Synthesis of the originally proposed structures of elatenyne and an enyne from *Laurencia majuscula*.

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Experimental

The synthesis and spectroscopic data for compounds **3**, **4**, **9**, **13**, **15**, **18**, **19**, **53**, **56**, **57**, **60-66**, **70**, **71-75**, and **81-86** have been reported previously[1] see:
http://www.wiley-vch.de/contents/jc_2002/2006/z602211_s.pdf - see this web address for tabulated ^{13}C NMR data for the central oxygen bearing carbons of the synthetic pyrano[3,2-*b*]pyrans and 2,2'-bifuranyls reported below.

General Information ^{1}H and ^{13}C NMR spectra were recorded on Bruker DPX-400 or Bruker DRX-500 equipped with an inverse ^{13}C-^{1}H Cryoprobe, using deuterochloroform as an internal deuterium lock. Chemical shifts are quoted in units of δ relative to tetramethylsilane (δ=0). Multiplets are indicated as s, singlet; d, doublet; t, triplet; q, quartet; qn, quintet; dd, double doublet; m, multiplet; br, broad, etc. Coupling constants *J* are quoted in Hz. For many of the compounds the *J* values have been extracted and placed alongside conformational diagrams of the synthetic intermediates. In some instances it was not possible to assign the 4-C or 8-C protons as axial or equatorial and in these cases the protons are denoted 4-H and 4-H', and 8-H and 8-H'. Coupling constants in red for C_2-symmetric molecules are taken from an NMR simulation using gNMR. Where useful, the FID was zero-filled (128 K) and sine-bell shifted (ssb = 30) prior to Fourier Transformation in order to provide baseline-resolved multiplets and easily identifiable coupling constants. Double Quantum Filtered and magnitude COSY and HMQC spectra were typically acquired with 256 slices in F_1 and 2048 points in F_2 (acquisition time approximately 20 min). ^{13}C spectra were recorded with proton decoupling; *J* resolved spin-echo APT or DEPT-135, and in some cases HMQC, were recorded to assist assignment.

Infrared spectra were recorded on a Perkin-Elmer 1600 series FTIR spectrometer calibrated relative to polystyrene absorption at 1630 cm^{-1}. The samples were prepared as a thin film or a solution in the solvent indicated.

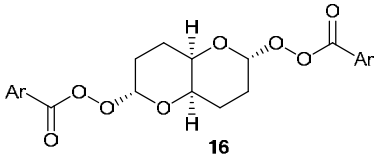
Mass spectra were recorded by the Mass Spectrometry Service at the University of Cambridge Chemical Laboratory. Microanalyses were carried out by the Microanalytical Service at the University of Cambridge Chemical Laboratory.

Optical specific rotations were measured on a Perkin-Elmer 241 polarimeter and are quoted in units of $^{\circ}10^{-1}cm^2g^{-1}$. The concentration (*c*) is expressed in g/0.1 dm^3.

Flash chromatography was carried out on silica gel [Merck 9385 Kieselgel 60 (230-400 ASTM)]. Analytical TLC was carried out on 0.25 mm thick plates precoated with Merck Kieselgel F_{254} silica gel and visualised by UV and aqueous potassium permanganate solution or ethanolic phosphomolybdic acid solution. Preparative layer chromatography was carried out on 1 mm thick plates of Merck Kieselgel PF_{254}.

Melting points were determined using a Kofler hot-stage apparatus and are uncorrected.
Kugelrohr bulb-to-bulb distillations were carried out using a Büchi GKR-51 machine. Boiling points are oven temperatures.
Dry THF was distilled from potassium in a recycling still using benzophenone ketyl as indicator. Other solvents were purified by standard techniques. Ether refers to diethyl ether. Petroleum ether (PE) refers to the fraction boiling at 40-60 °C.

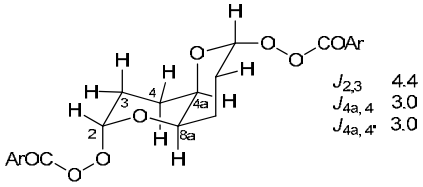
(2S, 4aR, 6S, 8aR)-2,6-Di(meta-chloroperbenzoyloxy)-octahydropyrano[3,2-b]pyran **16** and ***(4aR, 8aR)-Hexahydropyrano[3,2-b]pyran-2,6-dione*** **8**

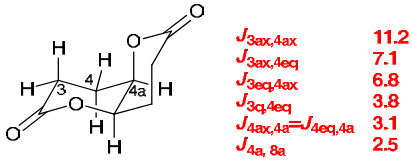


16 **8**

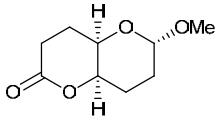
To a stirred solution of (2*S*, 4a*R*, 6*S/R*, 8a*R*)-2,6-dimethoxy-octahydropyrano[3,2-*b*]pyran **9** (250 mg, 1.24 mmol) in DCM (20 mL) over 4 Å molecular sieves was added recrystallised 100% *meta*-chloroperbenzoic acid (1.71 g, 9.90 mmol) followed by BF_3•OEt_2 (156 µL, 175 mg, 1.24 mmol) and the resulting solution stirred at room temperature for 30 min. The reaction was quenched with saturated aqueous $NaHCO_3$ solution (20 mL) and the organic layer washed with saturated aqueous $Na_2S_2O_3$ solution (2 × 20 mL) and saturated aqueous $NaHCO_3$ solution (4 × 20 mL), dried (Na_2SO_4) and concentrated *in vacuo* to yield (2*S*, 4a*R*, 6*S*, 8a*R*)-2,6-di(meta-chloroperbenzoyloxy)-octahydropyrano[3,2-*b*]pyran **16** contaminated with *m*CPBA byproducts; R_f 0.50 (EtOAc: hexane, 3:7); δ_H (400 MHz, $CDCl_3$) 7.93 (2H, t, *J* 1.7, Ar*H*), 7.84 (2H, ddd, *J* 1.3, 1.6, 7.8, Ar*H*), 7.55 (2H, ddd, *J* 1.1, 2.1, 8.0, Ar*H*), 7.39 (2H, t, *J* 7.8, Ar*H*), 5.62 (2H, brd, *J* 4.4, H-2,6), 4.29 (2H, t, *J* 3.0, H-4a,8a), 2.16 (2H, tt, *J* 4.6, 14.1), 1.96-2.05 (2H, m), 1.69-1.81 (4H, m); δ_C (100 MHz, $CDCl_3$) 163.9 (C), 134.3 (CH), 130.7 (C), 130.6 (CH), 130.1 (CH), 128.9 (C), 128.2 (CH), 102.5 (CH), 64.8 (CH), 23.8 (CH_2), 21.6 (CH_2); *m/z* (ESI+) Found $(M+Na)^+$, 505.0439 $C_{22}H_{20}O_8{}^{35}Cl_2Na$ req. 505.0433.

The anomeric peroxyster **16** was immediately redissolved in DCM (20 mL) over 4 Å molecular sieves and 1,5,7-triazabicyclo[4.4.0]dec-5-ene on polystyrene (Fluka, 1.67 g of resin with loading ~2.6 mmol/g, 4.33 mmol) added. The resulting suspension was stirred at room temperature for 2 h then filtered and concentrated *in vacuo* to yield (4a*R*, 8a*R*)-hexahydropyrano[3,2-*b*]pyran-2,6-dione **8** (147 mg, 70%) as white crystals; R_f 0.19 (EtOAc); mp 106-110 °C (from EtOAc); $[\alpha]_D^{20}$ +23.0 (*c* 0.20, $CHCl_3$); δ_H (400 MHz, $CDCl_3$) 4.65-4.67 (2H, m, H-4a,8a), 2.72 (2H, ddd, *J* 7.1, 11.2, 18.1, H-3_{ax},7_{ax}), 2.58 (2H, ddd, *J* 3.8, 6.8, 18.1, H-3_{eq},7_{eq}), 2.14-2.23 and 2.26-2.32 (4H, m, 2CHCH_2); δ_C (100 MHz, $CDCl_3$) 169.5 (C), 72.9 (CH), 25.5 (CH_2), 24.7 (CH_2); ν_{max}/cm^{-1} ($CDCl_3$) 2943, 1740 (C=O), 1448, 1370, 1235, 1195, 1166, 1059; *m/z* (ESI+) 193 ($[M+Na]^+$, 47%), 158 (100), [Found $(M+Na)^+$ 193.0471, $C_8H_{10}O_4Na$ req. 193.0477].

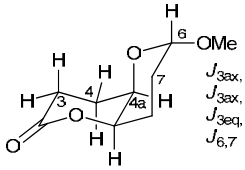




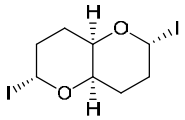
In optimisation studies ***(4aR, 6S, 8aR)-6-methoxy-hexahydropyrano[3,2-b]pyran-2-one*** was also isolated as colourless crystals.



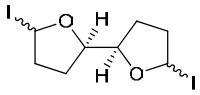
R_f 0.56 (EtOAc); mp 75-78 °C (from $CHCl_3$); $[\alpha]_D^{20}$ +41.3 (*c* 0.15, $CHCl_3$); δ_H (400 MHz, $CDCl_3$) 4.72 (1H, brd, *J* 3.4, H-6), 4.33 (1H, m, H-4a or 8a), 4.03 (1H, dt, *J* 1.6, 3.6, H-4a or 8a), 3.37 (3H, s, OCH_3), 2.70 (1H, ddd, *J* 7.9, 11.1, 18.1, H-3), 2.49 (1H, ddd, *J* 3.1, 6.5, 18.1, H-3'), 1.88-2.12 (4H, m), 1.57-1.59 (2H, m); δ_C (100 MHz, $CDCl_3$) 171.3 (C), 98.2 (CH), 75.3 (CH), 60.6 (CH), 54.9 (CH_3), 25.0 (CH_2), 24.9 (CH_2), 23.0 (CH_2), 22.9 (CH_2); ν_{max}/cm^{-1} ($CDCl_3$) 3151, 2984, 1793 (C=O), 1612, 1472, 1381, 1097; *m/z* 209 ($[M+Na]^+$, 100%), [Found $(M+Na)^+$ 209.0791, $C_9H_{14}O_4Na$ req. 209.0790].



***(2*R*,4a*R*,6*R*,8a*R*)-2,6-Diiodooctahydropyrano[3,2-*b*]pyran* 26, *(2*R*,2'*R*)-5,5'-diiodooctahydro-2,2'-bifuran* 29**



26



29

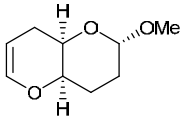
NMR experiments

To the acetals **9** or **15** (10 mg, 0.05 mmol) in an oven dried NMR tube was added dry d_3-MeCN (0.7 mL) and TMSI (84 μL, 118 mg, 0.59 mmol).

Data for **26**; δ_H (500 MHz, d_3-MeCN) 7.37 (2H, br, H-2, H-6), 3.87 (2H, m, H-4a, H-8a), 2.28-2.23 (2H, m), 2.10-2.07 (2H, m), 2.03-2.01 (2H, m), 1.80-1.77 (2H, m); δ_C (125 MHz, d_3-MeCN) 84.0 (C-2, 6-C), 69.5 (C-4a, C-8a), 33.2 (CH_2), 24.9 (CH_2).

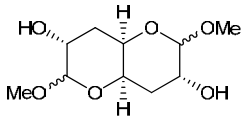
Data for **29**; Some of the resonances corresponding to **29** in the ^{1}H NMR and ^{13}C NMR were broad and there were some resonances missing from the ^{13}C NMR which indicated that the anomeric iodides are in intermediate exchange on the NMR timescale; δ_H (500 MHz, d_3-MeCN) 7.15 (2H, br, H-5, H-5'), 4.56 (2H, br m, H-2, H-2'), 2.50 (4H, br m), 2.39-2.36 (2H, br m), 2.03-2.01 (2H, br m); δ_C (125 MHz, d_3-MeCN) 82.0 (CH), 42.4 (CH_2), 25.1 (CH_2).

During the optimisation studies for the formation of the bis-*endo* cyclic enol ether **19**, ***(2S, 4aR, 8aR)-2-methoxy-2,3,4,4a,8,8a-hexahydropyrano[3,2-b]pyran*** was isolated



R_f 0.70 (EtOAc:hexane, 3:7); $[\alpha]_D^{23}$ +116.5 (*c* 0.20, $CHCl_3$); δ_H (400 MHz, $CDCl_3$) 6.42 (1H, dddd, *J* 0.6, 1.3, 2.5, 6.2, H-6), 4.77 (1H, brd, *J* 2.8, H-2), 4.63 (1H, dddd, *J* 1.3, 2.1, 5.1, 6.2, H-7), 4.06 (1H, dm, *J* 5.3, H-8a), 3.83 (1H, m, H-4a), 3.38 (3H, s, OCH_3), 2.36 (1H, dddd, *J* 1.3, 2.5, 5.7, 18.0, H-8), 1.92-2.07 (5H, m, H-8', 3, 3', 4, 4'); δ_C (125 MHz, $CDCl_3$) 143.4 (CH), 98.8 (CH), 96.8 (CH), 68.7 (CH), 62.5 (CH), 54.6 (CH_3), 26.0 (CH_2), 23.7 ($2CH_2$); ν_{max}/cm^{-1} ($CHCl_3$) 3044, 1655 (enol ether), 1422, 1322, 1218); *m/z* (ESI+) 283 (100%), 200 (83), 193 ([*M*+Na]$^+$, 57), 176 (79), [Found (*M*+Na)$^+$ 193.0841, $C_9H_{14}O_3Na$ req. 193.0841

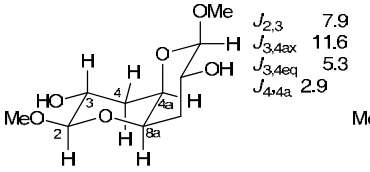
(3R, 4aR, 7R, 8aR)-2,6-Dimethoxy-octahydropyrano[3,2-b]pyran-3,7-diol **31** as a mixture of diastereomers at C-2 and C-6

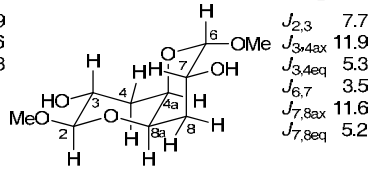


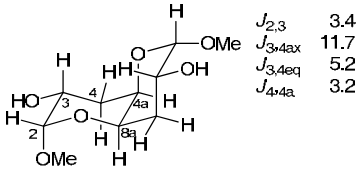
31

To a stirred solution of crude (4a*R*, 8a*R*)-4,4a,8,8a-tetrahydropyrano[3,2-*b*]pyran **19** (0.520 mmol) in methanol/DCM (1:1, 10 mL) at 0 °C under nitrogen was added *meta*-chloroperbenzoic acid (197 mg, 1.14 mmol) and the resulting solution allowed to warm to room temperature over 24 h. The reaction mixture was concentrated *in vacuo* and purified by flash chromatography (DCM:MeOH, 95:5) to yield the title compound **31** as a white amorphous solid (90 mg, 74% over 2 steps) comprising an inseparable mixture of anomers; R_f 0.70-0.74 (DCM:MeOH, 8:2); δ_H (400 MHz, $CDCl_3$) ββ 4.06 (2H, d, *J* 7.9, H-2,6), 3.77 (2H, ddd, *J* 5.3, 7.9, 11.6, H-3,7), 3.67 (2H, t, *J* 2.9, H-4a,8a), 3.52 (6H, s, 2OCH_3), 2.29 (2H, ddd, *J* 2.9, 5.3, 13.8, H-4,8$_{eq}$), 1.63 (2H, ddd, *J* 2.9, 11.6, 13.8, H-4,8$_{ax}$); αβ 4.66 (1H, brd, *J* 3.5, H-6), 4.05 (1H, d, *J* 7.7, H-2), 4.01 (1H, ddd, *J* 3.5, 5.2, 11.6, H-7), 3.80 (1H, m, H-4a), 3.72 (1H, ddd, *J* 5.3, 7.7, 11.9, H-3), 3.69 (1H, m, H-8a), 3.54 (3H, s, OCH_3), 3.44 (3H, s, OCH_3), 2.19 (1H, ddd, *J* 3.0, 5.2, 13.9, H-8$_{eq}$), 2.09 (1H, ddd, *J* 2.2, 5.3, 13.0, H-4$_{eq}$), 1.83 (1H, ddd, *J* 3.6, 11.9, 13.0, H-4$_{ax}$), 1.59 (1H, ddd, *J* 3.6, 11.6, 13.9, H-8$_{ax}$); αα 4.66 (2H, brd, *J* 3.4, H-2,6), 3.99 (2H, ddd, *J* 3.4, 5.2, 11.7, H-3,7), 3.69 (2H, t, *J* 3.2, H-4a,8a), 3.53 (6H, s, 2OCH_3), 1.98 (2H, ddd, *J* 3.2, 5.2, 14.0, H-4,8$_{eq}$), 1.79 (2H, ddd, *J* 3.2, 11.7, 14.0, H-4,8$_{ax}$); δ_C (125 MHz, $CDCl_3$) (mixture) 106.3 (CH), 106.2 (CH), 99.4 (2CH), 72.3 (CH), 72.0 (CH), 66.0 (CH),

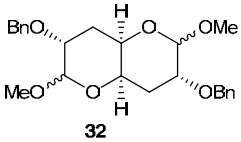
65.8 (CH), 64.6 (CH), 64.3 (CH), 63.8 (CH), 63.7 (CH), 56.7 ($2CH_3$), 55.3 ($2CH_3$), 34.5 (CH_2), 34.2 (CH_2), 32.1 (CH_2), 31.8 (CH_2); ν_{max}/cm^{-1} ($CDCl_3$) 3452 (OH), 2862, 2069; *m/z* (ESI+) 257 ([*M*+Na]$^+$, 100%), [Found (*M*+Na)$^+$ 257.0995, $C_{10}H_{18}O_6Na$ req. 257.1001].





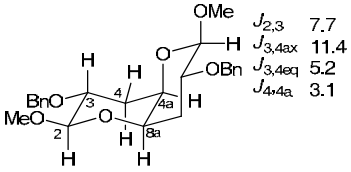


***(3R, 4aR, 7R, 8aR)-3,7-Bisbenzyloxy-2,6-dimethoxy-octahydropyrano[3,2-b]pyran* 32** as a mixture of diastereomers at C-2 and C-6

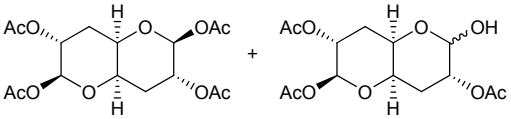


32

To a stirred solution of a mixture of anomers of **31** (83 mg, 0.355 mmol) in DMF (8 mL) was added sodium hydride (57 mg of a 60% suspension in mineral oil, 1.42 mmol) and the resulting suspension stirred for 30 min at room temperature. Benzyl bromide (168 μL, 243 mg, 1.42 mmol) was added dropwise and the resulting solution stirred overnight. The reaction was quenched by the cautious addition of water (8 mL) then diluted with EtOAc (10 mL) and washed with water (3 ×10 mL). The organic layer was dried ($MgSO_4$) filtered and concentrated *in vacuo* and the residue purified by flash chromatography (EtOAc:hexane, 2:8) to yield the title compound **32** as a colourless oil (57 mg, 39%) as a mixture of 3 anomers, a sample of the least polar anomer was separated and used for characterisation; R_f 0.40-0.44 (EtOAc:hexane, 3:7); $[\alpha]_D^{23}$ -26.0 (*c* 0.1, $CHCl_3$); δ_H (400 MHz, $CDCl_3$) 4.82 (2H, d, *J* 11.7, 2C*H*'Ph), 4.59 (2H, d, *J* 11.7, 2CH*H*'Ph), 4.20 (2H, d, *J* 7.7, H-2,6), 3.64 (2H, ddd, *J* 5.2, 7.7, 11.4, H-3,7), 3.62 (2H, t, *J* 3.1, H-4a,8a), 3.53 (6H, s, 2OCH_3), 2.31 (2H, ddd, *J* 3.1, 5.2, 13.9, H-4,8_{eq}), 1.64 (2H, ddd, *J* 3.1, 11.4, 13.9, H-4,8_{ax}); δ_C (100 MHz, $CDCl_3$) 127.8-129.0 (2C and 10CH), 107.0 (C-2,6), 73.5 (C-4a,8a), 73.5 ($2CH_2$), 72.1 (C-3,7), 56.9 ($2CH_3$), 34.7 (C-4,8); ν_{max}/cm^{-1} ($CHCl_3$) 3012, 1522, 1424, 1224, 1046; *m/z* (ESI+) 437 ([*M*+Na$^+$], 100%), [Found (*M*+Na$^+$) 437.1946, $C_{24}H_{20}O_6Na$ req. 437.1940].



***(2S, 3R, 4aR, 6S, 7R, 8aR)-2,3,6,7-Tetraacetoxy-octahydropyrano[3,2-b]pyran* 33** and ***(2S, 3R, 4aR, 7R, 8aR)-6-Hydroxy-2,3,7-triacetoxy-octahydropyrano[3,2-b]pyran* 34**

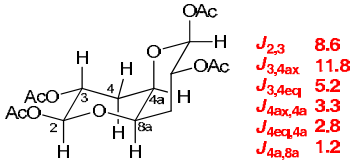


33 **34**

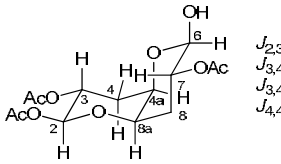
According to the method of Gin:[2] To a stirred solution of bis-enol ether **19** (10 mg, 0.072 mmol) in DCM (1 mL) at -45 °C under N_2 was added iodobenzene diacetate (56 mg, 0.174 mmol) followed by BF_3•OEt_2 (4 μL, 4 mg, 0.029 mmol). The resulting solution was stirred at -45 °C for 30 min, then warmed to -25 °C and stirred for 30 min, then recooled to –45 °C and triethylamine (101 μL, 73 mg, 0.725 mmol) added. The reaction mixture was warmed to room temperature over 20 min, then diluted with DCM (5 mL) and washed with saturated aqueous $NaHCO_3$ solution (5 mL). The aqueous layer was extracted with DCM (2 × 5mL) and the combined organic layers dried ($MgSO_4$), filtered and concentrated *in vacuo* to give the crude product as a colourless oil which was purified by flash chromatography (EtOAc:hexane1:3→1:0, 2% Et_3N) to yield the tetraacetate **33** (4 mg, 15%) as colourless crystals; R_f 0.42 (EtOAc:hexane, 1:1); mp 166.5-167 °C (from $CDCl_3$); $[\alpha]_D^{21}$ -27 (*c* 0.2, $CHCl_3$); δ_H (400 MHz, $CDCl_3$) 5.57 (2H, d, *J* 8.6, H-2,6), 5.11 (2H, ddd, *J* 5.6, 8.6, 11.6, H-3,7), 3.85 (2H, brt, *J* 3.0, H-4a,8a), 2.43 (2H, ddd, *J* 3.0, 5.6, 13.8, H-4,8_{eq}), 2.11 (6H, s, 2COCH_3), 2.01 (6H, s, 2COCH_3), 1.71 (2H, ddd, *J* 3.0, 11.6,

13.8, H-4,8$_{ax}$); δ_C (100 MHz, $CDCl_3$) 170.0 (C), 169.8 (C), 93.9 (C-2,6), 72.2 (C-4a,8a), 66.3 (C-3,7), 33.2 (C-4,8), 21.4 (CH_3), 21.3 (CH_3); ν_{max}/cm^{-1} (neat film) 3000, 1744 (C=O), 1372, 1219, 1144, 1050; *m/z* (ESI+) 397 ([*M*+Na]$^+$, 100%), 337 ([*M*+Na-AcOH]$^+$, 83%), 277 ([*M*+Na-2AcOH]$^+$, 62%), [Found (*M*+Na)$^+$ 397.1100, $C_{16}H_{22}O_{10}Na$ req. 397.1111].

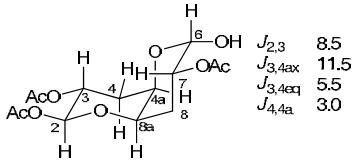
And (2*S*, 3*R*, 4a*R*, 7*R*, 8a*R*)-6-hydroxy-2,3,7-triacetoxy-octahydropyrano[3,2-*b*]pyran **34** (4 mg, 19%) as a colourless oil comprising a 1.67:1 α:β anomeric mixture at C-6; R_f 0.21 (EtOAc:hexane, 1:1); δ_H (400 MHz, $CDCl_3$) 5.60 (1Hα, d, *J* 8.5, H-2α), 5.59 (1Hβ, d, *J* 8.3, H-2β), 5.36 (1Hα, brd, *J* 2.8, H-6α), 5.10-5.16 (1Hα, 1Hβ, m, H-7α,3β), 5.05 (1Hα, ddd, *J* 5.5, 8.5, 11.5, H-3α), 4.95 (1Hβ, ddd, *J* 4.8, 8.3, 12.5, H-7β), 4.53 (1Hβ, brd, *J* 8.2, H-6β), 4.16 (1Hα, brt, *J* 3.0, H-8a or 4aα), 3.92 (1Hα, brt, *J* 3.0, H-8a or 4aα), 3.86 (1Hβ, brt, *J* 3.2, H-8aβ), 3.77 (1Hβ, brt, *J* 3.2, H-4aβ), 3.37 (1Hα, brs, O*H*α), 2.64 (1Hβ, brs, O*H*β), 2.46 (1Hβ, ddd, *J* 3.0, 5.5, 13.8, H-4β), 2.25-2.34 (1Hα, 1Hβ, m, 2 × ddd), 2.12- 2.00 (1Hα, 1Hβ, m), 2.11 (3Hα, s), 2.07 (3Hβ, s), 2.03 (3Hα, s), 2.02 (3Hβ, s), 2.01 (3Hα, s), 2.01 (3Hβ, s) 1.66-1.80 (2Hα, 1Hβ, m); δ_C (100 MHz, $CDCl_3$) 172.0, 170.5, 170.1, 170.0, 169.8, 98.0 (C-6β), 94.0, 93.9 (C-2α, C-2β), 90.5 (C-6α), 73.0 (C-8a or 4aα), 72.6 (C-8a or 4aβ), 71.9 (C-8a or 4aβ), 69.7 (CH), 66.8 (CH), 66.5 (CH), 64.1 (C-8a or 4aα), 33.4 (CH_2), 33.2 ($2CH_2$), 27.7 (CH_2), 21.4 ($6CH_3$); ν_{max}/cm^{-1} (film) 3449 (OH), 2932, 1740 (C=O), 1444, 1372, 1240, 1100, 1011, 924; *m/z* (ESI+) 355 ([*M*+Na]$^+$, 100%), 295 ([*M*+Na-AcOH]$^+$, 88%), 273 (63), [Found (*M*+Na)$^+$ 355.1006, $C_{14}H_{20}O_9Na$ req. 355.1005].



$J_{2,3}$ 8.6
$J_{3,4ax}$ 11.8
$J_{3,4eq}$ 5.2
$J_{4ax,4a}$ 3.3
$J_{4eq,4a}$ 2.8
$J_{4a,8a}$ 1.2

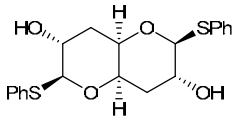


$J_{2,3}$ 8.3
$J_{3,4ax}$ -
$J_{3,4eq}$ 5.5
$J_{4,4a}$ 3.2
$J_{6,7}$ 8.3
$J_{7,8ax}$ 12.5
$J_{7,8eq}$ 4.8
$J_{8,8a}$ 3.2

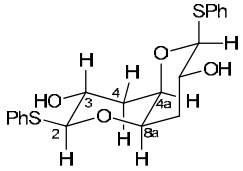


$J_{2,3}$ 8.5
$J_{3,4ax}$ 11.5
$J_{3,4eq}$ 5.5
$J_{4,4a}$ 3.0
$J_{8,8a}$ 3.0

(2S, 3R, 4aR, 6S, 7R, 8aR)-2,6-Bisphenylsulfanyl-octahydropyrano[3,2-b]pyran-3,7-diol

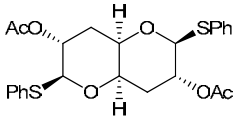


To a stirred solution of benzenethiol (63 µL, 68 mg, 0.616 mmol) in THF (0.5 mL) at 0 °C under argon was added dropwise a solution of *n*-BuLi (385 µL of a 1.6 M solution in hexane, 0.616 mmol) and the resulting solution stirred for 10 minutes. A solution of crude (2*S*, 3*R*, 4a*R*, 6*S*, 7*R*, 8a*R*)-2,3-6,7-bisepoxy-octahydropyrano[3,2-*b*]pyran **18** (~ 0.062 mmol) in THF (0.5 mL, 0.5 mL rinse) was added dropwise and the solution warmed to room temperature overnight. The reaction mixture was quenched with saturated aqueous NH_4Cl solution (1 mL), diluted with EtOAc (5 mL) and washed with 1 M aqueous sodium hydroxide solution (2 × 2 mL) The organic layer was dried ($MgSO_4$) and adsorbed onto silica, and the crude product purified by flash chromatography (EtOAc:hexane, 2:8→1:0) to yield the title compound (15 mg, 63% over 3 steps from **9**) as an amorphous white solid (inseparable 7:1 mixture with an unknown byproduct); R_f 0.10 (EtOAc:hexane, 3:7); δ_H (400 MHz, $CDCl_3$) 7.46-7.54 (4H, m, Ar*H*), 7.27-7.35 (6H, m, Ar*H*), 4.45 (2H, d, *J* 9.7, H-2,6), 3.81 (2H, ddd, *J* 5.1, 9.7, 11.2, H-3,7), 3.76 (2H, t, *J* 3.0, H-4a,8a), 2.47 (2H, ddd, *J* 3.0, 5.1, 13.8, H-4,8$_{eq}$), 1.65 (2H, ddd, *J* 3.0, 11.2, 13.8, H-4,8$_{ax}$); δ_C (100 MHz, $CDCl_3$) 132.6, 129.3, 128.2, 91.9, 74.8, 64.2, 36.5; ν_{max}/cm^{-1} ($CHCl_3$) 3689 (OH), 3600 (OH), 3154, 2984, 2901, 1794, 1641, 1601, 1560, 1470, 1384, 1264, 1094; *m/z* (ESI+) 413 ([*M*+Na]$^+$, 57%), 396 ([*M*+Na-OH]$^+$, 100), 368 (80), [Found (*M*+Na)$^+$ 413.0856, $C_{20}H_{22}O_4S_2Na$ req. 413.0857]

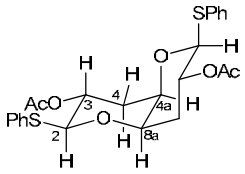


$J_{2,3}$ 9.7
$J_{3,4ax}$ 11.2
$J_{3,4eq}$ 5.1
$J_{4ax,4a}$ 3.0
$J_{4eq,4a}$ 3.0

(2S, 3R, 4aR, 6S, 7R, 8aR)-3,7-Bisacetoxy-2,6-bisphenylsulfanyl-octahydropyrano[3,2-b]pyran

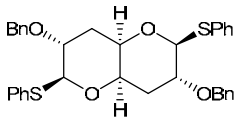


To a stirred solution of (2*S*, 3*R*, 4a*R*, 6*S*, 7*R*, 8a*R*)-2,6-bisphenylsulfanyl-octahydropyrano[3,2-b]pyran-3,7-diol (27 mg, 0.069 mmol) in pyridine (1 mL) was added acetic anhydride (1 mL) and the resulting solution stirred at room temperature overnight. The reaction mixture was diluted with EtOAc (10 mL) and washed with saturated aqueous $NaHCO_3$ solution until effervescence ceased (4 × 5 mL) then saturated aqueous copper sulphate solution (5 mL). The organic layer was dried ($MgSO_4$) and concentrated *in vacuo* to yield the title compound (30 mg, 91%) as white crystals. Further purification by flash chromatography (EtOAc:hexane 1:4→1:1) provided an analytical sample; R_f 0.33 (EtOAc:hexane, 3:7); mp 132-134 °C (from $CDCl_3$); $[\alpha]_D^{22.5}$ -66.2 (*c* 0.5, $CHCl_3$); δ_H (400 MHz, $CDCl_3$) 7.48-7.50 (4H, m, ArH), 7.26-7.32 (6H, m, ArH), 5.04 (2H, ddd, *J* 5.2, 10.0, 11.1, H-3,7), 4.58 (2H, d, *J* 10.0, H-2,6), 3.72 (2H, t, *J* 3.1, H-4a,8a), 2.43 (2H, ddd, *J* 3.1, 5.2, 14.0, H-4,8_{eq}), 2.07 (6H, s, 2COCH_3), 1.69 (2H, ddd, *J* 3.1, 11.1, 14.0, H-4,8_{ax}); δ_C (100 MHz, $CDCl_3$) 169.8, 133.2, 129.1, 128.2, 87.8, 74.1, 66.1, 35.1, 21.5; ν_{max}/cm^{-1} ($CHCl_3$) 2961, 1737 (C=O), 1641, 1603, 1560, 1468, 1377, 1260, 1095; *m/z* (ESI+) 497 ([*M*+Na]$^+$, 44%), 424 (57), 396 (100), 368 (88), [Found (*M*+Na)$^+$ 497.1074, $C_{24}H_{26}O_6S_2Na$ req. 497.1069].

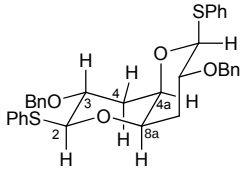


$J_{2,3}$	10.0
$J_{3,4ax}$	11.1
$J_{3,4eq}$	5.2
$J_{4ax,4a}$	3.1
$J_{4eq,4a}$	3.1
$J_{4a,8a}$	1.2

(2S, 3R, 4aR, 6S, 7R, 8aR)-3,7-Bisbenzyloxy-2,6-bisphenylsulfanyl-octahydropyrano[3,2-b]pyran



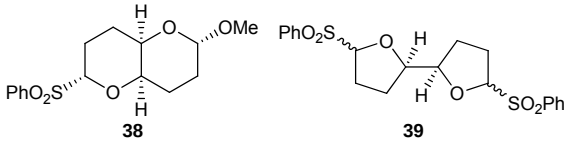
To a stirred solution of (2*S*, 3*R*, 4a*R*, 6*S*, 7*R*, 8a*R*)-2,6-bisphenylsulfanyl-octahydropyrano[3,2-*b*]pyran-3,7-diol (17 mg, 0.044 mmol) in THF (1.5 mL) was added sodium hexamethyldisilazide (174 µL of a 1 M solution in THF, 174 mmol) and the resulting brown suspension stirred for 15 minutes at room temperature. Benzyl bromide (52 µL, 72 mg, 0.436 mmol) was added *via* syringe, and the reaction mixture stirred at room temperature. After 2 h, benzyl bromide (26 µL, 36 mg, 0.218 mmol) and sodium hexamethyldisilazide (174 µL of a 1 M solution in THF, 174 mmol) were added and the reaction mixture stirred overnight at room temperature. The yellow solution was quenched with saturated aqueous NH_4Cl solution (2 mL) and extracted with EtOAc (2 × 5 mL). The organic layers were dried ($MgSO_4$), filtered and concentrated *in vacuo* and the residue purified by flash chromatography (EtOAc:hexane, 1:9→1:1) to yield the title compound (13 mg, 52%) as a yellow-white solid; R_f 0.46 (EtOAc:hexane, 3:7); mp 187-190 °C (from MeCN); $[\alpha]_D^{21}$ -60.0 (*c* 0.35, $CHCl_3$); δ_H (400 MHz, $CDCl_3$) 7.50-7.52 and 7.24-7.37 (20H, m, ArH), 4.68 (2H, d, *J* 11.2, 2C*H*H'Ph), 4.61 (2H, d, *J* 9.6, H-2,6), 4.56 (2H, d, *J* 11.2, 2CH*H*'Ph), 3.75 (2H, ddd, *J* 5.1, 9.6, 11.0, H-3,7), 3.71 (2H, t, *J* 3.0, H-4a,8a), 2.47 (2H, ddd, *J* 3.0, 5.1, 13.8, H-4,8_{eq}), 1.66 (2H, ddd, *J* 3.0, 11.0, 13.8, H-4,8_{ax}); δ_C (100 MHz, $CDCl_3$) 132.3, 128.6, 127.6-129.2 (20CH), 120.0, 89.3, 74.4, 73.0, 71.9, 36.0; ν_{max}/cm^{-1} ($CHCl_3$) 3036, 3875, 1522, 1476, 1422, 1238, 1045, 928; *m/z* (ESI+) 593 ([*M*+Na]$^+$, 16%), 577 (33), 576 (100), 558 (49), [Found (*M*+Na)$^+$ 593.1784, $C_{34}H_{34}O_4S_2Na$ req. 593.1789].



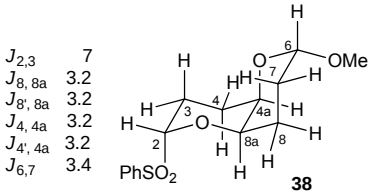
$J_{2,3}$	9.6
$J_{3,4ax}$	11.0
$J_{3,4eq}$	5.1
$J_{4ax,4a}$	3.0
$J_{4eq,4a}$	3.0
$J_{4a,8a}$	1.2

Neither (2S, 3R, 4aR, 6S, 7R, 8aR)-3,7-Bisacetoxy-2,6-bisphenylsulfanyl-octahydropyrano[3,2-b]pyran nor (2S, 3R, 4aR, 6S, 7R, 8aR)-3,7-Bisbenzyloxy-2,6-bisphenylsulfanyl-octahydropyrano[3,2-b]pyran gave the desired bis-alkoxy δ-lactone corresponding to ***7*** *on oxidation under the conditons of Hatanaka.*[3]

***(2R, 4aR, 6S, 8aR)-2-Benzenesulfonyl-6-methoxy-octahydropyrano[3,2-b]pyran 38 and (2R, 2'R)-5,5'-Bisbenzenesulfonyl-octahydro-[2,2']bifuranyl* 39**

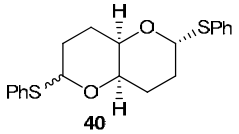


Sulfone synthesis by the method of Ley:[4] To a stirred solution of (2*R* and 2*S*, 4a*R*, 6*S*, 8a*R*)-2,6-dimethoxy-octahydropyrano[3,2-*b*]pyran **9** (24 mg, 0.119 mmol) in DCM (1 mL) was added calcium chloride (79 mg, 0.713 mmol) followed by benzenesulfinic acid (101 mg, 0.713 mmol) and the resulting suspension stirred for 20 h at room temperature. The reaction mixture was diluted with DCM (5 mL), washed with aqueous Na_2CO_3 solution (3 × 2 mL), dried ($MgSO_4$), filtered and concentrated *in vacuo*. The residue was purified by flash chromatography (EtOAc:hexane, 2:8→1:0) to yield benzenesulfinic acid methyl ester (22 mg, 20% consumption of $PhSO_2H$) as a colourless oil, (2*R*, 4a*R*, 6*S*, 8a*R*)-2-benzenesulfonyl-6-methoxy-octahydropyrano[3,2-*b*]pyran **38** (10 mg, 27%) as colourless crystals; R_f 0.40 (EtOAc:hexane, 3:7); mp 108.5-109 °C (from $CHCl_3$); $[\alpha]_D^{20}$ +326 (*c* 0.2, $CHCl_3$); δ_H (400 MHz, $CDCl_3$) 7.89 (2H, dd, *J* 1.6, 7.5, ArH), 7.65 (1H, tt, *J* 1.6, 7.5, ArH), 7.56 (2H, tt, *J* 1.6, 7.5, ArH), 4.72 (1H, d, *J* 7.0, H-2), 4.68 (1H, brd, *J* 3.2, H-6), 4.47 (1H, brt, *J* 3.2, H-8a), 3.86 (1H, brt, *J* 3.2, H-4a), 3.35 (3H, s, OC*H*$_3$), 2.35-2.44 (2H, m, H-3,4), 2.21-2.23 (1H, m, H-3'), 1.99 (1H, ddt, *J* 2.9, 4.6, 13.9, H-8_{ax}), 1.76-1.85 (2H, m, H-4',7), 1.51-1.57 (1H, dddd, *J* 2.3, 3.1, 4.2, 13.9, H-8_{eq}), 1.40 (1H, dddd, *J* 1.3, 2.3, 4.2, 13.3, H-7'); δ_C (100 MHz, $CDCl_3$) 138.1 (C), 134.1 (CH), 129.4 (2CH), 129.3 (2CH), 98.8 (C6), 89.9 (C2), 67.4 (CH), 62.1 (CH), 55.1 (CH_3), 24.0 (CH_2), 23.6 ($2CH_2$), 16.4 (CH_2); ν_{max}/cm^{-1} ($CHCl_3$) 3154, 2883, 2801, 1634, 1540, 1474 (S=O), 1376 (S=O), 909, 734; *m/z* (ESI+) 335 ([*M*+Na]$^+$, 70%), 316 (100), 193 ([*M*-$PhSO_2H$+Na]$^+$, 88), [Found (*M*+Na)$^+$ 335.0938, $C_{15}H_{20}O_5SNa$ req. 335.0929].



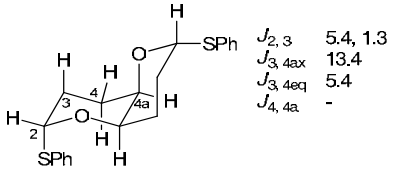
And (2*R*, 2'*R*)-5,5'-bisbenzenesulfonyl-octahydro-[2,2']bifuranyl **39** comprising an inseparable mixture of the (5*S*, 5'*S*) and (5*R*, 5'*R*) epimers as a colourless oil (5 mg, 10%); R_f 0.11 (EtOAc:hexane, 3:7); δ_H (400 MHz, $CDCl_3$) 7.88 (4H, ddd, *J* 1.3, 6.6, 8.4, Ar*H*), 7.59-7.68 (4H, m, Ar*H*), 7.53 (2H, t, 7.3, Ar*H*), 7.44 (2H, dd, *J* 7.4, 8.3, Ar*H*), 4.92 ($1H_{D1}$, dd, *J* 2.5, 8.2, H-5_{D1}), 4.82 ($1H_{D2}$, dd, *J* 4.0, 8.0, H5_{D2}), 4.48-4.50 ($1H_{D1}$, m, H-2_{D1}), 4.29-4.33 ($1H_{D2,}$ m, H-2_{D2}), 2.79 ($1H_{D1}$, ddt, *J* 2.5, 8.0, 14.1, H-4_{D1}), 2.56 ($1H_{D2}$, dddd, *J* 4.0, 6.5, 8.9, 13.1, H-4_{D2}), 2.20-2.39 ($2H_{D1}$, $1H_{D2}$, m), 2.04-2.19 ($1H_{D2}$, m), 1.90-1.98 ($1H_{D1}$, m), 1.80-1.87 ($1H_{D2}$, m); δ_C (100 MHz, $CDCl_3$) 137.5 (C), 134.3 (CH), 134.0 (CH), 129.8 (CH), 129.6 (CH), 129.4 (CH), 129.3 (CH), 95.5 (CH), 94.8 (CH), 86.6 (CH), 83.1 (CH), 27.8 (CH_2), 27.5 (CH_2), 27.0 (CH_2), 25.8 (CH_2); ν_{max}/cm^{-1} ($CDCl_3$) 3131, 2981, 2861, 1793, 1642, 1562, 1470, 1383, 1308, 1153, 1236; *m/z* (ESI+) 445 ([*M*+Na]$^+$, 100%), 303 ([*M*-$PhSO_2H$+Na]$^+$, 38), [Found (*M*+Na)$^+$ 445.0775, $C_{20}H_{22}O_6S_2Na$ req. 445.0756]. And the separable (5*R*, 5'*S*) epimer as a colourless oil (3 mg, 6%); R_f 0.06 (EtOAc:hexane, 3:7); $[\alpha]_D^{21}$ -16.7 (*c* 0.15, $CHCl_3$); δ_H (400 MHz, $CDCl_3$) 7.92 (4H, ddd, *J* 1.3, 6.6, 8.5, *o*C*H*), 7.62-7.67 (2H, m, *p*C*H*), 7.50-7.53 (4H, m, *m*C*H*), 4.97 (1H, dd, *J* 3.7, 7.7, H-5), 4.86 (1H, dd, *J* 2.7, 8.3, H-5'), 4.61 (1H, q, *J* 7.0, H-2), 4.00 (1H, td, *J* 7.0, 9.1, H-2'), 2.69-2.80 (2H, m, H-4,4'), 2.25-2.38 (3H, m, H-4,4',3), 1.97-2.20 (2H, m, 2H-3'), 1.66-1.71 (1H, m, H-3); δ_C (100 MHz, $CDCl_3$) 134.2 (2CH), 129.8 (CH), 129.7 (CH), 129.5 (2CH), 94.9 (2CH), 85.7 (CH), 84.6 (CH), 27.7 (CH_2), 27.6 (CH_2), 27.1 (CH_2), 25.6 (CH_2); ν_{max}/cm^{-1} ($CHCl_3$) 3015, 2894, 1521, 1476 (S=O), 1423, 1230, 1046, 928; *m/z* (ESI+) 445 ([*M*+Na]$^+$, 100%), 303 ([*M*-$PhSO_2H$+Na]$^+$, 60), [Found (*M*+Na)$^+$ 445.0763, $C_{20}H_{22}O_6S_2Na$ req. 445.0756].

(2R, 4aR, 6R, 8aR)- and ***(2R, 4aR, 6S, 8aR)-2,6-Bisbenzenesulfanyl-octahydropyrano[3,2-b]pyran* 40**



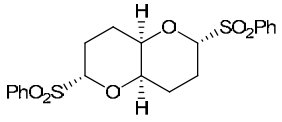
40

To a stirred solution of (2*R* and 2*S*, 4a*R*, 6*S*, 8a*R*)-2,6-dimethoxy-octahydropyrano[3,2-*b*]pyran **9** (100 mg, 0.495 mmol) in DCM (5 mL) over 4 Å molecular sieves was added thiophenol (305 μL, 327 mg, 2.97 mmol) followed by $BF_3{\cdot}OEt_2$ (62 μL, 70 mg, 0.495 mmol). The resulting solution was stirred at room temperature for 1 hour, then diluted with EtOAc (15 mL) and washed with 1 M aqueous NaOH solution (3 × 10 mL). The organic layer was dried ($MgSO_4$), filtered and concentrated *in vacuo* to yield the title compound **40** (154 mg, 87%) as a white solid comprising an inseparable mixture of anomers (αα:αβ ~2.5:1) which was used without further purification; R_f 0.79 (EtOAc:hexane, 3:7); mp 120-123.0 °C (from hexane); δ_H (400 MHz, $CDCl_3$) 7.43-7.53 (4H, m), 7.18-7.31 (6H, m), 5.67 (1Hαα, td, *J* 1.3, 5.4, H-2,6αα), 5.66 (1Hαβ, brd, *J* 4.3, H-2αβ), 4.82 (1Hαβ, dd, *J* 2.1, 11.7, H-6αβ), 4.29-4.32 (2Hαα, m, H-4a,8aαα), 4.20 (1Hαβ, brt, *J* 3.2, H-4a or 8aαβ), 3.62 (1Hαβ, brt, *J* 3.2, H-8a or H-4aαβ), 2.53 (1Hαβ, tt, *J* 4.3, 13.6, H-3αβ), 2.40 (2Hαα, tt, *J* 5.4, 13.4, H-3,7αα), 1.87-2.09 (2Hαα, 2Hαβ, m), 1.68-1.82 (4Hαα, 4Hαβ, m); δ_C (100 MHz, $CDCl_3$) αα 132.7 (C), 131.4 (CH), 129.2 (CH), 127.1 (CH), 85.8 (CH), 64.1 (CH), 26.0 (CH_2), 25.1 (CH_2), αβ 136.9 (C), 131.6 (CH), 129.5 (CH), 127.9 (CH), 127.4 (CH), 85.8 (CH), 84.9 (CH), 73.1 (CH), 63.1 (CH), 29.8 (CH_2), 26.7 (CH_2), 25.8 (CH_2), 25.7 (CH_2); ν_{max}/cm^{-1} ($CHCl_3$) 3154, 2954, 1794, 1659, 1584, 1560, 1475, 1381, 1214, 1109, 909, 735; *m/z* (ESI+) 381 ($[M+Na]^+$, 100%), 341 (38), 316 (25), 271 (23), [Found $(M+Na)^+$ 381.0951, $C_{20}H_{22}O_2S_2Na$ req. 381.0959]



$J_{2,3}$ 5.4, 1.3
$J_{3,4ax}$ 13.4
$J_{3,4eq}$ 5.4
$J_{4,4a}$ -

***((2R, 4aR, 6R, 8aR)-2,6-Bisbenzenesulfonyl-octahydropyrano[3,2-b]pyran* 37**

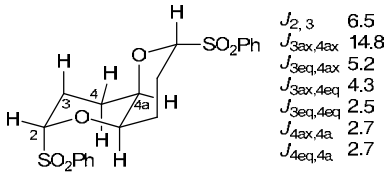


37a

By the method of Ley:[4] To a stirred solution of benzenesulfinic acid (45 mg, 0.319 mmol) in DCM (1 mL) over 4 Å molecular sieves was added a solution of (4a*R*, 8a*R*)-4,4a,8,8a-tetrahydropyrano[3,2-*b*]pyran **19** (11 mg, 0.08 mmol) in DCM (1 mL). The resulting solution was stirred at room temperature for 1 hour then diluted with DCM (5 mL) and washed with 1 M aqueous Na_2CO_3 solution (3 × 2 mL), dried ($MgSO_4$), filtered and concentrated *in vacuo*. The residue was purified by flash chromatography (EtOAc:hexane, 2:8→1:0) to yield the title compound **37a** (2 mg, 6%) as a white solid; R_f 0.23 (EtOAc:hexane, 3:7); mp 101-102 °C (from $CHCl_3$); $[\alpha]_D^{21}$ +208 (*c* 0.1, $CHCl_3$); δ_H (400 MHz, $CDCl_3$) 7.87 (4H, td, *J* 1.3, 7.2, *oCH*), 7.67 (2H, tt, *J* 1.3, 7.2, *pCH*), 7.57 (4H, tt, *J* 1.3, 7.2, *mCH*), 4.66 (2H, brd, *J* 6.5, H-2,6), 4.62 (2H, brt, *J* 2.7, H-4a,8a), 2.40 (2H, ddt, *J* 2.7, 5.2, 14.8, H-4,8_{ax}), 2.32 (2H, dddd, *J* 1.2, 2.5, 5.2, 15.1, H-3,7_{eq}), 2.09 (2H, dddd, *J* 4.3, 6.5, 14.8, 15.1, H-3,7_{ax}), 1.68-1.75 (2H, dm, *J* 14.8, H-4,8_{eq}); δ_C (100 MHz, $CDCl_3$) 137.8 (C), 134.3 (CH), 129.5 (2CH), 129.1 (2CH), 89.4 (C-2,6), 66.4 (C-4a,8a), 24.1 (CH_2), 15.8 (CH_2); ν_{max}/cm^{-1} ($CHCl_3$) 3008, 2894, 1522, 1476 (S=O), 1424, 1196, 1046, 929; *m/z* (ESI+) 445 ($[M+Na]^+$, 86%), 375 (39), 316 (54), 303 ($[M-PhSO_2H+Na]^+$, 100), [Found $(M+Na)^+$ 445.0754, $C_{20}H_{22}O_6S_2Na$ req. 445.0756].

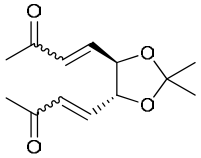
The bis-sulfone **37a** was also prepared, as an inseparable mixture with the corresponding C-2 epimer by oxidation of the sulfides **40**. To a stirred solution of (2*R*, 4a*R*, 6*R* and 6*S*, 8a*R*)-2,6-bisbenzenesulfanyl-octahydropyrano[3,2-*b*]pyran **40** (154 mg, 0.430 mmol) in EtOAc (10 mL) was added $NaHCO_3$ (434 mg, 5.16 mmol) followed by *m*CPBA (75% purity, 495 mg, 2.15 mmol). The resulting suspension was stirred

at room temperature for 1 h, then quenched with saturated $Na_2S_2O_3$ solution (20 mL) and the organic layer separated and washed with aqueous Na_2CO_3 solution (3 × 20 mL), dried ($MgSO_4$) and concentrated *in vacuo*. The residue was sufficiently pure to be used without further purification, but was purified further by flash chromatography (EtOAc:hexane, 3:7→1:0) to yield the title compound **37** (184 mg, 94%) as a white solid comprising an inseparable mixture of the αα anomer identical to that previously synthesised, and the αβ anomer; R_f 0.15 (EtOAc:hexane, 3:7); δ_H (400 MHz, $CDCl_3$) 4.51 (1H, d, *J* 7.1, H-2), 4.44 (2H, dd, *J* 2.5, 11.5, H-6, and brt, *J* 3.6, H-4a), 3.62 (1H, brt, *J* 3.6, H-8a); δ_C (100 MHz, $CDCl_3$) 91.5, 89.2, 72.5, 65.9, 29.2, 28.0, 18.5, 16.3. Other signals were co-incident with those of the αα anomer.



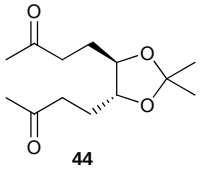
$J_{2,3}$	6.5
$J_{3ax,4ax}$	14.8
$J_{3eq,4ax}$	5.2
$J_{3ax,4eq}$	4.3
$J_{3eq,4eq}$	2.5
$J_{4ax,4a}$	2.7
$J_{4eq,4a}$	2.7

(5*R*, 6*R*)-5,6-Dihydroxy-5,6-*O*-isopropylidene-deca-3,7-diene-2,9-dione[5]



To a stirred solution of dimethyl-(2*S*, 3*S*)-2,3-*O*-isopropylidene-D-tartrate **12** (10 g, 45.9 mmol) in toluene (160 mL) at –78 °C under argon was added dropwise DIBAL (61.2 mL of a 1.5 M solution in toluene, 91.7 mmol) at a rate to maintain the internal temperature below –77 °C. The reaction mixture was stirred at –78 °C for 2 h after the addition was complete. A solution of (acetylmethylene)triphenylphosphorane (36.5 g, 114.7 mmol) in anhydrous methanol (150 mL) was added dropwise at a rate to maintain the internal temperature below –75 °C. When the addition was complete, the reaction mixture was stirred at –78 °C for 6 minutes then at room temperature overnight. The reaction was quenched by the addition of saturated aqueous NH_4Cl (200 mL. The organic layer was separated and the residue was extracted with EtOAc (4 × 100 mL) and the organic layers dried ($MgSO_4$), filtered through a Celite® pad and concentrated *in vacuo*. The resulting yellow solid was triturated with ether (9 × 100 mL), filtered and the filtrate concentrated *in vacuo*. The crude product was purified by flash chromatography (EtOAc:hexane, 3:7) to yield the title compound (8.76 g, 80%) as a yellow oil consisting of an inseparable mixture of double bond isomers.

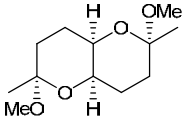
***(5R, 6R)-5,6-Dihydroxy-5,6-O-isopropylidene-deca-2,9-dione* 44**



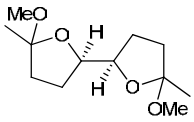
44

To a stirred solution of (5*R,* 6*R*)-5,6-dihydroxy-5,6-*O*-isopropylidene-deca-3,7-diene-2,9-dione (1 g, 4.20 mmol) in dry methanol (20 mL) was added palladium 5% on carbon (75 mg) and the resulting suspension degassed and purged with hydrogen (3 cycles) and stirred for 2 h under 1 atm. hydrogen. The reaction mixture was filtered through Celite™ and the filter plug washed with methanol. The filtrate was concentrated *in vacuo* to yield the unstable title compound **44** (quantitative) as a colourless liquid which darkened on storage; δ_H (400 MHz, $CDCl_3$) 3.54-357 (2H, m, 2C*H*), 2.64 (2H, ddd, *J* 5.4, 8.9, 17.8, 2C*H*H'CO), 2.54 (2H, ddd, *J* 6.9, 9.0, 17.8, 2CH*H'*CO), 2.13 (6H, s, 2COCH_3), 1.84-1.92 (2H, m, 2C*H*H'), 1.61-1.71 (2H, m, 2CH*H'*), 1.32 (6H, s, C[CH_3]$_2$); δ_C (100 MHz, $CDCl_3$) 208.6, 108.8, 80.3, 40.3, 30.5, 27.7, 26.8; ν_{max}/cm^{-1} ($CDCl_3$) 3152, 2988, 1713 (C=O), 1469, 1379, 1216, 1163, 1097; *m/z* (EI+) 242 (M^+, 33%), 167 (37), 87 (100), [Found M^+ 242.1528, $C_{13}H_{22}O_4$ req. 242.1518]

(2*S*, 4a*R*, 6*S*, 8a*R*)-2,6-Dimethoxy-2,6-dimethyl-octahydropyrano[3,2-*b*]pyran 43[6] and ***(2R, 2'R)-5,5'-dimethoxy-5,5'-dimethyl-octahydro[2,2']bifuranyl* 45**



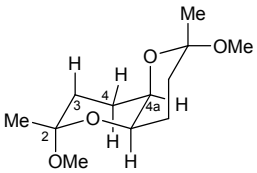
43



45

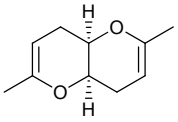
To a stirred solution of (5*R,* 6*R*)-5,6-dihydroxy-5,6-*O*-isopropylidene-deca-2,9-dione **44** (280 mg, 1.16 mmol) in methanol:DCM (1:2, 9 mL) was added water (6 drops) and BF_3•OEt_2 (146 μL, 163 mg, 1.16 mmol) and the resulting solution stirred at room temperature for 22 h. The reaction mixture was concentrated *in vacuo* and the residue purified by flash chromatography (EtOAc:hexane 1:9→1:0) to yield (2*S*, 4a*R*, 6*S*, 8a*R*)-2,6-dimethoxy-2,6-dimethyl-octahydropyrano[3,2-*b*]pyran **43** as white crystals (134 mg, 50%); R_f 0.74 (EtOAc:hexane, 3:7); mp 41-43 °C; (from EtOAc) [lit.[6] (racemate) 110-111 °C (from EtOAc/PE]; $[\alpha]_D^{23}$ +149.5 (*c* 1.1, $CHCl_3$); δ_H (400 MHz, $CDCl_3$) 3.50 (2H, t, *J* 2.9, H-4a,8a), 3.17 (6H, s, 2OCH_3), 1.97 (2H, ddt, *J* 2.9, 4.5, 13.6, H-4,8$_{ax}$), 1.78 (2H, dt, *J* 4.5, 13.6, H-3,7$_{ax}$), 1.58 (2H, tdd, *J* 2.9, 4.5, 13.6, H-4,8$_{eq}$), 1.47 (2H, ddd, *J* 2.6, 4.5, 13.6, H-3,7$_{eq}$), 1.27 (6H, s, 2CH_3).

And (2*R*, 2'*R*)-5,5'-dimethoxy-5,5'-dimethyl-octahydro[2,2']bifuranyl **45** as a colourless oil which rapidly decomposed; R_f 0.42 (EtOAc:hexane, 3:7); δ_H (400 MHz, $CDCl_3$) 3.96-4.01 (2H, m, 2C*H*), 3.25 (6H, s, 2OCH_3), 1.70-2.17 (8H, m, 2CH_2CH_2), 1.43 (6H, s, 2CH_3); δ_C (100 MHz, $CDCl_3$) 81.2, 49.0, 37.8, 27.2, 21.8; *m/z* (ESI+) 253 ([*M*+Na]$^+$, 26%), 239 (100), 207 (36, ketal), 167 (44), [Found (*M*+Na)$^+$ 253.1414, $C_{12}H_{22}O_4Na$ req. 253.1416.



$J_{3ax,4ax}$	13.6	**13.6**
$J_{3eq,4ax}$	4.5	**4.4**
$J_{3ax,4eq}$	4.5	**4.5**
$J_{3eq,4eq}$	2.9	**2.3**
$J_{4ax,4a}$	2.9	**2.9**
$J_{4eq,4a}$	2.9	**2.9**
$J_{4a,8a}$	-	**1.0**

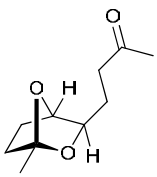
***(4aR, 8aR)-2,6-Dimethyl-4,4a,8,8a-tetrahydropyrano[3,2-*b*]pyran* 42**



42

To a stirred solution of (2*S*, 4a*R*, 6*S*, 8a*R*)-2,6-dimethoxy-2,6-dimethyl-octahydropyrano[3,2-*b*]pyran **43** (15 mg, 0.065 mmol) in DCM (1.5 mL) was added bromotrimethylsilane (82 μL, 95 mg, 0.619 mmol) and the resulting solution stirred at room temperature for 2 h. The pale yellow solution was concentrated *in vacuo* and the crystalline residue immediately redissolved in DCM (1.5 mL), DBU (29 μL, 30 mg, 0.196 mmol) added and the resulting solution stirred at room temperature for 45 minutes. The reaction mixture was filtered through a plug of deactivated (6% w/w water) basic alumina washing with hexane, and the filtrate concentrated *in vacuo* to yield the title compound **42** (6 mg, 55%); R_f 0.76 (EtOAc:hexane, 3:7); $[\alpha]_D^{20}$ +106.6 (*c* 0.5, $CHCl_3$); δ_H (400 MHz, $CDCl_3$) 4.41-4.44 (2H, m, H-3,7), 4.08 (2H, dm, *J* 5.7, H-4a,8a), 2.31-2.39 (2H, dm, *J* 17.8, H-4,8), 2.13-2.20 (2H, dddd, *J* 1.6, 3.1, 4.7, 17.8, H-4',8'), 1.75-1.76 (6H, m, 2CH_3); δ_C (100 MHz, $CDCl_3$) 150.8, 92.5, 68.9, 27.4, 20.4; ν_{max}/cm^{-1} ($CHCl_3$) 1684 (enol ether), 1602, 1510, 1476, 1424, 1224; *m/z* (EI+) 167 ([*M*+H]$^+$, 15%), 69 (100), [Found (*M*+H)$^+$ 167.1077, $C_{10}H_{15}O_2$ req. 167.1072].

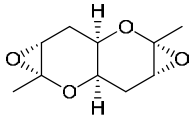
Other elimination conditions also yielded ***(3'R, 4'R)-4-(1-methyl-2,7-dioxabicyclo[2.2.1]hept-3-yl)-butan-2-one* 46**



46

R_f 0.24 (EtOAc:hexane, 3:7); $[\alpha]_D^{23}$ +20.8 (*c* 0.25, $CHCl_3$); δ_H (500 MHz, $CDCl_3$) 4.36 (1H, d, *J* 4.8, H-4'), 3.66 (1H, dd, *J* 4.4, 8.0, H-3'), 2.53 (1H, ddd, *J* 6.0, 7.9, 17.7, C*H*H'CO), 2.45 (1H, dt, *J* 7.1, 17.7, CH*H*'CO), 2.13 (3H, s, COCH_3), 1.80-1.88 (2H, m, 2H-5'), 1.61-1.75 (4H, m, 2H-6', 2H-4), 1.60 (3H, s, CH_3); δ_C (125 MHz, $CDCl_3$) 208.6 (C), 108.4 (C), 80.2 (CH), 79.6 (CH), 38.7 (CH_2), 35.8 (CH_2), 29.9 (CH_3), 29.0 (CH_2), 28.3 (CH_2), 18.4 (CH_3); ν_{max}/cm^{-1} ($CDCl_3$) 3150, 2987, 1713 (C=O), 1642, 1602, 1560, 1470, 1384, 1169, 1095, 907; *m/z* (ES+) 184 (M^+, 39%), 113 ($C_6H_9O_2^+$, 30), 95 (55), 84 (73), 72 ($C_4H_8O^+$, 100), 58 (38), [Found M^+ 184.1107, $C_{10}H_{16}O_3$ req. 184.1099].

***(2S, 3R, 4aR, 6S, 7R, 8aR)-2,3-6,7-Bisepoxy-2,6-dimethyl-octahydropyrano[3,2-b]pyran* 41**

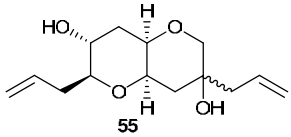


41

Note: It is vital to use DMDO in DCM that is less than one week old in order to achieve reproducible results in this reaction

To a stirred solution of (4a*R*, 8a*R*)-2,6-dimethyl-4,4a,8,8a-tetrahydropyrano[3,2-*b*]pyran **42** (6.7 mg, 0.040 mmol) in DCM (1 mL) at 0 °C was added solid $NaHCO_3$ (200 mg) followed by a solution of DMDO in DCM (4.4 mL of a ~0.02 M solution, 0.88 mmol). The resulting suspension was stirred at 0 °C for 20 minutes then concentrated *in vacuo* at 0 °C to give the unstable title compound **41** (quantitative) as a colourless oil; δ_H (400 MHz, $CDCl_3$) 3.61-3.63 (2H, m, H-4a,8a), 2.97-2.99 (2H, m, H-3,7), 2.18 (4H, m, H-4,8), 1.56 (6H, s, 2CH_3); δ_C (100 MHz, $CDCl_3$) 79.4, 62.7, 53.7, 29.4, 21.1; ν_{max}/cm^{-1} ($CDCl_3$) 2933, 1479, 1440, 1383, 1228, 1088, 1035, 825; *m/z* (ESI+) 301 (100%), 257 (53), 221 ([*M*+Na]$^+$, 42), [Found (*M*+Na)$^+$ 221.0808, $C_{10}H_{14}O_4Na$ req. 221.0790].

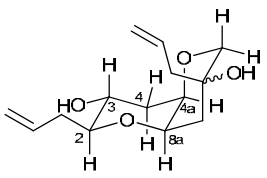
Details of the preparation of the diols **53** have been reported. Under these reaction conditions if the epoxide **18** was not crystallised prior to reaction then ***(2S, 3R, 4aR, 6S, 7S, 8aR)-2,7-diallyl-octahydropyrano[3,2-b]pyran-3,7-diol* 55** was isolated as a colourless oil and approximately 3:1 mixture of inseparable diastereoisomers



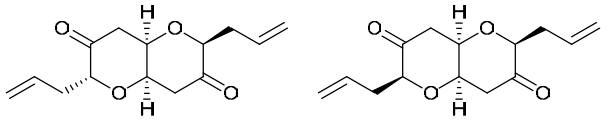
55

R_f 0.05 (EtOAc:PE, 3:7); mp 81-84 °C (from EtOAc); *data for major diastereomer* δ_H (400 MHz, $CDCl_3$) 5.97-5.87 (2H, m, 2C*H*=CH_2), 5.25-5.05 (4H, m, 2C*H*=CH_2), 3.71 (1H, ddt, *J* 4.8, 9.0, 11.3, H-3), 3.57 (1H, dd, *J* 2.6, 11.0, H-6), 3.57 (1H, ddd, *J* 1.3, 2.6, 4.0, H-8a), 3.53 (1H, dt, *J* 1.3, 3.0, H-4a), 3.23 (1H, d, *J* 11.0, H-6'), 3.12 (1H, ddd, *J* 4.0, 6.5, 9.0, H-2), 2.75 (1H, ddm, *J* 7.0, 13.5, C*H*H'C-7), 2.56-2.49 (1H, m, C*H*H'C-2), 2.44 (1H, ddm, *J* 8.1, 13.5, CH*H*'C-7), 2.38-2.31 (1H, m, CH*H*'C-2), 2.24 (1H, ddd, *J* 3.0, 4.8, 13.2, H-4_{eq}), 2.12 (1H, dt, *J* 2.6, 13.9, H-8), 1.63 (1H, ddd, *J* 1.2, 4.0, 13.9, H-8'), 1.58 (1H, ddd, *J* 3.0, 11.3, 13.2, H-4_{ax}), 1.49 (1H, d, *J* 4.8, OH-3); δ_C (125 MHz, $CDCl_3$) 134.7 (CH), 133.4 (CH), 120.2 (CH_2), 117.2 (CH_2), 80.8 (C-2), 75.5 (CH_2), 74.7 (C-4a), 72.8 (C-8a), 67.2 (C), 66.1 (CH), 42.9 (CH_2), 39.4 (CH_2), 37.5 (CH_2), 36.7 (CH_2); ν_{max}/cm^{-1} (film) 3420 (OH), 2923, 2857, 1435, 1260, 1103, 1023, 915; *m/z* (ESI+) 280 (14%), 279 (100), 277 ([*M*+Na]$^+$, 7), [Found; (*M*+Na)$^+$ 277.1421, $C_{14}H_{22}O_4Na$ req. 277.1416].

$J_{2,3}$	9.0
$J_{3,4ax}$	11.3
$J_{3,4eq}$	4.8
$J_{4ax,4a}$	3.0
$J_{4eq,4a}$	3.0
$J_{4a,8a}$	1.3

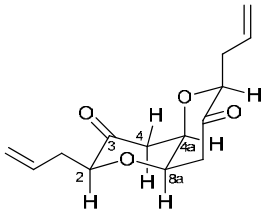


(2S, 4aR, 6S, 8aR)-2,6-Diallyl-tetrahydropyrano[3,2-b]pyran-3,7-dione* 63a and *(2R, 4aR, 6S, 8aR)-2,6-diallyl-tetrahydropyrano[3,2-b]pyran-3,7-dione



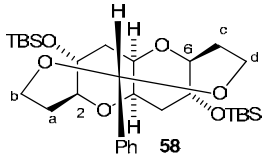
To a stirred solution of (2*S* and 2*R*, 3*R*, 4a*R*, 6*S*, 7*R*, 8a*R*)-2,6-diallyl-octahydropyrano[3,2-*b*]pyran-3,7-diol **53** (6 mg, 0.024 mol) in acetone (1 mL) at 0 °C was added dropwise Jones reagent (34 µL, 0.094 mmol) and the resulting solution stirred for 1 h. The solution was decanted and partitioned between EtOAc (5 mL) and saturated aqueous $NaHCO_3$ solution (5 mL). The organic layer was dried ($MgSO_4$), filtered, concentrated *in vacuo* and purified by flash chromatography (EtOAc:PE, 35:65) to yield (2*S*, 4a*R*, 6*S*, 8a*R*)-2, 6-diallyl-tetrahydropyrano[3,2-*b*]pyran-3, 7-dione (4.2 mg, 71%) as a colourless oil; R_f 0.47 (EtOAc:PE, 1:1); $[\alpha]_D^{20}$ -139.0 (*c* 0.21, $CHCl_3$); δ_H (400 MHz, $CDCl_3$) 5.78-5.88 (2H, tdd, *J* 6.3, 10.1, 17.2, C*H*=CHH'), 5.10 (2H, app. qd, *J* 1.7, 17.2, CH=C*H*H'), 5.06 (2H, app. tdd, *J* 1.3, 1.7, 10.1, CH=CH*H*') 4.13-4.16 (2H, m, H-4a,8a), 3.83 (2H, dd, *J* 4.4, 7.2, H-2,6), 2.82 (2H, dd, *J* 5.0, 15.8, H-4,8), 2.76 (2H, dd, *J* 0.8, 5.3, 15.8, H-4',8'), 2.58 (2H, tddd, *J* 1.3, 3.1, 5.7, 14.8, C*H*H'), 2.41 (2H, ttd, *J* 1.3, 6.3, 14.8, CH*H*'); δ_C (125 MHz, $CDCl_3$) 206.8 (C), 133.2 (CH), 117.8 (CH_2), 82.3 (CH), 73.8 (CH), 42.8 (CH_2), 34.5 (CH_2); ν_{max}/cm^{-1} (film) 2929, 1732 (C=O), 1104; *m/z* (ESI+) 273 ([*M*+Na]$^+$, 100%), [Found (*M*+Na)$^+$ 273.1094, $C_{14}H_{18}O_4Na$ req. 273.1103]. And (2*R*, 4a*R*, 6*S*, 8a*R*)-2,6-diallyl-tetrahydropyrano[3,2-*b*]pyran-3,7-dione (1.3 mg, 22%) as a colourless oil which was not particularly stable; R_f 0.62 (EtOAc:PE, 1:1); δ_H (400 MHz, $CDCl_3$) 5.73-5.83 (2H, m, 2C*H*=CH_2), 5.06-5.15 (4H, m, 2CH=CH_2), 4.47 (1H, dt, *J* 4.5, 6.8), 4.15-4.19 (2H, m), 3.81 (1H, dd, *J* 4.5, 6.6), 2.83 (1H, dd, *J* 3.9, 15.8), 2.81 (1H, dd, *J* 6.8, 14.8), 2.56 (1H, dd, *J* 3.3, 15.8), 2.35-2.61 (4H, m, 2CH_2allyl) ; δ_C (125 MHz, $CDCl_3$) 209.1 (C), 207.8 (C), 133.0 (CH), 132.4 (CH), 118.5 (CH_2), 118.1 (CH_2), 83.3 (CH), 77.2 (CH), 73.2 (CH), 70.3 (CH), 41.0 (CH2), 40.6 (CH_2), 35.3 (CH_2), 34.2 (CH_2); ν_{max}/cm^{-1} (film) 1730 (C=O), 1644, 1398, 1086, 921.

$J_{4ax,4a}$	5.0	5.0
$J_{4eq,4a}$	5.3	5.0
$J_{4a,8a}$	-	3.0



Attempted epimerisation of the ketones under basic conditions resulted in decomposition.

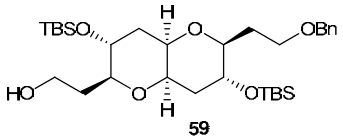
***(3R, 4S, 12S, 13R, 15R, 16R)-3,13-Bis-(t-butyldimethylsilanyloxy)-8-phenyl-7,9,16,17-tetraoxa-tricyclo[10.3.1.1^{4,15}]heptadecane* 58** (numbering used for spectral assignment is shown)



To a stirred solution of (2*S*, 3*R*, 4a*R*, 6*S*, 7*R*, 8a*R*)-3,7-bis-(*t*-butyldimethylsilanyloxy)-2,6-bis-(2-hydroxyethyl)-octahydropyrano[3,2-*b*]pyran **57a** (9.2 mg, 0.019 mmol) in toluene (2 mL) over 4 Å molecular sieves was added benzaldehyde dimethyl acetal (8.4 µL, 8.6 mg, 0.056 mmol) and catalytic PPTS (1 crystal) and the resulting solution heated under reflux for 24 h. The reaction mixture was allowed to cool, washed with saturated aqueous $NaHCO_3$ solution (2 mL), dried (Na_2SO_4), filtered, concentrated *in vacuo* and the residue purified by flash chromatography (EtOAc:PE, 5:95) to yield the title compound **58** (4.5 mg, 41%) as an unstable, colourless oil; R_f 0.94 (EtOAc:PE, 3:7), 0.65 (1:9); δ_H (400 MHz, $CDCl_3$) 7.45 (2H, d, *J* 7.6, Ar*H*), 7.33 (2H, t, *J* 7.4, Ar*H*), 7.28 (1H, m, Ar*H*), 5.53 (1H, s, acetal*H*), 4.59 (1H, ddd, *J* 4.9, 9.3, 11.0, H-7), 4.49 (1H, ddd, *J* 1.4, 8.6, 12.2, H-b), 4.46 (1H, ddd, *J* 5.0, 9.1, 10.9, H-3), 3.82 (1H, dd, *J* 9.1, 10.6, H-d), 3.67-3.82 (2H, m, H-b' and 4a or 8a), 3.59 (1H, m, H-4a or 8a), 3.32 (1H, dd, *J* 7.1, 9.1, H-2), 3.23 (1H, dd, *J* 6.5, 9.3, H-6), 2.84 (1H, dt, *J* 9.2, 13.4, H-d'), 2.37 (1H, ddd, *J* 3.0, 12.2, 15.5, H-a), 2.06-2.19 (3H, m, H-4,8,c), 1.72 (1H, ddd, *J* 1.3, 3.3, 7.1, 15.5, H-a'), 1.38-1.50 (3H, m, H-4',8',c'), 0.92 (9H, s, SiC[CH_3]$_3$), 0.90 (9H, s, SiC[CH_3]$_3$), 0.21 (3H, s, SiCH_3), 0.18

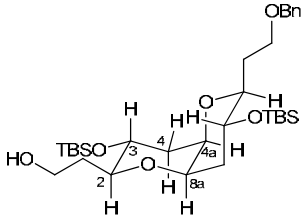
(3H, s, SiCH_3), 0.13 (3H, s, SiCH_3), 0.11 (3H, s, SiCH_3); δ_C (100 MHz, $CDCl_3$) 128.4 (CH), 1282. (CH), 127.6 (CH), 101.9 (CH), 77.1 (CH), 76.6 (CH), 71.8 (C-4a or 8a), 71.6 (C-4a or 8a), 66.2 (CH), 66.2 (CH_2), 65.8 (CH), 57.6 (CH_2), 38.8 (C-4 and 8), 29.7 (CH_2), 29.2 (CH_2), 26.4 (CH_3), 26.3 (CH_3), 18.4 (CH), -3.7 (CH_3), -3.8 (CH_3), -3.9 (CH_3), -4.0 (CH_3); *m/z* (ESI+) 601 ([*M*+Na]$^+$, 59%), 598 (100), [Found (*M*+Na)$^+$ 601.3340, $C_{31}H_{34}O_6Si_2Na$ req. 601.3357].

***(2S, 3R, 4aR, 6S, 7R, 8aR)-6-(2-Benzyloxyethyl)-2-(2-hydroxyethyl)-3,7-bis-(t-butyldimethylsilanyloxy)-octahydropyrano[3,2-b]pyran* 59**



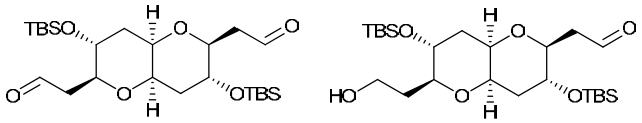
59

To a stirred solution of the acetal **58** (13.8 mg, 0.024 mmol) in toluene (2 mL) at 0 °C was added DIBAL (111 μL of a 1.5 M solution, 0.167 mmol) and the resulting solution stirred at room temperature overnight. The reaction mixture was cooled to 0 °C, quenched with saturated aqueous sodium potassium tartrate solution (2 mL) and extracted with EtOAc (4 × 1 ml). The combined organic layers were dried ($MgSO_4$), filtered, concentrated *in vacuo*, and purified by flash chromatography (EtOAc:PE, 1:9) to yield recovered starting material (44%) and the title compound **59** (2.4 mg, 17%) as colourless crystals; (R_f 0.75 (EtOAc:PE, 3:7); $[\alpha]_D^{25}$ -55.9 (*c* 0.17, $CHCl_3$); mp 65-66 °C (from $CHCl_3$); δ_H (400 MHz, $CDCl_3$) 7.32-7.33 (5H, m, Ar*H*), 4.55 (1H, d, *J* 12.3, C*H*H'Ph), 4.46 (1H, d, *J* 12.3, CH*H*'Ph), 3.77-3.82 (2H, m, C*HH*'O), 3.52-3.66 (5H, m, C*HH*'O, H-3,7,4a or 8a), 3.48 (1H, t, *J* 3.4, H-4a or 8a), 3.29 (1H, dt, *J* 3.0, 8.9, H-2 or 6), 3.16 (1H, dt, *J* 2.9, 9.5, H-2 or 6), 2.89-2.91 (1H, m, O*H*), 2.18 (1H, dtd, *J* 3.5, 8.5, 10.9), 2.09 (1H, ddd, *J* 3.0, 4.6, 13.6), 1.78-2.08 (2H, m), 1.68-1.78 (1H, m), 1.57-1.68 (1H, m), 1.55 (1H, ddd, *J* 3.5, 10.9, 14.1), 1.48 (1H, ddd, *J* 3.6, 10.9, 13.8), 0.86 (9H, s, SiC[CH_3]$_3$), 0.85 (9H, s, SiC[CH_3]$_3$), 0.04 (3H, s, SiCH_3), 0.03 (6H, s, SiCH_3), 0.03 (3H, s, SiCH_3); δ_C (125 MHz, $CDCl_3$) 139.8 (C), 128.5 (CH), 127.6 (CH), 127.4 (CH), 83.7 (CH), 78.9 (CH), 74.1 (CH), 73.8 (CH), 73.4 (CH_2), 67.3 (CH), 66.7 (CH), 66.5 (CH_2), 62.0 (CH_2), 38.8 (CH_2), 38.2 (CH_2), 34.3 (CH_2), 32.0 (CH_2), 25.8 (CH_3), 17.9 (2C), -4.1 (CH_3), -4.2 (CH_3), -4.7 (2CH_3); ν_{max}/cm^{-1} (film) 3469, 2928, 1472, 1253, 1095, 837, 775; *m/z* (ESI+) 603 ([*M*+Na]$^+$, 100%), [Found (*M*+Na)$^+$ 603.3533, $C_{31}H_{36}O_6Si_2Na$ req. 603.3513].



$J_{2,3}$ and $J_{6,7}$ 8.9 and 9.5 (or vice versa)
$J_{4a/8a,4ax/8ax}$ 3.4
$J_{4a/8a,4eq/8ax}$ 3.4

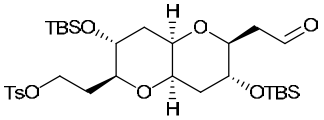
2S, 3R, 4aR, 6S, 7R, 8aR)-3,7-Bis-(t-butyldimethylsilanyloxy)-6-(2-hydroxyethyl)-2-(2-oxoethyl)-octahydropyrano[3,2-b]pyran and **(*2S, 3R, 4aR, 6S, 7R, 8aR)-3,7-bis-(t-butyldimethylsilanyloxy)-2,6-bis-(2-oxoethyl)-octahydropyrano[3,2-b]pyran***



To a stirred solution of (2*S*, 3*R*, 4a*R*, 6*S*, 7*R*, 8a*R*)-3,7-bis-(*t*-butyldimethylsilanyloxy)-2,6-bis-(2-hydroxyethyl)-octahydropyrano[3,2-*b*]pyran **57a** (11.5 mg, 0.023 mmol) in DCM (1 mL) at room temperature was added NMO (4.4 mg, 0.038 mmol) and powdered activated 4 Å molecular sieves and the resulting suspension stirred for 10 minutes before catalytic TPAP was added. The reaction mixture was stirred for 30 minutes, filtered through a short pad of silica and the filtrate concentrated *in vacuo* and purified by flash chromatography (EtOAc:PE, 1:9) to yield (2*S*, 3*R*, 4a*R*, 6*S*, 7*R*, 8a*R*)-3,7-bis-(*t*-butyldimethylsilanyloxy)-6-(2-hydroxyethyl)-2-(2-oxoethyl)-octahydropyrano[3,2-*b*]pyran (4.7 mg, 41%) as a colourless oil; R_f 0.57 (EtOAc:PE, 3:7); $[\alpha]_D^{18}$ -78.1 (*c* 0.32, $CHCl_3$); δ_H (400 MHz, $CDCl_3$) 9.78 (1H, dd, *J* 1.8, 3.0, C*H*O), 3.78-3.83 (2H, m, C*HH*'OH), 3.58-3.67 (5H, m, H-2,3,4a,7,8a), 3.30 (1H, dt, *J* 2.8, 8.9, H-6), 2.73 (2H, ddd, *J* 1.8, 3.3, 16.2, C*H*H'CHO and brs, O*H*), 2.50 (1H, ddd, *J* 3.0, 8.2, 16.2,

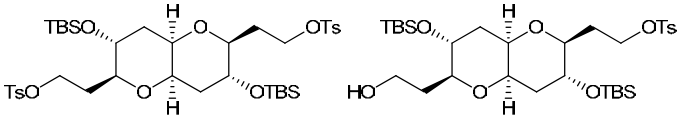
CH*H*'CHO), 2.15 (1H, dm, *J* 16.1), 1.67-1.76 (1H, m), 1.60 (1H, ddd, *J* 3.3, 10.5, 13.8), 1.52 (1H, ddd, *J* 3.3, 10.9, 13.7), 0.85 (18H, 2 × s, 2SiC[CH_3]$_3$), 0.04 (12H, s, 2Si[CH_3]$_2$); δ_C (100 MHz, $CDCl_3$) 202.0 (CH), 83.9 (CH), 78.2 (CH), 74.2 (CH), 74.1 (CH), 67.2 (CH), 66.9 (CH), 62.2 (CH_2), 46.6 (CH_2), 38.9 (CH_2), 38.4 (CH_2), 34.1 (CH_2), 26.1 (CH_3), 18.2 (C), -3.7 (CH_3), -3.8 (CH_3), -4.4 (2CH_3); ν_{max}/cm^{-1} (film) 3756, 2929, 1733 (C=O), 1258, 1096, 837, 777; *m/z* (ESI+) 511 ([*M*+Na]$^+$, 100%) [Found (*M*+Na)$^+$ 511.2906, $C_{24}H_{48}O_6Si_2$ req. 511.2887]. And recovered starting material (0.6 mg, 5%) and (2*S*, 3*R*, 4a*R*, 6S, 7*R*, 8a*R*)-3,7-bis-(*t*-butyldimethylsilanyloxy)-2,6-bis-(2-oxoethyl)-octahydropyrano[3,2-*b*]pyran **57a** (3.2 mg, 28%) as colourless crystals; R_f 0.79 (EtOAc:PE, 3:7); mp 56-57 °C (from $CHCl_3$); $[\alpha]_D^{22}$ -42.5 (*c* 0.16, $CHCl_3$); δ_H (400 MHz, $CDCl_3$) 9.77 (2H, dd, *J* 1.8, 3.0, C*H*O), 3.57-3.65 (6H, m, H-2,3,4a,6,7,8a), 2.73 (2H, dd, *J* 1.9, 3.3, 16.3, C*H*H'CHO), 2.48 (2H, ddd, *J* 3.0, 3.8, 16.3, CH*H*'CHO), 2.14 (2H, ddd, *J* 2.9, 3.8, 13.7, H-4,8$_{eq}$), 1.55 (2H, ddd, *J* 3.3, 10.6, 13.7, H-4,8$_{ax}$), 0.84 (18H, s, 2SiC[CH_3]$_3$), 0.04 (6H, s, 2SiCH_3), 0.03 (6H, s, 2SiCH_3); δ_C (100 MHz, $CDCl_3$) 202.1 (CH), 78.2 (CH), 74.3 (CH), 67.1 (CH), 46.7 (CH_2), 38.6 (CH_2), 26.1 (CH_3), 18.2 (C), -3.7 (CH_3), -4.4 (CH_3); ν_{max}/cm^{-1} (film) 2931, 1732 (C=O), 1254, 1099, 838, 777; *m/z* was not obtained due to instability

(2S, 3R, 4aR, 6S, 7R, 8aR)-3,7-bis-(t-butyldimethylsilanyloxy)-2-(2-toluene-4-sulfonyloxyethyl)-6-(2-oxoethyl)-octahydropyrano[3,2-b]pyran



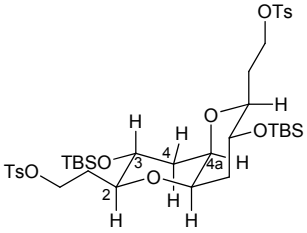
To a stirred solution of (2*S*, 3*R*, 4a*R*, 6*S*, 7*R*, 8a*R*)-3,7-bis-(*t*-butyldimethylsilanyloxy)-6-(2-hydroxyethyl)-2-(2-oxoethyl)-octahydropyrano[3,2-*b*]pyran (11.2 mg, 0.023 mmol) in DCM (1 ml) and Et_3N (0.3 mL) was added DMAP (11.2 mg, 0.092 mmol) and TsCl (19.6 mg, 0.115 mmol). The resulting solution was stirred at room temperature overnight, then poured into saturated aqueous $NaHCO_3$ solution (2 mL) and extracted with DCM (2 1 mL). The combined organic layers were dried ($MgSO_4$), filtered and concentrated *in vacuo* to give a brown residue which was purified by flash chromatography (EtOAc:PE, 1:9) to yield the title compound (4 mg, 23%)as a colourless oil; R_f 0.86 (EtOAc:PE, 3:7); $[\alpha]_D^{18}$ -64.3 (*c* 0.21, $CHCl_3$); δ_H (400 MHz, $CDCl_3$) 9.75 (1H, dd, *J* 1.8, 3.0, C*H*O), 7.79 (2H, td, J 1.9, 8.4, Ar*H*), 7.33 (2H, dm, *J* 8.4, Ar*H*), 4.15 (2H, dd, *J* 5.0, 7.9, CH_2OTs), 3.52-3.59 (3H, m), 3.43-3.50 (1H, m), 3.35 (1H, dt, *J* 1.0, 3.0, H-4a or 8a), 3.04 (1H, ddd, *J* 2.8, 9.2, 9.9, H-2), 2.70 (1H, ddd, *J* 1.8, 3.4, 16.1, C*H*H'CHO), 2.45 (1H, ddd, *J* 3.0, 8.0, 16.1, CH*H*'CHO), 2.43 (3H, s, ArCH_3), 2.16 (1H, tdd, J 2.8, 7.9, 16.1, C*H*H'CH_2), 2.06 (1H, ddd, *J* 3.0, 4.7, 13.2, H-4 or 8$_{eq}$), 1.94 (1H, ddd, *J* 3.3, 4.3, 13.4, H-4 or 8$_{eq}$), 1.56-1.62 (1H, m, CH*H*'CH_2), 1.42-1.50 (2H, m, H-4,8$_{ax}$), 0.85 (9H, s, SiC[CH_3]$_3$), 0.83 (9H, s, SiC[CH_3]$_3$), 0.03 (3H, s, SiCH_3), 0.02 (3H, s, SiCH_3), -0.00 (3H, s, SiCH_3), -0.02 (3H, s, SiCH_3); δ_C (100 MHz, $CDCl_3$) 202.1 (CH), 144.8 (C), 140.0 (C), 130.1 (CH), 128.2 (CH), 78.1 (2CH), 74.2 (CH), 74.0 (CH), 67.6 (CH_2), 67.4 (CH), 67.1 (CH), 46.6 (CH_2), 38.6 (CH_2), 38.5 (CH_2), 31.7 (CH_2), 26.1 (CH_3), 18.2 (C), 15.6 (CH_3), -3.7 (CH_3), -4.4 (CH_3); ν_{max}/cm^{-1} (film) 2931, 2858, 1728 (C=O), 1360, 1178, 1097, 837, 777; *m/z* (ESI+) 665 ([*M*+Na]$^+$, 52%), 576 (100), 558 (56), 373 (37), [Found (*M*+Na)$^+$ 665.2973, $C_{31}H_{54}O_8Si_2SNa$ req. 665.2976]

(2S, 3R, 4aR, 6S, 7R, 8aR)-3,7-Bis-(t-butyldimethylsilanyloxy)-6-(2-hydroxyethyl)-2-(2-toluene-4-sulfonyloxyethyl)-octahydropyrano[3,2-b]pyran and ***(2S, 3R, 4aR, 6S, 7R, 8aR)-3,7-bis-(t-butyldimethylsilanyloxy)-2,6-bis-(2-toluene-4-sulfonyloxyethyl)-octahydropyrano[3,2-b]pyran***



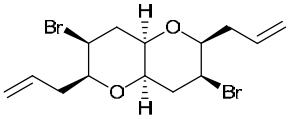
Many methods were used for this transformation, an example follows: To a stirred solution of (2*S*, 3*R*, 4a*R*, 6*S*, 7*R*, 8a*R*)-3,7-bis-(*t*-butyldimethylsilanyloxy)-2,6-bis-(2-hydroxyethyl)-octahydropyrano[3,2-*b*]pyran **57a** (21 mg, 0.043 mmol) in THF (1.5 mL) at 0 °C was added dropwise KHMDS (90 μL of a 0.5 M solution, 0.045 mmol) and the resulting suspension stirred for 5 minutes. A solution of tosyl chloride (8 mg, 0.043 mmol) in THF (1 mL) was added dropwise and the reaction mixture stirred for 10 minutes. The reaction was quenched with saturated aqueous NH_4Cl solution (2 mL) and extracted with DCM (3 ×

3 mL). The combined organic layers were dried ($MgSO_4$), concentrated and purified by flash chromatography (EtOAc:PE, 1:10) to yield (2*S*, 3*R*, 4a*R*, 6S, 7*R*, 8a*R*)-3,7-bis-(*t*-butyldimethylsilanyloxy)-6-(2-hydroxyethyl)-2-(2-toluene-4-sulfonyloxyethyl)-octahydropyrano[3,2-*b*]pyran (4 mg, 14.5%) as colourless crystals; R_f 0.56 (EtOAc:PE, 3:7); mp 79-79.5 °C (from $CHCl_3$); $[\alpha]_D^{22}$ -51.2 (c 0.125, $CHCl_3$); δ_H (400 MHz, $CDCl_3$) 7.79 (2H, td, *J* 1.9, 8.3, 2C*H*), 7.33 (2H, dm, *J* 8.3, 2C*H*), 4.15-4.18 (2H, m, C*HH*'OTs), 3.76-3.80 (2H, m, C*HH*'OH), 3.54 (1H, dt, *J* 0.9, 3.3, H-8a or 4a), 3.54 (1H, ddd, *J* 4.6, 6.4, 9.3, H-3 or 7), 3.47 (1H, ddd, *J* 4.9, 9.2, 11.0, H-3 or 7), 3.34 (1H, dt, *J* 0.9, 3.6, H-4a or 8a), 3.26 (1H, dt, *J* 3.0, 9.3, H-6 or 2), 3.05 (1H, ddd, *J* 2.6, 9.4, 9.9, H-2 or 6), 2.43 (3H, s, ArCH_3), 2.17 (1H, tdd, *J* 2.7, 7.5, 14.3, C*H*H'CH_2OTs), 2.06 (1H, ddd, *J* 3.1, 4.6, 13.7, H-8 or 4_{eq}), 1.99 (1H, dm, *J* 14.9, C*H*H'CH_2OH), 1.91 (1H, ddd, *J* 2.9, 4.9, 13.6, H-4 or 8_{eq}), 1.63-1.72 (1H, m, CH*H*'CH_2OH), 1.57 (1H, tdd, *J* 4.6, 10.0, 14.4, CH*H*'CH_2OTs), 1.51 (1H, ddd, *J* 2.8, 10.4, 13.7, H-8 or 4_{ax}), 1.42 (1H, ddd, *J* 3.4, 10.9, 13.9, H-4 or 8_{ax}), 0.85 (9H, s, SiC[CH_3]$_3$), 0.83 (9H, s, SiC[CH_3]$_3$), 0.03 (6H, s, 2SiCH_3), 0.00 (3H, s, SiCH_3), -0.01 (3H, s, SiCH_3); δ_C (100 MHz, $CDCl_3$) 144.8 (C), 132.3 (CH), 129.9 (CH), 83.2 (C-6), 78.1 (C-2), 74.2 (C-8a), 73.9 (C-4a), 67.6 (C-3), 67.5 (CH_2), 67.0 (C-7), 62.2 (CH_2), 39.0 (C-4), 38.4 (C-8), 34.0 (CH_2), 31.7 (CH_2), 26.1 (6CH_3), 22.0 (CH_3), 18.2 (2C), -3.7 (CH_3), -3.8 (CH_3), -4.3 (CH_3), -4.4 (CH_3); ν_{max}/cm^{-1} (film) 3534, 2929, 1361, 1252, 1173, 1095, 837, 775; *m/z* (ESI+) 670 (9%), 669 (25), 668 (44), 667 ([*M*+Na]$^+$, 100%), [Found (*M*+Na)$^+$ 667.3129, $C_{31}H_{56}O_8SSi_2Na$ req. 667.3132]. And recovered starting material (13.7 mg, 65%) and (2*S*, 3*R*, 4a*R*, 6*S*, 7*R*, 8a*R*)-3,7-bis-(*t*-butyldimethylsilanyloxy)-2,6-bis-(2-toluene-4-sulfonyloxyethyl)-octahydropyrano[3,2-*b*]pyran (2.4 mg, 7%); R_f 0.69 (EtOAc:PE, 3:7); $[\alpha]_D^{21}$ -25.7 (*c* 0.175, $CHCl_3$); δ_H (400 MHz, $CDCl_3$) 7.78 (4H, d, *J* 8.4, 2C*H*), 7.31 (4H, dd, *J* 0.7, 8.4, 2C*H*), 4.11-4.17 (4H, m, 2C*HH*'), 3.38 (2H, ddd, *J* 4.8, 9.1, 10.9, H-3,7), 3.26 (2H, t, *J* 3.4, H-4a,8a), 2.99 (2H, ddd, *J* 2.8, 9.1, 10.0, H-2,6), 2.43 (6H, s, 2ArCH_3), 2.09-2.19 (2H, m, 2C*H*H'), 1.84 (2H, ddd, *J* 3.4, 4.8, 13.5, H-4,8_{eq}), 1.50-1.54 (2H, m, 2CH*H*'), 1.36 (2H, ddd, *J* 3.4, 10.9, 13.5, H-4,8_{ax}), 0.84 (18H, s, 2SiC[CH_3]$_3$), -0.01 (6H, s, 2SiCH_3), -0.02 (6H, s, 2SiCH_3); δ_C (100 MHz, $CDCl_3$) 144.8 (C), 130.1 (CH), 128.3 (CH), 115.2 (C), 78.0 (CH), 74.0 (CH), 67.7 (CH_2), 67.5 (CH), 38.6 (CH_2), 31.7 (CH_2), 26.1 (3CH_3), 22.0 (CH_3), 14.6 (C), -3.8 (CH_3), -4.4 (CH_3); ν_{max}/cm^{-1} (film) 2958, 1366, 1178, 1095, 838, 777; *m/z* (ESI+) 825 (6%), 824 (13), 823 (36), 822 (54), 821 ([*M*+Na]$^+$, 100), [Found (*M*+Na)$^+$ 821.3193, $C_{38}H_{62}O_{10}S_2Si_2Na$ req. 821.3221].



$J_{2,3}$	9.1
$J_{3,4ax}$	10.9
$J_{3,4eq}$	4.8
$J_{4ax,4a}$	3.4
$J_{4eq,4a}$	3.4

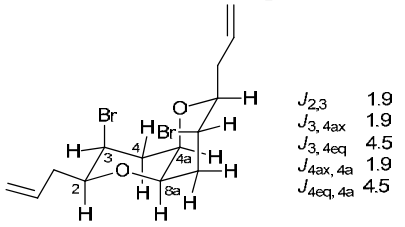
***(2S, 3S, 4aR, 6S, 7S, 8aR)-2,6-Diallyl-3,7-dibromo-octahydropyrano[3,2-b]pyran* 68**



68

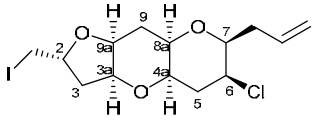
To a stirred solution of (2*S*, 3*R*, 4a*R*, 6*R/S*, 7*R*, 8a*R*)-2,6-diallyl-octahydropyrano[3,2-*b*]pyran-3,7-diol **53** (9 mg, 0.035 mmol) in DCM (2 mL) at room temperature was added pyridine (40 mL, 39 mg, 0.496 mmol) and dropwise trifluoromethanesulfonic anhydride (72 mL, 120 mg, 0.425 mmol). The resulting brown suspension was stirred for 30 minutes then diluted with DCM (3 mL) and washed with saturated aqueous $NaHCO_3$ (4 mL), saturated aqueous $CuSO_4$ solution (4 mL) and water (4 mL). The organic layer was dried ($MgSO_4$), filtered through a 5 mm silica pad and concentrated *in vacuo* to yield the crude ditriflate **67** as a yellow oil; R_f 0.72 (EtOAc:PE, 3:7); δ_H (400 MHz, $CDCl_3$) 5.84 (2H, ddt, *J* 7.0, 10.4, 13.8, 2C*H*=CH_2), 5.13-5.20 (4H, m, 2CH=C*HH*'), 4.86 (2*H*, ddd, *J* 5.2, 9.5, 11.1, H-3,7), 3.72 (2H, t, *J* 3.1, H-4a,8a), 3.43 (2H, ddd, *J* 3.1, 7.5, 9.5, H-2,6), 2.57 (2H, ddd, *J* 3.1, 5.3, 13.2, H-4,8_{eq}), 2.51 (2H, tddd, *J* 1.3, 3.2, 7.0, 14.7, 2C*H*H'), 2.33 (2H, ttd, *J* 1.3, 7.0, 14.7, 2CH*H*'), 1.93 (2H, ddd, *J* 3.1, 11.1, 13.2, H-4,8_{ax}). The ditriflate was dissolved in toluene (2 mL), tetrabutylammonium bromide (69 mg, 0.213 mmol) added and the resulting solution heated to reflux for 2 h. The solution was cooled to room

temperature, filtered through a short silica pad and the filtrate concentrated and purified by flash chromatography (EtOAc:PE, 1:9) to yield the title compound **68** (2.3 mg, 17%) as a yellow oil; R_f 0.47 (EtOAc:PE, 3:7); $[\alpha]_D^{20}$ ~0 ($CHCl_3$); δ_H (500 MHz, C_6D_6) 5.87 (2H, dddd, *J* 6.3, 8.1, 10.2, 16.8, 2C*H*=CH_2), 5.24 (2H, tdd, *J* 1.0, 1.6, 16.8, 2CH=C*H*H'), 5.13 (2H, tdd, *J* 1.0, 1.6, 10.2, 2CH=CH*H*'), 3.66 (2H, td, *J* 2.0, 4.7, H-3,7), 2.87-2.89 (2H, m, H-4a,8a), 2.78 (2H, dt, *J* 2.0, 6.6, H-2,6), 2.73 (2H, tdd, *J* 1.6, 6.6, 13.1, 2C*H*H'), 2.48-2.53 (2H, m, 2CH*H*'), 2.43 (2H, td, *J* 2.0, 15.6, H-4,8), 1.64 (2H, td, *J* 4.7, 15.6, H-4',8'); δ_C (125 MHz, $CDCl_3$) 133.4 (CH), 118.0 (CH_2), 79.0 (C-2,6), 71.4 (C-4a,8a), 46.3 (C-3,7), 39.5 (CH_2), 37.3 (C-4,8); δ_C (125 MHz, C_6D_6) 134.2 (CH), 117.7 (CH_2), 79.2 (CH), 71.3 (CH), 46.3 (CH), 40.1 (CH_2), 37.3 (CH_2); ν_{max}/cm^{-1} (film) 1345, 1110, 913, 720, 688; *m/z* (ESI+) 405, 403, 401 ([*M*+Na]$^+$, 30:60:30%), 242 ([*M*-2Br+Na]$^+$, 100), 239 (41), [Found (*M*+Na)$^+$ 404.9687, 402.9714, 400.9734, $C_{14}H_{20}O_2{}^{79}Br_2Na$ req. 400.9722].

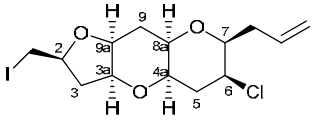


$J_{2,3}$	1.9
$J_{3,4ax}$	1.9
$J_{3,4eq}$	4.5
$J_{4ax,4a}$	1.9
$J_{4eq,4a}$	4.5

***(2*R*, *3a*S, *4a*R, *6*S, *7*S, *8a*R, *9a*S)-7-*Allyl-6-chloro-2-iodomethyl-decahydro-furo[3,2-*b*]pyrano[2,3-*e*]pyran* 76a *and (2*S*, *3a*S, *4a*R, *6*S, *7*S, *8a*R, *9a*S)-7-allyl-6-chloro-2-iodomethyl-decahydro-furo[3,2-*b*]pyrano[2,3-*e*]pyran* 76b**

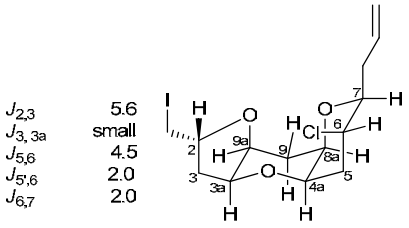


76a



76b

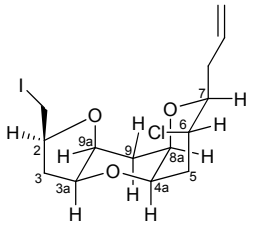
To a stirred solution of the chloride **75** (25 mg, 88 μmol) in CH_2Cl_2 (5 mL) was added a saturated aqueous solution of $NaHCO_3$ (5 mL). To the resulting vigorously stirred two phase system was added iodine (26 mg, 101 μmol) and stirring was continued for 1 h. A saturated aqueous solution of $Na_2S_2O_2$ (10 mL) and EtOAc (20 mL) were added and the aqueous phase was separated, extracted with EtOAc (2 × 10 mL). The organic phases were washed with brine, dried ($MgSO_4$) and the solvent removed *in vacuo*. Purification by flash chromatography (EtOAc:PE, 1:1) gave the iodide **76a** (30 mg, 75 μmol, 86%) as a clear and colourless oil; R_f 0.3 (EtOAc:PE, 1:1); $[\alpha]_D^{20}$ =+31.2 (*c* = 0.25 in $CHCl_3$); δ_H (500 MHz, $CDCl_3$) 5.77 (1H, dddd, *J* 17.1, 10.1, 7.9, 6.4, CH_2CH=CH_2), 5.16 (1H, dq, *J* 17.1, 1.6 Hz, CH_2CH=C*H*$_{trans}$), 5.06 (1H, ddt, *J* 2.0, 10.6, 0.9, CH_2CH=C*H*$_{cis}$H), 4.34 (1H, dddd, *J* 9.9, 6.1, 5.6, 3.0, H-2), 4.02-4.0 (2H, m,H-8a or H-9a), 3.97 (1H, dt, *J* 4.6, 2.0, H-6), 3.44-3.41 (3H, m, H-4a, H-7 and H-8a or H-9a), 3.37 (1H, dd, *J* 9.9, 2.7, C*H*HI), 2.54-2.43 (3H, m, H-5, C*H*$_2$CH=CH_2), 2.33 (1H, brd, *J* 15.8, H-9), 3.22 (1H, dd, *J* 13.2, 5.6, H-3), 2.52-2.35 (5H, m, 2 × C*H*$_2$CH=CH_2, H-8), 2.23 (1H, dd, *J* 14.8, 2.8, H-4), 2.16 (1H, dt, *J* 15.5, *J* 4.4 Hz, H-5'), 1.81-1.86 (2H, m, H-3' and H-9'); δ_C (125 MHz, $CDCl_3$) 133.5 (CH_2*C*H=CH_2), 118.0 (CH_2CH=*C*H$_2$), 79.5 (C-7), 77.2 (C-3a or C-9a), 76.4 (C-2), 74.0 (C-3a or C-9a), 71.5 (C-4a or C-8a), 68.1 (C-4a or C-8a), 54.2 (C-6) 41.4 (C-3), 37.6 (*C*H$_2$CH=CH_2), 36.9 (C-5), 31.2 (C-9), 13.5 (CH_2I);; *m/z* (ESI+) [Found [*M*+H]$^+$ 399.0211 (60%), $C_{14}H_{21}{}^{35}ClO_3I$ req. 399.0214].



$J_{2,3}$	5.6
$J_{3,3a}$	small
$J_{5,6}$	4.5
$J_{5',6}$	2.0
$J_{6,7}$	2.0

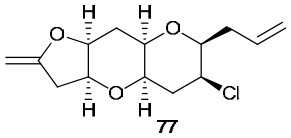
Further elution of the column gave the iodide **76b** (4 mg, 10 μmol, 11%) as a clear and colourless oil; R_f 0.2 (EtOAc:PE, 1:1); $[\alpha]_D^{20}$ =-13.5 (*c* = 0.185 in $CHCl_3$); δ_H (500 MHz, $CDCl_3$) 5.79 (1H, dddd, *J* 17.3, 10.1, 7.8, 6.4, CH_2CH=CH_2), 5.18 (1H, ddt, *J* 17.3, 2.0, 1.1, CH_2CH=C*H*$_{trans}$), 5.07 (1H, ddt, *J*2.0, 10.1, 1.1 Hz, CH_2CH=C*H*$_{cis}$H), 4.32 (1H, dq, *J* 9.1, 5.8, H-2), 3.98 (1H, dt, *J* 4.9, 2.1, H-6), 3.94 (1H, q, *J* 2.3,

H-3a), 3.79 (1H, ddd, *J* 4.8, 2.3, 1.8, H-9a), 3.77 (1H, t, *J* 9.1, CH*H*I), 3.57 (1H, dd, *J* 9.1, 5.8, C*H*HI), 3.42 (1H, ddd, *J* 4.9, 1.8, 1.1, H-8a), 3.38 (1H, ddd, *J* 3.9, 2.1, 1.1, H-4a), 2.52 (1H, dtt, *J* 14.0, 6.3, 1.2 Hz, CH*H*CH=CH_2), 2.48 (1H, dt, *J* 15.6, 2.1, H-5), 2.42 (1H dtt, *J* 14.0, 7.8, 1.1 Hz, C*H*HCH=CH_2), 2.37 (1H, dt, *J* 15.9, 1.8, H-9_{eq}), 2.18 (1H, dt, *J* 15.6, 4.9, 3.9, H-5') 1.88 (1H dt, *J* 15.9, 4.9 Hz, H-9_{ax}); δ_C (125 MHz, $CDCl_3$) 133.5 (CH_2CH=CH_2), 118.0 (CH_2CH=CH_2), 79.7 (C-7), 79.0 (C-2), 77.2 (C-3a), 75.1 (C-9a), 71.4 (C-8a), 69.0 (C-4a), 54.3 (C-6), 38.6 (C-3), 37.7 (CH_2CH=CH_2), 36.9 (C-5), 31.2 (C-9), 12.3 (CH_2I); *m/z* (ESI+) [Found $[M+H]^+$ 399.0211 (60%), $C_{14}H_{21}{}^{35}ClO_3I$ req. 399.0214].



$J_{2,3}$	5.8	$J_{8a,\ 4a}$	1.1
$J_{3,3a}$	2.3	$J_{4a,\ 5ax}$	3.9
$J_{3a,\ 9a}$	2.3	$J_{4a,\ 5eq}$	2.1
$J_{9a,\ 9ax} = J_{9ax,\ 8a}$	4.8	$J_{5ax,\ 6}$	4.9
$J_{9a,\ 9eq} = J_{9eq,\ 8a}$	1.8	$J_{5eq,\ 6} = J_{6,\ 7}$	2.1

***(3aS, 4aR, 6S, 7S, 8aR, 9aS)-7-Allyl-6-chloro-2-methylene-decahydro-furo[3,2-b]pyrano[2,3-e]pyran* 77 and *1-((2S,3S,4aR,6S,7S,8aR)-6-allyl-7-chloro-3-hydroxyoctahydropyrano[3,2-b]pyran-2-yl)propan-2-one* 78**



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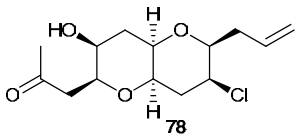

78

To a stirring solution of the iodide **76a** (12 mg, 30 μmol) in toluene (2 mL) was added DBU (20 μL, 20 mg, 130 μmol) and the resulting solution heated under reflux for 6 h. The reaction mixture was allowed to cool and the solvent removed *in vacuo*. Purification by gravity chromatography (EtOAc:PE, 1:1) on basic alumina (deactivated with 6% water) gave the title compound **77** as a clear and colourless oil (8 mg, 29 μmol, 96%); δ_H (500 MHz, $CDCl_3$) 5.80 (1H, dddd, *J* 6.3, 7.7, 10.1, 17.2, C*H*=CH_2), 5.19 (1H, dm, *J* 17.2, 2CH=C*H*H'), 5.09 (1H, dm, *J* 10.1, 2CH=CH*H*'), 4.33-4.32 (1H, m, OCH=C*H*H), 4.10 (1H, td, *J* 2.1, 4.3), 4.03 (1H, m), 3.95 (1H, td, *J* 1.9, 4.3) 3.87 (1H, br s, OCH=C*H*H) 3.48-3.43 (3H, m), 2.78-2.67 (2H, m), 2.56-2.45 (4H, m), 2.18 (1H, dt, 15.6, 4.1), 1.97 (1H, dt, 15.6, 4.7); ν_{max}/cm^{-1} (film) 1675; *m/z* (ESI+) 271, 273 ($[M+H]^+$, 70:25%), [Found $(M+H)^+$ 271.1098, $C_{14}H_{20}O_3{}^{35}Cl$ req. 271.1101], which readily hydrolysed to the ketone **78**; δ_H (400 MHz, $CDCl_3$) 5.81-5.72 (1H, m, 2C*H*=CH_2), 5.16 (2H, dm, *J* 16.9, CH=C*H*H'), 5.09 (1H, dm, *J* 10.2, 2CH=CH*H*'), 3.98-3.96 (1H, brm, H-7), 3.76 (1H, ddt, *J* 1.0, 5.7, 7.4, H-2), 3.58 (1H, brm, H-4a), 3.56 (1H, brm, H-8a), 3.51 (1H, dt, *J* 11.7, 3.0, H-3), 3.46-3.42 (1H, m, H-6), 3.30 (1H, d, *J* 11.7, OH), 2.91 (1H, dd, *J* 16.5, 7.4, C*H*HCOCH_3), 2.68 (1H, dt, *J* 16.5, 5.6, CH*H*COCH_3) 2.50-2.35 (3H, m, H-8, CH_2CH=CH_2), 2.26 (1H, dt, *J* 15.1, 3.0, H-4), 2.19 (3H, s, $CH_2CO$$CH_3$), 2.11 (1H, dt, *J* 15.4, 4.2, H-8'), 1.84 (1H, dt, *J* 15.1, 3.0, H-4'); δ_C (125 MHz, $CDCl_3$) 208.2 (CO), 133.0 (*C*H=CH_2), 118.3 (CH=*C*H_2), 79.7 (C-6), 77.2 (C-2), 73.4 (C-4a), 70.5 (C-8a), 65.4 (C-3), 54.2 (C-7), 45.5 ($CH_2CO$$CH_3$), 37.6 ($CH_2CH$=$CH_2$), 36.7 (C-8), 34.9 (C-4), 31.5 ($CH_2CO$$CH_3$); ν_{max}/cm^{-1} (film) 3505, 1717; *m/z* (ESI+) 311, 313 ($[M+Na]^+$, 75:25%), [Found $(M+Na)^+$ 311.1019, $C_{14}H_{21}O_4{}^{35}ClNa$ req. 311.1026].

Comparison of the ^{1}H and ^{13}C NMR of elatenyne[7] and synthetic 3.

Atom[a]	δ_H 3 ($CDCl_3$)	δ_H elatenyne ($CDCl_3$)	δ_H 3 (C_6D_6)	δ_H elatenyne (C_6D_6)
1 (C≡C*H*)	3.10	3.09	2.08-2.88[d]	2.81
3 (C=C*H*CCH)	5.55	5.49	5.47	5.37
4 (C*H*=CHCCH)	6.13	5.94	6.04	5.74
5 (CH_2CH=CH)	2.80, 2.62	2.51, 2.51	3.08, 2.78-2.88[d]	2.36-2.48
6 (6)	3.27	3.89	2.78-2.88[d]	4.06
7 (7)	4.03	3.82	3.58[e]	3.68
8 (8)	2.61, 2.37[b]	2.32	2.38, 1.54-1.67[f]	1.98
9 (8a)	3.54[c]	3.87	2.08-2.88[d]	3.84
10 (4a)	3.52[c]	3.87	2.08-2.88[d]	3.84
11 (4)	2.61, 2.37[b]	2.32	2.38, 1.54-1.67[f]	1.98
12 (3)	4.05	3.77	3.56[e]	3.55
13 (2)	3.04	3.77	2.52	3.92
14 (CH_2CH_3)	1.79, 1.61	1.51	1.95, 1.54-1.67[f]	1.22, 1.39
15 (CH_3)	0.91	0.87	0.88	0.82

Table 1 Comparison of ^{1}H NMR chemical shifts of elatenyne[7] and synthetic **3**. [a] Natural product numbering for the originally described structure (systematic numbering); [b, c, e] assignments are interchangeable between pairs of signals; [d] part of 5H m; [f] part of 3H m

Atom[a]	δ_C 3 ($CDCl_3$)	δ_C 3 (C_6D_6)	δ_C elatenyne (C_6D_6)
1 (C≡*C*H)	82.5	82.7	83.0
2 (*C*≡CH)	80.5	80.4	80.0
3 (C=*C*HCCH)	110.7	110.6	111.2
4 (*C*H=CHCCH)	141.2	141.3	140.1
5 (*C*H_2CH=CH)	36.6	36.7	34.7
6 (6)	78.9	78.7	86.4
7 (7)	46.9[b]	46.4	49.2
8 (8)	37.8[c]	37.4[e]	39.0
9 (8a)	71.8[d]	71.4[f]	80.0
10 (4a)	71.6[d]	71.2[f]	79.5
11 (4)	37.7[c]	37.3[e]	39.3
12 (3)	46.8[b]	46.4	48.9
13 (2)	82.1	80.9	88.6
14 (CH_2CH_3)	28.5	28.7	26.8
15 (CH_3)	9.8	9.7	10.2

Table 2 Comparison of ^{13}C NMR chemical shifts of elatenyne[7] and synthetic **3**. [a] Natural product numbering for the originally described structure (systematic numbering); [b, c, d, e, f] assignments are interchangeable between pairs of signals.

Comparison of the ^{1}H and ^{13}C NMR of the chloroenyne from *L. majuscula*[8] and synthetic 4.

Atom[a]	**δ_H 4 ($CDCl_3$)**	**δ_H** chloroenyne from *L. majuscula* **($CDCl_3$)**
1 (C≡C*H*)	2.82, d, *J*2.2	2.83, dd, 0.7, 2.2
OH	3.07, d, 11.8	2.95, brd, 10.6
3 (C=C*H*CCH)	5.60, dddd, *J*15.9, 2.2, 1.8, 1.3	5.59, dddd, 15.9, 2.2, 1.6, 1.5
4 (C*H*=CHCCH)	6.20, ddd, *J* 15.9, 8.2, 6.9	6.22, dtd, 15.9, 7.4, 0.7
5 (CH_2CH=CH)	2.42, dddd, 14.2, 8.2, 6.9 2.56, dtd, 14.2, 6.9, 1.8	2.46, m
6 (6)	3.44, dt, 1.9, 6.9	4.08, ddd, 6.5, 5.6, 5.4
7 (7)	3.94, dt, 4.3, 1.9	3.96, ddd, 7.8, 5.4, 4.2
8 (8)	2.13, dt, 15.6, 4.3 2.49, dt, 15.6, 1.9	2.05, ddd, 13.8, 9.1, 7.8 2.18, ddd, 13.8, 6.8, 4.2
9 (8a)	3.52-3.53, m	4.41, ddd, 9.1, 6.8, 2.6
10 (4a)	3.56-3.58, m	4.11, dddd, 9.8, 3.3, 2.6
11 (4)	1.78, dt, 14.8, 3.5 2.27, dt, 14.9, 2.8	1.78, dd, *J* 14.0, 3.3 2.25, ddd, *J* 14.0, 9.8, 5.5
12 (3)	3.54, ddd, 11.8, 3.5, 2.8	4.05, br m
13 (2)	3.10, dt, 0.8, 6.8	3.54, dt, 2.5, 6.9
14 (CH_2CH_3)	1.62-1.82, m	1.70, ddd, 6.9, 7.5, 14.0
15 (CH_3)	0.92, t, 7.5	0.98, t, 7.5

Table 3 Comparison of ^{1}H NMR chemical shifts and coupling constants for the chloroenyne from *L. majuscula*[8] and synthetic **4** [a] Natural product numbering for the originally described structure (systematic numbering).

Atom	**δ_C 4 ($CDCl_3$)**	**δ_C** chloroenyne from *L. majuscula* **($CDCl_3$)**
1 (C≡*C*H)	76.7	77.2
2 (*C*≡CH)	82.3	81.7
3 (C=*C*HCCH))	112.0	112.4
4 (*C*H=CHCCH)	140.7	139.9
5 (*C*H_2CH=CH)	36.9	36.6
6 (6)	79.1	86.0
7 (7)	54.3	58.2
8 (8)	36.8	38.1
9 (8a)	70.5	79.2
10 (4a)	73.9	77.9
11 (4)	35.4	35.1
12 (3)	64.7	71.0
13 (2)	81.6	85.7
14 (CH_2CH_3)	24.7	21.8
15 (CH_3)	9.9	10.5

Table 4 Comparison of ^{13}C NMR chemical shifts and coupling constants for the chloroenyne from *L. majuscula*[8] and synthetic **4** [a] Natural product numbering for the originally described structure (systematic numbering).

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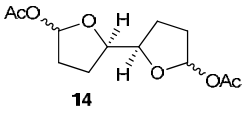
^{1}H NMR (400 MHz, $CDCl_3$)



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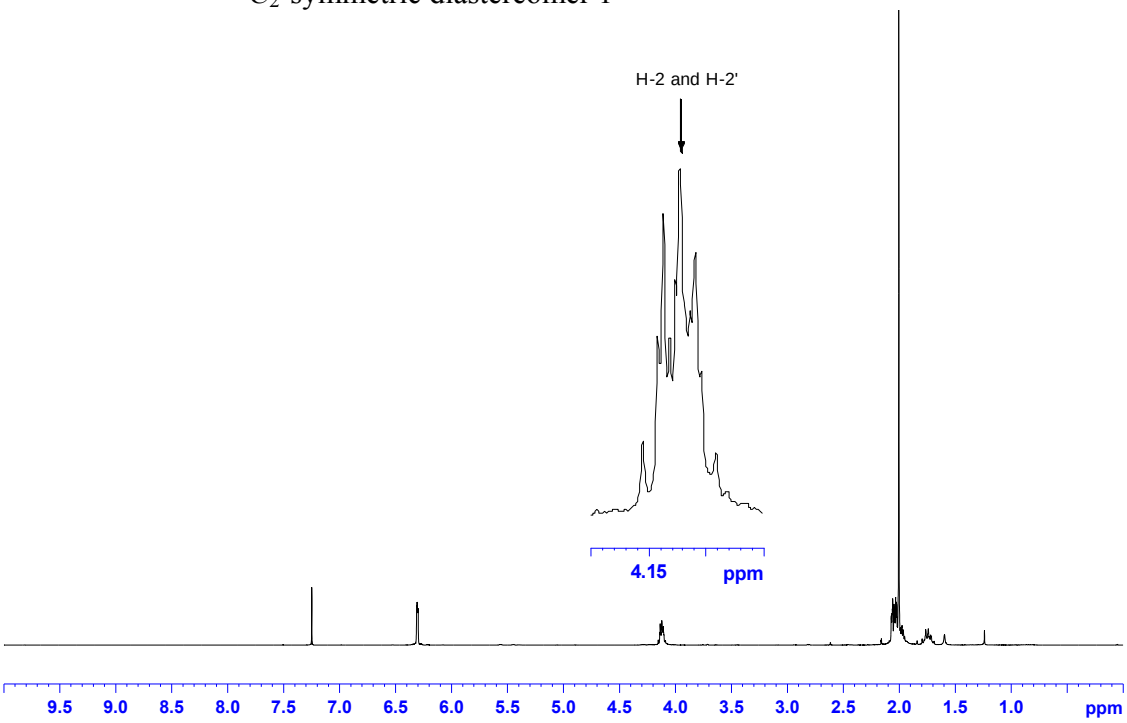

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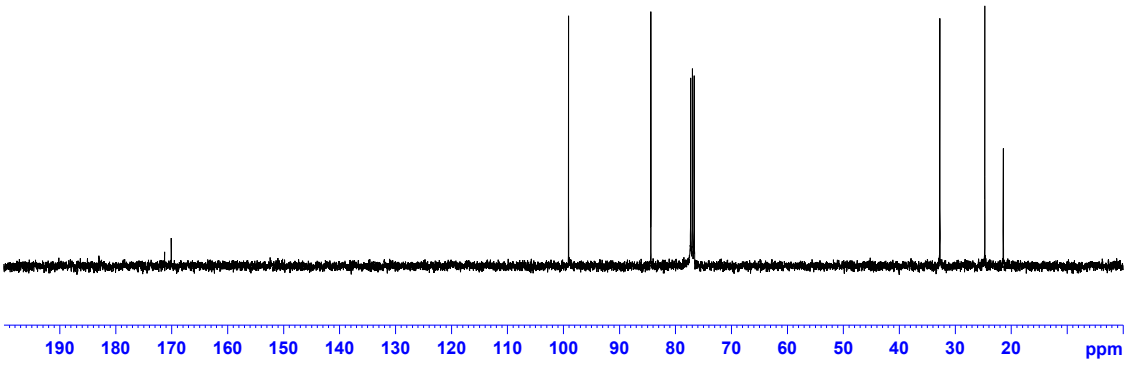

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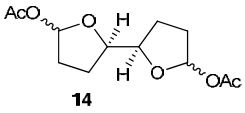

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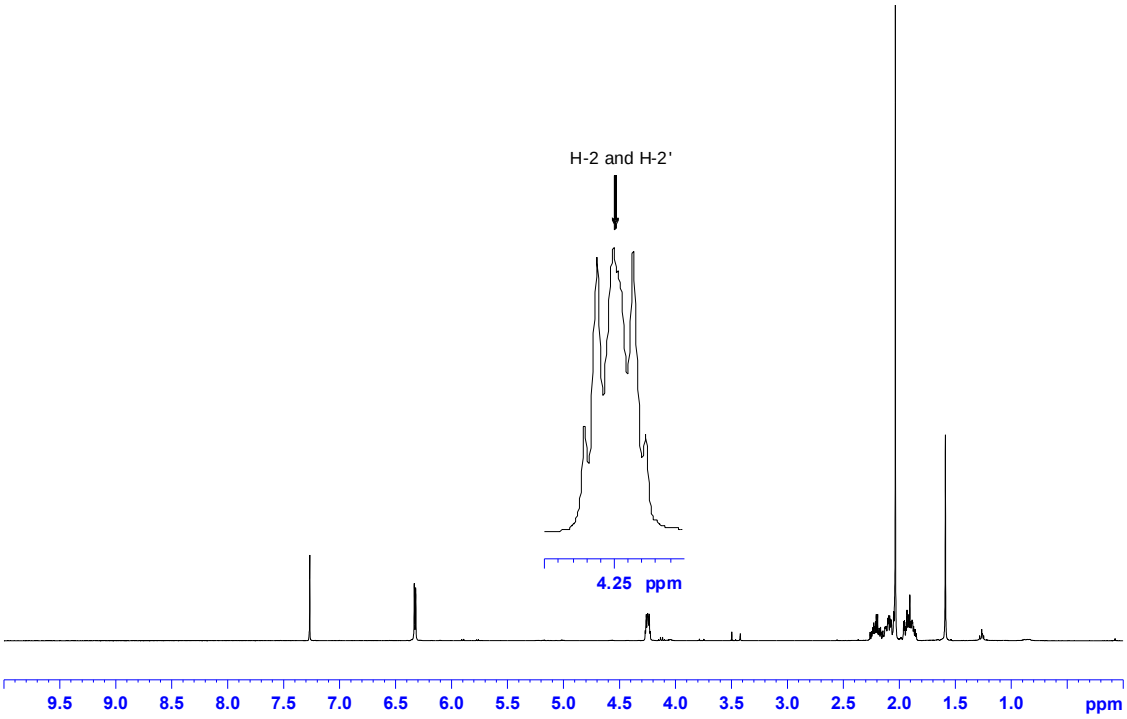

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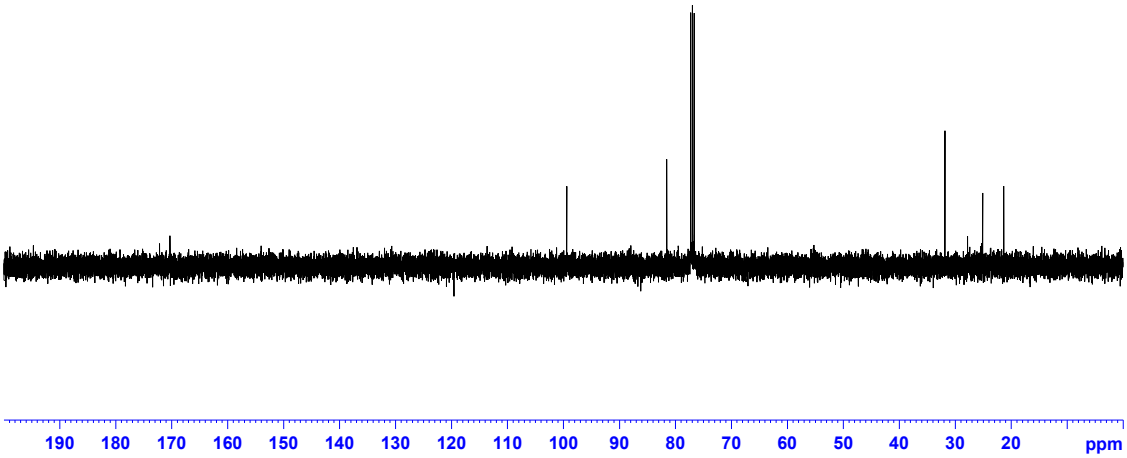

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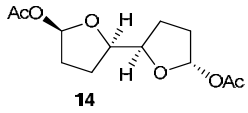
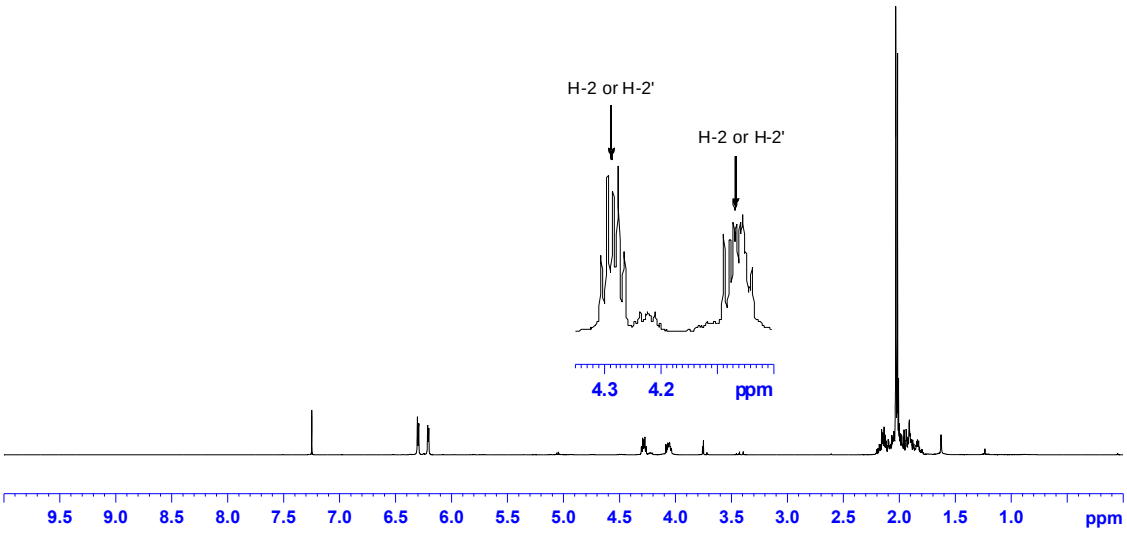


14 non-C_2-symmetric diastereomer



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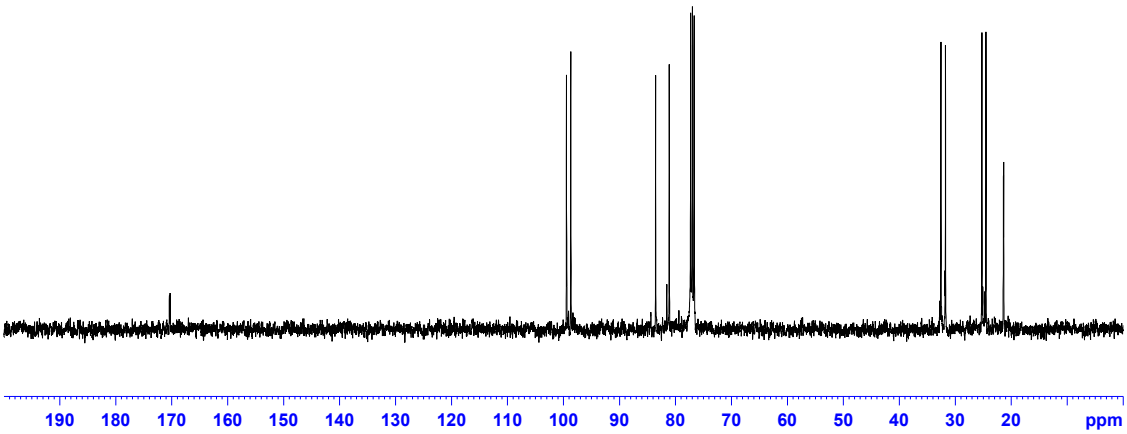

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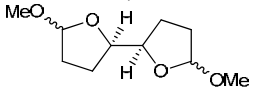

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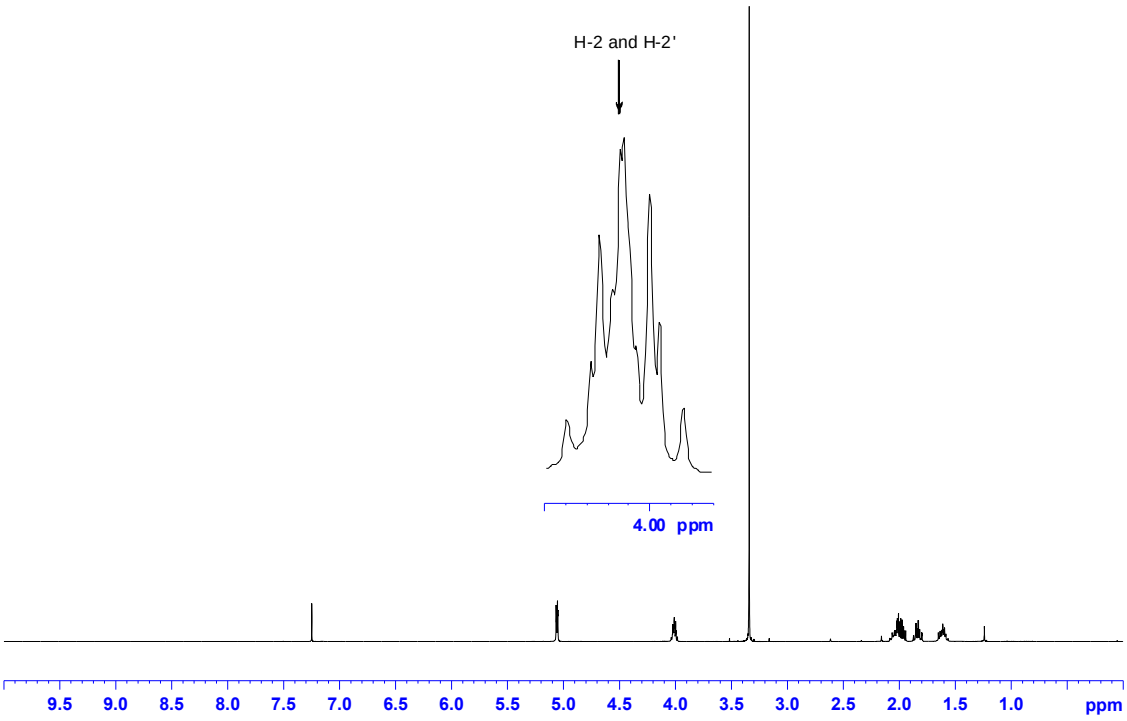

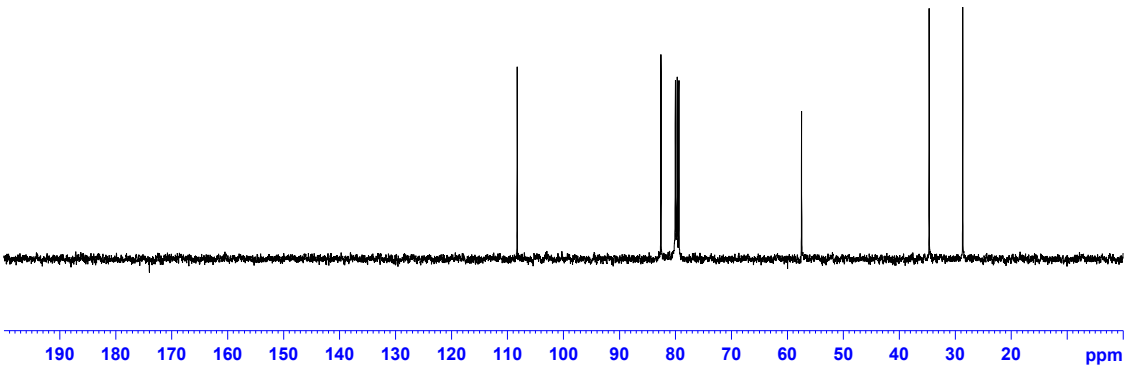

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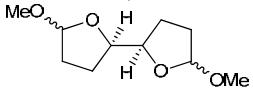

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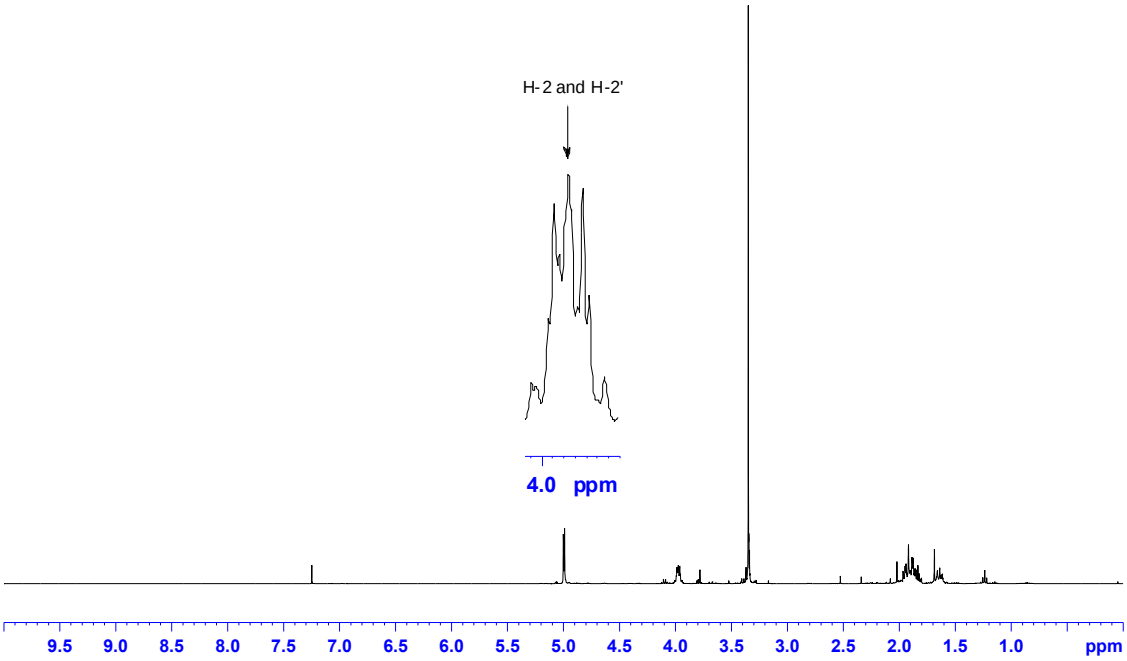

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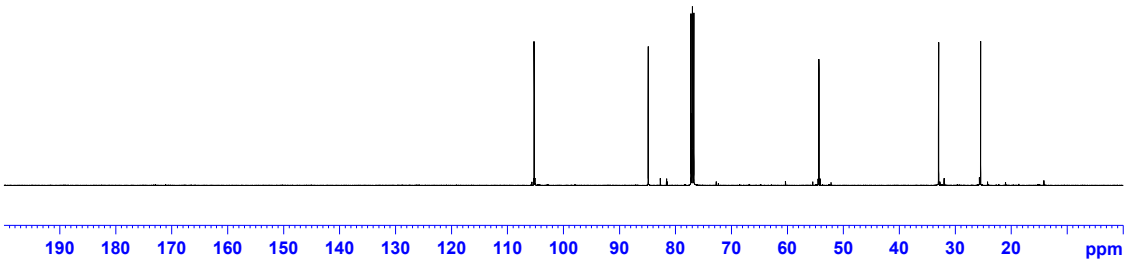

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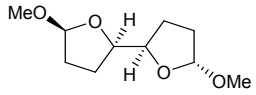
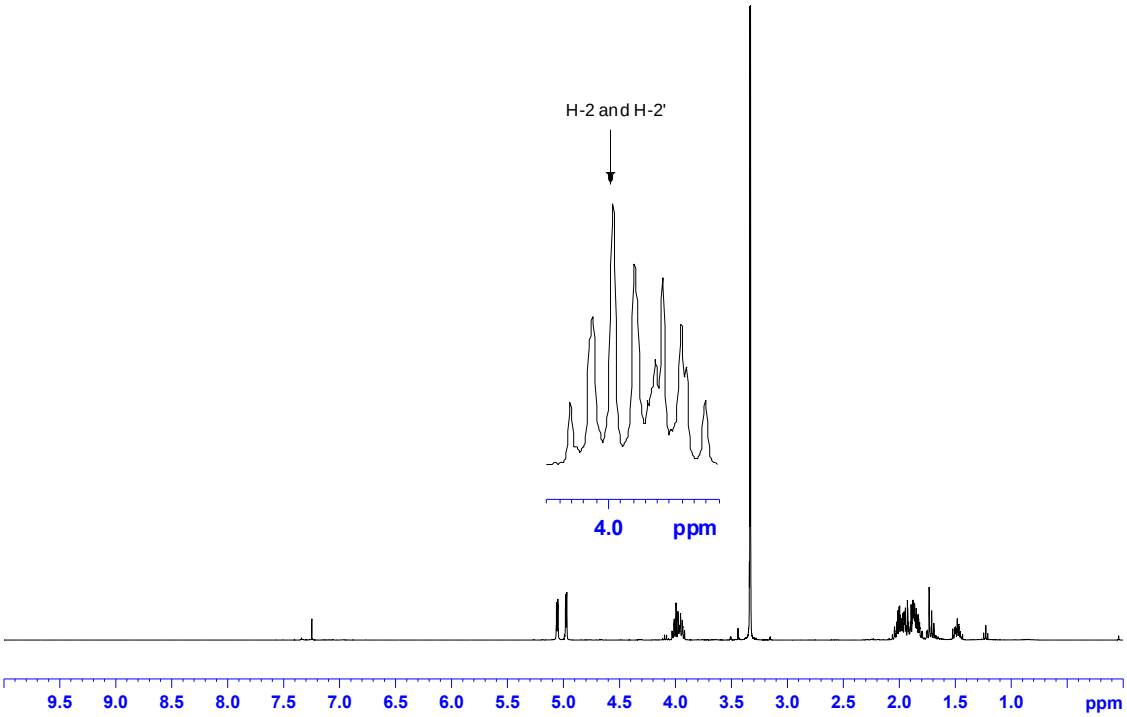


15 non-C_2-symmetric diastereomer



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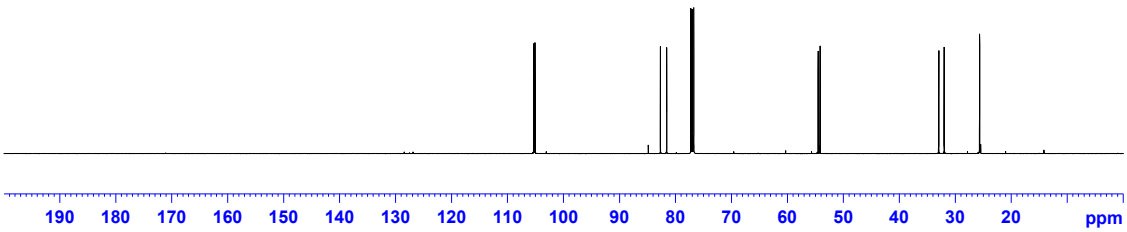

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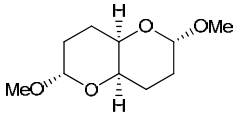

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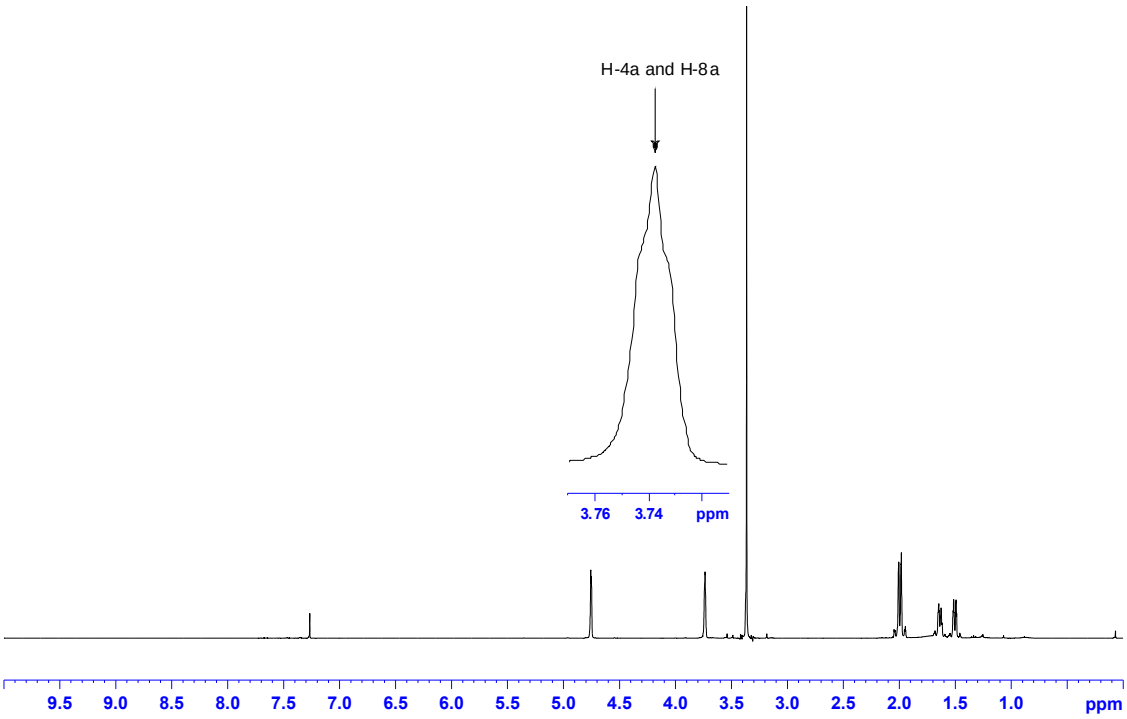

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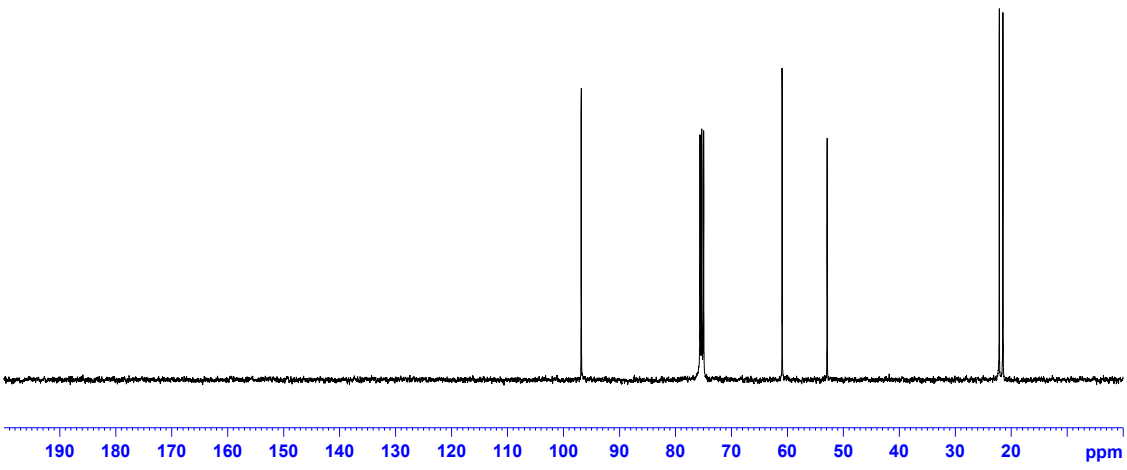

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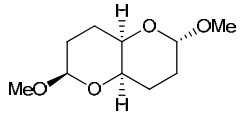

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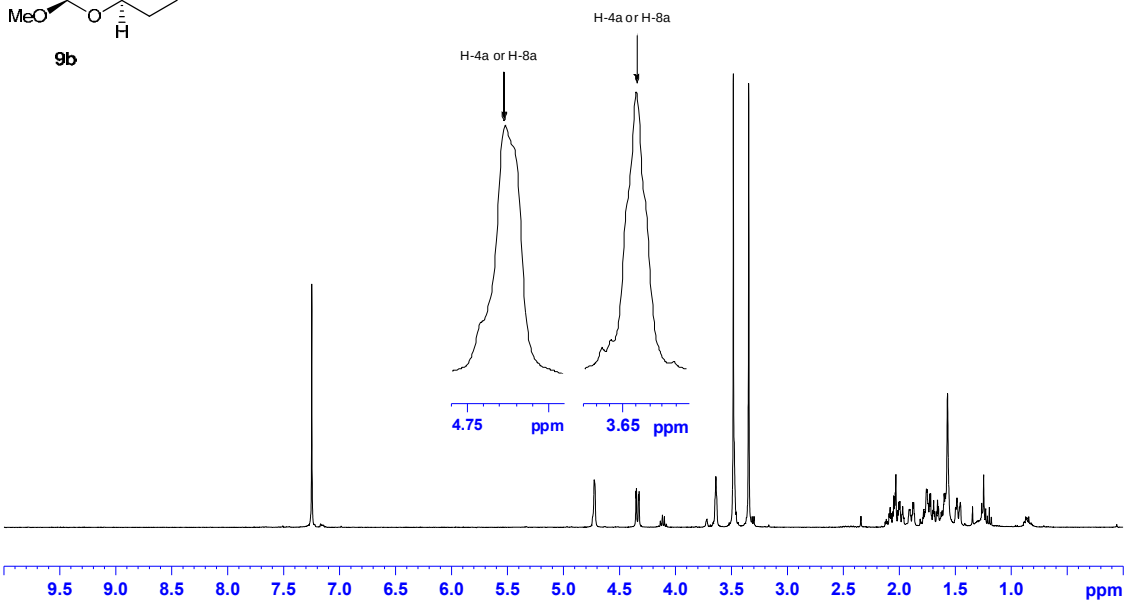

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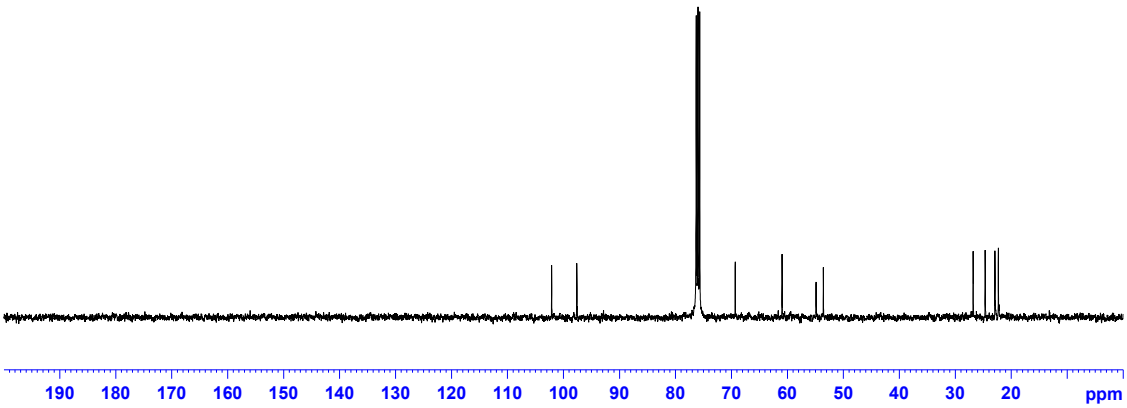

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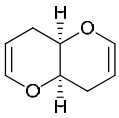

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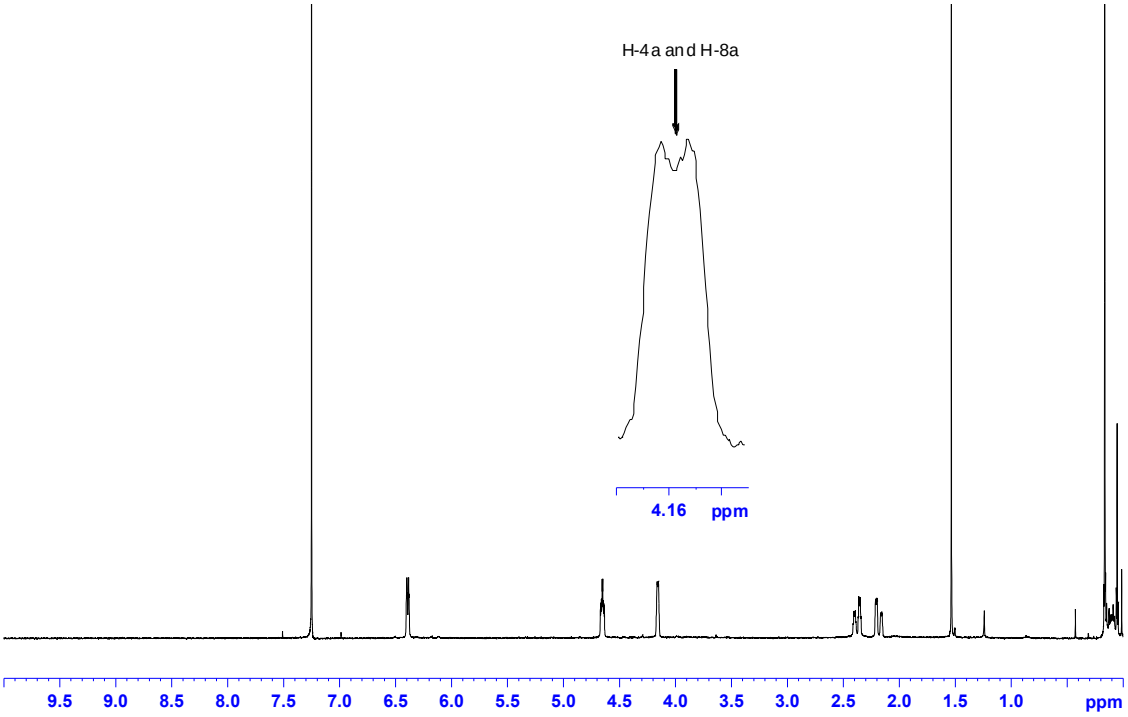

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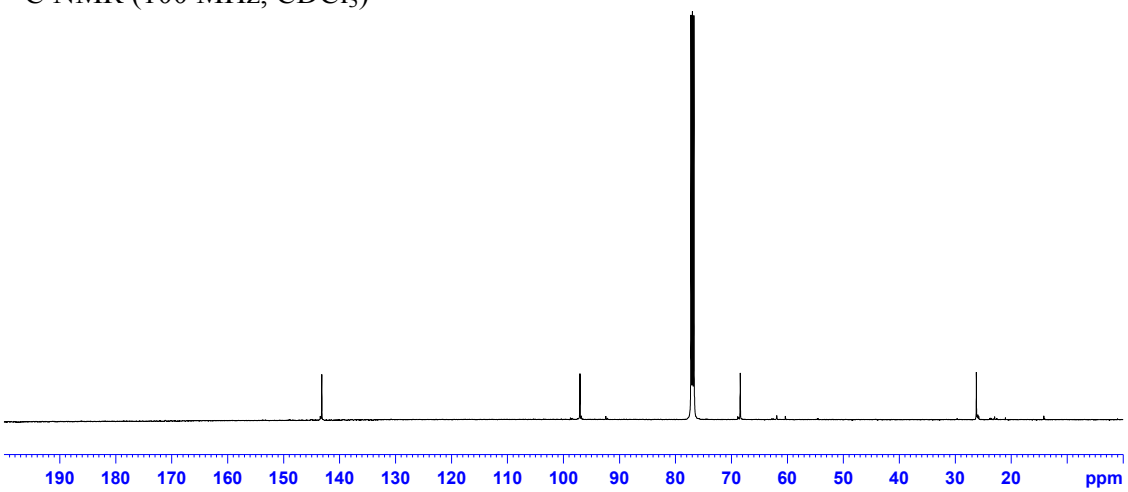

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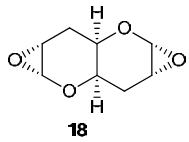
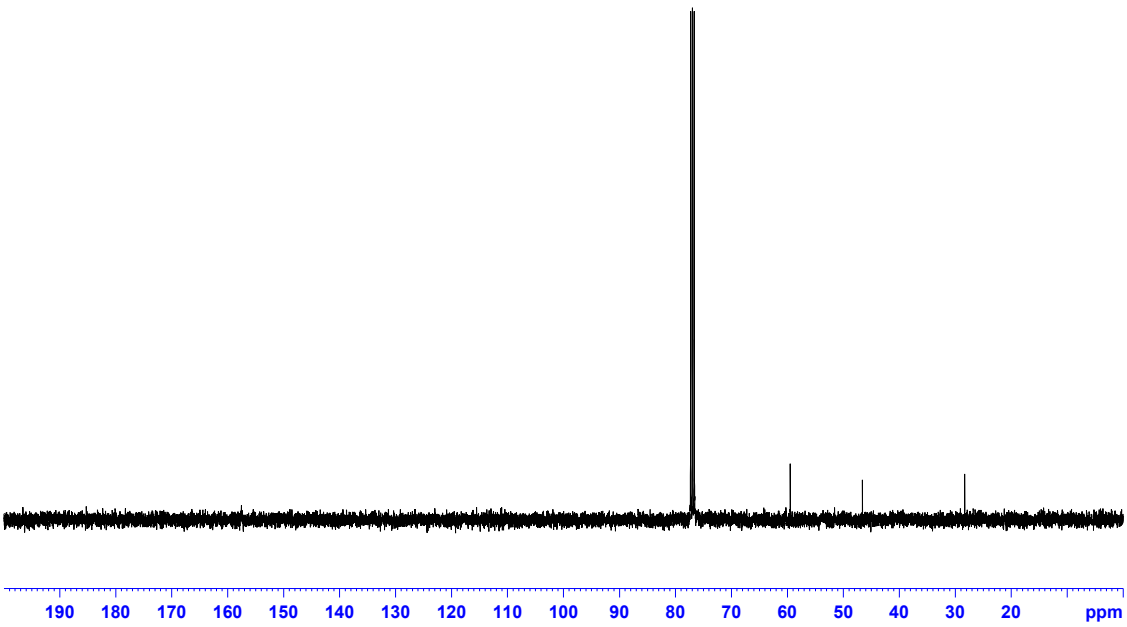
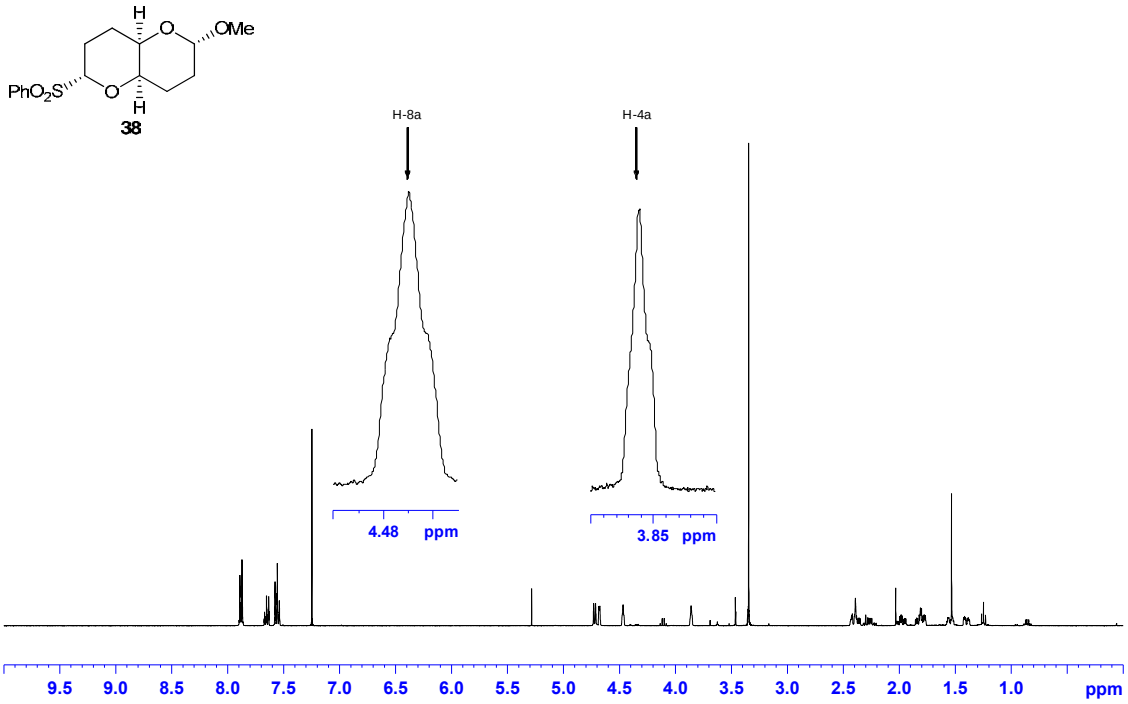


18

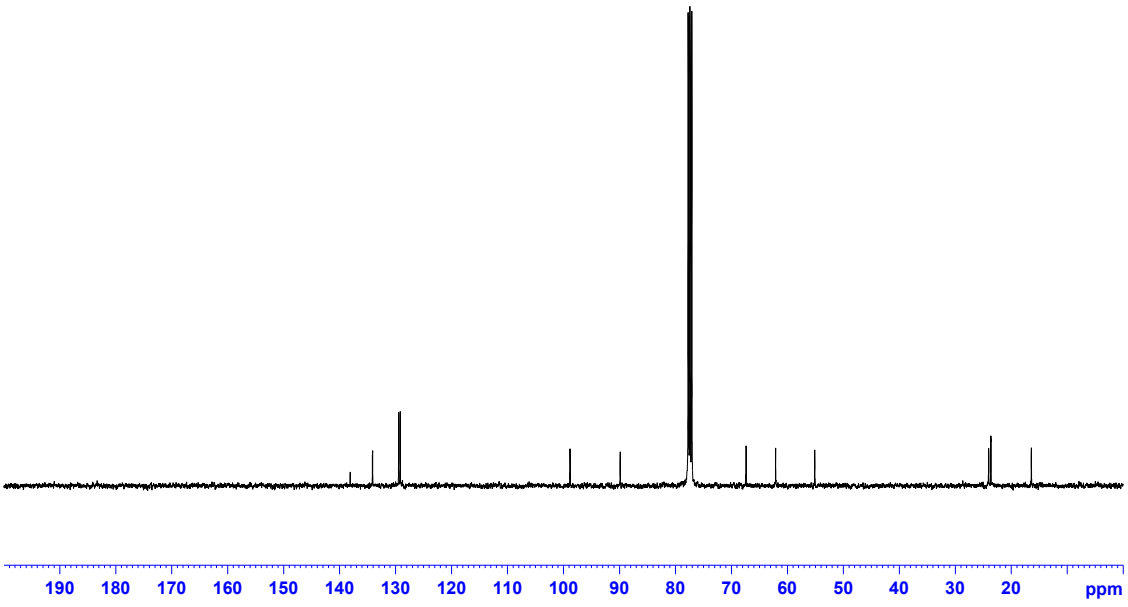
^{13}C NMR (400 MHz, $CDCl_3$)



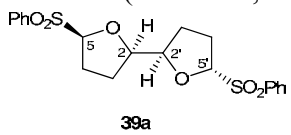
^{1}H NMR (400 MHz, $CDCl_3$)



^{13}C NMR (100 MHz, $CDCl_3$)

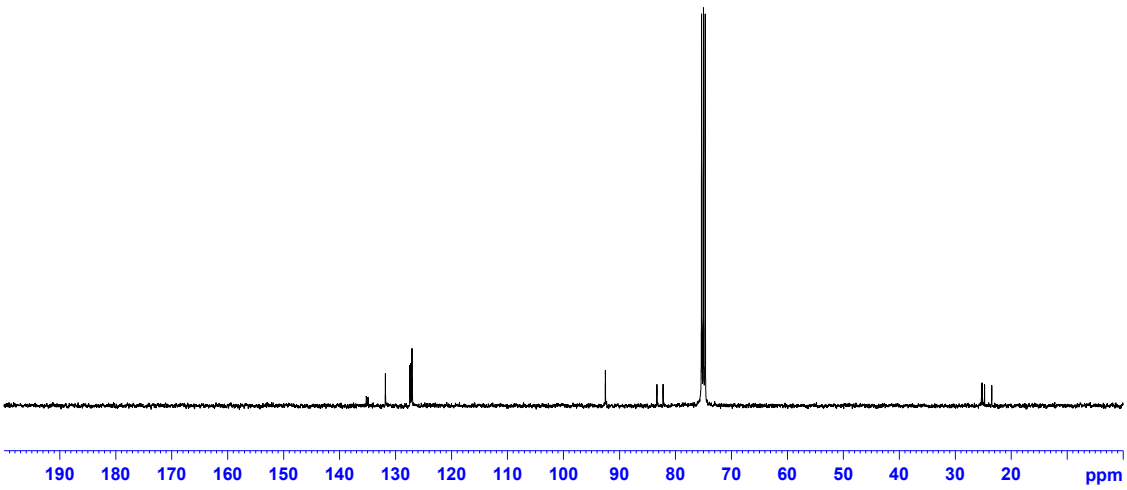


^{1}H NMR (400 MHz, $CDCl_3$)

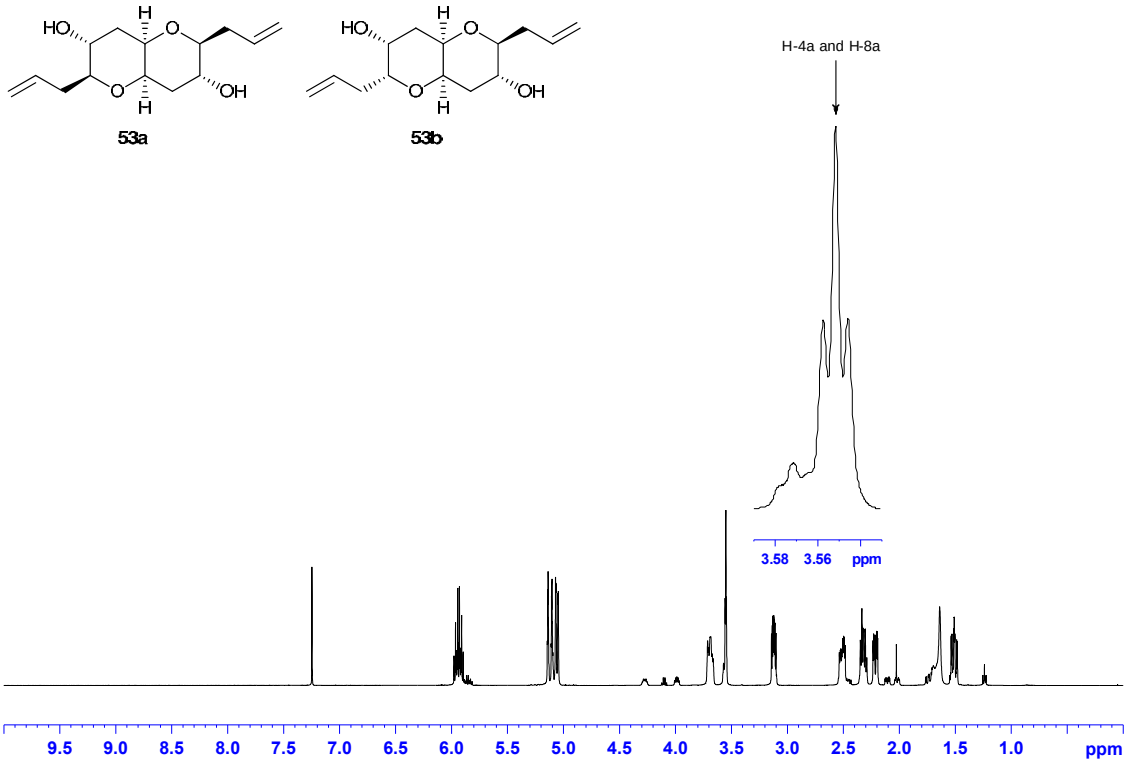


39a

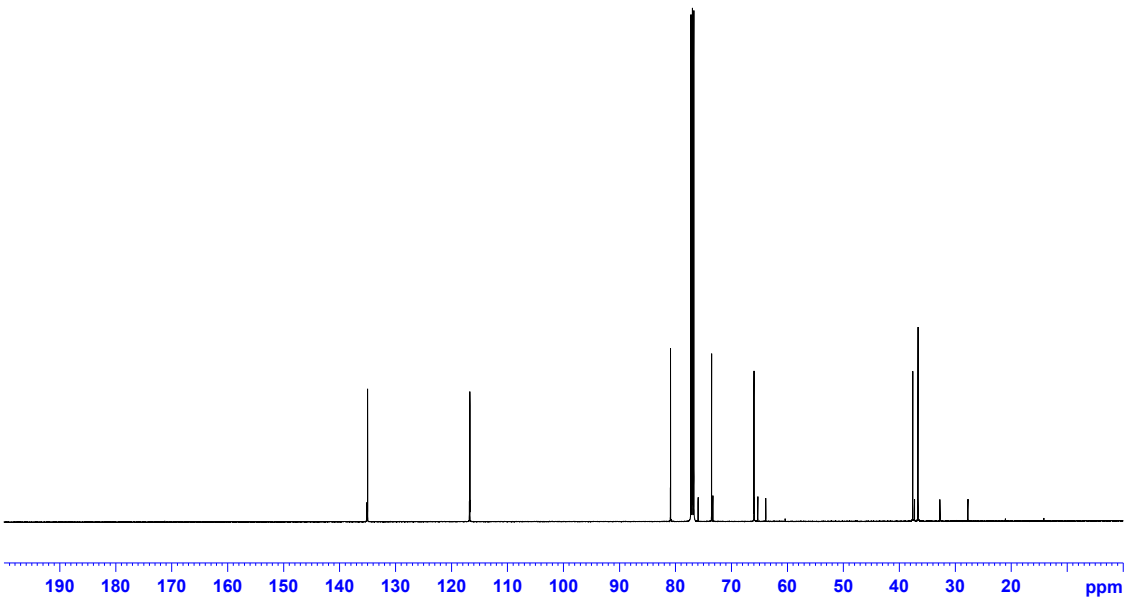
^{13}C NM R (100 MHz, $CDCl_3$)



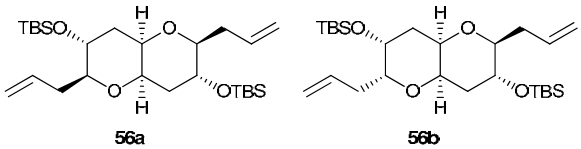
^{1}H NMR (500 MHz, $CDCl_3$) 5:1 mixture of diastereomers 60a:60b

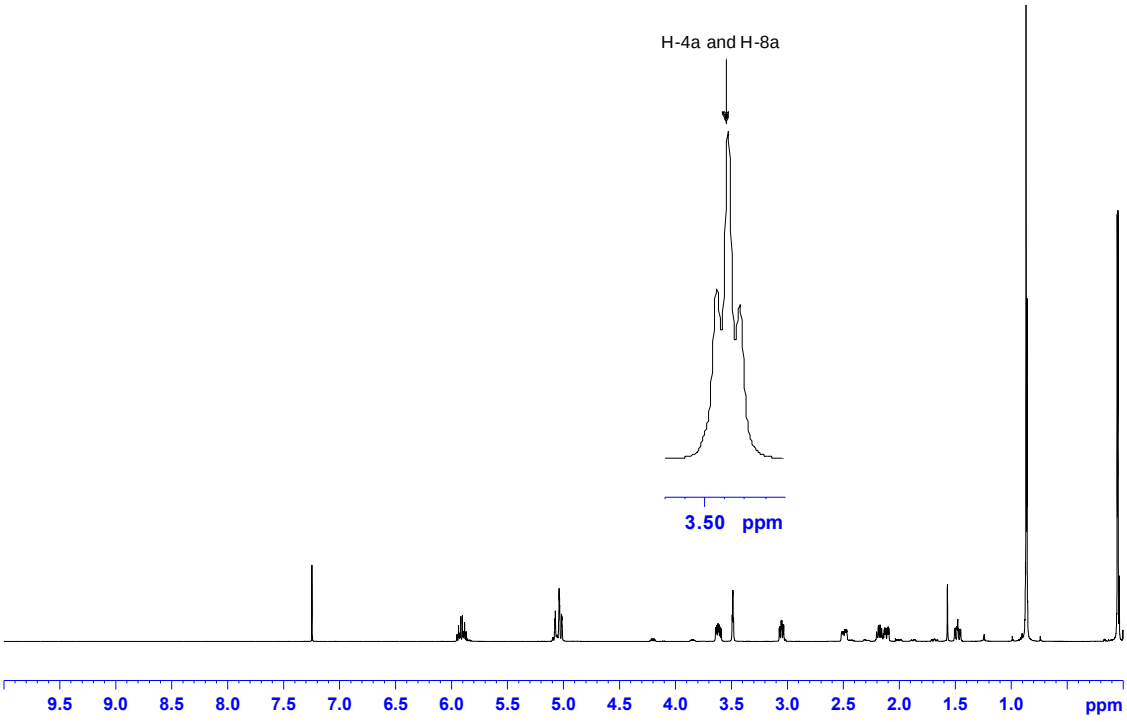


^{13}C NMR (125 MHz, $CDCl_3$) 5: 1mixture of diastereomers

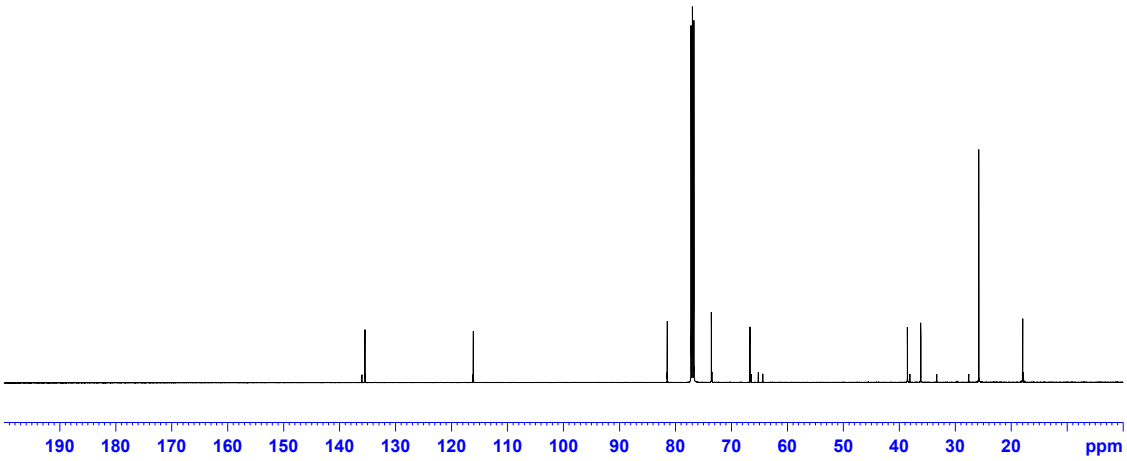


^{1}H NMR (500 MHz, $CDCl_3$) 5:1 mixture of diastereomers **64a**:**64b**

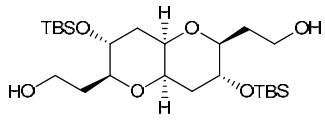




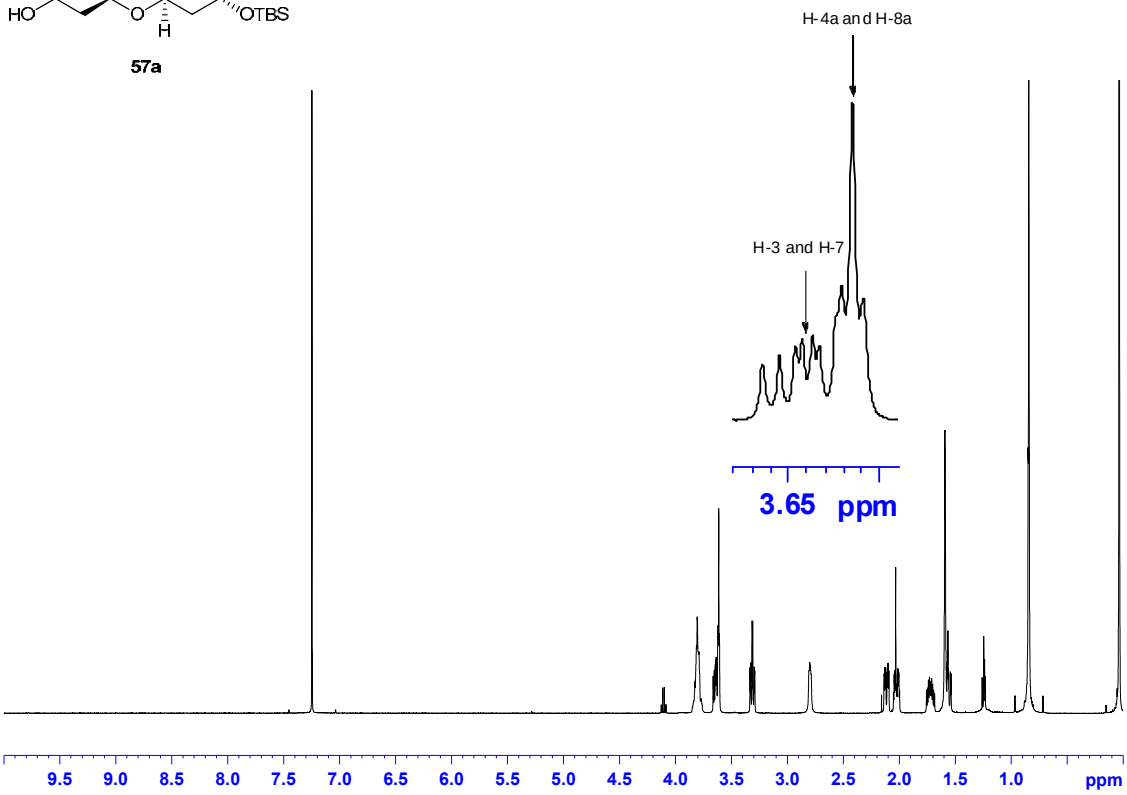
^{13}C NMR (125 MHz, $CDCl_3$) 5:1 mixture of diastereomers **64a**:**64b**



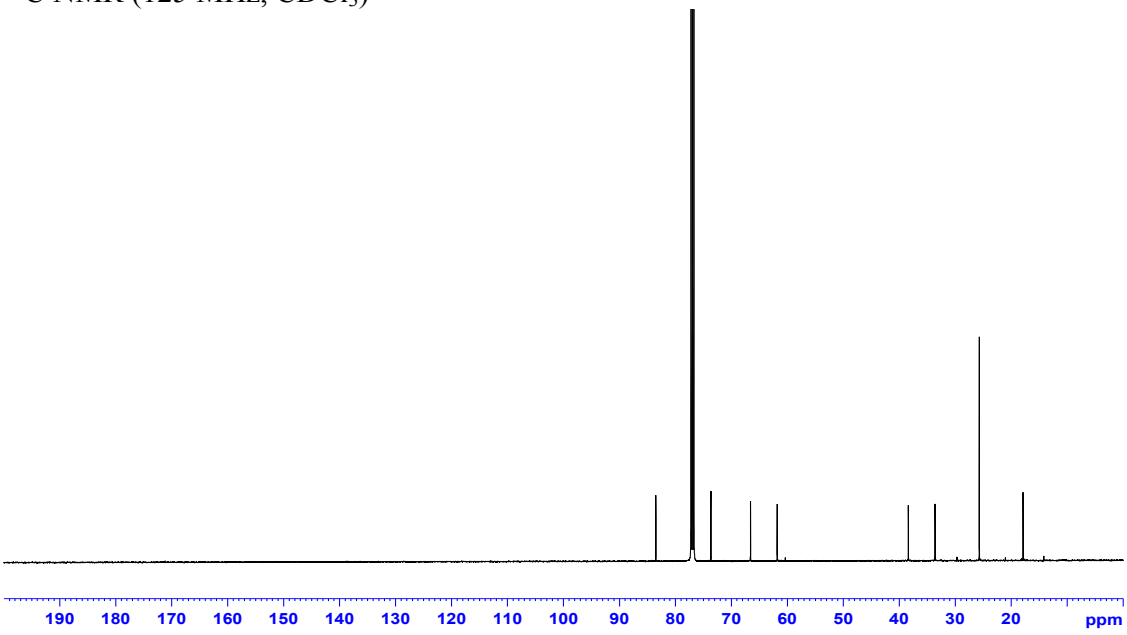
^{1}H NMR (500 MHz, $CDCl_3$)



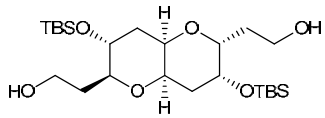
57a



^{13}C NMR (125 MHz, $CDCl_3$)

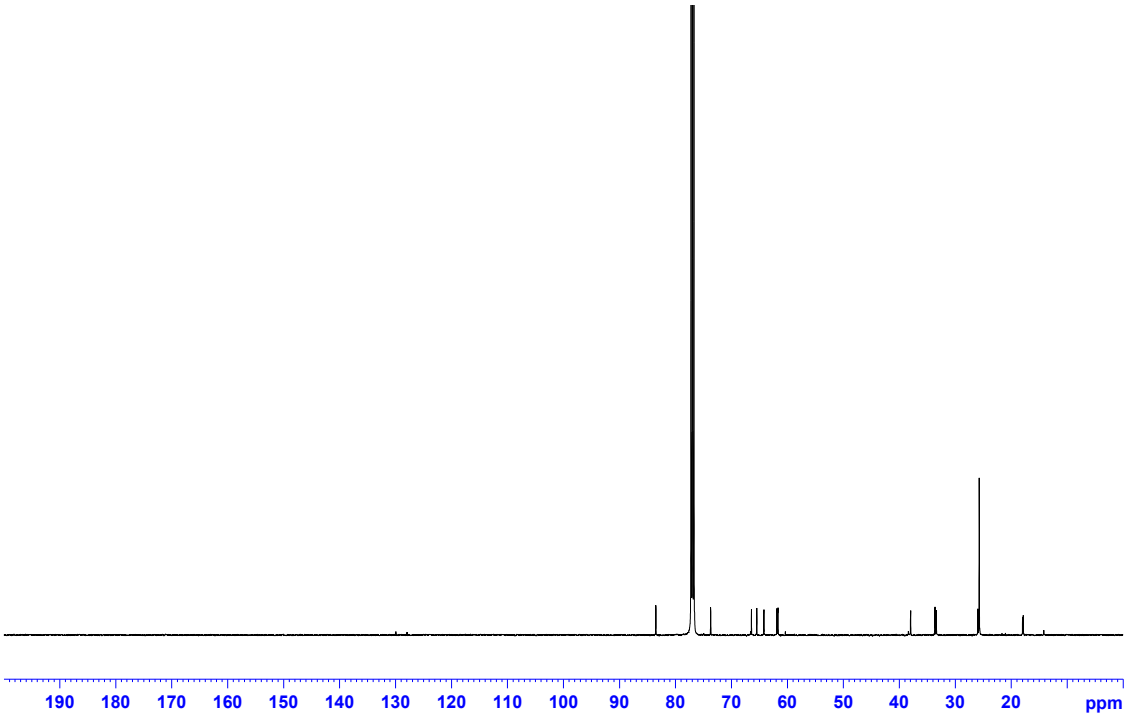


^{1}H NMR (400 MHz, $CDCl_3$)

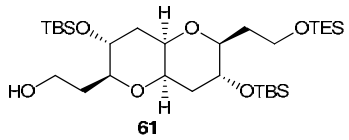


57b

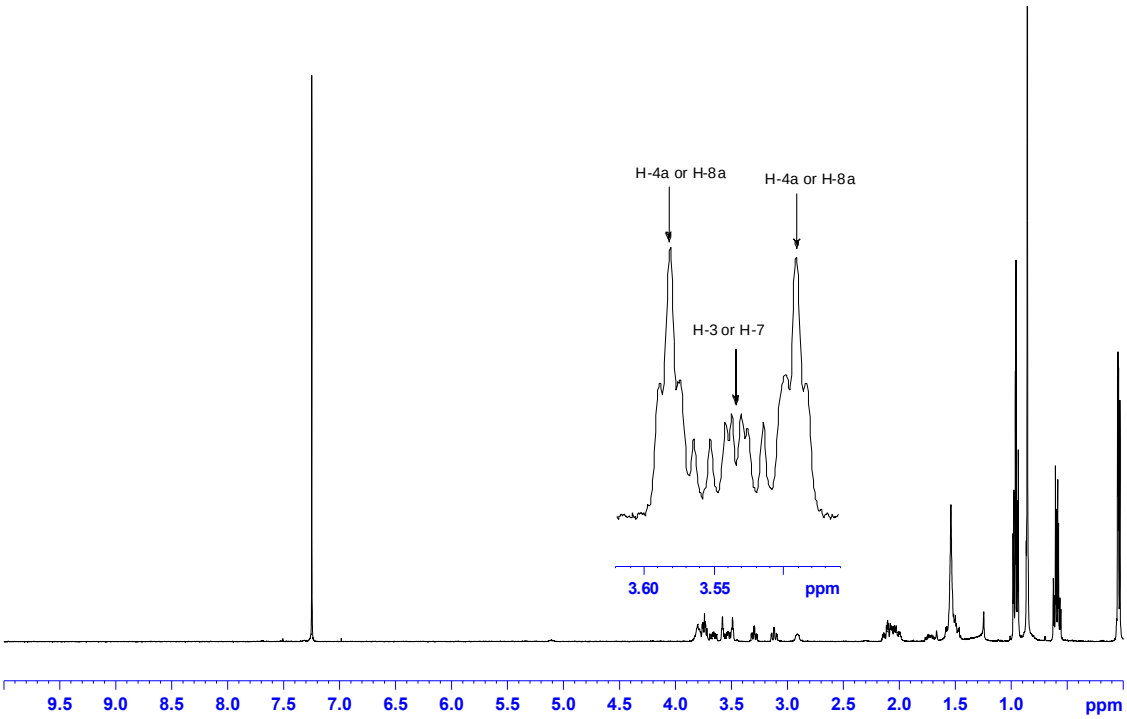
^{13}C NMR (125 MHz, $CDCl_3$)



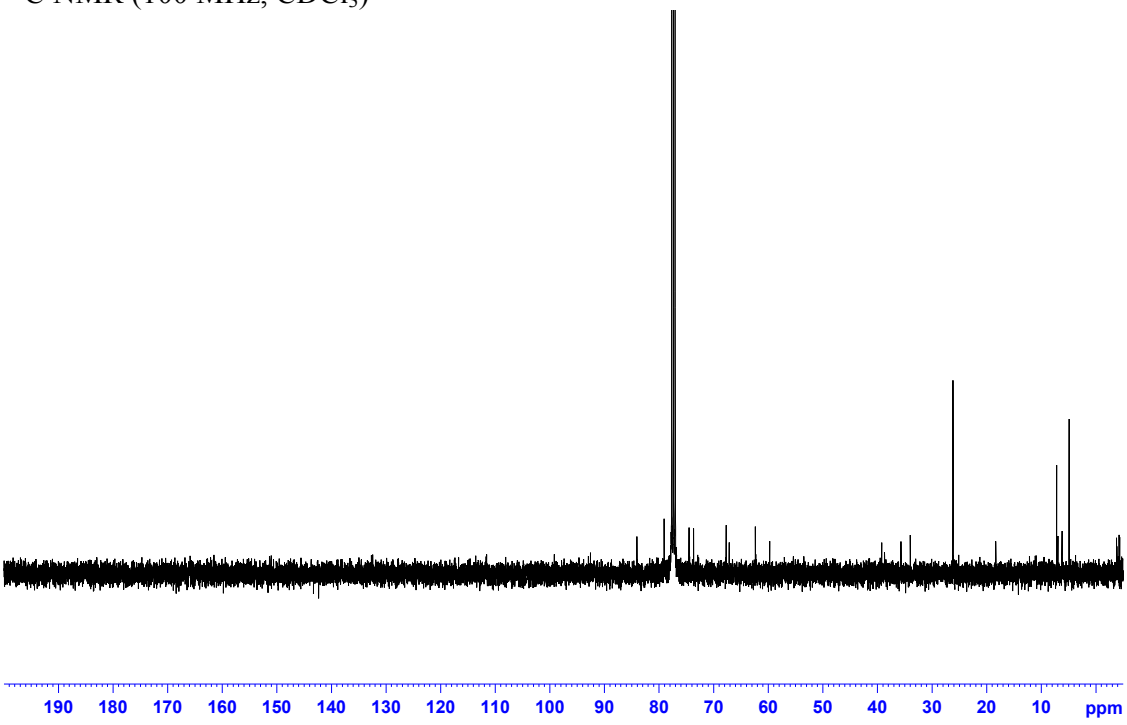
^{1}H NMR (400 MHz, $CDCl_3$)



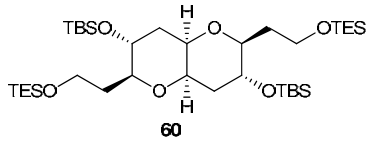
61



^{13}C NMR (100 MHz, $CDCl_3$)



^{1}H NMR (500 MHz, $CDCl_3$)



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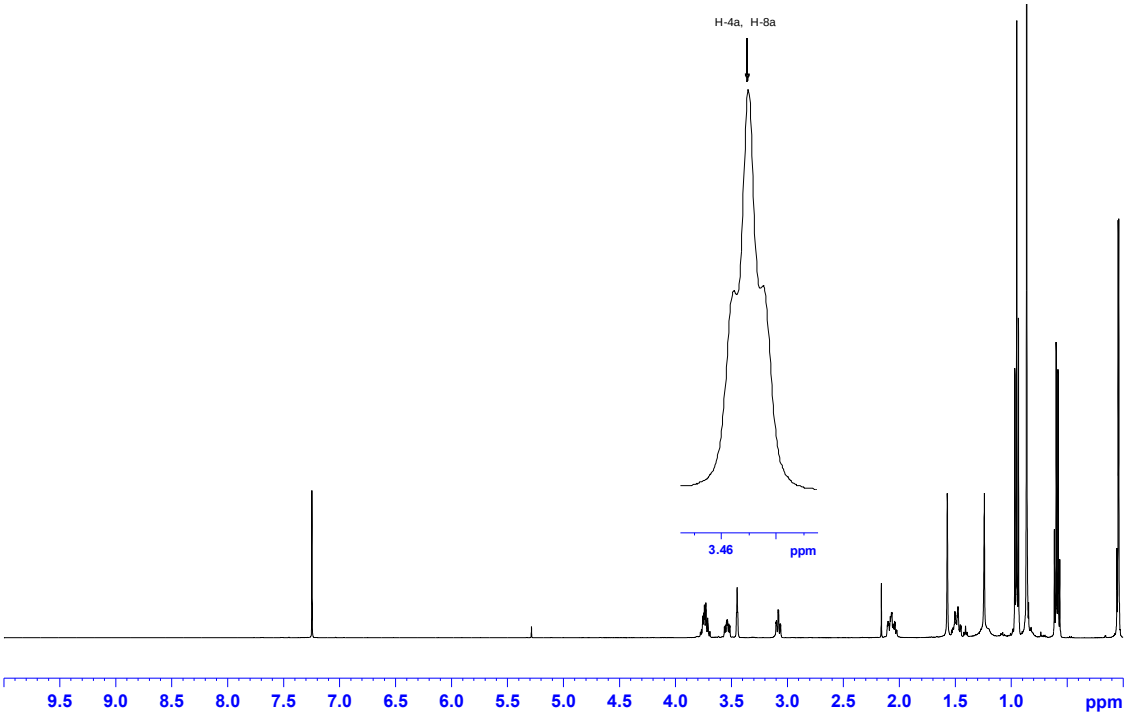
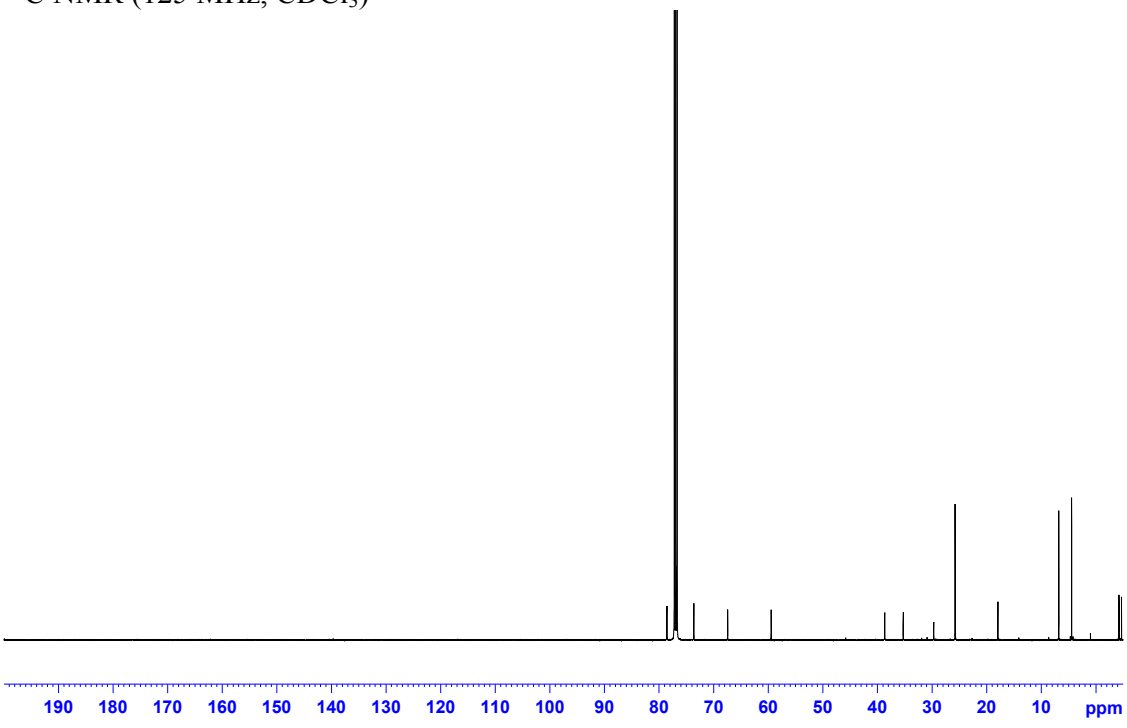
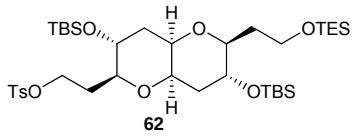


^{13}C NMR (125 MHz, $CDCl_3$)



^{1}H NMR (500 MHz, $CDCl_3$)



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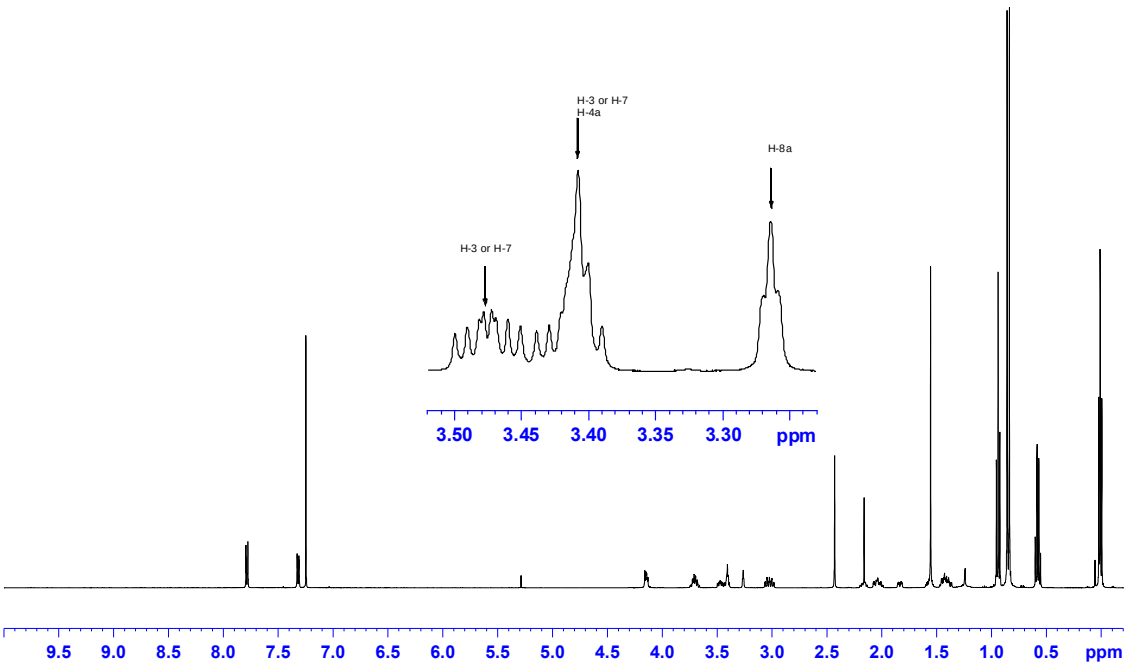
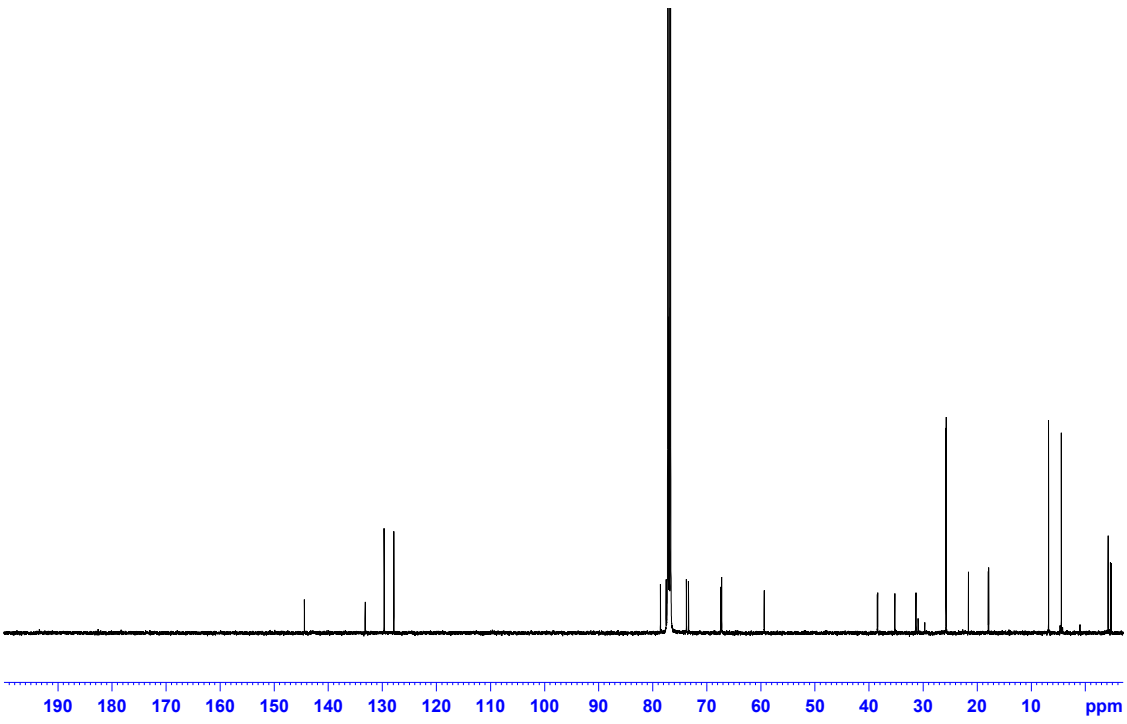
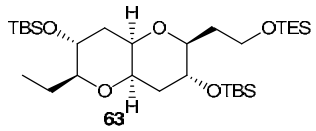


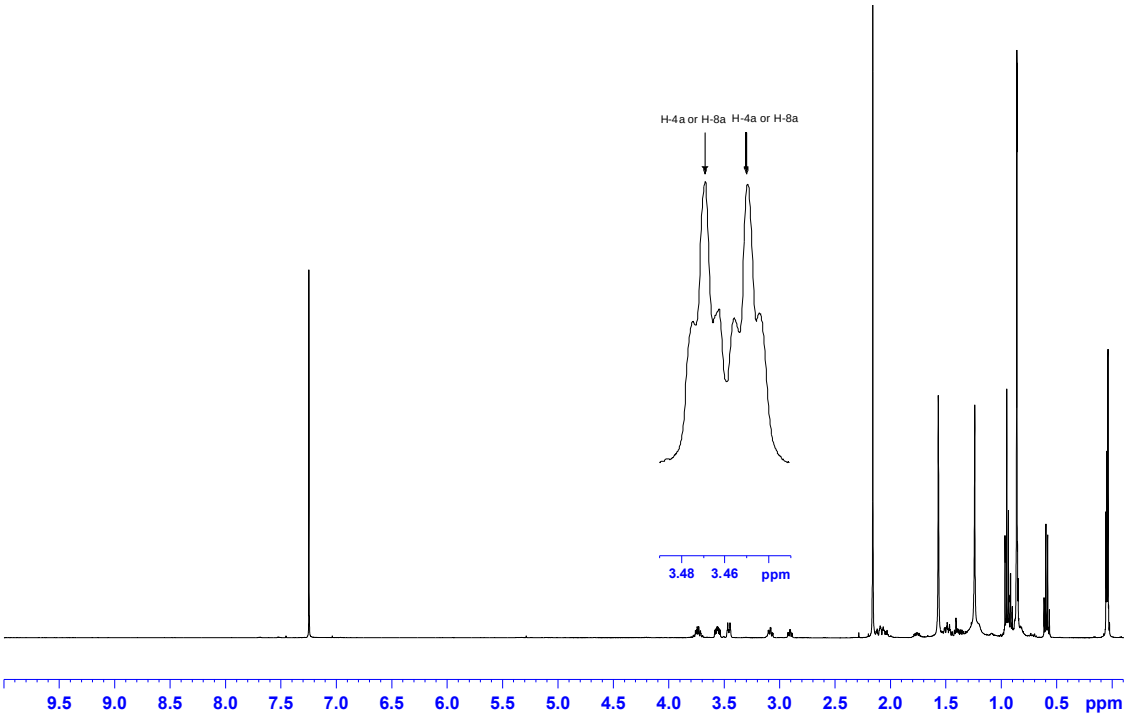
^{13}C NMR (125 MHz, $CDCl_3$)



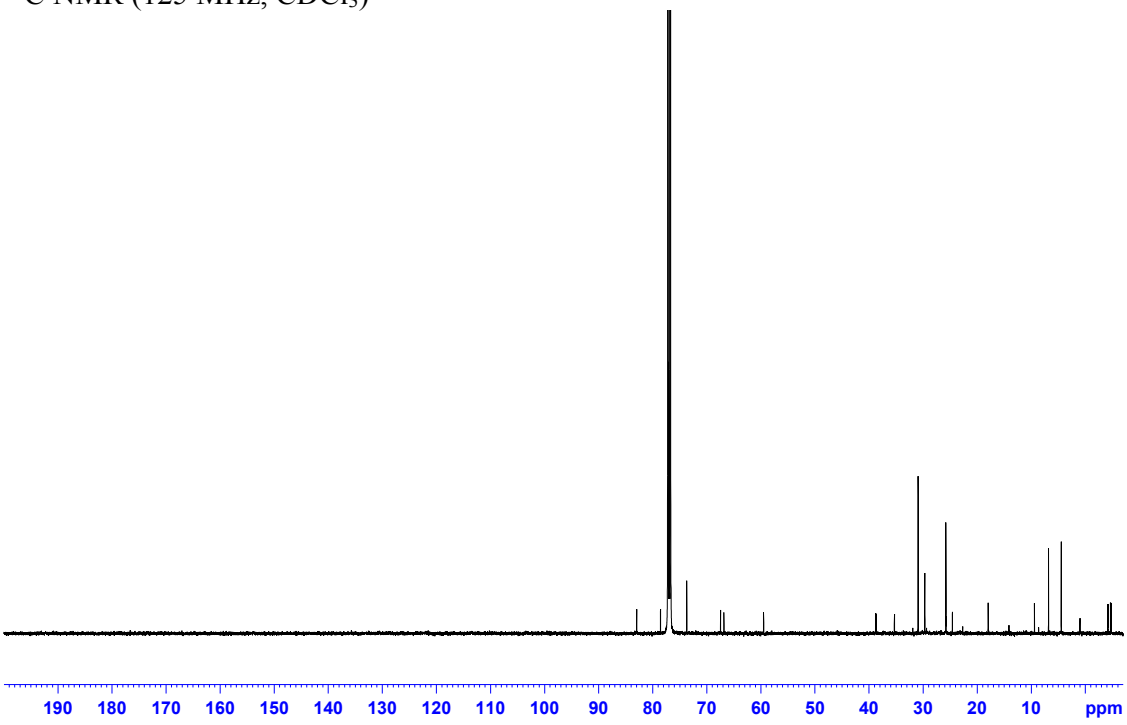
^{1}H NMR (500 MHz, $CDCl_3$)



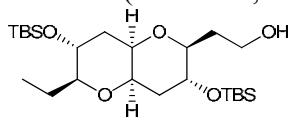
63

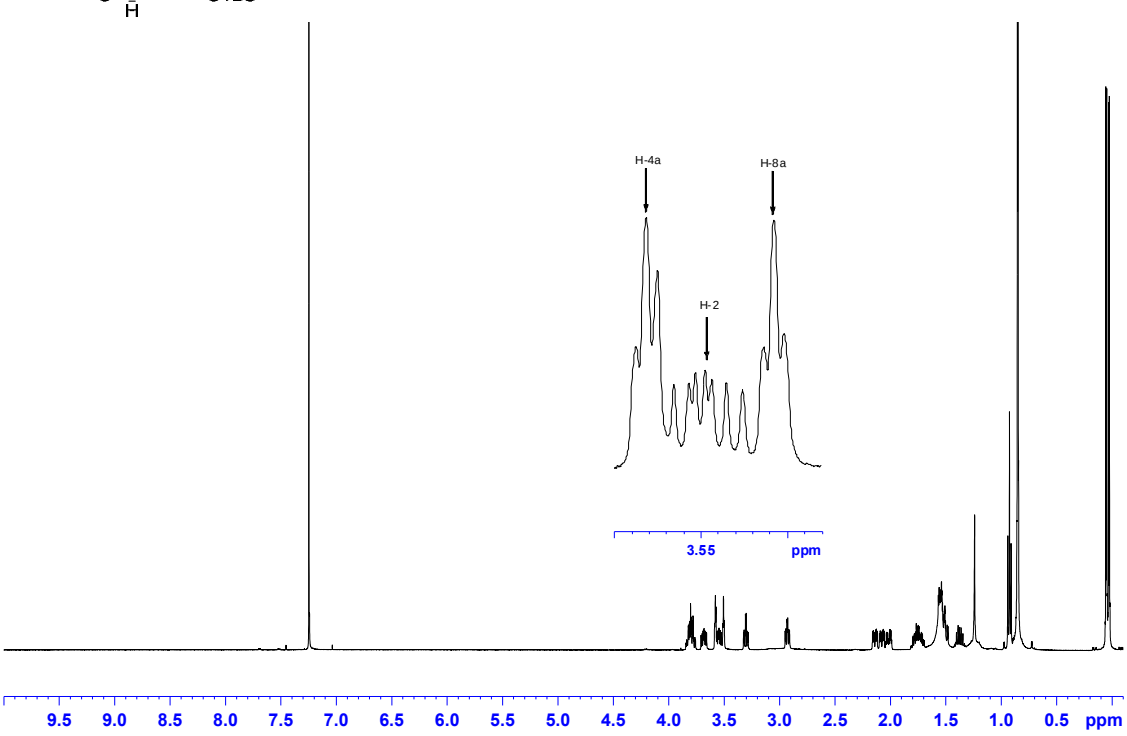


^{13}C NMR (125 MHz, $CDCl_3$)

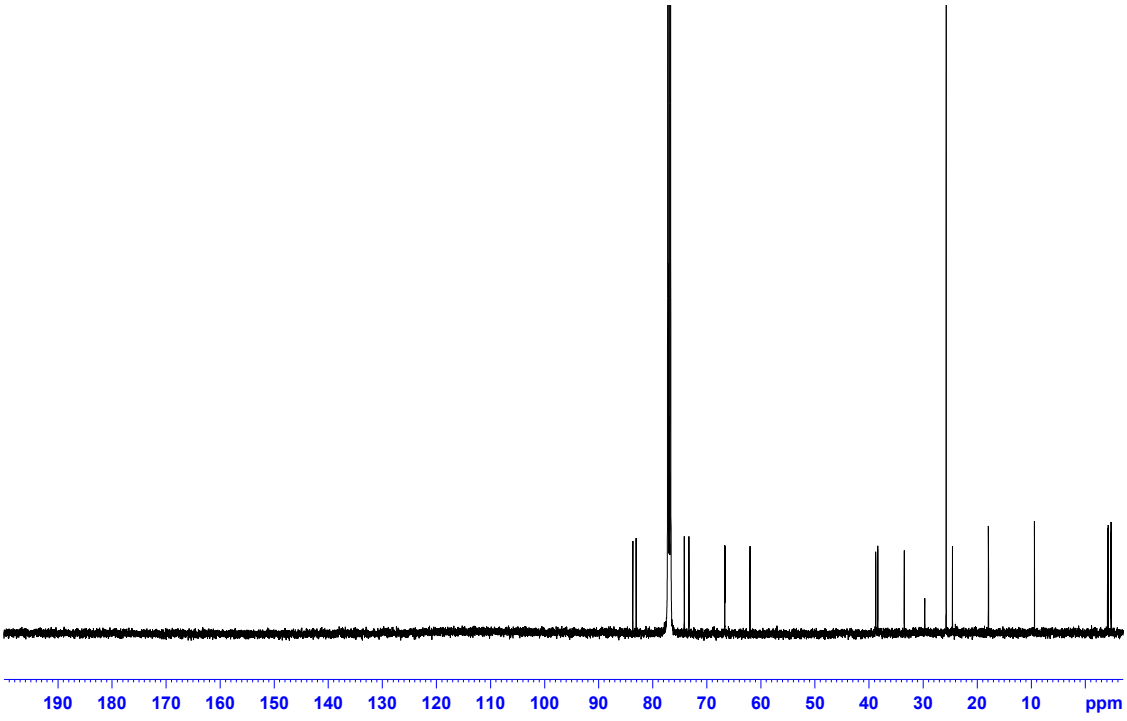


^{1}H NMR (500 MHz, $CDCl_3$)

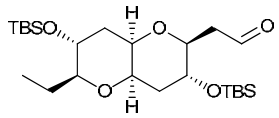




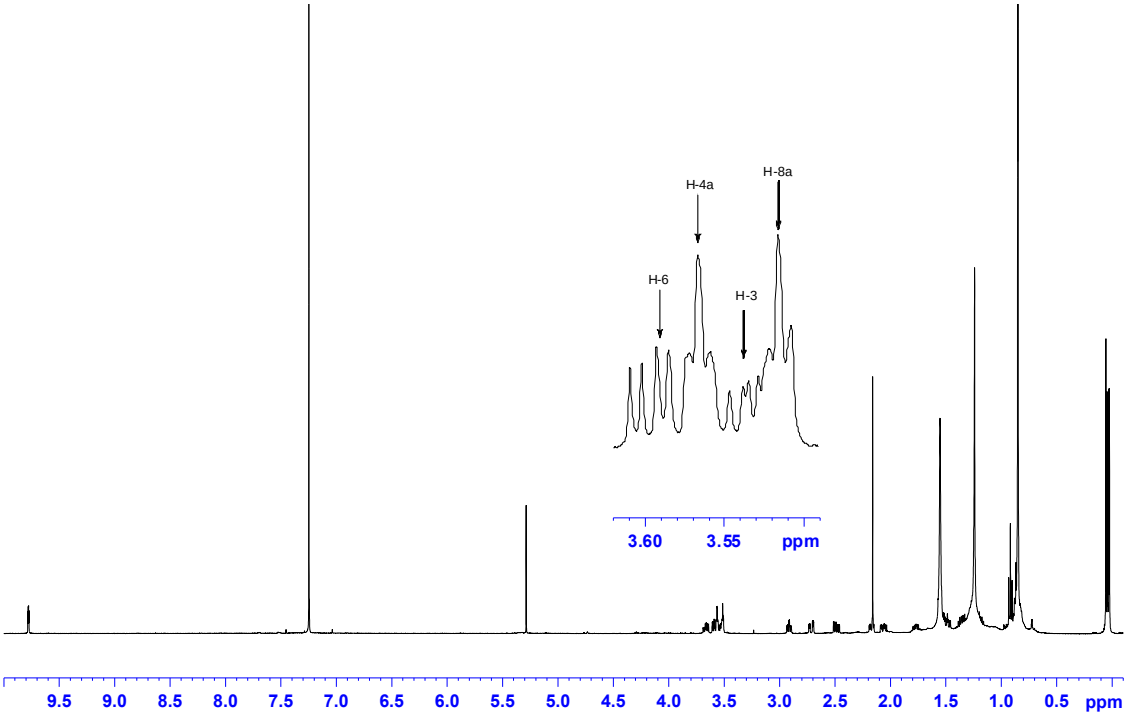
^{13}C NMR (125 MHz, $CDCl_3$)



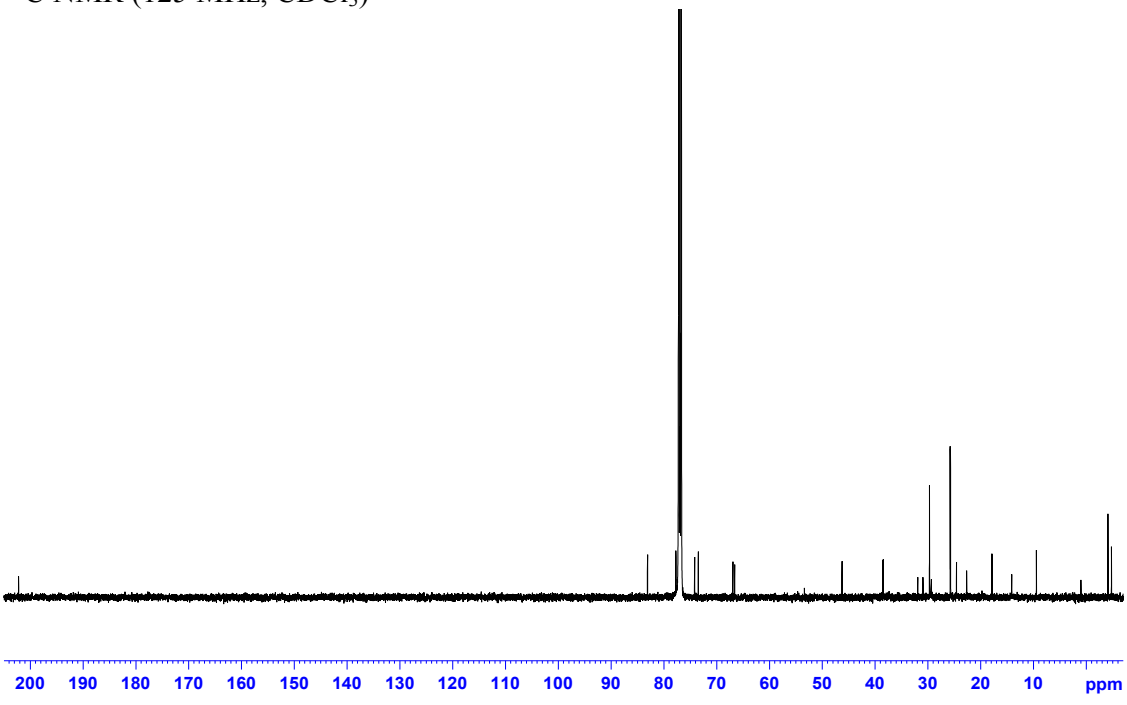
^{1}H NMR (500 MHz, $CDCl_3$)



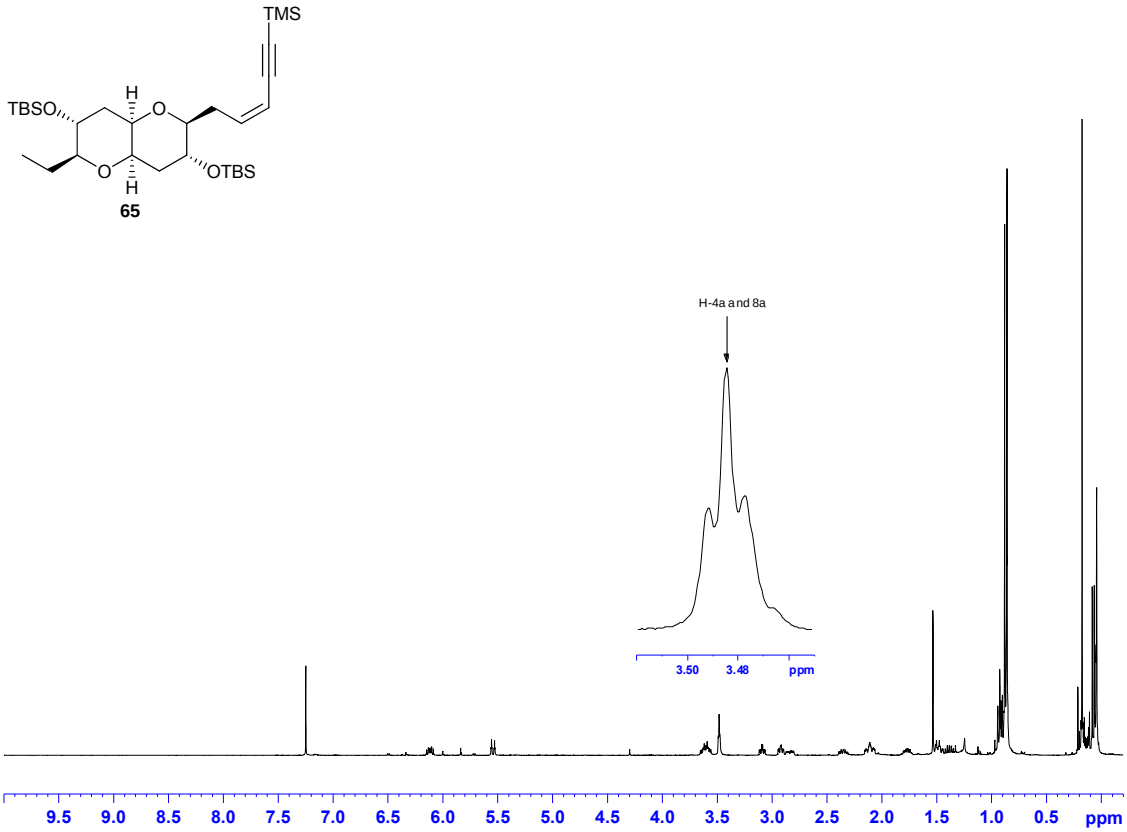
64



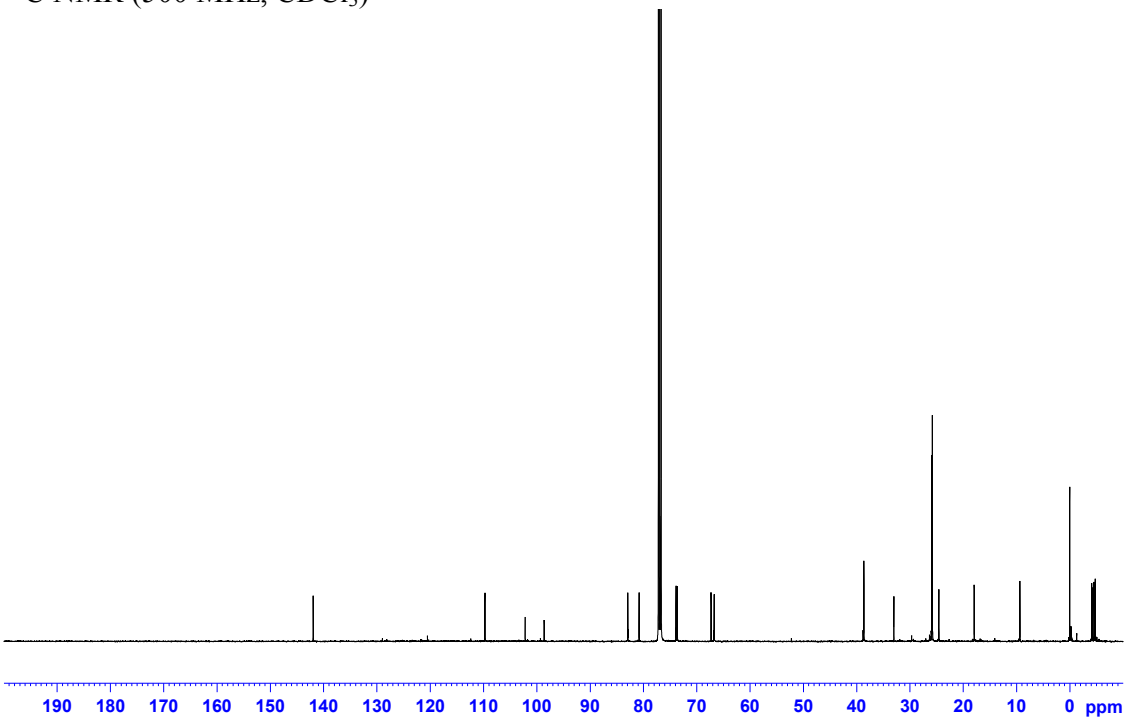
^{13}C NMR (125 MHz, $CDCl_3$)



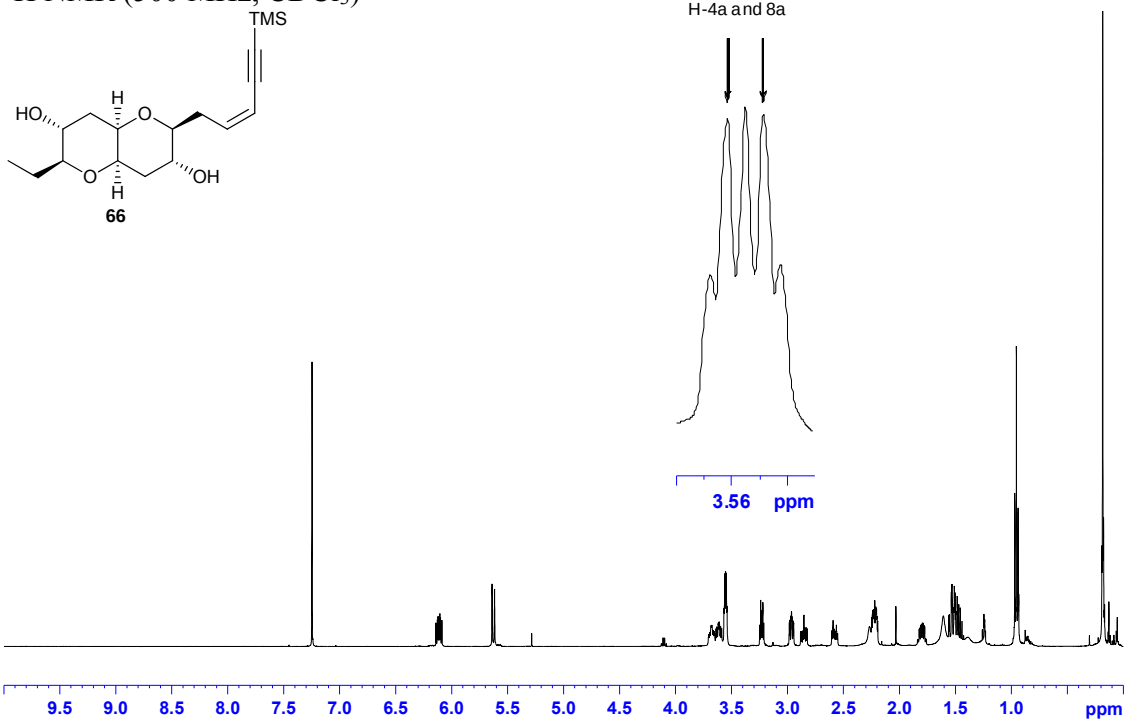
^{1}H NMR (400 MHz, $CDCl_3$)



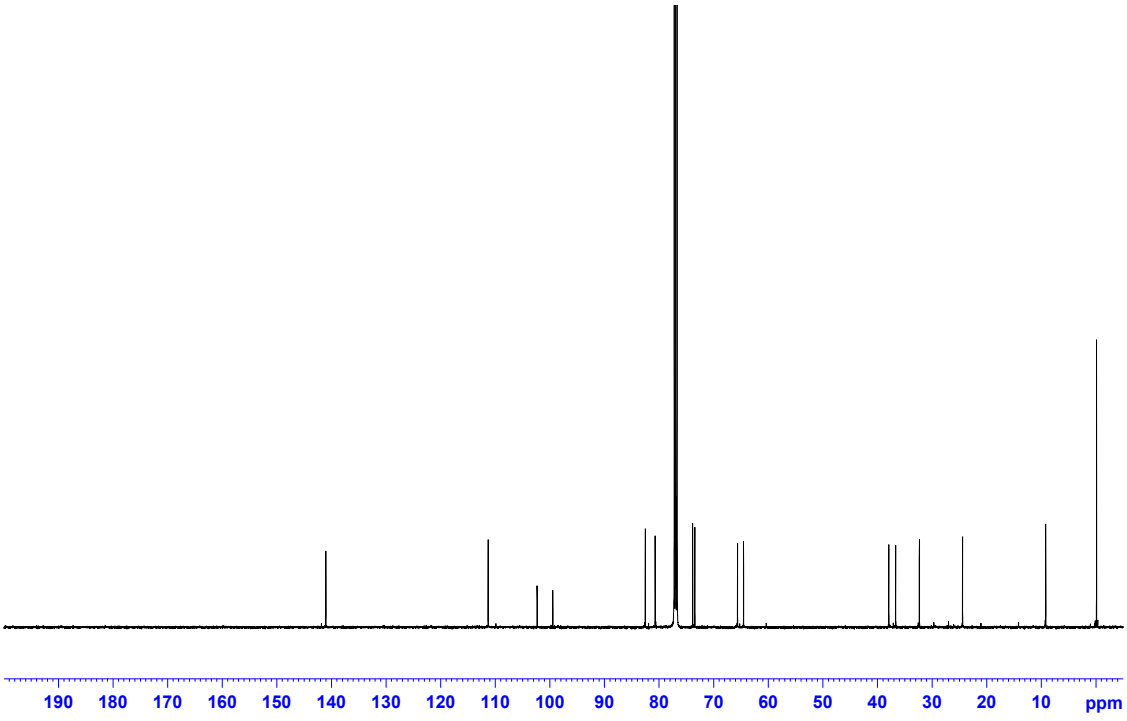
^{13}C NMR (500 MHz, $CDCl_3$)



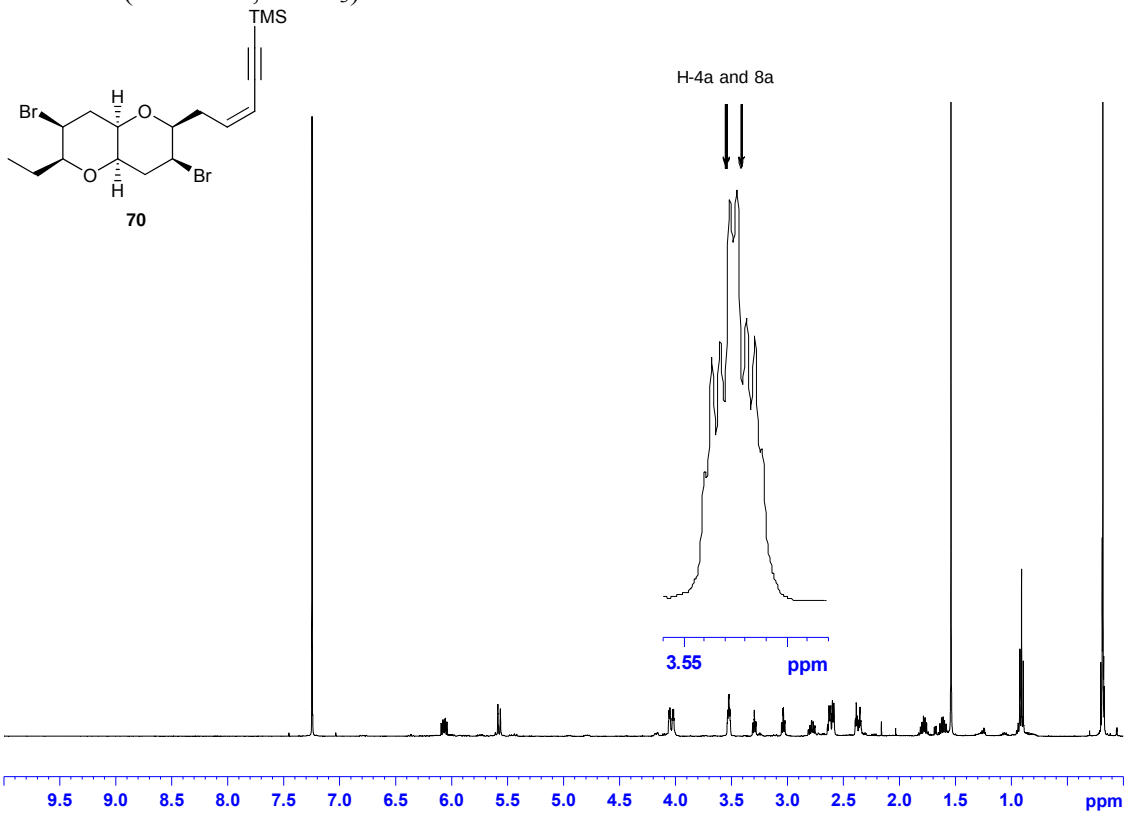
^{1}H NMR (500 MHz, $CDCl_3$)



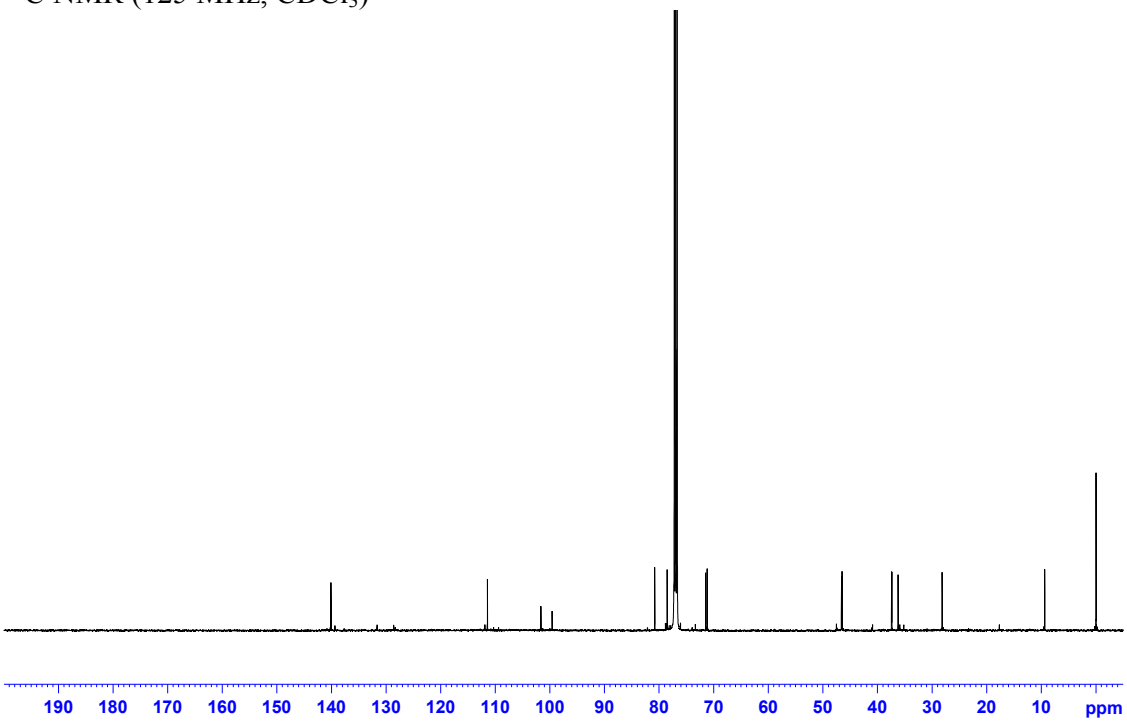
^{13}C NMR (125 MHz, $CDCl_3$)



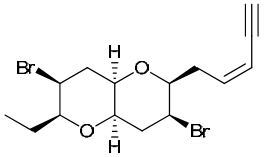
^{1}H NMR (500 MHz, $CDCl_3$)



^{13}C NMR (125 MHz, $CDCl_3$)



^{1}H NMR (500 MHz, $CDCl_3$)



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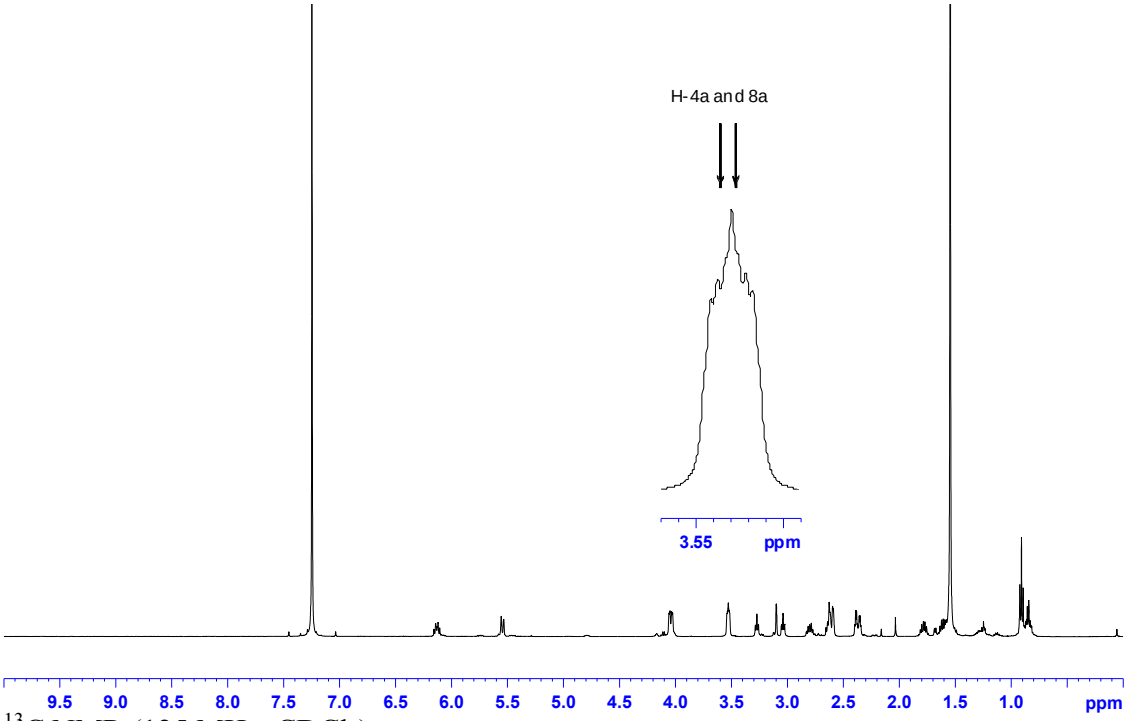
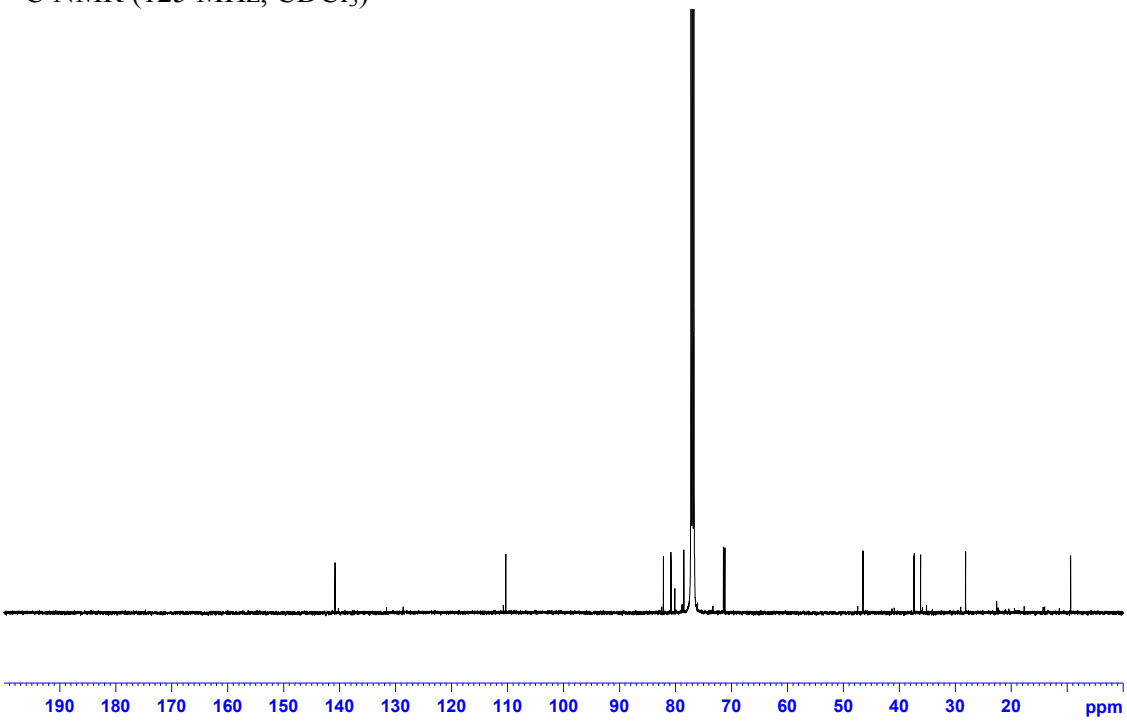
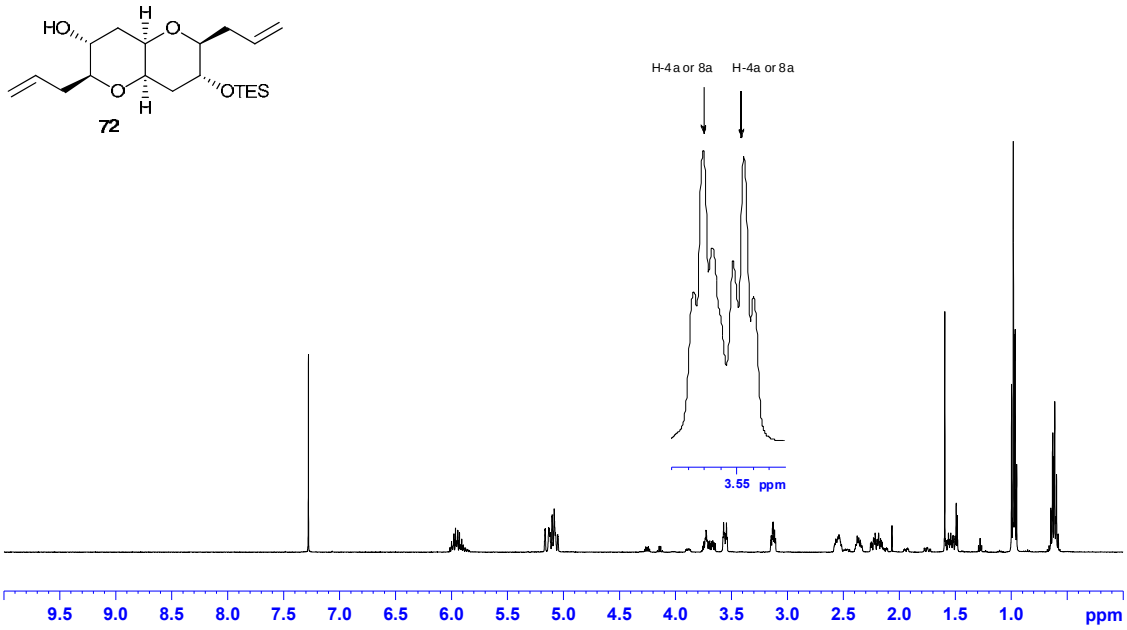


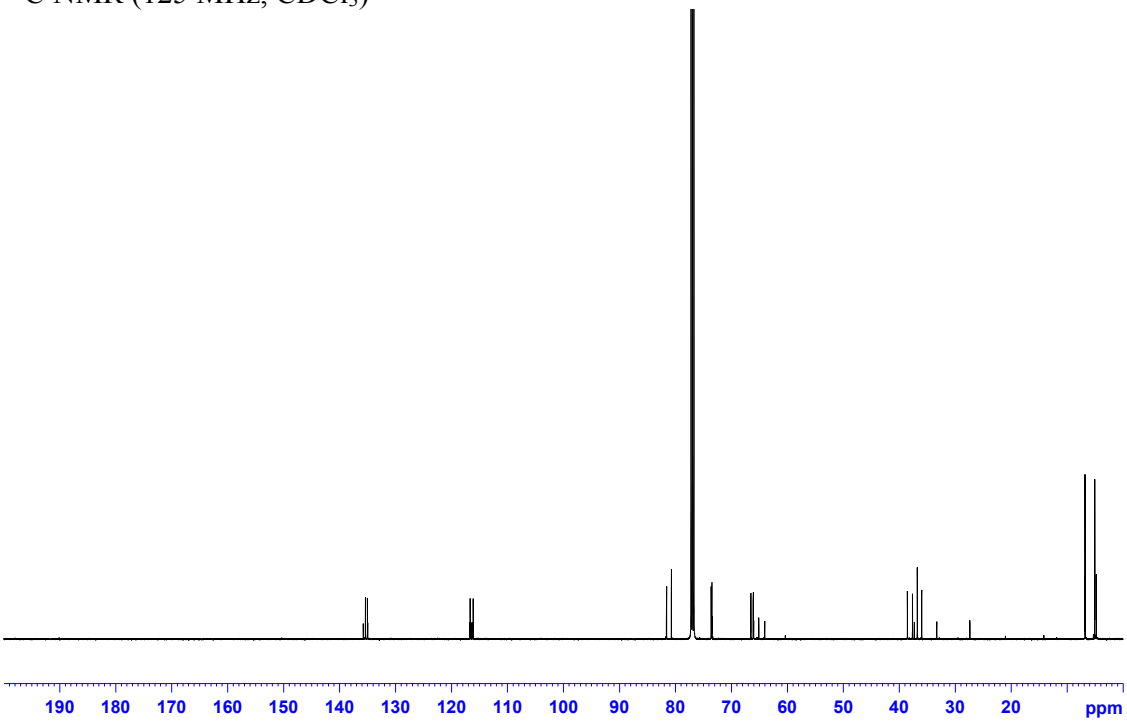
^{13}C NMR (125 MHz, $CDCl_3$)



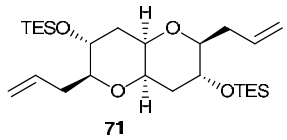
^{1}H NMR (400 MHz, $CDCl_3$) - 5:1 mixture of diastereomers



^{13}C NMR (125 MHz, $CDCl_3$)

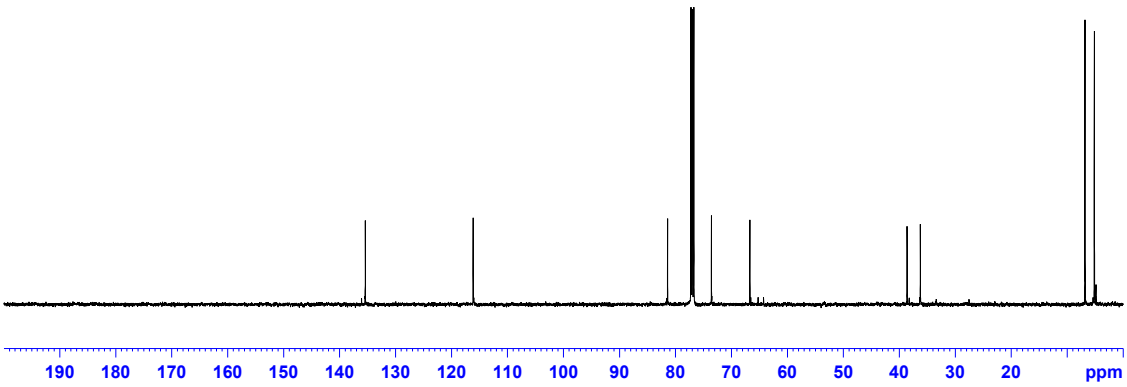


^{1}H NMR (500 MHz, $CDCl_3$) – predominantly one diastereomer

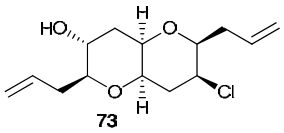


71

^{13}C NMR (125 MHz, $CDCl_3$)



^{1}H NMR (500 MHz, $CDCl_3$)



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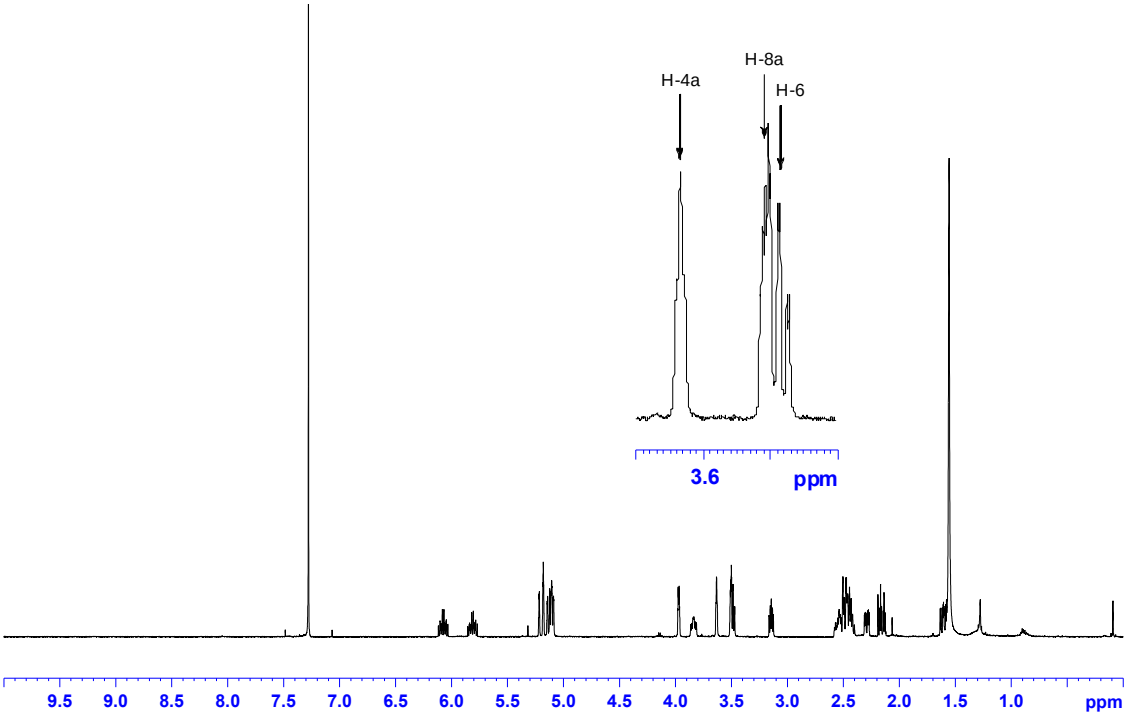
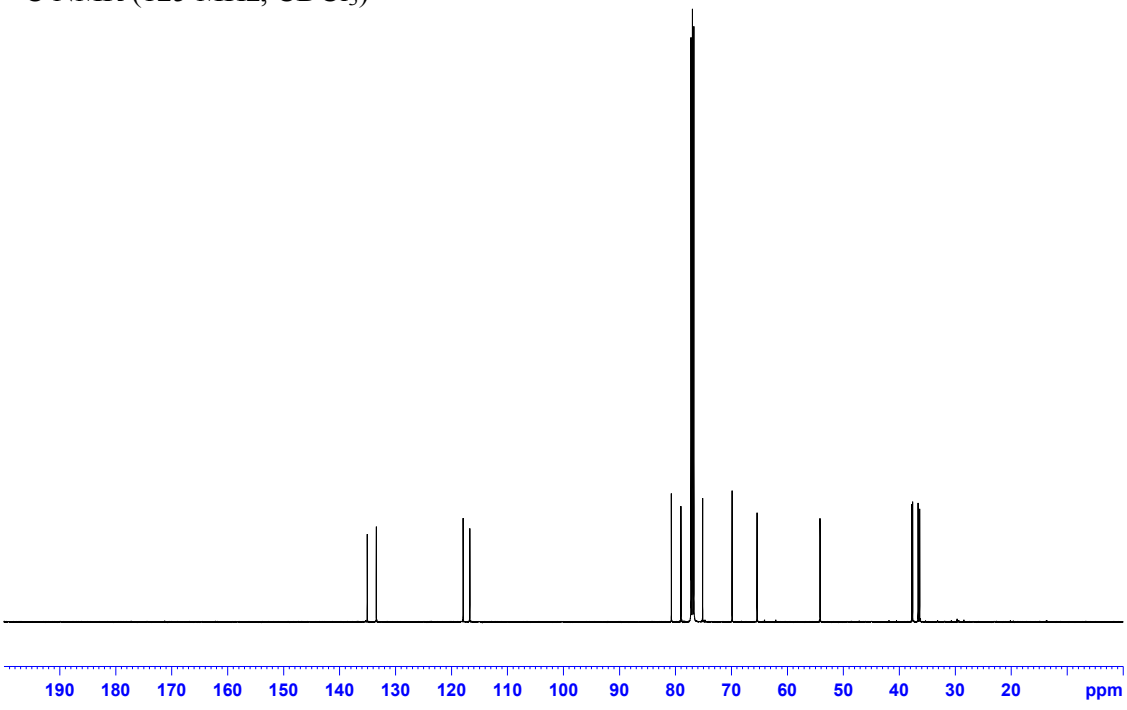
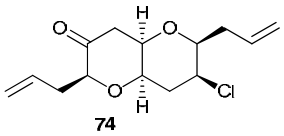


^{13}C NMR (125 MHz, $CDCl_3$)

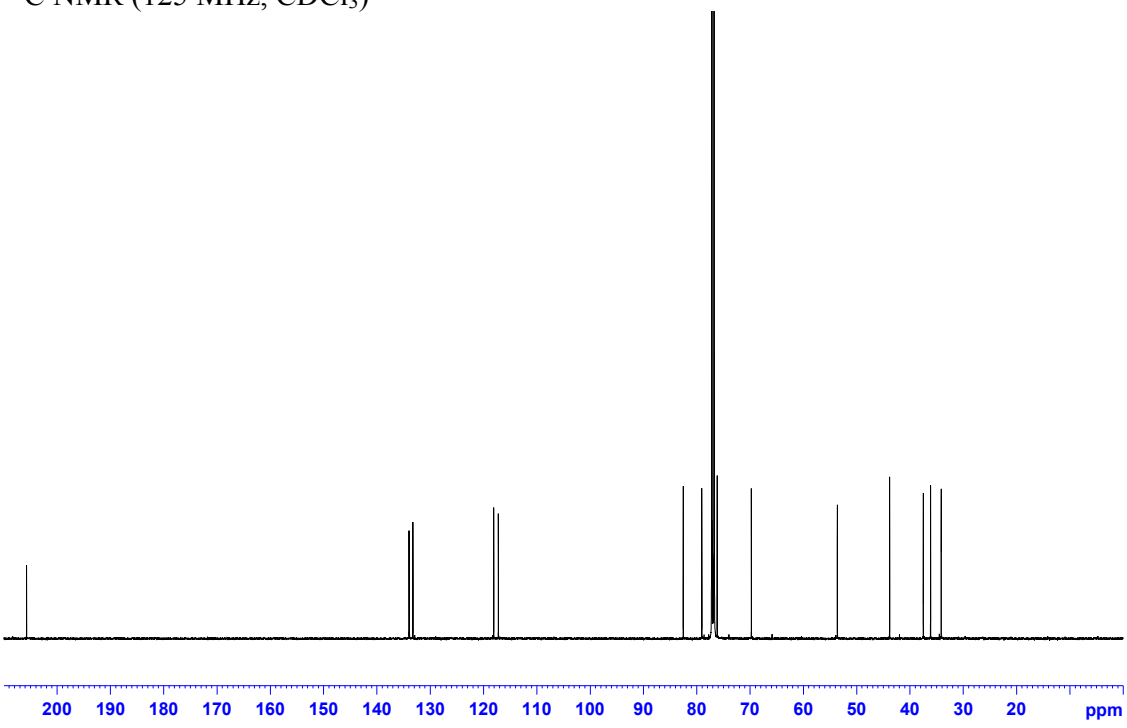


^{1}H NMR (500 MHz, $CDCl_3$)

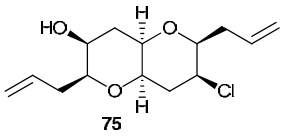


74

^{13}C NMR (125 MHz, $CDCl_3$)

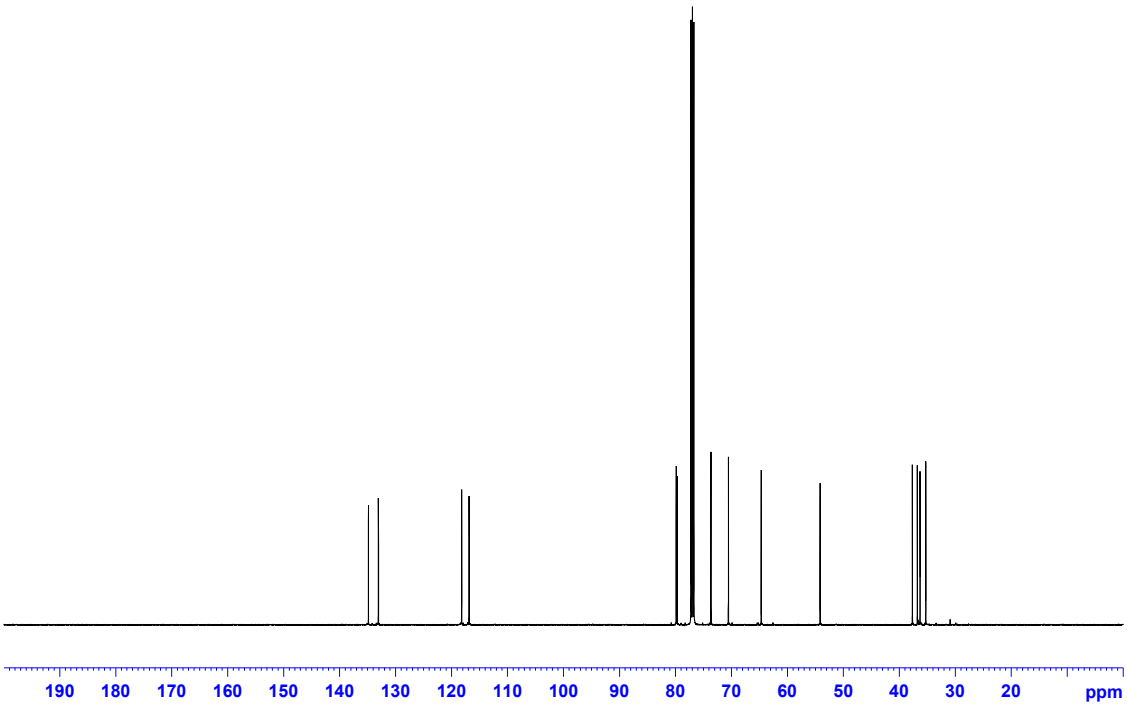


^{1}H NMR (500 MHz, $CDCl_3$)

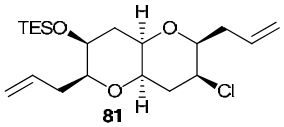


75

^{13}C NMR (125 MHz, $CDCl_3$)



^{1}H NMR (500 MHz, $CDCl_3$)



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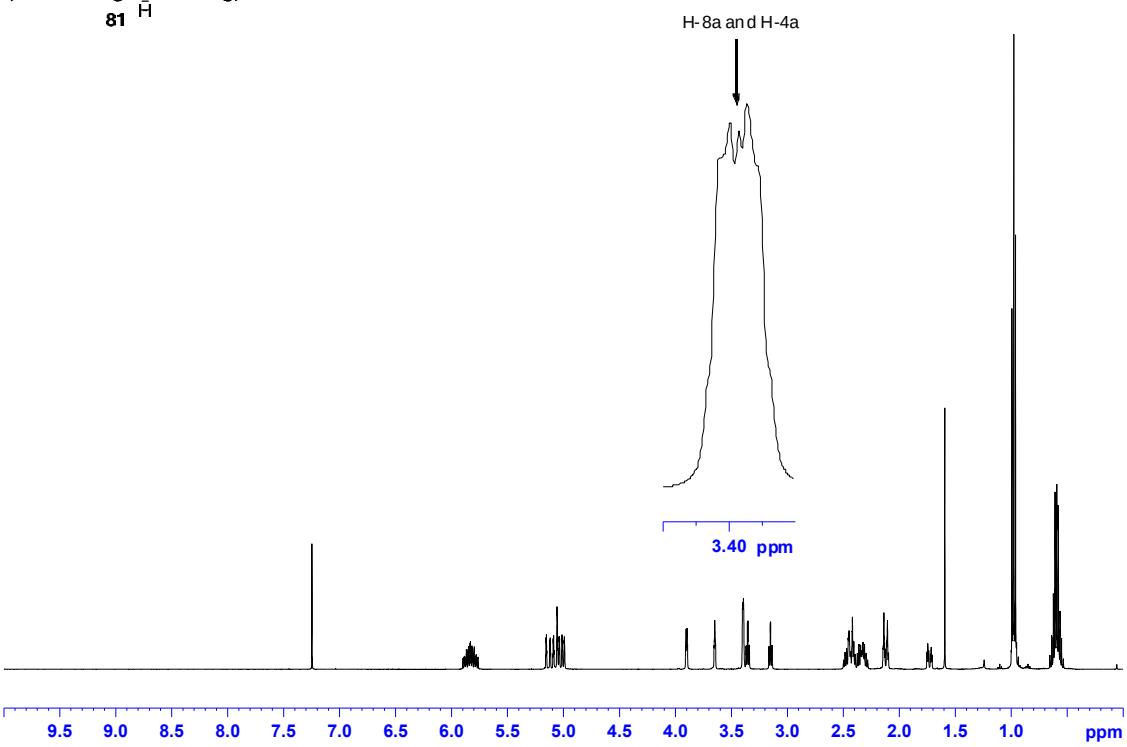
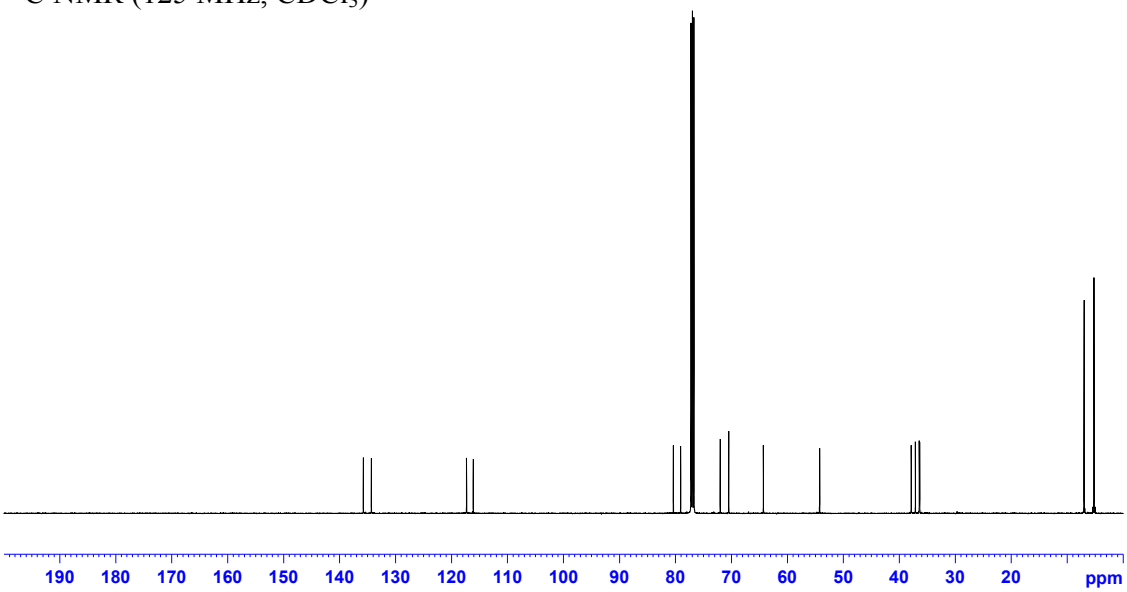
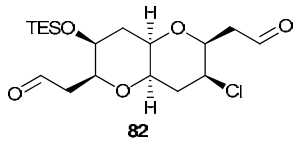


^{13}C NMR (125 MHz, $CDCl_3$)



^{1}H NMR (500 MHz, $CDCl_3$)



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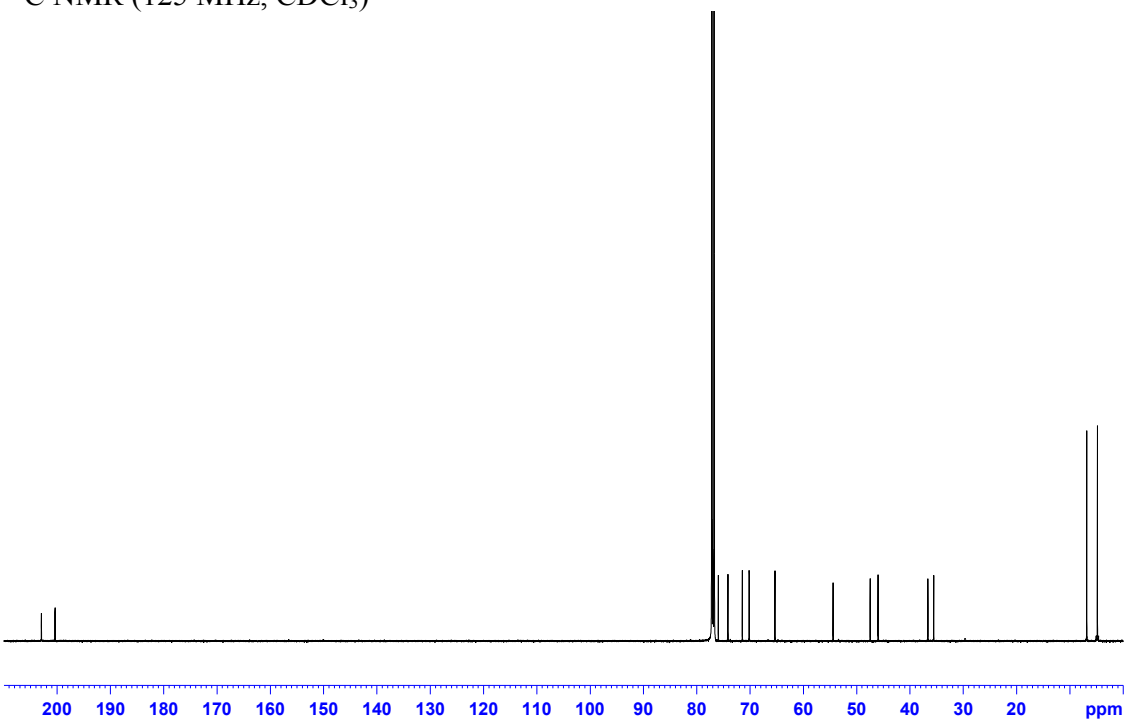
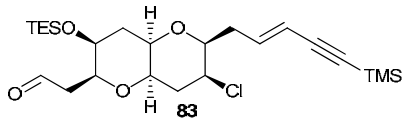
^{13}C NMR (125 MHz, $CDCl_3$)



^{1}H NMR (500 MHz, $CDCl_3$) ca. 8:1 mixture of geometric isomers



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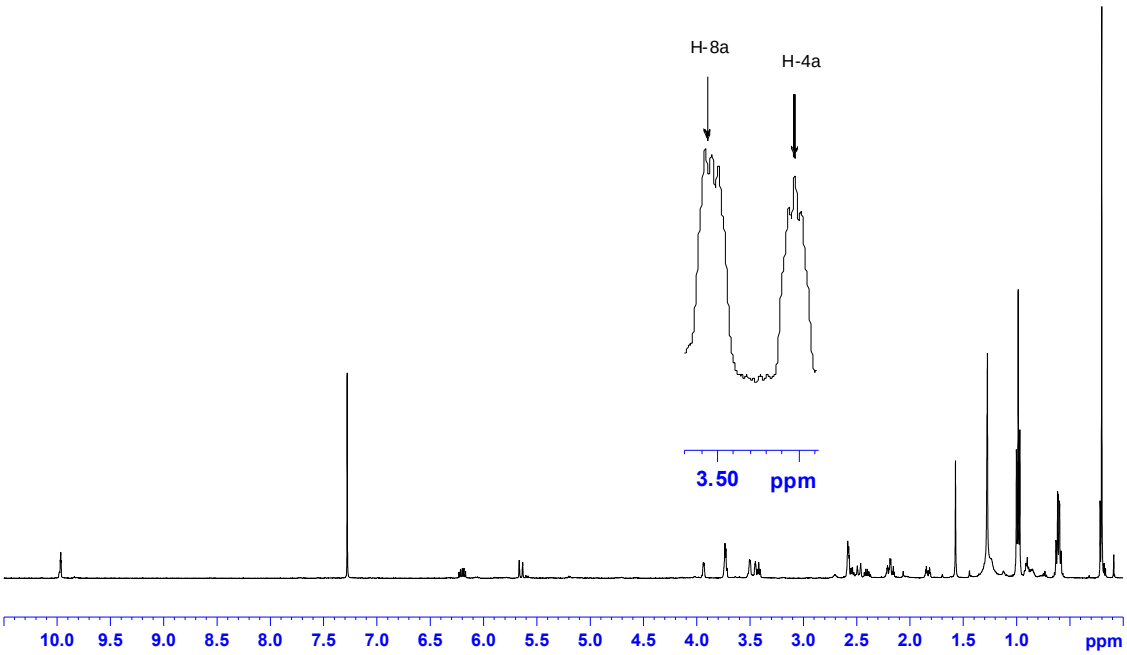
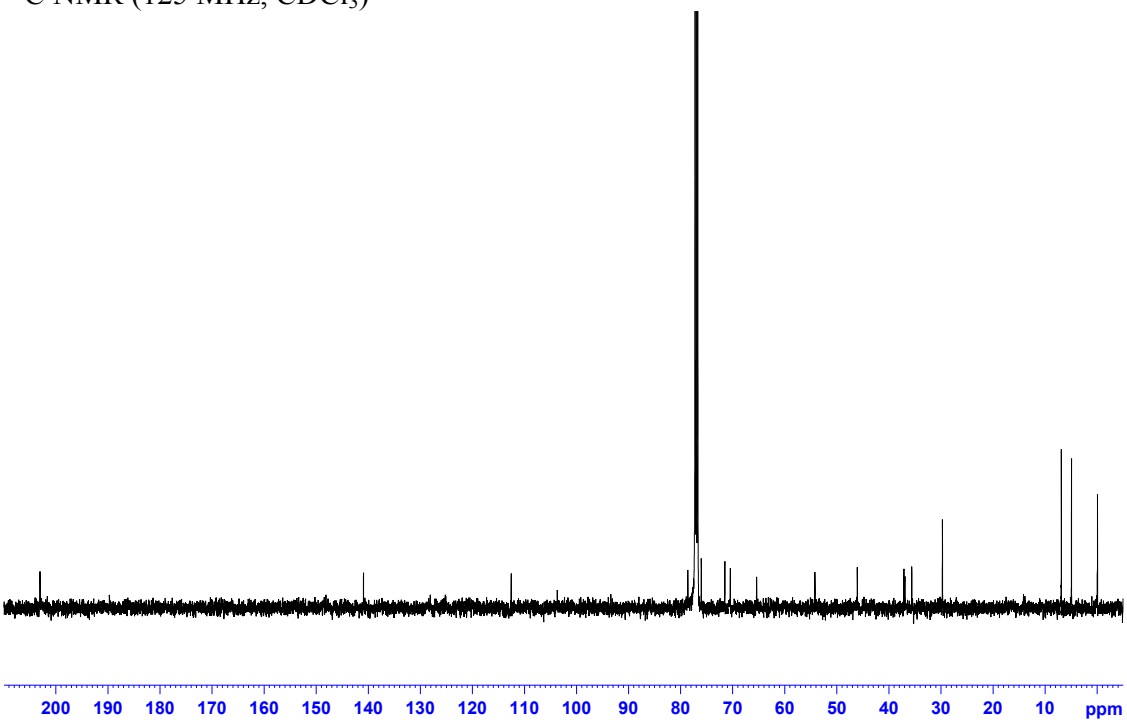
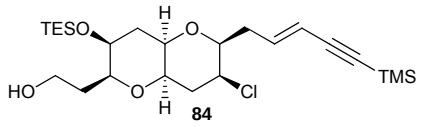


^{13}C NMR (125 MHz, $CDCl_3$)



^{1}H NMR (500 MHz, $CDCl_3$) ca. 8:1 mixture of geometric isomers



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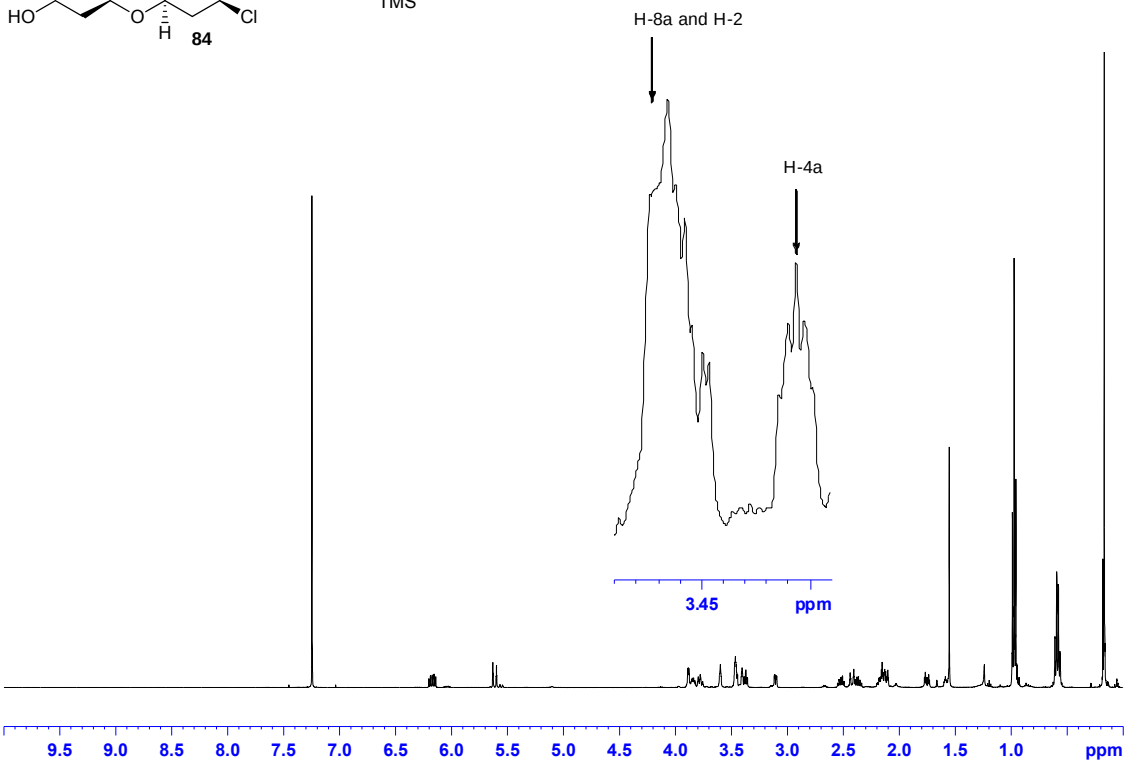
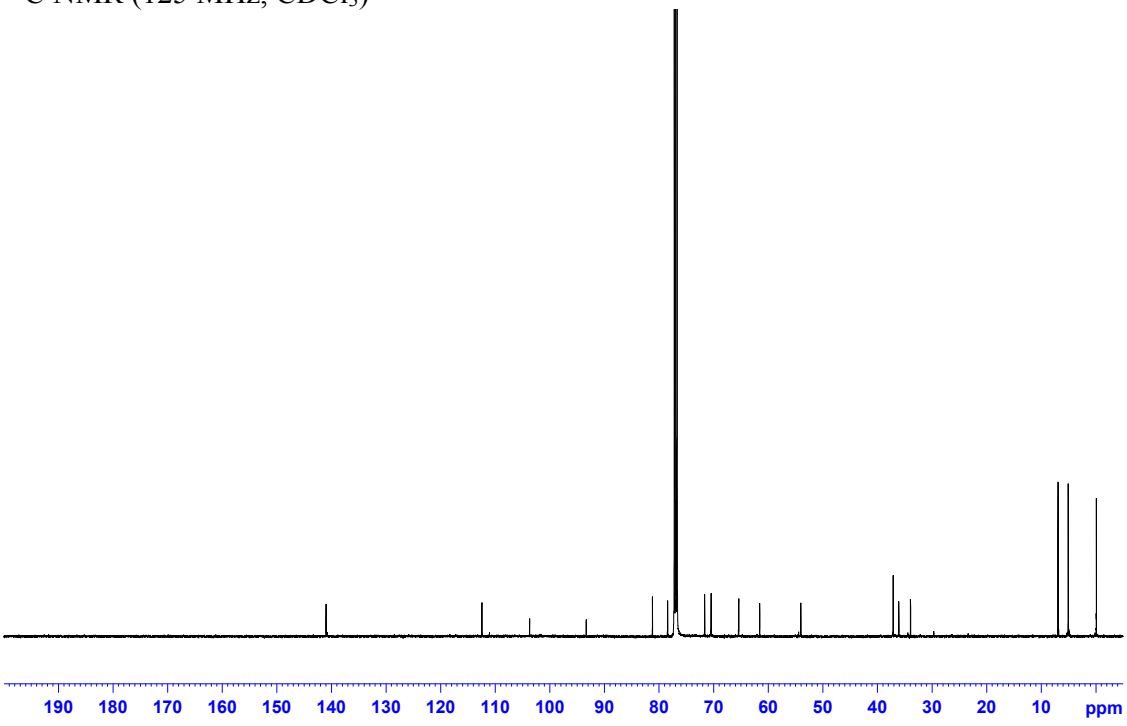
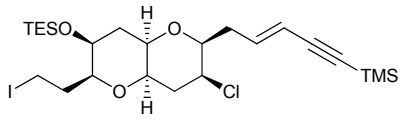


^{13}C NMR (125 MHz, $CDCl_3$)



^{1}H NMR (500 MHz, $CDCl_3$) ca. 8:1 mixture of geometric isomers



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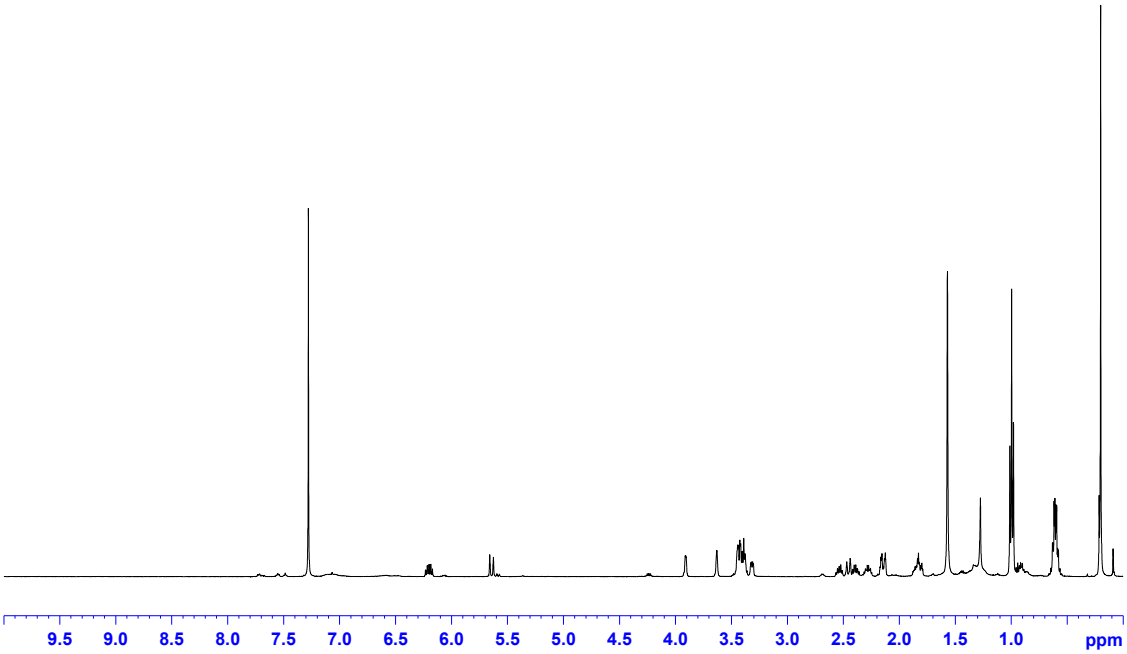
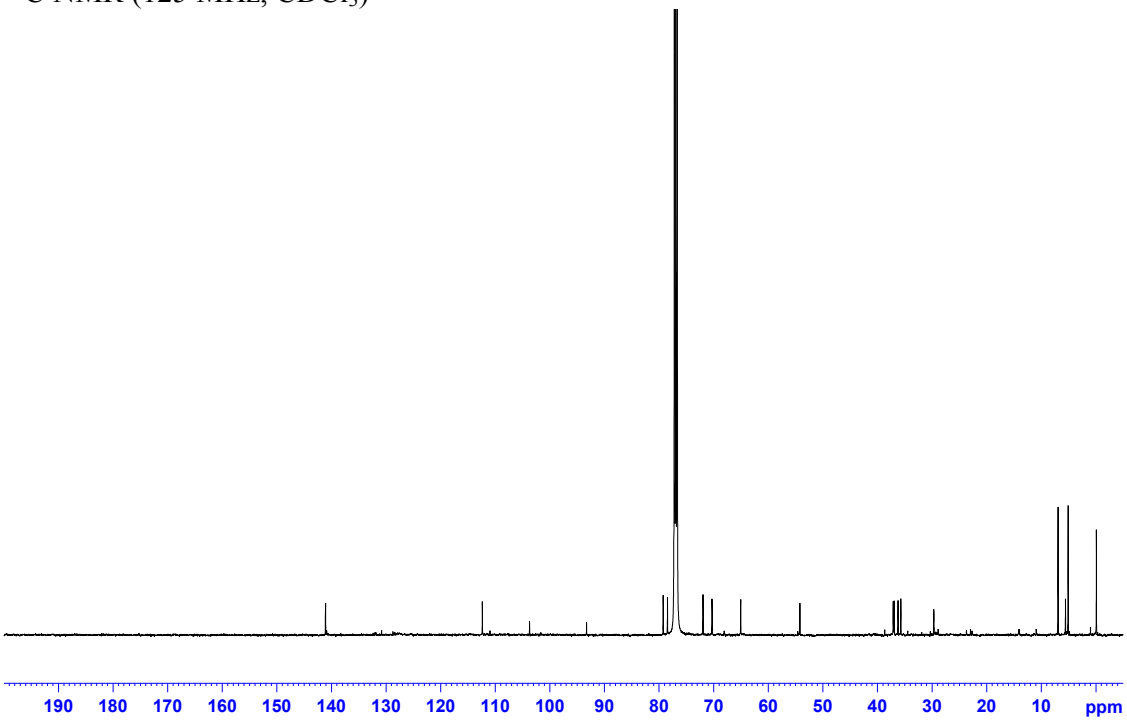
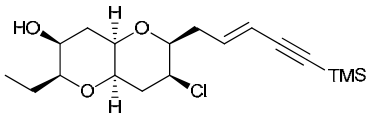


^{13}C NMR (125 MHz, $CDCl_3$)



^{1}H NMR (500 MHz, $CDCl_3$) ca. 8:1 mixture of geometric isomers



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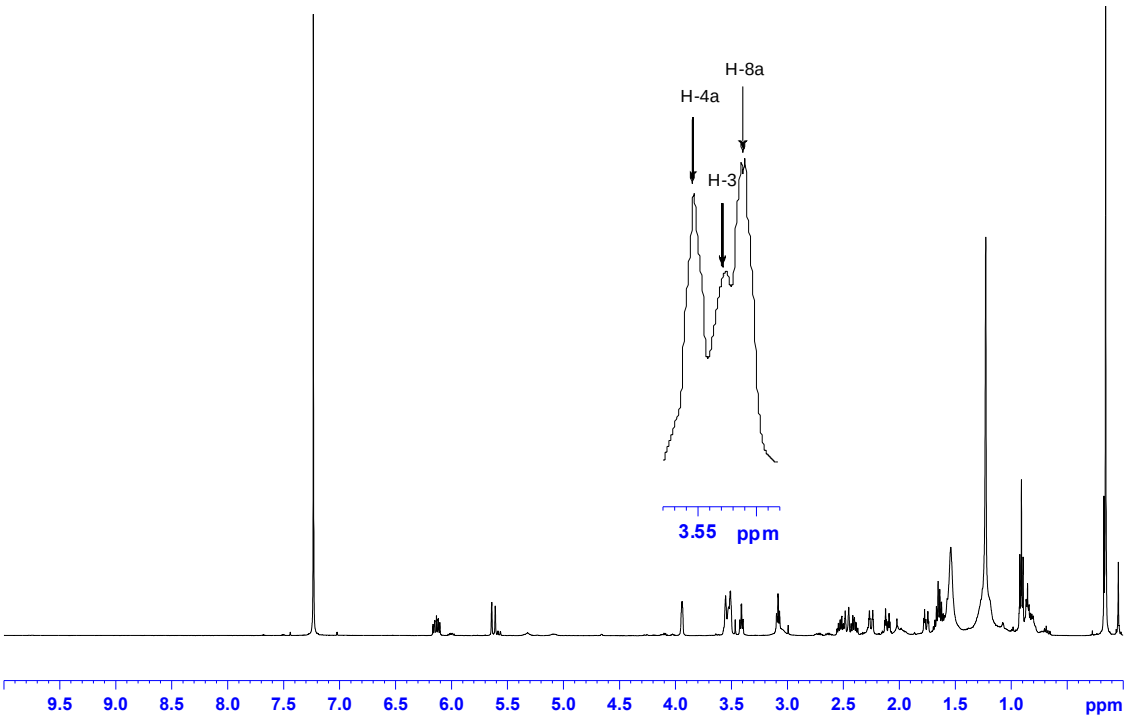
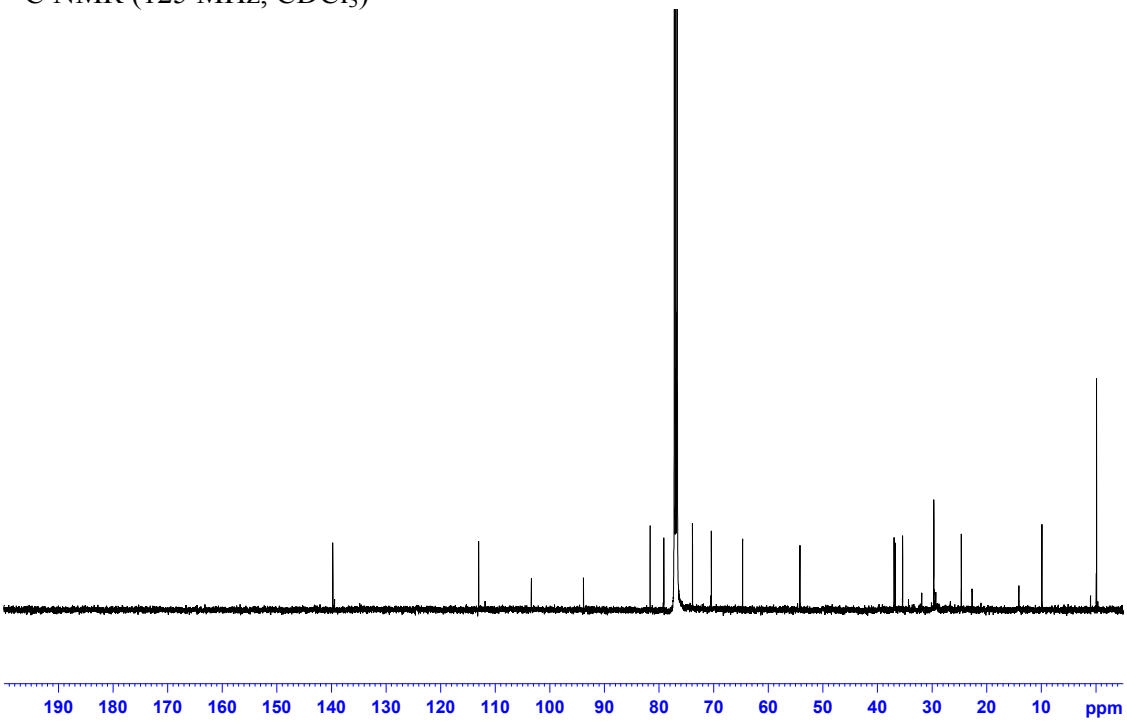
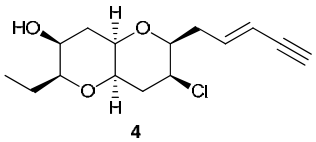


^{13}C NMR (125 MHz, $CDCl_3$)



^{1}H NMR (500 MHz, $CDCl_3$) ca. 8:1 mixture of geometric isomers



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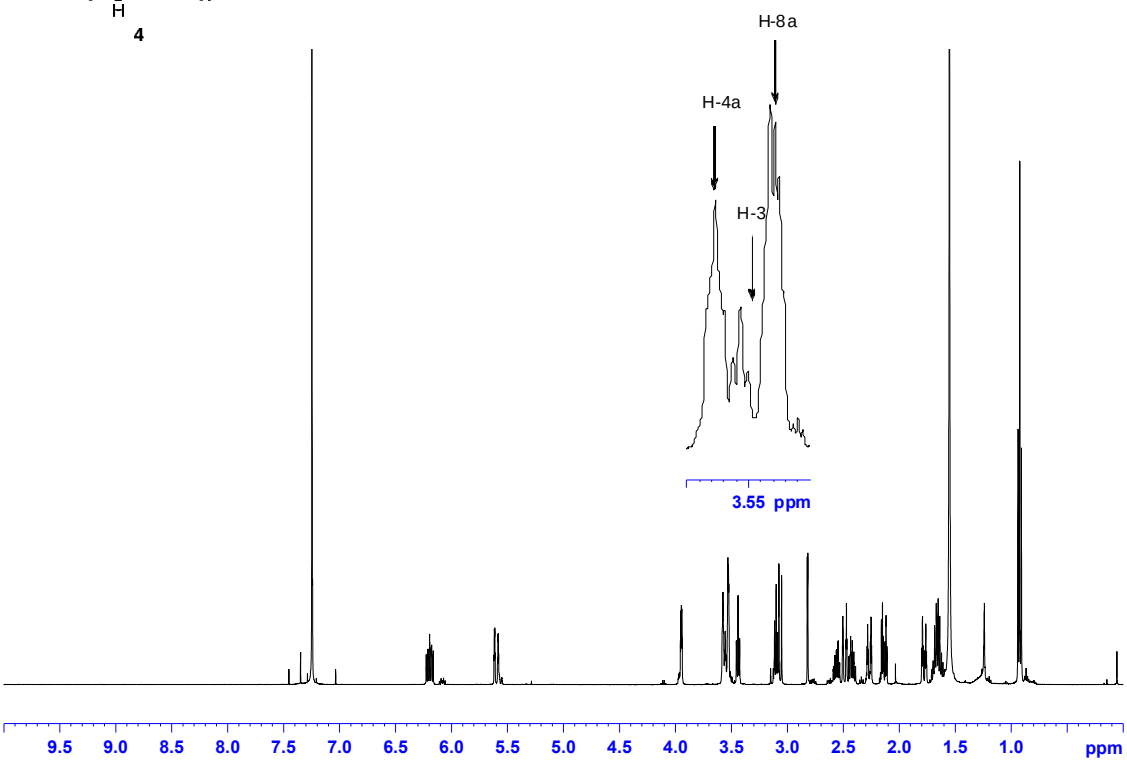

^{13}C NMR (125 MHz, $CDCl_3$)