Electronic Supplementary Material (ESI) for Organic & Biomolecular Chemistry.

On the ozonolysis of unsaturated tosylhydrazones as a direct approach to diazocarbonyl compounds

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Model Study for Selective Ozonolysis

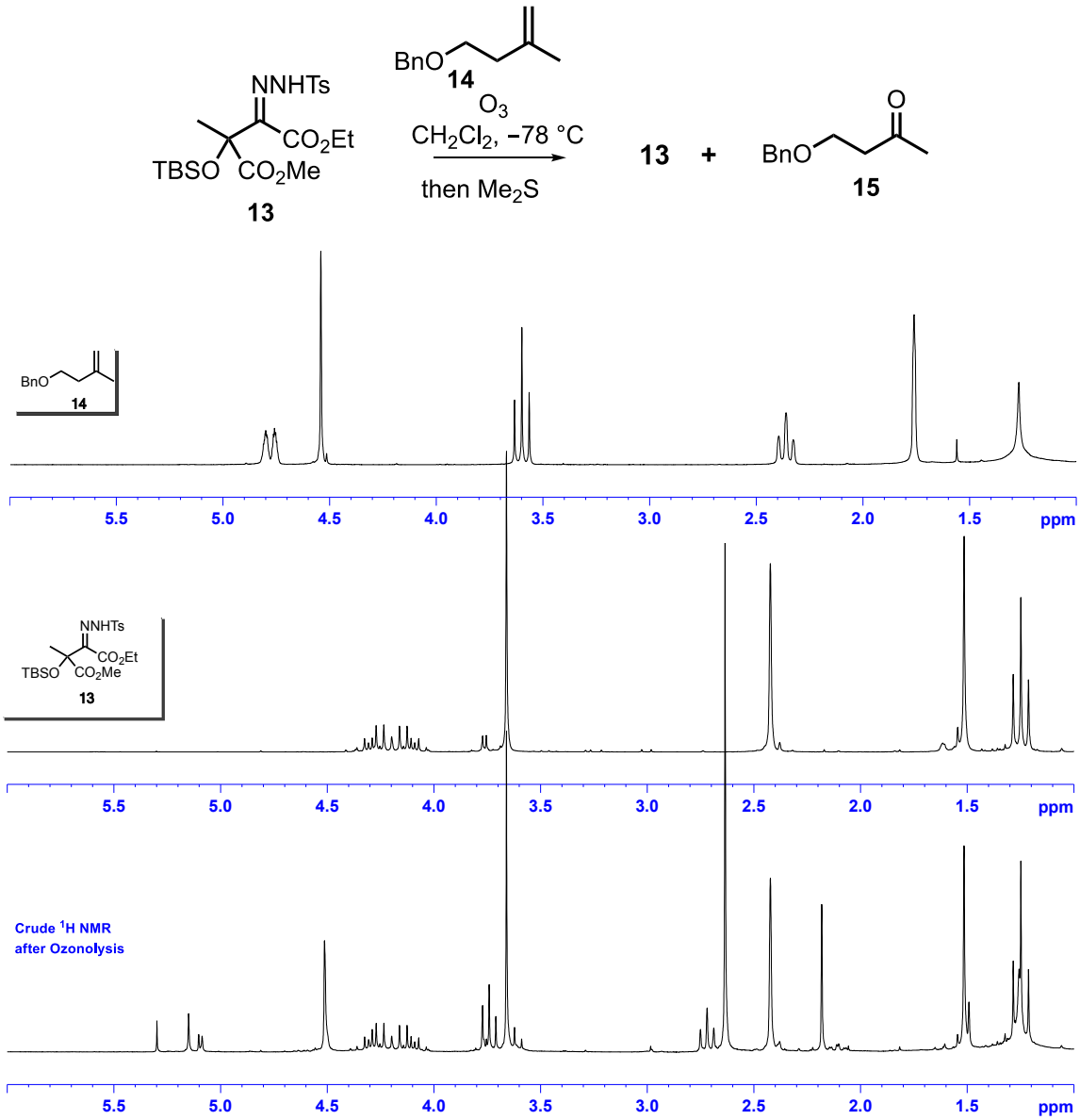


Fig S1. ^{1}H NMR (200 MHz, $CDCl_3$) comparison of alkene **14** and model hydrazone **13** with crude product from ozonolysis of **14** and **13**.

Single Crystal X-ray Diffraction Determination

Low temperature single crystal X-ray diffraction data for tetrahydropyridazinol **35** were collected with a (Rigaku) Oxford Diffraction SuperNova A diffractometer at 150 K. Data were reduced using the CrysAlisPro. All structures were solved *ab initio* using SuperFlip[1] and the structures were refined using CRYSTALS.[2] Further details about the refinement are documented in the CIF. The crystallographic data have been deposited with the CCDC as entry 1815202. Crystals suitable for X-ray diffraction were grown by vapour diffusion of pentane into a concentrated solution of **35** in benzene.

Compound Number	**35**
Moiety Formula	$C_{14}H_{18}N_2O_5S$
CCDC	1815202
Space Group	P $2_1/c$
a [Å]	10.0967(3)
b [Å]	11.1751(3)
c [Å]	13.8100(4)
α [°]	90
β [°]	104.850(3)
γ [°]	90
V [Å^3]	1506.16(8)
Z	4
T [K]	150
Total Reflections	14431
R_{int}	0.0218
Reflections, Restraints, Parameters (I>-3.0/ σ (I))	3124, 0, 199
Min. and Max. Residual Density, [eÅ^{-3}]	-0.40, 0.28
R_1 (I>2σ(I)) wR_2	0.0299 0.0781

Table S1. Summary of X-ray crystallographic data for tetrahydropyridazinol **35**

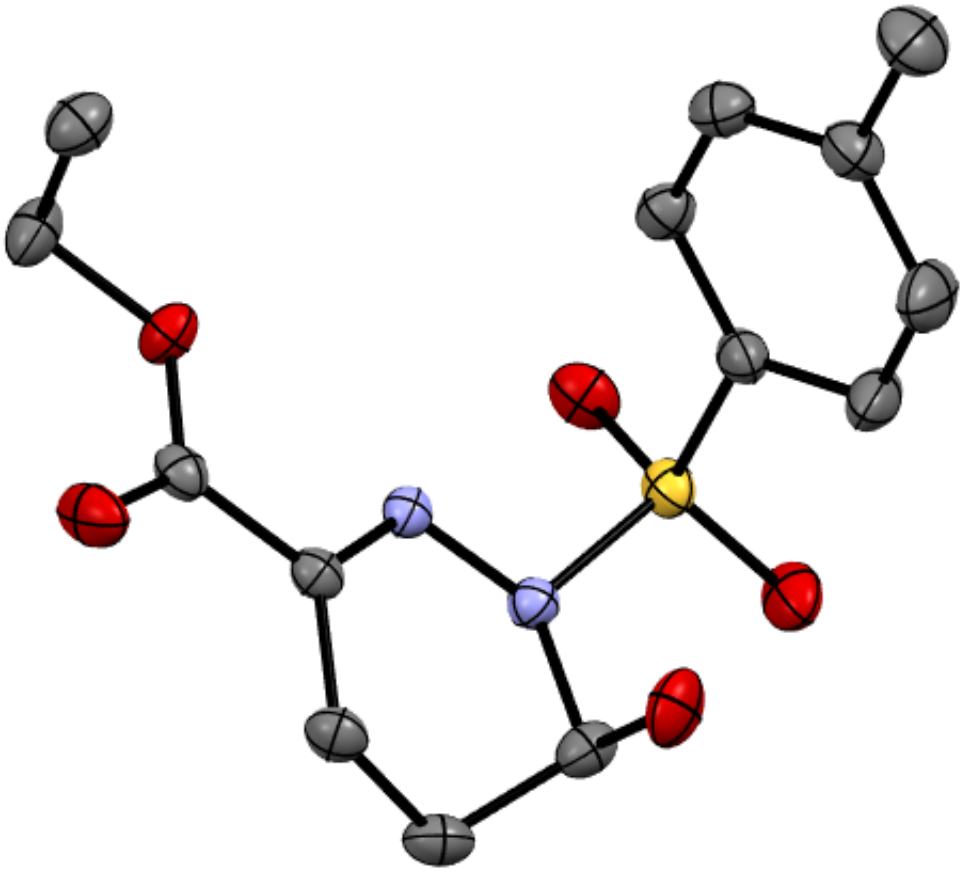


Fig S2. Solid state structure of tetrahydropyridazinol **35**. Displacement ellipsoid plots are drawn at 50% probability. Hydrogen atoms are omitted for clarity.

NMR exchange and NOE studies

NMR investigations of *s-cis*/*trans* isomerism in α-diazoaldehyde **41,** arising from partial double bond character in the N_2C□CHO bond, were undertaken on a sample in $CDCl_3$ at temperatures from 298 to 233 K. At 298 K there was clear evidence of isomer exchange between *s-cis* and *s-trans* forms in 1D NOESY spectra. At 233 K this process was slowed sufficiently such that no exchange between isomers could be detected. Under these conditions, NOEs between the aldehydic protons and neighboring CH_2 protons indicated the major isomer (~ 82%) to adopt the *s-trans* conformation (Fig. S3).

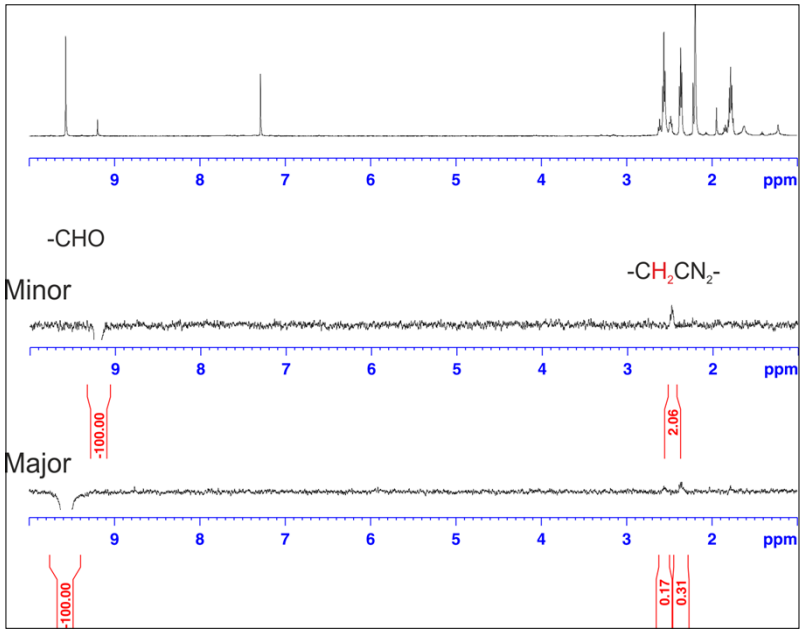
To investigate the barrier to rotation between isomers, as series of 1D magnetisation transfer experiments were undertaken over a range of temperatures from 263 to 298 K. Probe temperatures were pre-calibrated using a methanol standard. 1D EXSY experiments

were recorded using the Bruker selective 1D NOESY sequence *selnogp* with selection of the major rotamer –CHO proton using a 80 ms Gaussian 180° pulse. Chemical exchange to the minor rotamer was monitored by increasing the exchange mixing times from 20 to 500 ms. Plots of the normalised exchange peak intensity (I_{minor}/I_{major}) *versus* mixing time were used to derive exchange rate constants from the initial, linear regions of build-up profiles (Fig. S4). These data (Table S2) were used to derive thermodynamic parameters from the respective Eyring plot (Fig. S5) and Arrhenius plot (Fig. S6): $\Delta H^{\ddagger}$ =72.8 ± 0.4 kJ mol^{-1}; $\Delta S^{\ddagger}$ =-3.5 ± 1.3 J K^{-1} mol^{-1}; $\Delta G^{\ddagger}$ (298 K) =73.8 ± 0.1 kJ mol^{-1}; Ea = 75.1 ± 0.4 kJ mol^{-1}.

	Normalised Exchange peak intensity						
Mixing time /s	**263 K**	**273 K**	**278 K**	**283 K**	**288 K**	**293 K**	**298 K**
0.02	-	0.0009	0.0023	0.0038	0.0057	0.0099	0.0177
0.05	0.0002	0.0026	0.0037	0.0078	0.0137	0.0237	0.0397
0.1	0.0014	0.0044	0.0089	0.0159	0.0278	0.0466	0.0740
0.15	0.0020	0.0071	0.0118	0.0241	0.0406	0.0661	0.1015
0.2	0.0030	0.0095	0.0167	0.0306	0.0526	0.0829	0.1254
0.25	0.0034	0.0114	0.0192	0.0386	0.0631	0.0997	0.1445
0.3	0.0038	0.0135	0.0242	0.0452	0.0738	0.1134	0.1593
0.5	0.0063	0.0222	0.0392	0.0686	0.1092	0.1546	0.1952
Rate constant (s^{-1})	0.013	0.044	0.078	0.152	0.262	0.434	0.702
Standard error	0.0007	0.0006	0.0015	0.0036	0.0047	0.0123	0.0125

Table S2. 1D EXSY normalised exchange peak intensities as a function of mixing times for α-diazoaldehyde **41**, recorded for temperatures from 263 to 298 K. Exchange rate constants were derived from linear regions of these build-up profiles. Standard errors were dervied using the LINEST function of Excel and were used to estimate upper and lower limits of thermodynamic parameters.

a)



b)

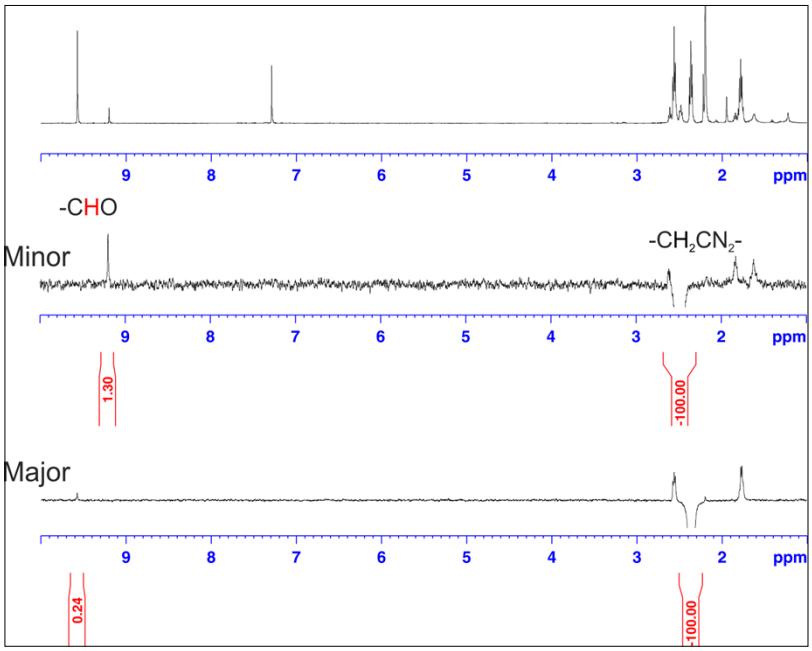


Fig S3. 1D NOESY spectra (800 ms mixing) at 233 K with reference 1D ^{1}H spectrum shown above. a) Irradiation of aldehyde protons; b) irradiation of -CH_2CN_2- protons. Integrals in NOESY spectra are intended to illustrate relative intensity differences only.

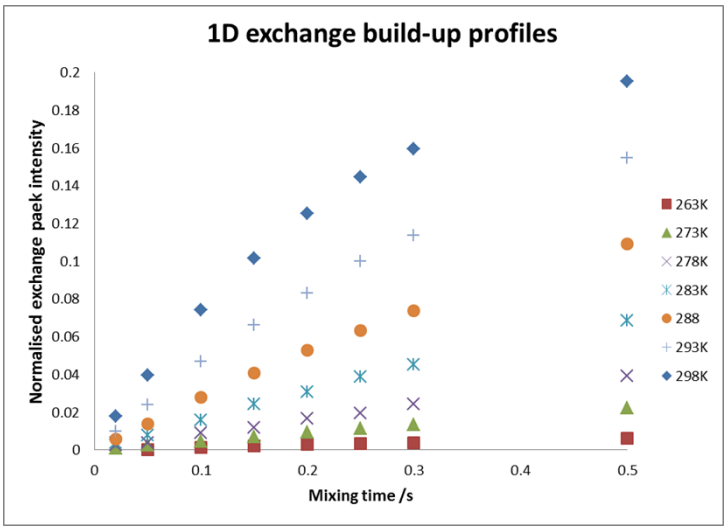


Fig S4. Temperature dependent 1D EXSY build-up profiles for α-diazoaldehyde **41**.

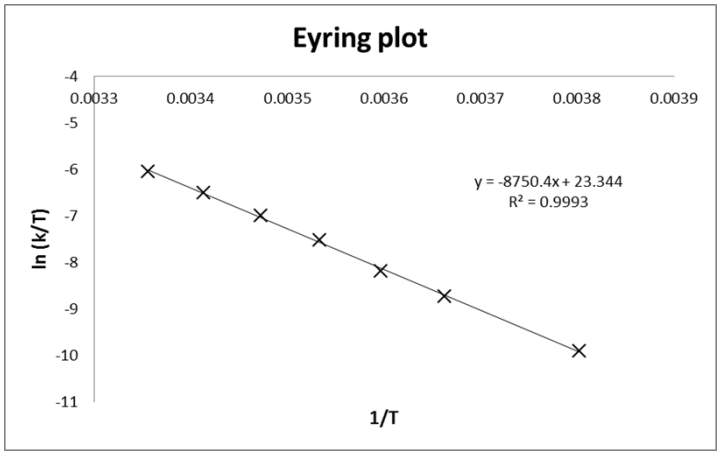


Fig S5. Eyring plot for α-diazoaldehyde **41.**

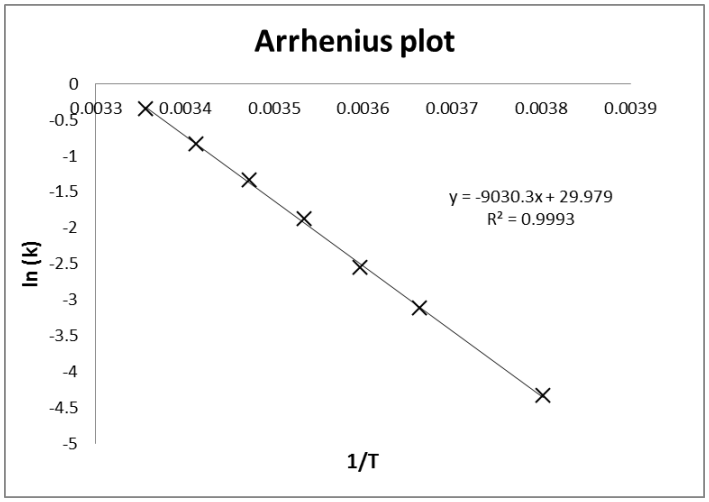
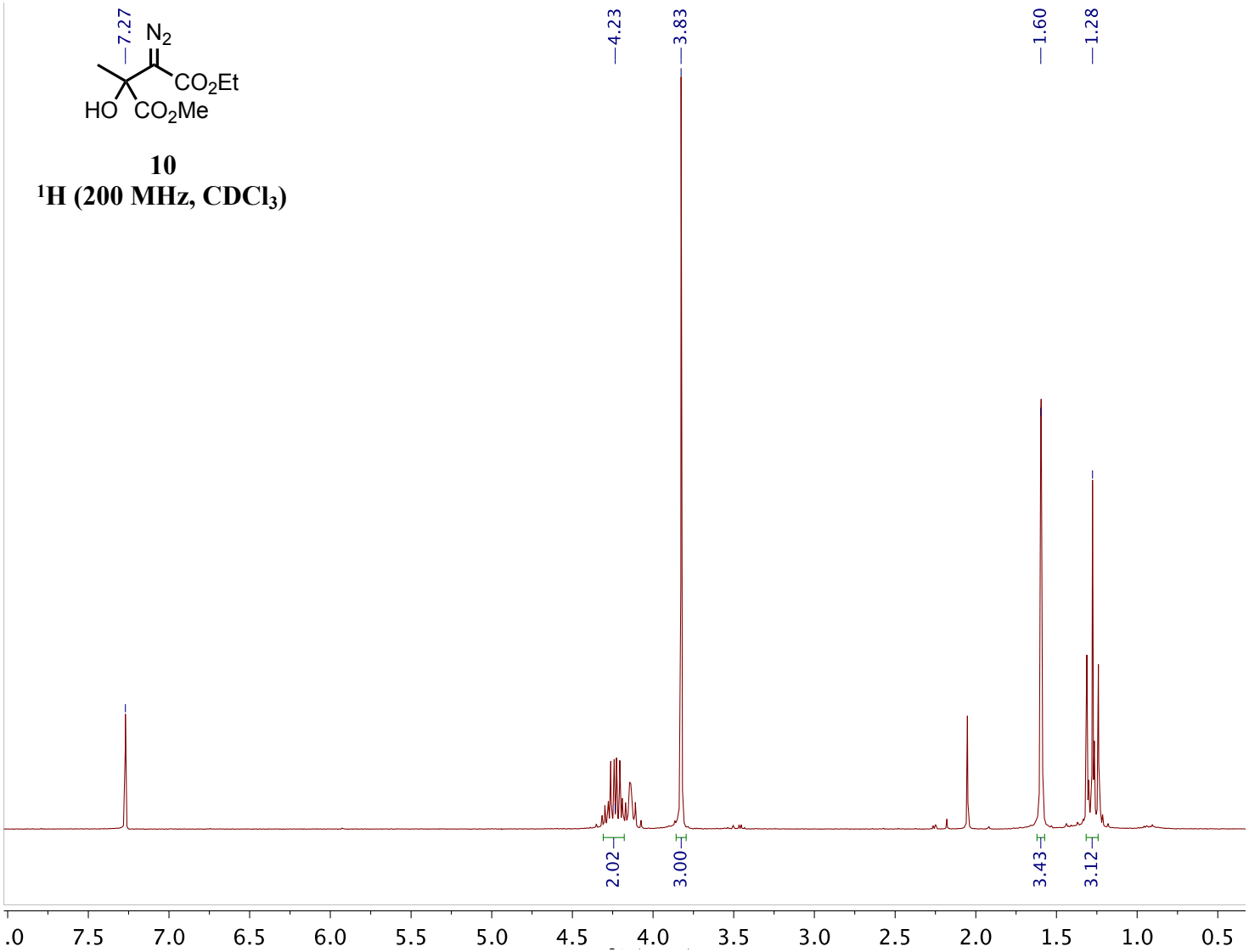
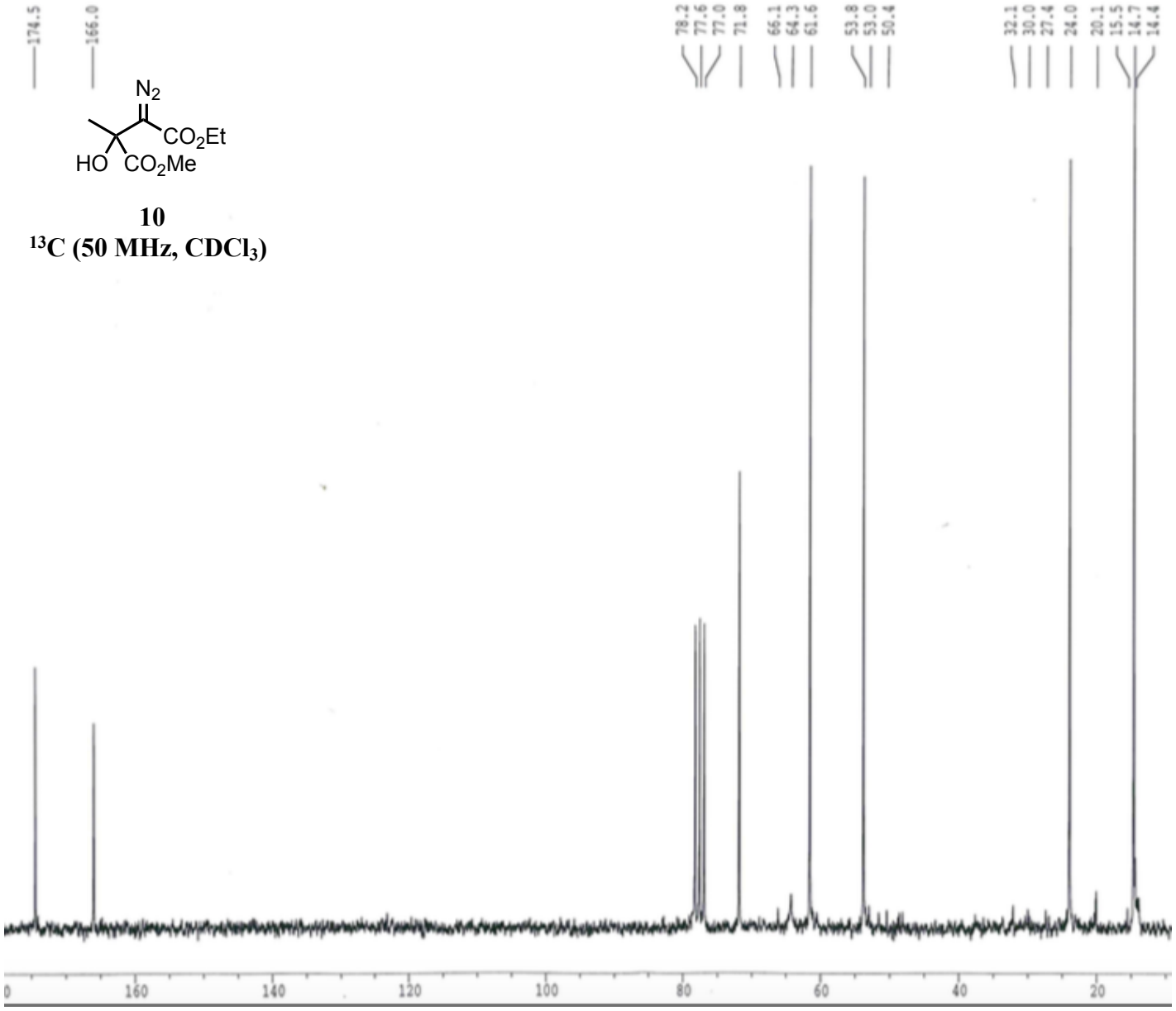


Fig S6. Arrhenius plot for α-diazoaldehyde **41.**

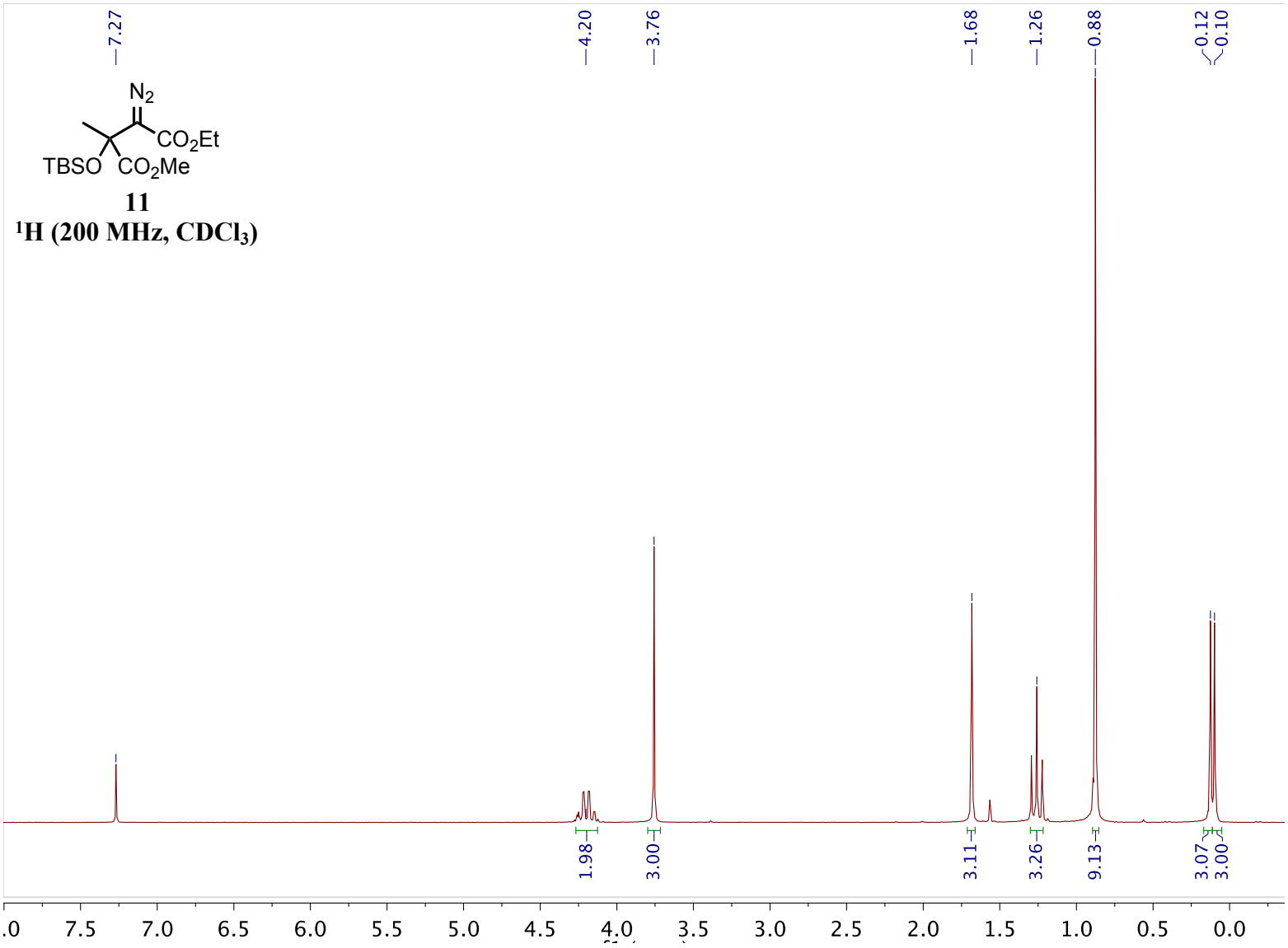
Spectra


7.27
N2
CO2Et
HO
CO2Me
10
1H (200 MHz, CDCl3)
4.23
3.83
1.60
1.28
2.02
3.00
3.43
3.12
.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



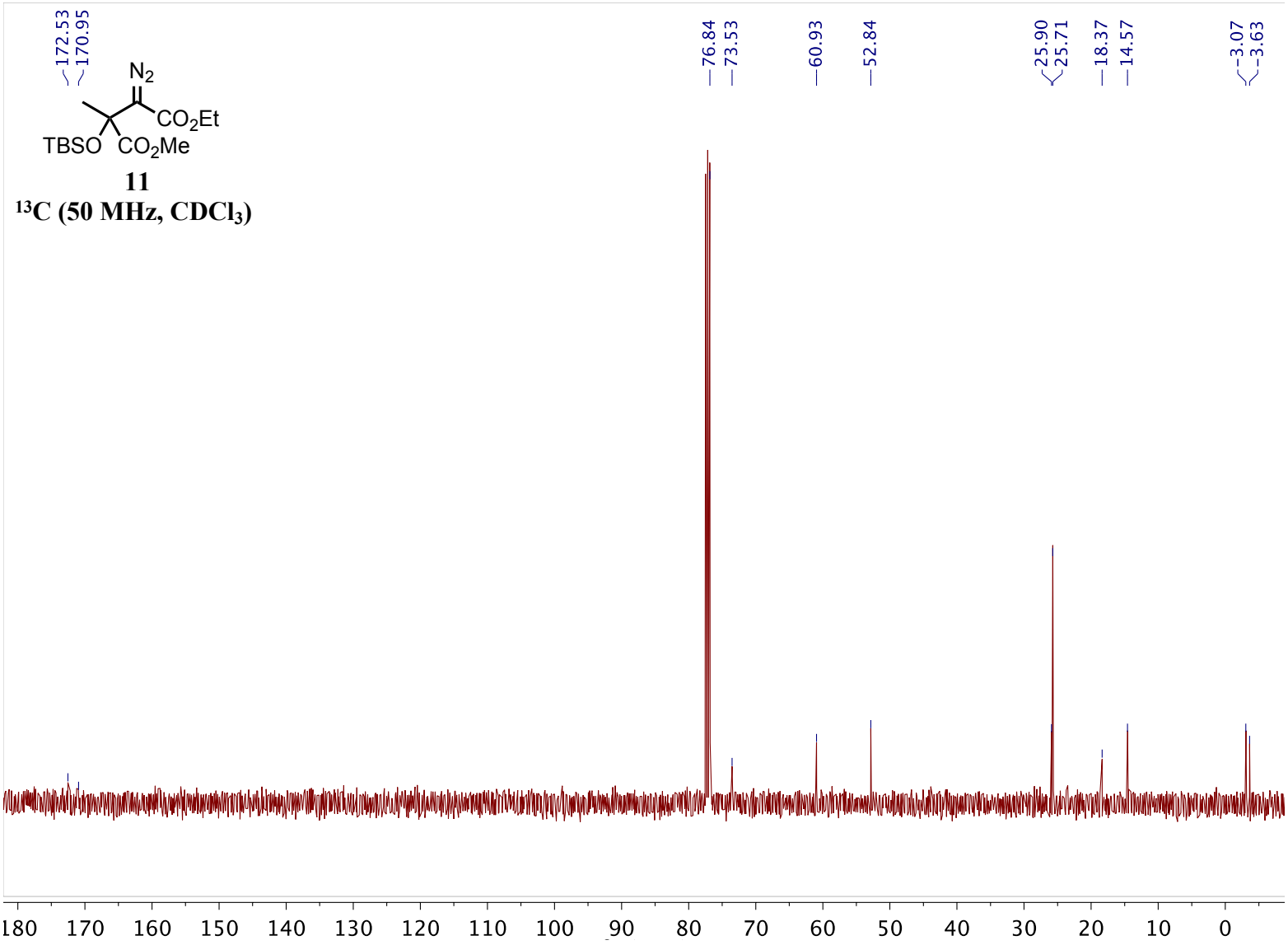
10

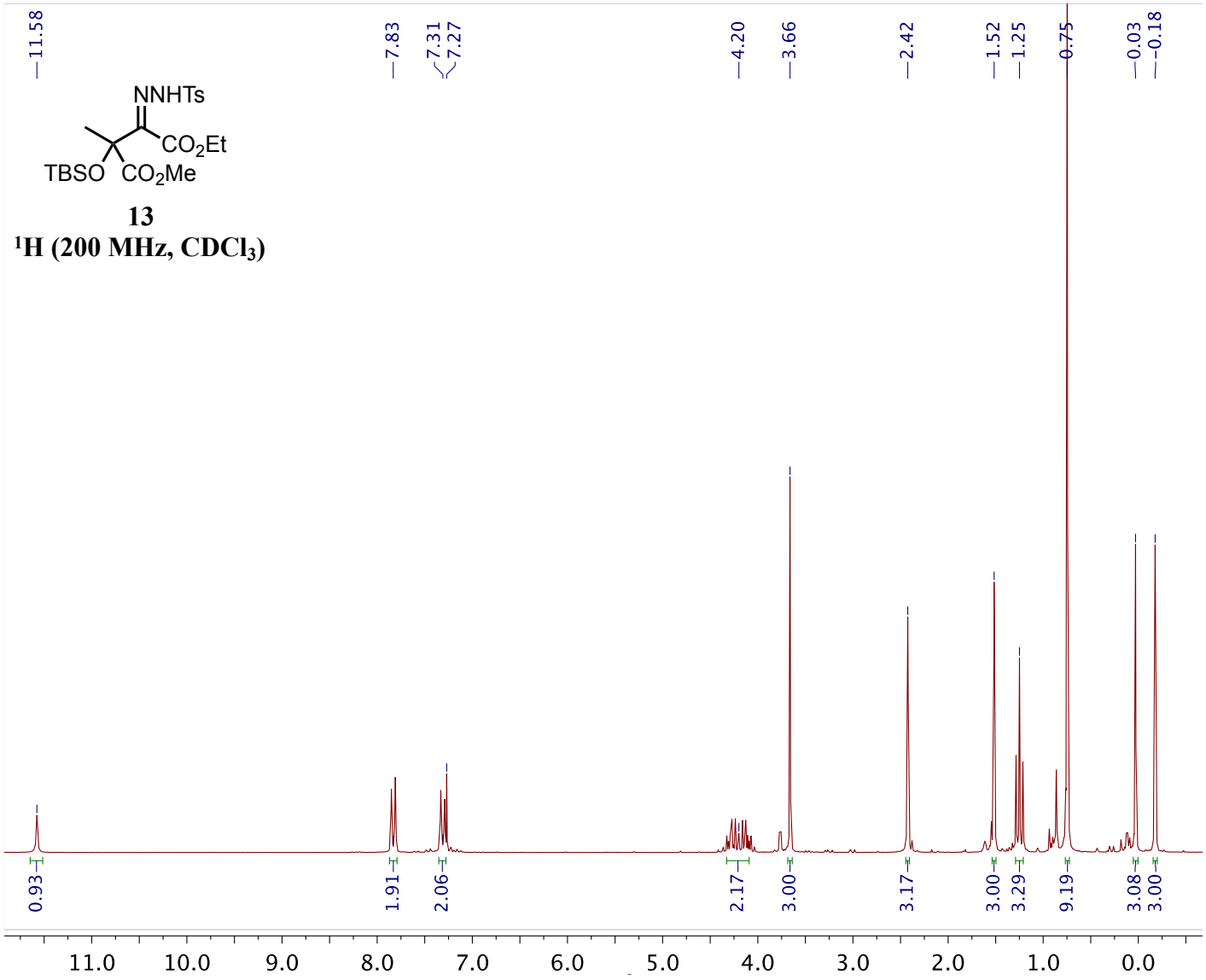
^{13}C (50 MHz, $CDCl_3$)



11

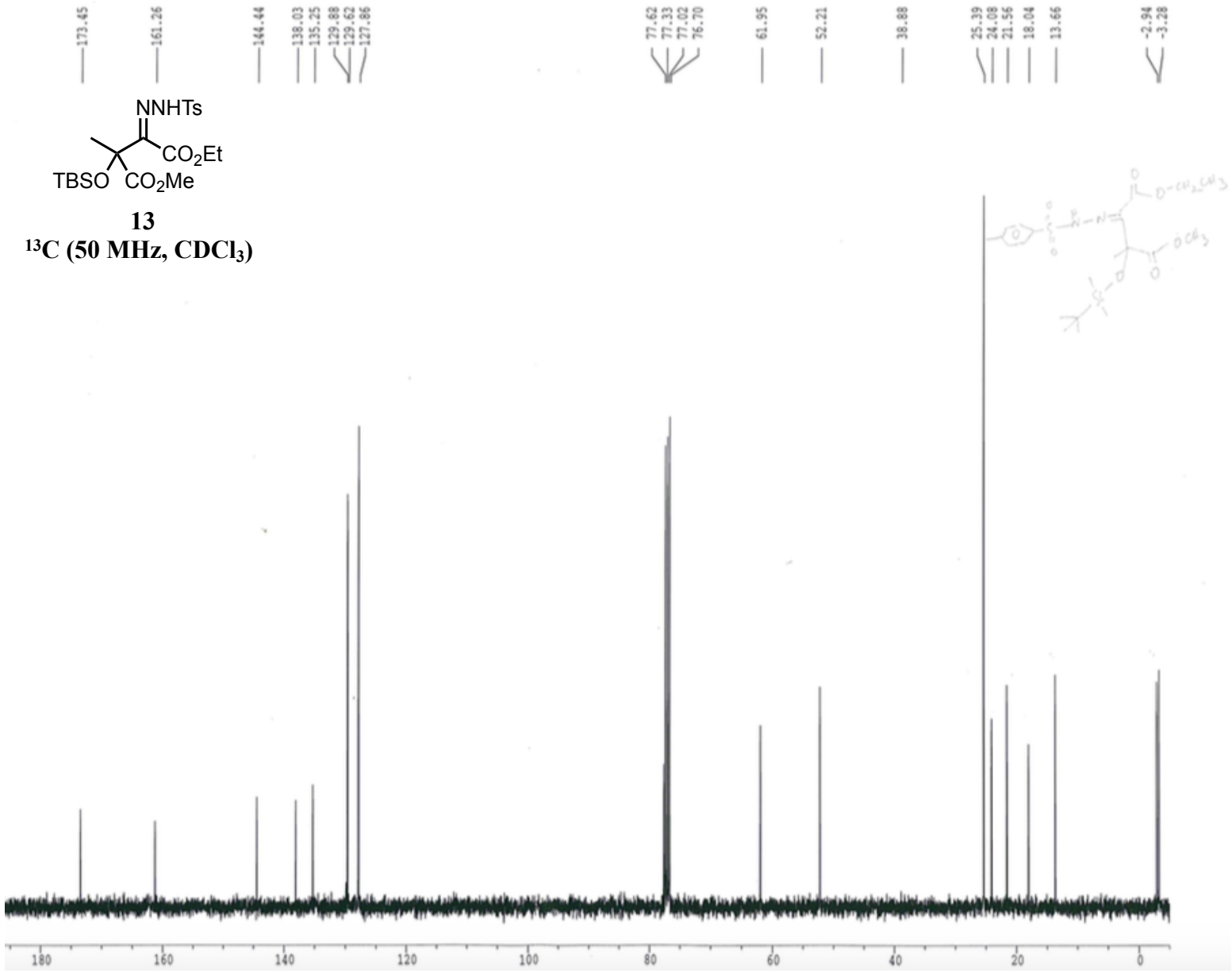
^{1}H (200 MHz, $CDCl_3$)


172.53
170.95
N2
CO2Et
TBSO
CO2Me
11
13C (50 MHz, CDCl3)
76.84
73.53
60.93
52.84
25.90
25.71
18.37
14.57
-3.07
-3.63
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0



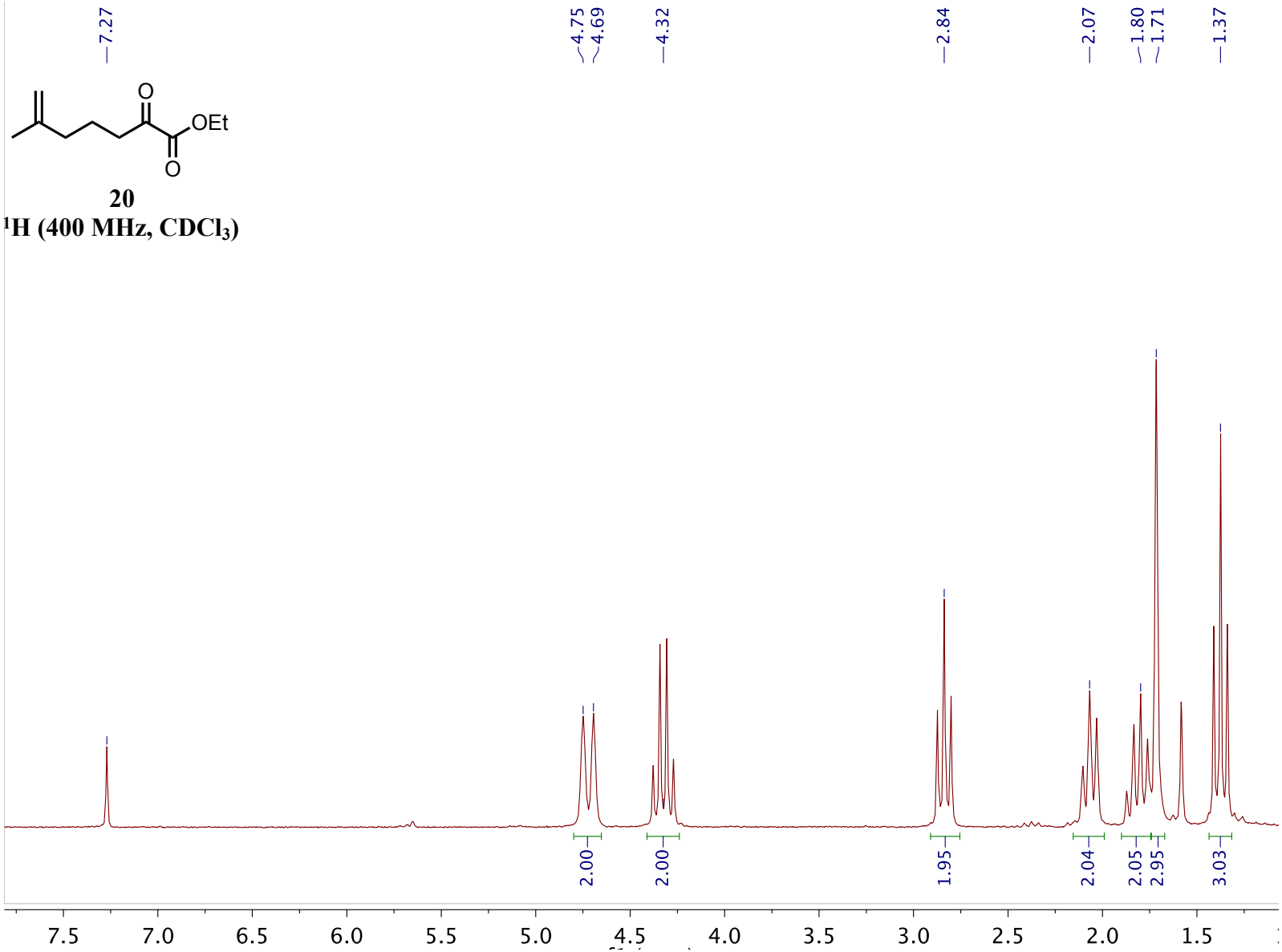
13

^{1}H (200 MHz, $CDCl_3$)



13

^{13}C (50 MHz, $CDCl_3$)



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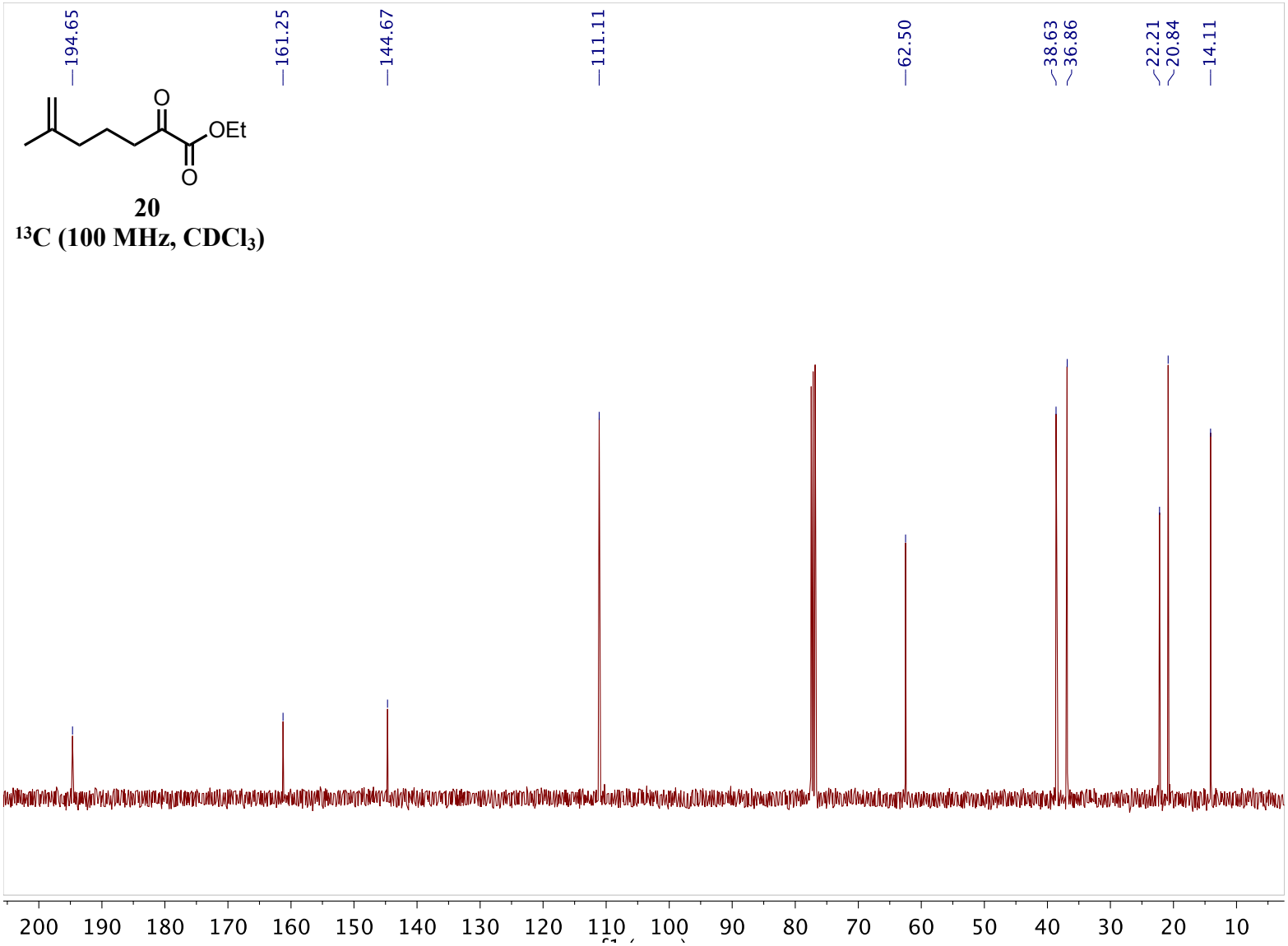
^{1}H (400 MHz, $CDCl_3$)



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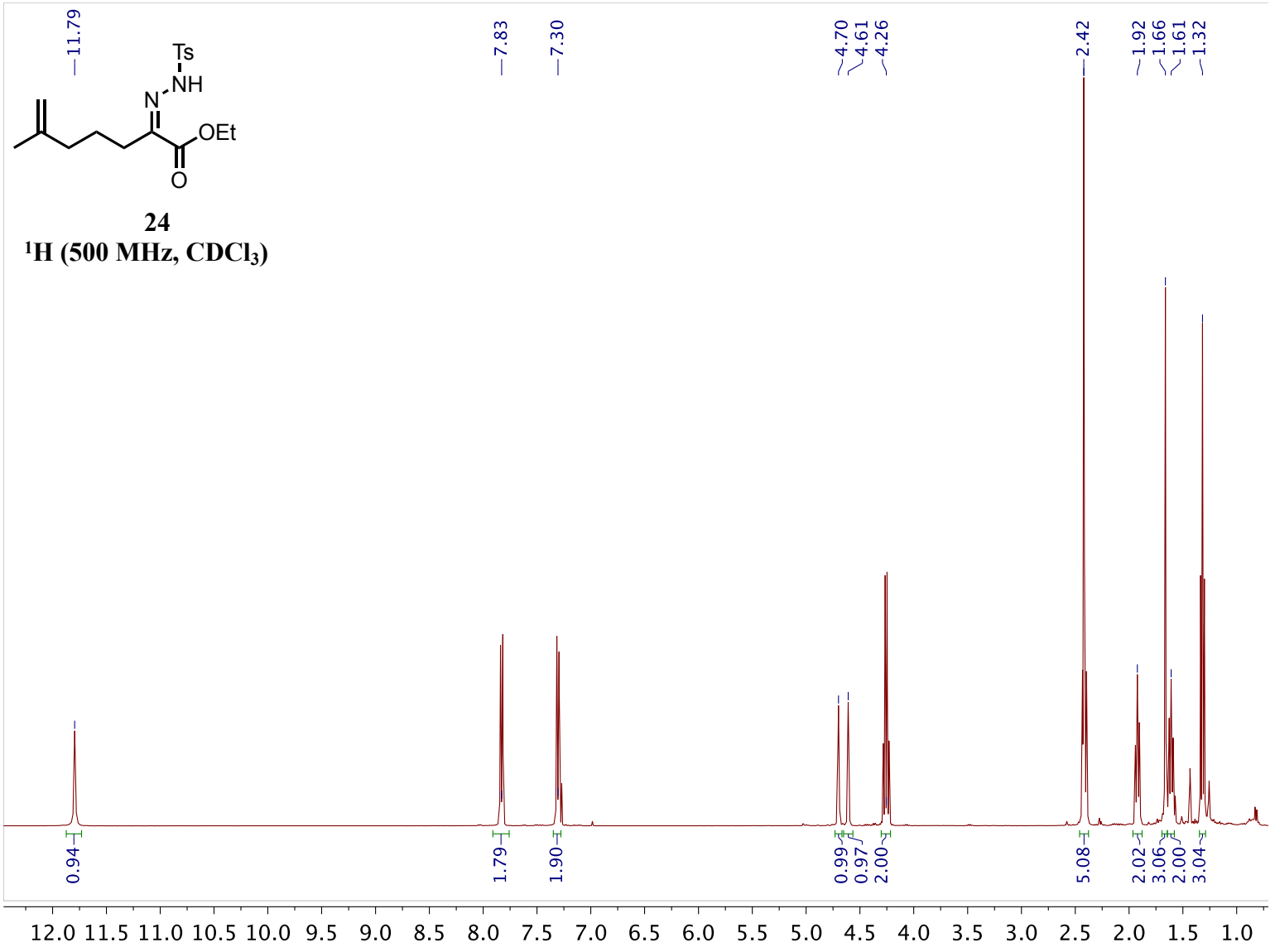
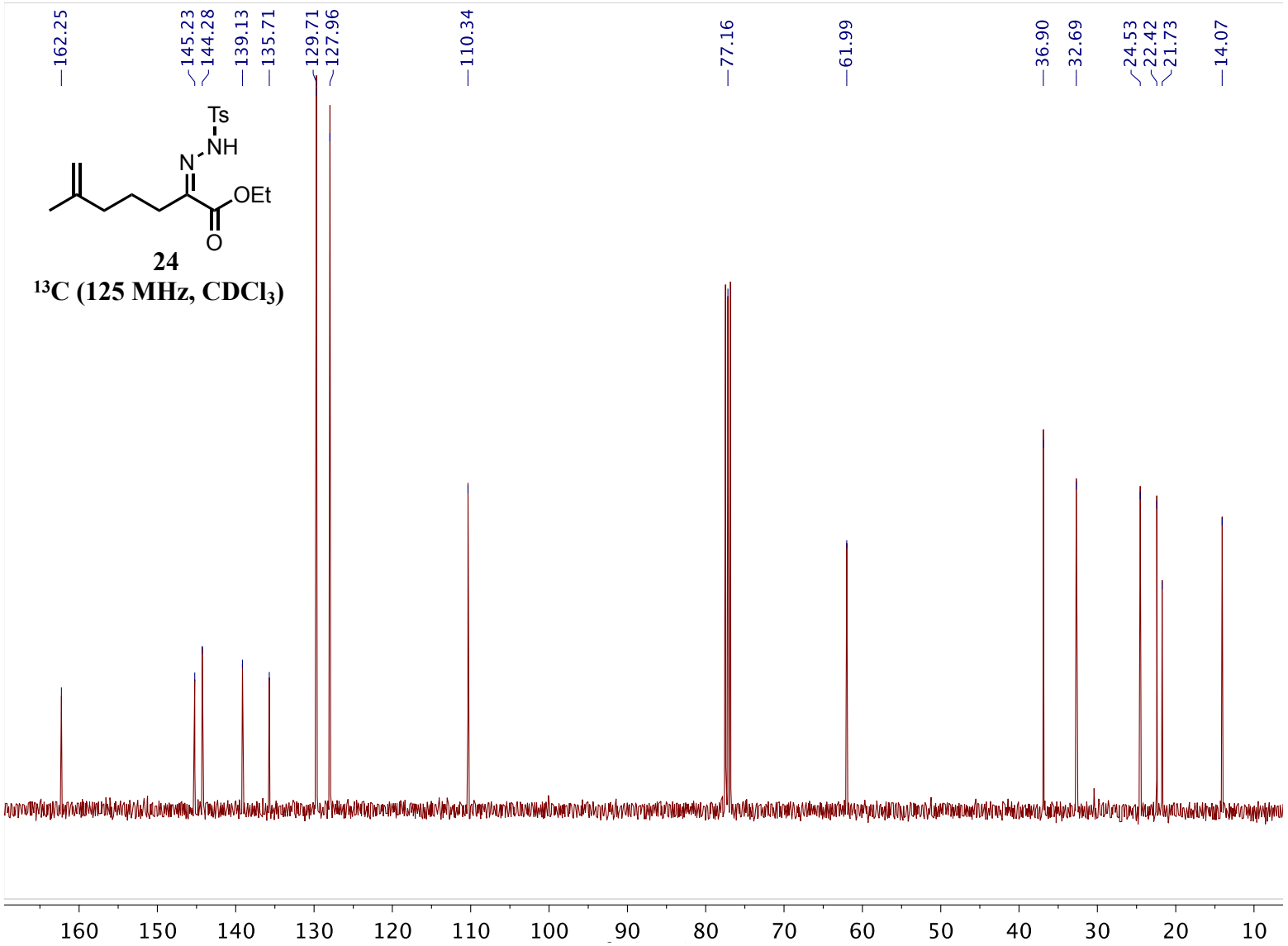
^{13}C (100 MHz, $CDCl_3$)



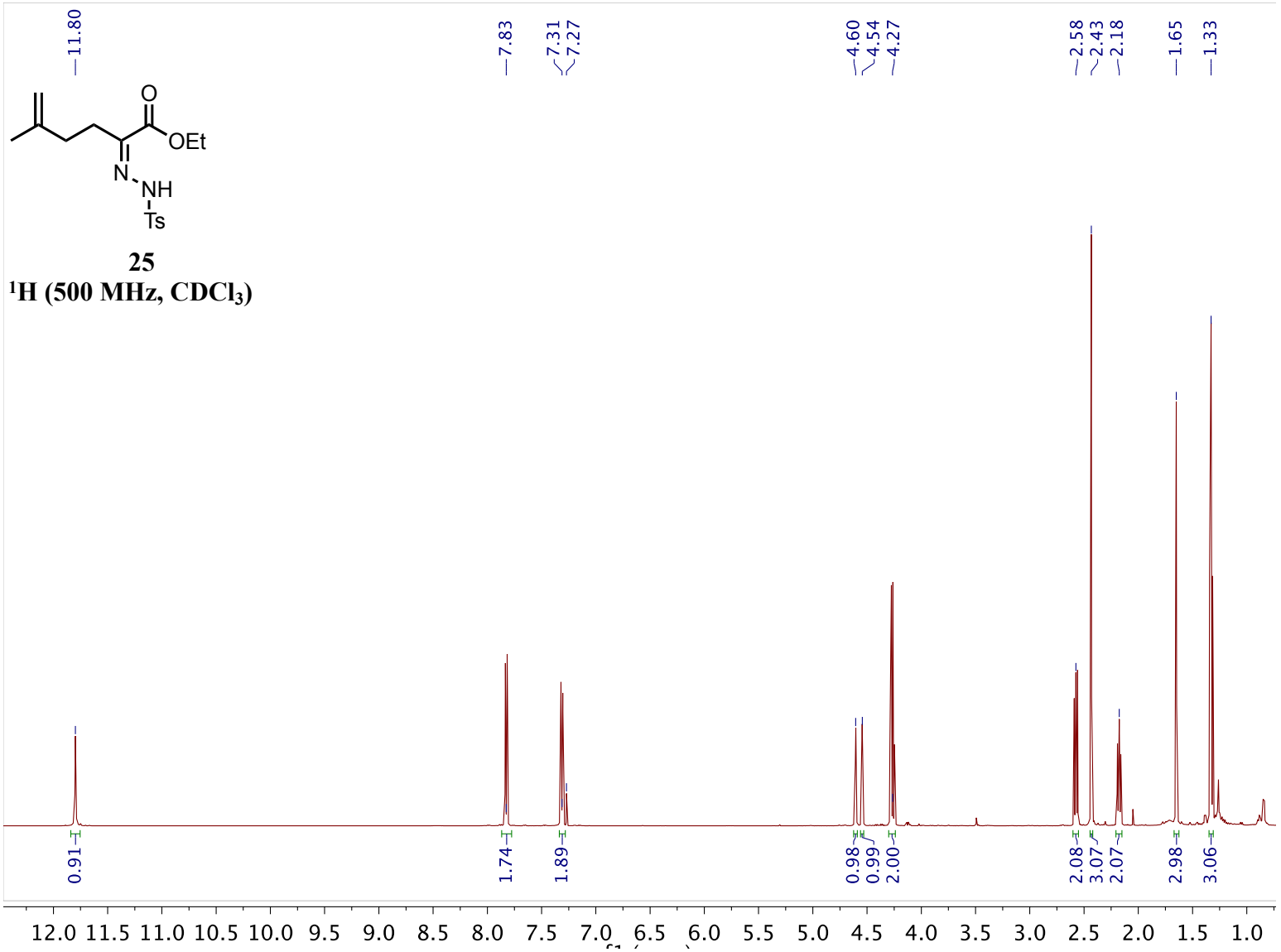
24

^{1}H (500 MHz, $CDCl_3$)



24

^{13}C (125 MHz, $CDCl_3$)



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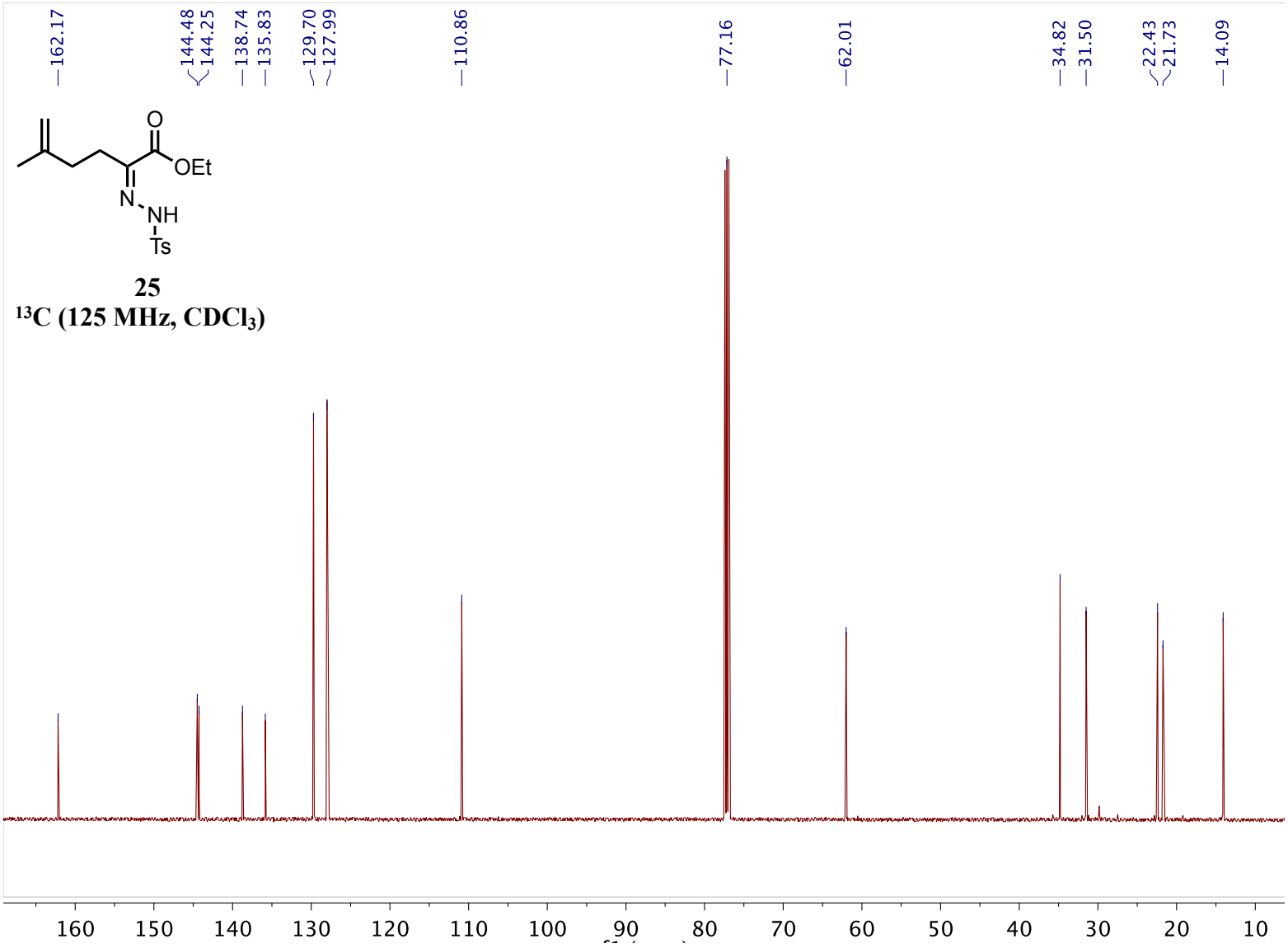
^{1}H (500 MHz, $CDCl_3$)



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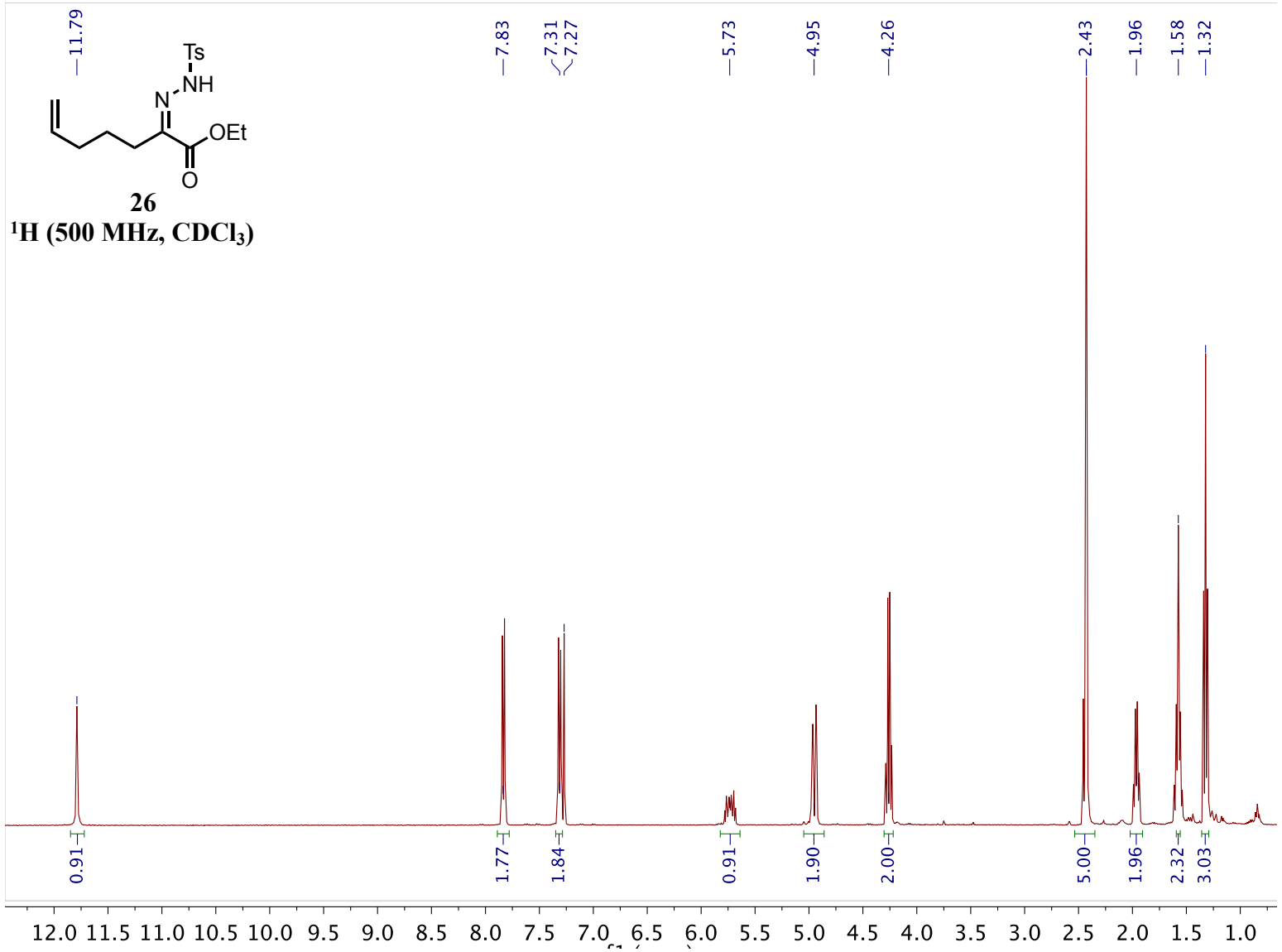
^{13}C (125 MHz, $CDCl_3$)



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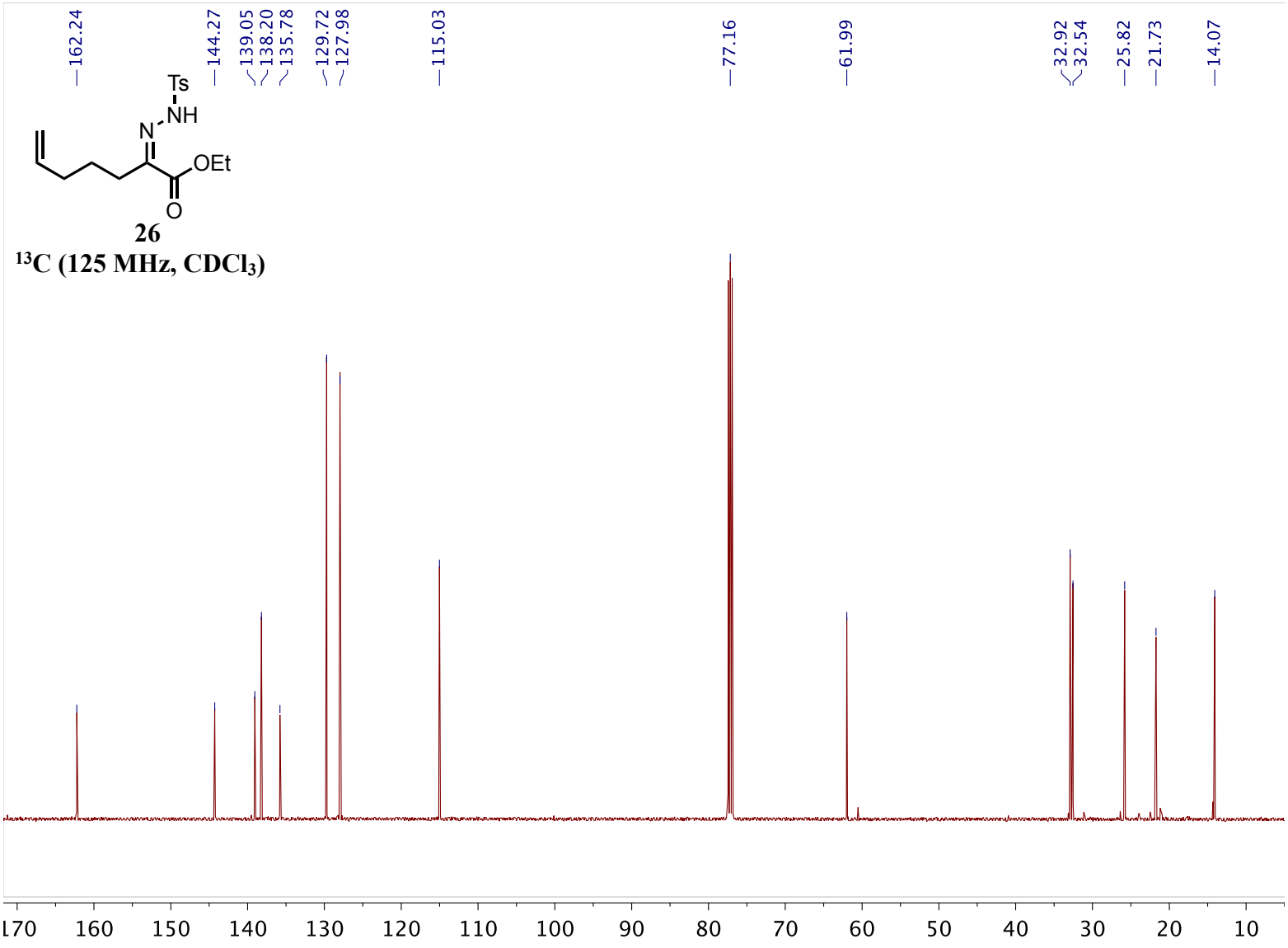
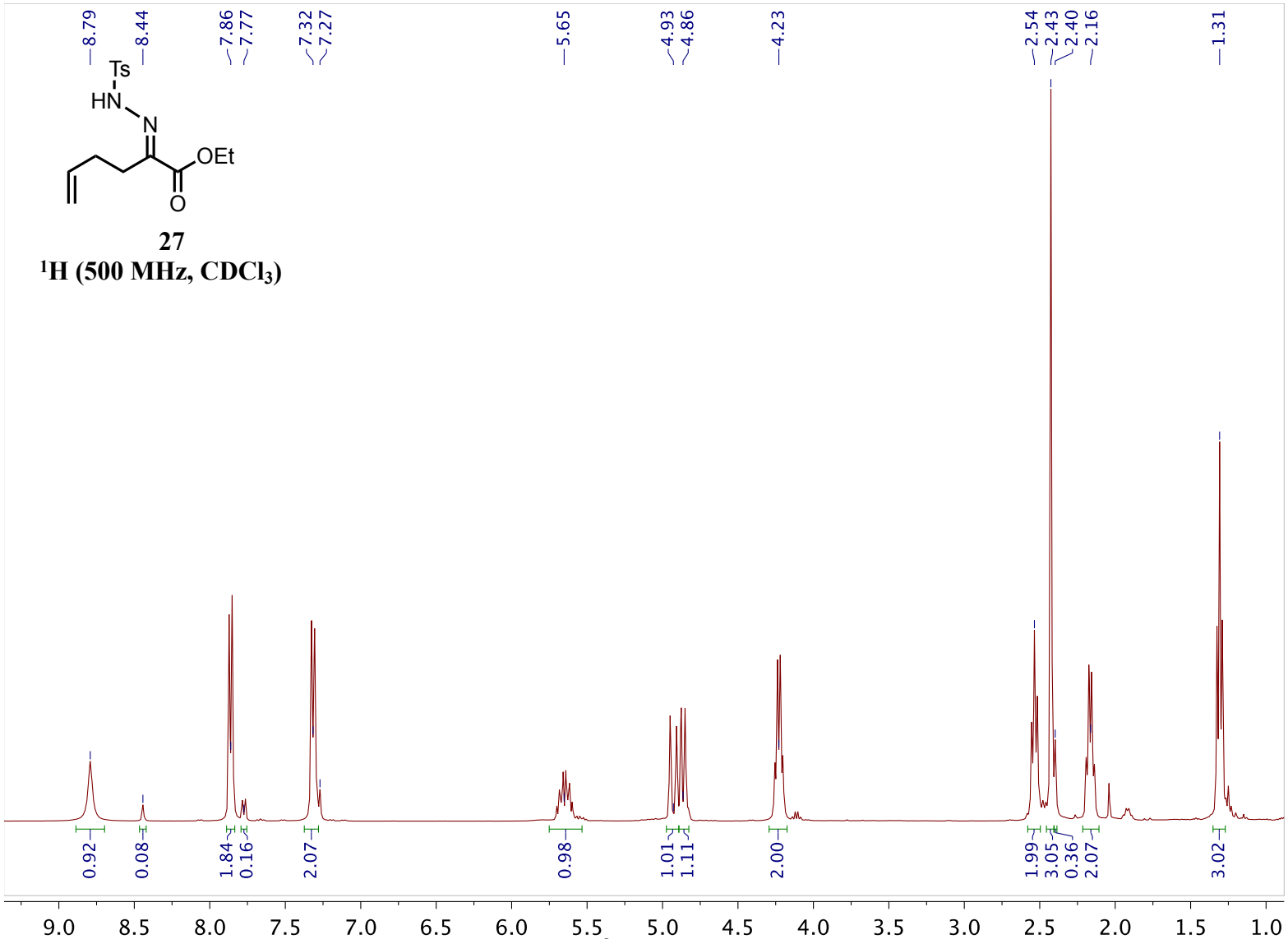
^{1}H (500 MHz, $CDCl_3$)


162.24
144.27
139.05
138.20
135.78
129.72
127.98
115.03
77.16
61.99
32.92
32.54
25.82
21.73
14.07
Ts
NH
N
OEt
O
26
13C (125 MHz, CDCl3)
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10



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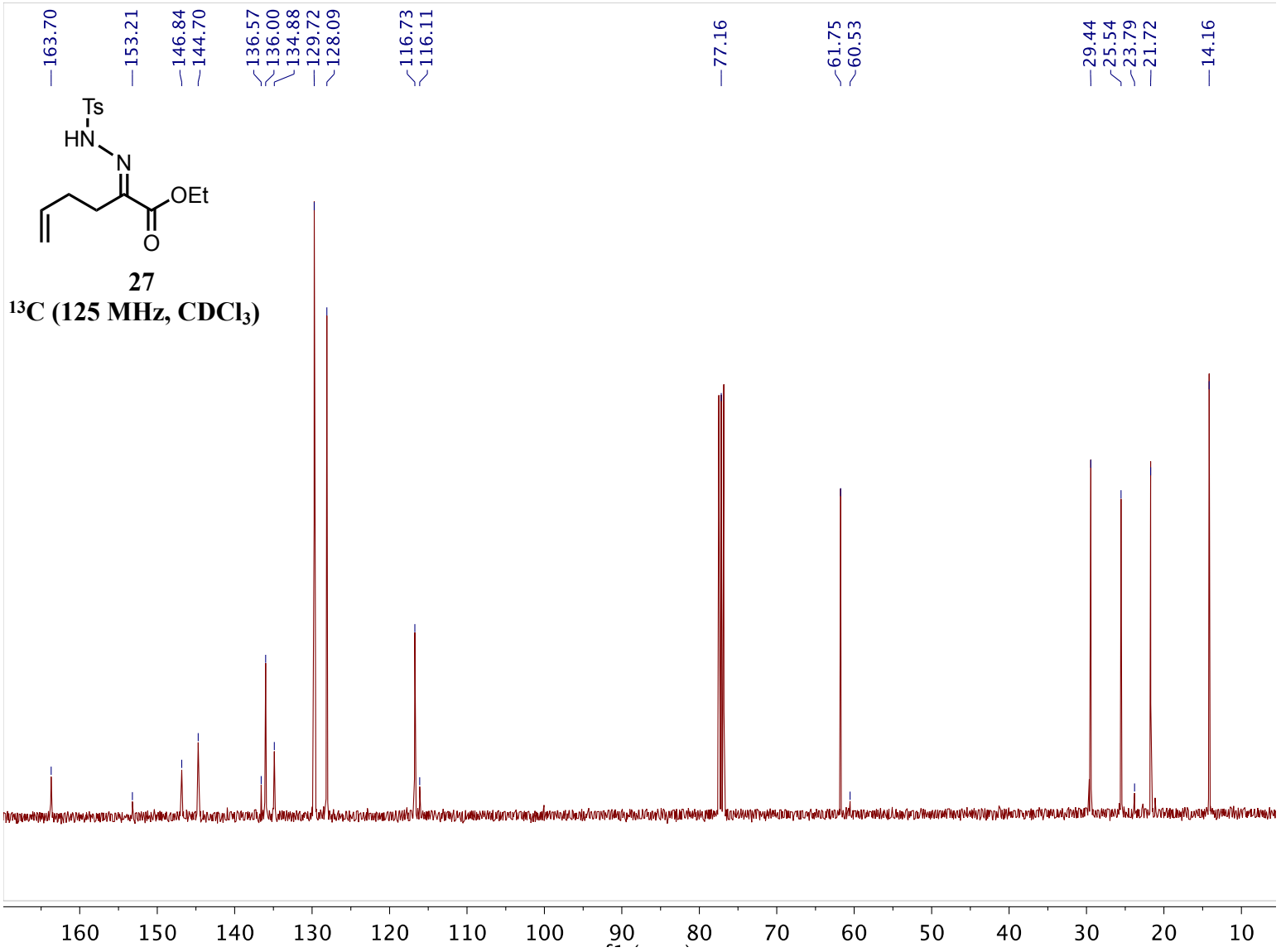
^{1}H (500 MHz, $CDCl_3$)



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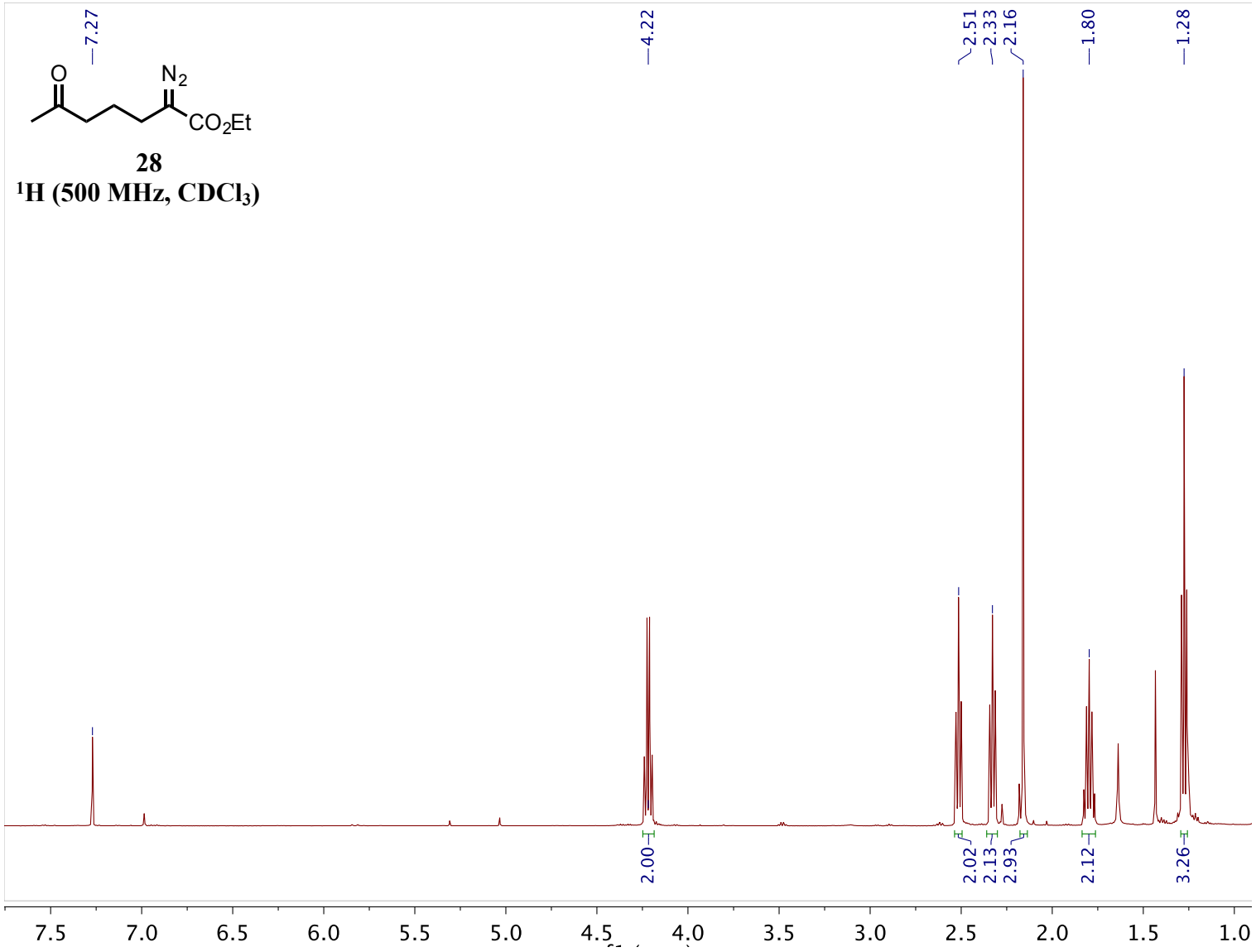

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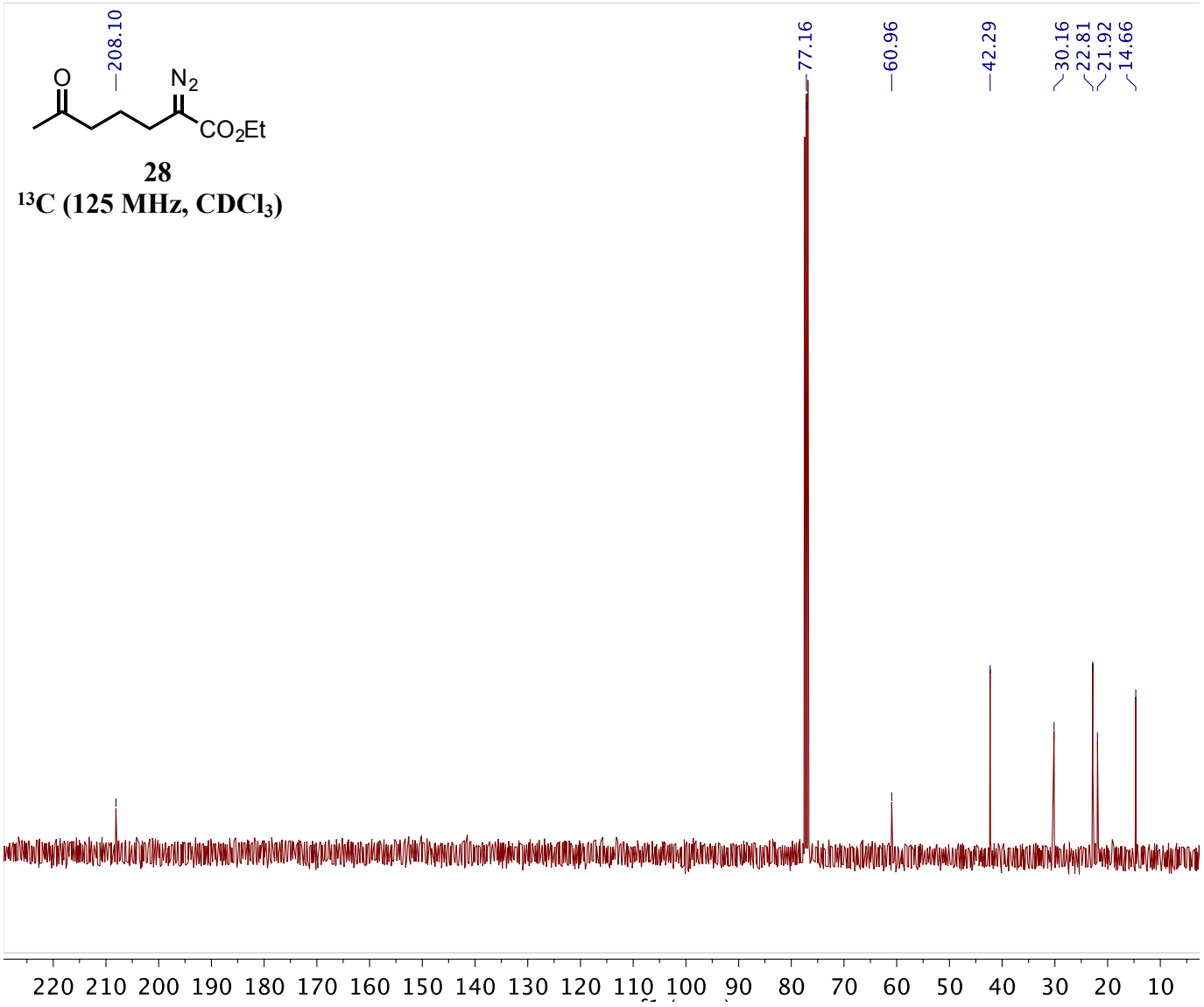

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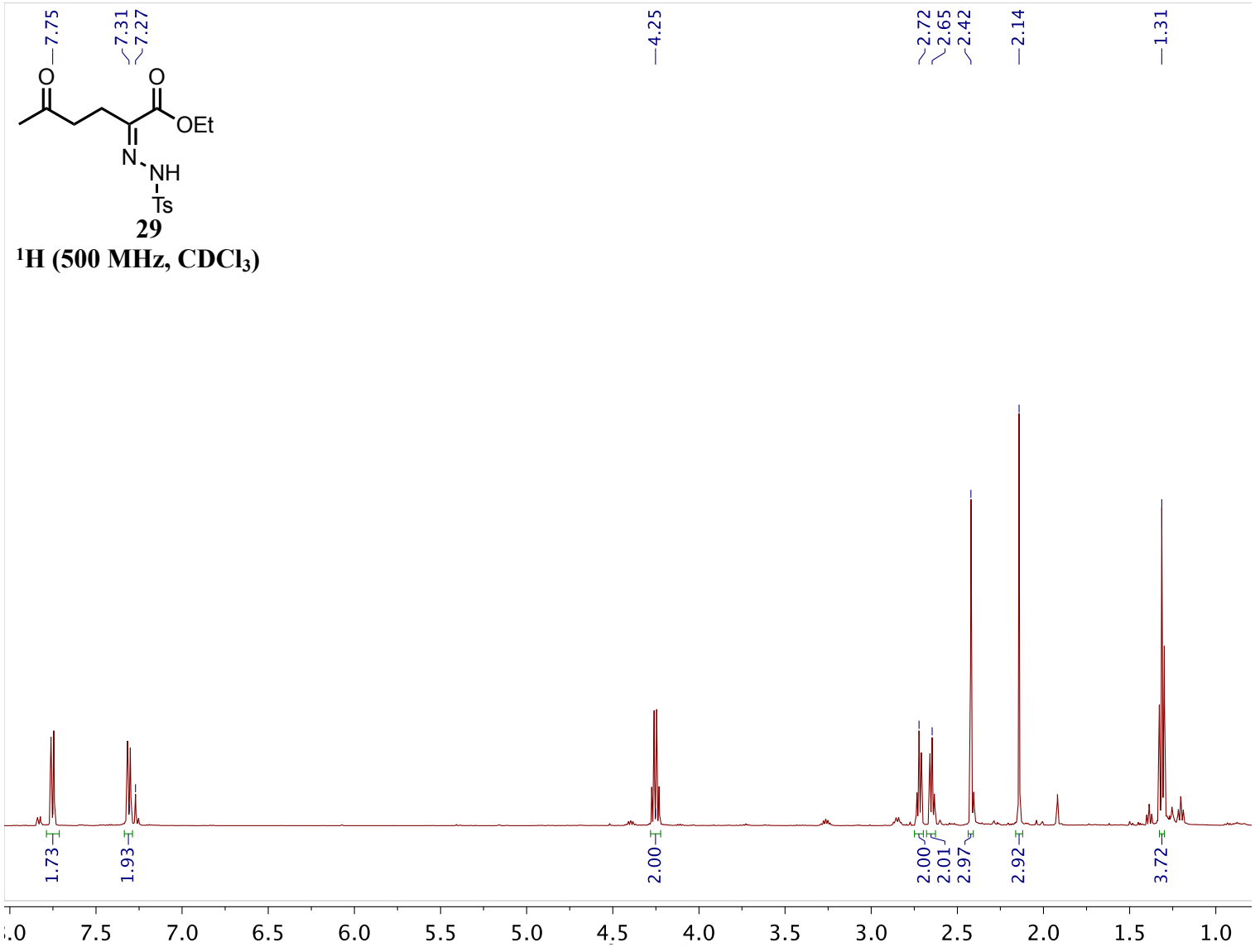

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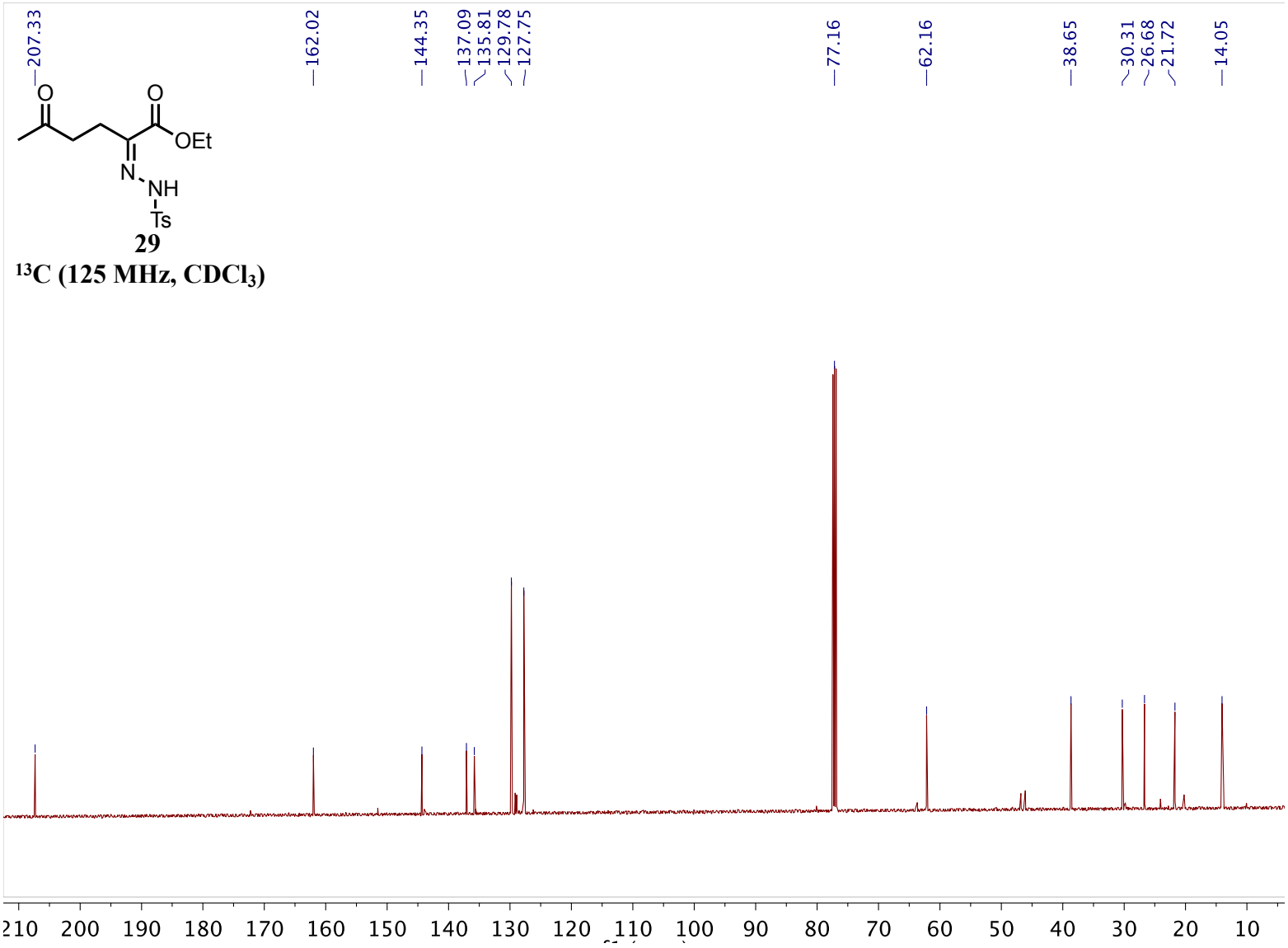

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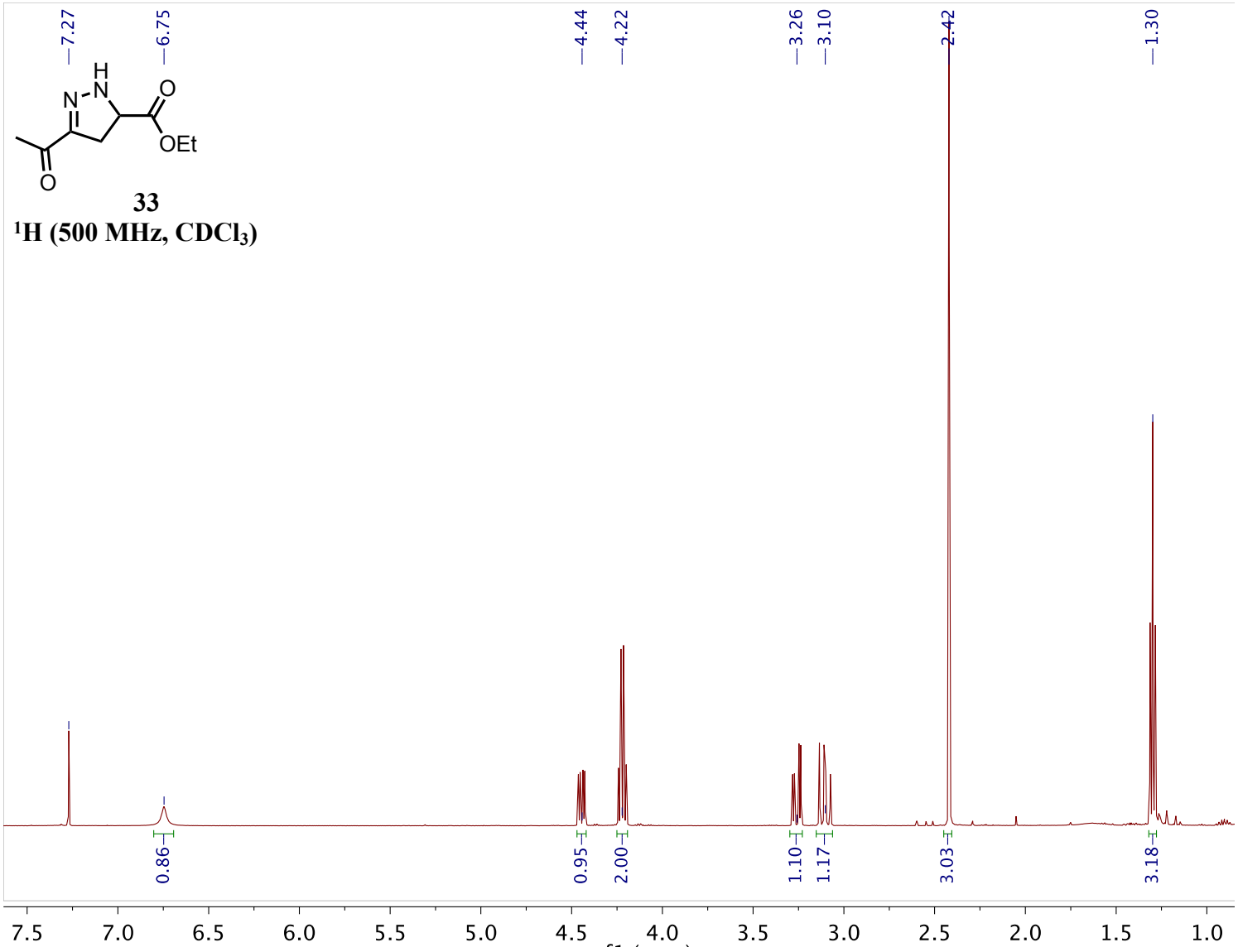

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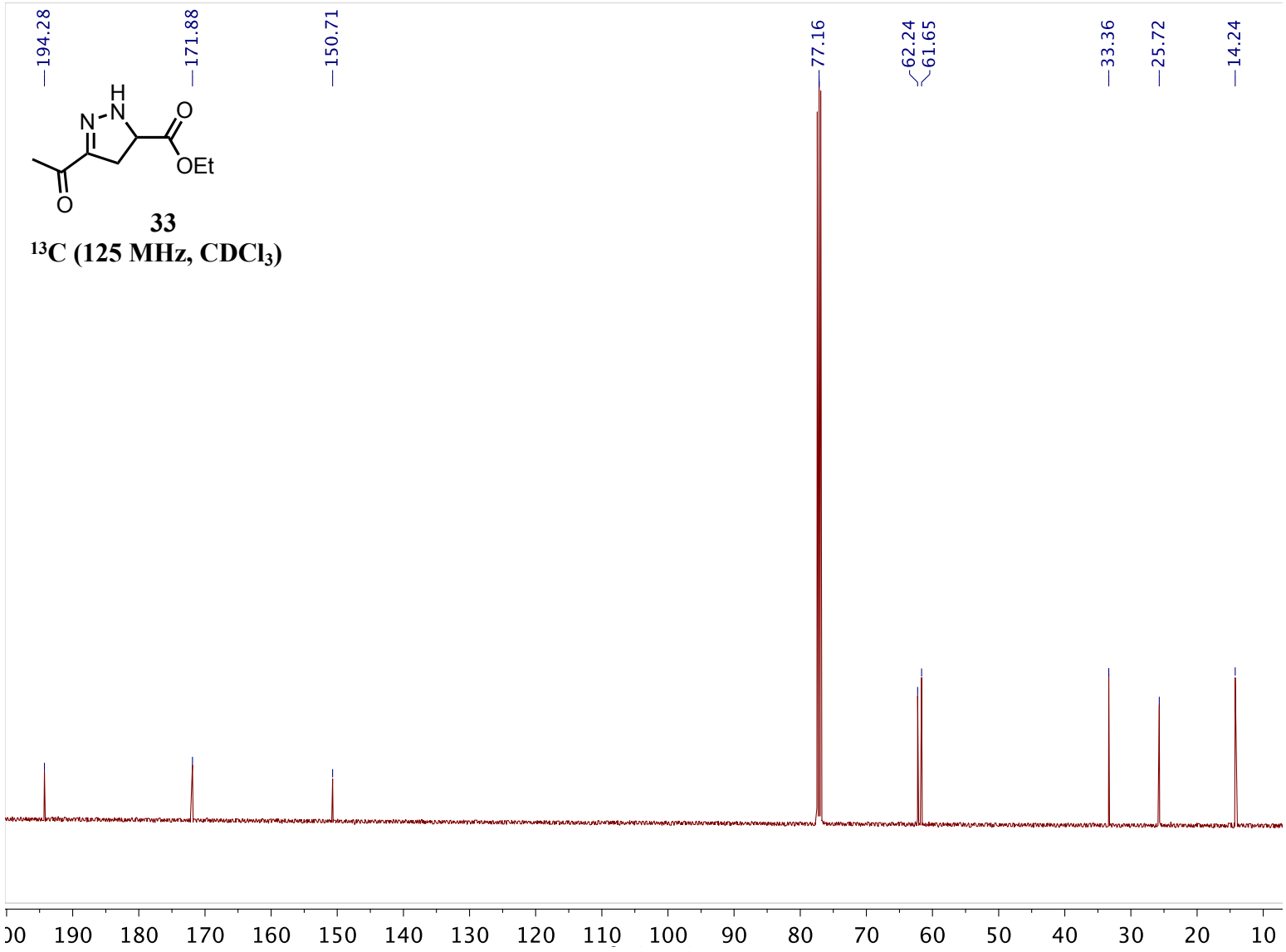

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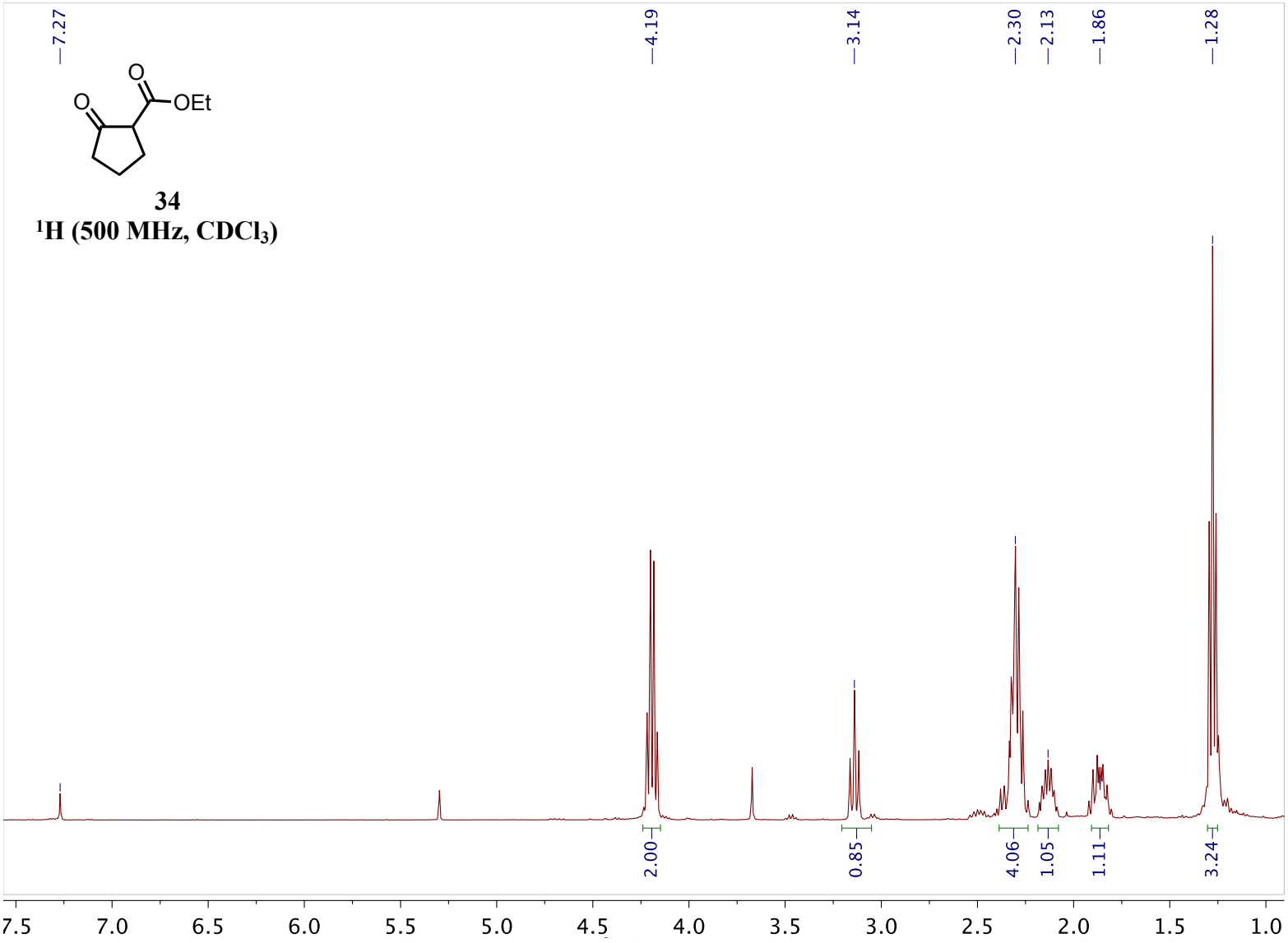
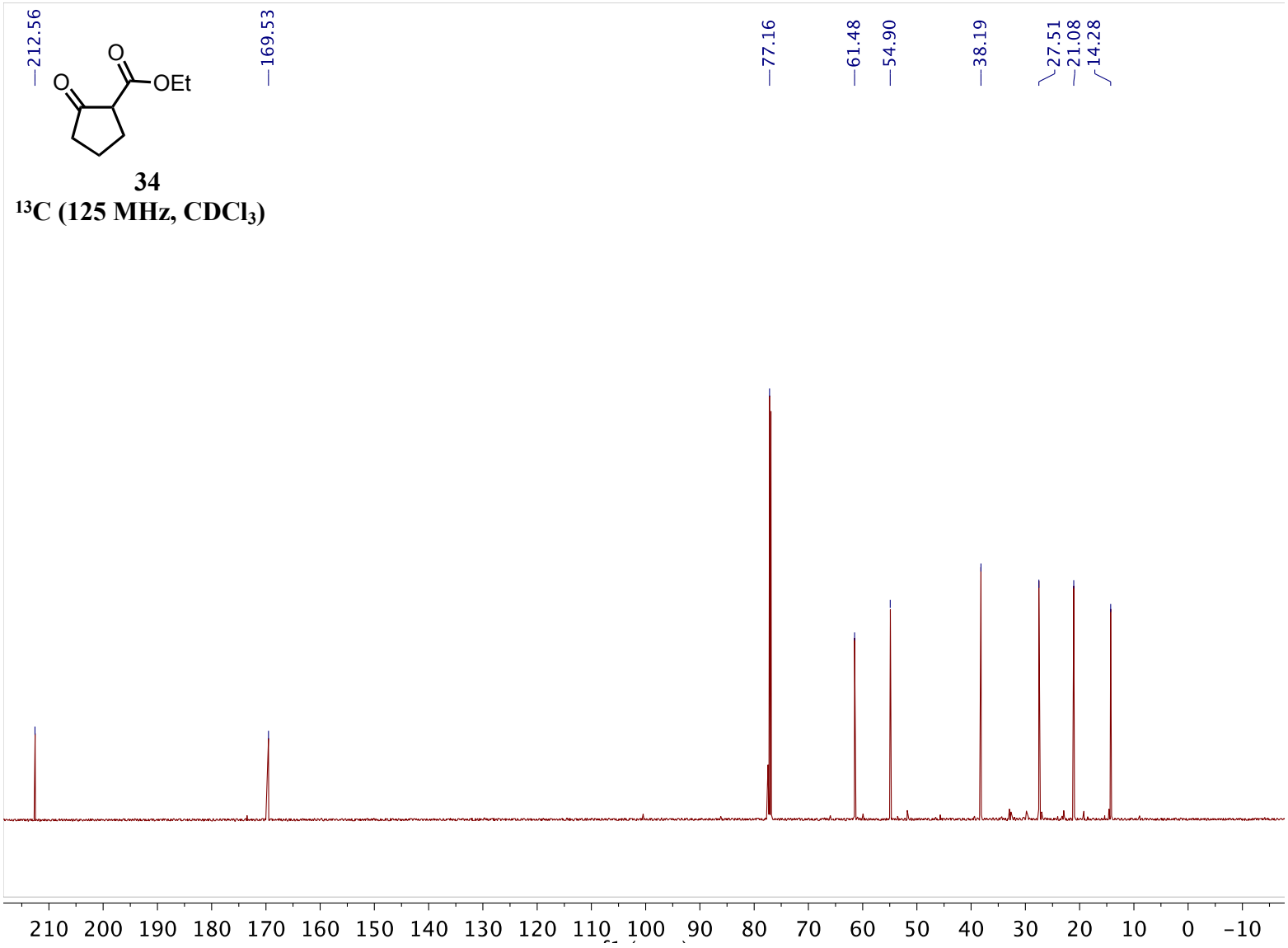

7.27
4.19
3.14
2.30
2.13
1.86
1.28
O
O
OEt
34
1H (500 MHz, CDCl3)
2.00
0.85
4.06
1.05
1.11
3.24
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0



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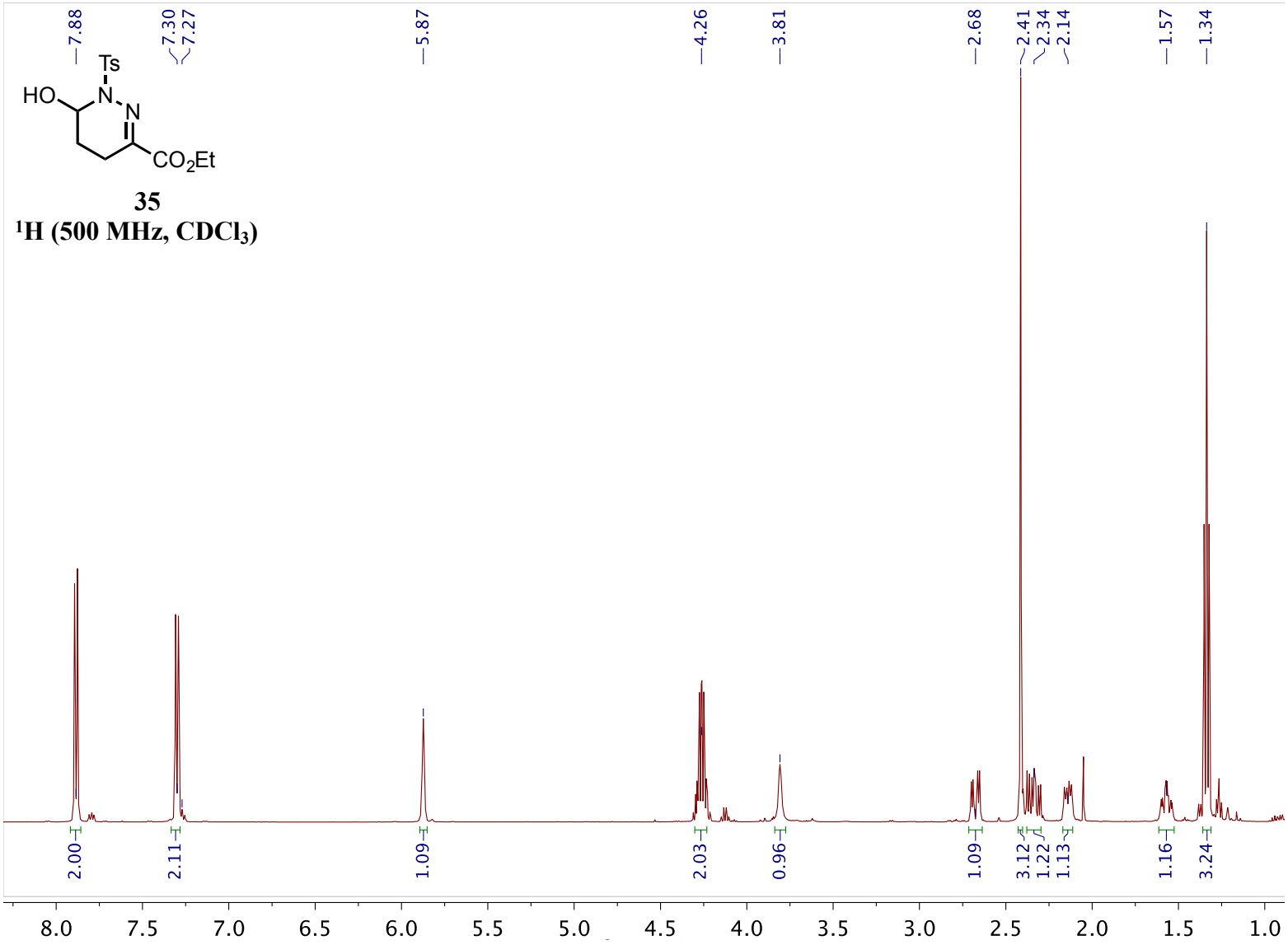
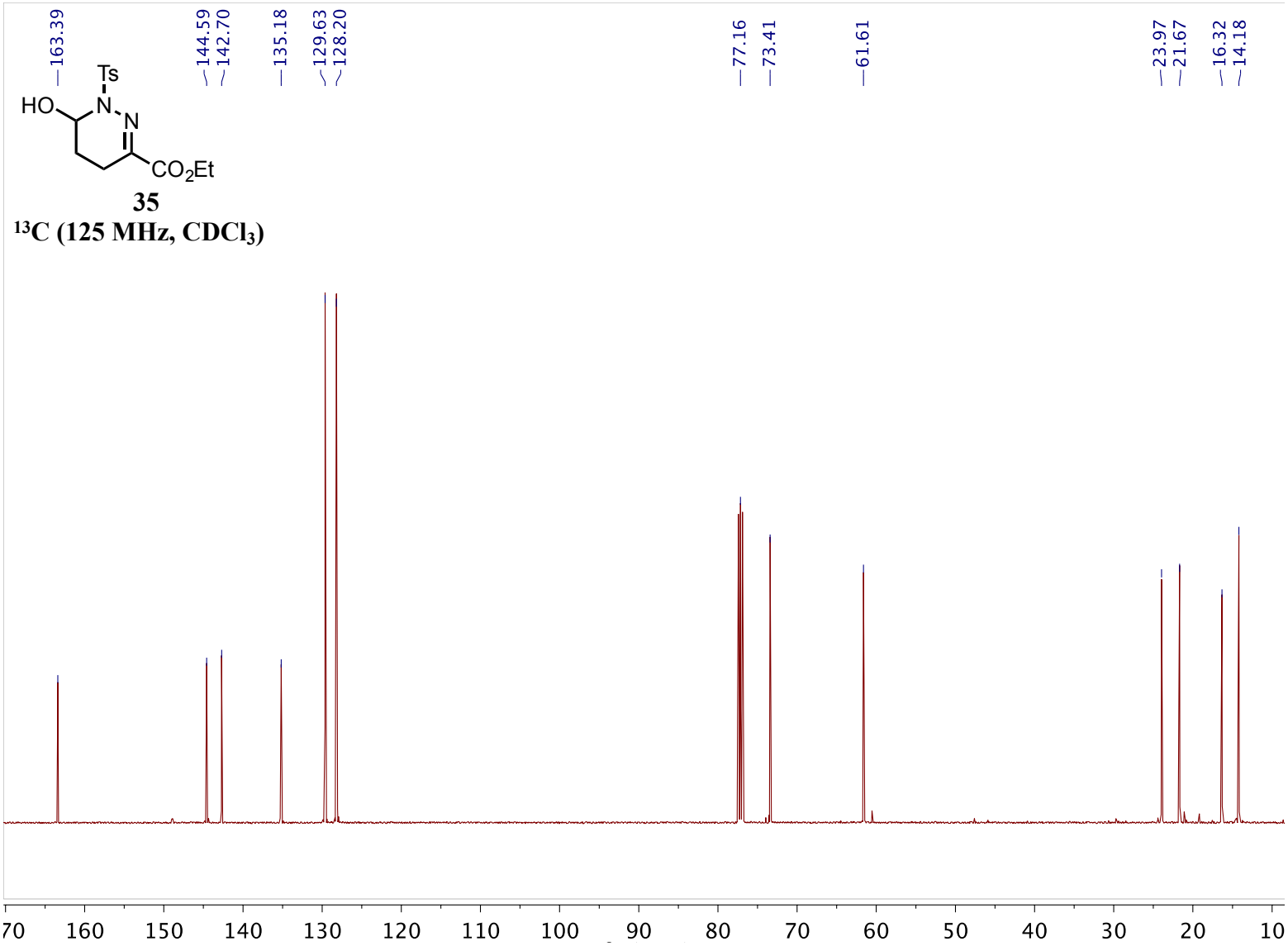
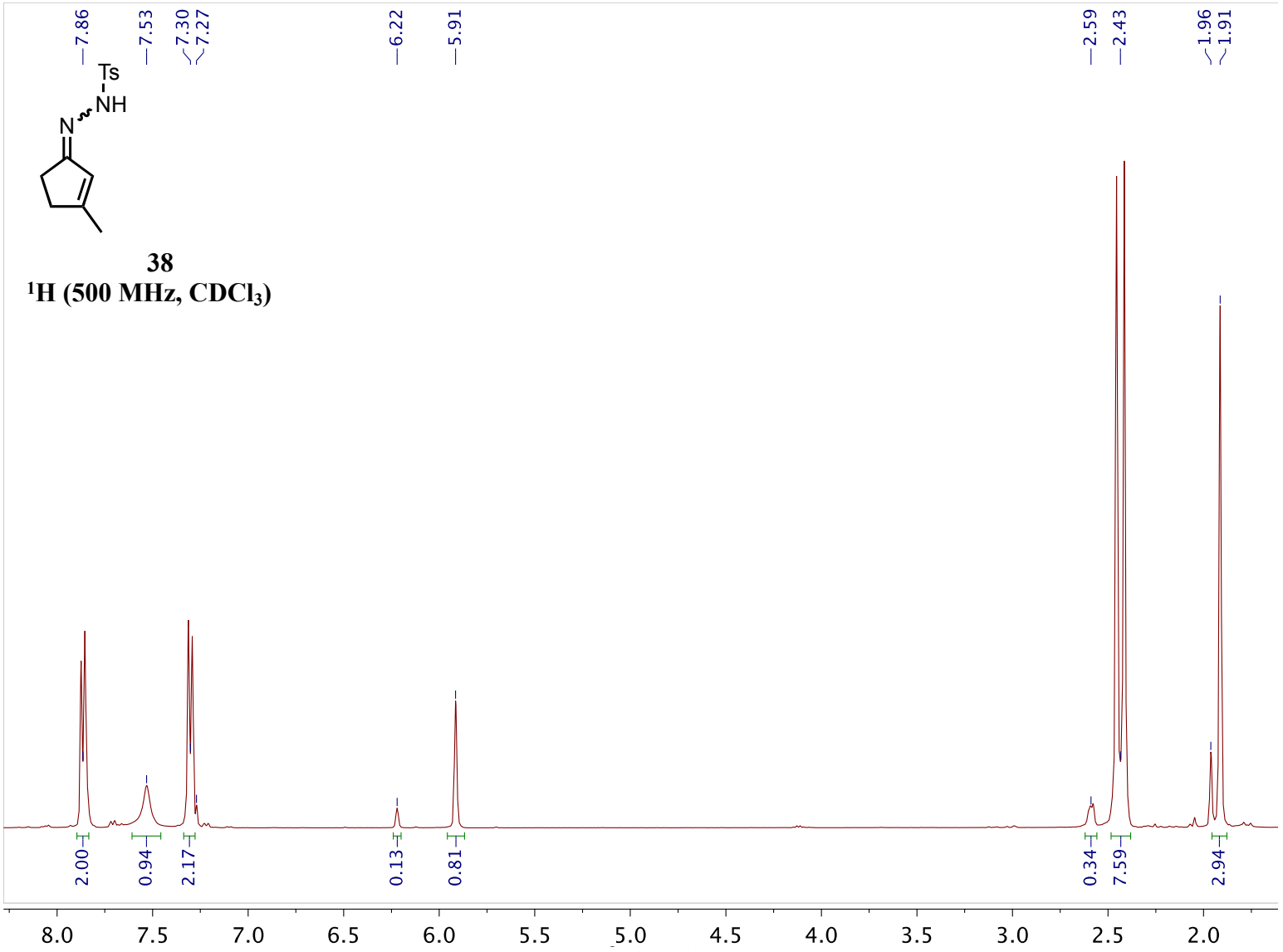


35

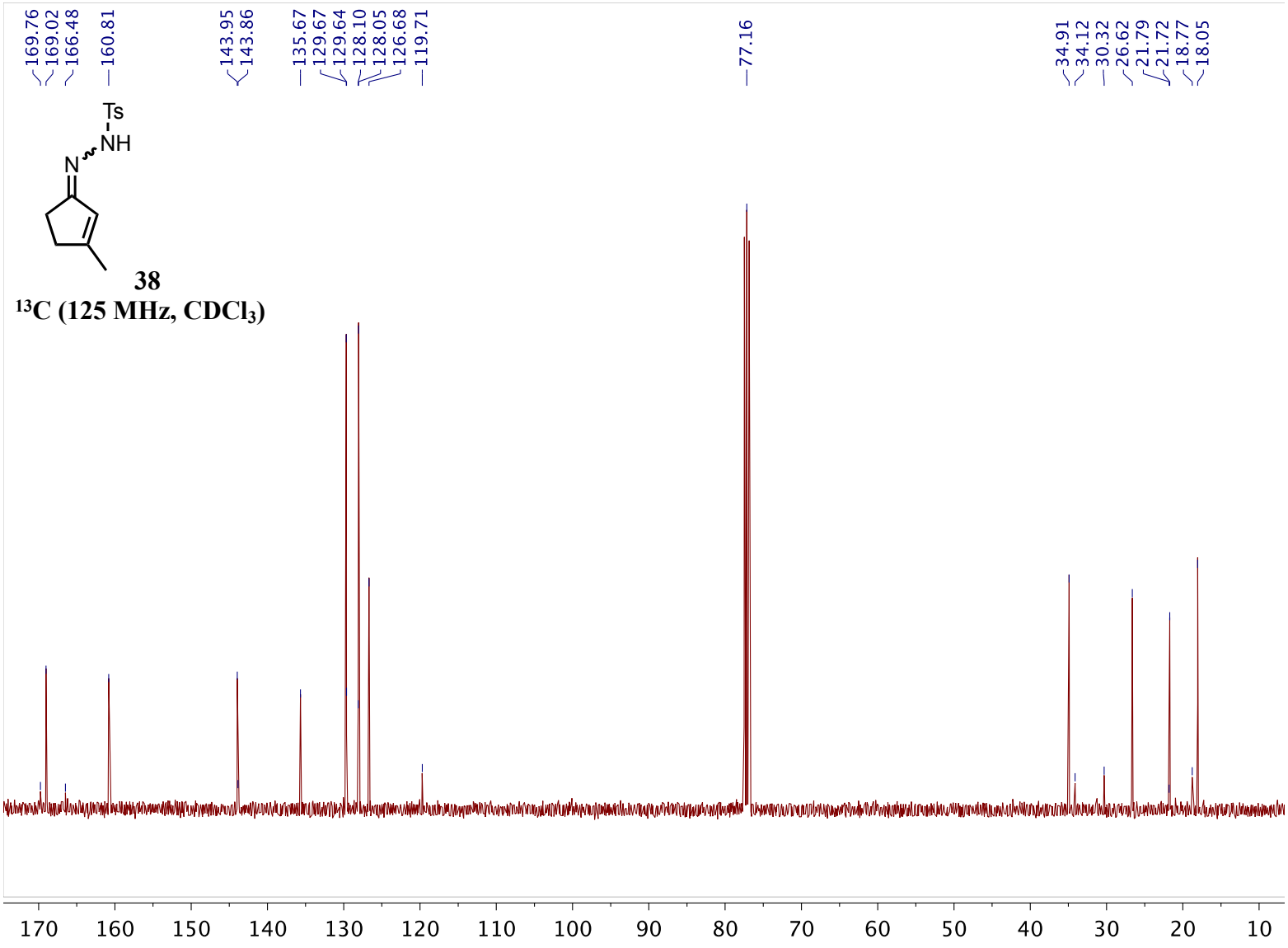
^{1}H (500 MHz, $CDCl_3$)

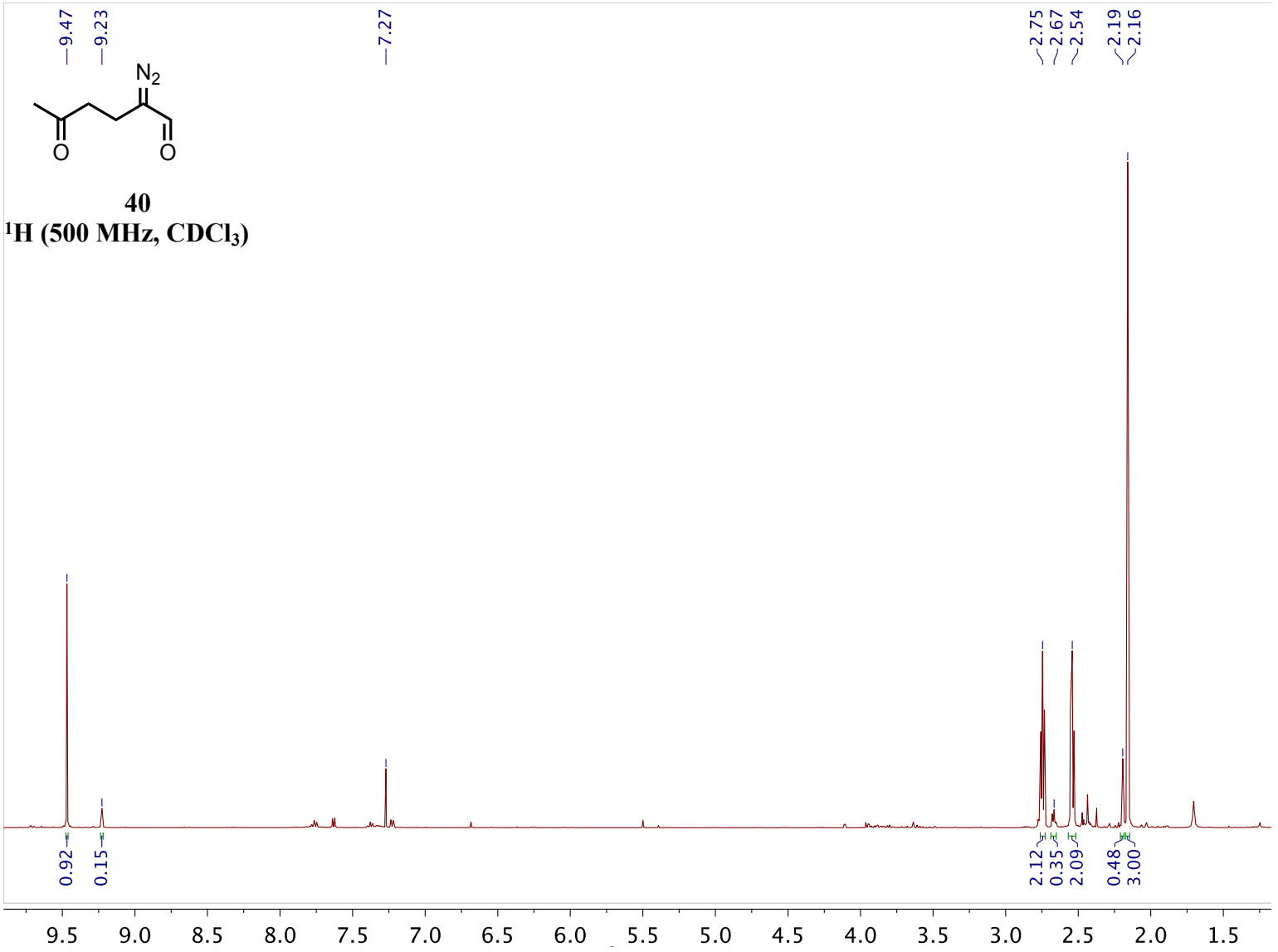

163.39
144.59
142.70
135.18
129.63
128.20
77.16
73.41
61.61
23.97
21.67
16.32
14.18
Ts
HO
N
N
CO2Et
35
13C (125 MHz, CDCl3)
70
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10



38

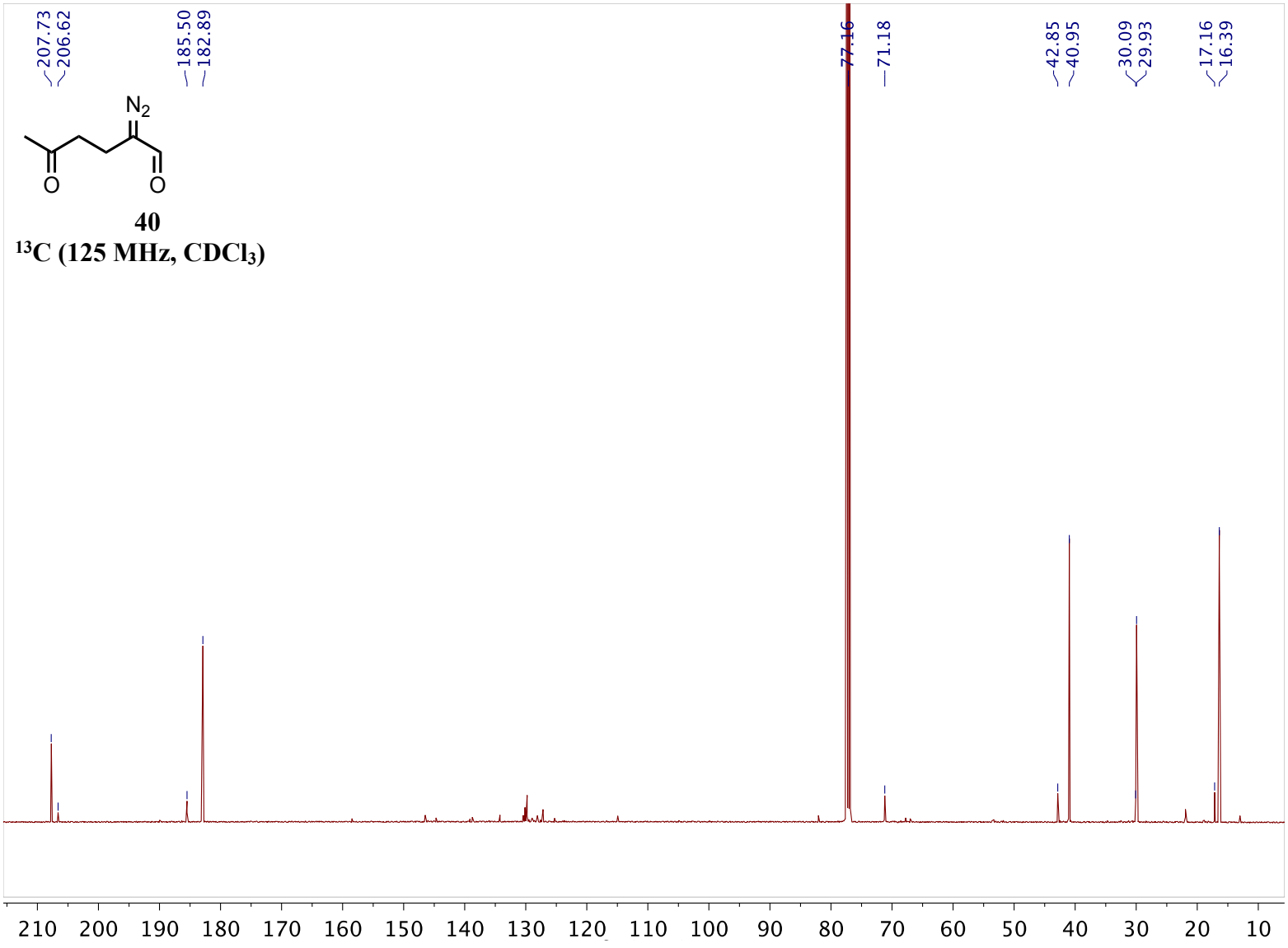
^{1}H (500 MHz, $CDCl_3$)


169.76
169.02
166.48
160.81
143.95
143.86
135.67
129.67
129.64
128.10
128.05
126.68
119.71
77.16
34.91
34.12
30.32
26.62
21.79
21.72
18.77
18.05
Ts
NH
N
38
13C (125 MHz, CDCl3)
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10



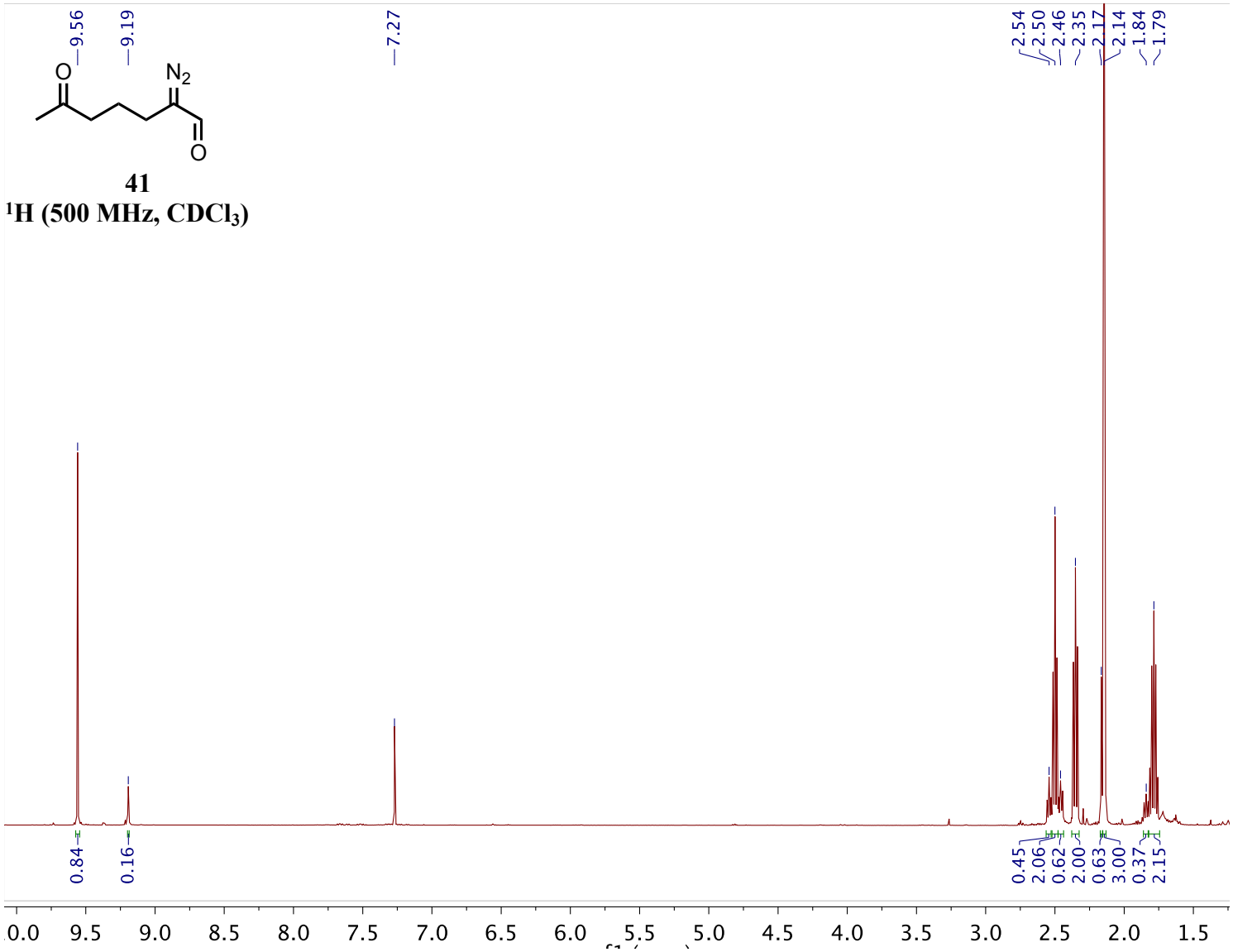
40

^{1}H (500 MHz, $CDCl_3$)



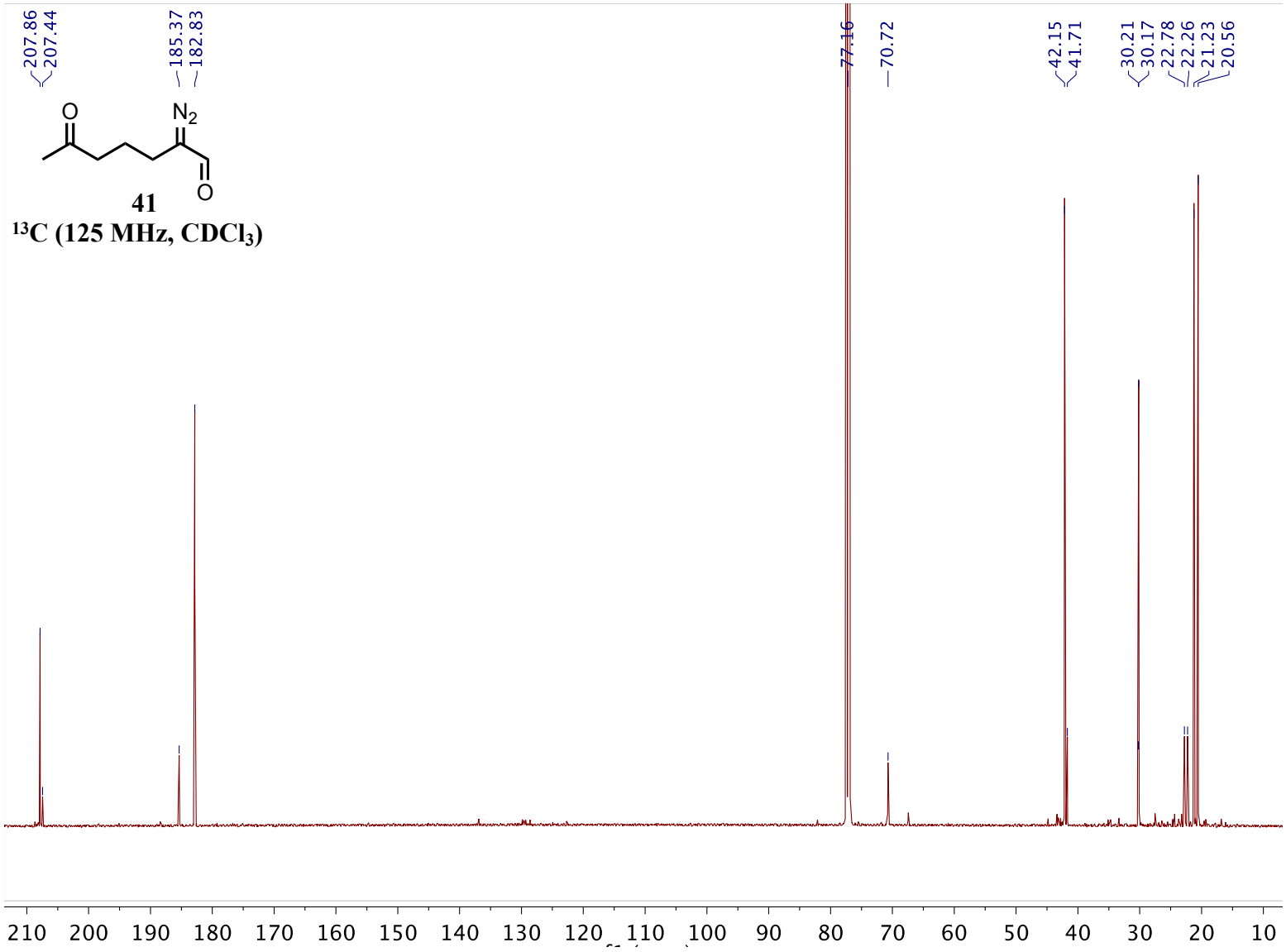
40

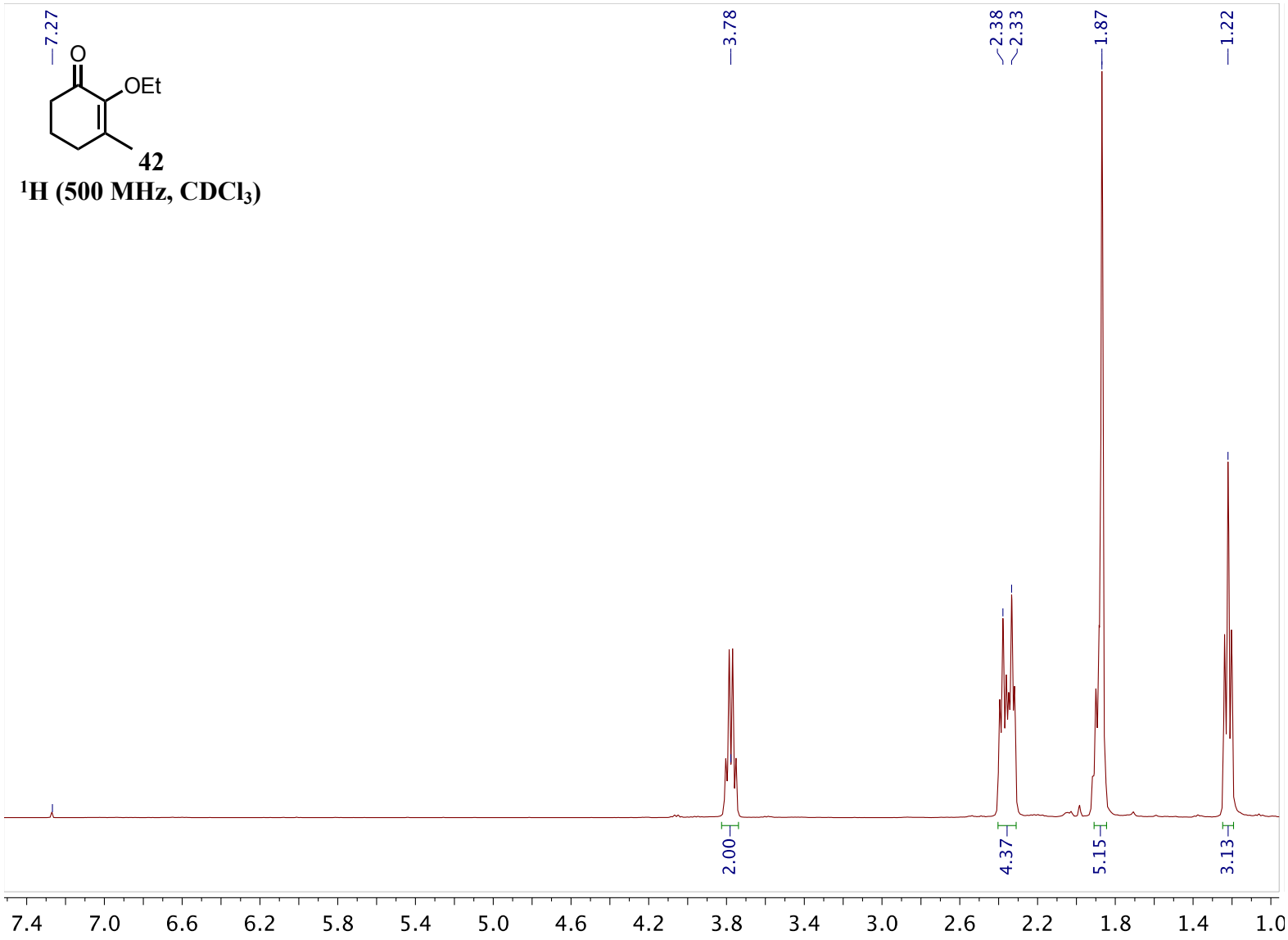
^{13}C (125 MHz, $CDCl_3$)

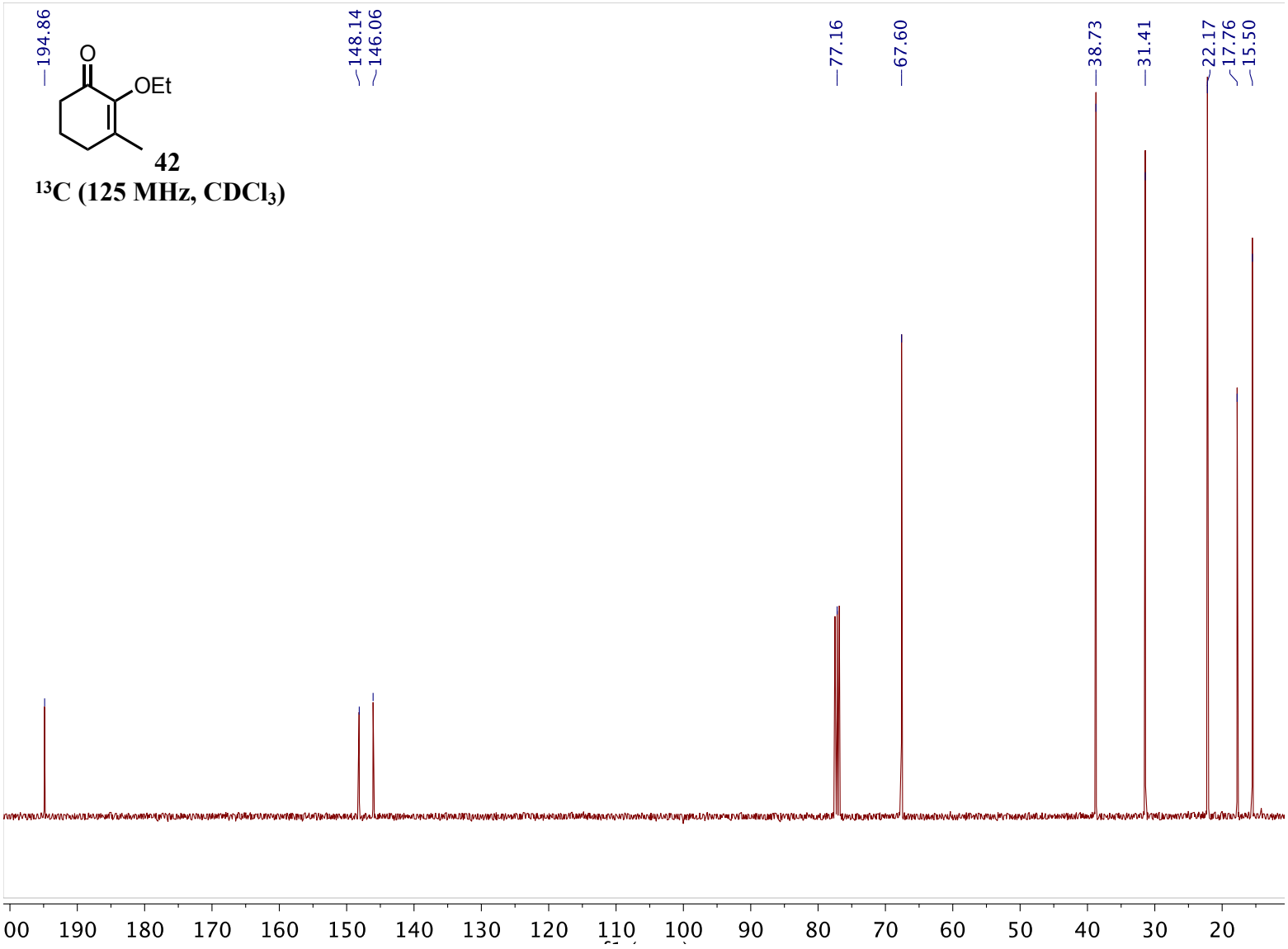


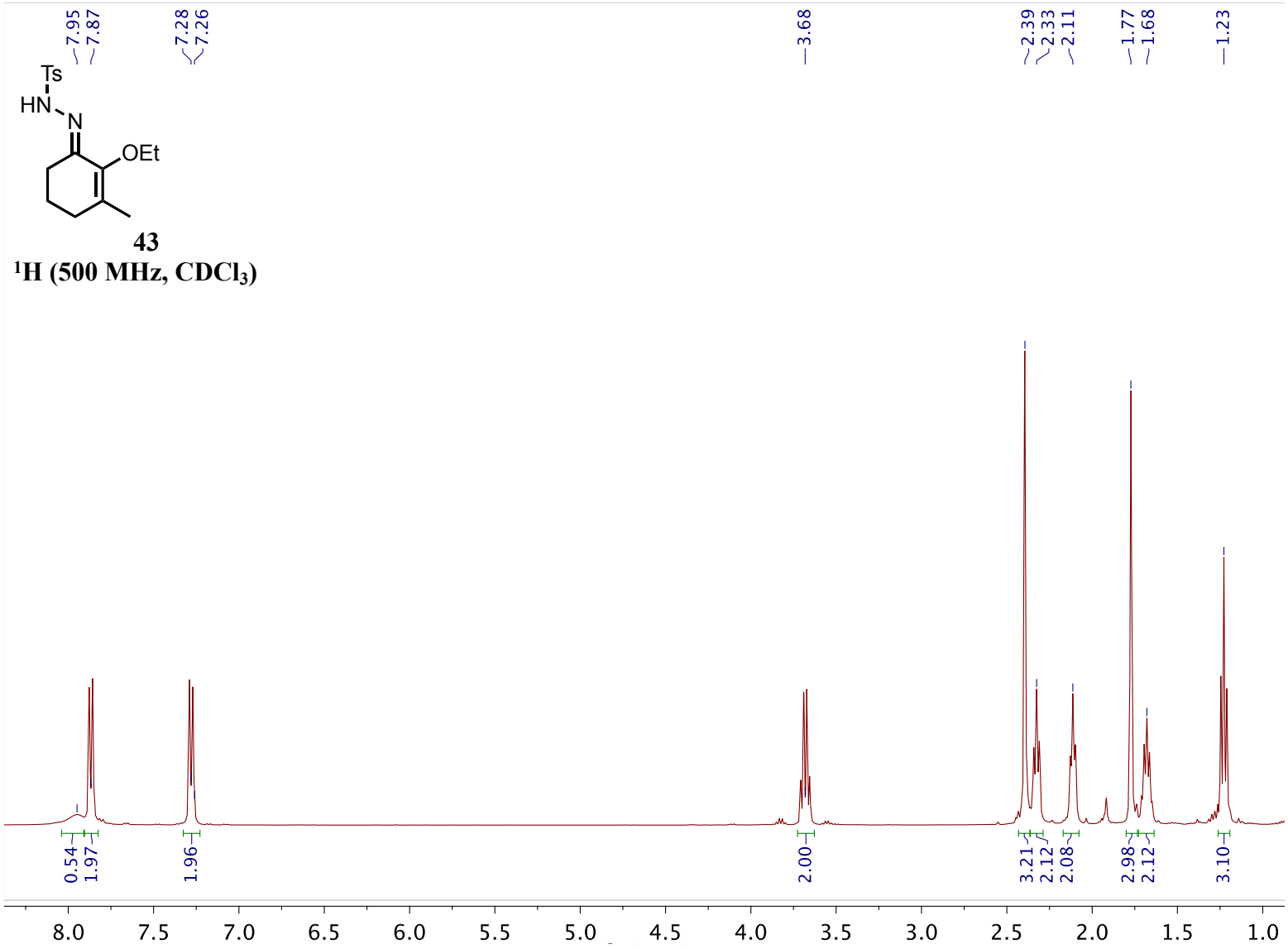
41

^{1}H (500 MHz, $CDCl_3$)


207.86
207.44
185.37
182.83
77.16
70.72
42.15
41.71
30.21
30.17
22.78
22.26
21.23
20.56
O
N2
O
41
13C (125 MHz, CDCl3)
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10

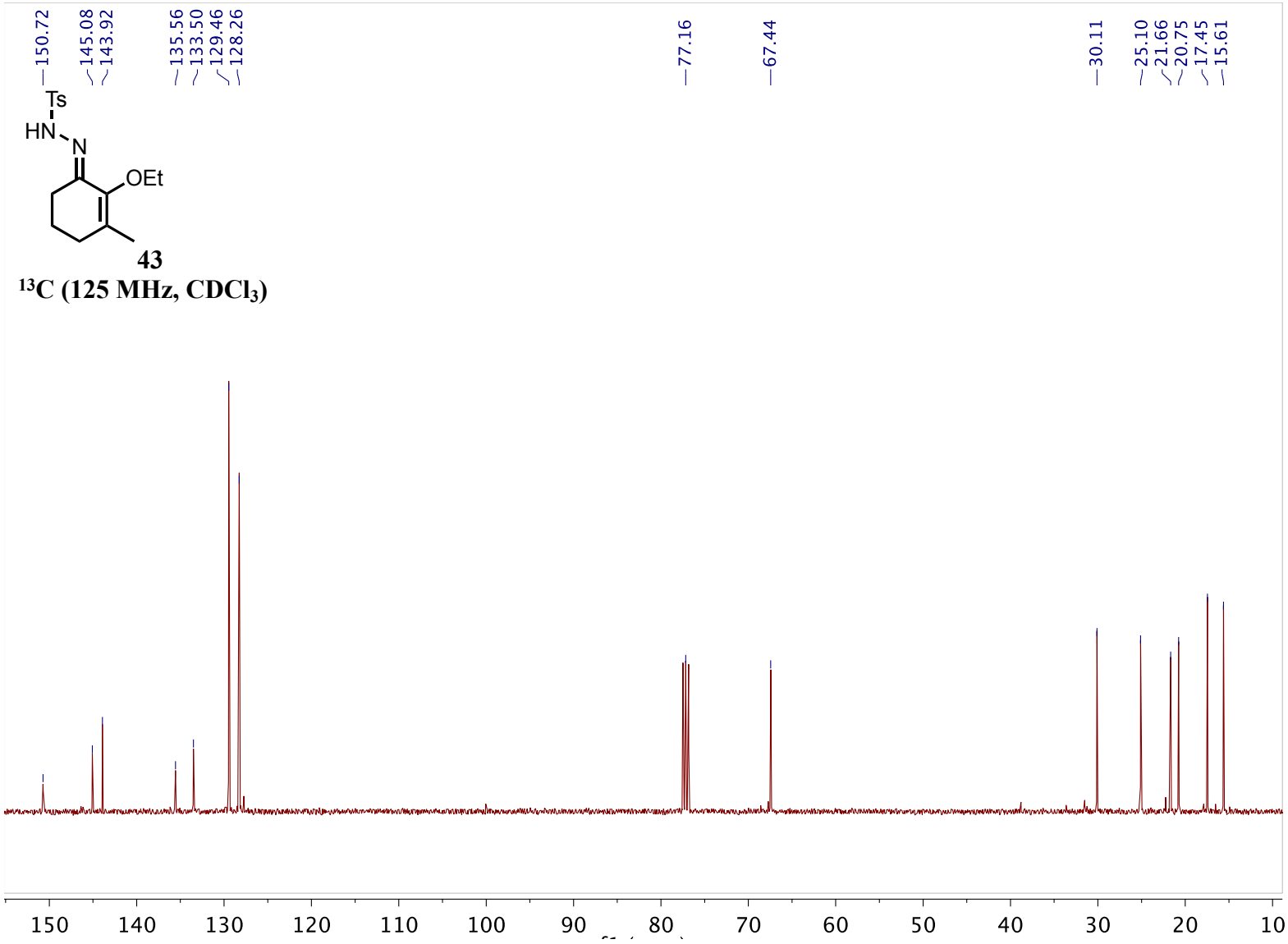

7.27
3.78
2.38
2.33
1.87
1.22
O
OEt
42
^{1}H (500 MHz, CDCl$_3$)
2.00
4.37
5.15
3.13
7.4
7.0
6.6
6.2
5.8
5.4
5.0
4.6
4.2
3.8
3.4
3.0
2.6
2.2
1.8
1.4
1.0


194.86
148.14
146.06
77.16
67.60
38.73
31.41
22.17
17.76
15.50
O
OEt
42
13C (125 MHz, CDCl3)
00 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20



43

^{1}H (500 MHz, $CDCl_3$)



43

^{13}C (125 MHz, $CDCl_3$)

References

1. L. Palatinus and G. Chapuis, *J. Appl. Cryst.*, 2007, **40**, 786.

2. (*a*) P. W. Betteridge, J. R. Carruthers, R. I. Cooper, K. Prout and D. J. Watkin, *J. Appl. Cryst.,* 2003, **36**, 1487; (*b*) R. I. Cooper, A. L. Thompson and D. J. Watkin, *J. Appl. Cryst.,* 2010, **43**, 1100.