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Biomimetic Synthesis of Nudicaulins I and II, Yellow Pigments from the Iceland Poppy *Papaver nudicaule*

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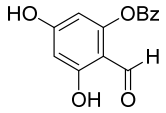
SUPPORTING INFORMATION

General Experimental Details

Commercially available reagents were used throughout without purification unless otherwise stated. Anhydrous solvents were used as supplied. Dichloromethane, acetonitrile and dimethylformamide were dried using an LC Technology Solutions Inc. SP-1 solvent purification system under an atmosphere of dry nitrogen. All reactions were routinely carried out in oven-dried glassware under a nitrogen atmosphere unless otherwise stated. Powdered 4 Å molecular sieves we activated prior to use by heating at 250 °C under vacuum overnight. Analytical thin layer chromatography was performed using silica plates and compounds were visualized at 254 and/or 360 nm ultraviolet irradiation followed by staining ethanolic vanillin solution. Optical rotations were measured using a Perkin-Elmer 341 polarimeter at $\lambda = 598$ nm and are given in deg dm^{-1} cm^3 g^{-1}. Melting points were recorded on an Electrothermal melting point apparatus and are uncorrected. Infrared spectra were obtained using a Perkin Elmer spectrum One Fourier Transform Infrared spectrometer as thin films between sodium chloride plates. Absorption maxima are expressed in wavenumbers (cm^{-1}). NMR spectra were recorded on a Bruker DRX400 spectrometer operating at 400 MHz for ^1H nuclei and 100 MHz for ^{13}C nuclei. Chemical shifts are reported in parts per million (ppm) relative to the tetramethylsilane peak recorded as δ 0.00 ppm in $CDCl_3$/TMS solvent, or the residual chloroform (δ 7.26 ppm), or DMSO (δ 2.50 ppm) or methanol (δ 3.31 ppm) peaks. The ^{13}C NMR values were referenced to the residual chloroform (δ 77.1 ppm), DMSO (δ 39.5 ppm) or methanol (δ 49.0) peaks. ^{13}C NMR values are reported as chemical shift δ and assignment. ^1H NMR shift values are reported as chemical shift δ, relative integral, multiplicity (s, singlet; d, doublet; t, triplet; q, quartet; m, multiplet), coupling constant (*J* in Hz) and assignment. Assignments are made with the aid of COSY, NOESY, ROESY, HMBC and edited HSQC experiments. All experiments were conducted at 298 K. Conventional NMR tubes (5 mm diameter, Norell) using a sample volume of 500 µL were used. High resolution mass spectra were obtained by electrospray ionization in positive ion mode at a nominal accelerating voltage of 70 eV on a Bruker micrOTOF-QII mass spectrometer.

Experimental Procedures

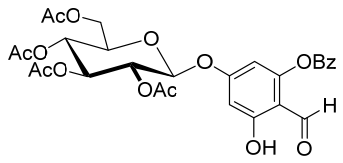
2-Benzoyloxy-4,6-dihydroxybenzaldehyde (11)



To 2,4,6-trihydroxybenzaldehyde[1] (1.00 g, 6.49 mmol) in aqueous potassium hydroxide (0.2 M, 40 mL) at 0 °C was added dropwise benzoyl chloride (0.38 mL, 3.24 mmol). The resulting mixture was stirred for 40 mins at this temperature, an excess of saturated aqueous sodium bicarbonate added and the solution stirred for a further 30 mins. The solution was then warmed to room temperature, ethyl acetate (100 mL) added and the layers separated. The aqueous phase was extracted with ethyl acetate (3 x 100 mL), and the combined organic extracts dried over Na_2SO_4. Concentration *in vacuo* afforded the crude, which was purified by flash column chromatography on silica gel eluting with light petroleum – ethyl acetate (5:1 → 3:1) to give the *title compound* as an off-white solid (504 mg, 1.95 mmol, 30% (42% brsm)). Mp 198-200 °C (decomp.); HRMS [ESI, M + Na]$^+$ Found: 281.0417 [$C_{14}H_{10}O_5$ + Na]$^+$ requires 281.0420; ν_{max} (neat)/cm^{-1} 3177, 1749, 1637, 1596, 1452, 1226, 1159, 1087, 849, 697; δ_H (400 MHz, DMSO-d_6) 11.37 (1 H, s, OH), 11.00 (1 H, br s, OH), 10.00 (1 H, s, CHO), 8.11 (2 H, dd, *J* 8.3, 1.2, ArH), 7.76-7.72 (1 H, m, ArH), 7.62-7.58 (2 H, m, ArH), 6.32 (1 H, d, *J* 2.1, ArH), 6.27 (1 H, d, *J* 2.1, ArH); δ_C (100 MHz, DMSO-d_6) 188.3 (C=O), 165.2 (C), 164.2 (C), 164.1 (C=O), 153.3 (C), 134.0 (CH), 129.9 (2 x CH), 128.9 (2 x CH), 108.1 (C), 102.9 (CH), 100.3 (CH), not observed: 1 x C.

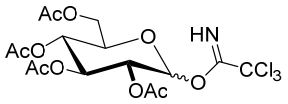
(1) P. Chen, S. Ren, H. Song, C. Chen, F. Chen, Q. Xu, Y. Kong, H. Sun, *Bioorg. Med. Chem.* **2019**, *27*, 116-124.

2-Benzoyloxy-4-*O*-tetraacetyl-β-D-glucosyl-6-hydroxybenzaldehyde (8)



To a suspension of phloroglucinaldehyde **11** (199 mg, 0.77 mmol) and 2,3,4,6-tetra-*O*-acetyl-α-D-glucopyranosyl bromide (319 mg, 0.78 mmol) in neat quinoline (2.8 mL) was added silver oxide (183 mg, 0.79 mmol). The mixture was stirred vigorously for 40 mins then diluted with dichloromethane (20 mL) and filtered through a bed of Celite. To the filtrate was added hydrochloric acid (0.1 M, 20 mL) and the phases separated. The aqueous phase was further extracted with dichloromethane (2 x 20 mL), the combined organic extracts dried over Na_2SO_4 and concentrated *in vacuo*. Purification by flash column chromatography on silica gel eluting with light petroleum – ethyl acetate (2:1) gave the *title compound* as a pale yellow solid (167 mg, 0.28 mmol, 37%). $[\alpha]_D^{27}$ +32.7 (*c* 0.321, CH_2Cl_2); Mp 67-70 °C; HRMS [ESI, M + Na]$^+$ Found: 611.1362 [$C_{28}H_{28}O_{14}$ + Na]$^+$ requires 611.1371; ν_{max} (neat)/cm^{-1} 2923, 1742, 1635, 1368, 1209, 1172, 1065, 1033, 906, 703; δ_H (400 MHz, $CDCl_3$) 11.94 (1 H, s, O<u>H</u>), 10.00 (1 H, s, C<u>H</u>O), 8.19-1.17 (2 H, m, Ar<u>H</u>), 7.71-7.67 (1 H, m, Ar<u>H</u>), 7.55 (2 H, t, *J* 7.8, Ar<u>H</u>), 6.48 (1 H, d, *J* 2.3, <u>H</u>-3 *or* <u>H</u>-5), 6.46 (1 H, d, *J* 2.3, <u>H</u>-3 *or* <u>H</u>-5), 5.33-5.25 (2 H, m, <u>H</u>-2′, <u>H</u>-3′), 5.19 (1 H, d, *J* 7.6, <u>H</u>-1′), 5.15-5.11 (1 H, m, <u>H</u>-4′), 4.24 (1 H, dd, *J* 12.3, 6.1, <u>H</u>-6$_a$′), 4.18 (1 H, dd, *J* 12.3, 2.4, <u>H</u>-6$_b$′), 3.92 (1 H, ddd, *J* 10.0, 6.1, 2.4, <u>H</u>-5′), 2.07 (3 H, s, <u>Me</u>), 2.06 (3 H, s, <u>Me</u>), 2.05 (3 H, s, <u>Me</u>), 2.03 (3 H, s, <u>Me</u>); δ_C (100 MHz, $CDCl_3$) 191.3 (C=O), 170.6 (C=O), 170.1 (C=O), 169.4 (C=O), 169.2 (C=O), 165.1 (C6), 164.4 (C=O), 163.4 (C4), 154.7 (C2), 134.5 (CH), 130.4 (2 x CH), 129.0 (2 x CH), 128.0 (C), 109.8 (C1), 103.7 (C3 *or* C5), 101.7 (C3 *or* C5), 97.7 (C1′), 72.56 (C5′ *or* C3′), 72.52 (C5′ *or* C3′), 70.8 (C2′), 68.1 (C4′), 61.9 (C6′), 20.63 (Me), 20.58 (3 x Me).

Tetra-*O*-acetyl-α/β-D-glucose trichloroacetimidate (S1)



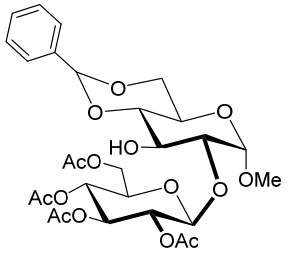
To 2,3,4,6-tetra-*O*-acetyl-α-D-glucopyranosyl bromide (11.68 g, 28.4 mmol) in moist acetone (30 mL) at 0 °C was added silver carbonate (13.20 g, 47.9 mmol) portion wise over 30 mins. The resulting cloudy suspension was then heated to 50 °C, filtered and the filtrate concentrated *in* vacuo to give 2,3,4,6-tetra-*O*-acetyl-D-glucose as a colourless foam, which was solved in dichloromethane (140 mL). Trichloroacetonitrile (8.50 mL, 84.8 mmol) and potassium carbonate (5.89 g, 42.6 mmol) were then added and the resulting mixture stirred at room temperature for 18 h. An additional portion of trichloroacetonitrile (2.80 mL, 27.9 mmol) was added and stirring continued for a further 23 h. The reaction mixture was then filtered and the filtrate concentrated *in vacuo* to give the crude material. Purification by flash column chromatography on silica gel eluting with light petroleum – ethyl acetate (2:1) gave the *title compound*. The **α-anomer** and **β-anomer** eluted separately:

α anomer: colourless foam (6.74 g, 13.7 mmol, 48%). $[\alpha]_D^{18}$ +91.9 (*c* 1.068, $CHCl_3$); δ_H (400 MHz, $CDCl_3$) 8.69 (1 H, s, NH), 6.55 (1 H, d, *J* 3.7, H-1), 5.56 (1 H, t, *J* 9.8, H-3), 5.17 (1 H, t, *J* 9.8, H-4), 5.13 (1 H, dd, *J* 10.2, 3.7, H-2), 4.27 (1 H, dd, *J* 12.2, 4.2, H-6_a), 4.23-4.19 (1 H, m, H-5), 4.12 (1 H, dd, *J* 12.2, 2.1, H-6_b), 2.07 (3 H, s, Me), 2.04 (3 H, s, Me), 2.02 (3 H, s, Me), 2.01 (3 H, s, Me). Characterisation data consistent with literature.[2]

β anomer: colourless solid (3.39 g, 6.88 mmol, 24%). $[\alpha]_D^{17}$ +9.97 (*c* 1.314, $CHCl_3$); Mp 42-45 °C; HRMS [ESI, M + Na]$^+$ Found: 514.0045 [$C_{16}H_{20}Cl_3NO_{10}$ + Na]$^+$ requires 514.0045; ν_{max} (neat)/cm^{-1} 1735, 1678, 1369, 1212, 1089, 1061, 1034, 910, 831, 802; δ_H (400 MHz, $CDCl_3$) 8.71 (1 H, s, NH), 5.88-5.87 (1 H, m, H-1), 5.30-5.26 (2 H, m, H-2, H-3), 5.24 (1 H, m, H-4), 4.31 (1 H, dd, *J* 12.5, 4.4, H-6_a), 4.16 (1 H, dd, *J* 12.5, 2.4, H-6_b), 3.90 (1 H, ddd, *J* 9.8, 4.4, 2.4, H-5), 2.08 (3 H, s, Me), 2.04 (3 H, s, Me), 2.03 (3 H, s, Me), 2.02 (3 H, s, Me); δ_C (100 MHz, $CDCl_3$) 170.6 (C=O), 170.2 (C=O), 169.4 (C=O), 169.0 (C=O), 160.9 (C=O), 95.5 (C1), 72.7 (C5), 72.6 (C3), 70.2 (C2), 67.9 (C4), 61.6 (C6), 20.7 (Me), 20.6 (2 x Me), 20.5 (Me), not observed: 1 x C.

(2) W. Pilgrim, P.V. Murphy, *J. Org. Chem.* **2010**, *75*, 6747-6755.

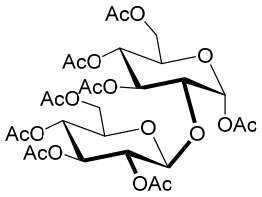
Methyl 4,6-*O*-benzylidene-2-*O*-(tetra-*O*-acetyl-β-D-glucosyl)-α-D-glucoside (12)



The *title compound* was prepared *via* a modified procedure based on that described by Coxon and Fletcher.[3] To a mixture of methyl 4,6-*O*-benzylidene-α-D-glucoside (3.92 g, 13.9 mmol), trichloroacetimidate **S1** (10.13 g, 20.6 mmol, α:β, 2:1) and powdered 4 Å molecular sieves (2.00 g) in dichloromethane (120 mL) at -41 °C was added boron trifluoride diethyl etherate (0.85 mL, 6.86 mmol) and the resulting solution stirred at this temperature for 1 h. The reaction was quenched upon addition of triethylamine, warmed to room temperature and the mixture filtered through a bed of Celite. The filtrate was collected and concentrated *in vacuo* to provide the crude residue (14.64 g), which was used in the next step without further purification.

(3) B. Coxon, H. G. Fletcher Jr, *J. Org. Chem*., **1961**, *26*, 2892-2894.

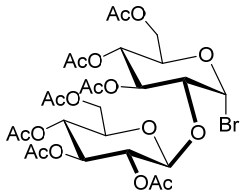
α-D-Sophorose octaacetate (13)



To crude **12** (14.64 g) in acetic anhydride (13.3 mL) at 0 °C was added dropwise sulfuric acid (4% in acetic anhydride, 11.4 mL) and the resulting mixture stirred at room temperature for 17 h. The solution was then cooled to 0 °C and carefully quenched with saturated aqueous sodium bicarbonate, diluted with dichloromethane (200 mL) and the phases partitioned. The aqueous layer was further extracted with dichloromethane (3 x 200 mL), the combined organic extracts dried over Na_2SO_4 and concentrated in *vacuo*. Purification by flash column chromatography on silica gel eluting with light petroleum – ethyl acetate (1:1) gave the *title compound* as a colourless solid (6.14 g, 9.05 mmol, 65% over two steps). $[\alpha]_D^{20}$ +46.2 (*c* 1.051, $CHCl_3$); Mp 110-113 °C; HRMS [ESI, M + Na]$^+$ Found: 701.1896 [$C_{28}H_{38}O_{19}$ + Na]$^+$ requires 701.1899; ν_{max} (neat)/cm^{-1} 2956, 2918, 1741, 1367, 1209, 1029, 938, 906; δ_H (400 MHz, $CDCl_3$) 6.29 (1 H, d, *J* 3.8, H-1), 5.41 (1 H, t, *J* 9.9, H-3), 5.13 (1 H, t, *J* 9.4, H-3′), 5.07-5.02 (2 H, m, H-4, H-

4′), 4.92-4.88 (1 H, m, H-2′), 4.60 (1 H, d, *J* 7.9, H-1′), 4.30-4.26 (1 H, m, H-6$_a$), 4.16 (2 H, d, *J* 3.6, H-6$_a$′, H-6$_b$′), 4.04-4.00 (2 H, m, H-5, H-6$_b$), 3.89 (1 H, dd, *J* 9.9, 3.8, H-2), 3.65 (1 H, dt, *J* 9.9, 3.6, H-5′), 2.15 (3 H, s, Me), 2.10 (3 H, s, Me), 2.06 (6 H, s, Me), 2.02 (3 H, s, Me), 2.01 (3 H, s, Me), 1.99 (3 H, s, Me), 1.98 (3 H, s, Me); δ_C (100 MHz, $CDCl_3$) 170.7 (C=O), 170.6 (C=O), 170.3 (C=O), 169.8 (C=O), 169.7 (C=O), 169.3 (C=O), 169.0 (C=O), 168.7 (C=O), 101.1 (C1), 90.2 (C1′), 75.5 (C2), 72.6 (C3′), 72.0 (C5′), 71.5 (C3), 71.1 (C2′), 69.2 (C5), 68.2 (C4′), 67.9 (C4), 61.6 (C6/6′), 61.5 (C6/6′), 20.84 (Me), 20.77 (Me), 20.71 (Me), 20.68 (Me), 20.6 (3 x Me), 20.4 (Me).

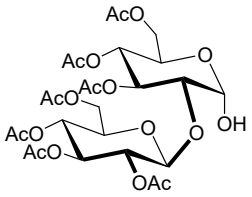
Acetobromo-α-D-sophorose (14)



To a solution of α-sophorose octaacetate (**13**) (20 mg, 0.029 mmol) in dichloromethane (1.3 mL) at 0 °C was slowly added hydrobromic acid in acetic acid (33% w/w, 0.3 mL) and the mixture stirred at room temperature for 1.5 h with protection from ambient light. The resulting translucent orange solution was cooled to 0 °C and carefully quenched with saturated aqueous sodium bicarbonate, diluted with dichloromethane (10 mL) and the phases partitioned. The organic layer was washed with ice-cold saturated aqueous sodium bicarbonate (2 x 10 mL) and ice-cold brine (10 mL), dried over Na_2SO_4 and concentrated in *vacuo* to give the *title compound* as a colourless solid (18 mg, 0.026 mmol, 87%). $[\alpha]_D^{19}$ +97.4 (*c* 0.815, $CHCl_3$); Mp 181-191 °C; HRMS [ESI, M + Na]$^+$ Found: 721.0952 [$C_{26}H_{35}BrO_{17}$ + Na]$^+$ requires 721.0950; ν_{max} (neat)/cm^{-1} 1742, 1370, 1225, 1211, 1175, 1136, 1038, 918, 908; δ_H (400 MHz, $CDCl_3$) 6.43 (1 H, d, *J* 4.0, H-1), 5.46 (1 H, t, *J* 9.7, H-3), 5.17-5.05 (3 H, m, H-4, H-3′, H-4′), 4.97 (1 H, t, *J* 8.5, H-2′), 4.68 (1 H, d, *J* 7.9, H-1′), 4.36-4.22 (3 H, m, H-6$_a$, H-5, H-6$_a$′), 4.16 (1 H, dd, *J* 12.4, 4.5, H-6$_b$′), 4.07 (1 H, dd, *J* 12.3, 1.7, H-6$_b$), 3.78 (1 H, dd, *J* 9.7, 4.0, H-2), 3.67 (1 H, ddd, *J* 9.5, 4.5, 2.6, H-5′), 2.11 (3 H, s, Me), 2.07 (3 H, s, Me), 2.06 (3 H, s, Me), 2.03 (3 H, s, Me), 2.01 (3 H, s, Me), 1.99 (3 H, s, Me), 1.98 (3 H, s, Me); δ_C (100 MHz, $CDCl_3$) 170.6 (C=O), 170.4 (C=O), 170.3 (C=O), 169.7 (C=O), 169.5 (C=O), 169.3 (C=O), 169.0 (C=O), 101.0 (C1′), 88.7 (C1), 76.4 (C2), 72.5 (C3′), 72.12, 72.08, 71.9 (C3, C5, C5′), 71.0 (C2′), 68.2 (C4′),

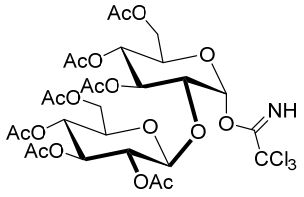
67.1 (C4), 61.5 (C6 *or* C6′), 61.1 (C6 *or* C6′), 20.73 (2 x Me), 20.66 (Me), 20.56 (3 x Me), 20.3 (Me).

Hepta-*O*-acetyl-α-D-sophorose (S2)



To a solution of α-sophorose octaacetate (**13**) (1.30 g, 1.91 mmol) in dimethylformamide (15 mL) was added hydrazine acetate (281 mg, 3.05 mmol) and the resulting mixture stirred at room temperature for 1 h. Dichloromethane (65 mL) and saturated aqueous sodium bicarbonate (50 mL) was then added and the phases separated. The aqueous phase was further extracted with dichloromethane (2 x 65 mL), the combined organic extracts washed with brine (150 mL), dried over Na_2SO_4 and concentrated *in vacuo* to give the crude material (1.08 g), which was used in the next step without further purification.

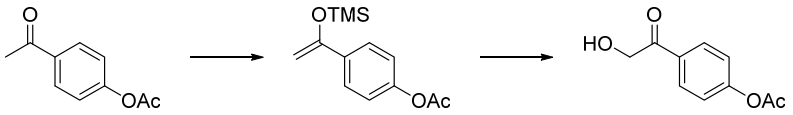
Hepta-*O*-acetyl-α-D-sophorose trichloroacetimidate (15)



To crude **S2** (1.08 g) in dichloromethane (15 mL) at 0 °C was added trichloroacetonitrile (0.50 mL, 4.99 mmol) and 1,8-diazabicyclo[5.4.0]undec-7-ene (0.33 mL, 2.21 mmol) and the resulting mixture warmed to room temperature and stirred for 4.5 h. Concentration *in vacuo* afforded the crude material, which was purified by flash column chromatography on silica gel eluting with light petroleum – ethyl acetate (1:1) to give the *title compound* as a colourless solid (810 mg, 1.04 mmol, 54% over two steps). $[\alpha]_D^{24}$ +46.9 (*c* 0.495, CH_2Cl_2); Mp 72-74 °C; HRMS [ESI, M + Na]$^+$ Found: 802.0863 [$C_{28}H_{36}Cl_3NO_{18}$ + Na]$^+$ requires 802.0890; ν_{max} (neat)/cm^{-1} 3290, 2974, 1742, 1675, 1449, 1368, 1206, 1174, 1074, 1024, 798; δ_H (400 MHz, $CDCl_3$) 8.66 (1 H, s, NH), 6.46 (1 H, d, *J* 3.7, H-1), 5.48 (1 H, t, *J* 9.8, H-3), 5.15-5.01 (3 H, m, H-4, H-3′, H-4′), 4.89 (1 H, dd, *J* 9.5, 7.9, H-2′), 4.65 (1 H, d, *J* 7.9, H-1′), 4.28 (1 H, dd, *J* 12.4, 4.0, H-6$_a$), 4.20-4.05 (4 H, m, H-5, H-6$_b$, H-6$_a$′, H-6$_b$′), 3.99 (1 H, dd, *J* 9.8, 3.7, H-2), 3.67 (1 H, ddd, *J* 9.9, 4.7, 2.6, H-5′), 2.09 (3 H, s, Me), 2.06 (3 H, s, Me), 2.05 (3 H, s, Me),

2.02 (3 H, s, Me), 2.00 (3 H, s, Me), 1.96 (6 H, s, Me); δ_C (100 MHz, $CDCl_3$) 170.6 (C=O), 170.5 (C=O), 170.3 (C=O), 169.7 (C=O), 169.5 (C=O), 169.3 (C=O), 168.8 (C=O), 160.7 (C), 100.9 (C1′), 94.4 (C1), 90.8 (C), 75.6 (C2), 72.6 (C3′), 72.0 (C5′), 71.6 (C3), 71.0 (C2′), 69.7 (C5), 68.3 (C4′), 67.8 (C4), 61.9 (C6 *or* C6′), 61.5 (C6 *or* C6′), 20.8 (2 x Me), 20.65 (Me), 20.59 (Me), 20.55 (2 x Me), 20.3 (Me).

2-Hydroxy-4′-acetoxyacetophenone (16)



The title compound was prepared with slight modification to the procedure described by Dangles and Elhajji.[4] To 4′-acetoxyacetophenone (1.01 g, 5.68 mmol) in dimethylformamide (1.5 mL) was added triethylamine (3.1 mL, 22.4 mmol) and trimethylsilyl chloride (1.8 mL, 10.4 mmol) and the resulting mixture stirred at 70 °C in a sealed tube for 23 h. After cooling to room temperature, an ice-cold ethyl acetate: light petroleum mixture (1:2, 30 mL) was added followed by ice cold saturated aqueous sodium bicarbonate (30 mL) and the phases separated. The organic phase was collected, dried over Na_2SO_4 and concentrated *in vacuo* to give the silyl enol ether as an orange oil (1.39 g), which was used in the next step without further purification.

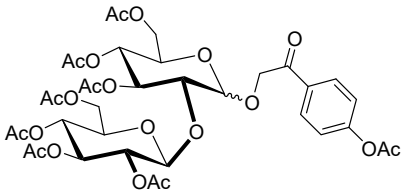
To crude silyl enol ether (1.39 g) in dichloromethane (60 mL) was added $MgSO_4$ (2.70 g) and the suspension cooled to -20 °C. *meta*-Chloroperoxybenzoic acid (≤77%, 1.80 g) was then added portion wise over 15 mins. The mixture was stirred at this temperature for 4 h and then an excess of saturated aqueous sodium sulphite was added and stirring continued for a further 20 mins. The resulting mixture was filtered and the residue washed successively with dichloromethane before the filtrate was partitioned into two layers. The aqueous layer was extracted with dichloromethane (3 x 50 mL), the combined organic extracts washed with saturated aqueous sodium bicarbonate (100 mL) and brine (100 mL), dried over Na_2SO_4 and concentrated *in vacuo*. The resulting residue was subsequently solved in methanol (5 mL) and aqueous citric acid (0.1 N, 0.2 mL) added and the mixture stirred at room temperature for 10 mins. Concentration *in vacuo* afforded the crude material, which was purified by flash column chromatography on silica gel eluting with light petroleum – ethyl acetate (4:1 → 1:1) to give the *title compound* as a colourless crystalline solid (680 mg, 3.50 mmol, 62% over three steps). Mp 93-94 °C; δ_H (400 MHz, $CDCl_3$) 7.96 (2 H, dt, *J* 8.9, 2.2, ArH), 7.25 (2 H, dt, *J* 8.9, 2.2

ArH), 4.86 (2 H, s, CH$_2$), 3.46 (1 H, br s, OH), 2.34 (3 H, s, Me). Characterisation data consistent with literature.[5]

(4) O. Dangles, K. Elhajji, *Helv. Chem. Acta.* **1994**, *77*, 1595-1610.

(5) J. Huang, J. Li, J. Zheng, W. Wu, W. Hu, L. Ouyang, H. Jiang, *Org. Lett.* **2017**, *19*, 3354-3357.

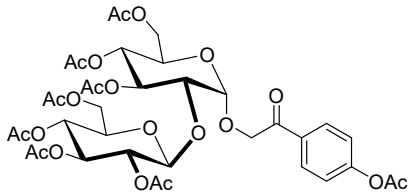
2-*O*-Tetraacetyl-D-sophorosyl-4′-acetoxyacetophenone (α/β-9)



Powdered 4 Å molecular sieves (200 mg) were added to a solution of alcohol **16** (12 mg, 0.062 mmol) and trichloroacetimidate **15** (73 mg, 0.093 mmol) in acetonitrile (1 mL) and the mixture cooled to -41 °C. Trimethylsilyl trifluoromethanesulfonate (5.7 μL, 0.031mmol) was added dropwise and the resulting mixture stirred at this temperature for 15 mins. The reaction was quenched upon addition of triethylamine, warmed to room temperature and the mixture filtered through a bed of Celite. The filtrate was collected and concentrated *in vacuo* to provide the crude residue. Purification by flash column chromatography on silica gel eluting with light petroleum – ethyl acetate (1:1) afforded the *title compound* as a colourless foam (37 mg, 0.046 mmol, 74%, α:β, 1:2). $[\alpha]_D^{20}$ +12.1 (*c* 0.710, CH_2Cl_2); HRMS [ESI, M + Na]$^+$ Found: 835.2288 $[C_{36}H_{44}O_{21} + Na]^+$ requires 835.2267; ν_{max} (neat)/cm^{-1} 2944, 1741, 1600, 1432, 1367, 1213, 1164, 1033, 979, 907, 854, 734; δ_H (400 MHz, $CDCl_3$) β anomer: 7.98 (2 H, dt, *J* 9.3, 2.4, H-2′/6′), 7.23 (2 H, dt, *J* 9.3, 2.4, H-3′/5′), 5.22-5.14 (2 H, m CH) 5.07, 4.84 (2 H, ABq, *J* 15.7, H-2), 5.10-4.96 (2 H, m, 2 x CH), 4.93 (1 H, d, *J* 7.8, H-1‴), 4.93-4.89 (1 H, m, CH), 4.67 (1 H, d, *J* 7.4, H-1″), 4.28-4.23 (1 H, m, CH), 4.21 (1 H, d, *J* 4.6, H-6″/6‴), 4.17-4.10 (2 H, m, 2 x H-6″/6‴), 4.05 (1 H, dd, *J* 12.3, 2.3, H-6″/6‴), 3.82 (1 H, dd, *J* 9.2, 7.4, H-2″), 3.76-3.69 (1 H, m, CH), 2.33 (3 H, s, Me), 2.060 (3 H, s, Me), 2.058 (3 H, s, Me), 2.04 (3 H, s, Me), 2.013 (3 H, s, Me), 2.009 (3 H, s, Me), 1.99 (3 H, s, Me), 1.97 (3 H, s, Me) α anomer: see spectral data for **α-9**; δ_C (100 MHz, $CDCl_3$) β anomer: 193.3 (C1), 170.8 (C=O), 170.7 (C=O), 170.4 (C=O), 170.0 (C=O), 169.8 (C=O), 169.5 (C=O), 169.4 (C=O), 168.8 (C=O), 154.9 (C4′), 132.3 (C1′), 130.0 (C2′/6′), 122.1 (C3′/5′), 101.4 (C1″), 100.5 (C1‴), 78.2 (C2″), 73.7 (CH), 73.2 (CH), 71.93 (C2, CH), 71.86 (CH), 68.5 (2 x CH), 68.1 (CH), 61.9 (C6″ *or* C6‴), 61.8 (C6″ *or* C6‴), 21.3 (Me), 20.9 (Me), 20.83 (Me), 20.79 (Me), 20.76 (Me), 20.72 (2 x Me), 20.5

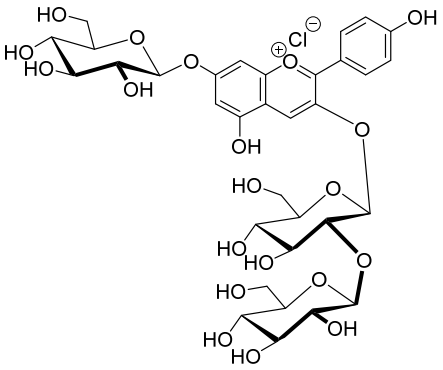
(Me) α anomer: see spectral data for **α-9**. Complete assignment of aliphatic region not possible due to peak overlap.

2-*O*-Tetraacetyl-α-D-sophorosyl-4′-acetoxyacetophenone (α-9)



Powdered 4 Å molecular sieves (240 mg) were added to a solution of alcohol **16** (37 mg, 0.19 mmol) and trichloroacetimidate **15** (212 mg, 0.27 mmol) in dichloromethane (5 mL) and the mixture cooled to -41 °C. Trimethylsilyl trifluoromethanesulfonate (0.02 mL, 0.09 mmol) was added dropwise and the resulting mixture slowly warmed to -20 °C over 50 mins. The reaction was quenched upon addition of triethylamine, warmed to room temperature and the mixture filtered through a bed of Celite. The filtrate was collected and concentrated *in vacuo* to provide the crude residue. Purification by flash column chromatography on silica gel eluting with light petroleum – ethyl acetate (1:1) afforded the *title compound* as a colourless solid (154 mg, 0.19 mmol, *quant.*). $[\alpha]_D^{21}$ +33.3 (*c* 0.705, CH_2Cl_2); Mp 71-74 °C; HRMS [ESI, M + Na]$^+$ Found: 835.2288 $[C_{36}H_{44}O_{21} + Na]^+$ requires 835.2267; ν_{max} (neat)/cm^{-1} 2963, 1740, 1600, 1434, 1368, 1212, 1165, 1031, 980, 907, 853; δ_H (400 MHz, $CDCl_3$) 8.05 (2 H, dt, *J* 9.4, 2.2, H-2′/6′), 7.28-7.26 (2 H, m, H-3′/5′), 5.47 (1 H, t, *J* 9.9, H-3″), 5.14 (1 H, t, *J* 9.5, H-3‴), 5.07 (1 H, d, *J* 3.7, H-1″), 5.04-4.99 (2 H, m, H-4″, H-4‴), 4.95-4.92 (1 H, m, H-2‴), 4.92, 4.73 (2 H, ABq, *J* 15.6, H-2), 4.63 (1 H, d, *J* 8.0, H-1‴), 4.29-4.24 (2 H, m, H-6$_a$″, H-5″), 4.21-4.13 (2 H, m, H-6$_a$‴, H-6$_b$‴), 4.00-3.96 (1 H, m, H-6$_b$″), 3.79 (1 H, dd, *J* 9.9, 3.7, H-2″), 3.70-3.64 (1 H, m, H-5‴), 2.34 (3 H, s, Me), 2.08 (3 H, s, Me), 2.059 (3 H, s, Me), 2.055 (3 H, s, Me), 2.03 (3 H, s, Me), 2.02 (3 H, s, Me), 2.01 (3 H, s, Me), 2.00 (3 H, s, Me); δ_C (100 MHz, $CDCl_3$) 194.1 (C1), 170.68 (C=O), 170.63 (C=O), 170.4 (C=O), 170.0 (C=O), 169.7 (C=O), 169.4 (C=O), 169.2 (C=O), 168.8 (C=O), 154.9 (C4′), 132.4 (C1′), 130.3 (C2′/6′), 122.1 (C3′/5′), 101.5 (C1‴), 99.2 (C1″), 77.2 (C2″), 72.8 (C2), 72.6 (C3‴), 72.2 (C5‴), 71.6 (C3″), 71.2 (C2‴), 68.4 (C4″, C4‴), 67.9 (C5″), 62.0 (C6″ *or* C6‴), 61.9 (C6″ *or* C6‴), 21.3 (Me), 20.93 (Me), 20.85 (Me), 20.80 (Me), 20.71 (Me), 20.68 (2 x Me), 20.5 (Me).

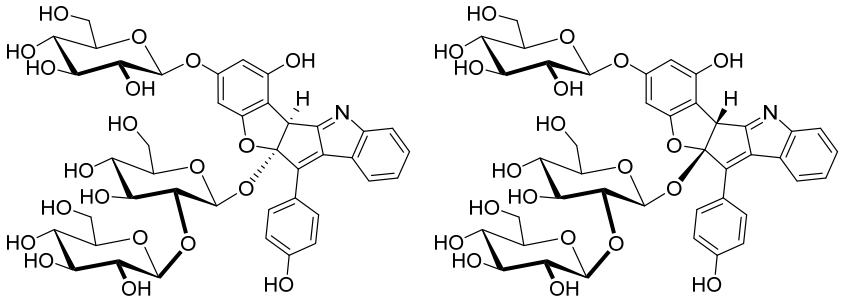
Orientalin chloride (1)



To aldehyde **8** (67 mg, 0.114 mmol) and ketone **9** (93 mg, 0.114 mmol) in dry ethyl acetate (2.5 mL) at -20 °C was bubbled dry hydrogen chloride gas for 45 mins. The reaction mixture was allowed to warm to room temperature and stirring continued for a further 72 h, during which time a red colour gradually developed. The solvent was removed *in vacuo* and to the residue was added aqueous potassium hydroxide (0.9 M, methanol: water, 1:1, 4.0 mL). The resulting muddy brown solution was stirred at room temperature for 3 h, cooled to 0 °C and then carefully acidified with concentrated hydrochloric acid (2.7 mL). The deep red mixture was concentrated *in vacuo* to afford a dark red residue, which was taken up in an ethanol: methanol mixture (1:1, freshly sat. with hydrogen chloride). The suspension was filtered through a bed of Celite to remove the majority of contaminating potassium chloride and the filtrate concentrated *in vacuo*. The residue was then dissolved in hydrochloric acid (0.1 M, 20 mL), ethyl acetate (20 mL) added and the layers separated. The aqueous layer was further washed with ethyl acetate (2 x 20 mL) then concentrated to approximately 1 mL in volume. Purification by flash column chromatography on C18 silica gel eluting with water (0.1% HCl) – methanol (0% → 35% methanol) provided the *title compound* as a dark red solid (22.0 mg, 0.028 mmol, 24%). $[\alpha]_D^{20}$ unattainable due to intensely coloured solution (*c* 0.100, 01.% HCl); Mp 179-182 °C (decomp.); HRMS [ESI, M]$^+$ Found: 757.2188 $[C_{33}H_{41}O_{20}]^+$ requires 757.2186; ν_{max} (neat)/cm^{-1} 3269, 2922, 2490, 1635, 1605, 1575, 1472, 1371, 1332, 1269, 1175, 1061, 1009, 848; δ_H (400 MHz, methanol-d$_4$) *Aglycon* 9.03 (1 H, s, H-4), 8.67 (2 H, d, *J* 8.9, H-2′/6′), 7.34 (1 H, br s, H-8), 7.10 (2 H, d, *J* 8.9, H-3′/5′), 6.84 (1 H, d, *J* 1.4, H-6); *Anomeric centres* 5.52 (1 H, d, *J* 7.5, H-1″), 5.22 (1 H, d, *J* 6.9, H-1‴″), 4.79 (1 H, d, *J* 7.7, H-1‴); *Aliphatic region*, 4.07 (1 H, t, *J* 8.2, H-2″), 3.98-3.91 (2 H, m, CH$_2$), 3.78 (1 H, t, *J* 8.9, CH), 3.75-3.70 (2 H, m, CH$_2$), 3.67-3.48 (6 H, m, 5 x CH, ½ CH$_2$), 3.45-3.39 (2 H, m, CH, ½ x CH$_2$), 3.27 (1 H, d, *J* 8.9, CH), 3.21 (2 H, m, 2 x CH), 2.97-2.94 (1 H, m, CH); δ_C (100 MHz, methanol-d$_4$) *Aglycon* 167.6 (C7 & C4′), 166.5 (C2), 158.4 (C5), 156.8 (C9), 146.6 (C3), 136.8 (C2′/6′),

136.1 (C4), 120.8 (C1′), 118.2 (C3′/5′), 114.0 (C10), 104.1 (C6), 96.0 (C8)*; Anomeric centres* 104.6 (C1‴), 102.1 (C1″), 101.8 (C1‴′)*; Aliphatic region* 81.5 (C2″), 78.8 (CH), 78.7 (CH), 78.1 (CH), 78.0 (CH), 77.9 (CH), 77.8 (CH), 75.8 (CH), 74.6 (CH), 71.5 (CH), 71.2 (CH), 70.9 (CH), 62.6 (2 x CH_2), 62.3 (CH_2). Complete assignment of aliphatic region not possible due to peak overlap.

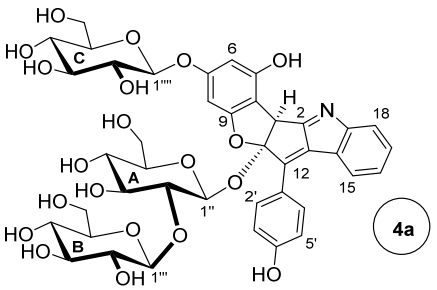
Nudicaulins I and II (4a and 4b)

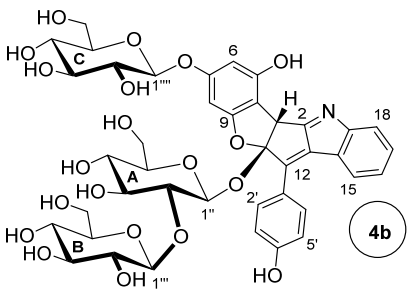


4a **4b**

To orientalin chloride (**1**) (8.0 mg, 0.010 mmol) in a sodium acetate – acetic acid buffer (pH 3.6, 0.7 mL) was added indole (1.1 mg, 0.009 mmol) and the resulting mixture stirred vigorously at room temperature open to air for 7 h. The solution was then diluted with methanol (1.5 mL) and concentrated *in vacuo* to afford the crude material. Purification by reverse phase column chromatography (Alltech C18 SPE cartridge) eluting with water (0.1% TFA) – methanol (0% → 40% methanol) provided an orange solid comprising a 2:3 inseparable mixture of **4a**:**4b** (7.5 mg, 0.009 mmol, 92%). $[\alpha]_D^{19}$ -65.0 (*c* 0.080, methanol); Mp 205-209 °C (decomp.); HRMS [ESI, M + H]$^+$ Found: 872.2602 [$C_{41}H_{45}NO_{20}$ + H]$^+$ requires 872.2608; ν_{max} (neat)/cm^{-1} 3336, 2905, 1785, 1671, 1545, 1512, 1448, 1348, 1297, 1179, 1068, 1018, 832, 773; δ_H (400 MHz, methanol-d_4) see Table **S1**, δ_C (100 MHz, methanol-d_4 + 1% d-TFA) see Table **S2**.

Table S1. ^{1}H NMR (methanol-d$_4$) comparison of natural **4a** and **4b** with synthetic **4a** and **4b**.



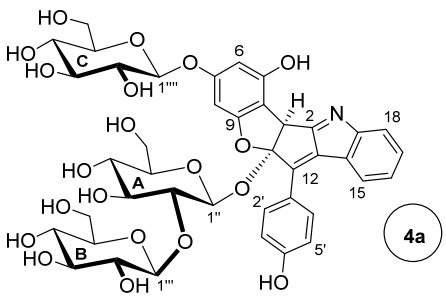


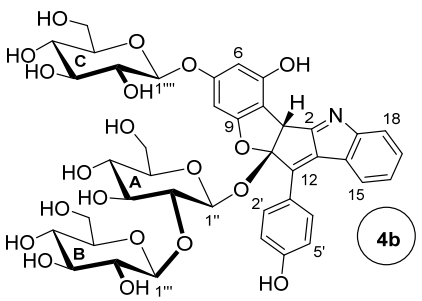
No.	δ_H Natural Nu I (**4a**)[6]	δ_H Synthetic Nu I (**4a**)	Δδ	δ_H Natural Nu II (**4b**)[6]	δ_H Synthetic Nu II (**4b**)	Δδ
Aglycon						
3	5.63, s	5.63, s	0	5.80, s	5.80, s	0
6	6.33, d, *J* 2.0	6.34, d, *J* 1.9	+0.01	6.35, d, *J* 2.0	6.36, d, *J* 1.9	+0.01
8	6.29, d, *J* 2.0	6.30, d, *J* 1.9	+0.01	6.27, d, *J* 2.0	6.28, d, *J* 1.9	+0.01
15	8.33, d, *J* 7.8	8.31, d, *J* 7.2	-0.02	8.31, d, *J* 7.8	8.30, d, *J* 7.2	-0.01
16	7.59, dd, *J* 7.8, 7.8	7.60-7.55, m	0	7.58, dd, *J* 7.8, 7.8	7.60-7.55, m	0
17	7.66, dd, *J* 7.8, 7.8	7.67-7.63, m	0	7.65, dd, *J* 7.8, 7.8	7.67-7.63, m	0
18	7.72, d, *J* 7.8	7.74-7.72, m	0	7.73, d, *J* 7.8	7.74-7.72	0
2′/6′	8.63, d, *J* 9.1	8.63, d, *J* 9.0	0	8.58, d, *J* 9.0	8.57, d, *J* 9.0	-0.01
3′/5′	7.16, d, *J* 9.0	7.16, d, *J* 9.0	0	7.15, d, *J* 9.0	7.14, d, *J* 9.0	-0.01
Glc A						
1″	4.78, d, *J* 7.4	4.80, d, *J* 7.6	+0.02	5.08, d, *J* 7.9	5.09, d, *J* 7.9	+0.01
2″	3.56	3.57	+0.01	3.86	3.85	-0.1
3″	3.55	3.55	0	3.63	3.67	+0.04
4″	3.39	3.40	+0.01	3.37	3.39	+0.02
5″	3.33	3.34	+0.01	3.09	3.09	0
6″A	3.87, dd, *J* 12.0, 2.0	3.87, overlap	0	3.88, overlap	3.88, overlap	0
6″B	3.67, dd, *J* 12.0, 5.9	3.65, overlap	-0.02	3.62, overlap	3.63, overlap	+0.01
Glc B						
1‴	4.51, d, *J* 7.7	4.52, d, *J* 7.6	+0.01	4.96, d, *J* 7.5	4.96, d, *J* 7.5	0
2‴	3.24	3.25	-0.01	3.39	3.40	+0.01
3‴	3.06	3.06	0	3.20	3.20	0
4‴	3.05	3.06	+0.01	3.34	3.34	0
5‴	3.39	3.40	+0.01	3.36	3.34	-0.02
6‴A	3.31, dd, *J* 11.8, 1.9	3.30, overlap	0	3.71, dd, *J* 11.8, 1.9	3.69, overlap	-0.02
6‴B	3.00, dd, *J* 11.8, 5.7	3.02, overlap	+0.02	3.24, dd, *J* 11.8, 6.0	3.25, overlap	+0.01
Glc C						
1⁗	4.78, d, *J* 7.4	4.80, d, *J* 7.6	+0.02	4.81, d, *J* 7.3	4.82, d, *J* 8.0	+0.01
2⁗	3.38	3.39	+0.01	3.39	3.40	+0.01
3⁗	3.18	3.19	+0.01	3.32	3.33	+0.01

4′′′′	3.33	3.33	0	3.38	3.40	+0.02
5′′′′	3.31	3.33	+0.02	3.20	3.21	+0.01
6′′′′A	3.79, dd, *J* 12.1, 2.1	3.80, overlap	+0.01	3.85, overlap	3.83, overlap	-0.02
6′′′′B	3.70, dd, *J* 12.1, 5.3	3.72, overlap	+0.02	3.64, overlap	3.65, overlap	+0.01

(6) E. C. Tatsis, A. Schaumlöffel, A. C. Warskulat, G. Massiot, B. Schneider, G. Bringmann, *Org. Lett.* **2013**, *15*, 156-159.

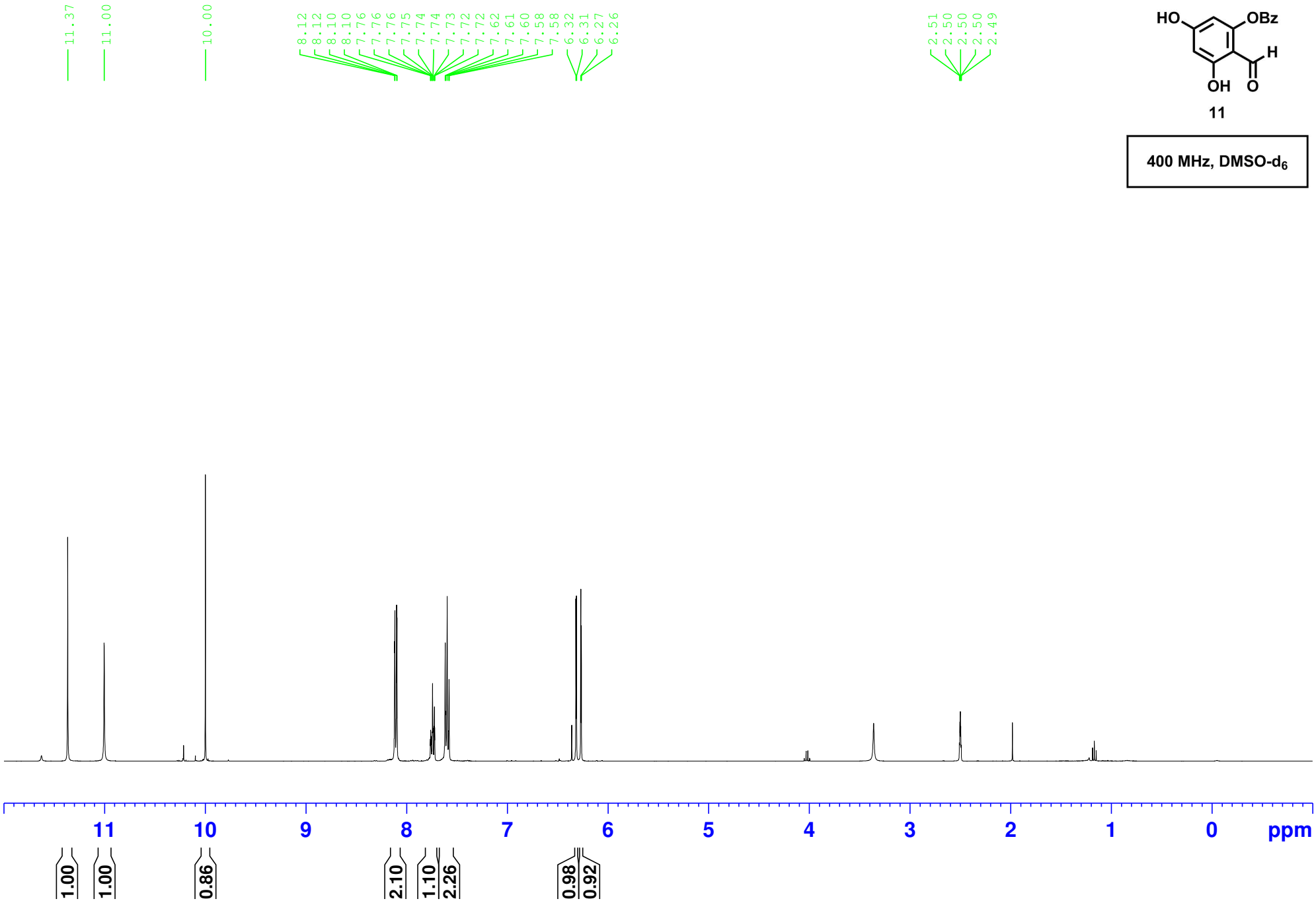
Table S2. ^{13}C NMR (methanol-d_4 +1% d-TFA) comparison of natural **4a** and **4b** with synthetic **4a** and **4b**. (Comparison to ^{13}C NMR spectra supplied by Professor Bernd Schneider, Max Planck Institute for Chemical Ecology, see pages 44 and 45).





No.	δ_C Natural Nu I (**4a**)	δ_C Synthetic Nu I (**4a**)	Δδ	δ_C Natural Nu II (**4b**)	δ_C Synthetic Nu II (**4b**)	Δδ
Aglycon						
2	177.5	177.4	-0.1	177.8	177.7	-0.1
3	49.7	49.8	+0.1	-	49.3[a]	-
4	101.7	101.8	+0.1	101.8	101.9	+0.1
5	156.3	156.4	+0.1	156.3	156.4	+0.1
6	99.1	99.3	+0.2	99.4	99.5	+0.1
7	162.5	162.6	+0.1	162.3	162.4	+0.1
8	92.3	92.3	0	91.9	92.1	+0.2
9	161.0	161.2	+0.2	161.2	161.1	-0.1
11	126.7	126.8	+0.1	125.5	125.5	0
12	168.3	168.3	0	169.7	169.6	-0.1
13	131.1	131.1	0	130.9	131.0	+0.1
14	122.6	122.6	0	122.7	122.8	+0.1
15	125.5	125.4	-0.1	125.3	125.2	-0.1
16	128.4	128.4	0	128.4	128.4	0
17	131.4	131.4	0	131.4	131.4	0
18	117.1	117.2	+0.1	117.1	117.2	+0.1
19	148.3	148.3	0	148.3	148.3	0
1′	122.8	122.8	0	122.6	122.6	0
2′/6′	139.2	139.2	0	139.4	139.4	0
3′/5′	118.2	118.2	0	118.1	118.2	+0.1
4′	168.1	167.9	-0.2	167.9	168.1	+0.2
Glc A						
1″	99.4	99.5	+0.1	97.3	97.3	0
2″	83.7	83.7	0	77.9	77.9	0
3″	77.6	77.6	0	78.8	78.8	0
4″	70.3	70.4	+0.1	70.6	70.6	0

5″	77.7	77.7	0	78.3	78.3	0
6″	61.9	62.0	+0.1	61.7	61.8	+0.1
Glc B						
1‴	106.0	106.0	0	103.0	103.1	+0.1
2‴	76.0	76.0	0	77.7	77.7	0
3‴	78.0	78.0	0	72.1	72.2	+0.1
4‴	71.7	71.7	0	74.5	74.5	0
5‴	77.8	77.7	-0.1	78.0	78.0	0
6‴	62.6	62.7	+0.1	63.1	63.1	0
Glc C						
1⁗	102.0	102.0	0	102.0	102.0	0
2⁗	74.5	74.5	0	77.7	77.7	0
3⁗	78.6	78.6	0	71.0	71.1	+0.1
4⁗	71.1	71.1	0	75.6	75.6	0
5⁗	77.5	77.5	0	78.0	78.0	0
6⁗	62.3	62.3	0	62.2	62.3	+0.1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11.00
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8.12
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6.31
6.27
6.26
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2.50
2.50
2.50
2.49
HO
OBz
H
OH
O
11
400 MHz, DMSO-d6
11
10
9
8
7
6
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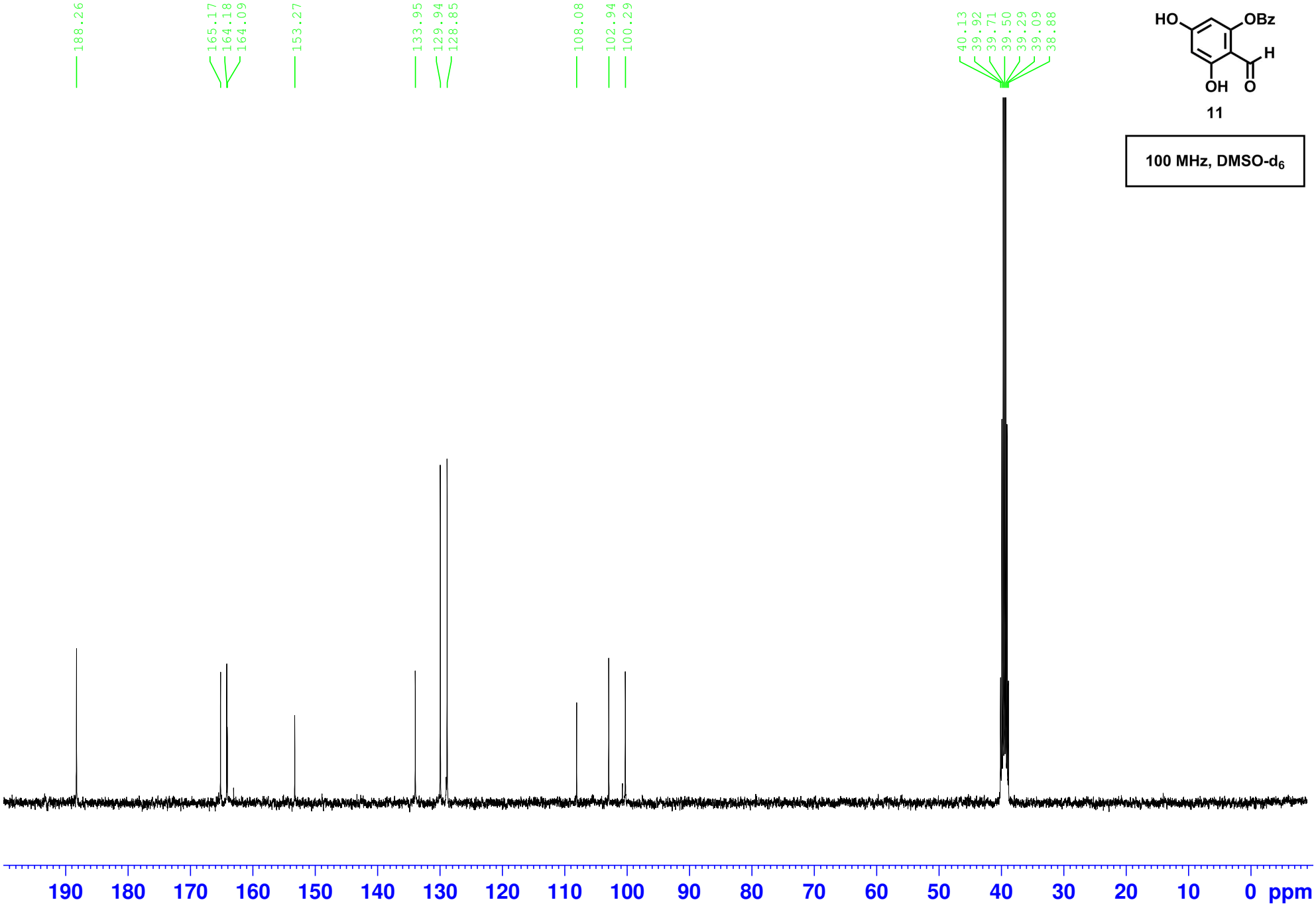
0.92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102.94
100.29
40.13
39.92
39.71
39.50
39.29
39.09
38.88
HO
OBz
H
OH
O
11
100 MHz, DMSO-d6
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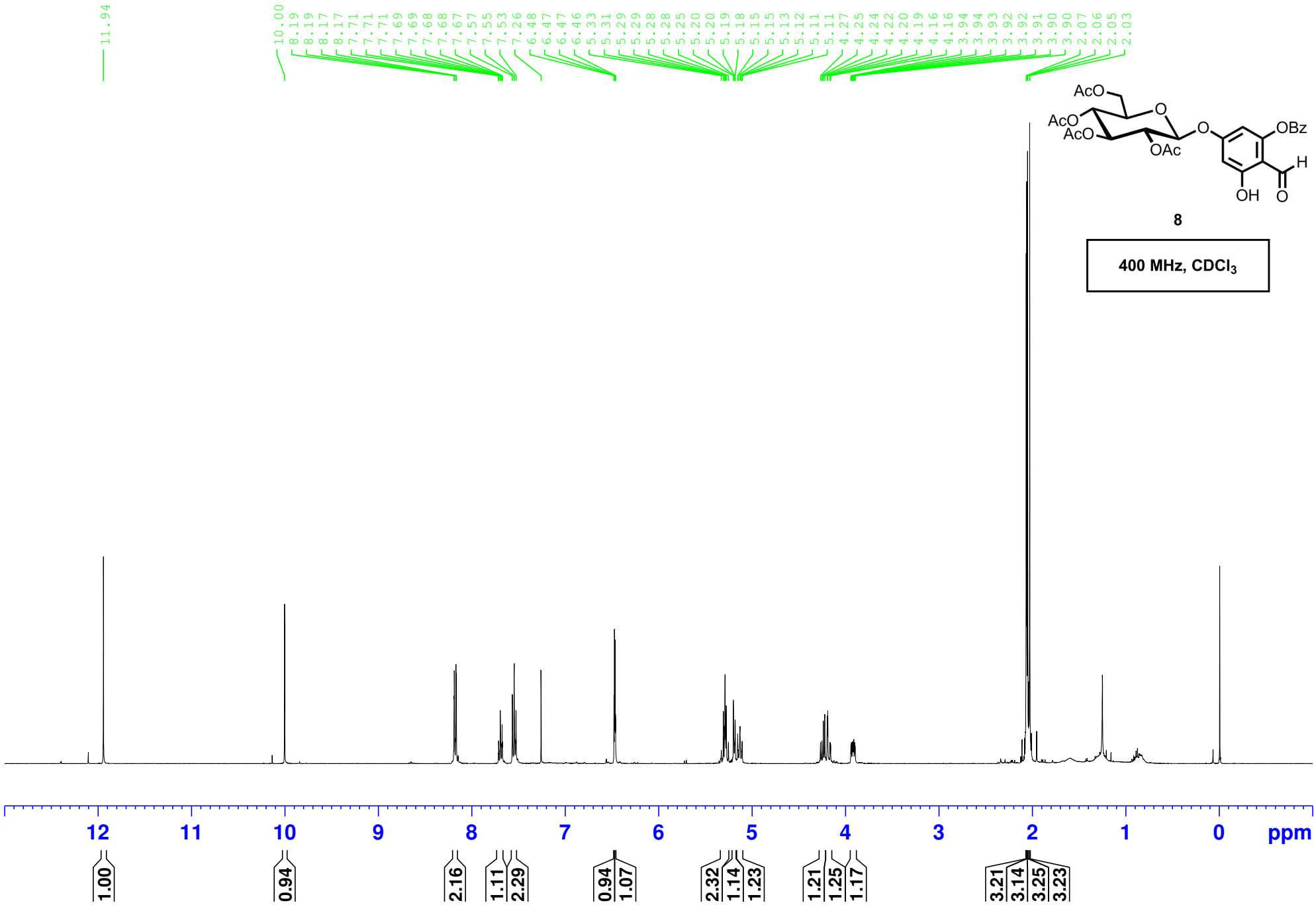
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6.47
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5.28
5.25
5.20
5.20
5.19
5.18
5.15
5.15
5.13
5.12
5.11
5.11
4.27
4.25
4.24
4.22
4.20
4.19
4.16
4.16
3.94
3.94
3.93
3.92
3.92
3.91
3.90
3.90
2.07
2.06
2.05
2.03
AcO
AcO
AcO
O
O
OAc
OBz
H
OH
O
8
400 MHz, CDCl3
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11
10
9
8
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5
4
3
2
1
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ppm
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0.94
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1.11
2.29
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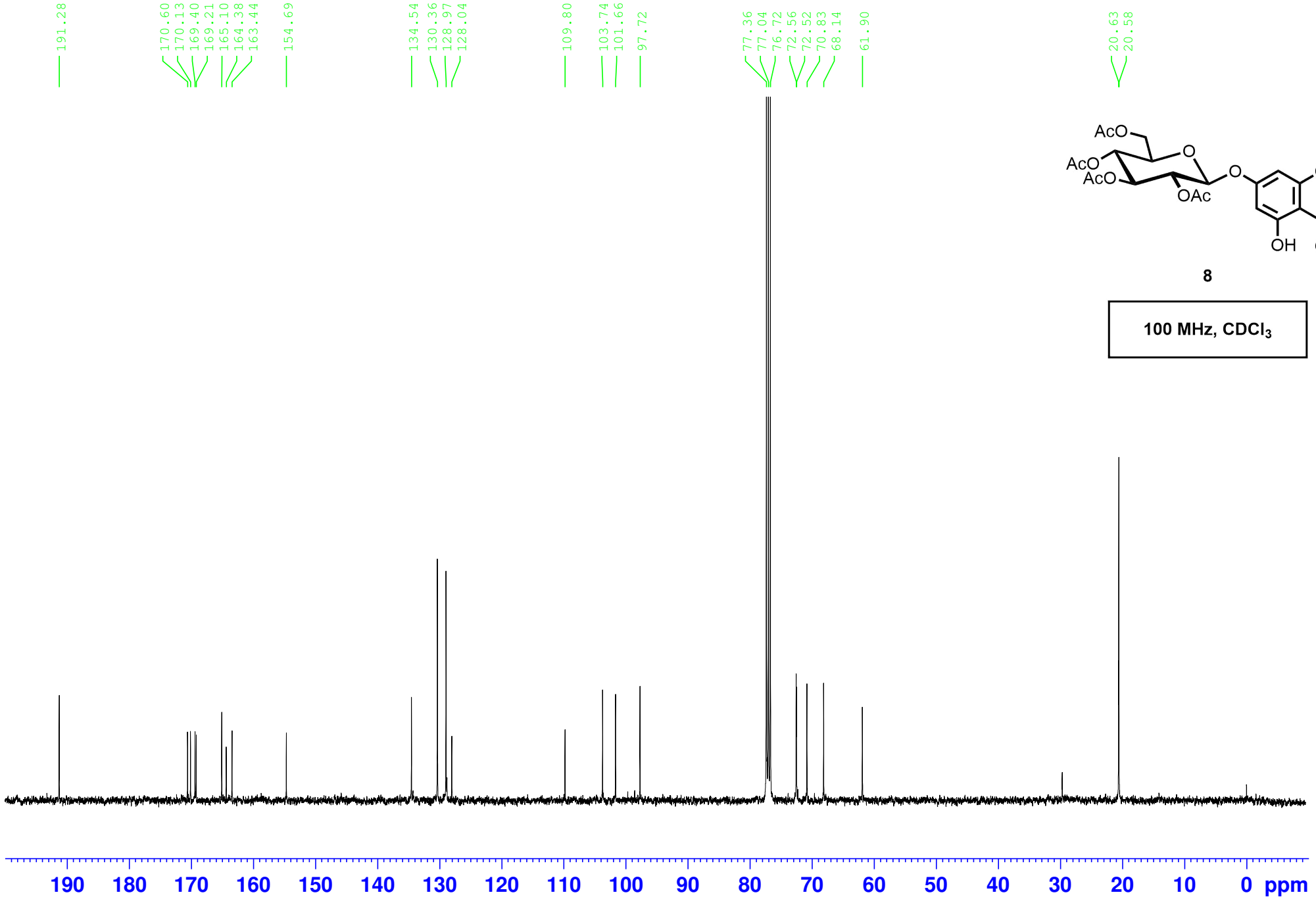
3.23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128.04
109.80
103.74
101.66
97.72
77.36
77.04
76.72
72.56
72.52
70.83
68.14
61.90
20.63
20.58
AcO
AcO
AcO
OAc
O
O
OBz
H
OH
O
8
100 MHz, CDCl3
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140
130
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110
100
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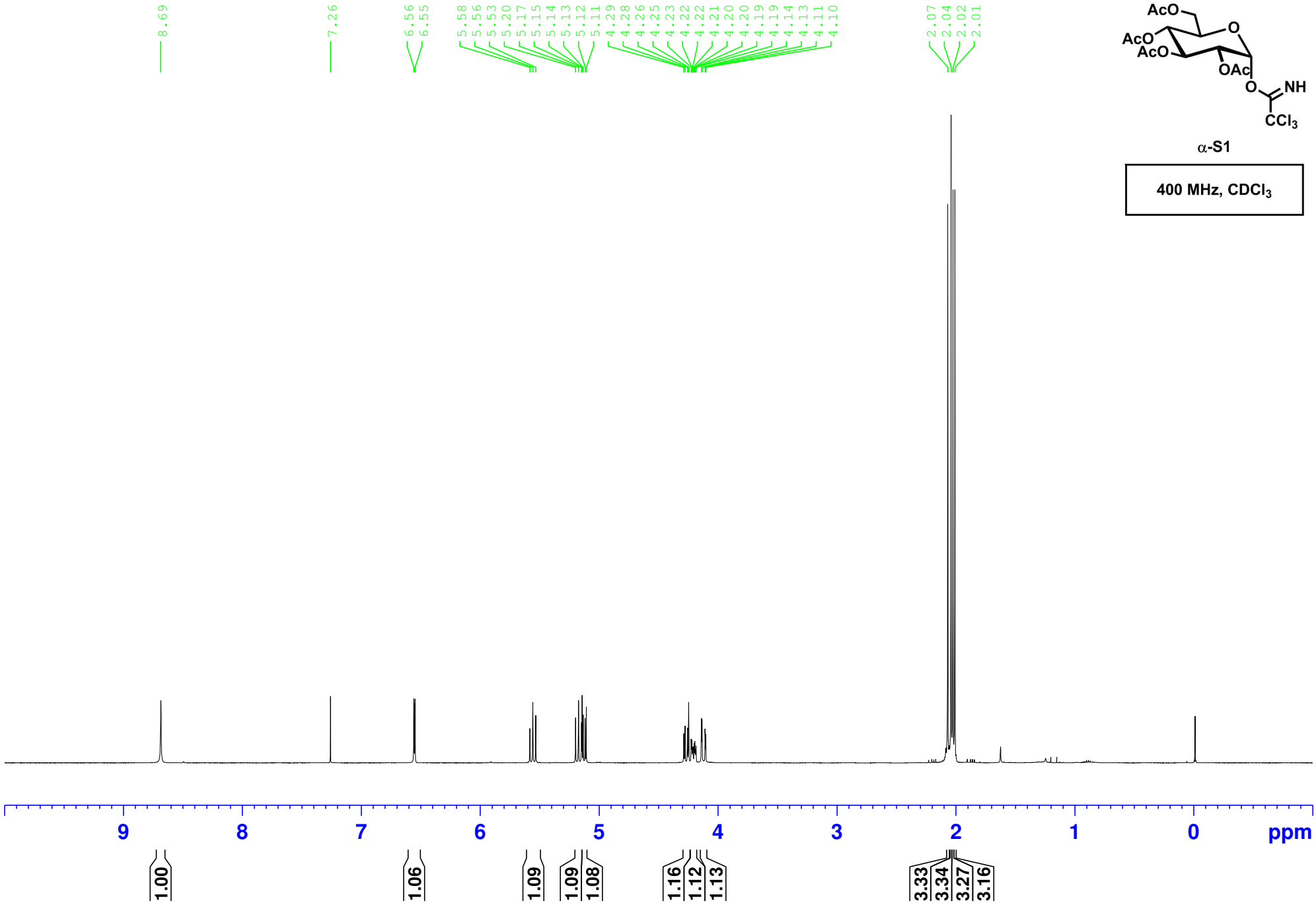
ppm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4.19
4.19
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4.13
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4.10
2.07
2.04
2.02
2.01
AcO
AcO
AcO
O
OAc
O
NH
CCl3
α-S1
400 MHz, CDCl3
9
8
7
6
5
4
3
2
1
0
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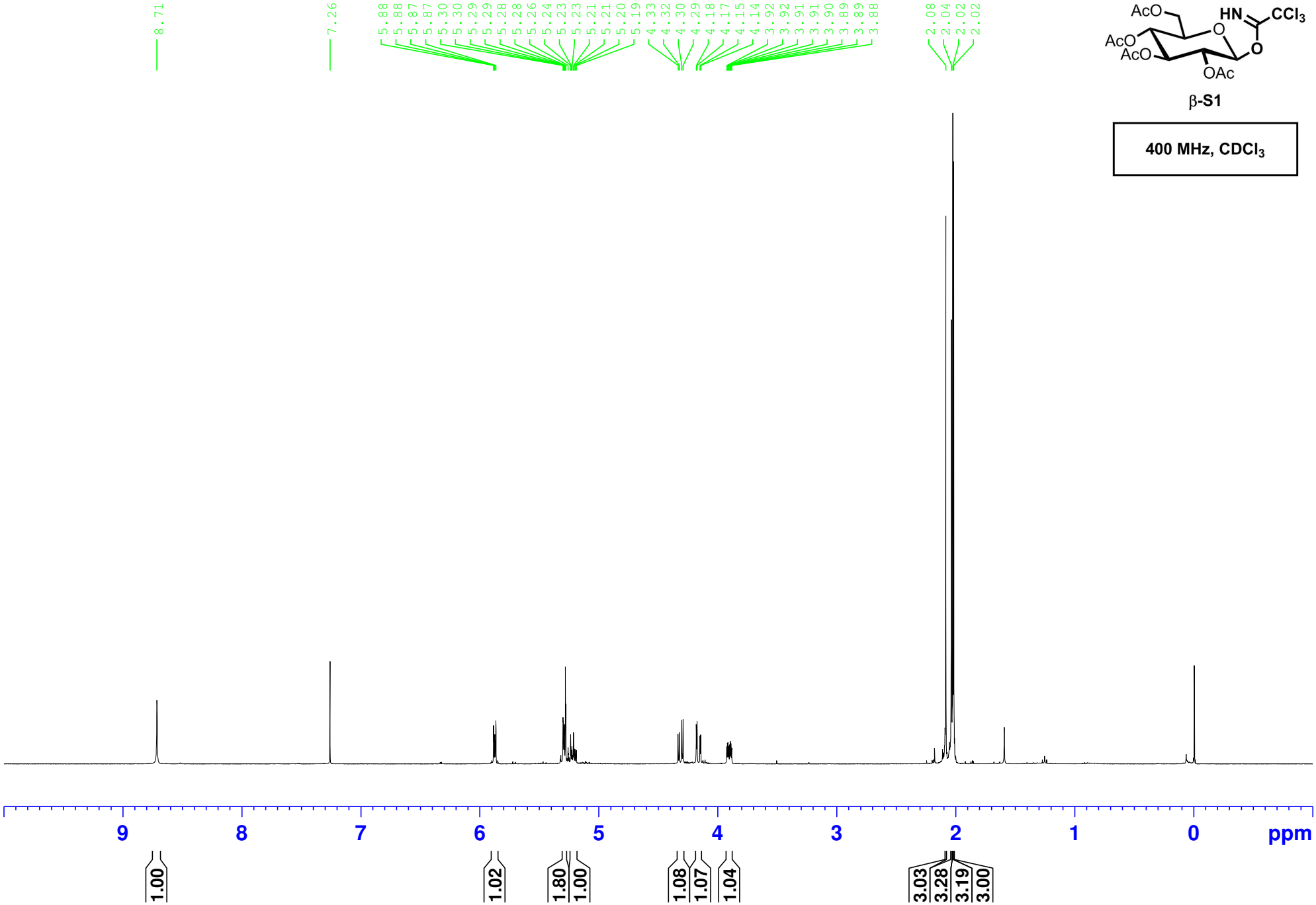
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4.18
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4.15
4.14
3.92
3.92
3.91
3.91
3.90
3.89
3.89
3.88
2.08
2.04
2.02
2.02
AcO
HN
CCl3
AcO
AcO
O
O
OAc
β-S1
400 MHz, CDCl3
9
8
7
6
5
4
3
2
1
0
ppm
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1.02
1.80
1.00
1.08
1.07
1.04
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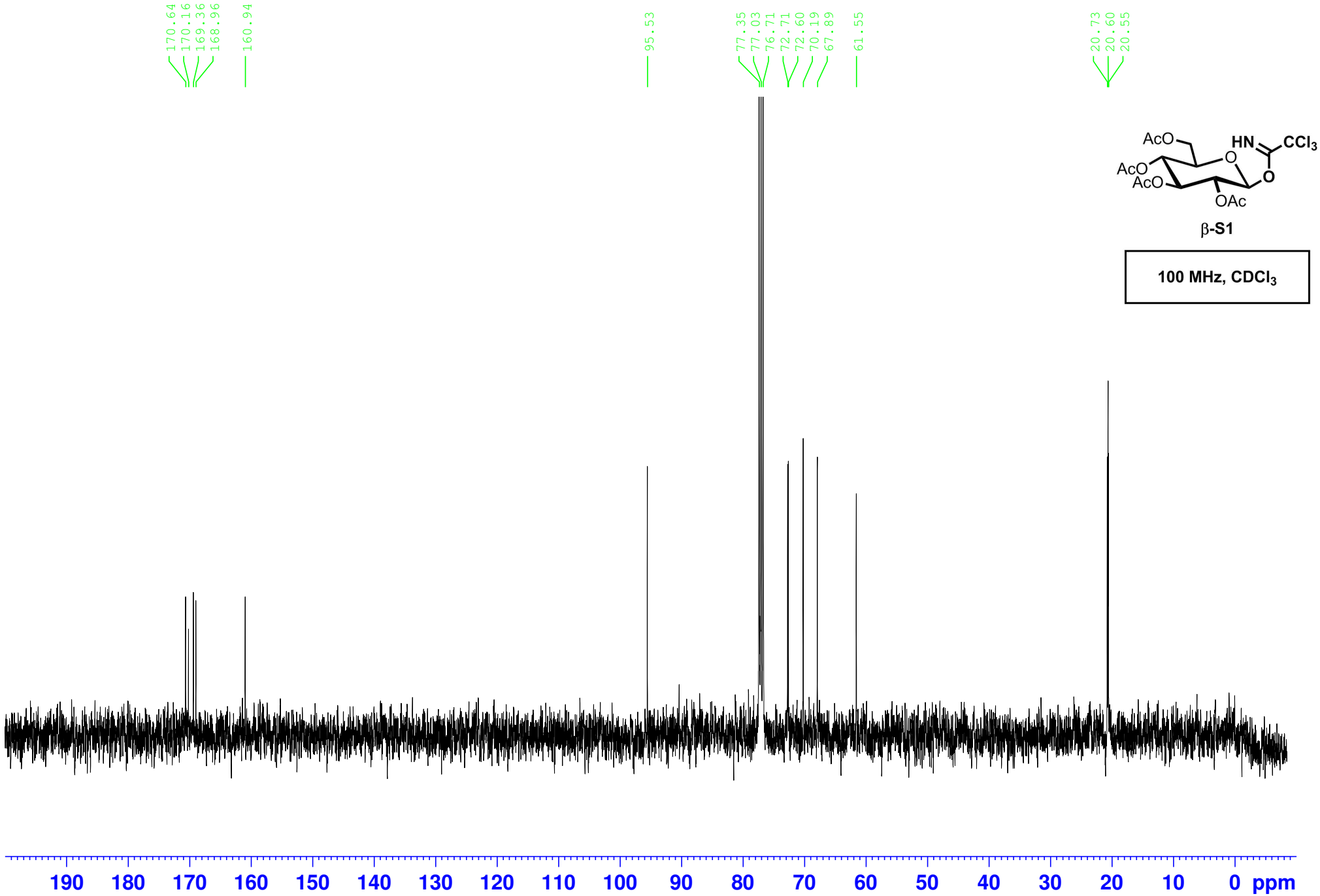
3.19
3.00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77.35
77.03
76.71
72.71
72.60
70.19
67.89
61.55
20.73
20.60
20.55
AcO
AcO
AcO
OAc
HN
CCl3
O
O
β-S1
100 MHz, CDCl3
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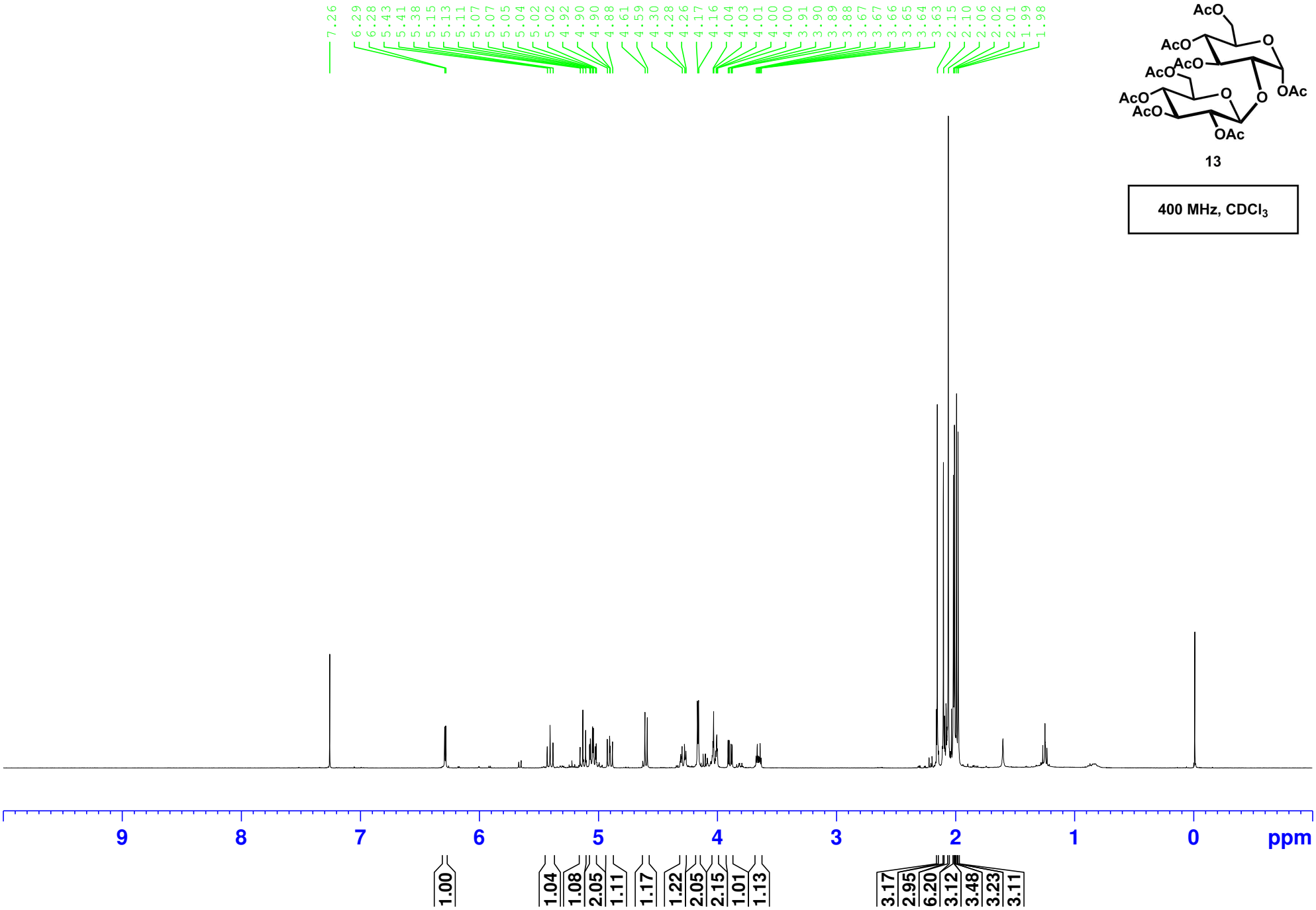
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5.13
5.11
5.07
5.07
5.05
5.04
5.02
5.02
4.92
4.90
4.90
4.88
4.61
4.59
4.30
4.28
4.26
4.17
4.16
4.04
4.03
4.01
4.00
4.00
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3.90
3.89
3.88
3.67
3.67
3.66
3.65
3.64
3.63
2.15
2.10
2.06
2.02
2.01
1.99
1.98
AcO
AcO
AcO
AcO
AcO
AcO
O
O
O
OAc
OAc
13
400 MHz, CDCl3
9
8
7
6
5
4
3
2
1
0
ppm
1.00
1.04
1.08
2.05
1.11
1.17
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1.01
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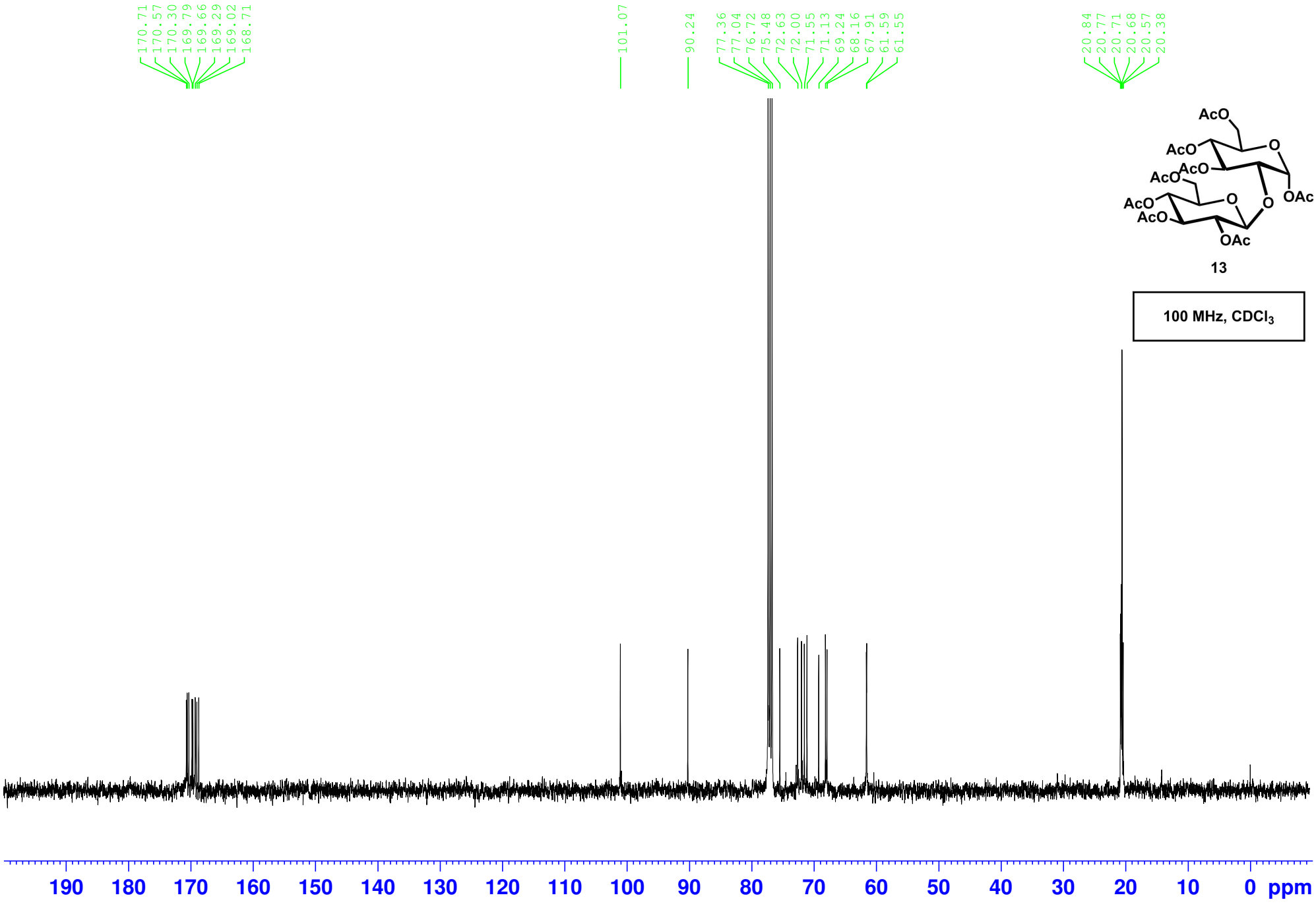
3.23
3.11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169.29
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75.48
72.63
72.00
71.55
71.13
69.24
68.16
67.91
61.59
61.55
20.84
20.77
20.71
20.68
20.57
20.38
AcO
AcO
AcO
AcO
AcO
AcO
O
O
O
OAc
OAc
13
100 MHz, CDCl3
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180
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140
130
120
110
100
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60
50
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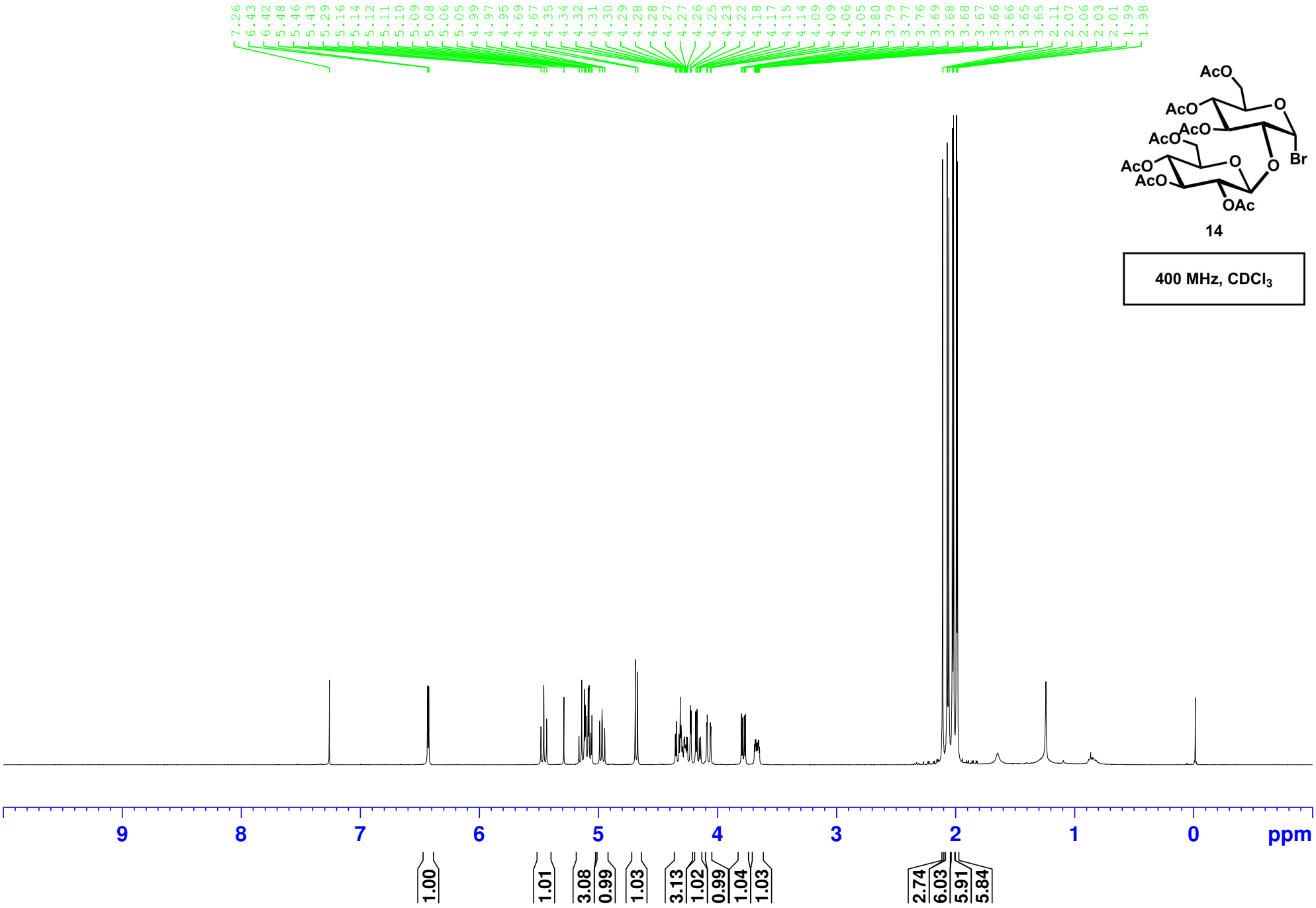
30
20
10
0
ppm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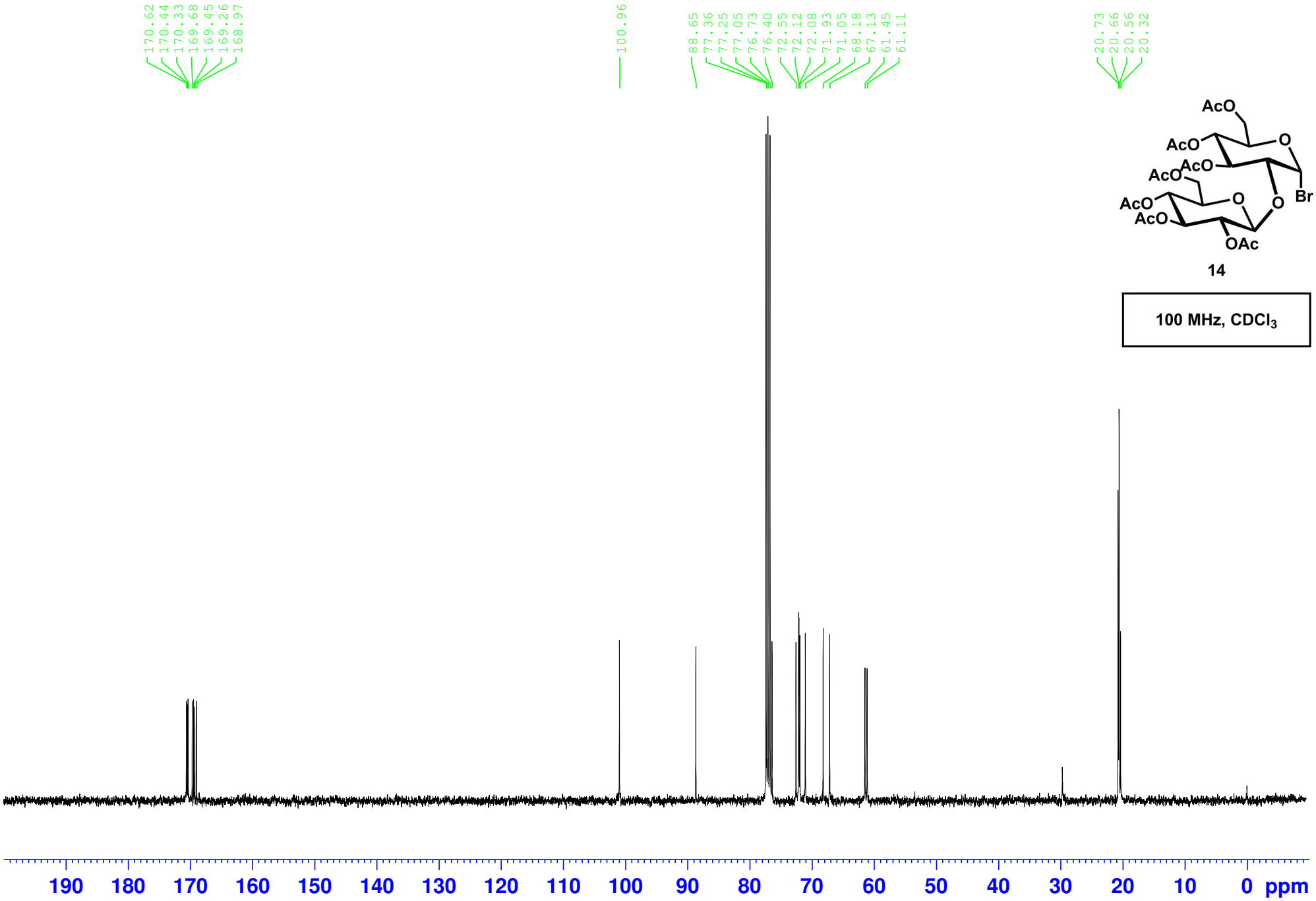
AcO
AcO
AcO
AcO
AcO
AcO
O
O
O
Br
OAc
14
400 MHz, CDCl3
9 8 7 6 5 4 3 2 1 0 ppm
1.00 1.01 3.08 0.99 1.03 3.13 1.02 0.99 1.04 1.03 2.74 6.03 5.91 5.84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72.08
71.93
71.05
68.18
67.13
61.45
61.11
20.73
20.66
20.56
20.32
AcO
AcO
AcO
AcO
AcO
AcO
O
O
O
Br
OAc
14
100 MHz, CDCl3
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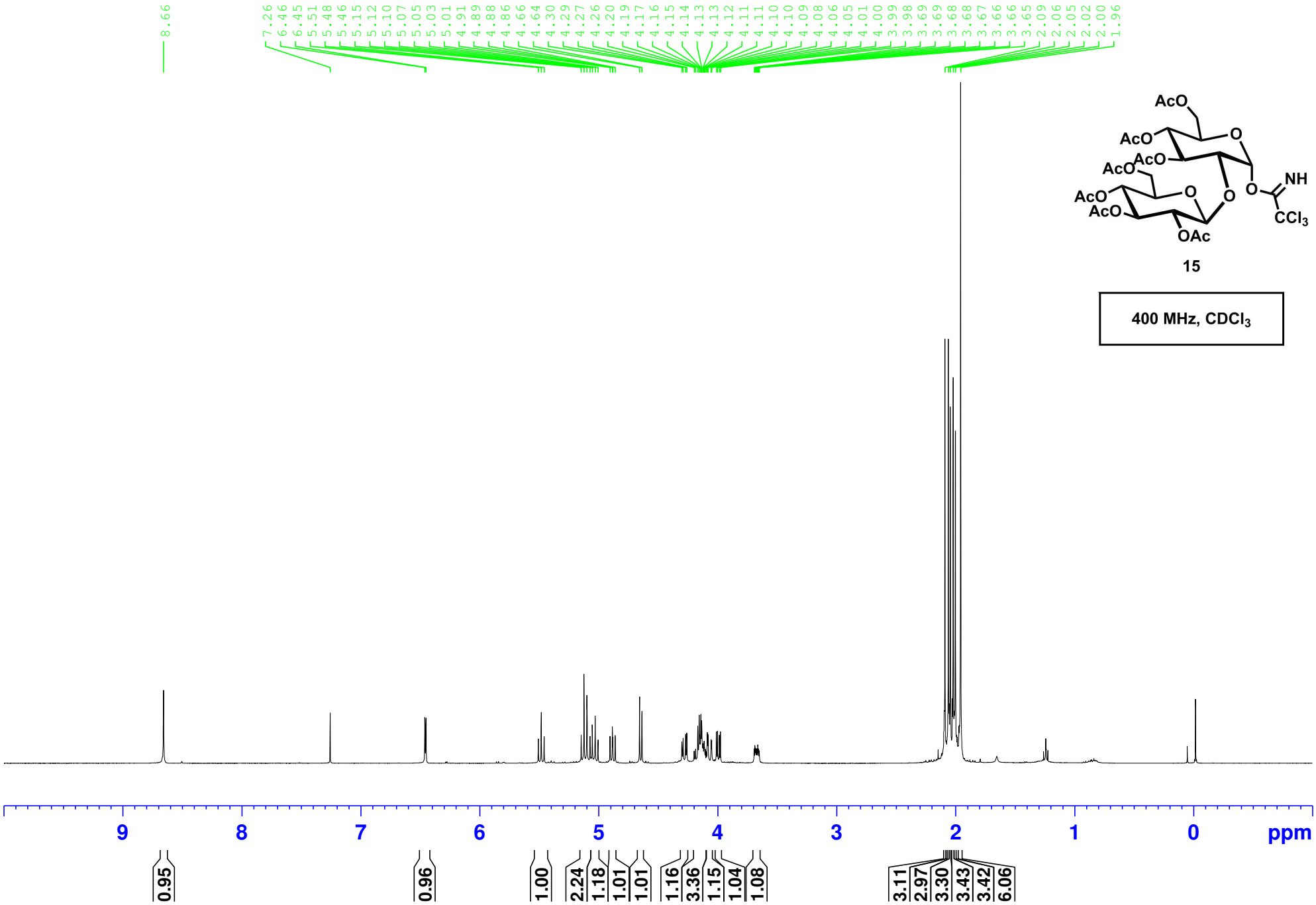
10
0
ppm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5.07
5.05
5.03
5.01
4.91
4.89
4.88
4.86
4.66
4.64
4.30
4.29
4.27
4.26
4.20
4.19
4.17
4.16
4.15
4.14
4.13
4.13
4.12
4.11
4.11
4.10
4.10
4.09
4.08
4.06
4.05
4.01
4.00
3.99
3.98
3.69
3.69
3.68
3.68
3.67
3.66
3.65
2.09
2.06
2.05
2.02
2.00
1.96
AcO
AcO
AcO
AcO
AcO
AcO
O
O
O
O
NH
CCl3
OAc
15
400 MHz, CDCl3
9
8
7
6
5
4
3
2
1
0
ppm
0.95
0.96
1.00
2.24
1.18
1.01
1.01
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1.04
1.08
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2.97
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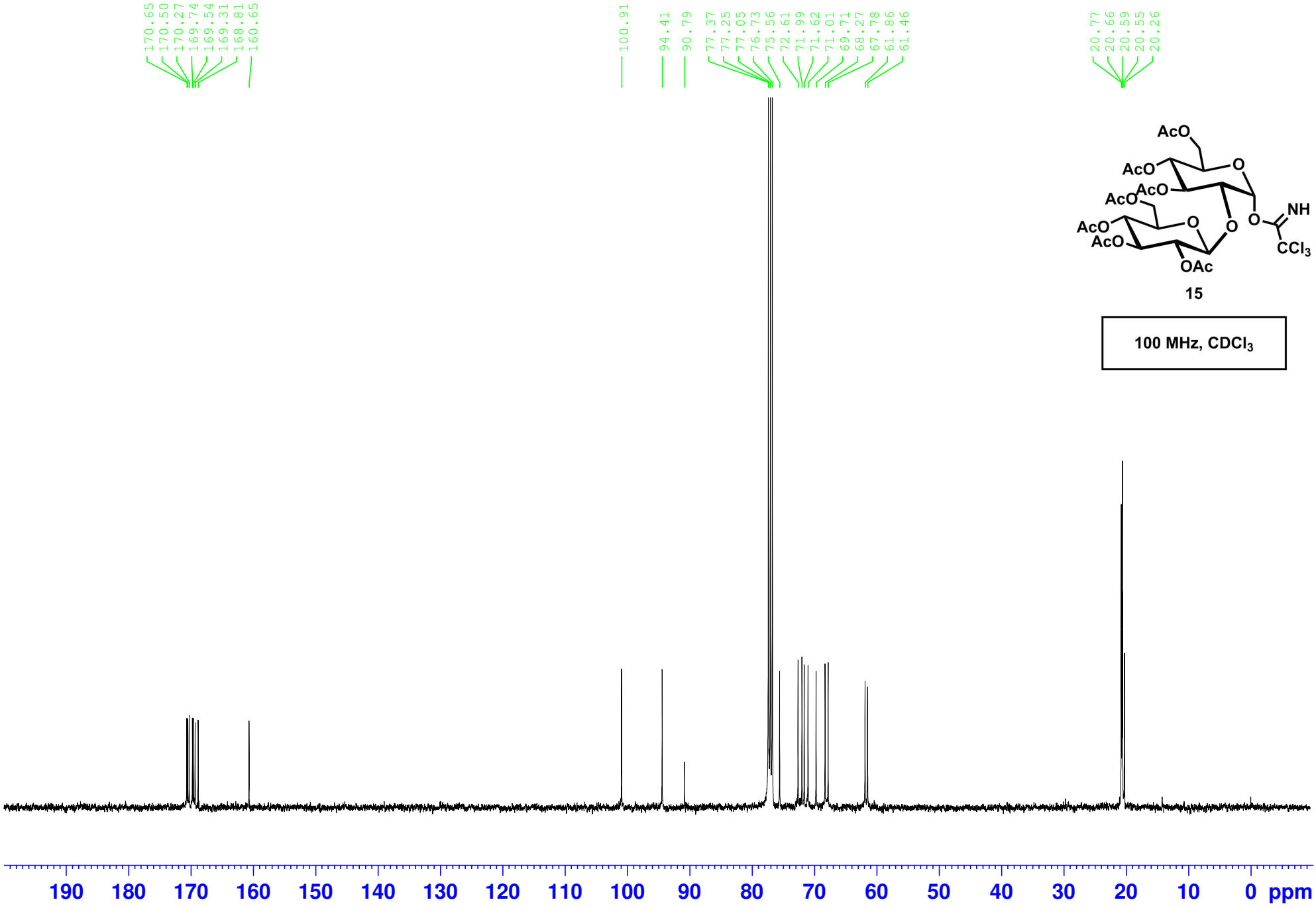
3.42
6.06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94.41
90.79
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77.25
77.05
76.73
75.56
72.61
71.99
71.62
71.01
69.71
68.27
67.78
61.86
61.46
20.77
20.66
20.59
20.55
20.26
AcO
AcO
AcO
AcO
AcO
AcO
OAc
O
O
O
O
NH
CCl3
15
100 MHz, CDCl3
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120
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100
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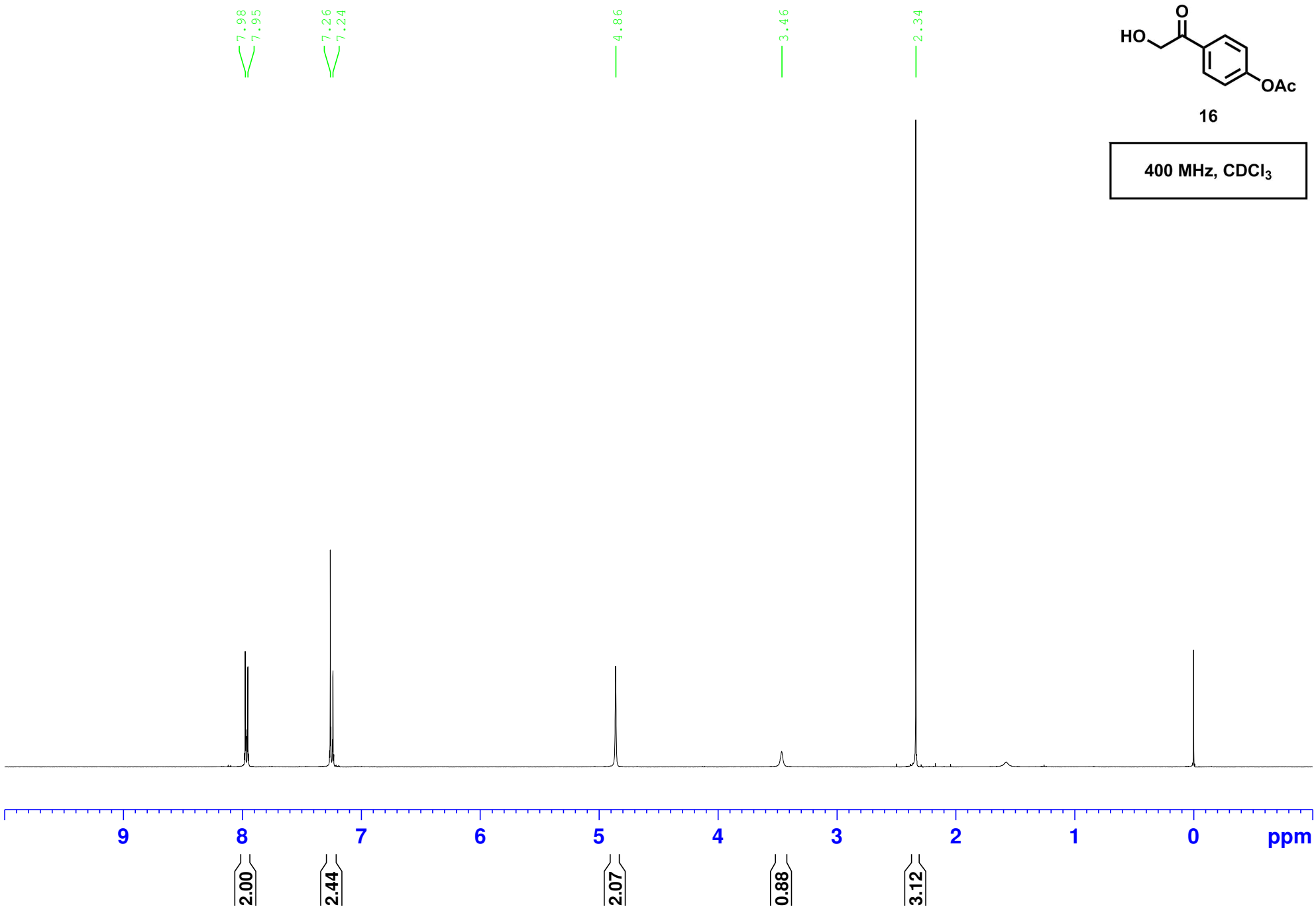
10
0
ppm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7.24
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3.46
2.34
HO
O
OAc
16
400 MHz, CDCl3
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6
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4
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2
1
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ppm
2.00
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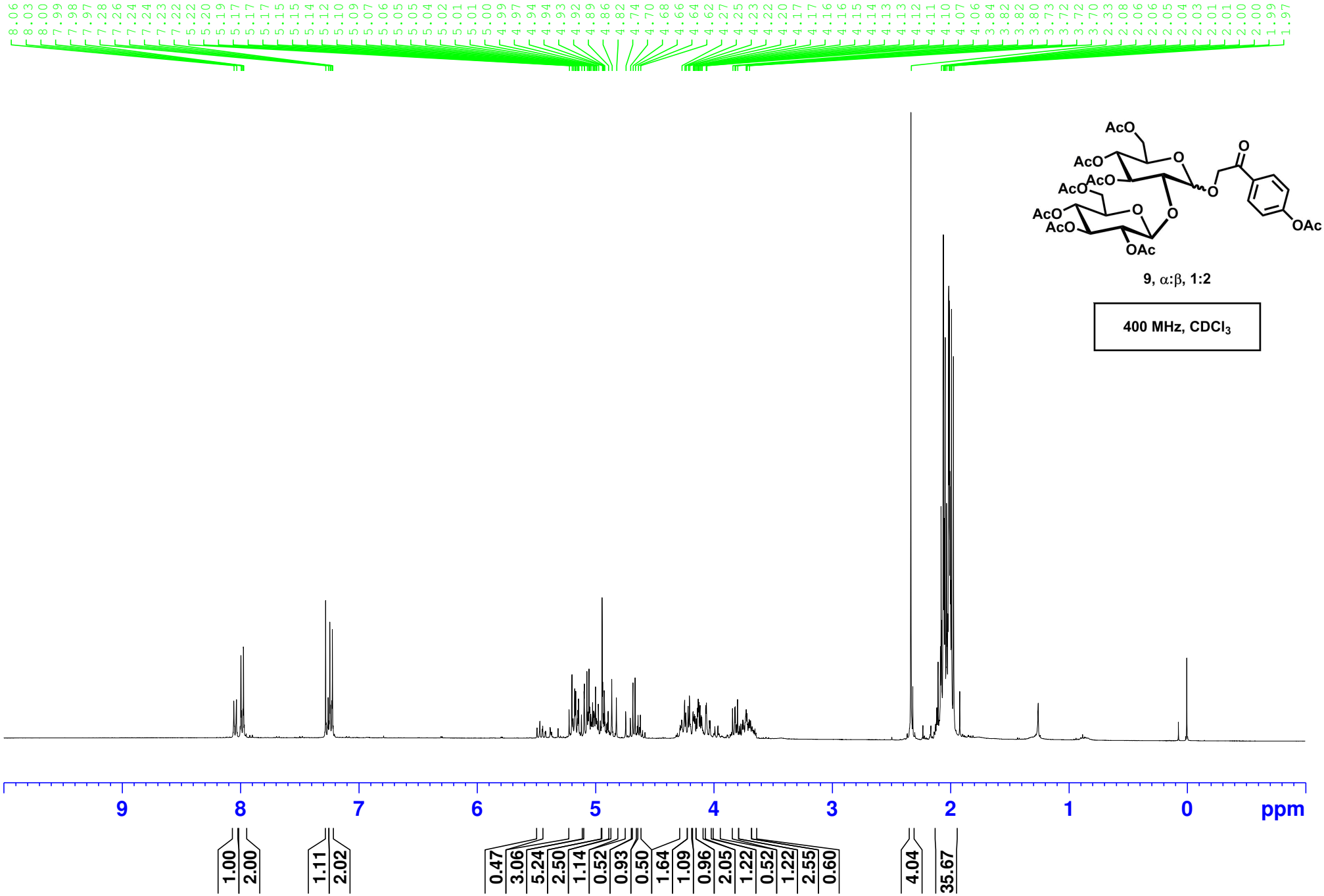
3.12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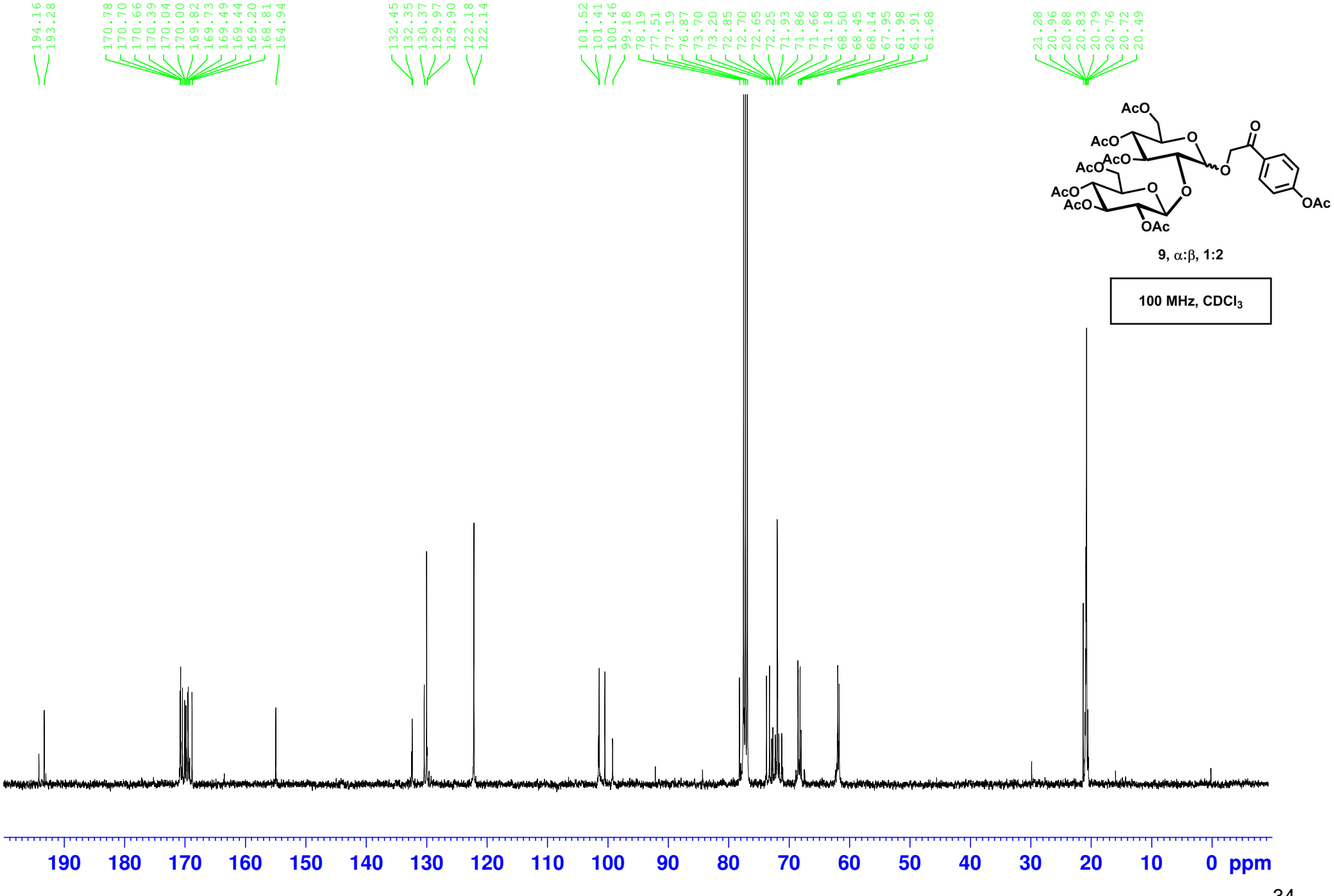
AcO
AcO
AcO
AcO
AcO
AcO
O
O
O
O
O
OAc
OAc
9, α:β, 1:2
400 MHz, CDCl3
9 8 7 6 5 4 3 2 1 0 ppm
1.00 2.00 1.11 2.02 0.47 3.06 5.24 2.50 1.14 0.52 0.93 0.50 1.64 1.09 0.96 2.05 1.22 0.52 1.22 2.55 0.60 4.04 35.67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168.81
154.94
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132.35
130.37
129.97
129.90
122.18
122.14
101.52
101.41
100.46
99.18
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77.51
77.19
76.87
73.70
73.20
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72.70
72.65
72.25
71.93
71.86
71.66
71.18
68.50
68.45
68.14
67.95
61.98
61.91
61.68
21.28
20.96
20.88
20.83
20.79
20.76
20.72
20.49
AcO
AcO
AcO
AcO
AcO
AcO
OAc
OAc
O
O
O
O
O
O
9, α:β, 1:2
100 MHz, CDCl3
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60
50
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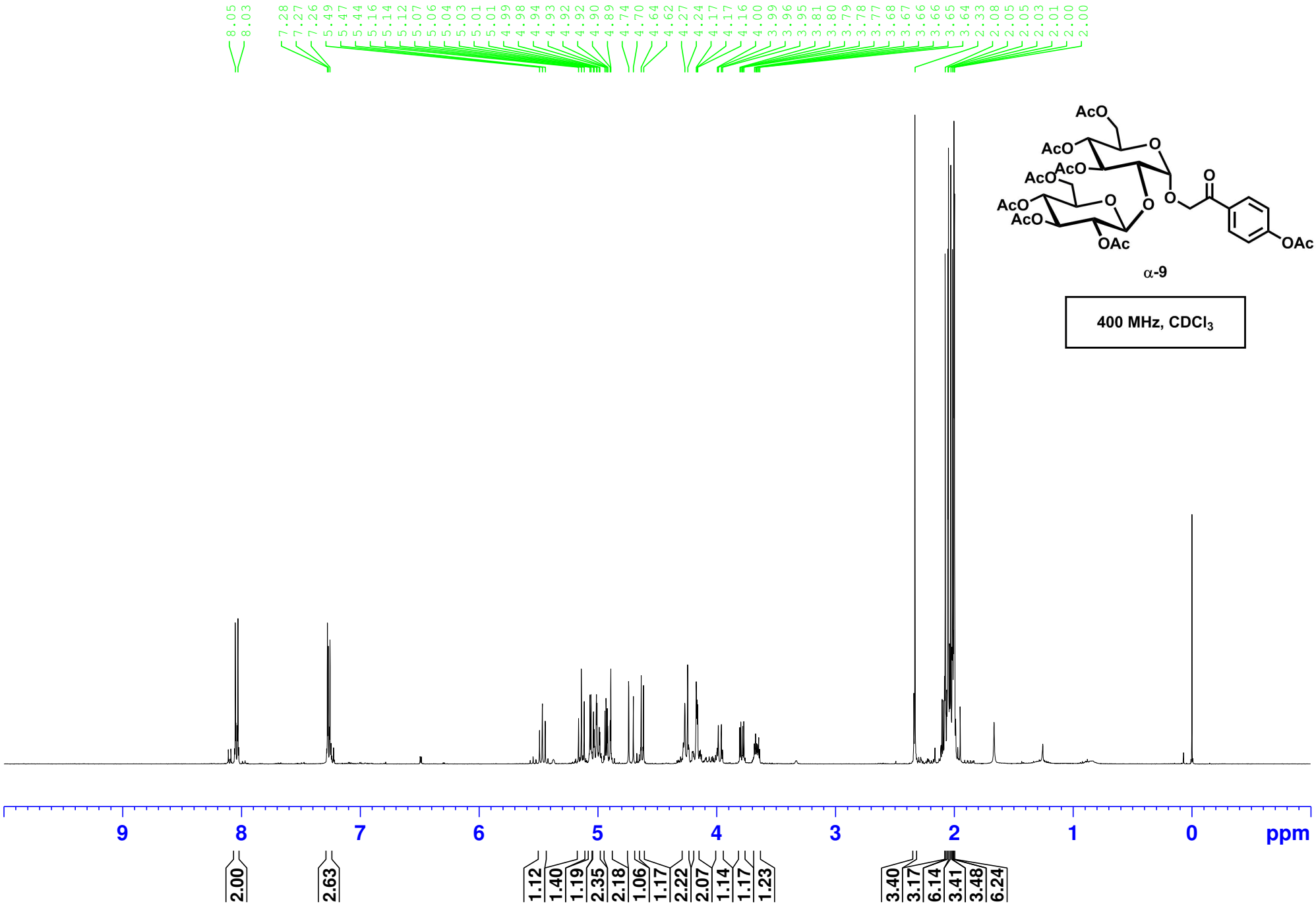
10
0
ppm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4.98
4.94
4.93
4.92
4.92
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4.89
4.74
4.70
4.64
4.62
4.27
4.24
4.17
4.17
4.16
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3.95
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3.77
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2.05
2.03
2.01
2.00
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AcO
AcO
AcO
AcO
AcO
AcO
OAc
OAc
α-9
400 MHz, CDCl3
9
8
7
6
5
4
3
2
1
0
ppm
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1.40
1.19
2.35
2.18
1.06
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1.17
1.23
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3.17
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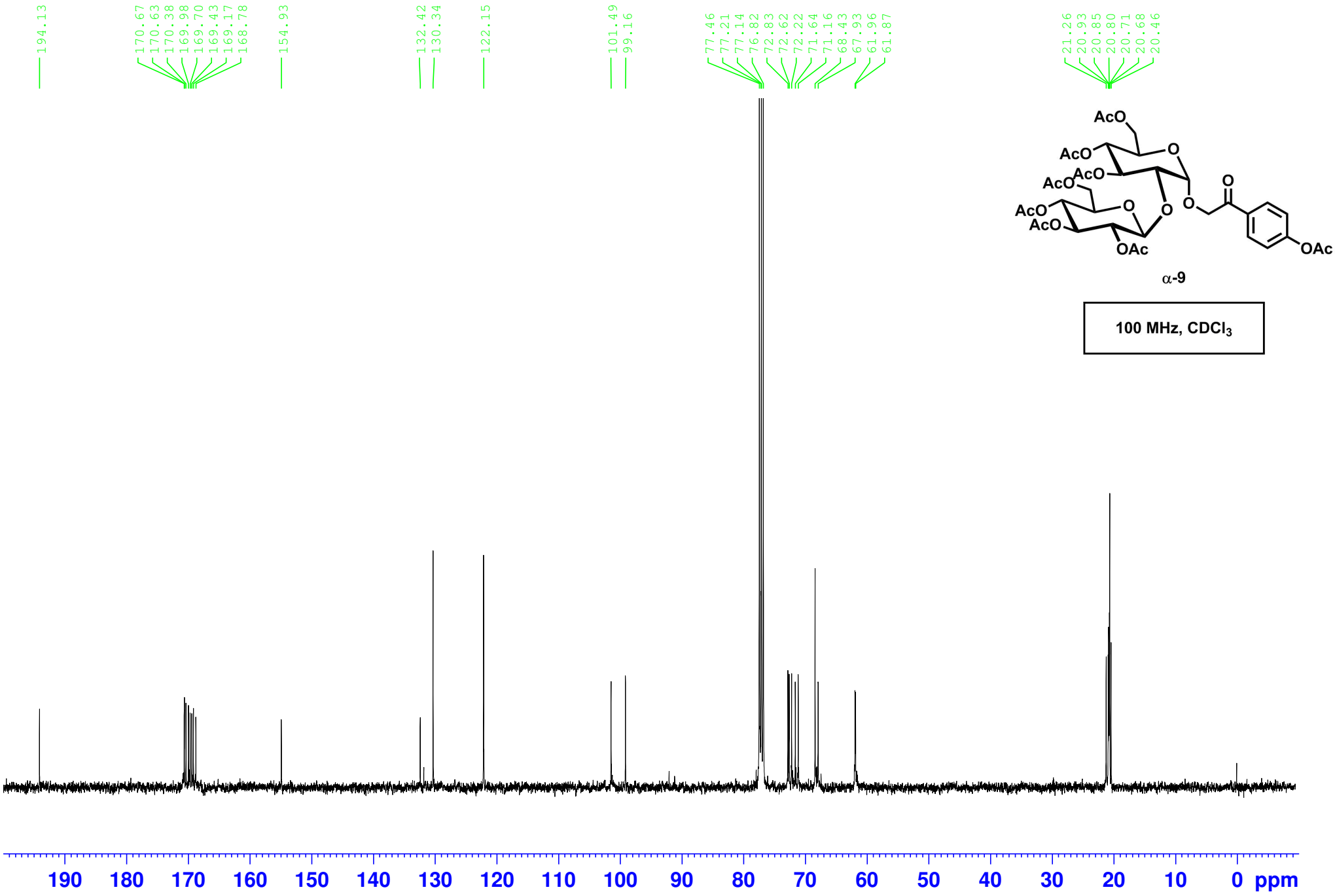
3.48
6.24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101.49
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76.82
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71.64
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67.93
61.96
61.87
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20.93
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20.68
20.46
AcO
AcO
AcO
AcO
AcO
AcO
O
O
O
O
O
OAc
OAc
α-9
100 MHz, CDCl3
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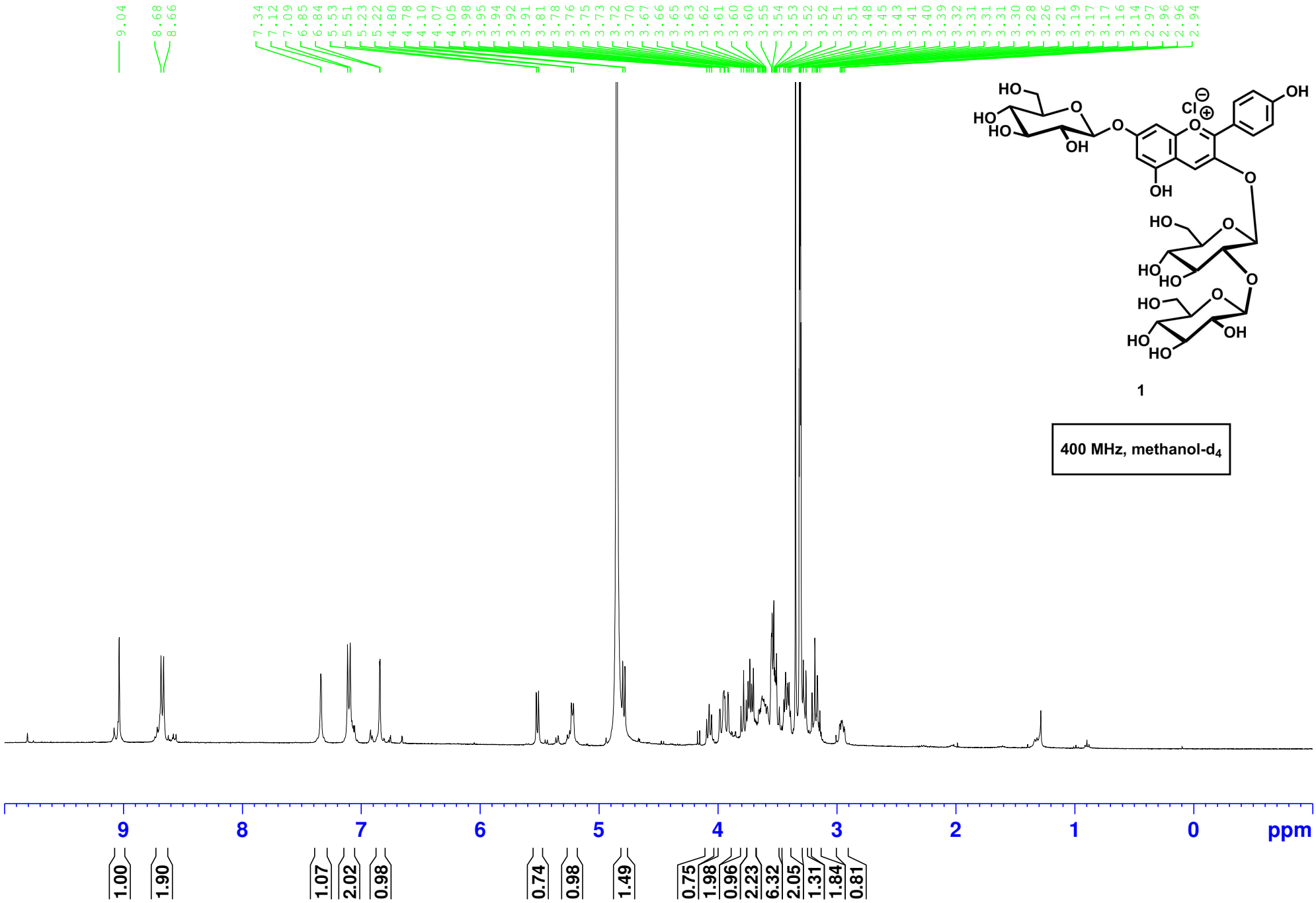
10
0
ppm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5.23
5.22
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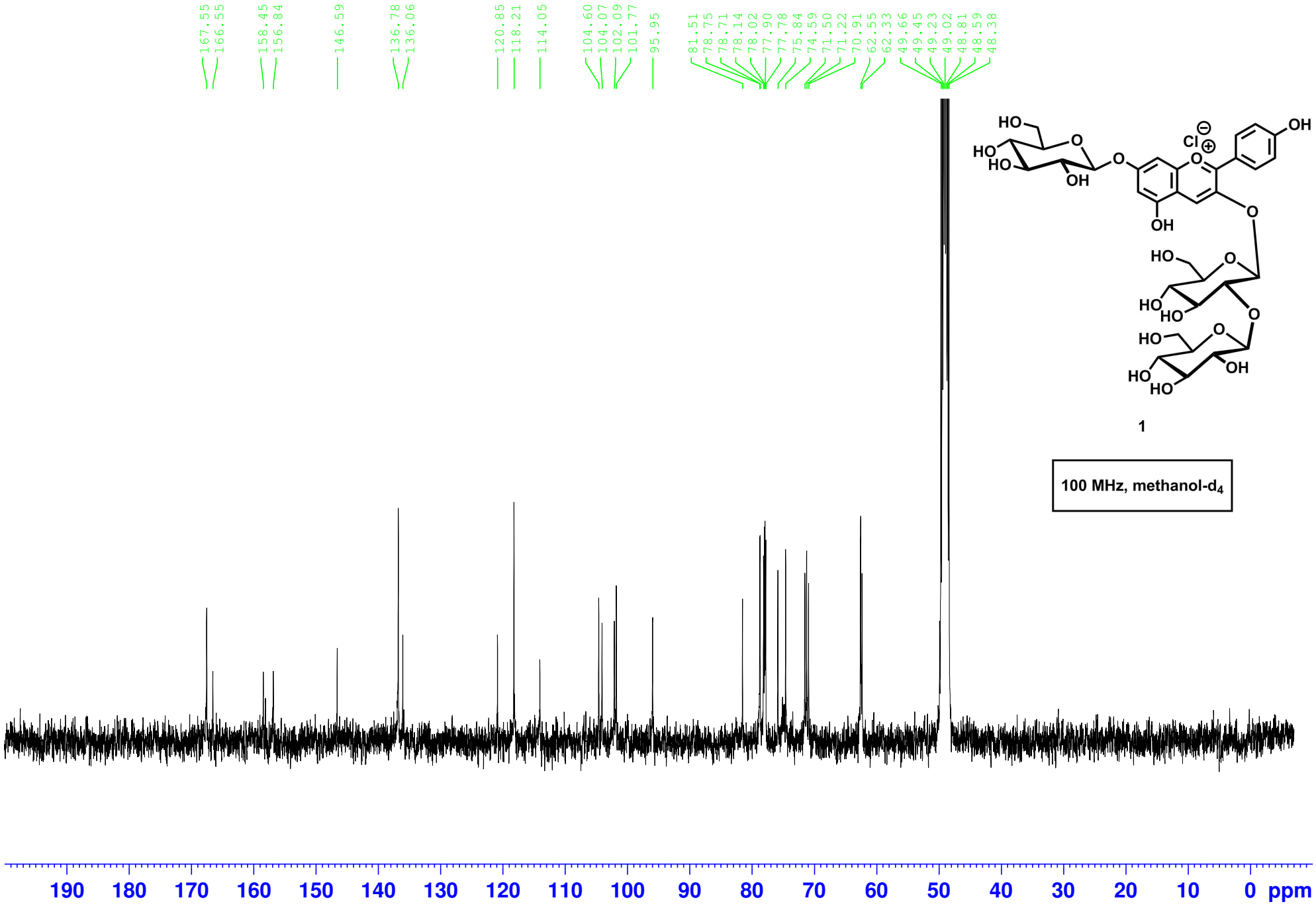
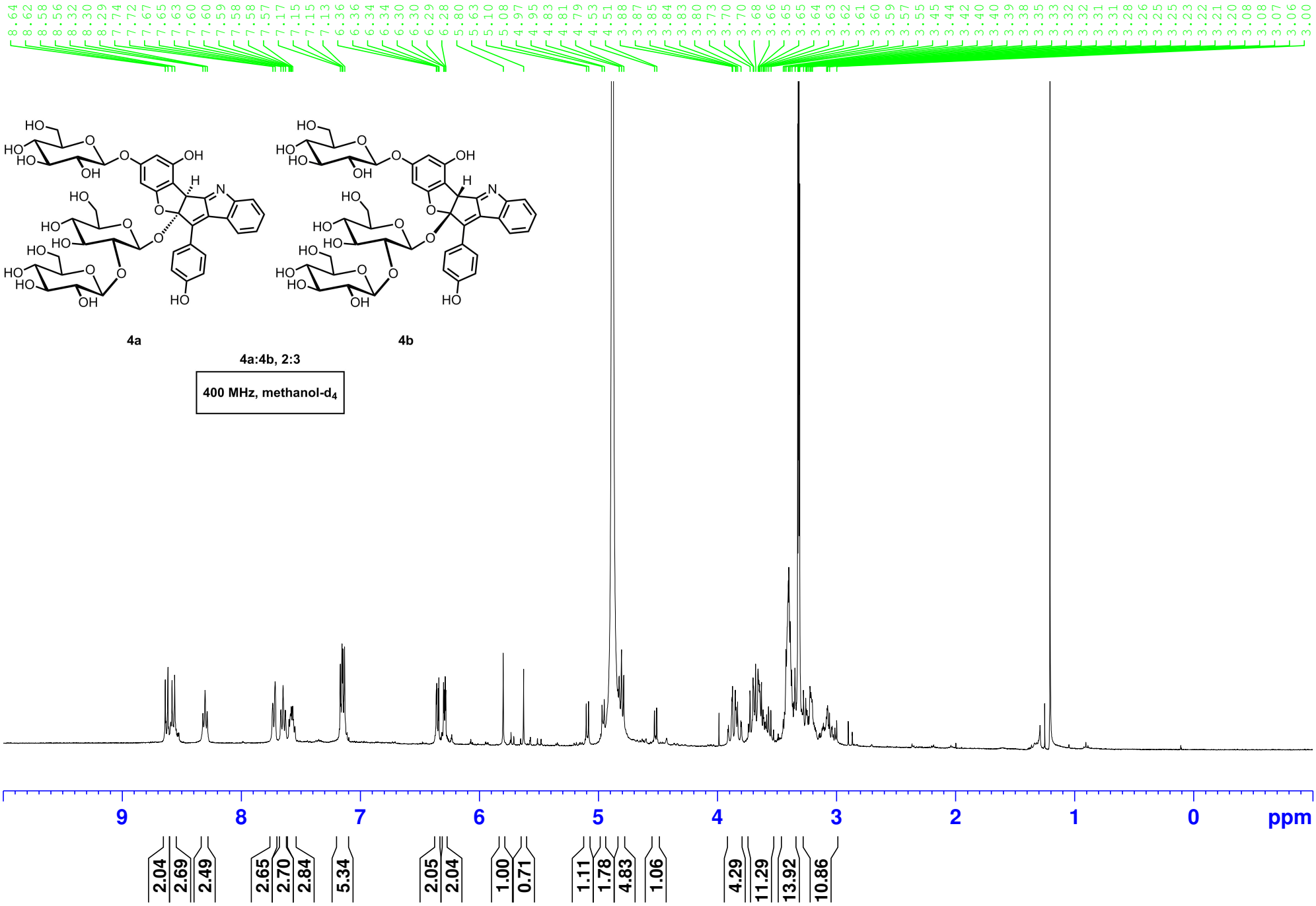
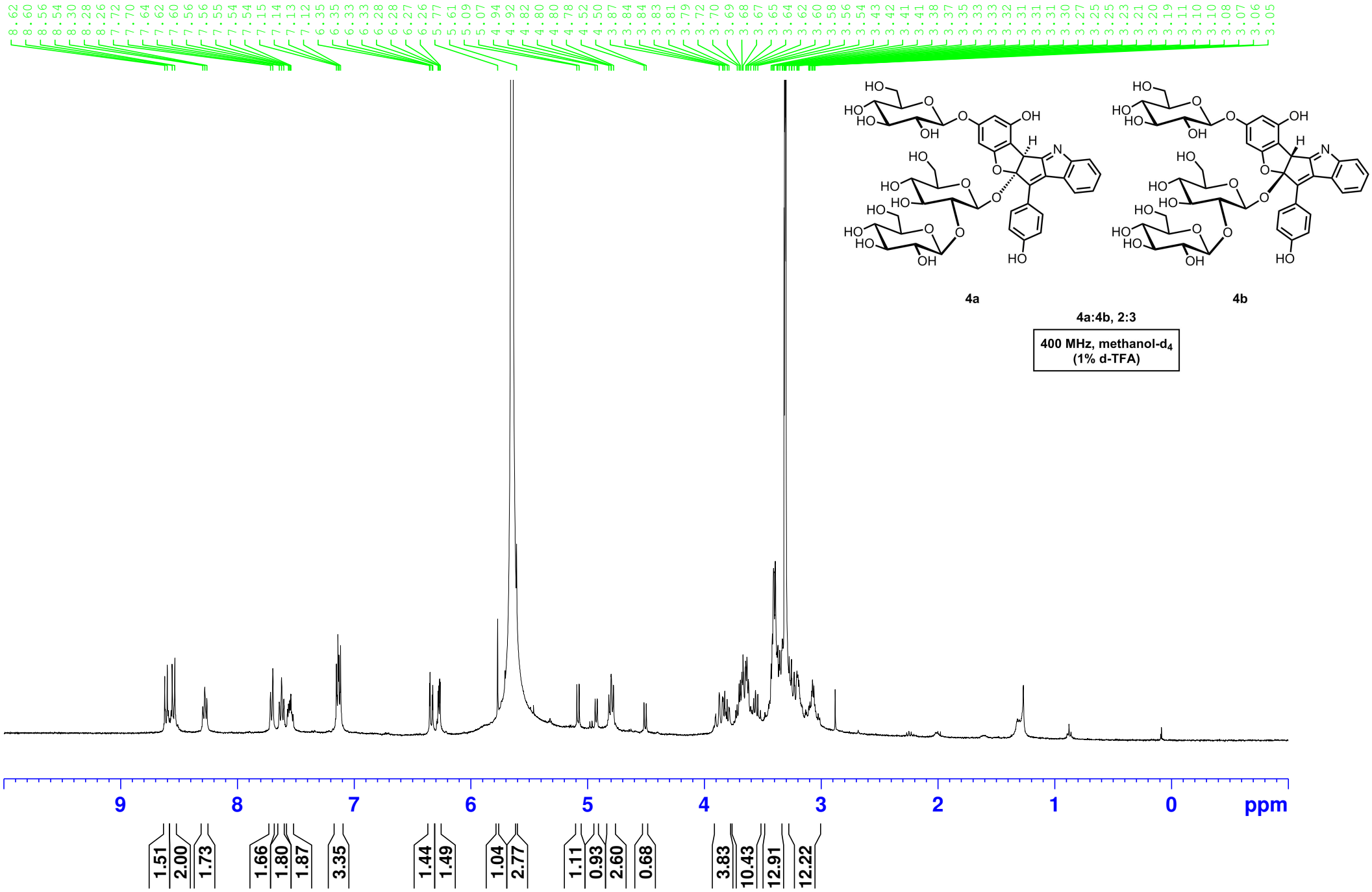
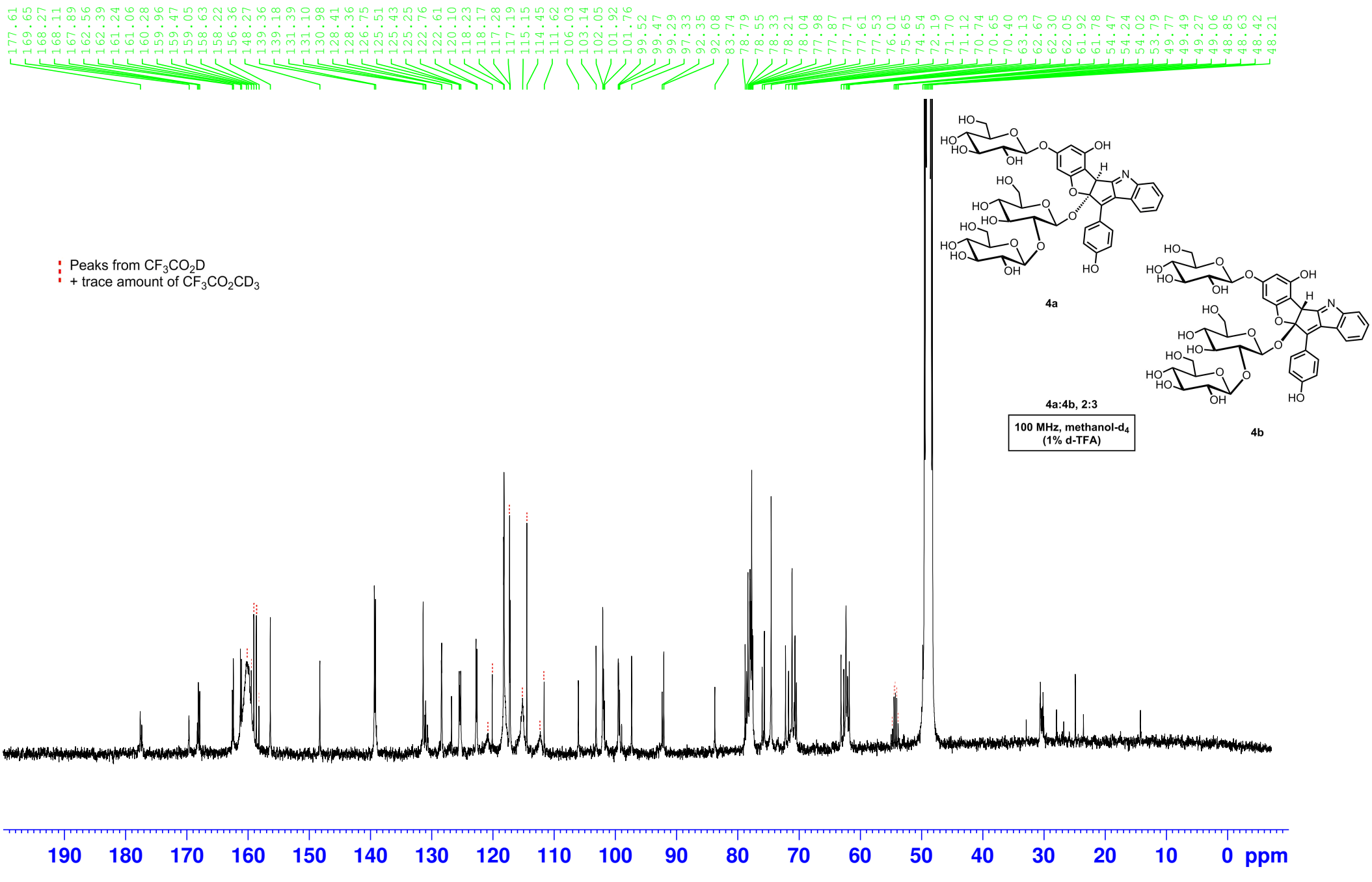
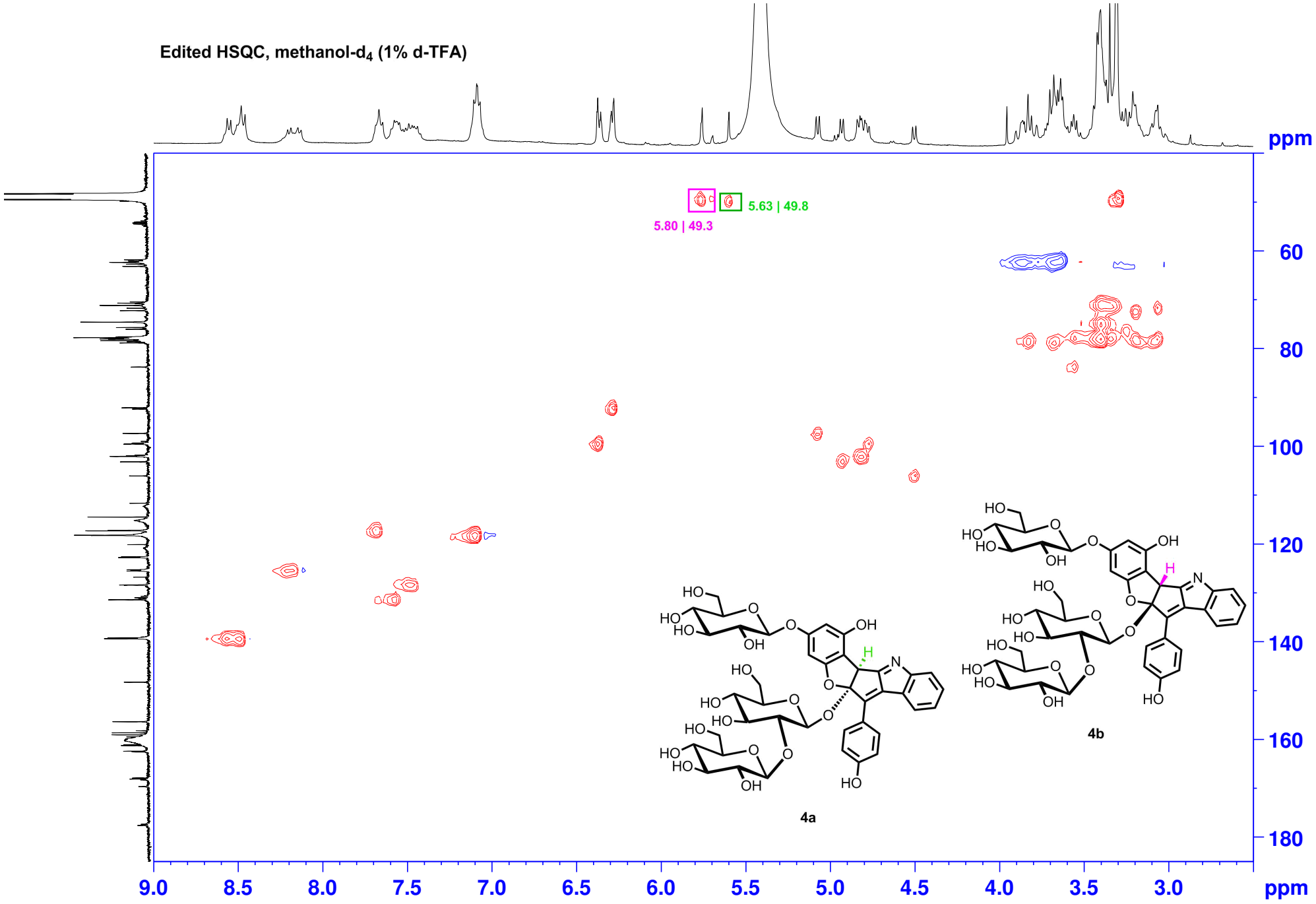
3.21
3.19
3.17
3.17
3.16
3.14
2.97
2.96
2.96
2.94
HO
HO
HO
O
OH
O
Cl
O
OH
OH
O
HO
HO
HO
O
O
HO
HO
HO
O
OH
HO
HO
1
400 MHz, methanol-d4
9
8
7
6
5
4
3
2
1
0
ppm
1.00
1.90
1.07
2.02
0.98
0.74
0.98
1.49
0.75
1.98
0.96
2.23
6.32
2.05
1.31
1.84
0.81

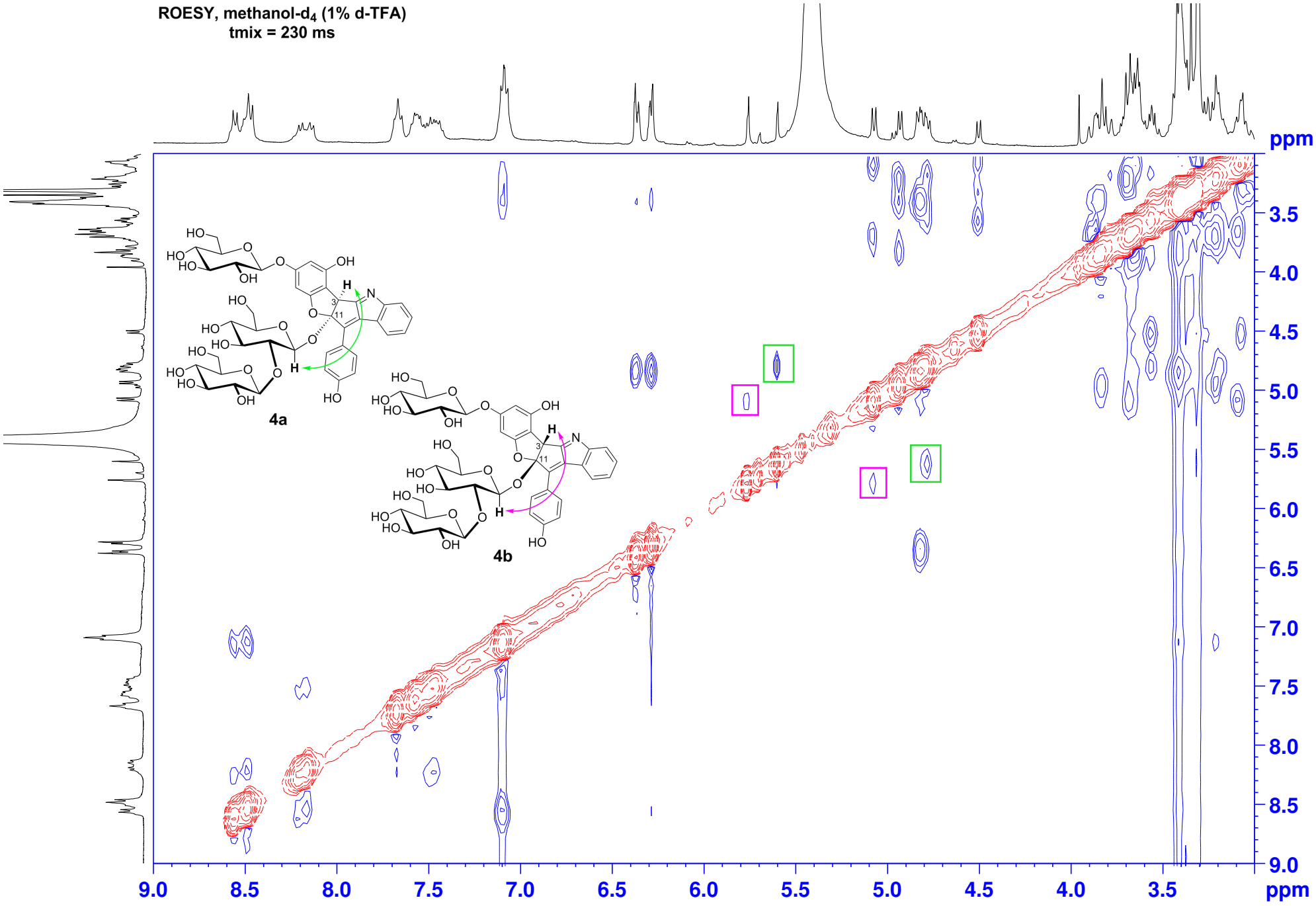

167.55
166.55
158.45
156.84
146.59
136.78
136.06
120.85
118.21
114.05
104.60
104.07
102.09
101.77
95.95
81.51
78.75
78.71
78.14
78.02
77.90
77.78
75.84
74.59
71.50
71.22
70.91
62.55
62.33
49.66
49.45
49.23
49.02
48.81
48.59
48.38
HO
HO
HO
OH
O
O
Cl
OH
OH
O
HO
O
HO
HO
O
HO
O
HO
HO
OH
1
100 MHz, methanol-d4
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm

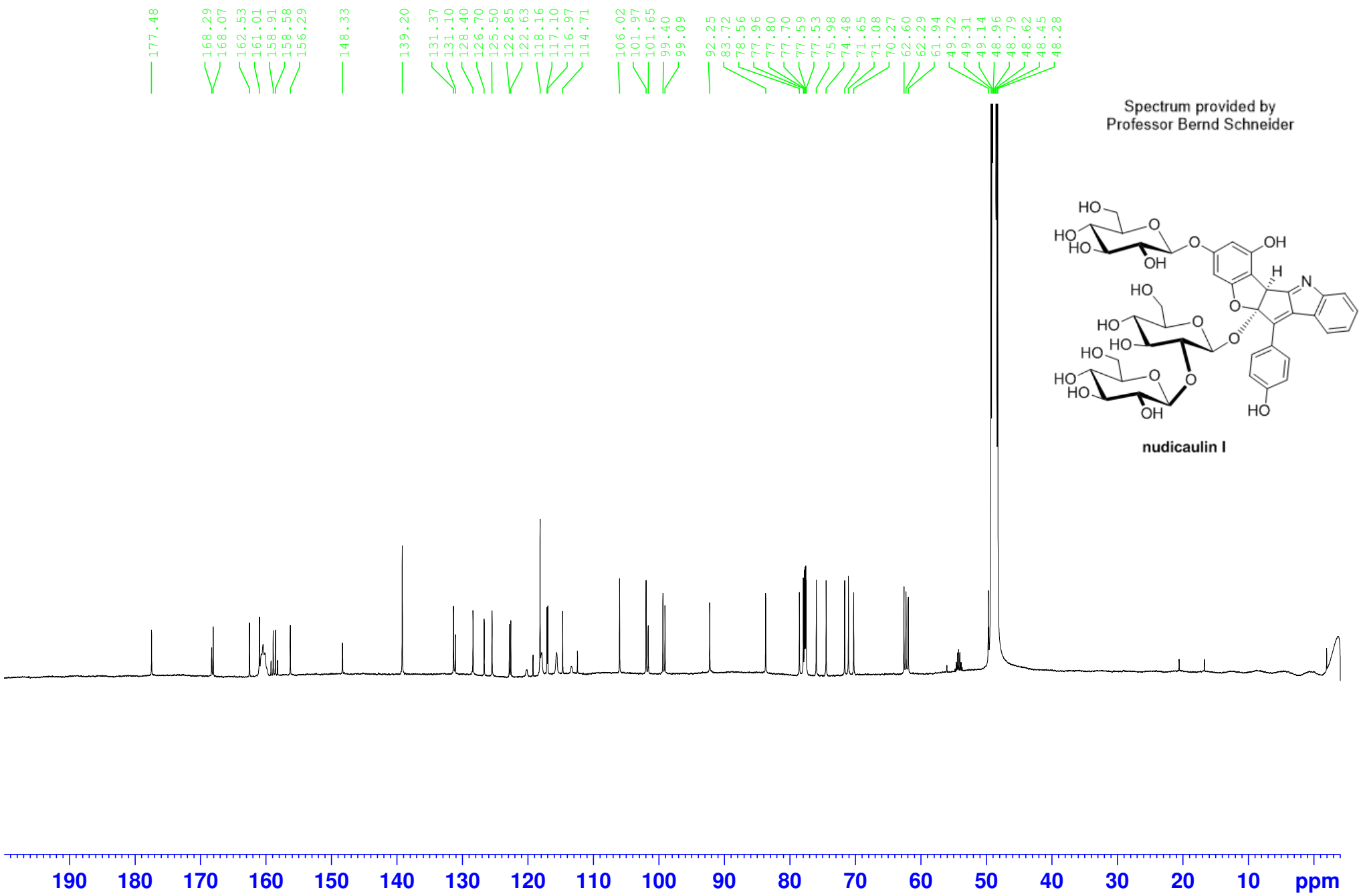

8.64 8.62 8.58 8.56 8.32 8.30 8.29 7.74 7.72 7.67 7.65 7.63 7.60 7.60 7.59 7.58 7.58 7.57 7.17 7.15 7.15 7.13 6.36 6.36 6.34 6.34 6.30 6.29 6.28 5.80 5.63 5.10 5.08 4.97 4.95 4.83 4.81 4.79 4.53 4.51 3.88 3.87 3.85 3.84 3.83 3.80 3.73 3.70 3.70 3.68 3.66 3.65 3.65 3.64 3.63 3.62 3.61 3.60 3.59 3.57 3.55 3.45 3.44 3.42 3.40 3.40 3.39 3.38 3.35 3.33 3.32 3.32 3.31 3.31 3.28 3.26 3.25 3.25 3.23 3.22 3.21 3.20 3.08 3.08 3.07 3.06 3.00
4a
4b
4a:4b, 2:3
400 MHz, methanol-d4
9 8 7 6 5 4 3 2 1 0 ppm
2.04 2.69 2.49 2.65 2.70 2.84 5.34 2.05 2.04 1.00 0.71 1.11 1.78 4.83 1.06 4.29 11.29 13.92 10.86

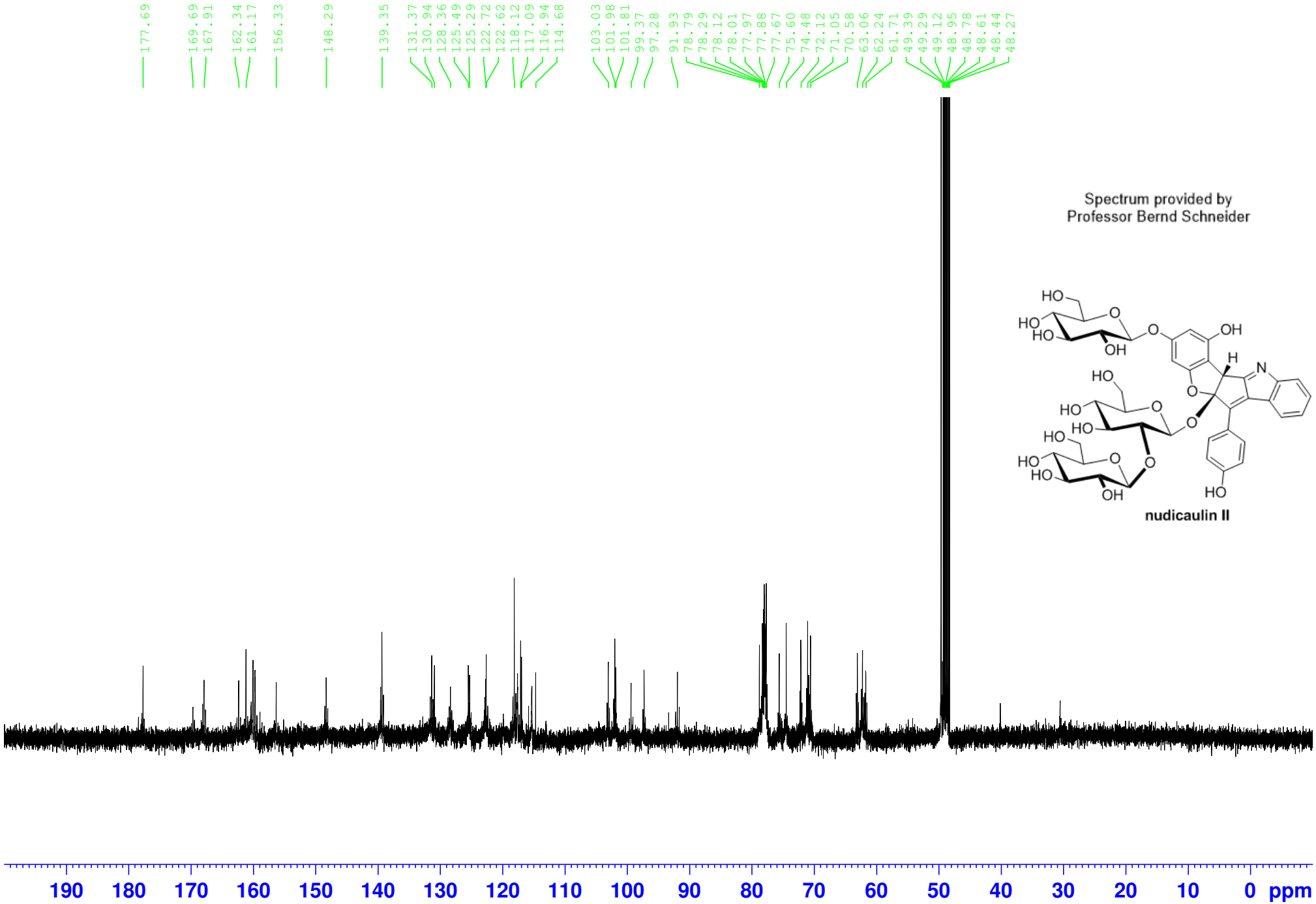

8.62 8.60 8.56 8.54 8.30 8.28 8.26 7.72 7.70 7.64 7.62 7.60 7.56 7.56 7.55 7.54 7.54 7.15 7.14 7.13 7.12 6.35 6.33 6.33 6.28 6.28 6.27 6.26 5.77 5.61 5.09 5.07 4.94 4.92 4.82 4.80 4.80 4.78 4.52 4.50 3.87 3.84 3.84 3.83 3.81 3.79 3.72 3.70 3.69 3.68 3.67 3.65 3.64 3.62 3.60 3.58 3.56 3.54 3.43 3.42 3.41 3.41 3.38 3.37 3.35 3.33 3.33 3.32 3.31 3.31 3.31 3.30 3.27 3.25 3.25 3.23 3.21 3.20 3.19 3.11 3.10 3.10 3.08 3.07 3.06 3.05
4a
4b
4a:4b, 2:3
400 MHz, methanol-d4
(1% d-TFA)
9 8 7 6 5 4 3 2 1 0 ppm
1.51 2.00 1.73 1.66 1.80 1.87 3.35 1.44 1.49 1.04 2.77 1.11 0.93 2.60 0.68 3.83 10.43 12.91 12.22


177.61
169.65
168.27
168.11
167.89
162.56
162.39
161.24
161.06
160.28
159.96
159.47
159.05
158.63
158.22
156.36
148.27
139.36
139.18
131.39
131.10
130.98
128.41
128.36
126.75
125.51
125.43
125.25
122.76
122.61
120.10
118.23
118.17
117.28
117.19
115.15
114.45
111.62
106.03
103.14
102.05
101.92
101.76
99.52
99.47
99.29
97.33
92.35
92.08
83.74
78.79
78.55
78.33
78.21
78.04
77.98
77.87
77.71
77.61
77.53
76.01
75.65
74.54
72.19
71.70
71.12
70.74
70.65
70.40
63.13
62.67
62.30
62.05
61.92
61.78
54.47
54.24
54.02
53.79
49.77
49.49
49.27
49.06
48.85
48.63
48.42
48.21
Peaks from CF3CO2D
+ trace amount of CF3CO2CD3
4a
4b
4a:4b, 2:3
100 MHz, methanol-d4
(1% d-TFA)
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm


Edited HSQC, methanol-d4 (1% d-TFA)
5.63 | 49.8
5.80 | 49.3
ppm
60
80
100
120
140
160
180
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
ppm
4a
4b


ROESY, methanol-d4 (1% d-TFA)
tmix = 230 ms
4a
4b
ppm
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5


177.48
168.29
168.07
162.53
161.01
158.91
158.58
156.29
148.33
139.20
131.37
131.10
128.40
126.70
125.50
122.85
122.63
118.16
117.10
116.97
114.71
106.02
101.97
101.65
99.40
99.09
92.25
83.72
78.56
77.96
77.80
77.70
77.59
77.53
75.98
74.48
71.65
71.08
70.27
62.60
62.29
61.94
49.72
49.31
49.14
48.96
48.79
48.62
48.45
48.28
Spectrum provided by
Professor Bernd Schneider
nudicaulin I
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm


177.69
169.69
167.91
162.34
161.17
156.33
148.29
139.35
131.37
130.94
128.36
125.49
125.29
122.72
122.62
118.12
117.09
116.94
114.68
103.03
101.98
101.81
99.37
97.28
91.93
78.79
78.29
78.12
78.01
77.97
77.88
77.67
75.60
74.48
72.12
71.05
70.58
63.06
62.24
61.71
49.39
49.29
49.12
48.95
48.78
48.61
48.44
48.27
Spectrum provided by
Professor Bernd Schneider
nudicaulin II
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm