The first stereoselective total synthesis of the *Z*-isomer of (6*S*,7*R*,9*R*)-6,7-dihydroxy-9-propylnon-4-eno-9-lactone

Palakodety Radha Krishna,[a]* Sunchu Prabhakar[a] and Kallaganti V. S. Rama Krishna[b]

Organic & Biomolecular Chemistry Division, CSIR-Indian Institute of Chemical Technology, Hyderabad-500 007, India

E-mail: prkgenius@iict.res.in

Experimental

Materials and Instrumentations

^{1}H NMR and ^{13}C NMR (Avance 300, Innova 400 MHz and Innova 500 MHz) spectra were recorded in $CDCl_3$. Chemical shifts (δ) were reported in ppm, and spin-spin coupling constants (*J*) in Hz and signal patterns are indicated as follows: s, singlet; d, doublet; dd, doublet of doublet; td, triplet of doublet; quin, quintet; t, triplet; m, multiplet; br. s, broad singlet. Melting points were determined on a Fischer-Johns melting point apparatus. MS were recorded on a Thermo Nicolet Nexus 670 FT-IR spectrometer and Finnegan MAT 1020 mass spectrometer operating at 70 eV. Optical rotations were measured at 25 °C.

Synthesis

((2*S*,3*S*)-3-((*R*)-2-(4-Methoxybenzyloxy)pentyl)oxiran-2-yl)methanol (7).

In a dry two neck round bottom flask, 4Å molecular sieves powder (1 g) was placed and evacuated with flame under argon. Dry CH_2Cl_2 (5 mL) was injected into the round bottom flask. The solution was allowed to cool to -20 °C, then $Ti(O^iPr)_4$ (0.13 mL, 0.45 mmol) and (+)-DIPT (0.19 mL, 0.896 mmol) were added sequentially. After stirring for 5 min, TBHP (1.22 mL, 6.71 mmol) was added drop wise for 15 min. After stirring for 30 min at -20 °C, a solution of allylic alcohol **8** (1.18 g, 4.48 mmol) in dry CH_2Cl_2 (2 mL) was added to the reaction mixture and stirred for 8 h at the same temperature, then warmed up to 0 °C and quenched with an aq. basic solution (3 M NaOH: brine 3:7, 6.0 mL). After stirring for 1 h, the reaction mixture was filtered through a pad of celite and the pad was further washed with CH_2Cl_2 (2 x 50 mL) The filtrate was concentrated and the residue was purified by column chromatography (Silica gel, 60-120 mesh, EtOAc:*n*-hexane, 15:85) to result in chiral epoxy alcohol **7** (1.14 g, 91%) as colorless liquid. $[\alpha]_D^{25}$ -19.12 *(c* 0.24, $CHCl_3$); ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.27 (d, *J* = 8.4 Hz, 2H), 6.88 (d, *J*

= 8.4 Hz, 2H), 4.54-4.43 (m, 2H), 3.88 (dd, *J* = 12.4, 2.6 Hz, 1H), 3.80 (br. s, 3H), 3.66-3.52 (m, 2H), 3.13-3.04 (m, 1H), 2.97-2.89 (m, 1H), 2.12-1.55 (m, 3H), 1.55-1.22 (m,3H), 0.92 (t, *J* = 7.3 Hz, 3H); ^{13}C NMR (75 MHz, $CDCl_3$): δ 159.0, 130.6, 129.2(2), 113.7(2), 76.2, 70.9, 61.6, 58.9, 55.2, 53.5, 36.6, 36.5, 18.3, 14.1; HRMS: *m/z* calcd for $C_{16}H_{24}O_4Na$ $[M+Na]^+$: 303.1566; found: 303.1551.

(2*S*,3*R*,5*R*)-1,2-Dihydroxy-5-(4-methoxybenzyloxy)octan-3-yl benzoate (6).

To a stirred solution of epoxy alcohol **7** (1.09 g, 3.9 mmol) in dry CH_2Cl_2 (15 mL) was added $Ti(O^iPr)_4$ (1.7 mL, 5.85 mmol) under argon at 0 ^oC. The mixture was stirred for 15 min, benzoic acid (0.71 g, 5.85 mmol) was added at the same temperature, then the mixture was allowed to warm to room temperature and allowed to stir for 2 h. The CH_2Cl_2 was evaporated under reduced pressure, the mixture was diluted with diethyl ether (30 mL) and 3% H_2SO_4 (5 mL) was added, and the mixture was allowed to stir until two clear layers were obtained (1 h). The two layers were separated. The organic layer was washed with a sat. aq. $NaHCO_3$ solution (30 mL), brine (20 mL) and, dried (Na_2SO_4), and concentrated in *vaccuo*. The residue was purified by column chromatography (Silica gel, 60-120 mesh, EtOAc: *n*-hexane, 3:7) to yield dihydroxy benzoate **6** (1.33 g, 85%) as pale yellow liquid. $[\alpha]_D^{25}$ -42.63 *(c* 0.31, $CHCl_3$); ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.98 (d, *J* = 6.9 Hz, 2H), 7.59 (t, *J* = 7.3 Hz, 1H), 7.45 (t, *J* = 7.7 Hz, 2H), 7.24 (d, *J* = 8.4 Hz, 2H), 6.85 (d, *J* = 8.4 Hz, 2H), 5.21-5.11 (m, 1H), 4.57-4.37 (m, 2H), 3.80 (br. s, 3H), 3.76-3.63 (m, 3H), 3.62-3.52 (m, 1H), 2.14-2.06 (m, 2H), 1.70-1.54 (m, 3H), 1.43-1.28 (m, 3H), 0.88 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (75 MHz, $CDCl_3$): δ 166.2, 159.3, 133.2, 129.7(4), 128.4(4), 113.8(2), 74.9, 72.3, 72.1, 70.3, 63.1, 55.2, 35.3, 34.8, 18.0, 14.1; HRMS: *m/z* calcd for $C_{23}H_{30}O_6Na$ $[M+Na]^+$: 425.1934; found: 425.1901**.**

(2*S*,3*R*,5*R*)-1-(*tert*-Butyldimethylsilyloxy)-2-hydroxy-5-(4-methoxybenzyloxy)octan-3-yl benzoate (9).

To a stirred solution of dihydroxy benzoate **6** (1.29 g, 3.21 mmol) in dry CH_2Cl_2 (10 mL) at 0 ºC dibutyl tin oxide (cat) was added and stirred for it 10 min then imidazole (0.65 g, 9.64 mmol) was added at the same temperature and stirred for about 30 min, then *tert*-butyldimethyl silylchloride (0.53 g, 3.53 mmol) was added and stirred for 0.5 h. The reaction mixture was diluted with CH_2Cl_2 (10 mL) and washed with water (20 mL), and brine (15 mL), dried (Na_2SO_4) and concentrated in *vaccuo*. The crude residue purified by column chromatography (Silica gel, 60-120 mesh, EtOAc: *n*-hexane, 1:9) to afford **9** (1.38 g, 83%) as a pale yellow

liquid. $[\alpha]_D^{25}$ -26.54 *(c* 0.38, $CHCl_3$); ^1H NMR (300 MHz, $CDCl_3$): δ 8.00 (d, *J* = 7.5 Hz, 2H), 7.57 (t, *J* = 7.5 Hz, 1H), 7.45 (d, *J* = 7.7 Hz, 2H), 7.20 (d, *J* = 8.4 Hz, 2H), 6.79 (d, *J* = 8.4 Hz, 2H), 5.29-5.20 (m, 1H), 4.43 (br. s, 2H), 3.91-3.82 (m, 1H), 3.77 (br. s, 3H), 3.76-3.55 (m, 3H), 3.06 (br. s, 1H), 2.21-2.09 (m, 1H), 2.07-1.92 (m, 2H), 1.44-1.25 (m, 2H), 0.88 (br. s, 9H), 0.93-0.82 (m, 3H), 0.03 (br. s, 3H), 0.00 (br. s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$): δ 165.8, 159.0, 132.9, 130.3, 130.1, 129.6(2), 129.5(2), 128.3(2), 113.6(2), 75.0, 72.7, 72.5, 70.1, 63.7, 55.2, 35.7, 35.2, 34.4, 25.8(3), 18.1, 14.1, -5.4(2); HRMS: *m/z* calcd for $C_{29}H_{44}O_6NaSi$ $[M+Na]^+$: 539.2799; found: 539.2765.

(2*S*,3*R*,5*R*)-1-(*tert*-Butyldimethylsilyloxy)-5-(4-methoxybenzyloxy)octane-2,3-diol (10).

To stirred solution of **9** (1.33 g, 2.58 mmol) in MeOH (6 mL) was added potassium carbonate solid (0.71 g, 5.16 mmol) at 0 ^oC and allowed it to stir at room temperature. After stirring for 1h, solvent MeOH was removed under reduced pressure. The crude residue was washed with water (10 mL) and extracted with EtOAc (2 x 15 mL). The organic layer was dried (Na_2SO_4), concentrated and purified by column chromatography (Silica gel, 60-120 mesh, EtOAc:*n*-hexane 15:85) to obtain diol **10** (0.94 g, 88%) as a pale yellow liquid. $[\alpha]_D^{25}$ -34.81*(c* 0.35, $CHCl_3$); ^1H NMR (500 MHz, $CDCl_3$): δ 7.25 (d, *J* = 8.5 Hz, 2H), 6.87 (d, *J* = 8.6 Hz, 2H), 4.45-4.35 (m, 2H), 3.87 (br. s, 1H), 3.80 (br. s, 3H), 3.79-3.69 (m, 2H), 3.53-3.42 (m, 1H), 2.77 (dd, *J* = 18.0, 3.9 Hz, 1H), 2.34-2.16 (m, 1H), 1.92 (td, *J* = 14.8, 2.7 Hz, 1H), 1.77 (t, *J* = 6.1 Hz, 1H), 1.73-1.47 (m, 2H), 1.45-1.32 (m, 1H), 0.94 (t, *J* = 7.3 Hz, 3H), 0.90 (br. s, 9H), 0.08 (br. s, 6H); ^{13}C NMR (125 MHz, $CDCl_3$): δ 159.2, 129.5(2), 129.4, 113.9, 113.8, 79.2, 73.6, 73.5, 72.7, 70.2, 64.1, 55.2, 36.9, 35.8, 29.6, 25.8, 18.5, 18.1, 17.8, 14.3, -5.4; HRMS: *m/z* calcd for $C_{22}H_{40}O_5SiNa$ $[M+Na]^+$: 435.2537; found: 435.2510.

***tert*-Butyl(((4*R*,5*R*)-5-((*R*)-2-(4-methoxybenzyloxy)pentyl)-2,2-dimethyl-1,3-dioxolan-4-yl)methoxy)dimethylsilane (11).**

To a stirred solution of diol **10** (0.89 g, 2.15 mmol) in dry CH_2Cl_2 (2 mL) at 0 °C PPTS (cat.) was added and the solution stirred for 20 min, and then 2,2-DMP (0.3 mL, 2.57 mmol) was added and the solution stirred for additional 1 h. The reaction mixture was quenched with Et_3N (0.5 mL) and concentrated in *vaccuo*. The crude residue was purified by column chromatography (Silica gel, 60-120 mesh, EtOAc:*n*-hexane, 2:98) to afford **11** (0.92 g, 95%) as a colorless liquid.

$[\alpha]_D^{25}$ -290.10(*c* 0.33, $CHCl_3$); ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.27 (d, *J* = 8.0 Hz, 2H), 6.86 (d, *J* = 8.5 Hz, 2H), 4.45 (br. s, 2H), 4.25 (quin, *J* = 9.9, 4.8 Hz, 1H), 4.07-3.99 (m, 1H), 3.80 (br. s, 3H), 3.69-3.62 (m, 1H), 3.62-3.53 (m, 2H), 1.95-1.88 (m, 1H), 1.81-1.74 (m, 1H), 1.62-1.44 (m, 2H), 1.41 (br. s, 3H), 1.33 (br. s, 3H), 0.95-0.86 (m, 5H), 0.89 (br. s, 9H), 0.06 (br. s, 6H); ^{13}C NMR (125 MHz, $CDCl_3$): δ 159.0, 131.1, 131.0, 129.3, 113.7, 113.6, 107.6, 77.8, 76.0, 74.4, 70.4, 61.9, 55.2, 36.0, 33.2, 28.2, 25.8(3), 25.5(2), 18.2, 14.2, -5.4, -5.3; HRMS: *m/z* calcd for $C_{25}H_{44}O_5SiNa$ $[M+Na]^+$: 475.2850; found: 475.2830.

((4*R*,5*R*)-5-((*R*)-2-(4-Methoxybenzyloxy)pentyl)-2,2-dimethyl-1,3-dioxolan-4-yl)methanol (12)

To a stirred solution of compound **11** (0.88 g, 1.95 mmol) in anhydrous THF was added 5 mL of TBAF (0.77 g, 2.93 mmol, 1.0 M solution in THF) at 0 ^{o}C and reaction mixture stirred at room temperature for 1 h then the solvent was concentrated in *vaccuo*. The crude residue was purified by column chromatography (Silica gel, 60-120, EtOAc:*n*-hexane, 2:8) to afforded primary alcohol **12** (0.59 g) in 89% yield as a pale yellow oil. $[\alpha]_D^{25}$ -19.76 *(c* 0.28, $CHCl_3$); ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.26 (d, *J* = 8.4 Hz, 2H), 6.88 (d, *J* = 8.4 Hz, 2H), 4.59-4.24 (m, 3H), 4.15-4.01 (m, 1H), 3.80 (br. s, 3H), 3.65-3.45 (m, 3H), 2.07-1.86 (m, 2H), 1.78-1.50 (m, 4H), 1.47 (br. s, 3H), 1.35 (br. s, 35), 0.92 (t, *J* = 7.3 Hz, 3H); ^{13}C NMR (125 MHz, $CDCl_3$): δ 159.1, 130.6, 129.2(2), 113.7(2), 107.9, 77.8, 75.7, 73.6, 70.4, 61.6, 55.2, 35.7, 32.9, 28.2, 25.4, 18.4, 14.1; HRMS: *m/z* calcd for $C_{19}H_{30}O_5Na$ $[M+Na]^+$: 361.1985; found: 361.1969.

(4*R*,5*R*)-4-((*R*)-2-(4-Methoxybenzyloxy) pentyl)-2,2-dimethyl-5-vinyl-1,3-dioxolane (13)

To a solution of oxalyl chloride (0.3 mL, 3.35 mmol) in dry CH_2Cl_2 (3 mL) at -78 ^{0}C, dry DMSO (0.5 mL, 6.70 mmol) was added drop wise and stirred for 10 min. A solution of alcohol **12** (0.57 g, 1.68 mmol) in dry CH_2Cl_2 (1 mL) was added and stirred for 1 h at -78 ^{0}C. It was quenched with Et_3N (1.87 mL, 13.43 mmol) and diluted with CH_2Cl_2 (10 mL). The reaction mixture was washed with water (10 mL), brine (5 mL), dried (Na_2SO_4) and evaporated to furnish the corresponding aldehyde.

The Wittig salt (2.15 g, 5.07 mmol) and the KO^{t}Bu (0.47 g, 4.23 mmol) dissolved in dry THF (10 mL) was stirred at -10 ^{o}C for 4 h, then the aldehyde (0.57 g, 1.69 mmol) was dissolved in dry

THF (3 mL) was added at the same temperature add the mixture allows to stir for 1 h. Then the reaction mixture was quenched with sat. aq. NH_4Cl solution (2 mL) and extracted with EtOAc (2 x 10 mL). The combined organic layers were washed with water (10 mL), brine (5 mL), dried (Na_2SO_4) and evaporated. The crude product was purified by column chromatography (Silica gel 60-120 mesh, EtOAc:*n*-hexane, 4:96) to afford **13** (0.44 g, 78%, over two steps) as a pale yellow oil. $[\alpha]_D^{25}$ -36.04 *(c* 0.22, $CHCl_3$); ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.27 (d, *J* = 8.4 Hz, 2H), 6.87 (d, *J* = 8.6 Hz, 2H), 5.85-5.70 (m, 1H), 5.31-5.15 (m, 2H), 4.56-4.21 (m, 5H), 3.80 (br. s, 3H), 3.47 (quin, *J* = 11.8, 6.0 Hz, 1H), 1.91-1.78 (m, 1H), 1.62-1.50 (m, 3H), 1.48 (br. s, 3H), 1.43-1.32 (m, 1H), 1.35 (br. s, 3H), 0.90 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (125 MHz, $CDCl_3$): δ 159.1, 134.4, 130.8, 129.3(2), 118.4, 113.7(2), 108.0, 79.8, 75.3, 74.9, 70.2, 55.2, 35.9, 34.5, 28.2, 25.6, 18.3, 14.2; HRMS: *m/z* calcd for $C_{20}H_{30}O_4Na$ $[M+Na]^+$: 357.2036; found: 357.2021.

(*R*)-1-((4*R*,5*R*)-2,2-Dimethyl-5-vinyl-1,3-dioxolan-4-yl)pentan-2-ol (4).

To a stirred solution of **13** (0.41 g, 1.24 mmol) in CH_2Cl_2:H_2O (19:1, 2 mL) at 0 ºC, DDQ (0.31 g, 1.36 mmol) was added and stirred for about 0.5 h. The reaction mixture was quenched with sat. aq. $NaHCO_3$ (1 mL) and filtered through celite pad with CH_2Cl_2 (2 x 20 mL) and washed with brine (5 mL), dried (Na_2SO_4) and concentrated in *vaccuo*. The crude residue was purified by column chromatography (Silica gel, 60-120 mesh, EtOAc:*n*-hexane, 1:9) to furnish **4** (0.22 g, 83%) as a pale yellow liquid. $[\alpha]_D^{25}$ -46.20 *(c* 0.21, $CHCl_3$); ^{1}H NMR (500 MHz, $CDCl_3$): δ 5.84-5.75 (m, 1H), 5.32 (td, *J* = 17.0, 1.3 Hz, 1H), 5.26 (qd, *J* = 10.2, 1.5, 0.9 Hz, 1H), 4.58-4.54 (m, 1H), 4.39-4.34 (m, 1H), 3.85-3.78 (m, 1H), 3.19 (br. s, 1H), 1.69 (br. s, 1H), 1.60-1.46 (m, 3H), 1.51 (br. s, 3H), 1.45-1.33 (m, 2H), 1.38 (br. s, 3H), 0.93 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (75 MHz, $CDCl_3$): δ 133.8, 118.6, 108.8, 79.8, 78.4, 71.1, 39.6, 37.2, 28.0, 25.5, 18.5, 14.0; HRMS: *m/z* calcd for $C_{12}H_{22}O_3Na$ $[M+Na]^+$: 237.1460; found: 237.1452.

(*R*)-1-((4*R*,5*R*)-2,2-Dimethyl-5-vinyl-1,3-dioxolan-4-yl)pentan-2-yl pent-4-enoate (3).

To a stirred solution of **4** (0.19 g, 0.89 mmol) in dry CH_2Cl_2 (1.0 mL) were added DCC (0.37 g, 1.78 mmol) and DMAP (0.22 g, 1.78 mmol) followed by **5** (0.1 mL, 1.32 mmol) in dry CH_2Cl_2 (1.0 mL) at 0 ^{o}C and allowed to stir at room temperature for 12 h. The solvent was evaporated off and the residue adsorbed on to the silica and purified by column chromatography (Silica gel, 60-120 mesh, EtOAc:*n*-hexane, 2:98) to give **3** (0.22g, 82%) as a colorless liquid. $[\alpha]_D^{25}$ -11.2 *(c*

0.31, $CHCl_3$); ^{1}H NMR (300 MHz, $CDCl_3$): δ 5.92-5.71 (m, 2H), 5.38-5.21 (m, 2H), 5.12-4.96 (m, 3h), 4.50 (t, *J* = 6.6 Hz, 1H), 4.24-4.14 (m, 1H), 2.46-2.23 (m, 5H), 1.86-1.73 (m, 1H), 1.68-1.44 (m, 2H), 1.48 (br. s, 3H), 1.42-1.21 (m, 2H), 1.34 (br. s, 3H), 0.90 (t, *J* = 7.3 Hz, 3H); ^{13}C NMR (75 MHz, $CDCl_3$): δ 172.7, 136.7, 134.1, 118.6, 115.3, 108.3, 79.7, 75.0, 71.3, 36.3, 33.7, 28.8, 28.1, 25.5, 18.3, 13.8; HRMS: *m/z* calcd for $C_{17}H_{28}O_4Na$ $[M+Na]^+$: 319.1879; found: 319.1866.

(3a*R*,5*R*,11a*S*,*Z*)-2,2-Dimethyl-5-propyl-4,5,8,9-tetrahydro-3aH-[1,3]dioxolo[4,5-d]oxecin-7(11aH)-one (14)

A solution of bis-olefin **3** (0.06 g, 0.18 mmol) and Grubbs second generation catalyst (0.02 g, 10 mol%) in CH_2Cl_2 (6 mL) was stirred at reflux temperature for 2 h. Later, solvent was removed under reduced pressure and the crude residue purified by column chromatography (Silica gel, 60-120 mesh, EtOAc: *n*-hexane, 4:96) to afford cyclized product **14** (0.041 g, 75%) as a pale yellow oil. $[\alpha]_D^{25}$ -24.62 *(c* 0.41, $CHCl_3$); ^{1}H NMR (300 MHz, $CDCl_3$): δ 5.53 (dt, *J* = 11.1, 4.9 Hz, 1H), 5.41 (t, *J* = 10.7 Hz, 1H), 5.15-5.05 (m, 1H), 4.99-4.91 (m, 1H), 4.34 (qd, *J* = 11.7, 5.4, 2.6 Hz, 1H), 2.74-2.48 (m, 2H), 2.29-2.10 (m, 2H), 2.06-1.88 (m, 2H), 1.85-1.58 (m, 3H), 1.55-1.38 (m, 1H), 1.42 (br. s, 3H), 1.33 (br. s, 3H), 0.87 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (125 MHz, $CDCl_3$): δ 171.3, 129.5, 129.4, 107.2, 74.6, 74.0, 70.3, 34.0, 33.4, 31.5, 28.5, 26.1, 22.5, 19.3, 13.7; HRMS: *m/z* calcd for $C_{15}H_{24}O_4Na$ $[M+Na]^+$: 291.1566; found: 291.1543.

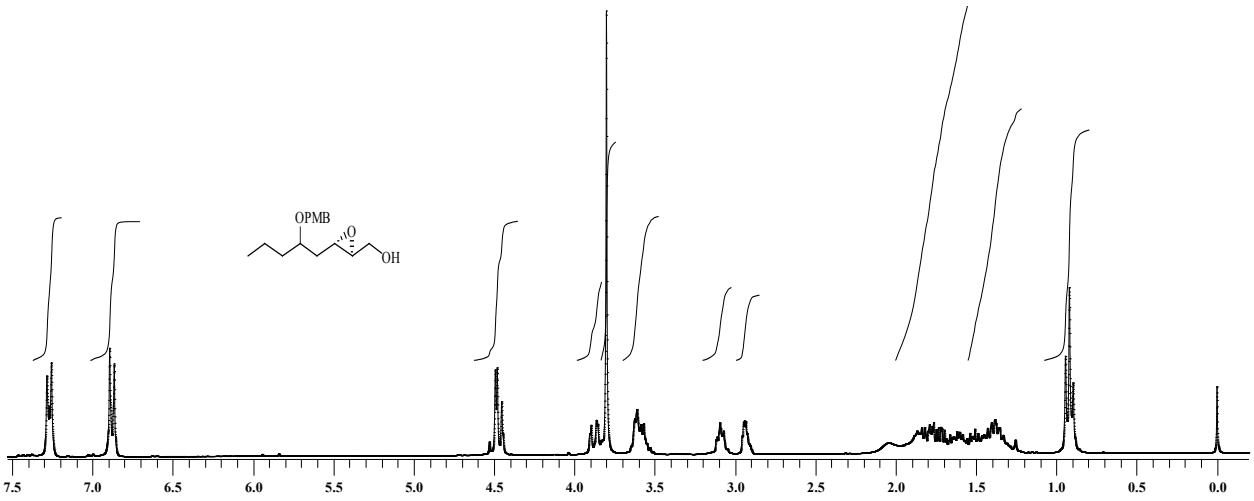
(4*R*,6*R*,7*S*)-6,7-Dihydroxynon-8-en-4-yl pent-4-enoate (15)

To a stirred solution of compound **3** (0.03 g, 0.14 mmol) in MeOH (1 mL) at 0 ^oC catalytic amount of PTSA was added. After 0.5 h the reaction mixture treated with Et_3N (0.2 mL). Solvent was evaporated in *vaccuo* and the residue was purified by column chromatography (Silica gel, 60-120 mesh, EtOAc:*n*-hexane, 12:88) to result **15** (0.02 g, 91%) as a yellow liquid. $[\alpha]_D^{25}$ +4.51 *(c* 0.36, $CHCl_3$); ^{1}H NMR (300 MHz, $CDCl_3$): δ 5.93-5.77 (m, 2H), 5.40-5.23 (m, 2H), 5.11-4.98 (m, 3H), 4.15-4.09 (m, 1H), 3.79-3.73 (m, 1H), 2.53-2.32 (m, 4H), 1.72 (t, *J* = 6.2 Hz, 1H), 1.67-1.49 (m, 2H), 1.47-1.23 (m, 3H), 0.91 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (125 MHz, $CDCl_3$): δ 173.2, 136.5, 135.9, 117.7, 115.5, 75.7, 72.6, 71.8, 36.6, 33.8, 29.6, 28.8, 18.4, 13.8; HRMS: *m/z* calcd for $C_{14}H_{24}O_4Na$ $[M+Na]^+$: 279.1668; found: 279.1627.

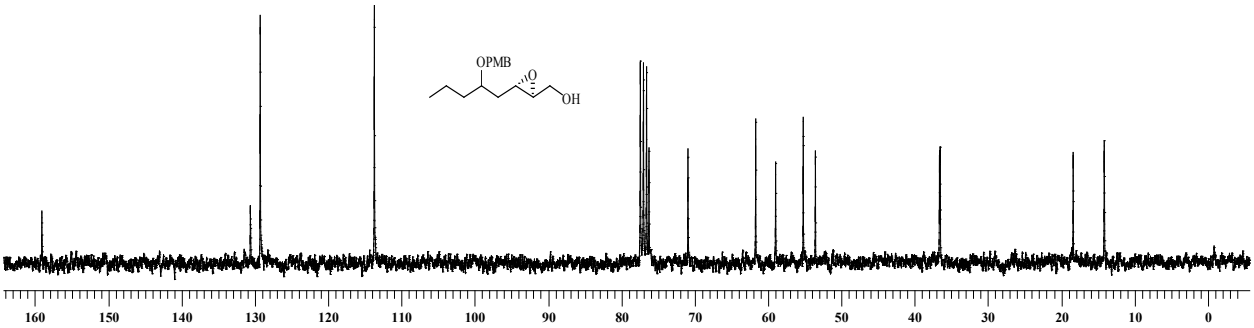
(7*S*,8*R*,10*R*,*Z*)-7,8-Dihydroxy-10-propyl-3,4,7,8,9,10-hexahydro-2H-oxecin-2-one (2)

To a stirred solution of compound **14** (0.033 g, 0.12 mmol) in MeOH (1 mL) at 0 ^{o}C catalytic amount of PTSA was added. After 0.5 h the reaction mixture treated with Et_3N (0.2 mL). Solvent was evaporated in *vaccuo* and the residue was purified by column chromatography (Silica gel, 60-120 mesh, EtOAc:*n*-hexane, 2:8) to result **2** (0.026 g, 93%) in white solid; m. p. 98-100 ^{o}C. $[\alpha]_D^{25}$ +8.30 *(c* 0.38, CH_3OH); ^{1}H NMR (500 MHz, $CDCl_3$): δ 5.73-5.64 (m, 2H), 5.02-4.95 (m, 1H), 4.80 (dd, *J* = 6.4, 2.4 Hz, 1H), 4.19 (td, *J* = 11.2, 3.5 Hz, 1H), 2.86-2.74 (m, 1H), 2.61 (qd, *J* = 14.9, 3.5, 1.3 Hz, 1H), 2.31-2.22 (m, 1H), 2.13-2.06 (m, 1H), 1.89-1.75 (m, 2H), 1.73-1.63 (m, 1H), 1.59-1.50 (m, 1H), 1.47-1.18 (m, 5H), 0.94 (t, *J* = 7.3 Hz, 3H); ^{13}C NMR (125 MHz, $CDCl_3$): δ 171.4, 130.7, 128.3, 71.3, 69.8, 68.3, 35.2, 33.7, 29.6, 23.2, 19.2, 13.6; HRMS: *m/z* calcd for $C_{12}H_{20}O_4Na$ $[M+Na]^+$: 251.1253; found: 251.1245.

Copies of ^{1}H and ^{13}C-NMR Specta:

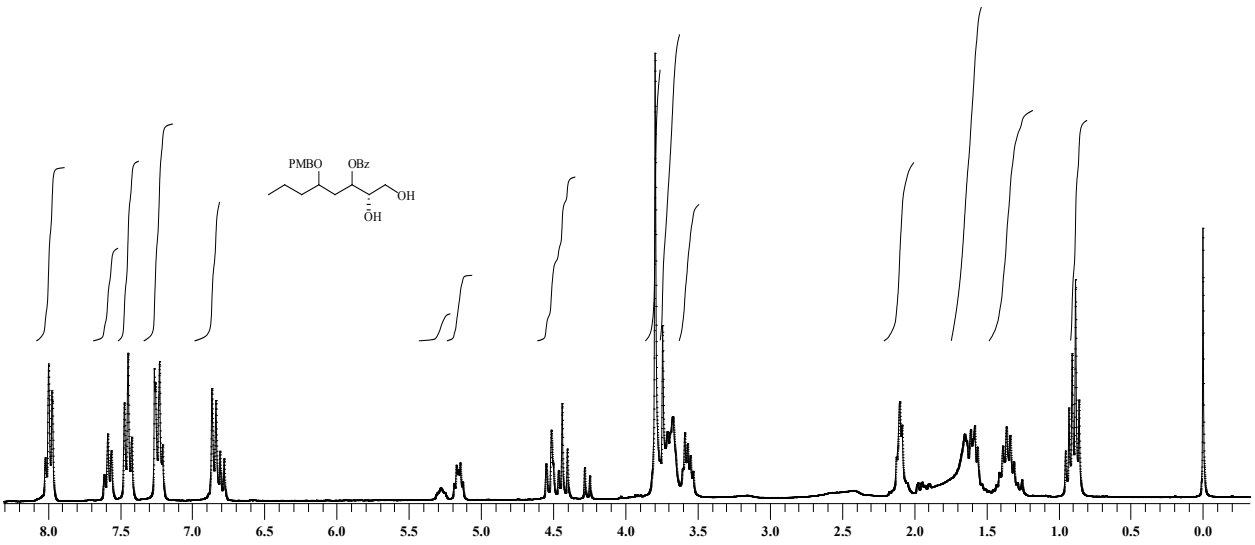


Spectrum 1: ^{1}H NMR Spectrum of compound **7** in $CDCl_3$ (300 MHz)

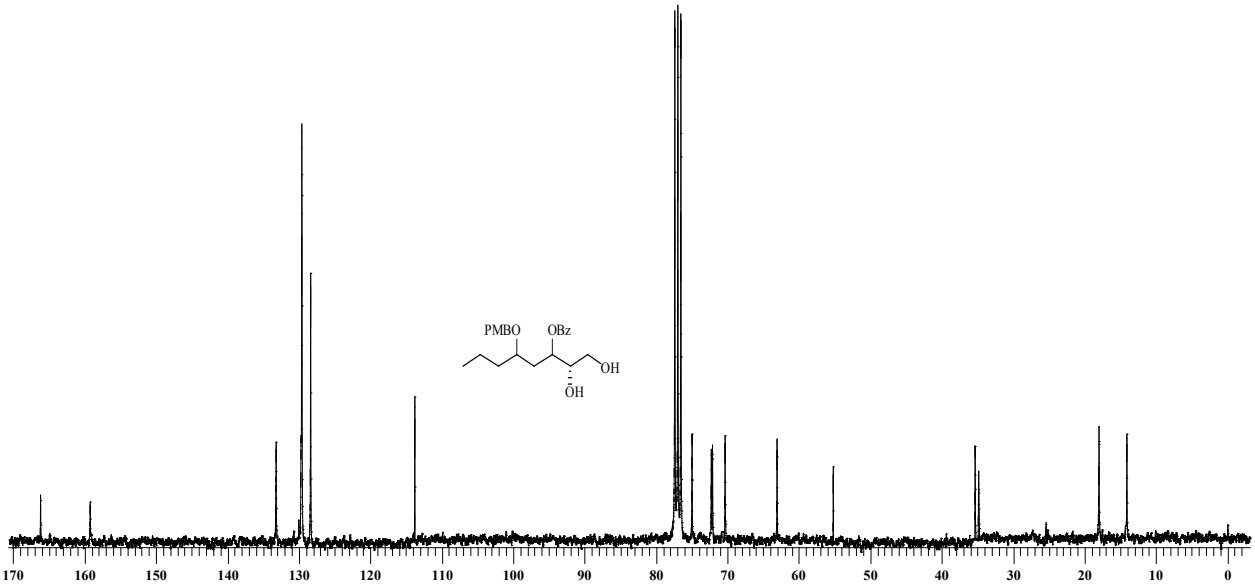


Spectrum 2: ^{13}C NMR Spectrum of compound **7** in $CDCl_3$ (75 MHz)

[Type text]



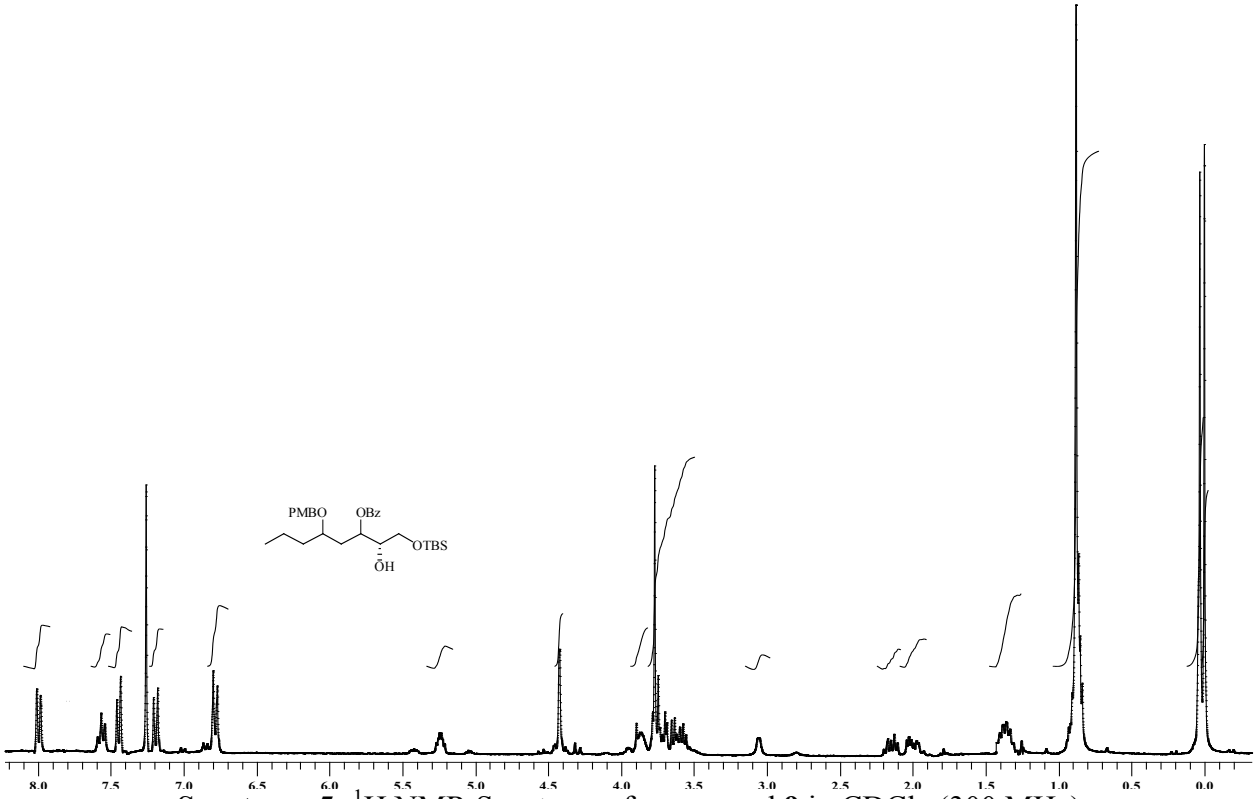
Spectrum 3: ^{1}H NMR Spectrum of compound **6** in $CDCl_3$ (500 MHz)



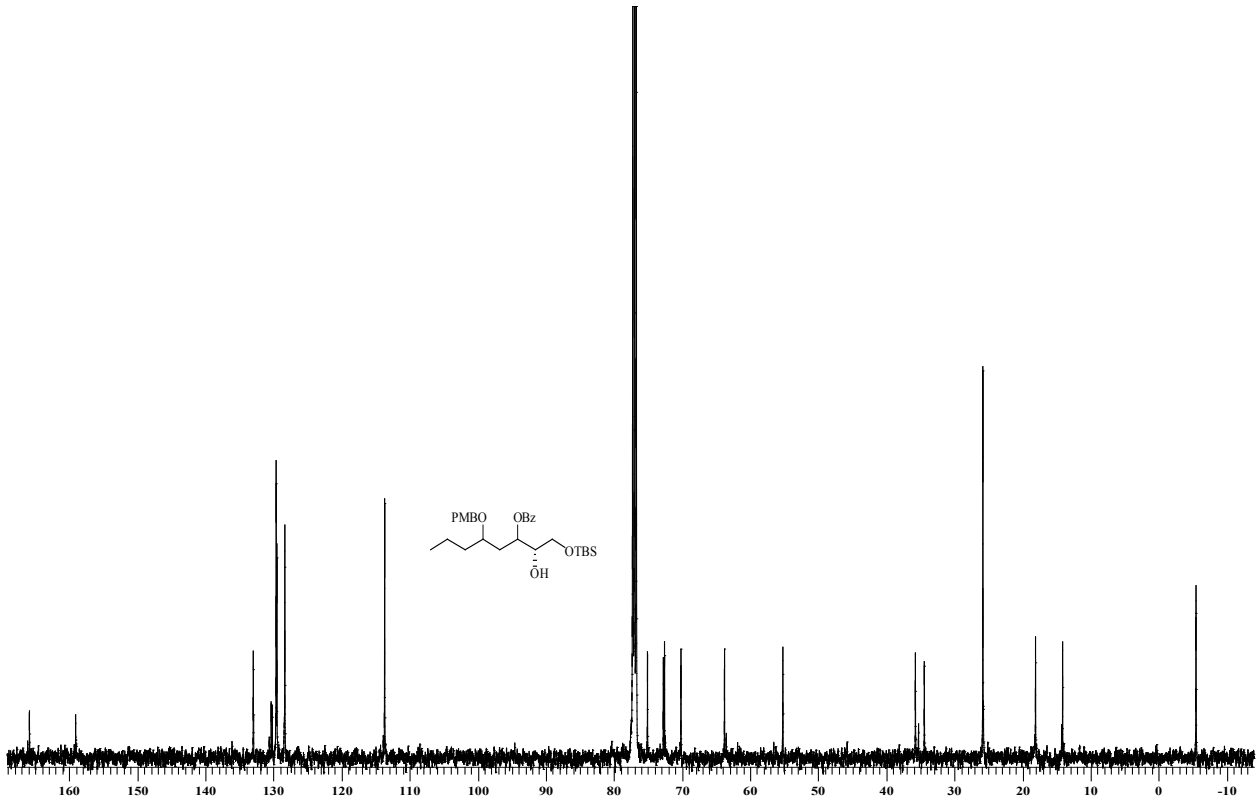
Spectrum 4: ^{13}C NMR Spectrum of compound **6** in $CDCl_3$ (75 MHz)

[Type text]

[Type text]

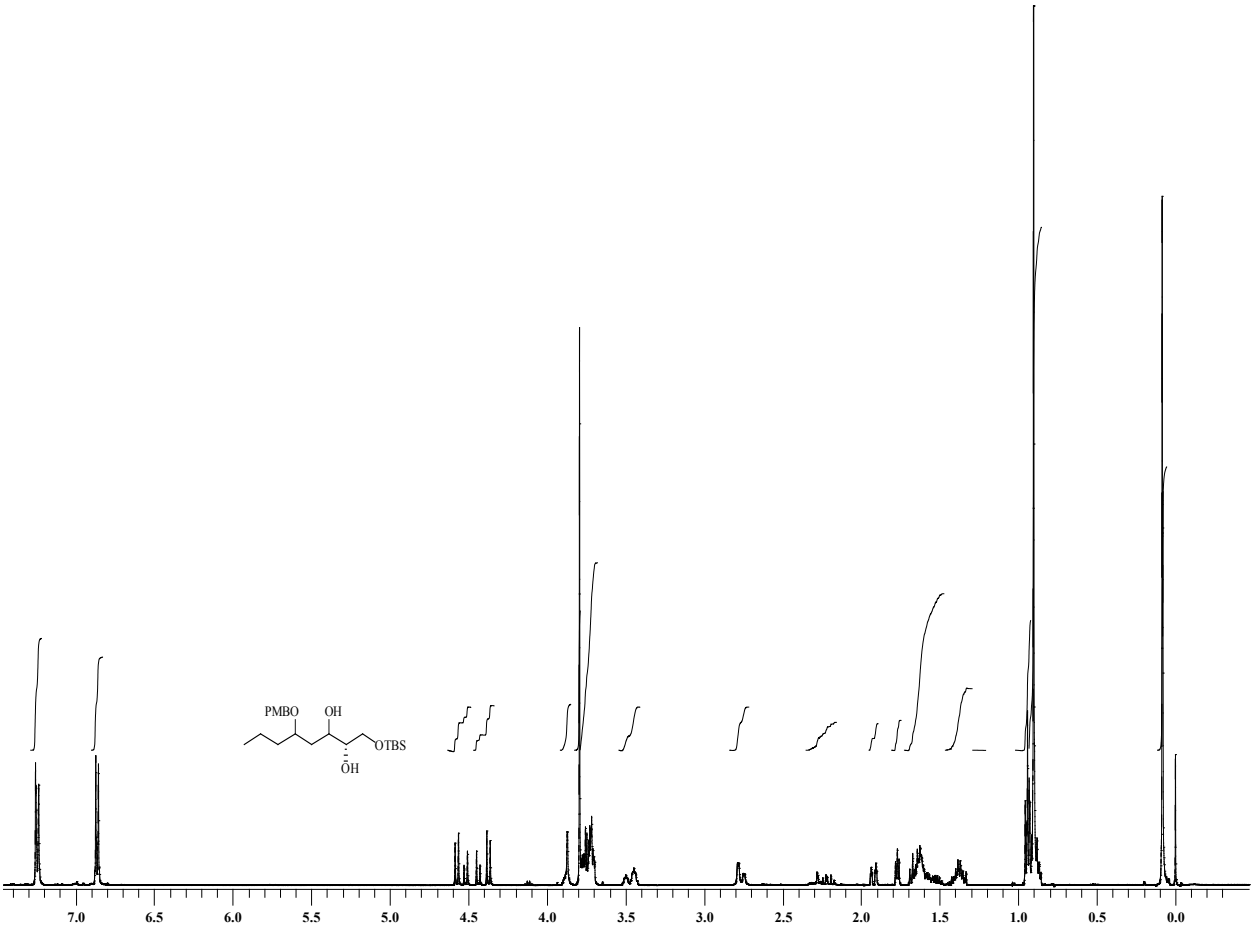


Spectrum 5: ^{1}H NMR Spectrum of compound **9** in $CDCl_3$ (300 MHz)

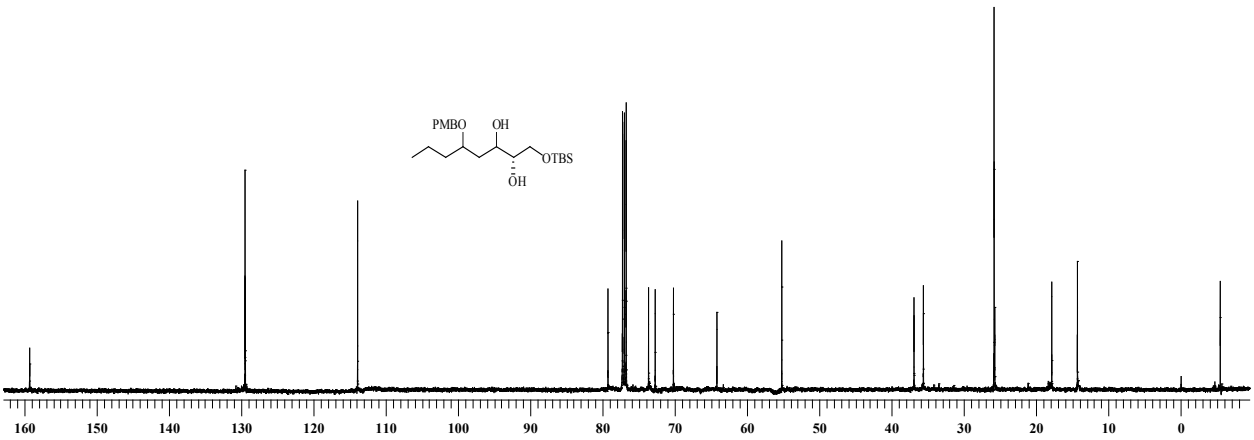


Spectrum 6: ^{13}C NMR Spectrum of compound **9** in $CDCl_3$ (75 MHz)

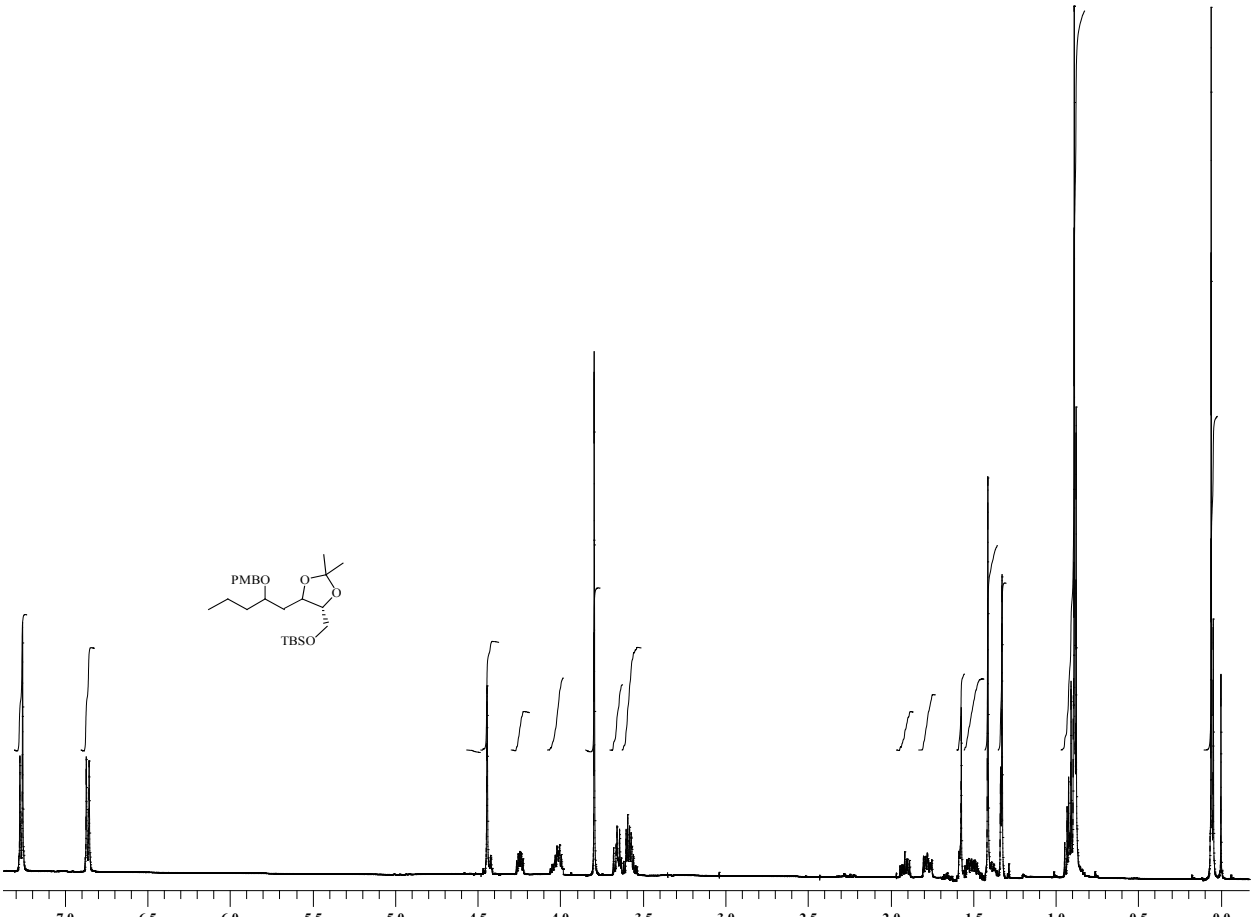
[Type text]



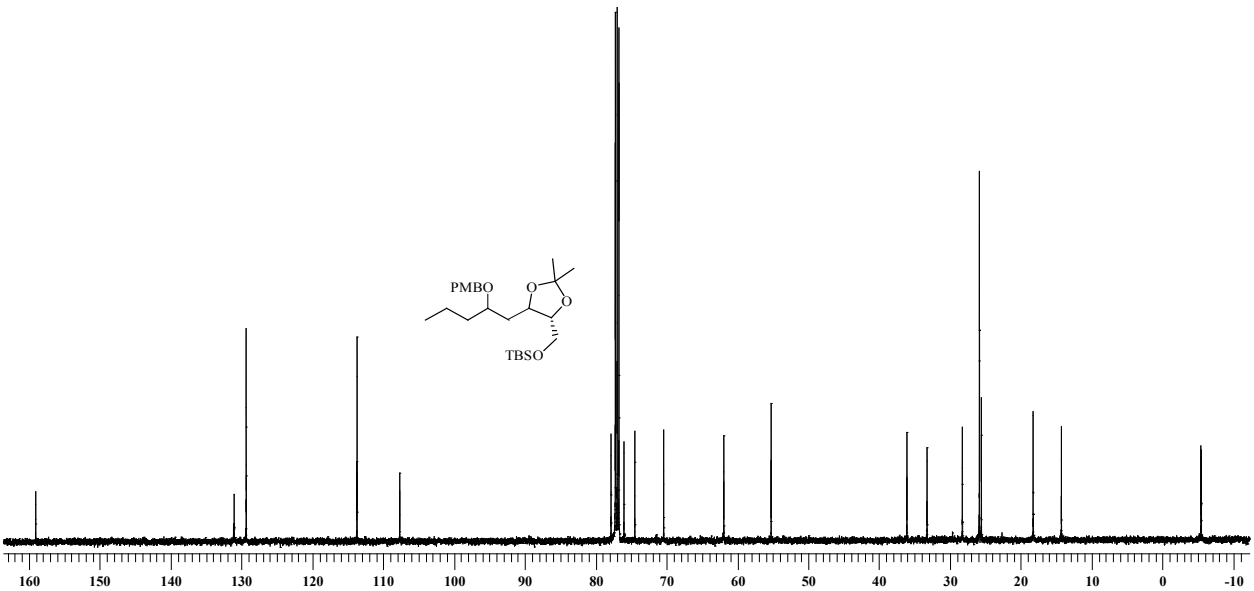
Spectrum 7: ^{1}H NMR Spectrum of compound **10** in $CDCl_3$ (500 MHz)



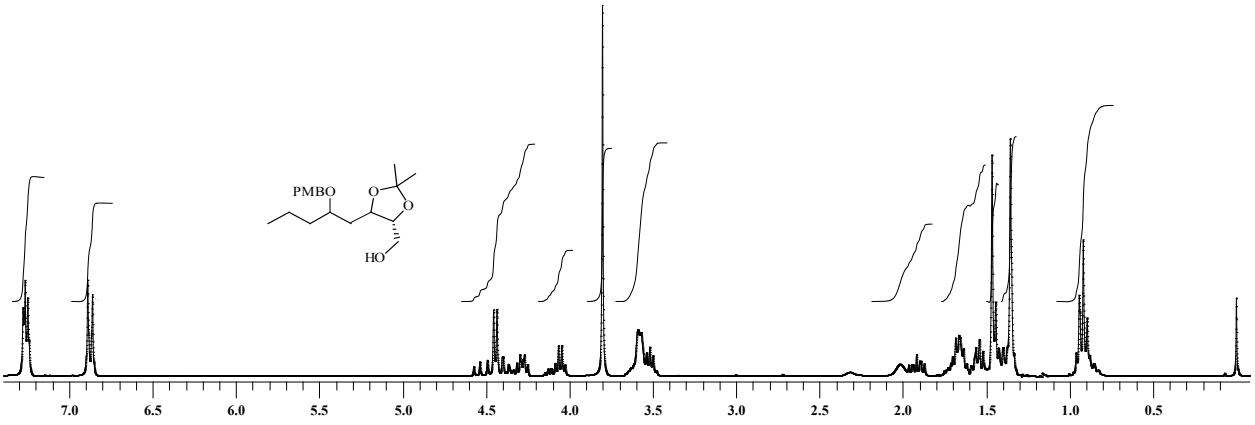
Spectrum 8: ^{13}C NMR Spectrum of compound **10** in $CDCl_3$ (125 MHz)



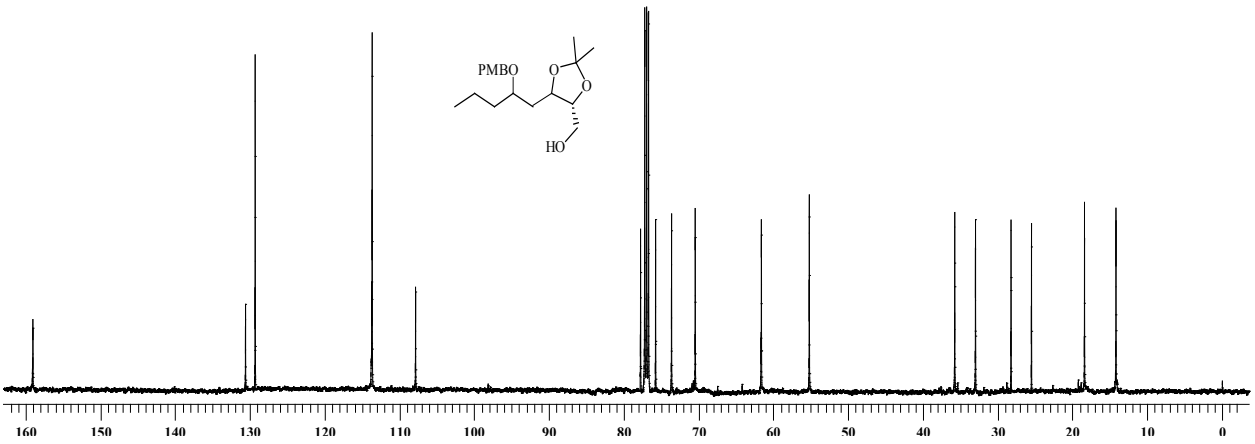
Spectrum 9: ^{1}H NMR Spectrum of compound **11** in $CDCl_3$ (500 MHz)



Spectrum 10: ^{13}C NMR Spectrum of compound **11** in $CDCl_3$ (125 MHz)

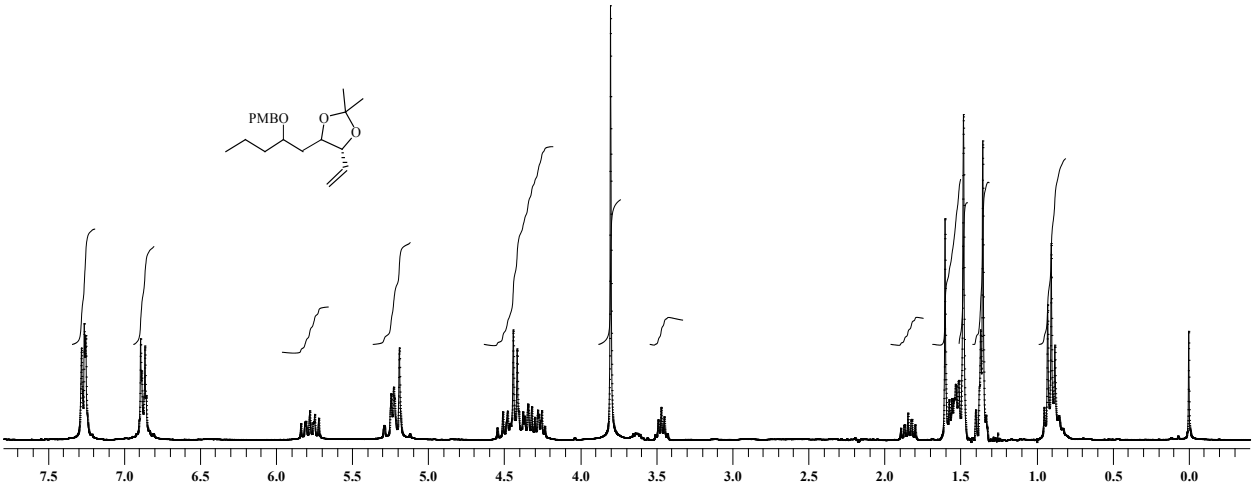


Spectrum 11: ^{1}H NMR Spectrum of compound **12** in $CDCl_3$ (300 MHz)

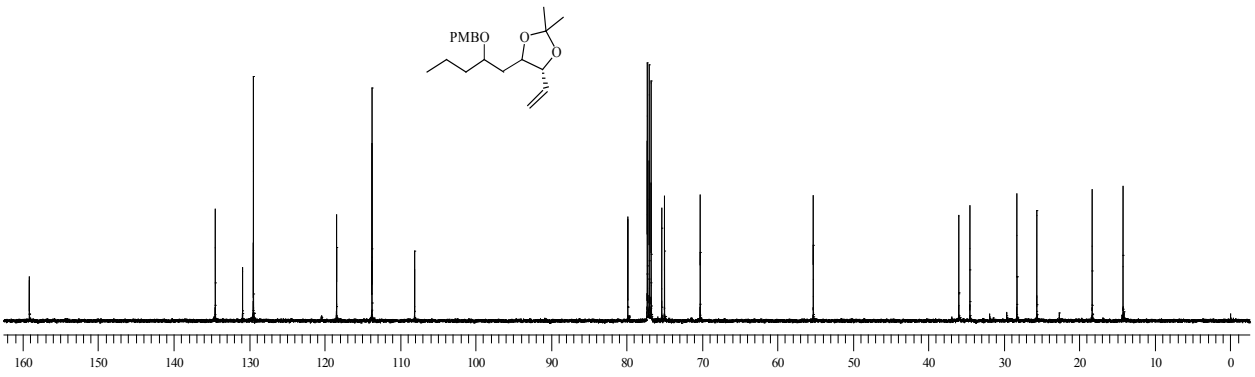


Spectrum 12: ^{13}C NMR Spectrum of compound **12** in $CDCl_3$ (125 MHz)

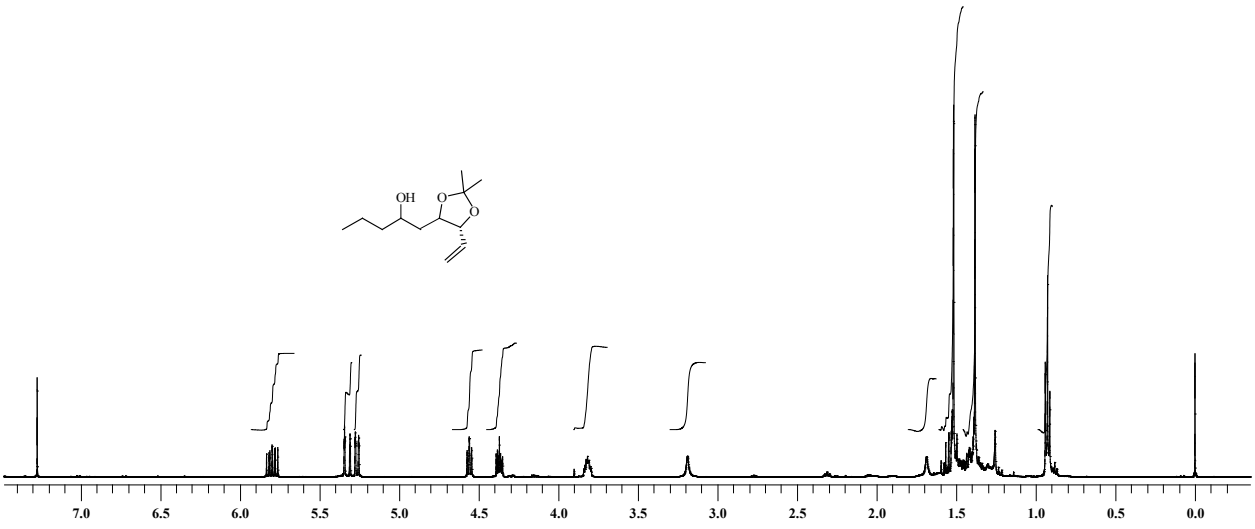
[Type text]



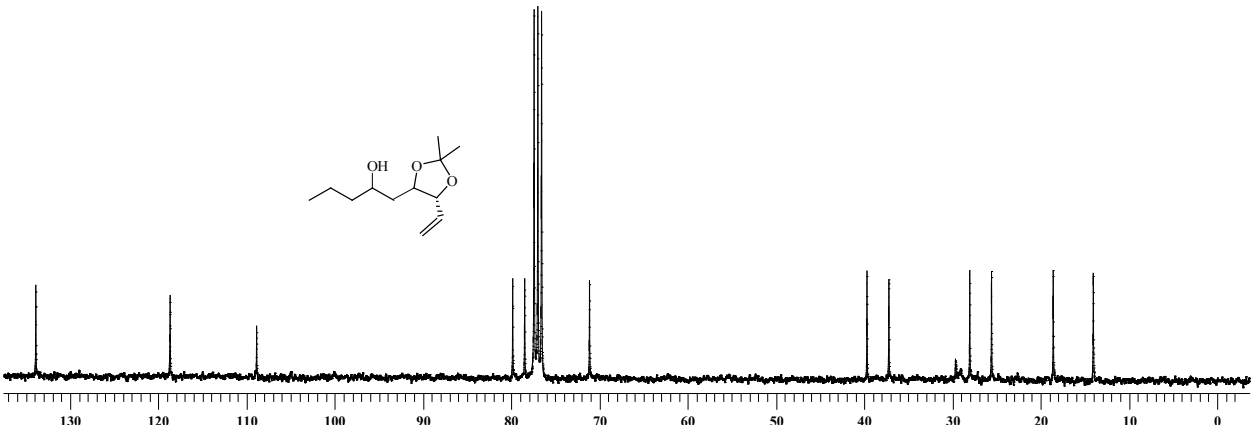
Spectrum 13: ^{1}H NMR Spectrum of compound **13** in $CDCl_3$ (300 MHz)



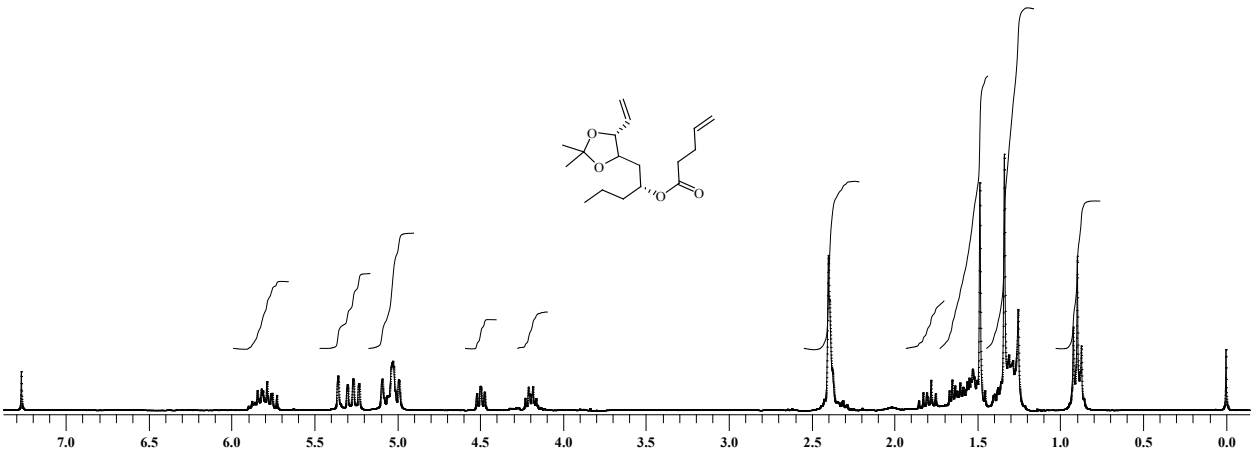
Spectrum 14: ^{13}C NMR Spectrum of compound **13** in $CDCl_3$ (125 MHz)



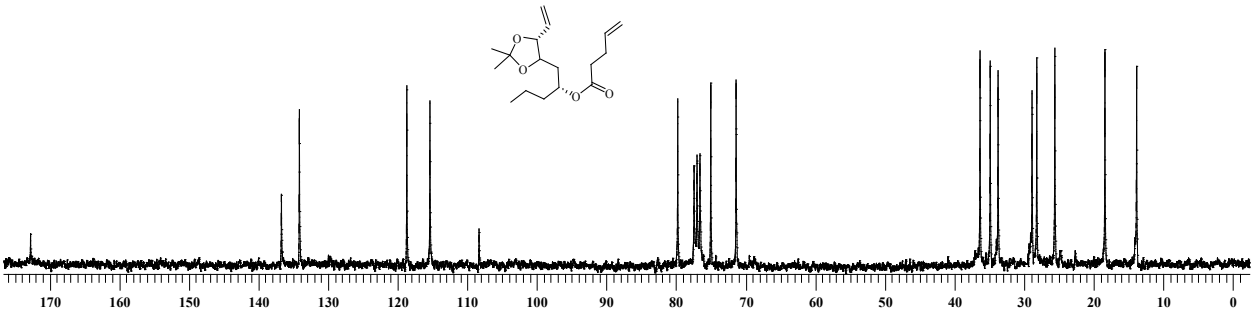
Spectrum 15: ^{1}H NMR Spectrum of compound **4** in $CDCl_3$ (500 MHz)



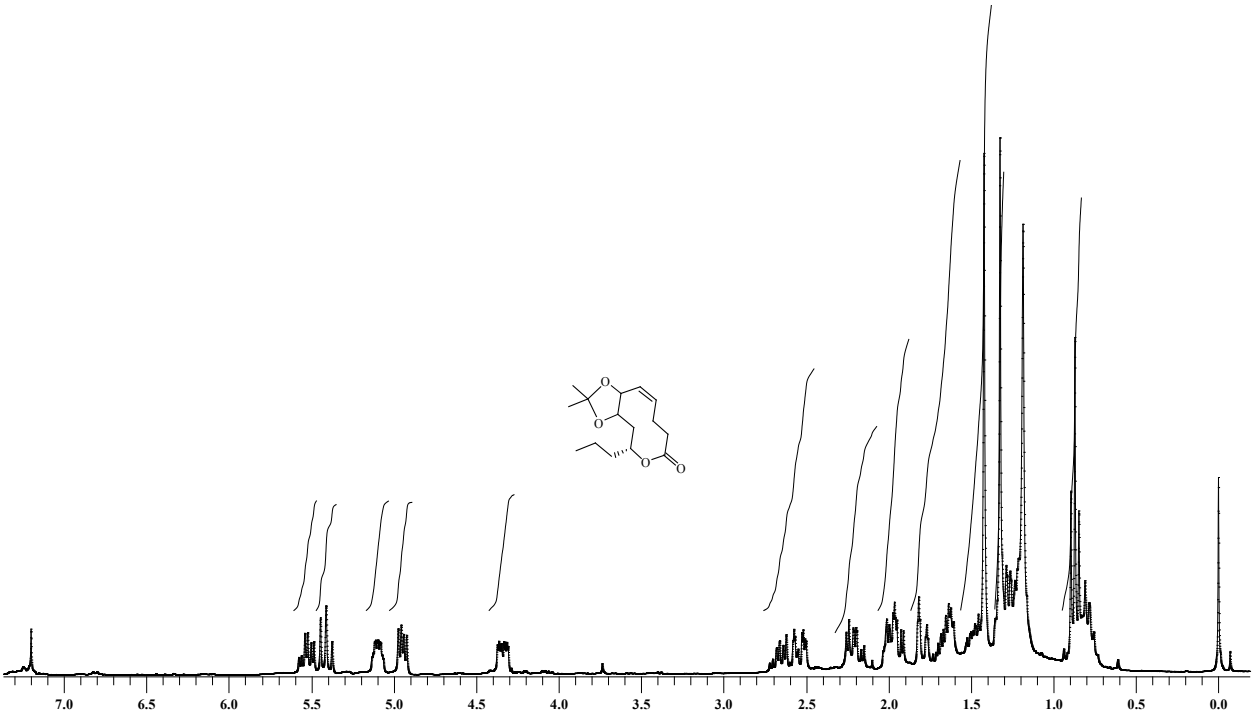
Spectrum 16: ^{13}C NMR Spectrum of compound **4** in $CDCl_3$ (75 MHz)



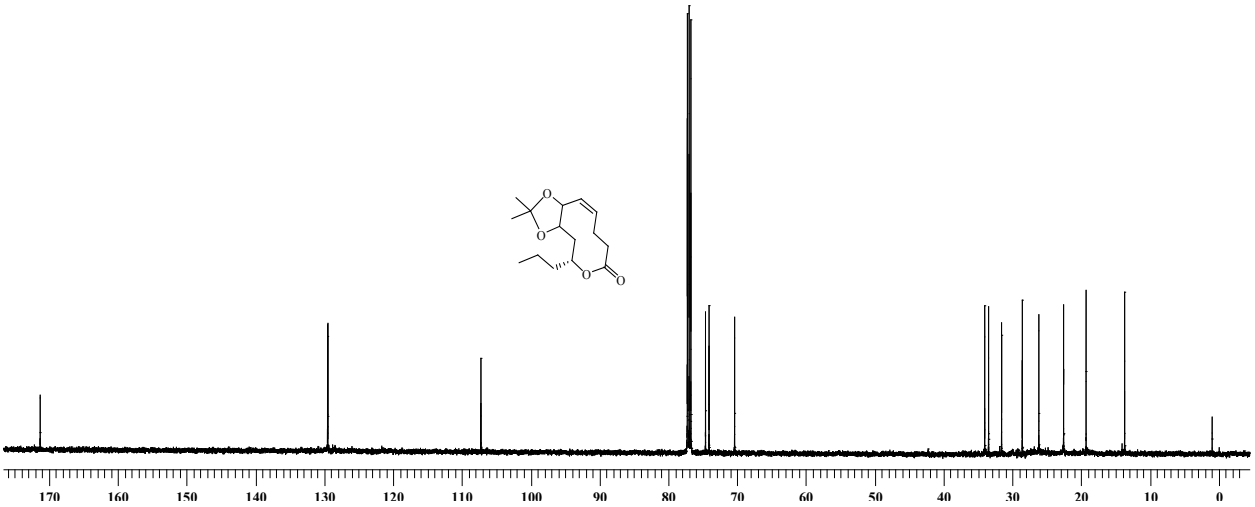
Spectrum 17: ^{1}H NMR Spectrum of compound **3** in $CDCl_3$ (300 MHz)



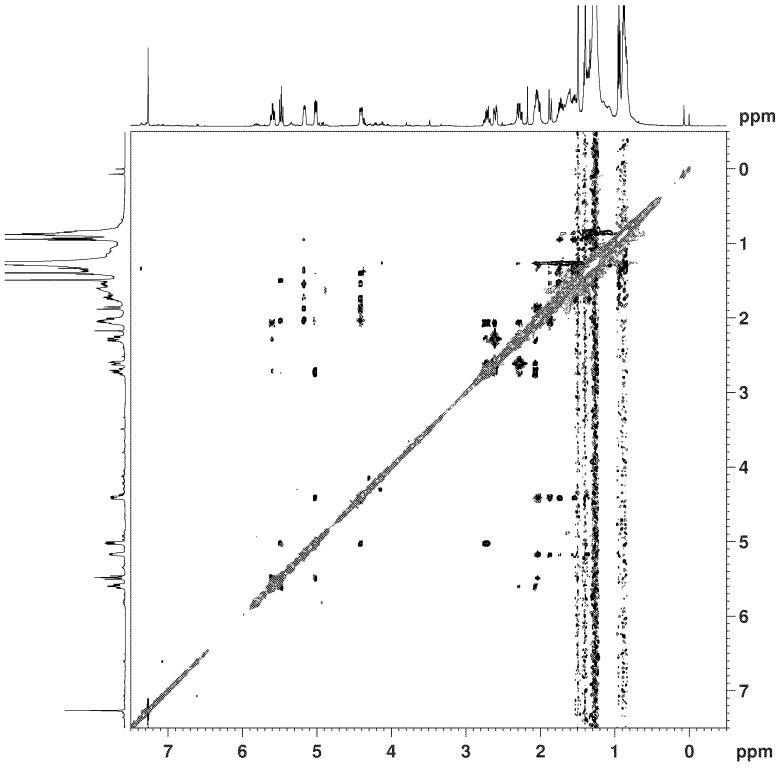
Spectrum 18: ^{13}C NMR Spectrum of compound **3** in $CDCl_3$ (75 MHz)



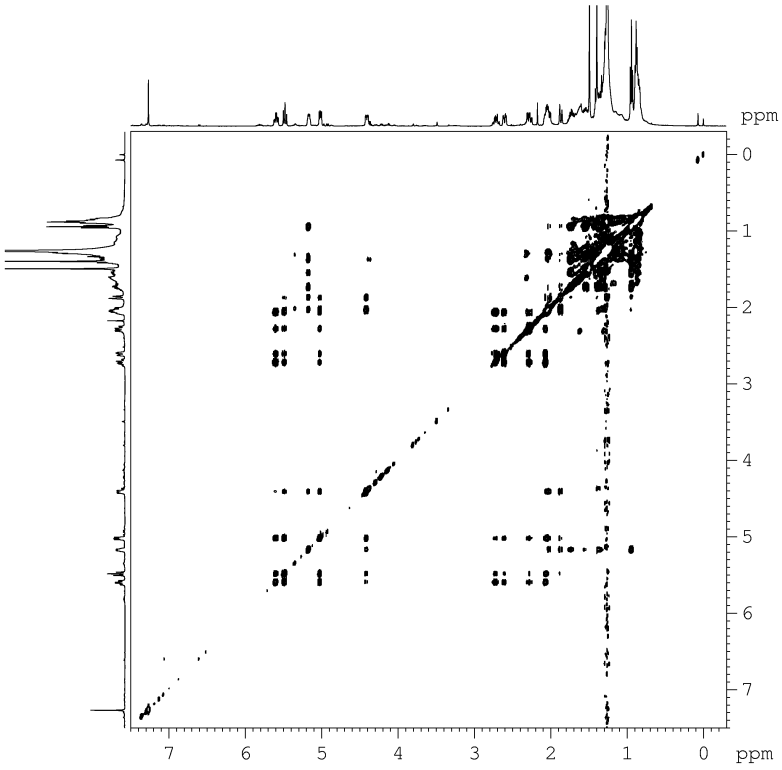
Spectrum 19: ^{1}H NMR Spectrum of compound **14** in $CDCl_3$ (500 MHz)



Spectrum 20: ^{13}C NMR Spectrum of compound **14** in $CDCl_3$ (125 MHz)

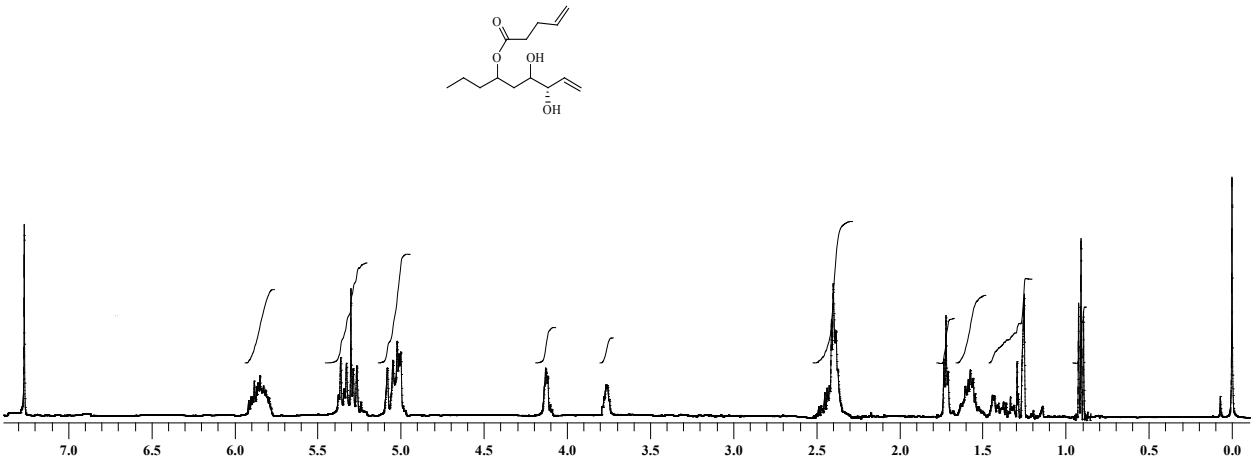


Spectrum 21: 2D-NOESY spectrum of compound **14** in $CDCl_3$ (500 MHz).

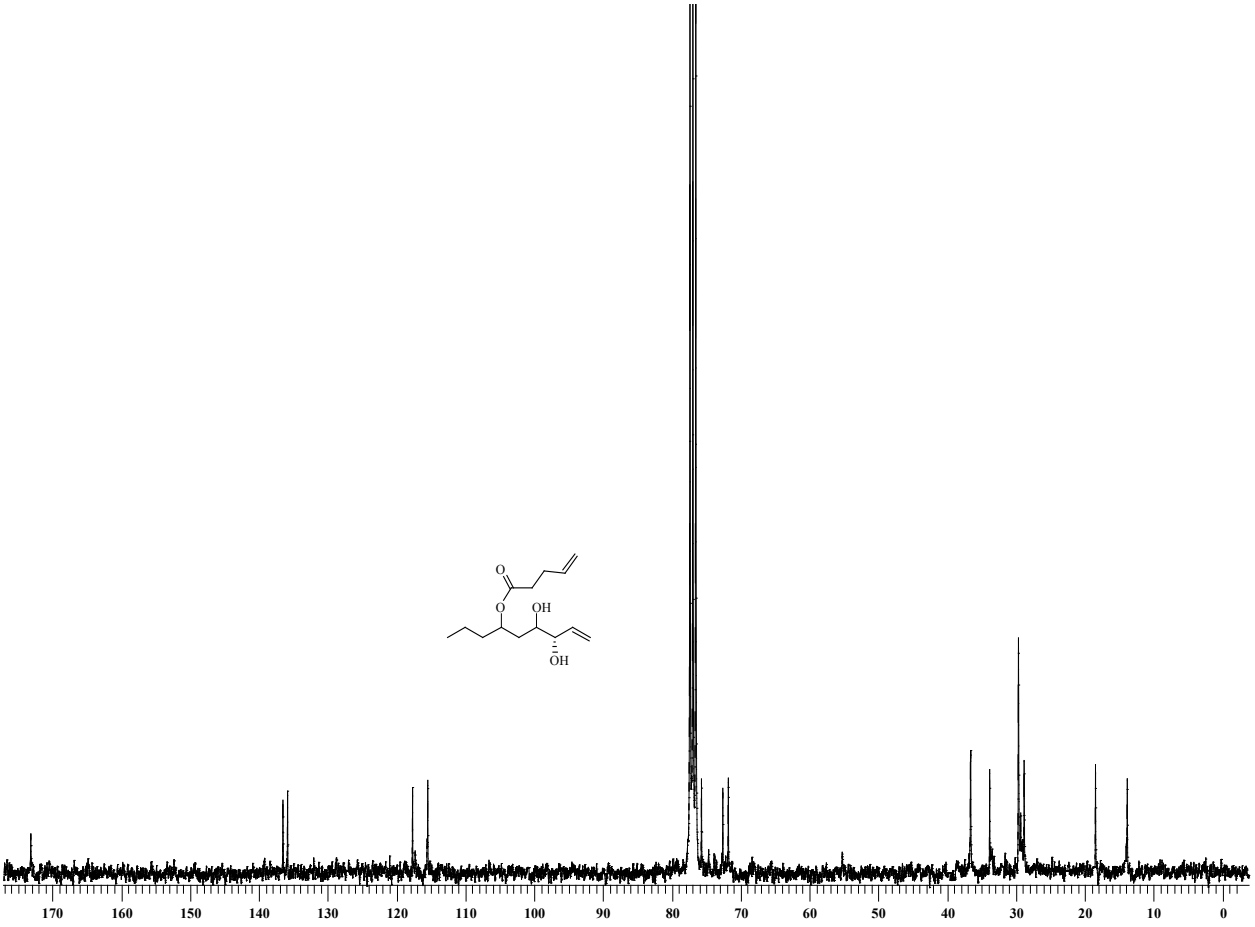


Spectrum 22: 2D-TOCSY spectrum of compound **14** in $CDCl_3$ (500 MHz).

[Type text]



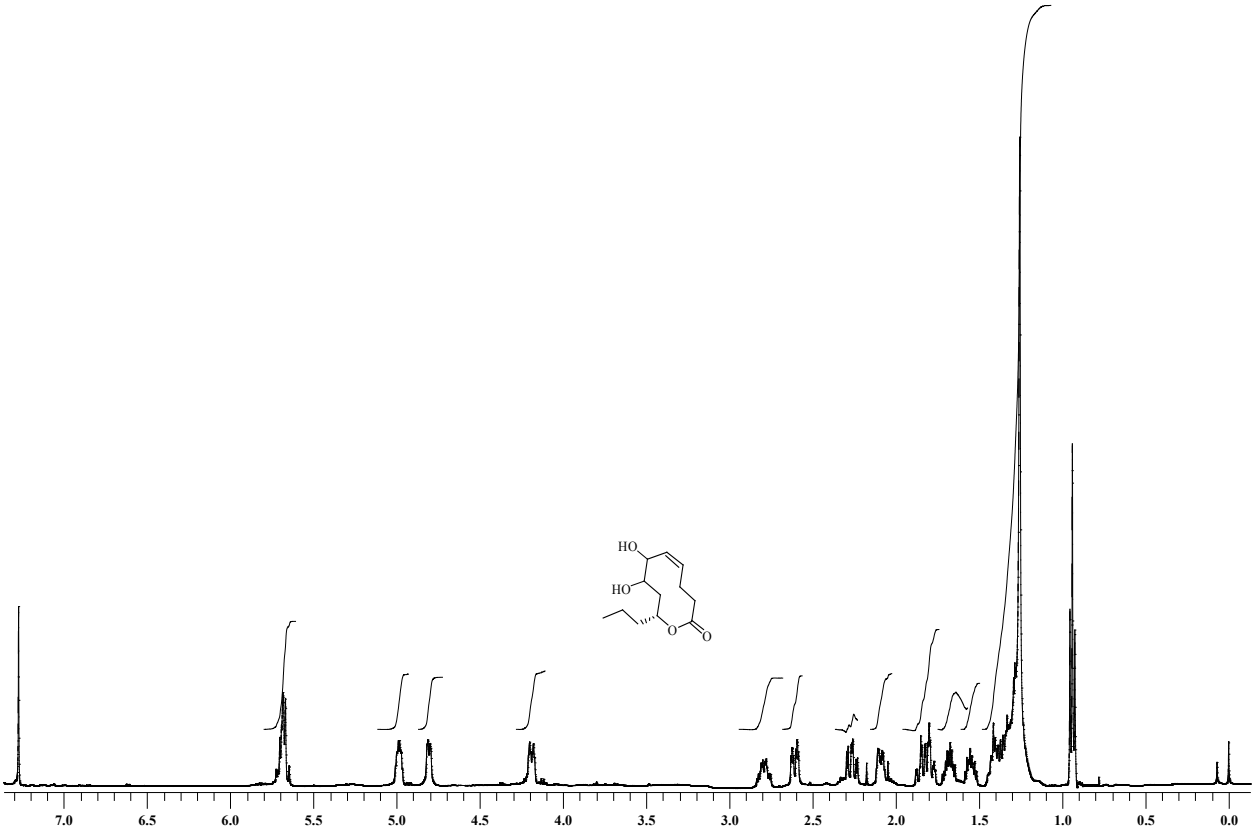
Spectrum 23: ^{1}H NMR Spectrum of compound **15** in $CDCl_3$ (300 MHz)



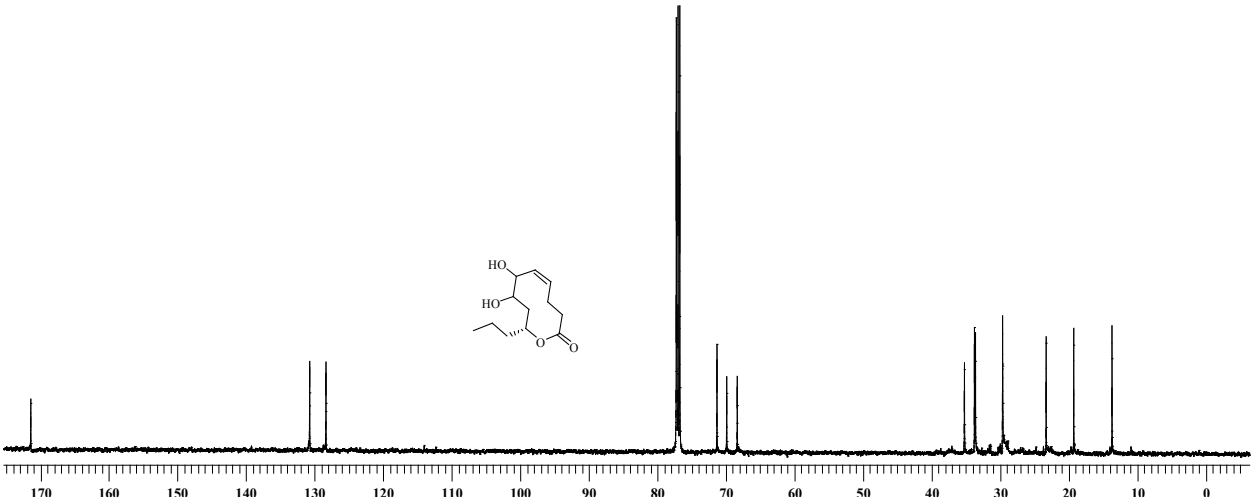
Spectrum 24: ^{13}C NMR Spectrum of compound **15** in $CDCl_3$ (75 MHz)

[Type text]

[Type text]

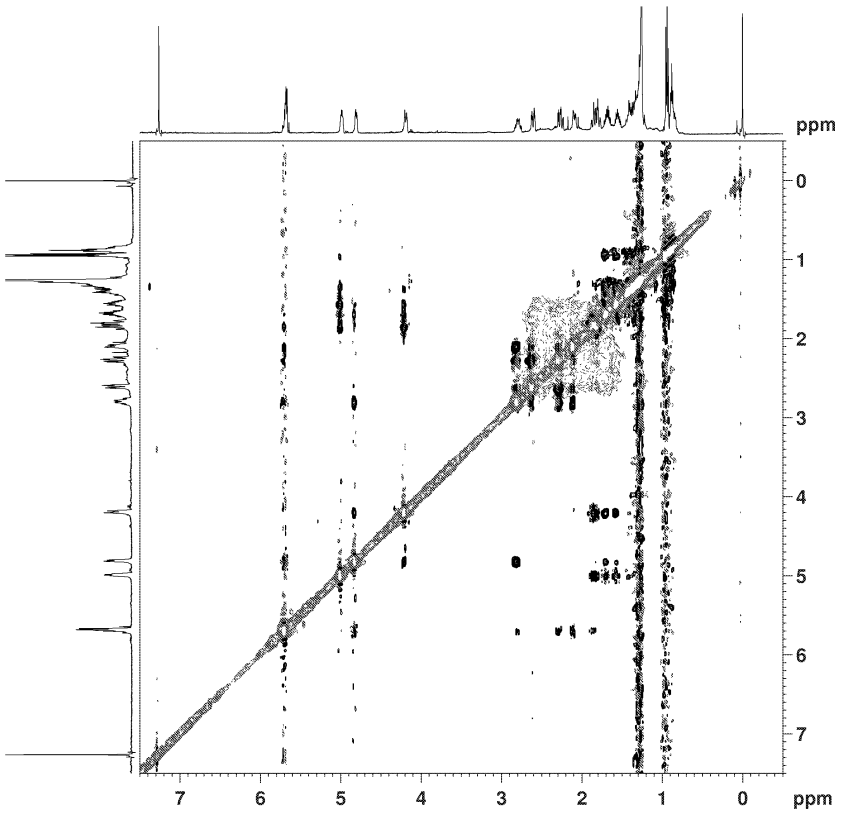


Spectrum 25: ^{1}H NMR Spectrum of compound **2** in $CDCl_3$ (500 MHz)

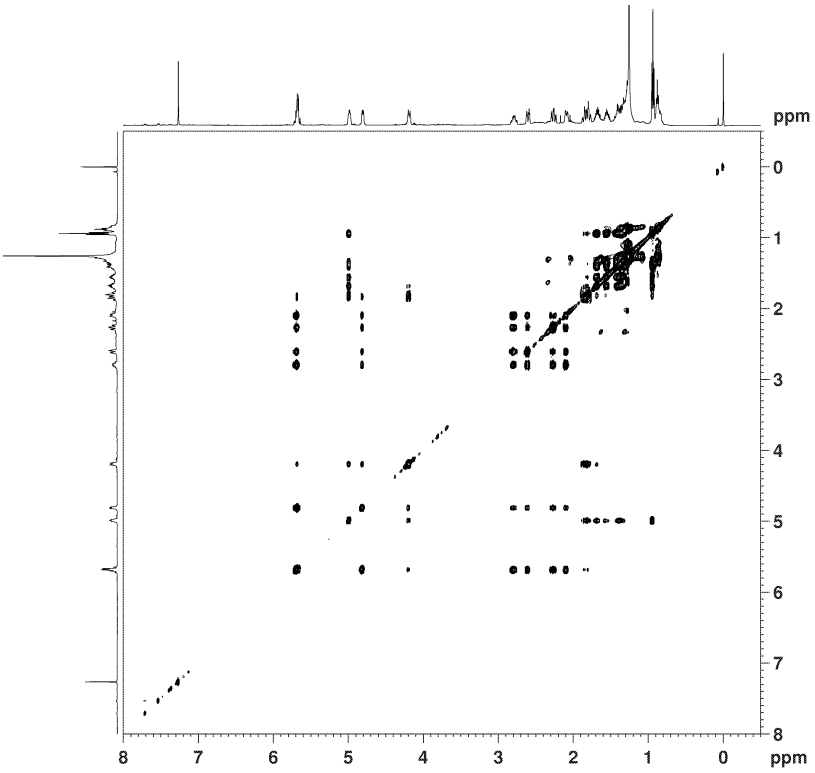


Spectrum 26: ^{13}C NMR Spectrum of compound **2** in $CDCl_3$ (125 MHz)

[Type text]



Spectrum 27: 2D-NOESY spectrum of compound **2** in $CDCl_3$ (500 MHz).



Spectrum 28: 2D-TOCSY spectrum of compound **2** in $CDCl_3$ (500 MHz).