Supporting Information

Structure Proof and Synthesis of Kotalanol and De-*O*-sulfonated Kotalanol, Glycosidase Inhibitors Isolated from an Herbal Remedy for the Treatment of Type-2 Diabetes

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Experimental Section

General. Optical rotations were measured at 23 °C. ^{1}H and ^{13}C NMR spectra were recorded at 600 and 150 MHz, respectively. All assignments were confirmed with the aid of two-dimensional ^{1}H, ^{1}H (COSYDFTP) or ^{1}H, ^{13}C (INVBTP) experiments using standard pulse programs. Column chromatography was performed with Silica gel 60 (230-400 mesh). High resolution mass spectra were obtained by the electrospray ionization method, using an Agilent 6210 TOF LC/MS high resolution magnetic sector mass spectrometer.

1,3-*O*-Benzylidene-2,5-*O*-methylene-D-mannitol (25)[1]. Compound **25** was prepared from 1,3:4,6-di-*O*-benzylidene-D-mannitol (**24**) by using the literature methods with some variations. Thus, compound **24**[2] was converted into 1,3:4,6-di-*O*-benzylidene-2,5-*O*-methylene-D-mannitol as described.[3] The product was then treated with PTSA to yield compound **25** as described below. To a solution of 1,3:4,6-di-*O*-benzylidene-2,5-*O*-methylene-D-mannitol (5.00 g, 13.51 mmol) in MeOH (250 mL) was added PTSA (200 mg), and the reaction mixture was stirred at 70 ^{o}C for 2 h. The reaction mixture was then quenched by addition of Et_3N (2 mL), and the solvents were removed under vacuum to give a colorless solid. The solids were dissolved in ethyl acetate (75 mL) and filtered, and the filtrate was concentrated to give the crude 1,3-*O*-Benzylidene-2,5-*O*-methylene-D-mannitol. The undissolved solids (~ 1.1 g, 5.67 mmol, of 2,5-*O*-methylene-D-mannitol) were mixed with dry DMF (20 mL), benzaldehyde dimethylacetal (0.849 mL, 5.67 mmol), and PTSA (50 mg). The resulting reaction mixture was heated at 60 ^{o}C under a rotary evaporator vacuum for 2 h. The reaction was neutralized by the addition of Et_3N (1 mL), and the solvents were evaporated to give a crude product. The combined crude products were diluted with ethyl acetate (200 mL) and washed with water (150 mL) and brine (150 mL). The organic solution was dried (Na_2SO_4) and concentrated, and the crude product was purified by flash column chromatography (hexanes/EtOAc 3:7) to give **25** [19] in 65% (2.47 g) over the two steps.

4-*O*-Benzyl-1,3-*O*-benzylidene-2,5-*O*-methylene-D-mannitol (26). To a mixture of **25** (2.50 g, 8.86 mmol), and imidazole (1.45 g, 21.3 mmol), in dry DMF (30 mL) was added portionwise TBDMSCl (1.46 g, 9.70 mmol) and the mixture was stirred at 0 ^{o}C under nitrogen for 2 h. The reaction was quenched by the addition of ice-cold water (25 mL), and the reaction mixture was partitioned between Et_2O (200 mL) and water (100 mL). The separated organic solution was dried (Na_2SO_4) and concentrated on a rotary evaporator to give a crude product which was directly treated in the next step without further purification. The crude product was kept under high vacuum for 1 h, then dissolved in dry DMF (50 mL), the reaction mixture was cooled with an ice bath, and 60% NaH (1.06 g, 26.5 mmol) was added. A solution of benzyl bromide (3.16 mL, 26.5 mmol) was added, and the solution was stirred at room temprature for 1 h. The mixture was added to ice-water (150 mL) and extracted with Et_2O (3 x 100 mL). The organic solution was dried (Na_2SO_4) and concentrated to give a crude product. The crude residue was dissolved in THF (50 mL) and then TBAF (1.0 M solution in THF, 8.9 mL, 9.0 mmol) was added. After 20 h at rt, the reaction mixture was concentrated and the residue was purified by flash chromatography (hexanes/EtOAc 2:3) to yield **26** as a colorless solid (2.04 g, 62%). Mp 150-152 ^{o}C; $[\alpha]_D^{23}$ = - 26.5° (*c* = 1.0, CH_2Cl_2). ^{1}H NMR ($CDCl_3$): δ 7.54-7.28 (10H, m, Ar), 5.60 (1H, s, Ph-C*H*), 4.95 and 4.71 (2H, 2d, J_{AB} = 11.0 Hz, Ph-CH_2), 4.90 and 4.83 (2H, 2 d, J_{AB} = 4.2 Hz, O-CH_2-O), 4.35 (1H, dd, $J_{1a,1b}$ = 10.8, $J_{1a,2}$ = 5.4 Hz, H-1a), 3.94 (1H, m, H-6a), 3.86 (1H, dd, $J_{2,3}$ = 9.3, $J_{3,4}$ = 7.2 Hz, H-3), 3.81 (1H, td, H-2), 3.77-3.73 (3H, m, H-1b, H-5, H-6b), 3.69 (1H, dd, $J_{4,5}$ = 9.6 Hz, H-4), 2.01 (1H, t, $J_{1ab,\,OH}$ = 6.6 Hz, -OH). ^{13}C NMR ($CDCl_3$): δ 138.0-126.0 (m, Ar), 100.7 (Ph-*C*H), 93.2 (O-*C*H_2-O), 86.3 (C-3), 79.7 (C-4), 75.1 (Ph-*C*H_2), 75.0 (C-5), 69.3 (C-1), 64.2 (C-2), 63.1 (C-6). HRMS Calcd for $C_{21}H_{25}O_6$ (M + H): 373.1651. Found: 373.1653.

4-*O*-Benzyl-1,3-*O*-benzylidene-2,5-*O*-methylene-D-manno-hep-6-enitol (27). Compound **26** (2.00 g, 5.37 mmol) was dissolved in dry CH_2Cl_2 (30 mL), Dess Martin periodinane (2.48 g, 5.90 mmol) and $NaHCO_3$ (2.03 g, 24.16 mmol) were added, and the reaction mixture was stirred at rt for 15 min, then diluted with ether (100 mL) and poured into saturated aqueous $NaHCO_3$ (100 mL) containing a sevenfold excess of $Na_2S_2O_3$. The mixture was stirred to dissolve the solid, and the layers were separated. The ether

layer was dried (Na_2SO_4) and the solvents were removed under vacuum to give the aldehyde that was further dried under high vacuum for 1 h. *n*-BuLi (*n*-hexane solution, 8.0 mmol, 1.5 equiv) was added dropwise to a solution of methyltriphenylphosphonium bromide (2.3 g, 6.44 mmol) in dry THF (20 mL) at -78 ^oC under nitrogen. The mixture was stirred for 1 h at the same temperature. A solution of the previously made aldehyde in dry THF (10 mL) was introduced into the solution at -78 ^oC, and the resulting solution was allowed to warm to rt and stirred overnight. The reaction mixture was quenched by adding acetone (1 mL), and extracted with ether (3 x 100 mL). The organic layer was washed with brine, dried (Na_2SO_4), and concentrated in vacuo. Purification by column chromatography on silica gel (hexanes/EtOAc 4:1) gave **27** (1.1 g, 56%) as a colorless solid. Mp 133-135 ^oC; $[\alpha]_D^{23}$ = - 48.5° (*c* = 1.0, CH_2Cl_2). ^1H NMR ($CDCl_3$): δ 7.54-7.28 (10H, m, Ar), 6.10 (1H, ddd, $J_{5,6}$ = 6.0, $J_{6,7b}$ = 10.8, $J_{6,7a}$ = 17.0 Hz, H-6), 5.60 (1H, s, Ph-C*H*), 5.46 (1H, dd $J_{7a,7b}$ = 1.2 Hz, H-7a), 5.31 (1H, dd, H-7b), 4.92 and 4.84 (2H, 2d, J_{AB} = 4.2 Hz, O-CH_2-O), 4.88 and 4.67 (2H, 2 d, J_{AB} = 10.8 Hz, Ph-CH_2), 4.36 (1H, dd, $J_{1a,1b}$ = 10.2, $J_{1a,2}$ = 4.2 Hz, H-1a), 4.17 (1H, dd, $J_{4,5}$ = 9.6 Hz, H-5), 3.88-3.82 (2H, m, H-2, H-3), 3.75 (1H, t, $J_{1b,2}$ = 9.6 Hz, H-1b), 3.50 (1H, dd, $J_{3,4}$ = 7.8 Hz, H-4). ^{13}C NMR ($CDCl_3$): δ 138.2-126.0 (m, Ar), 135.5 (C-6), 116.9 (C-7), 100.7 (Ph-*C*H), 92.9 (O-*C*H_2-O), 86.1 (C-3), 83.2 (C-4), 75.6 (C-5), 75.3 (Ph-*C*H_2), 69.3 (C-1), 64.1 (C-2). HRMS Calcd for $C_{22}H_{25}O_5$ (M + H): 369.1702. Found: 369.1697.

4-*O*-Benzyl-1,3-*O*-benzylidene-2,5-*O*-methylene-D-glycero-D-manno-heptitol (28). To a solution of **27** (1.0 g, 2.71 mmol) in acetone:water (9:1, 20 mL) at rt were added NMO (*N*-methylmorpholine-*N*-oxide) (348 mg, 2.97 mmol) and OsO_4 (3.4 mg, 0.01 mmol, 2.5 wt % solution in 2-methyl-2-propanol). The reaction mixture was stirred at room temperature for 30 h before it was quenched with a saturated solution of $NaHSO_3$ (5 mL). After being stirred for an additional 15 min the reaction mixture was concentrated under reduced pressure, then extracted with ethyl acetate (3 x 100 mL), and the organic layer was washed with water (50 mL) and brine (50 mL), dried (Na_2SO_4), and concentrated. Chromatographic purification of the crude product ($CHCl_3$/MeOH 97:3) afforded **28** (0.91 g, 84%) and **31** (0.13 g, 12%) as colorless solids. Data for **28**: Mp 154-156 ^oC; $[\alpha]_D^{23}$ = - 25.0° (*c* = 0.8, CH_2Cl_2). ^1H NMR (DMSO- d_6): δ 7.44-7.25 (10H,

m, Ar), 5.66 (1H, s, Ph-C*H*), 4.83 and 4.65 (2H, 2d, J_{AB} = 4.2 Hz, O-CH_2-O), 4.79 (1H, d, $J_{6,OH}$ = 5.4 Hz, 6-OH) 4.77 and 4.67 (2H, 2 d, J_{AB} = 10.8 Hz, Ph-CH_2), 4.56 (1H, t, $J_{7,OH}$ = 5.5 Hz, 7-OH), 4.22 (1H, dd, $J_{1a,1b}$ = 9.6, $J_{1a,2}$ = 4.2 Hz, H-1a), 3.92 (1H, br dd, J = 11.4, J = 6.0 Hz, H-6), 3.77-3.60 (6H, m, H-1b H-2, H-3, H-4, H-5, H-7a), 3.43 (1H, m, H-7b). ^{13}C NMR (DMSO-d_6): δ 143.9-131.1 (m, Ar), 104.9 (Ph-*C*H), 98.1 (O-*C*H_2-O), 91.3 (C-2), 85.0 (C-4), 82.3 (C-5), 78.9 (Ph-*C*H_2), 76.4 (C-6), 73.6 (C-1), 68.9 (C-3), 66.8 (C-7). HRMS Calcd for $C_{22}H_{27}O_7$ (M + H): 403.1757. Found: 403.1759.

4,6,7-Tri-*O*-benzyl 2,5-*O*-methylene-D-glycero-D-manno-heptitol (29). A mixture of compound **28** (1.0 g, 2.48 mmol) and 60% NaH (3 equiv) in DMF (20 mL) was stirred in an ice bath for 20 min. A solution of benzyl bromide (0.88 ml, 7.44 mmol) in DMF (3 mL) was added, and the mixture was stirred at room temperature for 2 h. The reaction was quenched with ice water (40 mL) and the mixture was diluted with Et_2O (3 x 40 mL). The organic phase was dried (Na_2SO_4) and concentrated. The crude product was dissolved in MeOH (30 mL), *p*-toluenesulfonic acid (100 mg) was added, and the resulting reaction mixture was stirred for 24 h at rt. The reaction was quenched by addition of excess Et_3N (2 mL), and the solvents were removed under vacuum to give a colorless syrup which was dissolved in ethyl acetate (100 mL) and washed with water (40 mL) and brine (40 mL), dried (Na_2SO_4), and concentrated. Chromatographic purification of the crude product (hexanes/EtOAc 1:4) afforded **29** (0.91 g, 74%) as a colorless syrup. $[\alpha]_D^{23}$ = - 15.2° (*c* = 1.3, CH_2Cl_2). ^{1}H NMR (DMSO- d_6): ^{1}H NMR ($CDCl_3$): δ 7.41-7.23 (15H, m, Ar), 4.84 (2H, s, O-CH_2-O), 4.79-4.54 (6H, 6 d, J_{AB} = 11.5 Hz, Ph-CH_2), 4.04 (1H, ddd, $J_{5,6}$ = 2.4, $J_{6,7a}$ = 4.2, $J_{6,7b}$ = 6.6 Hz, H-6), 3.96 (1H, dd, $J_{4,5}$ = 9.0 Hz, H-5), 3.87-3.76 (2H, m, H-1a, H-b) 3.82 (1H, dd, $J_{7a,7b}$ = 10.2 Hz, H-7a), 3.74 (1H, dd, H-7b), 3.68 (2H, m, H-2, H-3), 3.58 (1H, dd, $J_{3,4}$ = 6.6 Hz, H-4). ^{13}C NMR ($CDCl_3$): δ 138.4-127.8 (m, Ar), 93.7 (O-*C*H_2-O), 82.6 (C-4), 78.8 (C-6), 76.4 (C-5), 75.9 and 75.4 (C-2 and C-3), 73.9, 73.4, 72.7 (3 x Ph-*C*H_2), 70.0 (C-7), 63.7 (C-1); HRMS Calcd for $C_{29}H_{35}O_7$ (M + H): 495.2383. Found: 495.2378.

4,6,7-Tri-*O*-benzyl-2,5-*O*-methylene-D-glycero-D-manno-heptitol-1,3-cyclic sulfate (30). A mixture of **29** (0.90 g, 1.82 mmol) and Et_3N (1.0 mL, 7.28 mmol) in CH_2Cl_2 (25

mL) was stirred in an ice bath. Thionyl chloride (0.2 mL, 2.73 mmol) in CH_2Cl_2 (5 mL) was then added dropwise over 15 min, and the mixture was stirred for an additional 30 min. The mixture was poured into ice-cold water and extracted with CH_2Cl_2 (3 x 50 mL). The combined organic layers were washed with brine and dried over Na_2SO_4. The solvent was removed under reduced pressure and the residue was dried under high vacuum for 1 h. The diasteromeric mixture of cyclic sulfites was dissolved in a mixture of CH_3CN:CCl_4 (1:1, 50 mL) and sodium periodate (584 mg, 2.73 mmol) and $RuCl_3$ (20 mg) were added, followed by water (5 mL). The mixture was then stirred for 2 h at rt. The reaction mixture was filtered through Celite and washed repeatedly with ethyl acetate. The volatile solvents were removed, and the aqueous solution was extracted with EtOAc (2 x 50 mL). The combined organic layers were washed with saturated NaCl (50 mL), dried over Na_2SO_4, and evaporated under reduced pressure. The residue was purified by flash column chromatography (hexanes/EtOAc 4:1) to give **30** as a colorless syrup (612 mg, 61%). $[\alpha]_D^{23}$ = - 1.7° (*c* = 1.0, CH_2Cl_2). ^{1}H NMR ($CDCl_3$): δ 7.41-7.29 (15H, m, Ar), 4.87 and 4.78 (2H, 2d, J_{AB} = 4.8 Hz, O-C*H*$_2$-O), 4.83 (1H, dd, $J_{3,4}$ = 7.2, $J_{2,3}$ = 10.2 Hz, H-3), 4.81-4.64 (4H, 4 d, J_{AB} = 10.8 Hz, Ph-C*H*$_2$), 4.66 (1H, t, $J_{1a,1b}$ = $J_{1a,2}$ = 11.4 Hz, H-1a), 4.54 (2H, s, Ph-C*H*$_2$), 4.52 (1H, dd, $J_{1b,2}$ = 5.4 Hz, H-1b), 4.20 (1H, td, $J_{1,2}$ = 5.4 Hz, H-2), 4.14 (1H, br t, *J* = 6.0 Hz, H-6), 3.95-3.90 (2H, m, H-4, H-5), 3.79 (1H, dd, $J_{6,7a}$ = 5.4, $J_{7a,7b}$ = 9.6 Hz, H-7a), 3.70 (1H, dd, H-7b). ^{13}C NMR ($CDCl_3$): δ 138.2-127.8 (m, Ar), 93.7 (O-*C*H$_2$-O), 90.8 (C-5), 78.4 (C-4), 77.9 (C-6), 75.7 (C-5), 74.9 (C-1), 73.5, 72.8, 71.9 (3 x Ph-*C*H$_2$), 69.5 (C-7), 62.1 (C-2); HRMS Calcd for $C_{29}H_{33}O_9S$ (M + H): 557.1845. Found: 557.1843.

1,3-*O*-Benzylidene-2,5-*O*-methylene-7-*O*-(*tert*-butyldimethylsilyl)-D-glycero-D-manno-heptitol-4,6-cyclic sulfate (31). Compound **28** (200 mg, 0.49 mmol) was dissolved in MeOH (25 mL) and the solution was stirred with 10% Pd/C (100 mg) under 80 psi of H_2 for 12 h. The catalyst was removed by filtration through Celite, then evaporation of the solvent followed by purification using a short column of silica gel ($CHCl_3$/MeOH 9:1) gave the 1,3-*O*-Benzylidene-2,5-*O*-methylene-D-glycero-D-manno-heptitol (90 mg, 59%). A mixture of the resulting triol (50 mg, 0.16 mmol), imidazole (44 mg, 0.64 mmol), and TBDMSCl (26 mg, 0.18 mmol) in dry DMF (2 mL) was stirred

at 0 °C under N_2 for 2 h. The reaction was quenched by the addition of ice-cold water (2 mL), and the reaction mixture was partitioned between Et_2O (25 mL) and H_2O (15 mL). The organic phase was washed with water (25 mL) and brine (25 mL), dried over anhydrous Na_2SO_4, and concentrated. The crude product was directly converted into the cyclic sulfate **31** by treatment with $SOCl_2$ and Et_3N, followed by oxidation with $RuCl_3$ and $NaIO_4$ as described for the synthesis of compound **30**. Data for **31**: Colorless syrup, 42 mg, yield 54% over two steps. $[\alpha]_D^{23}$ = - 73.0° (*c* = 2.0, CH_2Cl_2). ^{1}H NMR ($CDCl_3$): δ 7.53-7.39 (5H, m, Ar), 5.53 (1H, s, Ph-C*H*), 4.89 and 4.82 (2H, 2d, J_{AB} = 4.2 Hz, O-CH_2-O), 4.78 (1H, dd, $J_{4,5}$ = 10.2, $J_{3,4}$ = 7.8 Hz, H-4), 4.77 (1H, ddd, $J_{6,7b}$ = 1.2, $J_{6,7a}$ = 3.0, $J_{5,6}$ = 10.2 Hz, H-6), 4.37 (1H, dd, $J_{1a,2}$ = 4.2, $J_{1a,1b}$ = 10.2 Hz, H-1a), 4.33 (1H, dd, H-5), 4.04 (1H, dd, $J_{7a,7b}$ = 12.6 Hz, H-7a), 3.94 (1H, dd, H-7b), 3.90 (1H, dd, $J_{2,3}$ = 9.0 Hz, H-3), 3.84 (1H, ddd, $J_{1b,2}$ = 10.2 Hz, H-2), 3.79 (1H, dd, H-1b), 0.95 (9H, s, TBDMS), 0.14 and 0.12 (6H, 2 s, 2 x Me). ^{13}C NMR ($CDCl_3$): δ 136.6-126.1 (m, Ar), 100.1 (Ph-*C*H), 93.6 (O-*C*H_2-O), 84.3 (C-4), 84.0 (C-6), 80.8 (C-3), 68.7 (C-1), 64.7 (C-2), 62.9 (C-5), 60.4 (C-7), 25.8 (TBDMS), -5.3 and -5.5 (2 x Me). HRMS Calcd for $C_{21}H_{33}O_9SSi$ (M + H): 489.1615. Found: 489.1617.

4-*O*-Benzyl-5,7-*O*-benzylidene-3,6-*O*-methylene-D-glycero-D-galacto-heptitol (32). A mixture of AD-mix-β (3.8 g), *tert*-butyl alcohol (5mL), and water (5 mL) was stirred at rt for 5 min to produce a biphasic layer. The mixture was cooled to 0 °C, and the olefin **27** (1.0 g, 2.71 mmol) was added at once, and the heterogeneous slurry was stirred vigorously at 0 °C for 7 days. The reaction mixture was quenched by addition of solid sodium sulfite (4 g), stirred at rt for 30 min, extracted with ethyl acetate (3 x 100 mL), and the organic layer was washed with water (50 mL) and brine (50 mL), dried (Na_2SO_4), and concentrated. Chromatographic purification of the residue ($CHCl_3$/MeOH 97:3) afforded **32** (0.69 g, 64%) and **28** (98 mg, 9%) as colorless solids. Data for **32**: Mp 208-210 °C; $[\alpha]_D^{23}$ = - 12.0° (*c* = 0.3, CH_2Cl_2). ^{1}H NMR (DMSO- d_6): δ 7.45-7.24 (10H, m, Ar), 5.67 (1H, s, Ph-C*H*), 4.83 and 4.67 (2H, 2d, J_{AB} = 4.2 Hz, O-CH_2-O), 4.76 and 4.70 (2H, 2 d, J_{AB} = 10.8 Hz, Ph-CH_2), 4.69 (1H, d, $J_{2,OH}$ = 6.6 Hz, 2-OH), 4.65 (1H, t, $J_{1,OH}$ = 6.0 Hz, 1-OH), 4.22 (1H, dd, $J_{7a,7b}$ = 9.6, $J_{6,7a}$ = 4.2 Hz, H-7a), 3.86 (1H, br q, $J_{1,2}$ = $J_{2,3}$ = 7.5 Hz, H-2), 3.78-3.64 (5H, m, H-3, H-4, H-5, H-6, H-7b), 3.42 (2H, m, H-1a, H-1b).

^{13}C NMR (DMSO- d_6): δ 139.3-126.4 (m, Ar), 100.2 (Ph-*C*H), 93.0 (O-*C*H$_2$-O), 86.3 (C-5), 79.2 (C-4), 74.5 (Ph-*C*H$_2$), 73.5 (C-3), 69.2 (C-2), 68.9 (C-7), 64.3 (C-6), 62.0 (C-1). HRMS Calcd for $C_{22}H_{27}O_7$ (M + H): 403.1757. Found: 403.1758.

1,2,4-Tri-*O*-benzyl-3,6-*O*-methylene-D-glycero-D-galacto-heptitol (33). Compound **33** was obtained as a colorless syrup (0.94 g, 77% yield) from **32** (1.0 g, 2.48 mmol) using the same procedure that was used to obtain **29**. $[\alpha]_D^{23}$ = - 1.7° (*c* = 2.3, CH_2Cl_2). ^{1}H NMR ($CDCl_3$): δ 7.39-7.26 (15H, m, Ar), 4.85 and 4.66 (2H, 2d, J_{AB} = 4.8 Hz, O-C*H*$_2$-O), 4.81-4.51 (6H, 6 d, J_{AB} = 12.0 Hz, Ph-C*H*$_2$), 4.07 (1H, ddd, $J_{2,3}$ = 1.2, $J_{1a,2}$ = 5.4, $J_{1b,2}$ = 7.2 Hz, H-2), 3.91 (1H, dd, $J_{3,4}$ = 9.0 Hz, H-3), 3.87 (1H, m, H-7a), 3.79 (1H, dd, $J_{1a,1b}$ = 9.6 Hz, H-1a), 3.75 (1H, m, H-7b), 3.74-3.70 (3H, m, H-4, H-5, H-6), 3.69 (1H, dd, H-1b), 2.38 (1H, d, $J_{5,OH}$ = 3.6 Hz, 5-O*H*), 2.17 (1H, t, $J_{7,OH}$ = 6.0 Hz, 7-O*H*). ^{13}C NMR ($CDCl_3$): δ 138.5-127.5 (m, Ar), 93.6 (O-*C*H$_2$-O), 81.9 (C-4), 76.1 (C-2), 75.5 (C-5), 75.0 (C-6), 74.2 (C-3), 73.6, 73.5, 72.5 (3 x Ph-*C*H$_2$), 68.7 (C-1), 63.8 (C-7). HRMS Calcd for $C_{29}H_{35}O_7$ (M + H): 495.2383. Found: 495.2377.

1,2,4-Tri-*O*-benzyl-3,6-*O*-methylene-D-glycero-D-galacto-heptitol-5,7-cyclic sulfate (34). Compound **34** was obtained as a colorless syrup (0.65 g, 64% yield) from **33** (0.9 g, 1.82 mmol) using the same procedure which was used to obtain **30**. Colorless syrup; $[\alpha]_D^{23}$ = + 23.2° (*c* = 1.3, CH_2Cl_2). ^{1}H NMR ($CDCl_3$): δ 7.40-7.27 (15H, m, Ar), 4.90-4.44 (6H, 6 d, J_{AB} = 11.0 Hz, Ph-C*H*$_2$), 4.88 (1H, dd, $J_{4,5}$ = 7.8, $J_{5,6}$ = 8.4 Hz, H-5), 4.83 and 4.55 (2H, 2d, J_{AB} = 4.2 Hz, O-C*H*$_2$-O), 4.63 (1H, dd, $J_{6,7a}$ = 10.8, $J_{7a,7b}$ = 11.4 Hz, H-7a), 4.51 (1H, dd, $J_{6,7b}$ = 5.4 Hz, H-7b), 4.23 (1H, td, H-6), 4.15 (1H, ddd, $J_{2,3}$ = 1.8, $J_{1a,2}$ = 5.4, $J_{1b,2}$ = 7.8 Hz, H-2), 4.05 (1H, dd, $J_{3,4}$ = 10.2 Hz, H-4), 3.92 (1H, dd, H-3), 3.73 (1H, dd, $J_{1a,1b}$ = 9.6 Hz, H-1a), 3.65 (1H, dd, H-1b). ^{13}C NMR ($CDCl_3$): δ 137.8-127.4 (m, Ar), 93.6 (O-*C*H$_2$-O), 90.9 (C-5), 77.4 (C-4), 75.0 (C-2), 74.7 (C-7), 73.9 (C-3), 73.5, 72.9, 71.9 (3 x Ph-*C*H$_2$), 67.7 (C-1), 62.2 (C-6). HRMS Calcd for $C_{29}H_{33}O_9S$ (M + H): 557.1845. Found: 557.1841.

1,4-Dideoxy-1,4-[[2*S*,3*S*,4*R*,5*R*,6*R*]-4,6,7-tri-*O*-benzyl-2,5-*O*-methylene-3-(sulfooxy)heptyl]-(*R*)-*epi*-sulfoniumylidine]-D-arabinitol Inner Salt (37). The cyclic

sulfate **30** (250 mg, 0.45 mmol) and the thiosugar **35** (275 mg, 0.54 mmol) were dissolved in HFIP (3 mL), and anhydrous K_2CO_3 (10 mg) was added. The mixture was stirred in a sealed tube in an oil bath (75 ^oC) for 7 days. The solvent was removed under reduced pressure, and the product was purified through a short silica column by eluting with EtOAc/MeOH 95:5 to yield the protected sulfonium salt **36** (351 mg) in 67% yield. To the resulting compound **36** in CH_2Cl_2 (0.5 mL) was added trifluoroacetic acid (5 mL), followed by H_2O (0.5 mL), and the mixture was stirred at room temperature for 2 h. The solvents were then evaporated under reduced pressure, and the residue was purified by flash column chromatography (CH_2Cl_2/MeOH 8:2) to give **37** as a colorless syrup (190 mg, 82%). $[\alpha]_D^{23}$ = + 4.4° (*c* = 0.9, MeOH). ^{1}H NMR (CD_3OD): δ 6.96-6.84 (15H, m, Ar), 4.60 (1H, d, J_{AB} = 10.2 Hz, Ph-C*H*$_2$), 4.51 and 4.37 (2H, 2d, J_{AB} = 4.2 Hz, O-C*H*$_2$-O), 4.26 (2H, 2d, J_{AB} = 12.0 Hz, Ph-C*H*$_2$), 4.20 (1H, br dd, *J* = 2.4 Hz, H-2), 4.12 (1H, dd, $J_{2',3'}$ = 7.8, $J_{3',4'}$ = 6.6 Hz, H-3'), 4.07 (1H, d, J_{AB} = 12.0 Hz, Ph-C*H*$_2$), 4.06 (2H, br s, Ph-C*H*$_2$), 4.01 (1H, br d, *J* = 1.8 Hz, H-3), 3.97 (1H, td, $J_{1'a,2'}$ = 7.8, $J_{1'b,2'}$ = 3.6 Hz, H-2'), 3.69 (1H, dd, $J_{1'a,1'b}$ = 13.2 Hz, H-1'a), 3.61-3.57 (4H, m, H-1'b, H-4, H-5a, H-6'), 3.53-3.43 (2H, m, H-5b, H-5'), 3.47 (1H, dd, $J_{1a,1b}$ = 12.0, $J_{1a,2}$ = 1.8, H-1a), 3.45 (1H, dd, $J_{4',5'}$ = 7.8 Hz, H-4'), 3.39 (1H, dd, $J_{1b,2}$ = 3.6, H-1b), 3.34 (1H, dd, $J_{7'a,7'b}$ = 10.8, $J_{7'a,6'}$ = 3.6 Hz, H-7'a), 3.24 (1H, dd, $J_{7'b,6'}$ = 6.0 Hz, H-7'b). ^{13}C NMR (CD_3OD): δ 137.9-126.8 (m, Ar), 93.1 (O-*C*H$_2$-O), 80.8 (C-3'), 80.6 (C-4'), 78.1 (C-3), 78.0 (C-4), 77.1 (C-2), 76.6 (C-5'), 73.4, 72.5 and 71.6 (3 x *C*H$_2$Ph), 71.5 (C-6'), 70.8 (C-2'), 68.9 (C-7'), 59.1 (C-5), 49.5 (C-1), 49.2 (C-1'). HRMS Calcd for $C_{34}H_{43}O_{12}S_2$ (M + H): 707.2195. Found: 707.2195.

1,4-Dideoxy-1,4-[[2*S*,3*S*,4*R*,5*R*,6*R*]-2,3,4,5,6,7-hexahydroxy-heptyl]-(*R*)-*epi*-sulfoniumylidine]-D-arabinitol methyl sulfate (38). To a solution of compound **37** (150 mg, 0.21 mmol) in CH_2Cl_2 (10 mL) at -78 ^oC was added 1.0 M BCl_3 (2 mL) in CH_2Cl_2. The mixture was then warmed to rt over a period of 20 min and stirred for 12 h. MeOH was added to quench the reaction mixture and all the volatile components were removed under reduced pressure. The residue was dissolved in water (5 mL) and washed with CH_2Cl_2 (3 x 5 mL). The water layer was evaporated to give a crude product which was purified by reverse-phase HPLC [MeCN-H_2O (4:96, v/v) to yield compound **38** (54 mg, 74%) as a colorless syrup. $[\alpha]_D^{23}$ = - 4.0° (*c* = 0.8, MeOH). ^{1}H NMR (CD_3OD): δ 4.62

(1H, br d, J = 2.4 Hz, H-2), 4.37 (1H, br s, H-3), 4.17 (1H, td, $J_{1'a,2}$ = 3.6, $J_{1'b,2} = J_{2',3'}$ = 8.4 Hz, H-2'), 4.05 (1H, dd, $J_{4,5a}$ = 4.8, $J_{5a,5b}$ = 10.8 Hz, H-5a), 4.02 (1H, dd, $J_{4,5b}$ = 9.6 Hz, H-4), 3.93 (1H, dd, H-5b), 3.94 (1H, dd, $J_{1'a,2'}$ = 3.6, $J_{1'a,1'b}$ = 12.6 Hz, H-1a'), 3.88 (1H, dd, $J_{3',4'}$ = 2.4, $J_{4',5'}$ = 7.2 Hz, H-4'), 3.86 (2H, d like, J = 2.4 Hz, H-1a, H-1b), 3.85 (1H, dd, H-3'), 3.83 (1H, d like, J = 7.8 Hz, H-6'), 3.80 (1H, br d, J = 9.6 Hz, H-7'a), 3.75 (1H, dd, H-1'b), 3.71 (1H, d like, J = 6.6 Hz, H-5'), 3.68 (3H, s, CH_3OSO$_3$), 3.67 (1H, m, H-7'b). ^{13}C NMR (CD_3OD): δ 79.5 (C-3), 79.4 (C-2), 74.8 (C-6'), 74.0 (C-3'), 73.7 (C-4), 73.1 (C-5'), 71.9 (C-4'), 69.4 (C-2'), 64.4 (C-7'), 61.1 (C-5), 55.2 (CH$_3$OSO$_3$), 52.7 (C-1'), 51.9 (C-1). HRMS Calcd for $C_{13}H_{28}O_{12}S_2$ (M - CH_3OSO_3): 345.1219. Found: 345.1218.

1,4-Dideoxy-1,4-[[2*S*,3*S*,4*R*,5*R*,6*S*]-2,3,4,5,6,7-hexahydroxy-heptyl]-(*R*)-*epi*-sulfoniumylidine]-D-arabinitol methyl sulfate (40). The cyclic sulfate **34** (250 mg, 0.45 mmol) and the thiosugar **35** (275 mg, 0.54 mmol) were dissolved in HFIP (3 mL), and anhydrous K_2CO_3 (10 mg) was added. The mixture was stirred in a sealed tube in an oil bath (75 ^{o}C) for 7 days. The solvent was removed under reduced pressure, and the product was purified through a short silica column by eluting with EtOAc/MeOH 95:5 to yield the protected sulfonium salt **39** (325 mg, 61%). To a solution of the protected compound **39** (200 mg, 0.19 mmol) in CH_2Cl_2 (10 mL) at -78 ^{o}C was added 1.0 M BCl_3 (3 mL) in CH_2Cl_2. The mixture was then warmed to rt over a period of 20 min and stirred for 12 h. MeOH was added to quench the reaction mixture and all the volatile components were removed under reduced pressure. The residue was dissolved in water (5 mL) and washed with CH_2Cl_2 (3 x 5 mL). The water layer was evaporated to give a crude product that was purified by reverse-phase HPLC [MeCN-H_2O (4:96, v/v) to yield compound **40** (40 mg, 61%) as a colorless syrup. $[\alpha]_D^{23}$ = + 10.0° (c = 0.6, MeOH). ^{1}H NMR (CD_3OD): δ 4.62 (1H, ddd, $J_{1a,2}$ = 3.0, $J_{1b,2} = J_{2,3}$ = 2.4 Hz, H-2), 4.37 (1H, dd, $J_{3,4}$ = 1.2 Hz, H-3), 4.18 (1H, td, $J_{1'a,2'}$ = 3.6, $J_{1'b,2} = J_{2',3'}$ = 8.4 Hz, H-2'), 4.05 (1H, dd, $J_{4,5a}$ = 4.8, $J_{5a,5b}$ = 10.8 Hz, H-5a), 4.01 (1H, br dd, $J_{4,5b}$ = 9.0 Hz, H-4), 3.94 (1H, dd, $J_{1a,1b}$ = 13.2 Hz, H-1'a), 3.93 (1H, m, H-6'), 3.87 (2H, br d, J = 3.0 Hz, H-1a, H-1b), 3.85 (1H, dd, $J_{3',4'}$ = 1.2 Hz, H-3'), 3.84 (1H, br d, $J_{4',5'}$ = 7.8 Hz, H-5'), 3.76 (1H, dd, H-1'b), 3.69 (3H, s, CH_3OSO$_3$), 3.66 (2H, br d, J = 6.6 Hz, H-7'a, H-7'b), 3.65 (1H, dd, H-4'). ^{13}C NMR (CD_3OD): δ 79.5 (C-3), 79.4 (C-2), 73.7 (C-4), 73.6 (C-5'), 71.7 (C-6'), 71.2 (C-4'),

70.2 (C-3'), 69.7 (C-2'), 64.9 (C-7'), 61.1 (C-5), 55.2 (CH$_3$OSO$_{3)}$, 52.7 (C-1'), 51.9 (C-1). HRMS Calcd for $C_{13}H_{28}O_{12}S_2$ (M - CH_3OSO_3): 345.1219. Found: 345.1216.

5,7-Di-*O*-benzylidene-2,4,6-tri-*O*-*p*-methoxybenzyl-D-perseitol (42) and 1,3-Di-*O*-benzylidene-2,4,6-tri-*O*-*p*-methoxybenzyl-D-perseitol (43). A mixture of compound **41**[4] (8.50 g, 21.89 mmol) and 60% NaH (4 equiv) in DMF (90 mL) was stirred in an ice bath for 20 min. A solution of *p*-methoxybenzyl chloride (12.2 ml, 87.55 mmol) in DMF (20 mL) was added, and the mixture was stirred at room temperature for 2 h. The reaction was quenched with ice water (150 mL) and the mixture was diluted with Et_2O (3 x 150 mL). The organic phase was dried (Na_2SO_4) and concentrated. The crude product was dissolved in MeOH (100 mL), *p*-toluenesulfonic acid (2.0 g) was added, and the resulting reaction mixture was stirred for 30 min at rt. The reaction was quenched by addition of excess Et_3N (~20 mL), and the solvents were removed under vacuum to give a colorless syrup which was dissolved in ethyl acetate (500 mL) and washed with water (100 mL) and brine (100 mL), dried (Na_2SO_4), and concentrated. Chromatographic purification of the crude product (hexanes/EtOAc 3:7) afforded **42** (4.0 g, 44%) and **43** (3.1 g, 34%) (yield was calculated based on recovered 1,3:5,7-di-*O*-benzylidene-2,4,6-tri-*O*-*p*-methoxybenzyl-D-perseitol, 6.0 g). Data for **42**: Pale yellow syrup, $[\alpha]_D^{23}$ = + 19.0° (*c* = 1.1, $CHCl_3$). ^{1}H NMR ($CDCl_3$+D_2O): δ 7.47-6.86 (17H, m, Ar), 5.46 (1H, s, Ph-C*H*), 4.70-4.41 (6H, 6 d, J_{AB} = 11.4 Hz, Ph-CH_2), 4.44 (1H, dd, $J_{7a,7b}$ = 10.2, $J_{7a,6}$ = 4.2 Hz, H-7a), 4.14 (1H, dd, $J_{5,6}$ = 9.6, $J_{4,5}$ = 1.8 Hz, H-5), 4.12 (1H, dd, $J_{3,4}$ = 8.4, $J_{2,3}$ = 1.8 Hz, H-3), 3.99 (1H, dd, H-4), 3.96 (1H, dd, $J_{1a,1b}$ = 12.6, $J_{1a,2}$ = 4.2 Hz, H-1a), 3.93 (1H, td, $J_{6,7b}$ = 10.2 Hz, H-6), 3.81 (9H, br s, 3 x OMe), 3.80 (1H, dd, $J_{1b,2}$ = 1.8 Hz, H-1b), 3.75 (1H, td, H-2), 3.66 (1H, dd, H-7b). ^{13}C NMR ($CDCl_3$+D_2O): δ 159.8, 159.4 and 159.1 (Ar), 137.6 and 129.7-113.7 (m, Ar), 101.6 (Ph-*C*H), 79.9 (C-5), 76.3 (C-2), 75.8 (C-4), 72.6, 71.4, and 71.2 (3 x Ph-*C*H_2), 71.4 (C-3), 69.7 (C-7), 68.1 (C-6), 63.1 (C-1), 55.3 (3 x OMe). HRMS Calcd for $C_{38}H_{45}O_{10}$ (M + H): 661.3012. Found: 661.3003.

Data for **43**: Pale yellow syrup, $[\alpha]_D^{23}$ = + 22.5° (*c* = 0.8, $CHCl_3$). ^{1}H NMR ($CDCl_3$): δ 7.52-6.80 (17H, m, Ar), 5.60 (1H, s, Ph-C*H*), 4.84-4.28 (6H, 6 d, J_{AB} = 11.4 Hz, Ph-CH_2), 4.63 (1H, dd, $J_{1a,1b}$ = 12.6, $J_{1a,2}$ = 1.2 Hz, H-1a), 4.26 (1H, dd, $J_{3,4}$ = 9.0, $J_{4,5}$ = 1.2

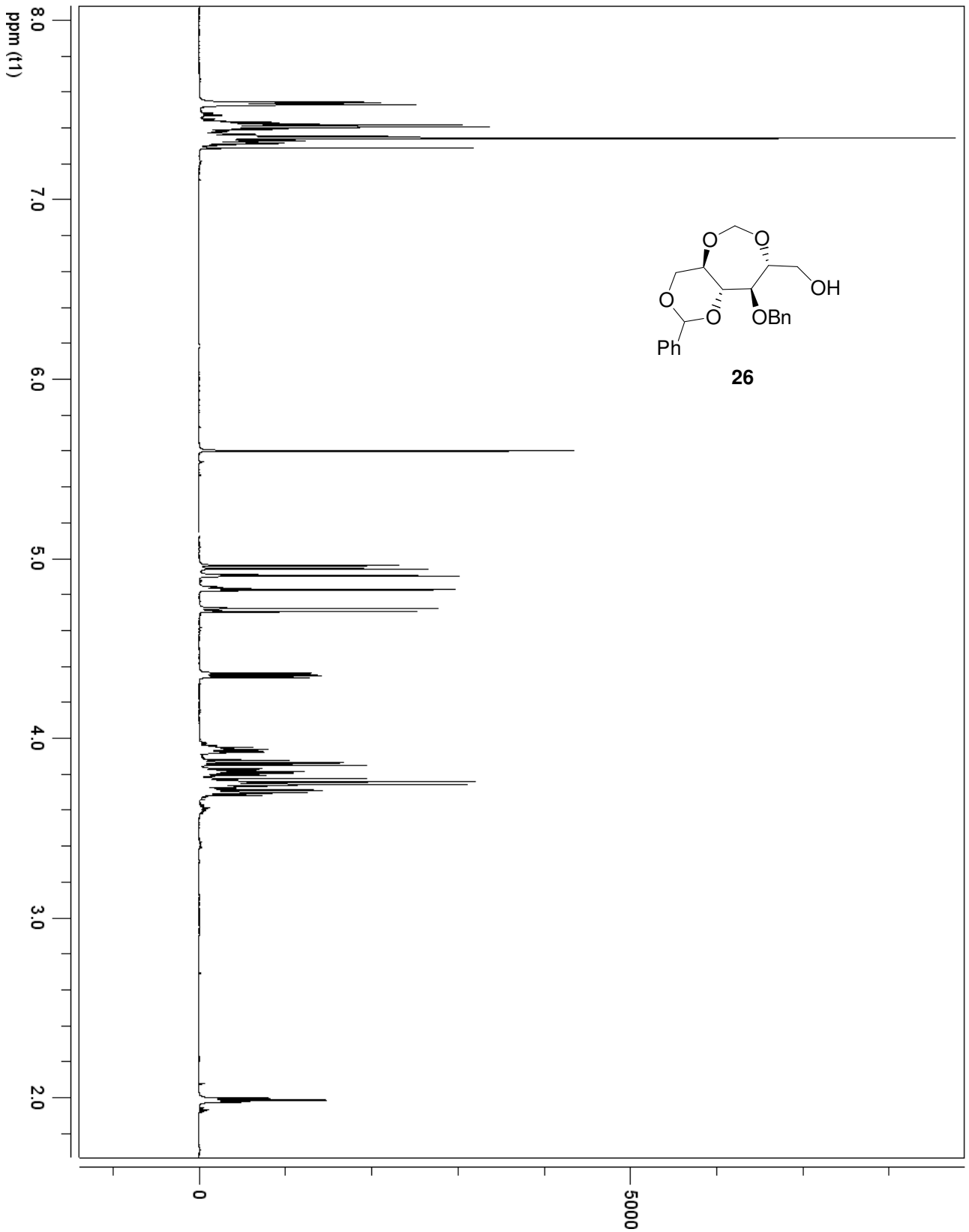
Hz, H-4), 4.15 (1H, dd, $J_{2,3}$ = 1.2 Hz, H-3), 4.09 (1H, br d, $J_{5,6}$ = 8.4 Hz, H-5), 3.96 (1H, dd, $J_{1b,2}$ = 1.2 Hz, H-1b), 3.91-3.90 (2H, m, H-7a, H-7b), 3.82, 3.80 and 3.77 (9H, 3 s, 3 x OMe), 3.62 (1H, br d, H-2), 3.56 (1H, ddd, $J_{6,7a}$ = $J_{6,7b}$ = 4.2 Hz, H-6). ^{13}C NMR ($CDCl_3$): δ 159.3, 159.3 and 159.1 (Ar), 137.9 and 130.2-113.8 (m, Ar), 101.5 (Ph-*C*H), 78.3 (C-3), 78.1 (C-6), 74.6 (C-4), 73.6, 70.7, and 69.7 (3 x Ph-*C*H_2), 70.3 (C-5), 69.3 (C-2), 67.3 (C-1), 61.4 (C-7), 55.4, 55.3 (3 x OMe). HRMS Calcd for $C_{38}H_{45}O_{10}$ (M + H): 661.3012. Found: 661.3005.

1,3-*O*-Benzylidene-2,4,6-tri-*O*-*p*-methoxybenzyl-D-perseitol-5,7-cyclic sulfate (44). Compound **44** was obtained as a colorless foam (2.5 g, 77% yield) from **43** (3.0 g, 4.54 mmol) using the same procedure as used to obtain **30**. $[\alpha]_D^{23}$ = + 5.8° (*c* = 0.5, $CHCl_3$). ^{1}H NMR ($CDCl_3$): δ 7.59-6.84 (17H, m, Ar), 5.67 (1H, s, Ph-C*H*), 5.16 (1H, dd, $J_{5,6}$ = 9.6, $J_{4,5}$ = 1.2 Hz, H-5), 4.86 (1H, d, J_{AB} = 11.4 Hz, Ph-CH_2), 4.67 (1H, dd, $J_{1a,1b}$ = 13.2, $J_{1a,2}$ = 1.2 Hz, H-1a), 4.48-4.45 (2H, 2 d, J_{AB} = 11.4 Hz, Ph-CH_2), 4.45-4.43 (3H, m, H-4, H-7a, H-7b), 4.35 (2H, s, Ph-CH_2), 4.28 (1H, d, J_{AB} = 11.4 Hz, Ph-CH_2), 4.20 (1H, dd, $J_{3,4}$ = 10.2, $J_{2,3}$ = 1.8 Hz, H-3), 4.13 (1H, td, $J_{6,7a}$ = $J_{6,7b}$ = 7.2 Hz, H-6), 3.99 (1H, dd, $J_{1b,2}$ = 1.2 Hz, H-1b), 3.83, 3.81 and 3.80 (9H, 3 s, 3 x OMe), 3.64 (1H, br d, H-2). ^{13}C NMR ($CDCl_3$): δ NMR ($CDCl_3$): δ 159.8, 159.3, 137.5, 129.9-113.8 (m, Ar), 101.1 (Ph-*C*H), 84.2 (C-5), 76.3 (C-3), 73.9, 72.1, and 69.7 (3 x Ph-*C*H_2), 73.1 (C-4), 71.9 (C-7), 68.8 (C-2), 67.0 (C-1), 66.7 (C-6), 55.4, 55.3 (3 x OMe). HRMS Calcd for $C_{38}H_{43}O_{12}S$ (M + Na): 745.2294. Found: 745.2277.

2,3,5-Tri-*O*-*p*-methoxybenzyl-1,4-dideoxy-1,4-[[2*S*,3*S*,4*R*,5*R*,6*S*]-5,7-benzylidene-2,4,6-tri-*O*-*p*-methoxybenzyl-3-(sulfooxy)heptyl]-(*R*)-*epi*-sulfoniumylidine]-D-arabinitol Inner Salt (45). Compound **45** was obtained as a colorless syrup (238 mg, 69% yield) by reacting compounds **44** (200 mg, 0.28 mmol) and **35** (171 mg, 0.34 mmol) using the same procedure as used to obtain **36.** $[\alpha]_D^{23}$ = + 5.4° (*c* = 0.4, acetone). ^{1}H NMR (acetone-d_6): δ 7.71-6.75 (29H, m, Ar), 5.78 (1H, s, Ph-C*H*), 4.96 (1H, br d, $J_{3',4'}$ = 9.6 Hz, H-3'), 4.85-4.15 (12H, Ph-CH_2), 4.67 (1H, br d, $J_{7'a,7'b}$ = 12.6 Hz, H-7'a), 4.66 (1H, ddd, $J_{1a,2}$ = 2.4, $J_{1b,2}$ = 3.6, $J_{2,3}$ = 3.0 Hz, H-2), 4.61 (1H, m, H-5'), 4.48 (1H, br d, H-3), 4.39 (1H, dd, $J_{1'a,1'b}$ = 13.8, $J_{1'a,2}$ = 4.2 Hz, H-1'a), 4.29 (1H, dd, $J_{1'b,2}$ = 2.4 Hz, H-1'b),

4.27 (1H, ddd, $J_{2',3'}$ = 1.8 Hz, H-2'), 4.25 (1H, br s, H-4'), 4.10 (1H, dd, $J_{1a,1b}$ = 13.8 Hz, H-1a), 4.04 (1H, br d, H-7'b), 3.92(1H, dd-like, $J_{5a,4}$ = 7.8, $J_{5b,4}$ = 7.2 Hz, H-4), 3.89 (1H, dd, H-1b), 3.81-3.72 (18H, 6s, OMe), 3.74 (1H, m, H-6'), 3.60 (1H, dd, $J_{5a,5b}$ = 10.2 Hz, H-5a), 3.54 (1H, dd, H-5b). ^{13}C NMR (acetone-d_6): δ 159.8-159.0, 139.6, 129.8-126.6, 113.8-113.4 (m, Ar), 100.4 (Ph-*C*H), 83.4 (C-3), 81.7 (C-2), 76.7 (C-5'), 74.4 (C-4'), 74.2 (C-2'), 73.5 (C-3'), 72.7-69.3 (6 x Ph-*C*H_2), 70.6 (C-6'), 66.9 (C-7'), 66.3 (C-5), 64.5 (C-4), 54.7-54.6 (6 x OMe), 49.6 (C-1'), 47.8 (C-1). HRMS Calcd for $C_{67}H_{77}O_{18}S_2$ (M + H): 1233.4551. Found: 1233.4561.

1,4-Dideoxy-1,4-[[2*S*,3*S*,4*R*,5*R*,6*S*]-2,4,5,6,7-pentahydroxy-3-(sulfooxy)heptyl]-(*R*)-*epi*-sulfoniumylidine]-D-arabinitol Inner Salt (20). Compound **45** (100 mg, 0.08 mmol) in CH_2Cl_2 (0.5 mL) was added trifluoroacetic acid (5 mL), followed by H_2O (0.5 mL), and the mixture was stirred at room temperature for 2 h. The solvents were then evaporated under reduced pressure, and the residue was dissolved in water (5 mL) and washed with CH_2Cl_2 (3 x 5 mL). The water layer was evaporated to give a crude product that was purified on silica gel column by eluting with EtOAc/MeOH/H_2O 7:3:1 (v/v) to give compound **20** in 93% yield (32 mg) as a colorless solid. $[\alpha]_D^{23}$ = + 7.0° (*c* = 0.6, H_2O). ^{1}H NMR (pyridine-d_5) (coupling constant values are determined by D_2O addition): δ 5.64 (1H, dd, $J_{2',3'}$ = 8.4, $J_{3',4'}$ = 1.2 Hz, H-3'), 5.24 (1H, ddd, $J_{1'a,2'}$ = $J_{1'b,2'}$ = 4.2 Hz, H-2'), 5.15 (1H, br s, H-3), 5.12 (1H, dd, $J_{4',5'}$ = 9.6 Hz, H-4'), 5.07 (1H, dd-like, $J_{1a,2}$ = 1.8, $J_{1b,2}$ = 3.6 Hz, H-2), 4.93 (1H, dd, $J_{1'a,1'b}$ = 13.2 Hz, H-1'a), 4.88 (1H, ddd, $J_{5',6'}$ = 1.8, $J_{6',7'a}$ = 5.4, $J_{6',7'b}$ = 4.2 Hz, H-6'), 4.86 (1H, dd, H-5'), 4.65 (1H, dd, H-1'b), 4.62 (1H, br t, $J_{4,5a}$ = $J_{4,5b}$ = 10.2 Hz, H-4), 4.51 (2H, dd-like, J = 7.8 Hz, H-5a, H-5b), 4.40 (1H, dd, $J_{7'a,7'b}$ = 10.8 Hz, H-7'a), 4.31 (2H, dd-like, $J_{1a,1b}$ = 13.2 Hz, H-1a, H-1b), 4.24 (1H, dd, H-7'b). ^{13}C NMR (pyridine-d_5): δ 79.4 (C-3), 78.1 (C-2), 77.9 (C-3'), 72.6 (C-6'), 72.2 (C-4), 71.3 (C-5'), 70.5 (C-4'), 67.4 (C-2'), 65.4 (C-7'), 60.0 (C-5), 53.8 (C-1'), 50.1 (C-1). HRMS Calcd for $C_{12}H_{25}O_{12}S_2$ (M + Na): 447.0606. Found: 447.0596.



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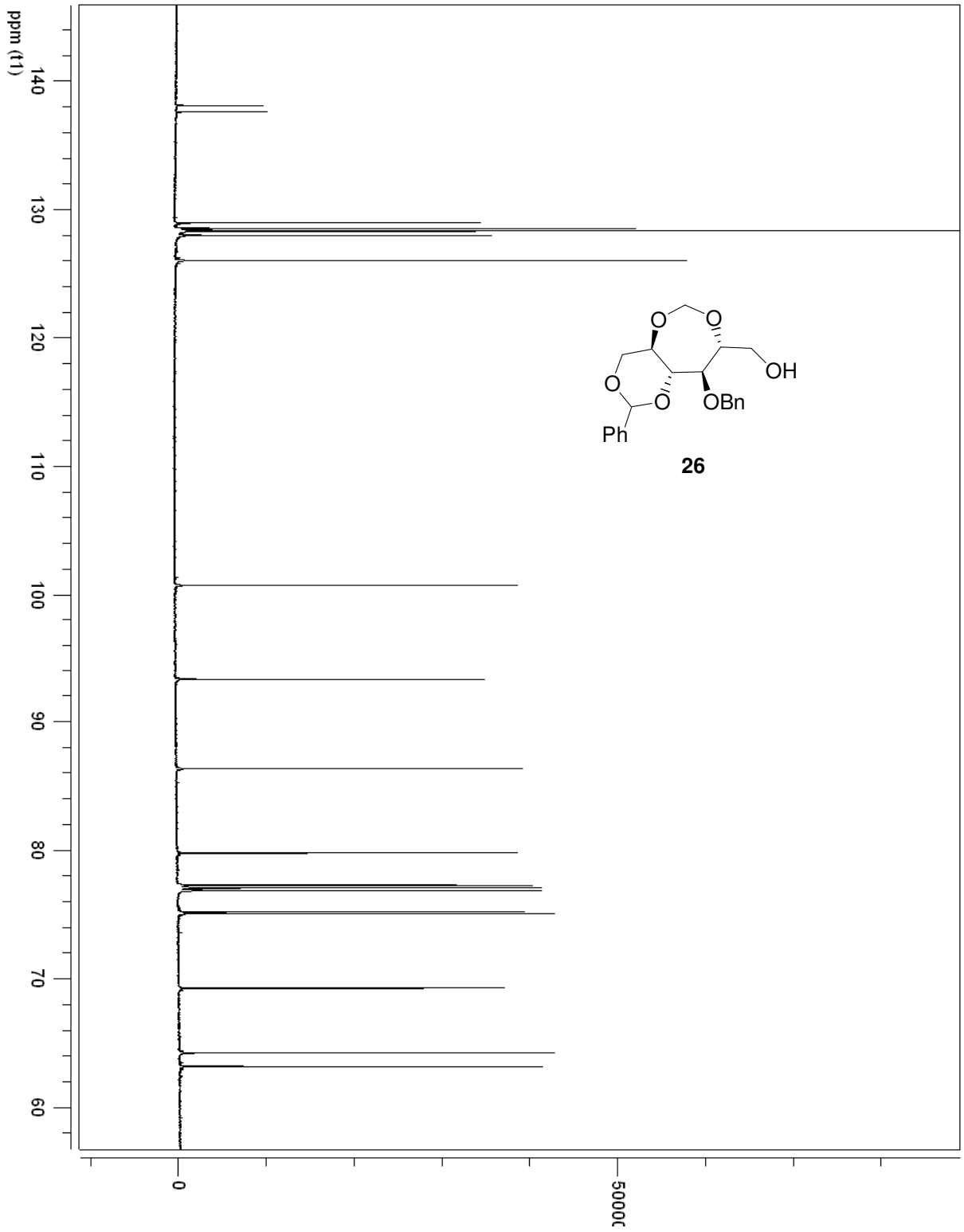

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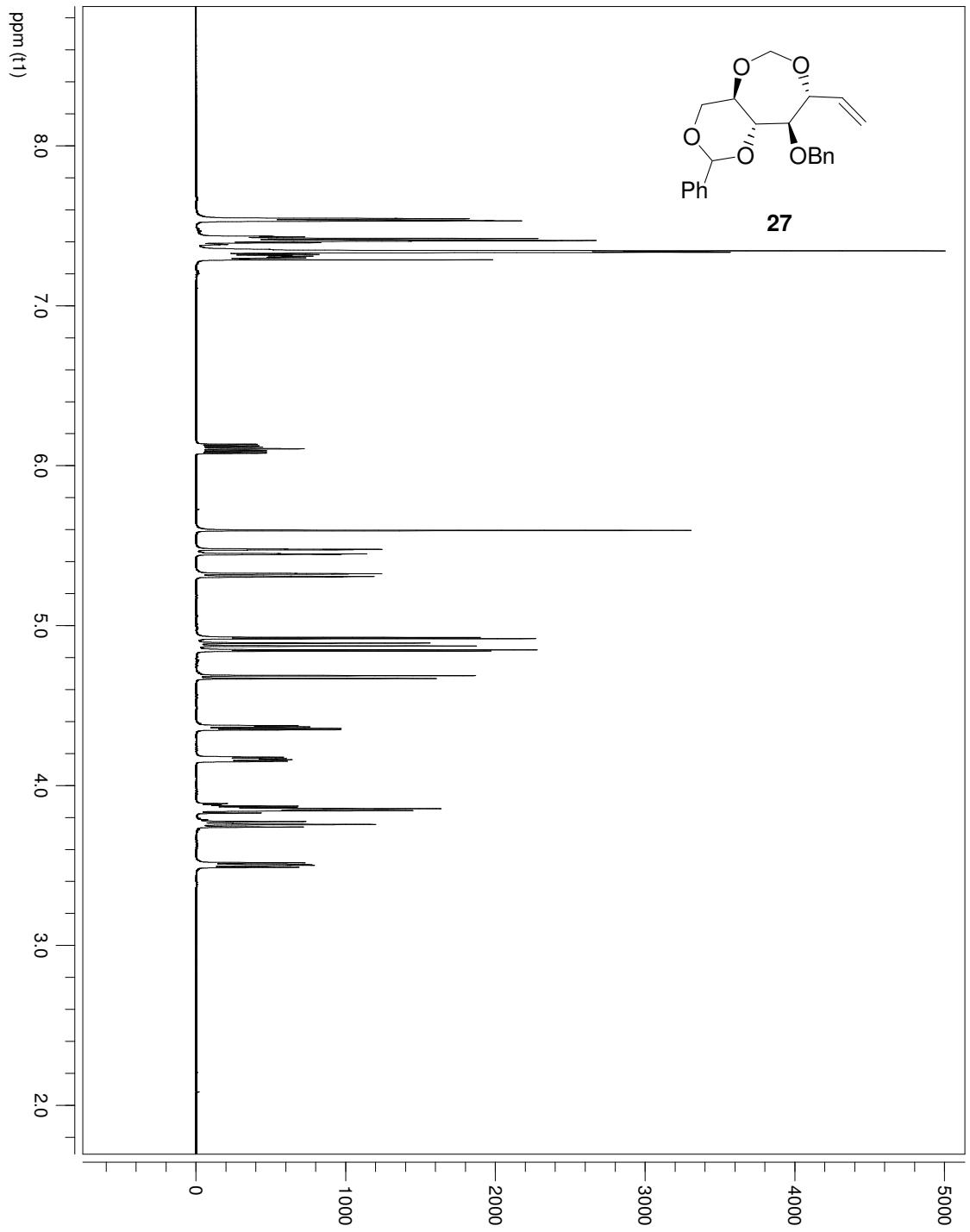

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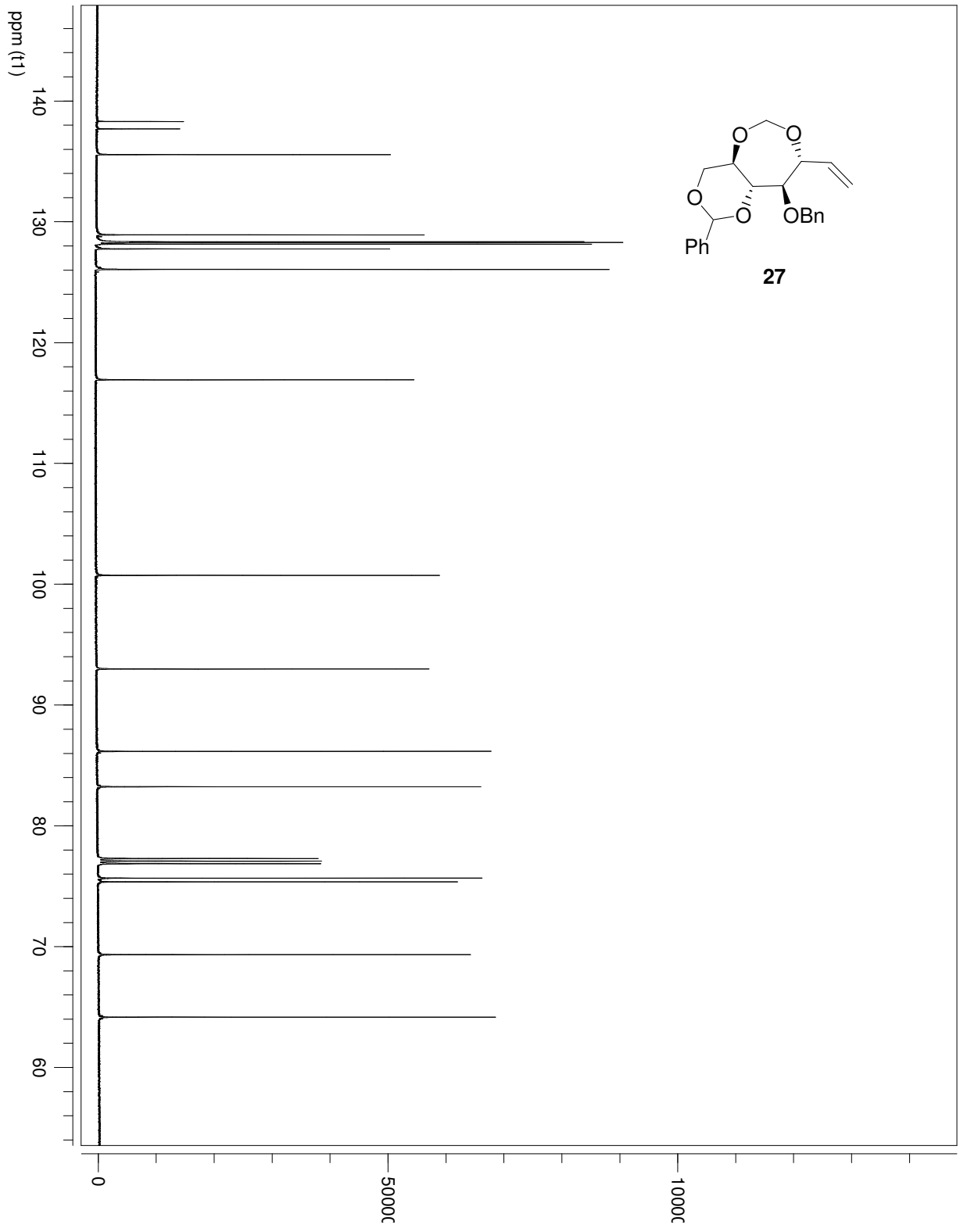

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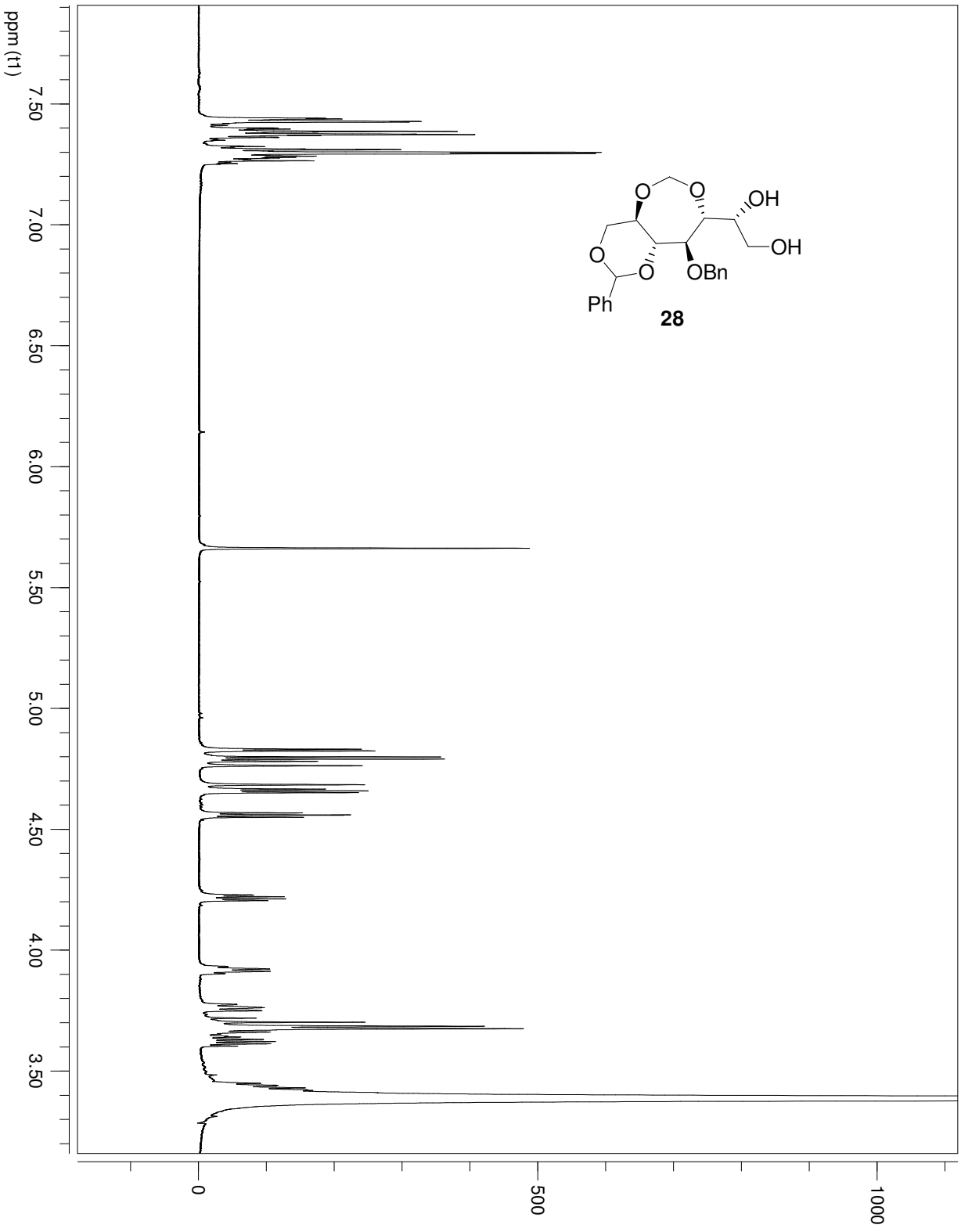
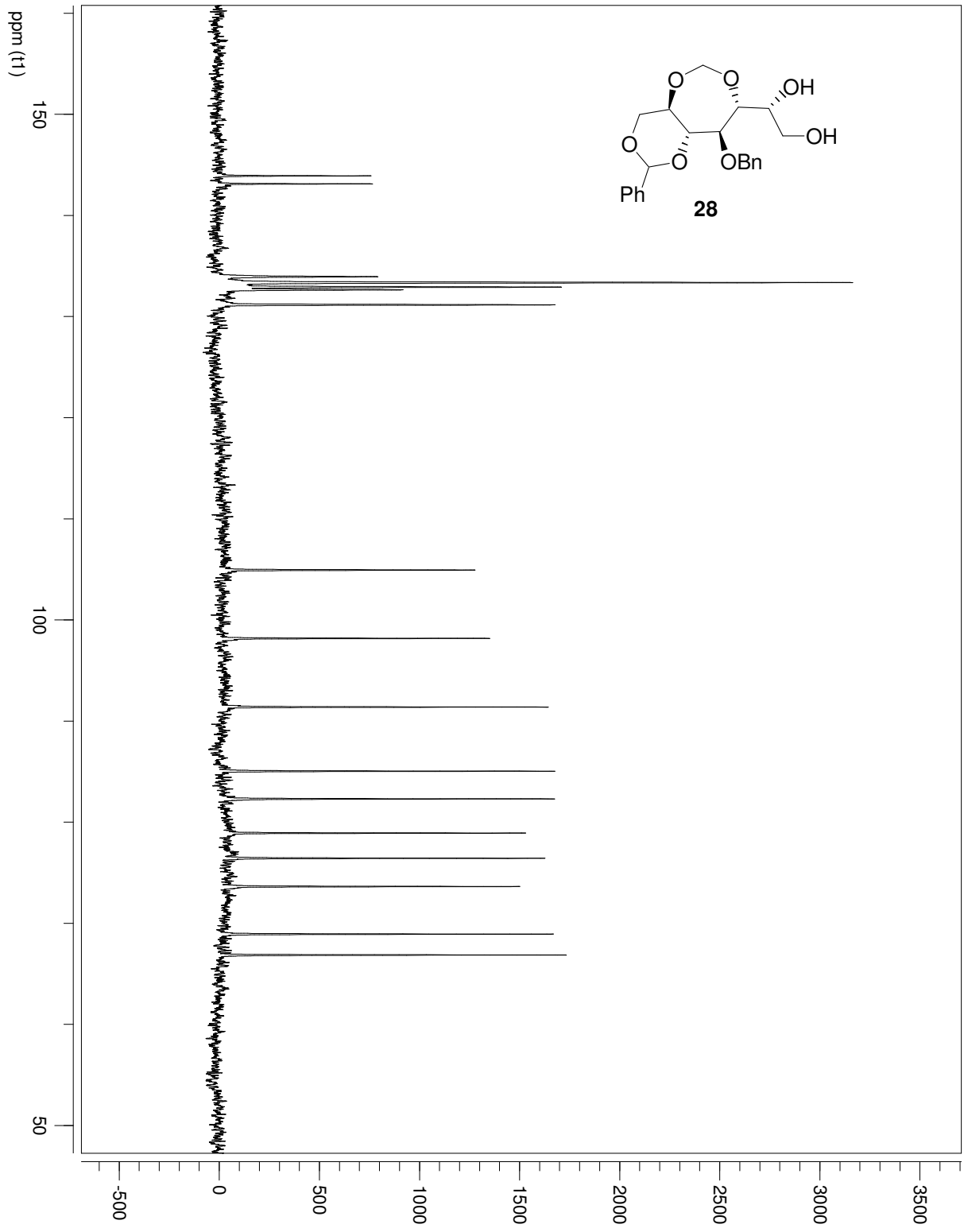

ppm (t1)
7.50
7.00
6.50
6.00
5.50
5.00
4.50
4.00
3.50
0
500
1000
O
O
OH
O
OH
O
O
OBn
Ph
28


ppm (t1)
150
100
50
-500
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500
1000
1500
2000
2500
3000
3500
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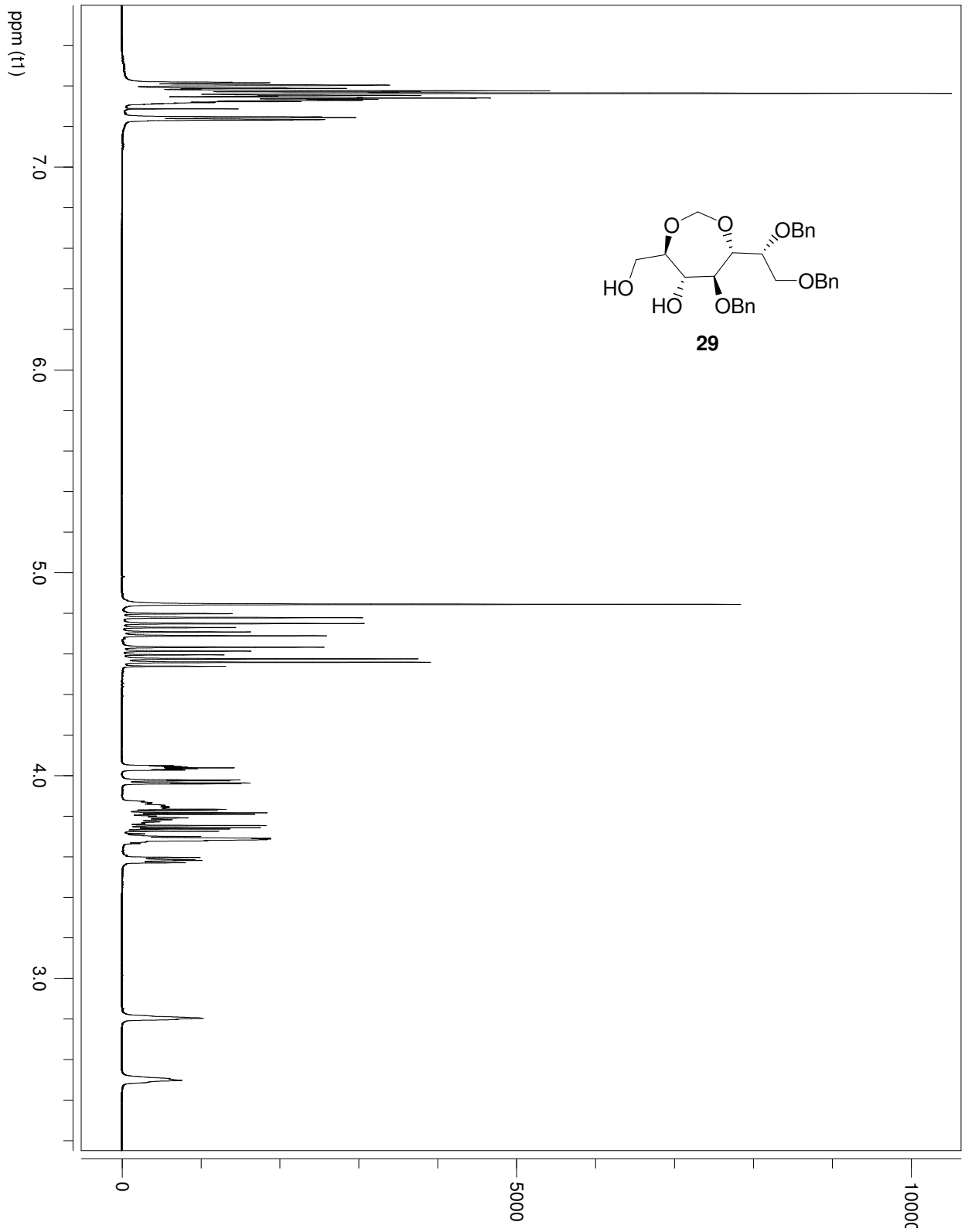
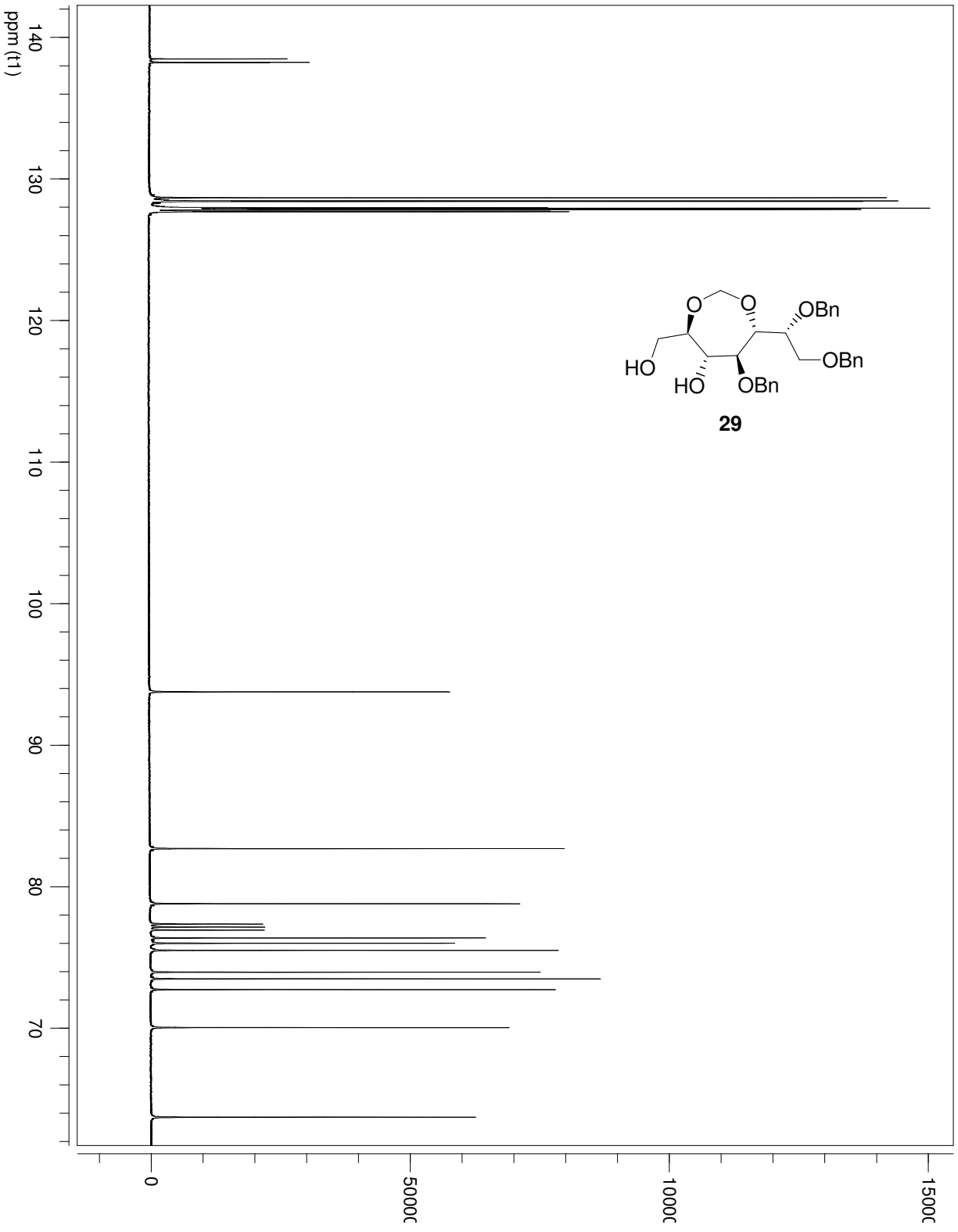
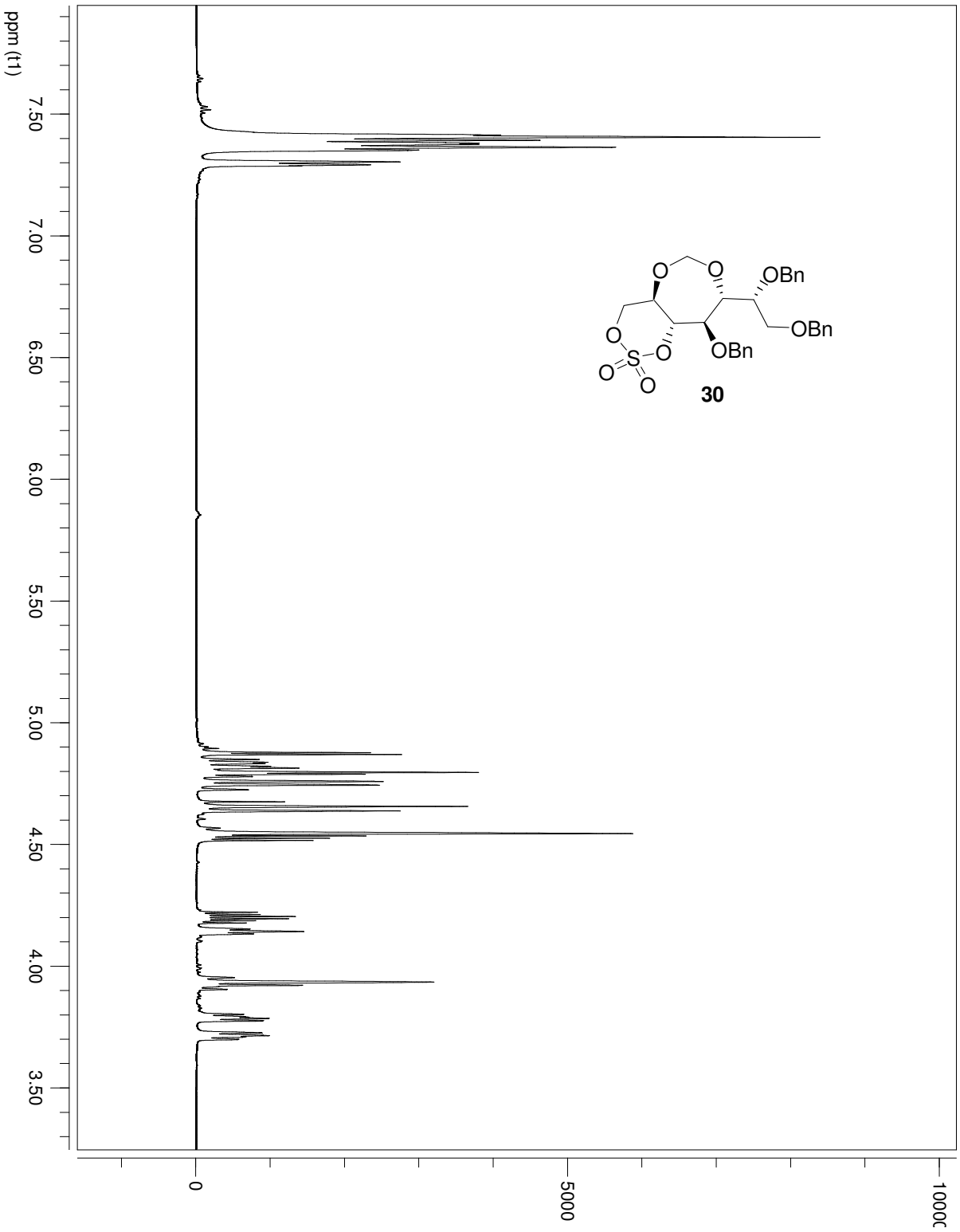
O
OH
OH
O
O
OBn
Ph
28

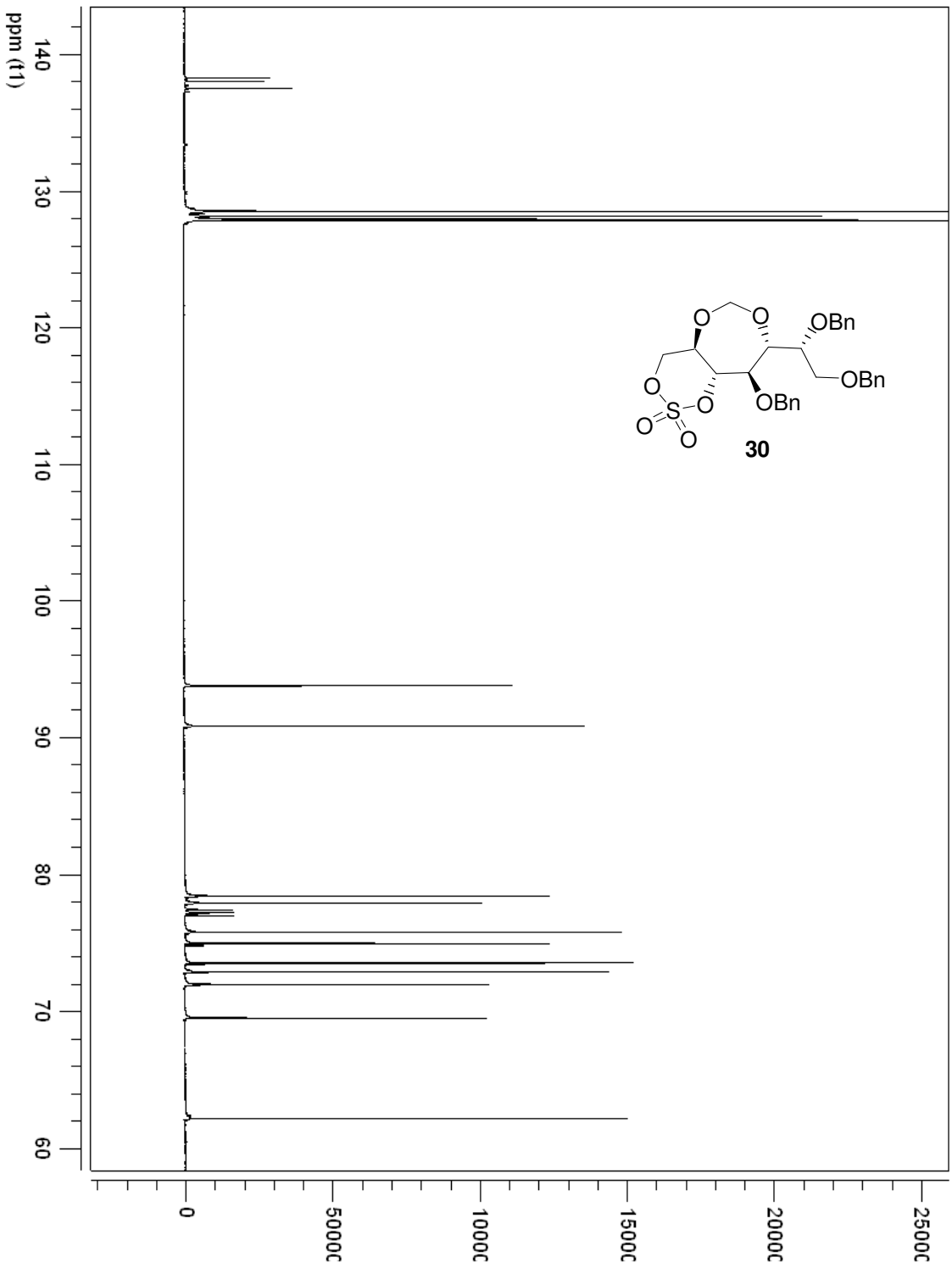


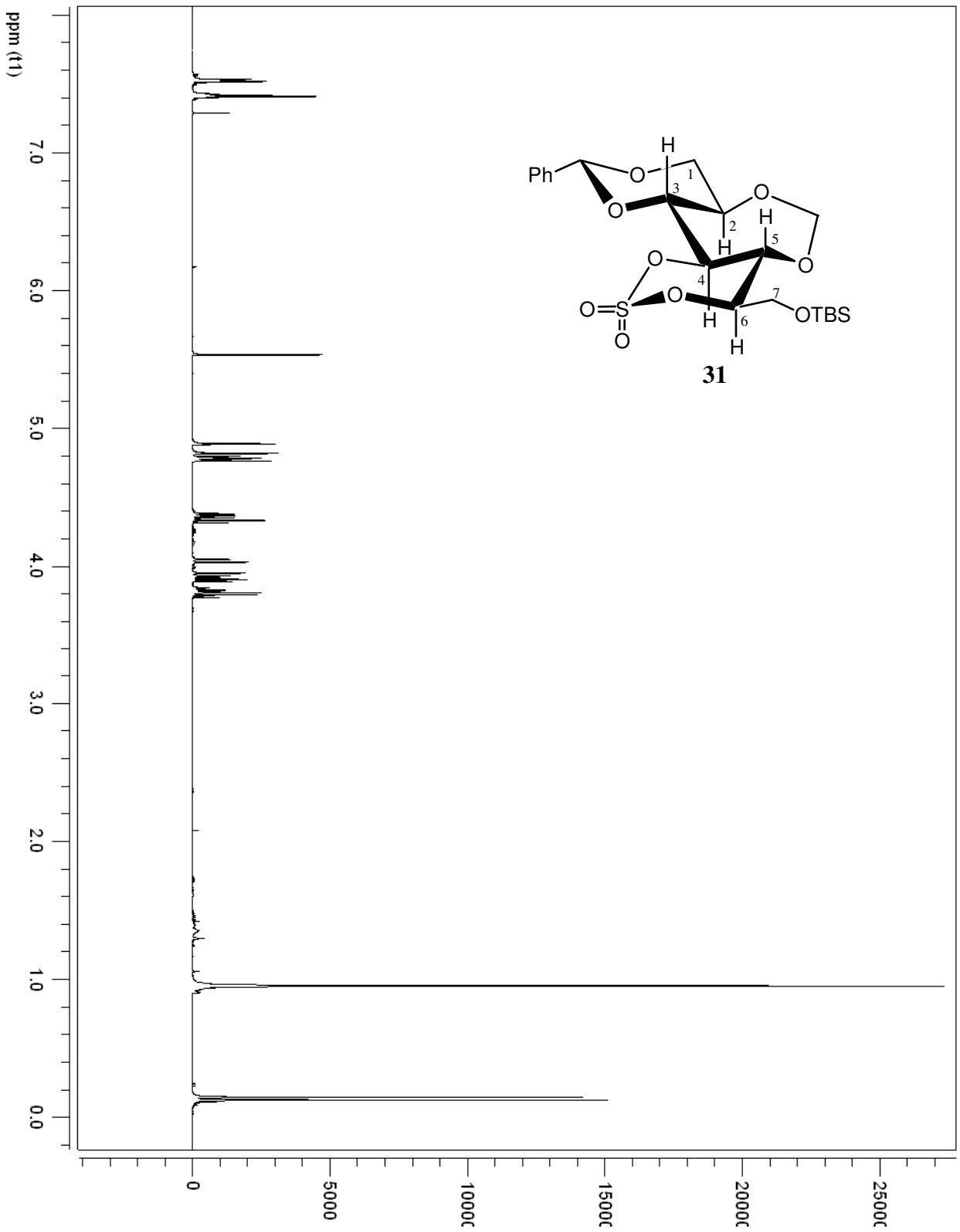
29


ppm (t1)
140
130
120
110
100
90
80
70
0
50000
100000
150000
O
O
OBn
OBn
HO
HO
OBn

29


ppm (t1)
7.50
7.00
6.50
6.00
5.50
5.00
4.50
4.00
3.50
0
5000
10000
OBn
OBn
OBn
O
O
O
O
S
O
O
O
30


ppm (f1)
140
130
120
110
100
90
80
70
60
0
5000
10000
15000
20000
25000
O
O
OBn
OBn
O
S
O
O
O
OBn
30


ppm (t1)
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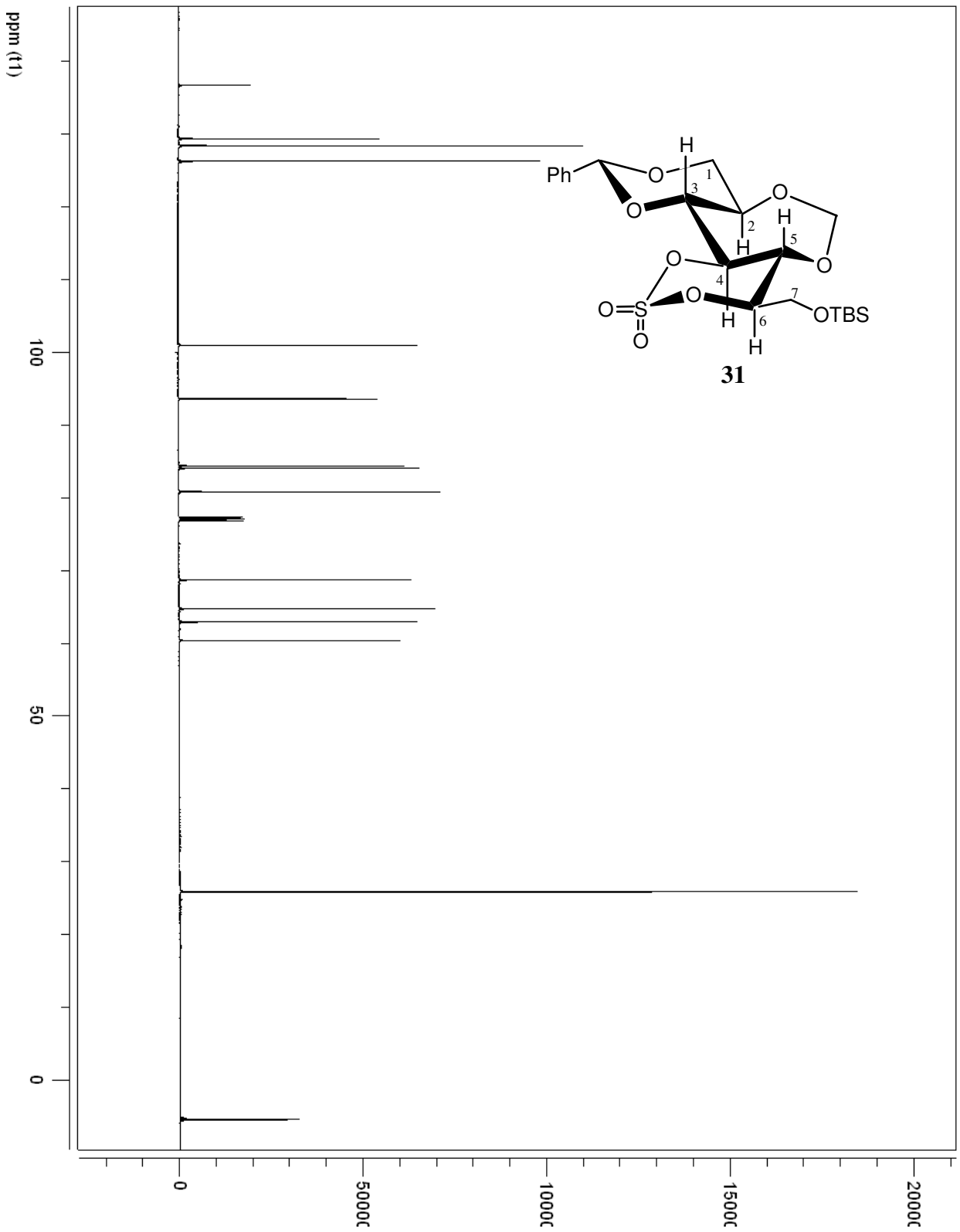
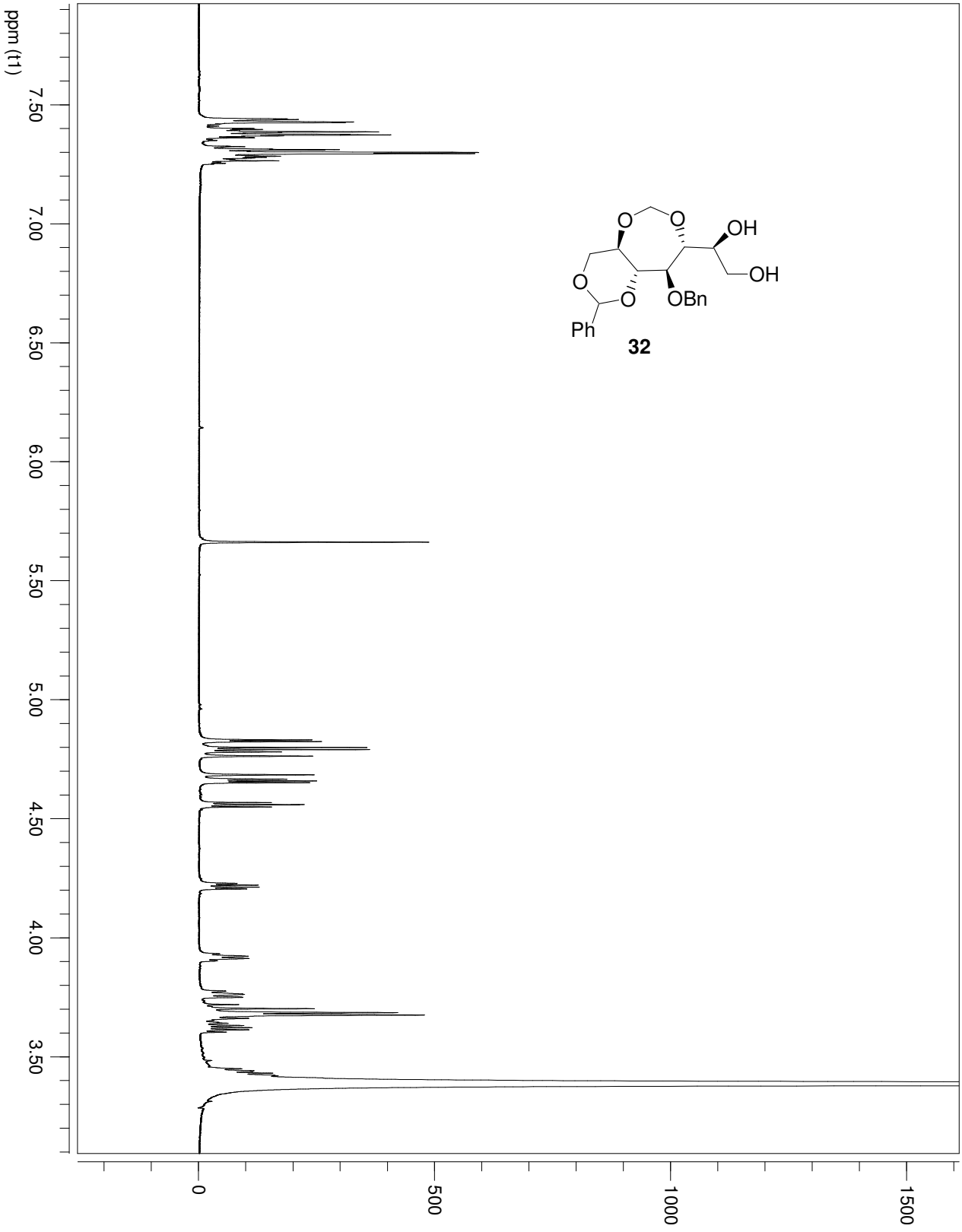
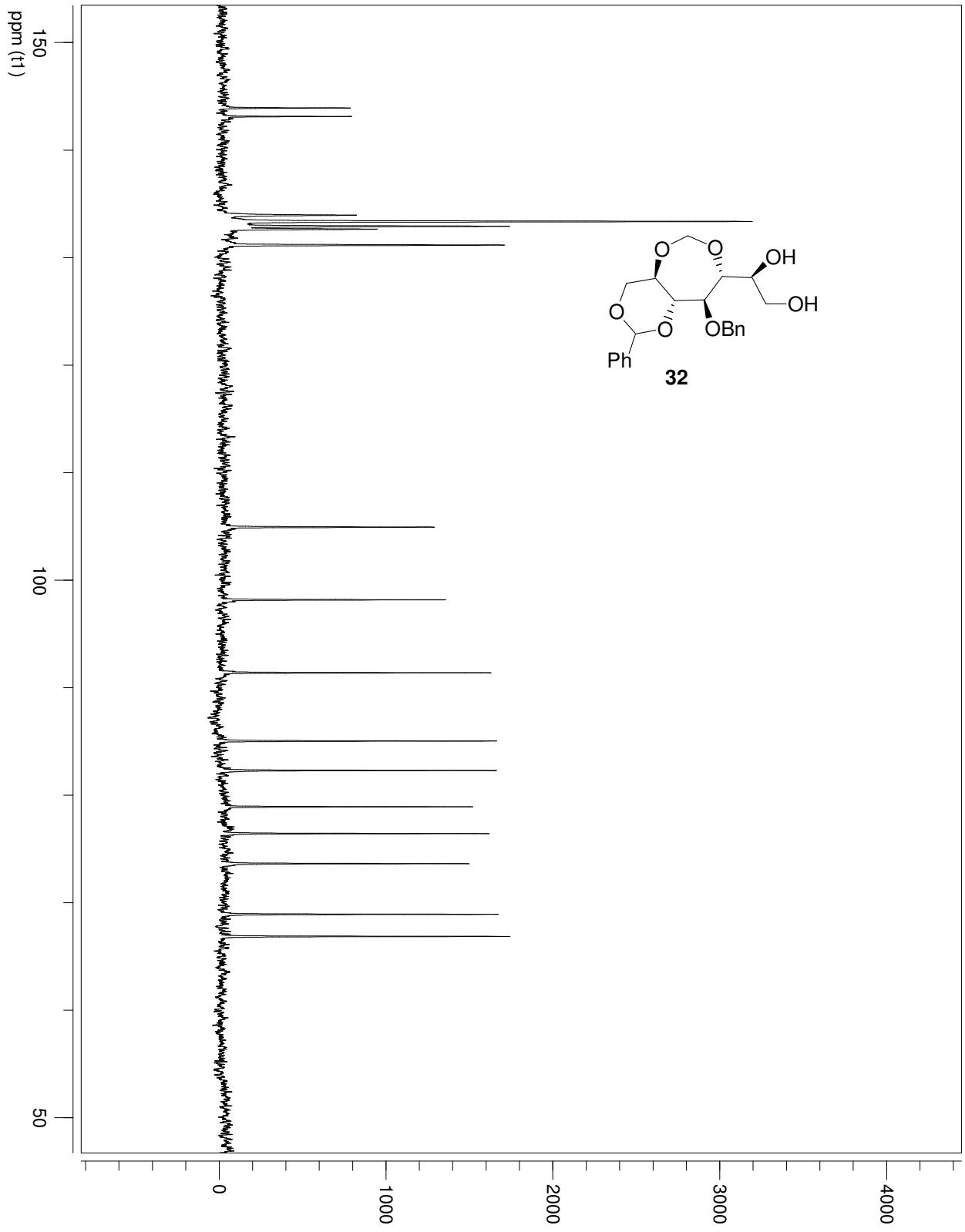
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0
5000
10000
15000
20000
25000
Ph
O
H
1
3
O
O
2
H
H
5
O
O
4
O
O=S=O
7
O
H
6
OTBS
H

31

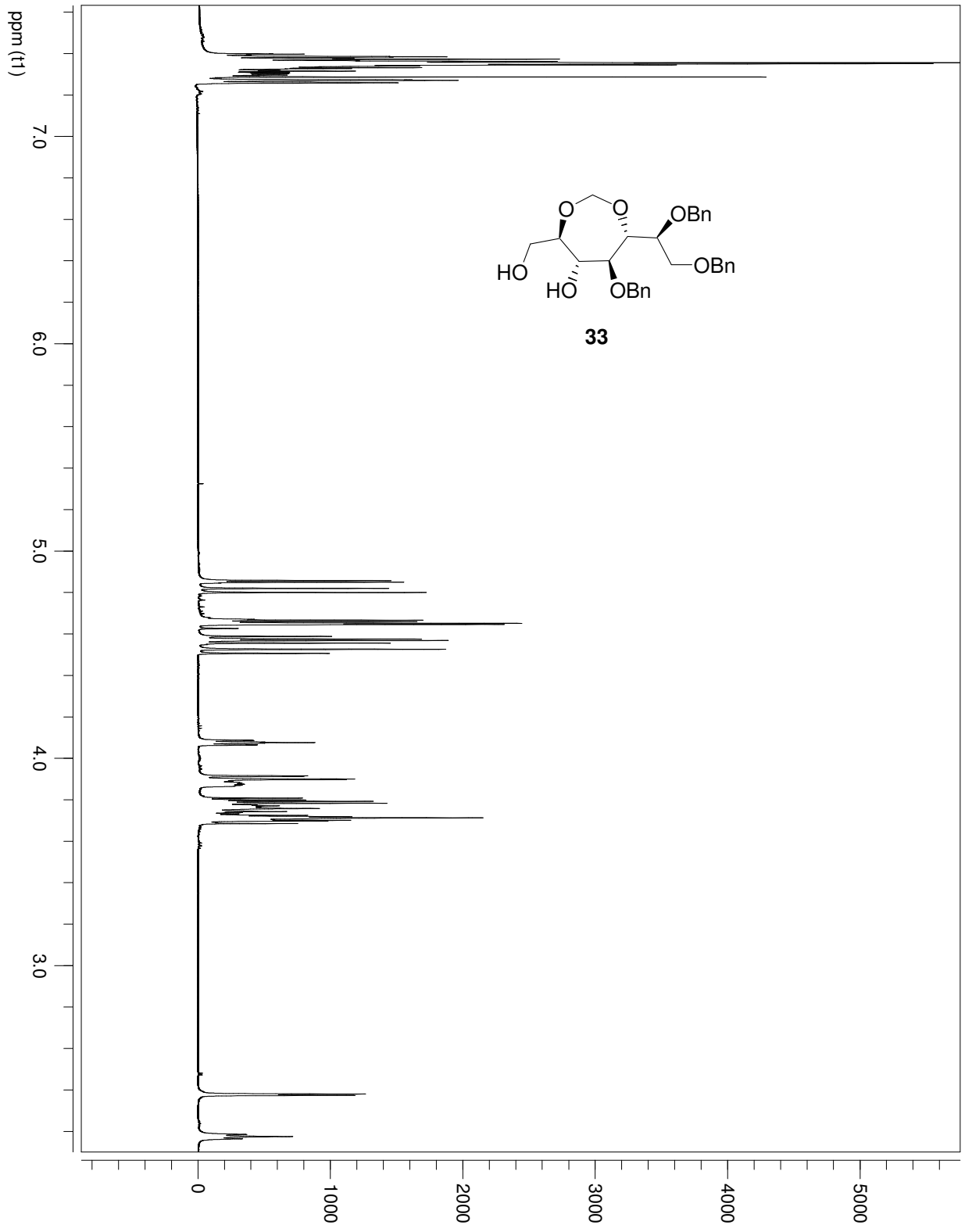

ppm (t1)
100
50
0
0
50000
100000
150000
200000
Ph
O
H
1
3
2
O
O
H
5
H
O
O
4
O
7
O=S=O
H
6
OTBS
H

31

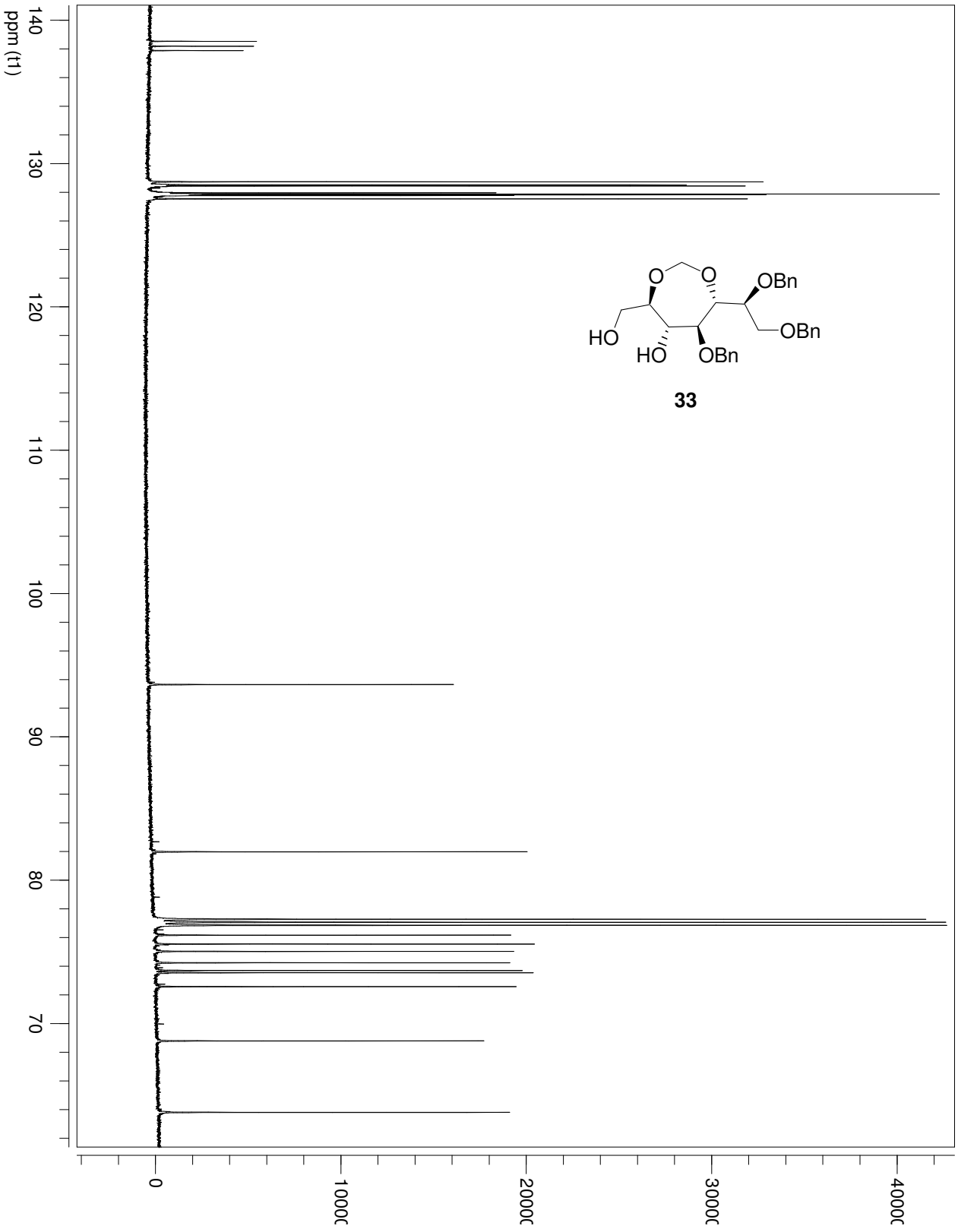

ppm (t1)
7.50
7.00
6.50
6.00
5.50
5.00
4.50
4.00
3.50
0
500
1000
1500
O
O
OH
O
OH
O
O
OBn
Ph
32



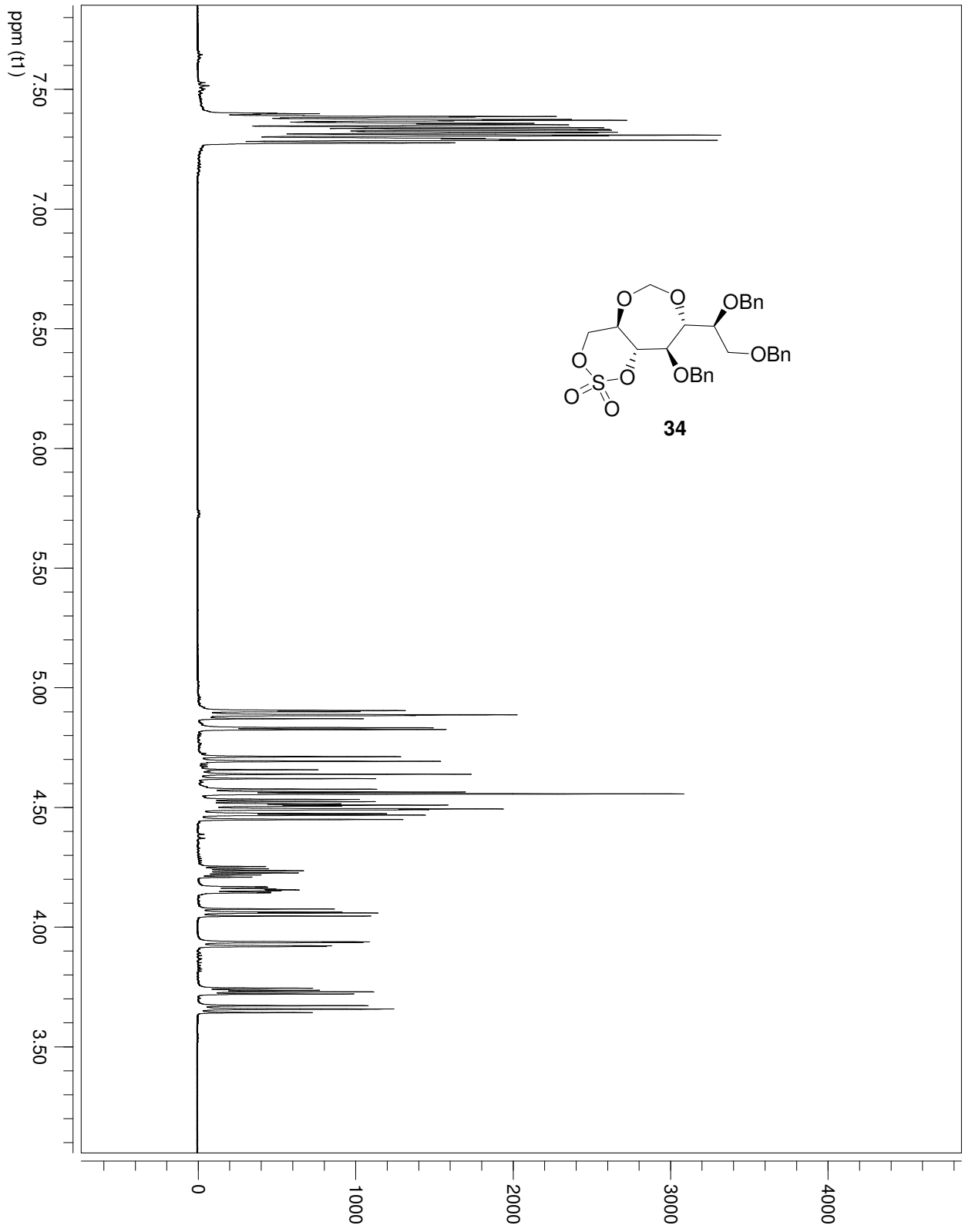
32


ppm (t1)
7.0
6.0
5.0
4.0
3.0
0
1000
2000
3000
4000
5000
O
O
OBn
OBn
HO
HO
OBn

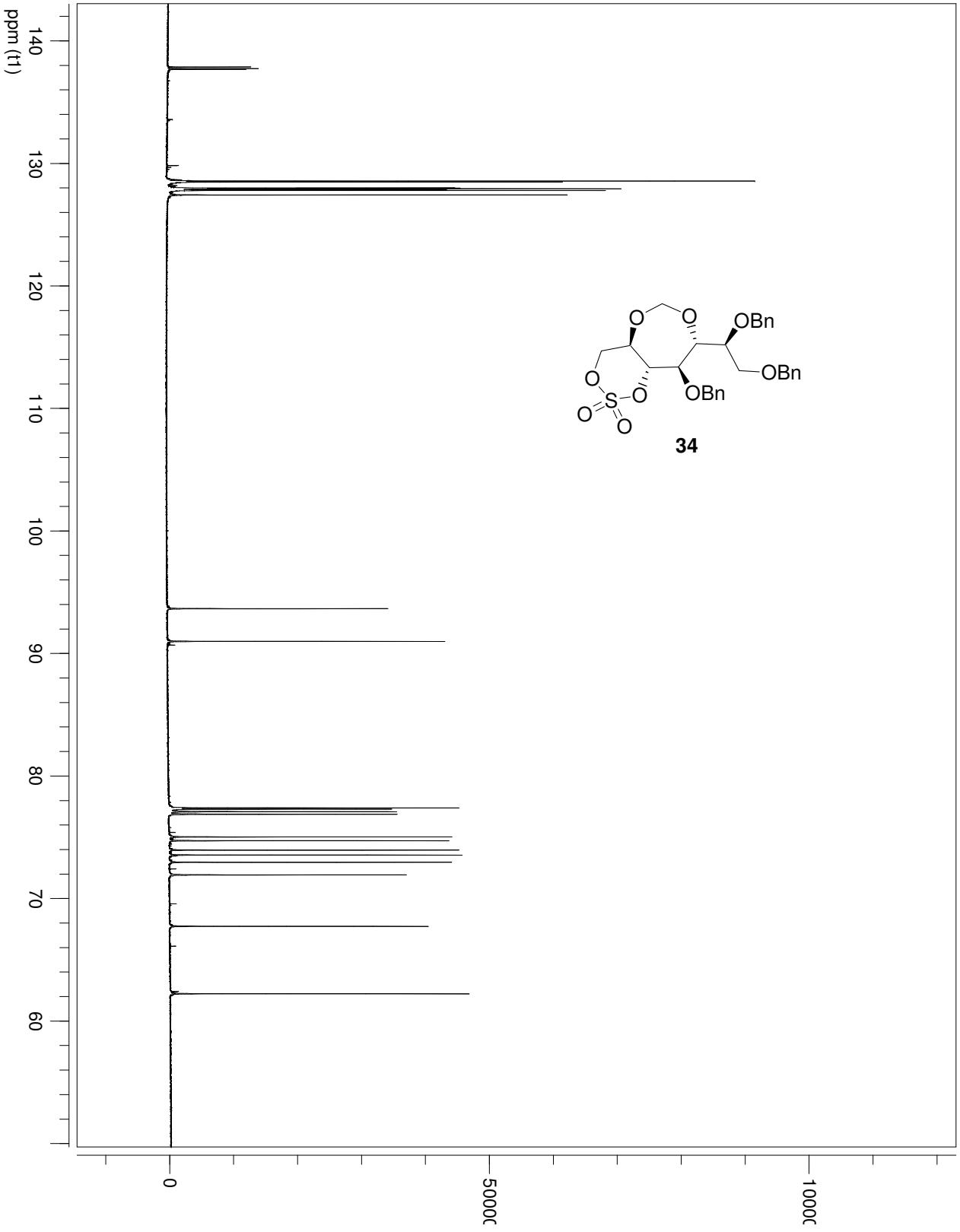
33

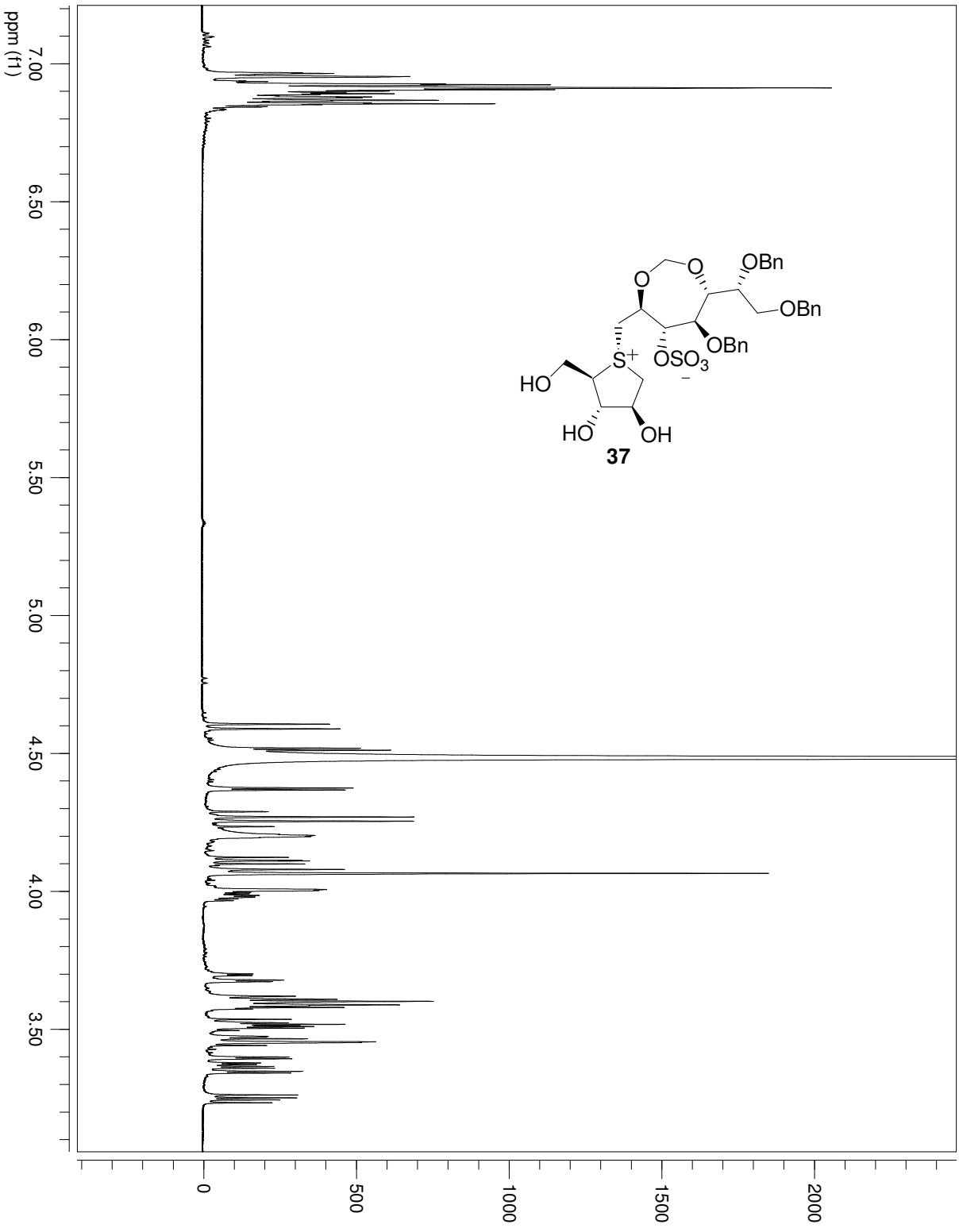

ppm (t1)
140
130
120
110
100
90
80
70
0
10000
20000
30000
40000
O
O
OBn
OBn
HO
HO
OBn

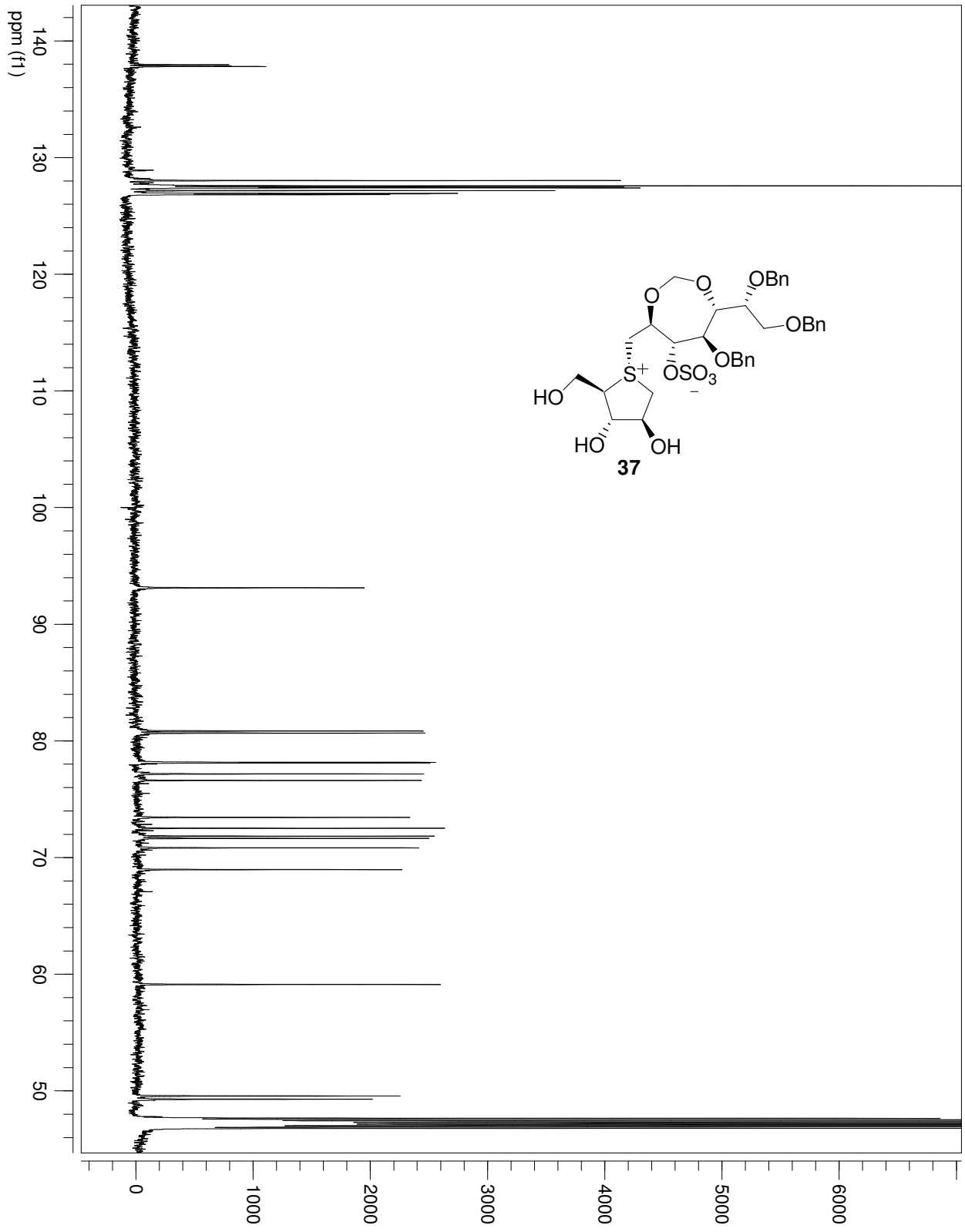
33

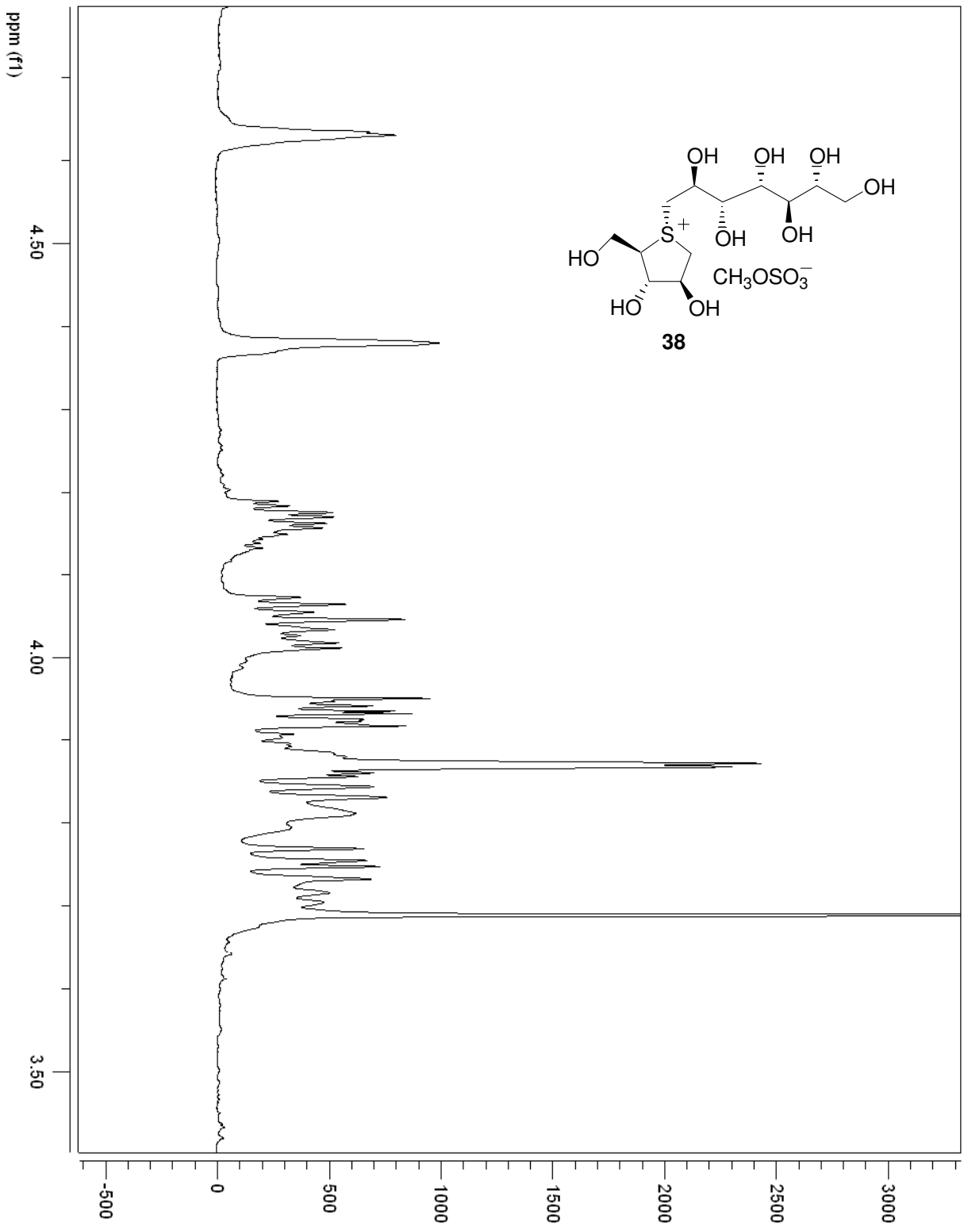

ppm (t1)
7.50
7.00
6.50
6.00
5.50
5.00
4.50
4.00
3.50
0
1000
2000
3000
4000
OBn
OBn
OBn
O
O
O
O
S
O
O
O

34

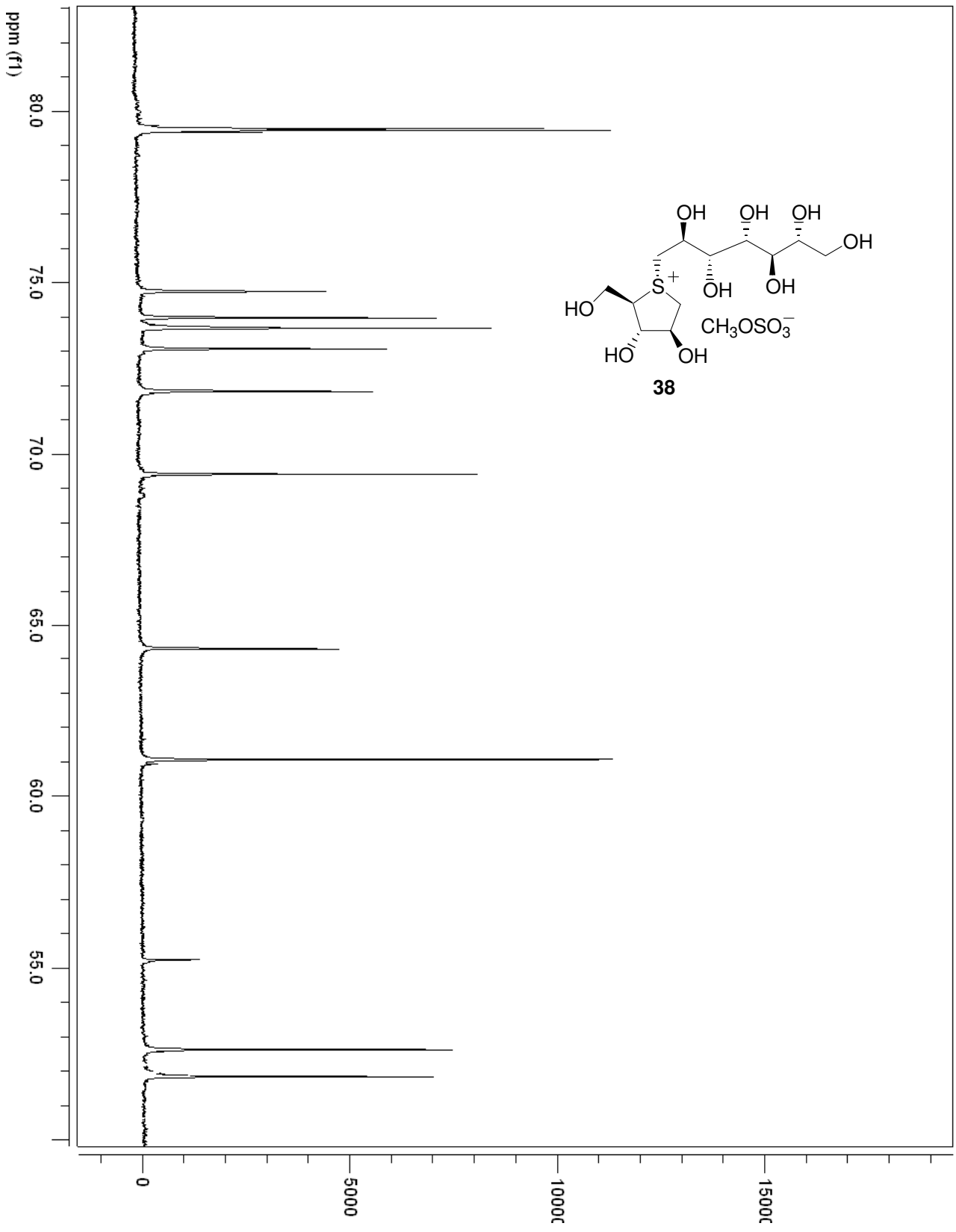

ppm (t1)
140
130
120
110
100
90
80
70
60
0
5000
10000
O
O
OBn
OBn
O
O
S
O
O
OBn
34


ppm (f1)
7.00
6.50
6.00
5.50
5.00
4.50
4.00
3.50
0
500
1000
1500
2000
OBn
OBn
OBn
OSO3
HO
HO
OH
37

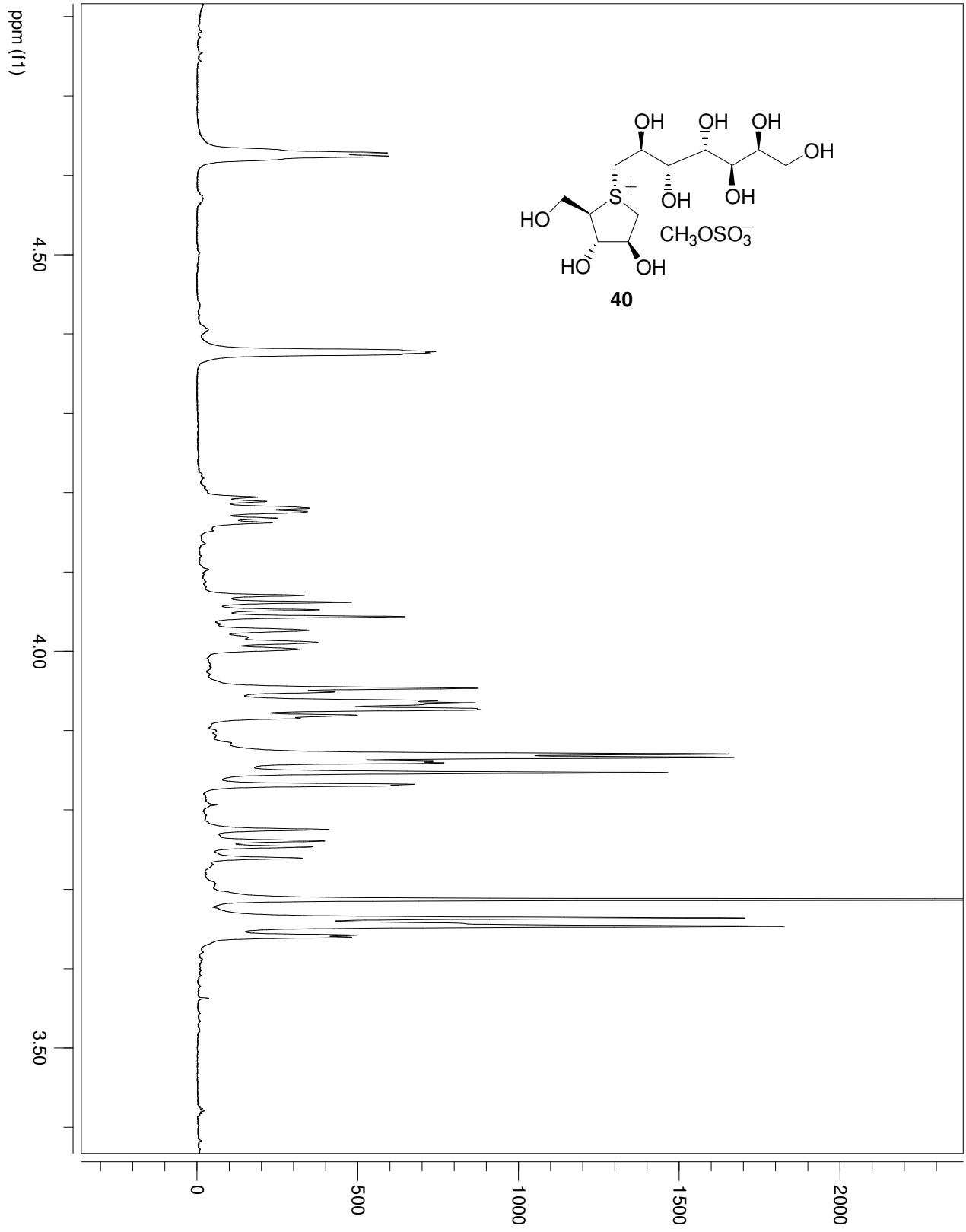

ppm (f1)
140
130
120
110
100
90
80
70
60
50
0
1000
2000
3000
4000
5000
6000
OBn
OBn
OBn
O
O
S+
OSO3
HO
HO
OH
37


ppm (f1)
4.50
4.00
3.50
-500
0
500
1000
1500
2000
2500
3000
OH
OH
OH
OH
OH
OH
HO
HO
OH
S+
CH3OSO3−

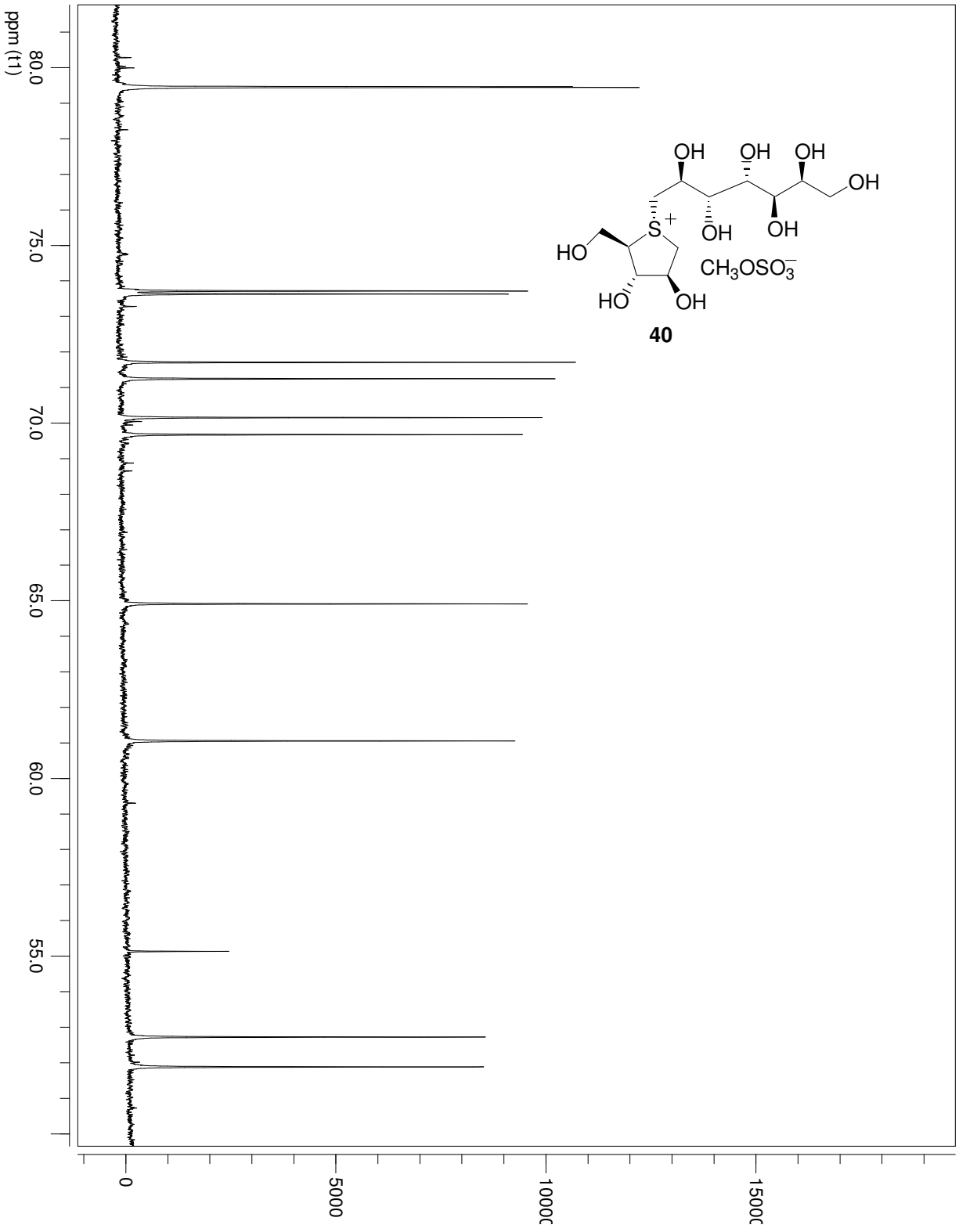
38


ppm (f1)
80.0
75.0
70.0
65.0
60.0
55.0
0
5000
10000
15000
OH
OH
OH
OH
OH
OH
HO
HO
OH
S+
CH3OSO3−

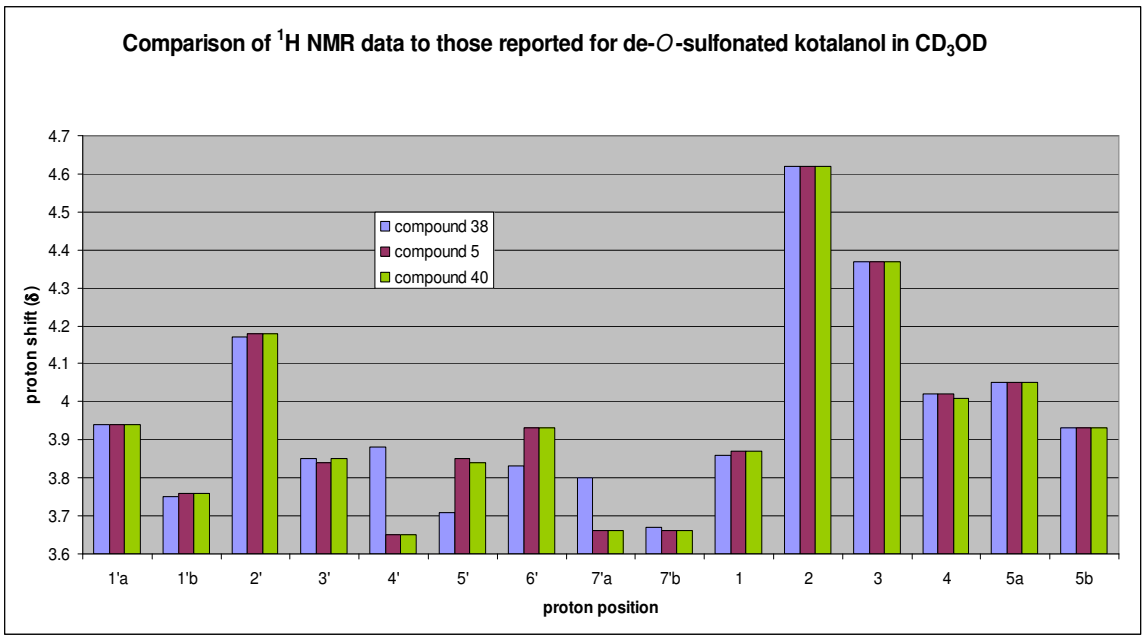
38

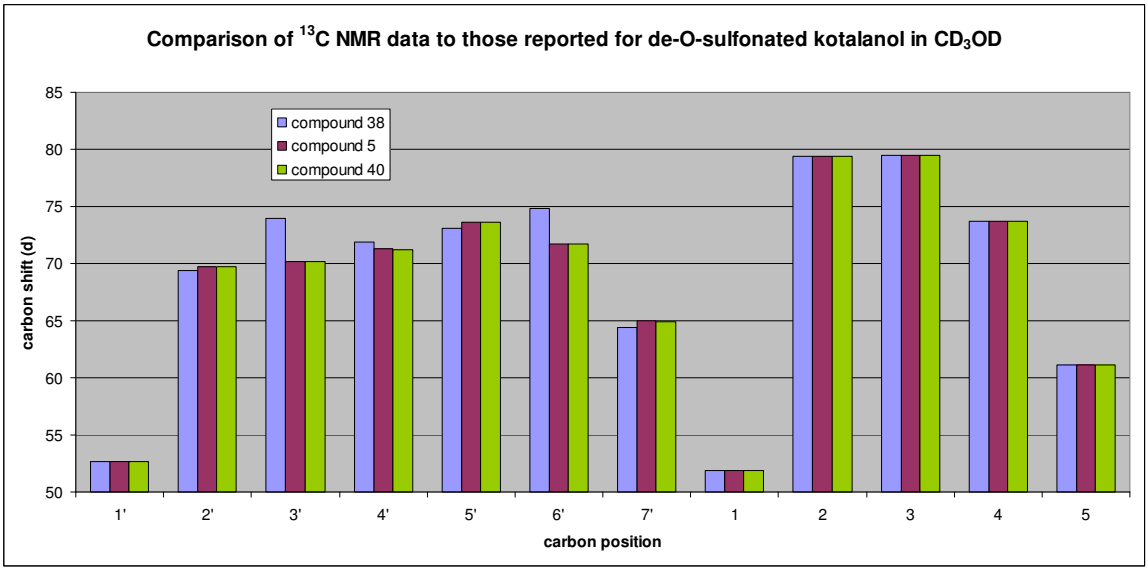

ppm (f1)
4.50
4.00
3.50
0
500
1000
1500
2000
OH
OH
OH
OH
OH
OH
S+
HO
CH3OSO3−
HO
OH

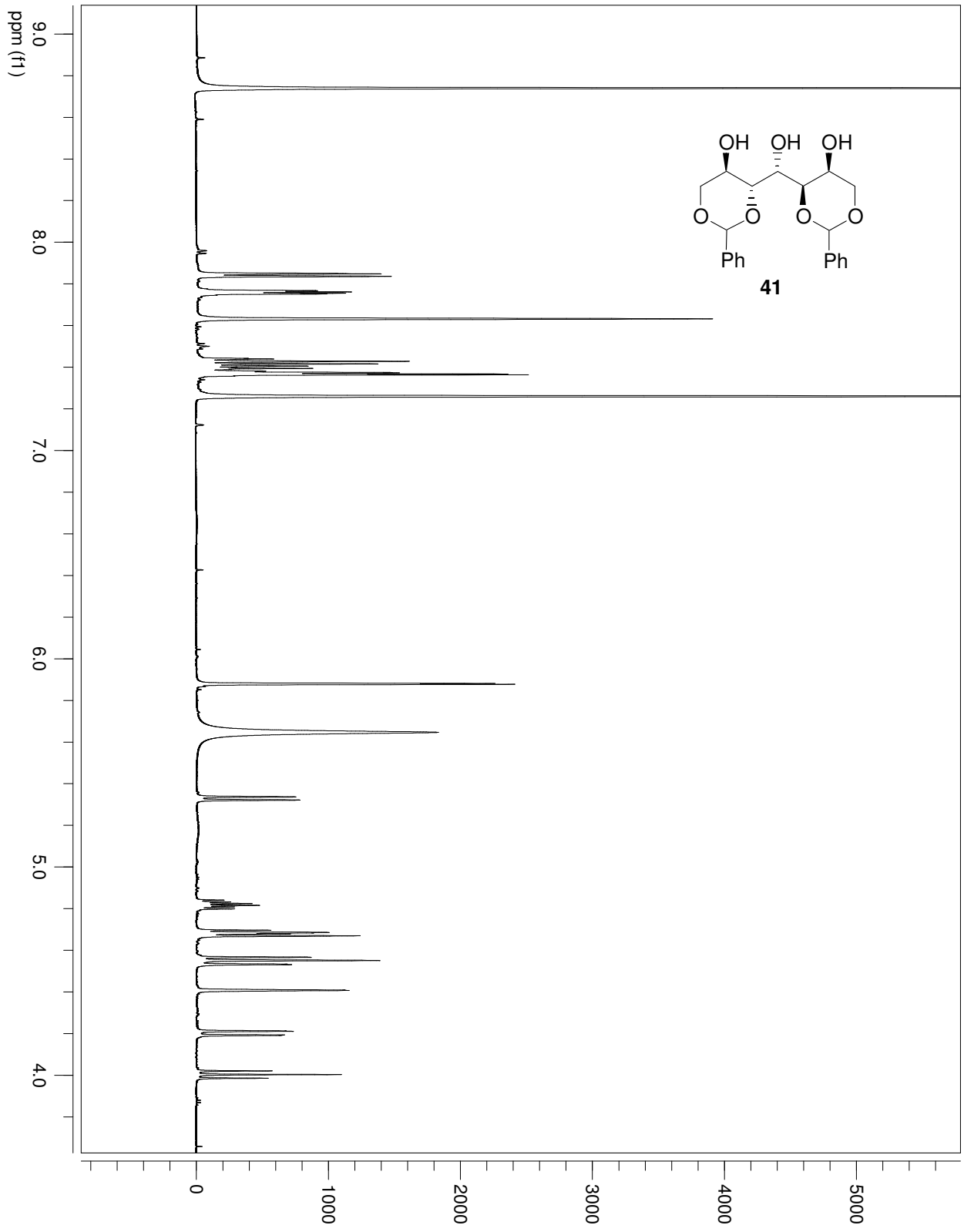
40

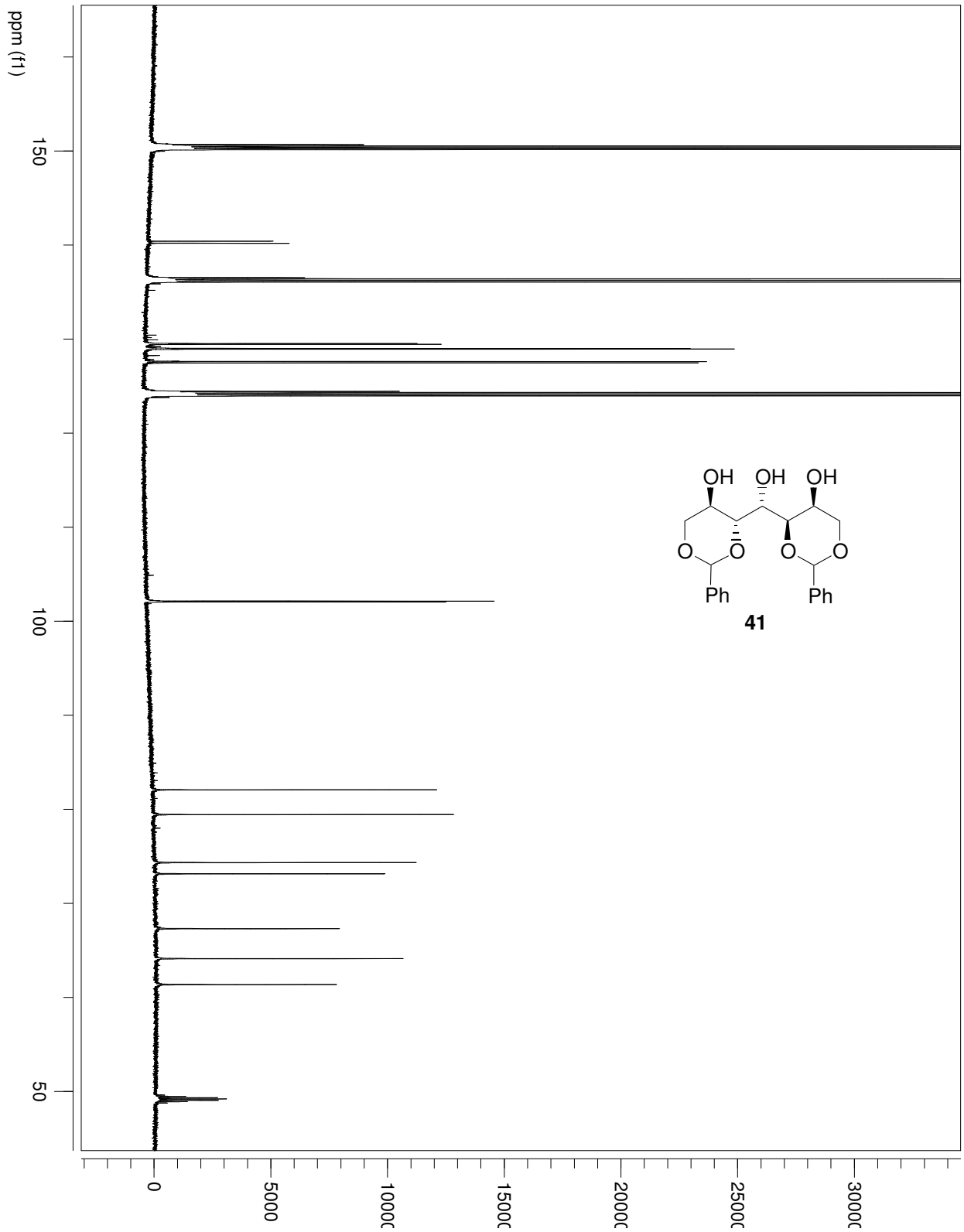

ppm (t1)
80.0
75.0
70.0
65.0
60.0
55.0
0
5000
10000
15000
OH
OH
OH
OH
OH
OH
OH
HO
HO
S+
CH3OSO3−

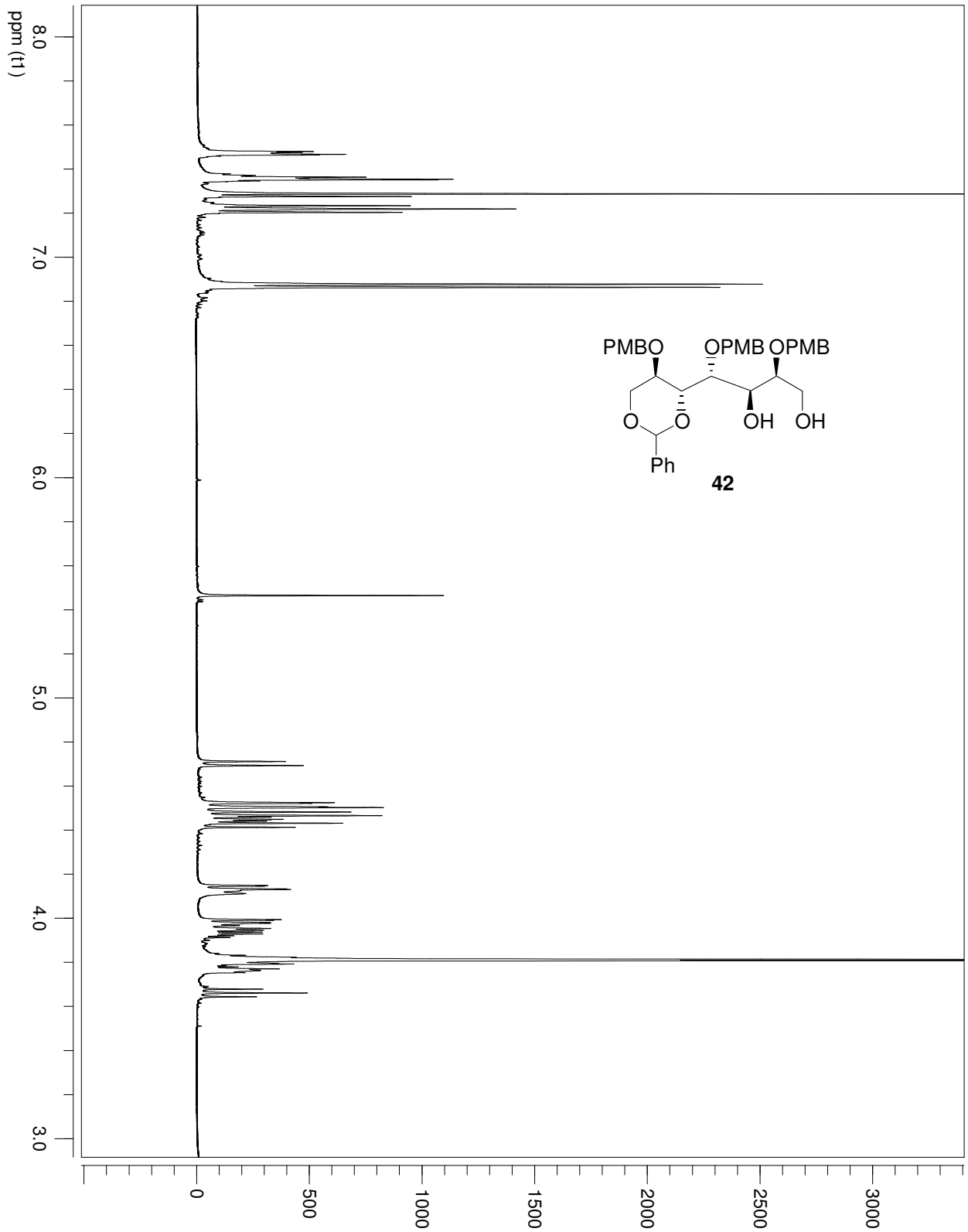
40

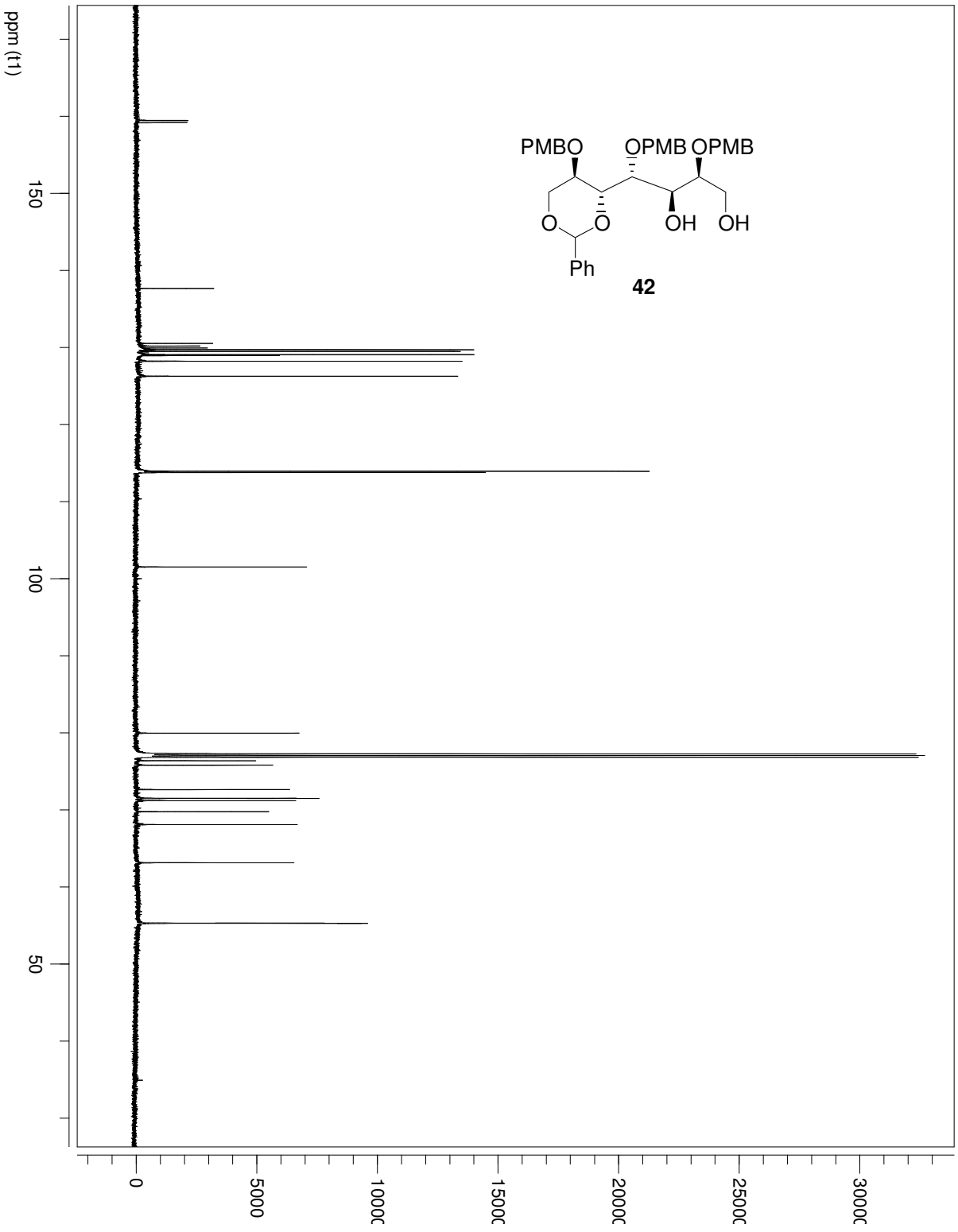

Comparison of ^{1}H NMR data to those reported for de-*O*-sulfonated kotalanol in CD_3OD
proton shift (δ)
4.7
4.6
4.5
4.4
4.3
4.2
4.1
4
3.9
3.8
3.7
3.6
compound 38
compound 5
compound 40
1'a
1'b
2'
3'
4'
5'
6'
7'a
7'b
1
2
3
4
5a
5b
proton position


Comparison of ^{13}C NMR data to those reported for de-O-sulfonated kotalanol in CD_3OD
carbon shift (d)
85
80
75
70
65
60
55
50
compound 38
compound 5
compound 40
1'
2'
3'
4'
5'
6'
7'
1
2
3
4
5
carbon position

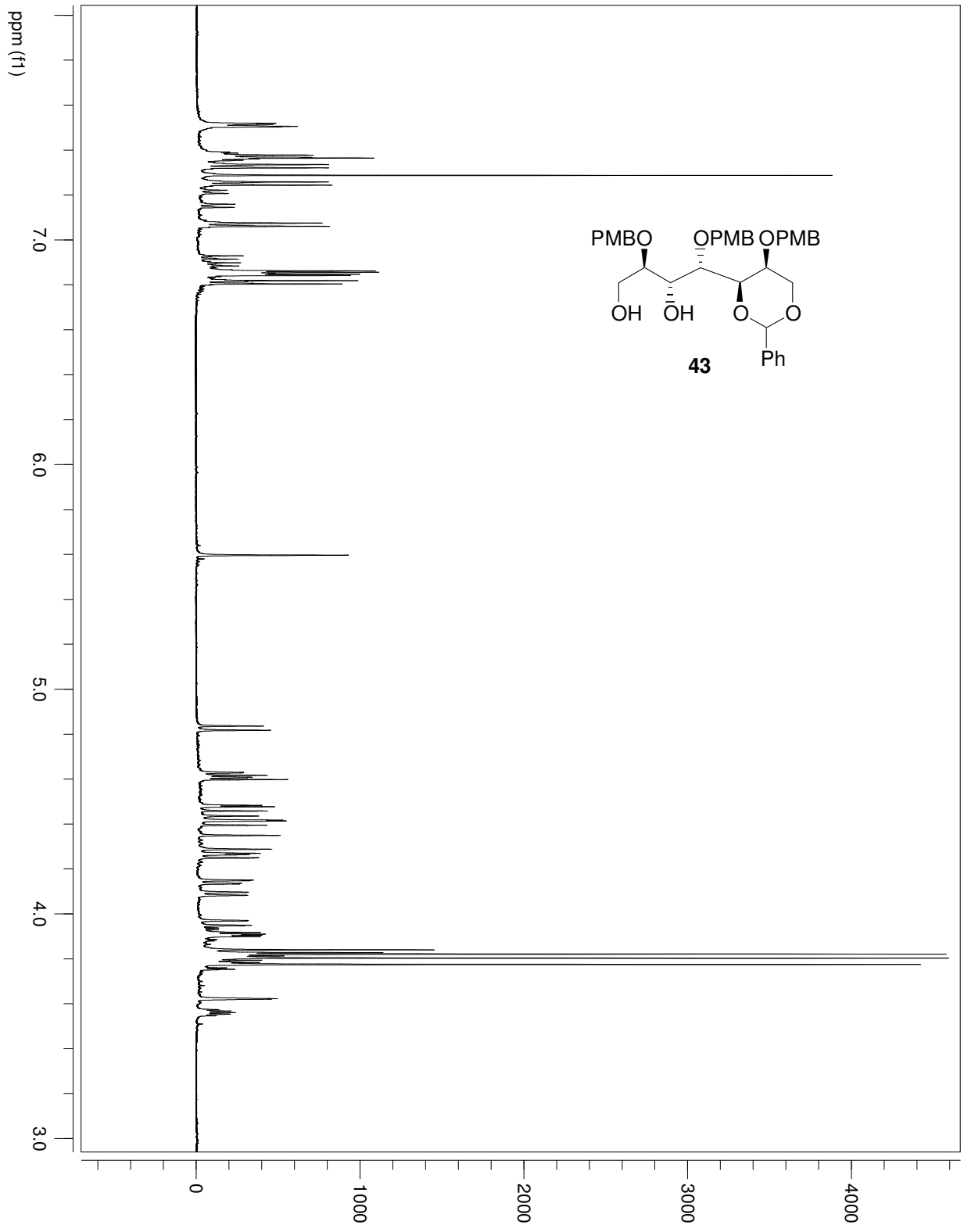

ppm (f1)
9.0
8.0
7.0
6.0
5.0
4.0
0
1000
2000
3000
4000
5000
OH
OH
OH
O
O
O
O
Ph
Ph
41

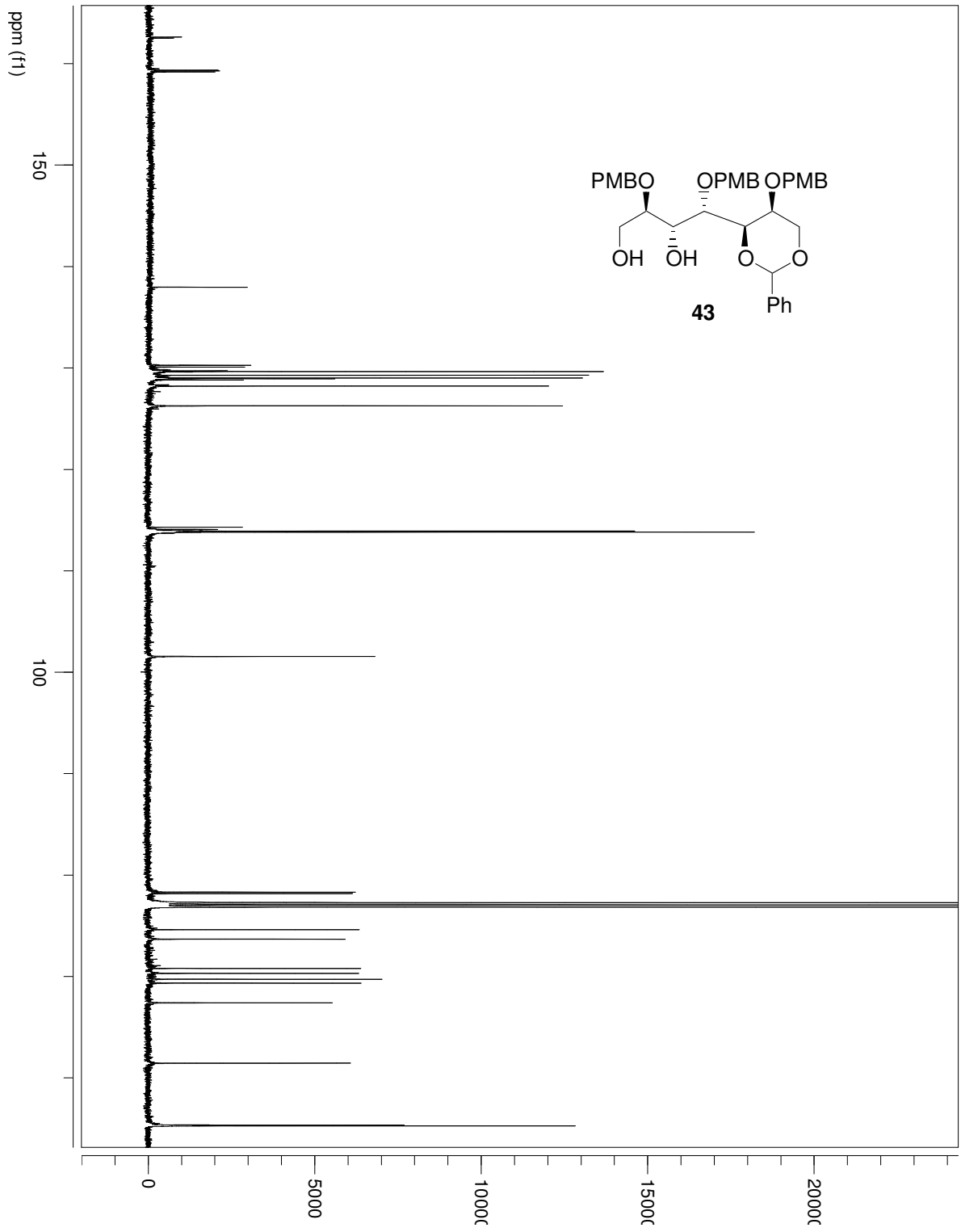

ppm (f1)
150
100
50
0
5000
10000
15000
20000
25000
30000
OH
OH
OH
O
O
O
O
Ph
Ph
41

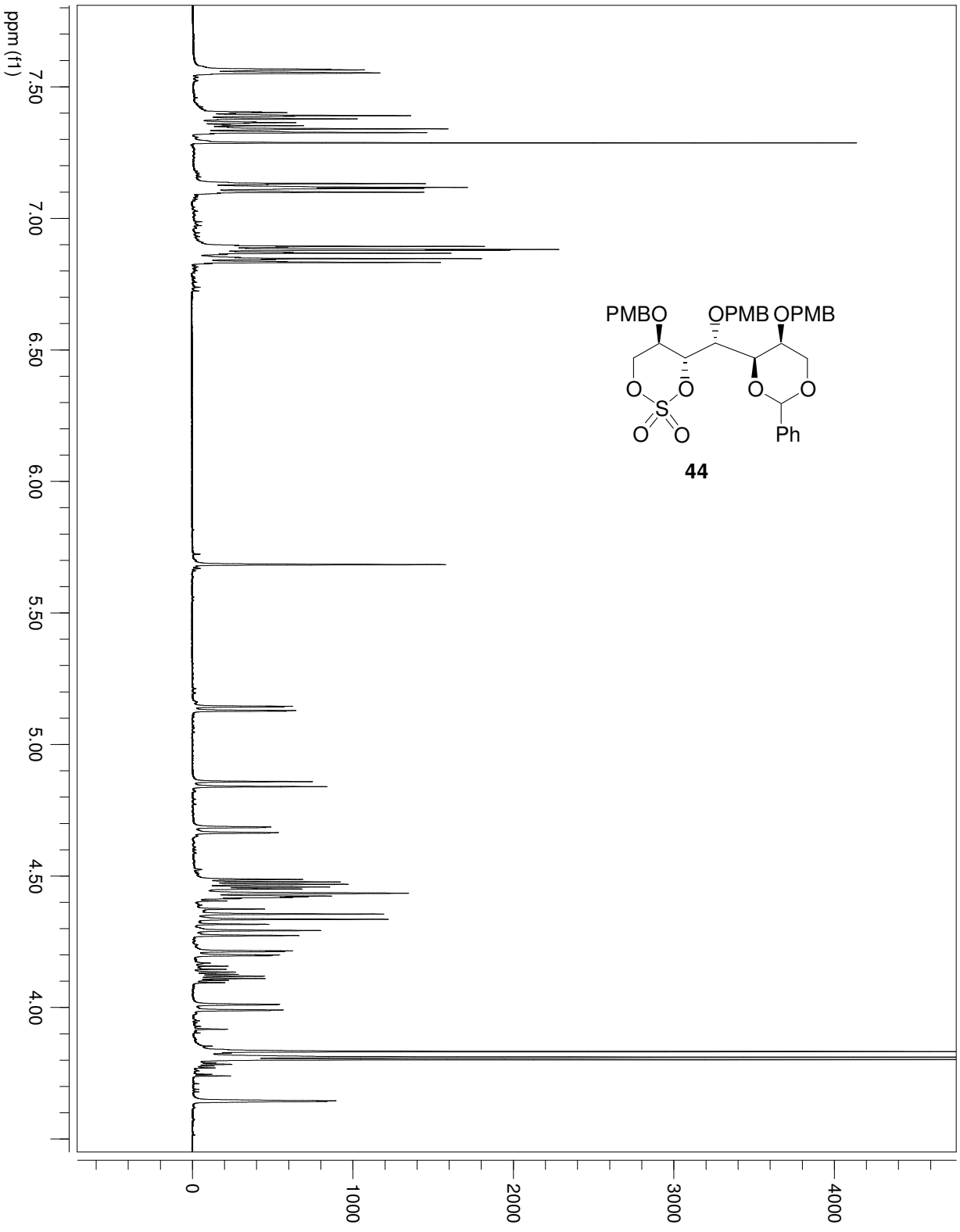

ppm (t1)
8.0
7.0
6.0
5.0
4.0
3.0
0
500
1000
1500
2000
2500
3000
PMBO
OPMB
OPMB
O
O
OH
OH
Ph
42


ppm (t1)
150
100
50
0
5000
10000
15000
20000
25000
30000
PMBO
OPMB
OPMB
O
O
OH
OH
Ph

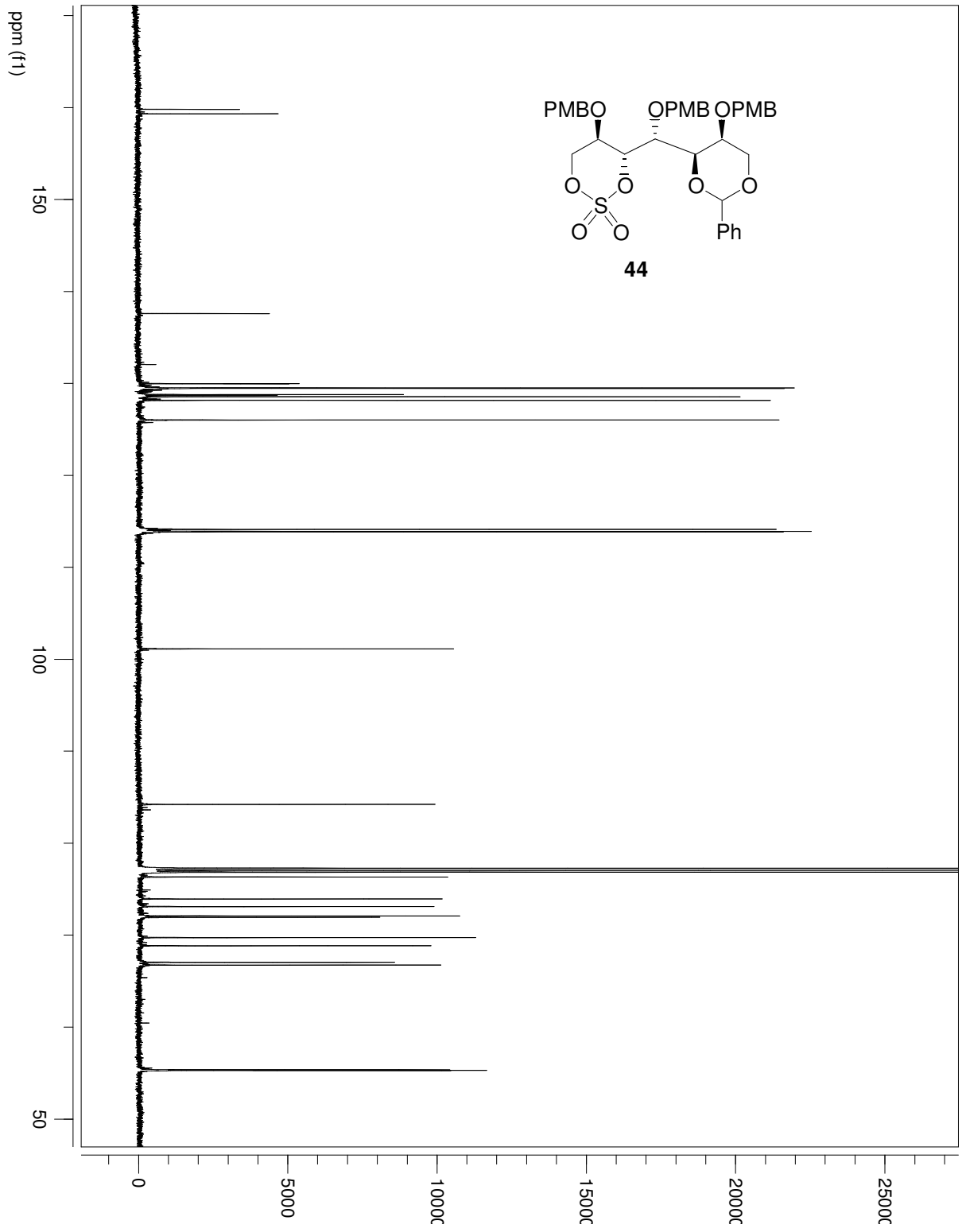
42


ppm (f1)
7.0
6.0
5.0
4.0
3.0
0
1000
2000
3000
4000
PMBO
OPMB
OPMB
OH
OH
O
O
Ph
43

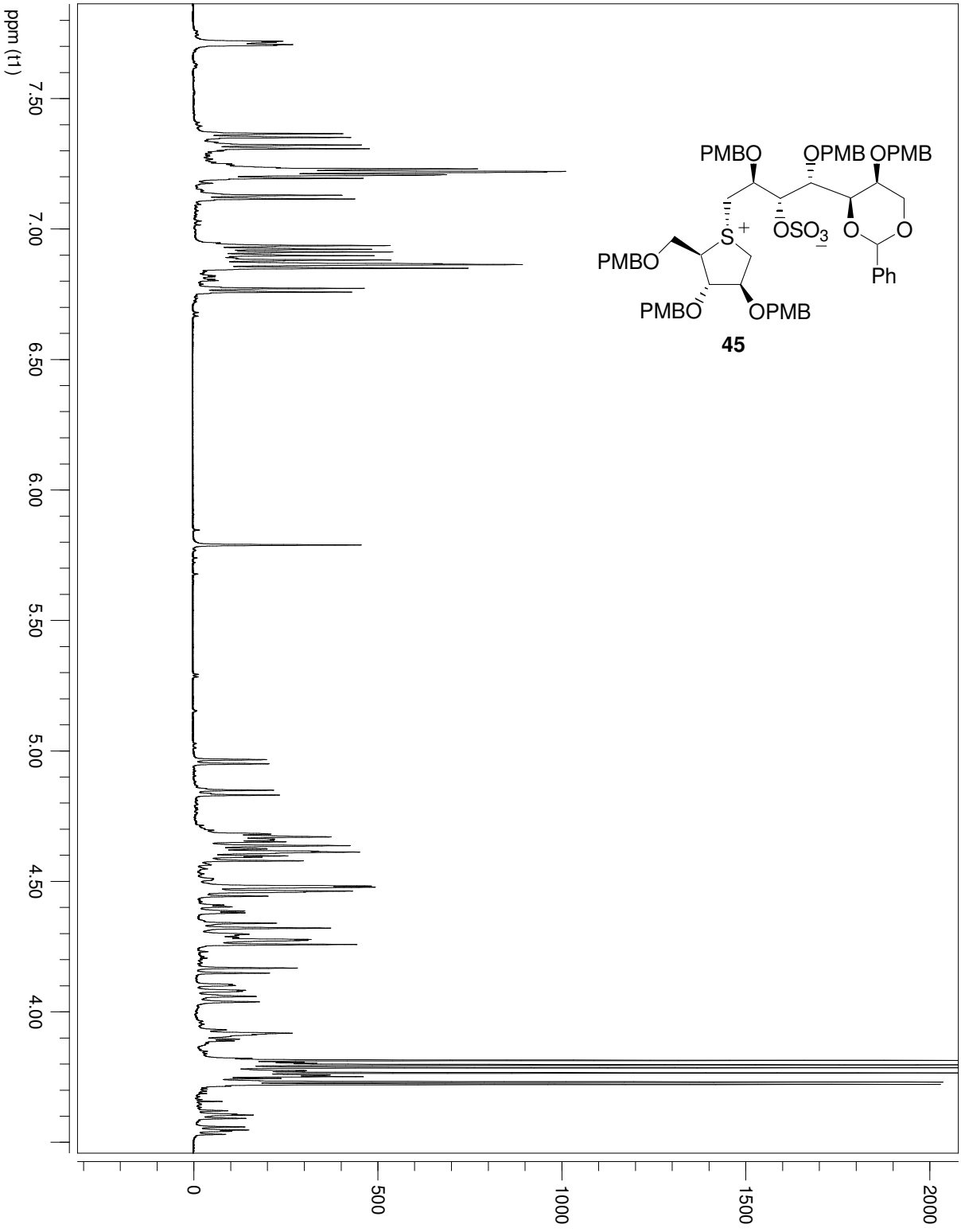

ppm (f1)
150
100
0
5000
10000
15000
20000
PMBO
OPMB
OPMB
OH
OH
O
O
Ph
43


ppm (f1)
7.50
7.00
6.50
6.00
5.50
5.00
4.50
4.00
0
1000
2000
3000
4000
PMBO
OPMB
OPMB
O
S
O
O
O
O
O
O
Ph

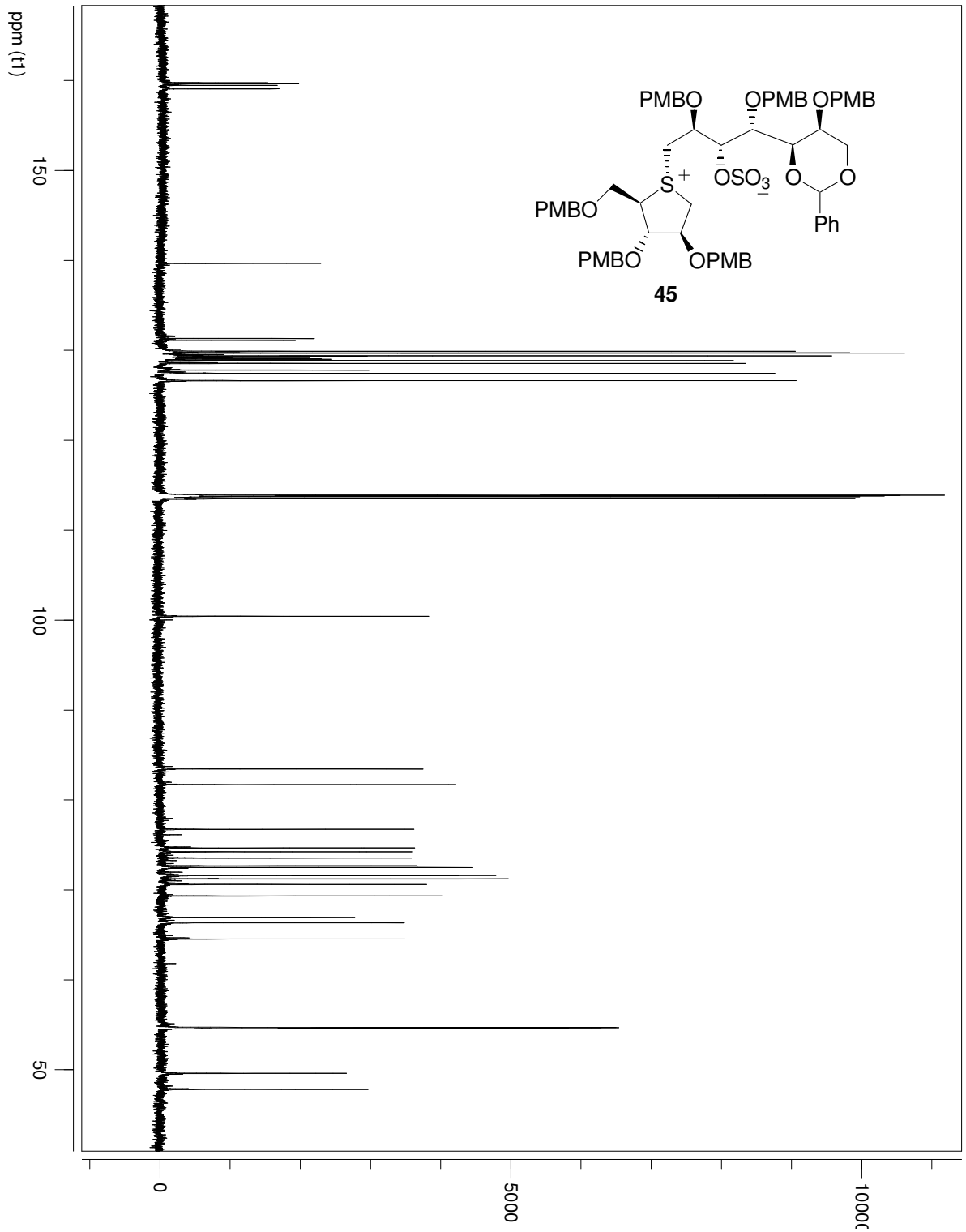
44


ppm (f1)
150
100
50
0
5000
10000
15000
20000
25000
PMBO
OPMB
OPMB
O
O
S
O
O
O
O
Ph

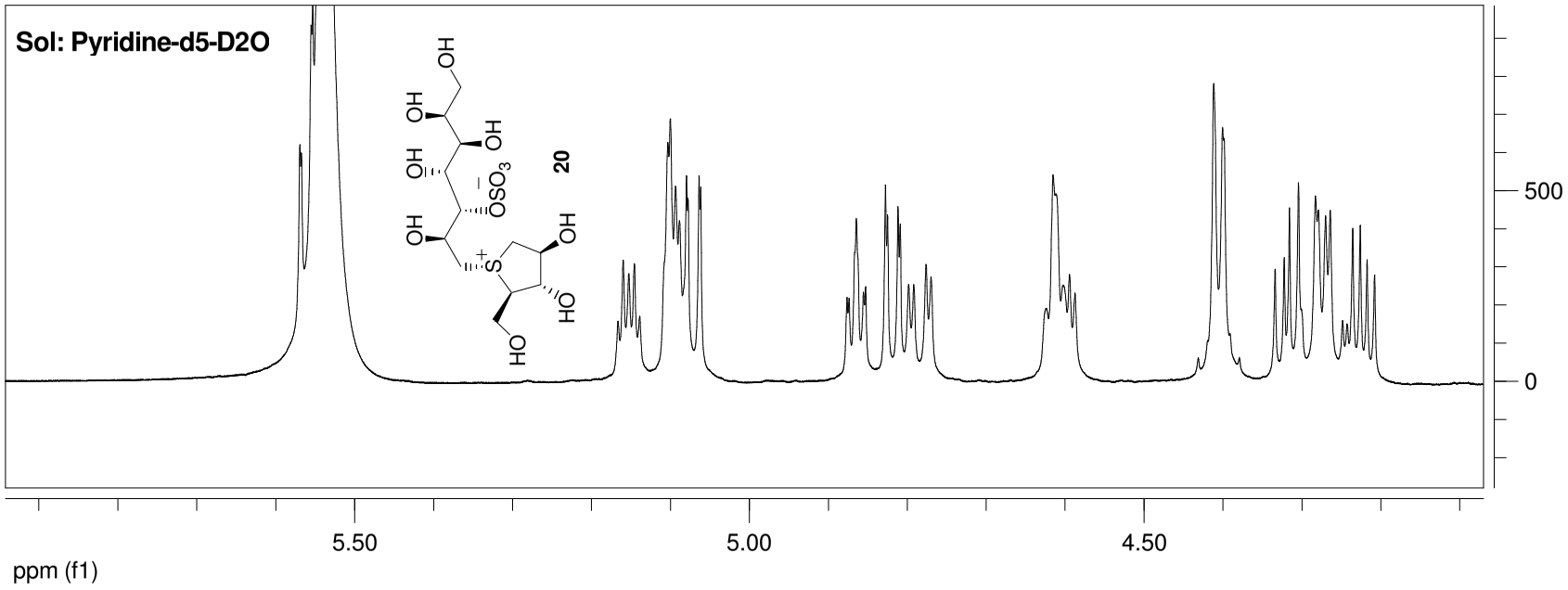
44

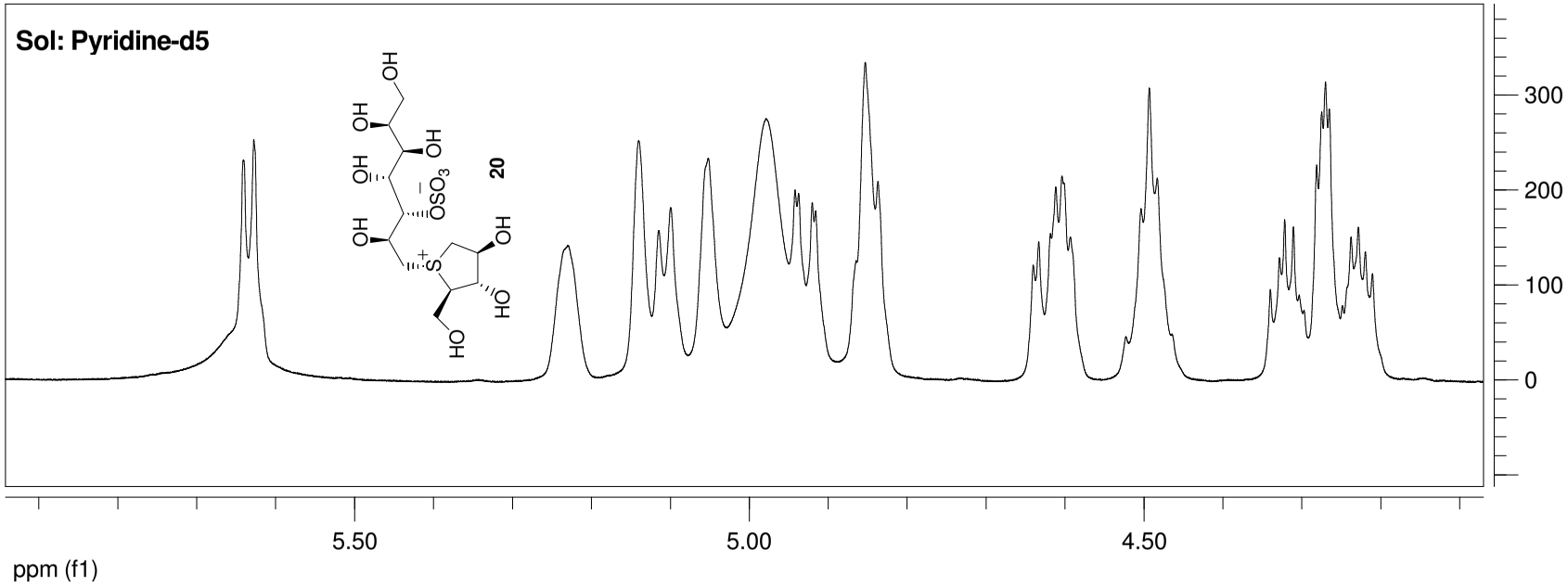

ppm (t1)
7.50
7.00
6.50
6.00
5.50
5.00
4.50
4.00
0
500
1000
1500
2000
PMBO
OPMB
OPMB
S+
OSO3−
O
O
Ph
PMBO
PMBO
OPMB

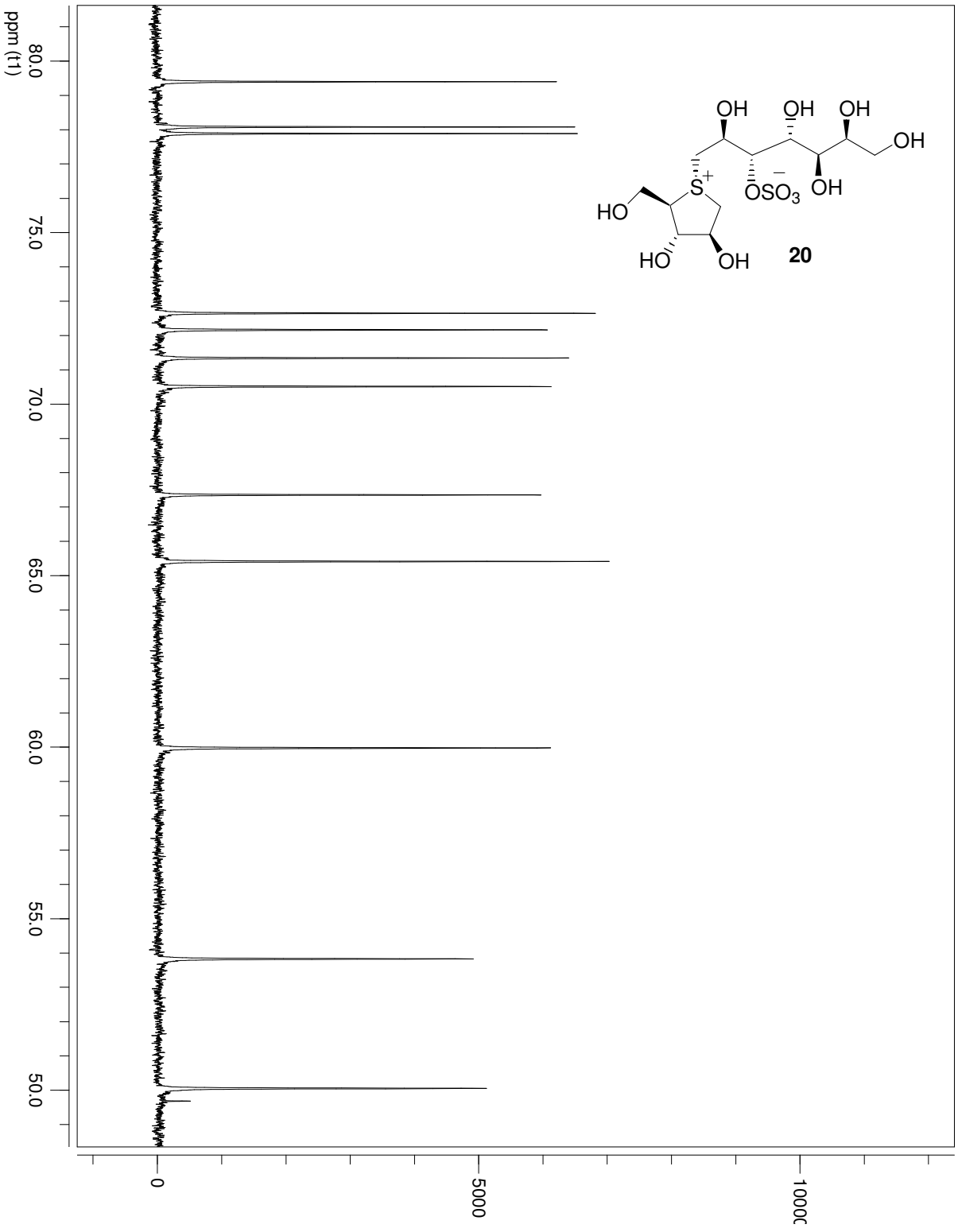
45


ppm (t1)
150
100
50
0
5000
10000
PMBO
OPMB
OPMB
OSO3
O
O
Ph
S
PMBO
PMBO
OPMB

45


Sol: Pyridine-d5-D2O
20
500
0
5.50
5.00
4.50
ppm (f1)


Sol: Pyridine-d5
20
300
200
100
0
5.50
5.00
4.50
ppm (f1)


ppm (t1)
80.0
75.0
70.0
65.0
60.0
55.0
50.0
0
5000
10000
OH
OH
OH
OH
HO
OSO3
OH
HO
OH
20

References

(1) Grindley, T. B.; Szarek, W. A. *Can. J. Chem.* **1974**, *52*, 4062-4070.

(2) Baggett, N.; Stribblehill, P. *J. Chem. Soc., Perkin Trans. 1*, **1977**, 1123-1126.

(3) Kim, K. S.; Szarek, W. A. *Synthesis* **1978**, 48-50.

(4) Ness, A. T.; Hann, R. M.; Hudson, C. S. *J. Am. Chem. Soc.* **1948**, *70*, 765-770.