Electronic Supplementary Material (ESI) for RSC Advances

Supplementary Information

Developing highly active small molecule ice recrystallization inhibitors based upon *C*-linked antifreeze glycoprotein analogues

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Table of Contents

Ice recrystallization inhibition (IRI) assay

Sample analysis for IRI activity was performed using the "splat cooling" method as previously described.[1] In this method, the analyte was dissolved in phosphate buffered saline (PBS) solution and a 10 μL droplet of this solution was dropped from a micropipette through a two meter high plastic tube (10 cm in diameter) onto a block of polished aluminum precooled to approximately -80 °C. The droplet froze instantly on the polished aluminum block and was approximately 1 cm in diameter and 20 μm thick. This wafer was then carefully removed from the surface of the block and transferred to a cryostage held at -6.4 °C for annealing. After a period of 30 min, the wafer was photographed between crossed polarizing filters using a digital camera (Nikon CoolPix 5000) fitted to the microscope. A total of three images were taken from each wafer. During flash freezing, ice crystals spontaneously nucleated from the supercooled solution. These initial crystals were relatively homogeneous in size and quite small. During the annealing cycle, recrystallization occurred, resulting in a dramatic increase in ice crystal size. A quantitative measure of the difference in recrystallization inhibition of two compounds X and Y is the difference in the dynamics of the ice crystal size distribution. Image analysis of the ice wafers was performed using a novel domain recognition software (DRS) program.[2] This processing employed the Microsoft Windows Graphical User Interface to allow a user to visually demarcate and store the vertices of ice domains in a digital micrograph. The data was then used to calculate the domain areas. All data was plotted and analyzed using Microsoft Excel. The mean grain (or ice crystal) size (MGS) of the sample was compared to the MGS of the control PBS solution for that same day of testing. IRI activity is reported as the percentage of the MGS (% MGS) relative to the PBS control, and the % MGS for each sample was plotted along with its standard error of the mean. Small percentages represent a small MGS, which is indicative of high IRI activity.

Thermal Hysteresis (TH) assay

Nanoliter osmometry was performed using a Clifton nanoliter osmometer (Clifton Technical Physics, Hartford, NY), as described by Chakrabartty and Hew. [3] All of the measurements were performed in doubly distilled water. Ice crystal morphology was observed through a Leitz compound microscope equipped with an Olympus 20× (infinity-corrected) objective, a Leitz Periplan 32X photo eyepiece, and a Hitachi KPM2U CCD camera connected to a Toshiba MV13K1 TV/VCR system. Still images were captured directly using a Nikon CoolPix digital camera.

Experimental Section

General Experimental

All anhydrous reactions were performed in flame-dried glassware under a positive pressure of dry argon. Air- or moisture-sensitive reagents and anhydrous solvents were transferred with dry syringes or cannulae. All flash chromatography was performed with E. Merck silica gel 60 (230-400 mesh). All solution-phase reactions were monitored using analytical thin layer chromatography (TLC) with 0.2 mm precoated silica gel aluminum plates 60 F254 (E. Merck). Components were visualized by illumination with a short-wavelength (254 nm) ultraviolet light and/or staining (ceric ammonium molybdate, potassium permanganate, ninhydrin, vanillin or orcinol stain solution). Dry-vacuum chromatography was carried out according to the protocol outlined by Pedersen and Rosenbohm.[4] All solvents used for anhydrous reactions were distilled. Tetrahydrofuran (THF) was freshly distilled from a solution preserved with sodium and benzophenone under nitrogen. Dichloromethane (DCM), triethylamine, toluene and diisopropylethylamine (DIPEA) were distilled over calcium hydride. N,N-Dimethylformamide (DMF) was stored over activated 4 Å molecular sieves under argon. Following work-up, standard procedure was to dry organic phases with anhyrouds magnesium sulfate, filter the solution through a glass-wool plug, and concentrate the filtrate under reduced pressure. ^{1}H (300, 400 or 500 MHz) and ^{13}C NMR (75, 101 or 126 MHz) spectra were recorded at ambient temperature, unless otherwise indicated, on a Bruker Avance 300, Bruker Avance 400, Bruker Avance 500, or Varian Inova 500 spectrometer. Deuterated chloroform ($CDCl_3$), methanol (CD_3OD or MeOD), water (D_2O), dimethyl sulfoxide (DMSO-d6), or acetone ($(CD_3)_2CO$) were used as NMR solvents. Chemical shifts are reported in ppm downfield from trimethylsilane (TMS) or the solvent residual peak as an internal standard. Splitting patterns are designated as follows: s, singlet; d, doublet; t, triplet; q, quartet; p, quintet; sext, sextet; sept, septuplet; m, multiplet; and br, broad. Low resolution mass spectrometry (LRMS) was performed on a Micromass Quatro-LC Electrospray spectrometer with a pump rate of 20 μL/min using electrospray ionization (ESI), a Voyager DE-Pro matrix-assisted laser desorption/ionization-time-of-flight (MALDI-TOF) (Applied Biosystem, Foster City, CA) mass spectrometer operated in the reflectron/positive ion mode with DHB in 20% EtOH/H_2O as the MALDI matrix, or a Bruker Microflex MALDI-TOF mass spectrometer with DHB in 20% acetonitrile/H_2O as the MALDI matrix. Analytical and preparatory scale RP-HPLC were carried out with Varian Polaris C-18 columns on a Varian Prostar HPLC system equipped with a variable wavelength detector (ProStar 330 PDA).

Compounds below are in order of appearance in the manuscript.

General protocol for solid-phase glycopeptide synthesis

The syntheses of the peptides were carried out using an Advanced Chem Tech APEX 396 automated peptide synthesizer (40 wells), equipped with a dual arm system and argon atmosphere controlled from an IBM PC using *Advanced Chem Tech* version 1.6 software. Preloaded Fmoc-Gly-Wang resin was swollen in DMF for 1 hour followed by filtration, and then were subjected to 20% piperidine in DMF twice successively for 30 mins. Peptide couplings were carried out according to standard protocols for Fmoc solid phase peptide synthesis (SPPS) (Fig. S1) using DIPEA and HCTU as coupling agent.[5,6] All glycine residues were coupled using 5 equivalents of amino acid per functionalized position on the resin with 1 hour reaction times. Glycoconjugate **5a**[6] was coupled using 1.5 equivalents of amino acid per functionalized position on the resin with 24 hour reaction times. Following the coupling of each residue deprotection of the Fmoc moiety was accomplished by treatment with 20% piperidine in DMF twice successively for 30 mins. Before and after each coupling, the beads were shaken 4 times with 4 mL of DMF followed by filtration. Following the synthesis the beads were washed extensively with DMF (6 x 4 mL), MeOH (6 x 4 mL), DCM (6 X4 mL), hexanes (6 x 4 mL), and finally by ethanol (3 x 6 mL) and then removed from the synthesizer and stored in a desiccator under vacuum in the presence of P_2O_5 until required. Glycopeptides were cleaved from the Wang resin using 92.5:5:2.5 (v/v/v) TFA: triisopropylsilane: water. Volatiles were removed under a continuous air-flow. The residue was triturated with hexanes and diethyl ether successively to remove hydrophobic impurities. The remaining residue was re-dissolved in 0.1 M sodium methoxide in methanol and stirred for 3 to 6 hours before being neutralized with trifluoroacetic acid. Solvent was removed, the residue resuspended in doubly distilled water and passed through a SPE cartridge (0 % to 70 % acetonitrile in water; the 0 % fraction was discarded, the other eluants were combined) and lyophilized before the crude mass was determined. The lyophilized peptide was purified using RP-HPLC (isocratic at 1.5 % acetonitrile in water, then a ramp to 25% acetonitrile in water over 35 mins followed by isocratic flow at 75 % acetonitrile in water for 10 mins).

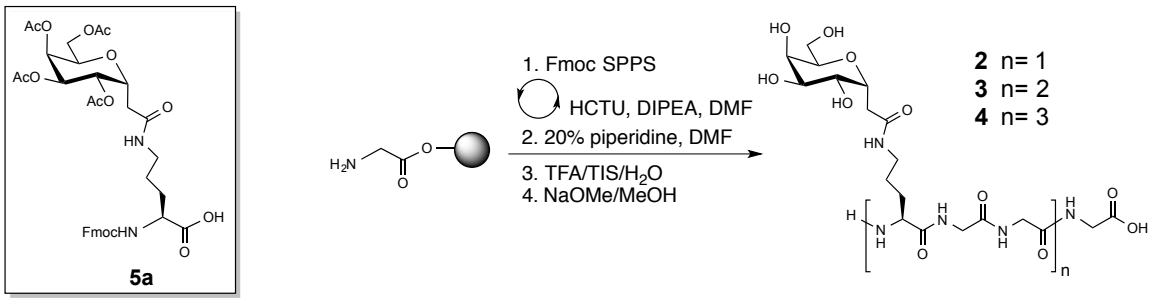


Fig. S1 Solid-phase synthesis of glycopeptides **2**-**4**.

Glycopeptide 2

Glycopeptide **2** was prepared using 200 mg of Wang resin according to standard Fmoc protocols (0.122 mmol scale) using Fmoc-protected galactosyl-ornithine building block **5a**.[6] The compound was cleaved off the bead and purified through preparatory TLC (60% methanol in water). The product was eluted off the silica using pure water and was filtered through a sub-micron filter and lyophilized to yield 27 mg (0.053 mmol) of **2** as a white powder in 44 % yield.

^{1}H NMR (500 MHz, D_2O) δ_{ppm} 7.21 (NH, bs) 4.53 (1H, ddd , J = 10.6, 5.8, 4.2 Hz), 4.18-3.99 (6H, m), 3.92-3.81 (3H, m), 3.79 (1H, dd, J = 10.0, 3.1 Hz), 3.73 (2H, d, J = 5.8 Hz), 3.29 (2H, t, J = 6.4 Hz), 2.72 (1H, dd, J = 15.1, 10.8 Hz), 2.63 (1H, dd, J = 15.0, 4.2 Hz), 2.02-1.89 (2H, m), 1.71-1.61 (2H, m); **^{13}C NMR** (126 MHz, D_2O) δ_{ppm} 181.2, 173.7, 171.6, 171.1, 169.5, 73.1, 72.5, 69.5, 68.9, 67.5, 61.0, 53.0, 43.3, 42.5, 42.4, 38.5, 32.3, 28.1, 23.2. **ESI-MS** *m/z* calcd for $C_{19}H_{33}N_5O_{11}$ $[M + H]^+$: 508.23; $[M + Na]^+$: 530.21. Found 508.24, 530.22.

Glycopeptide 3

Glycopeptide **3** was prepared using 100 mg of Wang resin according to standard Fmoc protocols (0.061 mmol scale) using Fmoc-protected galactosyl-ornithine building block **5a**.[6] The peptide was cleaved off the bead as described above and purified through RP-HPLC under the conditions described above. The bulk of the acetonitrile was removed, and the remaining solvent was removed through lyophilization to yield 20 mg (0.021 mmol) of **3** as a white powder in 35 % yield.

^{1}H NMR (500 MHz, D_2O) δ_{ppm} 4.45 (2H, dt, J = 10.2, 5.0 Hz), 4.32 (1H, ddd, J = 9.1, 5.2, 5.4 Hz), 4.05-3.83 (12H, m), 3.81-3.77 (3H, m), 3.75-3.69 (4H, m), 3.68-3.59 (4H, m), 3.20 (4H, dd, J = 13.6, 6.8 Hz), 2.64 (2H, dd, J = 14.9, 10.8 Hz), 2.56 (2H, dd, J = 14.7, 5.5 Hz), 1.89-1.64 (4H, m), 1.63-1.49 (4H, m); **^{13}C NMR** (126 MHz, D_2O) δ_{ppm} 179.8, 173.6, 173.51, 173.49, 171.8, 171.6, 171.5, 171.3, 171.0, 72.9, 72.9, 72.5, 72.4, 69.5, 69.5, 68.7, 68.7, 67.4, 67.4, 60.83, 60.78, 53.6, 53.2, 43.2, 43.1, 42.5, 42.3, 42.2, 38.65, 38.60, 32.3, 32.3, 28.3, 28.0, 24.7, 24.1. **ESI-MS** *m/z* calcd for $C_{36}H_{61}N_9O_{20}$ $[M + H]^+$: 940.41; $[M + K]^+$: 978.37. Found: 940.64, 978.59.

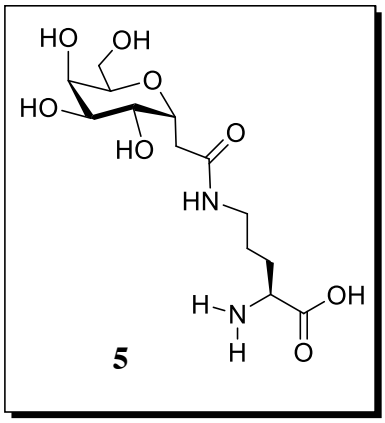
Glycopeptide 4

Glycopeptide **4** was prepared using 100 mg of Wang resin according to standard Fmoc protocols (0.061 mmol) using Fmoc-protected galactosyl-ornithine building block **5a**.[6] The peptide was cleaved off the bead as described above and purified through RP-HPLC under the conditions described above. The bulk of the acetonitrile was removed, and the remaining solvent was removed through lyophilization to yield 26 mg (0.019 mmol) of **4** as a white powder in 31 % yield.

^{1}H NMR (500 MHz, D_2O) δ_{ppm} 4.45 (3H, ddd, J = 10.7, 5.2, 5.2 Hz), 4.35-4.27 (2H, m), 4.04-3.89 (18H, m), 3.79 (3H, t, J = 6.0 Hz), 3.76-3.68 (6H, m), 3.67-3.62 (6H, m), 3.23-

3.16 (6H, m), 2.63 (3H, dd, *J* = 14.8, 10.8 Hz), 2.55 (3H, dd, *J* = 15.0, 4.4 Hz), 1.90-1.78 (3H, m), 1.77-1.66 (3H, m), 1.65-1.43 (6H, m); **^{13}C NMR** (126 MHz, D_2O) δ_{ppm} 181.0, 173.7, 173.6, 171.9, 171.5, 171.4, 171.3, 171.1, 72.9, 72.6, 72.5, 69.6, 68.7, 67.5, 60.9, 60.8, 53.7, 52.9, 42.9, 42.5, 42.4, 42.3, 38.7, 38.5, 32.4, 28.0, 24.8, 23.9. **ESI-MS** *m/z* calcd for $C_{19}H_{33}N_5O_{11}$ $[M + H]^+$: 508.50; $[M + K]^+$: 530.48. Found: 508.24, 530.22.

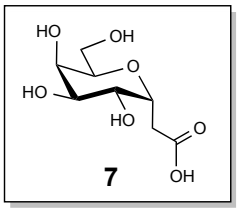
Galactosyl-Ornithine Derivative 5



5

Fmoc-protected galactosyl-ornithine building block **5a**[6] (100.2 mg, 0.138 mmol) was dissolved in 3 mL of methanol, 1 mL of water, and 2 mL of diethyl ether with stirring. Piperidine (1 mL, 10.1 mmol) was added and the mixture was allowed to stir for 20 minutes. At this point, 6N NaOH (1 mL) was added and the reaction mixture was stirred for an addition 5 hours. The two phases were separated and the aqueous phase was washed twice with diethyl ether. The aqueous layer was concentrated and redissolved in minimum TFA. Ether was added until the solution became cloudy and the solution was allowed to stand at 4 ºC for 12 hours. The precipitate was collected by filtration, redissolved in water and lyophilized to yield 34 mg of **5** as a white powder (73 % yield). **^{1}H NMR** (400 MHz, D_2O) δ_{ppm} 4.49 (1H, ddd, *J* = 10.5, 5.9, 4.8 Hz), 4.02 (1H, dd, *J* = 9.9, 6.0 Hz), 3.98 (1H, dd, *J* = 3.2, 1.5 Hz), 3.82 (1H, ddd, *J* = 6.3, 5.0, 1.0 Hz), 3.77-3.72 (2H, m), 3.70 (1H, d, *J* = 6.7 Hz), 3.69 (1H, d, *J* = 5.3 Hz), 3.25 (2H, t, *J* = 6.8 Hz), 2.67 (1H, dd, *J* = 14.9, 10.6 Hz), 2.59 (1H, dd, *J* = 15.0, 4.5 Hz), 1.95-1.79 (2H, m), 1.70-1.50 (2H, m); **^{13}C NMR** (101 MHz, D_2O) δ_{ppm} 181.5, 174.6, 73.0, 72.6, 69.6, 68.8, 67.6, 60.9, 54.4, 28.8, 32.4, 27.8, 24.3. **ESI-MS** *m/z* calcd for $C_{13}H_{24}N_2O_8$ $[M + H]^+$: 337.16; $[M + Na]^+$: 359.14; $[M + K]^+$: 375.12. Found: 337.18, 359.18, 375.20.

2-(α-D-galactopyranosyl)ethanoic acid (7)

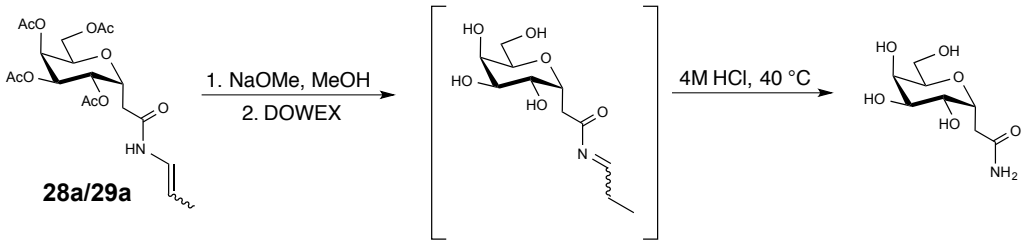


7

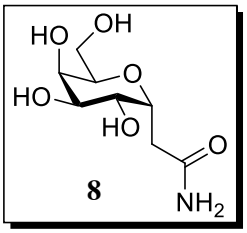
Carboxylic acid **6** (163 mg, 0.418 mmol) was dissolved in 5 mL of 0.1 M NaOMe in methanol and stirred for six hours. Dowex-50X resin was added and the solution was stirred an additional five minutes before the resin was removed by filtration and washed with methanol. Solvent was removed *in vacuo* and 83 mg of pure **7** was obtained as a white powder (89 % yield).

^{1}H NMR (300 MHz, D_2O) δ_{ppm} 4.89 (1H, dt, *J* = 7.1, 5.4 Hz), 4.68 (1H, dd, *J* = 6.8, 5.7 Hz), 4.12 (1H, t, *J* = 3.0 Hz), 4.01-3.89 (2H, m), 3.85 (1H, t, *J* = 10.2 Hz), 3.72 (1H, dd, *J* = 12.0, 3.9 Hz), 2.94 (1H, dd, *J* = 18.3, 7.2 Hz), 2.76 (1H, dd, *J* = 18.4, 5.1 Hz); **^{13}C NMR** (76 MHz, D_2O) δ_{ppm} 178.4, 83.1, 75.4, 70.7, 69.5, 67.9, 59.6, 33.0. **ESI-MS** *m/z* calcd for $C_8H_{13}O_7$ $[M-H]^-$: 221.07. Found: 221.05.

*Synthesis of Primary Amide **8***



2-(α-D-galactopyranosyl)acetamide (8)



A mixture of *Z*- and *E*-*N*-(1-propenyl)-2-(2,3,4,6-tetra-*O*-acetyl-α-D-galactopyranosyl)ethylamide (**28a** and **29a**) (10 mg, 0.023 mmol) were dissolved in 0.1 M NaOMe in methanol (5 mL) and stirred for 3 hours. Solvent was removed under reduced pressure and the crude deprotected product was redissolved in water. DOWEX 50WX8 (50-100 mesh) ion exchange resin was added and the reaction stirred for one hour, to isomerize the enamide to the imide, and then diluted with 4 M HCl and warmed to 40 ºC at 700 mbar. The reaction mixture was neutralized with 10 % sodium hydroxide to pH = 9 and filtered through a sintered glass frit. Solvent was removed *in vacuo* and the crude product was redissolved in minimum boiling methanol. The supernatant was decanted, concentrated and the process repeated on this crude product.[1] The recovered product from the supernatant was lyophilized to provide 2.1 mg of **8** as a white powder (41 % yield). Spectral data is consistent with the literature.[7]

^{1}H NMR (500 MHz, D_2O) δ_{ppm} 4.50 (1H, dd, J = 6.8, 5.7 Hz), 3.94 (1H, t, J = 3.0, 3.0 Hz), 3.82-3.77 (2H, m), 3.67 (1H, dd, J = 12.1, 8.5 Hz), 3.61-3.48 (2H, m), 2.75 (1H, dd, J = 18.3, 7.3 Hz), 2.59 (1H, dd, J = 18.4, 5.2 Hz); **^{13}C NMR** (126 MHz, D_2O) δ_{ppm} 178.3, 82.9, 75.3, 70.6, 69.4, 67.8, 59.6, 32.9. **ESI-MS** *m/z* calcd for $C_8H_{15}NO_6$ $[M + H]^+$: 222.10; $[M + Na]^+$: 244.08. Found: 222.16, 244.21.

General Protocol for the preparation of alkylated 2-(galactopyranosyl)ethylamide derivatives

CDI (0.95 eq.) or HCTU (0.95 eq.) and carboxylic acid **6**[6] (1 eq.) were dissolved in DCM or DMF (0.13 M) into a flame dried round-bottom flask under an argon atmosphere containing activated powdered 4 Å molecular sieves and stirred for 30 minutes. DIPEA (2-3 eq.) and the appropriate amine were injected and the flask was sealed under argon and allowed to stir until TLC indicated completion of the reaction (16-72 hours). The reaction mixture was diluted by a factor of 2 with ethyl acetate and filtered through a

[1] The precipitate also showed product (as the salt), but contaminated with several organic impurities.

celite pad, which was then washed twice with ethyl acetate, to remove the sieves. The reaction mixture was then washed sequentially with 10 % HCl, saturated sodium bicarbonate and brine. The organic phase was dried with magnesium sulfate, filtered through a glass wool plug, and concentrated under reduced pressure. The crude product was resuspended in DCM and purified through flash chromatography to provide the title compounds. A general synthetic scheme is provided in Fig. S2.

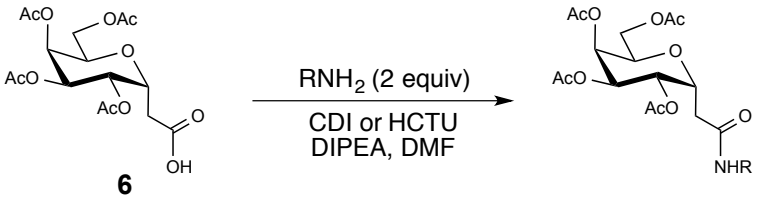
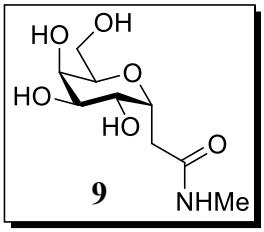


Fig. S2 General scheme for the preparation of alkylated derivatives.

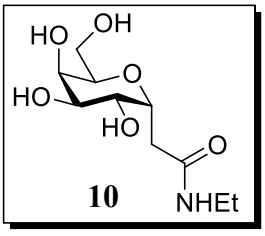
N-Methyl-2-(α-D-galactopyranosyl)ethylamide (9)



Using the general coupling conditions (Fig. S2), 100 mg (0.26 mmol) of carboxylic acid **6**, 42 mg of CDI (0.25 mmol), 19 mg of methylamine hydrochloride (0.28 mmol) and 50 µL of DIPEA, (0.29 mmol), were stirred for 20 hours; following standard work-up, the crude product was directly subjected to deacetylation by the addition of 10 mL of 0.1 M NaOMe in MeOH. The reaction mixture was stirred for 18 hours, at which point it was neutralized with amberlite IR-120 resin beads to pH = 6. The beads were then filtered off and the solvent removed *in vacuo*. The crude product was purified by preparatory TLC (3:1:1:1 EtOAc: MeOH: CH_3CN: H_2O). Removing the solvent under reduced pressure yielded **9** as a white powder (40 mg, 65%).

^{1}H NMR (500 MHz, *MeOD*) δ_{ppm} 4.38 (1H, dt, *J* = 5.0, 13.0 Hz), 3.92 (1H, dd, *J* = 3.5, 4.0 Hz), 3.88-3.83 (2H, m), 3.79-3.75 (1H, m), 3.67-3.60 (2H, m), 2.70 (3H, s), 2.58 (1H, dd, *J* = 13, 19 Hz), 2.45 (1H, dd, *J* = 4.5, 19 Hz); **^{13}C NMR** (126 MHz, *MeOD*) δ_{ppm} 174.9, 75.1, 72.2, 72.1, 70.2, 69.6, 61.7, 34.4, 26.4. **ESI-MS** *m/z* calcd for $C_9H_{15}NO_6$ $[M + H]^+$: 236.11; $[M + Na]^+$: 258.10; . Found: 236.11, 258.09.

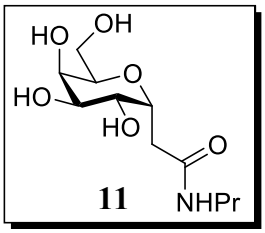
N-Ethyl-2-(α-D-galactopyranosyl)ethylamide (10)



Using the general coupling conditions (Fig. S2), 50 mg (0.13 mmol) of carboxylic acid **6**, 64 mg of HCTU (0.16 mmol), 53 mg of ethylamine hydrochloride (0.65 mmol) and 230 µL of DIPEA, (1.3 mmol), were stirred for 20 hours; following standard work-up, the crude product was directly subjected to deacetylation by the addition of 10 mL of 0.1 M NaOMe in MeOH. The reaction mixture was stirred for 18 hours, at which point it was neutralized with amberlite IR-120 resin beads to pH = 6. The beads were then filtered off and the solvent removed *in vacuo*. The crude product was purified by preparatory TLC

(3:1:1:1 EtOAc: MeOH: CH_3CN: H_2O). Removing the solvent under reduced pressure yielded **10** as a white powder (6.5 mg, 20%).
^{1}H NMR (500 MHz, *MeOD*) δ_{ppm} 4.39 (1H, dt, *J* = 4.0, 10.5 Hz), 3.93 (1H, dd, *J* = 3.0, 3.5 Hz), 3.88-3.84 (2H, m), 3.79 (1H, ddd, J=11.0, 4.5, 3.0 Hz), 3.66-3.62 (2H, m), 3.20 (2H, q, *J* = 7.5 Hz), 2.58 (1H, dd, *J* = 15.0, 10.5 Hz), 2.44 (1H, dd, *J* = 15.0, 3.5 Hz), 1.11 (3H, t, *J* = 7.0 Hz); **^{13}C NMR** (126 MHz, *MeOD*) δ_{ppm} 174.0, 75.0, 72.4, 72.1, 70.2, 69.6, 61.7, 35.4, 34.5, 14.8. **ESI-MS** *m/z* calcd for $C_{10}H_{17}NO_6$ $[M + H]^+$: 250.13; $[M + Na]^+$: 272.11. Found 250.12, 272.02.

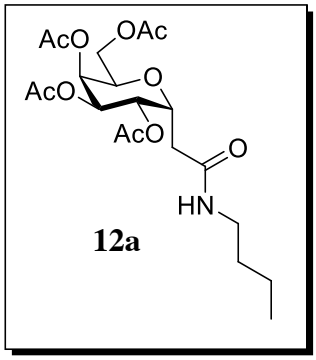
_N_-Propyl-2-(α-D-galactopyranosyl)ethylamide (11)



11

Using the general coupling conditions (Fig. S2), 100 mg (0.26 mmol) of carboxylic acid **6**, 124 mg of HCTU (0.31 mmol), 170 µL of propylamine (2.08 mmol) and 90 µL of DIPEA, (0.52 mmol), were stirred for 20 hours; following standard work-up, the crude product was directly subjected to deacetylation by the addition of 10 mL of 0.1 M NaOMe in MeOH. The reaction mixture was stirred for 18 hours, at which point it was neutralized with amberlite IR-120 resin beads to pH = 6. The beads were then filtered off and the solvent removed *in vacuo*. The crude product was purified by preparatory TLC (7:1:1:1 EtOAc: MeOH: CH_3CN: H_2O). Removing the solvent under reduced pressure yielded **11** as a white powder (51 mg, 45 % yield).
^{1}H NMR (300 MHz, *MeOD*) δ_{ppm} 7.98 (1H, t, *J* = 5.6 Hz), 4.41 (1H, ddd, *J* = 10.4, 4.8, 4.1 Hz), 3.95 (1H, t, *J* = 3.0, 3.0 Hz), 3.92-3.75 (3H, m), 3.69-3.61 (2H, m), 3.19-3.10 (2H, m), 2.62 (1H, dd, *J* = 15.2, 10.4 Hz), 2.47 (1H, dd, *J* = 15.2, 3.8 Hz), 1.53 (2H, quintet, *J* = 7.3 Hz), 0.93 (t, *J* = 7.4, 7.4 Hz, 1H); **^{13}C NMR** (75 MHz, *MeOD*) δ_{ppm} 174.2, 75.0, 72.4, 72.1, 70.2, 69.6, 61.7, 42.3, 34.5, 23.6, 11.8. **ESI-MS** *m/z* calcd for $C_{11}H_{19}NO_6$ $[M + H]^+$: 264.29. Found: 264.23.

_N_-Butyl-2-(2,3,4,6-tetra-_O_-acetyl-α-D-galactopyranosyl)ethylamide (12a)

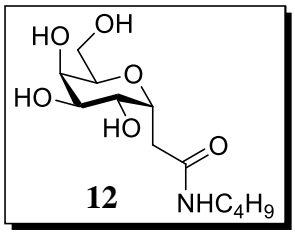


12a

Using the general coupling conditions (Fig. S2), 100 mg (0.26 mmol) of carboxylic acid **6**, 100 mg (0.24 mmol) of HCTU, 90 µL (0.50 mmol) of DIPEA, and 51 µL (0.52 mmol) of butylamine were stirred in 2 mL of DCM for 16 hours. Following standard work-up, 140 mg of crude yellow oil was recovered that was purified by flash chromatography (9:1 dichloromethane: methanol) to yield 110 mg of **12a** as a slightly yellow, thick oil (95 % yield).
^{1}H NMR (400 MHz, *$CDCl_3$*) δ_{ppm} 6.22 (1H, t, *J* = 5.4 Hz), 5.42 (1H, t, *J* = 2.8 Hz), 5.28 (1H, dd, *J* = 8.6, 4.7 Hz), 5.17 (1H, dd, *J* = 8.6, 3.3 Hz), 4.68 (1H, td, *J* = 9.3, 4.4 Hz), 4.26-4.15 (3H, m), 3.39-3.14 (2H, m), 2.58 (1H, dd, *J* = 15.5, 9.6 Hz), 2.43 (1H, dd, *J* = 15.5, 4.2 Hz), 2.13 (3H, s), 2.08 (3H, s), 2.06 (3H, s), 2.05 (3H, s), 1.56-1.44 (2H, m), 1.40-1.30 (2H, m), 0.93 (3H, t, *J* = 7.3 Hz); **^{13}C NMR** (101 MHz, *$CDCl_3$*) δ_{ppm} 170.4, 169.9, 169.7, 169.5, 169.0, 69.3, 68.8,

67.8, 67.7, 66.9, 61.2, 39.2, 34.3, 31.5, 20.60, 20.60, 20.59, 20.53, 19.9, 13.6. **ESI-MS** *m/z* calcd for $C_{20}H_{31}N_1O_{10}$ $[M + Na]^+$: 468.19. Found: 468.19.

***N*-Butyl-2-(α-D-galactopyranosyl)ethylamide (12)**

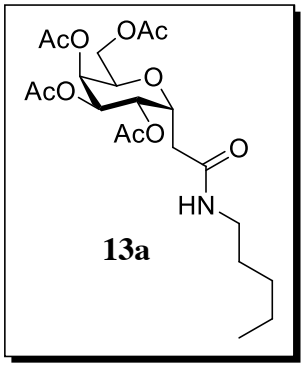


12

Butyl derivative **12a** (35 mg) was dissolved in 20 mL of 0.1 M NaOMe in methanol and stirred for four hours. Dowex-50X resin was added and the solution was stirred an additional five minutes before the resin was removed by filtration and washed with water and methanol successively. Solvent was removed in vacuo and the compound was purified through flash chromatography (6: 1: 1: 1, ethyl acetate: water: methanol: acetonitrile), concentrated and lyophilized to yield 18 mg of **12** as a white powder (82 % yield).

^{1}H NMR (400 MHz, D_2O) δ_{ppm} 4.47 (1H, ddd, J = 10.6, 5.9, 4.3 Hz), 4.01 (1H, dd, J = 9.9, 6.1 Hz), 3.98 (1H, dd, J = 3.3, 1.5 Hz), 3.81 (1H, dt, J = 6.1, 1.4 Hz), 3.73 (1H, dd, J = 9.9, 3.3 Hz), 3.67 (1H, d, J = 6.2 Hz), 3.67 (1H, d, J = 5.8 Hz), 3.26-3.11 (2H, m), 2.66 (1H, dd, J = 14.9, 10.9 Hz), 2.56 (1H, dd, J = 15.0, 4.2 Hz), 1.47 (2H, tt, J = 7.8, 7.2 Hz), 1.31 (2H, qt, J = 7.3, 7.2 Hz), 0.87 (3H, t, J = 7.3 Hz); **^{13}C NMR** (101 MHz, D_2O) δ_{ppm} 173.4, 73.0, 72.3, 69.6, 68.7, 67.5, 60.7, 39.2, 32.3, 30.4, 19.4, 12.9. **ESI-MS** *m/z* calcd for $C_{13}H_{25}N_1O_6$ $[M+H]^+$: 278.16. Found: 278.18.

***N*-Pentyl-2-(2,3,4,6-tetra-*O*-acetyl-α-D-galactopyranosyl)ethylamide (13a)**

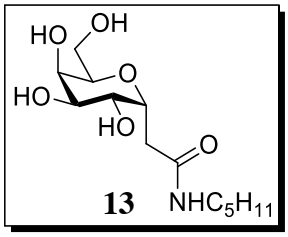


13a

Using the general coupling conditions (Fig. S2), 200 mg (0.51 mmol) of carboxylic acid **6**, 202 mg (0.48 mmol) of HCTU, 174 μL (1.0 mmol) of DIPEA, and 115 μL (1.0 mmol) of pentylamine were stirred in 4 mL of DCM for 16 hours. Following standard work-up, 220 mg of crude yellow oil was recovered that was purified by flash chromatography (4: 6 hexanes: ethyl acetate) to yield 172 mg of **13a** as a slightly yellow, thick oil (73 % yield).

^{1}H NMR (400 MHz, $CDCl_3$) δ_{ppm} 6.23 (1H, t, J = 5.5 Hz), 5.42 (1H, t, J = 2.9 Hz), 5.27 (1H, dd, J = 8.6, 4.7 Hz), 5.17 (1H, dd, J = 8.6, 3.3 Hz), 4.68 (1H, td, J = 9.2, 4.4, Hz), 4.31-4.08 (3H, m), 3.33-3.15 (2H, m), 2.58 (1H, dd, J = 15.5, 9.6 Hz), 2.43 (1H, dd, J = 15.5, 4.2 Hz), 2.13 (3H, s), 2.08 (3H, s), 2.06 (3H, s), 2.05 (3H, s), 1.51 (2H, q, J = 6.9 Hz), 1.39-1.22 (4H, m), 0.90 (3H, t, J = 6.9 Hz); **^{13}C NMR** (101 MHz, $CDCl_3$) δ_{ppm} 170.5, 169.9, 169.7, 169.5, 169.0, 69.4, 68.8, 67.9, 67.7, 66.9, 61.2, 39.6, 34.4, 29.2, 29.0, 22.3, 20.7, 20.7, 20.7, 20.6, 13.9. **ESI-MS** *m/z* calcd for $C_{21}H_{33}N_1O_{10}$ $[M + H]^+$: 460.20; $[M + Na]^+$: 482.18. Found: 460.26, 482.26.

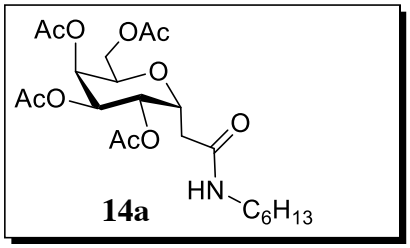
***N*-Pentyl-2-(α-D-galactopyranosyl)ethylamide (13)**



Acetylated pentyl derivative **13a** (72 mg) was dissolved in 10 mL of 0.1 M NaOMe in methanol and stirred for four hours. Dowex-50X resin was added and the solution was stirred an additional five minutes before the resin was removed by filtration and washed with water and methanol successively. The filtrate was concnetrated, resuspended in water and lyophilized to provide 40 mg of **13** as a white solid (87 % yield).

^{1}H NMR (400 MHz, D_2O) δ_{ppm} 4.47 (1H, ddd, J = 10.7, 5.9, 4.3 Hz), 4.01 (1H, dd, J = 9.9, 6.1 Hz), 3.98 (1H, dd, J = 3.2, 1.4 Hz), 3.81 (1H, dt, J = 6.0, 1.2 Hz), 3.73 (1H, dd, J = 10.0, 3.4 Hz), 3.67 (1H, d, J = 6.5 Hz), 3.67 (1H, d, J = 5.7 Hz), 3.25-3.08 (2H, m), 2.65 (1H, dd, J = 15.0, 11.0 Hz), 2.55 (1H, dd, J = 15.0, 4.2 Hz), 1.49 (2H, tt, J = 7.2, 7.0 Hz), 1.35-1.22 (4H, m), 0.85 (3H, t, J = 7.0 Hz); **^{13}C NMR** (101 MHz, D_2O) δ_{ppm} 173.4, 73.0, 72.3, 69.6, 68.7, 67.5, 60.7, 39.5, 32.3, 28.3, 28.0, 21.7, 13.2. **ESI-MS** *m/z* calcd for $C_{13}H_{25}N_1O_6$ $[M + H]^+$: 292.18; $[M + Na]^+$: 314.16; $[M + K]^+$: 330.13. Found: 292.21, 314.18, 330.17.

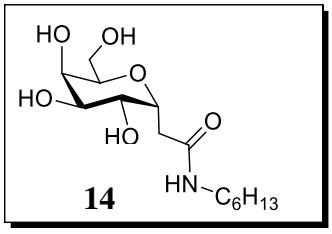
***N*-Hexyl-2-(2,3,4,6-tetra-*O*-acetyl-α-D-galactopyranosyl)ethylamide (14a)**



Using the general coupling conditions (Fig. S2), 100 mg (0.26 mmol) of carboxylic acid **6**, 100 mg (0.24 mmol) of HCTU, 60 μL (0.33 mmol) of DIPEA, and 100 μL (0.77 mmol) of hexylamine were stirred in 2 mL of DCM for 16 hours. Following standard work-up, 120 mg of crude yellow oil was recovered that was purified by flash chromatography (1: 1 hexanes: ethyl acetate) to yield 80 mg of **14a** as a clear, thick oil (65% yield).

^{1}H NMR (400 MHz, $CDCl_3$) δ_{ppm} 6.28 (1H, t, J = 5.3, Hz), 5.42 (1H, t, J = 2.6 Hz), 5.28 (1H, dd, J = 8.7, 4.8 Hz), 5.17 (1H, dd, J = 8. 7, 3.2 Hz), 4.69 (1H, dt, J = 9.2, 4.4 Hz, 1H), 4.27-4.15 (3H, m), 3.32-3.15 (2H, m), 2.59 (1H, dd, J = 15.48, 9.58 Hz), 2.44 (1H, dd, J = 15.47, 4.25 Hz), 2.13 (3H, s), 2.08 (3H, s), 2.06 (3H, s), 2.05 (3H, s), 1.50 (2H, q, J = 7.0 Hz), 1.39-1.21 (6H, m), 0.88 (3H, t, J = 6.62 Hz); **^{13}C NMR** (101 MHz, $CDCl_3$) δ_{ppm} 170.4, 169.9, 169.7, 169.5, 169.0, 69.3, 68.9, 67.8, 67.7, 66.9, 61.2, 39.6, 34.3, 31.3, 29.4, 26.5, 22.4, 20.6, 20.5, 13.9. **ESI-MS** *m/z* calcd for $C_{22}H_{35}N_1O_{10}$ $[M + H]^+$: 474.23; $[M + Na]^+$: 496.21. Found: 474.28, 496.26.

***N*-Hexyl-2-(α-D-galactopyranosyl)ethylamide (14)**



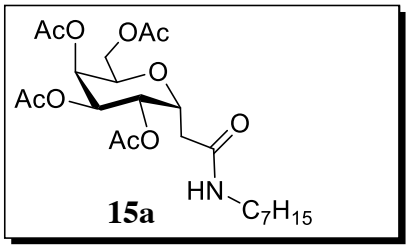
Hexyl derivative **14a** (75 mg, 0.16 mmol) was dissolved in 15 mL of 0.1 M NaOMe in methanol and stirred for four hours. Dowex-50X resin was added and the solution was stirred an additional five minutes before the resin was removed by filtration and washed with water and methanol successively. The filtrate was concentrated, and further purifed by preperatory TLC (6: 1: 1: 1, ethyl acetate: water: methanol:

acetonitrile), resuspended in water and lyophilized to provide 38 mg (0.12 mmol) of **14** as a white solid (78 % yield).

^{1}H NMR (400 MHz, *D_2O*) δ_{ppm} 4.47 (1H, m), 4.01 (1H, dd, *J* = 9.9, 6.1 Hz), 3.98 (1H, dd, *J* = 3.3, 1.4 Hz), 3.80 (1H, dt, *J* = 6.2, 1.3 Hz), 3.73 (1H, dd, *J* = 9.9, 3.4 Hz), 3.70-3.64 (2H, m), 3.26-3.07 (2H, m), 2.65 (1H, dd, *J* = 14.9, 11.0 Hz), 2.55 (1H, dd, *J* = 15.0, 4.1 Hz), 1.48 (2H, q, *J* = 7.3 Hz), 1.35-1.18 (6H, m), 0.84 (3H, t, *J* = 6.9 Hz); **^{13}C NMR** (101 MHz, *D_2O*) δ_{ppm} 173.3, 73.0, 72.3, 69.6, 68.7, 67.5, 60.6, 39.5, 32.3, 30.7, 28.3, 25.7, 21.9, 13.3. **ESI-MS** *m/z* calcd for $C_{14}H_{27}N_1O_6$ $[M + H]^+$: 306.19; $[M + Na]^+$: 328.17; $[M + K]^+$: 344.15. Found: 306.20, 328.18, 344.15.

N-Heptyl-2-(2,3,4,6-tetra-*O*-acetyl-α-D-galactopyranosyl)ethylamide (15a)

Using the general coupling conditions (Fig. S2), 145 mg (0.37 mmol) of carboxylic acid **6**, 146 mg (0.35 mmol) of HCTU, 130 μL (0.74 mmol) of DIPEA, and 111 μL (0.74 mmol) of heptylamine were stirred in 3 mL of DMF for 48 hours. Following standard work-up, 173 mg of crude yellow oil was recovered that was purified by flash chromatography (1: 1 hexanes: ethyl acetate) to yield 150 mg of **15a** as a clear, thick oil (83% yield).

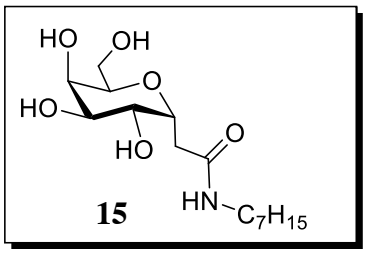


15a

^{1}H NMR (400 MHz, *$CDCl_3$*) δ_{ppm} 6.35 (1H, t, *J* = 5.6 Hz), 5.42 (1H, t, *J* = 3.0 Hz), 5.28 (1H, dd, *J* = 8.6, 4.7 Hz), 5.18 (1H, dd, *J* = 8.7, 3.3 Hz), 4.69 (1H, dt, *J* = 9.1, 4.5 Hz), 4.30-4.07 (3H, m), 3.30-3.16 (2H, m), 2.60 (1H, dd, *J* = 15.4, 9.5 Hz), 2.44 (1H, dd, *J* = 15.4, 4.4 Hz), 2.13 (3H, s), 2.08 (3H, s), 2.06 (3H, s), 2.05 (3H, s), 1.50 (2H, q, *J* = 6.8 Hz), 1.36-1.18 (8H, m), 0.88 (3H, t, *J* = 6.9 Hz); **^{13}C NMR** (101 MHz, *$CDCl_3$*) δ_{ppm} 170.5, 169.9, 169.8, 169.5, 169.2, 69.2, 28.7, 27.8, 27.6, 66.9, 61.2 39.5, 34.2, 31.5, 29.4, 28.8, 26.7, 22.4, 20.5, 20.4, 13.8. **Rf**= 0.77 (9: 1, DCM: methanol).

N-Heptyl-2-(α-D-galactopyranosyl)ethylamide (15)

Heptyl derivative **15a** (110 mg, 0.23 mmol) was dissolved in 16 mL of 0.1 M NaOMe in methanol and stirred for 12 hours. Dowex-50X resin was added and the solution was stirred an additional five minutes before the resin was removed by filtration and washed with water and methanol successively. The filtrate was concentrated, and dissolved in methanol. Diethyl ether was added until the solution became cloudy and was left to stand for 2 hours at -20 ºC. The solid was collected by filtration, resuspended in water and lyophilized to provide 57 mg (0.18 mmol) of **15** as a white solid (78 % yield).

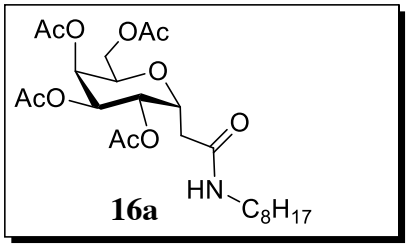


15

^{1}H NMR (300 MHz, *MeOD*) δ_{ppm} 4.40 (1H, td, *J* = 9.1, 4.0 Hz), 3.94 (1H, t, *J* = 2.9 Hz), 3.90-3.75 (3H, m), 3.68-3.59 (2H, m), 3.16 (2H, t, *J* = 7.1 Hz), 2.60 (1H, dd, *J* = 15.3, 10.4 Hz), 2.46 (1H, dd, *J* = 15.1, 3.9 Hz), 1.49 (2H, p, *J* = 6.5 Hz), 1.37-1.23 (8H, m), 0.89 (3H, t, *J* = 6.6 Hz); **^{13}C NMR** (126 MHz, *MeOD*) δ_{ppm} 174.2, 75.0, 72.4, 72.1,70.2,

69.6, 61.7, 40.6, 35.5, 33.0, 30.4, 30.2, 28.1, 23.7, 14.5. **ESI-MS** *m/z* calcd for $C_{15}H_{29}N_1O_6$ $[M + Na]^+$: 342.19. Found: 342.20.

N-Octyl-2-(2,3,4,6-tetra-*O*-acetyl-α-D-galactopyranosyl)ethylamide (16a)

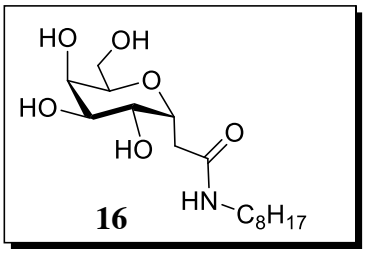


16a

Using the general coupling conditions (Fig. S2), 100 mg (0.26 mmol) of carboxylic acid **6**, 100 mg (0.24 mmol) of HCTU, 60 μL (0.33 mmol) of DIPEA, and 130 μL (0.78 mmol) of octylamine were stirred in 2 mL of DCM for 16 hours. Following standard work-up, 100 mg of crude brown oil was recovered that was purified by flash chromatography (1: 1 hexanes: ethyl acetate) to yield 55 mg of **16a** as a clear, thick oil (43% yield).

^{1}H NMR (400 MHz, *$CDCl_3$*) δ_{ppm} 6.18 (1H, t, *J* = 5.4, Hz), 5.42 (1H, t, *J* = 3.0 Hz), 5.28 (1H, dd, *J* = 8.6, 4.7 Hz), 5.16 (1H, dd, *J* = 8.6, 3.3 Hz), 4.68 (1H, dt, *J* = 9.3, 4.4 Hz), 4.27-4.15 (3H, m), 3.30-3.16 (2H, m), 2.57 (1H, dd, *J* = 15.5, 9.6 Hz), 2.43 (1H, dd, *J* = 15.5, 4.2 Hz), 2.13 (3H, s), 2.08 (3H, s), 2.05 (6H, s), 1.50 (2H, p, *J* = 6.7 Hz), 1.33-1.23 (10H, m), 0.88 (1H, t, *J* = 6.9 Hz); **^{13}C NMR** (101 MHz, *$CDCl_3$*) δ_{ppm} 170.4, 169.9, 169.7, 169.5, 169.1, 69.4, 68.9, 67.9, 67.7, 66.9, 61.2, 39.6, 34.4, 31.7, 29.53, 29.50, 29.17, 29.12, 26.9, 22.5, 20.65, 20.65, 20.65, 20.57, 14.0. **Rf** = 0.35 (2: 8, hexanes: ethyl acetate).

N-Octyl-2-(α-D-galactopyranosyl)ethylamide (16)

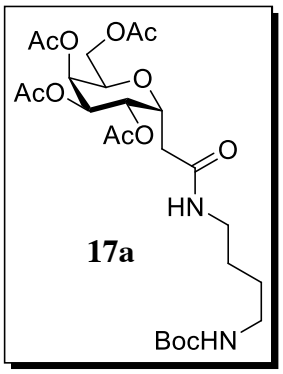


16

Octyl derivative **16a** (82 mg, 0.16 mmol) was dissolved in 15 mL of 0.1 M NaOMe in methanol and stirred for four hours. Dowex-50X resin was added and the solution was stirred an additional five minutes before the resin was removed by filtration and washed with water and methanol successively. The filtrate was concentrated, and further purifed by preperatory TLC (6: 1: 1: 1, ethyl acetate: water: methanol: acetonitrile), resuspended in water and lyophilized to provide 36 mg (0.10 mmol) of **16** as a white solid (70 % yield).

^{1}H **NMR** (400 MHz, *MeOD*) δ_{ppm} 4.34-4.20 (m, 1H), 3.86-3.76 (m, 1H), 3.80-3.76 (m, 1H), 3.62 (t, *J* = 6.0, 6.0 Hz, 1H), 3.58-3.43 (m, 1H), 3.04-2.92 (m, 1H), 2.46 (dd, *J* = 15.0, 10.9 Hz, 1H), 2.34 (dd, *J* = 14.9, 3.8 Hz, 1H), 1.39-1.24 (m, 1H), 1.20-1.00 (m, 1H), 0.68 (t, *J* = 6.6, 6.6 Hz, 1H); **^{13}C NMR** (101 MHz, *MeOD*) δ_{ppm} 174.2, 73.8, 73.6, 71.0, 69.7, 68.9, 61.6, 40.6, 33.4, 32.3, 29.65, 29.63, 29.58, 27.3, 23.2, 14.4. **ESI-MS** *m/z* calcd for $C_{13}H_{25}N_1O_6$ $[M + H]^+$: 334.22; $[M + Na]^+$: 356.41; $[M + K]^+$: 372.52. Found: 334.21, 356.19, 372.18.

_N_-[(4-_tert_-butoxycarbonylamino)butyl]-2-(2,3,4,6-tetra-_O_-acetyl-α-D-galactopyranosyl) ethylamide (17a)

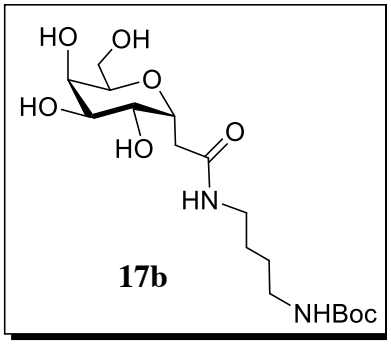


17a

Using the general coupling conditions (Fig. S2), 100 mg (0.26 mmol) of carboxylic acid **6**, 56 mg (0.34 mmol) of CDI, 60 μL (0.34 mmol) of DIPEA, and *tert*-Butyl-4-aminobutylcarbamate[8] (150 mg, 0.80 mmol) were stirred in 2 mL of DCM for 18 hours. Following standard work-up, the recovered residue was purified by flash chromatography (1:1, ethyl acetate: hexanes) to yield 106 mg (0.19 mmol) of **17a** as a clear thick gel that solidifies upon extended standing (73 % yield).

^{1}H NMR (400 MHz, *$CDCl_3$*) δ_{ppm} 6.59 (1H, bs), 5.41 (1H, t, *J* = 2.9 Hz), 5.29 (1H, dd, *J* = 8.7, 4.8 Hz), 5.17 (1H, dd, *J* = 8.7, 3.3 Hz), 4.85 (1H, bs), 4.70 (1H, dt, *J* = 9.3, 4.6 Hz), 4.28-4.13 (3H, m), 3.34-3.20 (2H, m), 3.17-3.09 (2H, m), 2.60 (1H, dd, *J* = 15.3, 9.6 Hz), 2.44 (1H, dd, *J* = 15.3, 4.5 Hz), 2.13 (3H, s), 2.07 (3H, s), 2.05 (6H, s), 1.56-1.50 (4H, m), 1.44 (9H, s); **^{13}C NMR** (101 MHz, *$CDCl_3$*) δ_{ppm} 170.4, 169.9, 169.7, 169.5, 169.2, 156.1, 79.0, 69.0, 69.0, 67.7, 67.7, 67.0, 61.1, 39.7, 39.1, 34.2, 28.2, 27.2, 26.3, 20.55, 20.55, 20.55, 20.48. **ESI-MS** *m/z* calcd for $C_{25}H_{40}N_2O_{12}$ $[M + H]^+$: 561.27; $[M + Na]^+$: 583.25. Found: 561.27, 583.25.

N-[(4-_tert_-butoxycarbonylamino)butyl]-2-(α-D-galactopyranosyl)ethylamide (17b)



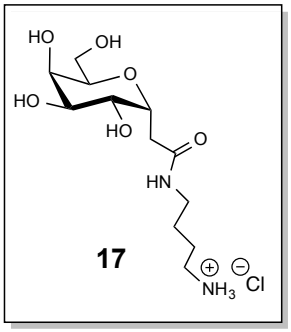
17b

Acetylated derivative **17a** (160 mg, 0.29 mmol) was dissolved in 20 mL of 0.1 M NaOMe in methanol and stirred for 12 hours. Dowex-50X resin was added and the solution was stirred an additional ten minutes before the resin was removed by filtration and washed with methanol. The filtrate was concentrated, resuspended in water and lyophilized to yield 108 mg (0.274 mmol) of **17b** as a yellow gel (96 % yield).

^{1}H NMR (500 MHz, *D_2O*)[2] δ_{ppm} 4.44 (1H, ddd, *J* = 10.6, 5.9, 4.4 Hz), 3.98 (1H, dd, *J* = 9.9, 6.1 Hz), 3.95 (1H, dd, *J* = 3.2, 1.2 Hz), 3.78 (1H, t, *J* = 6.0 Hz), 3.70 (1H, dd, *J* = 9.9, 3.3 Hz), 3.64 (1H, d, *J* = 6.6 Hz), 3.64 (1H, d, *J* = 5.5 Hz), 3.21-3.12 (2H, m), 3.06-3.00 (2H, m), 2.63 (1H, dd, *J* = 14.9, 11.0 Hz), 2.53 (1H, dd, *J* = 15.0, 4.1 Hz), 1.52-1.41 (4H, m), 1.28 (9H, s); **^{13}C NMR** (101 MHz, *D_2O*) δ_{ppm} 173.5, 158.3, 80.8, 72.9, 72.4, 69.6, 68.7, 67.5, 60.7, 39.6, 39.1, 32.3, 27.7, 26.4, 25.6. **ESI-MS** *m/z* calcd for $C_{17}H_{32}N_2O_8$ $[M + H]^+$: 393.22; $[M + Na]^+$: 415.21; $[M + K]^+$: 431.18. Found: 393.24, 415.21, 431.18.

[2] With a presaturation protocol at the frequency of the water peak (4.79 ppm).

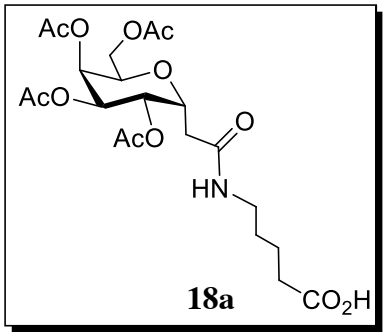
N-(4-aminobutyl)-2-(α-D-galactopyranosyl)ethylamide (hydrochloride) (17)



Intermediate **17b**, (90 mg, 0.230 mmol) was dissolved in 2 mL of TFA to which 2 mL of DCM was added. The reaction was stirred for 3 hours at ambient temperature and concentrated under a flow of air and was reduced to a brown residue. This residue was triturated four times with diethyl ether and formed a yellow paste. NMR analysis showed complete removal of the Boc protecting group. The paste was resuspended in 50 % HCl and stirred for 10 minutes. The reaction mixture was concentrated under reduced pressure, resuspended in water and lyophilized to provide 31 mg (0.0945 mmol) of **17** as an off-white solid in 41 % yield.

^{1}H NMR (400 MHz, *D_2O*) δ_{ppm} 4.44 (1H, ddd, *J* = 10.5, 5.8, 4.5 Hz), 3.98 (1H, dd, *J* = 9.9, 6.1 Hz), 3.93 (1H, dd, *J* = 3.3, 1.5 Hz), 3.78 (1H, dt, *J* = 6.1, 1.4 Hz), 3.70 (1H, dd, *J* = 9.9, 3.3 Hz), 3.65 (1H, d, *J* = 6.2 Hz), 3.64 (1H, d, *J* = 5.9 Hz), 3.19 (2H, bt, *J* = 6.8 Hz), 2.95 (2H, bt, *J* = 7.4 Hz), 2.63 (1H, dd, *J* = 15.0, 10.6 Hz), 2.54 (1H, dd, *J* = 15.0, 4.4 Hz), 1.77-1.58 (2H, m), 1.58-1.48 (2H, m); **^{13}C NMR** (101 MHz, *D_2O*) δ_{ppm} 172.5, 71.8, 71.4, 68.5, 67.6, 64.9, 59.7, 37.9, 37.5, 31.2, 34.3, 23.0. **ESI-MS** *m/z* calcd for $C_{12}H_{24}N_2O_6$ $[M + H]^+$: 293.17. Found: 293.16.

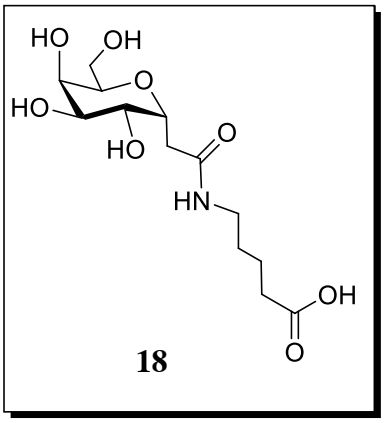
***N*-(4-carboxybutyl)-2-(2,3,4,6-tetra-*O*-acetyl-α-D-galactopyranosyl)ethylamide (18a)**



Alcohol derivative **19a** (160 mg, 0.34 mmol) was dissolved in 4.8 mL of acetone and cooled to 0 ºC. Jones reagent (500 μL, 1.0 mmol, 2.0 M) was added and the reaction was allowed to warm to ambient temperature and stirred for 3 hours when TLC showed consumption of the starting material. Isopropanol was added dropwise (0.51 mmol, 40 μL) upon which the solution turned deep green. The reaction mixture was diluted with 70 mL of DCM. The reactin mixture was washed three times with brine. The organic phase was dried with $MgSO_4$, filtered through a glass-wool plug and concetrated under reduced pressure. 200 mg of black oil was recovered and purified by dry vacuum chromatography (100 % DCM to 75 % DCM, 25 % methanol in 2.5 % increments) to yield 30 mg (0.061 mmol) of **18a** as a white solid in 18 % yield.

^{1}H NMR (500 MHz, *MeOD*) δ_{ppm} 5.41 (1H, t, *J* = 2.6 Hz), 5.27 (1H, dd, *J* = 9.5, 4.8 Hz), 5.23 (1H, dd, *J* = 9.5, 3.0 Hz), 4.67 (1H, td, *J* = 9.3, 5.0 Hz), 4.24 (1H, dt, *J* = 6.3, 2.1 Hz), 4.19-4.09 (2H, m), 3.26-3.15 (2H, m), 2.66 (1H, dd, *J* = 14.8, 9.3 Hz), 2.51 (1H, dd, *J* = 14.7, 5.1 Hz), 2.32 (2H, t, *J* = 7.2 Hz), 2.12 (3H, s), 2.05 (3H, s), 2.02 (3H, s), 2.00 (3H, s), 1.67-1.60 (2H, m), 1.55 (2H, m); **^{13}C NMR** (126 MHz, *MeOD*) δ_{ppm} 177.2, 172.19, 172.16, 171.9, 171.5, 171.3, 71.2, 70.1, 69.3, 69.0, 68.9, 62.5, 40.2, 39.9, 34.5, 29.8, 23.4, 20.74, 20.68, 20.67, 20.58. **ESI-MS** *m/z* calcd for $C_{21}H_{31}NO_{12}$ $[M + H]^+$: 490.19; $[M + Na]^+$: 512.17. Found: 490.30, 512.28.

***N*-(4-carboxybutyl)-2-(α-D-galactopyranosyl)ethylamide (18)**

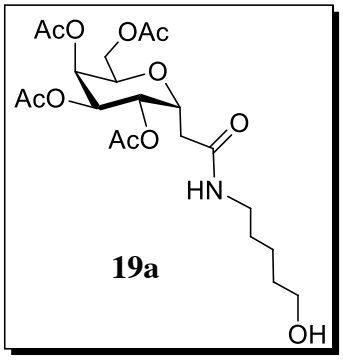


18

Carboxylic acid **18a** (20 mg, 0.041 mmol) was dissolved in 5 mL of 0.1 M NaOMe in methanol and stirred for 12 hours. The reaction was quenched with 10 % HCl and the reaction mixture was concentrated under reduced pressure and purified using preperatory TLC (3:1:1:1, ethyl acetate: methanol: water: acetonitrile). The eluted product was redissolved in water and and lyophilized providing 12 mg (0.037 mmol) of **18** as white powder (91 % yield).

^{1}H NMR (500 MHz, D_2O) δ_{ppm} 4.44 (1H, ddd, J = 10.6, 5.9, 4.3 Hz), 3.98 (1H, dd, J = 9.9, 6.1 Hz), 3.95 (1H, dd, J = 3.3, 1.4 Hz), 3.78 (1H, dt, J = 6.1, 1.3 Hz), 3.71 (1H, dd, J = 9.9, 3.3 Hz), 3.64 (1H, d, J = 6.7 Hz), 3.64 (1H, d, J = 5.4 Hz), 3.20-3.14 (2H, m), 2.63 (1H, dd, J = 14.9, 10.9 Hz), 2.54 (1H, dd, J = 15.0, 4.1 Hz), 2.26 (2H, t, J = 7.2 Hz), 1.60-1.51 (2H, m), 1.52-1.44 (2H, m); **^{13}C NMR** (75 MHz, H_2O) δ_{ppm} 183.3, 173.4, 72.9, 72.4, 69.6, 68.7, 67.5, 60.7, 39.2, 36.9, 32.3, 28.1, 23.1. **ESI-MS** *m/z* calcd for $C_{13}H_{23}N_1O_8$ $[M + H]^+$: 322.15; $[M + Na]^+$: 344.13. Found: 322.22, 344.19. **Rf** = 0.58 (3:1:1:1, ethyl acetate: water: methanol: acetonitrile).

***N*-(5-hydroxypentyl)-2-(2,3,4,6-tetra-*O*-acetyl-α-D-galactopyranosyl)ethylamide (19a)**

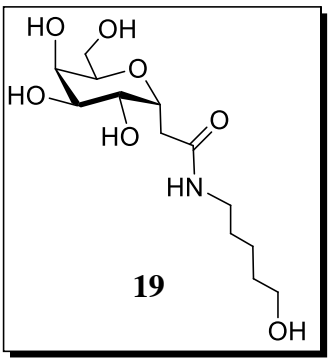


19a

Using the general coupling conditions (Fig. S2), 300 mg (0.77 mmol) of carboxylic acid **6**, 302 mg (0.74 mmol) of HCTU, 270 μL (1.53 mmol) of DIPEA, and 159 mg (1.54 mmol) of 5-aminopentanol were stirred in 6 mL of DMF for 18 hours. Following standard work-up, the recovered residue was purified by flash column chromatography (100% ethyl acetate to 5 % methanol in 95 % ethyl acetate) to yield 295 mg (0.62 mmol) of **19a** as a thick clear gel (81 % yield).

^{1}H NMR (500 MHz, $CDCl_3$) δ_{ppm} 6.24 (1H, t, J = 5.4 Hz), 5.42 (1H, t, J = 3.0 Hz), 5.27 (1H, dd, J = 8.5, 4.7 Hz), 5.16 (1H, dd, J = 8.6, 3.3 Hz), 4.67 (1H, td, J = 9.3, 4.4 Hz), 4.27 (1H, dd, J = 10.1, 6.2 Hz), 4.21-4.13 (2H, m), 3.65 (2H, t, J = 6.3 Hz), 3.33-3.20 (2H, m), 2.57 (1, dd, J = 15.5, 9.7 Hz), 2.42 (1H, dd, J = 15.5, 4.2 Hz), 2.13 (3H, s), 2.08 (3H, s), 2.06 (3H, s), 2.05 (3H, s), 1.62-1.51 (4H, m), 1.45-1.37 (2H, m); **^{13}C NMR** (101 MHz, $CDCl_3$) δ_{ppm} 170.6, 170.0, 169.8, 169.6, 169.3, 69.3, 68.9, 67.9, 67.7, 66.9, 62.3, 61.2, 39.4, 34.4, 32.0, 29.2, 23.0, 20.69, 20.67, 20.67, 20.59. **ESI-MS** *m/z* calcd for $C_{24}H_{39}NO_{11}$ $[M + H]^+$: 476.21; $[M + Na]^+$: 498.20. Found: 476.22, 498.21. **Rf** = 0.46 (9:1, ethyl acetate: methanol).

N-(5-hydroxypentyl)-2-(α-D-galactopyranosyl)ethylamide (19)

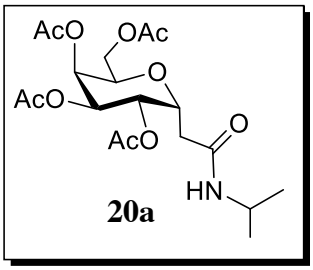


19

Alcohol **19a** (20 mg, 0.042 mmol) was dissolved in 5 mL of 0.1 M NaOMe in methanol and stirred for 18 hours. DOWEX 50WX8 (50-100 mesh) ion exchange resin was added and stirred for 20 minutes. Following filtration, the filtrate was concentrated under reduced pressure. The crude product was redissolved in methanol and purified by preperatory TLC (4: 1: 1: 1, ethyl acetate: water: methanol: acetonitrile). The pure product was resuspended in water and lyophilized to yield 9.3 mg (0.030 mmol) of **19** as a white powder (72 % yield).

^{1}H NMR (400 MHz, D_2O) δ_{ppm} 4.47 (1H, ddd, J = 10.6, 5.8, 4.1 Hz), 4.01 (1H, dd, J = 9.9, 6.0 Hz), 3.98 (1H, dd, J = 3.3, 1.5 Hz), 3.81 (1H, dt, J = 6.2, 6.2, 1.2 Hz), 3.73 (1H, dd, J = 9.9, 3.4 Hz), 3.67 (1H, d, J = 6.5 Hz), 3.67 (1H, d, J = 5.7 Hz), 3.58 (2H, t, J = 6.6, 6.6 Hz), 3.25-3.13 (2H, m), 2.66 (1H, dd, J = 15.0, 10.8 Hz), 2.56 (1H, dd, J = 15.0, 4.2 Hz), 1.59-1.47 (4H, m), 1.39-1.29 (2H, m); **^{13}C NMR** (101 MHz, D_2O) δ_{ppm} 173.4, 73.0, 72.4, 69.6, 68.7, 67.5, 61.6, 60.7, 39.4, 32.3, 30.9, 28.1, 22.4. **ESI-MS** *m/z* calcd for $C_{13}H_{25}NO_7$ $[M + H]^+$: 308.17; $[M + Na]^+$: 330.15. Found: 308.24, 330.22.

***N*-(isopropyl)-2-(2,3,4,6-tetra-*O*-acetyl-α-D-galactopyranosyl)ethylamide (20a)**

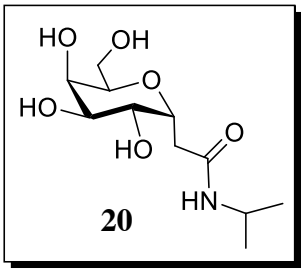


20a

Using the general coupling conditions (Fig. S2), 100 mg (0.26 mmol) of carboxylic acid **6**, 100 mg (0.25 mmol) of HCTU, 90 μL (0.50 mmol) of DIPEA, and 60 μL (0.73 mmol) of isopropylamine were stirred in 2 mL of DCM for 18 hours. Following standard work-up, the recovered residue was purified preparatory TLC (6: 3: 1, acetone: toluene: methanol) to yield 100 mg (0.23 mmol) of **20a** as a clear thick oil (89 % yield).

^{1}H NMR (400 MHz, $CDCl_3$) δ_{ppm} 6.04 (1H, d, J = 7.7 Hz), 5.43-5.40 (1H, m), 5.28 (1H, dd, J = 8.6, 4.8 Hz), 5.17 (1H, dd, J = 8.6, 3.3 Hz), 4.69 (1H, dt, J = 9.2, 4.5 Hz), 4.27-4.16 (3H, m), 4.07 (1H, septd, J = 7.7, 6.6 Hz), 2.56 (1H, dd, J = 15.3, 9.5 Hz), 2.41 (1H, dd, J = 15.3, 4.3 Hz), 2.13 (3H, s), 2.08 (3H, s), 2.06 (3H, s), 2.05 (3H, s), 1.16 (6H, d, J = 6.6 Hz); **^{13}C NMR** (101 MHz, $CDCl_3$) δ_{ppm} 170.4, 169.8, 169.7, 169.4, 168.2, 69.3, 68.9, 67.8, 67.7, 66.9, 61.1, 41.3, 34.5, 22.6, 22.5, 20.60, 20.56, 20.56, 20.49.

***N*-(isopropyl)-2-(α-D-galactopyranosyl)ethylamide (20)**

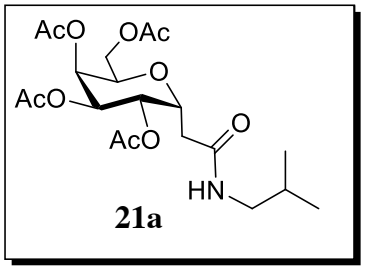


20

Acetylated isopropyl derivative **20a** (30 mg, 0.070 mmol) was dissolved in 10 mL of 0.1 M NaOMe in methanol and stirred for four hours. Dowex-50X resin was added and the solution was stirred an additional five minutes before the resin was removed by filtration and washed with methanol. The filtrate was concentrated and the recovered residue was resuspended in water and lyophilized to yield 17 mg (0.067 mmol) of **20** as a white solid (95 % yield).

^{1}H NMR (400 MHz, D_2O) δ_{ppm} 4.47 (1H, ddd, J = 10.6, 5.9, 4.4 Hz), 4.01 (1H, dd, J = 10.0, 6.1 Hz), 3.97 (1H, dd, J = 3.3, 1.5 Hz), 3.96-3.88 (1H, m), 3.80 (1H, dt, J = 6.6, 1.3 Hz), 3.73 (1H, dd, J = 10.0, 3.3 Hz), 3.68 (1H, d, J = 6.6 Hz), 3.67 (1H, d, J = 5.6 Hz), 2.62 (1H, dd, J = 14.9, 10.8 Hz), 2.53 (1H, dd, J = 14.9, 4.3 Hz), 1.12 (6H, d, J = 6.6 Hz); **^{13}C NMR** (101 MHz, D_2O) δ_{ppm} 174.8, 75.6, 74.9, 72.2, 71.3, 70.1, 63.3, 44.3, 34.9, 23.9, 23.8. **ESI-MS** m/z calcd for $C_{11}H_{21}NO_6$ $[M + H]^+$: 264.14; $[M + Na]^+$: 286.13; $[M + K]^+$: 302.10. Found: 264.28, 286.26, 302.30.

***N*-(isobutyl)-2-(2,3,4,6-tetra-*O*-acetyl-α-D-galactopyranosyl)ethylamide (21a)**

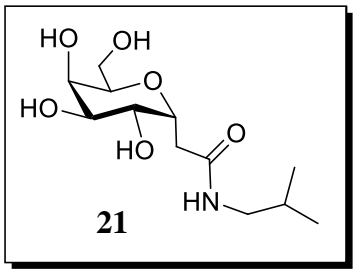


21a

Using the general coupling conditions (Fig. S2), 58 mg (0.15 mmol) of carboxylic acid **6**, 32 mg (0.20 mmol) of CDI, 34 μL (0.19 mmol) of DIPEA, and 44 μL (0.44 mmol) of isobutylamine were stirred in 1 mL of DCM for 18 hours. Following standard work-up, the recovered residue was purified preparatory TLC (6:3:1, acetone: toluene: methanol) to yield 60 mg (0.13 mmol) of **21a** as a clear thick oil (90 % yield). Characterization is only provided for the major rotamer.

^{1}H NMR (400 MHz, $CDCl_3$) δ_{ppm} 6.22 (1H, t, J = 5.6 Hz), 5.42 (1H, t, J = 2.8 Hz), 5.28 (1H, dd, J = 8.6, 4.7 Hz), 5.17 (1H, dd, J = 8.6, 3.3 Hz), 4.69 (1H, td, J = 9.2, 4.3, 4.3 Hz), 4.25-4.15 (3H, m), 3.21-2.96 (2H, m), 2.59 (1H, dd, J = 15.5, 9.6 Hz), 2.44 (1H, dd, J = 15.5, 4.1 Hz), 2.13 (3H, s), 2.08 (3H, s), 2.05 (3H, s), 2.05 (3H, s), 1.78 (1H, tsept J = 6.6, 4.1 Hz), 0.92 (6H, d, J = 6.7 Hz); **ESI-MS** m/z calcd for $C_{20}H_{31}NO_{10}$ $[M + H]^+$: 446.21. Found: 446.24.

***N*-(isobutyl)-2-(α-D-galactopyranosyl)ethylamide (21)**

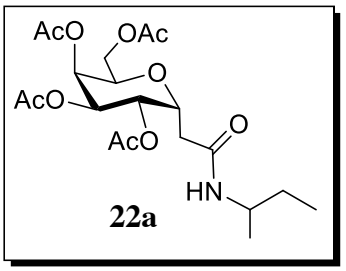


21

Acetylated isobutyl derivative **21a** (20 mg, 0.045 mmol) was dissolved in 5 mL of 0.1 M NaOMe in methanol and stirred for four hours. Dowex-50X resin was added and the solution was stirred an additional five minutes before the resin was removed by filtration and washed with methanol. The filtrate was concentrated and the recovered residue was resuspended in water and lyophilized to yield 11 mg (0.042 mmol) of **21** as a white solid (93 % yield).

^{1}H NMR (400 MHz, D_2O) δ_{ppm} 4.49 (1H, ddd, J = 10.6, 5.9, 4.3 Hz), 4.02 (1H, dd, J = 10.0, 6.1 Hz), 3.99 (1H, dd, J = 3.4, 1.6 Hz), 3.83 (1H, ddd, J = 6.2, 6.1, 1.4 Hz), 3.74 (1H, dd, J = 9.9, 3.3 Hz), 3.68 (2H, dd, J = 6.1, 1.2 Hz), 3.04 (1H, dd, J = 13.2, 6.8 Hz), 2.99 (1H, dd, J = 13.2, 6.8 Hz), 2.69 (1H, dd, J = 15.0, 10.8 Hz), 2.59 (1H, dd, J = 15.0, 4.2 Hz), 1.76 (1H, tsept, J = 6.8 Hz), 0.88 (6H, d, J = 6.7 Hz); **^{13}C NMR** (101 MHz, D_2O) δ_{ppm} 173.5, 73.0, 72.3, 69.6, 68.7, 67.6, 60.6, 49.9, 32.3, 27.8, 19.29, 19.28. **ESI-MS** m/z calcd for $C_{21}H_{33}NO_{10}$ $[M + H]^+$: 278.16; $[M + Na]^+$: 300.14. Found: 278.11, 300.10.

***N*-(*sec*-butyl)-2-(2,3,4,6-tetra-*O*-acetyl-α-D-galactopyranosyl)ethylamide (22a)**

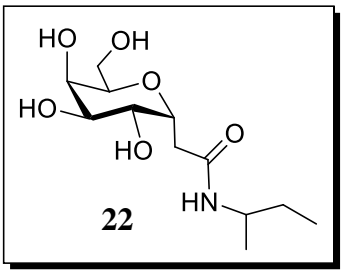


22a

Using the general coupling conditions (Fig. S2), 100 mg (0.26 mmol) of carboxylic acid **6**, 56 mg (0.34 mmol) of CDI, 60 μL (0.34 mmol) of DIPEA, and 79 μL (0.79 mmol) of racemic *sec*-butylamine were stirred in 2 mL of DCM for 18 hours. Following standard work-up, the recovered residue was purified preparatory TLC (6:3:1, acetone: toluene: methanol) to yield 100 mg (0.22 mmol) of **22a**, as a mixture of diastereomers, as a clear thick oil (86 % yield). Characterization is provided for major diastereomer (minor diastereomer is in parentheses).

^{1}H NMR (400 MHz, *$CDCl_3$*) δ_{ppm} 5.93 (1H, dd, *J* = 8.1, 3.0 Hz), 5.43-5.40 (1H, m), 5.28 (1H, ddd, *J* = 8.2, 4.5, 3.5 Hz), 5.17 (1H, ddd, *J* = 8.6, 2.9, 2.9 Hz), 4.69 (1H, dddd, *J* = 7.1, 4.3, 4.3, 2.8 Hz), 4.24-4.16 (3H, m), 3.91 (1H, tsext., *J* = 6.6, 1.7 Hz), 2.57 (1H, dd, *J* = 15.3, 9.6 Hz), 2.42 (1H, ddd, *J* = 15.4, 4.2, 0.7 Hz), 2.13 (3H, s), 2.08 (3H, s), 2.05 (3H, s), 2.05 (3H, s), 1.47 (1H, p, *J* = 7.3 Hz), 1.13 (3H, d, *J* = 6.6 Hz), 0.91 (3H, t, *J* = 7.4 Hz); **^{13}C NMR** (101 MHz, *$CDCl_3$*) δ_{ppm} 170.4, 169.8, 169.65 (169.67), 169.43 (169.46), 168.37 (168.40), 69.33 (69.36), 68.92 (68.83), 67.83 (67.93), 67.7, 66.91 (66.87), 61.1 (61.0), 46.5 (46.6), 34.57 (34.62), 29.5 (29.4), 20.61, 20.59 (20.58), 20.50, 20.21 (20.23), 10.25 (10.21). **ESI-MS** *m/z* calcd for $C_{20}H_{31}NO_{10}$ $[M + H]^+$: 446.21; $[M + Na]^+$: 468.19. Found: 446.25, 468.22.

***N*-(*sec*-butyl)-2-(α-D-galactopyranosyl)ethylamide (22)**

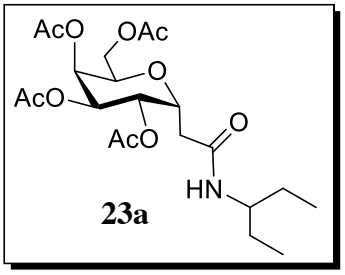


22

Acetylated *sec*-butyl derivative **22a** (23 mg, 0.052 mmol) was dissolved in 5 mL of 0.1 M NaOMe in methanol and stirred for four hours. Dowex-50X resin was added and the solution was stirred an additional five minutes before the resin was removed by filtration and washed with methanol. The filtrate was concentrated, and the residue was purified by preperatory TLC (6: 1: 1: 1, ethyl acetate: water: methanol: acetonitrile), resuspended in water and lyophilized to yield 12 mg of **22**, as a mixture of diastreomers, as a white solid (84 % yield). Characterization is provide for major diastereomer (minor diastereomer is in parentheses).

^{1}H NMR (400 MHz, *D_2O*) δ_{ppm} 4.49 (ddd, *J* = 10.6, 5.8, 4.4 Hz, 1H), 4.03 (1H, dd, *J* = 9.9, 6.1 Hz), 4.01-3.98 (1H, m), 3.83 (1H, ddd, *J* = 6.9, 4.2, 1.3 Hz), 3.82-3.73 (1H, m), 3.74 (1H, dd, *J* = 9.9, 3.4 Hz), 3.68 (2H, bd, *J* = 6.4 Hz), 2.65 (1H, dd, *J* = 14.9, 10.8 Hz), 2.57 (1H, dd, *J* = 15.0, 4.3 Hz), 1.55-1.35 (2H, m), 1.10 (3H, d, *J* = 6.6 Hz), 0.86 (3H, dt, *J* = 7.5, 2.9 Hz); **^{13}C NMR** (101 MHz, *D_2O*) δ_{ppm} 172.7, 73.0, 72.2 (72.4), 69.6 (69.7), 68.6 (68.7), 67.5 (67.6), 60.5 (60.7), 47.33 (47.34), 32.3 (32.4), 28.7, 19.3 (19.5), 9.8 (9.7). **ESI-MS** *m/z* calcd for $C_{21}H_{33}NO_{10}$ $[M + H]^+$: 278.16; $[M + Na]^+$: 300.14; $[M + K]^+$: 316.12. Found: 278.18, 300.16, 316.14.

***N*-(1-ethylpropyl)-2-(2,3,4,6-tetra-*O*-acetyl-α-D-galactopyranosyl)ethylamide (23a)**

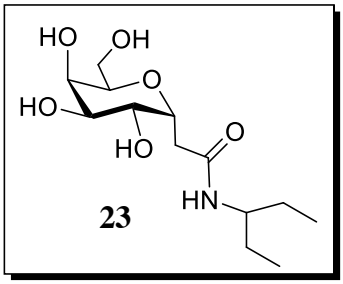


23a

Using the general coupling conditions (Fig. S2), 50 mg (0.13 mmol) of carboxylic acid **6**, 27 mg (0.17 mmol) of CDI, 30 μL (0.17 mmol) of DIPEA, and 45 μL (0.38 mmol) of 1-ethylpropylamine were stirred in 1 mL of DCM for 18 hours. Following standard work-up, the recovered residue was purified by gradient flash chromatography (100% hexanes to 100 % ethyl acetate in 10% increments) to yield 55 mg (0.12 mmol) of **23a** as a clear thick oil (92 % yield).

^{1}H NMR (400 MHz, *CDCl$_3$*) δ_{ppm} 5.70 (1H, d, *J* = 8.9 Hz), 5.42 (1H, dt, *J* = 2.8, 1.3 Hz), 5.27 (1H, dd, *J* = 8.4, 4.6 Hz), 5.16 (1H, dd, *J* = 8.4, 3.3 Hz), 4.69 (1H, td, *J* = 8.8, 4.2 Hz), 4.24-4.19 (2H, m), 3.85-3.73 (1H, m), 3.56-3.45 (1H, m), 2.56 (1H, dd, *J* = 15.3, 9.8 Hz), 2.43 (1H, dd, *J* = 15.3, 4.0 Hz), 2.12 (3H, s), 2.09 (3H, s), 2.05 (3H, s), 2.05 (3H, s), 1.62-1.47 (2H, m), 1.43-1.30 (2H, m), 0.90 (6H, dt, *J* = 7.4, 2.4 Hz); **^{13}C NMR** (101 MHz, *CDCl$_3$*) δ_{ppm} 170.5, 169.9, 169.7, 169.5, 168.8, 69.54, 68.9, 68.0, 67.8, 66.8, 61.0, 52.1, 34.8, 27.34, 27.31, 20.70, 20.68, 20.66, 20.60, 10.20, 10.16. **ESI-MS** *m/z* calcd for $C_{21}H_{33}NO_{10}$ $[M + H]^+$: 460.22; $[M + Na]^+$: 482.20; $[M + K]^+$: 498.17. Found: 460.34, 482.34, 498.34.

***N*-(1-ethylpropyl)-2-(α-D-galactopyranosyl)ethylamide (23)**

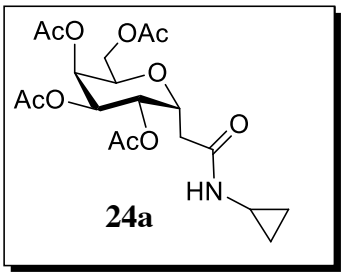


23

Acetylated 1-ethylpropyl derivative **23a** (55 mg, 0.12 mmol) was dissolved in 5 mL of 0.1 M NaOMe in methanol and stirred for four hours. Dowex-50X resin was added and the solution was stirred an additional five minutes before the resin was removed by filtration and washed with methanol. The filtrate was concentrated, and recrystallized from methanol and ether. The recovered precipitate was resuspended in water and lyophilized to yield 30 mg (0.10 mmol) of **23** as a white solid (86 % yield).

^{1}H NMR (400 MHz, *D$_2$O*) δ_{ppm} 4.36 (1H, ddd, *J* = 10.5, 5.8, 4.4 Hz), 3.89 (1H, dd, *J* =10.1, 6.2 Hz), 3.87 (1H, dd, *J* = 3.4, 1.6 Hz), 3.69 (1H, dt, *J* = 6.2, 1.4 Hz), 3.61 (1H, dd, *J* = 9.9, 3.3 Hz), 3.55 (2H, d, *J* = 6.2 Hz), 3.48 (1H, tt, *J* = 9.0, 4.8 Hz), 2.55 (1H, dd, *J* = 15.0, 10.6 Hz), 2.47 (1H, dd, *J* = 15.1, 4.3 Hz), 1.50-1.34 (2H, m), 1.29-1.17 (2H, m), 0.72 (3H, t, *J* = 7.4 Hz), 0.71 (3H, t, *J* = 7.4 Hz); **^{13}C NMR** (101 MHz, *D$_2$O*) δ_{ppm} 173.3, 73.0, 72.2, 69.65, 68.59, 67.5, 60.4, 53.2, 32.3, 26.9, 26.8, 9.73, 9.66. **ESI-MS** *m/z* calcd for $C_{13}H_{25}NO_6$ $[M + H]^+$: 292.18; $[M + Na]^+$: 314.16; $[M + K]^+$: 330.13. Found: 292.17, 314.14, 330.13.

***N*-Cyclopropyl-2-(2,3,4,6-tetra-*O*-acetyl-α-D-galactopyranosyl)ethylamide (24a)**

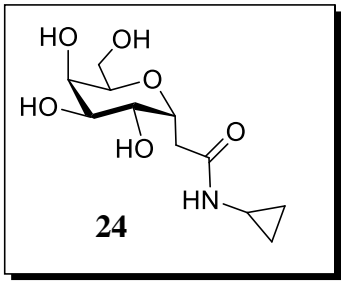


24a

Using the general coupling conditions (Fig. S2), 79 mg (0.20 mmol) of carboxylic acid **6**, 42 mg (0.26 mmol) of CDI, 45 μL (0.26 mmol) of DIPEA, and 42 μL (0.60 mmol) of cyclopropylamine were stirred in 2 mL of DCM for 18 hours. Following standard work-up, the recovered residue was purified by gradient flash chromatography (100% hexanes to 100 % ethyl acetate in 10% increments) to yield 70 mg (0.16 mmol) of **24a** as a clear thick oil (82 % yield).

^{1}H NMR (400 MHz, *$CDCl_3$*) δ_{ppm} 6.39 (1H, d, *J* = 1.8 Hz), 5.41 (1H, t, *J* = 3.1 Hz), 5.26 (1H, dd, *J* = 8.5, 4.7 Hz), 5.15 (1H, dd, *J* = 8.5, 3.3 Hz), 4.65 (1H, td, *J* = 9.3, 4.3 Hz), 4.27-4.15 (3H, m), 2.71 (1H, dtt, *J* = 7.1, 3.7, 3.7 Hz), 2.56 (1H, dd, *J* = 15.6, 9.8 Hz), 2.39 (1H, dd, *J* = 15.6, 4.1 Hz), 2.12 (3H, s), 2.09 (3H, s), 2.08 (3H, s), 2.05 (3H, s), 0.80-0.75 (2H, m), 0.53-0.49 (2H, m); **^{13}C NMR** (101 MHz, *$CDCl_3$*) δ_{ppm} 170.6, 170.5, 169.9, 169.7, 169.5, 69.4, 68.6, 67.9, 67.6, 66.9, 61.3, 34.2, 22.5, 20.7, 20.6, 20.6, 20.6, 6.6, 6.4. **ESI-MS** *m/z* calcd for $C_{19}H_{27}NO_6$ $[M + H]^+$: 430.17; $[M + Na]^+$: 452.15. Found: 430.31, 452.30.

N-Cyclopropyl-2-(α-D-galactopyranosyl)ethylamide (24)

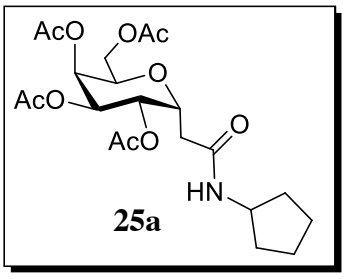


24

Cyclopropyl derivative **24a** (70 mg, 0.16 mmol) was dissolved in 10 mL of 0.1 M NaOMe in methanol and stirred for four hours. Dowex-50X resin was added and the solution was stirred an additional five minutes before the resin was removed by filtration and washed with methanol. The filtrate was concentrated, resuspended in water and lyophilized to yield 35 mg (0.13 mmol) of **24** as a white solid (84 % yield).

^{1}H NMR (400 MHz, *D_2O*) δ_{ppm} 4.47 (1H, ddd, *J* = 10.5, 5.6, 4.8 Hz), 4.01 (1H, dd, *J* = 9.9, 6.1 Hz), 3.97 (1H, dd, *J* = 3.2, 1.3 Hz), 3.78 (1H, ddd, *J* = 6.7, 5.2, 1.2 Hz), 3.73 (1H, dd, *J* = 9.9, 3.4 Hz), 3.68 (1H, d, *J* = 6.7 Hz), 3.67 (1H, d, *J* = 5.3 Hz), 2.67-2.50 (3H, m), 0.78-0.70 (2H, m), 0.56-0.49 (2H, m); **^{13}C NMR** (101 MHz, *D_2O*) δ_{ppm} 175.4, 72.9, 72.5, 69.6, 68.8, 67.5, 60.8, 32.1, 22.0, 5.5, 5.2. **ESI-MS** *m/z* calcd for $C_{11}H_{19}NO_6$ $[M + H]^+$: 262.13; $[M + Na]^+$: 284.11. Found: 262.13, 284.26.

***N*-Cyclopentyl-2-(2,3,4,6-tetra-*O*-acetyl-α-D-galactopyranosyl)ethylamide (25a)**

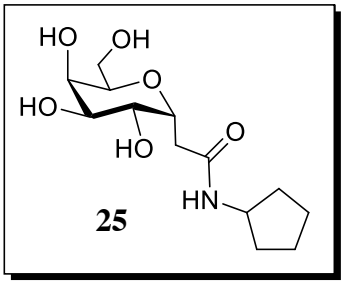


25a

Using the general coupling conditions (Fig. S2), 100 mg (0.26 mmol) of carboxylic acid **6**, 56 mg (0.34 mmol) of CDI, 60 μL (0.34 mmol) of DIPEA, and 78 μL (0.79 mmol) of cyclopentylamine were stirred in 2 mL of DCM for 18 hours. Following standard work-up, the recovered residue was purified by gradient flash chromatography (100% hexanes to 100 % ethyl acetate in 10% increments) to yield 90 mg (0.20 mmol) of **25a** as a clear thick oil (76 % yield).

^{1}H NMR (400 MHz, *$CDCl_3$*) δ_{ppm} 6.30 (1H, d, *J* = 7.3 Hz), 5.41 (1H, dt, *J* = 2.9, 1.4 Hz), 5.28 (1H, dd, *J* = 8.8, 4.8 Hz), 5.17 (1H, dd, *J* = 8.8, 3.3 Hz), 4.77 (1H, d, *J* = 7.2 Hz), 4.70 (1H, td, *J* = 9.4, 4.7 Hz), 4.25-4.14 (3H, m), 2.57 (1H, dd, *J* = 15.3, 9.4 Hz), 2.43 (1H, dd, *J* = 15.3, 4.6 Hz), 2.13 (3H, s), 2.07 (3H, s), 2.05 (3H, s), 2.04 (3H, s), 2.02-1.88 (2H, m), 1.73-1.50 (4H, m), 1.47-1.30 (2H, m); **^{13}C NMR** (101 MHz, *$CDCl_3$*) δ_{ppm} 170.45, 169.9, 169.7, 169.5, 168.7, 69.2, 69.0, 67.74, 67.71, 67.0, 61.2, 51.8, 33.4, 32.9, 32.8, 23.6, 23.5, 20.58, 20.56, 20.56, 20.49.

***N*-Cyclopentyl-2-(α-D-galactopyranosyl)ethylamide (25)**

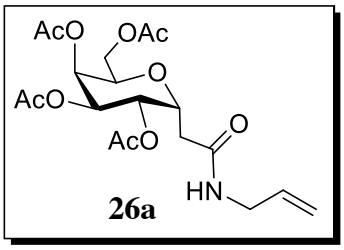


25

Cyclopentyl derivative **25a** (85 mg, 0.19 mmol) was dissolved in 15 mL of 0.1 M NaOMe in methanol and stirred for four hours. Dowex-50X resin was added and the solution was stirred an additional five minutes before the resin was removed by filtration and washed with methanol. The filtrate was concentrated, resuspended in water and lyophilized to yield 51 mg (0.18 mmol) of **25** as a white solid (93 % yield).

^{1}H NMR (400 MHz, *D_2O*) δ_{ppm} 4.48 (1H, dt, *J* = 10.1, 4.6 Hz), 4.12-3.96 (3H, m), 3.81 (1H, t, *J* = 6.0 Hz), 3.74 (1H, dd, *J* = 10.1, 3.2 Hz), 3.68 (2H, d, *J* = 6.1 Hz), 2.64 (1H, dd, *J* = 14.7, 11.0 Hz), 2.54 (1H, dd, *J* = 14.9, 4.1 Hz), 1.90 (2H, ddd, *J* = 12.8, 6.4, 6.4 Hz), 1.73-1.51 (4H, m), 1.45 (2H, ddd, *J* = 12.9, 6.3, 6.3 Hz); **^{13}C NMR** (101 MHz, *D_2O*) δ_{ppm} 172.9, 73.1, 72.4, 69.6, 68.8, 67.5, 60.8, 51.5, 32.3, 32.2, 32.0, 32.0, 23.4. **ESI-MS** *m/z* calcd for $C_{13}H_{23}NO_6$ $[M + H]^+$: 290.16; $[M + Na]^+$: 312.14. Found: 290.16, 312.12.

***N*-Allyl-2-(2,3,4,6-tetra-*O*-acetyl-α-D-galactopyranosyl)ethylamide (26a)**



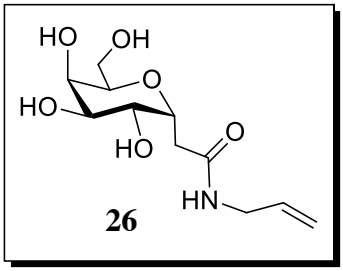
26a

Using the general coupling conditions (Fig. S2), 300 mg (0.75 mmol) of carboxylic acid **6**, 300 mg (0.72 mmol) of HCTU, 270 μL (1.5 mmol) of DIPEA, and 120 μL (1.6 mmol) of allylamine were stirred in 4 mL of DMF for 72 hours. Following standard work-up the crude yellow oil was recovered and purified by flash chromatography (3: 7 hexanes: ethyl acetate) to yield 260 mg (0.61 mmol) of **26a** as a thick clear oil (81 % yield).

^{1}H NMR (400 MHz, *$CDCl_3$*) δ_{ppm} 6.60 (1H, t, *J* = 5.7, 5.7 Hz), 5.76 (1H, tdd, *J* = 17.1, 10.5, 5.4 Hz), 5.34 (1H, t, *J* = 3.1 Hz), 5.20 (1H, dd, *J* = 8.6, 4.7 Hz), 5.10 (1H, ddd, *J* = 17.0, 1.5, 3.0 Hz), 5.09 (1H, dd, *J* = 8.7, 3.2 Hz) 5.05 (1H, ddd, *J* = 10.3, 2.7, 1.3 Hz), 4.64 (1H, td, *J* = 9.3, 4.4 Hz), 4.24-4.12 (2H, m), 4.05 (1H, dd, *J* = 10.7, 3.6 Hz) 3.86-3.75 (2H, m), 2.59 (1H, dd, *J* = 15.4, 9.7 Hz), 2.42 (1H, dd, *J* = 15.4, 4.3 Hz), 2.05 (3H, s), 2.00 (3H, s), 1.97 (3H, s), 1.97 (3H, s); **^{13}C NMR** (101 MHz, *$CDCl_3$*) δ_{ppm} 170.7, 169.93, 169.92, 169.74, 169.50, 133.8, 115.9, 69.4, 68.5, 67.9, 67.6, 66.9, 61.1, 41.7, 32.3, 20.6, 20.51, 20.50, 20.4. **ESI-MS** *m/z* calcd for $C_{19}H_{27}N_1O_{10}$ $[M + H]^+$: 430.17; [M +

Na]$^+$: 452.15; [M + K]$^+$: 468.13. Found: 430.30, 452.29, 468.29. **Rf** = 0.32 (7:3, ethyl acetate: hexanes).

***N*-Allyl-2-(α-D-galactopyranosyl)ethylamide (26)**

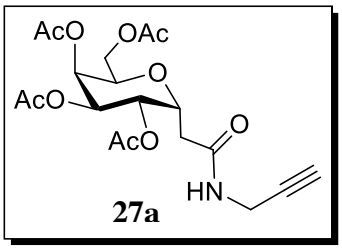


26

Allyl derivative **26a** (120 mg, 0.20 mmol) was dissolved in 15 mL of 0.1 M NaOMe in methanol to which was added 5 mL of DCM and stirred for four hours. Dowex-50X resin was added and the solution was stirred an additional five minutes before the resin was removed by filtration and washed with methanol. The filtrate was concentrated, and purified by dry vacuum chromatography (100 % ethyl acetate to 60 % ethyl acetate in methanol in 5 % steps) to yield 60 mg (0.14 mmol) of **26** as a white solid following lyophilization (71 % yield).

^{1}H NMR (400 MHz, D_2O)[3] δ_{ppm} 5.86 (1H, ddt, *J* = 17.3, 10.4, 5.1 Hz), 5.20 (1H, ddd, *J* = 17.3, 3.1, 1.6 Hz), 5.15 (1H, ddd, *J* = 10.4, 2.9, 1.5 Hz), 4.51 (1H, ddd, *J* = 10.5, 5.8, 4.3 Hz), 4.03 (1H, dd, *J* = 9.9, 6.1 Hz), 3.99 (1H, dd, *J* = 3.3, 1.5 Hz), 3.87-3.79 (3H, m), 3.76 (1H, dd, *J* = 9.9, 3.4 Hz), 3.70 (2H, dd, *J* = 6.0, 4.3 Hz), 2.72 (1H, dd, *J* = 15.0, 10.8 Hz), 2.63 (1H, dd, *J* = 15.1, 4.2 Hz); **^{13}C NMR** (101 MHz, D_2O) δ_{ppm} 173.6, 133.4, 115.7, 72.9, 72.5, 69.6, 68.7, 67.6, 60.8, 41.7, 32.3. **ESI-MS** *m/z* calcd for $C_{11}H_{20}NO_6$ [M + H]$^+$: 262.13; [M + Na]$^+$: 284.11. Found: 262.11, 284.08.

***N*-Propargyl-2-(2,3,4,6-tetra-*O*-acetyl-α-D-galactopyranosyl)ethylamide (27a)**



27a

Using the general coupling conditions (Fig. S2), 90 mg (0.23 mmol) of carboxylic acid **6**, 49 mg (0.30 mmol) of CDI, 53 μL (0.3 mmol) of DIPEA, and 44 μL (0.69 mmol) of propargylamine were stirred in 2 mL of DMF for 18 hours. Following standard work-up, 200 mg of crude brown oil was recovered that was purified by gradient flash chromatography (100% hexanes to 100 % ethyl acetate in 10% steps) to yield 80 mg of **27a** as a clear thick oil (81 % yield).

^{1}H NMR (400 MHz, $CDCl_3$) δ_{ppm} 6.36 (1H, t, *J* = 5.2 Hz), 5.43 (1H, t, *J* = 3.2 Hz), 5.26 (1H, dd, *J* = 8.3, 4.6 Hz), 5.16 (1H, dd, *J* = 8.3, 3.2 Hz), 4.66 (1H, dt, *J* = 9.5, 4.2 Hz), 4.30 (1H, dd, *J* = 12.9, 9.4 Hz), 4.23-4.16 (2H, m), 4.06 (2H, ddd, *J* = 5.4, 3.4, 2.7 Hz), 2.60 (1H, dd, *J* = 15.9, 9.8 Hz), 2.45 (1H, dd, *J* = 15.8, 3.8 Hz), 2.23 (1H, t, *J* = 2.5 Hz), 2.12 (3H, s), 2.10 (3H, s), 2.09 (3H, s), 2.06 (3H, s); **^{13}C NMR** (101 MHz, $CDCl_3$) δ_{ppm} 170.4, 169.9, 169.7, 169.6, 168.9, 71.8, 69.8, 68.4, 68.0, 67.7, 66.8, 61.2, 34.3, 29.2, 20.4, 20.3, 20.26, 20.26. **ESI-MS** *m/z* calcd for $C_{19}H_{25}NO_{10}$ [M + H]$^+$: 428.16; [M + Na]$^+$: 450.14. Found: 428.16, 450.13. **Rf** = 0.77 (9:1, ethyl acetate: methanol).

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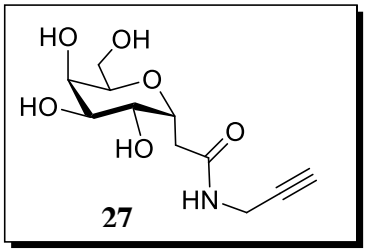
[3] With a presaturation protocol at the frequency of the water peak (4.79 ppm).

***N*- Propargyl-2-(α-D-galactopyranosyl)ethylamide (27)**

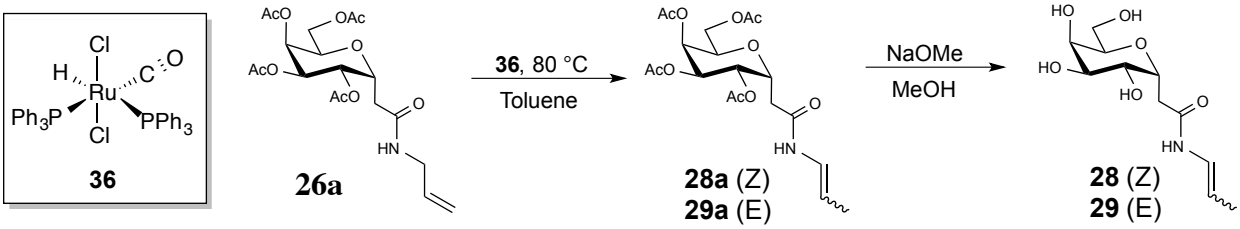


27

Propargyl derivative **27a** (100 mg, 0.23 mmol) was treated with 20 mL of 0.1 M sodium methoxide in methanol for 12 hours. The reaction mixture was neutralized with DOWEX 50WX8 (50-100 mesh) ion exchange resin, filtered through a sintered glass funnel, and the resin was washed sequentially with methanol and water. Solvent was then removed under reduced pressure, and the resulting residue was purified through dry vacuum chromatography (100% ethyl acetate to 60% ethyl acetate in methanol by 5% increments) to yield 48 mg (0.18 mmol) of **27** as a white solid (81 % yield).

^{1}H NMR (500 MHz, D_2O) δ_{ppm} 4.37 (1H, ddd, J = 10.6, 5.8, 4.4 Hz), 3.89 (1H, dd, J = 9.9, 6.1 Hz), 3.85 (1H, dd, J = 3.3, 1.4 Hz), 3.84 (1H, dd, J = 5.2, 2.6 Hz), 3.68 (1H, J = 6.4, 4.9, 1.1 Hz), 3.61 (1H, dd, J = 9.9, 3.4 Hz), 3.55 (1H, dd, J = 18.1, 7.1 Hz), 3.55 (1H, ddd, J = 18.0, 10.7, 4.3 Hz), 2.56 (1H, dd, J = 15.0, 10.9 Hz), 2.47 (1H, dd, J = 15.1, 4.3 Hz), 2.44 (1H, t, J = 2.6 Hz); **^{13}C NMR** (101 MHz, $CDCl_3$) δ_{ppm} 173.5, 79.5, 72.9, 72.4, 71.7, 69.6, 68.7, 67.5, 60.7, 32.2, 28.8. **ESI-MS** *m/z* calcd for $C_{11}H_{17}NO_6$ [M + H]$^+$: 260.11; [M + Na]$^+$: 282.09. Found: 260.10, 282.06.

*Synthesis of 1-propenamide derivatives **28** and **29***



***Z*-*N*-(1-propenyl)-2-(2,3,4,6-tetra-*O*-acetyl-α-D-galactopyranosyl)ethylamide (28a) and *E*-*N*-(1-propenyl)-2-(2,3,4,6-tetra-*O*-acetyl-α-D-galactopyranosyl)ethylamide (29a)**

Allyl amide **26a** 75 mg (0.175 mmol) was dissolved in 400μL of dry toluene under an argon atmosphere equipped with a water-cooled condenser. Immediately, 3.4 mg (0.0036 mmol, 2 mol %) of Ruthenium catalyst **36**[9] was added and the system was equipped with a balloon. The reaction was heated to 80 ºC for 3 hours. The reaction was cooled to 0 ºC and filtered through celite and washed with ethyl acetate. Solvent was removed *in vacuo*. NMR showed a 1: 7: 15 mixture of the three compounds (**26a**: ***28a***: ***29a***). The crude product was purified through preparatory TLC (6: 4, hexanes: ethyl acetate) using multiple elutions. The top fraction provided 30 mg of **29a** (40% yield, characterized by J coupling of olefinic protons) and the bottom fraction provided 16 mg of **28a** (21% yield) both as clear oils. The middle fraction provided 22 mg of mixed ***28a*** and ***29a*** enamides (29% yield).

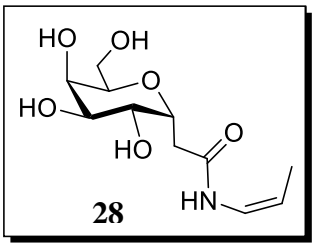
Characterization data for **29a**

^{1}H NMR (400 MHz, *$CDCl_3$*) δ_{ppm} 7.65 (1H, d, *J* = 10.3 Hz), 6.74 (1H, qdd, *J* = 13.7, 10.5, 1.6 Hz), 5.42 (1H, dd, *J* = 3.2, 3.2 Hz), 5.26 (1H, dd, *J* = 8.4, 4.6 Hz), 5.22-5.14 (2H, m), 4.66 (1H, ddd, *J* = 9.7, 4.2, 4.2 Hz), 4.28 (1H, dd, *J* = 12.7, 9.3 Hz), 4.21-4.15 (2H, m), 2.59 (1H, dd, *J* = 15.7, 9.7 Hz), 2.44 (1H, dd, *J* = 15.8, 4.0 Hz), 2.12 (3H, s), 2.07 (3H, s), 2.05 (3H, s), 2.04 (3H, s), 1.67 (3H, dd, *J* = 6.7, 1.7 Hz); **^{13}C NMR** (101 MHz, *$CDCl_3$*) δ_{ppm} 170.7, 169.9, 169.8, 169.6, 166.2, 123.0, 108.6, 69.8, 68.6, 68.0, 67.7, 66.9, 61.4, 34.4, 20.8, 20.75, 20.74, 20.68, 14.8. **ESI-MS** *m/z* calcd for $C_{19}H_{27}N_1O_{10}$ $[M + H]^+$: 430.17; $[M + Na]^+$: 452.15; $[M + K]^+$: 468.12. Found: 430.23, 542.22, 468.20. **Rf** = 0.5 (8:2, ethyl acetate: hexanes).

Characterization data for **28a**

^{1}H NMR (400 MHz, *$CDCl_3$*) δ_{ppm} 7.71 (1H, d, *J* = 10.3 Hz), 6.73 (1H, qdd, *J* = 10.6, 8.8, 1.7 Hz), 5.43 (1H, dd, *J* = 3.1, 3.1 Hz), 5.27 (1H, dd, *J* = 8.4, 4.6 Hz), 5.17 (1H, dd, *J* = 8.4, 3.3 Hz), 4.83 (1H, dqd, *J* = 8.8, 7.2, 0.6 Hz), 4.71 (1H, ddd, *J* = 9.1, 4.3, 4.3 Hz), 4.31-4.06 (3H, m), 2.66 (1H, dd, *J* = 15.9, 9.6 Hz), 2.51 (1H, dd, *J* = 15.9, 4.1 Hz), 2.12 (3H, s), 2.08 (3H, s), 2.05 (3H, s), 2.02 (3H, s), 1.62 (3H, dd, *J* = 7.1, 1.8 Hz); **^{13}C NMR** (101 MHz, *$CDCl_3$*) δ_{ppm} 170.7, 169.9, 169.8, 169.6, 166.5, 121.8, 106.0, 69.8, 68.6, 67.9, 67.6, 66.9, 61.3, 34.3, 20.76, 20.72, 20.67, 20.63, 11.0. **ESI MS** calcd for $C_{19}H_{27}N_1O_{10}$ $[M + H]^+$: 430.17; $[M + Na]^+$: 452.15; $[M + K]^+$: 468.12. Found: 430.22, 542.22, 468.22. **Rf** = 0.5 (8:2, ethyl acetate: hexanes).

***Z*-*N*-(1-propenyl)-2-(α-D-galactopyranosyl)ethylamide (28)**

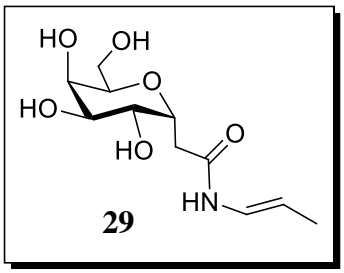


28

Enamine **28a** (10 mg, 0.233 mmol) was treated with 10 mL of a 0.1 M sodium methoxide in methanol with vigorous stirring for 2 hours. The solution was diluted with 20 mL of water and solvent was removed *in vacuo*. The solution was resuspended in a further 20 mL of water and again solvent was removed *in vacuo*. The solution was resuspended in methanol and filtered through a 20 μm filter. The filtrate was less basic than the original solution by pH test. Solvent was removed and the filtration process was repeated. The product was resuspended in water and lyophilized to give 5 mg of **28** as white crystals in 82% yield.

^{1}H NMR (400 MHz, *D_2O*) δ_{ppm} 6.49 (1H, qd, *J* = 8.7, 1.7 Hz), 5.05 (1H, qd, *J* = 8.8, 7.2 Hz), 4.52 (1H, ddd, *J* = 10.5, 5.9, 4.5 Hz), 4.03 (1H, dd, *J* = 9.9, 6.0 Hz), 3.99 (1H, dd, *J* = 3.4, 1.5 Hz), 3.86 (1H, ddd, *J* = 6.7, 5.1, 1.3 Hz), 3.75 (1H, dd, *J* = 9.9, 3.3 Hz), 3.68 (2H, dd, *J* = 6.0, 3.8 Hz), 3.66-3.57 (m, 1H), 2.80 (1H, dd, *J* = 15.1, 10.5 Hz), 2.68 (1H, dd, *J* = 15.0, 4.3 Hz), 1.63 (3H, dd, *J* = 7.1, 1.7 Hz); **^{13}C NMR** (101 MHz, *D_2O*) δ_{ppm} 171.7, 120.7, 111.0, 72.7, 69.7, 69.6, 68.8, 67.6, 60.8, 32.2, 10.5. **ESI-MS** *m/z* calcd for $C_{11}H_{19}N_1O_6$ $[M + Na]^+$: 284.11. Found: 284.26.

***E*-*N*-(1-propenyl)-2-(α-D-galactopyranosyl)ethylamide (29)**

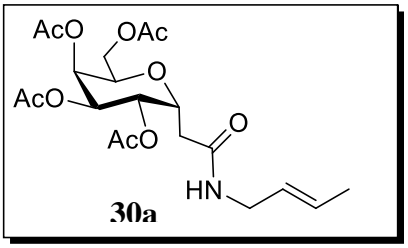


29

Enamine **29a** (6 mg, 0.014 mmol) was treated with 10 mL of a 0.1 M sodium methoxide in methanol with vigorous stirring for 2 hours. The solution was diluted with 20 mL of water and solvent was removed *in vacuo*. The solution was resuspended in a further 20 mL of water and again solvent was removed *in vacuo*. The solution was resuspended in methanol and filtered through a 20 μm filter. The filtrate was less basic than the original solution by pH test. Solvent was removed and the filtration process was repeated. The product was resuspended in water and lyophilized to give 2.8 mg of **29** as white crystals in 77% yield.

^{1}H NMR (500 MHz, D_2O) δ_{ppm} 6.57 (1H, qd, J = 14.1, 1.5 Hz), 5.38 (1H, qd, J = 14.1, 6.8 Hz), 4.47 (1H, ddd, J = 10.5, 6.0, 4.7 Hz), 4.00 (1H, dd, J = 9.9, 6.0 Hz), 3.96 (1H, dd, J = 3.3, 1.5 Hz), 3.68-3.63 (1H, m), 3.72 (1H, dd, J = 9.9, 3.3 Hz), 3.65 (2H, ddd, J = 4.2, 4.2, 1.6 Hz), 2.66 (1H, dd, J = 15.0, 10.6 Hz), 2.59 (1H, dd, J = 15.0, 4.5 Hz), 1.63 (3H, dd, J = 6.8, 1.5 Hz); **^{13}C NMR** (126 MHz, D_2O) δ_{ppm} 170.5, 121.9, 112.2, 72.5, 69.65, 69.62, 68.7, 67.5, 60.7, 32.2, 14.1. **ESI-MS** *m/z* calcd for $C_{11}H_{19}N_1O_6$ $[M + Na]^+$: 284.11. Found: 284.25.

***E*-*N*-(crotyl)-2-(2,3,4,6-tetra-*O*-acetyl-α-D-galactopyranosyl)ethylamide (30a)**

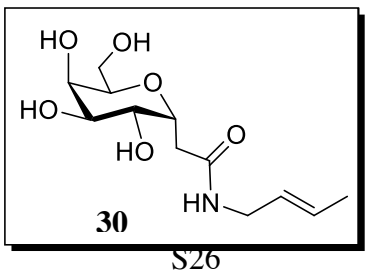


30a

Using the general coupling conditions (Fig. S2), 200 mg (0.51 mmol) of carboxylic acid **6**, 200 mg (0.48 mmol) of HCTU, 180 μL (1 mmol) of DIPEA, and 400 μL (5 mmol) of crotyl amine[10,11] were stirred in 4 mL of DMF for 18 hours. Following standard work-up, 250 mg of crude brown oil was recovered that was purified by flash chromatography (6: 4 ethyl acetate: hexanes, Rf= 0.16) to yield 160 mg of **30a** as a clear thick oil (71 % yield).

^{1}H NMR (400 MHz, $CDCl_3$) δ_{ppm} 6.35 (1H, t, J = 5.4 Hz), 5.63 (1H, tqd, J = 15.4, 6.3, 1.3 Hz), 5.46 (1H, dddt, J = 12.0, 7.6, 6.0, 1.6 Hz), 5.42 (1H, t, J = 2.6 Hz), 5.29 (1H, dd, J = 8.8, 4.8 Hz, 1H), 5.17 (1H, dd, J = 8.8, 3.3 Hz, 1H), 4.71 (1H, td, J = 9.4, 4.6 Hz), 4.27-4.14 (3H, m), 3.81 (1H, td, J = 6.3, 0.7 Hz), 2.62 (1H, dd, J = 15.5, 9.6 Hz), 2.46 (1H, dd, J = 15.5, 4.4 Hz), 2.13 (3H, s), 2.07 (3H, s), 2.05 (3H, s), 2.04 (3H, s), 1.68 (3H, ddd, J = 6.3, 2.7, 1.3 Hz); **^{13}C NMR** (101 MHz, $CDCl_3$) δ_{ppm} 170.5, 170.0, 169.8, 169.6, 169.0, 128.1, 126.7, 69.3, 69.0, 67.9, 67.8, 67.1, 61.4, 41.4, 34.3, 20.68, 20.68, 20.66, 20.61, 17.6. **ESI-MS** *m/z* calcd for $C_{20}H_{29}NO_{10}$ $[M + H]^+$: 444.19; $[M + Na]^+$: 466.17. Found: 444.28, 466.26. **Rf** = 0.16 (6:4, ethyl acetate: hexanes).

***E*-*N*-(crotyl)-2-(α-D-galactopyranosyl)ethylamide (30)**



30

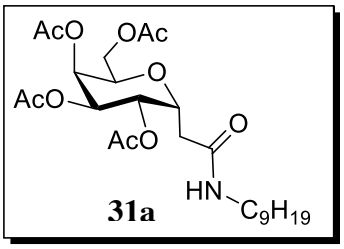
Crotyl derivative **30a** (100 mg, 0.22 mmol) was dissolved in 10 mL of 0.1 M NaOMe in methanol and stirred for four hours. Dowex-50X resin was added and the solution was stirred an additional five

minutes before the resin was removed by filtration and washed with methanol. The filtrate was concentrated, and purified by preparatory TLC (6:1:1:1, ethyl acetate: water: methanol: acetonitrile) to yield 50 mg of off yellow gel. This gel was redissolved in minimum methanol and ether was added until the solution became cloudy and allowed to stand for 16 hours at -20 ºC. The resulting white precipitate was collected by filtration, resuspended in water and lyophilized to provide 28 mg (0.10 mmol) of **30** as a white solid (46 % yield).

^{1}H NMR (400 MHz, D_2O) δ_{ppm} 5.67 (1H, tqd, *J* = 15.4, 6.6, 1.5 Hz), 5.47 (1H, dddt, *J* = 10.5, 7.2, 5.6, 1.4 Hz), 4.48 (1H, ddd, *J* = 10.6, 5.9, 4.2 Hz), 4.02 (1H, dd, *J* = 9.9, 6.1 Hz), 3.98 (1H, dd, *J* = 3.3, 1.5 Hz), 3.81 (1H, ddd, *J* = 6.7, 5.2, 1.3 Hz), 3.68 (2H, dd, *J* = 6.0, 3.6 Hz), 3.78-3.65 (3H, m), 2.68 (1H, dd, *J* = 14.9, 11.0 Hz), 2.58 (1H, dd, *J* = 15.0, 4.2 Hz), 1.65 (3H, ddd, *J* = 6.4, 2.8, 1.3 Hz); **^{13}C NMR** (75 MHz, D_2O) δ_{ppm} 173.2, 128.5, 125.6, 72.9, 72.4, 69.6, 68.7, 67.5, 60.7, 41.1, 32.2, 16.8. **ESI-MS** *m/z* calcd for $C_{12}H_{21}NO_6$ $[M + H]^+$: 276.15; $[M + Na]^+$: 298.13. Found: 276.17, 298.15.

N-Nonyl-2-(2,3,4,6-tetra-*O*-acetyl-α-D-galactopyranosyl)ethylamide (31a)

Using the general coupling conditions (Fig. S2), 100 mg (0.26 mmol) of carboxylic acid **6**, 100 mg (0.24 mmol) of HCTU, 90 μL (0.50 mmol) of DIPEA, and 140 μL (0.78 mmol) of nonylamine were stirred in 1 mL of DMF for 36 hours. Following standard work-up, the crude brown oil was recovered that was purified by dry vacuum chromatography (100 % hexanes to 50 % ethyl acetate in hexanes in 5 % steps) to yield 105 mg of **31a** as a clear, thick oil (85 % yield).

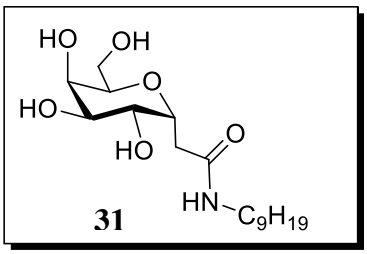


31a

^{1}H NMR (400 MHz, $CDCl_3$) δ_{ppm} 6.25 (1H, t, *J* = 5.4, Hz), 5.42 (1H, t, *J* = 3.0 Hz), 5.28 (1H, dd, *J* = 8.6, 4.7 Hz), 5.16 (1H, dd, *J* = 8.6, 3.3 Hz), 4.68 (1H, dt, *J* = 9.3, 4.4 Hz), 4.27-4.15 (3H, m), 3.30-3.16 (2H, m), 2.57 (1H, dd, *J* = 15.5, 9.6 Hz), 2.43 (1H, dd, *J* = 15.5, 4.2 Hz), 2.13 (3H, s), 2.08 (3H, s), 2.05 (6H, s), 1.50 (2H, p, *J* = 6.7 Hz), 1.33-1.23 (12H, m), 0.88 (1H, t, *J* = 6.9 Hz); **^{13}C NMR** (101 MHz, $CDCl_3$) δ_{ppm} 170.4, 169.9, 169.8, 169.5, 169.1, 69.4, 68.9, 67.9, 67.7, 66.9, 61.2, 39.6, 34.4, 31.7, 29.56, 29.35, 29.20, 29.15, 26.9, 22.5, 20.65, 20.65, 20.65, 20.60, 14.0. **ESI-MS** *m/z* calcd for $C_{25}H_{41}N_1O_{10}$ $[M + H]^+$: 516.28; $[M + Na]^+$: 538.26. Found: 516.31, 538.29. **Rf** = 0.39 (2: 8, hexanes: ethyl acetate).

N-Nonyl-2-(α-D-galactopyranosyl)ethylamide (31)

Nonyl derivative **31a** (50 mg, 0.10 mmol) was dissolved in 10 mL of 0.1 M NaOMe in methanol and stirred for four hours. Dowex-50X resin was added and the solution was stirred an additional five minutes before the resin was removed by filtration and washed with water and methanol successively. The filtrate was concentrated, and dissolved in methanol. Diethyl ether was added until the solution became cloudy

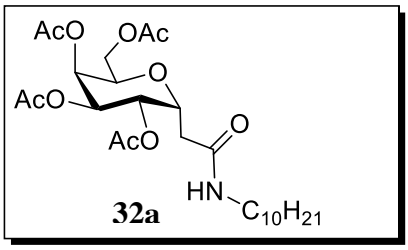


31

and was left to stand for 2 hours at -20 ºC. The solid was collected by filtration, resuspended in water and lyophilized to provide 25 mg (0.072 mmol) of **31** as a white solid (72 % yield).

^{1}H NMR (400 MHz, *MeOD*) δ_{ppm} 4.40 (1H, td, *J* = 9.1, 4.0 Hz), 3.94 (1H, t, *J* = 3.0 Hz), 3.90-3.75 (3H, m), 3.65 (1H, dd, *J* = 9.5, 3.7 Hz), 3.63 (1H, dd, *J* = 6.7, 3.8 Hz), 3.16 (2H, t, *J* = 7.2, 7.2 Hz), 2.60 (1H, dd, *J* = 15.2, 10.5 Hz), 2.46 (1H, dd, *J* = 15.2, 3.7 Hz), 1.49 (2H, p, *J* = 7.0 Hz), 1.37-1.24 (12H, m), 0.89 (3H, t, *J* = 6.9 Hz); **^{13}C NMR** (101 MHz, *MeOD*) δ_{ppm} 174.1, 74.9, 72.4, 72.1, 70.2, 69.6, 61.7, 40.6, 34.5, 33.1, 30.7, 30.5, 30.5, 30.4, 28.1, 23.8, 14.5. **ESI-MS** *m/z* calcd for $C_{17}H_{33}N_1O_6$ $[M + H]^+$: 348.24; $[M + Na]^+$: 370.22. Found: 348.26, 370.24.

N-Decyl-2-(2,3,4,6-tetra-*O*-acetyl-α-D-galactopyranosyl)ethylamide (32a)

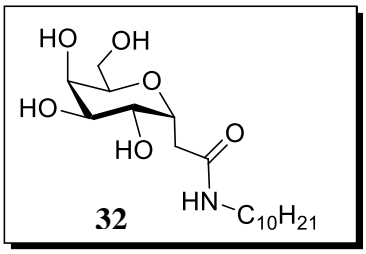


32a

Using the general coupling conditions (Fig. S2), 100 mg (0.26 mmol) of carboxylic acid **6**, 100 mg (0.24 mmol) of HCTU, 60 μL (0.5 mmol) of DIPEA, and 154 μL (0.76 mmol) of decylamine were stirred in 2 mL of DCM for 18 hours. Following standard work-up, 200 mg of crude clear oil was recovered that was purified by flash chromatography (6:4 hexanes: ethyl acetate) to yield 121 mg of **32a** as an amorphous white solid (73 % yield).

^{1}H NMR (400 MHz, *CDCl$_3$*) δ_{ppm} 6.24 (1H, bs), 5.42 (1H, dd, *J* = 2.9 Hz), 5.28 (1H, dd, *J* = 8.6, 4.8 Hz), 5.16 (1H, dd, *J* = 8.6, 3.3 Hz), 4.68 (1H, dt, *J* = 9.3, 4.4 Hz), 4.27-4.14 (3H, m), 3.22 (1H, dt, *J* = 7.2, 6.1 Hz), 2.57 (1H, dd, *J* = 15.5, 9.6 Hz), 2.43 (1H, dd, *J* = 15.5, 4.3 Hz), 2.12 (3H, s), 2.07 (3H, s), 2.05 (3H, s), 2.05 (3H, s), 1.49 (2H, q, *J* = 7.3 Hz), 1.36-1.19 (14H, m), 0.88 (3H, t, *J* = 6.8 Hz); **^{13}C NMR** (101 MHz, *CDCl$_3$*) δ_{ppm} 170.0, 169.9, 169.7, 169.4, 169.0, 69.2, 69.0, 67.8, 67.7, 67.0, 61.2, 34.2, 31.8, 29.49, 29.46, 29.43, 29.42, 29.20, 29.28, 26.8, 22.5, 20.9, 20.6, 20.6, 20.5, 14.0. **ESI-MS** *m/z* calcd for $C_{26}H_{43}NO_{10}$ $[M + H]^+$: 530.30; $[M + Na]^+$: 552.28. Found: 530.46, 552.44.

N-Decyl-2-(α-D-galactopyranosyl)ethylamide (32)



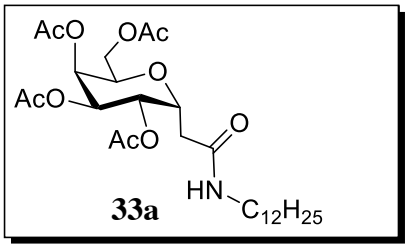
32

Decyl derivative **32a** (20 mg, 0.037 mmol) was dissolved in 15 mL of 0.1 M NaOMe in methanol and stirred for four hours. Dowex-50X resin was added and the solution was stirred an additional five minutes before the resin was removed by filtration and washed with water and methanol successively. The filtrate was concentrated, and further purifed by preperatory TLC (8:1:1:1, ethyl acetate: water: methanol: acetonitrile), resuspended in water and lyophilized to provide 9 mg (0.025 mmol) of **32** as a white solid (68 % yield).

^{1}H NMR (400 MHz, *MeOD*) δ_{ppm} 4.41 (1H, ddd, *J* = 8.9, 4.2, 4.2 Hz), 3.95 (1H, t, *J* = 3.0, Hz), 3.88 (1H, dd, *J* = 8.1, 4.9 Hz), 3.86 (1H, dd, *J* = 11.0, 7.8 Hz), 3.79 (1H, m), 3.66 (1H, dd, *J* = 10.8, 4.5 Hz), 3.63 (1H, dd, *J* = 8.1, 3.2 Hz), 3.17 (2H, t, *J* = 7.1, 7.1

Hz,), 2.60 (1H, dd, *J* = 15.2, 10.5 Hz), 2.46 (1H, dd, *J* = 15.2, 3.7 Hz), 1.50 (2H, m), 1.39-1.23 (14H, m), 0.90 (3H, t, *J* = 6.8 Hz). **^{13}C NMR** (101 MHz, *MeOD*) δ_{ppm} 174.1, 75.0, 72.4, 72.1, 70.2, 69.6, 61.7, 40.6, 34.5, 33.1, 30.8, 30.5, 30.4, 28.1, 23.8, 14.5. **ESI-MS** *m/z* calcd for $C_{13}H_{25}N_1O_6$ $[M + H]^+$: 362.25; $[M + Na]^+$: 384.24. Found: 362.26, 384.22. **Rf** = 0.26 (12:1:1:1, ethyl acetate: water :acetonitrile: methanol).

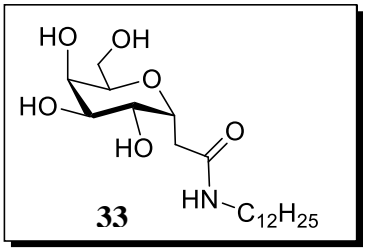
N-Dodecyl-2-(2,3,4,6-tetra-*O*-acetyl-α-D-galactopyranosyl)ethylamide (33a)



33a

Using the general coupling conditions (Fig. S2), 100 mg (0.26 mmol) of carboxylic acid **6**, 100 mg (0.24 mmol) of HCTU, 60 μL (0.5 mmol) of DIPEA, and 142 mg (0.77 mmol) of dodecylamine were stirred in 2 mL of DCM for 16 hours. Following standard work-up, 100 mg of crude brown oil was recovered that was purified by flash chromatography (1: 1 hexanes: ethyl acetate) to yield 80 mg of **33a** as a white amorphous solid (55% yield).
^{1}H NMR (400 MHz, *CDCl$_3$*) δ_{ppm} 6.15 (1H, s, *J* = 5.4 Hz), 5.39 (1H, t, *J* = 2.8 Hz), 5.25 (1H, dd, *J* = 8.6, 4.7 Hz), 5.13 (1H, dd, *J* = 8.6, 3.3 Hz), 4.65 (1H, dt, *J* = 9.3, 4.6 Hz), 4.23-4.11 (3H, m), 3.25-3.14 (2H, m), 2.54 (1H, dd, *J* = 15.5, 9.6 Hz), 2.40 (1H, dd, *J* = 15.5, 4.2 Hz), 2.10 (3H, s), 2.05 (3H, s), 2.03 (3H, s), 2.02 (3H, s), 1.45 (2H, p, *J* = 6.7 Hz), 1.33-1.17 (18H, m), 0.85 (3H, t, *J* = 6.8 Hz); **^{13}C NMR** (101 MHz, *CDCl$_3$*) δ_{ppm} 170.4, 169.9, 169.7, 169.5, 169.0, 69.4, 68.9, 67.9, 67.7, 66.9, 61.2, 39.7, 34.4, 31.8, 29.58, 29.56, 29.54, 29.52, 29.49, 29.28, 29.25, 26.9, 22.6, 20.7, 20.6, 14.0. **Rf** = 0.26 (6: 4 hexanes:ethyl acetate).

N-Dodecyl-2-(α-D-galactopyranosyl)ethylamide (33)

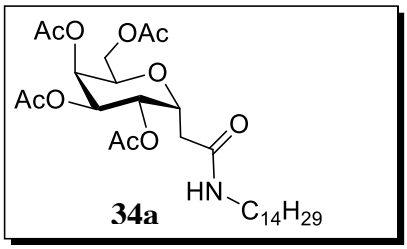


33

Dodecyl derivative **33a** (25 mg, 0.044 mmol) was dissolved in 15 mL of 0.1 M NaOMe in methanol and stirred for four hours. Dowex-50X resin was added and the solution was stirred an additional five minutes before the resin was removed by filtration and washed with water and methanol successively. The filtrate was concentrated, and further purifed by preperatory TLC (8:1:1:1, ethyl acetate: water: methanol: acetonitrile), resuspended in water and lyophilized to provide 14 mg (0.036 mmol) of **33** as a white solid (81 % yield).
^{1}H NMR (400 MHz, *MeOD*) δ_{ppm} 4.41 (1H, dt, *J* = 8.9, 4.1, Hz), 3.95 (1H, t, *J* = 3.0 Hz), 3.88 (1H, dd, *J* = 8.1, 4.9 Hz), 3.86 (1H, dd, *J* = 11.0, 7.8 Hz), 3.79 (1H, m), 3.66 (1H, dd, *J* = 10.8, 4.5 Hz), 3.63 (1H, dd, *J* = 8.1, 3.2 Hz), 3.17 (2H, t, *J* = 7.0 Hz), 2.61 (1H, dd, *J* = 15.2, 10.5 Hz), 2.47 (1H, dd, *J* = 15.2, 3.7 Hz), 1.56-1.43 (2H, m), 1.37-1.25 (m, 18H), 0.90 (3H, t, *J* = 6.9 Hz); **^{13}C NMR** (101 MHz, *MeOD*) δ_{ppm} 174.1, 74.9, 72.5, 72.1, 70.2, 69.6, 61.7, 40.6, 35.5, 33.1, 30.8, 30.8, 30.8, 30.8, 30.53, 30.52, 30.4, 28.1, 23.8, 14.5. **ESI-MS** *m/z* calcd for $C_{20}H_{39}NO_6$ $[M + H]^+$: 390.29; $[M + Na]^+$: 412.27. Found: 390.30, 412.27. **Rf** = 0.3 (12:1:1:1, ethyl acetate: water: acetonitrile: methanol).

***N*-Tetradecyl-2-(2,3,4,6-tetra-*O*-acetyl-α-D-galactopyranosyl)ethylamide (34a)**

Using the general coupling conditions (Fig. S2), 200 mg (0.51 mmol) of carboxylic acid **6**, 200 mg (0.48 mmol) of HCTU, 178 μL (1 mmol) of DIPEA, and 243 mg (1.5 mmol) of tetradecylamine (92% technical grade) were stirred in 4 mL of DCM for 48 hours. Following standard work-up, 440 mg crude white solid was recovered that was purified by flash chromatography (6: 4 hexanes: ethyl acetate) to yield 202 mg of **34a** as a white solid (68 % yield).

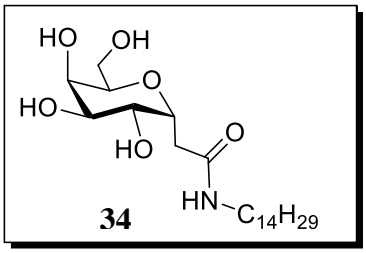


34a

^{1}H NMR (500 MHz, *CDCl$_3$*) δ_{ppm} 6.44 (1H, t, *J* = 5.6 Hz), 5.41 (1H, t, *J* = 2.9 Hz), 5.29 (1H, dd, *J* = 8.7, 4.8 Hz), 5.17 (1H, dd, *J* = 8.7, 3.3 Hz), 4.70 (1H, ddd, *J* = 9.3, 4.5 Hz), 4.27-4.13 (3H, m), 2.60 (1H, dd, *J* = 15.4, 9.7 Hz), 2.44 (1H, dd, *J* = 15.4, 4.3 Hz), 2.12 (3H, s), 2.07 (3H, s), 2.05 (3H, s), 2.04 (3H, s), 1.49 (2H, bt, *J* = 6.3 Hz), 1.28 (2H, q, *J* = 6.1 Hz), 1.27-1.23 (22 H, m), 0.88 (3H, t, *J* = 6.9, Hz); **^{13}C NMR** (101 MHz, *CDCl$_3$*) δ_{ppm} 170.5, 170.0, 169.9, 169.8, 169.6, 169.1, 69.5, 68.8, 68.0, 67.8, 66.9, 61.2, 29.66, 29.64, 29.62, 29.57, 29.56, 29.52, 29.32, 29.28, 26.9, 23.3, 22.7, 20.7, 14.1. **ESI-MS** *m/z* calcd for $C_{30}H_{51}NO_{10}$ $[M + H]^+$: 586.36; $[M + Na]^+$: 608.34. Found: 586.48, 608.47. **Rf** = 0.34 (6:4 hexanes: ethyl acetate).

***N*-Tetradecyl-2-(α-D-galactopyranosyl)ethylamide (34)**

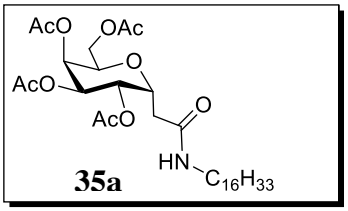
Tetradecyl derivative **34a** (110 mg, 0.19 mmol) was dissolved in 15 mL of 0.1 M NaOMe in methanol to which was added 5 mL of DCM and stirred for four hours. Dowex-50X resin was added and the solution was stirred an additional five minutes before the resin was removed by filtration and washed with methanol. The filtrate was concentrated, and purified by dry vacuum chromatography (100 % ethyl acetate to 60 % ethyl acetate in methanol in 5 % steps) to yield 45 mg of **34** a white solid following drying *in vacuo* (56 % yield).



34

^{1}H NMR (500 MHz, *CDCl$_3$/MeOD*) δ_{ppm} 4.42 (1H, td, *J* = 9.4, 4.8 Hz), 3.97 (1H, t, *J* = 3.0 Hz), 3.91 (1H, dd, *J* = 8.4, 5.1 Hz), 3.89 (1H, dd, *J* = 11.5, 7.2 Hz), 3.78 (1H, ddd, *J* = 7.1, 3.7, 3.0), 3.69 (1H, dd, *J* = 11.6, 4.1 Hz), 3.64 (1H, dd, *J* = 8.4, 3.4 Hz), 3.25-3.12 (2H, m), 2.61-2.47 (2H, m), 1.56-1.44 (2H, m), 1.36-1.21 (22H, m), 0.88 (3H, t, *J* = 6.8, 6.8 Hz); **^{13}C NMR** (126 MHz, *CDCl$_3$/MeOD*) δ_{ppm} 173.5, 74.3, 71.9, 71.6, 69.8, 69.2, 61.6, 40.4, 34.2, 32.6, 30.32, 30.31, 30.30, 30.28, 30.25, 30.23, 30.02, 30.00, 29.97, 27.7, 23.3, 14.4. **ESI-MS** *m/z* calcd for $C_{13}H_{25}N_1O_6$ $[M + H]^+$: 418.32; $[M + Na]^+$: 440.30; $[M + K]^+$: 456.27. Found: 418.49, 440.47, 456.46. **Rf** = 0.50 (2:8 methanol: ethyl acetate).

***N*-Hexadecyl-2-(2,3,4,6-tetra-*O*-acetyl-α-D-galactopyranosyl)ethylamide (35a)**

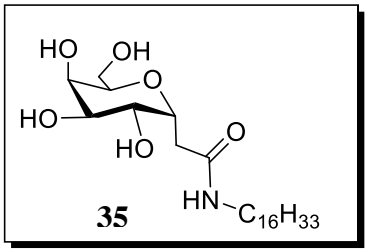


35a

Using the general coupling conditions (Fig. S2), 200 mg (0.51 mmol) of carboxylic acid **6**, 200 mg (0.48 mmol) of HCTU, 178 μL (1.5 mmol) of DIPEA, and 281 mg (1.5 mmol) of hexadecylamine were stirred in 4 mL of DCM for 48 hours. Following standard work-up, 440 mg crude white solid was recovered that was purified by flash chromatography (6: 4 hexanes: ethyl acetate) to yield 220 mg of **35a** as a white solid (72% yield).

^{1}H NMR (500 MHz, *$CDCl_3$*) δ_{ppm} 6.44 (1H, t, *J* = 5.4, Hz), 5.33 (1H, dd, *J* = 2.6, 2.6 Hz), 5.20 (1H, dd, *J* = 8.8, 4.9 Hz), 5.09 (1H, dd, *J* = 8.8, 3.2 Hz), 4.62 (1H, td, *J* = 9.2, 4.5, 4.5 Hz,), 4.16-4.05 (3H, m), 2.53 (1H, dd, *J* = 15.4, 9.6 Hz), 2.37 (1H, dd, *J* = 15.4, 4.3 Hz), 2.04 (3H, s), 1.98 (3H, s), 1.96 (3H, s), 1.95 (3H, s), 1.40 (2H, bt, *J* = 6.0 Hz), 1.19 (2H, q, *J* = 6.1 Hz),1.19-1.15 (24H, bs), 0.79 (3H, t, *J* = 6.9 Hz); **^{13}C NMR** (101 MHz, *$CDCl_3$*) δ_{ppm} 170.5, 169.9, 169.8, 169.5, 169.0, 69.5, 68.8, 68.0, 67.8, 66.9, 60.2, 39.7, 34.5, 31.9, 29.7, 29.6, 29.55, 29.53, 29.33, 29.28, 26.9, 23.3, 22.7, 20.7, 20.7, 20.7, 20.6, 14.1. **ESI-MS** *m/z* calcd for $C_{32}H_{55}NO_{10}$ $[M + H]^+$: 614.39; $[M + Na]^+$: 636.37; $[M + K]^+$: 652.35. Found: 614.46, 636.46, 652.45. **Rf** = 0.32 (6:4, hexanes: ethyl acetate).

***N*-Hexadecyl-2-(α-D-galactopyranosyl)ethylamide (35)**



35

Hexadecyl derivative **35a** (120 mg, 0.20 mmol) was dissolved in 15 mL of 0.1 M NaOMe in methanol to which was added 5 mL of DCM and stirred for four hours. Dowex-50X resin was added and the solution was stirred an additional five minutes before the resin was removed by filtration and washed with methanol. The filtrate was concentrated, and purified by dry vacuum chromatography (100 % ethyl acetate to 60 % ethyl acetate in methanol in 5 % steps) to yield 60 mg (0.14 mmol) of **35** as a white solid following drying *in vacuo* (71 % yield).

^{1}H NMR (400 MHz, *$CDCl_3$/MeOD*) δ_{ppm} 4.43 (1H, ddd, *J* = 9.4, 9.2, 4.7 Hz), 3.97 (1H, t, *J* = 2.9 Hz), 3.95-3.85 (2H, m), 3.80 (1H, ddd, *J* = 7.1, 3.7, 3.1 Hz), 3.70 (1H, dd, *J* = 11.4, 4.0 Hz), 3.64 (1H, dd, *J* = 8.5, 3.4 Hz), 3.25-3.12 (2H, m), 2.63-2.48 (2H, m), 1.50 (2H, t, *J* = 6.9), 1.35-1.21 (26H, m), 0.89 (3H, t, *J* = 6.8 Hz); **^{13}C NMR** (101 MHz, *$CDCl_3$/MeOD*) δ_{ppm} 173.4, 73.9, 71.9, 71.3, 69.4, 69.1, 61.4, 40.2, 33.7, 32.5, 30.28, 30.28, 30.28, 30.26, 30.24, 30.20, 30.1, 30.0, 29.8, 29.7, 27.6, 23.3, 14.4. **ESI-MS** *m/z* calcd for $C_{13}H_{25}N_1O_6$ $[M + H]^+$: 446.35; $[M + Na]^+$: 468.33; $[M + K]^+$: 484.30. Found: 446.53, 468.51, 484.50. **Rf** = 0.52 (2:8, methanol: ethyl acetate).

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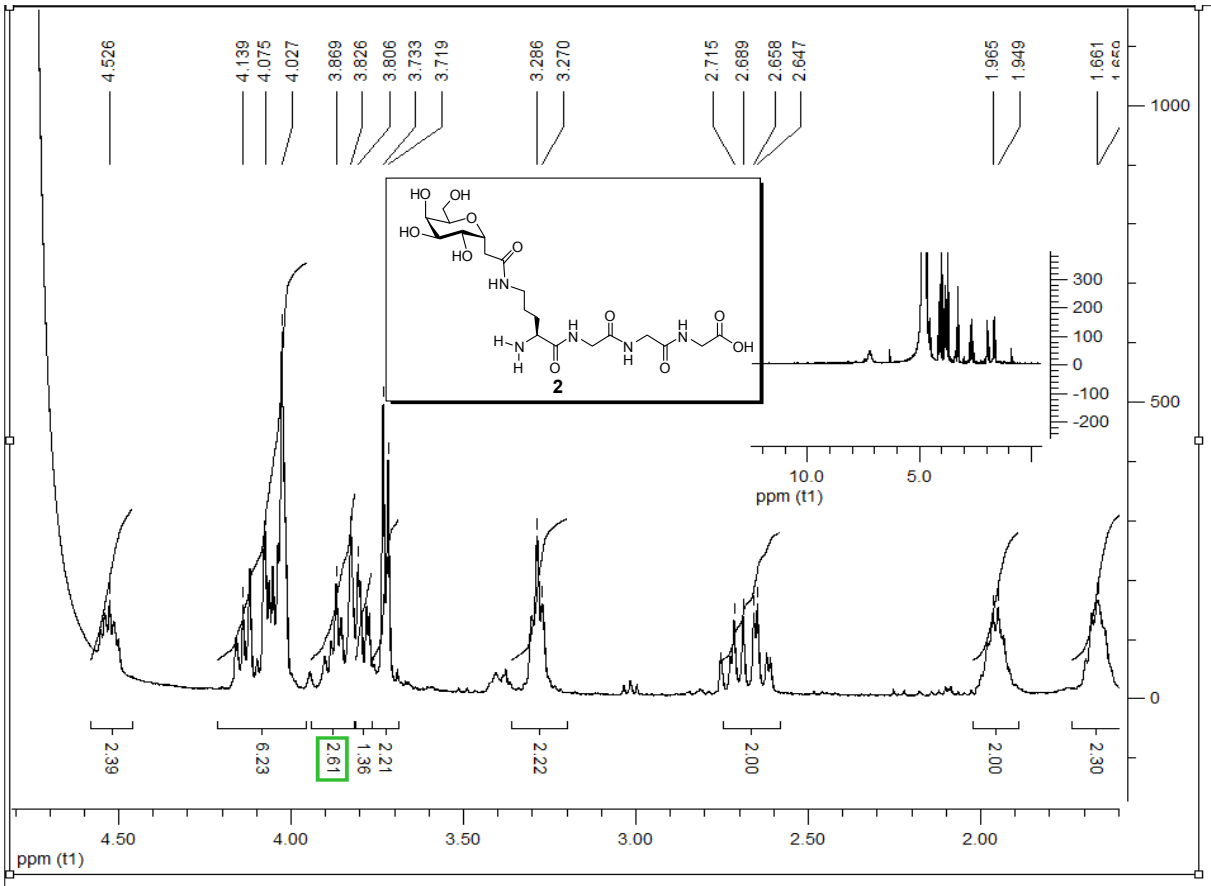

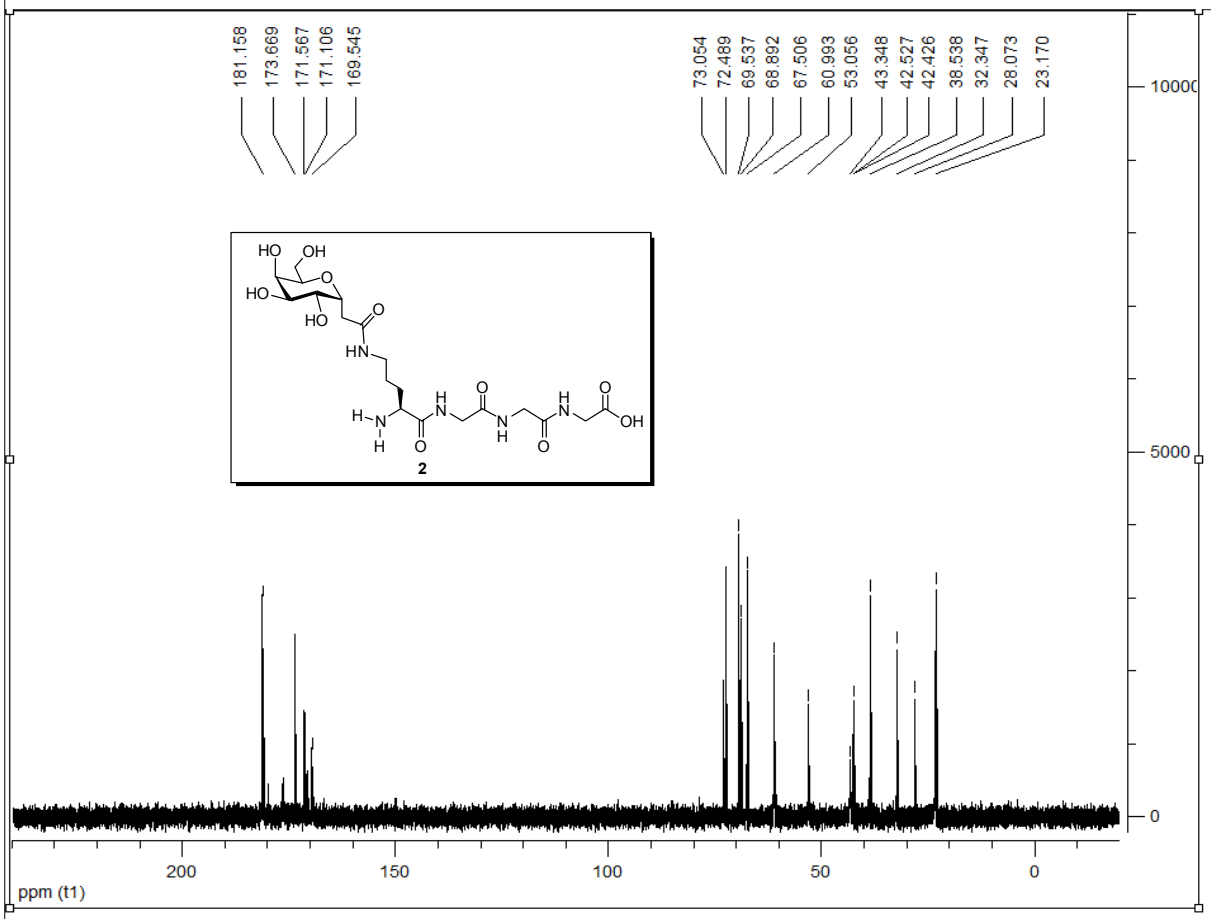

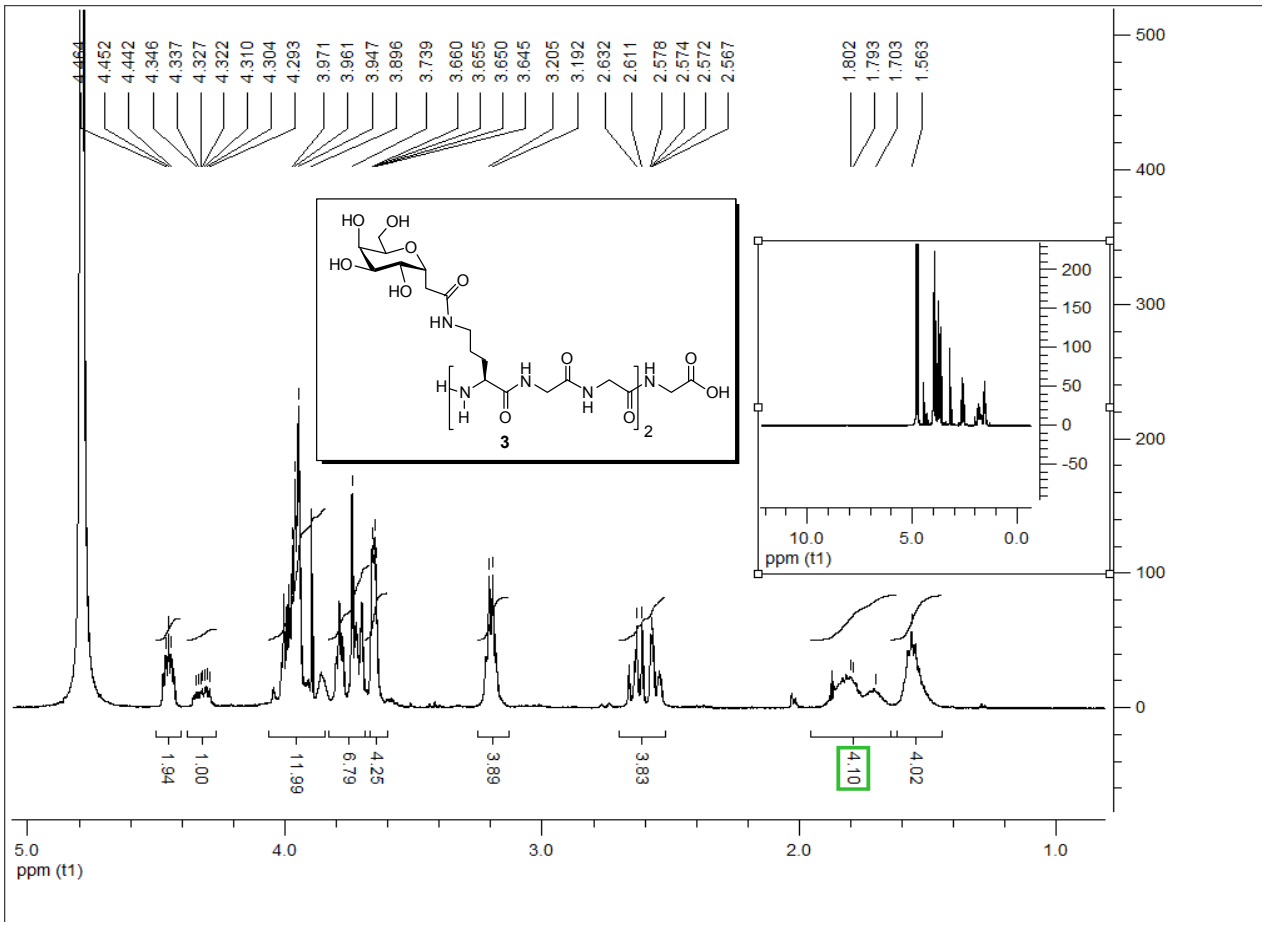

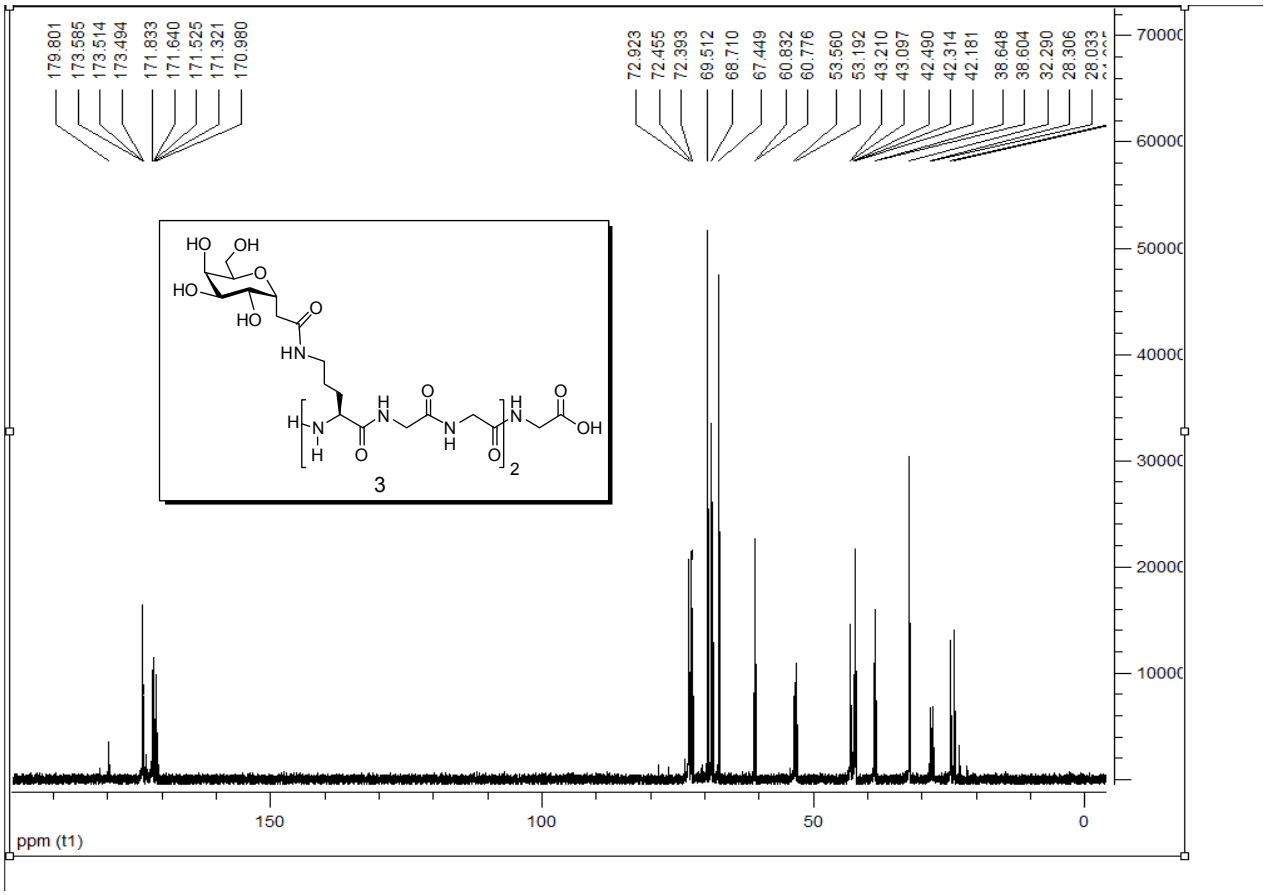

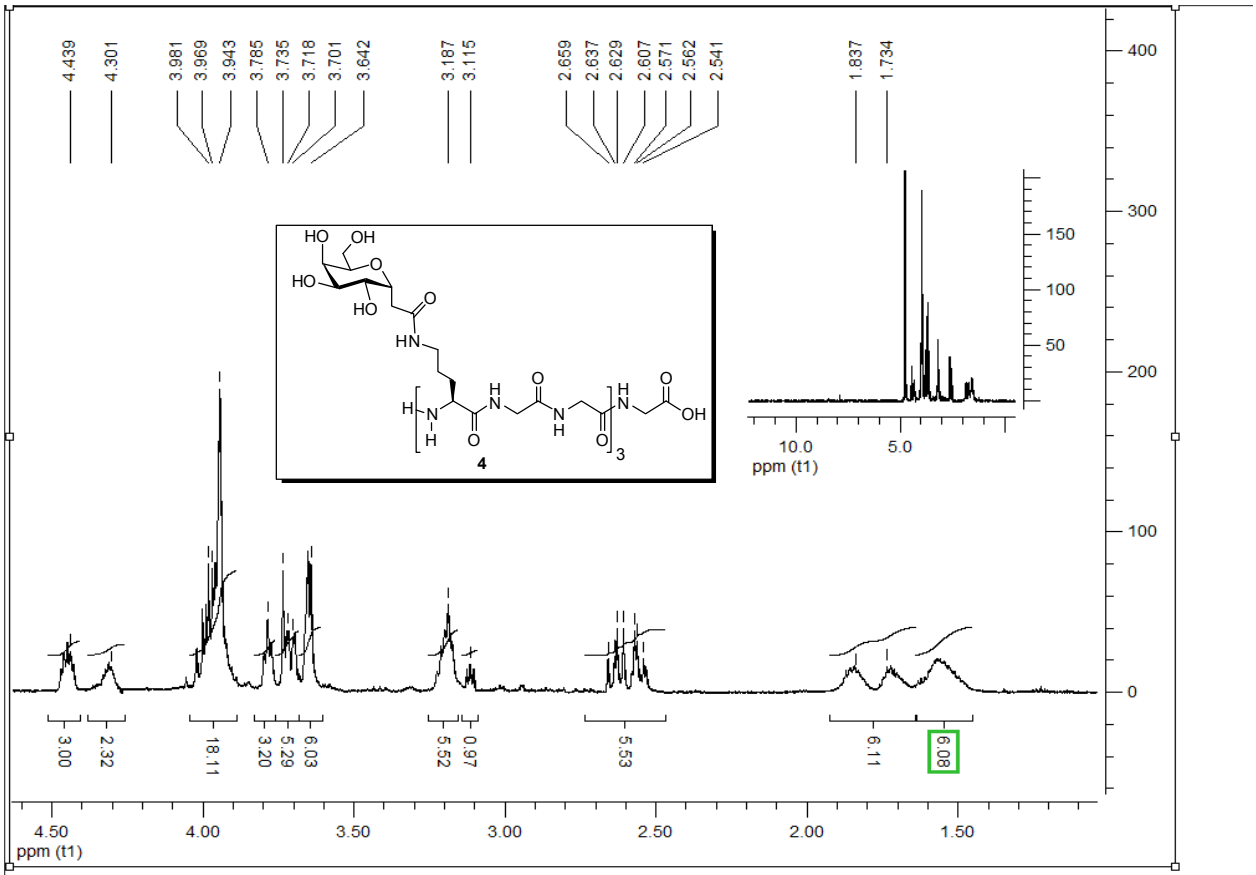

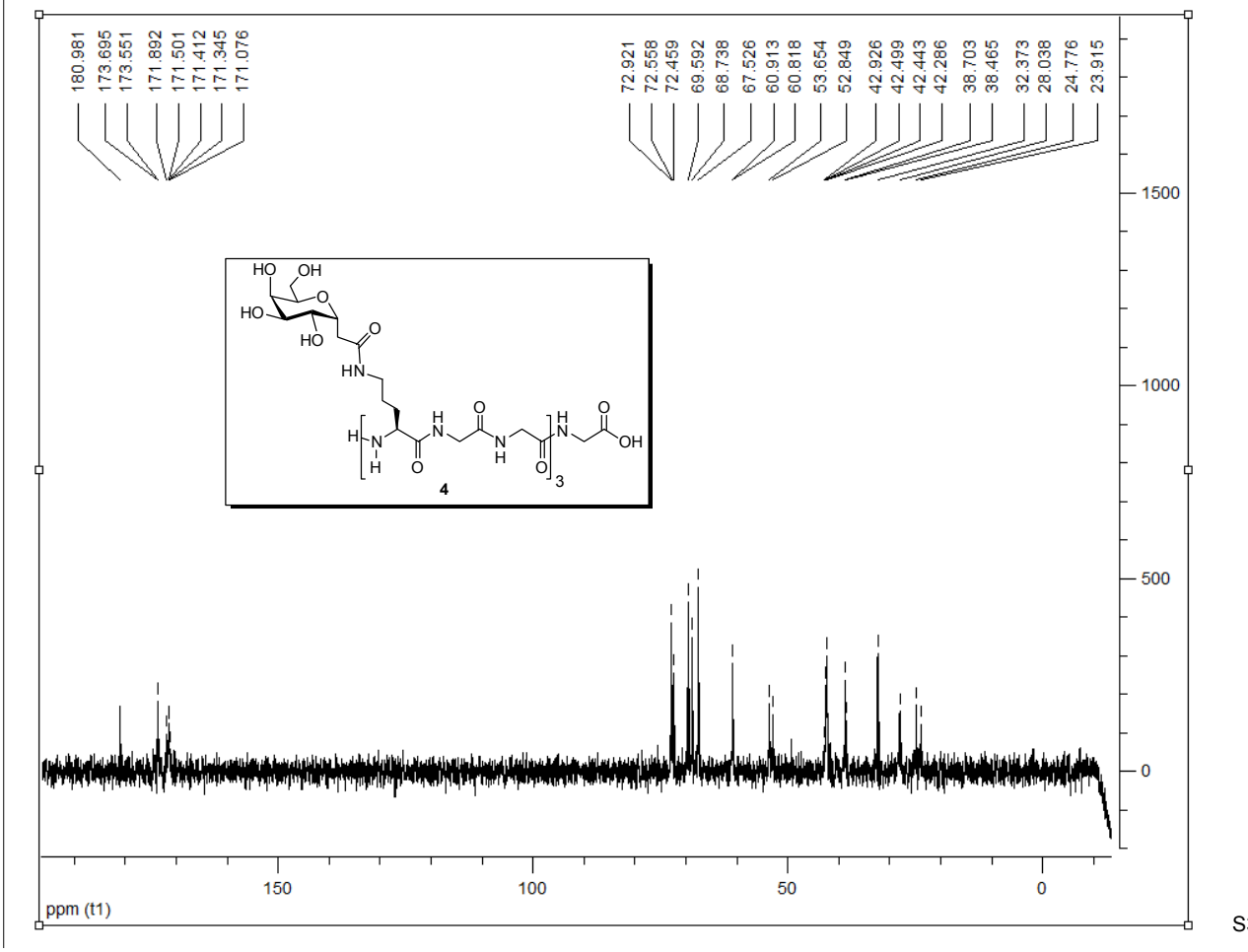

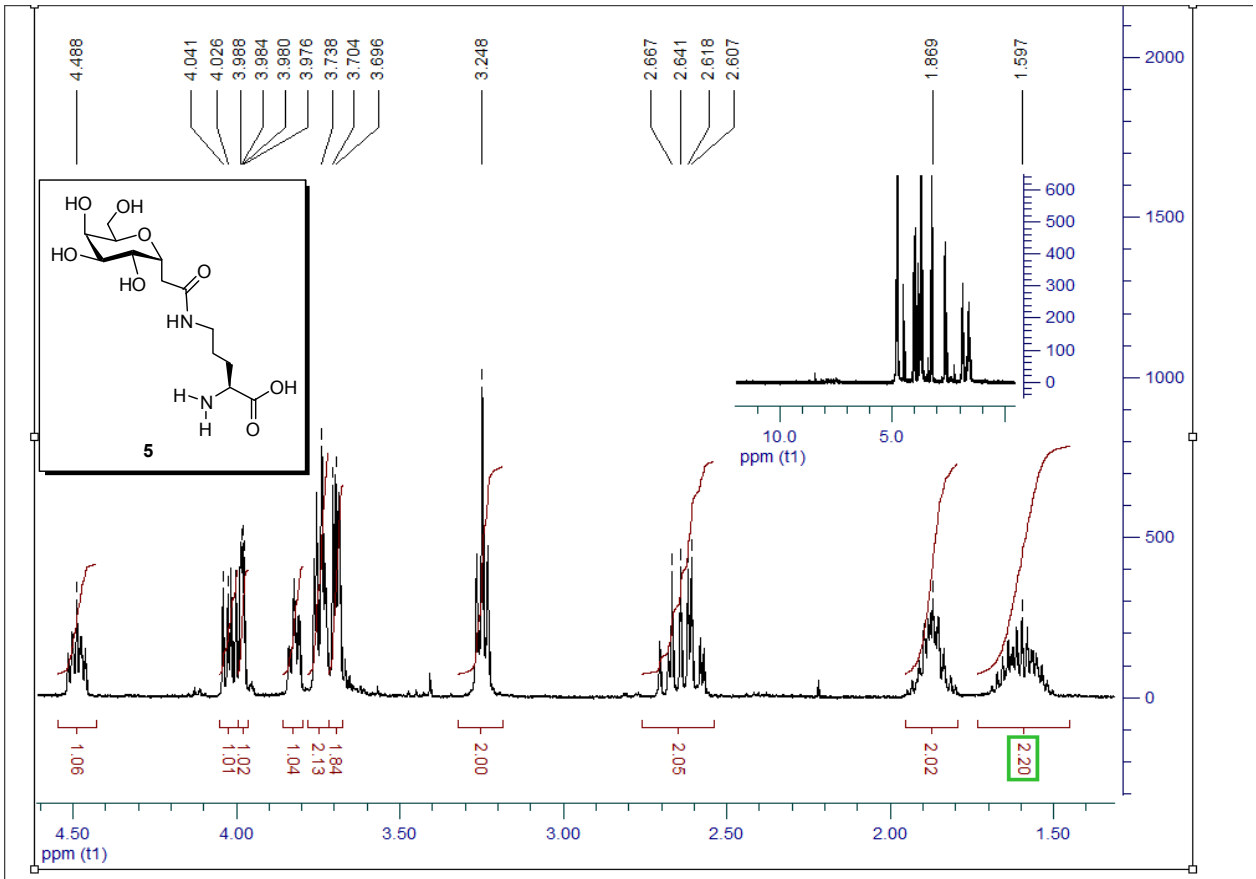

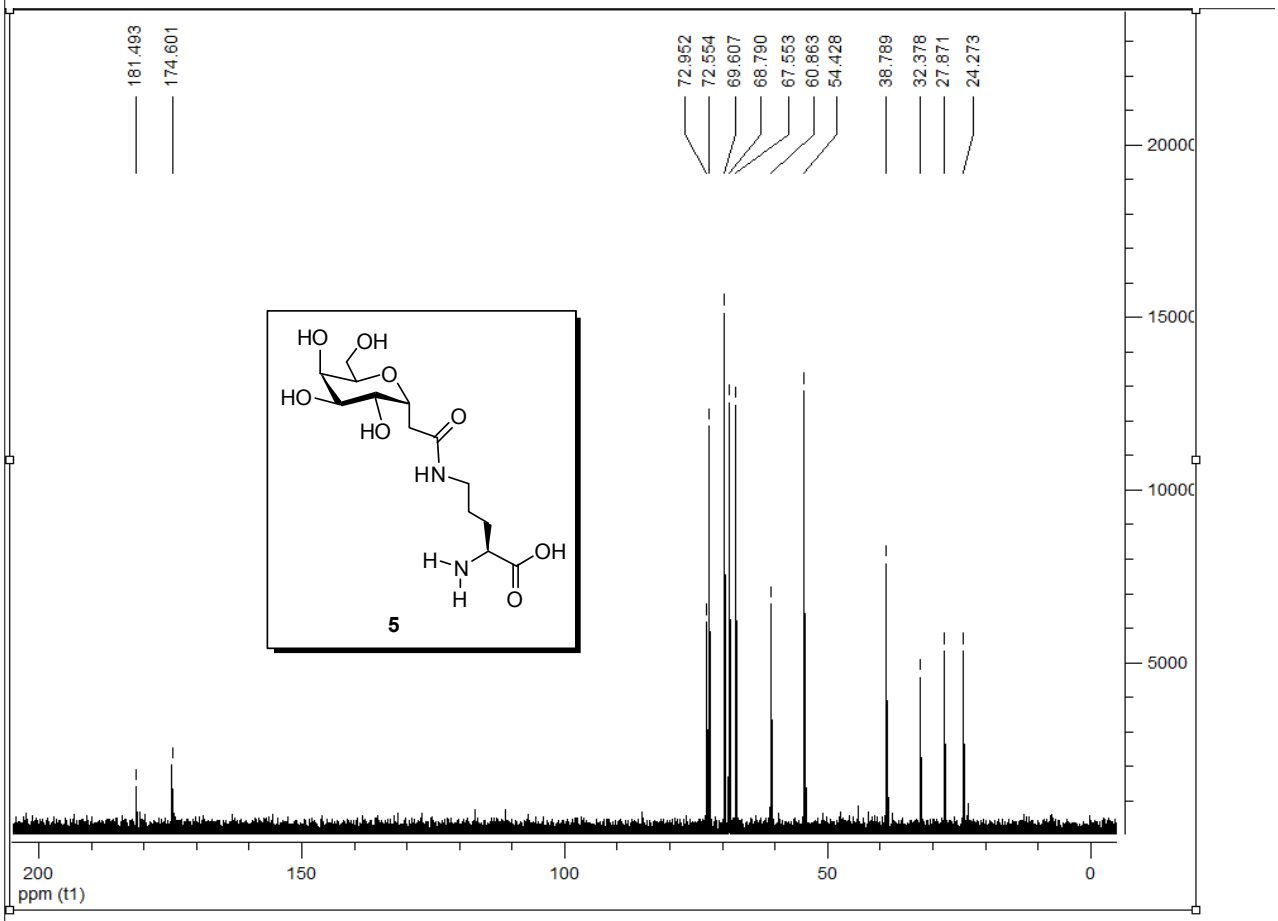

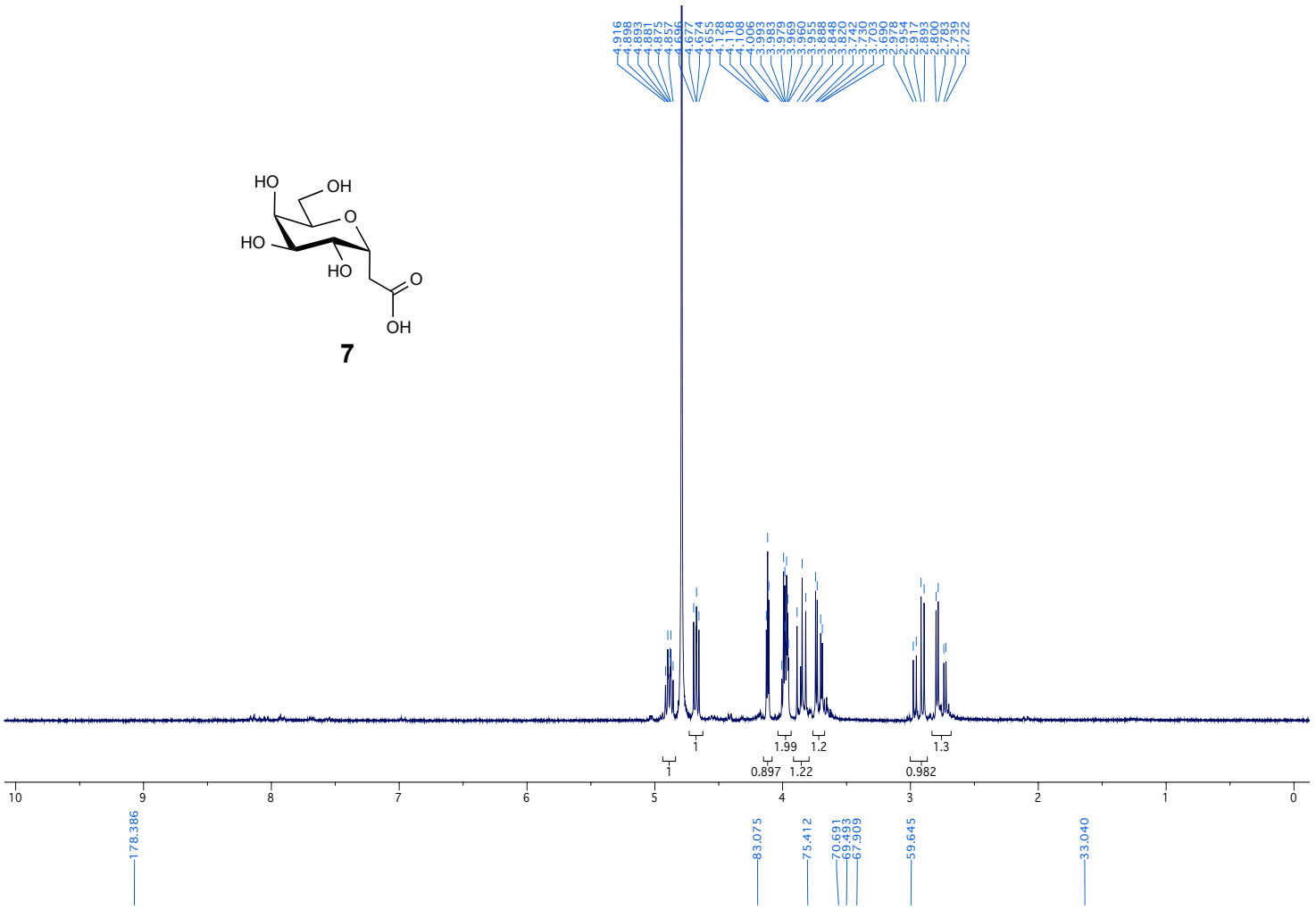
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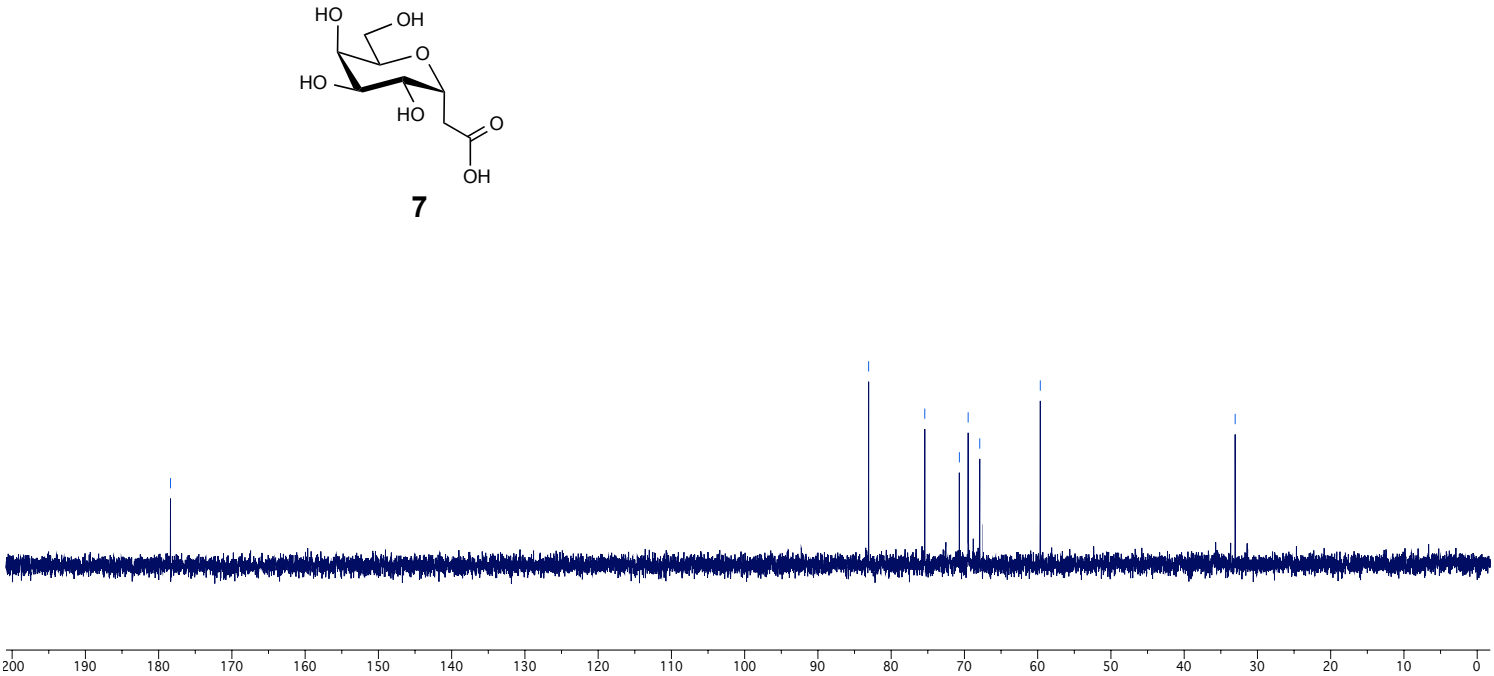
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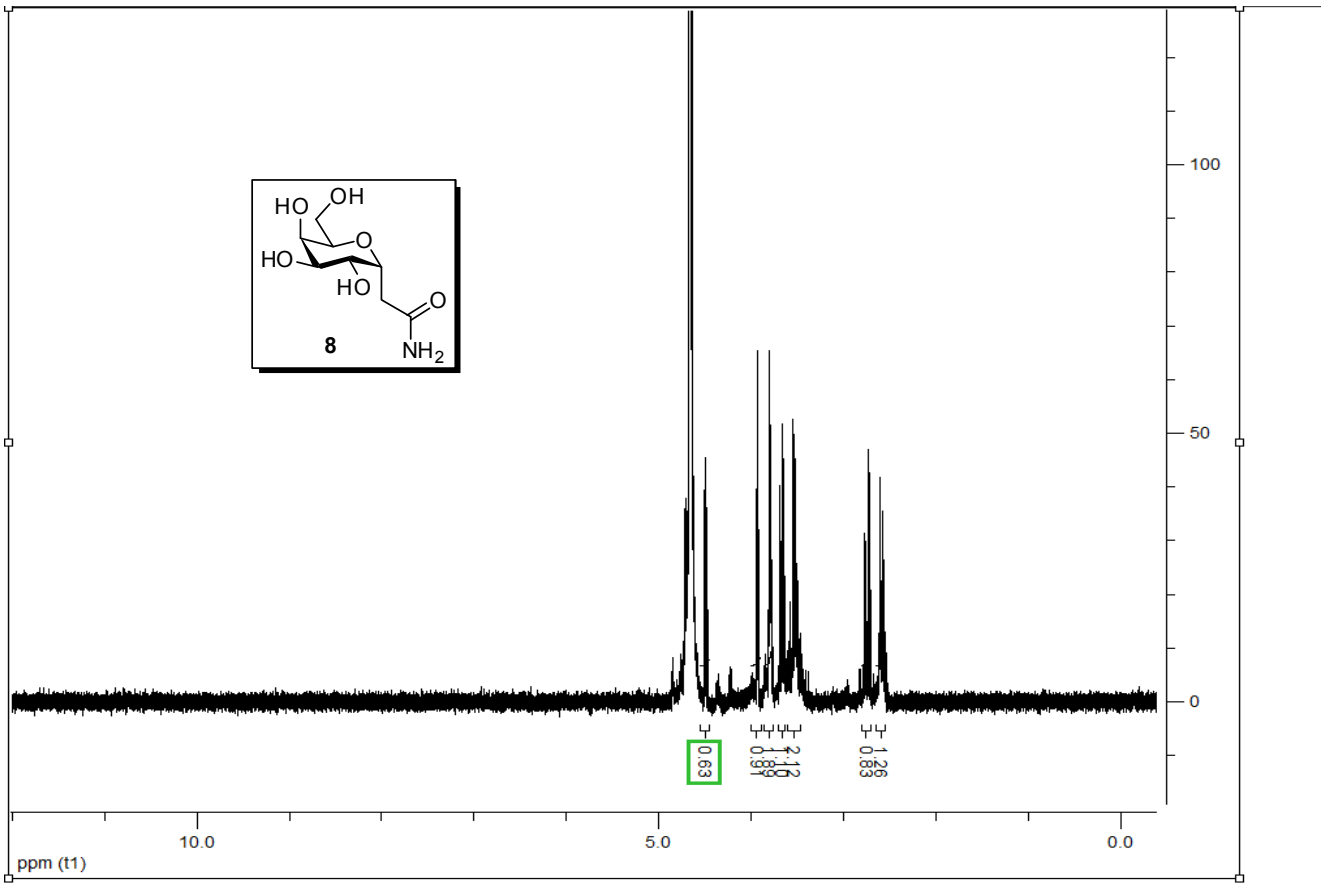

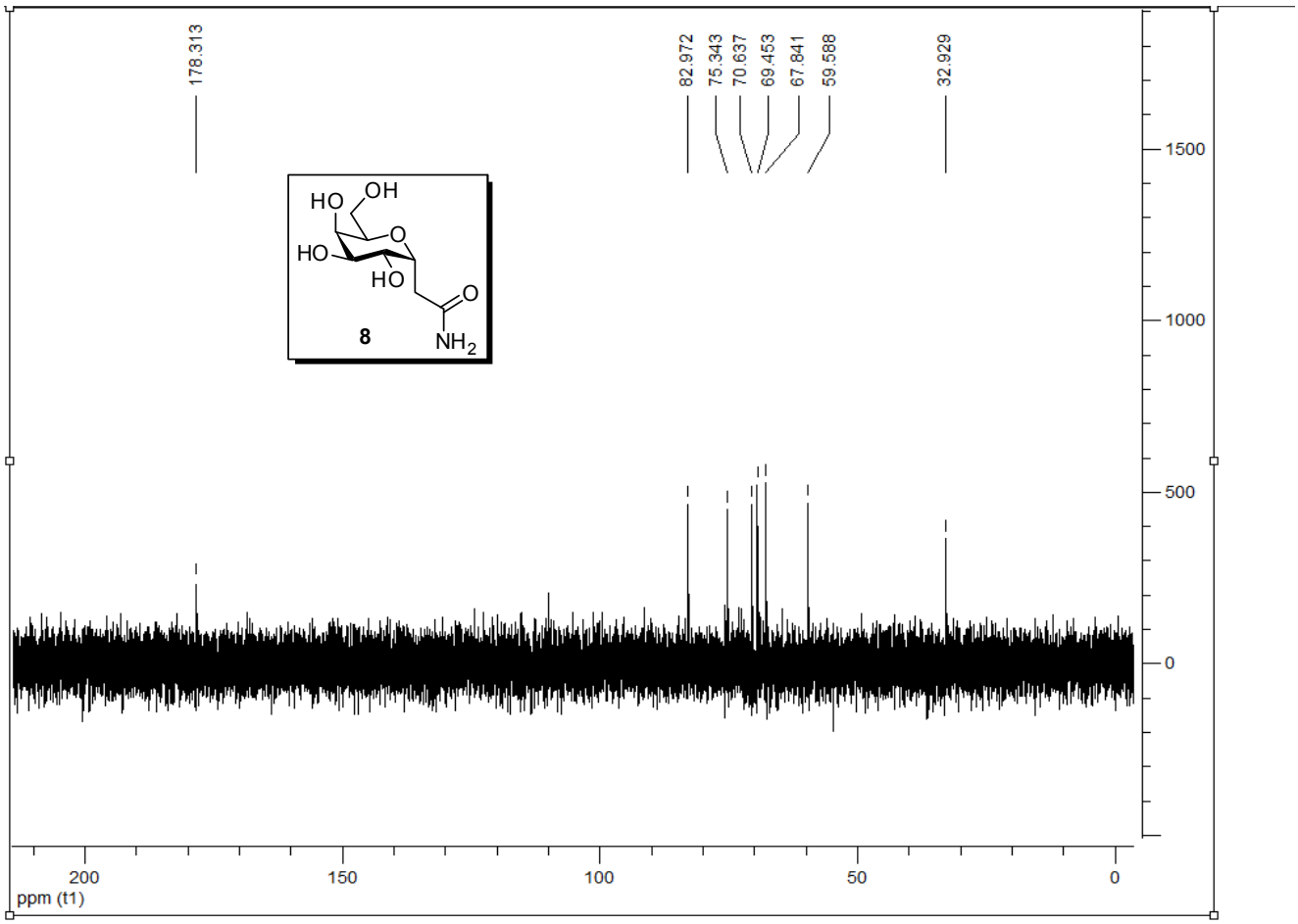

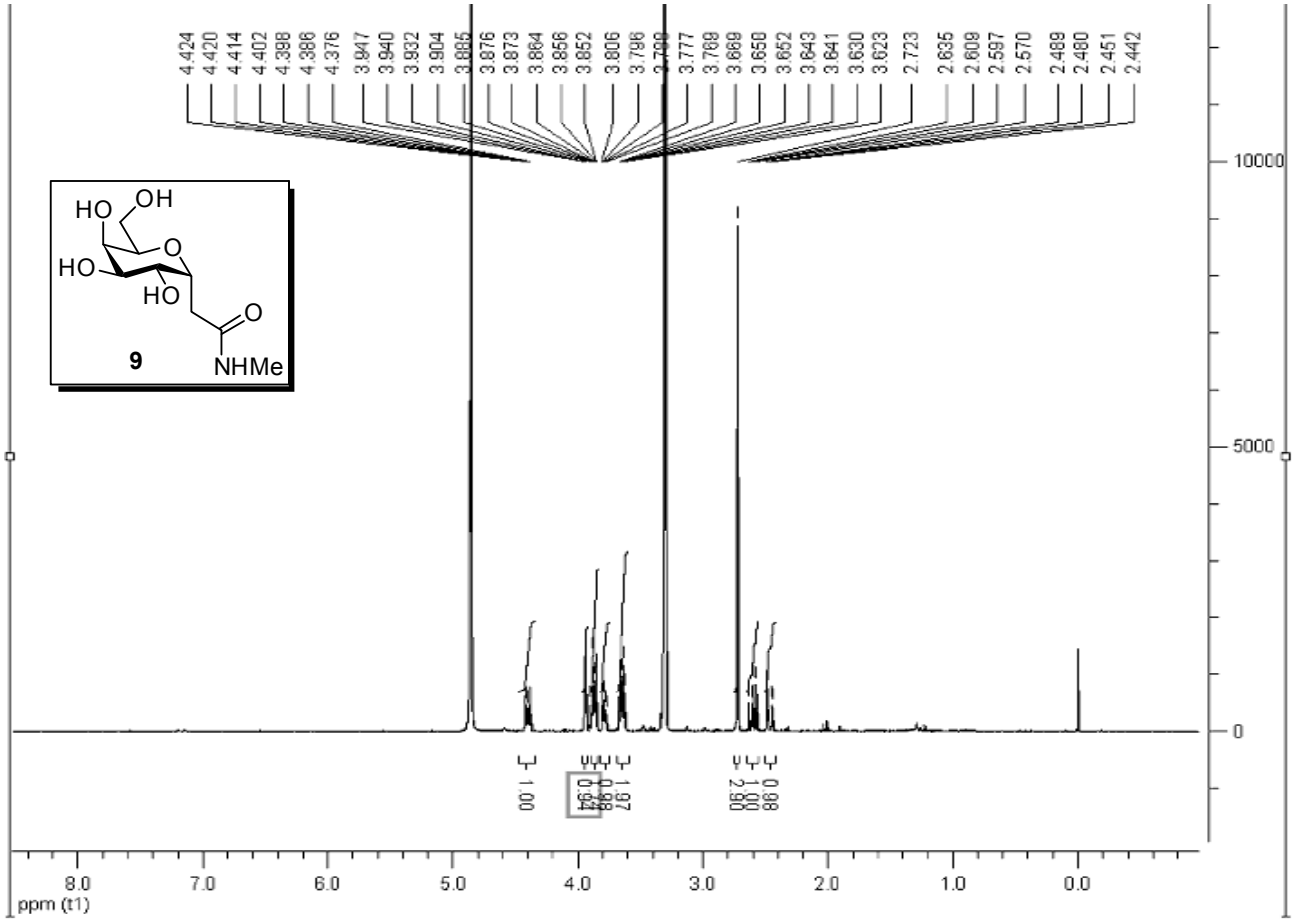

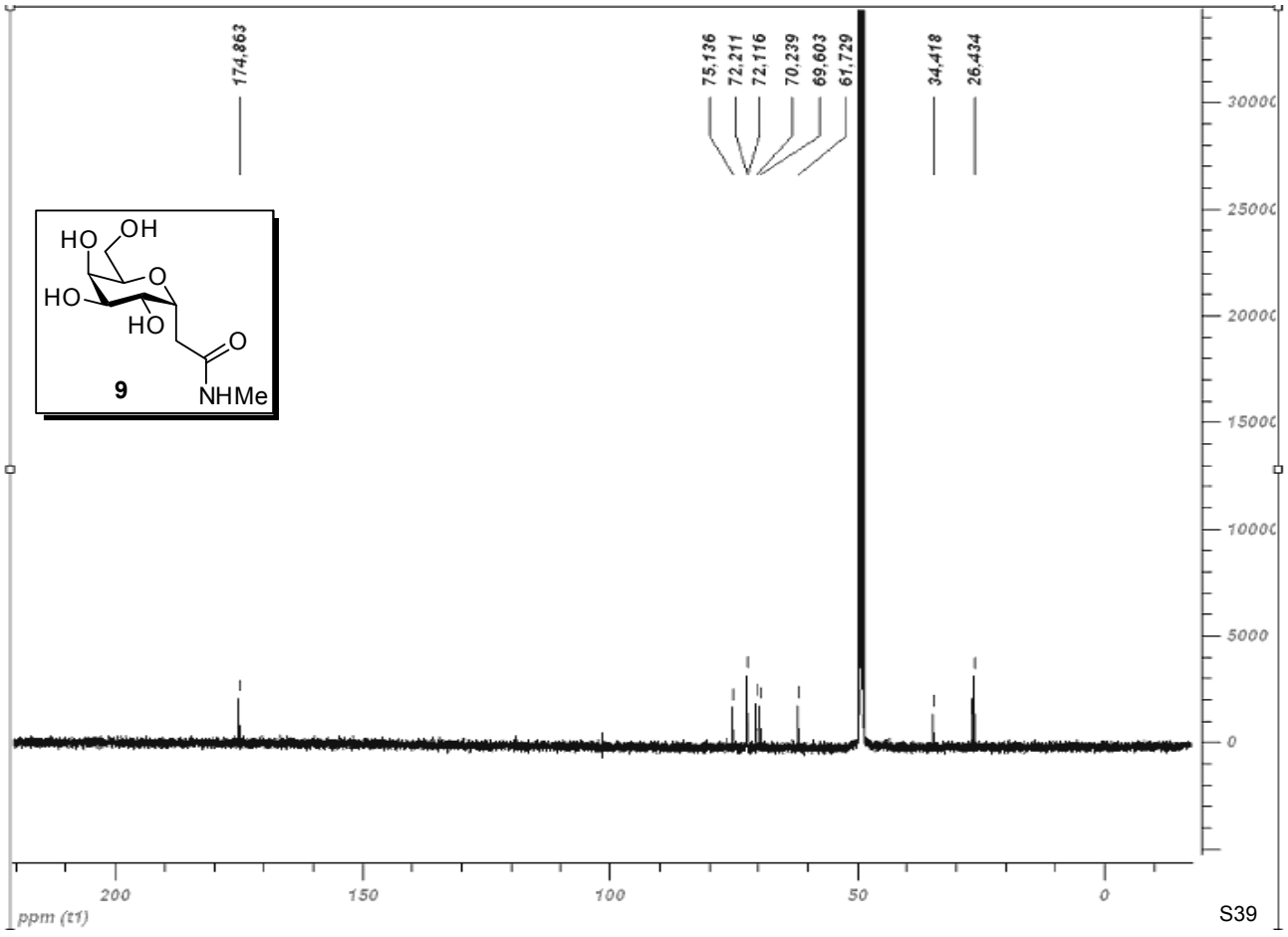

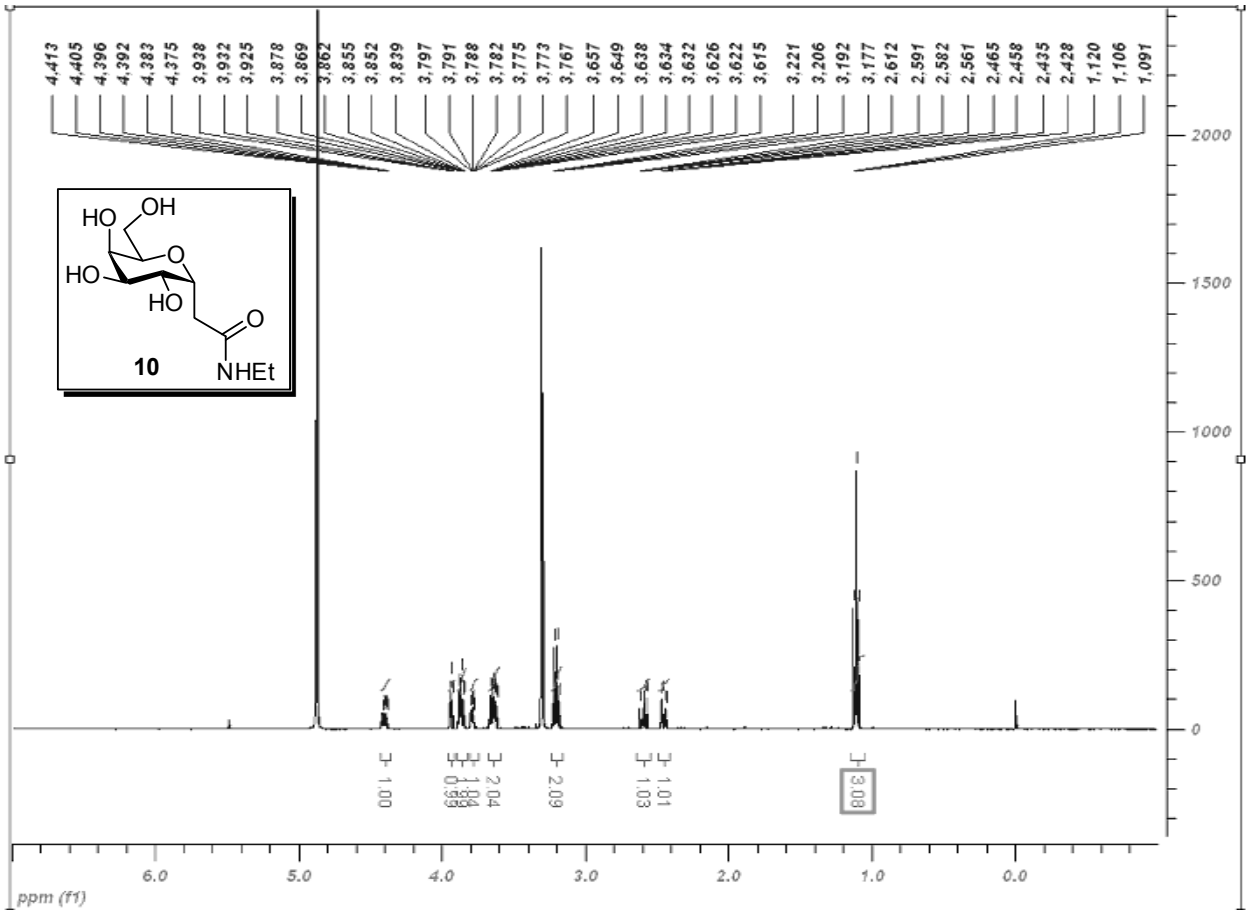

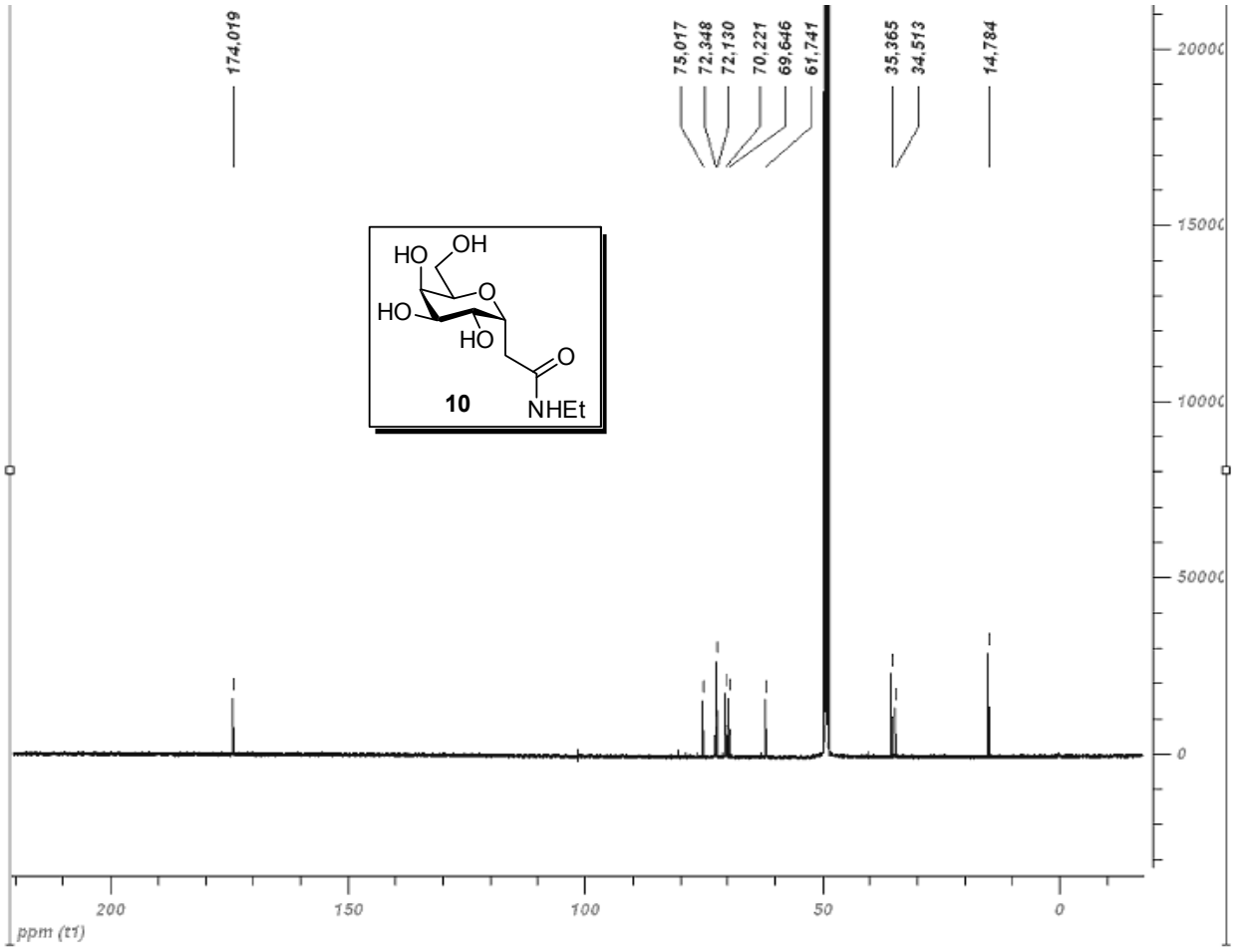

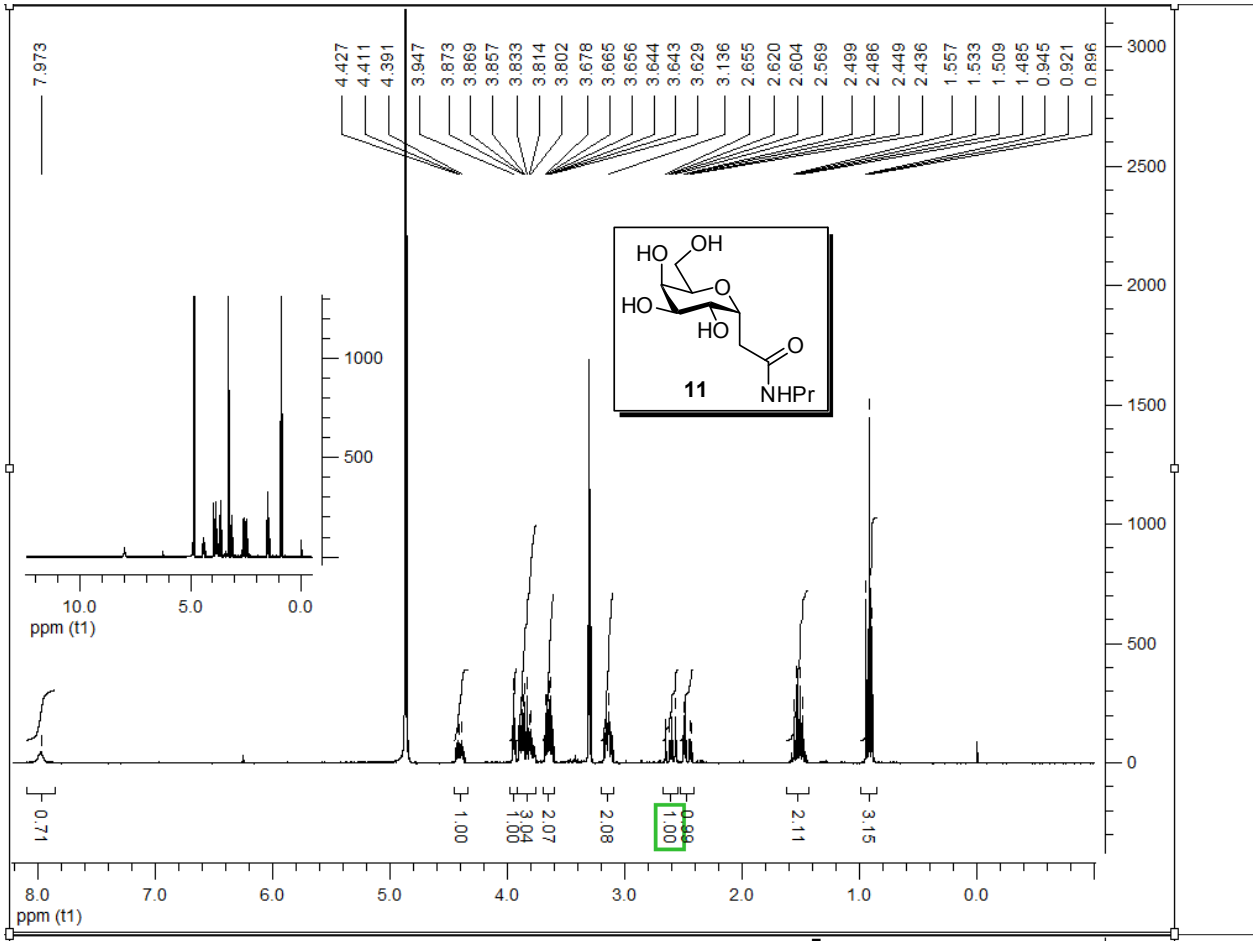

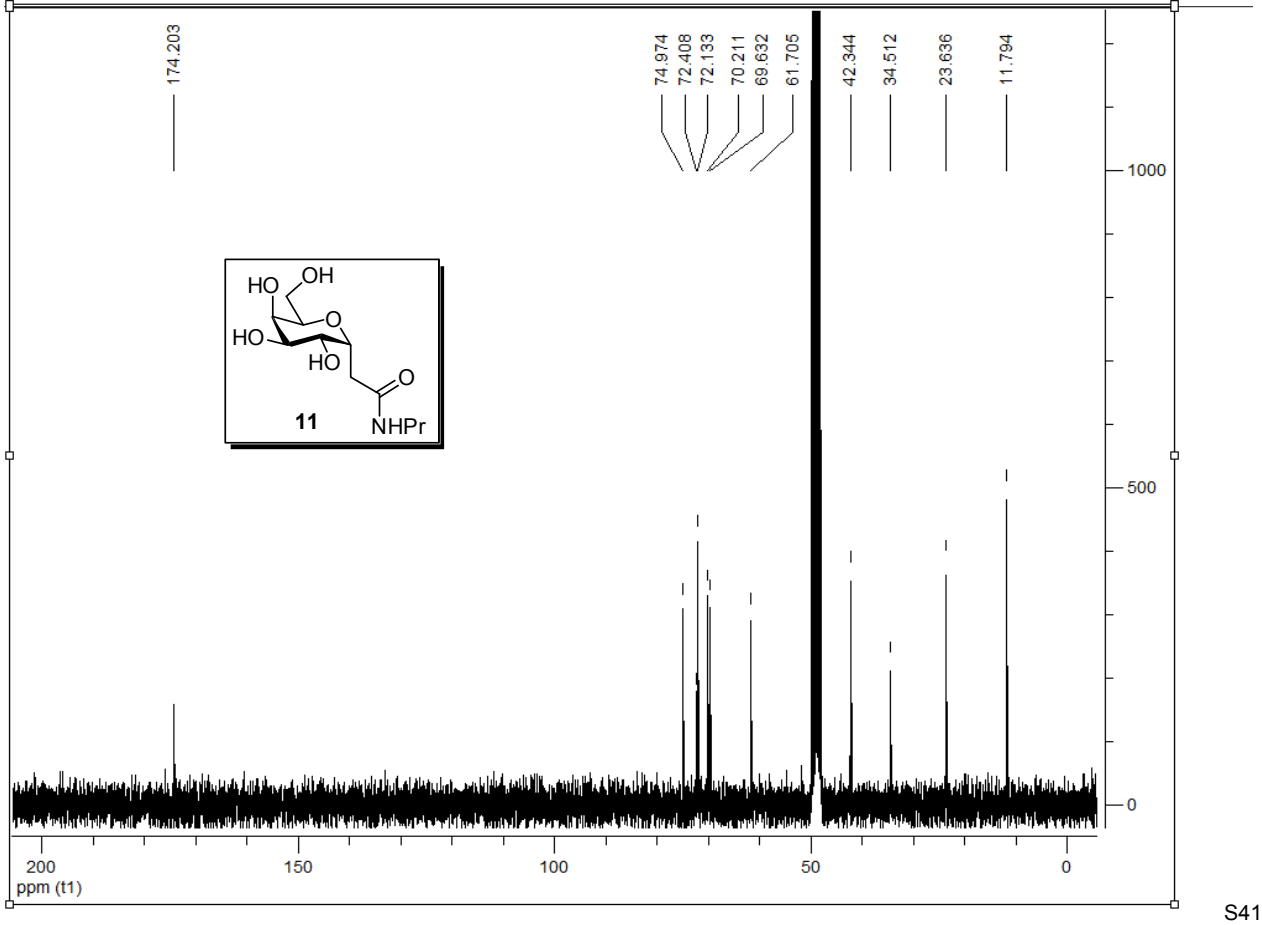

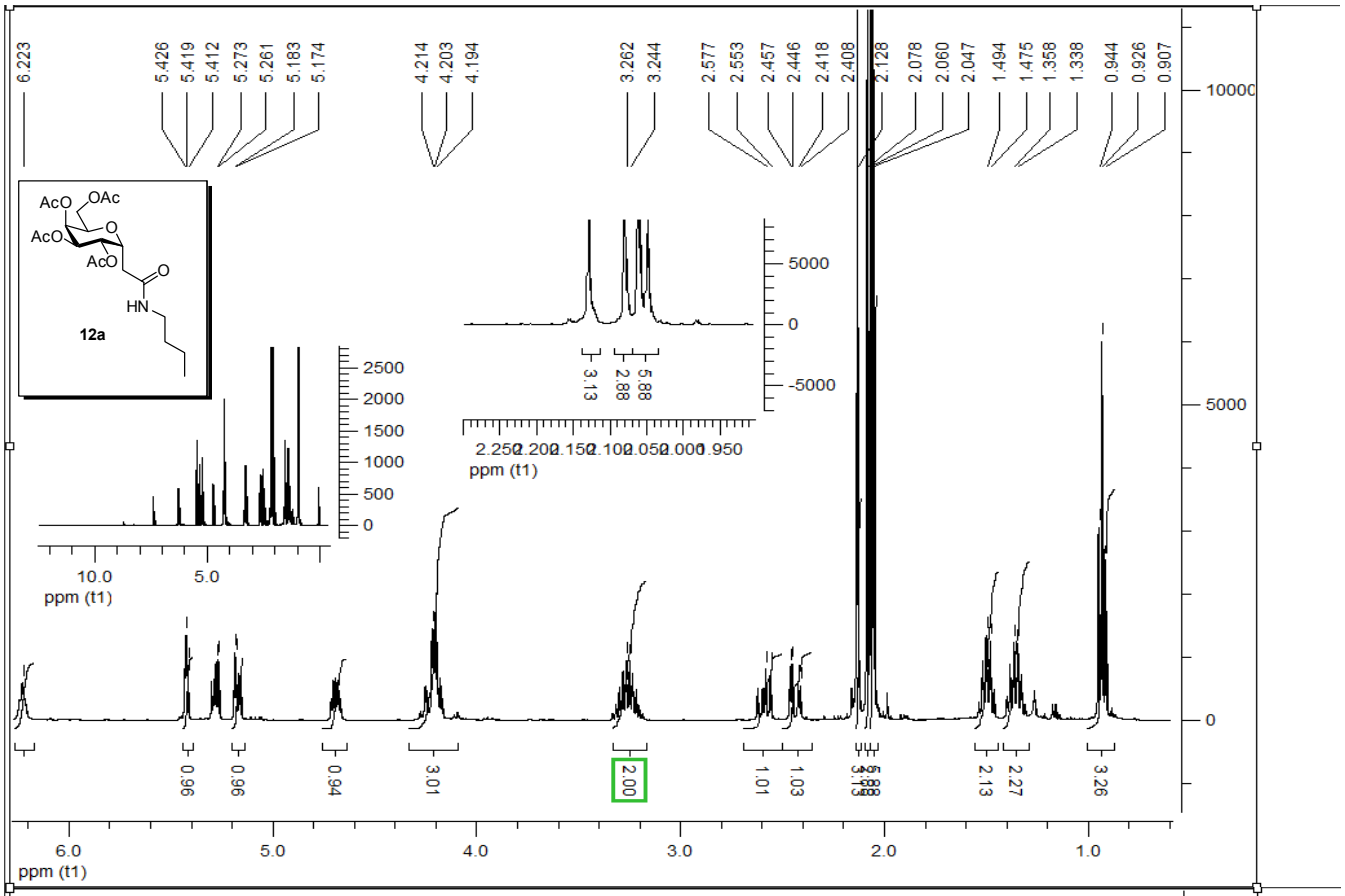

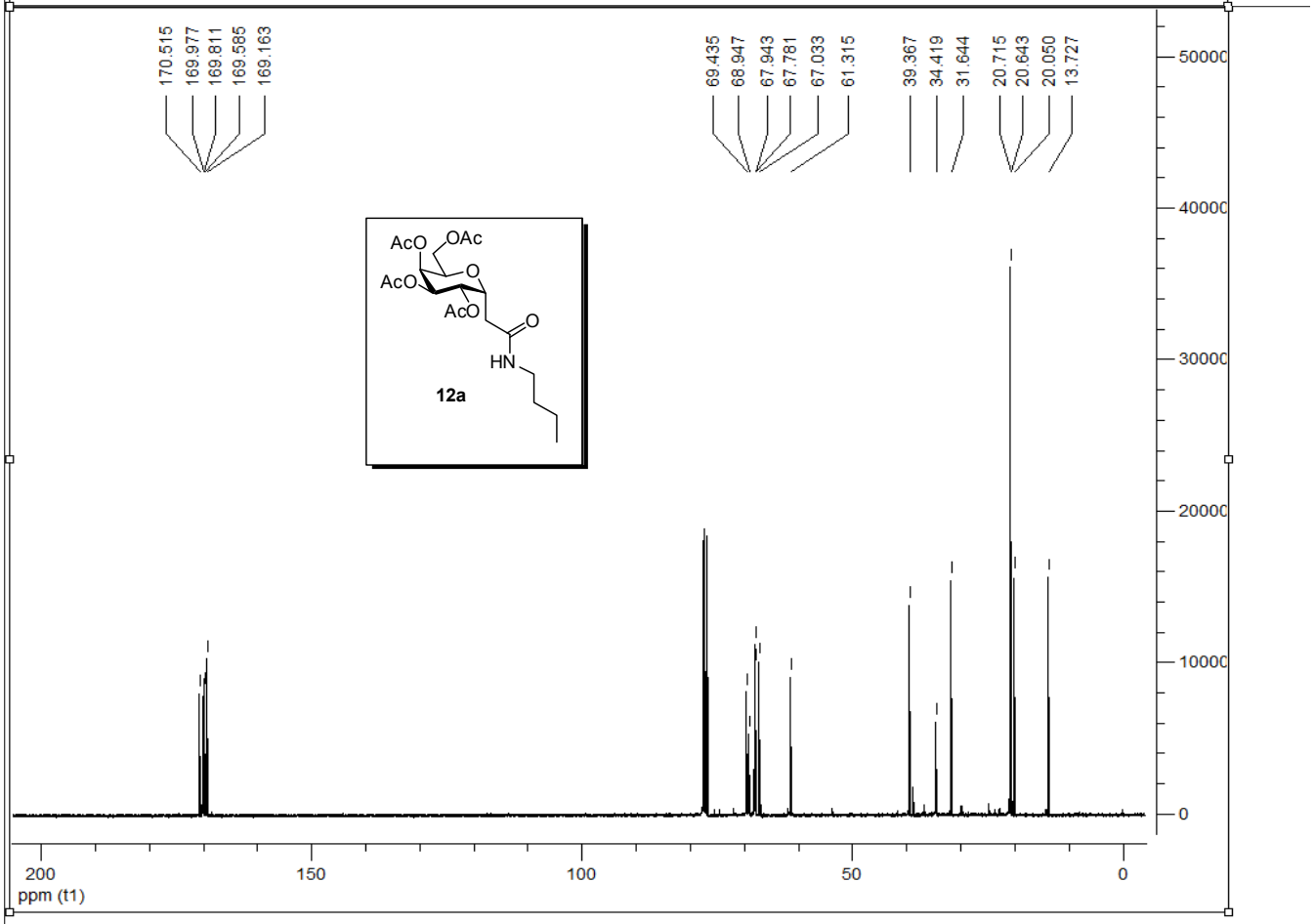

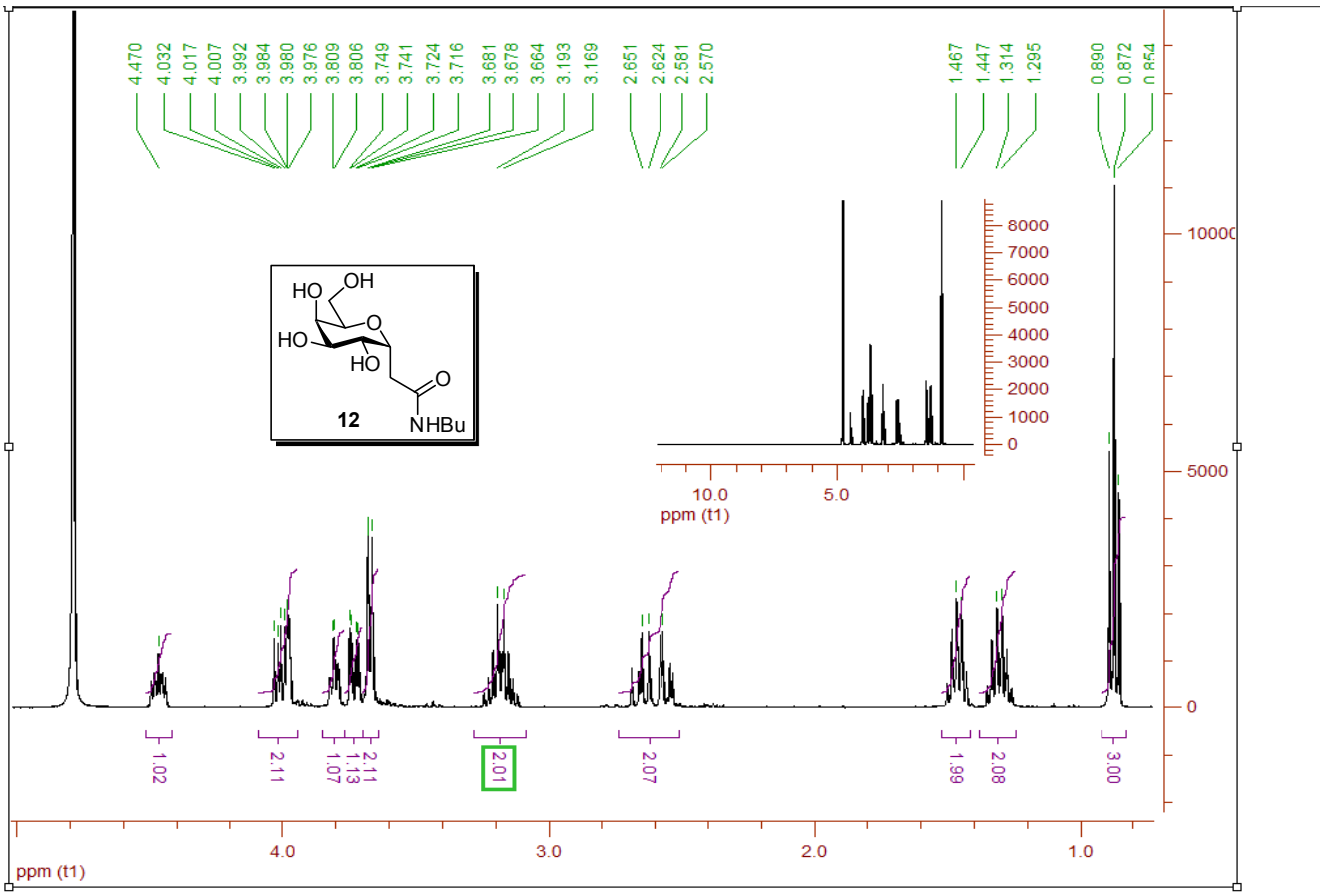

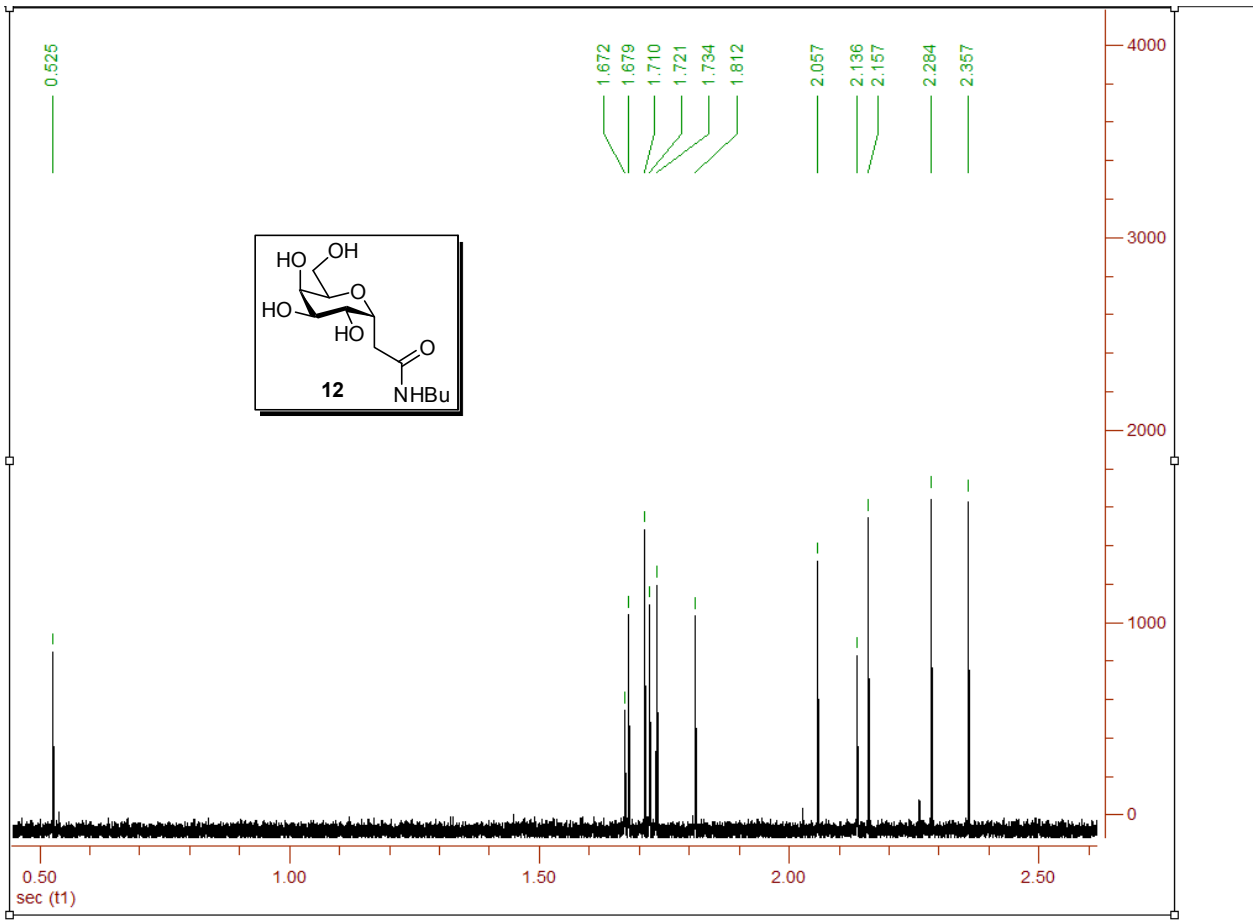

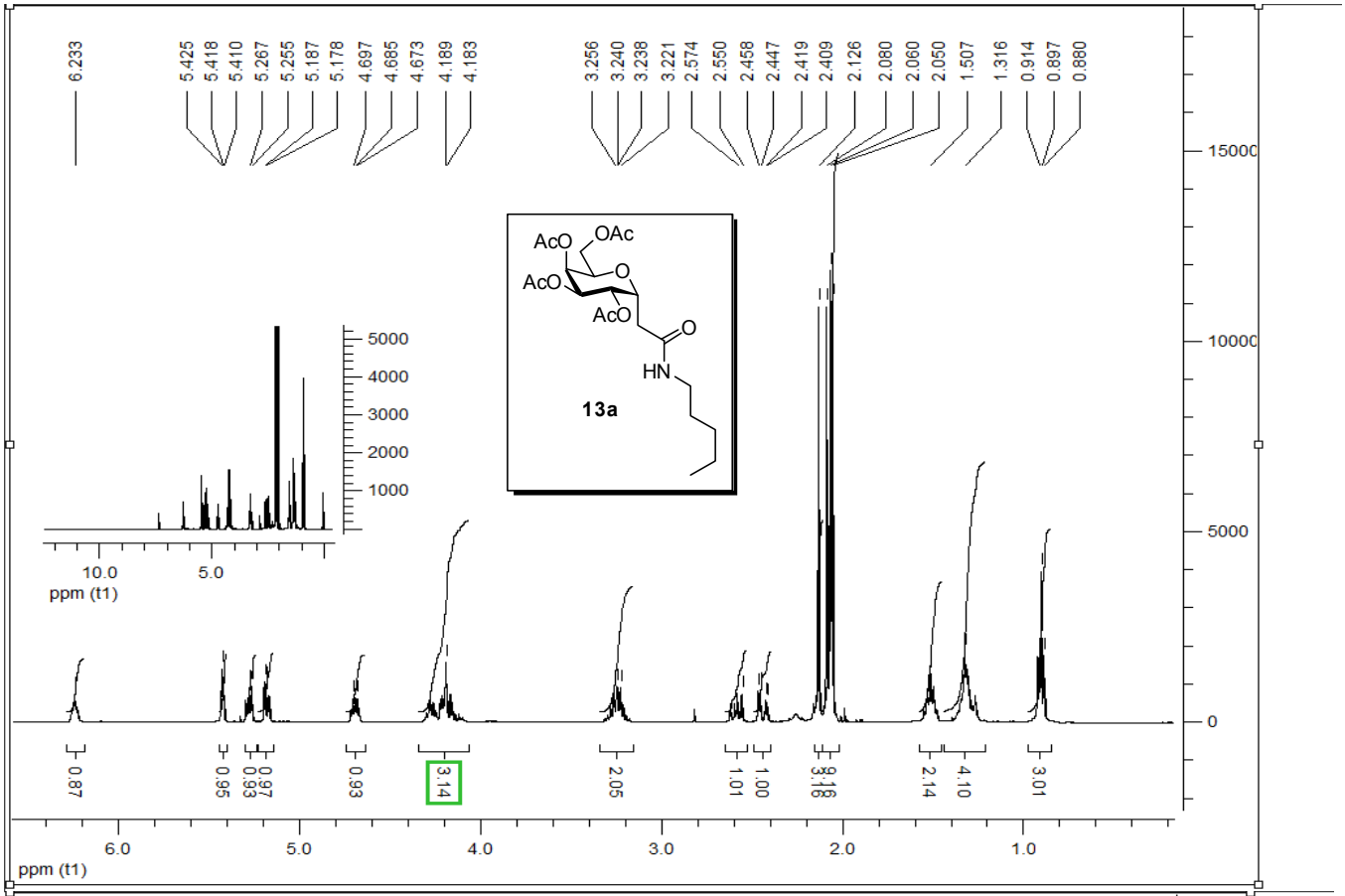

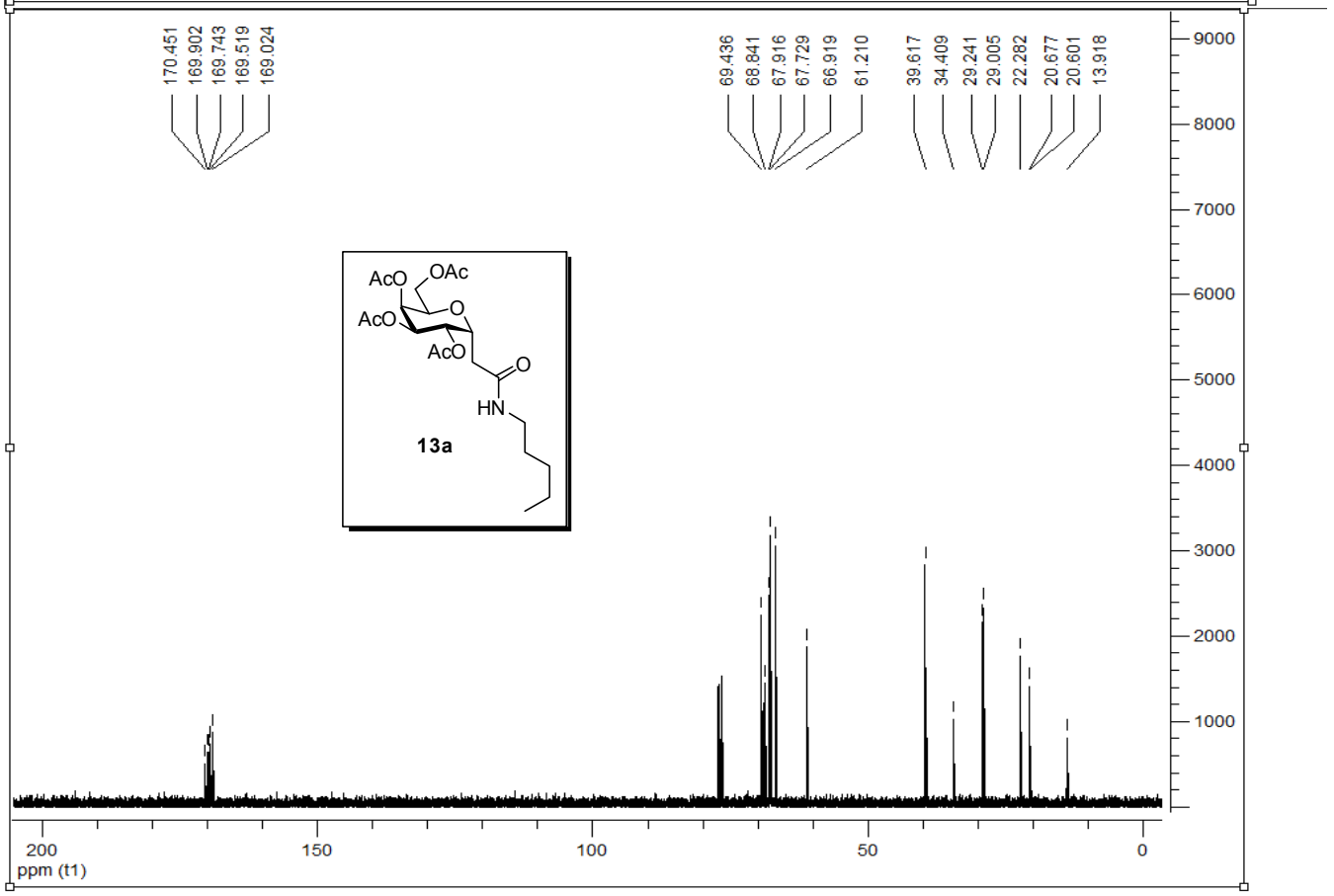

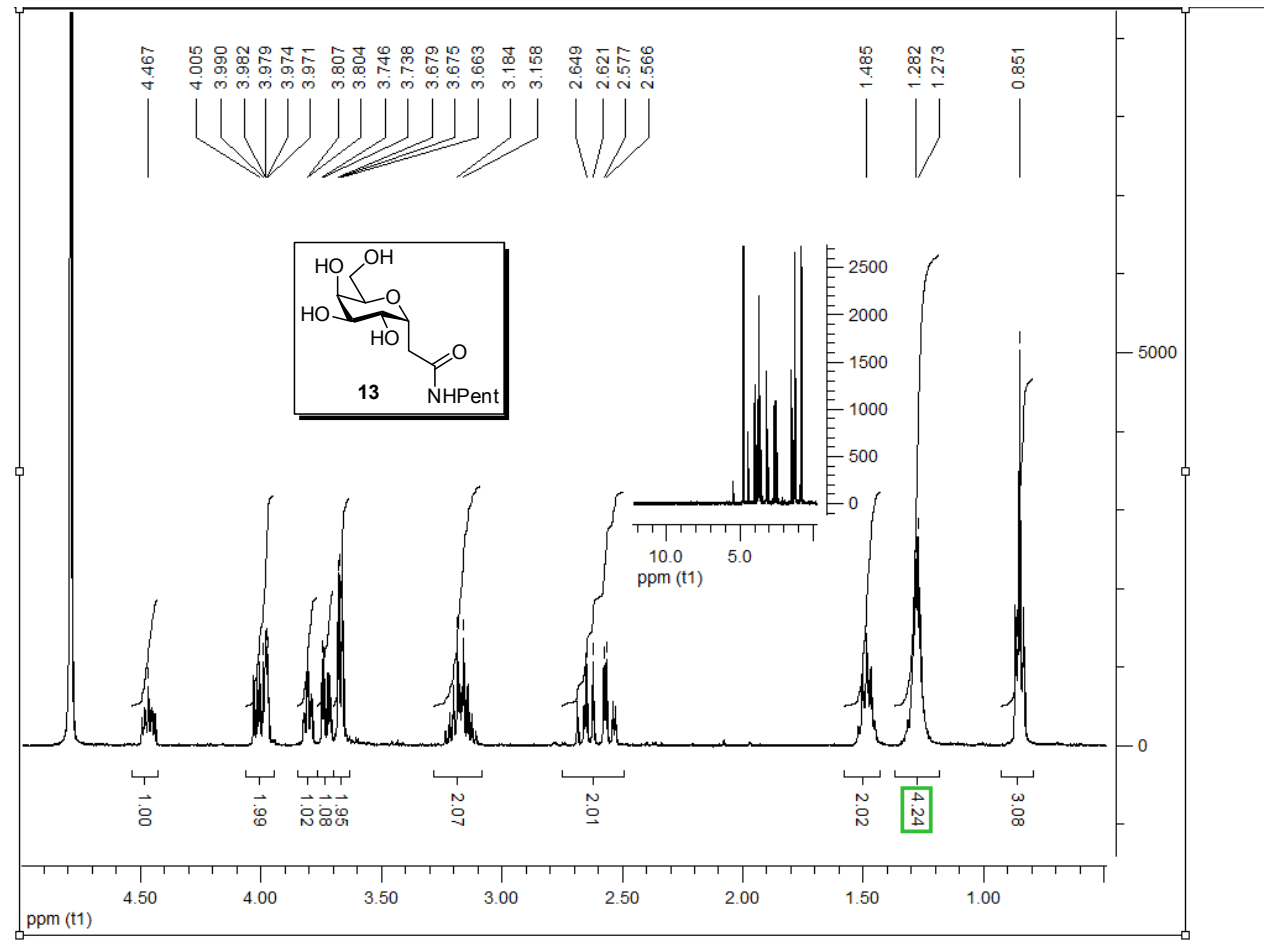

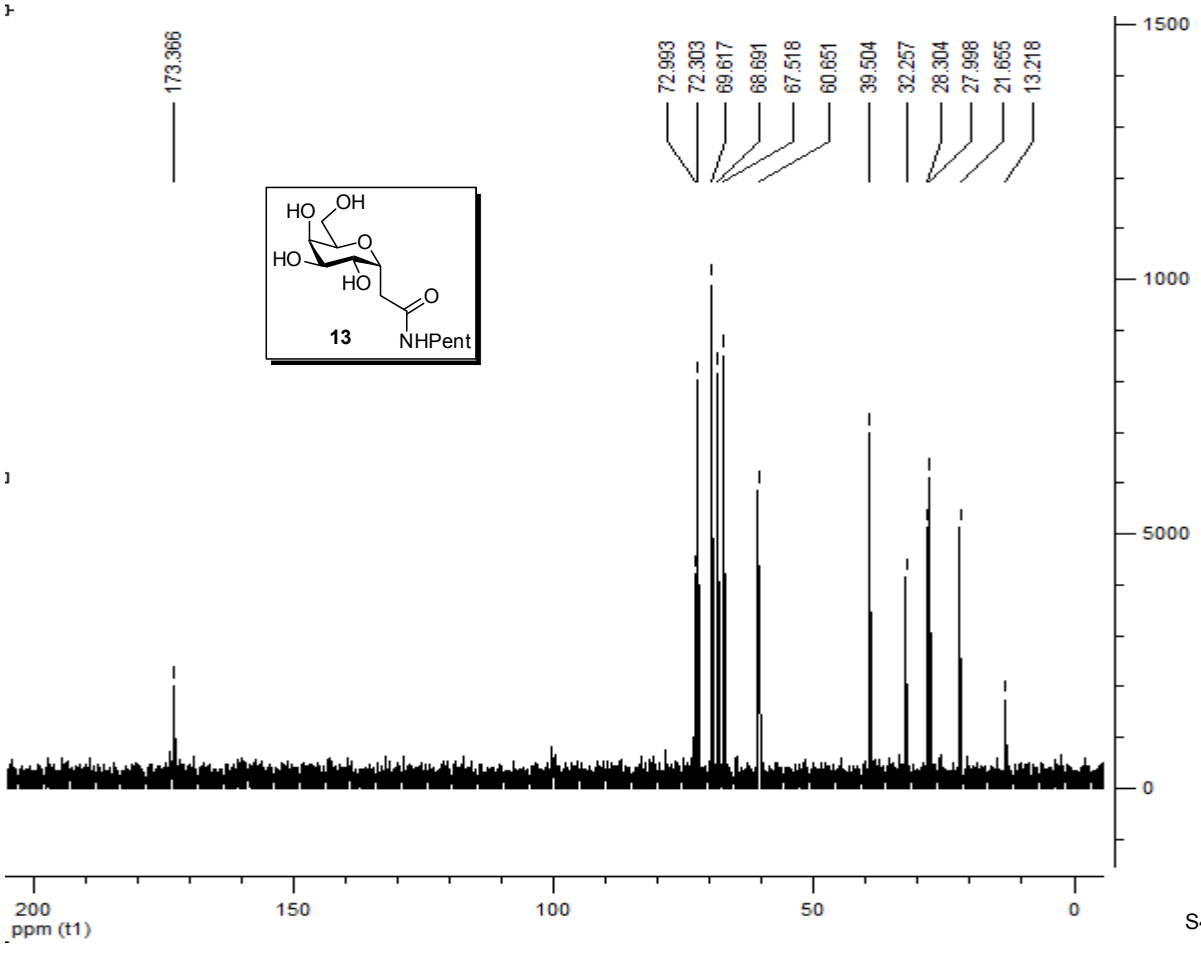

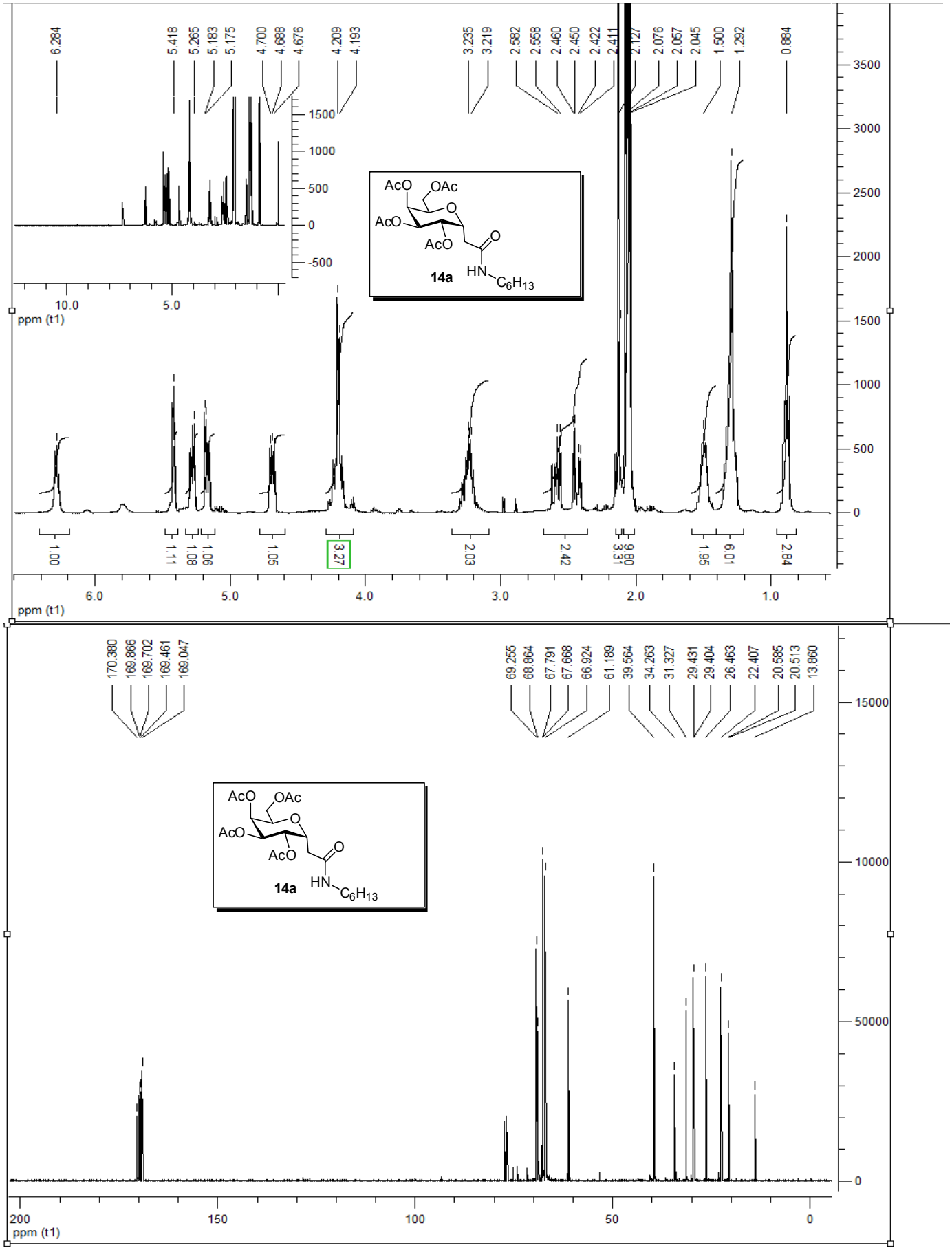

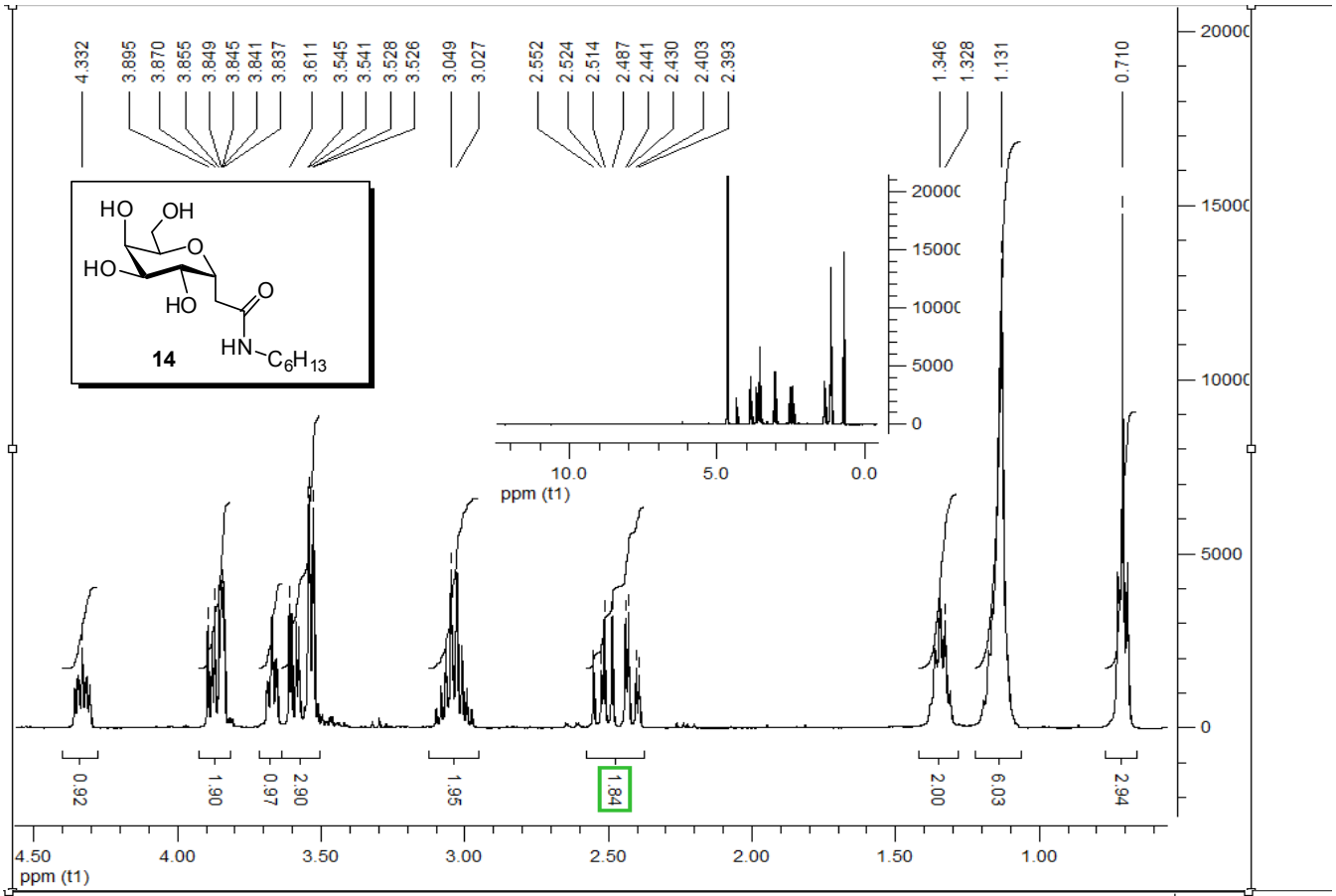

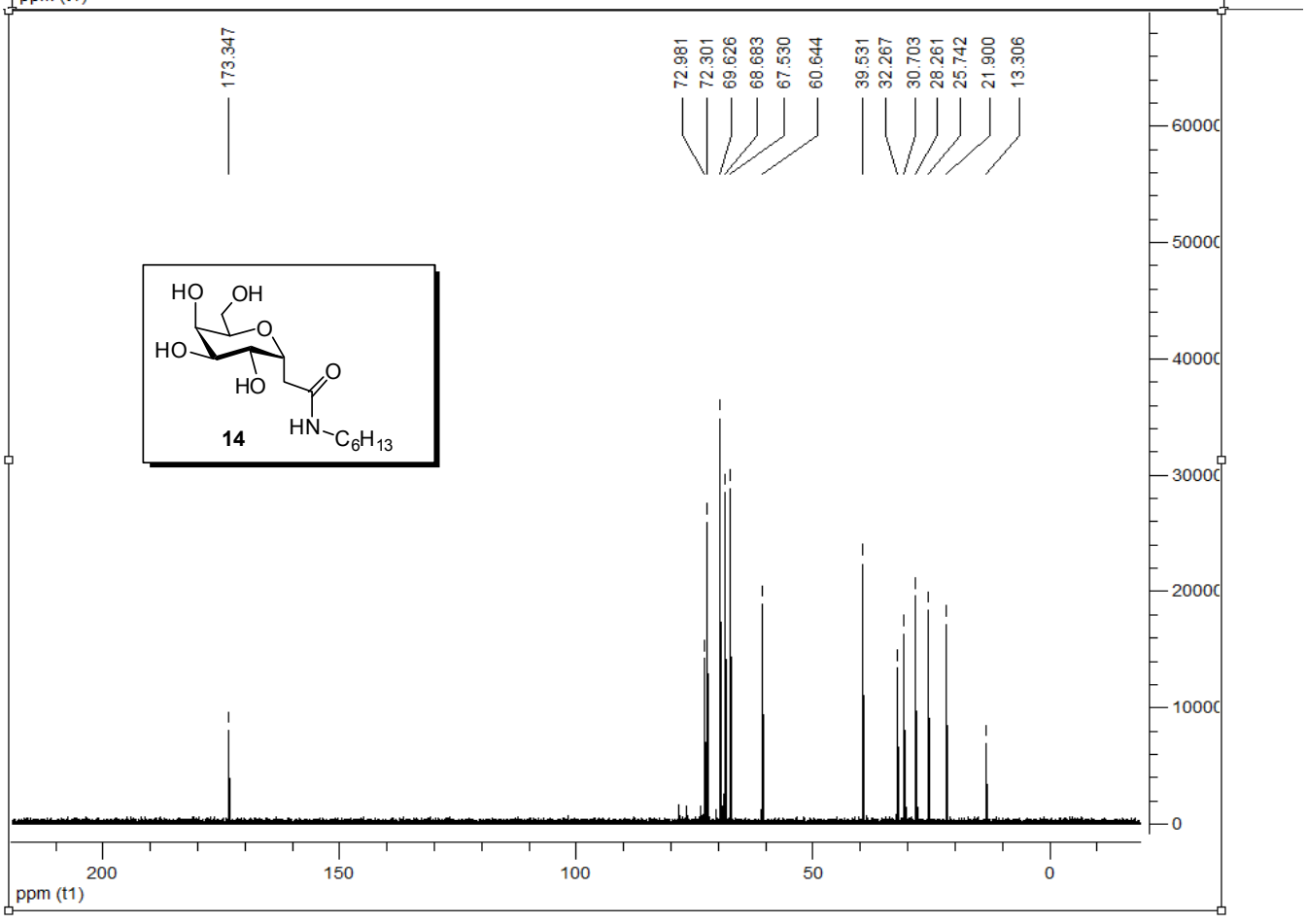

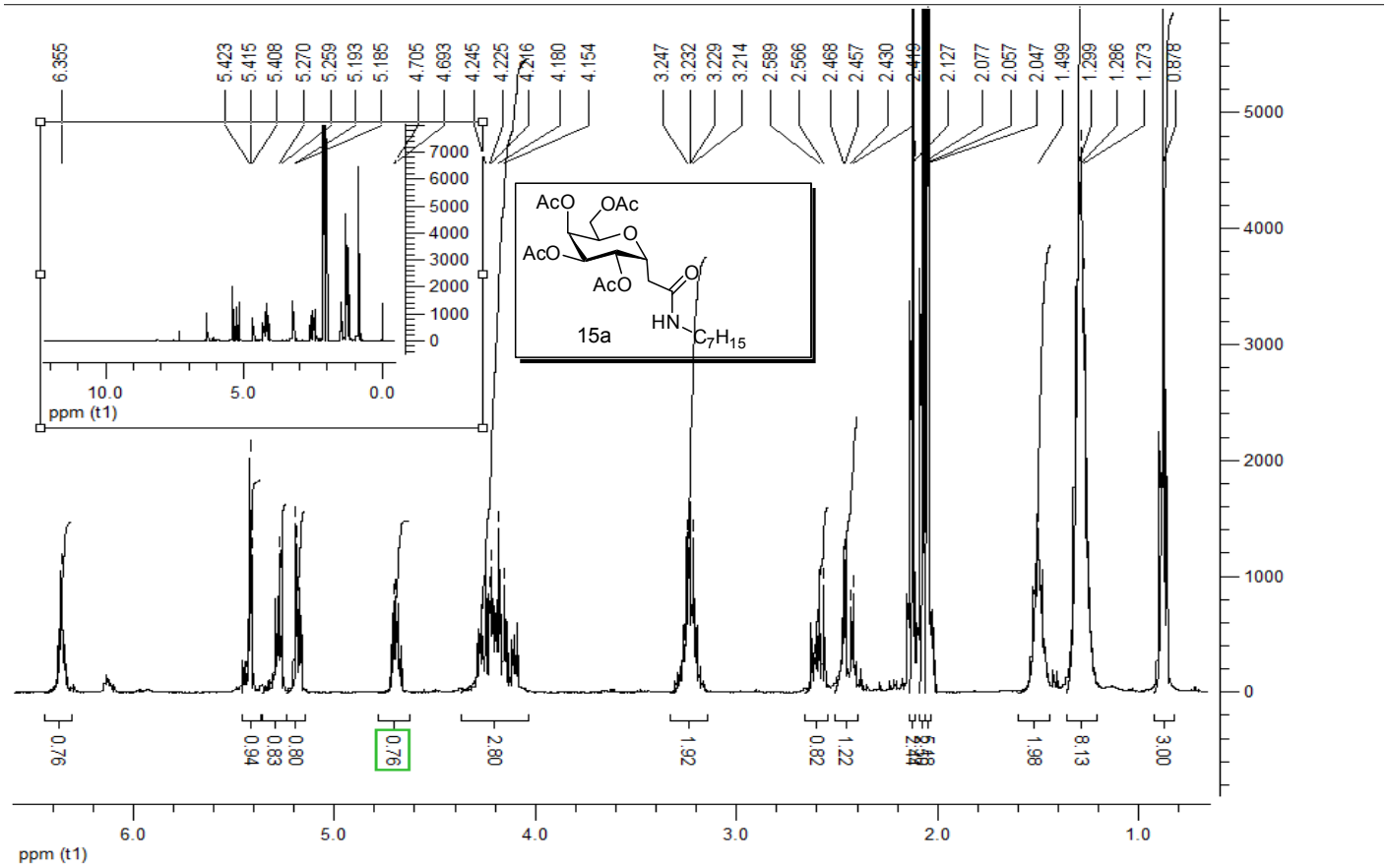

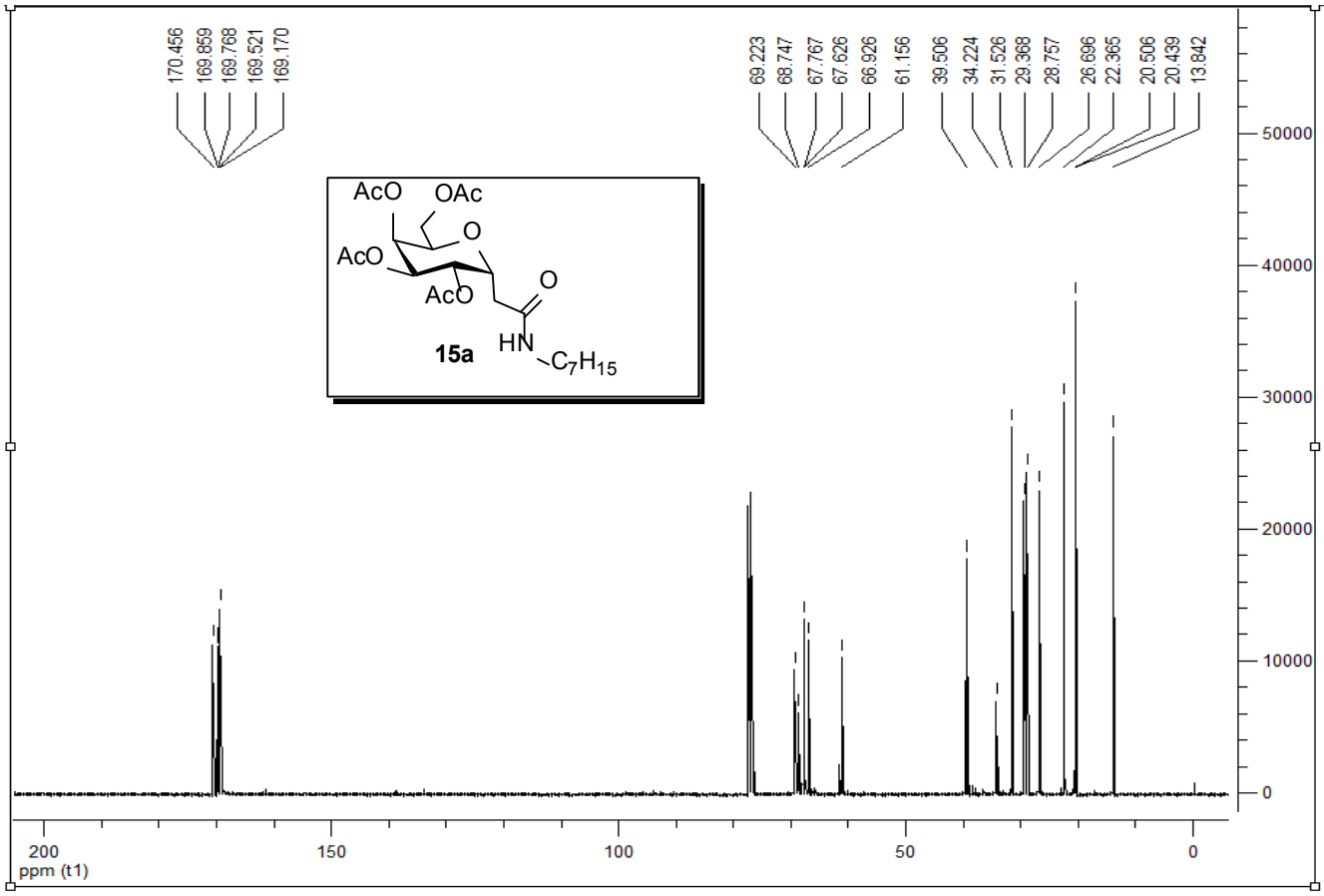

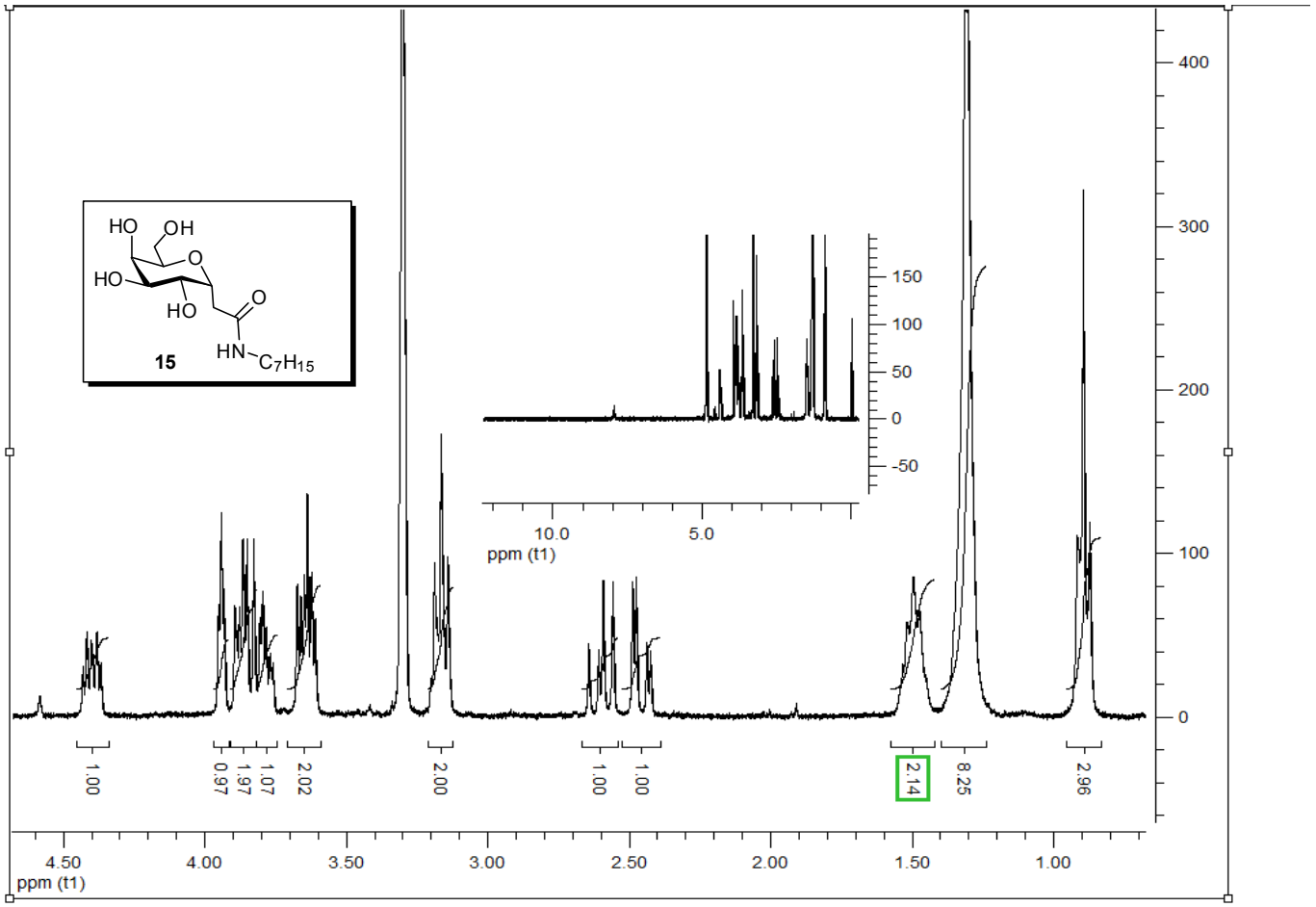

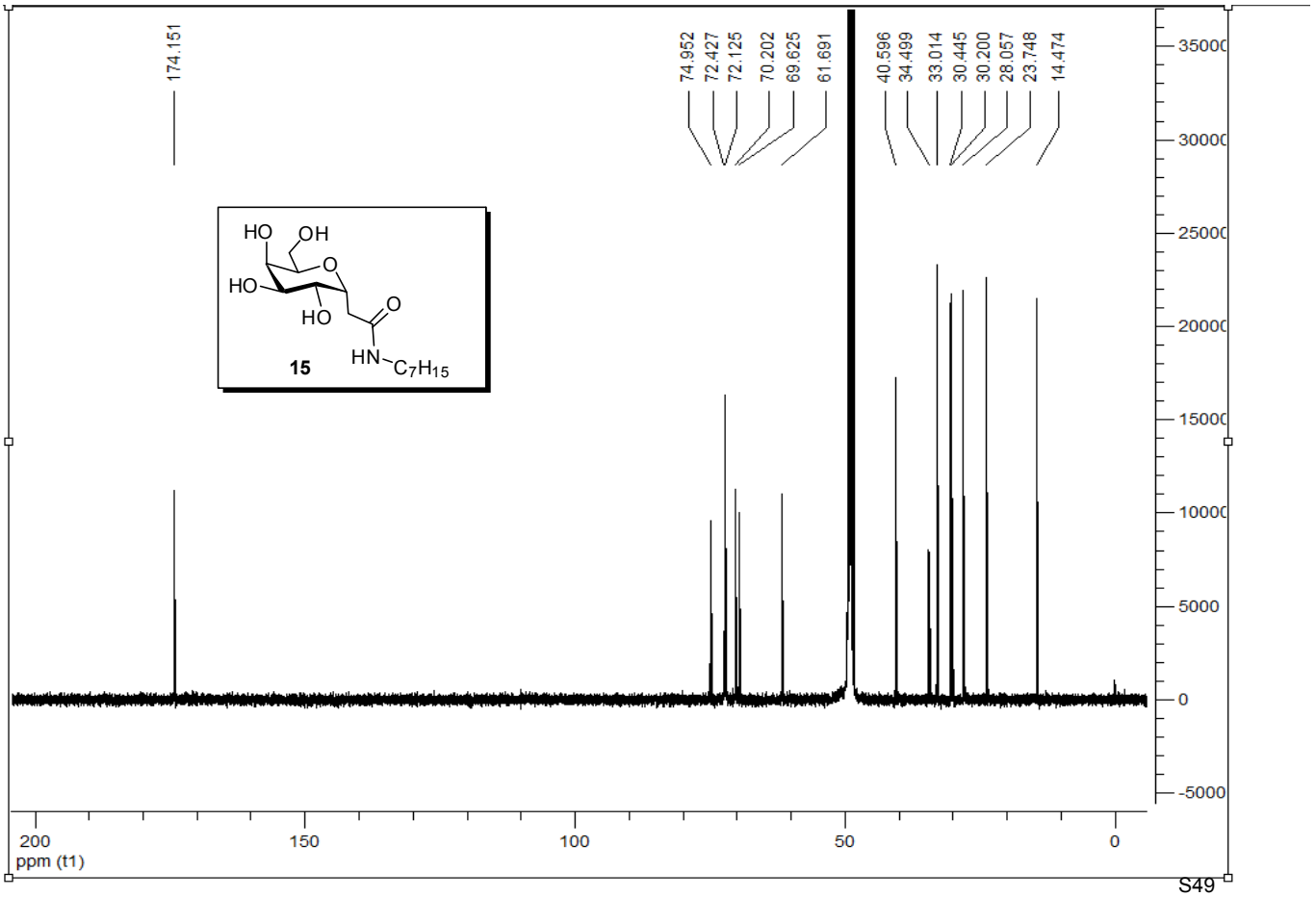

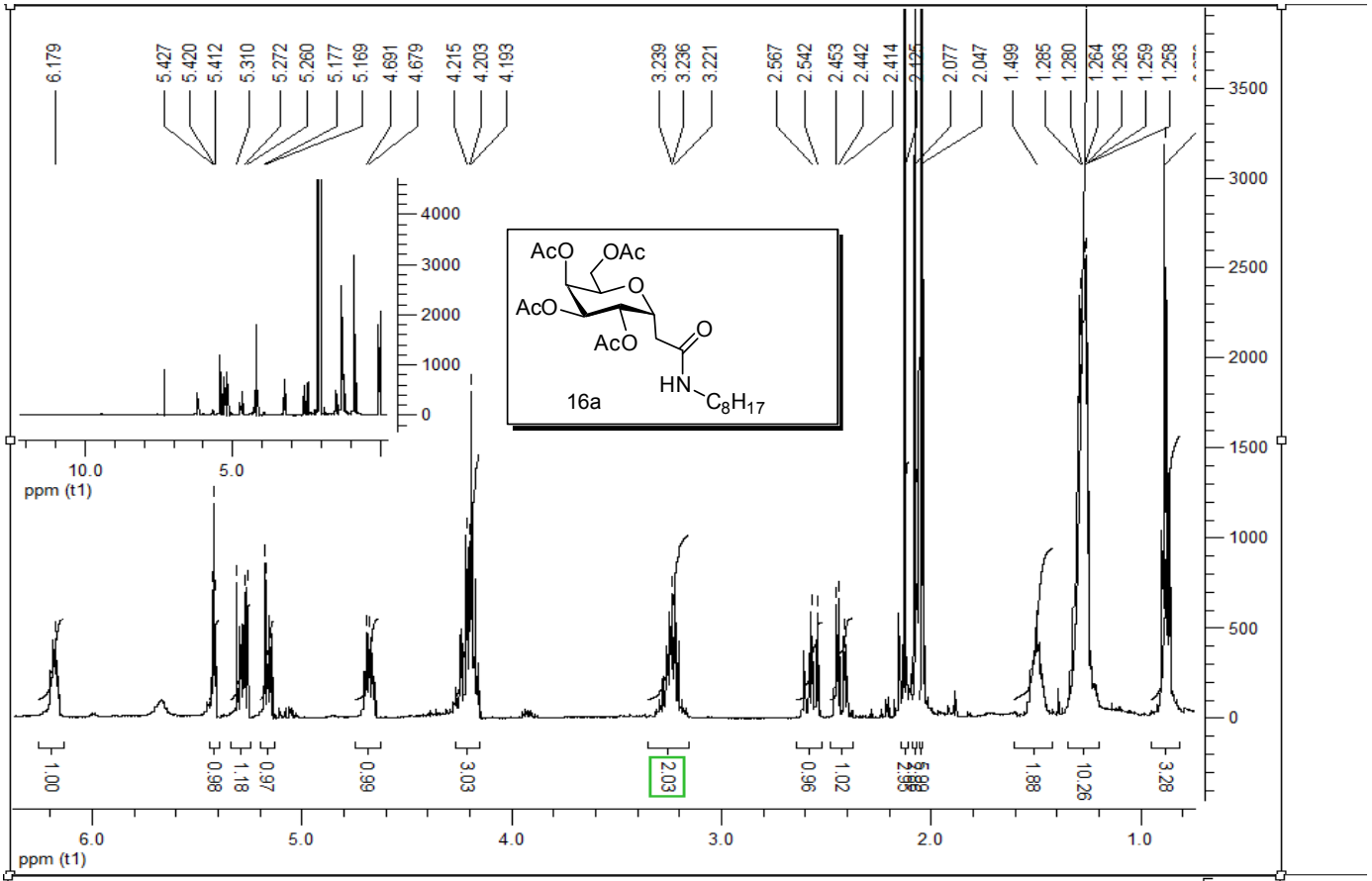

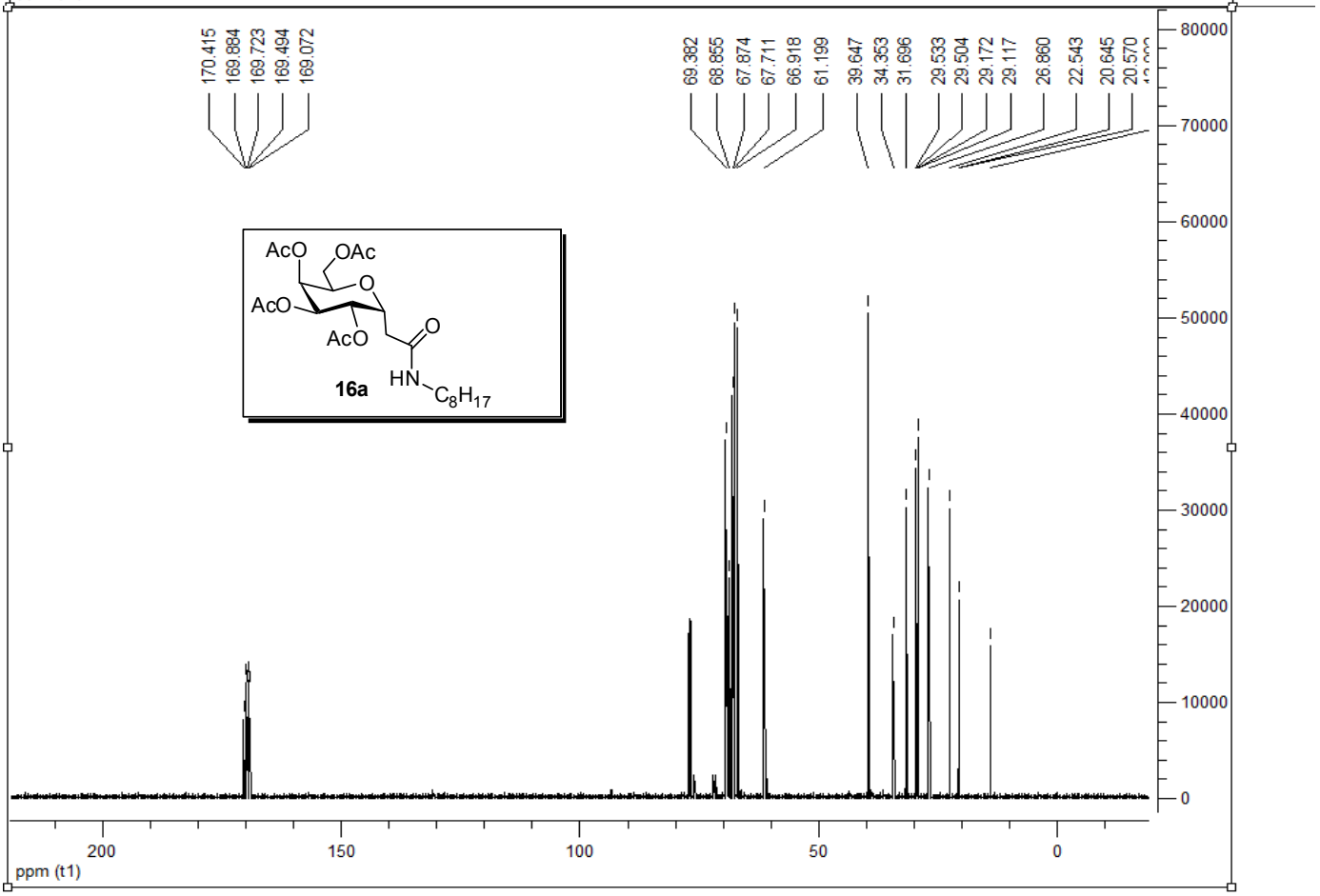

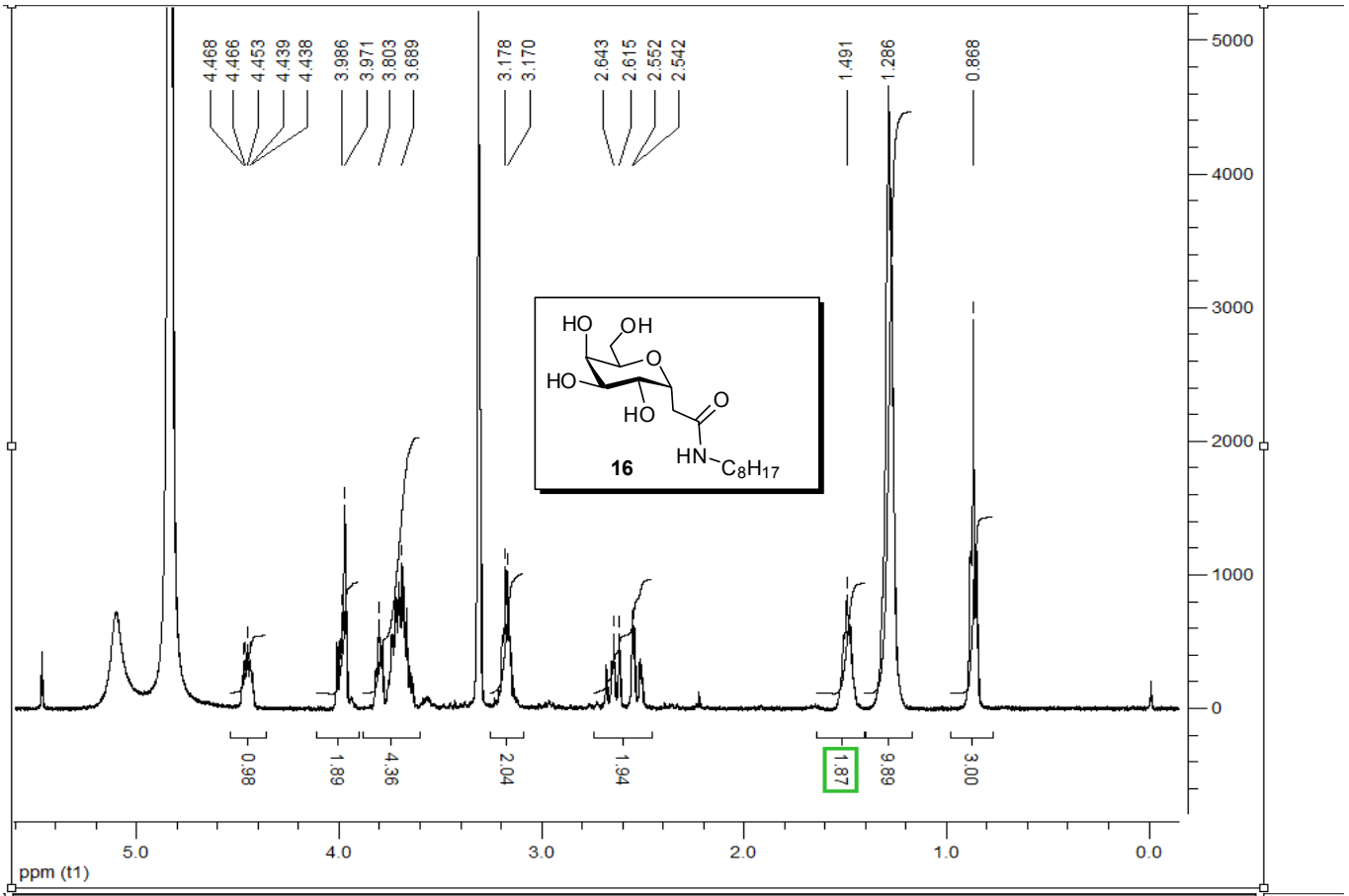

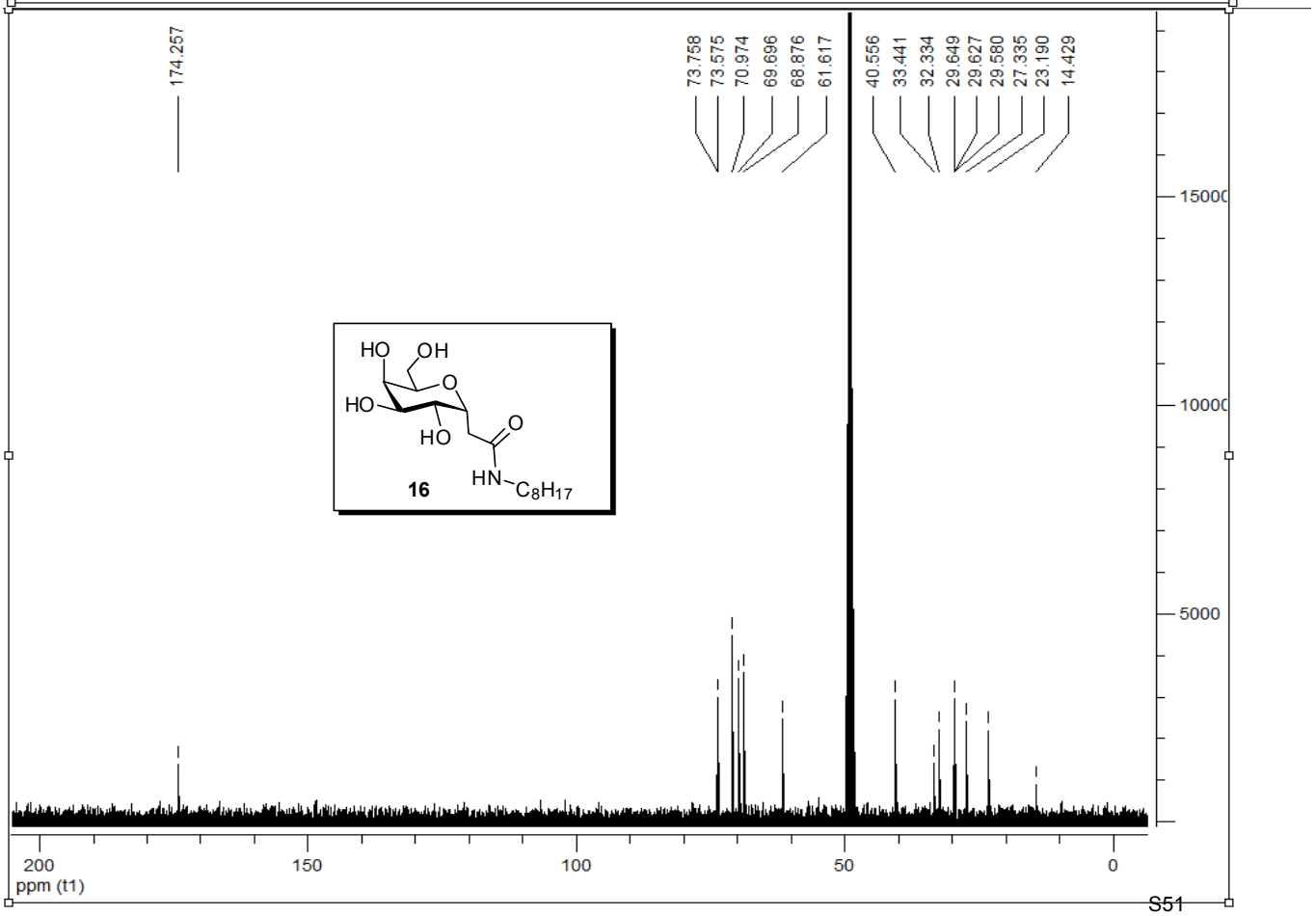

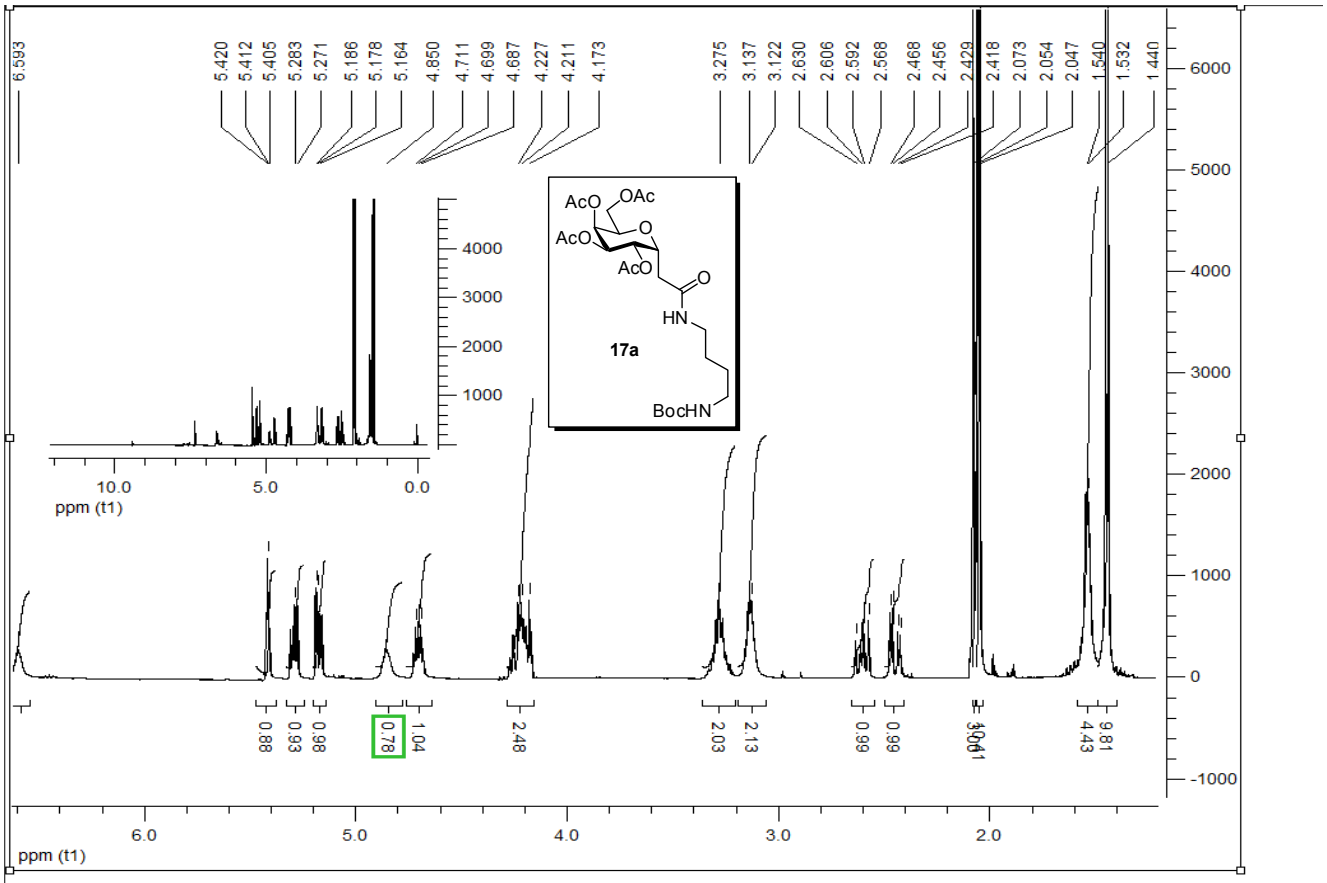

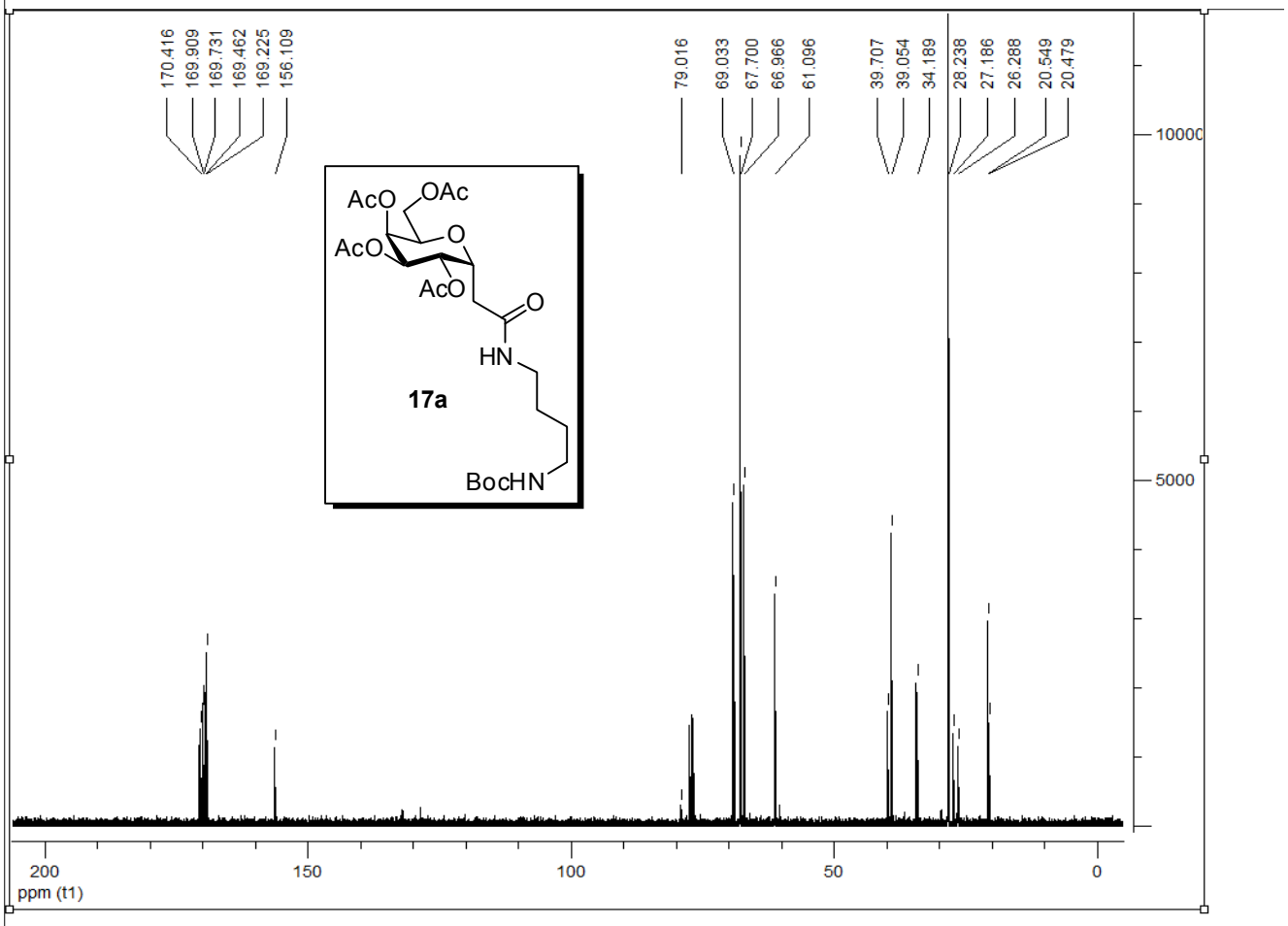

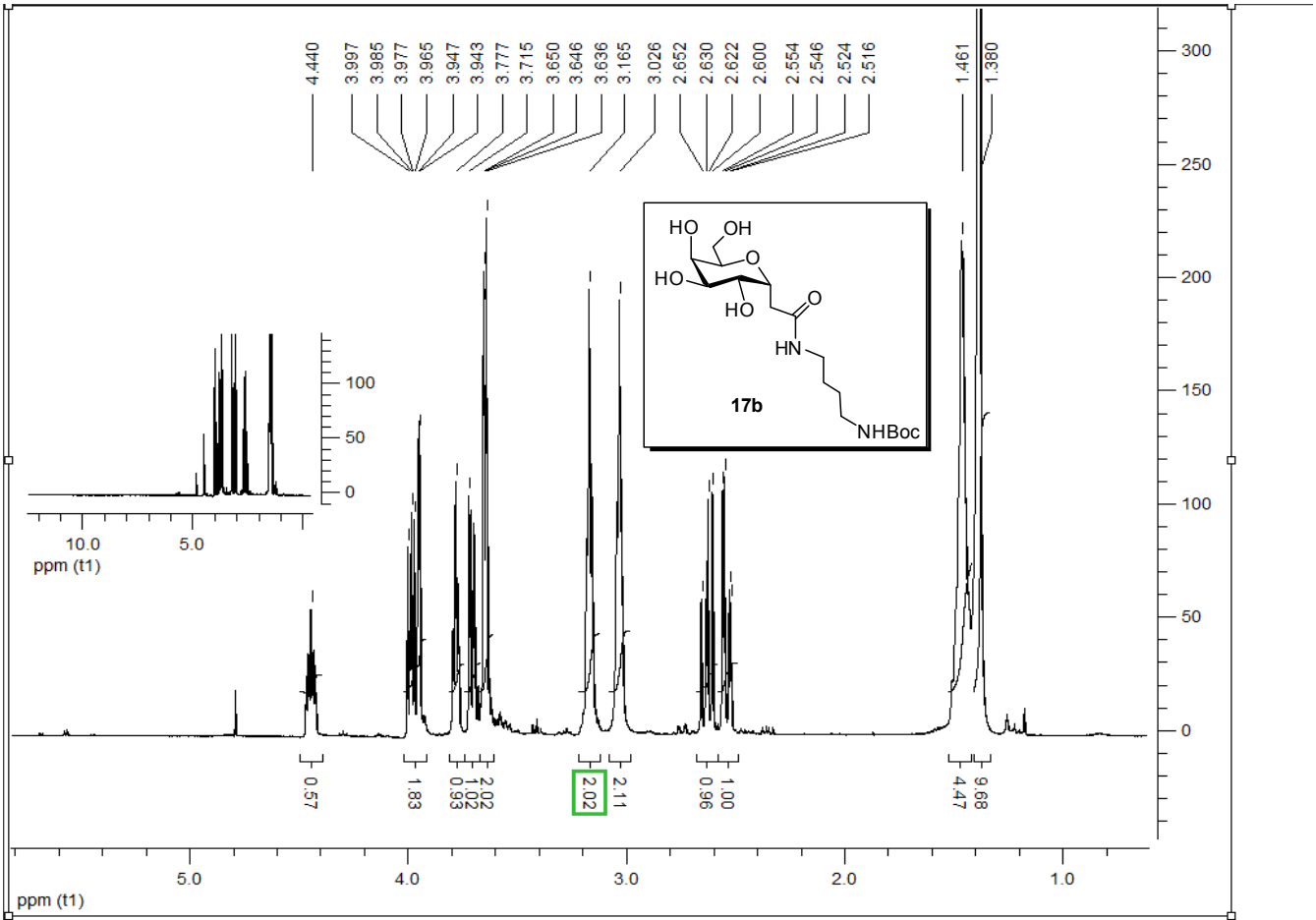

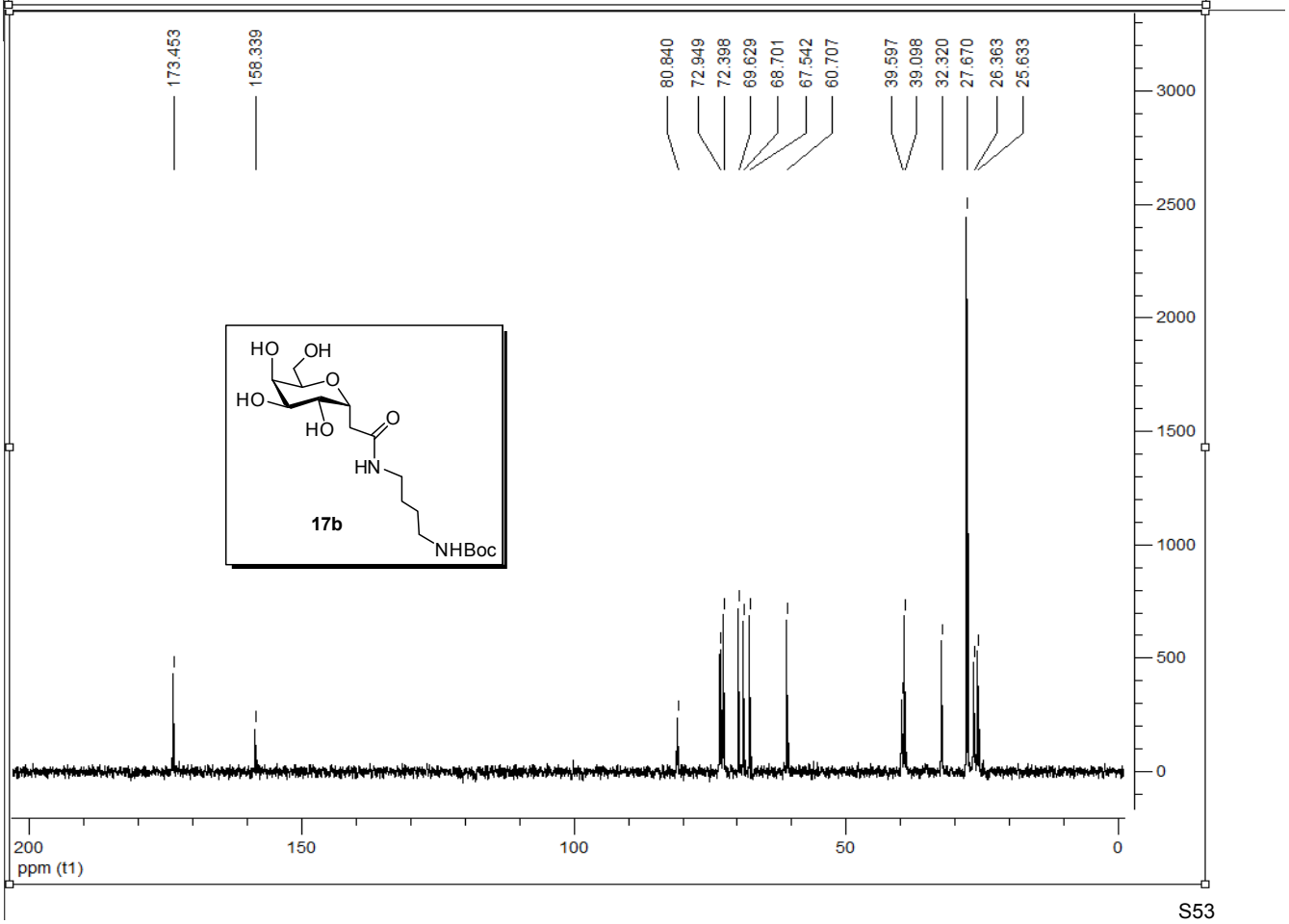

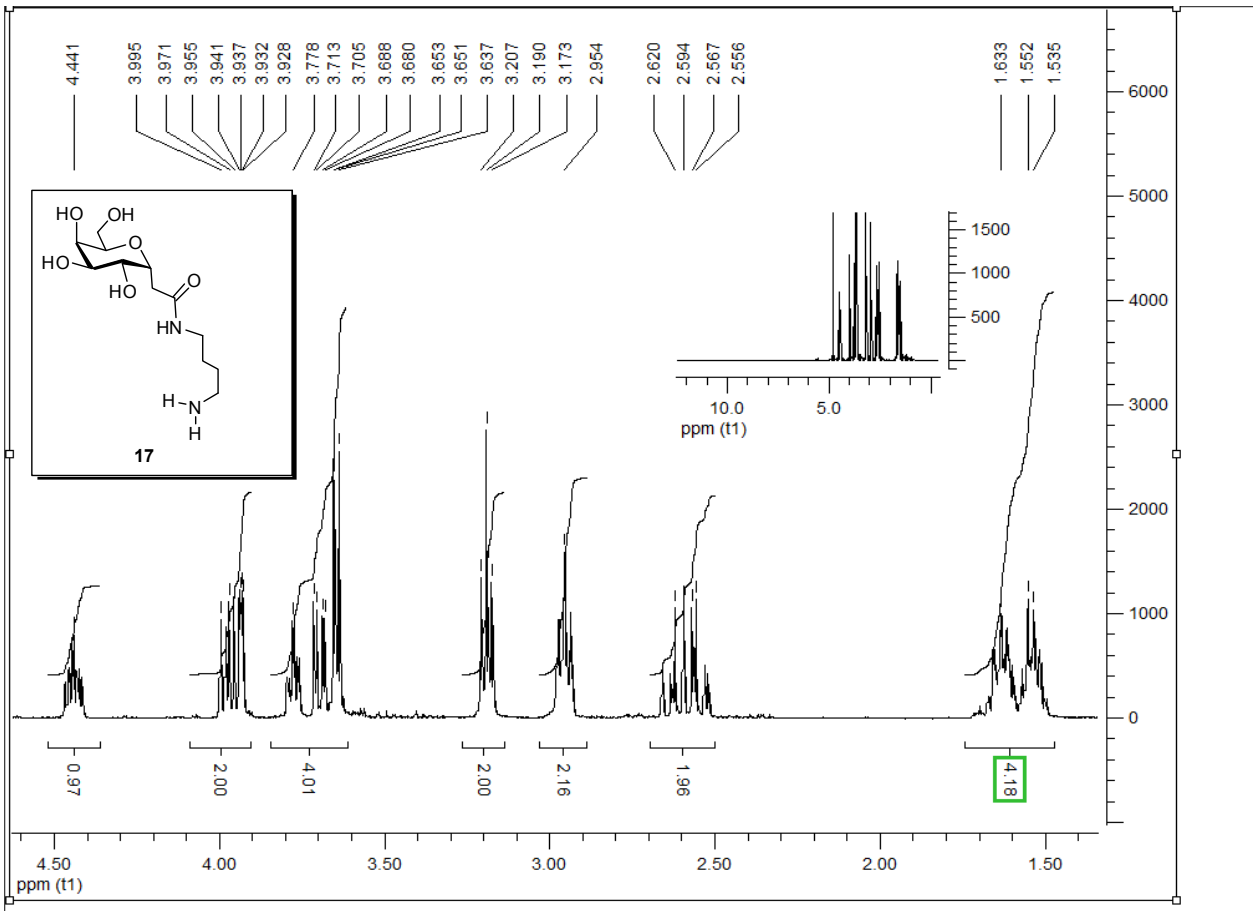

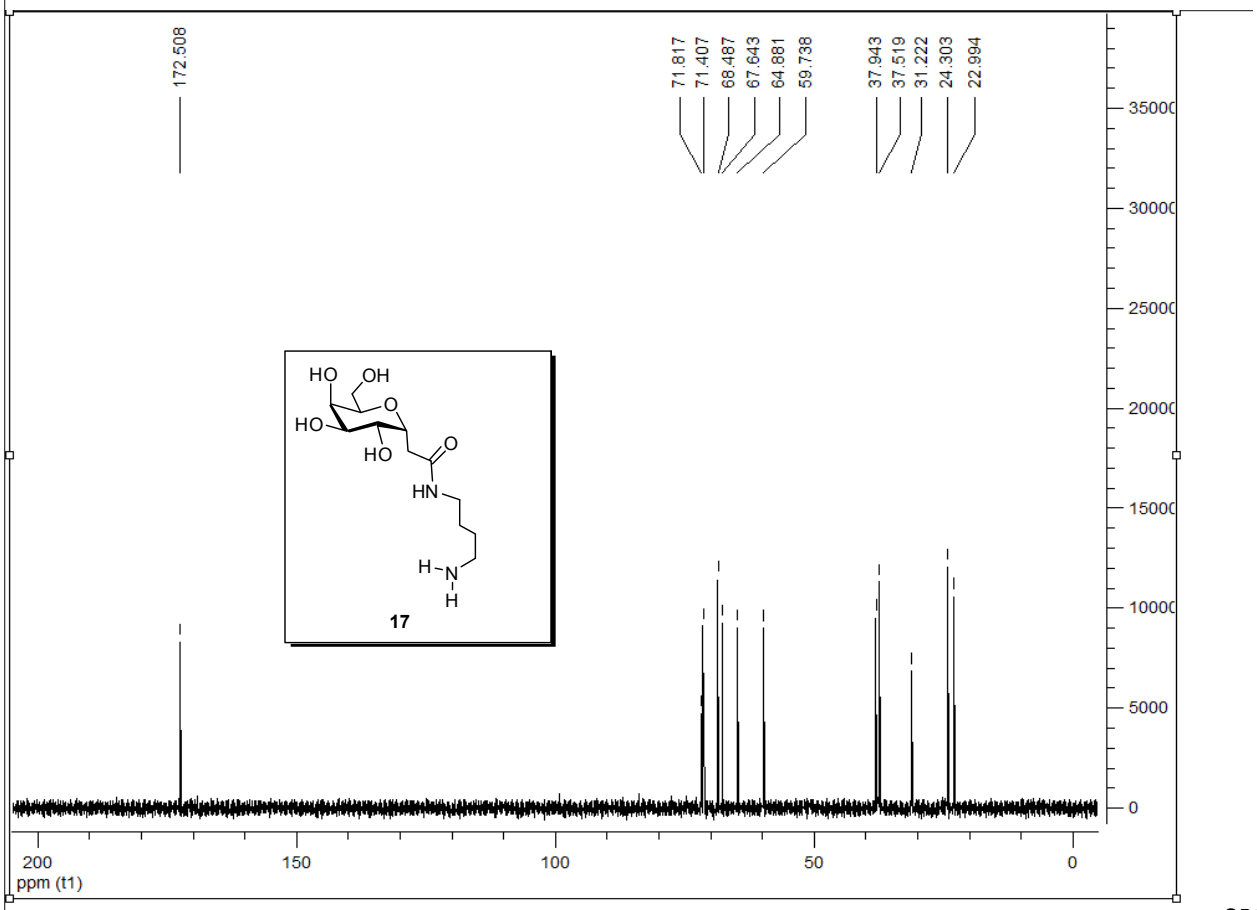

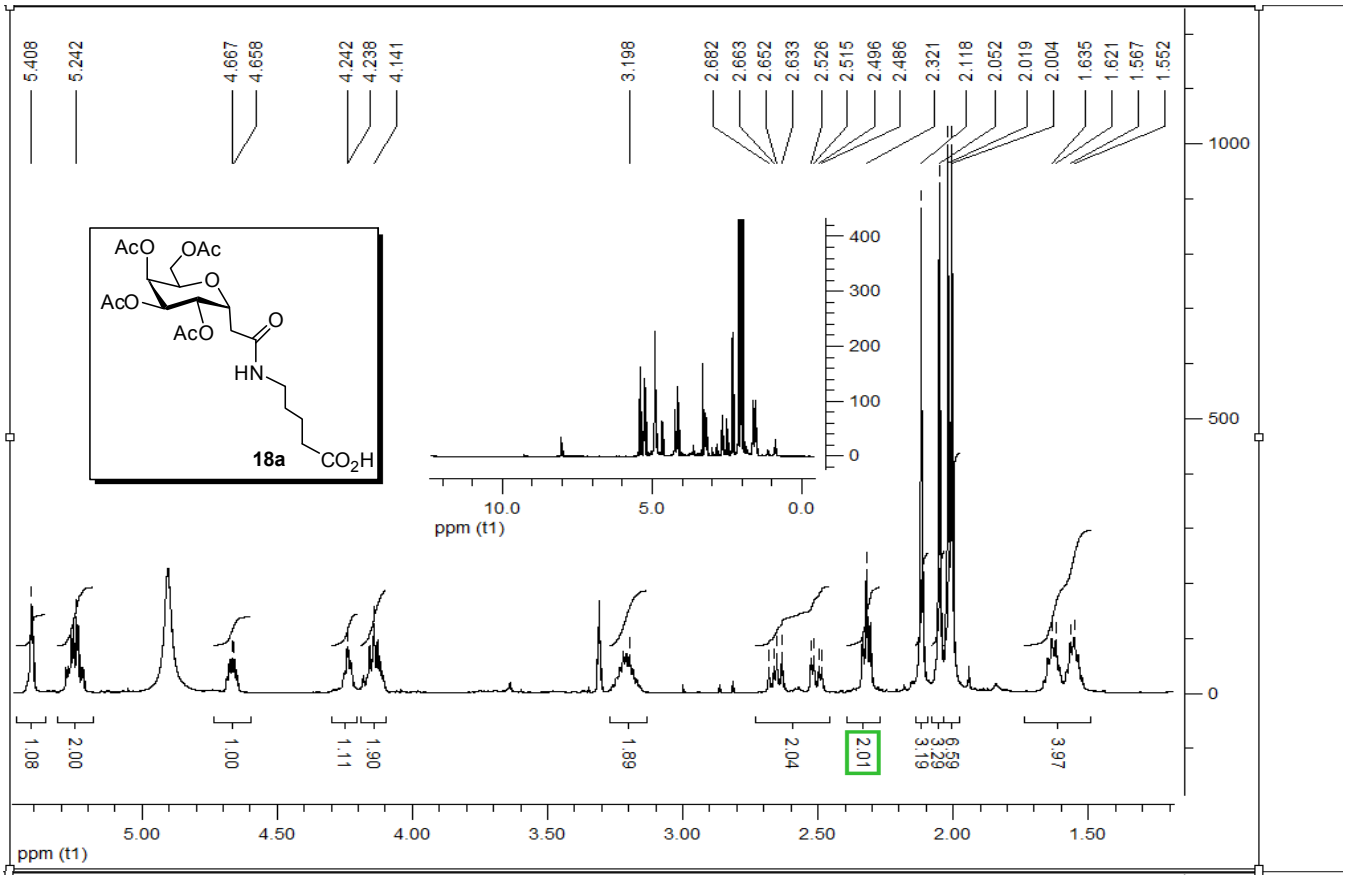

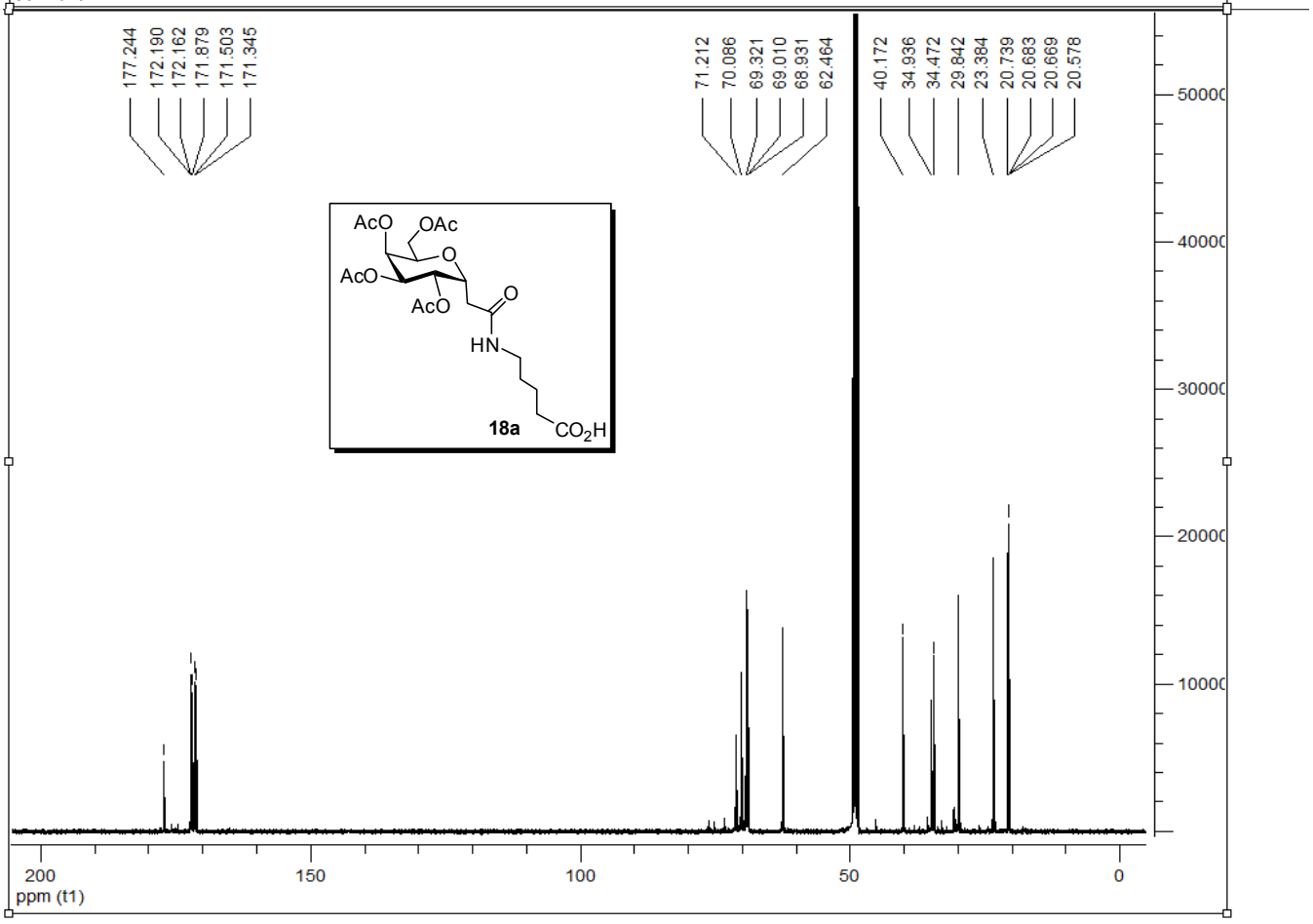

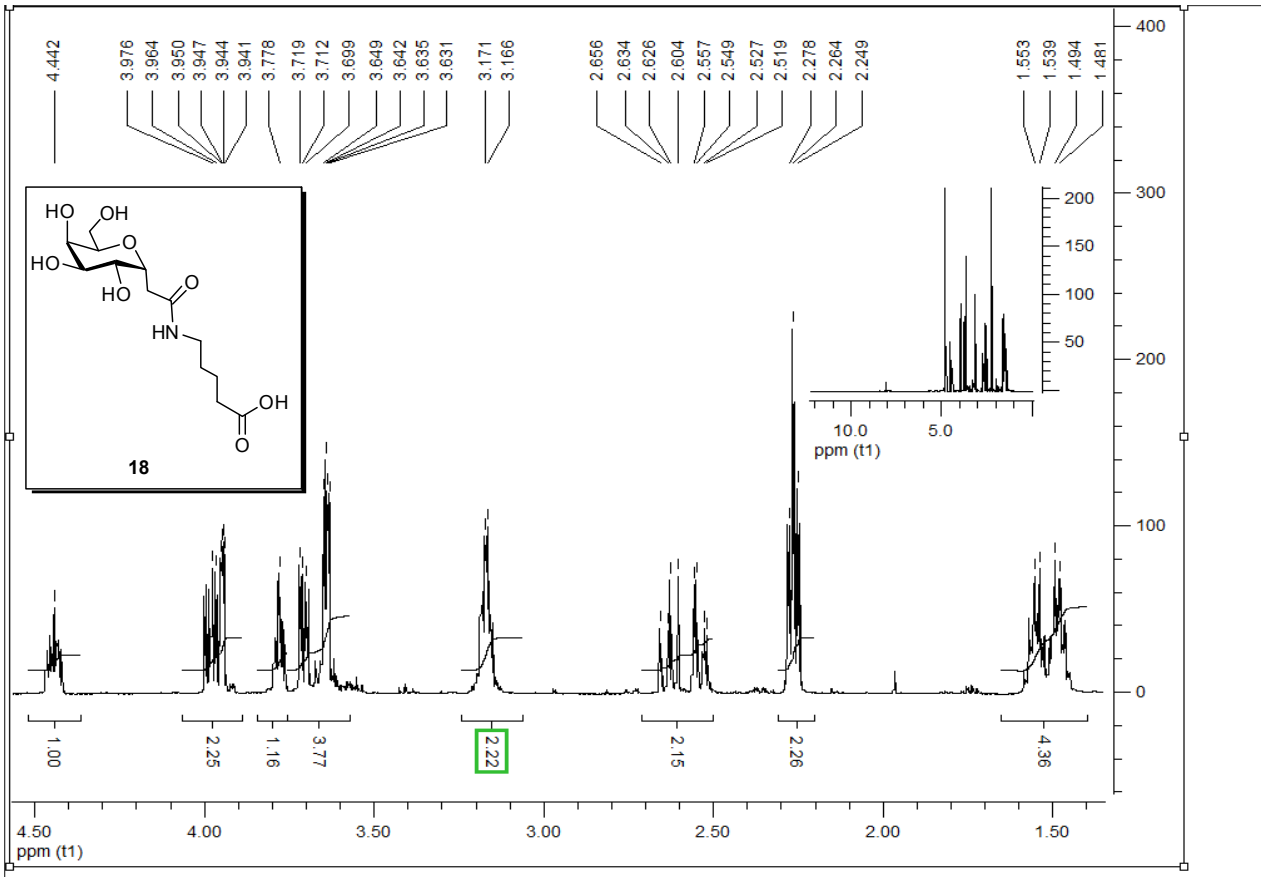

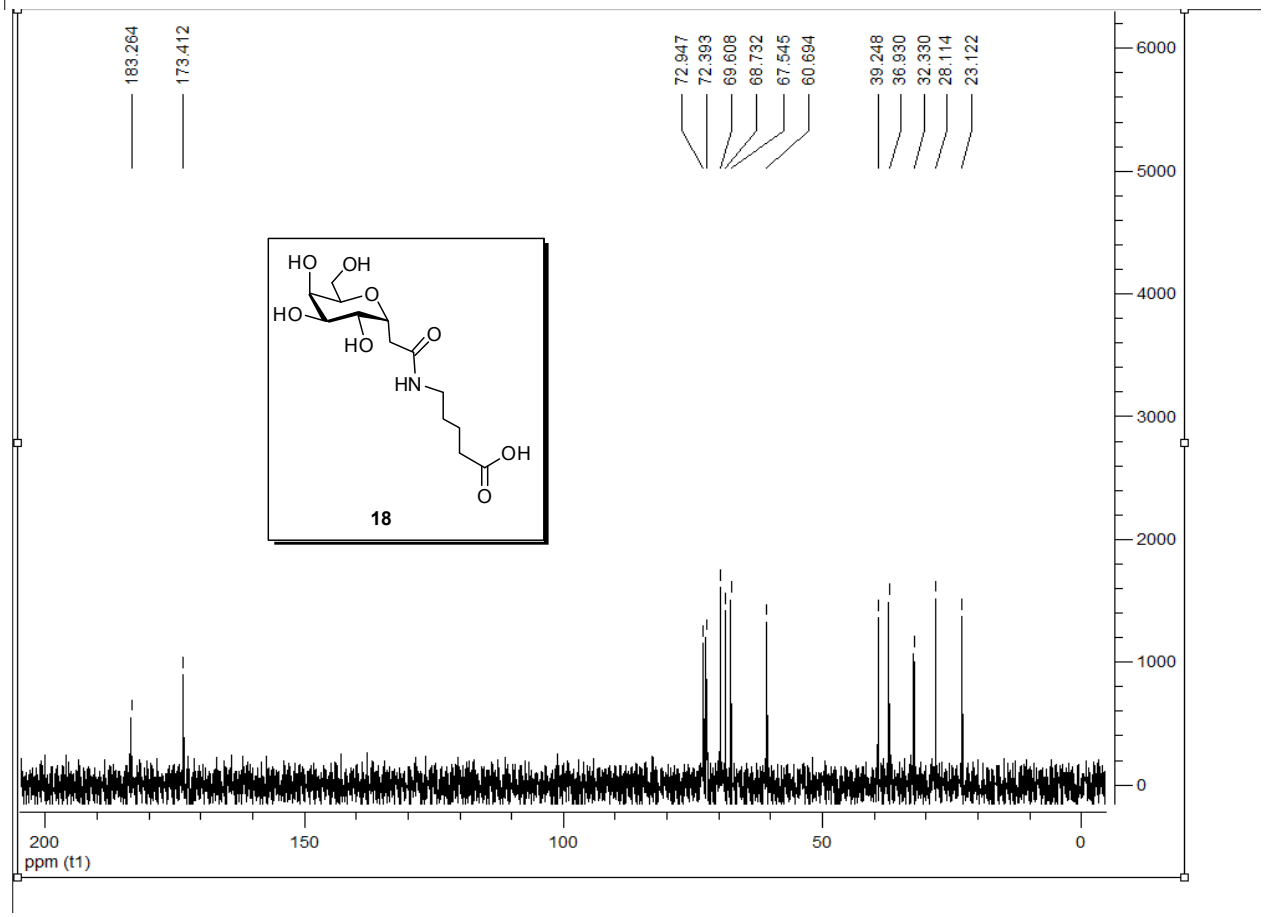

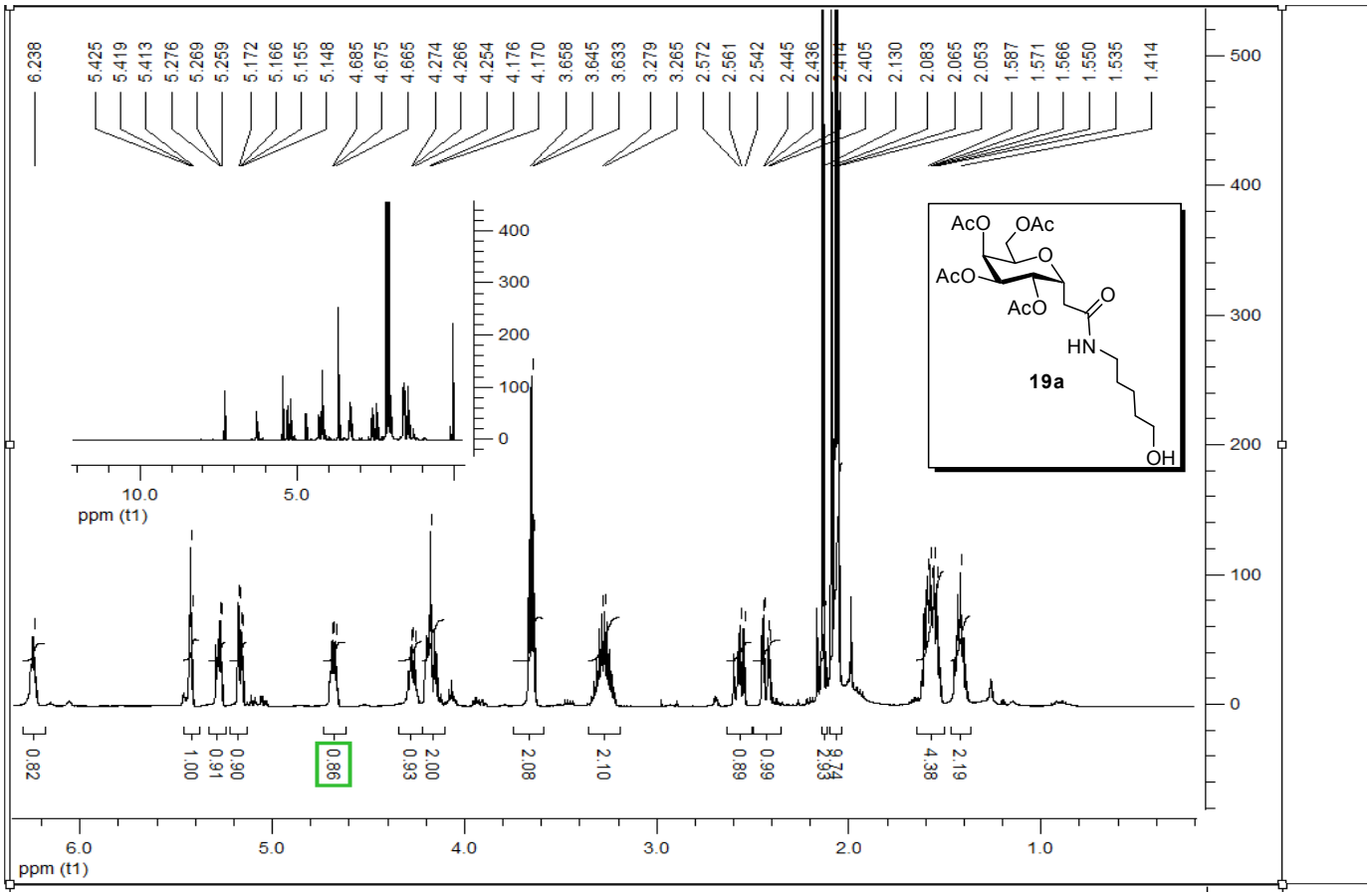
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2.414
2.405
2.130
2.083
2.065
2.053
1.587
1.571
1.566
1.550
1.535
1.414
AcO
OAc
O
AcO
AcO
O
HN
19a
OH
ppm (t1)
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1.00
0.91
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0.93
2.00
2.08
2.10
0.89
0.99
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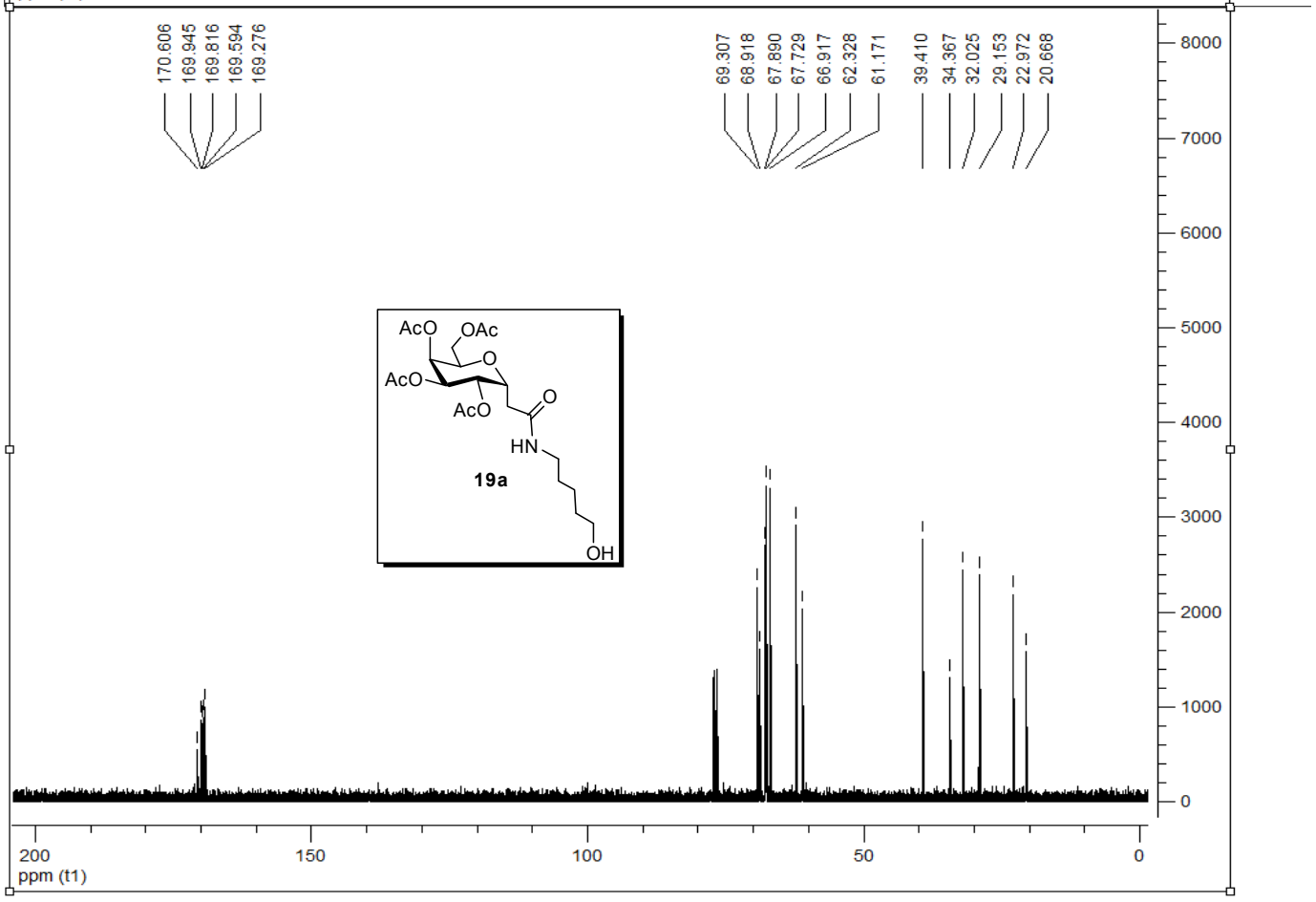
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39.410
34.367
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OAc
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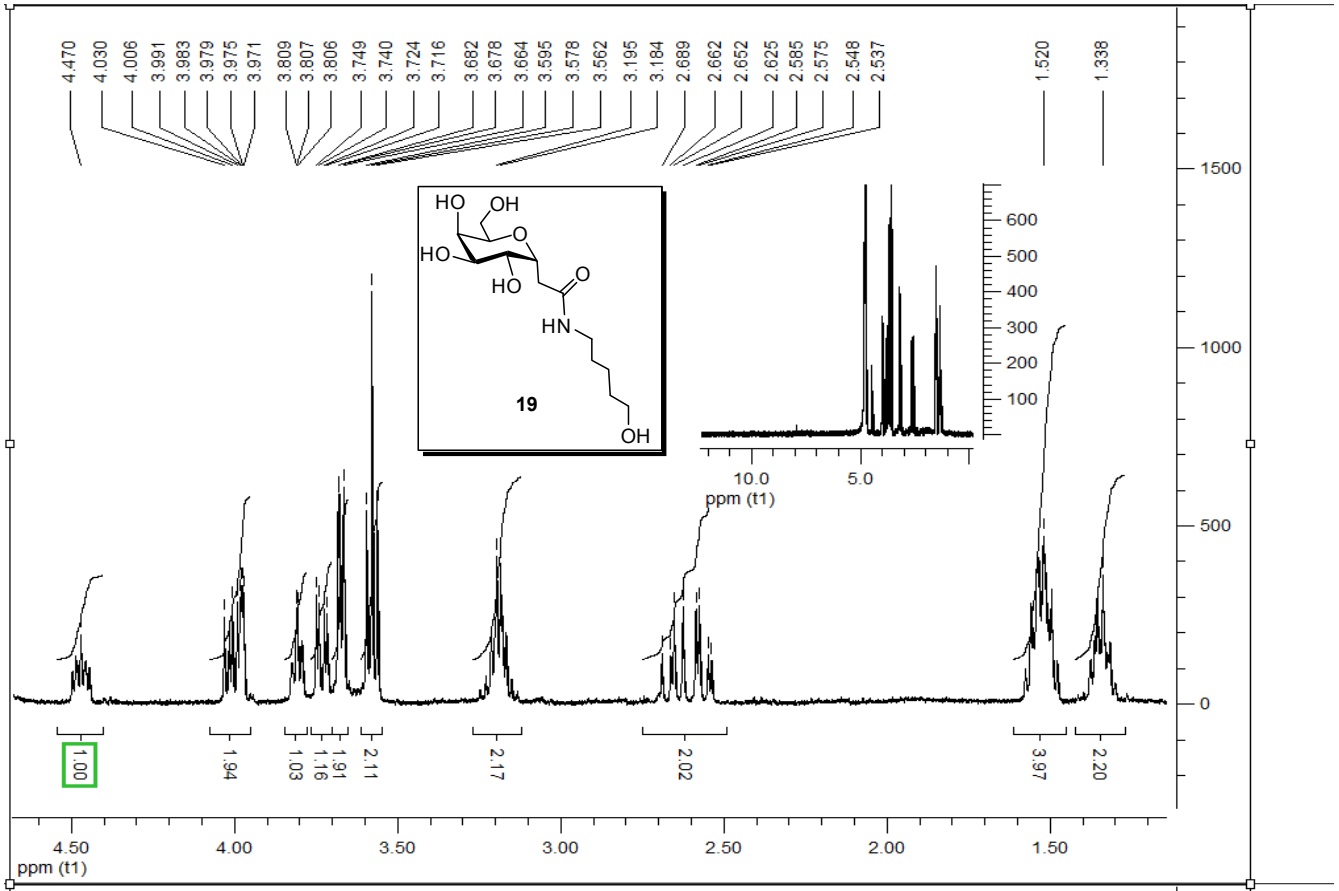
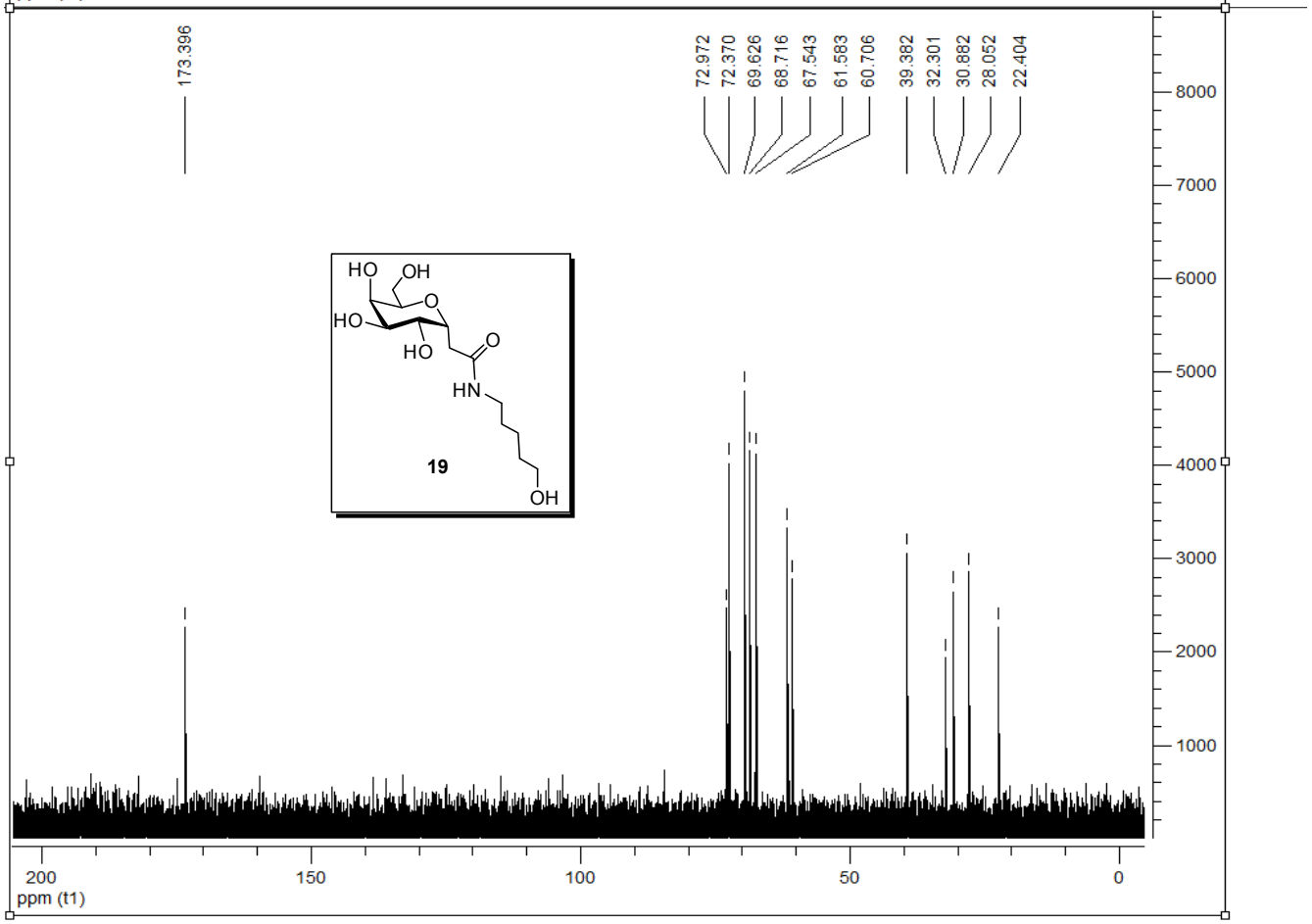
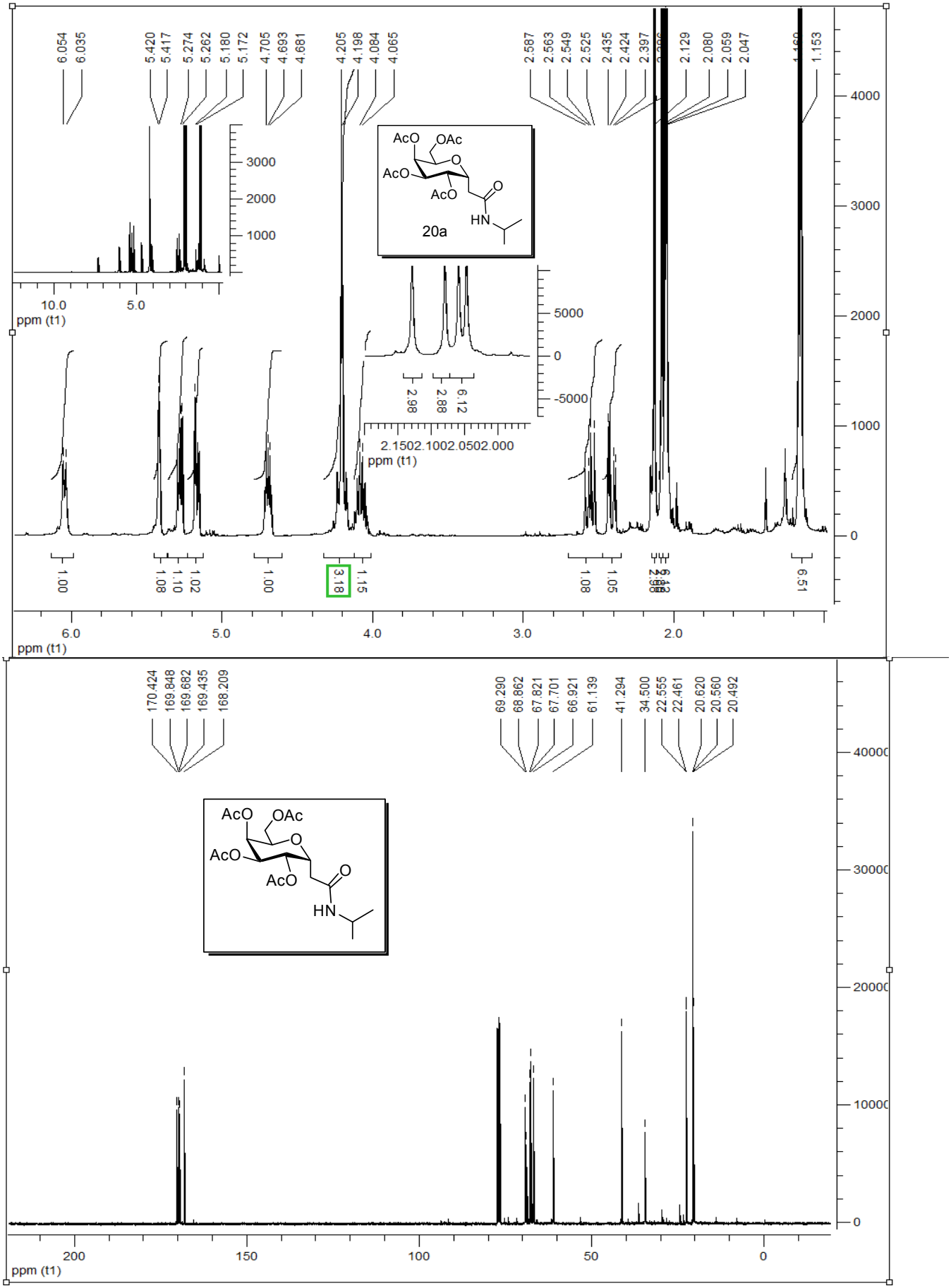
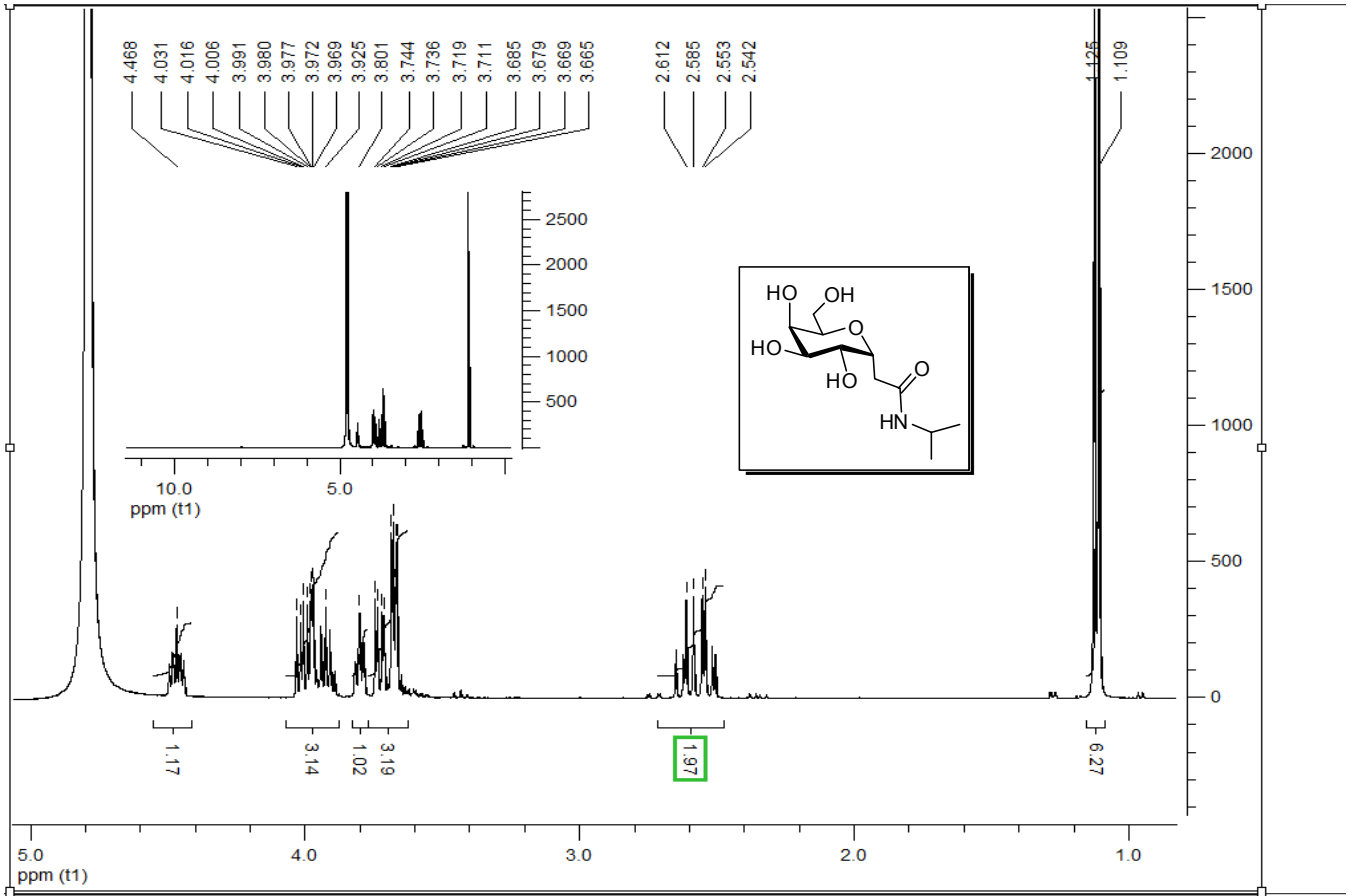
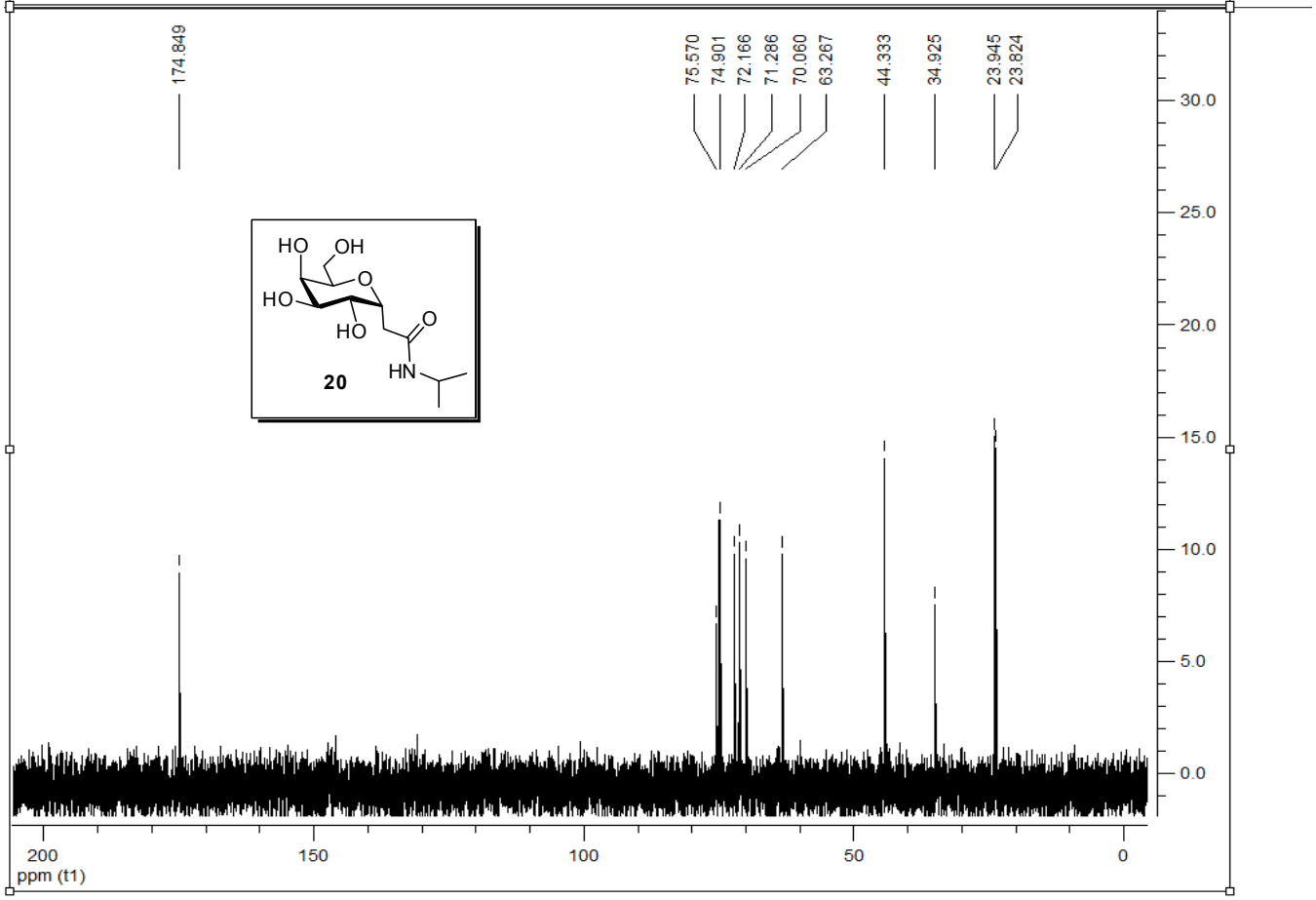
AcO
AcO
O
HN
19a
OH
ppm (t1)

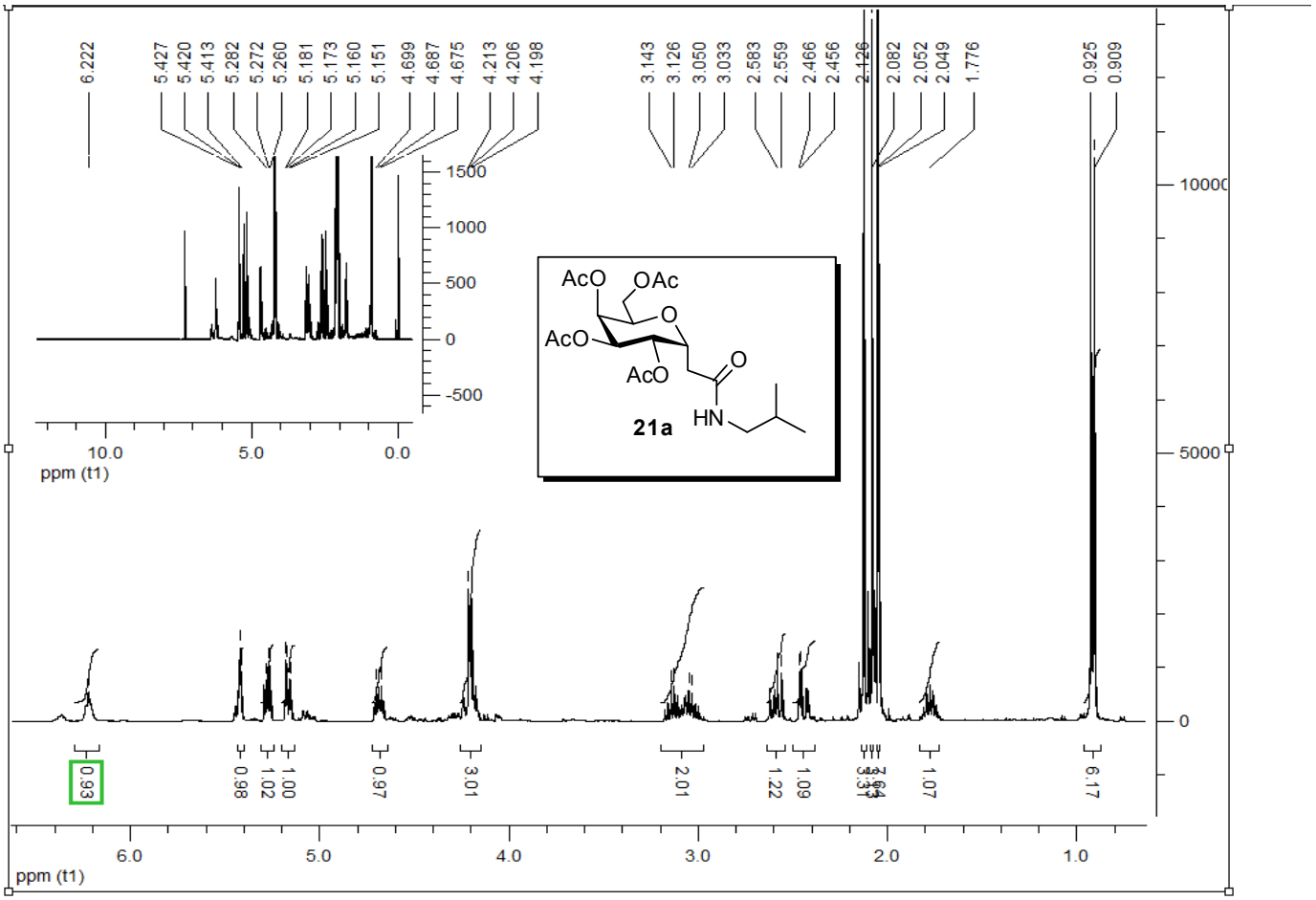


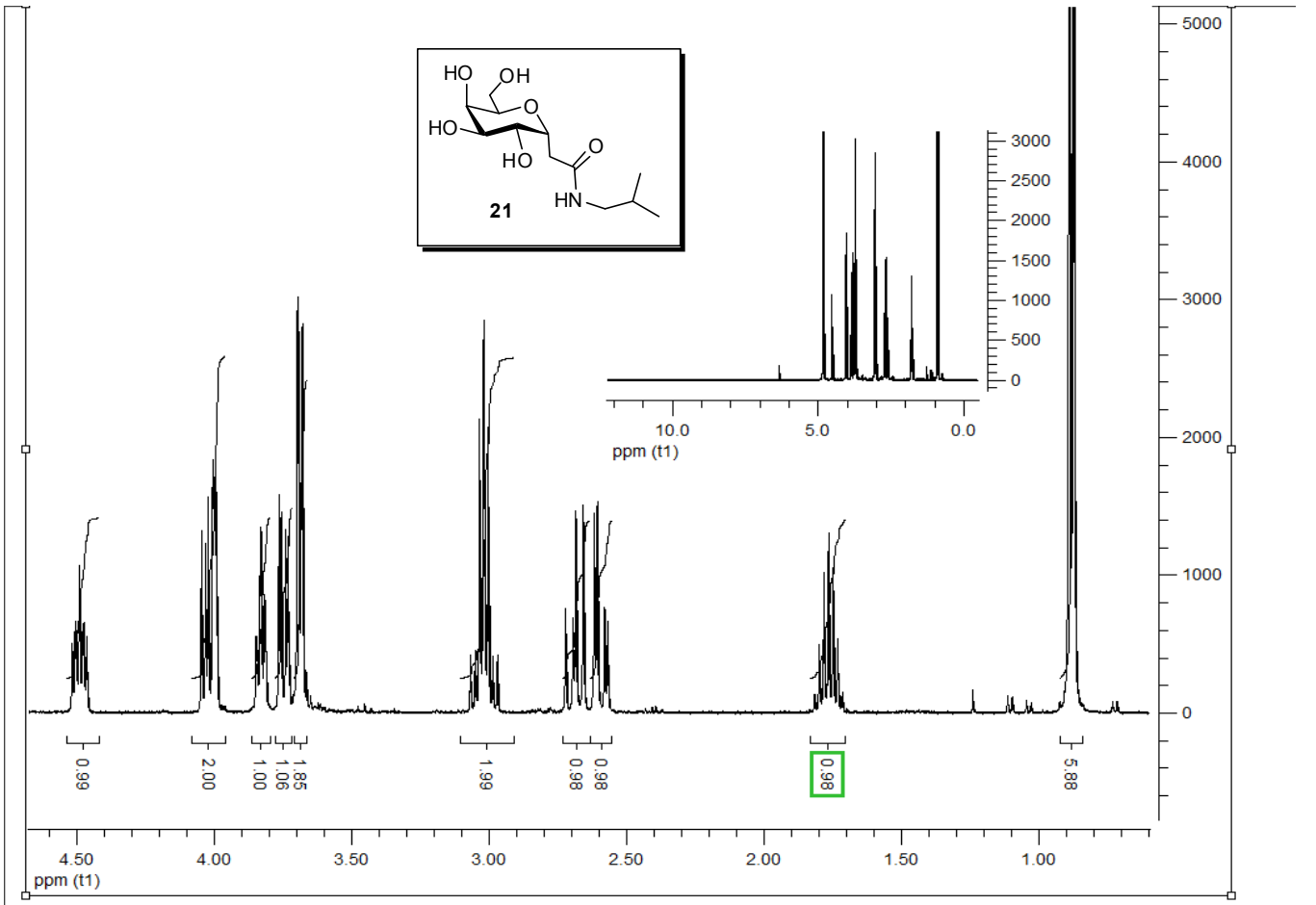


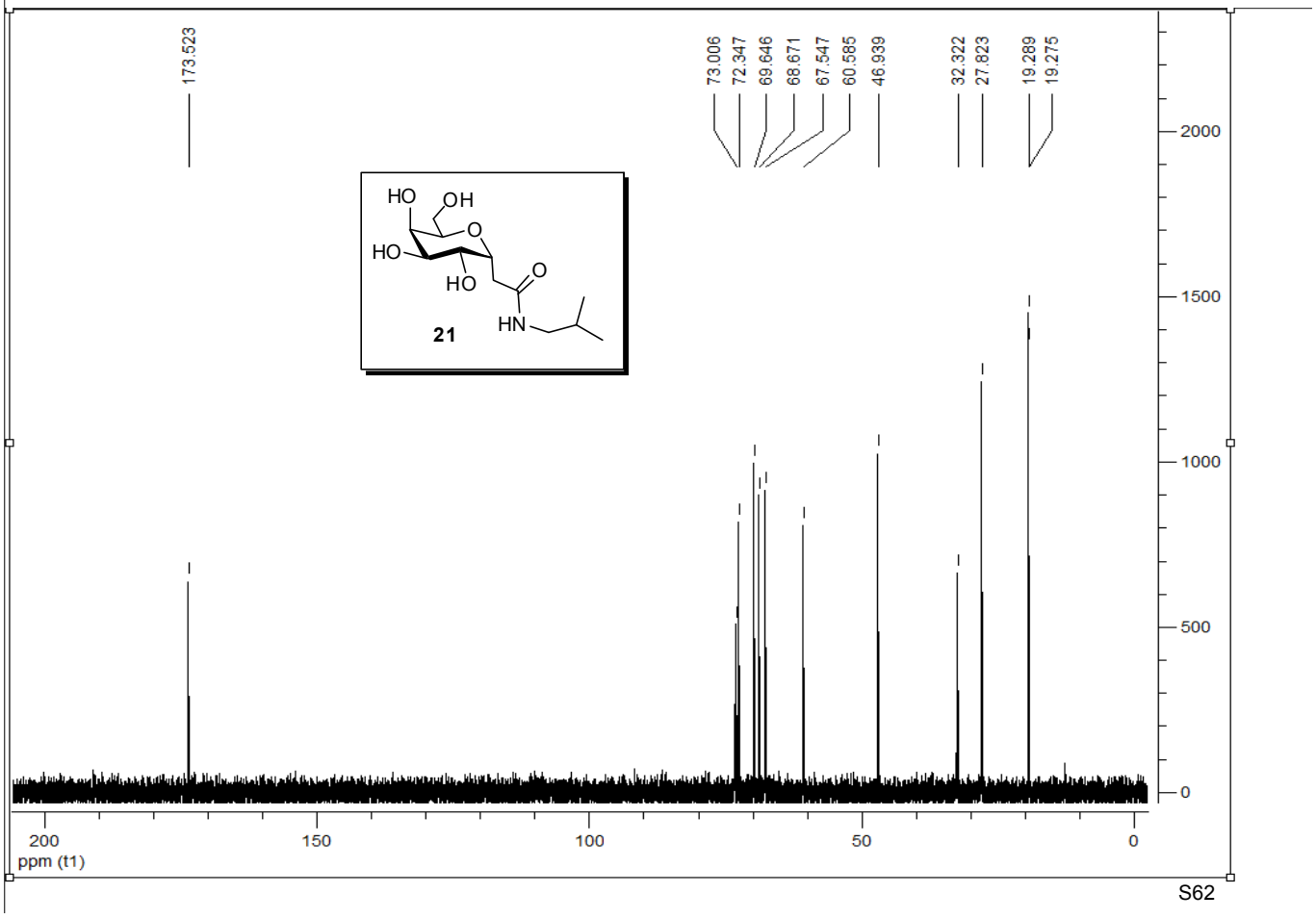


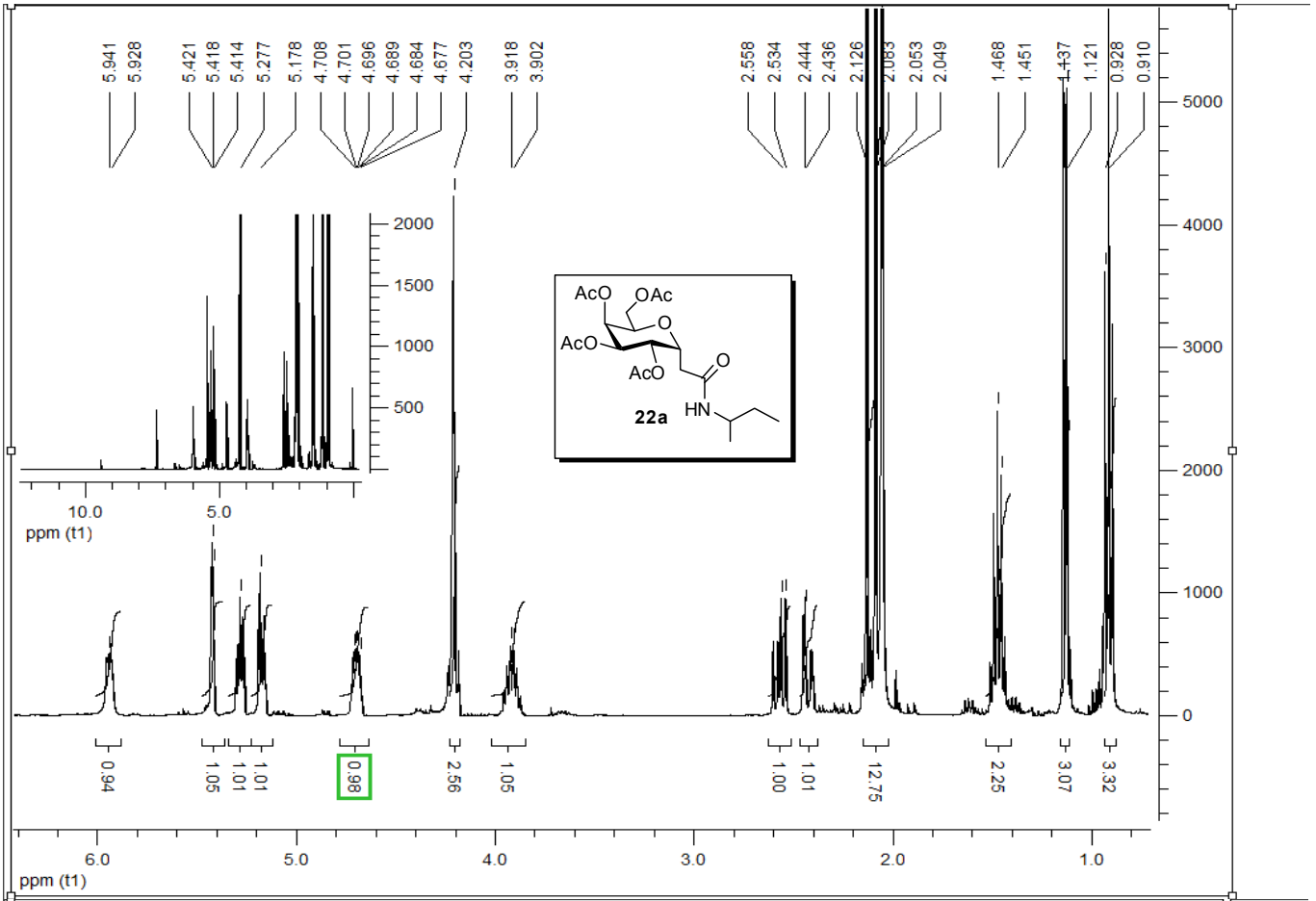


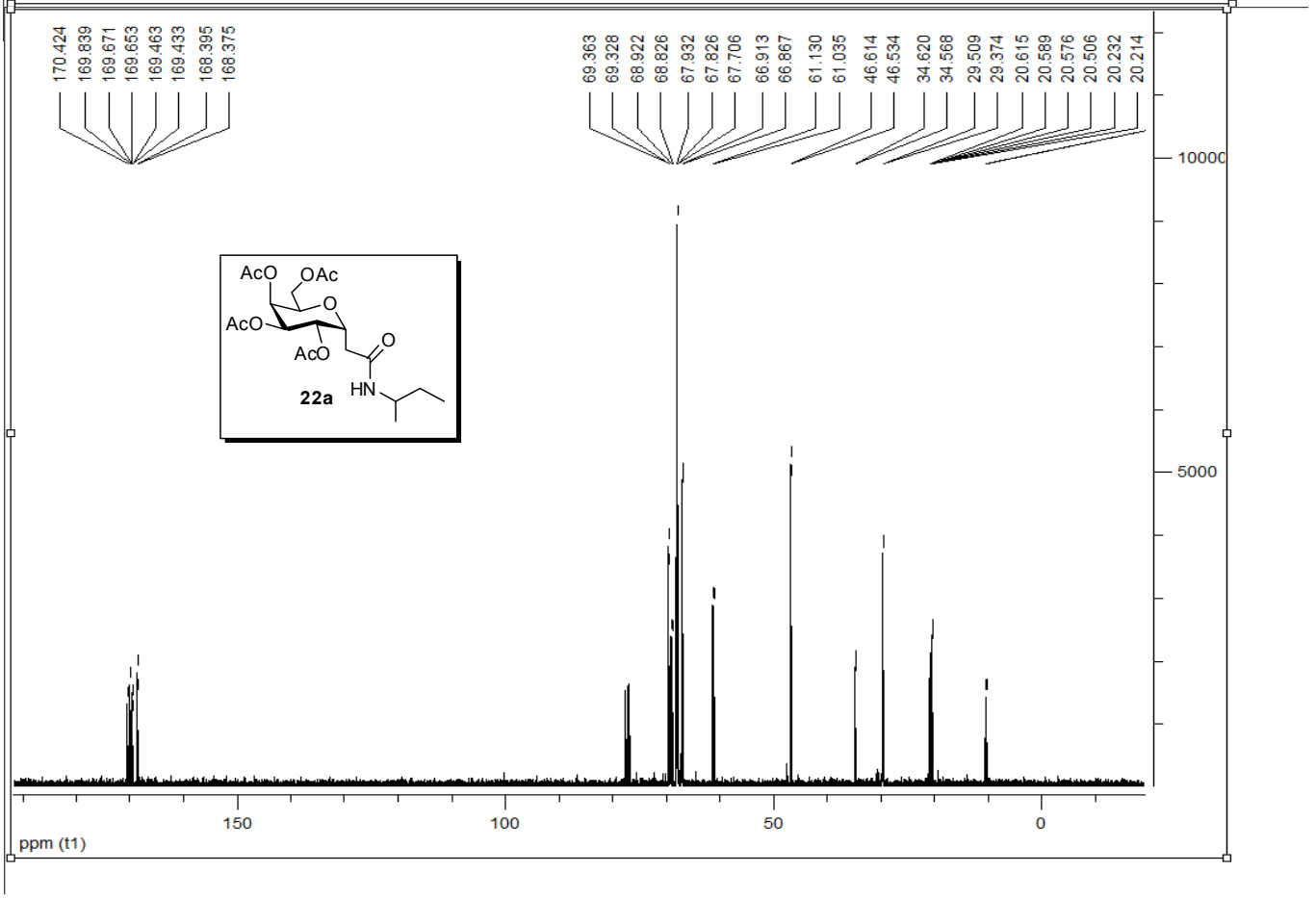


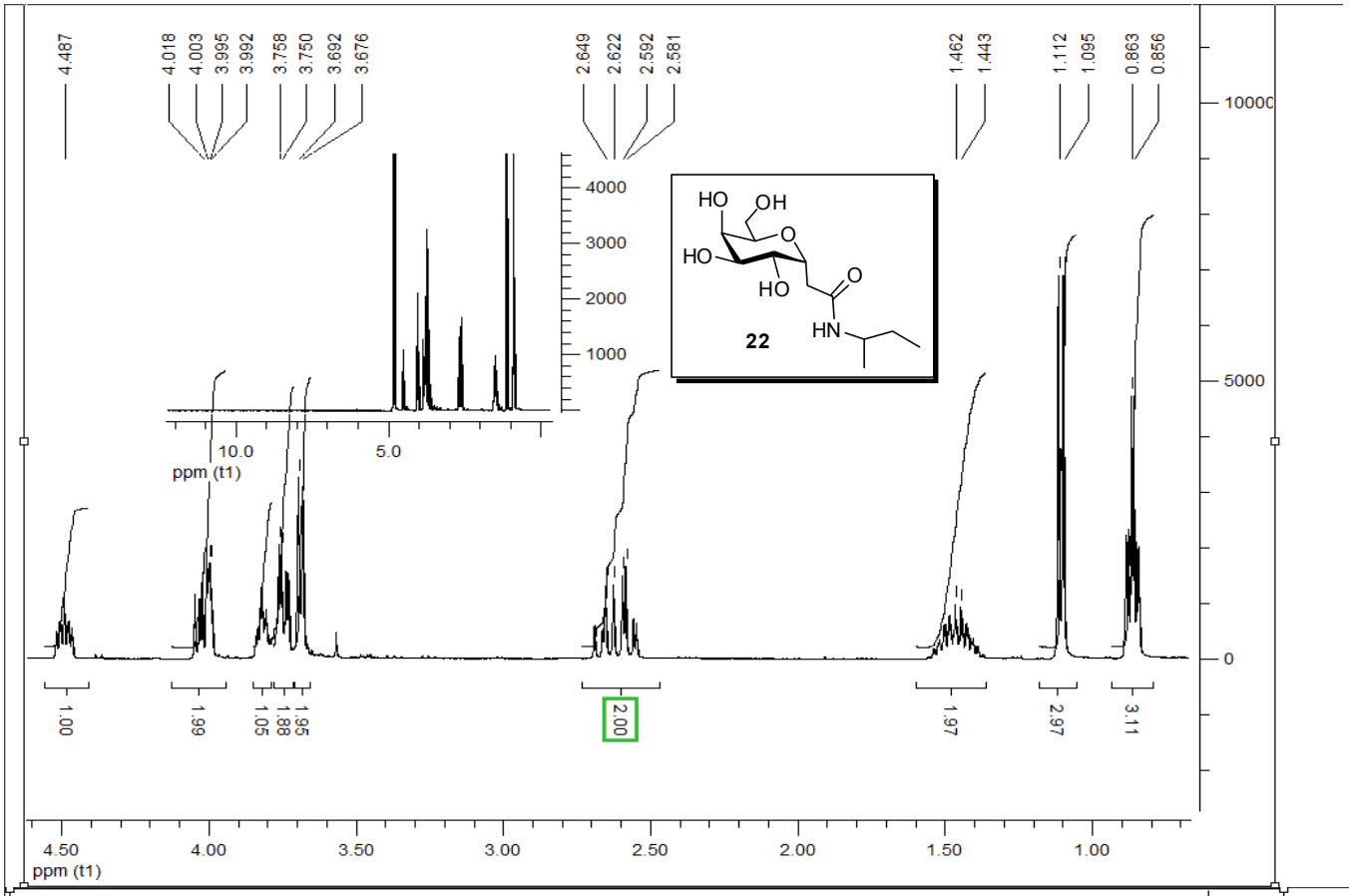


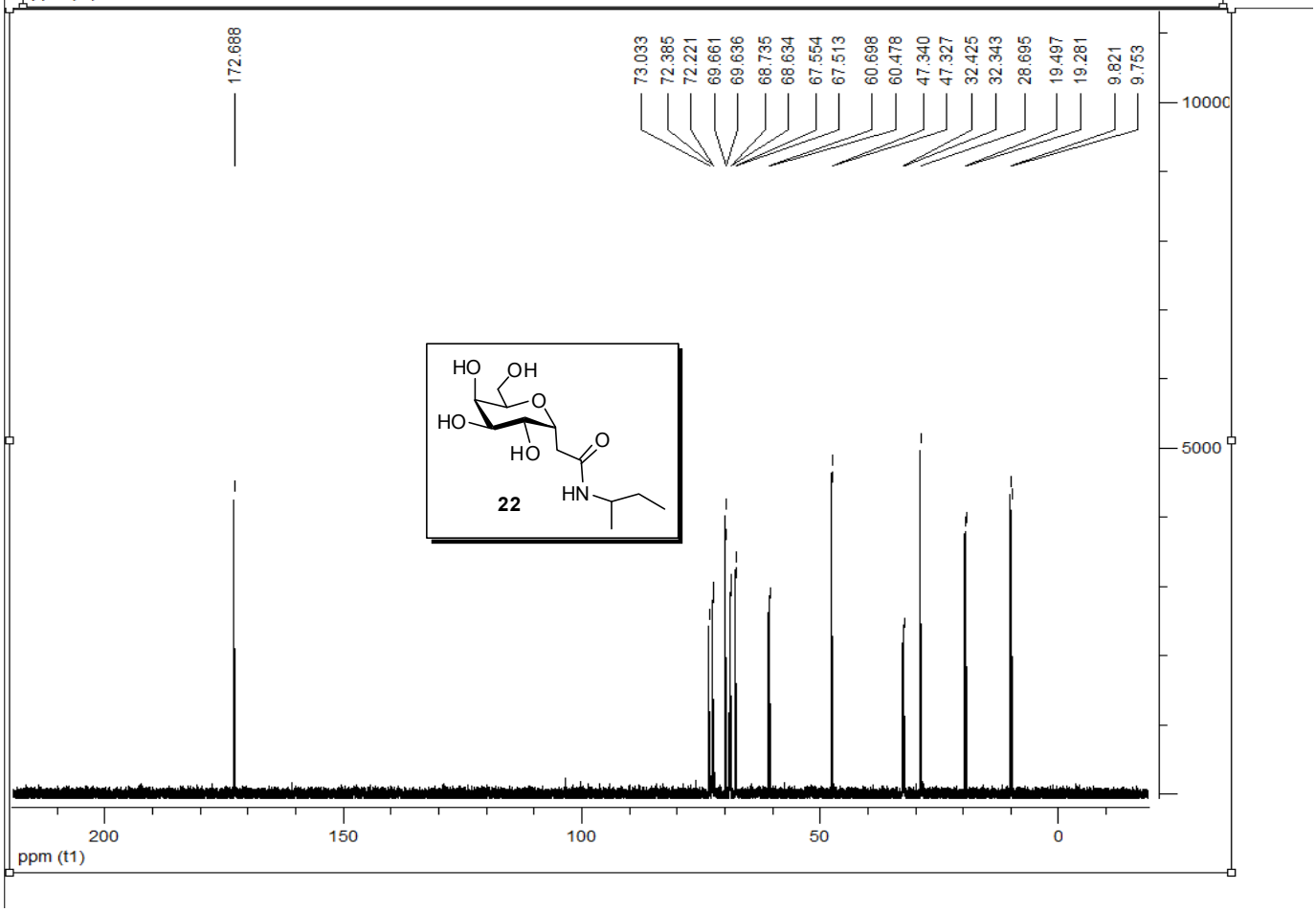


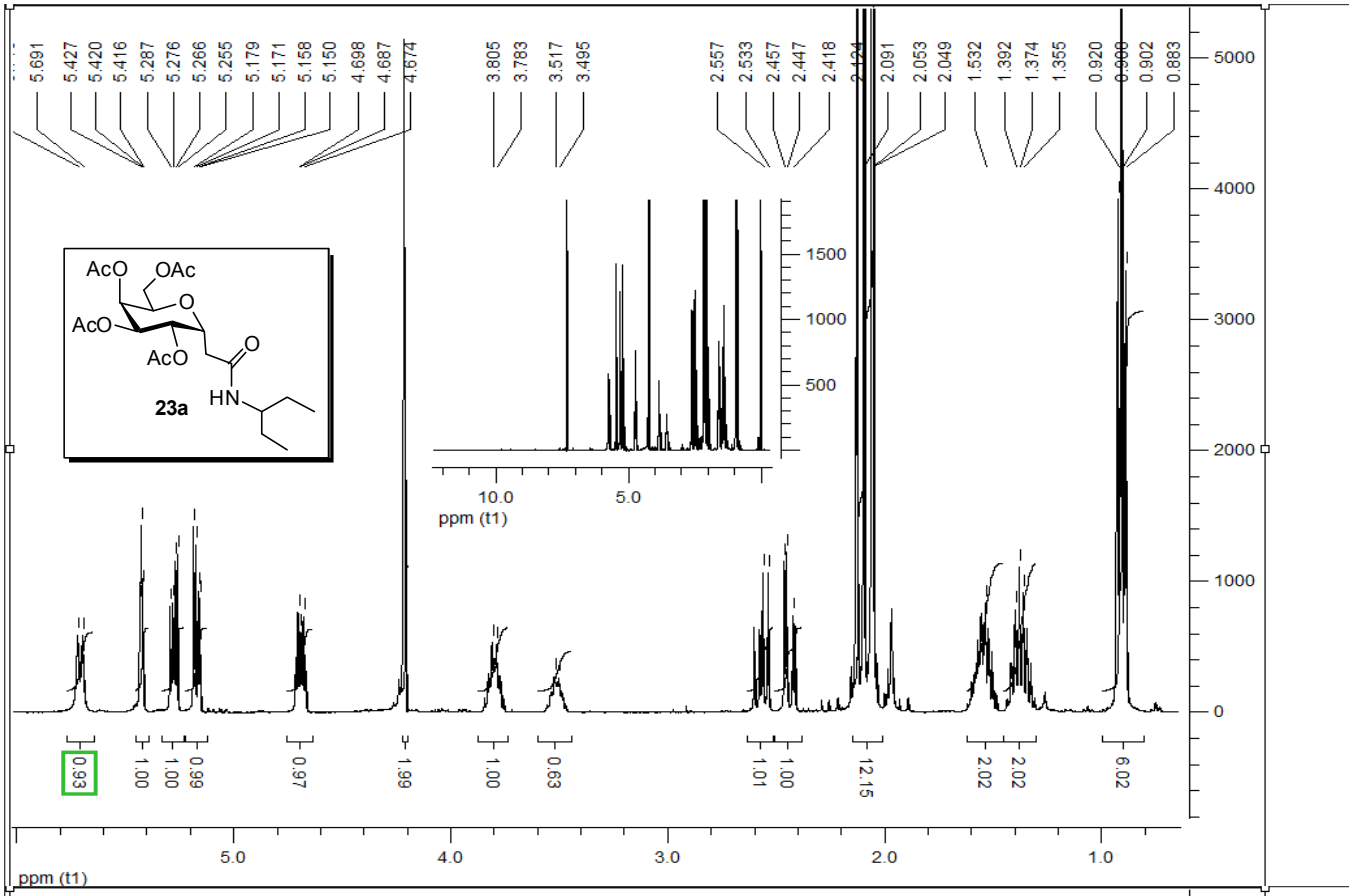


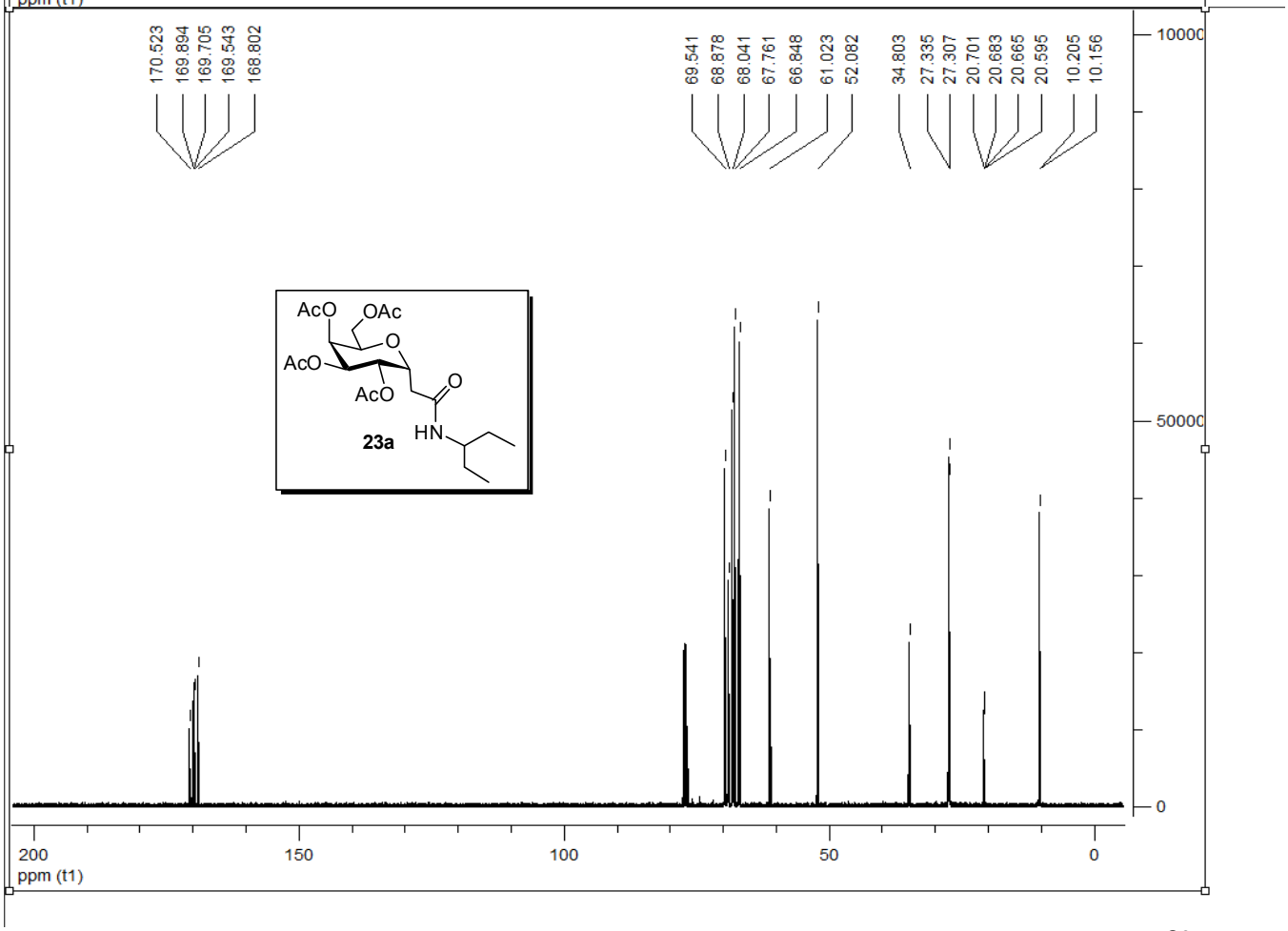


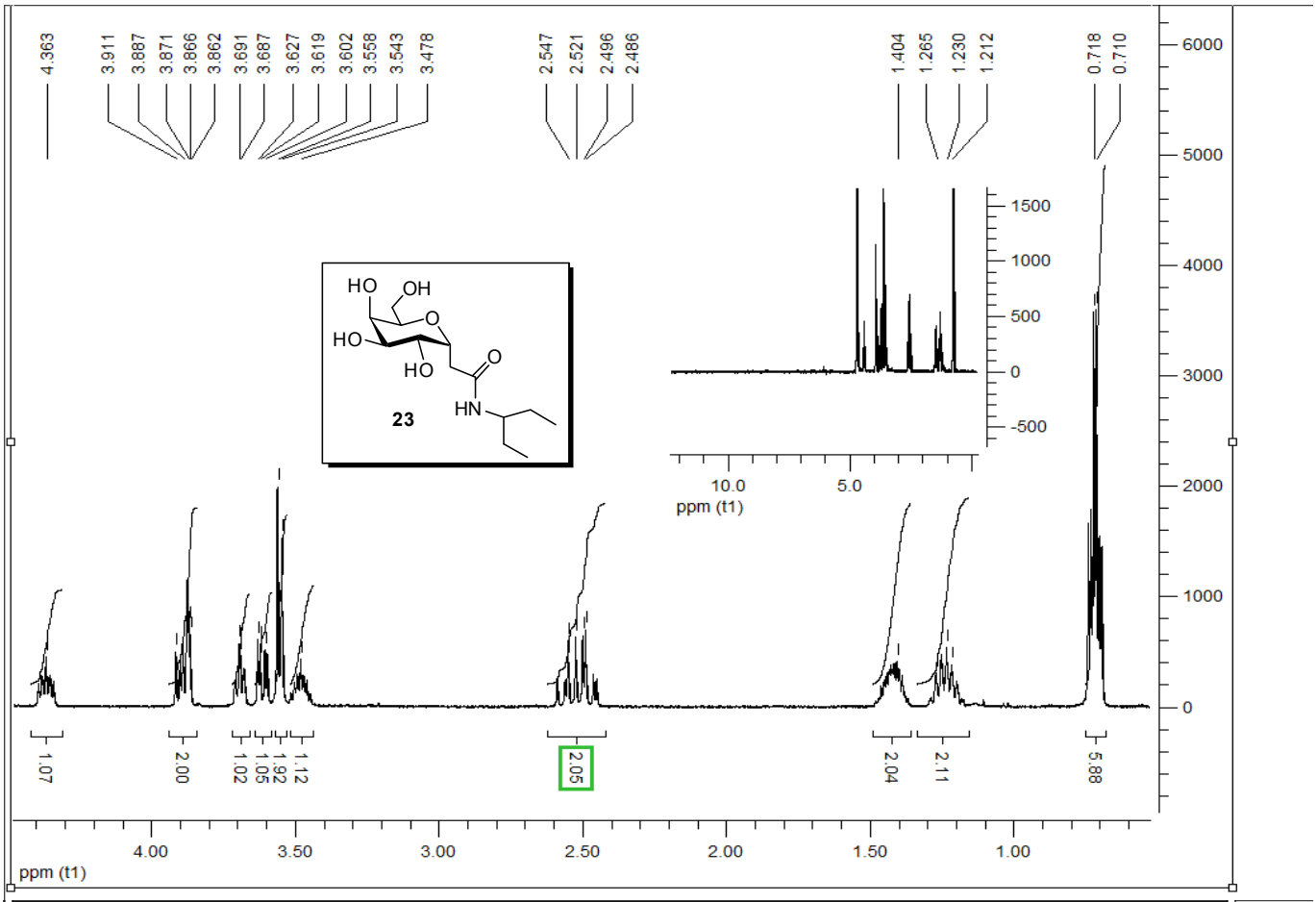


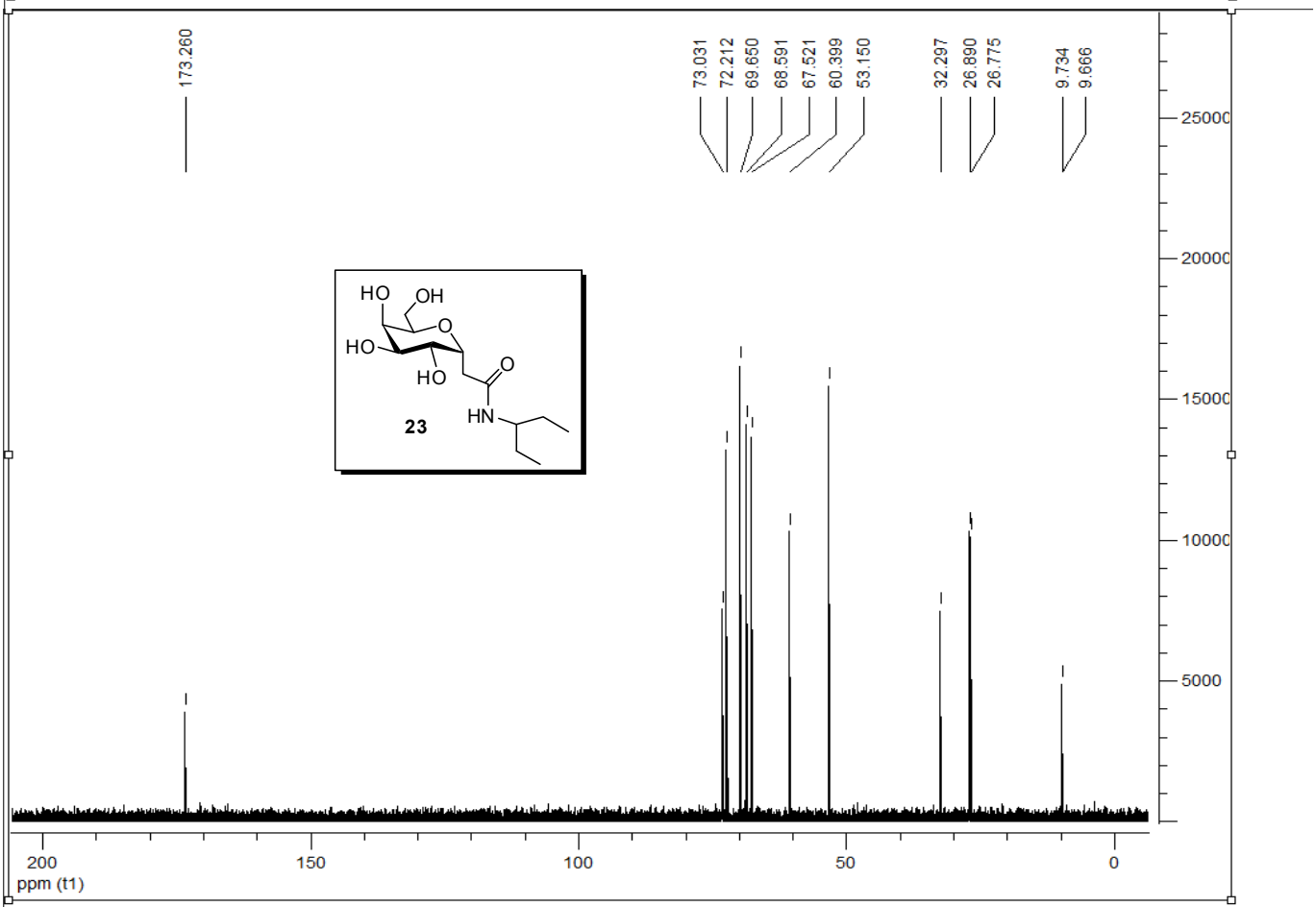


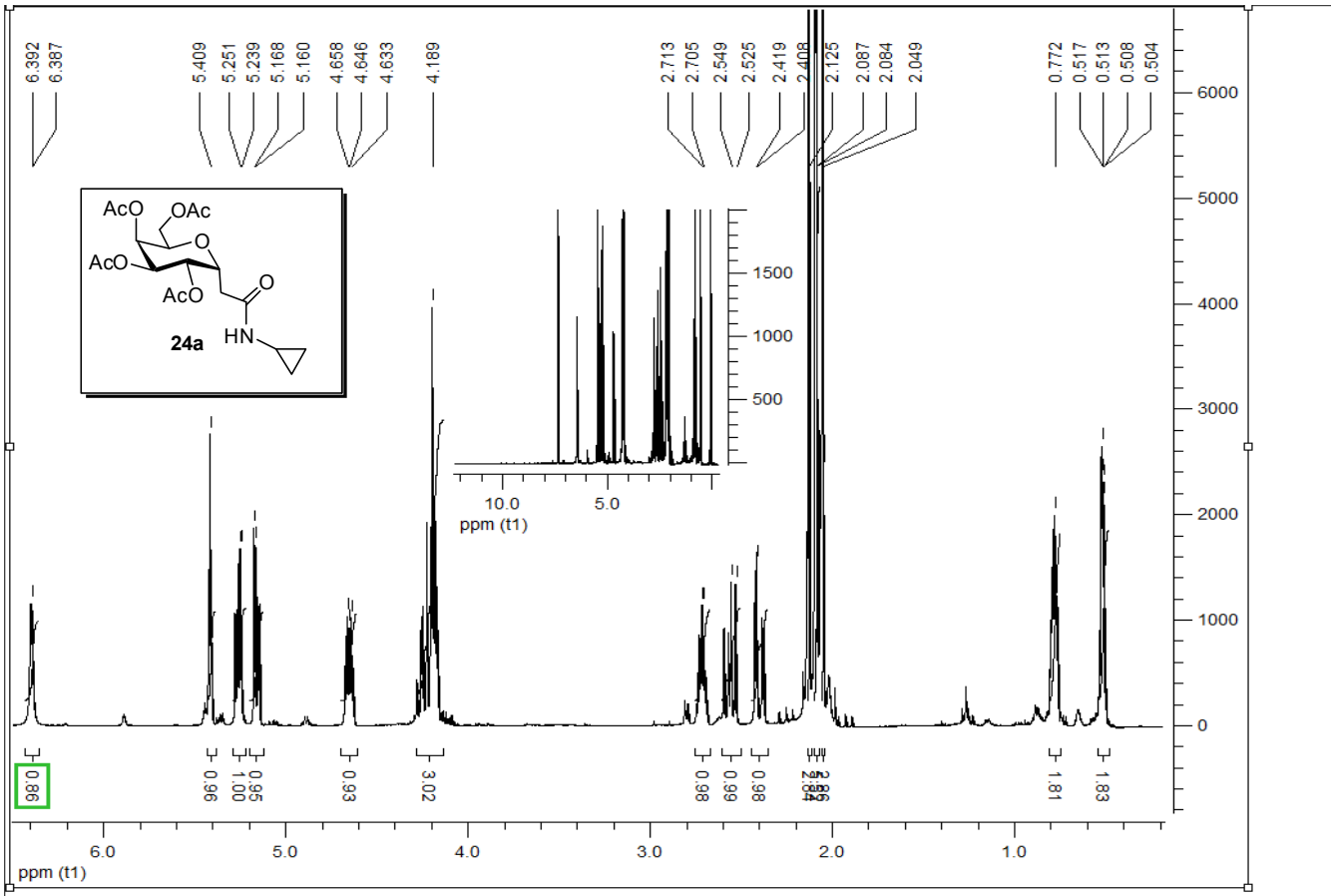


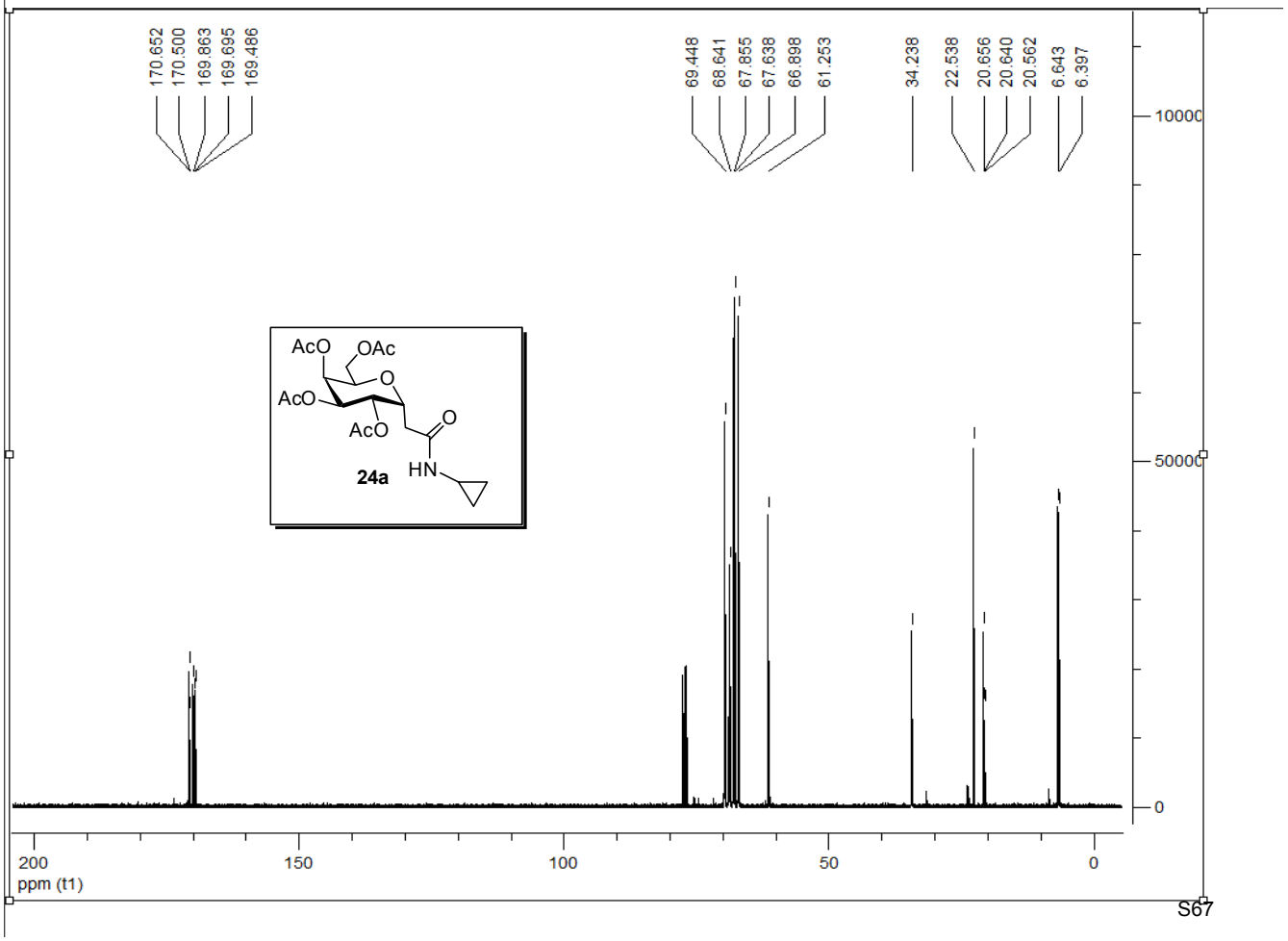


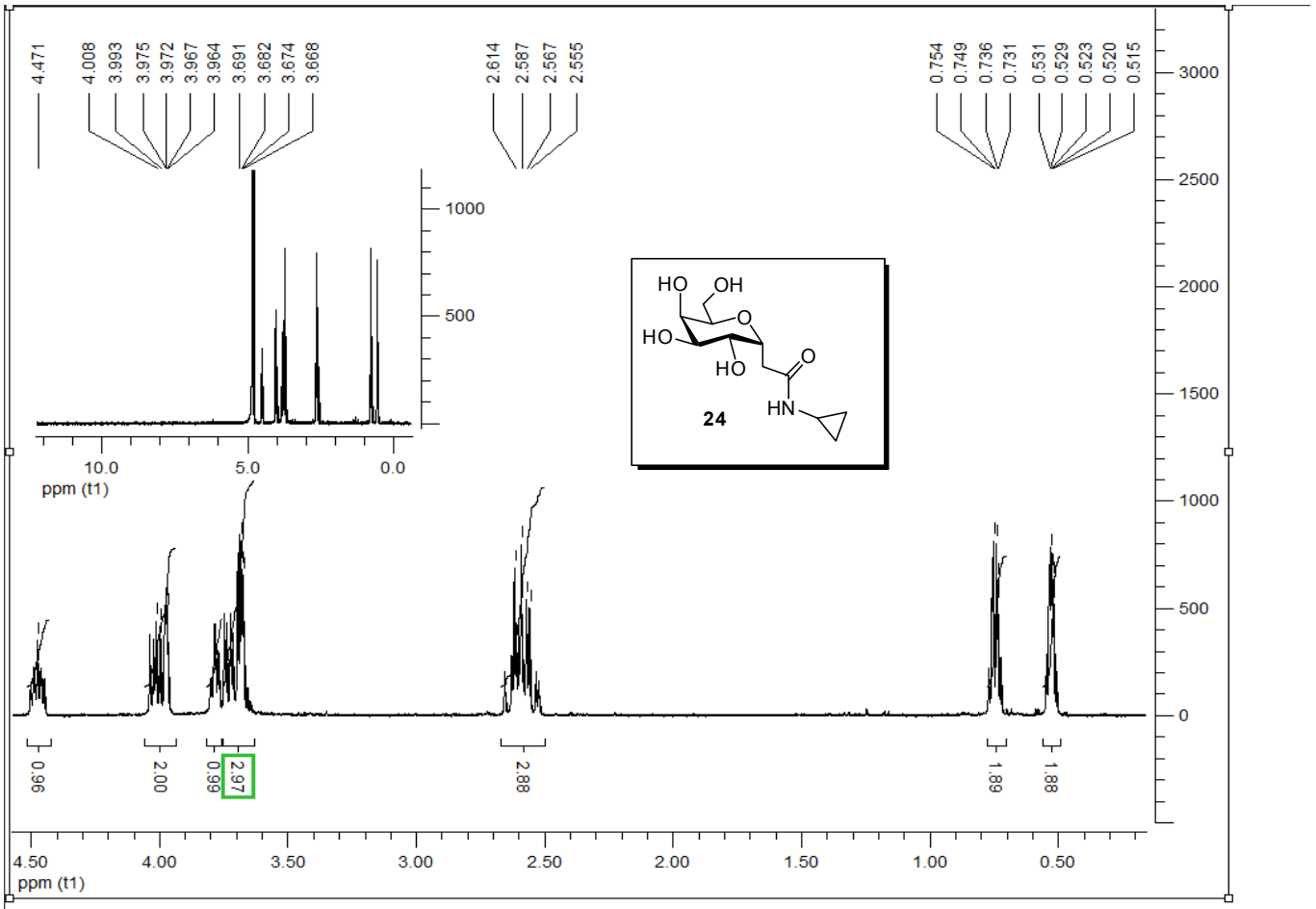


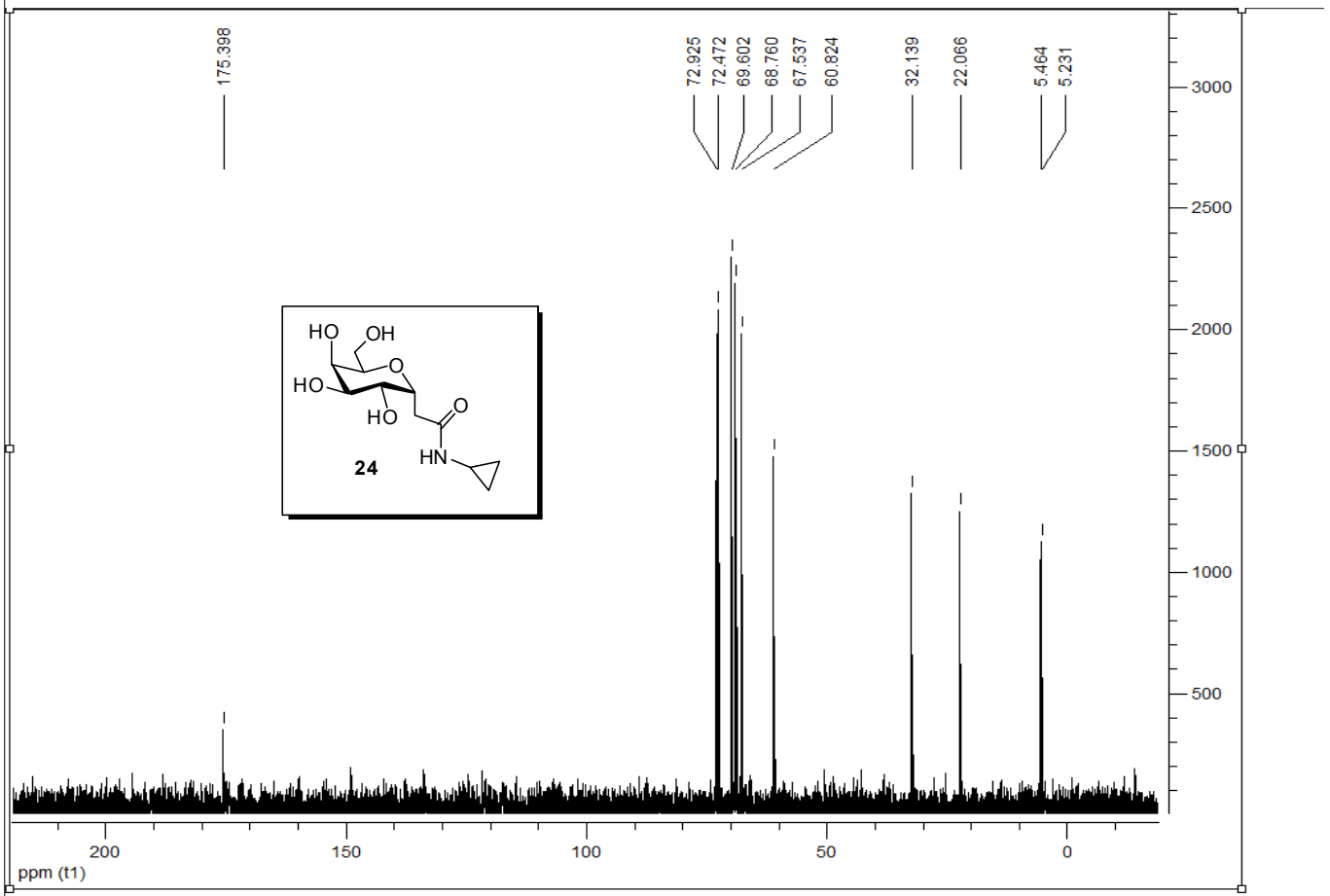


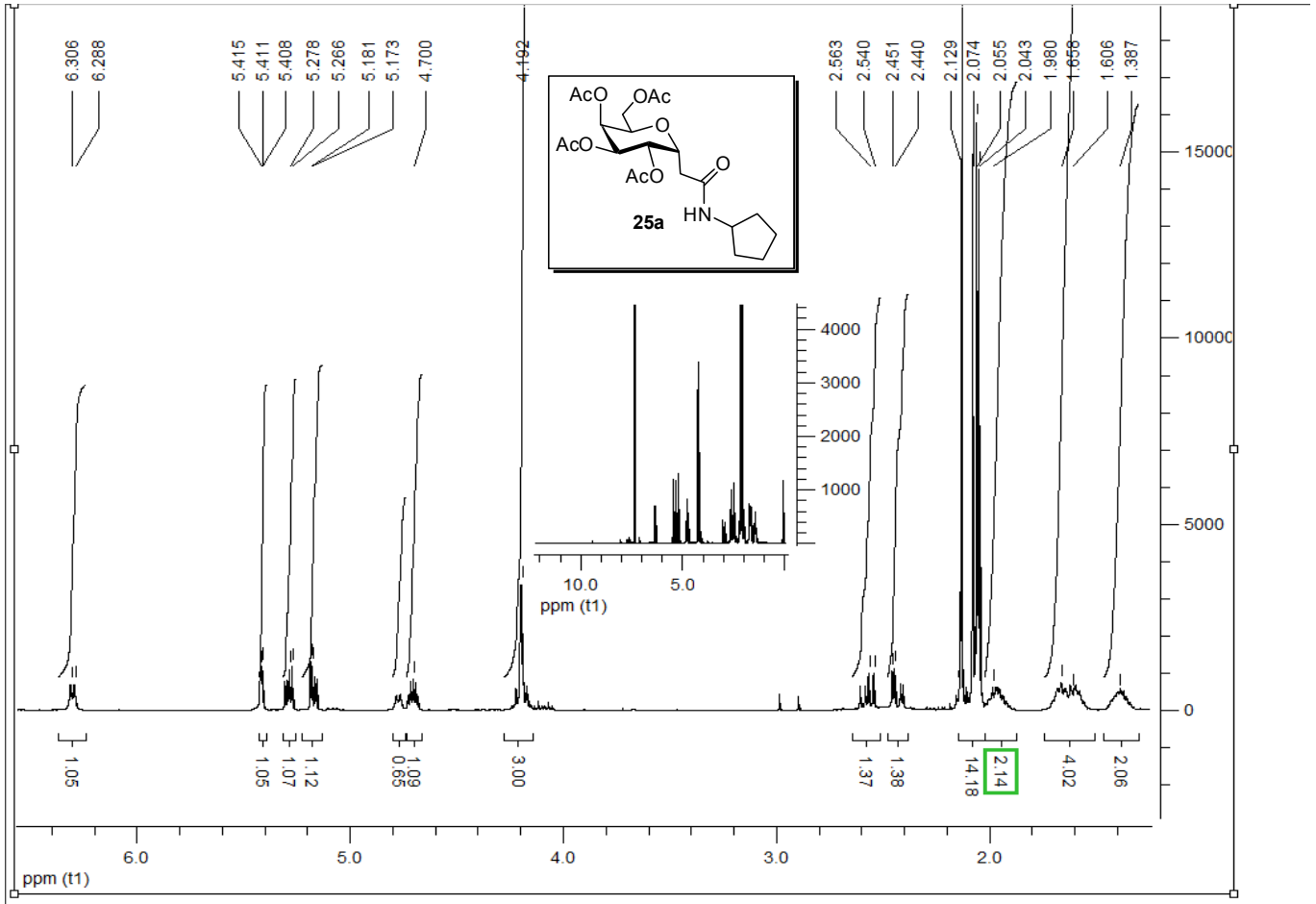


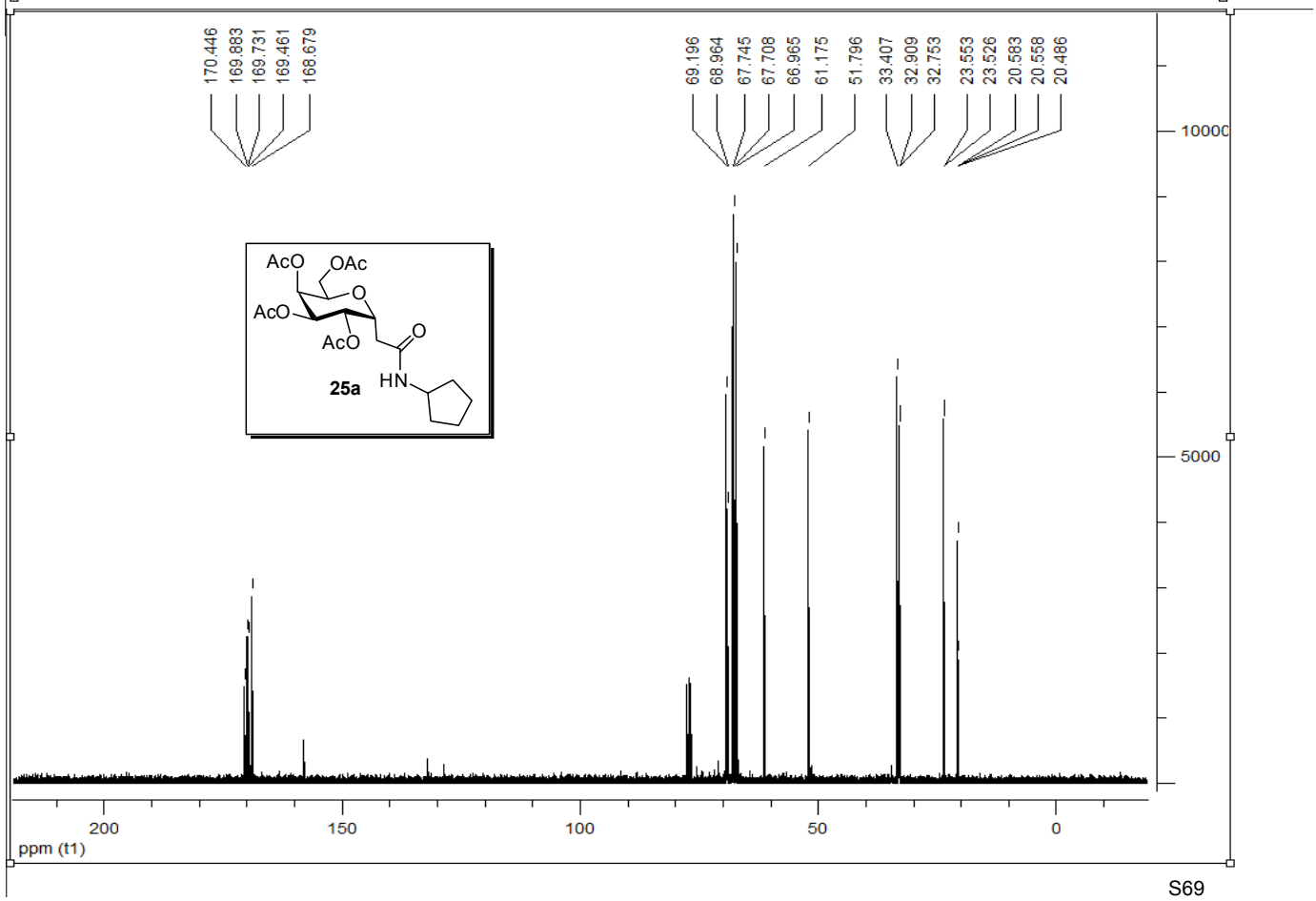


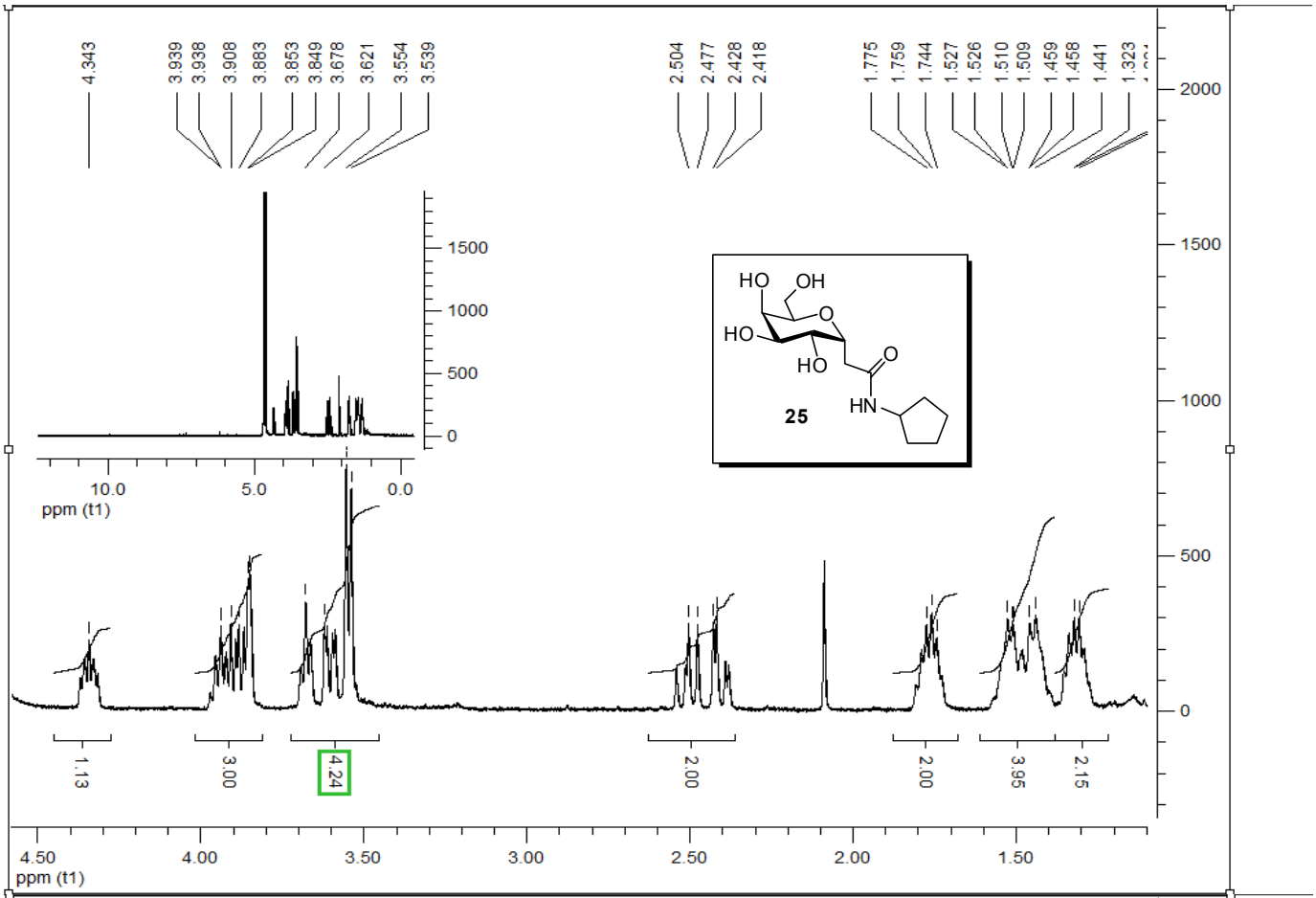


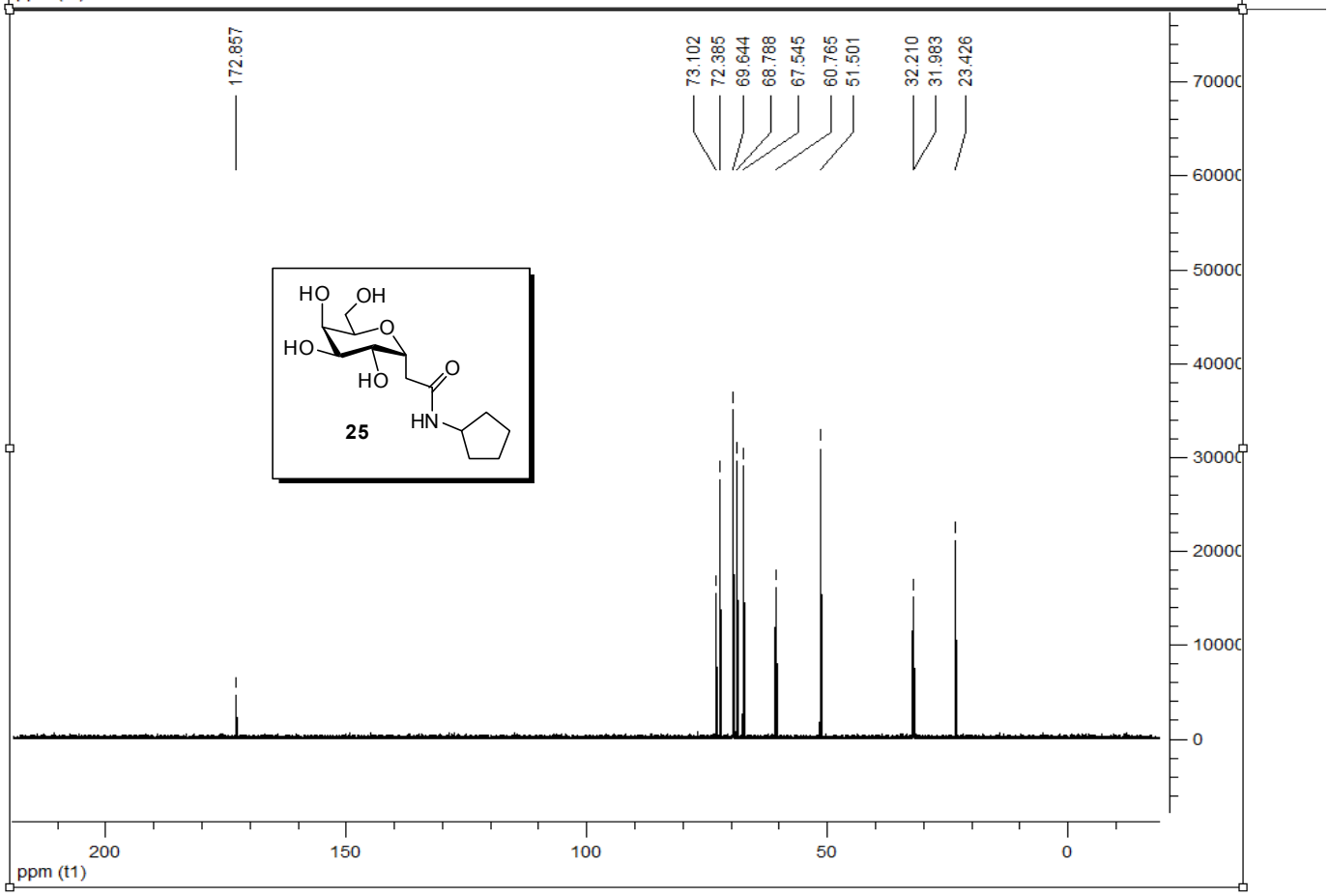


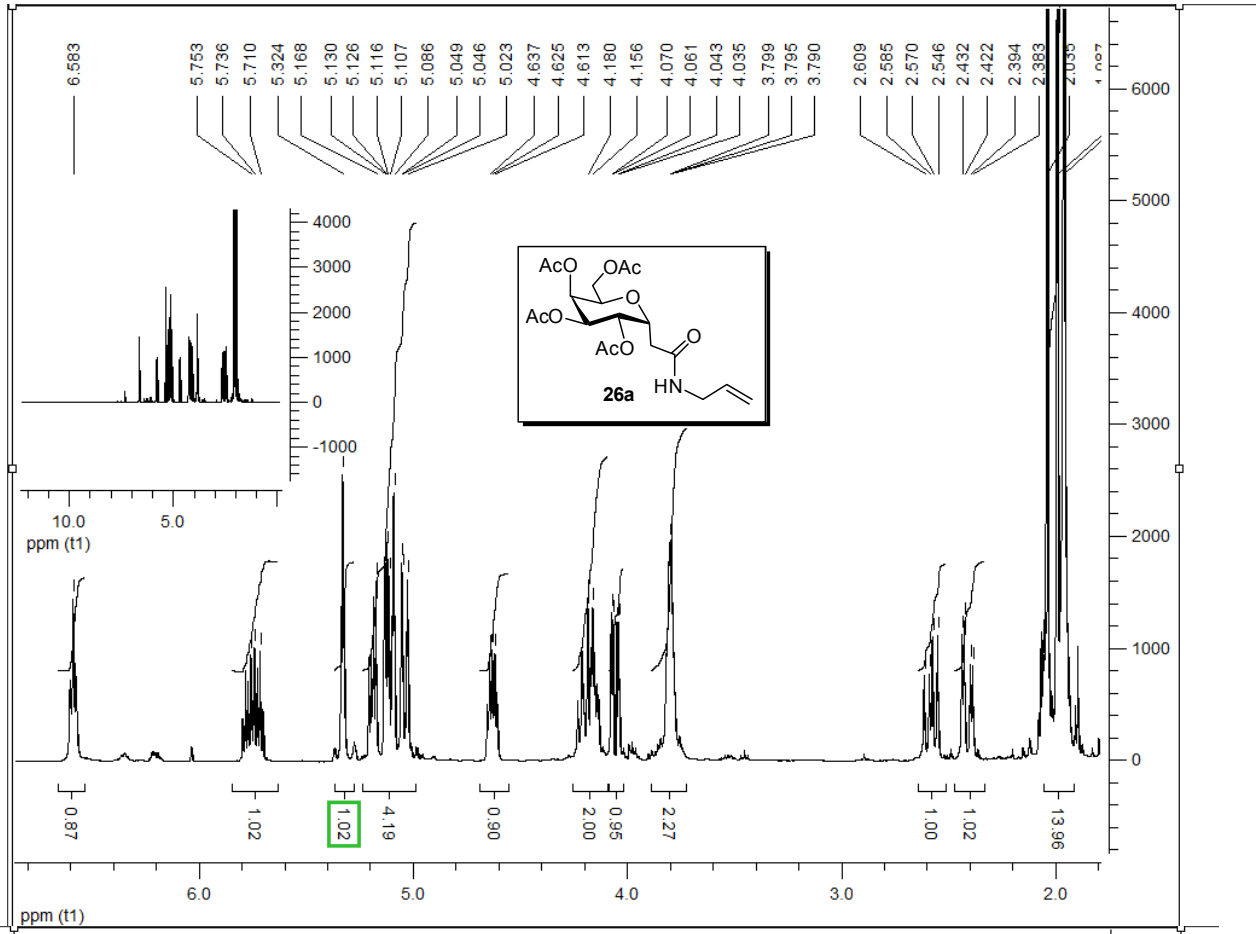


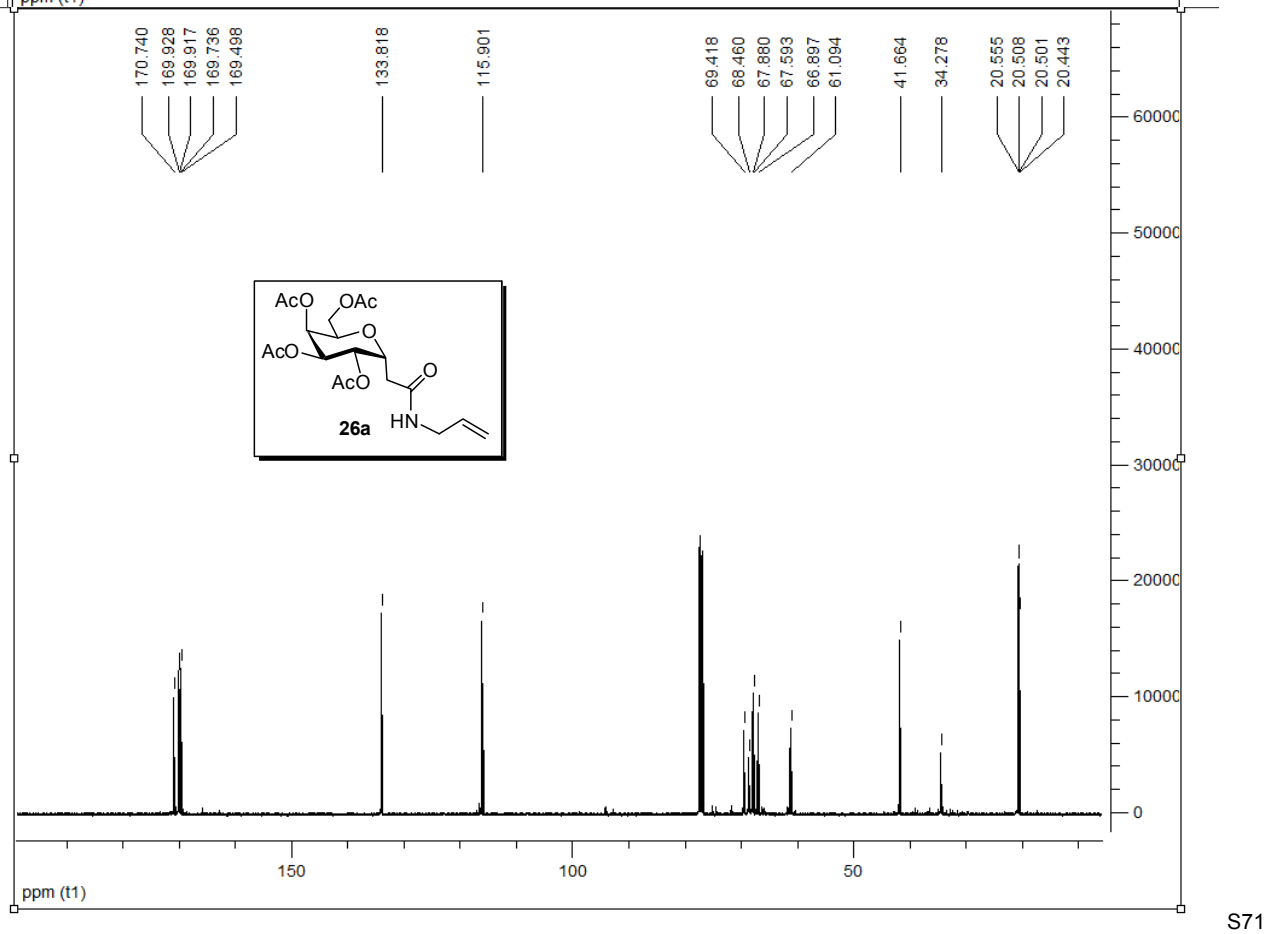


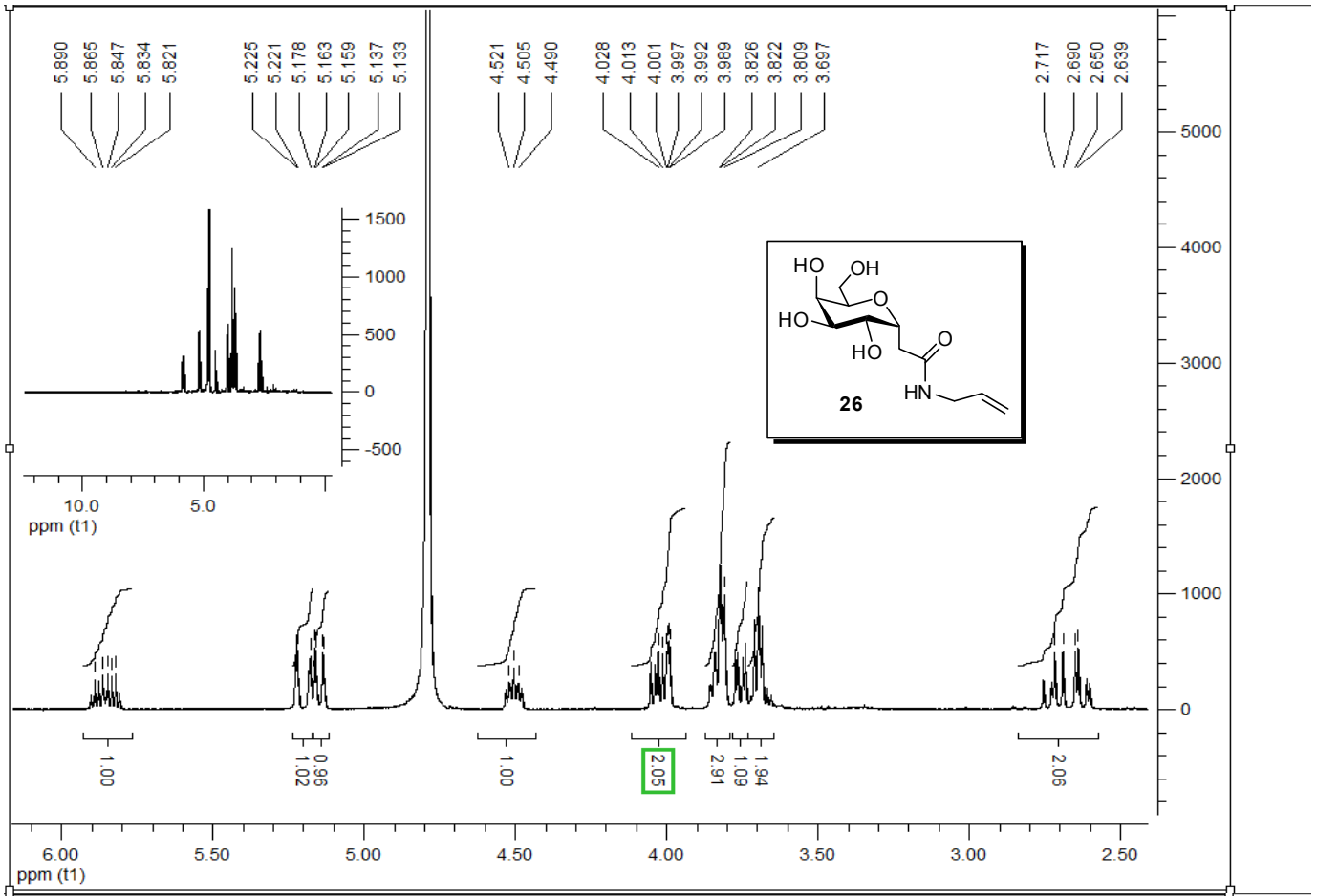


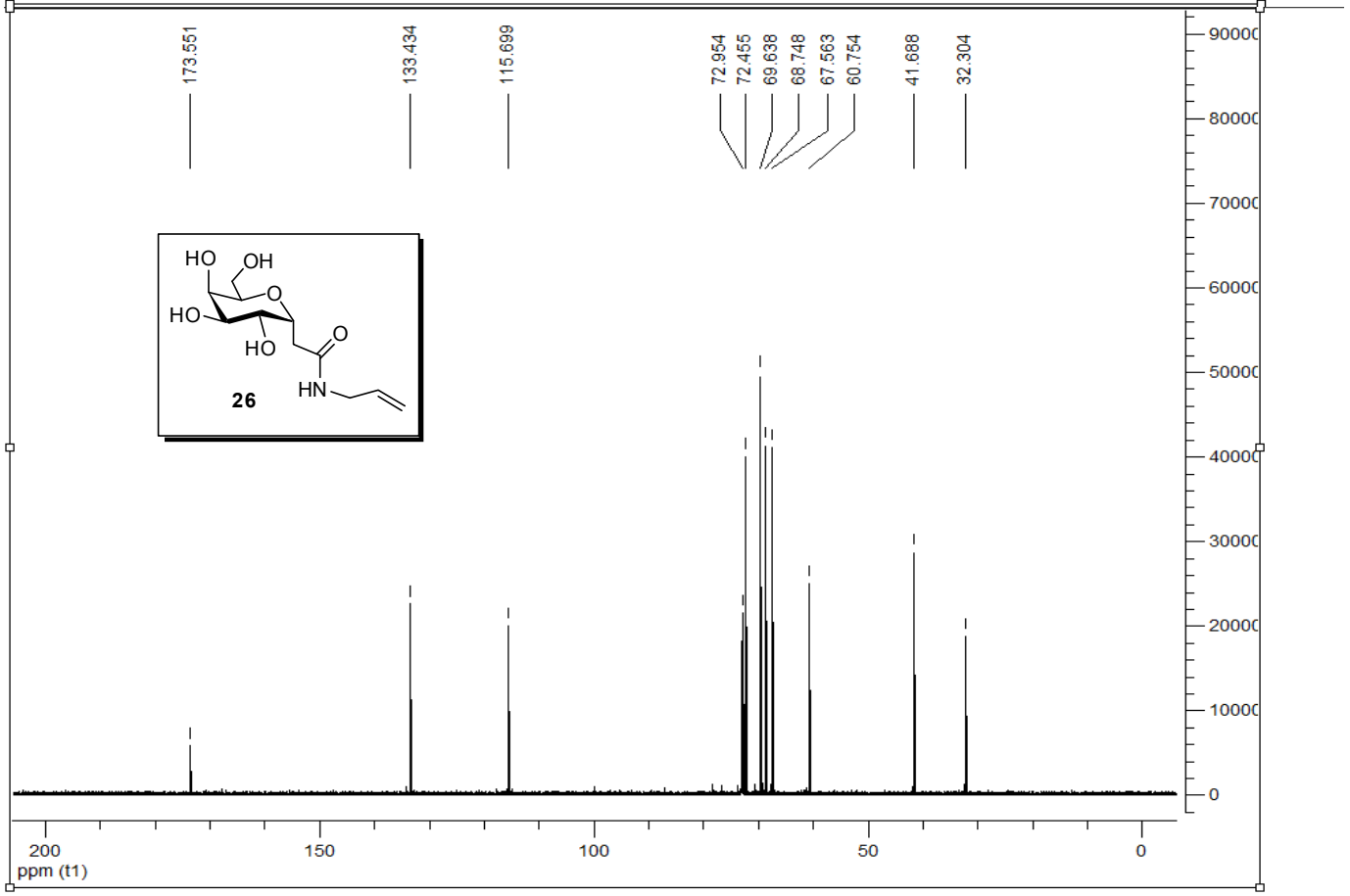


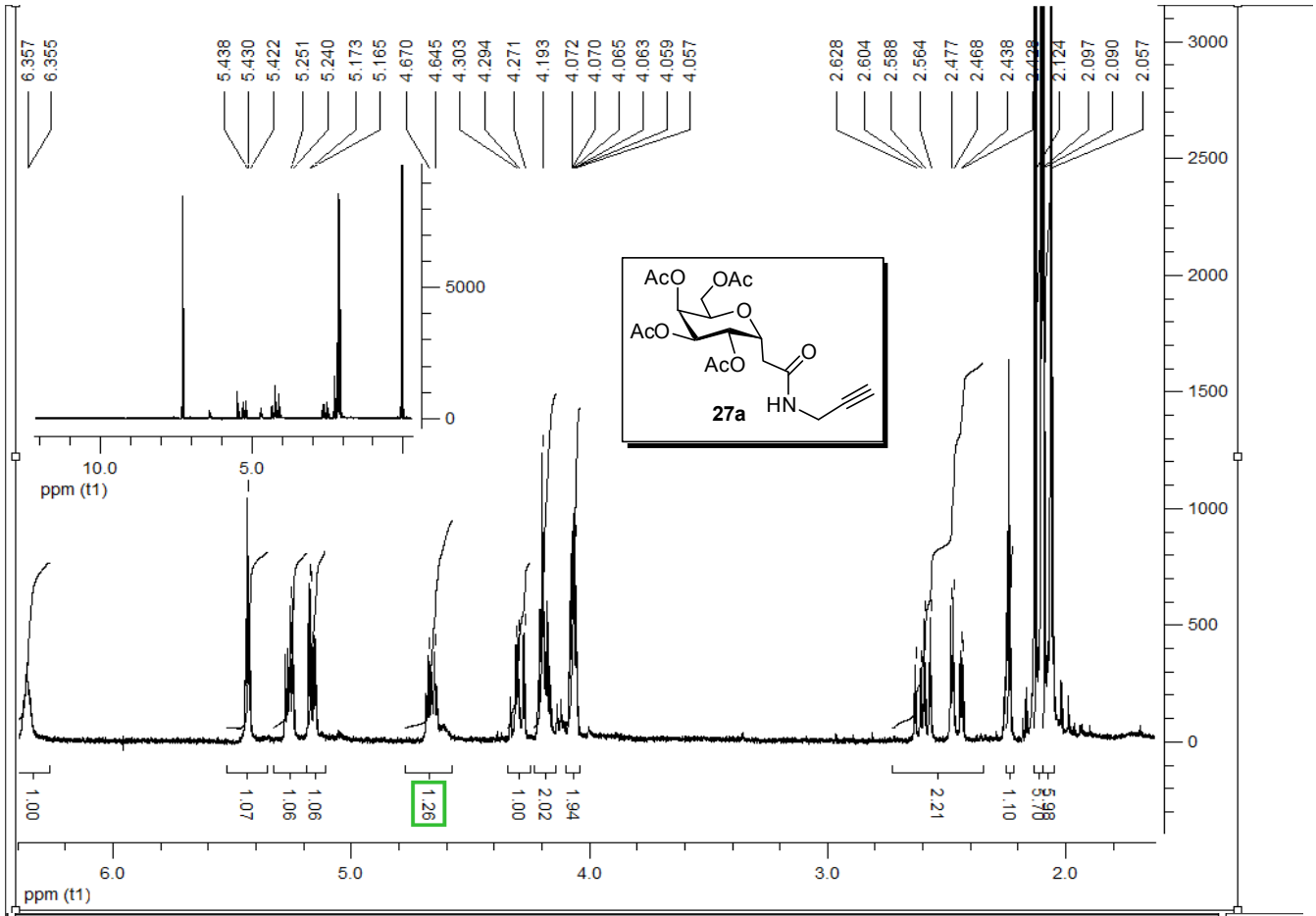


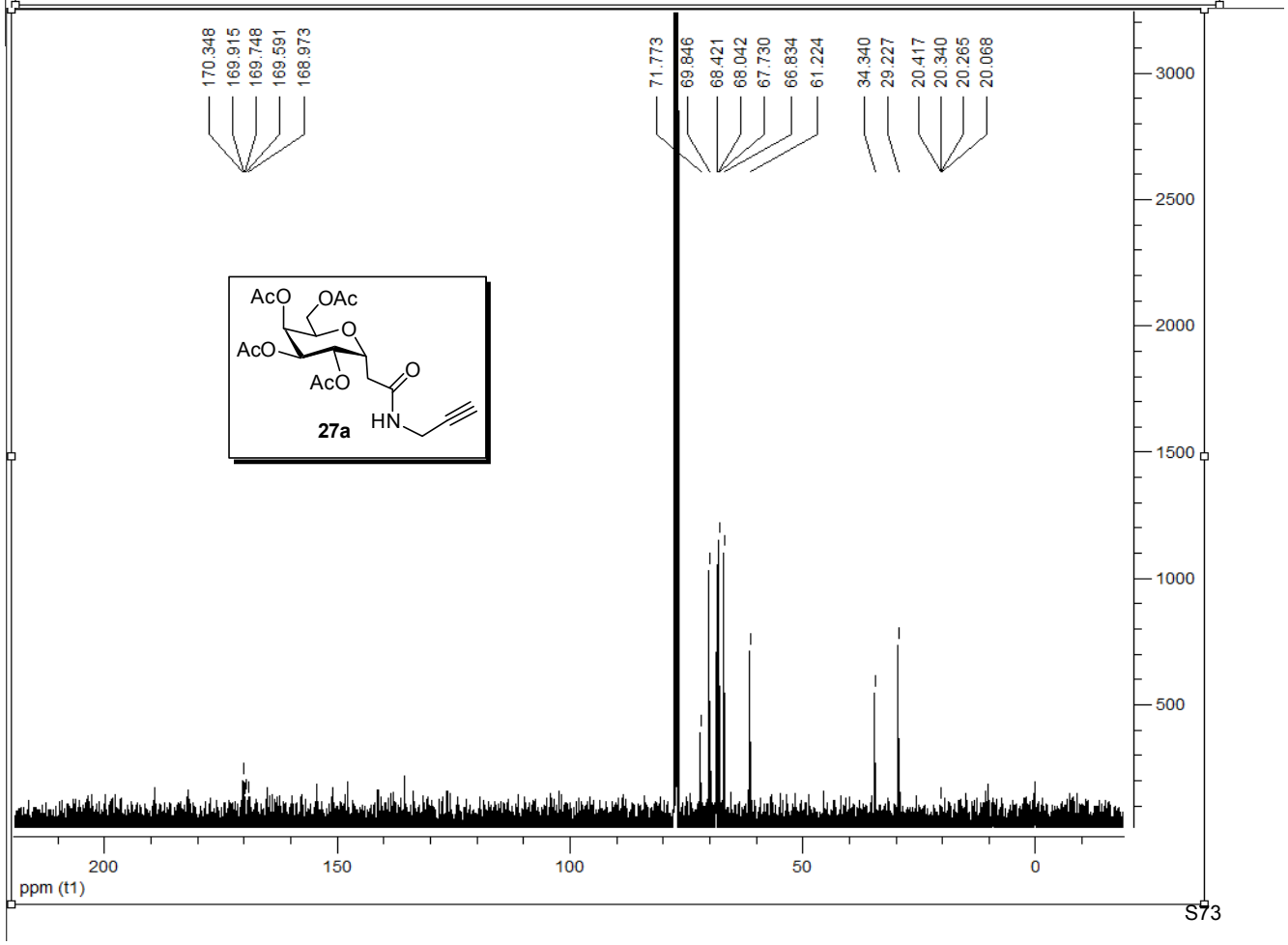


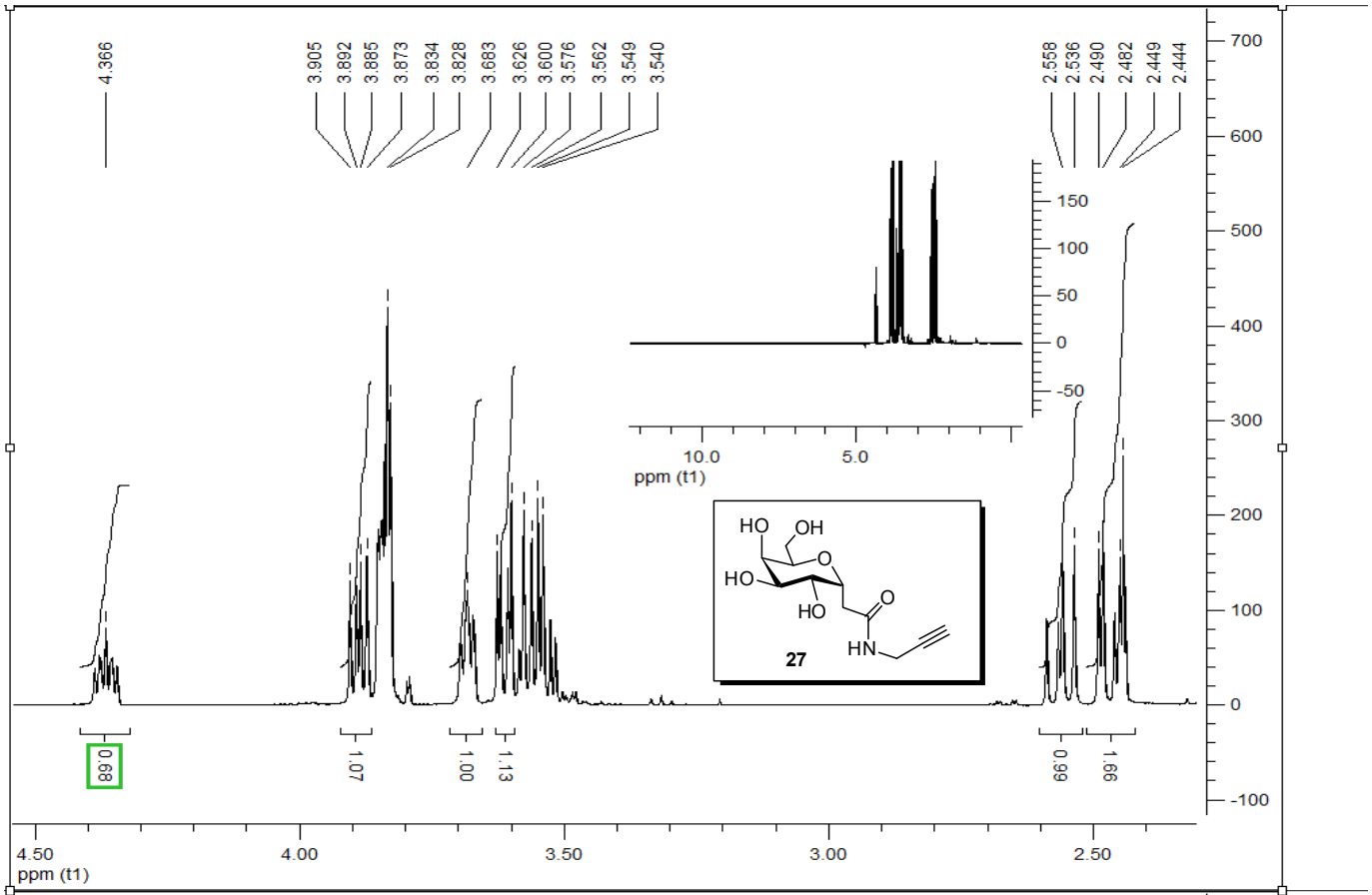


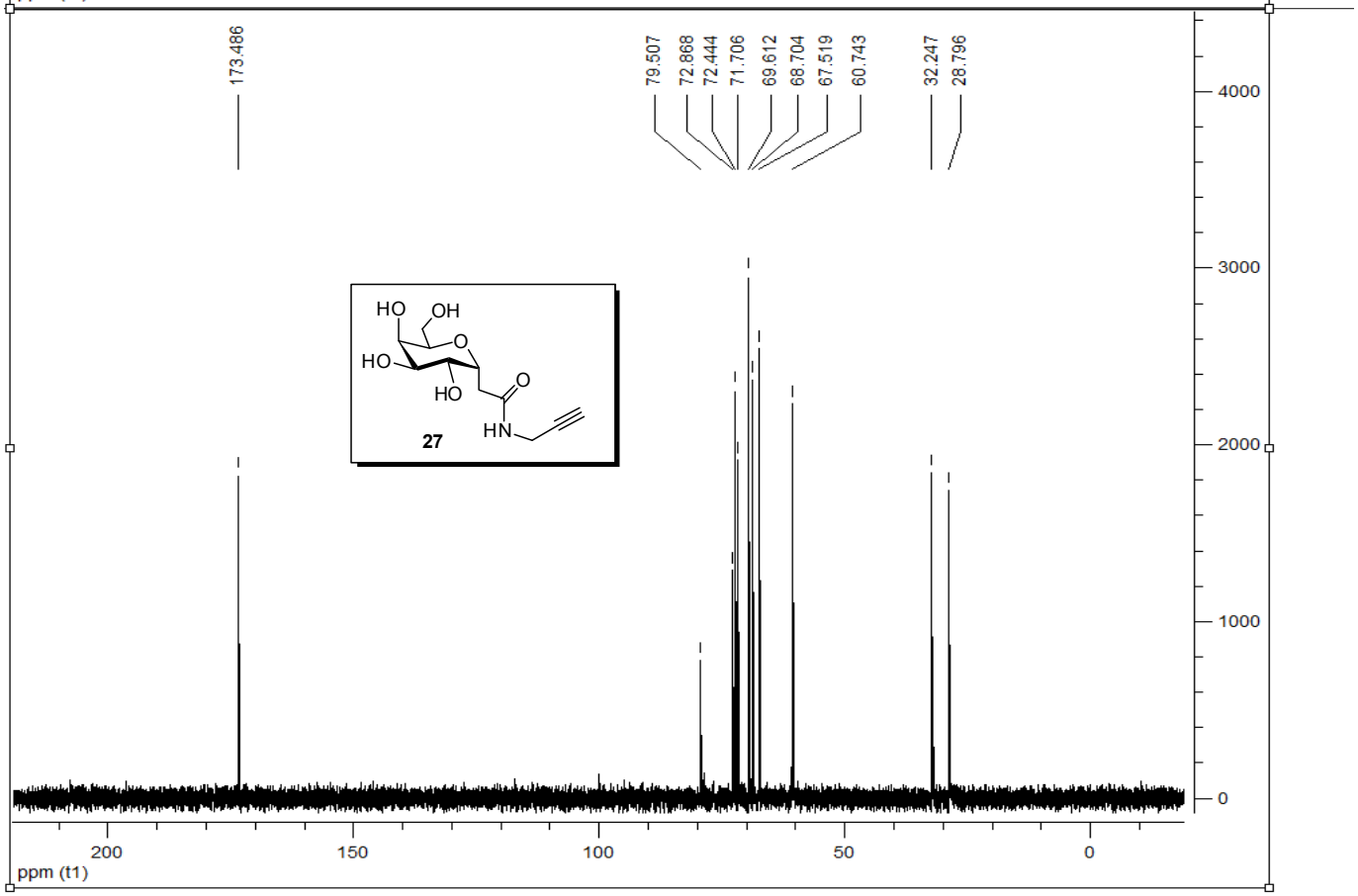


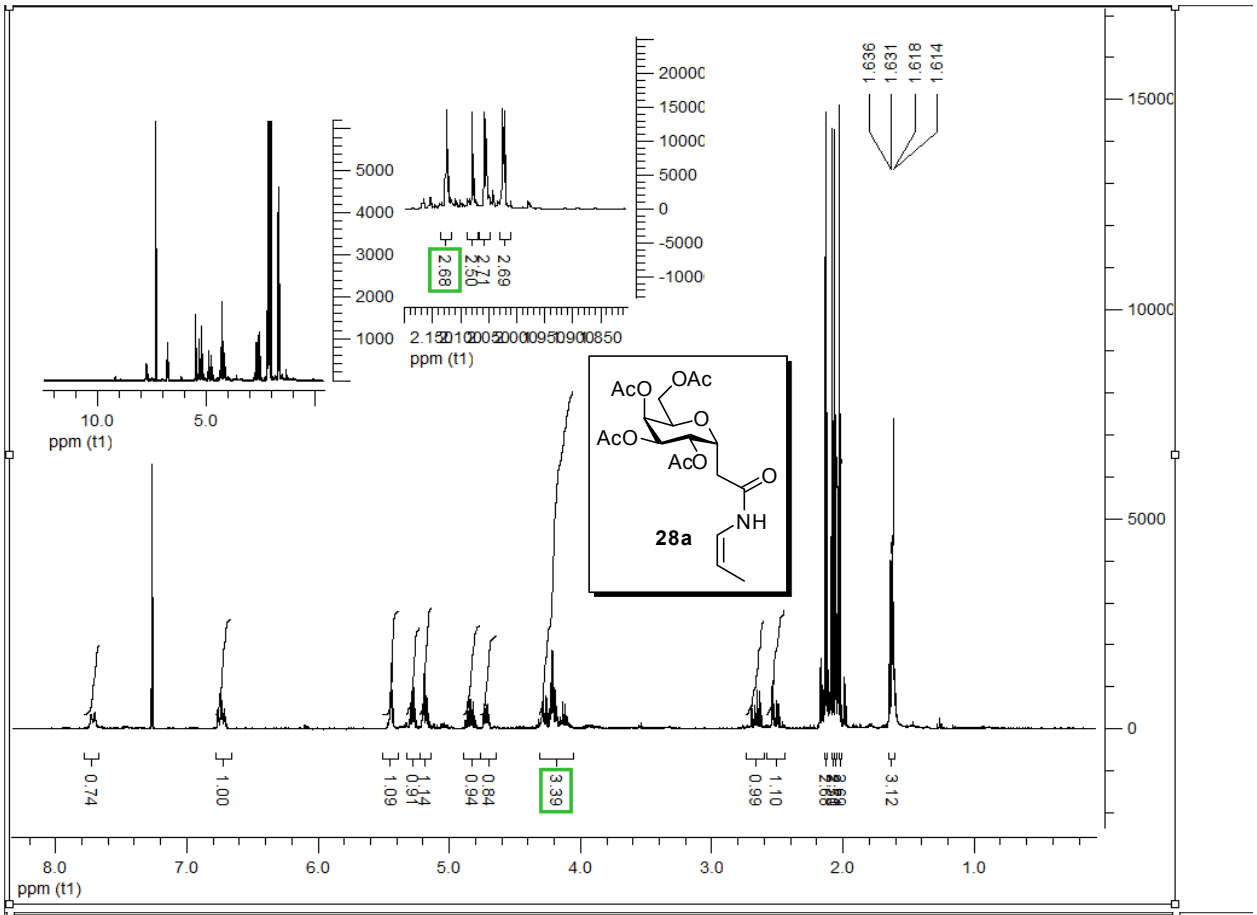


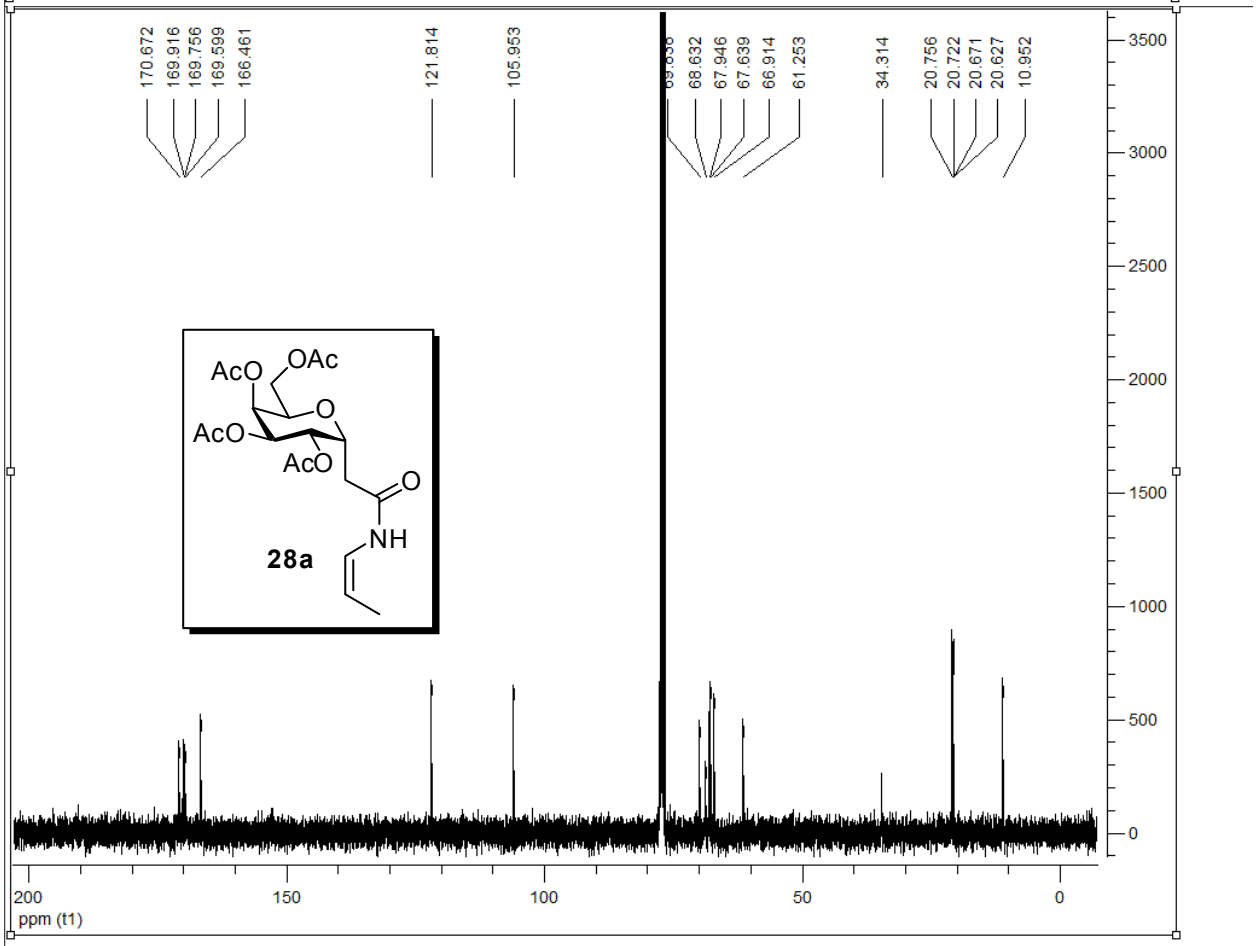


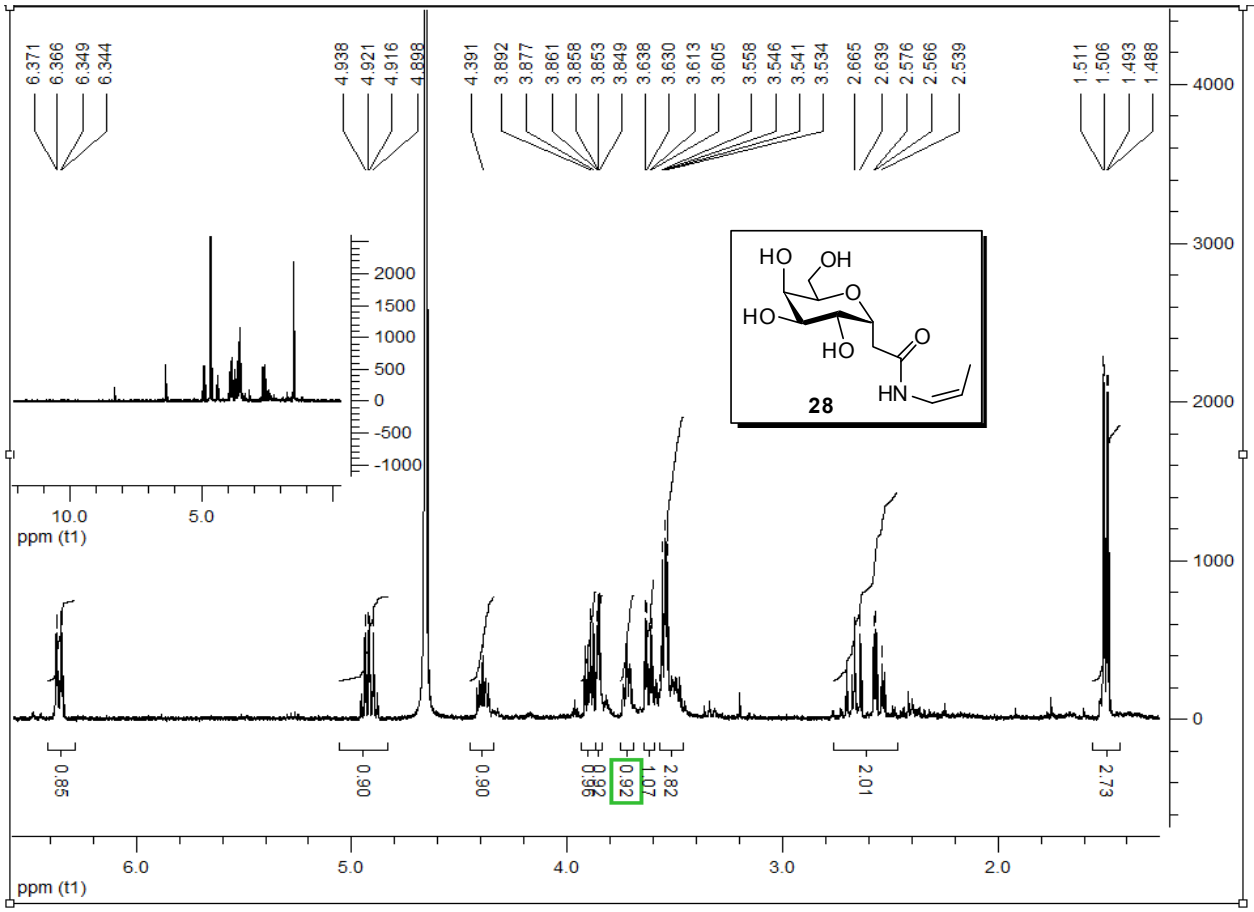


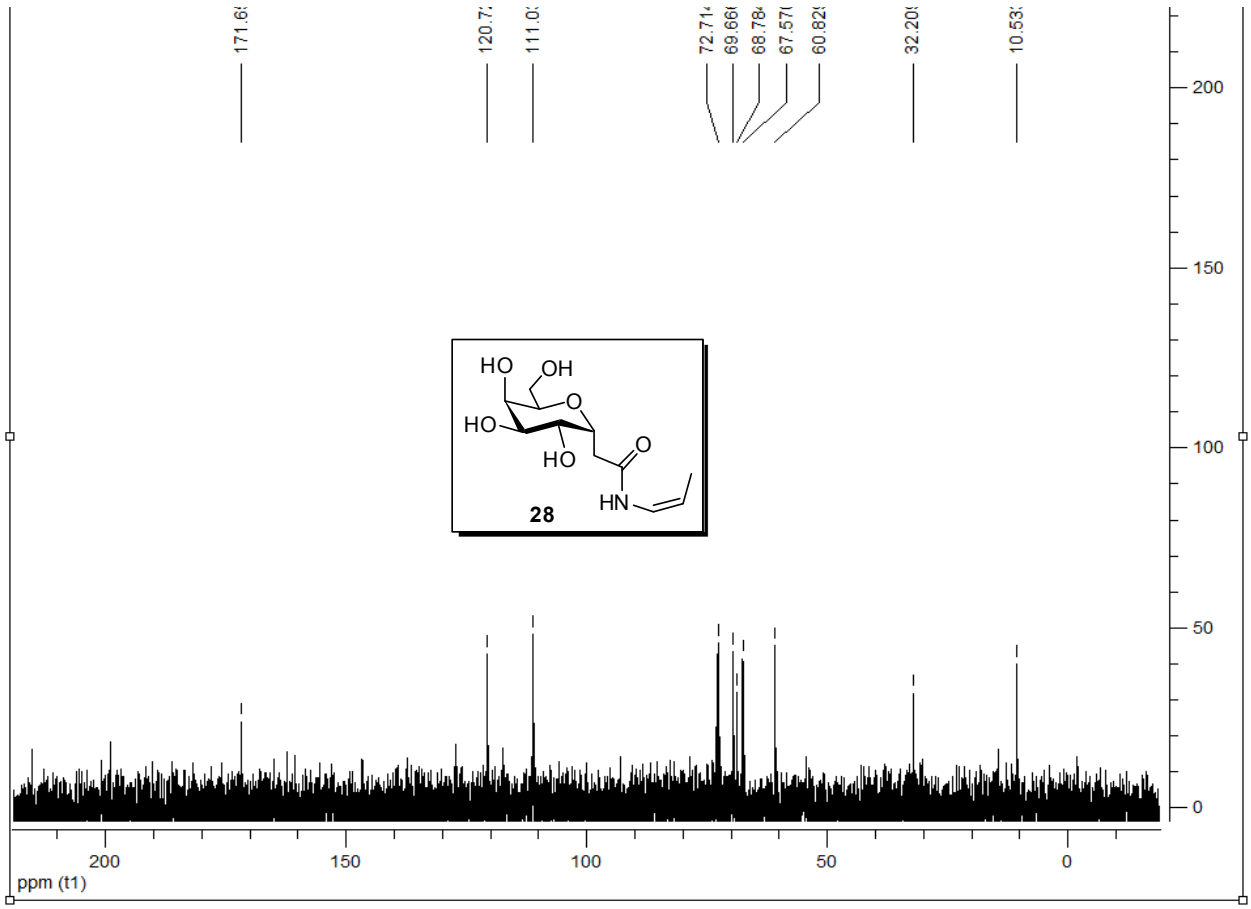


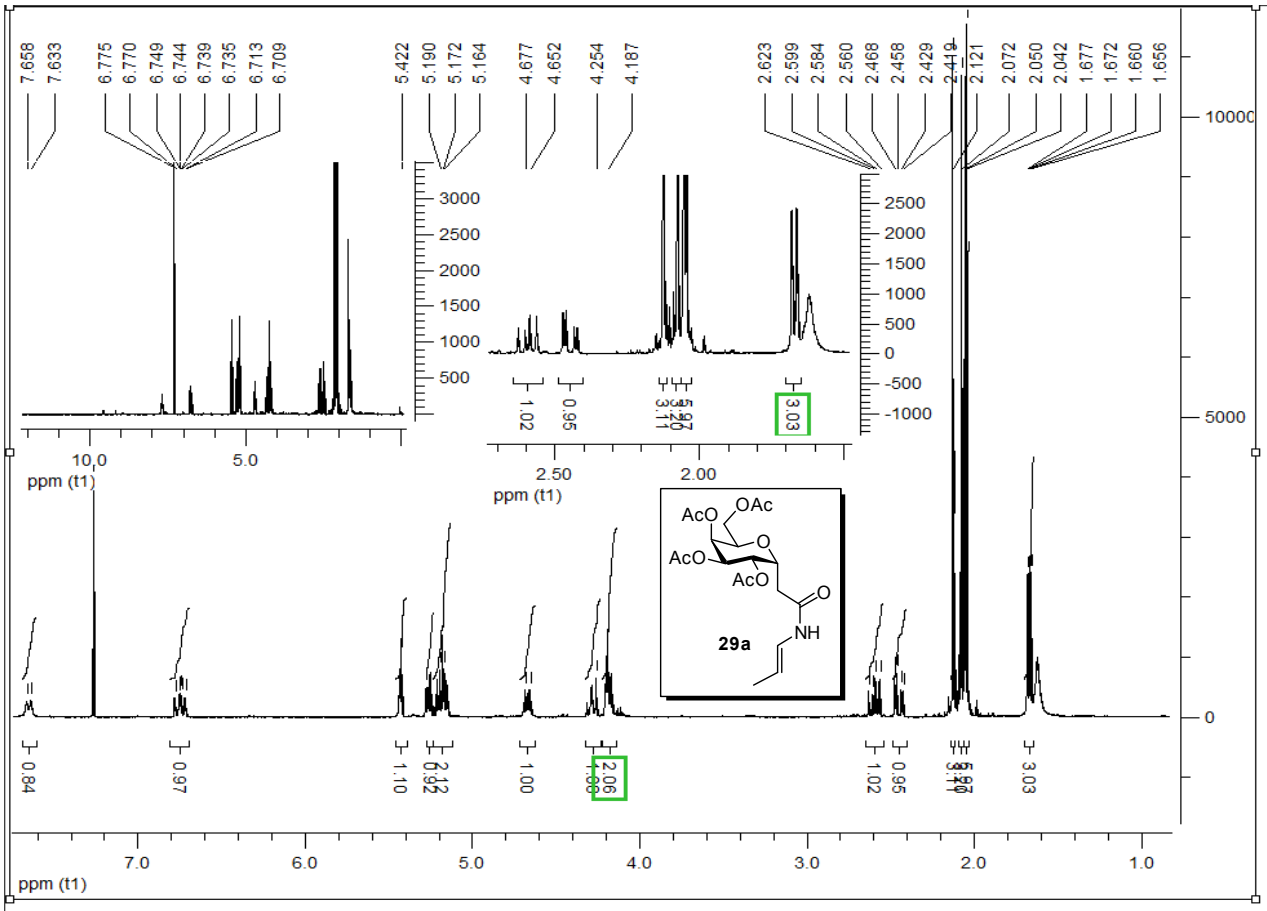


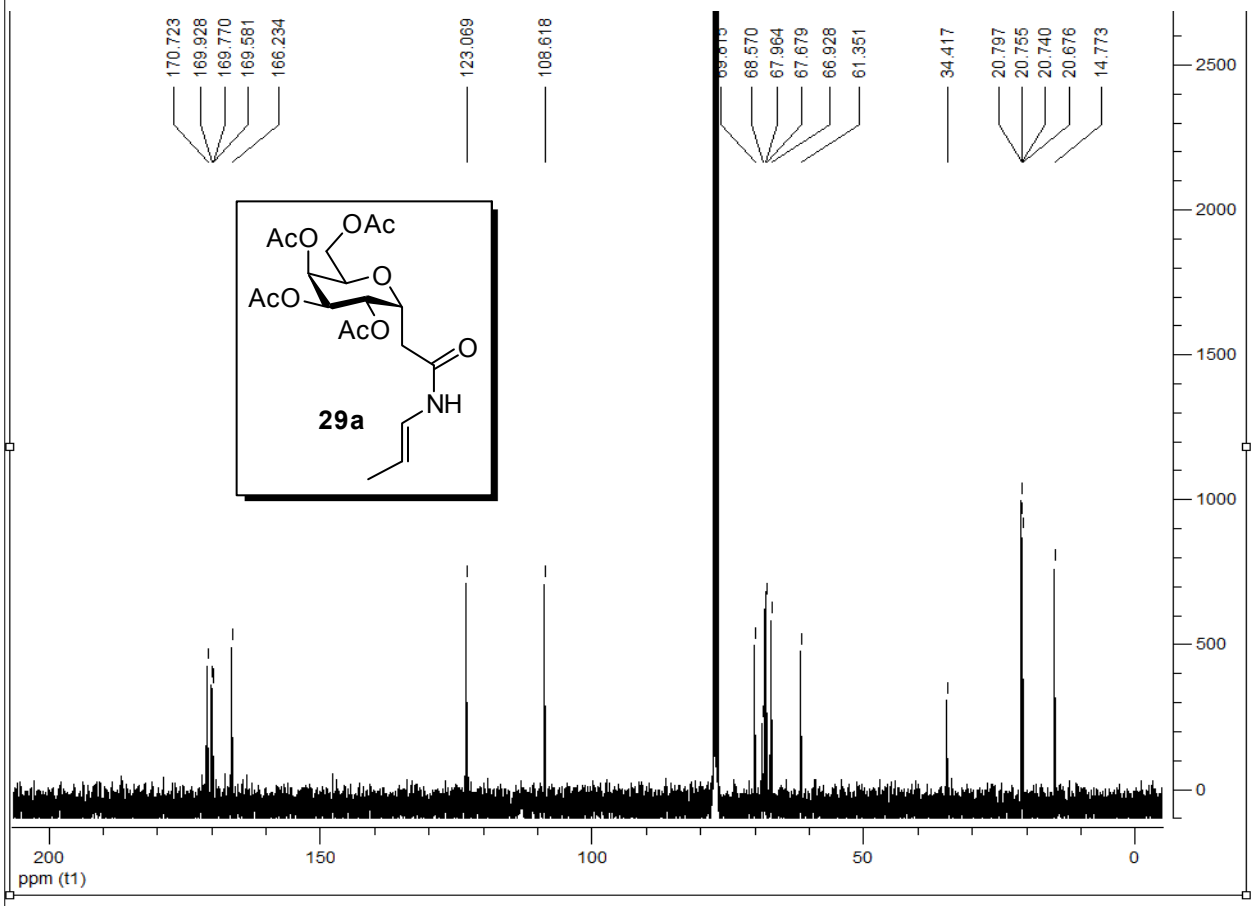


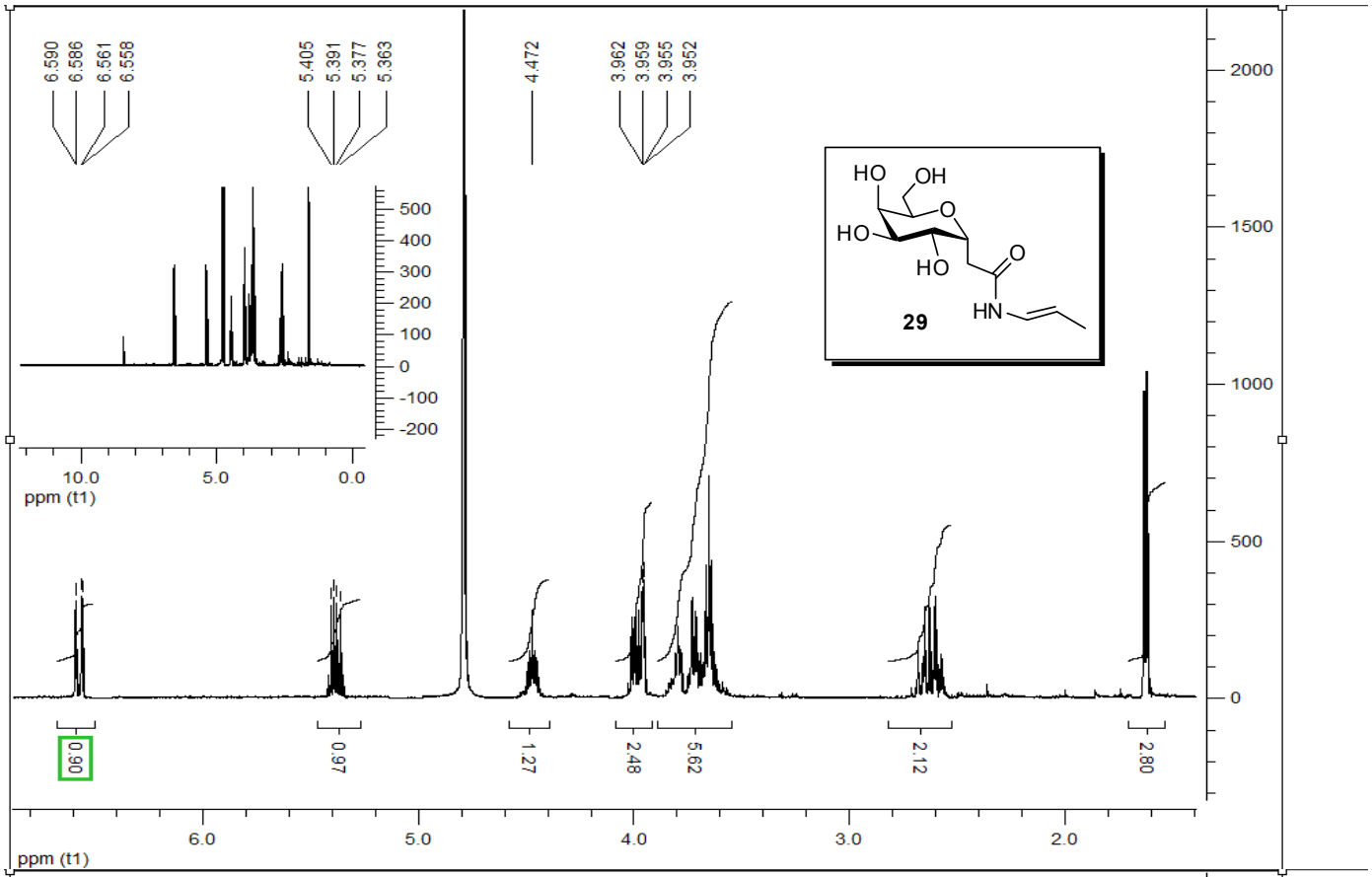


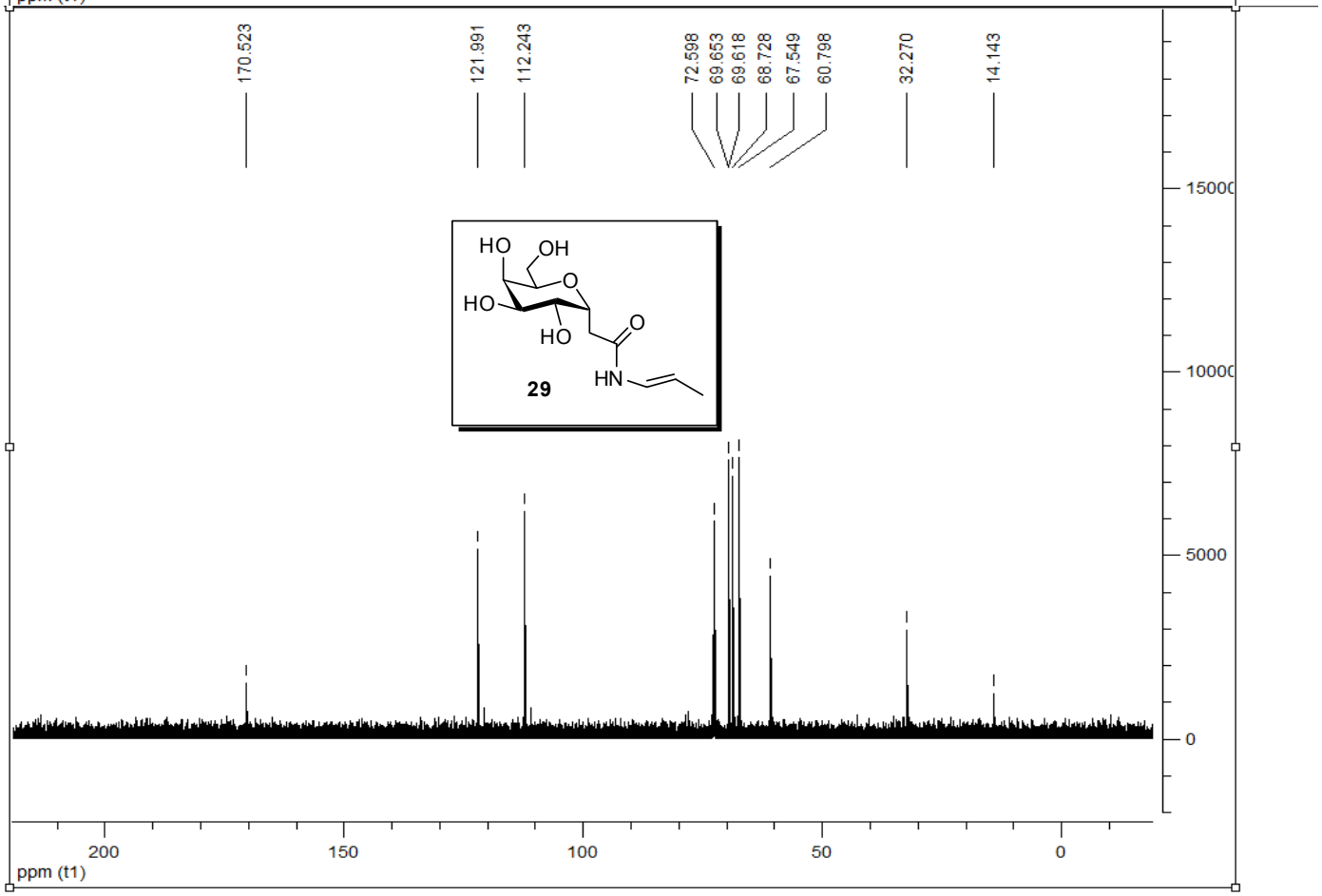


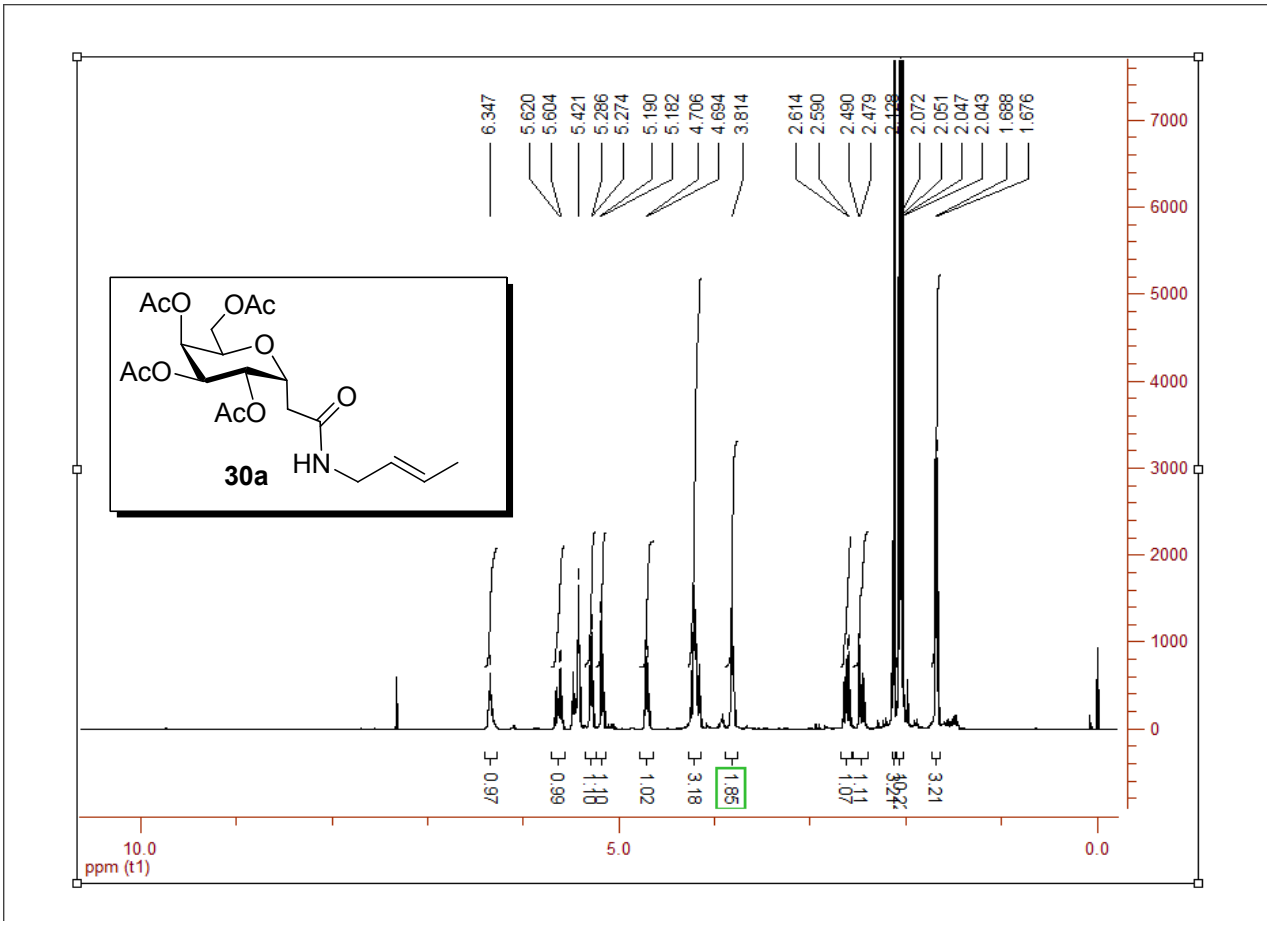


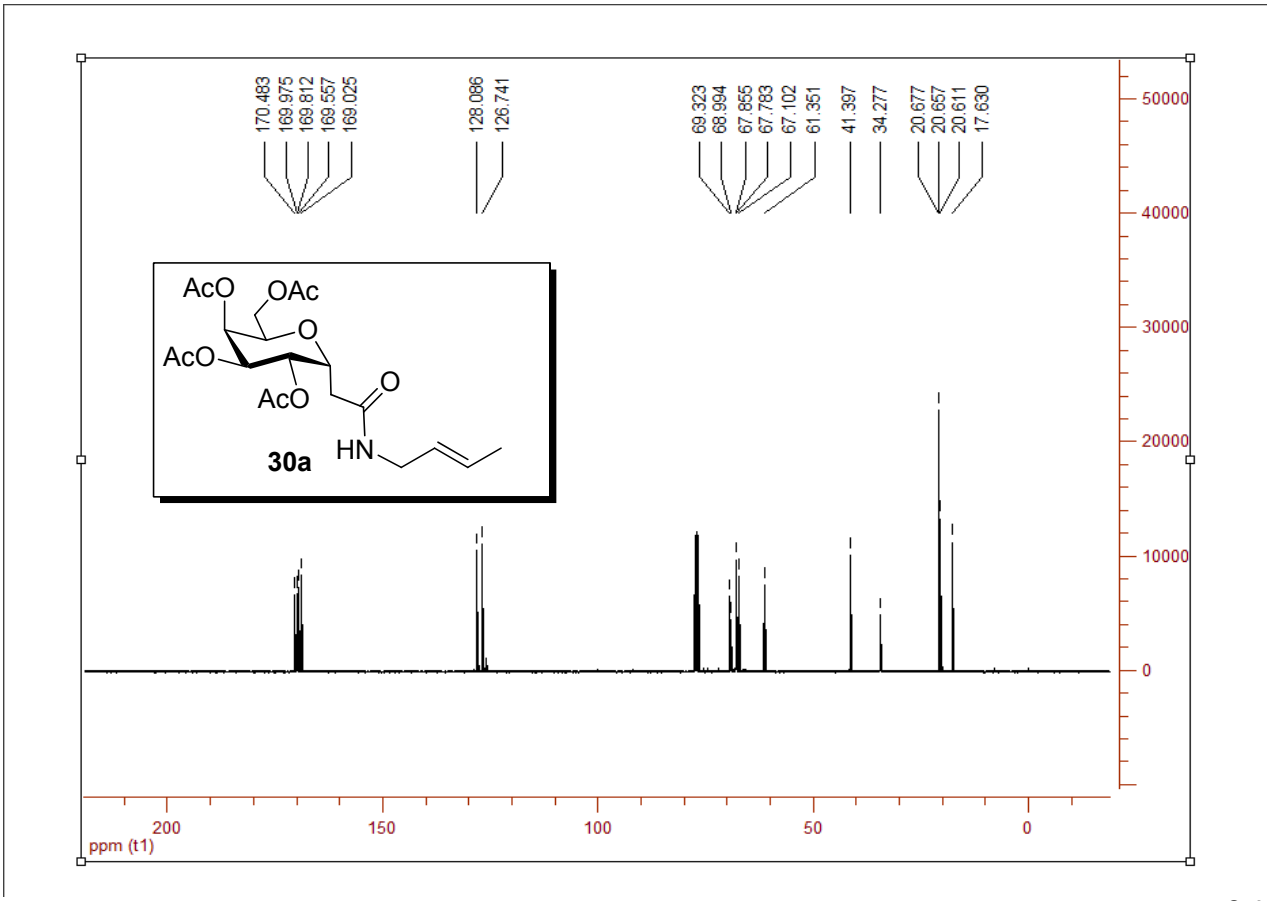


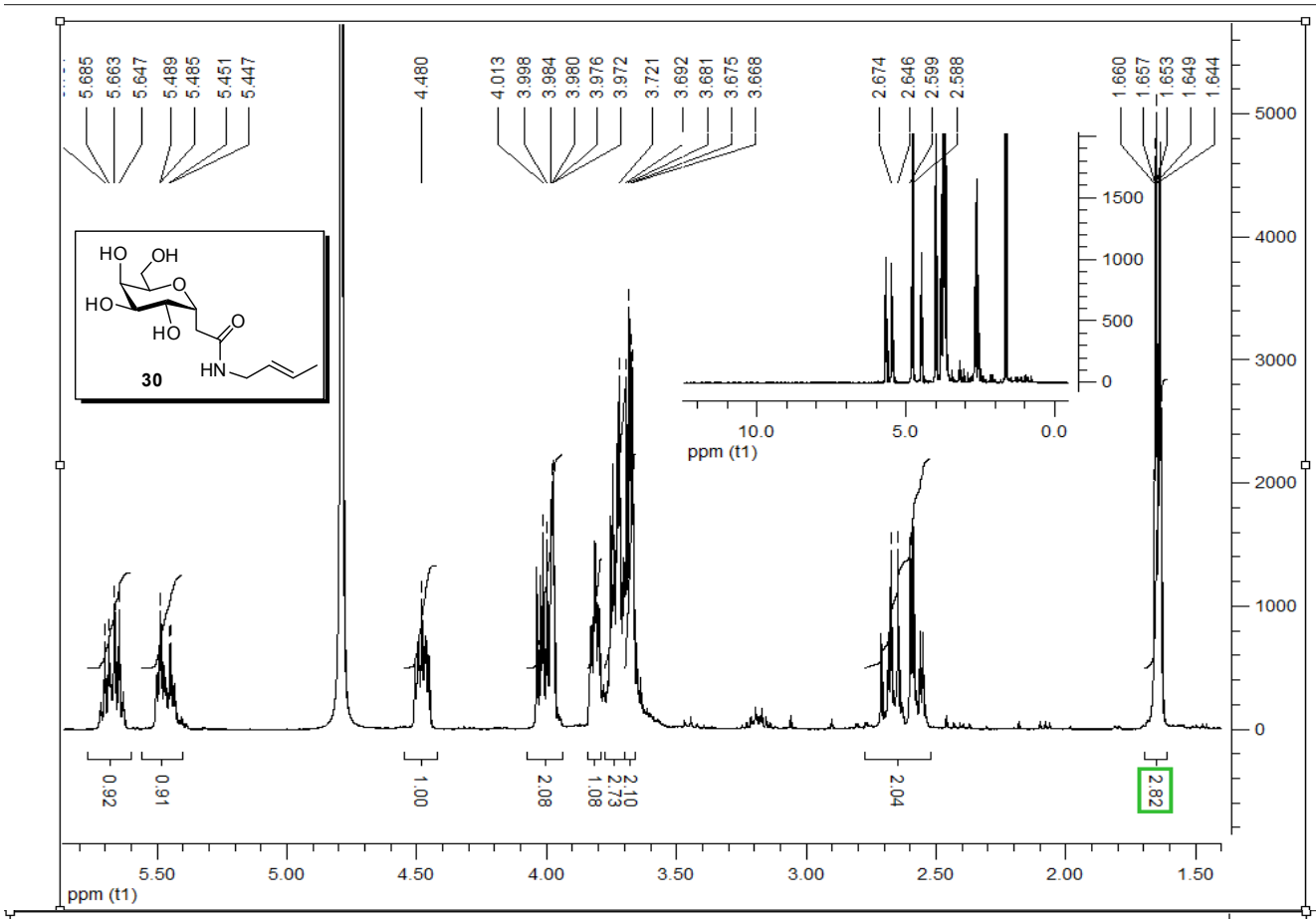


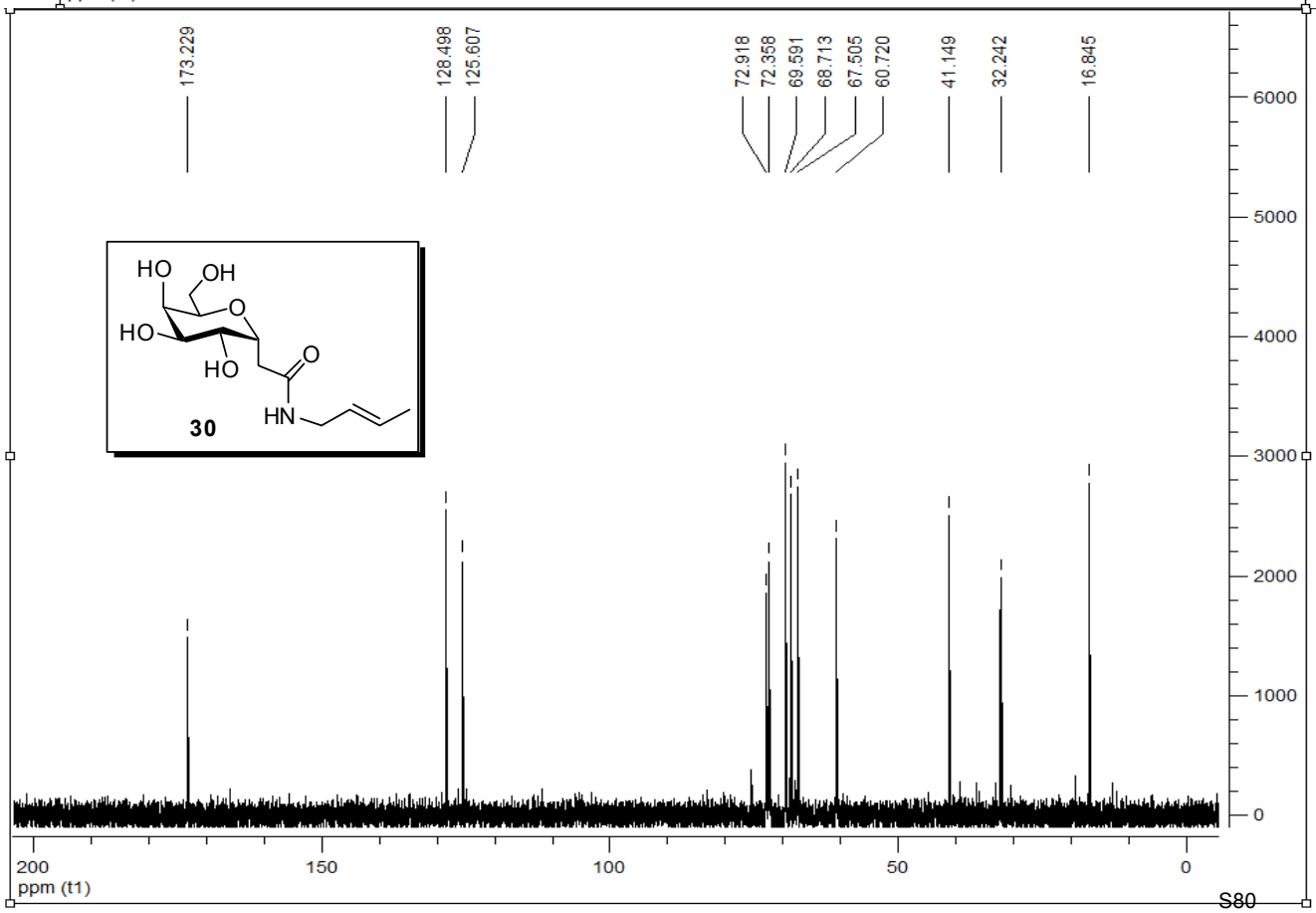


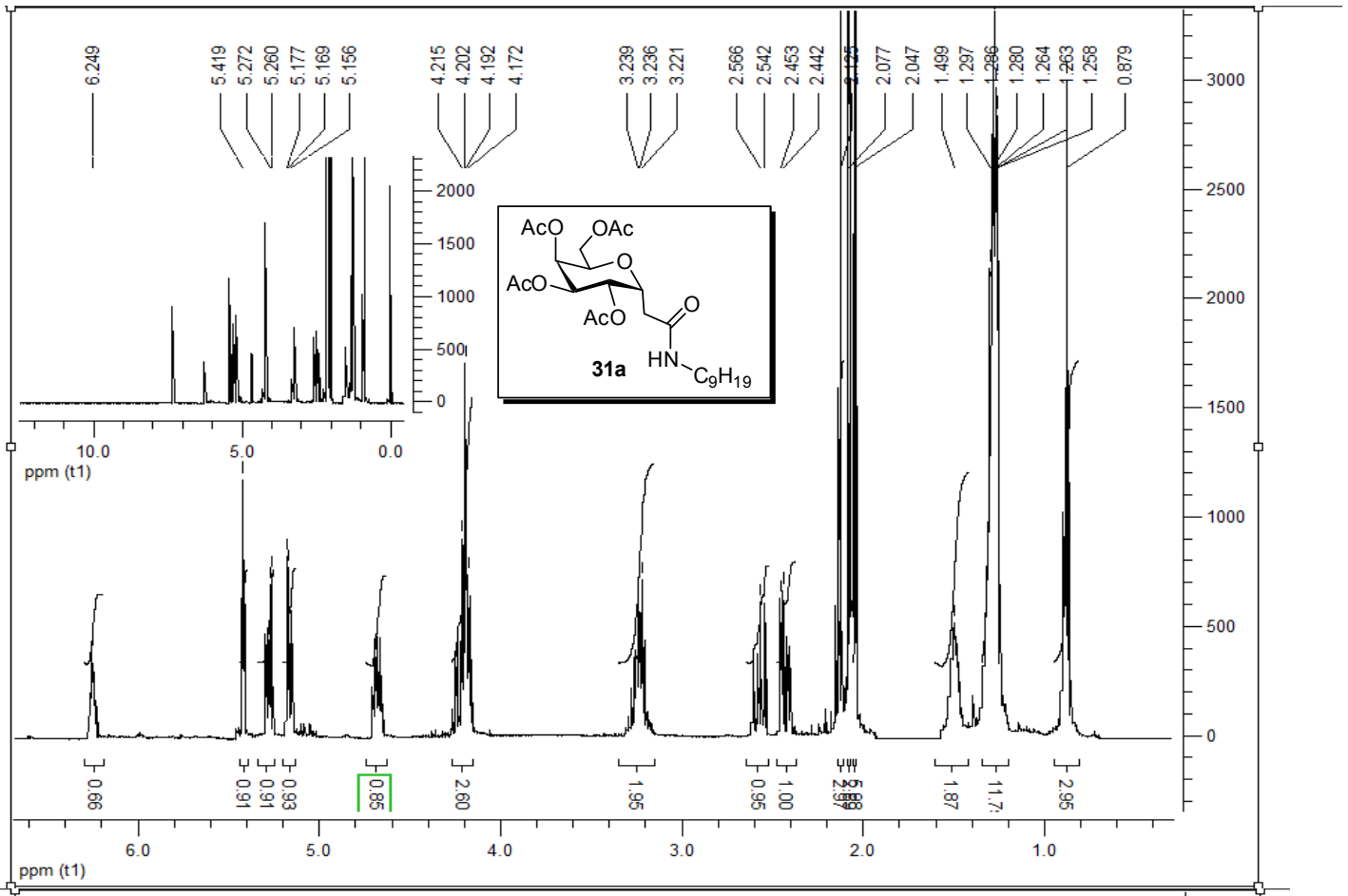


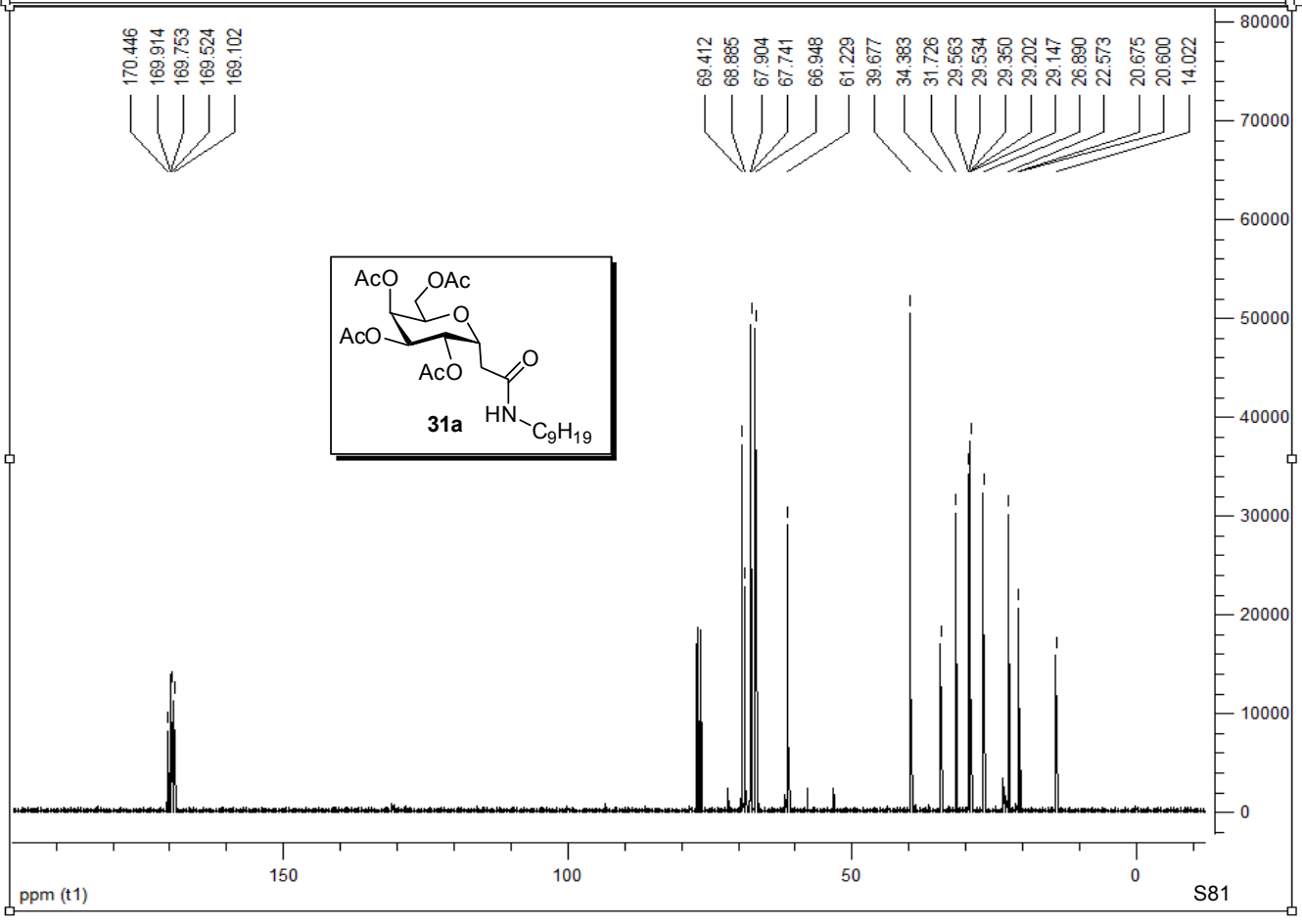


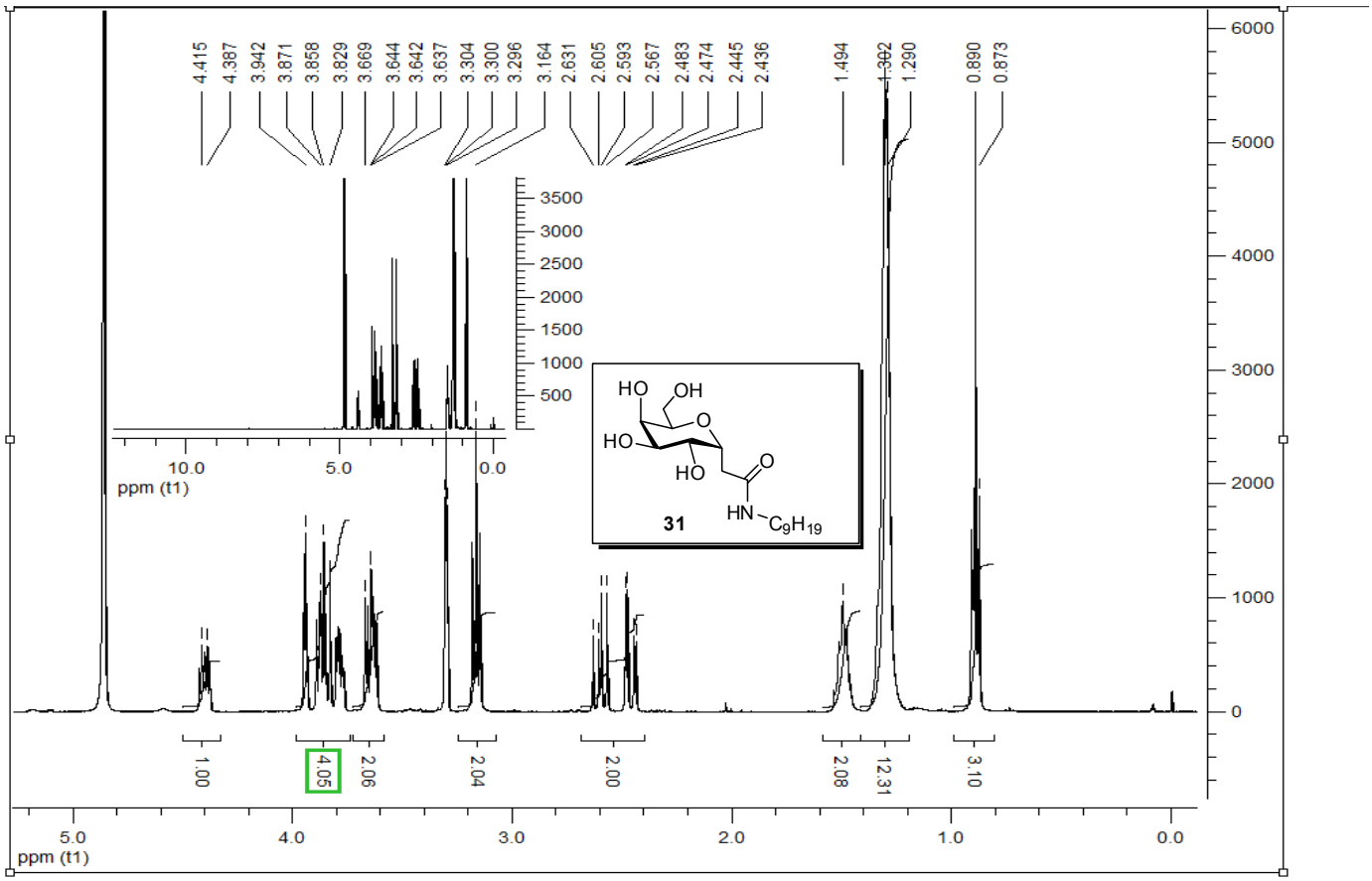


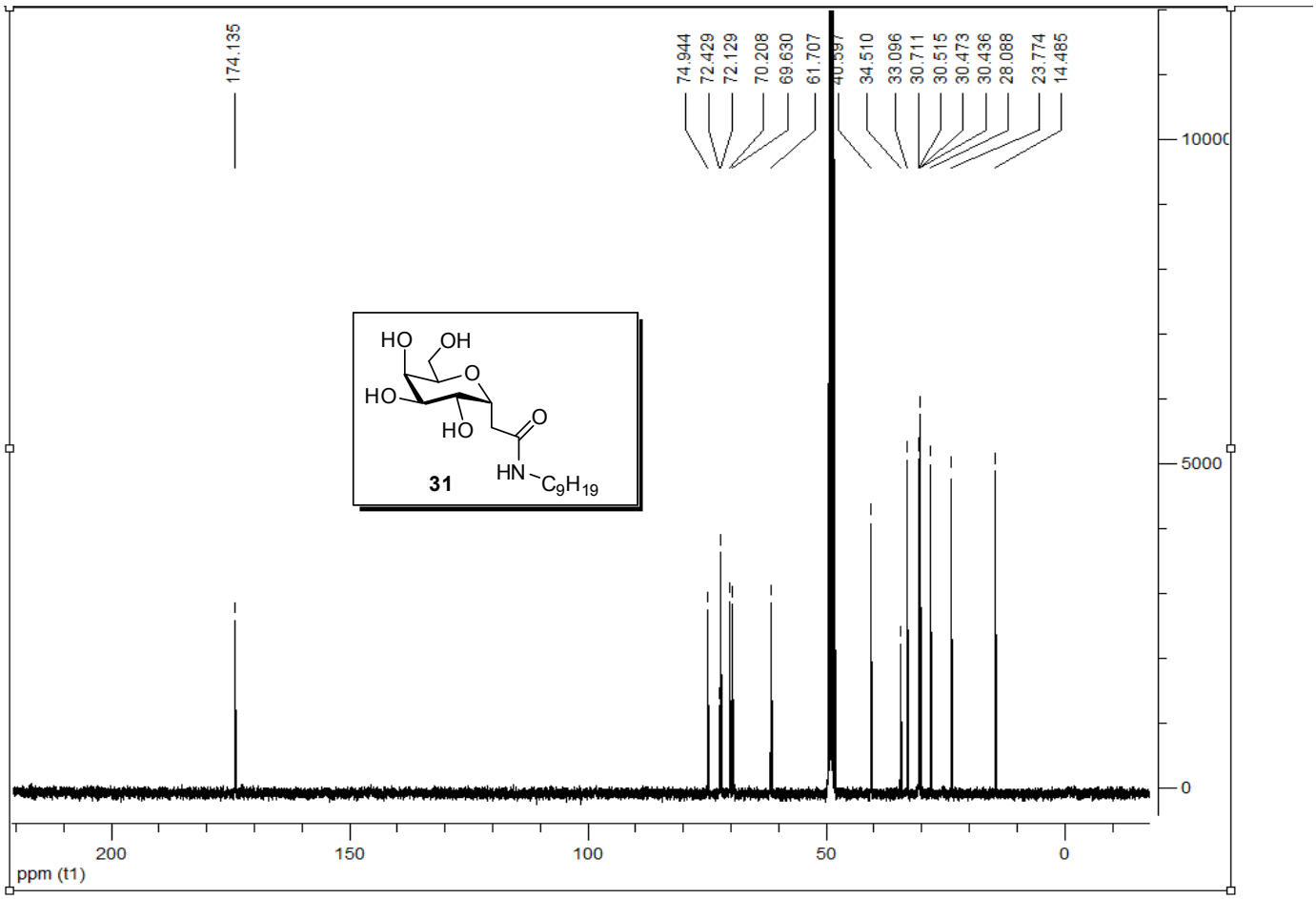


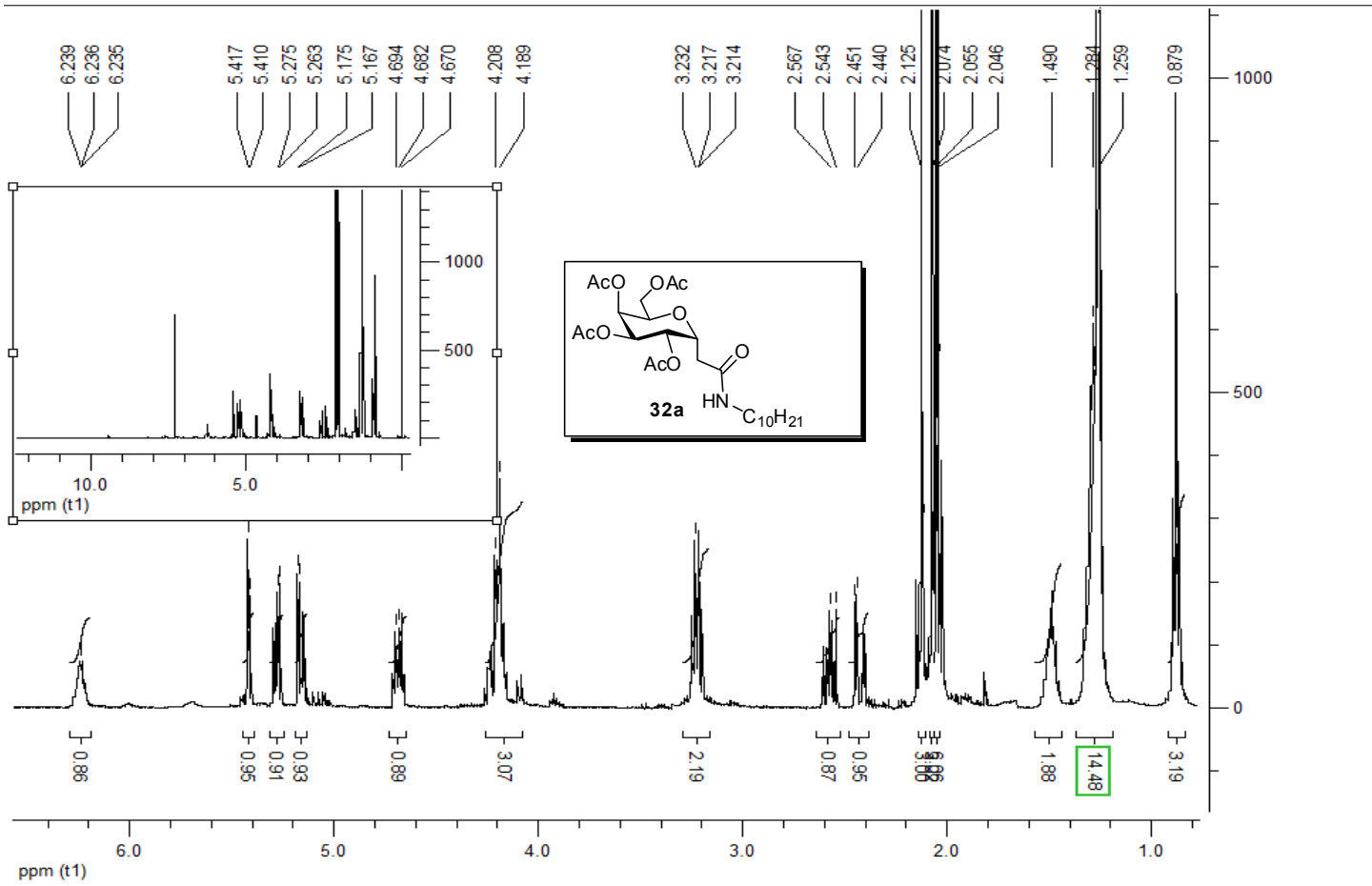


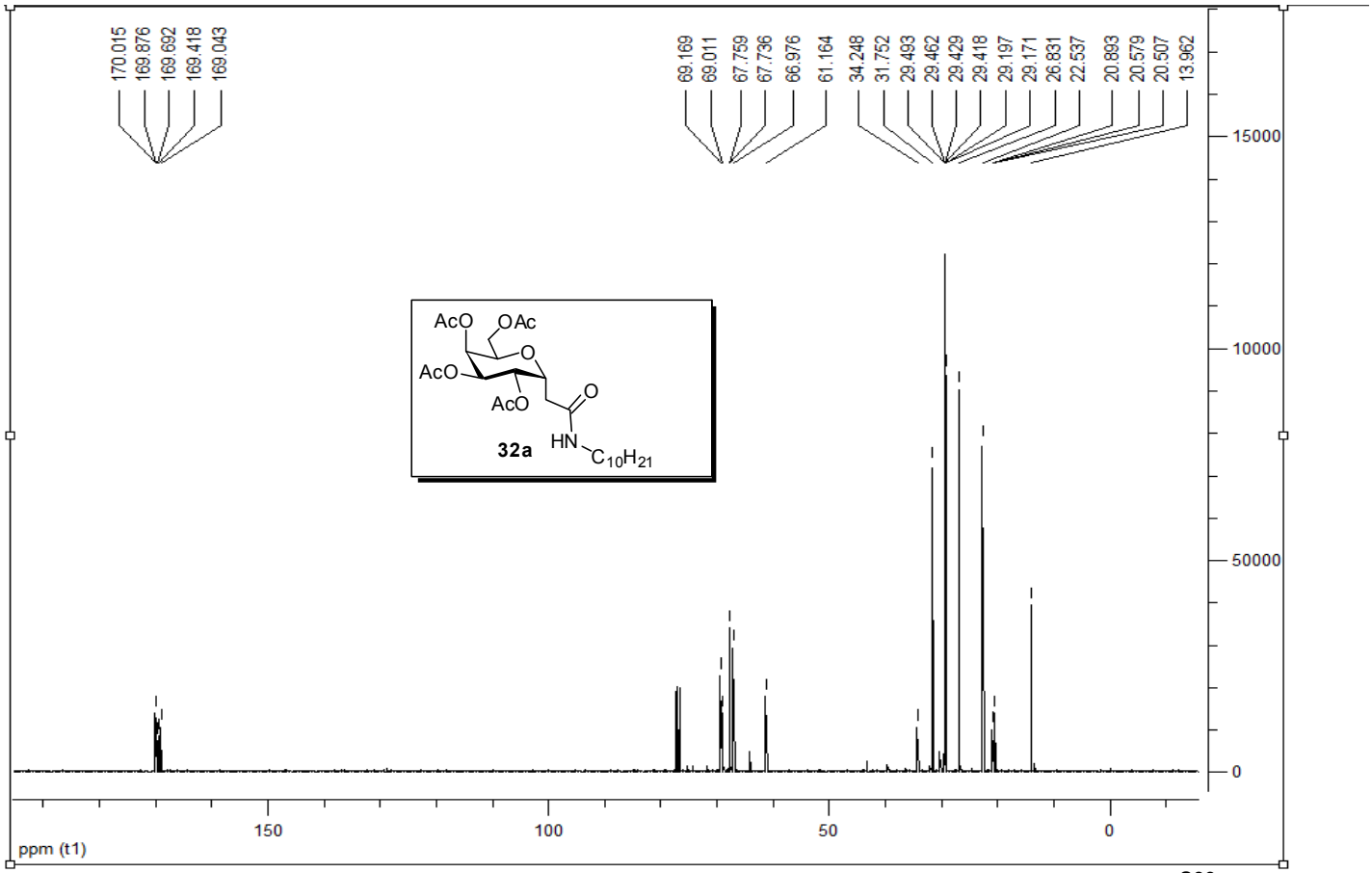


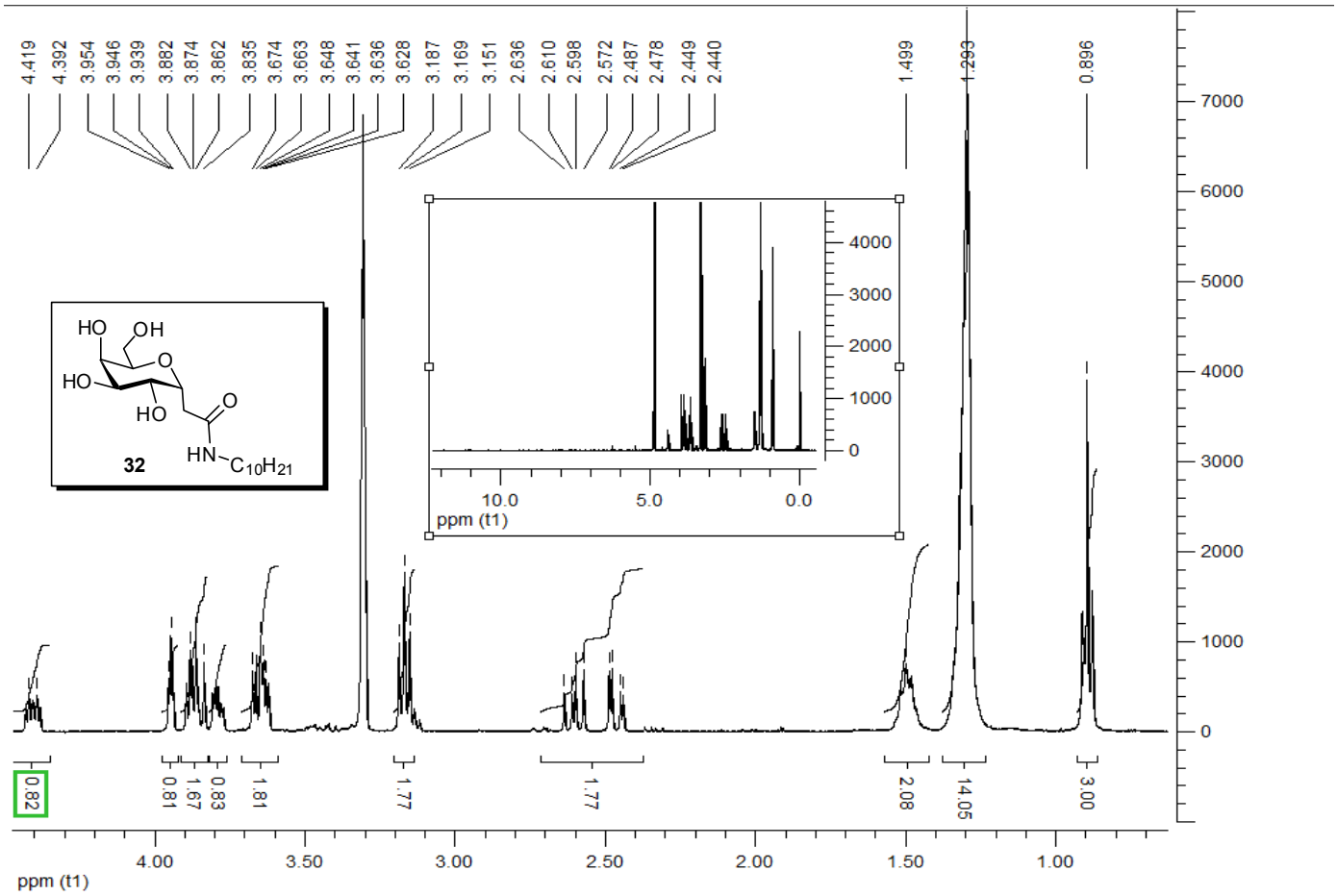


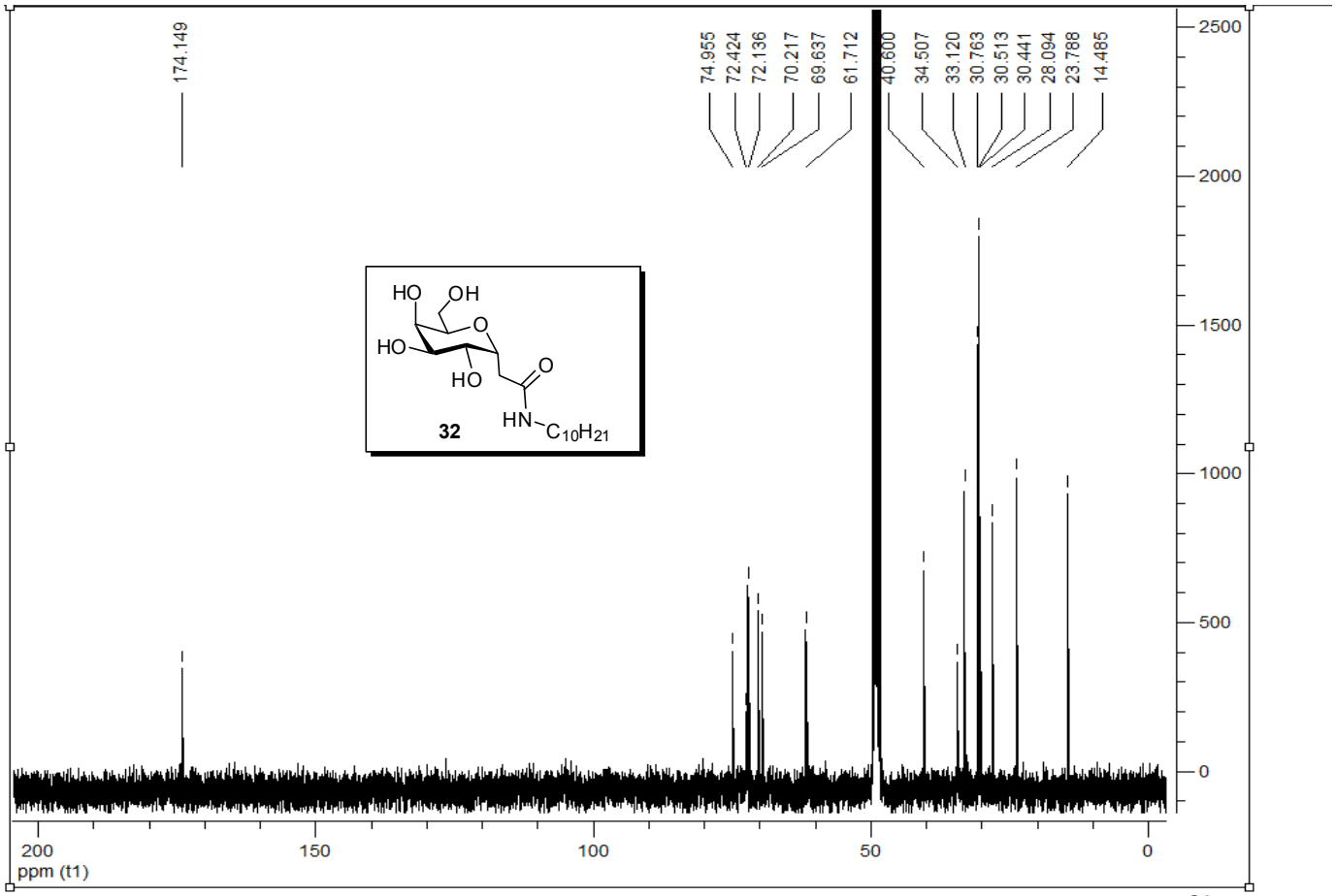


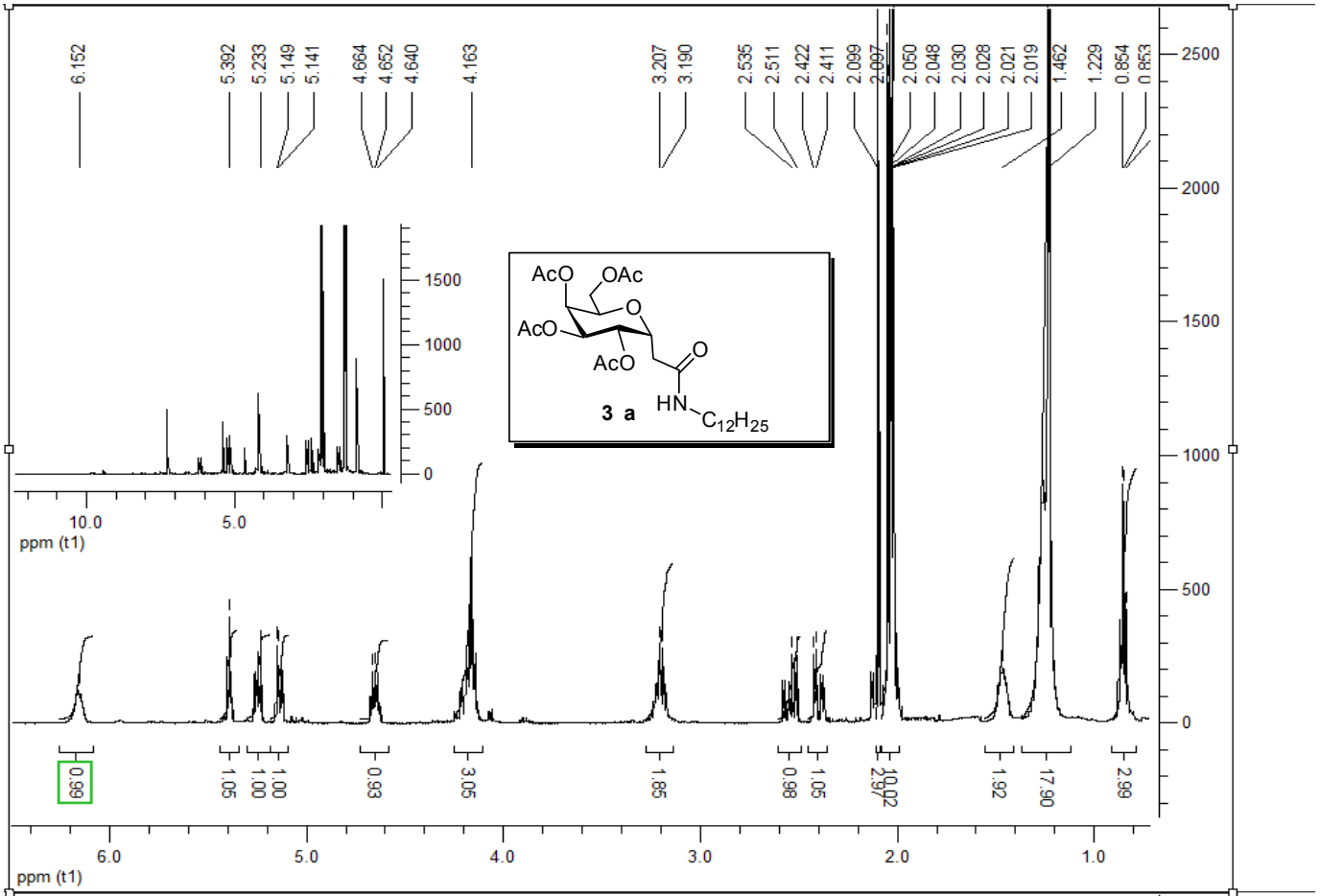


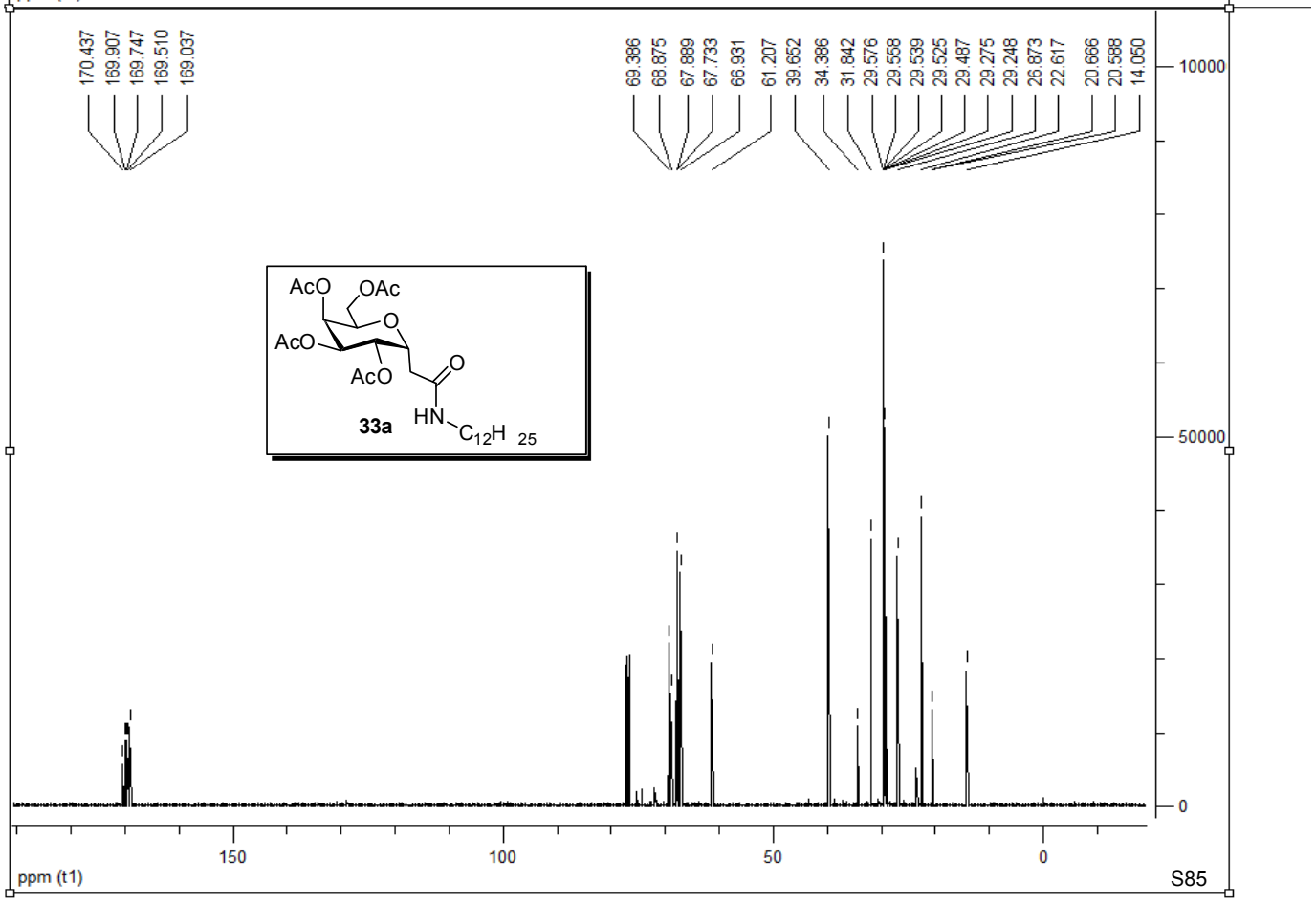


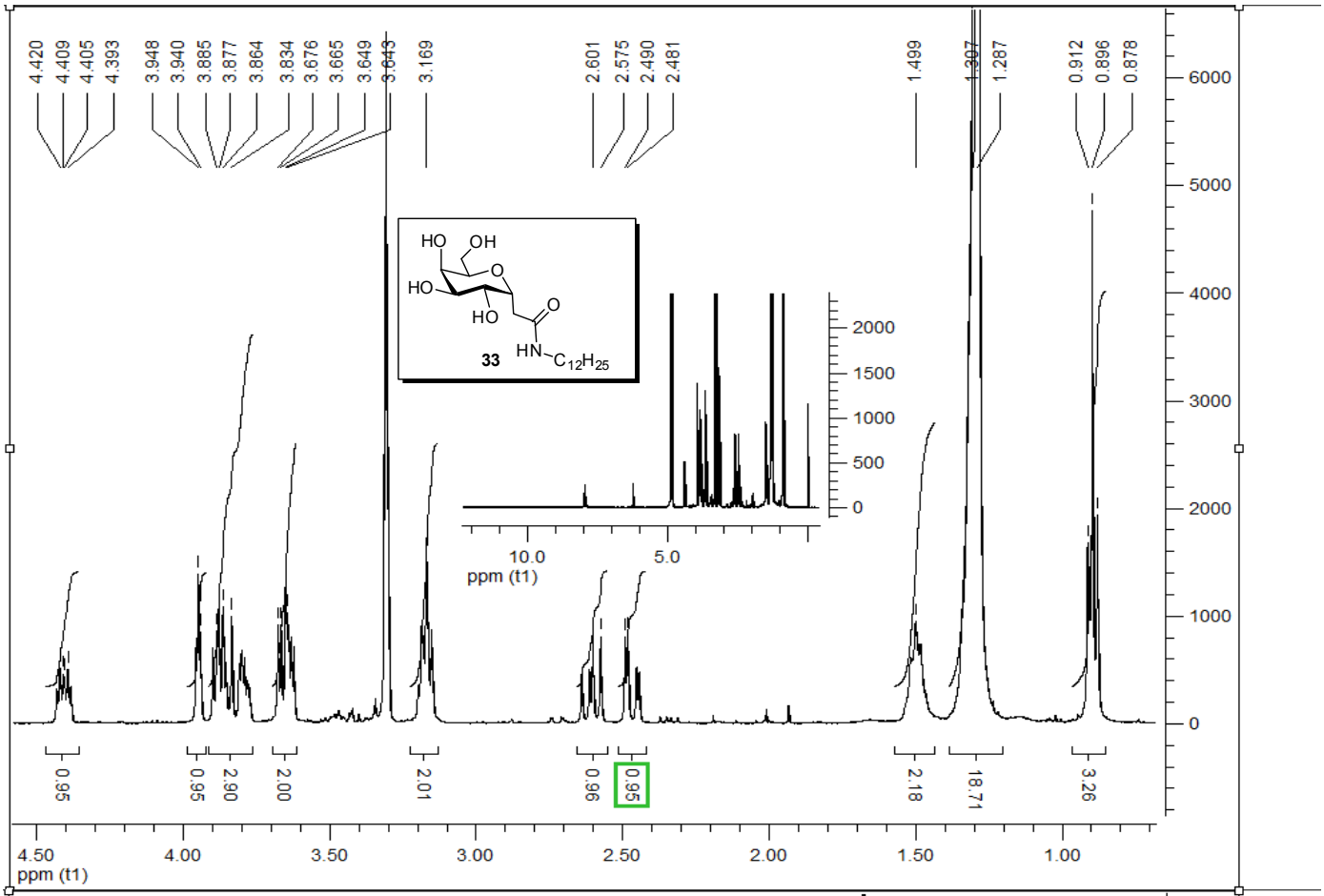


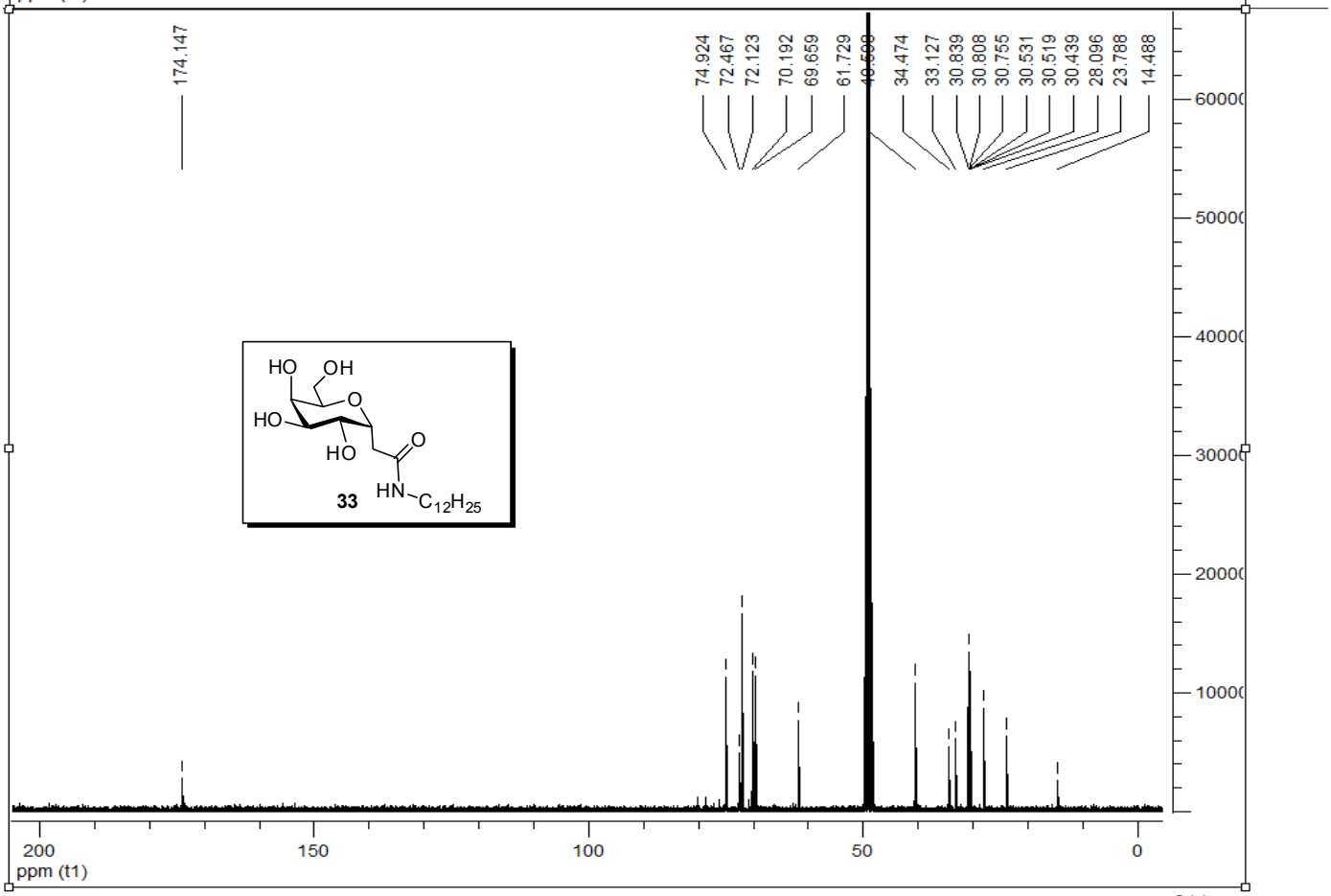


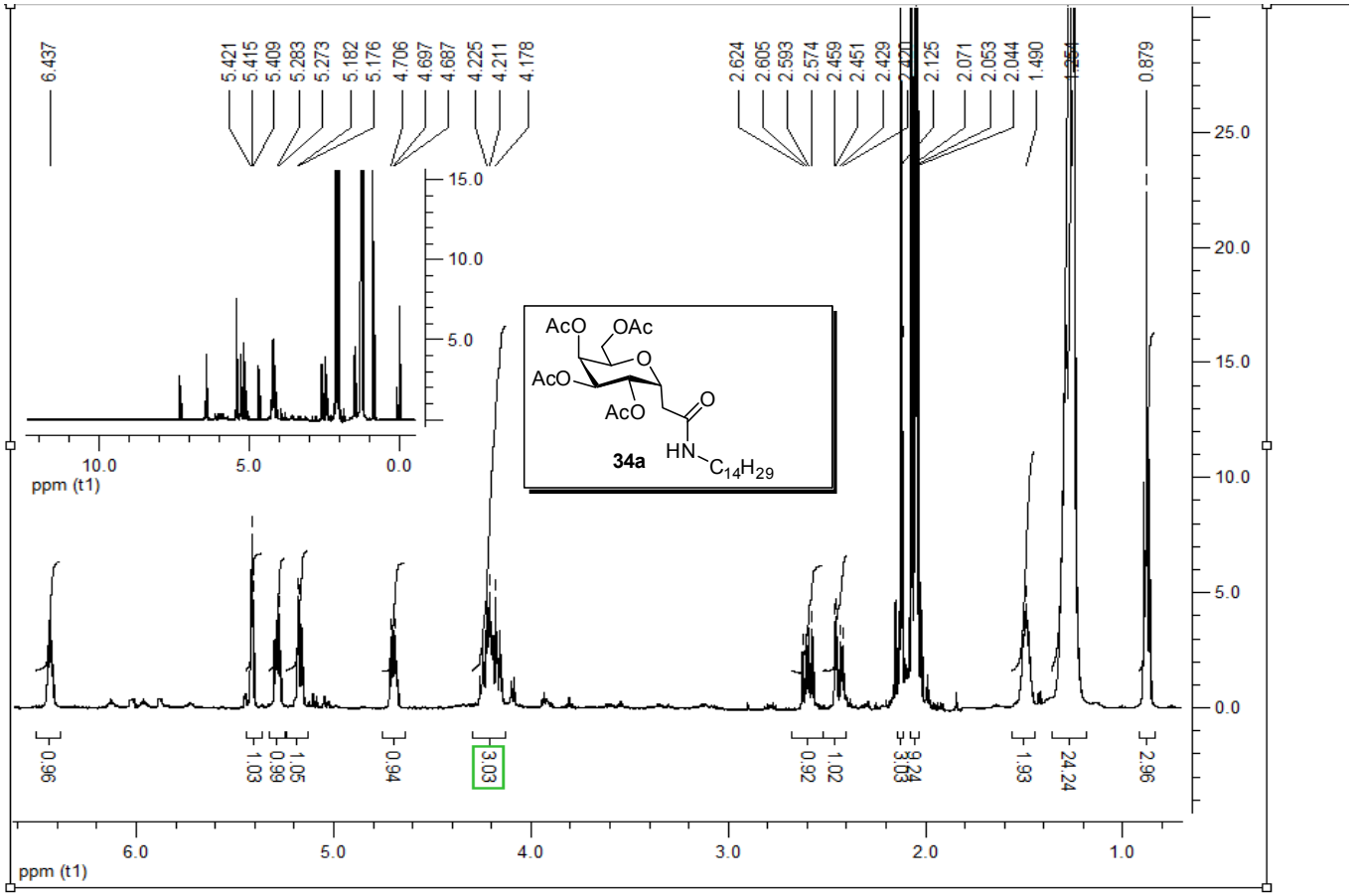


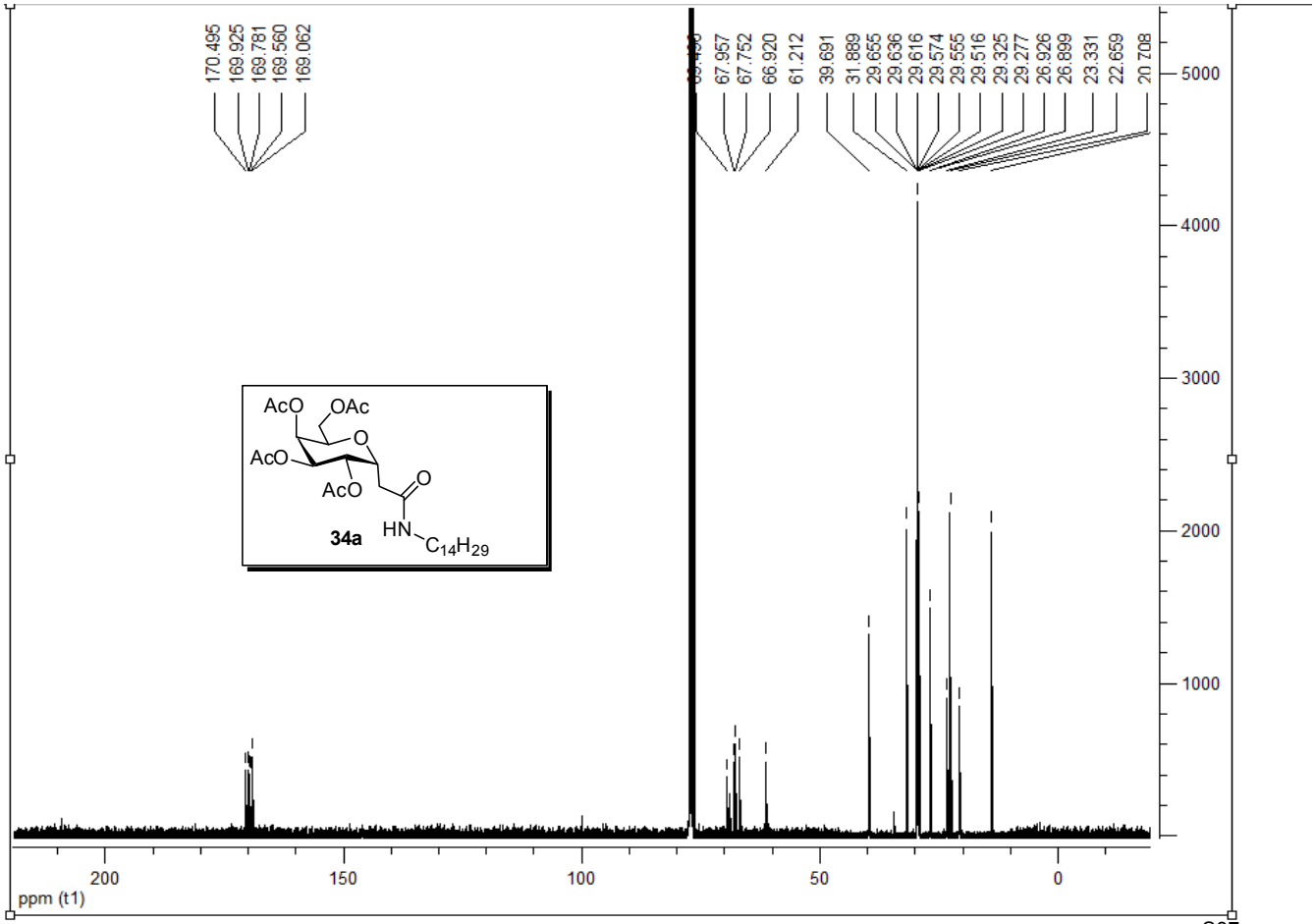


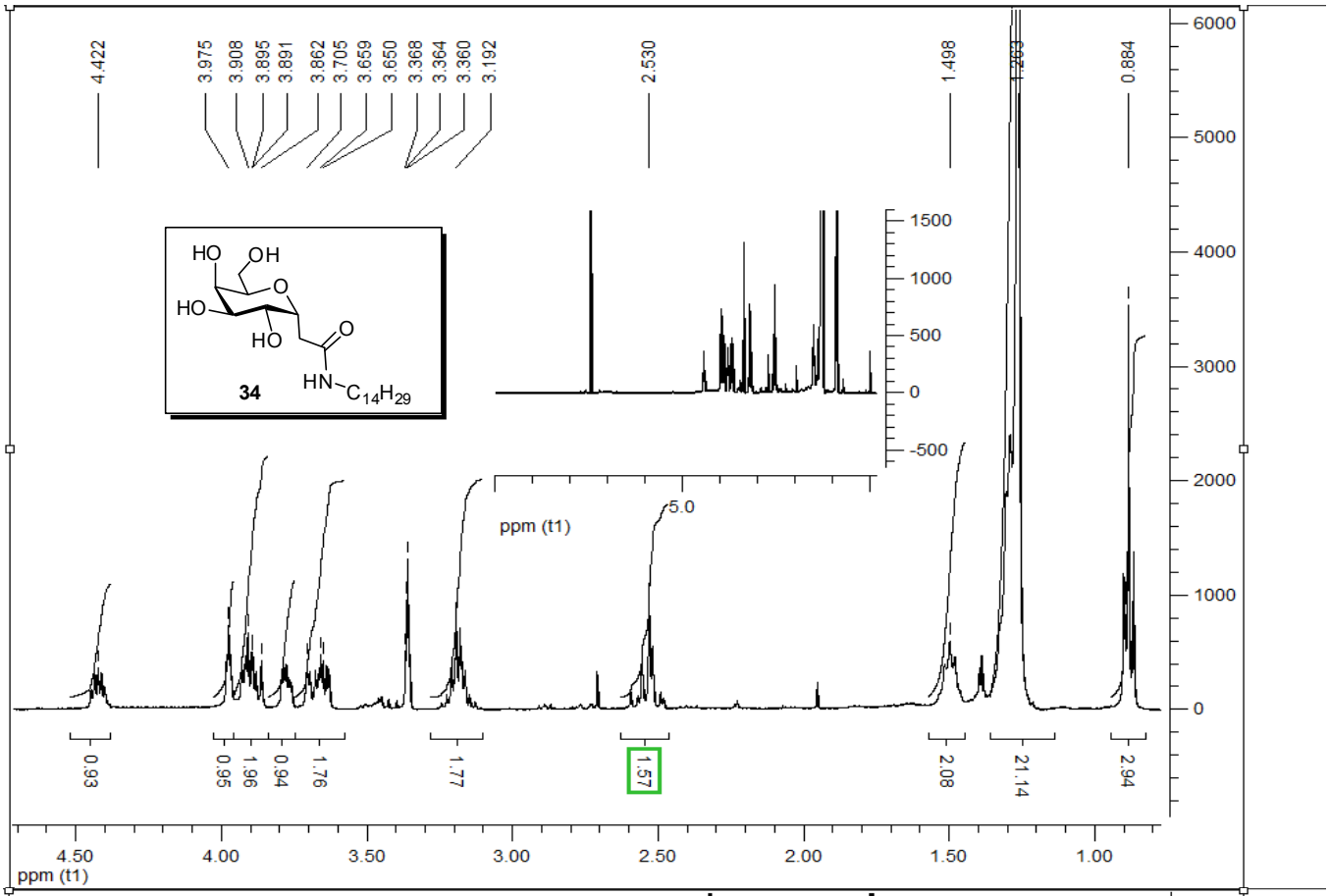


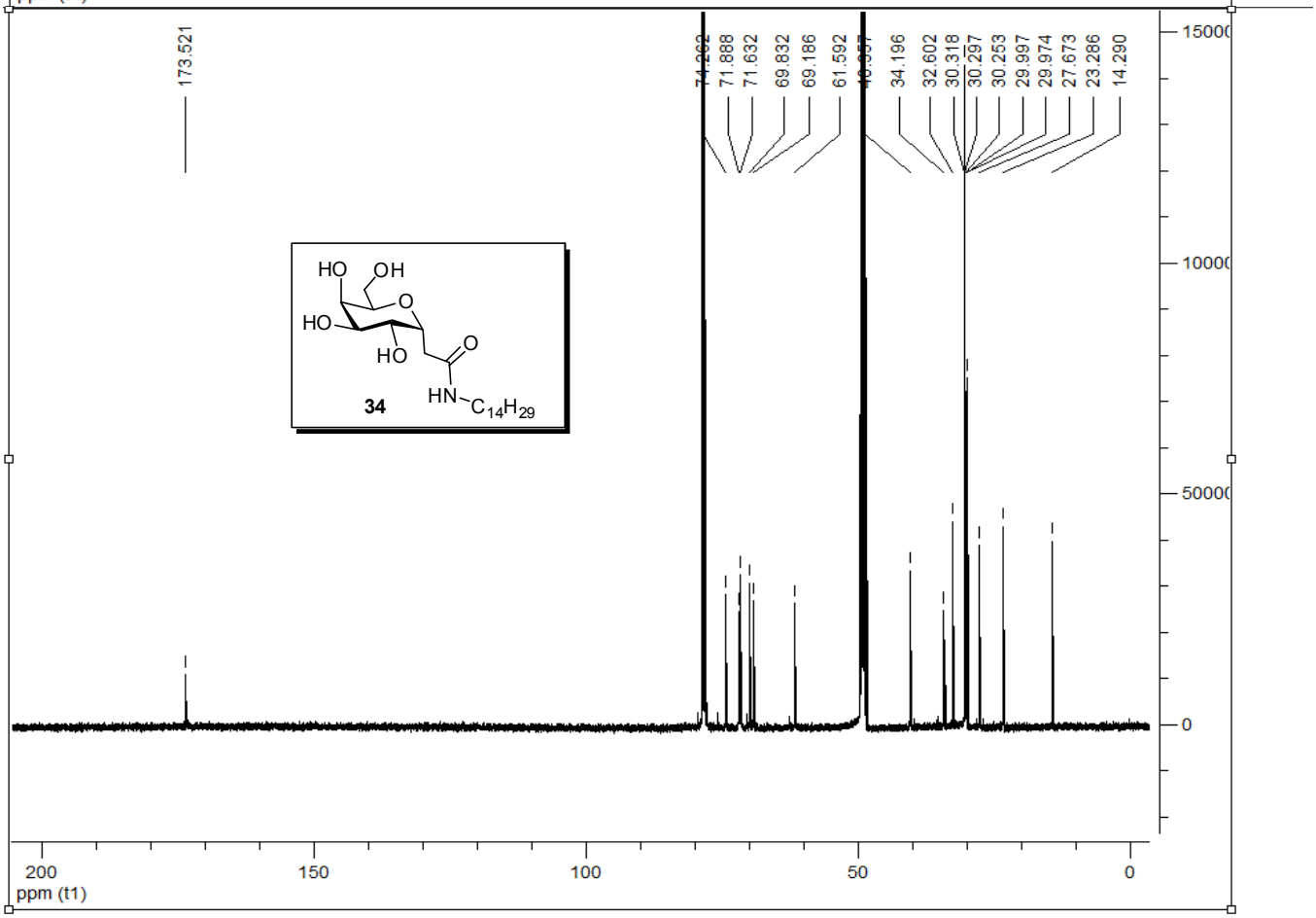


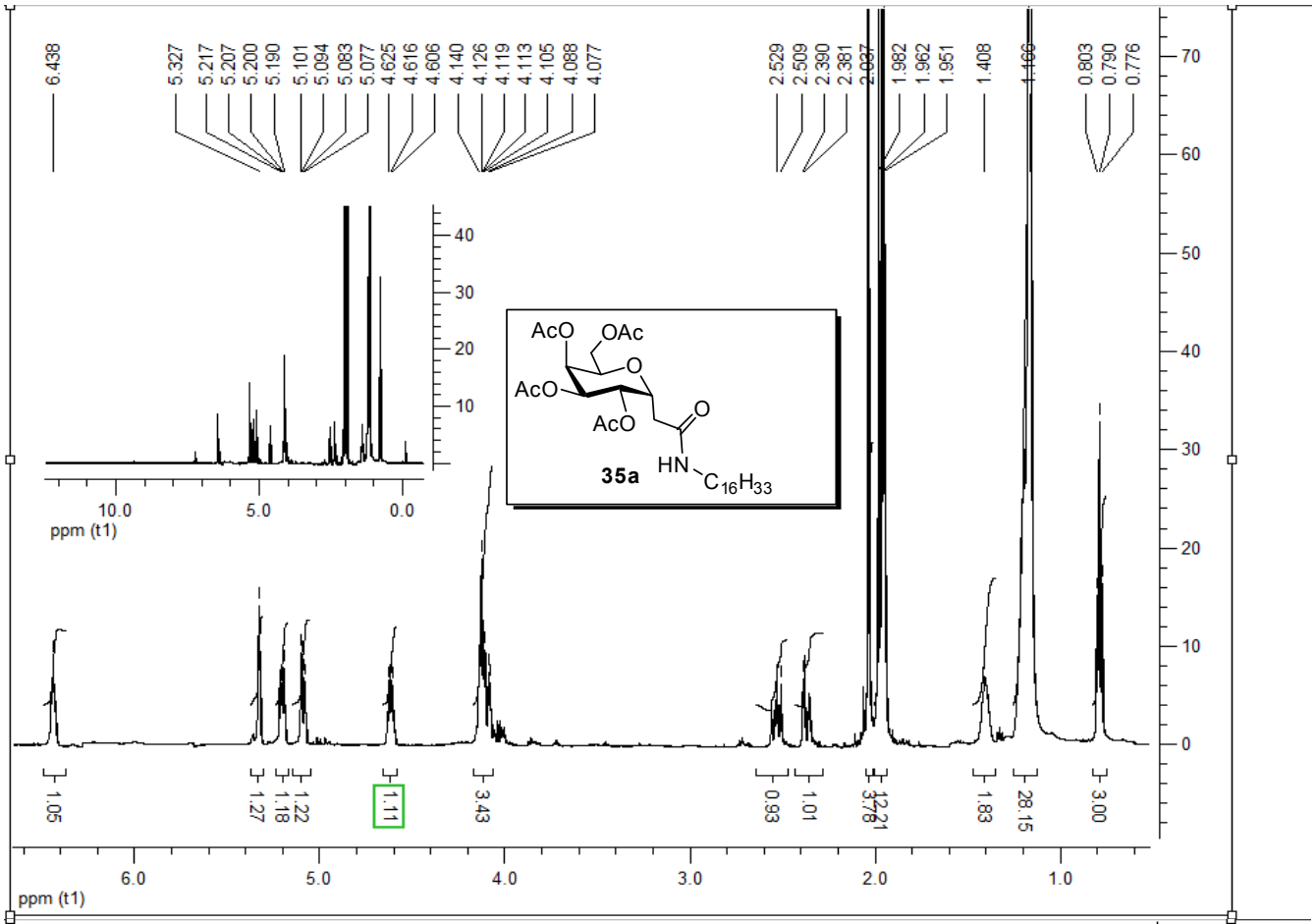


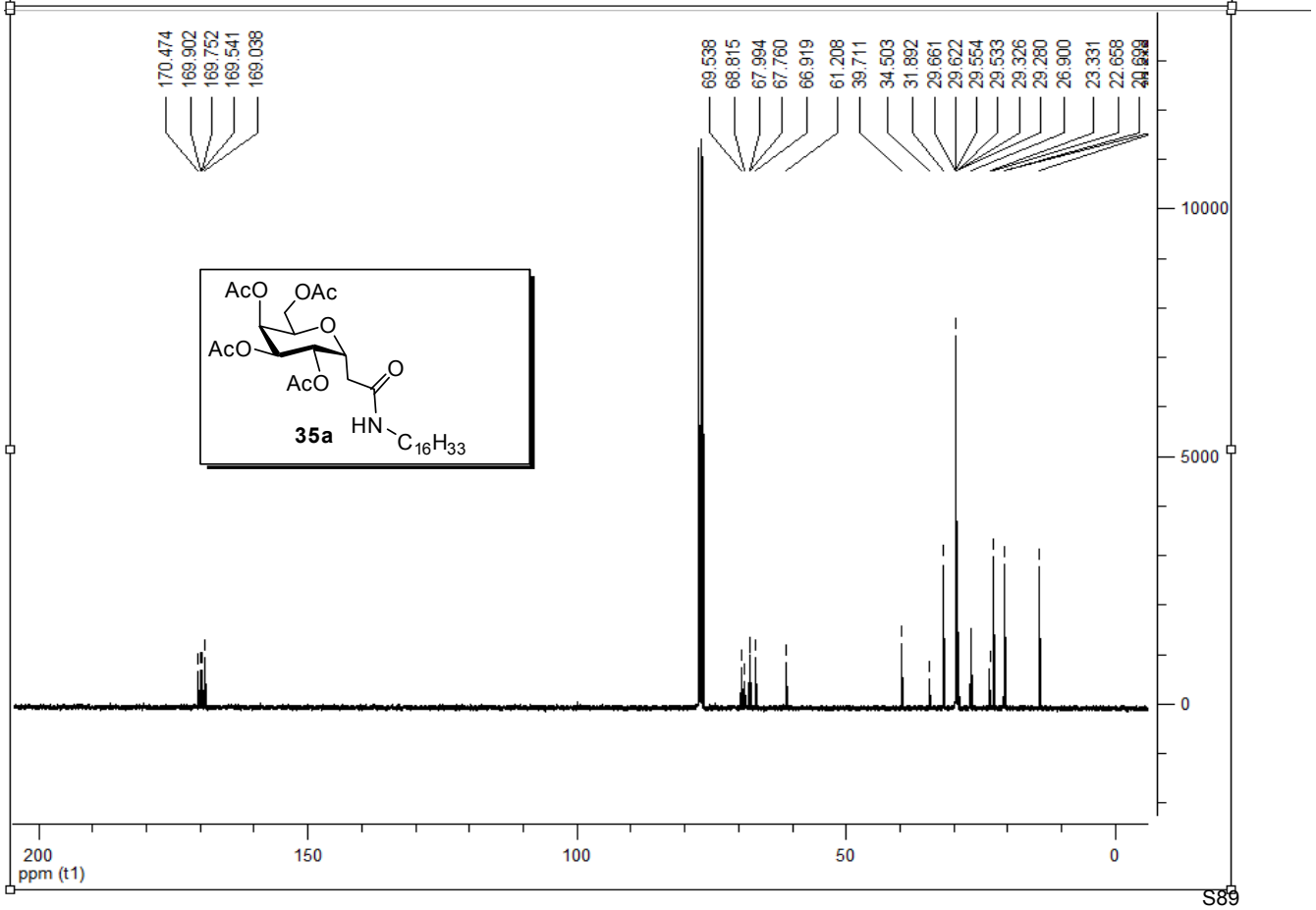


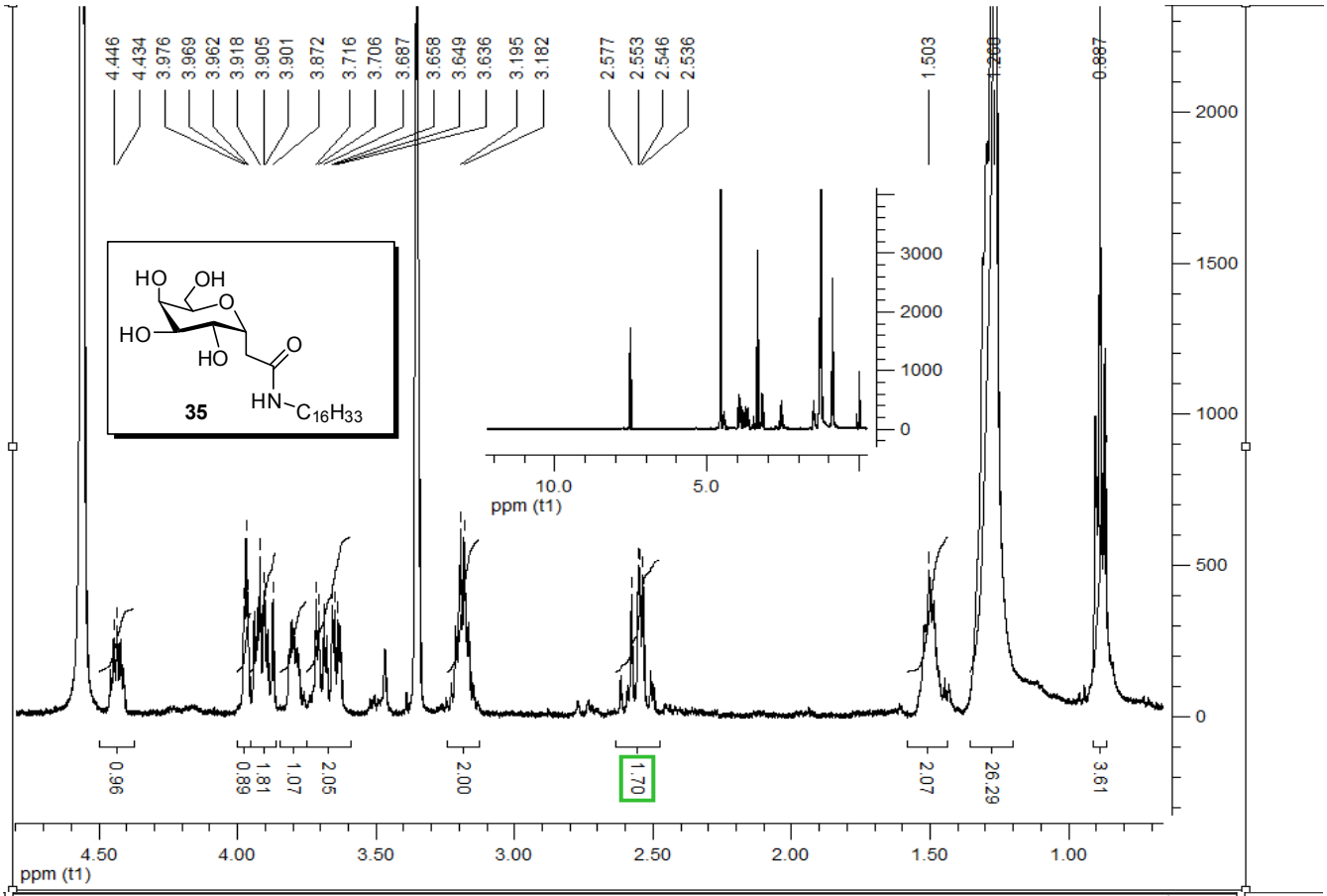








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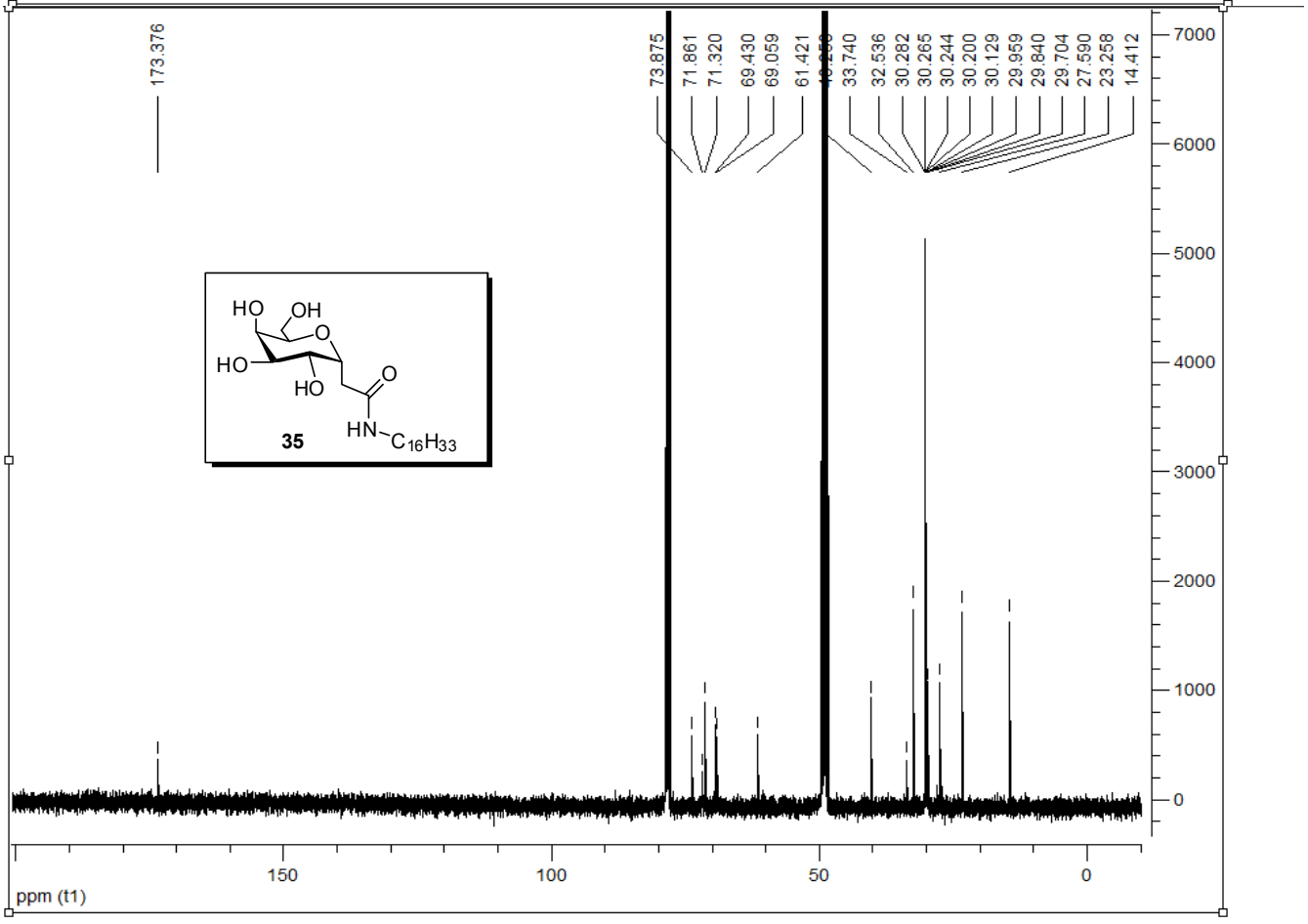
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ppm (t1)