Supporting Information

Stereoselective Cascade Reactions that Incorporate a 7-*exo* Acyl Radical Cyclization

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General Experimental Details

Acetonitrile, benzene, dimethyl formamide, diethyl ether, methanol, methylene chloride, and tetrahydrofuran were dried by passage through a Glass Contour solvent drying system containing cylinders of activated alumina.[1] Flash chromatography was carried out using 60–230 mesh silica gel. ^{1}H NMR spectra were acquired on 300 or 500 MHz spectrometers with chloroform (7.27 ppm) as internal reference. Signals are reported as follows: s (singlet), d (doublet), t (triplet), q (quartet), dd (doublet of doublets), dt (doublet of triplets), ddd (doublet of doublet of doublets), br s (broad singlet), m (multiplet). Coupling constants are reported in hertz (Hz). ^{13}C NMR spectra were acquired on spectrometers operating at 75 or 125 MHz with chloroform (77.23 ppm) as internal reference. Infrared spectra were obtained on an FT-IR spectrometer. Mass spectral data were obtained using EI, FAB, or ESI techniques.

4-Methoxybenzyl 2-(2-(4-methoxybenzyloxy)ethyl)benzoate (3). To a solution of isochromanone (**2**, 9.28 g, 62.4 mmol) in THF (90 mL) and MeOH (30 mL) was added aq NaOH (4 M, 125 mL, 500 mmol) dropwise, and the resulting orange solution was stirred at rt under N_2 for 1.5 h. The reaction was quenched by slow addition of 6 N HCl until pH ≈ 2 (ca. 100 mL), and the mixture was extracted with EtOAc (5 × 60 mL). The combined organic extracts were washed with H_2O (90 mL), dried (Na_2SO_4), and concentrated in vacuo. Azeotropic drying with benzene afforded the hydroxy acid as a white powder which was used directly in the next step.

[1] Pangborn, A. B.; Giardello, M. A.; Grubbs, R. H.; Rosen, R. K.; Timmers, F. J. *Organometallics* **1996**, *15*, 1518.

To a solution of the crude hydroxy acid in anhydrous THF (250 mL) and anhydrous DMF (13 mL) was added NaH (60% in mineral oil, 6.24 g, 156.1 mmol). 4-Methoxybenzyl chloride (25.4 mL, 29.3 g, 187 mmol) and tetrabutylammonium iodide (23.0 g, 62.4 mmol) were then added, and the mixture stirred at rt under N_2 for 3.5 h. The reaction was quenched with 1 N HCl until pH ≈ 6 and diluted with EtOAc (100 mL). The organic layer was separated, the aqueous layer was extracted with EtOAc (4 × 100 mL), and the combined organic layers were washed with brine (2 × 120 mL), dried (Na_2SO_4), and concentrated in vacuo. Flash chromatography (SiO_2, 8 × 80 cm, 5–15% EtOAc in hexanes gradient elution) yielded **3** (17.96 g, 44.2 mmol, 71% over two steps) as a pale crystalline solid: ^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.88 (d, *J* = 7.8 Hz, 1H), 7.37–7.17 (m, 7H), 6.87 (d, *J* = 6.6 Hz, 2H), 6.82 (d, *J* = 6.6 Hz, 2H), 5.23 (s, 2H), 4.37 (s, 2H), 3.74 (s, 3H), 3.73 (s, 3H), 3.64 (t, *J* = 6.9 Hz, 2H), 3.28 (t, *J* = 6.9 Hz, 2H); ^{13}C NMR ($CDCl_3$, 75 MHz) δ 167.5, 159.7, 159.1, 140.7, 131.9 (3C), 130.8, 130.2 (2C), 130.1 (2C), 129.2, 128.2, 126.3, 114.0 (2C), 113.7 (2C), 72.4, 70.8, 66.5, 55.3, 55.2, 34.9; IR (film) ν_{max} 3028, 2941, 2853, 1715, 1608, 1511, 1251, 1085 cm^{-1}; HRMS (FAB) *m*/*z* 429.1685 (MNa^+, $C_{25}H_{26}O_5Na$ requires 429.1678).

***tert*-Butyl(2-(2-(4-methoxybenzyloxy)ethyl)benzyloxy)dimethylsilane (4).** To a solution of **3** (11.13 g, 27.4 mmol) in anhydrous THF (120 mL) was added $LiAlH_4$ (1.0 M in Et_2O, 30.0 mL, 30.0 mmol). The solution was stirred at rt under Ar for 3 h and quenched by successive dropwise addition of EtOAc (20 mL) and 1 N HCl (120 mL). The solution was extracted with EtOAc (4 × 75 mL) and the combined extracts were washed with H_2O (150 mL), dried (Na_2SO_4), and concentrated in vacuo to give the crude benzyl alcohol as a yellow oil (11.36 g), which was used directly in the next step.

To a solution of the benzyl alcohol (11.36 g) in anhydrous DMF (200 mL) was added imidazole (5.60 g, 82.3 mmol) and *tert*-butyldimethylsilyl chloride (12.73 g, 84.4 mmol). The resultant mixture was stirred at rt under N_2 for 23 h, then partitioned into Et_2O and H_2O (100 mL each). The organic layer was separated, and the aqueous layer was extracted with Et_2O (3 × 100 mL). The combined organic layers were washed with H_2O (100 mL), dried (Na_2SO_4), and concentrated in vacuo. Flash chromatography (SiO_2, 5.5 × 47 cm, 5–8% Et_2O in hexanes gradient elution) afforded **4** (9.96 g, 25.8 mmol, 94%) as a colorless oil: ^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.44–7.40 (m, 1H), 7.24–7.15 (m, 5H), 6.86 (dd, *J* = 6.6, 2.1 Hz, 2H), 4.75 (s, 2H), 4.44 (s, 2H), 3.78 (s, 3H), 3.64 (t, *J* = 7.5 Hz, 2H), 2.92 (t, *J* = 7.5 Hz, 2H), 0.93 (s, 9H), 0.08 (s, 6H); ^{13}C NMR ($CDCl_3$, 75 MHz) δ 159.4, 139.5, 136.2, 130.7, 129.9, 129.4 (2C), 127.3, 127.3, 126.6, 114.0 (2C), 72.9, 70.7, 63.3, 55.4, 32.8, 26.2 (3C), 18.6, –5.1 (2C); IR (film) ν_{max} 2940, 2862, 1610, 1508, 1463, 1369, 1248, 1177, 1084, 839, 769 cm^{-1}; HRMS (FAB) *m*/*z* 409.2181 (MNa^+, $C_{23}H_{34}O_3SiNa$ requires 409.2175).

2-(2-((*tert*-Butyldimethylsilyloxy)methyl)phenyl)ethanol (5). Differentially protected diol **4** (22.0 g, 56.9 mmol) was dissolved in CH_2Cl_2 (440 mL) and distilled H_2O (22 mL), and 2,3-dichloro-5,6-dicyano-1,4-benzoquinone (DDQ, 14.85 g, 65.4 mmol) was added. The dark green solution was stirred at rt under N_2 for 2.5 h, during which time the color faded to a pale pink. The reaction was quenched with sat aq $NaHCO_3$ (330 mL), the organic layer was separated, and the aqueous layer was extracted with CH_2Cl_2 (2 × 220 mL). The combined organic layers were washed successively with sat aq $NaHCO_3$ and brine (275 mL each), dried (Na_2SO_4), and concentrated in vacuo. Flash chromatography (SiO_2, 0.25–1.0% MeOH in CH_2Cl_2 gradient elution) afforded mono-

TBS diol **5** (12.84 g, 48.2 mmol, 85%) as a colorless oil: ^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.37–7.34 (m, 1H), 7.25–7.17 (m, 3H), 4.74 (s, 2H), 3.81 (dt, *J* = 6.6, 5.7 Hz, 2H), 2.89 (t, *J* = 6.6 Hz, 2H), 2.52 (t, *J* = 5.7 Hz, 1H), 0.94 (s, 9H), 0.12 (s, 6H); ^{13}C NMR ($CDCl_3$, 75 MHz) δ 139.1, 137.0, 130.0, 128.3, 127.9, 126.7, 63.7, 63.4, 35.5, 26.1 (3C), 18.6, −5.1 (2C); IR (film) ν_{max} 3360 (br), 3065, 3026, 2941, 2873, 1464, 1383, 1253, 1064, 844, 769 cm^{-1}; HRMS (FAB) *m*/*z* 289.1613 (MNa^+, $C_{15}H_{26}O_2SiNa$ requires 289.1600).

Diethyl 2-(2-((*tert*-butyldimethylsilyloxy)methyl)phenethyl)-3-oxopentanedioate (6). LiBr (17.6 g, 20.3 mmol) was thoroughly flame dried under reduced pressure, cooled, and suspended in anhydrous THF (190 mL). A solution of alcohol **5** (5.35 g, 20.1 mmol) in anhydrous THF (10 mL) was added to this mixture, followed by Et_3N (7.0 mL, 5.08 g, 50.2 mmol) and methanesulfonyl chloride (3.4 mL, 5.03 g, 43.9 mmol). The resulting mixture was stirred at rt under N_2 for 6 d, quenched with H_2O (150 mL), and extracted with Et_2O (4 × 75 mL). The combined extracts were washed with H_2O (100 mL), dried (Na_2SO_4), and concentrated in vacuo to the corresponding bromide (6.17 g, 18.7 mmol, 93%) as a yellow oil that was used directly in the following step: ^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.38–7.35 (m, 1H), 7.25–7.16 (m, 3H), 4.73 (s, 2H), 3.56 (t, *J* = 8.1 Hz, 2H), 3.19 (t, *J* = 8.1 Hz, 2H), 0.94 (s, 9H), 0.11 (s, 6H); ^{13}C NMR ($CDCl_3$, 75 MHz) δ 139.1, 137.1, 129.8, 128.5, 127.9, 127.3, 63.8, 36.4, 32.5, 26.2 (3C), 18.6, –5.0 (2C); IR (film) ν_{max} 3023, 2942, 2869, 1463, 1384, 1254, 1071, 843, 770 cm^{-1}; HRMS (FAB) *m*/*z* 351.0763 (MNa^+, $C_{15}H_{25}OBrSiNa$ requires 351.0756).

To a suspension of NaH (60% dispersion in mineral oil, 257 mg, 6.42 mmol) in anhydrous THF (10 mL) at 0 °C under Ar was added diethyl acetone-1,3-dicarboxylate (1.16 mL, 1.29 g, 6.39 mmol) dropwise, with rapid evolution of gas. The mixture was

stirred at 0 °C for 10 min, treated with the phenethyl bromide described above (450 μL, 513 mg, 1.56 mmol), and the resultant mixture was concentrated in vacuo. The sticky orange residue was dissolved in anhydrous acetonitrile (5.0 mL), treated with NaI (118 mg, 0.79 mmol), and the resultant mixture was heated at 60 °C under Ar for 6.75 d, after which most of the solvent had evaporated. The residue was cooled to rt, diluted with EtOAc (7 mL), and treated with 1 M HCl (6 mL). The organic layer was separated and the aqueous layers were extracted with EtOAc (3 × 6 mL). The combined organic layers were washed with brine (10 mL), dried (Na_2SO_4), and concentrated in vacuo. Flash chromatography (SiO_2, 3.2 × 37 cm, 10% EtOAc in hexanes elution) gave **6** (590 mg, 1.31 mmol, 84%) in equilibrium with multiple enol tautomers as a yellow oil (data for major tautomer): ^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.44–7.41 (m, 1H), 7.24–7.18 (m, 2H), 7.15–7.12 (m, 1H), 4.74 (s, 2H), 4.26–4.15 (m, 4H), 3.68 (t, *J* = 7.2 Hz, 1H), 3.60 (d, *J* = 15.9 Hz, 1H), 3.55 (d, *J* = 15.9 Hz, 1H), 2.65–2.60 (m, 2H), 2.20–2.12 (m, 2H), 1.31–1.24 (m, 6H), 0.94 (s, 9H), 0.10 (s, 6H); ^{13}C NMR ($CDCl_3$, 75 MHz) δ 197.5, 169.1, 166.8, 139.1, 138.0, 129.2, 127.6, 127.4, 126.6, 63.0, 61.9, 61.7, 58.7, 48.3, 29.9, 28.9, 26.1 (3C), 18.6, 14.2 (2C), –5.1 (2C); IR (film) ν_{max} 2934, 2858, 1741, 1650, 1464, 1370, 1317, 1251, 1077, 842, 776 cm^{-1}; HRMS (FAB) *m*/*z* 473.2342 (MNa^+, $C_{24}H_{38}O_6SiNa$ requires 473.2335).

***syn*-Diethyl 3-(*tert*-butyldimethylsilyloxy)-2-(2-((*tert*-butyldimethylsilyloxy) methyl)phenethyl)pentanedioate (7).** To a solution of ketoester **6** (163 mg, 0.36 mmol) in MeOH (3.5 mL) at 0 °C was added $NaBH_4$ (30 mg, 0.78 mmol). The solution was stirred at 0 °C under N_2 for 15 min, quenched with sat aq NH_4Cl (3 mL), and extracted

with CH_2Cl_2 (4 × 3 mL). The combined extracts were dried (Na_2SO_4) and concentrated in vacuo.

To a solution of the crude alcohol in anhydrous CH_2Cl_2 (1.8 mL) at 0 °C under Ar was added 2,6-lutidine (130 μL, 120 mg, 1.12 mmol). The mixture was stirred for 5 min and then treated with *tert*-butyldimethylsilyl trifluoromethanesulfonate (166 μL, 191 mg, 0.72 mmol). The resultant mixture was allowed to warm to rt and stir under Ar for 43 h, then poured into sat aq $NaHCO_3$ (2 mL). The organic phase was separated and the aqueous phase was extracted with CH_2Cl_2 (3 × 2 mL). The combined organic extracts were dried (Na_2SO_4) and concentrated in vacuo, then purified by flash chromatography (SiO_2, 2.1 × 19 cm, 5% EtOAc in hexanes elution) to afford **7** (122 mg, 0.22 mmol, 60%, ca. 2:1 mixture of diastereomers) as a yellow oil: ^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.46–7.41 (m, 1H), 7.23–7.16 (m, 2H), 7.13–7.10 (m, 1H), 4.75 and 4.74 (2s, 2H), 4.45–4.36 (m, 1H), 4.21–4.06 (m, 4H), 2.70–2.60 (m, 2H), 2.57–2.41 (m, 3H), 1.98–1.72 (m, 2H), 1.30 (t, *J* = 7.2 Hz, 3H), 1.23 (t, *J* = 7.2 Hz, 3H), 0.94 (s, 9H), 0.84 (s, 9H), 0.10 (s, 6H), 0.06 and 0.04 (2s, 3H), 0.03 and 0.01 (2s, 3H); ^{13}C NMR ($CDCl_3$, 75 MHz) δ 173.6 and 173.5, 171.8 and 171.6, 139.0 and 138.9, 138.7 and 138.6, 129.1 and 129.0, 127.3 and 127.3, 127.2 and 127.1, 126.3, 70.8 and 70.3, 63.0 and 62.8, 60.6, 52.2 and 51.7, 40.0 and 39.7, 30.6 and 30.5, 29.4, 27.9, 26.1 (3C), 25.8 (3C), 18.5, 18.1, 14.5, 14.3, –4.6 and –4.7, –4.8, –5.1 (2C); IR (film) ν_{max} 2934, 2859, 1735, 1465, 1378, 1254, 1182, 1083, 838, 777 cm^{-1}; HRMS (FAB) *m*/*z* 589.3365 (MNa^+, $C_{30}H_{54}O_6Si_2Na$ requires 589.3357).

***syn*-3-(*tert*-Butyldimethylsilyloxy)-2-(2-((*tert*-butyldimethylsilyloxy)methyl)-phenethyl)-*N*^{1},*N*^{5}-dimethoxy-*N*^{1},*N*^{5}-dimethylpentanediamide (8).** To a stirred suspension of MeNH(OMe)•HCl (106 mg, 1.09 mmol) in anhydrous THF (2.0 mL) at

–10 °C (ice/acetone bath) under Ar was added *i*-PrMgCl (2.0 M in THF, 1.1 mL, 2.2 mmol) dropwise. The mixture was stirred for 10 min at –10 °C, then treated with a solution of diester **7** (244 mg, 0.43 mmol) in anhydrous THF (0.8 mL + 0.4 mL rinse). The resultant mixture was allowed to warm to rt and stir under Ar for 26 h, then treated with sat aq NH_4Cl (5 mL) and extracted with CH_2Cl_2 (4 × 5 mL). The combined organic layers were dried (Na_2SO_4) and concentrated in vacuo. Flash chromatography (SiO_2, 2.5 × 23 cm, 2% MeOH in CH_2Cl_2 elution) afforded bis-Weinreb amide **8** (184 mg, 0.308 mmol, 72%, mixture of diastereomers possibly including *E*/*Z* Weinreb amides) as an orange oil: ^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.47–7.42 (m, 1H), 7.22–7.16 (m, 3H), 4.79–4.72 (m, 2H), 4.62–4.53 (m, 1H), 3.68 (s, 3H), 3.64 (s, 3H), 3.21 (s, 3H), 3.14–3.05 (m, 1H), 3.13 (s, 3H), 2.74–2.52 (m, 2H), 2.52–2.37 (m, 2H), 2.08–1.88 (m, 2H), 0.94 (s, 9H), 0.85 (s, 9H), 0.10 (s, 6H), 0.06 (s, 3H), 0.02 (s, 3H); ^{13}C NMR ($CDCl_3$, 75 MHz) δ 173.7, 172.6, 139.1, 139.0, 129.2, 127.1, 127.0, 126.2, 68.8, 62.7, 61.5, 61.4, 48.3 (2C), 35.6 (2C), 30.6 (2C), 26.1 (3C), 25.9 (3C), 18.6, 18.1, –4.8 (2C), –5.1 (2C); IR (film) ν_{max} 2935, 2893, 2858, 1663, 1464, 1386, 1254, 1077, 839 cm^{-1}; HRMS (FAB) *m*/*z* 619.3579 (MNa^+, $C_{30}H_{56}O_6N_2Si_2Na$ requires 619.3575).

***syn*-3-(*tert*-Butyldimethylsilyloxy)-2-(2-((*tert*-butyldimethylsilyloxy)methyl) phenethyl)-*N*-methoxy-*N*-methylhex-5-enamide (9).** To a solution of bis-Weinreb amide **8** (184 mg, 0.31 mmol) in anhydrous THF (1.8 mL) at –78 °C under Ar was added DIBAL (1.0 M in THF, 1.23 mL, 1.23 mmol) dropwise, and the solution was stirred at –78 °C under Ar for 2.0 h, then treated with sat aq potassium sodium tartrate (5.0 mL). The mixture was allowed to warm to rt and stirred vigorously at rt for 1.0 h, then extracted with CH_2Cl_2 (4 × 4 mL). The combined extracts were washed with brine (5

mL), dried (Na_2SO_4), filtered, and concentrated in vacuo to give the crude monoaldehyde (192 mg).

To a suspension of methyltriphenylphosphonium bromide (359 mg, 1.01 mmol) in anhydrous THF (2.0 mL) under Ar was added *n*-BuLi (1.6 M in hexanes, 0.54 mL, 0.86 mmol) dropwise, and the yellow solution was stirred at rt for 10 min then cooled to –78 °C. A solution of the crude monoaldehyde (192 mg) in anhydrous THF (0.4 mL + 2 × 0.3 mL rinses) was then added dropwise, and the mixture was allowed to warm to rt and stir under Ar for 18.5 h. The reaction was quenched with sat aq NH_4Cl (3 mL), and the mixture was extracted with EtOAc (4 × 3 mL). The combined organic layers were washed with brine (7 mL), dried (Na_2SO_4), and concentrated in vacuo. The residue was purified by flash chromatography (SiO_2, 2.5 × 22 cm, 0.5% MeOH in CH_2Cl_2 elution) to afford **9** (95 mg, 0.18 mmol, 57% over two steps) as a yellow oil: ^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.43–7.40 (m, 1H), 7.22–7.11 (m, 3H), 5.97–5.82 (m, 1H), 5.10–5.01 (m, 2H), 4.74 (d, *J* = 13.2 Hz, 1H), 4.69 (d, *J* = 13.2 Hz, 1H), 4.01 (quin, *J* = 4.2 Hz, 1H), 3.69 (s, 3H), 3.23–3.12 (m, 1H), 3.20 (s, 3H), 2.49 (t, *J* = 8.1 Hz, 2H), 2.39–2.30 (m, 1H), 2.28–2.16 (m, 1H), 1.91–1.78 (m, 1H), 1.75–1.63 (m, 1H), 0.94 (s, 9H), 0.86 (s, 9H), 0.09 (s, 6H), 0.05 (s, 3H), 0.00 (s, 3H); ^{13}C NMR ($CDCl_3$, 75 MHz) δ 175.2, 139.1, 138.9, 134.4, 129.0, 127.2, 127.2, 126.2, 117.5, 72.6, 62.8, 61.4, 46.5, 38.4, 32.2, 30.0, 29.0, 26.2 (3C), 26.0 (3C), 18.6, 18.2, –4.6, –4.6, –5.1 (2C); IR (film) ν_{max} 2933, 2858, 1661, 1465, 1254, 1075, 839, 776 cm^{-1}; HRMS (FAB) *m*/*z* 558.3409 (MNa^+, $C_{29}H_{53}O_4NSi_2Na$ requires 558.3410).

***syn*-4-(*tert*-Butyldimethylsilyloxy)-3-(2-((*tert*-butyldimethylsilyloxy)methyl) phenethyl)-1,6-heptadiene (10).** To a solution of Weinreb amide **9** (131 mg, 0.24

mmol) in anhydrous THF (1.3 mL) at –78 °C under Ar was added DIBAL (1.0 M in THF, 1.22 mL, 1.22 mmol) dropwise, and the resulting solution was stirred at –78 °C under Ar for 6 h, then poured into a stirred solution of sat aq potassium sodium tartrate (5.0 mL). The quenched mixture was stirred vigorously at rt for 2.5 h, then diluted with H_2O (2.0 mL) and extracted with CH_2Cl_2 (4 × 4 mL). The combined extracts were dried (Na_2SO_4), filtered, and concentrated in vacuo to give the crude aldehyde, which was combined with another portion of the identical aldehyde (43 mg, 0.09 mmol).

To a suspension of methyltriphenylphosphonium bromide (523 mg, 1.55 mmol) in anhydrous THF (1.4 mL) under Ar was added *n*-BuLi (1.4 M in hexanes, 1.0 mL, 1.4 mmol) dropwise. The red solution was stirred at rt for 10 min, cooled to –78 °C, and then added dropwise via syringe to a solution of the aldehyde (149 mg) in anhydrous THF (1.0 mL) at –78 °C. The resulting solution was allowed to warm to rt and stir under Ar for 18 h, then poured into sat aq NH_4Cl (5 mL). The mixture was extracted with EtOAc (4 × 3 mL), and the combined extracts were dried (Na_2SO_4) and concentrated in vacuo. The crude product was purified by flash chromatography (SiO_2, 2.5 × 20 cm, 2% Et_2O in hexanes elution) to afford diene **10** (90 mg, 0.19 mmol, 58% over two steps) as a colorless oil: ^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.45–7.40 (m, 1H), 7.23–7.10 (m, 3H), 5.81–5.67 (m, 2H), 5.17 (dd, *J* = 1.8, 10.2 Hz, 1H), 5.11–4.98 (m, 3H), 4.72 (s, 2H), 3.65 (dt, *J* = 3.0, 6.3 Hz, 1H), 2.69–2.59 (m, 1H), 2.47–2.37 (m, 1H), 2.29–2.10 (m, 3H), 1.81–1.69 (m, 1H), 1.66–1.51 (m, 1H), 0.94 (s, 9H), 0.88 (s, 9H), 0.10 (s, 6H), 0.03 (s, 3H), 0.01 (s, 3H); ^{13}C NMR ($CDCl_3$, 75 MHz) δ 139.8, 139.0, 138.9, 135.8, 128.9, 127.2, 127.1, 126.0, 117.4, 117.0, 75.5, 63.0, 49.7, 39.5, 31.7, 30.3, 26.2 (3C), 26.1 (3C), 18.7, 18.3,

–3.9, –4.2, –5.0 (2C); IR (film) ν_{max} 3074, 2955, 2929, 2857, 1472, 1255, 1077, 912, 837, 775 cm^{-1}; HRMS (FAB) *m*/*z* 497.3249 (MNa^+, $C_{28}H_{50}O_2Si_2Na$ requires 497.3247).

(2-(*syn*-4-(*tert*-Butyldimethylsilyloxy)-3-vinylhept-6-enyl)phenyl)methanol (11). To a solution of **10** (87 mg, 0.18 mmol) in CH_2Cl_2 (1.9 mL) at 0 °C under Ar was added a solution of (1*S*)-(+)-(10)-camphorsulfonic acid (9.3 mg, 0.04 mmol) in MeOH (1.9 mL). The mixture was stirred at 0 °C under Ar for 1 h and 40 min, then poured into sat aq $NaHCO_3$ (3 mL) and diluted with CH_2Cl_2 and H_2O (1 mL each). The organic phase was collected and the aqueous phase extracted with CH_2Cl_2 (3 × 3 mL). The combined organic layers were dried (Na_2SO_4) and concentrated in vacuo, then purified by flash chromatography (SiO_2, 1.5 × 16.5 cm, 7% EtOAc in hexanes elution) to afford benzyl alcohol **11** (57 mg, 0.16 mmol, 87%) as a yellow oil: ^1H NMR ($CDCl_3$, 300 MHz) δ 7.39–7.34 (m, 1H), 7.26–7.15 (m, 3H), 5.81–5.67 (m, 2H), 5.17 (dd, *J* = 1.8, 10.2 Hz, 1H), 5.11–4.98 (m, 3H), 4.68 (s, 2H), 3.65 (dt, *J* = 3.3, 6.3 Hz, 1H), 2.77–2.66 (m, 1H), 2.55–2.44 (m, 1H), 2.29–2.10 (m, 3H), 1.83–1.71 (m, 1H), 1.67–1.54 (m, 2H), 0.87 (s, 9H), 0.03 (s, 3H), 0.00 (s, 3H); ^{13}C NMR ($CDCl_3$, 75 MHz) δ 140.9, 139.0, 138.5, 135.8, 129.5, 128.3, 128.1, 126.3, 117.4, 117.0, 75.4, 63.2, 49.6, 39.4, 32.1, 30.5, 26.1 (3C), 18.3, –4.0, –4.3; IR (film) ν_{max} 3332 (br), 3075, 2955, 2928, 2857, 1466, 1254, 1089, 914, 836, 775 cm^{-1}; HRMS (FAB) *m*/*z* 383.2373 (MNa^+, $C_{22}H_{36}O_2SiNa$ requires 383.2382).

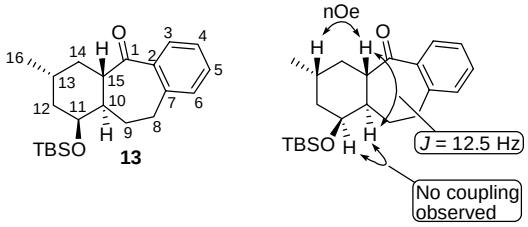
***Se*-Phenyl 2-(*syn*-4-(*tert*-butyldimethylsilyloxy)-3-vinylhept-6-enyl)benzoselenoate (12).** To a solution of oxalyl chloride (51 μL, 74 mg, 0.58 mmol) in anhydrous CH_2Cl_2 (1.0 mL) at –78 °C under Ar was added a solution of DMSO (80 μL, 88 mg, 1.13 mmol) in anhydrous CH_2Cl_2 (0.6 mL) dropwise. The resultant solution

was stirred at –78 °C under Ar for 15 min, then treated with a solution of benzyl alcohol **11** (66 mg, 0.18 mmol) in anhydrous CH_2Cl_2 (0.5 mL + 2 × 0.5 mL rinses). The resulting solution stirred at –78 °C under Ar for 80 min. A solution of Et_3N (260 μL, 189 mg, 1.87 mmol) in anhydrous CH_2Cl_2 (0.6 mL) was then added, and stirring continued as the mixture warmed from –78 to 10 °C over 2.5 h. The reaction was then quenched with sat aq $NaHCO_3$ (3 mL). The organic phase was collected and the aqueous phase extracted with CH_2Cl_2 (3 × 3 mL). The combined organic layers were dried (Na_2SO_4) and concentrated in vacuo to give the aldehyde (67 mg).

To a solution of the crude aldehyde in *t*-BuOH (2.0 mL) and H_2O (0.5 mL) was added successively 2-methyl-2-butene (0.24 mL, 156 mg, 2.23 mmol), NaH_2PO_4 (28 mg, 0.24 mmol), and NaOClO (102 mg, 1.13 mmol). The orange solution was stirred at rt under Ar for 13 h and 45 min, after which it had faded to a clear solution. It was then treated with sat aq NH_4Cl (3 mL) and extracted with CH_2Cl_2 (4 × 3 mL). The combined extracts were dried (Na_2SO_4) and concentrated in vacuo to give the benzoic acid (71 mg).

To a solution of the crude acid in anhydrous CH_2Cl_2 (1.8 mL) under Ar was added PhSeSePh (1.0 M solution in CH_2Cl_2, 0.28 mL, 0.28 mmol) and Bu_3P (0.11 mL, 86 mg, 0.43 mmol) dropwise. The orange solution was stirred at rt under Ar for 5 h and 40 min, after which TLC analysis indicated incomplete conversion. Additional PhSeSePh (1.0 M solution in CH_2Cl_2, 0.15 mL, 0.15 mmol) and Bu_3P (75 μL, 62 mg, 0.30 mmol) were added, and the solution was stirred at rt under Ar for an additional 2.5 h, then treated with sat aq NH_4Cl (3 mL). The layers were separated, and the aqueous phase was extracted with CH_2Cl_2 (3 × 3 mL). The combined organic layers were dried (Na_2SO_4) and concentrated in vacuo. Flash chromatography (SiO_2, 2.5 × 28 cm, 1% Et_2O in hexanes

elution) afforded phenyl selenoester **12** (81 mg, 0.16 mmol, 87% over three steps) as a yellow oil: ^{1}H NMR ($CDCl_3$, 500 MHz) δ 7.82 (d, *J* = 8 Hz, 1H), 7.61–7.58 (m, 2H), 7.45–7.40 (m, 4H), 7.31 (t, *J* = 8.0 Hz, 1H), 7.27–7.23 (m, 1H), 5.75–5.66 (m, 2H), 5.13 (dd, *J* = 2.0, 10.5 Hz, 1H), 5.05–4.97 (m, 3H), 3.62 (dt, *J* = 3.5, 6.5 Hz, 1H), 2.88–2.82 (m, 1H), 2.67–2.60 (m, 1H), 2.24–2.08 (m, 3H), 1.81–1.72 (m, 1H), 1.66–1.57 (m, 1H), 0.85 (s, 9H), 0.01 (s, 3H), –0.02 (s, 3H); ^{13}C NMR ($CDCl_3$, 125 MHz) δ 195.6, 141.0, 139.0, 136.2 (2C), 135.7, 133.2, 132.1, 131.1, 129.6 (2C), 129.4, 129.1, 128.7, 126.2, 117.4, 117.0, 75.3, 49.3, 39.6, 32.6, 31.6, 26.1 (3C), 18.3, –4.0, –4.2; IR (film) ν_{max} 3073, 2954, 2928, 2856, 1703, 1477, 1254, 1090, 912, 836, 736 cm^{-1}; HRMS (FAB) *m*/*z* 537.1702 (MNa^+, $C_{28}H_{38}O_2SeSiNa$ requires 537.1704).



Tricycle 13. Phenyl selenoester **12** (28 mg, 0.055 mmol) was dried azeotropically with anhydrous benzene (2 × 2.5 mL), then dissolved in anhydrous benzene (12 mL) in a 3-neck round-bottom flask. $(TMS)_3SiH$ (34 μL, 27 mg, 0.11 mmol) and Et_3B (0.10 mL of a 1.0 M solution in hexanes, 0.10 mmol) were added, and a constant supply of dry air was provided by passing compressed air through a short tube of Drierite and over the solution (venting with a needle allowed a continuous flow). An additional portion of Et_3B (1.0 mL of a 1.0 M solution in hexanes, 1.0 mmol) was added by syringe pump over 8 h while the solution was stirred and exposed to dry air as explained above. Following the addition period, TLC analysis indicated incomplete

conversion. Additional $(TMS)_3SiH$ (34 μL, 27 mg, 0.11 mmol) was added as well as another portion of Et_3B (1.0 mL of a 1.0 M solution in hexanes, 1.0 mmol) by syringe pump over 12.5 h while the reaction mixture was still exposed to dry air. The solution was stirred for an additional 3 h then concentrated in vacuo. The residue was purified by flash chromatography (SiO_2, 1.5 × 17 cm, 3% Et_2O in hexanes elution) to afford **13** (18 mg, 0.051 mmol, 93%) as a yellow oil: ^{1}H NMR ($CDCl_3$, 500 MHz) δ 7.33 (dt, *J* = 1.5, 7.5 Hz, 1H), 7.24 (dt, *J* = 1.0, 7.5 Hz, 1H), 7.18 (d, *J* = 7.5 Hz, 1H), 7.14 (dd, *J* = 1.5, 7.5 Hz, 1H), 4.02 (br s, 1H), 2.79–2.69 (m, 3H), 2.53–2.46 (m, 1H), 2.44 (t, *J* = 12.5 Hz, 1H), 2.07–1.99 (m, 1H), 1.78–1.73 (m, 1H), 1.71–1.61 (m, 3H), 1.32–1.26 (m, 1H), 0.90 (d, *J* = 7.5 Hz, 3H), 0.86 (s, 9H), 0.02 (s, 3H), 0.01 (s, 3H); ^{13}C NMR ($CDCl_3$, 125 MHz) δ 212.4, 142.9, 138.2, 129.9, 129.6, 126.2, 123.5, 76.0, 51.3, 48.8, 43.2, 40.9, 34.6, 32.7, 31.4, 26.0 (3C), 18.3, 15.9, –4.4, –4.8; IR (film) ν_{max} 2955, 2930, 2857, 1696, 1461, 1254, 1113, 1061, 910, 836, 735 cm^{-1}; HRMS (FAB) *m*/*z* 359.2405 (MH^+, $C_{22}H_{34}O_2SiH$ requires 359.2406).

Compound **13** was treated with LDA followed by D_2O, and in the ^{1}H NMR of the resultant compound the left-hand edge of the multiplet at 2.79–2.69 disappeared. Additionally, the triplet at 2.44 collapsed to a doublet. This established the former signal as belonging to H-15 and the latter as being derived from H-10. 2D ^{1}H–^{1}H COSY NMR ($CDCl_3$, 500 MHz) 4.02/1.71–1.61 (m, H-11/H-12), 4.02/1.32–1.26 (w, H-11/H-12), 2.79–2.69/2.44 (s, H-15/H-10), 2.79–2.69/2.07–1.99 (w, H-15/H14$_{ax}$), 2.79–2.69/1.78–1.73 (m, H-8/H-9), 2.79–2.69/1.71–1.61 (m, H-8/H-9), 2.53–2.46/2.07–1.99 (m, H-13/H-14$_{ax}$), 2.53–2.46/1.71–1.61 (m, H-13/H-12), 2.53–2.46/1.32–1.26 (m, H-13/H-12), 2.53–2.46/0.90 (s, H-13/H-16), 2.44/2.07–1.99 (m, H-10/H-14$_{ax}$), 2.07–1.99/1.71–1.61 (w, H-

14_{ax}/H-14_{eq}), 1.78–1.73/1.71–1.61 (m, H-9a/H-9b), 1.71–1.61/1.32–1.26 (s, H-12a/H-12b); 2D ^{1}H–^{1}H ROESY NMR ($CDCl_3$, 500 MHz) 2.79–2.69/2.53–2.46 (m, H-15/H-13).

***Se*-Phenyl 2-(*syn*-4-hydroxy-3-vinylhept-6-enyl)benzoselenoate (14).** A solution of **12** (10 mg, 0.019 mmol) in anhydrous CH_2Cl_2 (0.4 mL) at 0 °C under Ar was treated with a solution of (1*S*)-(+)-(10)-camphorsulfonic acid (9 mg, 0.039 mmol) in CH_3OH (0.4 mL). The resulting mixture was allowed to warm to rt and stir under Ar for 12 h. It was then poured into sat aq $NaHCO_3$ (0.3 mL), diluted with CH_2Cl_2 and H_2O (ca. 0.1 mL each), and extracted with CH_2Cl_2 (4 × 1 mL). The combined organic layers were dried (Na_2SO_4) and concentrated in vacuo. Flash chromatography (SiO_2, 7% EtOAc in hexanes elution) gave **14** (6.5 mg, 0.016 mmol, 84%) as a yellow oil: ^{1}H NMR ($CDCl_3$, 500 MHz) δ 7.86 (dd, *J* = 1.0, 8.0 Hz, 1H), 7.61–7.59 (m, 2H), 7.47–7.43 (m, 4H), 7.33 (dt, *J* = 1.0, 7.5 Hz, 1H), 7.28 (d, *J* = 7.0 Hz, 1H), 5.86–5.70 (m, 2H), 5.23 (dd, *J* = 2.0, 10.5 Hz, 1H), 5.15–5.08 (m, 3H), 3.60–3.57 (m, 1H), 2.85–2.72 (m, 2H), 2.31–2.26 (m, 1H), 2.19–2.09 (m, 2H), 1.86–1.79 (m, 1H), 1.68–1.60 (m, 2H); ^{13}C NMR ($CDCl_3$, 75 MHz) δ 196.0, 140.8, 138.9, 138.4, 136.3 (2C), 135.4, 132.3, 131.3, 129.7 (2C), 129.3, 128.9, 127.4, 126.4, 118.5, 117.9, 72.6, 49.8, 39.6, 33.2, 31.7; IR(film) ν_{max} 3444, 2925, 1700, 1639, 1477, 1438, 1184, 885, 738 cm^{-1}; HRMS (ESI) *m/z* 401.1017 (MH^+, $C_{22}H_{24}O_2SeH$ requires 401.1014).

Tricycle 15. Phenyl selenoester **14** (7.5 mg, 0.019 mmol) was dried azeotropically with anhydrous benzene (2 × 2.0 mL) then dissolved in anhydrous benzene (6.4 mL) in a 3-necked round-bottom flask under an atmosphere of dry air. $(TMS)_3SiH$ (18.2 μL, 0.0591 mmol) and Et_3B (1.0 M in hexane, 54 μL, 0.054 mmol) were added to the mixture, and additional Et_3B (1.0 M in hexane, 536 μL, 0.536 mmol) was then added

slowly by syringe pump over 4 h while a continuous flow of compressed air was passed over the reaction. TLC analysis indicated incomplete conversion, so additional $(TMS)_3SiH$ (54 uL, 0.0591 mmol) was added, and another portion of Et_3B (1.0 M in hexane, 536 μL, 0.536 mmol) was added by syringe pump over 40 min while a constant supply at air was still passed over the reaction. Following the addition the reaction was stirred for an additional 3h, then concentrated in vacuo. Flash chromatography (SiO_2, 1.5% ether in hexanes elution) afforded **15** (3.8 mg, 0.016 mmol, 82%) as a yellow oil: ^{1}H NMR ($CDCl_3$, 500 MHz) δ 7.33 (dt, *J* = 1.0, 7.0 Hz, 1H), 7.27–7.23 (m, 2H), 7.19–7.14 (m, 1H), 4.12 (br s, 1H), 2.84–2.74 (m, 3H), 2.54–2.45 (m, 2H), 2.10–2.04 (m, 1H), 1.94–1.89 (m, 1H), 1.76–1.63 (m, 3H), 1.45–1.39 (m, 1H), 1.26 (br s, 1H), 0.93 (d, *J* = 7.0 Hz, 3H); ^{13}C NMR ($CDCl_3$, 125MHz) δ 211.8, 142.8, 137.8, 130.0, 129.8, 126.4, 123.7, 75.8, 50.7, 48.7, 42.7, 40.8, 34.8, 32.6, 30.6, 15.9; IR (film) ν_{max} 3445 (br), 2924, 1693, 1456, 1286, 1266, 1101, 1023, 758 cm^{-1}; HRMS (ESI) *m/z* 245.1538 (MH^+, $C_{16}H_{20}O_2H$ requires 245.1536).

Tricycle **15** was spectroscopically identical to the compound obtained from desilylation of **13** (TBAF, THF, rt, 2h), thereby establishing the stereochemistry of **15** by correlation with **13**.

***anti*-Diethyl 3-(*tert*-butyldimethylsilyloxy)-2-(2-((*tert*-butyldimethylsilyloxy) methyl)phenethyl)pentanedioate (16).** Freshly prepared $Zn(BH_4)_2$[2] (0.10 M in ether, 50 mL, 4.99 mmol) was added dropwise at 0 °C under Ar to a stirred solution of **6** (1.50 g, 3.33 mmol) in anhydrous Et_2O (68 mL). The resulting solution was stirred for 10 min at 0 °C, and then treated with sat aq NH_4Cl (1 mL). The organic phase was collected, and

[2] Gensler, W. J.; Johnson, F.; Sloan, A. D. B. *J. Am. Chem. Soc.* **1960**, *82*, 6074.

the aqueous phase was extracted with CH_2Cl_2 (3 × 5 mL). The combined organic extracts were dried (Na_2SO_4) and concentrated in vacuo.

To a solution of the crude alcohol in anhydrous CH_2Cl_2 (16.6 mL) at 0 °C under Ar was added 2,6-lutidine (1.16 mL, 1.07 g, 9.98 mmol). The solution was stirred at 0 °C for 5 min, then treated dropwise with TBS-OTf (1.53 mL, 1.76 g, 6.66 mmol). The resultant mixture was stirred for 16 h, then treated with sat aq $NaHCO_3$ (18 mL). The layers were separated, and the aqueous layer was extracted with CH_2Cl_2 (3 × 15 mL). The combined organic extracts were dried (Na_2SO_4) and concentrated in vacuo. Flash chromatography (SiO_2, 5% EtOAc in hexanes elution) afforded **16** (1.215 g, 2.14 mmol, 64%, ca. 4:1 mixture of diastereomers) as a yellow oil: ^{1}H NMR ($CDCl_3$, 500 MHz) δ 7.46–7.42 (m, 1H), 7.23–7.20 (m, 2H), 7.15–7.12 (m, 1H), 4.75 and 4.74 (2s, 2H), 4.44–4.36 (m, 1H), 4.22–4.08 (m, 4H), 2.69–2.61 (m, 2H), 2.59–2.44 (m, 3H), 1.98–1.71 (m, 2H), 1.31 (t, *J* = 7.0 Hz, 3H), 1.25 (t, *J* = 7.0 Hz, 3H), 0.95 (s, 9H), 0.85 (s, 9H), 0.11 and 0.10 (2s, 6H) 0.06 and 0.02 (2s, 3H), 0.04 (s, 3H); ^{13}C NMR ($CDCl_3$, 125 Hz) δ 173.7 and 173.3, 171.9 and 171.7, 139.0 and 138.9, 138.6 and 138.6, 129.1 and 129.0, 127.3 and 127.2, 127.1, 126.4, 70.8 and 70.4, 63.0 and 62.8, 60.7 and 60.6, 52.2 and 51.8. 40.0 and 39.8, 30.6 and 30.5, 29.4, 27.9, 26.2 (3C), 25.9 (3C), 18.6, 18.2 and 18.1, 14.5, 14.4, –4.5, –4.7, –5.0 (2C); IR (film) ν_{max} 2955, 2929, 2896, 2856, 1736, 1471, 1463, 1376, 1254, 1182, 1081, 836, 776 cm^{-1}; HRMS (ESI) *m/z* 567.3534 (MH^+, $C_{30}H_{54}O_6Si_2H$ requires, 567.3531).

***anti*-3-(*tert*-Butyldimethylsilyloxy)-2-(2-((*tert*-butyldimethylsilyloxy)methyl)-phenethyl)-*N*^{1},*N*^{5}-dimethoxy-*N*^{1},*N*^{5}-dimethylpentanediamide (17).** Application of the procedure detailed for the preparation of **8** with 627 mg of MeNHOMe•HCl (6.42 mmol)

in 10.0 mL of anhydrous THF, 6.4 mL of 2.0 M *i*-PrMgCl in THF (12.8 mmol), and 1.21 g of **16** (2.14 mmol) in 5 mL of anhydrous THF with alteration of the flash chromatography conditions (SiO_2, 25% EtOAc in hexanes elution) afforded **17** (0.86 g, 1.44 mmol, 67%) as an orange oil: ^{1}H NMR ($CDCl_3$, 500 MHz) δ 7.44–7.42 (m, 1H), 7.21–7.15 (m, 3H), 4.74 (s, 2H), 4.53–4.49 (m, 1H), 3.67 (s, 3H), 3.63 (s, 3H), 3.20 (s, 3H), 3.16–3.13 (m, 1H), 3.15 (s, 3H), 2.77 (m, 1H), 2.66–2.52 (m, 3H), 2.05–1.99 (m, 1H), 1.88–1.83 (m, 1H), 0.94 (s, 9H), 0.86 (s, 9H), 0.10 (s, 6H), 0.05 (s, 3H), 0.02 (s, 3H); ^{13}C NMR ($CDCl_3$, 125 MHz) δ 175.0, 172.3, 139.1, 139.0, 128.9, 127.2, 127.0, 126.2, 70.5, 62.9, 61.5, 61.3, 47.0, 38.1, 32.3 (2C), 30.2, 28.7, 26.2 (3C), 26.2 (3C), 18.6, 18.2, –4.5 (2C), –5.0 (2C); IR (film) ν_{max} 2929, 2894, 2856, 1665, 1462, 1413, 1385, 1360, 1254, 939, 812 cm^{-1}; HRMS (ESI) *m/z* 619.3564 (MNa^+, $C_{30}H_{56}N_2O_6Si_2Na$ requires 619.3569).

***anti*-3-(*tert*-Butyldimethylsilyloxy)-2-(2-((*tert*-butyldimethylsilyloxy)methyl) phenethyl)-*N*-methoxy-*N*-methylhex-5-enamide (18).** Application of the two-step procedure detailed for the preparation of **9** with 303 mg of **17** (0.507 mmol) in 3 mL of anhydrous THF, 2.0 mL of DIBAL (1.0 M in THF, 2.0 mmol), 0.81 g of Ph_3PCH_3Br (2.28 mmol) in 3.3 mL of anhydrous THF, 832 μL of *n*-BuLi (2.5 M in hexane, 2.08 mmol), and 1.6 mL of anhydrous THF with alteration of the flash chromatography conditions (SiO_2, 4% EtOAc in hexanes elution) afforded **18** (147 mg, 0.275 mmol, 54%) as a yellow oil: ^{1}H NMR ($CDCl_3$, 500 MHz) δ 7.44 (t, *J* = 5.0 Hz, 1H), 7.21–7.14 (m, 3H), 5.86–5.78 (m, 1H), 5.04–5.00 (m, 2H), 4.75 (d, *J* = 13.0 Hz, 1H), 4.71 (d, *J* = 13.5 Hz, 1H), 4.02 (dt, *J* = 4.0, 6.5 Hz, 1H), 3.59 (s, 3H), 3.19 (s, 3H), 3.00 (br s, 1H), 2.63–2.49 (m, 2H), 2.37–2.23 (m, 2H), 2.00–1.94 (m, 2H), 0.95 (s, 9H), 0.89 (s, 9H), 0.10 (s,

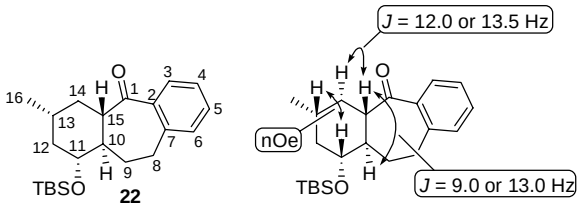
6H), 0.06 (s, 3H), 0.04 (s, 3H); ^{13}C NMR ($CDCl_3$, 125 MHz) δ 175.6, 139.1 (2C), 135.0, 128.7, 127.1, 126.9, 126.1, 117.4, 73.0, 62.9, 61.3, 46.3, 40.8, 32.5, 29.9, 29.0, 26.2 (3C), 26.2 (3C), 18.6, 18.3, –3.9, –4.2, –5.0 (2C); IR (film) ν_{max} 2928, 2856, 1663, 1471, 1384, 1254, 1078, 837, 775 cm^{-1}; HRMS (ESI) *m/z* 558.3417 (MNa^+, $C_{29}H_{53}NO_4Si_2Na$ requires 558.3405).

***anti*-4-(*tert*-Butyldimethylsilyloxy)-3-(2-((*tert*-butyldimethylsilyloxy)methyl) phenethyl)-1,6-heptadiene (19).** Application of the two-step procedure detailed for the preparation of **10** with 30.9 mg of **18** (0.0576 mmol) in 360 μL of anhydrous THF, 288 μL of DIBAL (1.0 M in THF, 0.288 mmol), 92.6 mg of Ph_3PCH_3Br (0.26 mmol) in 220 μL of anhydrous THF, 94 μL of *n*-BuLi (2.5 M in hexane, 0.23 mmol), and 160 μL of anhydrous THF afforded **19** (16.1 mg, 0.0339 mmol, 59%) as a colorless oil: ^{1}H NMR ($CDCl_3$, 500 MHz) δ 7.45–7.43 (t, *J* = 4.5 Hz, 1H), 7.21–7.18 (m, 2H), 7.16–7.14 (m, 1H), 5.85–5.70 (m, 2H), 5.17 (dd, *J* = 2.0, 10.0 Hz, 1H), 5.11–5.00 (m, 3H), 4.73 (s, 2H), 3.64 (q, *J* = 5.5 Hz, 1H), 2.69–2.63 (m, 1H), 2.45–2.38 (m, 1H), 2.29–2.18 (m, 3H), 1.88–1.81 (m, 1H), 1.51–1.43 (m, 1H), 0.96 (s, 9H), 0.89 (s, 9H), 0.11 (s, 6H), 0.04 (s, 3H), 0.03 (s, 3H); ^{13}C NMR ($CDCl_3$, 75 MHz) δ 140.0, 139.9, 138.9, 135.5, 128.9, 127.2, 127.1, 126.0, 117.1, 116.8, 75.3, 63.0, 49.6, 39.2, 30.5, 30.2, 26.2 (3C), 26.2 (3C), 18.7, 18.4, –3.9, –4.2, –5.0 (2C); IR (film) ν_{max} 3072, 2954, 2928, 2856, 1471, 1462, 1434, 1254, 1072, 1004, 913, 836, 774 cm^{-1}; HRMS (ESI) *m/z* 492.3708 (MNH_4^+, $C_{28}H_{50}O_2Si_2NH_4$ requires 492.3687).

(2-(*anti*-4-(*tert*-Butyldimethylsilyloxy)-3-vinylhept-6-enyl)phenyl)methanol (20). Application of the procedure detailed for the preparation of **11** with 33.3 mg of **19** (0.0701 mmol) in 0.7 mL of CH_2Cl_2, and 3.6 mg of CSA (0.015 mmol) in 0.7 mL of

CH_3OH afforded **20** (22 mg, 0.061 mmol, 87%) as a yellow oil: ^{1}H NMR ($CDCl_3$, 500 MHz) δ 7.39–7.37 (m, 1H), 7.27–7.19 (m, 3H), 5.85–5.69 (m, 2H), 5.16 (dd, *J* = 2.0, 10.0 Hz, 1H), 5.10–5.00 (m, 3H), 4.74–4.69 (m, 2H), 3.64 (q, *J* = 5.5 Hz, 1H), 2.77–2.71 (m, 1H), 2.53–2.47 (m, 1H), 2.29–2.18 (m, 3H), 1.92–1.85(m, 1H), 1.53–1.45 (m, 2H), 0.89 (s, 9H), 0.04 (s, 3H), 0.02 (s, 3H); ^{13}C NMR ($CDCl_3$, 75 MHz) δ 141.0, 140.0, 138.5, 135.4, 129.6, 128.4, 128.2, 126.4, 117.1, 116.9, 75.2, 63.3, 49.5, 39.3, 31.1, 30.4, 26.2 (3C), 18.4, –3.9, –4.2; IR (film) ν_{max} 3327(br), 3074, 2954, 2928, 2856, 1639, 1471, 1462, 1255, 1065, 1004, 913, 836, 774 cm^{-1}; HRMS (ESI) *m/z* 383.2357 (MNa^+, $C_{22}H_{36}O_2SiNa$ requires 383.2376).

***Se*-Phenyl 2-(*anti*-4-(*tert*-butyldimethylsilyloxy)-3-vinylhept-6-enyl)benzoselenoate (21).** Application of the three-step procedure detailed for the preparation of **12** with 10.0 mg of **20** (0.0277 mmol) and all reagents and solvents scaled to the appropriate amounts afforded **21** (11.4 mg, 0.0222 mmol, 80%) as a yellow oil: ^{1}H NMR ($CDCl_3$, 500 MHz) δ 7.83 (dd, *J* = 1.5, 8.0 Hz, 1H), 7.61–7.59 (m, 2H), 7.46–7.43 (m, 4H), 7.32 (dt, *J* = 1.0, 7.5 Hz, 1H), 7.28–7.26 (m, 1H), 5.80–5.68 (m, 2H), 5.11 (dd, *J* = 2.0, 10.0 Hz, 1H), 5.06–4.96 (m, 3H), 3.61 (q, *J* = 5.5 Hz, 1H), 2.89–2.83 (m, 1H), 2.69–2.63 (m, 1H), 2.25–2.14 (m, 3H), 1.86–1.80 (m, 1H), 1.56–1.48 (m, 1H), 0.87 (s, 9H), 0.02 (s, 3H), –0.01 (s, 3H); ^{13}C NMR ($CDCl_3$, 125 MHz) δ 195.6, 141.0, 139.8, 139.0, 136.2 (2C), 135.7, 132.1, 131.2, 129.6 (2C), 129.1, 128.7, 127.5, 126.2, 117.0, 116.7, 75.4, 49.2, 39.0, 31.6, 31.2, 26.2 (3C), 18.4, –4.0, –4.2; IR (film) ν_{max} 3073, 2953, 2927, 2855, 1703, 1639, 1570, 1476, 1438, 1254, 1183, 1065, 912, 835, 736 cm^{-1}; HRMS (ESI) *m/z* 532.2192 (MNH_4^+, $C_{28}H_{38}O_2SeSiNH_4$ requires 532.2144).



Tricycle 22. Phenyl selenoester **21** (5.0 mg, 0.0097 mmol) was dried azeotropically with anhydrous benzene (2 × 2.0 mL), then dissolved in anhydrous benzene (2.0 mL) in a 3-necked round-bottom flask under an atmosphere of dry air. $(TMS)_3SiH$ (6.0 μL, 0.0195 mmol) and Et_3B (1.0 M in hexane, 18 μL, 0.018 mmol) were added to the mixture, and additional Et_3B (1.0 M in hexane, 177 μL, 0.177 mmol) was then added slowly by syringe pump over 1.5 h while a continuous flow of compressed air was passed over the reaction. The mixture was stirred vigorously throughout the addition time. TLC analysis indicated incomplete conversion, so additional $(TMS)_3SiH$ (6.0 uL, 0.0195 mmol) was added, and another portion of Et_3B (1.0 M in hexane, 177 μL, 0.177 mmol) was added by syringe pump over 15 min while the reaction was still stirring vigorously under air. Following the addition, the reaction was stirred for an additional 3 h, then concentrated in vacuo. Flash chromatography (SiO_2, 1.5% ether in hexanes elution) afforded **22** (2.8 mg, 0.0079 mmol, 81%) as a yellow oil: ^{1}H NMR ($CDCl_3$, 500 MHz) δ 7.31 (dt, *J* = 1.5, 7.5 Hz, 1H), 7.23 (dt, *J* = 1.0, 7.5 Hz, 1H), 7.16 (d, *J* = 8.0 Hz, 1H), 7.11 (d, *J* = 7.5 Hz, 1H), 3.59 (dt, *J* = 6.0, 8.5 Hz, 1H), 2.79–2.74 (m, 2H), 2.69 (ddd, *J* = 3.0, 9.5, 14.0 Hz, 1H), 2.57 (dd, *J* = 12.0, 13.5 Hz, 1H), 2.15 (tdd, *J* = 3.5, 9.0, 13.0 Hz, 1H), 2.09–2.02 (m, 1H), 1.90–1.85 (m, 1H), 1.84–1.79 (m, 1H), 1.59–1.53 (m, 1H), 1.34–1.24 (m, 2H), 0.94 (d, *J* = 7.0 Hz, 3H), 0.86 (s, 9H), 0.02 (s, 3H), 0.01 (s, 3H); ^{13}C NMR ($CDCl_3$, 125 MHz) δ 212.0, 142.6, 138.1, 129.9, 129.6, 126.3, 123.5, 70.2, 54.5, 49.0, 42.1, 40.6, 34.1, 33.6, 32.9, 26.1 (3C), 18.2, 16.1, –4.5, –4.2; IR (film) ν_{max}

3348(br), 2954, 2926, 2855, 1700, 1598, 1471, 1360, 1287, 1125, 1090, 868, 775 cm^{-1}; HRMS (ESI) *m/z* 381.2216 (MNa^+, $C_{22}H_{34}O_2SiNa$ requires 381.2220).

2D ^1H–^1H COSY NMR ($CDCl_3$, 500 MHz) 3.59/1.84–1.79 (m, H-11/H-12), 3.59/1.59–1.53 (w, H-11/H-9), 3.59/1.34–1.24 (m, H-11/H-12), 2.79–2.74/2.57 (s, H-15/H-14_{ax}), 2.79–2.74/2.15 (s, H-15/H-10), 2.79–2.74/1.90–1.85 (w, H-15/H-14_{eq}), 2.79–2.74/1.34–1.24 (w, H-8/H-9), 2.69/1.34–1.24 (m, H-8/H-9), 2.57/1.90–1.85 (s, H-14_{ax}/H-14_{eq}), 2.15/1.34–1.24 (m, H-10/H-9), 2.09–2.02/1.90–1.85 (w, H-13/H-14_{eq}), 2.09–2.02/1.84–1.79 (w, H-13/H-12), 2.09–2.02/1.34–1.24 (m, H-13/H-12), 2.09–2.02/0.94 (s, H-13/H-16), 1.84–1.79/1.34–1.24 (s, H-12/H-12), 1.59–1.53/1.34–1.24 (m, H-9/H-9); 1D nOe NMR ($CDCl_3$, 500 MHz) Irradiation of the signal at 2.09–2.02 led to an enhancement in the signal at 3.59 (H-13/H-11).

Diethyl 2-(2-((*tert*-butyldimethylsilyloxy)methyl)phenethyl)malonate (23). To a suspension of NaH (60% dispersion in mineral oil, 160 mg, 4.00 mmol) in anhydrous THF (4 mL) at rt under Ar was added diethyl malonate (607 μl, 640 mg, 4.00 mmol) dropwise. The resulting mixture was stirred at rt for 10 min, treated with the bromide derived from **5**[3] (329.4 mg, 1.00 mmol), and most of the THF was removed in vacuo. The residue was dissolved in anhydrous acetonitrile (2 mL), a solution of NaI (75.0 mg, 0.50 mmol) in anhydrous CH_3CN (2 mL) was added, and the reaction mixture was stirred at 60 °C for 12 h. The reaction was cooled to rt and quenched with 1 M HCl (until pH ≈ 6). The organic phase was collected, the aqueous phase was extracted with EtOAc (3 × 7 mL), and the combined organic layers were washed with brine (15 mL), dried ($NaSO_4$), and concentrated in vacuo. The residue was purified by flash chromatography (SiO_2, 2.0

[3] See procedure for **6**.

× 15 cm, 5–15% EtOAc in hexanes elution) to give **23** (326 mg, 0.80 mmol, 80%) as a yellow oil: ^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.41–7.38 (m, 1H), 7.22–7.11 (m, 3H), 4.72 (s, 2H), 4.18 (q, *J* = 7.2 Hz, 4H), 3.36 (t, *J* = 7.5 Hz, 1H), 2.63 (m, 2H), 2.16 (m, 2H), 1.24 (t, *J* = 6.9 Hz, 6H), 0.91 (s, 9H), 0.07 (s, 6H); ^{13}C NMR ($CDCl_3$, 75 MHz) δ 169.4 (2C), 139.0, 138.1, 129.2, 127.5, 127.4, 126.5, 63.0, 61.6 (2C), 51.9, 29.9 (2C), 26.1 (3C), 18.6, 14.3 (2C), –5.1 (2C); IR (film) ν_{max} 2955, 2856, 1732, 1471, 1463, 1389, 1369, 1255, 1181, 1116, 838, 776 cm^{-1}; HRMS (ESI) *m/z* 409.2405 (MH^+, $C_{22}H_{36}O_5SiH$, requires 409.2405).

2-(2-((*tert*-Butyldimethylsilyloxy)methyl)phenethyl)propane-1,3-diol (24). To a solution of **23** (158 mg, 0.387 mmol) in anhydrous Et_2O (4 mL) at 0 °C under Ar was added LAH (1.0 M in Ether, 813 μl, 0.813 mmol). The reaction was allowed to warm up to rt and stir for 5 h. It was then treated with 1 N HCl (until pH ≈ 6) and diluted with distilled H_2O (10 mL). The organic phase was collected, the aqueous phase was extracted with CH_2Cl_2 (3 × 10 mL), and the combined organic layers were washed with brine (10 mL), dried ($NaSO_4$), and concentrated in vacuo. Flash chromatography (SiO_2, 2.0 × 25 cm, 20–50% EtOAc in hexanes gradient elution) afforded **24** (116.7 mg, 0.360 mmol, 93%) as a white solid: ^{1}H NMR ($CDCl_3$, 500 MHz) δ 7.42–7.40 (m, 1H), 7.22–7.20 (m, 2H), 7.17–7.16 (m, 1H), 4.76 (s, 2H), 3.83 (dd, *J* = 3.5, 11.0 Hz, 2H), 3.68 (dd, *J* = 7.0, 10.5 Hz, 2H), 3.19 (s, 2H), 2.69–2.65 (m, 2H), 1.85–1.80 (m, 1H), 1.59–1.55 (m, 2H) 0.96 (s, 9H), 0.13 (s, 6H); ^{13}C NMR ($CDCl_3$, 125 MHz) δ 139.6, 138.5, 129.0, 127.7, 127.5, 126.3, 65.9 (2C), 63.3, 42.1, 29.9, 28.9, 26.1 (3C), 18.6, –5.0 (2C); IR (film) ν_{max} 3357, 2929, 1471, 1255, 1215, 1078, 838, 776 cm^{-1}; HRMS (ESI) *m/z* 347.2010 (MNa^+, $C_{18}H_{32}O_3SiNa$ requires 347.2012).

4-(2-((*tert*-Butyldimethylsilyloxy)methyl)phenyl)-2-((4-methoxybenzyloxy) methyl)butan-1-ol (25). To a solution of **24** (126.4 mg, 0.390 mmol) in anhydrous THF (0.42 mL) and DMSO (0.10 mL) at 0 °C under Ar was added NaH (60% dispersion in mineral oil, 15.6 mg, 0.39 mmol). The reaction mixture was warmed to rt and stirred at rt for 1 h. The mixture was cooled to 0 °C again, tetrabutylammonium iodide (25.0 mg, 0.070 mmol) was added, and 4-methoxybenzyl chloride (53 μl, 61.1 mg, 0.390 mmol) was added dropwise. The resultant mixture was stirred at rt for 10 h, then treated with sat aq NH_4Cl (2 mL). The organic phase was collected, the aqueous phase was extracted with EtOAc (3 × 3 mL), and the combined organic layers were washed with brine (3 mL), dried ($NaSO_4$), and concentrated in vacuo. Flash chromatography (SiO_2, 2.0 × 20 cm, 20% EtOAc in hexanes elution) afforded **25** (100.3 mg, 0.226 mmol, 58%) as a yellow oil: ^{1}H NMR ($CDCl_3$, 500 MHz) δ 7.41–7.38 (m, 1H), 7.25–7.11 (m, 5H), 6.90–6.80 (m, 2H), 4.72 (s, 2H), 4.47 (d, *J* = 11.5 Hz, 1H), 4.44 (d, *J* = 12.0 Hz, 1H), 3.80 (s, 3H), 3.78–3.62 (m, 3H), 3.50–3.47 (m, 1H), 2.70–2.58 (m, 3H), 1.97–1.90 (m, 1H), 1.66–1.51 (m, 2H), 0.93 (s, 9H), 0.09 (s, 6H); ^{13}C NMR ($CDCl_3$, 125 MHz) δ 159.5, 139.6, 138.8, 130.2, 129.5 (2C), 128.9, 127.6, 127.4, 126.2, 114.1 (2C), 73.9, 73.4, 66.2, 63.2, 55.5, 40.8, 30.0, 29.4, 26.2 (3C), 18.6, –5.0 (2C); IR (film) ν_{max} 3357, 2953, 2938, 2856, 1513, 1250, 1082, 1038, 838, 776 cm^{-1}; HRMS (FAB) *m/z* 467.2589 (MNa^+, $C_{26}H_{40}O_4SiNa$ requires 467.2594).

6-(2-((*tert*-Butyldimethylsilyloxy)methyl)phenyl)-4-((4-methoxybenzyloxy) methyl)hex-1-en-3-ol (26). To a solution of oxalyl chloride (869 μl, 1.28 g, 10.1 mmol) in anhydrous CH_2Cl_2 (3.90 mL) at –78 °C under Ar was added DMSO (1.65 mL, 1.82 g, 23.3 mmol) in anhydrous CH_2Cl_2 (11.40 mL) dropwise. The solution was stirred at –78

°C under Ar for 30 min, then treated with a solution of **25** (1.50 g, 3.38 mmol) in anhydrous CH_2Cl_2 (4.20 mL + 2 × 4.20 mL rinses), and the resulting mixture was stirred at –78 °C under Ar for 1 h. Et_3N (7.18 mL, 5.22 g, 51.6 mmol) was added to the mixture dropwise, then the reaction was warmed to 0 °C and stirred for another hour. The mixture was treated with brine (50 mL), the organic phase was collected, and the aqueous phase was extracted with Et_2O (3 × 50 mL). The combined organic layers were washed with brine (100 mL), dried (Na_2SO_4), and concentrated in vacuo to give the aldehyde.

To a solution of the crude aldehyde in anhydrous THF (16.0 mL) at 0 °C under Ar was added vinylmagnesium bromide (1.0 M in THF, 5.06 mL, 5.06 mmol) dropwise. The mixture was stirred at 0 °C under Ar for 1 h. The reaction was quenched with sat aq NH_4Cl (30 mL), the organic phase was collected, and the aqueous phase was extracted with CH_2Cl_2 (3 × 40 mL). The combined organic layers were dried (Na_2SO_4) and concentrated in vacuo. Flash chromatography (SiO_2, 2.5 × 30 cm, 5% EtOAc in hexanes elution) afforded **26** (1.16 g, 2.46 mmol, 73% over two steps) as a yellow oil that was a ca. 1:1 mixture of diastereomers: ^{1}H NMR ($CDCl_3$, 500 MHz) δ 7.43–7.37 (m, 1H), 7.27–7.10 (m, 5H), 6.89 (d, *J* = 9.0 Hz, 2H), 5.90–5.83 (m, 1H), 5.30 (dd, *J* = 1.5, 17.0 Hz, 1H), 5.20–5.16 (m, 1H), 4.74 and 4.72 (2s, 2H), 4.47–4.41 (m, 2H), 4.34 and 4.25–4.20 (br s and m, 1H), 3.82 and 3.81 (2s, 3H), 3.75 (dd, *J* = 3.5, 9.5 Hz, 1H), 3.55–3.52 (m, 1H), 3.59, 3.21, and 3.17 (3d, *J* = 5.5, 6.0, and 5.5 Hz, 1H), 2.66–2.58 (m, 2H), 2.05–1.99 and 1.88–1.81 (2m, 1H) 1.77–1.49 (m, 2H), 0.94 (s, 9H), 0.10 (s, 6H); ^{13}C NMR ($CDCl_3$, 75 MHz) δ 159.5, 140.2, 139.5, 138.8 and 138.5, 130.1, 129.6 and 129.5, 128.9 (2C), 127.3 (2C), 126.2, 115.7, 115.6, 114.1, 75.6 and 75.3, 73.4, 71.9 and 71.2, 63.1, 55.5, 43.6, 30.4 and 30.0, 29.6 and 27.8, 26.2 (3C), 18.9, –5.0 (2C); IR (film) ν_{max} 3473,

3071, 3002, 2954, 2929, 2856, 1613, 1514, 1463, 1250, 1086, 1038, 837, 776 cm^{-1}; HRMS (FAB) *m/z* 493.2742 (MNa^+, $C_{28}H_{42}O_4SiNa$ requires 493.2745).

6-(2-((*tert*-Butyldimethylsilyloxy)methyl)phenyl)-4-((4-methoxybenzyloxy) methyl)-2-(*tert*-Butyldimethylsilyloxy)-hex-1-en-3-ol (27). To a solution of **26** (1.16 g, 2.46 mmol) in anhydrous DMF (28 mL) was added imidazole (503 mg, 7.39 mmol) and *tert*-butyldimethylsilyl chloride (1.11 g, 7.39 mmol). The resulting mixture was stirred at rt under Ar for 23 h, then diluted with Et_2O (10 mL) and H_2O (10 mL). The organic phase was collected and the aqueous phase was extracted with Et_2O (3 × 10 mL). The combined organic layers were washed with brine (10 mL), dried ($NaSO_4$), and concentrated in vacuo. Flash chromatography (SiO_2, 2.5 × 35 cm, 5% Et_2O in hexanes elution) afforded **27** (1.21 g, 2.06 mmol, 84%) as a yellow oil that was a ca. 1:1 mixture of diastereomers: ^1H NMR ($CDCl_3$, 300 MHz) δ 7.41–7.44 (m, 1H), 7.08–7.26 (m, 5H), 6.85 (d, *J* = 8.7 Hz, 2H), 5.84–5.70 (m, 1H), 5.19–5.04 (m, 2H), 4.71 (s, 2H), 4.47–4.24 (m, 3H), 3.87 (s, 3H), 3.55–3.39 (m, 2H), 2.70–2.47 (m, 2H), 1.83–1.65 (m, 2H), 1.56–1.40 (m, 1H), 0.93 (s, 9H), 0.87 (s, 9H), 0.07, 0.06, 0.02, and –0.01 (4s, 12H); ^{13}C NMR ($CDCl_3$, 75 MHz) δ 159.3, 140.4 and 139.8, 139.6, 138.9, 130.9, 129.4 and 129.3, 128.9 (2C), 127.1 (2C), 126.8, 126.0, 115.5, 114.8 and 114.0, 74.5, 73.4 and 73.0, 70.4 and 70.0, 63.0, 55.4, 45.6 and 45.5, 30.8 and 30.5, 28.4 and 27.7, 26.2 (3C), 26.1 (3C), 18.6, 18.4, –4.0 and –4.1, –4.7 and –4.8, –5.0 (2C); IR (film) ν_{max} 3072, 2999, 2954, 2929, 2885, 2856, 1613, 1514, 1471, 1463, 1251, 1078, 1038, 1006, 836, 776 cm^{-1}; HRMS (ESI) *m/z* 607.3614 (MNa^+, $C_{34}H_{56}O_4Si_2Na$ requires 607.3609).

3-(*tert*-Butyl-dimethyl-silyloxy)-2-{2-[2-(*tert*-butyl-dimethyl-silyloxymethyl)-phenyl]-ethyl}-pent-4-en-1-ol (28). A solution of **27** (1.21 g, 2.06 mmol) in CH_2Cl_2

(29.3 mL) was treated with distilled H_2O (1.46 mL) and 2,3-dichloro-5,6-dicyano-1,4-benzoquinone (DDQ, 469 mg, 2.06 mmol). The solution was stirred at rt under N_2 for 1 h, then treated with sat aq $NaHCO_3$ (15 mL). The organic layer was collected and the aqueous layer was extracted with CH_2Cl_2 (3 × 10 mL). The combined organic layers were washed with sat aq $NaHCO_3$ (15 mL) and brine (15 mL), dried ($NaSO_4$), and concentrated in vacuo. Flash chromatography (SiO_2, 2.5 × 35 cm, 15% EtOAc in hexanes elution) afforded **28** (774 mg, 1.59 mmol, 77%) as a yellow oil that was a ca. 1:1 mixture of diastereomers: ^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.53–7.48 (m, 1H), 7.30–7.20 (m, 3H), 6.04–5.89 (m, 1H), 5.39–5.23 (m, 2H), 4.84 and 4.81 (2s, 2H), 4.38 and 4.23 (2t, *J* = 4.5 and 5.0 Hz, 1H), 3.94–3.65 (m, 2H), 3.20 and 2.90 (2s, 1H), 2.88–2.63 (m, 2H), 2.07–2.01 and 1.87–1.74 (2m, 1H), 1.66–1.40 (m, 2H), 1.03, 1.02, and 0.99 (3s, 18H), 0.19, 0.17, and 0.14 (3s, 12H); ^{13}C NMR ($CDCl_3$, 75 MHz) δ 140.3 and 139.6, 139.5 and 138.8, 137.5, 129.0 and 128.9, 127.6 and 127.3, 127.4 and 127.2, 126.3 and 126.2, 116.5 and 115.8, 78.4, 64.1 and 63.2, 63.1 and 62.9, 46.3 and 45.9, 30.5 and 30.1, 29.3 and 28.7, 26.2 (3C), 26.1 and 26.0 (3C), 18.6, 18.3 and 18.2, –3.9 and –4.3, –4.7 and –4.9, –5.0 (2C); IR (film) ν_{max} 3448, 2955, 2929, 2885, 2857, 1472, 1463, 1254, 1121, 1075, 1028, 1005, 837, 776 cm^{-1}; HRMS (ESI) *m/z* 487.3042 (MNa^+, $C_{26}H_{48}O_3Si_2Na$ requires 487.3034).

1-(*tert*-Butyl-dimethyl-silyloxymethyl)-2-[4-(*tert*-butyl-dimethyl-silyloxy)-3-vinyl-hex-5-enyl]-benzene (29). To a solution of oxalyl chloride (134 μl, 198 mg, 1.56 mmol) in anhydrous CH_2Cl_2 (5.50 mL) at –78 °C under Ar was added DMSO (232 μl, 255.4 mg, 3.27 mmol) in anhydrous CH_2Cl_2 (1.60 mL) dropwise. The solution was stirred at –78 °C under Ar for 30 min, then a solution of alcohol **28** (220 mg, 0.474

mmol) in anhydrous CH_2Cl_2 (0.6 mL + 2 × 0.6 mL rinses) was added, and the resulting mixture was stirred at –78 °C under Ar for 1 h. Et_3N (1.0 mL, 733.7 mg, 7.25 mmol) was added to the mixture dropwise, then the reaction was warmed to 0 °C and stirred for another hour. It was treated with brine (7 mL), the layers were separated, and the aqueous phase was extracted with Et_2O (3 × 7 mL). The combined organic layers were washed with brine (14 mL), dried (Na_2SO_4), and concentrated in vacuo to give the aldehyde.

To a suspension of methyltriphenylphosphonium bromide (1.01 g, 2.84 mmol) in anhydrous THF (14.5 mL) at –15 °C under Ar was added *n*-BuLi (2.5 M in hexane, 0.95 mL, 2.37 mmol) dropwise. The yellow mixture was stirred at –15 °C under Ar for 30 min. The crude aldehyde was dissolved in anhydrous THF (3.1 mL), and the prepared Wittig reagent was added to this solution. The resultant mixture was stirred at –10 to –15 °C under Ar for 1 h, warmed to rt, and stirred at rt under Ar for 10 h. The reaction was quenched with sat aq NH_4Cl (15 mL), the organic layer was collected, and the aqueous phase was extracted with Et_2O (3 × 15 mL). The combined organic layers were washed with brine (30 mL), dried (Na_2SO_4), and concentrated in vacuo. Flash chromatography (SiO_2, 2.5 × 20 cm, 5% EtOAc in hexanes elution) afforded **29** (157 mg, 0.341 mmol, 72%) as a yellow oil that was a ca. 1:1 mixture of diastereomers: ^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.40–7.28 (m, 1H), 7.14–7.05 (m, 3H), 5.78–5.57 (m, 2H), 5.11–4.99 (m, 4H), 4.67 (s, 2H), 4.00 (t, *J* = 4.8 Hz, 1H), 2.64–2.54 (m, 1H), 2.44–2.32 (m, 1H), 2.14–2.05 (m, 1H), 1.83–1.73 (m, 1H), 1.49–1.36 (m, 1H), 0.94 and 0.83 (2s, 9H), 0.89 (9H), 0.04 (6H), –0.02, –0.03, and –0.05 (3s, 6H); ^{13}C NMR ($CDCl_3$, 75 MHz) δ 139.9 and 139.8, 139.7 and 139.3, 138.9, 134.1 and 133.8, 129.0, 128.7 and 128.6, 127.2 and 127.0, 126.0,

117.1 and 116.7, 115.1, 77.1, 63.0, 51.6 and 51.4, 30.9, 30.2 and 30.0, 26.2 (3C), 26.1 (3C), 18.7, 18.5, –3.9 and –4.0, –4.6, –5.0 (2C); IR (film) ν_{max} 2955, 2929, 2885, 2857, 1253, 1078, 837, 776 cm^{-1}; HRMS (ESI) *m/z* 483.3094 (MNa^+, $C_{27}H_{48}O_2Si_2Na$ requires 483.3085).

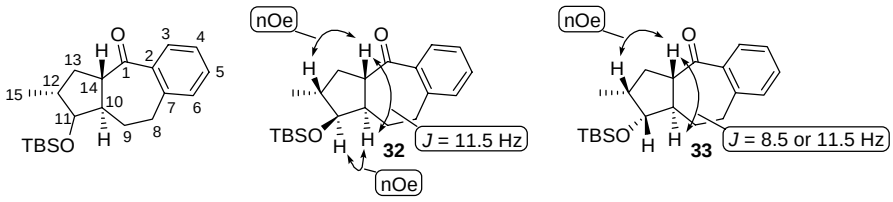
{2-[4-(*tert*-Butyl-dimethyl-silyloxy)-3-vinyl-hex-5-enyl]-phenyl}-methanol (30). To a solution of diene **29** (300 mg, 0.65 mmol) in anhydrous CH_2Cl_2 (5.2 mL) at 0 °C under Ar was added a solution of (1*S*)-(+)-(10)-camphorsulfonic acid (21.8 mg, 0.09 mmol) in anhydrous MeOH (5.2 mL). The mixture was stirred at 0 °C under Ar for 1 h and 40 min. The reaction was treated with sat aq $NaHCO_3$ (8 mL), CH_2Cl_2 (3 mL), and distilled H_2O (3 mL). The organic layer was collected, and the aqueous phase was extracted with CH_2Cl_2 (3 × 8 mL). The combined organic layers were dried (Na_2SO_4) and concentrated in vacuo. Flash chromatography (SiO_2, 2.5 × 25 cm, 5% EtOAc in hexanes elution) afforded **30** (132 mg, 0.39 mmol, 60%) as a yellow oil that was a ca. 1:1 mixture of diastereomers: ^1H NMR ($CDCl_3$, 300 MHz) δ 7.40–7.37 (m, 1H), 7.27–7.18 (m, 3H), 5.85–5.64 (m, 2H), 5.19–5.05 (m, 4H), 4.71 (s, 2H), 4.09–4.04 (m, 1H), 2.79–2.69 (m, 1H), 2.60–2.48 (m, 1H), 2.21–2.12 (m, 1H), 1.93–1.80 (m, 1H), 1.59–1.45 (m, 2H), 0.90 and 0.89 (2s, 9H), 0.04, 0.03 and 0.02 (3s, 6H); ^{13}C NMR ($CDCl_3$, 75 MHz) δ 141.0 and 140.9, 139.9 and 139.7, 139.5 and 139.3, 129.6 and 129.5, 128.3 and 128.1, 126.3, 117.2, 116.8, 115.2, 115.1, 77.1 and 77.0, 63.3, 51.4 and 51.2, 31.3 and 30.9, 30.4 and 30.3, 26.1 and 26.0 (3C), 18.4, –4.0 and –4.1, –4.6, and –4.7; IR (film) ν_{max} 3322, 3075, 2955, 2929, 2885, 2857, 2360, 2342, 1471, 1462, 1252, 1080, 1028, 1005, 837, 775 cm^{-1}; HRMS (ESI) *m/z* 369.2219 (MNa^+, $C_{21}H_{34}O_2SiNa$ requires 369.2220).

***Se*-Phenyl 2-[4-(*tert*-Butyl-dimethyl-silyloxy)-3-vinyl-hex-5-enyl] benzoselenoate (31).** To a solution of oxalyl chloride (13.8 μl, 27.8 mg, 0.22 mmol) in anhydrous CH_2Cl_2 (0.76 mL) at –78 °C under Ar was added DMSO (32.3 μl, 35.5 mg, 0.46 mmol) in anhydrous CH_2Cl_2 (0.22 mL) dropwise. The solution was stirred at –78 °C under Ar for 30 min, then treated with a solution of alcohol **30** (23 mg, 0.066 mmol) in anhydrous CH_2Cl_2 (0.1 mL + 2 × 0.1 mL rinses), and the resulting mixture was stirred at –78 °C under Ar for 1 h. Et_3N (140 μl, 102 mg, 1.01 mmol) was added to the mixture dropwise, then it was warmed to 0 °C and stirred for another hour. The reaction was quenched with brine (2 mL), the organic phase was collected, and the aqueous phase was extracted with Et_2O (3 × 2 mL). The combined organic layers were washed with brine (4 mL), dried (Na_2SO_4), and concentrated in vacuo to give the aldehyde.

To a solution of the crude aldehyde in *t*-BuOH (0.72 mL) and H_2O (0.18 mL) was added successively 2-methyl-2-butene (83.9 μl, 55.6 mg, 0.79 mmol), NaH_2PO_4 (9.6 mg, 0.08 mmol), and NaOClO (35.8 mg, 0.40 mmol). The resultant orange solution was stirred at rt under Ar for 5 h. The reaction was quenched with sat aq NH_4Cl (2 mL) and extracted with CH_2Cl_2 (4 × 2 mL). The combined organic layers were dried (Na_2SO_4) and concentrated in vacuo to give the acid.

To a solution of the crude acid in anhydrous CH_2Cl_2 (0.60 mL) at rt under Ar was added PhSeSePh (99 μl of a 1.0 M solution in CH_2Cl_2, 0.099 mmol) and Bu_3P (35.8 μl, 29.4 mg, 0.15 mmol) dropwise. The resultant orange solution was stirred at rt under Ar for 5 h and 40 min, after which TLC analysis indicated incomplete conversion. Additional PhSeSePh (49.5 μl of a 1.0 M solution in CH_2Cl_2, 0.0495 mmol) and Bu_3P (17.9 μl, 14.7 mg, 0.08 mmol) were added, and the solution was stirred at rt under Ar for

2.5 h, then quenched with sat aq NH_4Cl (1 mL). The organic phase was collected and the aqueous layer was extracted with Et_2O (3× 2 mL). The combined organic layers were washed with brine (4 mL), dried (Na_2SO_4), and concentrated in vacuo. Flash chromatography (SiO_2, 1.0 × 25 cm, 1% Et_2O in hexanes elution) afforded **31** (20.4 mg, 0.041 mmol, 62% over three steps) as a yellow oil that was a ca. 1:1 mixture of diastereomers: ^{1}H NMR ($CDCl_3$, 500 MHz) δ 7.83–7.82 (d, *J* = 8.0 Hz, 1H), 7.62–7.60 (m, 2H), 7.46–7.42 (m, 4H), 7.33–7.27 (m, 2H), 5.81–5.74 (m, 1H), 5.72–5.65 (m, 1H), 5.15–5.10 (m, 2H), 5.08–5.02 (m, 2H), 4.05–4.03 (m, 1H), 2.91–2.83 (m, 1H), 2.72–2.64 (m, 1H), 2.17–2.09 (m, 1H), 1.88–1.80 (m, 1H), 1.58–1.50 (m, 1H), 0.89 and 0.88 (2s, 9H), 0.02, 0.01, and –0.01 (3s, 6H); ^{13}C NMR ($CDCl_3$, 125 MHz) δ 194.3, 140.9, 139.9 and 139.7, 139.5 and 139.1, 136.2 (2C), 132.1, 131.1, 129.5 (2C), 129.1 and 128.6, 127.5, 126.2, 117.1, 116.7, 115.1, 115.0, 77.1, 51.2 and 50.9, 31.8 and 31.4, 31.1 and 30.0, 26.1 (3C), 18.4, –4.1 (2C); IR (film) ν_{max} 3073, 2927, 2855, 2360, 2342, 1703, 1477, 1439, 1252, 1183, 1078, 1023, 919, 866, 836, 775 cm^{-1}; HRMS (ESI) *m/z* 523.1354 (MNa^+, $C_{27}H_{36}O_2SiSeNa$ requires 523.1542).



Tricycles 32 and 33. Phenyl selenoester **31** (22.5 mg, 0.045 mmol) was dried azeotropically with anhydrous benzene (2 × 2.3 mL), then dissolved in anhydrous benzene (11.2 mL) in a 3-necked round buttom flask under an atmosphere of dry air. $(TMS)_3SiH$ (27.8 μl, 0.090 mmol) and Et_3B (1.0 M in hexane, 80 μl, 0.080 mmol) were added to the mixture, and additional Et_3B (1.0 M in hexane, 0.82 ml, 0.82 mmol) was

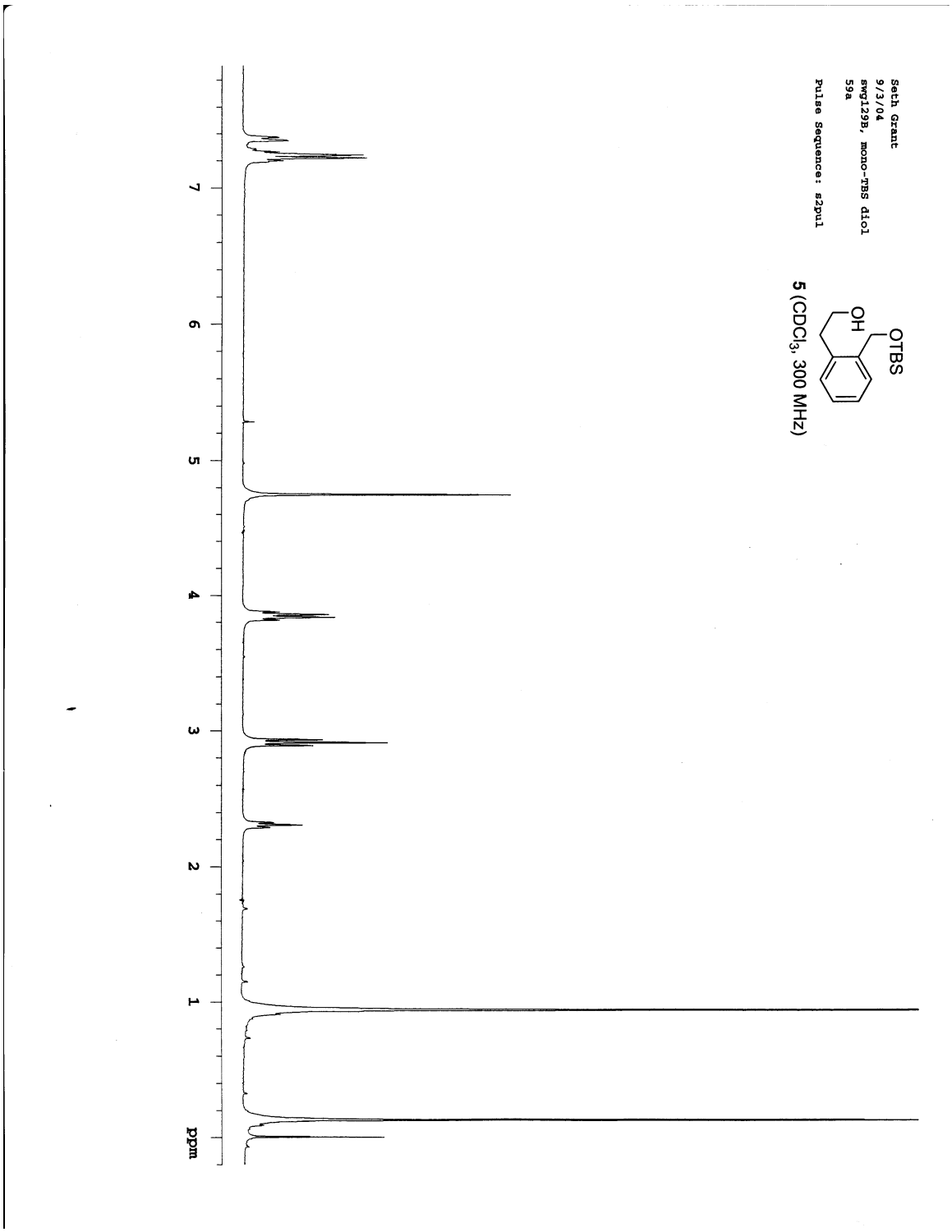
added slowly by syringe pump (80 μl/h, 10.25 h) while a continuous flow of compressed air was passed over the reaction. The mixture was stirred vigorously throughout the addition time. TLC analysis indicated incomplete conversion, so additional $(TMS)_3SiH$ (27.8 μl, 0.090 mmol) was added, and another portion of Et_3B (1.0 M in hexane, 0.82 ml μl, 0.82 mmol) was added by syringe pump (13 μl/h, 63 h) while the reaction was still stirring vigorously under air. Following the addition, the mixture was stirred for an additional 12 h, then concentrated in vacuo. Flash chromatography (SiO_2, 1.0 × 20 cm, 1% Et_2O in hexanes elution) afforded **32** and **33** (12.5 mg, 0.036 mmol, 81%) in a 1:1 ratio as a yellow oil. Diastereomerically pure samples could be obtained by preparative TLC. For **32**: ^{1}H NMR ($CDCl_3$, 500 MHz) δ 7.81 (dd, *J* = 1.0, 8.0 Hz, 1H), 7.42 (dt, *J* = 1.5, 7.5 Hz, 1H), 7.32 (t, *J* = 7.5 Hz, 1H), 7.19 (d, *J* = 7.5 Hz, 1H), 3.89 (t, *J* = 3.0 Hz, 1H), 3.13 (dt, *J* = 4.5, 11.5 Hz, 1H), 2.97 (ddd, *J* = 6.0, 12.0, 14.5 Hz, 1H), 2.88 (ddd, *J* = 3.5, 6.0, 14.0 Hz, 1H), 2.44 (ddd, *J* = 4.0, 8.5, 13.0 Hz, 1H), 2.11–2.05 (m, 1H), 2.00–1.93 (m, 1H), 1.95–1.88 (m, 1H), 1.81–1.74 (m, 1H), 1.79–1.70 (m, 1H), 0.97 (d, *J* = 7.0 Hz, 3H), 0.96 (s, 9H), 0.072 (s, 3H), 0.067 (s, 3H); ^{13}C NMR ($CDCl_3$, 125 MHz) δ 208.8, 140.1, 138.5, 132.4, 130.3, 129.2, 127.0, 78.2, 52.9, 47.5, 40.0, 33.9, 32.0, 30.0, 26.3 (3C), 26.0, 15.4, –3.7, –3.9; IR (film) ν_{max} 2927, 2855, 1677, 1461, 1252, 1023, 834, 773 cm^{-1}; HRMS (ESI) *m/z* 367.2060 (MNa^+, $C_{21}H_{32}O_2SiNa$ requires 367.2064).

2D ^{1}H–^{1}H COSY NMR ($CDCl_3$, 500 MHz) 3.89/2.00–1.93 (w, H-11/H-10), 3.89/1.95–1.88 (w, H-11/H-12), 3.18/2.44 (w, H-14/H-13), 3.18/2.00–1.93 (s, H-14/H-10), 3.18/1.79–1.70 (s, H-14/H-13), 2.97/2.88 (s, H-8/H-8), 2.97/2.11–2.05 (m, H-8/H-9), 2.97/1.81–1.74 (s, H-8/H-9), 2.88/2.11–2.05 (w, H-8/H-9), 2.88/1.81–1.74 (w, H-8/H-9), 2.44/1.95–1.88 (m, H-13/H-12), 2.44/1.79–1.70 (s, H-13/H-13), 2.11–2.05/1.81–1.74 (s,

H-9/H-9), 2.00–1.93/1.81–1.74 (w, H-10/H-9), 1.95–1.88/1.79–1.70 (m, H-12/H-13), 1.95–1.88/0.97 (s, H-12/H-15); nOe NMR ($CDCl_3$, 500 MHz) Irradiation of the signal at 3.89 led to an enhancement in the signal at 2.00–1.93 (H-11/H-10). Irradiation of the signal at 3.18 led to enhancements in the signals at 1.95–1.88 (H-14/H-12) and 1.79–1.70 (H-14/H-13).

For **33**: ^{1}H NMR ($CDCl_3$, 500 MHz) δ 7.78 (dd, *J* = 1.5, 8.0 Hz, 1H), 7.41 (dt, *J* = 1.5, 7.5 Hz, 1H), 7.31 (dt, *J* = 1.0, 7.5 Hz, 1H), 7.21 (d, *J* = 7.0 Hz, 1H), 3.74 (dd, *J* = 2.0, 5.0 Hz, 1H), 3.20 (td, *J* = 8.5, 11.5 Hz, 1H), 3.03 (ddd, *J* = 5.5, 11.5, 14.5 Hz, 1H), 2.88 (td, *J* = 4.5, 14.5 Hz, 1H), 2.33–2.27 (m, 1H), 2.16–2.10 (m, 1H), 2.05–1.99 (m, 2H), 1.80–1.71 (m, 2H), 0.91 (d, *J* = 7.0 Hz, 3H), 0.91 (s, 9H), 0.07 (s, 3H), 0.06 (s, 3H); ^{13}C NMR ($CDCl_3$, 125 MHz) δ 206.7, 141.5, 138.6, 132.3, 130.4, 128.9, 126.9, 82.2, 53.7, 44.4, 41.8, 32.9, 32.1, 29.9, 26.1 (3C), 25.6, 19.9, –4.3, –4.6; ν_{max} 2926, 2855, 1677, 1461, 1252, 1077, 835, 774 cm^{-1}; HRMS (ESI) *m/z* 367.2056 (MNa^+, $C_{21}H_{32}O_2SiNa$ requires 367.2064).

2D ^{1}H–^{1}H COSY NMR ($CDCl_3$, 500 MHz) 3.74/2.05–1.99 (w, H-11/H-12), 3.20/2.33–2.27 (w, H-14/H-13), 3.20/2.05–1.99 (m, H-14/H-10), 3.20/1.80–1.71 (m, H-14/H-13), 3.03/2.88 (s, H-8/H-8), 3.03/2.16–2.10 (w, H-8/H-9), 3.03/1.80–1.71 (m, H-8/H-9), 2.88/2.16–2.10 (w, H-8/H-9), 2.88/1.80–1.71 (w, H-8/H-9), 2.33–2.27/2.05–1.99 (w, H-13/H-12), 2.33–2.27/1.80–1.71 (s, H-13/H-13), 2.16–2.10/1.80–1.71 (s, H-9/H-9), 2.05–1.99/1.80–1.71 (w, H-12/H-13 or H-10/H-9), 2.05–1.99/0.91 (s, H-12/H-15); 1D nOe NMR ($CDCl_3$, 500 MHz) Irradiation of the signal at 3.20 led to an enhancement in the signal at 2.05–1.99 (H-14/H-12).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9/3/04
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3
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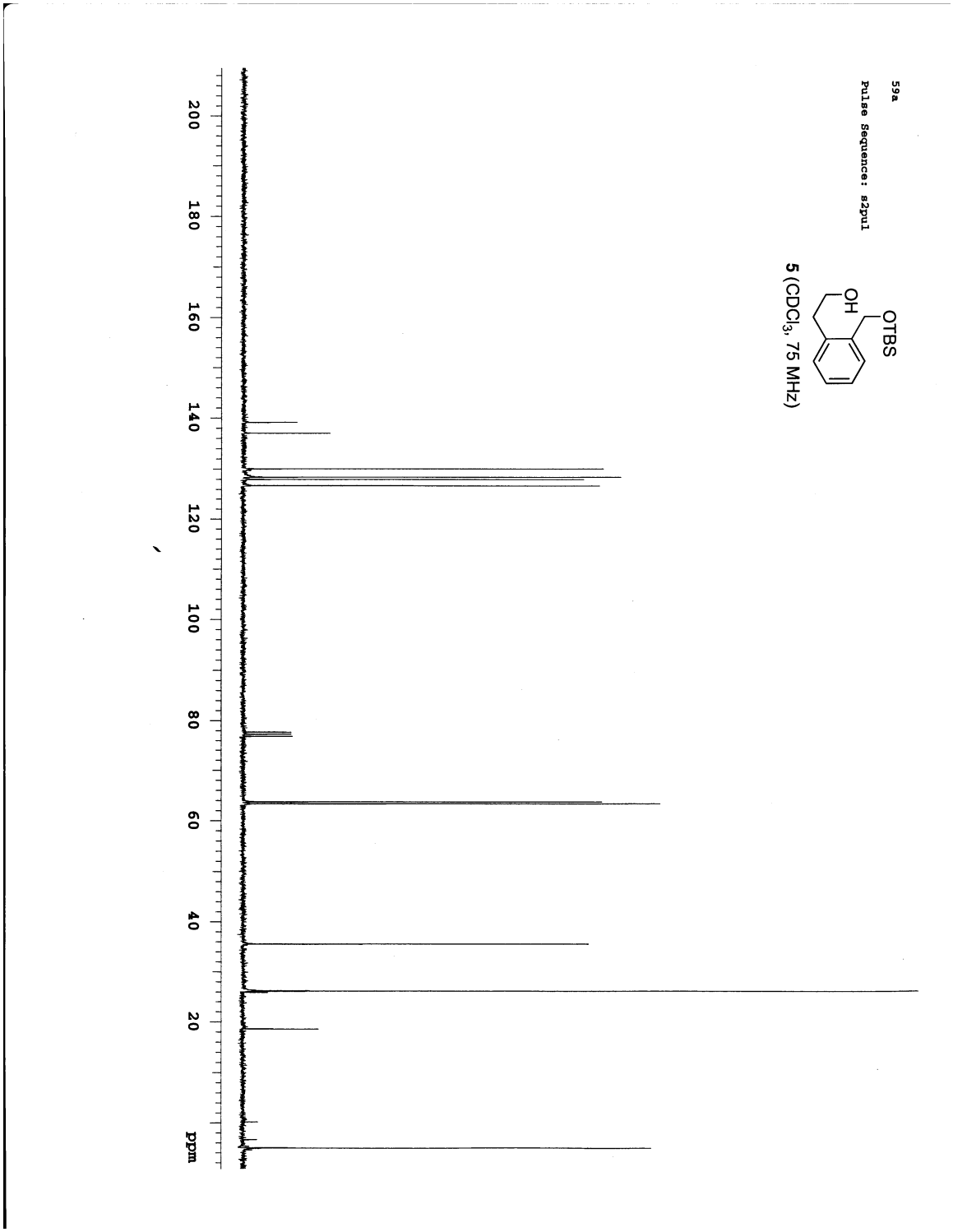
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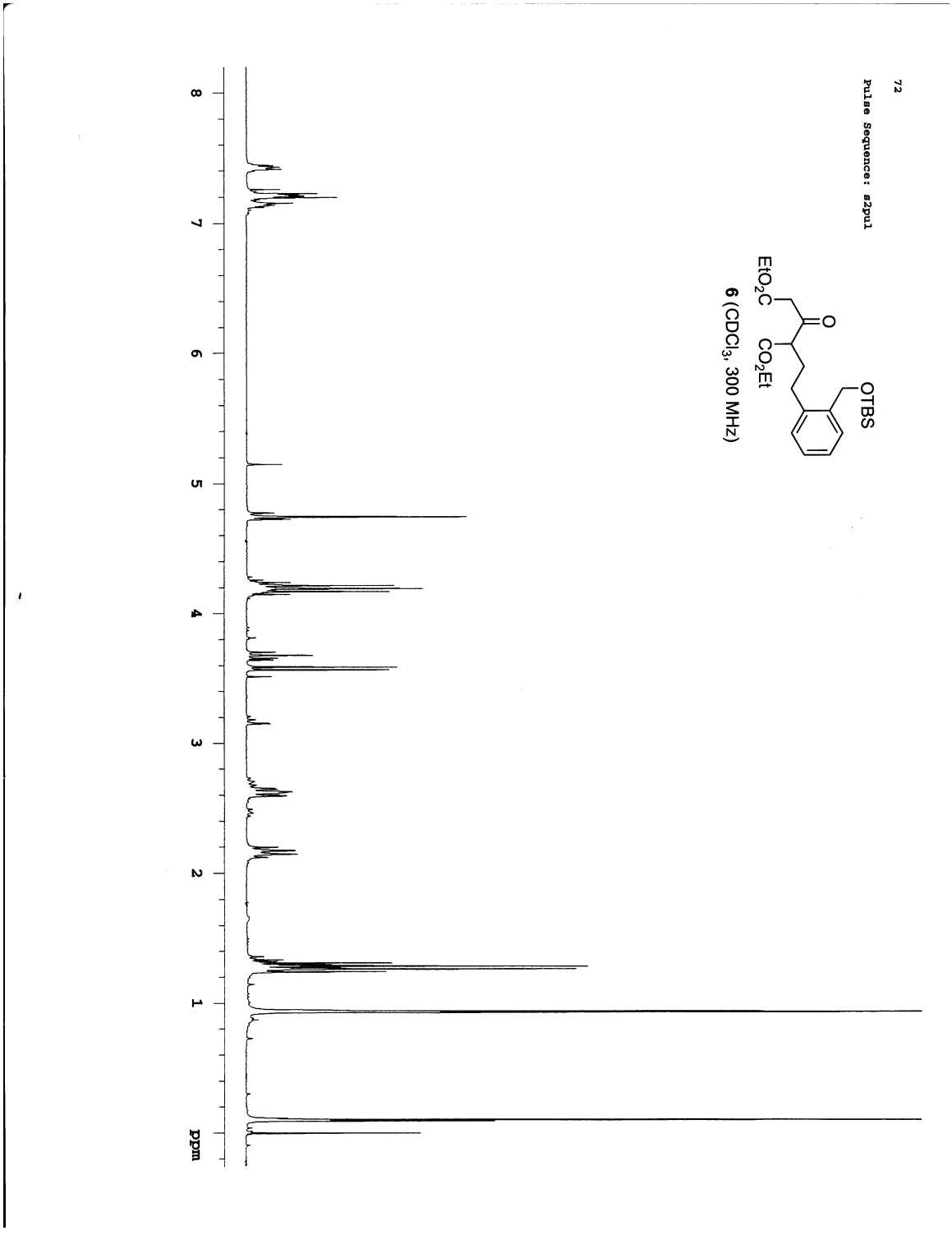
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EtO2C
O
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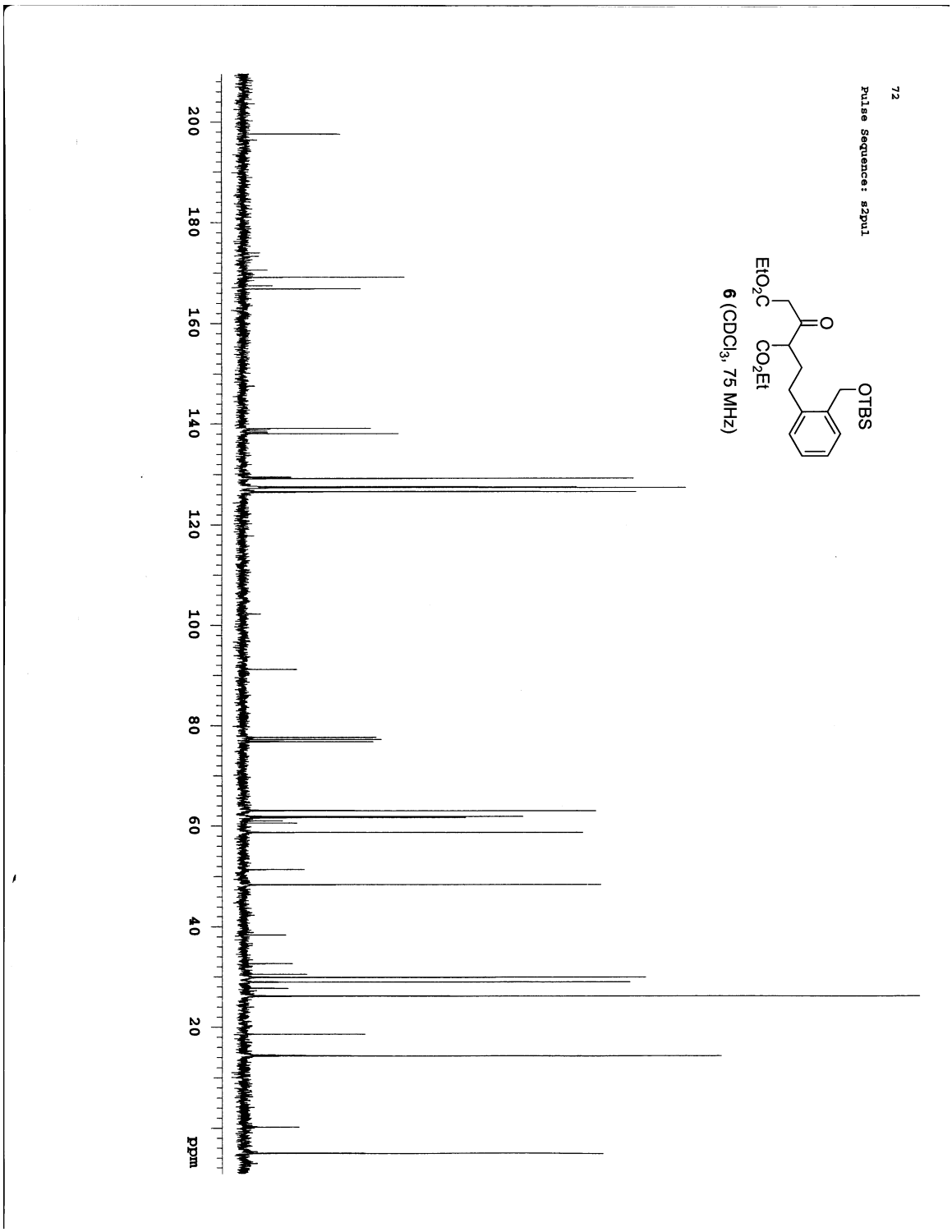
7
6
5
4
3
2
1
ppm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CO2Et
EtO2C
O
6 (CDCl3, 75 MHz)
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160
140
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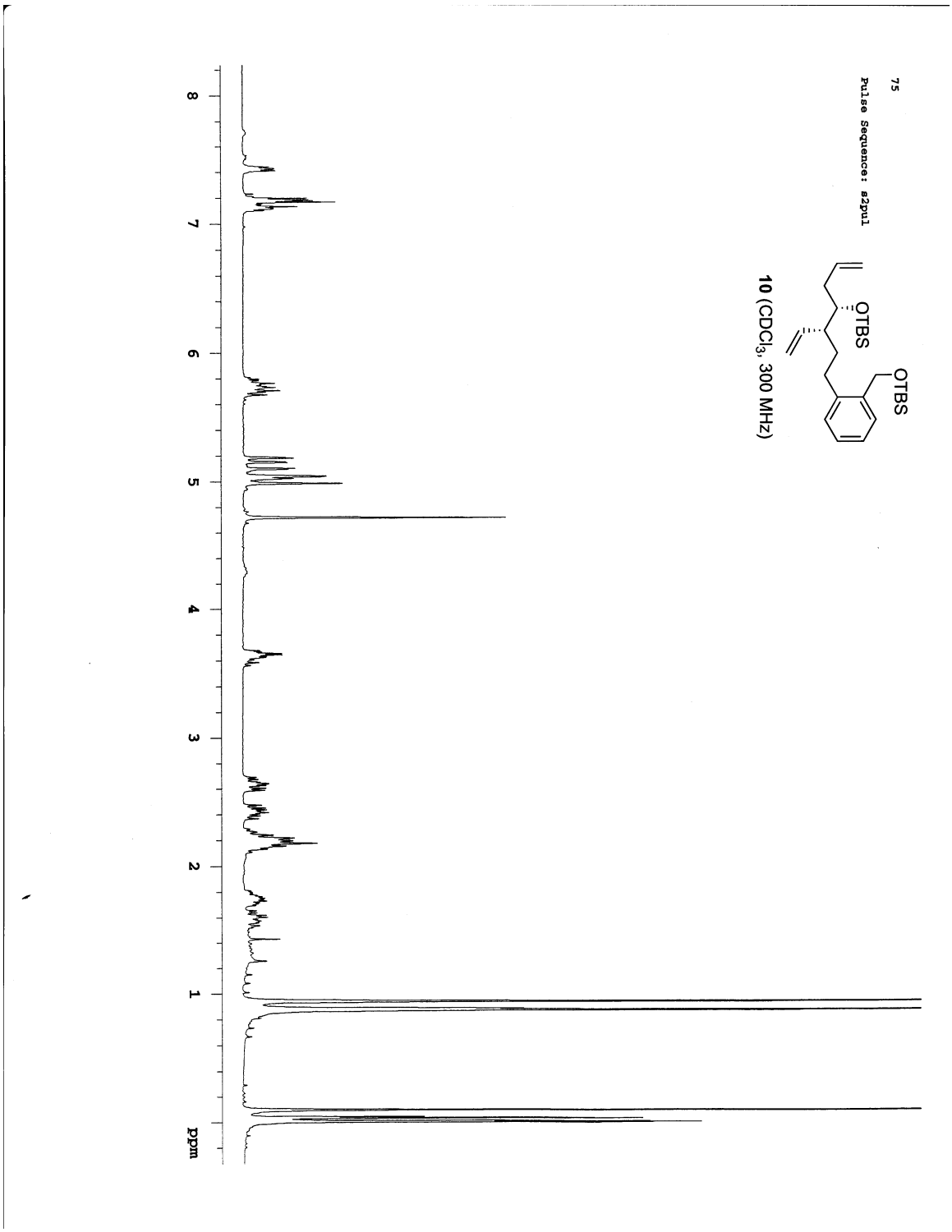
100
80
60
40
20
ppm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OTBS
OTBS
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7
6
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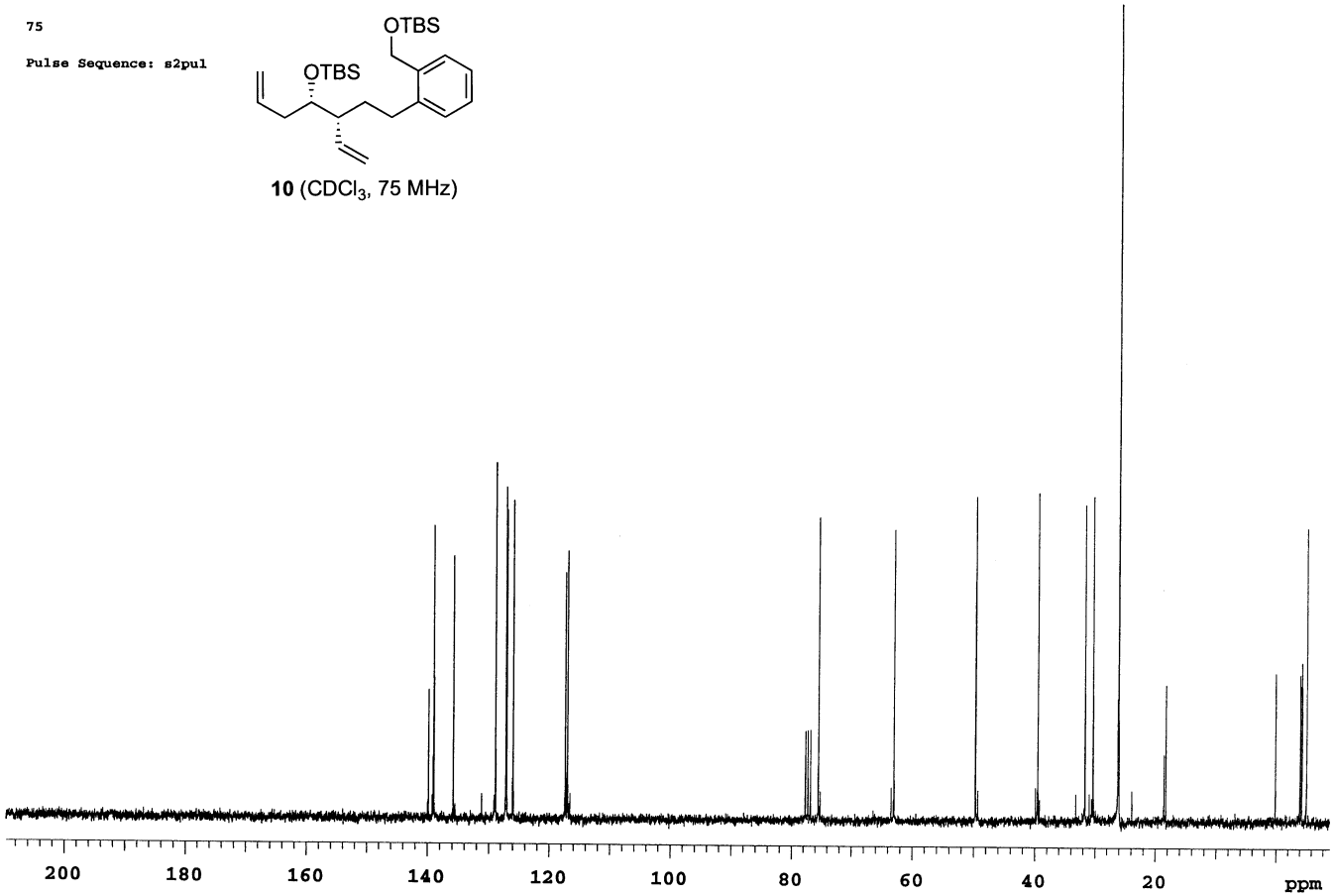
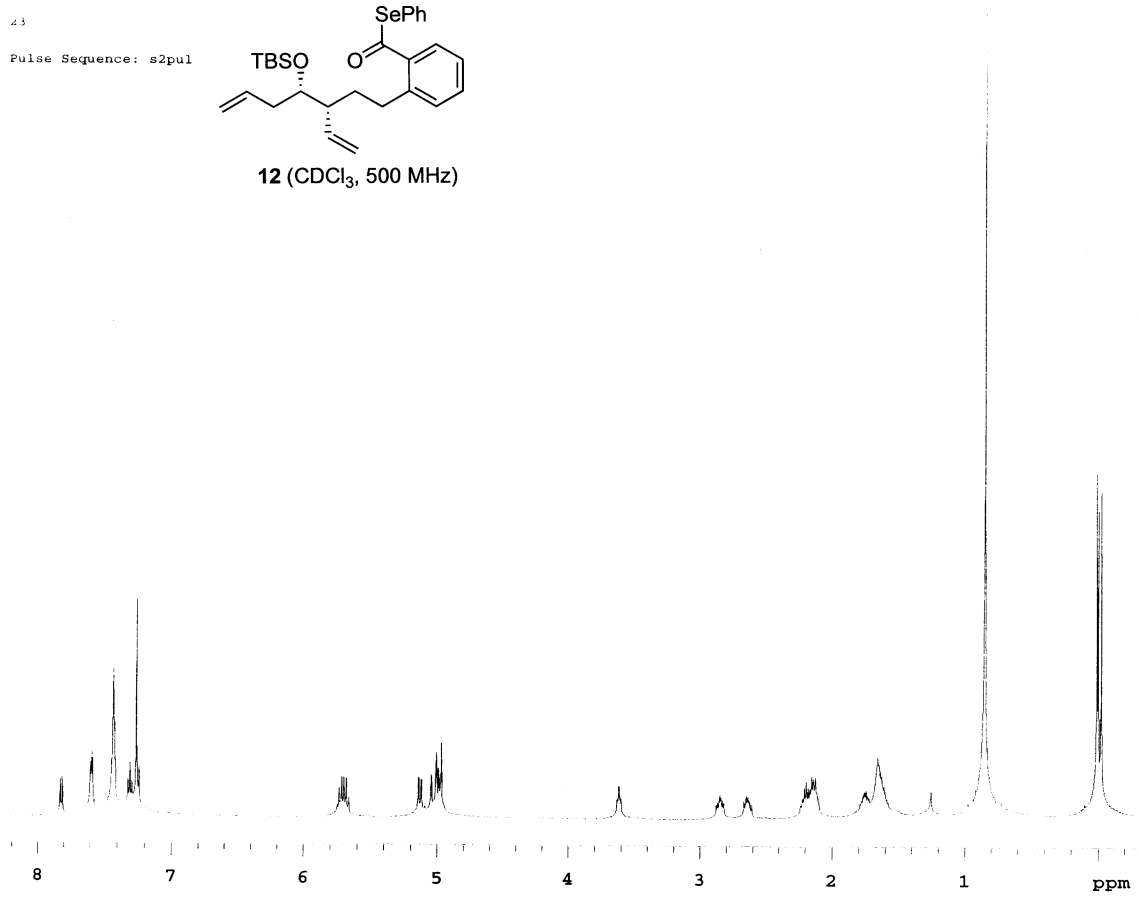
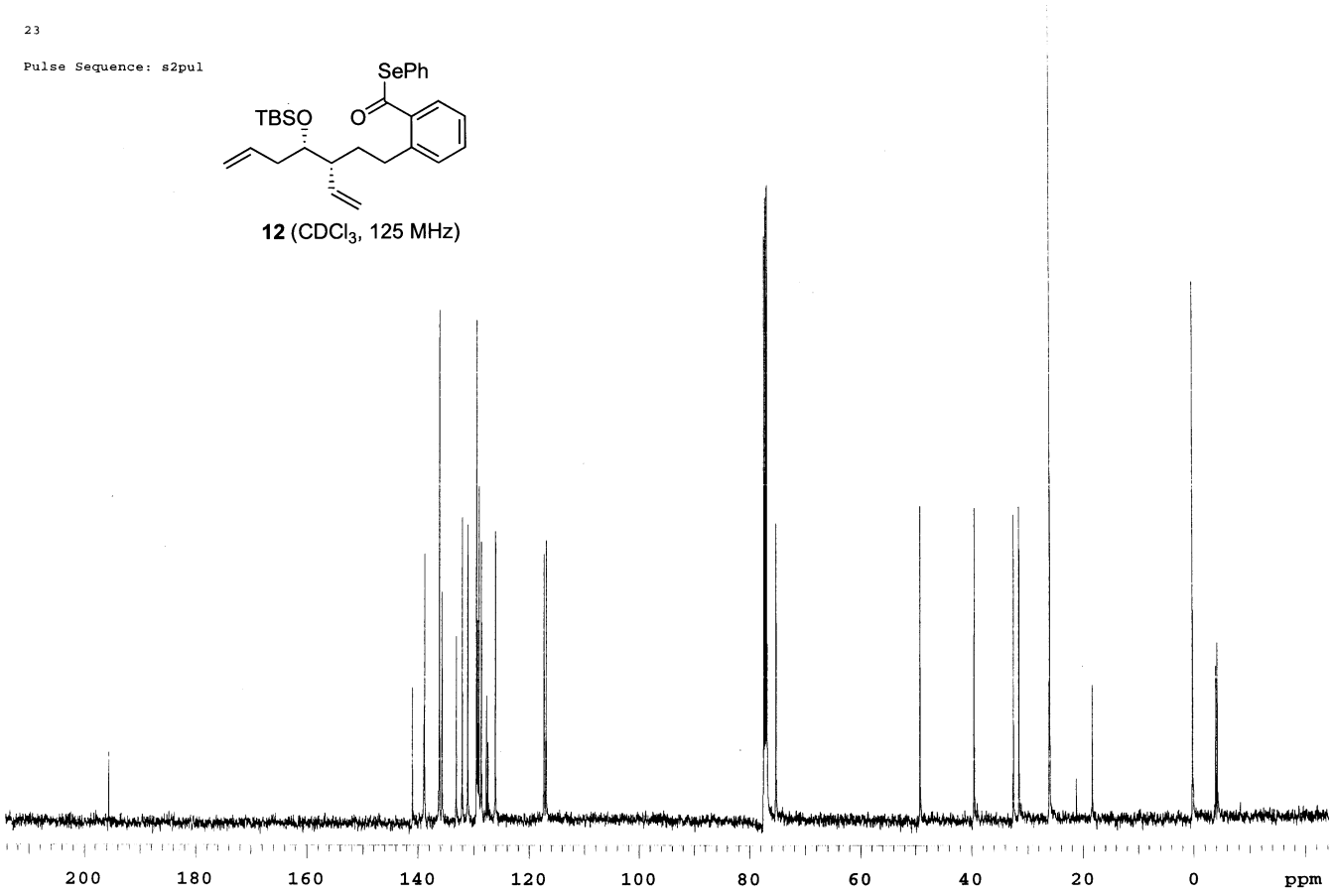
4
3
2
1
ppm



10 ($CDCl_3$, 75 MHz)



12 ($CDCl_3$, 500 MHz)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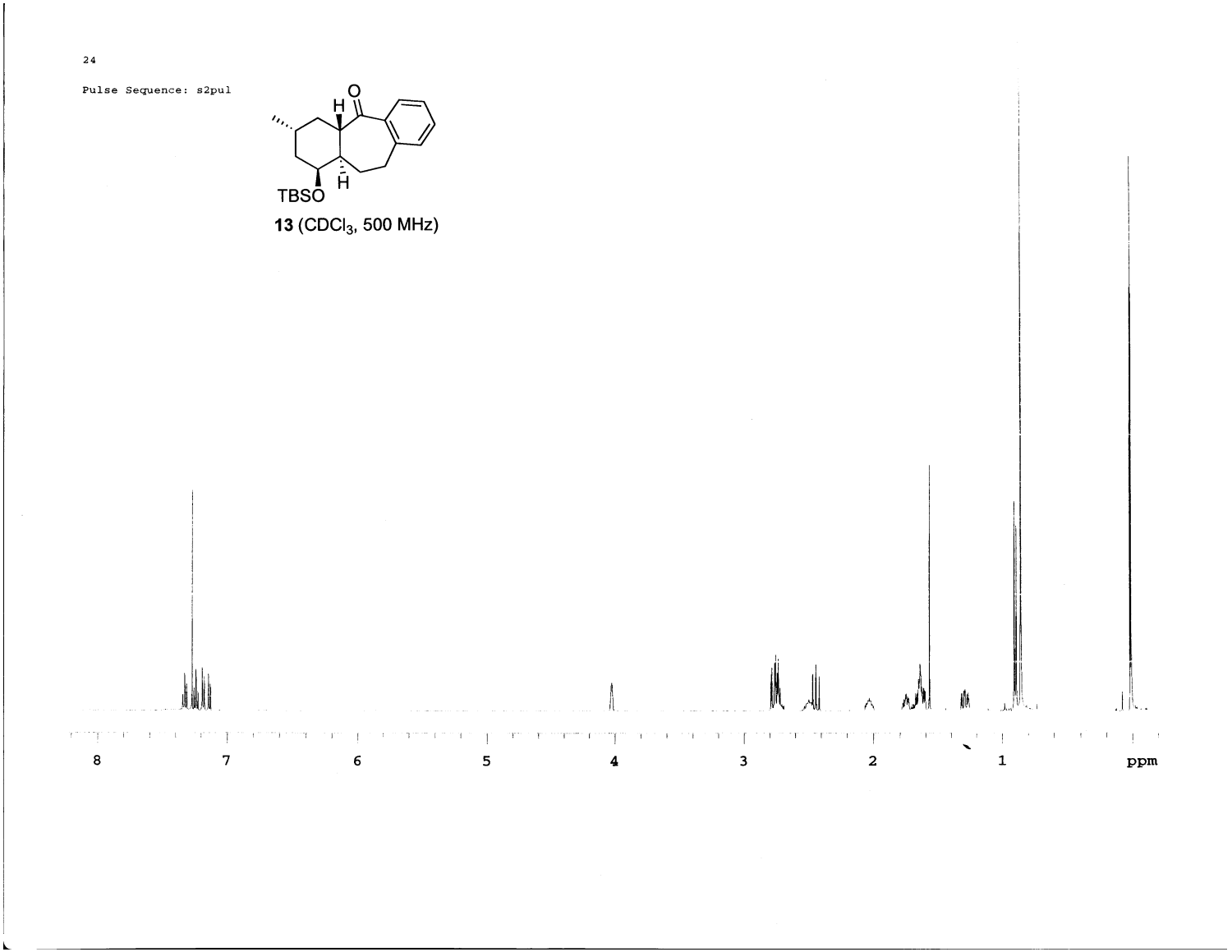
20
0
ppm


24
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TBSO
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7
6
5
4
3
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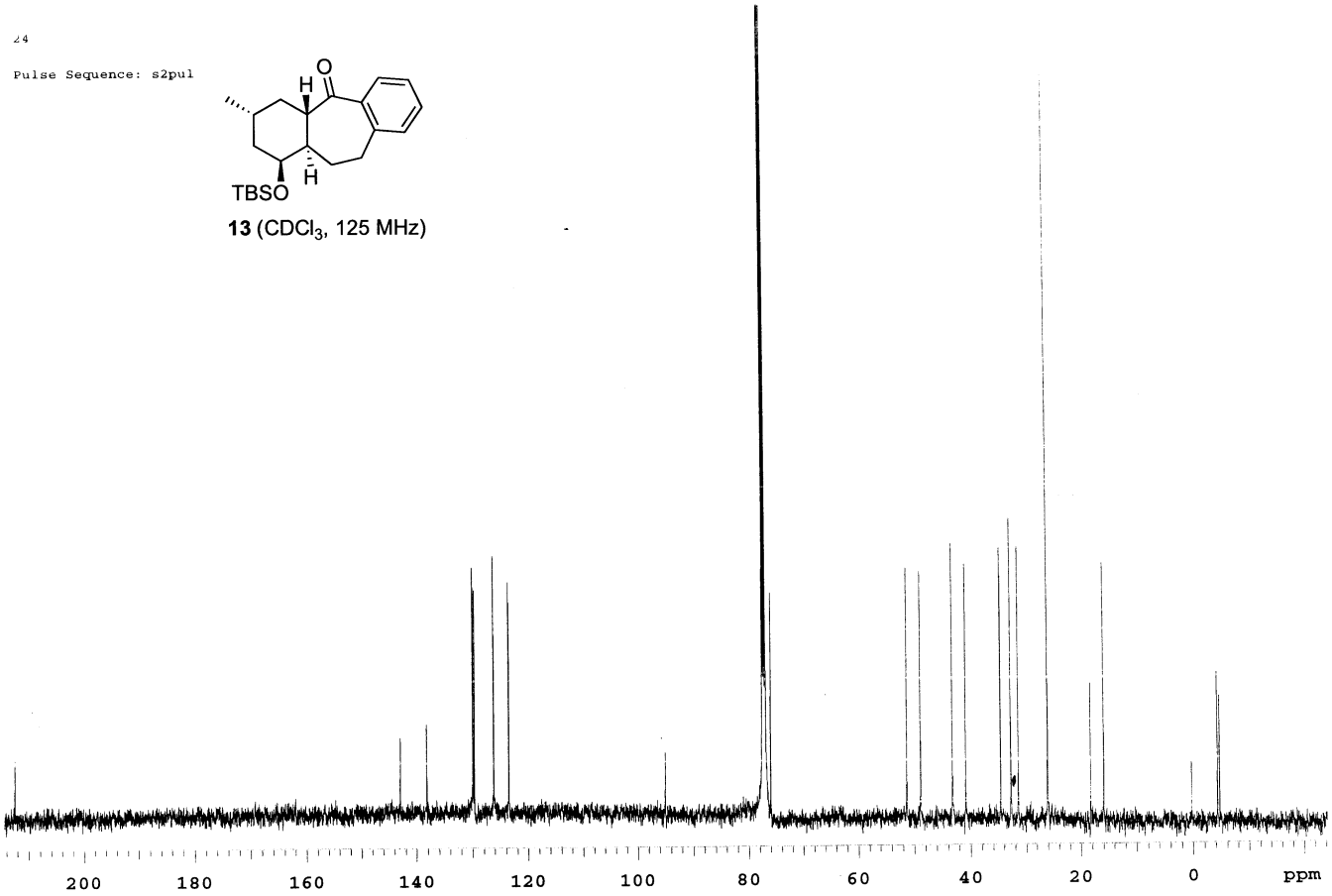
ppm


24
Pulse Sequence: s2pul
O
H
H
TBSO
13 (CDCl3, 125 MHz)
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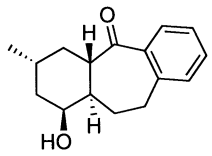
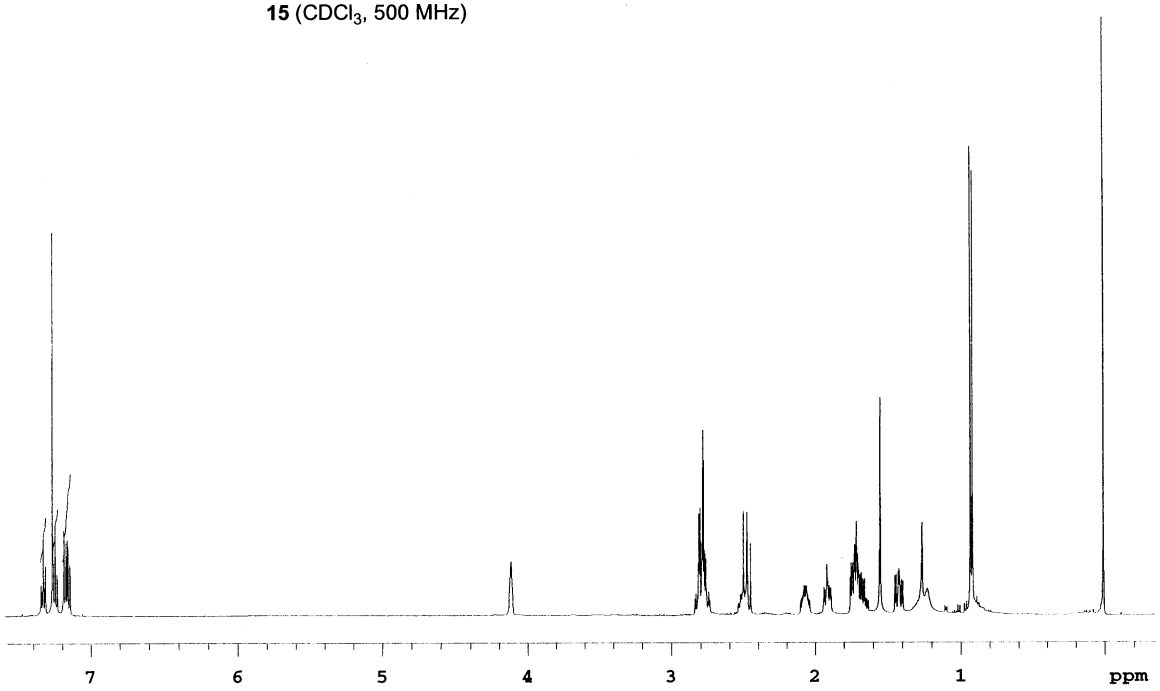
180
160
140
120
100
80
60
40
20
0
ppm

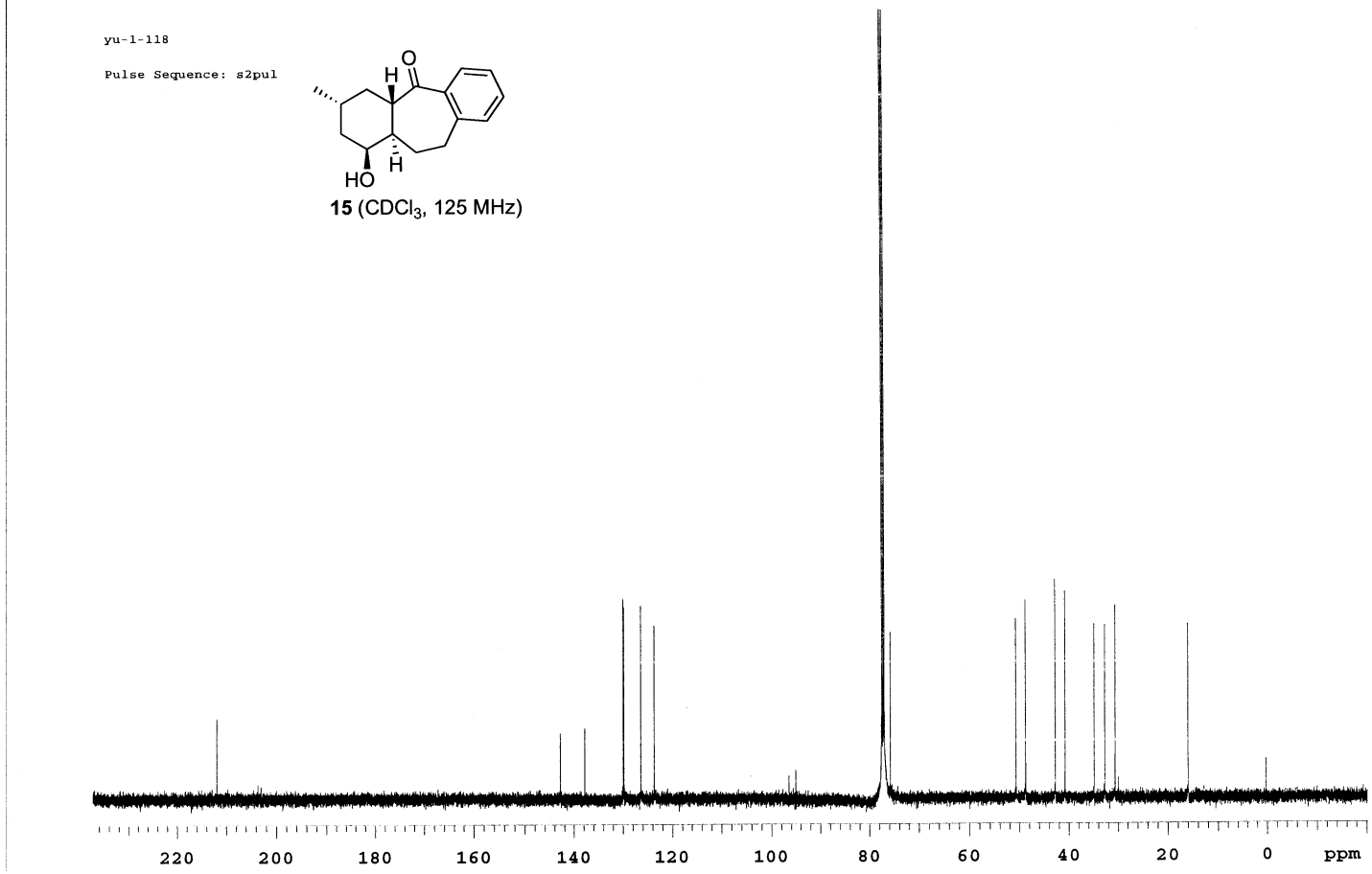
yu-1-118

Pulse Sequence: s2pul

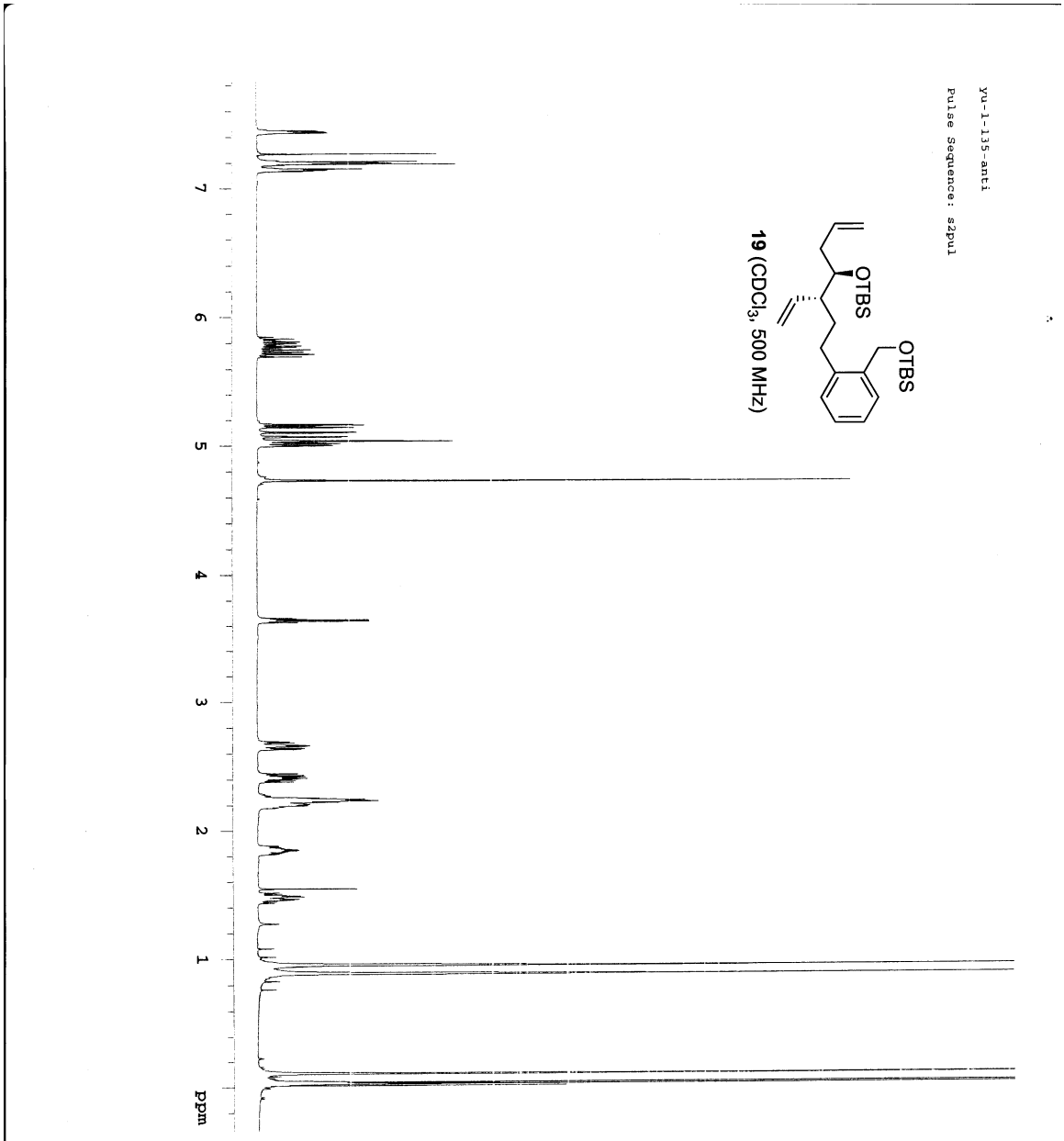


15 ($CDCl_3$, 500 MHz)





15 ($CDCl_3$, 125 MHz)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OTBS
OTBS
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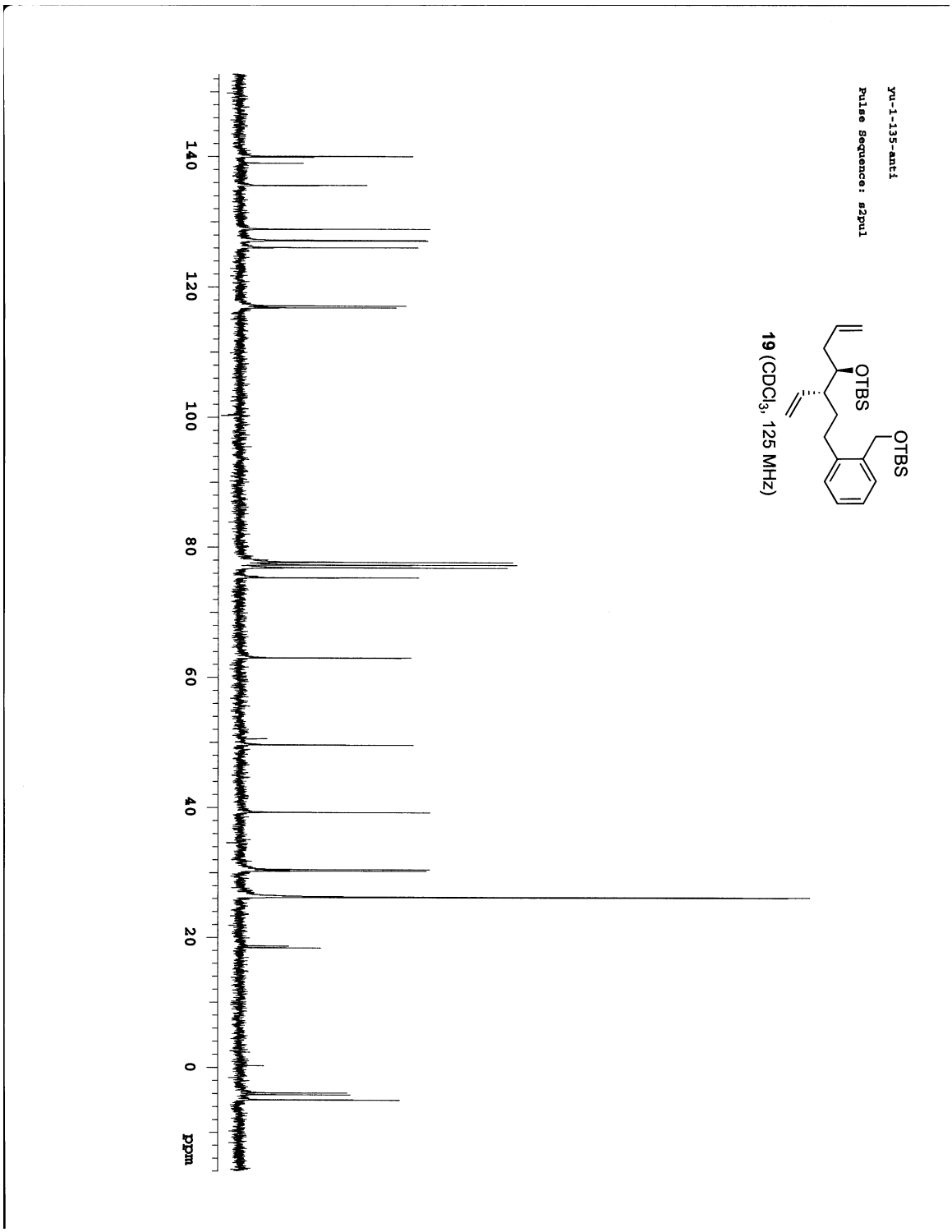
7
6
5
4
3
2
1
ppm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OTBS
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120
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0
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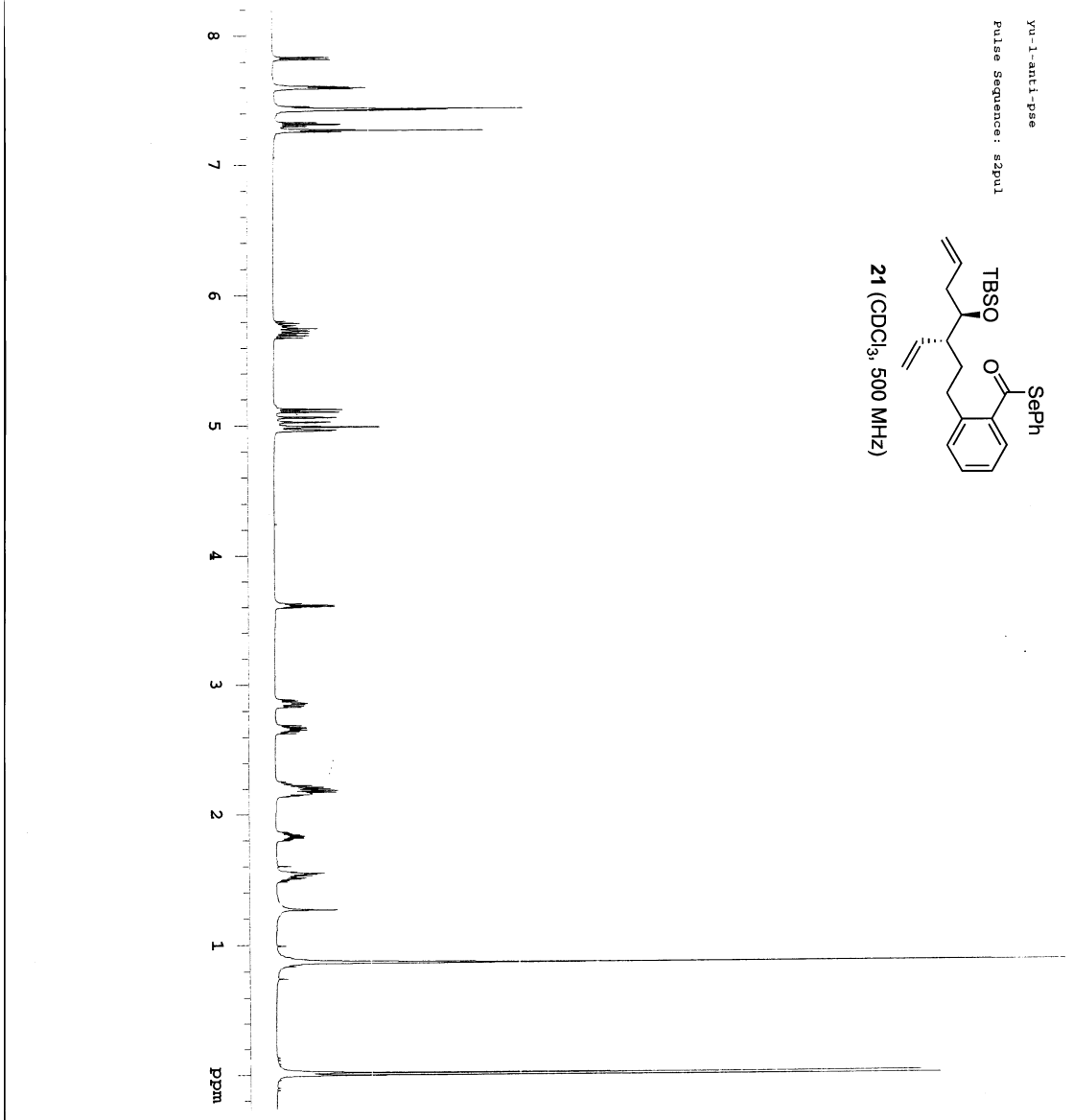
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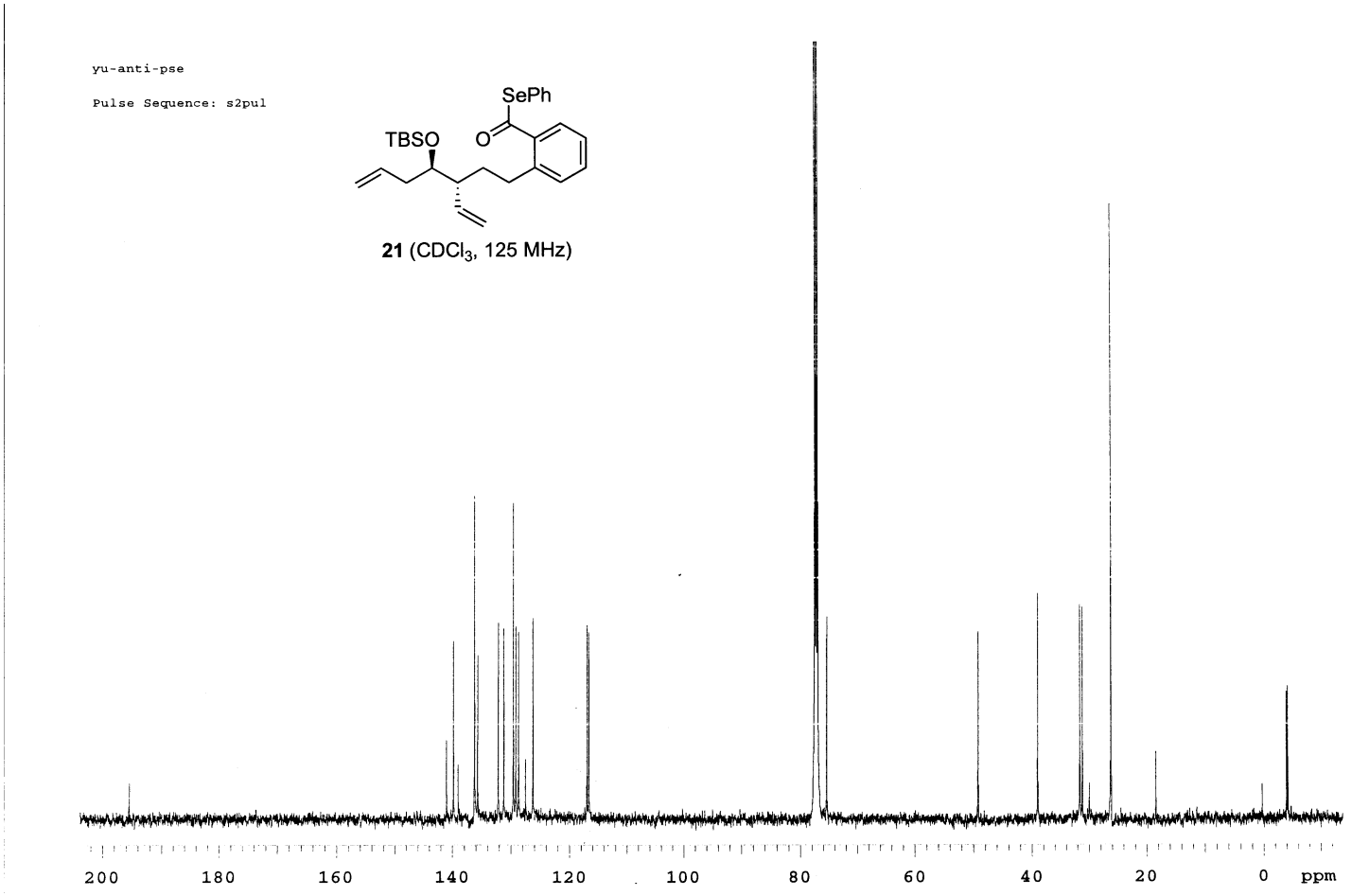
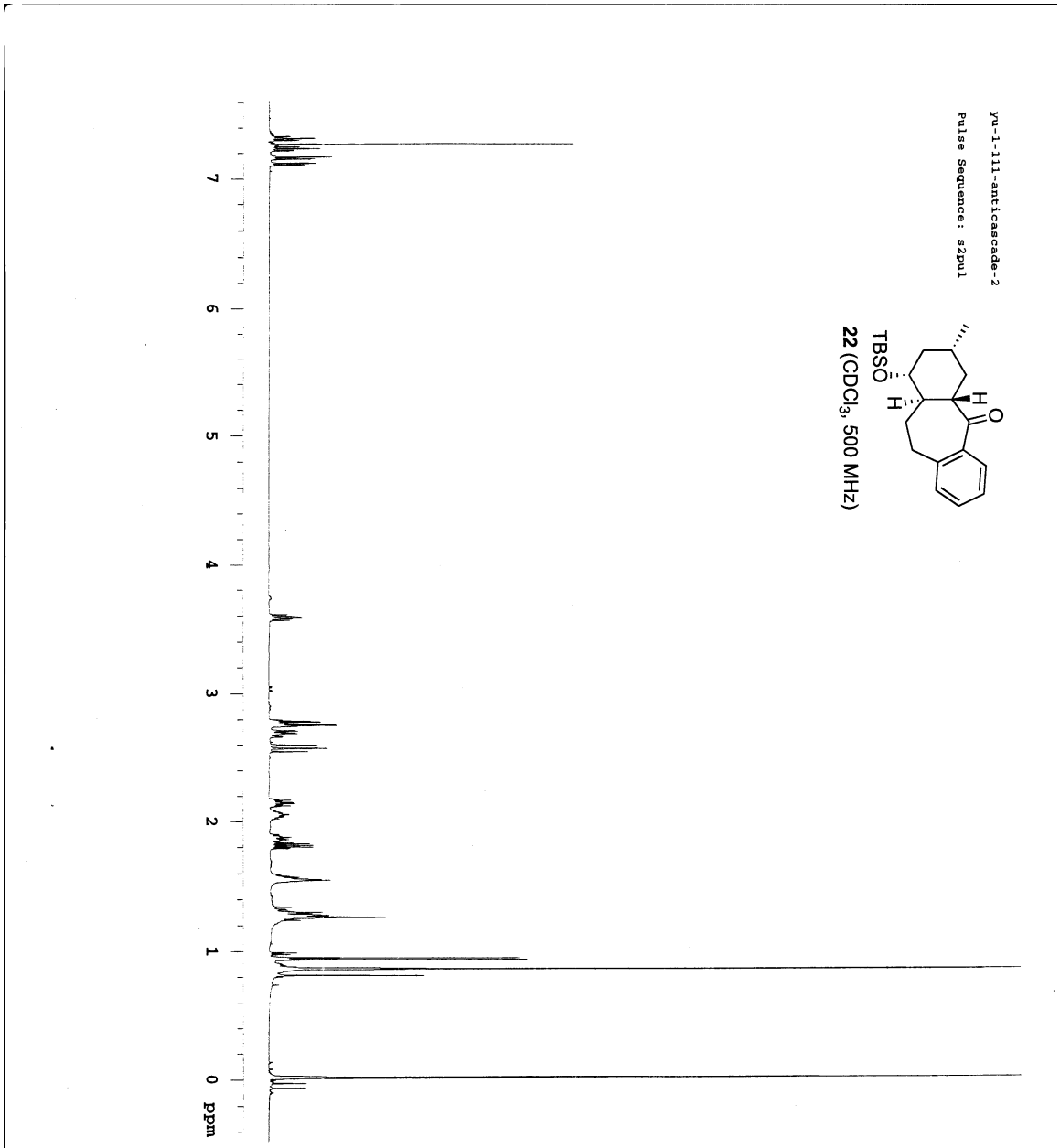
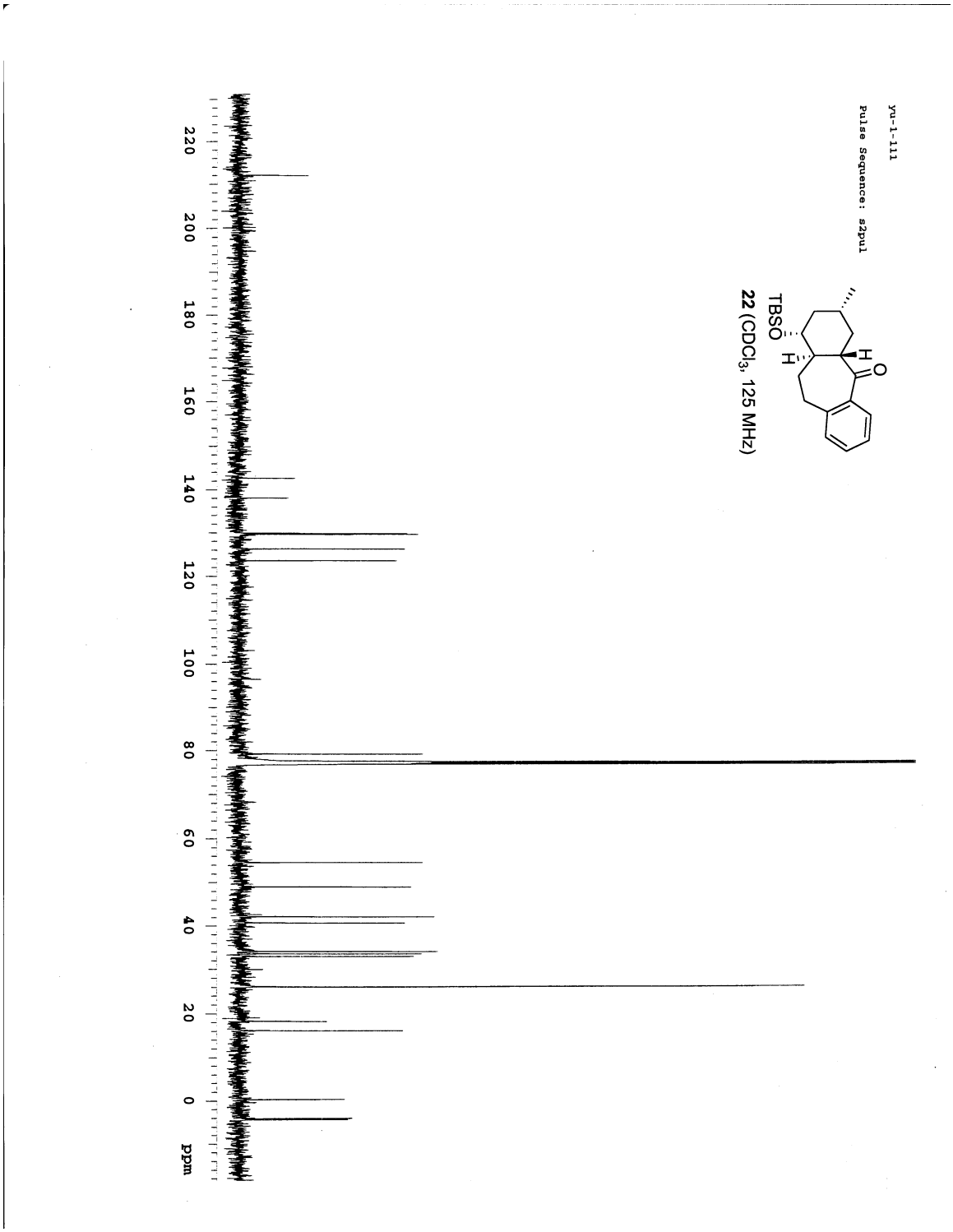
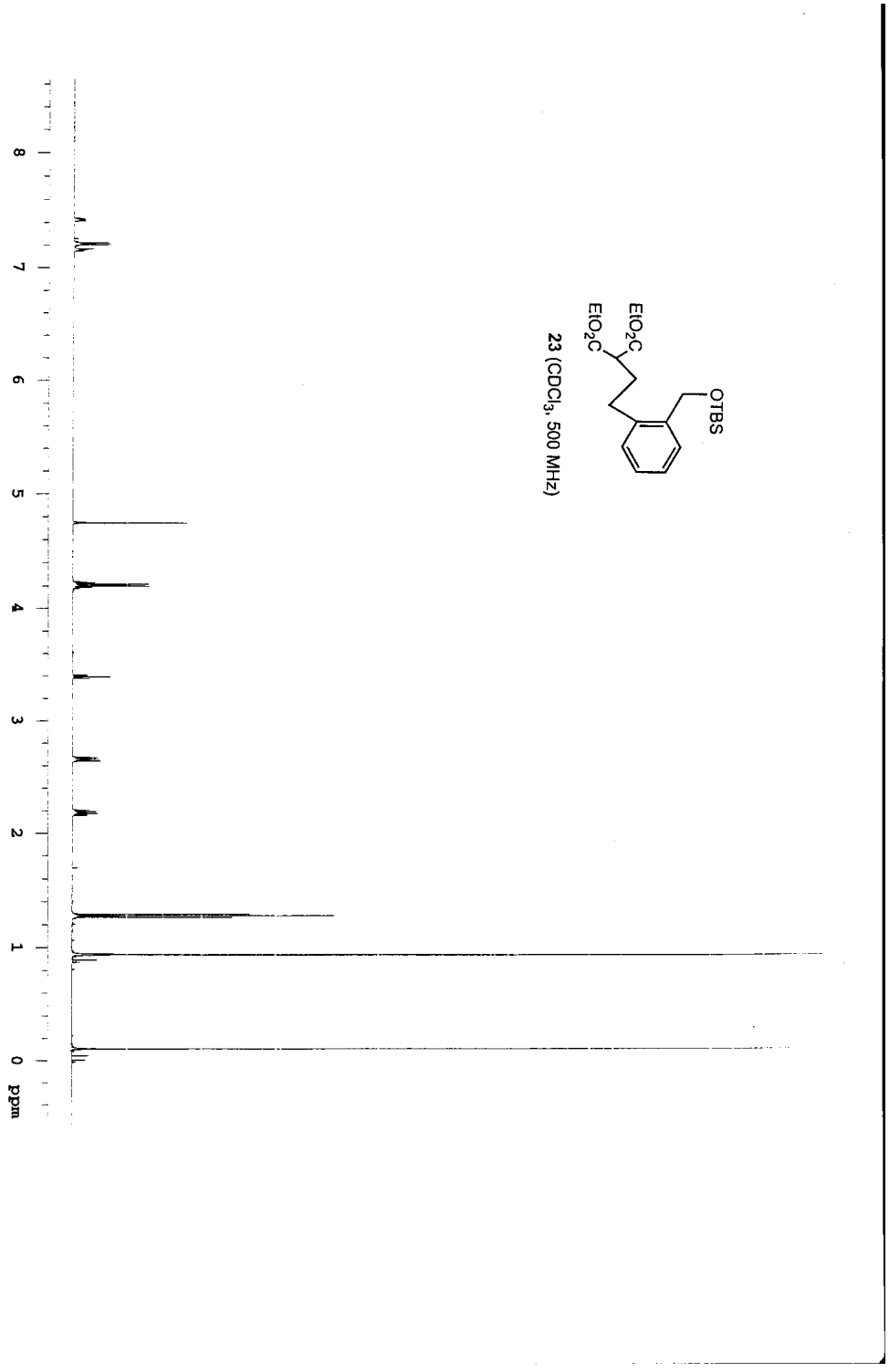
8
7
6
5
4
3
2
1
ppm

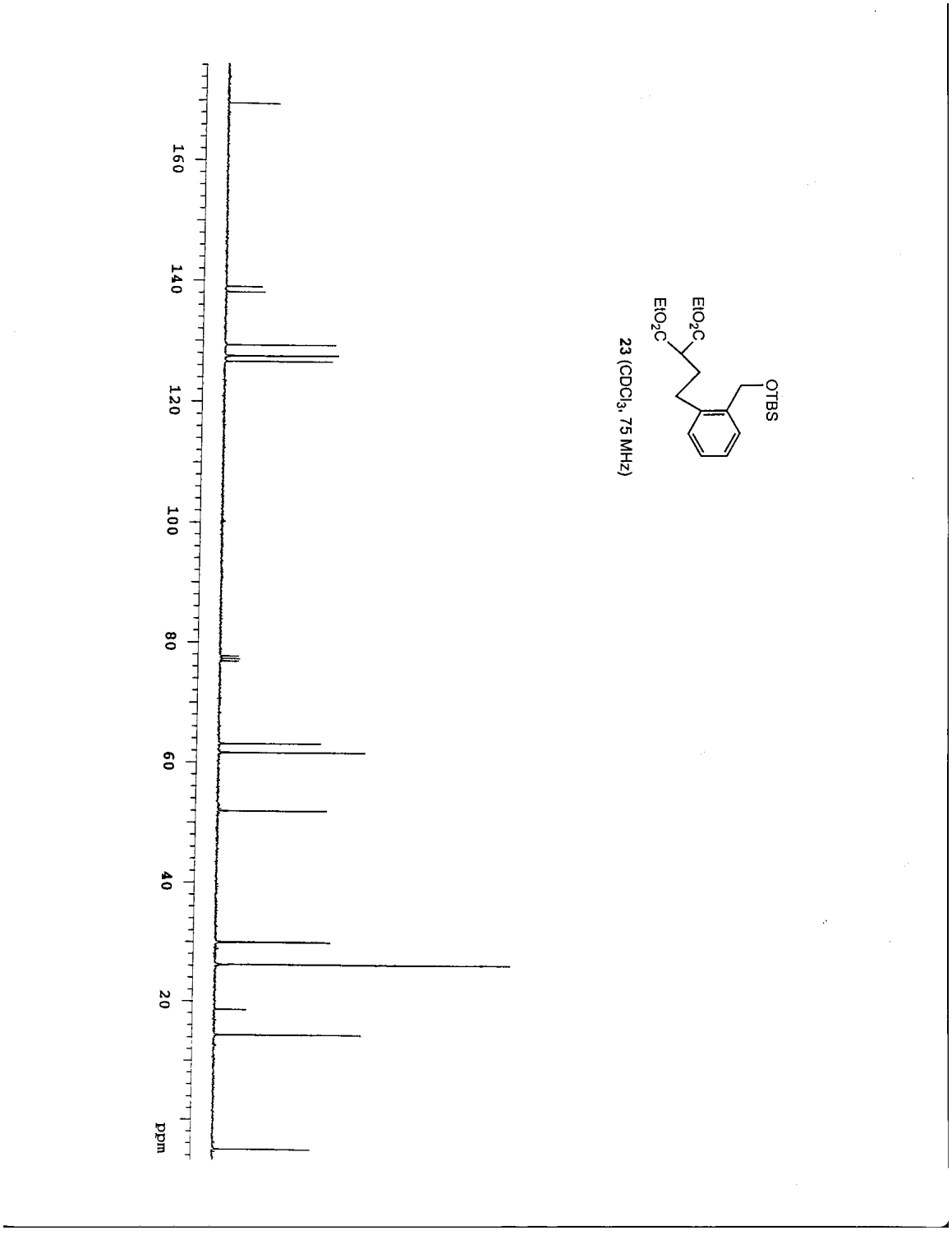


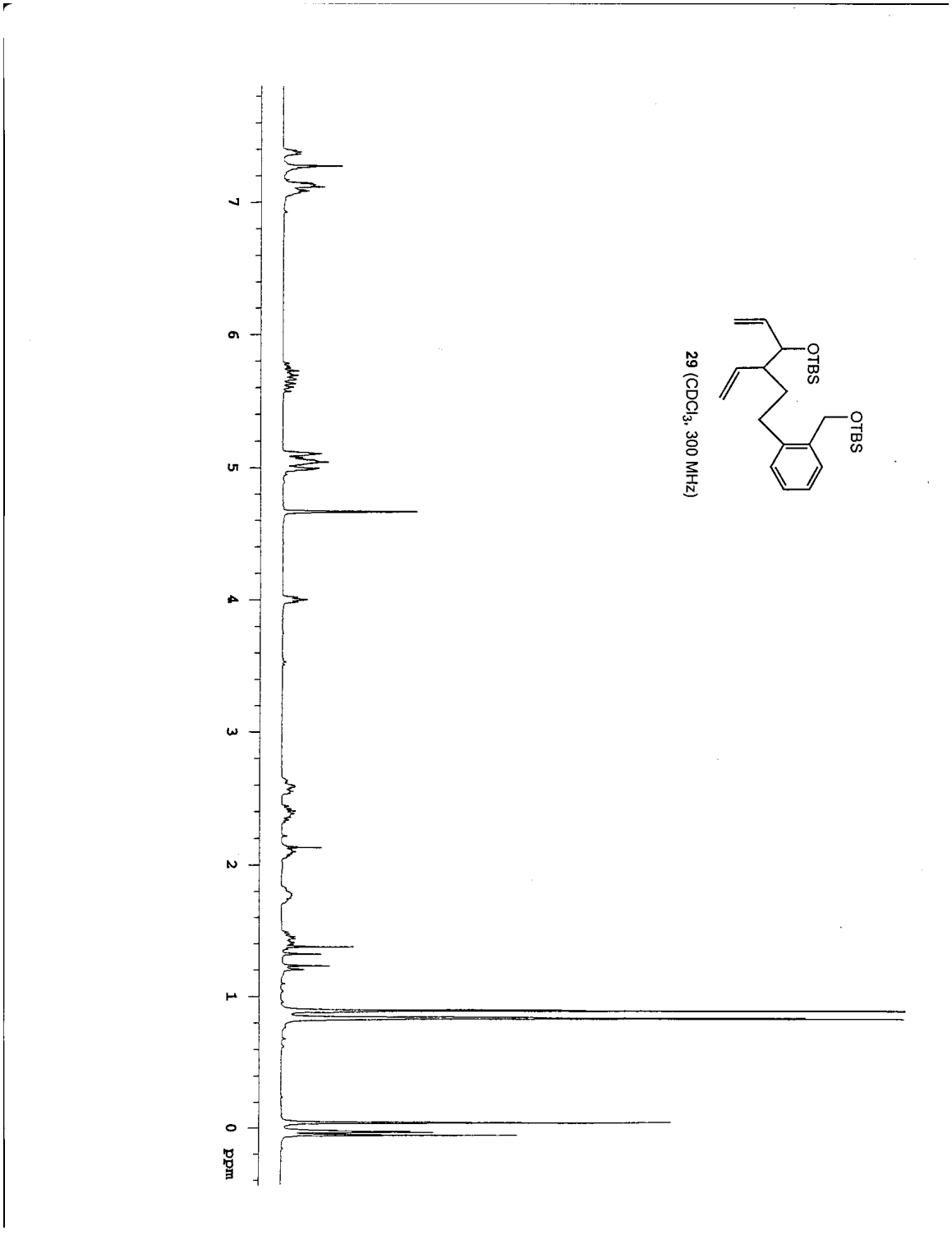
21 ($CDCl_3$, 125 MHz)

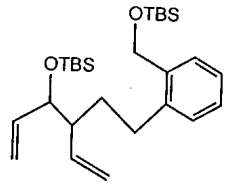

yu-1-111-anticascade-2
Pulse Sequence: s2pul
TBSO
H
H
O
22 (CDCl3, 500 MHz)
7
6
5
4
3
2
1
0 ppm


yu-1-111
Pulse Sequence: s2pul
TBSO
H
H
O
22 (CDCl3, 125 MHz)
220
200
180
160
140
120
100
80
60
40
20
0
ppm

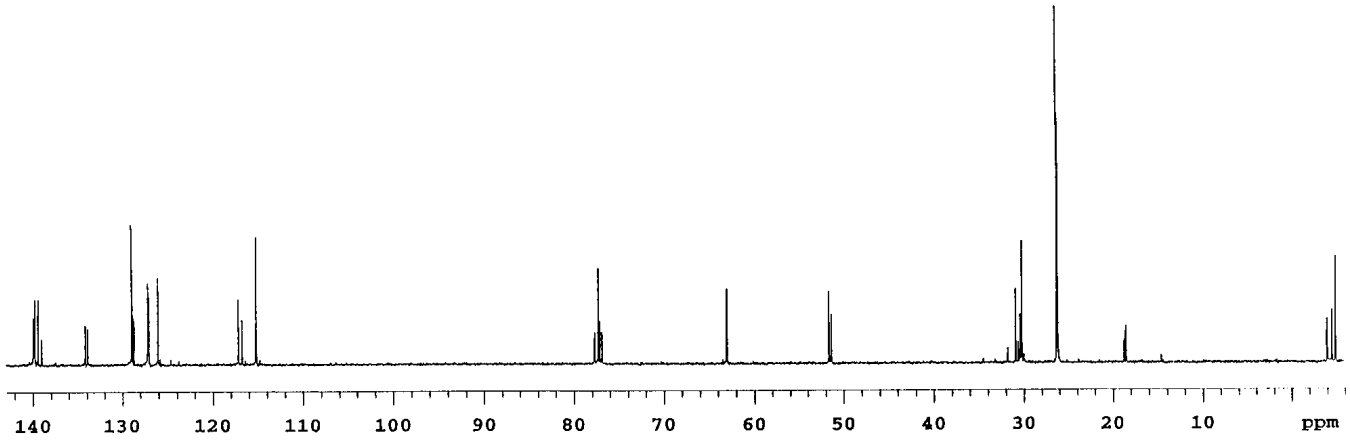

EtO2C
EtO2C
OTBS
23 (CDCl3, 500 MHz)
8
7
6
5
4
3
2
1
0 ppm

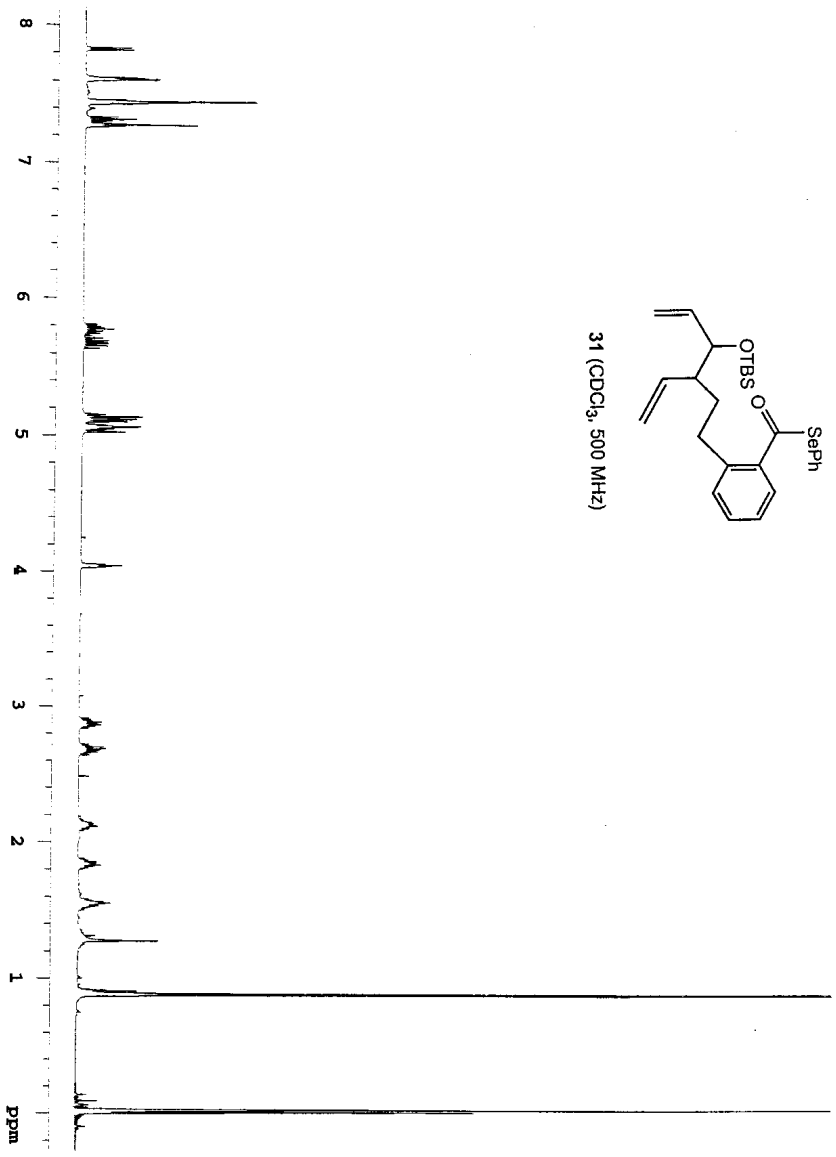

EtO2C
EtO2C
OTBS
23 (CDCl3, 75 MHz)
160
140
120
100
80
60
40
20
ppm

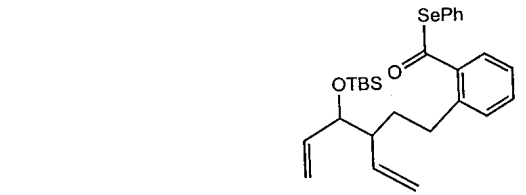

OTBS
OTBS
29 ($CDCl_3$, 300 MHz)
7
6
5
4
3
2
1
0 ppm



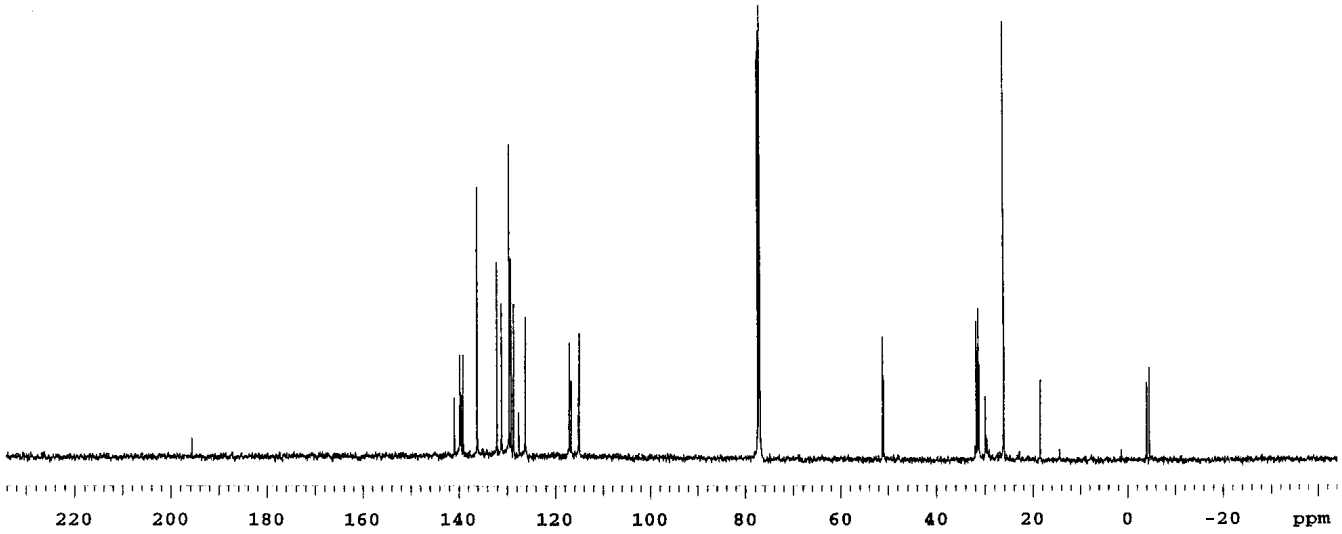
29 ($CDCl_3$, 75 MHz)

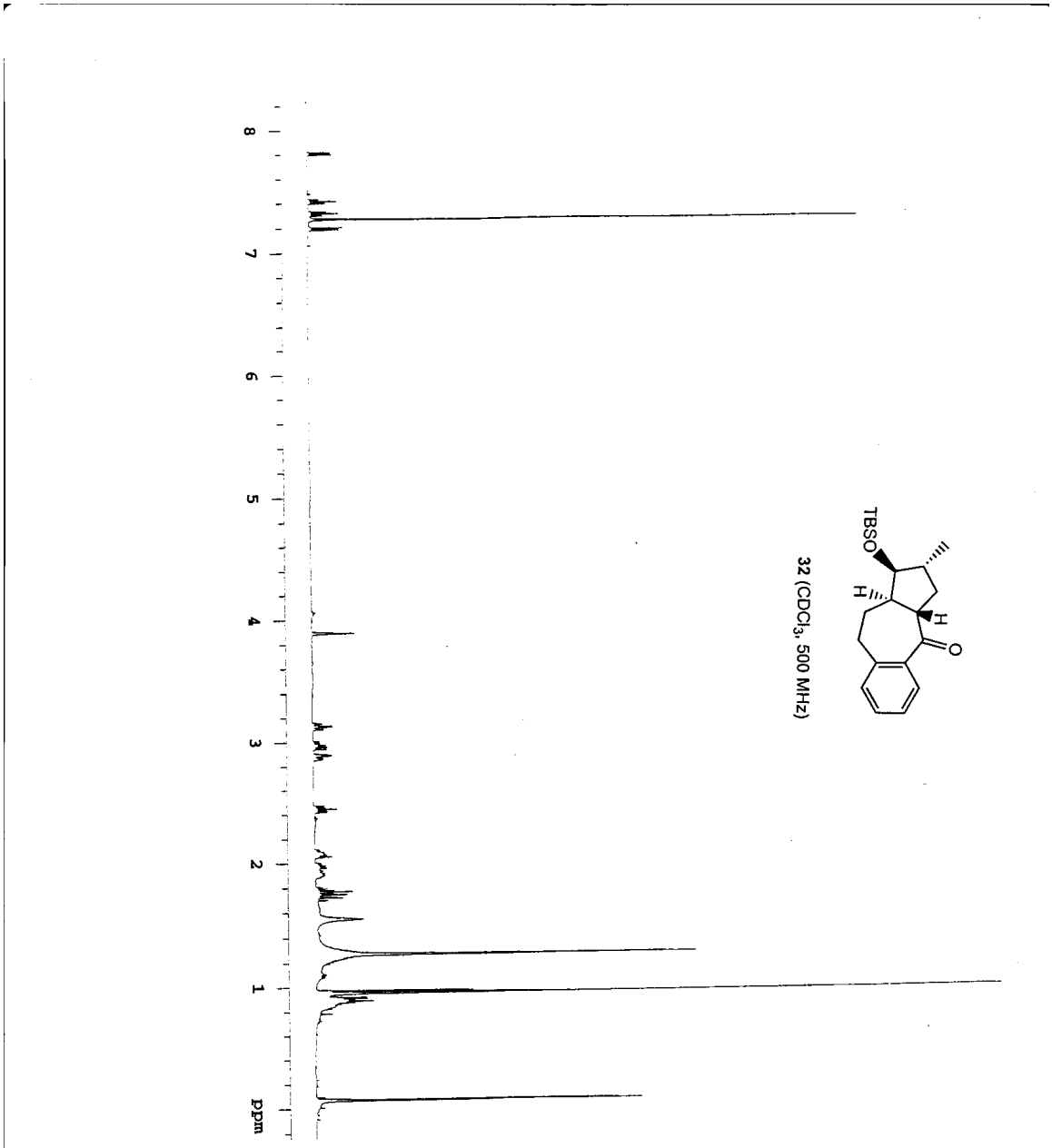


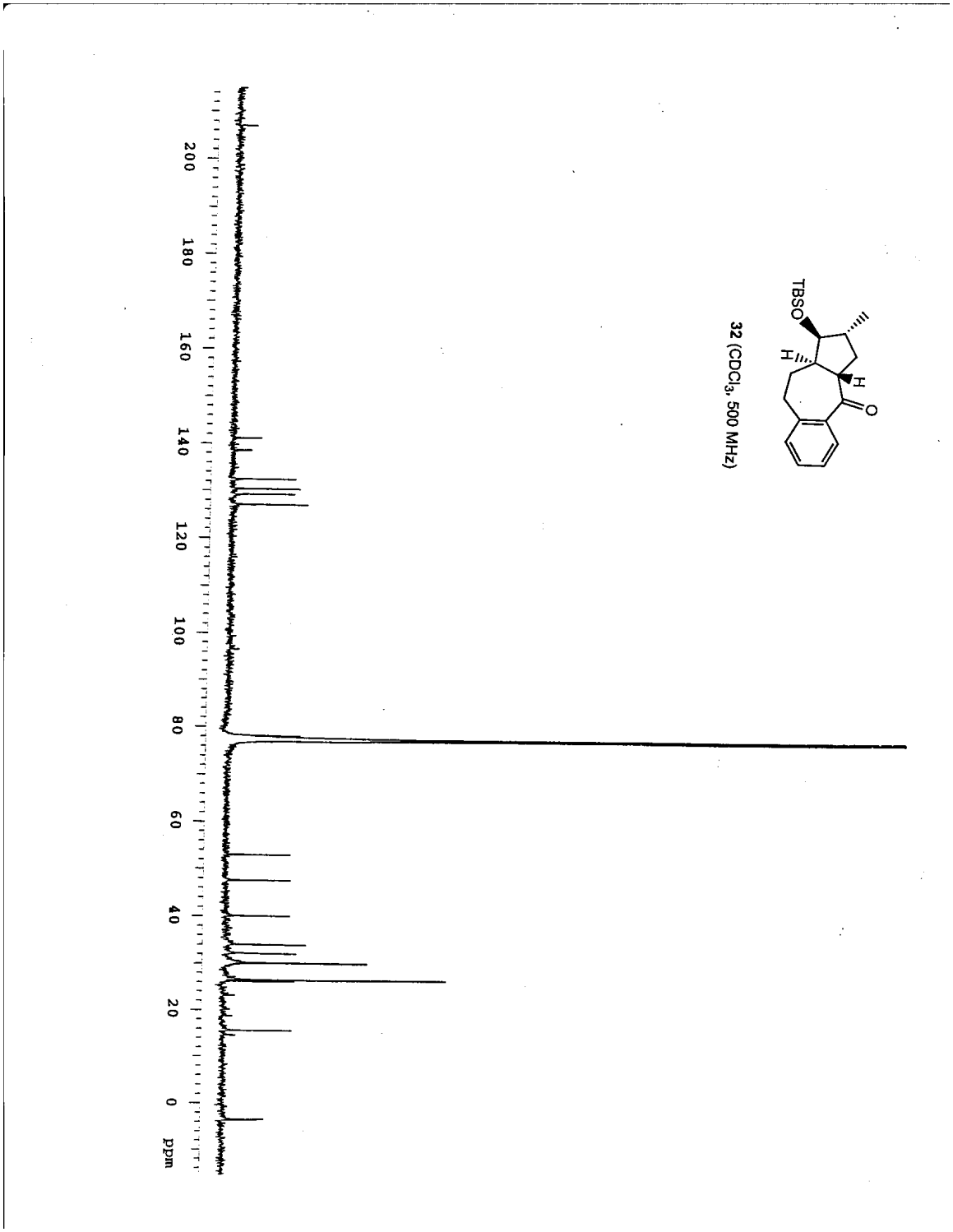

OTBS
O
SePh
31 (CDCl3, 500 MHz)
8
7
6
5
4
3
2
1
ppm

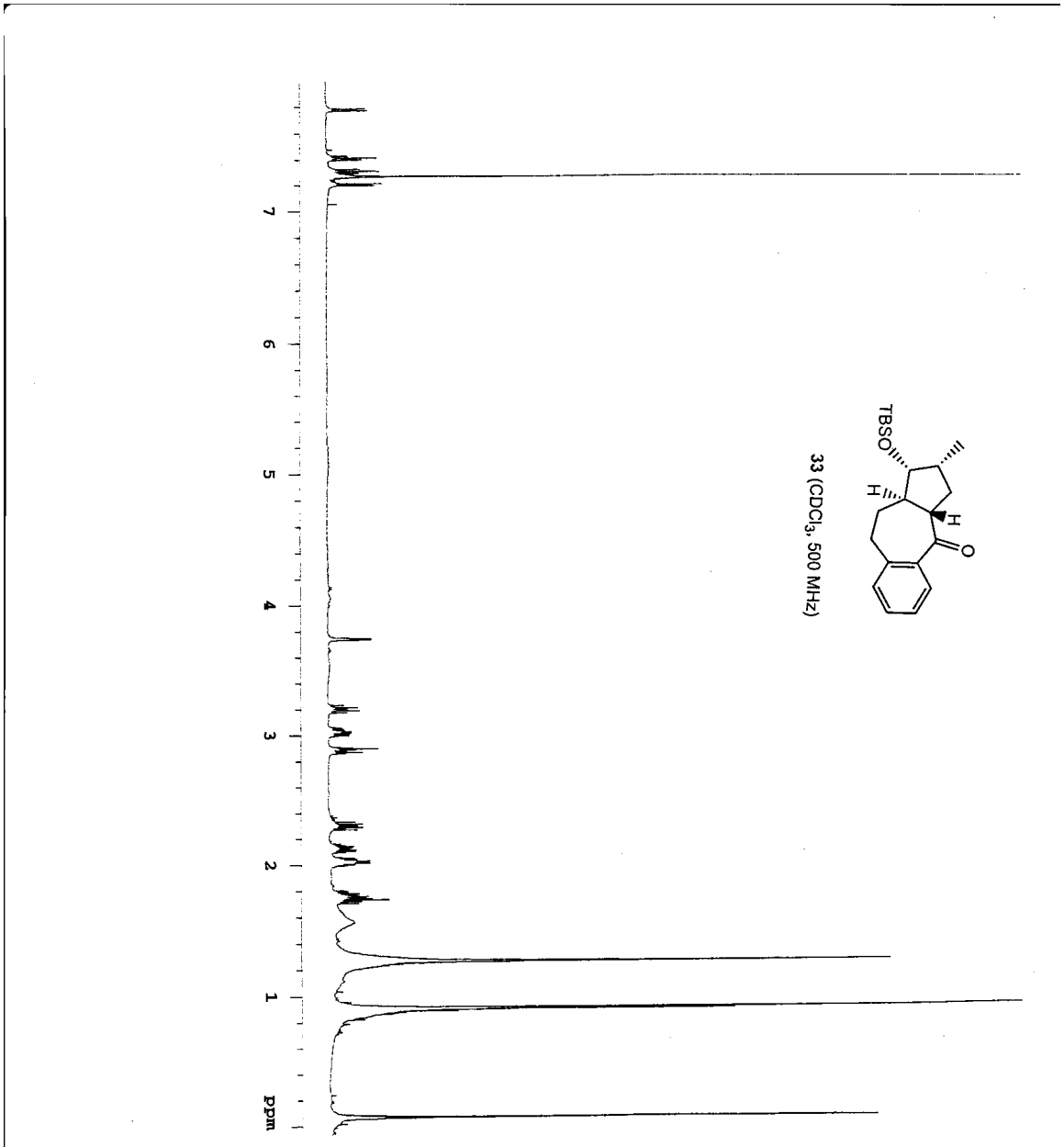


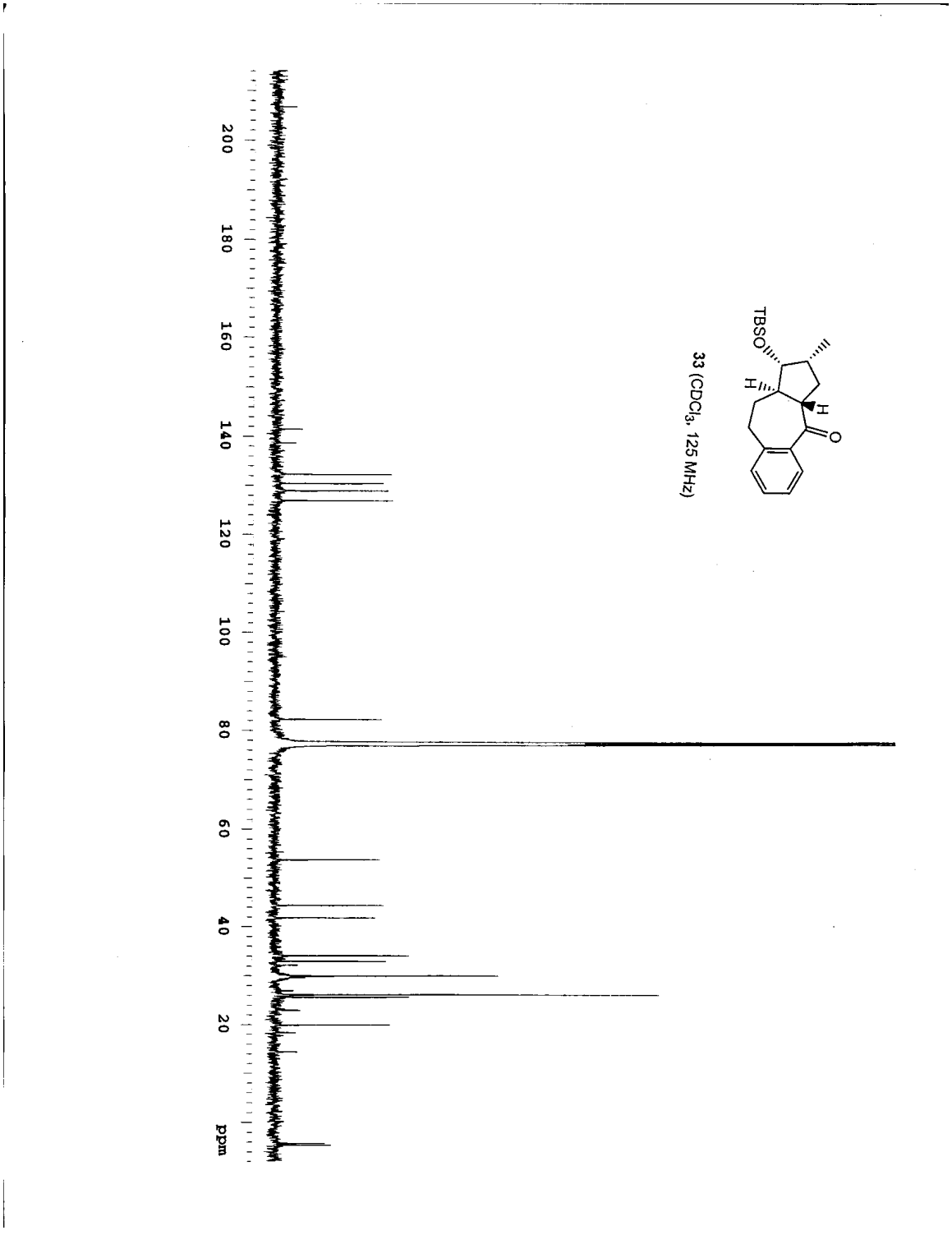
31 ($CDCl_3$, 125 MHz)




TBSO
H
H
O
32 (CDCl3, 500 MHz)
8
7
6
5
4
3
2
1
ppm


TBSO
H
H
O
32 (CDCl3, 500 MHz)
200
180
160
140
120
100
80
60
40
20
0
ppm


TBSO
H
H
O
33 (CDCl3, 500 MHz)
7
6
5
4
3
2
1
ppm


TBSO
H
H
O
33 ($CDCl_3$, 125 MHz)
200
180
160
140
120
100
80
60
40
20
ppm