Formation of Chiral Allylic Ethers via an Enantioselective Palladium-Catalyzed Alkenylation of Acyclic Enol Ethers

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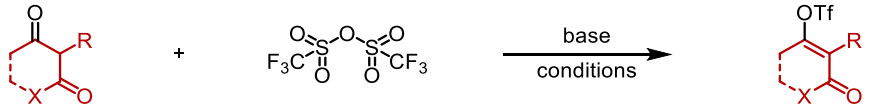
General considerations:

Dry dimethylformamide (DMF) and dimethylacetamide (DMA) were purchased from Aldrich and stored over activated 3 Å molecular sieves (3 Å MS). All glassware was dried in a 120 ºC oven or flame-dried and cooled under nitrogen or vacuum, unless otherwise noted. Powdered 3 Å MS were activated by heating under a flame, under high vacuum and then stored under nitrogen. Alkene substrates were purchased from Aldrich, TCI or Alfa Aesar or prepared according to the literature procedures. Triflates were prepared according to the literature procedures. Tris(dibenzylideneacetone)dipalladium(0) was synthesized according to the literature procedure.[1] The PyrOx ligand used in these studies was synthesized according to the literature procedure.[2] ^{1}H NMR spectra were obtained at 300 MHz, 400 MHz, or 500 MHz, chemical shifts are reported in ppm, and referenced to the $CHCl_3$ singlet at 7.26 ppm. ^{13}C NMR spectra were obtained at 75 MHz, 100 MHz, or 126 MHz and referenced to the center peak of the $CDCl_3$ triplet at 77.00 ppm. The abbreviations s, d, t, q, p, sext, dd, dt, and m stand for the resonance multiplicities singlet, doublet, triplet, quintet, doublet of doublets, doublet of triplets and multiplet, respectively. Thin-layer chromatography was performed with EMD silica gel 60 F254 plates eluting with solvents indicated, visualized by a 254 nm UV lamp and stained with phosphomolybdic acid. Flash chromatography was performed using EM reagent silica 60 (230-400 mesh). IR spectra were recorded using a Thermo Nicolet FT-IR. High resolution mass spectrometry (HRMS) data were obtained on a Waters LCP Premier XE instrument by ESI/TOF. SFC (supercritical fluid chromatography) analysis was performed at 25–40 ºC, using a Waters instrument fitted with a chiral stationary phase as indicated. Gas chromatography analysis was performed using a Hewlett Packard HP6890 instrument under the conditions indicated. Optical rotations were measured (Na D line) on a Perkin Elmer Model 343 Polarimeter fitted with a micro cell with a 1 dm path length; concentrations are reported in g/100 mL.

Synthesis of Substrates:

Preparation of Alkenyl Triflates

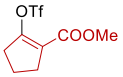
General reaction for the preparation of alkenyl triflates.



(*Z*)-1-(2-oxodihydrofuran-3(2H)-ylidene)ethyl trifluoromethanesulfonate (**1a**):

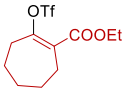
A previously reported procedure was used for the synthesis of **1a** from 3-acetyldihydrofuran-2(3H)-one.[3]

methyl 2-(((trifluoromethyl)sulfonyl)oxy)cyclopent-1-ene-1-carboxylate (**1b**):



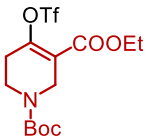
A previously reported procedure was used for the synthesis of **1b** from methyl 2-oxocyclopentane-1-carboxylate.[4]

ethyl 2-(((trifluoromethyl)sulfonyl)oxy)cyclohept-1-ene-1-carboxylate (**1c**):



A previously reported procedure was used for the synthesis of **1c** from ethyl 2-oxocycloheptane-1-carboxylate.[5]

1-(tert-butyl) 3-ethyl 4-(((trifluoromethyl)sulfonyl)oxy)-5,6-dihydropyridine-1,3(2H)-dicarboxylate (**1d**):

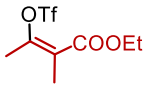


A previously reported procedure was used for the synthesis of **1d** from 1-(tert-butyl) 3-ethyl 4-oxopiperidine-1,3-dicarboxylate.[6]

2-methyl-3-oxocyclohex-1-en-1-yl trifluoromethanesulfonate (**1e**):

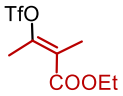
A previously reported procedure was used for the synthesis of **1e** from 2-methyl-3-oxocyclohexanone.[6]

ethyl (*Z*)-2-methyl-3-(((trifluoromethyl)sulfonyl)oxy)but-2-enoate (**1f**):



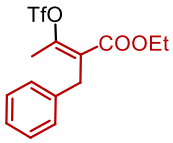
A previously reported procedure was used for the synthesis of **1f** from ethyl 2-methyl-3-oxobutanoate.[7]

ethyl (*E*)-2-methyl-3-(((trifluoromethyl)sulfonyl)oxy)but-2-enoate (**1g**):



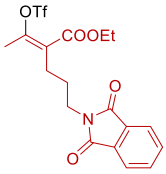
A previously reported procedure was used for the synthesis of **1g** from ethyl 2-methyl-3-oxobutanoate.[7]

ethyl (*Z*)-2-benzyl-3-(((trifluoromethyl)sulfonyl)oxy)but-2-enoate (**1h**):



A previously reported procedure was used for the synthesis of **1h** from ethyl 2-benzyl-3-oxobutanoate.[7]

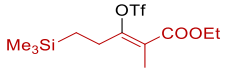
ethyl(*Z*)-5-(1,3-dioxoisoindolin-2-yl)-2-(1-(((trifluoromethyl)sulfonyl)oxy)ethylidene)pentanoate (**1i**):



A previously reported procedure was used for the synthesis of **1i** from ethyl 2-acetyl-5-(1,3-

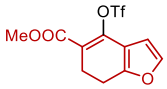
dioxoisoindolin-2-yl)pentanoate.[8]

ethyl (*Z*)-2-methyl-3-(((trifluoromethyl)sulfonyl)oxy)-5-(trimethylsilyl)pent-2-enoate (**1j**):



A previously reported procedure was used for the synthesis of **1j** from ethyl 2-methyl-3-oxo-5-(trimethylsilyl)pentanoate.[8]

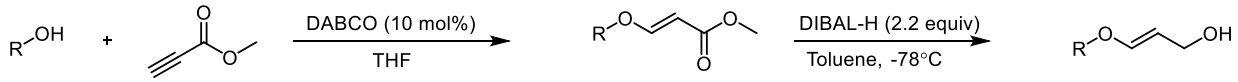
methyl 4-(((trifluoromethyl)sulfonyl)oxy)-6,7-dihydrobenzofuran-5-carboxylate (**1k**):



A previously reported procedure was used for the synthesis of **1k** from ethyl 4-oxo-4,5,6,7-tetrahydrobenzofuran-5-carboxylate.[9]

Synthesis of alkenol substrates:

General procedure A: Preparation of acyclic enol ethers from methyl propiolate.



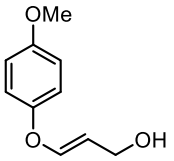
R = Et, PMB, Ar

Step 1: To a stirred solution of 1,4-diazabicyclo[2.2.2]octane (270 mg, 2.4 mmol, 0.10 equiv.) and alcohol or phenol (26.0 mmol, 1.1 equiv.) in THF (150 mL) at room temperature was added methyl propiolate (2.0 g, 24.0 mmol, 1 eq.) *via* syringe pump over 10 minutes, before stirring at room temperature for a further 30 minutes. Sodium hydroxide (10% solution, 200 mL) was added and the aqueous was extracted with DCM (4 x 100 mL), combined, washed with brine (3 x 150 mL), dried over sodium sulfate, filtered and concentrated in vacuum. The ester product was isolated after subsequent purification on silica gel by flash chromatography or used without further purification.

Step 2: To a stirred solution of the ester (1.0 equiv) in toluene (100 mL) at -78 °C was added

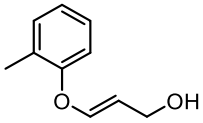
DIBAL-H (1M in tol., 2.5 equiv.) at a rate of 1 mL min^{-1}. After addition the reaction was stirred at -78 °C for 6 hours, before pouring onto ice-cold saturated Rochelle salt solution (100 mL) followed by the addition of EtOAc (100 mL). The biphasic mixture was vigorously stirred at 0 °C for 2 hours before separating and extracting with EtOAc (100 mL). The organics were combined and washed with saturated Rochelle salt solution (150 mL), dried over sodium sulfate, filtered and concentrated in vacuum to afford the primary alcohol product without further purification.

(*E*)-3-(4-methoxyphenoxy)prop-2-en-1-ol (**2l**)



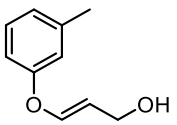
Product **2l** was synthesized according to the literature procedure.[10]

(*E*)-3-(o-tolyloxy)prop-2-en-1-ol (**2m**)



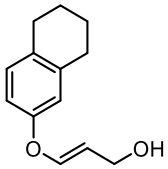
The general procedure A was followed with o-cresol (1.2 g, 11 mmol, 1.1 equiv), methyl propiolate (840 mg, 10 mmol, 1.0 equiv), and DABCO (110 mg, 1.0 mmol, 0.10 equiv). The resulting mixture (1.7 g, 9.0 mmol, 1.0 equiv) was reduced with DIBAL-H (3.2 g, 22 mmol, 2.5 equiv). Purification on silica gel (0-18% ethyl acetate in hexanes) yielded 1.4 g of a clear liquid (83% yield over 2 steps). $\mathbf{R_f}$ = 0.23 (30% EtOAc/hexanes). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.21 – 7.14 (m, 2H), 7.01 (td, *J* = 13.2, 7.4 Hz, 1H), 6.94 (dt, *J* = 8.0, 1.5 Hz, 1H), 6.69 (dt, *J* = 12.2, 1.2 Hz, 1H), 5.46 – 5.39 (m, 1H), 4.17 – 4.12 (m, 2H), 2.26 (s, 3H), 1.66 (bs, 1H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 154.74, 146.56, 131.15, 128.29, 126.93, 123.51, 116.70, 109.43, 59.89, 15.91. **IR** (neat) 3318, 3042, 2921, 2868, 1672, 1609, 1585, 1487, 1456, 1253, 1161, 1118 cm^{-1}. **HRMS** (ESI-TOF) *m*/*z* calcd for $C_{10}H_{13}O_2$ $(M)^+$: 165.0916, found 165.0900.

(*E*)-3-(m-tolyloxy)prop-2-en-1-ol (**2n**)



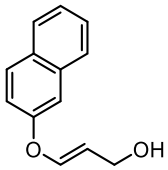
The general procedure A was followed using m-cresol (1.4 g 13 mmol, 1.1 equiv), methyl propiolate (840 mg, 12 mmol, 1.0 equiv), DABCO (130 mg, 1.2 mmol, 0.10 equiv). The resulting mixture (2.3 g, 12 mmol, 1.0 equiv) was reduced with DIBAL-H (4.3 g, 30 mmol, 2.5 equiv). Purification of this material by chromatography on silica gel (gradient elution: 0-15% EtOAc/hexanes) afforded a clear liquid (1.50 g, 76% yield over 2 steps) $\mathbf{R_f}$ = 0.10 (10% EtOAc/hexanes). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.21 – 7.16 (m, 1H), 6.88 (d, *J* = 7.6 Hz, 1H), 6.82 – 6.77 (m, 2H), 6.69 (m, 1H), 5.52 (m, 1H), 4.14 (d, *J* = 7.1 Hz, 2H), 2.33 (s, 3H), 1.67 – 1.61 (bs, 1H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 156.75, 145.71, 139.82, 129.33, 124.10, 117.64, 113.92, 110.49, 59.84, 21.32. **IR** (neat) 3318, 3042, 2921, 2868, 1672, 1609, 1585 1487, 1456, 1253, 1161, 1118 cm^{-1}. **HRMS** (ESI-TOF) *m*/*z* calcd for $C_{10}H_{13}O_2$ $(M)^+$: 165.0916, found 165.0899.

(*E*)-3-((5,6,7,8-tetrahydronaphthalen-2-yl)oxy)prop-2-en-1-ol (**2o**)



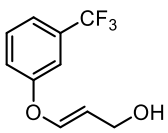
The general procedure A was followed using 5,6,7,8-tetrahydronaphthalen-2-ol (1.9 g, 13 mmol, 1.1 equiv), methyl propiolate (840 mg, 12 mmol, 1.0 equiv), and DABCO (130 mg, 1.2 mmol, 0.10 equiv). The resulting mixture (2.7 g, 12 mmol, 1.0 equiv) was reduced with DIBAL-H (4.3 g, 30 mmol, 2.5 equiv). The crude material of this reaction was used without further purification. (1.7g, 70% yield over 2 steps) $\mathbf{R_f}$ = 0.23 (30% EtOAc/hexanes). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.02 (d, *J* = 8.2 Hz, 1H), 6.76 (dd, *J* = 8.3, 2.7 Hz, 1H), 6.73 – 6.70 (m, 2H), 6.69 (d, *J* = 1.1 Hz, 1H), 5.51 (dt, *J* = 12.1, 7.3 Hz, 1H), 4.19 – 4.14 (m, 2H), 2.76 – 2.72 (m, 4H), 1.79 (p, *J* = 3.3 Hz, 4H), 1.29 (t, *J* = 5.5 Hz, 1H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 154.47, 146.41, 138.58, 132.14, 130.12, 117.18, 114.59, 109.79, 60.07, 29.53, 28.67, 23.21, 22.96. **IR** (neat) 3312, 2925, 2857, 2837, 2360, 2340, 1670, 1608, 1496, 1437, 1245, 1226, 1164 cm^{-1}. **HRMS** (ESI-TOF) *m*/*z* calcd for $C_{13}H_{17}O_2$ $(M)^+$: 205.1229, found 205.1216.

(*E*)-3-(naphthalen-2-yloxy)prop-2-en-1-ol (**2p**)



The general procedure A was followed using 2-naphthol (1.9 g, 13 mmol, 1.1 equiv), methyl propiolate (840 mg, 12 mmol, 1.0 equiv), and DABCO (130 mg, 1.2 mmol, 0.10 equiv). This resulting material (2.6 g, 12 mmol, 1.0 equiv) was reduced with DIBAL-H (4.3 g, 30 mmol, 2.5 equiv) Purification of this material by chromatography on silica gel (gradient elution: 0-10% EtOAc/hexanes) afforded product **2p** as a white solid (2.2 g, 92% yield over 2 steps) $\mathbf{R_f}$ = 0.2 (10% EtOAc/hexanes). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.82 (dd, *J* = 8.8, 3.4 Hz, 2H), 7.79 – 7.75 (m, 1H), 7.49 (m, 1H), 7.42 (m, 1H), 7.35 (d, *J* = 2.5 Hz, 1H), 7.23 (dd, *J* = 8.9, 2.5 Hz, 1H), 6.87 (d, *J* = 12.1 Hz, 1H), 5.65 (dt, *J* = 12.1, 7.2 Hz, 1H), 4.24 (d, *J* = 7.2 Hz, 2H), 1.63 (bs, 1H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 154.53, 145.33, 134.10, 130.04, 129.79, 127.68, 127.00, 126.61, 124.62, 118.64, 111.35, 111.26, 59.83. **IR** (neat) 3363, 3058, 2879, 2360, 2342, 1705, 1670, 1627, 1597, 1507, 1464, 1441, 1358 cm^{-1}. **HRMS** (ESI-TOF) *m*/*z* calcd for $C_{13}H_{13}O_2$ $(M)^+$: 201.0918, found 201.0916.

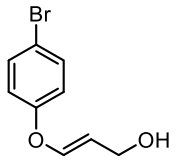
(*E*)-3-(3-(trifluoromethyl)phenoxy)prop-2-en-1-ol (**2q**)



The general procedure A was followed using 3-trifluoromethylphenol (2.1 g, 13 mmol, 1.1 equiv), methyl propiolate (840 mg, 12 mmol, 1.0 equiv), and DABCO (130 mg, 1.2 mmol, 0.10 equiv). This resulting mixture (2.7 g, 12 mmol, 1.0 equiv) was reduced with DIBAL-H (4.3 g, 30 mmol, 2.5 equiv). Purification of this material by chromatography on silica gel (gradient elution: 10-20% EtOAc/hexanes) afforded product **2q** as a white solid (2.6 g, 92% yield over 2 steps) $\mathbf{R_f}$ = 0.31 (30% EtOAc/hexanes). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.45 (t, *J* = 8.0 Hz, 1H), 7.36 (d, *J* = 7.7 Hz, 1H), 7.25 (s, 1H), 7.19 (d, *J* = 8.3 Hz, 1H), 6.72 (d, *J* = 12.0 Hz, 1H), 5.63 (dt, *J* = 12.0, 7.0 Hz, 1H), 4.22 (d, *J* = 6.8 Hz, 2H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 156.86, 144.37, 132.15 (q, *J* = 32.4 Hz), 130.29, 123.63 (d, *J* = 272.3 Hz), 120.24 (d, *J* = 1.5 Hz), 119.86 (q, *J* = 4.0 Hz), 113.71 (q, *J* = 3.9 Hz), 112.46, 59.69. **IR** (neat) 3312, 2878, 2361, 2340, 1675, 1594, 1492, 1451, 1324, 1224, 1115, 1063, 993 cm^{-1}. **HRMS** (ESI-TOF) *m*/*z* calcd for $C_{10}H_8O_2F_3$ $(M\text{-}H)^+$: 217.0476, found

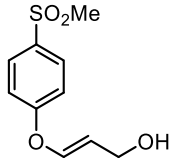
217.0502.

(*E*)-3-(4-bromophenoxy)prop-2-en-1-ol (**2r**)



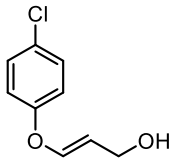
The general procedure A was followed using 4-bromophenol (2.3 g, 13 mmol, 1.1 equiv), methyl propiolate (840 mg, 12 mmol, 1.0 equiv), and DABCO (130 mg, 1.2 mmol, 0.10 equiv). This crude material (1.0 g, 3.9 mmol, 1.0 equiv) was reduced with DIBAL-H (1.4 g, 9.7 mmol, 2.5 equiv). Purification of this material by chromatography on silica gel (gradient elution: 10-15% EtOAc/hexanes) afforded product **2r** as a white solid (0.759 g, 77% yield over 2 steps) $\mathbf{R_f}$ = 0.18 (10% EtOAc/hexanes). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.43 – 7.39 (m, 3H), 6.89 – 6.86 (m, 2H), 6.65 (d, *J* = 12.1 Hz, 1H), 5.55 (d, *J* = 12.1 Hz, 1H), 4.19 – 4.13 (d, 2H), 1.51 (s, 1H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 155.79, 144.82, 132.53, 118.62, 115.65, 111.59, 59.55. **IR** (neat): 3317, 3072, 2872, 2360, 2341, 1701, 1672, 1585, 1483, 1228, 1167 cm^{-1}; **HRMS** (ESI-TOF) *m*/*z* calcd for $C_9H_8O_2Br$ $(M-H)^+$: 226.9708, found 226.9735.

(*E*)-3-(4-(methylsulfonyl)phenoxy)prop-2-en-1-ol (**2s**)



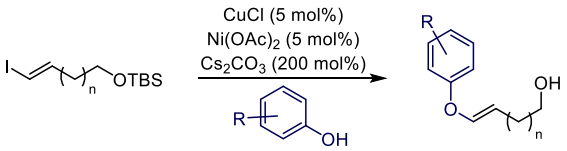
The general procedure A was followed using 4-(methylsulfonyl)phenol (2.2 g, 13 mmol, 1.1 equiv), methyl propiolate (840 mg, 12 mmol, 1.0 equiv), and DABCO (130 mg, 1.2 mmol, 0.10 equiv). This crude material (2.3 g, 8.8 mmol, 1.0 equiv) was reduced with DIBAL-H (3.2 g, 22 mmol, 2.5 equiv). Purification of this material by chromatography on silica gel (gradient elution: 10-40% EtOAc/hexanes) afforded product **2s** as a white solid (1.8 g, 90% yield over 2 steps) $\mathbf{R_f}$ = 0.37 (60% EtOAc/hexanes). ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.93 (d, *J* = 8.6 Hz, 2H), 7.16 (d, *J* = 8.6 Hz, 2H), 6.76 (d, *J* = 12.1 Hz, 1H), 5.73 (dt, *J* = 12.1, 6.8 Hz, 1H), 4.28 – 4.22 (m, 2H), 3.06 (s, 3H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 160.80, 142.90, 134.59, 129.71, 116.81, 114.25, 59.50, 44.76. **IR** (neat) 3380, 3009, 2926, 2361, 2341, 1638, 1589, 1491, 1290, 1143, 962 cm^{-1}. **HRMS** (ESI-TOF) *m*/*z* calcd for $C_{10}H_{12}O_4SNa$ $(M+Na)^+$: 251.0354, found 251.0351.

(*E*)-3-(4-chlorophenoxy)prop-2-en-1-ol (**2t**)



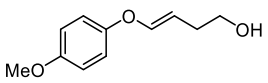
The general procedure A was followed using 3-chlorophenol (1.7 g, 13 mmol, 1.1 equiv), methyl propiolate (840 mg, 12 mmol, 1.0 equiv), and DABCO (130 mg, 1.2 mmol, 0.10 equiv). This crude material (1.0 g, 4.7 mmol, 1.0 equiv) was reduced with DIBAL-H (1.7 g, 11.8 mmol, 2.5 equiv) Purification of this material by chromatography on silica gel (gradient elution: 10% EtOAc/hexanes) afforded product **2t** as a yellow oil (0.50 g, 56% yield over 2 steps) $\mathbf{R_f}$ = 0.32 (30% EtOAc/hexanes). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.32 – 7.20 (m, 2H), 6.96 – 6.87 (m, 2H), 6.64 (d, *J* = 12.1 Hz, 1H), 5.53 (dt, *J* = 12.1, 7.3 Hz, 1H), 4.21 – 4.11 (d, *J* = 7.2 2H). **^{13}C NMR** (75 MHz, Chloroform-d) δ 155.30, 145.17, 129.63, 128.33, 118.28, 111.41, 59.79. **IR** (neat) 3306, 2873, 1672, 591, 1484, 1281, 1233, 1166, 1085, 990; **HRMS** (ESI-TOF) *m*/*z* calcd for $C_9H_8O_2Cl$ $(M-H)^+$: 183.0213, found 183.0234.

Preparation of enol ether via Cu catalyzed coupling reactions



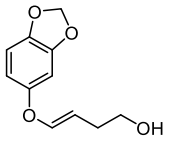
General Procedure B: In a 10 mL round bottom flask a mixture of (*E*)-alkenyl iodide (1.0 mmol, 1.0 equiv), the corresponding phenol (1.2 mmol, 1.2 equiv), Cs_2CO_3 (650 mg, 2 mmol, 2 equiv), $Ni(acac)_2$ (13 mg, 0.05 mmol, 5 mol %), CuI (10 mg, 0.05 mmol, 5 mol %) and NMP (3 mL) was heated at 100 ^{o}C under nitrogen for 12 h (TLC). The reaction mixture was then allowed to cool and was extracted with ethyl acetate (3 x 20 mL). The extract was washed with water (10 mL) and brine (10 mL). Then the organic phase was dried over sodium sulfate and evaporated to leave the crude product, which was purified by column chromatography over silica gel (hexane/ethyl acetate) to provide the pure acyclic enol ether.

(*E*)- 4-(4-methoxyphenoxy)but-3-en-1-ol (2u)



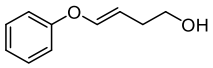
Compound **2u** was prepared according to the general procedure **B** using (*E*)-tert-butyl((4-iodobut-3-en-1-yl)oxy)dimethylsilane (310 mg, 1.0 mmol, 1.0 equiv) and *p*-methoxyphenol (150 mg, 1.2 mmol, 1.0 equiv) and purified using silica gel flash chromatography (gradient elution: 5→25% ethyl acetate/hexanes) to afford product **2u** as a white oil (160 mg, 82% yield): $\mathbf{R}_f$ = 0.12 (15% ethyl acetate in hexane). **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 6.95–6.88 (m, 2H), 6.87–6.80 (m, 2H), 6.46 (d, *J* = 12.1, 1H), 5.21 (dt, *J* = 12.2, 7.8, 1H), 3.77 (s, 3H), 3.68–3.61 (m, 2H), 2.26 (m, 2H). 1.43 (s, 1H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 155.36, 150.95, 145.16, 117.91, 114.67, 107.10, 62.35, 55.65, 30.80.; **IR** (neat) 3324, 3050, 3011, 2930, 2834, 1674, 1503, 1461, 1441, 1216, 1176. **HRMS** (ESI-TOF) *m*/*z* calcd for $C_{11}H_{14}O_3Na$ $(M+Na)^+$: 217.0841, found 217.0857.

(*E*)-4-(benzo[d][1,3]dioxol-5-yloxy)but-3-en-1-ol (2v)



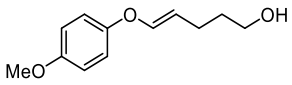
Compound **2v** was prepared according to the general procedure **B** using (*E*)-tert-butyl((4-iodobut-3-en-1-yl)oxy)dimethylsilane (310 mg, 1.0 mmol, 1.0 equiv) and sesamol (170 mg, 1.2 mmol, 1.0 equiv) and purified using silica gel flash chromatography (gradient elution: 15→40% ethyl acetate/hexanes) to afford product **2v** as a white oil (155 mg, 75% yield): $\mathbf{R}_f$ = 0.18 (40% ethyl acetate in hexane). **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 6.68 (dd, *J* = 8.4, 2.2 Hz, 1H), 6.52 (t, *J* = 2.4 Hz, 1H), 6.44–6.34 (s, 2H), 5.90 (s, 2H), 5.21 (dt, *J* = 12.2, 8.7, 1H), 3.61 (t, *J* = 6.4 Hz, 2H), 2.23 (m, 2H), 2.16 (s, 1 H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 152.11, 148.13, 144.60, 143.11, 108.61, 107.91, 107.78, 101.28, 99.71, 62.20, 30.63.; **IR** (neat) 3357, 2887, 2361, 1671, 1631, 1501, 1479, 1176, 1139; **HRMS** (ESI-TOF) *m*/*z* calcd for $C_{11}H_{13}O_4$ $(M+H)^+$: 209.0814, found 209.0811.

(*E*)-4-phenoxybut-3-en-1-ol (2w)



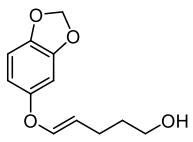
Compound **2w** was prepared according to the general procedure **B** using (*E*)-tert-butyl((4-iodobut-3-en-1-yl)oxy)dimethylsilane (310 mg, 1.0 mmol, 1.0 equiv) and phenol (110 mg, 1.2 mmol, 1.0 equiv) and purified using silica gel flash chromatography (gradient elution: 5→15% ethyl acetate/hexanes) to afford product **2w** as a white oil (140 mg, 85% yield): $\mathbf{R_f}$ = 0.22 (15% ethyl acetate in hexane). **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.30 (dd, *J* = 9.7, 5.9 Hz, 2H), 7.05 (td, *J* = 7.4, 1.2 Hz, 1H), 7.02 – 6.95 (m, 2H), 6.52 (d, *J* = 12.0, 1H), 5.33 (dt, *J* = 12.2, 7.7 Hz, 1H), 3.66 (t, *J* = 6.4 Hz, 2H), 2.29 (m, 2H), 2.18–2.14 (m, 1H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 157.05, 143.85, 129.59, 122.74, 116.48, 108.59, 62.29, 30.79.; **IR** (neat) 3329, 2925, 2361, 2339, 1672, 1590, 1489, 1226, 2339; **HRMS** (ESI-TOF) *m*/*z* calcd for $C_{10}H_{13}O_2$ $(M+H)^+$: 169.0916, found 169.0891.

(*E*)-5-(4-methoxyphenoxy)pent-4-en-1-ol (2x)



Compound **2x** was prepared according to the general procedure **B** using (*E*)-tert-butyl((5-iodopent-4-en-1-yl)oxy)dimethylsilane (330 mg, 1.0 mmol, 1.0 equiv) and *p*-methoxyphenol (150 mg, 1.2 mmol, 1.0 equiv) and purified using silica gel flash chromatography (gradient elution: 15→40% ethyl acetate/hexanes) to afford product **2x** as a white oil (150 mg, 72% yield): $\mathbf{R_f}$ = 0.14 (20% ethyl acetate in hexane). **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 6.94–6.85 (m, 2H), 6.88 – 6.79 (m, 2H), 6.39 (d, *J* = 12.1, 1H), 5.26 (dt, *J* = 12.2, 7.5, 1H), 3.77 (s, 3H), 3.72–3.65 (m, 2H), 2.10 (dt, *J* = 7.6, 1.3 Hz, 2H), 1.71–1.62 (m, 2H), 1.45 (s, 1H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 155.18, 151.16, 143.22, 117.72, 114.63, 111.16, 62.16, 55.65, 32.89, 23.59.; **IR** (neat) 3355, 2933, 2361, 1670, 1501, 1464, 1212, 1179, 1101; **HRMS** (ESI-TOF) *m*/*z* calcd for $C_{12}H_{17}O_3$ $(M+H)^+$: 209.1157, found 209.1178.

(*E*)-5-(4-methoxyphenoxy)pent-4-en-1-ol (2y)



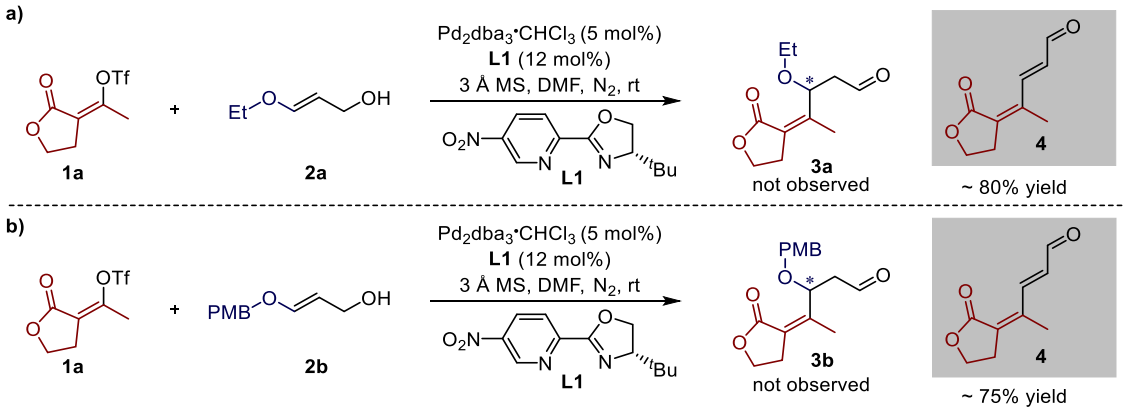
Compound **2y** was prepared according to the general procedure **B** using (*E*)-tert-butyl((5-iodopent-4-en-1-yl)oxy)dimethylsilane (330 mg, 1.0 mmol, 1.0 equiv) and sesamol (170 mg, 1.2 mmol) and

purified using silica gel flash chromatography (gradient elution: 15→40% ethyl acetate/hexanes) to afford product **2y** as a white oil (166 mg, 74% yield): $\mathbf{R}_f$ = 0.2 (45% ethyl acetate in hexane).**^{1}H NMR** (500 MHz, Chloroform-*d*) δ 6.70 (dd, *J* = 8.4, 0.8 Hz, 1H), 6.53 (s, *J* = 2.4, 1H), 6.41–6.38 (m, 1H), 6.34 (d, *J* = 12.1, 1H), 5.92 (s, 2H), 5.27 (dt, *J* = 12.0, 7.5, 1H), 3.77–3.60 (m, 2H), 2.09 (q, *J* = 7.6, 2H), 1.70 (s, 1H), 1.67–1.59 (m, 2H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 152.33, 148.14, 142.98, 142.88, 111.72, 108.43, 107.95, 101.31, 99.61, 62.03, 32.76, 23.50.; **IR** (neat) 3352, 2933, 23261, 1670, 1501, 1464, 1441, 1212, 1179, 1101; **HRMS** (ESI-TOF) *m*/*z* calcd for $C_{12}H_{15}O_4$ $(M+H)^+$: 223.0970, found 223.0973.

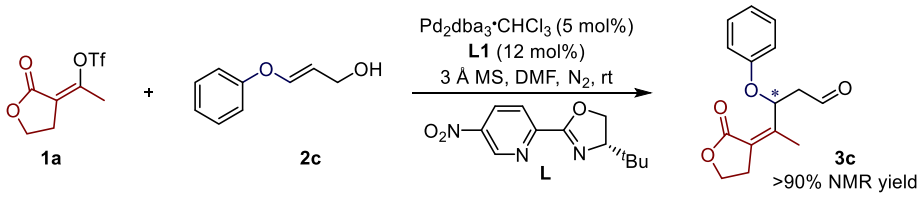
Optimization for the redox-relay Heck reaction of acyclic enol ethers:

General Procedure used for optimization: To a dry 1 dram vial, equipped with a stir bar, was added $Pd_2dba_3{\cdot}CHCl_3$ (5 mg, 0.005 mmol, 5.0 mol %), ligand (3 mg, 0.012 mmol, 12 mol %), 3Å MS (50 mg, 50 mg/mmol **1**) and sealed using a rubber septum. The reaction vial was evacuated and refilled with N_2 three times. To this, solvent (1 mL) was added under nitrogen and the resulting mixture was stirred for 10 min at room temperature. Next, the substrate alkenol (**2a**) (0.25 mmol, 1.0 equiv) and alkenyl triflate **1a** (0.25 mmol, 1.0 equiv) were added sequentially, via micro-syringe. The resulting mixture was stirred at room temperature for 12 h. The mixture was then diluted with EtOAc (150 mL) and washed with H_2O (2 x 30 mL) and brine (30 mL). The combined aqueous layers were back extracted using EtOAc (30 mL) and the organic layers were combined, dried over Na_2SO_4 and concentrated under reduced pressure. The resulting crude residue was analyzed via ^1H NMR using 2-methoxy naphthalene as an internal standard.

Results of the initial study using an alkyl enol ether in the redox relay Heck reaction.



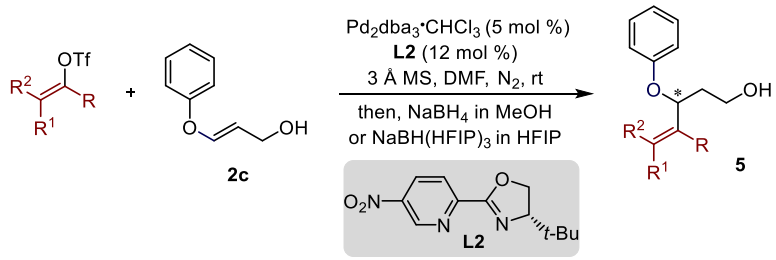
Results of the initial study using an aryl enol ether in the redox relay Heck reaction.



The isolation of the desired aldehyde product **3c** via column chromatography using either silica gel or neutral alumina resulted in the degradation of the product via E1cb elimination and leading

to a mixture of the decomposed product **4** and desired product **3c** in 1:1 ratio. Thus, for better isolation and characterization the aldehyde product **3c** was further processed and reduced to the alcohol using sodium borohydride in methanol. Although, this led to the addition of an extra step, it allowed easy isolation and handling of the alcohol product.

Optimized General Reaction:



General Procedure C:

Step 1: To a dry 1.5 dram vial, equipped with a stir bar, was added $Pd_2dba_3{\cdot}CHCl_3$ (26 mg, 0.025 mmol, 5.0 mol %), ligand (15 mg, 0.06 mmol, 12 mol %), 3Å MS (250 mg, 50 mg/mmol **1**) and sealed using a rubber septum. The reaction vial was evacuated and refilled with N_2 three times. To this, DMF (2 mL) was added under nitrogen and the resulting mixture was stirred for 10 min at room temperature. Next, the substrate alkenol (**2**) (0.5 mmol, 1.0 equiv) and alkenyl triflate **1** (0.5 mmol, 1.0 equiv) were added sequentially, via micro-syringe. The resulting mixture was stirred at room temperature for 12 h. The mixture was then diluted with EtOAc (150 mL) and washed with H_2O (2 x 30 mL) and brine (30 mL). The combined aqueous layers were back extracted using EtOAc (30 mL) and the organic layers were combined, dried over Na_2SO_4 and concentrated under reduced pressure.

Step2: The crude extract was then dissolved in 10 mL of MeOH in a 50 mL round bottomed flask equipped with a stir bar. The resulting mixture was cooled to 0 °C followed by addition of $NaBH_4$ (5 equiv). The resulting mixture was allowed to warm to room temperature and stirred for 2 hours. After complete consumption of the aldehyde by TLC, the reaction mixture was quenched by adding 1 mL of water. This mixture was concentrated under vacuum and then diluted with EtOAc (150 mL) and washed with H_2O (2 x 30 mL) and brine (30 mL). The organic layers were combined, dried over Na_2SO_4 and concentrated under reduced pressure. The resulting residue was purified by

silica gel flash chromatography to give the corresponding alcohol products (**5**).

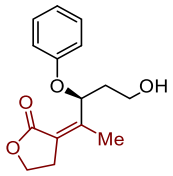
Note: Alternatively, for products **5d**, **5i** and **5n** the crude extract from step 1 was dissolved in 5 mL of hexafluoroisopropanol in a 50 mL round bottomed flask equipped with a stir bar. The resulting mixture was cooled to 0 °C followed by addition of $NaBH(HFIP)_3$ (2 equiv). The resulting mixture was allowed to warm to room temperature and stirred for 4-6 hours. After complete consumption of the aldehyde by TLC, the reaction mixture was quenched by adding 1mL of water. This mixture was diluted with EtOAc (150 mL) and washed with H_2O (2 x 30 mL) and brine (30 mL). The organic layers were combined, dried over Na_2SO_4 and concentrated under reduced pressure. The resulting residue was purified by silica gel flash chromatography to give the corresponding alcohol products (**5**).

General Procedure D:

To a dry 1.5-dram vial, equipped with a stir bar, was added $Pd_2dba_3{\cdot}CHCl_3$ (13 mg, 0.0125 mmol, 5.0 mol %), ligand (8 mg, 0.03 mmol, 12 mol %), 3Å MS (125 mg, 50 mg/mmol **1**) and sealed using a rubber septum. The reaction vial was evacuated and refilled with N_2 three times. To this, THF (1 mL) was added under nitrogen and the resulting mixture was stirred for 10 min at room temperature. Next, the substrate alkenol (**2**) (0.25 mmol, 1.0 equiv) and alkenyl triflate **1** (0.25 mmol, 1.0 equiv) were added sequentially, via micro-syringe. The resulting mixture was stirred at room temperature for 12 h. The mixture was then diluted with EtOAc (150 mL) and washed with H_2O (2 x 30 mL) and brine (30 mL). The combined aqueous layers were back extracted using EtOAc (30 mL) and the organic layers were combined, dried over Na_2SO_4 and concentrated under reduced pressure. The resulting crude residue was purified by silica gel flash chromatography to give the corresponding aldehyde products (**3**).

Characterization:

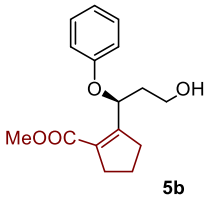
(*S*,*Z*)-3-(5-hydroxy-3-phenoxypentan-2-ylidene)dihydrofuran-2(3H)-one (5a)



5a

Compound **5a** was prepared according to the general procedure **C** using alkenyl triflate **1a** (130 mg, 0.50 mmol, 1.0 equiv) and reacting with alkenol substrate **2c** (75 mg, 0.5 mmol, 1.0 equiv) and purified using silica gel flash chromatography (gradient elution: 15→35% ethyl acetate/hexanes) to afford product **5a** as a light yellow oil (118 mg, 90% yield): $\mathbf{R}_f$ = 0.31 (40% ethyl acetate in hexane); $[\alpha]^{20}_{D}$ = + 45° (c = 0.22, $CHCl_3$); **^{1}H NMR** (500 MHz, $CDCl_3$) δ δ 7.31 – 7.18 (m, 2H), 7.00 – 6.83 (m, 3H), 6.51 (dt, *J* = 6.6, 4.8 Hz, 1H), 4.46 – 4.26 (m, 2H), 3.75 (m, 2H), 2.90 (m, 2H), 2.51 (s, 1H), 2.26–2.12 (m, 1H), 1.90–1.79 (m, 4H); **^{13}C NMR** (126 MHz, $CDCl_3$) δ 170.41, 157.47, 153.39, 129.59, 121.75, 121.19, 115.22, 71.74, 65.34, 59.52, 37.18, 27.64, 15.73.; **IR** (neat) 3446, 2951, 2361, 2337, 1707, 1636, 1598, 1494, 1435, 1238 cm^{-1}; **HRMS** (ESI-TOF) *m*/*z* calcd for $C_{15}H_{18}O_4$ $(M+Na)^+$: 285.1102, found 285.1102.

methyl (*S*)-2-(3-hydroxy-1-phenoxypropyl)cyclopent-1-ene-1-carboxylate (5b)

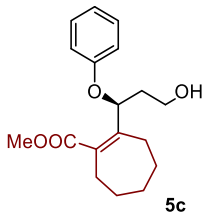


5b

Compound **5b** was prepared according to general procedure **C** using alkenyl triflate **1b** (137 mg, 0.50 mmol, 1.0 equiv) and reacting with alkenol substrate **2d** (75 mg, 0.5 mmol, 1.0 equiv) and purified using silica gel flash chromatography (gradient elution: 10 →25% ether/pentane) to afford product **5b** as a light yellow oil (120 mg, 85% yield): $\mathbf{R}_f$ = 0.22 (30% ether in hexane); $[\alpha]^{20}_{D}$ = + 74.7° (c = 0.37, $CHCl_3$); **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.31–7.14 (m, 2H), 6.91 (dt, *J* = 8.1, 6.4 Hz, 1H), 6.91–6.78 (m, 2H), 6.00 (t, *J* = 7.0 Hz, 1H), 3.85–3.65 (m, 5H), 2.77 (sb, 1H), 2.72–2.52 (m, 2H), 2.51–2.39 (m, 1H), 2.29–2.15 (m, 1H), 1.95–1.85 (m, 1H), 1.88–1.68 (m, 2H); **^{13}C NMR**

(126 MHz, $CDCl_3$) δ 166.50, 159.88, 157.82, 129.77, 129.46, 120.90, 114.94, 72.45, 59.44, 51.59, 36.85, 33.53, 32.90, 21.33.; **IR** (neat) 3446, 2951, 2361, 2337, 1707, 1636, 1598, 1494, 1435 cm^{-1}; **HRMS** (ESI-TOF) *m/z* calcd for $C_{16}H_{20}O_4Na$ $(M+Na)^+$:299.1259, found 299.1276.

methyl (*S*)-2-(3-hydroxy-1-phenoxypropyl)cyclohept-1-ene-1-carboxylate (5c)

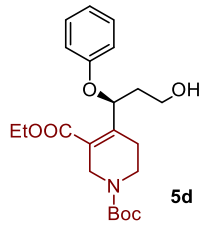


5c

Compound **5c** was prepared according to general procedure **C** using alkenyl triflate **1c** (150 mg, 0.50 mmol, 1.0 equiv) and reacting with alkenol substrate **2c** (75 mg, 0.75 mmol, 1.0 equiv) and purified using silica gel flash chromatography (gradient elution: 0→15% acetone/pentane) to afford product **5c** as a light yellow oil (110 mg, 70% yield): $\mathbf{R}_f$ = 0.21 (25% acetone in hexane); $[\alpha]^{20}_D$ = +52.4° (c = 1, $CHCl_3$); **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.31 – 7.16 (m, 2H), 6.93 – 6.85 (m, 1H), 6.89 – 6.77 (m, 2H), 5.66 (t, *J* = 7.0 Hz, 1H), 3.79 (s, 3H), 3.77 – 3.61 (m, 2H), 3.15 (s, 1H), 2.54 – 2.38 (m, 2H), 2.41 – 2.31 (m, 2H), 2.21 – 2.10 (m, 1H), 1.92 – 1.82 (m, 1H), 1.74 – 1.61 (m, 2H), 1.56 – 1.34 (m, 2H), 1.28 – 1.15 (m, 2H).; **^{13}C NMR** (126 MHz, $CDCl_3$) δ 170.07, 157.94, 152.80, 133.98, 129.22, 120.76, 115.41, 75.09, 59.24, 51.93, 36.45, 32.20, 30.20, 27.72, 25.94, 25.46; **IR** (neat) 3431, 2924, 2852, 1708, 1598, 1493, 1453, 1258, 1237 cm^{-1}; **HRMS** (ESI-TOF) *m/z* calcd for $C_{18}H_{24}O_4Na$ $(M+Na)^+$:327.1572, found 327.1587.

.

1-(tert-butyl) 3-ethyl (*S*)-4-(4-hydroxy-1-phenylbutan-2-yl)-5,6-dihydropyridine-1,3(2H)-dicarboxylate (5d)

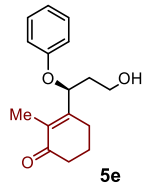


5d

Compound **5d** was prepared according to general procedure **C** using alkenyl triflate **1d** (200 mg, 0.50 mmol, 1.0 equiv) and reacting with alkenol substrate **2c** (75 mg, 0.5 mmol, 1.0 equiv) and purified using silica gel flash chromatography (gradient elution: 20→50% acetone/hexane) to

afford product **5d** as a light yellow oil (140 mg, 68% yield): $\mathbf{R_f}$ = 0.22 (50% acetone in hexane); $\mathbf{[\alpha]^{20}_D}$ = +11 ° (c = 0.23, $CHCl_3$); **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.34 – 7.18 (m, 2H), 6.92 (t, *J* = 7.3 Hz, 1H), 6.81 (d, *J* = 8.1 Hz, 2H), 6.07 (s, 1H), 4.25 (m, 2H), 4.05 (d, *J* = 18.1 Hz, 1H), 3.77 (m, 2H), 3.48 – 3.36 (m, 1H), 3.32 (s, 1H), 2.39 – 2.29 (m, 1H), 2.28 (s, 1H), 2.15 (m, 1H), 1.91 (m, 1H), 1.52 – 1.47 (m, 2H), 1.43 (s, 9H), 1.33 (t, *J* = 7.2 Hz, 3H); **^{13}C NMR** (126 MHz, $CDCl_3$) δ 165.85, 157.67, 154.48, 150.87, 129.56, 124.15, 121.19, 115.15, 80.07, 74.23, 61.08, 59.62, 37.08, 28.39, 28.34, 26.93, 24.31, 14.13.; **IR** (neat) 3435, 2977, 2931, 1697, 1595, 1491, 1420, 1238, 1166 cm^{-1}; **HRMS** (ESI-TOF) *m*/*z* calcd for $C_{22}H_{31}O_6NNa$ $(M+Na)^+$: 428.2049, found 428.2064.

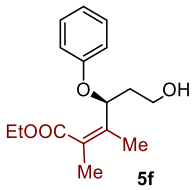
(*S*)-3-(3-hydroxy-1-phenoxypropyl)-2-methylcyclohex-2-en-1-one (5e)



5e

Compound **5e** was prepared according to general procedure **c** using alkenyl triflate **1e** (130 mg, 0.5 mmol, 1.0 equiv) and reacting with alkenol substrate **2c** (75 mg, 0.5 mmol, 1.0 equiv) and purified using silica gel chromatography (0-20% EtOAc in hexanes). Unfortunately, the ketone was also reduced by $NaBH_4$ and yielded a 3:1 diastereomeric ratio. This residue (80 mg, 0.3 mmol 1 equiv) was dissolved in CH_2Cl_2 (10 mL) and MnO_2 was added (260 mg, 3 mmol, 10 equiv) was added. The resultant mixture was stirred for three hours and upon consumption of starting material by TLC, the reaction mixture was filtered through a short silica plug, concentrated in vacuum and purified by column chromatography to obtain a light yellow oil (83mg, 64%). $\mathbf{R_f}$ = 0.21 (30% ethylacetate in hexane); $\mathbf{[\alpha]^{20}_D}$ = + 60° (c = 0.2, $CHCl_3$); **^{1}H NMR** (500 MHz, $CDCl_3$ ^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.28 – 7.22 (m, 2H), 6.95 (m, 1H), 6.81 – 6.76 (m, 2H), 5.29 (dd, *J* = 9.8, 3.5 Hz, 1H), 3.95 – 3.80 (m, 2H), 2.43 – 2.30 (m, 3H), 2.23 (m, 1H), 2.18 – 2.10 (m, 1H), 1.91 (t, *J* = 1.8 Hz, 3H), 1.90 – 1.80 (m, 2H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 199.26, 157.68, 157.39, 131.04, 129.66, 121.37, 114.87, 74.71, 59.37, 37.79, 36.12, 24.09, 22.35, 10.24.; **IR** (neat) 3421, 2929, 2871, 2361, 2339, 1653, 1598, 1489, 1228 cm^{-1}; **HRMS** (ESI-TOF) *m*/*z* calcd for $C_{16}H_{23}O_3Na$ $(M+Na)^+$: 283.1310, found 283.1310.

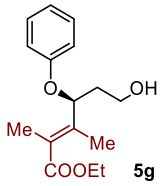
ethyl (*S*,*Z*)-6-hydroxy-2,3-dimethyl-4-phenoxyhex-2-enoate (5f)



5f

Compound **5f** was prepared according to general procedure **C** using alkenyl triflate **1f** (140 mg, 0.50 mmol, 1.0 equiv) and reacting with alkenol substrate **2c** (75 mg, 0.5 mmol, 1.0 equiv) and purified using silica gel flash chromatography (gradient elution: 0→20% ether/pentane) to afford product **5f** as a light yellow oil (111 mg, 80% yield): $\mathbf{R}_f$ = 0.26 (10% acetone in hexane); $\mathbf{[\alpha]^{20}_D}$ = + 104° (c = 0.26, $CHCl_3$); **^{1}H NMR** (500 MHz, $CDCl_3$) δ δ 7.24 – 7.16 (m, 2H), 6.93 – 6.85 (m, 1H), 6.85 – 6.79 (m, 2H), 5.77 (t, *J* = 6.9 Hz, 1H), 4.33 – 4.15 (m, 2H), 3.72 (m, 2H), 3.07 (s, 1H), 2.23 – 2.12 (m, 1H), 1.95 – 1.82 (m, 4H), 1.73 (s, 2H), 1.32 (td, *J* = 7.1, 1.3 Hz, 3H); **^{13}C NMR** (126 MHz, $CDCl_3$) δ 169.47, 158.07, 146.47, 129.61, 126.42, 121.16, 115.72, 75.44, 61.15, 59.69, 37.12, 16.09, 14.46, 13.67.; **IR** (neat) 3467, 2926, 2361, 2337, 1706, 1599, 1494, 1279, 1238 cm^{-1}; **HRMS** (ESI-TOF) *m/z* calcd for $C_{16}H_{22}O_4Na$ $(M+Na)^+$: 301.1416, found 301.1432.

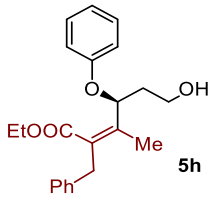
ethyl (*S*,*E*)-6-hydroxy-2,3-dimethyl-4-phenoxyhex-2-enoate (5g)



5g

Compound **5g** was prepared according to general procedure **C** using alkenyl triflate **1g** (140 mg, 0.50 mmol, 1.0 equiv) and reacting with alkenol substrate **2c** (75 mg, 0.5 mmol, 1.0 equiv) and purified using silica gel flash chromatography (gradient elution: 0→20% ether/pentane) to afford product **5g** as a light yellow oil (109.6 mg, 79% yield): $\mathbf{R}_f$ = 0.26 (10% acetone in hexane); $\mathbf{[\alpha]^{20}_D}$ = + 44.5° (c = 0.25, $CHCl_3$); **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.27 – 7.14 (m, 2H), 6.90 (ddt, *J* = 8.6, 7.3, 1.3 Hz, 1H), 6.85 – 6.78 (m, 2H), 5.81 – 5.74 (m, 1H), 4.26 (m, 2H), 3.80 – 3.65 (m, 2H), 3.00 (s, 1H), 2.23 – 2.10 (m, 1H), 1.96 – 1.84 (m, 4H), 1.73 (s, 3H), 1.33 (td, *J* = 7.1, 1.4 Hz, 3H); **^{13}C NMR** (126 MHz, $CDCl_3$) δ 169.20, 157.76, 146.20, 129.33, 126.17, 120.89, 115.44, 75.22, 60.88, 59.47, 36.81, 15.80, 14.18, 13.39.; **IR** (neat) 3391, 2930, 2361, 1704, 1594, 1491, 1235 cm^{-1}; **HRMS** (ESI-TOF) *m/z* calcd for $C_{16}H_{22}O_4Na$ $(M+Na)^+$: 301.1416, found 301.1424.

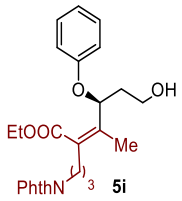
ethyl (*S*,*Z*)-2-benzyl-6-hydroxy-3-methyl-4-phenoxyhex-2-enoate (5h)



5h

Compound **5h** was prepared according to general procedure **C** using alkenyl triflate **1h** (180 mg, 0.50 mmol, 1.0 equiv) and reacting with alkenol substrate **2c** (75 mg, 0.5 mmol, 1.0 equiv) and purified using silica gel flash chromatography (gradient elution: 0→15% ether/pentane) to afford product 25h as a light yellow oil (140 mg, 81% yield): R_f = 0.2 (15% ether in hexane); $[\alpha]^{20}_D$ = +35 ° (c = 0.38, $CHCl_3$); **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.33 – 7.08 (m, 5H), 7.09 – 7.00 (m, 2H), 6.96 (tq, *J* = 7.3, 1.4 Hz, 1H), 6.94 – 6.86 (m, 2H), 5.86 (m, 1H), 4.26 – 4.07 (m, 2H), 3.89 – 3.74 (m, 2H), 3.73 (s, 2H), 2.26 (m, 1H), 2.07 – 1.92 (m, 1H), 1.83 (s, 1H), 1.21 (td, *J* = 7.1, 1.8 Hz, 3H); **^{13}C NMR** (126 MHz, $CDCl_3$) δ 168.66, 157.65, 147.77, 138.65, 130.02, 129.41, 128.36, 127.95, 126.10, 121.13, 115.71, 75.49, 60.97, 59.55, 36.92, 35.61, 14.02, 13.54.; **ATR-FTIR** (neat) 3443, 2930, 2361, 2338, 1701, 1599, 1494, 1288, 1237 cm^{-1}; **HRMS** (ESI-TOF) *m*/*z* calcd for $C_{22}H_{26}O_4Na$ $(M+Na)^+$:377.1729, found 377.1743.

ethyl (*S*,*Z*)-2-(3-(1,3-dioxoisoindolin-2-yl)propyl)-6-hydroxy-3-methyl-4-phenoxyhex-2-enoate (5i)

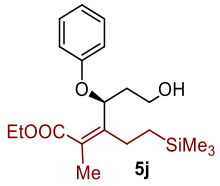


5i

Compound **5i** was prepared according to general procedure **C** using alkenyl triflate **1i** (220 mg, 0.50 mmol, 1.0 equiv) and reacting with alkenol substrate **2c** (75 mg, 0.75 mmol, 1.0 equiv) and purified using silica gel flash chromatography (gradient elution: 15→40% acetone/hexane) to afford product **5i** as a light yellow oil (200 mg, 87% yield): **R_f** = 0.37 (50% acetone in hexane); **$[\alpha]^{20}_D$** = + 36° (c = 0.3, $CHCl_3$); **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.83 (dt, *J* = 5.5, 3.2 Hz, 2H), 7.71 (dq, *J* = 5.2, 3.4, 3.0 Hz, 2H), 7.29 – 7.14 (m, 2H), 6.89 (tdt, *J* = 7.3, 2.2, 1.1 Hz, 1H), 6.86 – 6.75 (m, 2H), 5.70 – 5.63 (m, 1fH), 4.30 – 4.15 (m, 2H), 3.81 – 3.68 (m, 1H), 3.68 (td, *J* = 6.8, 2.2 Hz,

2H), 2.82 – 2.75 (m, 1H), 2.45 – 2.23 (m, 2H), 2.22 – 2.11 (m, 1H), 1.89 (m, 1H), 1.85 – 1.72 (m, 5H), 1.35 – 1.21 (m, 3H), 1.07 – 1.02 (m, 1H); **^{13}C NMR** (126 MHz, $CDCl_3$) δ 168.75, 168.24, 157.70, 146.49, 133.92, 132.04, 130.04, 129.40, 123.17, 121.02, 115.45, 75.61, 61.01, 59.54, 37.57, 37.91, 27.47, 27.26, 14.11, 12.95.; **ATR-FTIR** (neat) 2933, 2361, 2339, 1713, 1652, 1396, 1233 cm^{-1}; **HRMS** (ESI-TOF) *m*/*z* calcd for $C_{26}H_{29}NO_6Na$ $(M+Na)^+$:474.1893, found 474.1916.

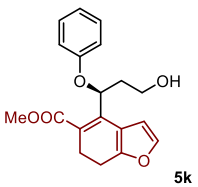
ethyl (*S*,*Z*)-6-hydroxy-2-methyl-4-phenoxy-3-(2-(trimethylsilyl)ethyl)hex-2-enoate (5j)



5j

Compound **5j** was prepared according to general procedure **C** using alkenyl triflate **1j** (190 mg, 0.50 mmol, 1.0 equiv) and reacting with alkenol substrate **2c** (86 mg, 0.75 mmol, 1.0 equiv) and purified using silica gel flash chromatography (gradient elution: 0→5% acetone/hexane) to afford product **5j** as a light yellow oil (55 mg, 30% yield) $\mathbf{R}_f$ = 0.25 (10% acetone in hexane); $\mathbf{[\alpha]^{20}_D}$ = + 38° (c = 0.32, $CHCl_3$); **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.29 – 7.16 (m, 2H), 6.90 (tdt, *J* = 7.4, 2.1, 1.1 Hz, 1H), 6.82 (dtt, *J* = 6.6, 2.0, 0.9 Hz, 2H), 5.78 (m, 1H), 4.27 (m, 1H), 4.27 – 4.13 (m, 1H), 3.79 – 3.66 (m, 2H), 2.95 (s, 1H), 2.28 – 2.09 (m, 3H), 2.02 – 1.90 (m, 1H), 1.90 (s, 3H), 1.33 (td, *J* = 7.0, 1.5 Hz, 3H), 0.57 (m, 1H), 0.46 (m, 1H), 0.0 (m, 9H); **^{13}C NMR** (126 MHz, $CDCl_3$) δ 169.63, 158.37, 152.59, 129.38, 125.65, 120.79, 115.36, 75.71, 60.94, 59.69, 37.73, 21.99, 15.88, 15.52, 14.24, -0.31, -2.04.; **ATR-FTIR** (neat) 2954, 2361, 2338, 1701, 1495, 1240, 1098 cm^{-1}; **HRMS** (ESI-TOF) *m*/*z* calcd for $C_{20}H_{32}O_4NaSi$ $(M+Na)^+$:387.1968, found 387.1982.

methyl (*S*)-4-(3-hydroxy-1-phenoxypropyl)-6,7-dihydrobenzofuran-5-carboxylate (5k)

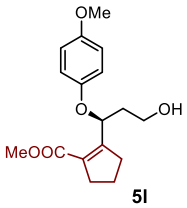


5k

Compound **5k** was prepared according to general procedure **C** using alkenyl triflate **1k** (160 mg, 0.50 mmol, 1.0 equiv) and reacting with alkenol substrate **2c** (86 mg, 0.75 mmol, 1.0 equiv) and purified using silica gel flash chromatography (gradient elution: 0→5% acetone/hexane) to afford product **5k** as a light yellow oil (74 mg, 45% yield) $\mathbf{R}_f$ = 0.22 (10% acetone in hexane) $\mathbf{[\alpha]^{20}_D}$ = +

35° (c = 1.0, $CHCl_3$); **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.25 – 7.16 (m, 3H), 6.92 – 6.81 (m, 4H), 6.32 (t, J = 6.9 Hz, 1H), 3.84 (s, 3H), 3.80 – 3.69 (m, 2H), 3.07 (s, 1H), 2.90 – 2.80 (m, 2H), 2.77 – 2.70 (m, 2H), 2.41 – 2.33 (m, 1H), 2.08 – 2.00 (m, 1H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 168.91, 157.60, 156.18, 145.39, 141.29, 129.39, 120.99, 119.68, 115.84, 115.30, 110.12, 73.43, 59.46, 52.08, 37.54, 26.05, 21.38. **ATR-FTIR** 3447, 2950, 2361, 2339, 1696, 1598, 1559, 1439, 1273, 1238 cm^{-1}; **HRMS** (ESI_TOF) *m/z* calcd for $C_{19}H_{21}O_5Na$ $(M+H)^+$: 329.1389, found 329.1381.

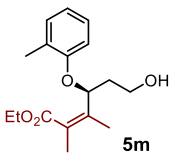
methyl (*S*)-2-(3-hydroxy-1-(4-methoxyphenoxy)propyl)cyclopent-1-ene-1-carboxylate (5l)



5l

The general procedure **C** was followed using (*E*)-3-(4-methoxyphenoxy)prop-2-en-1-ol (72 mg, 0.4 mmol, 1.0 equiv), methyl 2-(((trifluoromethyl)sulfonyl)oxy)cyclopent-1-ene-1-carboxylate (110 mg, 0.4 mmol, 1.0 equiv), Pd_2dba_3·$CHCl_3$ (21 mg, 0.02 mmol, 5 mol %), **L1** (12 mg, 0.05 mmol, 12 mol %), 3Å MS (120 mg, 300 mg/mmol) in DMF (4 mL) for 18 hours. Following work-up, the residue underwent $NaBH_4$ reduction and was successively purified by silica gel chromatography (0-18% EtOAc in hexanes) to yield **5l** as a clear oil (98 mg, 80% yield) **$[\alpha]^{20}_D$** = +50° (c= 0.2, $CHCl_3$). **R_f** = 0.14 (30% EtOAc in Hexanes) **^{1}H NMR** (500 MHz, $CDCl_3$ δ 6.75 (s, 4H), 5.89 (t, *J* = 6.9 Hz, 1H), 3.76 – 3.69 (m, 1H) 3.75 (s, 3H), 3.71 (s, 3H), 3.69 – 3.58 (m, 1H), 2.82 (s, 1H) 2.65 – 2.39 (m, 4H), 2.23 – 2.12 (m, 1H), 1.90 – 1.80 (m, 1H), 1.80 – 1.70 (m, 2H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 166.50, 160.08, 153.84, 151.84, 129.79, 115.86, 114.58, 73.02, 59.50, 55.58, 51.56, 36.77, 33.51, 32.88, 21.33. **ATR-FTIR** (neat) 3446, 2951, 2361, 2340, 1701, 1653, 1506, 1437, 1226, 1119, 1037 cm^{-1}. **HRMS** (ESI-TOF) *m/z* calcd for $C_{17}H_{22}NaO_5$ $(M+Na)^+$: 329.1365, found 329.1381.

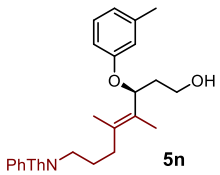
ethyl (*S*,*Z*)-6-hydroxy-2,3-dimethyl-4-(o-tolyloxy)hex-2-enoate (5m)



5m

The general Procedure **C** was followed using (*E*)-3-(2-methylphenoxy)prop-2-en-1-ol (66 mg, 0.4 mmol, 1.0 equiv), ethyl (*Z*)-2-methyl-3-(((trifluoromethyl)sulfonyl)oxy)but-2-enoate (170 mg, 0.6 mmol, 1.5 equiv), Pd_2dba_3·$CHCl_3$ (21 mg, 0.02 mmol, 5 mol %), **L1** (12 mg, 0.05 mmol, 12 mol %), 3Å MS (120 mg, 300 mg/mmol) in DMF (4 mL) for 18 hours. Following work-up, the residue underwent $NaBH_4$ reduction and was purified by silica gel chromatography (0-18% EtOAc in hexanes) to yield **5m** as a clear oil (70 mg, 63% yield). $\mathbf{R_f}$ = 0.33 (30% EtOAc in Hexanes); $\mathbf{[\alpha]^{20}_D}$ = +63° (c= 0.2, $CHCl_3$) **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.13 – 7.09 (m, 1H), 7.07 – 7.01 (m, 1H), 6.82 (t, *J* = 7.4 Hz, 1H), 6.67 (d, *J* = 8.1 Hz, 1H), 5.81 (t, *J* = 6.9 Hz, 1H), 4.31 – 4.22 (m, 2H), 3.81 – 3.67 (m, 2H), 2.95 (s, 1H), 2.26 – 2.16 (m, 5H), 1.97 – 1.90 (m, 1H), 1.89 (s, 3H), 1.73 (s, 3H), 1.59 (s, 1H), 1.*33* (t, *J* = 7.1 Hz, 3H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 169.25, 155.71, 146.56, 130.72, 126.71, 126.08, 120.43, 111.92, 74.91, 60.97, 59.69, 36.86, 16.45, 15.90, 14.25, 13.44. **ATR-FTIR** (neat) 3426, 2926, 1704, 1601, 1492, 1464, 1383, 1278, 1239, 1192, 1119, 1098 cm^{-1}. **HRMS** (ESI-TOF) *m*/*z* calcd for $C_{17}H_{24}NaO_5$ $(M+Na)^+$ 315.1572 , found 315.1569

(*S*,*E*)-2-(8-hydroxy-4,5-dimethyl-6-(m-tolyloxy)oct-4-en-1-yl)isoindoline-1,3-dione (**5n**)

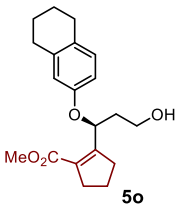


5n

The general procedure **C** was followed using (*E*)-3-(3-methylphenoxy)prop-2-en-1-ol (41 mg, 0.25 mmol, 1.0 equiv), ethyl (*Z*)-5-(1,3-dioxoisoindolin-2-yl)-2-(1-(((trifluoromethyl)sulfonyl)oxy)ethylidene)pentanoate (110 mg, 0.25 mmol, 1.0 equiv), Pd_2dba_3·$CHCl_3$ (13 mg, 0.01 mmol, 5 mol %), **L1** (7.5 mg, 0.03 mmol, 12 mol %), 3Å MS (75 mg, 300 mg/mmol) in DMF (2.5 mL) for 18 hours. Following work-up, the residue underwent $NaBH_4$ reduction and was purified by silica gel chromatography (0-18% EtOAc in hexanes) to yield **5n** as a clear oil (40 mg, 34% yield). $\mathbf{R_f}$ = 0.12 (30% EtOAc in Hexanes); $\mathbf{[\alpha]^{20}_D}$ = +6° (c= 0.2, $CHCl_3$). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.86 – 7.80 (m, 2H), 7.73 – 7.68 (m, 2H), 7.08 (t, *J* = 7.8 Hz, 1H), 6.70 (d, *J* = 7.2 Hz, 1H), 6.65 – 6.56 (m, 2H), 5.63 (t, *J* = 6.9 Hz, 1H), 4.28 – 4.12 (m, 3H), 3.76 – 3.63 (m, 2H), 3.67 (t, *J* = 7.2 Hz, 2H), 2.85 (s, 1H), 2.47 – 2.27 (m, 2H), 2.26 (s, 3H), 2.22 – 2.09 (m, 1H), 1.95 – 1.83 (m, 1H), 1.82 – 1.74 (m, 1H) 1.73 (s, 3H), 1.32 – 1.21 (m, 3H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 168.82, 168.25, 157.61, 146.47, 139.35, 133.93, 131.99, 130.06, 129.12,

123.17, 121.82, 116.32, 112.15, 75.47, 61.05, 59.55, 37.66, 36.81, 27.46, 27.23, 21.42, 14.12, 12.93. **ATR-FTIR** (neat) 3468, 2929, 2360, 1772, 1706, 1601, 1489, 1436, 1395, 1219. **HRMS** (ESI-TOF) *m*/*z* calcd for $C_{27}H_{31}NO_6Na$ $(M+Na)^+$ 488.2049, found 488.2057.

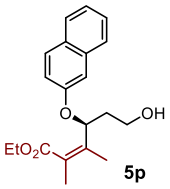
methyl (*S*)-2-(3-hydroxy-1-((5,6,7,8-tetrahydronaphthalen-2-yl)oxy)propyl)cyclopent-1-ene-1-carboxylate (5o)



5o

The general procedure **C** was followed using (*E*)-3-((5,6,7,8-tetrahydronaphthalen-2-yl)oxy)prop-2-en-1-ol (87 mg, 0.4 mmol, 1.0 equiv), ethyl (*Z*)-2-methyl-3-(((trifluoromethyl)sulfonyl)oxy)but-2-enoate (110 mg, 0.4 mmol, 1.0 equiv), Pd_2dba_3·$CHCl_3$ (21 mg, 0.02 mmol, 5 mol %), **L1** (12 mg, 0.05 mmol, 12 mol %), 3Å MS (120 mg, 300 mg/mmol) in DMF (4 mL) for 18 hours. Following work-up the residue underwent $NaBH_4$ reduction and was purified by silica gel chromatography (0-15% EtOAc in hexanes) to yield **5o** as a clear oil (120 mg, 90% yield). $\mathbf{R_f}$ = 0.17 (30% EtOAc in Hexanes); $[\alpha]^{20}_D$ = +38.0° (c= 0.2, $CHCl_3$). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 6.91 (d, *J* = 8.3 Hz, 1H), 6.58 (dd, *J* = 8.3, 2.8 Hz, 1H), 6.55 (d, *J* = 2.7 Hz, 1H), 5.93 (t, *J* = 6.9 Hz, 1H), 3.79 (s, 3H), 3.78 – 3.74 (m, 1H), 3.73 – 3.69 (m, 1H), 2.73 (s, 1H) 2.71 – 2.44 (m, 8H), 2.24 – 2.16 (m, 1H), 1.92 – 1.85 (m, 1H), 1.83 – 1.73 (m, 6H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 166.54, 160.12, 155.61, 138.21, 129.88, 129.61, 129.56, 115.25, 112.32, 72.62, 59.67, 51.55, 36.85, 33.56, 32.97, 29.63, 28.53, 23.36, 23.09, 21.34. **ATR-FTIR** (neat) 3431, 2925, 2360, 2341, 1706, 1636, 1609, 1499, 1434, 1249, 1228 cm^{-1}. **HRMS** (ESI-TOF) *m*/*z* calcd for $C_{20}H_{28}O_4Na$ $(M+Na)^+$ 353.1729, found 353.1739.

ethyl (*S*,*Z*)-6-hydroxy-2,3-dimethyl-4-(naphthalen-2-yloxy)hex-2-enoate (5p)

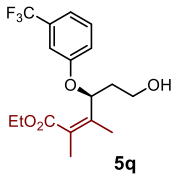


5p

The general procedure **C** was followed using (*E*)-3-(naphthalen-2-yloxy)prop-2-en-1-ol (80 mg,

0.4 mmol, 1.0 equiv), ethyl (*Z*)-2-methyl-3-(((trifluoromethyl)sulfonyl)oxy)but-2-enoate (110 mg, 0.4 mmol, 1.0 equiv), Pd_2dba_3·$CHCl_3$ (21 mg, 0.02 mmol, 5 mol %), **L1** (12 mg, 0.05 mmol, 12 mol %), 3Å MS (120 mg, 300 mg/mmol) in DMF (4 mL) for 18 hours.Following work-up, the residue underwent $NaBH_4$ reduction and was purified by silica gel chromatography (0-5% EtOAc in hexanes) to yield **5p** as a clear oil (89 mg, 71% yield). $\mathbf{R_f}$ = 0.26 (10% EtOAc in Hexanes); $[\alpha]^{20}_D$ = +1.2° (c= 0.4, $CHCl_3$). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.75 – 7.68 (m, 2H), 7.62 (dd *J* = 8.3, 2.4 Hz, 1H), 7.42 – 7.37 (m, 1H), 7.34 – 7.28 (m, 1H), 7.12 – 7.08 (m, 1H), 7.08 – 7.05 (m, 1H), 5.93 – 5.88 (m, 1H), 4.37 – 4.29 (m, 2H), 3.84 – 3.70 (m, 2H), 2.95 (bs, 1H), 2.30 – 2.21 (m, 1H), 2.01 – 1.93 (m, 1H), 1.89 (s, 3H), 1.75 (s, 3H), 1.41 – 1.36 (m, 3H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 169.47, 155.58, 145.73, 134.46, 129.36, 129.06, 127.56, 126.80, 126.24, 123.68, 119.07, 108.66, 75.41, 61.10, 59.53, 36.88, 15.93, 14.34, 13.35. **ATR-FTIR** (neat) 3396, 2926, 2361, 2339, 1706, 1629, 1600, 1510, 1466, 1389, 1277 cm^{-1}. **HRMS** (ESI-TOF) *m/z* calcd for $C_{20}H_{24}O_4Na$ $(M+Na)^+$ 351.1572, found 351.1580.

ethyl (*S*,*Z*)-6-hydroxy-2,3-dimethyl-4-(3-(trifluoromethyl)phenoxy)hex-2-enoate (**5q**)

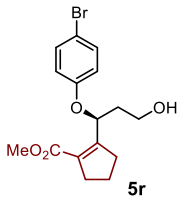


5q

The general procedure **C** was followed using (*E*)-3-(3-(trifluoromethyl)phenoxy)prop-2-en-1-ol (87 mg, 0.4 mmol, 1.0 equiv), ethyl (*Z*)-2-methyl-3-(((trifluoromethyl)sulfonyl)oxy)but-2-enoate (110 mg, 0.4 mmol, 1.0 equiv), Pd_2dba_3·$CHCl_3$ (21 mg, 0.02 mmol, 5 mol %), **L1**(12 mg, 0.05 mmol, 12 mol %), 3Å MS (120 mg, 300 mg/mmol) in DMF (4 mL) for 18 hours. Following work-up, the residue underwent $NaBH_4$ reduction and was purified by silica gel chromatography (0-5% EtOAc in hexanes) to yield **5q** as a clear oil (64 mg, 46% yield). $\mathbf{R_f}$ = 0.28 (30% EtOAc in Hexanes); $[\alpha]^{20}_D$ = +69.0° (c= 0.2, $CHCl_3$). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.32 (t, *J* = 8.0 Hz, 1H), 7.16 (d, *J* = 7.7 Hz, 1H), 7.04 (s, 1H), 7.00 (dd, *J* = 8.3, 2.6 Hz, 1H), 5.83 (t, *J* = 7.0 Hz, 1H), 4.27 (q, *J* = 7.1 Hz, 2H), 3.79 – 3.71 (m, 1H), 3.68 (dt, *J* = 8.4, 3.4 Hz, 1H), 2.95 (s, 1H), 2.24 – 2.16 (m, 1H), 1.96 – 1.90 (m, 1H), 1.89 (s, 3H), 1.71 (s, 3H), 1.34 (t, *J* = 7.1 Hz, 3H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 169.38, 157.86, 144.86, 131.72 (q, *J* = 32.2 Hz), 129.95, 127.53, 123.89 (q, *J* = 272.5 Hz), 117.59 (q, *J* = 3.8 Hz), 112.21 (q, *J* = 3.8 Hz), 75.21, 61.30, 59.07, 36.66, 15.91, 14.41, 13.32.

ATR-FTIR (neat) 3447, 2926, 2360, 2340, 1701, 1653, 1592, 1492, 1326, 1227, 1166, 1123 cm^{-1} **HRMS** (ESI-TOF) *m/z* calcd for $C_{17}H_{21}O_4F_3Na$ $(M+Na)^+$ 369.1290, found 369.1303.

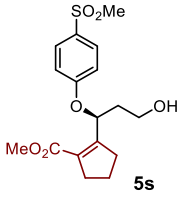
methyl (*S*)-2-(1-(4-bromophenoxy)-3-hydroxypropyl)cyclopent-1-ene-1-carboxylate (5r)



5r

The general procedure **C** was followed using (*E*)-3-(4-bromophenoxy)prop-2-en-1-ol (92 mg, 0.4 mmol, 1.0 equiv), methyl 2-(((trifluoromethyl)sulfonyl)oxy)cyclopent-1-ene-1-carboxylate (110 mg, 0.4 mmol, 1.0 equiv), Pd_2dba_3·$CHCl_3$ (21 mg, 0.02 mmol, 5 mol %), **L2** (12 mg, 0.05 mmol, 12 mol %), 3Å MS (120 mg, 300 mg/mmol) in DMF (4 mL) for 18 hours. Following work-up, the residue underwent $NaBH_4$ reduction and was purified by silica gel chromatography (0-15% EtOAc in hexanes) to yield **5r** as a clear oil (85 mg, 60% yield). $\mathbf{R_f}$ = 0.28 (30% EtOAc in Hexanes); $\mathbf{[\alpha]^{20}_D}$ = +22.0° (c= 0.2, $CHCl_3$). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.34 (d, *J* = 9.0 Hz, 2H), 6.74 (d, *J* = 9.0 Hz, 2H), 5.99 (t, *J* = 7.0 Hz, 1H), 3.81 (s, 3H), 3.76 (m, 1H), 3.68 (m, 1H), 2.69 – 2.63 (m, 2H), 2.62 – 2.53 (m, 2H), 2.42 (m, 1H), 2.27 – 2.19 (m, 1H), 1.94 – 1.86 (m, 1H), 1.84 – 1.76 (m, 2H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 166.59, 159.16, 156.90, 132.33, 130.43, 129.51, 116.80, 114.94, 113.09, 72.56, 59.21, 51.76, 36.70, 33.52, 32.79, 21.35. **ATR-FTIR** 3392, 2950, 2360, 2340, 1701, 1636, 1587, 1485, 1435, 1261, 1234, 1171 cm^{-1} **HRMS** (ESI-TOF) *m/z* calcd for $C_{16}H_{19}O_4BrNa$ $(M+Na)^+$ 377.0364, found 377.0369.

methyl (*S*)-2-(3-hydroxy-1-(4-(methylsulfonyl)phenoxy)propyl)cyclopent-1-ene-1-carboxylate (5s)

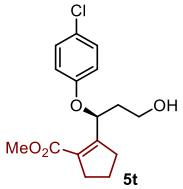


5s

The general procedure **C** was followed using (*E*)-3-(4-(methylsulfonyl)phenoxy)prop-2-en-1-ol (91 mg, 0.4 mmol, 1.0 equiv), methyl 2-(((trifluoromethyl)sulfonyl)oxy)cyclopent-1-ene-1-carboxylate (110 mg, 0.4 mmol, 1.0 equiv), Pd_2dba_3·$CHCl_3$ (21 mg, 0.02 mmol, 5 mol %), **L2** (12

mg, 0.05 mmol, 12 mol %), 3Å MS (120 mg, 300 mg/mmol) in DMF (4 mL) for 18 hours. Following work-up, the residue underwent $NaBH_4$ reduction and was purified by silica gel chromatography (0-30% EtOAc in hexanes) to yield **5s** as a white solid (75 mg, 53% yield). $\mathbf{R_f}$ = 0.2 (60% EtOAc in Hexanes); $[\alpha]^{20}_D$ = +75° (c= 0.4, $CHCl_3$). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.83 (d, *J* = 8.4 Hz, 2H), 6.98 (d, *J* = 8.5 Hz, 2H), 6.15 (t, *J* = 7.0 Hz, 1H), 3.83 (s, 3H), 3.82 – 3.74 (m, 1H), 3.72 – 3.64 (m, 1H), 3.03 (s, 3H), 2.74 – 2.64 (m, 2H), 2.62 – 2.53 (m, 2H), 2.44 – 2.34 (m, 1H), 2.31 – 2.22 (m, 1H), 1.97 – 1.89 (m, 1H), 1.88 – 1.76 (m, 2H), 1.58 (s, 1H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 166.58, 162.05, 157.94, 132.48, 131.07, 129.62, 115.45, 72.69, 58.81, 51.88, 44.78, 36.64, 33.52, 32.68, 21.33. **ATR-FTIR** 3524, 2927, 2361, 2340, 1702, 1616, 1593, 1496, 1313, 1295, 1255 cm^{-1}. **HRMS** (ESI-TOF) *m*/*z* calcd for $C_{17}H_{22}O_6SNa$ $(M+Na)^+$ 377.1035, found 377.1035.

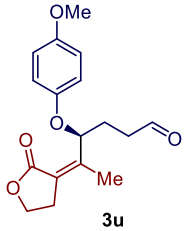
methyl (*S*)-2-(1-(4-chlorophenoxy)-3-hydroxypropyl)cyclopent-1-ene-1-carboxylate (**5t**)



5t

The general procedure **C** was followed using (*E*)-3-(4-chlorophenoxy)prop-2-en-1-ol (74 mg, 0.4 mmol, 1.0 equiv), methyl 2-(((trifluoromethyl)sulfonyl)oxy)cyclopent-1-ene-1-carboxylate (110 mg, 0.4 mmol, 1.0 equiv), Pd_2dba_3·$CHCl_3$ (21 mg, 0.02 mmol, 5 mol %), **L2** (12 mg, 0.05 mmol, 12 mol %), 3Å MS (120 mg, 300 mg/mmol) in DMF (4 mL) for 18 hours. Following work-up, the residue underwent $NaBH_4$ reduction and was purified by silica gel chromatography (0-15% EtOAc in hexanes) to yield **5t** as a clear oil (76 mg, 61% yield). $\mathbf{R_f}$ =0.16 (30% EtOAc in Hexanes); $[\alpha]^{20}_D$ = +51.0° (c= 0.2, $CHCl_3$). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.20 – 7.15 (m, 2H), 6.79 – 6.73 (m, 2H), 5.97 (t, *J* = 7.0 Hz, 1H), 3.79 (s, 3H), 3.77 – 3.72 (m, 2H), 3.70 – 3.63 (m, 1H), 2.70 – 2.61 (m, 3H), 2.60 – 2.51 (m, 1H), 2.45 – 2.35 (m, 1H), 2.25 – 2.16 (m, 1H), 1.92 – 1.84 (m, 1H), 1.83 – 1.74 (m, 2H), 1.60 (bs, 1H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 166.58, 159.21, 156.40, 130.39, 129.39, 125.78, 116.28, 72.64, 59.23, 51.74, 36.72, 33.53, 32.80, 21.36. **ATR-FTIR** (neat) 3395, 2951, 2361, 2340, 1706, 1636, 1489, 1436, 1239, 1119 cm^{-1}; **HRMS** (ESI-TOF) *m*/*z* calcd for $C_{16}H_{19}O_4ClNa$ $(M+Na)^+$ 333.0870, found 333.0875.

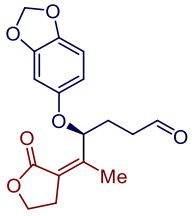
(*S*,*Z*)-4-(4-methoxyphenoxy)-5-(2-oxodihydrofuran-3(2H)-ylidene)hexanal (3u)



3u

Compound **3u** was prepared according to general procedure **D** using alkenyl triflate **1a** (65 mg, 0.25 mmol, 1.0 equiv) and reacting with alkenol substrate **2u** (48.5 mg, 0.25 mmol, 1.0 equiv) and purified using silica gel flash chromatography (gradient elution: 0→35% ethyl acetate/hexane) to afford product **3u** as a yellow oil (62 mg, 82% yield): $\mathbf{R}_f$ = 0.26 (40% ethyl acetate in hexane); $[\alpha]^{20}_{D}$ = +36° (c = 0.25, $CHCl_3$); **^{1}H NMR** (500 MHz, $CDCl_3$) δ 9.81 (t, *J* = 1.4 Hz, 1H), 6.82 – 6.73 (m, 4H), 6.28 (dd, *J* = 9.0, 4.6 Hz, 1H), 4.37 (dd, *J* = 9.4, 6.6, 2.0 Hz, 2H), 3.75 (s, 3H), 2.92 – 2.83 (m, 2H), 2.78 – 2.67 (m, 1H), 2.58 (m, 1H), 2.24 – 2.12 (m, 1H), 1.98 – 1.85 (m, 1H), 1.80 (s, 3H); **^{13}C NMR** (126 MHz, $CDCl_3$) δ 201.62, 169.69, 154.00, 153.33, 151.56, 121.74, 115.98, 114.69, 73.07, 65.02, 55.64, 40.46, 27.63, 27.04, 15.65; **ATR-FTIR** (neat) 3355, 2933, 2361, 1670, 1501, 1464, 1441, 1212, 1179, 1101 cm^{-1}; **HRMS** (ESI-TOF) *m*/*z* calcd for $C_{17}H_{20}O_5Na$ $(M+Na)^+$327.1208, found 327.1219.

(*S*,*Z*)-4-(benzo[d][1,3]dioxol-5-yloxy)-5-(2-oxodihydrofuran-3(2H)-ylidene)hexanal (3v)

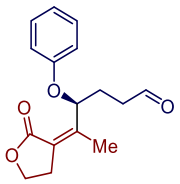


3v

Compound **3v** was prepared according to general procedure **D** using alkenyl triflate **1a** (65 mg, 0.25 mmol, 1.0 equiv) and reacting with alkenol substrate **2v** (52 mg, 0.25 mmol, 1.0 equiv) and purified using silica gel flash chromatography (gradient elution: 0→40% ethyl acetate/hexane) to afford product **3v** as a yellow oil (63 mg, 80% yield): $\mathbf{R}_f$ = 0.37 (10% ether in hexane); $[\alpha]^{20}_{D}$ = + 12° (c = 0.2, $CHCl_3$); **^{1}H NMR** (500 MHz, $CDCl_3$) δ 9.80 (t, *J* = 1.3 Hz, 1H), 6.63 (dd, *J* = 8.5, 0.9 Hz, 1H), 6.43 (dd, *J* = 2.5, 0.8 Hz, 1H), 6.29 – 6.19 (m, 2H), 5.88 (s, 2H), 4.42 – 4.26 (m, 2H), 2.92 – 2.79 (m, 2H), 2.77 – 2.66 (m, 1H), 2.63 – 2.52 (m, 1H), 2.16 (m, 1H), 1.91 (m, 1H), 1.88 –

1.71 (m, 3H); **^{13}C NMR** (126 MHz, $CDCl_3$) δ 201.57, 169.66, 153.06, 152.86, 148.24, 141.84, 122.75, 108.02, 106.36, 101.12, 98.40, 73.51, 65.04, 40.43, 27.60, 27.03, 15.64.; **ATR-FTIR** (neat) 2923, 2361, 2339, 1734, 1717, 1653, 1507, 1227, 1053 cm^{-1}; **HRMS** (ESI-TOF) *m/z* calcd for $C_{17}H_{18}O_6Na$ $(M+Na)^+$ 341.1001, found 341.1009.

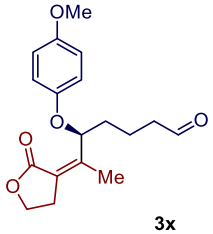
(*S*,*Z*)-5-(2-oxodihydrofuran-3(2H)-ylidene)-4-phenoxyhexanal (3w)



3w

Compound **3w** was prepared according to general procedure **D** using alkenyl triflate **1a** (65 mg, 0.25 mmol, 1.0 equiv) and reacting with alkenol substrate **2w** (41 mg, 0.25 mmol, 1.0 equiv) and purified using silica gel flash chromatography (gradient elution: 0→40% ethyl acetate/hexane) to afford product **3w** as a yellow oil (54 mg, 79% yield): $\mathbf{R}_f$ = 0.37 (10% ethyl acetate in hexane); $[\alpha]^{20}_D$ = + 79° (c = 0.2, $CHCl_3$); **^{1}H NMR** (500 MHz, $CDCl_3$) δ 9.82 (t, *J* = 1.4 Hz, 1H), 7.23 (ddd, *J* = 13.9, 5.8, 2.7 Hz, 2H), 6.96 – 6.89 (m, 1H), 6.88 – 6.81 (m, 2H), 6.36 (dd, *J* = 9.2, 4.5 Hz, 1H), 4.44 – 4.33 (m, 2H), 2.92 – 2.84 (m, 2H), 2.74 (m, 1H), 2.59 (m, 1H), 2.26 – 2.15 (m, 1H), 2.01 – 1.90 (m, 1H), 1.80 (s, 3H); **^{13}C NMR** (126 MHz, $CDCl_3$) δ 201.61, 169.70, 157.52, 153.11, 129.57, 121.69, 121.10, 115.02, 72.61, 65.06, 40.44, 27.61, 27.06, 15.66; **ATR-FTIR** (neat) 2923, 2361, 2339, 1735, 1506, 1376, 1227, 1035 cm^{-1}; **HRMS** (ESI-TOF) *m/z* calcd for $C_{16}H_{18}O_4Na$ $(M+Na)^+$ 297.1103, found 297.1112.

(*S*,*Z*)-5-(4-methoxyphenoxy)-6-(2-oxodihydrofuran-3(2H)-ylidene)heptanal (3x)

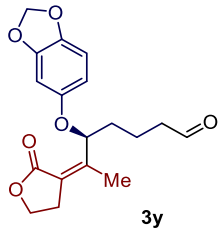


3x

Compound **3x** was prepared according to general procedure **D** using alkenyl triflate **1a** (65 mg, 0.25 mmol, 1.0 equiv) and reacting with alkenol substrate **2x** (52 mg, 0.25 mmol, 1.0 equiv) and purified using silica gel flash chromatography (gradient elution: 0→40% ethyl acetate/hexane) to

afford product **3x** as a yellow oil (64 mg, 80% yield): $\mathbf{R}_f$ = 0.37 (10% ethyl acetate in hexane); $[\alpha]^{20}_{D}$ = + 33.7° (c = 0.34, $CHCl_3$); **^{1}H NMR** (500 MHz, $CDCl_3$) δ 9.75 (t, *J* = 1.6 Hz, 1H), 6.85 – 6.72 (m, 5H), 6.30 (dd, *J* = 8.3, 4.6 Hz, 1H), 4.40 – 4.29 (m, 2H), 3.79 (s, 3H), 2.92 – 2.81 (m, 2H), 2.56 – 2.49 (m, 2H), 1.94 – 1.85 (m, 2H), 1.89 – 1.79 (m, 1H), 1.82 – 1.69 (m, 3H), 1.65 – 1.53 (m, 1H); **^{13}C NMR** (126 MHz, $CDCl_3$) δ 202.27, 169.70, 153.82, 151.79, 121.27, 115.96, 114.61, 114.6, 73.03, 64.93, 55.58, 43.20, 33.60, 27.56, 18.14, 15.60; **ATR-FTIR** (neat) 3379, 2929, 2857, 1764, 1695, 1671, 1504, 1424, 1206, 1162, 1140 cm^{-1}; **HRMS** (ESI-TOF) *m*/*z* calcd for $C_{18}H_{22}O_5Na$ $(M+Na)^+$ 341.1365, found 341.1376.

(*S*,*Z*)-5-(benzo[d][1,3]dioxol-5-yloxy)-6-(2-oxodihydrofuran-3(2H)-ylidene)heptanal (3y)



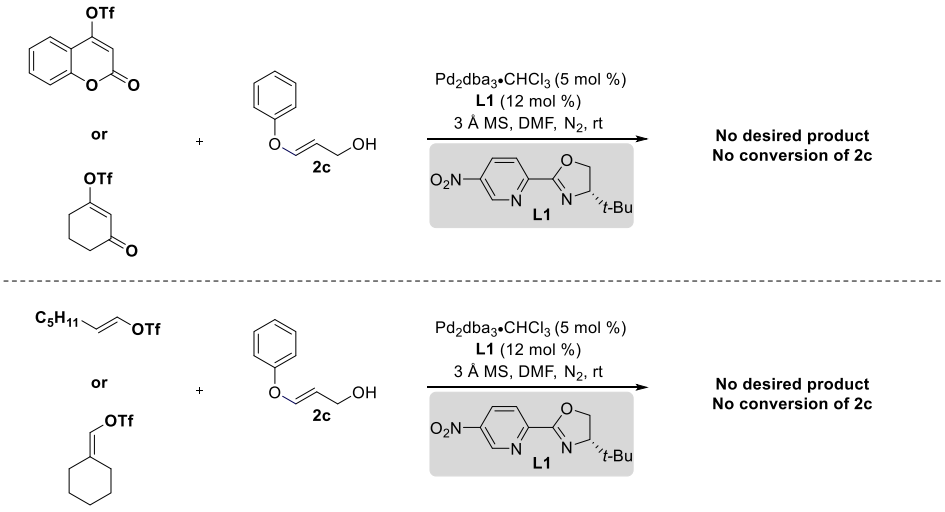
3y

Compound **3y** was prepared according to general procedure **D** using alkenyl triflate **1a** (65 mg, 0.25 mmol, 1.0 equiv) and reacting with alkenol substrate **2y** (56 mg, 0.25 mmol, 1.0 equiv) and purified using silica gel flash chromatography (gradient elution: 0→40% ethyl acetate/hexane) to afford product **3y** as a yellow oil (63 mg, 76% yield): $\mathbf{R}_f$ = 0.37 (10% ether in hexane); $[\alpha]^{20}_{D}$ = +14° (c = 0.26, $CHCl_3$); **^{1}H NMR** (500 MHz, $CDCl_3$) δ 9.77 (t, *J* = 1.5 Hz, 1H), 6.63 (d, *J* = 8.5 Hz, 1H), 6.45 (d, *J* = 2.5 Hz, 1H), 6.26 (m, 2H), 5.88 (q, *J* = 1.4 Hz, 2H), 4.37 (t, *J* = 7.5 Hz, 2H), 2.91 – 2.83 (m, 2H), 2.61 – 2.46 (m, 2H), 1.93 – 1.80 (m, 2H), 1.81 – 1.69 (m, 4H), 1.59 (m, 1H); **^{13}C NMR** (126 MHz, $CDCl_3$) δ 202.31, 169.70, 153.66, 153.15, 148.21, 141.69, 121.28, 108.01, 106.38, 101.07, 98.43, 73.52, 64.97, 43.21, 33.65, 27.58, 18.14, 15.66; **ATR-FTIR** (neat) 3379, 2929, 2857, 1764, 1695, 1671, 1504, 1424, 1206, 1162 cm^{-1}; **HRMS** (ESI-TOF) *m*/*z* calcd for $C_{18}H_{20}O_6Na$ $(M+Na)^+$ 355.1158, found 355.1166.

Other Alkenyl Triflates:

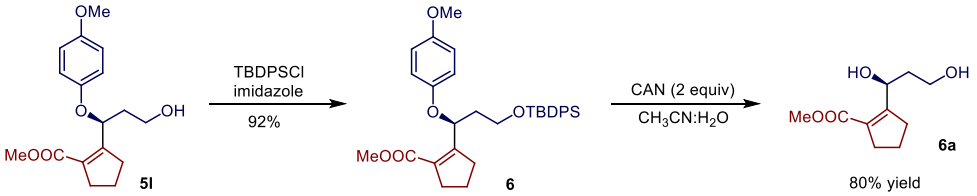
Note: The palladium catalyzed alkenylation of acyclic aryl enol ethers was unsuccessful when di- or tri-substituted alkenyl triflates were used as coupling partners. The results are summarized below:

In all cases (see figure below), di- or tri- substituted alkenyl triflates did not yield the desired relay product. In fact, no significant conversion of either starting material was observed. The results were similar in other solvents such as THF, DMA, DCM and EtOH.

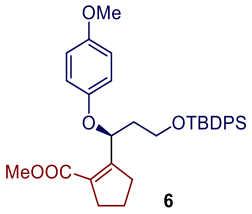


Derivatization of the generated products:

General reaction for the deprotection of the PMP group:

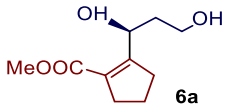


methyl (*S*)-2-(3-((tert-butyldiphenylsilyl)oxy)-1-(4-methoxyphenoxy)propyl)cyclopent-1-ene-1-carboxylate (6)



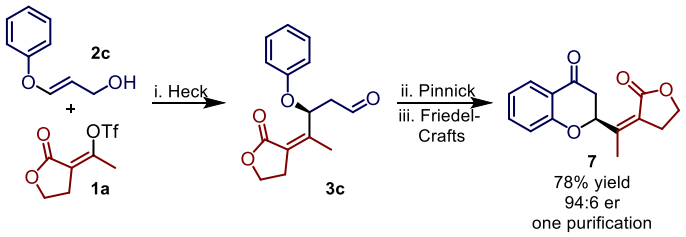
Compound **6** was prepared as follows: tert-butyl(chloro)diphenylsilane (0.24 mmol, 69 mg, 1.2 equiv) dissolved in 1 mL of DCM was added slowly to a 20 mL scintillation vial containing **3l** (61 mg, 0.2 mmol, 1.0 equiv) and imidazole (0.24 mmol, 20 mg, 1.2 equiv) dissolved in 5 mL of DCM, under stirring. The resulting mixture was stirred overnight. The crude reaction mixture was passed through a cotton plug and the resulting filtrate was concentrated in vacuum. The crude material obtained was purified with silica gel column chromatography eluting with hexanes to provide **6** as a white oil (92% yield, 100 mg). $\mathbf{R}_f$ = 0.44 (10% ether in hexane); $[\alpha]^{20}_D$ = + 19.8° (c = 0.32, $CHCl_3$); **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.76 – 7.59 (m, 4H), 7.48 – 7.35 (m, 3H), 7.39 – 7.33 (m, 1H), 7.37 – 7.22 (m, 2H), 6.91 – 6.73 (m, 4H), 6.00 (dd, *J* = 9.3, 4.0 Hz, 1H), 3.91 (m, 1H), 3.86 – 3.77 (m, 1H), 3.76 (s, 3H), 3.75 (s, 3H), 2.64 (tq, *J* = 8.4, 2.3 Hz, 2H), 2.59 – 2.41 (m, 1H), 2.13 – 2.02 (m, 1H), 1.97 (m, 1H), 1.83 – 1.65 (m, 2H), 1.28 (s, 1H), 1.15 – 0.99 (m, 9H); **^{13}C NMR** (126 MHz, $CDCl_3$) δ 165.74, 159.31, 153.61, 152.33, 135.55, 135.53, 133.88, 133.67, 129.48, 129.45, 129.12, 127.56, 127.53, 115.87, 114.52, 71.52, 60.19, 55.64, 51.28, 37.17, 33.86, 33.11, 26.78, 21.20, 19.16; **ATR-FTIR** (neat) 2929, 2856, 1710, 1506, 1472, 1429, 1229, 1111 cm^{-1}; **HRMS** (ESI-TOF) *m/z* calcd for $C_{33}H_{40}O_5SiNa$ $(M+Na)^+$ 567.2543, found 567.2459.

methyl (*S*)-2-(1,3-dihydroxypropyl)cyclopent-1-ene-1-carboxylate (6a)

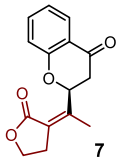


Compound **6a** was prepared as following: cerium ammonium nitrate (100mg, 0.2mmol, 2.0 equiv) was added to a solution of **6** (54 mg, 0.1 mmol, 1.0 equiv) in 2 mL of a mixture of acetonitrile/water (3:1) at 0 °C. The reaction was then allowed to warm to room temperature and stirred for 12 hours. The reaction mixture was quenched by the addition of H_2O (1 mL). The resulting mixture was diluted with 50 mL of ethyl acetate and washed with water and brine, respectively. The organic layer was dried over sodium sulfate, followed by concentration under vacuum. The resulting crude was purified using silica gel flash chromatography (gradient elution: 20→30% ether/hexane, followed by eluting with 50% ethyl acetate in hexane) to afford product 36 as a white oil (16 mg, 80% yield): $\mathbf{R}_f$ = 0.37 (60% ethyl acetate in hexane); $[\alpha]^{20}_D$ = – 2° (c = 0.24, $CHCl_3$); **^{1}H NMR** (500 MHz, $CDCl_3$) δ 5.02 (dt, *J* = 9.4, 4.9 Hz, 1H), 4.18 (d, *J* = 6.2 Hz, 1H), 3.80 (m, 2H), 3.74 (s, 3 H) 2.92 (s, 1H), 2.74 – 2.43 (m, 4H), 2.00 – 1.71 (m, 4H); **^{13}C NMR** (126 MHz, $CDCl_3$) δ 167.38, 162.41, 128.19, 69.03, 61.10, 51.76, 37.28, 35.26, 33.85, 21.52; **ATR-FTIR** (neat) 3389, 2952, 2926, 2361, 2339, 1701, 1685, 1636, 1436, 1264, 1117 cm^{-1}; **HRMS** (ESI-TOF) *m*/*z* calcd for $C_{10}H_{16}O_4Na$ $(M+Na)^+$ 223.0946, found 223.0950.

Preparation of alkenylated flavone:



(*S*,*Z*)-2-(1-(2-oxodihydrofuran-3(2H)-ylidene)ethyl)chroman-4-one (7)



The general procedure **C** was followed using (*E*)-3-phenoxyprop-2-en-1-ol (75 mg, 0.5 mmol, 1.0 equiv), (*Z*)-1-(2-oxodihydrofuran-3(2H)-ylidene)ethyl trifluoromethanesulfonate (140 mg, 0.5

mmol, 1.0 equiv), $Pd_2dba_3{\cdot}CHCl_3$ (26 mg, 0.025 mmol, 5 mol %), **L1** (15 mg, 0.05 mmol, 12 mol %), 3Å MS (150 mg, 300 mg/mmol) in DMF (5 mL) for 18 hours. The crude residue was dissolved in *t*-BuOH (1 mL) and H_2O (0.4 mL) and cooled to 0 °C. NaH_2PO_4 was added (120 mg, 2 mmol, 4 equiv) followed by 2-methyl-2-butene (140 mg, 2 mmol, 4 equiv). The resulting mixture was stirred 5 minutes and then $NaClO_2$ (118 mg, 2 mmol, 4 equiv) was added. This solution was stirred vigorously for 45 minutes at 0 °C then diluted with 5 mL H_2O and washed with EtOAc (2x 60 mL). The combined organic extracts were washed with brine, dried with Na_2SO_4, filtered, and concentrated. The resulting residue was dissolved in CH_2Cl_2, then trifluoroacetic acid (170 mg, 1.5 mmol, 3 equiv), and trifluoroacetic anhydride (320 mg, 1.5 mmol, 3 equiv) were added. The solution was stirred for 3 hours and diluted with CH_2Cl_2 (60 mL) and washed with water (3 x 15 mL) and brine. The organic layer was dried with Na_2SO_4, filtered, and concentrated *in vacuo*. Purification of the residue by silica gel chromatography (0-15% EtOAc in Hexanes) afforded a white solid. Mp 182-184 °C. $\boldsymbol{[\alpha]^{20}_D}$ = – 2° (c = 0.24, $CHCl_3$) ^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.89 (dt, *J* = 7.8, 1.8 Hz, 1H), 7.46 (dt, *J* = 8.8, 1.8 Hz, 1H), 7.05 – 6.98 (m, 1H), 6.95 (dd, *J* = 8.4, 1.7 Hz, 1H), 6.65 (dd, *J* = 13.9, 2.9 Hz, 1H), 4.44 – 4.33 (m, 2H), 3.08 – 2.93 (m, 2H), 2.84 (m, 1H), 2.64 (dt, *J* = 16.7, 2.3 Hz, 1H), 2.08 (s, 3H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 191.45, 169.18, 161.61, 148.29, 136.21, 127.26, 122.24, 121.80, 121.28, 118.08, 74.53, 65.24, 41.10, 27.90, 16.44. **ATR-FTIR** (neat) 2920.22, 2360.64, 2339.95, 1740.24, 1690.42, 1605.58, 1472.65, 1463.76, 1303.41, 1200.38, 1028.5 cm^{-1}; **HRMS** (ESI-TOF) *m/z* calcd for $C_{15}H_{14}O_4Na$ $(M+Na)^+$ 281.0790; obsvd: 281.0787

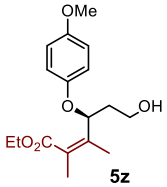
Optimization of Pinnick Oxidation

Pinnick Oxidation	Friedel-Crafts	er
3h	3h	86:14
2h	3h	93:7
0.75h	3h	94:6
0.5h	3h	94:6
10 min (22 °C)	3h	94:6

It was observed that upon varying the time given the Pinnick Oxidation to stir caused varying degrees of erosion of enantiomeric excess. At times beyond 2 hours, the erosion increases, but at times below 2 hours, the erosion is decreased.

Determination of absolute configuration:

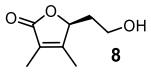
ethyl (*S*,Z)-6-hydroxy-4-(4-methoxyphenoxy)-2,3-dimethylhex-2-enoate (5z)



5z

The general procedure **C** was followed using (E)-3-(4-methoxyphenoxy)prop-2-en-1-ol (72 mg, 0.4 mmol, 1.0 equiv), ethyl (*Z*)-2-methyl-3-(((trifluoromethyl)sulfonyl)oxy)but-2-enoate (110 mg, 0.4 mmol, 1.0 equiv), Pd_2dba_3•$CHCl_3$ (21 mg, 0.02 mmol, 5 mol %), **L1** (12 mg, 0.05 mmol, 12 mol %), 3Å MS (120 mg, 300 mg/mmol) in DMF (4 mL) for 18 hours. Following work-up, the residue underwent $NaBH_4$ reduction and was successively purified by silica gel chromatography (0-18% EtOAc in hexanes). $\mathbf{R_f}$ =0.15 (30% EtOAc in Hexanes); $[\boldsymbol{\alpha}]_{\boldsymbol{d}}^{\mathbf{23}}$ = +50.0° (c= 0.2, $CHCl_3$) 71% yield. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 6.74 (s, 4H), 5.64 (t, *J* = 6.9 Hz, 1H), 4.27 – 4.17 (m, 2H), 3.76 – 3.64 (m, 2H) 3.72 (s, 3H), 2.92 (s, 1H), 2.19 – 2.10 (m, 1H), 1.90 – 1.83 (m, 1H), 1.85 (s, 3H) 1.72 (s, 3H), 1.30 (t, *J* = 7.1 Hz, 3H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 169.29, 153.98, 151.82, 146.20, 126.32, 116.60, 114.54, 76.21, 60.87, 59.66, 55.61, 36.79, 15.84, 14.22, 13.41. **ATR-FTIR** 3453, 2929, 2360, 2339, 1705, 1506, 1280, 1227, 1099 **HRMS** (ESI-TOF) *m*/*z* calcd for $C_{17}H_{24}O_5Na$ $(M+Na)^+$ 331.1521, found 331.1511.

(*S*)-5-(2-hydroxyethyl)-3,4-dimethylfuran-2(5H)-one (8):



8

Ethyl (*Z*)-6-hydroxy-4-(4-methoxyphenoxy)-2,3-dimethylhex-2-enoate (30 mg, 0.1 mmol, 1.0 equiv) was dissolved in acetonitrile/water (4:1, 2 mL) and cooled to 0 °C. Ceric ammonium nitrate was added (120 mg, 0.22 mmol, 2.2 equiv) and the resulting mixture was allowed to warm to room temperature overnight. 100 mL EtOAc were added which was then washed with water (3 x 15 mL), and brine. The organic layer was dried with sodium sulfate, filtered, and concentrated. The residue was purified by preparative thin layer chromatography according to the literature procedure. $\mathbf{R_f}$ = 0.4 (30% EtOAc/hexanes). 11mg residue obtained (74% yield). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 4.90 (d, *J* = 9.7 Hz, 1H), 3.90 – 3.80 (m, 2H), 2.19 – 2.11 (m, 1H), 1.97 (s, 3H), 1.81 (s, 3H), 1.59

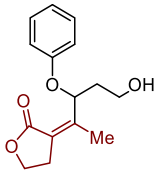
(ddt, *J* = 14.6, 9.8, 5.0 Hz, 1H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 174.39, 159.61, 123.27, 80.76, 58.87, 35.16, 11.98, 8.44. $[\boldsymbol{\alpha}]_{\boldsymbol{d}}^{\boldsymbol{23}}$ –33.0° (c= 0.2, $CHCl_3$).
See literature for the remainder of the data.[11]

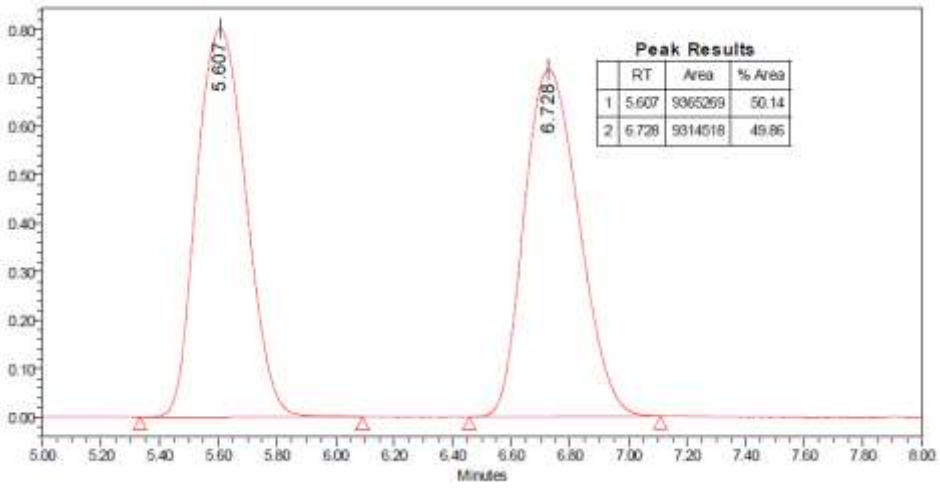
The optical rotation of **8** obtained via derivatization of **5u** (which was synthesized as per the developed procedure described in this communication) was found to be as follows: $[\alpha]_d^{23}$ –33.0° (c= 0.2, $CHCl_3$).

The optical rotation of 8, as per the literature was $\boldsymbol{[\alpha]^{20}_{D}}$ = –51.6° (c= 0.55, $CHCl_3$), which is S in configuration.
Therefore, the products obtained in the alkenylative Heck reactions of acyclic aryl enol ethers are 'S' in configuration.

Determination of Enantiomeric ratio

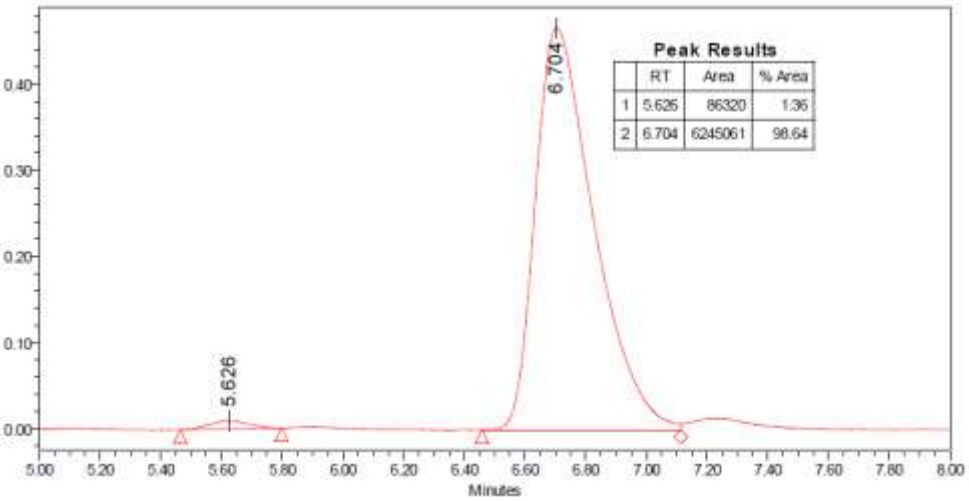
SFC Data and Traces:



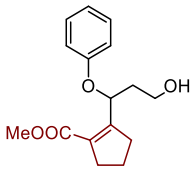


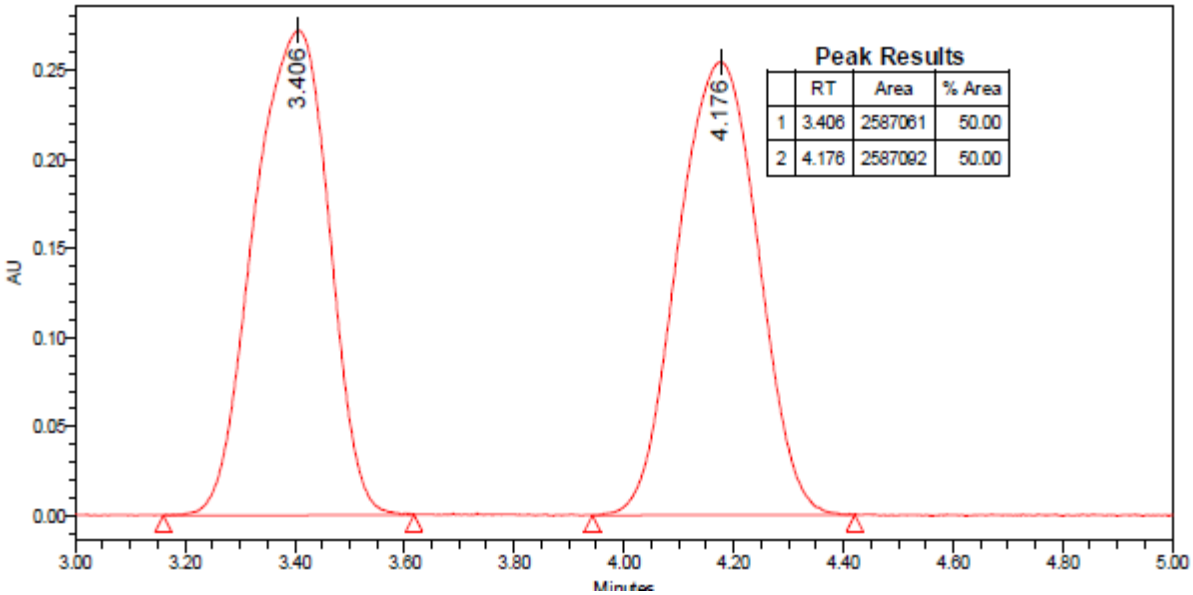
Racemic **5a**

Separation of enantiomers by SFC, Waters Trefoil AMY1 column, 40 ºC, *i*-PrOH:CO_2 = 8:92 (10 min), 2mL/min, 140 bar, major retention time: 6.7 min, minor retention time: 5.6 min.



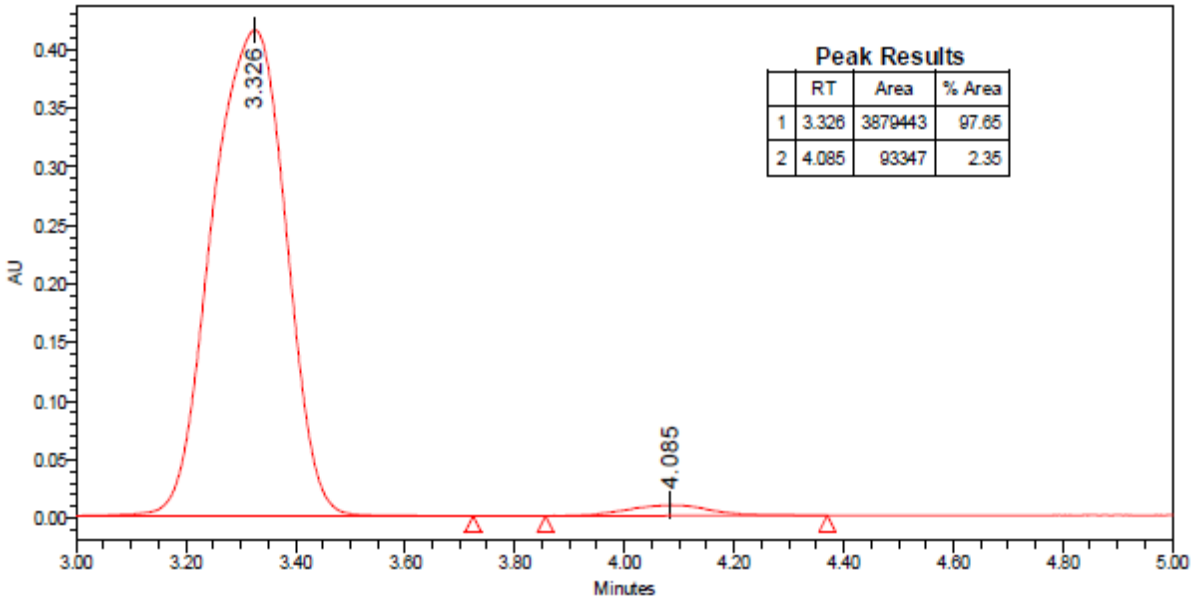
Enantioenriched **5a**



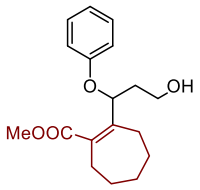


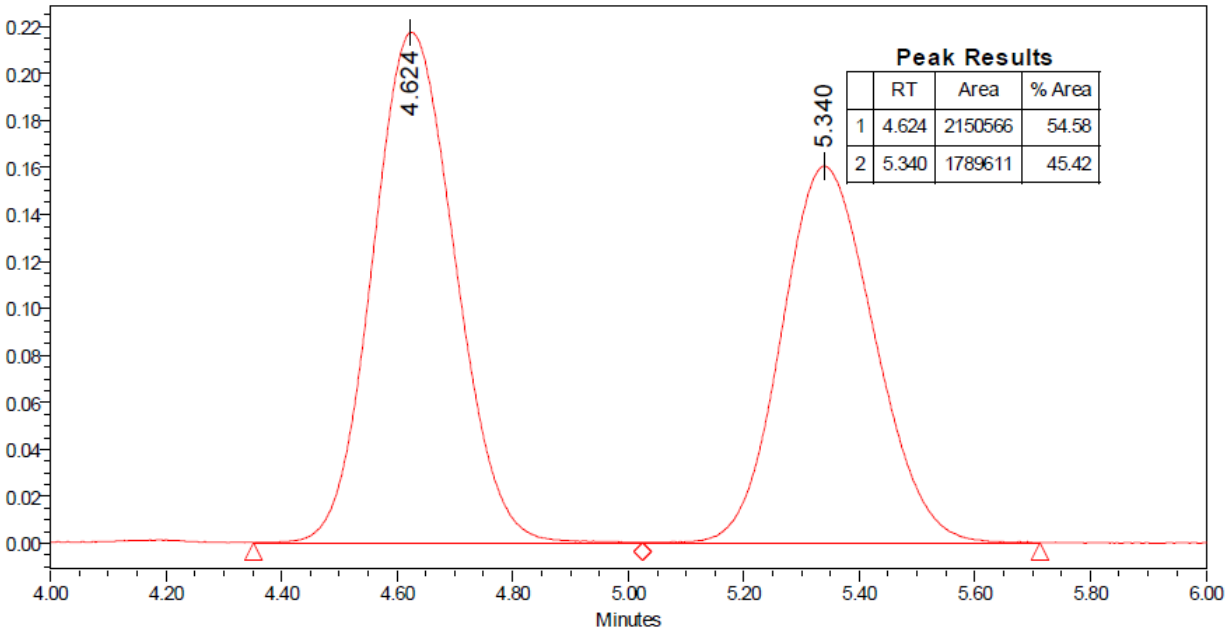
Racemic **5b**

Separation of enantiomers by SFC, Waters Trefoil Cel2 column, 40 °C, *i*-PrOH:CO_2 = 5:95 (15 min), 2mL/min, 140 bar, major retention time: 3.3 min, minor retention time: 4.0 min.



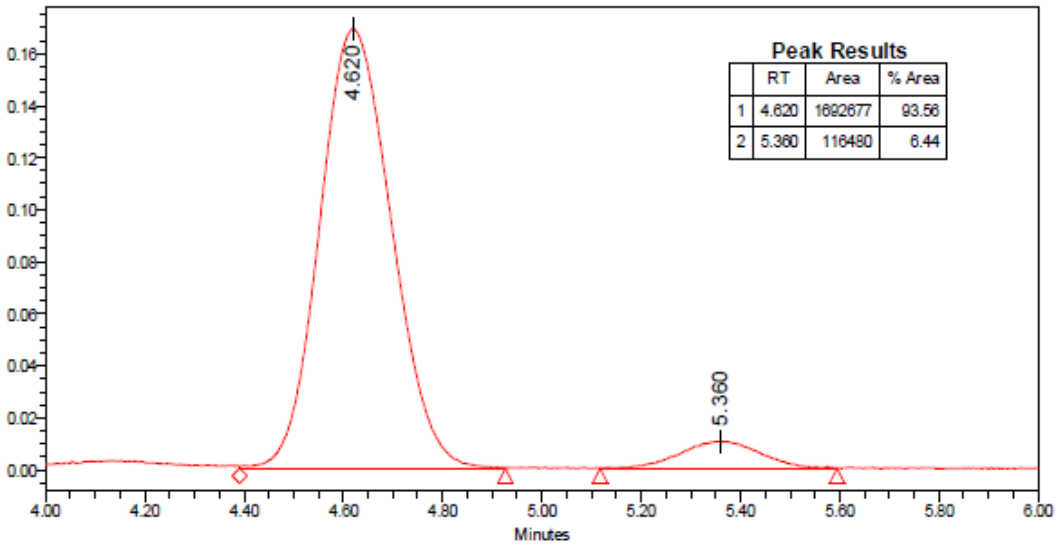
Enantioenriched **5b**



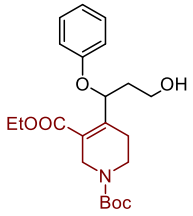


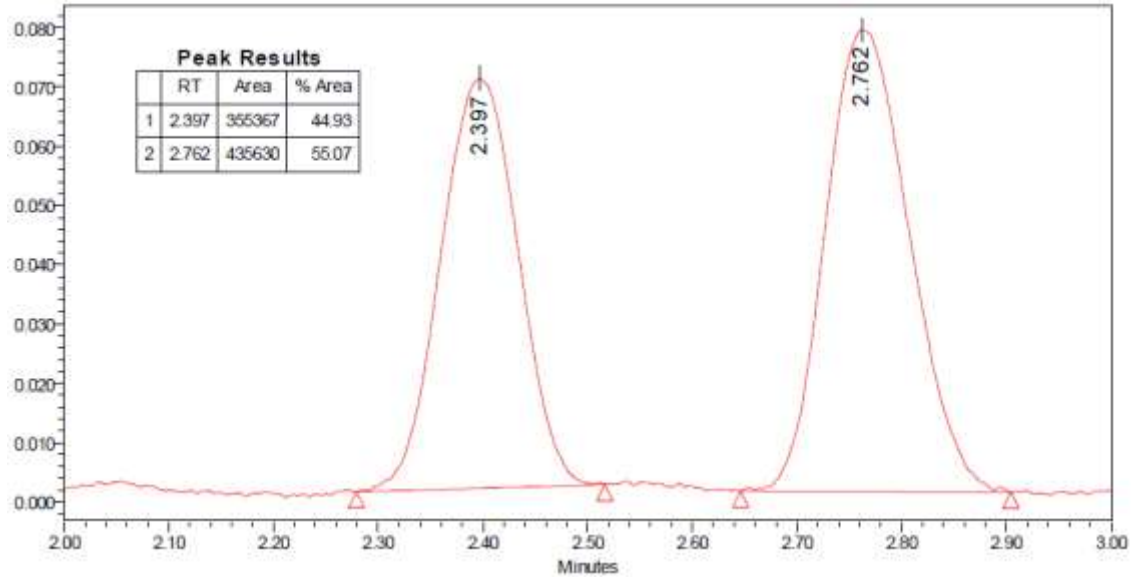
Racemic **5c**

Separation of enantiomers by SFC, Waters Trefoil Cel2 column, 40 °C, *i*-PrOH:CO_2 = 5:95 (15 min), 2mL/min, 140 bar, major retention time: 4.6 min, minor retention time: 5.3 min.



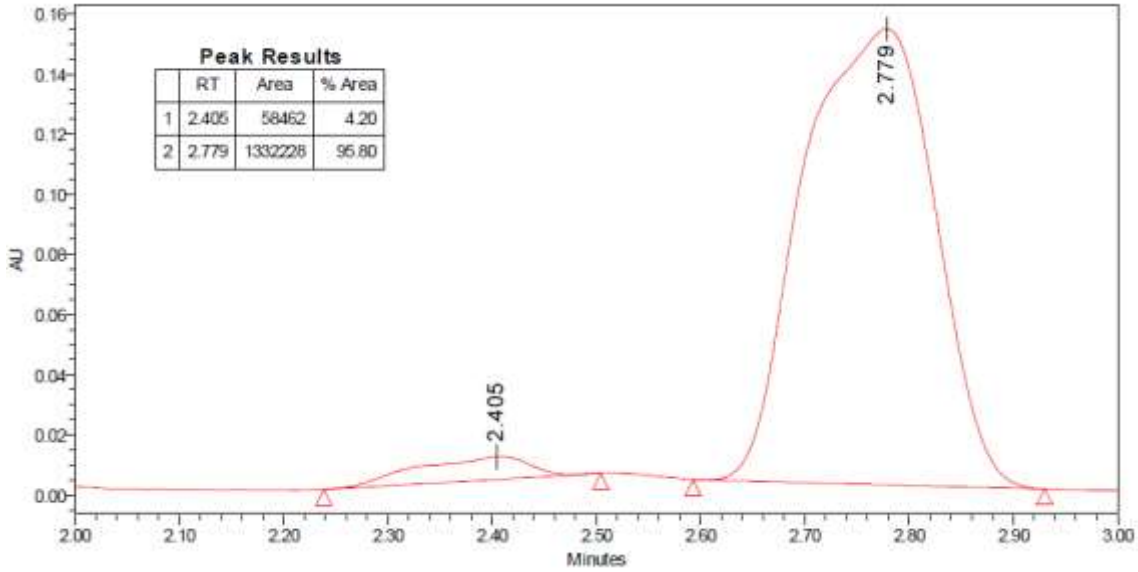
Enantioenriched **5c**



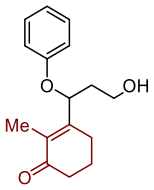


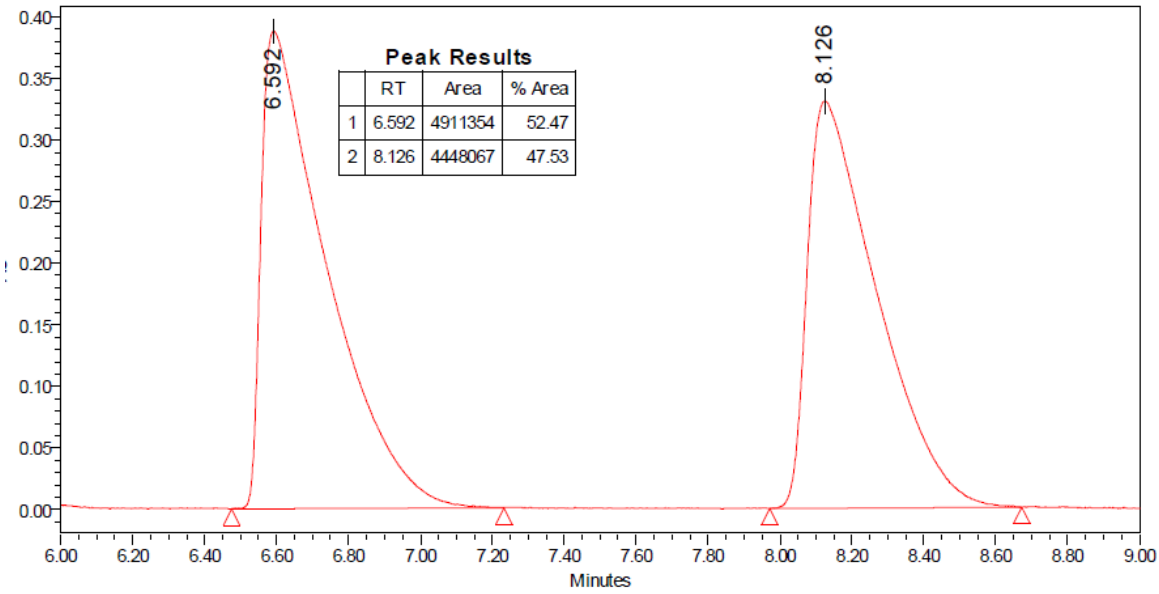
Racemic **5d**

Separation of enantiomers by SFC, Waters Trefoil Cel1 column, 40 ºC, *i*-PrOH:CO_2 = 2:98 (5 min), 2mL/min, 140 bar, major retention time: 2.7 min, minor retention time: 2.4 min.



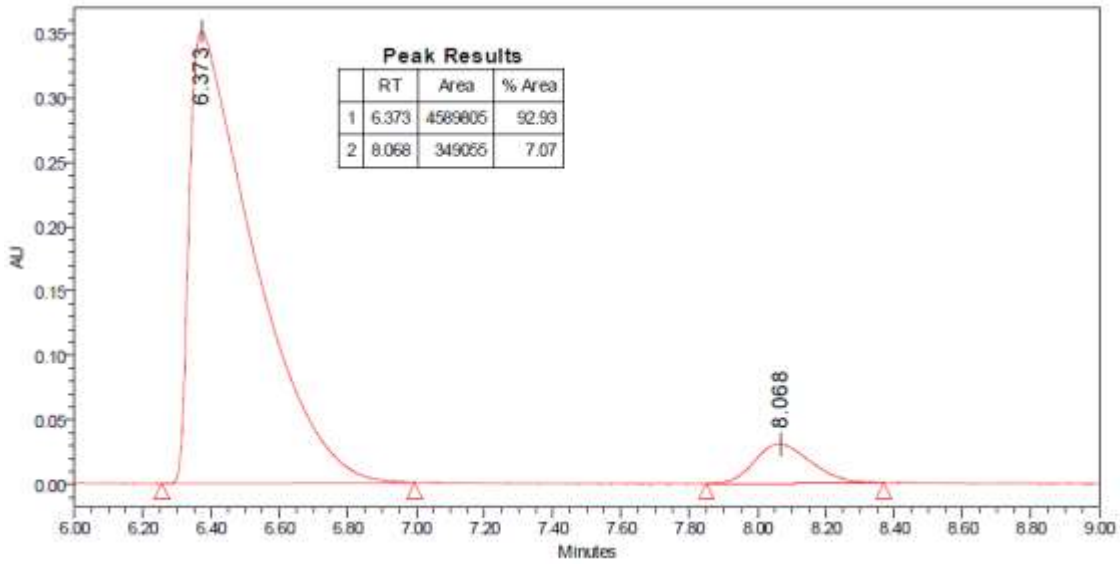
Enantioenriched **5d**



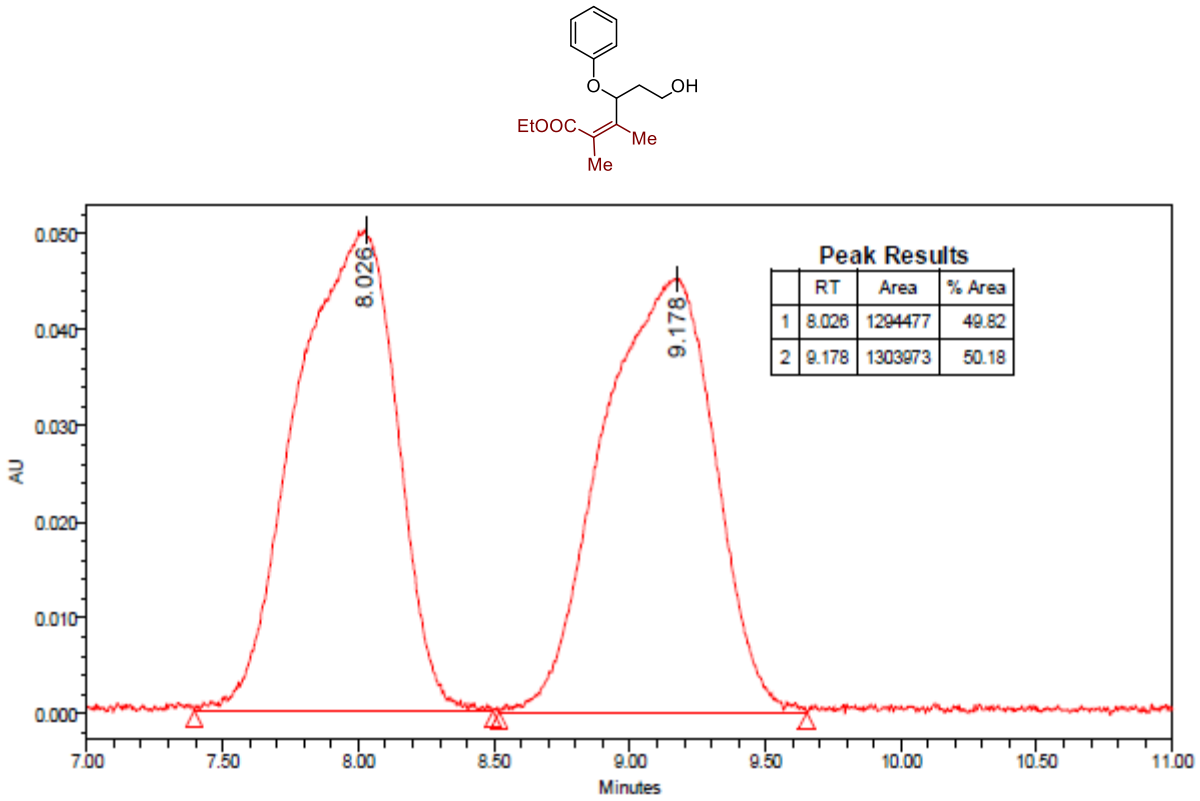


Racemic **5e**

Separation of enantiomers by SFC, Waters Trefoil Cel1 column, 40 ºC, *i*-PrOH:CO_2 = 5:95 (15 min), 2mL/min, 140 bar, major retention time: 6.3 min, minor retention time: 8.0 min.

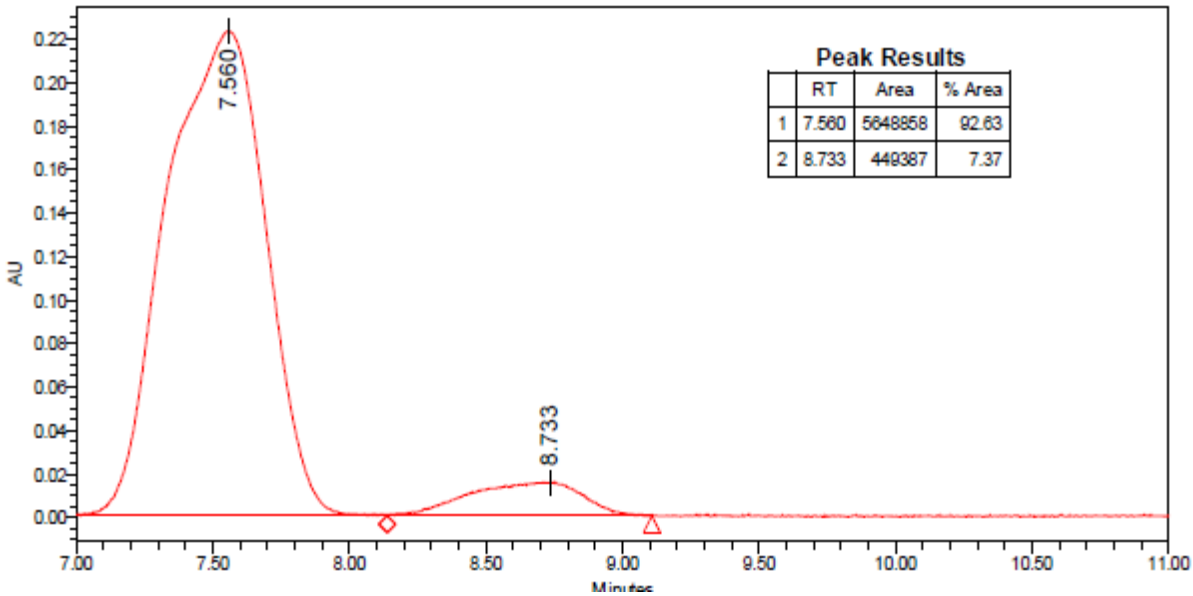


Enantioenriched **5e**

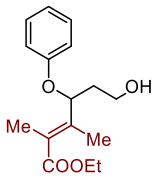


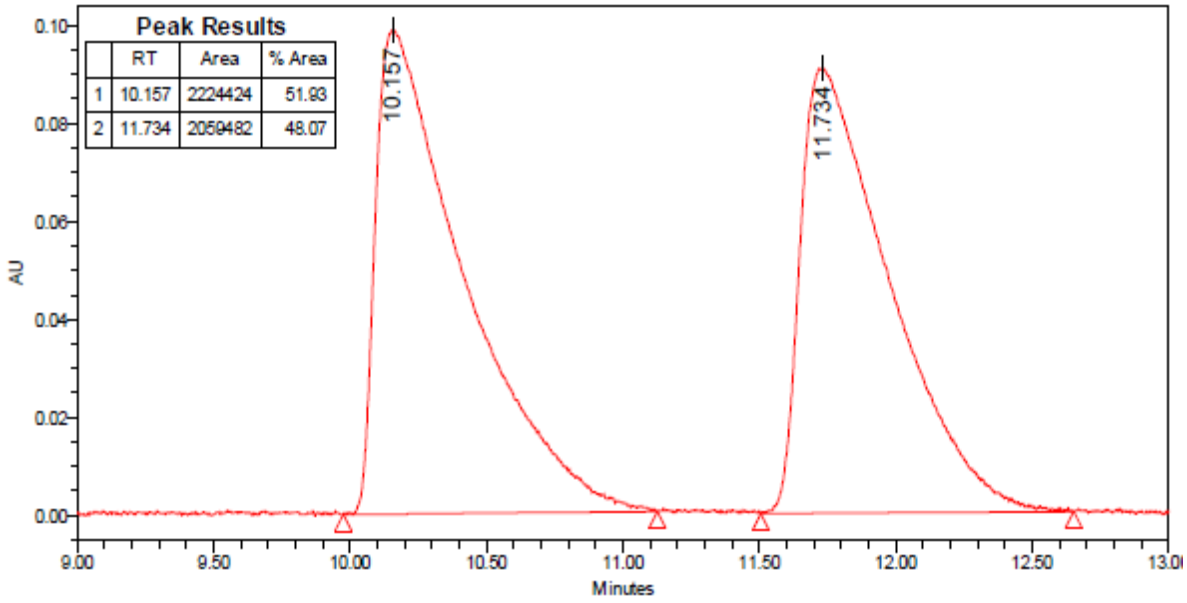
Racemic **5f**

Separation of enantiomers by SFC, Waters Trefoil Cel1 column, 40 ºC, *i*-PrOH:CO_2 = 2:98 (15 min), 2mL/min, 140 bar, major retention time: 7.5 min, minor retention time: 8.7 min.



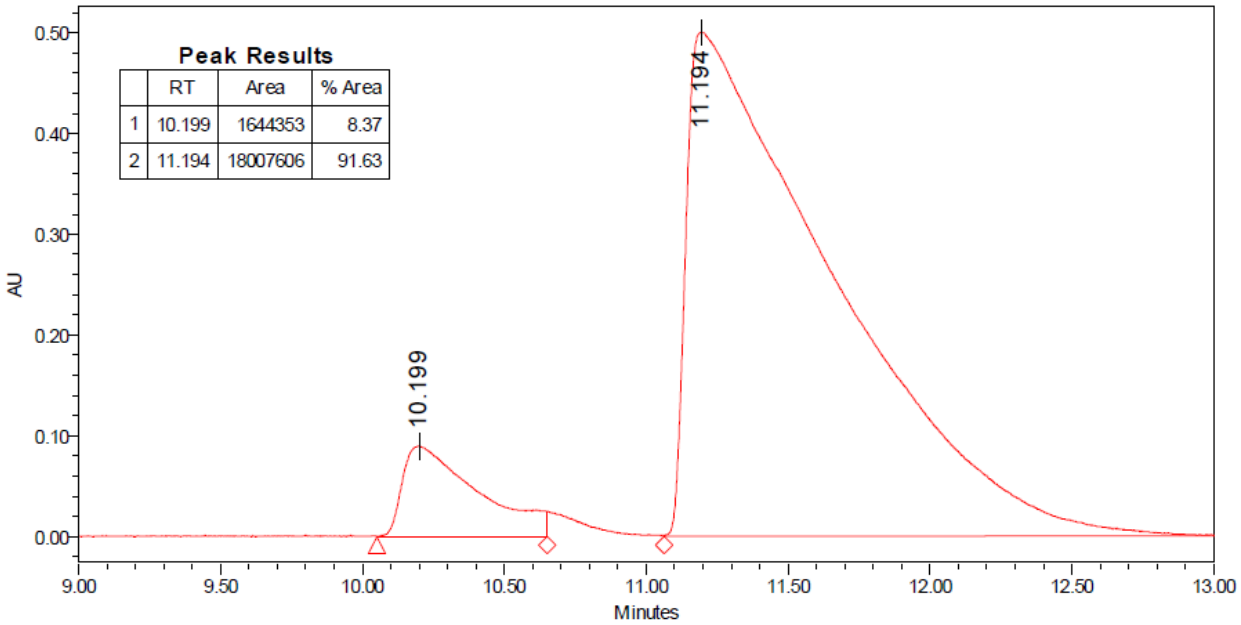
Enantioenriched **5f**



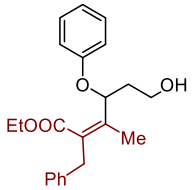


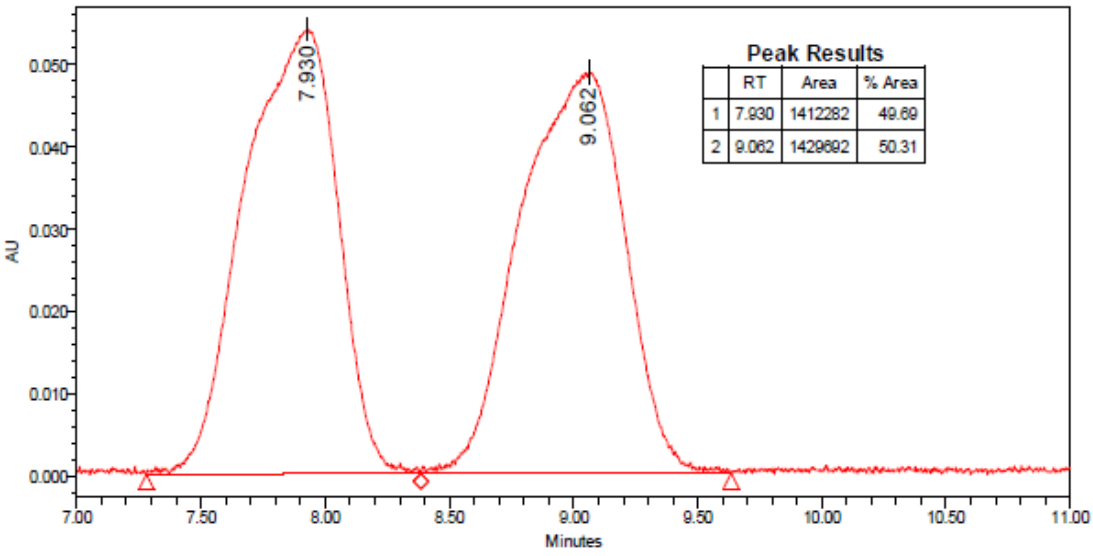
Racemic **5g**

Separation of enantiomers by SFC, Waters Trefoil Cel1 column, 40 °C, *i*-PrOH:CO_2 = 2:98 (15 min), 2mL/min, 140 bar, major retention time: 11.1 min, minor retention time: 10.1 min.



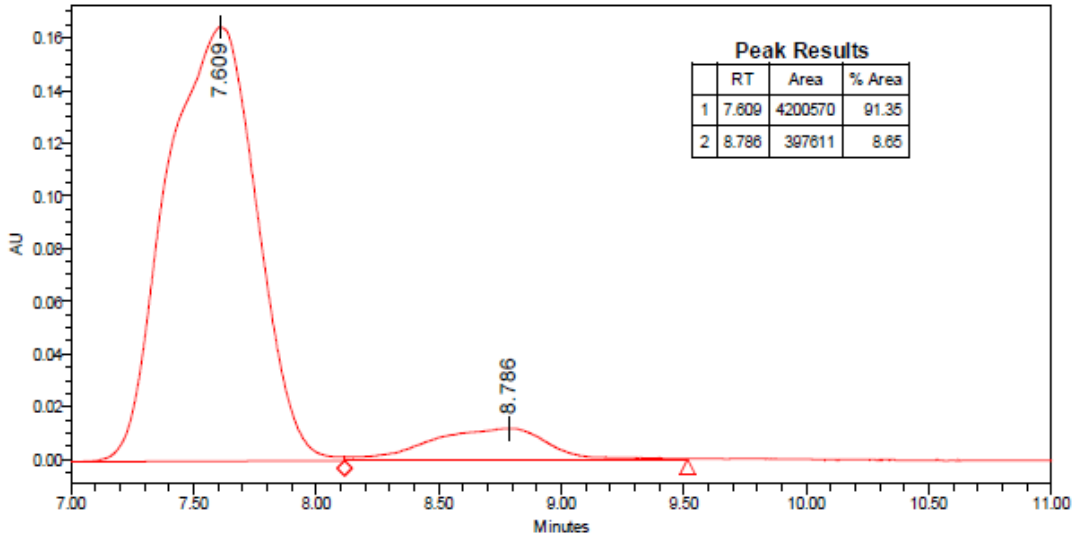
Enantioenriched **5g**



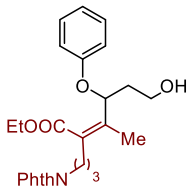


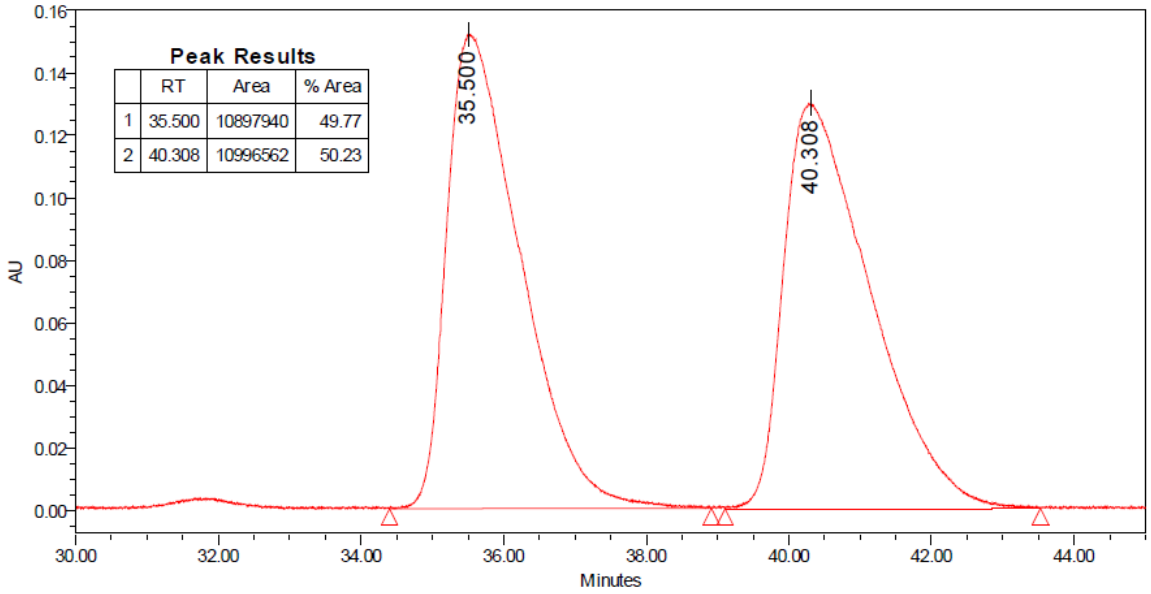
Racemic **5h**

Separation of enantiomers by SFC, Waters Trefoil Cel2 column, 40 °C, *i*-PrOH:CO_2 = 2:98 (15 min), 2mL/min, 140 bar, major retention time: 7.6 min, minor retention time: 8.7 min.



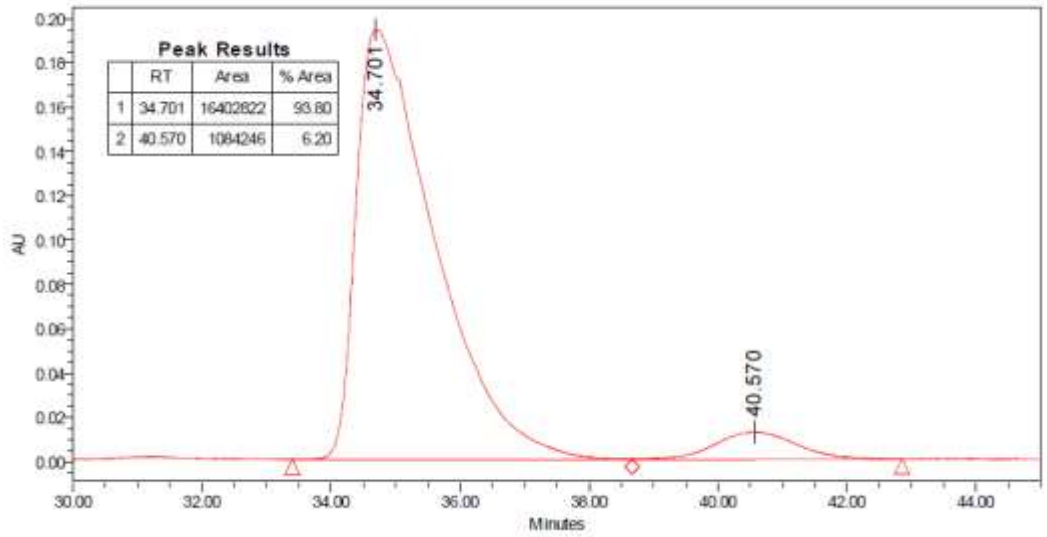
Enantioenriched **5h**



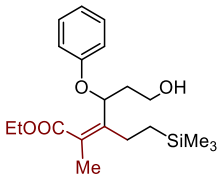


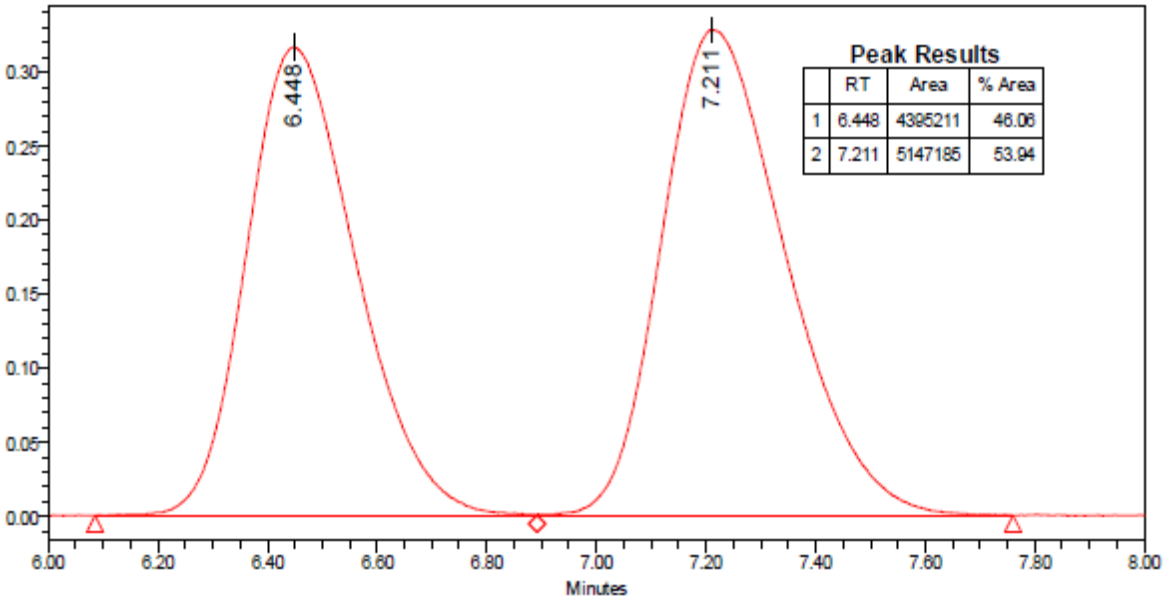
Racemic **5i**

Separation of enantiomers by SFC, Waters Trefoil Cel2 column, 40 ºC, *i*-PrOH:CO_2 = 5:95 (50 min), 2mL/min, 140 bar, major retention time: 34.7 min, minor retention time: 40.5 min.



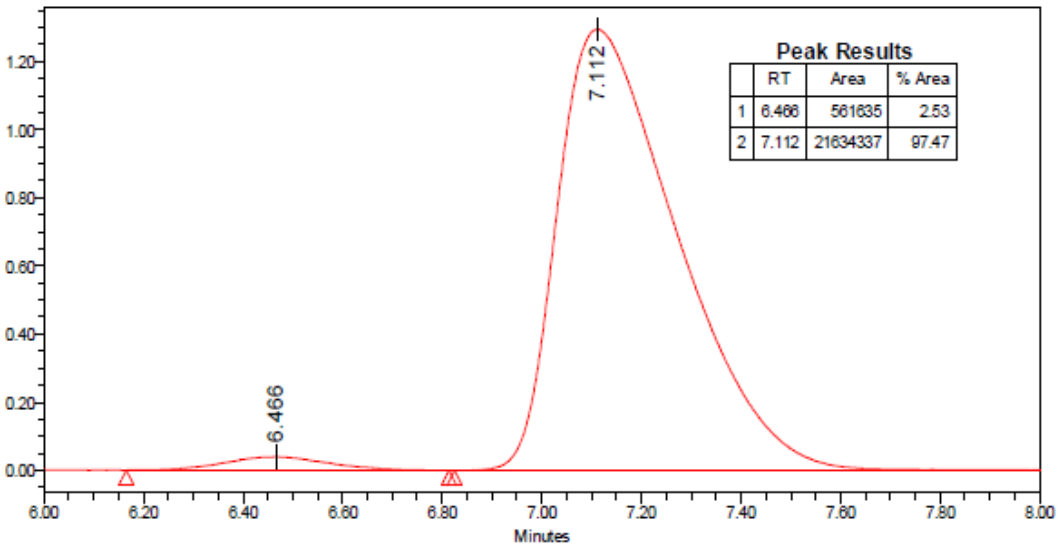
Enantioenriched **5i**



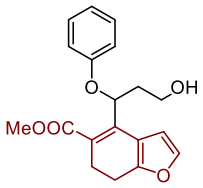


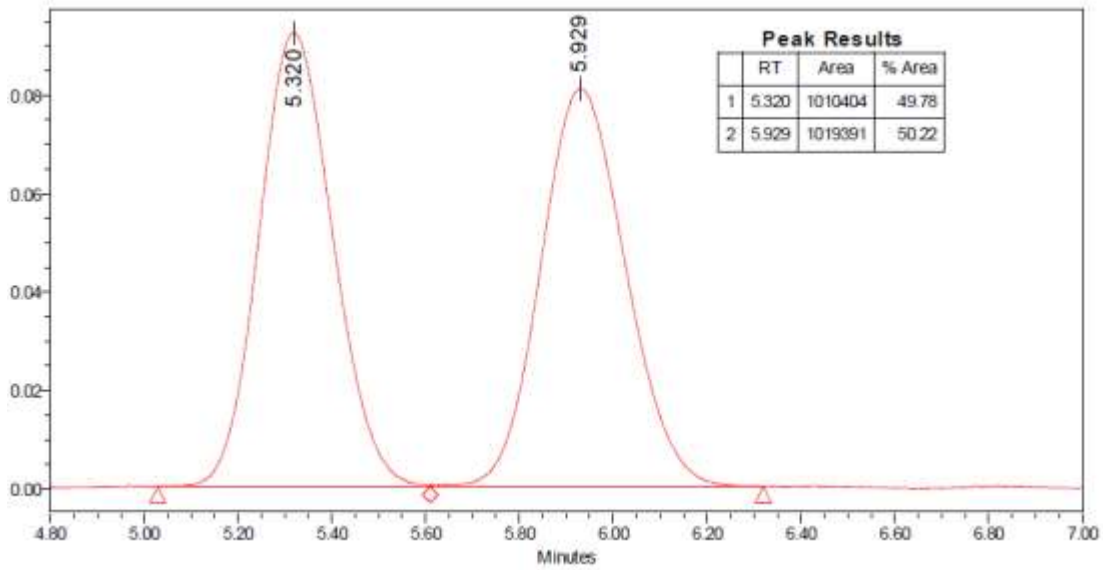
Racemic **5j**

Separation of enantiomers by SFC, Waters Trefoil AMY1 column, 40 ºC, *i*-PrOH:CO_2 = 10:90 (10 min), 2mL/min, 140 bar, major retention time: 7.1 min, minor retention time: 6.4 min.



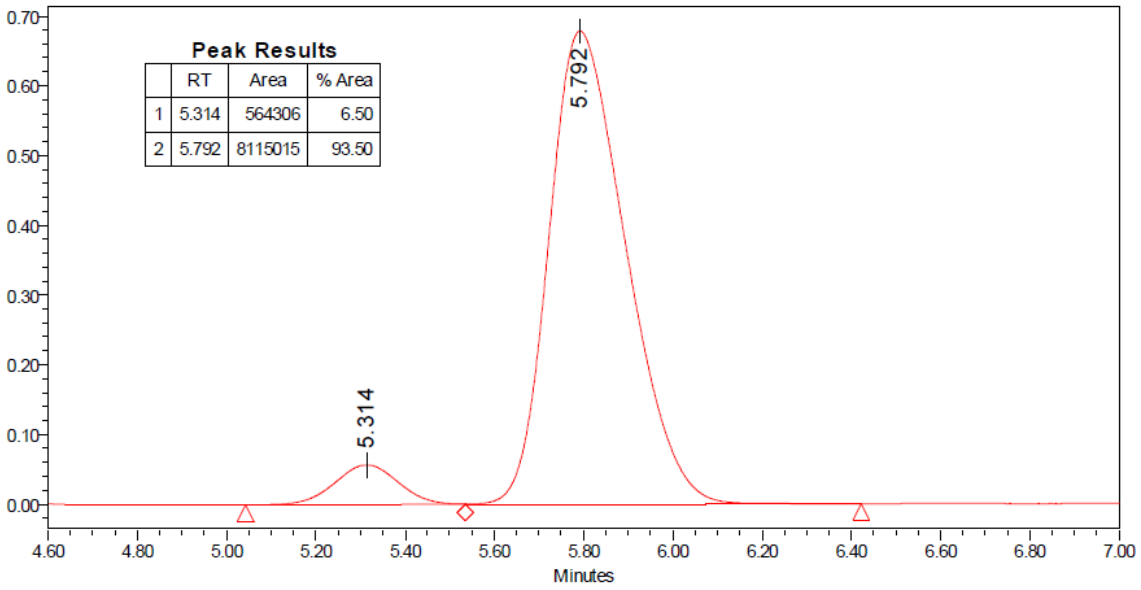
Enantioenriched **5j**



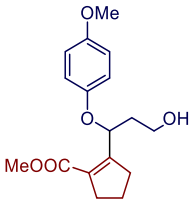


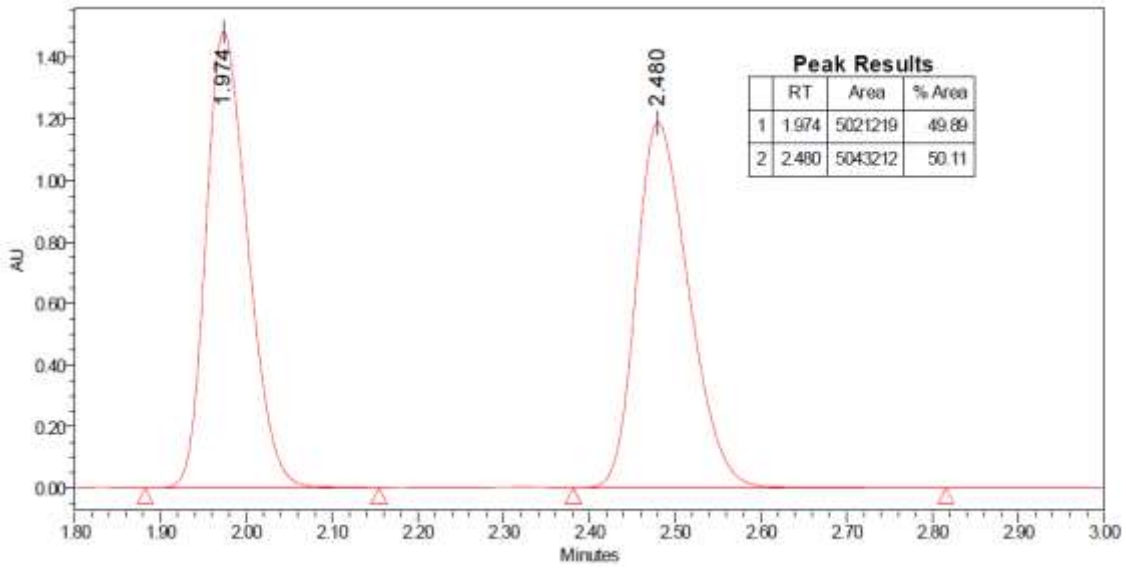
Racemic **5k**

Separation of enantiomers by SFC, Waters Trefoil AMY1 column, 40 ºC, *i*-PrOH:CO_2 = 5:95 (10 min), 2mL/min, 140 bar, major retention time: 5.7 min, minor retention time: 5.3 min.



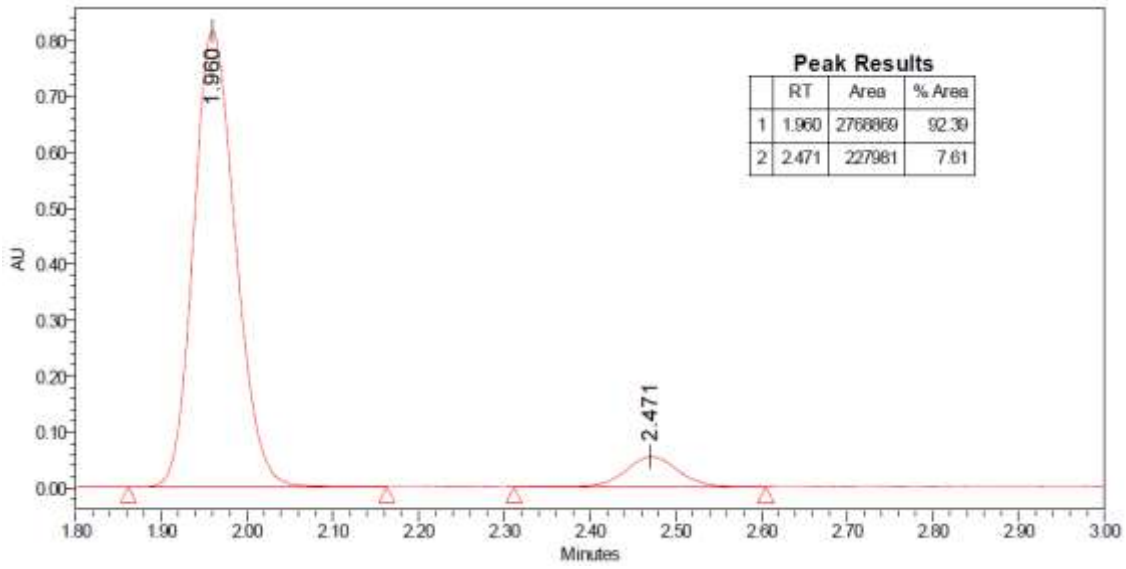
Enantioenriched **5k**



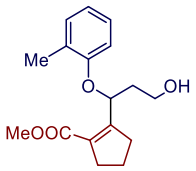


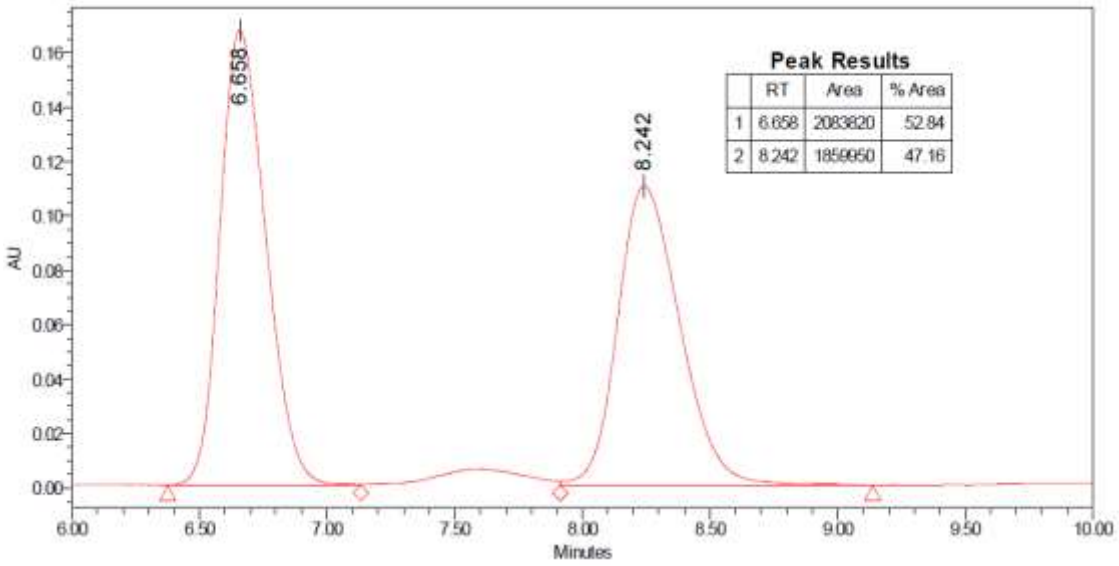
Racemic **5l**

Separation of enantiomers by SFC, Waters Trefoil Cel2 column, 40 °C, *i*-PrOH:CO_2 = 10:90 (5 min), 2mL/min, 140 bar, major retention time: 1.97 min, minor retention time: 2.48 min.



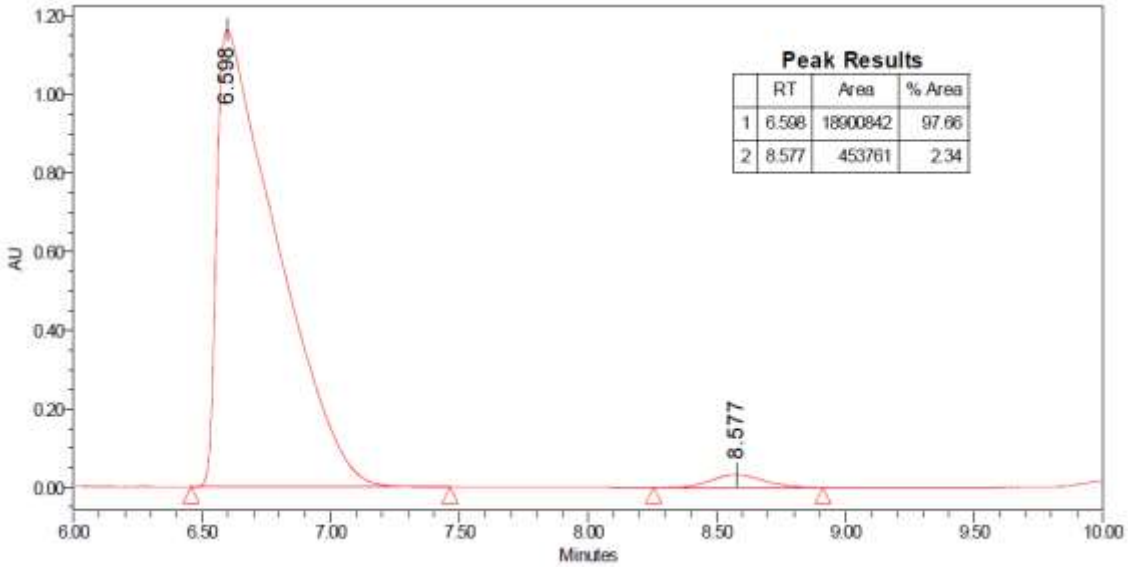
Enantioenriched **5l**



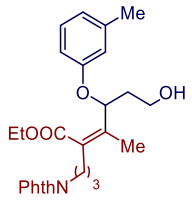


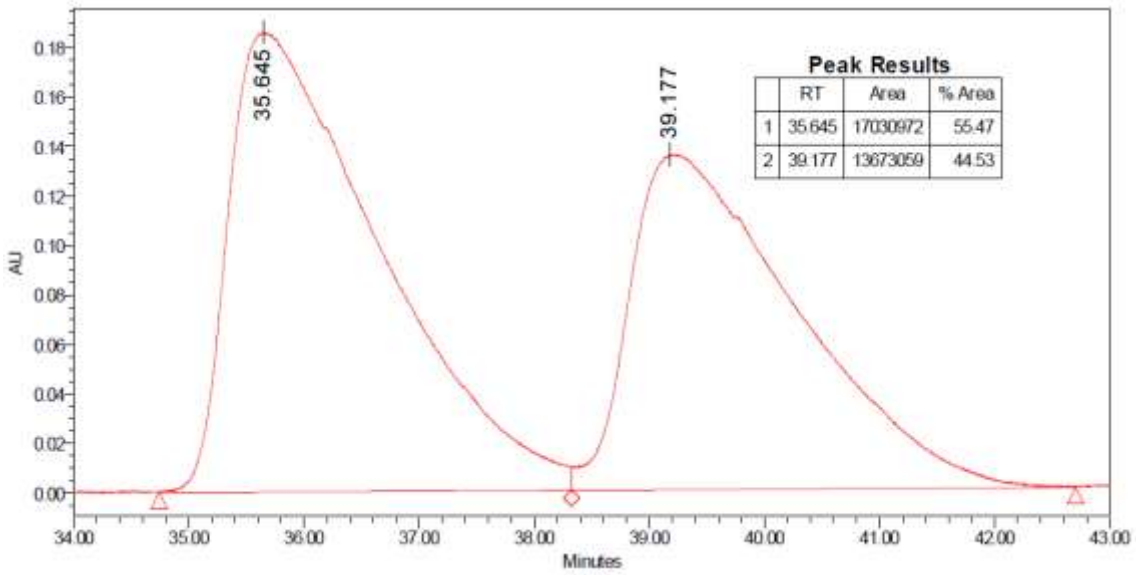
Racemic **5m**

Separation of enantiomers by SFC, Waters Trefoil Cel2 column, 40 ºC, *i*-PrOH:CO_2 = 2:98 (10 min), 2mL/min, 140 bar, major retention time: 6.56 min, minor retention time: 8.3 min.



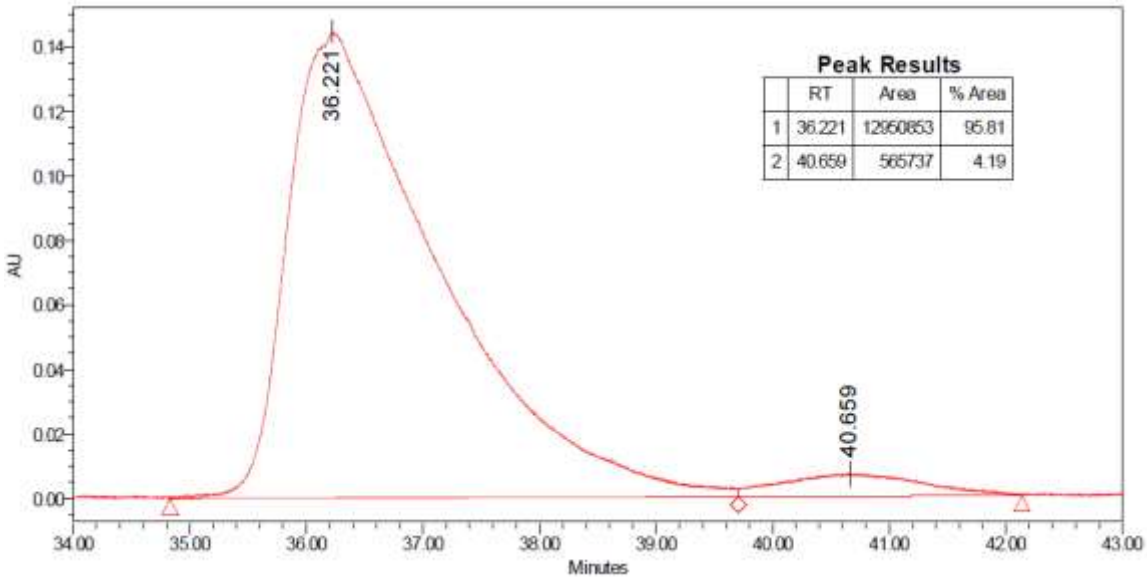
Enantioenriched **5m**



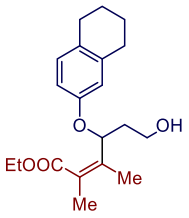


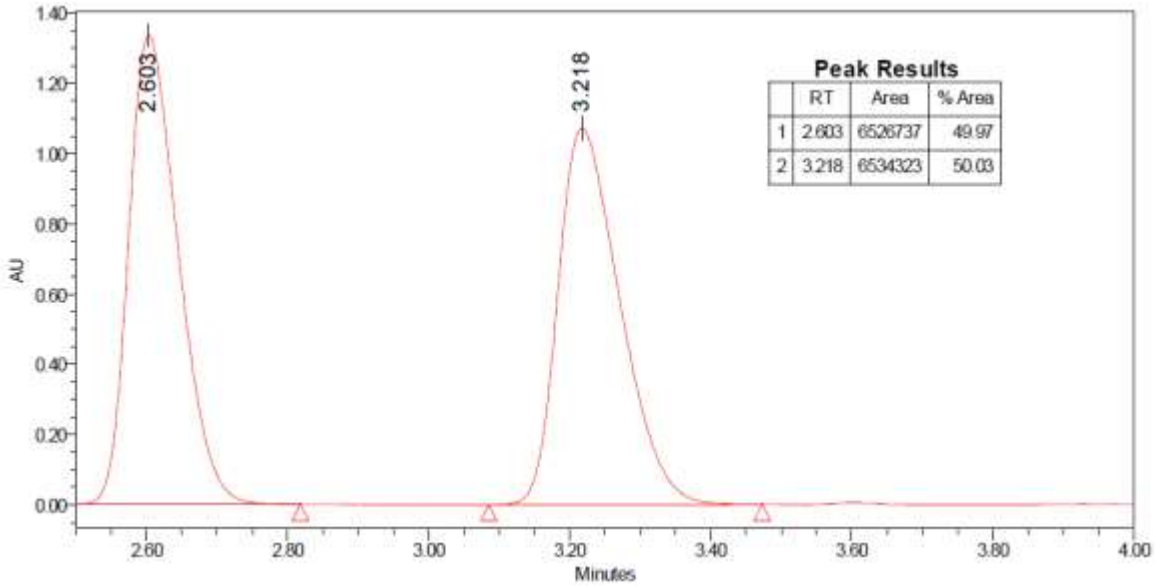
Racemic **5n**

Separation of enantiomers by SFC, Waters Trefoil Cel2 column, 40 ºC, *i*-PrOH:CO_2 = 5:95 (45 min), 2mL/min, 140 bar, major retention time: 35.6 min, minor retention time: 39.2 min.



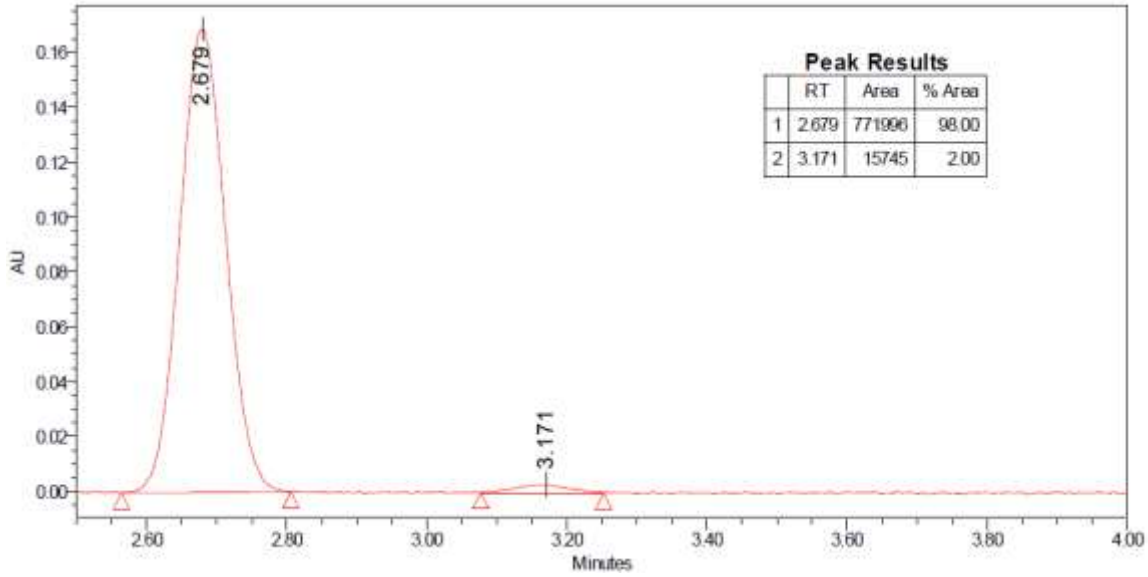
Enantioenriched **5n**



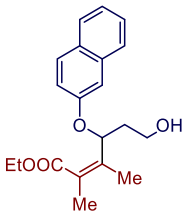


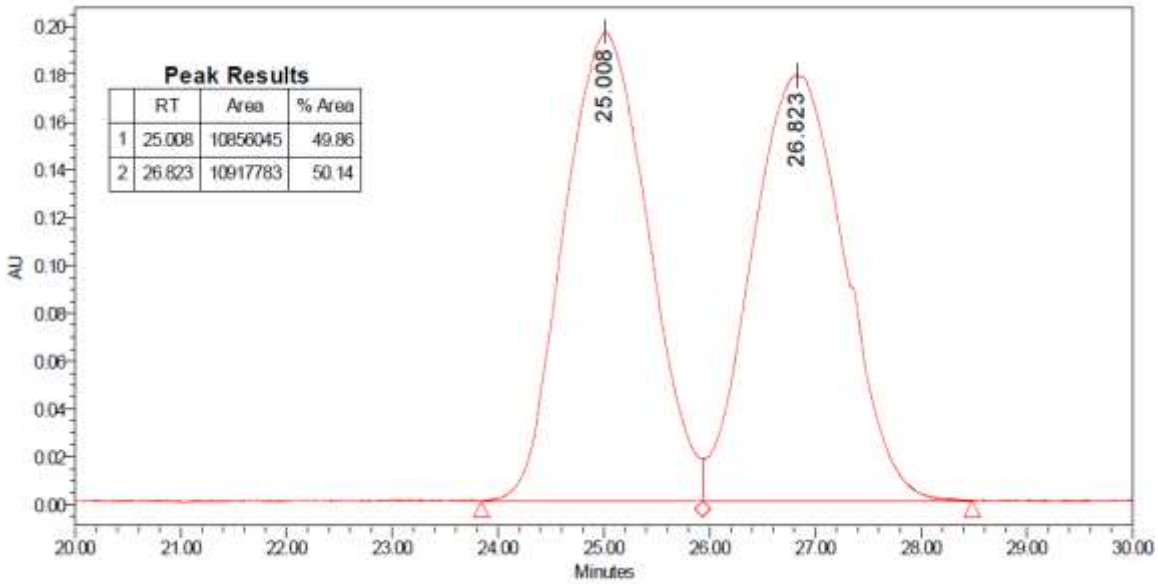
Racemic **5o**

Separation of enantiomers by SFC, Waters Trefoil Cel2 column, 40 ºC, *i*-PrOH:CO_2 = 10:90 (5 min), 2mL/min, 140 bar, major retention time: 2.6 min, minor retention time: 3.2 min.



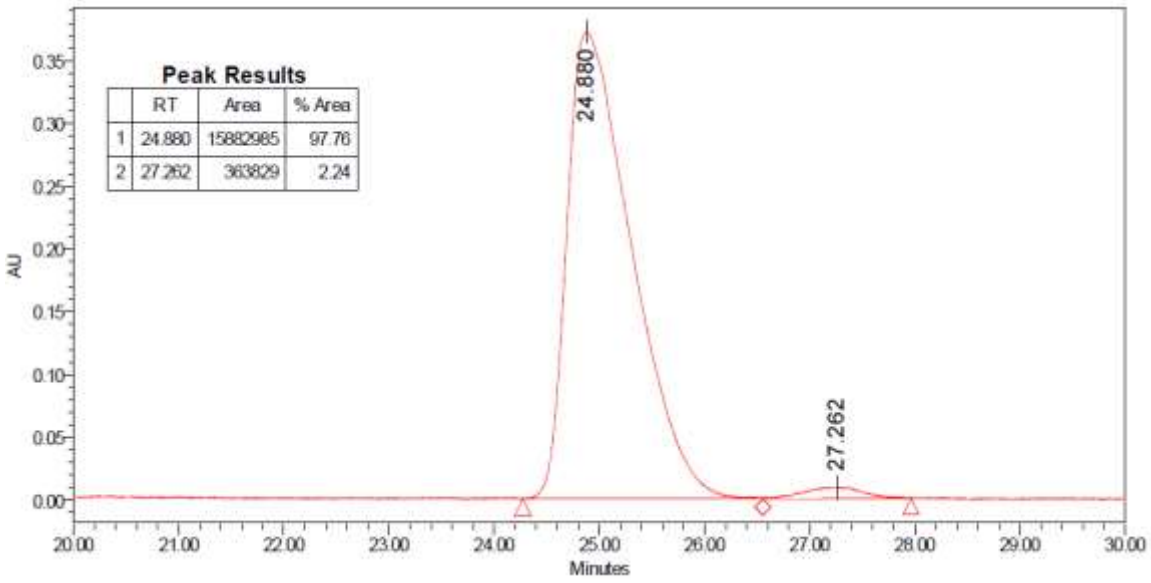
Enantioenriched **5o**



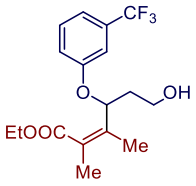


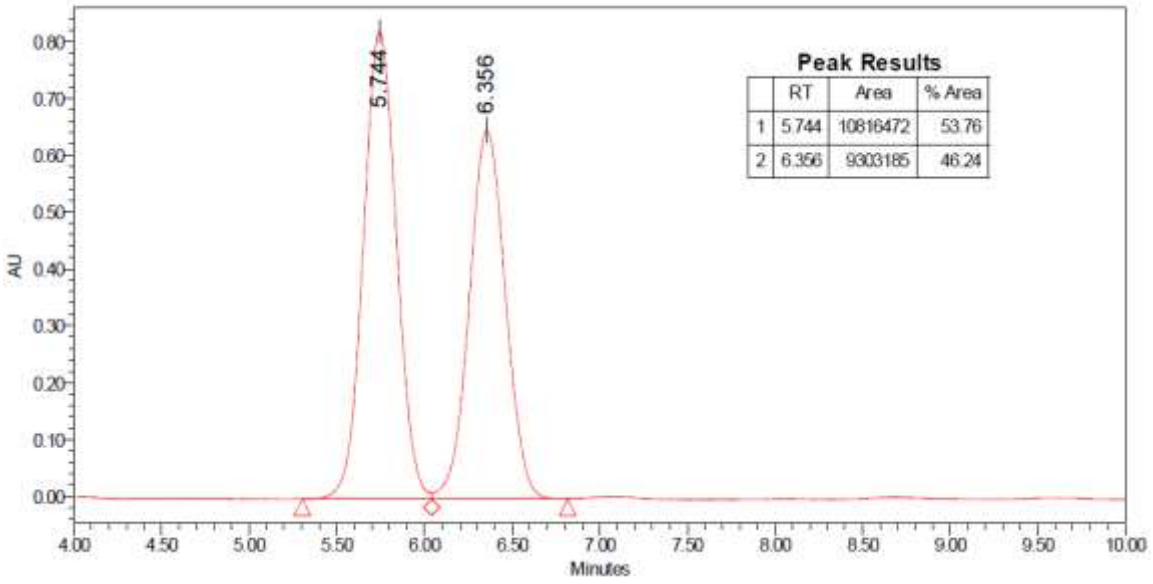
Racemic **5p**

Separation of enantiomers by SFC, Waters Trefoil Cel2 column, 40 °C, *i*-PrOH:CO_2 = 2:98 (30 min), 2mL/min, 140 bar, major retention time: 25 min, minor retention time: 27 min.



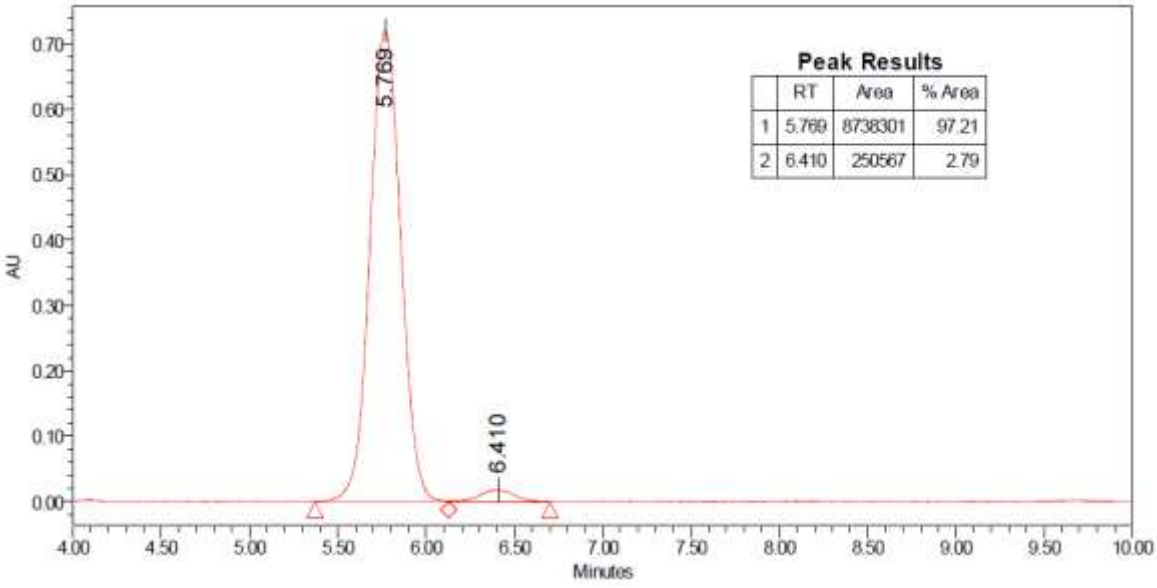
Enantioenriched **5p**



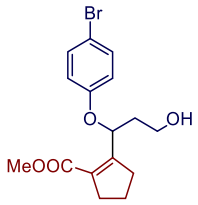


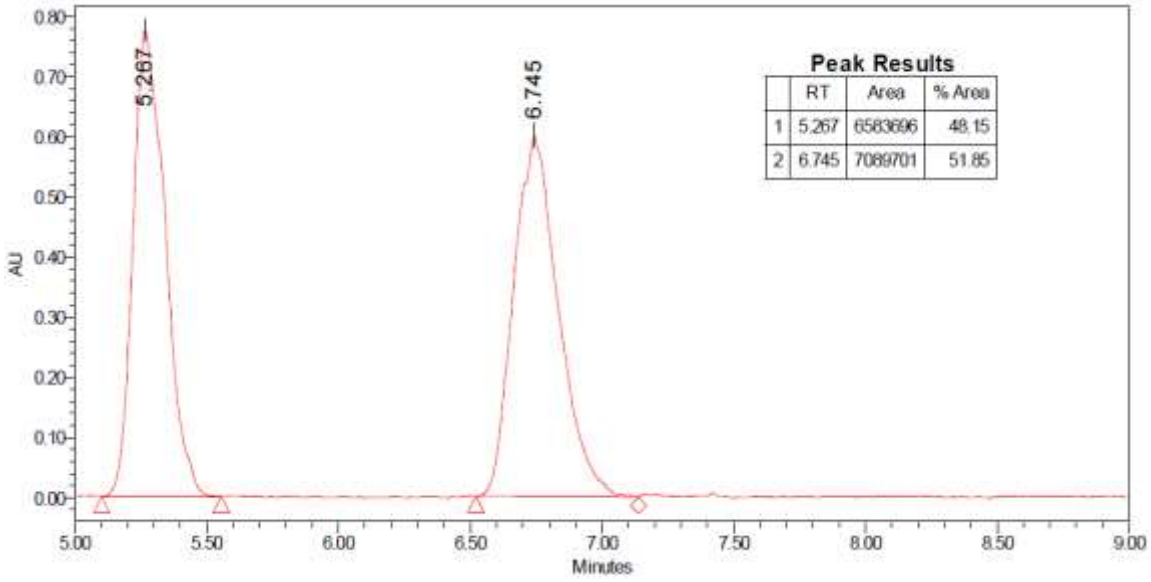
Racemic **5q**

Separation of enantiomers by SFC, Waters Trefoil Cel2 column, 40 ºC, *i*-PrOH:CO_2 = 4:96 (10 min), 2mL/min, 140 bar, major retention time: 5.7 min, minor retention time: 6.4 min.



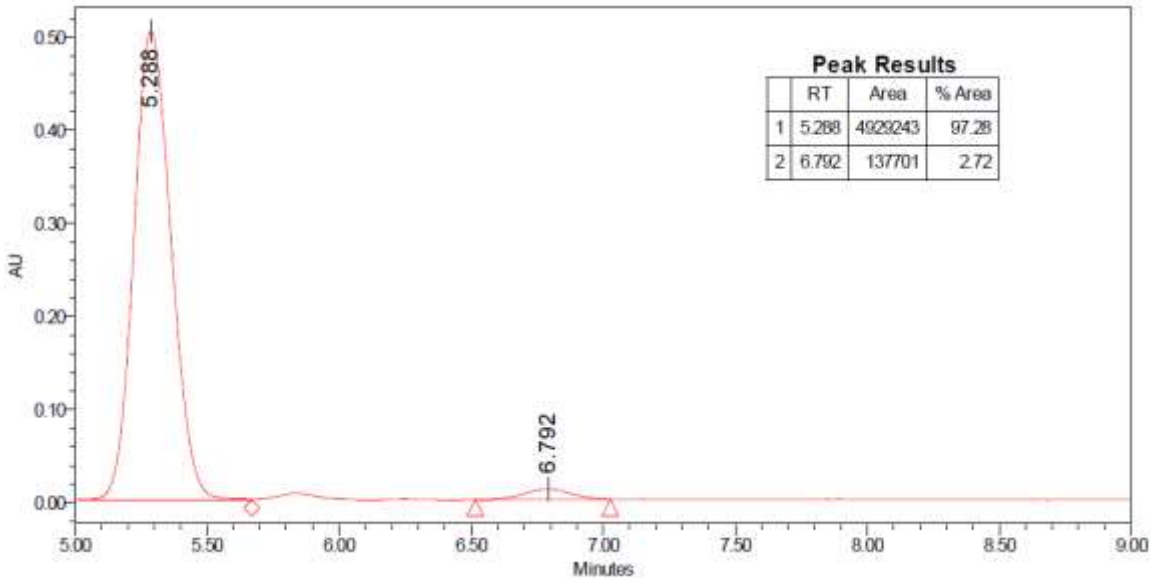
Enantioenriched **5q**



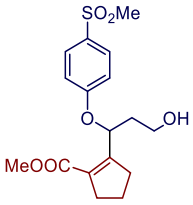


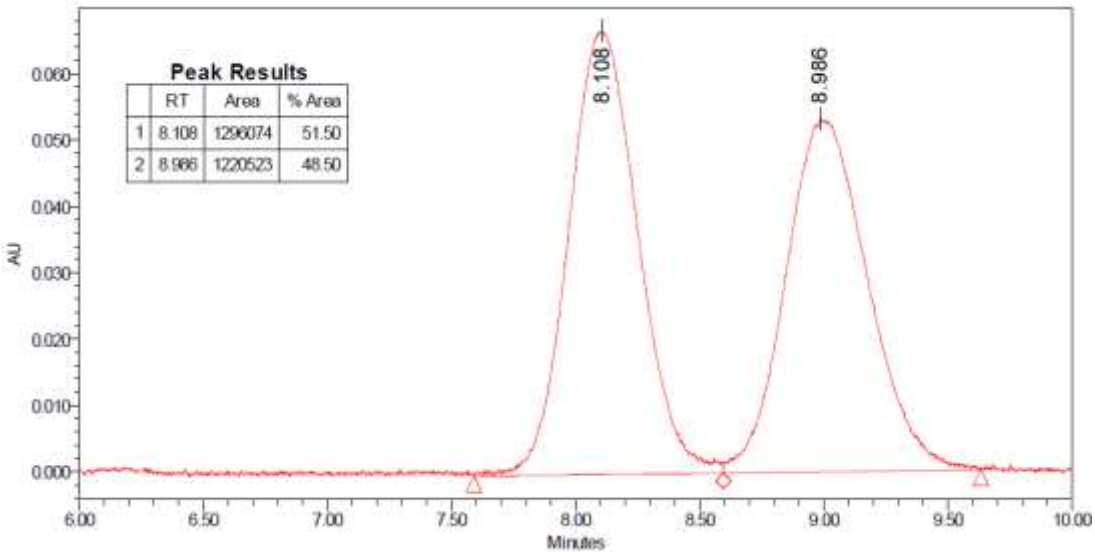
Racemic **5r**

Separation of enantiomers by SFC, Waters Trefoil Cel2 column, 40 °C, *i*-PrOH:CO_2 = 5:95 (10 min), 2mL/min, 140 bar, major retention time: 5.3 min, minor retention time: 6.8 min.



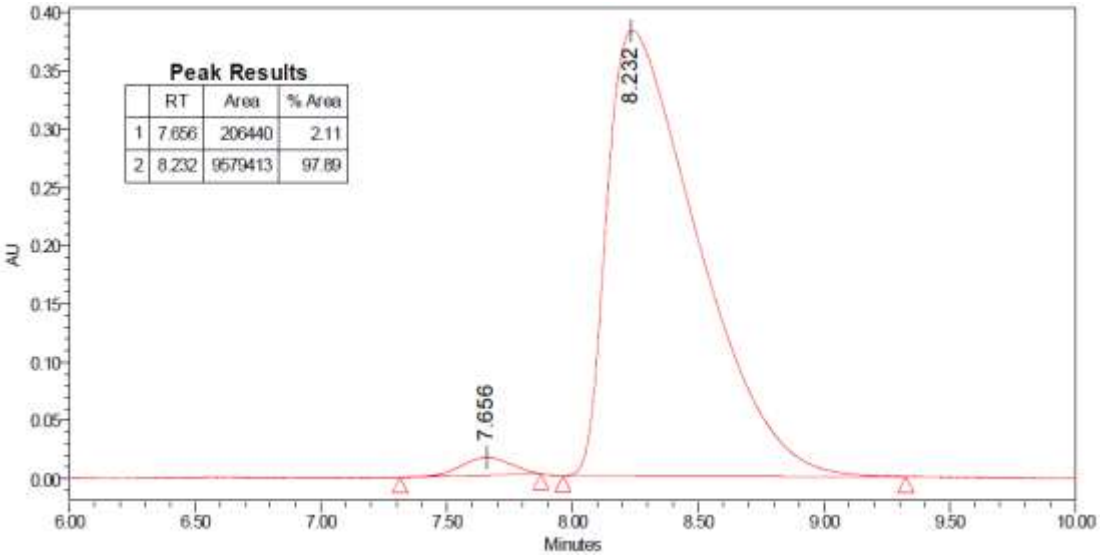
Enantioenriched **5r**



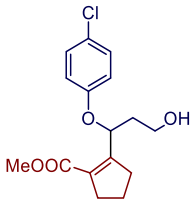


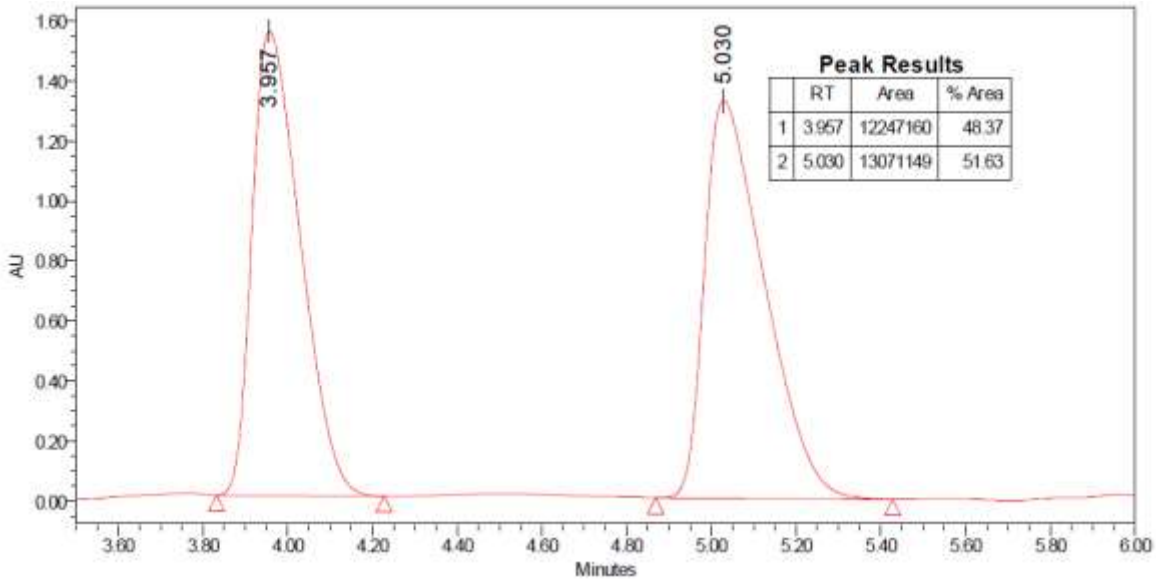
Racemic **5s**

Separation of enantiomers by SFC, Waters Trefoil Cel2 column, 40 ºC, MeOH:CO_2 = 5:98 (10 min), 2mL/min, 140 bar, major retention time: 8.2 min, minor retention time: 7.7 min.



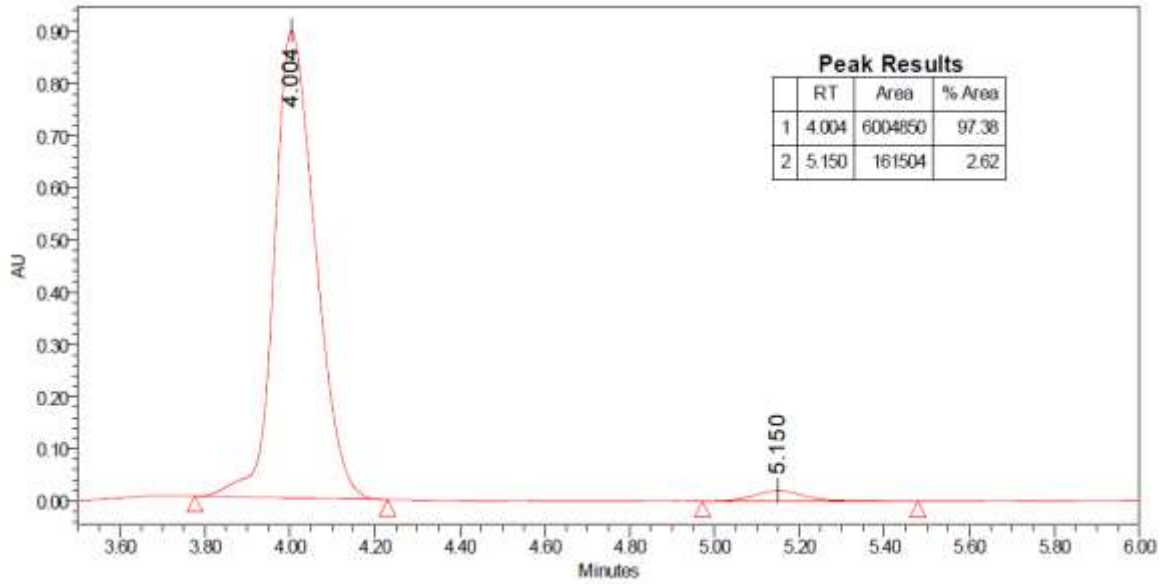
Enantioenriched **5s**



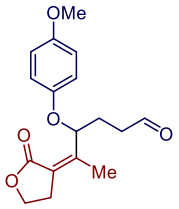


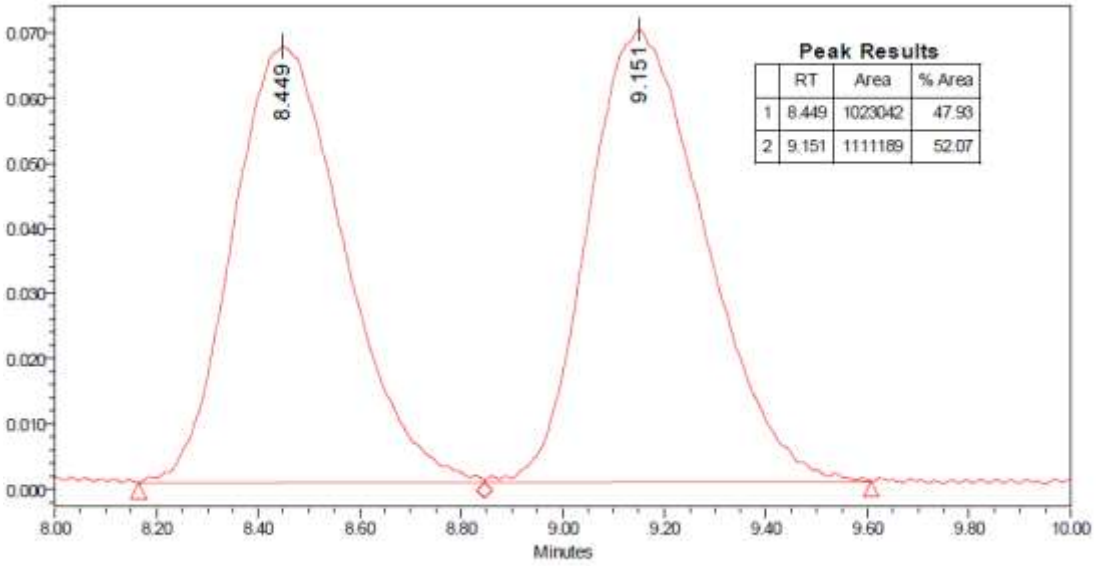
Racemic **5t**

Separation of enantiomers by SFC, Waters Trefoil Cel2 column, 40 °C, *i*-PrOH:CO_2 = 5:95 (10 min), 2mL/min, 140 bar, major retention time: 4 min, minor retention time: 5 min.



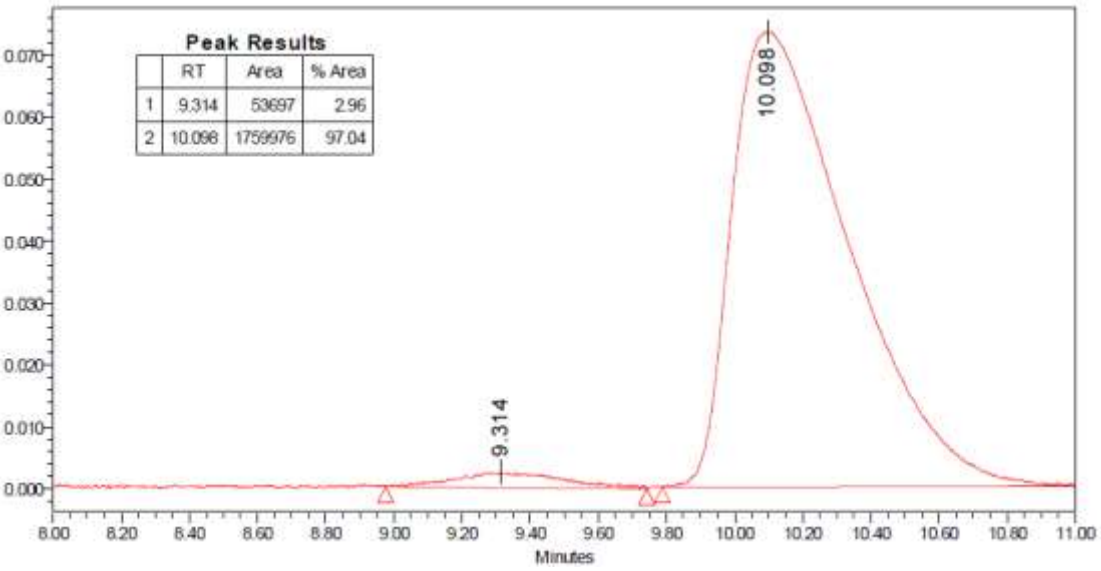
Enantioenriched **5t**



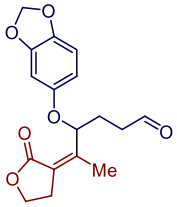


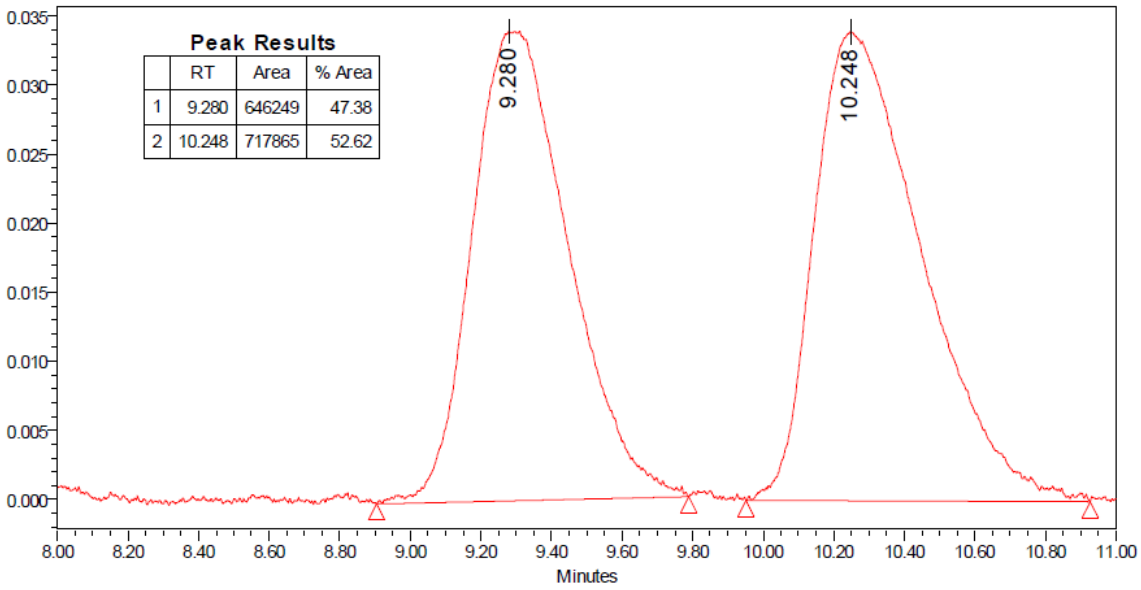
Racemic **3u**

Separation of enantiomers by SFC, Waters Trefoil Cel1 column, 40 ºC, *i*-PrOH:CO_2 = 8:92 (15 min), 2mL/min, 140 bar, major retention time: 10.0 min, minor retention time: 9.3 min.



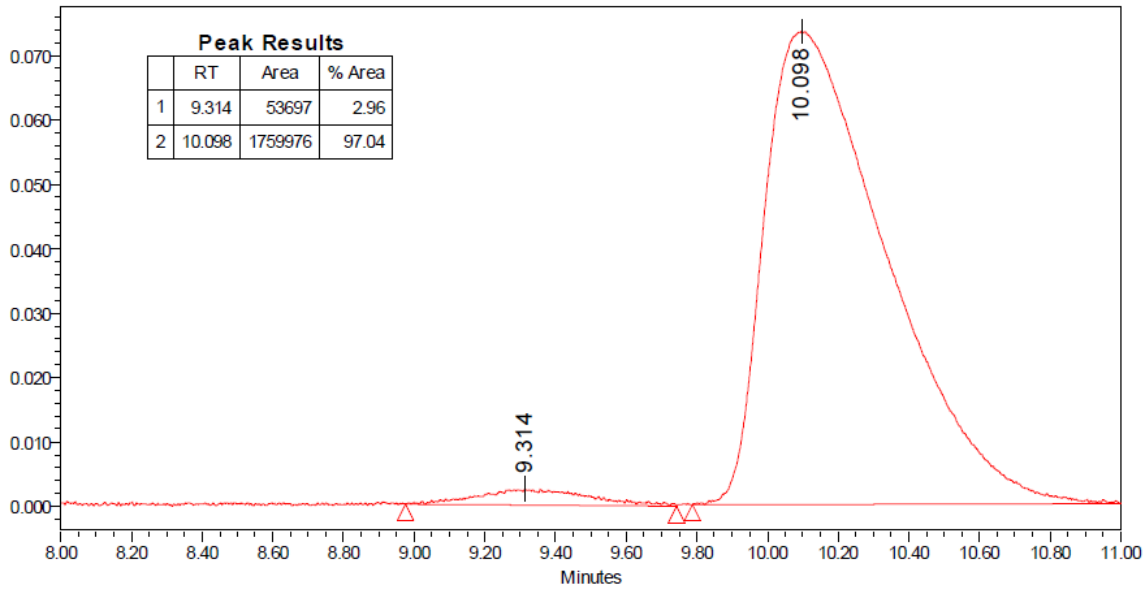
Enantioenriched **3u**



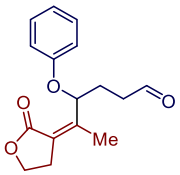


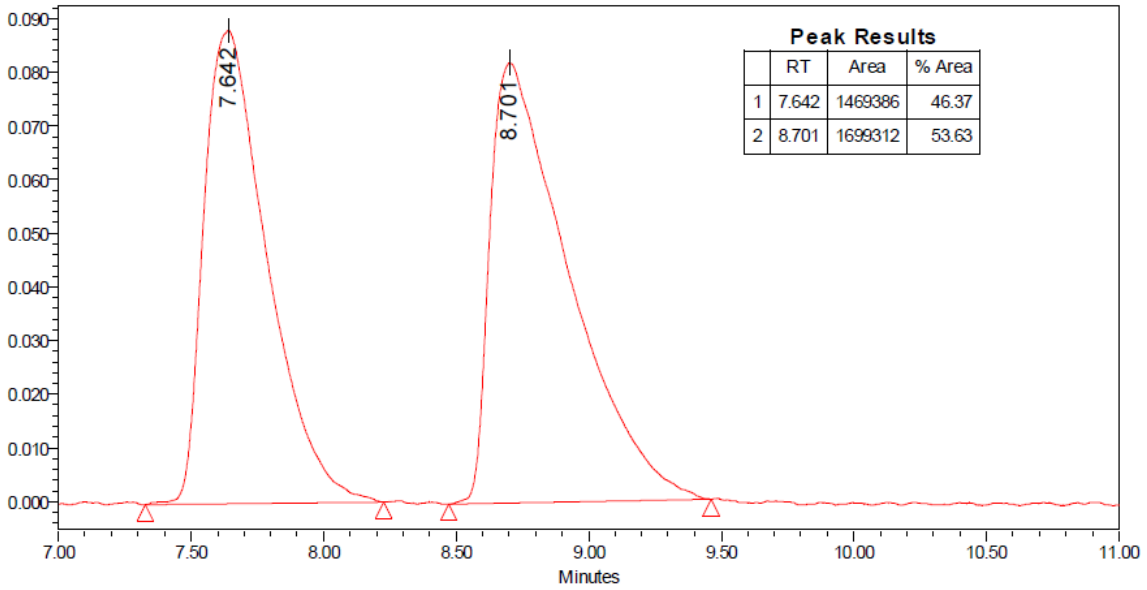
Racemic **3v**

Separation of enantiomers by SFC, Waters Trefoil Cel1 column, 40 ºC, *i*-PrOH:CO_2 = 5:95 (15 min), 3mL/min, 140 bar, major retention time: 10.0 min, minor retention time: 9.1 min.



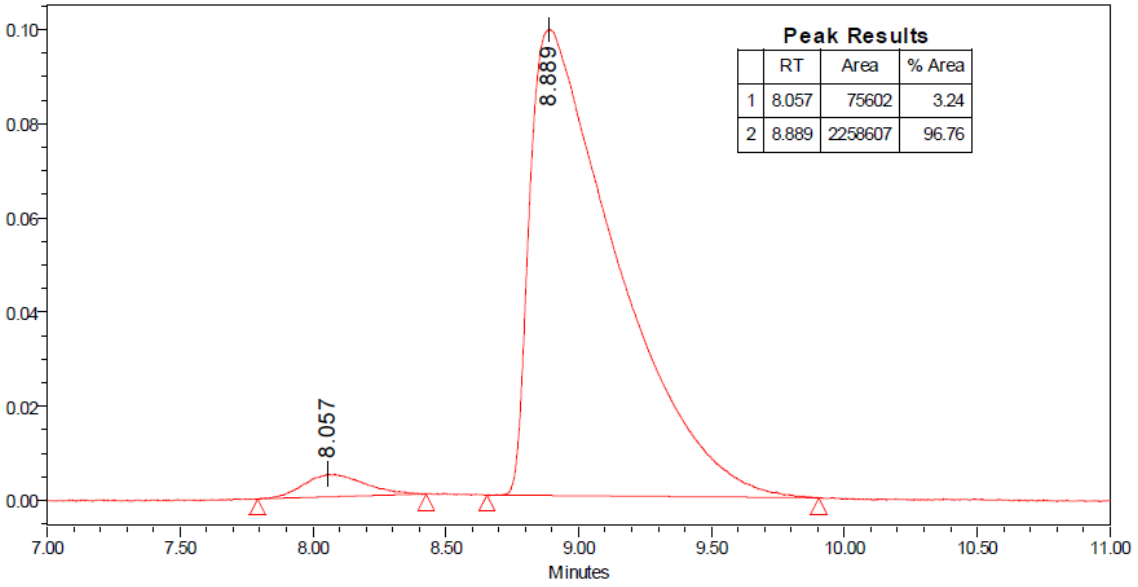
Enantioenriched **3v**



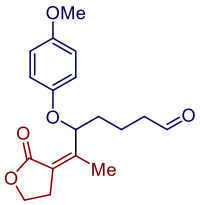


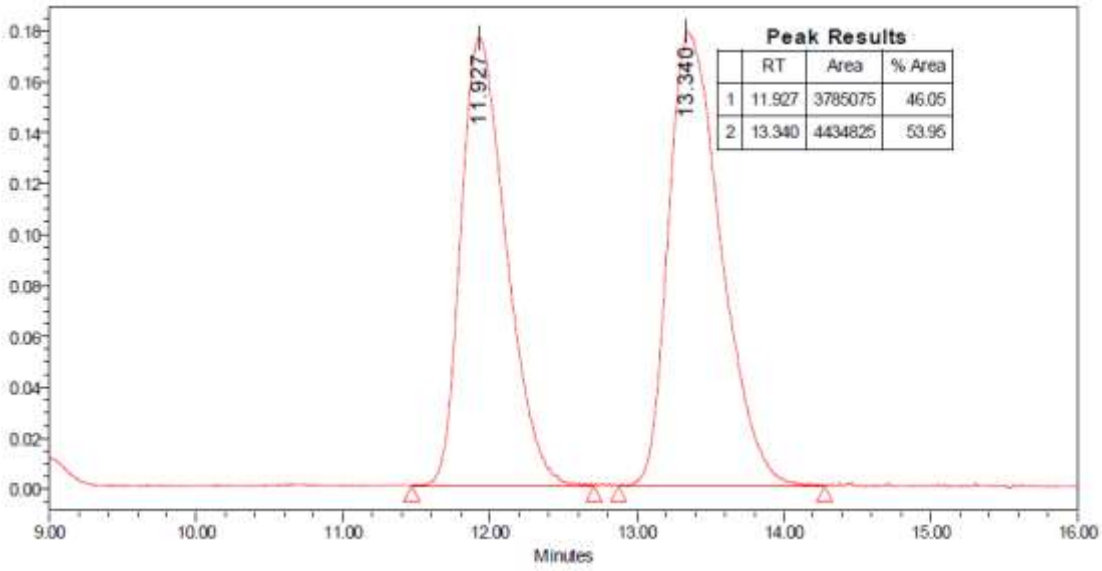
Racemic **3w**

Separation of enantiomers by SFC, Waters Trefoil Cel1 column, 40 °C, *i*-PrOH:CO_2 = 5:95 (20 min), 3mL/min, 140 bar, major retention time: 8.0 min, minor retention time: 8.8 min.



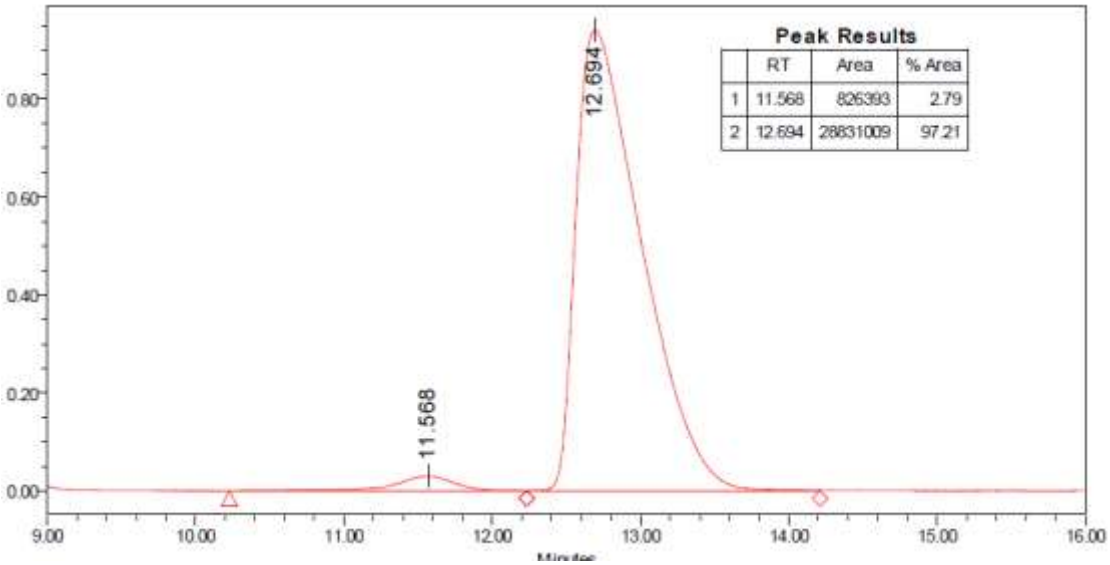
Enantioenriched **3w**



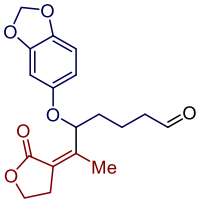


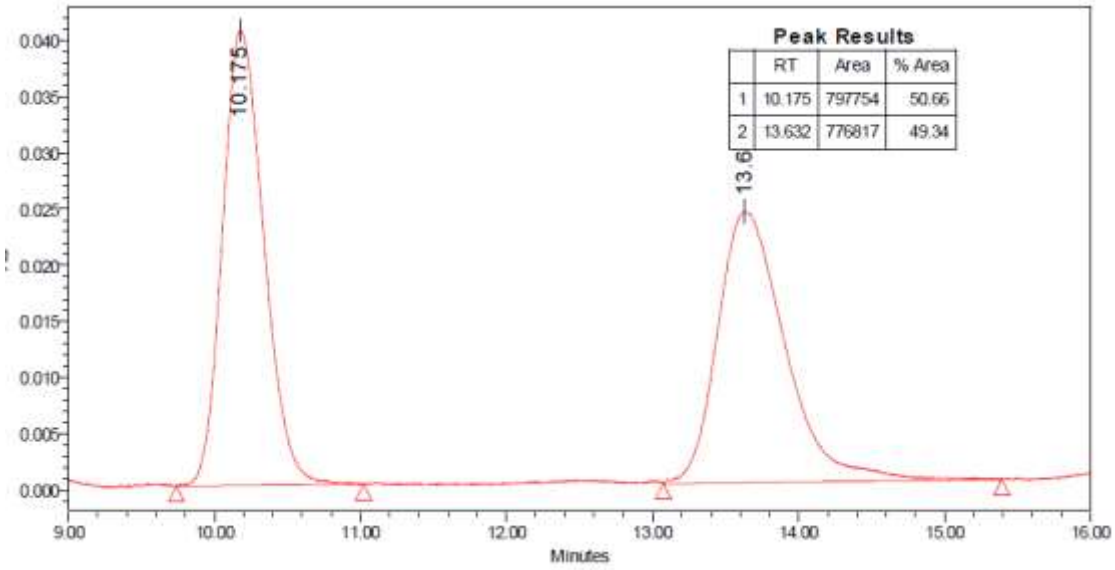
Racemic **3x**

Separation of enantiomers by SFC, Waters Trefoil AMY1 column, 40 ºC, *i*-PrOH:CO_2 = 8:92 (25 min), 2mL/min, 140 bar, major retention time: 12.6 min, minor retention time: 11.5 min.



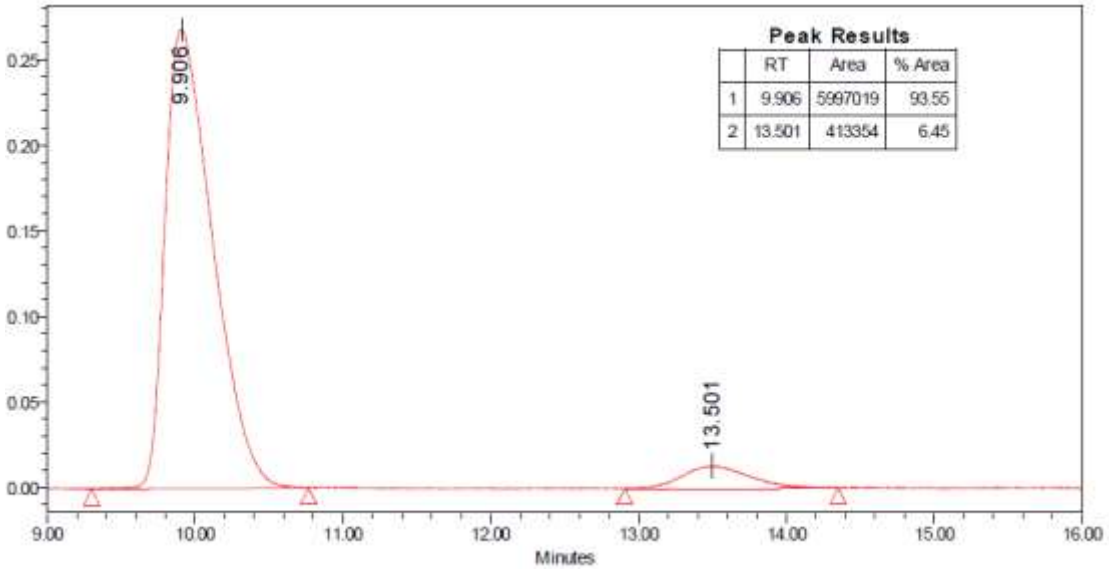
Enantioenriched **3x**



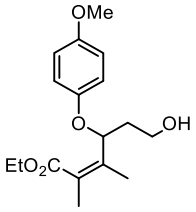


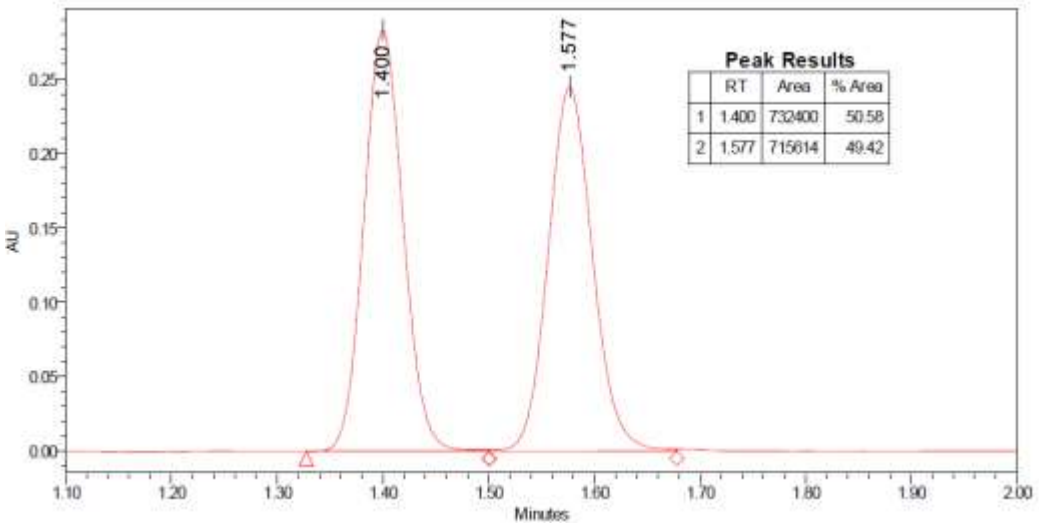
Racemic **3y**

Separation of enantiomers by SFC, Waters Trefoil AMY1 column, 40 °C, *i*-PrOH:CO_2 = 5:95 (25 min), 2mL/min, 140 bar, major retention time: 9.9 min, minor retention time: 13.5 min.



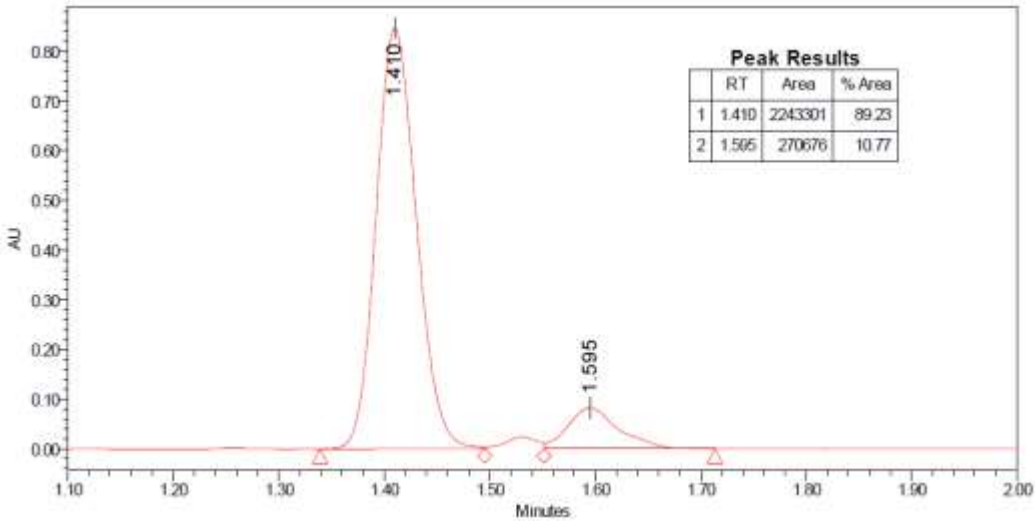
Enantioenriched **3y**



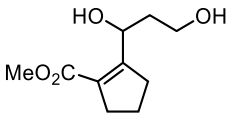


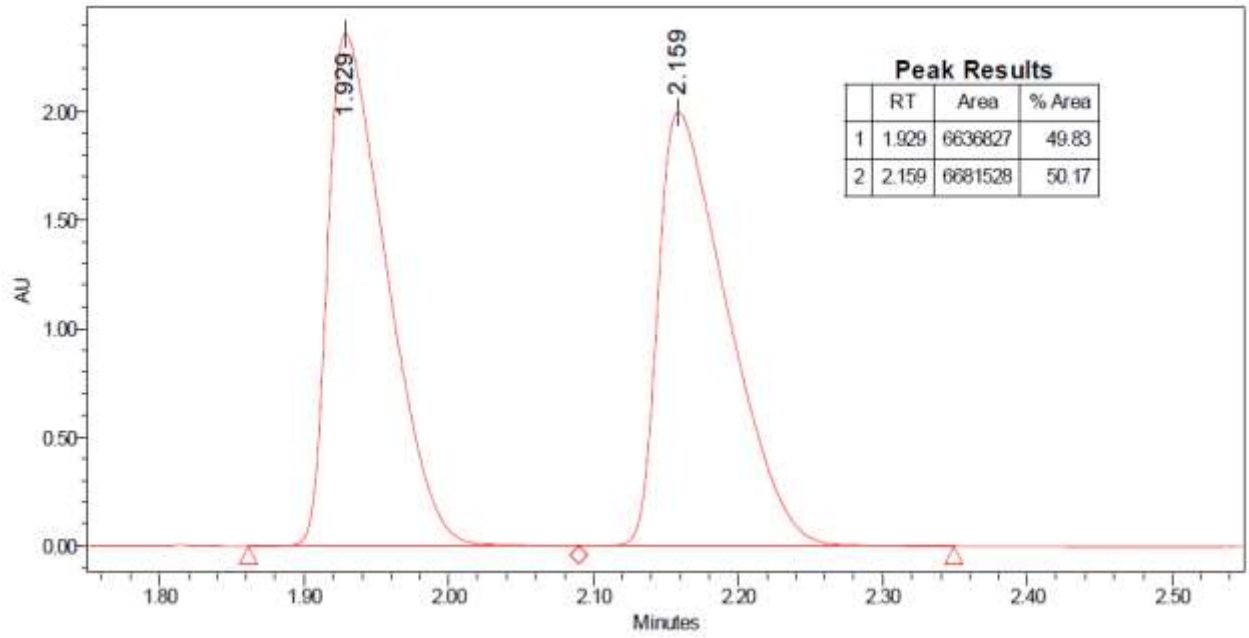
Racemic **5u**

Separation of enantiomers by SFC, Waters Trefoil Cel2 column, 40 ºC, *i*-PrOH:CO_2 = 5:95 (10 min), 2mL/min, 140 bar, major retention time: 1.4 min, minor retention time: 1.6 min.



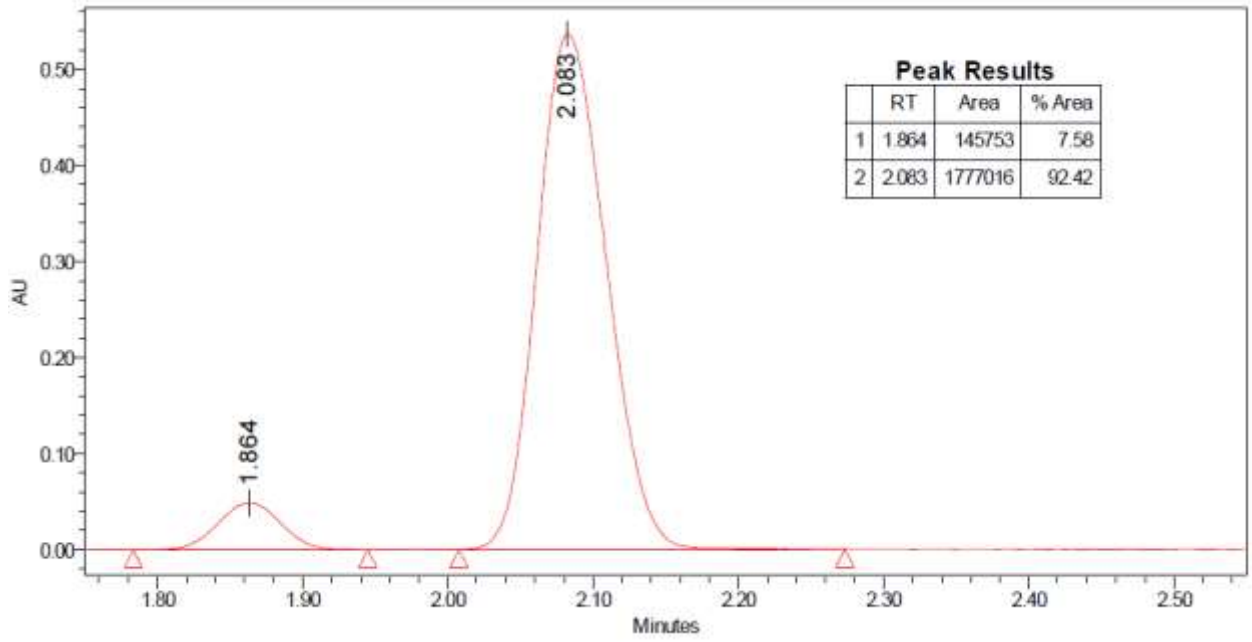
Enantioenriched 5u



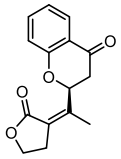


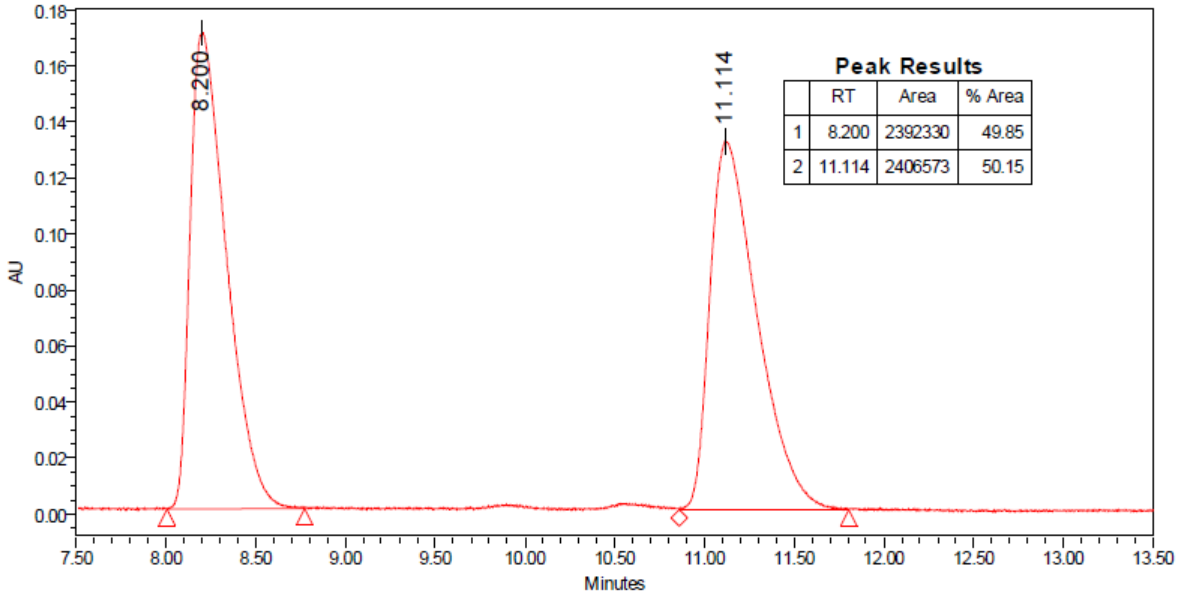
Racemic **6a**

Separation of enantiomers by SFC, Waters Trefoil Cel2 column, 40 ºC, MeOH:CO_2 = 10:90 (5 min), 2mL/min, 140 bar, major retention time: 2.1 min, minor retention time: 1.9 min.



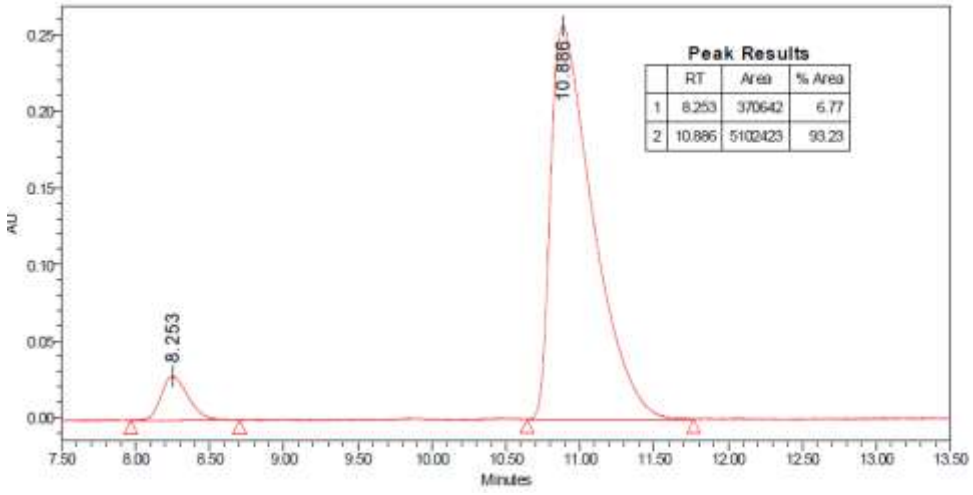
Enantioenriched **6a**





Racemic **7**

Separation of enantiomers by SFC, Waters Trefoil Cel2 column, 40 ºC, *i*-PrOH:CO_2 = 10:90 (15 min), 2mL/min, 140 bar, major retention time: 11 min, minor retention time: 8 min.



Enantioenriched **7**

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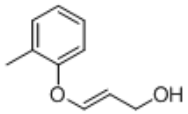
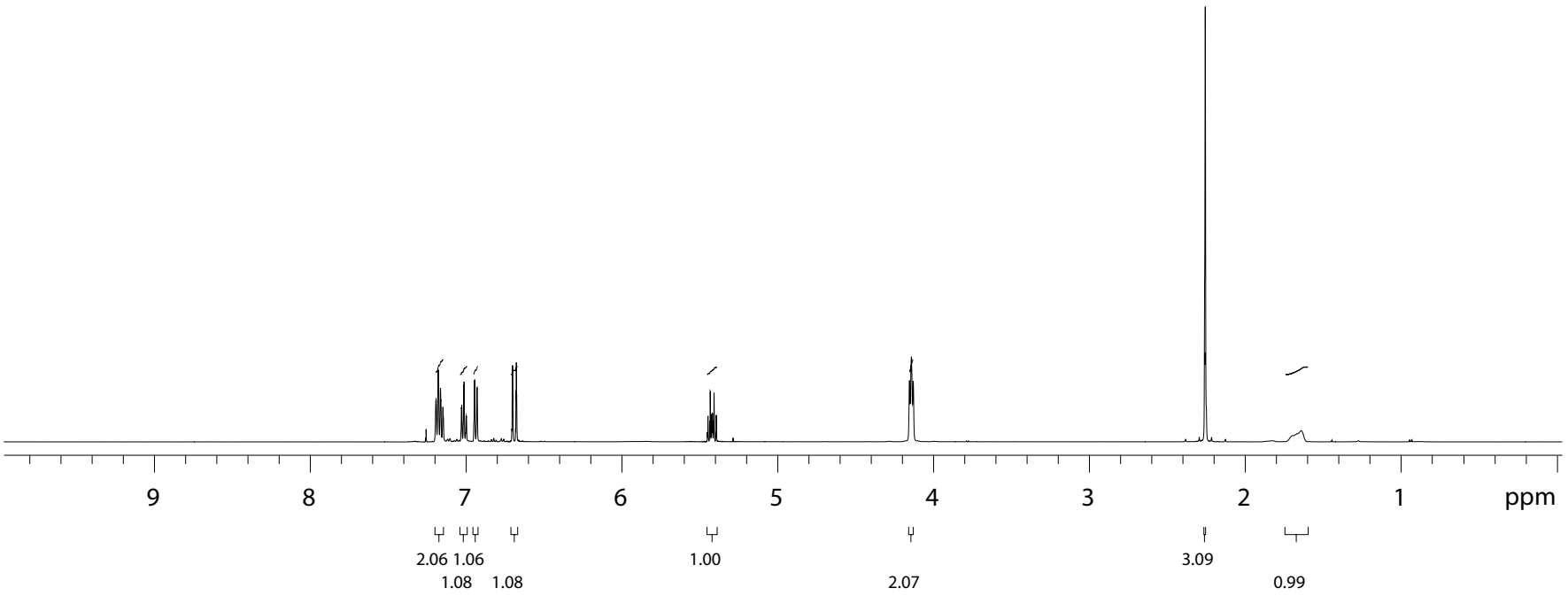
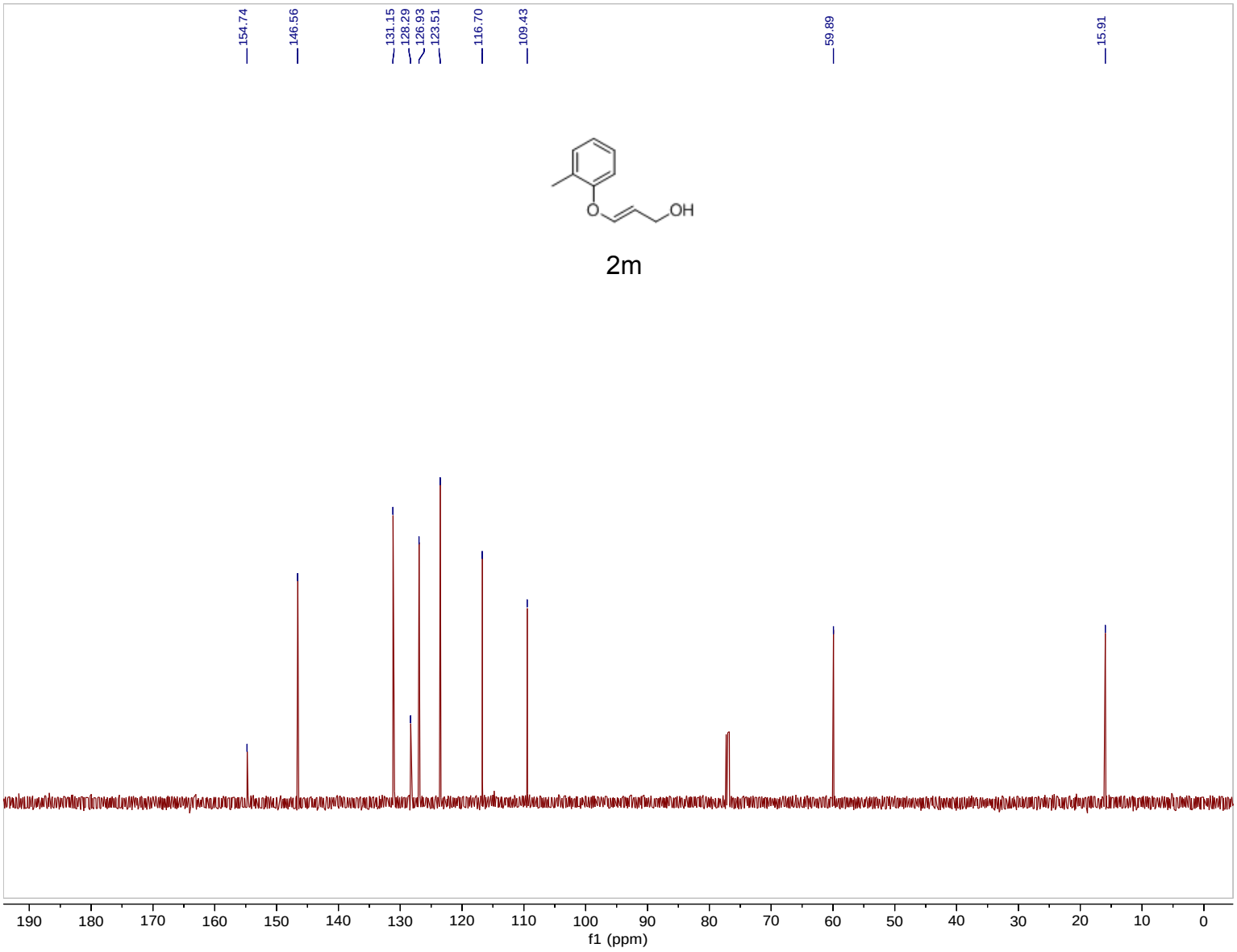
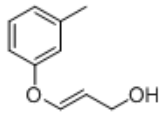


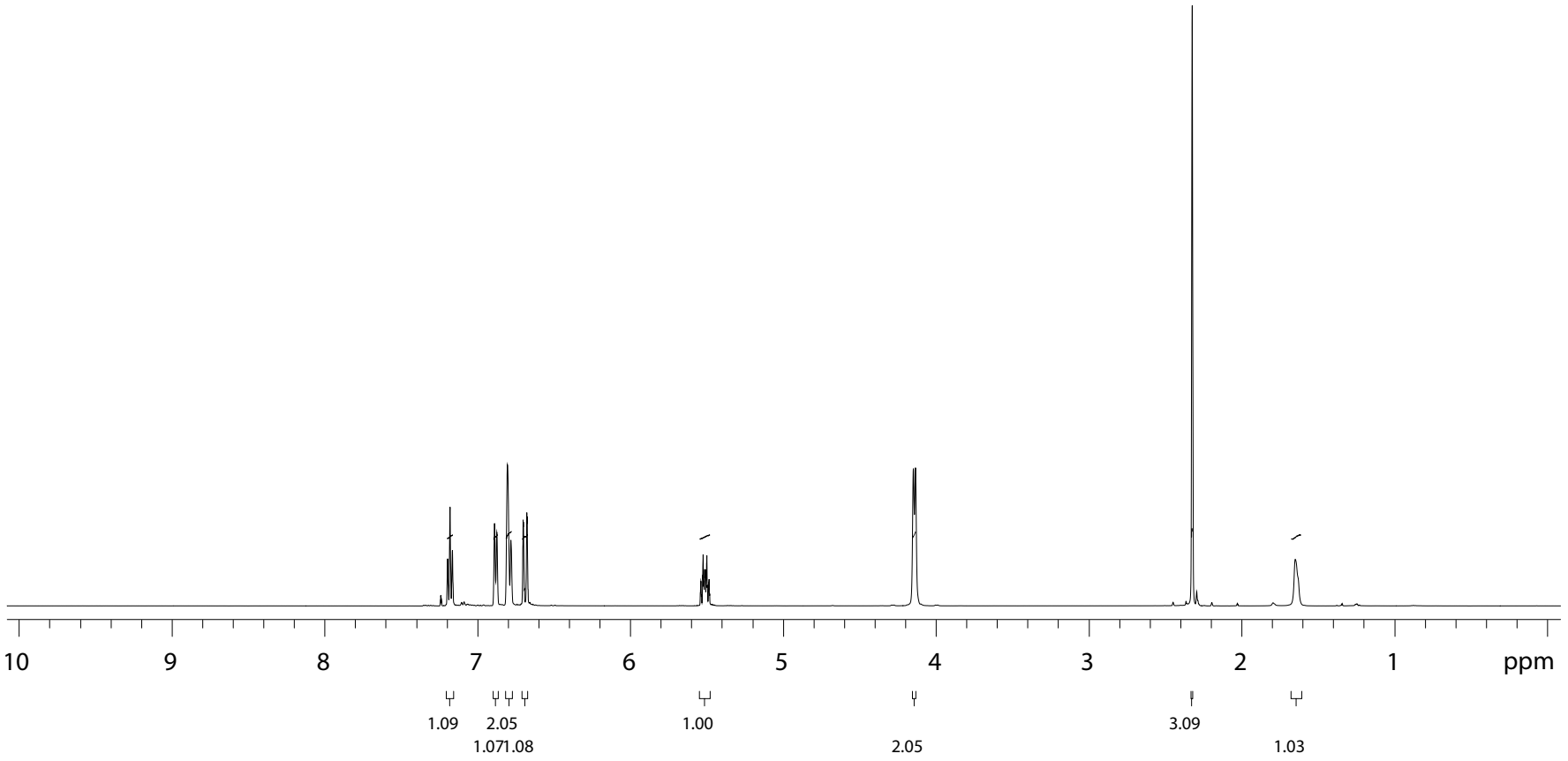
2m

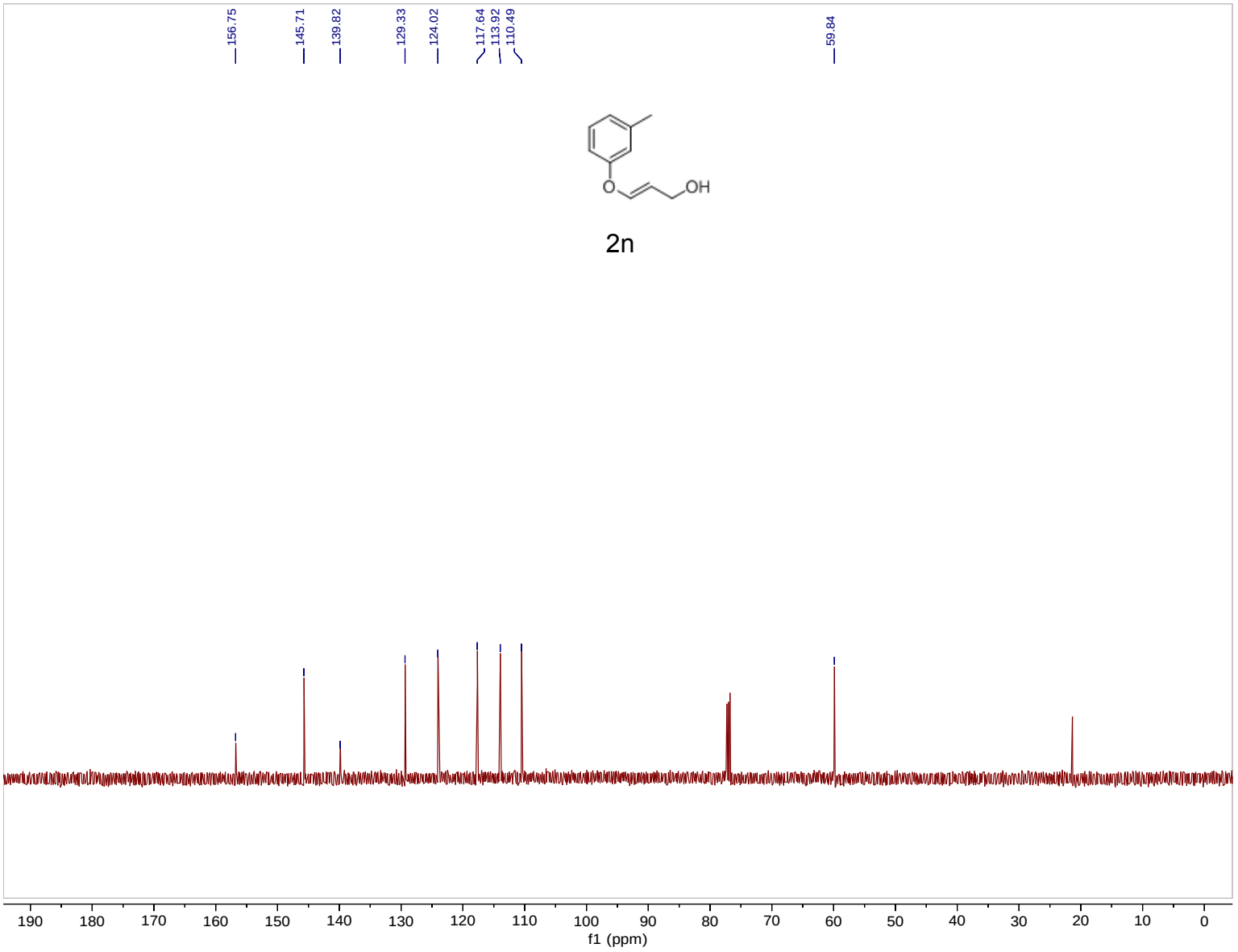


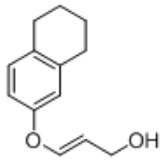

154.74
146.56
131.15
128.29
126.93
123.51
116.70
109.43
59.89
15.91
OH
2m
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)



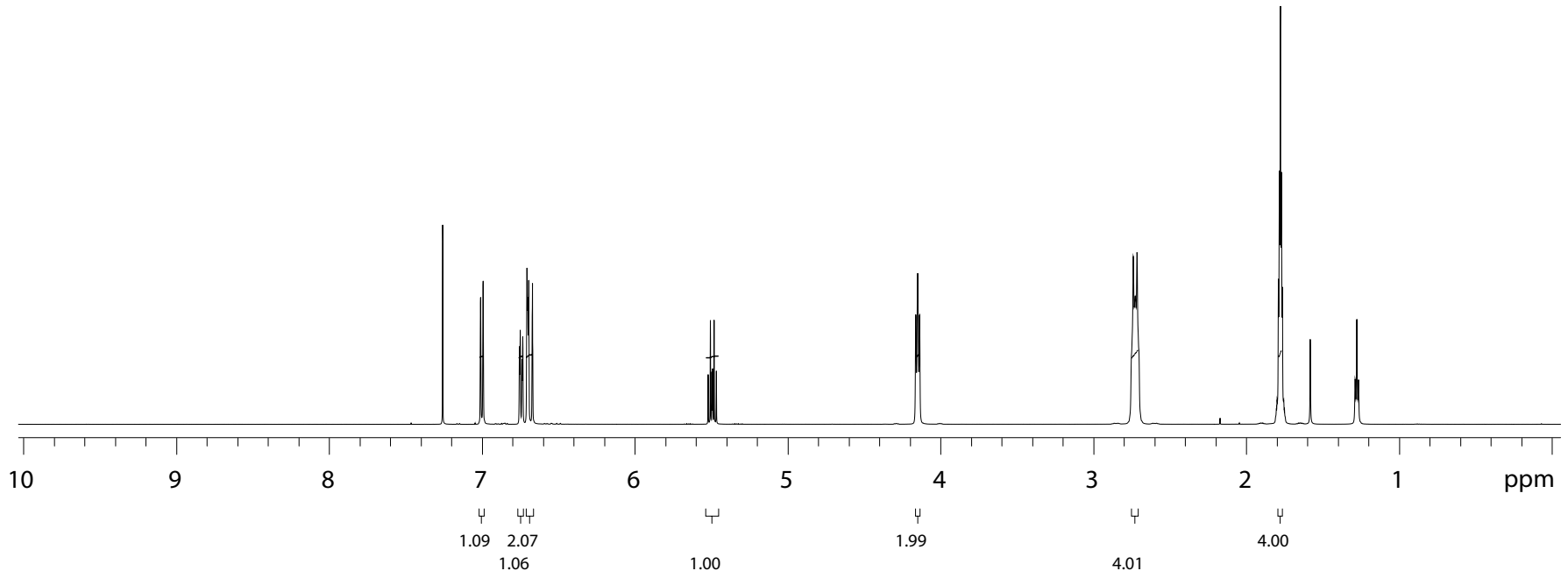
2n

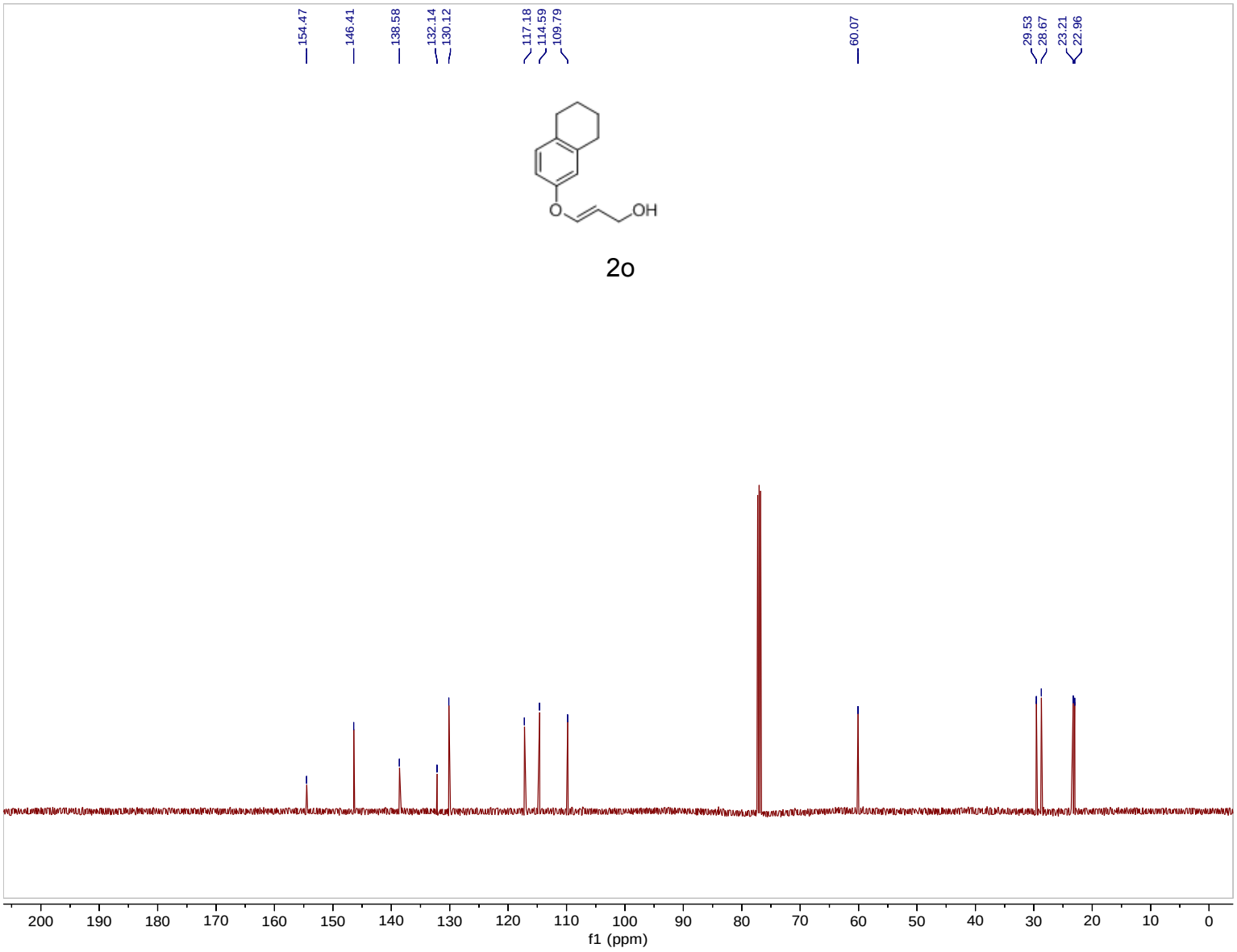


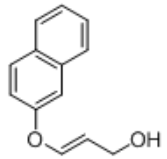

156.75
145.71
139.82
129.33
124.02
117.64
113.92
110.49
59.84
O
OH
2n
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)



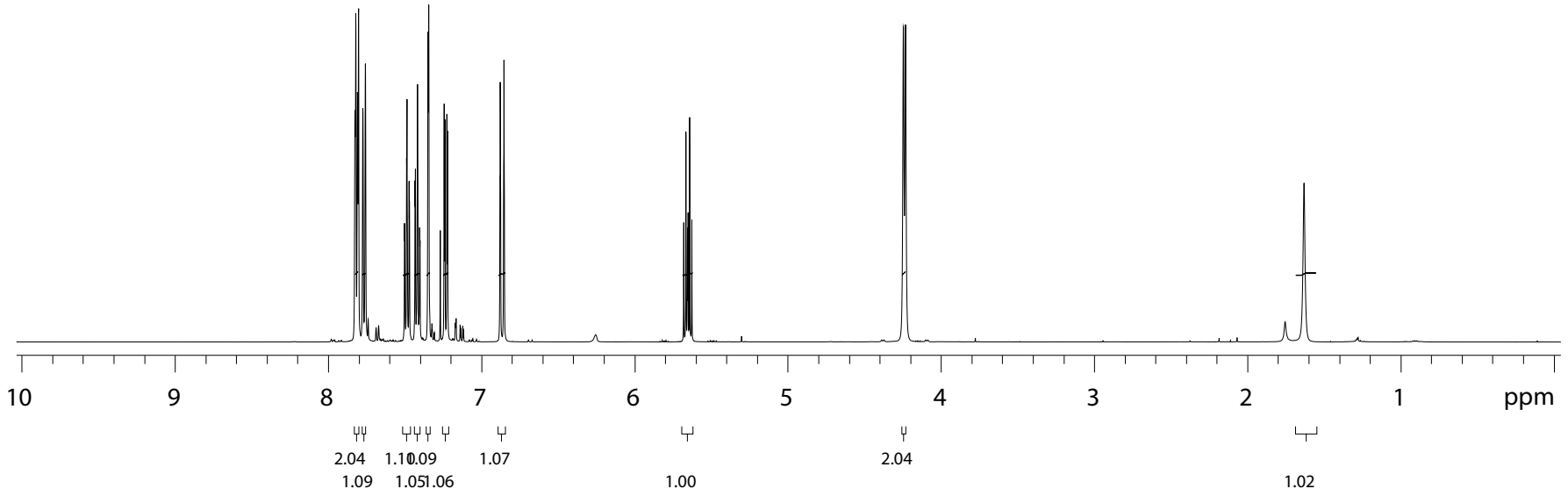
2o

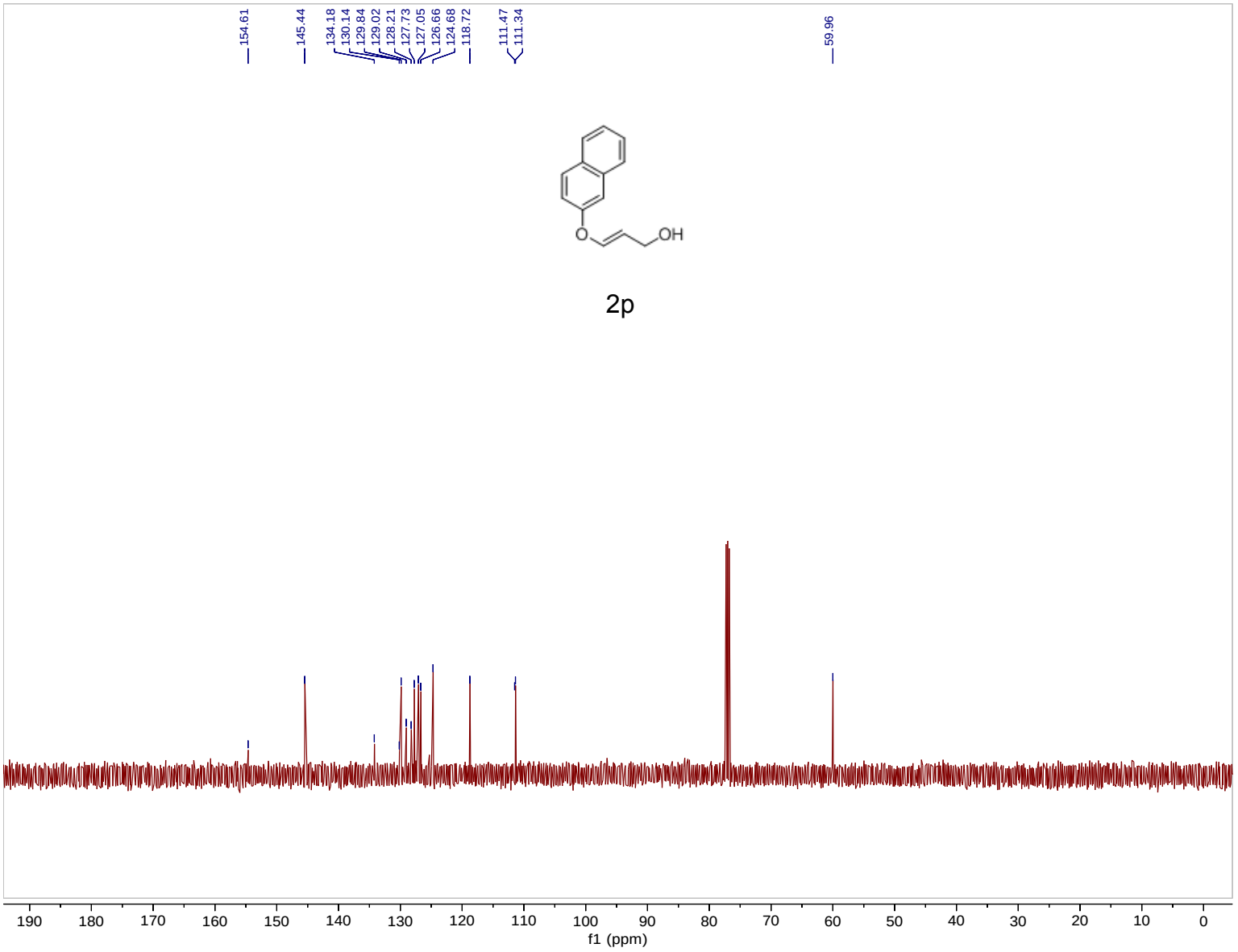


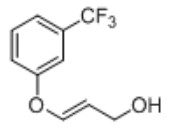

154.47
146.41
138.58
132.14
130.12
117.18
114.59
109.79
60.07
29.53
28.67
23.21
22.96
O
OH
2o
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)



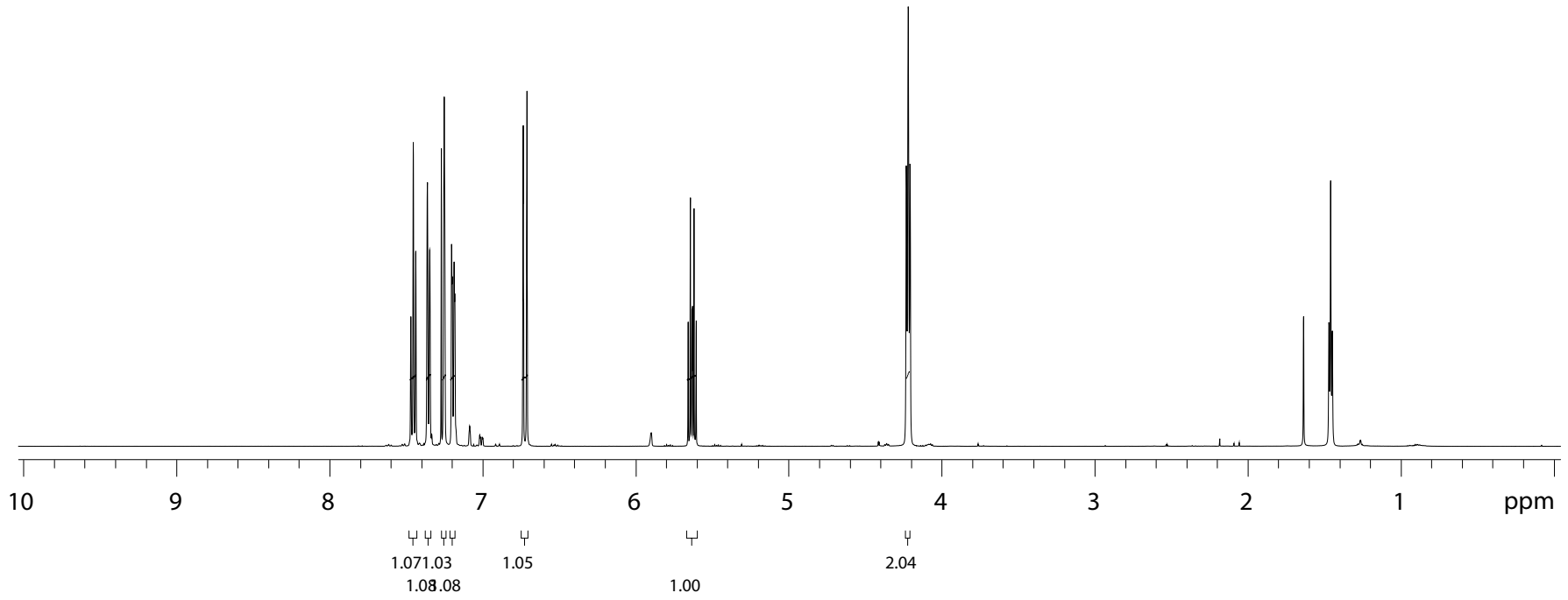
2p

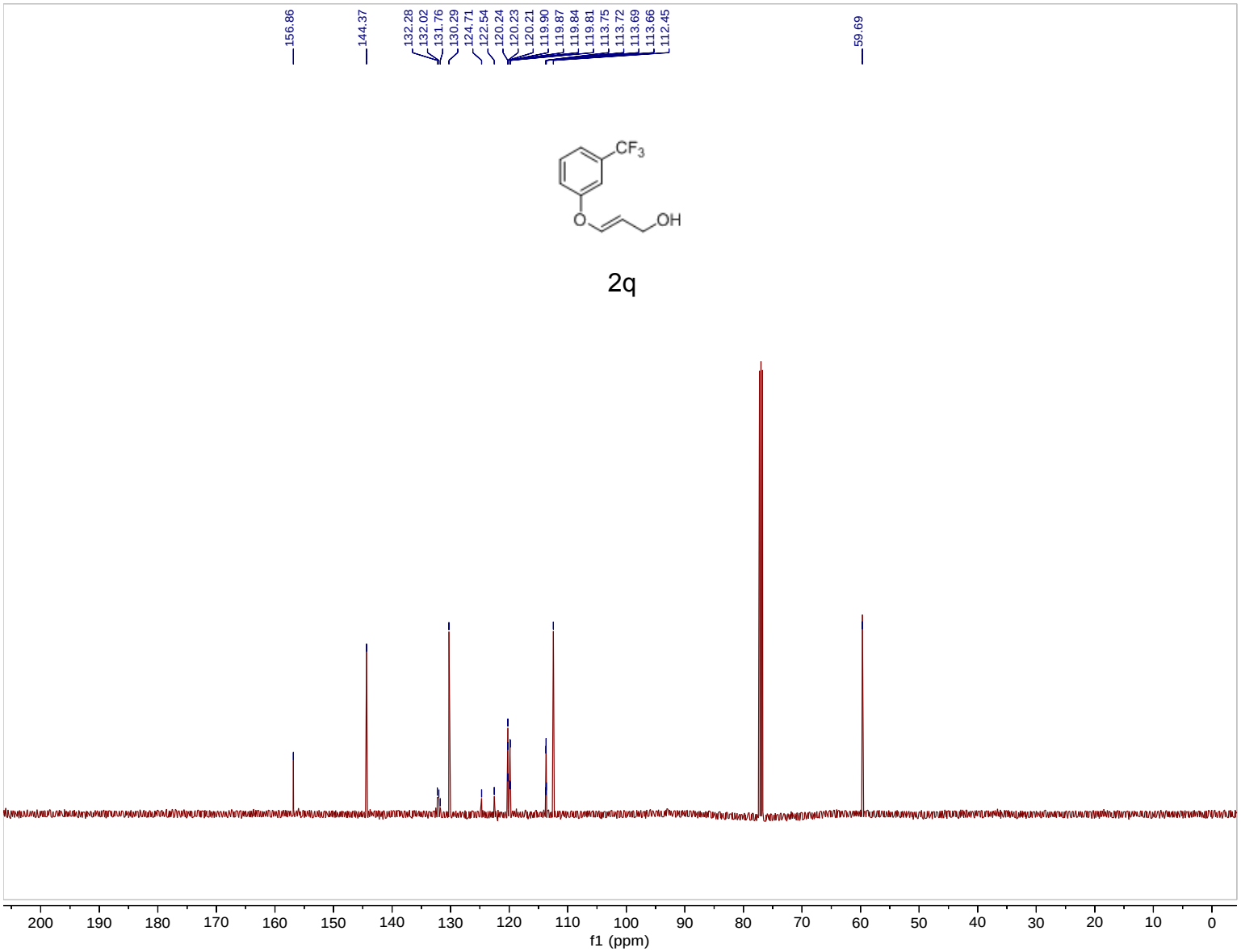


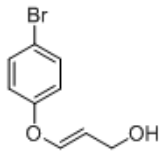

154.61
145.44
134.18
130.14
129.84
129.02
128.21
127.73
127.05
126.66
124.68
118.72
111.47
111.34
59.96
O
OH
2p
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)



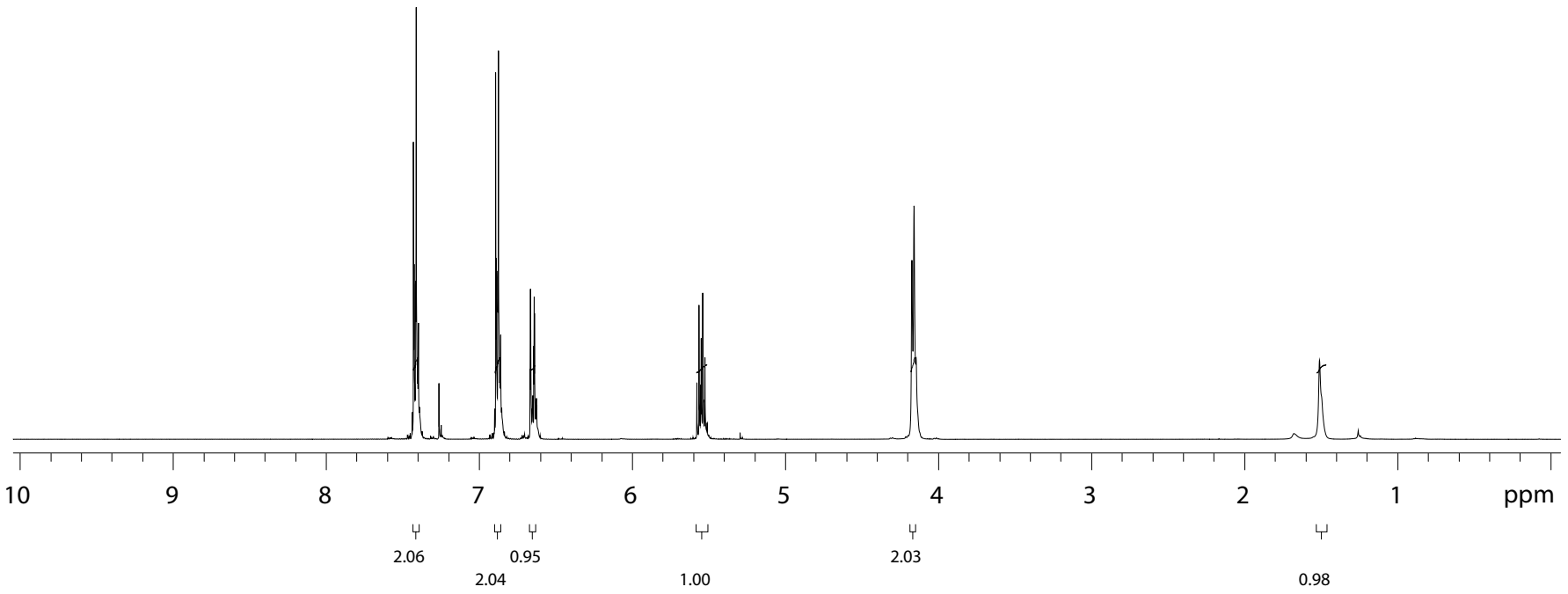
2q

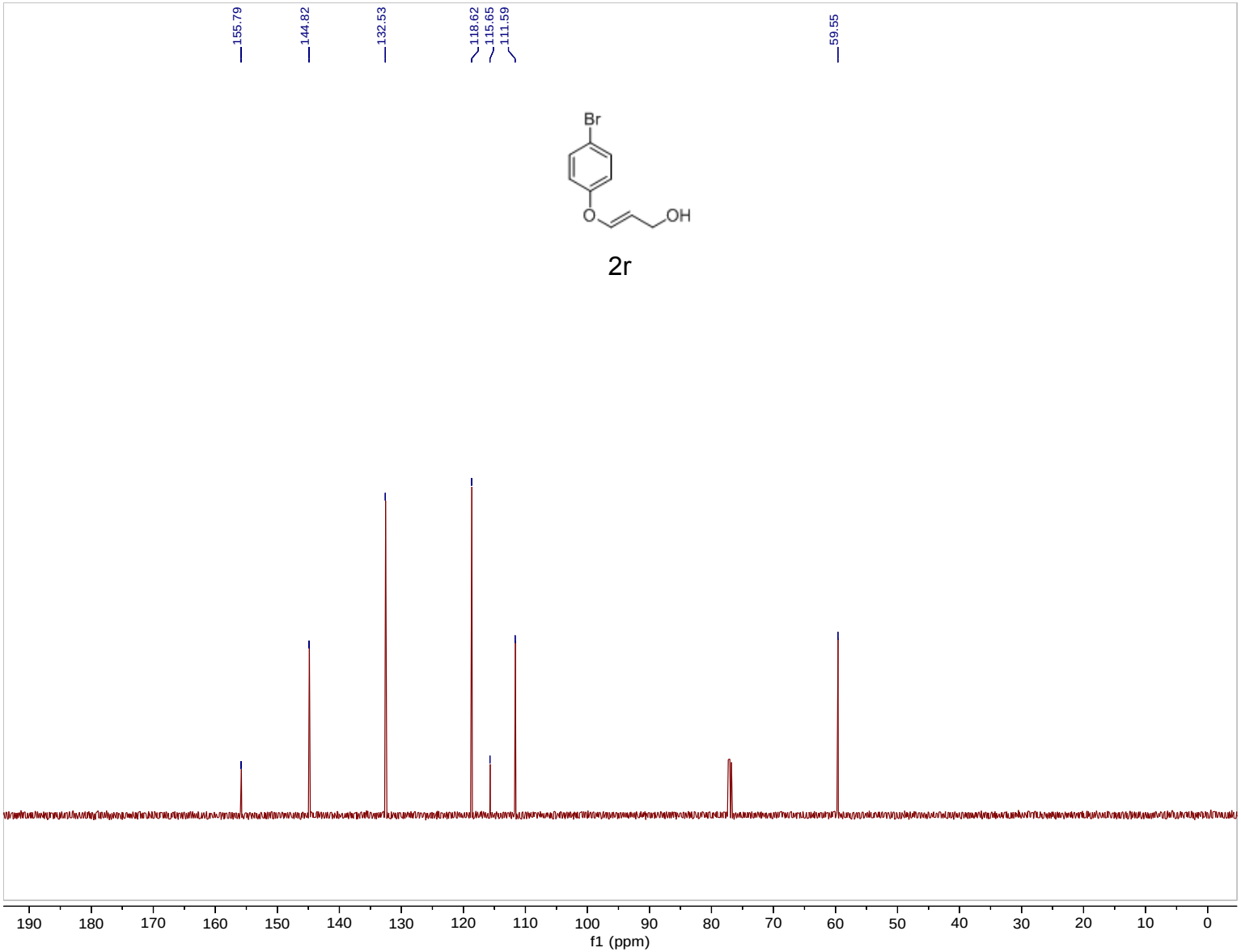


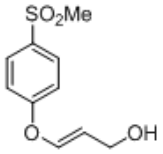

156.86
144.37
132.28
132.02
131.76
130.29
124.71
122.54
120.24
120.23
120.21
119.90
119.87
119.84
119.81
113.75
113.72
113.69
113.66
112.45
59.69
CF3
O
OH
2q
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)



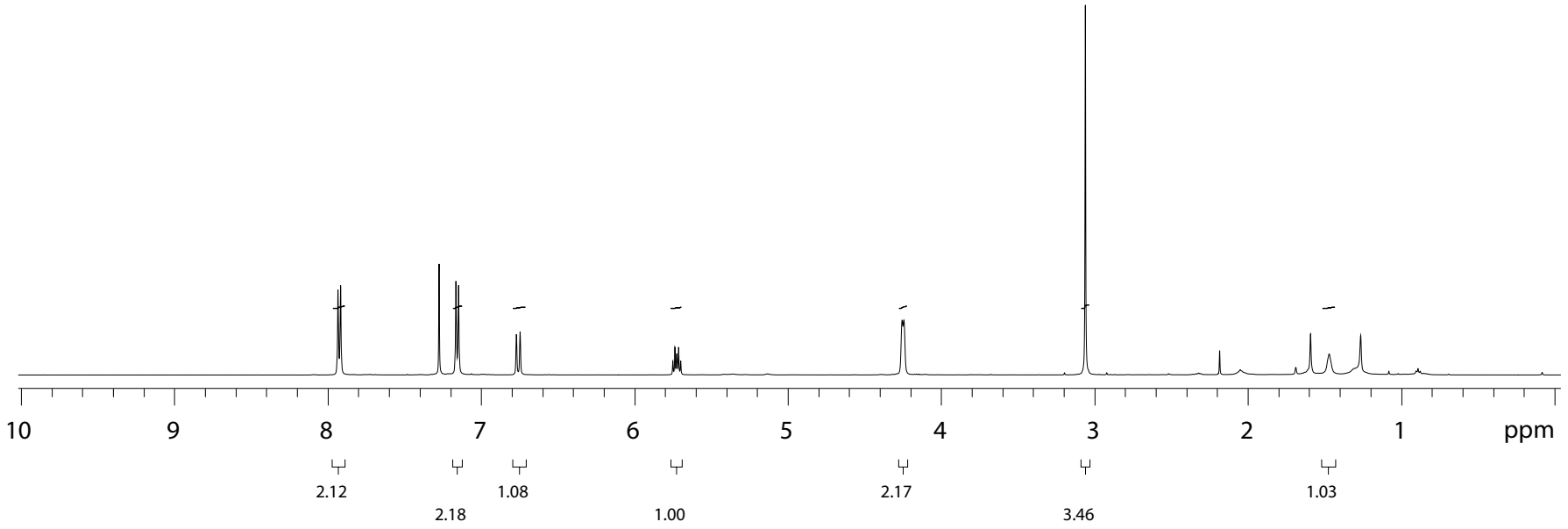
2r

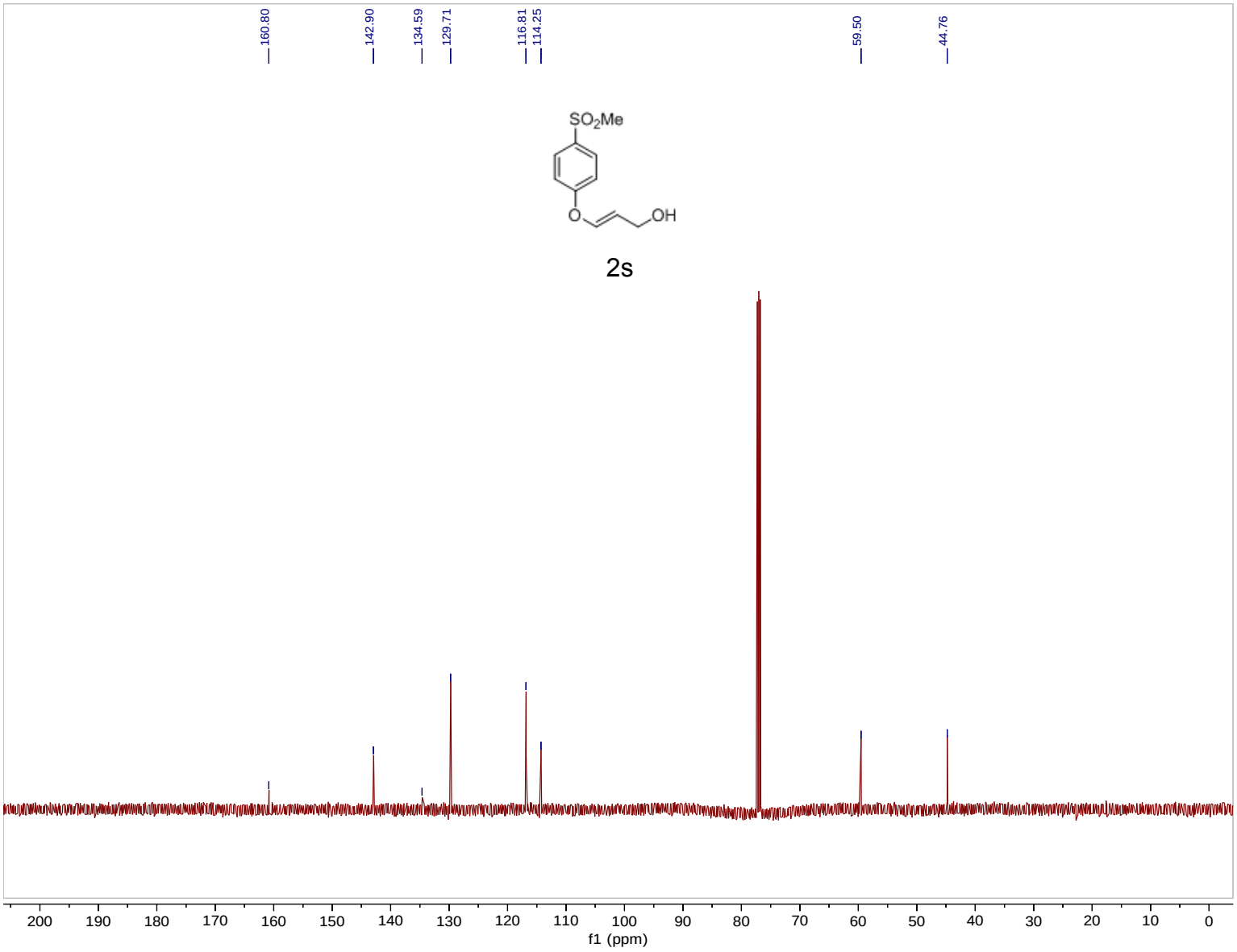


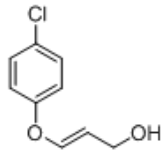

155.79
144.82
132.53
118.62
115.65
111.59
59.55
Br
O
OH
2r
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)



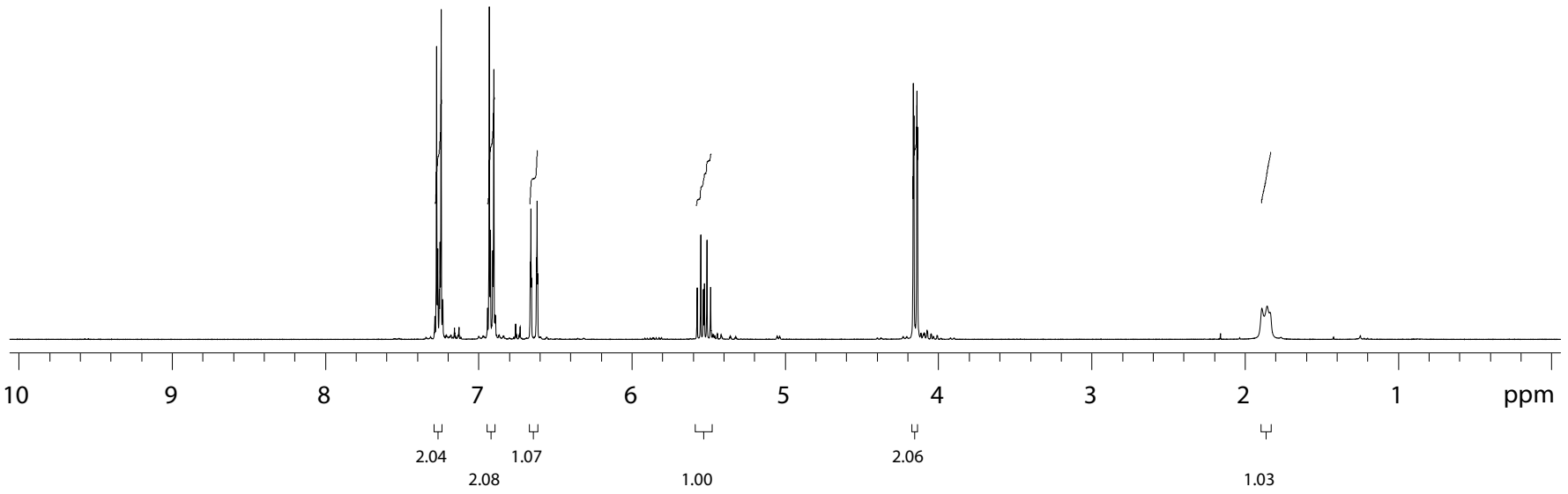
2s

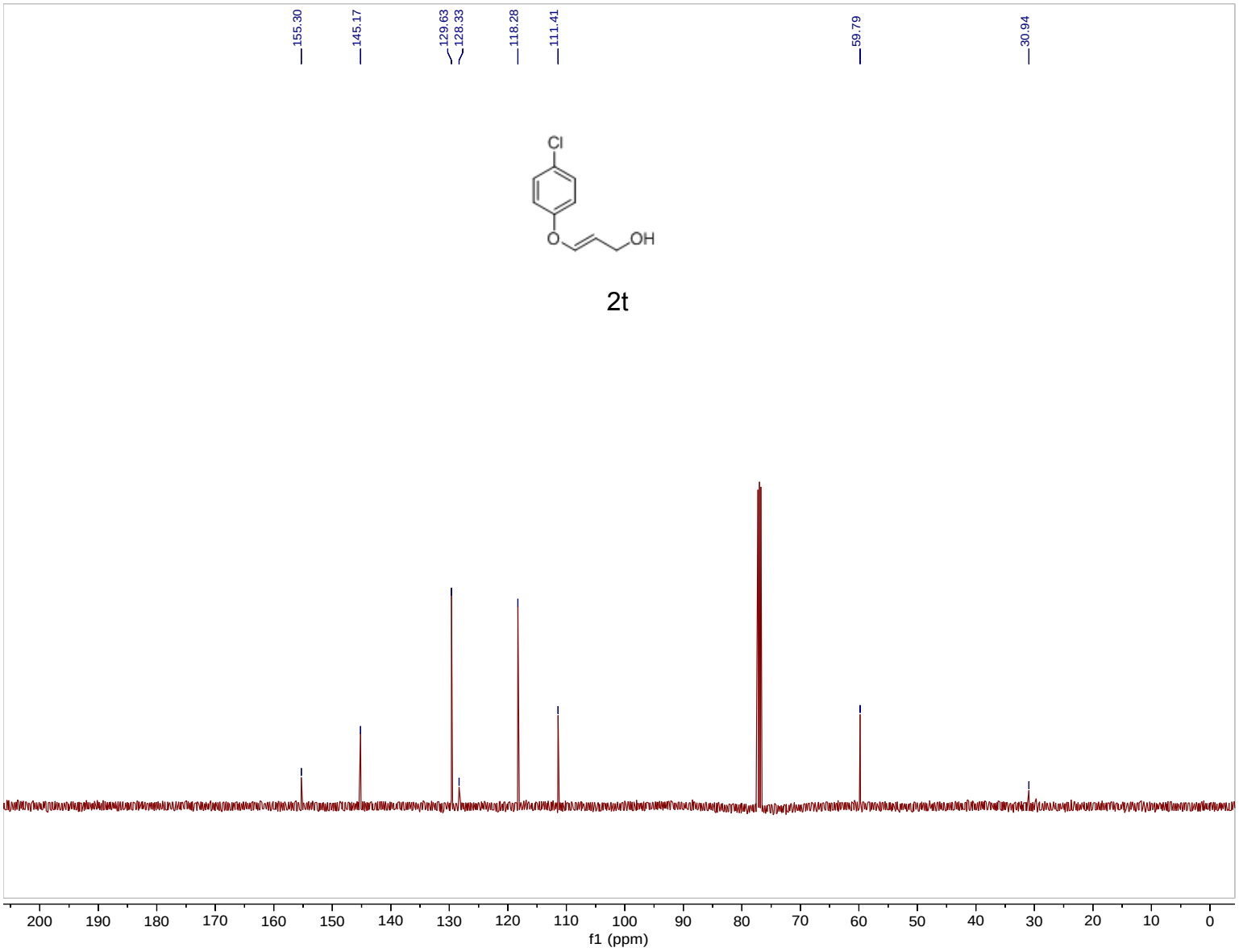


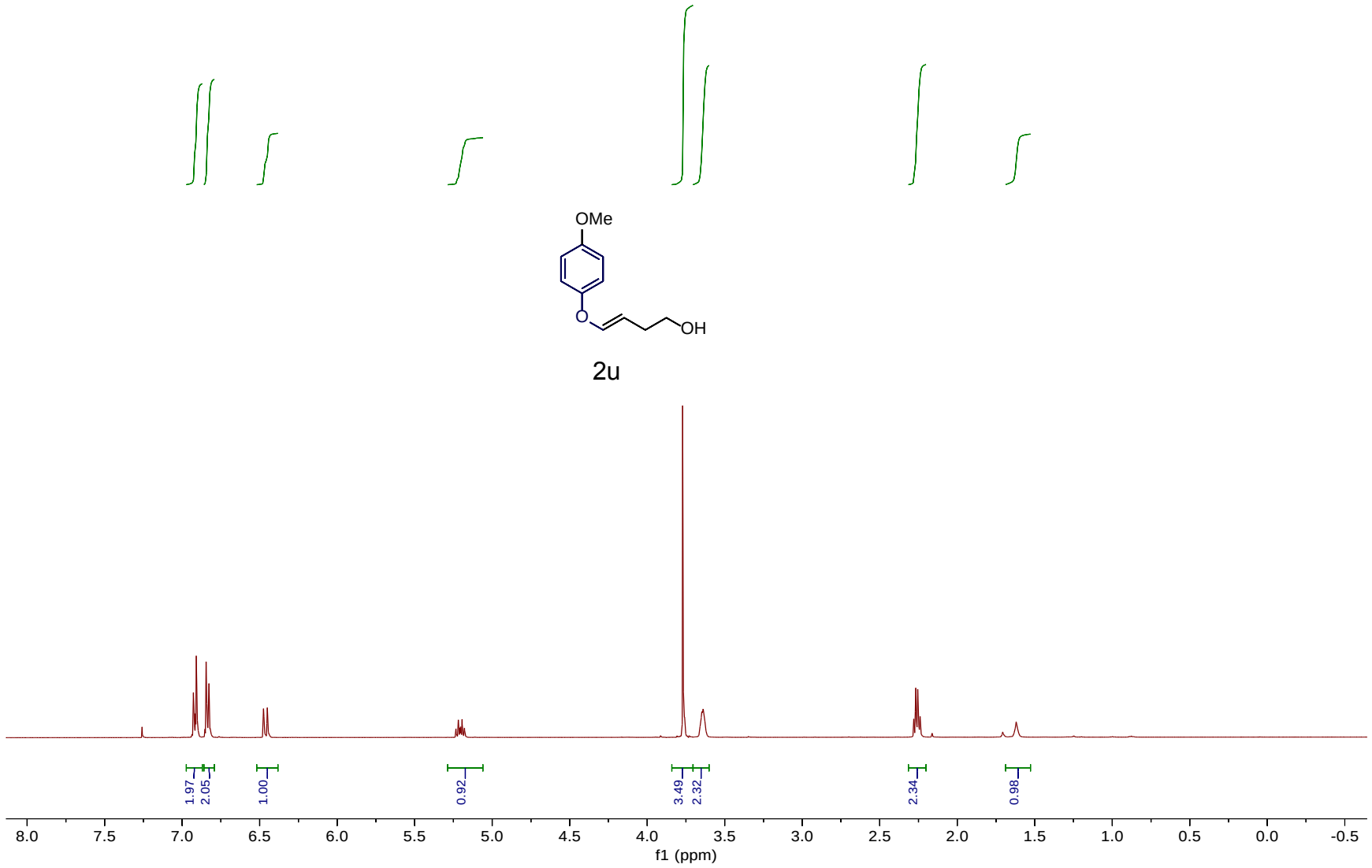

160.80
142.90
134.59
129.71
116.81
114.25
59.50
44.76
SO2Me
O
OH
2s
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

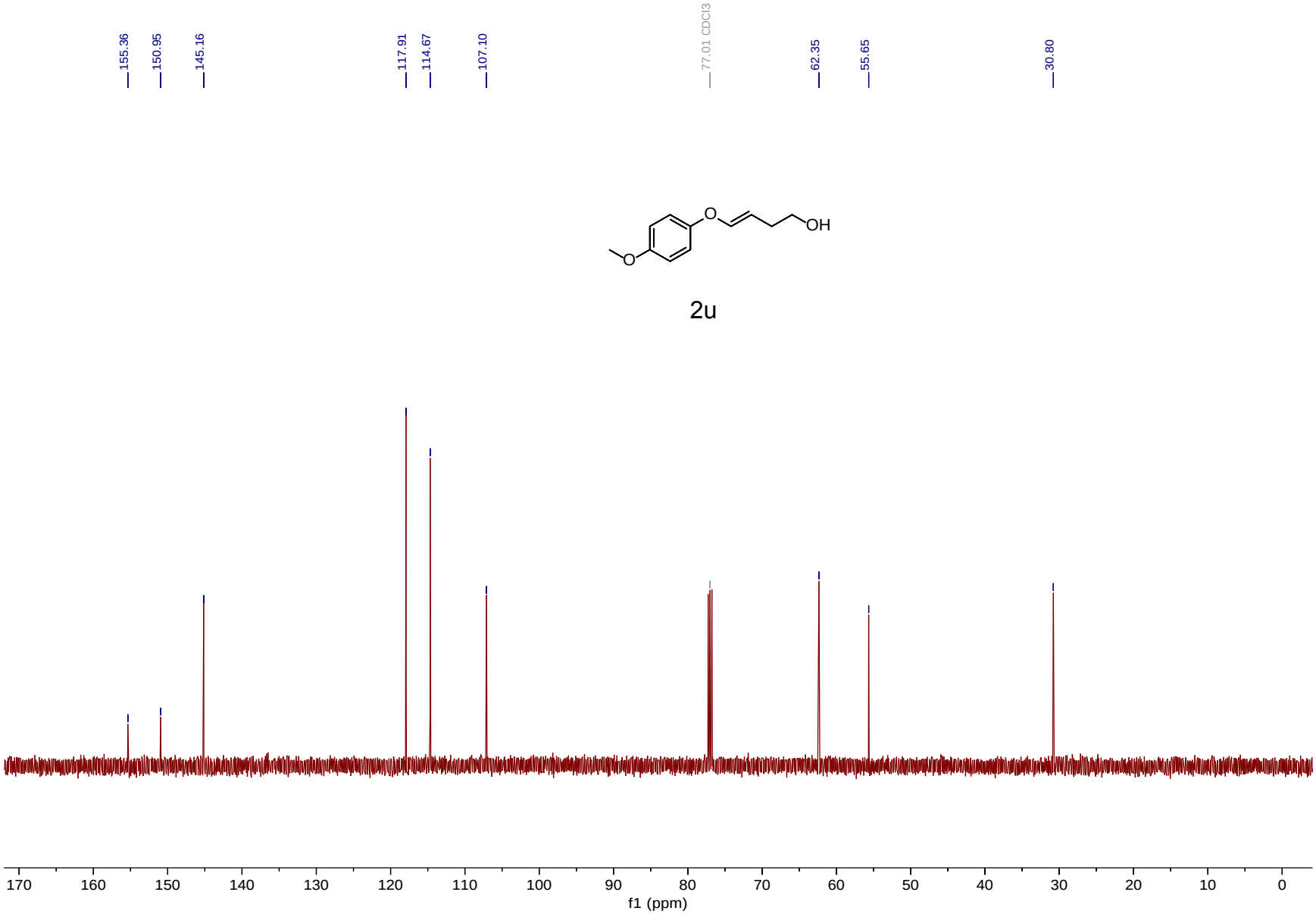


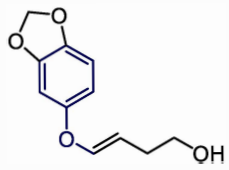
2t



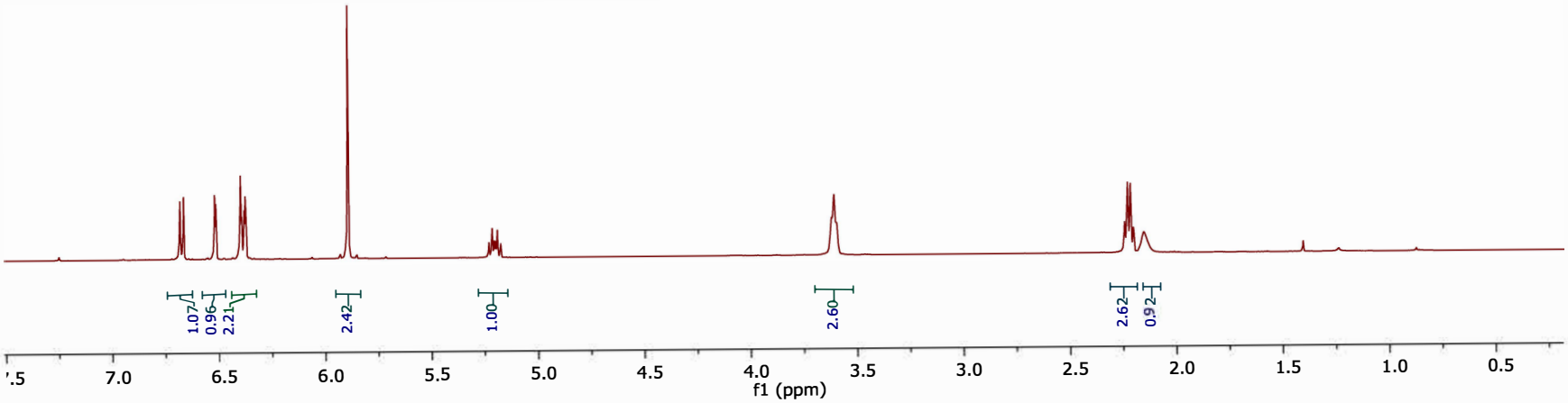

155.30
145.17
129.63
128.33
118.28
111.41
59.79
30.94
Cl
O
OH
2t
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

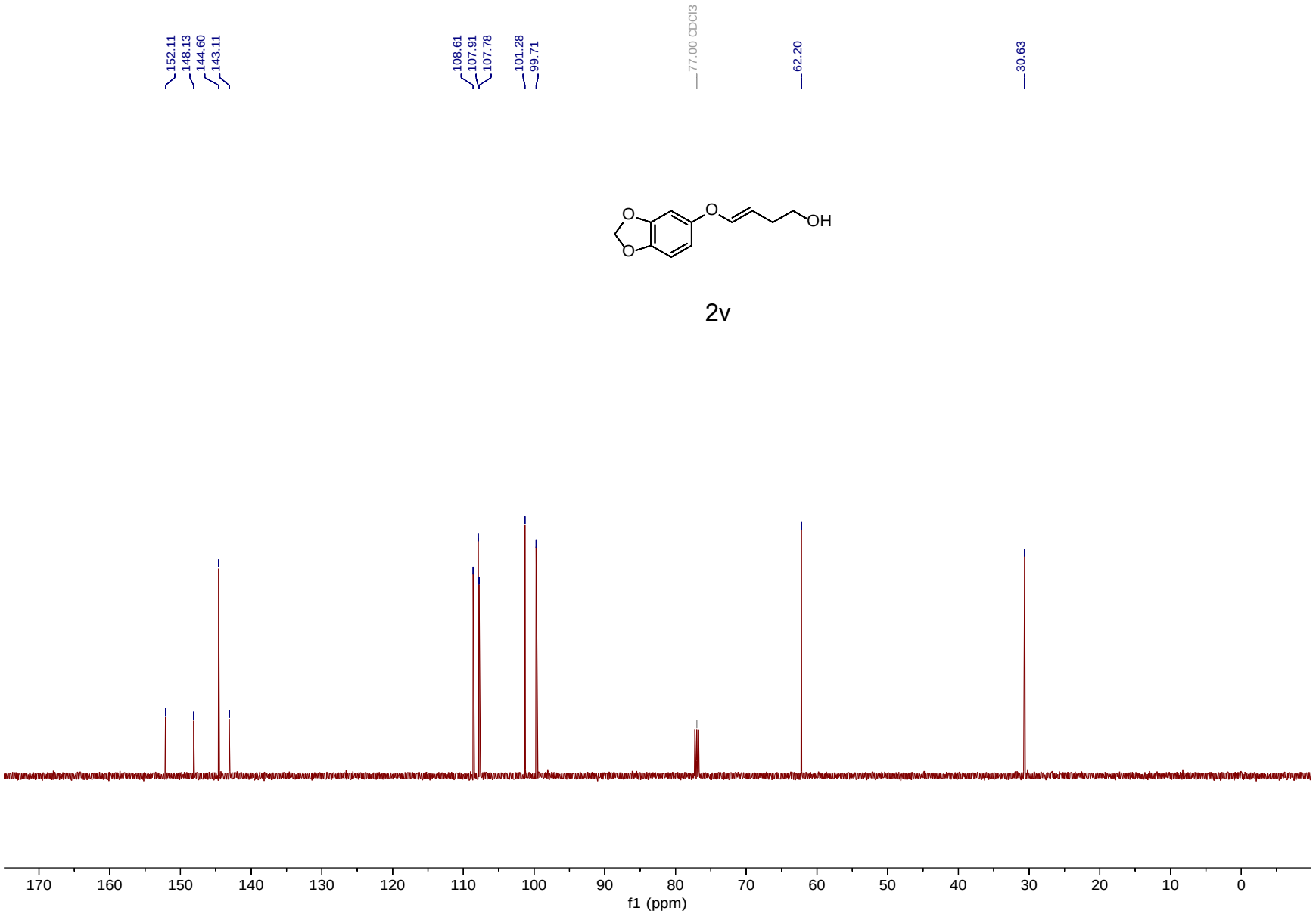

OMe
O
OH
2u
1.97
2.05
1.00
0.92
3.49
2.32
2.34
0.98
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

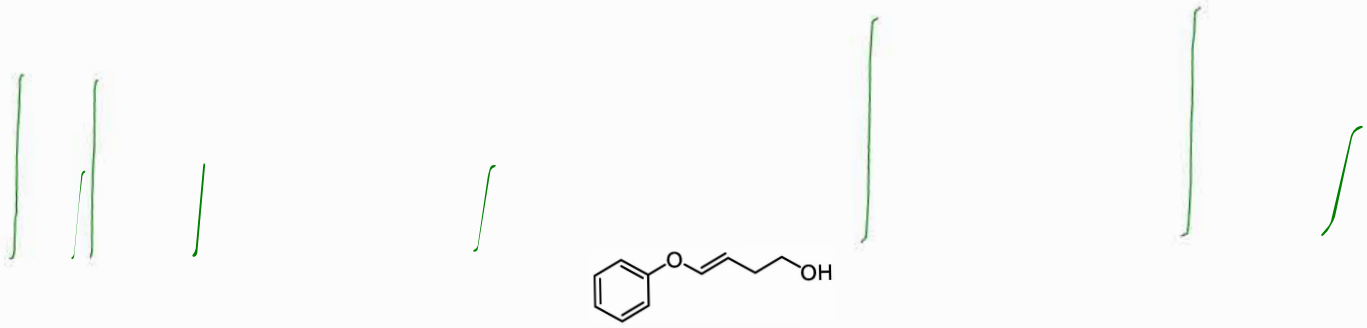

155.36
150.95
145.16
117.91
114.67
107.10
77.01 CDCl3
62.35
55.65
30.80
O
OH
O
2u
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


O
O
O
OH

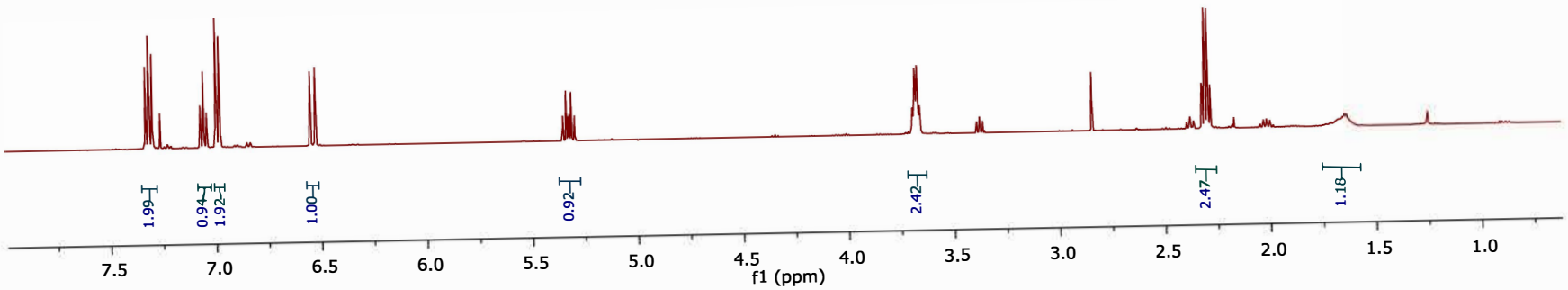
2v

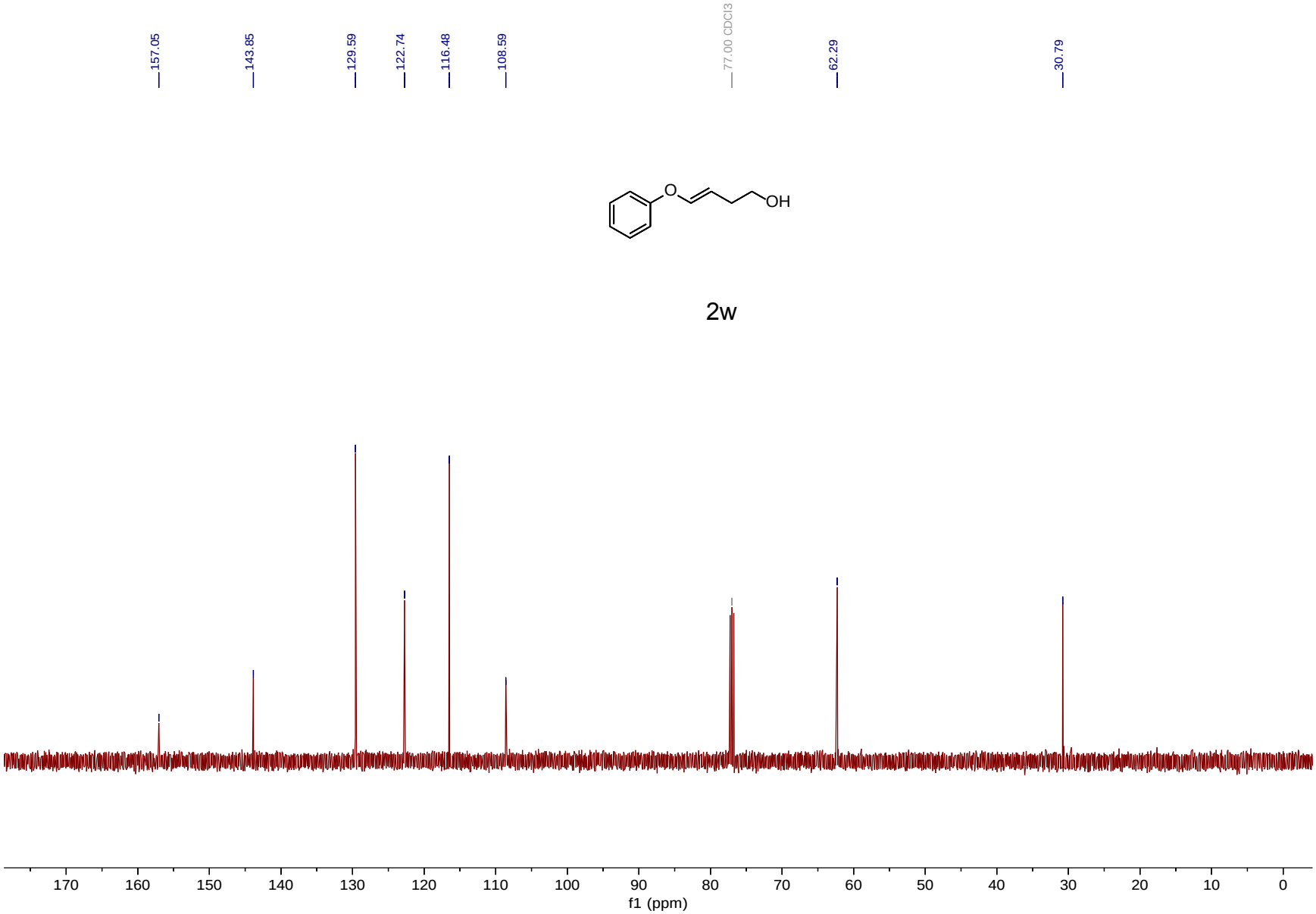

1.07
0.96
2.21
2.42
1.00
2.60
2.62
0.92
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
f1 (ppm)


152.11
148.13
144.60
143.11
108.61
107.91
107.78
101.28
99.71
77.00 CDCl3
62.20
30.63
O
O
O
OH
2v
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

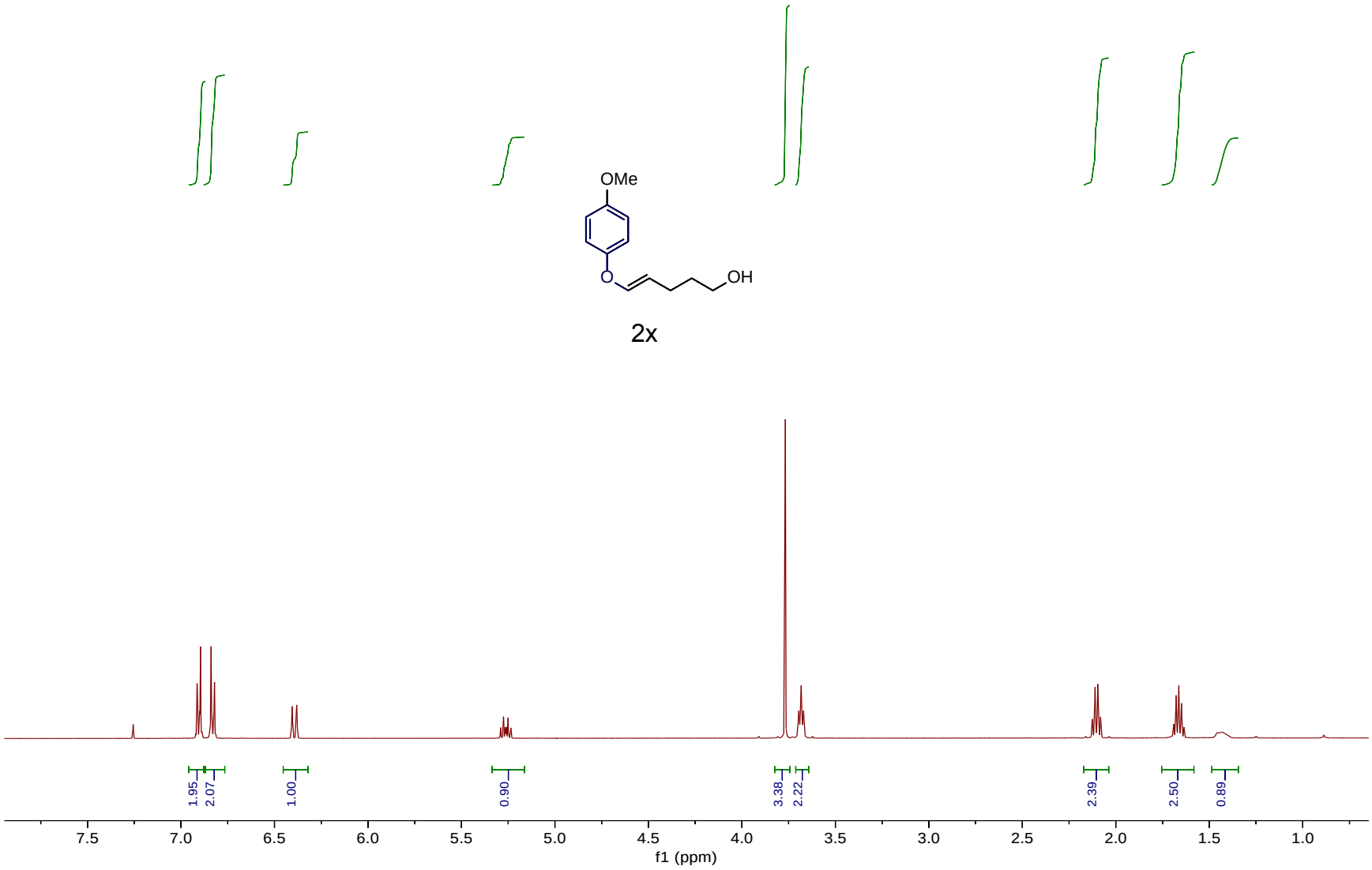

O
OH

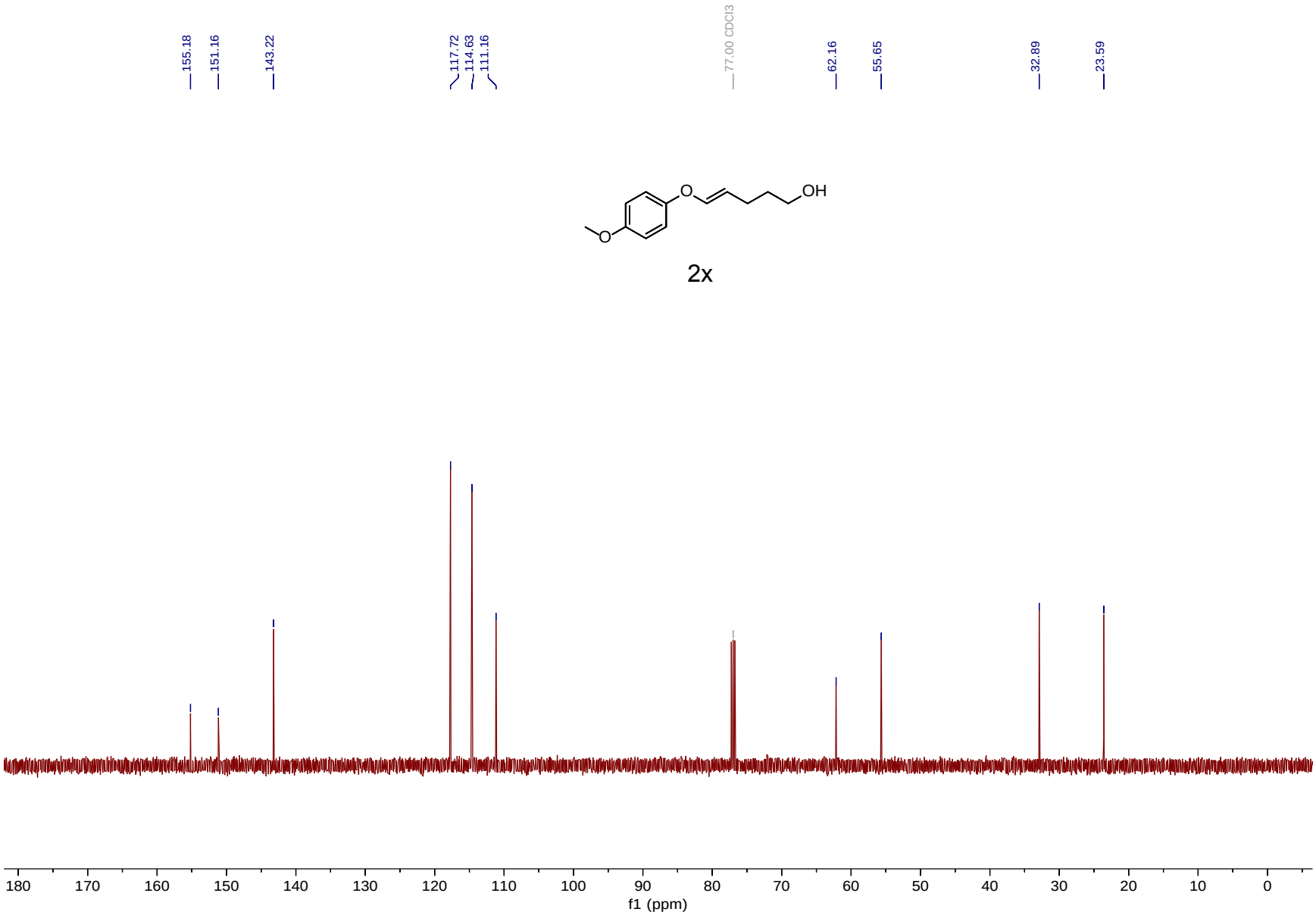
2w

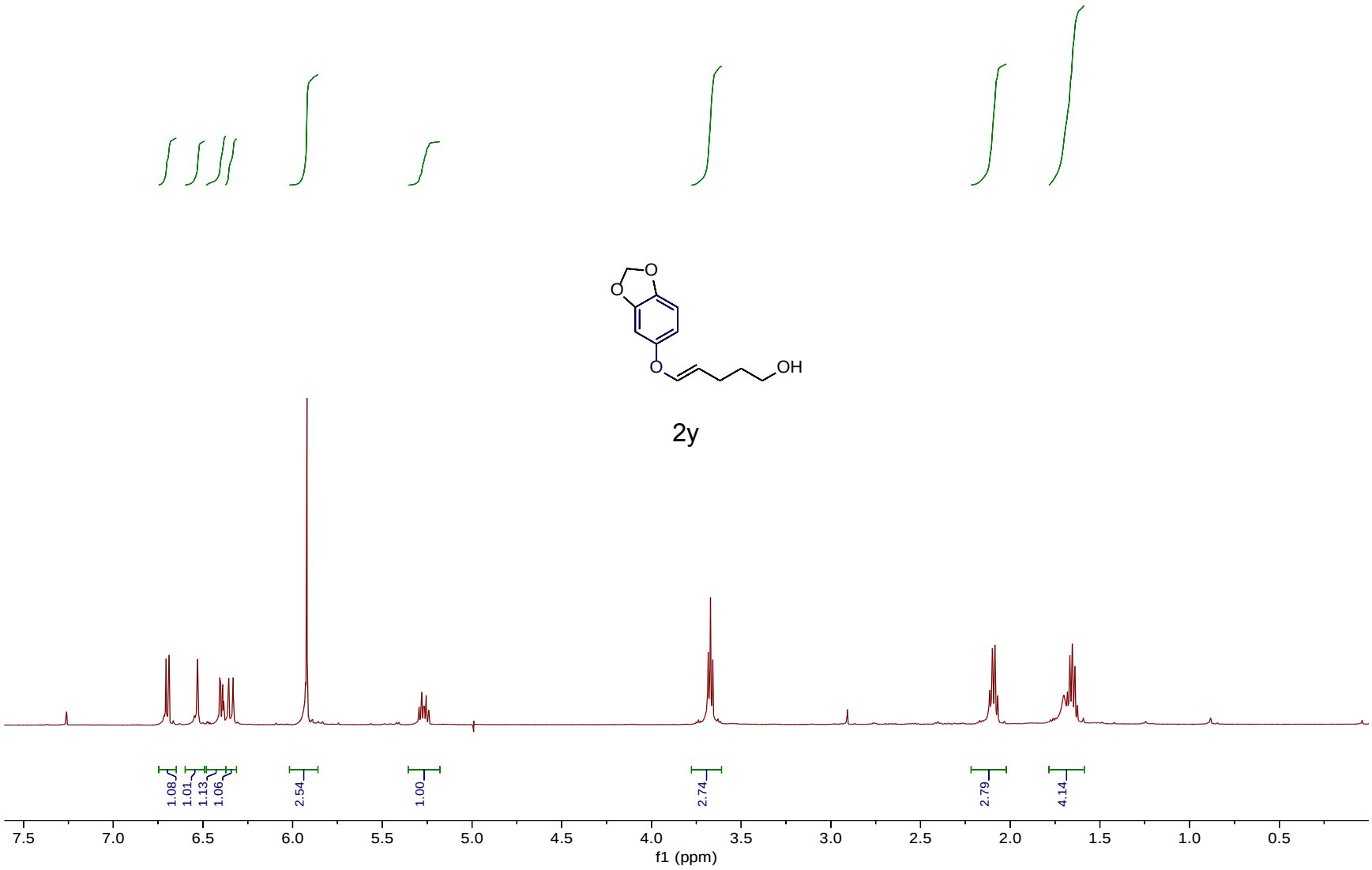

1.99
0.94
1.92
1.00
0.92
2.42
2.47
1.18
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
f1 (ppm)


157.05
143.85
129.59
122.74
116.48
108.59
77.00 CDCl3
62.29
30.79
O
OH
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

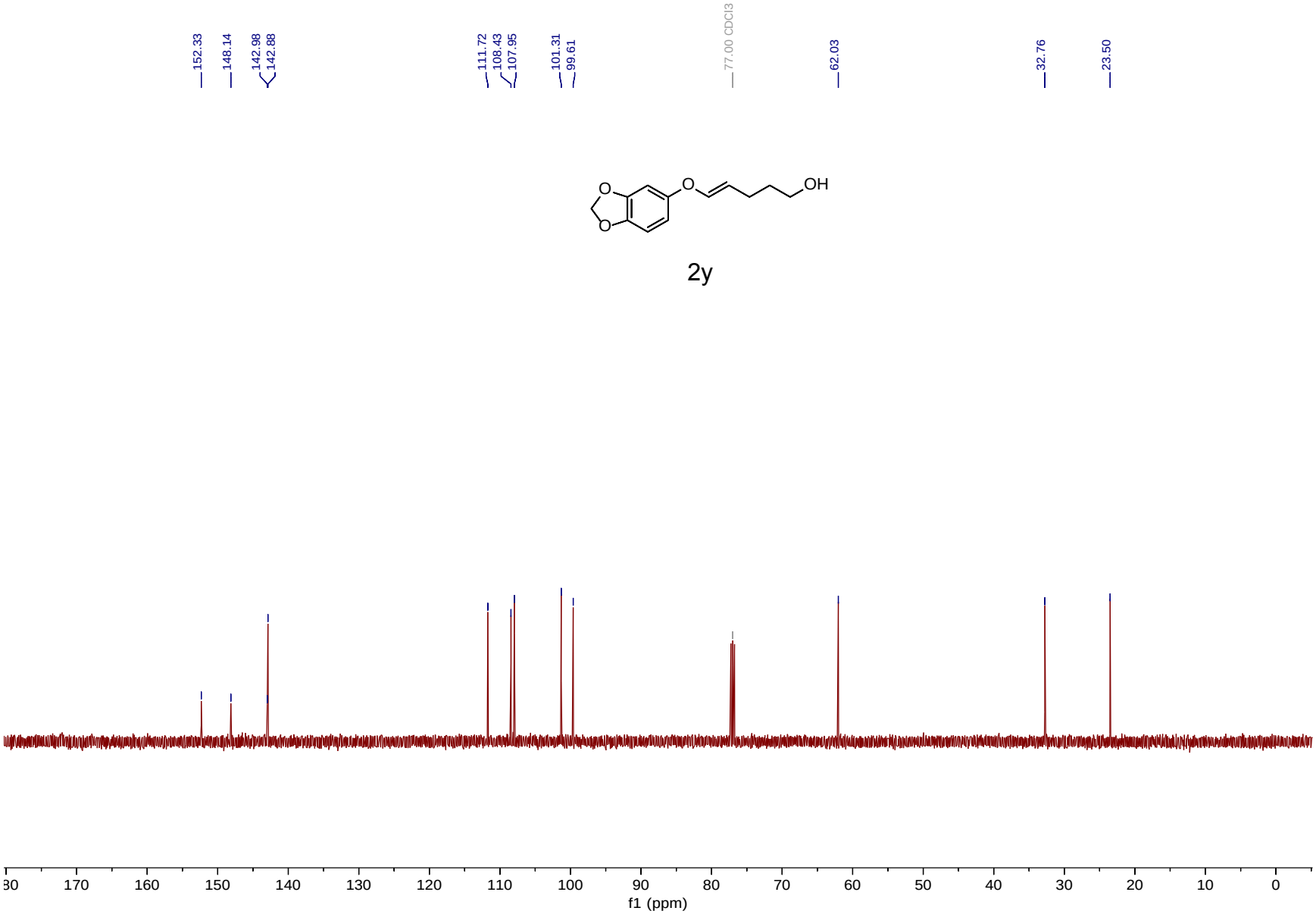
2w

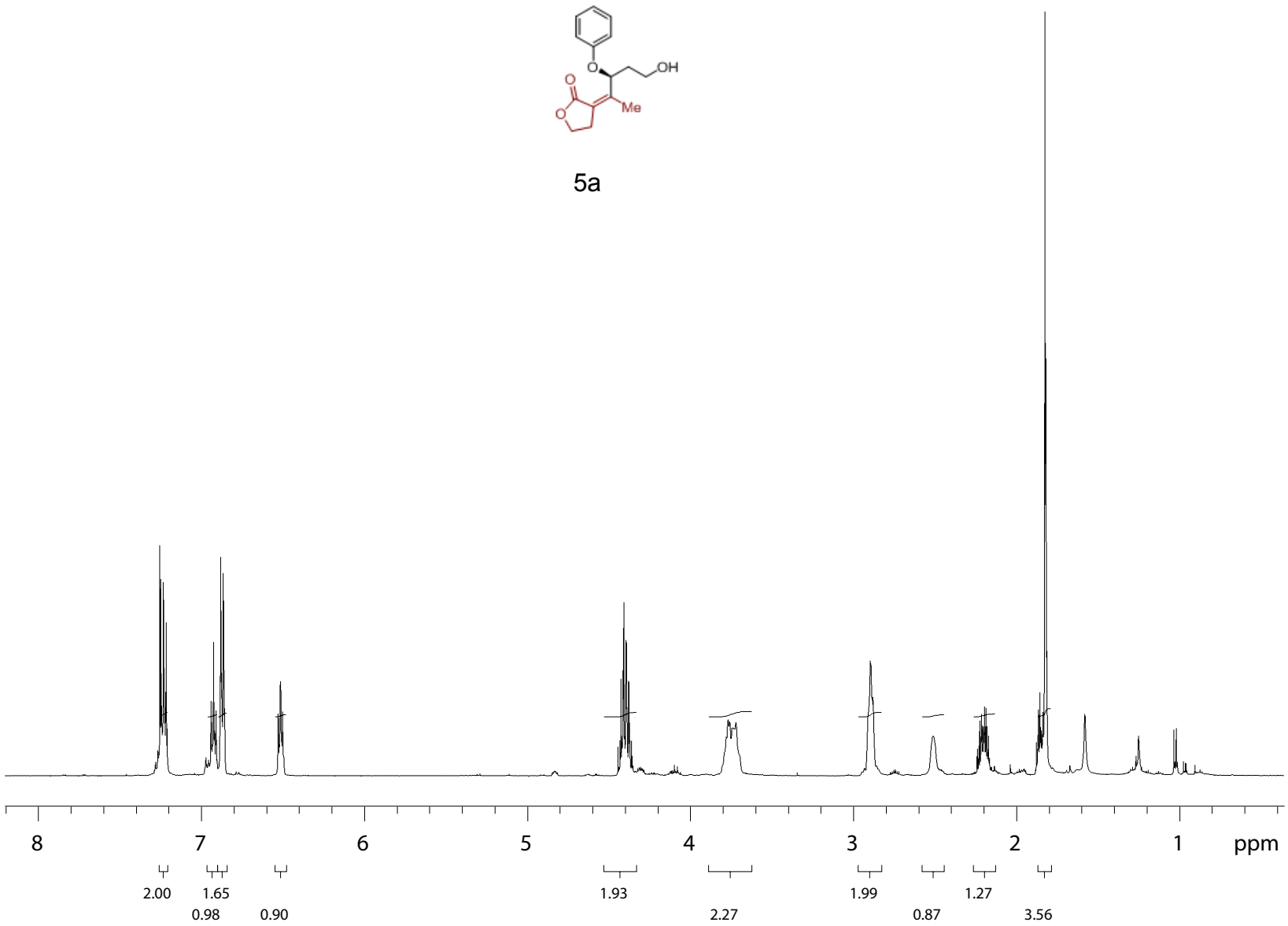

OMe
O
OH
2x
1.95
2.07
1.00
0.90
3.38
2.22
2.39
2.50
0.89
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
f1 (ppm)

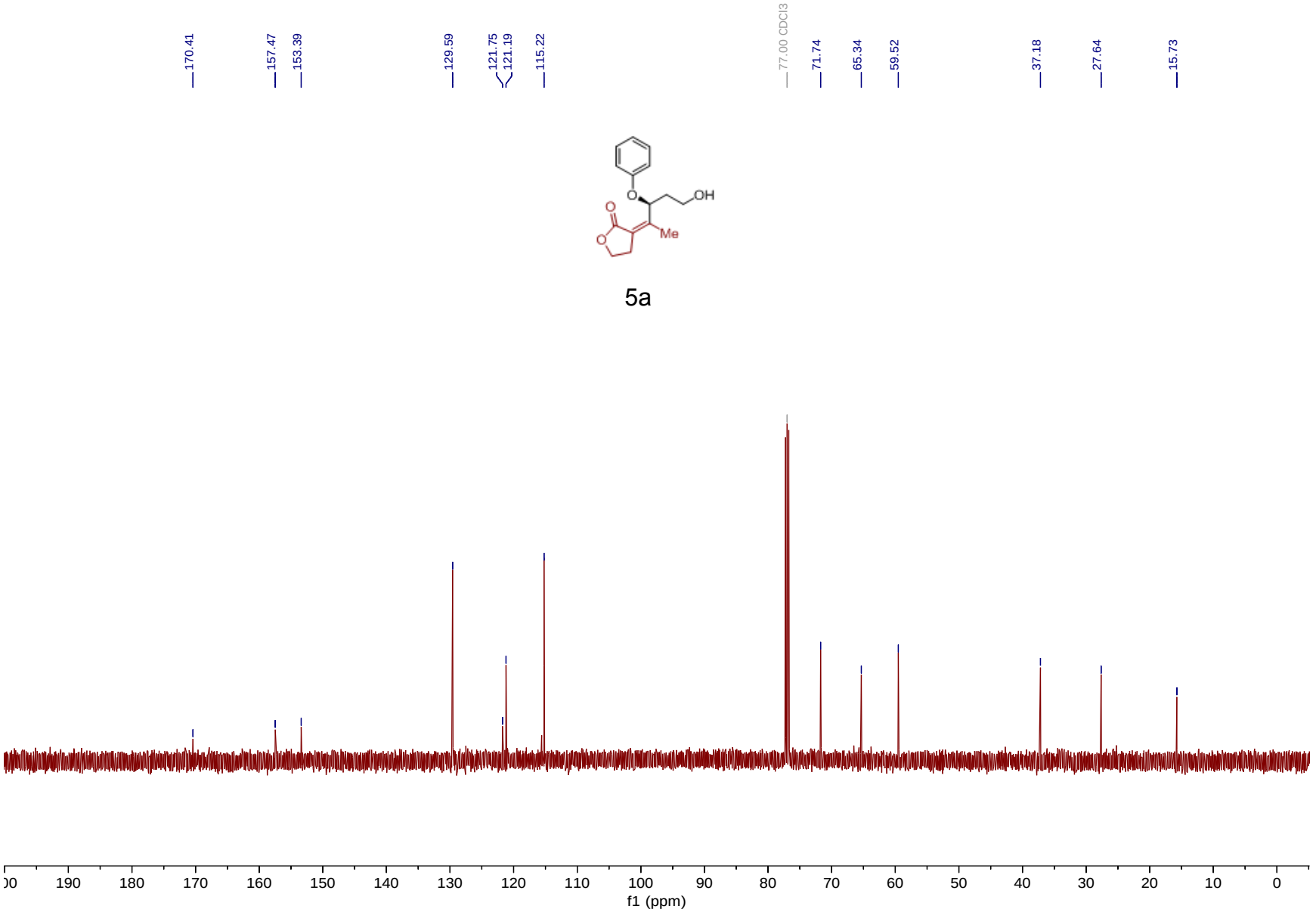

155.18
151.16
143.22
117.72
114.63
111.16
77.00 CDCl3
62.16
55.65
32.89
23.59
O
OH
O
2x
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


O
O
O
OH
1.08
1.01
1.13
1.06
2.54
1.00
2.74
2.79
4.14
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
f1 (ppm)

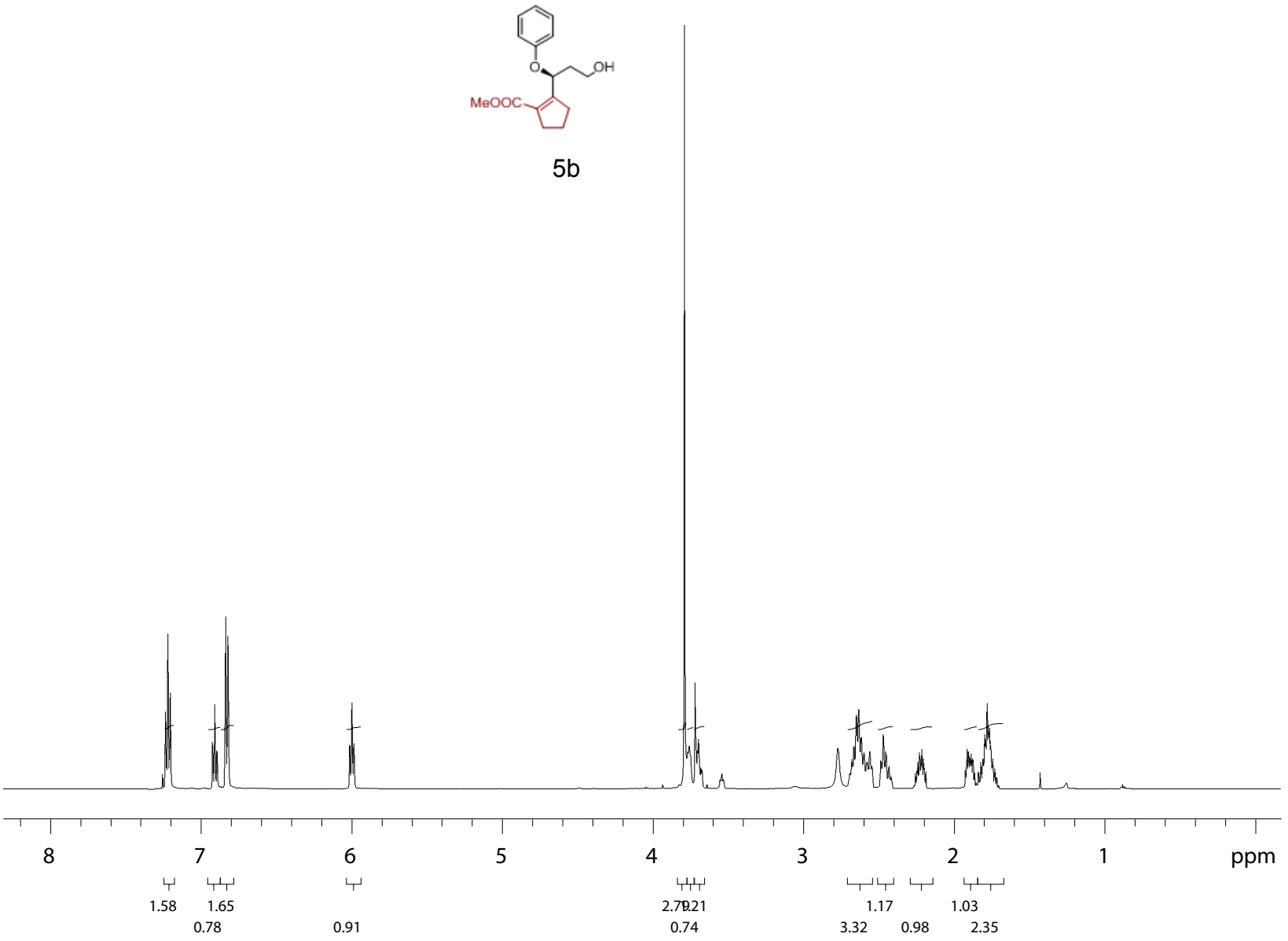
2y

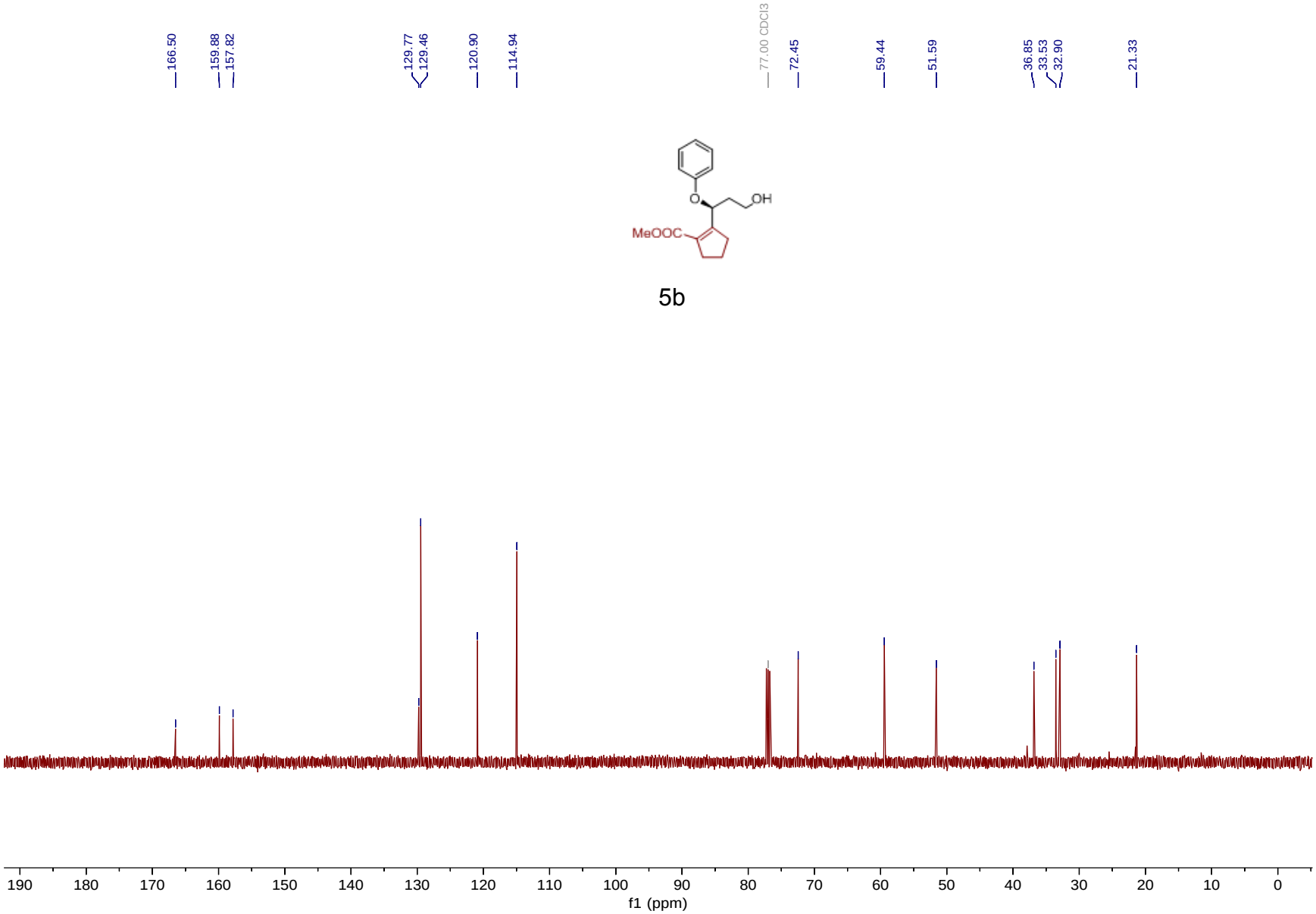

152.33
148.14
142.98
142.88
111.72
108.43
107.95
101.31
99.61
77.00 CDCl3
62.03
32.76
23.50
O
O
O
OH
2y
f1 (ppm)


OH
O
O
O
Me
5a
8
7
6
5
4
3
2
1
ppm
2.00
1.65
0.98
0.90
1.93
2.27
1.99
0.87
1.27
3.56

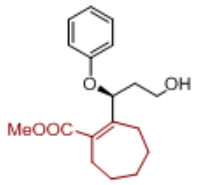

170.41
157.47
153.39
129.59
121.75
121.19
115.22
77.00 CDCl3
71.74
65.34
59.52
37.18
27.64
15.73
OH
O
O
Me
f1 (ppm)

5a


MeOOC
O
OH
5b
8
7
6
5
4
3
2
1
ppm
1.58
1.65
0.78
0.91
2.79
1.21
0.74
1.17
3.32
0.98
1.03
2.35

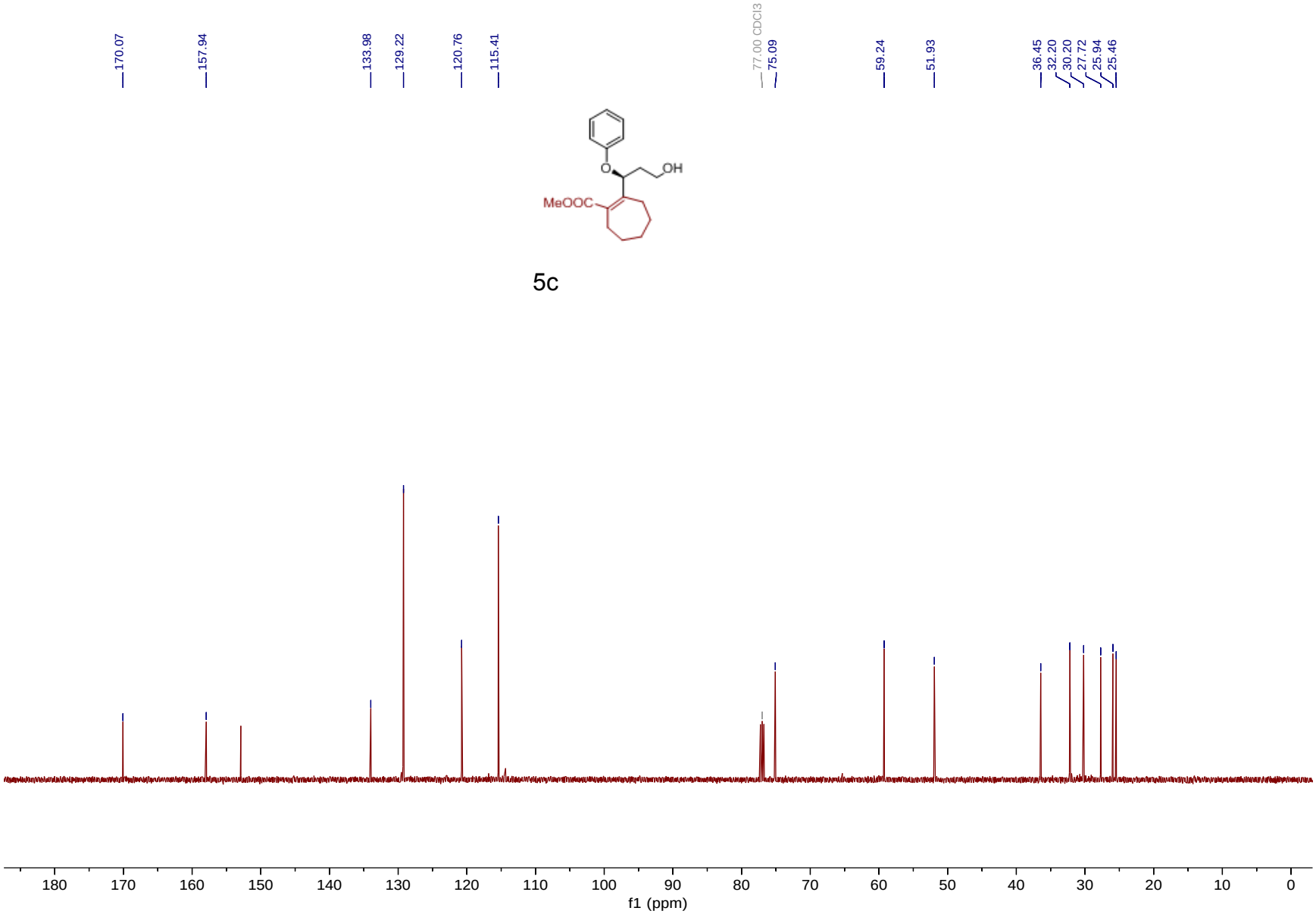

166.50
159.88
157.82
129.77
129.46
120.90
114.94
77.00 CDCl3
72.45
59.44
51.59
36.85
33.53
32.90
21.33
O
OH
MeOOC
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

5b

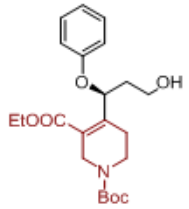

O
OH
MeOOC

5c

7
6
5
4
3
2
1
ppm
1.89
1.77
1.02
0.98
2.82
2.27
0.94
4.41
1.31
1.18
2.27
3.78
1.59

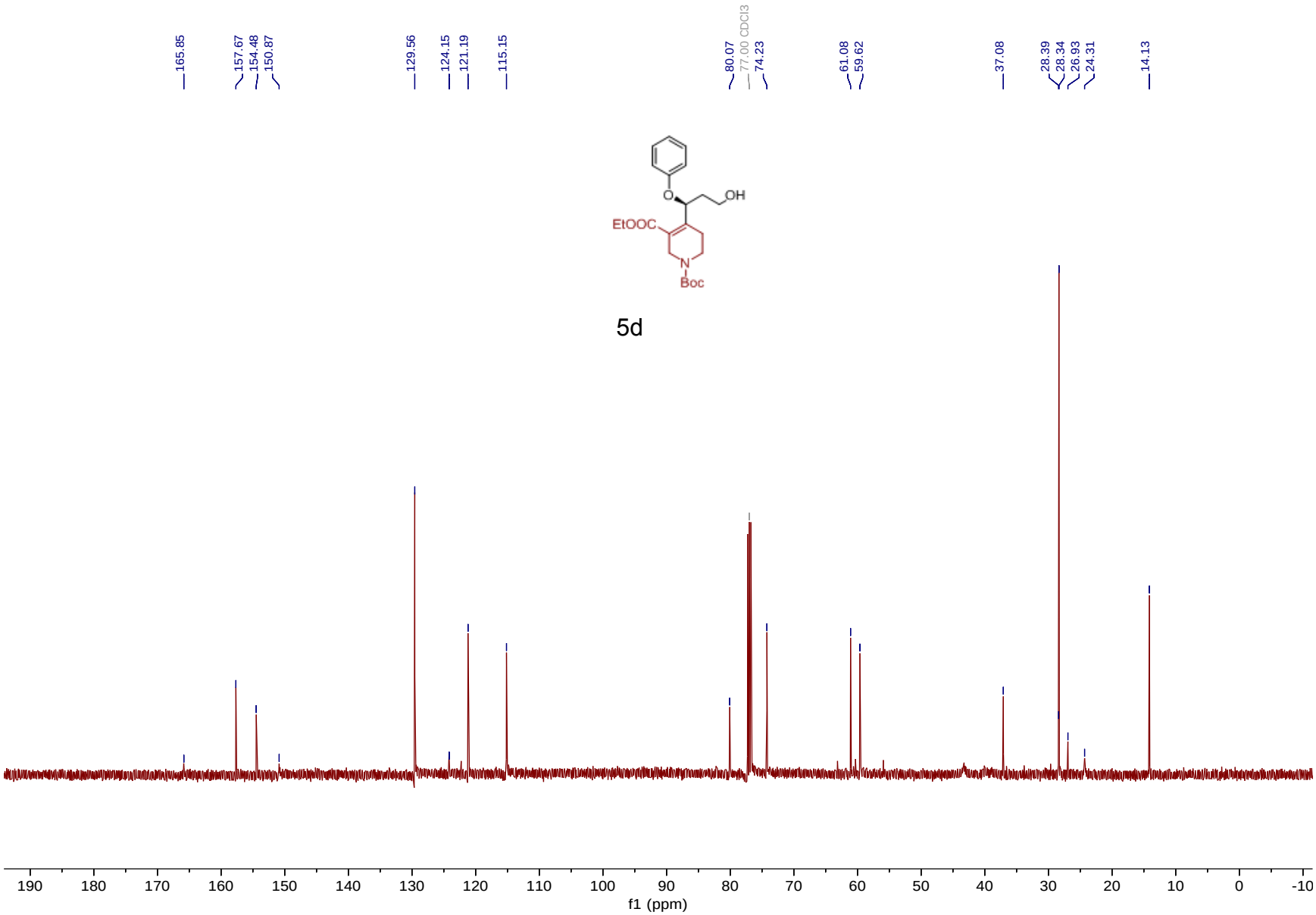

170.07
157.94
133.98
129.22
120.76
115.41
77.00 CDCl3
75.09
59.24
51.93
36.45
32.20
30.20
27.72
25.94
25.46
OH
O
MeOOC
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

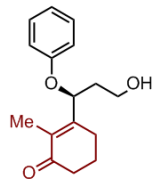
5c


O
OH
EtOOC
N
Boc

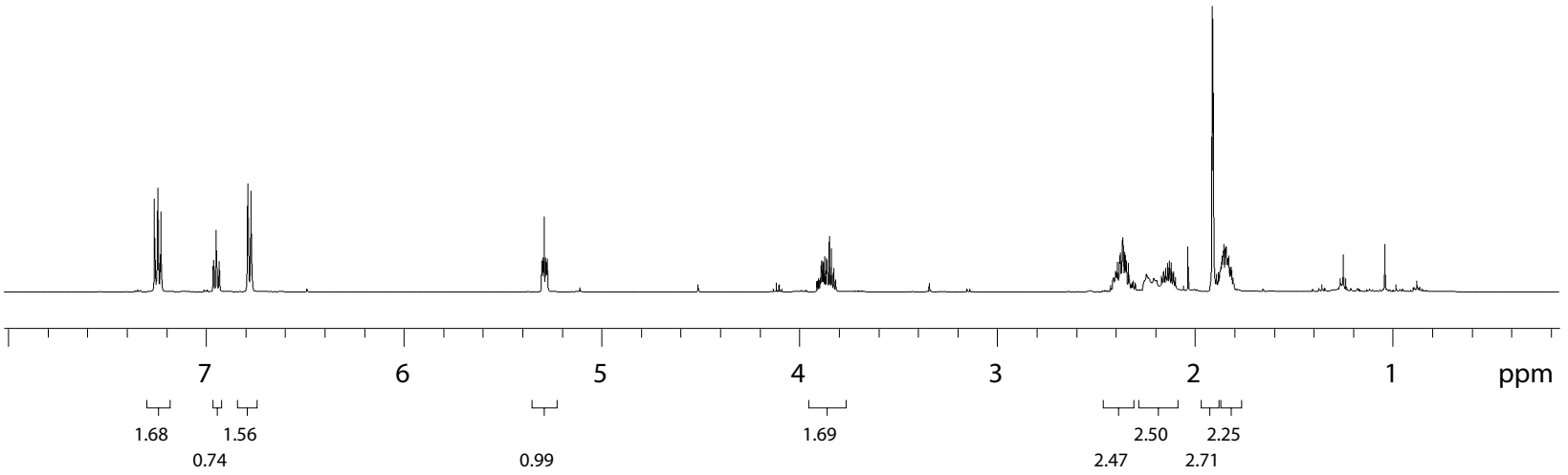
5d

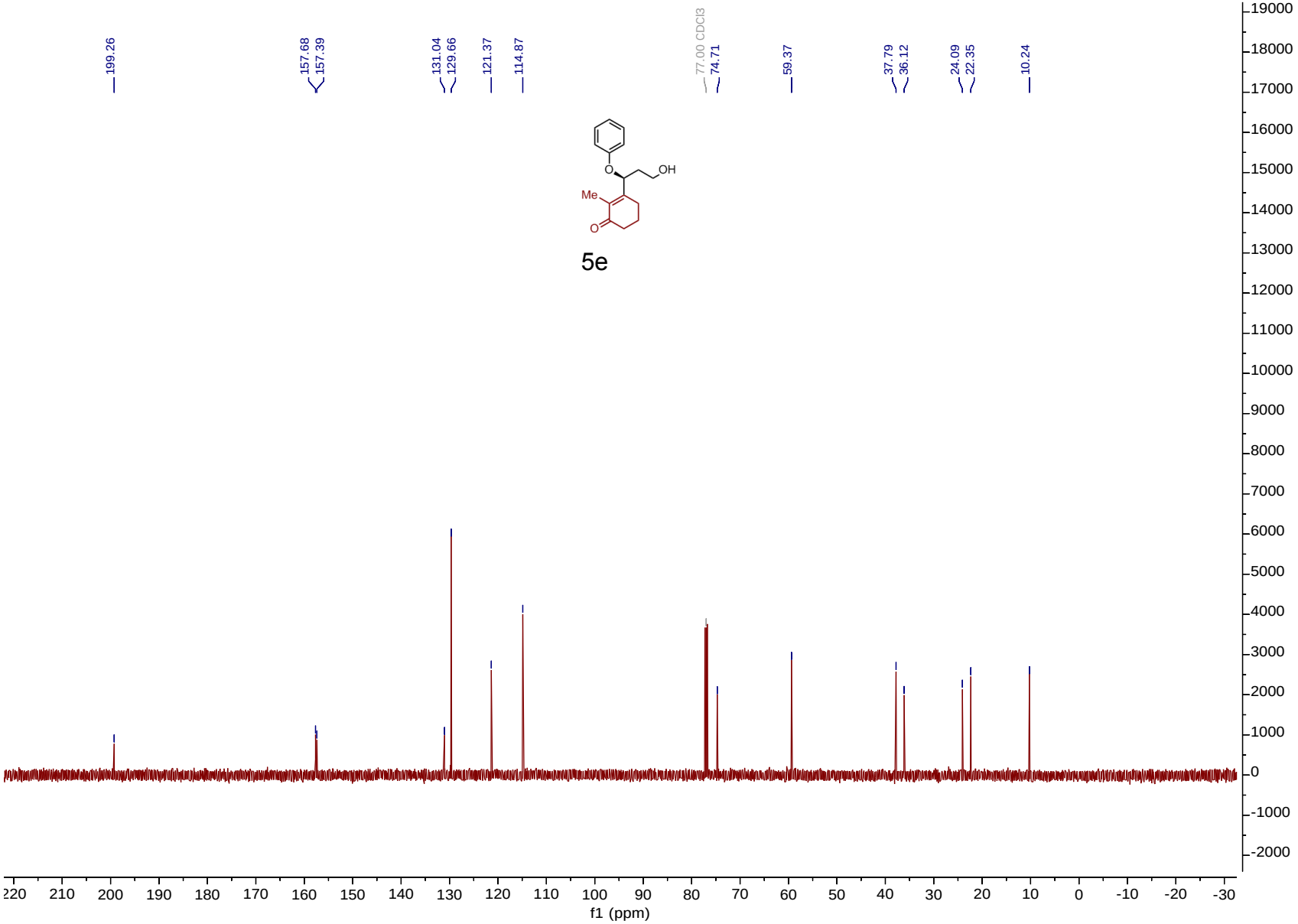
7
6
5
4
3
2
1
ppm
1.76
1.75
0.88
0.90
2.38
1.20
2.07
2.17
2.12
1.08
1.03
3.15
8.67

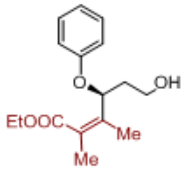

165.85
157.67
154.48
150.87
129.56
124.15
121.19
115.15
80.07
77.00 CDCl3
74.23
61.08
59.62
37.08
28.39
28.34
26.93
24.31
14.13
OH
O
EtOOC
N
Boc
5d
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)



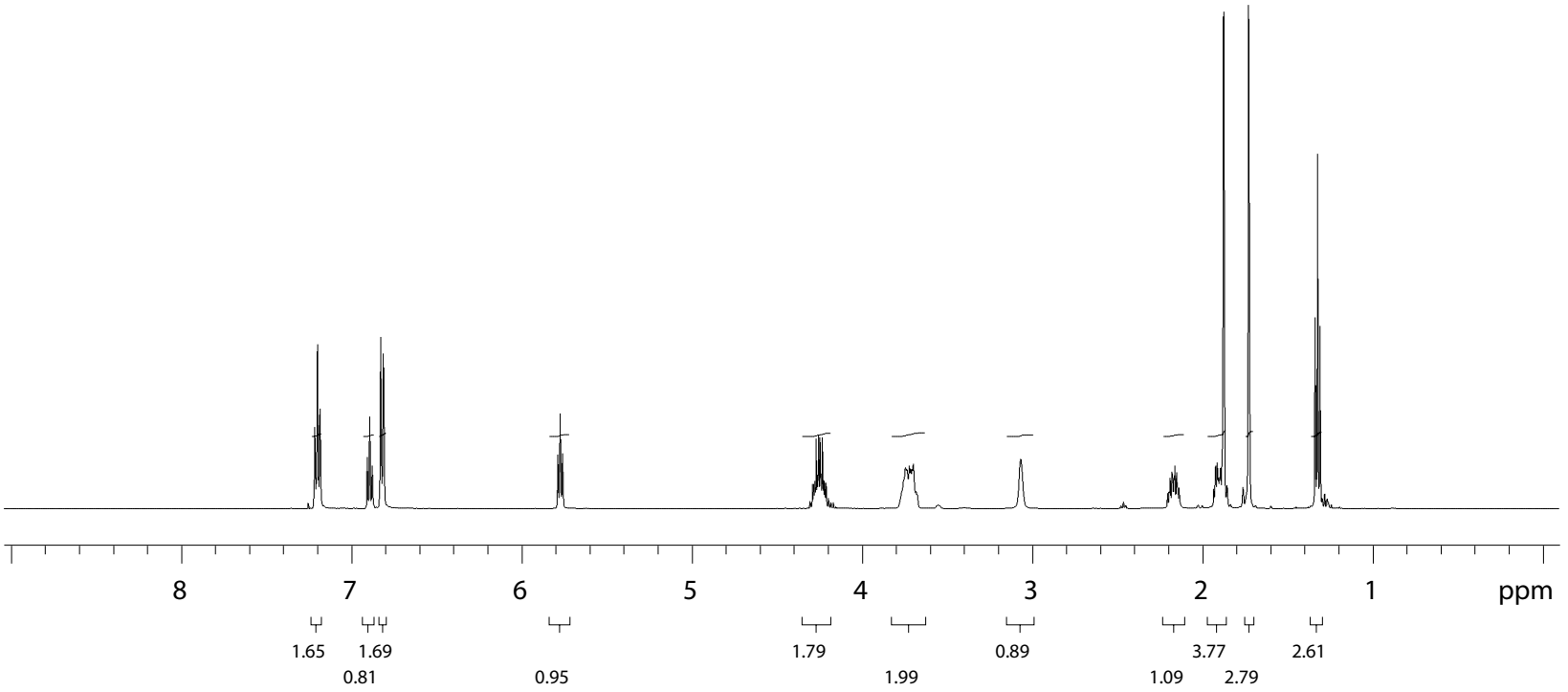
5e

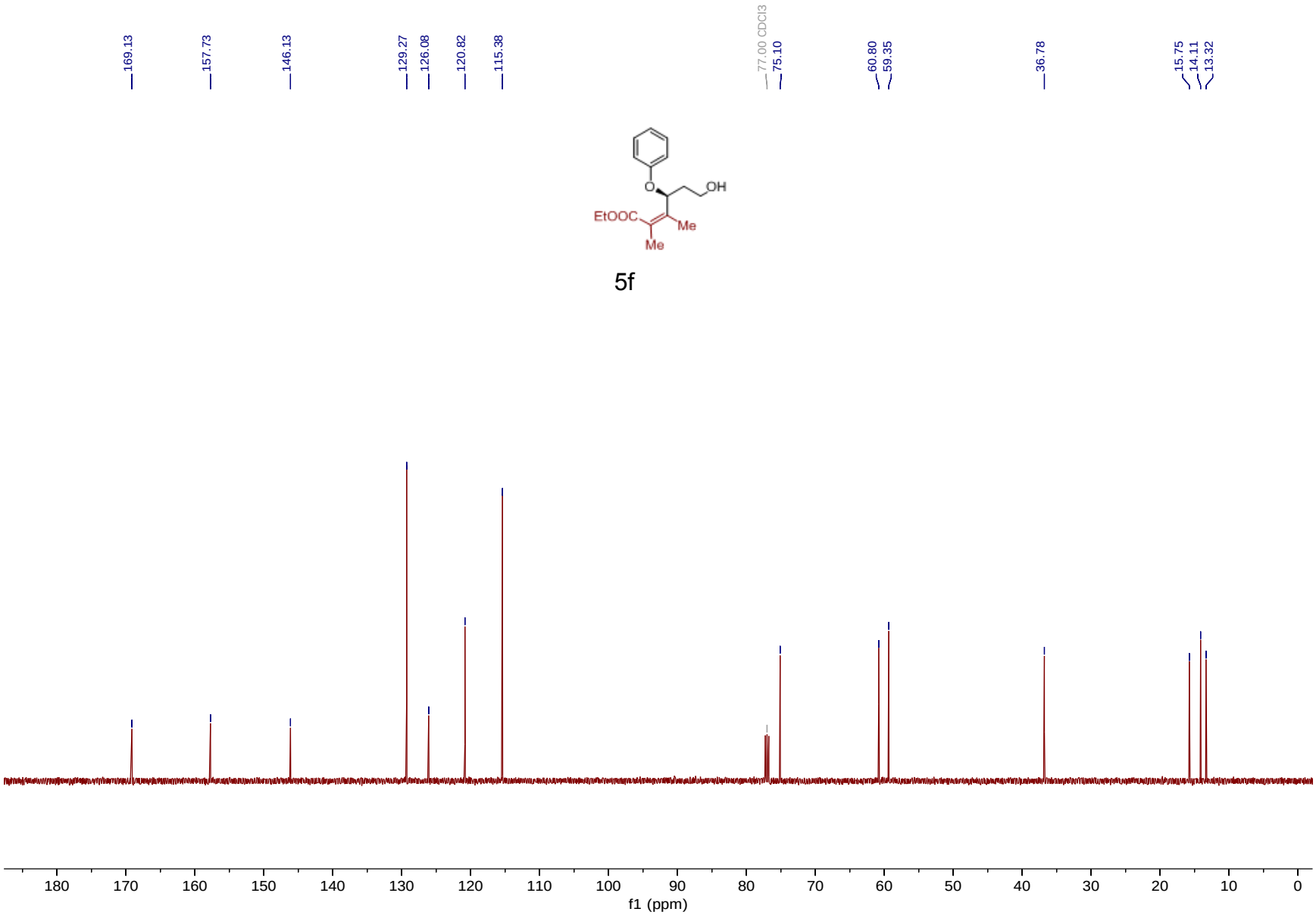



199.26
157.68
157.39
131.04
129.66
121.37
114.87
77.00 CDCl3
74.71
59.37
37.79
36.12
24.09
22.35
10.24
OH
Me
O
O
5e
f1 (ppm)

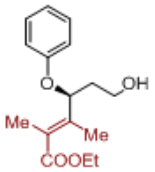

OH
O
EtOOC
Me
Me

5f

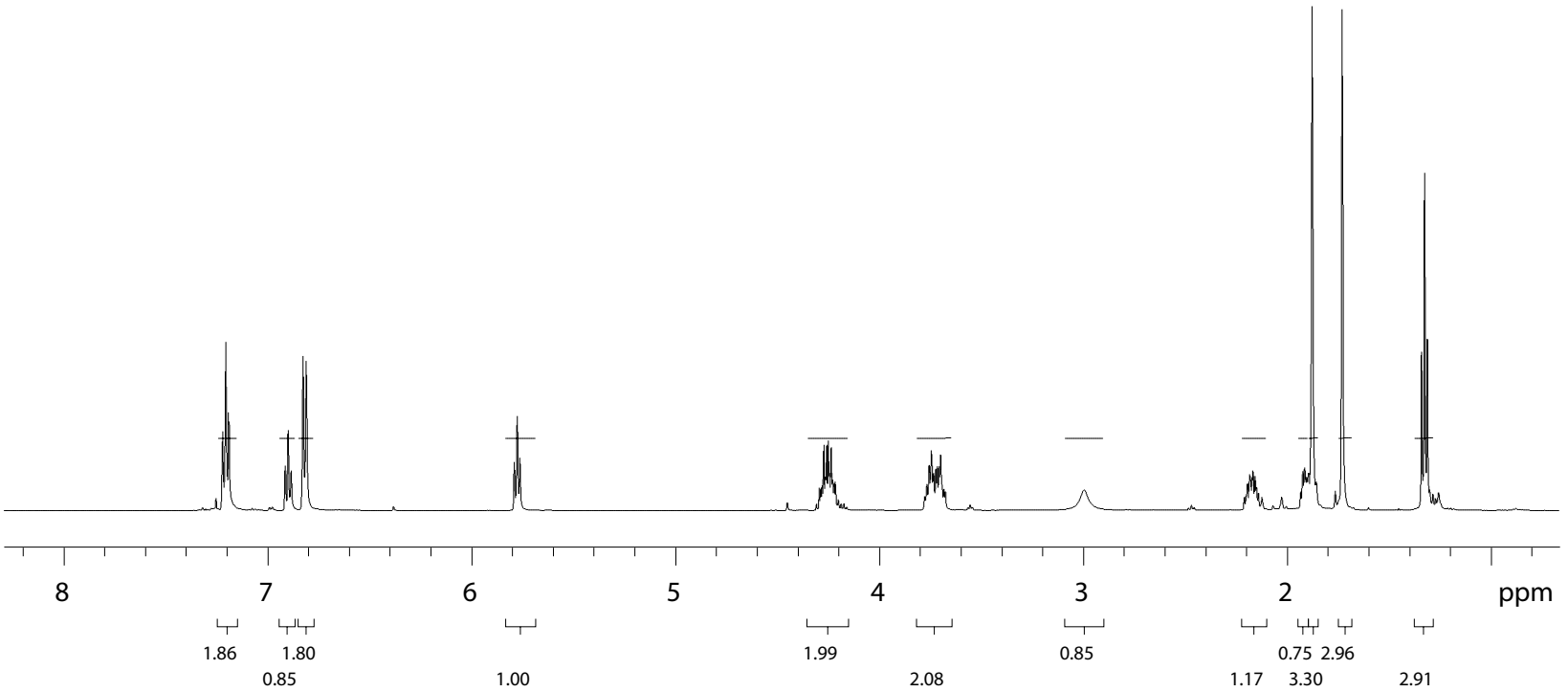

8
7
6
5
4
3
2
1
ppm
1.65
1.69
0.81
0.95
1.79
1.99
0.89
1.09
3.77
2.79
2.61

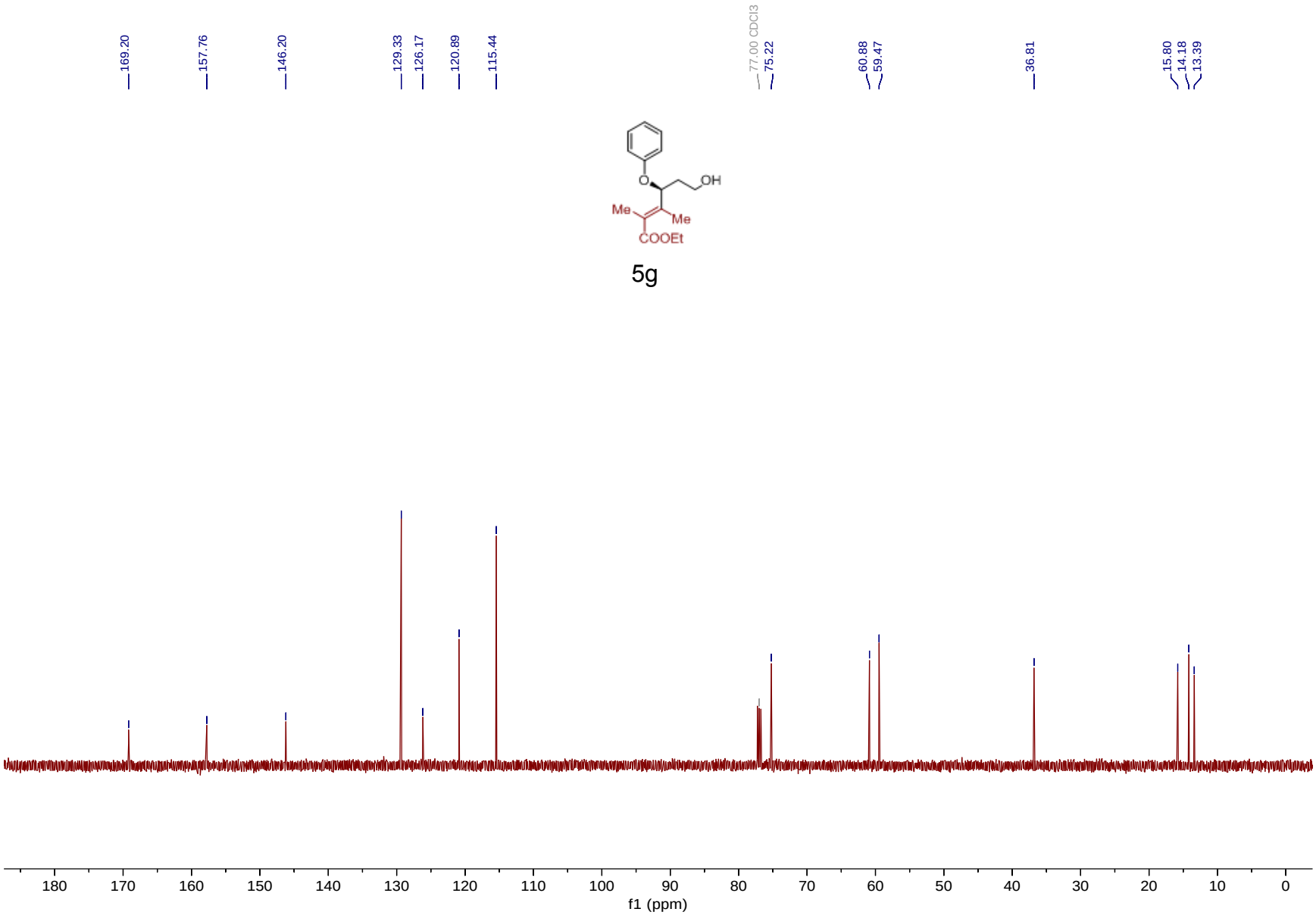

169.13
157.73
146.13
129.27
126.08
120.82
115.38
77.00 CDCl3
75.10
60.80
59.35
36.78
15.75
14.11
13.32
O
OH
EtOOC
Me
Me
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

5f

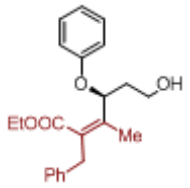

O
OH
Me
Me
COOEt

5g

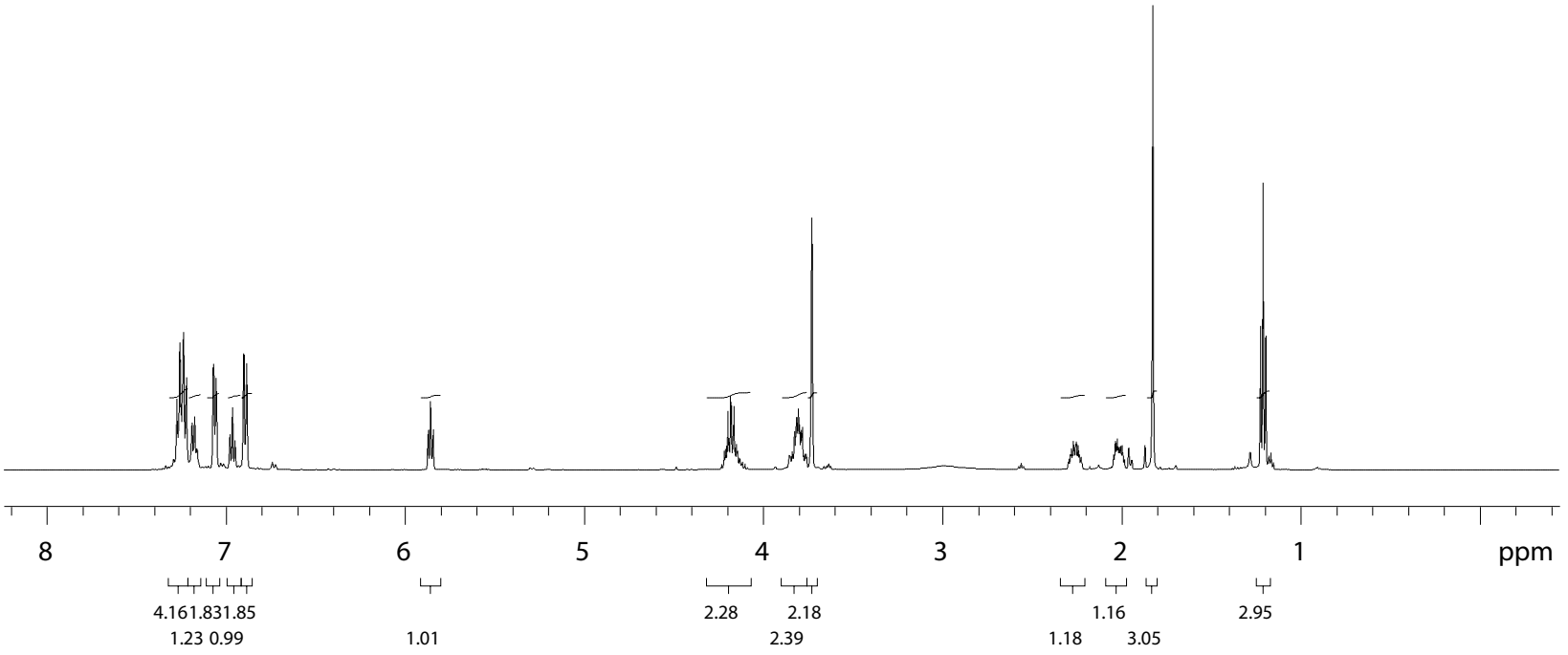

8
7
6
5
4
3
2
ppm
1.86
1.80
0.85
1.00
1.99
2.08
0.85
1.17
0.75
2.96
3.30
2.91

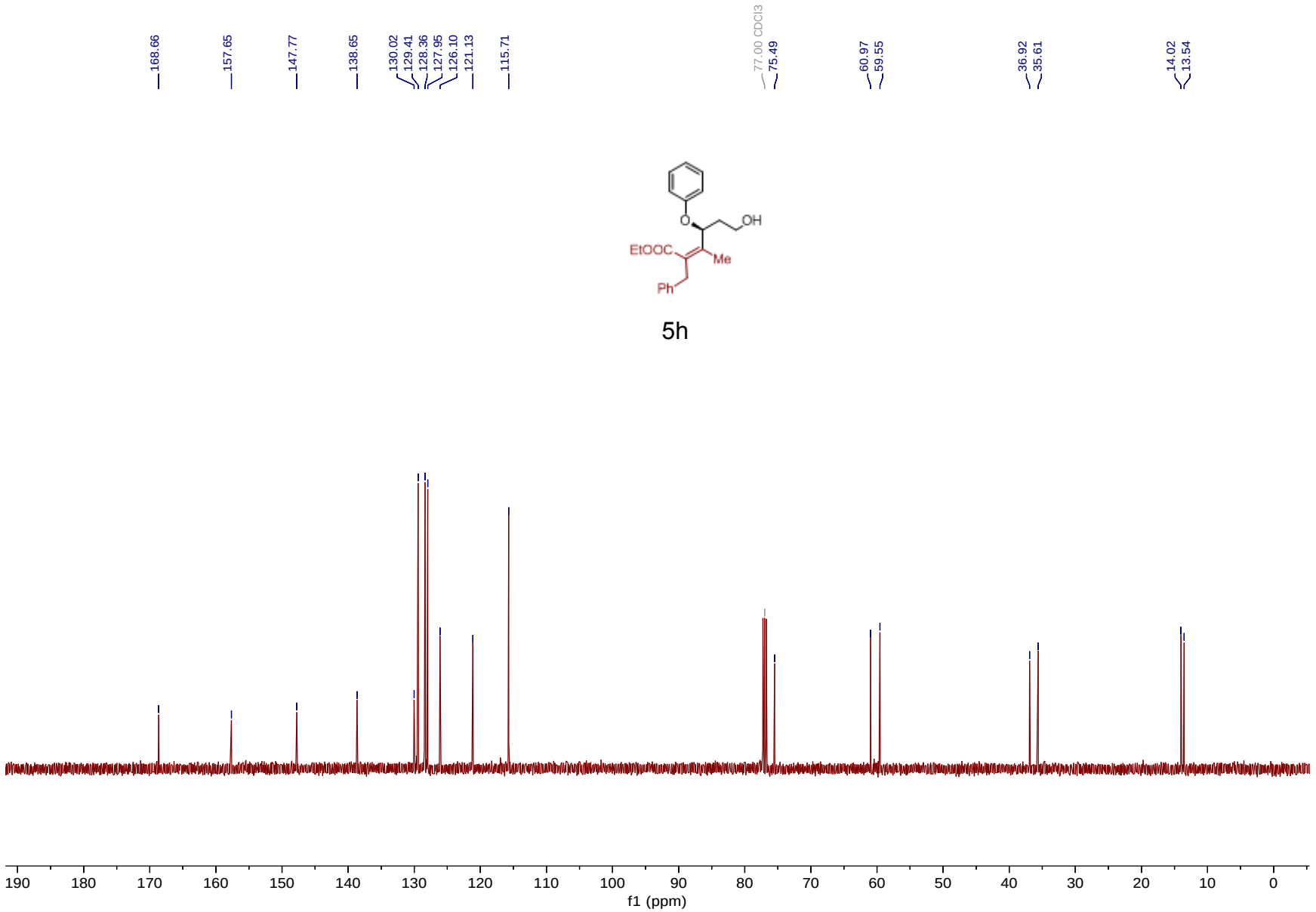

169.20
157.76
146.20
129.33
126.17
120.89
115.44
77.00 CDCl3
75.22
60.88
59.47
36.81
15.80
14.18
13.39
O
OH
Me
Me
COOEt
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

5g

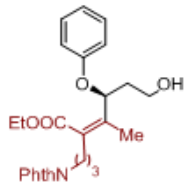

O
OH
EtOOC
Me
Ph

5h

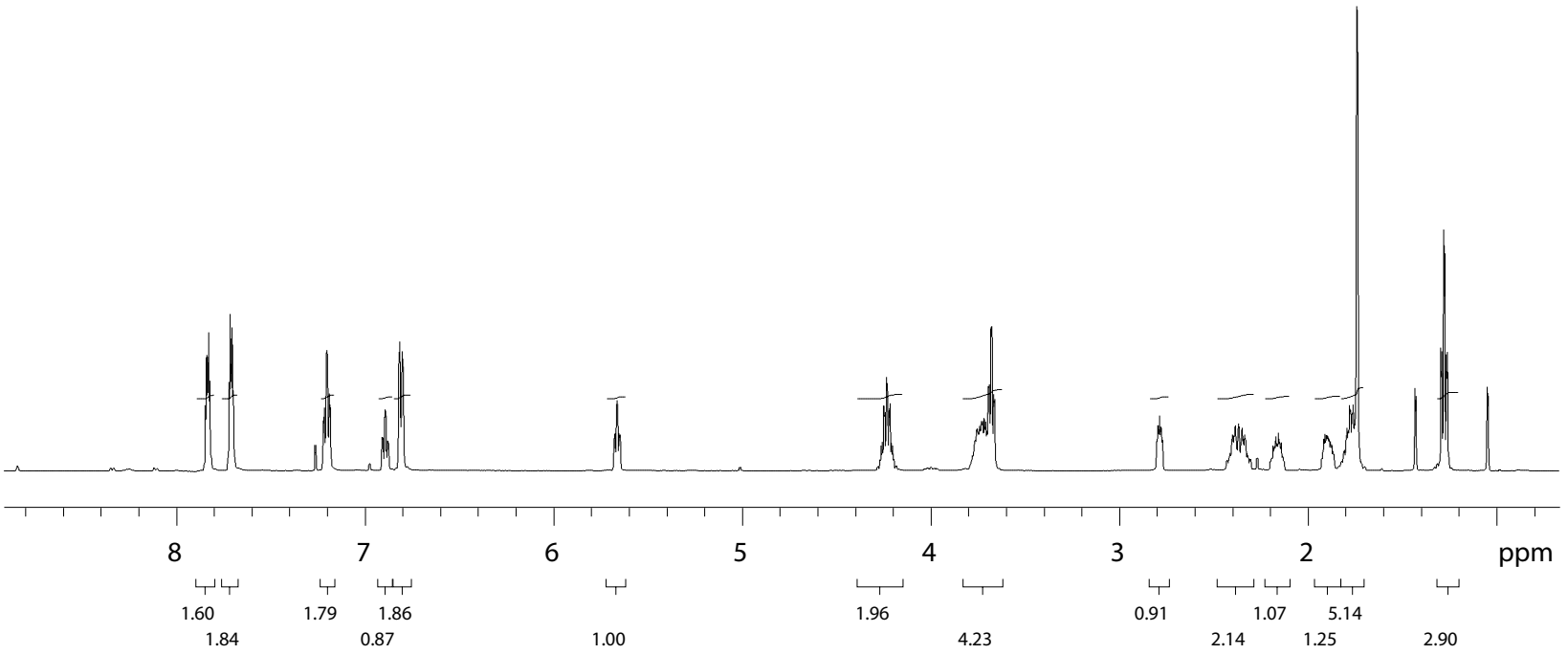

8
7
6
5
4
3
2
1
ppm
4.16 1.83 1.85
1.23 0.99
1.01
2.28
2.18
2.39
1.18
1.16
3.05
2.95

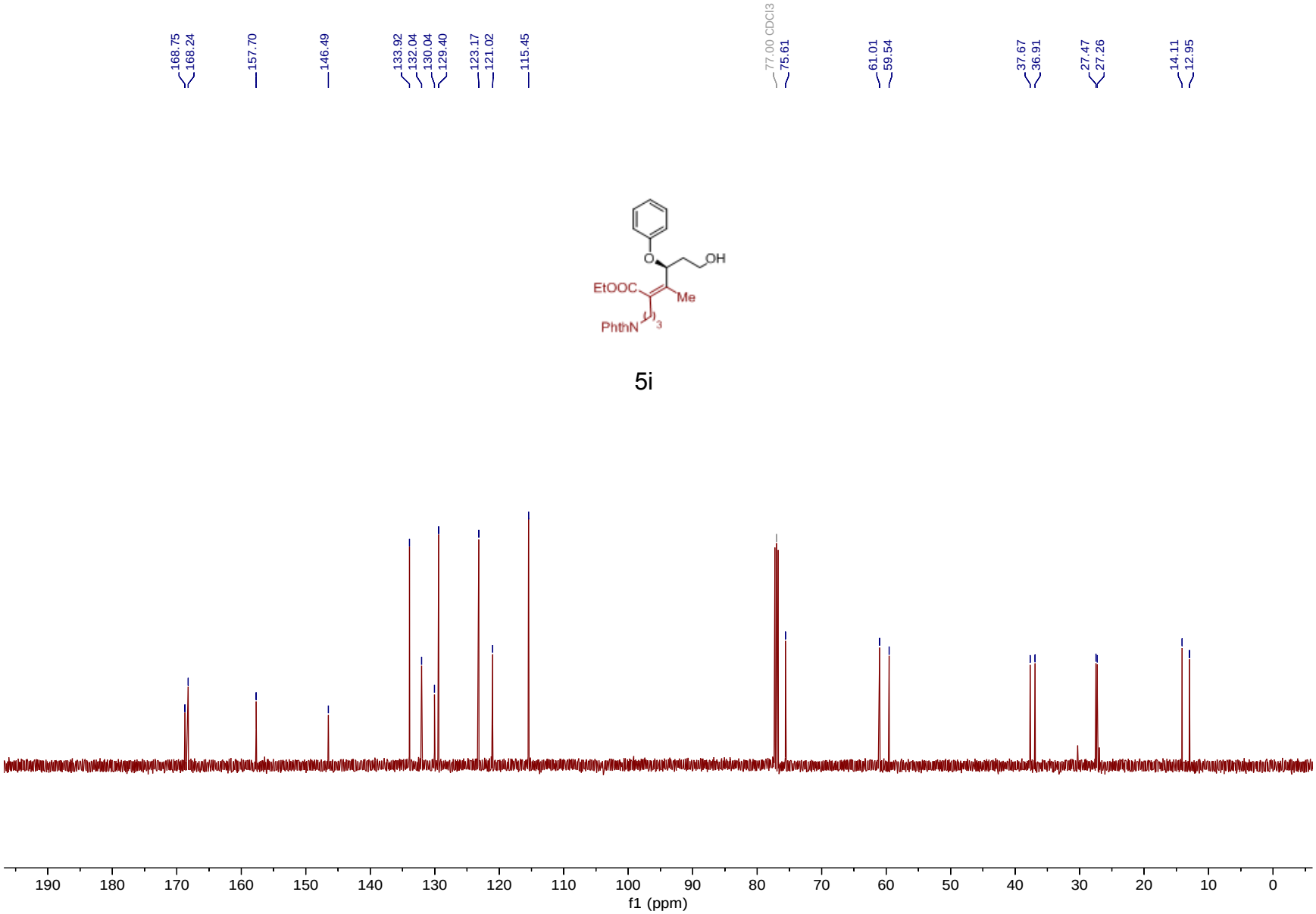

168.66
157.65
147.77
138.65
130.02
129.41
128.36
127.95
126.10
121.13
115.71
77.00 CDCl3
75.49
60.97
59.55
36.92
35.61
14.02
13.54
O
OH
EtOOC
Me
Ph
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

5h

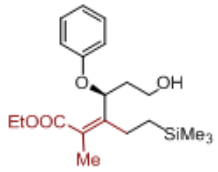

O
OH
EtOOC
Me
PhthN
3

5i


8
7
6
5
4
3
2
ppm
1.60
1.84
1.79
1.86
0.87
1.00
1.96
4.23
0.91
2.14
1.07
1.25
5.14
2.90

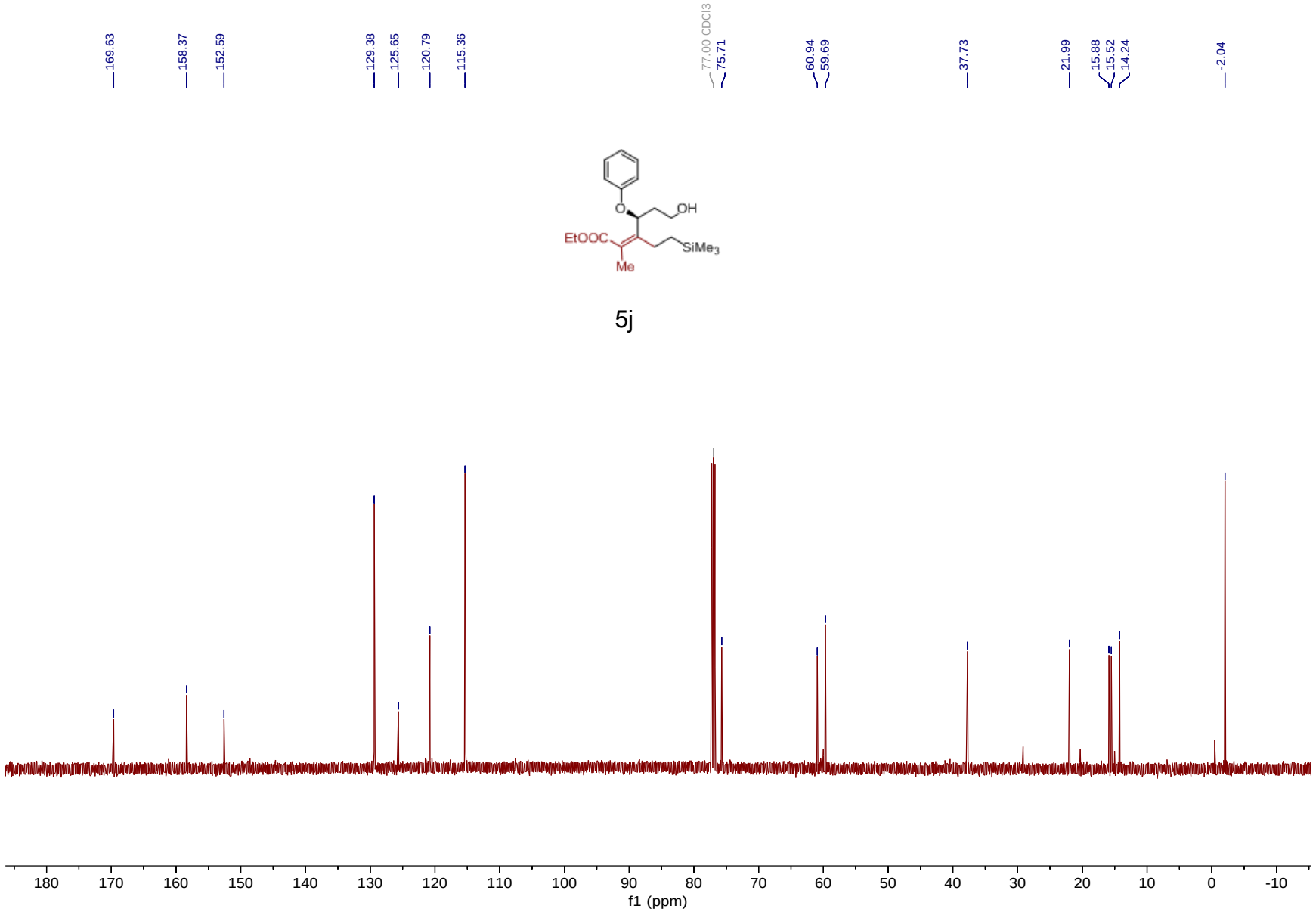

168.75
168.24
157.70
146.49
133.92
132.04
130.04
129.40
123.17
121.02
115.45
77.00 CDCl3
75.61
61.01
59.54
37.67
36.91
27.47
27.26
14.11
12.95
OH
O
EtOOC
Me
PhthN
3
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

5i

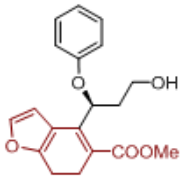

OH
EtOOC
SiMe3
Me

5j

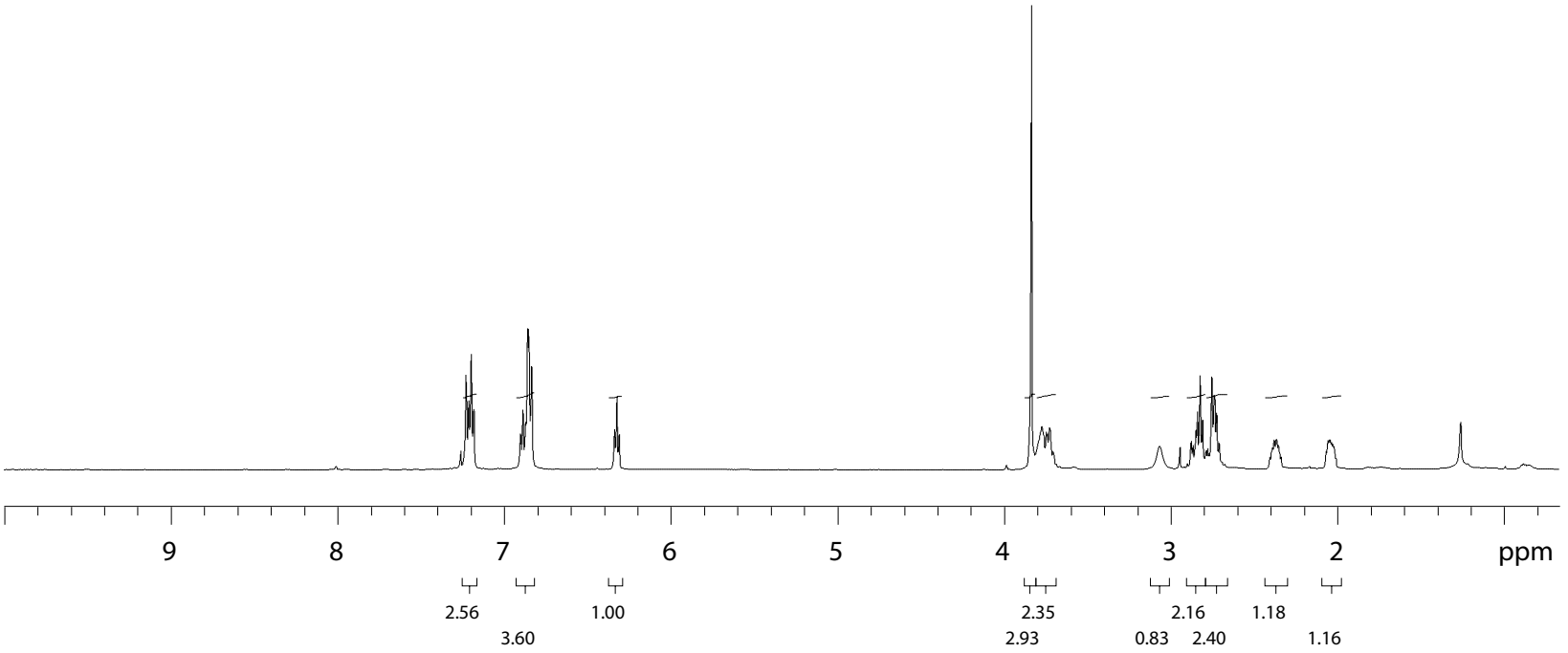
8
7
6
5
4
3
2
1
-0
ppm
1.63
1.63
0.92
0.89
1.94
1.99
0.75
3.83
3.55
3.26
1.09
1.01
7.50

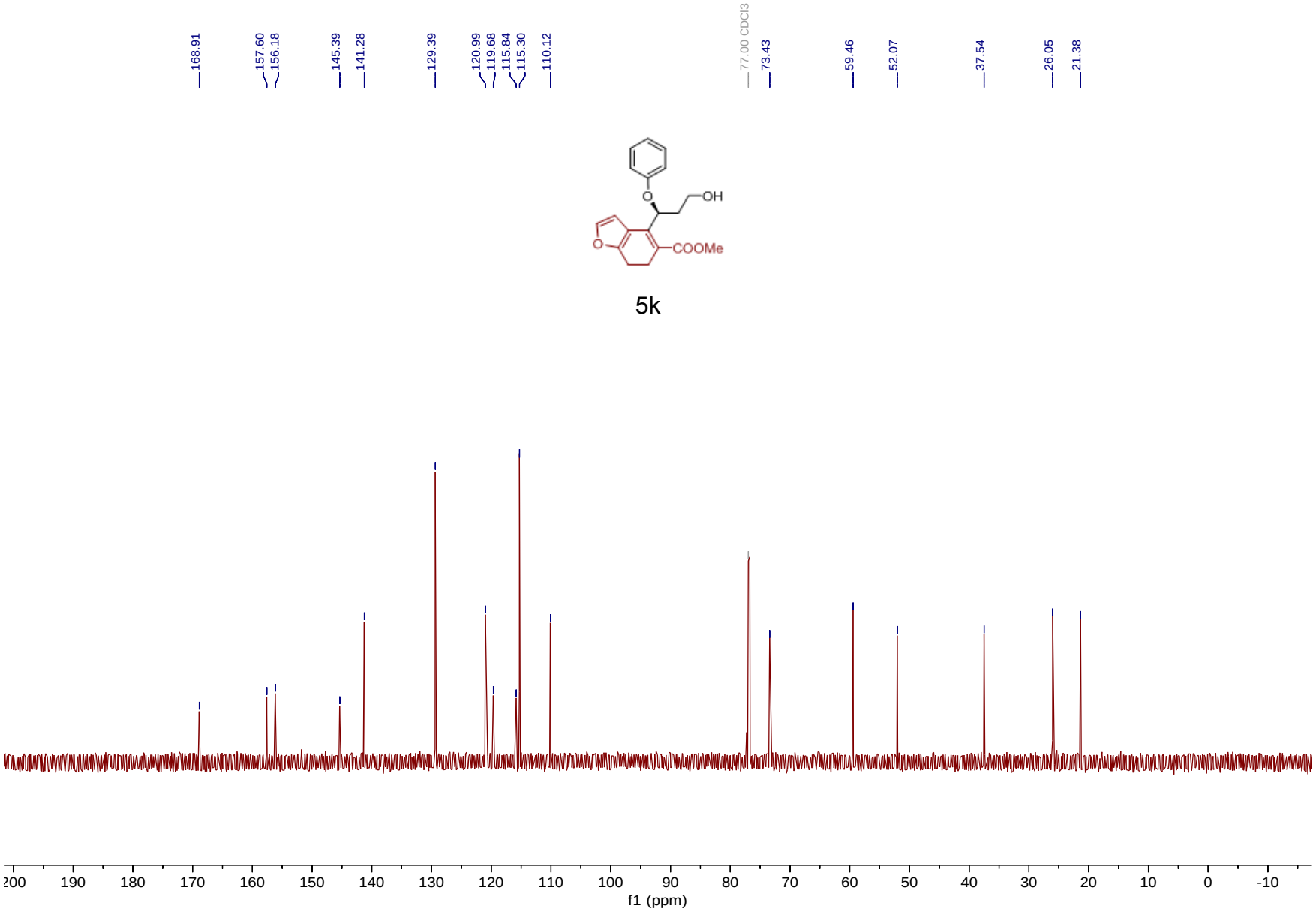

169.63
158.37
152.59
129.38
125.65
120.79
115.36
77.00 CDCl3
75.71
60.94
59.69
37.73
21.99
15.88
15.52
14.24
-2.04
O
OH
EtOOC
SiMe3
Me
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

5j

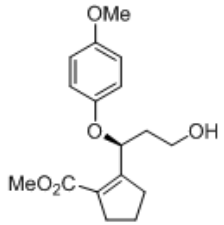

OH
O
O
COOMe

5k

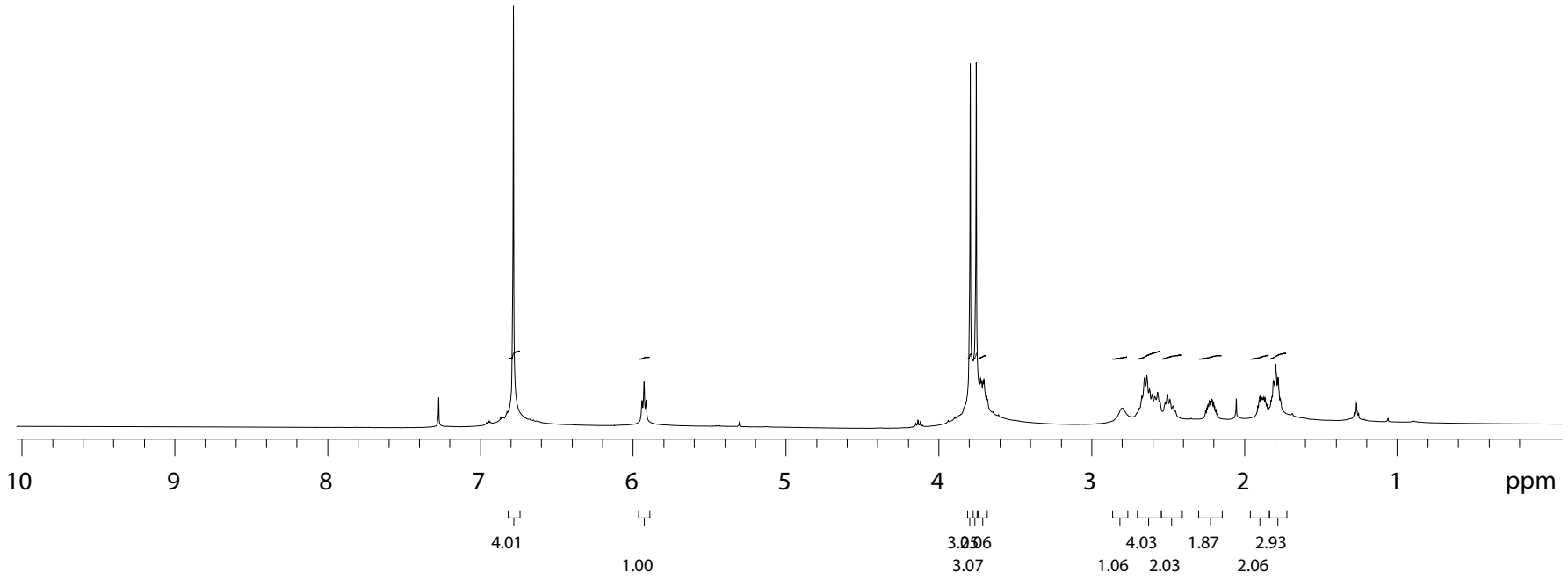

9
8
7
6
5
4
3
2
ppm
2.56
3.60
1.00
2.35
2.93
0.83
2.16
2.40
1.18
1.16

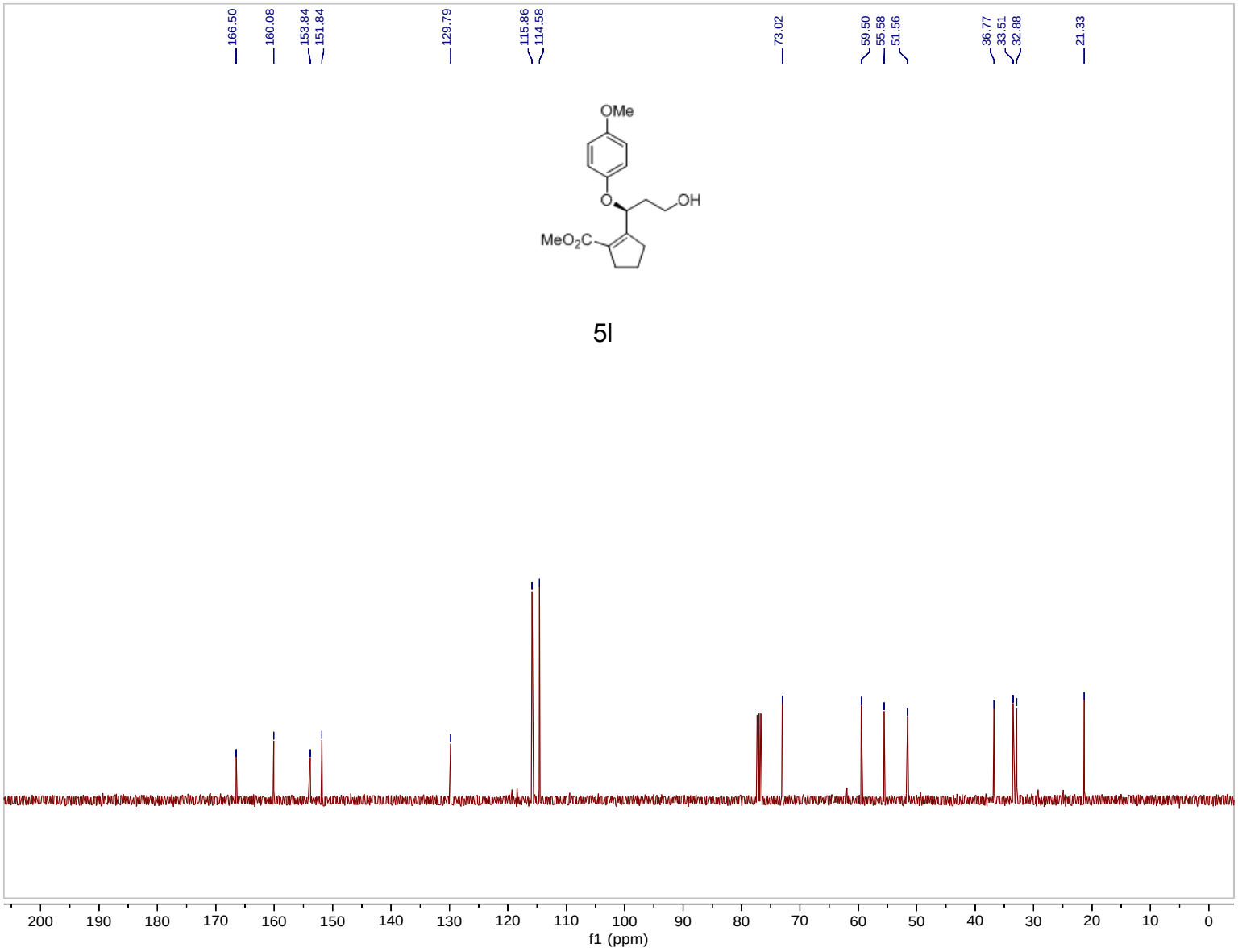

168.91
157.60
156.18
145.39
141.28
129.39
120.99
119.68
115.84
115.30
110.12
77.00 CDCl3
73.43
59.46
52.07
37.54
26.05
21.38
OH
O
O
COOMe
f1 (ppm)

5k

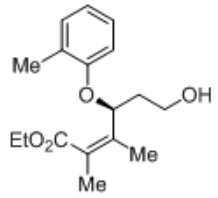


5l

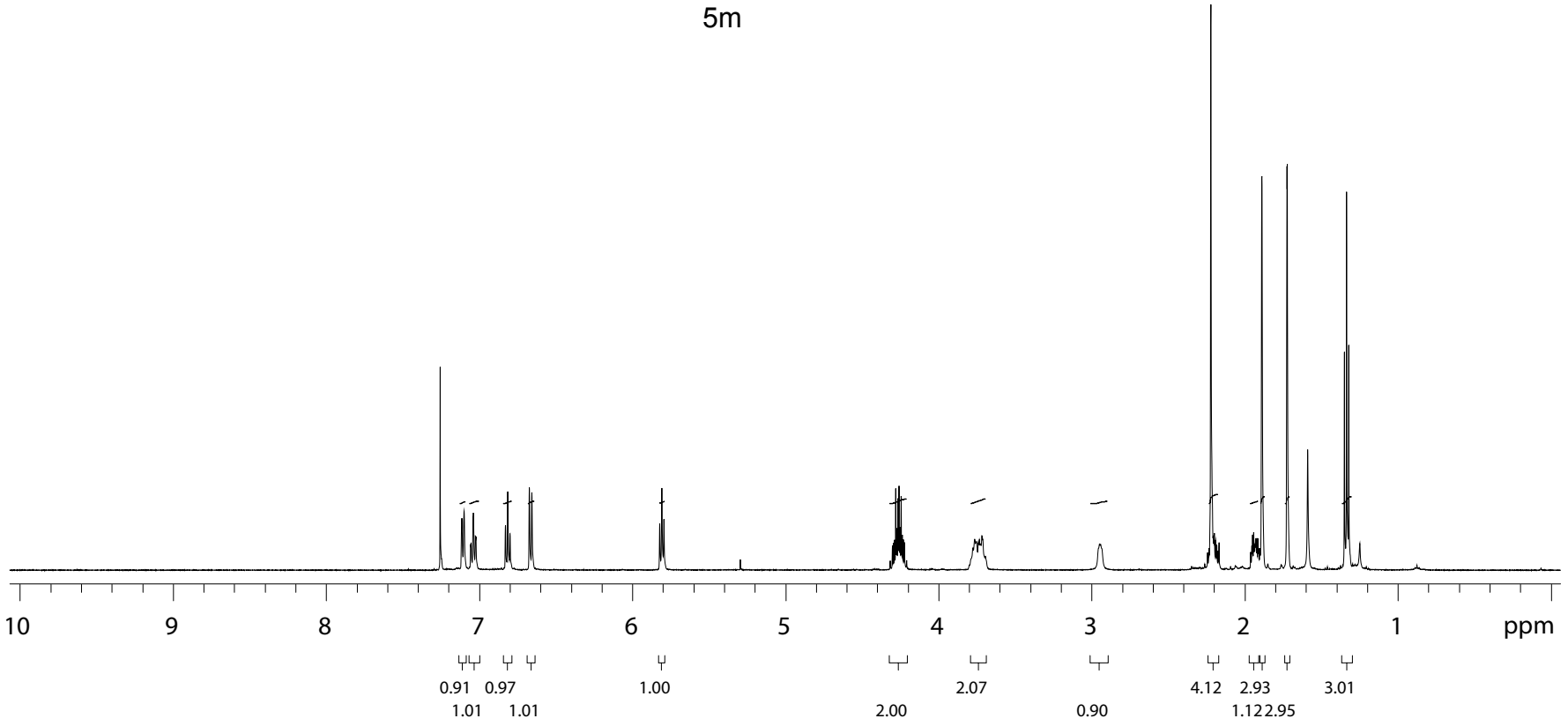


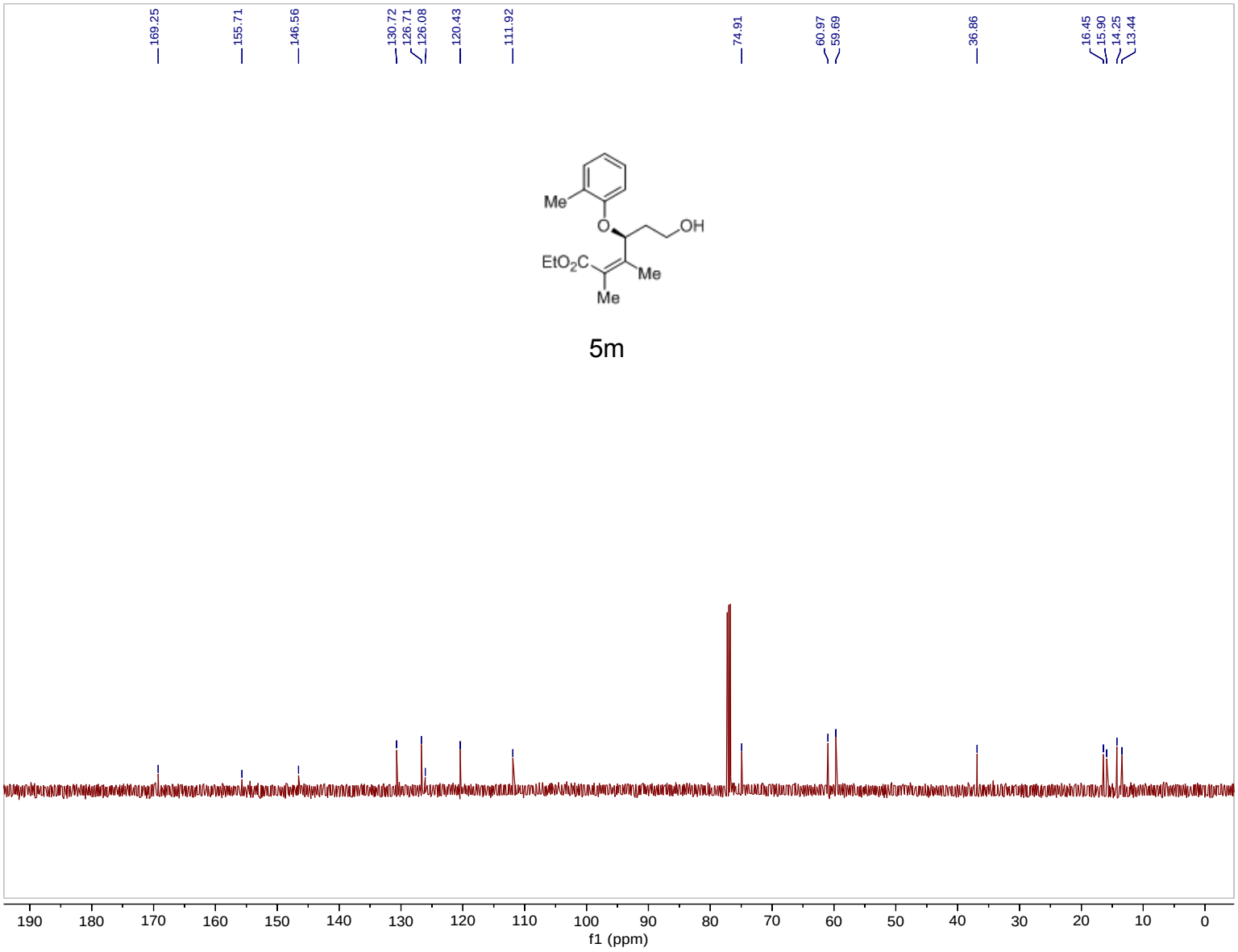

166.50
160.08
153.84
151.84
129.79
115.86
114.58
73.02
59.50
55.58
51.56
36.77
33.51
32.88
21.33
OMe
O
OH
MeO2C
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

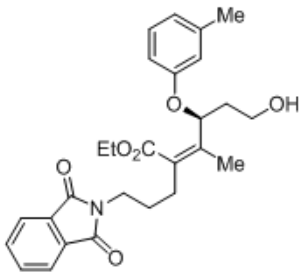
5l


Me
O
OH
EtO2C
Me
Me

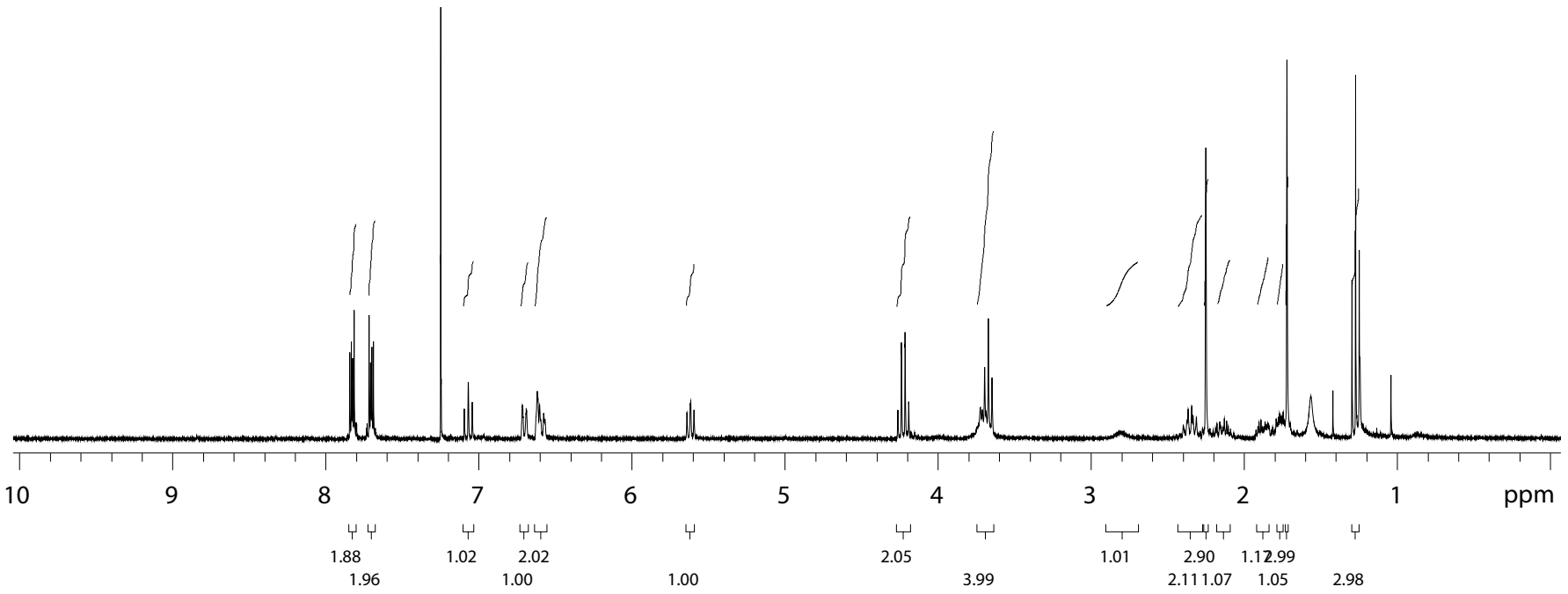
5m

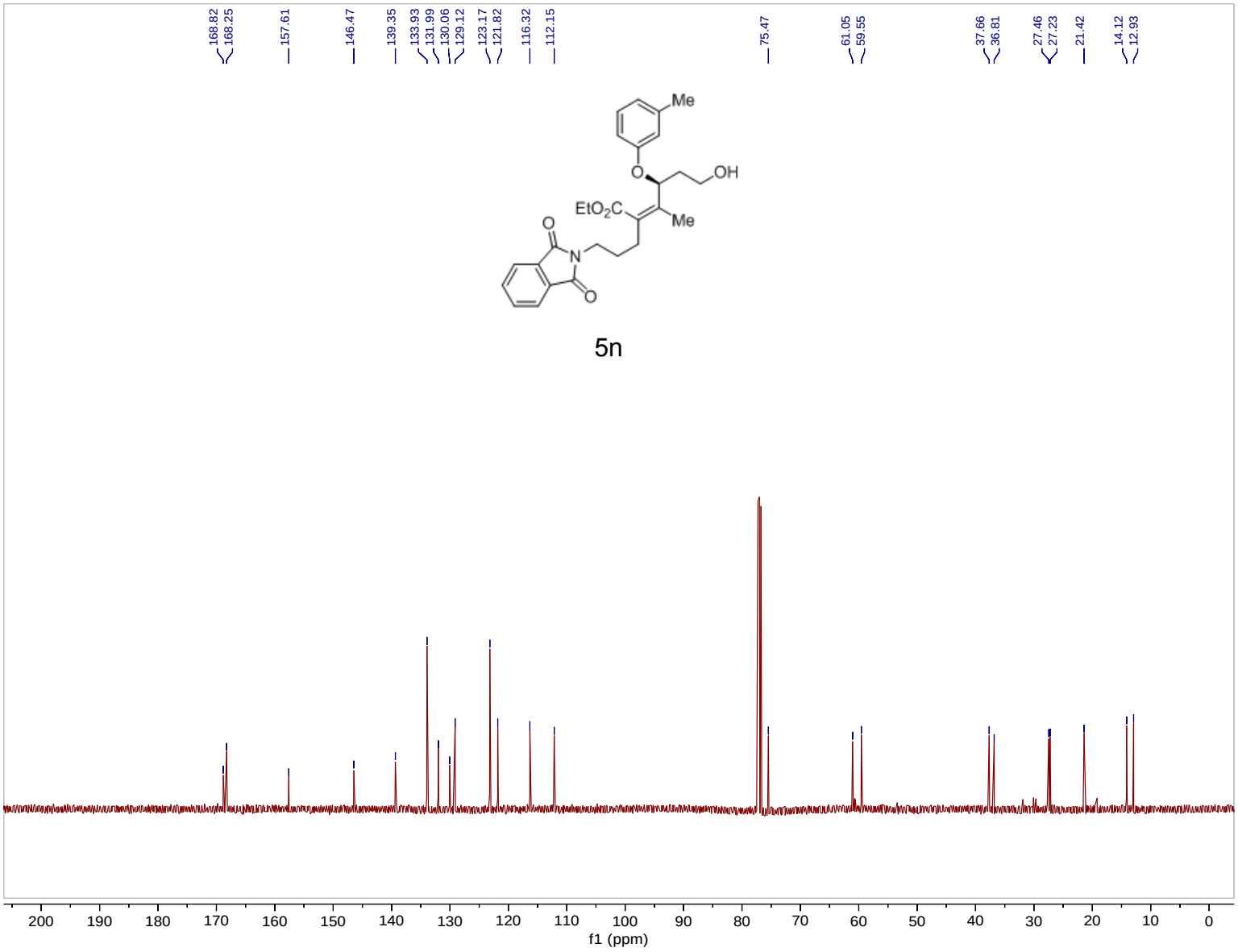

10
9
8
7
6
5
4
3
2
1
ppm
0.91
0.97
1.00
2.07
4.12
2.93
3.01
1.01
1.01
2.00
0.90
1.12
2.95


169.25
155.71
146.56
130.72
126.71
126.08
120.43
111.92
74.91
60.97
59.69
36.86
16.45
15.90
14.25
13.44
Me
O
OH
EtO2C
Me
Me
5m
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

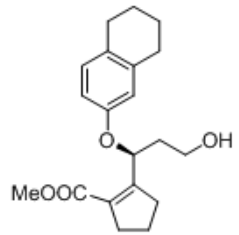

Me
O
OH
EtO2C
Me
O
N
O

5n

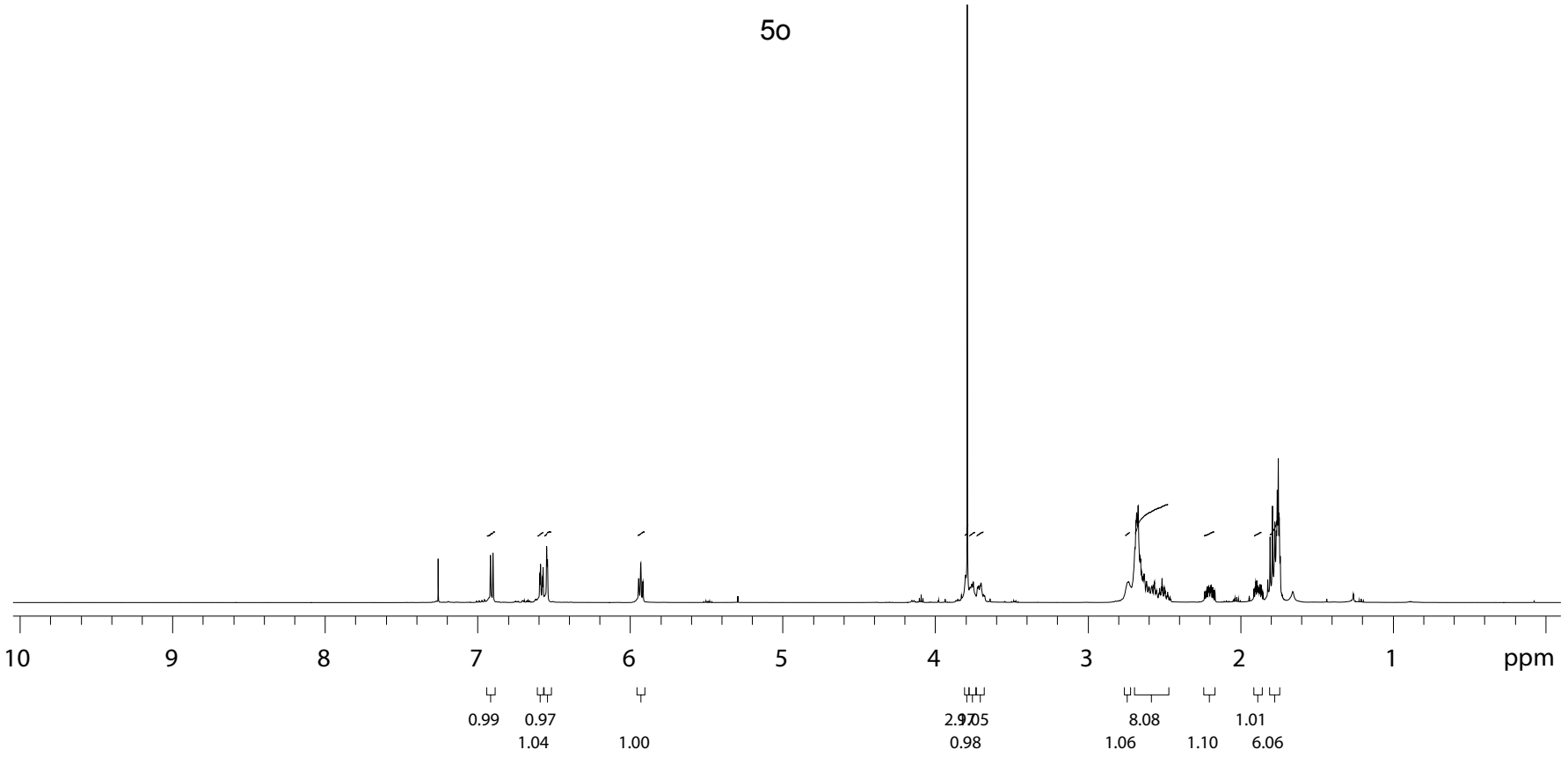

10
9
8
7
6
5
4
3
2
1
ppm
1.88
1.96
1.02
2.02
1.00
1.00
2.05
3.99
1.01
2.90
2.11
1.07
1.12
1.05
2.99
2.98

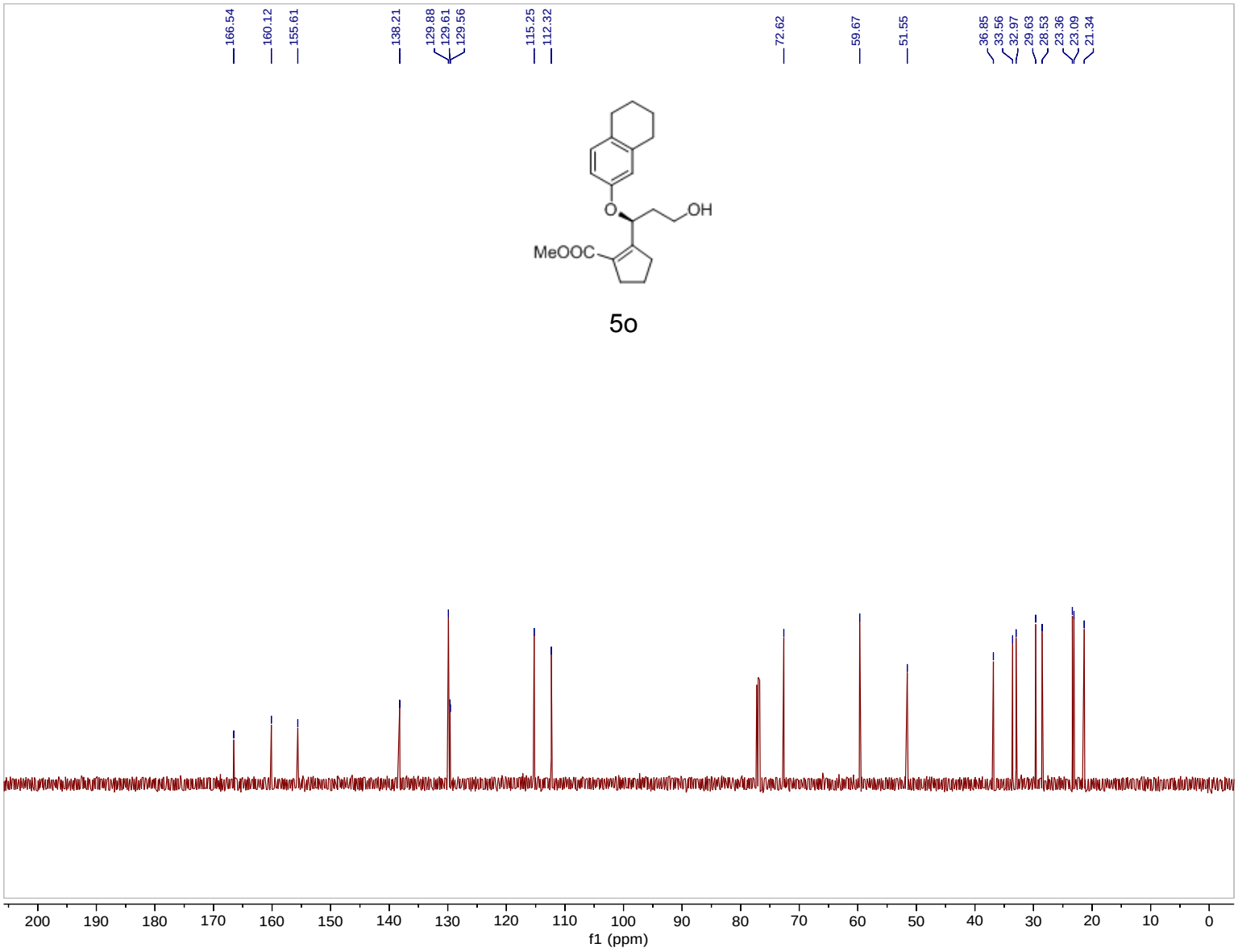

168.82
168.25
157.61
146.47
139.35
133.93
131.99
130.06
129.12
123.17
121.82
116.32
112.15
75.47
61.05
59.55
37.66
36.81
27.46
27.23
21.42
14.12
12.93
Me
O
OH
EtO2C
Me
O
N
O
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

5n

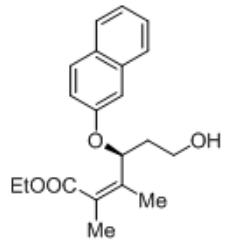

O
OH
MeOOC

5o

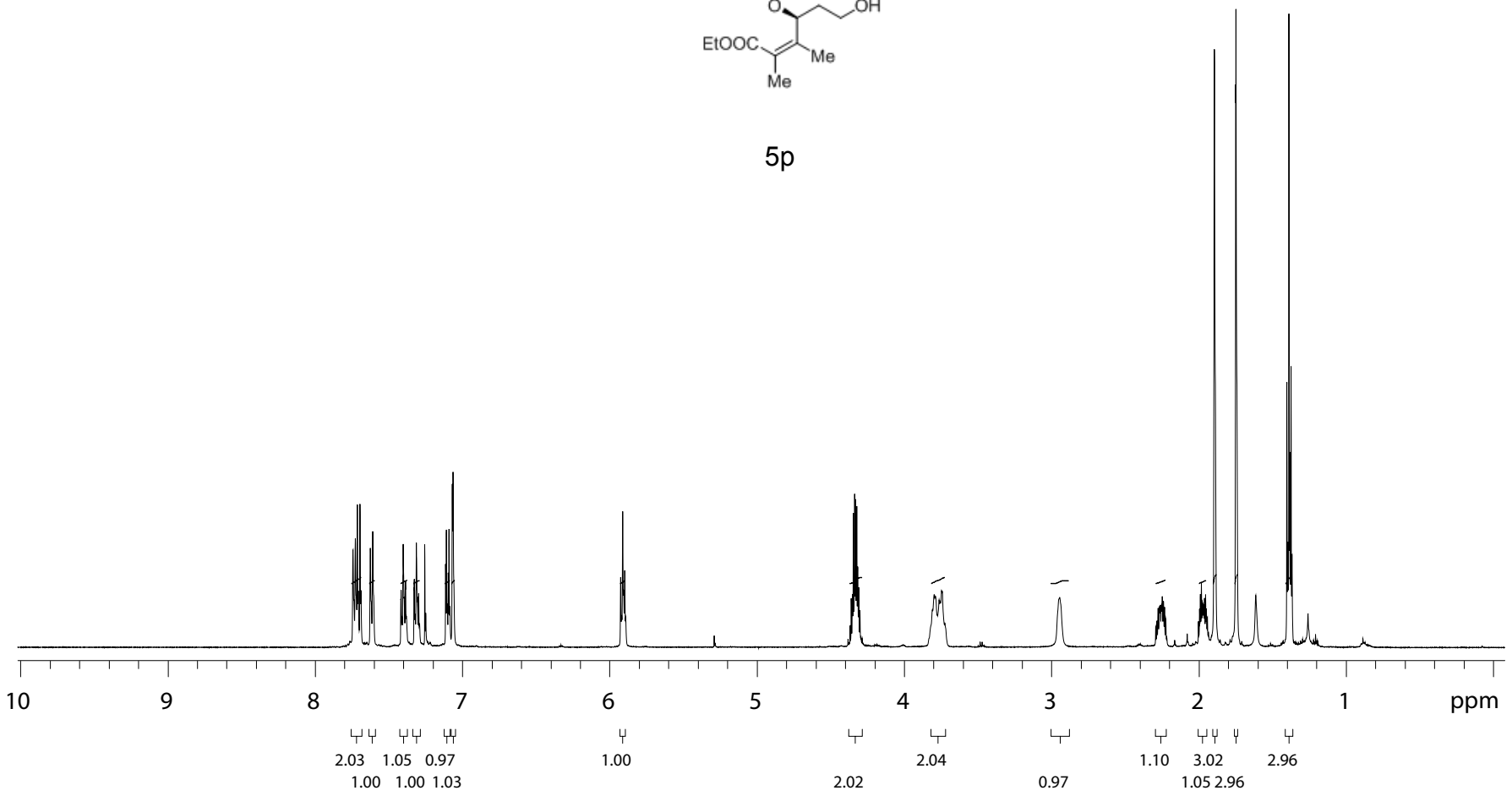

10
9
8
7
6
5
4
3
2
1
ppm
0.99
0.97
1.04
1.00
2.97
1.05
0.98
8.08
1.06
1.10
1.01
6.06

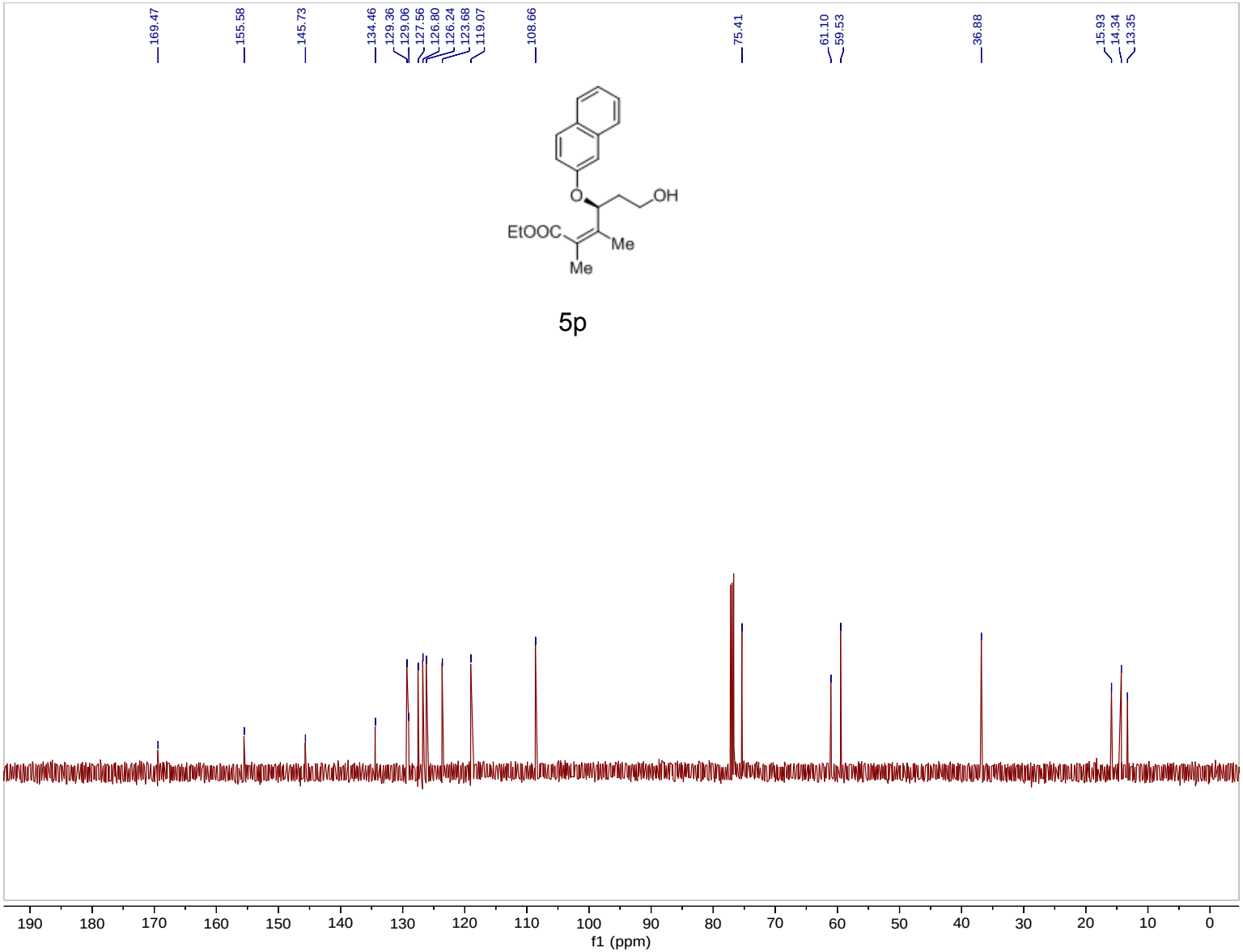

166.54
160.12
155.61
138.21
129.88
129.61
129.56
115.25
112.32
72.62
59.67
51.55
36.85
33.56
32.97
29.63
28.53
23.36
23.09
21.34
O
OH
MeOOC
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

5o

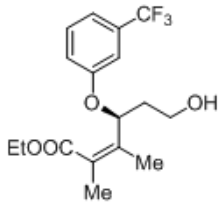

O
OH
EtOOC
Me
Me

5p

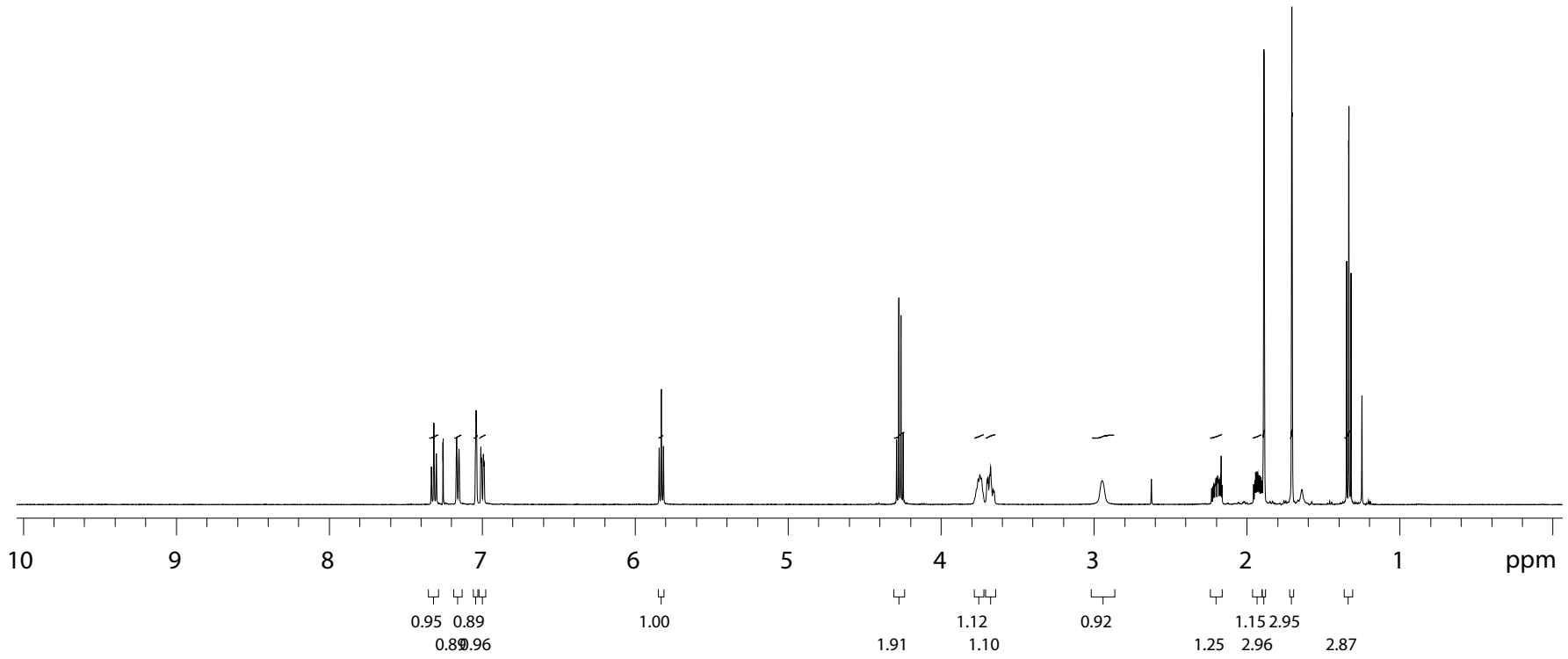

10
9
8
7
6
5
4
3
2
1
ppm
2.03
1.05
0.97
1.00
1.00
1.00
1.03
1.00
2.02
2.04
0.97
1.10
3.02
2.96
1.05
2.96

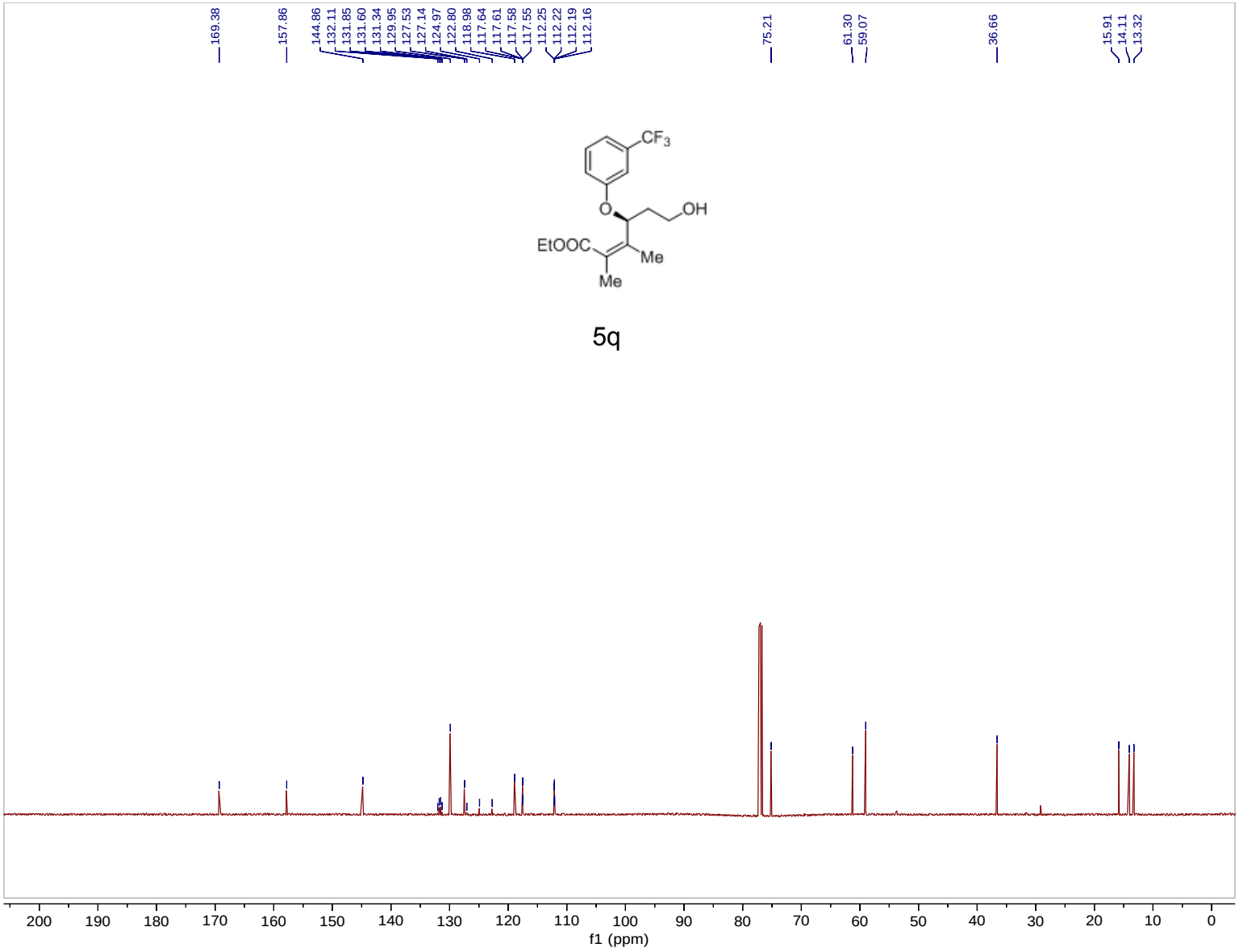

169.47
155.58
145.73
134.46
129.36
129.06
127.56
126.80
126.24
123.68
119.07
108.66
75.41
61.10
59.53
36.88
15.93
14.34
13.35
O
OH
EtOOC
Me
Me
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

5p

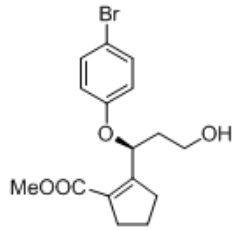

CF3
O
OH
EtOOC
Me
Me

5q

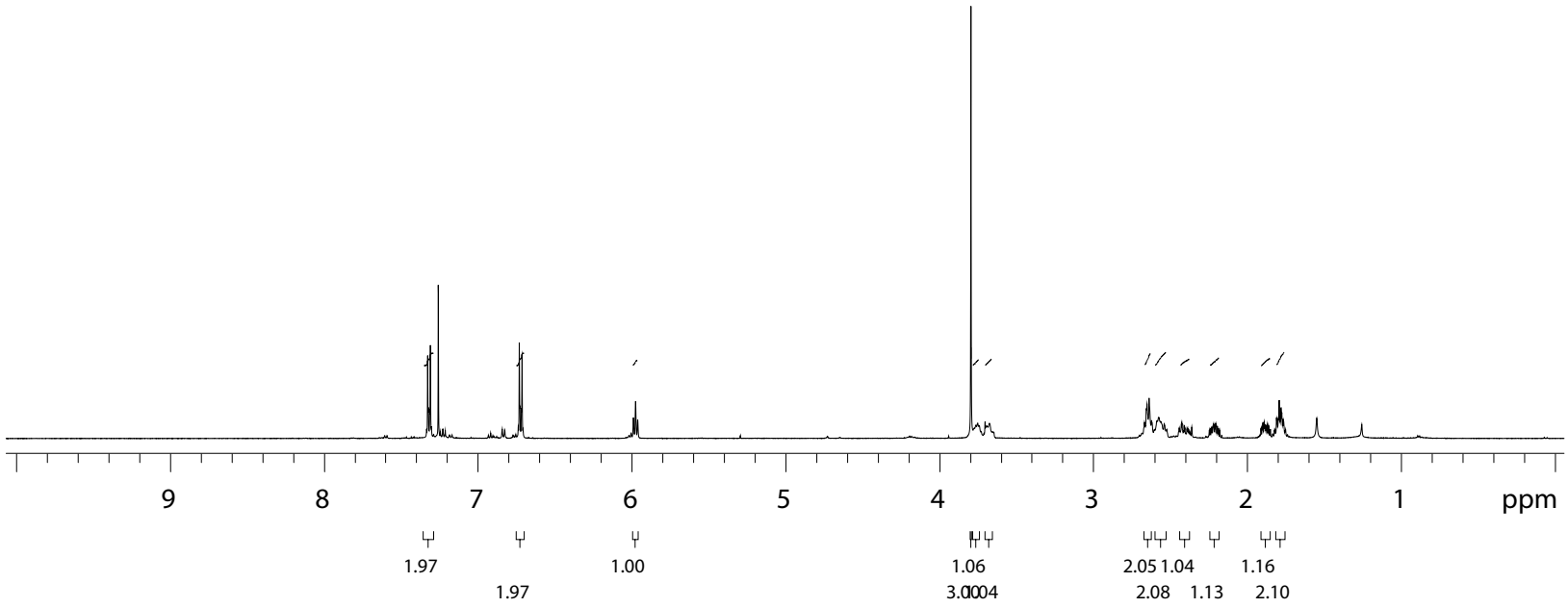

10
9
8
7
6
5
4
3
2
1
ppm
0.95
0.89
0.89
0.96
1.00
1.91
1.12
1.10
0.92
1.25
1.15
2.96
2.95
2.87

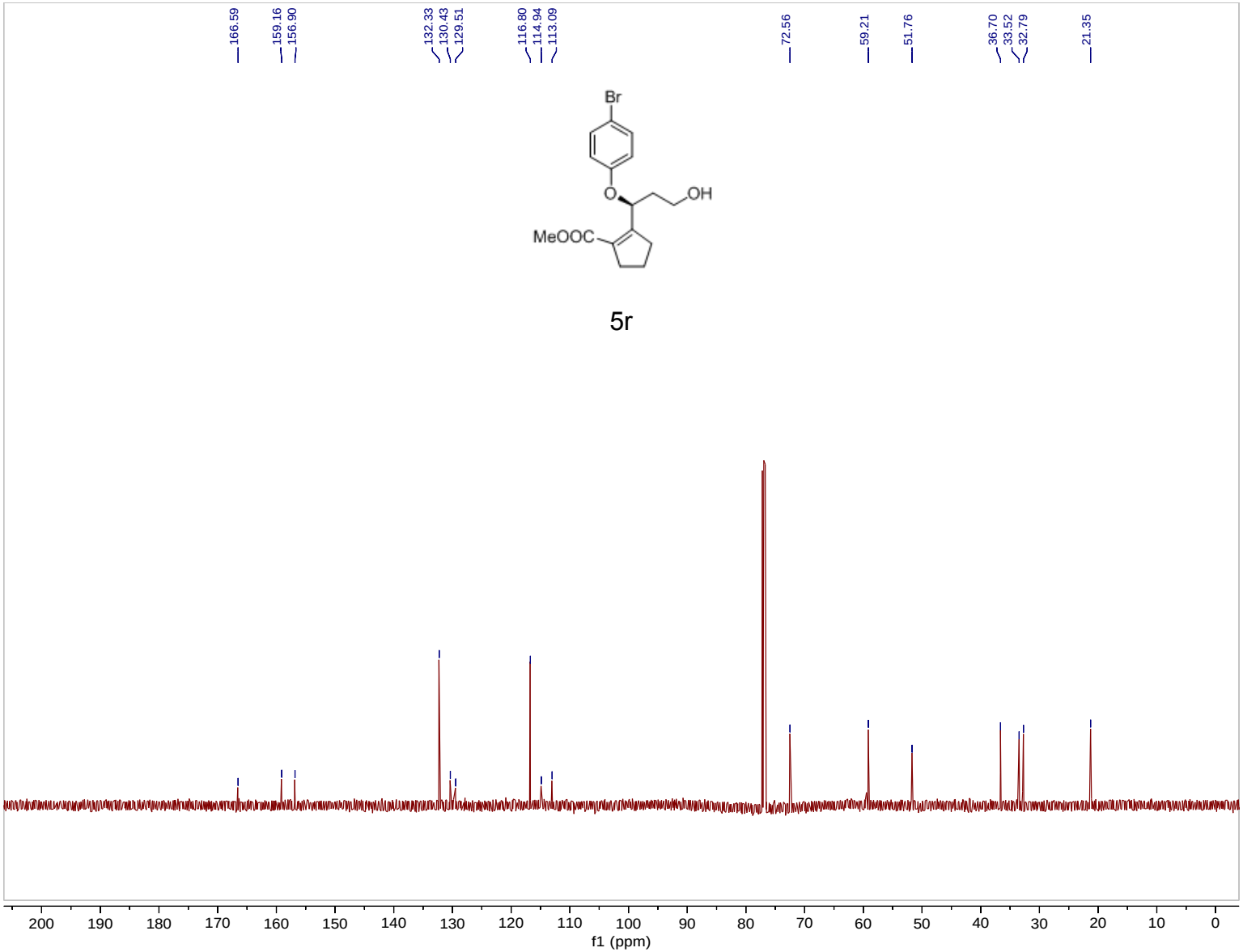

169.38
157.86
144.86
132.11
131.85
131.60
131.34
129.95
127.53
127.14
124.97
122.80
118.98
117.64
117.61
117.58
117.55
112.25
112.22
112.19
112.16
75.21
61.30
59.07
36.66
15.91
14.11
13.32
CF3
O
OH
EtOOC
Me
Me
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

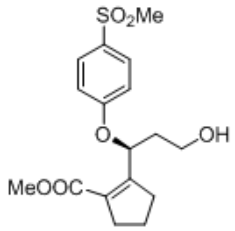
5q


Br
O
OH
MeOOC

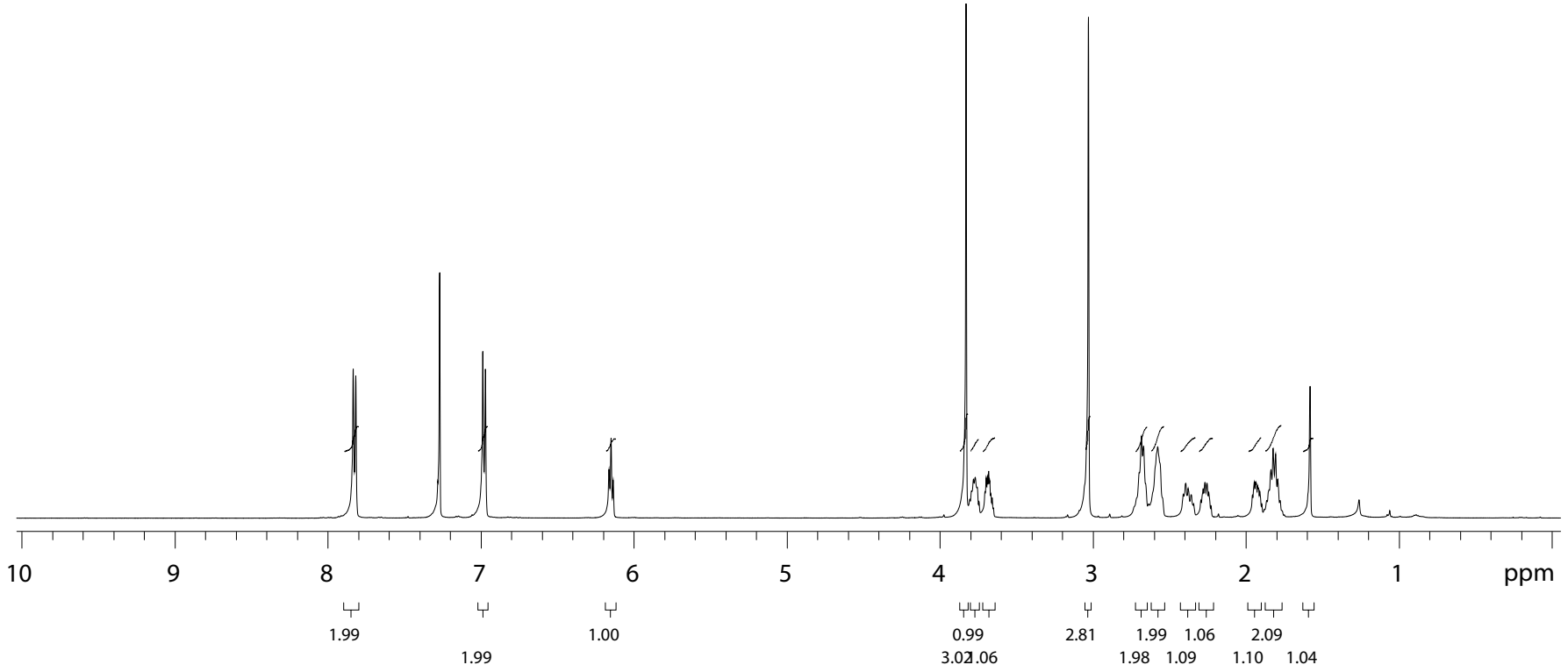
5r

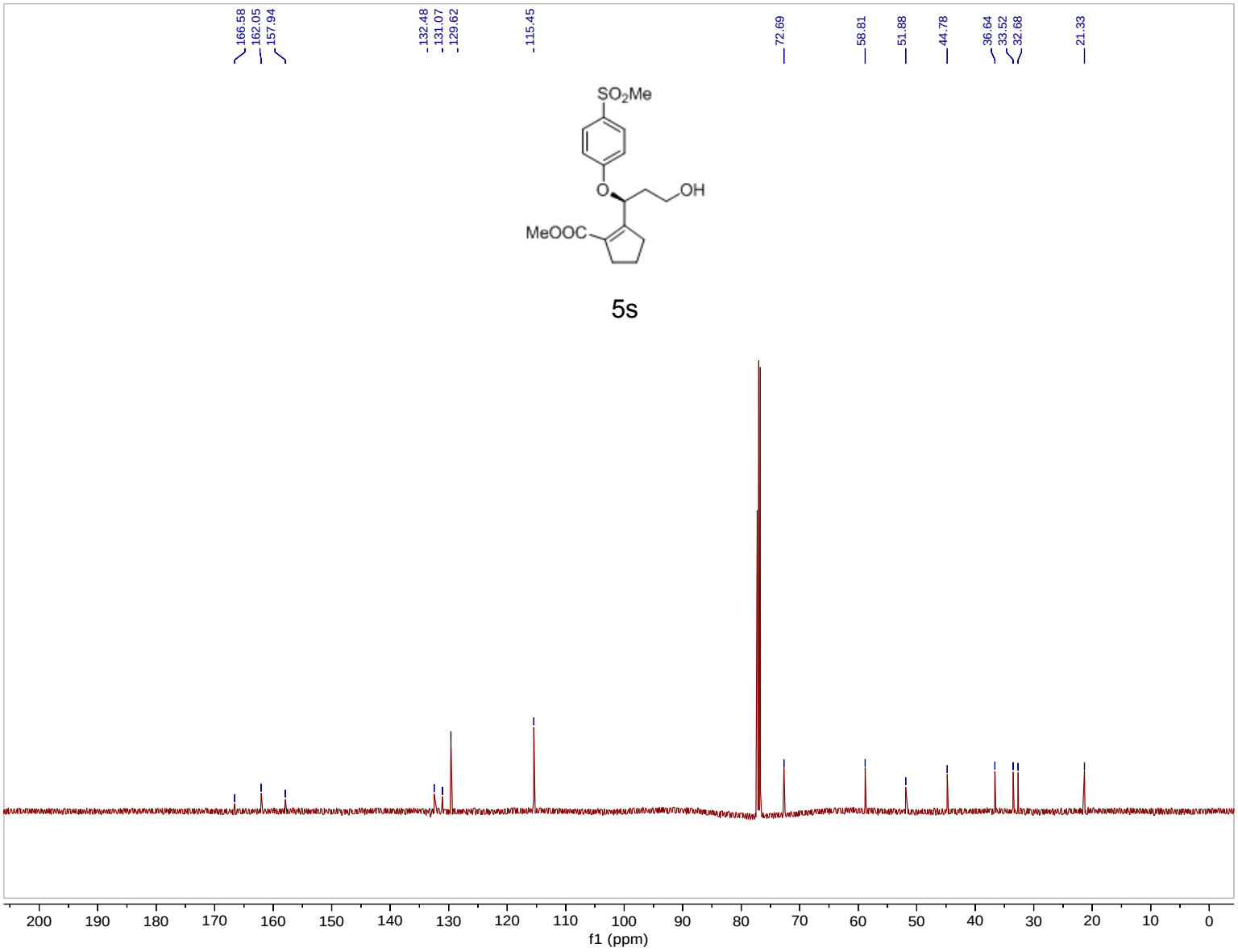

9
8
7
6
5
4
3
2
1
ppm
1.97
1.97
1.00
1.06
3.00
4
2.05
2.08
1.04
1.13
1.16
2.10


166.59
159.16
156.90
132.33
130.43
129.51
116.80
114.94
113.09
72.56
59.21
51.76
36.70
33.52
32.79
21.35
Br
O
OH
MeOOC
5r
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

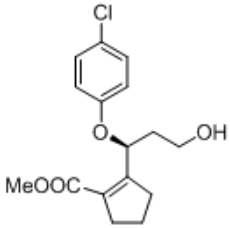

SO2Me
O
OH
MeOOC

5s

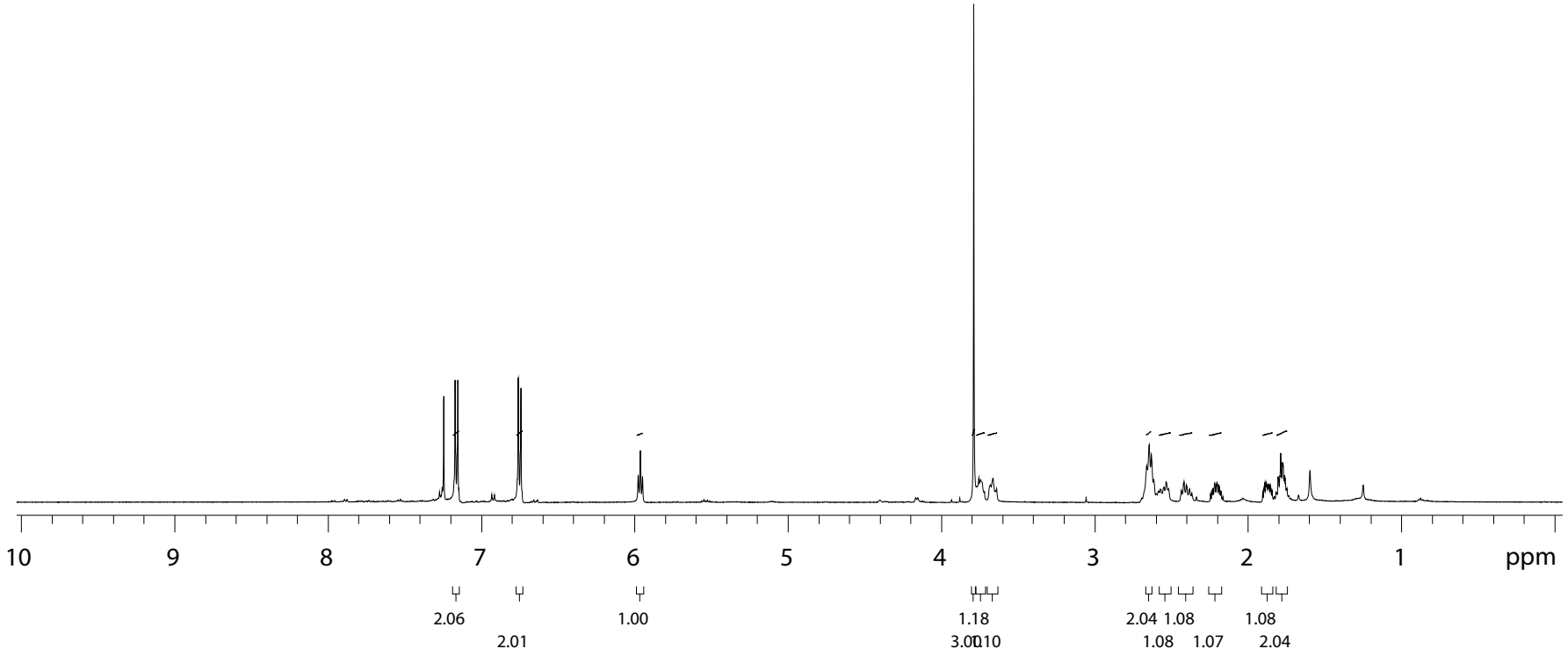

10
9
8
7
6
5
4
3
2
1
ppm
1.99
1.99
1.00
0.99
3.02
1.06
2.81
1.99
1.98
1.06
1.09
2.09
1.10
1.04

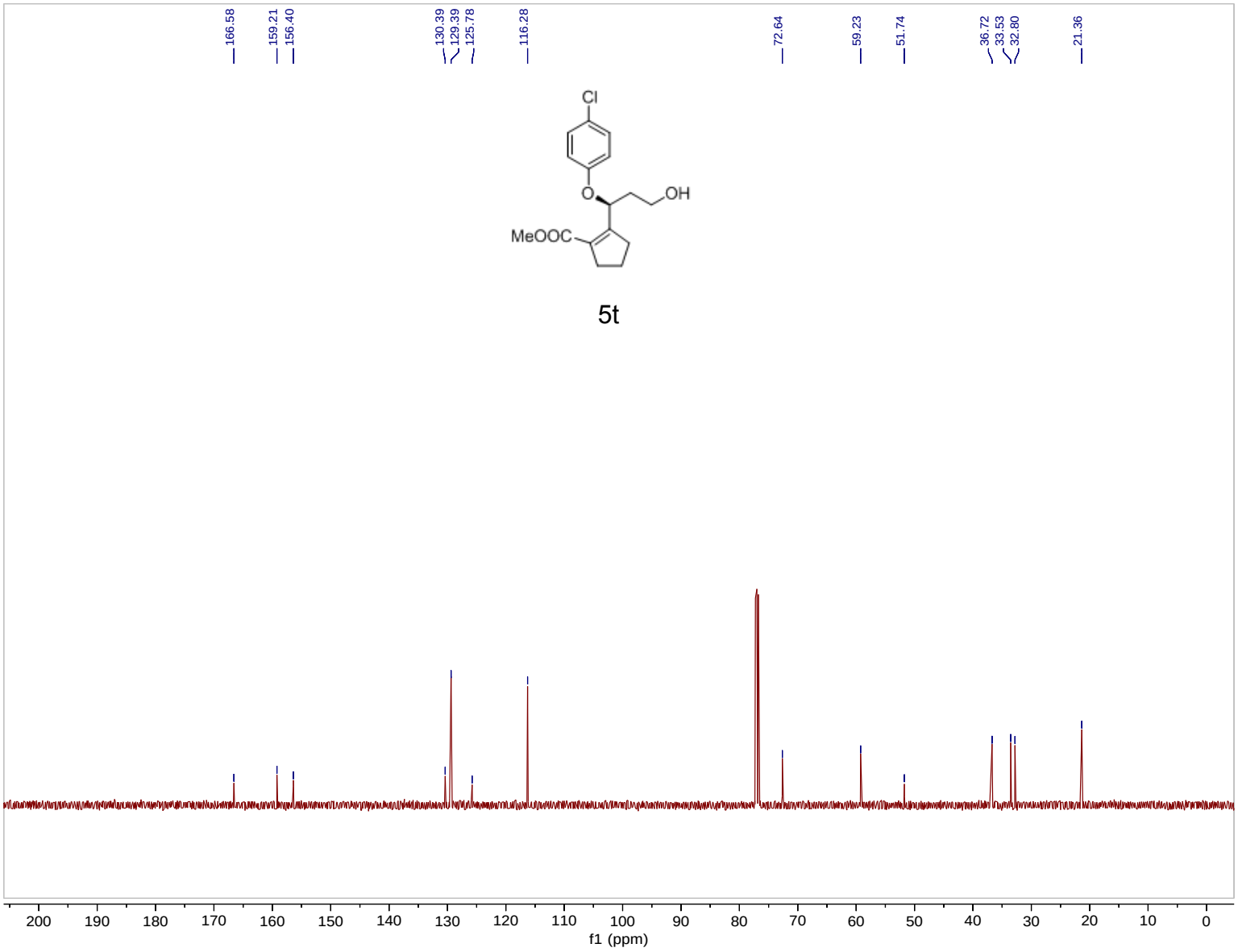

166.58
162.05
157.94
132.48
131.07
129.62
115.45
72.69
58.81
51.88
44.78
36.64
33.52
32.68
21.33
SO2Me
O
OH
MeOOC
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

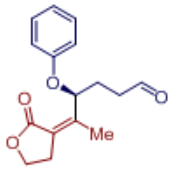
5s


Cl
O
OH
MeOOC

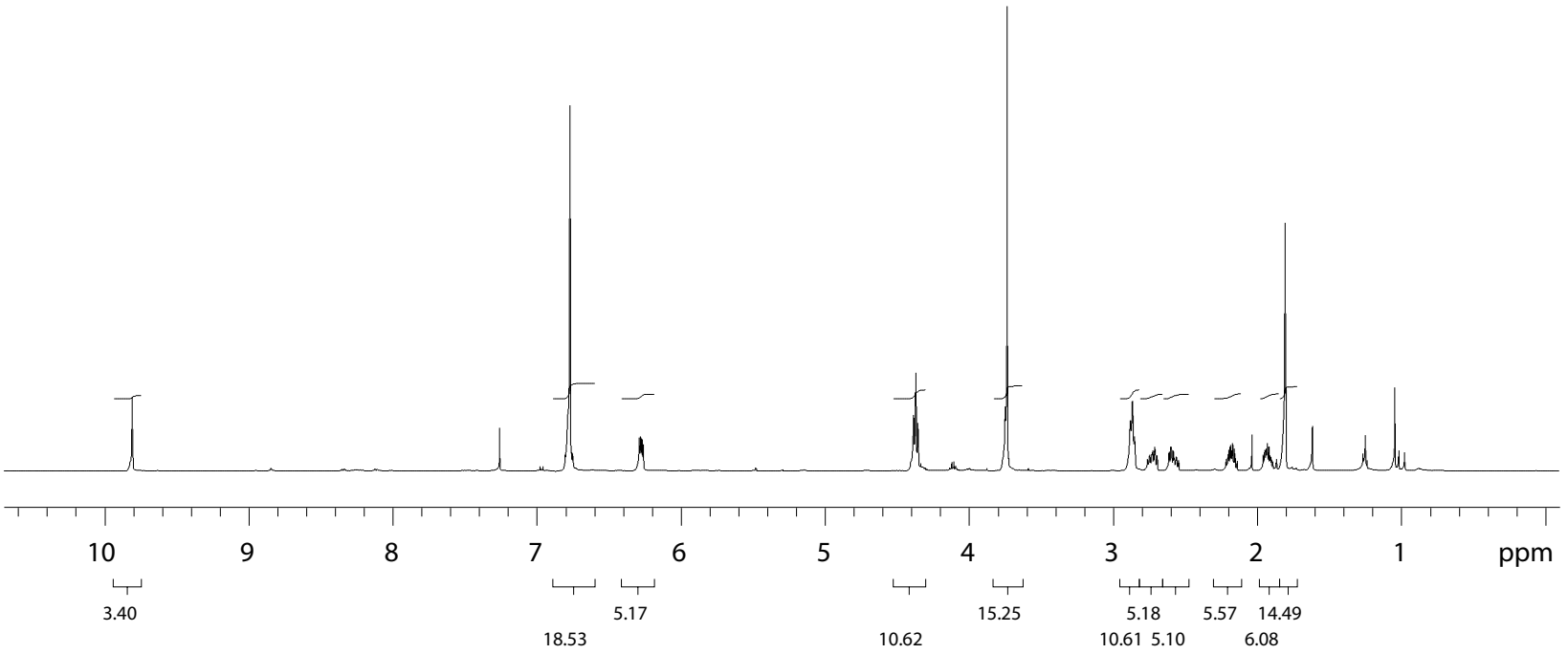
5t

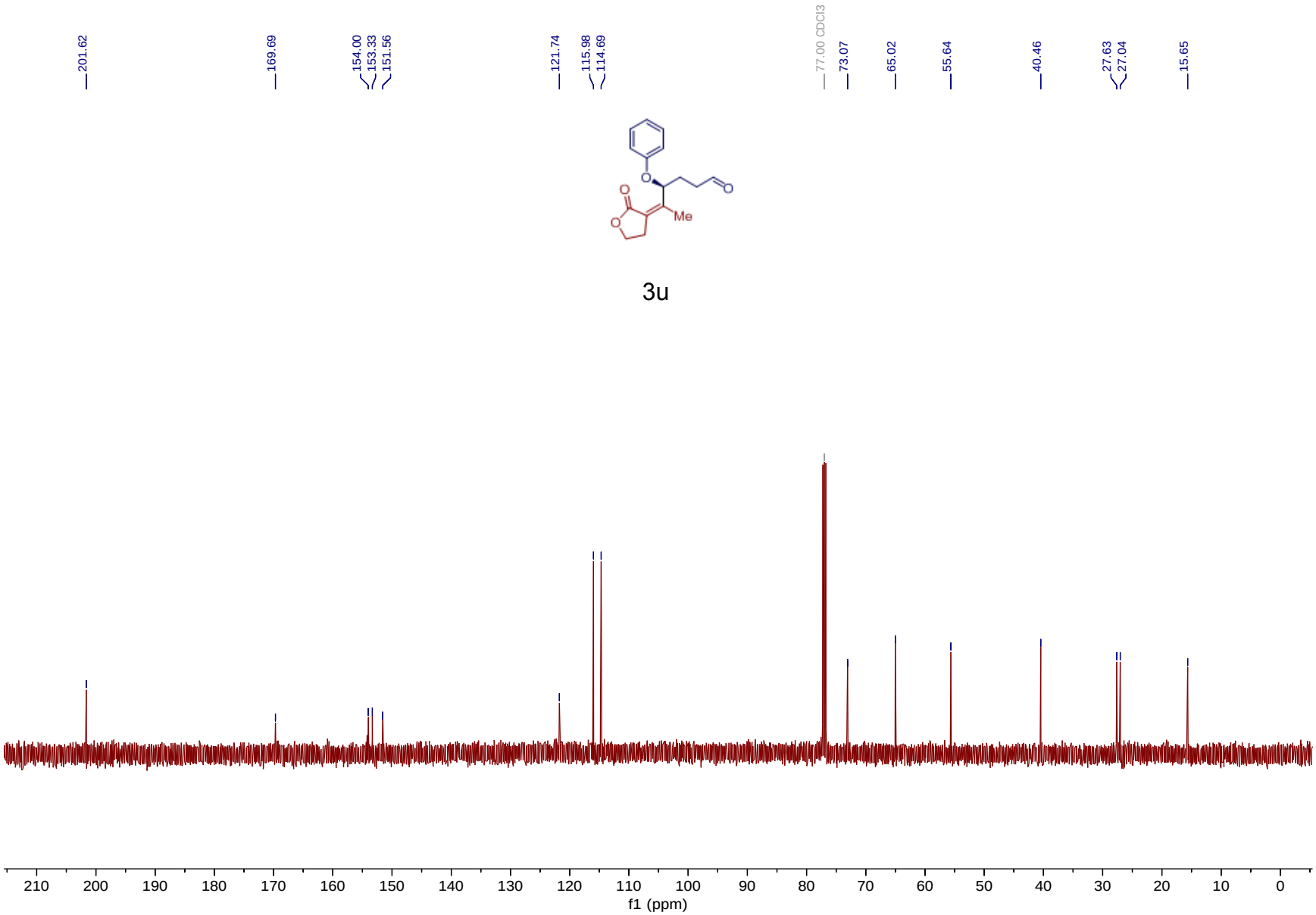

10
9
8
7
6
5
4
3
2
1
ppm
2.06
2.01
1.00
1.18
3.00
1.10
2.04
1.08
1.08
1.07
1.08
2.04


166.58
159.21
156.40
130.39
129.39
125.78
116.28
72.64
59.23
51.74
36.72
33.53
32.80
21.36
Cl
O
OH
MeOOC
5t
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

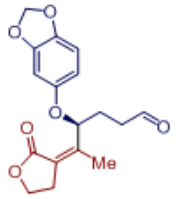

O
O
O
Me

3u

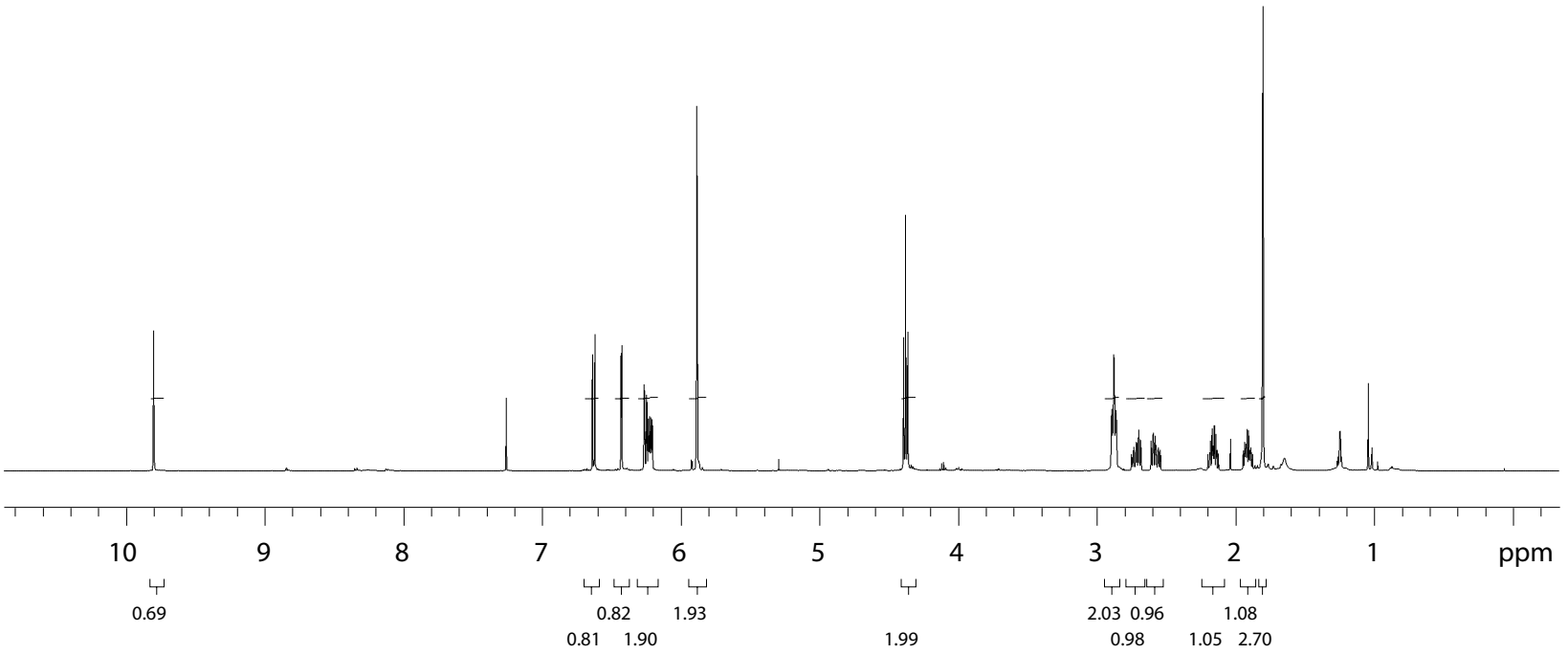

10
9
8
7
6
5
4
3
2
1
ppm
3.40
18.53
5.17
10.62
15.25
10.61
5.18
5.10
5.57
6.08
14.49

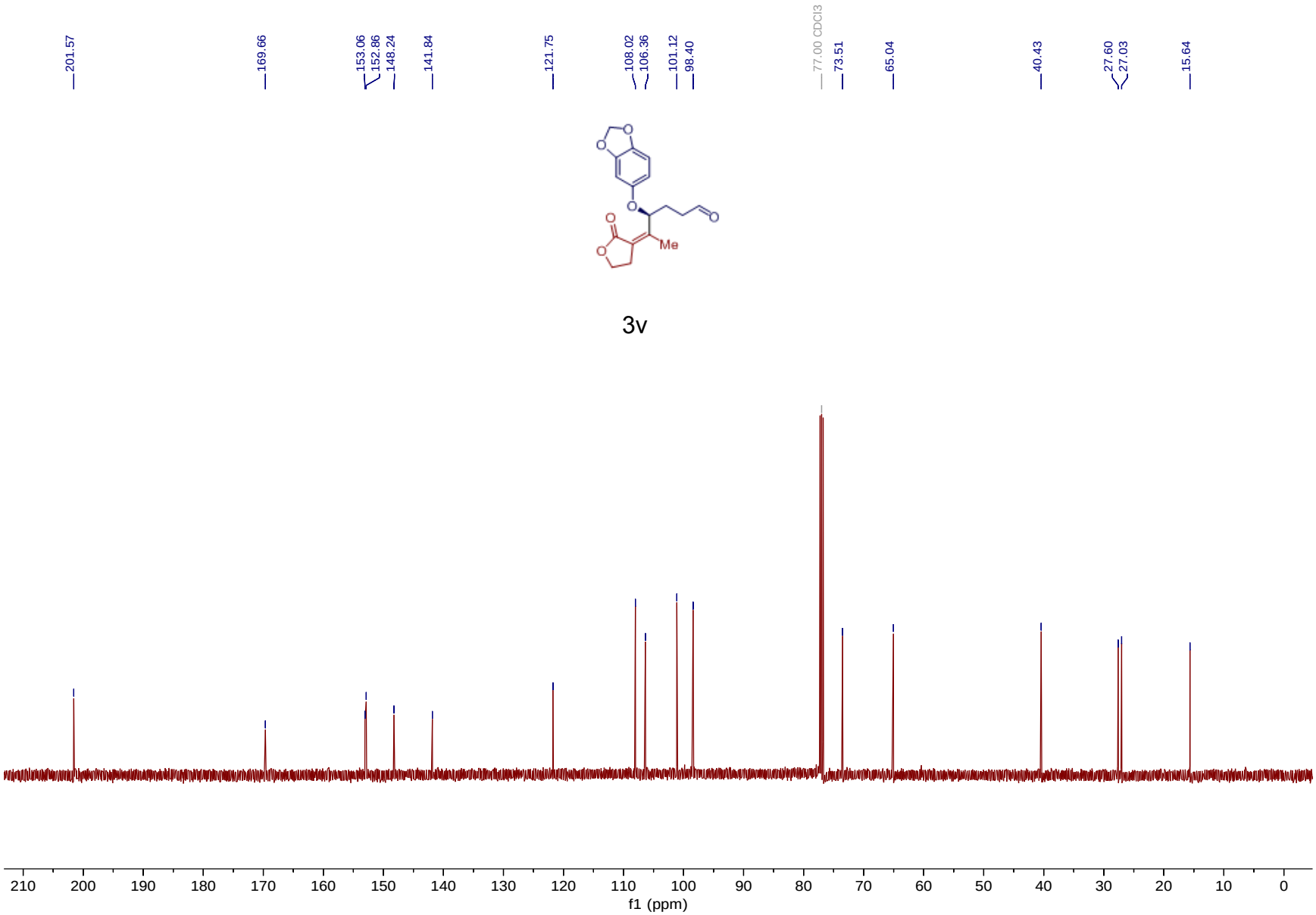

201.62
169.69
154.00
153.33
151.56
121.74
115.98
114.69
77.00 CDCl3
73.07
65.02
55.64
40.46
27.63
27.04
15.65
O
O
O
O
Me
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

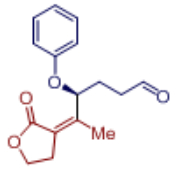
3u


Me

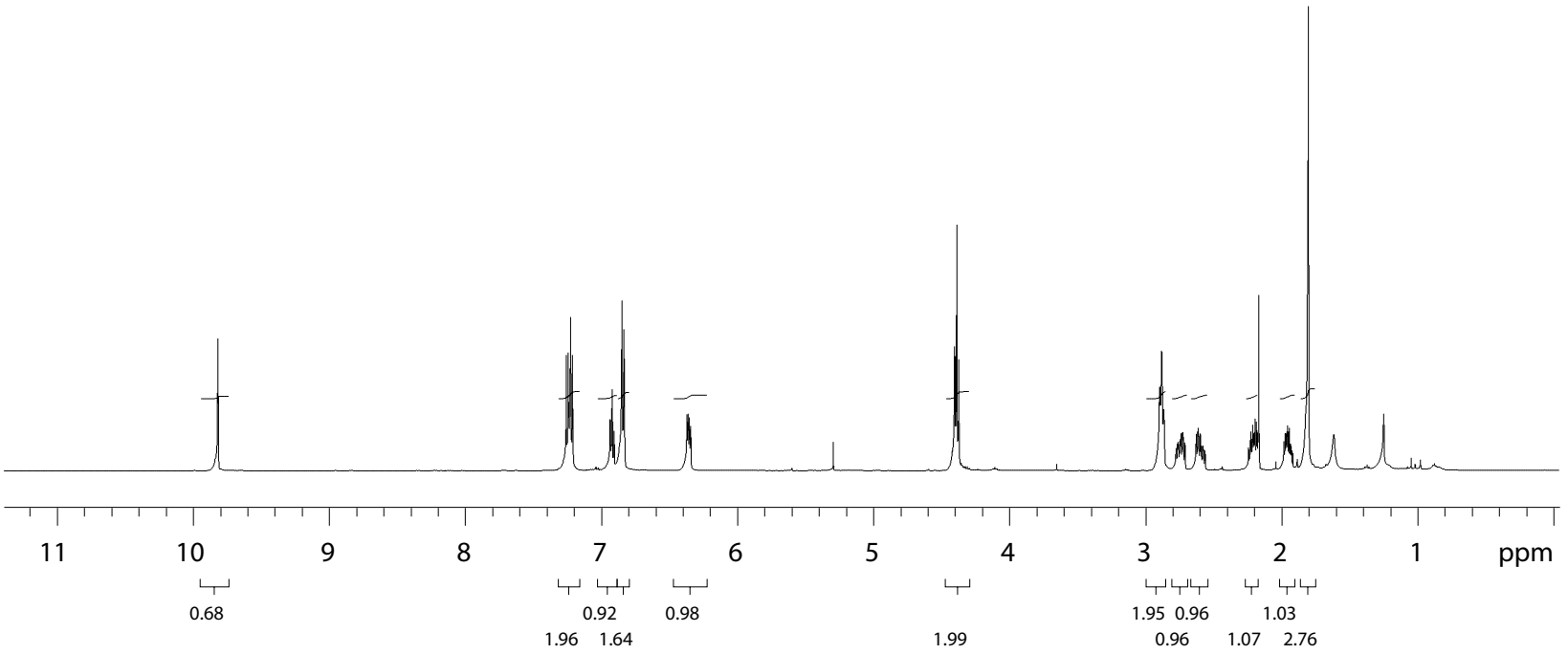
3v

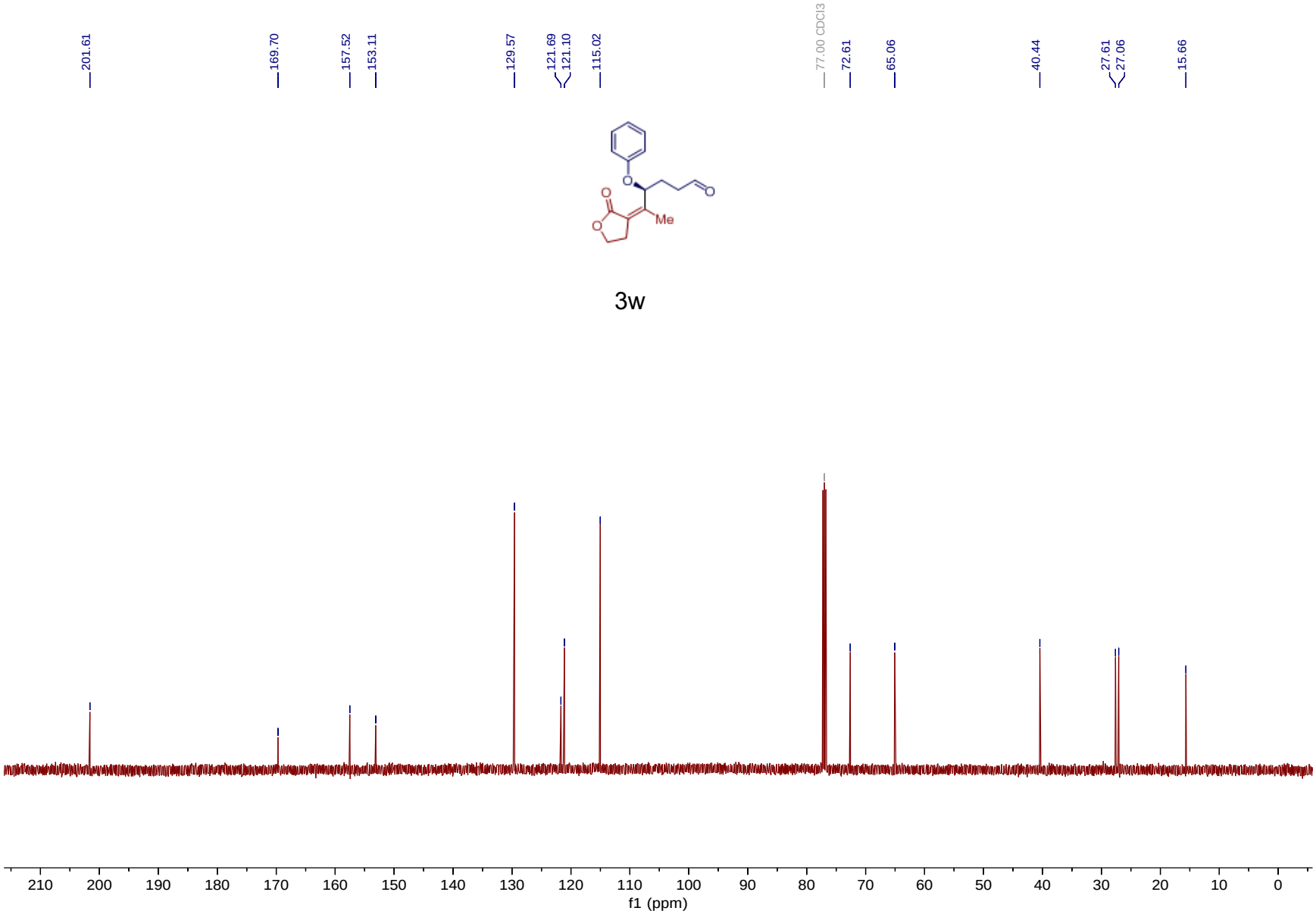

10
9
8
7
6
5
4
3
2
1
ppm
0.69
0.81
0.82
1.90
1.93
1.99
2.03
0.98
0.96
1.05
1.08
2.70


201.57
169.66
153.06
152.86
148.24
141.84
121.75
108.02
106.36
101.12
98.40
77.00 CDCl3
73.51
65.04
40.43
27.60
27.03
15.64
Me
3v
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


O
O
O
Me
O

3w


11
10
9
8
7
6
5
4
3
2
1
ppm
0.68
1.96
0.92
1.64
0.98
1.99
1.95
0.96
0.96
1.07
1.03
2.76

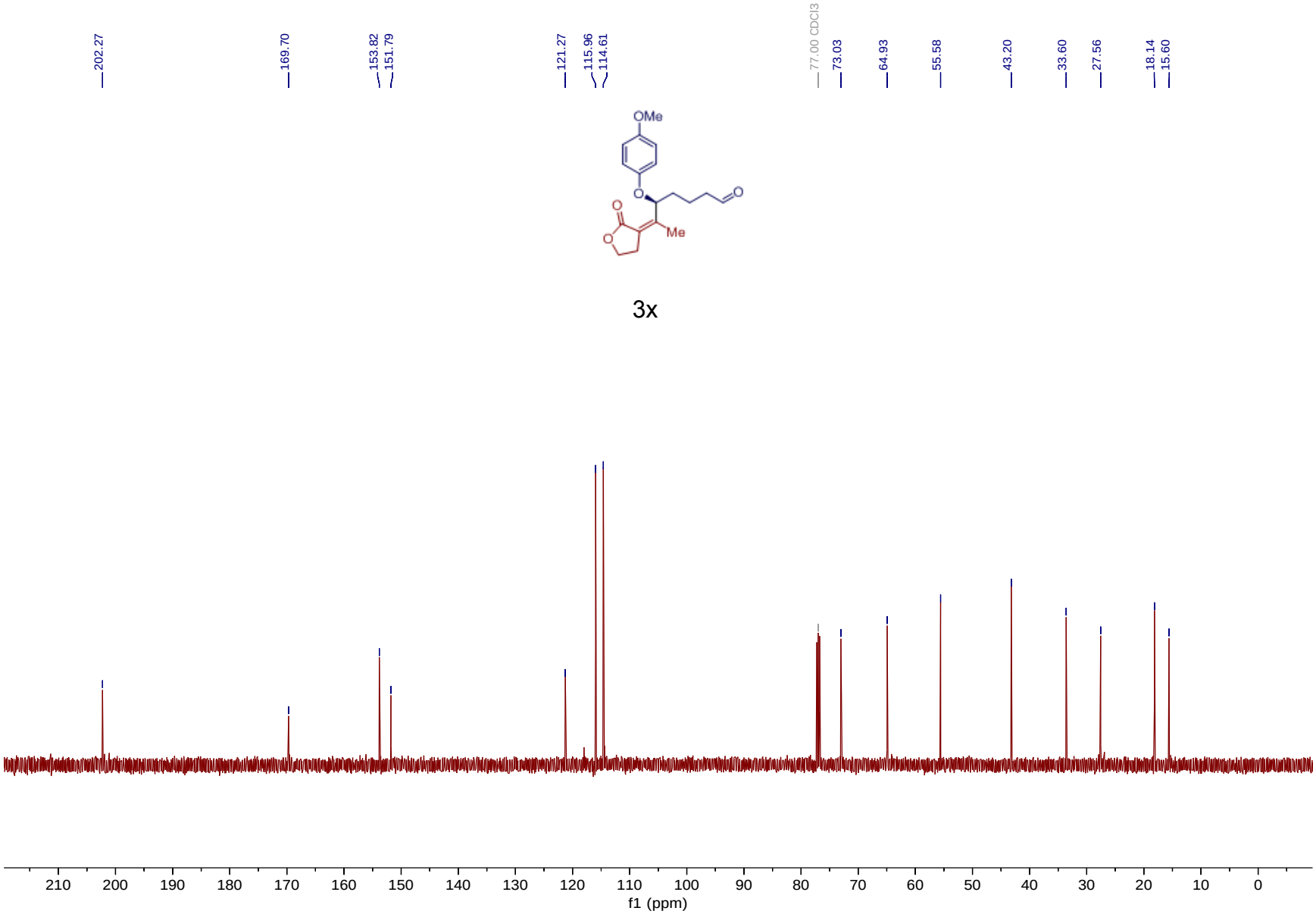

201.61
169.70
157.52
153.11
129.57
121.69
121.10
115.02
77.00 CDCl3
72.61
65.06
40.44
27.61
27.06
15.66
O
O
O
O
Me
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

3w

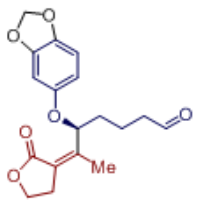

OMe
O
O
O
O
Me

3x

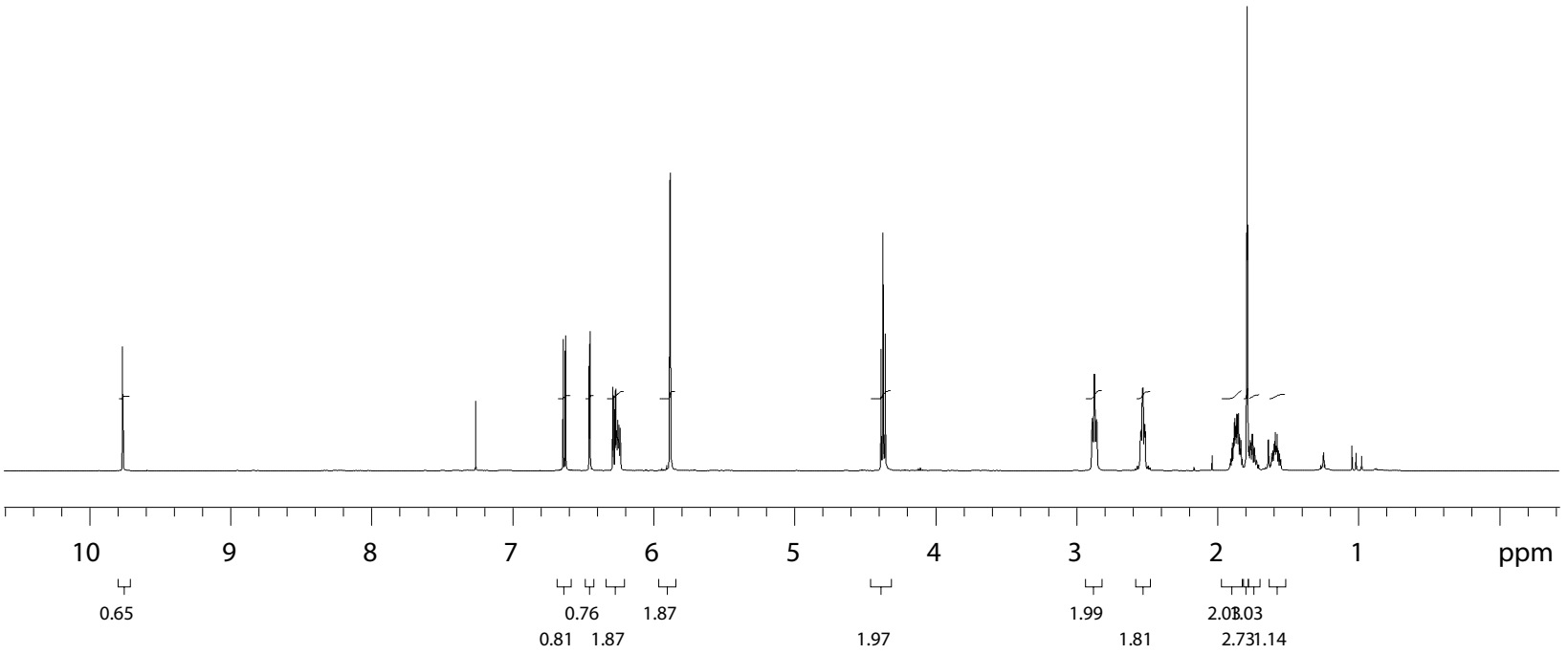
10
9
8
7
6
5
4
3
2
1
ppm
0.66
3.50
0.97
2.04
2.78
2.03
1.79
3.71
2.27
1.22

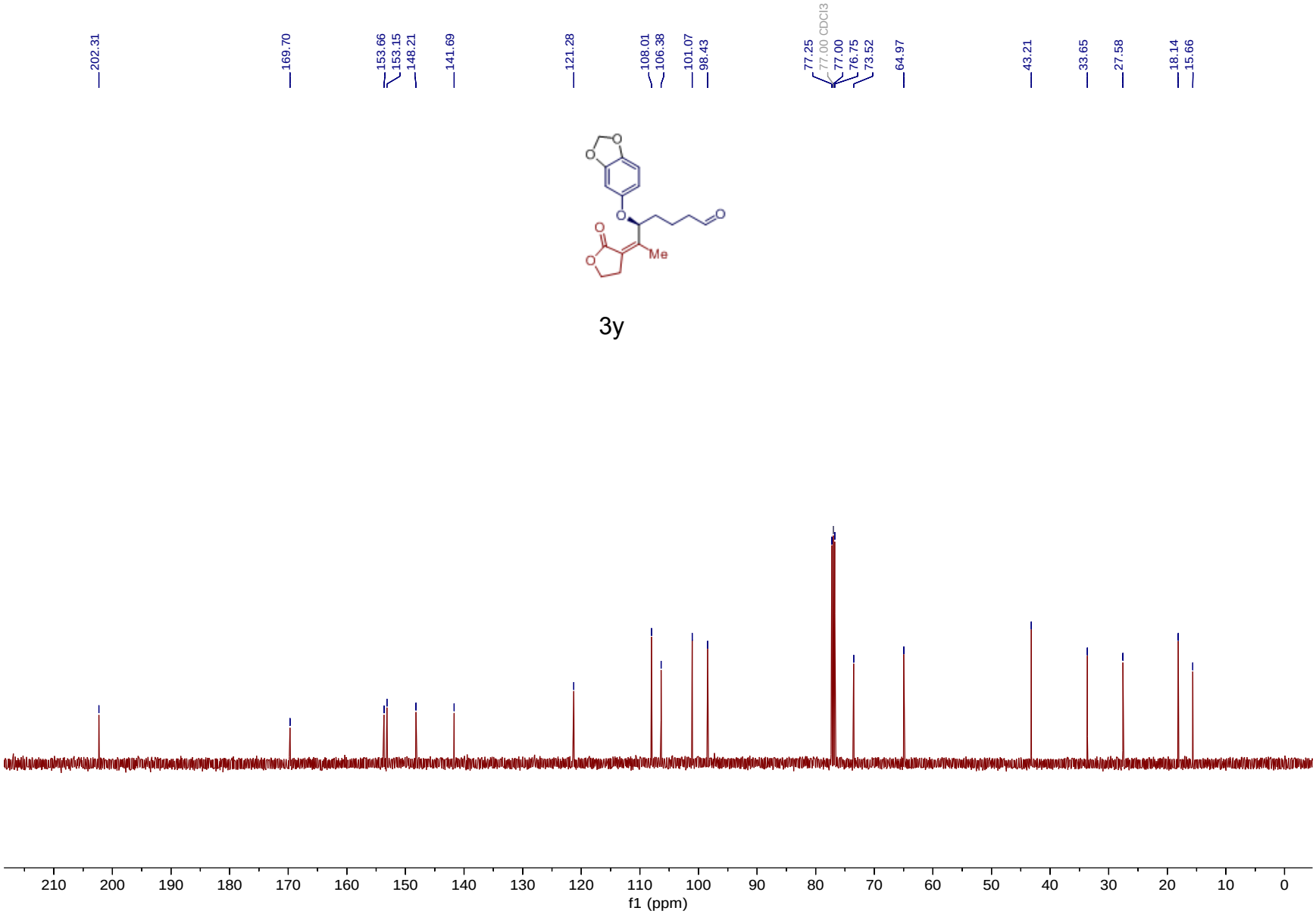

202.27
169.70
153.82
151.79
121.27
115.96
114.61
77.00 CDCl3
73.03
64.93
55.58
43.20
33.60
27.56
18.14
15.60
OMe
O
O
O
Me
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

3x

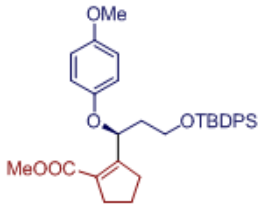

O
O
O
O
O
O
Me

3y


10
9
8
7
6
5
4
3
2
1
ppm
0.65
0.81
0.76
1.87
1.87
1.97
1.99
1.81
2.03
2.73
1.14

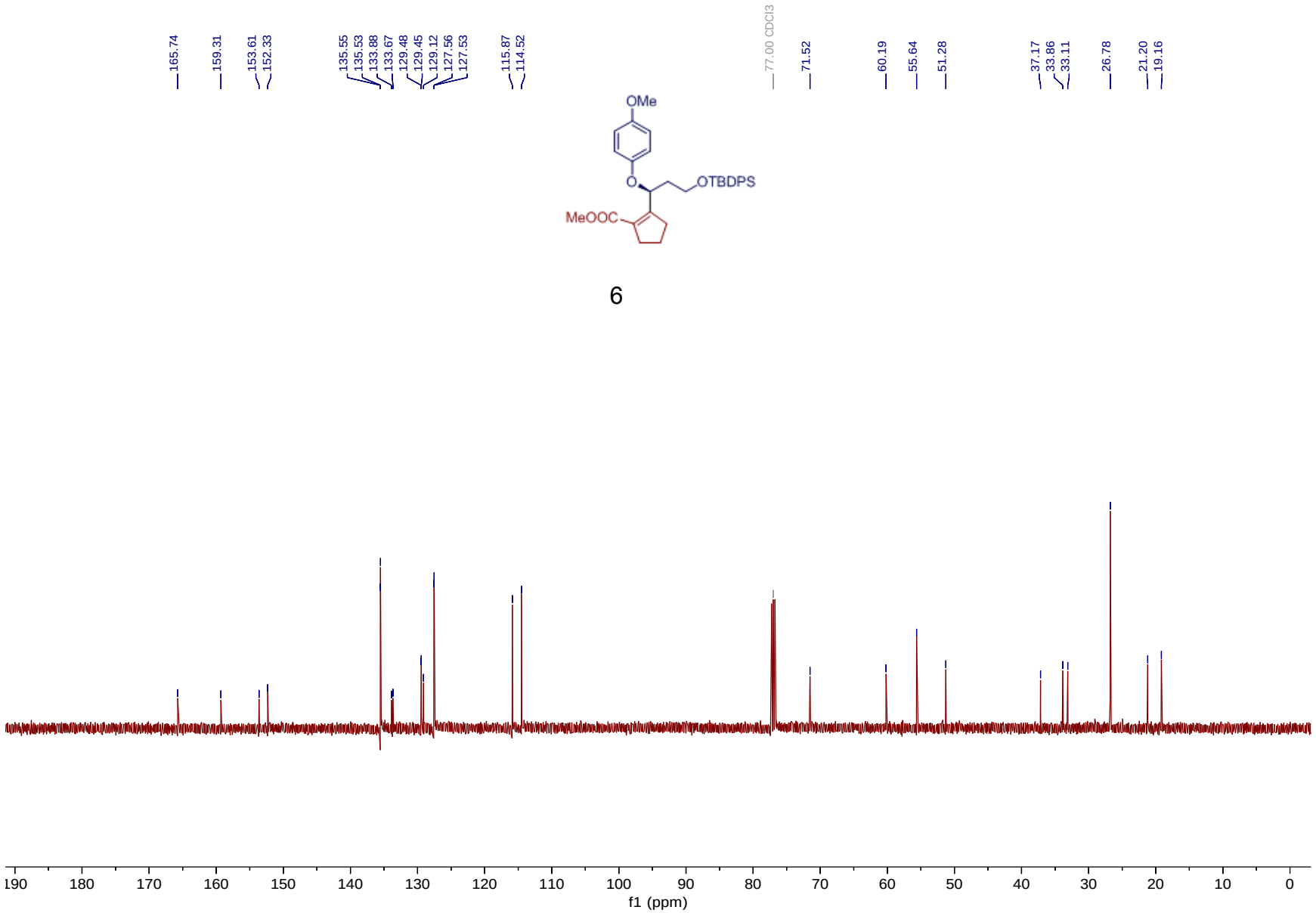

202.31
169.70
153.66
153.15
148.21
141.69
121.28
108.01
106.38
101.07
98.43
77.25
77.00 CDCl3
77.00
76.75
73.52
64.97
43.21
33.65
27.58
18.14
15.66
O
O
O
O
O
Me
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

3y

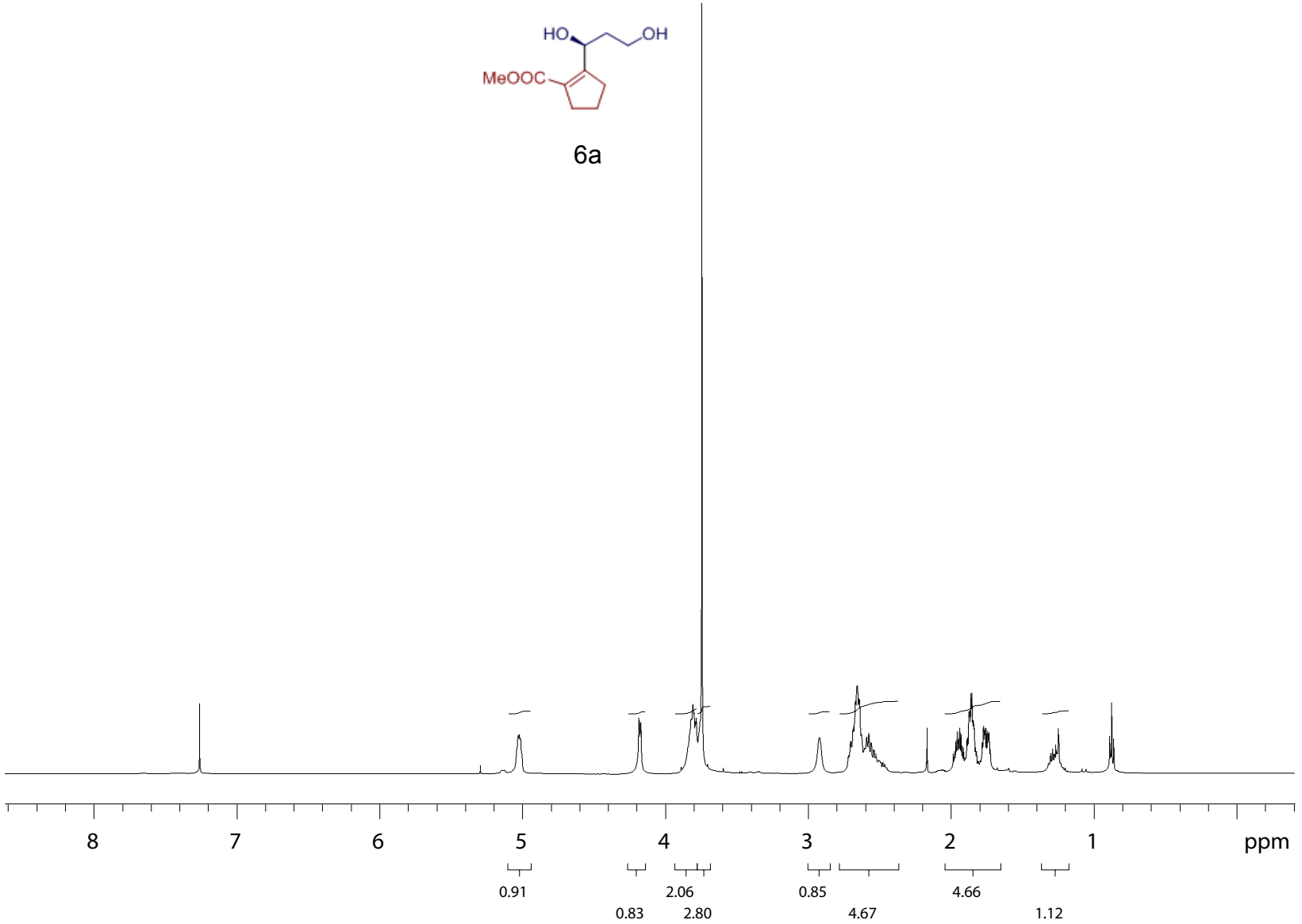

OMe
O
OTBDPS
MeOOC

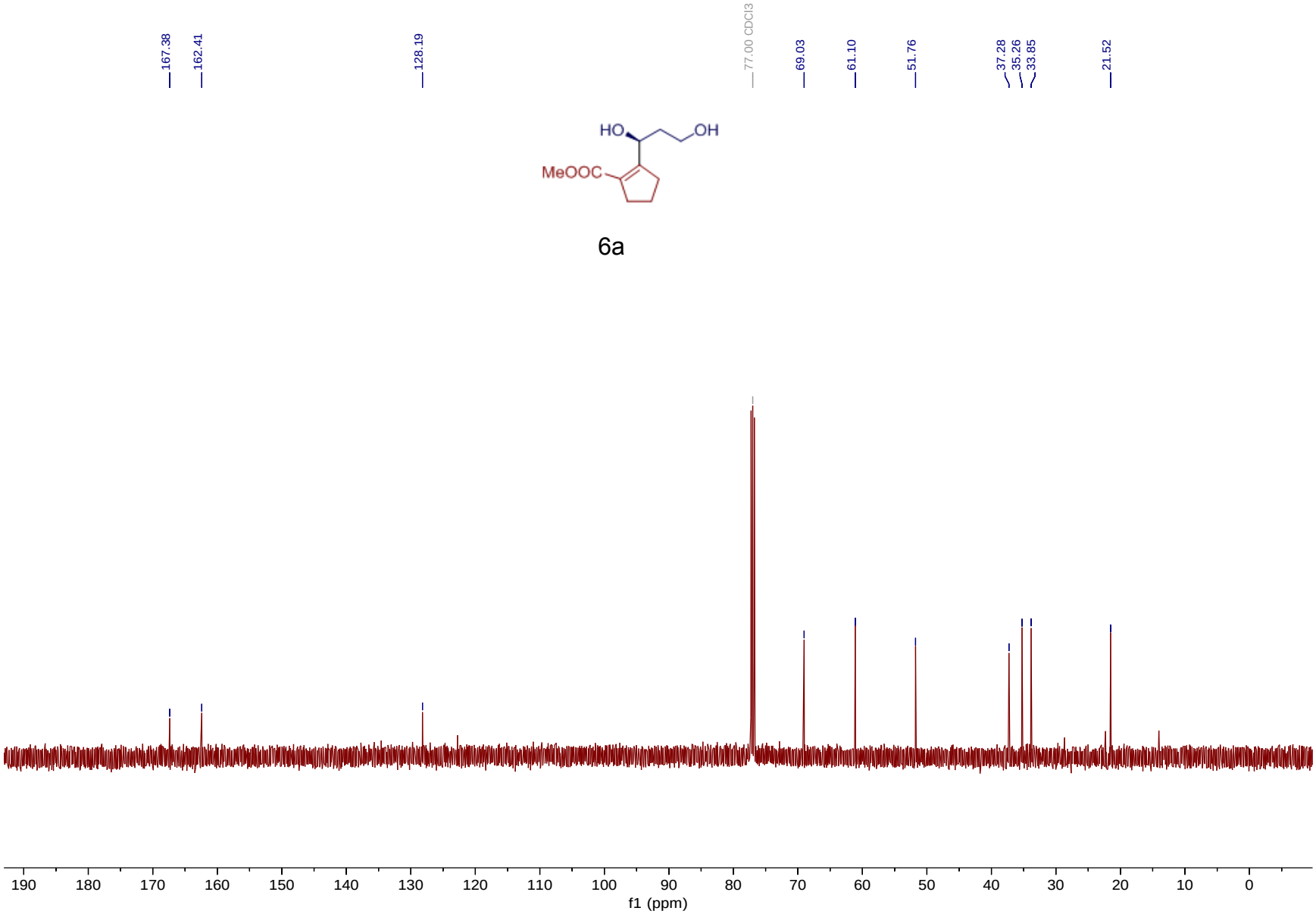
6

8
7
6
5
4
3
2
1
ppm
2.44
4.71
3.91
1.04
1.13
2.76
2.08
1.09
2.23
1.50
1.86
1.81
1.20
10.61

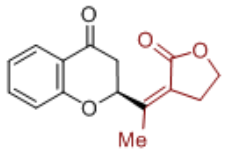

165.74
159.31
153.61
152.33
135.55
135.53
133.88
133.67
129.48
129.45
129.12
127.56
127.53
115.87
114.52
77.00 CDCl3
71.52
60.19
55.64
51.28
37.17
33.86
33.11
26.78
21.20
19.16
OMe
O
OTBDPS
MeOOC
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

6

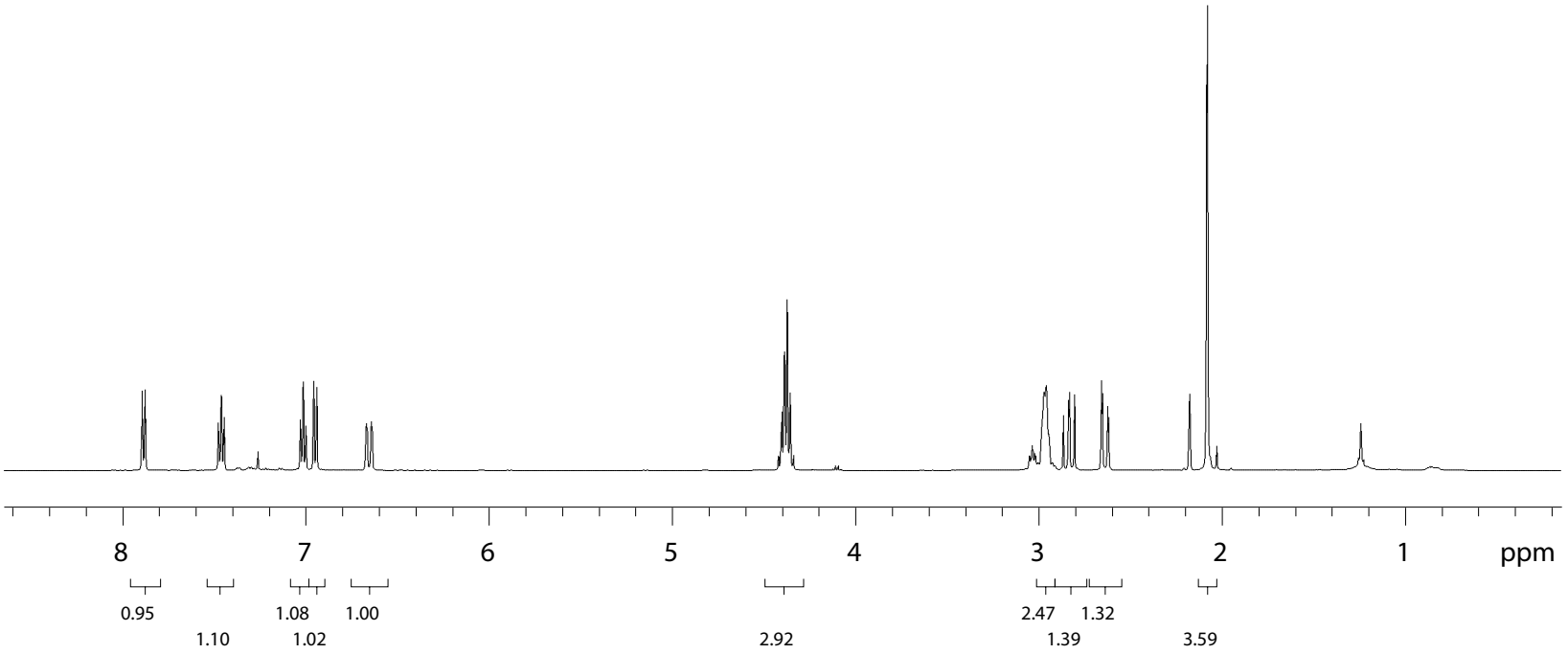

HO
OH
MeOOC
6a
8
7
6
5
4
3
2
1
ppm
0.91
0.83
2.06
2.80
0.85
4.67
4.66
1.12

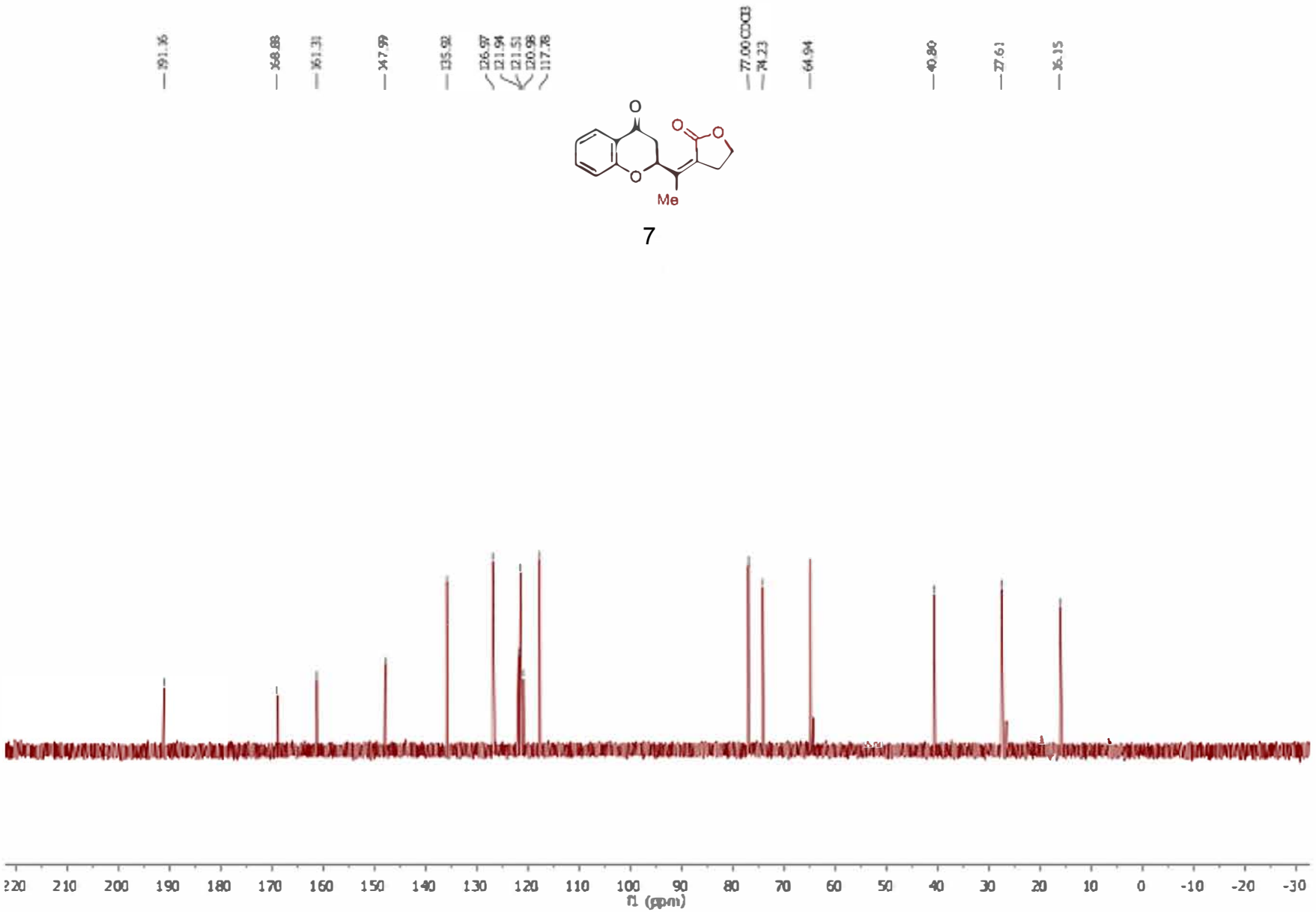

167.38
162.41
128.19
77.00 CDCl3
69.03
61.10
51.76
37.28
35.26
33.85
21.52
HO
OH
MeOOC
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

6a

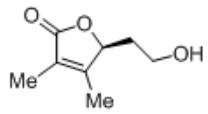


7

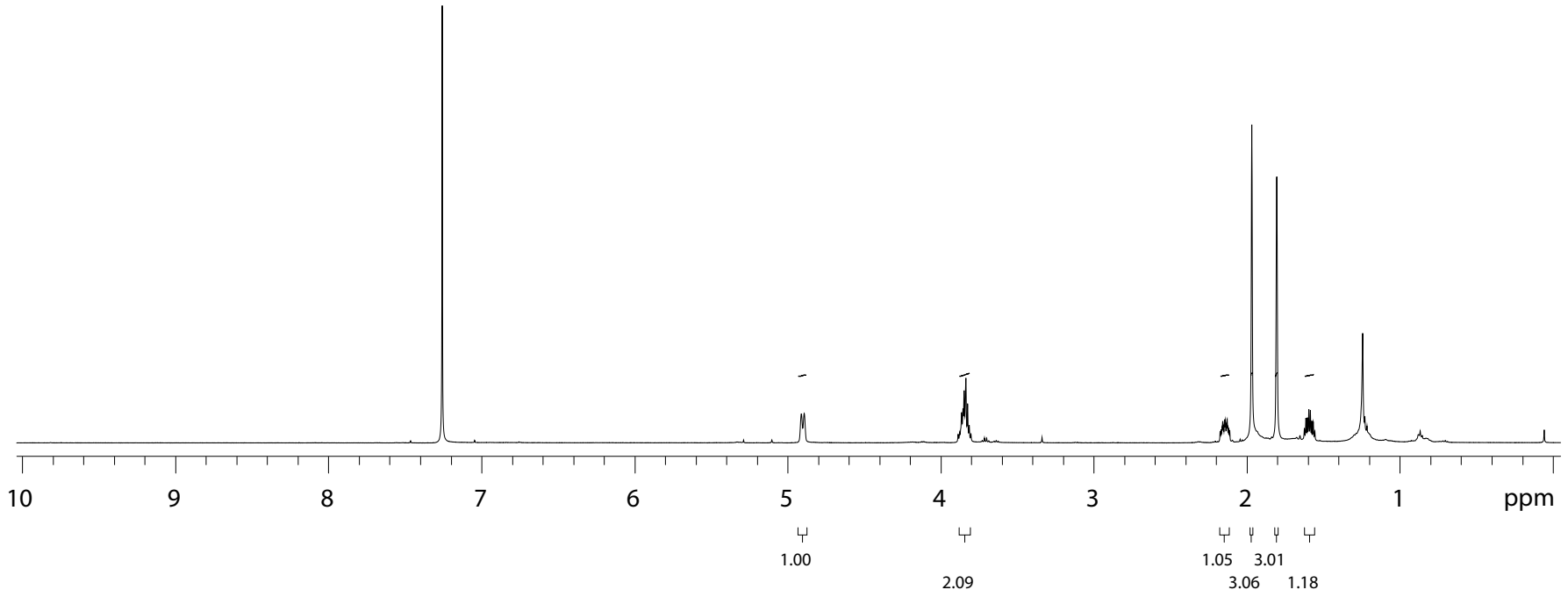


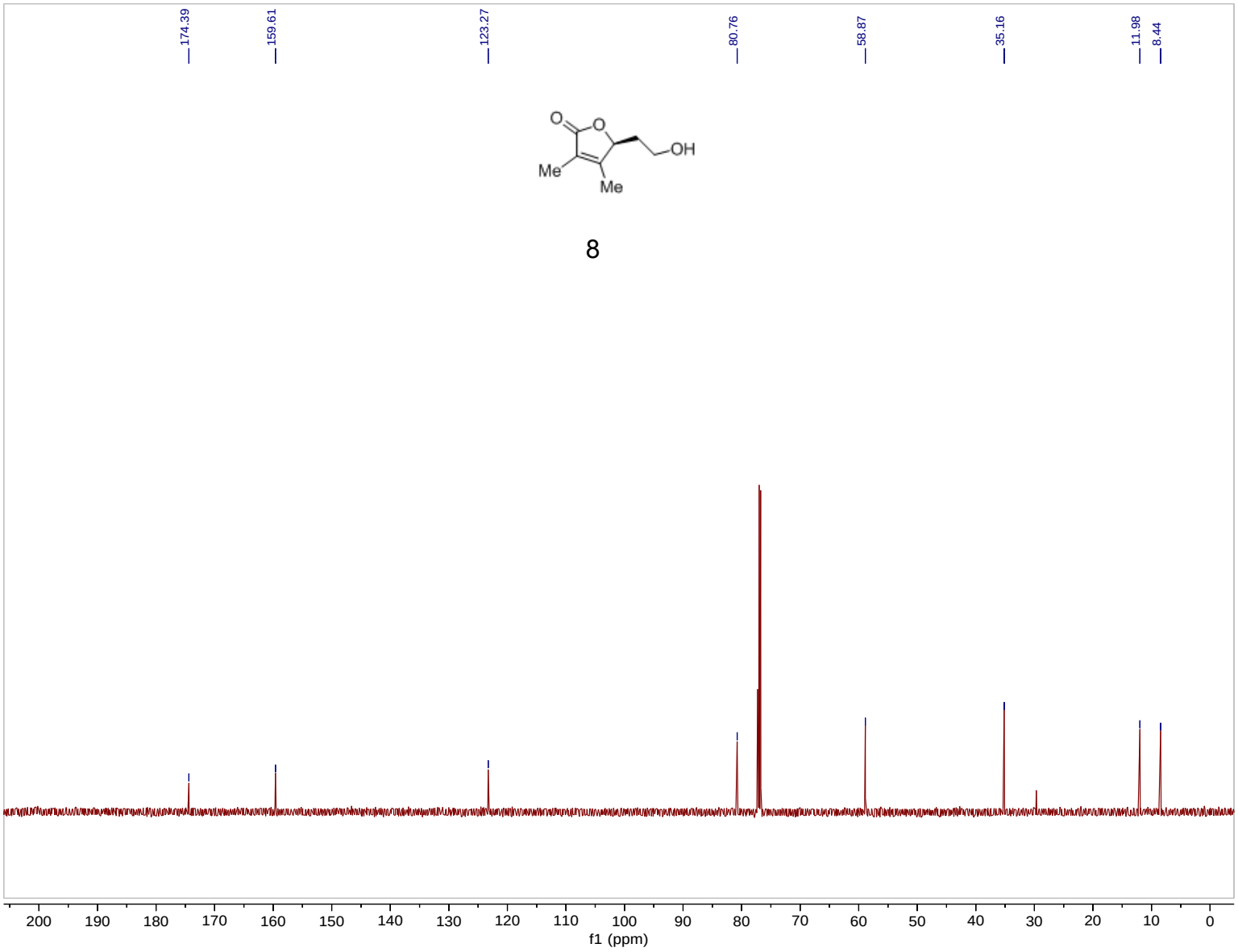

191.36
168.88
161.31
147.99
135.92
126.97
121.94
121.51
120.98
117.78
77.00 CDCl3
74.23
64.94
40.80
27.61
16.15
O
O
O
Me
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10 -20 -30
f1 (ppm)

7

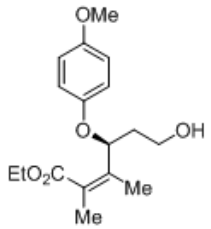


8

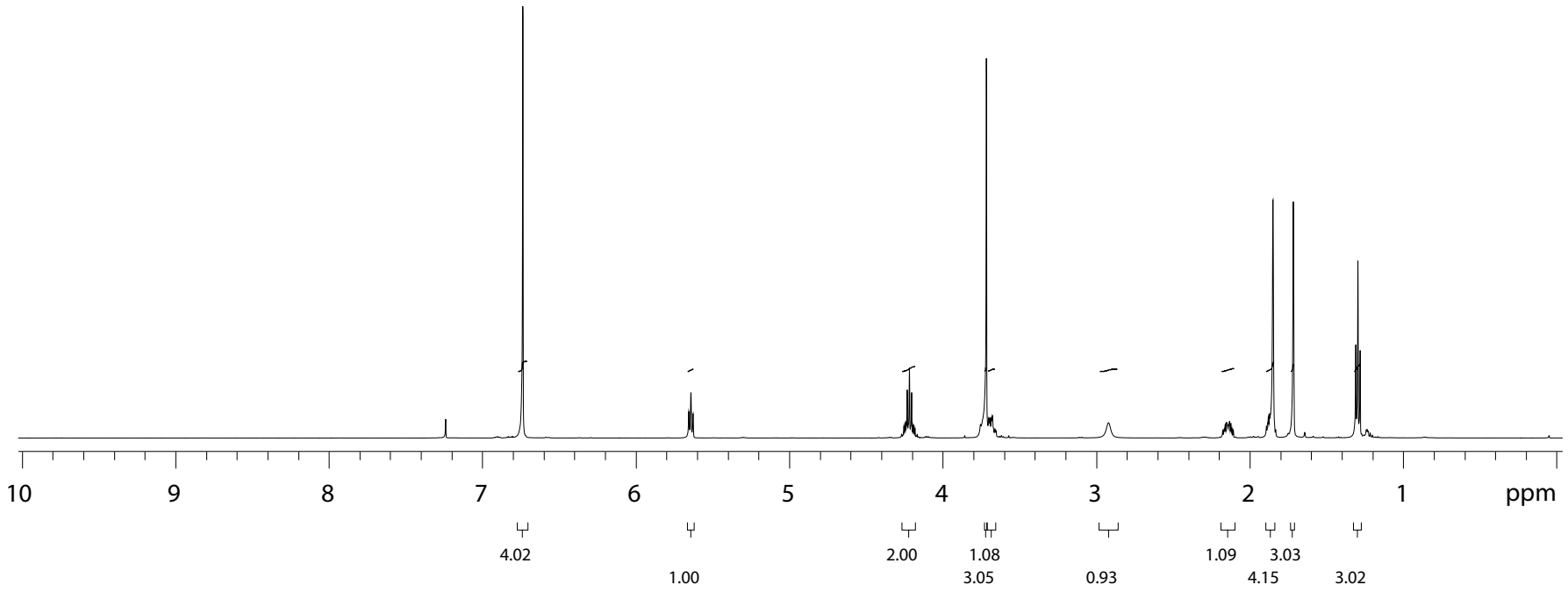


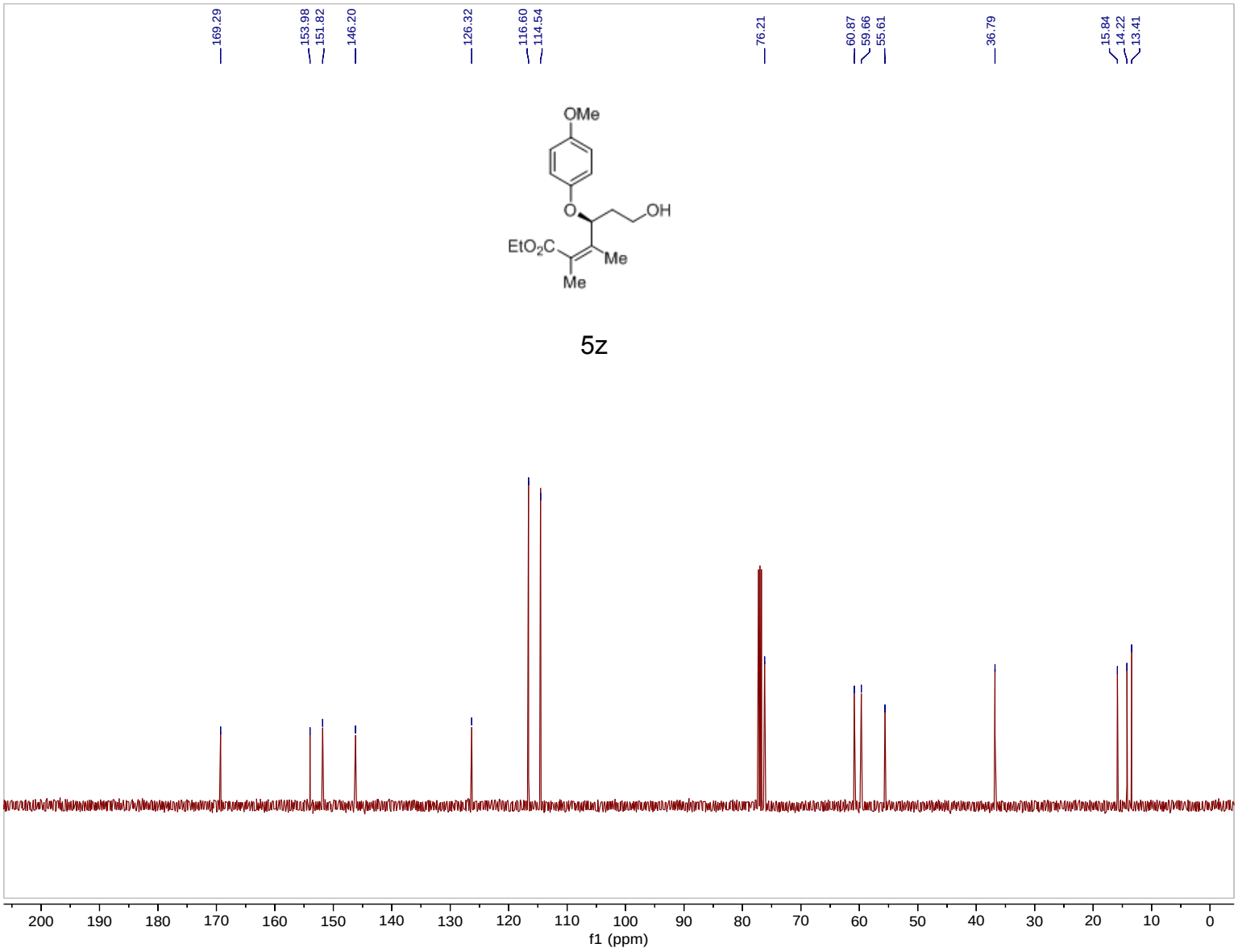

174.39
159.61
123.27
80.76
58.87
35.16
11.98
8.44
O
O
OH
Me
Me
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

8


OMe
O
OH
EtO2C
Me
Me

5z


10
9
8
7
6
5
4
3
2
1
ppm
4.02
1.00
2.00
1.08
3.05
0.93
1.09
3.03
4.15
3.02


169.29
153.98
151.82
146.20
126.32
116.60
114.54
76.21
60.87
59.66
55.61
36.79
15.84
14.22
13.41
OMe
O
OH
EtO2C
Me
Me
5z
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)