Supporting Information

Total Synthesis of (–)-Calyciphylline N

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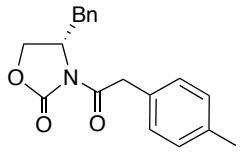
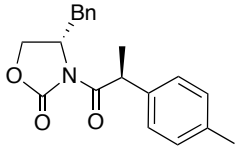
1. Materials and Methods

Reactions were conducted in oven- or flame-dried glassware under an atmosphere of nitrogen or argon, unless otherwise noted. All solvents were reagent grade. All chemicals were purchased from commercial vendors, unless otherwise referenced. Anhydrous tetrahydrofuran, diethyl ether, dichloromethane, and toluene were obtained from a Pure Solve^{TM} PS-400 solvent purification system. Chloroform was purchased from Fischer Scientific (HPLC grade, contains approx. 0.75% ethanol as a preservative). Triethylamine, diisopropylamine, and diisopropyl ethylamine were freshly distilled from CaH_2. Reactions were magnetically stirred unless otherwise stated. Reactions were monitored by thin layer chromatography (TLC) with 250 mm Silicycle pre-coated silica gel plates or by LCMS [analytical reverse-phased (Sunfire C18; 4.6 mm Å~ 50 mm, 5 mL) high-performance liquid chromatography with a Waters binary gradient module 2525 equipped with Waters 2996 PDA and Waters micromass ZQ]. Silica gel flash chromatography was performed using ACS grade solvents and silica gel from Silicycle or Sorbent Technologies. Preparative TLC was performed using ACS grade solvents and 500 mm Silicycle pre-coated silica gel plates. Medium pressure liquid chromatography purification was performed using an apparatus comprised of a solvent pump (Waters 510 HPLC pump), injection loop (5 mL), column (20 mm ID x 300 mm, ACE glass) packed with silica gel (particle size 18-32 micron, 60 Å pore size), a refractive index detector (Waters Associates Differential Refractometer R401), and a chart recorder. Yields refer to chromatographically and spectroscopically pure compounds, unless otherwise stated. All melting points were obtained on a Thomas-Hoover apparatus and are uncorrected. Infrared spectra were recorded on a Jasco Model FT/IR-480 Plus spectrometer. Proton and carbon NMR spectra were recorded on Bruker Avance III 500 MHz spectrometer equipped with either an Oxford cryomagnet or a Spectrospin/Bruker cryomagnet (500MHZ/52mm) with a 5 mm dual cryo probe. Chemical shifts are reported relative to chloroform (δ 7.26) for ^{1}H-NMR and chloroform (δ 77.16) or benzene (δ 128.0) for ^{13}C-NMR. Optical rotations were measured on a Jasco P-2000 polarimeter. High-resolution mass spectra (HRMS) were measured at the University of Pennsylvania on either a Waters LC-TOF mass spectrometer (model LCTXE Premier) or a Waters GCT Premier spectrometer. Single crystal X-ray structures were determined at the University of Pennsylvania. X-ray intensity data were collected on a Rigaku Mercury CCD or Bruker APEXII CCD area detector employing graphite-monochromated Mo-Kα radiation (λ=0.71073 Å) at a temperature of 143(1) K.

2. Experimental Procedures

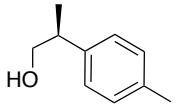


Imide (+)-S1: A 2 L round bottom flask fitted with a mechanical stirrer and 50 mL addition funnel was charged with *p*-tolylacetic acid (12.0 g, 80.6 mmol) and THF (160 mL). The resulting solution was cooled to –78 °C and Et_3N (11.6 mL, 84.0 mmol) was added dropwise via addition funnel. Pivaloyl chloride (9.8 mL, 80.6 mmol) was added dropwise via addition funnel and the resulting turbid white reaction mixture was stirred at –78 °C for 1 hour. In a separate flask, (*S*)-4-benzyl-2-oxazolidinone (11.9 g, 67.2 mmol) was dissolved in THF (140 mL) and cooled to –78 °C. A solution of *n*-BuLi (2.5M/hexanes, 32.3 mL, 80.6 mmol) was added dropwise via addition funnel and the resulting deep red solution was stirred at –78 °C for 40 minutes. The solution of lithiated oxazolidinone was transferred via cannula to the solution of the mixed anhydride over 1 hour at –78 °C. The reaction mixture was allowed to warm to room temperature and was quenched with saturated aqueous aqueous NH_4Cl (200 mL). The layers were separated and the aqueous layer was extracted with EtOAc (200 mL). The combined organic layer were washed with brine (50 mL), dried over $MgSO_4$, and concentrated *in vacuo*. The resulting white solid was triturated with pentane (100 mL x 3) to provide the title compound (17.9 g, 86%) as a crystalline white solid. $[\alpha]_D^{20}$ +64.0 (*c* 0.63 $CHCl_3$). **IR** (neat) 2918, 2857, 1779, 1697, 1389, 1358 cm^{-1}. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.33 - 7.25 (m, 3 H), 7.25 - 7.21 (m, 2 H), 7.19 - 7.11 (m, 4 H), 4.67 (tdd, *J* = 3.2, 7.3, 10.7 Hz, 1 H), 4.34 - 4.21 (m, 2 H), 4.21 - 4.14 (m, 2 H), 3.27 (dd, *J* = 3.2, 13.5 Hz, 1 H), 2.75 (dd, *J* = 9.5, 13.5 Hz, 1 H), 2.35 (s, 3 H). **^{13}C NMR** (125 MHz , $CDCl_3$) δ 171.6, 153.5, 137.0, 135.3, 130.6, 129.8, 129.6, 129.5, 129.1, 127.5, 66.3, 55.5, 41.3, 37.9, 21.3. **HRMS(ES+)** *m/z* 332.1255 [$(M+Na)^+$; calcd for $C_{19}H_{19}NO_3Na$: 332.1263].

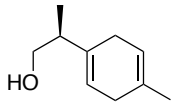


Imide (+)-S2: To a solution of imide (+)-**S1** (17.9 g, 57.9 mmol) in THF (250 mL) at –78 °C was added NaHMDS (1M/THF, 64 mL, 63.7 mmol) dropwise via addition funnel. The resulting light orange solution was stirred at this temperature for 1 h. Methyl iodide (17.2 mL, 278 mmol) was added dropwise via addition funnel and the reaction mixture was allowed to warm to room temperature overnight. The reaction was quenched with saturated aqueous aqueous NH_4Cl (200 mL) and the layers were separated. The aqueous layer was extracted with EtOAc (200 mL). The combined organic layers were washed with brine (50 mL), dried over $MgSO_4$, and concentrated *in vacuo*. The residue was purified by flash chromatography on silica gel (8:1 hexanes/EtOAc) to afford the title compound (14 g, 75%) as a highly viscous, greenish oil. $[\alpha]_D^{20}$ +141 (*c* 1.39 $CHCl_3$). **IR** (neat) 2975, 2919, 1779, 1697, 1379, 1360, 1234, 1210, 1189 cm^{-1}. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.39 - 7.33 (m, 2 H), 7.32 - 7.27 (m, 3 H), 7.27 - 7.22 (m, 2 H), 7.15 (app d, *J* =

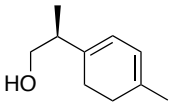
7.9 Hz, 2 H), 5.12 (q, *J* = 7.0 Hz, 1 H), 4.60 (dddd, *J* = 2.4, 3.2, 7.6, 9.7 Hz, 1 H), 4.11 (dd, *J* = 2.4, 9.1 Hz, 1 H), 4.06 - 3.99 (m, 1 H), 3.36 (dd, *J* = 3.2, 13.3 Hz, 1 H), 2.83 (dd, *J* = 9.6, 13.4 Hz, 1 H), 2.34 (s, 3 H), 1.56 (d, *J* = 6.9 Hz, 3 H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 174.8, 152.9, 137.4, 136.9, 135.5, 129.5, 129.4, 129.0, 128.1, 127.4, 65.9, 55.8, 42.8, 38.0, 21.1, 19.5. **HRMS(ES+)** *m/z* 346.1409 [$(M+Na)^+$; calcd for $C_{20}H_{21}NO_3Na$: 346.1419].



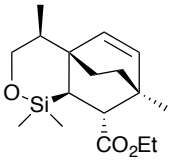
Alcohol (–)-8: To a solution of imide (+)-**S2** in THF/H_2O (1:1, 180 mL) was added $NaBH_4$ (6.55 g, 173.2 mmol) portion wise at 0 °C. The reaction mixture was warmed to room temperature and vigorously stirred overnight. The reaction mixture was diluted with EtOAc (100 mL) and the layers were separated. The aqueous layer was extracted with EtOAc (50 mL x 2). The combined organic layers were washed with brine (50 mL), dried over $MgSO_4$, and concentrated *in vacuo*. After removal of the solvent, (*S*)-4-benzyl-2-oxazolidinone was recovered by filtration and washing with Et_2O (200 mL). The washings, which contained the product, were concentrated *in vacuo* and the residue was distilled (78 °C/0.1 torr) to provide the title compound (5.94 g, 91%) as a colorless liquid. $[\alpha]_D^{20}$ –19.2 (*c* 0.82 $CHCl_3$). **IR** (neat) 3388, 2958, 2918, 2869, 2852, 1643 cm^{-1}. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.21 - 7.09 (m, 4 H), 3.68 (app d, *J* = 6.9 Hz, 2 H), 2.92 (sxt, *J* = 6.9 Hz, 1 H), 2.35 (s, 3 H), 1.27 (d, *J* = 7.1 Hz, 3 H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 140.7, 136.3, 129.4, 127.5, 68.8, 42.1, 21.1, 17.8. **HRMS(ES+)** *m/z* 150.1052 [$(M)^+$; calcd for $C_{10}H_{14}O$: 150.1045].



Alcohol (–)-9: Ammonia (1.2 L) was condensed at –78 °C into a 5-L round bottom flask fitted with a mechanical stirrer. A solution of alcohol (–)-**8** (28 g, 187 mmol) in absolute EtOH (190 mL) was added via cannula over 15 minutes. Lithium beads (6.47 g, 933 mmol) were added in portions until complete consumption of starting material (^{1}H NMR analysis). Excess lithium was quenched by further addition of EtOH (ca. 200 mL), followed by careful addition of saturated aqueous NH_4Cl, and the NH_3 was allowed to evaporate overnight under a stream of dry N_2. The residue was taken up in EtOAc (250 mL) and washed with water (100 mL). The organic layer was washed with brine, dried over $MgSO_4$, and concentrated *in vacuo* to afford the title compound (27.5 g, 99%) as a colorless liquid. $[\alpha]_D^{20}$ –2.0 (*c* 0.84 $CHCl_3$). **IR** (neat) 3355, 3019, 2961, 2923, 2875, 2819, 1640, 1039 cm^{-1}. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 5.55 (br. s., 1 H), 5.41 (br. s., 1 H), 3.53 - 3.43 (m, 2 H), 2.68 - 2.50 (m, 4 H), 2.32 (sxt, *J* = 6.9 Hz, 1 H), 1.66 (s, 3 H), 1.01 (d, *J* = 7.1 Hz, 3 H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 135.9, 131.4, 120.7, 118.5, 65.5, 43.2, 31.7, 27.2, 23.0, 15.5. **HRMS(ES+)** *m/z* 152.1206 [$(M)^+$; calcd for $C_{10}H_{16}O$: 152.1201].



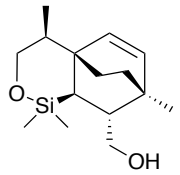
Alcohol 6: DMSO (250 mL) was roughly degassed by bubbling N_2 through for 0.5 h. Solid KOtBu (83.6 g, 746 mmol) was added and the suspension was cooled to 0 °C. A solution of alcohol (–)-**9** (28.3 g, 187 mmol) in toluene (250 mL) was added dropwise via cannula over 20 minutes. The resulting solution was stirred at 0 °C for 1 h, then at room temperature for 2 h. After cooling back down to 0 °C, saturated aqueous NH_4Cl (200 mL) was added and the layers were separated. The aqueous layer was extracted with EtOAc (100 mL x 2), and the combined organic layers were washed with brine, dried over $MgSO_4$, and concentrated *in vacuo*. The residue was filtered through a short silica plug (4:1 hexanes/EtOAc) to afford an inseparable 3.5:1 mixture of **6** to **(–)-9** (27.5 g, 97%). The following data is reported for this mixture. **IR** (neat) 3346, 2960, 2920, 2873, 2823, 1654, 1448, 1431, 1029 cm^{-1}. **^{1}H NMR** (500 MHz, $CDCl_3$) Diagnostic signals for **6**: δ 5.70 (d, J = 5.4 Hz, 1 H), 5.63 (d, J = 5.2 Hz, 1 H), 1.78 (s, 3 H). **^{13}C NMR** (125 MHz, $CDCl_3$) Major isomer **6**: δ 136.8, 134.7, 121.0, 119.3, 65.7, 43.2, 28.9, 24.4, 23.0, 15.3. **HRMS(ES+)** *m/z* 152.1205 [$(M)^+$; calcd for $C_{10}H_{16}O$: 152.1201].



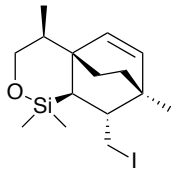
Ester (–)-5: A solution of the silyl acrylate **7** (76.7 g, 328 mmol) in CH_2Cl_2 (820 mL) was cooled to 0 °C and TfOH (58 mL, 657 mmol) was added dropwise via addition funnel. After stirring for 1 h, the solution was cooled to –78 °C and pyridine (64 mL, 789 mmol) was added dropwise via addition funnel (pyridinium triflate precipitates). A solution of the alcohols **6** and **(–)-9** (40 g, 263 mmol) in CH_2Cl_2 (375 mL) was added dropwise via cannula over 0.5 h. After stirring for an additional 0.5 h, the reaction mixture was allowed to warm to room temperature and pentane (200 mL) was added. The reaction mixture was filtered through a short pad of celite, which was washed with additional pentane (100 mL), and the filtrate was concentrated *in vacuo*. The residue, which still contained some of the pyridinium salt, was redissolved in pentane (300 mL) and filtered once more. The filter cake was washed with pentane (100 mL) and the filtrate was concentrated *in vacuo* to provide triene **10** (93 g crude weight), which was used without purification.

To a cooled (0 °C) solution of triene **10** in toluene (1.5 L) was added Et_2AlCl (1 M/hexanes, 265 mL) dropwise over 1 h via addition funnel. The resulting solution was stirred at 0 °C for 2 h, then allowed to stir at room temperature for 36 h. Upon completion, the reaction mixture was cooled to 0 °C and a saturated aqueous solution of Rochelle's salt (500 mL) was carefully added. The biphasic mixture was warmed to room temperature and vigorously stirred for 3 h. The layers were separated and the aqueous layer was extracted with EtOAc (300 mL) The combined organic layers were washed with brine, dried over $MgSO_4$, and concentrated *in vacuo*. The residue was purified by flash chromatography on silica gel (10:1 hexanes/EtOAc) to afford the title compound (30 g, 50% over 2 steps, 9:1 d.r.; yield based on amount of **6**) as a light yellow liquid.

$[\alpha]_D^{20}$ –50.2 (*c* 3.1 $CHCl_3$). **IR** (neat) 3037, 2955, 2908, 2873, 1736, 1637, 1462, 1371, 1250, 1158 cm^{-1}. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 6.28 (d, *J* = 8.3 Hz, 1 H), 5.94 (d, *J* = 8.3 Hz, 1 H), 4.09 (dq, *J* = 0.8, 7.1 Hz, 2 H), 3.74 - 3.66 (m, 2 H), 2.30 (d, *J* = 8.3 Hz, 1 H), 2.16 - 2.07 (m, 1 H), 1.71 - 1.64 (m, 1 H), 1.43 - 1.38 (m, 1 H), 1.24 (t, *J* = 7.1 Hz, 3 H), 1.23 - 1.20 (m, 2 H), 1.19 (s, 3 H), 0.89 (dd, *J* = 2.6, 8.3 Hz, 1 H), 0.86 (d, *J* = 6.9 Hz, 3 H), 0.30 (s, 3 H), 0.09 (s, 3 H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 175.4, 139.2, 134.8, 66.0, 60.2, 52.0, 41.2, 39.7, 37.7, 37.0, 35.6, 23.0, 21.4, 14.5, 12.6, 0.57, –2.63. **HRMS(ES+)** *m/z* 309.1896 [$(M+H)^+$; calcd for $C_{17}H_{29}O_3Si$: 309.1886].

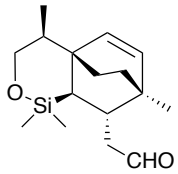


Alcohol (–)-S3: Lithium aluminum hydride (4.8 g, 126 mmol) was suspended in Et_2O (300 mL) and the suspension was cooled to 0 °C. In a separate flask, ester (–)-**5** (30 g, 97.4 mmol) was dissolved in Et_2O (300 mL) and transferred to the $LiAlH_4$ suspension via cannula over 0.5 h. The reaction mixture was allowed to warm to room temperature and was stirred for 1 h. Upon completion, the reaction mixture was cooled to 0 °C, and H_2O (4.8 mL) was slowly added dropwise over 0.5 h. Next, an aqueous solution of NaOH (15%, 4.8 mL) was added, followed by additional H_2O (14.4 mL). The suspension was warmed to room temperature and vigorously stirred for 15 minutes. The loose granular solid was filtered off and the filter cake was washed with Et_2O (150 mL). The filtrate was dried over $MgSO_4$ and concentrated *in vacuo*. The residue was purified by flash chromatography on silica gel (4:1 hexanes/EtOAc) to afford the title compound (24.5 g, 94%) as a colorless oil. $[\alpha]_D^{20}$ –67.4 (*c* 0.4 $CHCl_3$). **IR** (neat) 3434, 3029, 2951, 2872, 1250, 1102, 1065 cm^{-1}. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 6.24 (d, *J* = 8.5 Hz, 1 H), 5.84 (d, *J* = 8.3 Hz, 1 H), 3.72 - 3.67 (m, 2 H), 3.42 (dd, *J* = 4.7, 10.8 Hz, 1 H), 3.33 (dd, *J* = 5.3, 10.8 Hz, 1 H), 2.08 – 2.01 (m, 1 H), 1.73 - 1.67 (m, 1 H), 1.57 (td, *J* = 5.0, 7.4 Hz, 1 H), 1.42 - 1.35 (m, 1 H), 1.20 (s, 3 H), 1.19 - 1.14 (m, 2 H), 0.82 (d, *J* = 7.1 Hz, 3 H), 0.45 (dd, *J* = 2.6, 7.5 Hz, 1 H), 0.25 (s, 3 H), 0.14 (s, 3 H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 140.5, 135.0, 66.2, 66.1, 48.8, 41.3, 39.6, 36.8, 36.1, 36.0, 23.4, 22.1, 12.5, 1.16, –2.20. **HRMS(ES+)** *m/z* 267.1784 [$(M+H)^+$; calcd for $C_{15}H_{27}O_2Si$: 267.1780].



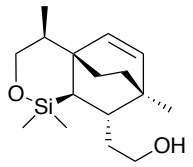
Iodide (–)-11: To a cooled (0 °C) solution of alcohol (–)-**S3** (2.40 g, 9.02 mmol) in THF (36 mL) was added PPh_3 (2.48 g, 9.47 mmol), imidazole (1.22 g, 18.0 mmol), and I_2 (2.73 g, 10.8 mmol) sequentially. The cold bath was removed and the brown solution was stirred at room temperature for 10 min. The reaction was quenched with saturated aqueous $Na_2S_2O_3$ (15 mL) and the layers were separated. The aqueous layer was extracted with EtOAc (15 mL x 2). The combined organic layers were washed with brine,

dried over $MgSO_4$, and concentrated *in vacuo*. The residue was purified by flash chromatography on silica gel (12:1 hexanes/EtOAc) to afford the title compound (2.87 g, 85%) as a colorless oil. $[\alpha]_D^{20}$ –32.1 (*c* 0.22 $CHCl_3$). **IR** (neat) 3034, 2953, 2916, 2869, 1636, 1462, 1370, 1250, 1104, 1070, 844 cm^{-1}. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 6.20 (d, *J* = 8.3 Hz, 1 H), 5.90 (d, *J* = 8.3 Hz, 1 H), 3.75 - 3.62 (m, 2 H), 3.16 (dd, *J* = 4.1, 10.2 Hz, 1 H), 2.95 (dd, *J* = 5.3, 10.2 Hz, 1 H), 2.07 (dddd, *J* = 5.0, 6.7, 11.7, 13.7 Hz, 1 H), 1.71 - 1.62 (m, 2 H), 1.41 - 1.33 (m, 1 H), 1.23 (s, 3 H), 1.18 - 1.13 (m, 2 H), 0.82 (d, *J* = 6.9 Hz, 3 H), 0.42 (dd, *J* = 2.1, 7.4 Hz, 1 H), 0.26 (s, 6 H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 138.8, 134.2, 66.2, 47.8, 41.7, 40.0, 39.2, 38.8, 36.5, 22.9, 21.9, 13.7, 12.5, 2.4, –1.8. **HRMS(ES+)** *m/z* 377.0798 [$(M+H)^+$; calcd for $C_{15}H_{26}IOSi$: 377.0798].

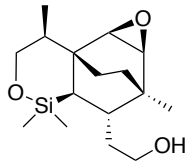


Aldehyde (–)-12: To a solution of iodide (–)-**11** (2.87 g, 7.63 mmol) in DMSO (17 mL) was added NaCN (561 mg, 11.4 mmol) and the reaction mixture was heated to 60 °C for 3 h. After cooling to room temperature, the solution was diluted with Et_2O and water (20 mL each). The layers were separated and the aqueous layer was extracted with EtOAc (20 mL x 2). The combined organic layers were washed with brine, dried over $MgSO_4$, and concentrated *in vacuo*. The residue was filtered through a silica plug (9:1 hexanes/EtOAc) and the product was used without further purification.

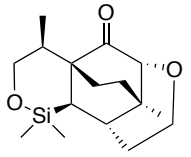
The resulting nitrile (1.99 g, 7.23 mmol) was dissolved in CH_2Cl_2 (25 mL), cooled to –78 °C, and DIBAL-H (1.5 M/toluene, 10.6 mL, 15.9 mmol) was added dropwise over 15 min. Excess DIBAL-H was quenched by the slow addition of EtOAc (5 mL) at –78 °C and the solution was allowed to warm to room temperature. Saturated aqueous Rochelle's salt (20 mL) was added and vigorous stirring was continued for 1.5 h. The layers were separated and the aqueous layer was extracted with CH_2Cl_2 (20 mL x 2). The combined organic layers were washed with brine, dried over $MgSO_4$, and concentrated *in vacuo*. The residue was purified by flash chromatography on silica gel (13:1 hexanes/EtOAc) to afford the title compound (1.89 g, 91% over 2 steps) as a colorless oil. $[\alpha]_D^{20}$ –42.5 (*c* 0.78 $CHCl_3$). **IR** (neat) 3029, 2953, 2911, 2873, 2723, 1724, 1463, 1371, 1251, 1102, 1069, 834 cm^{-1}. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 9.71 (t, *J* = 2.4 Hz, 1 H), 6.23 (d, *J* = 8.5 Hz, 1 H), 5.77 (d, *J* = 8.3 Hz, 1 H), 3.68 (app d, *J* = 8.1 Hz, 2 H), 2.41 - 2.34 (m, 1 H), 2.05 - 1.92 (m, 3 H), 1.71 (ddd, *J* = 3.6, 9.9, 12.9 Hz, 1 H), 1.42 (ddd, *J* = 4.7, 10.1, 12.2 Hz, 1 H), 1.26 (dt, *J* = 3.8, 12.2 Hz, 1 H), 1.20 - 1.12 (m, 1 H), 1.10 (s, 3 H), 0.82 (d, *J* = 6.9 Hz, 3 H), 0.34 (dd, *J* = 2.9, 6.8 Hz, 1 H), 0.30 (s, 3 H), 0.11 (s, 3 H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 202.9, 140.3, 134.2, 66.2, 50.6, 41.4, 41.2, 39.8, 39.5, 37.6, 35.3, 23.8, 22.0, 12.4, 1.49, –2.14. **HRMS(ES+)** *m/z* 279.1774 [$(M+H)^+$; calcd for $C_{16}H_{27}O_2Si$: 279.1780].



Alcohol (–)-13: Aldehyde (–)-**12** (9.0 g, 32.3 mmol) was dissolved in EtOH (150 mL) and $NaBH_4$ (1.46 g, 38.8 mmol) was added portion wise at room temperature. Upon completion, water was added carefully to quench excess hydride, the solution was concentrated to ca. 40 mL, and the aqueous layer was extracted with EtOAc (30 mL x 3). The combined organic layers were dried over $MgSO_4$, filtered, and concentrated *in vacuo*. The residue was purified by flash choromotography on silica gel (4:1 hexanes/EtOAc) to afford the title compound (9.0 g, 99%) as a colorless oil. $[\alpha]_D^{20}$ –55.6 (*c* 0.46 $CHCl_3$). **IR** (neat) 3408, 3029, 2950, 2872, 1645, 1250, 1104, 1067 cm^{-1}. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 6.19 (d, *J* = 8.3 Hz, 1 H), 5.79 (d, *J* = 8.3 Hz, 1 H), 3.69 (d, *J* = 7.9 Hz, 2 H), 3.61 - 3.45 (m, 2 H), 2.01 (qd, *J* = 7.3, 14.8 Hz, 1 H), 1.74 - 1.64 (m, 2 H), 1.48 (dt, *J* = 4.5, 7.0 Hz, 1 H), 1.40 - 1.33 (m, 1 H), 1.22 (dt, *J* = 4.0, 12.0, 1 H), 1.18 - 1.11 (m, 3 H), 1.16 (s, 3 H), 0.81 (d, *J* = 6.9 Hz, 3 H), 0.35 (dd, *J* = 2.9, 6.6 Hz, 1 H), 0.25 (s, 3 H), 0.18 (s, 3 H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 139.2, 135.1, 66.4, 61.1, 43.1, 41.4, 39.6, 38.9, 38.2, 37.7, 35.6, 23.7, 22.3, 12.5, 1.54, –1.86. **HRMS(ES+)** *m/z* 281.1944 [$(M+H)^+$; calcd for $C_{16}H_{29}O_2Si$: 281.1937].

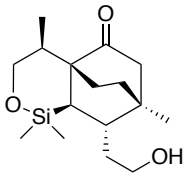


Epoxide (–)-14: To a cooled (0 °C) solution of alkene (–)-**13** (9.0 g, 32.1 mmol) in CH_2Cl_2 (200 mL) was added $NaHCO_3$ (5.4 g, 64.2 mmol), followed by *m*-CPBA (8.6 g, 38.6 mmol). The reaction mixture was allowed to warm to room temperature and stir for 1 h. Saturated aqueous $Na_2S_2O_3$ (20 mL) and saturated aqueous $NaHCO_3$ (20 mL) were added, and the mixture was vigorously stirred for an additional 0.5 h. After diluting with water (30 mL), the layers were separated and the aqueous layer was extracted with CH_2Cl_2 (30 mL x 2). The combined organic layers were dried over $MgSO_4$ and concentrated *in vacuo*. The residue was purified by flash chromatography on silica gel (2:1 hexanes/EtOAc) to afford the title compound (6.36 g, 70%) as a colorless oil. $[\alpha]_D^{20}$ –7.4 (*c* 1.78 $CHCl_3$). **IR** (neat) 3440, 2959, 2919, 2869, 1254, 1120, 1085, 1055 cm^{-1}. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 3.72 - 3.63 (m, 2 H), 3.63 - 3.50 (m, 2 H), 2.97 (d, *J* = 4.8 Hz, 1 H), 2.89 (dd, *J* = 1.0, 5.0 Hz, 1 H), 1.94 (tdd, *J* = 3.9, 7.8, 17.2 Hz, 1 H), 1.81 - 1.73 (m, 1 H), 1.60 - 1.44 (m, 3 H), 1.41 - 1.30 (m, 3 H), 1.11 (s, 3 H), 1.01 (dt, *J* = 4.4, 12.5 Hz, 1 H), 0.86 (d, *J* = 6.9 Hz, 3 H), 0.63 (dd, *J* = 2.5, 6.4 Hz, 1 H), 0.23 (s, 3 H), 0.21 (s, 3 H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 66.3, 61.2, 59.0, 56.6, 41.2, 40.9, 40.0, 37.7, 35.8, 35.2, 32.3, 23.8, 19.2, 12.2, 1.60, –1.08. **HRMS(ES+)** *m/z* 297.1899 [$(M+H)^+$; calcd for $C_{16}H_{29}O_3Si$: 297.1886].



Ketone (+)-15: Epoxide (–)-**14** (6.36 g, 21.4 mmol) was dissolved in CH_2Cl_2 (150 mL) and cooled to 0 °C. PPTS (268 mg, 1.07 mmol) was added and the resulting solution was stirred at 0 °C for 1 h. After warming to room temperature, the solution was washed with water (30 mL), and the aqueous layer was extracted with CH_2Cl_2 (20 mL x 2). The combined organic layers were dried over $MgSO_4$, filtered, and concentrated *in vacuo*. The product was used without purification.

The resulting alcohol was dissolved in CH_2Cl_2 (150 mL) and cooled to 0 °C. $NaHCO_3$ (3.59 g, 42.8 mmol) was added, followed by Dess-Martin periodinane (10.8 g, 25.7 mmol). The reaction mixture was stirred at room temperature for 1 h, then quenched with saturated aqueous $Na_2S_2O_3$ (30 mL). After stirring for 15 min, the layers were separated and the aqueous layer was extracted with CH_2Cl_2 (20 mL x 2). The combined organic layers were dried over $MgSO_4$ and concentrated *in vacuo*. The residue was purified by flash chromatography on silica gel (4:1 hexanes/EtOAc) to afford the title compound (4.2 g, 67% over 2 steps) as a colorless oil. $[\alpha]_D^{20}$ +98.0 (*c* 2.52 $CHCl_3$). **IR** (neat) 2950, 2863, 1720, 1473, 1253, 1137, 1103 cm^{-1}. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 3.71 - 3.61 (m, 3 H), 3.55 (dt, *J* = 3.6, 12.8 Hz, 1 H), 3.50 (d, *J* = 1.8 Hz, 1 H), 2.33 - 2.21 (m, 2 H), 1.98 - 1.91 (m, 1 H), 1.68 - 1.51 (m, 4 H), 1.15 (s, 3 H), 0.89 (td, *J* = 3.2, 13.7 Hz, 1 H), 0.77 (d, *J* = 6.9 Hz, 3 H), 0.72 (dd, *J* = 1.8, 4.6 Hz, 1 H), 0.34 (s, 3 H), 0.11 (s, 3 H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 211.0, 80.5, 65.8, 58.1, 48.7, 36.0, 35.1, 34.1, 31.7, 30.9, 29.5, 22.4, 17.5, 12.0, –0.60, –2.05. **HRMS(ES+)** *m/z* 295.1728 [$(M+H)^+$; calcd for $C_{16}H_{27}O_3Si$: 295.1729].

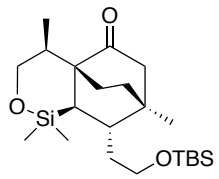


Alcohol (+)-16: The following reaction was run in two batches, which were combined for purification.

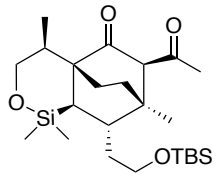
Batch 1 (1.56 g (+)-**15**, 5.31 mmol): A 1-L flask was charged with Sm^0 powder (3.18 g, 21.2 mmol) and the flask was flushed with nitrogen for 5 min. The flask was wrapped with aluminum foil and THF (212 mL) was added. The suspension was stirred vigorously while freshly distilled CH_2I_2 (1.7 mL, 21.2 mmol) was added dropwise in the dark. The suspension changed gradually to a teal, then deep blue solution within 0.5 h. The solution was stirred for an additional 4 h before a solution of the ketone (1.56 g, 5.31 mmol) in THF (6 mL) and MeOH (3 mL) was added dropwise at room temperature via cannula. The reaction mixture was rapidly poured into a vigorously stirring solution of saturated aqueous $NaHCO_3$ (30 mL) and the resulting suspension was filtered through a pad of celite. The layers were separated and the aqueous layer was extracted with EtOAc

(20 mL x 2). The combined organic layers were dried over $MgSO_4$ and concentrated *in vacuo* to afford the first batch of (+)-**16**.

Batch 2 (517 mg (+)-**15**, 1.76 mmol): To a rapidly stirring suspension of Sm^0 powder (1.05 g, 7.03 mmol) in THF (70 mL) was added freshly distilled CH_2I_2 (0.56 mL, 7.03 mmol) in the dark. The suspension gradually turned to a deep blue solution within 0.5 h and vigorous stirring was continued for an additional 4 h. A solution of ketone (+)-**16** (517 mg, 1.76 mmol) in THF (2 mL) and MeOH (1 mL) was added dropwise via cannula. An identical workup as above provided another batch of (+)-**16**. The combined batches were purified by flash chromatography on silica gel (1:1 hexanes/EtOAc) to afford the title compound (2.32 g, 82%) as a white solid. Melting point 103-105 °C. $[\alpha]_D^{20}$ +62.9 (*c* 0.94 $CHCl_3$). **IR** (neat) 3436, 2953, 2876, 1709, 1251 cm^{-1}. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 3.71 - 3.59 (m, 3 H), 3.58 - 3.51 (m, 1 H), 2.36 (dd, *J* = 2.5, 18.3 Hz, 1 H), 2.25 (tt, *J* = 6.7, 11.9 Hz, 1 H), 2.04 (d, *J* = 18.2 Hz, 1 H), 2.01 (ddd, *J* = 3.2, 10.5, 13.9 Hz, 1 H), 1.88 (dtd, *J* = 4.6, 7.5, 11.9 Hz, 1 H), 1.73 (dddd, *J* = 2.0, 7.1, 10.1, 13.1 Hz, 1 H), 1.67 - 1.56 (m, 2 H), 1.55 - 1.49 (m, 1 H), 1.35 (br. s., 1 H), 1.23 (ddd, *J* = 6.7, 13.9, 20.4 Hz, 1 H), 1.00 (s, 3 H), 0.72 (d, *J* = 6.7 Hz, 3 H), 0.65 (dd, *J* = 2.0, 5.9 Hz, 1 H), 0.35 (s, 3 H), 0.21 (s, 3 H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 213.7, 65.5, 61.0, 48.5, 46.6, 38.3, 36.8, 36.4, 36.3, 34.8, 25.2, 18.4, 12.2, 0.6, –1.3. **HRMS(ES+)** *m/z* 297.1890 [$(M+H)^+$; calcd for $C_{16}H_{29}O_3Si$: 297.1886].

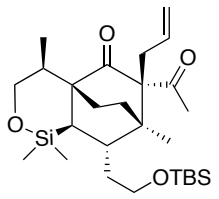


Ketone (+)-17: A solution of alcohol (+)-**16** (2.86 g, 9.66 mmol) and imidazole (1.97 g, 29.0 mmol) in DMF (39 mL) was cooled to 0 °C. TBSCl (1.74 g, 11.6 mmol) was added and the reaction mixture was allowed to warm to room temperature. After 2 h, the reaction mixture was diluted with EtOAc (30 mL) and quenched by the addition of water (30 mL). The layers were separated and the aqueous layer was extracted with EtOAc (30 mL x 2). The combined organic layers were dried over $MgSO_4$ and concentrated *in vacuo*. The residue was purified by flash chromatography on silica gel (10:1 hexanes/EtOAc) to afford the title compound (3.84 g, 97%) as a colorless oil. $[\alpha]_D^{20}$ +22.3 (*c* 0.63 $CHCl_3$). **IR** (neat) 2953, 2935, 2879, 2859, 1713, 1466, 1252, 1099, 1070, 834 cm^{-1}. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 3.67 - 3.56 (m, 3H), 3.54 - 3.45 (m, 1 H), 2.34 (dd, *J* = 2.6, 18.4 Hz, 1 H), 2.27 - 2.17 (m, 1 H), 2.02 - 1.96 (m, 1 H), 2.01 (dd, *J* = 1.4, 18.6 Hz, 1 H), 1.84 - 1.75 (m, 1 H), 1.75 - 1.66 (m, 1 H), 1.65 - 1.51 (m, 3 H), 1.13 (tdd, *J* = 5.9, 7.9, 13.7 Hz, 1 H), 0.96 (s, 3 H), 0.87 (s, 9 H), 0.71 (d, *J* = 6.7 Hz, 3 H), 0.60 (dd, *J* = 2.2, 6.1 Hz, 1 H), 0.32 (s, 3 H), 0.20 (s, 3 H), 0.03 (s, 3 H), 0.02 (s, 3 H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 213.8, 65.5, 61.1, 48.4, 46.6, 37.8, 37.0, 36.4, 36.2, 34.9, 34.8, 26.1, 25.3, 18.5, 18.4, 12.2, 0.51, –1.41, –5.06, –5.12. **HRMS(ES+)** *m/z* 411.2753 [$(M+H)^+$; calcd for $C_{22}H_{43}O_3Si_2$: 411.2751].



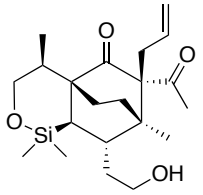
Diketone (+)-18: To a cooled (–78 °C) solution of diisopropylamine (0.85 mL, 6.14 mmol) in THF (25 mL) was added *n*-BuLi (2.5M/hexanes, 2.45 mL, 6.14 mmol) dropwise. After stirring for 0.5 h, a solution of ketone (+)-**17** (1.26 g, 3.07 mmol) in THF (9 mL) was added dropwise via cannula. The resulting solution was stirred for 0.5 h at –78 °C before MeCHO (5M/THF, 1.35 mL, 6.73 mmol) was added dropwise by syringe. The reaction was quenched at –78 °C with saturated aqueous NH_4Cl (10 mL). Upon warming to room temperature, water (10 mL) was added and the layers were separated. The aqueous layer was extracted with EtOAc (20 mL x 2). The combined organic layers were dried over $MgSO_4$ and concentrated *in vacuo*. The product was used without purification.

The resulting β-hydroxy ketone was dissolved in CH_2Cl_2 (20 mL) and cooled to 0 °C. Sodium bicarbonate (564 mg, 6.72 mmol) was added, followed by Dess-Martin periodinane (1.84 g, 4.36 mmol). The reaction mixture was stirred at 0 °C for 15 min, then at room temperature for 0.5 h. Upon completion, saturated aqueous $Na_2S_2O_3$ (10 mL) was added and the biphasic mixture was stirred vigorously for 15 min. The layers were separated and the aqueous layer was extracted with CH_2Cl_2 (15 mL x 2). The combined organic layers were dried over $MgSO_4$ and concentrated *in vacuo*. The residue was purified by flash chromatography on silica gel (12:1 hexanes/EtOAc) to afford the title compound (1.37 g, 91% over 2 steps) as a colorless oil. $[\alpha]_D^{20}$ +57.8 (*c* 0.8 $CHCl_3$). **IR** (neat) 2954, 2926, 2879, 2857, 1722, 1698, 1253, 1099 cm^{-1}. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 3.70 - 3.57 (m, 3 H), 3.53 (d, *J* = 1.2 Hz, 1 H), 3.49 (ddd, *J* = 5.7, 8.3, 10.3 Hz, 1 H), 2.28 (s, 3 H), 2.25 - 2.11 (m, 2 H), 1.96 (ddd, *J* = 2.4, 11.1, 14.1 Hz, 1 H), 1.92 - 1.79 (m, 2 H), 1.52 (ddd, *J* = 4.0, 5.9, 8.5 Hz, 1 H), 1.38 (ddt, *J* = 1.8, 7.7, 11.1 Hz, 1 H), 1.13 (tdd, *J* = 5.5, 8.5, 10.9 Hz, 1 H), 1.04 (s, 3 H), 0.88 (s, 9 H), 0.69 (d, *J* = 6.7 Hz, 3 H), 0.58 (dd, *J* = 2.2, 5.9 Hz, 1 H), 0.33 (s, 3 H), 0.20 (s, 3 H), 0.03 (s, 3 H), 0.02 (s, 3 H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 208.7, 205.0, 66.5, 65.4, 60.7, 48.6, 39.7, 38.7, 36.8, 36.0, 35.0, 33.6, 31.0, 26.0, 23.5, 18.4, 18.1, 12.0, 0.43, –1.30, –5.08, –5.13. **HRMS(ES+)** *m/z* 453.2858 [$(M+H)^+$; calcd for $C_{24}H_{45}O_4Si_2$: 453.2856].

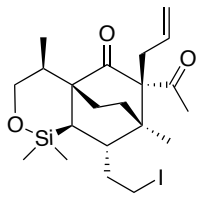


Diketone (–)-19: To a cooled (0 °C) solution of diketone (+)-**18** (1.37 g, 3.03 mmol) and $Pd(PPh_3)_4$ (174 mg, 0.151 mmol) in THF (16 mL) was added sodium hydride (60 wt% in mineral oil, 145 mg, 3.63 mmol), followed by dropwise addition of allyl acetate (0.39 mL, 3.63 mmol). The reaction mixture was warmed to room temperature and stirred for 0.5 h. The reaction was quenched by addition of saturated aqueous NH_4Cl (10 mL). The layers

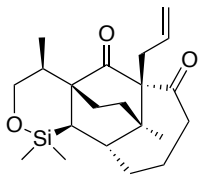
were separated and the aqueous layer was extracted with EtOAc (15 mL x 2). The combined organic layers were dried over $MgSO_4$ and concentrated *in vacuo*. The residue was purified by flash chromatography on silica gel (15:1 hexanes/EtOAc) to afford the title compound (1.41 g, 95%) as a colorless oil. $[\alpha]_D^{20}$ -1.8 (*c* 0.94 $CHCl_3$). **IR** (neat) 2955, 2927, 2881, 2857, 1699, 1469, 1253, 1097 cm^{-1}. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 5.72 (tdd, *J* = 7.1, 9.9, 17.0 Hz, 1 H), 5.04 (td, *J* = 0.9, 10.0 Hz, 1 H), 4.94 (dd, *J* = 1.7, 16.9 Hz, 1 H), 3.70 - 3.56 (m, 2 H), 3.49 (t, *J* = 6.1 Hz, 2 H), 2.85 - 2.76 (m, 1 H), 2.31 (tdd, *J* = 6.9, 11.7, 13.5 Hz, 1 H), 2.24 (s, 3 H), 2.14 (dd, *J* = 7.0, 13.6 Hz, 1 H), 2.05 - 1.88 (m, 2 H), 1.73 - 1.57 (m, 3 H), 1.33 (ddd, *J* = 6.2, 11.9, 14.0 Hz, 1 H), 1.07 (s, 3 H), 1.06 - 0.99 (m, 1 H), 0.87 (s, 9 H), 0.75 (d, *J* = 6.7 Hz, 3 H), 0.73 (dd, *J* = 2.0, 8.5, 1 H), 0.35 (s, 3 H), 0.24 (s, 3 H), 0.01 (s, 6 H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 210.8, 208.9, 133.3, 118.6, 66.9, 65.0, 62.6, 49.1, 43.4, 40.5, 38.6, 38.3, 35.5, 35.3, 33.9, 33.2, 26.2, 21.0, 18.6, 18.0, 12.6, 0.91, –1.71, –5.09, –5.16. **HRMS(ES+)** *m/z* 493.3172 [$(M+H)^+$; calcd for $C_{27}H_{49}O_4Si_2$: 493.3169].



Alcohol (–)-20: To a cooled (0 °C) solution of silyl ether (–)-**19** (3.57 g, 7.25 mmol) in MeOH (30 mL) was added *p*-toluenesulfonic acid (275 mg, 1.45 mmol). The reaction mixture was stirred at 0 °C for 0.5 h, then allowed to warm to room temperature. Ethyl acetate (20 mL) was added and the solution was washed with water (20 mL). The aqueous layer was extracted with EtOAc (20 mL x 2) and the combined organic layers were dried over $MgSO_4$ and concentrated *in vacuo*. The residue was purified by flash chromatography on silica gel (2:1 hexanes/EtOAc) to afford the title compound (2.52 g, 92%) as a white solid. Melting point 89-91 °C. $[\alpha]_D^{20}$ –4.5 (*c* 0.7 $CHCl_3$). **IR** (neat) 3442, 2956, 2924, 2882, 1697, 1354, 1253, 1053 cm^{-1}. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 5.73 (tdd, *J* = 7.1, 10.0, 17.0 Hz, 1 H), 5.04 (td, *J* = 0.7, 10.1 Hz, 1 H), 4.95 (dd, *J* = 1.5, 16.9 Hz, 1 H), 3.73 - 3.43 (m, 4 H), 2.80 (dd, *J* = 7.3, 13.7 Hz, 1 H), 2.32 (ddd, *J* = 4.9, 6.6, 11.3 Hz, 1 H), 2.25 (s, 3 H), 2.15 (dd, *J* = 6.7, 13.5 Hz, 1 H), 2.05 - 1.88 (m, 2 H), 1.75 - 1.63 (m, 2 H), 1.56 (ddd, *J* = 4.1, 5.5, 9.3 Hz, 1 H), 1.38 - 1.26 (m, 2 H), 1.11 - 1.05 (m, 1 H), 1.08 (s, 3 H), 0.78 (dd, *J* = 2.0, 9.0, 1 H), 0.76 (d, *J* = 6.5, 3 H), 0.36 (s, 3 H), 0.25 (s, 3 H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 210.6, 209.0, 133.3, 118.6, 66.9, 64.9, 62.8, 49.1, 43.3, 41.1, 38.6, 38.1, 35.7, 35.3, 33.8, 33.0, 20.7, 17.9, 12.6, 0.98, –1.72. **HRMS(ES+)** *m/z* 379.2308 [$(M+H)^+$; calcd for $C_{21}H_{35}O_4Si$: 379.2305].



Iodide (–)-21: To a cooled (0 °C) solution of alcohol (–)-**20** (2.52 g, 6.66 mmol) in THF (25 mL) was added PPh_3 (2.09 g, 8.00 mmol), imidazole (993 mg, 14.6 mmol), and I_2 (2.02 g, 8.00 mmol) sequentially. The cold bath was removed and the brown solution was stirred at room temperature for 10 min. The reaction was quenched with saturated aqueous $Na_2S_2O_3$ (15 mL) and the layers were separated. The aqueous layer was extracted with EtOAc (15 mL x 2). The combined organic layers were dried over $MgSO_4$ and concentrated *in vacuo*. The residue was purified by flash chromatography on silica gel (10:1 hexanes/EtOAc) to afford the title compound (3.17 g, 97%) as a colorless oil. $[\alpha]_D^{20}$ –1.6 (*c* 0.7 $CHCl_3$). **IR** (neat) 2956, 2924, 2882, 2860, 1698, 1353, 1253, 1169, 1101 cm^{-1}. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 5.72 (tdd, *J* = 7.1, 10.0, 17.0 Hz, 1 H), 5.05 (td, *J* = 0.9, 10.0 Hz, 1 H), 4.96 (dd, *J* = 1.7, 16.9 Hz, 1 H), 3.70 - 3.58 (m, 2 H), 3.17 - 3.06 (m, 2 H), 2.78 (dd, *J* = 7.5, 13.7 Hz, 1 H), 2.31 (ddd, *J* = 4.8, 6.6, 11.4 Hz, 1 H), 2.24 (s, 3 H), 2.21 - 2.15 (m, 1 H), 2.06 - 1.88 (m, 3 H), 1.68 (dddd, *J* = 2.2, 6.1, 11.5, 13.9 Hz, 1 H), 1.53 (ddd, *J* = 4.6, 5.7, 8.9 Hz, 1 H), 1.43 - 1.32 (m, 2 H), 1.14 (s, 3 H), 0.76 (d, *J* = 6.7 Hz, 3 H), 0.70 (dd, *J* = 2.2, 8.7 Hz, 1 H), 0.43 (s, 3 H), 0.27 (s, 3 H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 210.3, 208.7, 133.0, 118.8, 67.0, 64.9, 49.1, 46.6, 43.2, 39.1, 38.4, 35.3, 35.0, 33.8, 33.1, 21.0, 18.0, 12.6, 6.79, 1.33, –1.11. **HRMS(ES+)** *m/z* 489.1317 [$(M+H)^+$; calcd for $C_{21}H_{34}IO_3Si$: 489.1322].



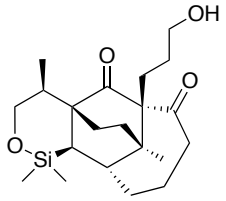
Diketone (+)-4: The following reaction was run in three batches, which were combined for purification.

Batch 1 (937 mg (–)-**21**, 1.92 mmol): To a cooled (–20 °C) solution of diisopropylamine (0.93 mL, 6.72 mmol) in THF (13.5 mL) was added *n*-BuLi (2.5 M/hexanes, 2.69 mL, 6.72 mmol) dropwise and the resulting solution was stirred at this temperature for 40 minutes. In a separate flask, iodide (–)-**22** (937 mg, 1.92 mmol) was dissolved in THF (13 mL) and cooled to –20 °C. The solution of LDA was added dropwise via cannula to the solution of (–)-**21** over 45 minutes while maintaining the temperature at –20 °C. The reaction mixture was allowed to warm to room temperature and quenched with saturated aqueous NH_4Cl (10 mL). The layers were separated and the aqueous layer was extracted with EtOAc (10 mL x 2). The combined organic layers were dried over $MgSO_4$ and concentrated *in vacuo* to provide the first batch of crude (+)-**4**.

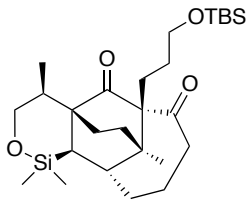
Batch 2 (980 mg (–)-**21**, 2.01 mmol): The exact procedure as above with the same quantities of all reagents and solvents provided a second batch of crude (+)-**4**.

Batch 3 (1.03 g (–)-**21**, 2.11 mmol): Diisopropylamine (1.03 mL, 7.38 mmol) was dissolved in THF (14 mL) and cooled to –20 °C. A solution of *n*-BuLi (2.5 M/hexanes, 2.95 mL, 7.38 mmol) was added dropwise and the resulting solution was stirred at –20 °C for 40 minutes. In a separate flask, iodide (–)-**21** was dissolved in THF (14 mL) and cooled to –20 °C. The solution of LDA was transferred dropwise via cannula to the solution of (–)-**21** over 1 h while maintaining the temperature at –20 °C. The reaction mixture was allowed to warm to room temperature and quenched with saturated aqueous NH_4Cl (30 mL). The layers were separated and the aqueous layer was extracted with

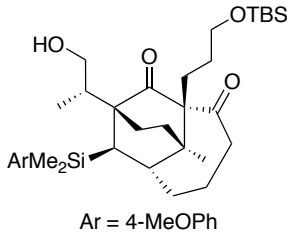
EtOAc (20 mL x 2). The combined organic layers were dried over $MgSO_4$ and concentrated *in vacuo*. The three crude batches were combined, adsorbed on silica, and purified by flash chromatography on silica gel (10:1 hexanes/EtOAc) to afford the title compound (1.68 g, 77%) as a white solid. X-ray quality crystals were obtained by slow evaporation from EtOAc. Melting point 123-125 °C. $[\alpha]_D^{20}$ +154 (*c* 0.91 $CHCl_3$). **IR** (neat) 2956, 2926, 2884, 2862, 1702, 1687, 1253, 1097, 1066 cm^{-1}. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 5.66 (dddd, *J* = 5.5, 8.3, 10.1, 16.8 Hz, 1 H), 4.96 (d, *J* = 10.1 Hz, 1 H), 4.90 (d, *J* = 17.0 Hz, 1 H), 3.77 - 3.62 (m, 2 H), 2.99 (dd, *J* = 5.5, 14.1 Hz, 1 H), 2.83 - 2.74 (m, 1 H), 2.51 - 2.37 (m, 2 H), 2.25 (dd, *J* = 8.2, 14.0 Hz, 1 H), 2.12 - 2.02 (m, 1 H), 1.98 - 1.90 (m, 1 H), 1.90 - 1.69 (m, 4 H), 1.53 - 1.42 (m, 2 H), 1.37 (td, *J* = 5.0, 13.5 Hz, 1 H), 1.18 (dd, *J* = 2.6, 5.9 Hz, 1 H), 0.88 (s, 3 H), 0.66 (d, *J* = 6.7 Hz, 3 H), 0.38 (s, 3 H), 0.13 (s, 3 H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 211.2, 208.6, 135.6, 117.1, 70.8, 65.6, 49.3, 43.7, 43.5, 40.3, 36.0, 34.8, 33.5, 33.0, 30.0, 21.2, 18.8, 16.6, 12.1, 0.40, –1.73. **HRMS(ES+)** *m/z* 383.2021 [$(M+Na)^+$; calcd for $C_{21}H_{32}O_3SiNa$: 383.2018].



Alcohol (+)-S4: The following reaction was run in two equal size batches side by side. A solution of 9-BBN (0.5M/THF, 0.48 mL, 0.237 mmol) was added to the alkene (+)-**4** (neat, 42.8 mg, 0.118 mmol) at room temperature and the reaction mixture was stirred for 1 h. The solution was cooled to 0 °C and a cold (0 °C) solution of aqueous NaOH (3.75 M, 0.31 mL, 1.18 mmol) was added dropwise. Then a cold (0 °C) solution of H_2O_2 (35 wt% in H_2O, 0.28 mL, 2.36 mmol) was carefully added dropwise. After stirring at 0 °C for 10 min, the cold bath was removed and the reaction mixture was vigorously stirred at room temperature for 1 h. The reaction mixture was diluted with water (10 mL) and EtOAc (10 mL). The layers were separated and the aqueous layer was extracted with EtOAc (10 mL x 2). The combined organic layers were dried over $MgSO_4$ and concentrated *in vacuo*. The combined residue from the two batches was purified by medium pressure liquid chromatography on silica gel (1:1 hexanes/EtOAc) to provide alcohol (+)-**S4** (63.3 mg, 71%) as a colorless oil. $[\alpha]_D^{20}$ +173 (*c* 0.45 $CHCl_3$). **IR** (neat) 3421, 2954, 2916, 2874, 1697, 1457, 1253, 1063 cm^{-1}. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 3.78 - 3.66 (m, 2 H), 3.63 - 3.53 (m, 2 H), 2.84 - 2.77 (m, 1 H), 2.52 - 2.40 (m, 2 H), 2.28 (ddd, *J* = 4.2, 11.1, 13.7 Hz, 1 H), 2.07 (dd, *J* = 11.1, 14.1 Hz, 1 H), 1.96 - 1.85 (m, 2 H), 1.85 - 1.78 (m, 1 H), 1.78 - 1.71 (m, 1 H), 1.64 - 1.55 (m, 2 H), 1.53 - 1.41 (m, 3 H), 1.40 - 1.32 (m, 1 H), 1.26 (ddd, *J* = 5.4, 11.3, 18.2 Hz, 1 H), 1.20 (dd, *J* = 2.4, 5.7 Hz, 1 H), 0.84 (s, 3 H), 0.70 (d, *J* = 6.7 Hz, 3 H), 0.38 (s, 3 H), 0.14 (s, 3 H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 212.8, 209.4, 70.2, 65.6, 63.1, 49.6, 43.5, 43.4, 40.4, 34.7, 33.6, 33.1, 29.8, 28.6, 26.5, 21.0, 19.0, 16.4, 12.2, 0.3, –1.7. **HRMS(ES+)** *m/z* 401.2124 [$(M+Na)^+$; calcd for $C_{21}H_{34}O_4SiNa$: 401.2124].

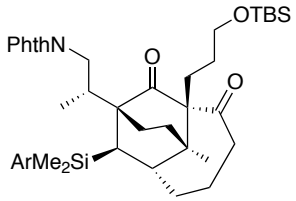


Silyl ether (+)-22: To a solution of alcohol (+)-**S4** (401 mg, 1.06 mmol) and imidazole (216 mg, 3.18 mmol) in DMF (10 mL) was added TBSCl (207 mg, 1.38 mmol) at 0 °C. The resulting solution was stirred at 0 °C for 1 h and allowed to warm to room temperature. The reaction mixture was quenched by the addition of water (10 mL) and diluted with EtOAc (20 mL). The layers were separated and the aqueous layer was extracted with EtOAc (20 mL x 2). The combined organic layers were dried over $MgSO_4$ and concentrated *in vacuo*. The residue was purified by flash chromatography on silica gel (10:1 hexanes/EtOAc) to afford the title compound (490 mg, 94%) as a colorless oil. $[\alpha]_D^{20}$ +115 (*c* 0.57 $CHCl_3$). **IR** (neat) 2954, 2929, 2854, 1693, 1472, 1253, 1100 cm^{-1}. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 3.78 - 3.65 (m, 2 H), 3.61 (td, *J* = 5.2, 10.2 Hz, 1 H), 3.50 (ddd, *J* = 4.9, 8.6, 10.0 Hz, 1 H), 2.84 - 2.72 (m, 1 H), 2.50 - 2.44 (m, 1 H), 2.42 (dd, *J* = 6.7, 11.5 Hz, 1 H), 2.12 (dt, *J* = 4.4, 12.5 Hz, 1 H), 2.04 (dd, *J* = 10.9, 13.7 Hz, 1 H), 1.92 - 1.86 (m, 2 H), 1.85 - 1.78 (m, 1 H), 1.76 (td, *J* = 2.2, 14.5 Hz, 1 H), 1.74 - 1.69 (m, 1 H), 1.64 (dt, *J* = 4.4, 12.8 Hz, 1 H), 1.51 - 1.30 (m, 5 H), 1.22 - 1.14 (m, 1 H), 1.19 (dd, *J* = 2.2, 5.7 Hz, 1 H), 0.86 (s, 9 H), 0.82 (s, 3 H), 0.69 (d, *J* = 6.7 Hz, 3 H), 0.37 (s, 3 H), 0.12 (s, 3 H), 0.02 (s, 3 H), 0.00 (s, 3 H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 212.8, 208.9, 70.1, 65.6, 63.4, 49.6, 43.6, 43.4, 40.4, 34.8, 33.6, 33.1, 29.8, 28.4, 27.0, 26.1, 21.0, 18.9, 18.4, 16.4, 12.3, 0.4, –1.7, –5.19, –5.15. **HRMS(ES+)** *m/z* 493.3167 [$(M+H)^+$; calcd for $C_{27}H_{49}O_4Si_2$: 493.3169].



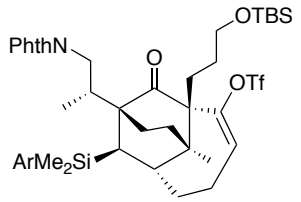
Alcohol (+)-23: To a suspension of 4-iodoanisole (128 mg, 0.55 mmol) in Et_2O (1.7 mL) at –78 °C was added *t*-BuLi (1.7M/pentane, 0.71 mL, 1.21 mmol) dropwise, at which point the suspension became a clear solution. The resulting solution was stirred at –78 °C for 20 min, then at room temperature for 45 min. In a separate flask, siloxane (+)-**22** (54.4 mg, 0.11 mmol) was dissolved in Et_2O (1.1 mL), and the solution of 4-methoxyphenyllithium was added dropwise over 10 min via cannula, at room temperature. The reaction was quenched by addition of saturated aqueous NH_4Cl (5 mL) and diluted with EtOAc (6 mL). The layers were separated and the aqueous layer was extracted with EtOAc (10 mL). The combined organic layers were washed with brine (3 mL), dried over $MgSO_4$, and concentrated *in vacuo*. The residue was purified by medium pressure liquid chromatography on silica gel (4:1 hexanes/EtOAc) to afford the title compound (62.6 mg, 95%) as a colorless oil. $[\alpha]_D^{20}$ +92.0 (*c* 1.45 $CHCl_3$). **IR** (neat) 3442, 2954, 2931, 2895, 2860, 1696, 1594, 1503, 1461, 1277, 1250, 1183, 1108 cm^{-1}. **^{1}H NMR** (500 MHz,

$CDCl_3$) δ 7.49 (d, *J* = 8.7 Hz, 2 H), 6.90 (d, *J* = 8.7 Hz, 2 H), 3.82 (s, 3 H), 3.69 (dd, *J* = 6.1, 10.7 Hz, 1 H), 3.62 (dd, *J* = 2.8, 10.5 Hz, 1 H), 3.56 (td, *J* = 5.4, 10.4 Hz, 1 H), 3.45 (ddd, *J* = 5.2, 8.0, 10.0 Hz, 1 H), 2.66 (dd, *J* = 6.6, 17.5 Hz, 1 H), 2.36 (ddd, *J* = 7.4, 11.4, 17.6 Hz, 1 H), 2.10 (ddd, *J* = 4.3, 11.9, 13.4 Hz, 1 H), 2.06 - 1.97 (m, 1 H), 1.93 - 1.87 (m, 1 H), 1.87 - 1.82 (m, 1 H), 1.76 (t, *J* = 3.4 Hz, 2 H), 1.73 - 1.66 (m, 1 H), 1.66 - 1.55 (m, 2 H), 1.48 (ddd, *J* = 4.6, 11.8, 13.3 Hz, 1 H), 1.44 - 1.32 (m, 2 H), 1.29 (d, *J* = 6.9 Hz, 3 H), 1.27 - 1.11 (m, 3 H), 0.98 (td, *J* = 5.9, 13.9 Hz, 1 H), 0.86 (s, 9 H), 0.72 (s, 3 H), 0.52 (s, 3 H), 0.45 (s, 3 H), 0.01 (s, 3 H), 0.00 (s, 3 H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 217.4, 209.3, 160.8, 135.6, 129.4, 113.8, 69.6, 64.5, 63.4, 55.2, 51.5, 45.0, 43.4, 42.4, 39.2, 32.2, 31.8, 29.7, 28.5, 28.0, 27.9, 26.1, 21.0, 18.4, 15.5, 13.7, –0.20, –0.98, –5.14, –5.18. **HRMS(ES+)** *m/z* 623.3539 [$(M+Na)^+$; calcd for $C_{34}H_{56}O_5Si_2Na$: 623.3533].



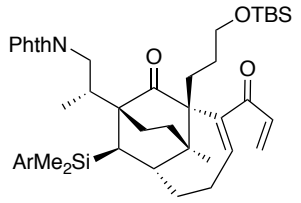
Ar = 4-MeOPh

Pthalimide (+)-24: To a solution of alcohol (+)-**23** (120.5 mg, 0.20 mmol) in THF (6 mL) were added phthalimide (65 mg, 0.44 mmol) and PPh_3 (116 mg, 0.44 mmol). The solution was cooled to 0 °C and DEAD (40 wt%/toluene, 0.17 mL, 0.56 mmol) was added dropwise. The resulting solution was allowed to warm to room temperature and stir for 0.5 h. The volatiles were removed *in vacuo* and the residue was purified by flash chromatography on silica gel (5:1 hexanes/EtOAc) to afford the title compound (144.7 mg, 99%) as a colorless oil. $[\alpha]_D^{20}$ +97.8 (*c* 1.24 $CHCl_3$). **IR** (neat) 2953, 2936, 2895, 2858, 1772, 1713, 1593, 1502, 1464, 1399, 1251, 1106 cm^{-1}. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.85 (dd, *J* = 3.0, 5.4 Hz, 2 H), 7.72 (dd, *J* = 3.0, 5.4 Hz, 2 H), 7.48 (d, *J* = 8.5 Hz, 2 H), 6.82 (d, *J* = 8.3 Hz, 2 H), 3.95 (dd, *J* = 10.1, 13.3 Hz, 1 H), 3.68 (s, 3 H), 3.57 (td, *J* = 5.3, 10.3 Hz, 1 H), 3.51 - 3.43 (m, 2 H), 2.71 (dd, *J* = 6.5, 17.2 Hz, 1 H), 2.38 (ddd, *J* = 7.5, 11.3, 18.4 Hz, 1 H), 2.29 - 2.19 (m, 1 H), 2.13 (ddd, *J* = 5.0, 11.3, 13.7 Hz, 1 H), 1.95 - 1.82 (m, 3 H), 1.82 - 1.70 (m, 2 H), 1.65 (dd, *J* = 10.9, 13.1 Hz, 1 H), 1.53 (ddd, *J* = 5.4, 11.0, 13.7 Hz, 1 H), 1.46 (t, *J* = 14.1 Hz, 1 H), 1.39 (td, *J* = 6.7, 14.5 Hz, 1 H), 1.34 - 1.21 (m, 3 H), 1.14 (d, *J* = 6.7 Hz, 3 H), 1.06 (td, *J* = 5.4, 12.9 Hz, 1 H), 0.82 (s, 9 H), 0.75 (s, 3 H), 0.47 (s, 3 H), 0.42 (s, 3 H), –0.01 (s, 3 H), –0.03 (s, 3 H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 215.3, 209.4, 168.5, 160.6, 135.7, 133.9, 132.2, 129.3, 123.2, 113.6, 69.3, 63.4, 55.0, 51.3, 44.8, 43.3, 40.4, 39.4, 39.3, 32.2, 31.7, 29.8, 28.3, 27.9, 27.8, 26.0, 21.0, 18.4, 15.5, 14.1, –0.5, –1.1, –5.2. **HRMS(ES+)** *m/z* 730.3943 [$(M+H)^+$; calcd for $C_{42}H_{60}NO_6Si_2$: 730.3928].



Ar = 4-MeOPh

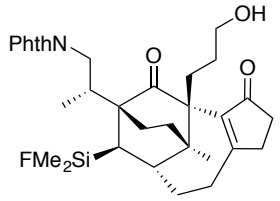
Triflate (+)-25: To a solution of ketone (+)-**24** (61 mg, 0.084 mmol) and $PhN(Tf)_2$ (45 mg, 0.125 mmol) in THF (3 mL) at –78 °C was added KHMDS (0.5M/toluene, 0.33 mL, 0.167 mmol) dropwise. The light yellow solution was stirred at –78 °C for 0.5 h, quenched at this temperature by the dropwise addition of saturated aqueous NH_4Cl (1.5 mL), then allowed to warm to room temperature. Water (5 mL) and EtOAc (10 mL) were added and the layers were separated. The aqueous layer was extracted with EtOAc (10 mL x 2), and the combined organic layers were dried over $MgSO_4$ and concentrated *in vacuo*. The residue was purified by medium pressure liquid chromatography on silica gel (6:1 hexanes/EtOAc) to afford the title compound (52.8 mg, 73%) as a colorless oil. $[\alpha]_D^{20}$ +95.2 (*c* 0.56 $CHCl_3$). **IR** (neat) 2953, 2929, 2893, 2854, 1773, 1716, 1595, 1399, 1211 cm^{-1}. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.86 (dd, *J* = 3.0, 5.4 Hz, 2 H), 7.73 (dd, *J* = 3.2, 5.5 Hz, 2 H), 7.47 (d, *J* = 8.7 Hz, 2 H), 6.83 (d, *J* = 8.5, 2 H), 6.02 (dd, *J* = 4.3, 10.2 Hz, 1 H), 3.95 (dd, *J* = 10.3, 13.3 Hz, 1 H), 3.70 (s, 3 H), 3.63 (td, *J* = 5.3, 10.0 Hz, 1 H), 3.51 (dd, *J* = 2.2, 13.3 Hz, 1 H), 3.47 (ddd, *J* = 5.2, 8.7, 10.1 Hz, 1 H), 2.33 - 2.20 (m, 1 H), 2.05 - 1.72 (m, 8 H), 1.66 - 1.50 (m, 3 H), 1.38 - 1.19 (m, 3 H), 1.09 (d, *J* = 7.1, 3 H), 1.08 (s, 3 H), 0.83 (s, 9 H), 0.47 (s, 3 H), 0.43 (s, 3 H), 0.00 (s, 3 H), –0.02 (s, 3 H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 212.1, 168.6, 160.7, 152.3, 135.8, 134.0, 132.2, 129.0, 123.8, 123.3, 113.7, 63.0, 61.7, 55.0, 50.6, 46.0, 40.5, 39.7, 38.9, 33.3, 32.1, 29.1, 28.4, 28.2, 27.1, 26.0, 21.0, 18.4, 18.2, 14.3, –0.51, –1.14, –5.26, –5.30. **HRMS(ES+)** *m/z* 884.3281 [$(M+Na)^+$; calcd for $C_{43}H_{58}F_3NO_8SSi_2Na$: 884.3272].



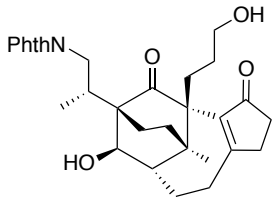
Ar = 4-MeOPh

Enone (+)-26: In a 20 mL pyrex reaction tube, LiCl (7.3 mg, 0.172 mmol) was thoroughly dried under vacuum using a heat gun, cooled under a stream of N_2, then $Pd(PPh_3)_4$ (2.5 mg, 0.0021 mmol) was added. A solution of triflate (+)-**25** (37 mg, 0.043 mmol) in DMF (2 mL + 2 mL rinse) was added to this mixture via cannula. The resulting light yellow solution was vigorously stirred and saturated with CO for 20 minutes, producing a deep yellow solution. Tetravinyltin (12 μL, 0.064 mmol) was added, and the reaction tube was fitted with a CO balloon. The reaction mixture was heated to 90 °C for 10 minutes, and the precipitation of black Pd indicated completion of the reaction. After cooling to room temperature, the solution was diluted with EtOAc (15 mL) and washed with water (4 mL x 3). The aqueous layer was extracted with EtOAc (10 mL) and the combined organic layers were washed with brine, dried over $MgSO_4$, and concentrated *in*

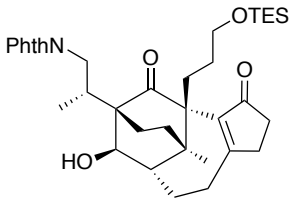
vacuo. The residue was purified by medium pressure liquid chromatography on silica gel (3:1 hexanes/EtOAc) to afford the product (32.1 mg, 97%) as a colorless oil. $[\alpha]_D^{20}$ +107 (*c* 0.97 $CHCl_3$). **IR** (neat) 2953, 2932, 2891, 2856, 1772, 1714, 1668, 1647, 1593, 1398, 1277, 1249, 1107 cm^{-1}. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.85 (dd, *J* = 3.1, 5.4 Hz, 2 H), 7.71 (dd, *J* = 3.0, 5.4 Hz, 2 H), 7.47 (d, *J* = 8.5 Hz, 2 H), 6.82 (d, *J* = 8.5 Hz, 2 H), 6.51 (dd, *J* = 10.4, 17.3 Hz, 1 H), 6.44 (dd, *J* = 4.4, 9.5 Hz, 1 H), 6.30 (dd, *J* = 1.5, 17.3 Hz, 1 H), 5.86 (dd, *J* = 1.5, 10.4 Hz, 1 H), 4.02 - 3.94 (m, 1 H), 3.68 (s, 3 H), 3.50 (dd, *J* = 1.8, 13.5 Hz, 1 H), 3.42 (ddd, *J* = 4.9, 6.4, 10.5 Hz, 1 H), 3.31 (ddd, *J* = 6.1, 7.9, 9.9 Hz, 1 H), 2.40 (dddd, *J* = 3.0, 7.5, 10.5, 14.0 Hz, 1 H), 2.30 - 2.18 (m, 2 H), 1.97 - 1.73 (m, 6 H), 1.71 - 1.57 (m, 3 H), 1.31 - 1.18 (m, 2 H), 1.14 (d, *J* = 6.7 Hz, 3 H), 1.01 (s, 3 H), 0.99 - 0.90 (m, 1 H), 0.79 (s, 9 H), 0.46 (s, 3 H), 0.41 (s, 3 H), -0.05 (s, 3 H), –0.08 (s, 3 H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 215.3, 195.5, 168.6, 160.6, 145.0, 141.7, 137.0, 135.8, 133.9, 132.3, 130.8, 129.4, 123.2, 113.6, 63.2, 60.2, 55.0, 51.4, 46.2, 40.9, 39.8, 39.1, 32.9, 32.5, 28.9, 28.5, 27.8, 26.0, 25.4, 22.2, 21.3, 18.4, 14.5, –0.4, –1.2, –5.24, –5.21. **HRMS(ES+)** *m/z* 768.4127 [$(M+H)^+$; calcd for $C_{45}H_{62}NO_6Si_2$: 768.4116].



Silyl fluoride (+)-27: To a solution of enone (+)-**26** (32.1 mg, 0.042 mmol) in CH_2Cl_2 (3 mL) was added HBF_4•OEt_2 (57 μL, 0.42 mmol) dropwise at room temperature. The resulting solution was stirred for 0.5 h and quenched by the dropwise addition of saturated aqueous $NaHCO_3$ (2 mL). The reaction mixture was diluted with CH_2Cl_2 (8 mL) and water (3 mL). The layers were separated and the aqueous layer was extracted with CH_2Cl_2 (10 mL x 2). The combined organic layers were dried over $MgSO_4$ and concentrated *in vacuo*. The residue was purified by medium pressure liquid chromatography (6:1 EtOAc/hexanes) to afford the product (19.5 mg, 82%) as a colorless oil. $[\alpha]_D^{20}$ +115 (*c* 0.54 $CHCl_3$). **IR** (neat) 3425, 2959, 2923, 2879, 1769, 1713, 1616, 1400 cm^{-1}. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.82 (dd, *J* = 3.1, 5.4 Hz, 2 H), 7.70 (dd, *J* = 3.1, 5.4 Hz, 2 H), 3.94 (dd, *J* = 8.7, 13.7 Hz, 1 H), 3.68 (ddd, *J* = 5.5, 10.7, 16.1 Hz, 1 H), 3.65-3.61 (m, 1 H), 3.61 (dd, *J* = 3.0, 13.9 Hz, 1 H), 3.12 (dt, *J* = 2.0, 13.9 Hz, 1 H), 2.68 - 2.55 (m, 3 H), 2.50 (dddd, *J* = 3.6, 6.5, 9.7, 13.1 Hz, 1 H), 2.44 (dd, *J* = 3.2, 6.9 Hz, 1 H), 2.37 (ddd, *J* = 2.6, 6.3, 18.4 Hz, 1 H), 1.99-1.91 (m 5 H), 1.88-1.81 (m, 2 H), 1.69 (ddd, *J* = 6.1, 12.1, 13.7 Hz, 1 H), 1.56 - 1.38 (m, 3 H), 1.35-1.27 (m, 2 H), 1.29 (d, *J* = 6.9 Hz, 3 H), 0.88 (s, 3 H), 0.37 (d, *J* = 7.5 Hz, 3 H), 0.34 (d, *J* = 9 Hz, 3 H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 214.4, 209.3, 181.2, 168.7, 139.2, 134.0, 132.2, 123.3, 62.8, 59.1, 50.3, 44.4, 41.2, 40.3, 39.5, 36.2, 33.6 (d), 32.6, 31.4, 28.9, 28.4, 28.3, 26.4, 24.2, 20.7, 15.0, 0.78 (d), 0.06 (d). **HRMS(ES+)** *m/z* 548.2628 [$(M–OH)^+$; calcd for $C_{32}H_{39}FNO_4Si$: 548.2632].

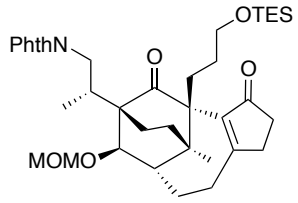


Diol (+)-28: To a solution of silyl fluoride (+)-**27** (97 mg, 0.172 mmol) in DMF (6 mL) was added KF (99 mg, 1.71 mmol), followed by *m*-CPBA (75 wt%, 392 mg, 1.71 mmol). The reaction mixture was stirred at room temperature for 5 h, diluted with EtOAc (5 mL), and quenched by the addition of saturated aqueous $Na_2S_2O_4$ (3 mL) and saturated aqueous $NaHCO_3$ (3 mL). The suspension was vigorously stirred at room temperature for 15 minutes, diluted with water (5 mL) and EtOAc (15 mL), and the layers were separated. The organic layer was washed with brine (4 mL) and the combined aqueous layers were extracted with EtOAc (10 mL x 2). The combined organic layers were dried over $MgSO_4$ and concentrated *in vacuo*. The residue was purified by medium pressure liquid chromatography (EtOAc) to afford the title compound (64 mg, 74%) as a colorless oil. $[\alpha]_D^{20}$ +60.0 (*c* 0.46 $CHCl_3$). **IR** (neat) 3457, 2957, 2932, 2884, 1770, 1712, 1614, 1443, 1400, 1377, 1357, 1049 cm^{-1}. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.82 (dd, *J* = 3.1, 5.4 Hz, 2 H), 7.70 (dd, *J* = 3.0, 5.5 Hz, 2 H), 4.03 (s, 1 H), 3.91 (d, *J* = 13.5 Hz, 1 H), 3.77 (dd, *J* = 9.2, 13.8 Hz, 1 H), 3.68 (ddd, *J* = 5.4, 10.7, 15.9 Hz, 1 H), 3.61 (qd, *J* = 4.3, 10.3 Hz, 1 H), 3.10 (dt, *J* = 2.5, 13.5 Hz, 1 H), 2.61 - 2.48 (m, 2 H), 2.44 (ddd, *J* = 3.4, 5.9, 18.4 Hz, 1 H), 2.37 (ddd, *J* = 2.8, 6.1, 12.7 Hz, 2 H), 2.40 - 2.28 (m, 1 H), 2.21 - 2.08 (m, 3 H), 2.07 - 1.97 (m, 2 H), 1.80 (td, *J* = 2.6, 14.1 Hz, 1 H), 1.76 - 1.68 (m, 2 H), 1.67 - 1.61 (m, 2 H), 1.61 - 1.54 (m, 1 H), 1.41 (s, 1 H), 1.31 - 1.20 (m, 1 H), 1.13 (d, *J* = 6.9 Hz, 3 H), 0.85 (s, 3 H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 214.8, 209.4, 181.1, 169.0, 139.1, 134.2, 132.1, 123.4, 62.8, 58.2, 55.4, 55.3, 41.0, 39.1, 37.3, 36.2, 32.2, 31.5, 28.9, 28.3, 25.1, 24.4, 20.3, 15.3. **HRMS(ES+)** *m/z* 528.2355 [$(M+Na)^+$; calcd for $C_{30}H_{35}NO_6Na$: 528.2362].

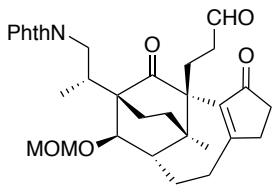


Alcohol (+)-29: To a cooled (0 °C) solution of diol (+)-**28** (46.9 mg, 0.092 mmol) in DMF (4 mL) was added imidazole (20 mg, 0.294 mmol) and TESCl (23 μL, 0.139 mmol) sequentially. After stirring at this temperature for 1.5 h, the reaction mixture was diluted with EtOAc (10 mL) and quenched with water (5 mL). The layers were separated and the organic layer was washed with brine (4 mL). The combined aqueous layers were extracted with EtOAc (10 mL x 2) and the combined organic layers were dried over $MgSO_4$ and concentrated *in vacuo*. The residue was purified by medium pressure liquid chromatography (1:1 hexanes/EtOAc) to afford the product (46.9 mg, 83%) as a colorless oil. $[\alpha]_D^{20}$ +51.1 (*c* 0.64 $CHCl_3$). **IR** (neat) 3466, 2954, 2935, 2916, 2875, 1772, 1714, 1616, 1443, 1399, 1377, 1357, 1091 cm^{-1}. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.83 (dd, *J* = 3.2, 5.4 Hz, 2 H), 7.71 (dd, *J* = 3.1, 5.4 Hz, 2 H), 4.00 (s, 1 H), 3.93 (d, *J* = 13.5 Hz, 1 H),

3.79 (dd, *J* = 9.7, 12.9 Hz, 1 H), 3.67 (ddd, *J* = 4.4, 6.9, 10.1 Hz, 1 H), 3.53 (ddd, *J* = 6.5, 8.1, 9.7 Hz, 1 H), 2.87 (ddd, *J* = 3.4, 11.9, 14.5 Hz, 2 H), 2.58 - 2.49 (m, 1 H), 2.49 - 2.40 (m, 1 H), 2.38 (td, *J* = 3.7, 7.1 Hz, 1 H), 2.34 (dd, *J* = 2.8, 5.9 Hz, 1 H), 2.30 (dd, *J* = 2.6, 6.1 Hz, 1 H), 2.20 - 2.10 (m, 2 H), 2.04 - 1.96 (m, 2 H), 1.81 - 1.70 (m, 3 H), 1.66 - 1.53 (m, 2 H), 1.35 - 1.26 (m, *J* = 5.2 Hz, 1 H), 1.26 - 1.16 (m, 1 H), 1.09 (d, *J* = 6.9 Hz, 3 H), 0.91 (t, *J* = 7.9 Hz, 9 H), 0.84 (s, 3 H), 0.55 (q, *J* = 7.9 Hz, 6 H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 214.4, 208.4, 179.1, 169.0, 139.2, 134.1, 132.2, 123.4, 63.1, 58.0, 55.6, 55.3, 41.0, 39.1, 37.3, 36.0, 32.2, 31.3, 29.1, 28.2, 25.2, 24.0, 20.4, 15.3, 6.9, 4.5. **HRMS(ES+)** *m/z* 642.3210 [$(M+Na)^+$; calcd for $C_{36}H_{49}NO_6SiNa$: 642.3227].

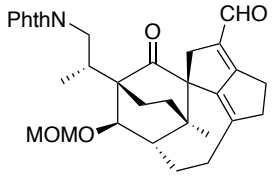


Enone (+)-30: To a solution of alcohol (+)-**29** (13.5 mg, 0.021 mmol) in 1,2-dichloroethane (1 mL) was added *i*-Pr_2NEt (40 μL, 0.231), followed by MOMBr (17 μL, 0.210 mmol) at room temperature, and the reaction mixture was heated to 80 °C for 4 h. The red solution was cooled to room temperature, diluted with CH_2Cl_2 (1 mL), and quenched by the dropwise addition of pH 7 buffer (1 mL). The biphasic mixture was vigorously stirred for 15 minutes, diluted with additional CH_2Cl_2 (4 mL) and pH 7 buffer (3 mL), and the layers were separated. The aqueous layer was extracted with CH_2Cl_2 (8 mL x 2) and the combined organic layers were dried over $MgSO_4$ and concentrated *in vacuo*. The residue was purified by flash chromatography on silica gel (2:1 hexanes/EtOAc) to afford the title compound (11.6 mg, 88%) as a colorless oil. $[\alpha]_D^{20}$ +53.2 (*c* 0.48 $CHCl_3$). **IR** (neat) 2953, 2935, 2911, 2880, 1774, 1715, 1618, 1398, 1095, 1028 cm^{-1}. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.83 (dd, *J* = 3.0, 5.4 Hz, 2 H), 7.70 (dd, *J* = 3.1, 5.4 Hz, 2 H), 4.74 (d, *J* = 6.9 Hz, 1 H), 4.66 (d, *J* = 7.1 Hz, 1 H), 3.97 (dd, *J* = 11.0, 13.0 Hz, 1 H), 3.92 (br s, 1 H), 3.54 (td, *J* = 7.3, 9.6 Hz, 1 H), 3.36 (s, 3 H), 2.90 (dt, *J* = 3.2, 13.0 Hz, 1 H), 2.59 - 2.45 (m, 2 H), 2.41 (ddd, *J* = 3.4, 6.7, 18.0 Hz, 1 H), 2.34 (dd, *J* = 2.1, 5.8 Hz, 1 H), 2.32 - 2.26 (m, 2 H), 2.24 - 2.11 (m, 3 H), 2.04 - 1.93 (m, 2 H), 1.85 (br. s., 1 H), 1.81 - 1.69 (m, 2 H), 1.68 - 1.63 (m, 1 H), 1.59 (td, *J* = 9.4, 13.4 Hz, 2 H), 1.38 - 1.23 (m, 2 H), 1.13 (d, *J* = 6.9 Hz, 3 H), 0.90 (t, *J* = 8.0 Hz, 9 H), 0.86 (s, 3 H), 0.55 (q, *J* = 7.9 Hz, 6 H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 214.5, 208.2, 179.2, 168.7, 139.4, 133.9, 132.3, 123.3, 96.0, 63.1, 58.1, 56.3, 54.4, 52.5, 40.8, 38.8, 36.8, 36.0, 32.3, 31.1, 29.1, 28.1, 25.9, 24.3, 20.3, 14.1, 6.9, 4.6. **HRMS(ES+)** *m/z* 664.3652 [$(M+H)^+$; calcd for $C_{38}H_{54}NO_7Si$: 664.3670].



Aldehyde (+)-31: To a solution of silyl ether (+)-**30** (7.4 mg, 0.011 mmol) in DMSO/THF (0.6 mL/0.3 mL) was added IBX (10.8 mg, 0.039 mmol) in one portion at

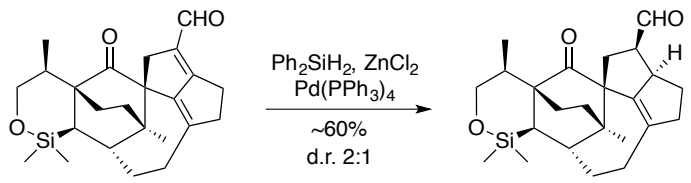
room temperature. The reaction mixture was stirred vigorously for 12 h, diluted with EtOAc (10 mL) and washed with H_2O (3 mL x 3). The aqueous layer was extracted with EtOAc (10 mL x 2) and the combined organic layers were dried over $MgSO_4$ and concentrated *in vacuo*. The residue was purified by flash chromatography on silica gel (1:1 hexanes/EtOAc) to afford the title compound (5.7 mg, 95%) as a colorless oil. $[\alpha]_D^{20}$ +56.0 (*c* 0.39 $CHCl_3$). **IR** (neat) 2933, 2827, 2726, 1771, 1714, 1469, 1441, 1400, 1377, 1358, 1150, 1100, 1037 cm^{-1}. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 9.72 (d, *J* = 0.6 Hz, 1 H), 7.82 (dd, *J* = 3.0, 5.4 Hz, 2 H), 7.69 (dd, *J* = 3.0, 5.5 Hz, 2 H), 4.74 (d, *J* = 7.1 Hz, 1 H), 4.64 (d, *J* = 7.1 Hz, 1 H), 3.97 (s, 1 H), 3.83 (dd, *J* = 10.4, 13.6 Hz, 1 H), 3.66 (dd, *J* = 2.8, 13.7 Hz, 1 H), 3.36 (s, 3 H), 3.17 (td, *J* = 6.5, 13.5 Hz, 1 H), 2.61 - 2.51 (m, 3 H), 2.43 (dd, *J* = 3.7, 6.0 Hz, 1 H), 2.42 - 2.38 (m, 1 H), 2.36 (td, *J* = 3.2, 6.1 Hz, 1 H), 2.25 - 2.16 (m, 3 H), 2.16 - 2.10 (m, 1 H), 2.07 - 1.98 (m, 2 H), 1.90 - 1.85 (m, 1 H), 1.78 (tt, *J* = 2.4, 14.2 Hz, 1 H), 1.71 - 1.64 (m, 1 H), 1.64 - 1.57 (m, 2 H), 1.13 (d, *J* = 6.9 Hz, 3 H), 0.87 (s, 3 H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 215.5, 208.4, 202.5, 180.5, 168.8, 139.0, 133.9, 132.3, 123.3, 95.9, 78.3, 57.4, 56.3, 54.5, 52.2, 40.9, 40.5, 38.6, 36.4, 36.1, 32.1, 31.1, 28.2, 26.0, 21.8, 20.2, 20.1, 13.8. **HRMS(ES+)** *m/z* 570.2472 [$(M+Na)^+$; calcd for $C_{32}H_{37}NO_7Na$: 570.2468].



Aldehyde (+)-32: To a solution of aldehyde (+)-**31** (10 mg, 0.018 mmol) in benzene (3.5 mL) was added a solution of dibenzylammonium trifluoroacetate (7.1 mg, 0.023 mmol) in CH_2Cl_2 (0.3 mL) at room temperature. The reaction mixture was heated to 50 °C for 17 h. The resulting bright yellow solution was cooled to room temperature, diluted with pH 5.0 citrate buffer (5 mL), and extracted with CH_2Cl_2 (10 mL x 2). The combined organic layers were dried over $MgSO_4$ and concentrated *in vacuo*. The residue was purified by preparative TLC (silica, 1:1 hexanes/EtOAc) to afford the product (5.3 mg) as a light yellow oil, along with recovered starting material (3 mg).

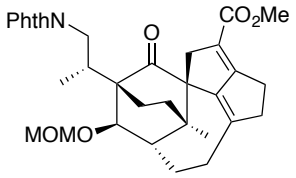
The recovered starting material (3 mg, 0.0055 mmol) was dissolved in PhH (1.5 mL) and a solution of dibenzylammonium trifluoroacetate (2.2 mg, 0.0071 μmol) in CH_2Cl_2 (0.2 mL) was added. The reaction mixture was heated to 50 °C for 21 hours. An identical workup and purification procedure provided a second batch of product (1.3 mg; total 6.6 mg, 69%). $[\alpha]_D^{20}$ +44.6 (*c* 0.15 $CHCl_3$). **IR** (neat) 2925, 2851, 1771, 1714, 1662, 1637, 1608, 1464, 1442, 1399, 1378, 1351, 1037 cm^{-1}. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 9.70 (s, 1 H), 7.82 (dd, *J* = 3.2, 5.4 Hz, 2 H), 7.69 (dd, *J* = 3.0, 5.4 Hz, 2 H), 4.79 (d, *J* = 7.1 Hz, 1 H), 4.66 (d, *J* = 7.1 Hz, 1 H), 4.06 (dd, *J* = 9.7, 13.5 Hz, 1 H), 4.06 (br. s., 1 H), 3.62 (dd, *J* = 3.1, 13.6 Hz, 1 H), 3.38 (s, 3 H), 3.07 - 2.92 (m, 3 H), 2.81 - 2.75 (m, 1 H), 2.41 - 2.31 (m, 1 H), 2.28 (ddd, *J* = 3.3, 11.3, 14.0 Hz, 1 H), 2.17 (d, *J* = 3.6 Hz, 1 H), 2.14 (s, 1 H), 2.11 - 2.02 (m, 1 H), 2.02 - 1.98 (m, 1 H), 1.98 - 1.88 (m, 2 H), 1.74 (ddd, *J* = 3.0, 11.5, 14.3 Hz, 1 H), 1.59 (ddd, *J* = 6.1, 11.5, 13.3 Hz, 1 H), 1.55 (s, 3 H), 1.11 (d, *J* = 6.9 Hz, 2 H), 0.90 (s, 3 H). **^{13}C NMR** (125 MHz, C_6D_6) δ 214.5, 185.4, 172.0, 168.2, 153.7, 146.7, 133.1, 132.5, 129.7, 122.7, 95.7, 74.5, 57.3, 55.6, 53.2, 51.4, 43.2, 41.4,

40.3, 37.0, 35.6, 31.8, 25.9, 24.2, 22.4, 21.9, 20.2, 13.5. **HRMS(ES+)** *m/z* 530.2548 [$(M+H)^+$; calcd for $C_{32}H_{36}NO_6$: 530.2543].



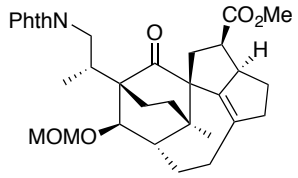
S5 **S6** (major)

Conjugate reduction of model aldehyde S5: To a solution of aldehyde **S5** (5.2 mg, 0.013 mmol) in $CHCl_3$ (0.3 mL) was added Ph_2SiH_2 (4.8 μL, 0.0262 mmol), wet $ZnCl_2$ (one small piece), and $Pd(PPh_3)_4$ (3 mg, 0.0026 mmol) sequentially at room temperature. The reaction mixture was stirred for 12 h and the volatiles were removed *in vacuo*. The residue was purified by flash chromatography on silica gel (8:1 hexa-nes/EtOAc) to afford aldehyde **S6** (2.6 mg, ca. 50%) which still contained inseparable impurities from the silyl reagent. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 9.75 (d, *J* = 3.0 Hz, 1 H), 3.92 - 3.83 (m, 1 H), 3.68 - 3.53 (m, 2 H), 2.96 - 2.89 (m, 1 H), 2.71 - 2.62 (m, 1 H), 2.59 (dd, *J* = 2.8, 14.3 Hz, 1 H), 2.41 - 2.36 (m, 1 H), 2.36 - 2.33 (m, 1 H), 2.26 - 2.20 (m, 1 H), 2.15 (dd, *J* = 8.9, 14.2 Hz, 1 H), 2.18 - 2.11 (m, 1 H), 2.09 - 2.05 (m, 1 H), 2.00 (ddd, *J* = 6.8, 12.0, 18.6 Hz, 1 H), 1.94 - 1.89 (m, 1 H), 1.75 - 1.62 (m, 3 H), 1.53 - 1.40 (m, 4 H), 1.05 (s, 3 H), 0.84 (d, *J* = 6.8 Hz, 3 H), 0.34 (s, 3 H), 0.21 (s, 3 H). Full details on the model system work will be published in the full account of this work.

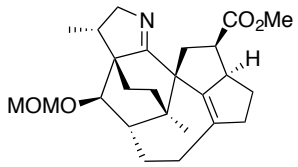


Ester (+)-2: To a solution of aldehyde (+)-**32** (6.6 mg, 12 μmol) in MeOH (1.0 mL) were added NaCN (11.8 mg, 0.24 mmol) and AcOH (10 μL, 0.18 mmol) sequentially. The yellow reaction mixture was stirred for 0.5 h before MnO_2 (73 mg, 0.84 mmol) was added in one portion. The resulting dark reaction mixture was vigorously stirred for 12 hours and filtered through a pad of celite, which was washed with CH_2Cl_2 (20 mL). After removal of the solvent *in vacuo*, the residue was purified by flash chromatography on silica gel (2:1 hexanes/EtOAc) to afford the title compound (5.5 mg, 82%) as a colorless oil. $[\alpha]_D^{20}$ +29.1 (*c* 0.15 $CHCl_3$). **IR** (neat) 2926, 2850, 1772, 1714, 1664, 1628, 1465, 1438, 1398, 1379, 1352, 1109, 1037 cm^{-1}. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.82 (dd, *J* = 3.1, 5.4 Hz, 2 H), 7.69 (dd, *J* = 3.1, 5.4 Hz, 2 H), 4.78 (d, *J* = 7.1 Hz, 1 H), 4.65 (d, *J* = 7.1 Hz, 1 H), 4.08 (dd, *J* = 9.4, 13.7 Hz, 1 H), 4.06 (br. s., 1 H), 3.70 (s, 3 H), 3.61 (dd, *J* = 3.0, 13.7 Hz, 1 H), 3.37 (s, 3 H), 3.09 - 2.93 (m, 2 H), 2.83 (m, 2 H), 2.68 (d, *J* = 3.2 Hz, 2 H), 2.36 - 2.27 (m, 1 H), 2.26 (ddd, *J* = 3.2, 11.2, 14.0 Hz, 1 H), 2.20 - 2.11 (m, 1 H), 2.11 - 2.00 (m, 2 H), 1.99 - 1.84 (m, 3 H), 1.73 (ddd, *J* = 3.4, 11.8, 15.0 Hz, 1 H), 1.61 - 1.53 (m, 1 H), 1.10 (d, *J* = 7.1 Hz, 3 H), 0.91 (s, 3 H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 216.2, 169.0, 168.6, 166.3, 152.2, 146.0, 133.8, 132.2, 123.1, 118.1, 96.0, 74.4, 57.5, 56.2,

53.4, 51.4, 51.1, 45.1, 41.8, 40.4, 37.2, 35.4, 31.9, 26.0, 25.5, 24.4, 22.0, 20.7, 13.4. **HRMS(ES+)** *m/z* 560.2651 [$(M+H)^+$; calcd for $C_{33}H_{38}NO_7$: 560.2648].



Ester (–)-33: To a solution of unsaturated ester (+)-**2** (5.8 mg, 0.010 mmol) in 1,2-dichloroethane (0.6 mL) was added [(cod)(py)(PCy_3)]IrBArF (15 mg, 0.010 mmol). The reaction mixture was placed in a Parr bomb and the bomb was pressurized to 900 psi of H_2. The reaction mixture was vigorously stirred at this pressure for 19 h. The volatiles were removed *in vacuo* and the residue was purified by flash chromatography on silica gel (4:1 hexanes/EtOAc) to afford the title compound (4.7 mg, 84%, 4:1 d.r.) as a colorless oil. The diastereomers were inseparable by flash chromatography but an analytically pure sample of the major diastereomer could be obtained by careful purification utilizing medium pressure liquid chromatography (4:1 hexanes/EtOAc). $[\alpha]_D^{20}$ –64.5 (*c* 0.27 $CHCl_3$). **IR** (neat) 2946, 2878, 2852, 1772, 1714, 1646, 1437, 1399, 1355, 1320, 1167, 1097, 1039 cm^{-1}. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.82 (dd, *J* = 3.0, 5.4 Hz, 2 H), 7.69 (dd, *J* = 3.0, 5.5 Hz, 2 H), 4.85 (s, 2 H), 4.14 (d, *J* = 4.6 Hz, 1 H), 3.85 (dd, *J* = 7.1, 13.9 Hz, 1 H), 3.78 (dd, *J* = 6.5, 13.9 Hz, 1 H), 3.60 (s, 3 H), 3.42 (s, 3 H), 3.06 - 2.98 (m, 1 H), 2.93 (ddd, *J* = 4.5, 9.1, 10.6 Hz, 1 H), 2.61 (dd, *J* = 7.1, 14.3 Hz, 1 H), 2.55 - 2.45 (m, 1 H), 2.38 (dd, *J* = 4.6, 13.7 Hz, 1 H), 2.35 - 2.24 (m, 3 H), 2.19 - 2.09 (m, 3 H), 2.09 - 2.01 (m, 1 H), 1.90 (dt, *J* = 1.8, 6.3 Hz, 1 H), 1.67 - 1.57 (m, 3 H), 1.51 - 1.42 (m, 2 H), 1.08 (s, 3 H), 1.06 (d, *J* = 7.3 Hz, 3 H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 215.3, 176.3, 168.7, 139.3, 135.5, 133.9, 132.4, 123.2, 97.0, 75.2, 61.4, 56.4, 54.8, 52.9, 51.3, 49.8, 43.0, 42.5, 41.3, 38.6, 38.0, 34.1, 33.4, 27.5, 25.8, 24.0, 23.2, 22.5, 14.4. **HRMS(ES+)** *m/z* 584.2618 [$(M+Na)^+$; calcd for $C_{33}H_{39}NO_7Na$: 584.2624].

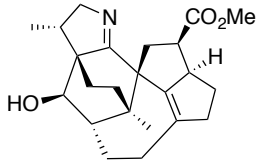


Imine (–)-34: To a solution of phthalimide (–)-**33** (4.7 mg, 0.0083 mmol) in absolute EtOH (1 mL) was added hydrazine hydrate (13 μL, 0.415 mmol) and the reaction mixture was stirred at room temperature for 12 h. The volatiles were removed *in vacuo* and the residue was redissolved in EtOH (2 mL). Saturated aqueous NH_4Cl (0.1 mL) was added and the resulting suspension was stirred at room temperature for 0.5 h. The reaction mixture was heated to 70 °C for 18 h, at which point LCMS analysis indicated complete consumption of the starting material. The reaction mixture was cooled to room temperature and partitioned between saturated aqueous Na_2CO_3 (5 mL) and CH_2Cl_2 (10 mL). The aqueous layer was extracted with CH_2Cl_2 (10 mL) and the combined organic layers were dried over $MgSO_4$ and concentrated *in vacuo*. The residue was purified by preparative TLC (1:1 hexanes/EtOAc) to afford the title compound (2.5 mg, 73% over 2 steps) as a colorless oil. $[\alpha]_D^{20}$ –101 (*c* 0.17 $CHCl_3$). **IR** (neat) 2947, 2928, 2865, 1733,

1644, 1436, 1371, 1318, 1192, 1167, 1099, 1048, 1019 cm^{-1}. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 4.80 (d, *J* = 6.7 Hz, 1 H), 4.71 (d, *J* = 6.7 Hz, 1 H), 3.94 (dd, *J* = 7.1, 15.3 Hz, 1 H), 3.83 (d, *J* = 4.6 Hz, 1 H), 3.64 (s, 3 H), 3.62 - 3.56 (m, 1 H), 3.44 (dd, *J* = 1.8, 15.3 Hz, 1 H), 3.41 (s, 3 H), 3.16 (dt, *J* = 4.8, 9.9 Hz, 1 H), 2.58 (dd, *J* = 5.0, 13.5 Hz, 1 H), 2.55 - 2.47 (m, 1 H), 2.35 (dd, *J* = 9.1, 13.5 Hz, 1 H), 2.32 - 2.27 (m, 1 H), 2.21 - 2.11 (m, 3 H), 2.05 (ddd, *J* = 1.8, 6.3, 8.5 Hz, 1 H), 2.02 - 1.96 (m, 1 H), 1.87 (td, *J* = 7.1, 11.9 Hz, 1 H), 1.80 (app t, *J* = 5.4 Hz, 1 H), 1.47 (ddd, *J* = 6.9, 11.3, 13.4 Hz, 1 H), 1.34 (ddd, *J* = 2.6, 11.1, 13.5 Hz, 1 H), 1.29 - 1.21 (m, 3 H), 1.10 (s, 3 H), 0.93 (d, *J* = 7.1 Hz, 3 H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 185.4, 176.3, 141.7, 132.5, 96.6, 75.3, 67.7, 56.3, 56.0, 54.5, 52.5, 51.1, 49.8, 42.6, 42.3, 39.7, 39.1, 37.4, 34.5, 27.5, 25.6, 24.4, 23.9, 22.1, 16.3. **HRMS(ES+)** *m/z* 414.2644 [$(M+H)^+$; calcd for $C_{25}H_{36}NO_4$: 414.2644].

Ph_2BBr

Bromodiphenylborane: The following procedure was slightly modified from a known protocol.[1] A 20 mL sealed tube was charged with $PhSiMe_3$ (4.1 mL, 24.0 mmol) and cooled to 0 °C. Boron tribromide (1.2 mL, 12.0 mmol) was added dropwise and the resulting mixture was allowed to warm to room temperature. The reaction mixture was heated to 180 °C for 18 h. The resulting black reaction mixture was cooled to room temperature and transferred to a 25 mL round bottomed flask via cannula. Trimethylsilyl bromide was distilled (bp 79 °C/760 torr) off, followed by a small amount of unreacted $PhSiMe_3$ (bp 60 °C/0.1 torr). The remaining residue was distilled (bp 120-122 °C/0.1 torr) to afford Ph_2BBr (2.67 g, 91%) as a colorless liquid which rapidly becomes a yellow and eventually red liquid upon storage. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 8.00 (dd, *J* = 1.3, 8.0 Hz, 2 H), 7.62 (tt, *J* = 1.2, 7.3 Hz, 1 H), 7.50 (t, *J* = 7.7 Hz, 2 H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 137.6, 133.2, 128.0.



(–)-Calyciphylline N (1): To a solution of imine (–)-**34** (2.5 mg, 0.006 mmol) in CH_2Cl_2 (1 mL) was added a freshly prepared solution of Ph_2BBr (1M/CH_2Cl_2, 30 μL, 0.030 mmol) at –40 °C. The resulting light yellow solution was allowed to warm to room temperature and stirred for an additional 0.5 h. The reaction was quenched by the addition of saturated aqueous $NaHCO_3$ (1 mL) and the emulsion was vigorously stirred at room temperature for 10 minutes. The reaction mixture was diluted with CH_2Cl_2 (5 mL) and saturated aqueous $NaHCO_3$ (5 mL). The layers were separated and the aqueous layer was extracted with CH_2Cl_2 (8 mL x 2). The combined organic layers were dried over $MgSO_4$ and concentrated *in vacuo*. The residue was purified by preparative TLC (100% EtOAc) to afford (–)-calyciphylline N (1.7 mg, 79%) as a colorless oil. $[\alpha]_D^{20}$ –85.3 (*c* 0.11 $CHCl_3$). **IR** (neat) 3358, 2923, 2859, 1733, 1667, 1642, 1554, 1461, 1436, 1373, 1318, 1192, 1168 cm^{-1}. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 4.01 - 3.99 (m, 1 H), 3.93, (dd, *J* = 7.0, 15.4 Hz, 1 H), 3.59 (s, 3 H), 3.56 - 3.52 (m, 1 H), 3.43 (dd, *J* = 1.2, 15.5 Hz, 1 H), 3.13 (ddd, *J* = 5.3, 9.3, 10.7 Hz, 1 H), 2.51 (dd, *J* = 5.2, 13.5 Hz, 1 H), 2.47 - 2.42 (m, 1

H), 2.30 (dd, *J* = 9.2, 13.6 Hz, 1 H), 2.25 (dd, *J* = 9.1, 15.5 Hz, 1 H), 2.19 - 2.09 (m, 3 H), 2.05 - 2.00 (m, 2 H), 1.89 - 1.85 (m, 1 H), 1.82 (dt, *J* = 7.3, 12.1 Hz, 1 H), 1.57 - 1.54 (m, 1 H), 1.42 - 1.38 (m, 1 H), 1.26 (ddd, *J* = 2.2, 11.1, 13.3 Hz, 1 H), 1.21 (m, 1 H), 1.19 - 1.15 (m, 1 H), 1.04 (s, 3 H), 0.97 (d, *J* = 7.1 Hz, 3 H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 185.3, 176.2, 141.4, 132.1, 68.0, 57.0, 54.4, 52.6, 51.9, 51.1, 42.7, 42.3, 39.5, 38.8, 37.0, 34.6, 27.4, 25.3, 23.4, 22.7, 21.5, 16.7. **HRMS(ES+)** *m/z* 370.2381 [$(M+H)^+$; calcd for $C_{23}H_{32}NO_3$: 370.2382].

^{1}H NMR shifts of (–)-calyciphylline N (natural vs. synthetic)

Chemical Shift (δ) Natural (–)-Calyciphylline N	**Chemical Shift (δ) Synthetic (–)-Calyciphylline N**	**Δ δ (ppm)**
4.00 (d, *J* = 5.9 Hz, 1 H)	4.00 (m, 1 H)	0
3.93 (dd, *J* = 6.8, 15.6 Hz, 1 H)	3.93, (dd, *J* = 7.0, 15.4 Hz, 1 H)	0
3.66 (s, 3 H)	3.59 (s, 3 H)	0.07
3.54 (m, 1 H)	3.56 - 3.52 (m, 1 H)	0
3.42 (dd, *J* = 1.4, 15.6 Hz, 1 H)	3.43 (dd, *J* = 1.2, 15.5 Hz, 1 H)	0.01
3.13 (m, 1 H)	3.13 (ddd, *J* = 5.3, 9.3, 10.7 Hz, 1 H)	0
2.53 (dd, *J* = 5.0, 13.6 Hz, 1 H)	2.51 (dd, *J* = 5.2, 13.5 Hz, 1 H)	0.02
2.48 (m, 1 H)	2.47 - 2.42 (m, 1 H)	0.03
2.31 (dd, *J* = 9.4, 13.6 Hz, 1 H)	2.30 (dd, *J* = 9.2, 13.6 Hz, 1 H)	0.01
2.27 (dd, *J* = 8.6, 14.6 Hz, 1 H)	2.25 (dd, *J* = 9.1, 15.5 Hz, 1 H)	0.02
2.12 (m, 2 H) 2.12 (m, 1 H)	2.19 - 2.09 (m, 3 H)	0.02
2.06 (m, 1 H) 2.01 (m, 1 H)	2.05 - 2.00 (m, 2 H)	-
1.88 (m, 1 H)	1.89 - 1.85 (m, 1 H)	0.01
1.81 (m, 1 H)	1.82 (dt, *J* = 7.3, 12.1 Hz, 1 H)	0.01
1.56 (m, 1 H)	1.57 - 1.54 (m, 1 H)	0
1.41 (m, 1 H)	1.42 - 1.38 (m, 1 H)	0.01
1.27 (m, 1 H)	1.26 (ddd, *J* = 2.2, 11.1, 13.3 Hz, 1 H)	0.01
1.20 (m, 1 H)	1.21 (m, 1 H)	0.01
1.16 (m, 1 H)	1.19 - 1.15 (m, 1 H)	0.01
1.04 (s, 3 H)	1.04 (s, 3 H)	0
0.97 (d, *J* = 6.9 Hz, 3 H)	0.97 (d, *J* = 7.1 Hz, 3 H)	0

^{13}C NMR shifts of (–)-calyciphylline N (natural vs. synthetic)

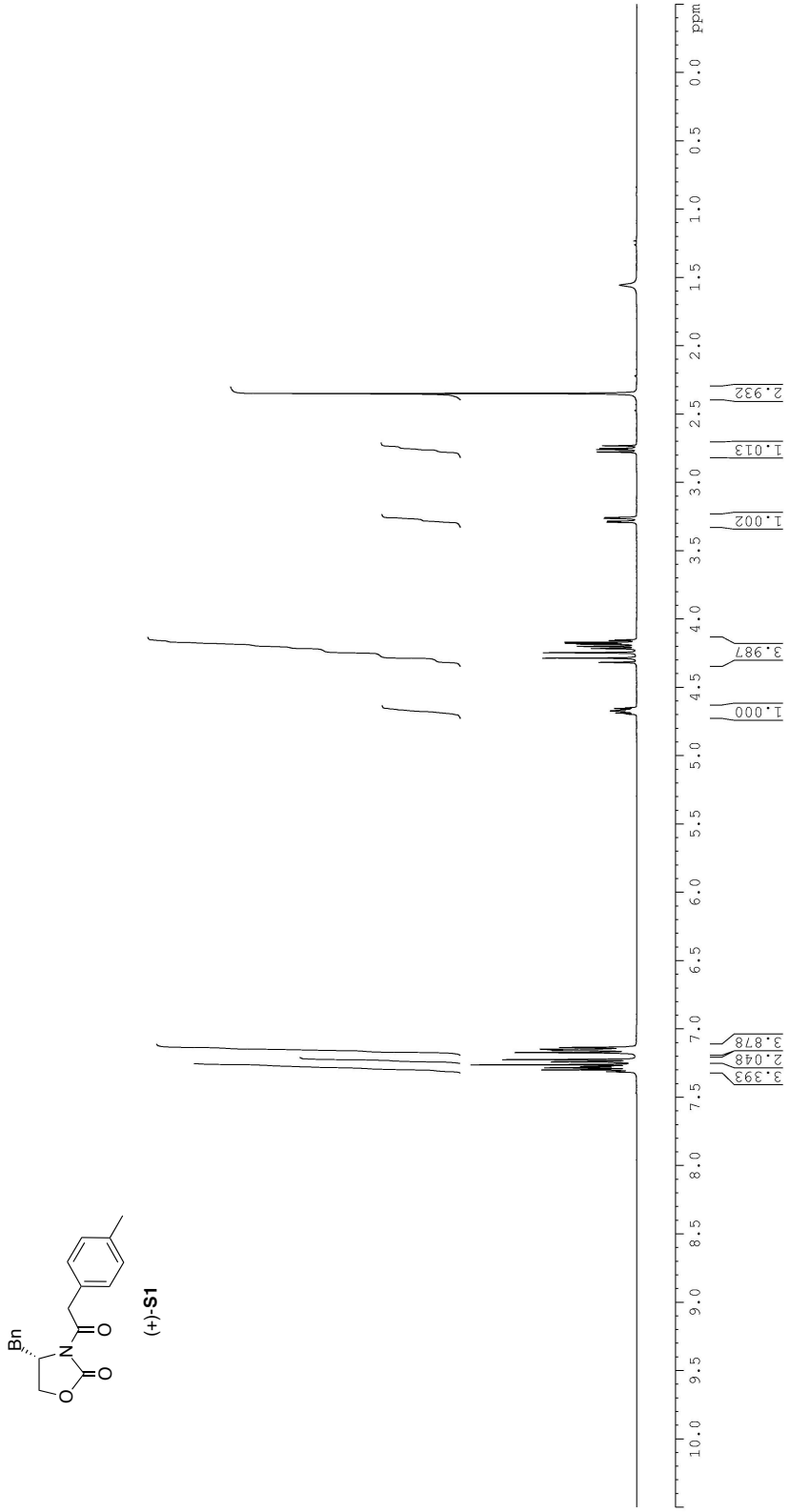
Chemical Shift (δ) Natural (–)-Calyciphylline N	**Chemical Shift (δ) Synthetic (–)-Calyciphylline N**	**Δ δ (ppm)**
185.7	185.3	0.4
176.2	176.2	0
141.2	141.4	0.2
132.2	132.1	0.1
67.6 67.8	68.0	0.2-0.4
57.0	57.0	0
54.3	54.4	0.1
52.6	52.6	0
51.8	51.9	0.1
51.0	51.1	0.1
42.7	42.7	0
42.2	42.3	0.1
39.4	39.5	0.1
38.8	38.8	0
37.0	37.0	0
34.6	34.6	0
27.3	27.4	0.1
25.2	25.3	0.1
23.3	23.4	0.1
22.8	22.7	0.1
21.4	21.5	0.1
16.6	16.7	0.1

3. References

1. Haubold, W.; Herdtle, J; Gollinger, W; Einholz, W. *J. Organomet. Chem.* **1986**, *315*, 1-8.

2. This ^{1}H NMR spectrum was referenced to $CDCl_3$ at δ 7.21.

Spectroscopic Data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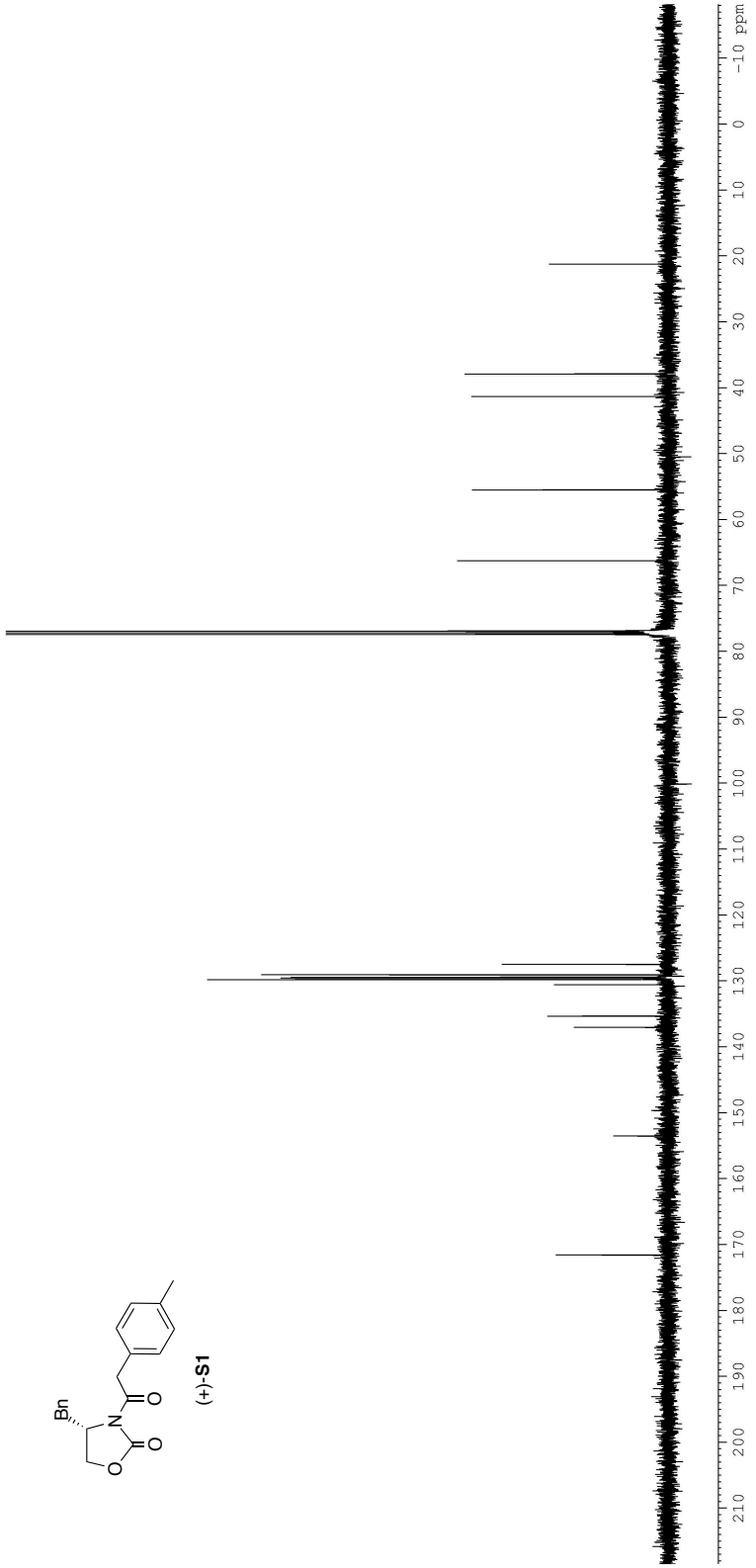
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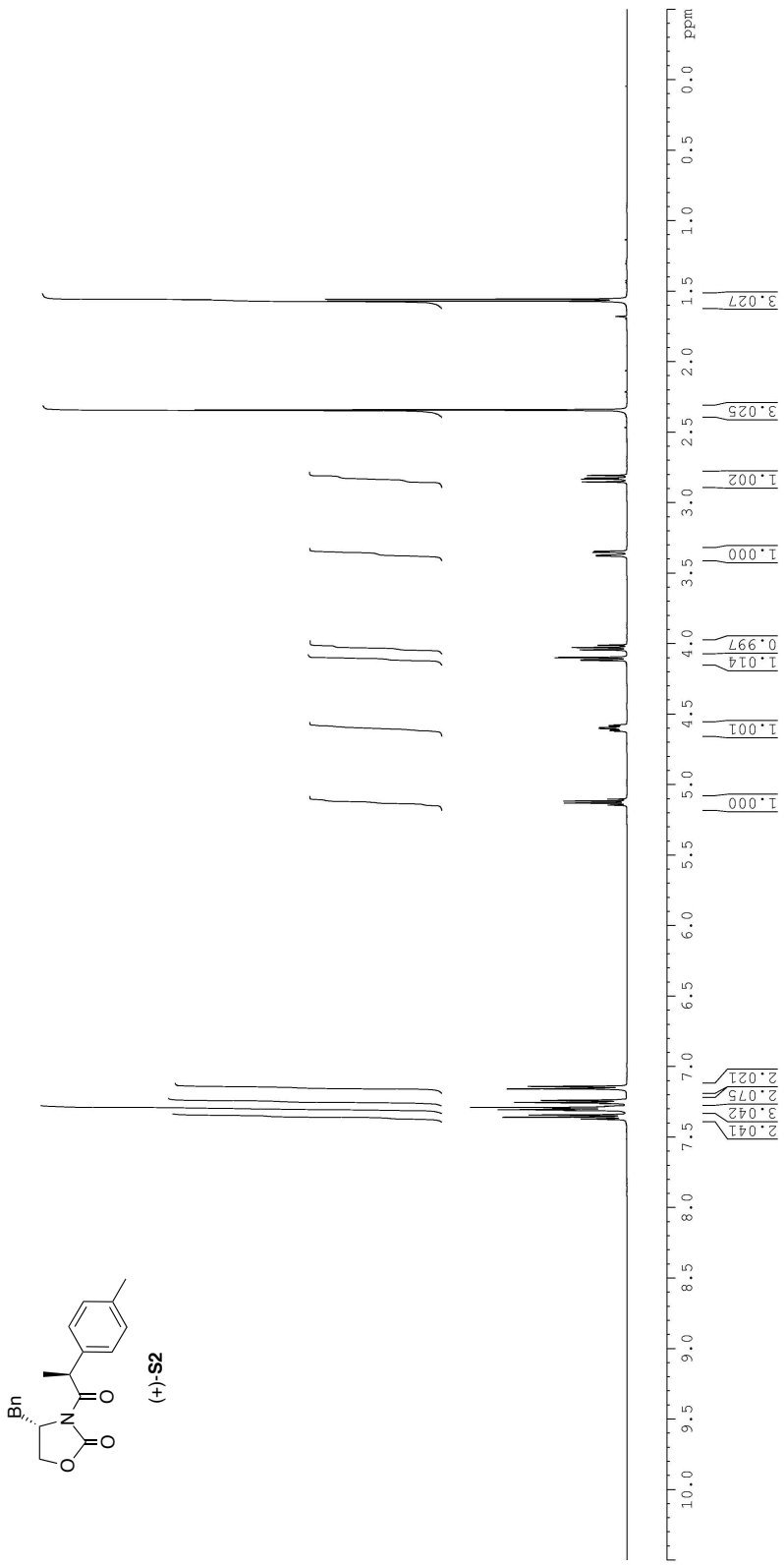
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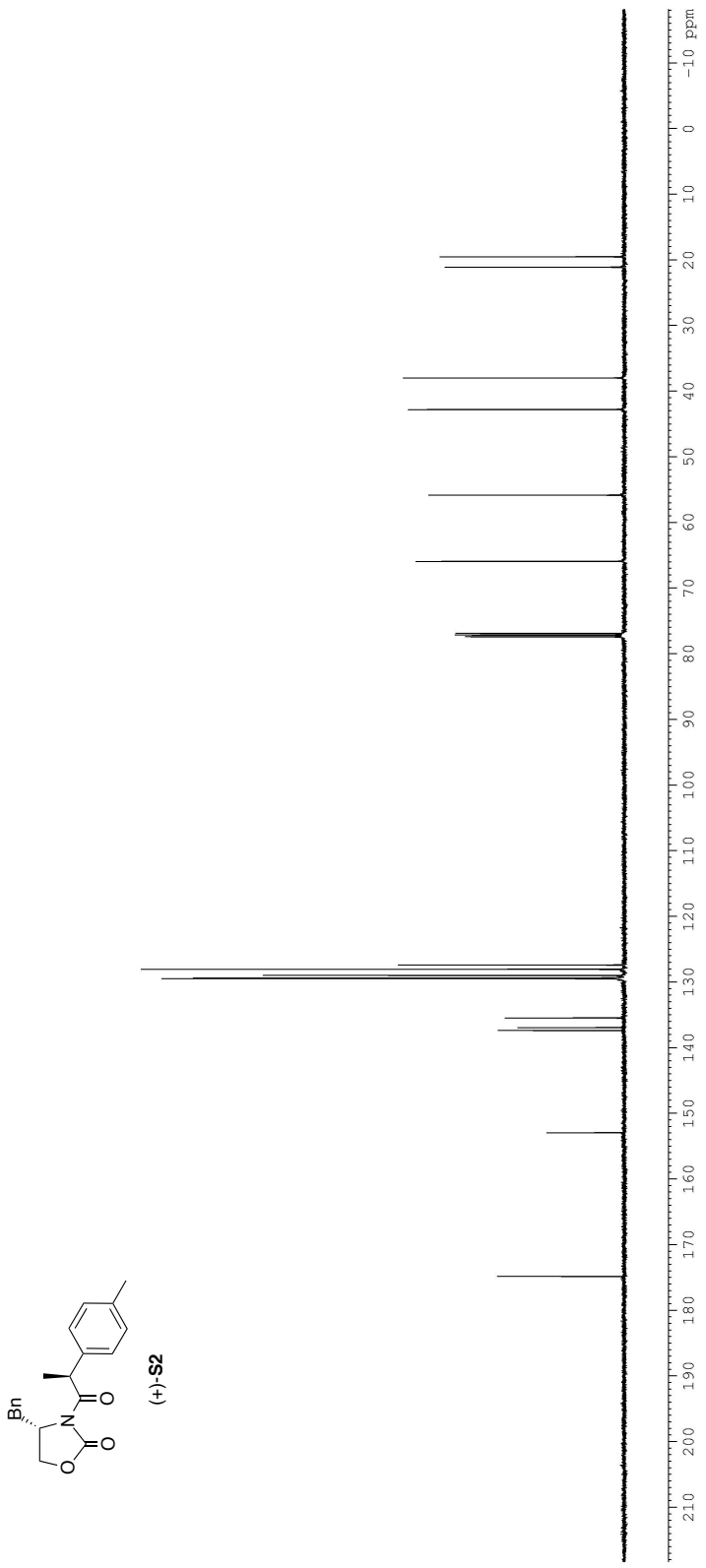
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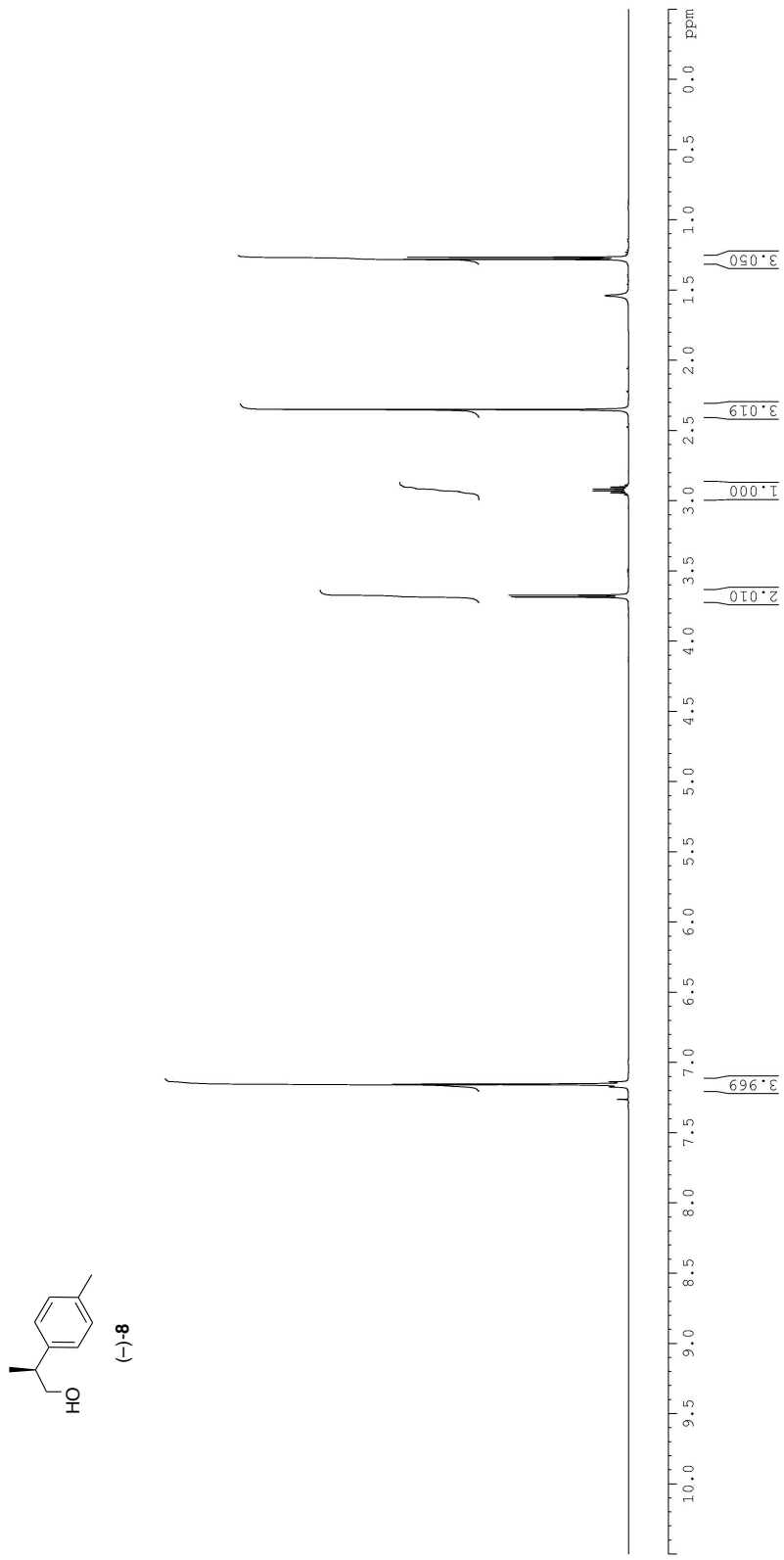
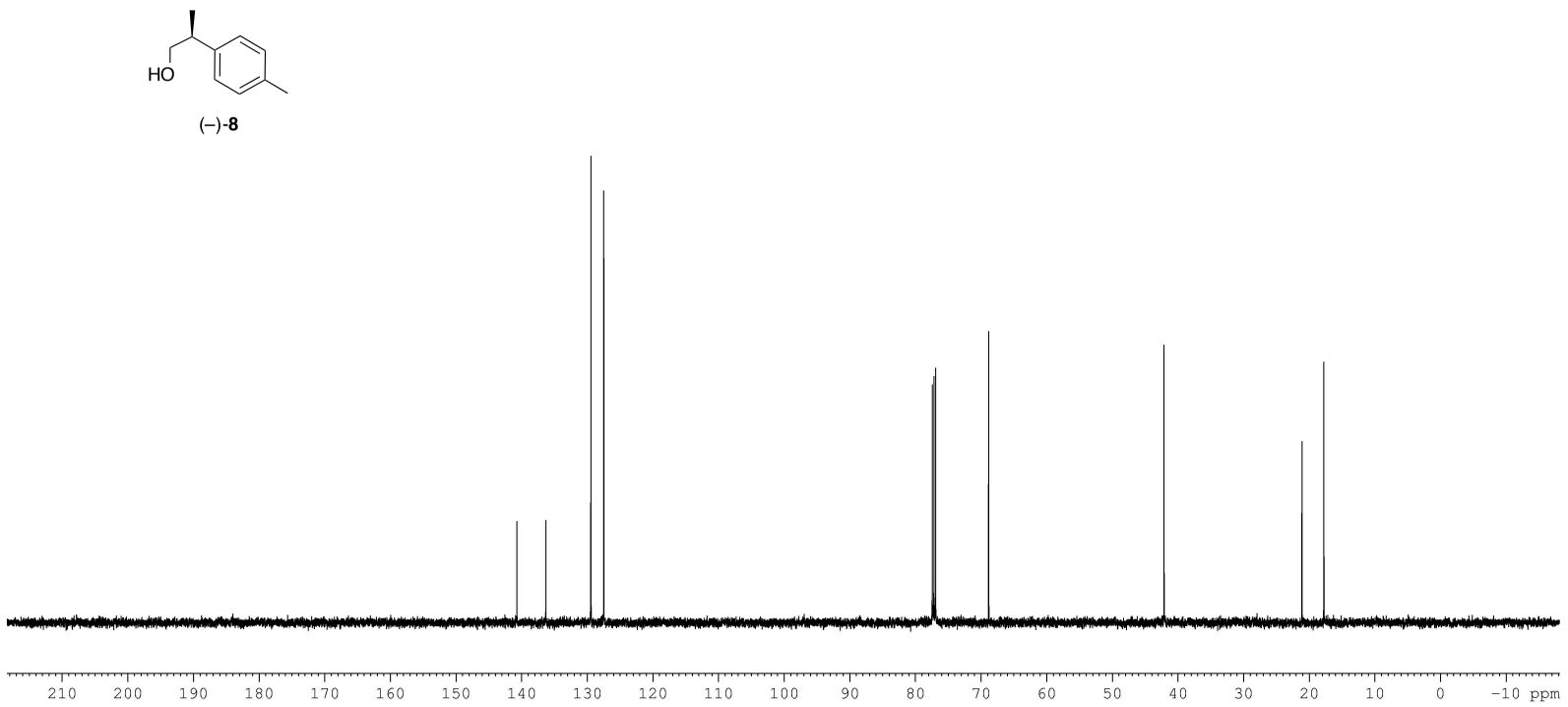


(–)-**8**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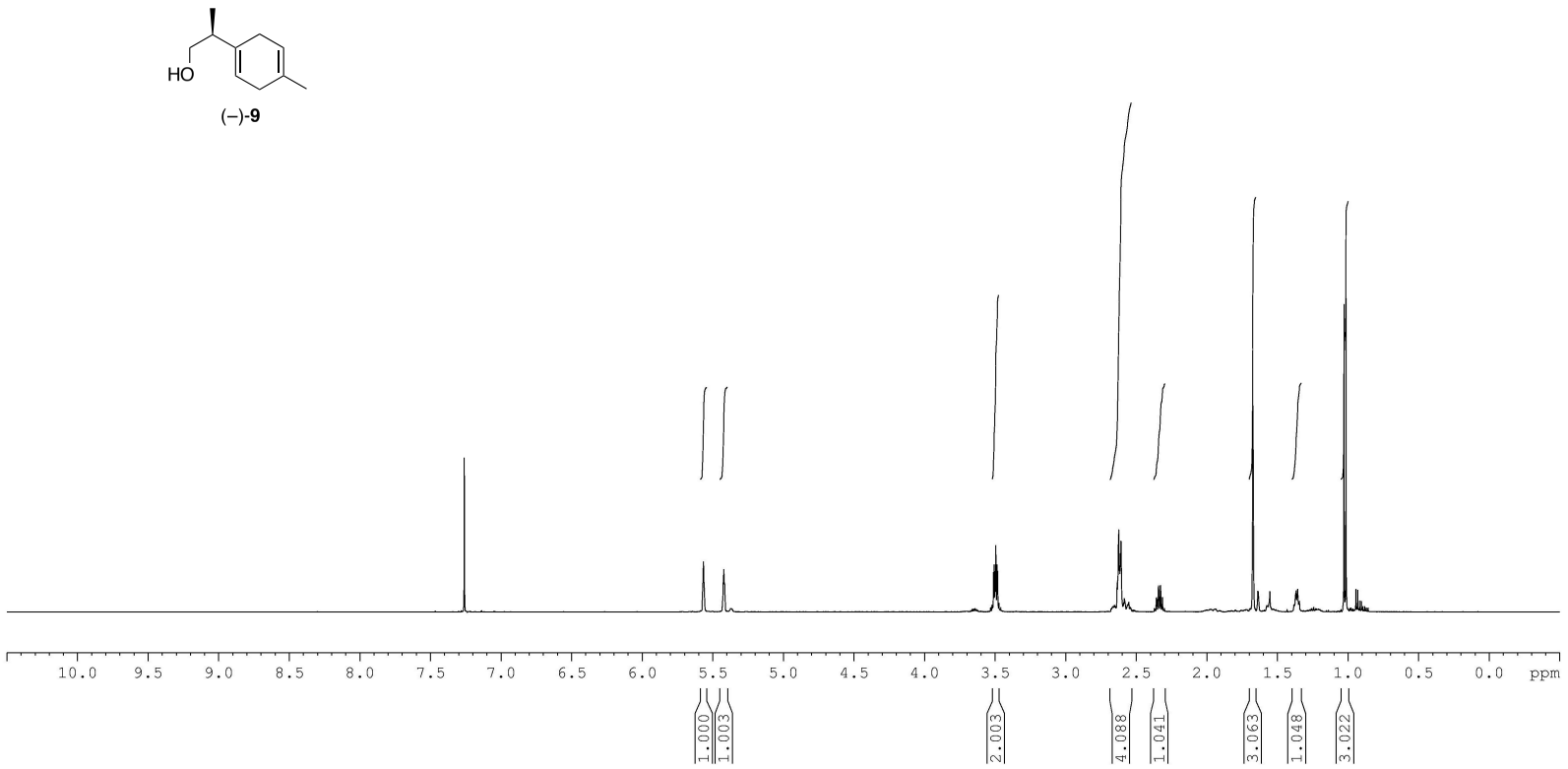
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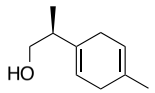
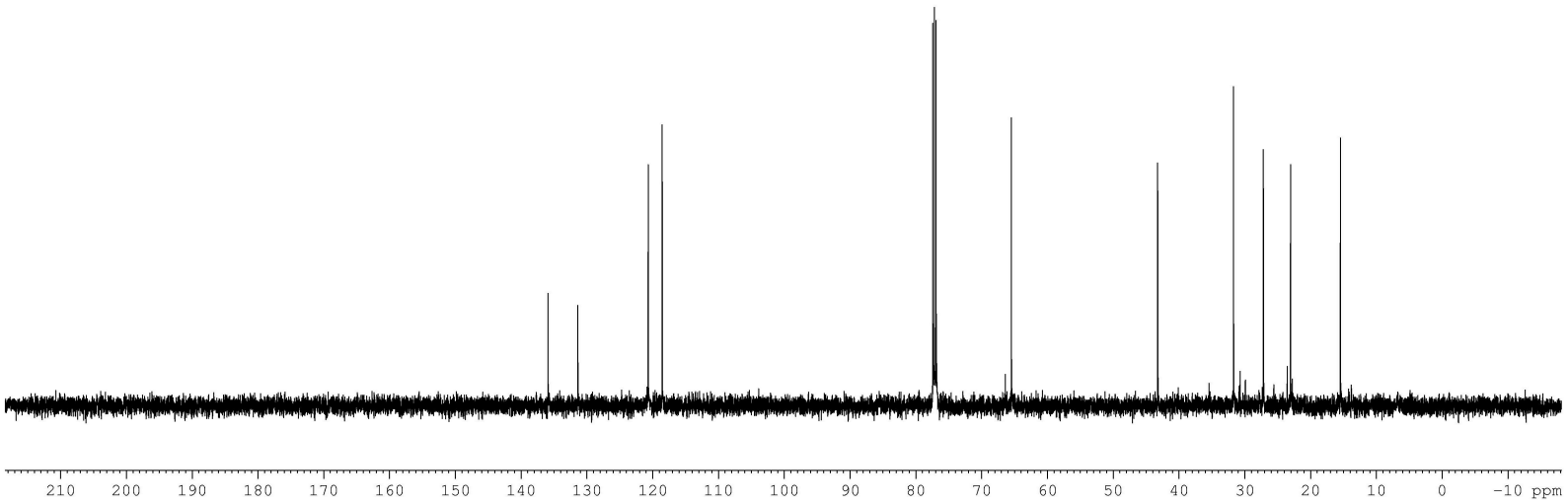

HO

(–)-**9**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200
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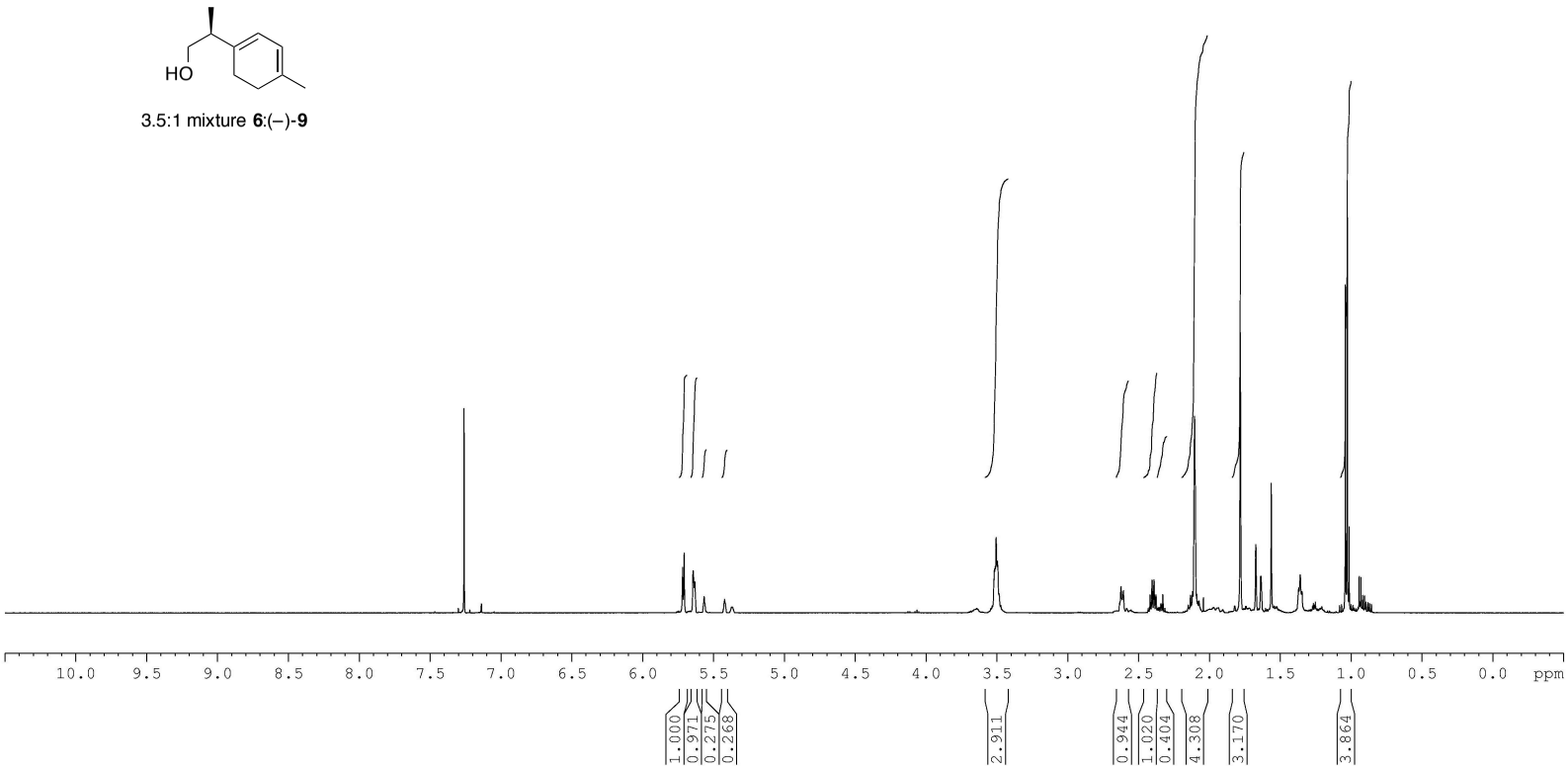
0
−10 ppm


HO
3.5:1 mixture 6:(–)-9
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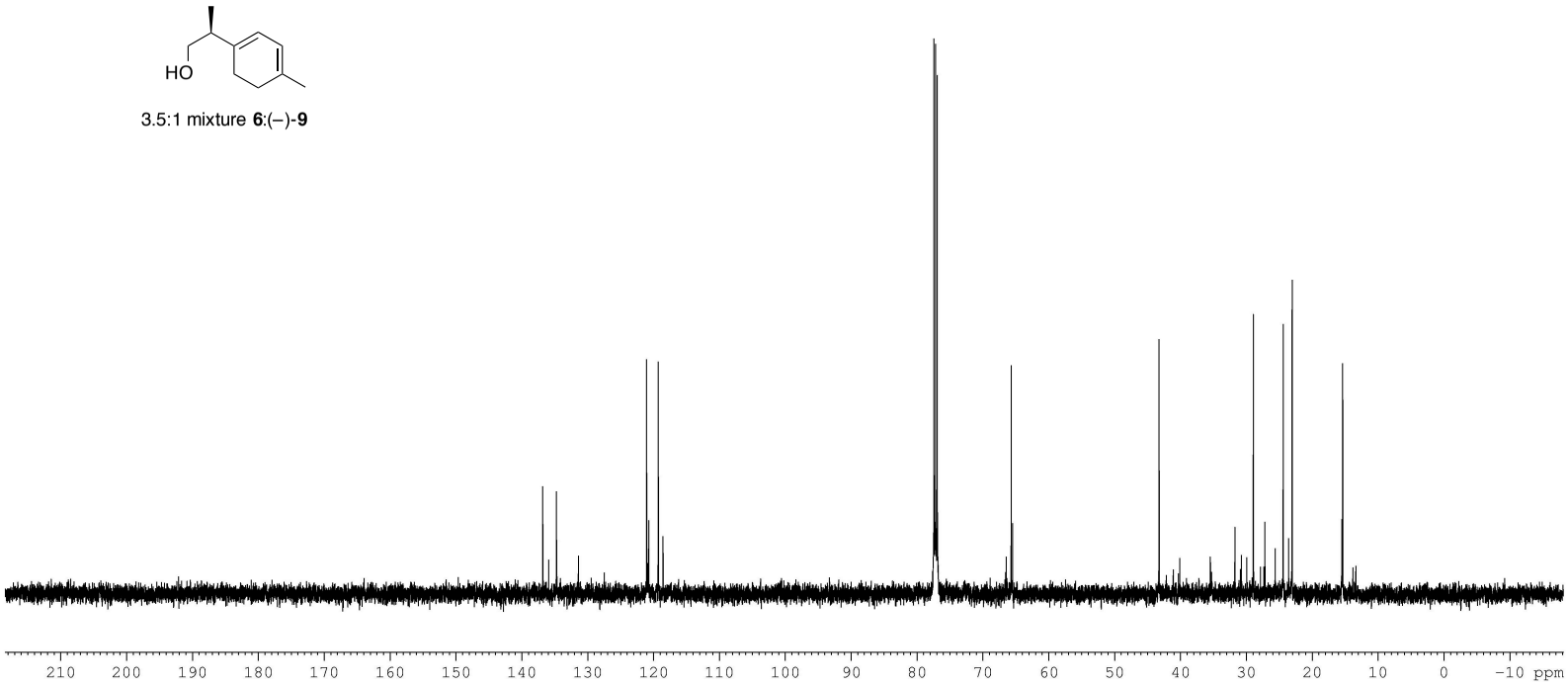
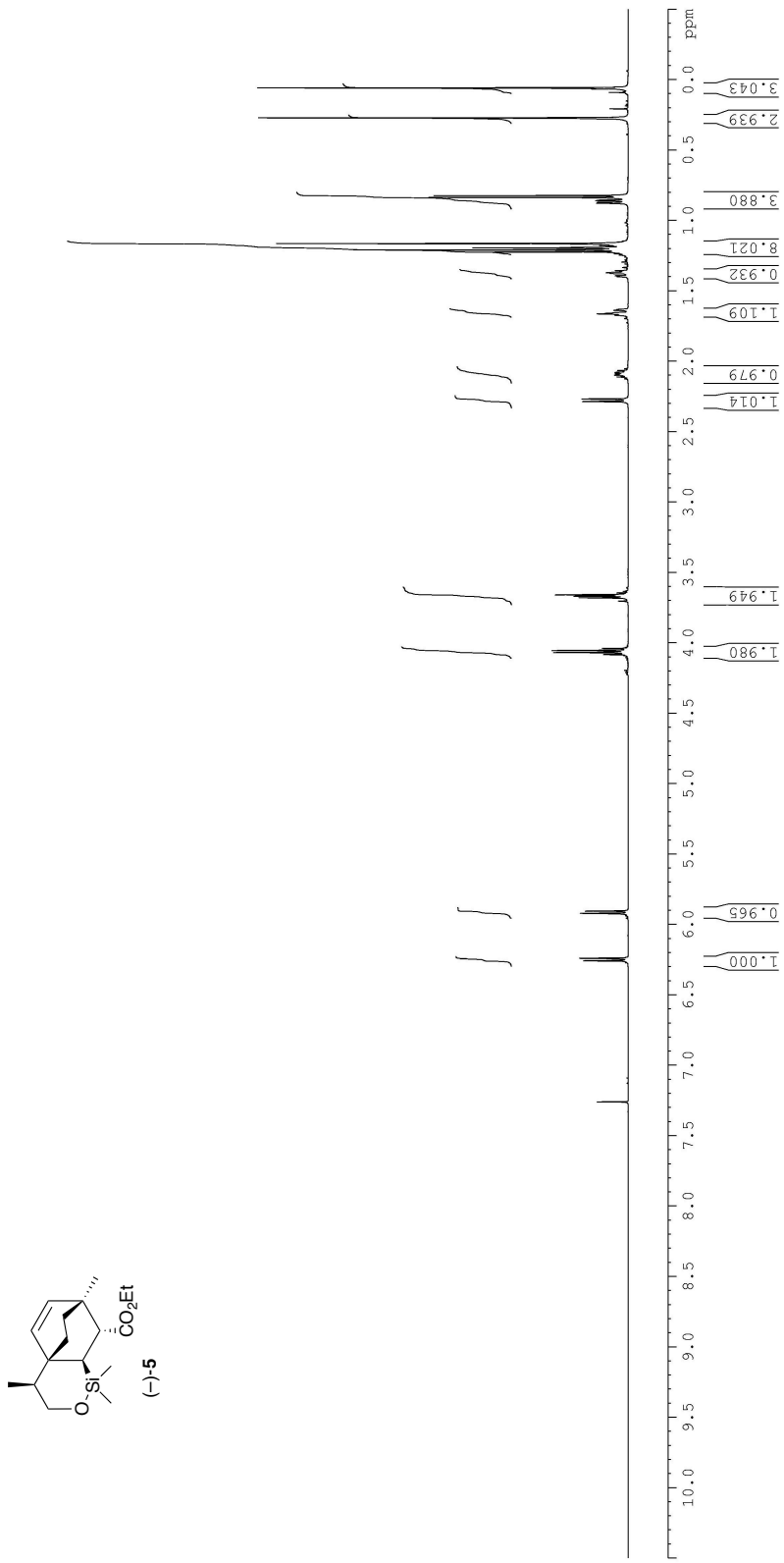
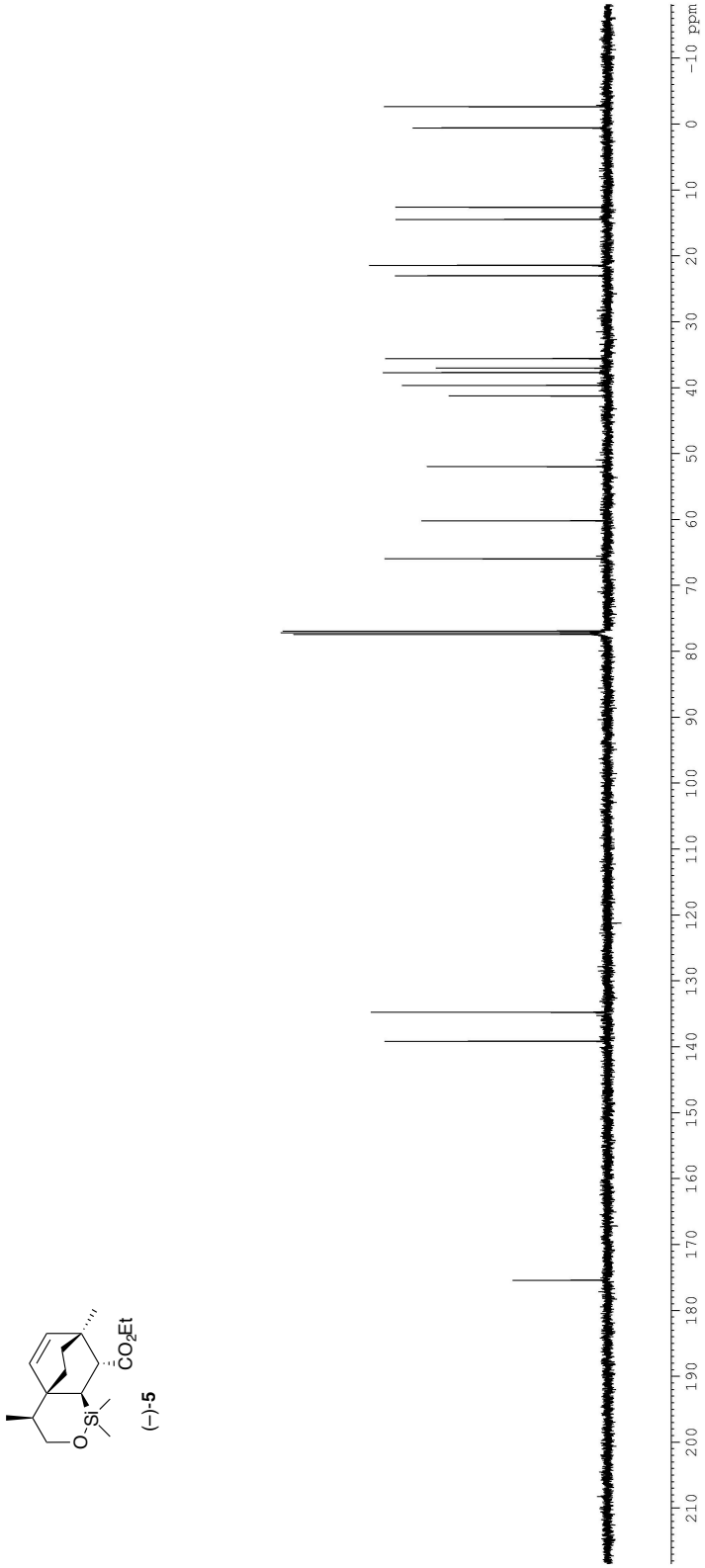
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
ppm
1.000
0.971
0.275
0.268
2.911
0.944
1.020
0.404
4.308
3.170
3.864

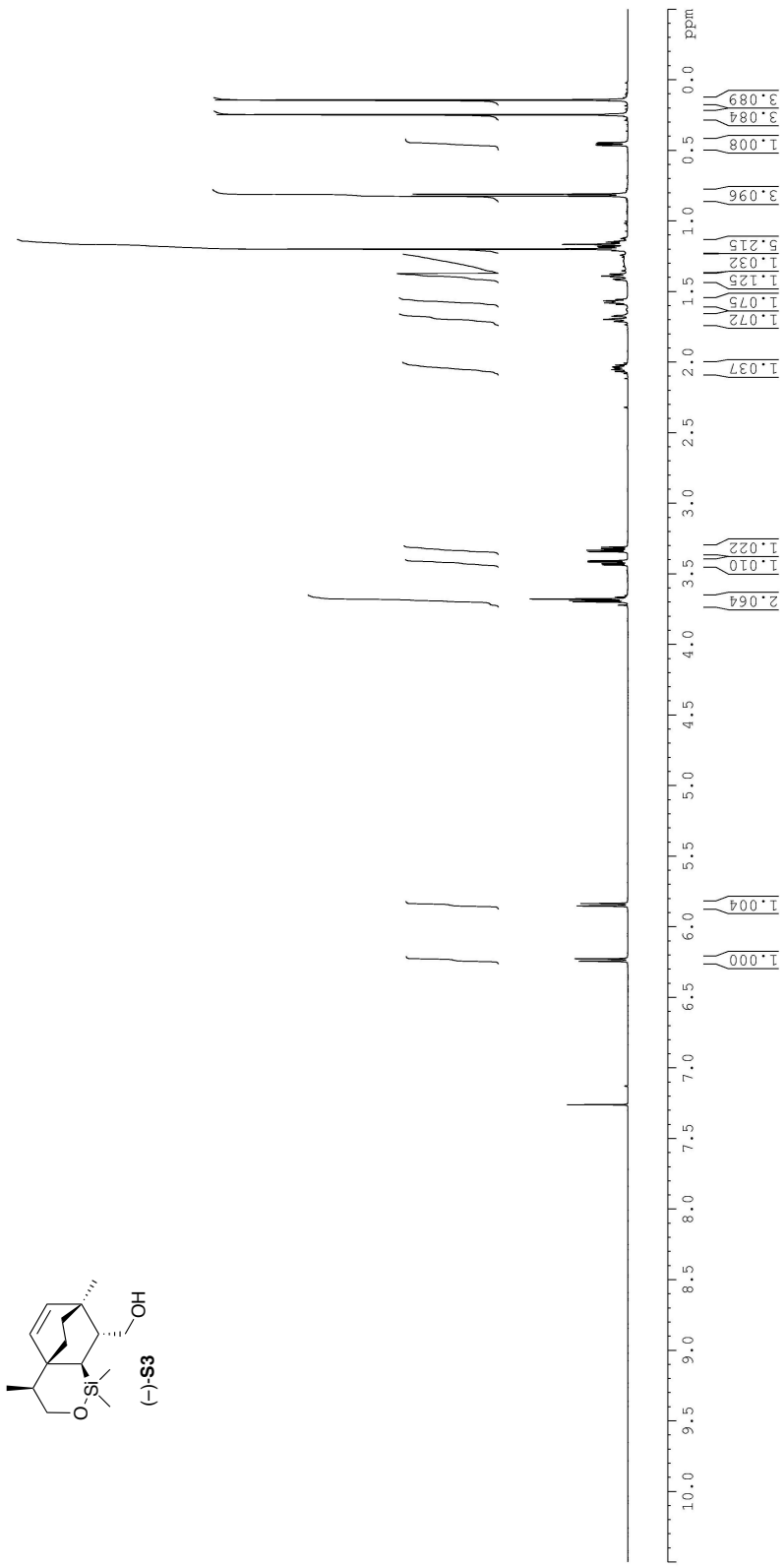


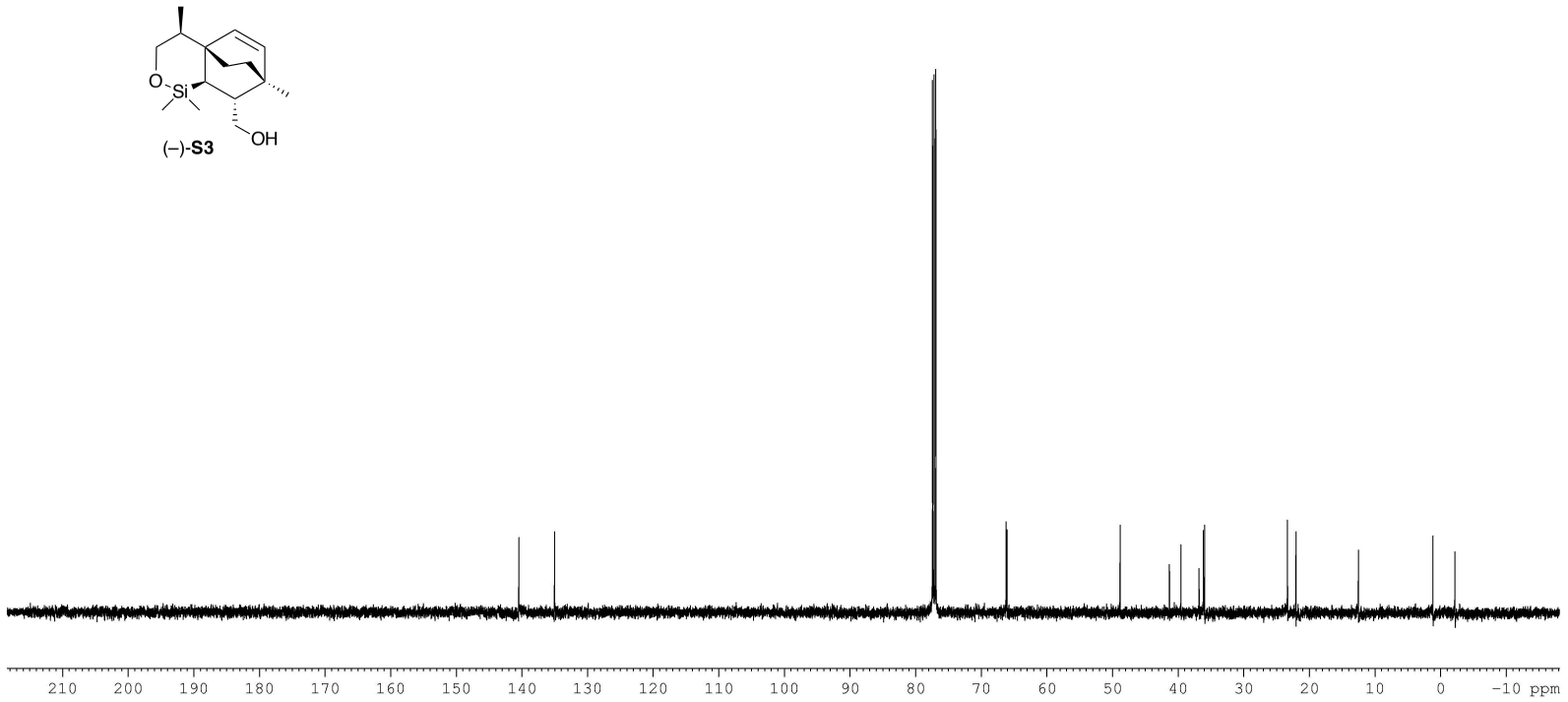
3.5:1 mixture **6**:(−)-**9**

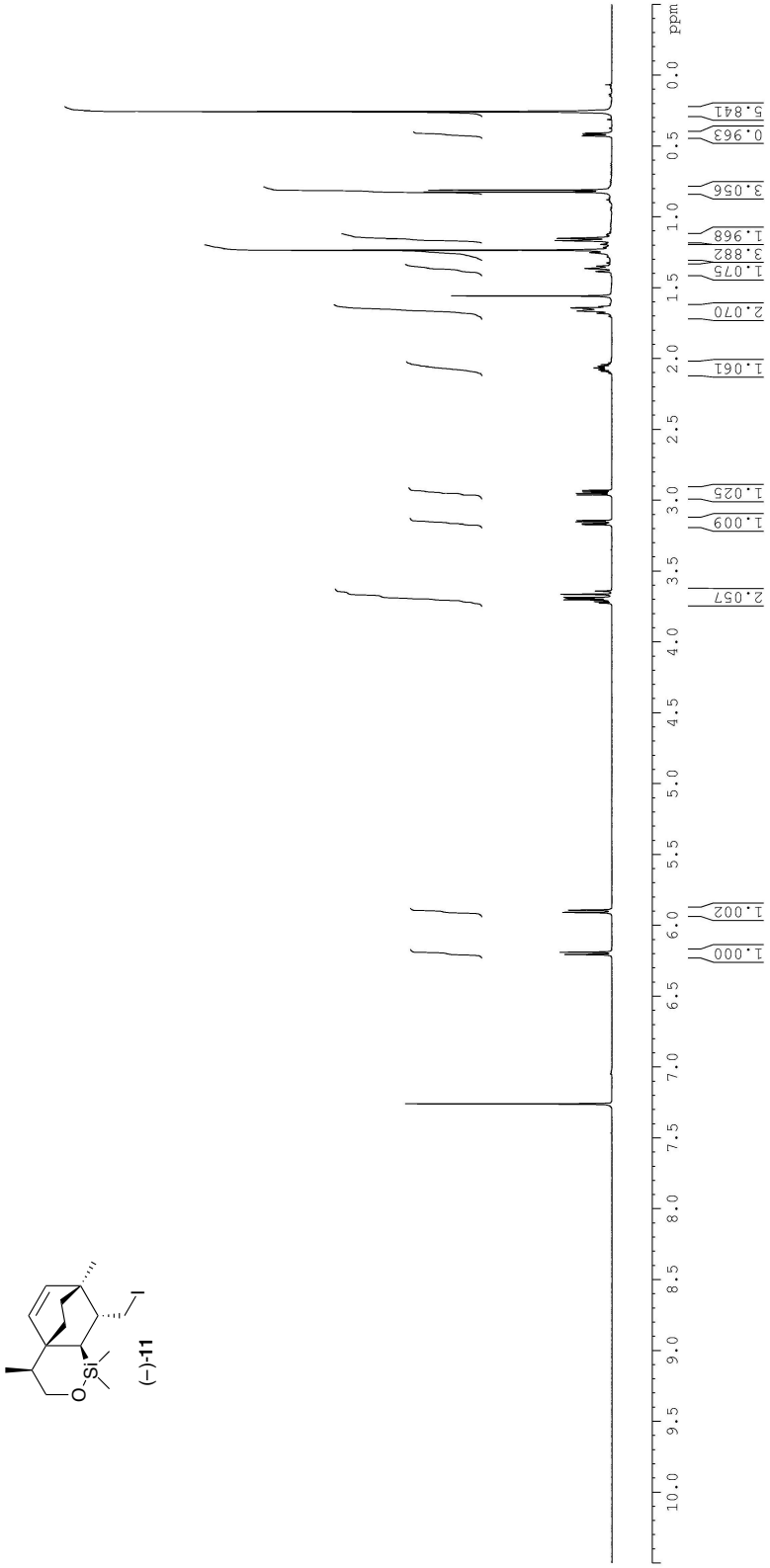

ppm
3.043
2.939
3.880
8.021
0.932
1.109
0.979
1.014
1.949
1.980
0.965
1.000
CO2Et
O
Si

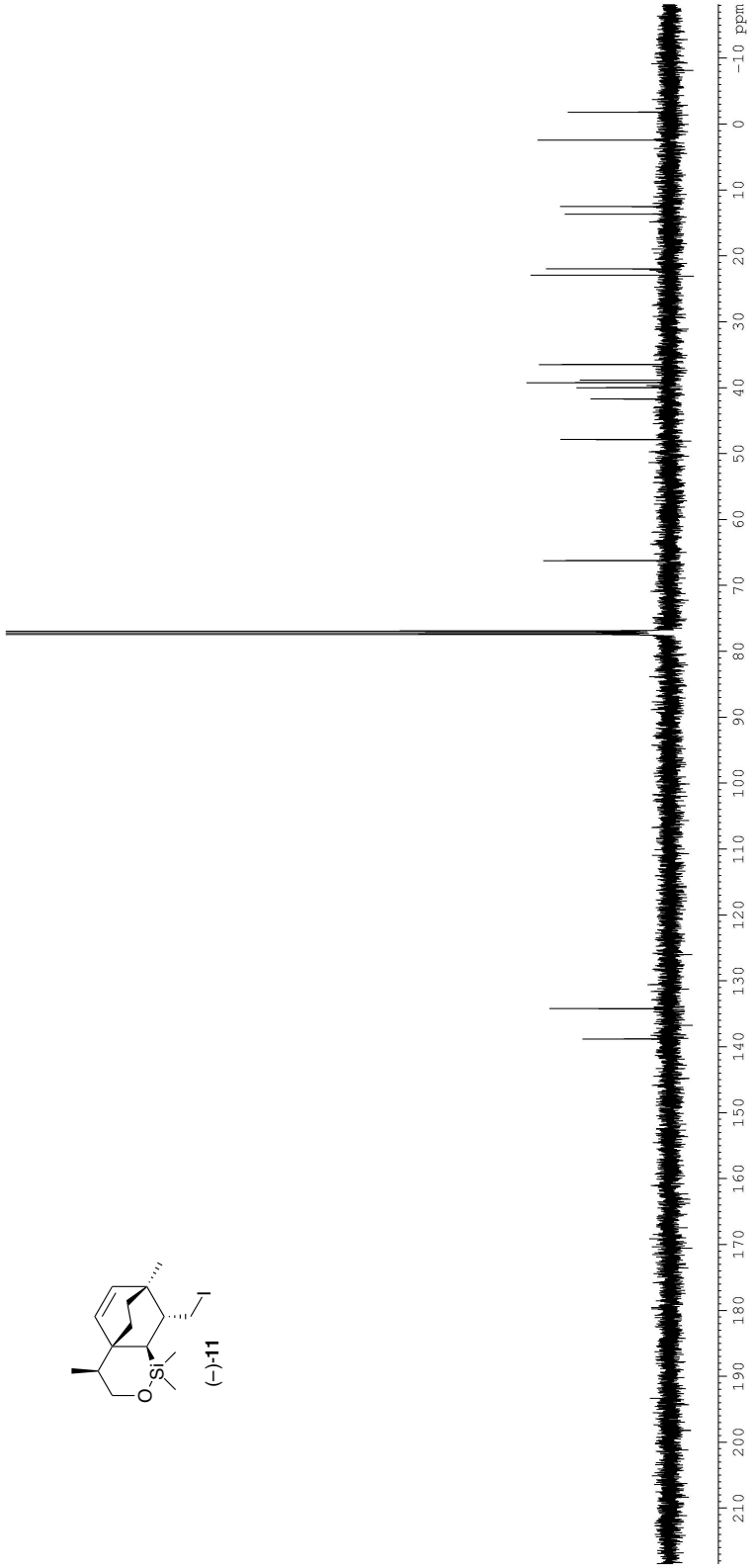
(–)-**5**

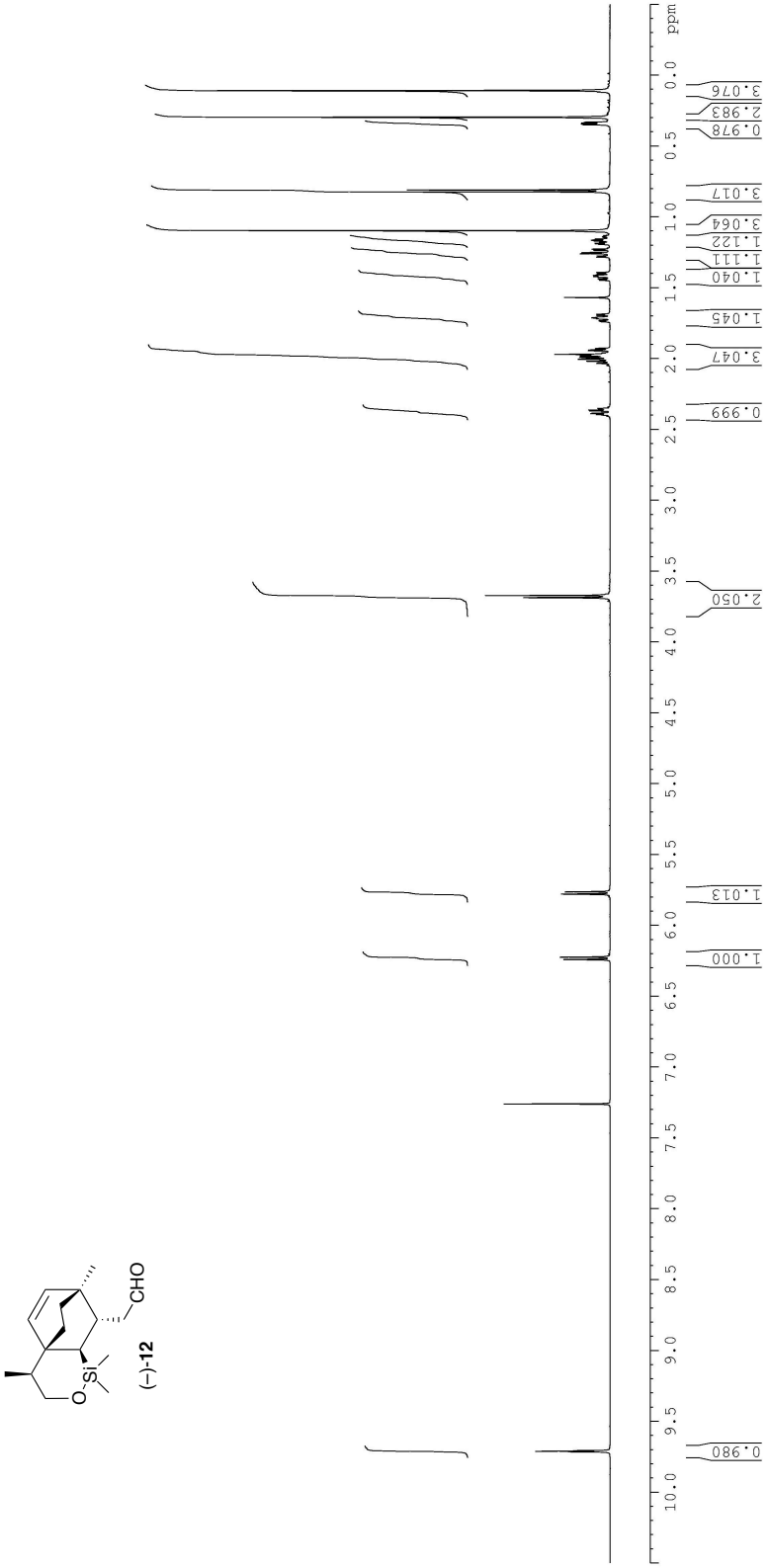

CO2Et
Si
O
(–)-5
ppm

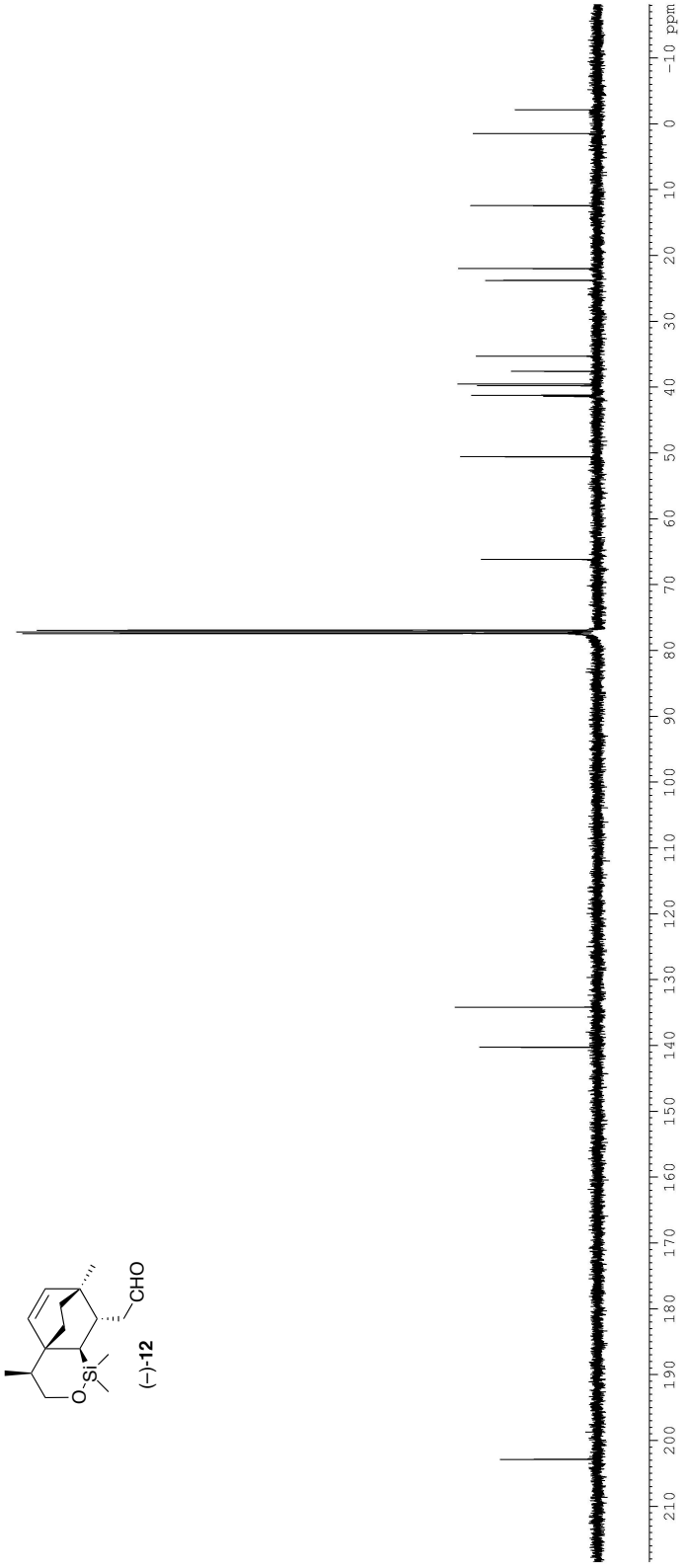

OH
Si
O
(−)-S3
ppm
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1.000
1.004
2.064
1.010
1.022
1.037
1.072
1.075
1.125
1.032
5.215
3.096
1.008
3.084
3.089

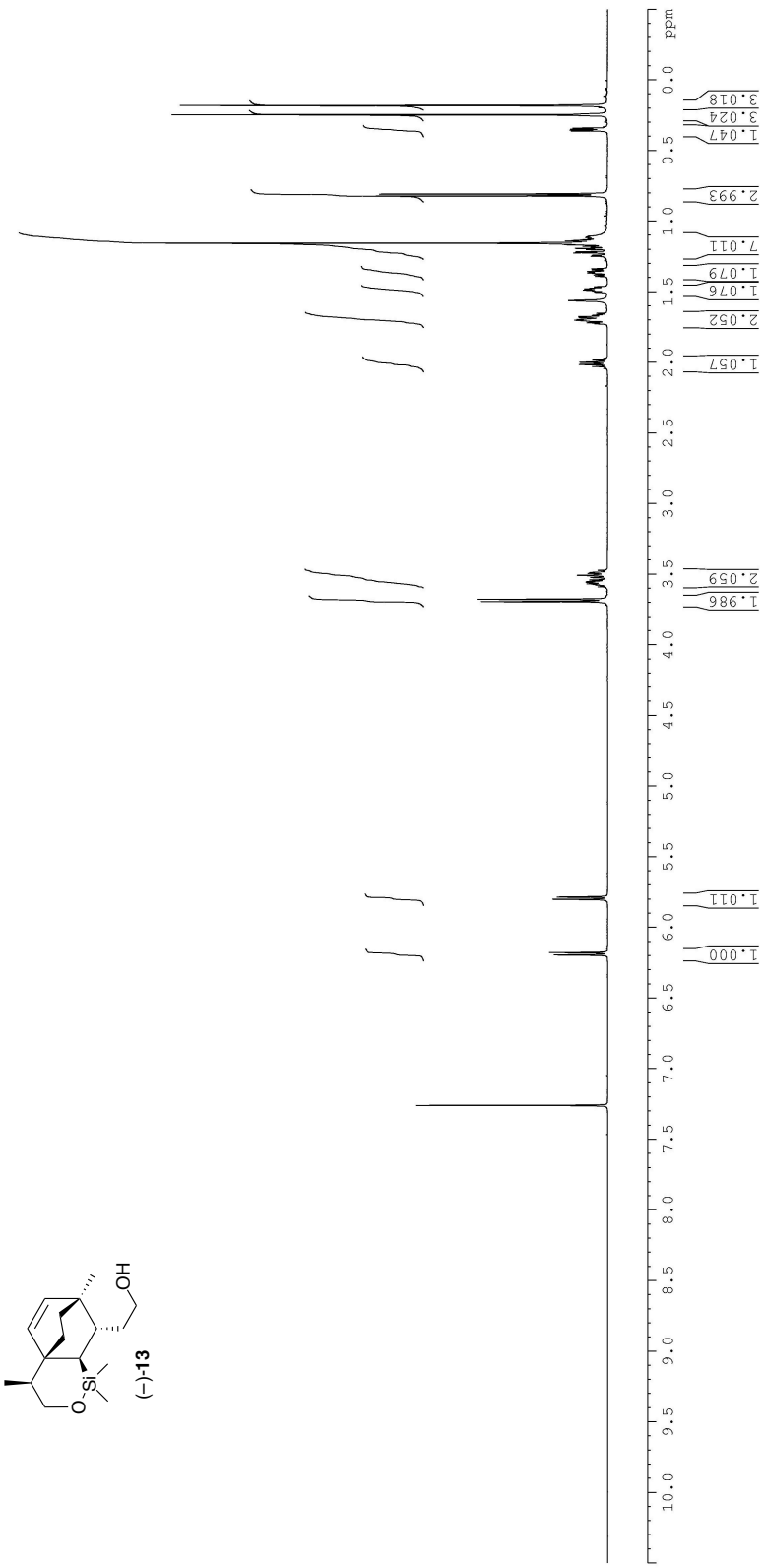

O
Si
OH
(–)-S3
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10 ppm

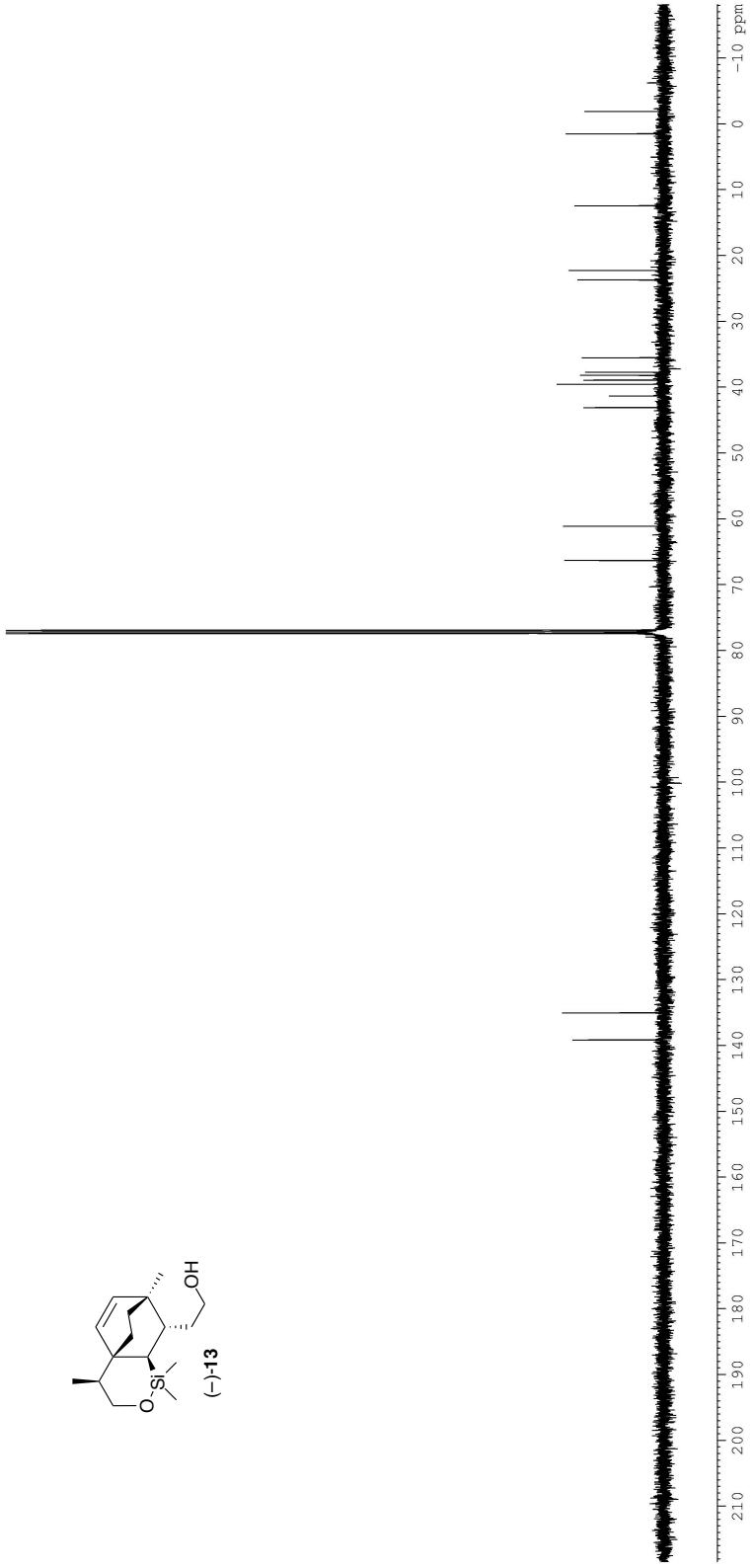

(−)-11
I
Si
O
ppm
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
8.5
9.0
9.5
10.0
5.841
0.963
3.056
1.968
3.882
1.075
2.070
1.061
1.025
1.009
2.057
1.002
1.000

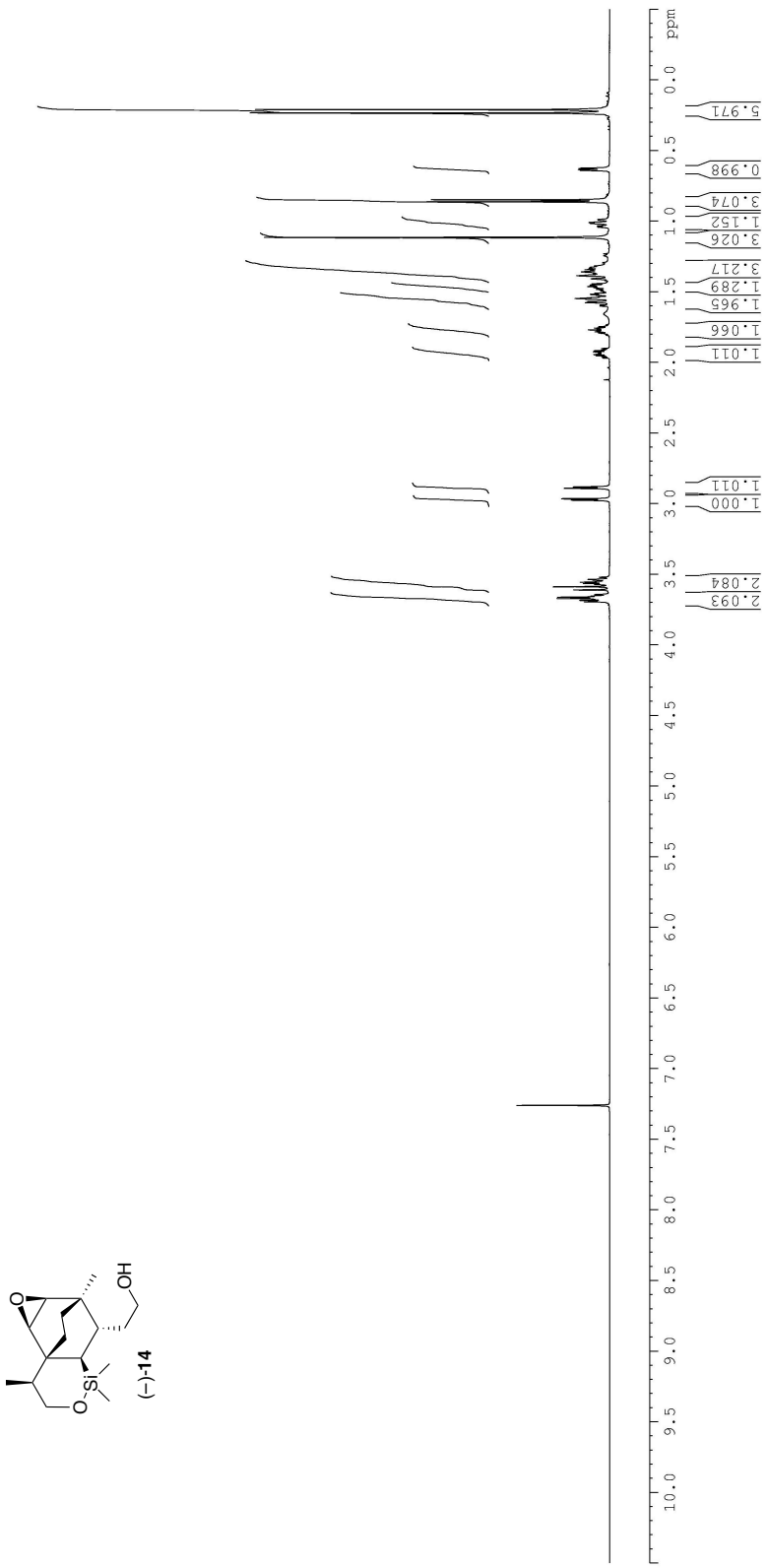

(–)-11
I
Si
O
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
–10 ppm

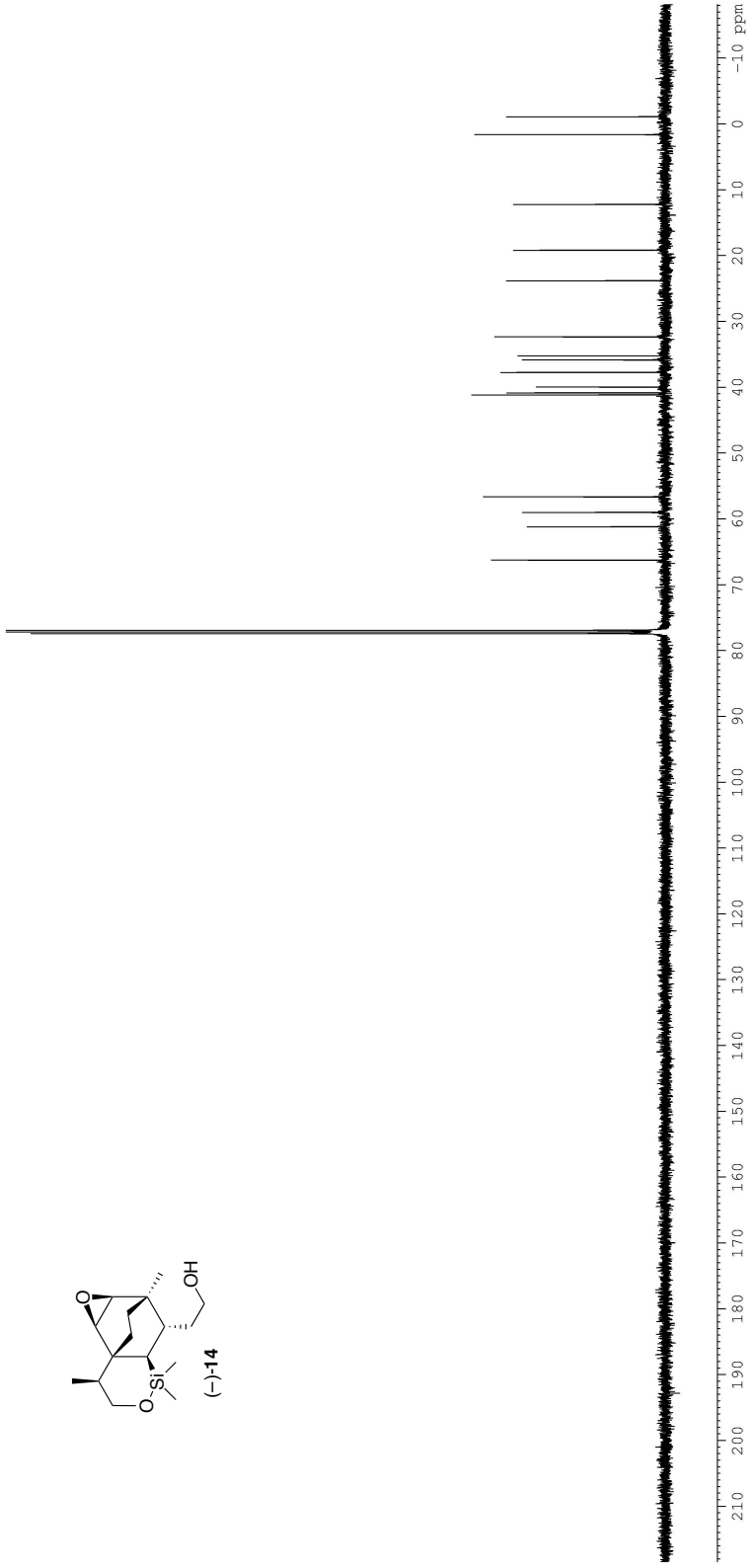

CHO
O
Si
(−)-12
ppm
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
8.5
9.0
9.5
10.0
3.076
2.983
0.978
3.017
3.064
1.122
1.111
1.040
1.045
3.047
0.999
2.050
1.013
1.000
0.980

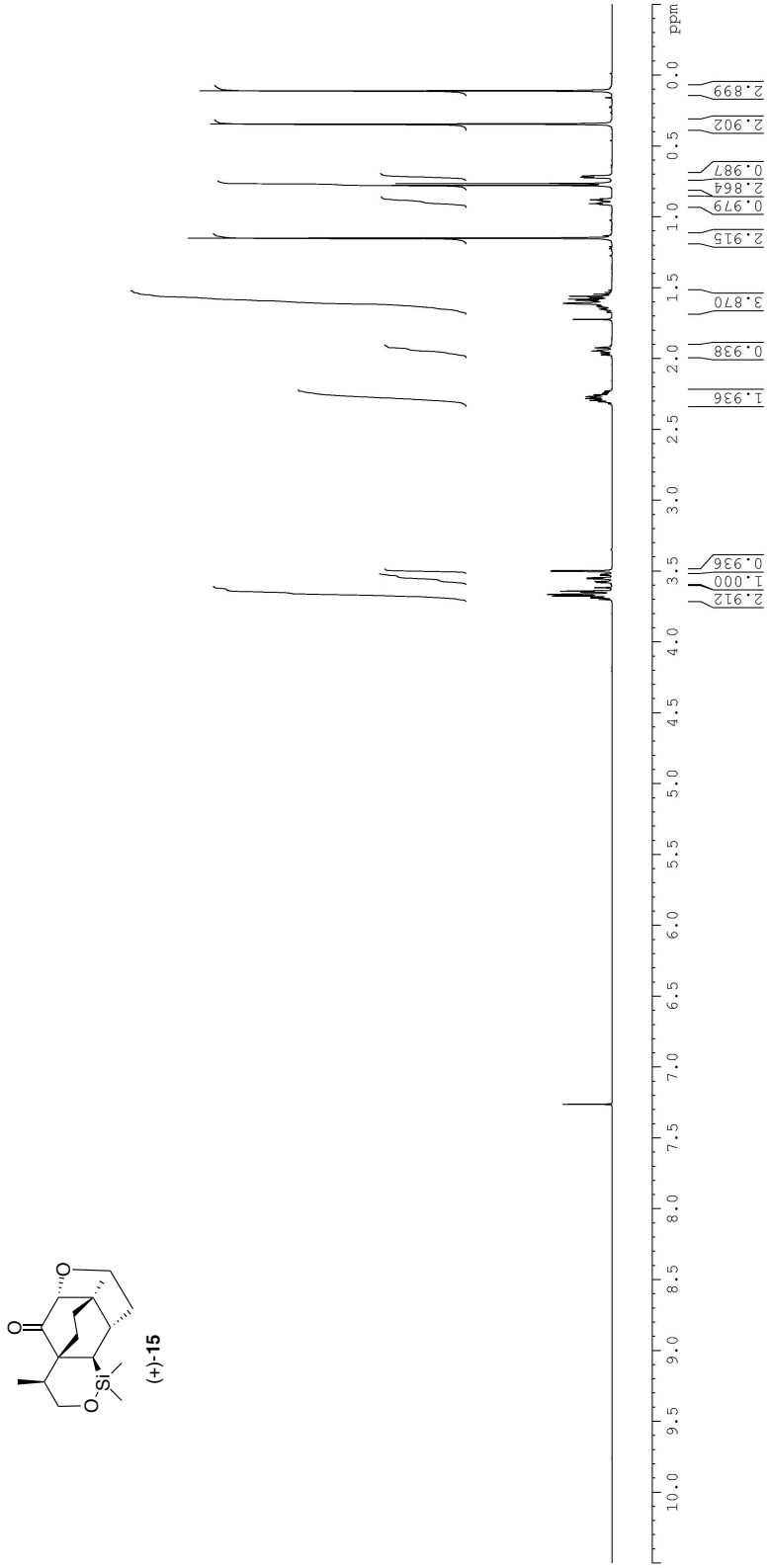

CHO
O
Si
(–)-12
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
–10 ppm


OH
O
Si
(−)-13
ppm
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
8.5
9.0
9.5
10.0
3.018
3.024
1.047
2.993
7.011
1.079
1.076
2.052
1.057
2.059
1.986
1.011
1.000

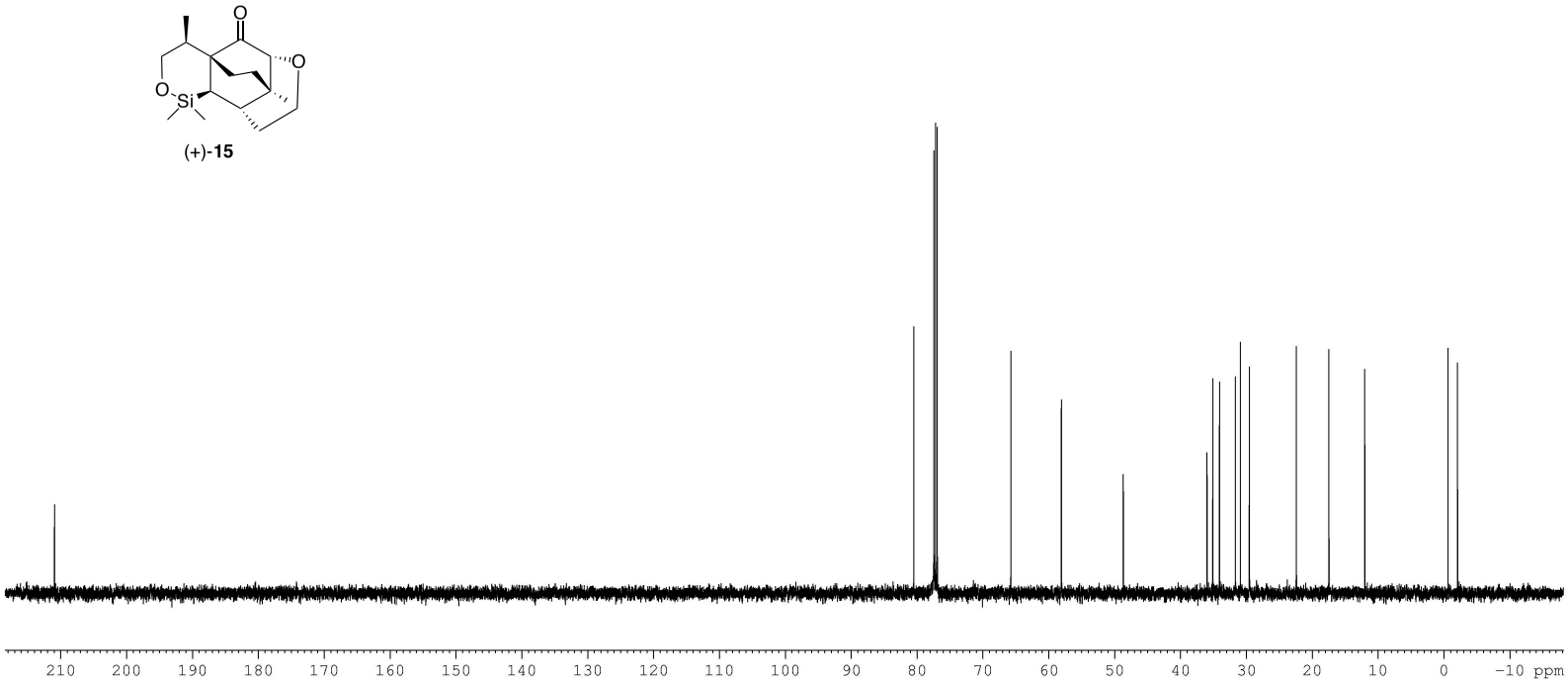

OH
O
Si
(−)-13
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10 ppm

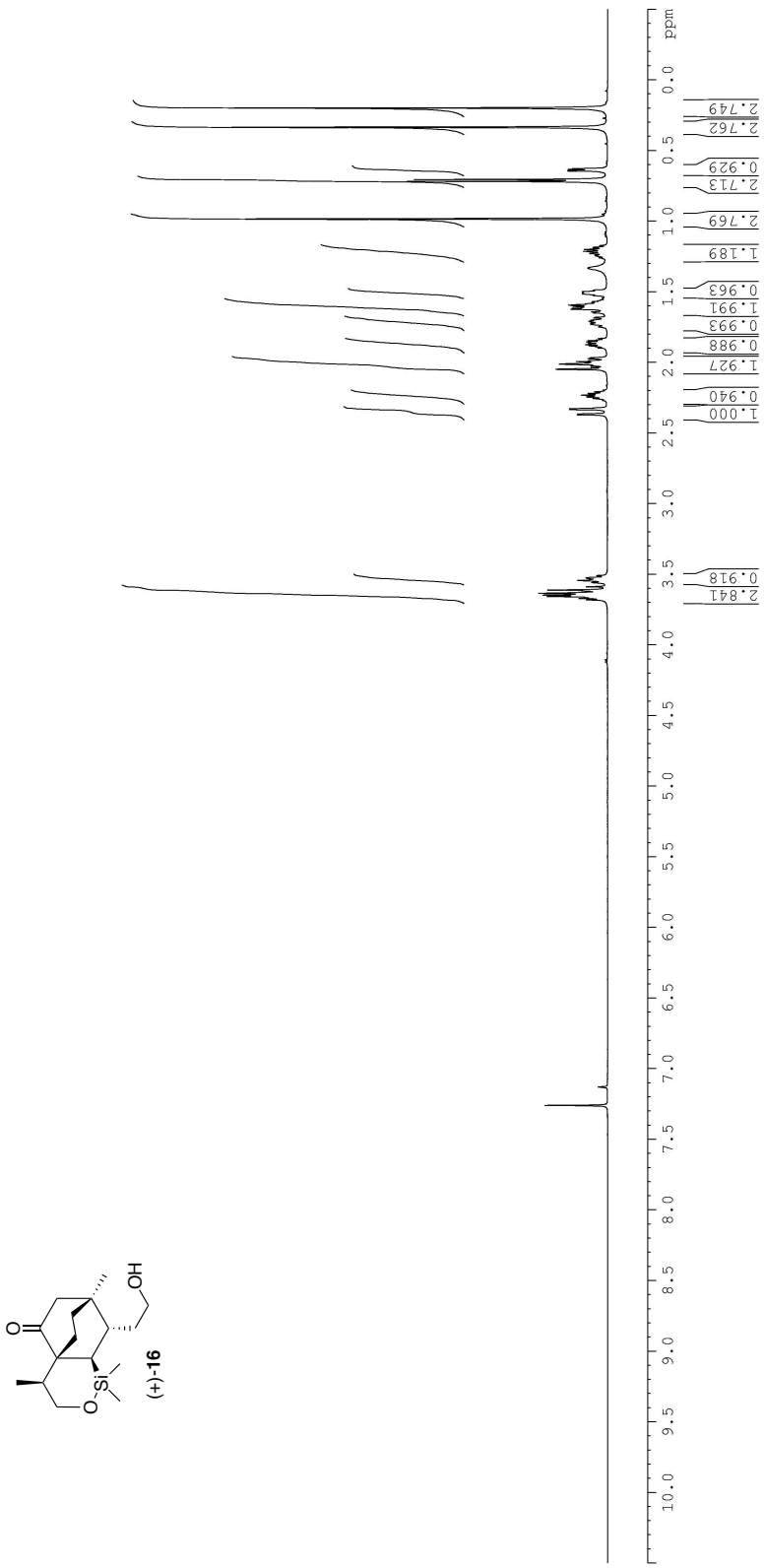

OH
O
O
Si
(−)-14
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
ppm
5.971
0.998
3.074
1.152
3.026
3.217
1.289
1.965
1.066
1.011
1.000
1.011
2.093
2.084

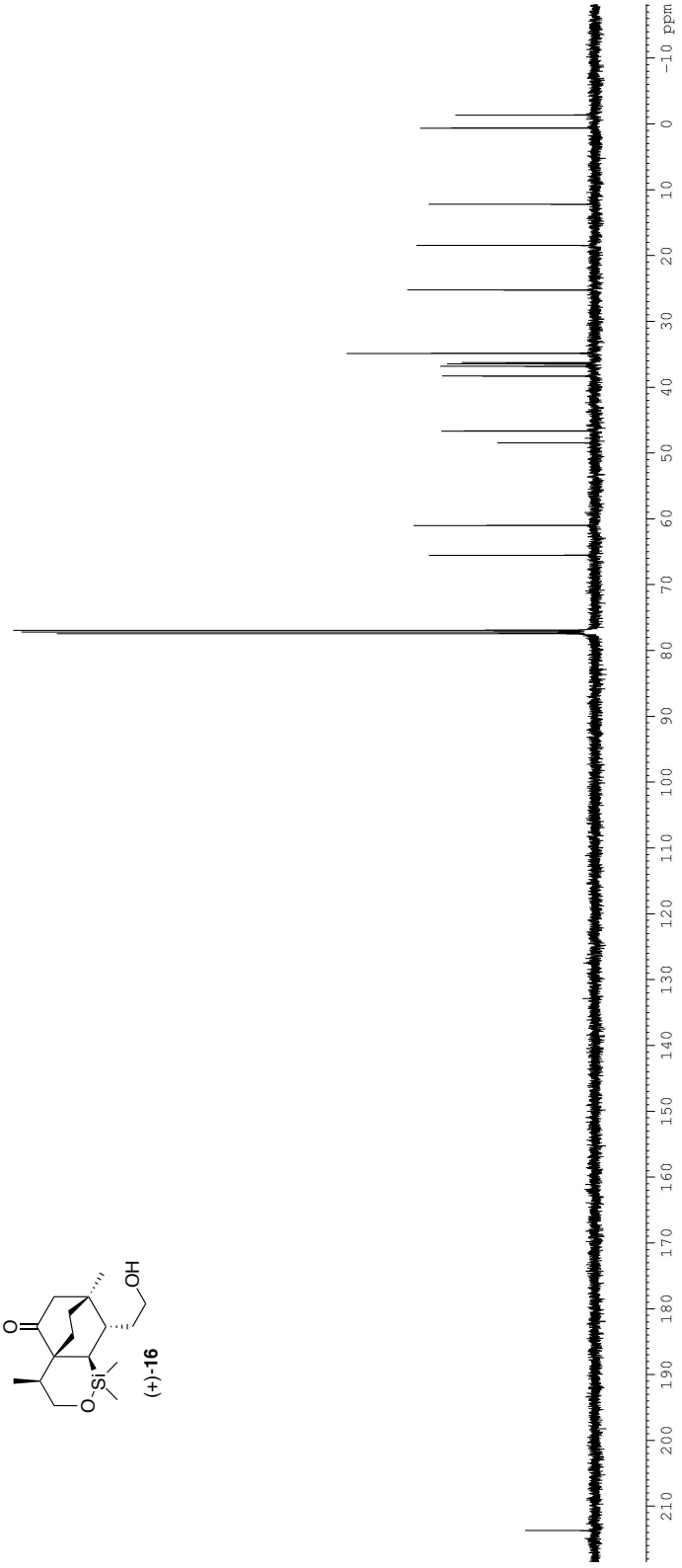

OH
O
O
Si
(−)-14
ppm
−10
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210

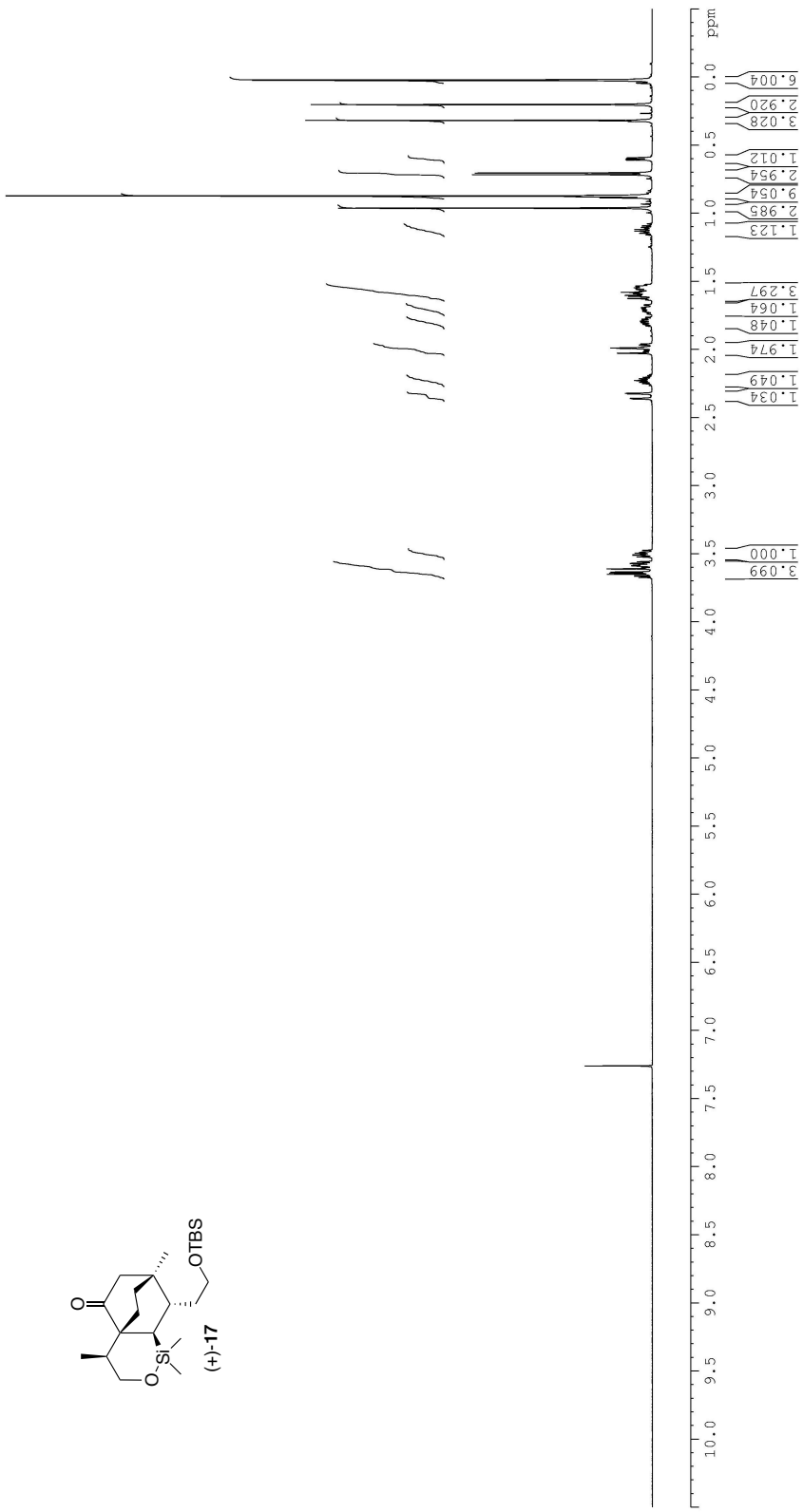

2.899
2.902
0.987
2.864
0.979
2.915
3.870
0.938
1.936
0.936
1.000
2.912
ppm

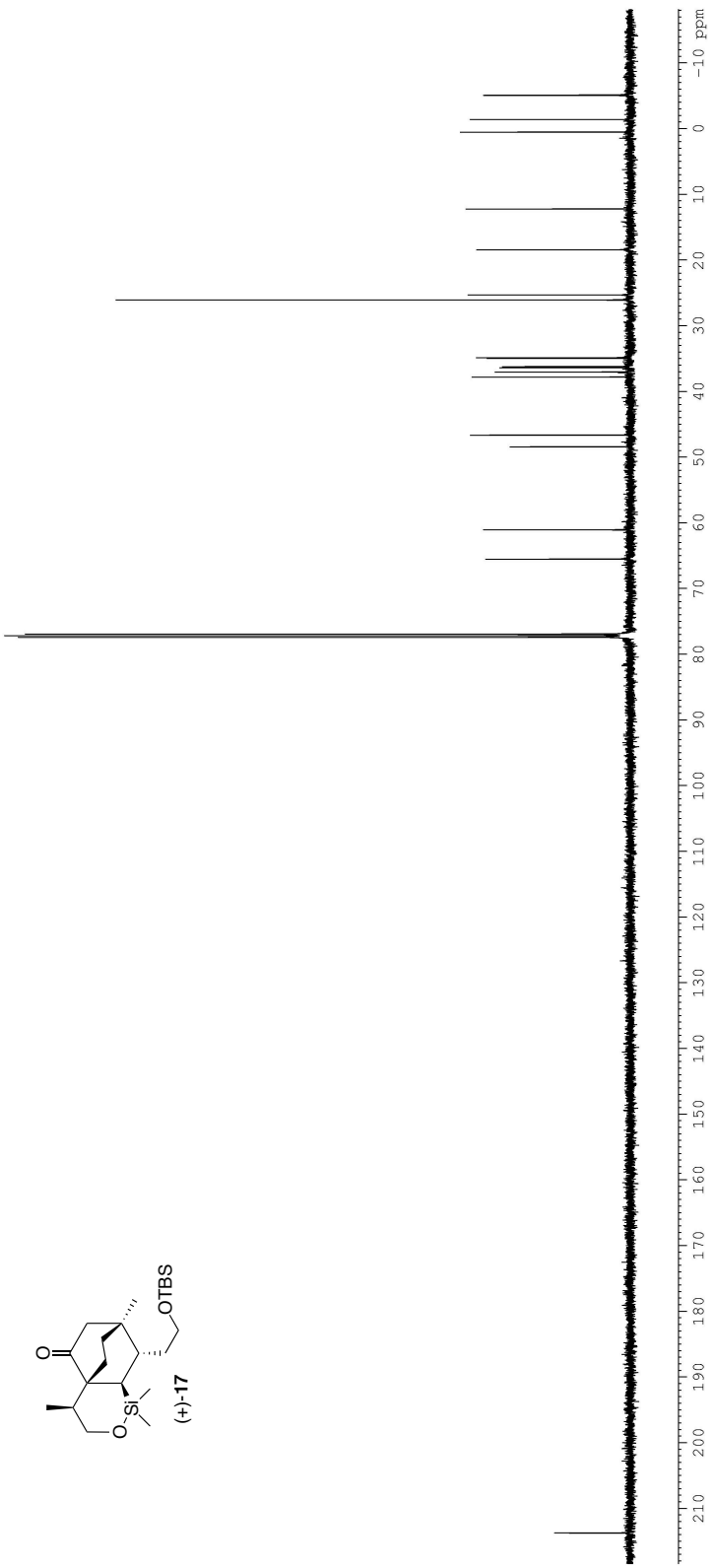
(+)-15

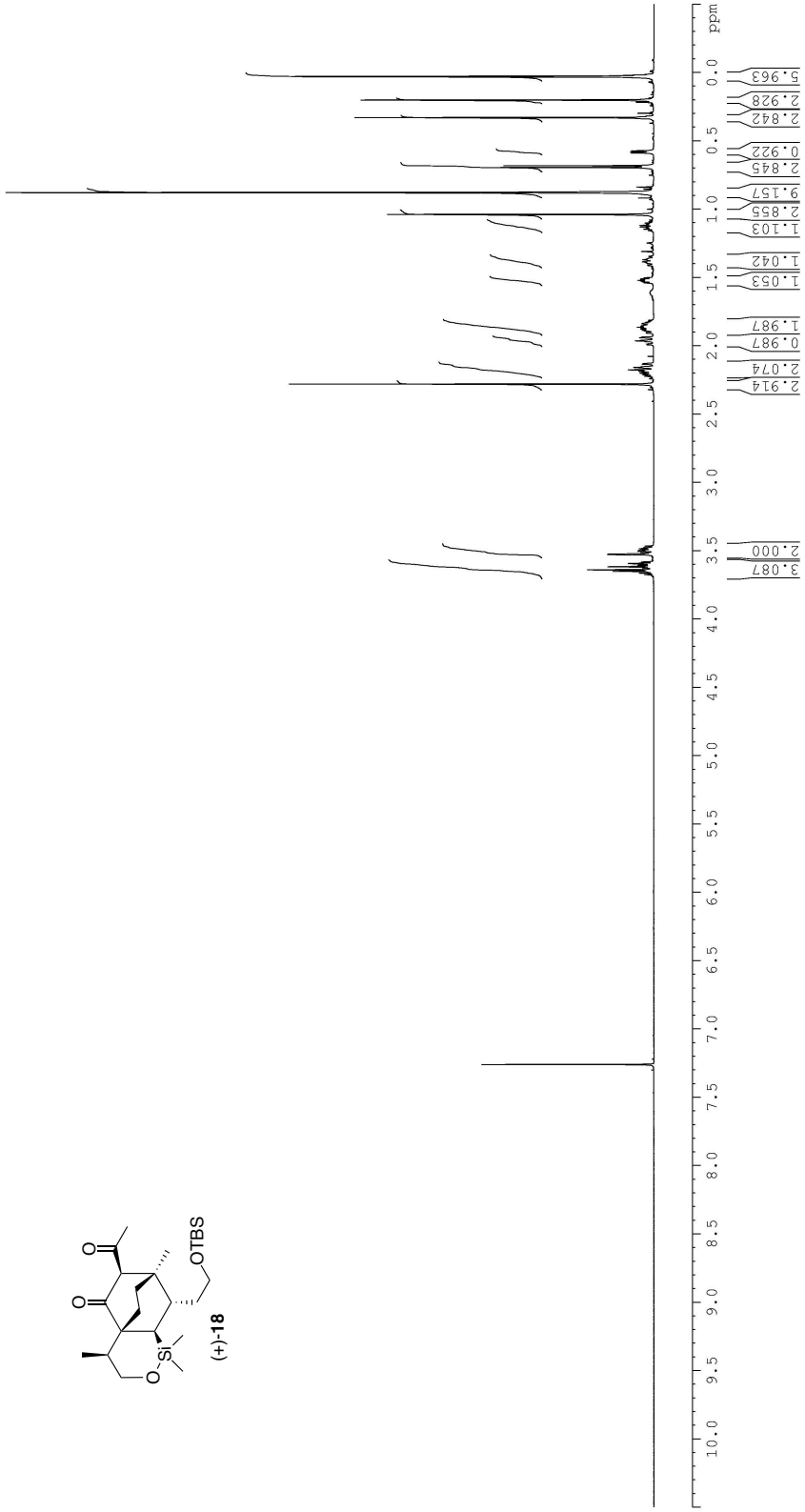

O
O
O
Si
(+)-15
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10 ppm

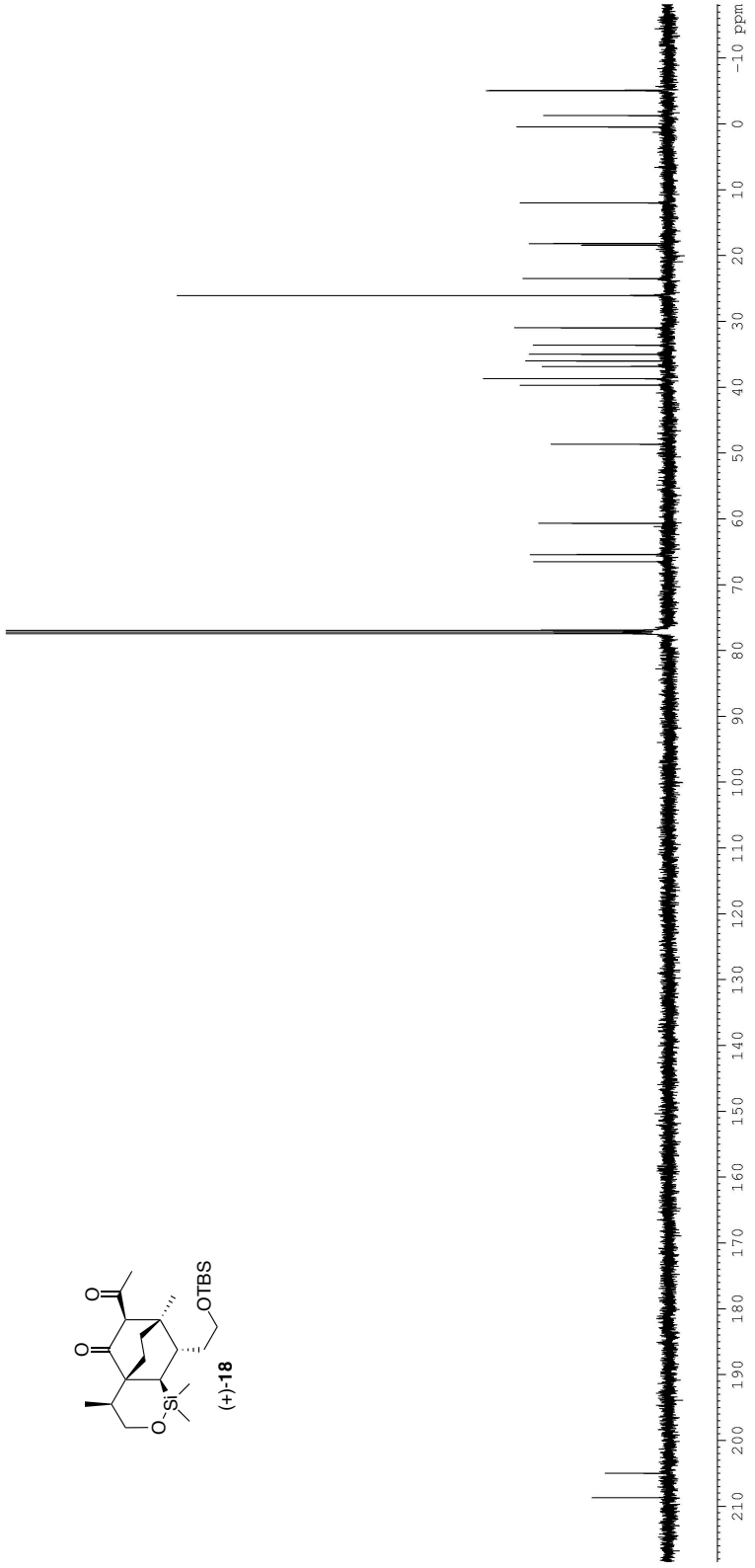

(+)-16
O
OH
Si
O
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
ppm
2.841
0.918
1.000
0.940
1.927
0.988
0.993
1.991
0.963
1.189
2.769
2.713
0.929
2.762
2.749

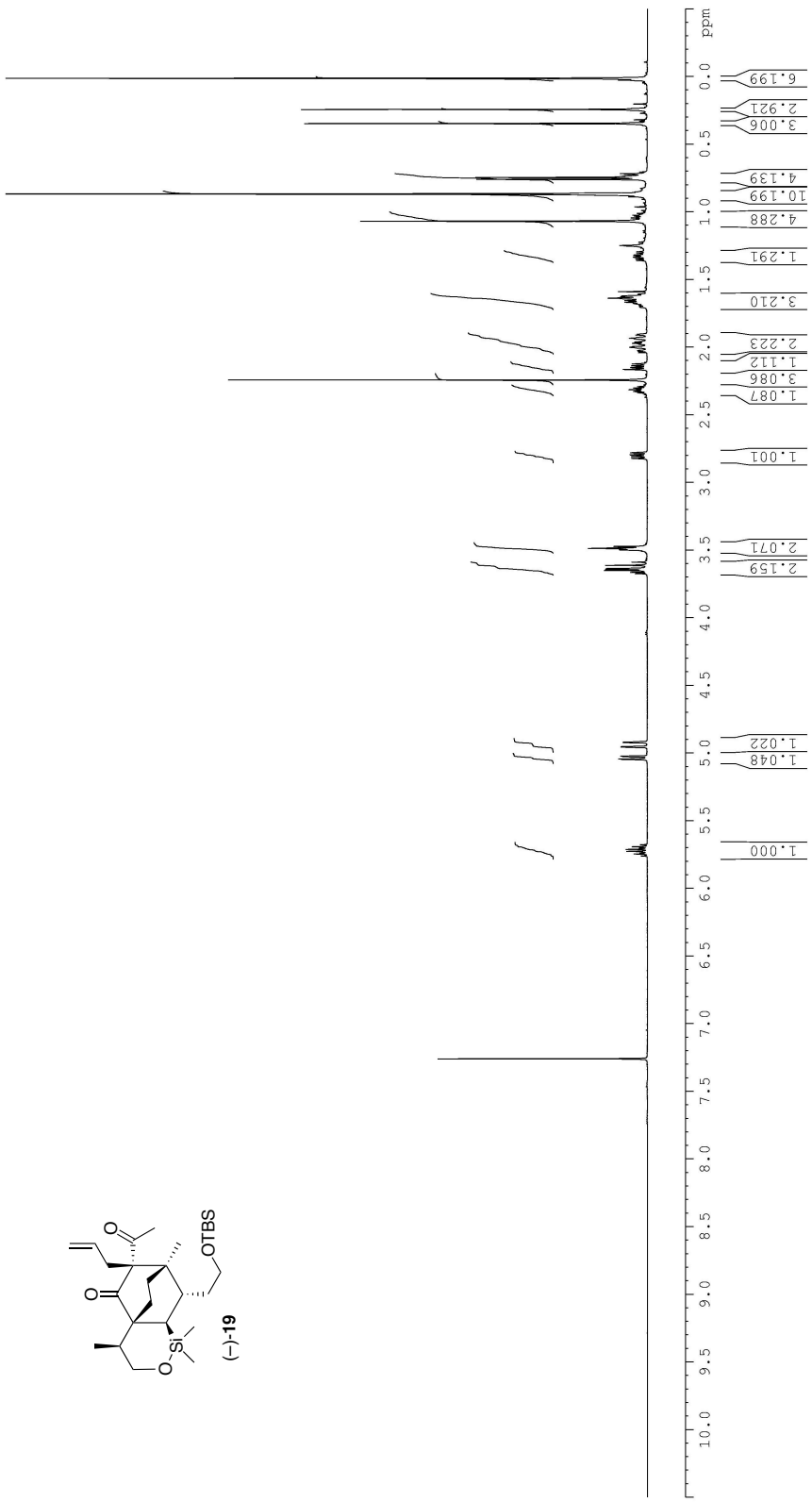

O
OH
O
Si
(+)-16
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10 ppm

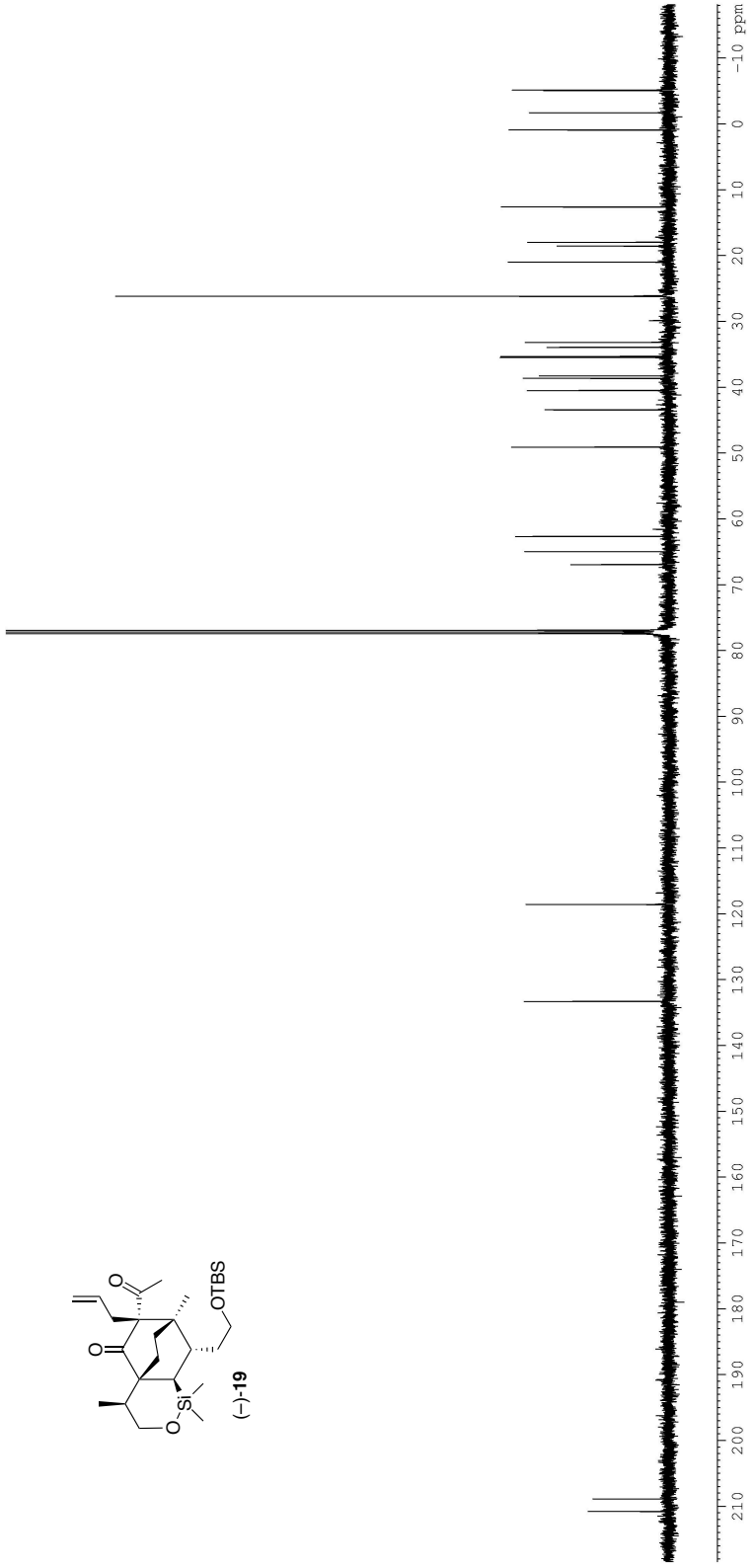

OTBS
O
O
Si
(+)-17
ppm
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
3.099
1.000
1.034
1.049
1.974
1.048
1.064
3.297
1.123
2.985
9.054
2.954
1.012
3.028
2.920
6.004

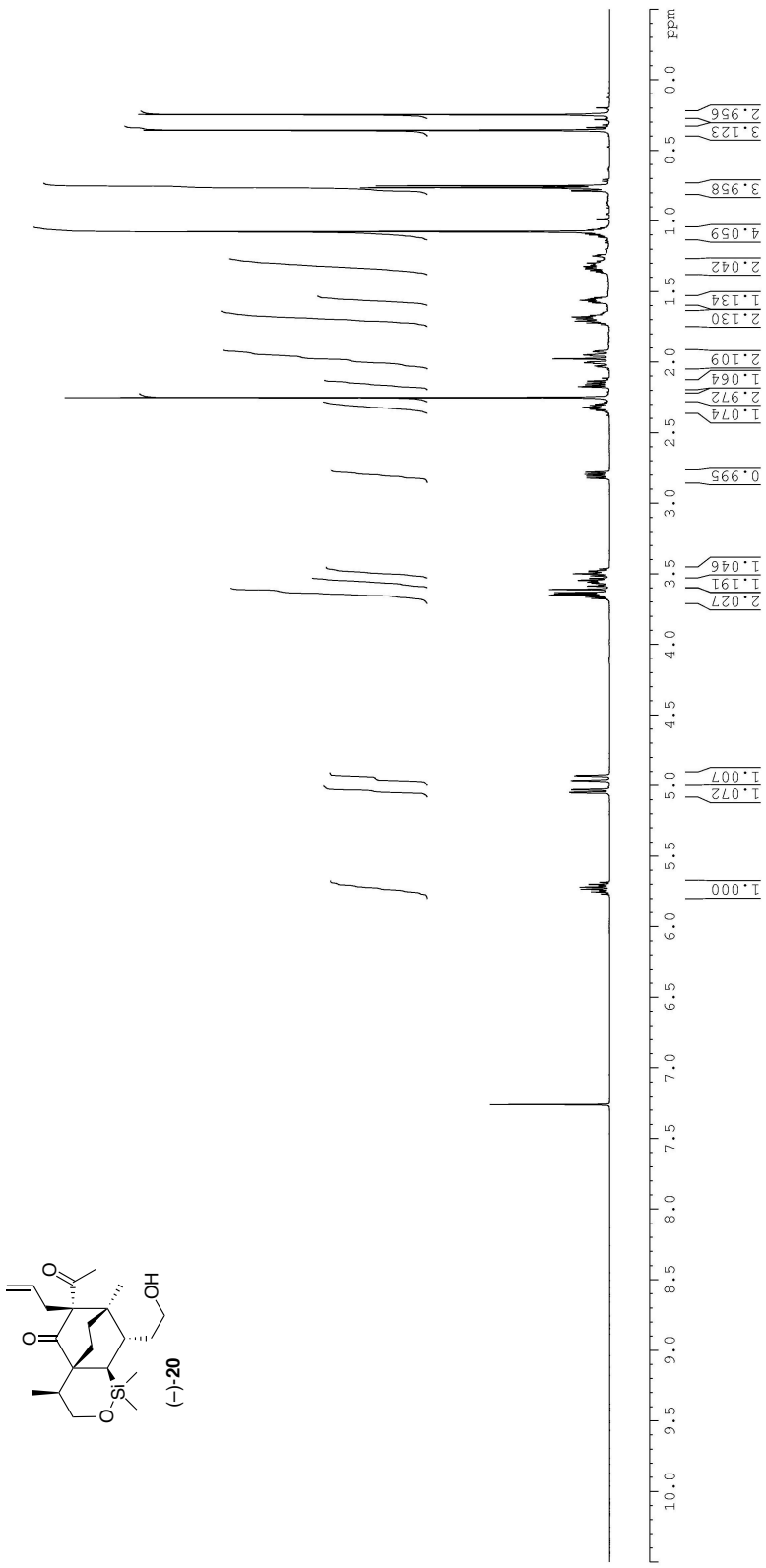

OTBS
O
Si
O
(+)-17
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10 ppm

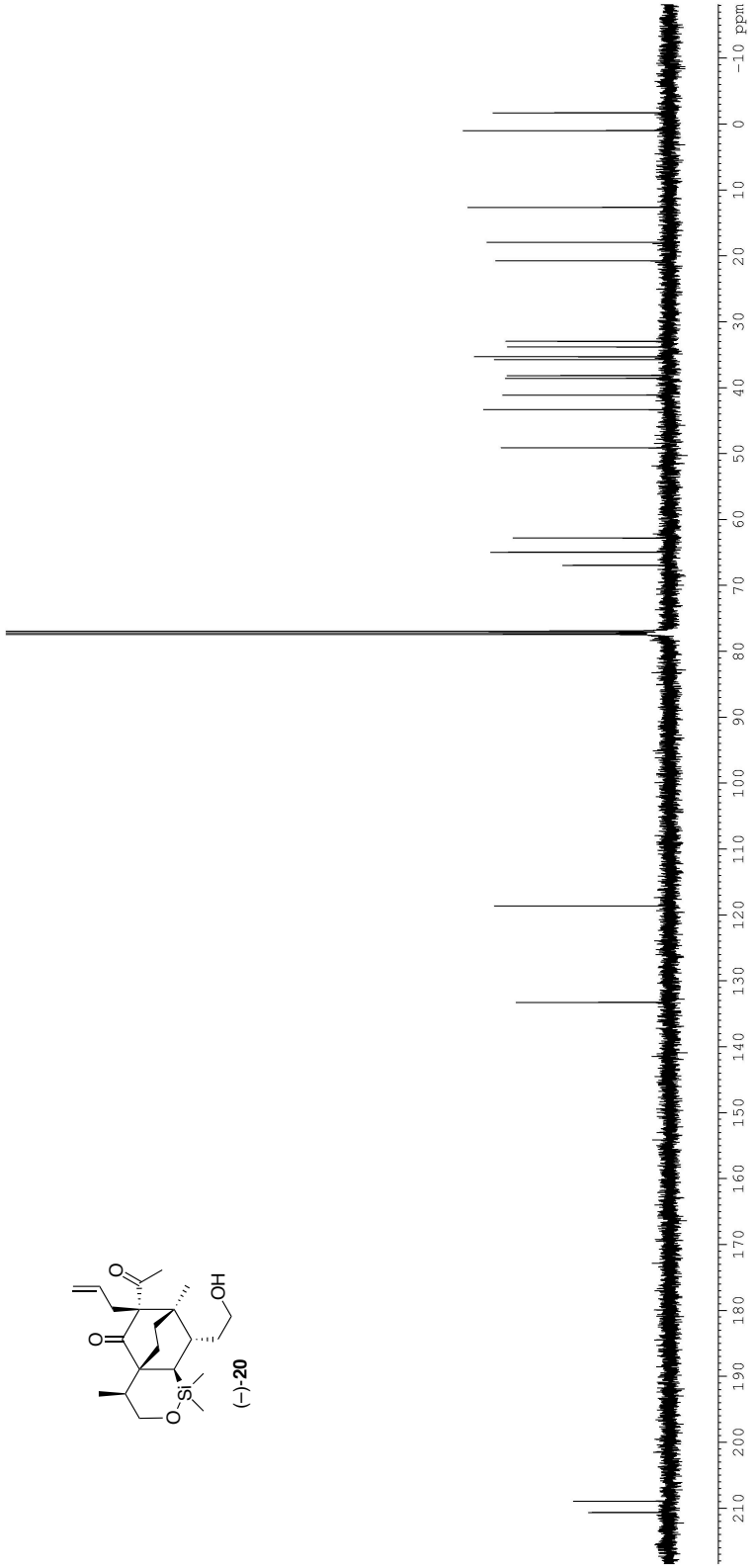

OTBS
(+)-18
ppm
3.087
2.000
2.914
2.074
0.987
1.987
1.053
1.042
1.103
2.855
9.157
2.845
0.922
2.842
2.928
5.963

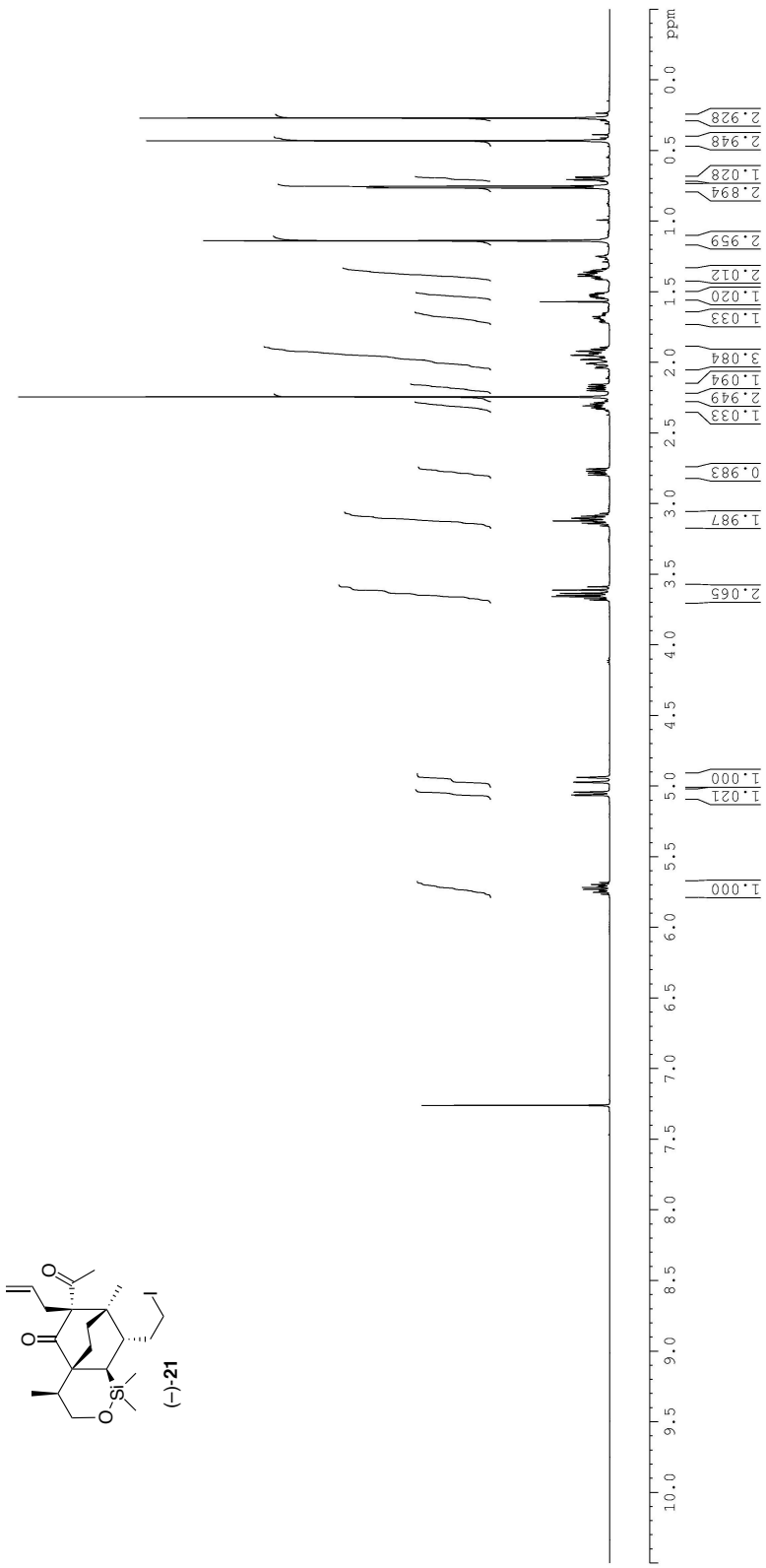

OTBS
(+)-18
ppm


OTBS
Si
(−)-19
ppm
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1.000
1.048
1.022
2.159
2.071
1.001
1.087
3.086
1.112
2.223
3.210
1.291
4.288
10.199
4.139
3.006
2.921
6.199

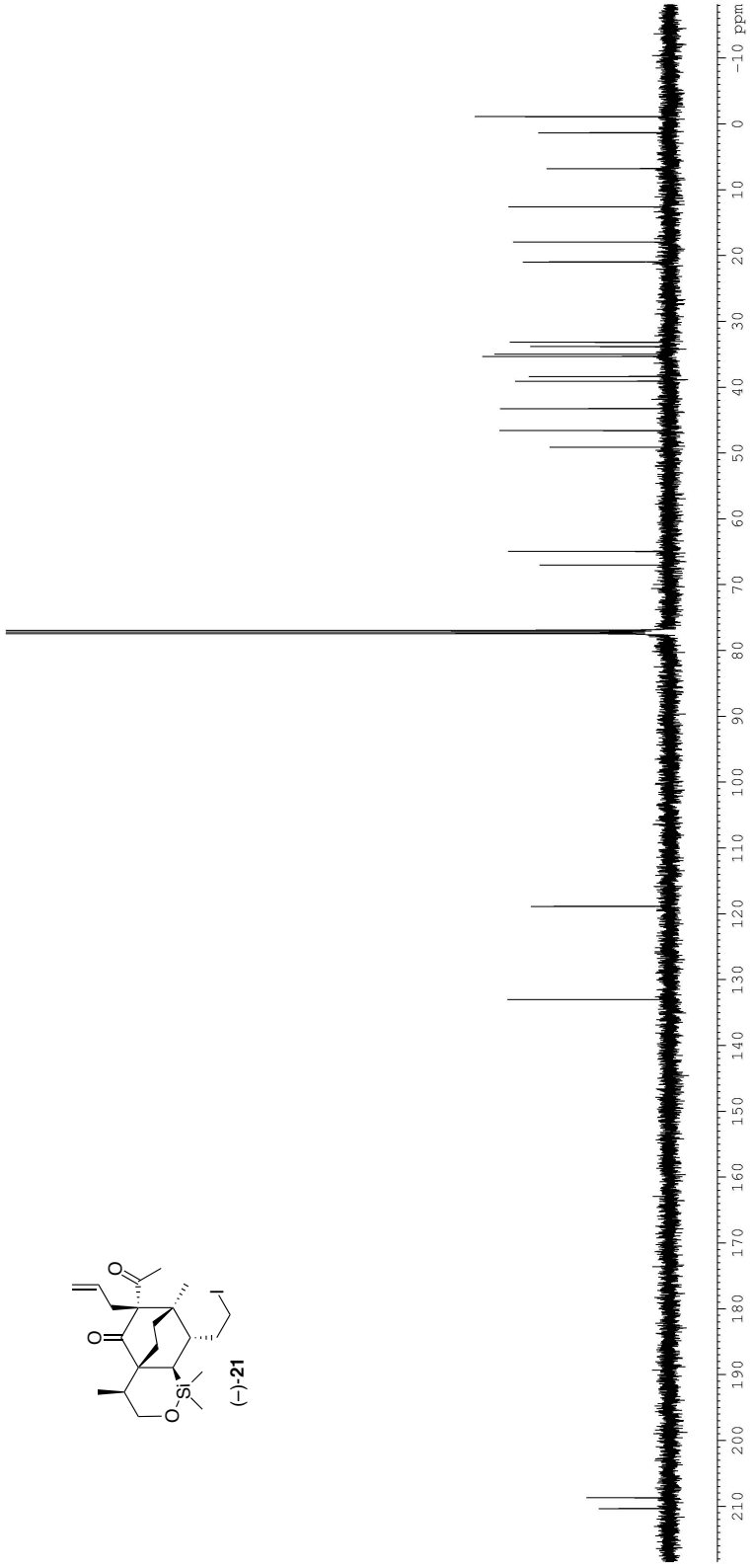

OTBS
O
O
O
Si
(−)-19
ppm
−10
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210

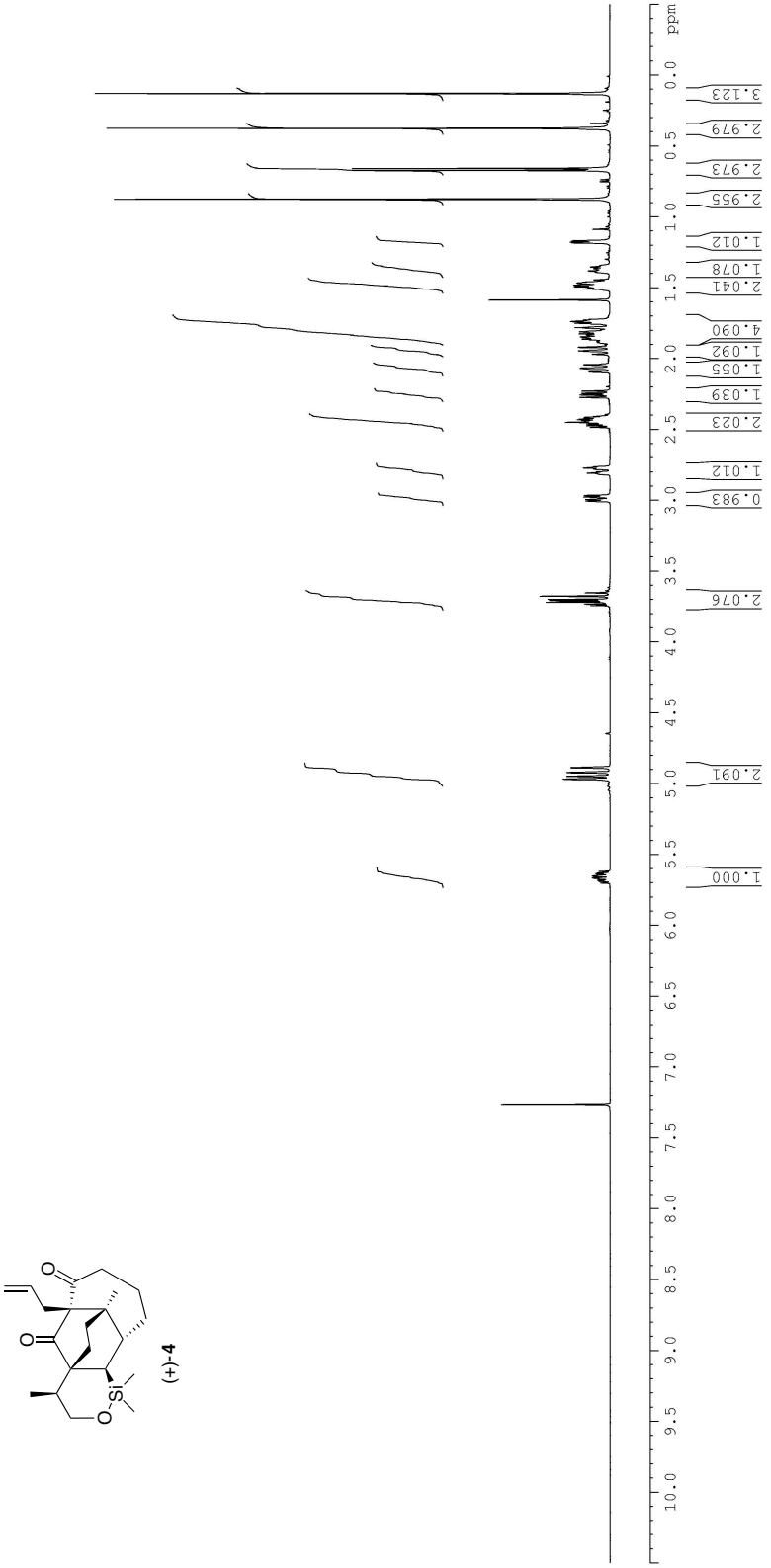

ppm
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1.000
1.007
1.072
2.027
1.191
1.046
0.995
1.074
2.972
1.064
2.109
2.130
1.134
2.042
4.059
3.958
3.123
2.956
O
O
OH
O
Si
(−)-20

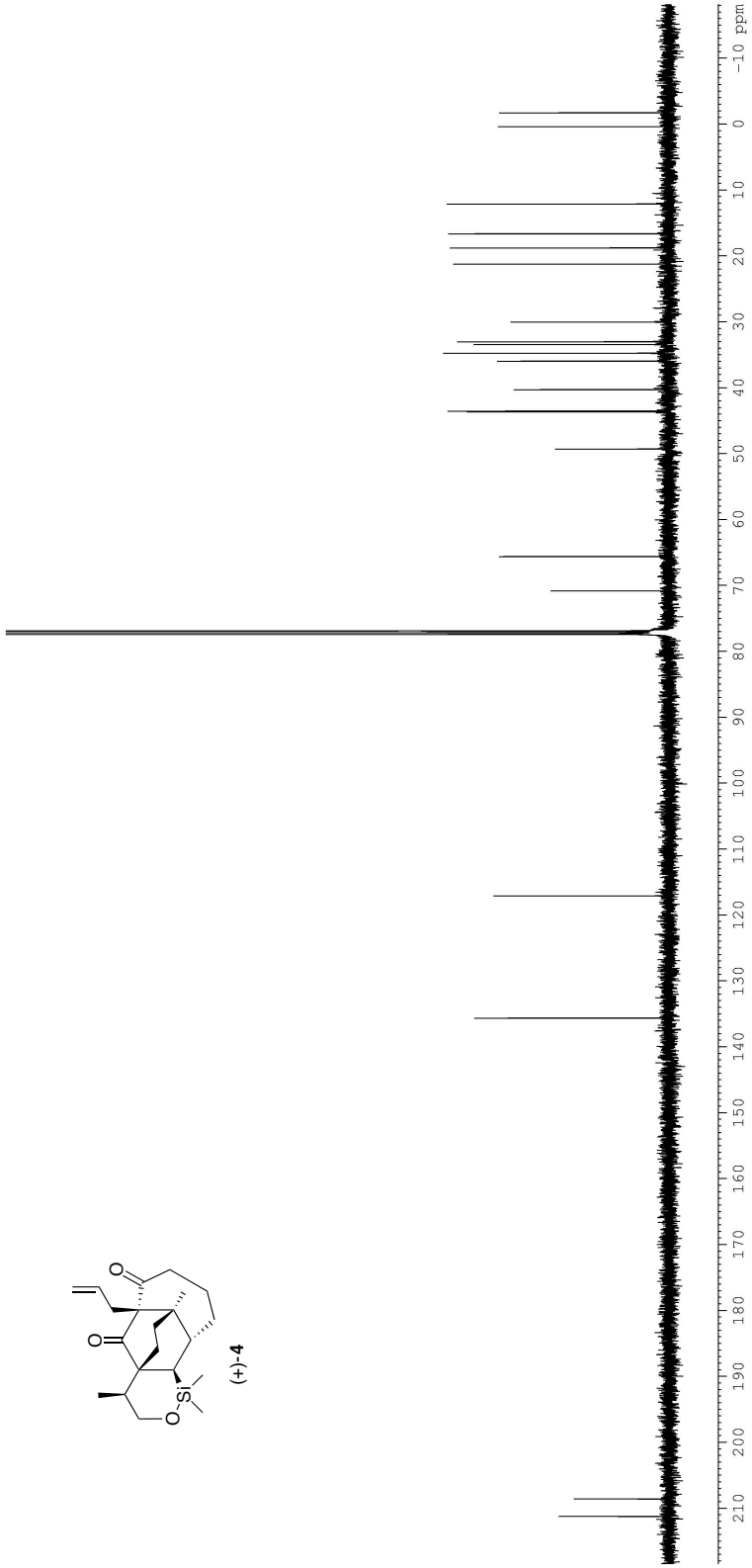

(–)-20
OH
O
O
Si
O
ppm
-10
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210


ppm
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
2.928
2.948
1.028
2.894
2.959
2.012
1.020
1.033
3.084
1.094
2.949
1.033
0.983
1.987
2.065
1.000
1.021
1.000

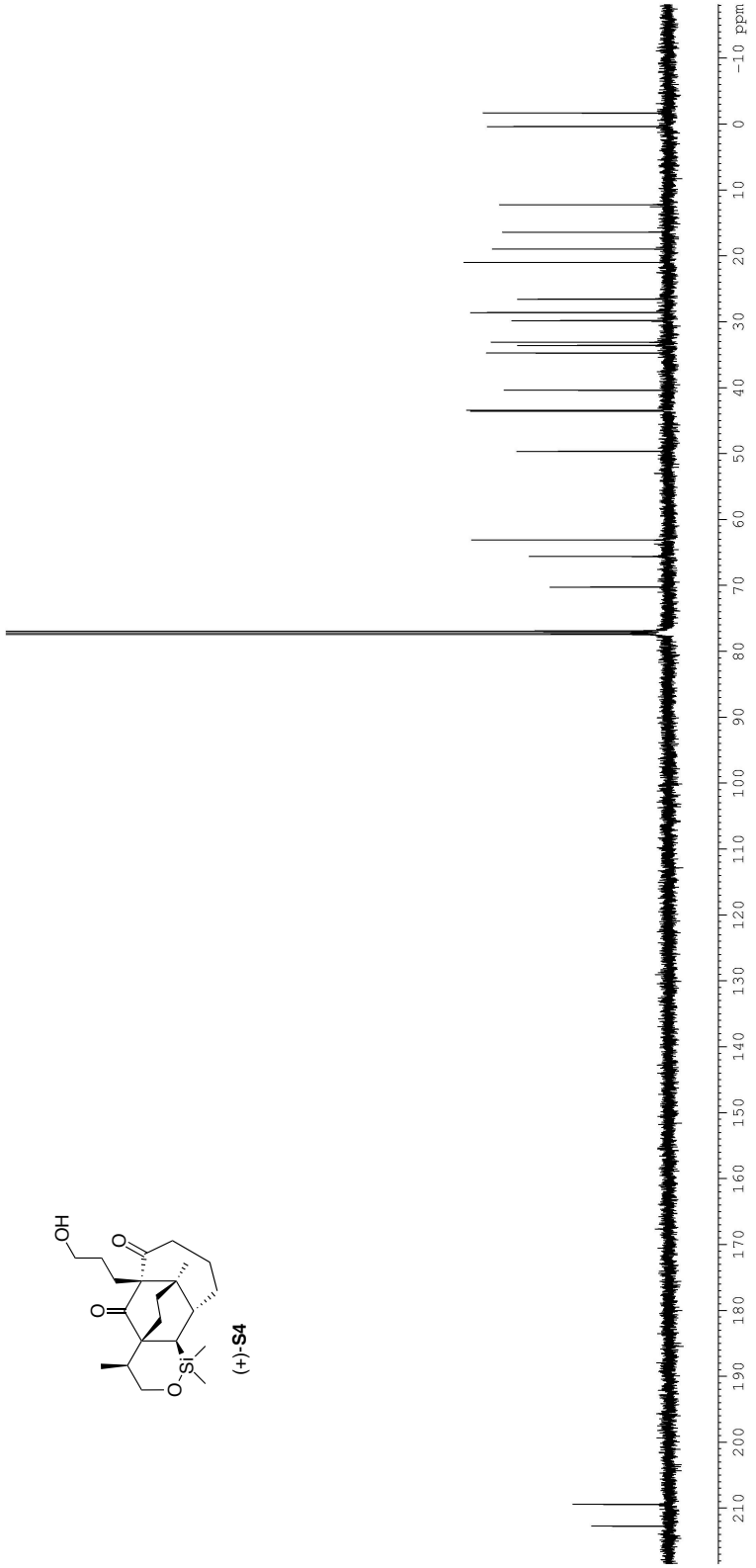
(−)-**21**

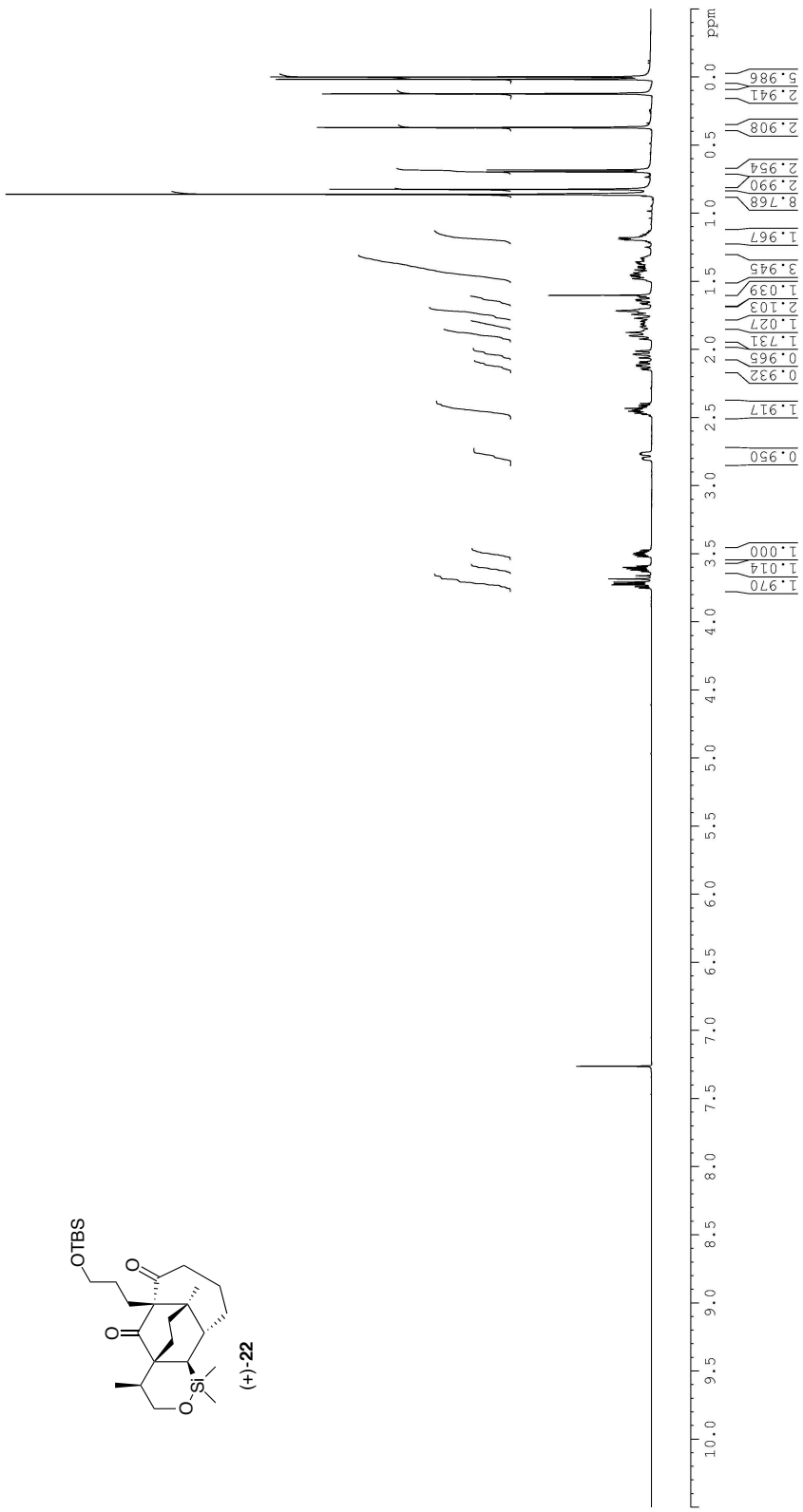

(−)-21
I
O
O
O
Si
ppm
−10
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210

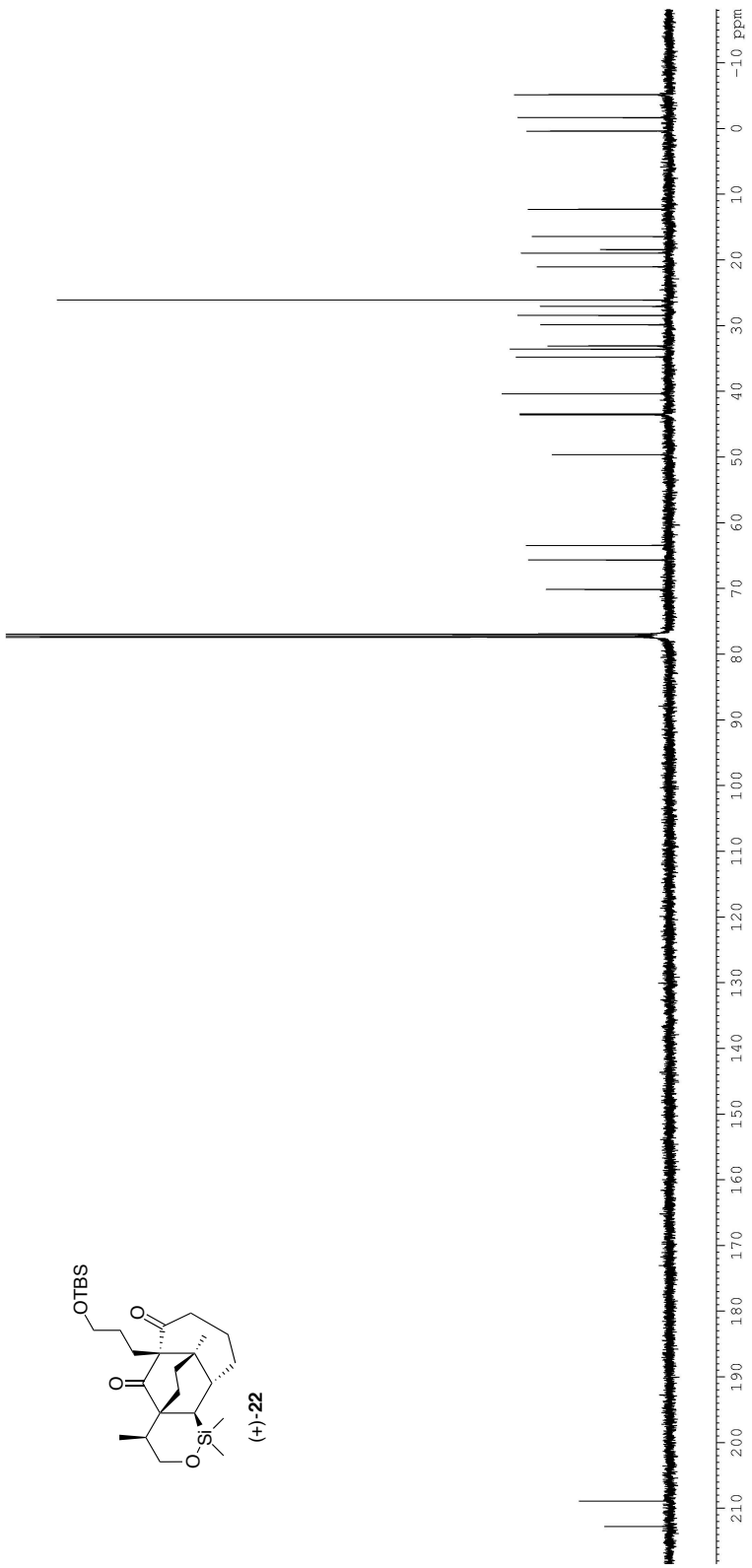

3.123
2.979
2.973
2.955
1.012
1.078
2.041
4.090
1.092
1.055
1.039
2.023
1.012
0.983
2.076
2.091
1.000
ppm
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
8.5
9.0
9.5
10.0
O
O
O
Si
(+)-4

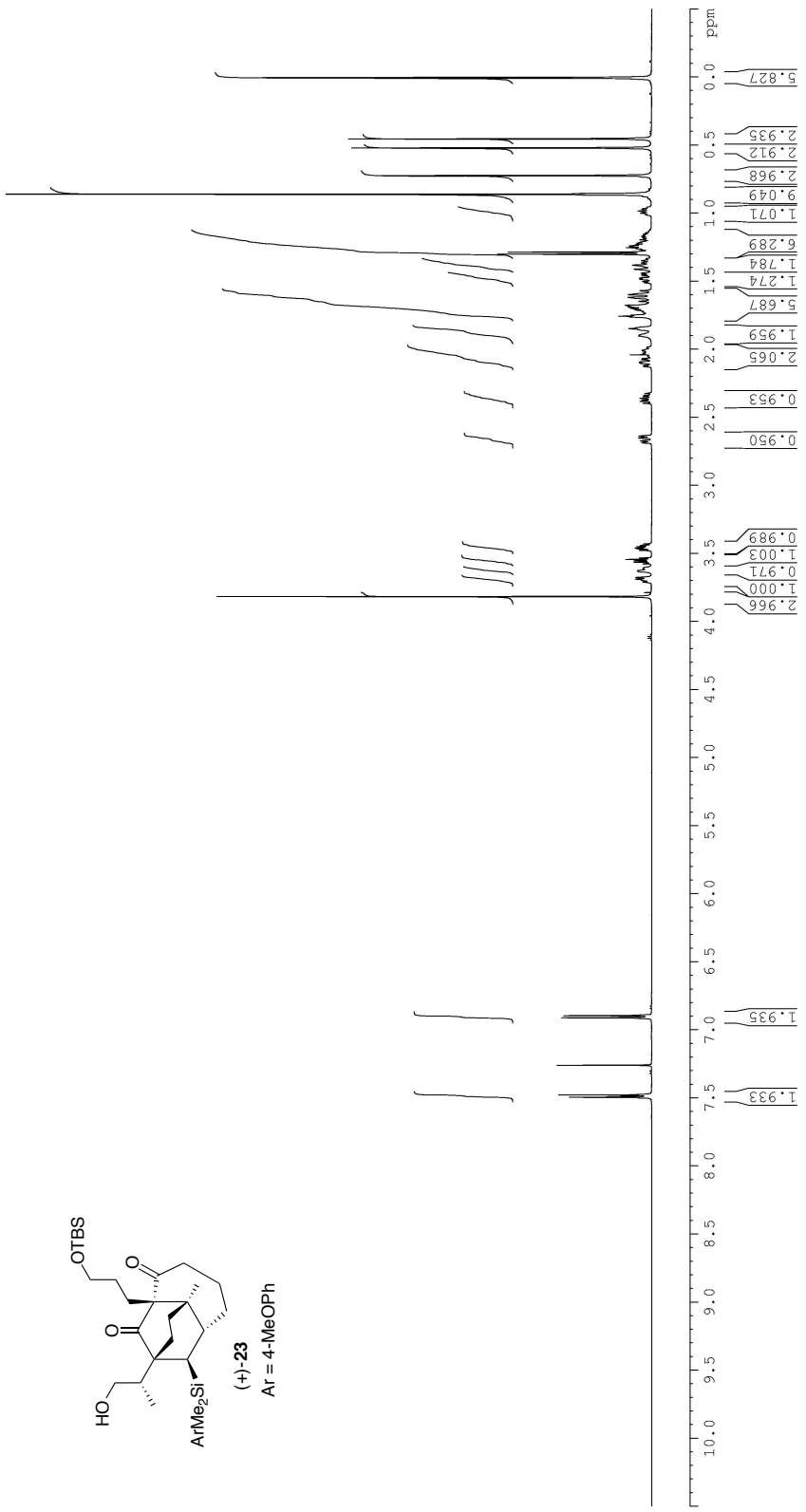

(+)-4
O
O
O
Si
-10 ppm
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210

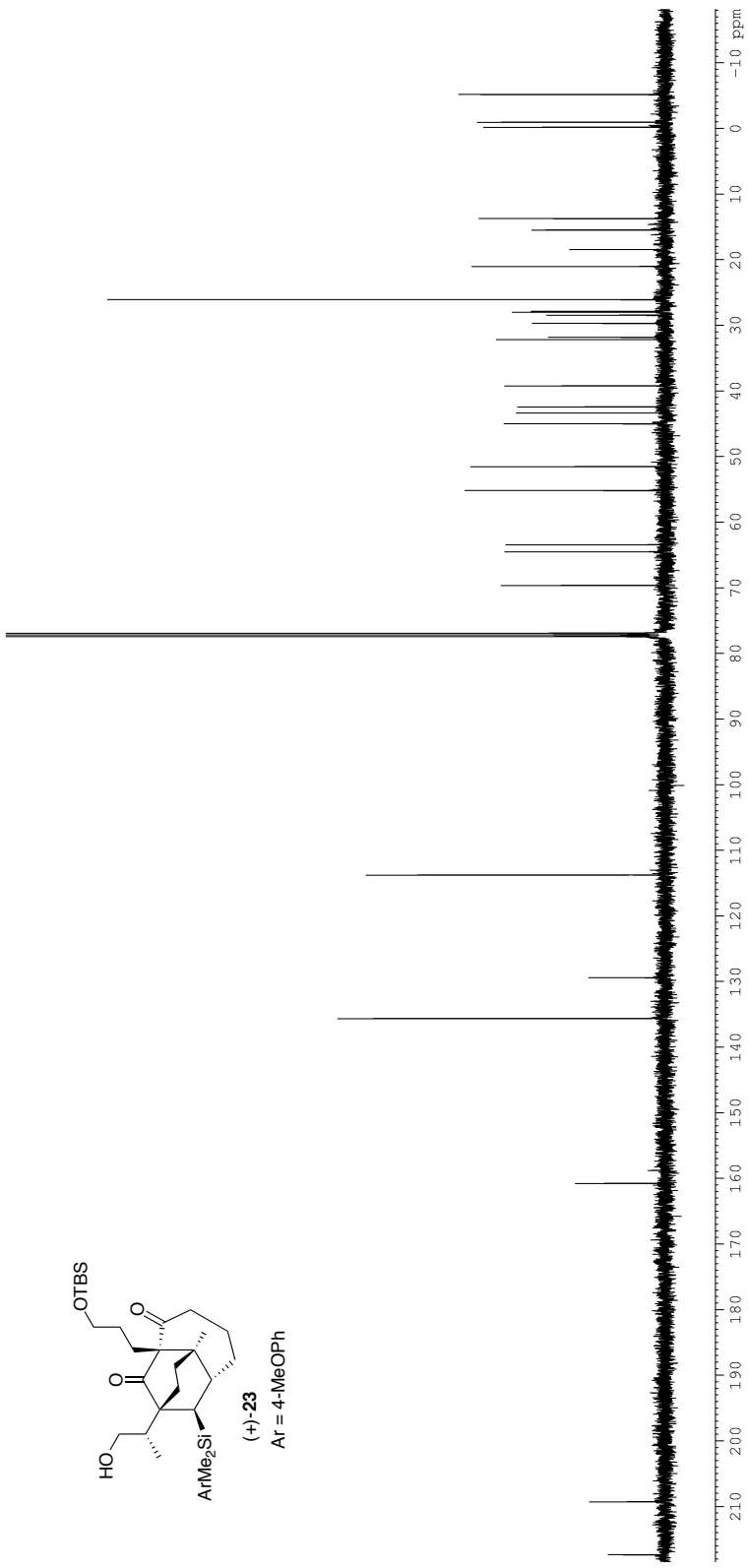
OH
O
O
O
Si
(+)-S4
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
ppm
2.959
3.057
3.023
3.140
2.689
1.514
3.359
2.211
3.671
2.108
1.076
1.031
1.941
0.973
2.014
2.000

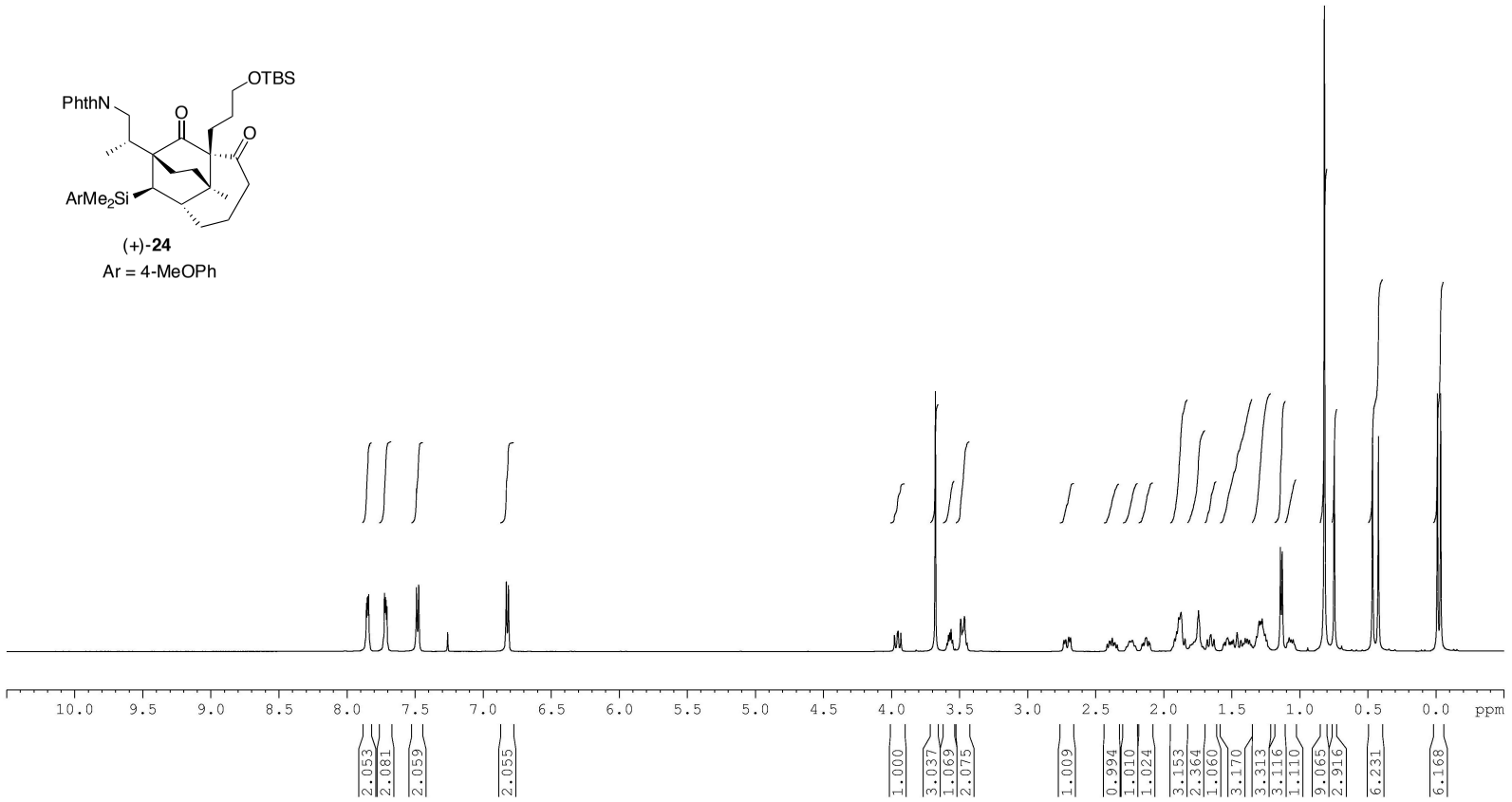

OH
O
O
Si
O
(+)-S4
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10 ppm

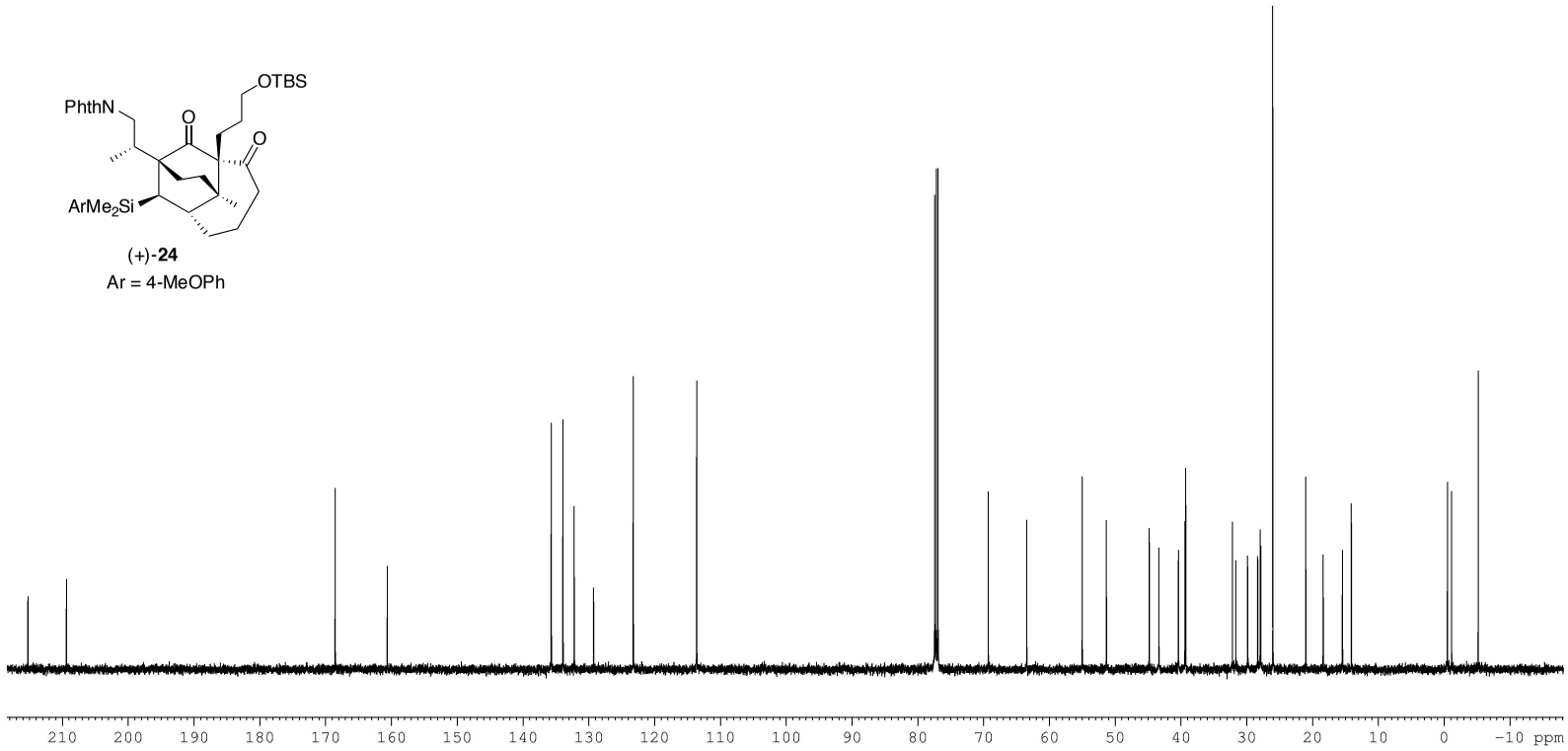

OTBS
O
O
O
Si
(+)-22
ppm
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1.970
1.014
1.000
0.950
1.917
0.932
0.965
1.731
1.027
2.103
1.039
3.945
1.967
8.768
2.990
2.954
2.908
2.941
5.986

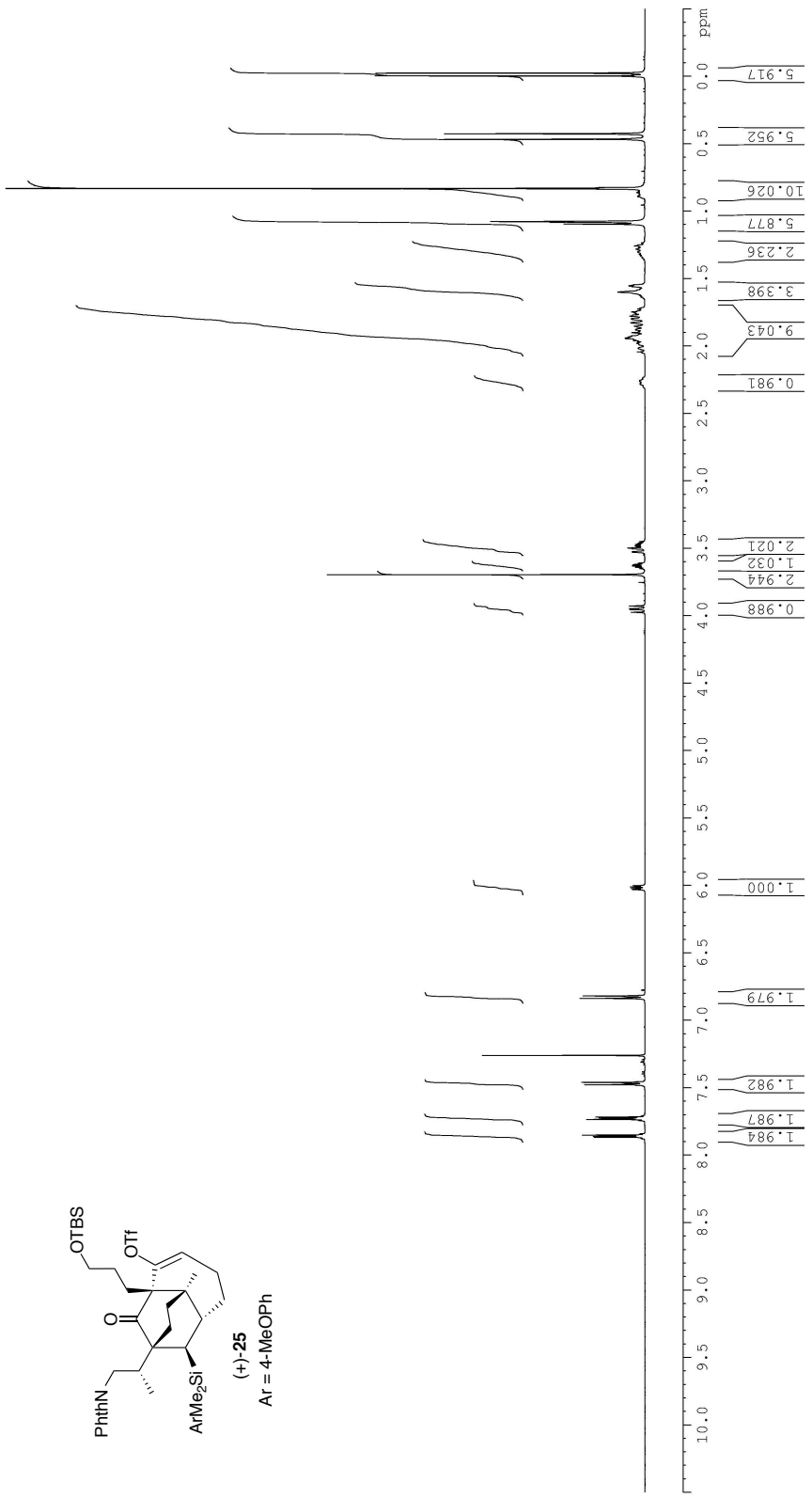

OTBS
O
O
O
Si
(+)-22
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10 ppm

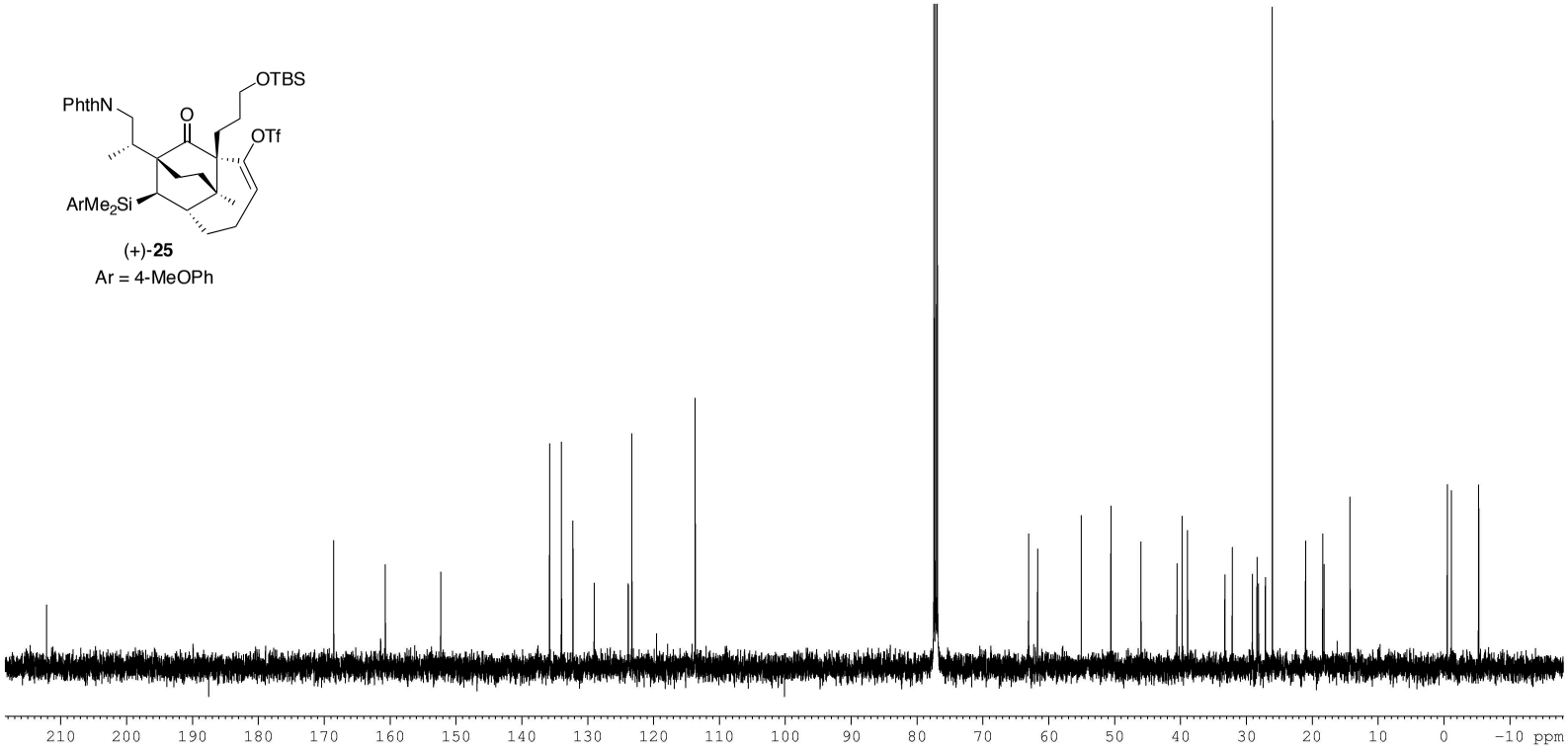

OTBS
O
O
HO
ArMe2Si
(+)-23
Ar = 4-MeOPh
ppm
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1.933
1.935
2.966
1.000
0.971
1.003
0.989
0.950
0.953
2.065
1.959
5.687
1.274
1.784
6.289
1.071
9.049
2.968
2.912
2.935
5.827

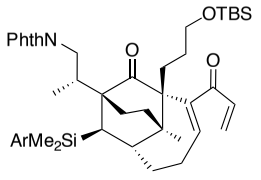

OTBS
O
O
HO
ArMe2Si
(+)-23
Ar = 4-MeOPh
ppm
-10
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210


PhthN
OTBS
O
O
ArMe2Si
(+)-24
Ar = 4-MeOPh
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 ppm
2.053 2.081 2.059 2.055 1.000 3.037 1.069 2.075 1.009 0.994 1.010 1.024 3.153 2.364 1.060 3.170 3.313 3.116 1.110 9.065 2.916 6.231 6.168


PhthN
OTBS
O
O
ArMe2Si
(+)-24
Ar = 4-MeOPh
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10 ppm

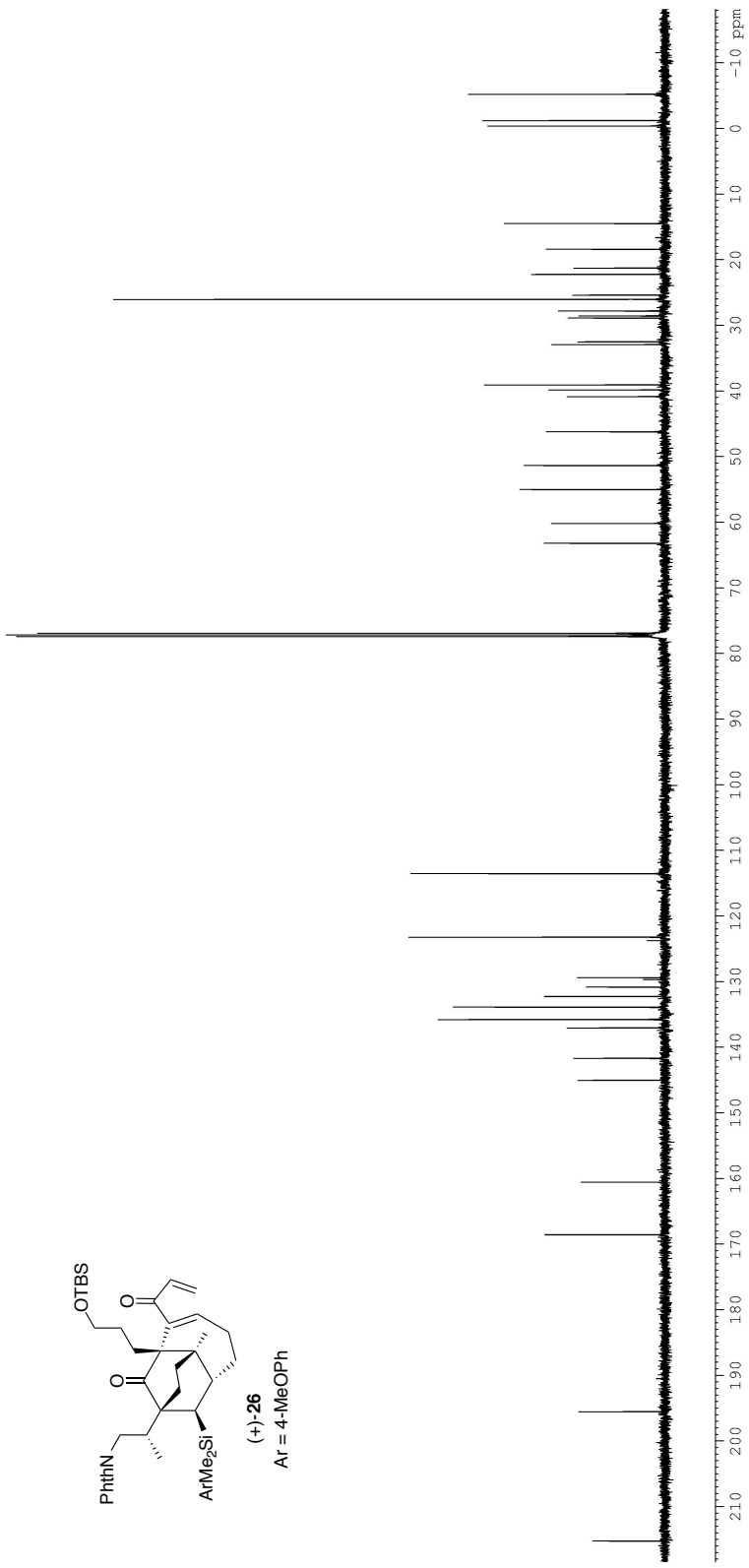

OTBS
OTf
O
PhthN
ArMe2Si
(+)-25
Ar = 4-MeOPh
ppm
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
5.917
5.952
10.026
5.877
2.236
3.398
9.043
0.981
2.021
1.032
2.944
0.988
1.000
1.979
1.982
1.987
1.984

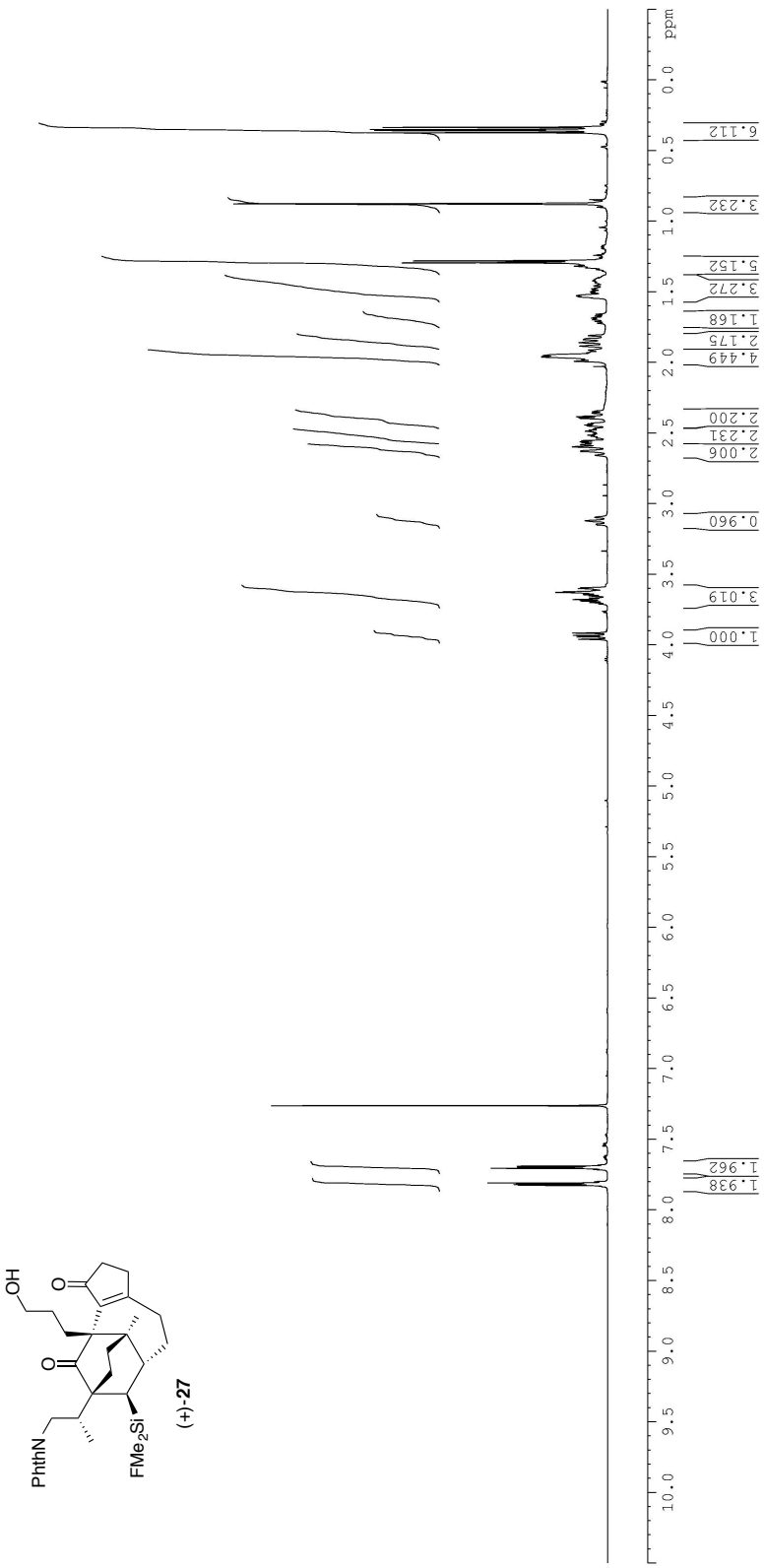

PhthN
O
OTBS
OTf
ArMe2Si
(+)-25
Ar = 4-MeOPh
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10 ppm


PhthN
OTBS
O
O
ArMe2Si

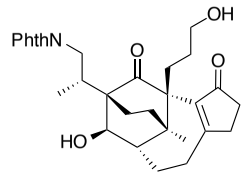
(+)-**26**
Ar = 4-MeOPh

10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 ppm
2.030 2.075 2.052 2.085 0.991 0.963 1.000 0.955 0.971 3.074 1.030 1.001 0.968 0.965 1.960 1.032 4.318 3.188 2.358 3.072 3.954 10.161 3.039 3.149 5.987

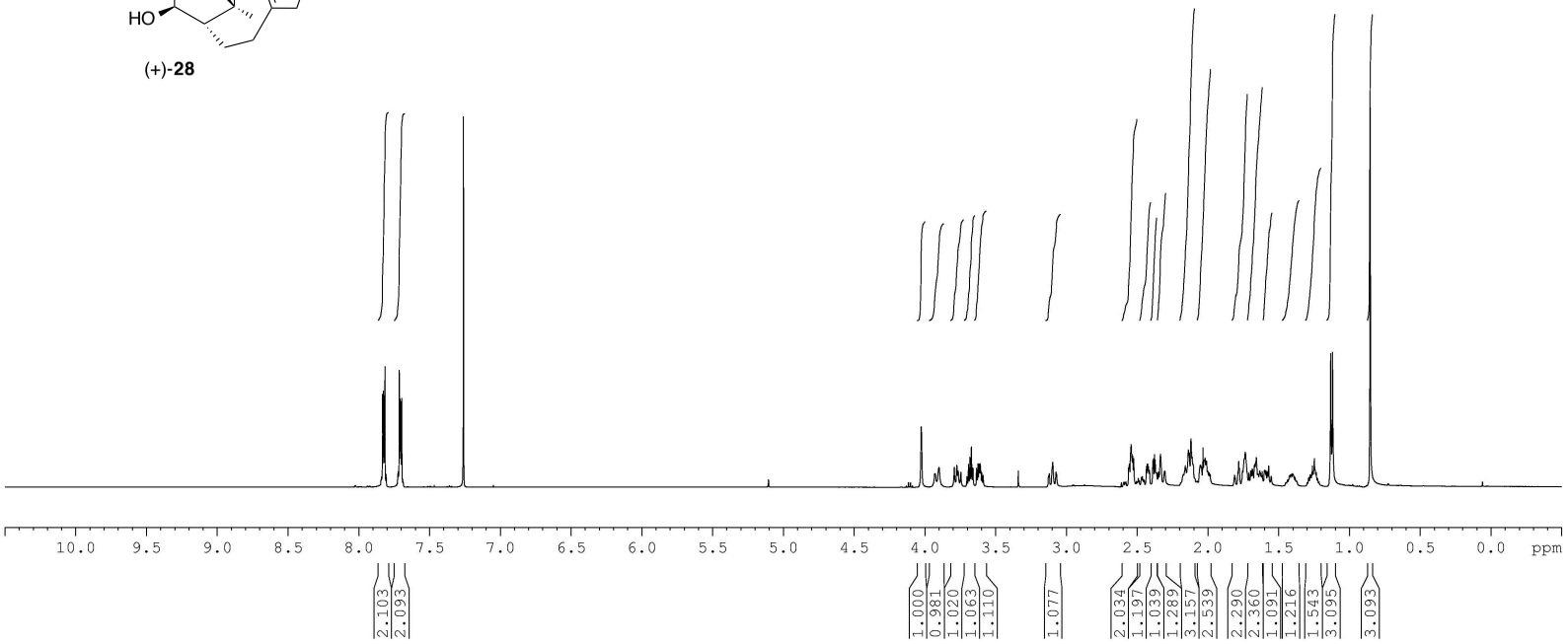

OTBS
O
O
PhthN
ArMe2Si
(+)-26
Ar = 4-MeOPh
ppm

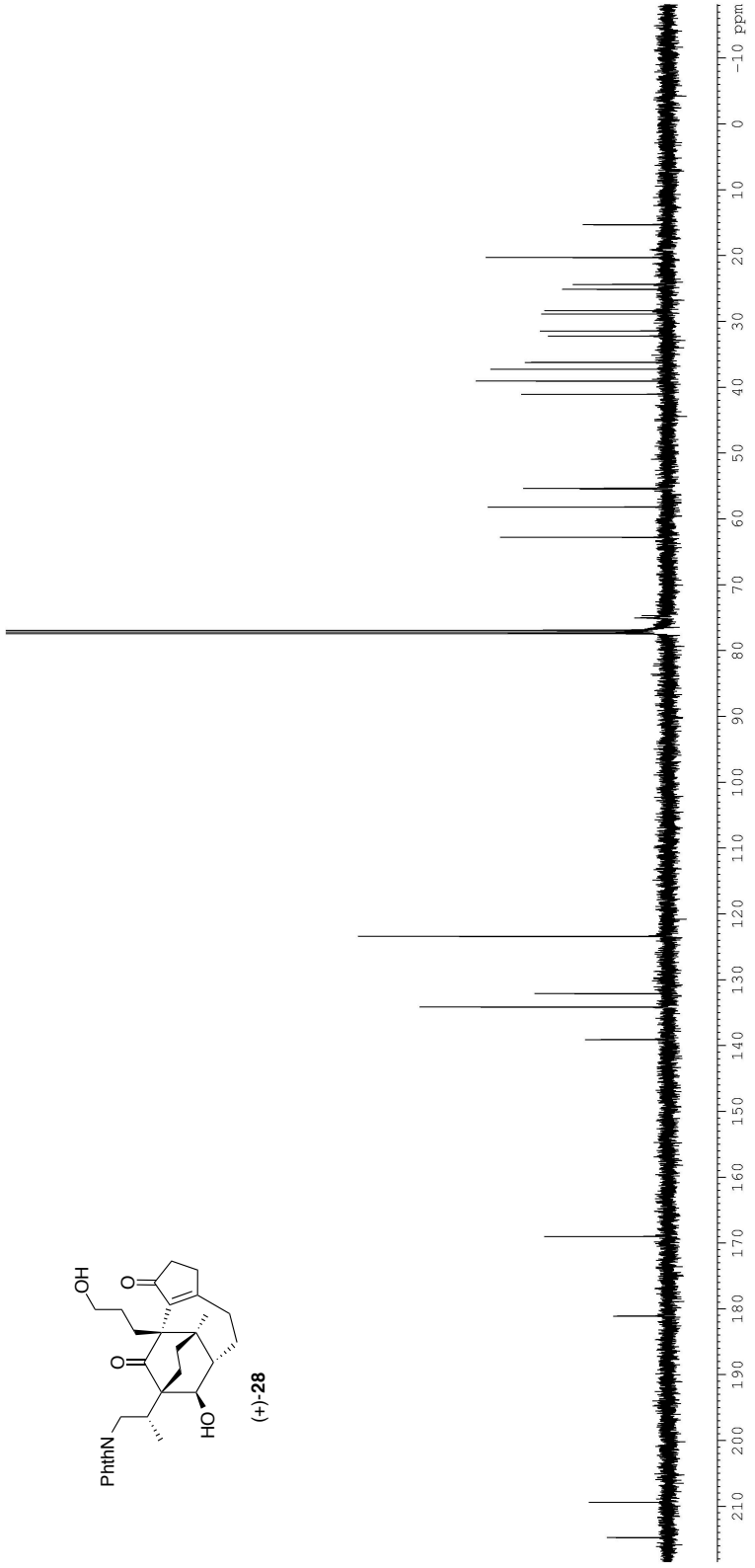

OH
O
O
PhthN
FMe2Si
(+)-27
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
ppm
6.112
3.232
5.152
3.272
1.168
2.175
4.449
2.200
2.231
2.006
0.960
3.019
1.000
1.962
1.938

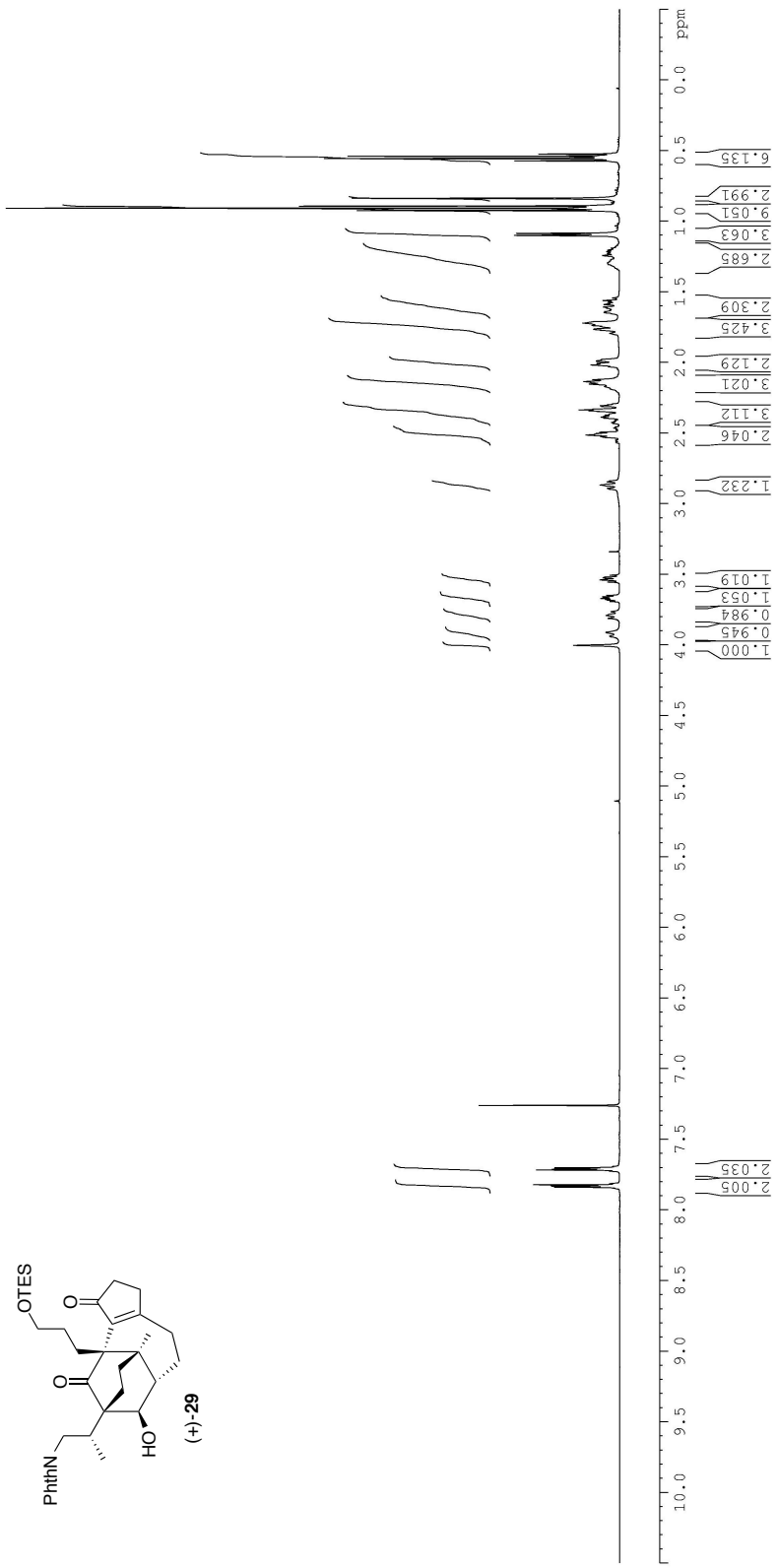
OH
O
O
PhthN
FMe2Si
(+)-27
ppm

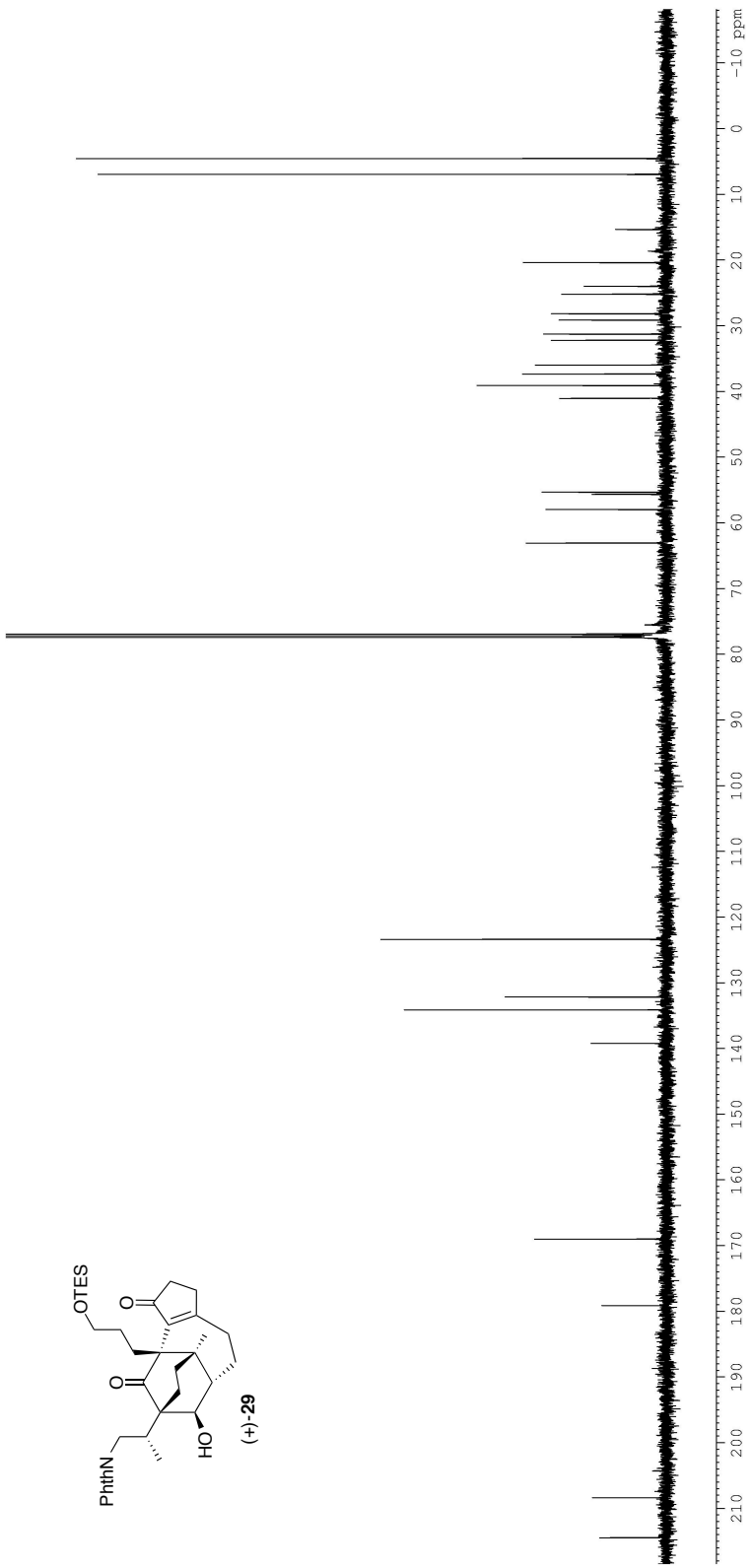

PhthN
O
O
OH
HO

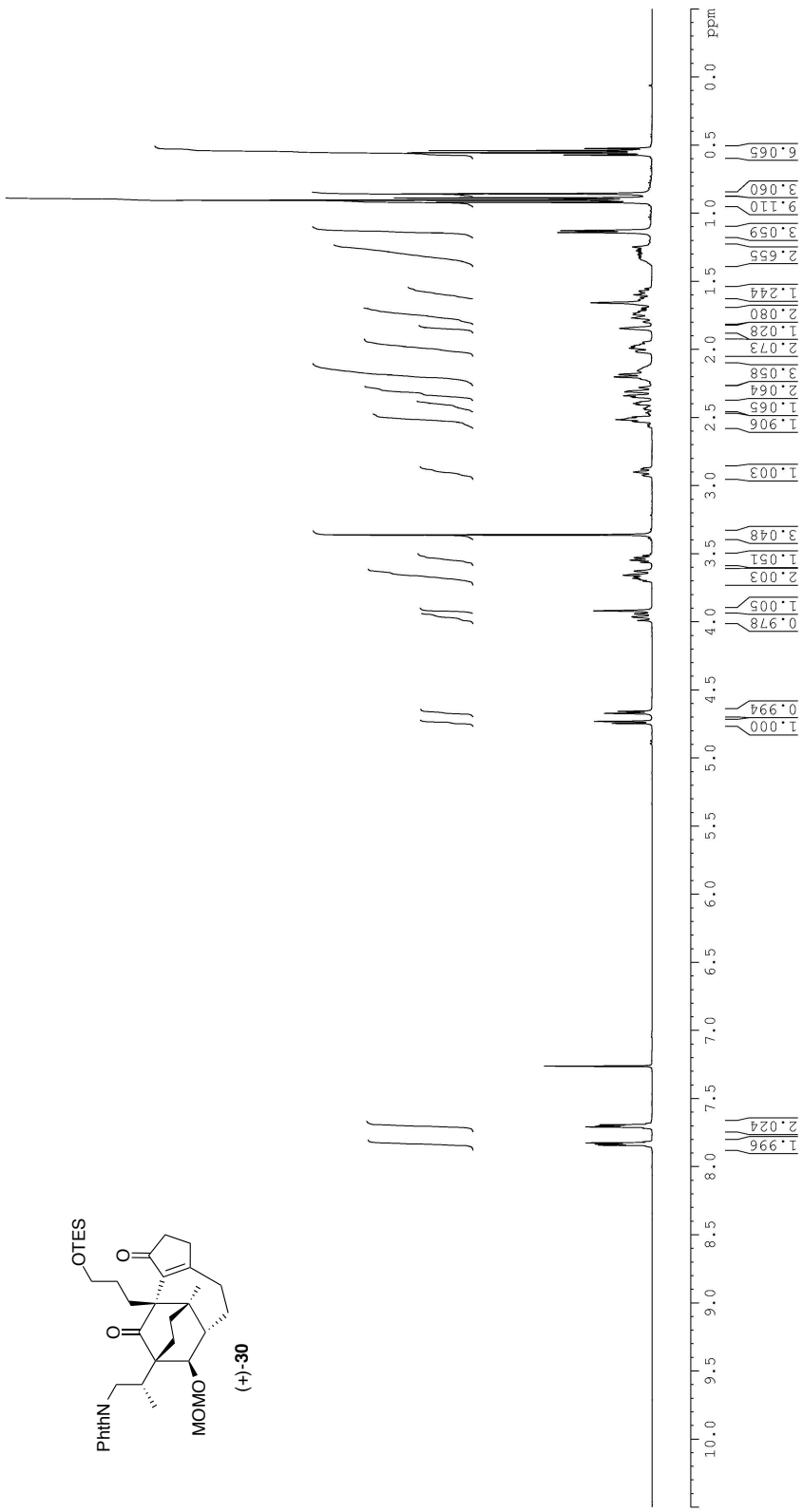
(+)-**28**


10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 ppm
2.103
2.093
1.000
0.981
1.020
1.063
1.110
1.077
2.034
1.197
1.039
1.289
3.157
2.539
2.290
2.360
1.091
1.216
1.543
3.095
3.093

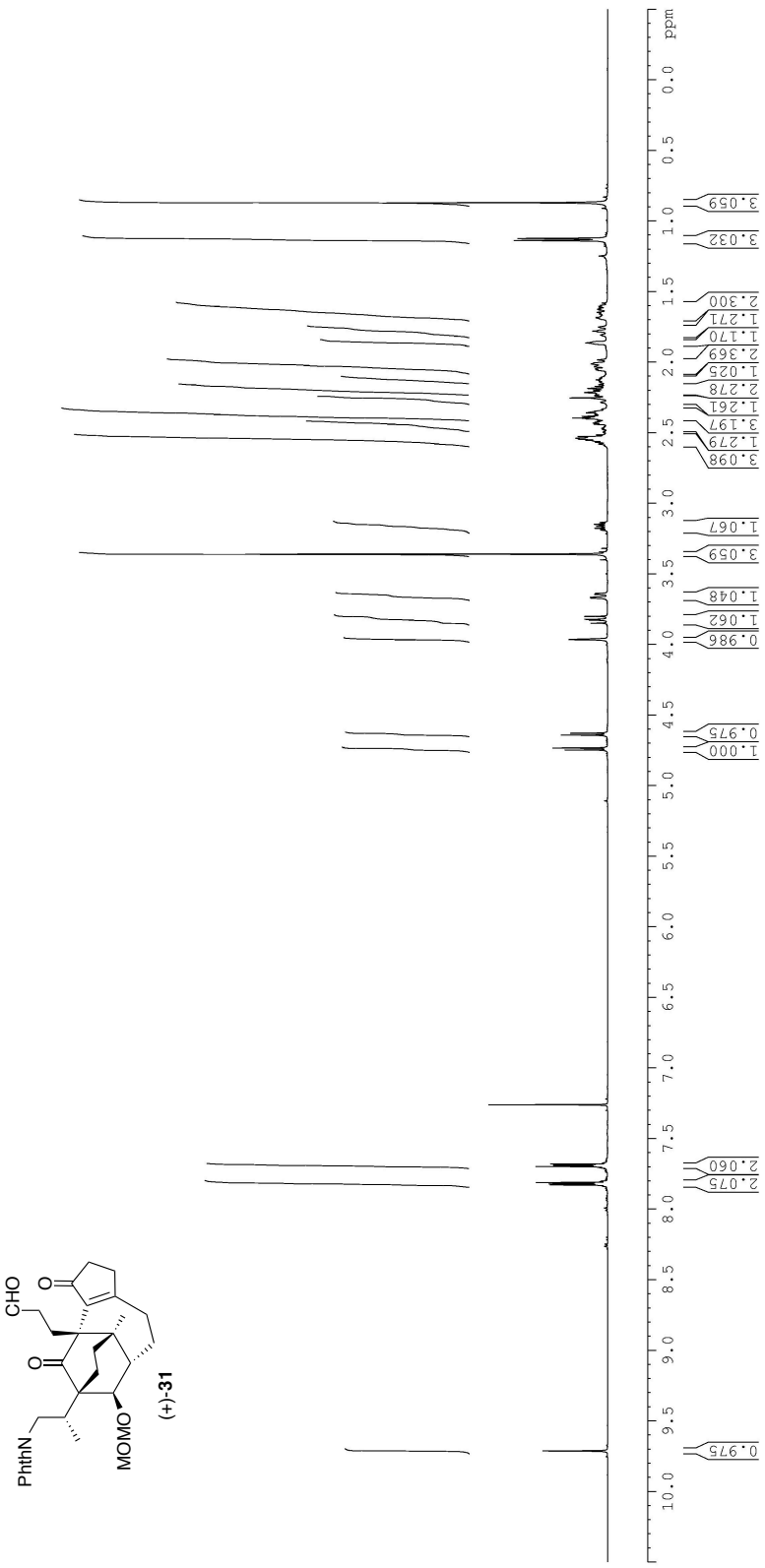

OH
O
O
HO
PhthN
(+)-28
ppm

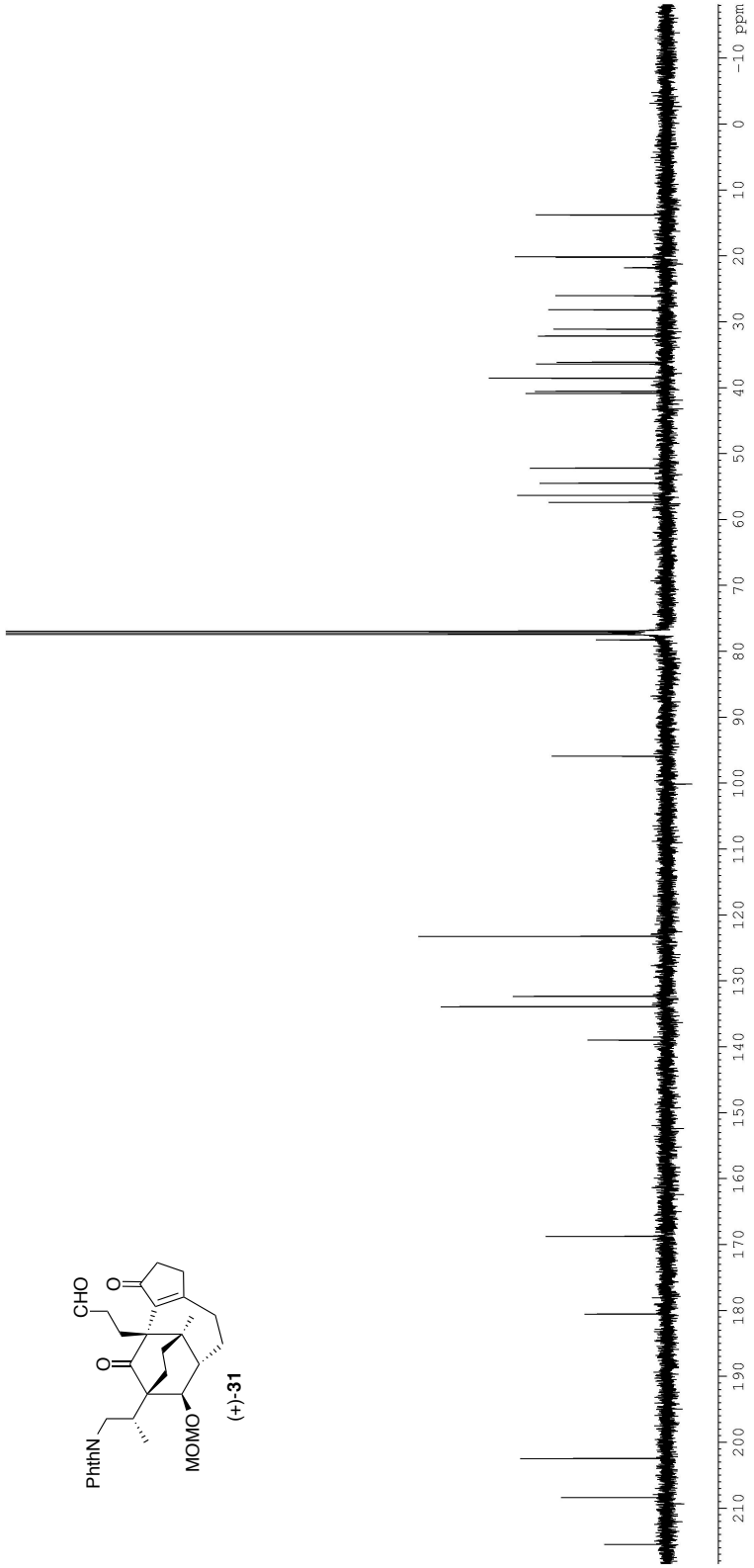

OTES
O
O
HO
PhthN
(+)-29
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
ppm
2.005
2.035
1.000
0.945
0.984
1.053
1.019
1.232
2.046
3.112
3.021
2.129
3.425
2.309
2.685
3.063
9.051
2.991
6.135

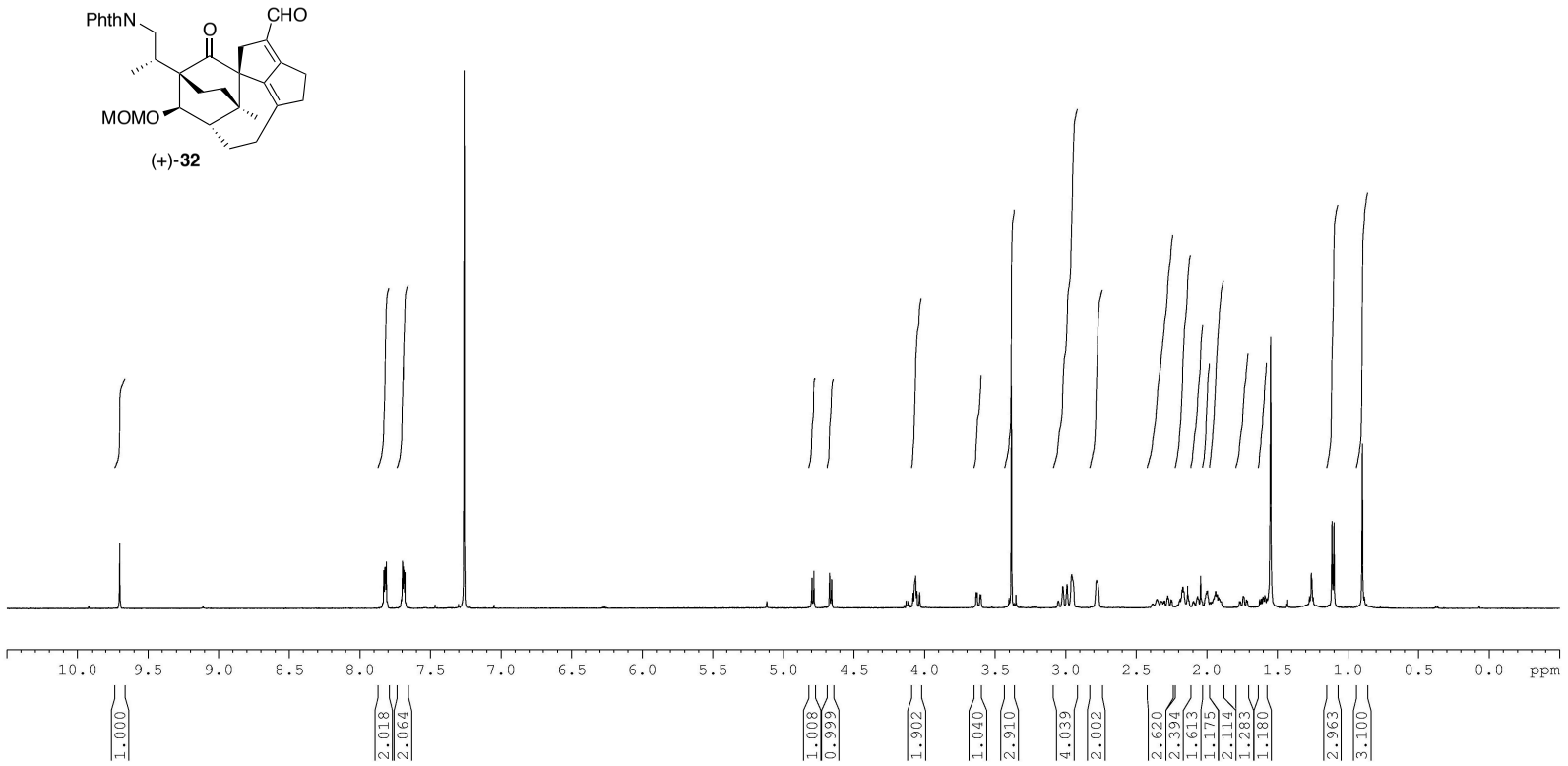

OTES
O
O
HO
PhthN
(+)-29
ppm

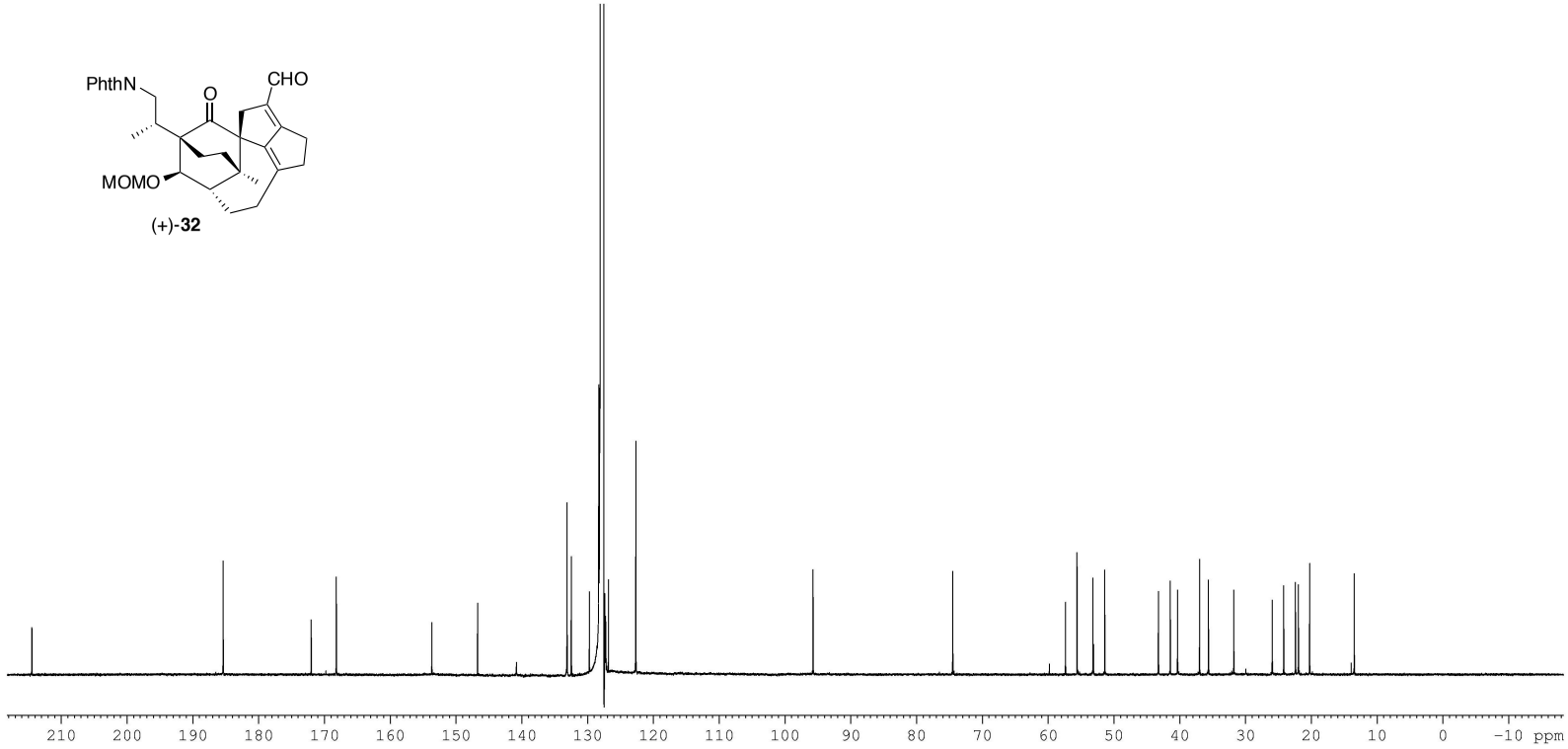

OTES
O
O
PhthN
MOMO
(+)-30
ppm
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
6.065
3.060
9.110
3.059
2.655
1.244
2.080
1.028
2.073
3.058
2.064
1.065
1.906
1.003
3.048
1.051
2.003
1.005
0.978
0.994
1.000
2.024
1.996

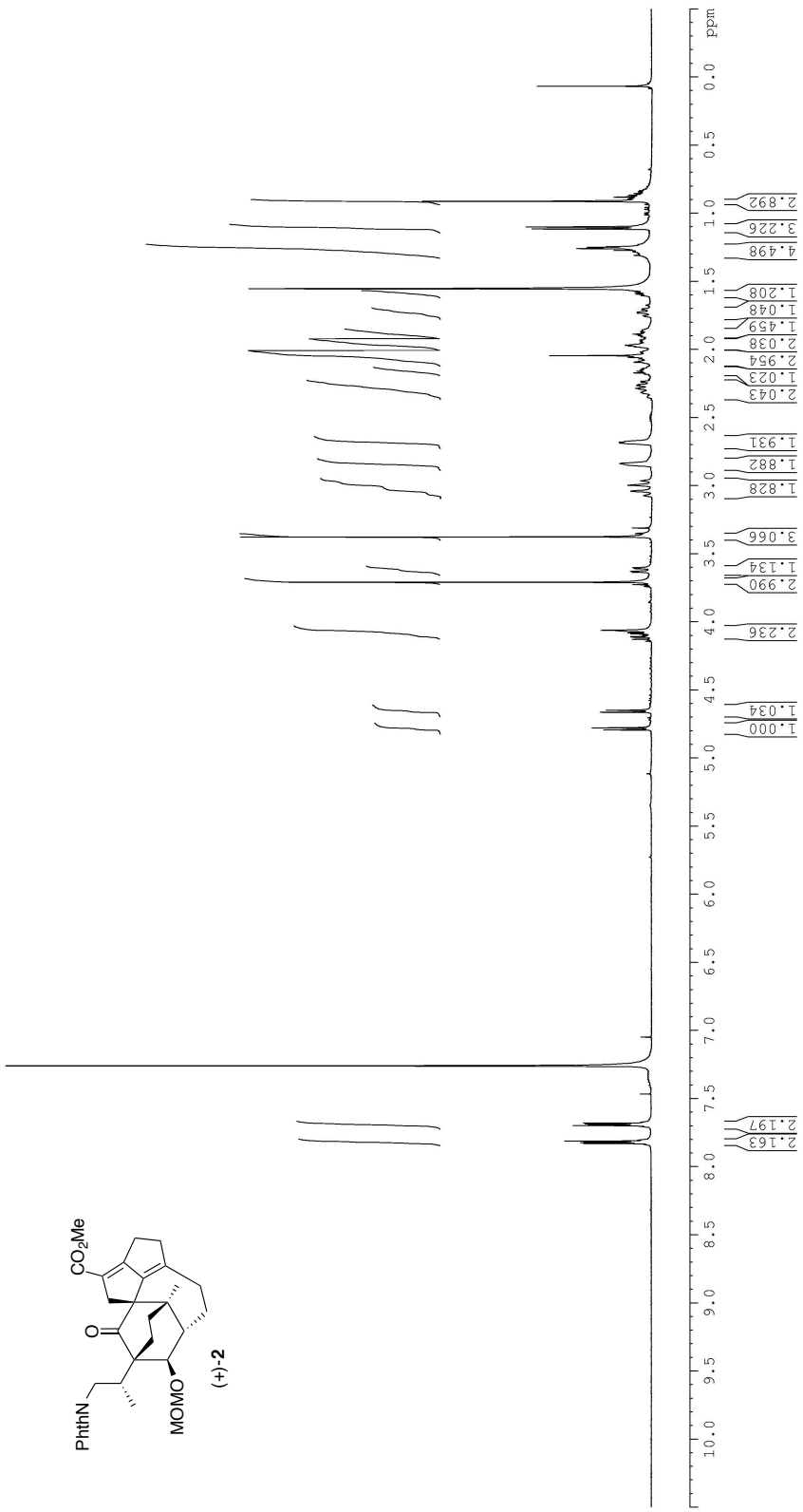
OTES
O
O
PhthN
MOMO
(+)-30
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10 ppm

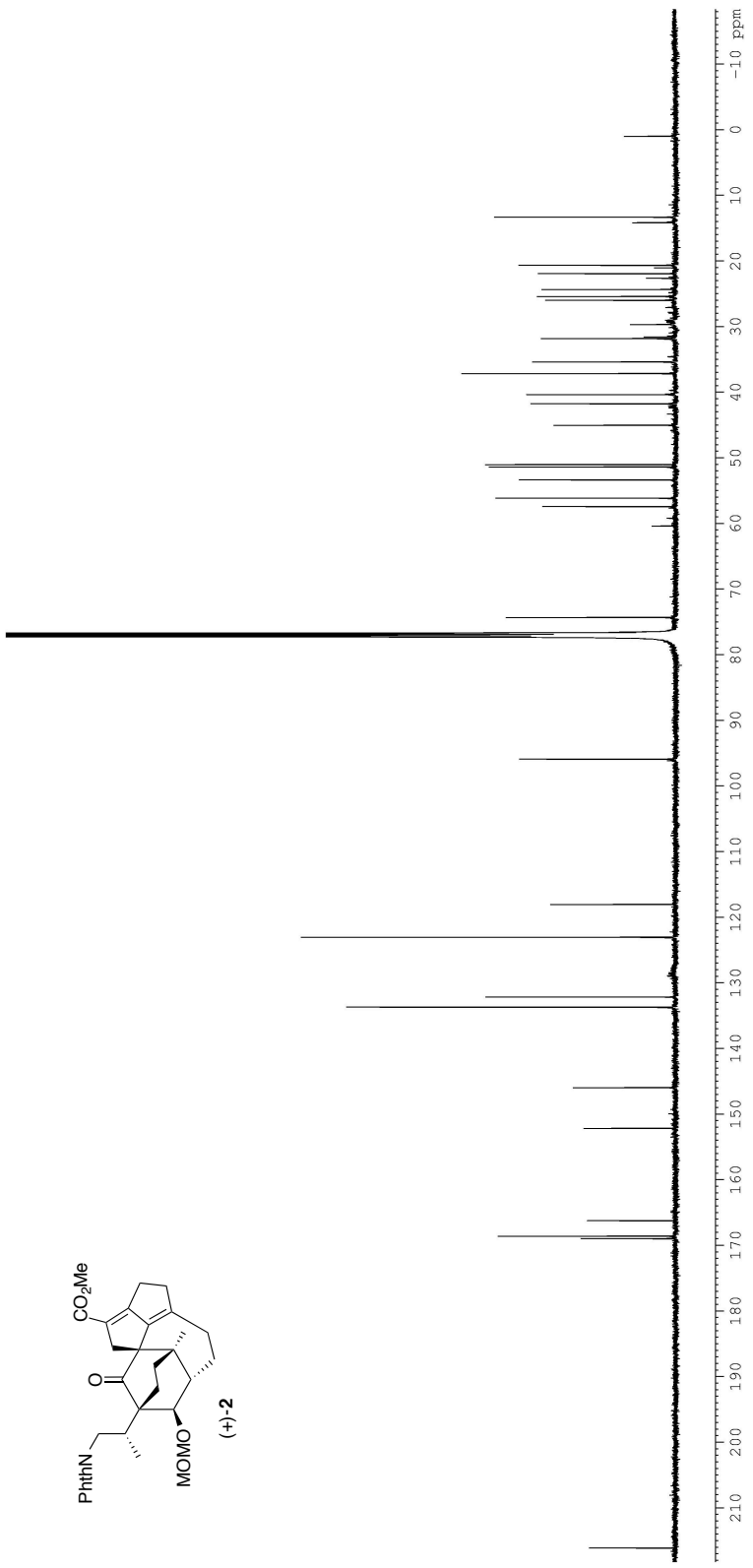

CHO
O
O
PhthN
MOMO
(+)-31
ppm
0.975
2.060
2.075
1.000
0.975
0.986
1.062
1.048
3.059
1.067
3.098
1.279
3.197
1.261
2.278
1.025
2.369
1.170
1.271
2.300
3.032
3.059

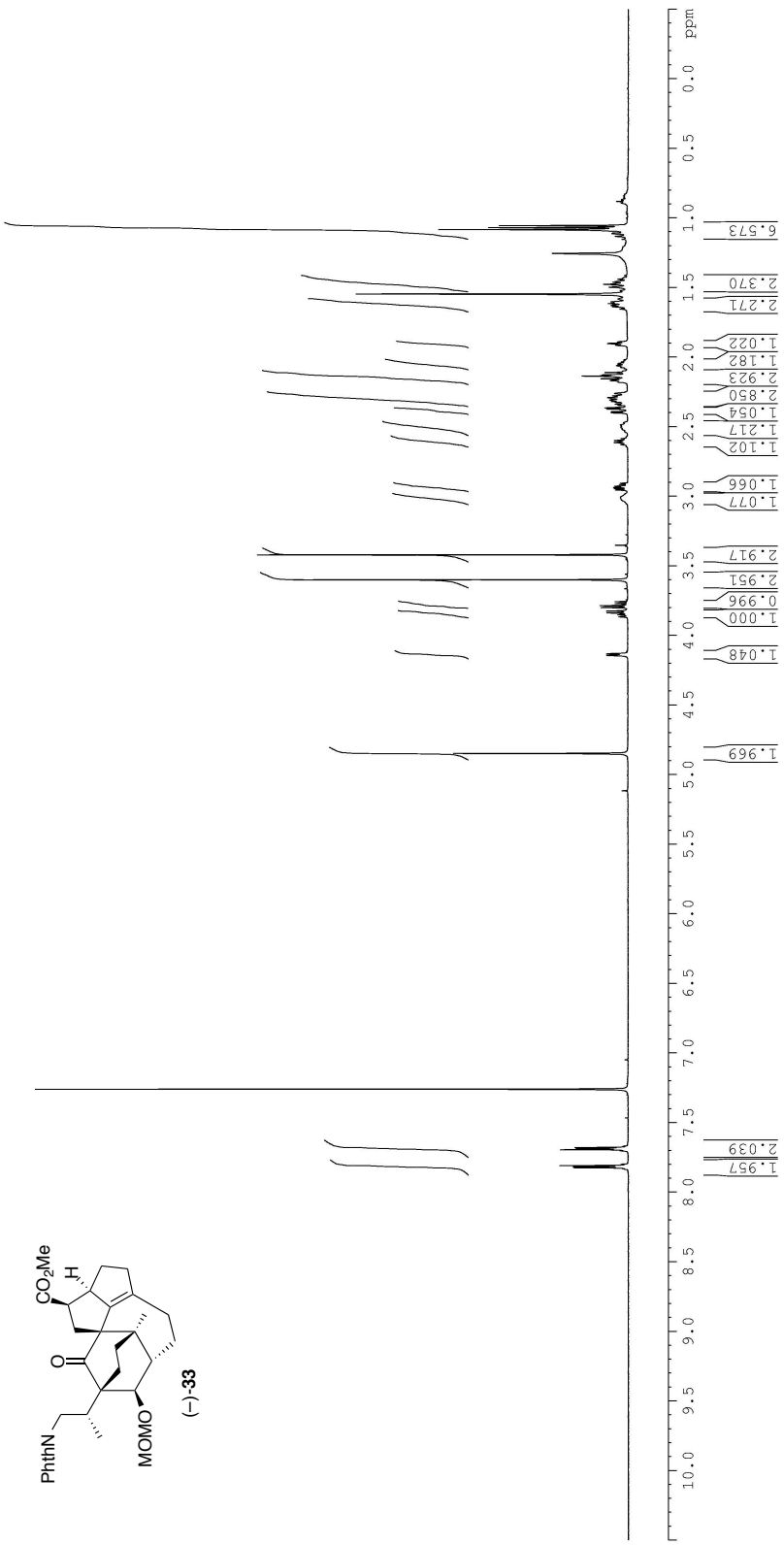

CHO
O
O
PhthN
MOMO
(+)-31
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10 ppm


PhthN
O
CHO
MOMO
(+)-32
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 ppm
1.000
2.018
2.064
1.008
0.999
1.902
1.040
2.910
4.039
2.002
2.620
2.394
1.613
1.175
2.114
1.283
1.180
2.963
3.100

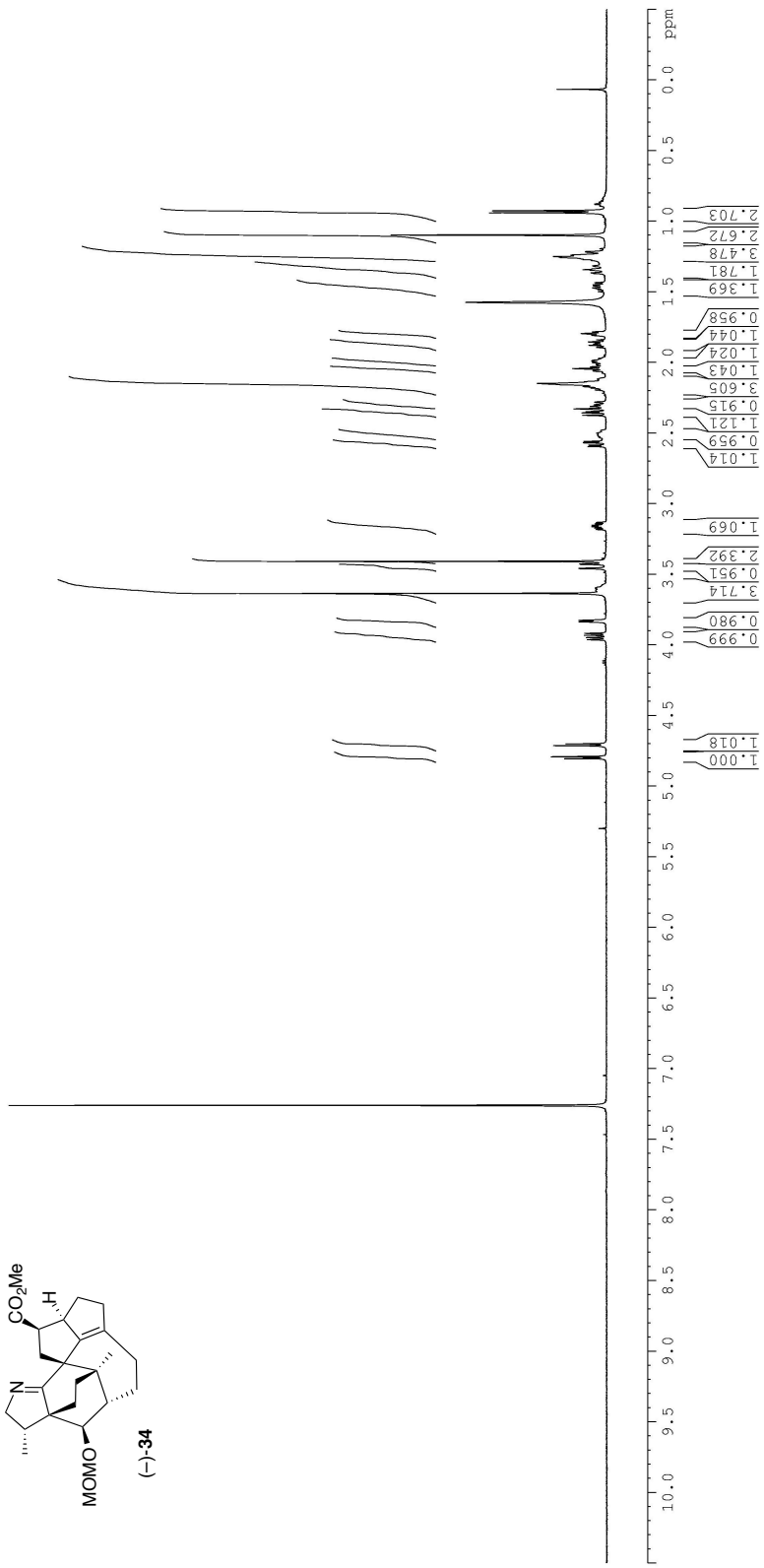

PhthN
O
CHO
MOMO
(+)-32
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10 ppm

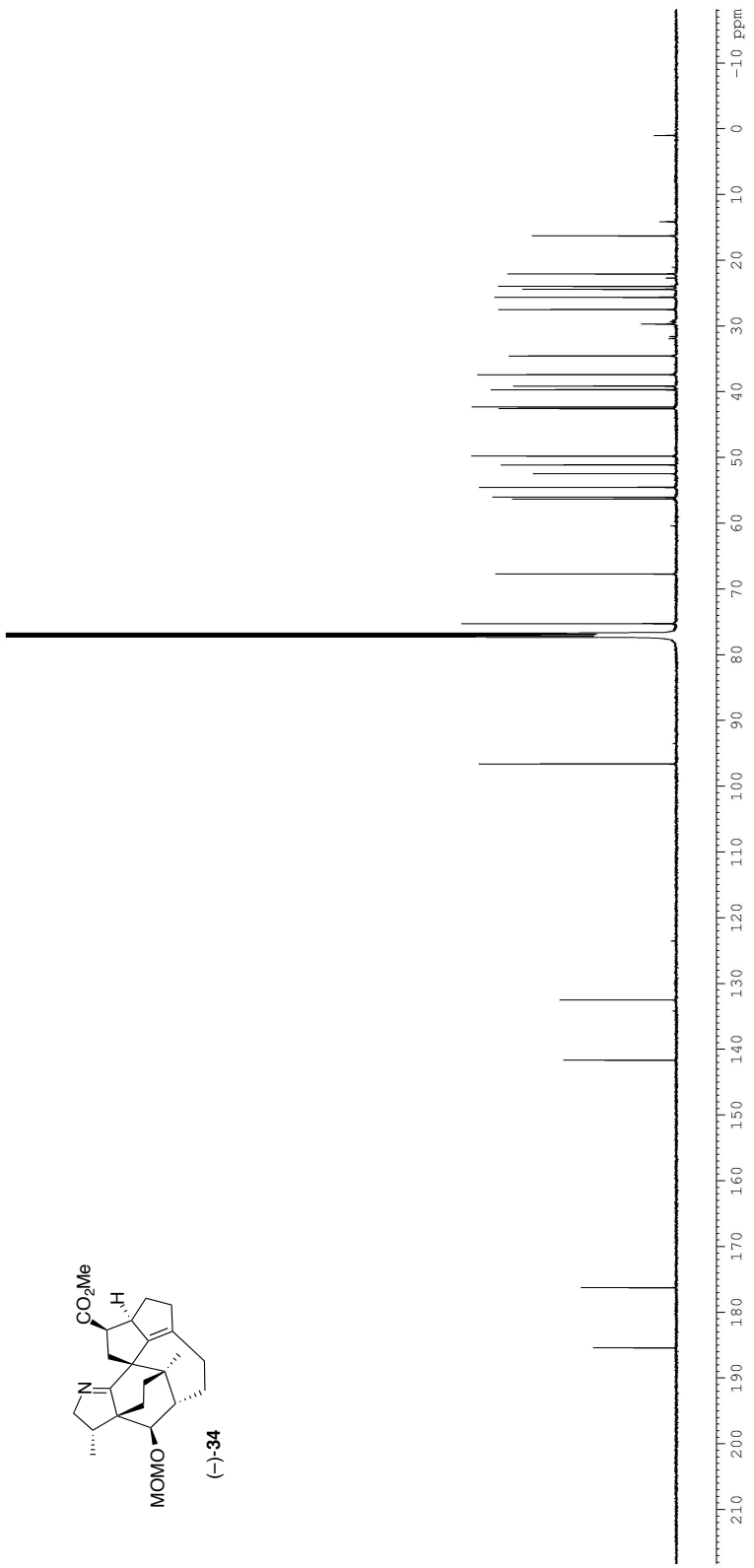

CO2Me
O
PhthN
MOMO
(+)-2
2.892
3.226
4.498
1.208
1.048
1.459
2.038
2.954
1.023
2.043
1.931
1.882
1.828
3.066
1.134
2.990
2.236
1.034
1.000
2.197
2.163
ppm

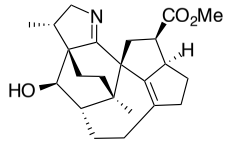

CO2Me
O
PhthN
MOMO
(+)-2
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10 ppm


CO2Me
H
O
PhthN
MOMO
(−)-33
ppm
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
6.573
2.371
2.271
1.022
1.182
2.923
2.850
1.054
1.217
1.102
1.066
1.077
2.917
2.951
0.996
1.000
1.048
1.969
2.039
1.957

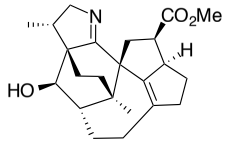
CO2Me
H
O
PhthN
MOMO
(−)-33
ppm


CO2Me
H
N
MOMO
(−)-34
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
ppm
1.000
1.018
0.999
0.980
3.714
0.951
2.392
1.069
1.014
0.959
1.121
0.915
3.605
1.043
1.024
1.044
0.958
1.369
1.781
3.478
2.672
2.703


CO2Me
H
N
MOMO
(−)-34
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10 ppm



(–)-Calyciphylline N (**1**)



(–)-Calyciphylline N (**1**)