

Supporting Material

C–O Hydrogenolysis Catalyzed by Pd-PMHS Nanoparticles in the Company of Chloroarenes

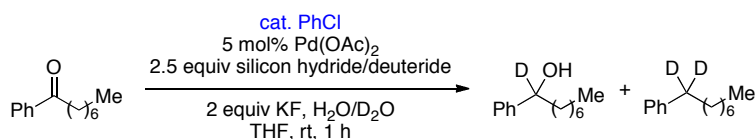
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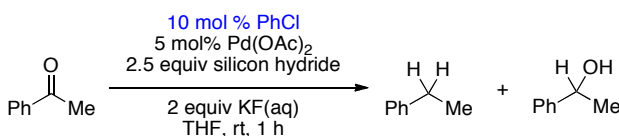
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Table SI1. Deuterium Labeling Experiments



Entry	mol% PhCl	Silicon Hydride	Water	%Yield	%Deuterium Incorporation	Product
1	0	Et ₃ Si-D	H ₂ O	97	90	C
2	0	PMHS	D ₂ O	100	3	C
3	10	Et ₃ Si-D	H ₂ O	38	58.5	D
4	10	PMHS	D ₂ O	92	36.5	D

Table SI2. Silicon Hydride Screening for Deoxygenation of Benzylic C–O Bonds.¹



Entry	Silicon Hydride	%Yield Methylene	%Yield Alcohol	% STARTING MATERIAL
1	PMHS	98	0	0
2	Et ₃ SiH	66	33	0
3	TMS ₃ SiH	46	53	0
4	EtO(Me) ₂ SiH	70	30	0
5	TMSO(Me) ₂ SiH	86	14	0
6	Me(MeO) ₂ SiH	0	14	82
7	Me(TMSO) ₂ SiH	89	10	0
8	(TMSO) ₃ SiH	0	0	100
9	1,3-bis(trimethylsiloxy)-1,3-dimethyldisiloxane	97	0	0
10	methylhydrocyclosiloxanes	20	70	5

a) Determined by ¹H NMR with an internal standard (CH₂Cl₂), average of two runs

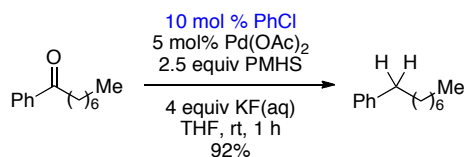
¹ Experiments aimed at elucidating if the altered reactivity between silicon hydride reagents is, in part, due to differences in nanoparticle size and morphology are ongoing. The results of these studies will be reported in elsewhere.

Methods: All reactions were carried out in oven dried glassware under an atmosphere of nitrogen, with magnetic stirring, and monitored by thin-layer chromatography with 0.25-mm precoated silica gel plates, unless otherwise noted. Visualization of all TLC's was performed by UV and/or staining with phosphomolybdic acid. Purifications were performed by silica gel flash chromatography with silica gel (Silicycle, 60 Å, 230-400 mesh) packed in glass columns and eluting with hexanes/EtOAc, unless otherwise noted. Water was degassed by sparging with nitrogen (12 hours for 500 mL).

Materials: Tetrahydrofuran was freshly distilled from sodium/benzophenone under nitrogen. Palladium(II) acetate (Strem), anhydrous A.C.S. grade potassium fluoride (Aldrich), and polymethylhydrosiloxane (PMHS, Aldrich) were used without purification. All other reagents and solvents were reagent grade and were used without further purification unless otherwise specified. 1-Phenyl-octan-1-one,² 4-(4-acetyl-phenyl)-butane-2-one,³ benzyl-bornyl ether,⁴ benzyl-(1-phenylethyl)-ether, 2S,3S-epoxy-3-phenylbutan-1-ol,⁵ and (*R*)-3-phenyl-butane-1,3-diol⁶ were prepared following literature procedures. The remaining substrates were purchased and used without purification.

Instrumentation: ¹H and ¹³C NMR spectra were recorded on a Varian Gemini 300 spectrometer (300 MHz for ¹H, respectively, and 75 MHz for ¹³C, respectively), and a Varian VXP 500 spectrometer (500 MHz for ¹H, respectively, and 125 MHz for ¹³C, respectively), with chemical shifts reported relative to the residue peaks of solvent chloroform (δ 7.26 for ¹H and 77.0 for ¹³C). IR spectra were obtained on a Nicolet IR/42 spectrometer using salt plates. Melting points were measured on a Thomas-Hoover capillary melting point apparatus and are uncorrected.

General Procedure: Typical procedure: Into a 25 mL round bottom flask, that had been purged with nitrogen, was charged Pd(OAc)₂ (0.05 mmol, 11 mg), freshly distilled THF (5 mL), and then the ketone (1.0 mmol). The flask was fitted with a balloon of nitrogen. A solution of potassium fluoride (4 mmol, 232 mg) in degassed water (2 mL) was added via syringe into the reaction, followed by chlorobenzene (0.1 mmol, 0.01 mL). PMHS (2.5 mmol, 0.15 mL) was then dropwise added via syringe into the reaction mixture. The resulting reaction was stirred for one hour. Ether was added to the reaction mixture, the layers were separated, and the aqueous layer was back extracted with ether. The combined organics were concentrated and subjected to flash chromatography. (**Caution:** *Rapid addition of PMHS can result in vigorous gas evolution! For reactions run on large scale, it is recommended that the reaction flask be fitted with a reflux condenser.*) 1 mmol hydride of PMHS = 0.06 mL



Following the general procedure 1-phenyl-octan-1-one (1 mmol, 0.217 mL) was reduced, affording 0.1759 g (92%) of 1-phenyloctane as a clear oil after flash chromatography (hexanes); ¹H NMR (300 MHz, CDCl₃), δ 7.20 (overlapping t, *J* = 7.1 Hz, 2 H), 7.11 (overlapping t, *J* = 7.1 Hz, 3 H), 2.54 (t, *J* = 7.7 Hz, 2 H), 1.55 (overlapping q, *J* = 7.7, 2 H), 1.21 (m, 10 H), 0.82 (overlapping t, *J* = 8.0 Hz, 3 H); ¹³C NMR (75 MHz, CDCl₃), δ 142.9, 128.3, 128.1, 125.5, 36.0, 31.9, 31.5, 29.5, 29.3, 29.2, 22.6, 14.1. Physical and spectral data were consistent with commercially available material.

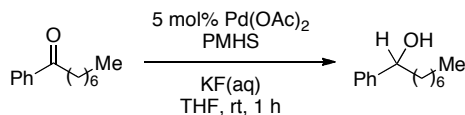
² Allen, C. F.H.; Barker, W. E. *Org. Syn*, CV 2, 156

³ Buntin, S. A.; Heck, R. F. *Org. Syn*, CV 7, 361

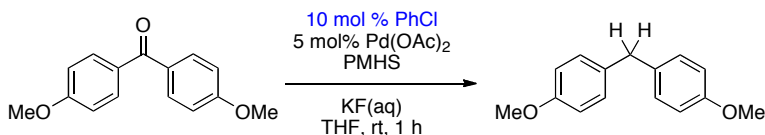
⁴ Dondoni, A.; Merino, P. *Org. Syn.*, CV 9, 52

⁵ Martín, R.; Islas, G.; Moyano, A.; Pericàs, M. A.; Riera, A. *Tetrahedron* **2001**, 57, 6367–6374.

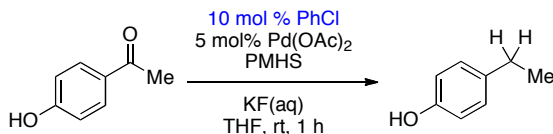
⁶ Erickson, T. J. *J. Org. Chem.* **1986**, 51, 934–935.



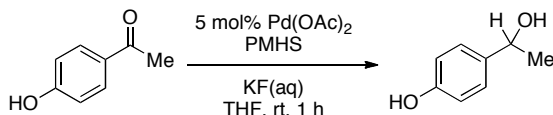
Following the general procedure in the absence of an aromatic chloride, with 1.5 equiv of PMHS (1.5 mmol, 0.09 mL) and 2 equiv KF (2 mmol, 0.116 g), 1-phenyl-octan-1-one (1 mmol, 0.217 mL) was reduced affording 0.182 g (88%) of 1-phenyl-octan-1-ol as a clear liquid after flash chromatography (hexanes/EtOAc: 95/5); ^1H NMR (300 MHz, CDCl_3), δ 7.31 (m, 5 H), 4.59 (t, J = 6.6 Hz, 1 H), 2.33 (s, 1 H), 1.83–1.58 (m, 2 H), 1.26 (m, 10 H), 0.87 (m, 3 H); ^{13}C NMR (75 MHz, CDCl_3), δ 144.9, 128.2, 127.0, 125.8, 74.5, 39.0, 31.7, 29.4, 29.1, 25.7, 22.5, 14.0. Physical and spectral data were consistent with commercially available material.



Following the general procedure 4,4'-dimethoxy-benzophenone (1 mmol, 0.242 g) was reduced, affording 0.2166 g (95%) of bis-(4-methoxy phenyl)-methane as a white solid after flash chromatography (hexanes/EtOAc: 95/5); mp = 52 °C; ^1H NMR (300 MHz, CDCl_3), δ 7.14 (d, J = 8.1 Hz, 4 H), 6.88 (d, J = 8.1 Hz, 4 H), 3.92 (s, 2 H), 3.81 (s, 6 H); ^{13}C NMR (75 MHz, CDCl_3), δ 157.7, 133.61, 129.6, 113.7, 55.0, 40.0. Physical and spectral data were consistent with those reported in the literature.⁷



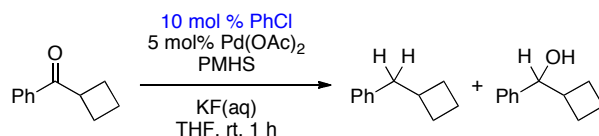
Following the general procedure 4'-hydroxyacetophenone (1mmol, 0.136 g) was reduced, affording 0.105 g (86%) of 4-ethyl-phenol as a white crystalline solid after flash chromatography (hexanes/EtOAc: 95/5 then 80/20); mp = 38–40 °C; ^1H NMR (300 MHz, CDCl_3), δ 7.06 (d, J = 7.1 Hz, 2 H), 6.78 (d, J = 7.1 Hz, 2 H), 5.57 (s, 1 H), 2.59 (q, J = 6.5 Hz, 2 H), 1.21 (t, J = 6.5 Hz, 3 H); ^{13}C NMR (75 MHz, CDCl_3), δ 153.2, 136.5, 128.8, 115.1, 27.9, 15.8. Physical and spectral data were consistent with commercially available material.



Following the general procedure in the absence on an aromatic chloride, with 1.5 equiv of PMHS (1.5 mmol, 0.09 mL) and 2 equiv KF (2 mmol, 0.116 g), 4'-hydroxyacetophenone (1mmol, 0.136 g) was reduced, affording 0.0922 g (67%) of 4-(1-hydroxy-ethyl)-phenol as a white crystalline solid and 0.0544 g (40%) starting material after flash chromatography (hexanes/EtOAc: 80/20 then 50/50); mp = 140 °C; ^1H NMR (300 MHz, CDCl_3 + $\text{DMSO}-d_6$), δ 8.51 (s, 1 H), 6.92 (d, J = 7.1 Hz, 2 H), 6.51 (d, J = 7.1 Hz, 2 H), 4.48 (m, 1 H), 4.04 (s, 1 H), 1.14 (d, J = 7.5 Hz, 3 H); ^{13}C NMR (75 MHz, CDCl_3 + $\text{DMSO}-d_6$), δ 155.6, 136.7, 126.0, 114.4, 68.5, 24.7. Physical and spectral data were consistent with those reported in the literature.⁸

⁷ Onaka, M.; Higuchi, K.; Nanami, H.; Izumi, Y. *Bull. Chem. Soc. Jpn.* **1993**, 66, 2638–2645.

⁸ Noji, M.; Ohno, T.; Fujii, K.; Futaba, N.; Tajima, H.; Ishii, K. *J. Org. Chem.* **2003**, 68, 9340–9347.

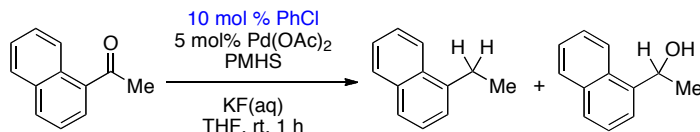


Following the general procedure benzoylcyclobutane (1 mmol, 0.152 mL) was reduced, affording 0.1059 g (72%) of benzylcyclobutane as a clear oil, and 0.0337 g (21%) of 1-cyclobutyl-1-phenylmethanol as light yellow oil after flash chromatography (hexanes/EtOAc: 95/5 then 80/20); (benzylcyclobutane) ¹H NMR (300 MHz, CDCl₃), δ 7.31 (t, *J* = 7.1 Hz, 2 H), 7.19 (m, 3 H), 2.74 (d, *J* = 7.7, 2 H), 2.62 (sep, *J* = 7.7, 1 H), 2.09 (m, 2 H), 1.96–1.69 (m, 4 H); ¹³C NMR (75 MHz, CDCl₃), δ 141.2, 128.4, 128.1, 125.5, 42.9, 37.2, 28.2, 18.3; Physical and spectral data were consistent with those reported in the literature;⁹ (1-cyclobutyl-1-phenylmethanol) ¹H NMR (300 MHz, CDCl₃), δ 7.16 (m, 5 H), 4.38 (d, *J* = 8.2 Hz, 1 H), 2.48 (m, 1 H), 2.18 (s, 1 H), 1.88 (m, 2 H), 1.65 (m, 4 H); ¹³C NMR (75 MHz, CDCl₃), δ 143.0, 128.1, 127.3, 126.0, 78.2, 42.2, 24.7, 24.2, 17.6. Physical and spectral data were consistent with those reported in the literature.¹⁰

Following the general procedure with 4 equiv PMHS (4 mmol, 0.24 mL) benzoylcyclobutane (1 mmol, 0.152 mL) was reduced, affording 0.1209 g (83%) of benzylcyclobutane as a clear oil, and 0.0201 g (12%) of 1-cyclobutyl-1-phenylmethanol.

Following the general procedure with 4 equiv PMHS (4 mmol, 0.24 mL), and 0.1 equiv 4-chloroanisole (0.1 mmol, 0.012 mL) benzoylcyclobutane (1 mmol, 0.152 mL) was reduced, affording 0.1374 g (94%) of benzylcyclobutane as a clear oil.

Following the general procedure in the absence of an aromatic chloride, with 1.5 equiv of PMHS (1.5 mmol, 0.09 mL) and 2 equiv KF (2 mmol, 0.116 g), benzoylcyclobutane (1 mmol, 0.152 mL) was reduced affording 0.1621 g (99%) of 1-cyclobutyl-1-phenylmethanol.



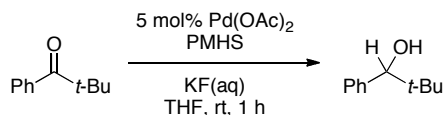
Following the general procedure 1-acetylnaphthalene (1 mmol, 0.152 mL) was reduced, affording 0.1249 g (80%) of 1-ethylnaphthalene as a light yellow liquid, and 0.0327 g (19%) of 1-[1]naphthyl-ethanol as a clear oil after flash chromatography (hexanes/EtOAc: 95/5 then 80/20); (1-ethylnaphthalene) ¹H NMR (300 MHz, CDCl₃), δ 8.07 (d, *J* = 8.2 Hz, 1 H), 7.86 (d, *J* = 9.3 Hz, 1 H), 7.72 (d, *J* = 8.2 Hz, 1 H), 7.56–7.32 (m, 4 H), 3.13 (q, *J* = 7.7 Hz, 2 H), 1.39 (t, *J* = 7.7, 3 H); ¹³C NMR (75 MHz, CDCl₃), δ 140.2, 133.8, 131.8, 128.7, 126.3, 125.6, 125.3, 124.8, 123.6, 23.8, 14.9; Physical and spectral data were consistent with commercially available material; (1-[1]naphthyl-ethanol); mp = 64 °C; ¹H NMR (300 MHz, CDCl₃), δ 8.06 (m, 1 H), 7.86 (m, 1 H), 7.75 (d, *J* = 8.2 Hz, 1 H), 7.64 (d, *J* = 7.1 Hz, 1 H), 7.49 (m, 3 H), 5.58 (q, *J* = 6.6 Hz, 1 H), 2.62 (bs, 1 H), 1.61 (d, *J* = 6.6 Hz, 3 H); ¹³C NMR (75 MHz, CDCl₃), δ 141.2, 133.6, 130.1, 128.7, 127.7, 125.8, 125.4, 123.0, 121.8, 66.8, 24.2. Physical and spectral data were consistent with those reported in the literature.¹¹

Following the general procedure with 0.1 equiv of 4-chloroanisole (0.1 mmol, 0.012 mL) 1-acetylnaphthalene (1 mmol, 0.152 mL) was reduced affording 0.1546 g (99%) of 1-ethylnaphthalene.

⁹ West, C. T.; Donnelly, S. J.; Kooistra, D. A.; Doyle, M. P. *J. Org. Chem.* **1973**, 38, 2675-2681.

¹⁰ Celebi, S.; Leyva, S.; Modarelli, D. A.; Platz, M. S. *J. Amer. Chem. Soc.* **1993**, 115, 8613-8620.

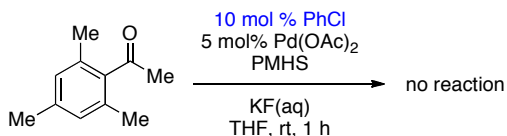
¹¹ Liu, S.; Wolf, C. *Org. Lett.* **2007**, 9, 2965-2968.



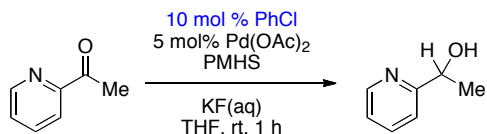
Following the general procedure 2,2-dimethyl-1-phenylpropan-1-one (1 mmol, 0.167 mL) was reduced, affording 0.1573 g (96%) of 2,2-dimethyl-1-phenylpropan-1-ol as a white solid after flash chromatography (hexanes/EtOAc: 95/5); mp = 44 °C; ^1H NMR (300 MHz, CDCl_3), δ 7.24 (s, 5 H), 4.30 (s, 1 H), 2.08 (s, 1 H), 0.87 (s, 9 H); ^{13}C NMR (75 MHz, CDCl_3), δ 142.1, 127.5, 127.4, 127.1, 82.2, 35.4, 25.8. Physical and spectral data were consistent with commercially available material.

Following the general procedure with 4 equiv PMHS (4 mmol, 0.24 mL) 2,2-dimethyl-1-phenylpropan-1-one (1 mmol, 0.167 mL) was reduced, affording 0.164 g (100%) of 2,2-dimethyl-1-phenylpropan-1-ol.

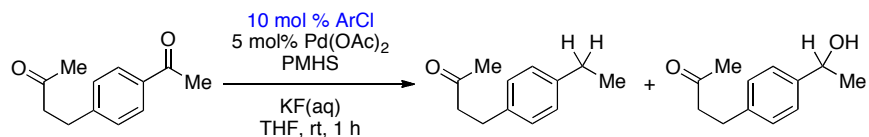
Following general procedure C in the absence of an aromatic chloride, with 1.5 equiv of PMHS (4 mmol, 0.24 mL) and 4 equiv KF (4 mmol, 0.232 g), 2,2-dimethyl-1-phenylpropan-1-one (1 mmol, 0.167 mL) was reduced, affording 0.160 g (96%) of 2,2-dimethyl-1-phenylpropan-1-ol.



Following the general procedure 2-acetylmesitylene (1 mmol, 0.166 mL) could not be reduced, with 98% of the starting material being recovered.



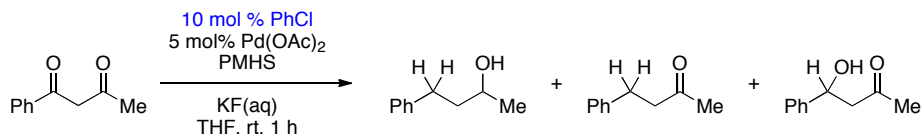
Following the general procedure 2-acetylpyridine (1 mmol, 0.112 mL) was reduced, affording 1-(pyridin-2-yl)ethanol in 98% yield, as determined by ^1H NMR ($d_1 = 1$, nt = 32) in $\text{THF}-d_8$ with CH_2Cl_2 (1 mmol, 0.064 mL) as an internal standard; 5.22 ppm (CH_2Cl_2 , set to 2 H), 1.34 (CH_3 for $\text{py}-\text{CH}(\text{OH})\text{CH}_3$, measured 2.93 H, 97.7%).



Following the general procedure 4-(4-acetylphenyl)butan-2-one (1 mmol, 0.19 g) was reduced, affording 0.0925 g (53%) of 4-(4-ethylphenyl)butan-2-one as a clear liquid, and 0.0846 g (44%) of 4-[4-(1-hydroxyethyl)phenyl]butan-2-one as a clear liquid after flash chromatography (hexanes/EtOAc: 95/5 then 80/20); (4-(4-ethylphenyl)butan-2-one): ^1H NMR (300 MHz, CDCl_3), δ 7.10 (s, 4 H), 2.83 (t, $J = 8.2$ Hz, 2 H), 2.75 (t, $J = 8.2$ Hz, 2 H), 2.60 (q, $J = 7.7$ Hz, 2 H), 2.12 (s, 3 H), 1.21 (t, $J = 7.7$ Hz, 3 H); ^{13}C NMR (75 MHz, CDCl_3), δ 208.0, 141.9, 138.0, 128.1, 127.9, 45.2, 30.0, 29.2, 28.3, 15.5; IR (neat) 3009, 2964, 2932, 2872, 1716, 1516, 1440, 1410, 1363, 1159, 819 cm^{-1} ; HRMS (EI) m/z found 176.1196 [(M $^+$) calcd. for $\text{C}_{12}\text{H}_{16}\text{O}$ 176.1201]; (4-[4-(1-hydroxyethyl)phenyl]butan-2-one): ^1H NMR (300 MHz, CDCl_3), δ 7.24 (d, $J = 8.2$ Hz, 2 H), 7.11 (d, $J = 8.2$ Hz, 2 H), 4.78 (q, $J = 6.6$ Hz, 1 H), 2.83 (t, $J = 7.1$ Hz, 2 H), 2.71 (t, $J = 6.9$ Hz, 2 H), 2.38 (bs, 1 H), 2.09 (s, 3 H), 1.42 (d, $J = 6.6$ Hz, 3 H); ^{13}C NMR (75 MHz, CDCl_3), δ 208.0, 143.6, 139.8, 128.1, 125.4, 69.8, 44.9, 29.8, 29.1, 24.9; IR (neat) 3420, 2972, 1709, 1385, 1089, 898, 821 cm^{-1} ; HRMS (EI) m/z 192.1149 [(M $^+$) calcd. for $\text{C}_{12}\text{H}_{16}\text{O}_2$ 192.1150].

Following the general procedure with 4 equiv PMHS (4 mmol, 0.24 mL), and 0.1 equiv 4-chloroanisole (0.1 mmol, 0.012 mL) 4-(4-acetyl-phenyl)-butan-2-one (1 mmol, 0.19 g) was reduced, affording 0.1275 g (72%) of 4-(4-ethyl-phenyl)-butan-2-one as a clear liquid, and 0.0481 g (25%) of 4-[4-(1-hydroxy-ethyl)-phenyl]-butan-2-one as a clear liquid.

Following the general procedure in the absence of an aromatic chloride, with 3 equiv PMHS (3 mmol, 0.18 mL) and 4 equiv KF (4 mmol, 0.232 g), 4-(4-acetyl-phenyl)-butan-2-one (1 mmol, 0.19 g) was reduced affording 0.1812 g (94%) of 4-[4-(1-hydroxy-ethyl)-phenyl]-butan-2-one as a clear liquid, and 0.007 g (4%) of starting material.



Following the general procedure 1-phenyl-1,3-butanedione (1 mmol, 0.162 g) was reduced, affording 0.0111 g (7.5%) of 4-phenyl-butan-2-one, 0.0171 g (11%) of 4-phenyl-butan-2-ol, 0.0789 g (48%) of 4-hydroxy-4-phenyl-butan-2-one, 0.0211 g (14%) of 1-phenyl-butan-1-ol, 0.0135 g (8%) of 1-phenyl-butane-1,3-diol, and 0.0135 g (8%) of starting material; (4-phenyl-butan-2-one) ^1H NMR (300 MHz, CDCl_3), δ 7.11 (m, 2 H), 7.04 (m, 3 H), 2.73 (t, J = 7.4 Hz, 2 H), 2.62 (t, J = 7.1 Hz, 2 H), 1.99 (s, 3 H); ^{13}C NMR (75 MHz, CDCl_3), δ 207.9, 140.9, 128.4, 128.2, 126.0, 45.1, 30.0, 29.6; (4-phenyl-butan-2-ol) ^1H NMR (300 MHz, CDCl_3), δ 7.20 (m, 5 H), 3.80 (sep, J = 6.0 Hz, 1 H), 2.70 (dquin, J = 6.0 Hz, 2 H), 1.75 (m, 3 H), 1.21 (d, J = 6.0 Hz, 3 H); ^{13}C NMR (75 MHz, CDCl_3), δ 142.0, 128.3, 125.7, 67.4, 40.8, 32.0, 23.5; (4-hydroxy-4-phenyl-butan-2-one) ^1H NMR (300 MHz, CDCl_3), δ 7.30 (m, 5 H), 5.11 (dd, J = 6.3 Hz, 1 H), 3.29 (bs, 1 H), 2.80 (ddd, J = 3.8, 8.7, 17.6 Hz, 2 H), 2.14 (s, 3 H); ^{13}C NMR (75 MHz, CDCl_3), δ 209.0, 142.6, 128.4, 127.6, 125.5, 69.7, 51.9, 30.7; (1-phenyl-butan-1-ol) ^1H NMR (300 MHz, CDCl_3), δ 7.18 (m, 5 H), 4.52 (t, J = 6.6 Hz, 1 H), 1.72 (bs, 1 H), 1.69–1.46 (m, 2 H), 1.35–1.05 (m, 2 H), 0.78 (t, J = 7.4 Hz, 3 H); ^{13}C NMR (75 MHz, CDCl_3), δ 144.8, 128.3, 127.4, 125.8, 74.3, 41.1, 19.0, 13.9; (1-phenyl-butane-1,3-diol) ^1H NMR (300 MHz, CDCl_3), δ 7.34 (m, 5 H), 4.92 (dd, J = 3.3, 9.9 Hz, 1 H), 4.13 (m, 1 H), 2.43 (bs, 2 H), 1.82 (m, 2 H), 1.20 (d, J = 6.6 Hz, 3 H); ^{13}C NMR (75 MHz, CDCl_3), δ 144.4, 128.5, 127.6, 125.6, 68.8, 47.0, 27.5, 24.0.

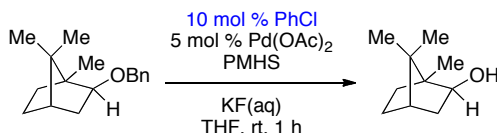
Following the general procedure with 5 equiv of PMHS (5 mmol, 0.3 mL), 1-phenyl-1,3-butanedione (1 mmol, 0.162 g) was reduced, affording 0.0193 g (14%) of butyl-benzene, 0.0486 g (32.8%) of 4-phenyl-butan-2-one, 0.0698 g (47%) of 4-phenyl-butan-2-ol, 0.002 g (1%) of 1-phenyl-butan-1-ol, 0.003 g (1.8%) of 1-phenyl-butane-1,3-diol; (butyl-benzene) ^1H NMR (300 MHz, CDCl_3), δ 7.26 (m, 2 H), 7.17 (m, 3 H), 2.60 (t, J = 7.69 Hz, 2 H), 1.59 (t, J = 7.69 Hz, 2 H), 1.34 (m, 2 H), 0.91 (t, J = 7.41 Hz, 3 H); ^{13}C NMR (75 MHz, CDCl_3), δ 142.9, 128.4, 128.2, 125.6, 35.7, 33.7, 22.4, 13.9.

Following the general procedure in the absence of an aromatic chloride, with 1.5 equiv of PMHS (1.5 mmol, 0.09 mL) and 2 equiv of KF (2 mmol, 0.116 g), 1-phenyl-1,3-butanedione (1 mmol, 0.162 g) was reduced, affording 0.083 g (51%) of 4-hydroxy-4-phenyl-butan-2-one and 3-hydroxy-1-phenyl-butan-1-one as a 4.6 / 1 mixture, 0.006 g (3.6%) of 1-phenyl-butane-1,3-diol, and 0.0742 g (46%) of STARTING MATERIAL; (3-hydroxy-1-phenyl-butan-1-one) ^1H NMR (300 MHz, CDCl_3), δ 7.92 (d, J = 7.7 Hz, 2 H), 7.56 (t, J = 7.7 Hz, 1 H), 7.44 (t, J = 7.7 Hz, 2 H), 4.43–4.31 (m, 1 H), 3.36 (bs, 1 H), 3.16 (dd, J = 3.0, 17.6 Hz, 1 H), 3.03 (dd, J = 8.8, 17.6 Hz, 1 H), 1.26 (d, J = 6.0 Hz, 3 H); ^{13}C NMR (75 MHz, CDCl_3), δ 200.7, 136.6, 133.4, 128.6, 128.0, 63.9, 46.4, 22.3.

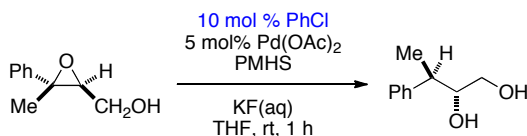


Following the general procedure 4-acetyl-methyl benzoate (1 mmol, 0.178 g) was reduced, affording 0.035 g (21%) of 4-ethyl-benzoic acid methyl ester as a clear oil, and 0.1418 g (77%) of 4-(1-hydroxy-ethyl)-benzoic acid methyl ester as a yellow oil after flash chromatography (hexanes/EtOAc: 95/5, 80/20 then 50/50); (4-ethyl-benzoic acid methyl ester): ¹H NMR (300 MHz, CDCl₃), δ 7.92 (d, *J* = 8.2 Hz, 2 H), 7.22 (d, *J* = 8.2 Hz, 2 H), 3.87 (s, 3 H), 2.65 (q, *J* = 7.7 Hz, 2 H), 1.22 (t, *J* = 7.7 Hz, 3 H); ¹³C NMR (75 MHz, CDCl₃), δ 167.1, 149.6, 129.6, 127.8, 127.5, 51.8, 28.8, 15.1; IR (neat) 2968, 2876, 1724, 1612, 1435, 1278, 1178, 1109 cm⁻¹; HRMS (EI) *m/z* 164.0839 [(M⁺) calcd. for C₁₀H₁₂O₂ 164.0837]; [4-(1-hydroxy-ethyl)-benzoic acid methyl ester]: ¹H NMR (300 MHz, CDCl₃), δ 7.88 (d, *J* = 8.2 Hz, 2 H), 7.32 (d, *J* = 8.2 Hz, 2 H), 4.83 (q, *J* = 6.6 Hz, 1 H), 3.81 (s, 3 H), 2.89 (bs, 1 H), 1.39 (d, *J* = 6.6 Hz, 3 H); ¹³C NMR (75 MHz, CDCl₃), δ 167.0, 151.0, 129.6, 128.8, 125.1, 69.6, 52.0, 25.0; IR (neat) 3431, 2974, 2930, 1722, 1612, 1437, 1280, 1194, 1115, 1089, 1018, 900, 858 cm⁻¹; HRMS (EI) *m/z* 180.0784 [(M⁺) calcd. for C₁₀H₁₂O₃ 180.0786].

Following the general procedure with 4 equiv PMHS (4 mmol, 0.24 mL), and 0.1 equiv 4-chloroanisole (0.1 mmol, 0.012 mL) 4-acetyl-methyl benzoate (1 mmol, 0.178 g) was reduced, affording 0.0858 g (52%) of 4-ethyl-benzoic acid methyl ester as a clear oil, and 0.0835 g (46%) of 4-(1-hydroxy-ethyl)-benzoic acid methyl ester as a yellow oil.

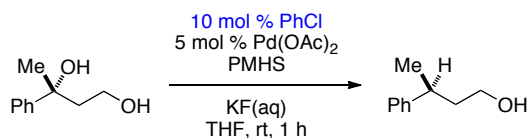


Following the general procedure benzyl bornyl ether (1 mmol, 0.244 g) was reduced, affording 0.1028 g (67%) of borneol as a white solid after flash chromatography (hexanes/EtOAc: 95/5 then 80/20); mp = 200–204 °C; ¹H NMR (300 MHz, CDCl₃), δ 3.58 (dd, *J* = 4.4, 6.6 Hz, 1 H), 1.76–1.38 (m, 6 H), 0.98 (s, 3 H), 0.95–0.90 (m, 1 H), 0.87 (s, 3 H), 0.78 (s, 3 H); ¹³C NMR (75 MHz, CDCl₃), δ 79.8, 48.9, 46.2, 44.9, 40.3, 33.8, 27.5, 27.1, 20.4, 20.0, 11.3. Physical and spectral data were consistent with commercially available material.



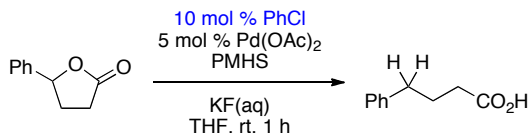
Following the general procedure (2*S*,3*S*)-epoxy-3-phenyl-butan-1-ol (1 mmol, 0.164 g, 89.5 %ee) was reduced, affording 0.1614 g (97%) of (2*R*,3*R*)-3-phenyl-butane-1,2-diol as a clear oil, and trace amounts of 3-phenyl-butan-1-ol after flash chromatography (hexanes/EtOAc: 95/5, 80/20 then 50/50); ¹H NMR (300 MHz, CDCl₃), δ 7.26 (m, 2 H), 7.15 (m, 3 H), 3.78 (bs, 1 H), 3.67 (m, 2 H), 3.33 (m, 1 H), 3.24 (m, 1 H), 2.70 (q, *J* = 7.4 Hz, 1 H), 1.30 (d, *J* = 6.6 Hz, 3 H); ¹³C NMR (75 MHz, CDCl₃), δ 143.7, 128.4, 127.8, 126.4, 76.5, 64.9, 42.7, 17.5; %de determined by GC using a Beta DEXTM 325 Fused Silica Capillary Column: 30mX0.25mmX0.25μm film thickness; GC conditions: starting temperature (30 °C), ramp rate (10 °C/min.), final temperature (200 °C for 15 min.), R.T. 20.17 (2.4%), 20.93 (97.6%); 95 %de. Physical and spectral data were consistent with those reported in the literature.¹²

¹² Pasto, M.; Moyano, A.; Pericas, M. A.; Riera, A. *J. Org. Chem.* **1997**, 62, 8425-8431.

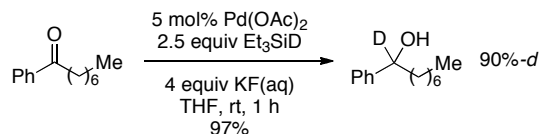


Following the general procedure (*R*)-3-phenyl-butane-1,3-diol (1 mmol, 0.166 g, 82.8 %ee) was reduced, affording 0.0926 g (61%) of (3*S*)-3-phenyl-butan-1-ol, and 0.0637 g (38%) of starting material after flash chromatography (hexanes/EtOAc: 95/5, 80/20 then 50/50); ^1H NMR (300 MHz, CDCl_3), δ 7.29 (m, 2 H), 7.21 (m, 3 H), 3.52 (m, 2 H), 2.87 (m, 1 H), 1.84 (q, J = 6.6 Hz, 2 H), 1.69 (bs, 1 H), 1.26 (d, J = 7.1 Hz, 3 H); ^{13}C NMR (75 MHz, CDCl_3), δ 146.7, 128.4, 126.8, 126.0, 61.0, 40.8, 36.3, 22.3. Spectral data was identical to authentic sample; %ee and absolute configuration was determined by derivatization of the alcohol with (*R*)-MPA. A dry 10 mL round bottom flask was charged with 1.1 equiv of (*R*)-(-)- α -methoxyphenylacetic acid (0.4305 mmol, 0.0715 g), and 3 crystals of DMAP. The round bottom flask was sealed and placed under an atmosphere of nitrogen. Freshly distilled CH_2Cl_2 (2 mL), (3*S*)-3-phenyl-butan-1-ol (0.3914 mmol, 0.0588 g) in 0.5 mL CH_2Cl_2 , and DCC (0.4305 mmol, 1.0M in CH_2Cl_2 , 0.4305 mL) were injected sequentially and the reaction was stirred over night. The white precipitate was filtered off and rinsed with CH_2Cl_2 . The filtrate was washed with 5% HCl (aq), sat. NaHCO_3 , dried over MgSO_4 , filtered, and concentrated. The crude material was subjected to flash chromatography (hexanes/EtOAc: 95/5 then 80/20) affording 0.1095 g (93%) of methoxy-phenyl-acetic acid 3-phenyl-butyl ester as a clear oil; ^1H NMR (300 MHz, CDCl_3), δ 7.46–7.31 (m, 5 H), 7.25–7.08 (m, 3 H), 7.04 (d, J = 7.1 Hz, 0.17 H), 6.94 (d, J = 6.6 Hz, 1.83 H), 4.69 (s, 1 H), 4.03 (m, 1 H), 3.89 (m, 1 H), 3.38 (s, 3 H), 2.62 (m, 1 H), 1.82 (m, 2 H), 1.18 (d, J = 6.6 Hz, 3 H); ^{13}C NMR (75 MHz, CDCl_3), δ 170.5, 145.7, 136.3, 128.7, 128.6, 128.4, 127.2, 126.8, 126.1, 82.4, 63.5, 57.2, 36.6, 36.2, 22.0; IR (neat) 3028, 2961, 2930, 2828, 1747, 1495, 1451, 1257, 1174, 1111, 1024, 700 cm^{-1} ; HRMS (EI) m/z 298.1564 [(*M*)+] calcd. for $\text{C}_{19}\text{H}_{22}\text{O}_3$ 298.1569].

To insure that the chiral (*R*)-MPA ester formed could distinguish the *R* and *S* enantiomers of 3-phenyl-butan-1-ol, a racemic mixture of 3-phenyl-butan-1-ol (0.2735 mmol, 0.041 g) was coupled with (*R*)-MPA following the procedure above; ^1H NMR (300 MHz, CDCl_3), δ 7.48–7.31 (m, 5 H), 7.28–7.09 (m, 3 H), 7.05 (d, J = 7.1 Hz, 1 H), 6.94 (d, J = 6.59 Hz, 1 H), 4.70 (s, 1 H), 4.10–3.83 (m, 2 H), 3.39 (s, 1.5 H), 3.38 (s, 1.5 H), 2.61 (m, 1 H), 1.82 (m, 2 H), 1.19 (d, J = 7.14 Hz, 1.5 H), 1.15 (d, J = 6.6 Hz, 1.5 H); ^{13}C NMR (75 MHz, CDCl_3), δ 170.5, 145.9, 145.7, 136.3, 128.6, 128.5, 128.4, 128.3, 127.2, 127.1, 126.7, 126.1, 82.5, 82.4, 63.5, 57.2, 36.6, 36.28, 36.23, 22.0, 21.9.

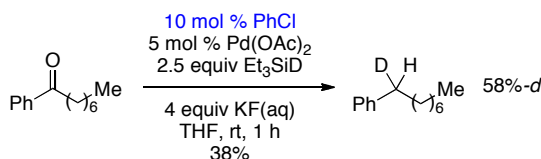


Following the general procedure with 1.5 equiv PMHS (1.5 mmol, 0.09 mL), and 2 equiv KF (2 mmol, 0.116 g) γ -phenyl- γ -butyrolactone (1 mmol, 0.162 g) was reacted, affording 0.1477 g (90%) of 4-phenyl-butyric acid as a white solid (>90% purity), and 0.1114 g (68%) analytically pure material after a second column; mp = 53 $^{\circ}\text{C}$; ^1H NMR (300 MHz, CDCl_3), δ 10.91 (bs, 1 H), 7.29 (m, 2 H), 7.20 (m, 3 H), 2.67 (t, J = 7.4 Hz, 2 H), 2.37 (t, J = 7.4 Hz, 2 H), 1.97 (q, J = 7.7 Hz, 2 H); ^{13}C NMR (75 MHz, CDCl_3), δ 180.0, 141.1, 128.4, 128.3, 125.9, 34.8, 33.2, 26.1. Physical and spectral data were consistent with commercially available material.

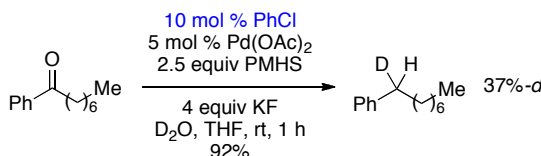


A dry 25 mL round bottom flask was charged with $\text{Pd}(\text{OAc})_2$ (0.085 mmol, 0.019 g), KF (6.8 mmol, 0.395 g), sealed, and flushed with nitrogen. While flushing the system, 8.5 mL of freshly

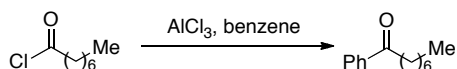
distilled THF, 1-phenyl-octan-1-one (1 mmol, 0.368 mL), and 3.4 mL of degassed water were injected sequentially. The nitrogen line was removed and a balloon of nitrogen was attached. Triethylsilane- d_1 (4.26 mmol, 0.5 g, 97% deuterium) was slowly injected dropwise followed by stirring for 1 hour. The reaction was diluted with ether, the layers separated, and the aqueous layer back extracted with ether. The combined organics were filtered through a plug of Celite (top layer) and neutral alumina (bottom layer) with EtOAc. The filtrate was concentrated then subjected to flash chromatography (hexanes/EtOAc: 100/0 then 95/5) affording 0.7871 g of 1-phenyloctan-1-ol (97%) and triethylsilanol as a clear oil. %Deuterium incorporation was determined by ^1H NMR; ^1H NMR (300 MHz, CDCl_3), δ 7.30 (m, 5 H), 4.61 (t, J = 6.6 Hz, 1 H, measured 0.1 H, 90% deuterium), 2.09 (bs, 1 H), 1.85–1.59 (m, 2 H), 1.22 (m, 10 H), 0.83 (m, 3 H).



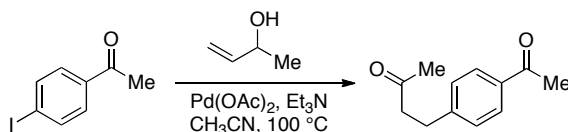
A dry 25 mL round bottom flask was charged with $\text{Pd}(\text{OAc})_2$ (0.08 mmol, 0.017 g), KF (6.8 mmol, 0.395 g), sealed, and flushed with nitrogen. While flushing the system, 8.5 mL of freshly distilled THF, 1-phenyl-octan-1-one (1.7 mmol, 0.368 mL), chlorobenzene (0.17 mmol, 0.017 mL), and 3.4 mL of degassed water were injected sequentially. The nitrogen line was removed and a balloon of nitrogen was attached. Triethylsilane- d_1 (4.26 mmol, 0.5 g, 97% deuterium) was slowly injected dropwise followed by stirring for 1 hour. The reaction was diluted with ether, the layers separated, and the aqueous layer back extracted with ether. The combined organics were filtered through a plug of Celite (top layer) and neutral alumina (bottom layer) with EtOAc. The filtrate was concentrated then subjected to flash chromatography (hexanes/EtOAc: 100/0 then 95/5) affording 0.122 g (38%) of 1-phenyloctane as a clear oil. %Deuterium incorporation was determined by ^1H NMR; ^1H NMR (300 MHz, CDCl_3), δ 7.26 (m, 5 H), 2.64 (m, 2 H, measured 0.85 H, 58% deuterium), 1.64 (m, 2 H), 1.32 (m, 10 H), 0.93 (m, 3 H); ^{13}C NMR (75 MHz, CDCl_3), δ 142.8, 128.3, 128.1, 125.5, 36.0, 35.8, 35.6, 35.3, 31.9, 31.5, 31.48, 31.40, 29.5, 29.3, 29.2, 22.6, 14.1.



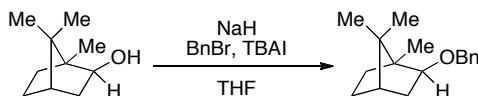
A dry 25 mL round bottom flask was charged with $\text{Pd}(\text{OAc})_2$ (0.05 mmol, 0.011 g), KF (4 mmol, 0.232 g), sealed, and flushed with nitrogen. While flushing the system, 5 mL of freshly distilled THF, 1-phenyl-octan-1-one (1 mmol, 0.216 mL), chlorobenzene (0.1 mmol, 0.01 mL), and 2 mL of deuterium oxide (D_2O) were injected sequentially. The nitrogen line was removed and a balloon of nitrogen was attached. PMHS (2.5 mmol, 0.15 mL) was slowly injected dropwise followed by stirring for 1 hour. The reaction was diluted with ether, the layers separated, and the aqueous layer back extracted with ether. The combined organics were filtered through a plug of Celite (top layer) and neutral alumina (bottom layer) with EtOAc. The filtrate was concentrated then subjected to flash chromatography (hexanes/EtOAc: 100/0 then 95/5) affording 0.1752 g (92%) of 1-phenyloctane as a clear oil. %Deuterium incorporation was determined by ^1H NMR; ^1H NMR (300 MHz, CDCl_3), δ 7.26 (m, 5 H), 2.64 (m, 2 H, measured 1.27 H, 36.5% deuterium), 1.65 (m, 2 H), 1.32 (m, 10 H), 0.93 (m, 3 H); ^{13}C NMR (75 MHz, CDCl_3), δ 142.9, 128.3, 128.1, 125.5, 36.0, 31.9, 31.5, 31.4, 29.5, 29.37, 29.34, 29.2, 22.6, 14.1.



Preparation of 1-phenyl-octan-1-one: A 500 mL three-necked round bottom flask was attached to a reflux condenser and addition funnel, and placed under a positive flow of nitrogen. The round bottom flask was charged with aluminum chloride (220 mmol, 29.3 g) and freshly distilled benzene (1800 mmol, 161 mL), and placed in an oil-bath at 75 °C. The addition funnel was then charged with the octanoyl chloride (200 mmol, 34.1 mL), after heating the benzene mixture for ten minutes the acid chloride was added drop-wise to the solution over an hour. The reaction mixture bubbled vigorously upon addition of the acid chloride. After complete addition of the acid chloride the oil-bath was turned off and the reaction was gradually cooled to rt over-night (~9 hours). The reaction mixture was poured into an Erlenmeyer flask with 200 mL ice and 50 mL con. HCl. The layers were separated, and the aqueous layer was back extracted with ether. The combined organics were dried over calcium chloride, filtered, and concentrated. The crude material was subjected to flash chromatography (hexanes/EtOAc: 90/10) affording 36.5 g (89%) of 1-phenyl-octan-1-one as a light yellow oil; ¹H NMR (300 MHz, CDCl₃), δ 7.94 (d, *J* = 7.1 Hz, 2 H), 7.50 (t, *J* = 7.1 Hz, 1 H), 7.41 (t, *J* = 7.7 Hz, 2 H), 2.92 (t, *J* = 7.4 Hz, 2 H), 1.70 (quin, *J* = 7.1 Hz, 2 H), 1.26 (m, 8 H), 0.85 (t, *J* = 6.9, 3 H); ¹³C NMR (75 MHz, CDCl₃), δ 200.3, 136.9, 132.7, 128.4, 127.9, 38.4, 31.6, 29.2, 29.0, 24.2, 22.5, 13.9. Physical and spectral data were consistent with those reported in the literature.¹³



Preparation of 4-(4-acetyl-phenyl)-butane-2-one: A 25 mL round bottom flask was charged with 4'-iodoacetophenone (20 mmol, 4.92 g), Pd(OAc)₂ (0.6 mmol, 0.135 g), and 10 mL CH₃CN. The round bottom flask was connected to a reflux condenser and flushed with nitrogen, and then 3-buten-2-ol (25 mmol, 2.17 mL) and Et₃N (25 mmol, 3.48 mL) were injected into the reaction. The round bottom flask was placed in an oil bath at 100 °C and the reaction was refluxed for 16 hours. The reaction mixture was cooled to room temperature and diluted with water and ether. The two layers were separated and the ether layer was washed with water. The aqueous layer was back extracted with ether. The combined organics were dried over MgSO₄, filtered, and concentrated. The crude reddish-orange material was subjected to flash chromatography (hexanes/EtOAc: 95/5 then 80/20) affording 2.86 g (75%) of 4-(4-acetyl-phenyl)-butane-2-one as a yellow solid; ¹H NMR (300 MHz, CDCl₃), δ 7.85 (d, *J* = 8.2 Hz, 2 H), 7.25 (d, *J* = 8.2 Hz, 2 H), 2.91 (m, 2 H), 2.77 (m, 2 H), 2.54 (s, 3 H), 2.12 (s, 3 H); ¹³C NMR (75 MHz, CDCl₃), δ 207.2, 197.7, 146.7, 135.1, 128.5, 128.4, 44.1, 30.0, 29.4, 26.5. Physical and spectral data were consistent with those reported in the literature.¹⁴

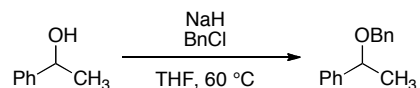


Preparation of benzyl-bornyl ether: A three-necked round bottom flask, equipped with a reflux condenser, addition funnel, and glass stopper was charged with *DL*-isoborneol (30.0 mmol, 4.63 g) and freshly distilled THF (150 mL). The round bottom flask was placed under a nitrogen atmosphere and NaH (60 mmol, 2.4 g, 60% mineral dispersion) was added in four portions, with 5 minutes of stirring between each portion. The mixture was heated to reflux for 30 minutes then cooled to room temperature, at which point a THF (50 mL) solution of benzyl bromide (60.0 mmol, 7.14 mL, filtered through neutral aluminum oxide) was added dropwise to the reaction over 30 minutes from the addition funnel. After complete addition tetrabutylammonium iodide (3.0 mmol, 1.1 g) dissolved in DMF (5 mL) was injected. The reaction was stirred over night then reheated to

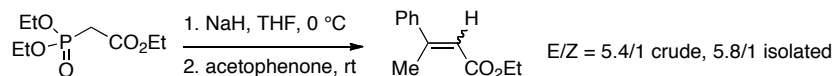
¹³ Suh, Y. S.; Lee, J.; Kim, S.; Rieke, R. D. *J. Organomet. Chem.* **2003**, 684, 20–36.

¹⁴ Condon, S.; Dupré, D.; Falgayrac, G.; Nédélec, J. Y. *Eur. J. Org. Chem.* **2002**, 105–11.

reflux for 1 hour. The reaction was cooled, quenched with water, and extracted with ether. The organic layer was dried over MgSO_4 , concentrated, and subjected to flash chromatography (hexanes/ EtOAc : 100/0, 99/1, 95/5, 90/10, 80/20) affording 7.18 g (98%) of benzyl-bornyl ether as a clear oil; ^1H NMR (300 MHz, CDCl_3), δ 7.35–7.18 (m, 5 H), 4.57 (d, J = 12.1 Hz, 1 H), 4.40 (d, J = 12.6 Hz, 1 H), 3.33 (dd, J = 3.6, 7.4 Hz, 1 H), 1.91–1.81 (m, 1 H), 1.76–1.45 (m, 4 H), 1.07 (s, 3 H), 1.01 (s, 1 H), 0.98 (s, 4 H), 0.85 (s, 3 H); ^{13}C NMR (75 MHz, CDCl_3), δ 139.6, 128.1, 126.9, 86.5, 70.5, 49.3, 46.5, 45.1, 38.4, 34.4, 27.3, 20.3, 20.2, 11.9. Physical and spectral data were consistent with those reported in the literature.¹⁵



Preparation of benzyl-(1-phenylethyl)-ether: A 250 mL round bottom flask equipped with a reflux condenser was charged with NaH (33.2 mmol, 1.328 g, 60% mineral dispersion) that was washed with hexanes three times and dried under high vacuum. Dry THF (30 mL) was injected, and to the vigorously stirred slurry was added a THF (70 mL) solution of *sec*-phenethyl alcohol (16.6 mmol, 2.0 mL) over 15 minutes. After complete addition the reaction was stirred for 30 minutes, followed by the addition of benzyl chloride (66.4 mmol, 7.6 mL) and placing the round bottom flask in an oil bath at 60 °C. The reaction was heated overnight (10 hours), cooled to room temperature, and carefully quenched with sat. NH_4Cl (aq). The mixture was diluted with water, and extracted with ether twice. The combined ether extracts were washed with water then brine, dried over MgSO_4 , and concentrated. The crude material was subjected to flash chromatography (hexanes/ EtOAc : 100/0, 90/10, 70/30, then 50/50) affording 2.48 g (70%) of benzyl-(1-phenylethyl)-ether as a light yellow oil; ^1H NMR (300 MHz, CDCl_3), δ 7.46–7.33 (m, 10 H), 4.59 (q, J = 6.6 Hz, 1 H), 4.45 (dd, J = 12.1, 47.5 Hz, 2 H), 1.58 (d, J = 6.6 Hz, 3 H); ^{13}C NMR (75 MHz, CDCl_3), δ 143.6, 138.5, 128.4, 128.3, 127.6, 127.46, 127.43, 126.3, 77.1, 70.2, 24.2. Physical and spectral data were consistent with those reported in the literature.¹⁶



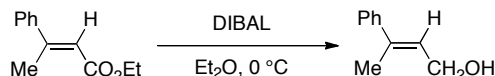
Preparation of (*E/Z*) 3-phenyl-but-2-enoic acid ethyl ester:¹⁷ A 100 ml three-necked round bottom flask equipped with a reflux condenser, addition funnel, and glass stopper, was charged with NaH (46.8 mmol, 1.86 g, 60% mineral dispersion), which was triple washed with hexanes then dried under vacuum. Dry THF (40 mL) was injected and the slurry was cooled with an ice bath. Triethyl phosphonoacetate (50 mmol, 10.54 mL) was added dropwise over 30 minutes from the addition funnel. The reaction was warmed to room temperature and the addition funnel was subsequently charged with acetophenone (31.2 mmol, 3.64 mL) and dry THF (20 mL), which were added dropwise over 30 minutes. After complete addition the reaction was stirred for 14 hours. The reaction mixture was poured into a separatory funnel containing water (30 mL) and ether (70 mL). The organic layer was washed with brine and the combined aqueous layers were back extracted with ether. The combined organics were dried over MgSO_4 , and concentrated, affording a light yellow oil (E/Z = 5.4/1). The crude material was subjected to flash chromatography (hexanes/ EtOAc : 99/1, 95/5, 90/10) affording 5.02 g (84%) of *E*-3-phenyl-but-2-enoic acid ethyl ester as a light yellow oil and 0.869 g (15%) of *Z*-3-phenyl-but-2-enoic acid ethyl ester as a light yellow oil (E/Z = 5.8/1); *E*-olefin: ^1H NMR (300 MHz, CDCl_3), δ 7.44 (m, 2 H), 7.33 (m, 3 H), 6.12 (s, 1 H), 4.19 (q, J = 7.1 Hz, 2 H), 2.56 (s, 3 H), 1.29 (t, J = 7.1 Hz, 3 H); ^{13}C NMR (75 MHz, CDCl_3), δ 166.8, 155.4, 142.1, 128.9, 128.4, 126.2, 117.0, 59.7, 17.8, 14.2; *Z*-olefin: ^1H NMR (300 MHz, CDCl_3), δ 7.3 (m, 3 H), 7.18 (d, J = 6.0 Hz, 2 H), 5.89 (s, 1 H), 3.97 (q, J = 7.1

¹⁵ Manabu, N.; Kiyoharu, N.; Yikihiro, S.; Kenichi, O.; Hiroaki, S.; Hideaki, K. *Tetrahedron* **1997**, 53, 12883–12894.

¹⁶ Miller, K. J.; Abu-Omar, M. M. *Eur. J. Org. Chem.* **2003**, 1294–1299.

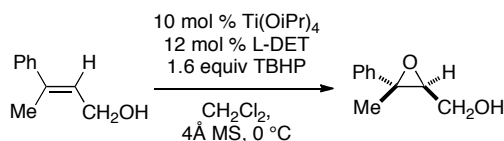
¹⁷ Wadsworth, W. S., Jr.; Emmons, W. D. *Org. Synth.* CV 5, 547.

Hz, 2 H), 2.15 (s, 3 H), 1.06 (t, $J = 7.1$ Hz, 3 H). Physical and spectral data were consistent with those reported in the literature.¹⁸



Preparation of (*E*)-3-phenyl-2-buten-1-ol:¹⁹ A 250 mL three-necked round bottom flask was connected to a reflux condenser, sealed, and placed under a positive flow of nitrogen. The round bottom flask was charged with (*E*)-3-phenyl-but-2-enoic acid ethyl ester (21 mmol, 4.0 g) and anhydrous ether (48 mL), then place in an ice bath. When the mixture had equilibrated DIBAL (46.25 mmol, 1 M solution in hexanes, 46.25 mL) was injected slowly over 20 minutes from a syringe. The reaction was gradually warmed to room temperature over night (10 hours). The reaction was re-cooled with an ice-bath and carefully quenched by the slow addition of water then brine. The white solid material formed was dissolved by the addition of 4 M HCl till there was two clear layers. The aqueous layer was back extracted with ether, and the combined organics were dried over MgSO_4 , and concentrated. The crude material was subjected to flash chromatography (hexanes/EtOAc: 80/20 then 50/50) affording 3.03 g (97%) of (*E*)-3-phenyl-2-buten-1-ol as a light yellow oil; ^1H NMR (300 MHz, CDCl_3), δ 7.42–7.36 (m, 2 H), 7.34–7.20 (m, 3 H), 5.96 (t, $J = 6.6$ Hz, 1 H), 4.33 (d, $J = 6.0$, 2 H), 2.05 (s, 3 H), 1.75 (bs, 1 H); ^{13}C NMR (75 MHz, CDCl_3), δ 142.7, 137.6, 128.2, 127.2, 126.4, 125.7, 59.8, 15.9. Physical and spectral data were consistent with those reported in the literature.¹⁸

Preparation of anhydrous *tert*-butylhydrogen peroxide (TBHP):²⁰ To a 1 L separatory funnel was added 360 mL of *tert*-butylhydrogen peroxide (30% aqueous solution) and 440 mL of toluene. The solution was swirled for 1 minute (not shaken!). The aqueous phase was separated and the organic layer was transferred to a 1 L round bottom flask equipped with a Dean-Stark trap and reflux condenser. Boiling chips were added and the solution was refluxed for 4 hours. The TBHP-toluene solution was cooled then transferred to an amber glass bottle with activated 4Å MS. The bottle was sealed and place under nitrogen, and stored in the freezer. The molarity of the solution was determined by NMR and found to be 3.9 M.



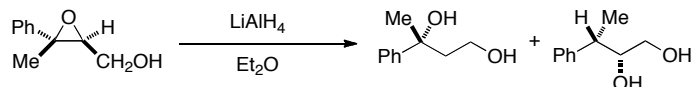
Preparation of (2*S*,3*S*)-epoxy-3-phenylbutan-1-ol via a Sharpless asymmetric epoxidation:¹⁹ A 250 mL three-necked round bottom flask, equipped with a thermometer and stir-bar, was charged with activated 4Å MS (3.6 g) and freshly distilled CH_2Cl_2 (130 mL) under nitrogen. The CH_2Cl_2 solution was cooled to $-22\text{ }^\circ\text{C}$, followed by sequential addition of *L*-diethyl tartrate (2.45 mmol, 0.421 mL), titanium isopropoxide (2.05 mmol, 0.609 mL), and dropwise addition of TBHP (32.7 mmol, 8.4 mL, 3.9 M solution in toluene). The mixture was stirred for 1 hour at $-22\text{ }^\circ\text{C}$, followed by the dropwise addition of (*E*)-3-phenyl-2-buten-1-ol (20.5 mmol, 3.03 g) in CH_2Cl_2 (6 mL), making sure the temperature did not rise above $-20\text{ }^\circ\text{C}$. After complete addition the reaction was stirred at $-25\text{ }^\circ\text{C}$ for 6 hours. The reaction was quenched with 15 mL of a 10% NaOH solution saturated with NaCl. The reaction was warmed to $-10\text{ }^\circ\text{C}$ and MgSO_4 (8 g), Celite (2 g), and ether were added. The reaction was warmed to room temperature and filtered through a pad of celite. The filtrate was concentrated and the crude material was subjected to flash chromatography (hexanes/EtOAc: 90/10) affording 2.309 g (68%) of (2*S*,3*S*)-epoxy-3-phenylbutan-1-ol as a clear oil. ^1H NMR (300 MHz, CDCl_3), δ 7.37 (m, 5 H), 3.92 (m, 1 H), 3.80 (m, 1 H), 3.07 (dd, $J = 4.1, 6.3$ Hz, 1 H), 2.68 (bs, 1 H), 1.66 (s, 3 H); ^{13}C NMR (75 MHz,

¹⁸ Murphy, J. A.; Patterson, C. W. *J. Chem. Soc., Perkin Trans. 1* **1993**, 405–410.

¹⁹ Martín, R.; Islas, G.; Moyano, A.; Pericàs, M. A.; Riera, A. *Tetrahedron* **2001**, 57, 6367–674.

²⁰ Katsuki, T.; Martin, V. S. "Asymmetric epoxidation of allylic alcohols: The Katsuki-Sharpless epoxidation reaction", *Org. React.*, 1996, 48, New York, p1-299.

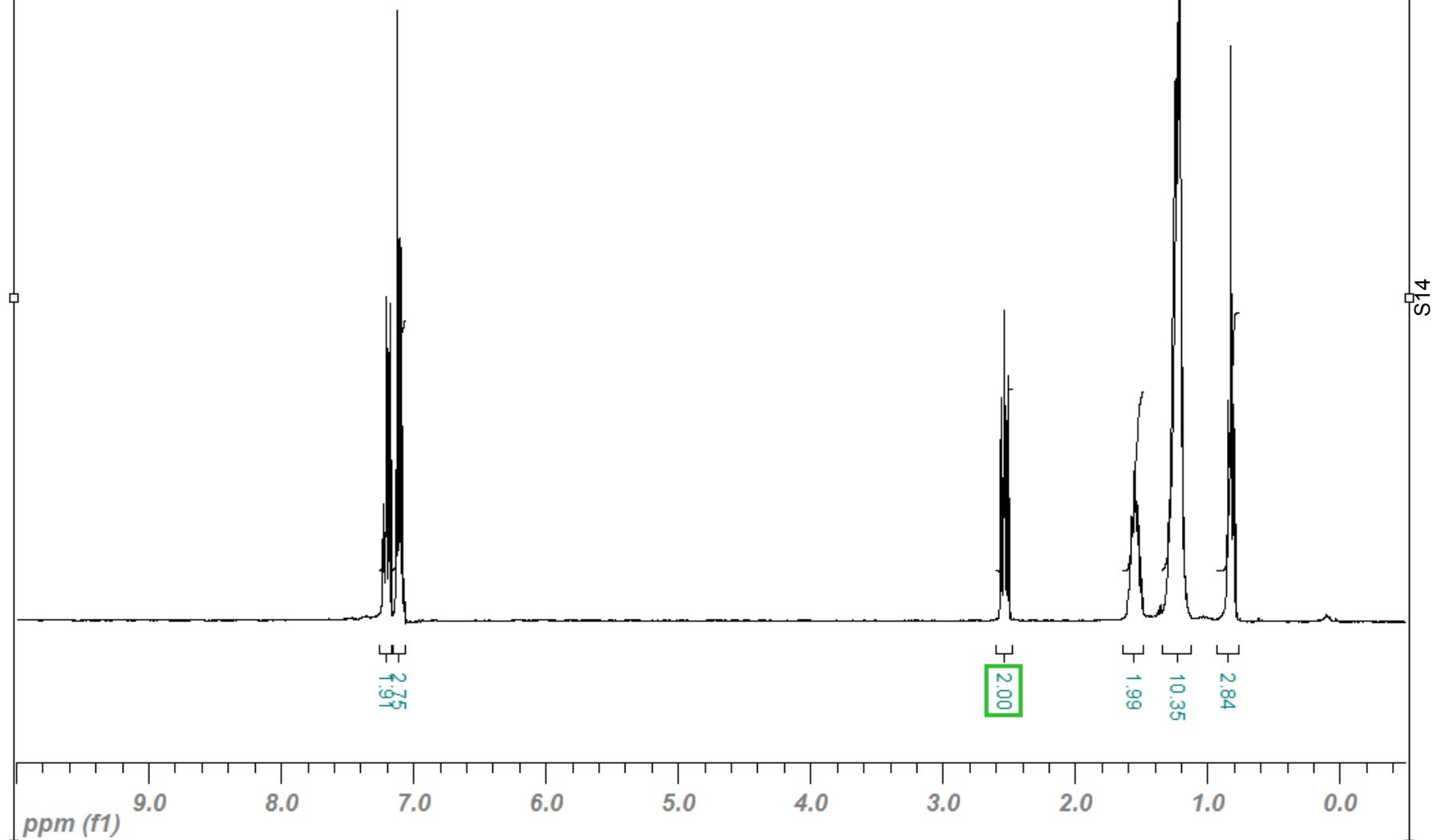
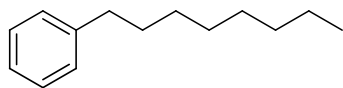
CDCl₃), δ 141.8, 128.2, 127.4, 124.9, 66.1, 61.1, 60.8, 17.6. %Ee determined by GC using a Beta DEXTM 325 Fused Silica Capillary Column: 30mX0.25mmX0.25 μ m film thickness. GC conditions: starting temperature (30 °C), ramp rate (10 °C/min.), final temperature (200 °C for 15 min.); R.T. 13.96 (5.3%: 2R,3R-enantiomer), 19.75 (94.7%: 2S,3S-enantiomer), 89.5 %ee. Physical and spectral data were consistent with those reported in the literature.¹⁹



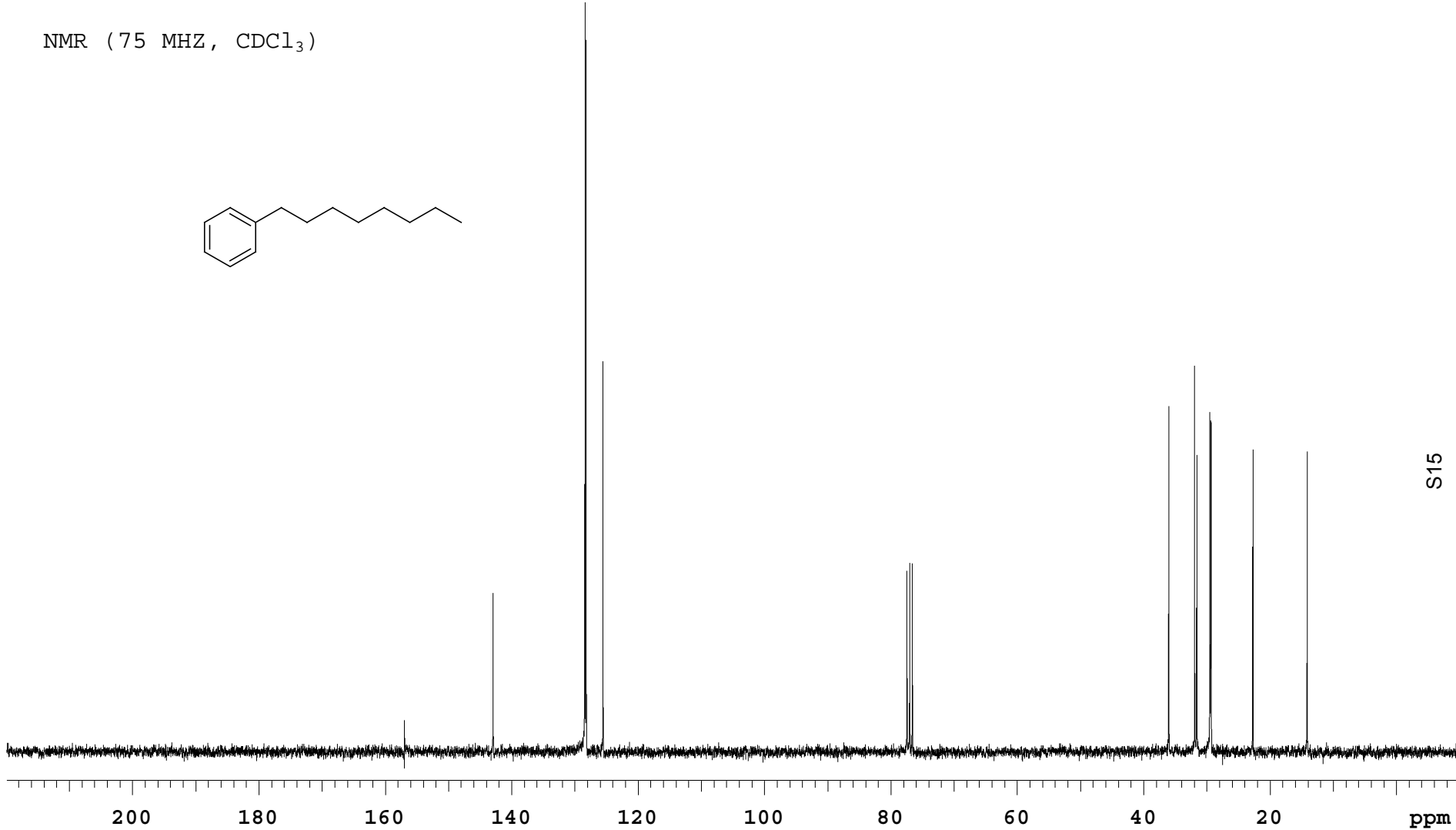
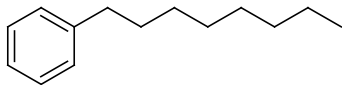
Preparation of (*R*)-3-phenyl-butane-1,3-diol and (2*R*,3*S*)-3-phenyl-butane-1,2-diol:²¹ A 100 mL round bottom flask equipped with a reflux condenser was charged with LiAlH₄ (7.8 mmol, 0.296 g). The round bottom flask was placed under an atmosphere of nitrogen and 35 mL of anhydrous ether was added. To the stirred solution of LAH, 2*S*,3*S*-epoxy-3-phenyl-butan-1-ol (3.9 mmol, 0.640 g) in 10 mL of anhydrous ether was added dropwise, followed by stirring the reaction for 3 hours. The reaction was quenched with 2 mL of H₂O, 0.5 mL 1 M NaOH, and 6 mL H₂O (all added dropwise until vigorous bubbling stopped). The solid white material was filtered off and rinsed with ether. The ethereal solution was dried over MgSO₄, filtered, and concentrated. NMR of the crude material showed a mixture of the 1,3 and 1,2-diol (1.07/1). The crude material was subjected to flash chromatography (hexanes/EtOAc: 90/10, 80/20, 50/50, then 20/80) affording 0.2528 g (39%) of (*R*)-3-phenyl-butane-1,3-diol as a white solid (mp = 62–63.5 °C), and 0.2879 g (44%) of (2*R*,3*S*)-3-phenyl-butane-1,2-diol as a clear viscous oil. 1,3-diol: ¹H NMR (300 MHz, CDCl₃), δ 7.42 (d, *J* = 7.1 Hz, 2 H), 7.33 (t, *J* = 7.7 Hz, 2 H), 7.23 (t, *J* = 3.6 Hz, 1 H), 3.74 (bs, 1 H), 3.54 (bt, *J* = 8.8 Hz, 1 H), 3.46 (bd, *J* = 5.5, 1 H), 2.37 (bs, 1 H), 2.03 (m, 2 H), 1.56 (s, 3 H); ¹³C NMR (75 MHz, CDCl₃), δ 147.4, 128.2, 126.5, 124.7, 75.8, 60.3, 43.9, 31.0; 1,2-diol: ¹H NMR (300 MHz, CDCl₃), δ 7.31–7.11 (m, 5 H), 3.68 (bt, *J* = 6.6 Hz, 1 H), 3.37 (bs, 2 H), 3.27 (m, 1 H), 3.15 (bs, 1 H), 2.72 (q, *J* = 7.4 Hz, 1 H), 1.31 (d, *J* = 7.1 Hz, 3 H); ¹³C NMR (75 MHz, CDCl₃), δ 143.7, 128.5, 127.4, 126.5, 76.5, 65.0, 42.8, 17.5. The %ee of the 1,3-diol was determined by derivatization with Mosher's acid chloride: A flame dried 5mL test tube was charged with 1.0 equiv 3-phenyl-butan-1,3-diol (0.1413 mmol, 0.023 g), a crystal of DMAP, and a stir bar. The test tube was sealed with a septa, rapped with Teflon tape, and flushed with nitrogen. Dry CH₂Cl₂ (1 mL), 4 drops of Et₃N (freshly distilled), and (*S*)-(+)-MTPA-Cl (0.1979 mmol, 0.05 g) were injected sequentially, and the reaction was stirred over night. The reaction mixture was subjected to FC with hexanes / ethyl acetate (80/20, then 50/50) affording the ester. ¹H NMR (300 MHz, CDCl₃), δ 7.49–7.18 (m, 10 H), 4.24 (t, *J* = 8.2 Hz, 2 H), 3.49 (s, 3 H), 2.20 (t, *J* = 6.9 Hz, 2 H), 1.61 (s, 0.27 H), 1.53 (s, 2.77 H): (*S*,*R*) vs. (*R*,*R*) = 1 / 10.65: %de = 82.8%. ¹³C NMR (75 MHz, CDCl₃), δ 166.3, 146.3, 132.0, 129.6, 128.48, 128.40, 127.1, 126.9, 124.4, 73.6, 63.6, 55.4, 41.5, 30.7.

²¹ Erickson, T. J. *J. Org. Chem.* **1986**, *51*, 934–935.

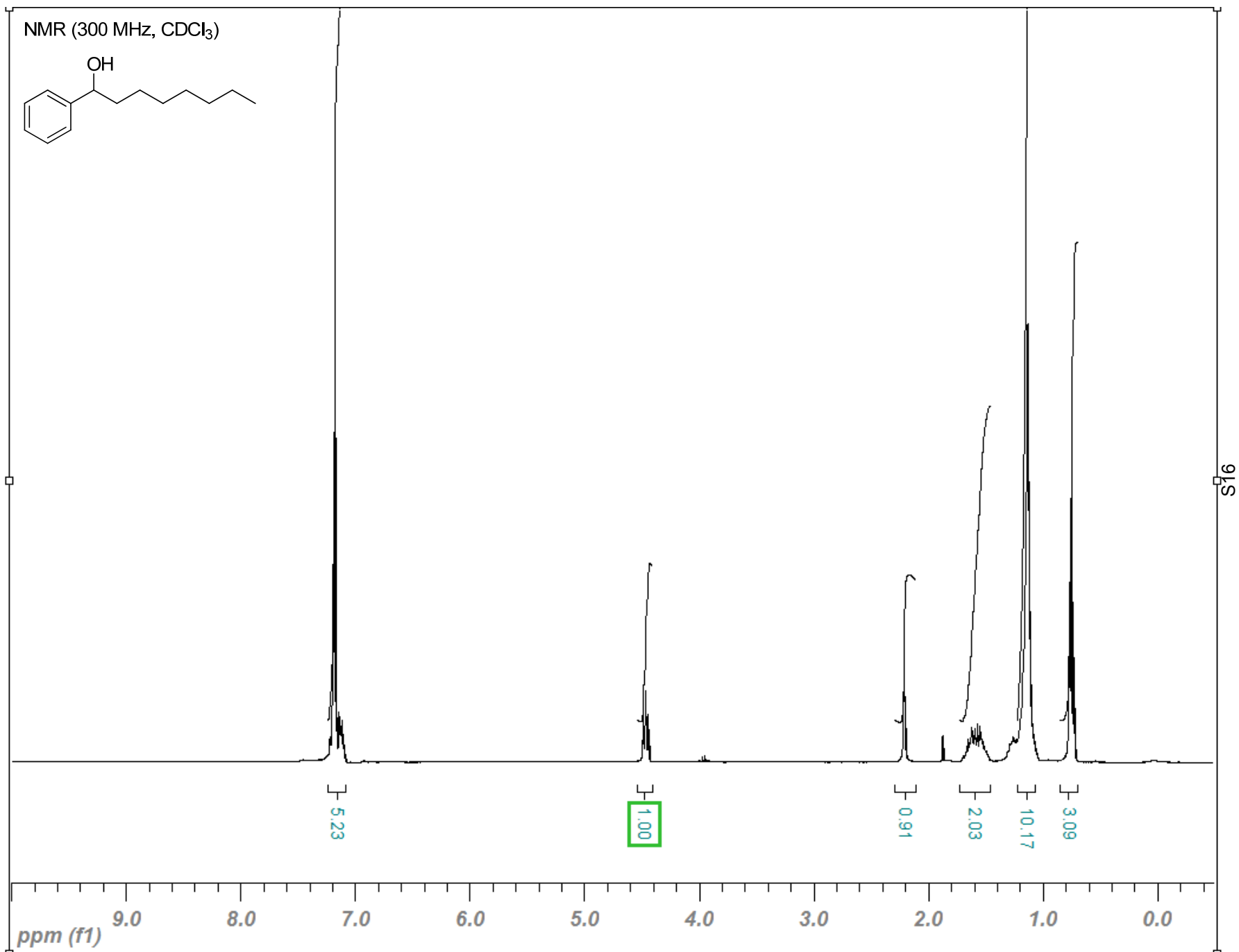
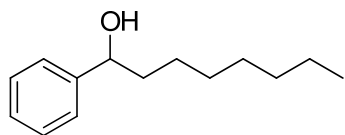
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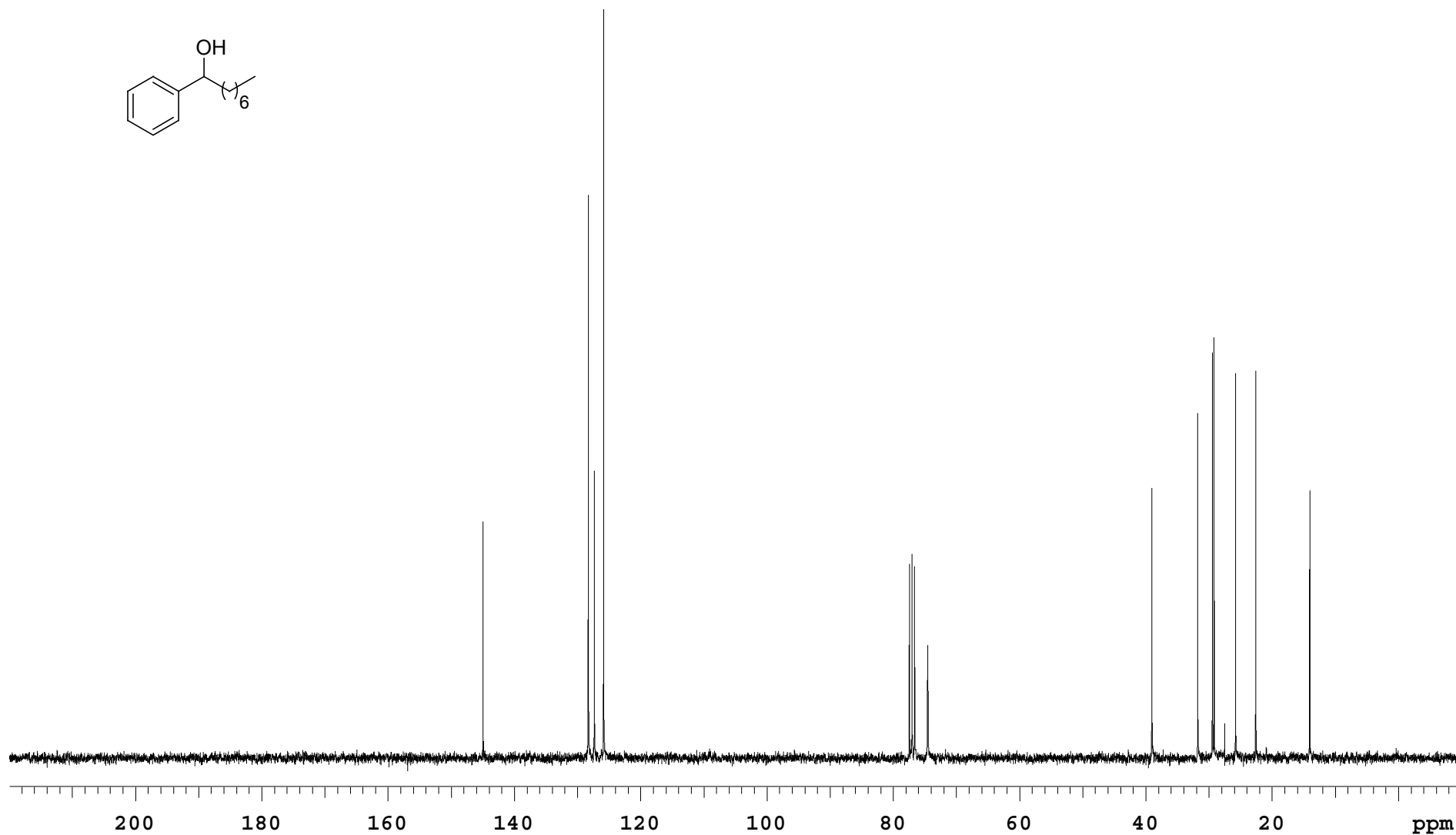
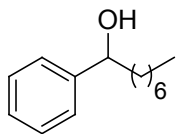
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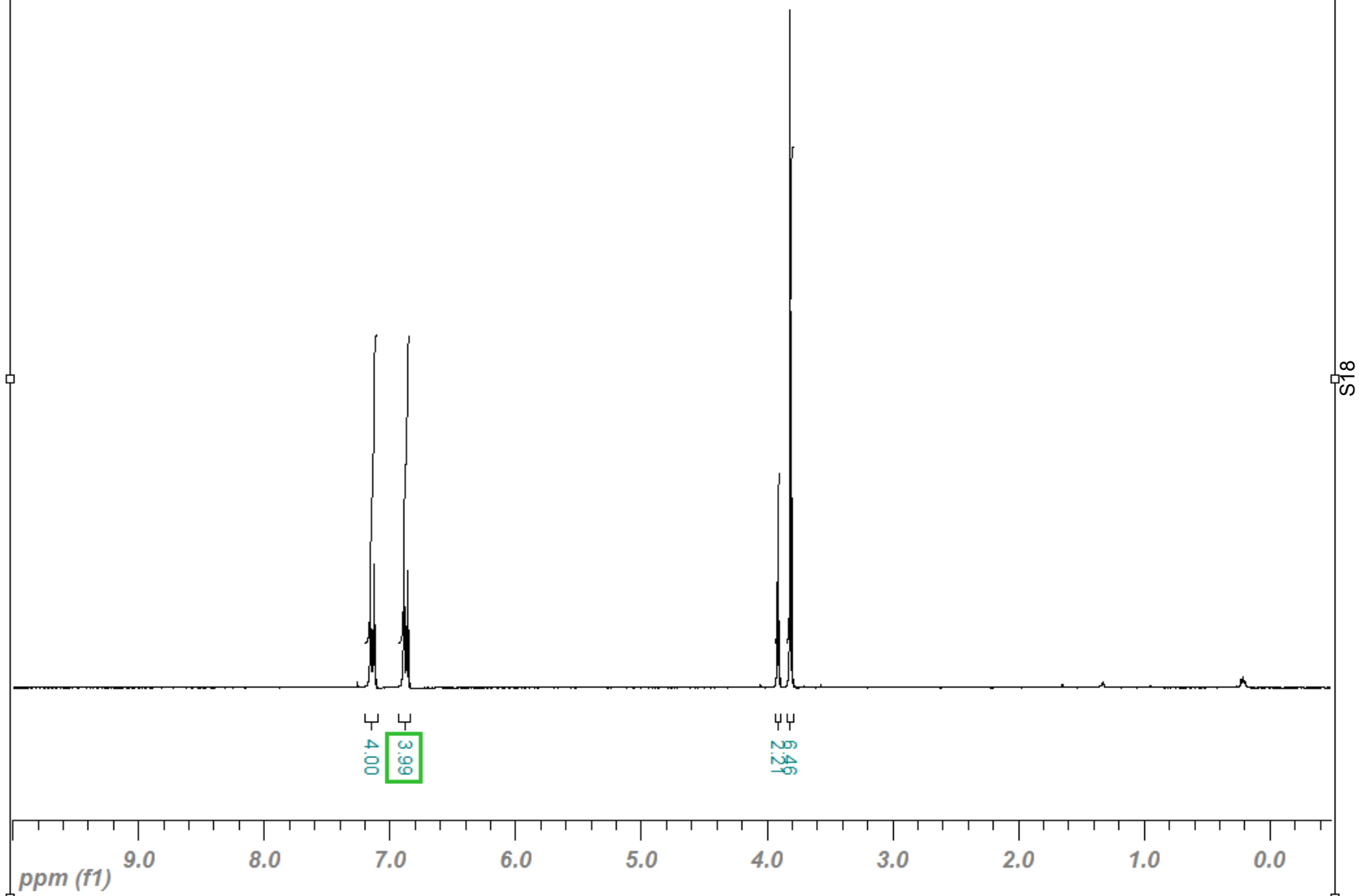
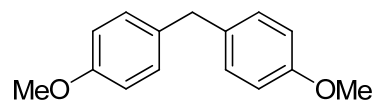
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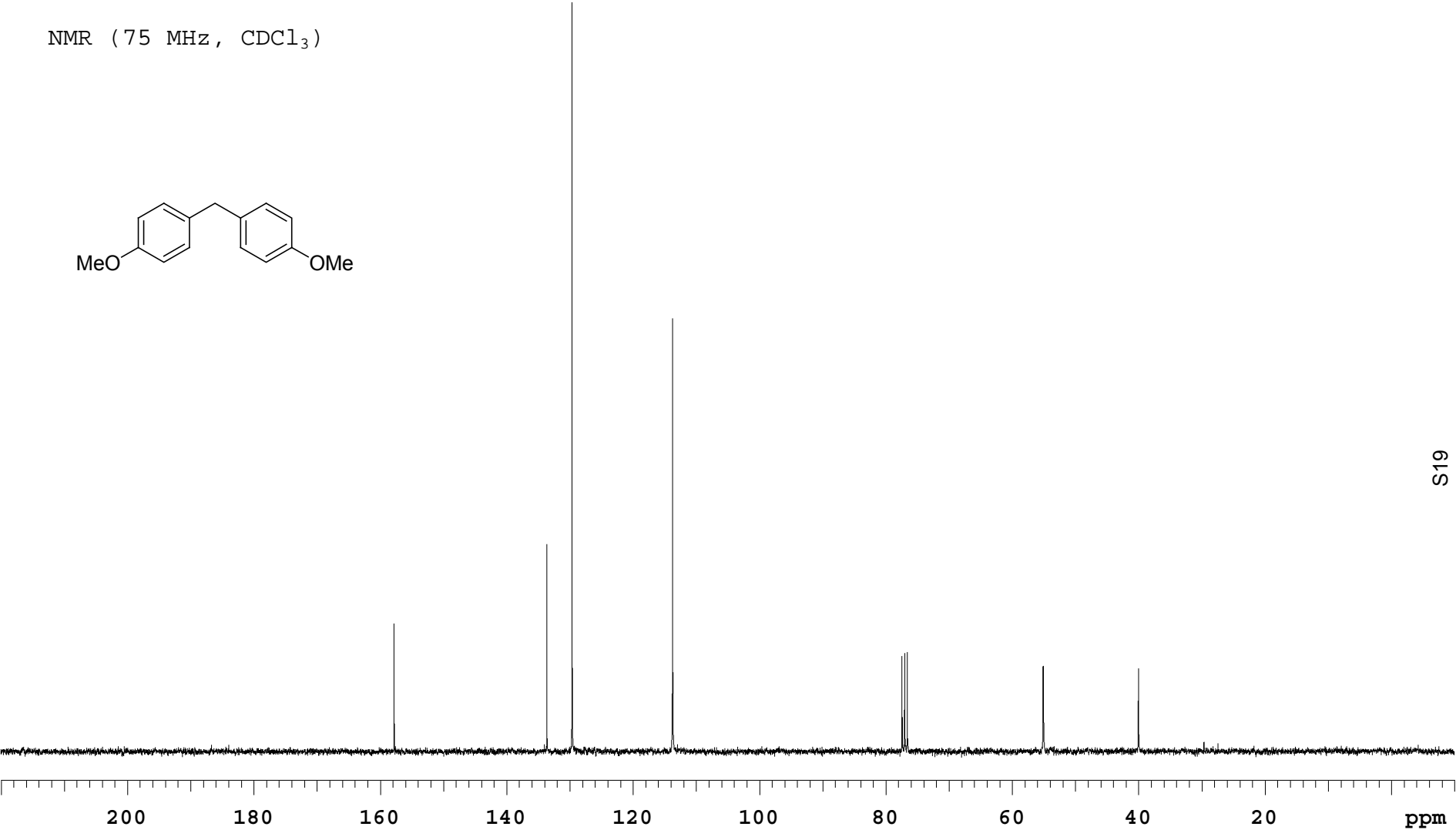
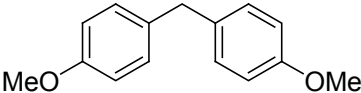
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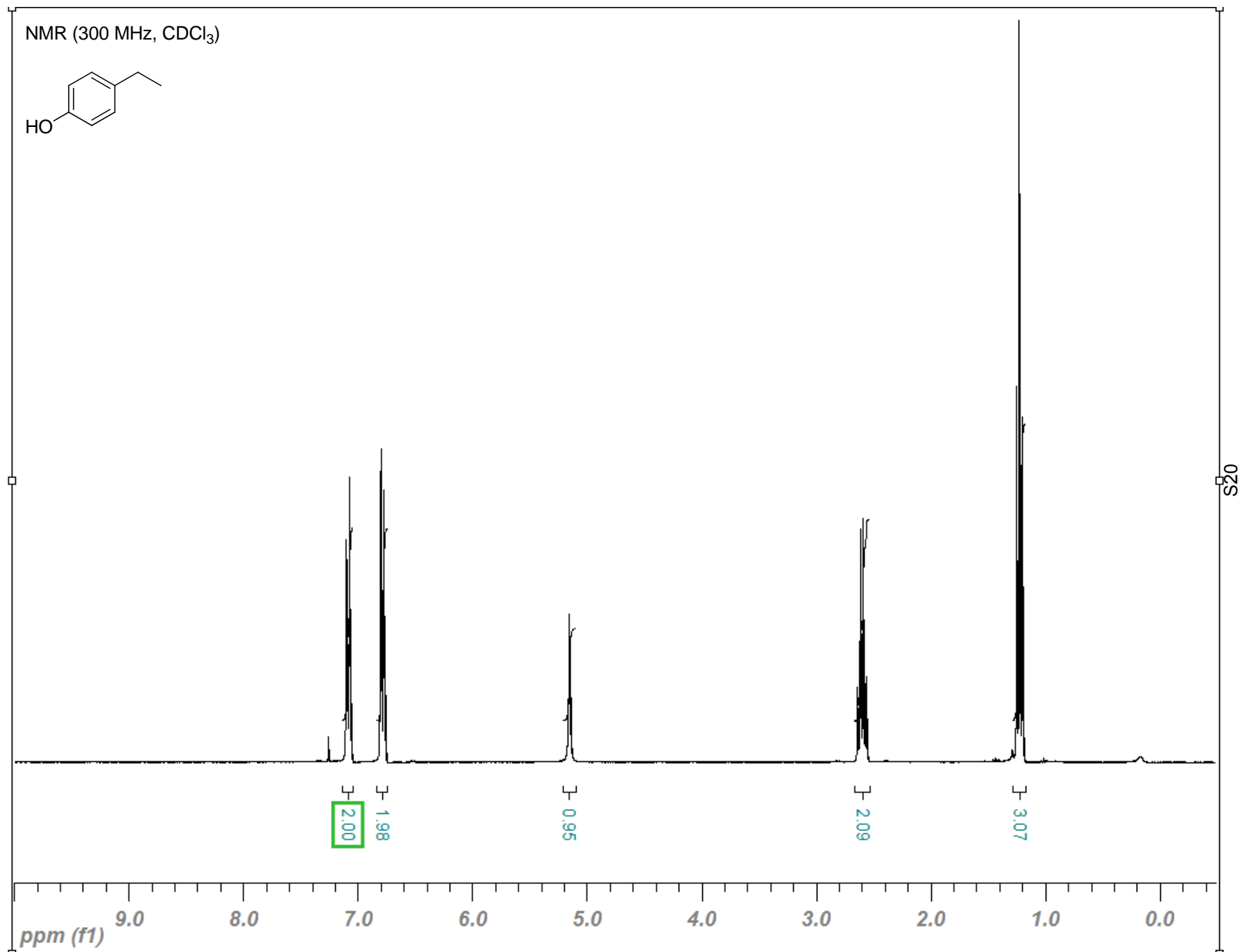
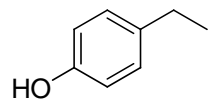
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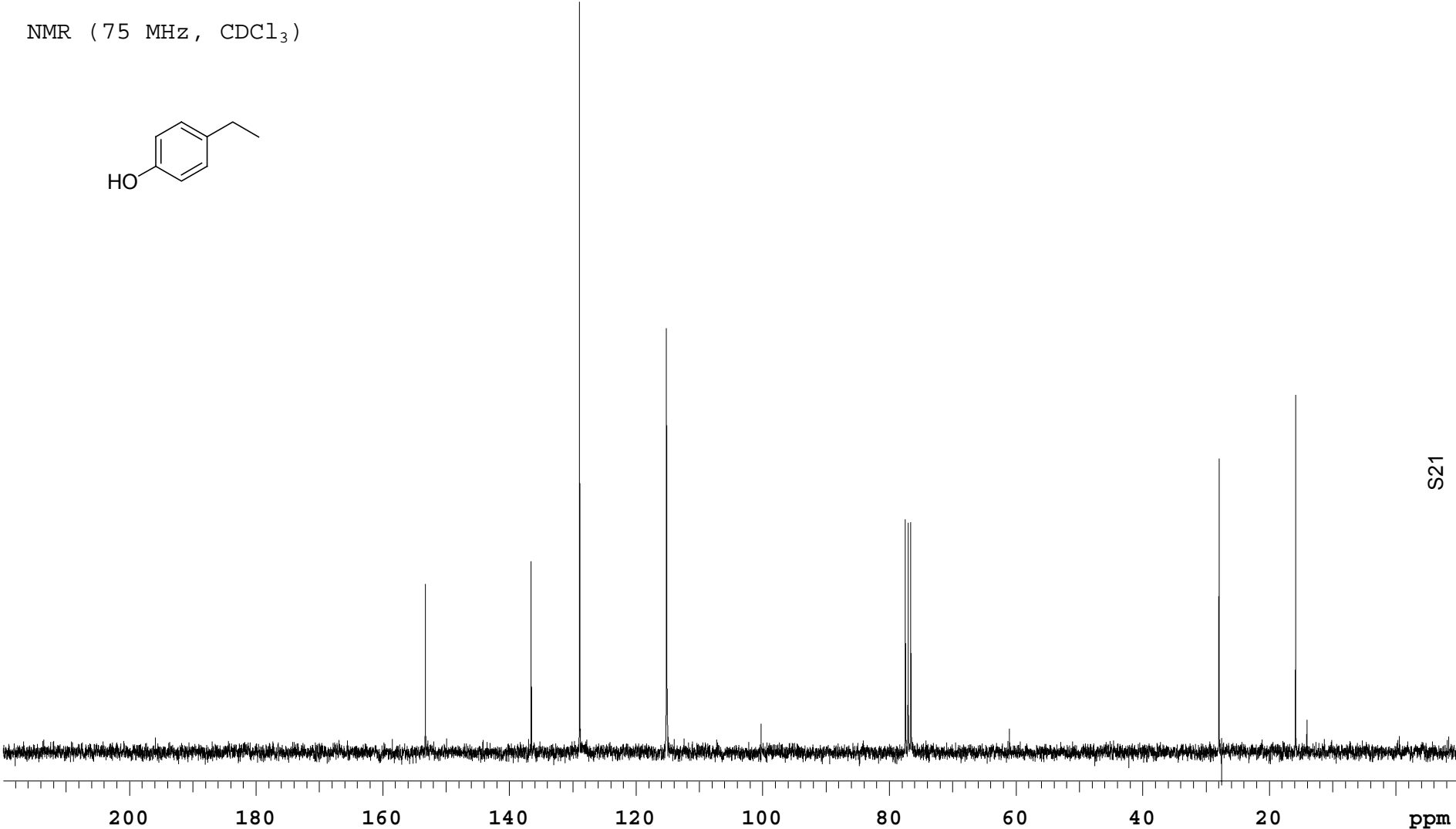
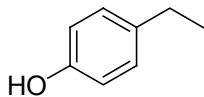
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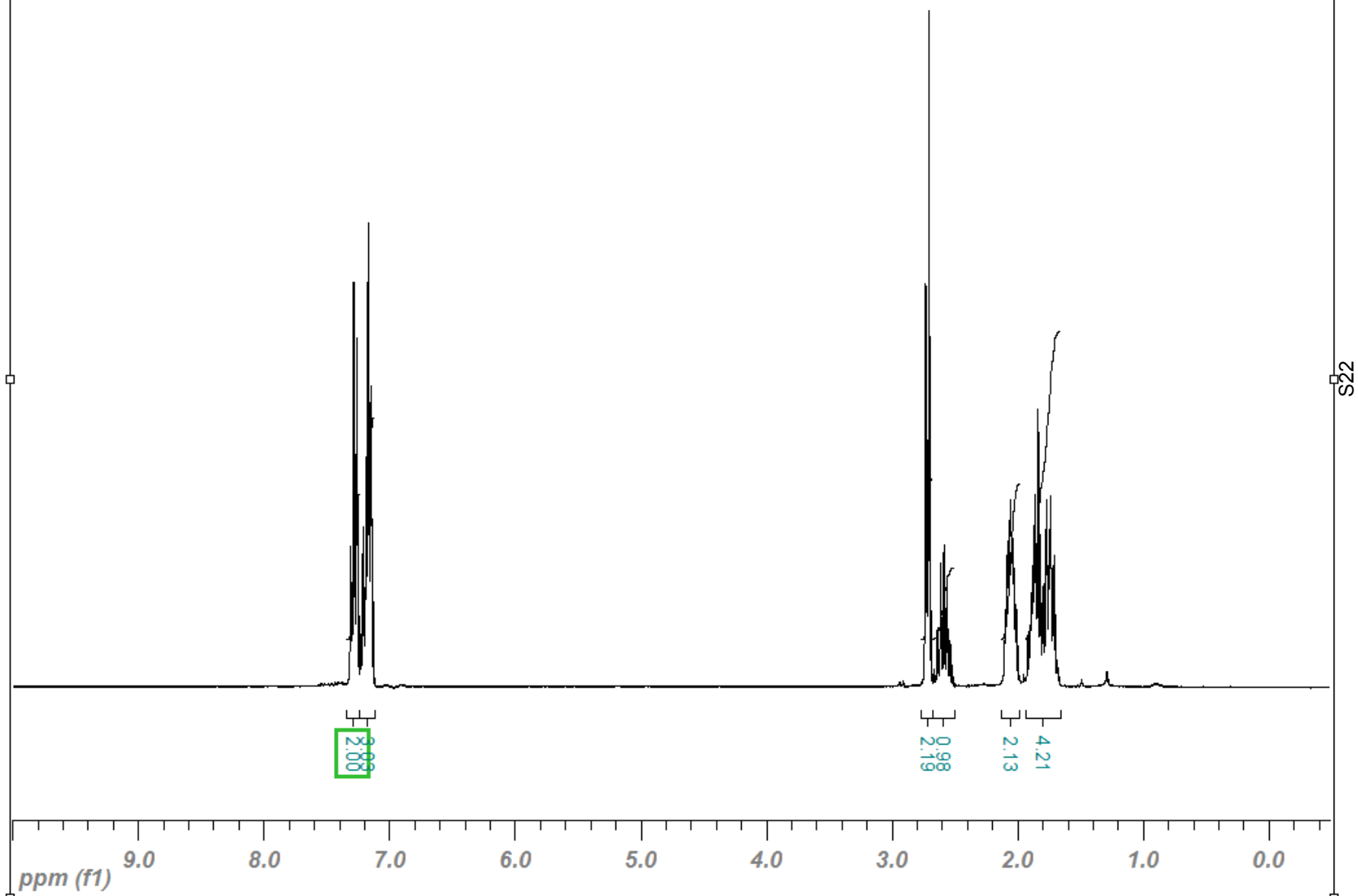
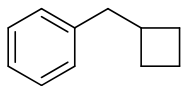
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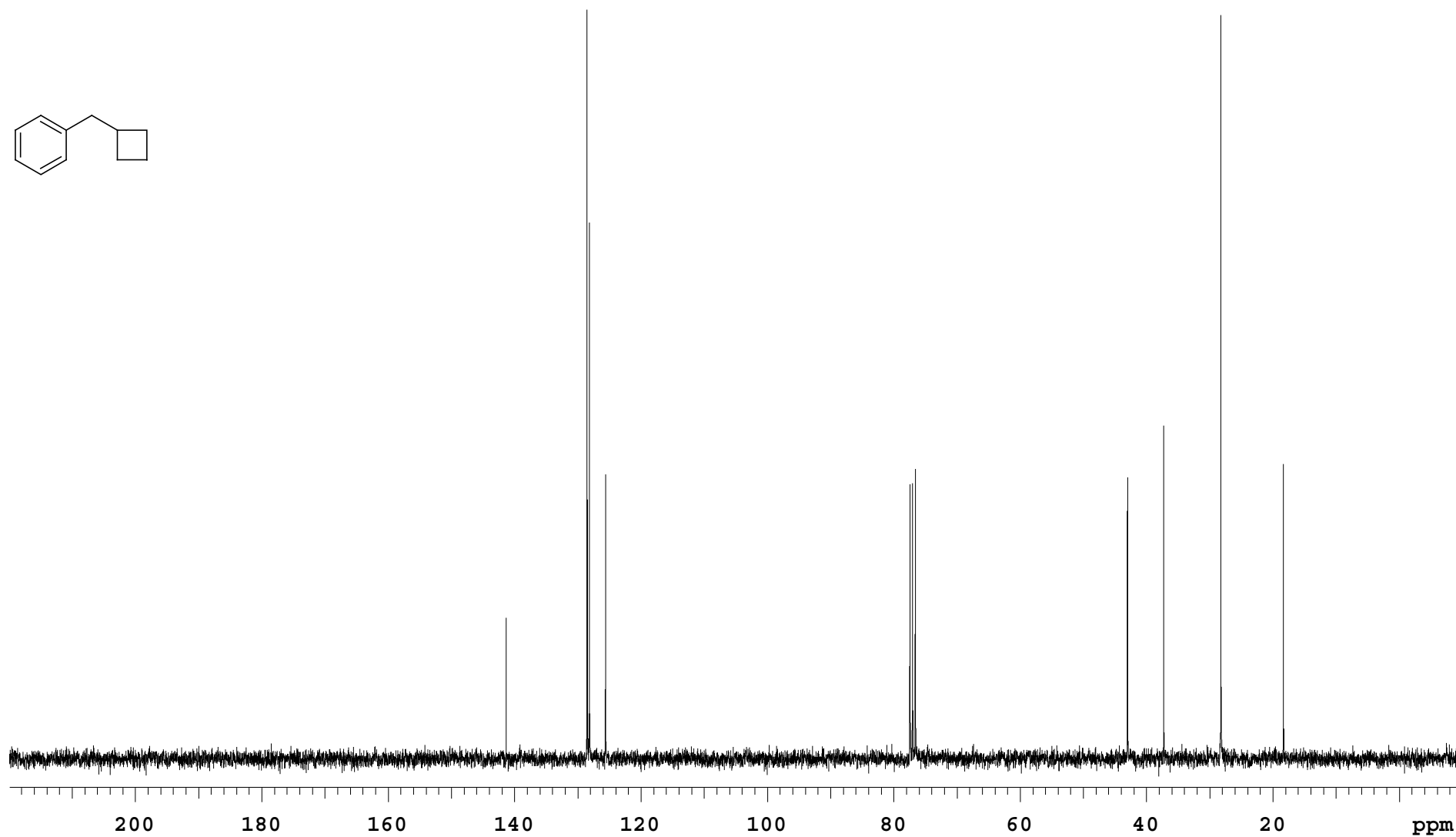
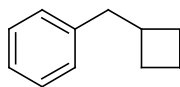
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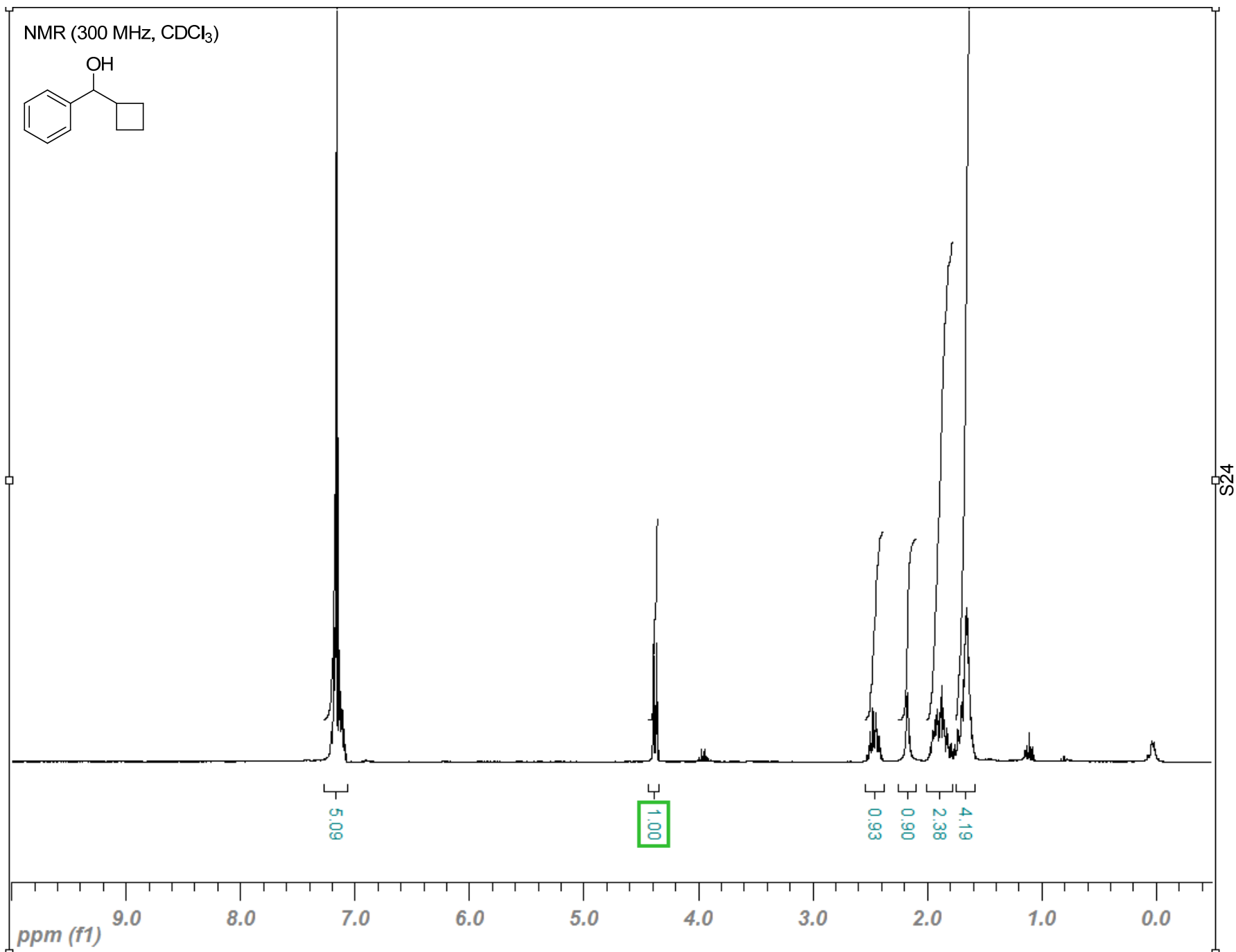
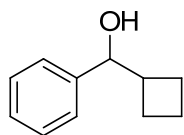
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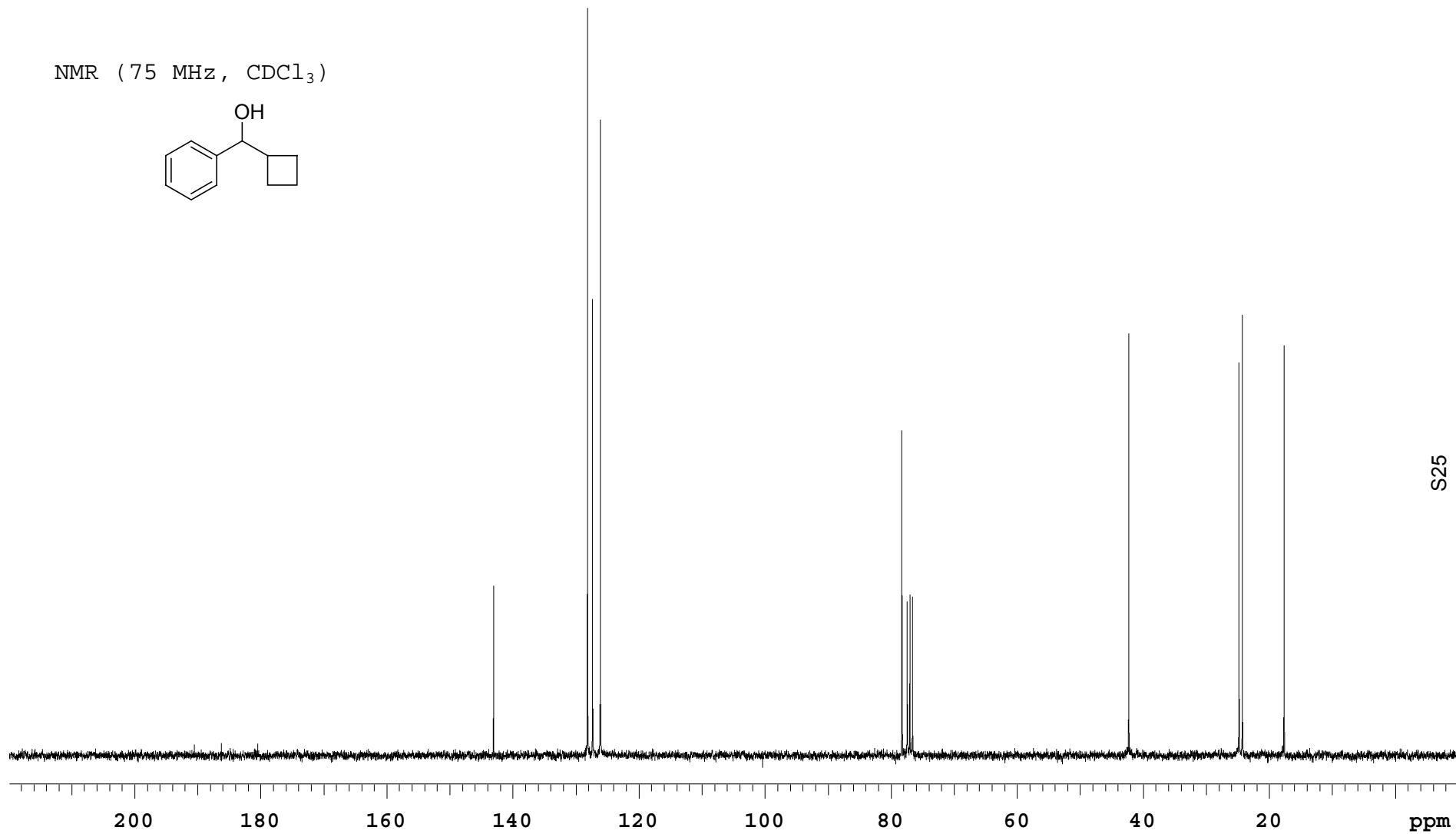
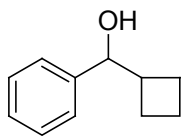
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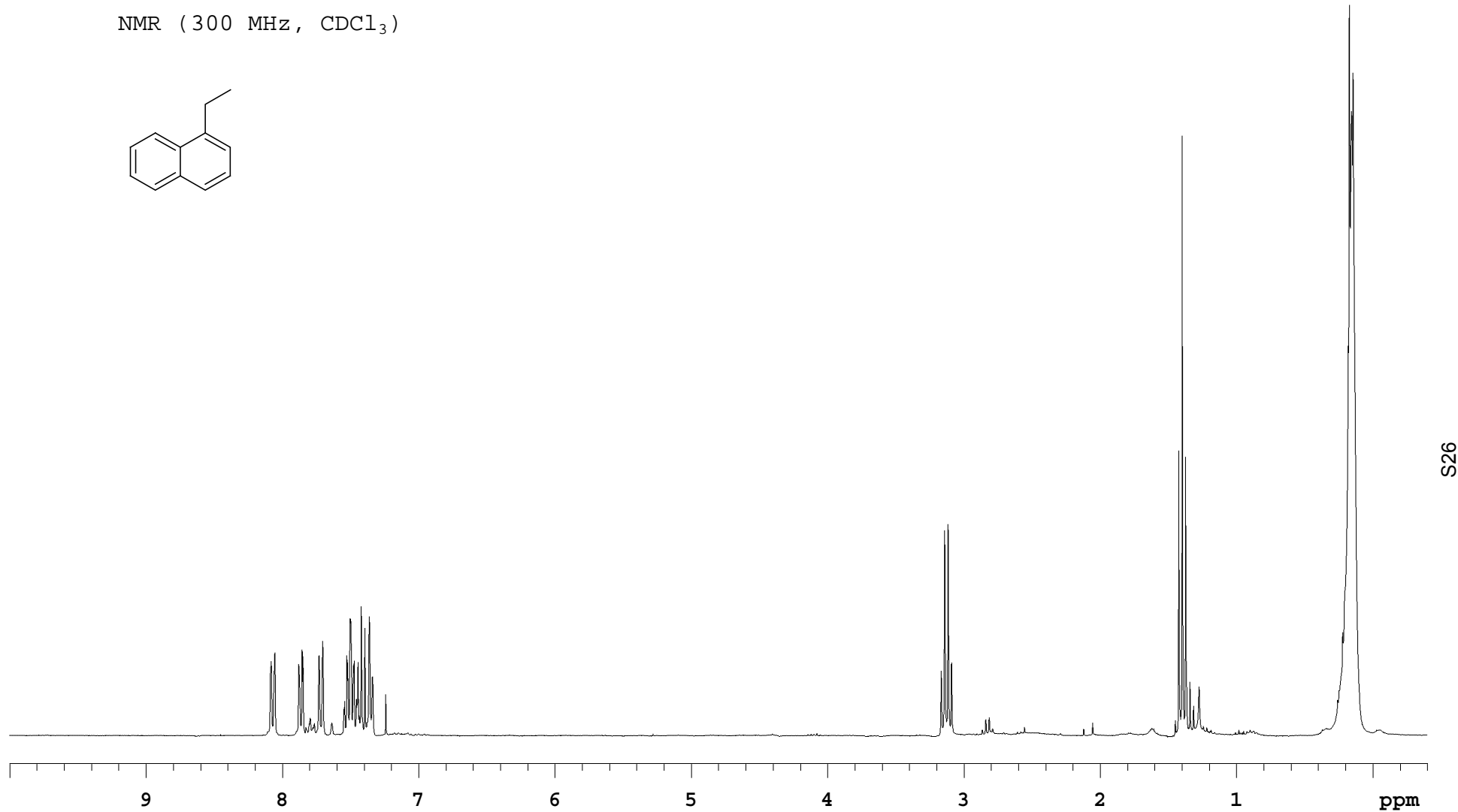
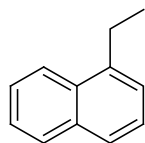
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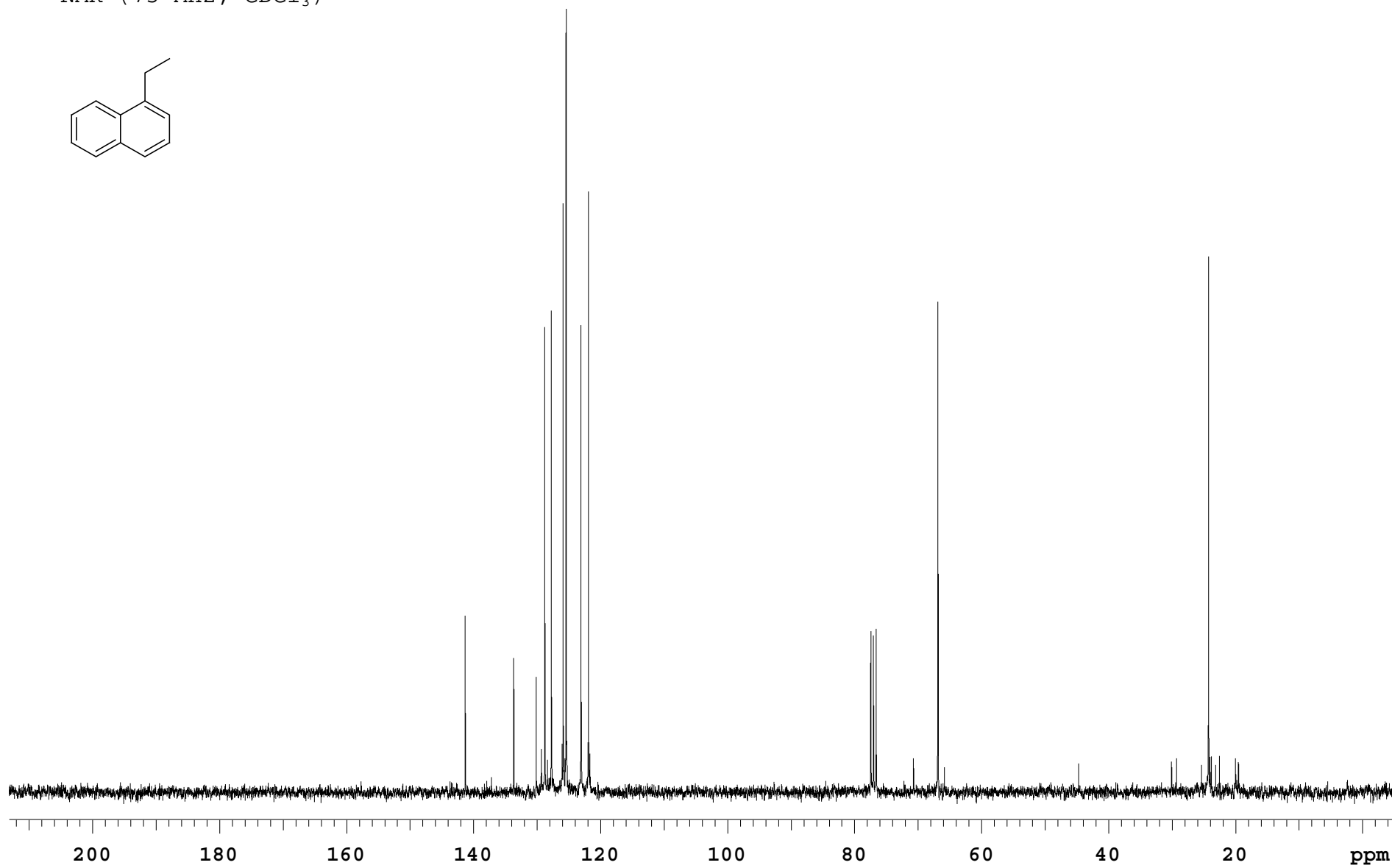
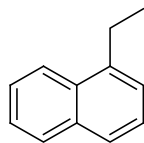
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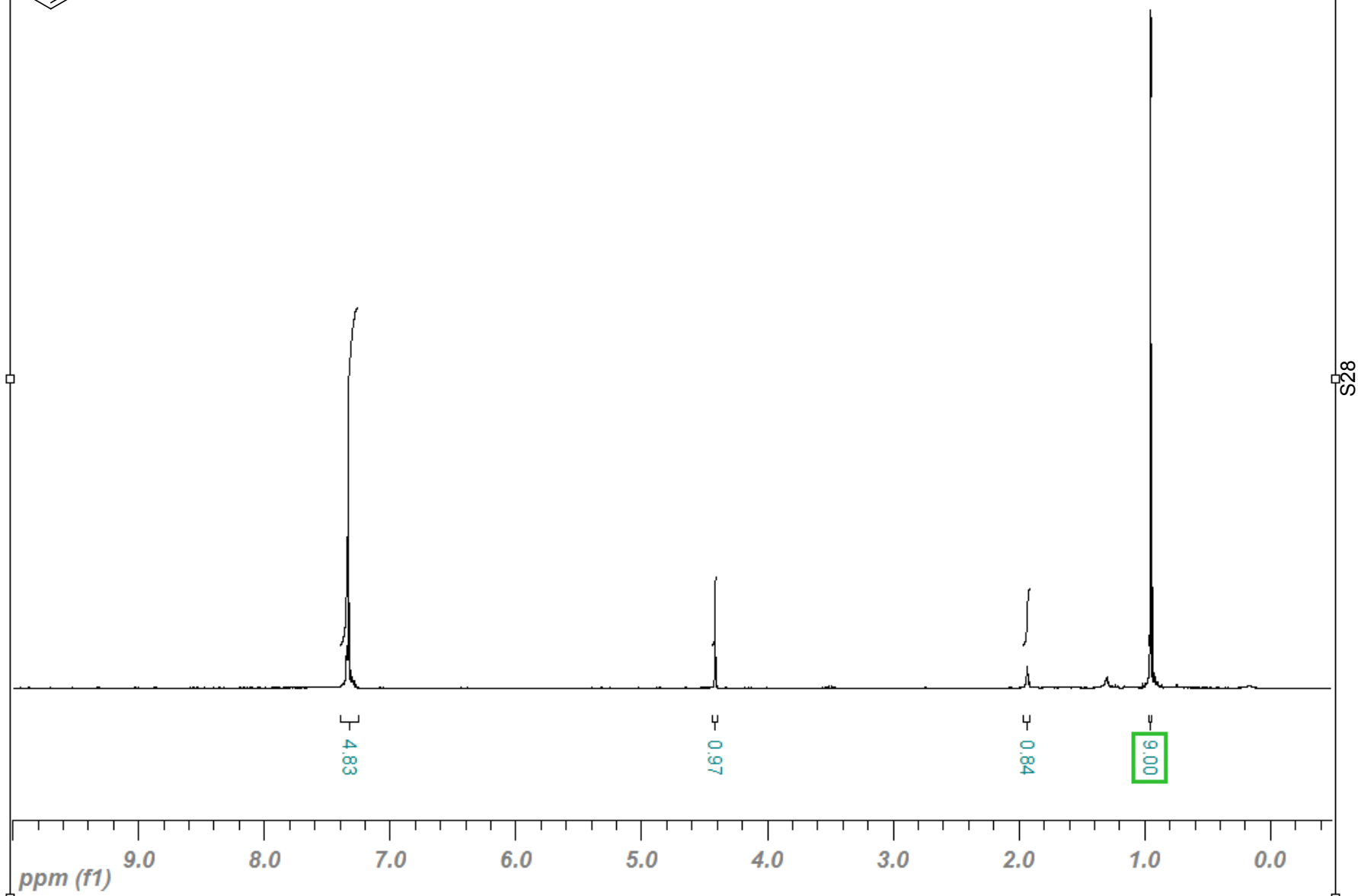
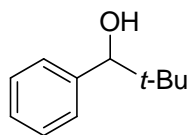
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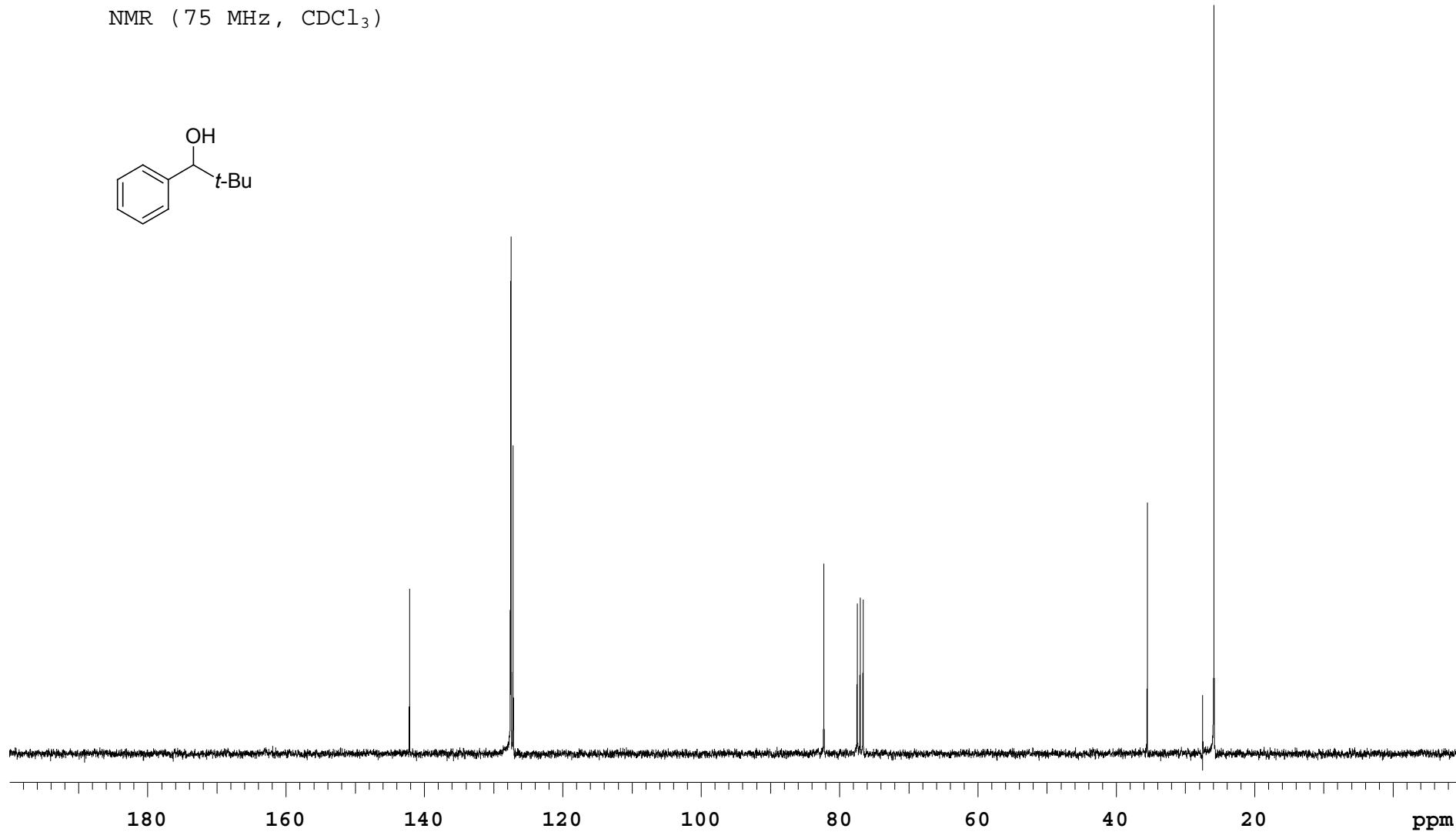
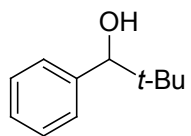
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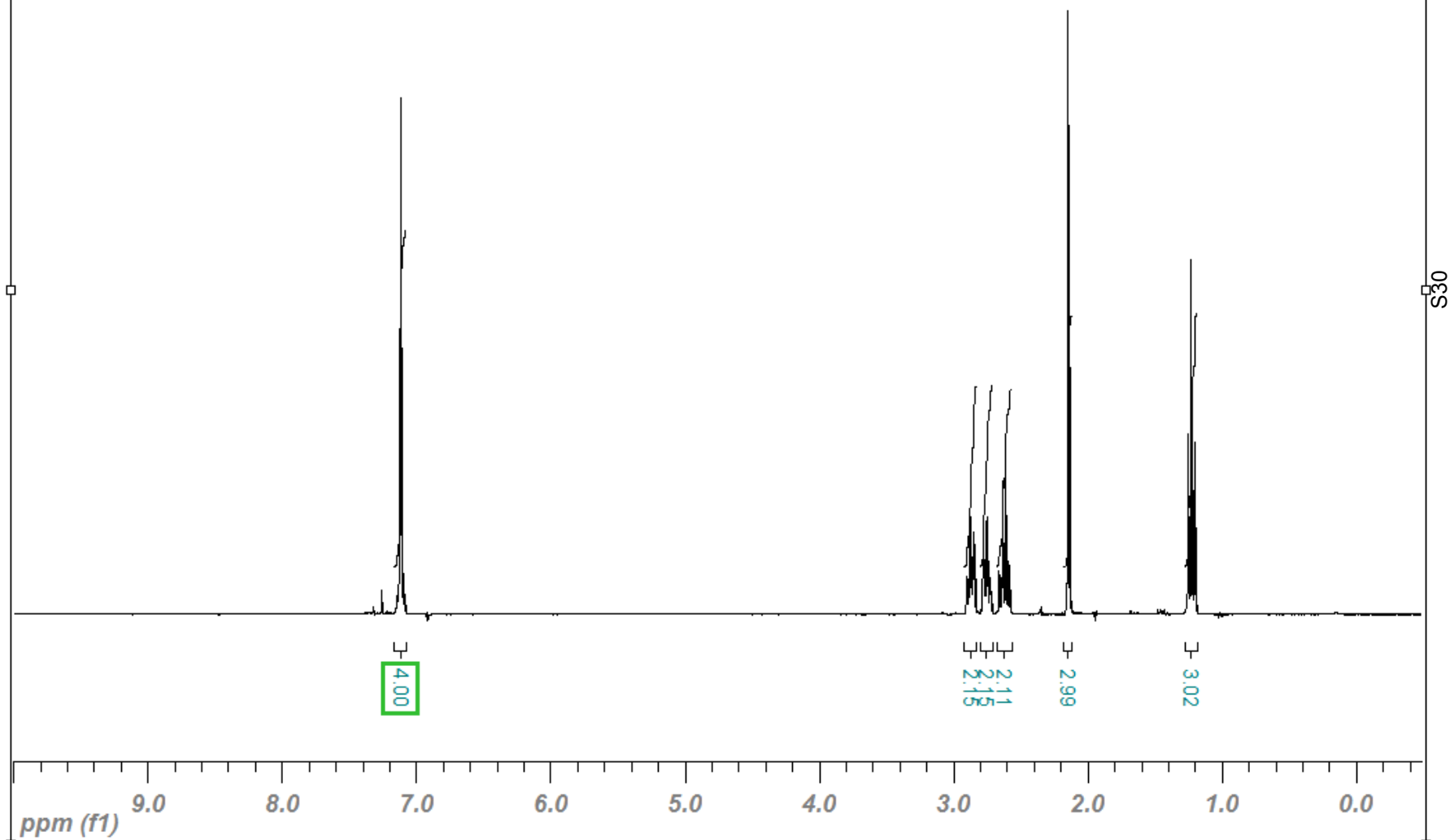
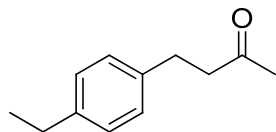
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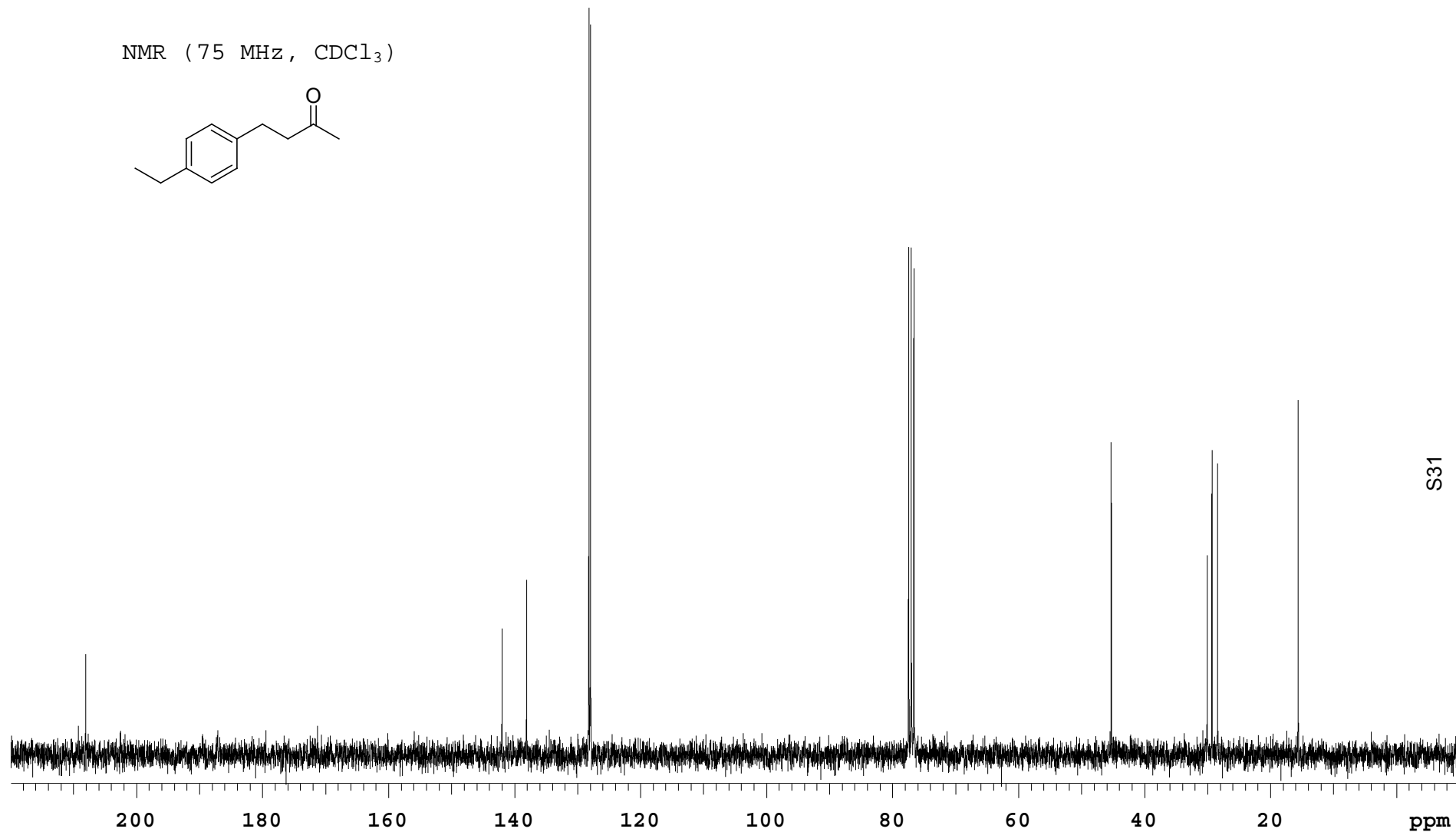
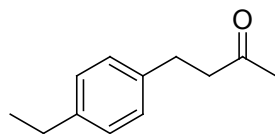
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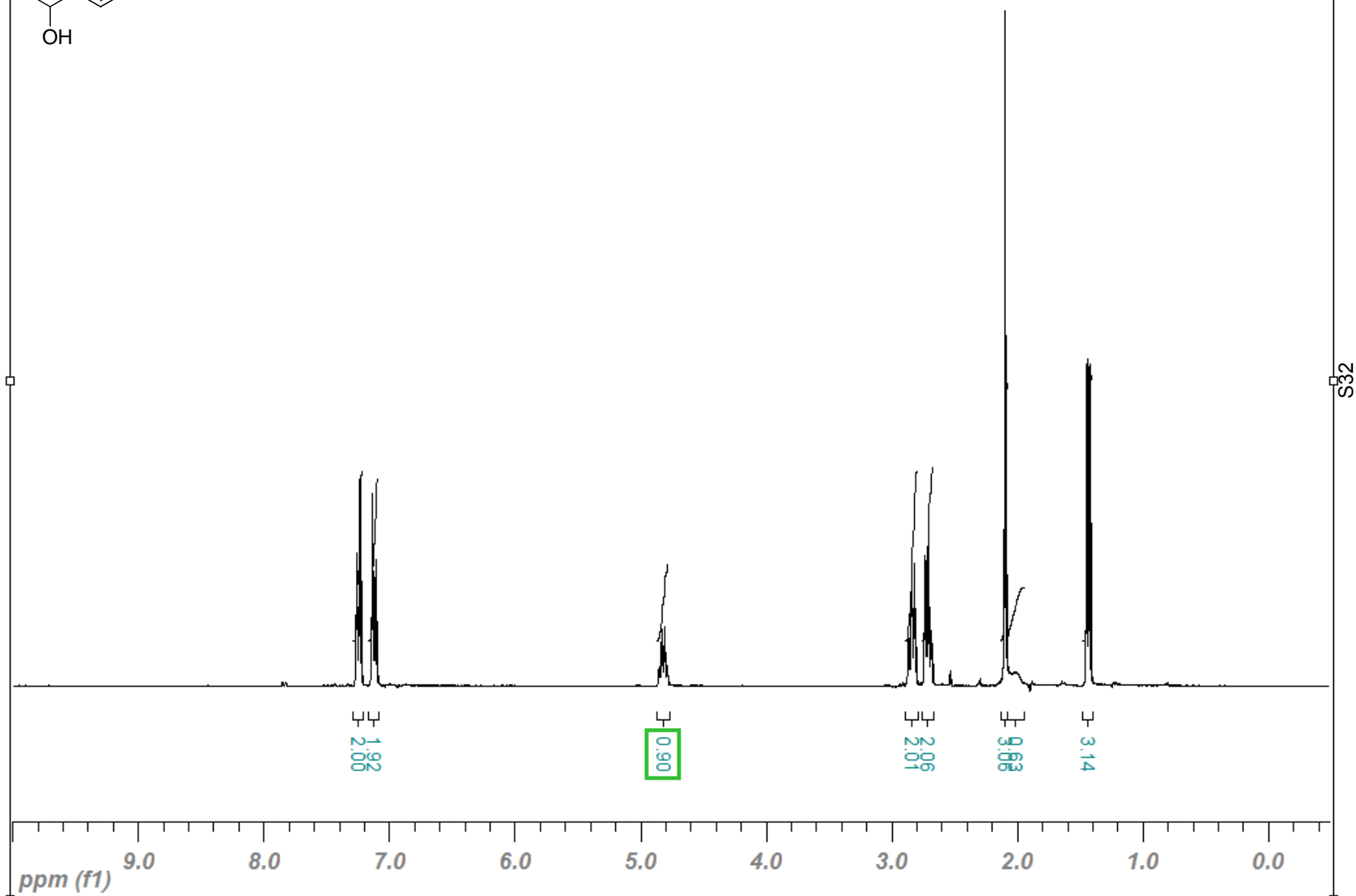
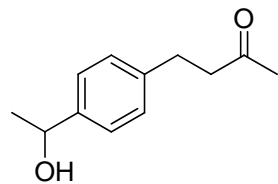
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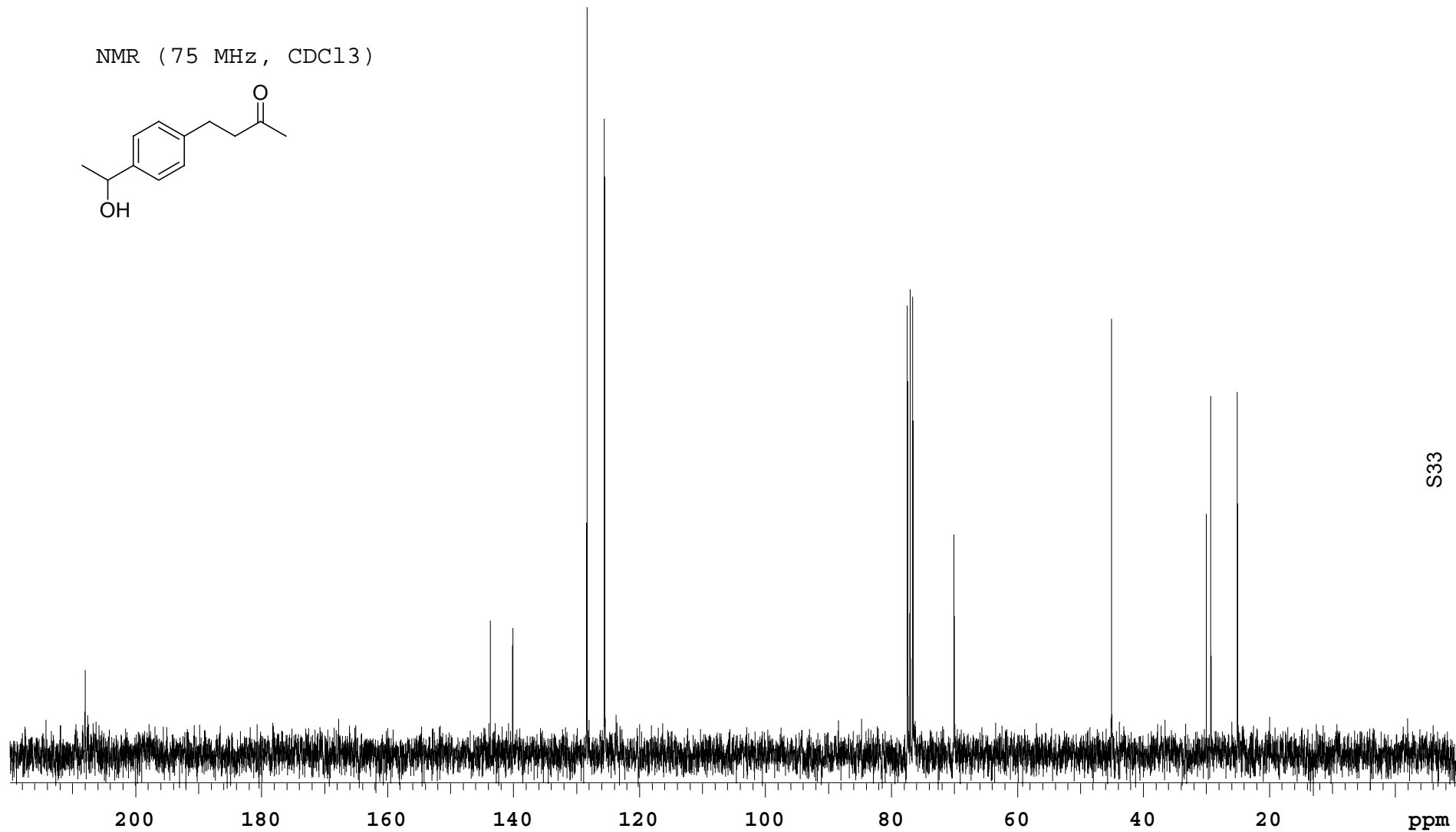
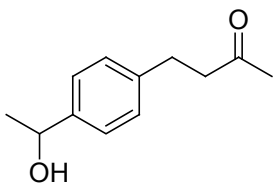
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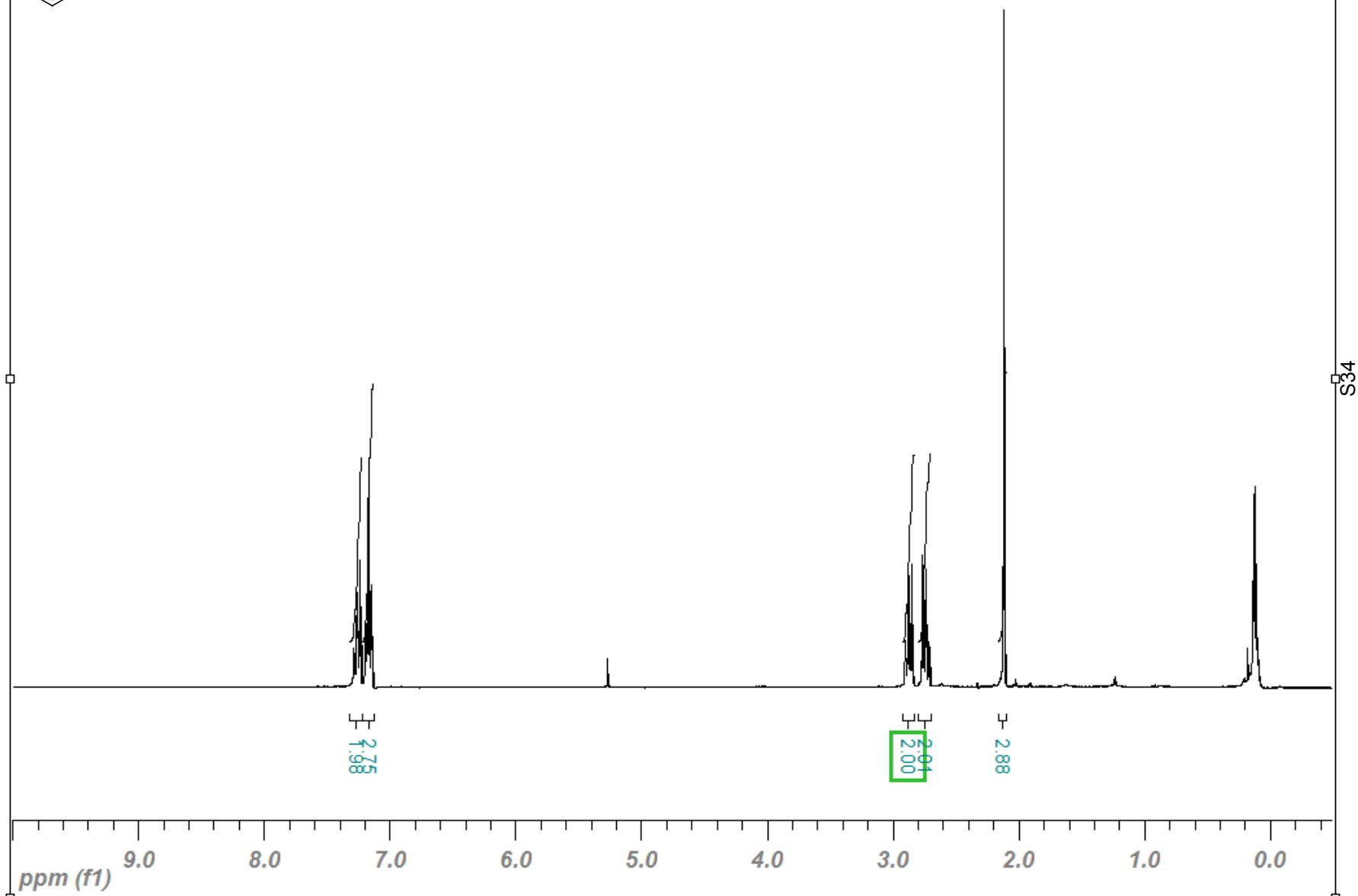
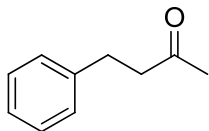
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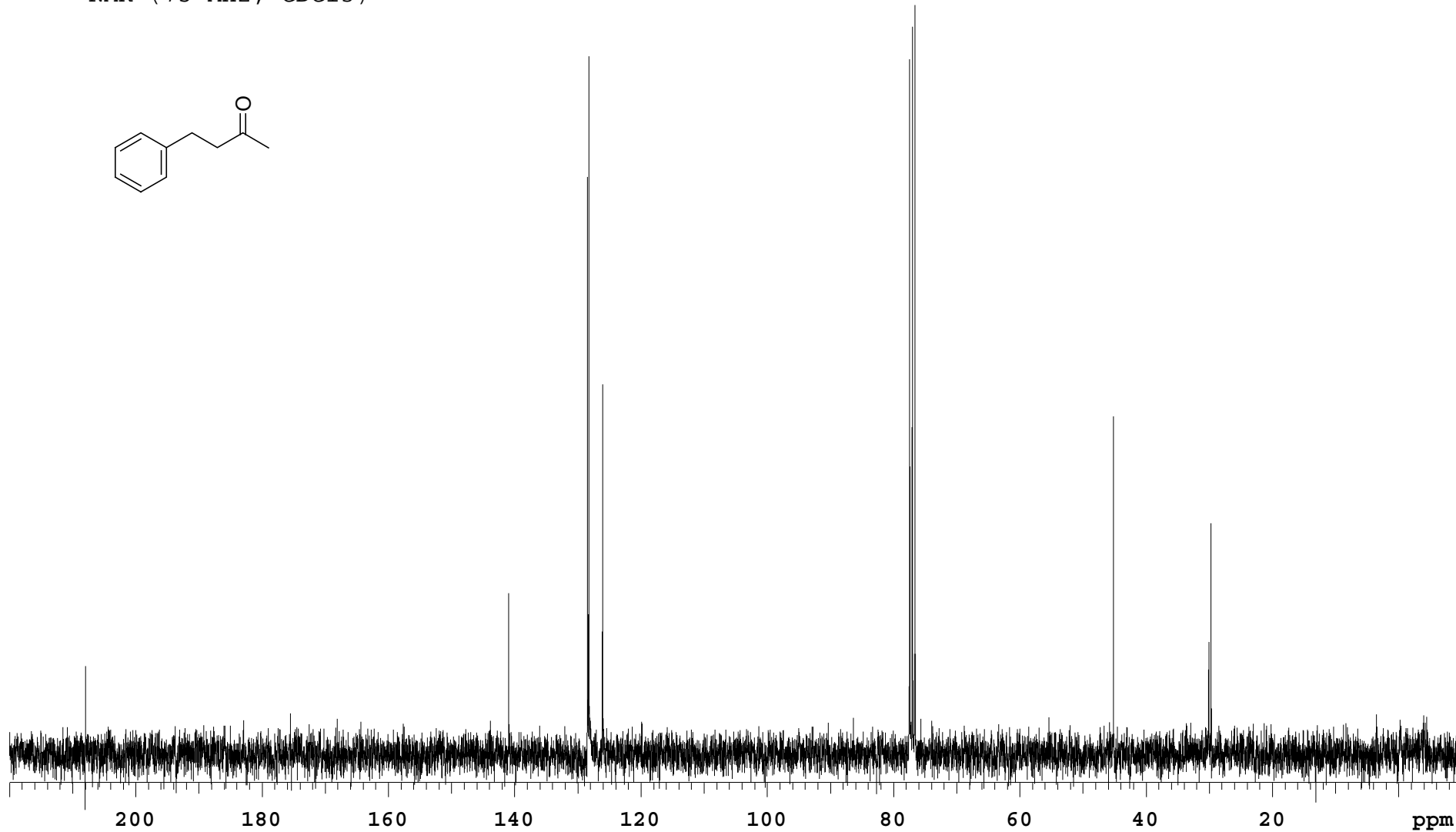
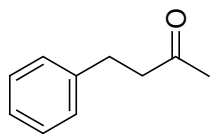
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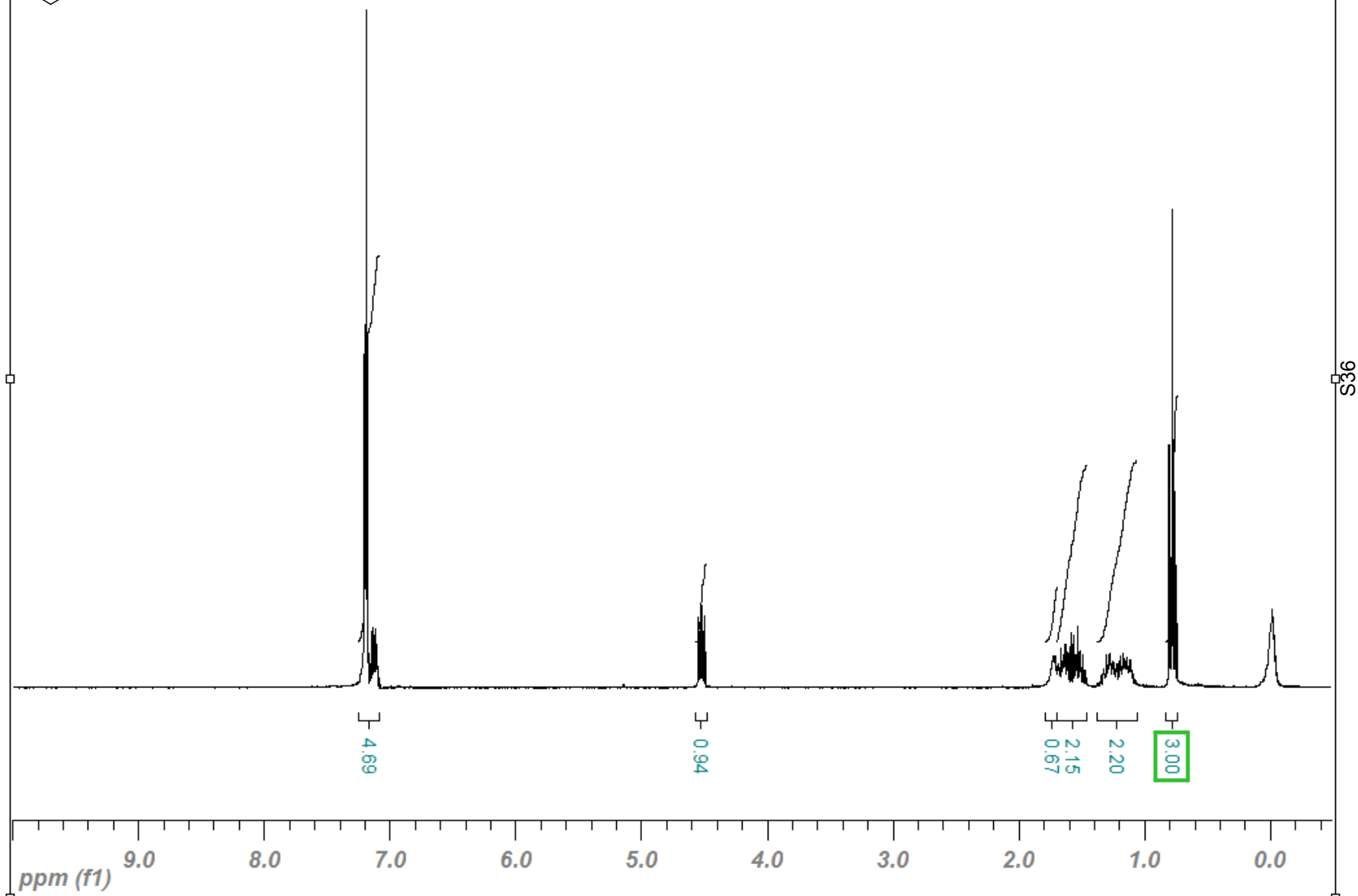
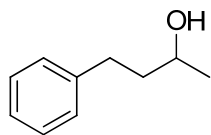
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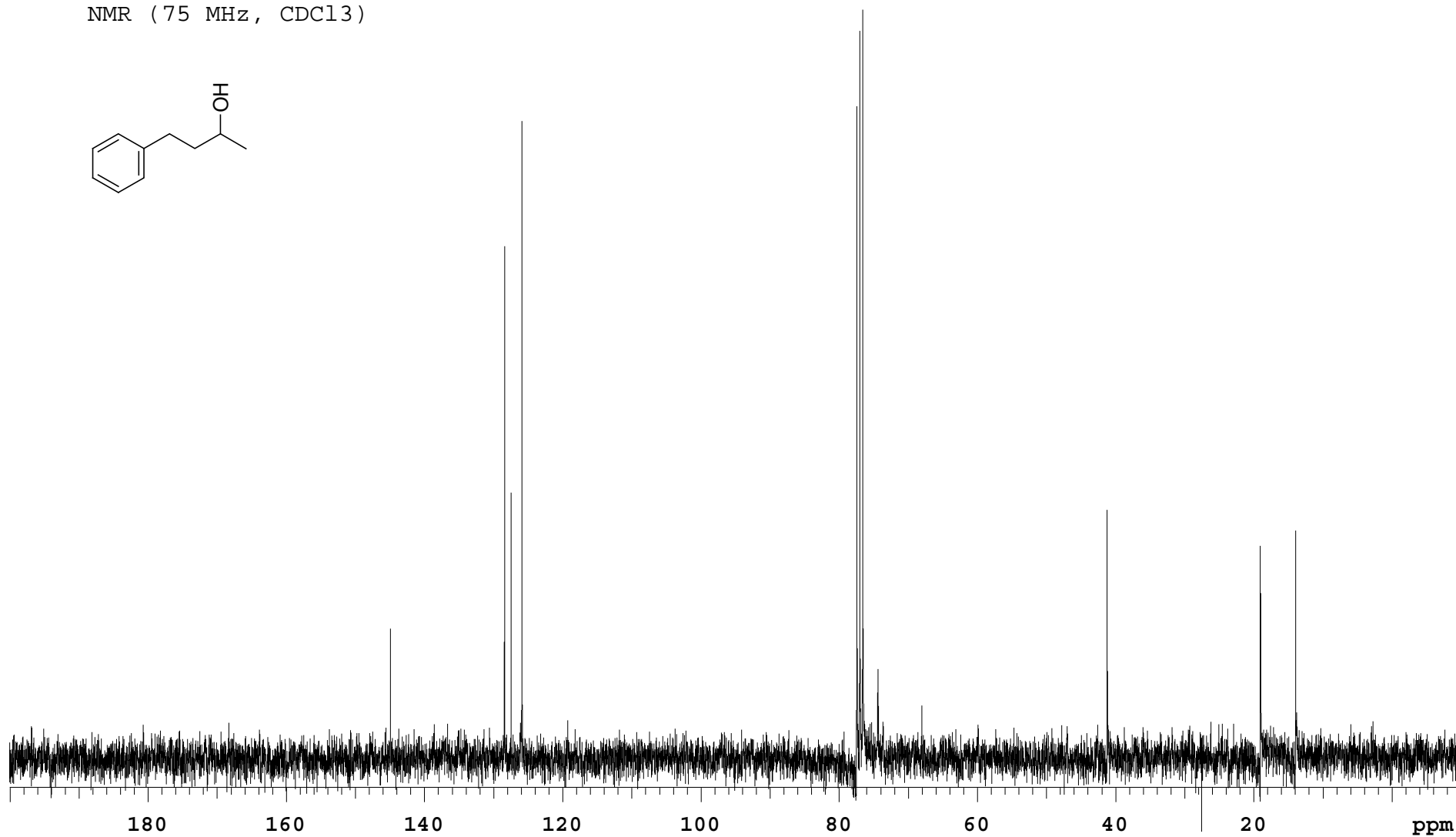
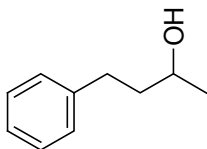
NMR (75 MHz, CDCl₃)



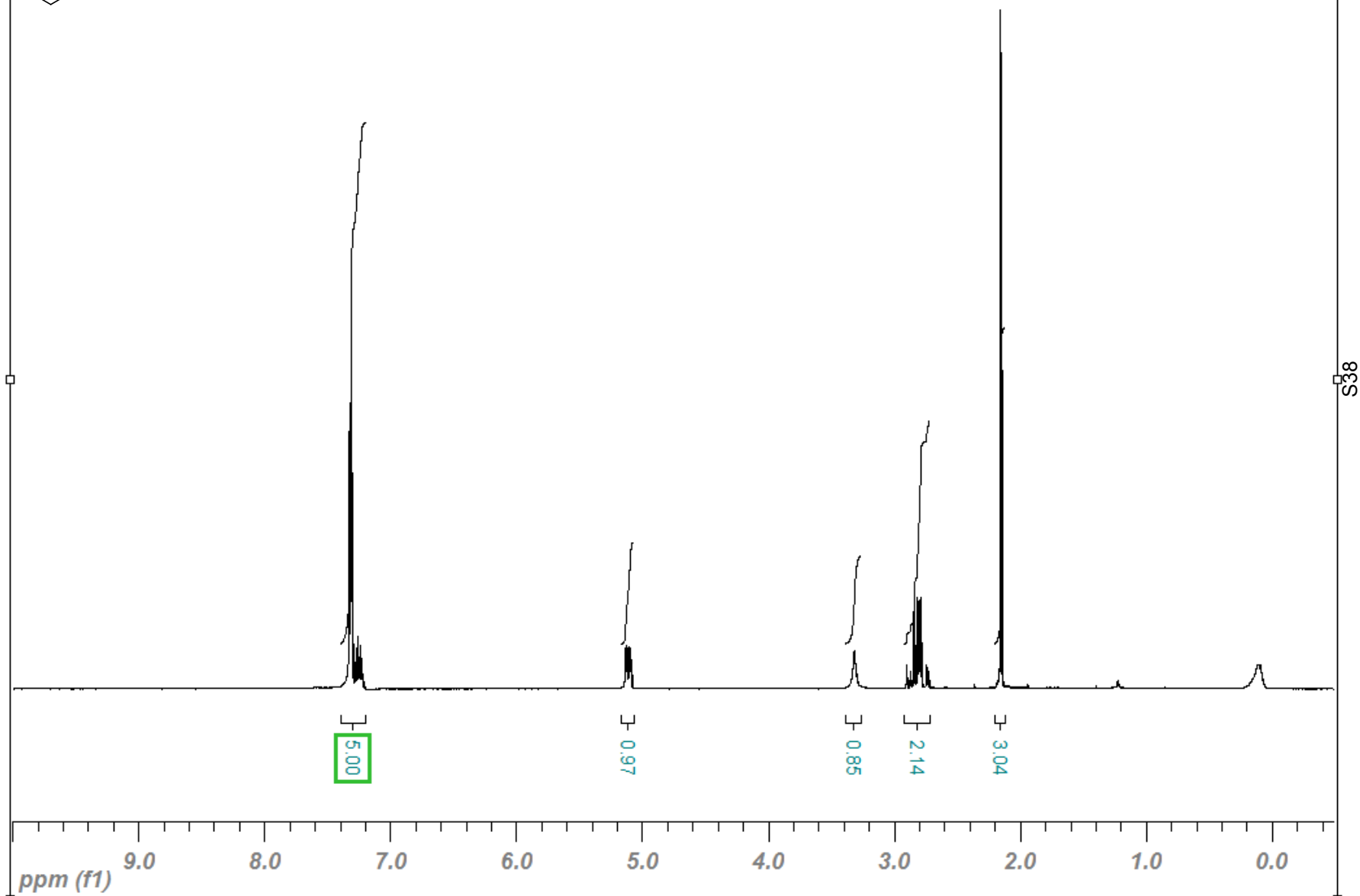
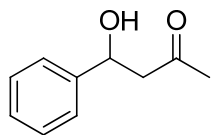
NMR (300 MHz, CDCl₃)



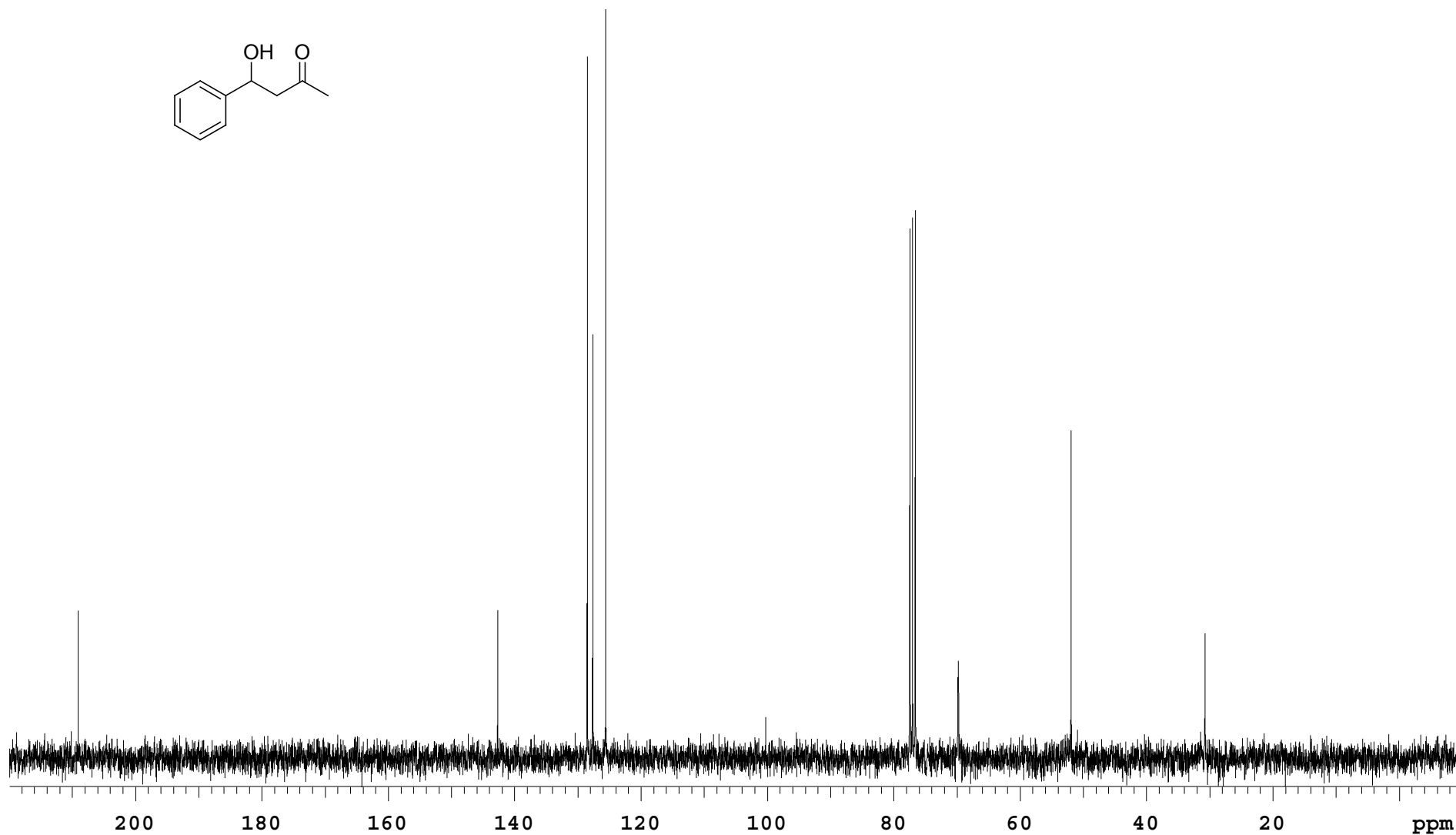
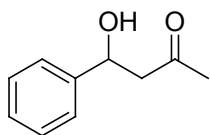
NMR (75 MHz, CDCl₃)



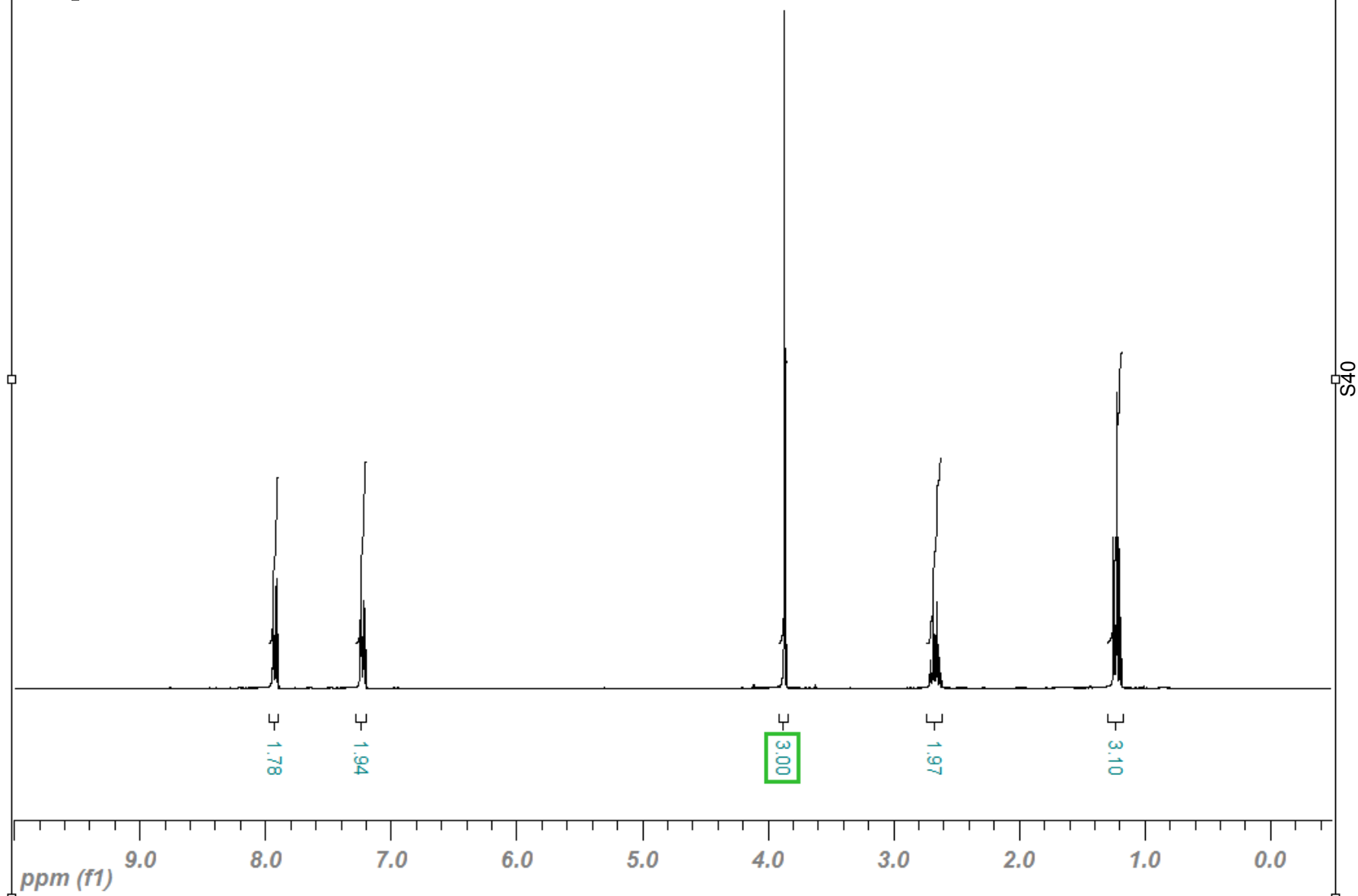
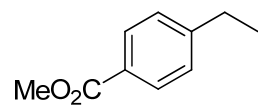
NMR (300 MHz, CDCl₃)



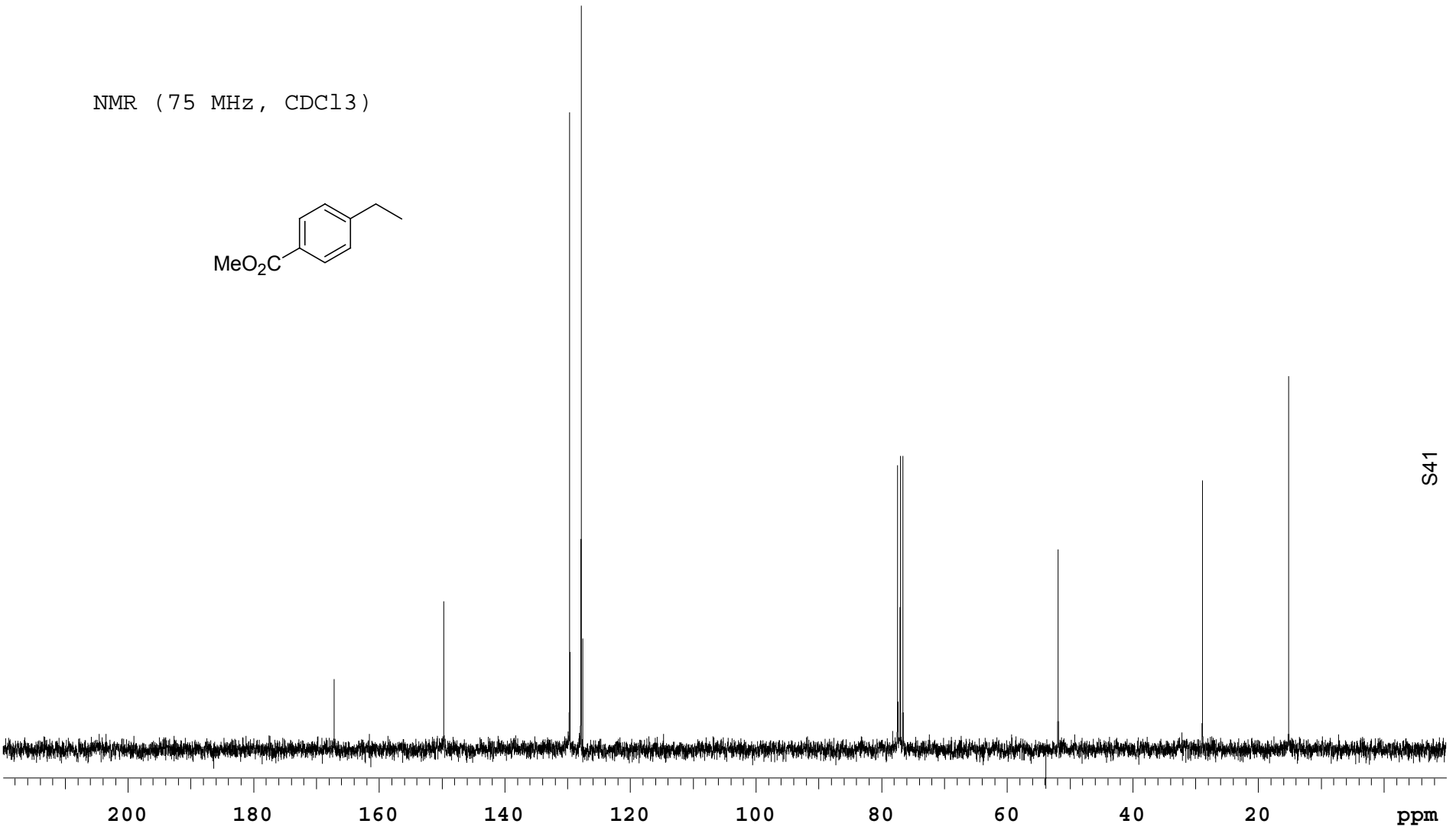
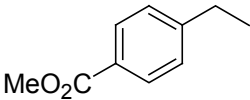
NMR (75 MHz, CDCl₃)



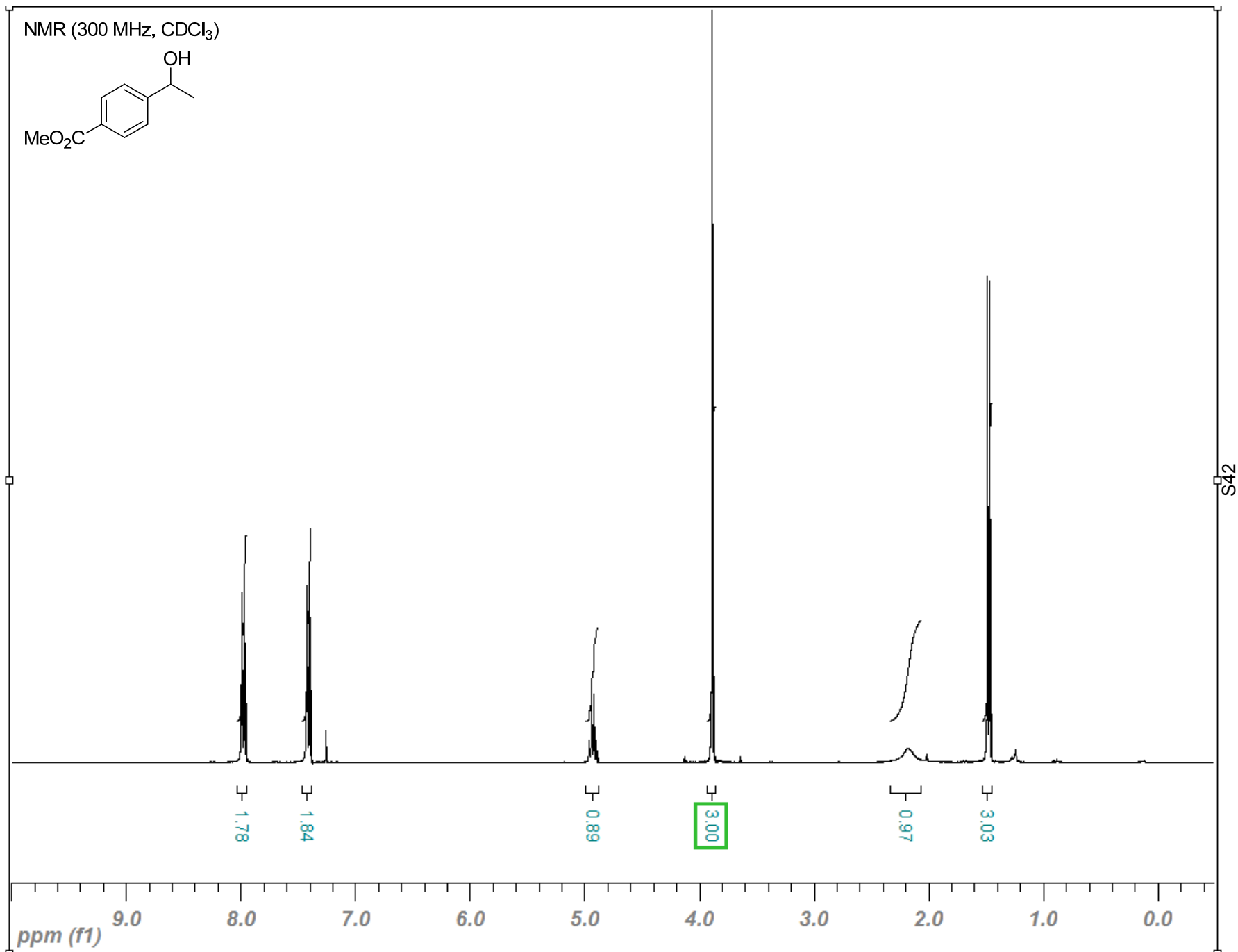
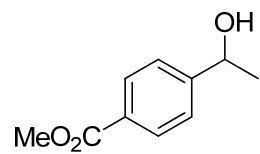
NMR (300 MHz, CDCl₃)



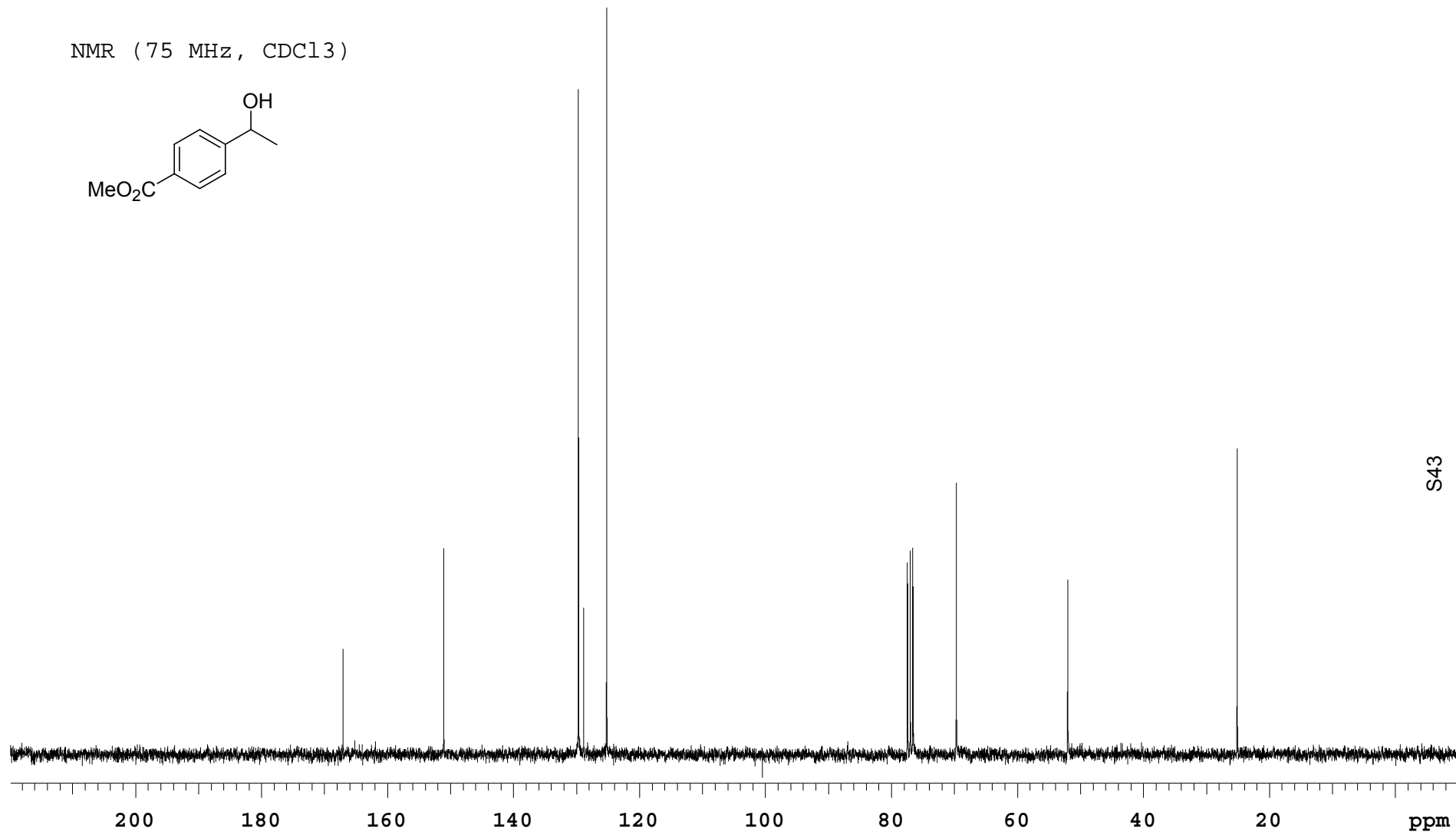
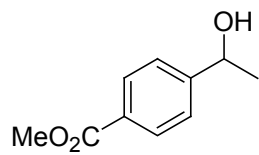
NMR (75 MHz, CDCl3)



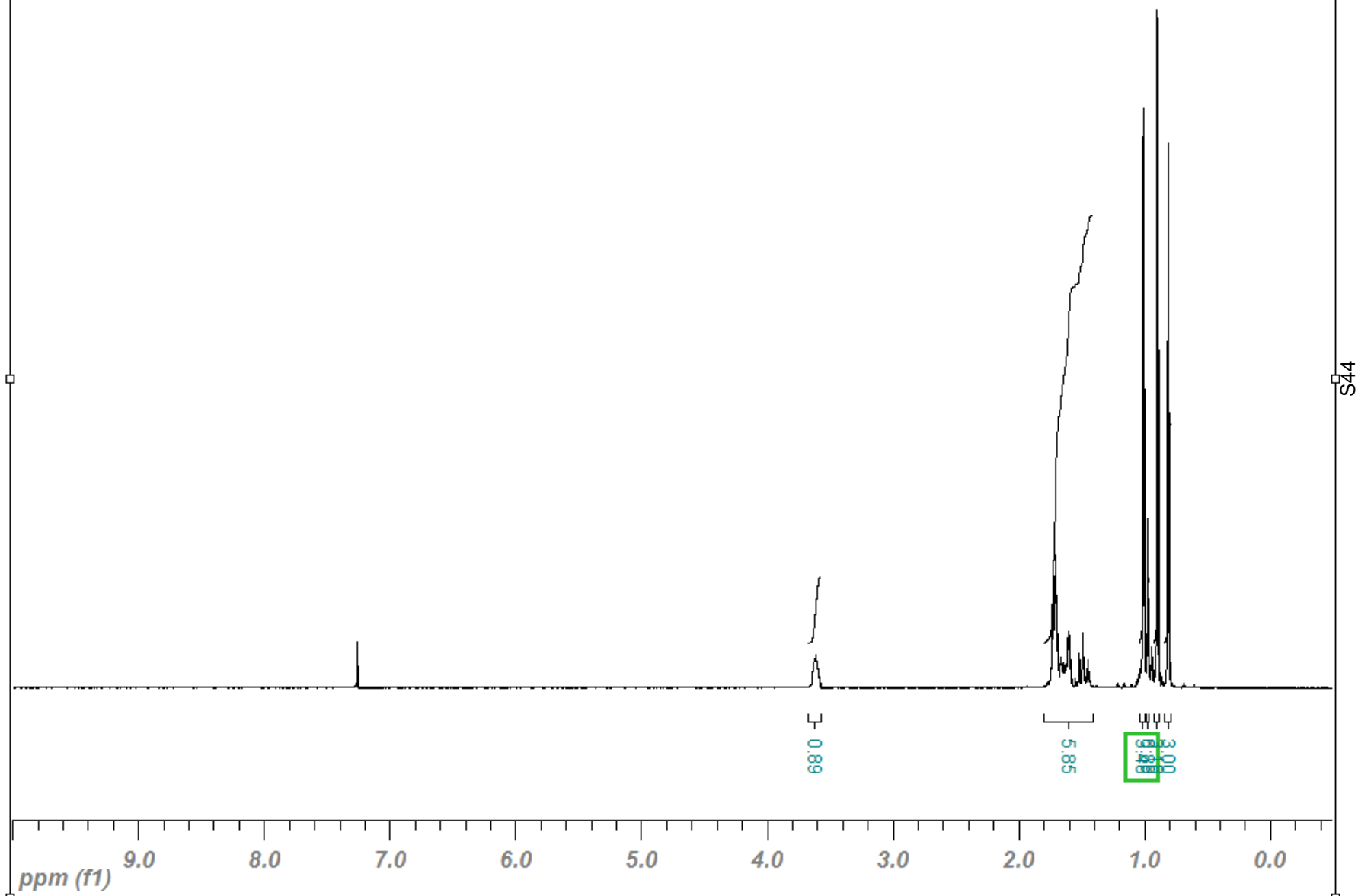
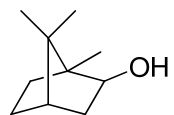
NMR (300 MHz, CDCl₃)



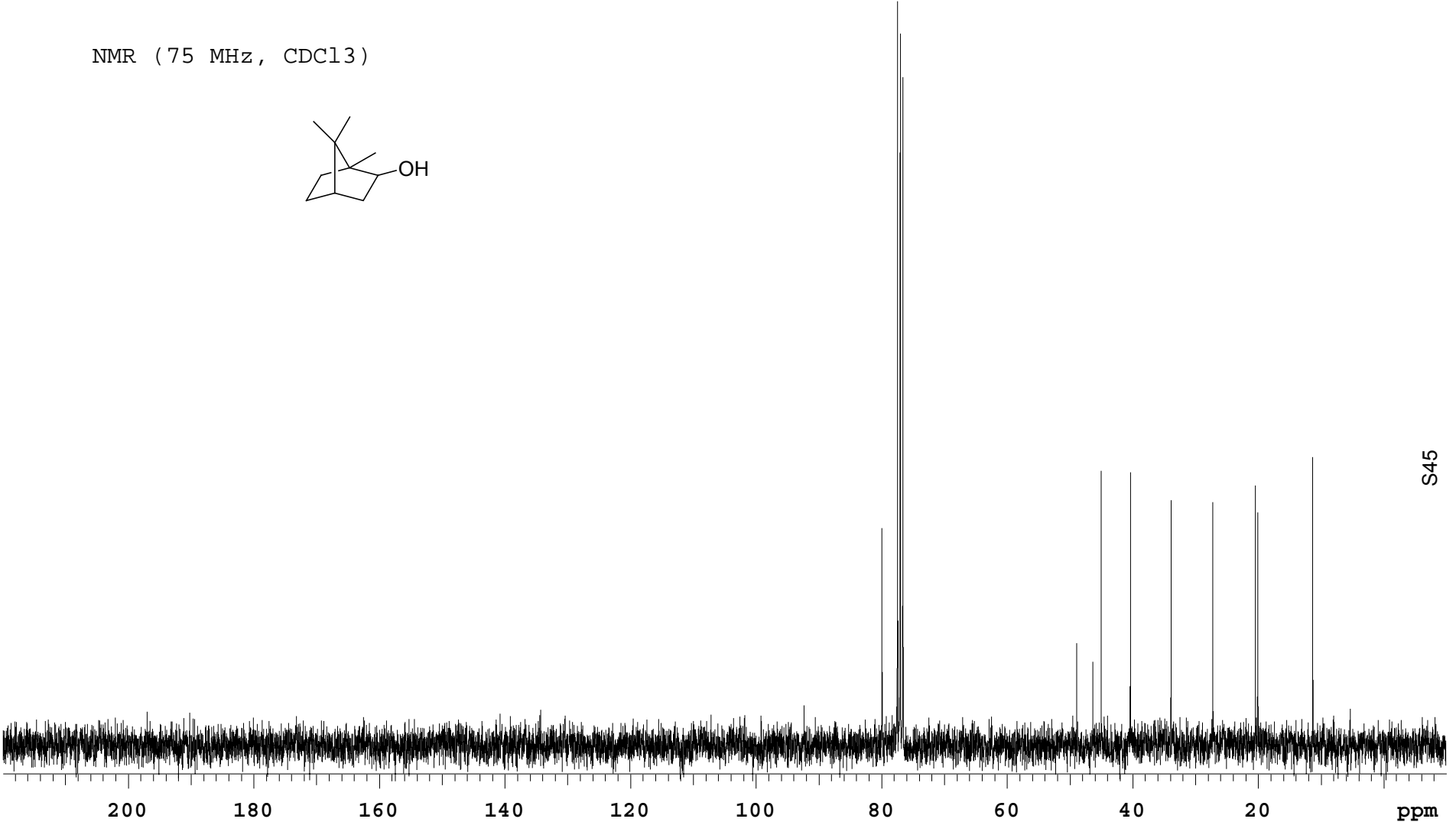
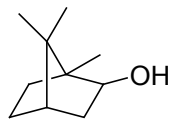
NMR (75 MHz, CDCl₃)



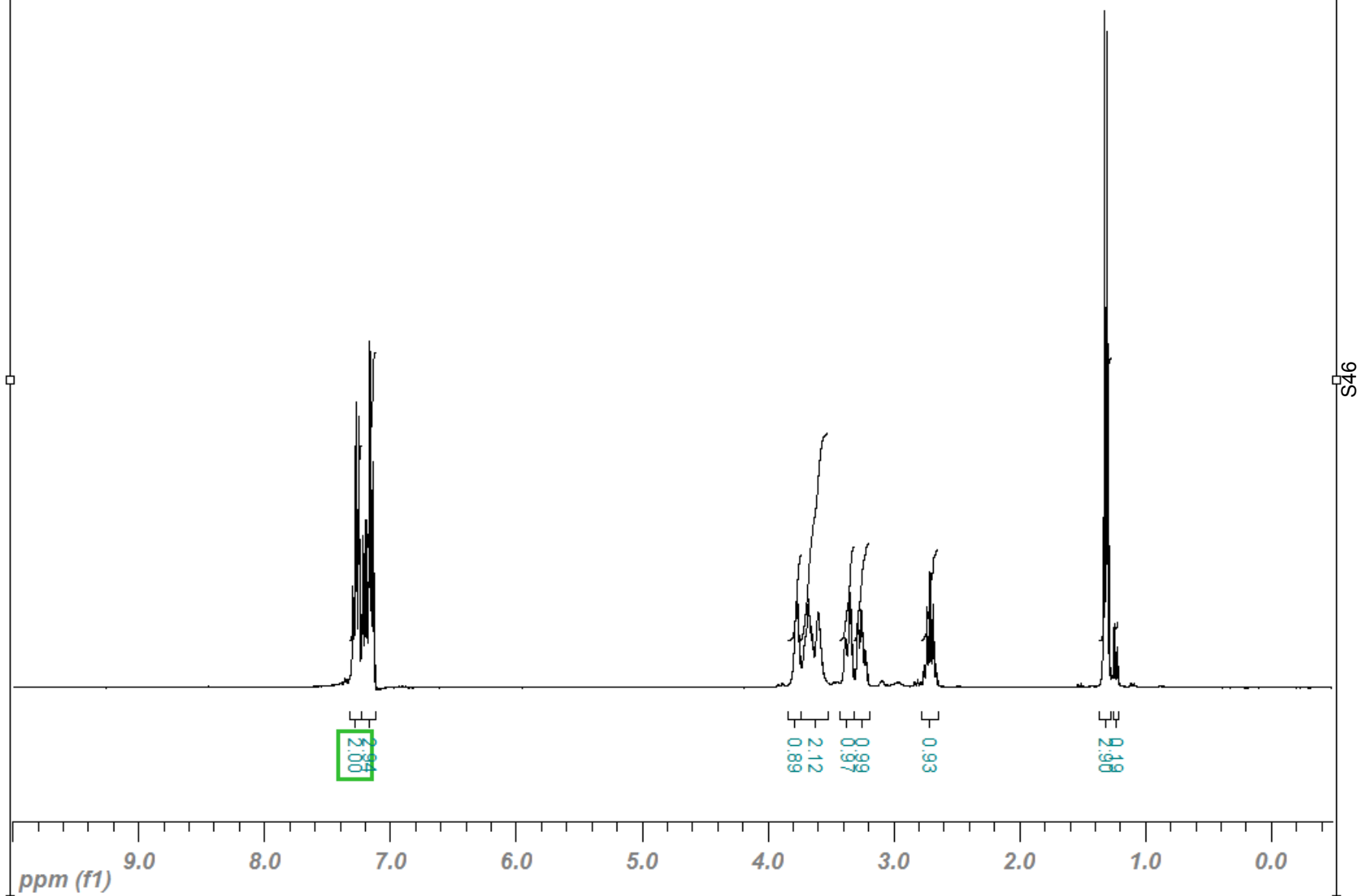
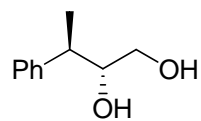
NMR (300 MHz, CDCl₃)



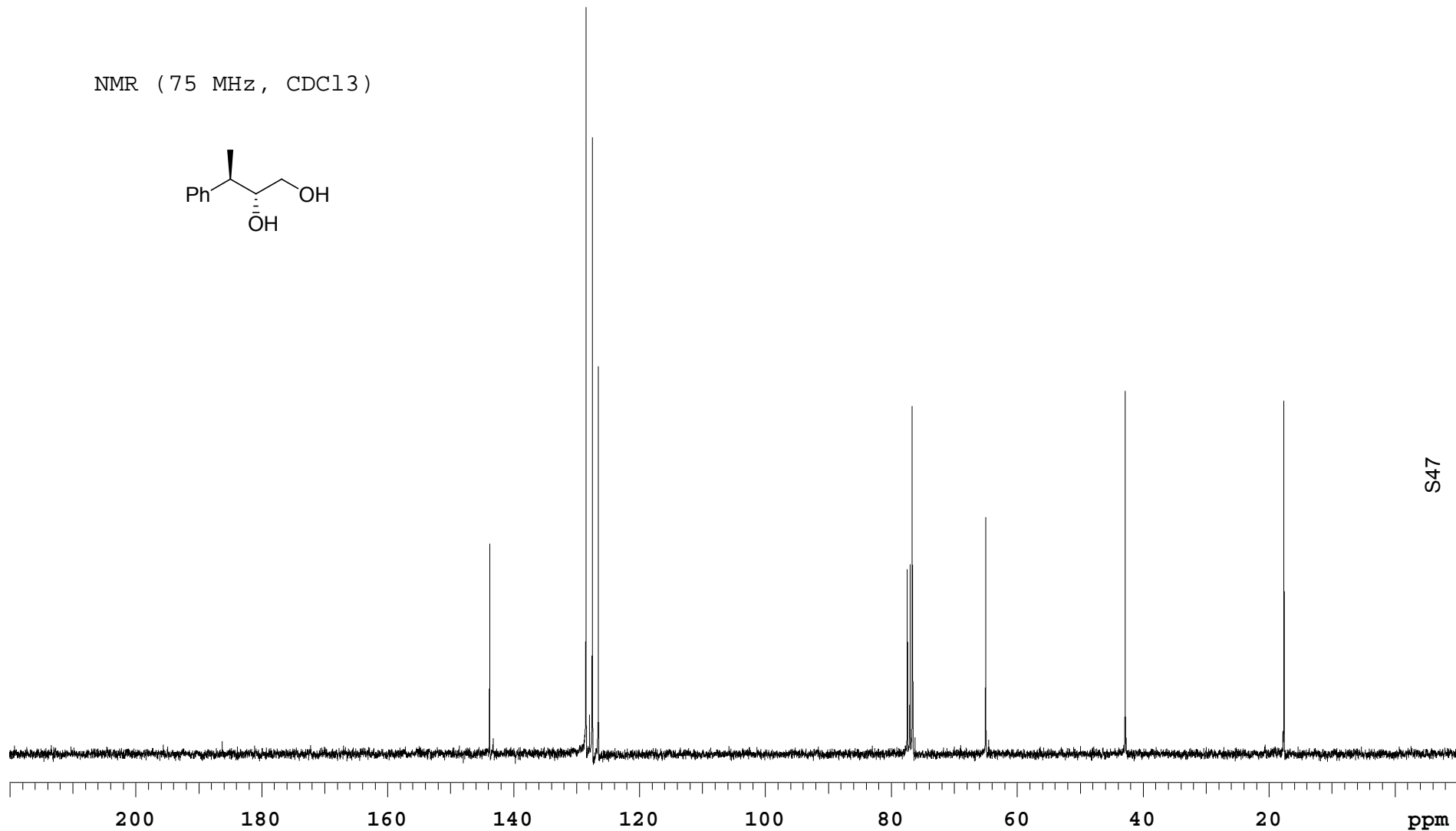
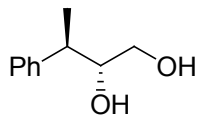
NMR (75 MHz, CDCl3)



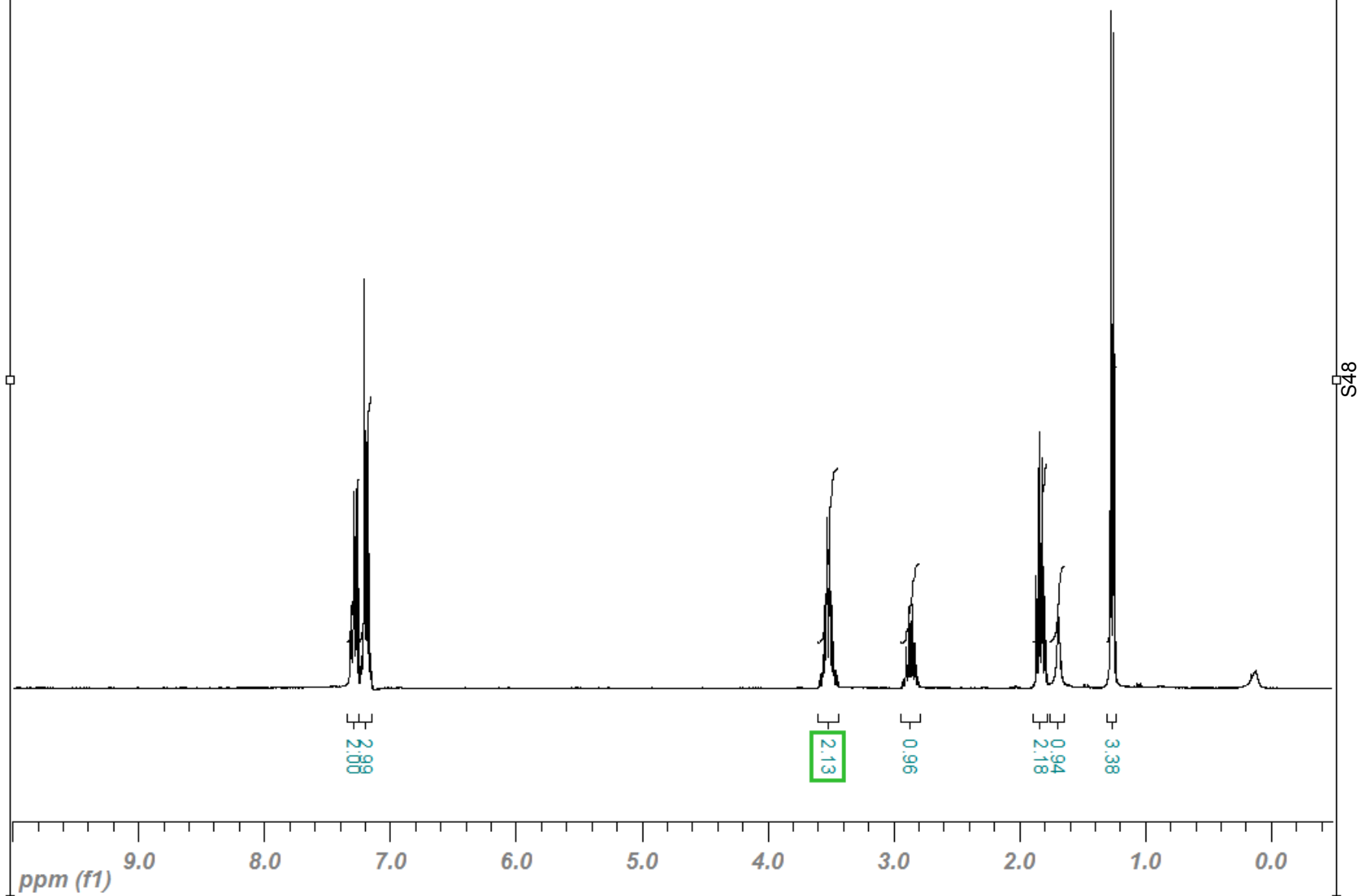
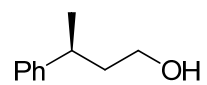
NMR (300 MHz, CDCl₃)



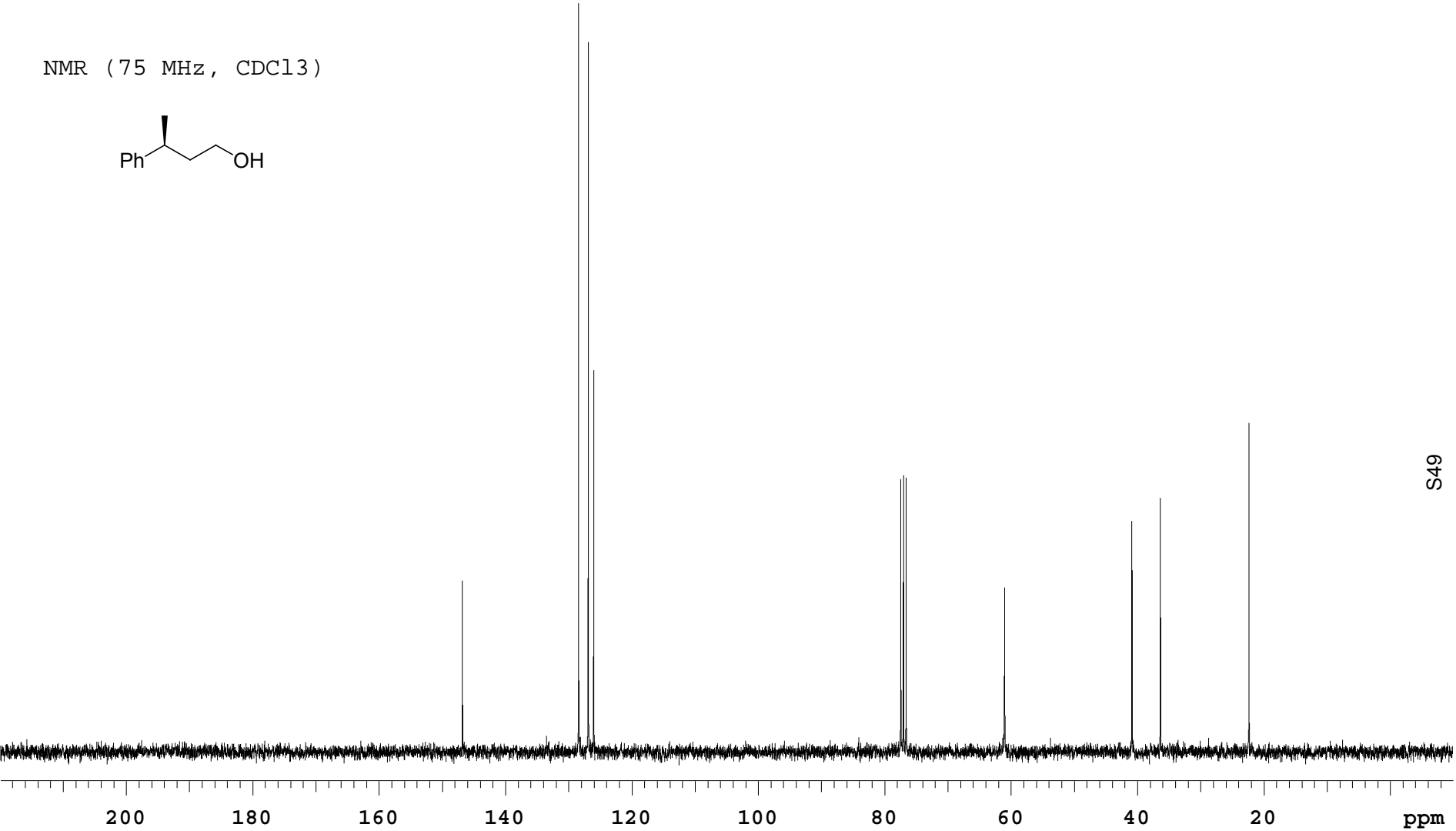
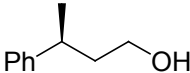
NMR (75 MHz, CDCl₃)



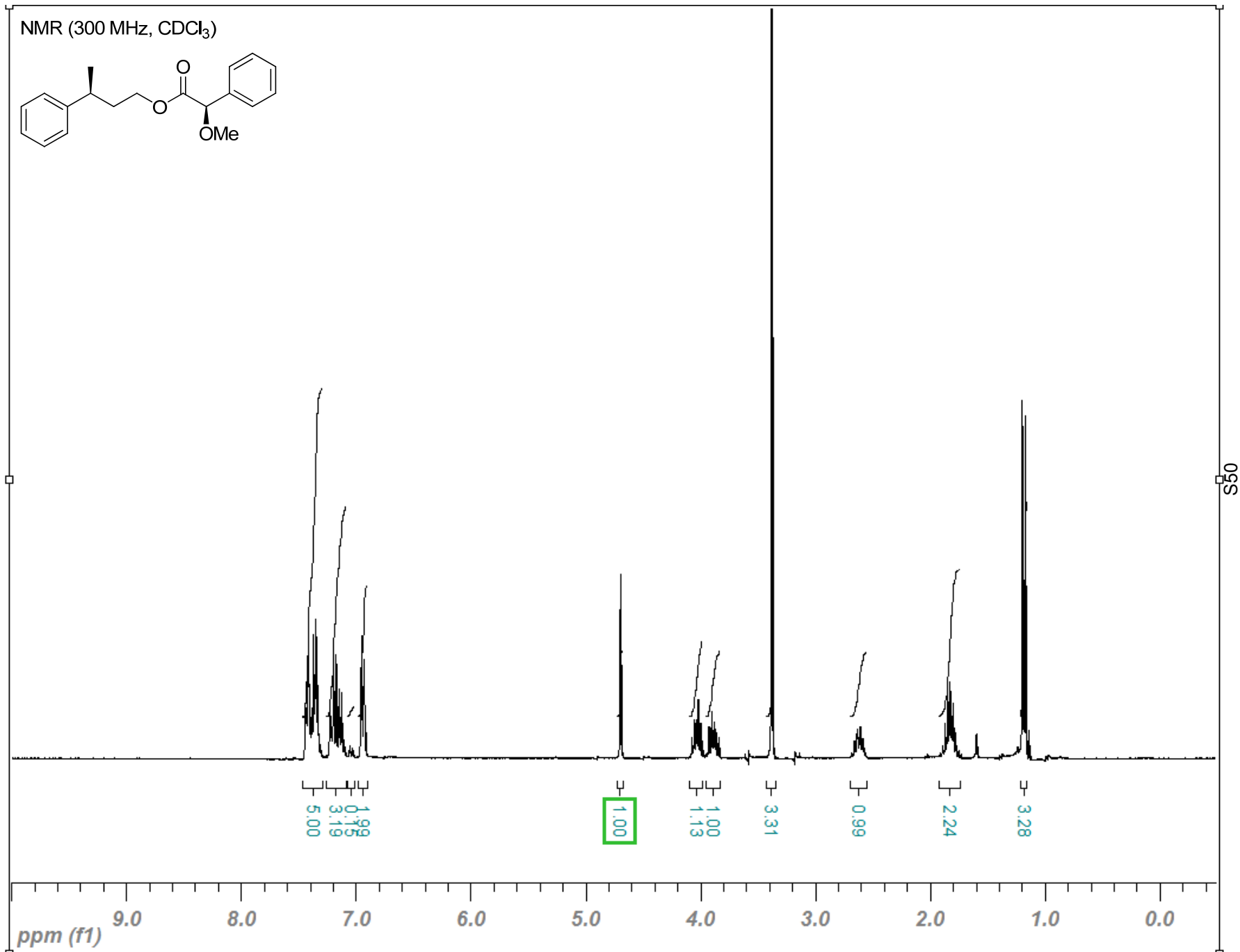
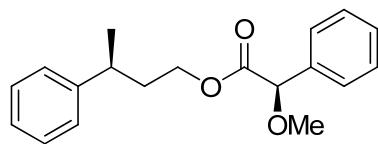
NMR (300 MHz, CDCl₃)



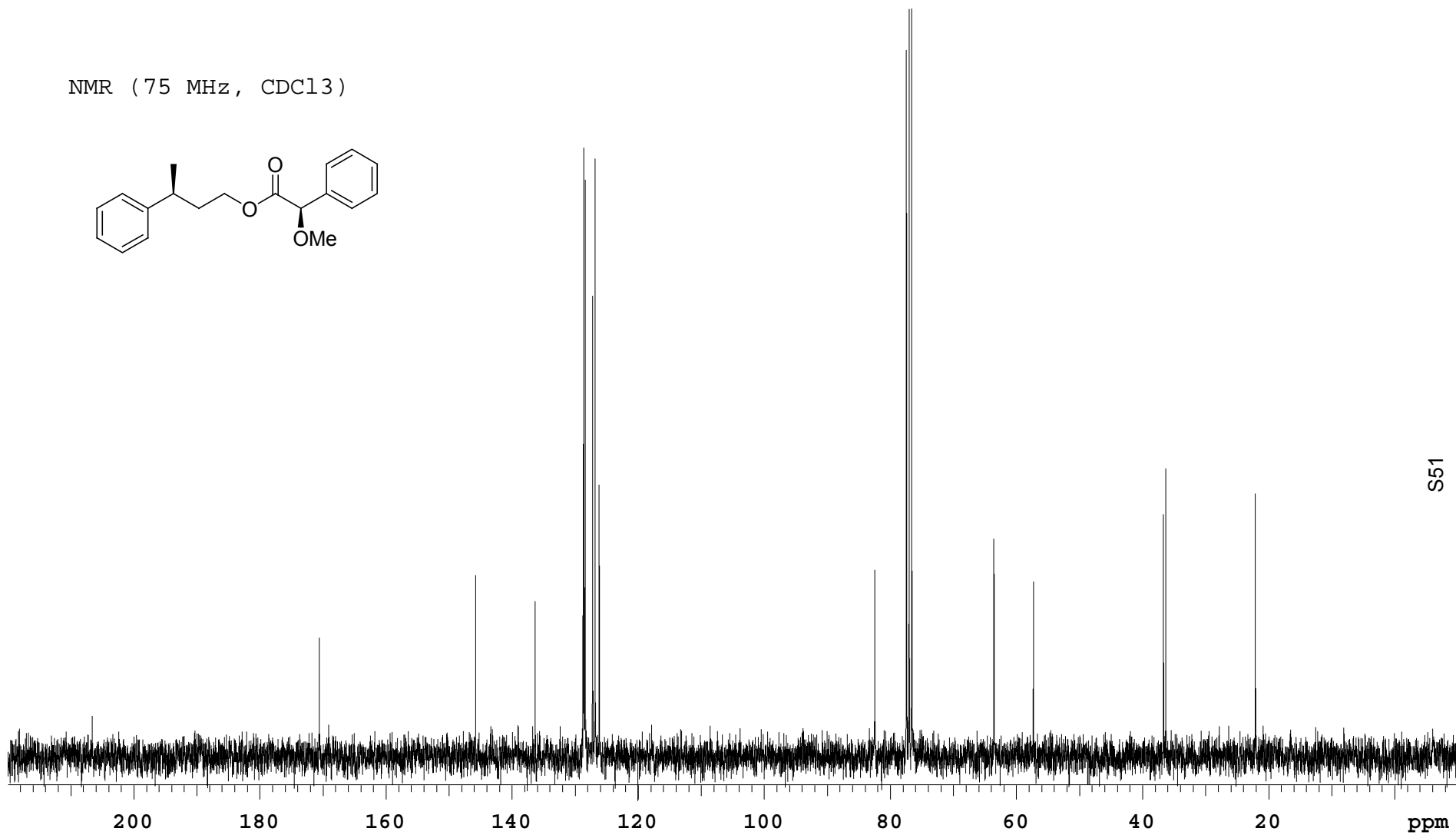
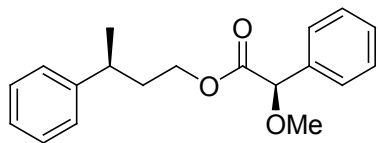
NMR (75 MHz, CDCl₃)



NMR (300 MHz, CDCl₃)

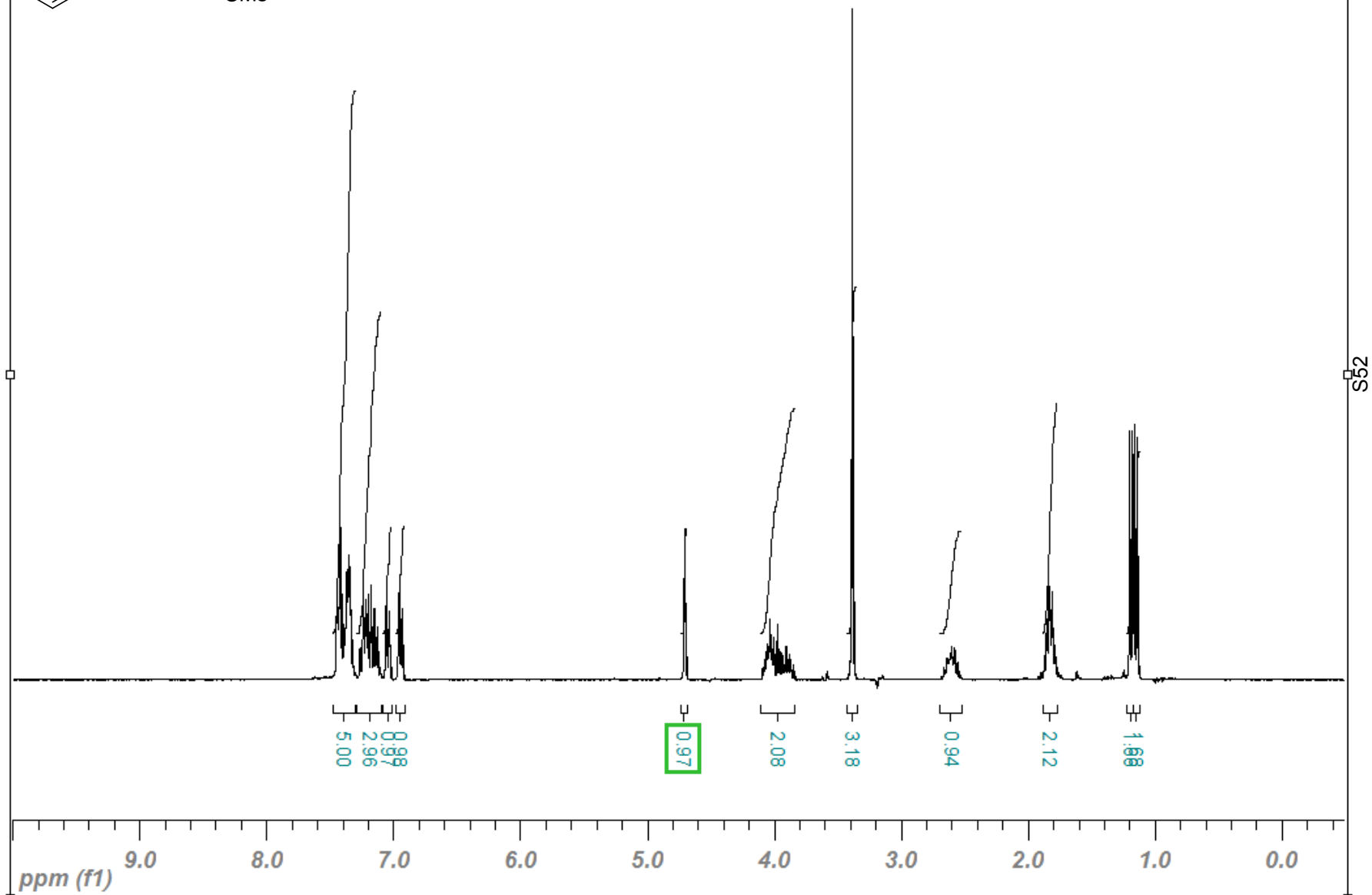
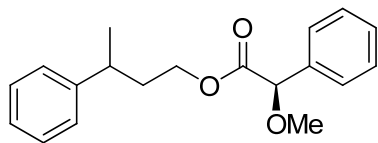


NMR (75 MHz, CDCl₃)

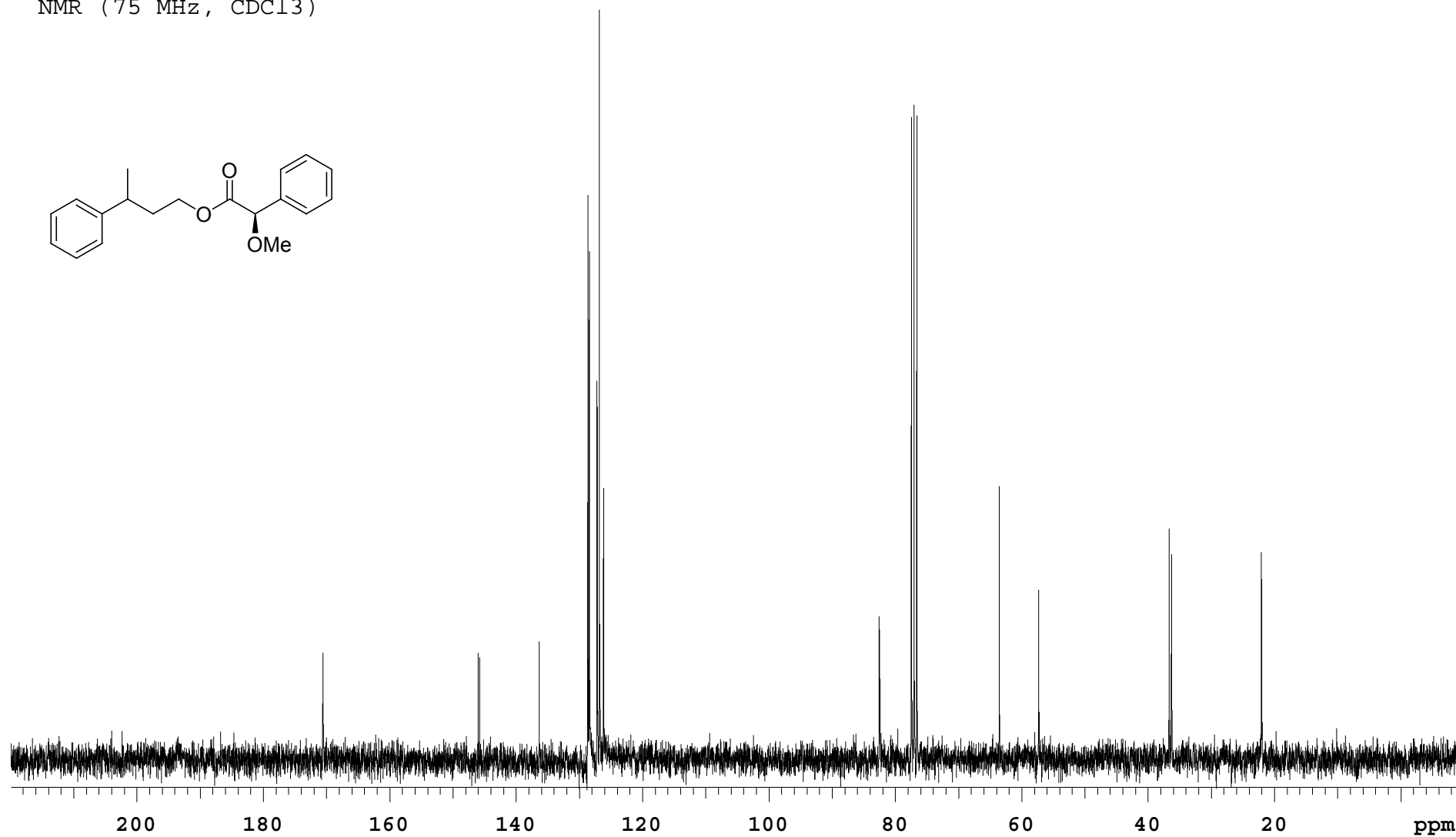
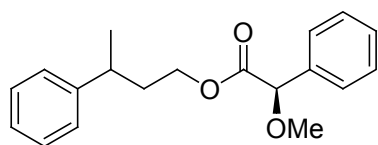


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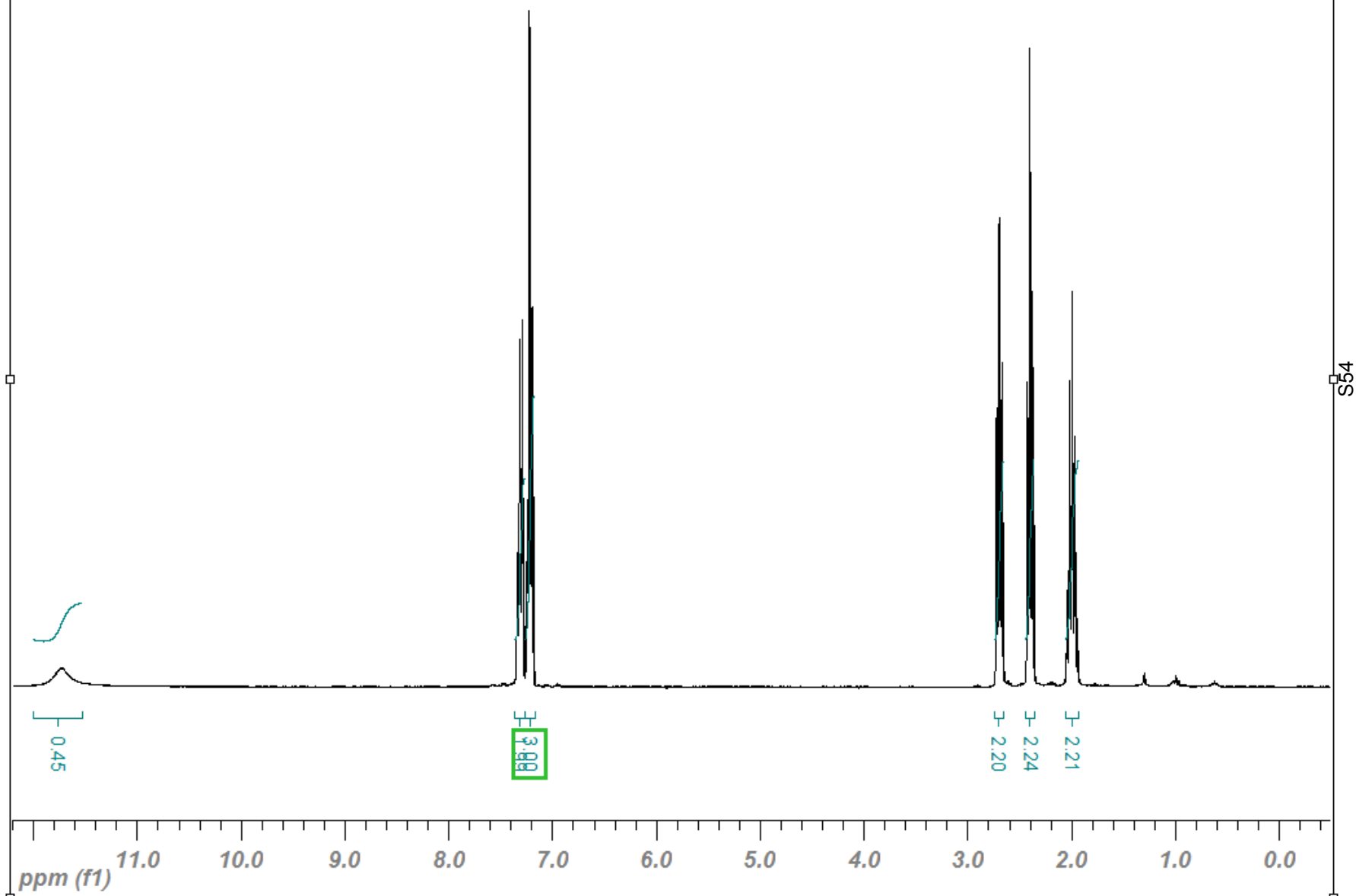
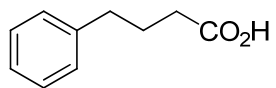
NMR (300 MHz, CDCl₃)



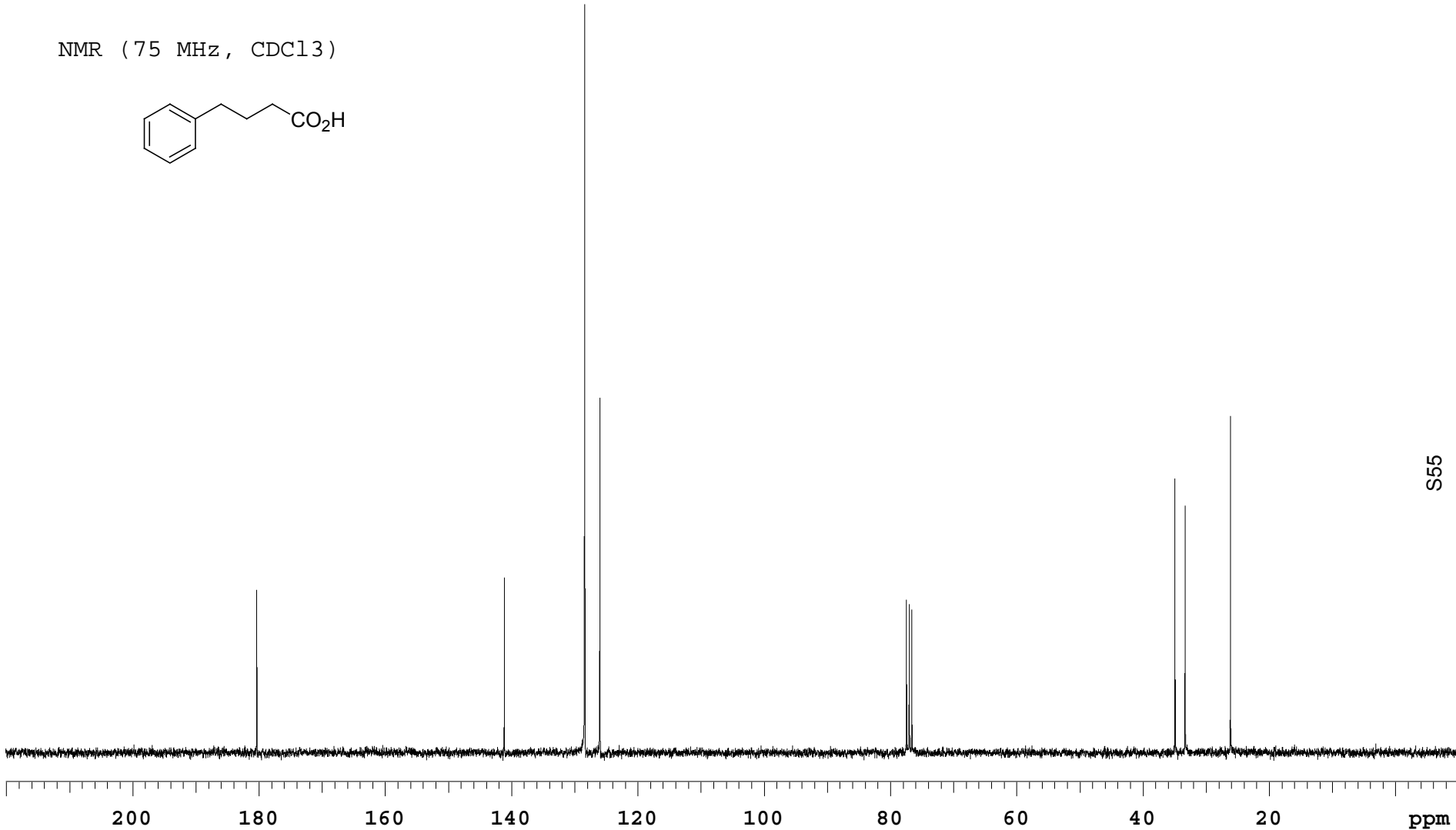
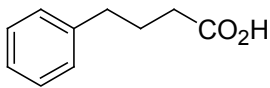
NMR (75 MHz, CDCl₃)



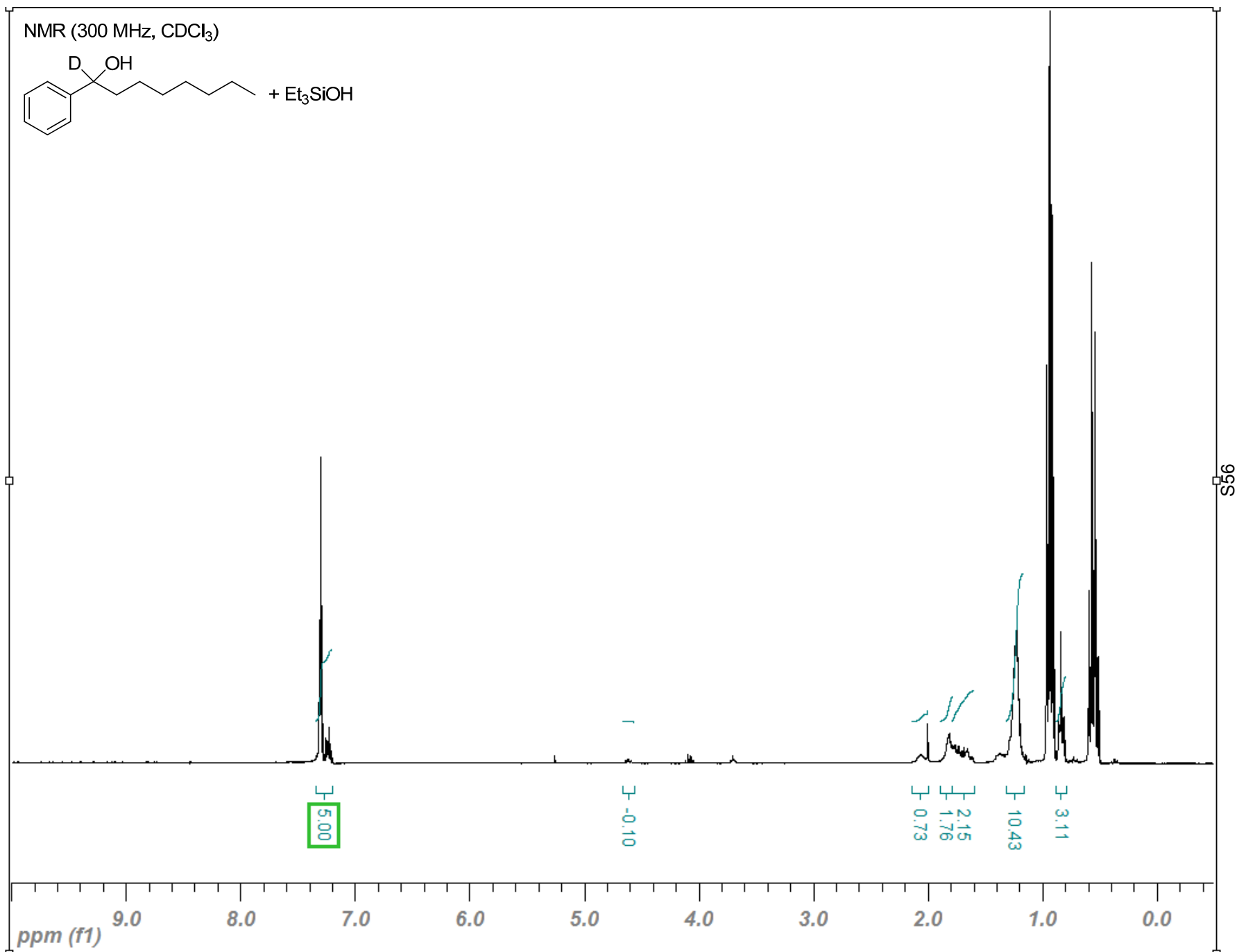
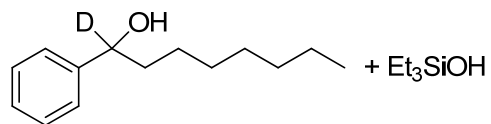
NMR (300 MHz, CDCl₃)



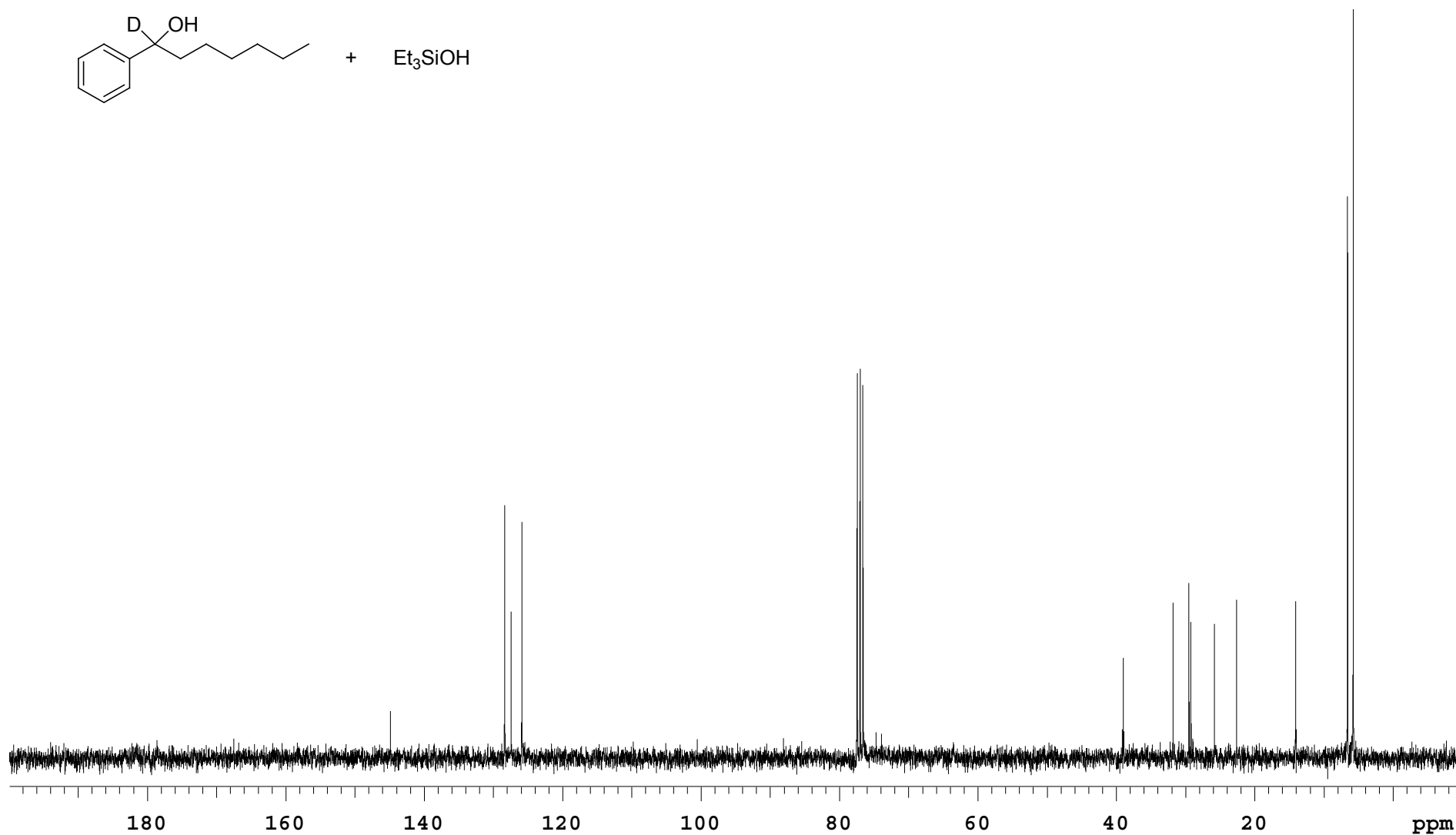
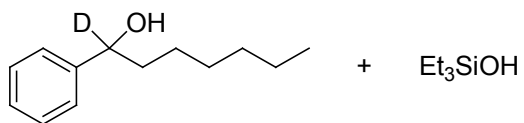
NMR (75 MHz, CDCl3)



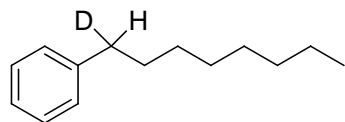
NMR (300 MHz, CDCl₃)



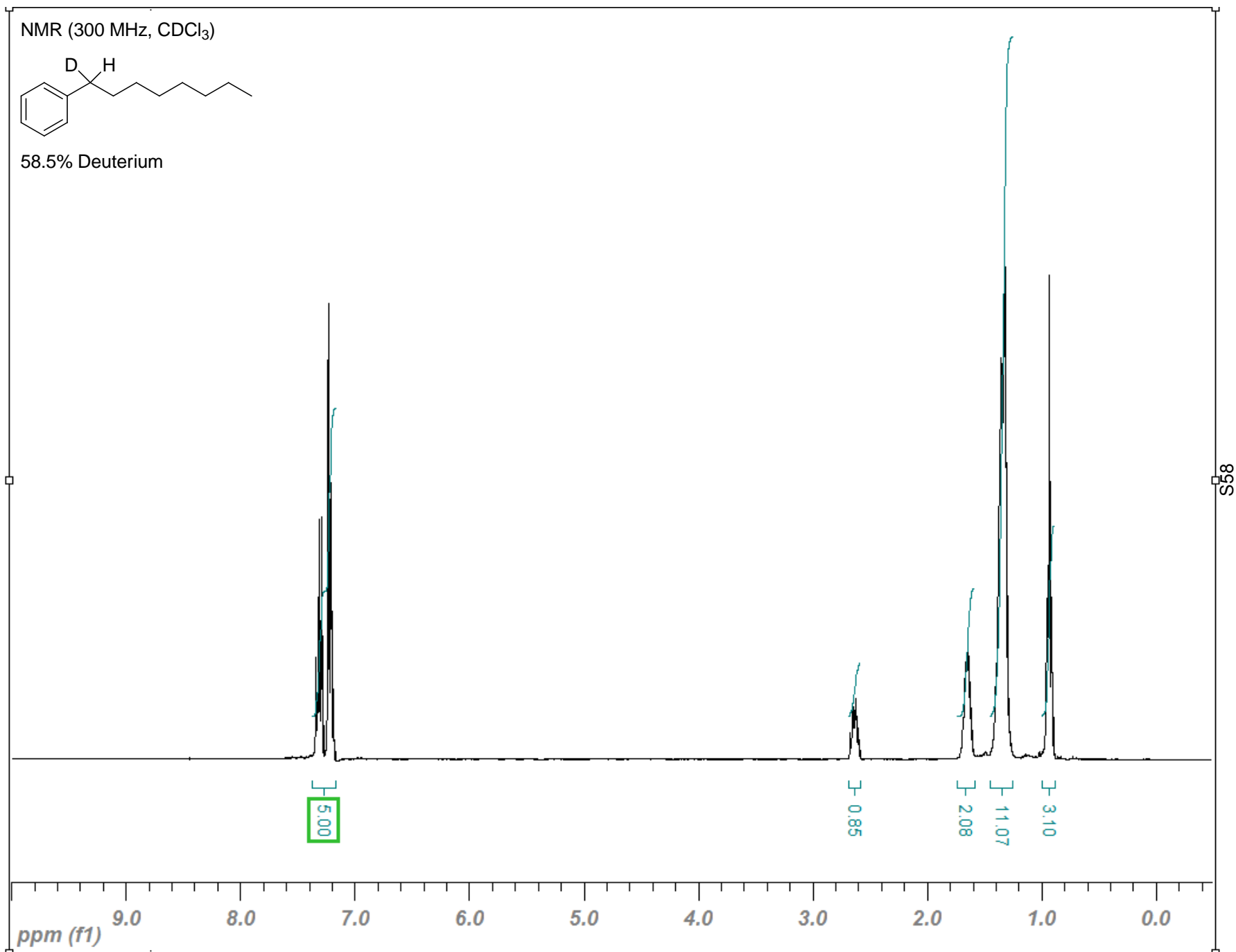
NMR (75 MHz, CDCl₃)



NMR (300 MHz, CDCl₃)

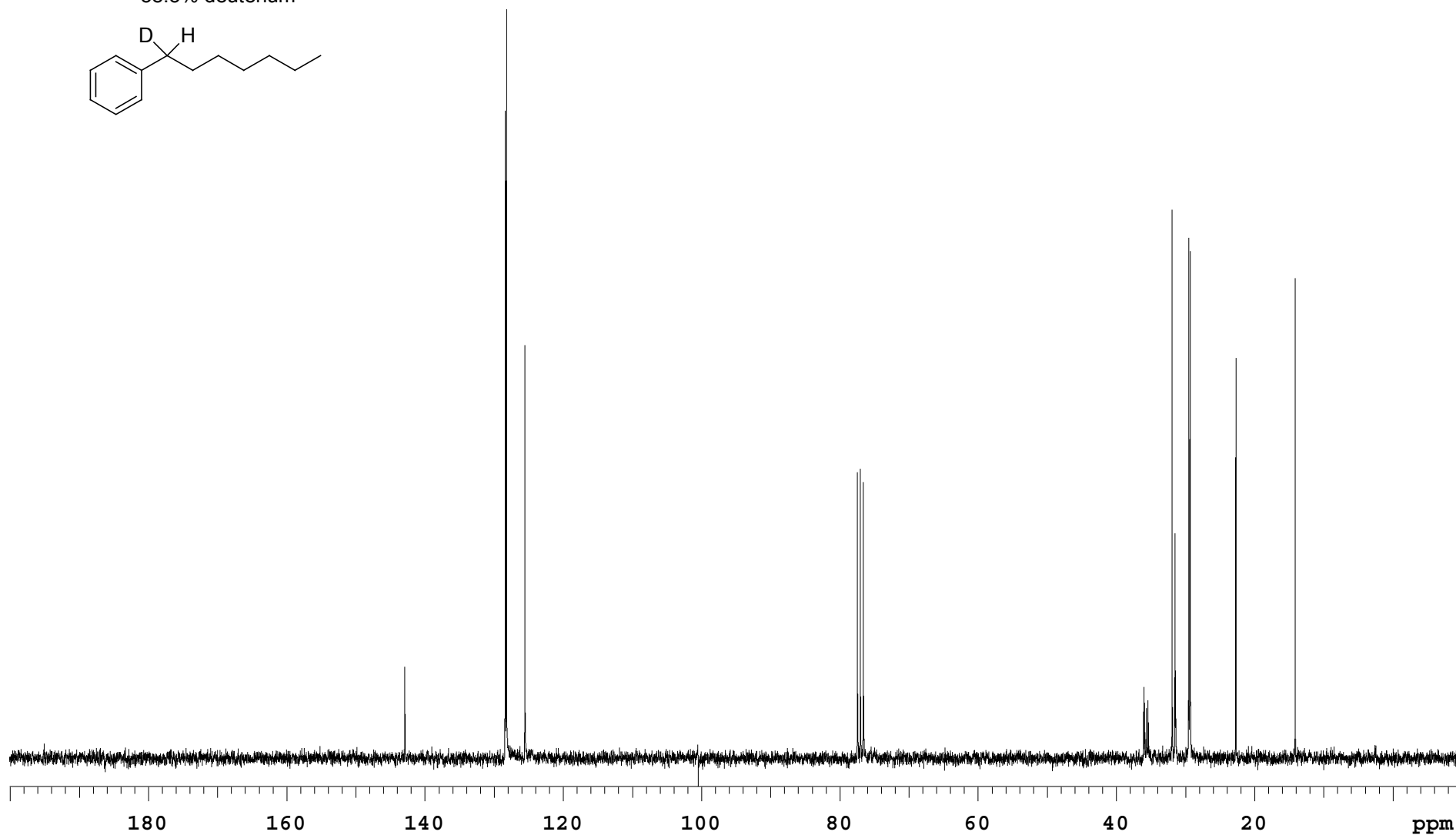
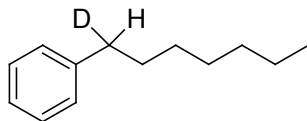


58.5% Deuterium

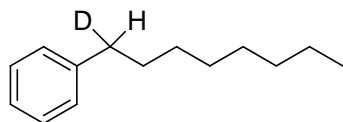


NMR (75 MHz, CDCl₃)

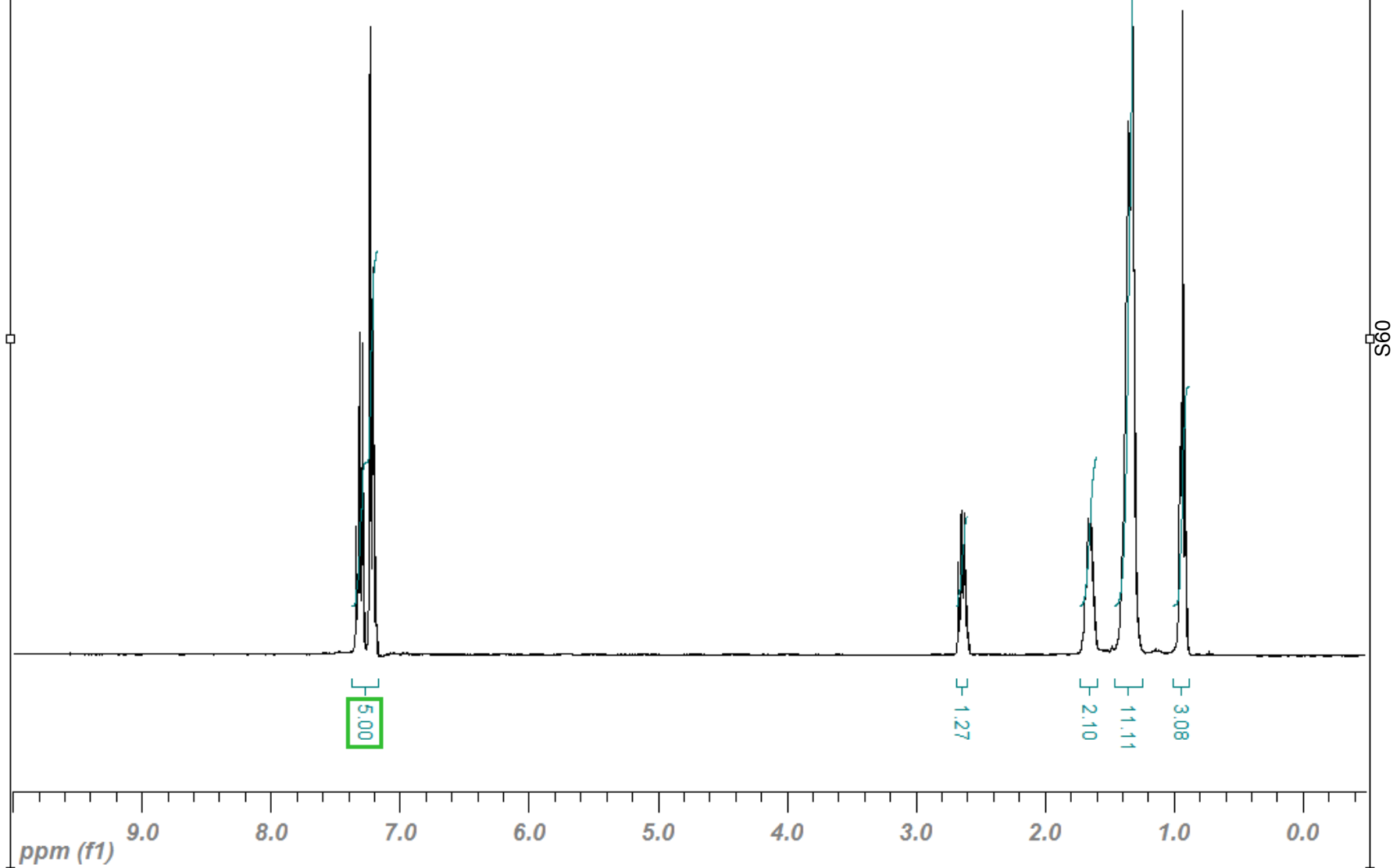
58.5% deuterium



NMR (300 MHz, CDCl₃)



36.5% Deuterium



NMR (75 MHz, CDCl₃)

36.5% deuterium

