Total Synthesis of Fostriecin: Via a Regio- and Stereoselective Polyene Hydration, Oxidation and Hydroboration Sequence

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Supporting Information:

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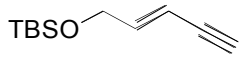
General Methods and Materials. ^{1}H and ^{13}C NMR spectra were recorded on Jeol (270 MHz) and Varian VXR-600 (600 MHz) spectrometers. Chemical shifts are reported relative to internal tetramethylsilane (δ 0.00 ppm) or $CDCl_3$ (δ 7.26 ppm) for ^{1}H NMR and $CDCl_3$ (δ 77.0 ppm) for ^{13}C NMR. Infrared (IR) spectra were obtained on a Prospect MIDAC FT-IR spectrometer. Optical rotations were measured with a Jasco DIP-370 digital polarimeter in the solvent specified. Melting points were determined with Electrothermal Mel-Temp apparatus and are uncorrected. Flash column chromatography was performed on ICN reagent 60 (60-200 mesh) silica gel. Analytical thin-layer chromatography was performed with precoated glass-backed plates (Whatman K6F 60Å, F_{254}) and visualized by quenching of fluorescence and by charring after treatment with *p*-anisaldehyde or phosphomolybdic acid or potassium permanganate stain. R_f values are obtained by elution in the stated solvent ratios (v/v). Ether, THF, methylene chloride and triethylamine were dried by passing through activated alumina (8 x 14 mesh) column with argon gas pressure. Commercial reagents were used without purification unless otherwise noted. Melting points are uncorrected. Air and/or moisture-sensitive reactions were carried out under an atmosphere of argon/nitrogen using oven/flamed-dried glassware and standard syringe/septa techniques.

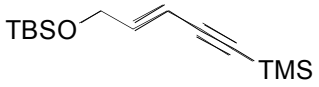
((*E*)-pent-2-en-4-ynyloxy)(*tert*-butyl)dimethylsiane (A).[‡]



A

To a stirred solution of 2-penten-4-yn-1-ol **11** (10 g, 121.8 mmol) in 100 mL of CH_2Cl_2 at room temperature was added Et_3N (42.4 mL, 304.5 mmol), TBSCl (23.8 g, 158.4 mmol) and DMAP (0.73 g, 6.1 mmol). After 15 hours, the reaction was quenched with saturated sodium bicarbonate aqueous solution and the aqueous layer was extracted with CH_2Cl_2. The combined organic layers were washed with brine and dried over anhydrous sodium sulfate. After removal of the solvents *in vacuo*, flash chromatography on silica gel (9:1 (v/v) hexanes/EtOAc) afforded compound **A** as a viscous oil (22.7 g, 95% yield): R_f = 0.59 (9:1 (v/v) hexane/EtOAc); IR (neat, cm^{-1}) 2955, 1740, 1463; ^1H NMR ($CDCl_3$, 270 MHz) δ 6.30 (ddd, J = 15.8, 4.0, 4.0 Hz, 1H), 5.75 (dddd, J = 15.8, 2.2, 2.2, 2.2 Hz, 1H), 4.23 (dd, J = 3.7, 2.5 Hz, 2H), 2.87 (d, J = 1.7 Hz, 1H), 0.91 (s, 9H), 0.69 (s, 6H); ^{13}C NMR ($CDCl_3$, 67.5 MHz): δ 144.3, 107.5, 82.1, 77.3, 62.7, 25.8 (3C), 18.3, -5.4 (2C); HRMS (CI) calcd for $[C_{11}H_{20}OSi + Na]^+$: 218.3522, Found: Sample was not charged well enough for electrospray. EI was not available.

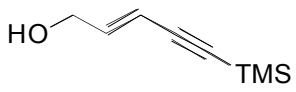
(*E*)- 5-(benzyldi methylsilyl)pent-2-en-4-ynyloxy)(*tert*-butyl)dimethylsilane (12).



12

To a solution of alcohol **A** (25.1 g, 128.1 mmol) in 150 mL of THF was added *n*-BuLi (2.3 M in hexane, 65.0 mL, 149.5 mmol) at –78 °C. After 30 minutes, TMSCl (18.1 g, 166.4 mmol) was added dropwise. The mixture was stirred for 2 hours and quenched with saturated NH_4Cl aqueous solution. The aqueous layer was extracted with EtOAc, the combined organic layers were washed with brine, dried over anhydrous sodium sulfate and the solvent was removed *in vacuo*. The crude product was purified by flash chromatography on silica gel (9:1 (v/v) hexane/EtOAc) to yield compound **12** (30.6 g, 89% yield) as a viscous oil. R_f = 0.58 (9:1 (v/v) hexane/EtOAc); IR (neat, cm^{-1}) 2980; ^1H NMR ($CDCl_3$, 270 MHz) δ 6.25 (ddd, *J* = 15.8, 4.2, 4.0 Hz, 1H), 5.79 (ddd, *J* = 15.8, 2.2, 2.0 Hz, 1H), 4.21 (dd, *J* = 4.2, 2.2 Hz, 2H), 0.90 (s, 9H), 0.18 (s, 9H), 0.05 (s, 6H); ^{13}C NMR ($CDCl_3$, 67.5 MHz): δ 143.6, 108.6, 103.6, 94.4, 62.7, 25.8 (3C), 18.3, –0.07 (3C), –5.4 (2C); HRMS (CI) calcd for $[C_{14}H_{20}OSi_2 + Na]^+$: 282.4701 Found: Sample was not charged well enough for electrospray. EI was not available.

(*E*)-5-(trimethylsilyl)pent-2-en-4-yn-1-ol (B).‡

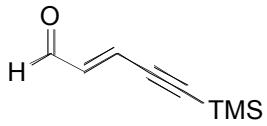


B

A mixture of 150 mL AcOH/H_2O/THF : 3/1/1 was added to silyl acetylene **12** (26.8 g, 100.0 mmol) at room temperature. The reaction was stirred for 12 hours and quenched with saturated K_2CO_3 aqueous solution. The aqueous layer was extracted with Et_2O. The combined organic layers were washed with brine, dried over anhydrous Na_2SO_4 and concentrated to afford the crude product. Flash chromatography on silica gel (8:2 (v/v)

hexane/EtOAc) provided compound **B** (13.2 g, 86% yield) as a colorless oil. R_f = 0.25 (7:3 (v/v) hexane/EtOAc); IR (neat, cm^{-1}) 3363, 2959, 1600, 1494; ^1H NMR ($CDCl_3$, 270 MHz) δ 6.27 (ddd, *J* = 15.8, 5.2, 5.0 Hz, 1H), 5.74 (ddd, *J* = 16.1, 2.0, 1.8 Hz, 1H), 4.20 (dd, *J* = 4.4, 3.7 Hz, 2H), 2.20 (bs, 1H), 0.17 (s, 9H); ^{13}C NMR ($CDCl_3$, 67.5 MHz): δ 142.9, 110.2, 103.0, 95.2, 62.6, -0.17 (3C); HRMS (CI) calcd for $[C_8H_{14}OSi + Na]^+$: 176.2722, Found: Sample was not charged well enough for electrospray. EI was not available.

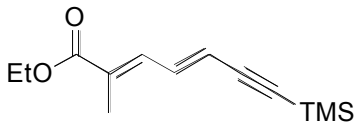
(*E*)-5-(trimethylsilyl)pent-2-en-4-yna1 (13).



13

To a solution of alcohol **B** (10.4 g, 67.5 mmol) in 100 mL of CH_2Cl_2 was added MnO_2 (58.0 g, 672 mmol) at room temperature. After 16 hours, the reaction mixture was filtered through a pad of Celite. The filtrate was concentrated to afford the crude product. Flash chromatography on silica gel (9:1 (v/v) hexane/EtOAc) provided compound **13** (9.3 g, 91% yield) as a colorless oil. R_f = 0.23 (9:1 (v/v) hexane/EtOAc); IR (neat, cm^{-1}) 3369, 2989,1680; ^1H NMR ($CDCl_3$, 270 MHz) δ 9.54 (d, *J* = 7.2, Hz, 1H), 6.57 (d, *J* = 15.8 Hz, 1H), 6.44 (dd, *J* = 15.8, 7.4 Hz, 1H), 0.22 (s, 9H); ^{13}C NMR ($CDCl_3$, 67.5 MHz) δ 193.1, 140.1, 132.1, 111.4, 100.6, -0.56 (3C); HRMS (CI) calcd for $[C_8H_{12}OSi + H]^+$: 153.0736, Found: 153.0730.

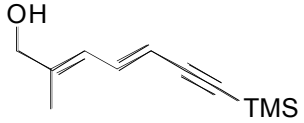
(2*E*, 4*E*)-ethyl-2-methyl-7-(trimethylsilyl)hepta-2,4-dien-6-ynoate (14a).



14a

To a solution of triethyl-2-phosphonopropionate (15.6 g, 65.7 mmol) in 200 mL of THF was added *n*-BuLi (2.3 M, 27.4 mL, 63.0 mmol) at –78 °C. After stirring for 30 minutes, aldehyde **13** (8.32 g, 54.8 mmol) in 10 mL of THF was added dropwise. After 2 hours, the reaction was quenched with saturated NH_4Cl aqueous solution. The aqueous layer was extracted with EtOAc. The combined organic layers were washed with brine, dried over anhydrous Na_2SO_4, and concentrated to afford the crude product. Flash chromatography on silica gel (9:1 (v/v) hexane/EtOAc) provided compound **14a** (12.2 g, 91% yield) as a colorless oil. R_f = 0.32 (9:1 (v/v) hexane/EtOAc); IR (neat, cm^{-1}) 2986, 1708; ^1H NMR ($CDCl_3$, 270 MHz) δ 7.14 (dd, *J* = 11.9, 1.2 Hz, 1H), 6.90 (dd, *J* = 15.3, 11.9 Hz, 1H), 5.90 (d, *J* = 15.3 Hz, 1H), 4.20 (q, *J* = 7.2, 2H), 1.96 (d, *J* = 1.2 Hz, 3H), 1.29 (t, *J* = 7.2, 3H), 0.19 (s, 9H); ^{13}C NMR ($CDCl_3$, 67.5 MHz) δ 167.8, 137.4, 136.5, 129.9, 117.3, 103.9, 100.8, 60.8, 14.2, 12.9, –0.25 (3C); HRMS (CI) calcd for $[C_{13}H_{20}O_2Si + H]^+$: 237.1311, Found: 237.1306.

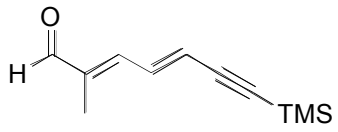
(2*E*, 4*E*)-2-methyl-7-(trimethylsilyl)hepta-2,4-dien-6-yn-1-ol (C).‡



C

To a solution of ester **14a** (8.69 g, 36.8 mmol) in 100 mL of THF was added DIBAL-H (92.0 ml, 1.0 M in hexanes, 92.0 mmol) dropwise at –78 °C. After 30 minutes, the reaction was quenched by adding 5 mL of acetone and 150 mL of 20% sodium potassium tartrate solution. The mixture was warmed to room temperature, diluted with ether (100 mL) and stirred for 1 hour. The aqueous layer was extracted with Et_2O. The combined organic layers were washed with brine and dried over anhydrous Na_2SO_4, and concentrated to afford the crude product. Flash chromatography on silica gel (8:2 (v/v) hexane/EtOAc) provided allylic alcohol **C** (6.66 g, 93% yield) as a colorless oil. R_f = 0.20 (8:2 (v/v) hexane/EtOAc); IR (neat, cm^{-1}) 3427, 2982; ^1H NMR ($CDCl_3$, 270 MHz) δ 6.88 (dd, *J* = 15.3, 11.1 Hz, 1H), 6.13-6.07 (m, 1H), 5.58 (d, *J* = 15.6 Hz, 1H), 4.05 (s, 2H), 1.71 (d, *J* = 0.8 Hz, 3H), 0.80 (s, 1H), 0.19 (s, 9H); ^{13}C NMR ($CDCl_3$, 67.5 MHz) δ 141.0, 138.4, 123.4, 110.4, 104.8, 96.9, 67.7, 14.3, –0.10 (3C); HRMS (CI) calcd for $[C_{11}H_{18}OSi + H]^+$: 195.1205, Found: 195.1216.

(2*E*, 4*E*)-2-methyl-7-(trimethylsilyl)hepta-2,4-dien-6-ynal (15a).

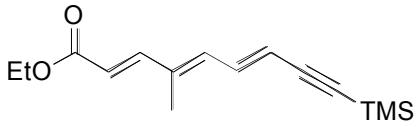


15a

To a solution of alcohol **C** (6.66 g, 34.3 mmol) in 80 mL of CH_2Cl_2 was added MnO_2 (29.9 g, 343.3 mmol) at room temperature. After 18 hours, the reaction mixture was filtered through a pad of Celite. The filtrate was concentrated to afford the crude product. Flash chromatography on silica gel (8:2 (v/v) hexane/EtOAc) provided compound **15a** (6.24 g, 94% yield) as a colorless oil. R_f = 0.64 (8:2 (v/v) hexane/EtOAc); IR (neat, cm^{-1})

3370, 2990, 1456; ^{1}H NMR ($CDCl_3$, 270 MHz) δ 9.45 (s, 1H), 7.04 (dd, *J* = 15.3, 11.4 Hz, 1H), 6.82 (d, *J* = 11.4 Hz, 1H), 6.04 (d, *J* = 15.3 Hz, 1H), 1.87 (d, *J* = 1.0 Hz, 3H), 0.21 (s, 9H); ^{13}C NMR ($CDCl_3$, 67.5 MHz) δ 194.4, 146.3, 139.5, 136.7, 119.5, 103.5, 103.0, 9.70, –0.31 (3C); HRMS (CI) calcd for $[C_{19}H_{24}O_2Si + Na]^+$: 335.1438, Found: 335.1439.

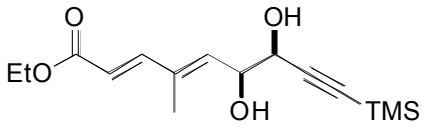
(2*E*,4*E*,6*E*)-ethyl-4-methyl-9-(trimethylsilyl)nona-2,4,6-trien-8-ynoate (10).



10

To a solution of aldehyde **15a** (5.57 g, 29.0 mmol) in 70 mL of toluene was added yield (13.1 g, 37.7 mmol), the mixture was refluxed for 5 hours. After cool it down to room temperature, the solvent was removed *in vacuo*. The crude product was purified by flash chromatography on silica gel (8:2 (v/v) hexane/EtOAc) provided compound **10** (7.15 g, 94% yield) as a colorless oil. R_f = 0.60 (8:2 (v/v) hexane/EtOAc); IR (neat, cm^{-1}) 2988, 1719; ^{1}H NMR ($CDCl_3$, 270 MHz) δ 7.30 (d, *J* = 15.6 Hz, 1H), 6.96 (dd, *J* = 15.3, 11.6 Hz, 1H), 6.38 (d, *J* = 11.6 Hz, 1H), 5.93 (d, *J* = 15.6 Hz, 1H), 5.78 (d, *J* = 15.3 Hz, 1H), 4.20 (q, *J* = 7.2 Hz, 2H), 1.93 (d, *J* = 0.73 Hz, 3H), 1.29 (t, *J* = 7.2 Hz, 3H), 0.19 (s, 9H); ^{13}C NMR ($CDCl_3$, 67.5 MHz) δ 167.0, 147.9, 137.9, 136.9, 136.1, 118.5, 114.9, 104.4, 100.1, 60.3, 14.3, 12.7, –0.20 (3C); HRMS (CI) calcd for $[C_{15}H_{22}O_2Si + Na]^+$: 285.1287, Found: 285.1281.

(2*E*,4*E*,6*S*,7*S*)-ethyl-6,7-dihydroxy-4-methyl-9-(trimethylsilyl)nona-2,4-dien-8-ynoate (D).‡

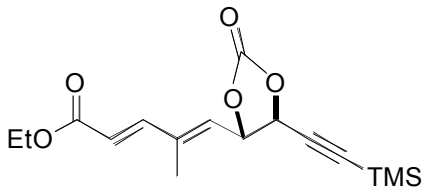


D

To a 500 mL round bottom flask was added *tert*-butyl alcohol (100 mL), H_2O (100 mL), $K_3Fe(CN)_6$ (26.8 g, 81.9 mmol), K_2CO_3 (11.3 g, 81.9 mmol), $KHCO_3$ (8.24 g, 81.9 mmol), $CH_3SO_2NH_2$ (2.60 g, 27.3 mmol), $(DHD)_2$-PHAL (420 mg, 0.55 mmol, 2 mol %) and OsO_4 (69 mg, 0.27 mmol, 1 mol %). The mixture was stirred at room temperature for 30 minutes and then cooled to 0 ^oC. To this solution was added trienoate **10** (7.15 g, 27.3 mmol) in 5 mL of CH_2Cl_2 dropwise and the reaction was stirred vigorously at 0 ^oC overnight. Saturated aqueous sodium sulfite solution (50 mL) was added to quench the reaction while stirring vigorously. Ethyl acetate (60 mL) was added to the reaction mixture, the aqueous layer was further extracted with ethyl acetate (3 x 30 mL). The combined organic layers were washed with 2 N KOH (40 mL) and brine (20 mL) to remove the methanesulfonamide, dried over anhydrous Na_2SO_4, and concentrated to afford the crude product. Flash chromatography on silica gel (1:1 (v/v) hexane/EtOAc) provided the compound **D** (6.47 g, 80% yield). R_f = 0.19 (9:1 (v/v) hexane/EtOAc); IR (neat, cm^{-1}) 3446, 2983, 1762; $[\alpha]^{25}_D$ +14^o (*c* 1.0, $CHCl_3$); ^1H NMR ($CDCl_3$, 270 MHz) δ δ 6.88 (dd, *J* = 15.3, 11.1 Hz, 1H), 6.15 (d, *J* = 12.1 Hz, 1H), 5.62 (d, *J* = 15.6 Hz, 1H), 4.30-4.21 (m, 4H), 1.84 (s, 3H), 1.28 (t, *J* = 7.2 Hz, 3H), 0.18 (s, 9H); ^{13}C NMR ($CDCl_3$, 67.5 MHz) δ 172.9, 139.3, 138.0, 125.4, 111.5, 104.5, 97.5, 76.7, 72.2, 62.2, 14.1, 13.8, –0.12 (3C); HRMS (CI) calcd for $[C_{15}H_{24}O_4Si + Na]^+$: 318.4254, Found: Sample was not

charged well enough for electrospray. EI was not available.

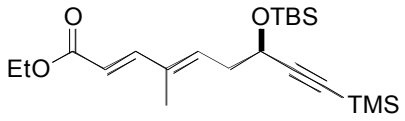
(2*E*,4*E*)-ethyl-4-methyl-((4*S*,5*S*)-5-(2-(trimethylsilyl)ethynyl)-2-oxo-1,3-dioxolan-4-yl)penta-2,4-dienoate (16).



16

To a solution of diol **D** (4.81 g, 16.2 mmol) in 60 mL of CH_2Cl_2 was added pyridine (4.68 mL, 56.9 mmol) and $(Cl_3CO)_2CO$ (5.78 g, 19.5 mmol) in 10 mL of CH_2Cl_2 at 0 ^oC. After 3 hours, the reaction was quenched by slow addition of saturated NH_4Cl.aqueous solution. The aqueous layer was extracted with Et_2O. The combined organic layers were washed with brine, dried over anhydrous Na_2SO_4, and concentrated to afford the crude product. Flash chromatography on silica gel (9:1 (v/v) hexane/EtOAc) provided acetonide **16** (4.76 g, 91% yield) as a colorless oil. R_f = 0.61 (9:1 (v/v) hexane/EtOAc); IR (neat, cm^{-1}) 2989, 1714; $[\alpha]^{25}_D$ –80^o (*c* 1.0, $CHCl_3$); ^{1}H NMR ($CDCl_3$, 270 MHz) δ 6.81 (dd, *J* = 15.6, 11.4 Hz, 1H), 6.21 (d, *J* = 11.4 Hz, 1H), 5.74 (d, *J* = 15.6 Hz, 1H), 5.02 (d, *J* = 5.2 Hz, 1H), 4.70 (d, *J* = 5.4 Hz, 1H), 4.32 (q, *J* = 7.2 Hz, 2H), 1.84 (s, 3H), 1.23 (t, *J* = 7.2 Hz, 3H), 0.19 (s, 9H); ^{13}C NMR ($CDCl_3$, 67.5 MHz) δ 166.9, 153.1, 136.2, 132.4, 128.9, 115.0, 103.7, 99.7, 82.7, 75.9, 62.9, 14.0, 11.6, –0.23 (3C); HRMS (CI) calcd for $[C_{16}H_{22}O_5Si + H]^+$: 322.1317, Found: 333.1306.

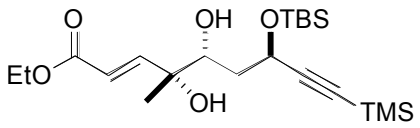
(*R*,2*E*,4*E*)-ethyl-7-*tert*-butyldimethylsiloxy-4-methyl-9-(trimethylsilyl)nona-2,4-dien-8-ynoate (17).



17

To a solution of carbonate **16** (103 mg, 0.32 mmol) in 5 mL of CH_2Cl_2 was added $Pd_2(dba)_3{\cdot}CHCl_3$ (7 mg, 0.007 mmol), PPh_3 (4 mg, 0.13 mmol), Et_3N (98 mg, 0.97 mmol) and HCO_2H (46 mg, 0.97 mmol) at room temperature. After 4 hours, the reaction mixture was quenched with saturated NH_4Cl. aqueous solution. The organic layers were washed with brine, dried over anhydrous Na_2SO_4, and concentrated to afford the crude product. To a solution of the above crude alcohol in 0.5 mL of DMF was added imidazole (66 mg, 0.97 mmol) and TBSCl (72 mg, 0.48 mmol) at room temperature. After 0.5 hour, the reaction mixture was purified by flash chromatography on silica gel (8:2 (v/v) hexane/EtOAc) without work up to provide compound **17** (43 mg, 34% yield for two steps) as a colorless oil with 30% of the recovered starting material. R_f = 0.36 (7:3 (v/v) hexane/EtOAc); IR (neat, cm^{-1}) 2968, 1690; $[\alpha]^{25}_D$ –20° (*c* 1.0, $CHCl_3$); ^1H NMR ($CDCl_3$, 270 MHz) δ 6.84 (dd, *J* = 15.3, 11.4 Hz, 1H), 5.92 (d, *J* = 11.4 Hz, 1H), 5.51 (d, *J* = 15.3 Hz, 1H), 4.27 (dd, *J* = 7.7, 4.7 Hz, 1H), 4.16 (q, *J* = 7.2 Hz, 2H), 2.49-2.41 (m, 2H), 1.83 (s, 3H), 1.27 (t, *J* = 6.6 Hz, 3H), 0.89 (s, 9H), 0.19 (s, 9H), 0.04 (s, 3H), 0.00 (s, 3H); ^{13}C NMR ($CDCl_3$, 62.5 MHz) δ 173.2, 138.8 138.0, 128.0, 109.4, 105.0, 96.3, 71.4, 60.8, 45.6, 25.7 (3C), 18.2, 17.5, 14.2, –0.03 (3C), –5.1, –5.3; HRMS (CI) calcd for $[C_{21}H_{38}O_3Si_2 + Na]^+$: 416.6875, Found: Sample was not charged well enough for electrospray. EI was not available.

(*E*,4*R*,5*R,7R*)-ethyl-4,5-dihydroxy-7-*tert*-butyldimethylsiloxy-4-methyl-9-(trimethyl silyl)non-2-en-8-ynoate (E).‡

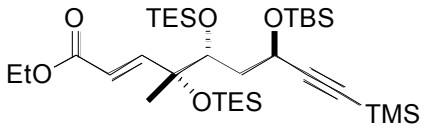


E

To a 100 mL round bottom flask was added *t*-butyl alcohol (20 mL), H_2O (20 mL), $K_3Fe(CN)_6$ (3.03 g, 9.22 mmol), K_2CO_3 (1.27 g, 9.22 mmol), $KHCO_3$ (0.93 g, 9.22 mmol), $CH_3SO_2NH_2$ (0.29 g, 3.07 mmol), $(DHQD)_2$-PHAL (99 mg, 0.13 mmol, 4 mol %) and OsO_4 (16 mg, 0.062 mmol, 2 mol %). The mixture was stirred at room temperature for 30 minutes and then cooled to 0 ^oC. To this solution was added dienoate **17** (1.18 g, 3.07 mmol) in 2 mL of CH_2Cl_2 dropwise and the reaction was stirred vigorously at 0 ^oC for 8 hours. Saturated aqueous sodium sulfite solution (20 mL) was added to quench the reaction while stirring vigorously. Ethyl acetate (40 mL) was added to the reaction mixture, and after separation of the layers, the aqueous layer was further extracted with ethyl acetate (3 x 20 mL). The combined organic layers were washed with 2 N KOH (10 mL) and brine (20 mL) to remove the methanesulfonamide, dried over anhydrous Na_2SO_4, and concentrated to afford the crude product. Flash chromatography on silica gel (1:1 (v/v) hexane/EtOAc) provided the compound **E** (0.53 g, 40% yield). R_f = 0.46 (1:1 (v/v) hexane/EtOAc); IR (neat, cm^{-1}) 3446, 2983, 1762; $[\alpha]^{25}_D$ +52^o (*c* 1.0, $CHCl_3$); ^1H NMR ($CDCl_3$, 270 MHz) δ 7.01 (d, *J* = 15.8 Hz, 1H), 6.13 (d, *J* = 15.6 Hz, 1H), 4.73 (dd, *J* = 4.7, 4.5 Hz, 1H), 4.19 (q, *J* = 7.2 Hz, 2H), 4.06-4.02 (m, 1H), 3.64 (bs, 1H), 2.58 (s, 1H), 1.84-1.80 (m, 2H), 1.28 (t, *J* = 7.2 Hz, 3H), 1.26 (s, 3H), 0.88 (s, 9H), 0.16 (s, 12H), 0.15

(s, 3H); ^{13}C NMR ($CDCl_3$, 67.5 MHz) δ 166.6, 152.3, 120.3, 105.5, 90.7, 74.7, 74.0, 62.5, 60.4, 37.6, 25.7 (3C), 22.6, 18.0, 14.2, –0.30 (3C), –4.6, –5.3; HRMS (CI) calcd for $[C_{21}H_{40}O_5Si_2 + Na]^+$: 451.2312, Found: 451.2307.

(*E*,4*R*,5*R*,7*R*)-ethyl-4,5-bistriethylsilyl-7-*tert*-butyldimethylsilyl-4-methyl-9-(trimethylsilyl)non-2-en-8-ynoate (18).

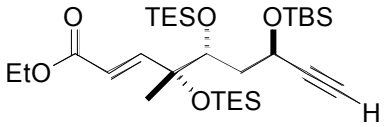


18

To a solution of diol **E** (43 mg, 0.10 mmol) in 1 mL of CH_2Cl_2 was added 2,6-lutidine (0.12 mL, 1.0 mmol) and TESOTf (0.14 mL, 0.6 mmol) at –78 °C. Then the reaction was warmed up to –10 °C for 2 hours and quenched with saturated NH_4Cl aqueous solution. The aqueous layer was extracted with Et_2O. The combined organic layers were washed with brine, dried over anhydrous Na_2SO_4, and concentrated to afford the crude product. Flash chromatography on silica gel (8:2 (v/v) hexane/EtOAc) provided compound **18** (54 mg, 82% yield) as a colorless oil. R_f = 0.52 (9:1 (v/v) hexane/EtOAc); IR (neat, cm^{-1}) 2986, 1752; $[\alpha]^{25}_D$ +14° (*c* 1.0, $CHCl_3$); ^{1}H NMR ($CDCl_3$, 270 MHz): δ 7.00 (d, *J* = 15.8 Hz, 1H), 5.97 (d, *J* = 15.6 Hz, 1H), 4.47 (dd, *J* = 7.7, 7.2 Hz, 1H), 4.20 (q, *J* = 7.2 Hz, 2H), 3.73 (dd, *J* = 5.9, 5.9 Hz, 1H), 1.98-1.88 (m, 1H), 1.59-1.49 (m, 1H), 1.49 (s, 3H), 1.28 (t, *J* = 7.2 Hz, 3H), 0.97 (t, *J* = 7.9 Hz, 9H), 0.93 (t, *J* = 7.9 Hz, 9H), 0.88 (s, 9H), 0.65 (q, *J* = 7.9 Hz, 6H), 0.52 (q, *J* = 7.9 Hz, 6H), 0.15 (s, 9H), 0.13 (s, 3H), 0.10 (s, 3H); ^{13}C NMR ($CDCl_3$, 67.5 MHz) δ 166.7, 152.1, 120.0, 108.2, 89.1, 78.7, 76.0, 60.8, 60.2, 43.6, 25.9 (3C), 25.3, 18.2, 14.2, 7.20 (3C), 6.98 (3C), 6.88 (3C), 5.39 (3C), –0.26 (3C),

–4.1, –4.4; HRMS (CI) calcd for $[C_{33}H_{68}O_5Si_4 + Na]^+$: 679.4042, Found: 679.4037.

(*E*,4*R*,5*R,7R*)-ethyl-4,5-bistriethylsilyl-7-*tert*-butyldimethylsilyl-4-methyl-9-non-2-en-8-ynoate (19).

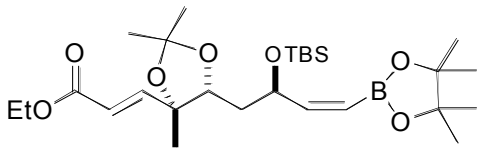


19

To a solution of silyl ester **18** (315 mg, 0.48 mmol) in 5 mL of EtOH was added K_2CO_3 (199 mg, 1.48 mmol) at room temperature. After 24 hours, the reaction was quenched by adding 3 mL of 1 M $NaHSO_4$ and diluted with EtOAc. The aqueous layer was extracted with Et_2O. The combined organic layers were washed with brine, dried over anhydrous Na_2SO_4, and concentrated to afford the crude product. Flash chromatography on silica gel (9:1 (v/v) hexane/EtOAc) provided allylic alcohol **19** (258 mg, 92% yield) as a colorless oil. R_f = 0.44 (9:1 (v/v) hexane/EtOAc); IR (neat, cm^{-1}) 2989, 1752; $[\alpha]^{25}_D$ +17° (*c* 1.0, $CHCl_3$); ^1H NMR ($CDCl_3$, 270 MHz): δ 7.01 (d, *J* = 15.8 Hz, 1H), 5.96 (d, *J* = 15.8 Hz, 1H), 4.48 (ddd, *J* = 8.2, 6.2, 2.0 Hz, 1H), 4.20 (q, *J* = 7.2 Hz, 2H), 3.74 (dd, *J* = 6.4, 5.7 Hz, 1H), 2.39 (d, *J* = 2.2 Hz, 1H), 1.99 (ddd, *J* = 13.9, 8.2, 5.4 Hz, 1H), 1.60-1.51 (m, 1H), 1.39 (s, 3H), 1.29 (t, *J* = 7.2 Hz, 3H), 0.97 (t, *J* = 7.9 Hz, 18H), 0.89 (s, 9H), 0.64 (q, *J* = 7.9 Hz, 12H), 0.14 (s, 3H), 0.11 (s, 3H); ^{13}C NMR ($CDCl_3$, 67.5 MHz) δ 166.6, 152.0, 120.1, 86.1, 78.5, 76.0, 72.8, 60.3, 60.1, 43.6, 25.8 (3C), 25.3, 18.2, 14.3, 7.19 (3C), 6.98 (3C), 6.86 (3C), 5.43 (3C), –4.10, –4.48; HRMS (CI) calcd for $[C_{30}H_{60}O_5Si_3 + Na]^+$: 607.3646, Found: 607.3643.

(2*E*,4*S*,5*R*,7*R*,8*Z*)-ethyl-7-*tert*-butyldimethylsiloxy-4-methyl-2,2,4-trimethyl-1',3'-

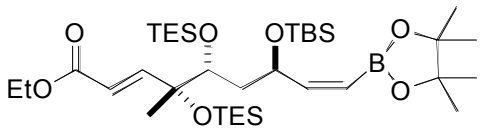
dioxolan-4-yl)-9-(3,3,4,4-tetramethylborolan-1-yl)nona-2,8-dienoate (23).



23

To a solution of $[Rh(COD)Cl]_2$ (8 mg, 0.017 mmol) in 1 mL of cyclohexane was added P^iPr_3 (11 mL, 0.068 mmol), Et_3N (38 mg, 0.37 mmol) and catecholborane (39 mg, 0.32 mmol) at room temperature. After being stirred at room temperature for 30 minutes, alkyne **22** (132 mg, 0.034 mmol) in 1 mL of cyclohexane was added. After 6 hours, pinacol (60 mg, 0.51 mmol) in 1 mL of cyclohexane was added dropwise and the resulting mixture was stirred for another 12 hours. The reaction was quenched with saturated NH_4Cl aqueous solution and the aqueous layer was extracted with Et_2O. The combined organic layers were washed with brine, dried over anhydrous Na_2SO_4, and concentrated to afford the crude product. Flash chromatography on silica gel (9:1 (v/v) hexane/EtOAc) provided compound **23** (119 mg, 70% yield) as a colorless oil. R_f = 0.24 (9:1 (v/v) hexane/EtOAc); IR (neat, cm^{-1}) 2986, 1758; $[\alpha]^{25}_D$ –0.03° (*c* 1.0, $CHCl_3$); ^1H NMR ($CDCl_3$, 270 MHz): 6.86 (d, *J* = 15.6 Hz, 1H), 6.30 (dd, *J* = 13.6, 8.4 Hz, 1H), 6.05 (d, *J* = 15.6 Hz, 1H), 5.32 (dd, *J* = 13.6, 0.75 Hz, 1H), 5.02 (ddd, *J* = 8.6, 8.6, 3.9 Hz, 1H), 4.18 (q, *J* = 7.2 Hz, 2H), 4.00 (dd, *J* = 8.9, 3.2 Hz, 1H), 1.52 (ddd, *J* = 8.4, 4.2, 4.2 Hz, 2H), 1.43 (s, 3H), 1.33 (s, 3H), 1.27 (t, *J* = 7.2 Hz, 3H), 1.25 (s, 12H), 1.15 (s, 3H), 0.83 (s, 9H), 0.03 (s, 3H), 0.00 (s, 3H); ^{13}C NMR ($CDCl_3$, 67.5 MHz) δ 166.4, 157.2, 149.7, 120.0, 107.8, 83.1, 81.4, 77.7, 69.3, 60.4, 37.7, 28.4, 26.4, 25.8 (3C), 24.8 (2C), 24.7 (2C), 21.1, 20.0, 18.1, 14.2, –4.40, –4.95; HRMS (CI) calcd for $[C_{27}H_{49}BO_7Si + Na]^+$: 547.3238, Found: 547.3234.

(2*E*,4*R*,5*R*,7*R*,8*Z*)-ethyl-4,5-bistriethylsilyl-7-*tert*-butyldimethylsilyl-4-methyl-9-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)nona-2,8-dienoateate (25a).

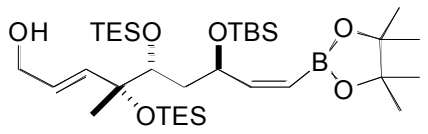


25a

To a solution of $[Rh(COD)Cl]_2$ (20 mg, 0.04 mmol) in 3 mL of cyclohexane was added P^iPr_3 (0.032 mL, 0.26 mmol), Et_3N (0.12 mL, 0.83 mmol) and catecholborane (86 mg, 0.71 mmol) at room temperature. After being stirred at room temperature for 30 minutes, alkyne **19** (438 mg, 0.72 mmol) in 1 mL of cyclohexane was added. After 8 hours, pinacol (133 mg, 1.13 mmol) in 1 mL of cyclohexane was added dropwise and the resulting mixture was stirred for 12 hours at room temperature. The reaction was quenched with saturated NH_4Cl aqueous solution. The aqueous layer was extracted with Et_2O. The combined organic layers were washed with brine, dried over anhydrous Na_2SO_4, and concentrated to afford the crude product. Flash chromatography on silica gel (9:1 (v/v) hexane/EtOAc) provided compound **25a** (407 mg, 79% yield) as a colorless oil. R_f = 0.35 (9:1 (v/v) hexane/EtOAc); IR (neat, cm^{-1}) 2986, 1758; $[\alpha]^{25}_D$ +24° (*c* 1.0, $CHCl_3$); ^1H NMR ($CDCl_3$, 270 MHz): δ 7.03 (d, *J* = 15.8 Hz, 1H), 6.19 (dd, *J* = 13.9, 8.9 Hz, 1H), 5.91 (d, *J* = 15.6 Hz, 1H), 5.30 (d, *J* = 13.6 Hz, 1H), 4.78 (td, *J* = 9.4, 3.7 Hz, 1H), 4.21-4.14 (m, 2H), 3.76 (dd, *J* = 8.1, 1.7 Hz, 1H), 2.14-2.05 (m, 1H), 1.87-1.79 (m, 1H), 1.36 (s, 3H), 1.26 (s, 12 H), 1.28 (t, *J* = 7.2 Hz, 3H), 0.96 (dt, *J* = 8.2, 7.7 Hz, 18H), 0.86 (s, 9H), 0.73-0.56 (m, 12H), 0.06 (s, 3H), 0.00 (s, 3H); ^{13}C NMR ($CDCl_3$, 67.5 MHz)

δ 166.9, 157.7, 153.0, 119.7, 83.2, 78.2, 75.4, 69.0, 60.2, 42.0, 26.9 (3C), 25.9 (2C), 24.9 (2C), 24.6, 24.2, 21.2, 17.9, 14.2, 7.20 (3C), 7.11 (3C), 6.74 (3C), 5.60 (3C), –3.00, –3.99; HRMS (CI) calcd for $[C_{36}H_{73}BO_7Si_3 + Na]^+$: 735.4655, Found: 735.4648.

(2*E*,4*R*,5*R*,7*R*,8*Z*)-4,5-bistriethylsilyl-7-*tert*-butyldimethylsilyl-4-methyl-9-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)nona-2,8-dien-1-ol (26a).

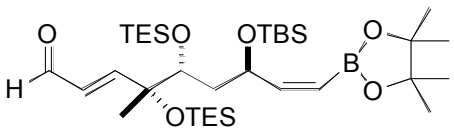


26a

To a solution of ester **25** (140 mg, 0.20 mmol) in 2 mL of THF was added DIBAL-H (0.45 mL, 1.0 M in hexanes, 0.45 mmol) dropwise at –78 °C. After 20 minutes, the reaction was quenched by adding 0.5 mL of acetone and 10 mL of 20% sodium potassium tartrate solution. The mixture was warmed to room temperature, diluted with ether (10 mL) and stirred for 1 hour. The aqueous layer was extracted with Et_2O. The combined organic layers were washed with brine, dried over anhydrous Na_2SO_4, and concentrated to afford the crude product. Flash chromatography on silica gel (8:2 (v/v) hexane/EtOAc) provided allylic alcohol **26a** (123 mg, 92% yield) as a colorless oil. R_f = 0.33 (8:2 (v/v) hexane/EtOAc); IR (neat, cm^{-1}) 3427, 2982; $[\alpha]^{25}_D$ +4° (*c* 1.0, $CHCl_3$); ^1H NMR ($CDCl_3$, 270 MHz) δ 6.19 (dd, *J* = 13.9, 8.9 Hz, 1H), 5.77-5.74 (m, 2H), 5.31 (d, *J* = 13.9 Hz, 1H), 4.76 (td, *J* = 9.4, 4.2 Hz, 1H), 4.15 (bs, 2H), 3.76 (dd, *J* = 7.4, 2.0 Hz, 1H), 1.82 (ddd, *J* = 14.1, 9.4, 2.2 Hz, 1H), 1.30 (s, 3H), 1.27 (s, 6 H), 1.26 (s, 6 H), 0.96 (dt, *J* = 8.2, 7.7 Hz, 18H), 0.86 (s, 9H), 0.72-0.53 (m, 12H), 0.07 (s, 3H), 0.01 (s, 3H); ^{13}C NMR ($CDCl_3$, 67.5 MHz) δ 157.8, 137.1, 128.1, 83.3 (3C), 77.9, 75.8, 69.4, 63.8,

42.4, 26.1 (3C), 25.0 (2C), 24.7 (2C), 23.4, 18.3, 7.34 (3C), 7.24 (3C), 6.86 (3C), 5.71 (3C), –2.89, –3.94; HRMS (CI) calcd for $[C_{34}H_{71}BO_6Si_3 + Na]^+$: 693.4549, Found: 693.4544.

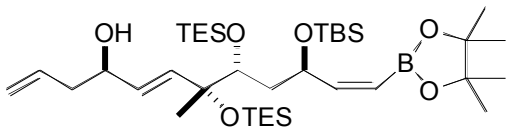
(2*E*,4*R*,5*R*,7*R*,8*Z*)-4,5-bistriethylsilyl-7-*tert*-butyldimethylsilyl-4-methyl-9-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)nona-2,8-dienal (27).



27

To a solution of alcohol **26** (30 mg, 0.045 mmol) in 1 mL of CH_2Cl_2 was added MnO_2 (39 mg, 0.45 mmol) at room temperature. After 5 hours, the reaction mixture was filtered through a pad of Celite. The filtrate was concentrated to afford the crude product. Flash chromatography on silica gel (9:1 (v/v) hexane/EtOAc) provided compound **27** (25 mg, 78% yield) as a colorless oil. R_f = 0.45 (9:1 (v/v) hexane/EtOAc); IR (neat, cm^{-1}) 3427, 2982, 1680; $[\alpha]^{25}_D$ +43° (*c* 1.0, $CHCl_3$); ^1H NMR ($CDCl_3$, 270 MHz) δ 9.56 (d, *J* = 7.9 Hz, 1H), 6.92 (d, *J* = 15.6 Hz, 1H), 6.25 (dd, *J* = 15.6, 7.9 Hz, 1H), 6.18 (dd, *J* = 13.9, 9.2 Hz, 1H), 5.31 (d, *J* = 13.9 Hz, 1H), 4.76 (td, *J* = 9.6, 3.7 Hz, 1H), 3.83 (dd, *J* = 8.4, 1.5 Hz, 1H), 1.88 (ddd, *J* = 14.3, 10.2, 2.4 Hz, 1H), 1.42 (s, 3H), 1.26 (s, 12H), 0.98 (t, *J* = 8.2 Hz, 9H), 0.95 (t, *J* = 7.4 Hz, 9H), 0.87 (s, 9H), 0.76-0.56 (m, 12H), 0.07 (s, 3H), 0.02 (s, 3H); ^{13}C NMR ($CDCl_3$, 67.5 MHz) δ 194.0, 162.7, 157.5, 130.7, 83.2, 78.3, 75.5, 68.8, 41.8, 26.1 (3C), 24.9, 24.6, 18.2, 7.21 (3C), 7.12 (3C), 6.79 (3C), 5.61 (3C), –2.91, –3.91; HRMS (CI) calcd for $[C_{34}H_{69}BO_6Si_3 + Na]^+$: 691.4393, Found: 691.4387.

(1*Z*,3*R*,5*R*,6*R*,7*E*,9*R*)-4,5-bistriethylsilyl-7-*tert*-butyldimethylsilyl-6-methyl-1-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)dodeca-1,7,11-trien-1-ol (29).

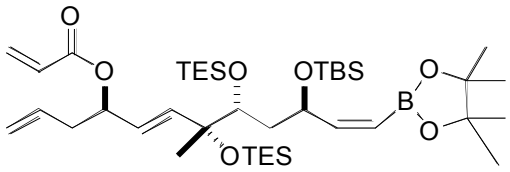


29

To a solution of (***S,S***)-**28** (102 mg, 0.19 mmol) in 0.5 mL of CH_2Cl_2 was added aldehyde **173** (42 mg, 0.063 mmol) in 0.4 mL of CH_2Cl_2 dropwise at −10 °C. The reaction flask was put in a freezer (−10 °C). After 24 hours, the reaction was diluted with EtOAc and quenched by adding 1 N $NaHSO_4$, and the mixture was vigorously stirred at room temperature for 1 h. The mixture was filtered through a pad of Celite and the layers were separated. The aqueous layer was extracted with EtOAc. The combined organic layers were washed with brine, dried over anhydrous Na_2SO_4, and concentrated to afford the crude product. Flash chromatography on silica gel (9:1 (v/v) hexane/EtOAc) provided compound **29** (38 mg, 85% yield) as a light yellow oil. R_f = 0.30 (9:1 (v/v) hexane/EtOAc); IR (neat, cm^{-1}) 3450, 2981, 1755; $[\alpha]^{25}_D$ +9° (*c* 1.0, $CHCl_3$); ^1H NMR ($CDCl_3$, 270 MHz): δ 6.19 (dd, *J* = 13.8, 9.2 Hz, 1H), 5.87-5.73 (m, 2H), 5.60 (dd, *J* = 15.8, 6.2 Hz, 1H), 5.30 (d, *J* = 13.9 Hz, 1H), 5.16-5.09 (m, 2H), 4.76 (td, *J* = 9.4, 3.7 Hz, 1H), 4.18 (dd, *J* = 6.2, 5.9 Hz, 1H), 3.71 (dd, *J* = 7.7, 1.5 Hz, 1H), 2.37-2.25 (M, 2H), 1.83 (ddd, *J* = 14.1, 9.6, 1.7 Hz, 1H), 1.10-1.21 (m, 1H), 1.30 (s, 3H), 1.26 (s, 6H), 1.25 (s, 6H), 0.97 (t, *J* = 8.2 Hz, 9H), 0.95 (t, *J* = 7.4 Hz, 9H), 0.87 (s, 9H), 0.69 (q, *J* = 8.2 Hz, 6H), 0.58 (q, *J* = 7.9 Hz, 6H), 0.08 (s, 3H), 0.01 (s, 3H); ^{13}C NMR ($CDCl_3$, 67.5 MHz) δ 157.8, 135.9, 134.3, 131.1, 118.0, 83.1, 77.8, 75.7, 71.6, 69.3, 42.3, 41.7 (3C), 26.0 (3C),

24.9 (2C), 24.6 (2C), 23.5, 18.2, 7.27 (3C), 7.16 (3C), 6.76 (3C), 5.63 (3C), −2.93, −4.05; HRMS (CI) calcd for $[C_{37}H_{75}BO_6Si_3 + Na]^+$: 733.4862, Found: 733.4855.

(4*R*,5*E*,7*R*,8*R*,10*R*,11*Z*)-7,8-bistriethylsilyl-10-*tert*-butyldimethylsilyl-7-methyl-12-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)dodeca-1,5,11-trien-4-ylacrylate (30).

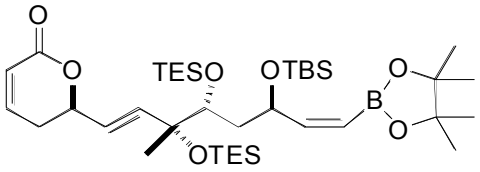


30

To a solution of alcohol **29** (30 mg, 0.043 mmol) in 1.5 mL of CH_2Cl_2 was added acrylic acid (15 mg, 0.21 mmol), DCC (43 mg, 0.21 mmol) and DMAP (2 mg, 0.4 mmol %). After 3 hours, the reaction mixture was diluted with Et_2O and filtered through a pad of Celite and washed with Et_2O. The organic layer was washed with saturated aqueous $NaHSO_4$ solution, brine and dried over anhydrous Na_2SO_4, concentrated to afford the crude product. Flash chromatography on silica gel (9:1 (v/v) hexane/EtOAc) provided ester **30** (25 mg, 76% yield) as a colorless oil. R_f = 0.50 (8:2 (v/v) hexane/EtOAc); IR (neat, cm^{-1}) 2987, 1736; $[\alpha]^{25}_D$ +10° (*c* 1.0, $CHCl_3$); ^1H NMR ($CDCl_3$, 600 MHz) δ 6.37 (dd, *J* = 17.4, 1.2 Hz, 1H), 6.18 (dd, *J* = 13.8, 9.0 Hz, 1H), 6.09 (dd, *J* = 17.4, 10.2 Hz, 1H), 5.80 (dd, *J* = 15.6, 10.8 Hz, 2H), 5.76-5.70 (m, 1H), 5.59 (dd, *J* = 15.6, 6.6 Hz, 1H), 5.41 (dd, *J* = 6.6, 6.0 Hz, 1H), 5.29 (d, *J* = 13.8 Hz, 1H), 5.08-5.03 (m, 2H), 3.96 (dt, *J* = 9.6, 3.6 Hz, 1H), 3.70 (dd, *J* = 7.8, 1.2 Hz, 1H), 3.21-3.17 (m, 1H), 2.42 (dd, *J* = 6.6, 6.6 Hz, 1H), 1.92-1.90 (m, 1H), 1.75-1.73 (m, 1H), 1.29 (s, 3H), 1.26 (s, 6H), 1.25 (s, 6H), 0.96 (t, *J* = 7.8 Hz, 9H), 0.92 (t, *J* = 8.4 Hz, 9H), 0.87 (s, 9H), 0.67 (qd, *J* = 7.8, 2.4 Hz,

6H), 0.56 (q, J = 7.8 Hz, 6H), 0.07 (s, 3H), 0.01 (s, 3H); ^{13}C NMR ($CDCl_3$, 150 MHz) δ 165.2, 157.9, 137.8, 133.2, 130.2, 128.8, 126.6, 117.9, 83.1, 77.8, 75.7, 73.4, 69.1, 55.7, 42.2, 39.1, 34.9 (3C), 26.1, 25.5 (3C), 24.9 (2C), 24.7 (2C), 24.6, 18.2, 7.23 (3C), 7.12 (3C), 6.79 (3C), 5.65 (3C), ⁻2.92, ⁻4.07; HRMS (CI) calcd for $[C_{40}H_{77}BO_7Si_3 + Na]^+$: 787.4968, Found: 787.4961.

(*R*)-5,6-dihydro-6-((1*E*,3*R*,4*R*,6*R*,7*Z*)-3,4-bistriethylsilyl-6-*tert*-butyldimethylsilyl-3-methyl-8-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)octa-1,7-dienyl)pyran-2-one (32).

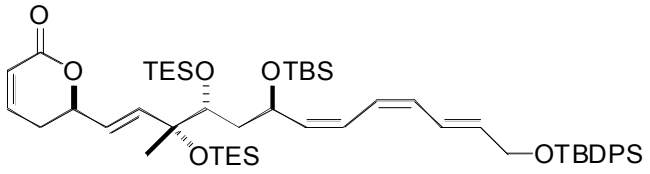


32

To a solution of triene **30** (25 mg, 0.032 mmol) in 3.5 mL of CH_2Cl_2 was added Grubbs catalyst **31** (6 mg, 20 %mmol). The reaction was heated at reflux for 3 hours. Solvent was removed under reduced pressure and the residue was purified by flash chromatography on silica gel (8:2 (v/v) hexane/EtOAc) to provide lactone **32** (20 mg, 82% yield) as a colorless oil. R_f = 0.35 (8:2 (v/v) hexane/EtOAc); IR (neat, cm^{-1}) 2930, 1731; $[\alpha]^{25}_D$ +32^o (*c* 1.0, $CHCl_3$); ^{1}H NMR ($CDCl_3$, 600 MHz) δ 6.86 (ddd, J = 8.4, 3.6, 1.2 Hz, 1 H), 6.20 (dd, J = 13.8, 9.6 Hz, 1H), 6.04 (ddd, J = 9.6, 1.8, 1.8 Hz, 1H), 5.91 (dd, J = 15.6, 1.2 Hz, 1H), 5.72 (dd, J = 15.6, 6.0 Hz, 1H), 5.30 (dd, J = 13.8, 1.2 Hz, 1H), 4.92 (ddd, J = 6.6, 6.0, 1.2 Hz, 1H), 4.79 (dd, J = 9.6, 3.6 Hz, 1H), 3.72 (dd, J = 9.6, 1.8 Hz, 1H), 2.43-2.41 (m, 2H), 1.84 (ddd, J = 14.4, 10.2, 1.8 Hz, 1H), 1.33 (s, 3H), 1.27 (s, 6H), 1.26 (s, 6H), 1.05 (m, 1H), 0.97 (dd, J = 8.4, 7.8 Hz, 9H), 0.92 (dd, J = 8.4, 7.8 Hz,

9H), 0.87 (s, 9H), 0.67 (qd, *J* = 8.4, 4.2 Hz, 6H), 0.59 (q, *J* = 7.8 Hz, 6H), 0.08 (s, 3H), 0.02 (s, 3H); ^{13}C NMR ($CDCl_3$, 150 MHz) δ 164.0, 157.8, 144.4, 138.9, 125.5, 121.7, 83.2, 77.9, 77.7, 75.6, 69.1, 42.1, 29.8 (3C), 26.1 (3C), 24.9 (2C), 24.6 (2C), 24.4, 18.2, 7.25 (3C), 7.18 (3C), 6.87 (3C), 5.67 (3C), –2.94, –3.98; HRMS (CI) calcd for $[C_{38}H_{73}BO_7Si_3 + Na]^+$: 759.4655, Found: 759.4648.

(*R*)-5,6-dihydro-6-((1*E*,3*R*,4*R*,6*R*,7*Z*,9*Z*,11*E*)-3,4-bistriethylsilyl-6-*tert*-butyldimethyl silyl-13-*tert*-butyldiphenylsilyl-3-methyltrideca-1,7,9-11-tetraenyl)pyran-2-one (33).

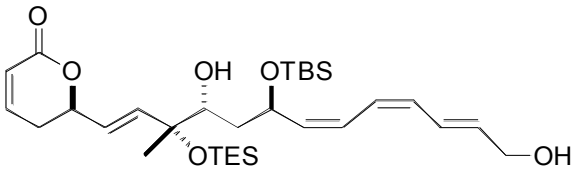


33

To a solution of $Pd_2(dba)_3{\cdot}CHCl_3$ (2 mg, 0.0019 mmol) in 0.5 mL of THF was added PPh_3 (4mg, 0.015 mmol). The color changed from dark red to light yellow, then the solution was canulated to a flask charged with iodide **8** (13 mg, 0.029 mmol). After two minutes, the mixture was cannulaed to a mixture of Z-vinylboronate **32** (7 mg, 0.0092 mmol) and Ag_2O (7 mg, 0.029 mmol) in 0.5 mL THF at room temperature. The reaction mixture was heated at 65 ^{o}C for 1 hour, and then cooled it down to room temperature, diluted with ether, filtered through a pad of Celite. The solvent was removed to afford the crude product. Flash chromatography on silica gel (9:1 (v/v) hexane/EtOAc) provided triene **33** (8 mg, 80% yield) as a colorless oil. R_f = 0.15 (9:1 (v/v) hexane/EtOAc); IR (neat, cm^{-1}) 2981, 1703; $[\alpha]^{25}_D$ +22 (*c* 0.6, $CHCl_3$); ^{1}H NMR ($CDCl_3$, 600 MHz) δ 7.69-7.60 (m, 4H), 7.44-7.36 (m, 6H), 6.85 (ddd, *J* = 9.6, 4.8, 3.6 Hz, 1H),

6.75 (dd, J = 15.6, 11.4 Hz, 1H), 6.30 (dd, J = 11.4, 11.4 Hz, 1H), 6.20 (dd, J = 11.4, 11.4 Hz, 1H), 6.06 (d, J = 11.4 Hz, 1H), 6.04 (ddd, J = 9.6, 1.8, 1.8 Hz, 1H), 5.87 (dd, J = 15.6, 1.2 Hz, 1H), 5.83 (ddd, J = 15.0, 5.4, 5.4 Hz, 1H), 5.75 (dd, J = 15.6, 6.6 Hz, 1H), 5.42 (dd, J = 11.4, 9.0 Hz, 1H), 4.93 (ddd, J = 15.6, 6.6, 1.2 Hz, 1H), 4.69 (td, J = 9.0, 9.0, 3.0 Hz, 1H), 4.29 (d, J = 3.6 Hz, 1H), 3.70 (dd, J = 8.4, 1.8 Hz, 1H), 2.43-2.41 (m, 3H), 1.90 (ddd, J = 14.4, 9.6, 1.8 Hz, 2H), 1.33 (s, 3H), 1.08 (s, 9H), 1.00 (t, J = 8.4 Hz, 9H), 0.96 (t, J = 8.4 Hz, 9H), 0.88 (s, 9H), 0.68 (qd, J = 7.8, 2.4 Hz, 6H), 0.68 (qd, J = 7.8, 1.2 Hz, 6H), 0.05 (s, 3H), 0.04 (s, 3H); ^{13}C NMR ($CDCl_3$, 150 MHz) δ 164.1, 144.5, 138.5, 136.6, 135.5 (4C), 134.8, 134.1, 133.6, 129.7, 129.6, 128.4, 127.7 (4C), 125.9, 124.6, 123.6, 122.4, 121.7, 78.0, 77.6, 76.2, 66.0, 64.2, 42.5, 29.8, 26.8 (3C), 26.0 (3C), 24.7, 19.3, 18.1, 7.20 (3C), 7.17 (3C), 6.91 (3C), 5.78 (3C), –3.07, –4.13; HRMS (CI) calcd for $[C_{53}H_{86}O_6Si_4 + Na]^+$: 953.5399, Found: 953.5395.

(*R*)-5,6-dihydro-6-((1*E*,3*R*,4*R*,6*R*,7*Z*,9*Z*,11*E*)-3-triethylsilyl-6-*tert*-butyldimethyl silyl-4,13-dihydroxy-3-methyltrideca-1,7,9-11-tetraenyl)pyran-2-one (34).



34

HF·pyridine complex (15 μL) was added to a solution of silyl ether **33** (10 mg, 0.011 mmol) in 0.5 mL a mixture of CH_3CN/H_2O/Pyridine: 9/1/2 at room temperature. After stirring for 2 days, the reaction was quenched with saturated aqueous $NaHCO_3$ and diluted with Et_2O. The aqueous layer was extracted with Et_2O. The combined organic

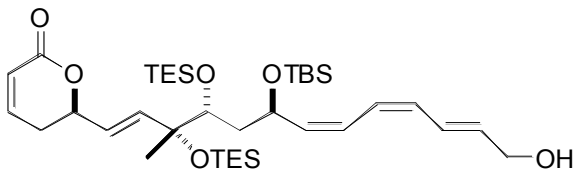
layers were washed with brine and dried over anhydrous Na_2SO_4, and concentrated to afford the crude product. Flash chromatography on silica gel (7:3 (v/v) hexane/EtOAc) provided alcohol **35** (3 mg, 40% yield) and diol **34** (3 mg, 45% yield).

R_f = 0.24 (5:5 (v/v) hexane/EtOAc); IR (neat, cm^{-1}) 3420, 2980, 1715; $[\alpha]^{25}_D$ –11° (*c* 0.4, $CHCl_3$); ^1H NMR ($CDCl_3$, 600 MHz) δ 6.88 (ddd, *J* = 9.0, 5.4, 3.6 Hz, 1H), 6.73 (ddd, *J* = 15.0, 11.4, 1.2 Hz, 1H), 6.38 (dd, *J* = 11.4, 11.4 Hz, 1H), 6.20 (dd, *J* = 11.4, 11.4 Hz, 1H), 6.06 (d, *J* = 10.8 Hz, 1H), 6.04 (ddd, *J* = 9.6, 1.8, 1.8 Hz, 1H), 5.91 (dd, *J* = 15.0, 6.0, 5.4 Hz, 1H), 5.88 (dd, *J* = 16.2, 1.2 Hz, 1H), 5.79 (dd, *J* = 15.6, 6.0 Hz, 1H), 5.55 (dd, *J* = 10.2, 9.6 Hz, 1H), 4.96 (ddd, *J* = 10.2, 6.0, 1.2 Hz, 1H), 4.91 (td, *J* = 7.8, 7.8, 2.4 Hz, 1H), 4.24 (dd, *J* = 4.8, 4.8 Hz, 1H), 3.67 (dd, *J* = 11.4, 2.4 Hz, 1H), 2.95 (d, *J* = 2.4 Hz, 1H), 2.46-2.42 (m, 2H), 1.64 (dd, *J* = 13.8, 7.8 Hz, 2H), 1.31 (s, 3H), 0.92 (t, *J* = 8.4 Hz, 9H), 0.87 (s, 9H), 0.77 (q, *J* = 7.8 Hz, 6H), 0.06 (s, 3H), 0.02 (s, 3H); ^{13}C NMR ($CDCl_3$, 150 MHz) δ 164.1, 144.6, 138.1, 136.3, 134.1, 129.8, 127.1, 126.2, 124.3, 122.3, 122.0, 77.8, 77.1, 75.1, 67.1, 63.6, 39.2, 29.8, 26.0 (3C), 22.3, 18.3, 7.26 (3C), 6.92 (3C), –4.14, –4.87; HRMS (CI) calcd for $[C_{31}H_{54}O_6Si_2 + Na]^+$: 601.3357, Found: 601.3350.

(Preparation from compound **35**)

HF·pyridine complex (12 μL) was added to a solution of silyl ether **35** (6 mg, 0.008 mmol) in 0.5 mL a mixture of CH_3CN/H_2O/Pyridine: 9/1/2 at room temperature. After stirring for 1 day, the reaction was quenched with saturated aqueous $NaHCO_3$ and diluted with Et_2O. The aqueous layer was extracted with Et_2O. The combined organic layers were washed with brine and dried over anhydrous Na_2SO_4, and concentrated to afford the crude product. Flash chromatography on silica gel (7:3 (v/v) hexane/EtOAc) provided diol **34** as a colorless oil (4 mg, 82% yield).

(*R*)-5,6-dihydro-6-((1*E*,3*R*,4*R*,6*R*,7*Z*,9*Z*,11*E*)-3,4-bistriethylsilyl-6-*tert*-butyldimethyl silyl-13-hydroxy-3-methyltrideca-1,7,9-11-tetraenyl)pyran-2-one (35).

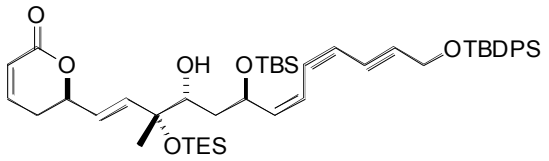


35

R_f = 0.52 (5:5 (v/v) hexane/EtOAc); IR (neat, cm^{-1}) 3425, 2987, 1720; $[\alpha]^{25}_D$ +45° (*c* 1.0, $CHCl_3$); ^1H NMR ($CDCl_3$, 600 MHz) δ 6.86 (ddd, *J* = 9.0, 4.8, 3.6 Hz, 1H), 6.73 (ddd, *J* = 15.0, 11.4, 1.2 Hz, 1H), 6.37 (dd, *J* = 11.4, 11.4 Hz, 1H), 6.24 (dd, *J* = 11.4, 11.4 Hz, 1H), 6.06 (d, *J* = 11.4 Hz, 1H), 6.04 (ddd, *J* = 9.6, 1.8, 1.8 Hz, 1H), 5.91 (dd, *J* = 15.6, 6.0, 5.4 Hz, 1H), 5.86 (dd, *J* = 15.6, 1.2 Hz, 1H), 5.74 (dd, *J* = 15.6, 6.6 Hz, 1H), 5.45 (dd, *J* = 10.2, 9.6 Hz, 1H), 4.93 (ddd, *J* = 15.6, 6.0, 1.2 Hz, 1H), 4.68 (td, *J* = 9.6, 9.6, 2.4 Hz, 1H),

4.25 (d, *J* = 4.8 Hz, 1H), 3.70 (dd, *J* = 8.4, 1.8 Hz, 1H), 2.43-2.41 (m, 2H), 1.89 (ddd, *J* = 14.4, 10.2, 1.8 Hz, 2H), 1.33 (s, 3H), 1.08 (ddd, *J* = 11.4, 8.4,3.0 Hz, 2H), 0.98 (t, *J* = 8.4 Hz, 9H), 0.95 (t, *J* = 8.4 Hz, 9H), 0.87 (s, 9H), 0.67 (qd, *J* = 7.8, 2.4 Hz, 6H), 0.61 (qd, *J* = 7.8, 1.2 Hz, 6H), 0.04 (s, 3H), 0.02 (s, 3H); ^{13}C NMR ($CDCl_3$, 150 MHz) δ 164.0, 144.5, 138.4, 137.1, 133.8, 129.4, 126.0, 125.9, 124.5, 122.2, 121.7, 77.9, 77.6, 76.2, 66.0, 63.4, 42.5, 29.7 (3C), 26.0 (3C), 24.7, 18.1, 13.3, 7.16 (3C), 7.17 (3C), 6.91 (3C), 5.78 (3C), -3.05, -4.10; HRMS (CI) calcd for $[C_{37}H_{68}O_6Si_3 + Na]^+$: 715.4221, Found: 715.4215.

(*R*)-5,6-dihydro-6-((1*E*,3*R*,4*R*,6*R*,7*Z*,9*Z*,11*E*)-3-bistriethylsilyl-4-hydroxy-6-*tert*-butyldimethylsilyl-13-*tert*-butyldiphenylsilyl-3-methyltrideca-1,7,9-11-tetraenyl)pyran-2-one (5).

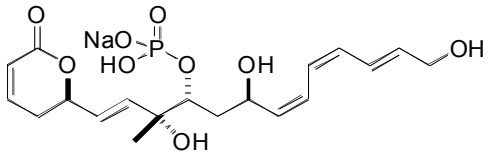


5

To a solution of alcohol **34** (5 mg, 0.0083 mmol) in 0.2 mL of CH_2Cl_2 was added imidazole (2 mg, 0.027 mmol) and TBDPSCl (3 mg, 0.012 mmol) at 0 ^oC. After 5 minutes, the reaction mixture was purified by using flash chromatography on silica gel (9:1 (v/v) hexane/EtOAc) without workup provided compound **5** (5 mg, 78% yield) as a yellow oil. R_f = 0.46 (8:2 (v/v) hexane/EtOAc); IR (neat, cm^{-1}) 3412, 2981, 1728; $[\alpha]^{25}_D$ −18 ^{o}(*c* 0.4, $CHCl_3$); ^1H NMR ($CDCl_3$, 600 MHz) δ 7.69-7.67 (m, 4H), 7.44-7.33 (m, 6H), 6.88 (ddd, *J* = 8.4, 5.4, 3.6 Hz, 1H), 6.75 (dd, *J* = 15.6, 11.4 Hz, 1H), 6.33 (dd, *J* = 11.4, 11.4 Hz, 1H), 6.15 (dd, *J* = 11.4, 11.4 Hz, 1H), 6.07-6.03 (m, 2H), 5.89 (dd, *J* = 15.6, 1.2 Hz, 1H), 5.83 (ddd, *J* = 15.6, 5.4, 5.4 Hz, 1H), 5.80 (dd, *J* = 15.6, 6.0 Hz, 1H), 5.53 (dd, *J* = 10.2, 9.6 Hz, 1H), 4.98-4.91 (m, 2H), 4.29 (d, *J* = 4.2 Hz, 2H), 3.68 (d, *J* = 10.8 Hz, 1H), 2.99 (d, *J* = 2.4 Hz, 1H), 2.46-2.43 (m, 2H), 1.64 (dd, *J* = 13.8, 7.8 Hz, 1H), 1.33-1.37 (m, 1H), 1.32 (s, 3H), 1.08 (s, 9H), 0.93 (t, *J* = 7.8 Hz, 9H), 0.88 (s, 9H), 0.57 (q, *J* = 7.8 Hz, 6H), 0.07 (s, 3H), 0.04 (s, 3H); ^{13}C NMR ($CDCl_3$, 150 MHz) δ 163.9, 144.3, 137.9, 135.5 (4C), 134.3, 133.6, 133.6, 130.1, 129.7 (2C), 127.7 (4C), 126.8, 124.5, 123.2, 122.3, 121.8, 77.6, 75.0, 67.0, 64.2, 39.0, 29.6 (3C), 26.8 (3C), 25.8 (3C), 22.2, 19.3, 18.1, 7.10 (3C), 6.73 (3C), −4.33, −5.07; HRMS (CI) calcd for $[C_{47}H_{72}O_6Si_3 + Na]^+$: 839.4534,

Found: 839.4528.

Fostriecin (1).



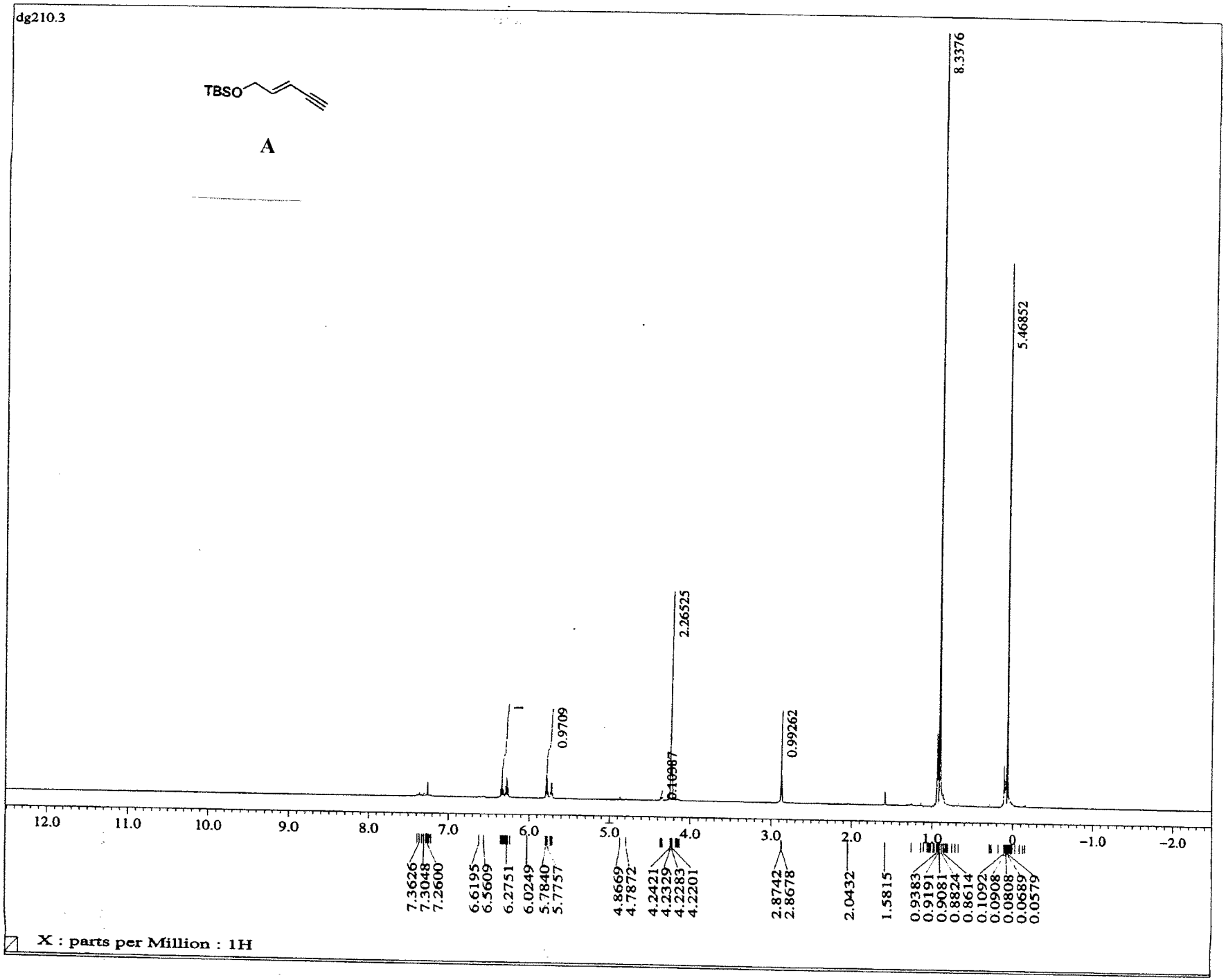
1

To a solution of alcohol **5** (5 mg, 0.006 mmol) in 0.4 mL of pyridine was added PCl_3 (2.5 mL, 0.03 mmol) at 0 ^oC and stirred for 15 minutes. 4-Methoxybenyl alcohol (19 μL, 0.15 mmol) was added, and then the reaction was gradually warmed to room temperature for 1 hour and dilute with 1.2 mL of CH_2Cl_2. *tert*-Butyl hydroperoxide (5.5 M in decane, 55 μL, 0.35 mmol) was added and stirred at room temperature for 1.5 hour. To the reaction mixture, saturated $NaHO_3$ solution was added; the mixture was stirred for several minutes, and then extracted with CH_2Cl_2. The organic layer was dried over Na_2SO_4 and concentrated under reduced pressure. The residue was treated with 48% HF-acetonitrile (1: 19, 0.3 mL) at room temperature for 15 minutes. After ice cooling, pyridine (95 μL) was added to the reaction mixture, and the mixture was stirred at room temperature for 23 hours. The reaction mixture was basified with saturated $NaHO_3$ solution and washed with ether. The aqueous layer was concentrated under reduced pressure, and the residue was purified by 18-reversed phase silica gel column chromatography (H_2O to H_2O/aetinitrile = 9/1) to give fostriecin **1** (0.5 mg, 31% yield) as a white solid. $[\alpha]^{25}_D$ −325 ^{o}(*c* 0.1 w/v %, D_2O)*; ^{1}H NMR (D_2O, 600 MHz) δ 7.03 (ddd, *J* = 10, 6, 3 Hz, 1H), 6.70 (dd, *J* = 15, 12 Hz, 1H), 6.49 (t, *J* = 11 Hz, 1H), 6.29 (t, *J* = 12 Hz, 1H), 6.09 (t, *J* =

11 Hz, 1H), 5.96 (dd, *J* = 10, 2 Hz, 1H), 5.92-5.84 (m, 3H), 5.50 (t, *J* = 10 Hz, 1H), 5.06 (m, 1H), 4.88 (t, *J* = 9 Hz, 1H), 4.12 (d, *J* = 6 Hz, 2H), 4.10-4.06 (m, 1H), 2.56 (td, *J* = 19, 6 Hz, 1H), 2.44-2.50 (m, 1H), 1.58 (t, *J* = 12 Hz, 1H), 1.46 (m, 1H), 1.24 (s, 3H), ^{13}C NMR: Data was not available due to lack of sample; HRMS (CI) calcd for $[C_{19}H_{26}O_9P+Na]^+$: 475.1104, Found: 475.1114

[‡] Structure was not shown in the text.

[*] The optical rotation data for our synthetic fostriecin did not match that of the natural material. This could be a result of both the different concentration and solvent. It should be noted that our optical rotation data for **5** did match that reported by Imanishi.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2.0432
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0.9191
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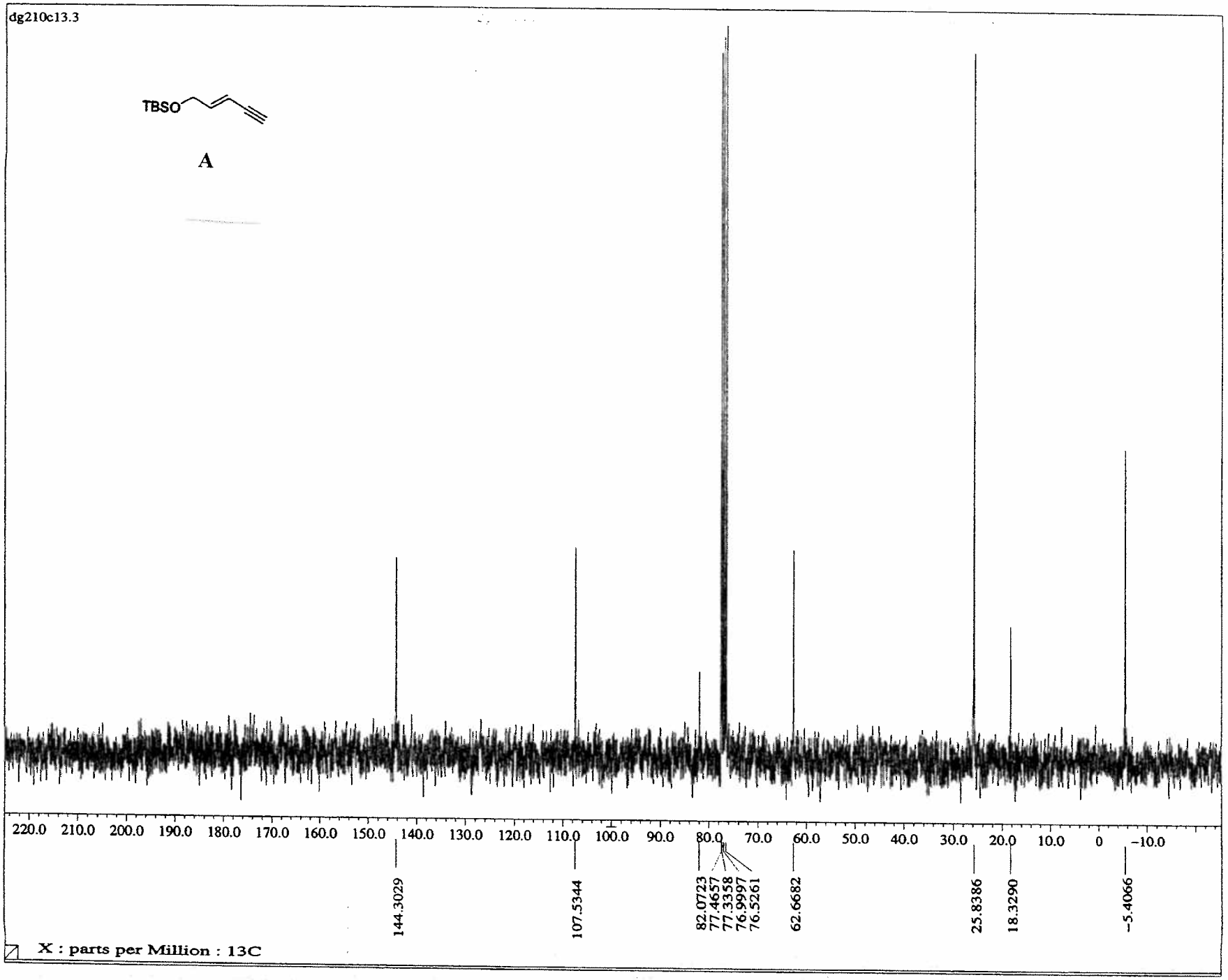
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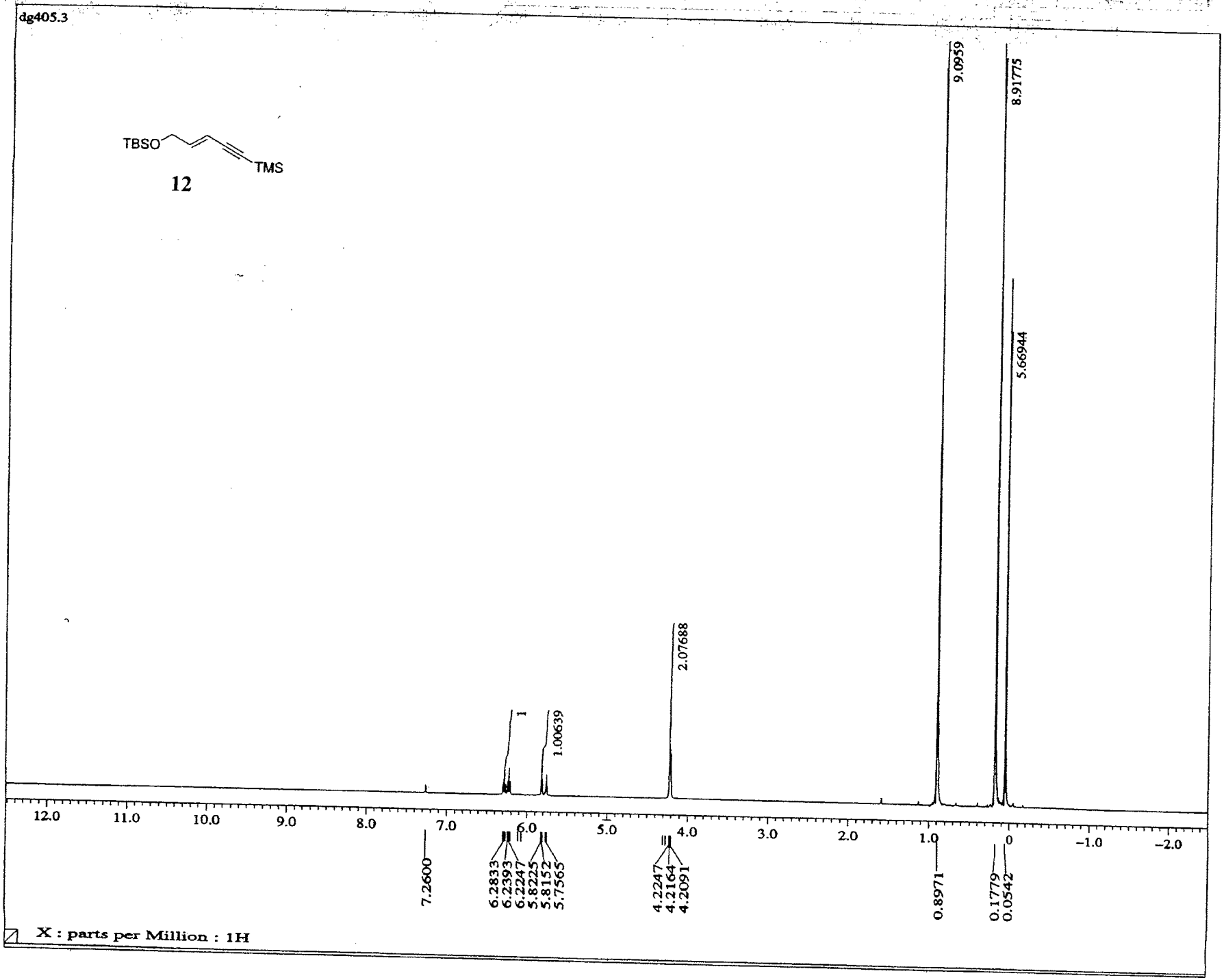
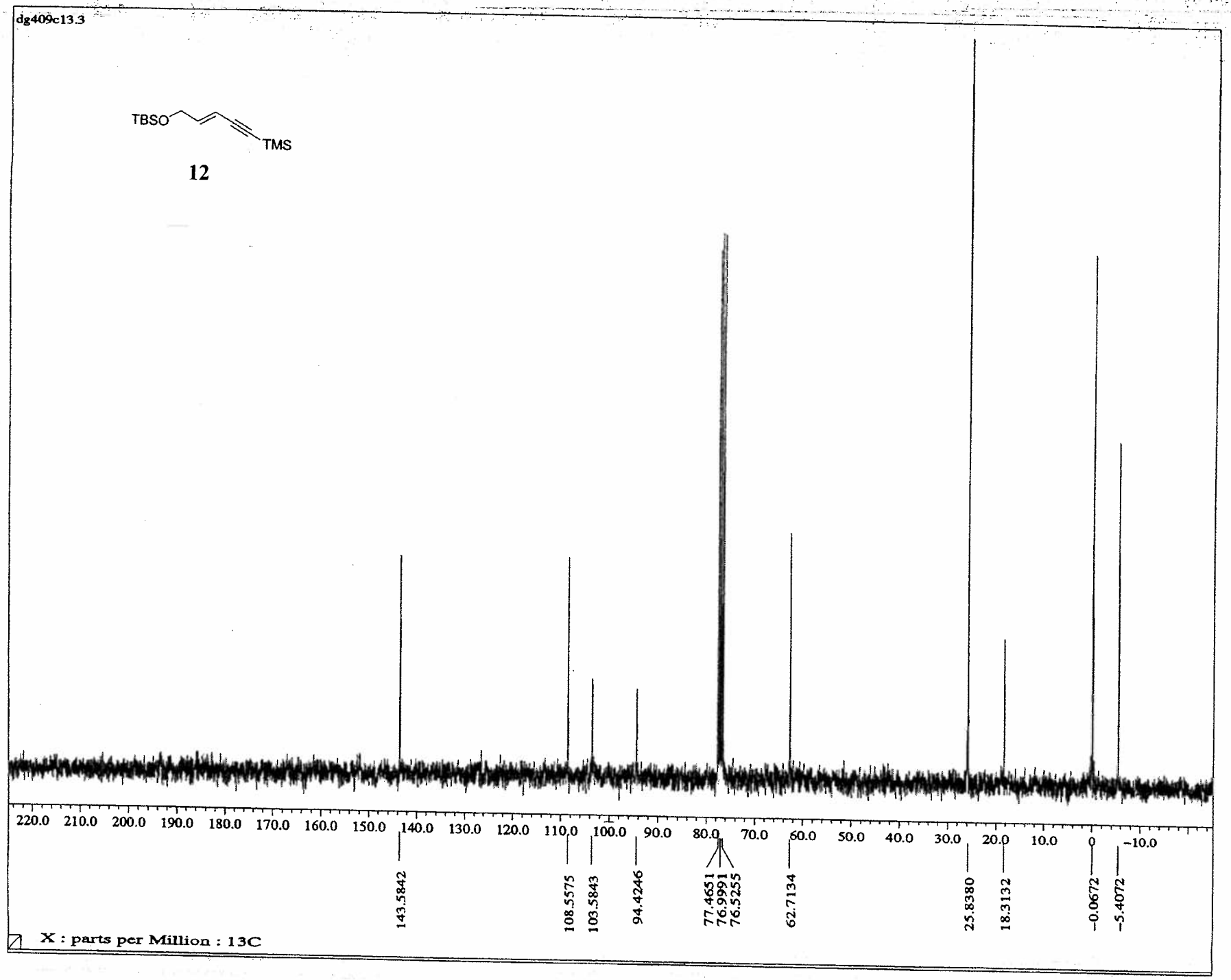
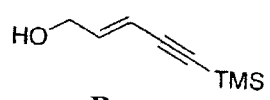
82.0723
77.4657
77.3358
76.9997
76.5261
62.6682
25.8386
18.3290
-5.4066
X : parts per Million : 13C


dg405.3
TBSO
TMS
12
9.0959
8.91775
5.66944
2.07688
1.00639
1
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
-1.0
-2.0
7.2600
6.2833
6.2393
6.2247
5.8225
5.8152
5.7565
4.2247
4.2164
4.2091
0.8971
0.1779
0.0542
X : parts per Million : 1H

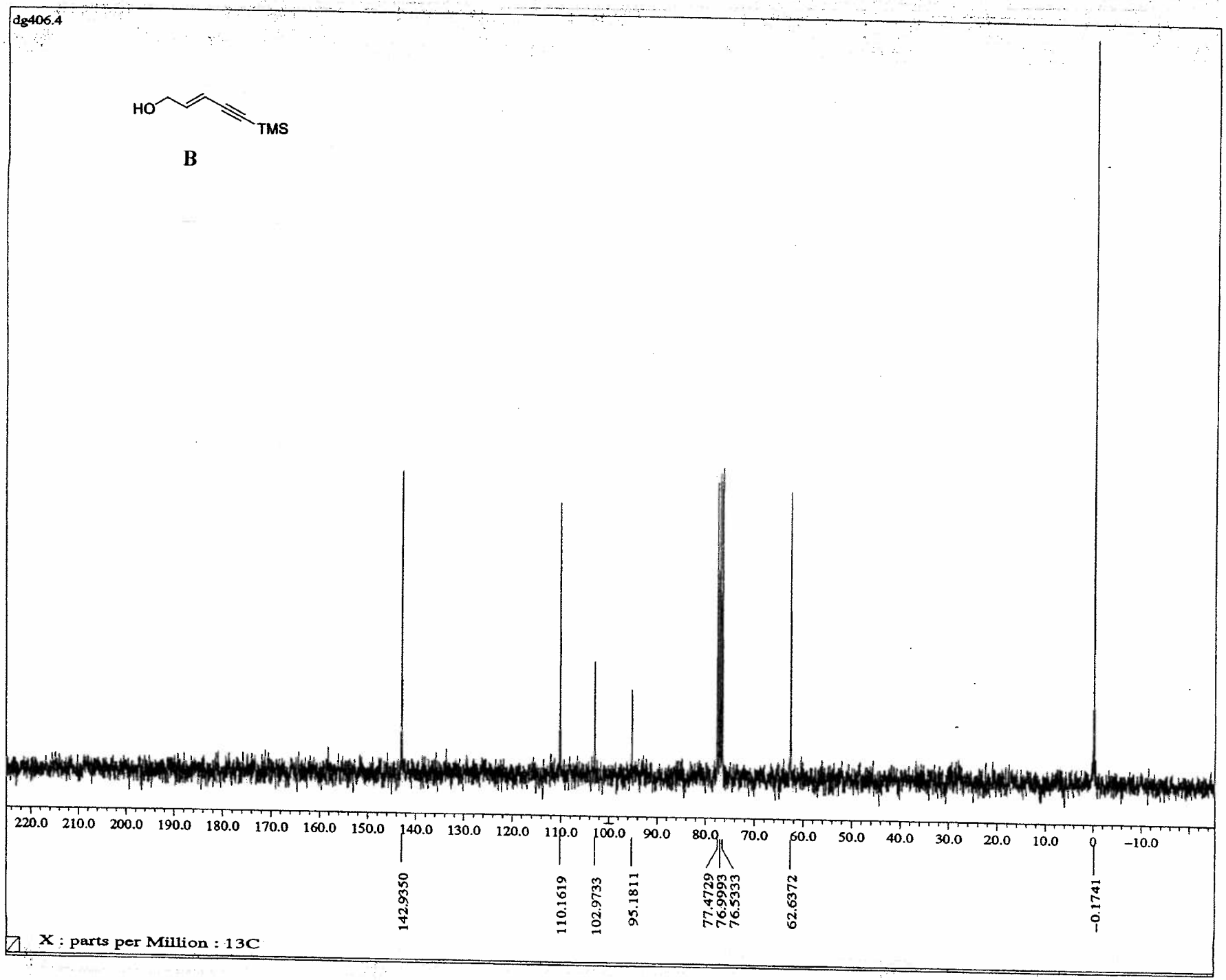

dg409c13.3
TBSO
TMS
12
220.0 210.0 200.0 190.0 180.0 170.0 160.0 150.0 140.0 130.0 120.0 110.0 100.0 90.0 80.0 70.0 60.0 50.0 40.0 30.0 20.0 10.0 0 −10.0
143.5842
108.5575
103.5843
94.4246
77.4651
76.9991
76.5255
62.7134
25.8380
18.3132
−0.0672
−5.4072
X : parts per Million : 13C

dg406.3

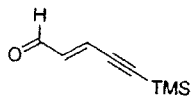

HO
TMS

B

7.51606
2.48833
1.15236
0.97083
1
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
-1.0
-2.0
7.2600
6.3035
6.2448
6.2256
5.7675
5.7602
5.7080
4.1596
4.1459
2.2036
0.1660
X : parts per Million : 1H


dg406.4
HO
TMS
B
220.0 210.0 200.0 190.0 180.0 170.0 160.0 150.0 140.0 130.0 120.0 110.0 100.0 90.0 80.0 70.0 60.0 50.0 40.0 30.0 20.0 10.0 0 -10.0
142.9350
110.1619
102.9733
95.1811
77.4729
76.9993
76.5333
62.6372
-0.1741
X : parts per Million : 13C

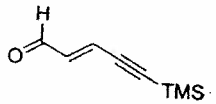
dg406.6


H
O
TMS

13

12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
−1.0
−2.0
9.5706
9.5550
9.5284
7.2600
6.6012
6.5426
6.4858
6.4812
6.4583
6.4537
6.4272
6.3997
0.2219
X : parts per Million : 1H

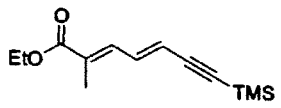
dg406.7


H
O
TMS

13

220.0 210.0 200.0 190.0 180.0 170.0 160.0 150.0 140.0 130.0 120.0 110.0 100.0 90.0 80.0 70.0 60.0 50.0 40.0 30.0 20.0 10.0 0 -10.0
193.1098
140.0694
132.0862
111.3528
100.5660
77.4720
76.9984
76.5324
-0.5569
X : parts per Million : 13C

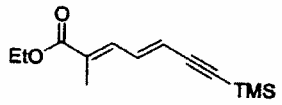
dg409.3


O
EtO
TMS

14a

12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
-1.0
-2.0
7.6081
7.5660
7.1171
6.9457
6.8889
6.8450
6.3841
6.3438
5.9269
5.8701
5.7510
5.6933
4.4821
4.2119
4.1853
3.9361
3.9095
2.1944
1.9938
1.9590
1.9544
1.3176
1.3076
1.2911
1.2645
1.2471
0.6562
0.2072
0.1944
0.1816
0.1770
-1.2916
X : parts per Million : 1H

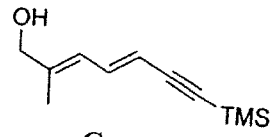
dg409.4


O
EtO
TMS

14a

220.0 210.0 200.0 190.0 180.0 170.0 160.0 150.0 140.0 130.0 120.0 110.0 100.0 90.0 80.0 70.0 60.0 50.0 40.0 30.0 20.0 10.0 0 -10.0
167.8322
137.4274
136.4648
129.9407
117.3204
103.8904
100.8499
77.4733
76.9996
76.5336
60.7812
14.2342
12.9355
-0.2501
X : parts per Million : 13C

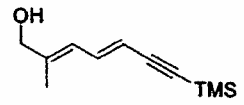
dg410.3


OH
TMS

C

8.78689
3.173
2.27731
1.18812
1.0724
1
0.79843
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
-1.0
-2.0
7.2600
6.9274
6.8862
6.8706
6.8285
6.1203
6.1175
6.1157
6.0754
5.6109
5.5531
4.0524
2.0451
1.7721
1.7693
0.1798
X : parts per Million : 1H

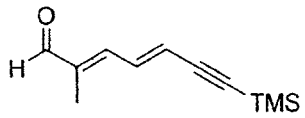
dg410C13.3


OH
TMS

C

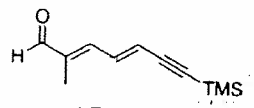
220.0 210.0 200.0 190.0 180.0 170.0 160.0 150.0 140.0 130.0 120.0 110.0 100.0 90.0 80.0 70.0 60.0 50.0 40.0 30.0 20.0 10.0 0 -10.0
141.0245
138.4118
123.4157
110.4058
104.7908
96.9298
77.4646
76.9986
76.5250
67.6633
14.3249
-0.0983
X : parts per Million : 13C

dg411crude.3



15a

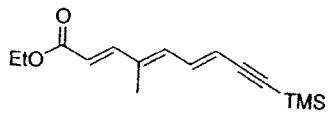
dg411.3


O
H
TMS

15a

220.0 210.0 200.0 190.0 180.0 170.0 160.0 150.0 140.0 130.0 120.0 110.0 100.0 90.0 80.0 70.0 60.0 50.0 40.0 30.0 20.0 10.0 0 -10.0
194.3623
146.3257
139.5266
136.7458
119.4578
103.4609
102.9720
77.4717
76.9980
76.5320
9.7025
-0.3128
X : parts per Million : 13C

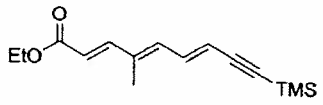
dg412.3


O
EtO
TMS

10

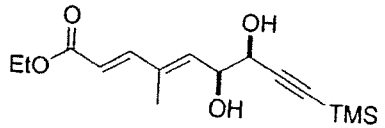
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
-1.0
-2.0
7.3323
7.2746
6.9686
6.9549
6.9118
6.3969
6.3539
5.9562
5.8985
5.8078
4.2393
4.2127
4.1862
2.1394
1.9058
1.9031
1.3121
1.2865
1.2599
0.6506
0.5654
0.4143
0.3886
0.1935
X : parts per Million : 1H

dg412c13.3



10

dg413.4



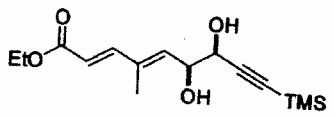
D

12.0 11.0 10.0 9.0 8.0 7.0 6.0 5.0 4.0 3.0 2.0 1.0 0 −1.0 −2.0

7.2600
6.8844
6.8688
6.8266
6.1716
6.1267
6.1047
5.6457
5.5880
5.5660
4.2623
4.2558
4.2366
3.5357
3.3296
3.3030
3.2352
2.9118
2.8559
1.8848
1.8802
1.8408
1.3085
1.2819
1.2554
0.1807

X : parts per Million : 1H

dg413c13.3



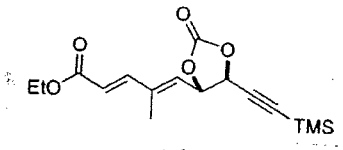
D

220.0 210.0 200.0 190.0 180.0 170.0 160.0 150.0 140.0 130.0 120.0 110.0 100.0 90.0 80.0 70.0 60.0 50.0 40.0 30.0 20.0 10.0 0 -10.0

172.8794
139.2736
137.9673
125.4234
111.4662
77.4708
76.9971
76.6839
76.5311
72.1996
62.2149
14.1172
13.8345
-0.1151

X : parts per Million : 13C

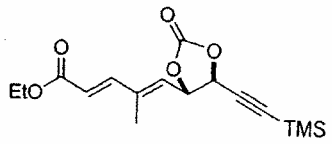
dg415.3


EtO
O
O
O
O
TMS

16

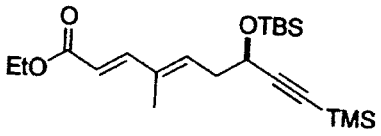
8.42126
3.08802
2.81645
1.94324
0.93546
0.92504
0.95108
0.93492
1
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
-1.0
-2.0
7.2599
6.8229
6.8074
6.7652
6.2302
6.1880
5.8316
5.7730
5.7162
5.0336
5.0144
4.7084
4.6882
4.3575
4.3318
4.3053
1.9461
1.8426
1.6355
1.3524
1.3258
1.2993
1.2709
0.8659
0.8403
0.2512
0.1907
0.1623
0.1568
0.1027
X : parts per Million : 1H

dg415c13.3



16

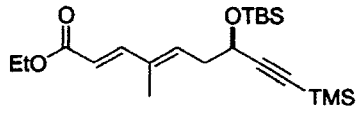
dg417b.3


O
EtO
OTBS
TMS

17

12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
-1.0
-2.0
7.2599
6.8522
6.8376
6.7954
5.9434
5.9040
5.8655
5.5375
5.5137
5.4807
4.2035
4.1761
4.1568
4.1495
2.4591
2.4417
2.4124
1.8627
1.8343
1.7179
1.5878
1.2846
1.2589
1.2507
0.8906
0.8824
0.8686
0.1998
0.1907
0.1815
X : parts per Million : 1H

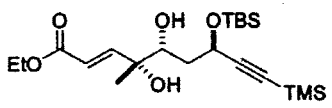
dg417b.4


O
OTBS
EtO
TMS

17

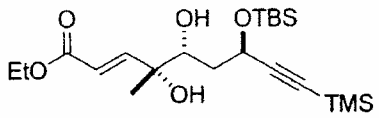
220.0 210.0 200.0 190.0 180.0 170.0 160.0 150.0 140.0 130.0 120.0 110.0 100.0 90.0 80.0 70.0 60.0 50.0 40.0 30.0 20.0 10.0 0 -10.0
173.1871
138.8403
137.9771
127.9618
109.3827
104.9672
96.3423
77.4729
76.9993
76.5333
71.3538
60.8267
45.6090
25.7159
25.6243
18.2217
17.4959
14.2492
14.1651
-0.0289
-4.8417
-5.0785
-5.2848
X : parts per Million : 13C

dgTBSDIOL.3



E

dgtbsdiolc13.3



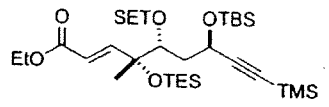
E

220.0 210.0 200.0 190.0 180.0 170.0 160.0 150.0 140.0 130.0 120.0 110.0 100.0 90.0 80.0 70.0 60.0 50.0 40.0 30.0 20.0 10.0 0 -10.0

166.5948
152.2785
120.3229
105.4948
90.6896
77.4658
76.9998
76.5262
74.6621
74.0281
62.5384
60.3917
37.6034
25.6782
22.6148
18.0312
14.2191
-0.3034
-4.6349
-5.3072

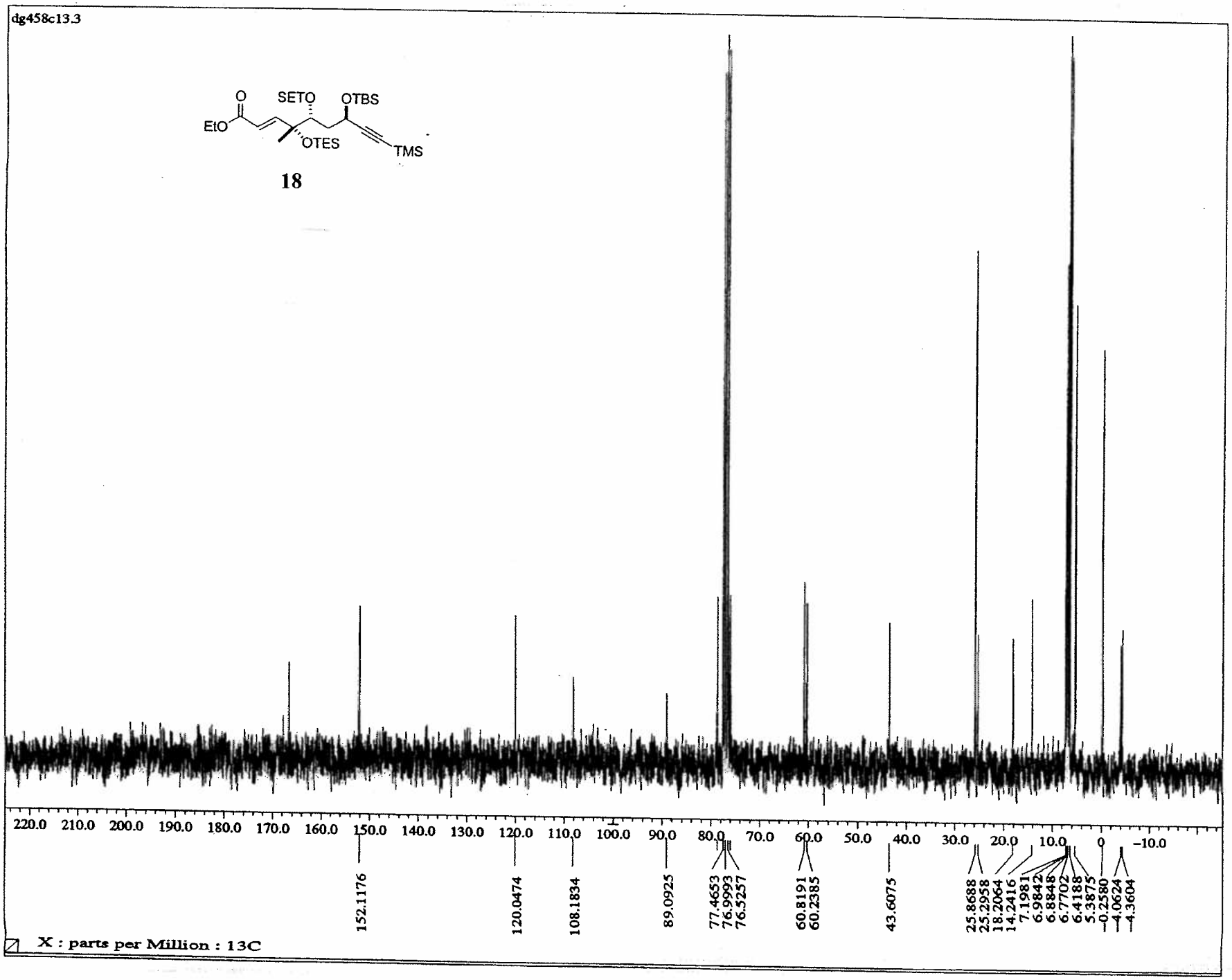
X : parts per Million : 13C

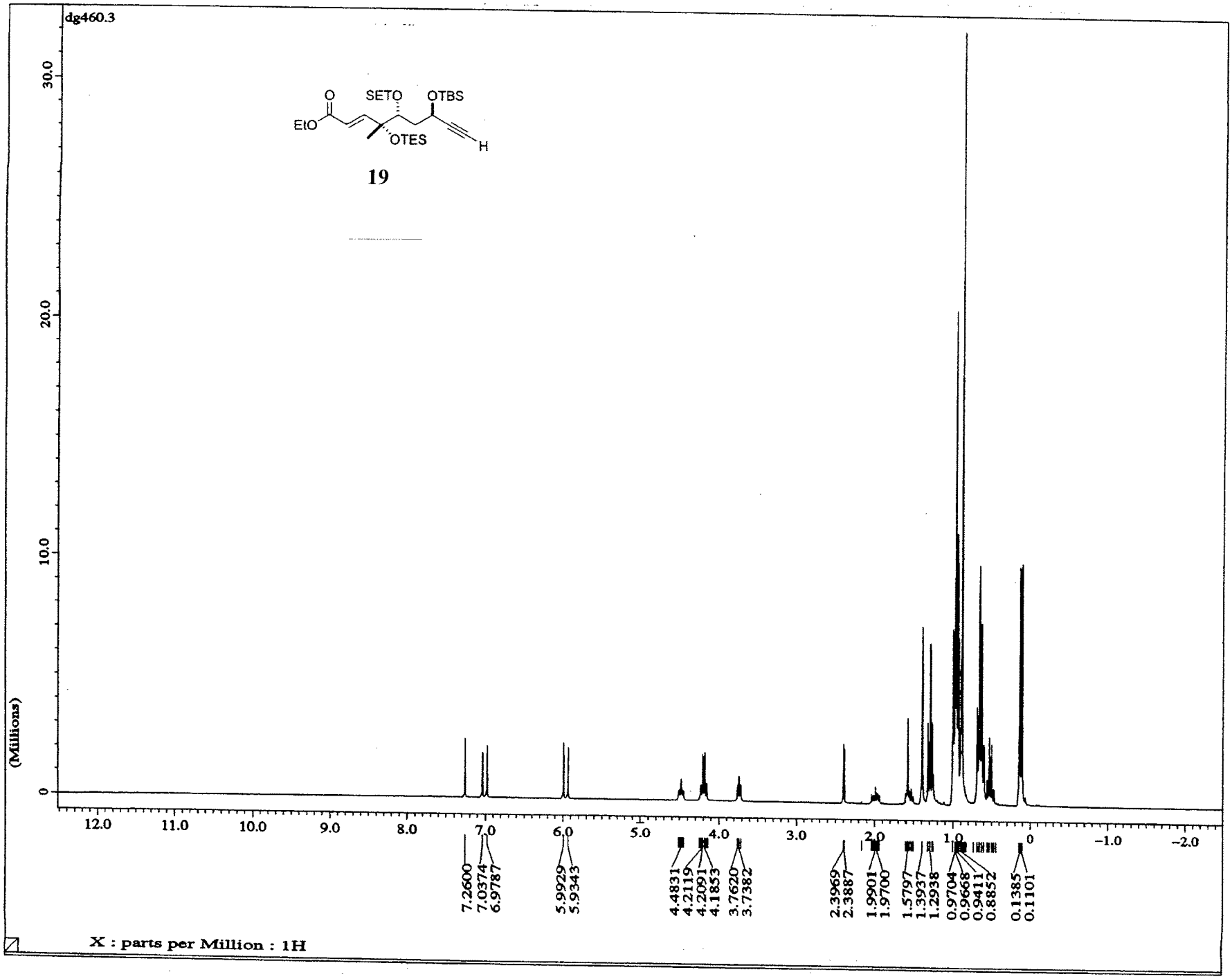
dg457.3


O
SETO
OTBS
EtO
OTES
TMS

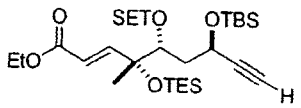
18

12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
-1.0
-2.0
7.2600
7.0200
6.9622
6.1459
6.0882
4.2357
4.2091
4.1825
4.1560
3.7638
3.7428
2.6479
1.3094
1.2828
1.2563
0.9814
0.9530
0.9246
0.8889
0.6672
0.6397
0.6094
0.5261
0.4968
0.1688
0.1569
0.1504
X : parts per Million : 1H


dg458c13.3
O
SETO
OTBS
EtO
OTES
TMS
18
220.0 210.0 200.0 190.0 180.0 170.0 160.0 150.0 140.0 130.0 120.0 110.0 100.0 90.0 80.0 70.0 60.0 50.0 40.0 30.0 20.0 10.0 0 -10.0
152.1176
120.0474
108.1834
89.0925
77.4653
76.9993
76.5257
60.8191
60.2385
43.6075
25.8688
25.2958
18.2064
14.2416
7.1981
6.9842
6.8848
6.7702
6.4188
5.3875
-0.2580
-4.0624
-4.3604
X : parts per Million : 13C

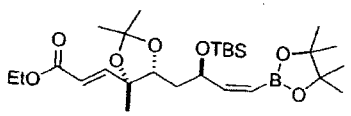

dg460.3
O
SETO
OTBS
EtO
OTES
H
19
(Millions)
30.0
20.0
10.0
0
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
-1.0
-2.0
7.2600
7.0374
6.9787
5.9929
5.9343
4.4831
4.2119
4.2091
4.1853
3.7620
3.7382
2.3969
2.3887
1.9901
1.9700
1.5797
1.3937
1.2938
0.9704
0.9668
0.9411
0.8852
0.1385
0.1101
X : parts per Million : 1H

dg460C13.4



19

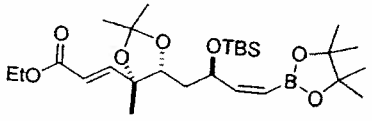
dg401.5


EtO
O
O
O
OTBS
O
B
O

23

12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
-1.0
-2.0
7.2600
6.8880
6.8303
6.2953
6.2641
6.0818
6.0241
5.3479
5.3452
5.0273
5.0126
4.1908
4.1642
4.1386
3.6805
2.2961
2.2641
2.0222
1.9196
1.4248
1.3341
1.2975
1.2819
1.2718
1.2508
1.1491
0.8348
0.0332
0.0002
-0.0520
-0.0676
-0.1876
X : parts per Million : 1H

dg401c13.4



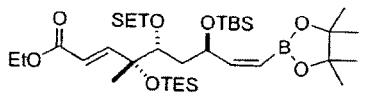
23

220.0 210.0 200.0 190.0 180.0 170.0 160.0 150.0 140.0 130.0 120.0 110.0 100.0 90.0 80.0 70.0 60.0 50.0 40.0 30.0 20.0 10.0 0 -10.0

166.4338
157.1595
149.6806
119.9785
107.7631
83.1031
81.3995
77.6715
77.4729
76.9992
76.5332
69.3140
60.3759
37.7097
28.3820
26.3958
25.8304
24.8297
24.7151
21.1093
20.0245
18.0994
14.1880
-4.3987
-4.9487

X : parts per Million : 13C

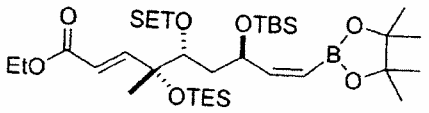
dg461.4


O
SETO
OTBS
EtO
B
O
O
OTES

25a

12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
7.2600
7.0621
7.0035
6.5234
6.4968
6.1798
5.9370
5.8793
5.5238
5.3250
5.2719
4.8056
4.7845
4.7698
4.1917
4.1862
4.1651
3.7831
3.7767
3.7538
2.1633
1.8243
1.6521
1.2636
1.2544
0.9704
0.9411
0.8596
0.3960
0.0579
0.0048
-0.2169
X : parts per Million : 1H

dg461c13.4



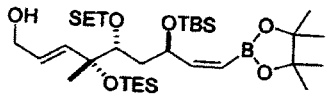
25a

220.0 210.0 200.0 190.0 180.0 170.0 160.0 150.0 140.0 130.0 120.0 110.0 100.0 90.0 80.0 70.0 60.0 50.0 40.0 30.0 20.0 10.0 0 −10.0

166.7554
157.7103
152.9892
119.6431
83.1650
78.1535
77.4660
77.0000
76.5263
75.3957
68.9633
60.1780
41.8892
26.0527
25.9534
24.9374
24.5783
24.2116
18.1765
14.2269
7.1987
7.1223
6.7479
5.6020
−2.9923
−3.9834

X : parts per Million : 13C

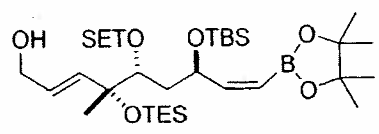
dg462.3


OH
SETO
OTBS
B
O
O
OTES

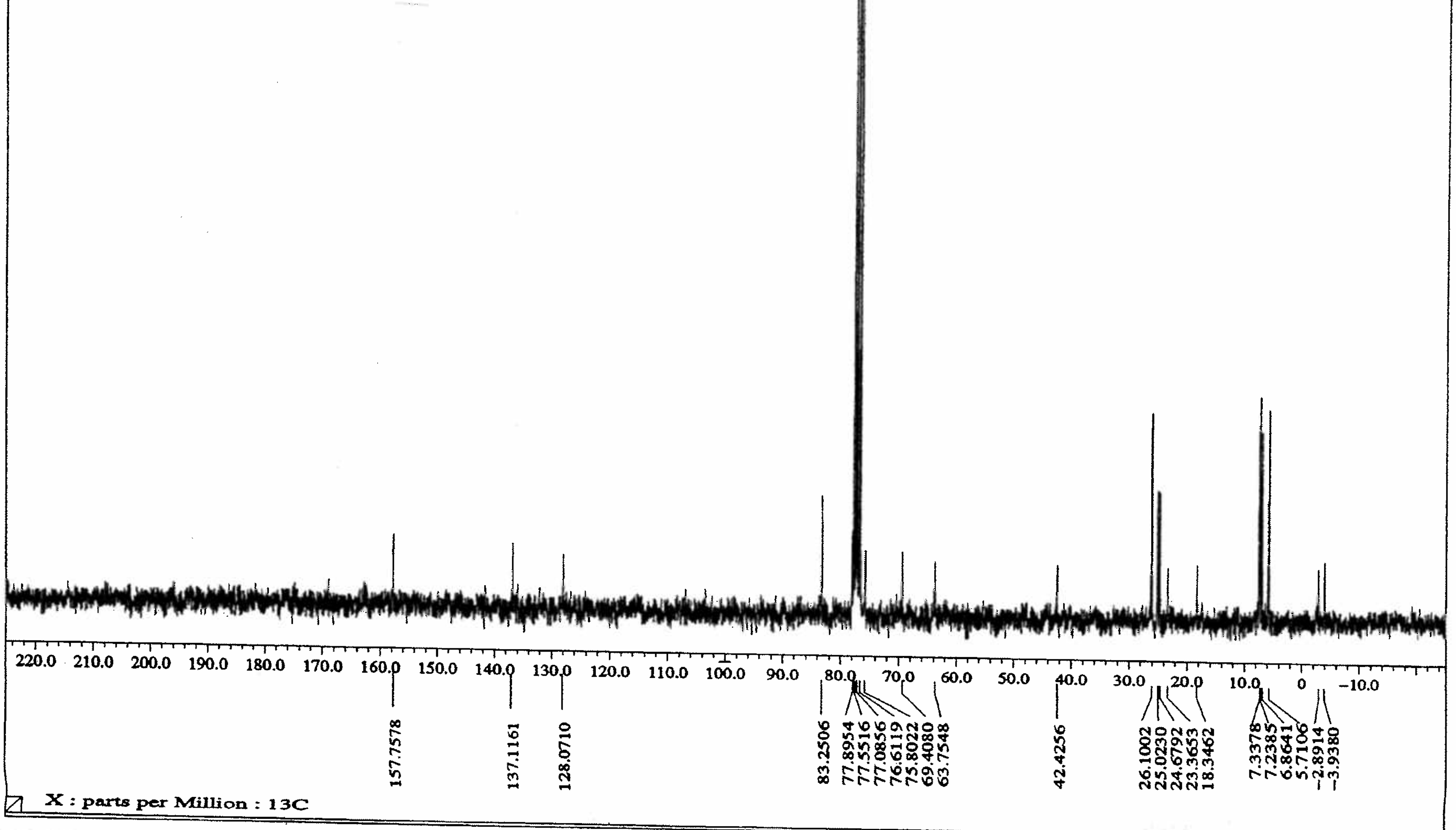
26a

12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
-1.0
-2.0
7.2847
7.2600
6.5490
6.5243
6.2055
6.1881
5.7685
5.7620
5.7446
5.3360
5.2847
4.7918
4.7726
4.7570
4.2357
4.1450
3.7071
3.6997
3.6796
2.0414
1.8335
1.8161
1.7812
1.6915
1.3039
1.2673
1.2590
0.9649
0.9329
0.8706
0.8642
0.0671
0.0350
0.0057
X : parts per Million : 1H

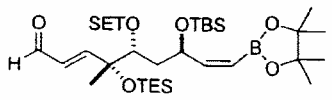
dg462–c13.3



26a



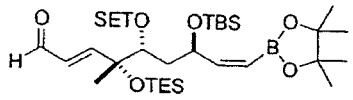
dg463.3


O
SETO
OTBS
O
B
O
H
OTES

27

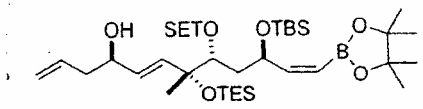
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
-1.0
-2.0
9.5697
9.5404
7.2600
6.9512
6.8935
6.2714
6.2421
6.1835
5.3351
5.2838
4.8257
4.8037
4.7909
3.8509
3.8454
3.8197
1.9324
1.8884
1.8793
1.8417
1.4230
1.2581
0.9878
0.9594
0.9457
0.9182
0.8687
0.6259
0.0698
0.0295
0.0176
0.0075
X : parts per Million : 1H

dg463C13.3



27

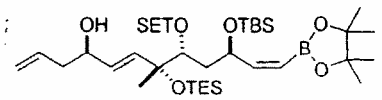
dg464.3


OH
SETO
OTBS
O
B
O
OTES

29

12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
-1.0
-2.0
7.2600
6.1826
6.1487
5.7281
5.6448
5.6219
5.3250
5.0887
4.7946
4.7808
4.1880
4.1651
4.1303
3.7171
3.6942
2.3145
2.3007
2.0414
1.2957
1.2636
1.2572
0.9704
0.9420
0.9347
0.9063
0.8687
0.7011
0.5911
0.0753
0.0121
-0.0300
X : parts per Million : 1H

dg464c13.3



29

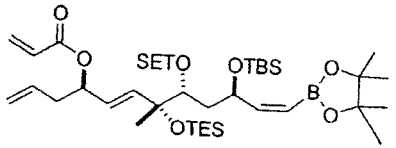
STANDARD PROTON PARAMETERS

Archive directory: /export/home/vnmr1/vnmrsys/data
Sample directory:
File: PROTON

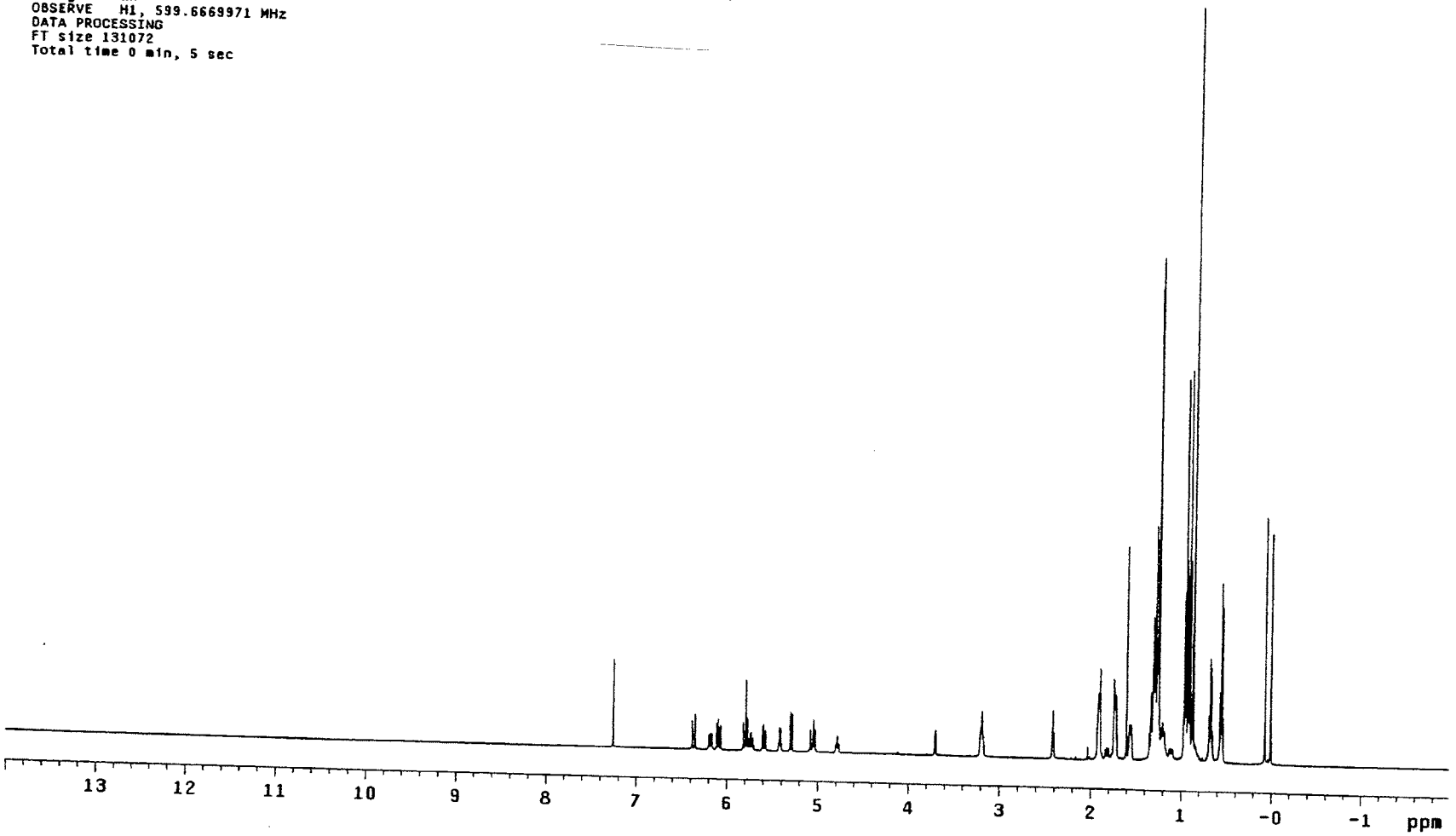
Pulse Sequence: s2pul

Solvent: CDCl3
Temp. 28.0 C / 301.1 K
INOVA-600 "inova600"

Relax. delay 1.000 sec
Pulse 30.0 degrees
Acq. time 4.880 sec
Width 9594.6 Hz
Single scan
OBSERVE H1, 599.6669971 MHz
DATA PROCESSING
FT size 131072
Total time 0 min, 5 sec



30

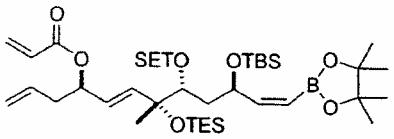


STANDARD CARBON PARAMETERS

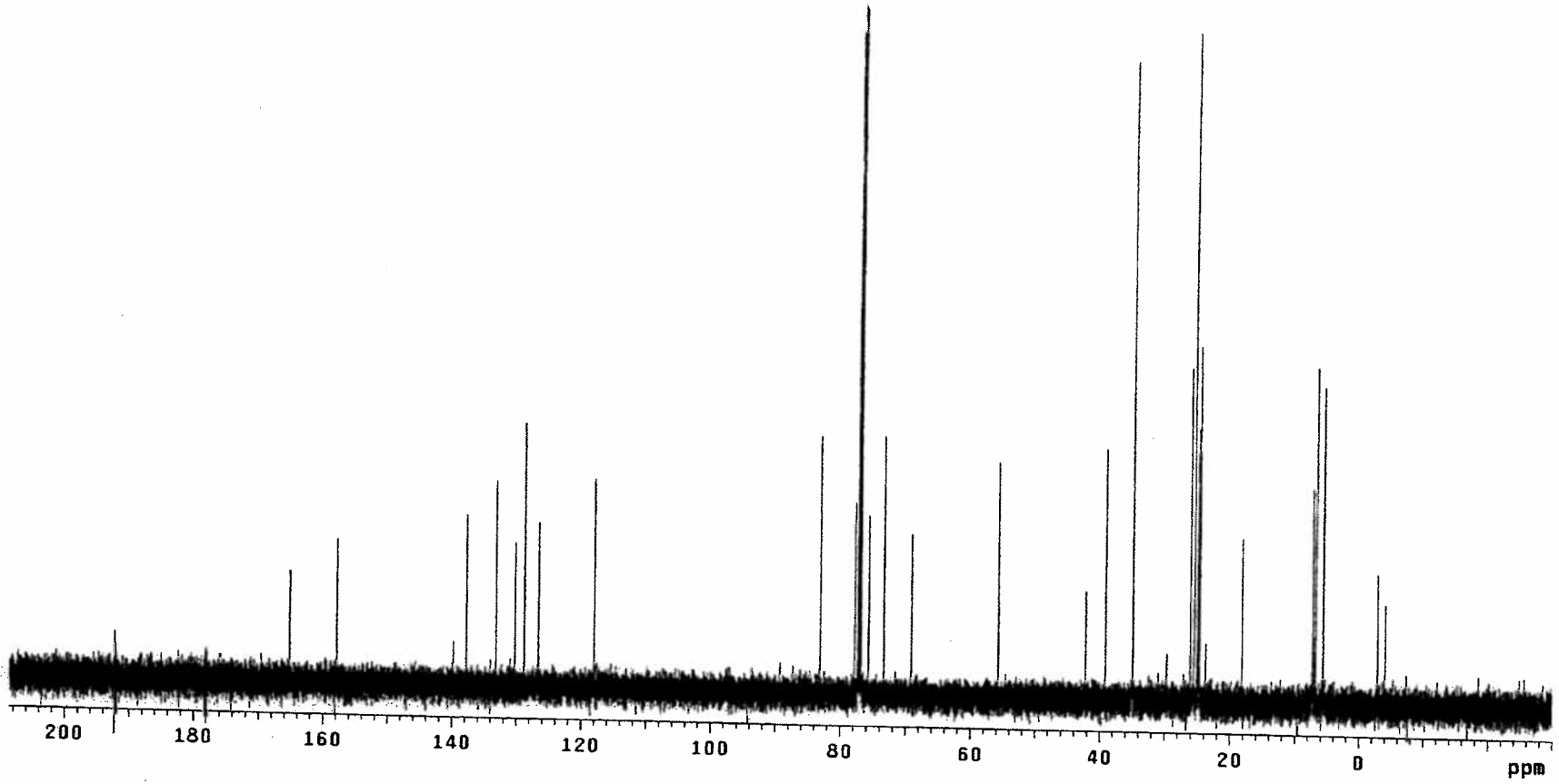
Pulse Sequence: s2pul

Solvent: CDCl3
Temp. 28.0 C / 301.1 K
User: 1-14-87
INOVA-600 "inova600"

Relax. delay 0.500 sec
Pulse 29.9 degrees
Acq. time 1.400 sec
Width 36003.6 Hz
416 repetitions
OBSERVE C13, 150.7863846 MHz
DECOUPLE H1, 599.6700024 MHz
Power 40 dB
continuously on
WALTZ-16 modulated
DATA PROCESSING
FT size 131072
Total time 32 min, 34 sec



30



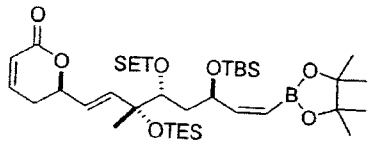
STANDARD PROTON PARAMETERS

Archive directory: /export/home/vnmr1/vnmrsys/data
Sample directory:
File: PROTON

Pulse Sequence: s2pul

Solvent: CDCl3
Temp. 28.0 C / 301.1 K
INOVA-600 "inova600"

Relax. delay 1.000 sec
Pulse 30.0 degrees
Acq. time 4.000 sec
Width 9594.6 Hz
16 repetitions
OBSERVE H1, 599.6669967 MHz
DATA PROCESSING
FT size 131072
Total time 1 min, 20 sec



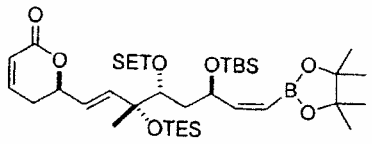
32

STANDARD CARBON PARAMETERS

Pulse Sequence: s2pul

Solvent: CDCl3
Temp. 28.0 C / 301.1 K
User: 1-14-87
INOVA-600 "inova600"

Relax. delay 0.500 sec
Pulse 29.9 degrees
Acq. time 1.400 sec
Width 36003.6 Hz
784 repetitions
OBSERVE C13, 150.7863841 MHz
DECOUPLE H1, 599.6780024 MHz
Power 40 dB
continuously on
WALTZ-16 modulated
DATA PROCESSING
FT size 131072
Total time 32 min, 34 sec



32

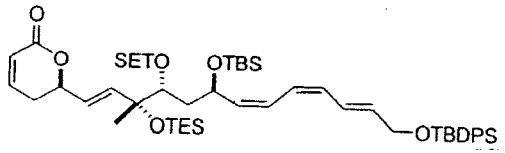
STANDARD PROTON PARAMETERS

Archive directory: /export/home/vnmr1/v
Sample directory:
File: PROTON

Pulse Sequence: s2pul

Solvent: CDCl3
Temp. 28.0 C / 301.1 K
INOVA-600 "inova600"

Relax. delay 1.000 sec
Pulse 30.0 degrees
Acq. time 4.000 sec
Width 9594.6 Hz
20 repetitions
OBSERVE H1, 599.6669957 MHz
DATA PROCESSING
FT size 131072
Total time 1 min, 40 sec



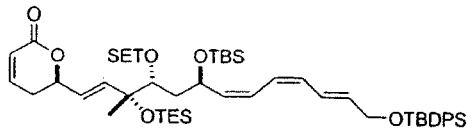
33

STANDARD CARBON PARAMETERS

Pulse Sequence: s2pul

Solvent: CDCl3
Temp. 28.0 C / 301.1 K
User: 1-14-87
INOVA-600 "inova600"

Relax. delay 0.500 sec
Pulse 29.9 degrees
Acq. time 1.400 sec
Width 36083.6 Hz
2896 repetitions
OBSERVE C13, 150.7863841 MH
DECOUPLE H1, 599.6700024 MHz
Power 40 dB
continuously on
WALTZ-16 modulated
DATA PROCESSING
FT size 131072
Total time 5 hr, 18 min, 9 sec



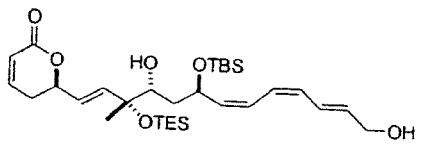
33

STANDARD PROTON PARAMETERS

Archive directory: /export/home/vnmr1/vnmrsys/data
Sample directory:
File: PROTON

Pulse Sequence: s2pul
Solvent: CDCl3
Temp. 28.8 C / 301.1 K
INOVA-600 "inova600"

Relax. delay 1.000 sec
Pulse 30.0 degrees
Acq. time 4.000 sec
Width 9594.6 Hz
16 repetitions
OBSERVE H1, 599.6669942 MHz
DATA PROCESSING
Line broadening 0.2 Hz
FT size 131072
Total time 1 min, 20 sec



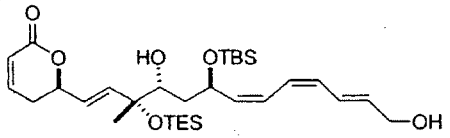
34

STANDARD CARBON PARAMETERS

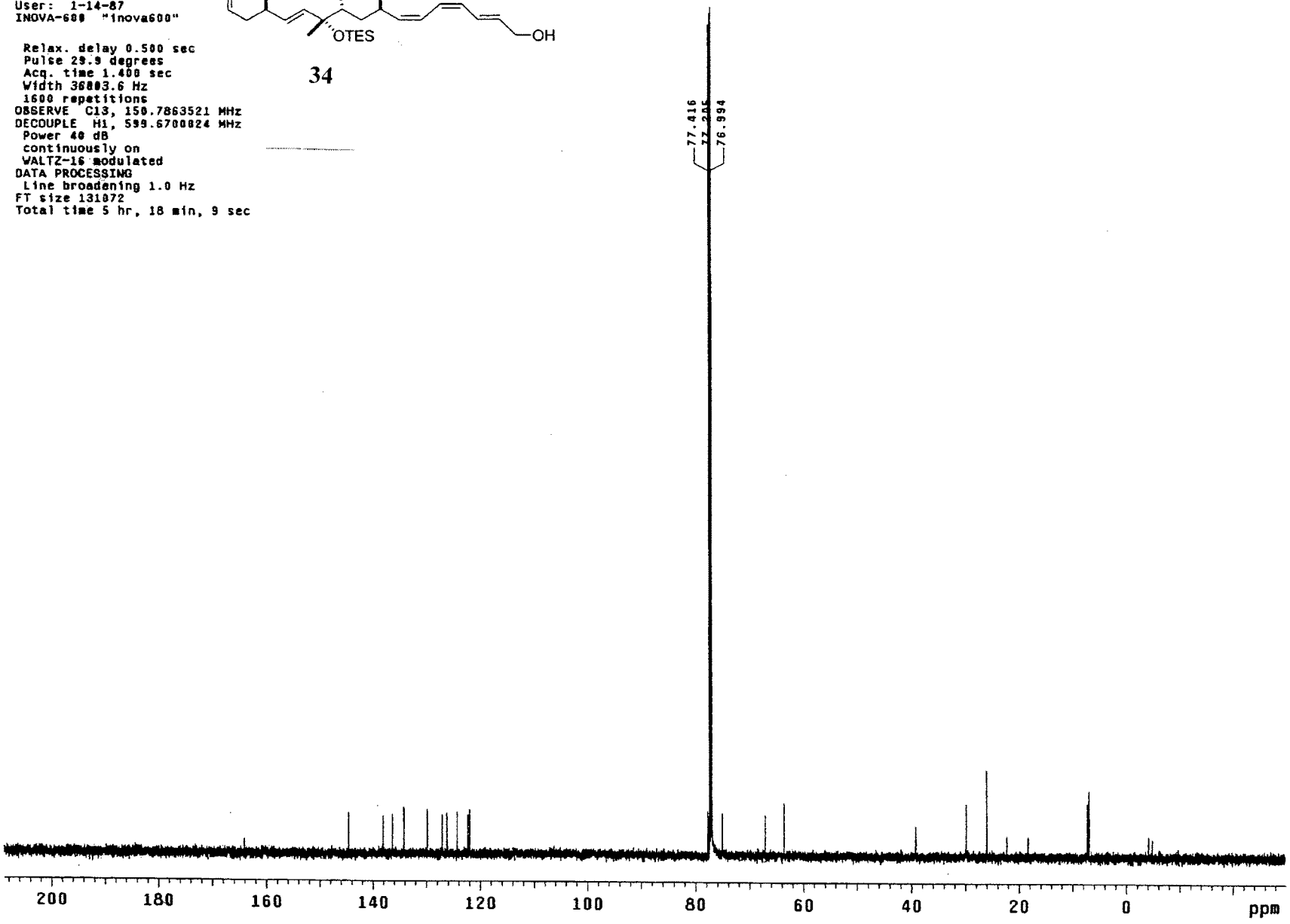
Pulse Sequence: s2pul

Solvent: CDCl3
Temp. 28.8 C / 301.1 K
User: 1-14-87
INOVA-600 "inova600"

Relax. delay 0.500 sec
Pulse 29.9 degrees
Acq. time 1.400 sec
Width 36883.6 Hz
1600 repetitions
OBSERVE C13, 150.7863521 MHz
DECOUPLE H1, 599.6700024 MHz
Power 40 dB
continuously on
WALTZ-16 modulated
DATA PROCESSING
Line broadening 1.0 Hz
FT size 131072
Total time 5 hr, 18 min, 9 sec



34

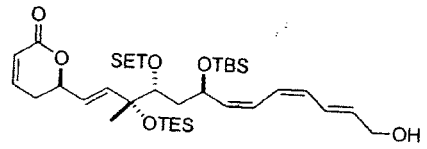


STANDARD PROTON PARAMETERS

Archive directory: /export/home/vnmr1/vnmrsys/data
Sample directory:
File: PROTON

Pulse Sequence: s2pul
Solvent: CDCl3
Temp. 28.0 C / 301.1 K
INOVA-600 "inova600"

Relax. delay 1.000 sec
Pulse 30.0 degrees
Acq. time 4.000 sec
Width 9594.6 Hz
20 repetitions
OBSERVE H1, 599.6669943 MHz
DATA PROCESSING
Line broadening 0.2 Hz
FT size 131072
Total time 1 min, 40 sec



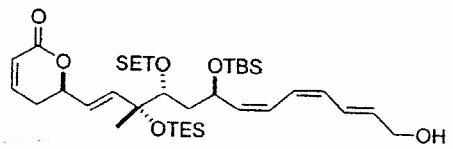
35

STANDARD CARBON PARAMETERS

Pulse Sequence: s2pul

Solvent: CDCl3
Temp. 28.0 C / 301.1 K
User: 1-14-87
INOVA-600 "inova600"

Relax. delay 0.500 sec
Pulse 29.9 degrees
Acq. time 1.400 sec
Width 36003.6 Hz
736 repetitions
OBSERVE C13, 150.7863830 MHz
DECOUPLE H1, 599.6780024 MHz
Power 40 dB
continuously on
WALTZ-16 modulated
DATA PROCESSING
Line broadening 1.0 Hz
FT size 131072
Total time 32 min, 34 sec



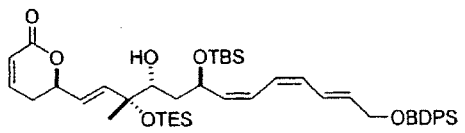
35

STANDARD PROTON PARAMETERS

Archive directory: /export/home/vnmr1/vnmrsys/data
Sample directory:
File: PROTON

Pulse Sequence: s2pul
Solvent: CDCl3
Temp. 28.0 C / 301.1 K
INOVA-600 "inova600"

Relax. delay 1.000 sec
Pulse 30.0 degrees
Acq. time 4.000 sec
Width 8594.6 Hz
20 repetitions
OBSERVE H1, 599.6669945 MHz
DATA PROCESSING
Line broadening 0.2 Hz
FT size 131072
Total time 1 min, 40 sec



5

STANDARD CARBON PARAMETERS

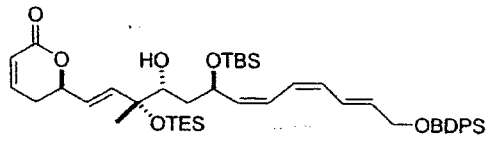
Puls

Sol

Tem

User

INOV



5

Rel.

Pulse 29.5 degrees

Acq. time 1.400 sec

Width 36003.6 Hz

4256 repetitions

OBSERVE C13, 150.786

DECOUPLE H1, 599.6700024 MHz

Power 40 dB

continuously on

WALTZ-16 modulated

DATA PROCESSING

Line broadening 1.0 Hz

FT size 131072

Total time 10 hr, 36 min, 18 sec

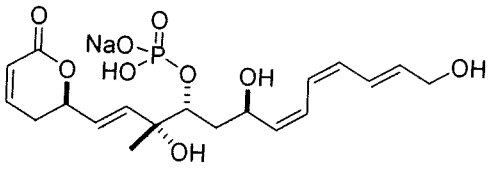
STANDARD PROTON PARAMETERS

Archive directory: /export/ho
Sample directory:
File: PROTON

Pulse Sequence: s2pul

Solvent: D2O
Temp. 28.0 C / 301.1 K
INOVA-600 "inova600"

Relax. delay 1.000 sec
Pulse 30.0 degrees
Acq. time 4.000 sec
Width 9594.6 Hz
256 repetitions
OBSERVE H1, 599.6684447 MHz
DATA PROCESSING
Line broadening 0.2 Hz
FT size 131072
Total time 21 min, 22 sec



1