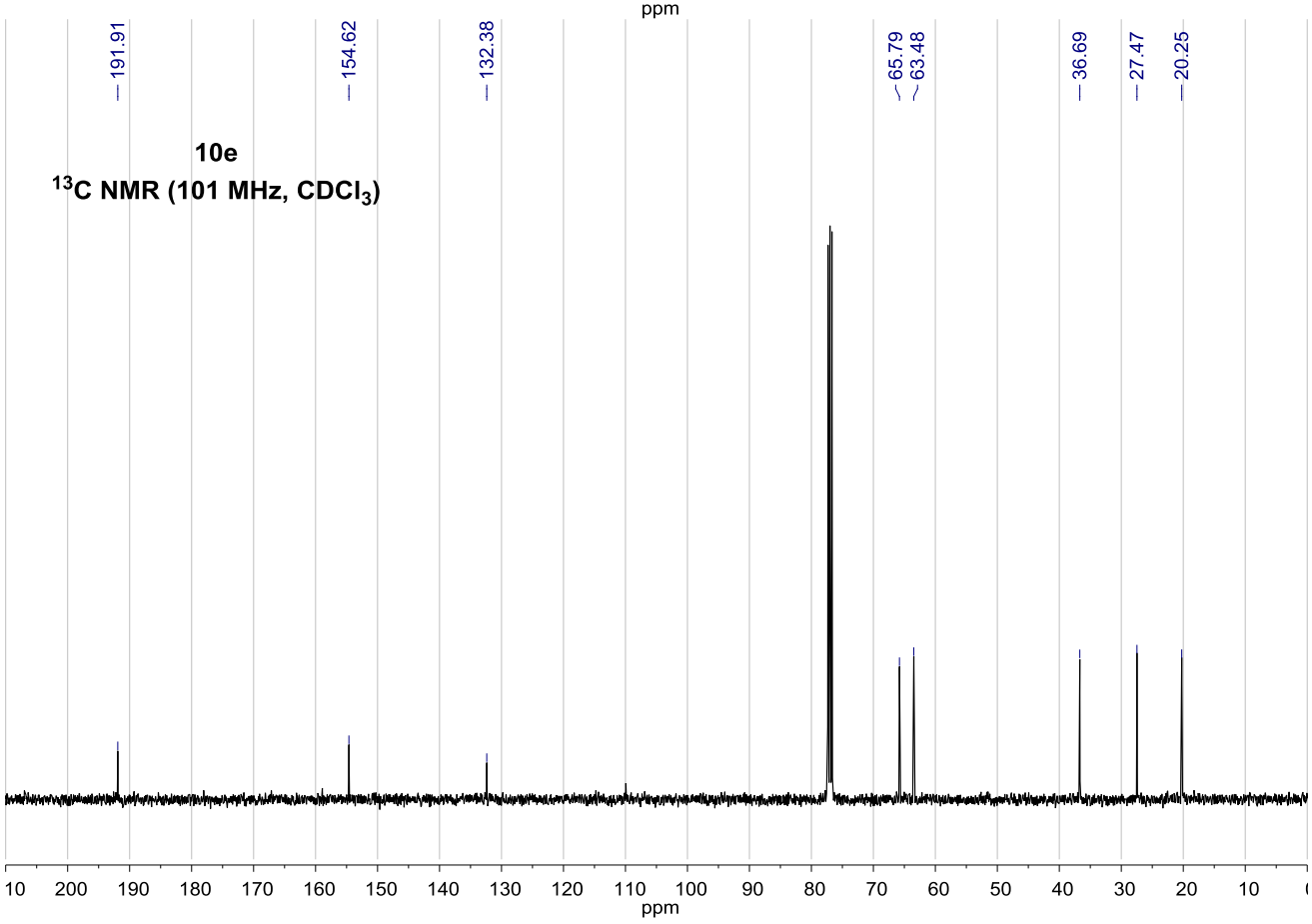

7.92
7.91
7.90
7.90
7.63
7.62
7.62
7.61
7.61
7.60
7.59
7.59
7.58
7.54
7.54
7.52
7.52
7.51
7.50
4.12
4.12
4.12
4.11
4.11
3.96
3.95
3.95
3.94
3.94
2.29
PhO2S
O
O
10c
1H NMR (400 MHz, CDCl3)
1.98
1.08
1.95
2.00
2.01
2.95
ppm

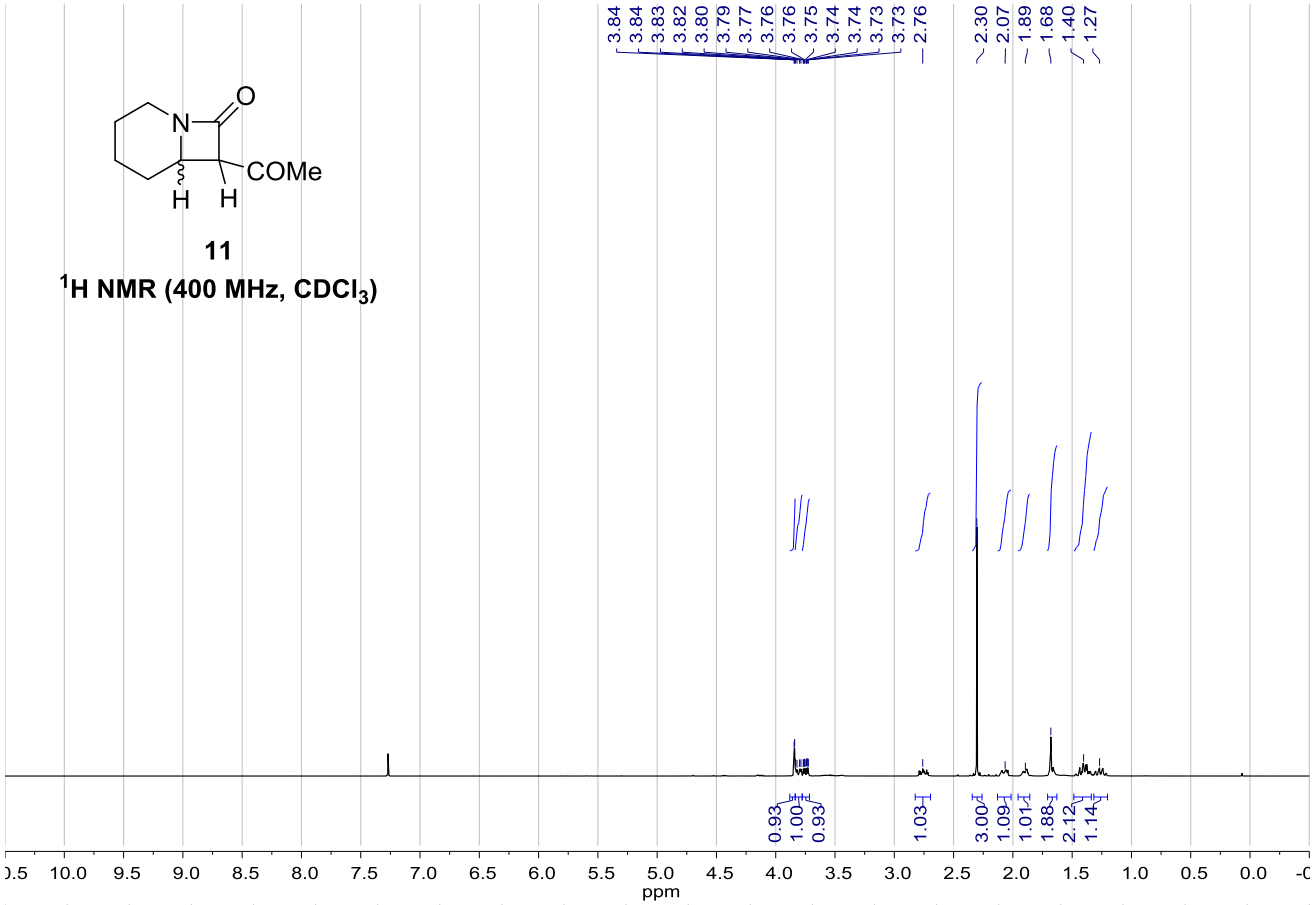

144.52
140.70
133.12
132.21
128.91
127.30
65.20
64.19
16.46
10c
13C NMR (101 MHz, CDCl3)
ppm


4.17 4.16 4.16 4.16 4.15 4.15 4.15 4.14 4.14 4.13 4.13 4.13 4.12 4.11 4.11 4.11 4.10 4.10 4.10 4.09 4.08 4.08 4.08 4.07 4.07 4.06 4.06 4.06 4.05 4.04 4.04 4.00 4.00 3.99 3.99 3.98 2.13 2.13 1.35 1.35 1.33 1.33 1.31 1.31
(EtO)2OP
O
O
10d
1H NMR (400 MHz, CDCl3)
5.96 2.00 2.97 5.96
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
ppm


148.09 147.70 123.47 121.06 65.11 63.44 63.37 62.08 62.03 16.50 16.24 16.18
10d
13C NMR (101 MHz, CDCl3)
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10
ppm

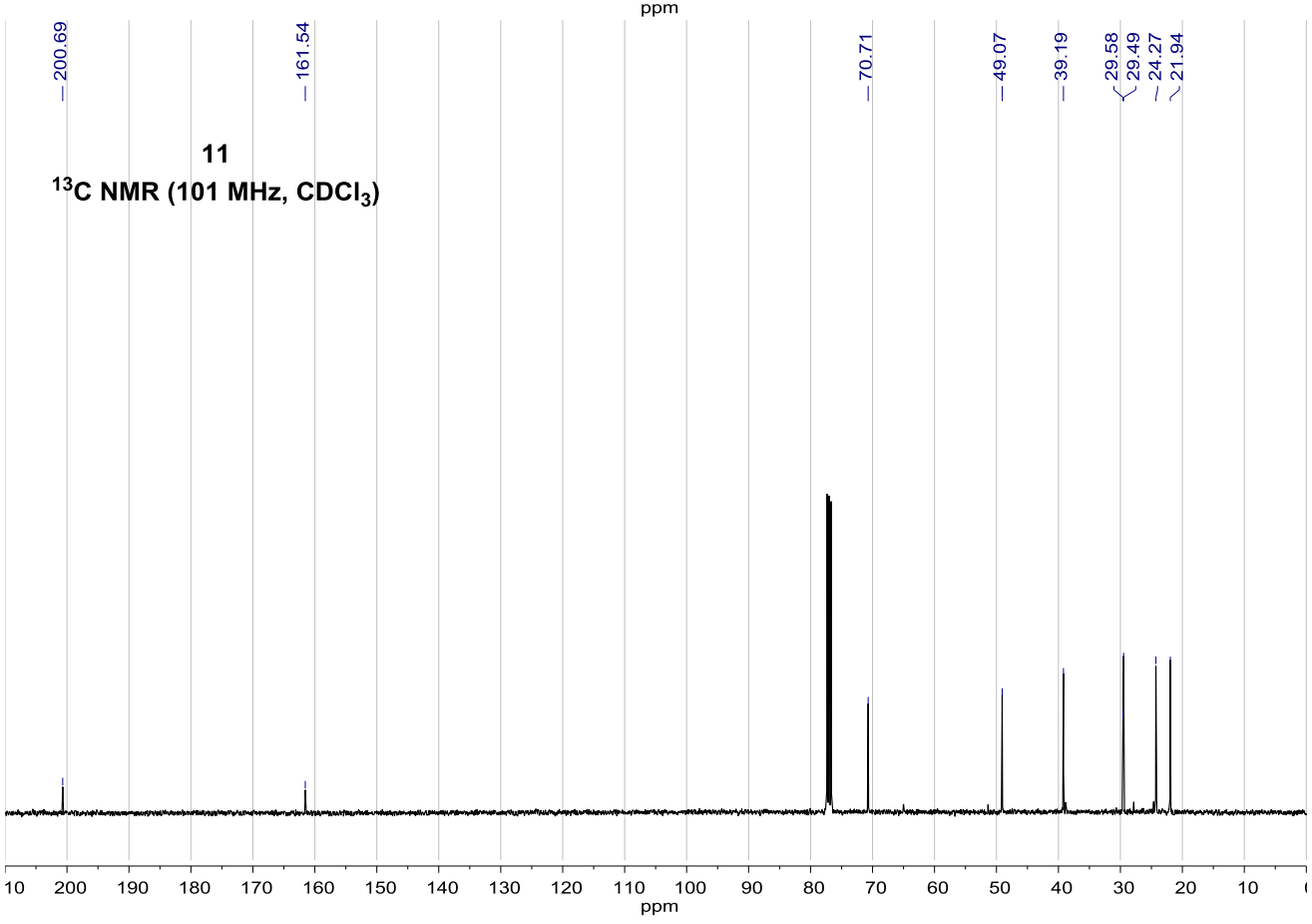

4.23
4.22
4.22
4.21
4.21
4.19
4.16
4.14
4.14
4.13
4.13
4.12
2.50
2.48
2.47
2.45
2.43
2.42
1.99
1.97
1.96
1.94
1.92
O
O
O
10e
^{1}H NMR (400 MHz, CDCl$_3$)
2.00
2.01
1.99
2.03
2.06
ppm


191.91
154.62
132.38
65.79
63.48
36.69
27.47
20.25
10e
^{13}C NMR (101 MHz, CDCl$_3$)
ppm



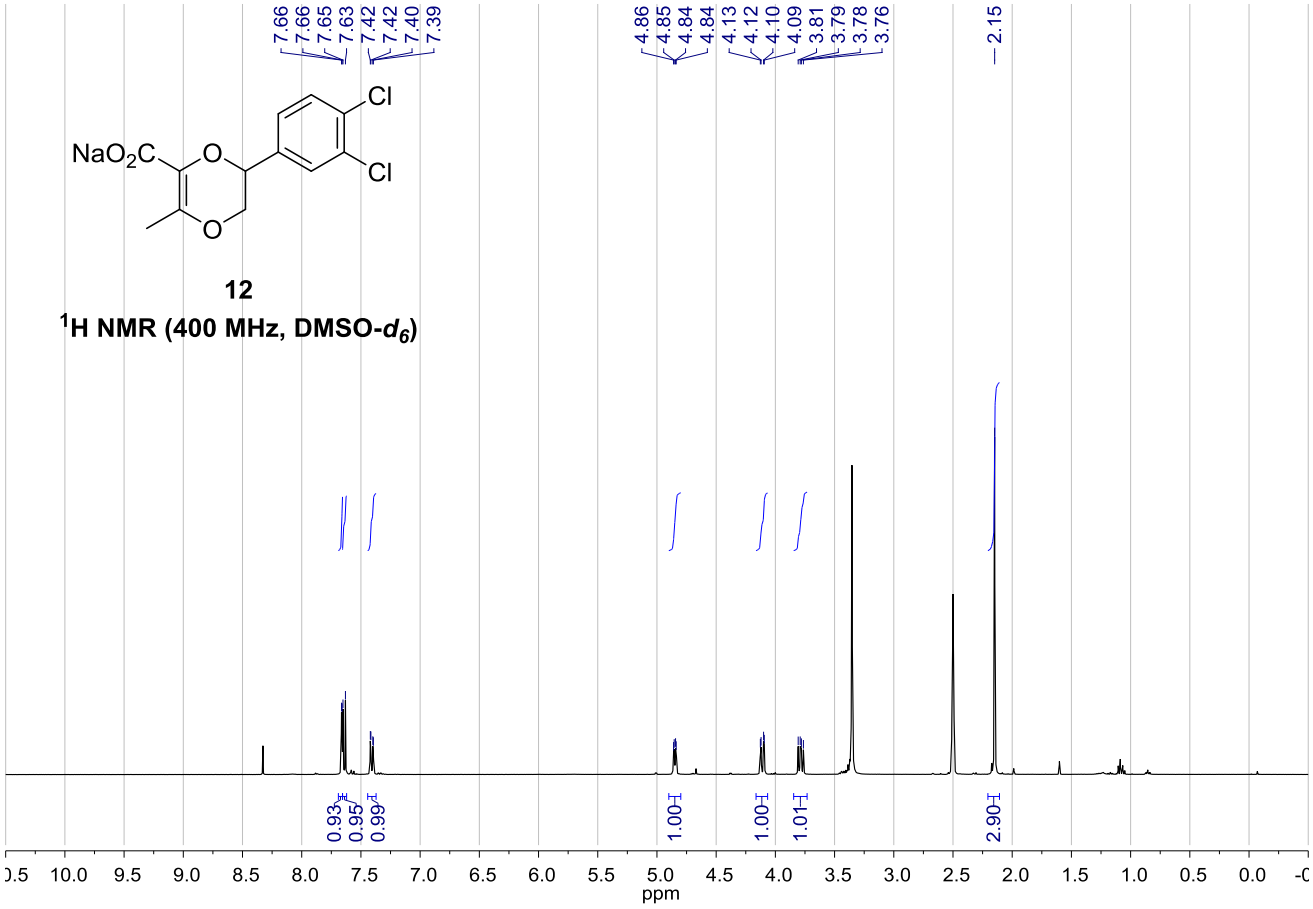
11

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



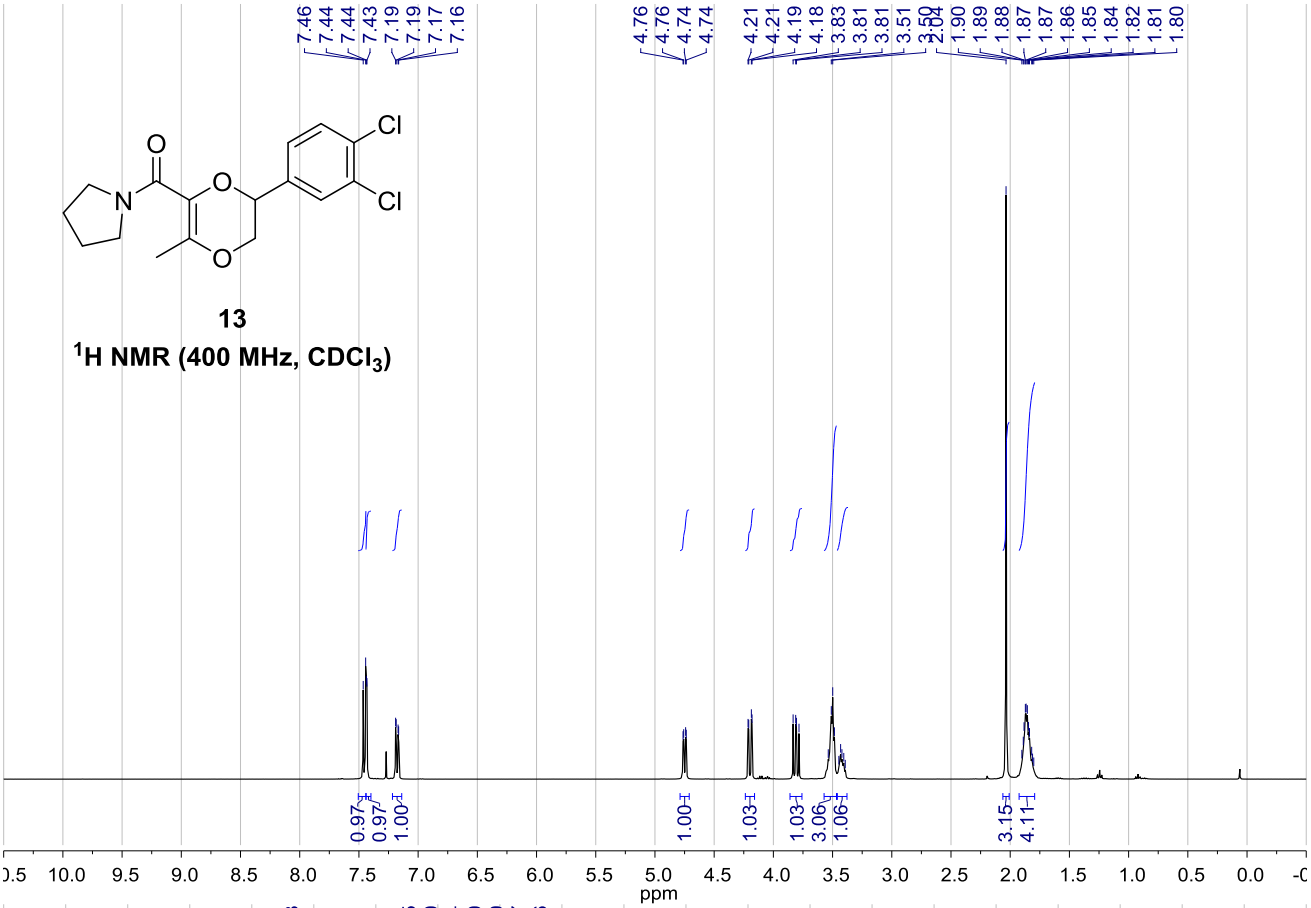
11

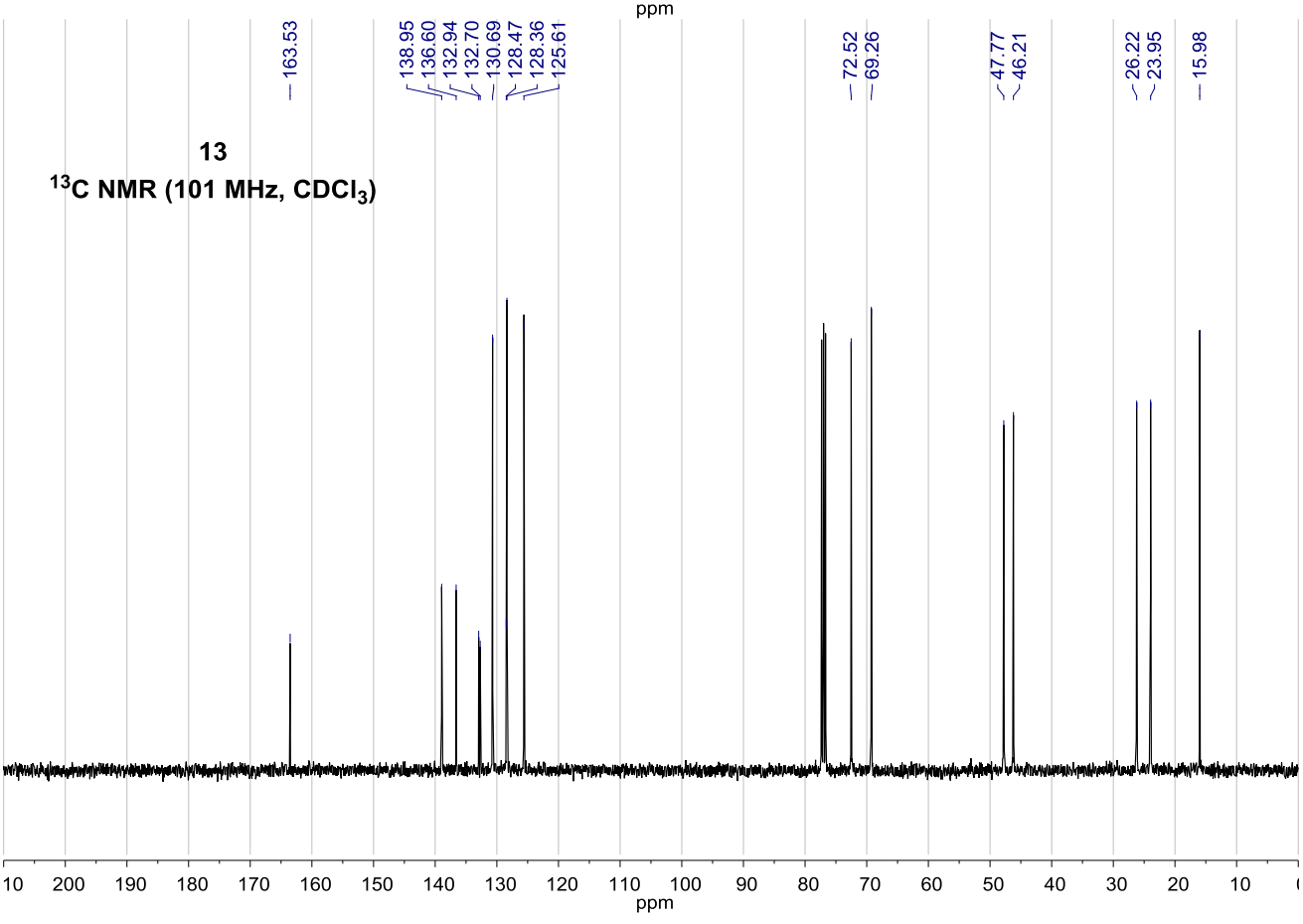
^{13}C NMR (101 MHz, $CDCl_3$)

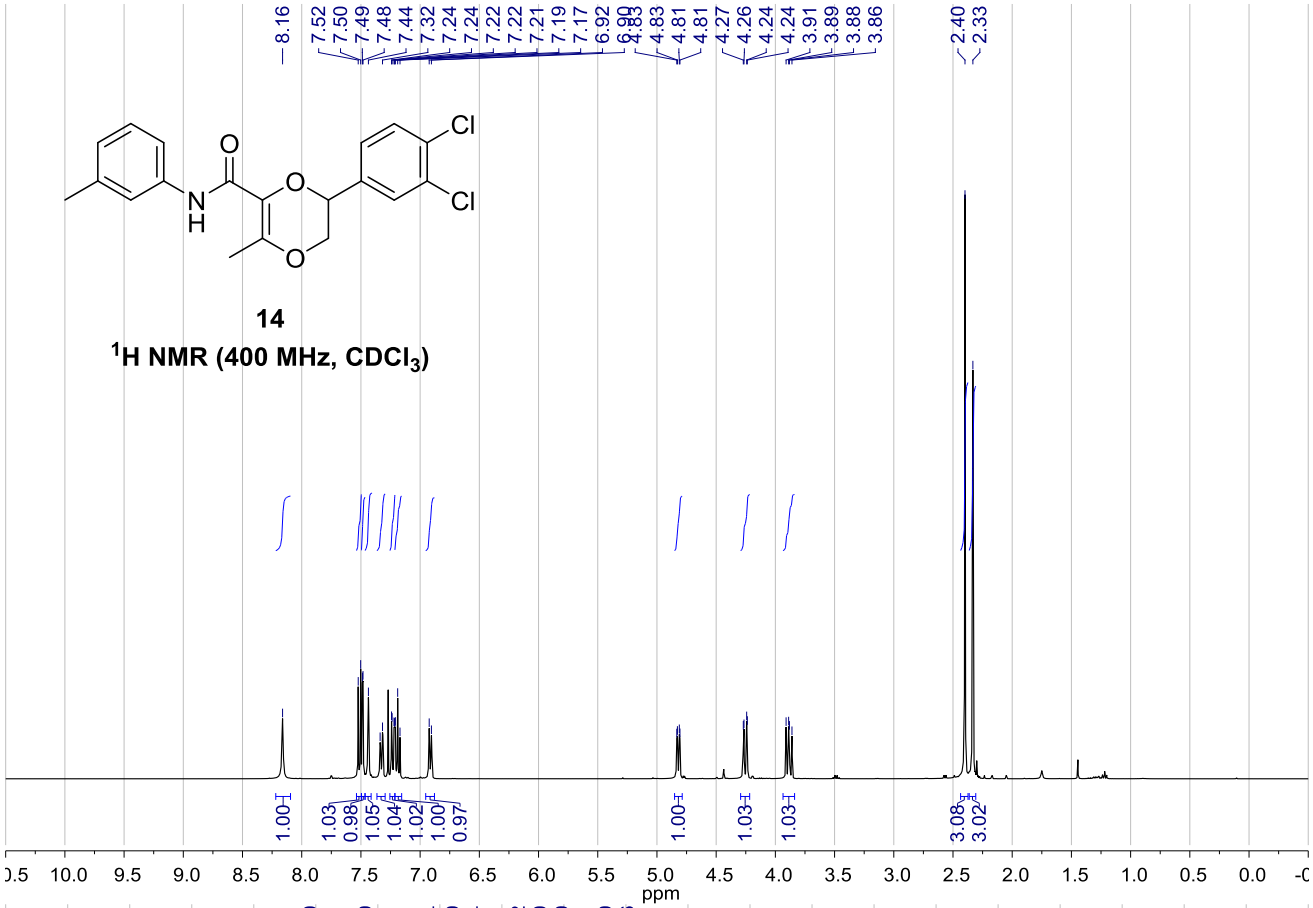


12

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

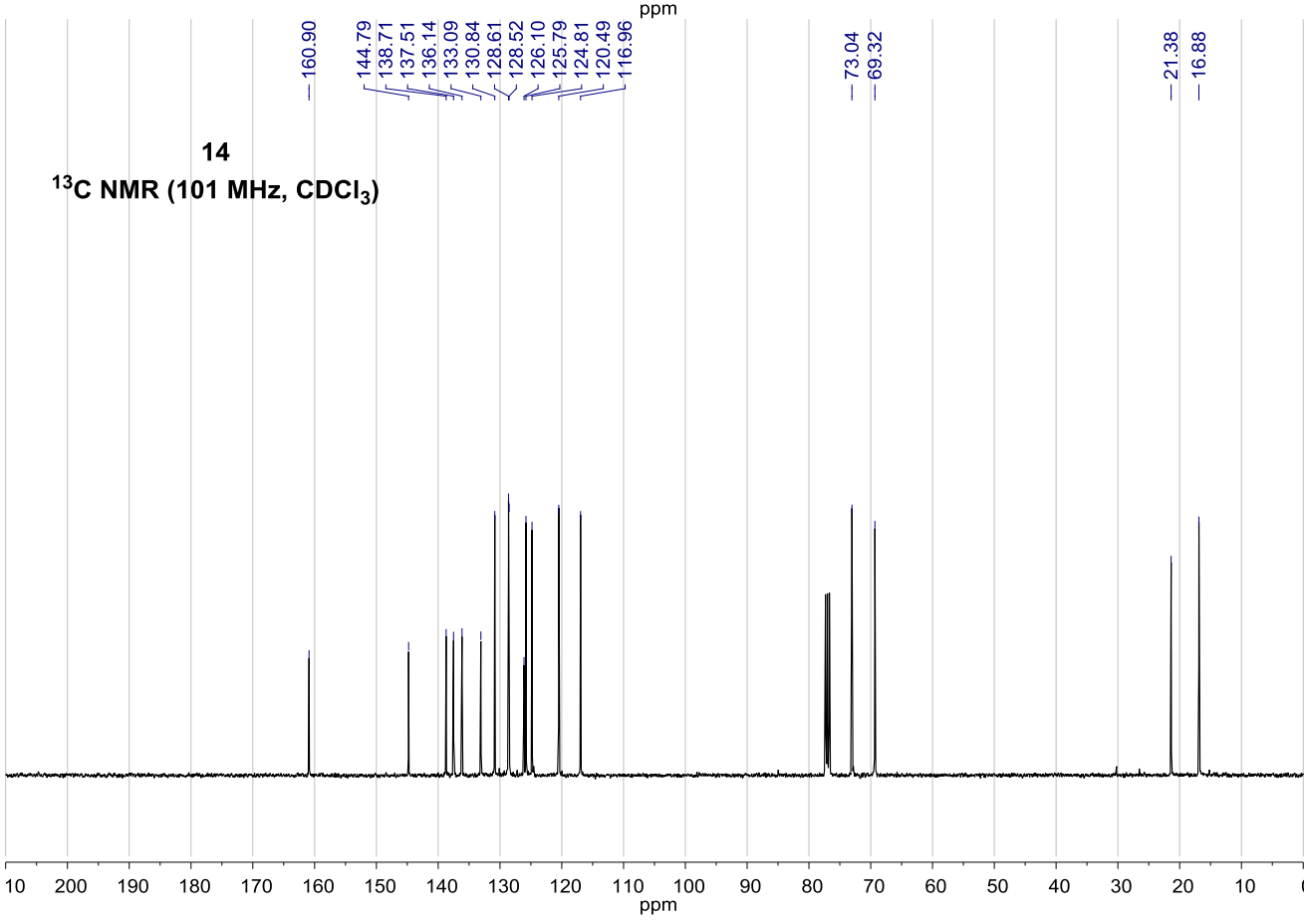

7.46
7.44
7.44
7.43
7.19
7.19
7.17
7.16
4.76
4.76
4.74
4.74
4.21
4.21
4.19
4.18
3.83
3.81
3.81
3.51
3.50
2.04
1.90
1.89
1.88
1.87
1.87
1.86
1.85
1.84
1.82
1.81
1.80
O
N
O
O
Cl
Cl
13
^{1}H NMR (400 MHz, CDCl$_3$)
0.97
0.97
1.00
1.00
1.03
1.03
3.06
1.06
3.15
4.11
ppm


163.53
138.95
136.60
132.94
132.70
130.69
128.47
128.36
125.61
72.52
69.26
47.77
46.21
26.22
23.95
15.98
13
^{13}C NMR (101 MHz, CDCl$_3$)
ppm



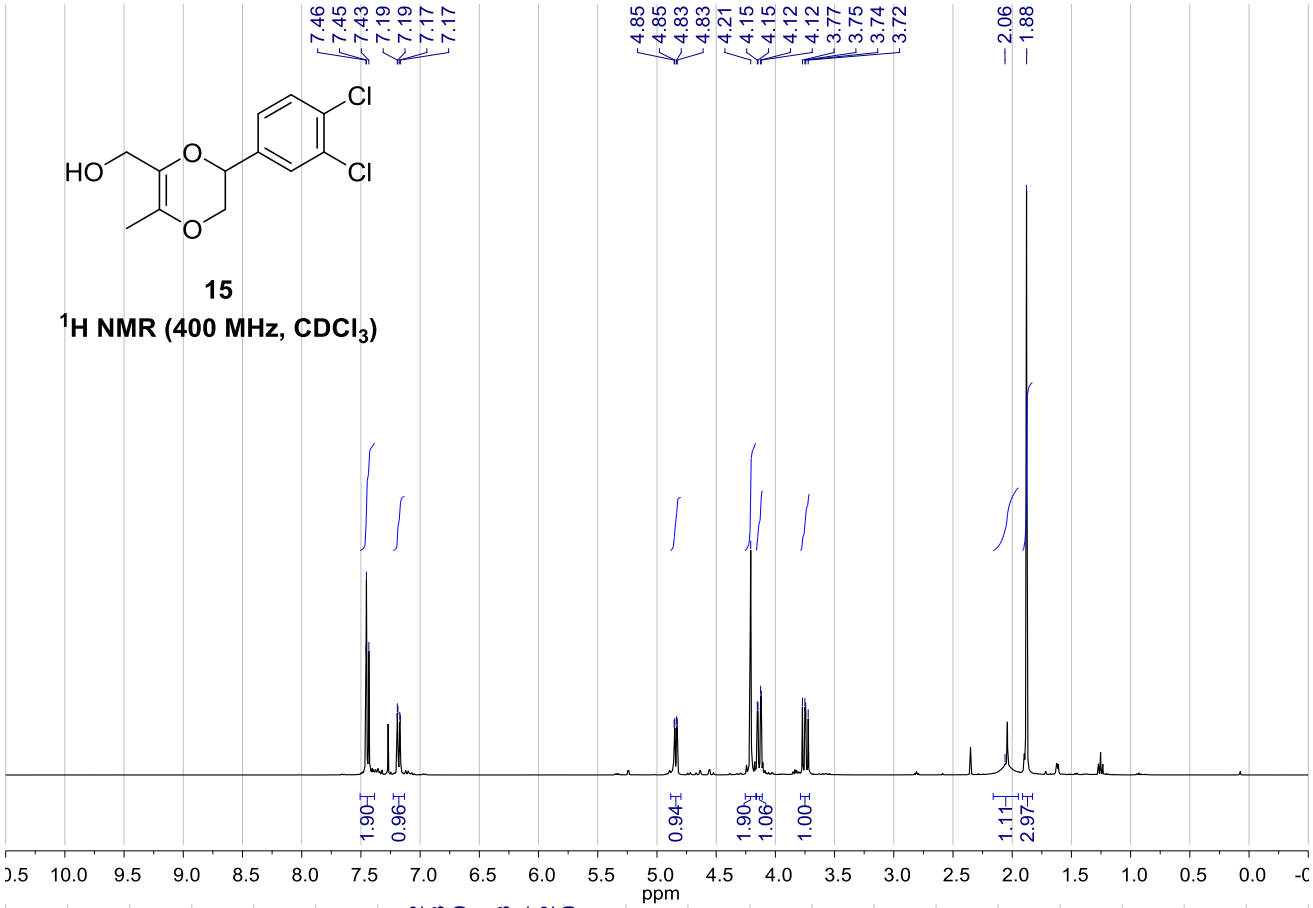
14

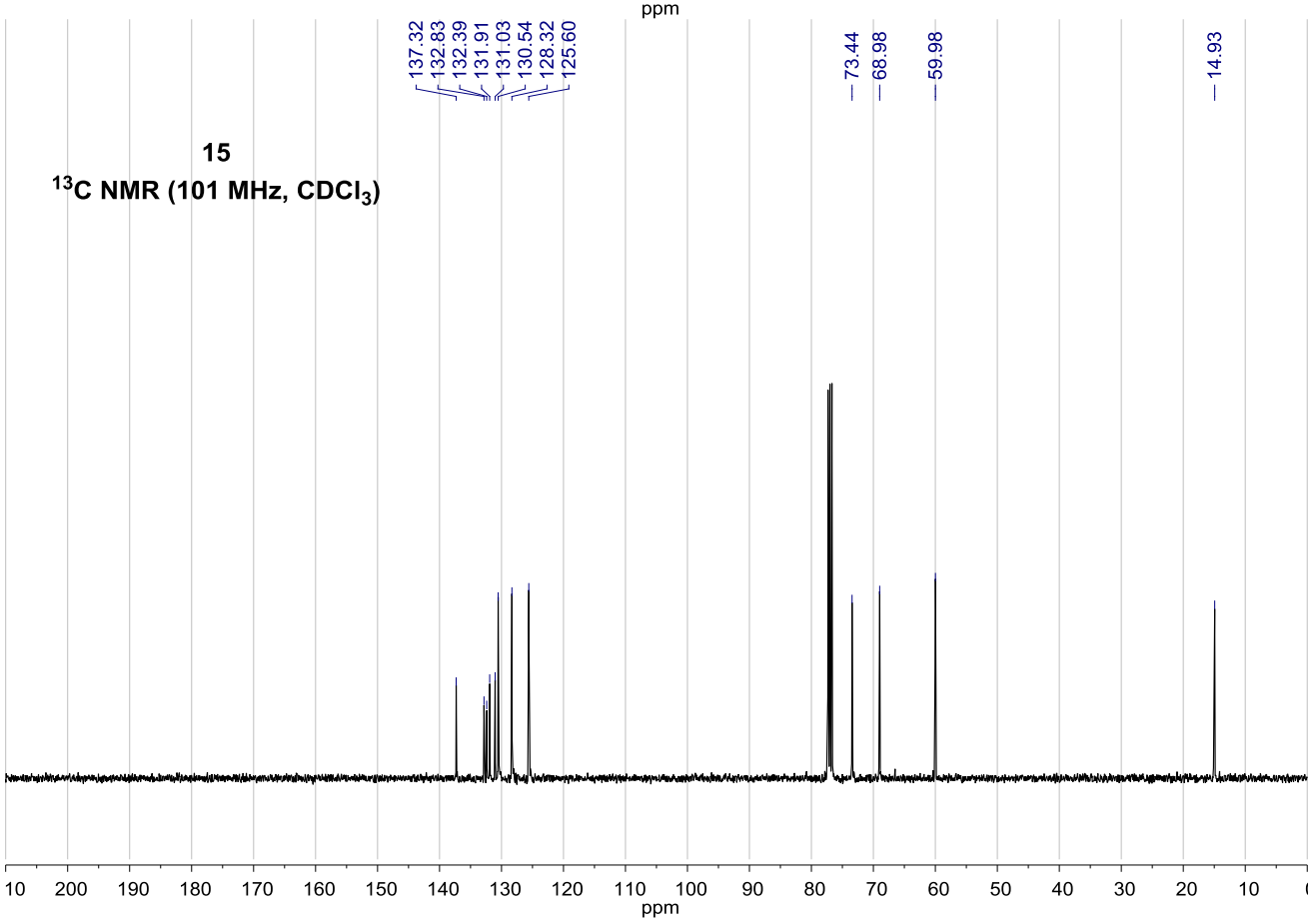
^{1}H NMR (400 MHz, $CDCl_3$)



14

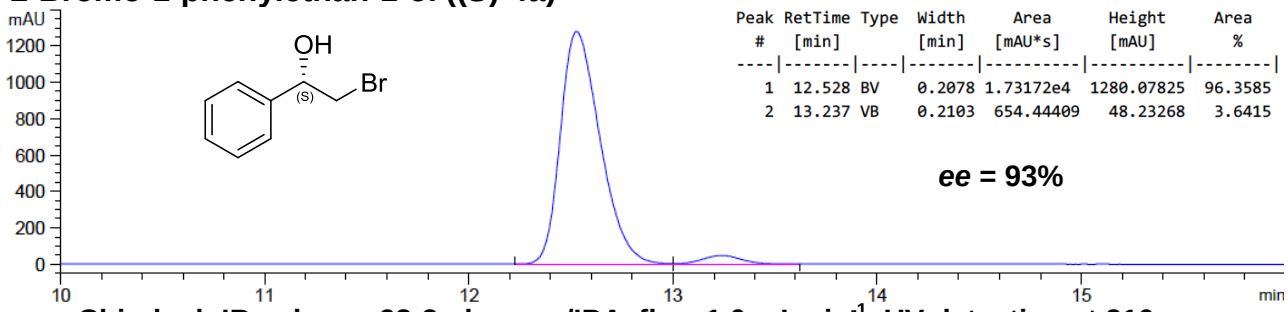
^{13}C NMR (101 MHz, $CDCl_3$)


7.46
7.45
7.43
7.19
7.19
7.17
7.17
4.85
4.85
4.83
4.83
4.21
4.15
4.15
4.12
4.12
3.77
3.75
3.74
3.72
2.06
1.88
Cl
Cl
HO
O
O
15
^{1}H NMR (400 MHz, CDCl$_3$)
1.90
0.96
0.94
1.90
1.06
1.00
1.11
2.97
ppm


137.32
132.83
132.39
131.91
131.03
130.54
128.32
125.60
73.44
68.98
59.98
14.93
15
^{13}C NMR (101 MHz, CDCl$_3$)
ppm

HPLC Traces

(1*S*)-2-Bromo-1-phenylethan-1-ol ((*S*)-4a)

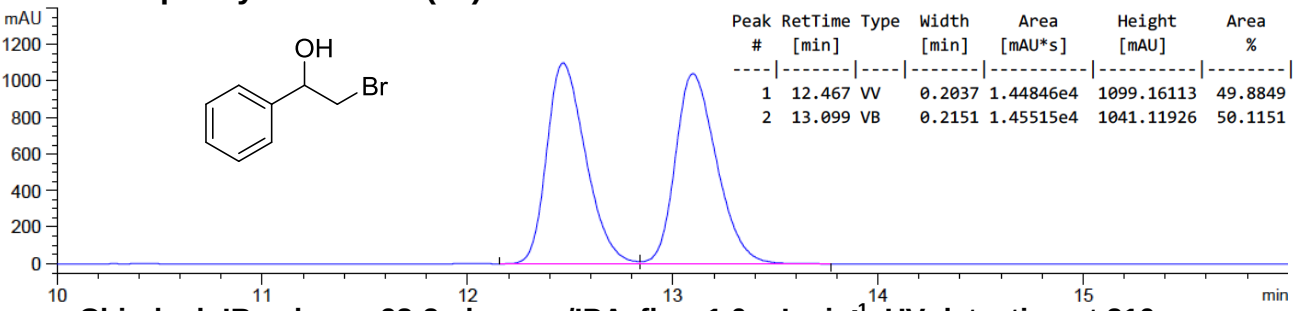


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	12.528	BV	0.2078	1.73172e4	1280.07825	96.3585
2	13.237	VB	0.2103	654.44409	48.23268	3.6415

***ee* = 93%**

Chiralpak-IB column, 98:2 *n*hexane/IPA, flow 1.0 mLmin^{-1}, UV detection at 210 nm

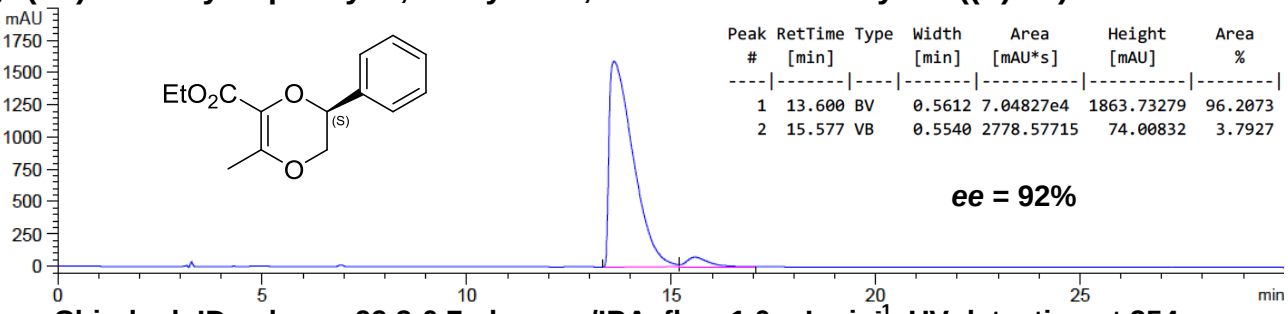
(±)-2-Bromo-1-phenylethan-1-ol (4a)



Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	12.467	VV	0.2037	1.44846e4	1099.16113	49.8849
2	13.099	VB	0.2151	1.45515e4	1041.11926	50.1151

Chiralpak-IB column, 98:2 *n*hexane/IPA, flow 1.0 mLmin^{-1}, UV detection at 210 nm

Ethyl (6*S*)-3-methyl-6-phenyl-5,6-dihydro-1,4-dioxine-2-carboxylate ((*S*)-6a)

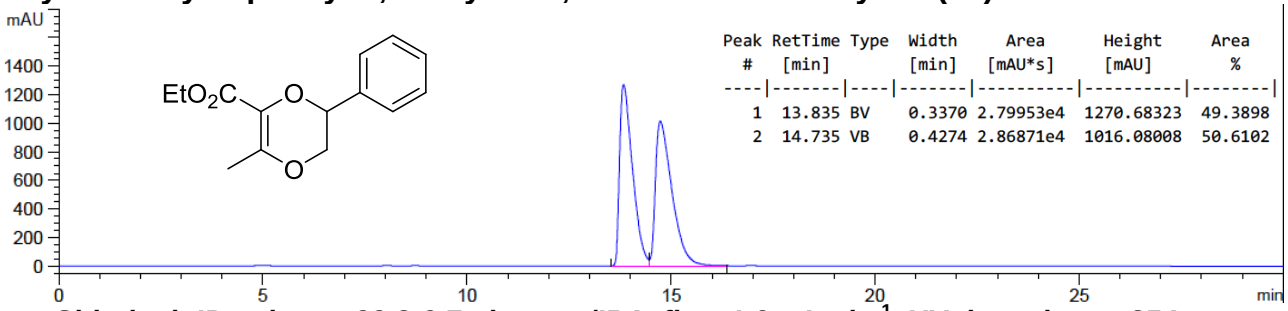


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	13.600	BV	0.5612	7.04827e4	1863.73279	96.2073
2	15.577	VB	0.5540	2778.57715	74.00832	3.7927

***ee* = 92%**

Chiralpak-ID column, 99.3:0.7 *n*hexane/IPA, flow 1.0 mLmin^{-1}, UV detection at 254 nm

(±)-Ethyl 3-methyl-6-phenyl-5,6-dihydro-1,4-dioxine-2-carboxylate (6a)



Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	13.835	BV	0.3370	2.79953e4	1270.68323	49.3898
2	14.735	VB	0.4274	2.86871e4	1016.08008	50.6102

Chiralpak-ID column, 99.3:0.7 *n*hexane/IPA, flow 1.0 mLmin^{-1}, UV detection at 254 nm

References

[1] Austeri, M.; Rix, D.; Zeghida, W.; Lacour, J. *Org. Lett.* **2011**, *13*, 1394.