Supporting Information

Synthetic studies toward marine metabolite prorocentin-4: Synthesis of the C1–C23 fragment

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Experimental section

General methods

All the air and moisture sensitive reactions were carried out under inert atmosphere (nitrogen or argon). Oven-dried glass apparatus were used to perform all the reactions. Freshly distilled anhydrous solvents were used for air and moisture sensitive reactions. Commercially available reagents were used as such. Purification of compounds was carried out via column chromatography by using silica gel (60-120 or 100-200 mesh) packed in glass columns. ^{1}H NMR and ^{13}C NMR were recorded in $CDCl_3$ solvent on 300 MHz, 400 MHz, 500 MHz, 700 MHz and 75 MHz,100MHz, 125 MHz spectrometer, respectively, using TMS as an internal standard. Chemical shifts are measured as ppm values relative to internal $CDCl_3$ δ 7.26 or TMS δ 0.0 for ^{1}H NMR and $CDCl_3$ δ 77 for ^{13}C NMR. In 1H NMR multiplicity defined as: s = singlet; d = doublet; t = triplet; q = quartet; dd = doublet of doublet; ddd = doublet of double of doublet; dt = doublet of triplet; m = multiplet; brs = broad singlet. Optical rotation values were recorded on Horiba sepa 300 polarimeter using a 2 mL cell with a 10 mm path length. FTIR spectra were recorded on Alpha (Bruker) infrared Spectrophotometer. High resolution mass spectra (HRMS) [ESI+] were obtained using either a TOF or a double focusing spectrometer. The diastereomeric excess of the products was measured by HPLC using Shimadzu LC-20AT series with XDB C18, 150 × 4.6, 5U column. Mass spectra were recorded on Micro Mass VG-7070H mass spectrometer for ESI and EI are given in mass units (*m/z*). High-resolution mass spectra (HRMS) [ESI] were obtained using either a TOF or a double focusing spectrometer.

Spectral data for all compounds

(4*S*,5*S*,*E*)-ethyl 7-(benzyloxy)-5-((*tert*-butyldimethylsilyl)oxy)-4-methylhept-2-enoate (13): To an ice-cooled solution of 2-(iodooxy)benzoic acid (2.3 g, 8.27 mmol) in anhydrous CH_3CN (10 mL) was added a solution of alcohol **7** (2.0 g, 5.91 mmol). The mixture was refluxed for 1 h, and then allowed to cool to RT. The solvent was removed under reduced pressure and the unstable crude aldehyde product was used directly for the next step without further purification by column chromatography.

The crude product was immediately dissolved in C_6H_6 (20 mL), and stable two-carbon Wittig yilide (2.5 g, 7.09 mmol) was added. The reaction mixture was refluxed for 3 h and then allowed to cool to RT. The solvent was removed under reduced pressure, and the compound was purified by silica gel column chromatography (5% EtOAc/hexane) to provide **13** (1.92 g, 80%) as pale yellow oil. $[\alpha]_D^{25}$: −6.8 (*c* = 1.2, $CHCl_3$); **IR (neat)**: 2930, 2856, 1721, 1459, 1047 cm^{-1}; **^{1}H NMR (300 MHz, $CDCl_3$)**: δ 7.31-7.18 (m, 5H), 5.58-5.51 (m, 2H), 4.42 (ABq, *J* = 17.3, 11.3 Hz, 2H), 4.06-3.96 (m, 2H), 3.73-3.63 (m, 1H), 3.48-3.40 (m, 2H), 2.28-2.17 (m, 1H), 1.77-1.45 (m, 2H), 0.81 (s, 9H), 0.76 (d, *J* = 6.8Hz, 3H), 0.04 (s, 6H). **^{13}C NMR ($CDCl_3$, 75 MHz)**: δ 138.4, 132.1, 130.1, 128.2, 127.5, 127.4, 72.8, 72.5, 67.4, 63.5, 38.6, 34.6, 25.8, 18.0, 14.4, −4.4, −4.5. HRMS (ESI) m/z calced for $C_{24}H_{40}O_4NaSi$ $[M+Na]^+$ = 443.2588, found = 443.2591.

(4*S*,5*S*,*E*)-7-(benzyloxy)-5-((*tert*-butyldimethylsilyl)oxy)-4-methylhept-2-en-1-ol (13a): To a solution of **13** (1.7 g, 4.19 mmol) in CH_2Cl_2 (20 mL) was added 8.4 mL of DIBAL-H (1.6 M in hexane, 13.4 mmol) at 0 °C. The solution was stirred for 1 h and quenched by addition of saturated Na/K tartrate at 0 °C. The solution was warmed to room temperature and stirred for 3 h until two clear layers were observed. The layers were separated, and the aqueous layer was further extracted with CH_2Cl_2 (2 × 20 mL). The combined organic layers were dried over anhydrous Na_2SO_4, and solvent was evaporated under reduced pressure. The crude product was purified by silica gel column chromatography (10% EtOAc/ hexane) to provide **13a** (1.4 g, 95%) as colorless oil. $[\alpha]_D^{25}$: −5.4 (*c* =

1.0, $CHCl_3$); **IR (neat)**: 3422, 2587, 1629, 1252, 1094 cm^{-1}; **^{1}H NMR (300 MHz, $CDCl_3$)**: δ 7.35-7.24 (m, 5H), 5.70 (dd, J = 15.5, 7.0 Hz, 1H), 5.62-5.55 (m, 1H), 4.46 (ABq, J = 25.1, 11.9 Hz, 2H), 4.06 (d, J = 5.9 Hz, 2H), 3.77-3.68 (m, 1H), 3.54-3.47 (m, 2H), 2.33-2.27 (m, 1H), 1.79-1.71 (m, 1H), 1.68-1.60 (m, 1H), 0.96 (d, J = 7.0 Hz, 3H), 0.87 (s, 9H), 0.03 (s, 3H), 0.02 (s, 3H). **^{13}C NMR ($CDCl_3$, 75 MHz)**: δ 138.3, 134.8, 128.8, 128.2, 127.6, 127.4, 72.9, 72.8, 67.0, 63.7, 41.7, 33.4, 25.8, 18.0, 15.2, −4.3, −4.6. HRMS (ESI) m/z calced for $C_{21}H_{37}O_3Si$ $[M+H]^+$ = 365.2512, found = 365.2516.

((2*R*,3*R*)-3-((2*S*,3*S*)-5-(benzyloxy)-3-((*tert*-butyldimethylsilyl)oxy)pentan-2-yl)oxiran-2-yl)methanol (14): To a freshly flame-dried, double-necked roundbottom flask that was equipped with activated molecular sieves (4 Å, ca. 3 g) and dry CH_2Cl_2 (20 mL) at –20 °C were added $Ti(OiPr)_4$ (0.20 mL, 0.71 mmol) and l-(-)-di Ethyl tartrate (0.18 g, 0.71 mmol), and the mixture was stirred for 30 min. To the reaction was added allyl alcohol **13a** (1.3 g, 3.57 mmol) followed by a 30 min interval, and then tert-butyl hydroperoxide (TBHP, 5 m solution in toluene, 1.1 mL, 5.35 mmol) was added. The stirring was continued until the reaction was complete (8 h). The mixture was warmed to 0 °C and then filtered through Celite. The filtrate was quenched with water (10 mL) and a 15% aqueous NaOH solution (1mL), and the resulting mixture was stirred vigorously for 1 h. The biphasic solution was separated, and the aqueous layer was extracted with CH_2Cl_2 (2 × 10 mL). The combined organic extracts were dried with anhydrous Na_2SO_4 and concentrated under vacuum. The crude residue was purified by column chromatography (30% EtOAc/hexane) to afford the pure epoxide **14** (1.26 g, 93%) as a colorless oil; $[\alpha]_D^{25}$: –30.7 (c = 1.2, $CHCl_3$); **IR (neat)**: 3447, 2932, 1641, 1253, 1100 cm^{-1}; **^{1}H NMR (400 MHz, $CDCl_3$)**: δ 7.38-7.27 (m, 5H), 4.53-4.44 (m, 3H), 4.02-3.97 (m, 1H), 3.92 (dd, J = 12.5, 2.4 Hz, 1H), 3.64-3.51 (m, 2H), 3.48 (t, J = 6.7 Hz, 1H), 3.0-2.87 (m, 2H), 1.98-1.84 (m, 1H), 1.81 (q, J = 6.7 Hz, 1H), 1.31 (d, J = 6.2 Hz, 3H), 0.89 (s, 9H), 0.08 (s, 3H), 0.06 (s, 3H). **^{13}C NMR ($CDCl_3$, 75 MHz)**: δ 138.4, 128.3, 127.5, 127.4, 72.9, 72.0, 66.9, 61.8, 57.6, 57.5, 40.4, 34.6, 25.8, 18.1, 9.8, −4.4, −4.6. HRMS (ESI) m/z calced for $C_{21}H_{37}O_4Si$ $[M+H]^+$ = 381.2455, found = 381.2455.

(2*S*,4*S*,5*S*)-7-(benzyloxy)-5-((*tert*-butyldimethylsilyl)oxy)-4-methylheptane-1,2-diol (14a): To a solution of **14** (1.0 g, 2.63 mmol) in CH_2Cl_2 (10 mL) was added 4.93 mL of DIBAL-H (1.6 M in hexane, 7.89 mmol) at 0 °C. The solution was stirred for 1 h and quenched by addition of saturated Na/K tartrate at 0 °C. The solution was warmed to room temperature and stirred for 3 h until two clear layers were observed. The layers were separated, and the aqueous layer was further extracted with CH_2Cl_2 (2 × 10 mL). The combined organic layers were dried over anhydrous Na_2SO_4, and solvent was evaporated under reduced pressure. The crude product was purified by silica gel column chromatography (10% EtOAc/ hexane) to provide **14a** (0.95 g, 95%) as colorless oil. $[\alpha]_D^{25}$: +5.0 (c = 1.1, $CHCl_3$); **IR (neat)**: 3408, 2930, 1461, 1074, 771 cm^{-1}; **^{1}H NMR (400 MHz, $CDCl_3$)**: δ 7.39-7.27 (m, 5H), 4.51 (d, J = 12.0 Hz, 1H), 4.46 (d, J = 11.7 Hz, 1H), 4.07-3.99 (m, 1H), 3.85-3.36 (m, 5H), 1.95-1.53 (m, 5H), 0.94-0.83 (m, 12H), 0.10 (s, 3H), 0.06 (s, 3H). **^{13}C NMR ($CDCl_3$, 75 MHz)**: δ 138.2, 128.2, 127.6, 127.4, 73.7, 72.8, 70.9, 67.2, 67.0, 35.9, 34.6, 31.9, 25.8, 17.9, 14.1, −4.3, −4.9. HRMS (ESI) m/z calced for $C_{21}H_{39}O_4Si$ $[M+H]^+$ = 383.2619, found = 383.2612.

(((2*S*,3*S*)-5-(benzyloxy)-2-methyl-1-((*S*)-oxiran-2-yl)pentan-3-yl)oxy)(*tert*-butyl)dimethylsilane (8): To a stirred solution of 60% sodium hydride dispersion in mineral oil (0.11 g, 4.59 mmol) in THF was added the diol **14a** (0.8 g, 2.09 mmol) followed by tosyl-imidazole (0.92 g, 4.18 mmol), and the mixture was stirred for 30 min at 0 °C. After completion of reaction, water was added and extracted with EtOAc (3 × 10 mL). The combined organic fraction was dried over anhydrous Na_2SO_4, and solvent was removed under reduced pressure. The residue was purified on silica gel column chromatography (10% EtOAc/hexane) to afford the epoxide **8** (0.60 g, 80%) as colorless oil. $[\alpha]_D^{25}$:

+10.3 (*c* = 1.0, $CHCl_3$); **IR (neat)**: 2955, 1463, 1253, 1097, 837 cm^{-1}; **^{1}H NMR (400 MHz, $CDCl_3$)**: δ 7.36-7.26 (m, 5H), 4.49 (ABq, *J* = 20.3, 11.8 Hz, 2H), 3.87-3.72 (m, 1H), 3.54-3.48 (m, 2H), 2.96-2.88 (m, 1H), 2.78 (dd, *J* = 5.1, 3.9 Hz, 1H), 2.46 (dd, *J* = 5.1, 2.6 Hz, 1H), 1.89-1.61 (m, 3H), 1.34-1.17 (m, 2H), 0.92 (t, *J* = 6.8 Hz, 3H), 0.87 (s, 9H), 0.04 (s, 3H), 0.03 (s, 3H). **^{13}C NMR ($CDCl_3$, 75 MHz)**: δ 138.4, 128.3, 127.6, 127.4, 72.9, 72.8, 67.3, 51.4, 47.9, 36.1, 34.9, 32.8, 25.8, 18.0, 14.7, −4.3, −4.6. HRMS (ESI) m/z calced for $C_{21}H_{37}O_3Si$ $[M+H]^+$ = 365.2509, found = 365.2506.

((2*R*,4*S*,5*S*)-5-(2-(benzyloxy)ethyl)-4-methyltetrahydrofuran-2-yl)methanol (15) : a To a solution that was cooled in an ice bath of epoxide **8** (0.55 g, 1.51 mmol) in CH_2Cl_2 (8 mL) was added *p*-TSA (0.05 g, 0.30 mmol) as a solid. The reaction mixture was stirred at room temp. for 3 h and then was quenched with solid $NaHCO_3$ (1 g). The resulting mixture was filtered, and the filtrate was concentrated under reduced pressure. The crude product was purified by column chromatography (60% EtOAc/hexane) to afford comound **15** (0.36 g, 95%) as a colorless oil; $[\alpha]_D^{25}$: +3.6 (*c* = 0.12, $CHCl_3$); **IR (neat)**: 3417, 2929, 1453, 1092 cm^{-1}; **^{1}H NMR (300 MHz, $CDCl_3$)**: δ 7.36-7.28 (m, 5H), 4.54-4.50 (m, 2H), 4.15-3.98 (m, 1H), 3.90-3.77 (m, 1H), 3.70-3.46 (m, 4H), 2.44-2.27 (m, 1H), 2.03-1.89 (m, 1H), 1.75-1.65 (m, 3H), 0.96 (d, *J* = 7.0 Hz, 3H). **^{13}C NMR ($CDCl_3$, 75 MHz)**: δ 138.4, 128.2, 127.5, 127.4, 78.5, 77.2, 72.9, 67.8, 65.4, 36.1, 35.3, 30.6, 14.1. HRMS (ESI) m/z calced for $C_{15}H_{23}O_3$ $[M+H]^+$ = 251.1643, found = 251.1641.

(*E*)-ethyl 3-((2*R*,4*S*,5*S*)-5-(2-(benzyloxy)ethyl)-4-methyltetrahydrofuran-2-yl)acrylate (16): To an ice-cold solution of 2-(iodooxy)benzoic acid (0.47 g, 1.68 mmol) in anhydrous MeCN (5 mL) was added a solution of alcohol **15** (0.3 g, 1.20 mmol). The mixture was heated at reflux temperature for 1 h and then allowed to cool to r.t. The solvent was removed under reduced pressure and the unstable crude aldehyde product was used directly in the next step without purification by column chromatography.

A solution of triethyl phosphonoacetate (0.28 g, 1.44 mmol) in THF (5 mL) was added slowly to a stirred solution of NaH (0.05 g, 2.4 mmol) in THF (5 mL) at 0 °C under N_2. The mixture was stirred at 0 °C for 30 min, after which a solution of the crude aldehyde in THF (10 mL) was added dropwise over 10 min at 0 °C. The resulting mixture was stirred at 0 °C for a further 30 min. The mixture was quenched with sat. NH_4Cl solution (5 mL), and the product extracted with EtOAc (3 × 5 mL). The combined extracts were dried over Na_2SO_4. The solvent was removed under reduced pressure and the crude residue was purified by silica gel column chromatography (10% EtOAc–hexane) to afford the (*E*)-alkene ester **16** (0.3 g, 85% over 2 steps) as a colorless liquid. $[\alpha]_D^{25}$: +7.2 (*c* = 1.0, $CHCl_3$); **IR (neat)**: 2964, 1716, 1370, 1299, 786 cm^{-1}; **^{1}H NMR (300 MHz, $CDCl_3$)**: δ 7.36-7.26 (m, 5H), 6.90 (dd, *J* = 15.5, 4.9 Hz, 1H), 6.01 (dd, *J* = 15.5, 1.6 Hz, 1H), 4.68-4.62 (m, 1H), 4.53 (s, 2H), 4.19 (q, *J* = 7.2 Hz, 2H), 4.14-4.07 (m, 1H), 3.69-3.59 (m, 2H), 2.38-2.26 (m, 1H), 1.88 (dd, *J* = 7.4, 5.5 Hz, 2H), 1.80-1.73 (m, 2H), 1.29 (t, *J* = 7.1 Hz, 3H), 0.95 (d, *J* = 7.0 Hz, 3H). **^{13}C NMR ($CDCl_3$, 75 MHz)**: δ 166.6, 145.5, 138.4, 128.3, 127.6, 127.5, 119.4, 78.9, 75.5, 73.1, 68.0, 60.3, 39.6, 35.8, 31.0, 14.2, 13.9. HRMS (ESI) m/z calced for $C_{19}H_{25}O_4$ $[M-H]^+$ = 317.1750, found = 317.1747.

(*E*)-3-((2*R*,4*S*,5*S*)-5-(2-(benzyloxy)ethyl)-4-methyltetrahydrofuran-2-yl)prop-2-en-1-ol (16a): To a solution of **16** (0.25 g, 0.78 mmol) in CH_2Cl_2 (5 mL) was added 1.5 mL of DIBAL-H (1.6 M in hexane, 2.34 mmol) at 0 °C. The solution was stirred for 1 h and quenched by addition of saturated Na/K tartrate at 0 °C. The solution was warmed to room temperature and stirred for 3 h until two clear layers were observed. The layers were separated, and the aqueous layer was further extracted with CH_2Cl_2 (2 × 5 mL). The combined organic layers were dried over anhydrous Na_2SO_4, and solvent was evaporated under reduced pressure. The crude product was purified by silica gel column chromatography (10% EtOAc/ hexane) to provide **16a** (0.20 g, 95%) as colorless oil. $[\alpha]_D^{25}$: +4.0 (*c* =

1.0, $CHCl_3$); **IR (neat)**: 3444, 2958, 1636, 1095 cm^{-1}; **^{1}H NMR (300 MHz, $CDCl_3$)**: δ 7.37-7.27 (m, 5H), 5.86-5.78 (m, 1H), 5.75-5.68 (m, 1H), 4.54-4.48 (m, 3H), 4.14-4.12 (m, 1H), 4.09 (dt, *J* = 10.0, 5.0 Hz, 1H), 3.68-3.49 (m, 3H), 2.35-2.24 (m, 1H), 1.81-1.61 (m, 4H), 0.94 (d, *J* = 7.0 Hz, 3H). **^{13}C NMR ($CDCl_3$, 125 MHz)**: δ 138.4, 133.1, 129.6, 128.3, 127.6, 127.4, 78.6, 76.8, 73.0, 68.1, 62.8, 40.2, 36.0, 31.0, 14.0. HRMS (ESI) m/z calced for $C_{17}H_{25}O_3$ $[M+H]^+$ = 277.1804, found = 277.1814.

((2*R*,3*R*)-3-((2*R*,4*S*,5*S*)-5-(2-(benzyloxy)ethyl)-4-methyltetrahydrofuran-2-yl)oxiran-2-yl)methanol (17): To a freshly flame-dried, double-necked roundbottom flask that was equipped with activated molecular sieves (4 Å, ca. 3 g) and dry CH_2Cl_2 (5 mL) at –20 °C were added Ti(O*i*Pr)$_4$ (0.05 mL, 0.19 mmol) and l-(-)-di Ethyl tartrate (0.03 g, 0.19 mmol), and the mixture was stirred for 30 min. To the reaction was added allyl alcohol **16a** (0.18 g, 0.65 mmol) followed by a 30 min interval, and then tert-butyl hydroperoxide (TBHP, 5 m solution in toluene, 0.19 mL, 0.97 mmol) was added. The stirring was continued until the reaction was complete (8 h). The mixture was warmed to 0 °C and then filtered through Celite. The filtrate was quenched with water (2 mL) and a 15% aqueous NaOH solution (2 mL), and the resulting mixture was stirred vigorously for 1 h. The biphasic solution was separated, and the aqueous layer was extracted with CH_2Cl_2 (2 x 5 mL). The combined organic extracts were dried with anhydrous Na_2SO_4 and concentrated under vacuum. The crude residue was purified by column chromatography (30% EtOAc/hexane) to afford the pure epoxide **17** (0.17 g, 90%) as a colorless oil; $[\alpha]_D^{25}$: –4.8 (*c* = 1.2, $CHCl_3$); **IR (neat)**: 3447, 2962, 1458, 771 cm^{-1}; **^{1}H NMR (400 MHz, $CDCl_3$)**: δ 7.36-7.28 (m, 5H), 4.51 (s, 2H), 4.08-4.02 (m, 2H), 3.93 (dd, *J* = 12.6, 2.3 Hz, 1H), 3.68-3.55 (m, 3H), 3.07-3.04 (m, 1H), 3.03 (dd, *J* = 4.4, 2.2 Hz, 1H), 2.34-2.27 (m, 1H), 1.96 (dt, *J* = 14.0, 7.0 Hz, 1H), 1.79-1.70 (m, 3H), 0.93 (d, *J* = 7.0 Hz, 3H). **^{13}C NMR ($CDCl_3$, 75 MHz)**: δ 138.4, 128.3, 127.6, 127.5, 79.2, 75.3, 73.0, 67.9, 61.2, 57.2, 56.5, 36.0, 35.7, 30.8, 13.9. HRMS (ESI) m/z calced for $C_{17}H_{25}O_4$ $[M+H]^+$ = 293.1748, found = 293.1747.

(1*S*,2*S*)-1-((2*R*,4*S*,5*S*)-5-(2-(benzyloxy)ethyl)-4-methyltetrahydrofuran-2-yl)-2-methylpropane-1,3-diol (9): To a stirred suspension of CuI (0.29 g, 1.53 mmol) in dry Et_2O (5 mL) was slowly added methyl lithium (1.9 mL, 1.6 M, 3.06 mmol) in ether at 0 °C under nitrogen atmosphere, and the resulting solution was stirred for 15 min at 0 °C. Epoxy alcohol **17** (0.15 g, 0.51 mmol) in dry Et_2O (3 mL) was then added dropwise at −40 °C. Once the addition was completed, the reaction mixture was stirred at 0 °C for 3 h. The reaction was quenched by the addition of saturated aqueous NH_4Cl. The mixture was filtered through a Celite pad, and the salts were washed several times with Et_2O. The organic layer was washed with brine, dried over Na_2SO_4, and concentrated under reduced pressure to provide a 3:1 mixture of the regioisomeric diols. The crude mixture was dissolved in 10% aqueous THF (5 mL), and $NaIO_4$ was added at 0 °C to cleave the 1,2-diol. The reaction was completed in 1 h. After the layers were separated, the aqueous layer was extracted with Et_2O. The organic layer was dried over anhydrous Na_2SO_4, and solvent was removed under reduced pressure. The crude residue was purified on silica gel column chromatography (70% EtOAc/hexane) to provide the desired diol **9** (0.12 g, 80%) as a yellow oil. $[\alpha]_D^{25}$: +18.1 (*c* = 1.2, $CHCl_3$); **IR (neat)**: 3448, 1634, 771 cm^{-1}; **^{1}H NMR (400 MHz, $CDCl_3$)**: δ 7.36-7.28 (m, 5H), 4.51 (s, 2H), 4.17-4.01 (m, 3H), 3.72 (dd, *J* = 8.8, 3.8 Hz, 1H), 3.69-3.57 (m, 3H), 2.34-2.24 (m, 1H), 1.79-1.71 (m, 4H), 1.60-1.53 (m, 1H), 0.94 (d, *J* = 7.0 Hz, 3H), 0.85 (d, *J* = 6.9 Hz, 3H). **^{13}C NMR ($CDCl_3$, 75 MHz)**: δ 138.4, 128.3 (2C), 127.6 (2C), 127.5, 78.9, 78.1, 76.7, 73.1, 67.9, 65.2, 40.2, 37.3, 35.8, 30.9, 14.1, 11.8 HRMS (ESI) m/z calced for $C_{18}H_{29}O_4$ $[M+H]^+$ = 309.2061, found = 309.2060.

(5*S*,6*S*)-5-((2*R*,4*S*,5*S*)-5-(2-(benzyloxy)ethyl)-4-methyltetrahydrofuran-2-yl)-2,2,3,3,6,9,9,10,10-nonamethyl-4,8-dioxa-3,9-disilaundecane (18): 2, 6-Lutidine (0.1 ml, 0.78 mmol) was added to a solution of alcohol **9** (0.08 g, 0.26 mmol) in dry CH_2Cl_2 (5 mL). The reaction mixture was stirred for 10 min at room temperature, followed by dropwise addition of TBSOTf (0.12 ml, 0.52 mmol). The

mixture was stirred for 1 h at room temperature and quenched by addition of water. The aqueous layer was extracted with CH_2Cl_2, dried over Na_2SO_4, and concentrated. The crude reaction mixture was purified by silica gel column chromatography (5% EtOAc/hexane) to provide the desired product **18** (0.13 g, 93%) as a colorless oil. $[\alpha]_D^{25}$: +10.5 (*c* = 1.2, $CHCl_3$); **IR (neat)**: 2956, 1465, 1253, 772 cm^{-1}; **^{1}H NMR (400 MHz, $CDCl_3$)**: δ 77.37-7.28 (m, 5H), 4.51 (s, 2H), 4.14-4.01 (m, 1H), 3.72-3.51 (m, 5H), 2.34- 2.15 (m, 1H), 2.02-1.85 (m, 1H), 1.80-1.60 (m, 4H), 0.99-0.81 (m, 24H), 0.12-0.04 (m, 12H). **^{13}C NMR ($CDCl_3$, 75 MHz)**: δ 138.4, 128.3 (2C), 127.6 (2C), 127.5, 78.9, 78.1, 77.7, 73.0, 67.8, 65.1, 40.1, 37.0, 36.3, 30.7, 25.9, 25.6, 18.1, 17.9, 14.2, 11.8, −3.6 (2C), −4.2, −4.4. HRMS (ESI) m/z calced for $C_{30}H_{56}NaO_4Si_2$ $[M+Na]^+$ = 559.3615, found = 559.3614.

(2*S*,3*S*)-3-((2*R*,4*S*,5*S*)-5-(2-(benzyloxy)ethyl)-4-methyltetrahydrofuran-2-yl)-3-((*tert*-butyldimethylsilyl)oxy)-2-methylpropan-1-ol (19): To a stirred solution of **18** (0.08 g, 0.15 mmol) in MeOH (2 mL) was added PPTS, and the mixture was stirred for 1 h at 0 °C. After completion of reaction, it was quinched with solid $NaHCO_3$, and methanol was removed under reduced pressure. Water was added and extracted with EtOAc (3 × 5 mL). The combined organic layer was dried over anhydrous Na_2SO_4 and concentrated under vacuum. The residue was purified on silica gel column chromatography (20% EtOAc/hexane) to provide **19** (0.058 g, 93%) as colorless oil. $[\alpha]_D^{25}$: +5.0 (*c* = 0.8, $CHCl_3$); **IR (neat)**: 3447, 2955, 1461, 1088, 773 cm^{-1}; **^{1}H NMR (400 MHz, $CDCl_3$)**: δ 7.36-7.28 (m, 5H), 4.50 (ABq, *J* = 14.0, 11.7 Hz, 2H), 4.10-4.02 (m, 2H), 3.66-3.51 (m, 5H), 2.29-2.21 (m, 1H), 2.0-1.94 (m, 1H), 1.92-1.85 (m, 1H), 1.76-1.69 (m, 3H), 0.98 (d, *J* = 7.0 Hz, 3H), 0.92 (d, *J* = 6.1 Hz, 3H), 0.89 (s, 9H), 0.08 (s, 6H). **^{13}C NMR ($CDCl_3$, 75 MHz)**: δ 138.4, 128.3, 127.6, 127.5, 78.9, 78.1, 76.7, 73.1, 67.9, 65.2, 40.2, 37.3, 35.8, 30.1, 25.9, 18.0, 14.1, 11.8, −4.2, −4.4. HRMS (ESI) m/z calced for $C_{24}H_{43}O_4Si$ $[M+H]^+$ = 423.2931, found = 423.2928.

diethyl ((3*R*,4*S*)-4-((2*R*,4*S*,5*S*)-5-(2-(benzyloxy)ethyl)-4-methyltetrahydrofuran-2-yl)-4-((*tert*-butyldimethylsilyl)oxy)-3-methyl-2-oxobutyl)phosphonate (3): Dess–Martin periodinane (0.04 g, 0.11 mmol) and $NaHCO_3$ (7 mg, 0.18 mmol) were added to a solution of alcohol **19** (0.04 g, 0.094 mmol) in CH_2Cl_2 (5 mL) at 0 °C. After stirring for 30 min, the reaction was warmed to 25 °C for 1 h. The reaction mixture was poured into a solution of $Na_2S_2O_3$ (3 mL), $NaHCO_3$ (5 mL) and Et_2O (5 mL), and then stirred for 30 min. The organic layer was separated and the aq layer was extracted with Et_2O (2 × 5 mL). The combined organic layers were washed with $Na_2S_2O_3$ (5 mL), $NaHCO_3$ (5 mL) and brine (5 mL), dried over anhydrous Na_2SO_4, filtered and concentrated under reduced pressure to provide the corresponding aldehyde as an oil. This aldehyde was used immediately in the next reaction without purification.

To a dry round-bottomed flask equipped with an addition funnel, under Ar, was added dimethyl methylphosphonate (0.04 mL, 0.28 mmol) in THF (5 mL). The solution was cooled to –78 °C and *n*-BuLi (0.15 mL, 1.6 M, 0.23 mmol) was added dropwise. The resulting white suspension was stirred for 1 h at –78 °C, after which the crude aldehyde in THF (8 mL) was added. The mixture was stirred for 1 h at –78 °C and then quenched with sat. NH_4Cl solution and warmed to r.t. The layers were separated and the aq layer was extracted with Et_2O (3 × 10 mL). The combined organic layers were washed with brine (10 mL), dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The crude product (0.05 g, 90%) was used immediately in the next reaction.

To a solution of the above crude material (0.05 g, 0.05 mmol) in CH_2Cl_2 (5 mL) were added Dess–Martin periodinane (0.03 g, 0.06 mmol) and $NaHCO_3$ (8 mg, 0.1mmol) at 0 °C. The mixture was stirred for 30 min at r.t., quenched with sat. $Na_2S_2O_3$-$NaHCO_3$ (5:1) solution, and stirred for 30 min at r.t. The layers were separated and the aq layer was extracted with CH_2Cl_2 (2 × 5 mL). The combined organic layers were dried over Na_2SO_4, filtered, and then concentrated under reduced pressure. The

crude product was purified via column chromatography (R_f = 0.4; hexane–EtOAc, 10:90) to afford ketone **3** (0.043 g, 81% over 3 steps) as a colorless liquid. $[\alpha]_D^{25}$: +2.4 (*c* = 0.5, $CHCl_3$); **IR (neat)**: 2930, 1710, 1640, 1253, 1023, 772 cm^{-1}; **^{1}H NMR (400 MHz, $CDCl_3$)**: δ 7.36-7.27 (m, 5H), 4.49 (ABq, *J* = 23.3, 15.7 Hz, 2H), 4.19-4.08 (m, 4H), 4.04 (dd, *J* = 6.2, 5.2 Hz, 1H), 3.97-3.89 (m, 1H), 3.56-3.47 (m, 2H), 3.27 (dd, *J* = 22.5, 14.0 Hz, 1H), 3.09 (dd, *J* = 21.8, 13.9 Hz, 1H), 2.88-2.82 (m, 1H), 2.36-2.21 (m, 2H), 2.07-1.94 (m, 1H), 1.70-1.60 (m, 3H), 1.32 (t, *J* = 7.0 Hz, 6H), 1.15 (d, *J* = 6.8 Hz, 3H), 0.89 (d, *J* = 7.0 Hz, 3H), 0.88 (s, 9H), 0.10 (s, 3H), 0.07 (s, 3H). **^{13}C NMR ($CDCl_3$, 75 MHz)**: δ 202.4, 138.4, 128.3, 127.6, 127.4, 78.4, 77.2, 76.3, 72.9, 67.9, 62.4, 51.6, 36.4, 35.9, 30.9, 29.6, 25.8, 17.9, 16.2, 14.1, 10.2, −4.5, −4.6 HRMS (ESI) m/z calced for $C_{29}H_{52}O_7PSi$ $[M+H]^+$ = 571.3218, found = 571.3218.

(*R*)-*tert*-butyl((1-((4-methoxybenzyl)oxy)but-3-yn-2-yl)oxy)dimethylsilane (10a): The compound **10** (2.5 g, 12.13 mmol) was dissolved in CH_2Cl_2 (10 mL), and then imidazole (1.65 g, 24.26 mmol) was added followed by TBDMSCl (2.24 g, 14.55 mmol). After 16 h the reaction was washed with water (1 × 10 mL), and the aqueous layer was extracted with CH_2Cl_2 (2 × 10 mL), dried over Na_2SO_4, and concentrated. Purification by silica gel chromatography (5% EtOAc/hexane) provided the silyl ether **10a** (3.5 g, 90%) as a yellow oil. $[\alpha]_D^{25}$: +15.4 (*c* = 1.2, $CHCl_3$); **IR (neat)**: 2931, 1513, 1249, 836 cm^{-1}; **^{1}H NMR (400 MHz, $CDCl_3$)**: δ 7.27-7.23 (m, 2H), 6.86 (d, *J* = 8.6 Hz, 2H), 4.53 (s, 2H), 3.81-3.76 (m, 4H), 3.57-3.49 (m, 2H), 2.39 (d, *J* = 2.1 Hz, 1H), 0.89 (s, 9H), 0.11 (d, *J* = 9.4 Hz, 3H), 0.08 (d, *J* = 6.1 Hz, 3H). **^{13}C NMR ($CDCl_3$, 75 MHz)**: δ 159.1, 129.2, 127.5, 113.7, 83.2, 74.0, 73.1, 72.9, 62.7, 55.2, 25.7, 18.2, −4.7, −4.9. HRMS (ESI) m/z calced for $C_{18}H_{32}O_3NSi$ $[M+NH_4]^+$ = 338.2146, found = 338.2146.

(*R*)-4-((*tert*-butyldimethylsilyl)oxy)-5-((4-methoxybenzyl)oxy)pent-2-yn-1-ol (11): A solution alkyne **10a** (2.0 g, 6.25 mmol) in dry THF (10 mL) was added dropwise to stirred solution of freshly prepared EtMgBr (prepared *in situ* from 0.3 g (12.5 mmol of Mg) and 0.92 mL (12.5 mmol) of ethyl bromide in 5 mL of dry THF) at 0 ^oC. After 1 h at rt para-formaldehyde (0.6 g) was added. The resulting mixture was further stirred for 3 h at rt and then quenched with saturated aqu. NH_4Cl solution. The organic layer was separated and aqueous layer was extracted with EtOAc (2 X 100 mL). The combined organic layers were washed with brine solution and dried over anhydrous Na_2SO_4, Concentrated and purified by silica-gel column chromatography (10% EtOAc/Hexane) provided alcohol **11** (1.96 g, 90%) as a liquid. $[\alpha]_D^{25}$: +15.0 (*c* = 1.1, $CHCl_3$); **IR (neat)**: 3421, 2930, 1513, 1250, 835 cm^{-1}; **^{1}H NMR (400 MHz, $CDCl_3$)**: δ 7.26 (d, *J* = 8.6 Hz, 12H), 6.89 (d, *J* = 8.5 Hz, 12H), 4.59-4.50 (m, 3H), 4.33 (dd, *J* = 3.0, 1.7 Hz, 1H), 4.28-4.25 (m, 1H), 3.81 (s, 3H), 3.63-3.50 (m, 2H), 0.91 (s, 9H), 0.13-0.09 (m, 6H). **^{13}C NMR ($CDCl_3$, 75 MHz)**: δ 159.4, 129.5, 129.2, 113.9, 83.4, 74.2, 73.1, 73.0, 63.0, 61.6, 55.2, 25.7, 18.2, −3.6, −5.1. HRMS (ESI) m/z calced for $C_{19}H_{31}O_4Si$ $[M+H]^+$ = 351.1992, found = 351.1992.

(*R*,*E*)-ethyl 6-((*tert*-butyldimethylsilyl)oxy)-7-((4-methoxybenzyl)oxy)hept-2-enoate (20): A 50 mL two-neck, round-bottomed flask was charged with $Pd(OH)_2/C$ (7 mol%). Benzene (5 mL) was added and a H_2 filled balloon was placed over the mixture for 30 min (to activate the catalyst). The balloon was removed and stirring was continued for 10 min, after which a solution of alcohol **11** (1.5 g, 4.28 mmol) in benzene (3 mL) was added. The reaction mixture was stirred for a further 60 min. After complete conversion of the alcohol into the corresponding aldehyde 5 (indicated by TLC), stable Wittig ylide (5.13 mmol) was added and the mixture was stirred at reflux temperature for 3 h. The reaction mixture was cooled r.t. and Concentrated and purified by silica-gel column chromatography (10% EtOAc/Hexane) provided alcohol **20** (1.60 g, 90%) as a liquid. $[\alpha]_D^{25}$: +16.6 (*c* = 1.0, $CHCl_3$); **IR (neat)**: 2938, 2857, 1720, 1515, 1251 cm^{-1}; **^{1}H NMR (400 MHz, $CDCl_3$)**: δ 7.24 (d, *J* = 8.6 Hz, 2H), 6.97 (dt, *J* = 15.5, 6.8 Hz, 1H), 6.87 (d, *J* = 8.6 Hz, 2H), 5.80 (dt, *J* = 15.7, 1.5 Hz,

1H), 4.44 (ABq, *J* = 16.0, 11.6 Hz, 2H), 4.18 (q, *J* = 7.0 Hz, 2H), 3.86-3.81 (m, 1H), 3.80 (s, 3H), 3.38 (dd, *J* = 9.4, 5.3 Hz, 1H), 3.30 (dd, *J* = 9.4, 5.9 Hz, 1H), 2.41-2.16 (m, 2H), 1.74-1.57 (m, 2H), 1.28 (t, *J* = 7.1 Hz, 3H), 0.87 (s, 9H), 0.04 (s, 3H), 0.03 (s, 3H). **^{13}C NMR ($CDCl_3$, 75 MHz)**: δ 166.6, 159.1, 140.2, 130.3, 129.2, 121.2, 113.7, 73.9, 72.9, 70.6, 60.1, 55.2, 32.9, 27.7, 25.8, 18.1, 14.2, −4.3, −4.8. HRMS (ESI) m/z calced for $C_{23}H_{42}O_5NSi$ $[M+NH_4]^+$ = 440.2820, found = 440.2826.

(*R*,*E*)-ethyl 6-hydroxy-7-((4-methoxybenzyl)oxy)hept-2-enoate (21): To a stirred solution of **20** (1.0 g, 2.37 mmol) in MeOH (5 mL) was added PPTS, and the mixture was stirred for 1 h at 0 °C. After completion of reaction, it was quinched with solid $NaHCO_3$, and methanol was removed under reduced pressure. Water was added and extracted with EtOAc (3 × 10 mL). The combined organic layer was dried over anhydrous Na_2SO_4 and concentrated under vacuum. The residue was purified on silica gel column chromatography (20% EtOAc/hexane) to provide **21** (0.67 g, 92%) as colorless oil. $[\alpha]_D^{25}$: +17.9 (*c* = 0.9, $CHCl_3$); **IR (neat)**: 3469, 2934, 1716, 1513, 1248 cm^{-1}; **^{1}H NMR (400 MHz, $CDCl_3$)**: δ 7.25 (d, *J* = 8.6 Hz, 2H), 6.96 (dt, *J* = 15.5, 6.8 Hz, 1H), 6.89 (d, *J* = 8.8 Hz, 2H), 5.83 (dt, *J* = 15.7, 1.6 Hz, 1H), 4.48 (s, 2H), 4.18 (q, *J* = 7.1 Hz, 2H), 3.81 (s, 3H), 3.80-3.77 (m, 1H), 3.47 (dd, *J* = 9.4, 3.2 Hz,1H), 3.30 (dd, *J* = 9.4, 7.6 Hz, 1H), 2.43-2.34 (m, 1H), 2.33-2.23 (m, 1H), 1.63-1.51 (m, 2H), 1.28 (t, *J* = 7.1 Hz, 3H). **^{13}C NMR ($CDCl_3$, 75 MHz)**: δ 166.5, 159.3, 148.4, 129.8, 129.3, 121.6, 113.8, 73.9, 73.0, 69.5, 60.1, 55.2, 31.3, 28.1, 14.2. HRMS (ESI) m/z calced for $C_{17}H_{25}O_5$ $[M+H]^+$ = 309.1702, found = 309.1712.

Ethyl 2-((2*R*,5*R*)-5-(((4-methoxybenzyl)oxy)methyl)tetrahydrofuran-2-yl)acetate (22): To a stirred solution of α,β-unsaturated ester **21** (0.5 g, 1.62 mmol) described above in MeOH (15 mL), a 40 wt% MeOH solution of Triton B (0.35 mL, 1.94 mmol) was added at r.t., and the mixture was stirred at r.t. for 15 min. After cooling to 0 °C, the mixture was diluted with sat. aq NH_4Cl (10 mL) and extracted with EtOAc (3 × 10 mL). The combined extracts were dried (Na_2SO_4) and concentrated. The residual oil was purified by column chromatography on silica gel (30 g; hexane–EtOAc, 9:1) to give 2,5-trans-tetrahydrofuran **22** (0.43 g. 92%). $[\alpha]_D^{25}$: −16.7 (*c* = 1.0, $CHCl_3$); **IR (neat)**: 2951, 1737, 1513, 1248, 1077 cm^{-1}; **^{1}H NMR (400 MHz, $CDCl_3$)**: δ 7.26 (d, *J* = 8.4 Hz, 2H), 6.87 (d, *J* = 8.7 Hz, 2H), 4.54-4.46 (m, 2H), 4.41-4.35 (m, 1H), 4.23-4.17 (m, 1H), 3.80 (s, 3H), 3.68 (s, 3H), 3.46-3.39 (m, 2H), 2.70-2.64 (m, 1H), 2.50-2.43 (m, 1H), 2.17-2.06 (m, 1H), 2.04-1.92 (m, 1H), 1.75-1.57 (m, 2H). **^{13}C NMR ($CDCl_3$, 75 MHz)**: δ 171.6, 159.1, 130.4, 129.3, 113.7, 77.8, 75.4, 72.9, 72.3, 55.2, 51.6, 40.4, 31.5, 28.4. HRMS (ESI) m/z calced for $C_{17}H_{25}O_5$ $[M+H]^+$ = 309.1712, found = 309.1713.

(2*R*,5*R*)-2-(((4-methoxybenzyl)oxy)methyl)-5-((*E*)-penta-2,4-dien-1-yl)tetrahydrofuran (23): To a solution of **22** (0.1 g, 0.32 mmol) in CH_2Cl_2 (5 mL) was added 0.27 mL of DIBAL-H (1.6 M in hexane, 0.41 mmol) at −78 °C. The solution was stirred for 1 h and quenched by addition of saturated Na/K tartrate at 0 °C. The solution was warmed to room temperature and stirred for 3 h until two clear layers were observed. The layers were separated, and the aqueous layer was further extracted with CH_2Cl_2 (2 × 20 mL). The combined organic layers were dried over anhydrous Na_2SO_4, and solvent was evaporated under reduced pressure. The unstable crude aldehyde product was used directly for the next step without further purification by column chromatography.

Allyl tri butyl phophine (0.37 g, 1.16 mmol) was added to a 10-mL flask and dried under high vacuum for 1 h. After freshly dried THF (5 mL) was added under Ar, *n*-BuLi (0.34 mL of a 2.5 M solution in THF), 0.87 mmol) was added dropwise. After being stirred for 1 h at 23 °C, the deep-red suspension was cooled to −78°C, and a precooled (−78 °C) solution of above unstable aldehyde in THF (5 mL) was added through a cannula. After being stirred for 8 h at −78 °C, the mixture was warmed to 23 °C and stirred for 8 h. During that time, a large amount of pale-white solid separated. The reaction was

quenched with satd aq NH_4Cl at 0 °C and stirred vigorously for 30 min. The solid was filtered off through Celite and washed thoroughly with Et_2O. The organic phase was separated, and the aq phase was extracted with Et_2O. The combined organic phase was washed with brine, dried over $MgSO_4$, filtered, and concentrated. The residue was purified by flash chromatography (SiO_2, hexane/EtOAc = 50/1 - 30/1) to provide the desired olefinic product **23** as a nearly colorless oil (0.07 g, 85% yield based on BuLi). $[\alpha]_D^{25}$: +4.9 (*c* = 1.2, $CHCl_3$); **IR (neat)**: 2923, 1512, 1247, 1082 cm^{-1}; **^{1}H NMR (400 MHz, $CDCl_3$)**: δ 7.28-7.25 (m, 2H), 6.87 (d, *J* = 8.5 Hz, 2H), 6.35-6.26 (m, 1H), 6.13-6.05 (m, 1H), 5.70 (dt, *J* = 15.0, 7.3 Hz, 1H), 5.10 (dd, *J* = 16.9 Hz, 1H), 4.98 (dd, *J* = 10.0 Hz, 1H), 4.53 (d, *J* = 11.7 Hz, 1H), 4.48 (d, *J* = 11.9 Hz, 1H), 4.22-4.16 (m, 1H), 4.09-4.0 (m, 1H), 3.80 (s, 3H), 3.49-3.39 (m, 2H), 2.45-2.35 (m, 1H), 2.30-2.23 (m, 1H), 2.03-1.89 (m, 2H), 1.70-1.62 (m, 1H), 1.58-1.49 (m, 1H). **^{13}C NMR ($CDCl_3$, 75 MHz)**: δ 159.1, 137.1, 133.0, 130.9, 130.4, 129.3, 115.3, 113.7, 78.8, 77.8, 77.2, 72.9, 55.2, 38.7, 31.1, 28.5. HRMS (ESI) m/z calced for $C_{18}H_{25}O_3$ $[M+H]^+$ = 289.1801, found = 289.1798.

((2*R*,5*R*)-5-((*E*)-penta-2,4-dien-1-yl)tetrahydrofuran-2-yl)methanol (4a): To a solution of the compound **23** (0.05 g, 0.17 mmol) in CH_2Cl_2 (10 mL) and water (1 mL), DDQ (0.05 g, 0.20 mmol) was added at 0 °C and allowed to stir for 2 h at room temperature. The reaction mixture was quenched with saturated $NaHCO_3$ solution (5 mL) and diluted with CH_2Cl_2 (10 mL). The two layers were separated and the aqueous layer was extracted with CH_2Cl_2 (3 x 5 mL). The combined organic layer was washed with brine (2 x 5 mL), dried over anhydrous Na_2SO_4 and evaporated to give the crude product which was a purified by column chromatography (5% EtOAc/Hexane) to provide the desired alcohol **4a** (0.024 g, 85%) as a colourless oil. $[\alpha]_D^{25}$: +10.9 (*c* = 1.2, $CHCl_3$); **IR (neat)**: 3423, 2825, 1517, 1238, 1072 cm^{-1}; **^{1}H NMR (400 MHz, $CDCl_3$)**: δ 6.35-6.26 (m, 1H), 6.13-6.05 (m, 1H), 5.70 (dt, *J* = 15.0, 7.3 Hz, 1H), 5.10 (dd, *J* = 16.9 Hz, 1H), 4.98 (dd, *J* = 10.0 Hz, 1H), 4.53 (d, *J* = 11.7 Hz, 1H), 4.48 (d, *J* = 11.9 Hz, 1H), 4.22-4.16 (m, 1H), 4.09-4.0 (m, 1H), 3.49-3.39 (m, 2H), 2.45-2.35 (m, 1H), 2.30-2.23 (m, 1H), 2.03-1.89 (m, 2H), 1.70-1.62 (m, 1H), 1.58-1.49 (m, 1H). **^{13}C NMR ($CDCl_3$, 75 MHz)**: δ 137.1, 133.0, 130.4, 115.3, 78.8, 77.8, 77.2, 72.9, 38.7, 31.1, 28.5. HRMS (ESI) m/z calced for $C_{10}H_{17}O_2$ $[M+H]^+$ = 169.1229, found = 169.1239.

2-((2*R*,5*R*)-5-(((4-methoxybenzyl)oxy)methyl)tetrahydrofuran-2-yl)ethanol (24): To a solution of **22** (0.2 g, 0.68 mmol) in CH_2Cl_2 (10 mL) was added 1.3 mL of DIBAL-H (1.6 M in hexane, 2.04 mmol) at 0 °C. The solution was stirred for 1 h and quenched by addition of saturated Na/K tartrate at 0 °C. The solution was warmed to room temperature and stirred for 3 h until two clear layers were observed. The layers were separated, and the aqueous layer was further extracted with CH_2Cl_2 (2 × 10 mL). The combined organic layers were dried over anhydrous Na_2SO_4, and solvent was evaporated under reduced pressure. The crude product was purified by silica gel column chromatography (10% EtOAc/ hexane) to provide **24** (0.17 g, 95%) as colorless oil. $[\alpha]_D^{25}$: +20.0 (*c* = 0.8, $CHCl_3$); **IR (neat)**: 3381, 2938, 1444, 1051 cm^{-1}; **^{1}H NMR (400 MHz, $CDCl_3$)**: δ 7.26 (d, *J* = 8.6 Hz, 2H), 6.88 (d, *J* = 8.2 Hz, 2H), 4.52-4.47 (m, 2H), 4.24-4.06 (m, 2H), 3.80 (s, 3H), 3.80-377 (m, 2H), 3.47-3.41 (m, 2H), 2.08-1.61 (m, 6H). **^{13}C NMR ($CDCl_3$, 75 MHz)**: δ 159.1, 130.3, 129.2, 113.7, 79.1, 77.8, 72.9, 72.3, 61.4, 55.2, 37.3, 32.0, 28.2. HRMS (ESI) m/z calced for $C_{15}H_{22}NaO_4$ $[M+Na]^+$ = 289.1416, found = 289.1426.

***tert*-butyl(2-((2*R*,5*R*)-5-(((4-methoxybenzyl)oxy)methyl)tetrahydrofuran-2-yl)ethoxy)dimethylsilane (25):** The compound **24** (0.07 g, 0.24 mmol) was dissolved in CH_2Cl_2 (10 mL), and then imidazole (0.03 g, 0.28 mmol) was added followed by TBDMSCl (0.05 g, 0.48 mmol). After 2 h the reaction was washed with water (1 × 5 mL), and the aqueous layer was extracted with CH_2Cl_2 (2 × 5 mL), dried over Na_2SO_4, and concentrated. Purification by silica gel chromatography (5% EtOAc/hexane) provided the silyl ether **25** (0.081 g, 90%) as a yellow oil. $[\alpha]_D^{25}$: +37.5 (*c* = 1.1,

$CHCl_3$); **IR (neat)**: 2930, 2858, 1513, 1250, 1065 cm^{-1}; **^{1}H NMR (400 MHz, $CDCl_3$)**: δ 7.26 (d, *J* = 8.5 Hz, 2H), 6.87 (d, *J* = 8.7 Hz, 2H), 4.50 (ABq, *J* = 25.7, 11.9 Hz, 2H), 4.19-4.14 (m, 1H), 4.09-4.01 (m, 1H), 3.80 (s, 3H), 3.74-3.68 (m, 2H), 3.47-3.38 (m, 2H), 2.03-1.80 (m, 2H), 1.70-1.51 (m, 4H), 0.89 (s, 9H), 0.05 (s, 6H). **^{13}C NMR ($CDCl_3$, 75 MHz)**: δ 159.1, 130.5, 129.2, 113.6, 77.8, 76.5, 72.9, 72.7, 60.5, 55.2, 38.8, 31.8, 28.6, 25.9, 18.3, −5.3, −5.4. HRMS (ESI) m/z calced for $C_{21}H_{37}O_4Si$ $[M+H]^+$ = 381.2461, found = 381.2450.

((2*R*,5*R*)-5-(2-((*tert*-butyldimethylsilyl)oxy)ethyl)tetrahydrofuran-2-yl)methanol (4): To a solution of the compound **25** (0.07 g, 0.18 mmol) in CH_2Cl_2 (5 mL) and water (0.1 mL), DDQ (0.05 g, 0.21 mmol) was added at 0 °C and allowed to stir for 2 h at room temperature. The reaction mixture was quenched with saturated $NaHCO_3$ solution (5 mL) and diluted with CH_2Cl_2 (5 mL). The two layers were separated and the aqueous layer was extracted with CH_2Cl_2 (3 x 5 mL). The combined organic layer was washed with brine (2 x 5 mL), dried over anhydrous Na_2SO_4 and evaporated to give the crude product which was a purified by column chromatography (5% EtOAc/Hexane) to provide the desired alcohol **4** (0.043 g, 90%) as a colourless oil. $[\alpha]_D^{25}$: +14.9 (*c* = 1.2, $CHCl_3$); **IR (neat)**: 3423, 2936, 1513, 1247, 1079 cm^{-1}; **^{1}H NMR (400 MHz, $CDCl_3$)**: δ 4.14-3.97 (m, 2H), 3.74-3.69 (m, 2H), 3.62 (dd, *J* = 11.4, 3.3 Hz, 1H), 3.51-3.45 (m, 1H), 2.08-1.56 (m, 6H), 0.89 (s, 9H), 0.06 (s, 6H). **^{13}C NMR ($CDCl_3$, 75 MHz)**: δ 78.7, 76.3, 65.0, 60.4, 38.7, 32.2, 27.4, 25.9, 18.3, −5.3 (2C). HRMS (ESI) m/z calced for $C_{13}H_{29}O_3Si$ $[M+H]^+$ = 261.1886, found = 261.1890.

(4*R*,5*S*,*E*)-5-((2*R*,4*S*,5*S*)-5-(2-(benzyloxy)ethyl)-4-methyltetrahydrofuran-2-yl)-5-((*tert*-butyldimethylsilyl)oxy)-1-((2*R*,5*R*)-5-(2-((*tert*-butyldimethylsilyl)oxy)ethyl)tetrahydrofuran-2-yl)-4-methylpent-1-en-3-one (26): Dess–Martin periodinane (0.06 g, 0.14 mmol) and $NaHCO_3$ (0.02 g, 0.22 mmol) were added to a solution of alcohol **4** (0.03 g, 0.115 mmol) in CH_2Cl_2 (5 mL) at 0 °C. After stirring for 30 min, the reaction was warmed to 25 °C for 1 h. The reaction mixture was poured into a solution of $Na_2S_2O_3$ (5 mL), $NaHCO_3$ (5 mL) and Et_2O (5 mL), and then stirred for 30 min. The organic layer was separated and the aq layer was extracted with Et_2O (2 × 5 mL). The combined organic layers were washed with $Na_2S_2O_3$ (5 mL), $NaHCO_3$ (5 mL) and brine (5 mL), dried over anhydrous Na_2SO_4, filtered and concentrated under reduced pressure to provide the corresponding aldehyde **4c** as an oil. This aldehyde **4c** was used immediately in the next reaction without purification.

To a solution of phosphonate **3** (0.03 g, 0.052 mmol) in THF (10 mL) was added $Ba(OH)_2{\cdot}8H_2O$ (0.02 g, 0.10 mmol, predried at 120 °C for 2 h). The resulting solution was allowed to stir at r.t. for 30 min. Next, a solution of the aldehyde **4c** (0.026 g, 0.052 mmol) in THF-H_2O (40:1, 2 mL) was added to the phosphonate solution, followed by another portion of the THF-H_2O mixture (2 mL). After stirring for 30 min, the mixture was diluted with EtOAc and filtered through a small pad of Celite. The filtrate was washed with aq $NaHCO_3$, and the organic layer was separated and the aq layer extracted with EtOAc (2 × 5 mL). The combined organic layers were dried over anhydrous Na_2SO_4 and concentrated under reduced pressure. The crude residue was purified by column chromatography (R_f = 0.1, hexane–EtOAc, 9:1) to provide the product **26** (0.03 g, 85%) as a colorless oil. $[\alpha]_D^{25}$: +27.0 (*c* = 1.0, $CHCl_3$); **IR (neat)**: 2931, 1710, 1631, 1253, 1093, 773 cm^{-1}; **^{1}H NMR (400 MHz, $CDCl_3$)**: δ 7.37-7.27 (m, 5H), 6.73 (ddd, *J* = 15.6, 7.1, 5.2 Hz, 1H), 6.39 (dd, *J* = 15.4, 5.5 Hz, 1H), 4.58-4.41 (m, 4H), 4.14 (t, *J* = 5.5 Hz, 1H), 4.10-3.96 (m, 2H), 3.95-3.79 (m, 1H), 3.77-3.69 (m, 2H), 3.60-3.46 (m, 1H), 2.81 (t, *J* = 6.8 Hz, 1H), 2.29-1.96 (m, 4H), 1.84-1.56 (m, 7H), 1.07 (d, *J* = 6.6 Hz, 3H), 0.93-0.82 (m, 21H), 0.10-0.01 (m, 12H). **^{13}C NMR ($CDCl_3$, 75 MHz)**: δ 201.1, 145.8, 138.6, 128.2, 127.7, 127.6, 127.5, 127.4, 78.4, 77.8, 77.4, 78.9, 75.2, 73.0, 68.3, 60.4, 49.3, 38.9, 36.2, 34.7, 31.9, 31.5, 31.0, 26.0, 25.9, 18.3, 18.0, 14.3, 11.8, −4.5, −4.6, −5.3 (2C). HRMS (ESI) m/z calced for $C_{38}H_{70}O_6NSi_2$ $[M+Na]^+$ = 692.4743, found = 692.4736.

(1*S*,2*R*)-1-((*tert*-butyldimethylsilyl)oxy)-5-((2*R*,5*R*)-5-(2-((*tert*-butyldimethylsilyl)oxy)ethyl)tetrahydrofuran-2-yl)-1-((2*R*,4*S*,5*S*)-5-(2-hydroxyethyl)-4-methyltetrahydrofuran-2-yl)-2-methylpentan-3-one (5): 10% Palladium on activated charcoal (100 mg) was added to a solution of **26** (0.02 g, 0.029 mmol) in hexane (5 mL) and was stirred for 3 h under a hydrogen (ballon) atmosphere. It was then filtered through a short pad of Celite and the Celite pad was washed with ether (10 mL). Evaporation of the solvent furnished **5** (0.015 g, 90%) as colorless oil. $[\alpha]_D^{25}$: + 4.9 (*c* 1.2, $CHCl_3$); **IR (neat)**: 3448, 2930, 2857, 1710, 1253, 1099 cm^{-1}; **^{1}H NMR (400 MHz, $CDCl_3$)**: δ 4.14-4.08 (m, 1H), 4.03-3.95 (m, 2H), 3.93-3.85 (m, 1H), 3.84-3.74 (m, 1H), 3.73-3.65 (m, 4H), 2.68-2.51 (m, 3H), 2.29-2.22 (m, 1H), 2.06-1.93 (m, 3H), 1.83-1.47 (m, 11H), 1.12 (d, *J* = 7.0 Hz, 3H), 0.92-0.86 (m, 21H), 0.10 (s, 3H), 0.07 (s, 3H), 0.04 (s, 6H). **^{13}C NMR ($CDCl_3$, 75 MHz)**: δ 210.9, 80.5, 78.2, 77.6, 77.2, 75.3, 61.0, 60.5, 39.1, 38.6, 36.2 (2C), 32.6, 32.1, 31.1, 29.6, 25.9, 25.8, 18.3, 18.0, 14.3, 10.2, −4.4, −4.5, −5.3 (2C). HRMS (ESI) m/z calced for $C_{31}H_{66}O_6NSi_2$ $[M+NH_4]^+$ = 604.4429, found = 604.4423.

(1*S*,2*R*)-1-((*tert*-butyldimethylsilyl)oxy)-5-((2*R*,5*R*)-5-(2-((*tert*-butyldimethylsilyl)oxy)ethyl)tetrahydrofuran-2-yl)-2-methyl-1-((2*R*,4*S*,5*S*)-4-methyl-5-(2-oxopropyl)tetrahydrofuran-2-yl)pentan-3-one (27): To a solution of alcohol **5** (0.011 g, 0.016 mmol) in dry CH_2Cl_2 (5 mL) were added Dess−Martin periodinane (9 mg, 0.019 mmol) and $NaHCO_3$ (3 mg, 0.032 mmol) at 0 °C under nitrogen atmosphere. The turbid solution was allowed to warm to room temperature and was stirred for 2 h. The reaction was diluted with CH_2Cl_2 (5 mL) and quenched with saturated aqueous $NaHCO_3$ (5 mL) and saturated aqueous $Na_2S_2O_3$ (5 mL). The mixture was vigorously stirred until a clear solution was formed. The organic layer was separated, and the aqueous layer was extracted with CH_2Cl_2 (2 × 5 mL). The combined organic extracts were washed with brine (1 × 5 mL), dried over anhydrous Na_2SO_4, filtered, and concentrated to give a crude aldehyde, which was used for the next step without further purification

MeMgBr (0.03 mL, 1M, 0.024 mmol) was added dropwise to a stirred solution of the aldehyde in dry THF (5 mL) at 0 °C. After addition was completed, the reaction mixture was allowed to stir at room temperature for 1 h and then quenched with saturated aqueous NH_4Cl solution. The organic layer was separated, and the compound from the aqueous layer was extracted with ethyl acetate (2 × 5 mL). The combined organic layers were washed with water and brine solution, dried over Na_2SO_4, and concentrated under reduced pressure. The crude mass was purified by silica gel column chromatography (20% EtOAc/hexane) to afford a racemic mixture as a viscous liquid.

To a solution of the above racemic alcohol (0.010 g, 0.016 mmol) in dry CH_2Cl_2 (5 mL) were added Dess−Martin periodinane (8 mg, 0.019 mmol) and $NaHCO_3$ (2 mg, 0.032 mmol) at 0 °C under nitrogen atmosphere. The turbid solution was allowed to warm to room temperature and was stirred for 2 h. The reaction was diluted with CH_2Cl_2 (2 mL) and quenched with saturated aqueous $NaHCO_3$ (4 mL) and saturated aqueous $Na_2S_2O_3$ (4 mL). The mixture was vigorously stirred until a clear solution was formed. The organic layer was separated, and the aqueous layer was extracted with CH_2Cl_2 (2 × 5 mL). The combined organic extracts were washed with brine (1 × 5 mL), dried over anhydrous Na_2SO_4, filtered, concentrated, and purified by silica gel column chromatography (20% EtOAc/hexane) to afford methyl ketone **27** (0.008 g, 75% for 3 steps) as a viscous liquid. $[\alpha]_D^{25}$: +42.6 (*c* = 0.6, $CHCl_3$); **IR (neat)**: 2929, 1715, 1633, 1253, 1087, 773 cm^{-1}; **^{1}H NMR (400 MHz, $CDCl_3$)**: δ 4.23-4.17 (m, 1H), 4.09 (t, *J* = 5.5 Hz, 1H), 4.01-3.93 (m, 1H), 3.92-3.83 (m, 1H), 3.79-3.65 (m, 3H), 2.58-2.51 (m, 4H), 2.35 (dd, *J* = 15.8, 5.4 Hz, 2H), 2.15 (s, 3H), 2.06-1.99 (m, 2H), 1.96-1.92 (m, 1H), 1.81-1.57 (m, 6H), 1.53-1.45 (m, 2H), 1.07 (d, *J* = 4.0 Hz, 3H), 0.90-0.83 (m, 21H), 0.08-0.02 (m, 12H). **^{13}C NMR ($CDCl_3$, 75 MHz)**: δ 211.0, 207.7, 78.1, 77.7, 76.4, 75.6, 75.2,

60.6, 51.2, 44.9, 39.3, 39.0, 35.7, 35.3, 32.1, 31.9, 30.7, 29.6, 25.9, 25.8, 18.3, 18.0, 14.3, 10.6, −4.4, −4.6, −5.3 (2C). HRMS (ESI) m/z calced for $C_{32}H_{62}NaO_6Si_2$ $[M+Na]^+$ = 621.3983, found = 621.3983.

(*E*)-*tert*-butyl((6-((4-methoxybenzyl)oxy)-3-methylhex-3-en-1-yl)oxy)diphenylsilane (30): To a solution of **29** (0.5 g, 1.71 mmol) in CH_2Cl_2 (20 mL) was added 5.1 mL of DIBAL-H (1.6 M in hexane, 5.13 mmol) at 0 °C. The solution was stirred for 1 h then adds TBDPSCl at 0 °C. The solution was stirred for 1 h and quenched by addition of saturated Na/K tartrate at 0 °C. The solution was warmed to room temperature and stirred for 3 h until two clear layers were observed. The layers were separated, and the aqueous layer was further extracted with CH_2Cl_2 (2 × 10 mL). The combined organic layers were dried over anhydrous Na_2SO_4, and solvent was evaporated under reduced pressure. The crude product was purified by silica gel column chromatography (10% EtOAc/ hexane) to provide **30** (0.75 g, 90%) as colorless oil. **IR (neat)**: 2930, 2857, 1253, 1099 cm^{-1}; **^{1}H NMR (400 MHz, $CDCl_3$)**: δ 7.73-7.65 (m, 4H), 7.43-7.35 (m, 6H), 7.25-7.22 (m, 2H), 6.86 (d, *J* = 8.5 Hz, 2H), 5.17 (dt, *J* = 22.4, 7.0 Hz, 1H), 4.41 (d, *J* = 19.0 Hz, 2H), 3.80 (s, 3H), 3.69 (dt, *J* = 21.0, 6.9 Hz, 2H), 3.37 (dt, *J* = 24.0, 14.5 Hz, 2H), 2.30 (t, *J* = 7.2 Hz, 2H), 2.26-2.19 (m, 2H), 1.55 (s, 3H), 1.07 (s, 9H). **^{13}C NMR ($CDCl_3$, 75 MHz)**: δ 159.0, 135.5, 134.7, 129.5, 129.4, 129.2, 127.6, 127.5, 122.8, 113.7, 72.4, 69.9, 62.4, 55.2, 35.3, 28.5, 26.8, 19.1. HRMS (ESI) m/z calced for $C_{31}H_{41}O_3Si$ $[M+H]^+$ = 489.2825, found = 489.2820.

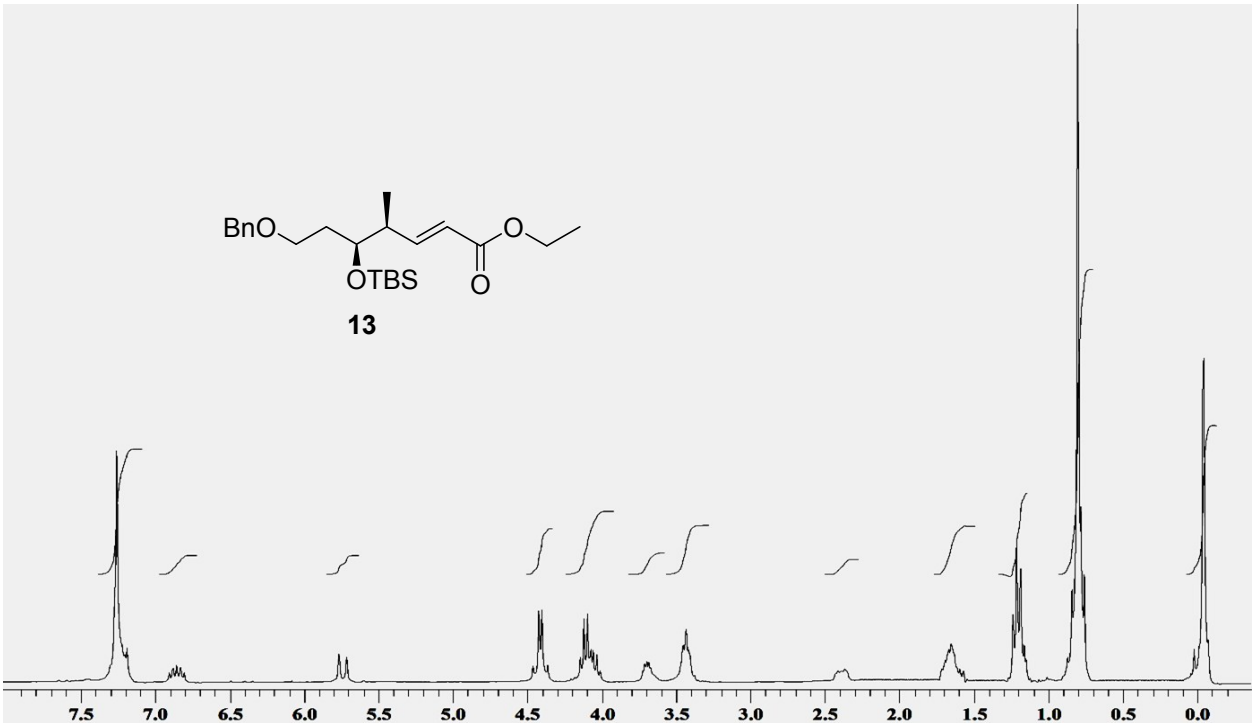
(*E*)-6-((*tert*-butyldiphenylsilyl)oxy)-4-methylhex-3-en-1-ol (31): To a solution of the compound **30** (0.5 g, 1.02 mmol) in CH_2Cl_2 (10 mL) and water (1 mL), DDQ (0.27 g, 1.22 mmol) was added at 0 °C and allowed to stir for 2 h at room temperature. The reaction mixture was quenched with saturated $NaHCO_3$ solution (5 mL) and diluted with CH_2Cl_2 (10 mL). The two layers were separated and the aqueous layer was extracted with CH_2Cl_2 (3 x 5 mL). The combined organic layer was washed with brine (2 x 5 mL), dried over anhydrous Na_2SO_4 and evaporated to give the crude product which was a purified by column chromatography (5% EtOAc/Hexane) to provide the desired alcohol **31** (0.32 g, 85%) as a colourless oil. **IR (neat)**: 3447, 2935, 1560, 1253, 1099 cm^{-1}; **^{1}H NMR (400 MHz, $CDCl_3$)**: δ 7.70-7.64 (m, 4H), 7.44-7.36 (m, 6H), 5.17 (dt, *J* = 21.0, 7.4 Hz, 1H), 3.70 (dt, *J* = 21.0, 6.7 Hz, 2H), 3.60 (t, *J* = 6.5 Hz, 1H), 3.53 (t, *J* = 6.4 Hz, 1H), 2.33 (t, *J* = 7.0 Hz, 2H), 2.29-2.24 (m, 1H), 1.66 (s, 3H), 1.04 (s, 9H). **^{13}C NMR ($CDCl_3$, 75 MHz)**: δ 135.8, 135.6, 135.5, 133.7, 129.2, 129.6, 129.5, 127.6, 127.5, 114.3, 62.3, 55.5, 35.1, 31.4, 26.8, 19.1. HRMS (ESI) m/z calced for $C_{23}H_{33}O_2Si$ $[M+Na]^+$ = 369.2250, found = 369.2247.

Salt 6: To a stirred solution of **31** (0.2 g, 0.54 mmol) in 10 mL of anhydrous THF, TPP (0.18 g, 0.70 mmol), imidazole (0.074 g, 1.08 mmol) and iodine (0.20 g, 0.81 mmol) were added successively at 0 °C. The resulting mixture was stirred at room temperature for 1 h. After completion of reaction, monitored by TLC, the reaction mixture was quenched with 10% aqueous $Na_2S_2O_3$ solution, extracted with ether and dried over anhydrous Na_2SO_4. The combined organic layer was concentrated under reduced pressure and purified by silica gel column chromatography (pet.ether:ethyl acetate, 9:1) to afford **30** as a liquid, the unstable iodo compound **31a** was immediately used for the next reaction.

A stirred suspension of **31a** (0.2 g, 0.40 mmol) and TPP (0.52 g, 2.0 mmol) in anhydrous CH_3CN (10 mL) was stirred at reflux temperature for 20 h. The reaction mixture was filtered through a Celite pad and the filtrate was concentrated under reduced pressure. The crude product was purified by column chromatography (pet.ether:ethyl acetate, 8:2) to furnish **6** (0.23 g, 95%) as a clear colorless oil. **IR (neat)**: 2920, 2857, 1619, 1257, 1084, 773 cm^{-1}; **^{1}H NMR (400 MHz, $CDCl_3$)**: δ 7.86-7.61 (m, 10H), 7.37-7.28 (m, 15H), 5.45 (t, *J* = 13.7 Hz, 1H), 3.66-3.55 (m, 4H), 2.47-2.32 (m, 2H), 2.11 (dt, *J* = 24.5, 7.4 Hz, 1H), 1.59 (s, 3H), 0.96 (s, 9H). **^{13}C NMR ($CDCl_3$, 75 MHz)**: δ 137.0, 135.3, 135.1,

135.5, 129.2, 130.4, 129.5, 128.6, 128.4, 127.6, 62.5, 61.8, 42.2, 35.1, 26.7, 20.9. MS (ESI) m/z calced for $C_{41}H_{47}OPSi$ $[M+H]^+$ = 613.

(1*S*,2*R*)-1-((*tert*-butyldimethylsilyl)oxy)-5-((2*R*,5*R*)-5-(2-((*tert*-butyldimethylsilyl)oxy)ethyl)tetrahydrofuran-2-yl)-1-((2*R*,4*S*,5*S*)-5-((2*Z*,5*E*)-8-((*tert*-butyldiphenylsilyl)oxy)-2,6-dimethylocta-2,5-dien-1-yl)-4-methyltetrahydrofuran-2-yl)-2-methylpentan-3-one (2): Salt **6** (9 mg, 0.015 mmol) was added to a 10-mL flask and dried under high vacuum for 1 h. After freshly dried THF (5 mL) was added under Ar, *n*-BuLi (6 μL of a 2.5 M solution in THF and 0.015 mmol) was added dropwise. After being stirred for 1 h at 23 °C, the deep-red suspension was cooled to −78 °C, and a precooled (−78 °C) solution of keto compound **27** (0.003 g, 0.005 mmol) in THF (5 mL) was added through a cannula. After being stirred for 8 h at 78 °C, the mixture was warmed to 23 °C and stirred for 8 h. During that time, a large amount of pale-white solid separated. The reaction was quenched with satd aq NH_4Cl at 0 °C and stirred vigorously for 30 min. The solid was filtered off through Celite and washed thoroughly with Et_2O. The organic phase was separated, and the aq phase was extracted with Et_2O. The combined organic phase was washed with brine, dried over $MgSO_4$, filtered, and concentrated. The residue was purified by flash chromatography (SiO_2, hexane/EtOAc = 50/1 - 30/1) to provide the desired olefinic product **2** as a nearly colorless oil (0.003 g, E/Z = 1/12.5, 80% yield based on BuLi). $[\alpha]_D^{25}$: +12.9 (*c* = 0.1, $CHCl_3$); **IR (neat)**: 2930, 2857, 1710, 1253, 1099 cm^{-1}; **^{1}H NMR (400 MHz, $CDCl_3$)**: δ 7.72-7.62 (m, 4H), 7.47-7.32 (m, 6H), 5.35 (t, *J* = 13.7 Hz, 1H), 5.15 (t, *J* = 7.3 Hz, 1H), 4.23-4.07 (m, 2H), 4.02-3.95 (m, 1H), 3.91- 3.79 (m, 2H), 3.76-3.60 (m, 4H), 2.64-2.44 (m, 4H), 2.09-1.92 (m, 4H), 1.79-1.59 (m, 8H), 1.53-1.40 (m, 4H), 1.25 (s, 3H), 1.15 (s, 3H), 1.08 (d, *J* = 7.0 Hz, 3H), 0.98 (d, *J* = 6.7 Hz, 3H), 0.87 (m, 27H), 0.08 (s, 6H), 0.04 (s, 6H); **^{13}C NMR ($CDCl_3$, 75 MHz)**: δ 207.5, 140.6, 138.6, 135.5, 133.9, 129.5, 127.6, 81.8, 78.4, 77.5, 76.5, 74.7, 75.2, 60.6, 51.2, 47.6, 41.5, 39.0, 38.5, 32.1, 31.2, 30.6, 29.7, 26.8, 26.1, 25.9, 25.8, 23.3, 18.3, 18.1, 16.9, 14.1, 11.2, −4.1, −4.6, −5.3 (2C); HRMS (ESI) m/z calced for $C_{55}H_{92}NaO_6Si_3$ $[M+Na]^+$ = 956.5616, found = 956.5617.



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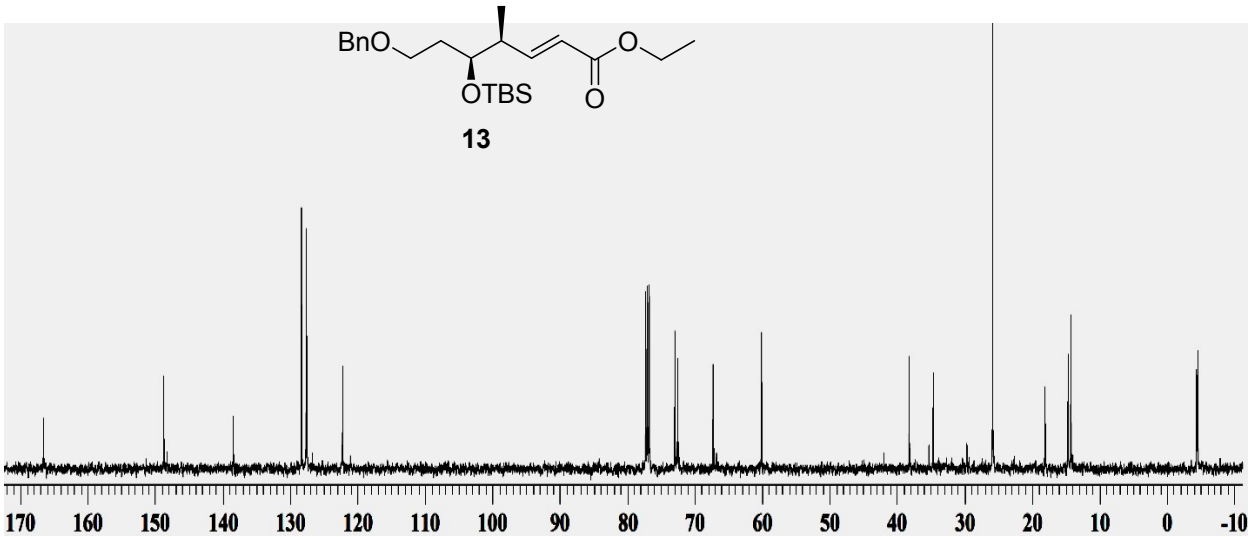
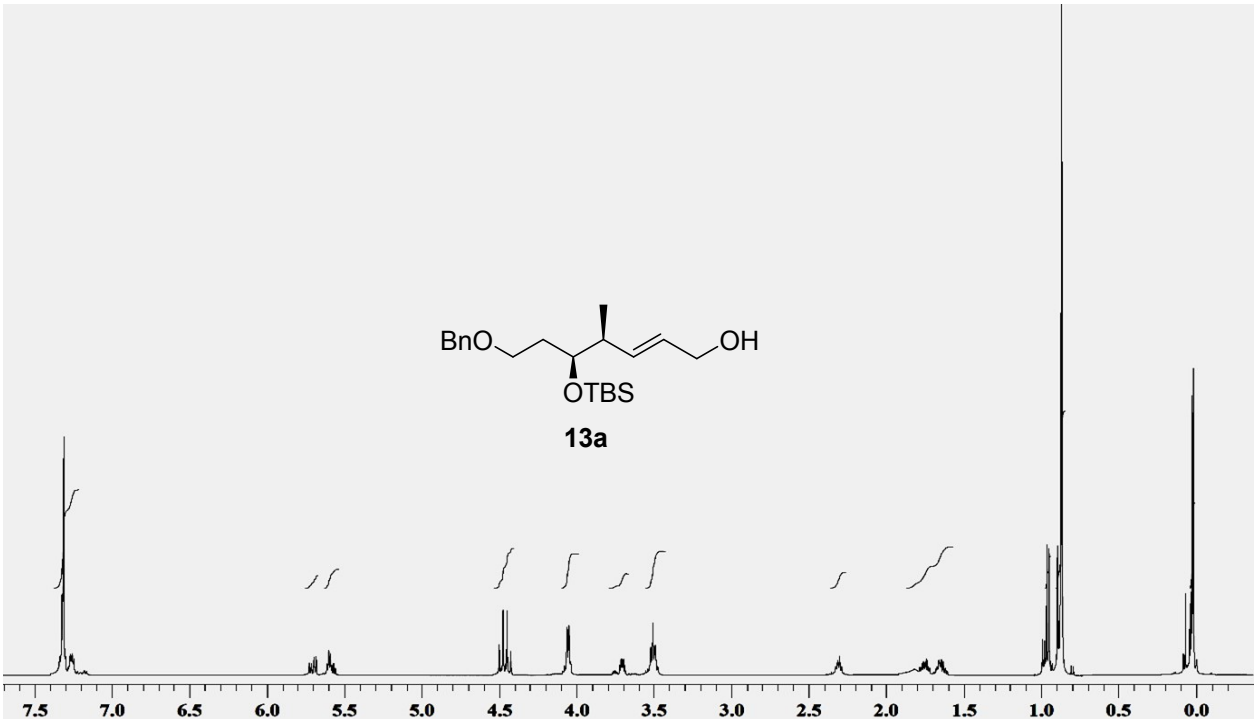


^{13}CNMR ($CDCl_3$, 75MHz)



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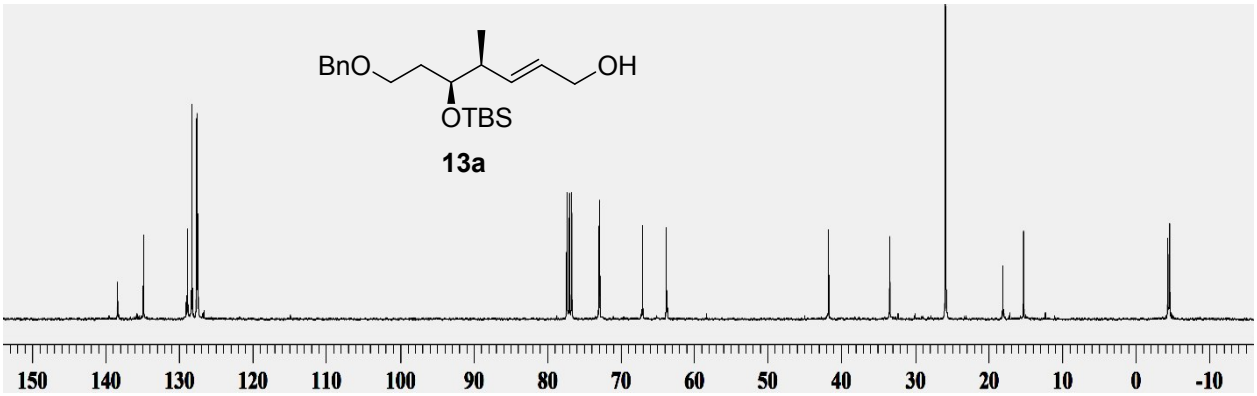

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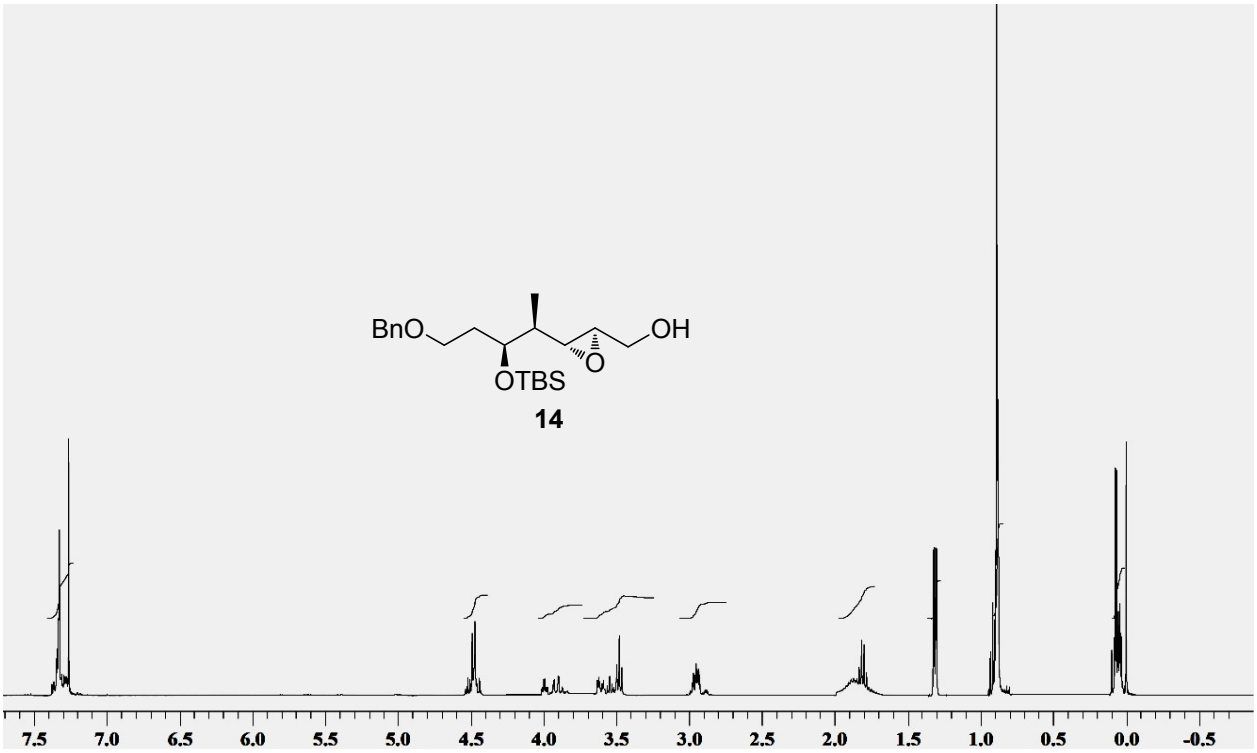
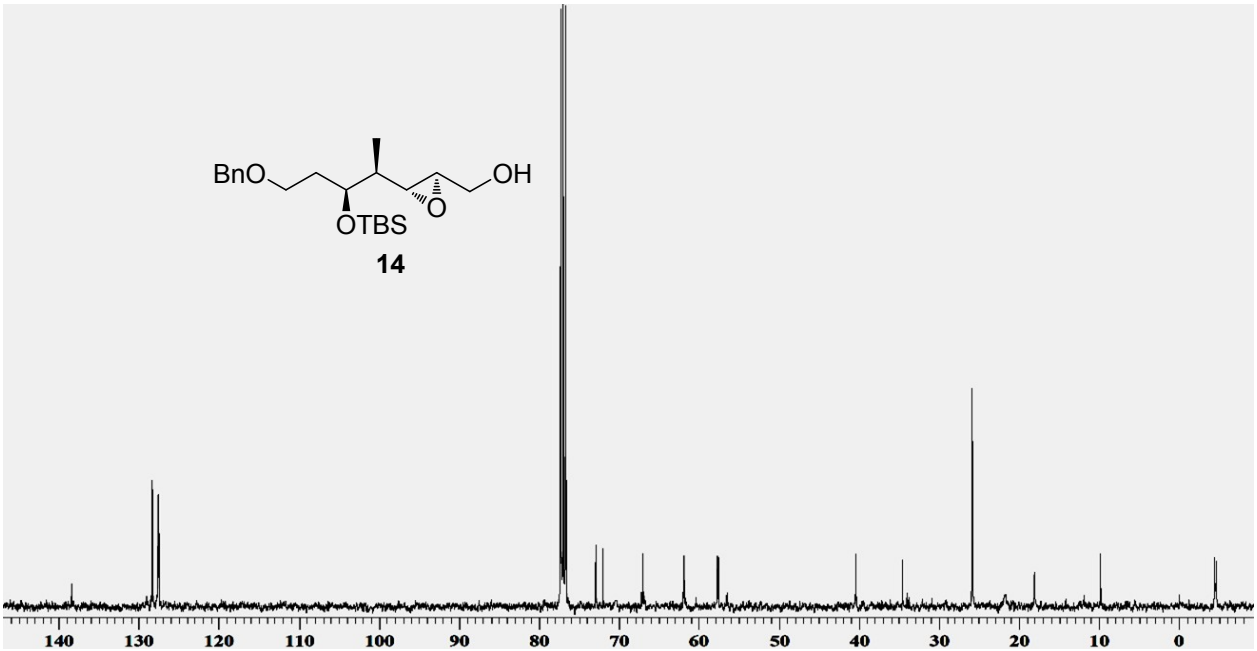
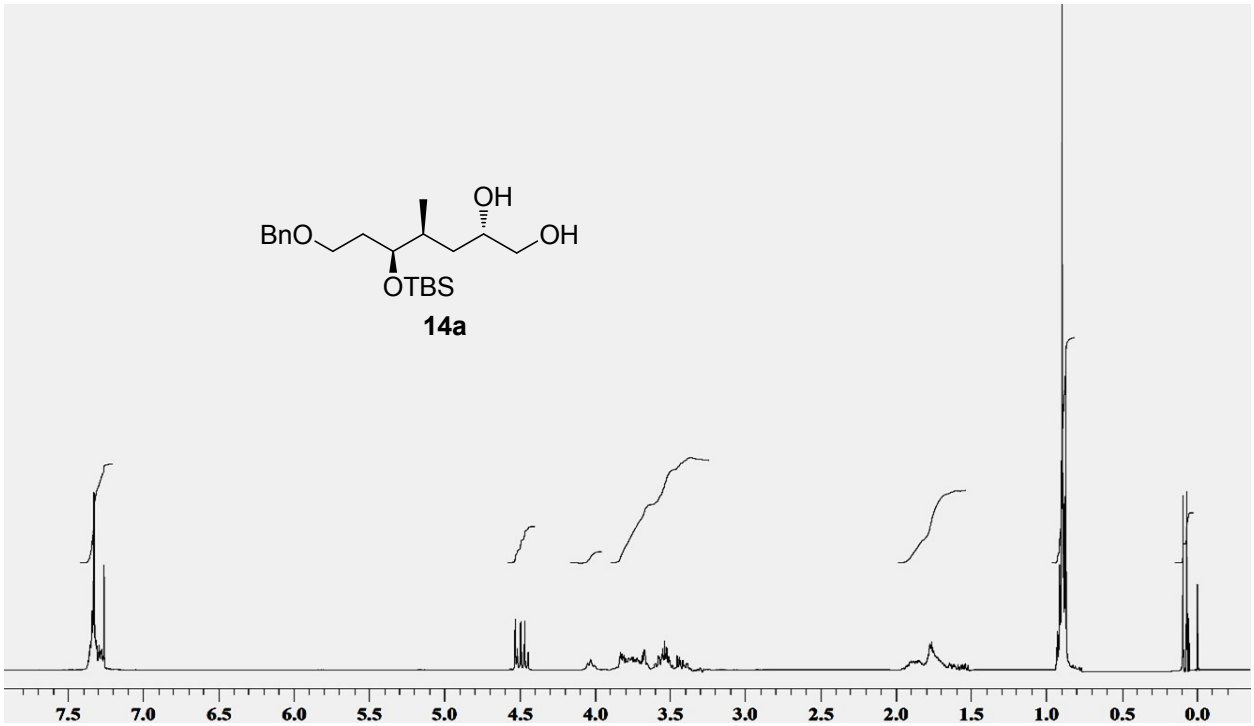


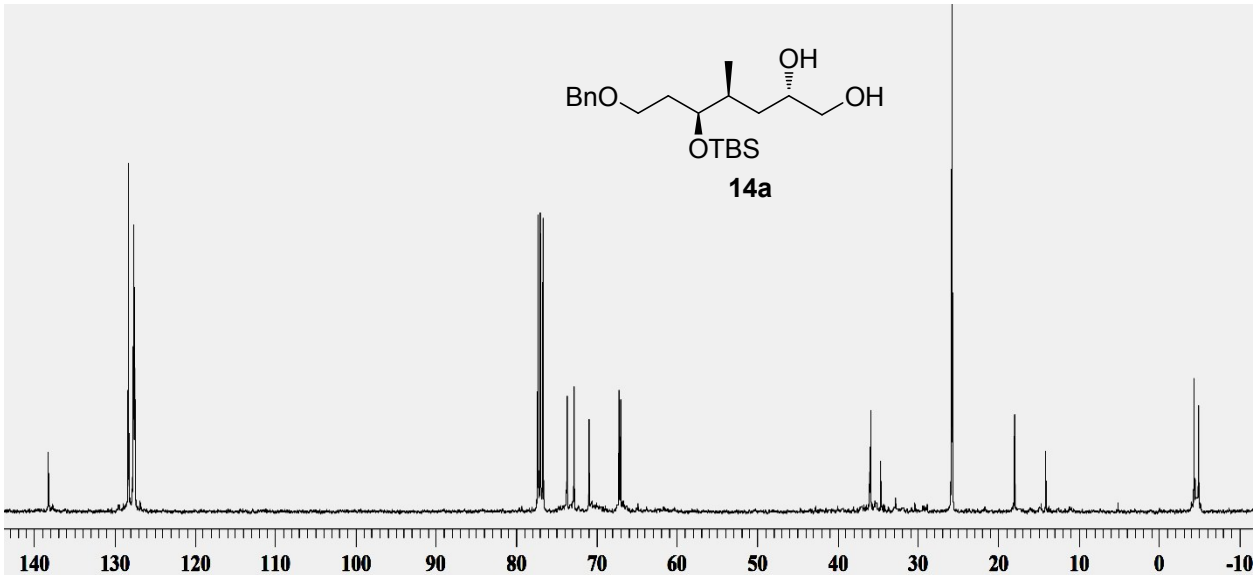
^{1}HNMR ($CDCl_3$, 500MHz)



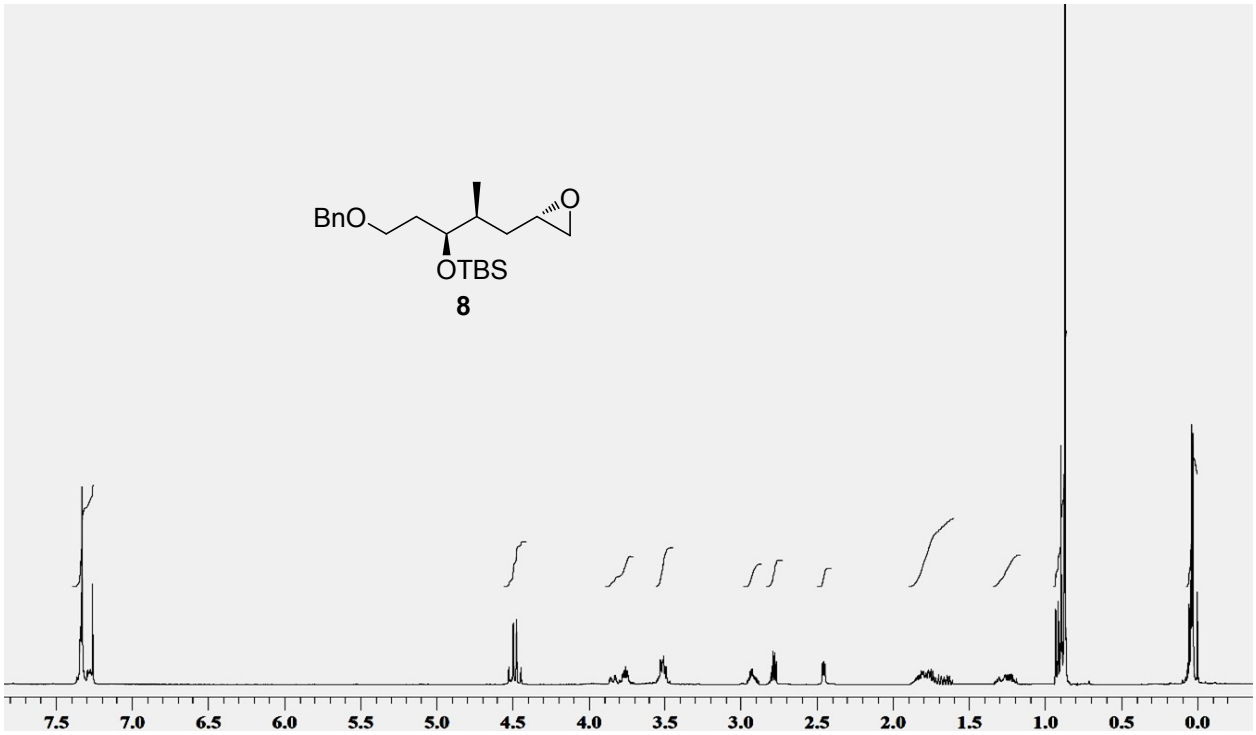
^{13}CNMR ($CDCl_3$, 125MHz)



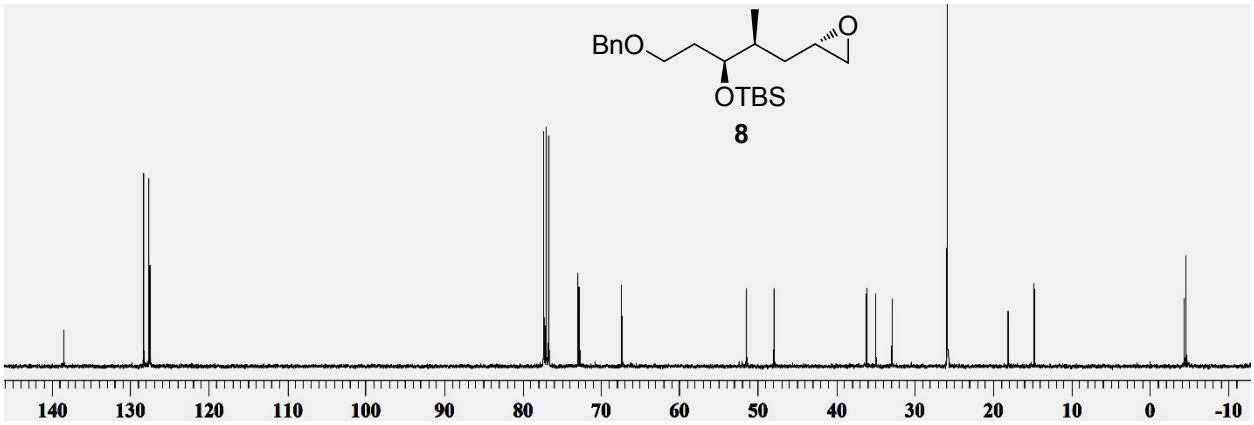
^{1}HNMR ($CDCl_3$, 500MHz)



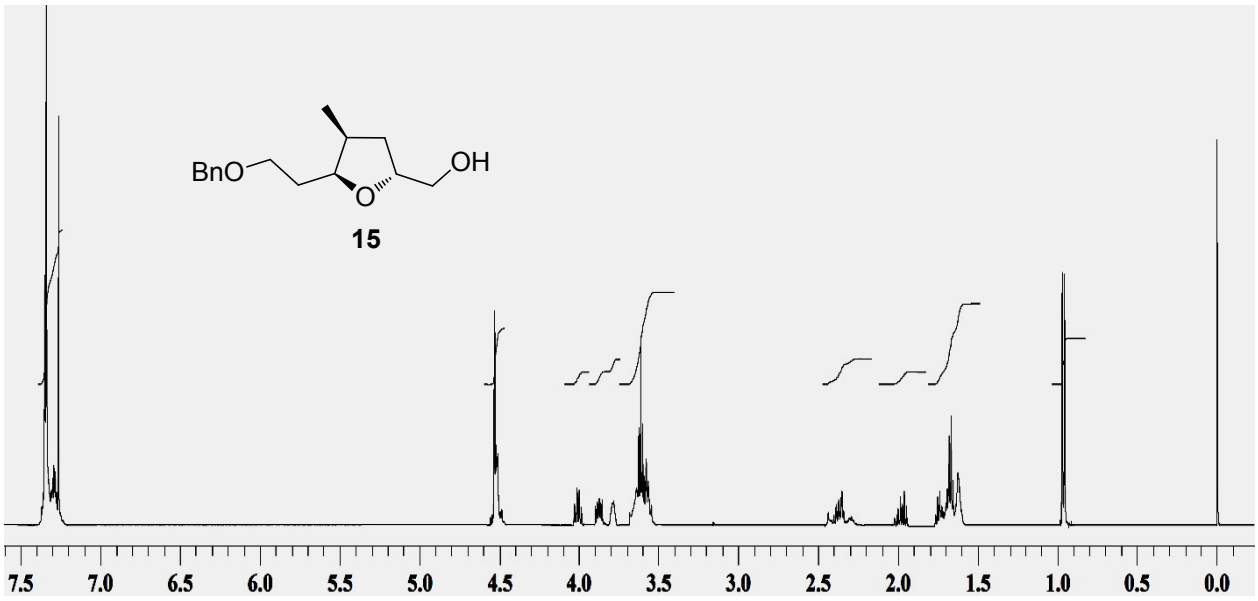
^{13}CNMR ($CDCl_3$, 75MHz)



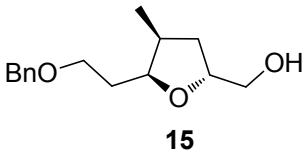
^{1}HNMR ($CDCl_3$, 400MHz)

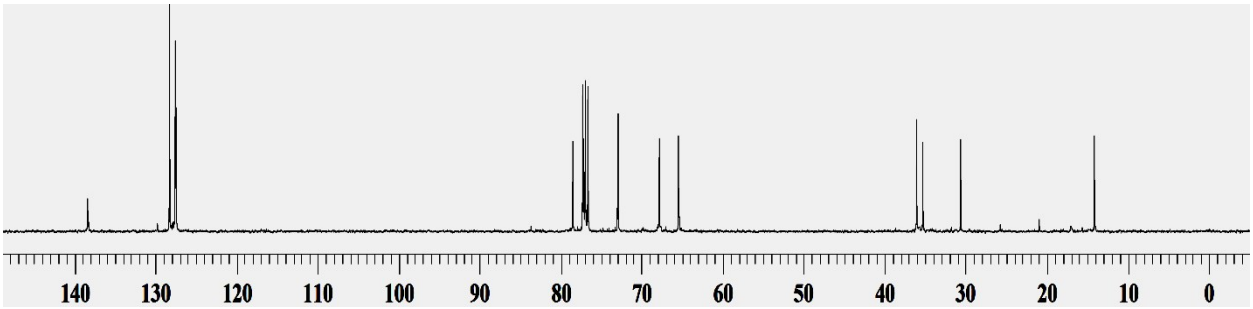


^{13}CNMR ($CDCl_3$, 75MHz)

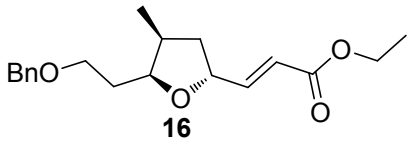


^{1}HNMR ($CDCl_3$, 400MHz)





^{13}CNMR ($CDCl_3$, 75MHz)



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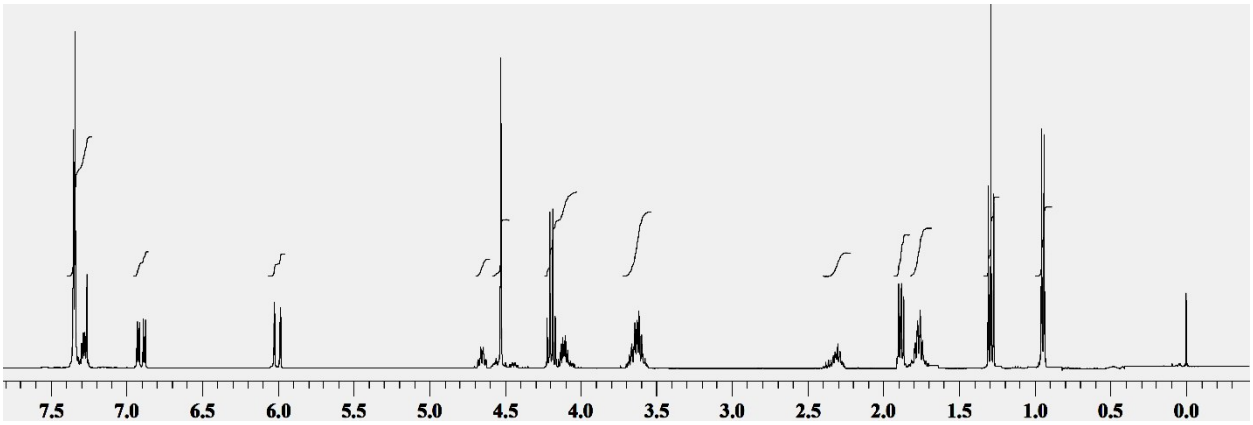
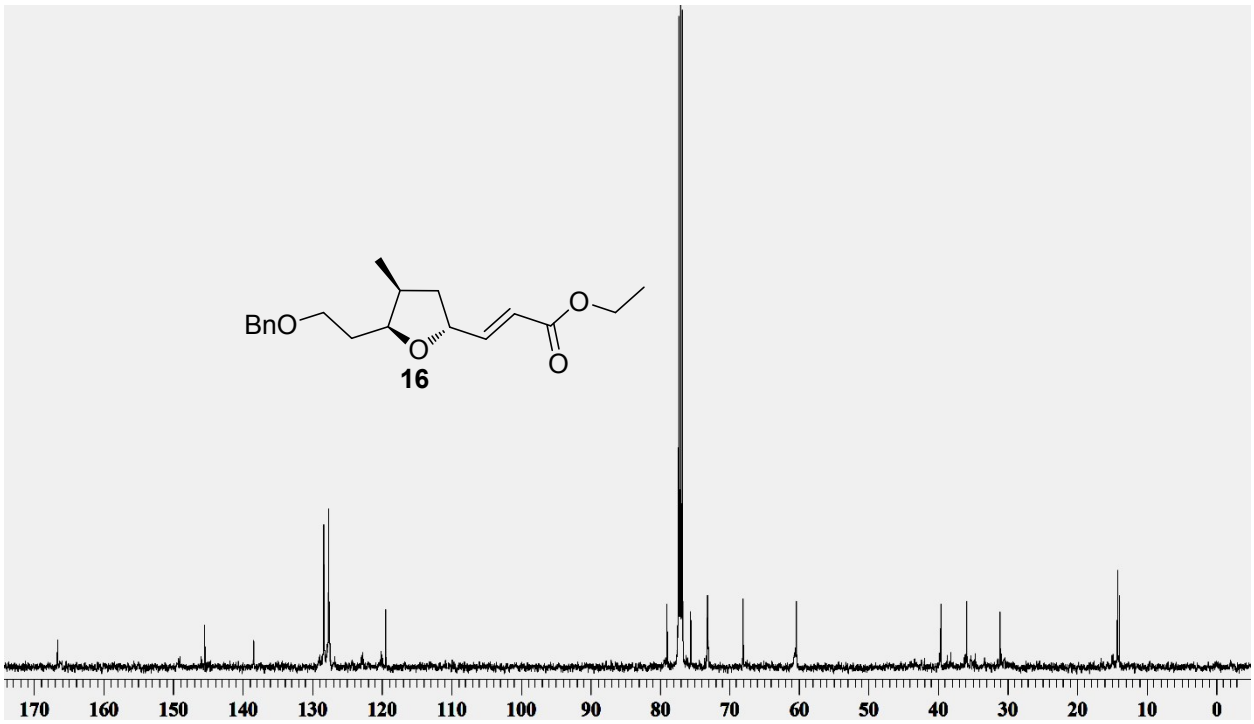


^{1}HNMR ($CDCl_3$, 400MHz)



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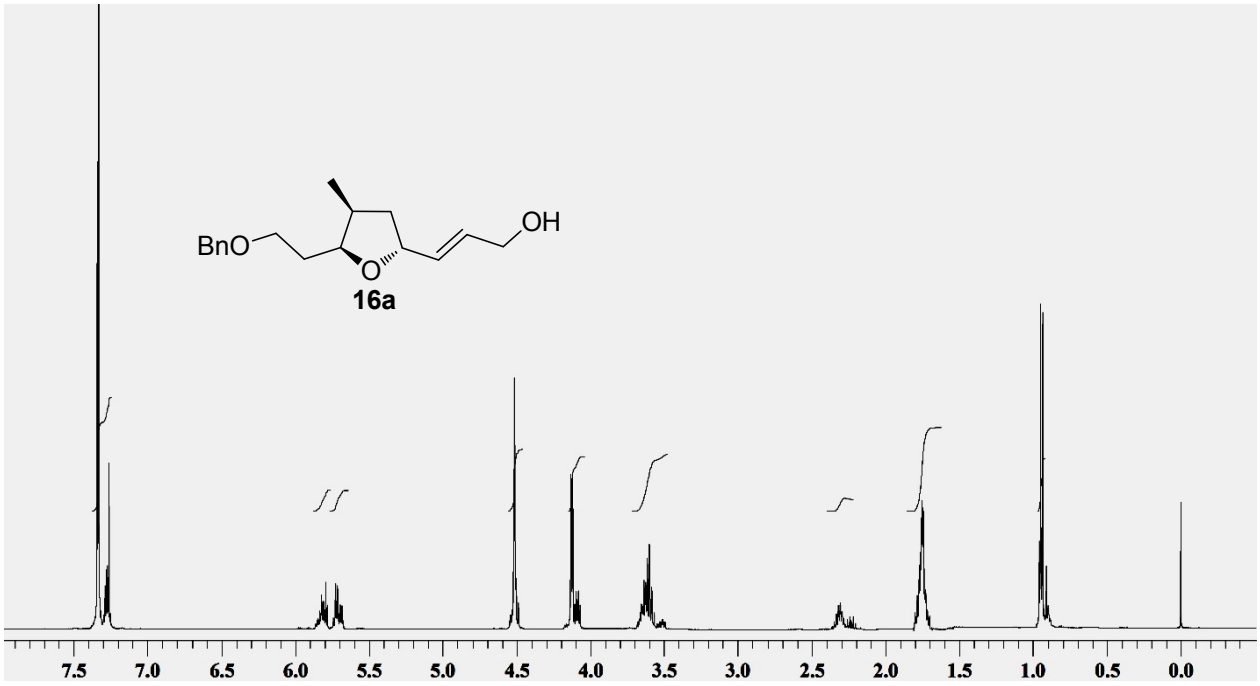
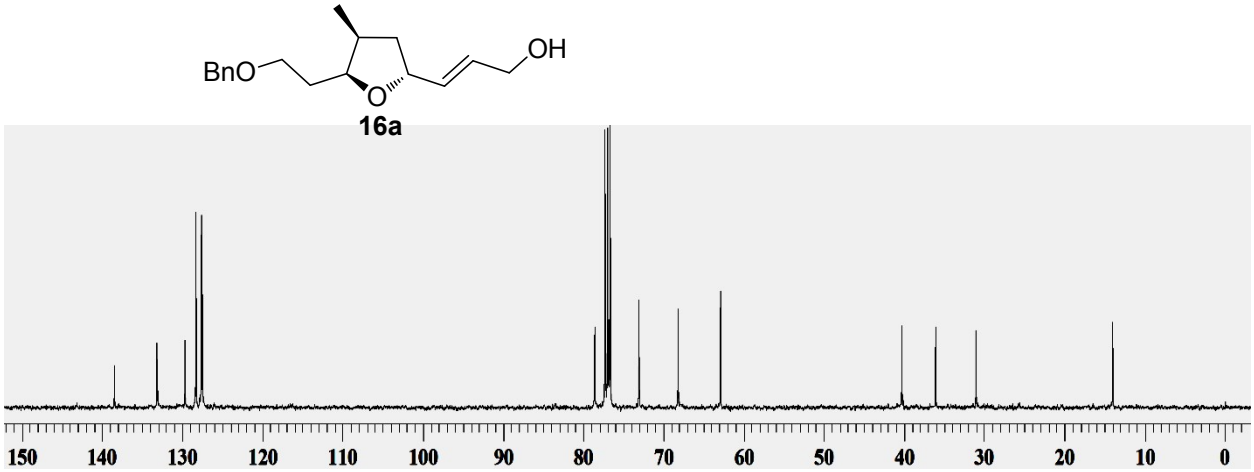
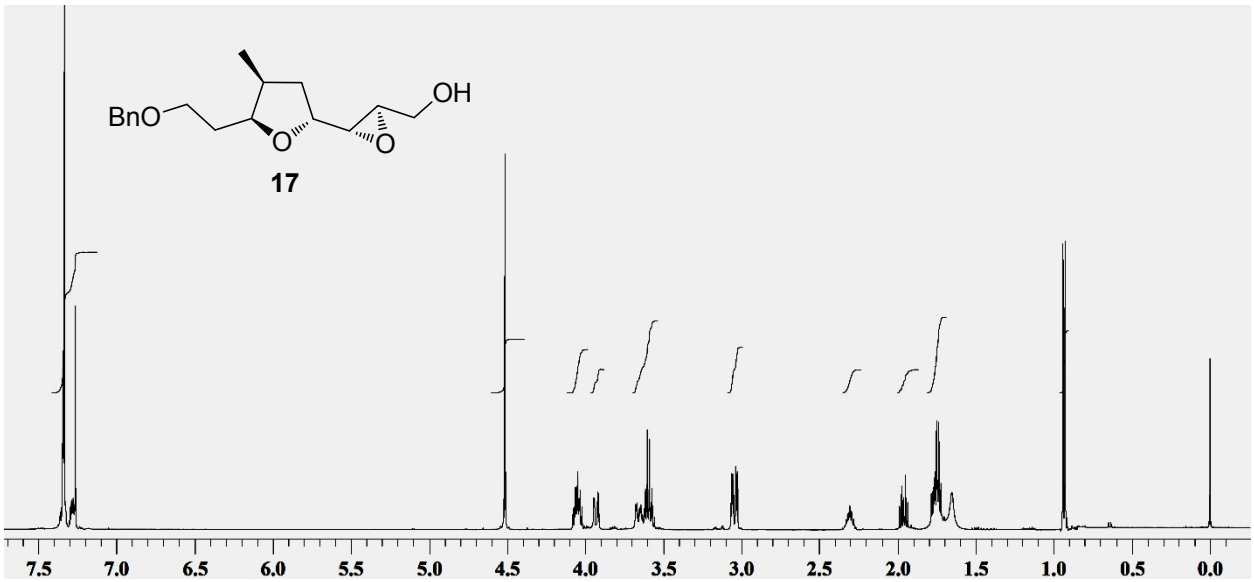
^{13}CNMR ($CDCl_3$, 75MHz)



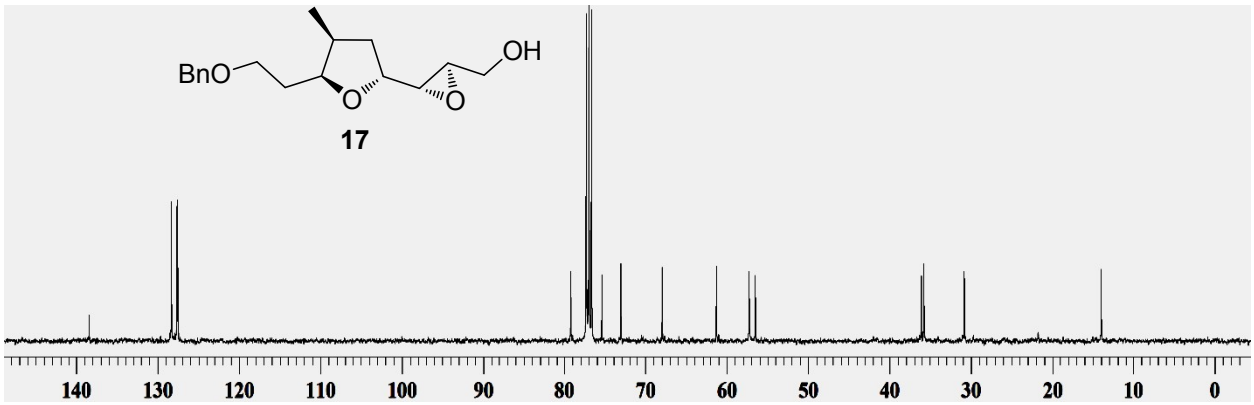
^{1}HNMR ($CDCl_3$, 400MHz)



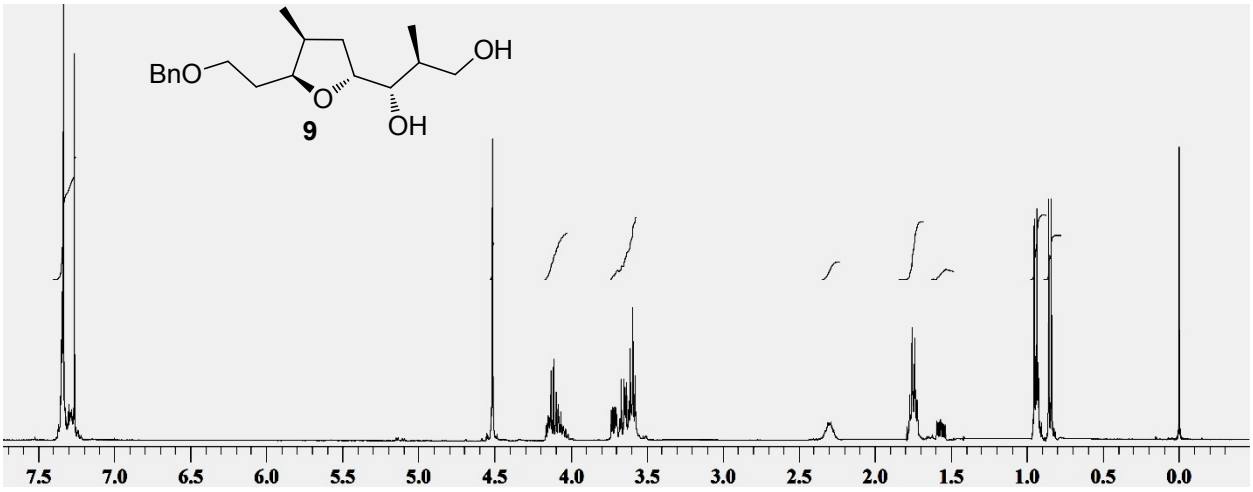
^{13}CNMR ($CDCl_3$, 125MHz)



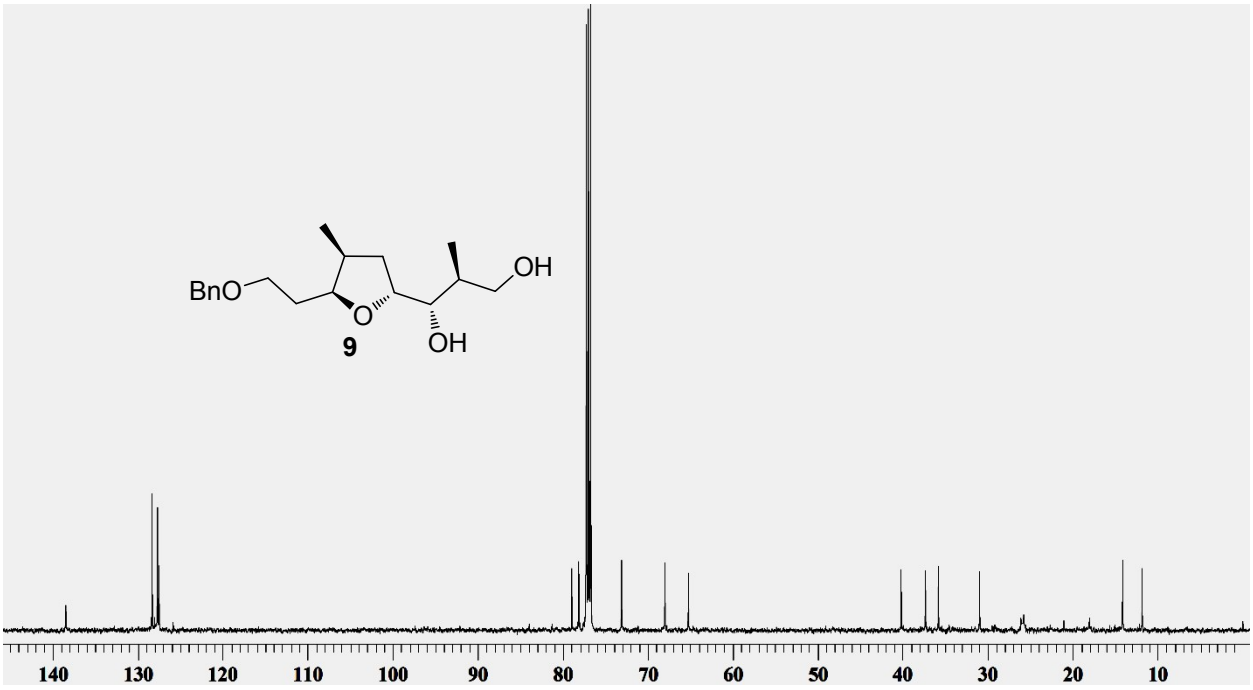
^{1}HNMR ($CDCl_3$, 400MHz)



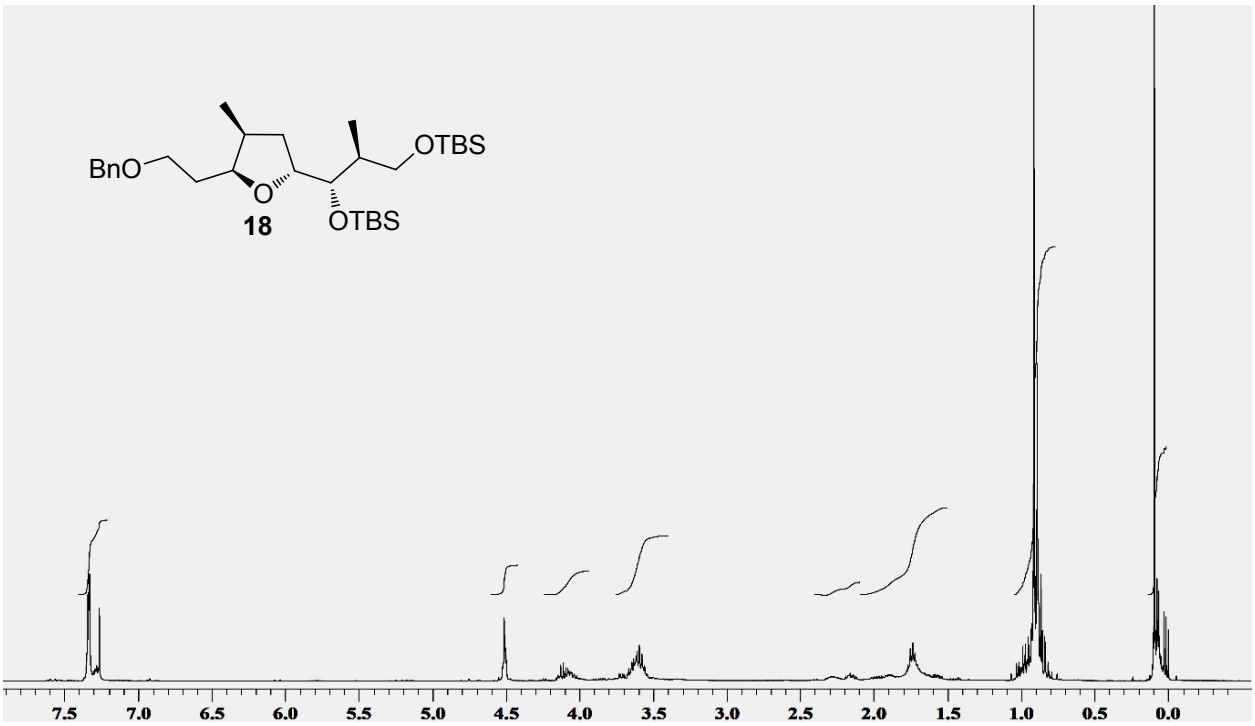
^{13}CNMR ($CDCl_3$, 125MHz)



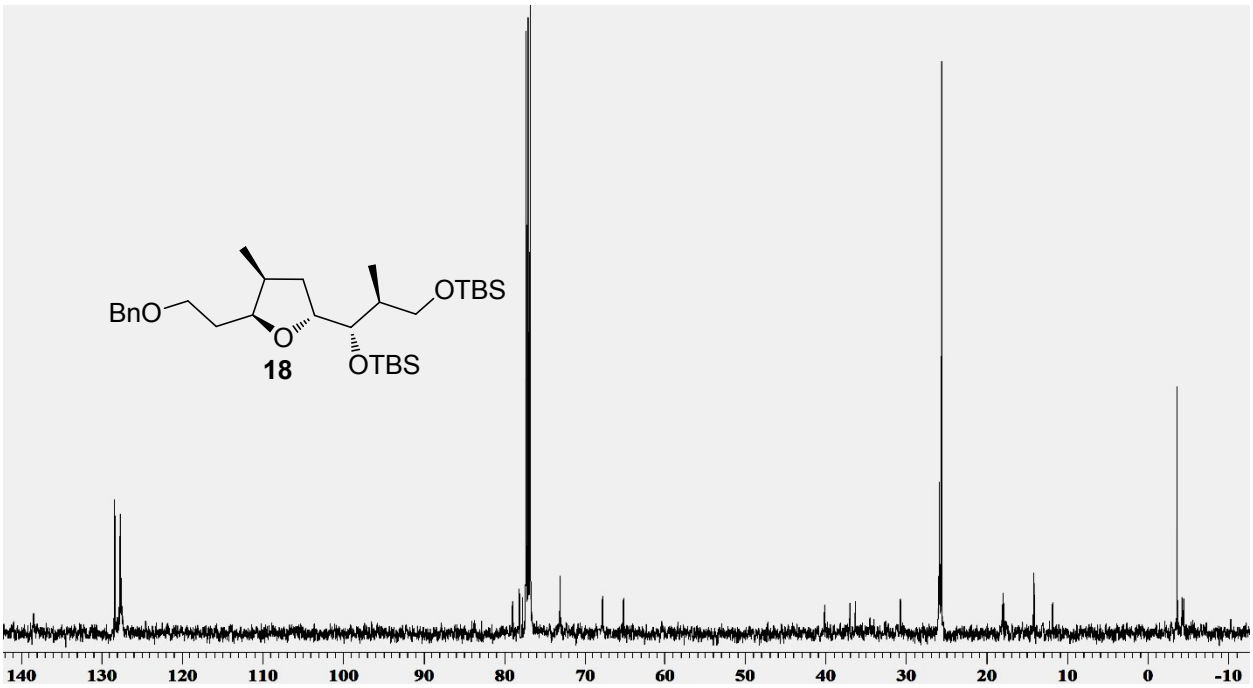
^{1}HNMR ($CDCl_3$, 300MHz)



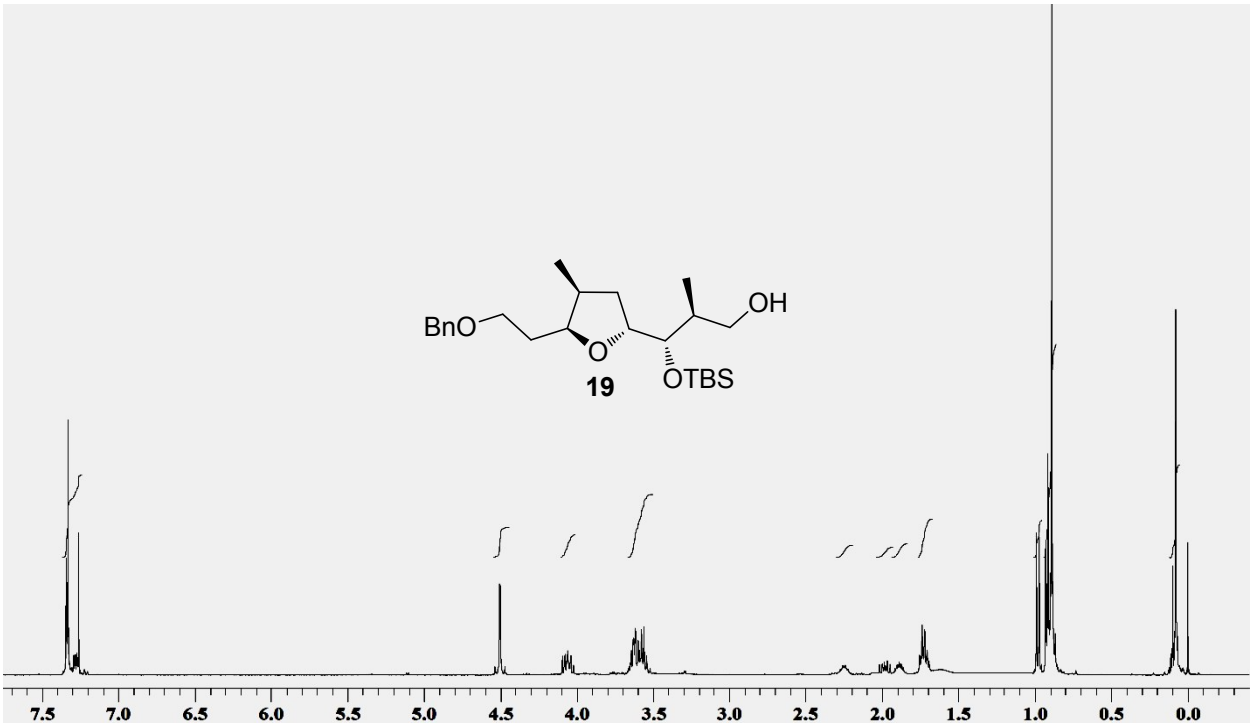
^{13}CNMR ($CDCl_3$, 125MHz)



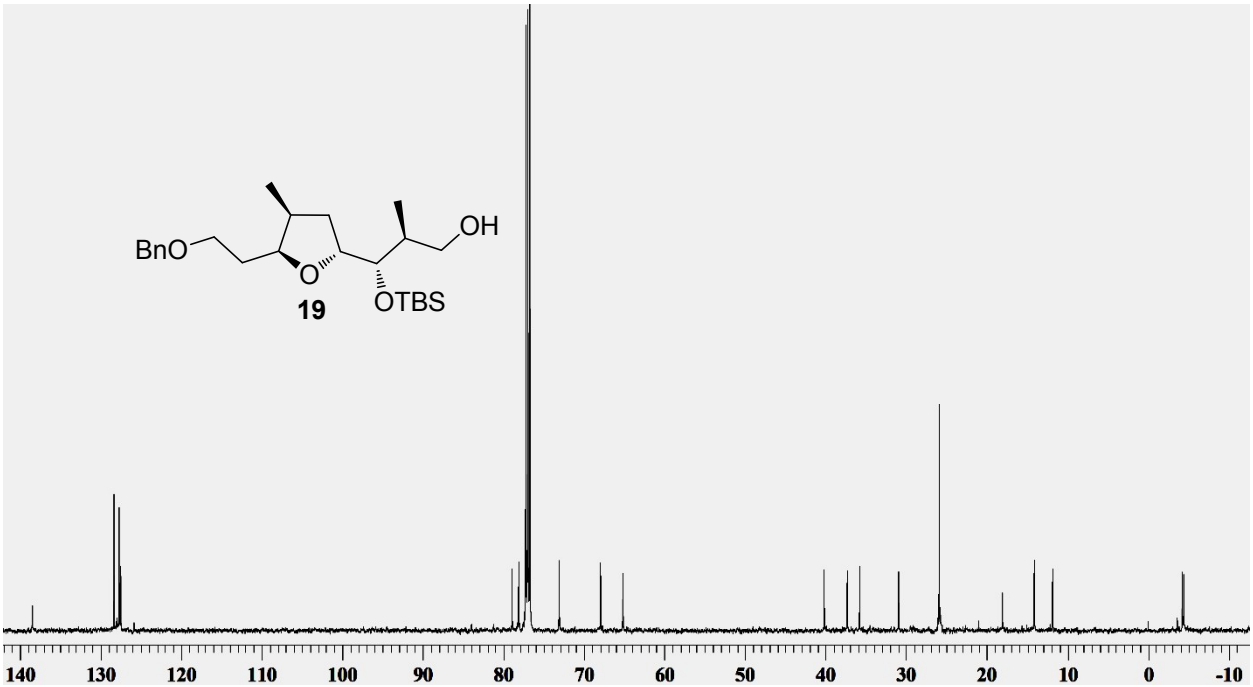
^{1}HNMR ($CDCl_3$, 300MHz)



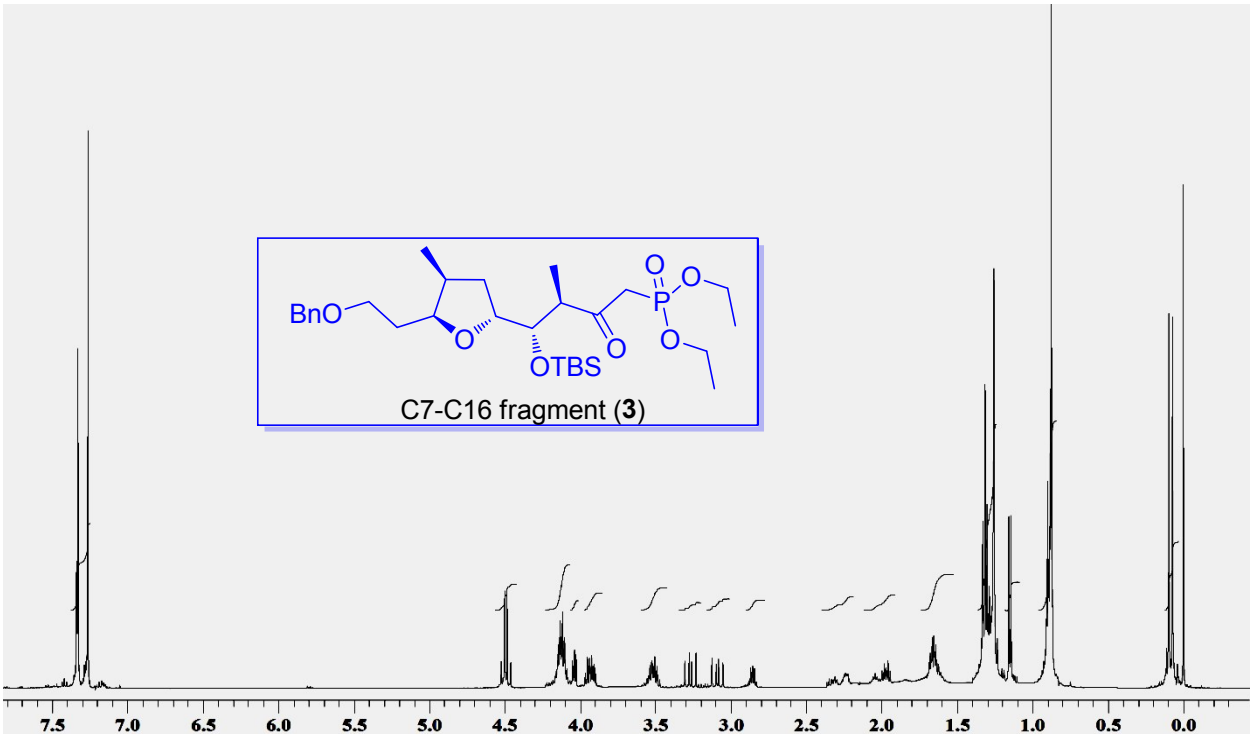
^{13}CNMR ($CDCl_3$, 75MHz)

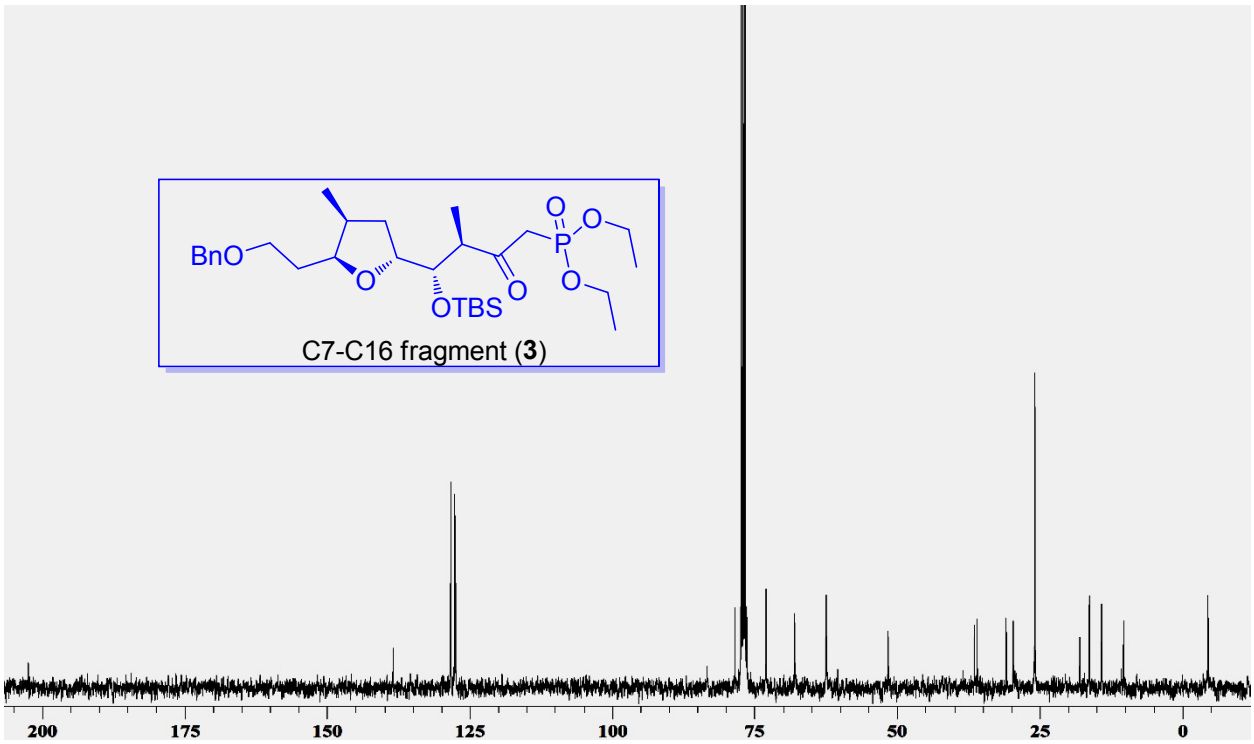


^{1}HNMR ($CDCl_3$, 400MHz)

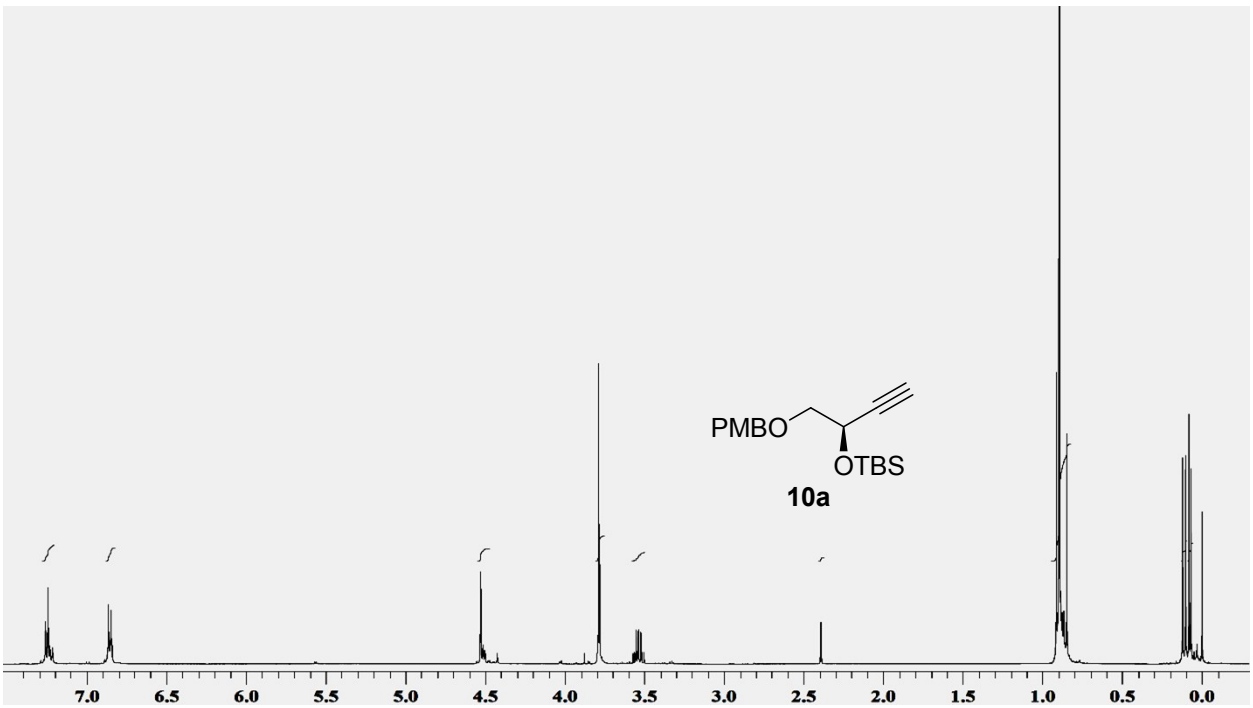


^{13}CNMR ($CDCl_3$, 125MHz)

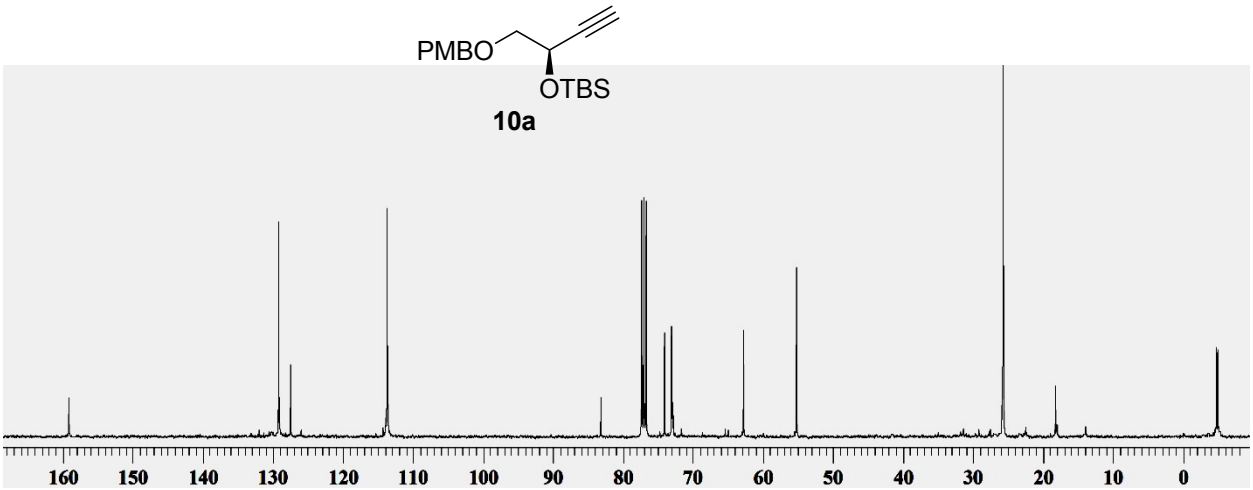




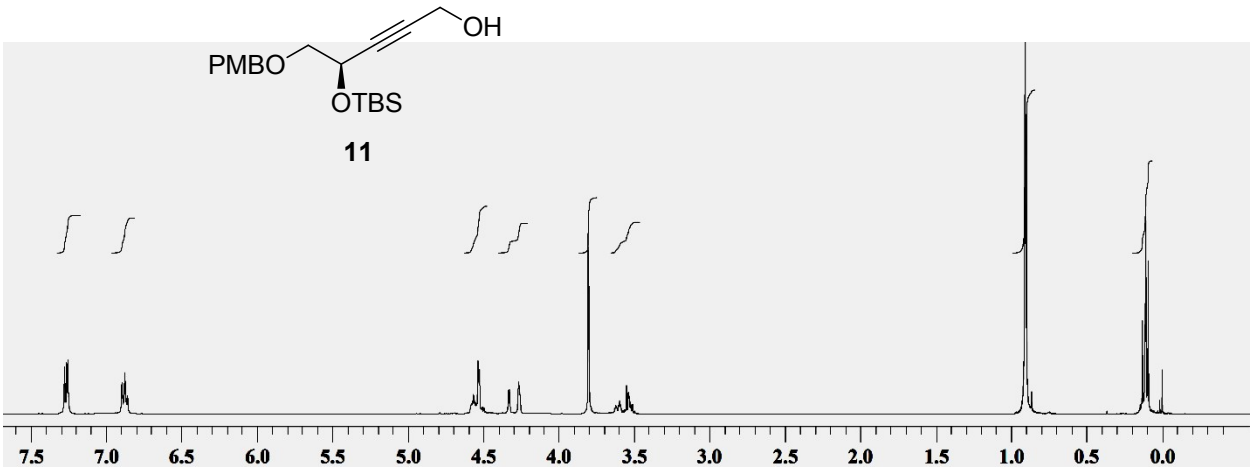
^{13}CNMR ($CDCl_3$, 125MHz)



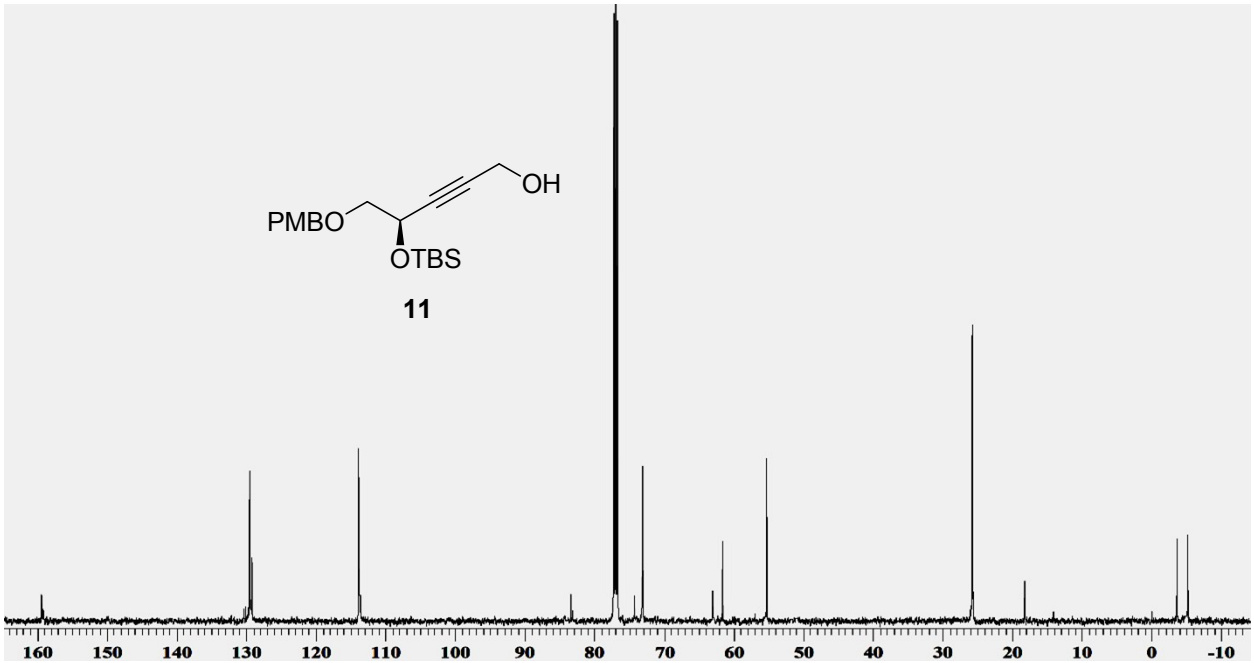
^{1}HNMR ($CDCl_3$, 500MHz)



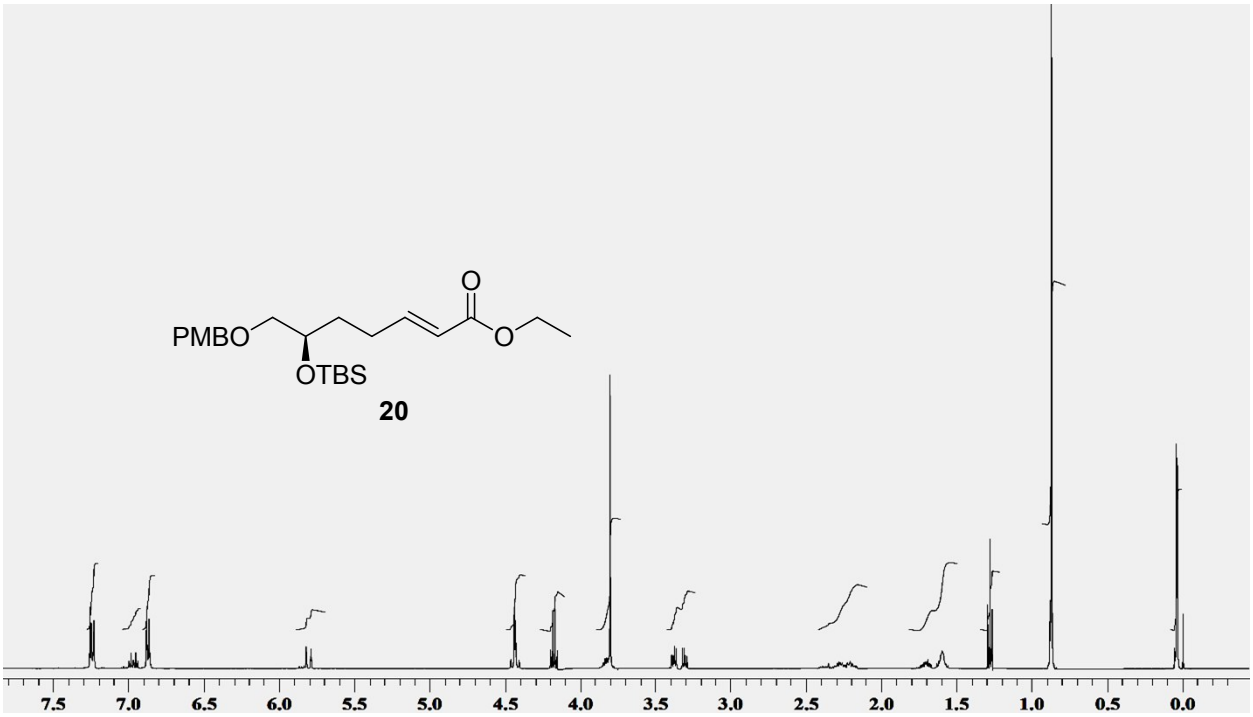
^{13}CNMR ($CDCl_3$, 125MHz)



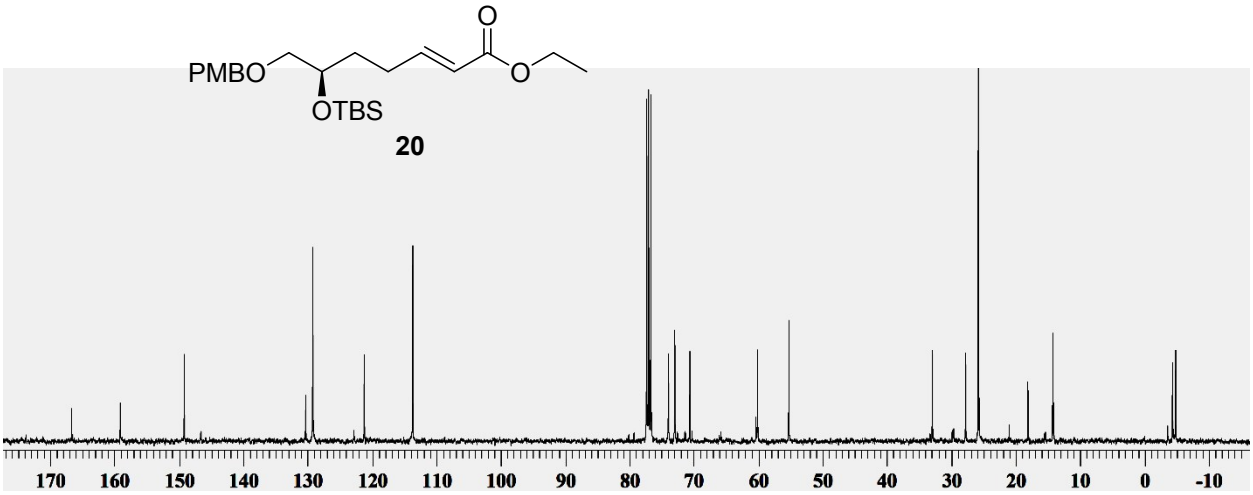
^{1}HNMR ($CDCl_3$, 500MHz)



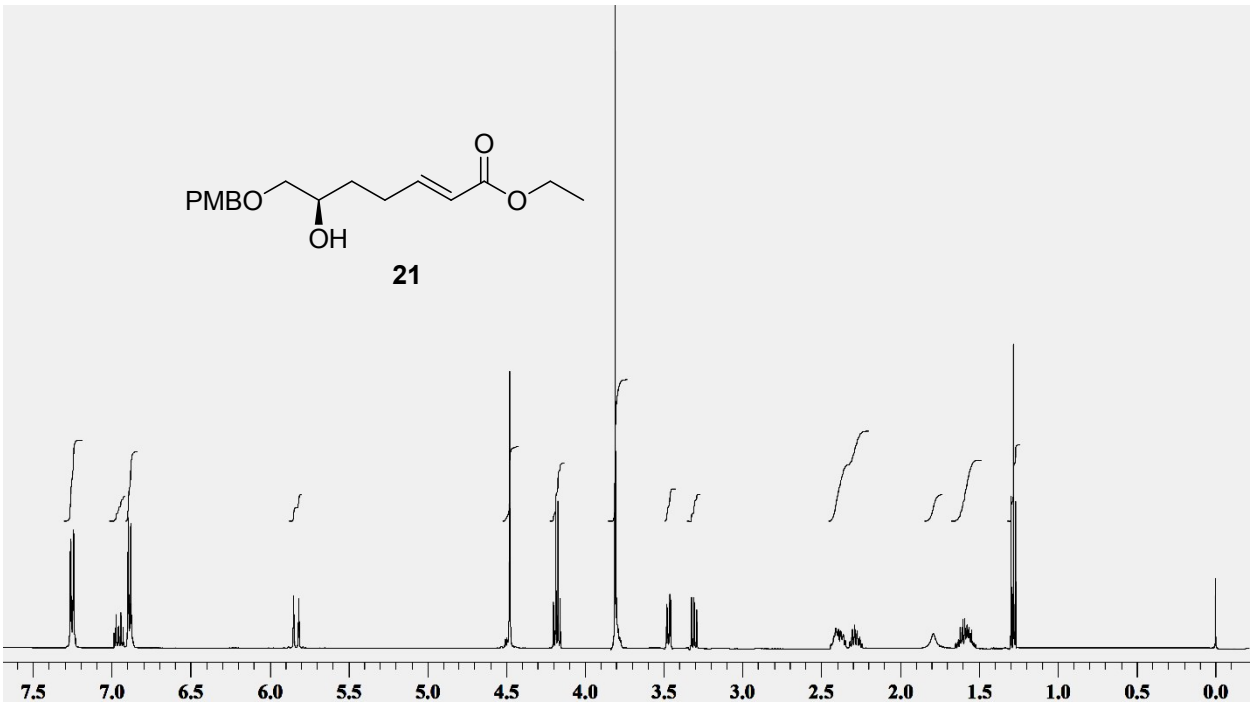
^{13}CNMR ($CDCl_3$, 125MHz)



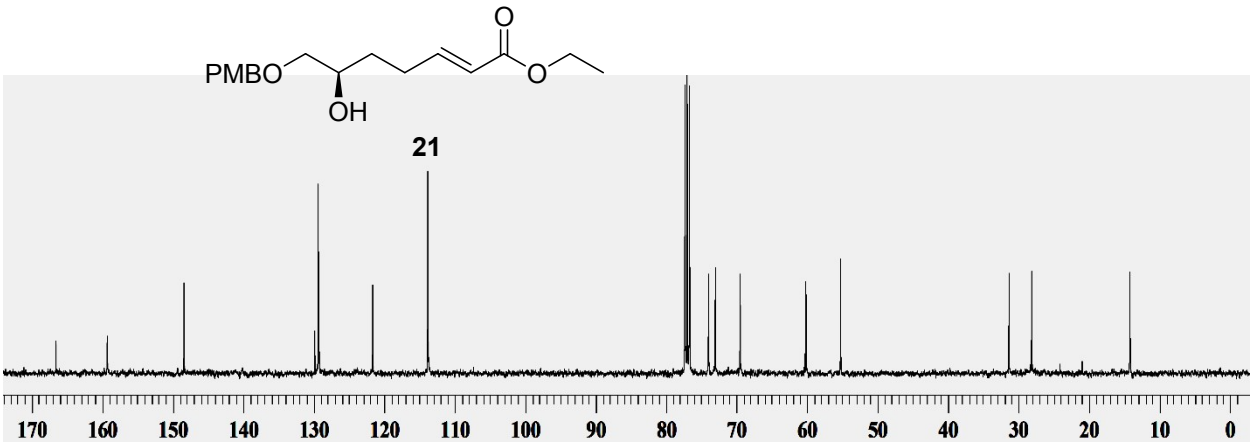
^{1}HNMR ($CDCl_3$, 500MHz)



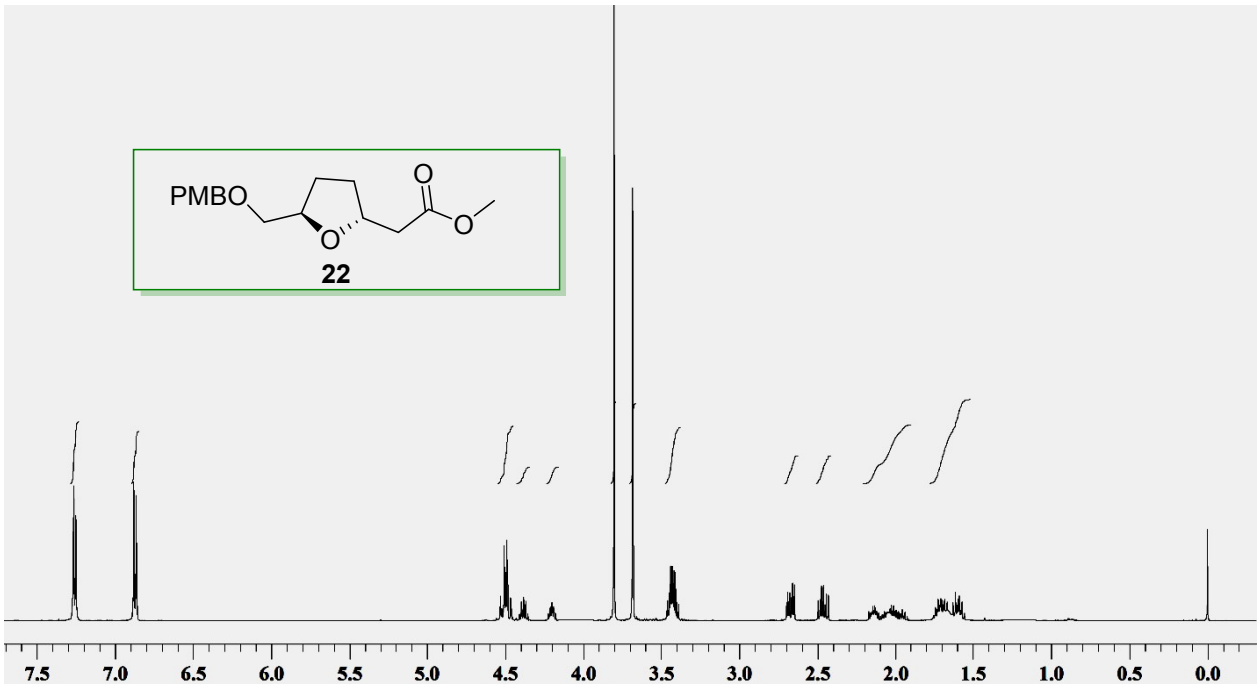
^{13}CNMR ($CDCl_3$, 125MHz)



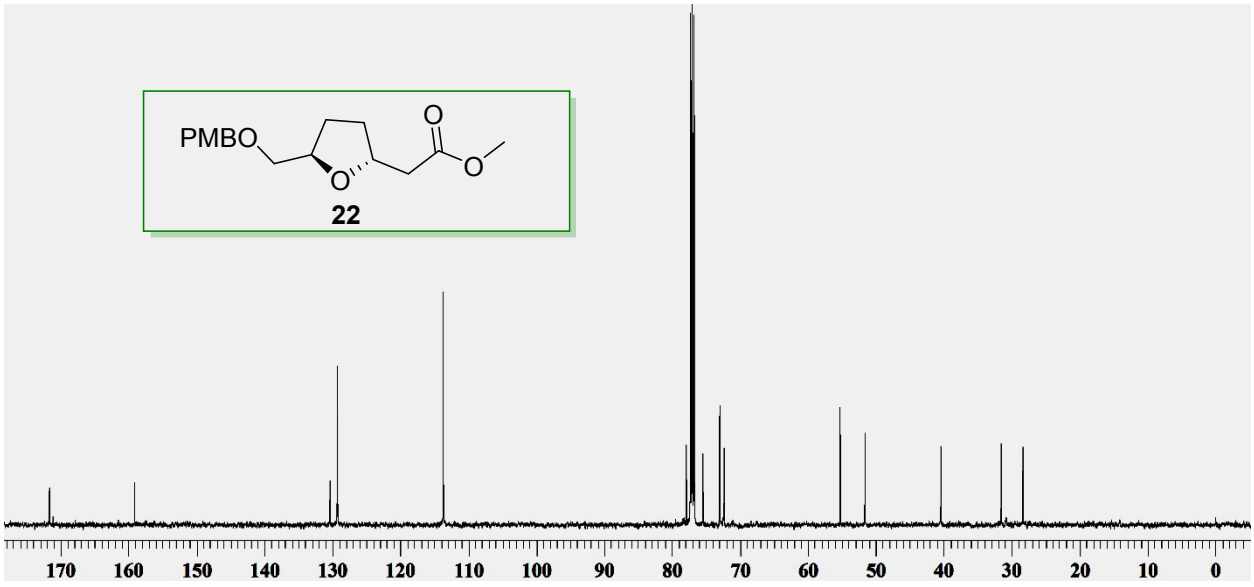
^{1}HNMR ($CDCl_3$, 500MHz)



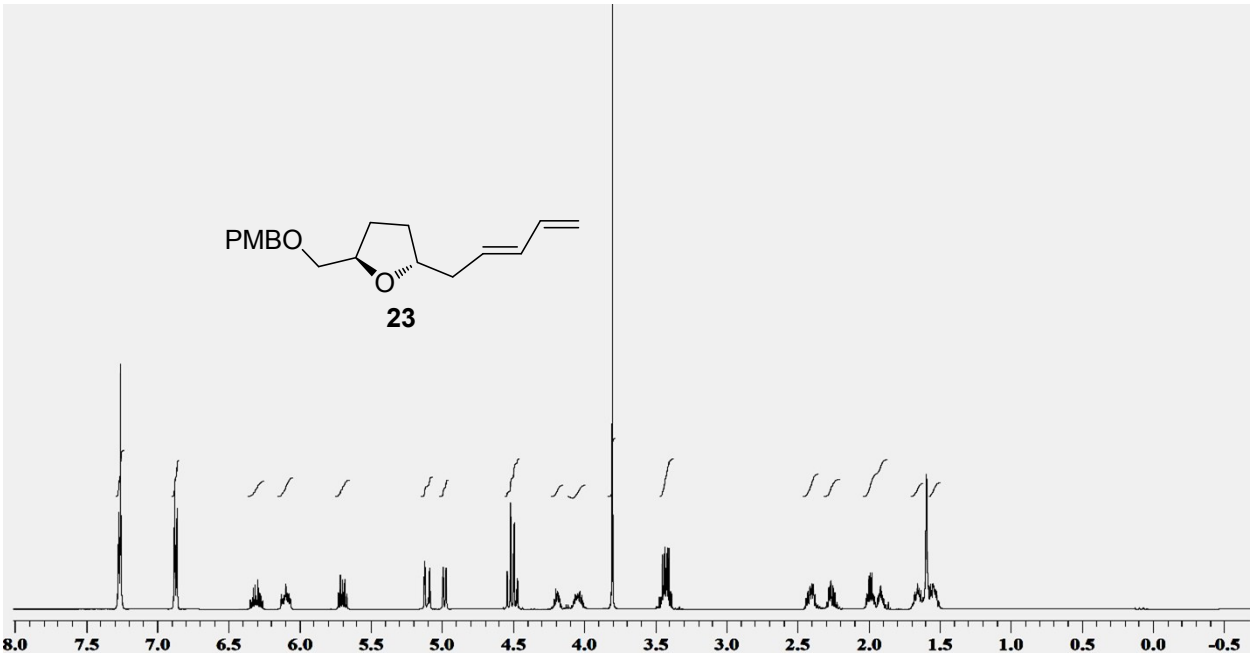
^{13}CNMR ($CDCl_3$, 125MHz)



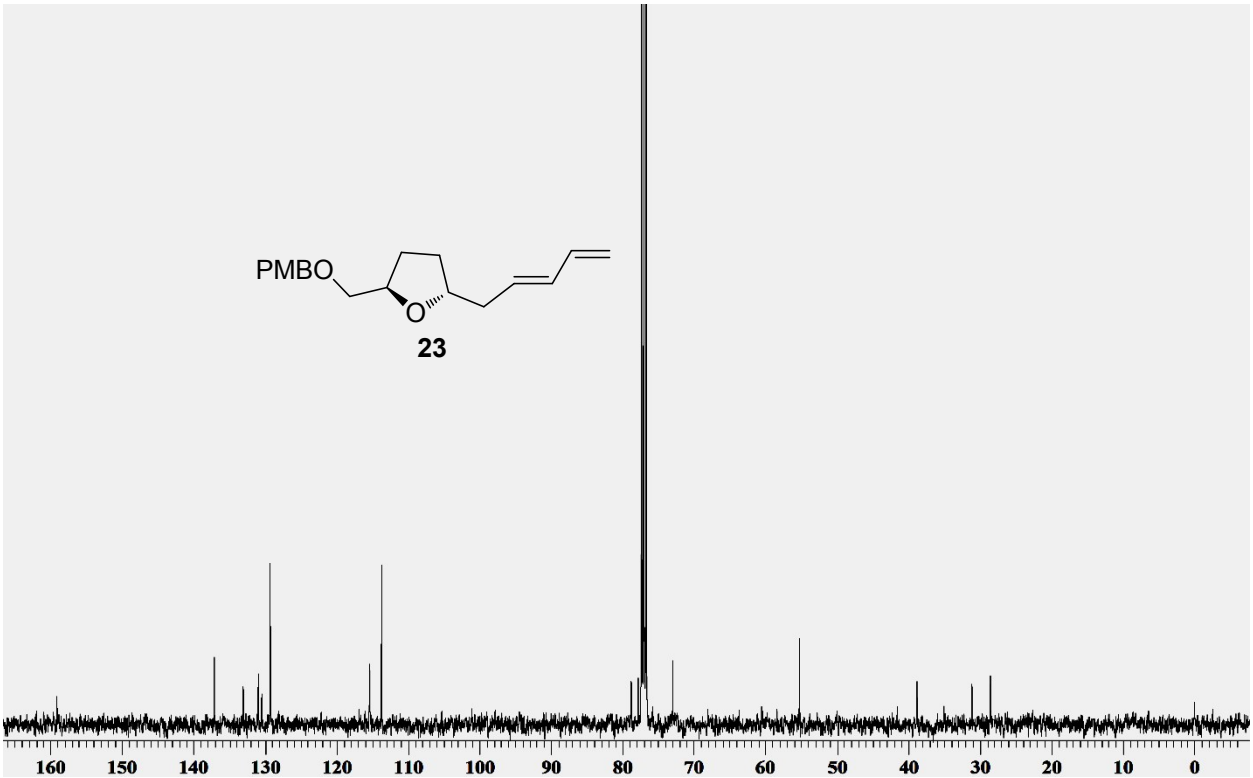
^{1}HNMR ($CDCl_3$, 400MHz)



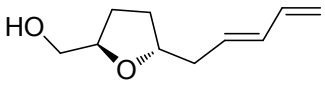
^{13}CNMR ($CDCl_3$, 100MHz)



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



^{13}CNMR ($CDCl_3$, 75MHz)



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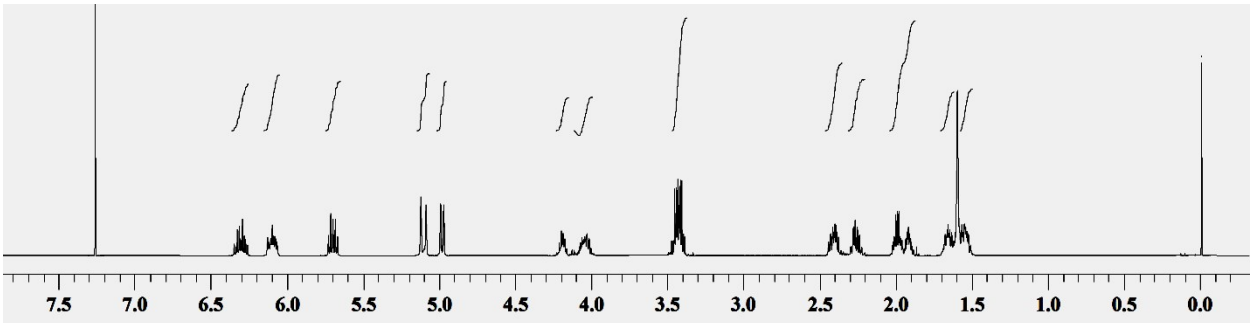
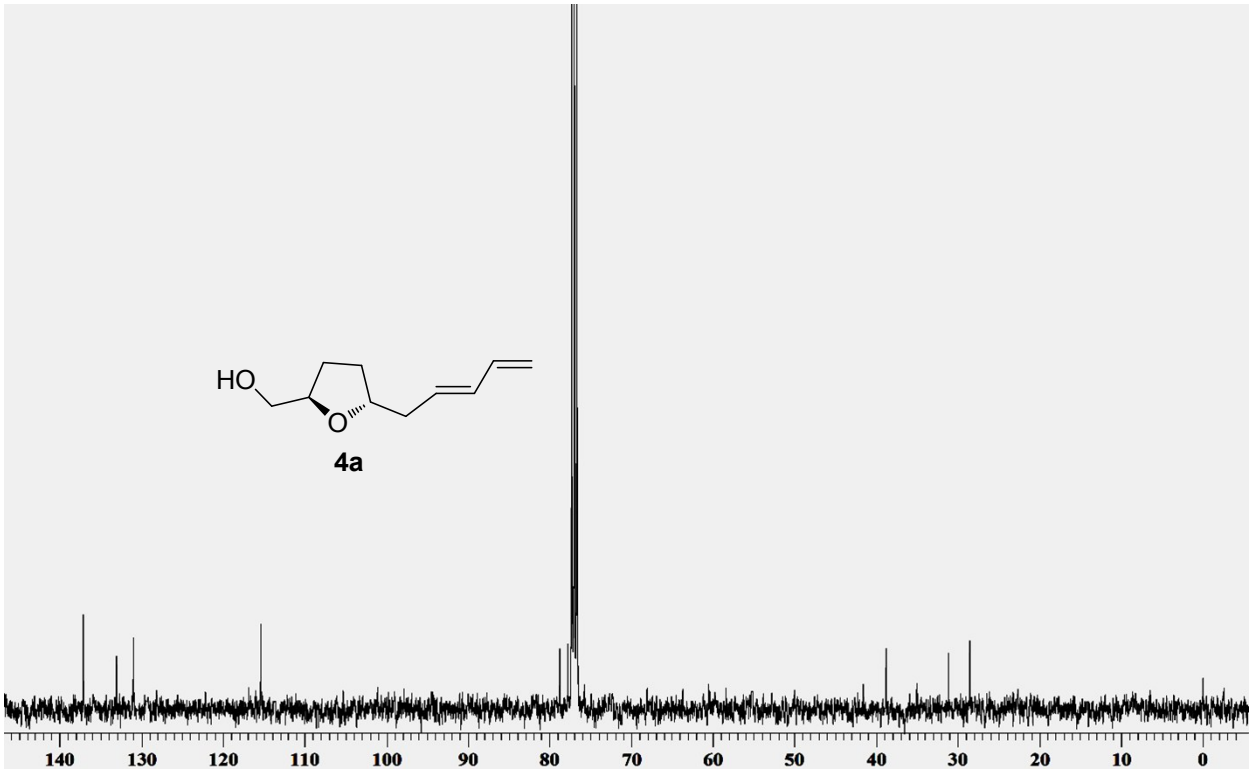
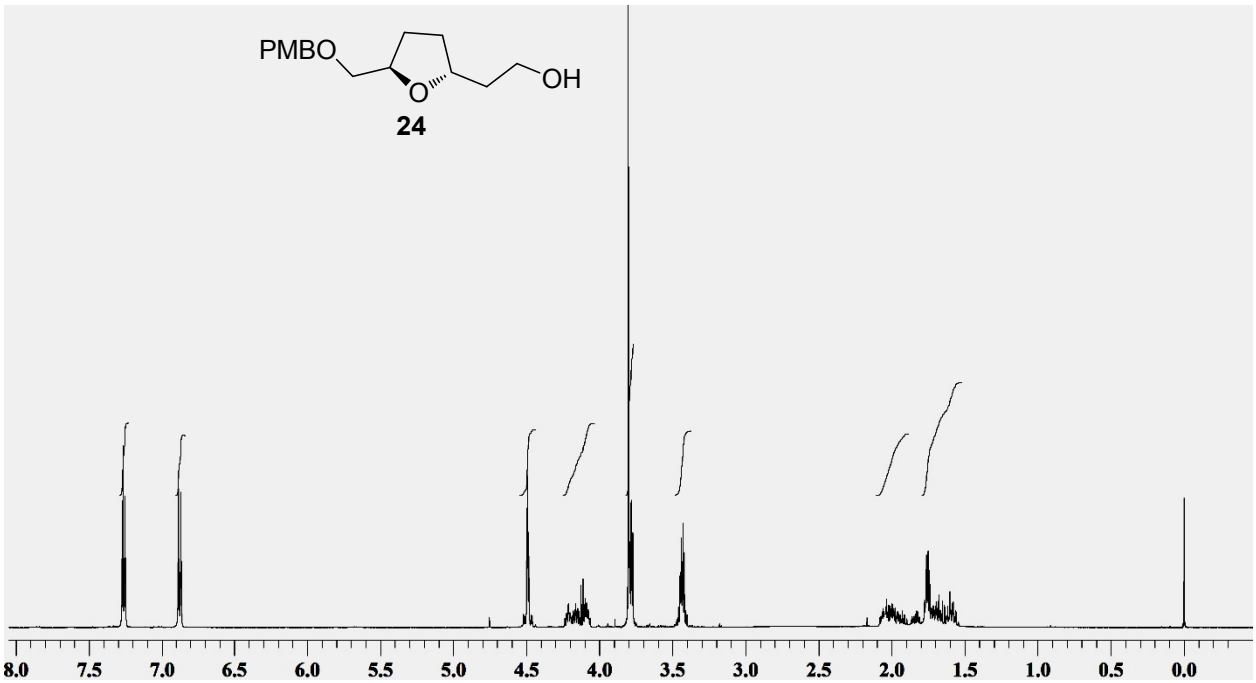


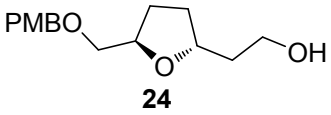
^{1}HNMR ($CDCl_3$, 500MHz)

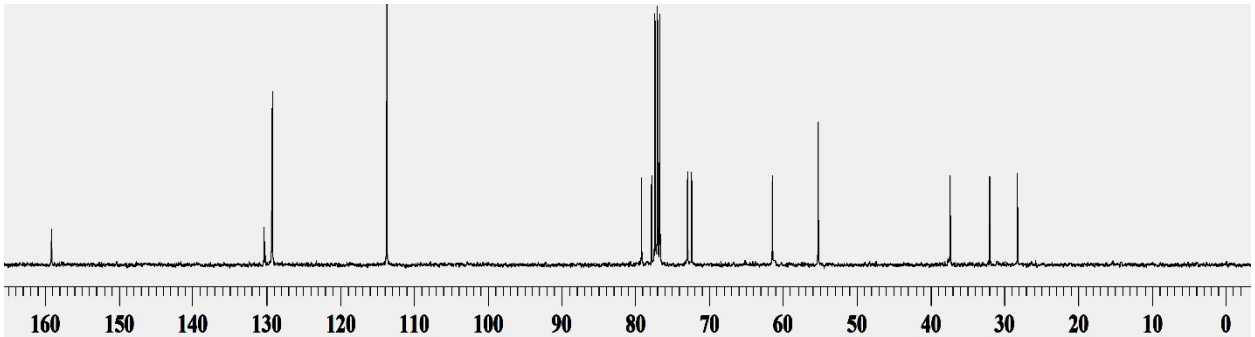


^{13}CNMR ($CDCl_3$, 75MHz)

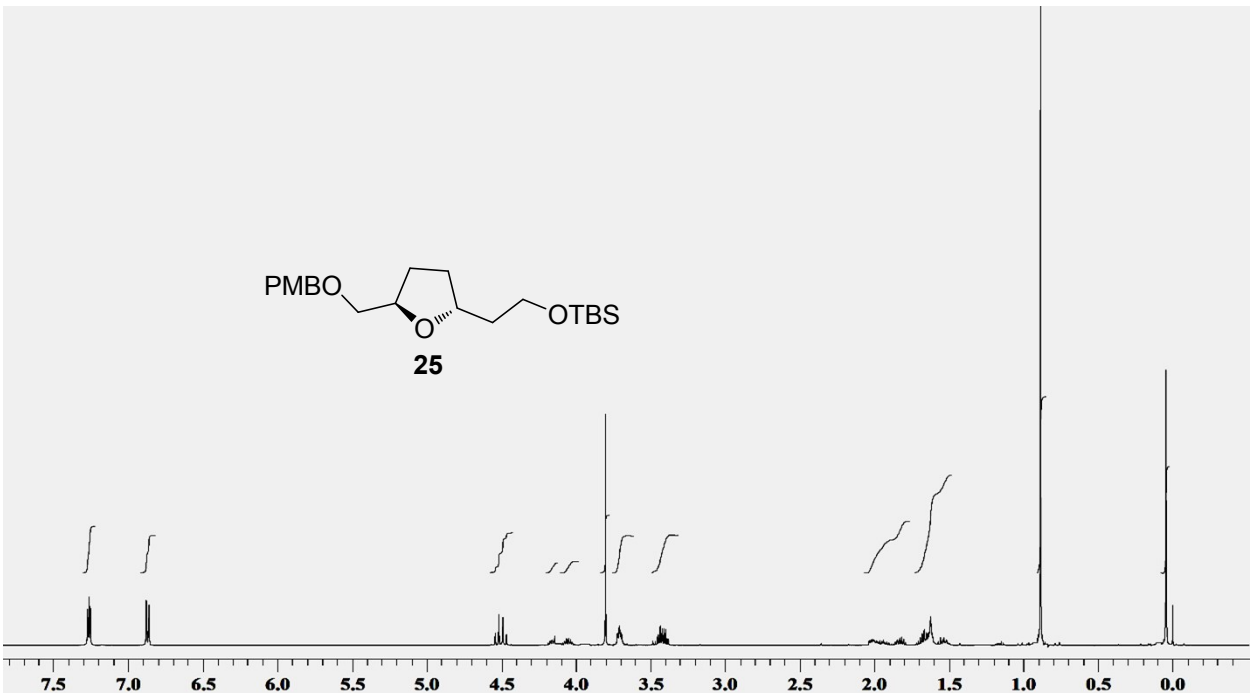


^{1}HNMR ($CDCl_3$, 500MHz)

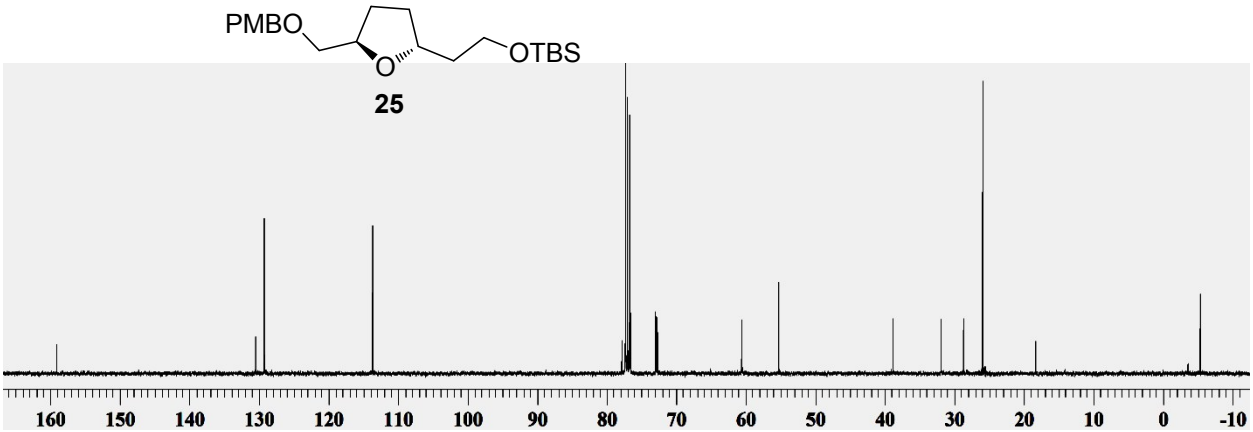




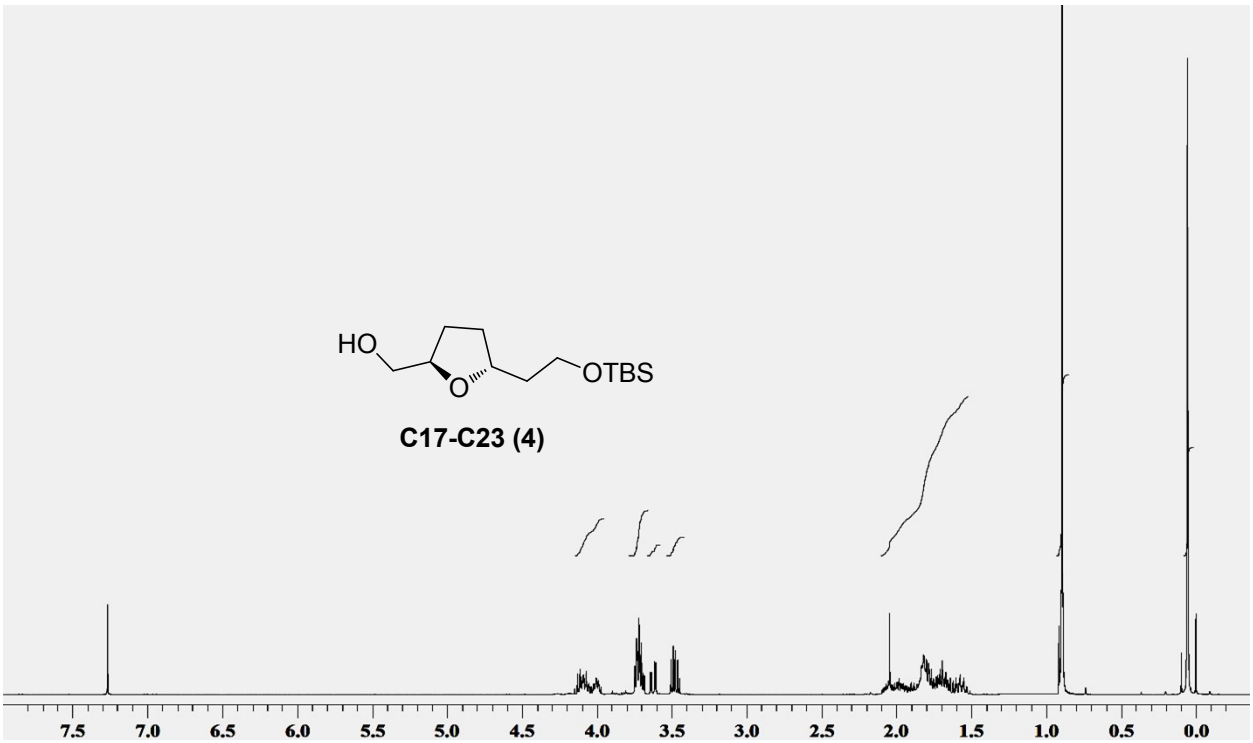
^{13}CNMR ($CDCl_3$, 100MHz)



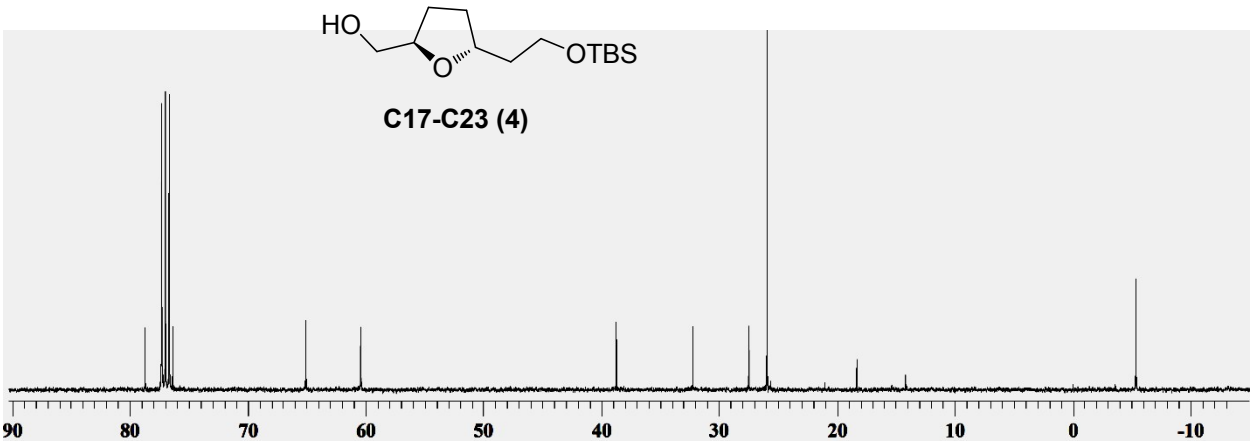
^{1}HNMR ($CDCl_3$, 500MHz)



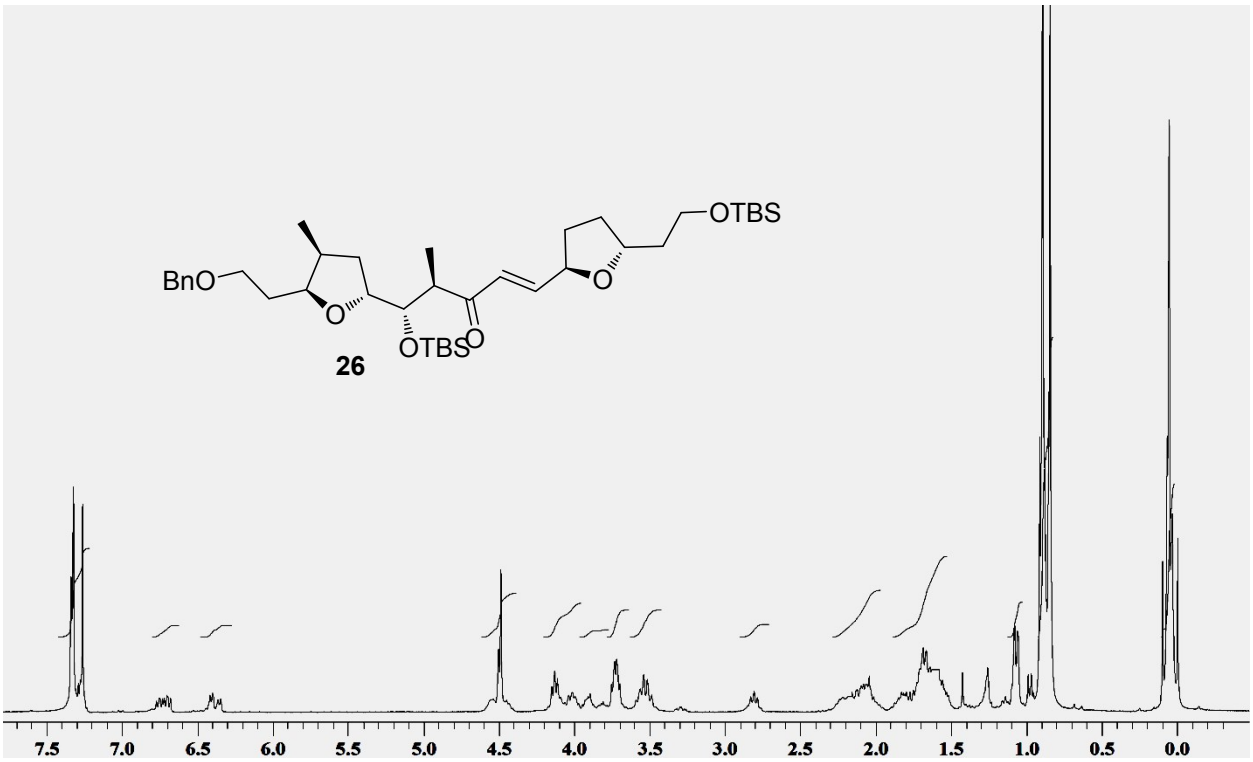
^{13}CNMR ($CDCl_3$, 125MHz)



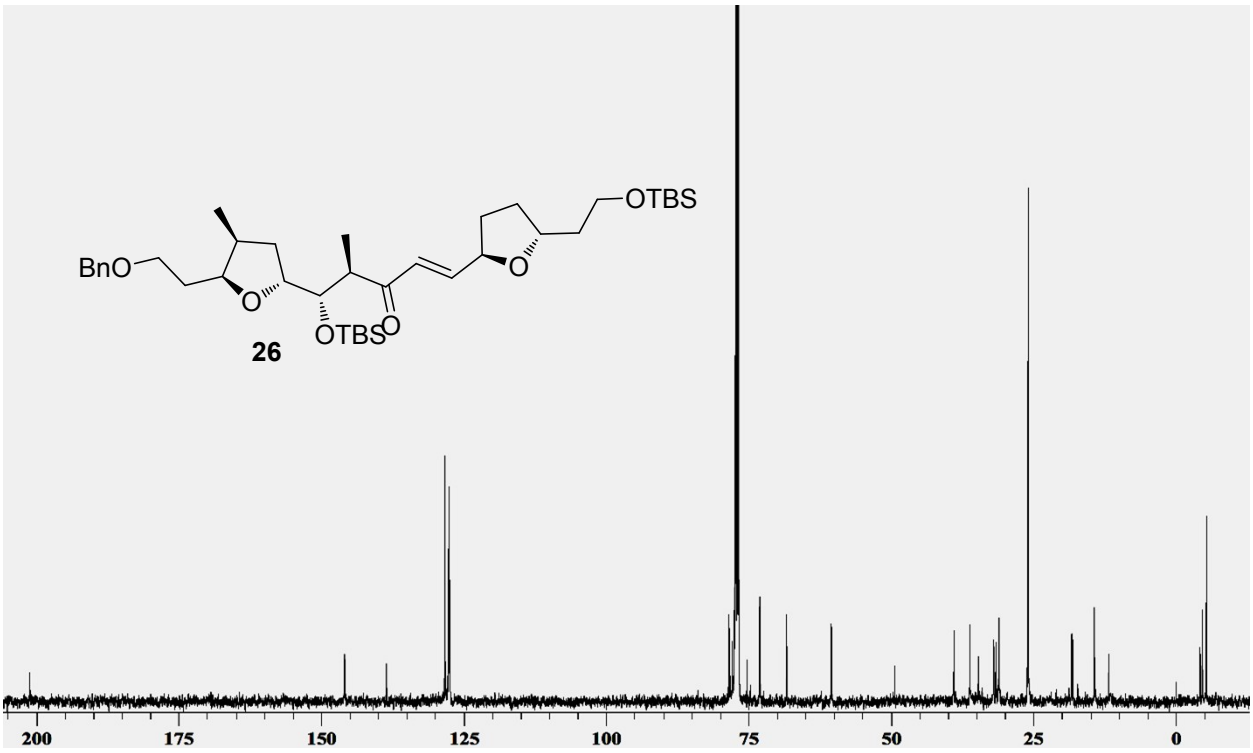
^{1}HNMR ($CDCl_3$, 500MHz)



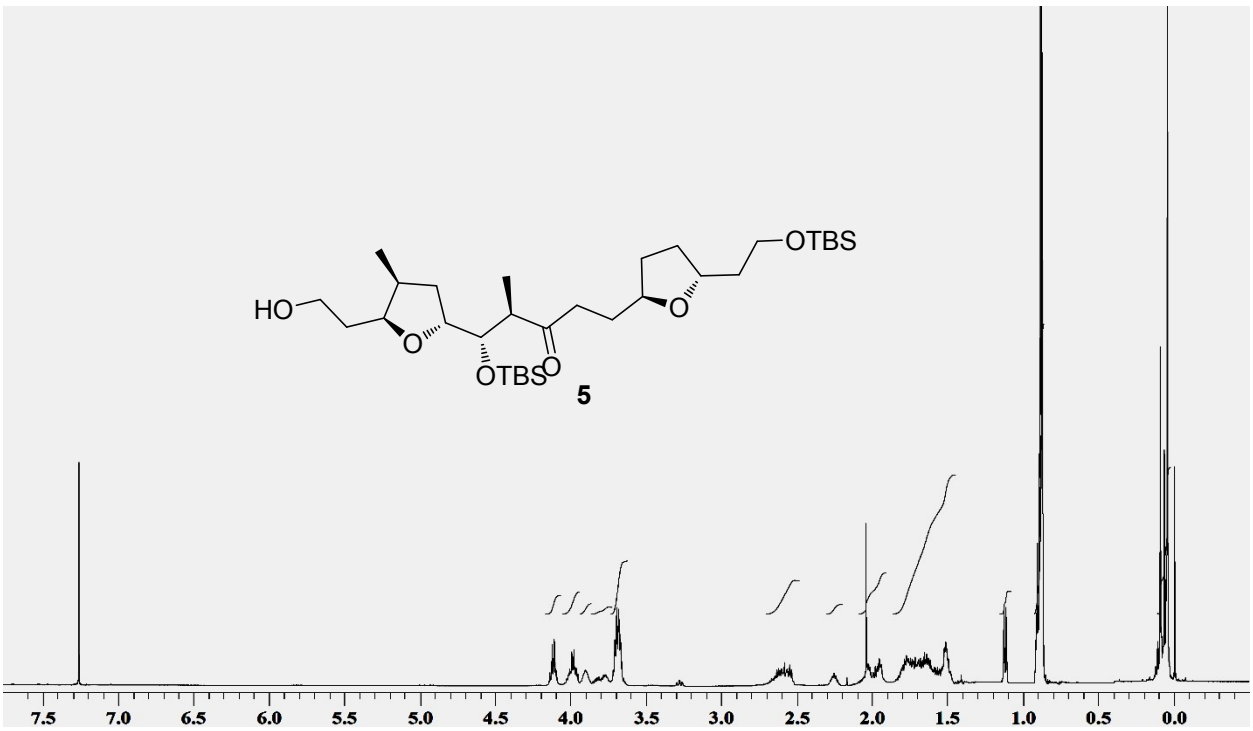
^{13}CNMR ($CDCl_3$, 125MHz)



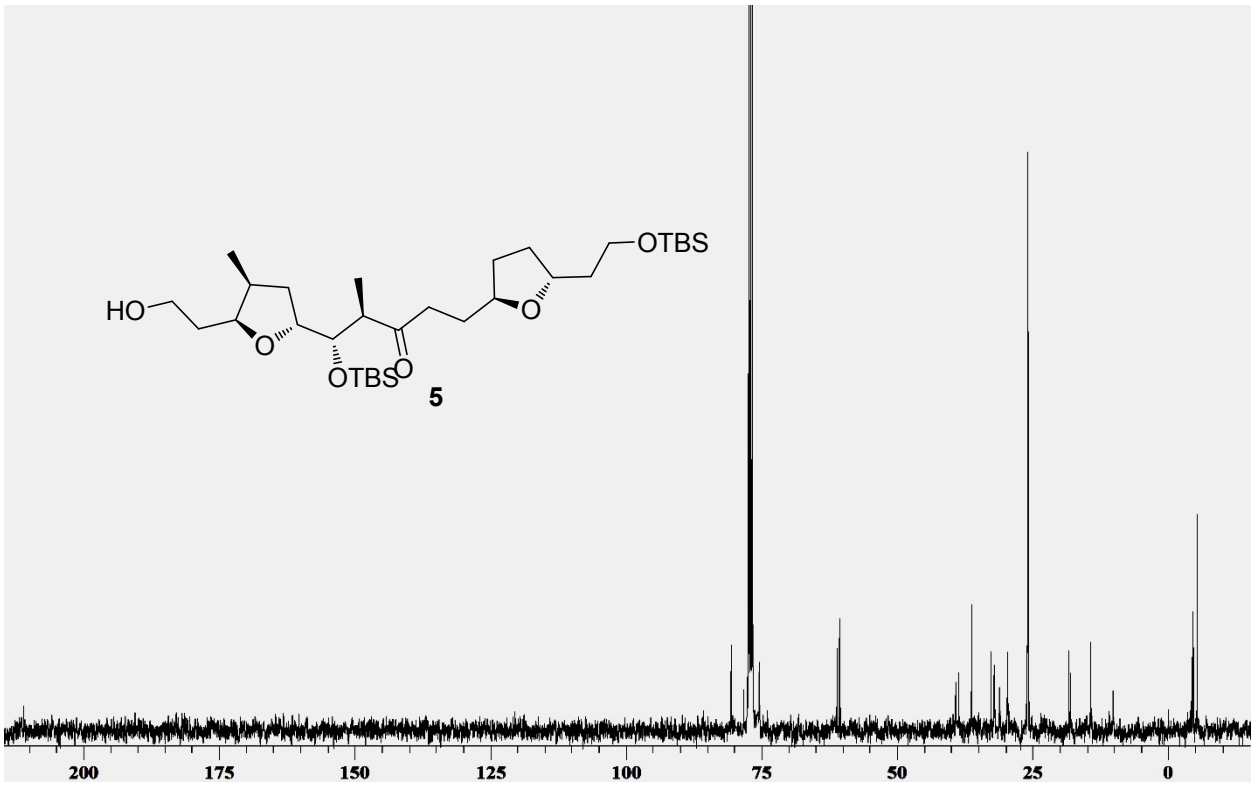
^{1}HNMR ($CDCl_3$, 400MHz)



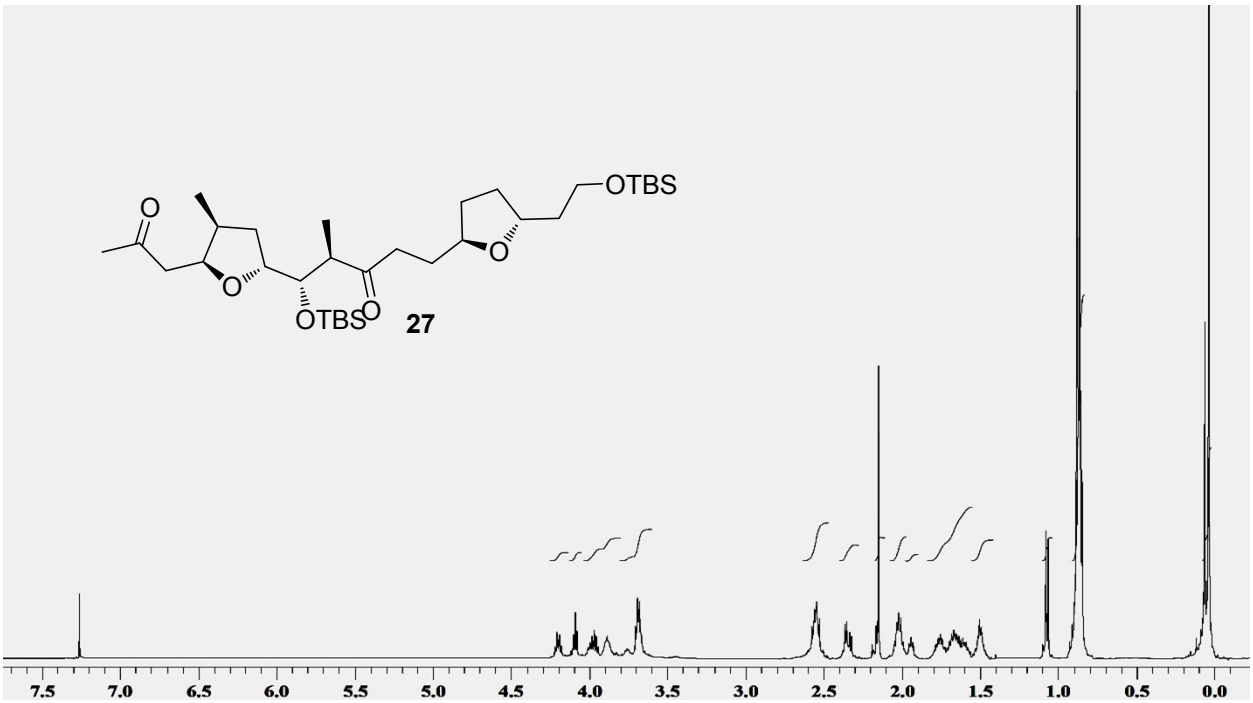
^{13}CNMR ($CDCl_3$, 75MHz)



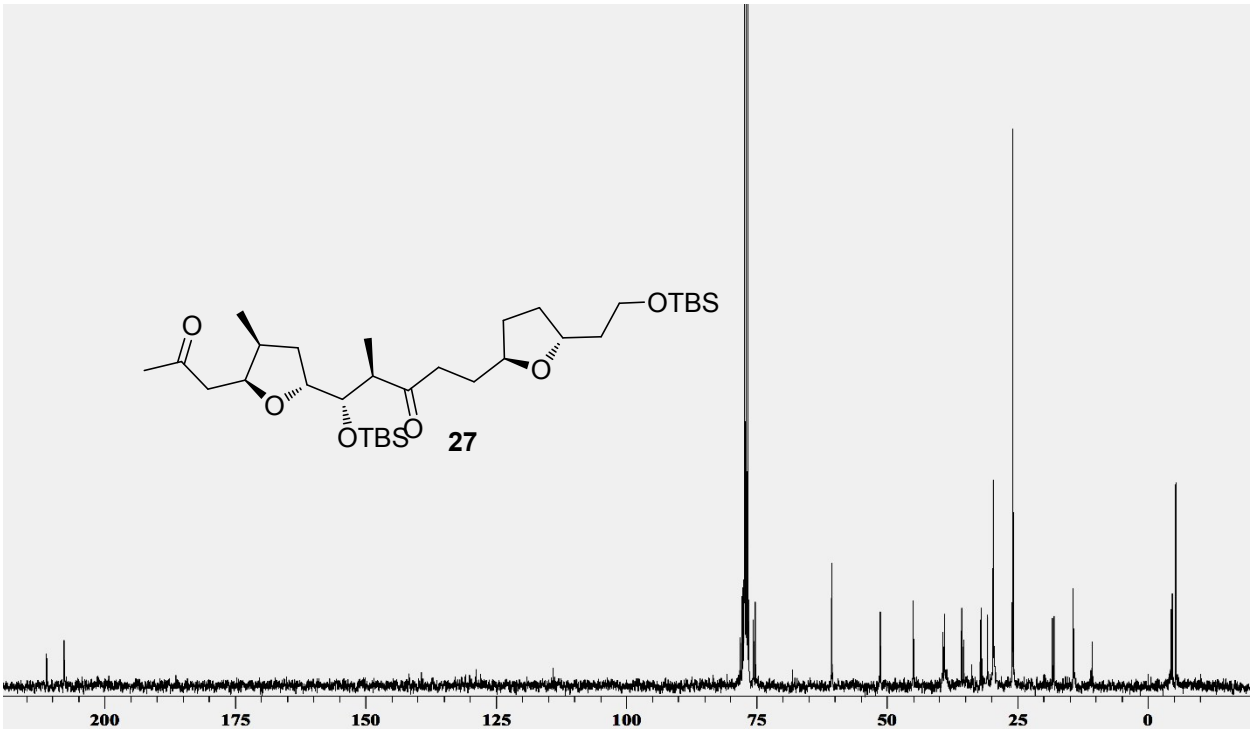
^{1}HNMR ($CDCl_3$, 400MHz)



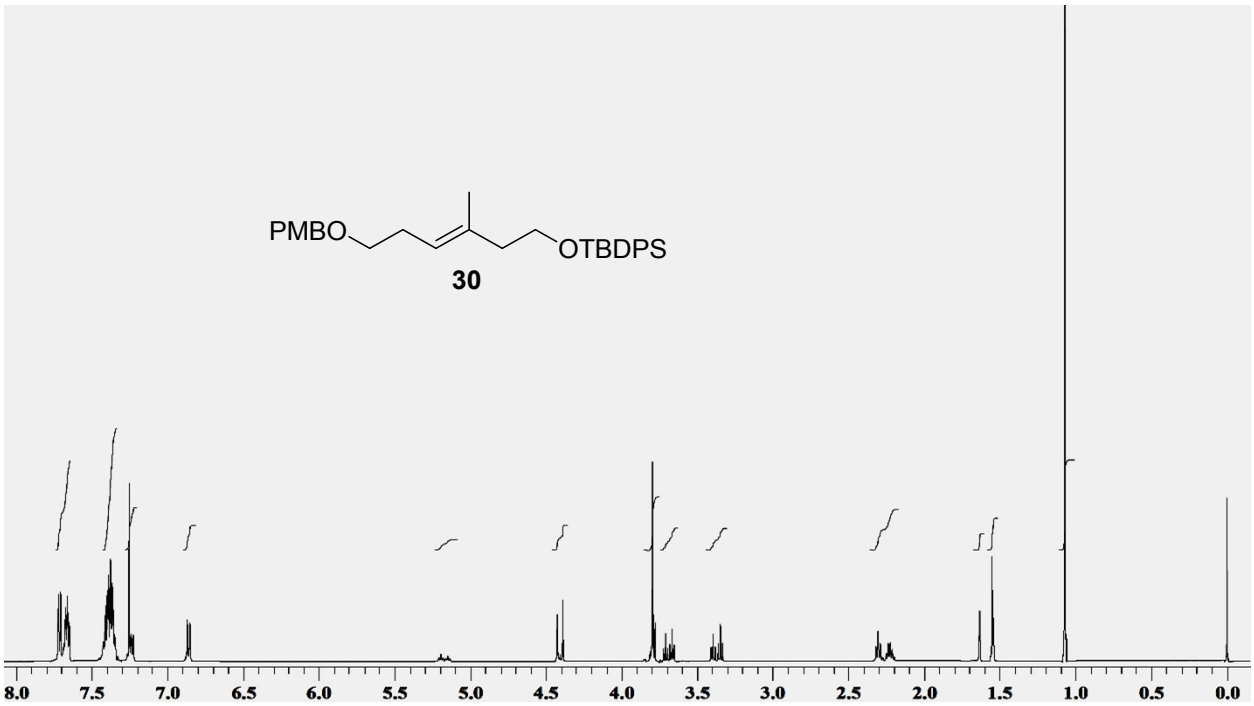
^{13}CNMR ($CDCl_3$, 75MHz)



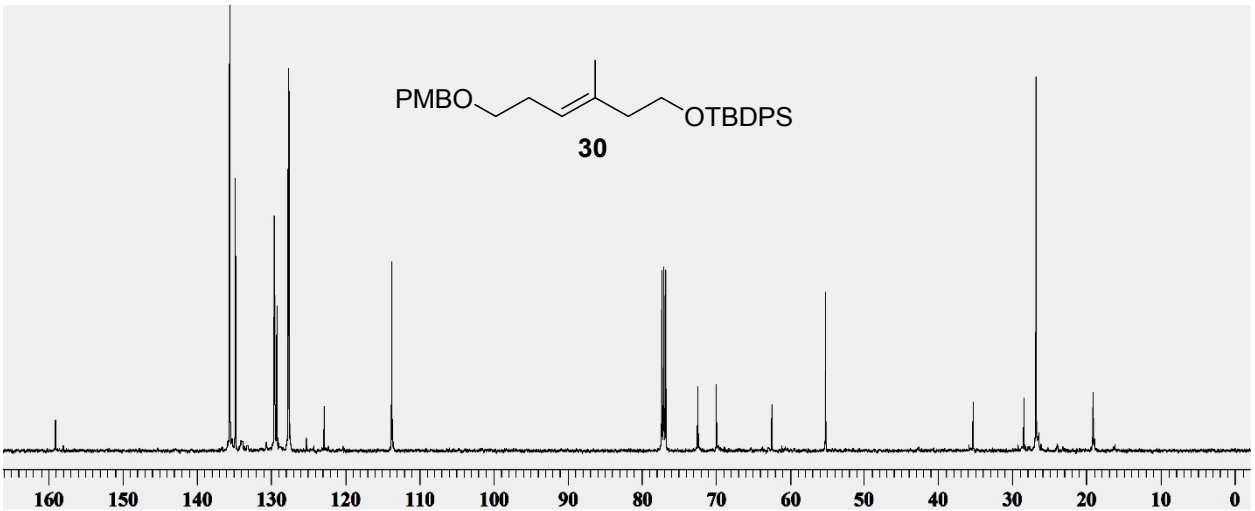
^{1}HNMR ($CDCl_3$, 500MHz)



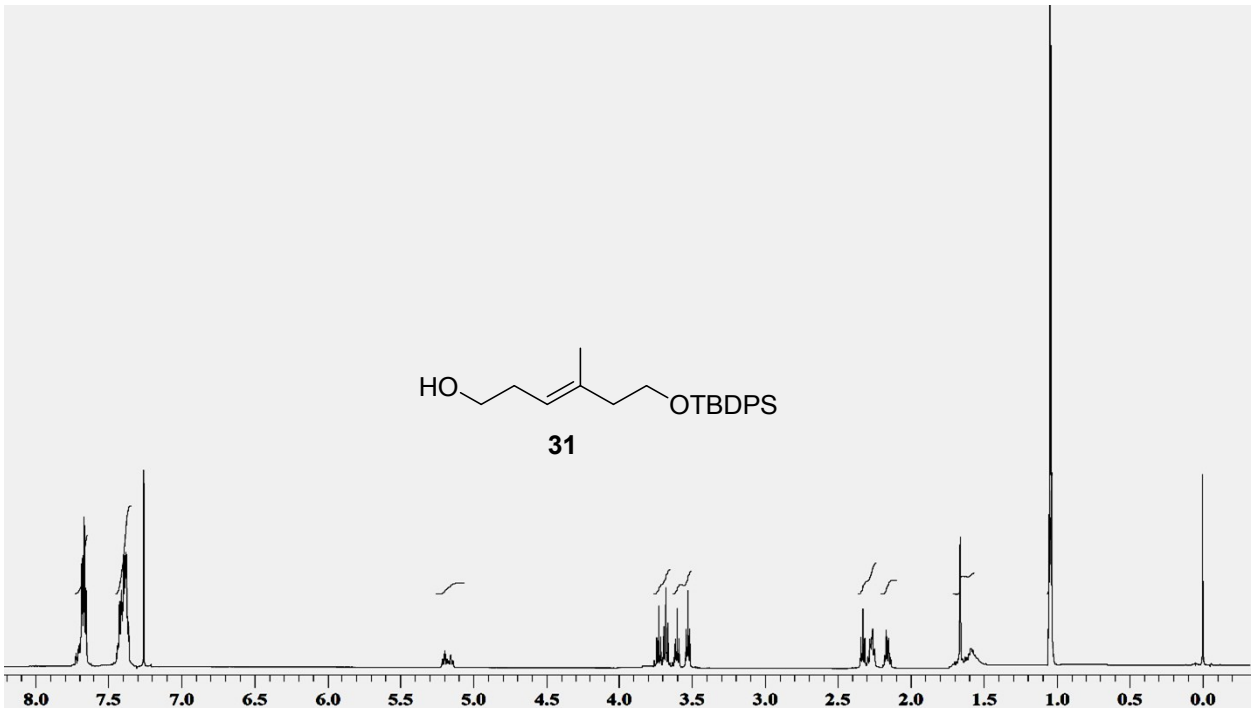
^{13}CNMR ($CDCl_3$, 100MHz)



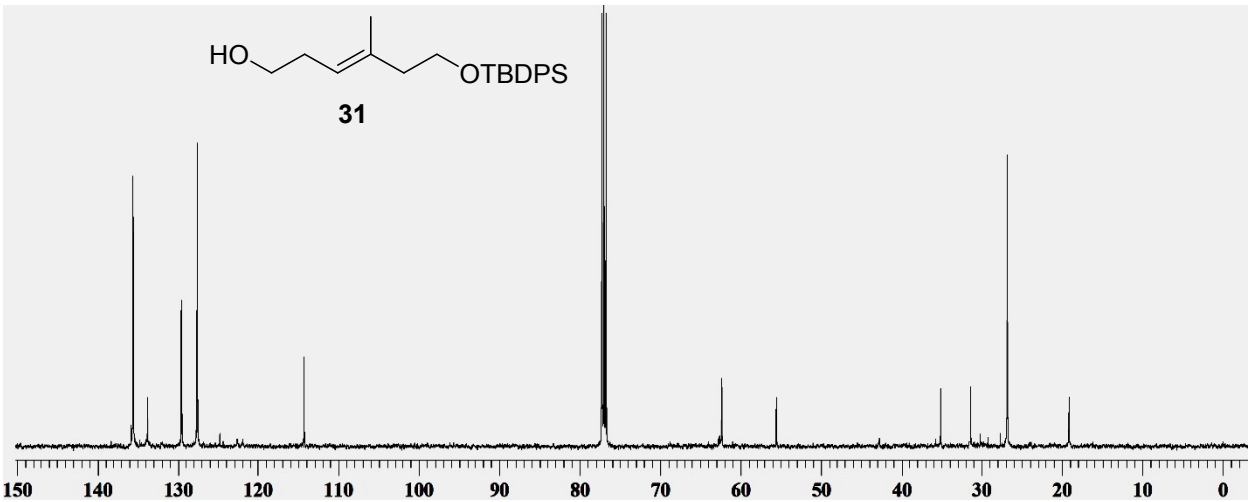
^{1}HNMR ($CDCl_3$, 500MHz)



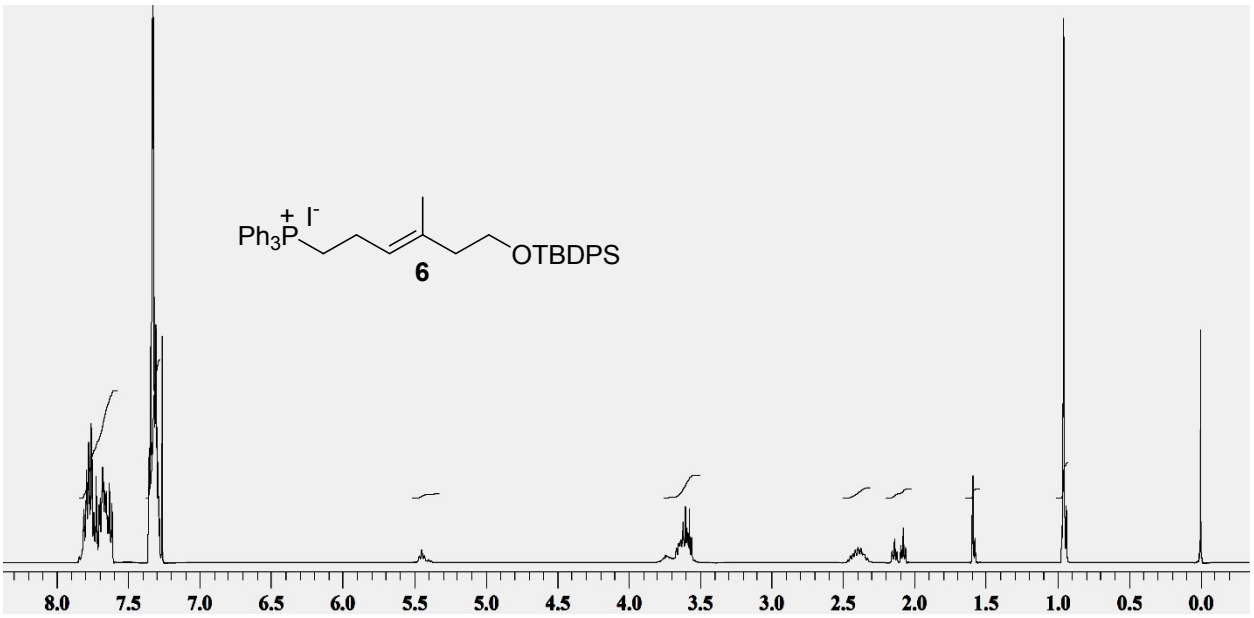
^{13}CNMR ($CDCl_3$, 75MHz)



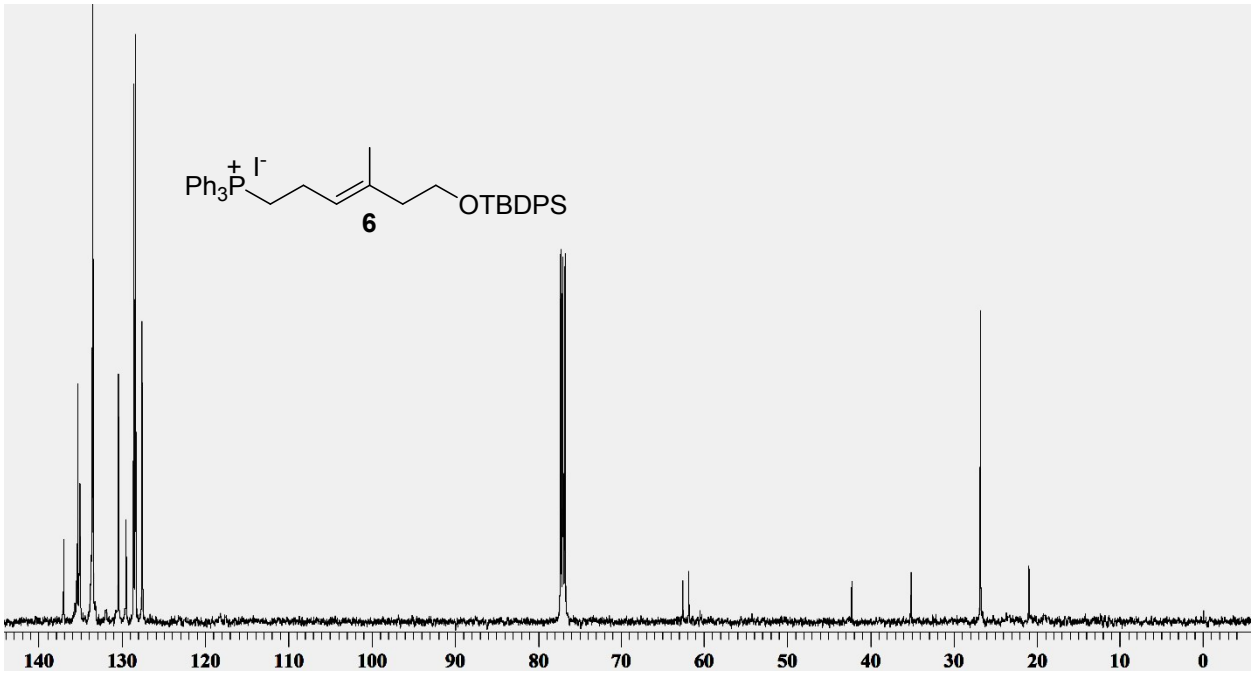
^{1}HNMR ($CDCl_3$, 500MHz)



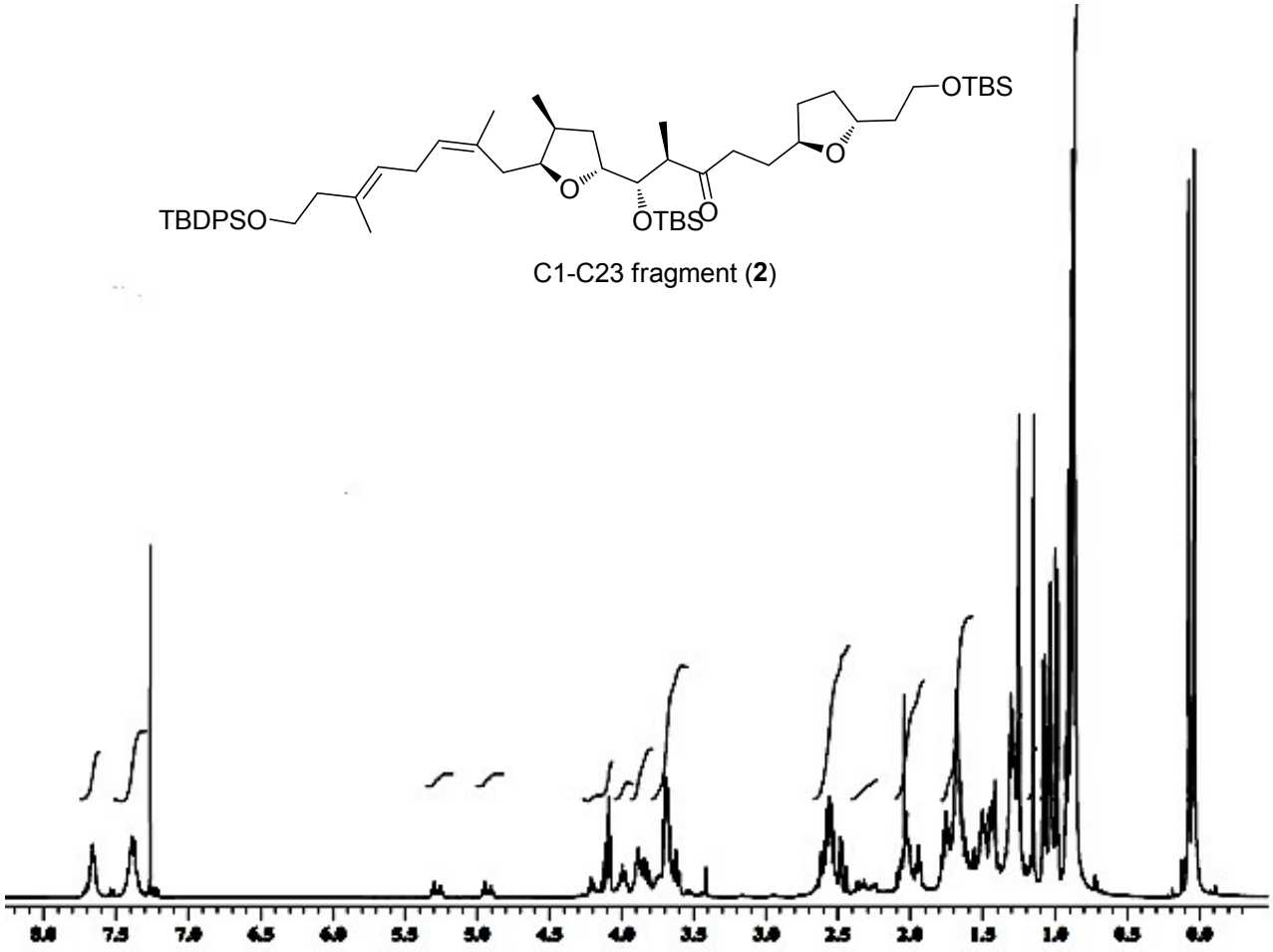
^{13}CNMR ($CDCl_3$, 100MHz)



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

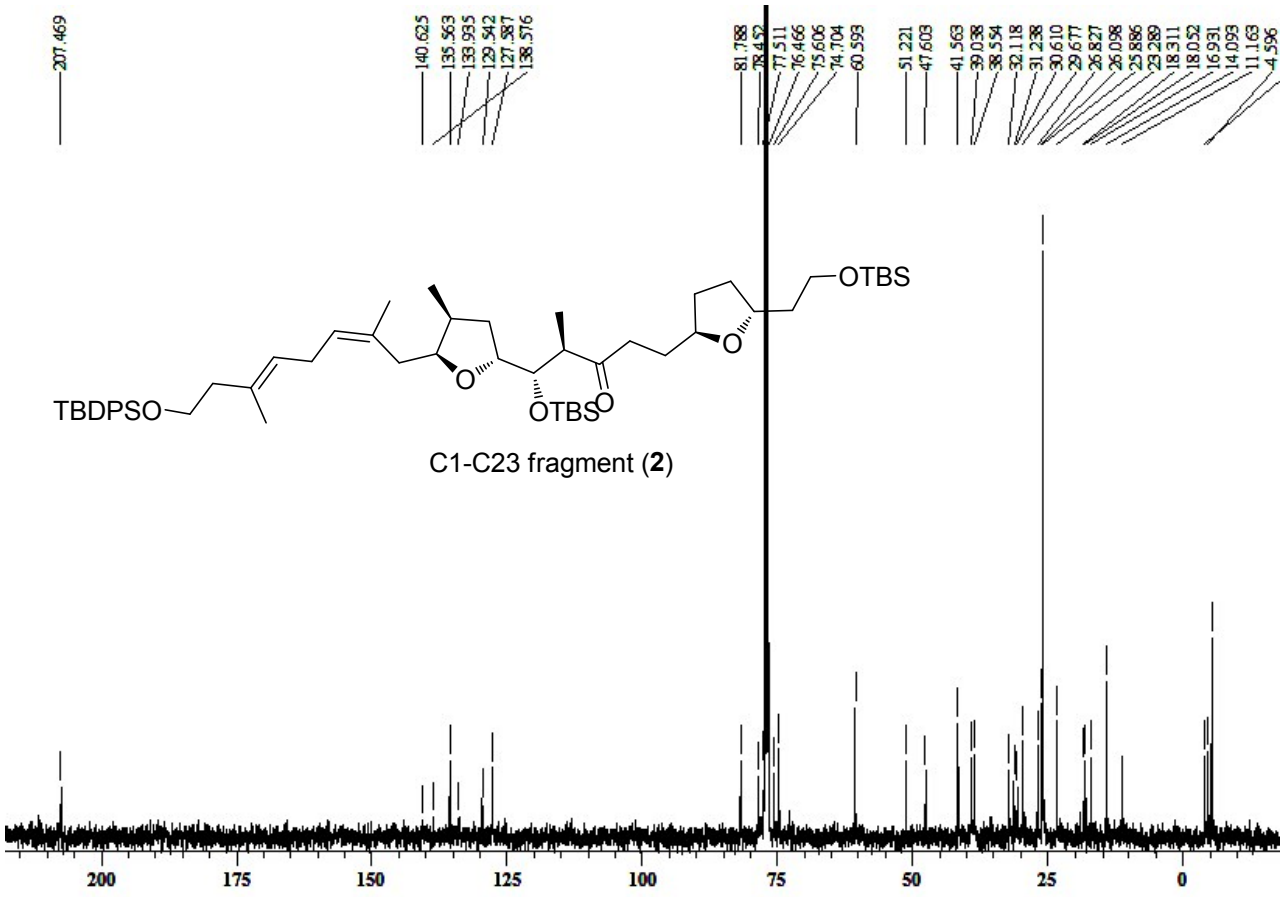


^{13}CNMR ($CDCl_3$, 75MHz)



C1-C23 fragment (**2**)

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



C1-C23 fragment (**2**)

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