Total Synthesis and Evaluation of Phostriecin and Key Structural Analogues

Christopher P. Burke,[†] Mark R. Swingle,[‡] Richard E. Honkanen,[‡] and Dale L. Boger*[,†]

[†]*Department of Chemistry and the Skaggs Institute for Chemical Biology, The Scripps Research Institute, 10550 North Torrey Pines Road, La Jolla, California 92037*

[‡]*Department of Biochemistry and Molecular Biology, University of South Alabama College of Medicine, Mobile,Alabama 36688*

boger@scripps.edu

Supporting Information

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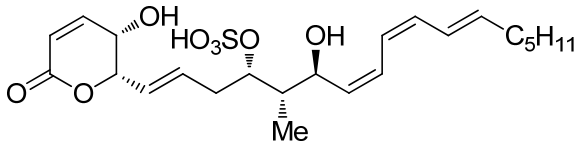
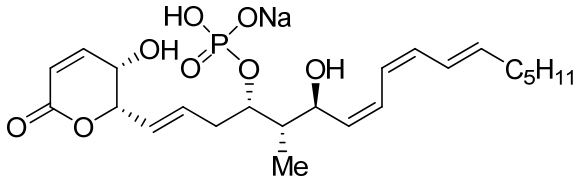
General Experimental Methods. All reactions were carried out under an inert atmosphere (N_2 or Ar) with dry solvents under anhydrous conditions unless otherwise stated. Dichloromethane, tetrahydrofuran (THF), benzene, and toluene were obtained by passing the solvents through a solvent purification system with activated alumina columns. Diethyl ether (Et_2O) was dried and distilled from sodium/benzophenone. All commercially available reagents were used without further purification. Thin layer chromatography (TLC) was performed with precoated silica gel 60 plates (0.25 mm) using UV light or an acidic solution of phosphomolybdic acid or ceric ammonium molybdate followed by heating for visualization. Normal phase column chromatography was performed using silica gel 60 (40–63 μm particle size). Reverse phase chromatography was performed using C_{18}-functionalized (35–75 μm particle size) silica gel. Unless stated otherwise, solvents were evaporated under reduced pressure on a rotary evaporator. NMR spectra were obtained with spectrometers operating at the indicated frequencies, and the spectra were referenced to TMS (δ 0.00) or residual undeuterated solvent peaks (C_6D_6: ^1H = δ 7.15, ^{13}C = δ 128.02; CD_3OD: ^1H = δ 3.31, ^{13}C = δ 49.05; DMSO-*d*$_6$: ^1H = δ 2.50 ^{13}C = δ 39.43; CD_3CN: ^1H = δ 1.94, ^{13}C = δ 1.24. All ^{31}P NMR spectra were referenced to H_3PO_4 (δ 0.00). IR spectra were recorded on an FT-IR spectrometer as thin films using ATR (attenuated total reflectance). High-resolution mass spectra (HRMS) were obtained on a spectrometer using ESI-TOF (electrospray ionization-time of flight).



Sultriecin (1). A solution of HF–pyridine complex (0.27 mL) in 0.40 mL of THF was added to a solution of **34** (0.0056 g, 0.0059 mmol) in 0.40 mL of THF and 0.10 mL of pyridine with stirring at room temperature. After 96 h, the reaction mixture was carefully transferred to a mixture of saturated aqueous $NaHCO_3$ (6.3 mL) and EtOAc (2.4 mL). The mixture was extracted with EtOAc (5 × 4 mL), and the combined organic fractions were dried (Na_2SO_4) and

concentrated under reduced pressure. The residue was purified by flash chromatography (SiO_2, 20% MeOH/CH_2Cl_2) to give 0.0017 g (60%) of sultriecin (**1**) as a white solid: $[\alpha]^{25}_D$ +9.0 (*c* 0.20, MeOH); ^{1}H NMR (CD_3OD, 600 MHz) δ 7.03 (dd, *J* = 9.6, 5.4 Hz, 1H), 6.59 (t, *J* = 12.0 Hz, 1H), 6.54 (dd, *J* = 14.4, 12.0 Hz, 1H), 6.21 (t, *J* = 12.0 Hz, 1H), 6.05 (d, *J* = 9.6 Hz, 1H), 6.02 (t, *J* = 12.0 Hz, 1H), 5.91 (dt, *J* = 15.6, 7.8 Hz, 1H), 5.83 (dd, *J* = 15.6, 7.2 Hz, 1H), 5.76 (dt, *J* = 14.4, 7.2 Hz, 1H), 5.38 (dd, *J* = 10.8, 9.6 Hz, 1H), 4.82 (ddd, *J* = 8.4, 6.6, 2.4 Hz, 1H), 4.61 (t, *J* = 9.6 Hz, 1H), 4.17 (dd, *J* = 5.4, 3.0 Hz, 1H), 2.80–2.74 (m, 1H), 2.50–2.43 (m, 1H), 2.13 (q, *J* = 7.2 Hz, 2H), 1.67–1.63 (m, 1H), 1.46–1.39 (m, 2H), 1.37–1.24 (m, 4H), 0.90 (t, *J* = 7.2 Hz, 3H), 0.83 (d, *J* = 7.2 Hz, 3H); ^{1}H NMR (DMSO-d_6, 600 MHz) δ 7.00 (dd, *J* = 9.6, 5.4 Hz, 1H), 6.56 (dd, *J* = 14.4, 10.8 Hz, 1H), 6.51 (t, *J* = 11.4 Hz, 1H), 6.09 (t, *J* = 10.8 Hz, 1H), 6.01 (t, *J* = 10.8 Hz, 1H), 5.98 (d, *J* = 9.6 Hz, 1H), 5.81–5.68 (m, 3H), 5.35 (t, *J* = 10.2 Hz, 1H), 4.97 (d, *J* = 4.2 Hz, 1H), 4.82 (dd, *J* = 6.6, 3.0 Hz, 1H), 4.51(ddd, *J* = 7.8, 5.4, 2.4 Hz, 1H), 4.32 (td, *J* = 9.0, 4.2 Hz, 1H), 4.15–4.09 (m, 1H), 4.08–4.04 (m, 1H), 2.63–2.57 (m, 1H), 2.32–2.26 (m, 1H), 2.11 (q, *J* = 7.2 Hz, 2H), 2.02–1.96 (m, 1H), 1.48–1.20 (m, 6H), 0.86 (t, *J* = 7.2 Hz, 3H), 0.66 (d, *J* = 7.2 Hz, 3H); ^{13}C NMR (DMSO-d_6, 150 MHz) δ 176.1, 163.3, 146.6, 136.8, 134.1, 131.3, 126.8, 125.5, 124.0, 122.3, 121.1, 80.9, 73.7, 66.9, 61.6, 41.2, 35.4, 32.2, 30.8, 28.3, 21.9, 13.9, 8.8; IR (film) ν_{max} 3426, 1720, 1253, 1042, 945 cm^{-1}; HRMS (ESI-TOF) calcd for $C_{23}H_{34}O_8S - H^+$ 469.1902; found 469.1887.

Purification of **1** by reverse phase C_{18} silica gel chromatography (H_2O/MeCN eluent), which does not affect counterion identity or protonation state, resulted in **1** identical spectroscopically to the product obtained from normal phase silica gel chromatography. Passing the material through a column of Dowex-Na^+ resin also yielded **1** with identical spectroscopic characterization.

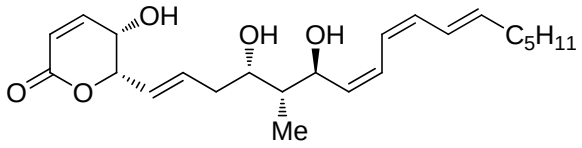


Phostriecin (2). HF–pyr (0.38 mL) in 0.57 mL of THF was added at room temperature to a solution of **37** (11.2 mg, 0.00859 mmol) in THF (0.57 mL) and pyridine (0.14 mL) and was stirred for 4 d in the dark. The reaction mixture was carefully transferred to a gently stirred mixture of saturated aqueous $NaHCO_3$ (9 mL) and EtOAc (3.5 mL) and was stirred until CO_2 evolution ceased. The phases were separated, and the aqueous phase was extracted with EtOAc (5 × 6 mL). The combined organic extracts were dried (Na_2SO_4) and concentrated under vacuum. The crude residue of **38** was dissolved in MeCN (1.6 mL), and Et_3N (0.45 mL) was added at room temperature. The mixture was stirred overnight before toluene (1.9 mL) was added, and the mixture was concentrated under a stream of N_2. H_2O (2.7 mL) was added to the residue, and the mixture was washed with hexanes (5 × 3 mL). The aqueous layer was concentrated under reduced pressure, and the residue was dissolved in 1:1 MeCN/H_2O and passed through a short column of Dowex–Na^+ (2 cm × 1 cm, 1:1 MeCN/H_2O eluent). The product-containing fractions were then concentrated under reduced pressure (the H_2O was azeotoped with MeCN), and the remaining residue was further purified by flash column chromatography (C_{18} reverse phase SiO_2, 0–10% MeCN/H_2O gradient) to give 2.67 mg (63%) of **2** as a white solid: $[\alpha]^{25}_D$ +21 (*c* 0.12, MeOH; lit. $[\alpha]^{24}_D$ +23 (*c* 1.0, MeOH))[1]; ^{1}H NMR (CD_3OD, 600 MHz) δ 7.04 (dd, *J* = 9.6, 5.4 Hz, 1H), 6.60 (t, *J* = 11.4 Hz, 1H), 6.55 (dd, *J* = 15.0, 11.4 Hz, 1H), 6.25 (t, *J* = 11.4 Hz, 1H), 6.06 (d, *J* = 9.6 Hz, 1H), 6.01 (t, *J* = 11.4 Hz, 1H),

[1] Ohkuma, H.; Naruse, N.; Nishiyama, Y.; Tsuno, T.; Hoshino, Y.; Sawada, Y.; Konishi, M.; Oki, T. *J. Antibiot.* **1992**, *45*, 1239.

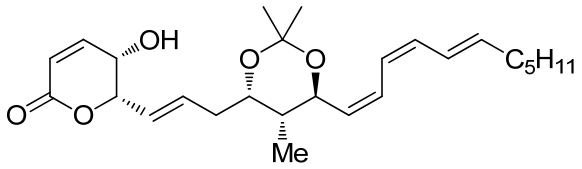
5.93 (dt, *J* = 15.6, 7.2 Hz, 1H), 5.82 (dd, *J* = 15.6, 7.2 Hz, 1H), 5.76 (dt, *J* = 15.0, 7.2 Hz, 1H), 5.39 (dd, *J* = 10.8, 9.6 Hz, 1H), 4.86 (m, 1H), 4.64 (dddd, *J* = 9.6, 7.8, 7.2, 1.8 Hz, 1H), 4.58 (t, *J* = 9.6 Hz, 1H), 4.20 (dd, *J* = 5.4, 3.0 Hz, 1H), 2.67–2.59 (m, 1H), 2.40–2.32 (m, 1H), 2.14 (q, *J* = 7.2 Hz, 1H), 1.57–1.51 (m, 1H), 1.45–1.25 (m, 6H), 0.91 (t, *J* = 7.2 Hz, 3H), 0.82 (d, *J* = 7.2 Hz, 3H); ^{1}H NMR (DMSO-d_6, 600 MHz) δ 6.98 (dd, *J* = 9.6, 5.4 Hz, 1H), 6.55 (dd, *J*= 14.4, 11.1 Hz, 1H), 6.47 (t, *J* = 11.4 Hz, 1H), 6.14 (t, *J* = 11.4 Hz, 1H), 5.98 (t, *J* = 11.1 Hz, 1H), 5.95 (d, *J* = 9.6 Hz, 1H), 5.80–5.72 (m, 2H), 5.63 (dd, *J* = 15.6, 7.2 Hz, 1H), 5.34 (t, *J* = 10.2 Hz, 1H), 4.79 (dd, *J* = 7.2, 3.0 Hz, 1H), 4.49–4.39 (m, 1H), 4.28 (t, *J* = 9.6 Hz, 1H), 4.08 (dd, *J* = 6.0, 3.0 Hz, 1H), 2.35–2.26 (m, 1H), 2.12–2.04 (m, 3H), 1.40–1.32 (m, 2H), 1.32–1.16 (m, 5H), 0.86 (t, *J* = 6.6 Hz, 3H), 0.63 (d, *J* = 6.6 Hz, 3H); ^{13}C NMR (CD_3OD, 150 MHz) δ 166.3, 147.4, 138.0, 133.77, 133.75, 132.0, 127.9, 126.8, 126.6, 123.6, 122.7, 83.4, 74.21, 74.17, 68.8, 63.7, 44.44, 44.41, 38.2, 34.0, 32.7, 30.2, 23.6, 14.4, 9.2; ^{31}P NMR (CD_3OD, 160 MHz) δ 3.4 (3.4–4.0, condition dependent); IR (film) ν_{max} 3414, 1719, 1662, 1088 cm^{-1}; HRMS (ESI-TOF) calcd for $C_{23}H_{35}O_8P + Na^+$ 493.1962; found 493.1966.

Experimental details for the preparation and characterization of compounds **8**–**10**, **12**–**15**, **19–34**, and **37** may be found in ref. 11.

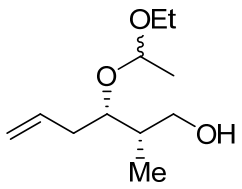


(5*S*,6*S*)-6-((1*E*,4*S*,5*R*,6*S*,7*Z*,9*Z*,11*E*)-4,6-Dihydroxy-5-methylheptadeca-1,7,9,11-tetraen-1-yl)-5-hydroxy-5,6-dihydro-2*H*-pyran-2-one (35). A solution of HF–pyr (0.10 mL) in 0.20 mL of THF was added to a solution of **33** (2.7 mg, 0.003 mmol) in THF (0.20 mL) and pyridine

(0.05 mL) at room temperature with stirring. After stirring for 12 h, the mixture was carefully transferred a mixture of saturated aq. $NaHCO_3$ (3 mL) and EtOAc (2 mL). The mixture was extracted with EtOAc, and the combined organic fractions were washed with saturated aq. $NaHCO_3$, dried (Na_2SO_4), and concentrated. The residue was purified by flash chromatography (SiO_2, 9:1 CH_2Cl_2/MeOH) to give 1.05 mg (90%) of the product as a colorless oil: $[\alpha]^{25}_D$ –62 (*c* 0.05, MeOH); ^{1}H NMR (CD_3OD, 600 MHz) δ 7.05 (dd, J = 9.6, 5.4 Hz, 1H), 6.59 (t, J = 10.8 Hz, 1H), 6.58–6.52 (m, 1H), 6.19 (t, J = 11.4 Hz, 1H), 6.07 (d, J = 10.2 Hz, 1H), 6.03 (t, J = 10.8 Hz, 1H), 5.97 (dt, J = 15.6, 6.6 Hz, 1H), 5.85–5.75 (m, 2H), 5.42 (t, J = 9.6 Hz, 1H), 4.87–4.85 (m, 1H), 4.56 (t, J = 9.0 Hz, 1H), 4.16 (dd, J = 5.4, 3.0 Hz, 1H), 4.10 (ddd, J = 8.4, 5.4, 2.4 Hz, 1H), 2.42–2.35 (m, 1H), 2.32–2.25 (m, 1H), 2.15 (q, J = 7.2 Hz, 2H), 1.62–1.53 (m, 1H), 1.46–1.38 (m, 2H), 1.38–1.26 (m, 6H), 0.91 (t, J = 7.2 Hz, 3H), 0.82 (d, J = 7.2 Hz, 3H); ^{1}H NMR (DMSO-d_6, 600 MHz) δ 7.00 (dd, J = 9.6, 5.4 Hz, 1H), 6.56 (dd, J = 14.4, 12.0 Hz, 1H), 6.49 (t, J = 11.4 Hz, 1H), 6.14 (t, J = 11.4 Hz, 1H), 6.00 (m, 1H), 5.99 (d, J = 9.6 Hz, 1H), 5.86 (dt, J = 15.6, 7.2 Hz, 1H), 5.77 (dt, J = 14.4, 7.2 Hz, 1H), 5.69 (dd, J = 15.6, 7.8 Hz, 1H), 5.58–5.48 (brs, 1H), 5.37 (t, J = 10.8 Hz, 1H), 4.82 (dd, J = 7.2, 3.0 Hz, 1H), 4.77–4.69 (brs, 1H), 4.35 (m, 1H), 4.04 (m, 1H), 3.94 (m, 1H), 2.25–2.18 (m, 1H), 2.15–2.04 (m, 3H), 1.41–1.32 (m, 3H), 1.32–1.19 (m, 6H), 0.86 (t, J = 6.6 Hz, 3H), 0.66 (d, J = 7.2 Hz, 3H); ^{13}C NMR (CD_3OD, 150 MHz) δ 166.1, 147.3, 138.3, 134.8, 134.2, 132.3, 127.3, 126.7, 126.2, 123.0, 122.7, 83.2, 71.1, 69.6, 63.8, 44.4, 39.1, 34.0, 32.7, 30.2, 23.6, 14.4, 9.8; IR (film) ν_{max} 3367, 1715, 1034 cm^{-1}; HRMS (ESI-TOF) calcd for $C_{23}H_{34}O_5 + Na^+$ 413.2298; found 413.2298.

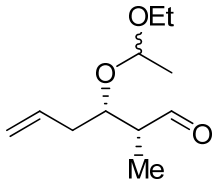


(5*S*,6*S*)-5-Hydroxy-6-((*E*)-3-((4*S*,5*R*,6*S*)-2,2,5-trimethyl-6-((1*Z*,3*Z*,5*E*)-undeca-1,3,5-trien-1-yl)-1,3-dioxan-4-yl)prop-1-en-1-yl)-5,6-dihydro-2*H*-pyran-2-one (36). *p*-TsOH·H_2O (0.15 mg, 0.8 μmol) was added to a solution of **35** (1.0 mg, 0.0027 mmol) and 2,2-dimethoxypropane (0.016 g, 0.15 mmol) in THF (0.63 mL) at room temperature with stirring. After 45 min, 3 drops of Et_3N were added, and the reaction mixture was concentrated. The residue was then purified by flash chromatography (SiO_2 pretreated with 2% Et_3N/hexanes; 50–60% EtOAc/hexanes gradient) to give 0.60 mg (52%) of the product as a colorless gum: $[\alpha]^{25}_D$ +53 (*c* 0.03, MeOH); ^{1}H NMR (CD_3CN, 600 MHz) δ 6.96 (dd, *J* = 9.9, 5.4 Hz, 1H), 6.60 (t, *J* = 10.8 Hz, 1H), 6.57 (dd, *J* = 15.0, 10.2 Hz, 1H), 6.22 (t, *J* = 10.8 Hz, 1H), 6.06 (t, *J* = 11.4 Hz, 1H), 6.00 (d, *J* = 9.9 Hz, 1H), 5.92–5.75 (m, 3H), 5.45 (dd, *J* = 8.7, 10.8 Hz, 1H), 4.80 (dd, *J* = 7.2, 3.0 Hz, 1H), 4.29 (t, *J* = 8.7 Hz, 1H), 4.14–4.09 (m, 1H), 4.00 (dt, *J*= 7.8, 6.0 Hz, 1H), 2.25–2.20 (m, 1H), 1.45–1.38 (m, 1H), 1.36–1.21 (m, 8H), 1.34 (s, 3H), 1.29 (s, 3H), 0.89 (t, *J* = 7.2 Hz, 3H), 0.82 (d, *J* = 7.2 Hz, 3H); ^{13}C NMR (CD_3CN, 150 MHz) δ 177.5, 146.5, 138.8, 133.8, 132.4, 131.6, 126.9, 126.6, 126.2, 122.7, 122.6, 101.3, 82.0, 71.2, 69.5, 63.4, 41.1, 34.4, 33.4, 32.1, 29.5, 25.0, 24.6, 23.1, 14.2, 11.4; IR (film) ν_{max} 3390, 1726 cm^{-1}; HRMS (ESI-TOF) calcd for $C_{26}H_{38}O_5$ + Na^+ 453.2611; found 453.2609.



(2*S*,3*S*)-3-(1-Ethoxyethoxy)-2-methylhex-5-en-1-ol (39). H_2O (4.2 mL) and DDQ (1.1 g, 4.9 mmol) were added to a solution of **14** (0.51 g, 1.6 mmol) in CH_2Cl_2 (74 mL) at 0 °C with stirring. After 1 h, saturated aqueous $NaHCO_3$ was added and the aqueous phase was extracted with CH_2Cl_2. The combined organic phases were washed with H_2O, saturated aqueous NaCl, dried (Na_2SO_4), and concentrated. The residue was purified by flash chromatography (SiO_2 pretreated with 2% Et_3N/hexanes, 5–20% EtOAc/hexanes gradient) to provide **39a** (0.095 g, 30%) as a colorless oil, and **39b** (0.091 g, 28%) as a colorless oil. Data for **39a**: $[\alpha]^{25}_D$ +76 (*c* 0.39, $CHCl_3$); ^{1}H NMR (C_6D_6, 500 MHz) δ 5.71–5.61 (m, 1H), 5.06–4.95 (m, 2H), 4.45 (q, J = 5.0 Hz, 1H), 3.88 (td, J = 7.0, 3.0 Hz, 1H), 3.77–3.69 (m, 1H), 3.60–3.53 (m, 1H), 3.19–3.10 (m, 3H), 2.33–2.26 (m, 1H), 2.14–2.06 (m, 1H), 1.84–1.74 (m, 1H), 1.13 (d, J = 5.0 Hz, 3H), 1.03 (t, J = 7.0 Hz, 3H), 0.82 (t, J = 7.0 Hz, 3H) ; ^{13}C NMR (C_6D_6, 125 MHz) δ 135.7, 116.9, 100.2, 75.8, 65.2, 61.4, 38.8, 37.4, 20.2, 15.3, 10.1; IR (neat) ν_{max} 3435, 1053 cm^{-1}; HRMS (ESI-TOF) calcd for $C_{11}H_{22}O_3$ + Na^+: 225.1461; found: 225.1463.

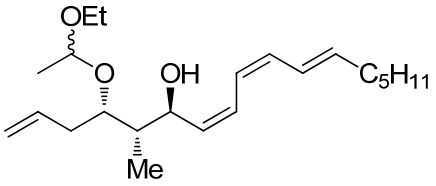
Data for **39b**: $[\alpha]^{25}_D$ –4.7 (*c* 0.47, $CHCl_3$); ^{1}H NMR (C_6D_6, 500 MHz) δ 5.86–5.76 (m, 1H), 5.09–4.97 (m, 2H), 4.62 (q, J = 5.5 Hz, 1H), 3.69 (td, J = 6.5, 3.0 Hz, 1H), 3.50–3.40 (m, 2H), 3.37–3.28 (m, 2H), 2.48–2.41 (m, 1H), 2.30–2.22 (m, 1H), 1.80–1.70 (m, 1H), 1.45–1.37 (brs, 1H), 1.22 (d, J = 5.5 Hz, 3H), 1.09 (t, J = 7.0 Hz, 3H), 0.80 (d, J = 7.0 Hz, 3H); ^{13}C NMR (C_6D_6, 125 MHz) δ 136.0, 116.5, 100.1, 77.2, 65.3, 60.3, 38.3, 37.0, 20.4, 15.5, 11.1; IR (neat) ν_{max} 3413, 992 cm^{-1}; HRMS (ESI-TOF) calcd for $C_{11}H_{22}O_3$ + Na^+: 225.1461; found: 225.1457.



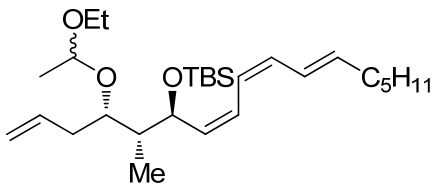
(2*R*,3*S*)-3-(1-Ethoxyethoxy)-2-methylhex-5-enal (40). Dess–Martin periodinane (0.03 g, 0.08 mmol) was added to a solution of **39a** (0.01 g, 0.05 mmol) in CH_2Cl_2 (2.4 mL) at room temperature with stirring. After 1 h, saturated aqueous $NaHCO_3$ (0.5 mL), saturated aqueous $Na_2S_2O_3$ (0.5 mL), and Et_2O (5 mL) were added and the mixture was stirred vigorously for 15 min. The phases were separated and the aqueous phase was extracted with Et_2O. The combined organic phases were washed with saturated aqueous NaCl, dried (Na_2SO_4), and concentrated. The residue was purified through a short column (SiO_2, 5% EtOAc/hexanes) to give 0.008 g (80%) of **40a** as a colorless oil: $[\alpha]^{25}_D$ +3.7 (*c* 0.82, $CHCl_3$); ^{1}H NMR (C_6D_6, 500 MHz) δ 9.61 (d, *J* = 0.5 Hz, 1H), 5.60–5.49 (m, 1H), 4.97–4.94 (m, 1H), 4.94–4.91 (m, 1H), 4.52 (q, *J* = 5.0 Hz, 1H), 3.93 (td, *J* = 6.5, 3.5 Hz, 1H), 3.27 (dq, *J* = 9.0, 7.0 Hz, 1H), 3.19 (dq, *J* = 9.0, 7.0 Hz, 1H), 2.26–2.17 (m, 1H), 2.16–2.09 (m, 1H), 2.05–1.98 (m, 1H), 1.12 (d, *J* = 5.0 Hz, 3H), 1.05 (t, *J* = 7.0 Hz, 3H), 1.05 (d, *J* = 7.0 Hz, 3H); ^{13}C NMR (C_6D_6, 125 MHz) δ 202.8, 134.6, 117.6, 99.0, 74.6, 59.7, 49.8, 37.0, 20.2, 15.4, 7.7; IR (neat) ν_{max} 1726, 1081 cm^{-1}; HRMS (ESI-TOF) calcd for $C_{11}H_{20}O_3 + Na^+$: 223.1305; found: 223.1304.

Data for **40b**: $[\alpha]^{25}_D$ –54 (*c* 0.23, $CHCl_3$); ^{1}H NMR (C_6D_6, 400 MHz) δ 9.49 (d, *J* = 0.8 Hz, 1H), 5.70–5.58 (m, 1H), 5.00–4.96 (m, 1H), 4.96–4.93 (m, 1H), 4.51 (q, *J* = 5.2 Hz, 1H), 3.88 (ddd, *J* = 7.6, 6.0, 3.6 Hz, 1H), 3.37 (dq, *J* = 9.2, 7.2 Hz, 1H), 3.24 (dq, *J* = 9.2, 7.2 Hz, 1H), 2.44–2.35 (m, 1H), 2.21–2.12 (m, 1H), 2.09 (qdd, *J* = 7.2, 3.6, 0.8 Hz, 1H), 1.12 (d, *J* = 5.2 Hz, 3H), 1.05 (t, *J* = 6.8 Hz, 3H), 0.97 (d, *J* = 7.2 Hz, 3H); ^{13}C NMR (C_6D_6, 100 MHz) δ 202.8, 134.9, 117.4,

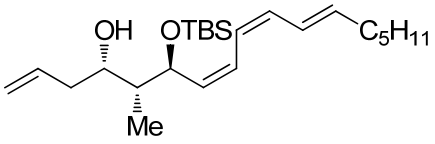
99.9, 75.0, 60.0, 49.7, 37.8, 20.2, 15.4, 7.7; IR (neat) ν_{max} 1726, 1082 cm^{-1}; HRMS (ESI-TOF) calcd for $C_{11}H_{20}O_3 + Na^+$: 223.1305; found: 223.1302.



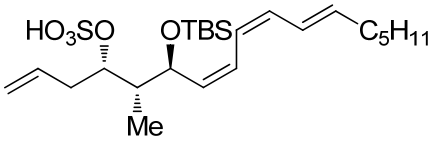
(4*S*,5*S*,6*S*,7*Z*,9*Z*,11*E*)-4-(1-Ethoxyethoxy)-5-methylheptadeca-1,7,9,11-tetraen-6-ol (41). Prepared from **9** and **40a** in 78% yield (0.038 g, >10:1 selectivity) according to the same procedure used for **59**. Purified by flash chromatography (SiO_2 pretreated with 2% Et_3N/hexanes, 5–20% EtOAc/hexanes gradient) to give **41** as a yellow oil: $[\alpha]^{25}_D$ –5.4 (*c* 0.65, $CHCl_3$); ^1H NMR (C_6D_6, 500 MHz) δ 6.66 (t, *J* = 11.5 Hz, 1H), 6.62–6.53 (m, 1H), 6.40 (t, *J* = 11.5 Hz, 1H), 6.00 (t, *J* = 11.0 Hz, 1H), 5.72–5.58 (m, 3H), 5.09–4.94 (m, 2H), 4.84 (td, *J* = 9.0, 4.0 Hz, 1H), 4.48 (q, *J* = 5.0 Hz, 1H), 4.19 (td, *J* = 7.0, 2.5 Hz, 1H), 4.02 (d, *J* = 4.0 Hz, 1H), 3.22–3.10 (m, 2H), 2.40–2.32 (m, 1H), 2.19–2.10 (m, 1H), 1.98 (q, *J* = 7.0 Hz, 2H), 1.73–1.64 (m, 1H), 1.38–1.08 (m, 6H), 1.16 (d, *J* = 5.0 Hz, 3H), 1.05 (t, *J* = 7.0 Hz, 3H), 0.96 (d, *J* = 7.0 Hz, 3H), 0.85 (t, *J* = 7.0 Hz, 3H); ^{13}C NMR (C_6D_6, 125 MHz) δ 136.8, 135.5, 134.6, 131.0, 126.1, 125.1, 123.3, 117.1, 100.4, 75.1, 68.9, 61.9, 43.2, 37.6, 33.3, 31.7, 29.3, 22.9, 20.3, 15.2, 14.2, 9.9; IR (neat) ν_{max} 3445, 1055, 988 cm^{-1}; HRMS (ESI-TOF) calcd for $C_{22}H_{38}O_3 + Na^+$: 373.2713; found: 373.2710.



(5*S*,6*R*,7*S*)-7-Allyl-2,2,3,3,6,9-hexamethyl-5-((1*Z*,3*Z*,5*E*)-undeca-1,3,5-trien-1-yl)-4,8,10-trioxa-3-siladodecane (42). $AgNO_3$ (0.09 g, 0.5 mmol) was added to a solution of **41** (0.038 g, 0.11 mmol) in CH_2Cl_2/pyridine (1:1) (2.2 mL) at room temperature with stirring. TBSCl (0.083 g, 0.55 mmol) was added, and the mixture was stirred in the dark overnight. The mixture was filtered through Celite and concentrated. The crude material was purified by flash chromatography (SiO_2 pretreated with 2% Et_3N/hexanes, hexanes eluent) to give 0.040 g (78%) of **42** as a colorless oil: $[\alpha]^{25}_D$ –41 (*c* 0.48, $CHCl_3$); ^{1}H NMR (C_6D_6, 500 MHz) δ 6.54 (t, *J* = 11.5 Hz, 1H), 6.54–6.50 (m, 1H), 6.40 (t, *J* = 11.5 Hz, 1H), 6.04 (t, *J* = 11.5 Hz, 1H), 5.90–5.80 (m, 1H), 5.62 (dt, *J* = 15.0, 7.0 Hz, 1H), 5.44 (t, *J* = 10.5 Hz, 1H), 5.15–5.02 (m, 2H), 4.96–4.89 (m, 1H), 4.74 (q, *J* = 5.0 Hz, 1H), 4.18 (ddd, *J* = 7.5, 5.0, 3.0 Hz, 1H), 3.61 (dq, *J* = 9.5, 7.0, Hz, 1H), 3.44 (dq, *J* = 9.0, 7.0 Hz, 1H), 2.50–2.42 (m, 1H), 2.32–2.24 (m, 1H), 1.98 (q, *J* = 7.0 Hz, 2H), 1.92–1.85 (m, 1H), 1.31 (d, *J* = 5.0 Hz, 3H), 1.29–1.10 (m, 6H), 1.06 (d, *J* = 3H), 1.04 (s, 9H), 0.85 (t, *J* = 7.0 Hz, 3H), 0.23 (s, 3H), 0.19 (s, 3H); ^{13}C NMR (C_6D_6, 125 MHz) δ 137.5, 135.8, 134.1, 131.6, 125.9, 124.9, 122.5, 116.8, 99.1, 74.6, 69.7, 60.8, 43.9, 37.7, 33.3, 31.7, 29.3, 26.3, 22.9, 21.1, 18.5, 15.8, 14.2, 10.0, –3.0, –4.3; IR (neat) ν_{max} 1058 cm^{-1}; HRMS (ESI-TOF) calcd for $C_{28}H_{52}O_3Si + Na^+$: 487.3578; found: 487.3583.

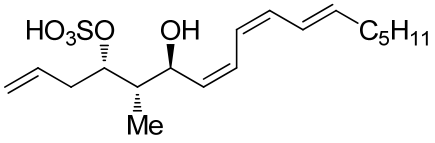


(4*S*,5*R*,6*S*,7*Z*,9*Z*,11*E*)-6-((*tert*-Butyldimethylsilyl)oxy)-5-methylheptadeca-1,7,9,11-tetraen-4-ol (43). A solution of 0.5 M aq. HCl (0.55 mL) was added to a solution of **42** (0.040 g, 0.086 mmol) in THF (35 mL) at room temperature with stirring. After 2.5 h, saturated aq. $NaHCO_3$ was added, and the mixture was extracted with EtOAc. The combined organic extracts were washed with H_2O, saturated sodium chloride, dried (Na_2SO_4) and concentrated. The crude alcohol was purified by flash chromatography (SiO_2, 3% EtOAc/hexanes) to give 0.028 g (82%) of **43** as a colorless oil: $[\alpha]^{25}_D$ –45 (*c* 0.27, $CHCl_3$); ^{1}H NMR (C_6D_6, 500 MHz) δ 6.55–6.47 (m, 1H), 6.44 (t, *J* = 11.5 Hz, 1H), 6.13 (t, *J* = 11.0 Hz, 1H), 6.03 (t, *J* = 11.0 Hz, 1H), 5.93–5.83 (m, 1H), 5.64 (dt, *J* = 15.0, 7.0 Hz, 1H), 5.54 (t, 11.0 Hz, 1H), 5.10–4.98 (m, 2H), 4.74 (dd, *J* = 9.0, 5.5 Hz, 1H), 4.26 (ddd, *J* = 10.5, 5.0, 2.0 Hz, 1H), 2.60 (d, *J* = 3.0 Hz, 1H), 2.39–2.32 (m, 1H), 2.10–2.03 (m, 1H), 1.99 (q, *J* = 7.0 Hz, 1H), 1.65–1.58 (m, 1H), 1.32–1.12 (m, 6H), 0.98 (d, *J* = 7.0 Hz, 3H), 0.96 (s, 9H), 0.85 (t, *J* = 7.0 Hz, 3H), 0.11 (s, 3H), 0.09 (s, 3H); ^{13}C NMR (C_6D_6, 125 MHz) δ 137.8, 136.2, 134.3, 131.8, 125.8, 124.1, 121.9, 116.7, 73.1, 70.2, 43.7, 40.1, 33.3, 31.7, 29.3, 26.0, 22.9, 18.3, 14.2, 10.2, –3.9, –4.9; IR (neat) ν_{max} 3510, 837 cm^{-1}; HRMS (ESI-TOF) calcd for $C_{24}H_{44}O_2Si + Na^+$: 415.3003; found: 415.3010.



***tert*-Butyldimethyl(((4*S*,5*S*,6*S*,7*Z*,9*Z*,11*E*)-5-methyl-4-((trioxidanylthio)oxy)heptadeca-1,7,9,11-tetraen-6-yl)oxy)silane (44).** SO_3–pyridine complex (0.004 g, 0.03 mmol) was added

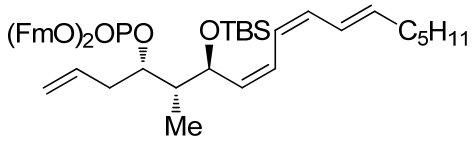
to a solution of **43** (0.0050 g, 0.013 mmol) in 0.5 mL of THF with stirring at room temperature. After 10 min, the mixture was transferred directly onto a short silica gel column and eluted with 15% MeOH/CH_2Cl_2 to give 0.0060 g (98%) of **44** as a white solid: $[\alpha]^{25}_D$ –38 (*c* 0.15, MeOH); ^{1}H NMR (CD_3OD, 500 MHz) δ 6.60–6.50 (m, 2H), 6.23 (t, *J* = 11.0 Hz, 1H), 6.02 (t, *J* = 11.0 Hz, 1H), 5.88–5.73 (m, 2H), 5.32 (t, *J* = 10.5 Hz, 1H), 5.15–5.02 (m, 2H), 4.80–4.72 (m, 2H), 2.76–2.68 (m, 1H), 2.45 (dt, *J* = 14.0, 8.0 Hz, 1H), 2.15 (q, *J* = 7.0 Hz, 2H), 1.77–1.68 (m, 1H), 1.43 (p, *J* = 7.0 Hz, 2H), 1.39–1.27 (m, 4H), 0.91 (t, *J* = 7.0 Hz, 3H), 0.88 (s, 9H), 0.82 (d, 7.0 Hz, 3H), 0.12 (s, 3H), 0.02 (s, 3H); ^{13}C NMR (CD_3OD, 150 MHz) δ 138.2, 135.9, 134.5, 132.1, 126.7, 125.7, 123.5, 117.5, 79.2, 70.1, 43.6, 38.4, 34.0, 32.7, 30.2, 26.7, 23.6, 19.0, 14.4, 9.8, –3.5, –4.3; IR (neat) ν_{max} 3441, 1249, 1066 cm^{-1}; HRMS (ESI-TOF) calcd for $C_{24}H_{44}O_5SSi - H^+$: 471.2606; found: 471.2603.



(4*S*,5*S*,6*S*,7*Z*,9*Z*,11*E*)-6-Hydroxy-5-methylheptadeca-1,7,9,11-tetraen-4-yl Sulfate (45). HF–pyr (0.24 mL) in 0.47 mL of THF was added to a solution of **44** in 0.47 mL of THF and 0.12 of mL pyridine at room temperature with stirring. After 3 h, the mixture was carefully transferred to a solution of saturated aq. $NaHCO_3$ and the mixture was thoroughly extracted with EtOAc. The combined organic extracts were dried (Na_2SO_4) and concentrated. The crude material was purified by flash chromatography (SiO_2, 15% MeOH/CH_2Cl_2) to give 4.0 mg (80%) of **45** as an amorphous white solid: $[\alpha]^{25}_D$ –48 (*c* 0.10, MeOH); ^{1}H NMR (CD_3OD, 500 MHz) δ 6.60 (t, *J* = 11.5 Hz, 1H), 6.57–6.51 (m, 1H), 6.21 (t, *J* = 11.5 Hz, 1H), 6.02 (t, *J* = 11.0 Hz, 1H), 5.85–5.73 (m, 2H), 5.37 (t, *J* = 9.5 Hz, 1H), 5.16–5.02 (m, 2H), 4.79 (ddd, *J* = 9.5, 5.0, 2.0 Hz, 1H), 4.59 (t,

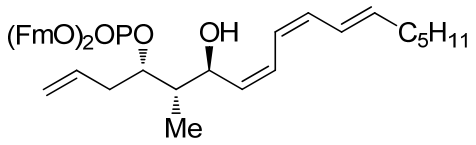
J = 9.5 Hz, 1H), 4.57 (s, 1H), 2.79–2.72 (m, 1H), 2.41 (dt, J = 13.0, 9.5 Hz, 1H), 2.14 (q, J = 7.0 Hz, 2H), 1.67–1.59 (m, 1H), 1.43 (p, J = 7.0 Hz, 2H), 1.38–1.25 (m, 4H), 0.91 (t, J = 7.0 Hz, 3H), 0.81 (d, J = 7.0 Hz, 3H); ^{13}C NMR (CD_3OD, 150 MHz) δ 138.2, 135.4, 133.2, 132.3, 126.8, 126.7, 123.3, 117.9, 78.2, 68.8, 42.8, 38.2, 34.0, 32.6, 30.2, 23.6, 14.4, 9.2; IR (film) ν_{max} 3426, 1215, 1065, 941 cm^{-1}; HRMS (ESI-TOF) calcd for $C_{18}H_{30}O_5S - H^+$: 357.1741; found: 357.1732.

Purification of **45** by reverse phase C_{18} silica gel chromatography (H_2O/MeCN eluent), which does not affect counterion identity or protonation state, resulted in **45** identical spectroscopically to the product obtained from normal phase silica gel chromatography. Passing the material through a column of Dowex-Na$^+$ resin also yielded **45** with identical spectroscopic characterization



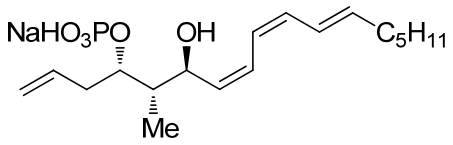
Bis((9*H*-fluoren-9-yl)methyl) ((4*S*,5*S*,6*S*,7*Z*,9*Z*,11*E*)-6-((*tert*-butyldimethylsilyl)oxy)-5-methylheptadeca-1,7,9,11-tetraen-4-yl) Phosphate (46). Prepared in 75% yield (9 mg) from **43** according to the procedure used to synthesize **64**. Purified by flash chromatography (SiO_2, 10% EtOAc/hexanes) to give **46** as a colorless oil: $[\alpha]^{25}_D$ –29 (*c* 0.30, $CHCl_3$); ^{1}H NMR (C_6D_6, 500 MHz) δ 7.56–7.49 (m, 5H), 7.49–7.45 (m, 2H), 7.38–7.33 (m, 1H), 7.23–7.17 (m, 3H), 7.14–7.09 (m, 4H), 7.07–7.03 (m, 1H), 6.54–6.46 (m, 2H), 6.38 (t, J = 11.5 Hz, 1H), 5.93 (t, J = 11.0 Hz, 1H), 5.79–5.68 (m, 1H), 5.58 (dt, J = 15.0, 7.0 Hz, 1H), 5.32 (t, J = 10.5 Hz, 1H), 5.18–5.12 (m, 1H), 5.05–4.94 (m, 3H), 4.34–4.15 (m, 4H), 4.07 (t, J = 7.0 Hz, 1H), 3.90 (t, J = 6.5 Hz, 1H), 2.58 (dt, J = 14.0, 6.5 Hz, 1H), 2.29 (dt, J = 14.5, 7.5 Hz, 1H), 1.97 (q, J = 7.0 Hz, 2H), 1.84–1.76 (m, 1H), 1.30–1.12 (m, 6H), 1.06 (s, 9 H), 0.88 (d, J = 7.0 Hz, 3H), 0.85 (t, J = 7.0 Hz,

3H), 0.36 (s, 3H), 0.21 (s, 3H); ^{13}C NMR (C_6D_6, 150 MHz) δ 143.95, 143.90, 143.81, 143.80, 141.81, 141.78, 137.6, 134.2, 133.5, 132.0, 127.4, 127.3, 125.9, 125.8, 125.6, 125.4, 125.2, 122.3, 120.3, 120.23, 120.20, 120.15, 117.8, 78.21, 78.17, 69.50, 69.46, 69.41, 68.98, 68.94, 48.5, 48.4, 43.71, 43.67, 38.83, 38.81, 33.3, 31.7, 29.4, 29.2, 26.4, 22.9, 18.5, 14.2, 9.5, –3.3, –4.4; ^{31}P NMR (C_6D_6, 160 MHz) δ –0.4; IR (neat) ν_{max} 1450, 1007 cm^{-1}; HRMS (ESI-TOF) calcd for $C_{52}H_{65}O_5PSi + Na^+$: 851.4231; found: 851.4244.



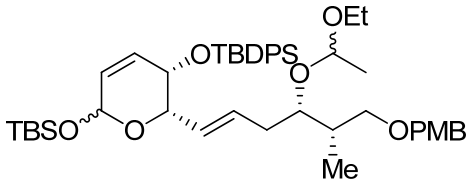
Bis((9*H*-fluoren-9-yl)methyl) ((4*S*,5*S*,6*S*,7*Z*,9*Z*,11*E*)-6-hydroxy-5-methylheptadeca-1,7,9,11-tetraen-4-yl) Phosphate (47). HF–pyr (0.41 mL) in 0.8 mL of THF was added at room temperature to a solution of **46** (0.017g, 0.021 mmol) in THF (0.8 mL) and pyridine (0.18 mL), and the solution was stirred for 18 h. The reaction mixture was carefully transferred to a gently stirred mixture of saturated aqueous $NaHCO_3$ (9 mL) and EtOAc (3.5 mL) and was stirred until CO_2 evolution ceased. The phases were separated, and the aqueous phase was thoroughly extracted with EtOAc. The combined organic extracts were dried (Na_2SO_4), concentrated, and the residue was purified by flash chromatography (SiO_2, 25% EtOAc/hexanes) to give 0.11 g (73%) of **47** as a colorless oil: $[\alpha]^{25}_D$ –3.4 (*c* 0.20, $CHCl_3$); ^{1}H NMR (C_6D_6, 500 MHz) δ 7.55–7.46 (m, 5H), 7.44–7.38 (m, 4H), 7.33–7.27 (m, 2H), 7.24–7.04 (m, 5H), 6.63 (t, *J* = 11.5 Hz, 1H), 6.60–6.57 (m, 1H), 6.34 (t, *J* = 11.5 Hz, 1H), 5.97 (t, *J* = 11.5 Hz, 1H), 5.67–5.58 (m, 2H), 5.53–5.43 (m, 1H), 5.14–5.07 (m, 1H), 4.91–4.81 (m, 2H), 4.81–4.74 (m, 1H), 4.72 (d, *J* = 5.0 Hz, 1H), 4.27–4.08 (m, 4H), 3.93 (t, *J* = 6.5 Hz, 1H), 3.79 (t, *J* = 6.0 Hz, 1H), 2.35–2.26 (m, 1H), 2.05–1.95 (m, 3H), 1.63–1.54 (m, 1H), 1.40–1.14 (m, 6H), 0.85 (t, *J* = 7.0 Hz, 3H), 0.78 (d, *J*

=7.0 Hz, 3H); ^{13}C NMR (C_6D_6, 150 MHz) δ 143.7, 143.61, 143.58, 143.5, 141.85, 141.80, 141.77, 141.75, 137.2, 134.0, 133.9, 131.3, 127.42, 127.41, 127.35, 126.1, 125.6, 125.4, 125.33, 125.31, 125.25, 123.0, 120.3, 120.24, 120.17, 117.7, 77.82, 77.78, 69.72, 69.68, 69.22, 69.18, 67.9, 48.33, 48.28, 48.2, 43.69, 43.66, 38.37, 38.35 33.3, 31.7, 29.3, 22.9, 14.2, 8.7; ^{31}P NMR (C_6D_6, 160 MHz) δ 1.5 IR (neat) ν_{max} 3399, 1450, 1009, 739 cm^{-1}; HRMS (ESI-TOF) calcd for $C_{46}H_{51}O_5P + Na^+$: 737.3366; found: 737.3369.

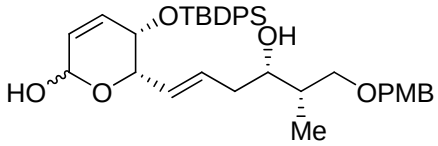


Sodium (4*S*,5*S*,6*S*,7*Z*,9*Z*,11*E*)-6-Hydroxy-5-methylheptadeca-1,7,9,11-tetraen-4-yl Hydrogenphosphate (48). Et_3N (0.71 mL) was added to a solution of **47** (11 mg, 0.015 mmol) in MeCN (2.8 mL) at room temperature with stirring. The mixture was stirred for 16 h and was then concentrated under a stream of N_2. H_2O (~5 mL) was then added and the cloudy white mixture was washed repeatedly with hexanes. The aqueous layer was concentrated under reduced pressure, and the residue was dissolved in 1:1 MeCN/H_2O and passed through a short column of Dowex–Na^+ (2 cm × 1 cm, 1:1 MeCN/H_2O eluent). The water was azeotroped with MeCN and the residue was purified by flash chromatography (C_{18} reverse phase SiO_2, 0–20% MeCN/H_2O gradient) to give 4.6 mg (81%) of **48** as a white solid: $[\alpha]^{25}_D$ –25 (*c* 0.23, MeOH); ^{1}H NMR (CD_3OD, 600 MHz) δ 6.59 (t, *J* = 10.8 Hz, 1H), 6.55–6.52 (m, 1H), 6.25 (t, *J* = 11.4 Hz, 1H), 6.00 (t, *J* = 11.4 Hz, 1H), 5.85–5.78 (m, 1H), 5.76 (dt, *J* = 15.0, 7.2 Hz, 1H), 5.37 (t, *J* = 9.6 Hz, 1H), 5.10 (dd, *J* = 17.4, 1.2 Hz, 1H), 5.02 (d, *J* = 10.2 Hz, 1H), 4.63–4.58 (m, 1H), 4.56 (t, *J* = 9.6 Hz, 1H), 2.67–2.61 (m, 1H), 2.33 (dt, *J* = 13.2, 9.0 Hz, 1H), 2.14 (q, *J* = 7.2 Hz, 2H), 1.55–1.48 (m, 1H), 1.43 (p, *J* = 7.2 Hz, 2H), 1.38–1.25 (m, 6H), 0.91 (t, *J* = 7.2 Hz, 3H), 0.79 (d,

J = 6.6 Hz, 3H); ^{13}C NMR (CD_3OD, 150 MHz) δ 138.0, 136.0, 133.8, 131.9, 126.8, 126.6, 123.6, 117.3, 74.11, 74.07, 68.8, 43.50, 43.47, 39.27, 39.26, 34.0, 32.7, 30.2, 23.6, 14.5, 8.9; ^{31}P NMR (CD_3OD, 160 MHz) 2.8; IR (film) ν_{max} 3359, 1666, 998 cm^{-1}; HRMS (ESI-TOF) calcd for $C_{18}H_{30}NaO_5P + H^+$: 381.1801; found: 381.1801.

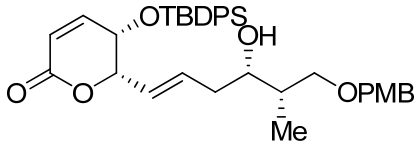


***tert*-Butyl(((2*S*,3*S*)-6-((*tert*-butyldimethylsilyl)oxy)-2-((4*S*,5*S*,*E*)-4-(1-ethoxyethoxy)-6-((4-methoxybenzyl)oxy)-5-methylhex-1-en-1-yl)-3,6-dihydro-2*H*-pyran-3-yl)oxy)diphenylsilane (50).** Prepared from **26** in quantitative yield (0.125 g) according to the same procedure used to synthesize **61**. The crude material was purified by flash chromatography (SiO_2 pretreated with 2% Et_3N/hexanes, 3% EtOAc/hexanes) to give **50** contaminated with a small amount of silicon impurity as a colorless oil: $[\alpha]^{25}_D$ +25 (*c* 0.33, $CHCl_3$); ^{1}H NMR (C_6D_6, 400 MHz) see spectrum; ^{13}C NMR (C_6D_6, 150 MHz) δ see spectrum; IR (film) ν_{max} 1108, 754 cm^{-1}; HRMS (ESI-TOF) calcd for $C_{46}H_{68}O_7Si_2 + Na^+$ 811.4396; found 811.4380.

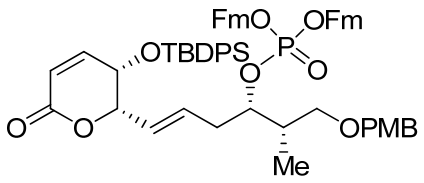


(5*S*,6*S*)-5-((*tert*-Butyldiphenylsilyl)oxy)-6-((4*S*,5*S*,*E*)-4-hydroxy-6-((4-methoxybenzyl)oxy)-5-methylhex-1-en-1-yl)-5,6-dihydro-2*H*-pyran-2-ol (51). Prepared from **50** in 52% yield (over 3 steps, 0.049 g) according to the same procedure used to synthesize **62**. The crude lactol was purified by flash chromatography (SiO_2, 33% EtOAc/hexanes) to give **51** as a colorless oil:

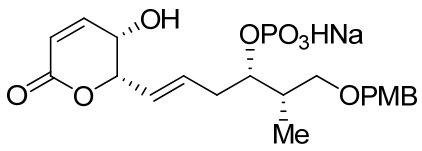
$[\alpha]^{25}_{D}$ +24 (*c* 1.6, $CHCl_3$); ^{1}H NMR (C_6D_6, 600 MHz) see spectrum; ^{13}C NMR (C_6D_6, 150 MHz) see spectrum; IR (film) ν_{max} 3410, 1246, 1105, 701 cm^{-1}; HRMS (ESI-TOF) calcd for $C_{36}H_{46}O_6Si + Na^+$ 625.2956; found 625.2948.



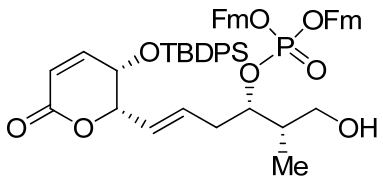
(5*S*,6*S*)-5-((*tert*-Butyldiphenylsilyl)oxy)-6-((4*S*,5*S*,*E*)-4-hydroxy-6-((4-methoxybenzyl)oxy)-5-methylhex-1-en-1-yl)-5,6-dihydro-2*H*-pyran-2-one (52). Prepared from **51** in 59% yield (0.029 g) according to the same procedure used to synthesize **63**. The crude lactone was purified by flash chromatography (SiO_2, 20–30% EtOAc/hexanes gradient) to give **52** as a colorless oil: $[\alpha]^{25}_{D}$ +43 (*c* 0.53, $CHCl_3$); ^{1}H NMR (C_6D_6, 400 MHz) δ 7.70–7.58 (m, 4H), 7.25–7.16 (m, 8H), 6.82–7.75 (m, 2H), 5.92 (dd, *J* = 15.6, 6.8 Hz, 1H), 5.89 (dd, *J* = 10.0, 4.4 Hz, 1H), 5.81 (dt, *J* = 15.6, 6.8 Hz, 1H), 5.67 (d, *J* = 10.0 Hz, 1H), 4.28–4.19 (m, 3H), 3.85 (dd, *J* = 4.4, 3.6 Hz, 1H), 3.85–3.79 (m, 1H), 3.36–3.26 (m, 2H), 3.30 (s, 3H), 2.39 (brs, 1H), 2.31–2.22 (m, 1H), 2.16–2.07 (m, 1H), 1.79–1.63 (m, 1H), 1.06 (s, 9H), 0.93 (d, *J* = 6.8 Hz, 3H); ^{13}C NMR (C_6D_6, 150 MHz) δ 162.4, 159.8, 144.3, 136.20, 136.19, 133.7, 133.2, 130.7, 130.4, 130.3, 129.5, 127.1, 122.5, 114.2, 81.3, 74.4, 73.2, 73.0, 65.1, 54.8, 38.13, 38.11, 27.0, 19.5, 10.9; IR (film) ν_{max} 3492, 1726, 1093, 701 cm^{-1}; HRMS (ESI-TOF) calcd for $C_{36}H_{44}O_6Si + Na^+$ 623.2799; found 623.2776.



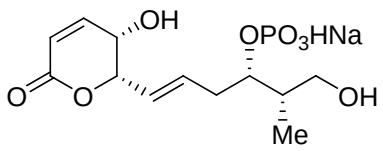
Bis((9*H*-fluoren-9-yl)methyl) ((2*S*,3*S*,*E*)-6-((2*S*,3*S*)-3-((*tert*-butyldiphenylsilyl)oxy)-6-oxo-3,6-dihydro-2*H*-pyran-2-yl)-1-((4-methoxybenzyl)oxy)-2-methylhex-5-en-3-yl) Phosphate (53). Prepared from **52** in 95% yield (0.023 g) according to the same procedure used to synthesize **64**. The crude product was purified by flash chromatography (SiO_2, 20–30% EtOAc/hexanes gradient) to give **53** as a colorless oil: $[\alpha]^{25}_D$ +26 (*c* 0.18, $CHCl_3$); ^{1}H NMR (C_6D_6, 600 MHz) δ 7.63–7.57 (m, 4H), 7.55–7.40 (m, 8H), 7.27–7.06 (m, 16H), 6.81–6.75 (m, 2H), 5.87 (dd, *J* = 9.6, 4.2 Hz, 1H), 5.85 (dd, *J* = 15.6, 7.2 Hz, 1H), 5.68 (d, *J* = 9.6 Hz, 1H), 5.60 (dt, *J* = 15.6, 7.2 Hz, 1H), 4.76–4.71 (m, 1H), 4.37–4.19 (m, 6H), 4.11 (dd, *J* = 7.2, 3.0 Hz, 1H), 3.96 (t, *J* = 6.0 Hz, 1H), 3.93 (t, *J* = 6.0 Hz, 1H), 3.77 (dd, *J* = dd, 4.2, 3.0 Hz, 1H), 3.39 (dd, *J* = 8.4, 7.8 Hz, 1H), 3.28 (s, 3H), 3.21 (dd, *J* = 9.0, 6.0 Hz, 1H), 2.61–2.54 (m, 1H), 2.37–2.30 (m, 1H), 2.03–1.95 (m, 1H), 1.03 (s, 9H), 0.84 (d, *J* = 7.2 Hz, 3H); ^{13}C NMR (C_6D_6, 150 MHz) δ 162.3, 159.7, 144.2, 143.9, 143.8, 141.83, 141.79, 136.1, 133.7, 133.1, 131.1, 130.9, 130.5, 130.3, 129.5, 127.5, 127.41, 127.37, 127.3, 125.63, 125.56, 125.52, 125.50, 125.38, 125.37, 122.6, 120.3, 120.24, 120.20, 120.18, 114.1, 80.9, 78.93, 78.89, 73.0, 71.8, 69.21, 69.17, 69.11, 69.08, 65.0, 54.8, 48.50, 48.47, 48.45, 48.42, 37.04, 37.01, 36.34, 36.33, 30.2, 26.9, 19.5, 10.9; ^{31}P NMR (C_6D_6, 160 MHz) δ –0.3; IR (film) ν_{max} 1730, 1246, 987 cm^{-1}; HRMS (ESI-TOF) calcd for $C_{64}H_{65}O_9PSi + H^+$ 1037.4208; found 1037.4205.



Sodium (2*S*,3*S*,*E*)-6-((2*S*,3*S*)-3-Hydroxy-6-oxo-3,6-dihydro-2*H*-pyran-2-yl)-1-((4-methoxybenzyl)oxy)-2-methylhex-5-en-3-yl Hydrogenphosphate (55). Et_3N (0.37 mL) was added at room temperature to a solution of **53** (7.4 mg, 0.0071 mmol) in MeCN (1.3 mL). The mixture was stirred overnight before toluene (1.6 mL) was added, and the mixture was concentrated under a stream of N_2. H_2O (2.5 mL) was added to the residue, and the mixture was washed repeatedly with hexanes. The aqueous phase was azeotroped with MeCN under reduced pressure, and the residue was dissolved in MeCN (0.45 mL). TAS–F (1.0 M in DMF, 0.014 mL, 0.014 mmol) was added to the solution, and the mixture was stirred overnight at room temperature after which time it was concentrated. The residue was dissolved in 0.1 M sodium phosphate buffer (pH 7) and was purified by flash chromatography (C_{18} reverse phase SiO_2, 0–10% MeCN/H_2O gradient) giving 2.21 mg (over 2 steps, 67%) of **55** as a white solid: $[\alpha]^{25}_D$ +40 (*c* 0.42, MeOH); ^{1}H NMR (CD_3OD, 600 MHz) δ 7.30–7.25 (m, 2H), 7.04 (dd, J = 9.6, 6.0 Hz, 1H), 6.92–6.85 (m, 2H), 6.05 (d, J = 9.6 Hz, 1H), 5.94 (dt, J = 15.6, 7.2 Hz, 1H), 5.78 (dd, J = 15.6, 7.8 Hz, 1H), 4.84 (dd, J = 7.8, 2.4 Hz, 1H), 4.47 (d, J = 11.4 Hz, 1H), 4.39 (d, J = 11.4 Hz, 1H), 4.32–4.26 (m, 1H), 4.22 (dd, J = 6.0, 3.0 Hz, 1H), 3.78 (s, 3H), 3.63 (dd, J = 9.6, 6.0 Hz, 1H), 3.42 (dd, J = 9.0, 7.2 Hz, 1H), 2.53–2.47 (m, 1H), 2.45–2.39 (m, 1H), 2.06–1.98 (m, 1H), 0.99 (d, J = 7.2 Hz, 3H); ^{13}C NMR (CD_3OD, 150 MHz) δ 166.4, 160.7, 147.5, 134.2, 132.1, 130.6, 127.8, 122.7, 114.7, 83.6, 76.7, 76.6, 74.0, 73.7, 63.7, 55.7, 38.6, 37.4, 12.2; ^{31}P NMR (CD_3OD 160 MHz) δ 2.4; IR (film) ν_{max} 3350, 1709, 1249, 1027 cm^{-1}; HRMS (ESI-TOF) calcd for $C_{20}H_{27}O_9P + H^+$ 443.1465; found 443.1452.



Bis ((9*H*-fluoren-9-yl)methyl) ((2*S*,3*S*,*E*)-6-((2*S*,3*S*)-3-((*tert*-butyldiphenylsilyl)oxy)-6-oxo-3,6-dihydro-2*H*-pyran-2-yl)-1-hydroxy-2-methylhex-5-en-3-yl) Phosphate (56). Prepared from **53** in 70% yield (5.0 mg) according to the same procedure used to synthesize **39**. The crude product was purified by flash chromatography (SiO_2, 50–100% EtOAc/hexanes gradient) to give the product as a colorless oil: $[\alpha]^{25}_D$ +28 (*c* 0.32, $CHCl_3$); ^{1}H NMR (C_6D_6, 600 MHz) δ 7.63–7.43 (m, 9H), 7.39–7.33 (m, 3H), 7.26–7.16 (m, 10H), 7.13–7.05 (m, 4H), 5.88 (dd, *J* = 9.6, 4.8 Hz, 1H), 5.75 (dd, *J* = 15.6, 6.6 Hz, 1H), 5.67 (d, *J* = 9.6 Hz, 1H), 5.52 (dt, *J* = 15.6, 7.2 Hz, 1H), 4.86–4.80 (m, 1H), 4.30 (dt, *J* = 10.2, 6.6 Hz, 1H), 4.18 (dt, *J* = 10.2, 6.6 Hz, 1H), 4.15–4.05 (m, 3H), 3.87 (t, *J* = 6.0 Hz, 1H), 3.84 (t, *J* = 6.0 Hz, 1H), 3.77 (dd, *J* = 4.8, 3.6 Hz, 1H), 3.62 (dd, *J* = 11.4, 10.2 Hz, 1H), 3.53 (dd, *J* = 11.4, 5.4 Hz, 1H), 2.36–2.29 (m, 1H), 2.13–2.05 (m, 1H), 1.80–1.71 (m, 1H), 1.03 (s, 9 H), 0.58 (d, *J* = 6.6 Hz, 3H); ^{13}C NMR (C_6D_6, 150 MHz) δ 162.1, 144.2, 143.7, 143.6, 143.55, 143.48, 141.84, 141.79, 141.760, 141.755, 136.13, 136.10, 133.6, 133.1, 130.5, 130.44, 130.38, 127.5, 127.41, 127.36, 125.50, 125.45, 125.43, 125.36, 122.5, 120.31, 120.26, 120.2, 80.6, 69.49, 69.45, 69.42, 69.38, 65.0, 63.9, 48.39, 48.34, 48.30, 48.25, 39.11, 39.09, 36.5, 36.4, 30.2, 26.9, 19.5, 8.6; ^{31}P NMR (C_6D_6 160 MHz) δ –1.7; IR (film) ν_{max} 3433, 1727, 987 cm^{-1}; HRMS (ESI-TOF) calcd for $C_{56}H_{57}O_8PSi + H^+$ 917.3633; found 917.3630.

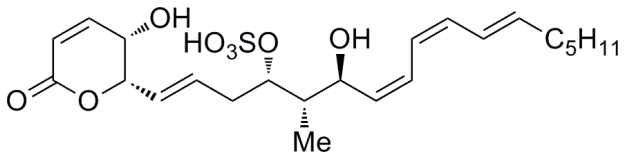


Sodium (2*S*,3*S*,*E*)-1-Hydroxy-6-((2*S*,3*S*)-3-hydroxy-6-oxo-3,6-dihydro-2*H*-pyran-2-yl)-2-methylhex-5-en-3-yl Hydrogenphosphate (58). Prepared from **56** in 84% yield (over 2 steps, 2.1 mg) according to the same procedure used to synthesize **55**. The crude product was purified by flash chromatography (C_{18} reverse phase SiO_2, H_2O) giving **58** as a white solid: $[\alpha]^{25}_D$ +48 (*c* 0.40, MeOH); ^{1}H NMR (CD_3OD, 600 MHz) δ 7.04 (dd, *J* = 9.6, 5.4 Hz, 1H), 6.06 (d, *J* = 9.6 Hz, 1H), 5.95 (dt, *J* = 15.6, 7.8 Hz, 1H), 5.82 (dd, *J* = 15.6, 7.8 Hz, 1H), 4.86 (dd, *J* = 7.8, 3.0 Hz, 1H), 4.41 (dddd, *J* = 9.6, 7.2, 7.2, 2.4 Hz, 1H), 4.22 (dd, *J* = 5.4, 3.0 Hz, 1H), 3.64 (dd, *J* = 11.4, 9.6 Hz, 1H), 3.41 (dd, *J* = 11.4, 5.4 Hz, 1H), 2.62–2.55 (m, 1H), 2.41–2.33 (m, 1H), 1.86–1.77 (m, 1H), 0.86 (d, *J* = 6.6 Hz, 3H); ^{13}C NMR (CD_3OD, 150 MHz) δ 166.3, 147.4, 134.0, 127.8, 122.7, 83.5, 74.7, 74.6, 65.2, 63.7, 40.22, 40.20, 37.84, 37.82, 9.8; ^{31}P NMR (CD_3OD 160 MHz) δ 3.5; IR (film) ν_{max} 3373, 1715, 1033 cm^{-1}; HRMS (ESI-TOF) calcd for $C_{12}H_{19}O_8P$ + H^+ 323.0890; found 323.0877.

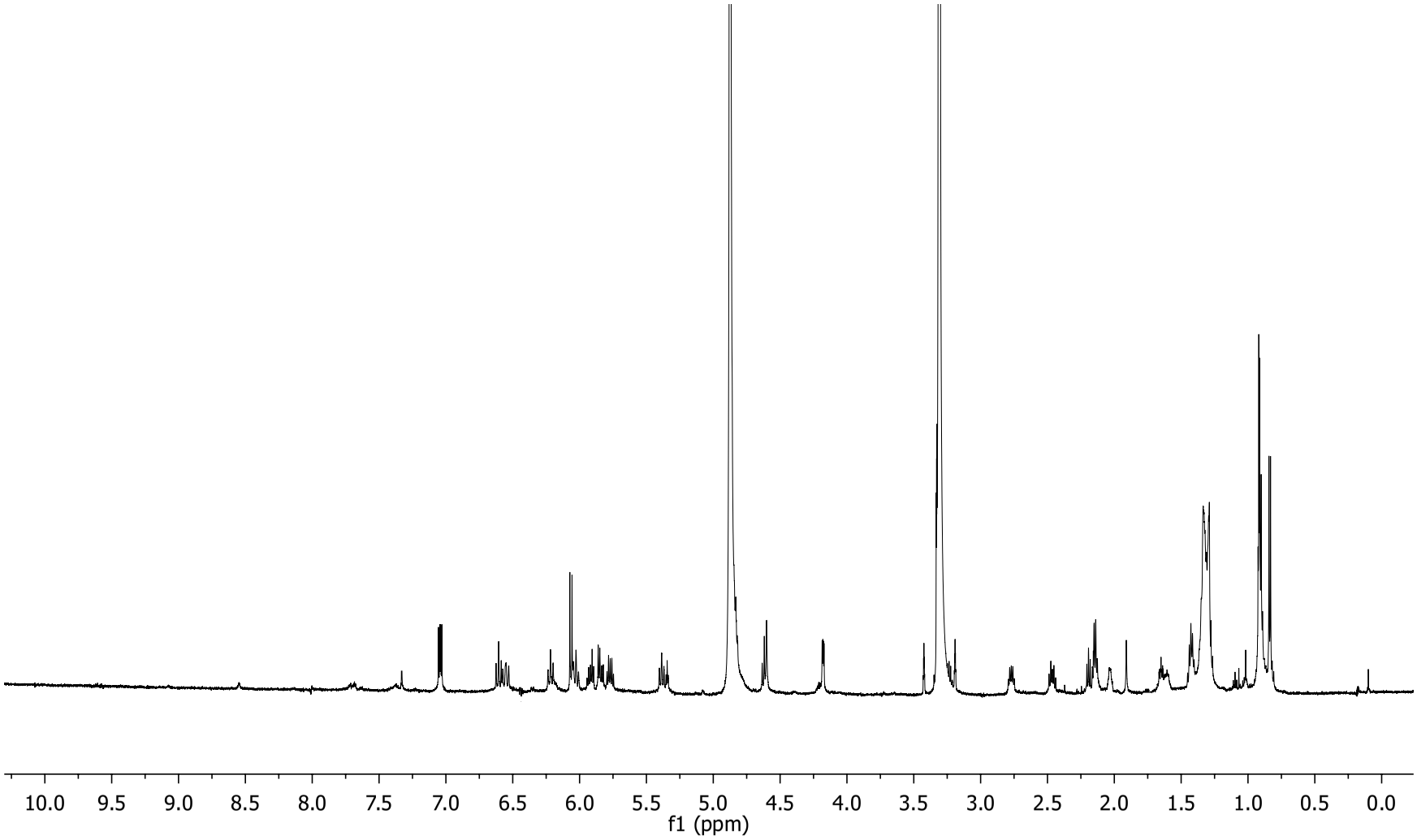
Phosphatase Inhibition Assays. Protein phosphatase activity against phosphohistone was measured by the quantification of [^{32}P] liberated from labeled phosphohistone according to established protocols (ref 1) with the following modifications. Dephosphorylation reactions were performed in 40 μL total volumes for 10 min at 37°C in the following buffer: 100 mM MOPS pH 7, 0.1 mM EDTA, 0.1 mg/mL BSA, 0.1% (vol/vol) 2-mercaptoethanol. Reactions also contained either 2 μL of DMF or DMF + inhibitor. Assays with recombinant PP1 contained 1 mM manganese (II) chloride. Reactions were stopped by the addition of 50 μL of acid (1 N H_2SO_4) containing 1 mM K_2HPO_4 (H_3PO_4 at pH 1) and 10 μL of ammonium molybdate (7.5%

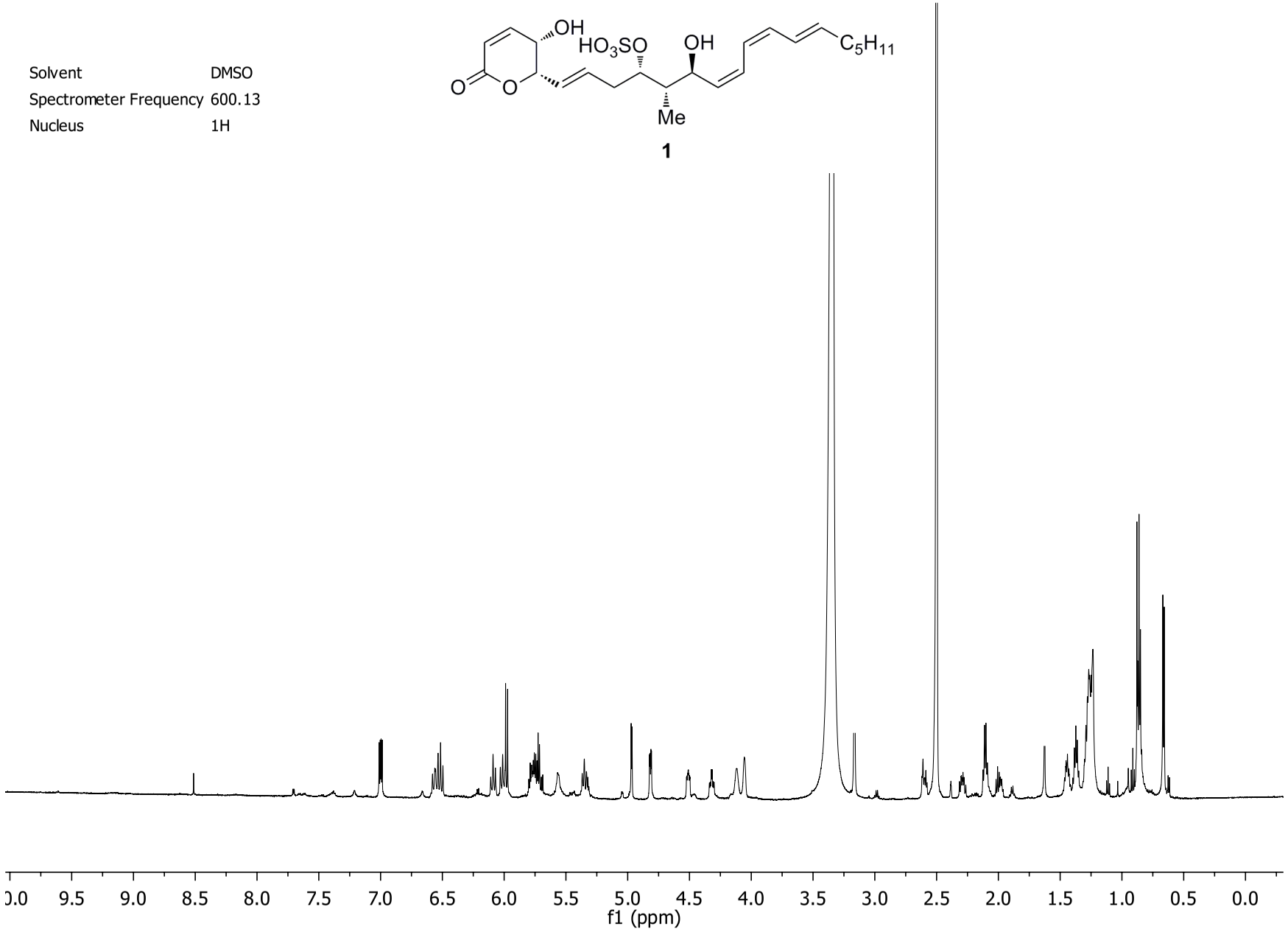
w/v in 1.4 N H_2SO_4). Orthophosphate (as phosphomolybdic acid) was extracted by adding 400 µL of isobutanol:methyl soyate (1:1, v/v) to each tube, vortexing for at least 5 sec (vortex set at maximum speed), then separating phases by centrifugation at 14,000 × G for 2 min. Aliquots of the organic phase (200 µL; 50% of extracted ^{32}P) were collected for scintillation counting.

Solvent	CD3OD
Spectrometer Frequency	600.13
Nucleus	1H

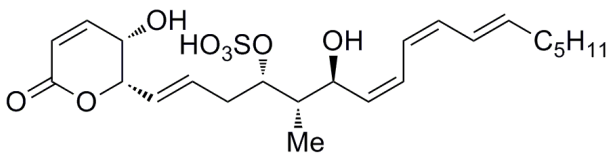


1



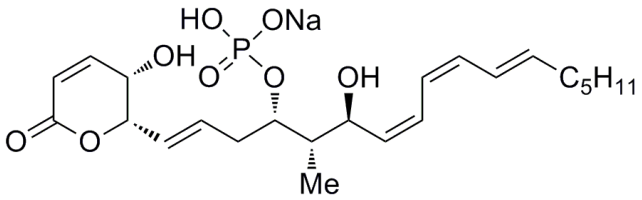

Solvent DMSO
Spectrometer Frequency 600.13
Nucleus 1H
OH
HO3SO
OH
C5H11
O
O
Me
1
0.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

Solvent	DMSO
Spectrometer Frequency	150.90
Nucleus	13C

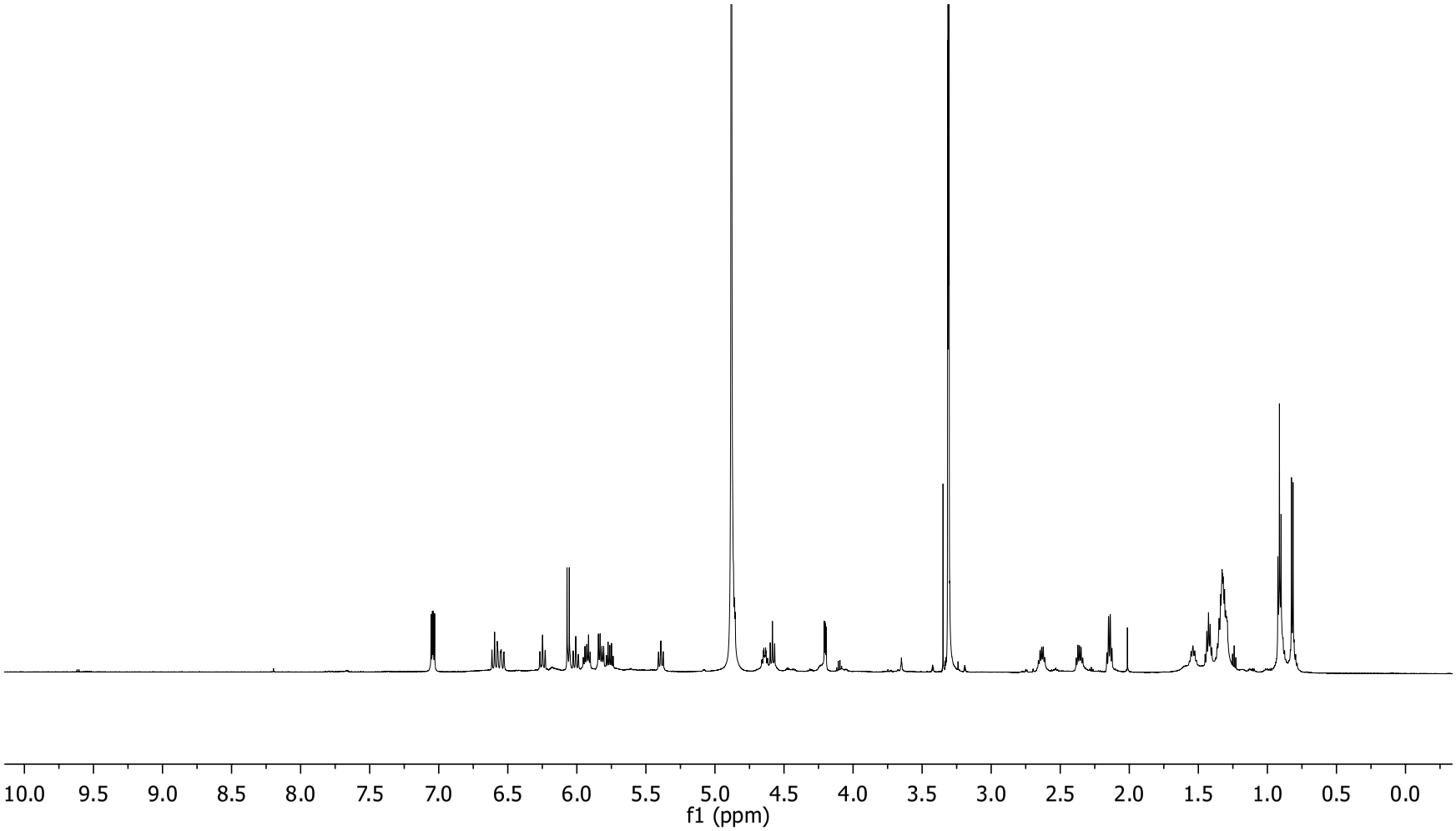


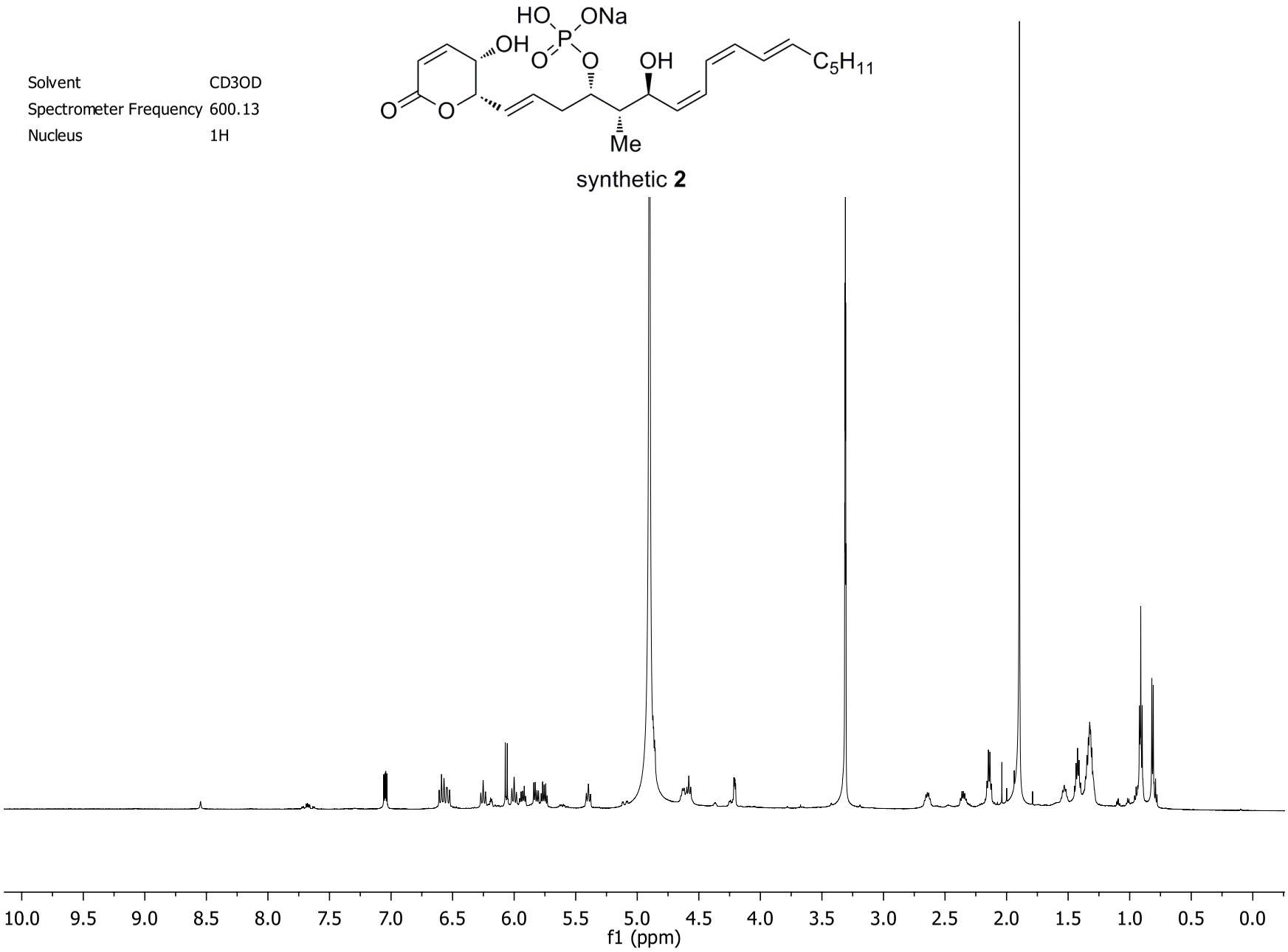
1

Solvent	CD3OD
Spectrometer Frequency	600.13
Nucleus	1H

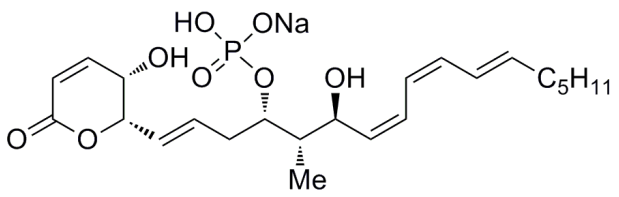


natural **2**



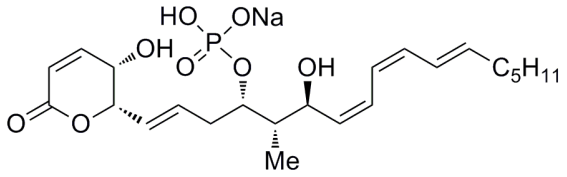

Solvent CD3OD
Spectrometer Frequency 600.13
Nucleus 1H
HO
ONa
OH
P
O
O
OH
C_5H_{11}
O
O
Me
synthetic **2**
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

Solvent	CD3OD
Spectrometer Frequency	150.90
Nucleus	13C

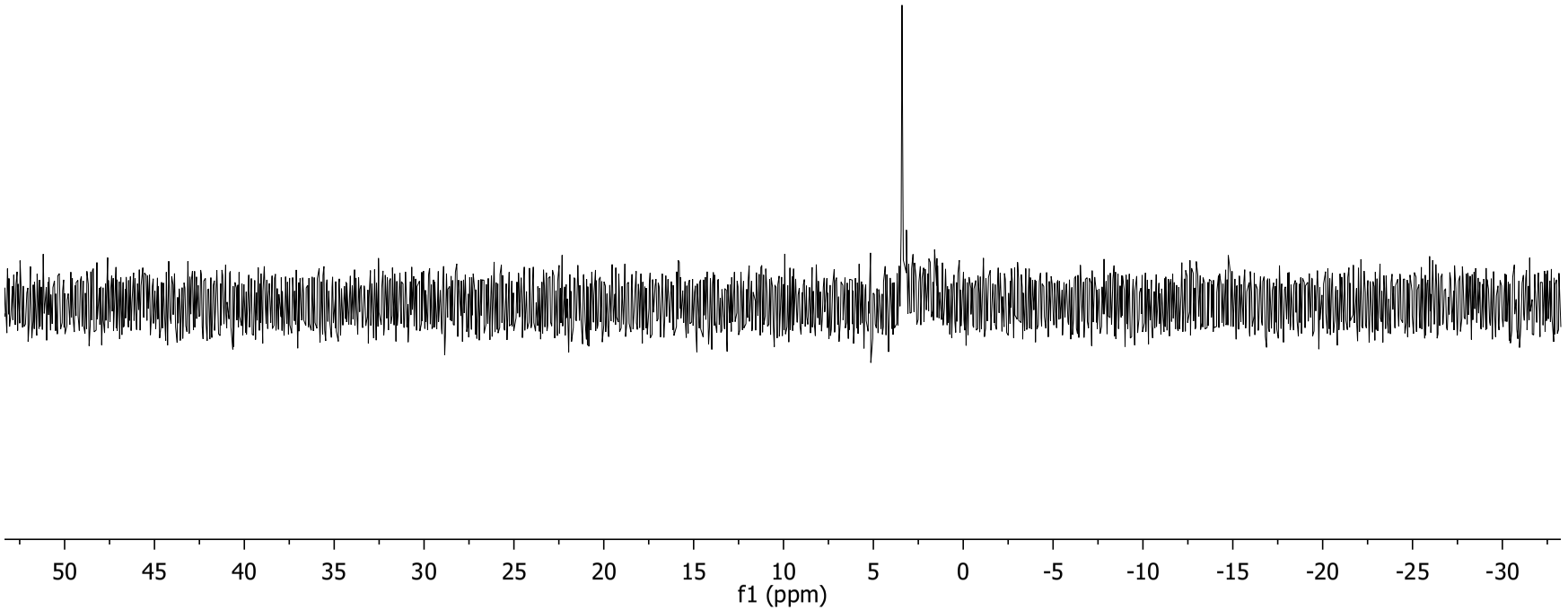


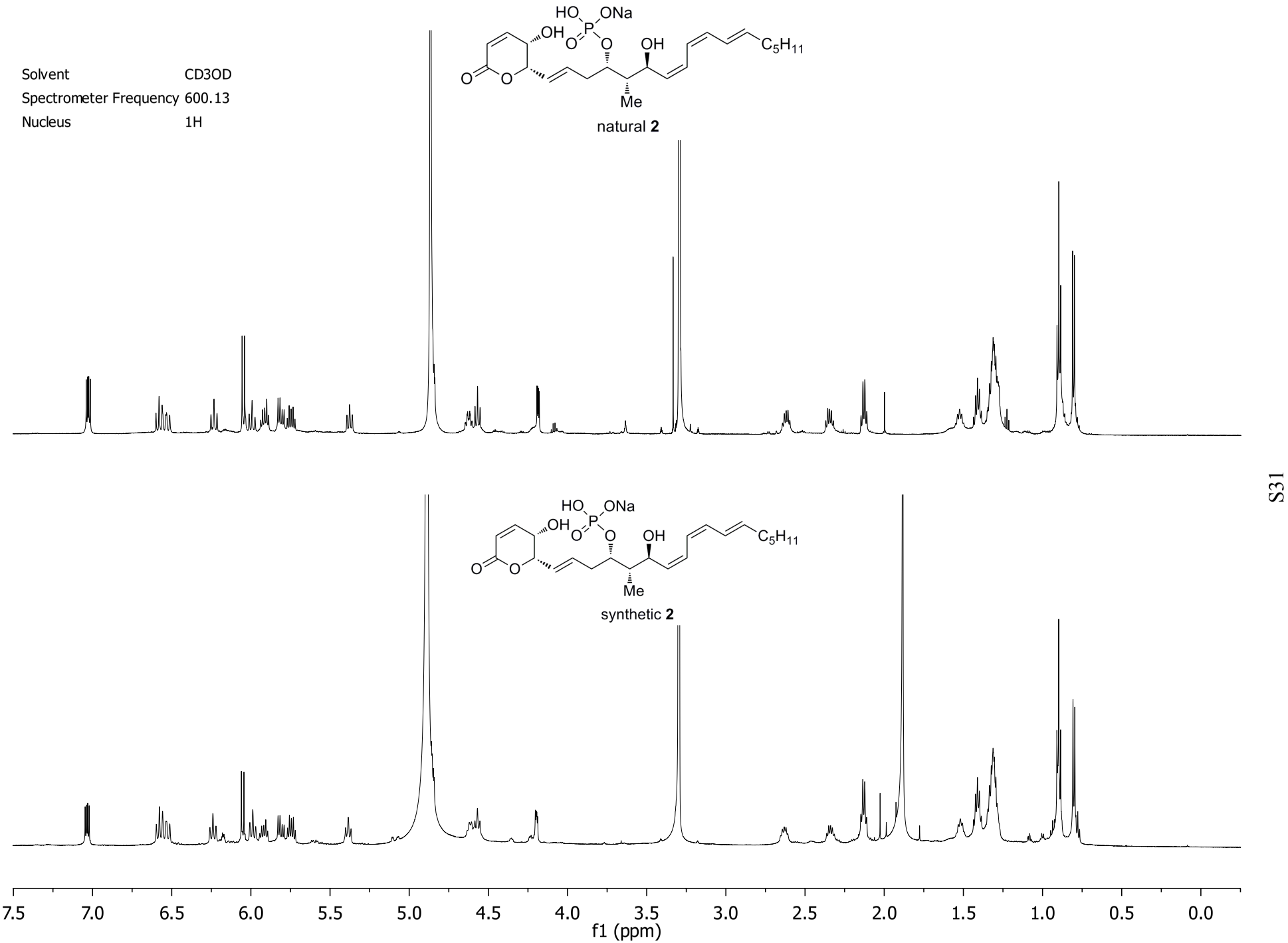
2

Solvent	CD3OD
Spectrometer Frequency	161.97
Nucleus	31P

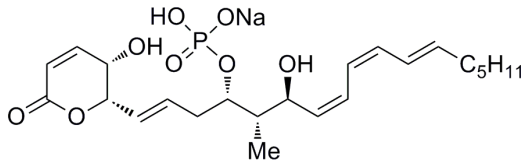


2

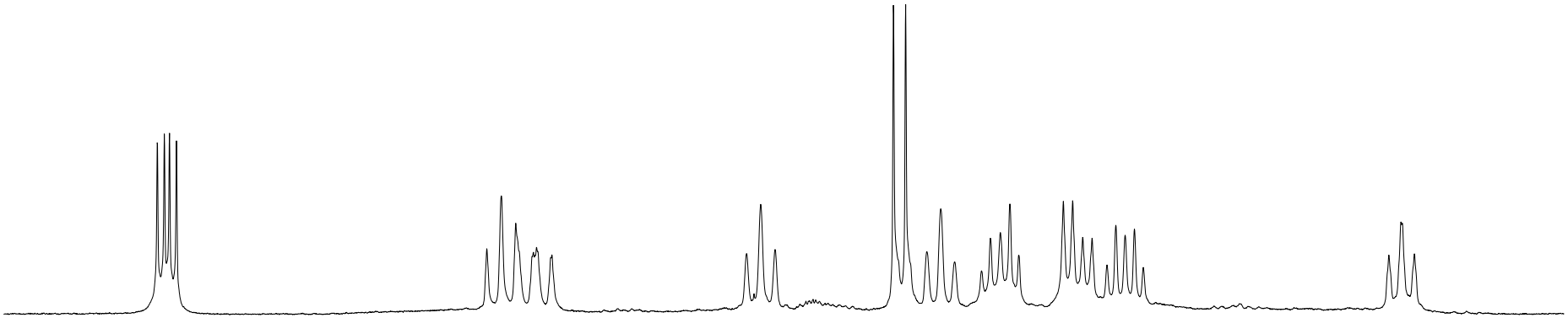


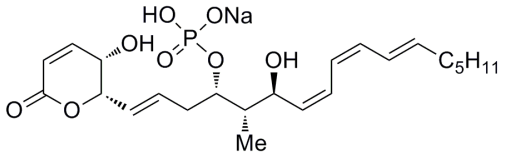

Solvent CD3OD
Spectrometer Frequency 600.13
Nucleus 1H
natural 2
synthetic 2
f1 (ppm)

Solvent	CD3OD
Spectrometer Frequency	600.13
Nucleus	1H

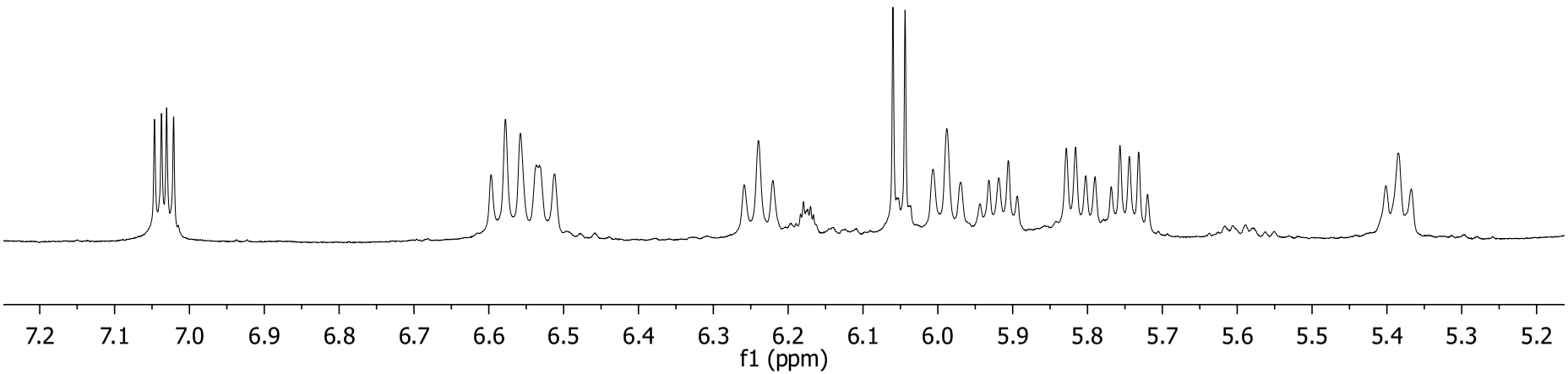


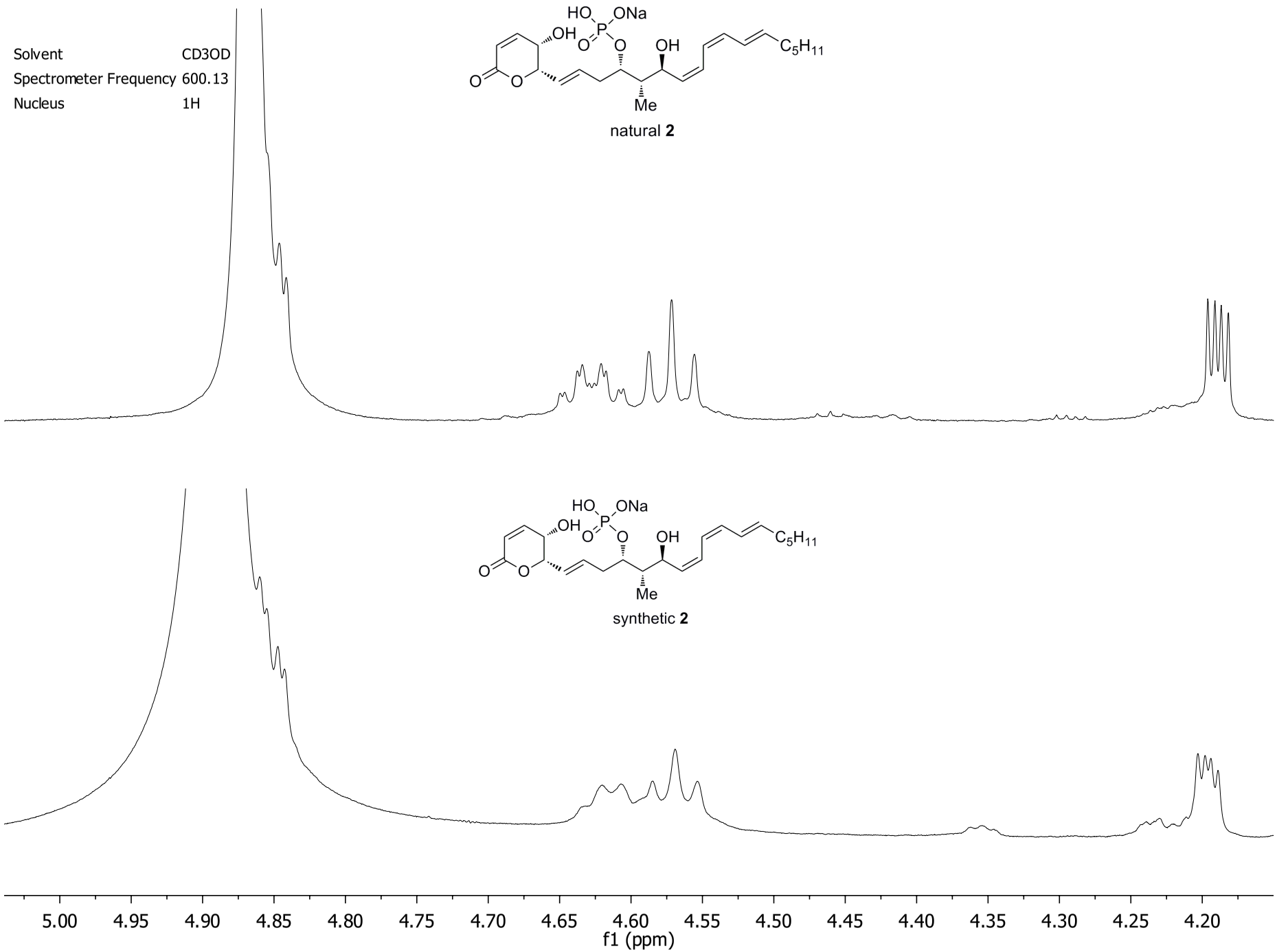
natural **2**



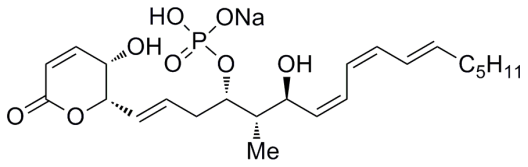


synthetic **2**

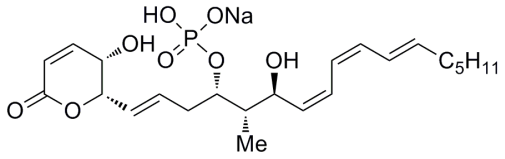



Solvent CD3OD
Spectrometer Frequency 600.13
Nucleus 1H
HO
ONa
OH
P
O
O
OH
C_5H_{11}
O
O
Me
natural 2
HO
ONa
OH
P
O
O
OH
C_5H_{11}
O
O
Me
synthetic 2
5.00
4.95
4.90
4.85
4.80
4.75
4.70
4.65
4.60
4.55
4.50
4.45
4.40
4.35
4.30
4.25
4.20
f1 (ppm)

Solvent CD3OD
Spectrometer Frequency 600.13
Nucleus 1H



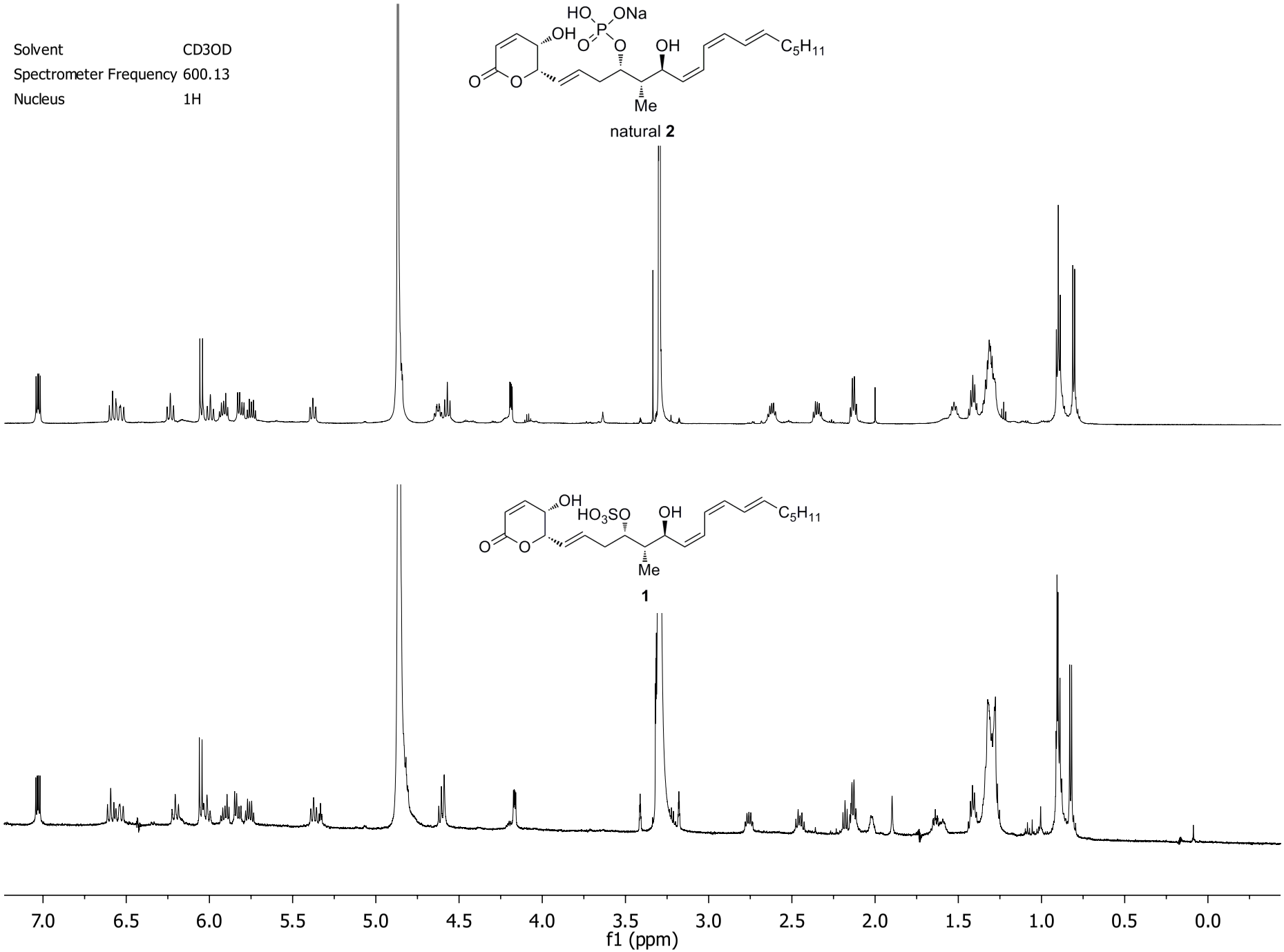
natural **2**

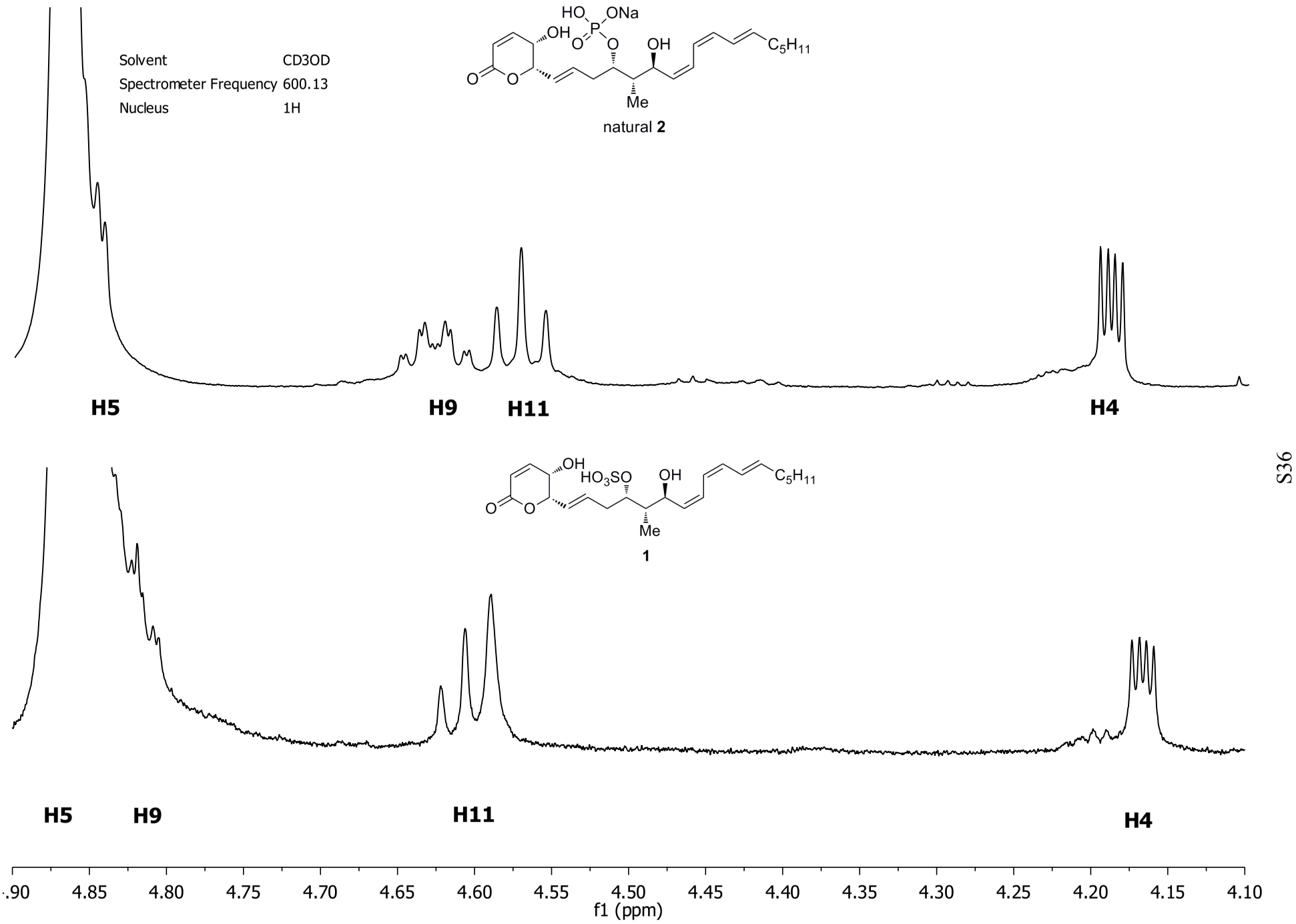


synthetic **2**

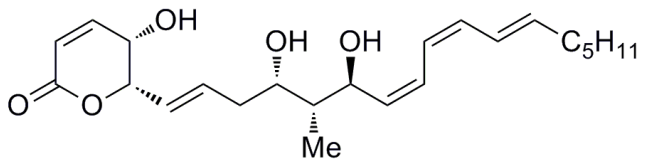
2.8 2.7 2.6 2.5 2.4 2.3 2.2 2.1 2.0 1.9 1.8 1.7 1.6 1.5 1.4 1.3 1.2 1.1 1.0 0.9 0.8 0.7 0.6

f1 (ppm)

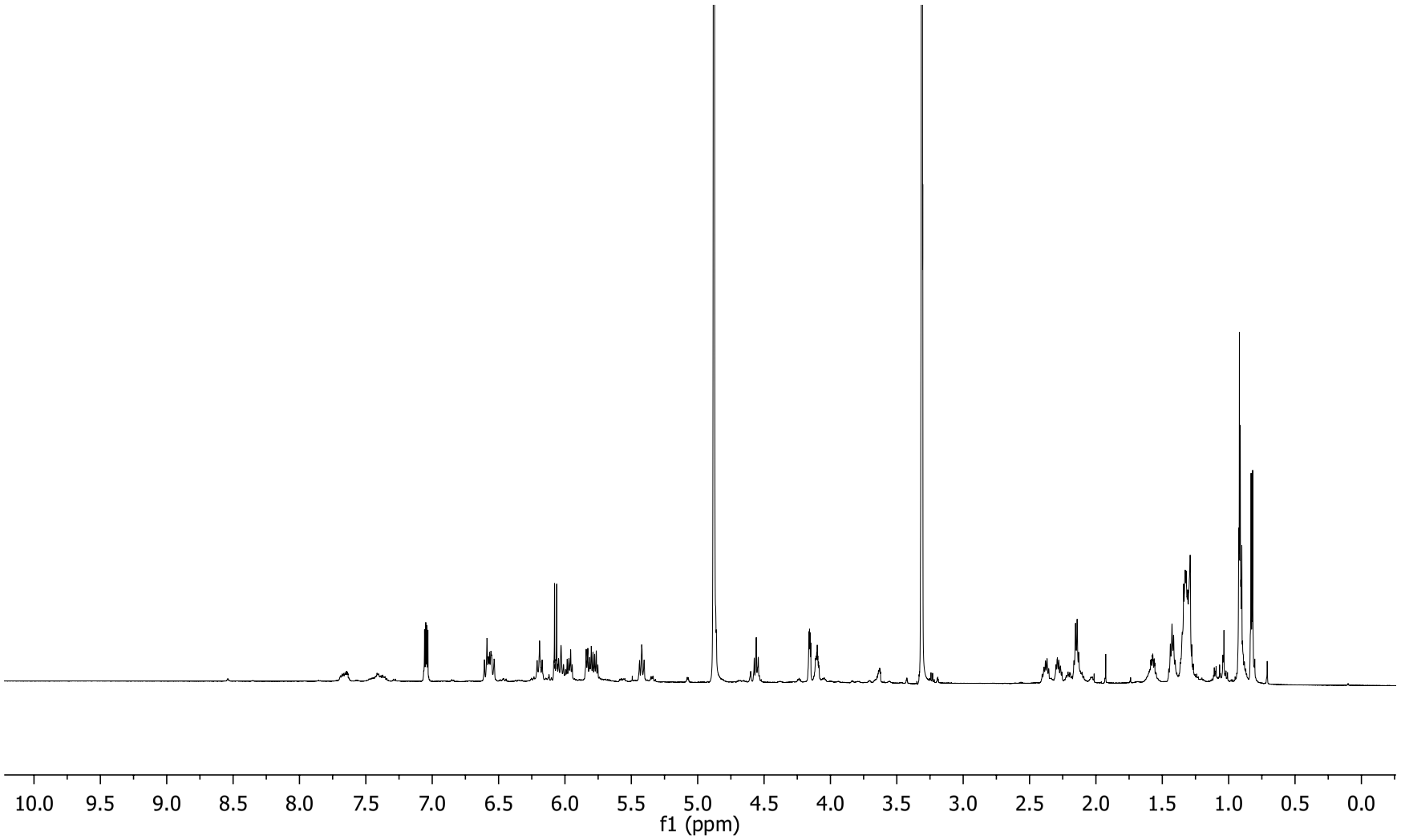

Solvent CD3OD
Spectrometer Frequency 600.13
Nucleus 1H
natural 2
1
f1 (ppm)
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0


Solvent CD3OD
Spectrometer Frequency 600.13
Nucleus 1H
natural 2
H5
H9
H11
H4
1
H5
H9
H11
H4
f1 (ppm)

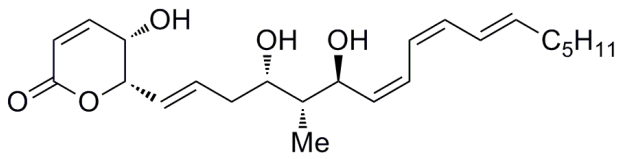
Solvent	CD3OD
Spectrometer Frequency	600.13
Nucleus	1H



35

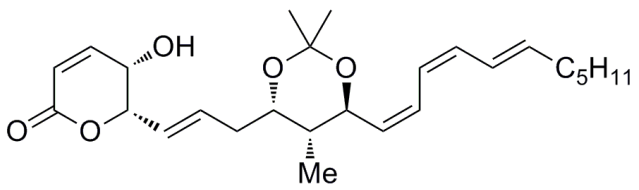


Solvent	CD3OD
Spectrometer Frequency	150.90
Nucleus	13C



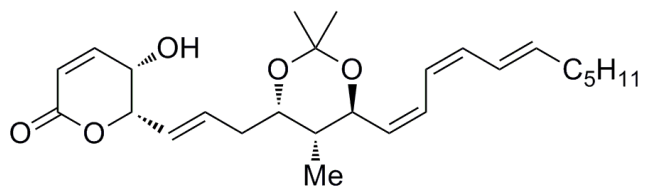
35

Solvent	CD3CN
Spectrometer Frequency	600.13
Nucleus	1H



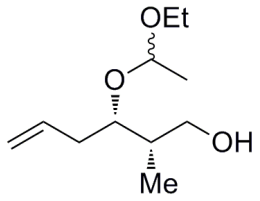
36

Solvent	CD3CN
Spectrometer Frequency	150.90
Nucleus	13C



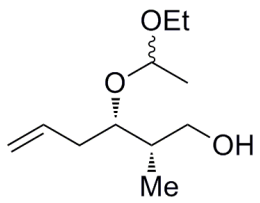
36

Solvent	C6D6
Spectrometer Frequency	500.13
Nucleus	1H

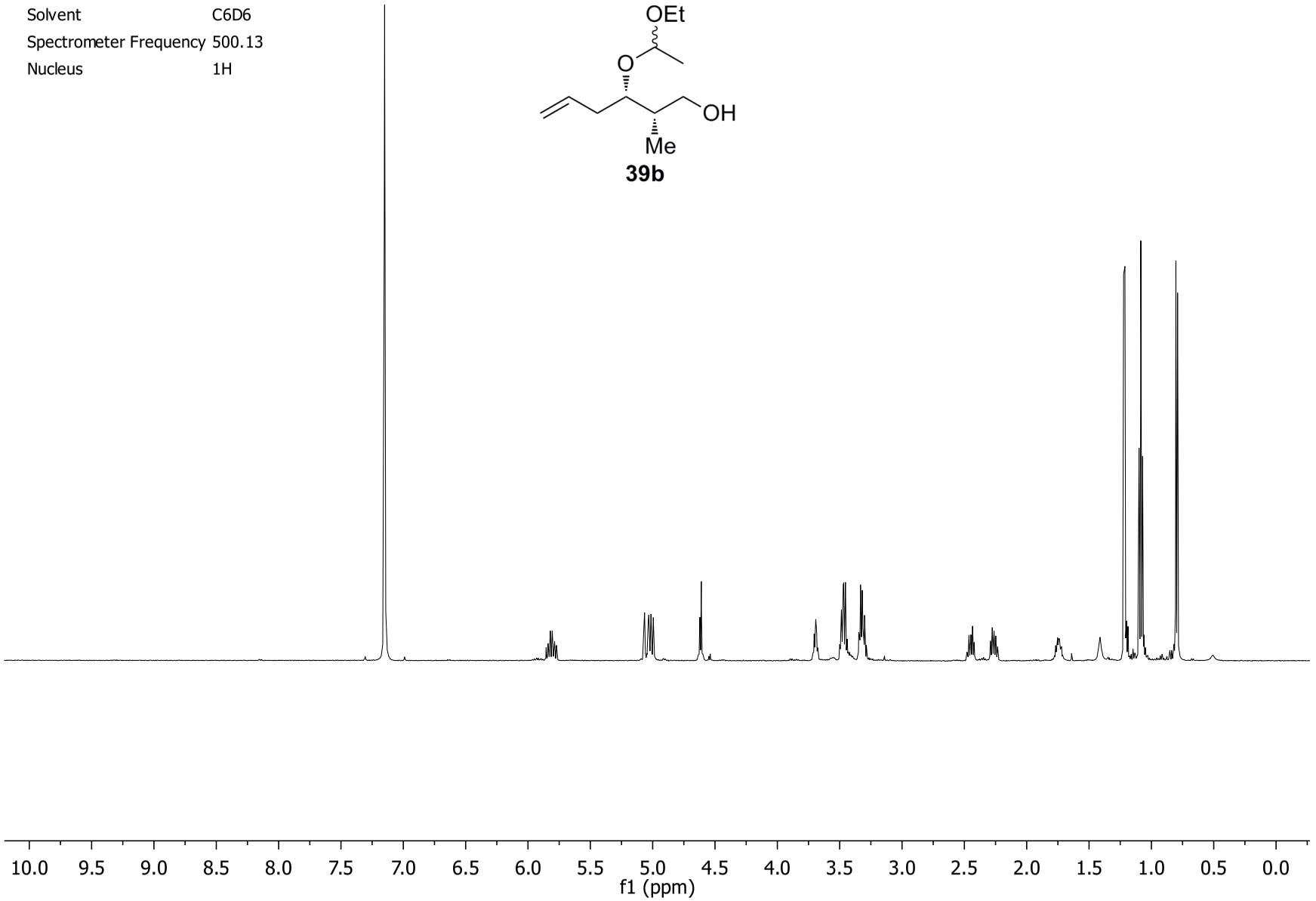


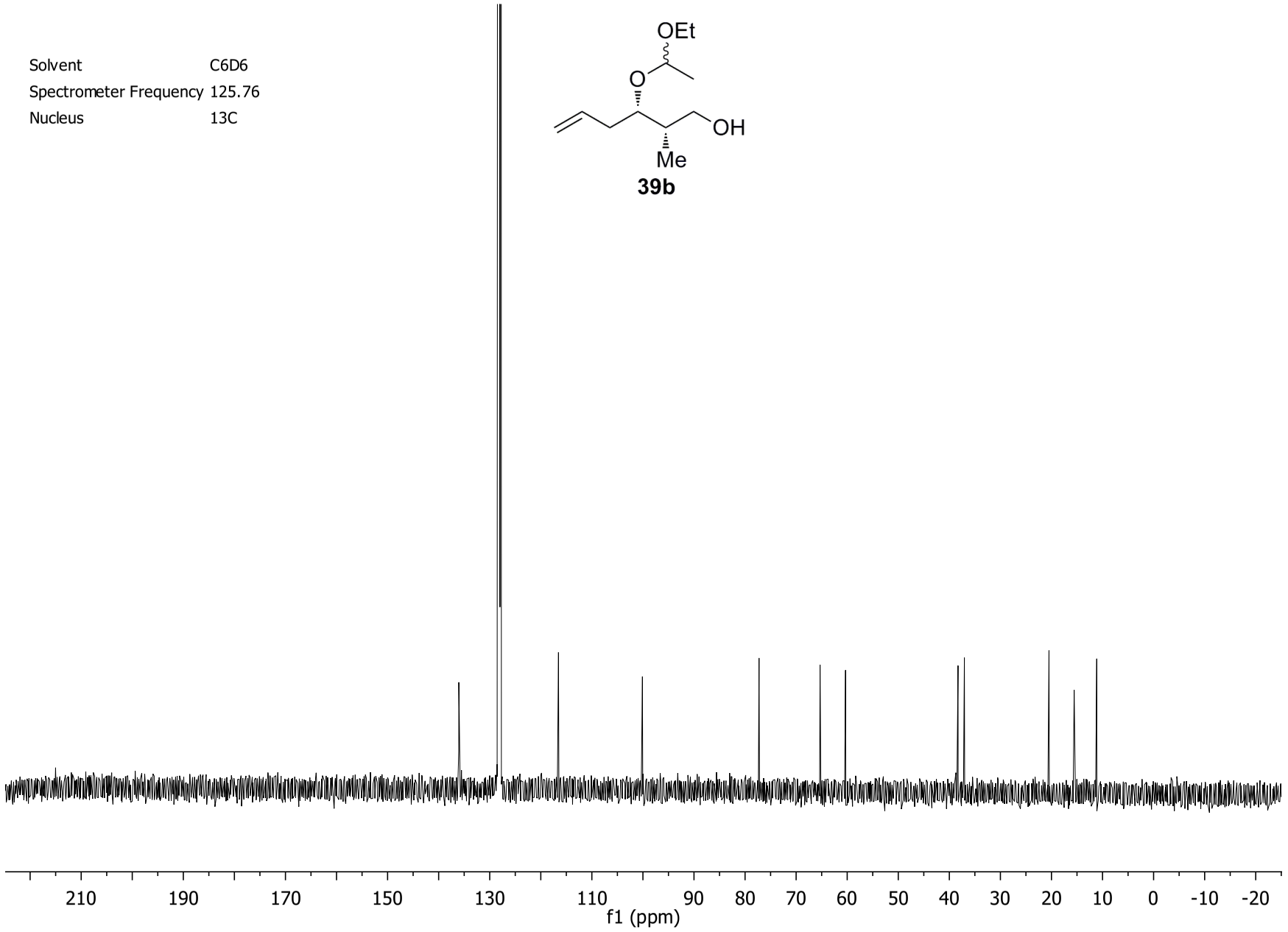
39a

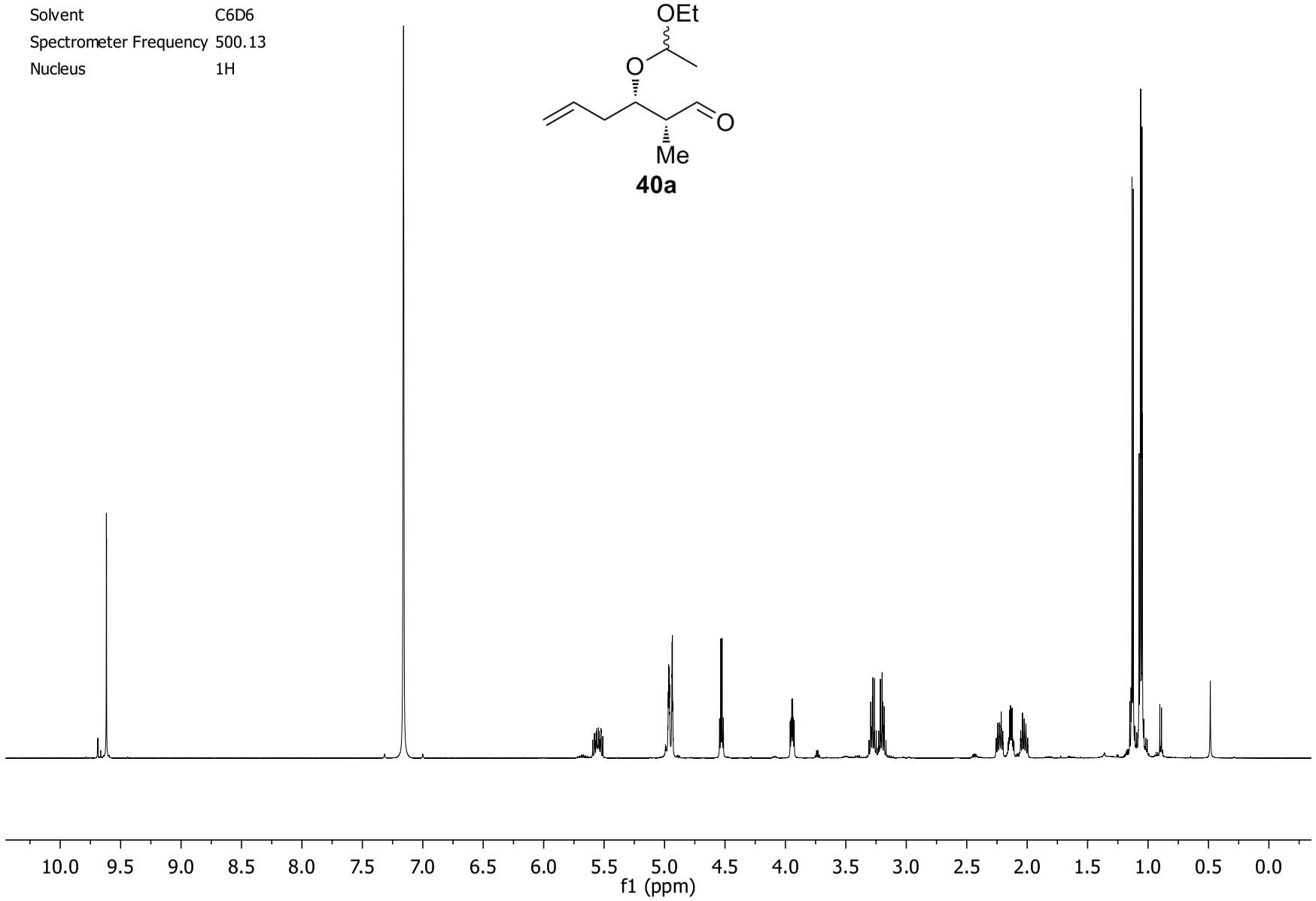
Solvent	C6D6
Spectrometer Frequency	125.77
Nucleus	13C

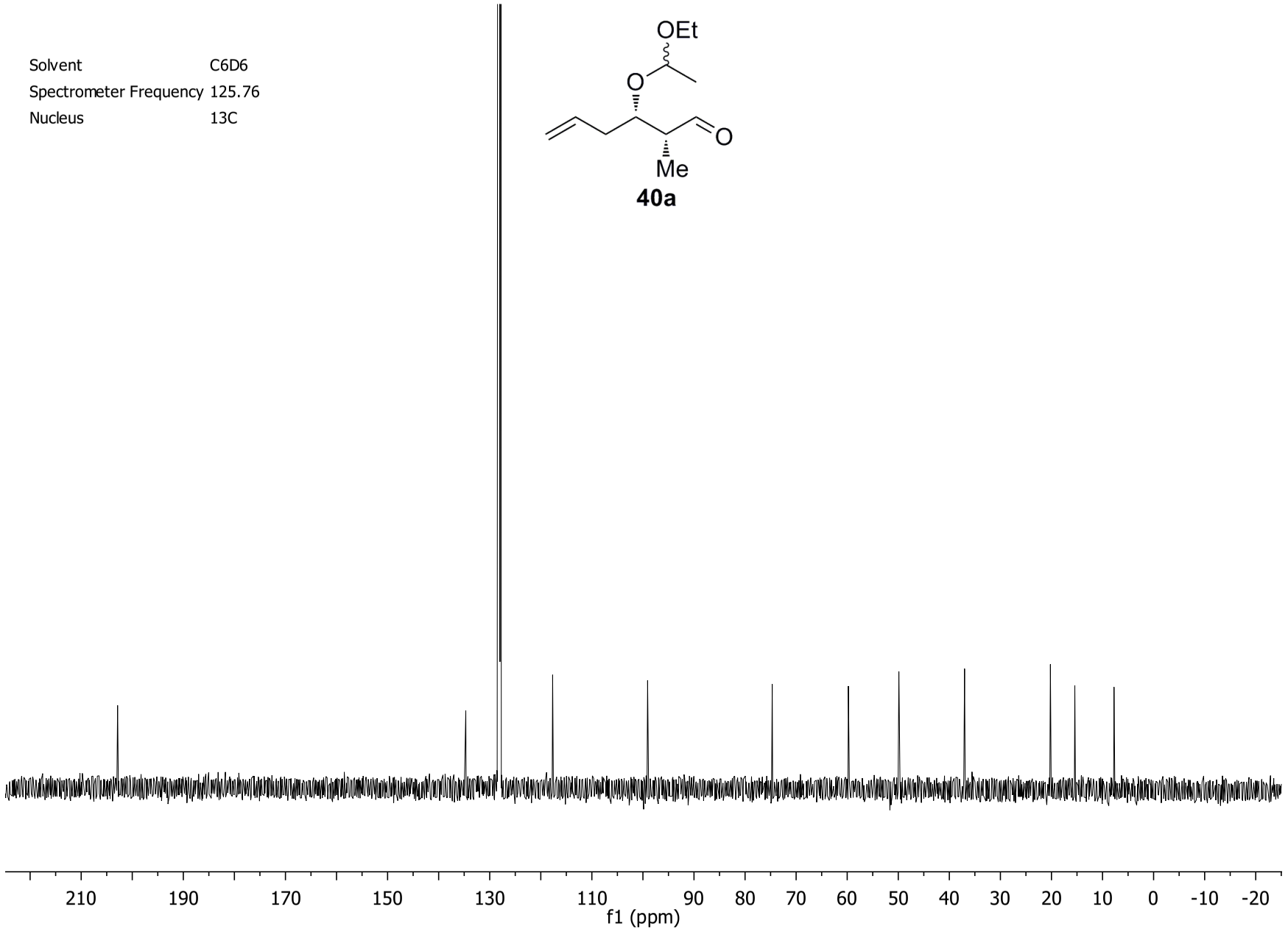


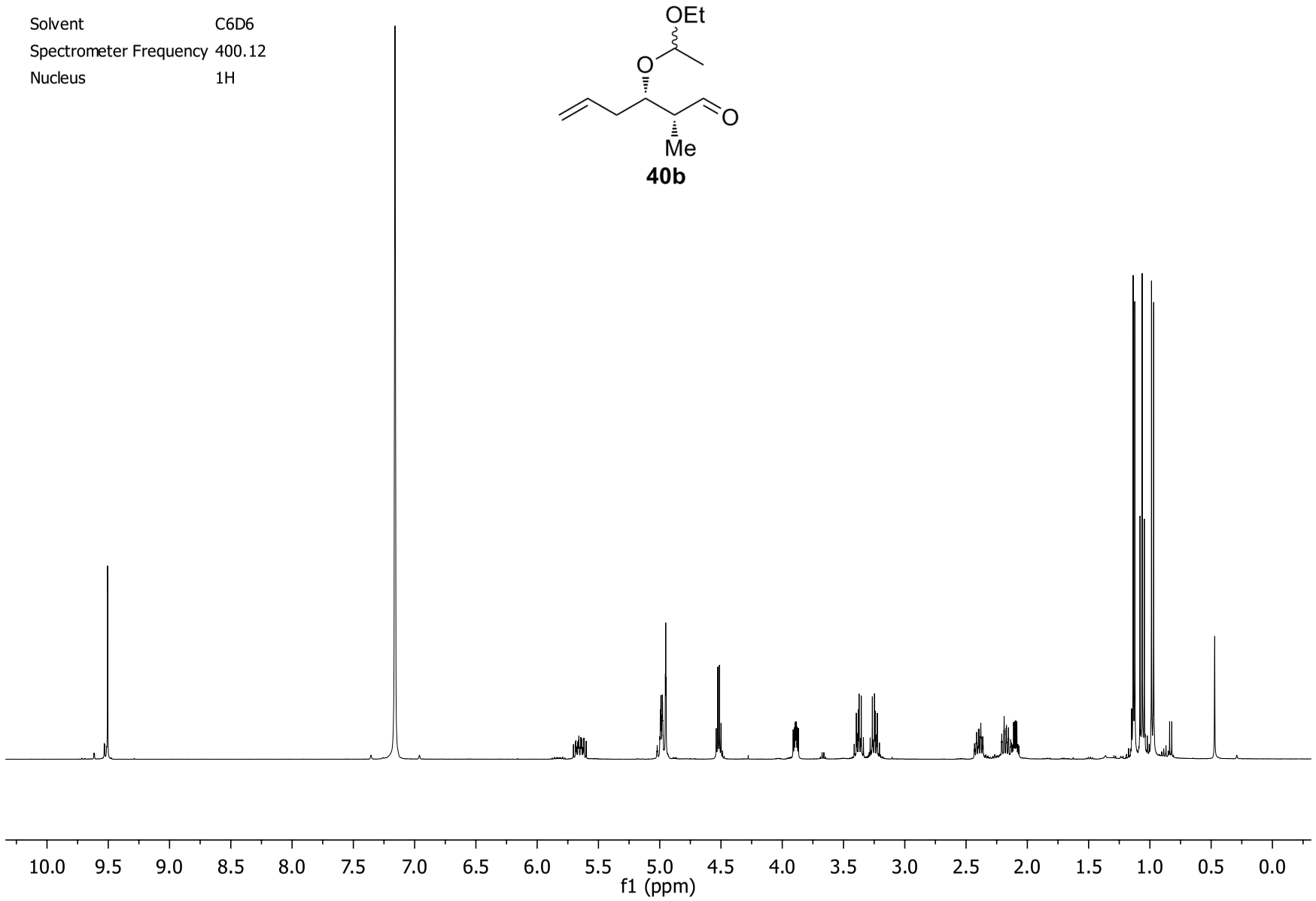
39a


Solvent C6D6
Spectrometer Frequency 500.13
Nucleus 1H
OEt
O
OH
Me
39b
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

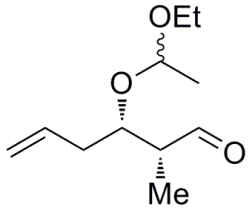

Solvent C6D6
Spectrometer Frequency 125.76
Nucleus 13C
OEt
O
OH
Me
39b
210
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0
-10
-20
f1 (ppm)


Solvent C6D6
Spectrometer Frequency 500.13
Nucleus 1H
OEt
O
O
Me
40a
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)


Solvent C6D6
Spectrometer Frequency 125.76
Nucleus 13C
OEt
O
O
Me
40a
210
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0
-10
-20
f1 (ppm)

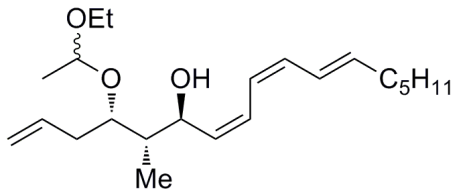

Solvent C6D6
Spectrometer Frequency 400.12
Nucleus 1H
OEt
O
O
Me
40b
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

Solvent C6D6
Spectrometer Frequency 100.61
Nucleus 13C



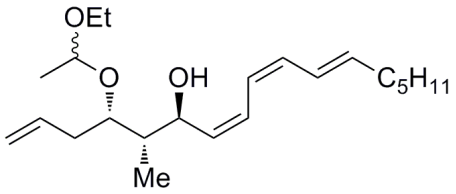
40b

Solvent C6D6
Spectrometer Frequency 500.13
Nucleus 1H

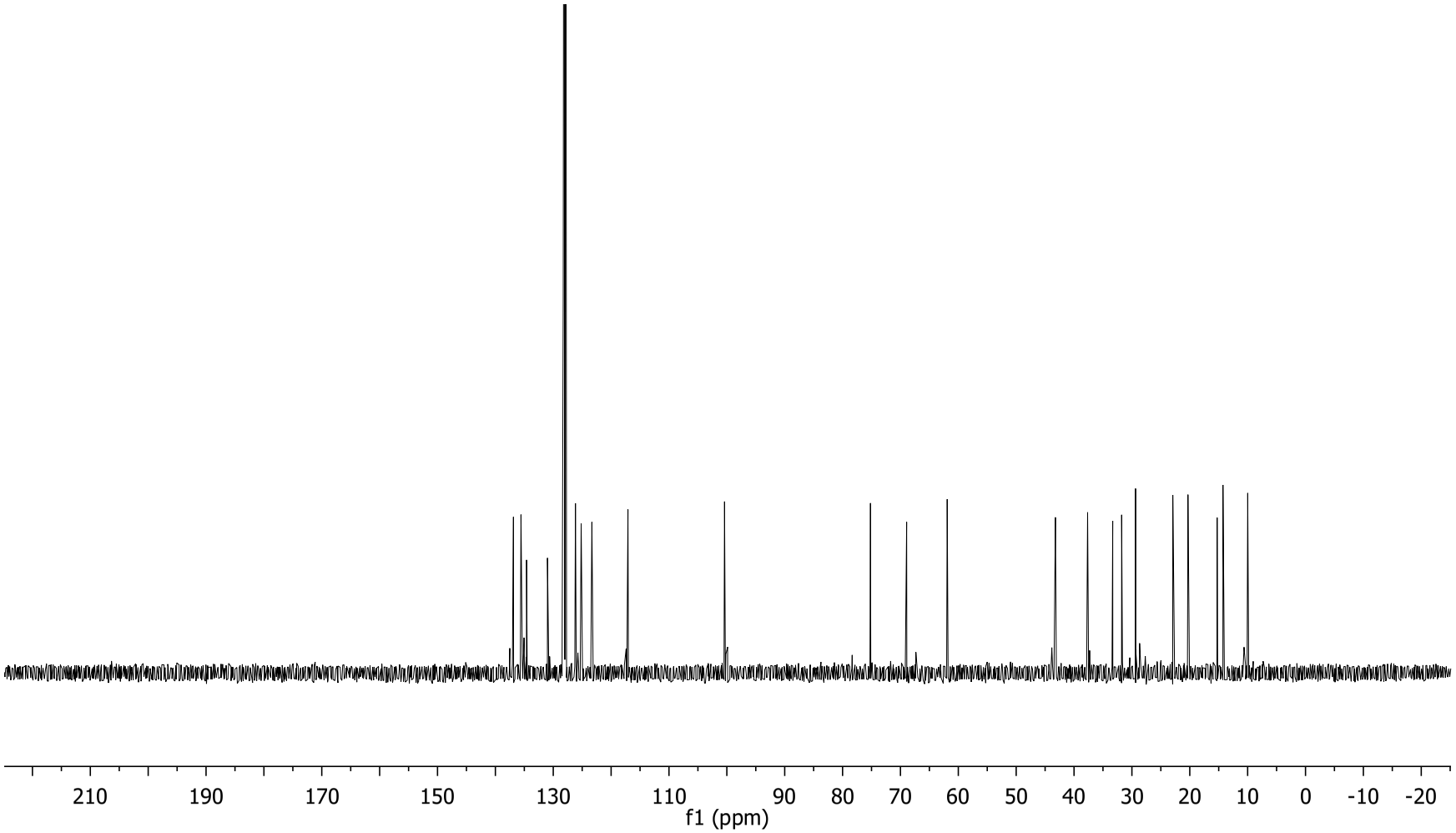


41

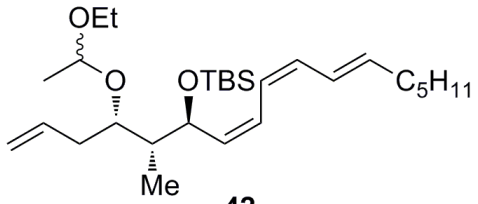
Solvent	C6D6
Spectrometer Frequency	125.77
Nucleus	13C



41

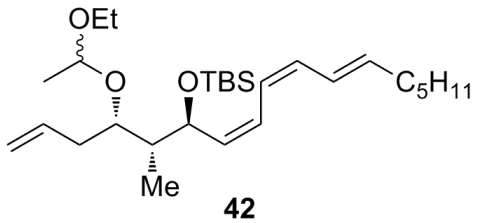


Solvent	C6D6
Spectrometer Frequency	500.13
Nucleus	1H

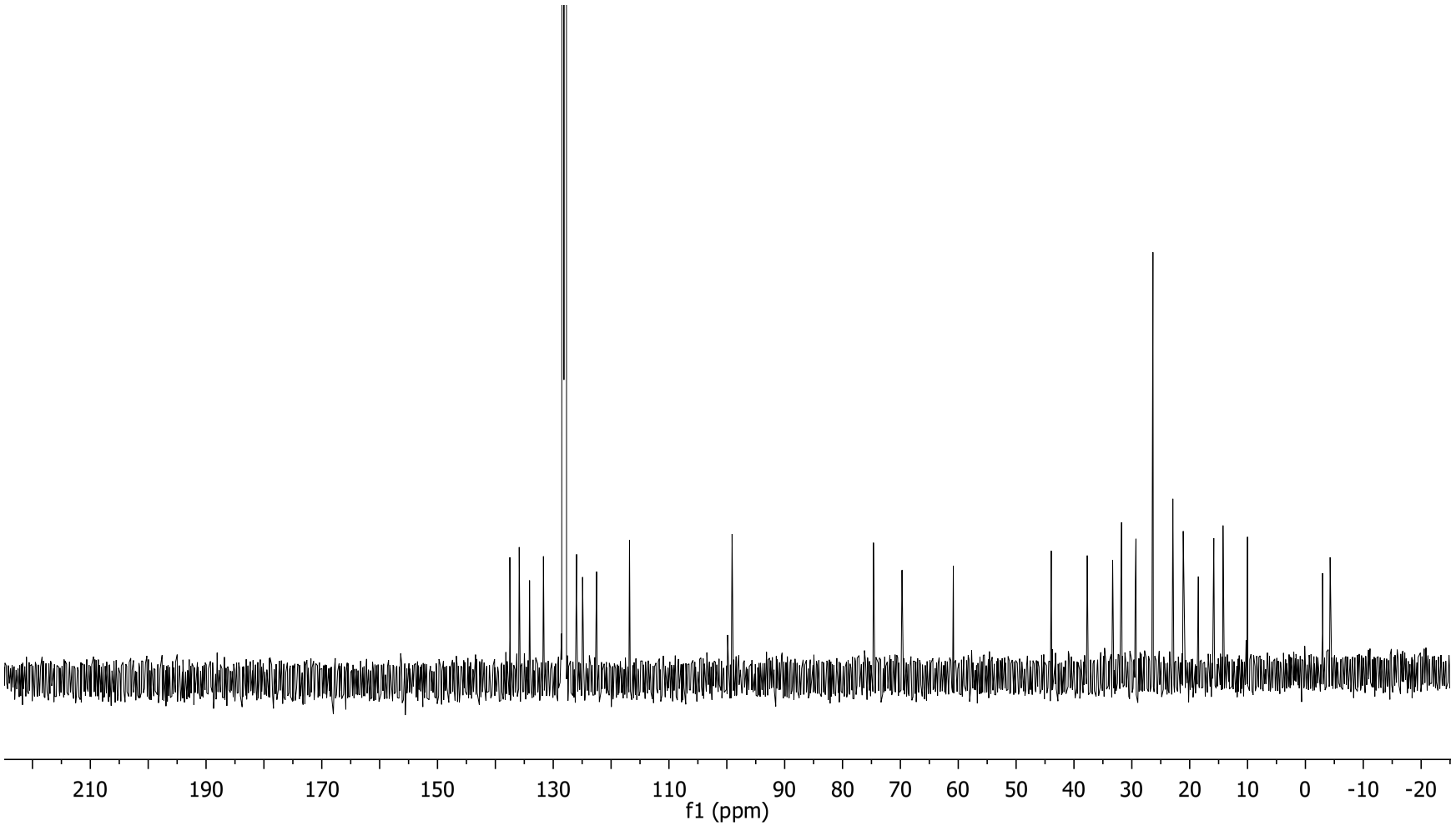


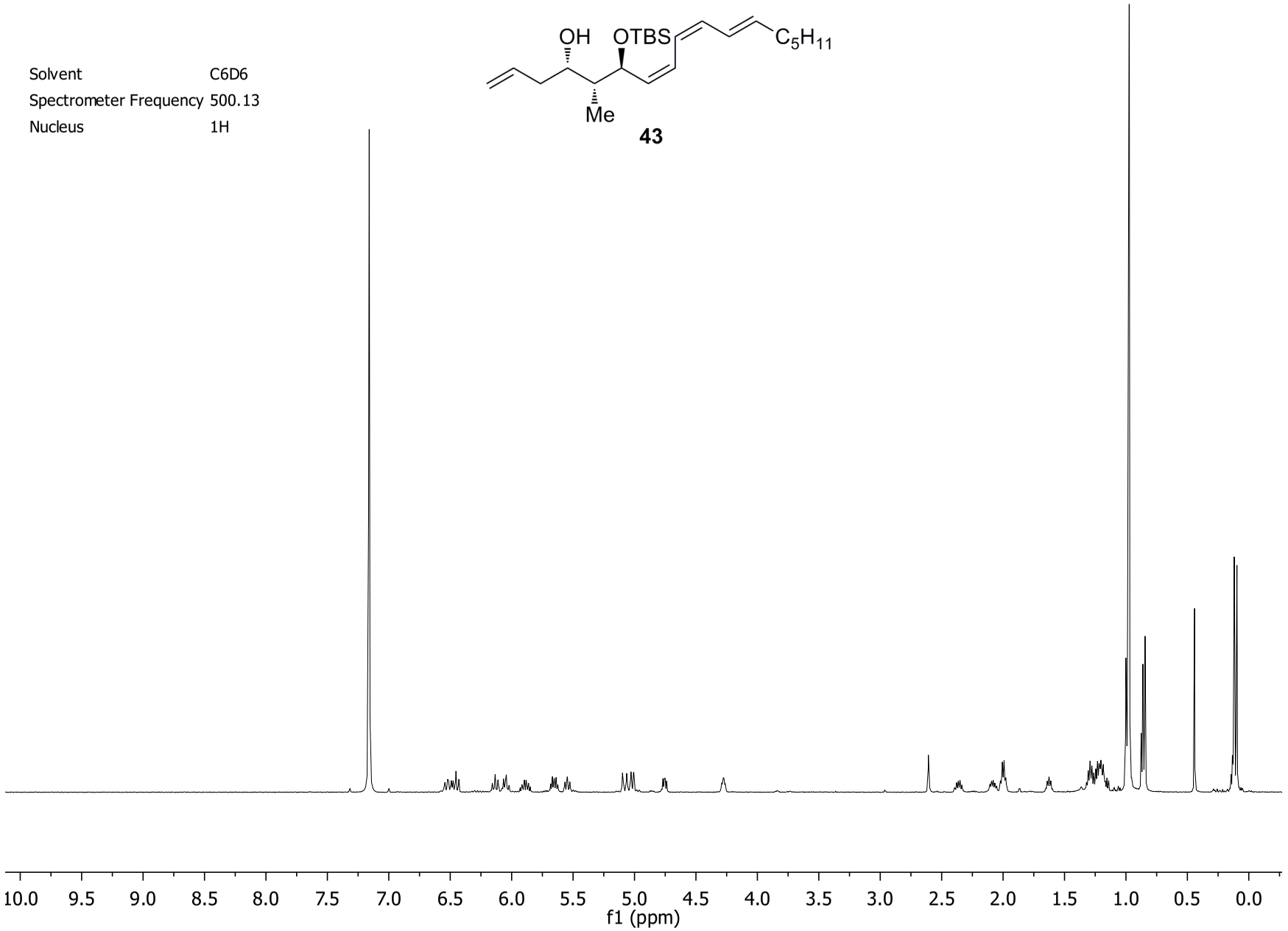
42

Solvent	C6D6
Spectrometer Frequency	125.76
Nucleus	13C

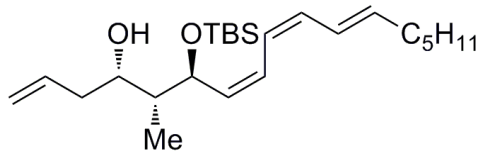


42

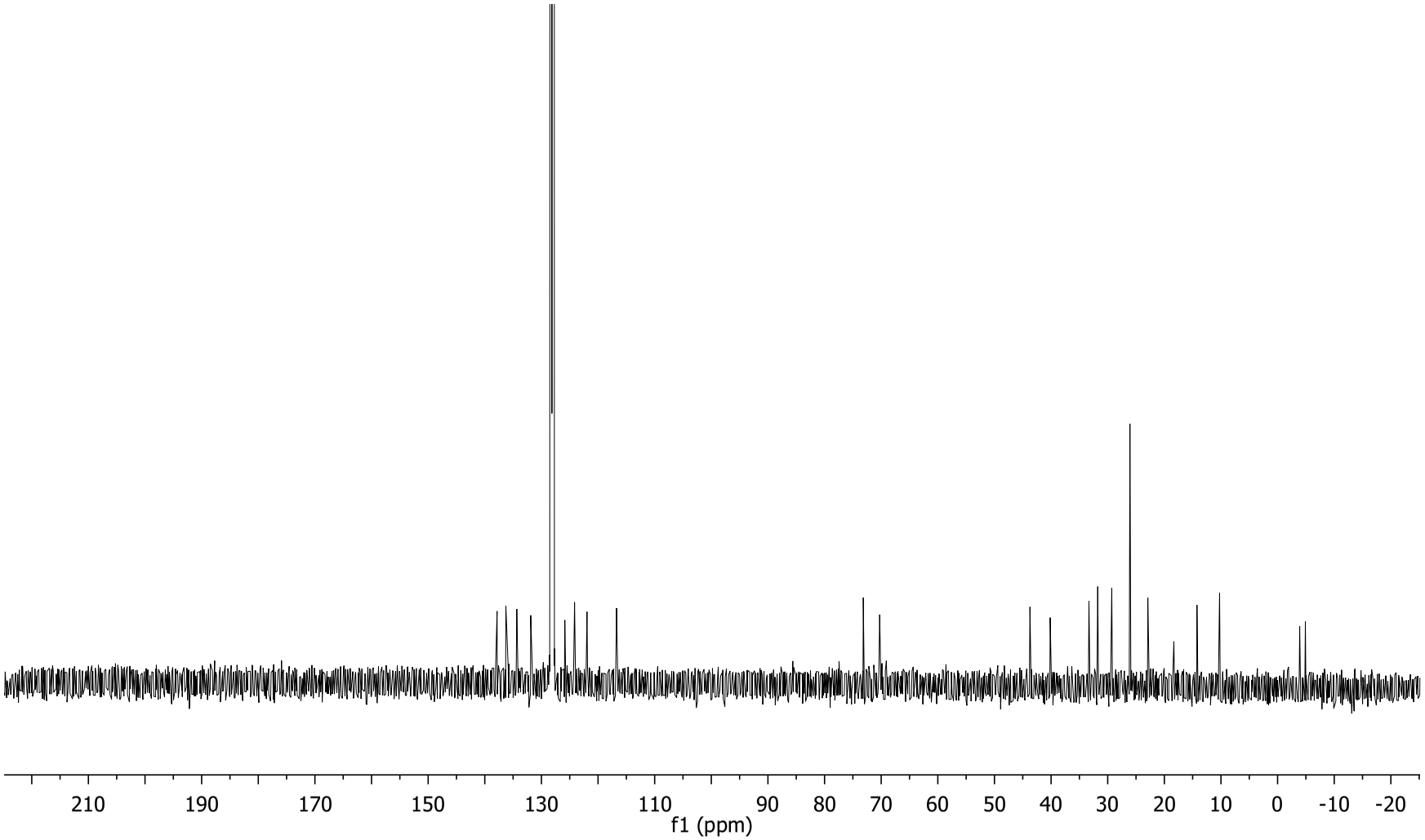



Solvent C6D6
Spectrometer Frequency 500.13
Nucleus 1H
OH
OTBS
C_5H_{11}
Me
43
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

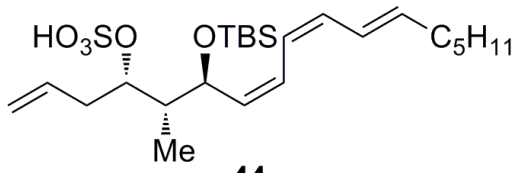
Solvent	C6D6
Spectrometer Frequency	125.76
Nucleus	13C



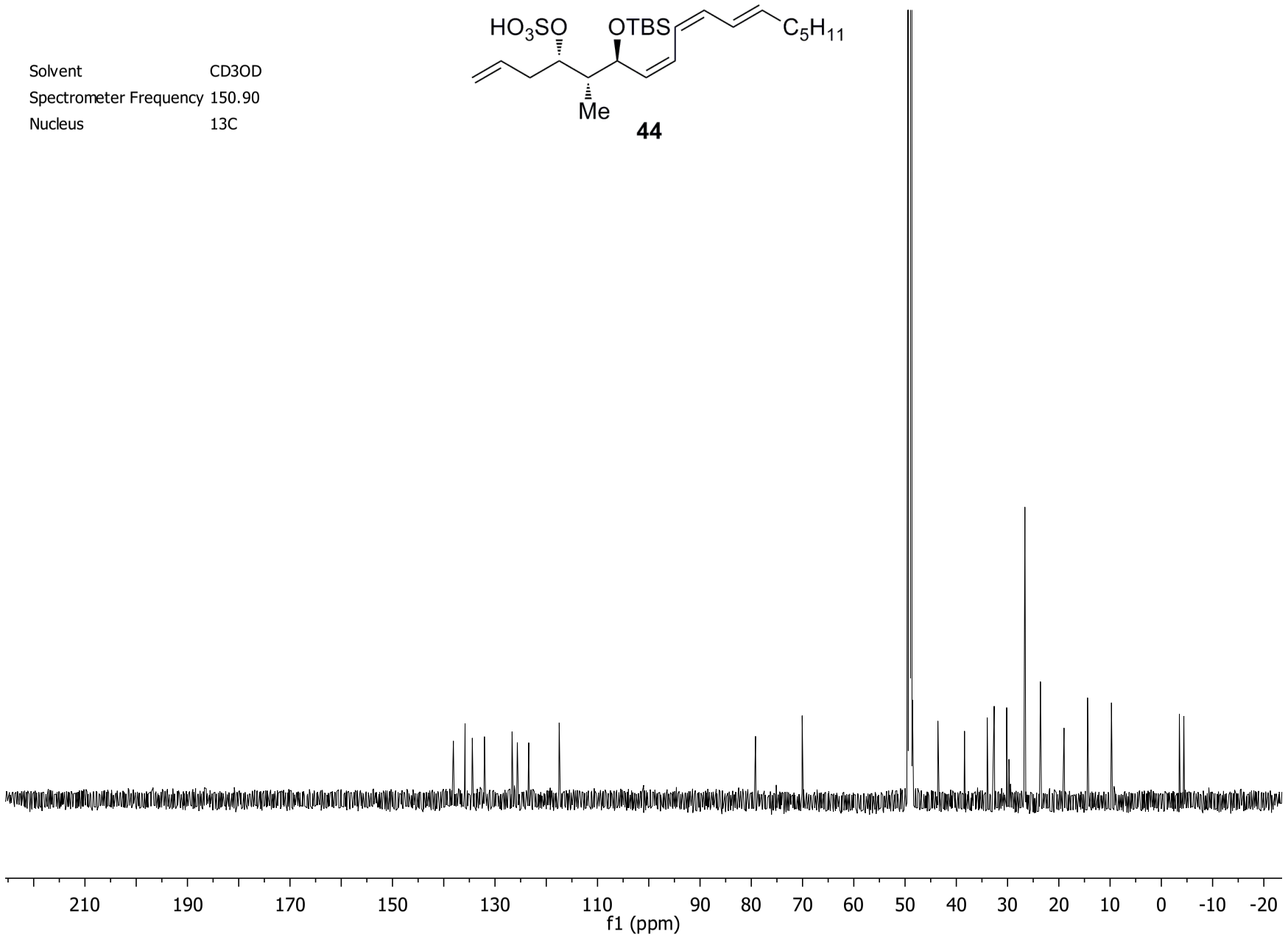
43



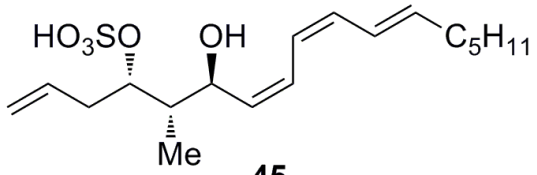
Solvent	CD3OD
Spectrometer Frequency	500.13
Nucleus	1H



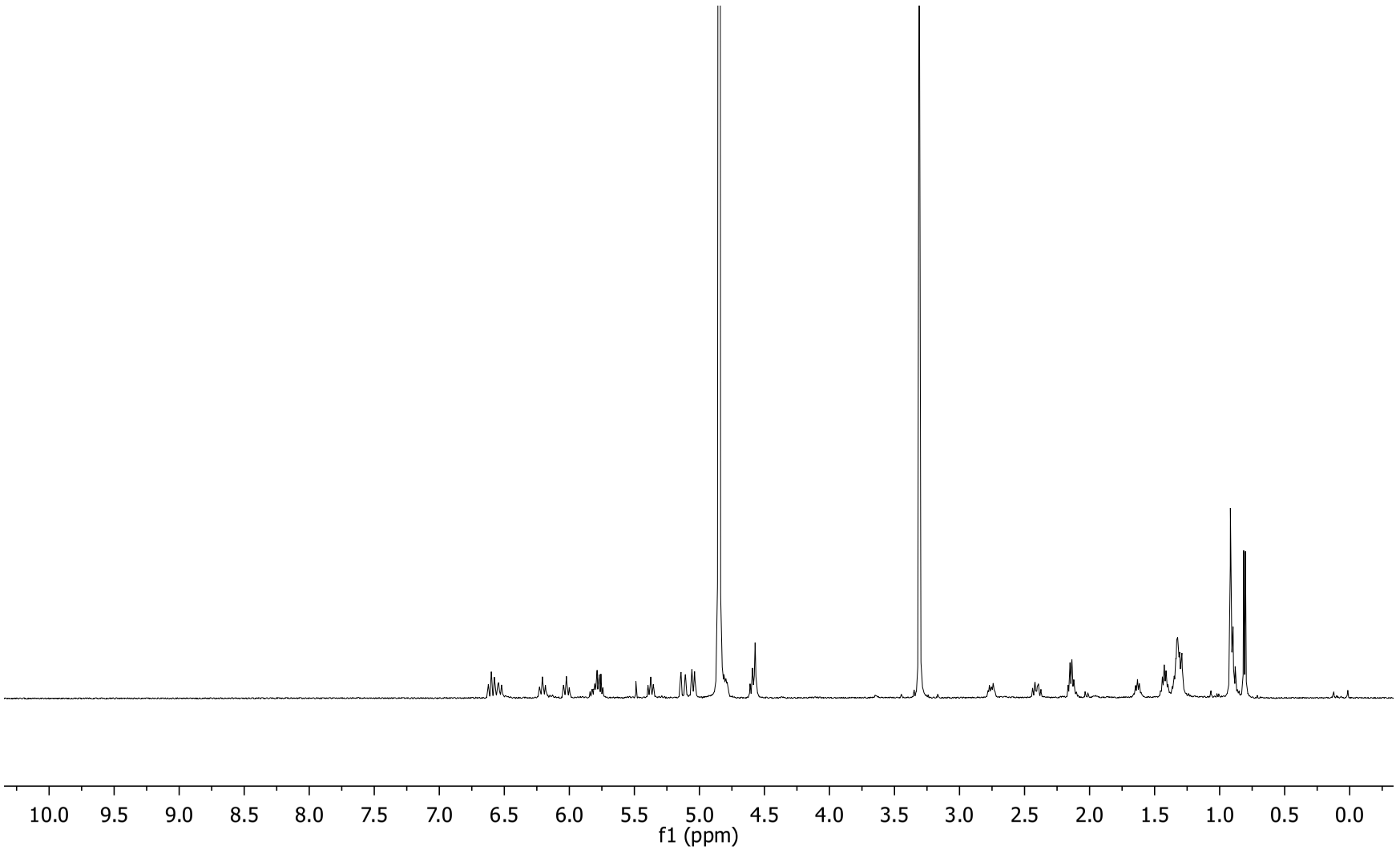
44


Solvent CD3OD
Spectrometer Frequency 150.90
Nucleus 13C
HO3SO
OTBS
C5H11
Me
44
210
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0
-10
-20
f1 (ppm)

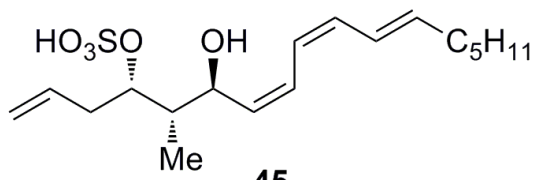
Solvent CD3OD
Spectrometer Frequency 500.13
Nucleus 1H



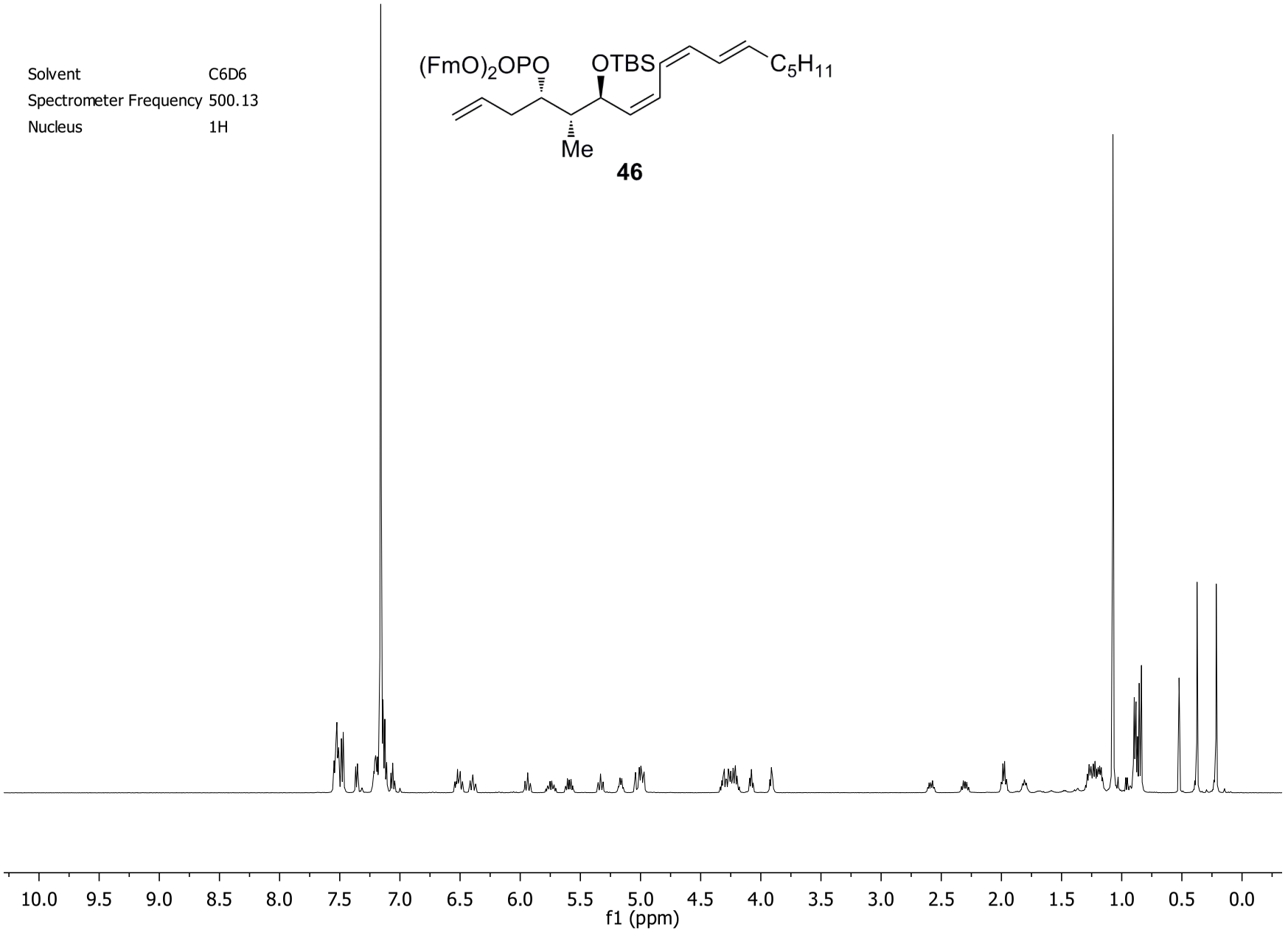
45



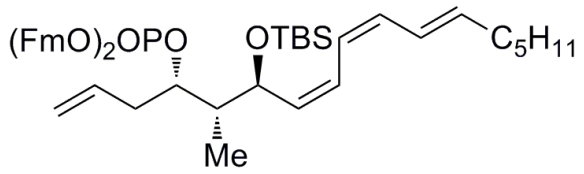
Solvent	CD3OD
Spectrometer Frequency	150.90
Nucleus	13C



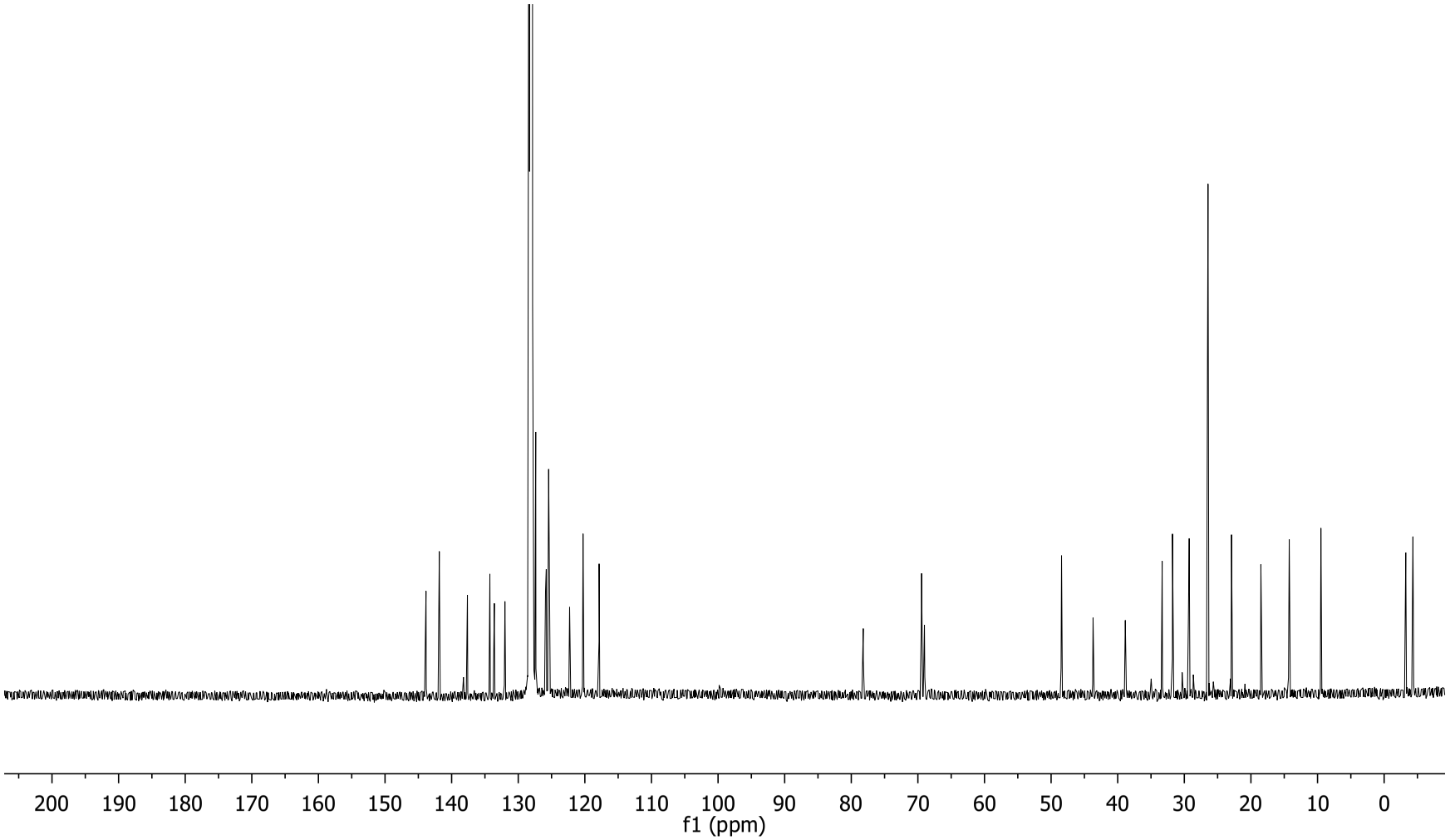
45


Solvent C6D6
Spectrometer Frequency 500.13
Nucleus 1H
(FmO)2OPO
OTBS
C5H11
Me
46
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

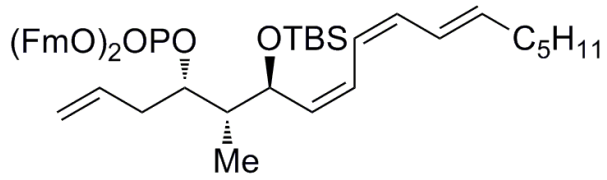
Solvent	C6D6
Spectrometer Frequency	150.90
Nucleus	13C



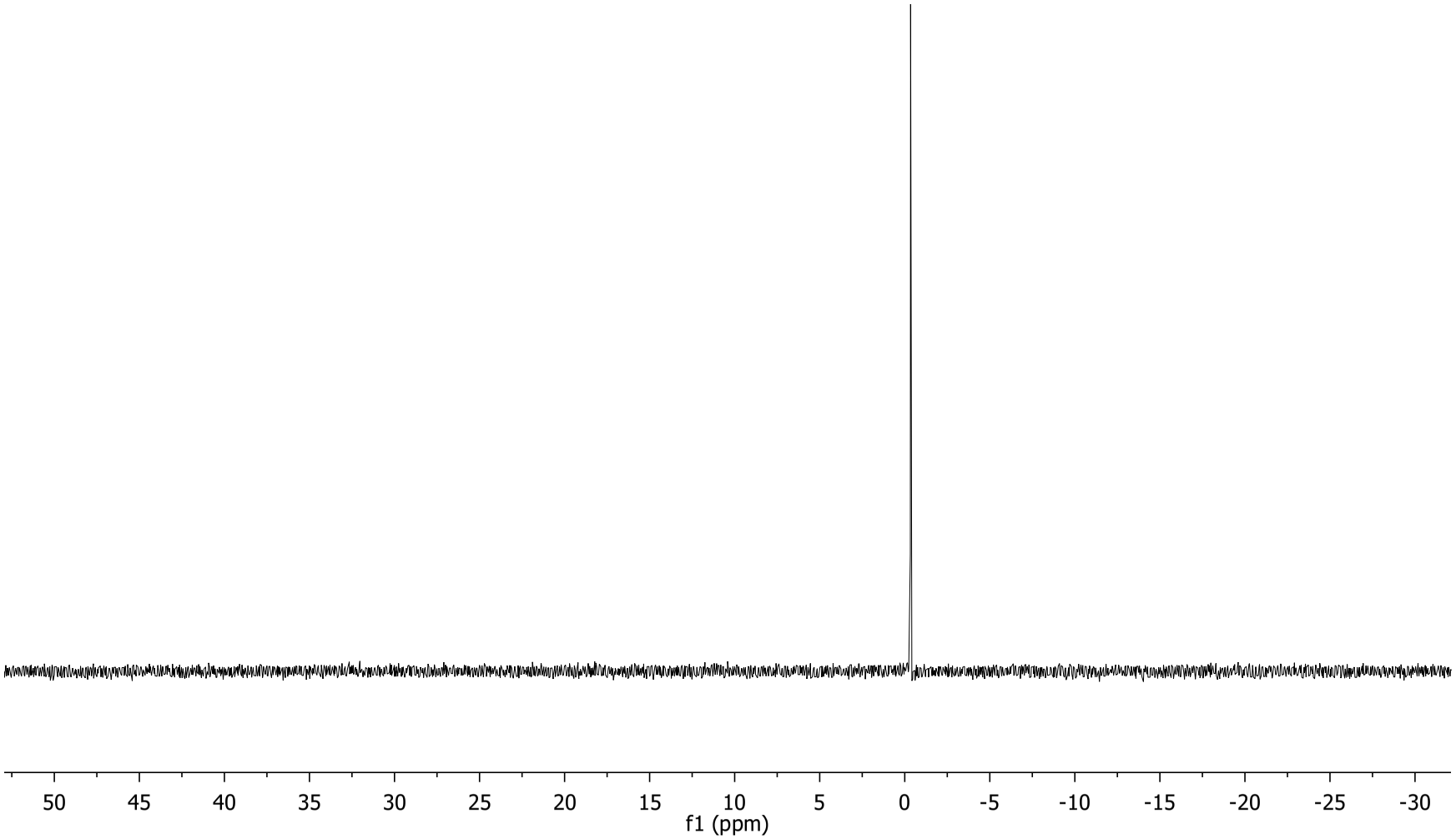
46

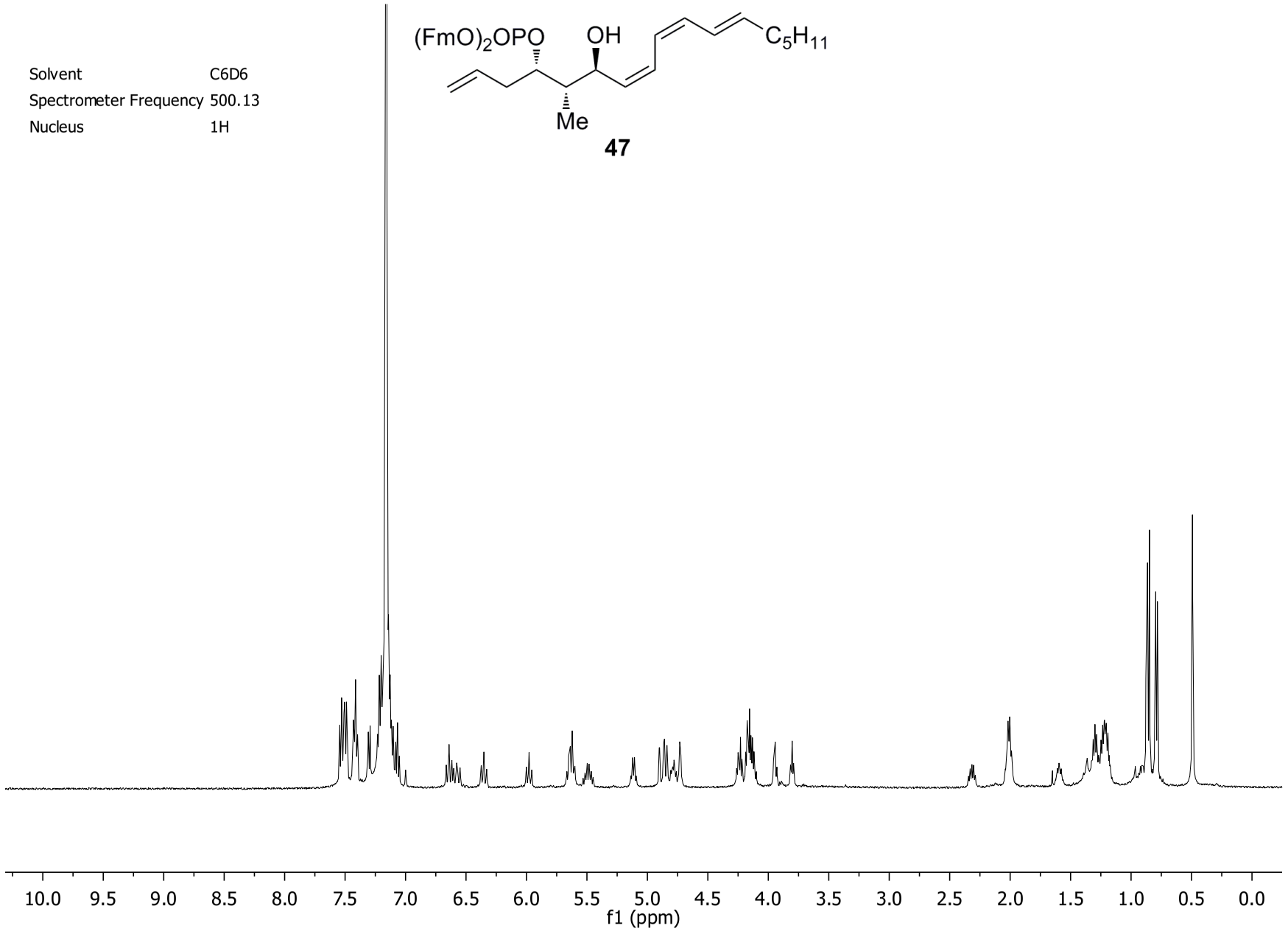


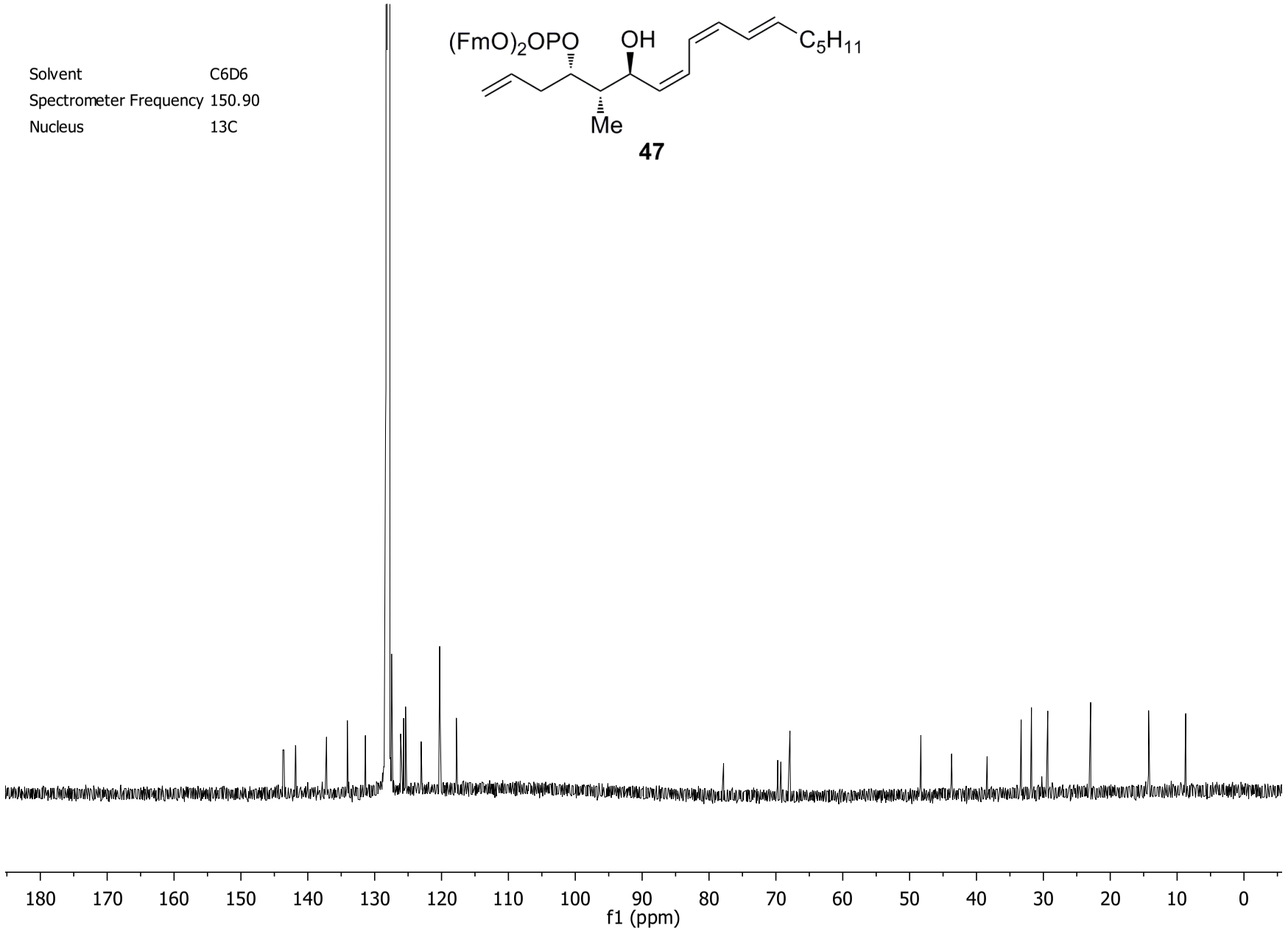
Solvent	C6D6
Spectrometer Frequency	161.97
Nucleus	31P



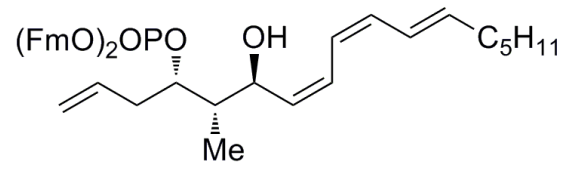
46



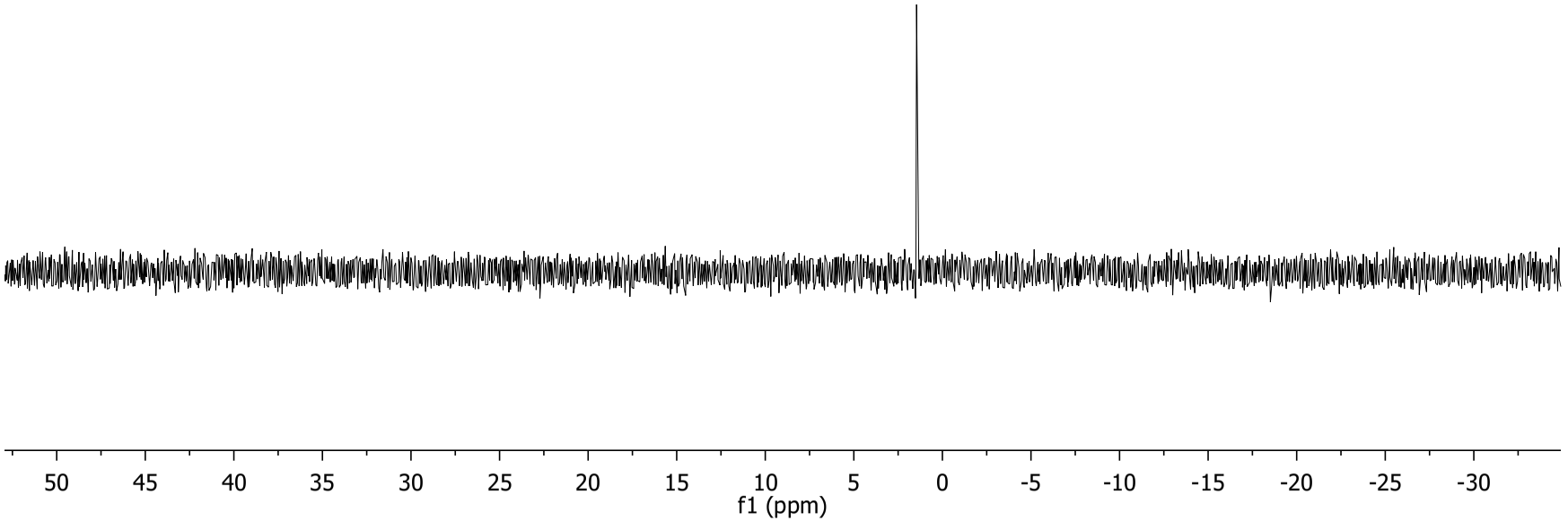

Solvent C6D6
Spectrometer Frequency 500.13
Nucleus 1H
(FmO)2OPO
OH
C5H11
Me
47
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

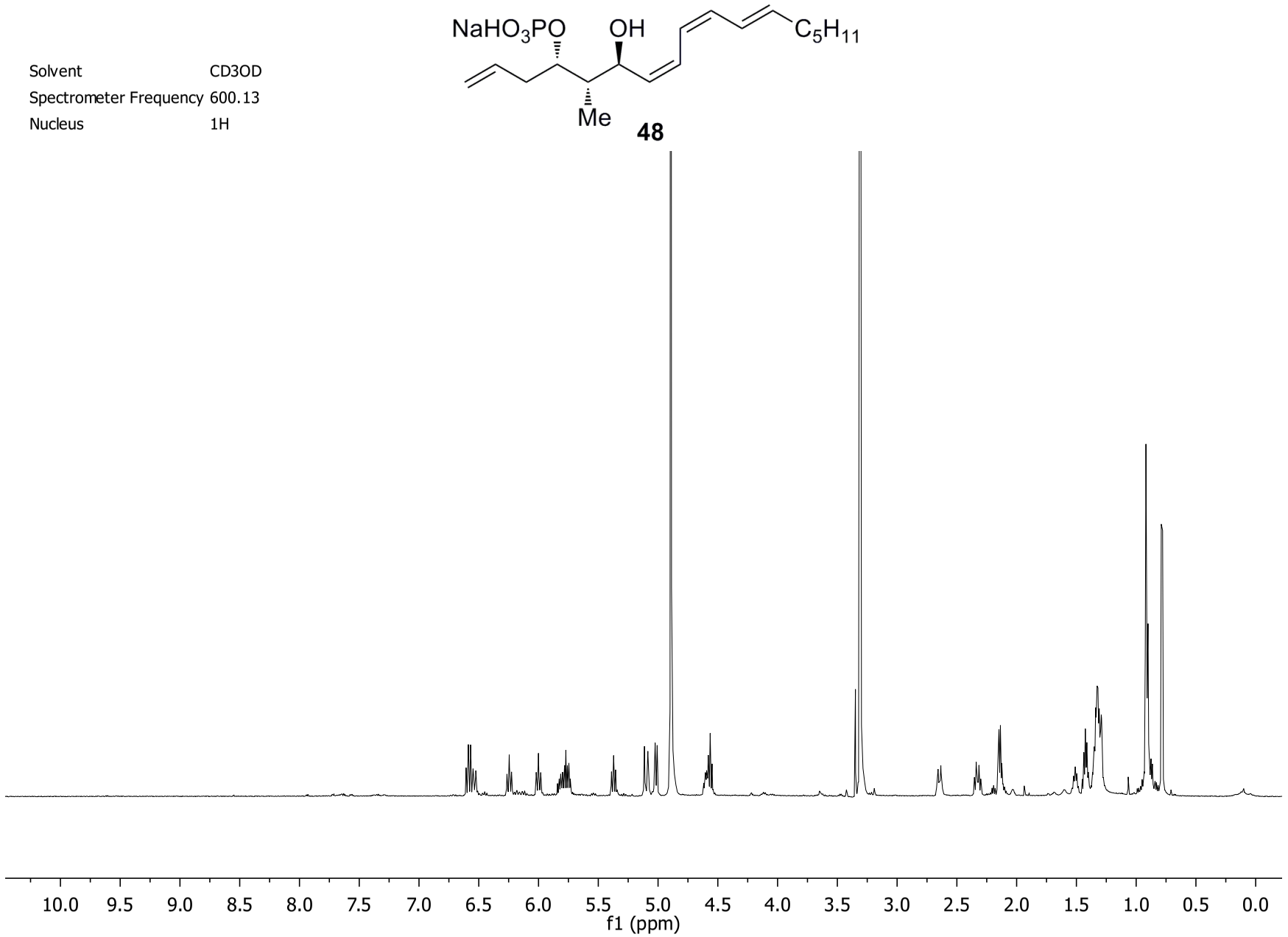

Solvent C6D6
Spectrometer Frequency 150.90
Nucleus 13C
(FmO)2OPO
OH
C5H11
Me
47
180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

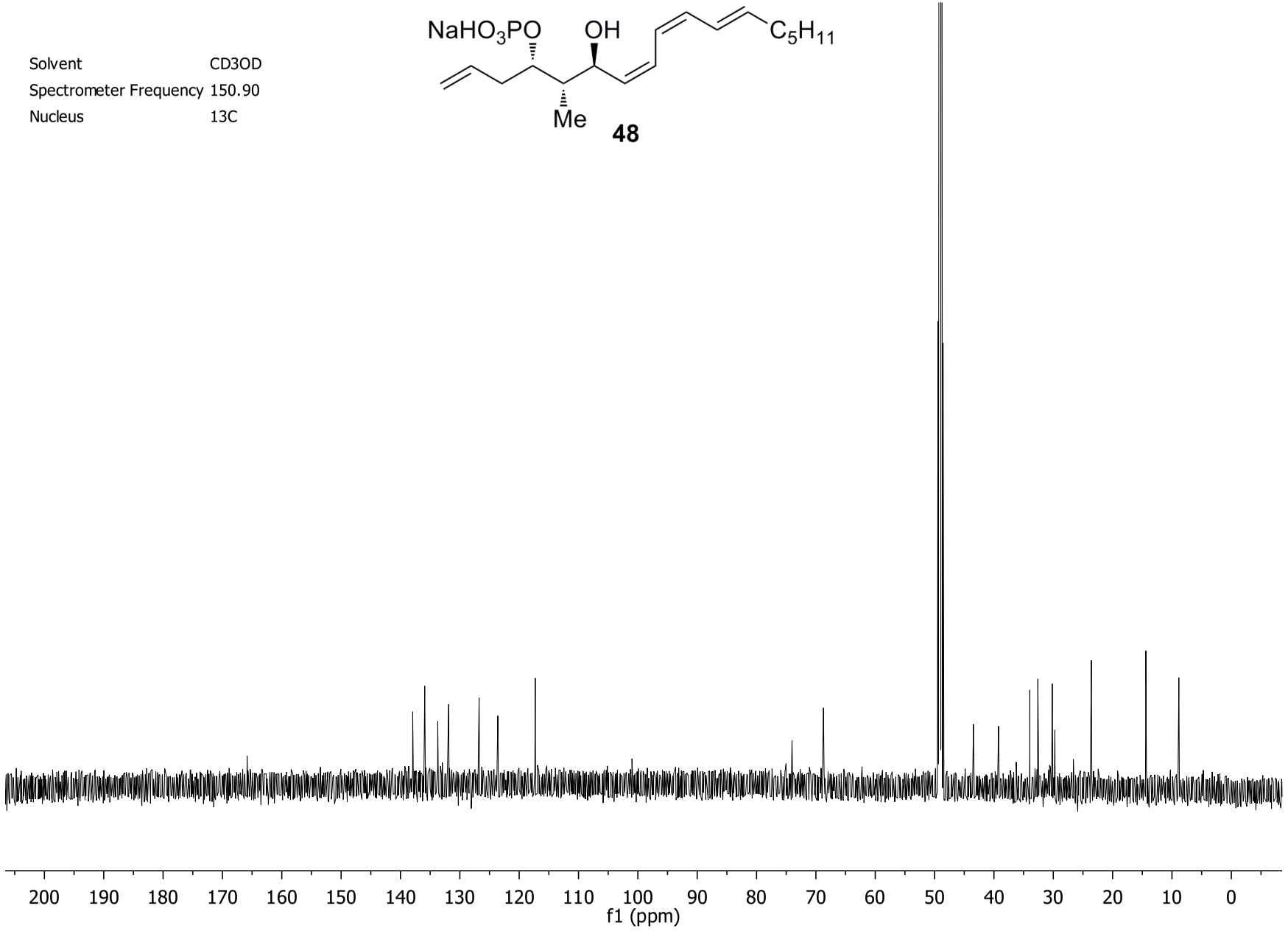
Solvent	C6D6
Spectrometer Frequency	161.97
Nucleus	31P



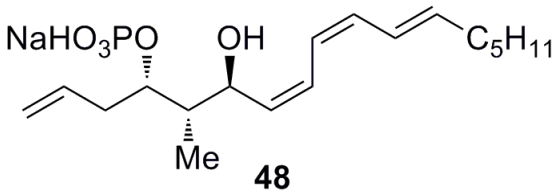
47



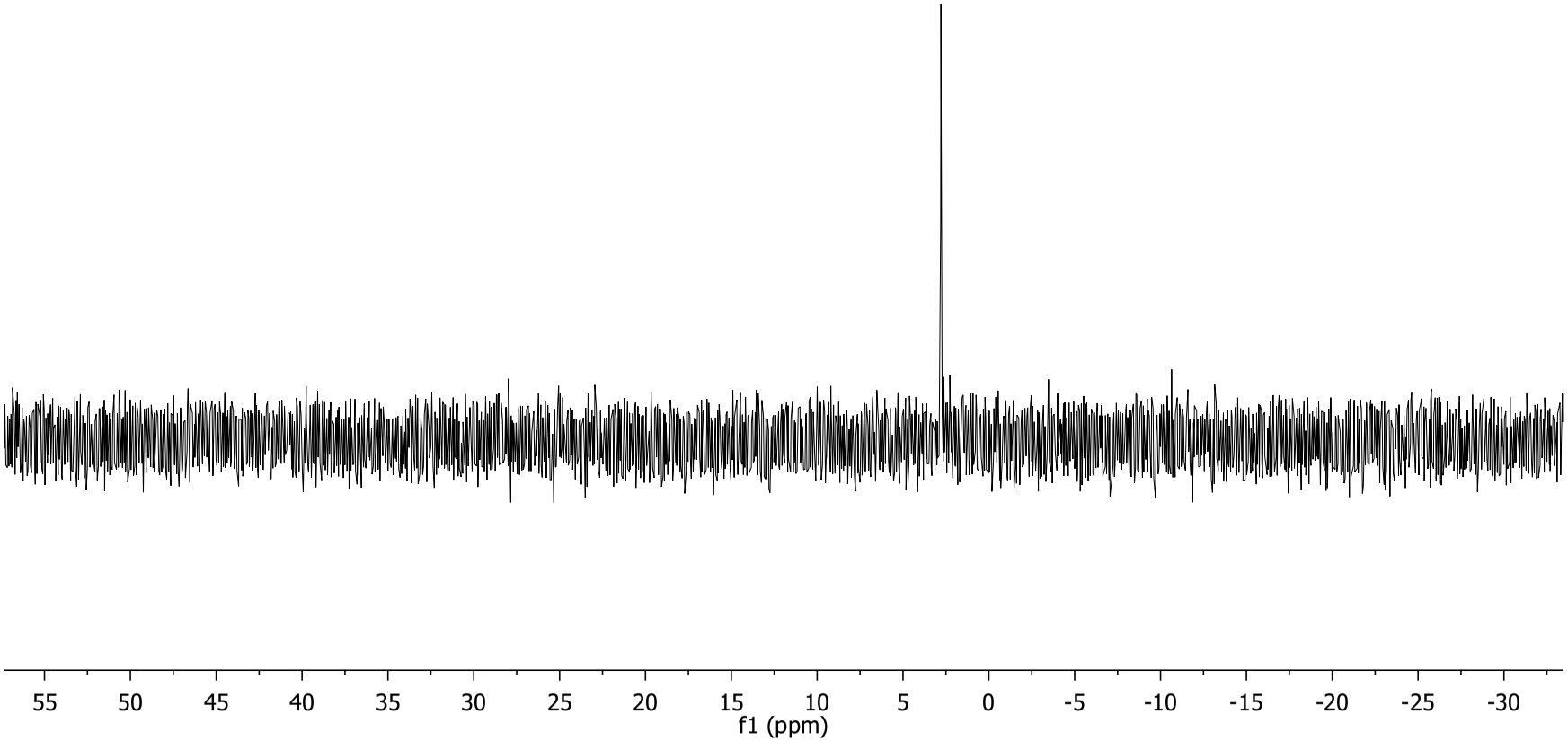

Solvent CD3OD
Spectrometer Frequency 600.13
Nucleus 1H
NaHO3PO
OH
C5H11
Me
48
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)


Solvent CD3OD
Spectrometer Frequency 150.90
Nucleus 13C
NaHO3PO
OH
C5H11
Me
48
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

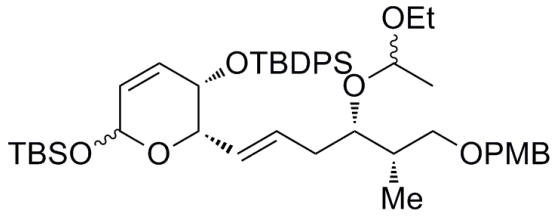
Solvent	CD3OD
Spectrometer Frequency	161.97
Nucleus	31P



48



Solvent	C6D6
Spectrometer Frequency	400.12
Nucleus	1H



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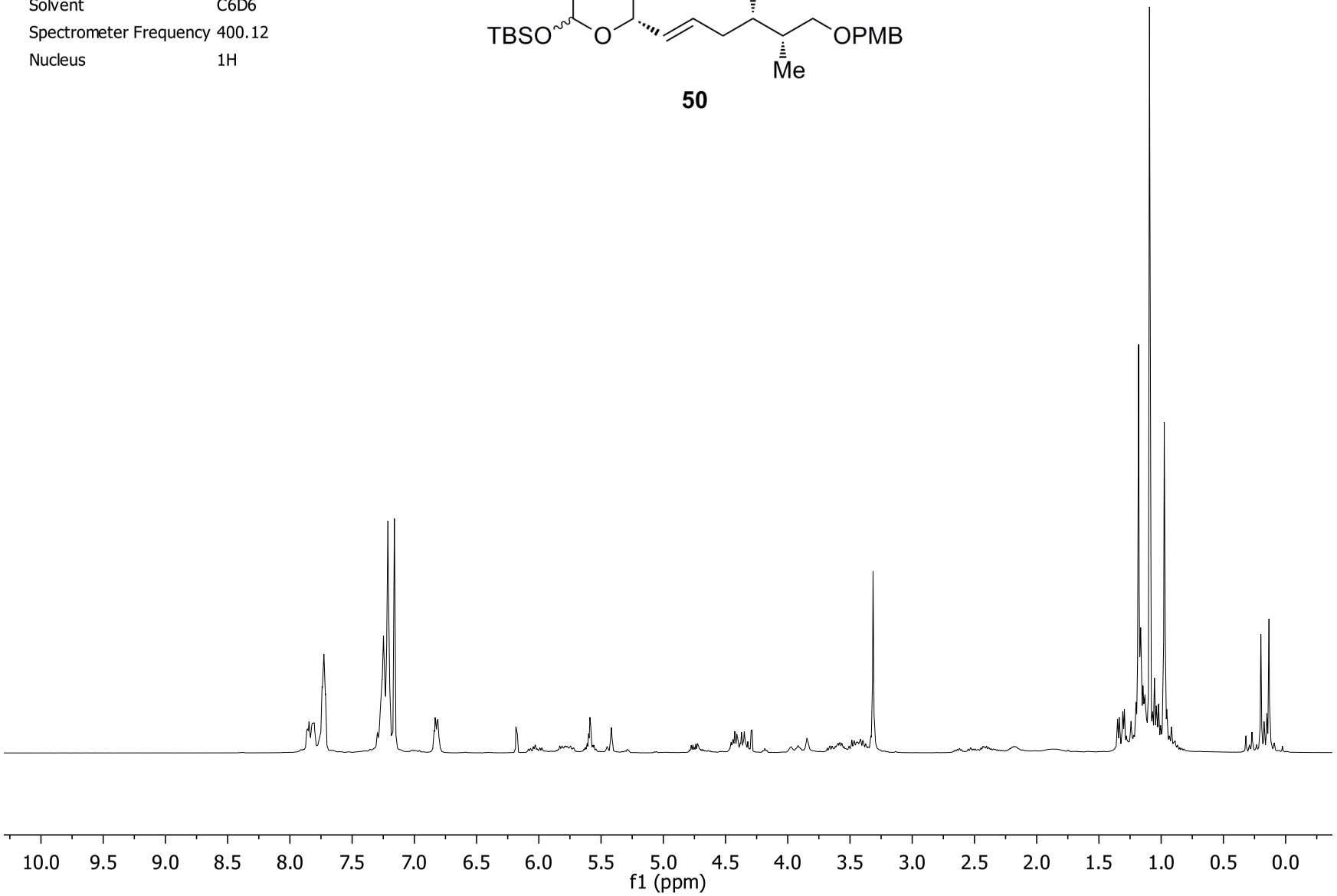
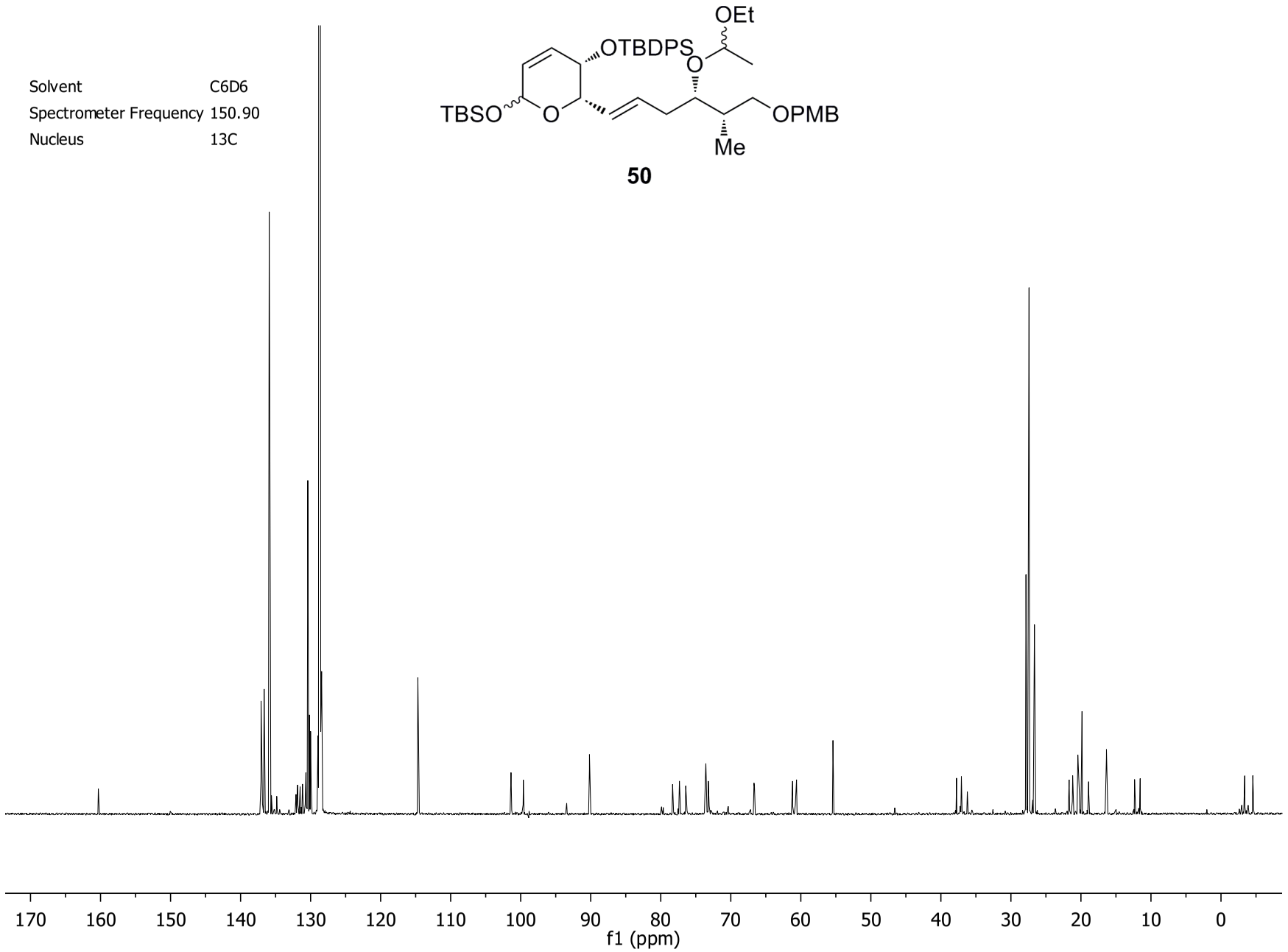
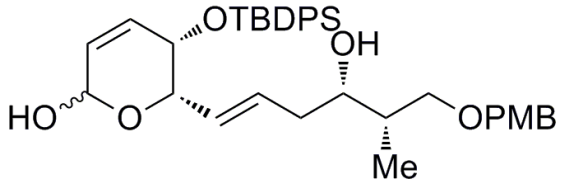



Solvent C6D6
Spectrometer Frequency 150.90
Nucleus 13C
OEt
OTBDPS
O
TBSO
O
OPMB
Me
50
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

Solvent	C6D6
Spectrometer Frequency	600.13
Nucleus	1H



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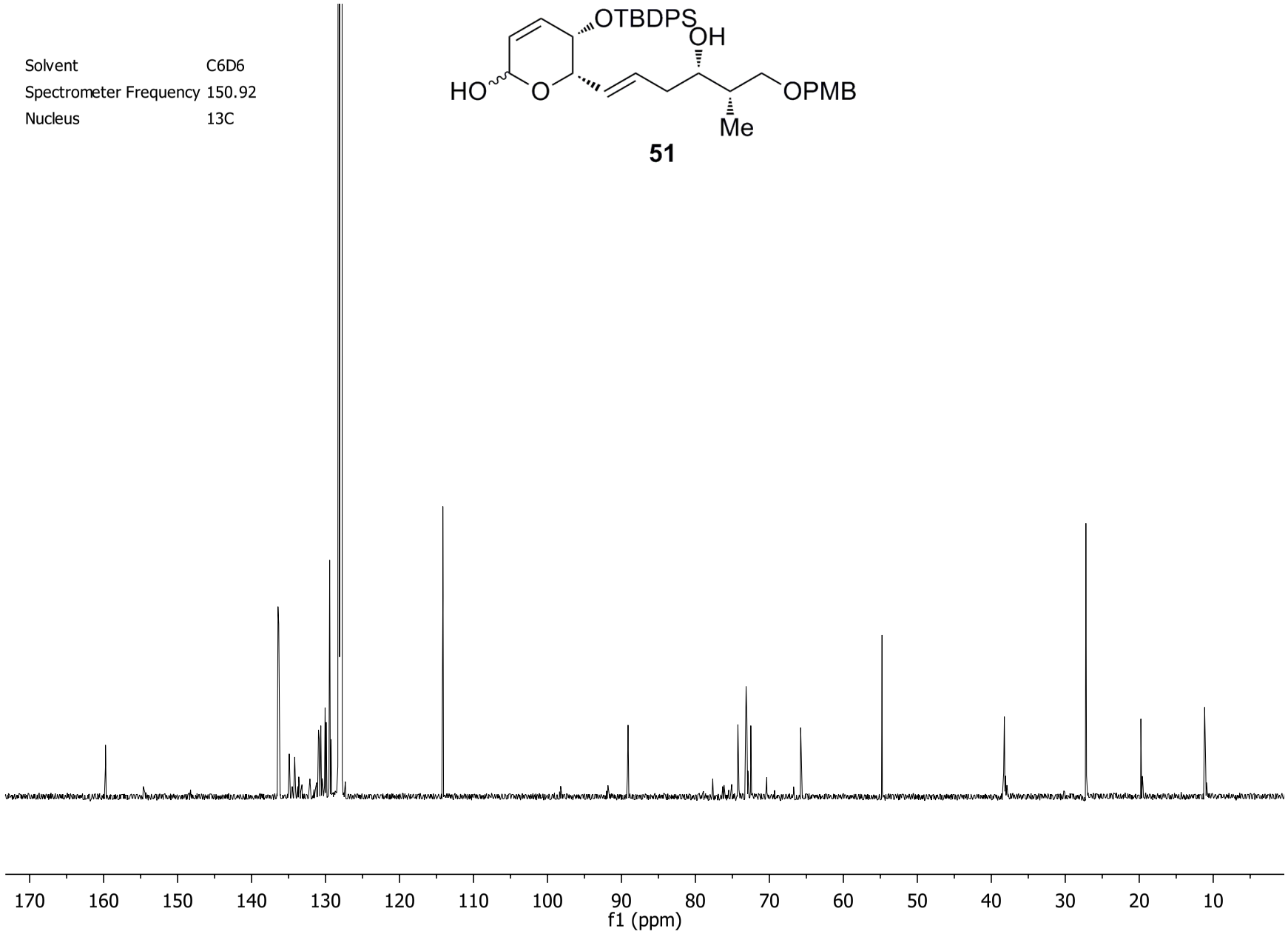
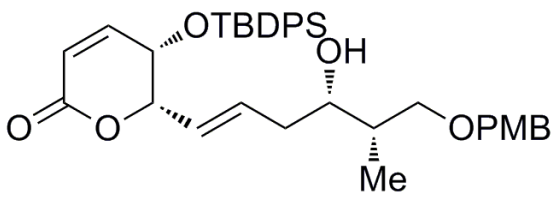
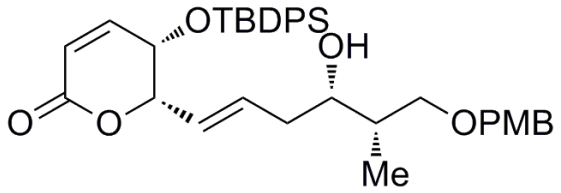

Solvent C6D6
Spectrometer Frequency 150.92
Nucleus 13C
OTBDPS
OH
HO
O
OPMB
Me
51
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
f1 (ppm)

Solvent	C6D6
Spectrometer Frequency	400.12
Nucleus	1H

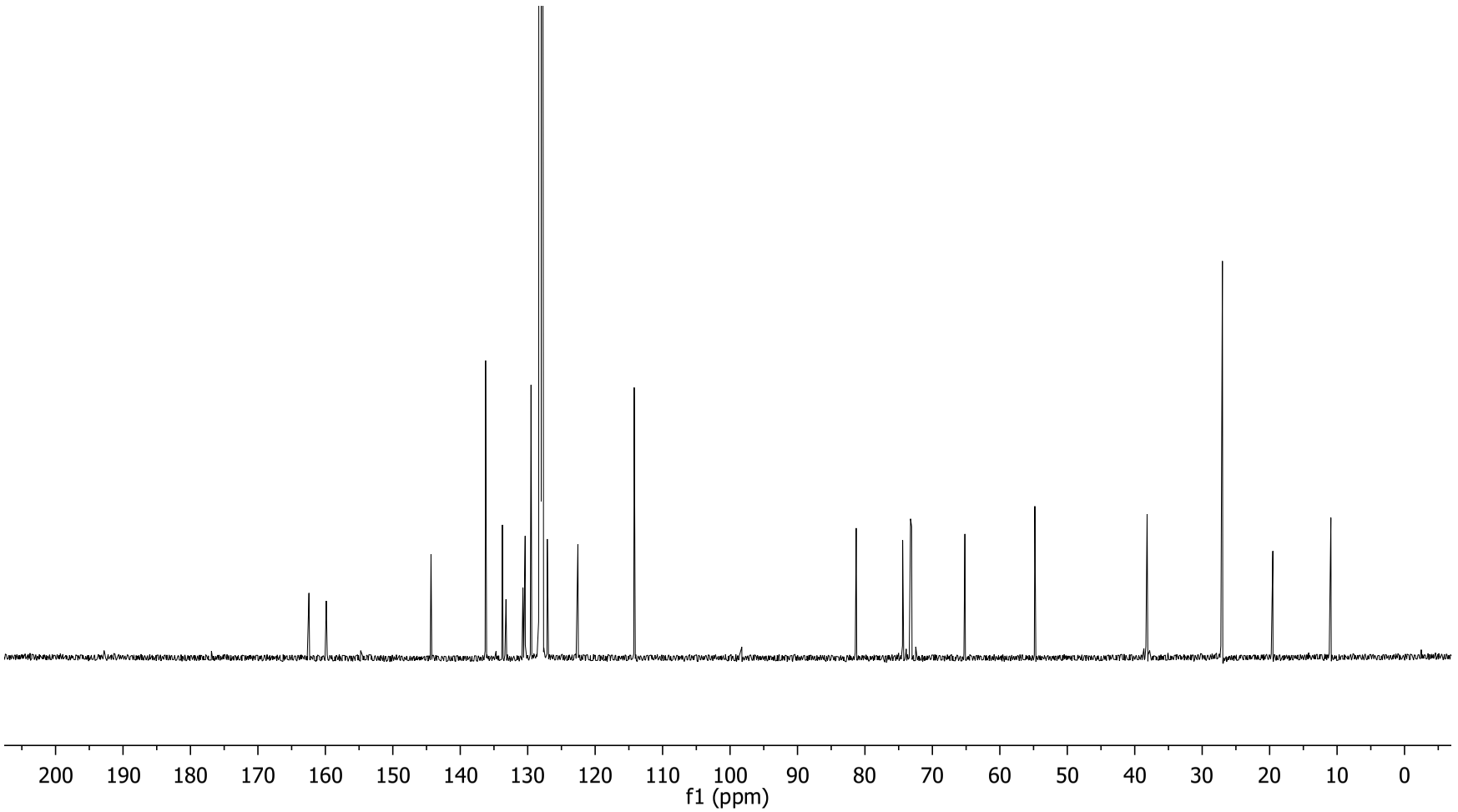


52

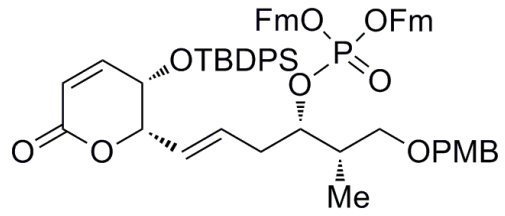
Solvent	C6D6
Spectrometer Frequency	150.90
Nucleus	13C



52

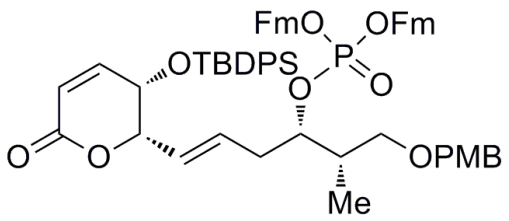


Solvent	C6D6
Spectrometer Frequency	600.13
Nucleus	1H



53

Solvent	C6D6
Spectrometer Frequency	150.92
Nucleus	13C



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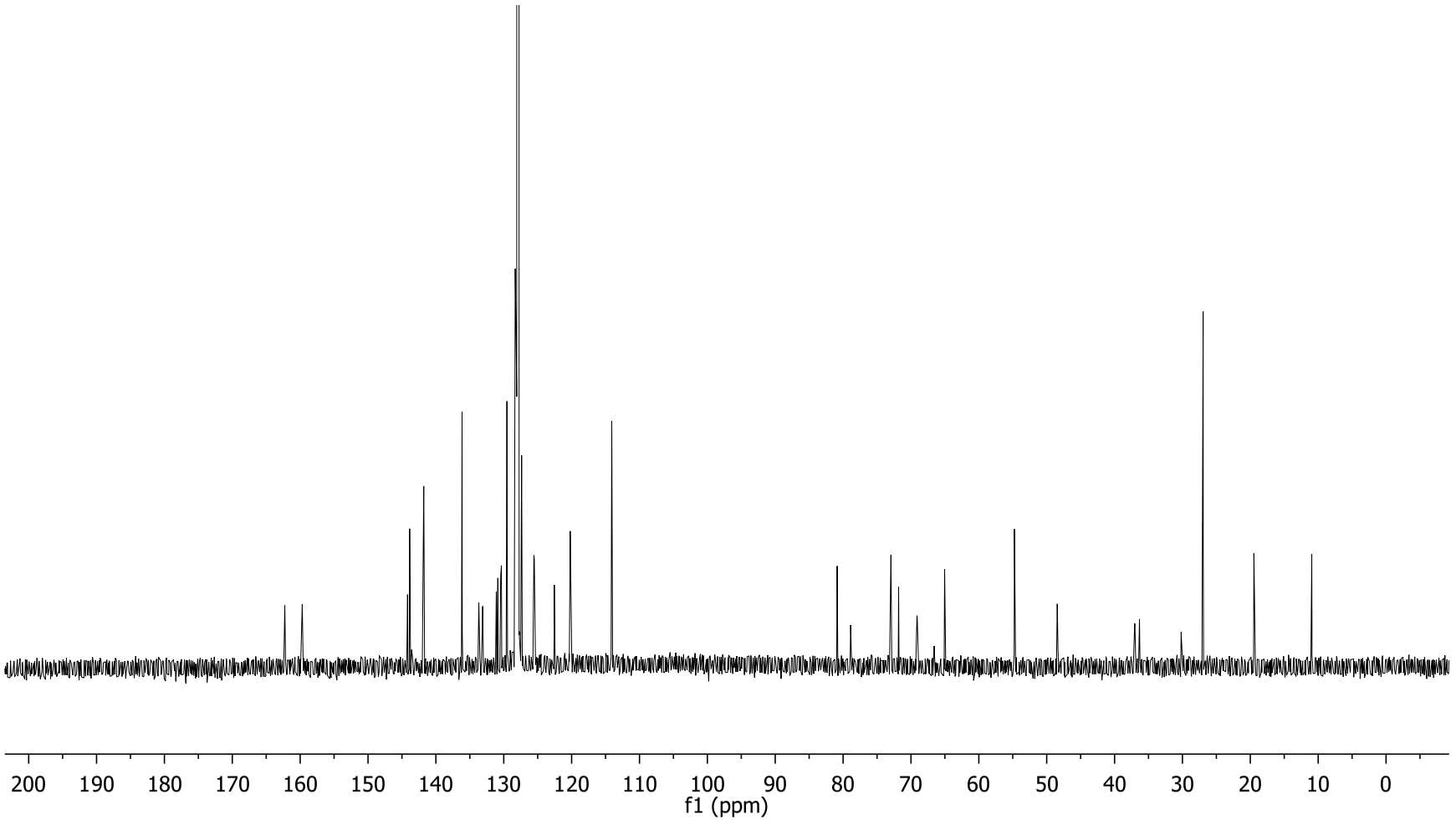
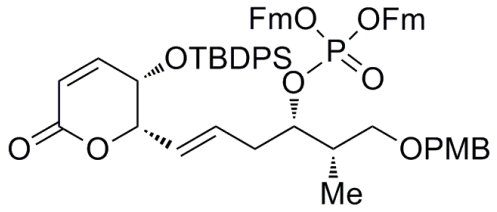


Solvent	C6D6
Spectrometer Frequency	161.97
Nucleus	31P



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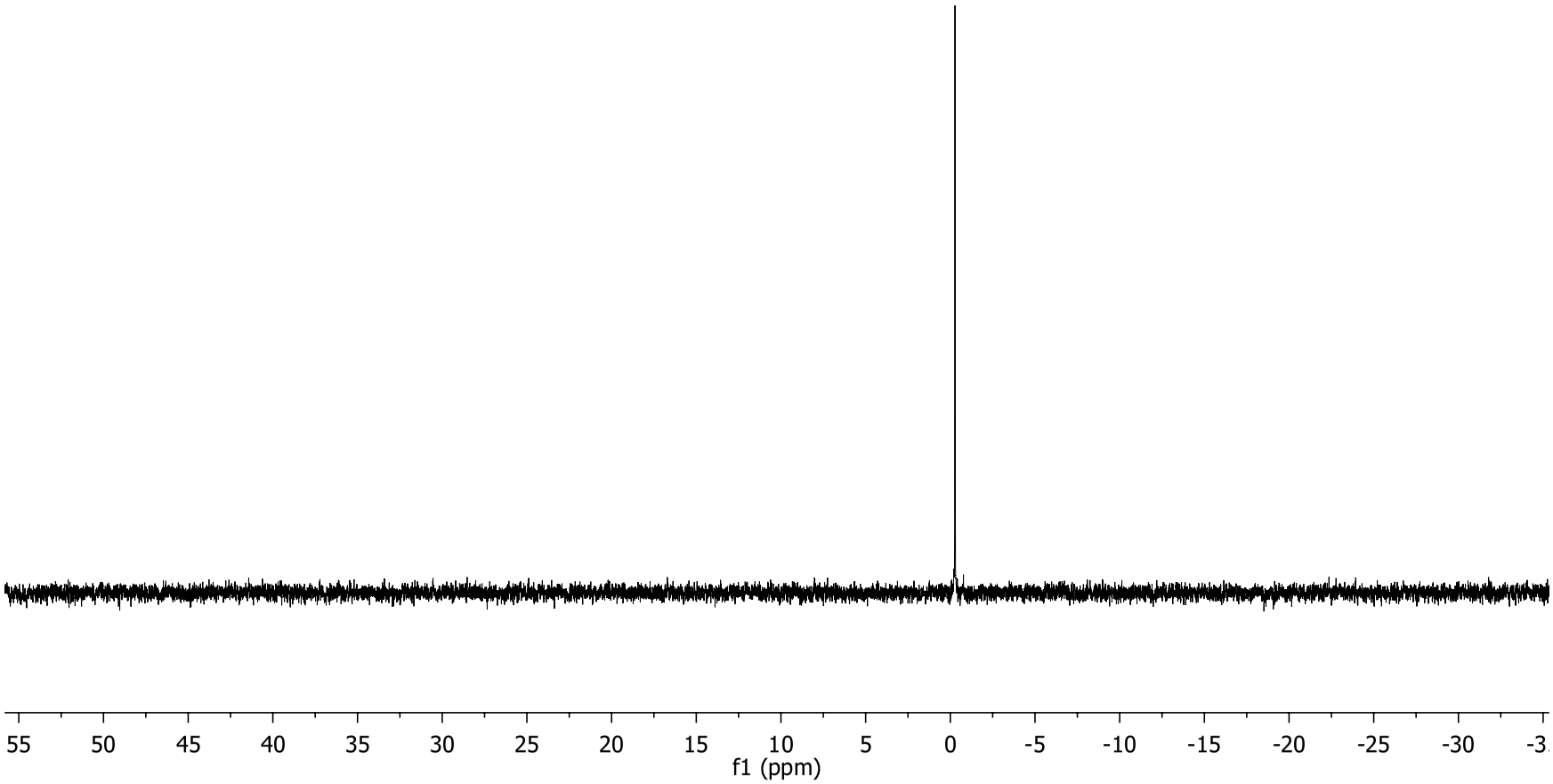
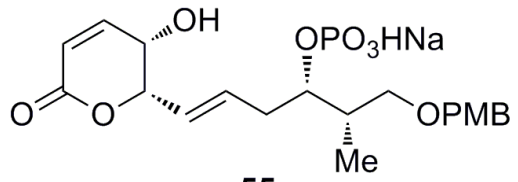


Solvent	CD3OD
Spectrometer Frequency	600.13
Nucleus	1H



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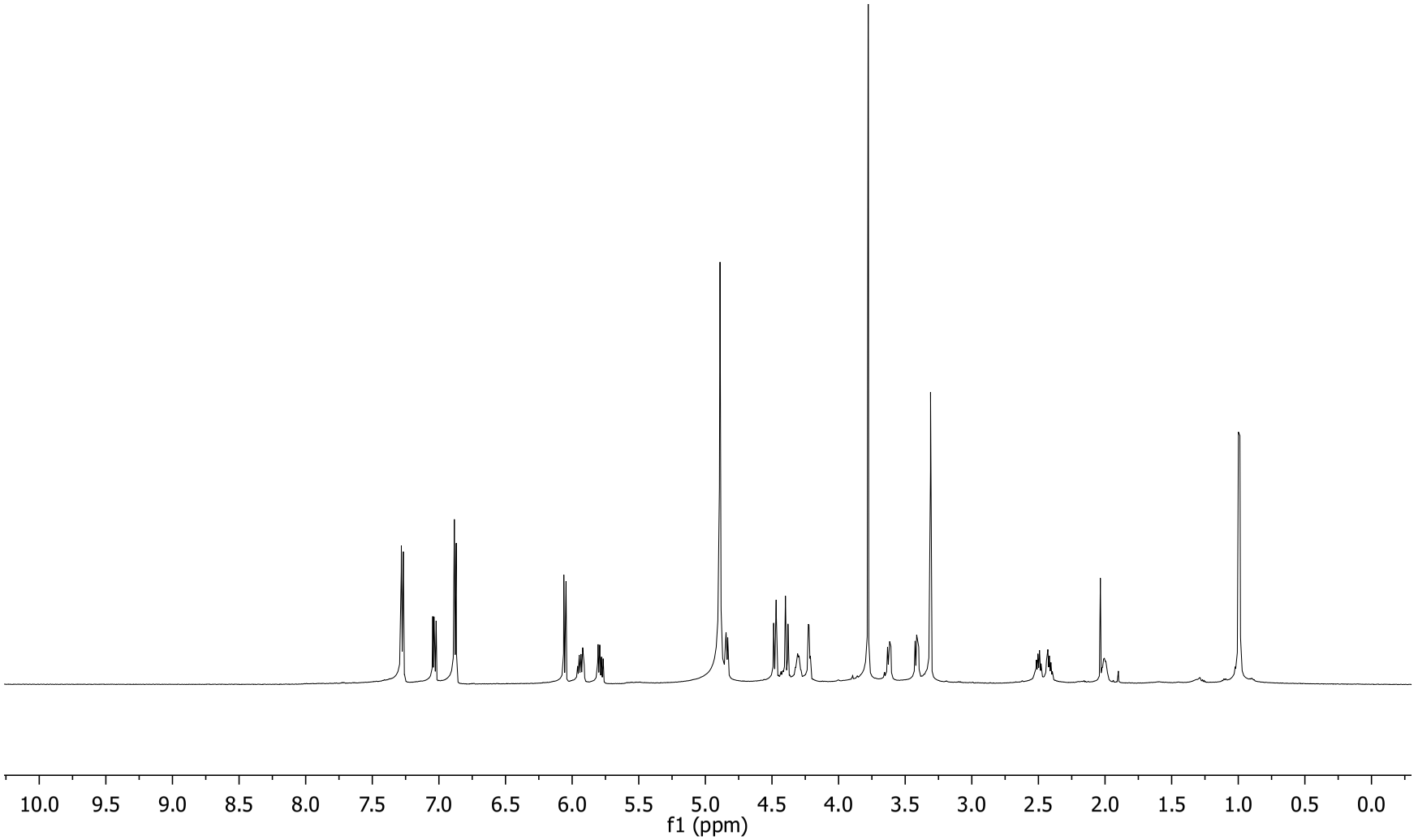
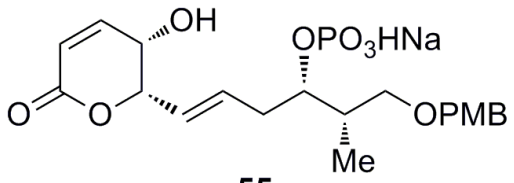
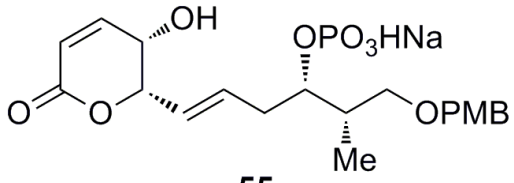


Solvent	CD3OD
Spectrometer Frequency	150.90
Nucleus	13C



55

Solvent	CD3OD
Spectrometer Frequency	161.97
Nucleus	31P



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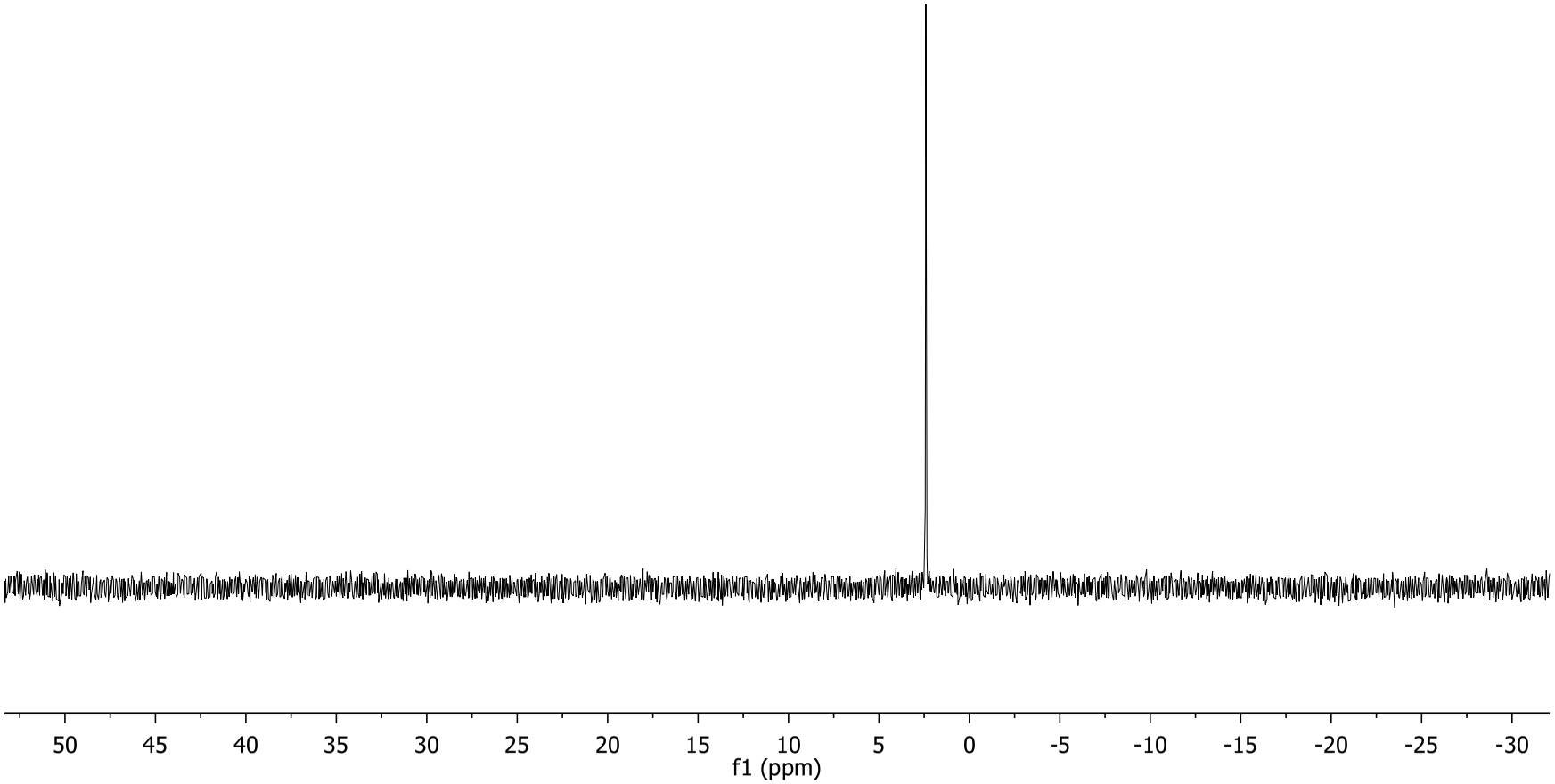
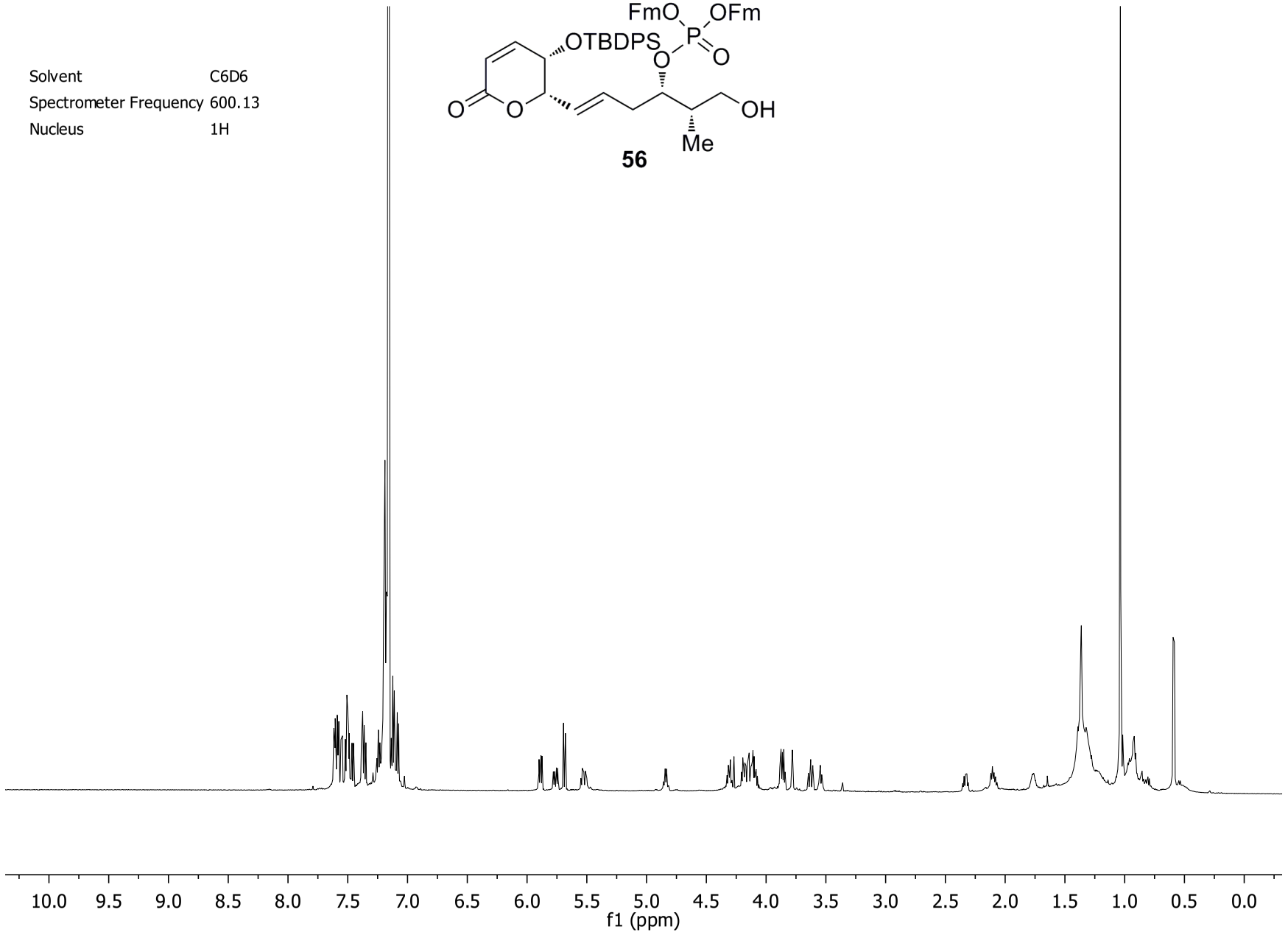
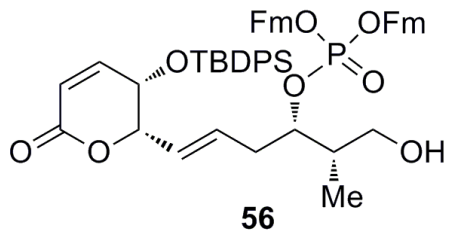



Solvent C6D6
Spectrometer Frequency 600.13
Nucleus 1H
FmO
OFm
OTBDPS
P
O
O
O
O
OH
Me
56
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

Solvent	C6D6
Spectrometer Frequency	150.90
Nucleus	13C



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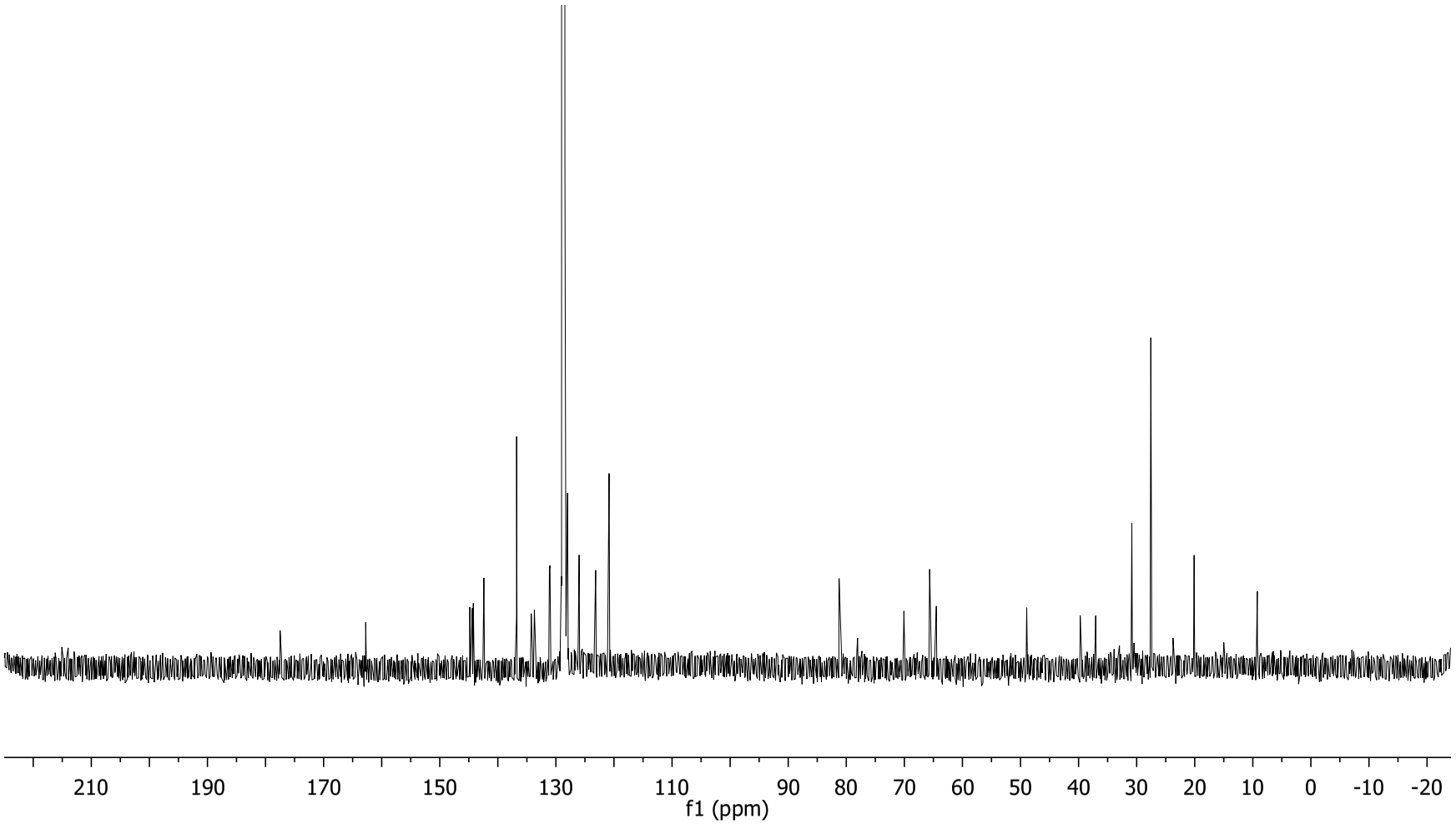
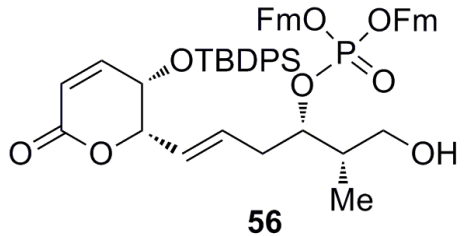
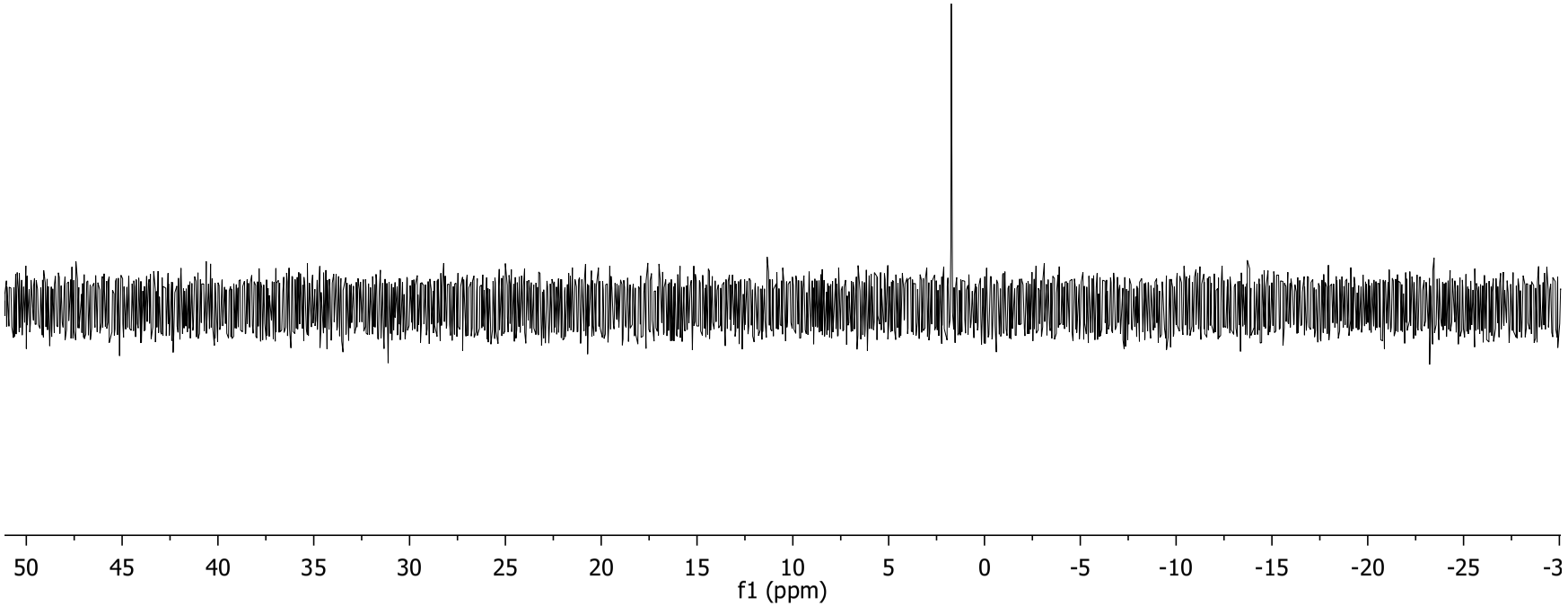


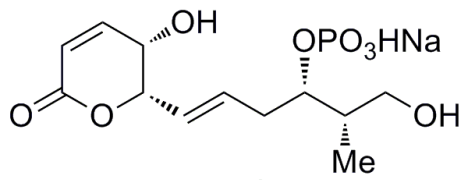
Solvent	C6D6
Spectrometer Frequency	161.97
Nucleus	31P



56



Solvent	CD3OD
Spectrometer Frequency	600.13
Nucleus	1H



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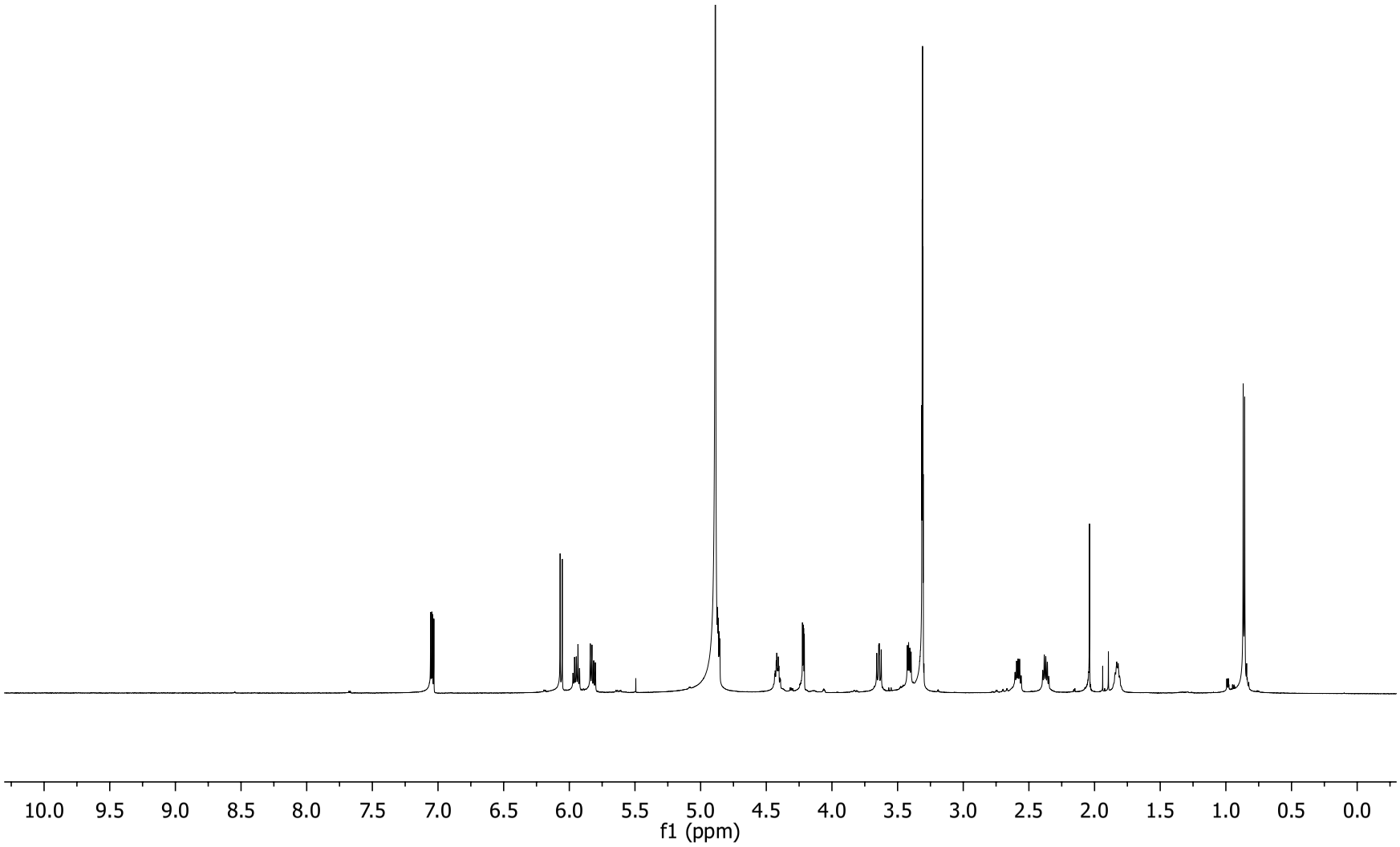
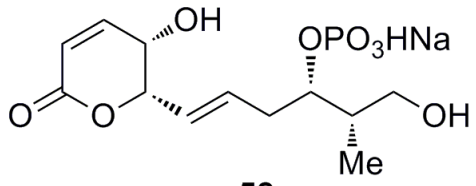
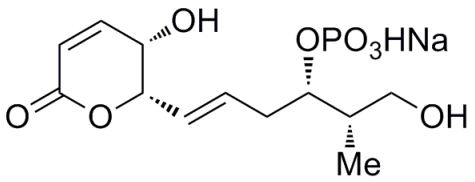


Solvent	CD3OD
Spectrometer Frequency	150.90
Nucleus	13C

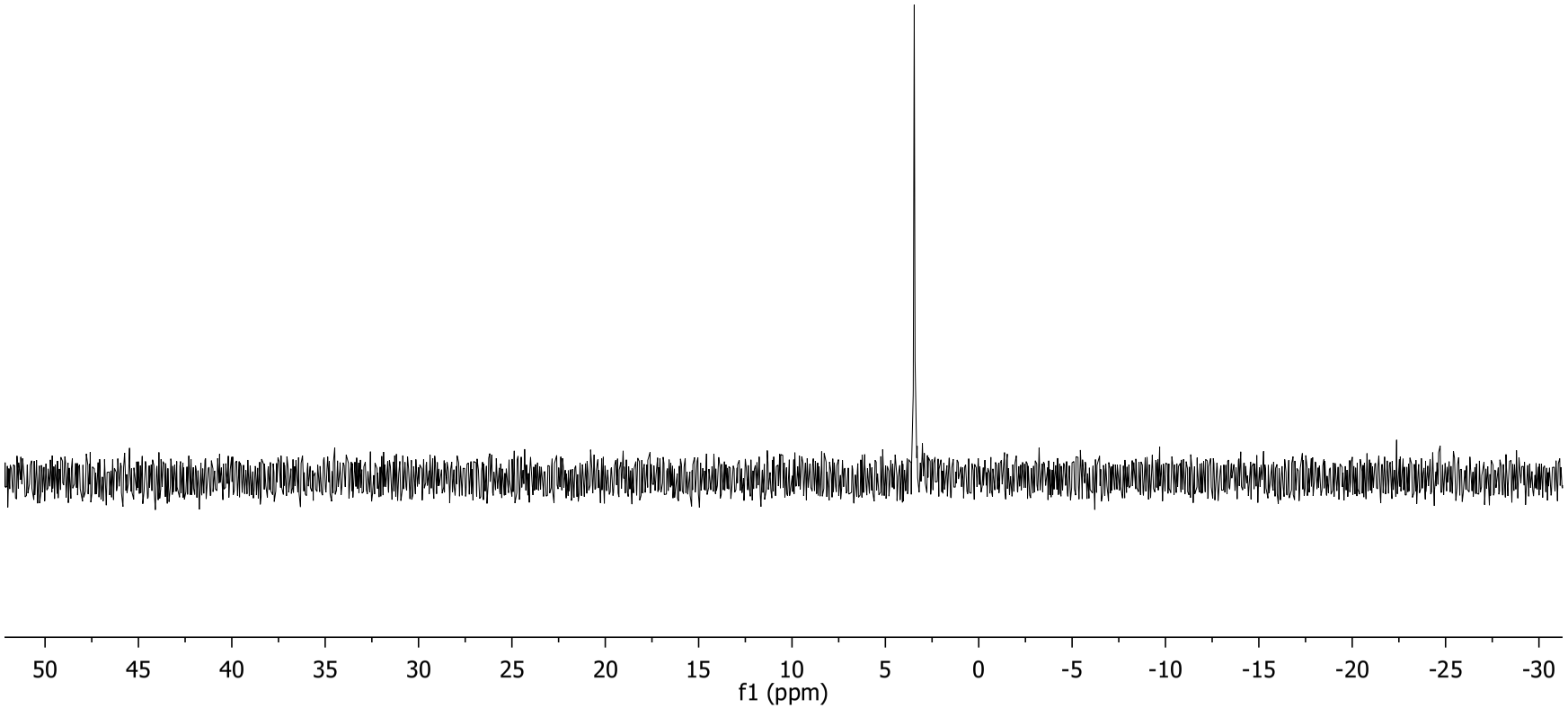


58

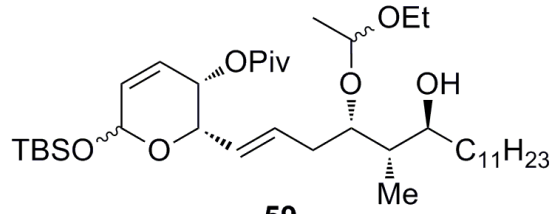
Solvent	CD3OD
Spectrometer Frequency	161.97
Nucleus	31P



58

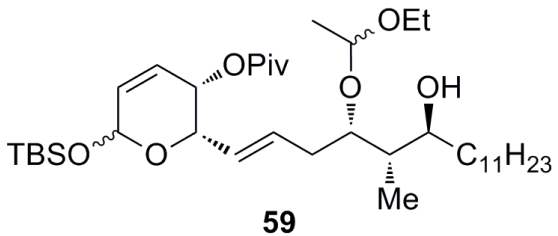


Solvent	C6D6
Spectrometer Frequency	400.12
Nucleus	1H



59

Solvent	C6D6
Spectrometer Frequency	150.90
Nucleus	13C



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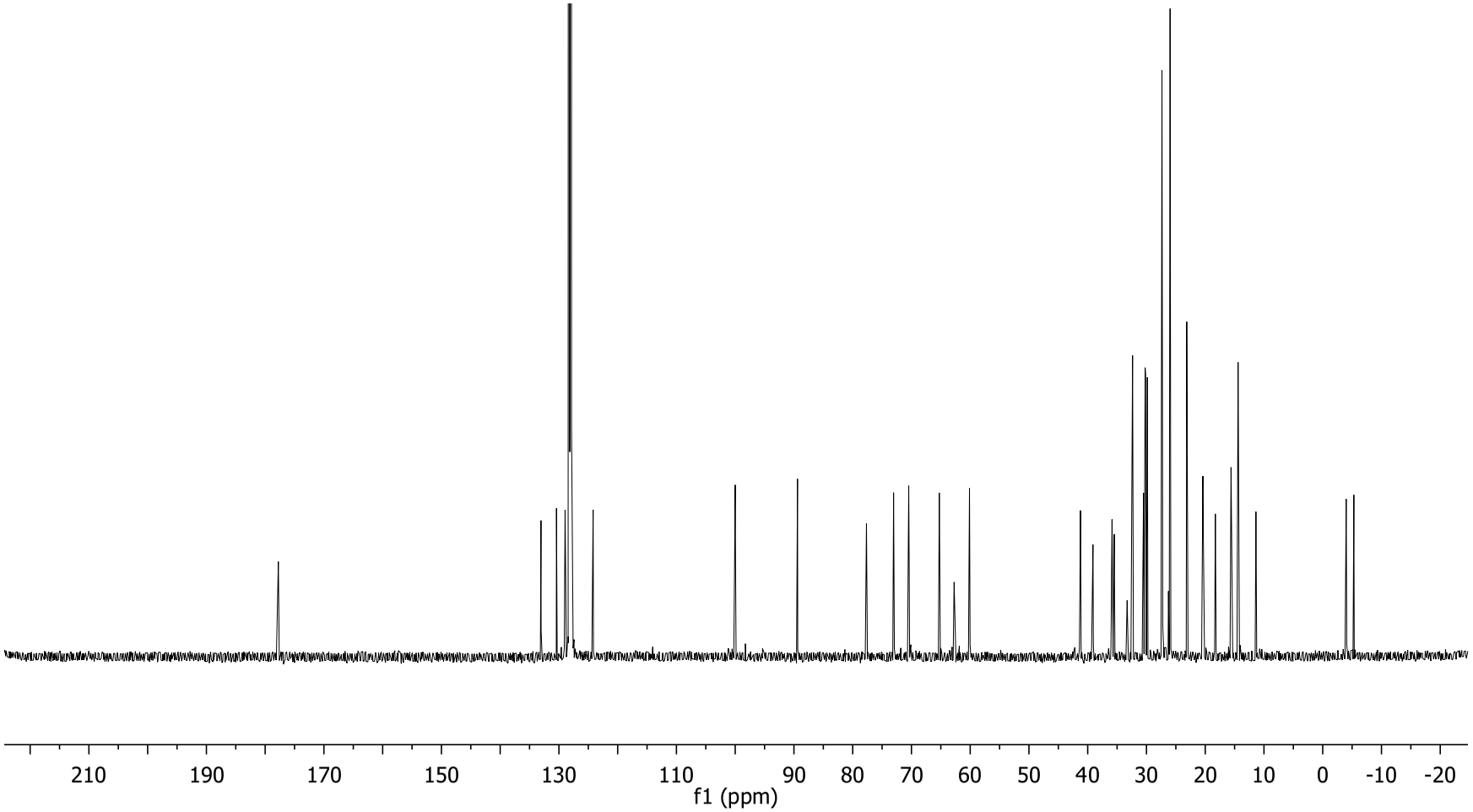
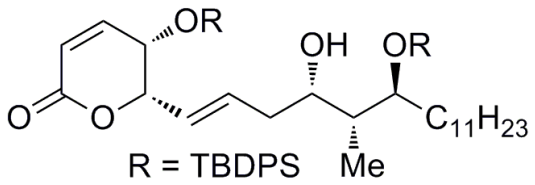
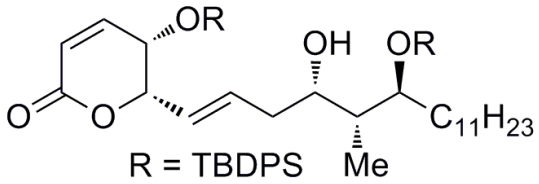


Solvent	C6D6
Spectrometer Frequency	600.13
Nucleus	1H

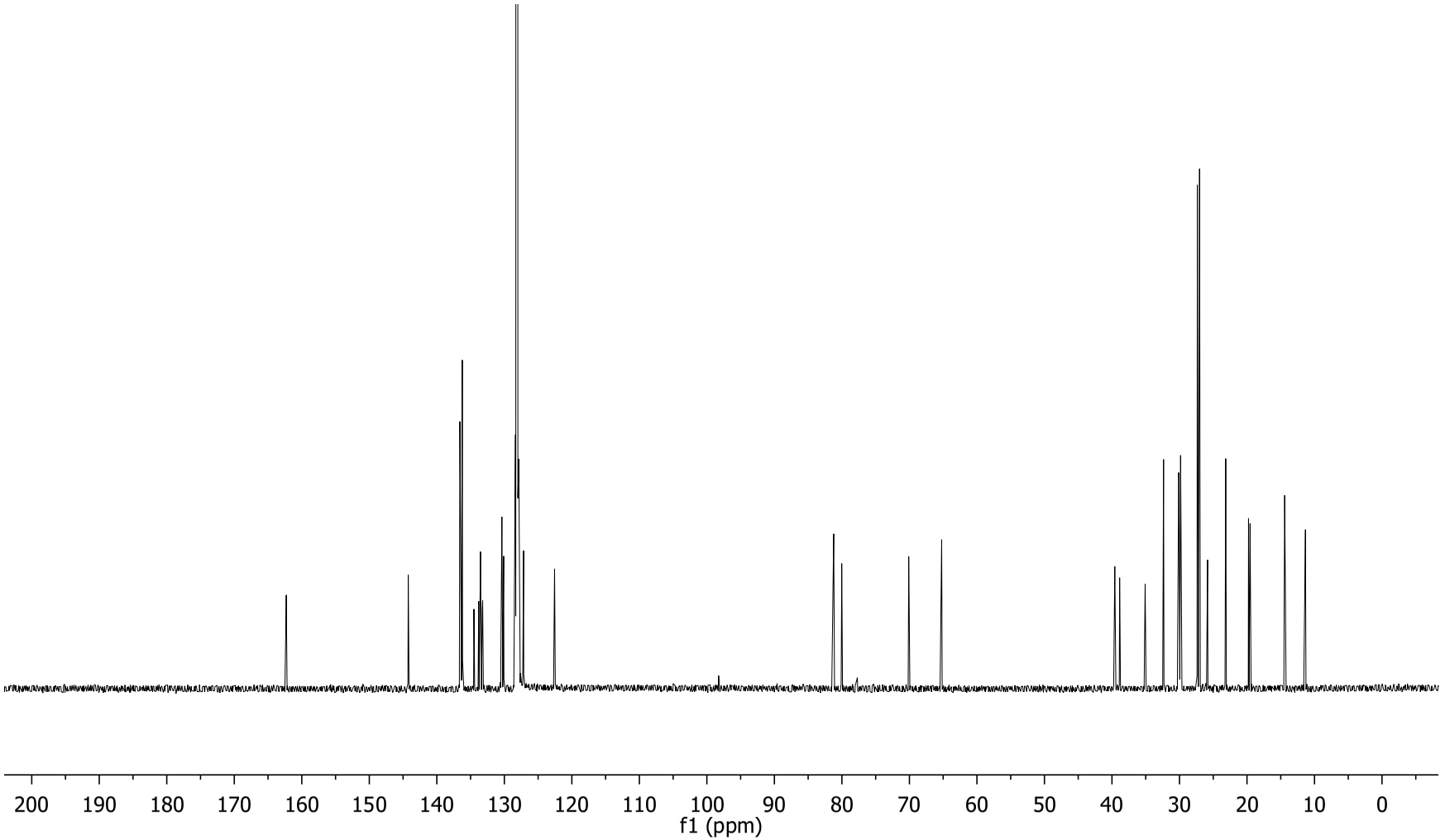


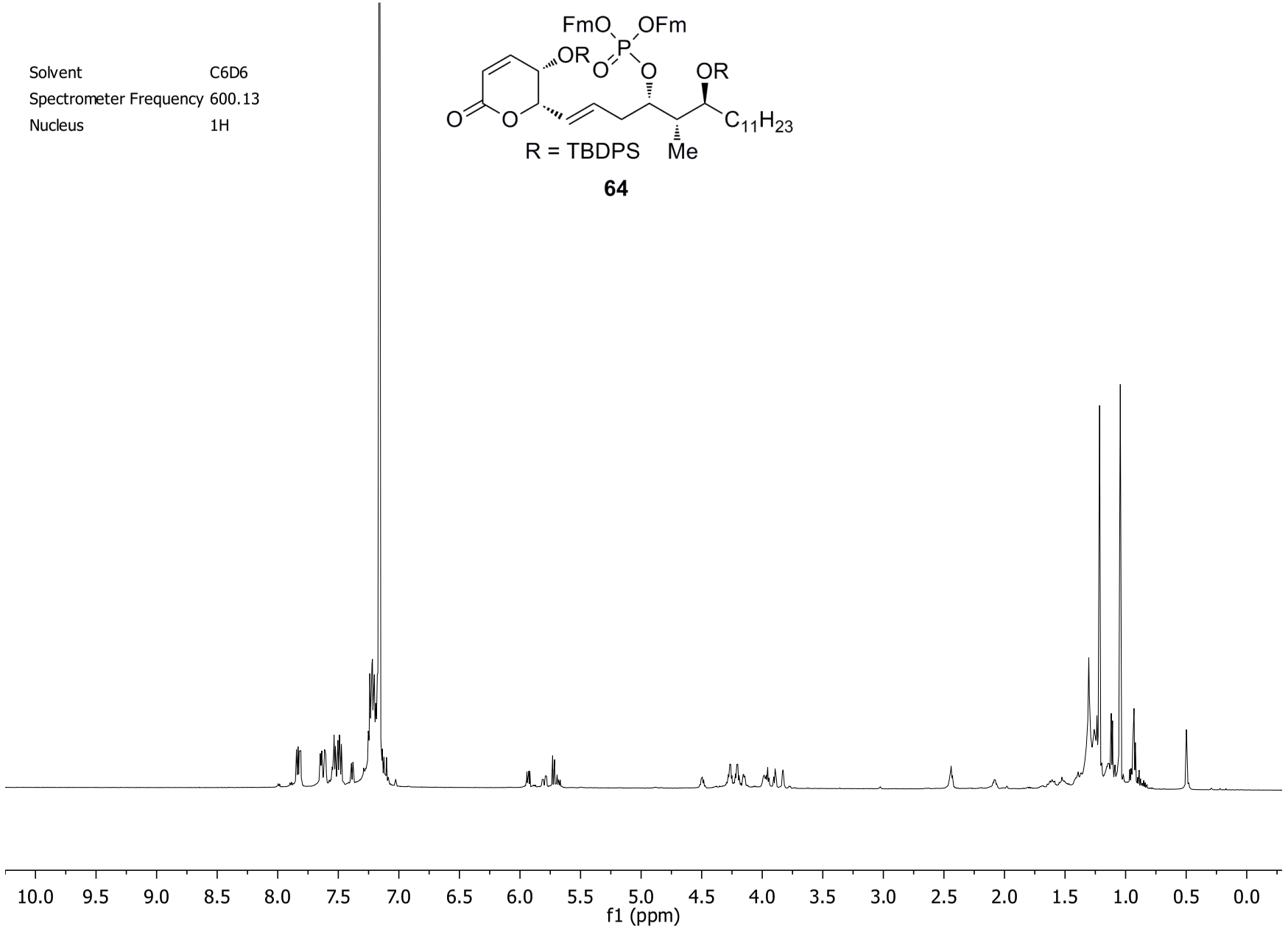
63

Solvent	C6D6
Spectrometer Frequency	150.90
Nucleus	13C

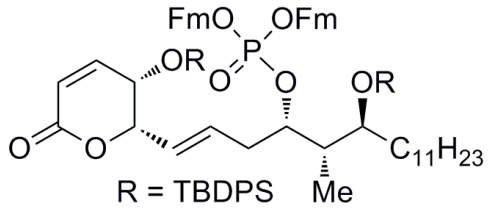


63




Solvent C6D6
Spectrometer Frequency 600.13
Nucleus 1H
FmO
OFm
OR
P
O
O
O
OR
O
O
C11H23
R = TBDPS
Me
64
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

Solvent	C6D6
Spectrometer Frequency	150.90
Nucleus	13C



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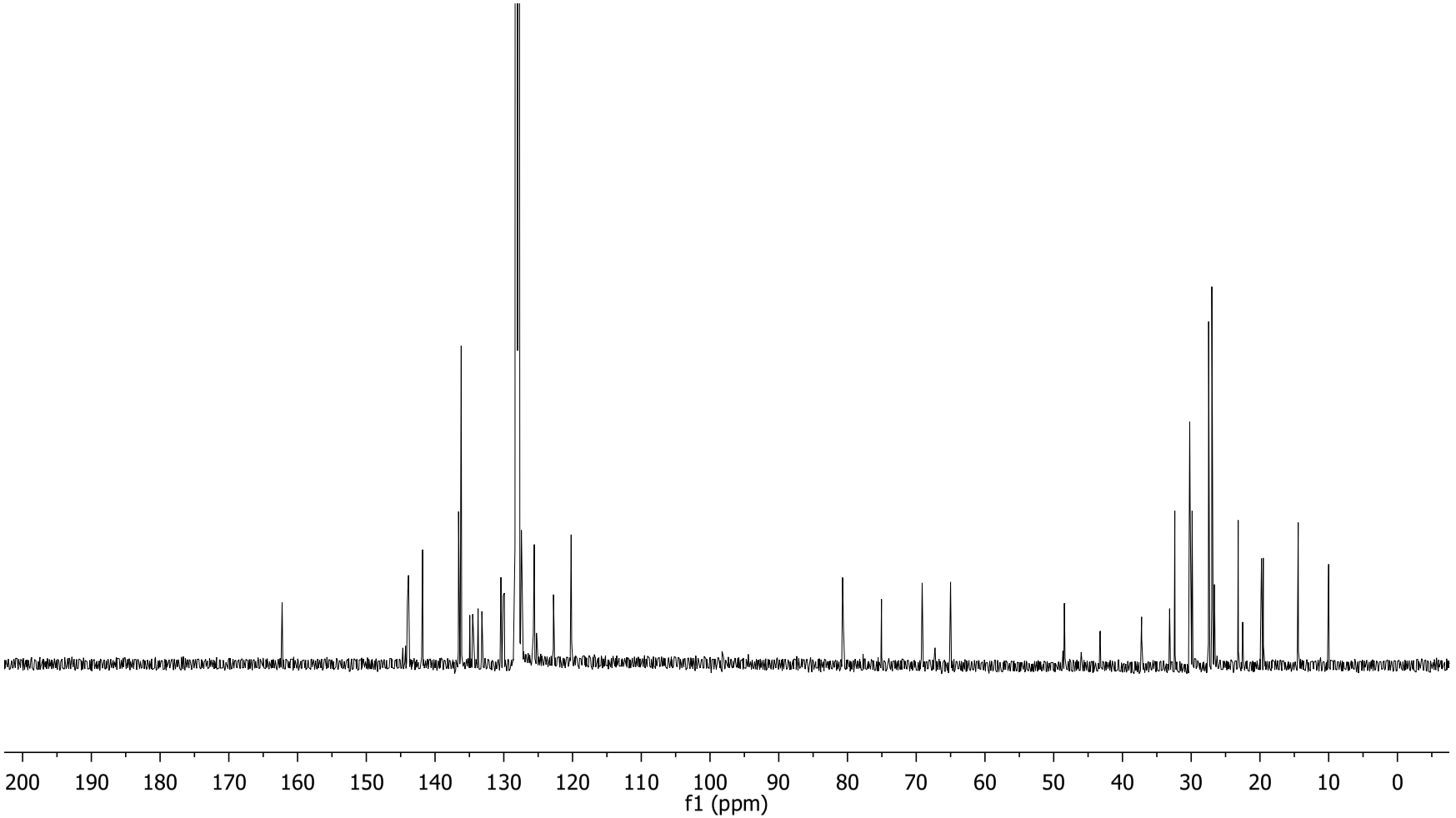
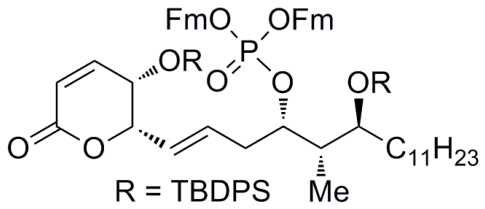


Solvent	C6D6
Spectrometer Frequency	161.97
Nucleus	31P



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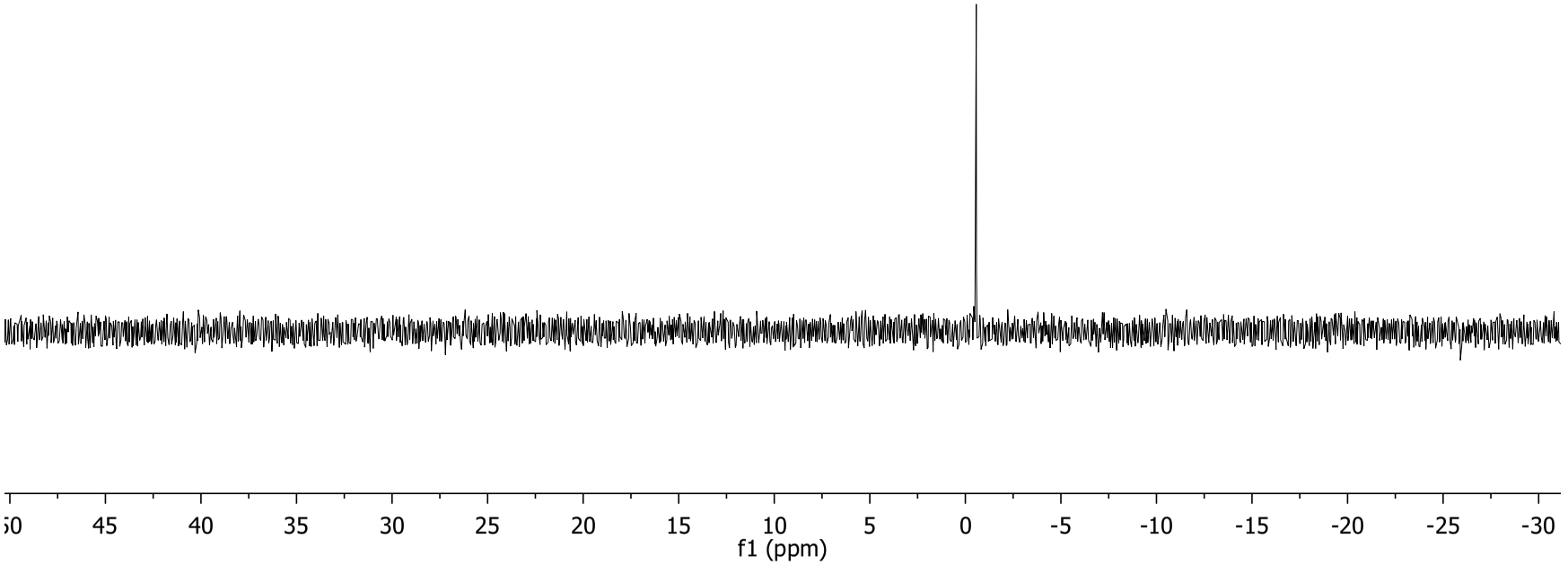
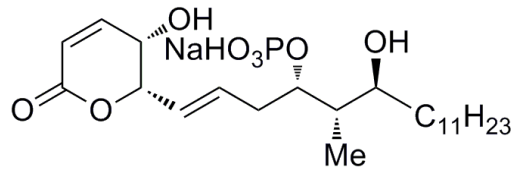
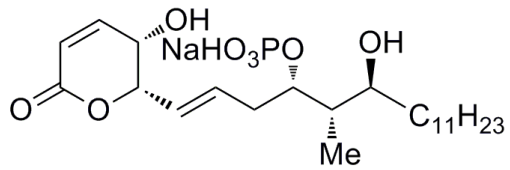


Solvent	CD3OD
Spectrometer Frequency	600.13
Nucleus	1H



65

Solvent	CD3OD
Spectrometer Frequency	150.90
Nucleus	13C



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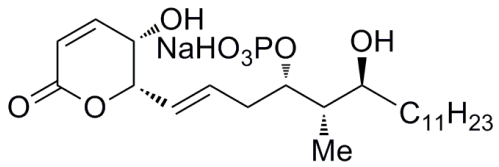
Solvent	CD3OD
Spectrometer Frequency	161.97
Nucleus	31P



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