

Synthesis of C-2-Methylene and C-2-Methyl C-Glycosides by Claisen Rearrangement of 2-Vinyloxymethyl Glycals

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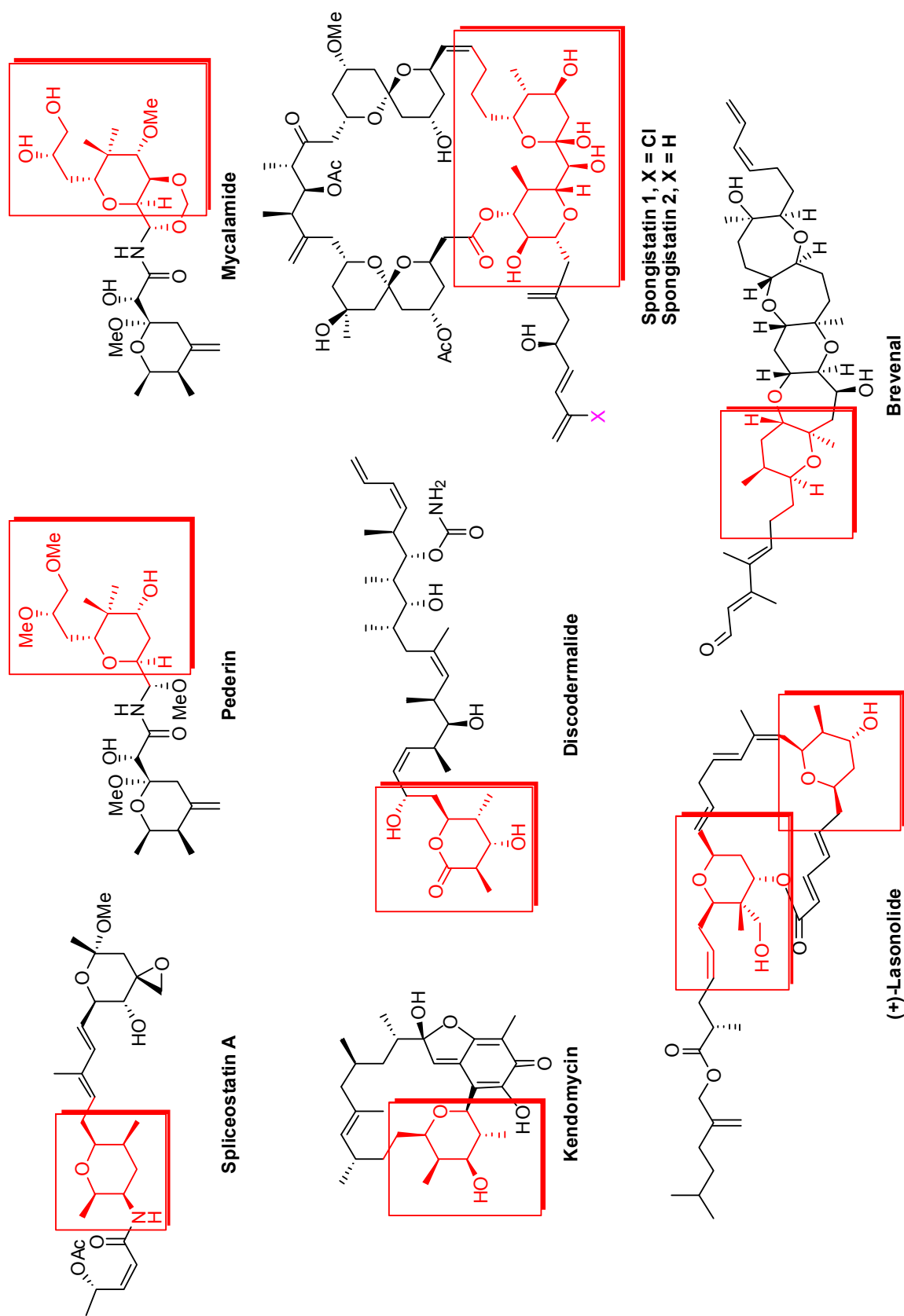
e-mail: prssc@uohyd.ernet.in

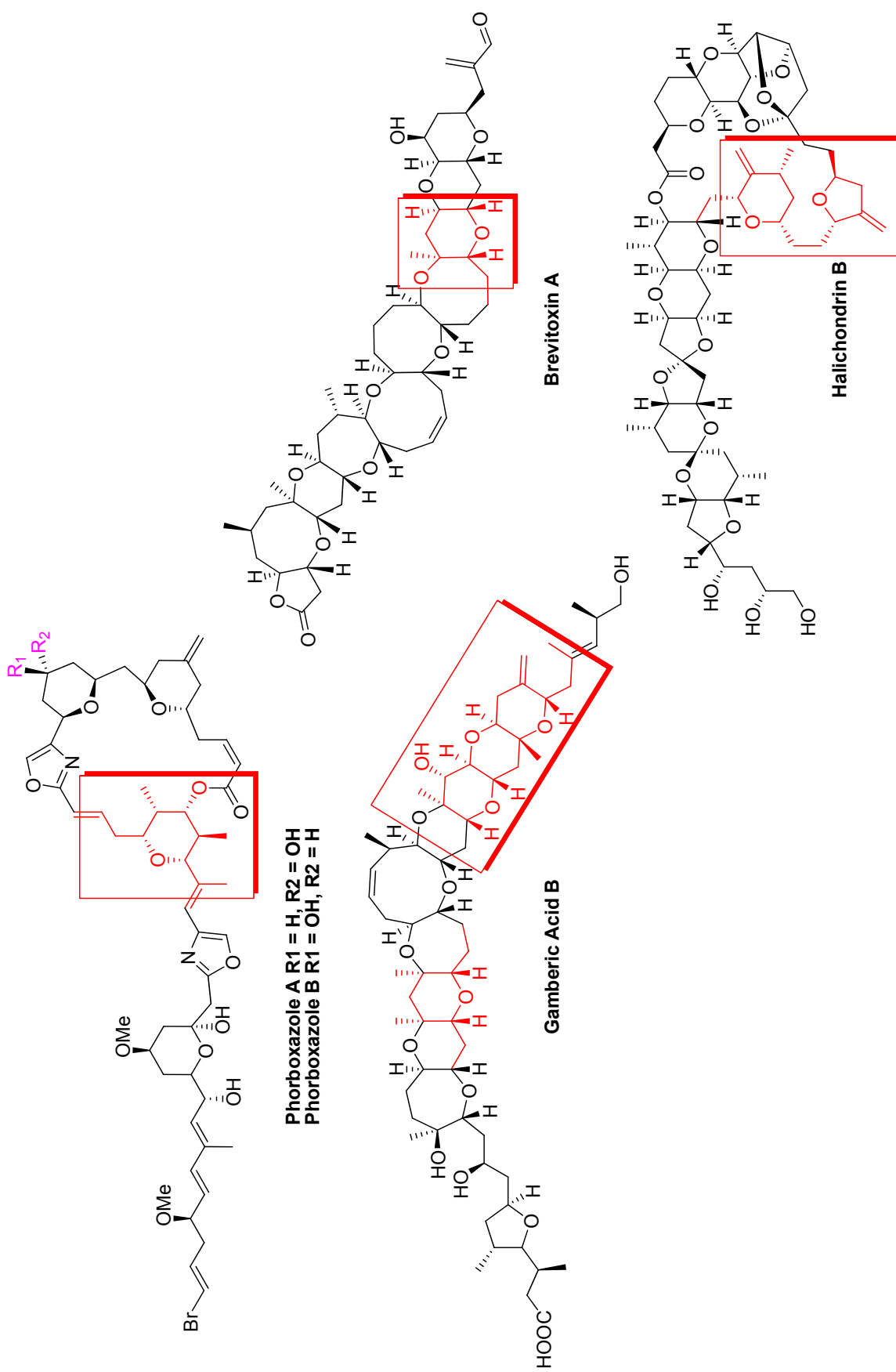
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1. Some of the bio-active Natural products possessing C-2-methylene/C-2-methyl-C-glycoside subunits





2. General Experimental procedures

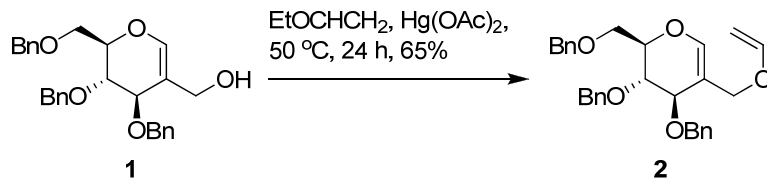
- 2.1. General procedure for the preparation of 2-formyl glycol derivatives:** To a solution of dry DMF (2 mL) and POCl₃ (3 mmol) at 0 °C was added a precooled solution of glycol (1 mmol) in of dry DMF (2 mL) dropwise for about 30 min. The mixture was allowed to stir for 5-6 h at room temperature. After complete disappearance of starting material (by TLC) the reaction was quenched with aq NaHCO₃ (sat) solution and diluted with diethylether. The organic layer was separated and the aqueous layer was extracted with diethyl ether. The combined ether layers were washed with brine solution, dried over anhydrous Na₂SO₄ and concentrated. The crude thus obtained was purified by column chromatography to yield 2-formyl glycol derivatives as pale yellow colored gummy compounds in 60-80% yield.
- 2.2. General procedure for the preparation of 2-hydroxymethyl glycol derivatives:** To a stirred solution of 2-formyl glycol (1 mmol) in dry ethanol (4 mL) at 0 °C, was added solid NaBH₄ (1.5 mmol) and the stirring was continued for 3 h. After completion of the reaction (by TLC), it was quenched with saturated NH₄Cl solution. Ethanol was evaporated under reduced pressure and aqueous suspension was extracted with dichloromethane (2x50 mL). The combined organic layers were washed with water, brine solution, dried over anhydrous NaSO₄ and concentrated. The obtained crude product was purified by silica-gel column chromatography to give 2-hydroxymethyl glycol derivatives in 90-95% yield.
- 2.3. General procedure for the preparation of 2-vinyloxymethyl glycol derivatives:** A mixture of primary alcohol (0.2 mmol), ethyl vinyl ether (3 mL, freshly distilled over sodium) and mercuric acetate (0.05 mmol) was stirred at reflux under an argon atmosphere. After 24 h the reaction was cooled to RT, and acetic acid (2.98 μL) was added and stirring was continued for 3 h at RT. The mixture was diluted with an equal volume of hexane and washed with 5% aqueous KOH (2 X 5 mL), water (3 X 5 mL), with brine solution and concentrated under reduced pressure. The residue was purified

using basic alumina to afford 2-vinyloxymethyl glycal derivatives as colorless gummy liquid in 45-60% yield.

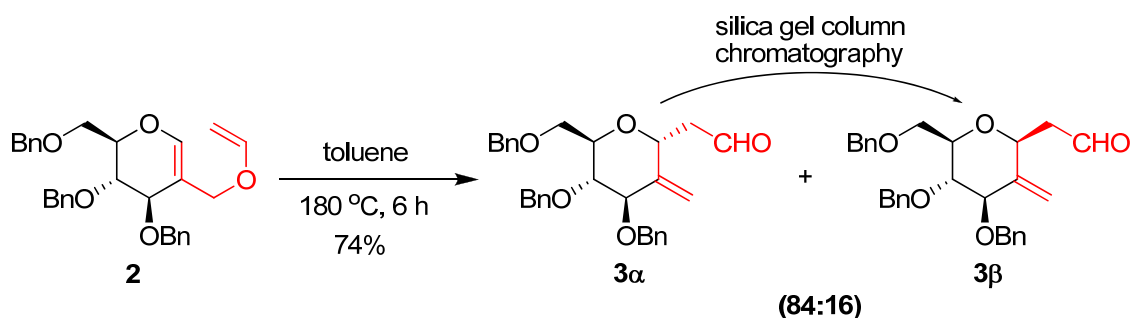
2.4. General procedure for Claisen rearrangement reaction: A solution of 2-vinyloxymethyl glycal derivative (1 mmol) in toluene (15 mL), was heated at 180-185 °C in sealed tube for 5-6 h. Cooling the reaction followed by evaporation of toluene over rotary evaporator and purification over silica-gel provided the C-2-methylene-C-glycoside derivatives in 60-80 % yield.

2.5. General procedure for Selective hydrogenation of olefin: To a stirred solution of olefin (0.2 mmol) in methanol (5 mL) was added Na₂CO₃ (0.2 mmol), 10% Pd/C (10 mg). The mixture was stirred for 4 h under H₂ atmosphere. After completion of the reaction (by TLC) the suspension was filtered through a pad of Celite and concentrated *in vacuo* to afford the corresponding C-2-methyl-C-glycoside derivative as oil in 90-95% yield.

3. Spectroscopic data for compounds:



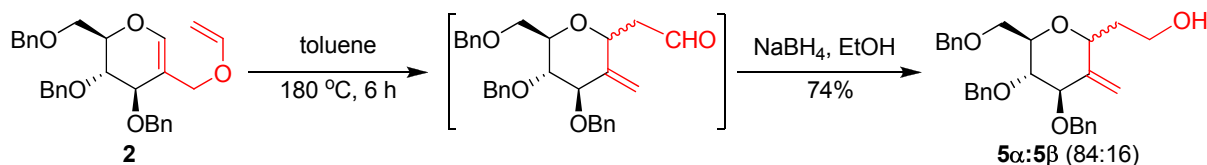
Compound 2: ^1H (500 MHz, CDCl_3): δ 7.30-7.38 (m, 15H), 6.56 (s, 1H), 6.49 (dd, 1H, $J = 7$ Hz, $J = 14.5$ Hz), 4.82 (d, 1H, $J = 13$ Hz), 4.69 (d, 1H, $J = 11$ Hz), 4.68 (d, 1H, $J = 11.5$ Hz), 4.60 (d, 1H, $J = 12.5$ Hz), 4.58 (s, 2H), 4.44 (d, 1H, $J = 11$ Hz), 4.25-4.30 (m, 3H), 4.07 (dd, 1H, $J = 2$ Hz, $J = 7$ Hz), 4.00 (d, 1H, $J = 11$ Hz), 3.97 (dd, 1H, $J = 5.5$ Hz, $J = 7$ Hz), 3.84 (dd, 1H, $J = 5.5$ Hz, $J = 11$ Hz), 3.76 (dd, 1H, $J = 3.5$ Hz, $J = 11$ Hz). ^{13}C (125 MHz, CDCl_3): δ 151.2, 144.1, 138.1, 137.9, 137.9, 128.4, 128.3, 128.3, 128.1, 127.9, 127.8, 127.7, 127.6, 127.6, 127.5, 109.1, 87.2, 76.7, 74.5, 74.0, 73.3, 73.1, 72.8, 68.1, 66.2. **Low-resolution MS** (EI): m/z : 472 (M^+), **HRMS** (ESI) calcd for $\text{C}_{30}\text{H}_{32}\text{O}_5+\text{Na}$ 495.2148, found 495.2148.



Compound 3 α : Not able to isolate in pure form due to its anomerization to the more stable **3 β** .

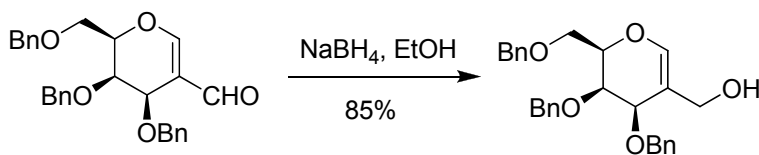
Compound 3 β : ^1H (500 MHz, CDCl_3): δ 9.86 (s, 1H), 7.18-7.40 (m, 15H), 5.37 (s, 1H), 4.98 (s, 1H), 4.88 (d, 1H, $J = 11$ Hz), 4.78 (d, 1H, $J = 11.5$ Hz), 4.71 (d, 1H, $J = 11.5$ Hz), 4.59 (d, 1H, $J = 12.5$ Hz), 4.54 (d, 1H, $J = 11$ Hz), 4.52 (d, 1H, $J = 12$ Hz), 4.34 (dd, 1H, $J = 5.5$ Hz, $J = 7.5$ Hz), 4.11 (d, 1H, $J = 8$ Hz), 3.67-3.72 (m, 2H), 3.63-3.64 (m, 1H), 3.56 (t, 1H, $J = 9$ Hz), 2.93 (ddd, 1H, $J = 2$ Hz, $J = 7.5$ Hz, $J = 16.5$ Hz), 2.82 (dd, 1H, $J = 5$ Hz, $J = 16.5$ Hz). ^{13}C (125 MHz, CDCl_3): δ 200.5, 143.3, 138.1, 138.1, 138.0, 128.5, 128.4, 128.3, 127.9, 127.8,

127.7, 127.6, 108.1, 84.2, 79.8, 79.3, 74.8, 73.4, 73.3, 72.6, 69.1, 45.3. **Low-resolution MS** (EI): m/z : 473 ($M^+ + 1$).

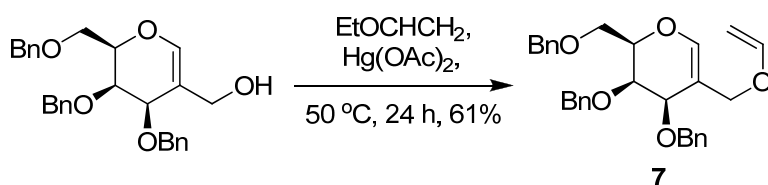


Compound 5α: ^1H (500 MHz, CDCl_3): δ 7.18-7.38 (m, 15H), 5.25 (s, 1H), 5.11 (s, 1H), 4.79 (d, 1H, $J = 11.0$ Hz), 4.72 (d, 1H, $J = 11.5$ Hz), 4.63 (d, 1H, $J = 11.5$ Hz), 4.60 (dd, 1H, $J = 5.5$ Hz, $J = 9.5$ Hz), 4.58 (d, 1H, $J = 12.0$ Hz), 4.52 (d, 1H, $J = 10$ Hz), 4.48 (d, 1H, $J = 11.5$ Hz), 4.20 (d, 1H, $J = 7.0$ Hz), 3.92-3.95 (m, 1H), 3.81-3.84 (m, 2H), 3.63-3.64 (m, 2H), 3.46 (dd, 1H, $J = 7.0$ Hz, $J = 8.5$ Hz), 2.62 (bs, 1H), 2.16-2.24 (m, 1H), 1.72-1.77 (m, 1H). ^{13}C (125 MHz, CDCl_3): δ 144.0, 138.0, 137.9, 128.4, 128.3, 127.9, 127.8, 127.7, 127.7, 111.0, 80.9, 80.1, 77.0, 73.9, 73.4, 73.0, 72.7, 69.4, 61.1, 33.2. **Low-resolution MS** (EI): m/z : 474 (M^+), **HRMS** (ESI) calcd for $\text{C}_{30}\text{H}_{34}\text{O}_5 + \text{Na}$ 497.2304, found 497.2304.

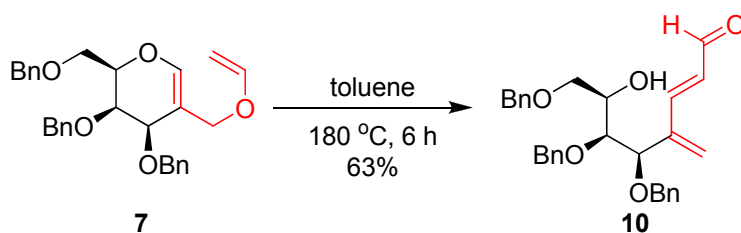
Compound 5β: ^1H (500 MHz, CDCl_3): 7.19-7.42 (m, 15H), 5.34 (s, 1H), 5.09 (s, 1H), 4.89 (d, 1H, $J = 10.5$ Hz), 4.78 (d, 1H, $J = 11.5$ Hz), 4.69 (d, 1H, $J = 11.5$ Hz), 4.57 (d, 1H, $J = 12.0$ Hz), 4.53 (d, 1H, $J = 11.0$ Hz), 4.52 (d, 1H, $J = 12.0$ Hz), 4.07 (d, 1H, $J = 8.5$ Hz), 4.00 (dd, 1H, $J = 2.5$ Hz, $J = 10.0$ Hz), 3.89 (t, 2H, $J = 5.0$ Hz), 3.70 (dd, 1H, $J = 2.0$ Hz, $J = 7.0$ Hz), 3.65 (ddd, 1H, $J = 2.0$ Hz, $J = 6.0$ Hz, $J = 9.0$ Hz), 3.57-3.61 (m, 2H), 3.46 (t, 1H, $J = 9.0$ Hz), 2.83 (bs, 1H), 2.06-2.12 (m, 1H), 1.94-1.99 (m, 1H). ^{13}C (125 MHz, CDCl_3): δ 144.1, 138.1, 138.0, 138.0, 128.5, 128.4, 128.3, 127.9, 127.8, 127.7, 127.6, 107.7, 84.3, 80.2, 78.8, 74.8, 73.4, 73.2, 69.6, 61.2, 33.4. **Low-resolution MS** (EI): m/z : 474 (M^+), **HRMS** (ESI) calcd for $\text{C}_{30}\text{H}_{34}\text{O}_5 + \text{Na}$ 497.2304, found 497.2304.



2-Hydroxymethyl-3,4,6-tri-*O*-benzyl-D-galactal: ^1H (400 MHz, CDCl_3): δ 7.34-7.42, (m, 15H), 6.46 (s, 1H), 4.89 (d, 1H, $J = 11.6$ Hz), 4.88 (d, 1H, 11.6 Hz), 4.72 (d, 1H, $J = 12$ Hz), 4.66 (d, 1H, $J = 11.6$ Hz), 4.61 (d, 1H, $J = 11.6$ Hz), 4.51 (d, 1H, $J = 12$ Hz), 4.40 (d, 1H, $J = 2.4$ Hz), 4.31 (bs, 1H), 4.17 (d, 1H, $J = 11.6$ Hz), 4.02-4.09 (m, 2H), 3.88 (dd, 1H, $J = 7.2$ Hz, $J = 10$ Hz), 3.80 (dd, 1H, $J = 5.2$ Hz, $J = 10$ Hz), 2.37 (bs, 1H). ^{13}C (100 MHz, CDCl_3): δ 142.3, 137.9, 137.6, 128.2, 128.1, 127.6, 127.5, 127.5, 112.0, 75.3, 72.1, 73.0, 72.7, 72.3, 71.1, 67.8, 61.0.

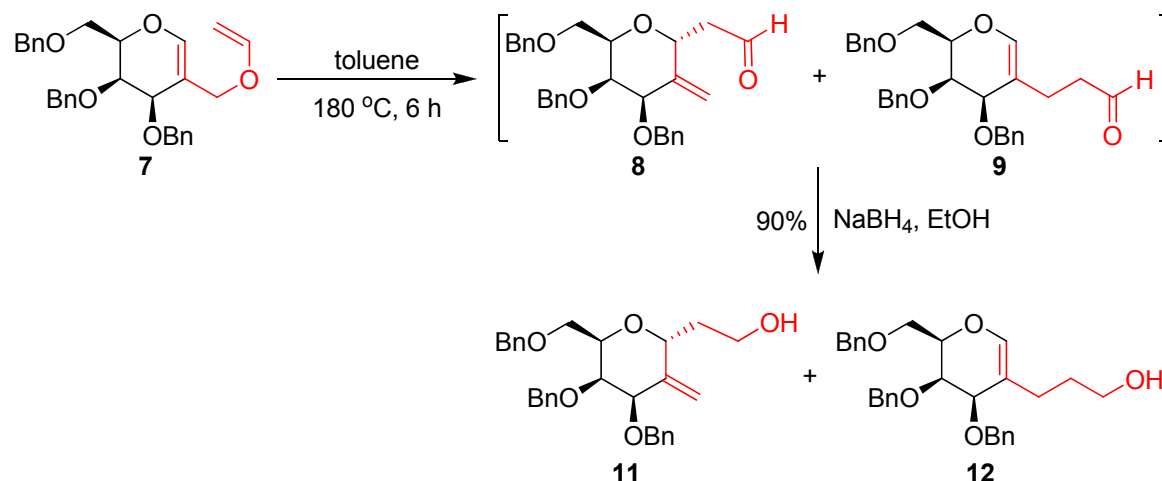


Compound 7: ^1H (400 MHz, CDCl_3): δ 7.30-7.34, (m, 15H), 6.45 (s, 1H), 6.42 (dd, 1H, $J = 6.8$ Hz, $J = 14.4$ Hz), 4.84 (d, 1H, $J = 11.6$ Hz), 4.77 (d, 1H, $J = 11.6$ Hz), 4.64 (d, 1H, $J = 11.6$ Hz), 4.64 (d, 1H, $J = 11.6$ Hz), 4.51 (d, 1H, $J = 12$ Hz), 4.45 (d, 1H, $J = 11.6$ Hz), 4.42 (d, 1H, $J = 12$ Hz), 4.21-4.29 (m, 3H), 3.99-4.09 (m, 3H), 3.79 (dd, 1H, $J = 7.6$ Hz, $J = 10$ Hz), 3.68 (dd, 1H, $J = 4.8$ Hz, $J = 10$ Hz). ^{13}C (100 MHz, CDCl_3): δ 151.4, 143.8, 138.4, 138.2, 138.0, 128.4, 128.0, 127.9, 127.9, 109.3, 87.3, 75.9, 73.4, 71.2, 68.1, 66.4. **Low-resolution MS** (EI): m/z : 472 (M^+), **HRMS** (ESI) calcd for $\text{C}_{30}\text{H}_{32}\text{O}_5 + \text{Na}$ 495.2148, found 295.2148.



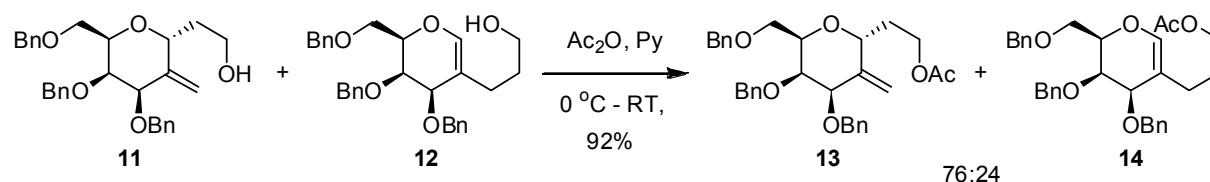
Compound 10: ^1H (400 MHz, CDCl_3): δ 9.52 (d, 1H, $J = 7.6$ Hz), 7.26-7.38 (m, 15H), 7.12 (d, 1H, $J = 16$ Hz), 6.46 (dd, 1H, $J = 7.6$ Hz, $J = 16$ Hz), 5.84 (s, 1H), 5.80 (s, 1H), 4.55 (d, 1H, $J = 12$ Hz), 4.53 (d, 1H, $J = 11.6$ Hz), 4.49 (d, 1H, $J = 12$ Hz), 4.37-4.40 (m, 3H), 4.32 (d, 1H, $J = 11.6$ Hz), 4.16 (m, 1H), 3.69 (dd, 1H, $J = 1.6$ Hz, $J = 8$ Hz), 3.56 (dd, 1H, $J = 6$ Hz, $J = 9.6$ Hz), 3.49 (dd, 1H, $J = 6.4$ Hz, $J = 9.6$ Hz), 2.64 (d, 1H, $J = 7.6$ Hz). (100 MHz, CDCl_3): δ

194.1, 151.3, 142.4, 137.8, 137.4, 137.2, 129.9, 128.5, 128.4, 128.3, 128.2, 128.0, 128.0, 127.8, 126.9, 79.1, 78.7, 74.1, 73.4, 71.0, 70.9, 69.2.



Compound 11: ¹H (500 MHz, CDCl₃): δ 7.27-7.37 (m, 15H), 5.26 (s, 1H), 5.15 (s, 1H), 4.79 (d, 1H, *J* = 12.0 Hz), 4.66 (d, 1H, *J* = 12.5 Hz), 4.58-4.61 (m, 2H), 4.53 (d, 2H, *J* = 12.5 Hz), 4.49 (d, 1H, *J* = 12.0 Hz), 4.28 (s, 1H), 4.13-4.16 (m, 1H), 3.91 (dd, 1H, *J* = 8.0 Hz, *J* = 10.0 Hz), 3.80-3.83 (m, 3H), 3.51 (dd, 1H, *J* = 4.0 Hz, *J* = 10.5 Hz), 2.79 (bs, 1H), 2.03-2.10 (m, 1H), 1.71-1.76 (m, 1H). ¹³C (125 MHz, CDCl₃): δ 143.1, 138.3, 138.1, 137.9, 128.4, 128.3, 128.2, 128.1, 127.8, 127.7, 127.6, 127.3, 111.3, 78.1, 75.7, 74.3, 73.4, 72.8, 72.7, 71.0, 68.7, 61.1, 33.1. **Low-resolution MS** (EI): *m/z*: 474 (M⁺), **HRMS** (ESI) calcd for C₃₀H₃₄O₅+Na 497.2304, found 297.2304.

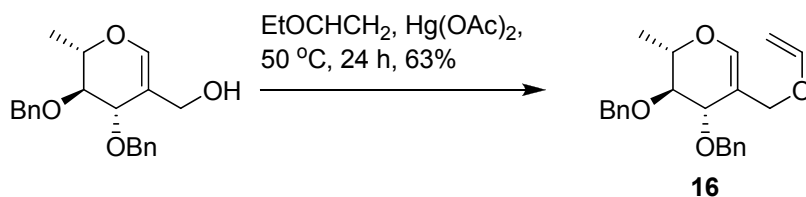
Compound 12: Compound 12 was not obtained in pure form and it was isolated along with compound 11.



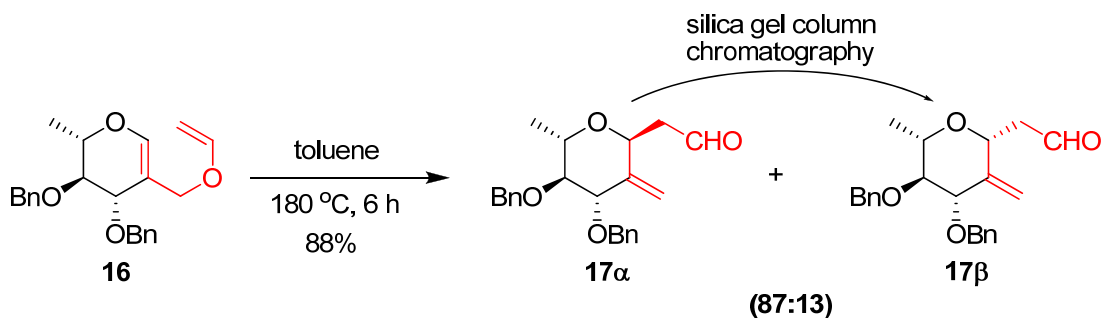
Compound 13: ¹H (500 MHz, CDCl₃): δ 7.23-7.34 (m, 15H), 5.30 (s, 1H), 5.12 (s, 1H), 4.83 (d, 1H, *J* = 12.0 Hz), 4.64 (d, 1H, *J* = 12.5 Hz), 4.61 (d, 1H, *J* = 12.0 Hz), 4.55 (d, 1H, *J* = 12.0 Hz), 4.46-4.50 (m, 2H), 4.42 (d, 1H, *J* = 11.5 Hz), 4.09-4.17 (m, 3H), 3.96-3.98 (td, 1H, *J*

= 2.0 Hz, $J = 6$ Hz), 3.89 (s, 1H), 3.67 (dd, 1H, $J = 6.5$ Hz, $J = 10$ Hz), 3.61 (dd, 1H, $J = 6$ Hz, $J = 10$ Hz), 2.00-2.09 (m, 1H), 2.01 (s, 3H), 1.84-1.91 (m, 1H). **^{13}C (125 MHz, CDCl_3):** δ 170.9, 142.5, 138.5, 138.2, 128.4, 128.3, 128.1, 127.8, 127.6, 127.6, 127.5, 127.2, 111.2, 78.1, 75.5, 73.4, 73.3, 73.2, 72.8, 71.2, 68.8, 61.3, 30.1, 20.9. **Low-resolution MS** (EI): m/z : 516 (M^+), **HRMS** (ESI) calcd for $\text{C}_{32}\text{H}_{36}\text{O}_6+\text{Na}$ 539.2410, found 539.2410.

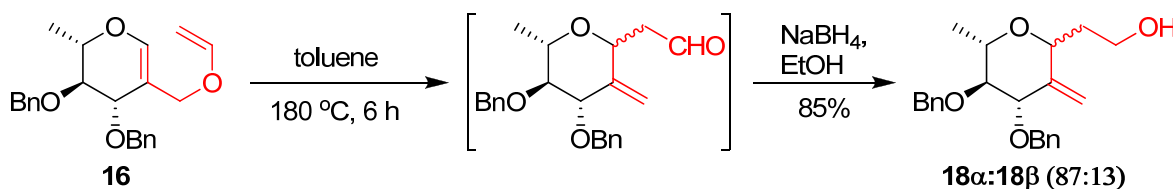
Compound 14: **^1H (500 MHz, CDCl_3):** δ 7.25-7.36 (m, 15H), 6.14 (s, 1H), 4.81 (s, 1H), 4.79 (s, 1H), 4.64 (d, 1H, $J = 12.0$ Hz), 4.53 (d, 1H, $J = 12.0$ Hz), 4.51 (d, 1H, $J = 11.5$ Hz), 4.43 (d, 1H, $J = 11.5$ Hz), 4.20-4.22 (m, 1H), 4.08 (d, 1H, $J = 4.0$ Hz), 3.95-4.01 (m, 3H), 3.79 (dd, 1H, $J = 7.5$ Hz, $J = 10.5$ Hz), 3.69 (dd, 1H, $J = 5.0$ Hz, $J = 10.5$ Hz), 2.10-2.18 (m, 1H), 2.00 (s, 3H), 1.91-1.97 (m, 1H), 1.55-1.65 (m, 2H). **^{13}C NMR (125 MHz, CDCl_3):** δ 171.0, 139.5, 138.4, 138.3, 138.1, 128.3, 127.9, 127.7, 127.7, 127.6, 127.6, 111.2, 75.2, 73.4, 73.1, 72.9, 72.7, 71.5, 68.2, 64.0, 27.2, 25.4, 20.9. **Low-resolution MS** (EI): m/z : 516 (M^+), **HRMS** (ESI) calcd for $\text{C}_{32}\text{H}_{36}\text{O}_6+\text{Na}$ 539.2410, found 539.2410.



Compound 16: **^1H (400 MHz, CDCl_3):** δ 7.30-6.37 (m, 10H), 6.48 (dd, 1H, $J = 6.4$ Hz, $J = 14.4$ Hz), 4.82 (d, 1H, $J = 11.2$ Hz), 4.71 (d, 1H, $J = 11.2$ Hz), 4.69 (d, 1H, $J = 11.2$ Hz), 4.64 (d, 1H, $J = 11.2$ Hz), 4.44 (d, 1H, $J = 11.2$ Hz), 4.24-4.28 (m, 2H), 4.12 (m, 1H), 4.05 (dd, 1H, $J = 2$ Hz, $J = 6.8$ Hz), 3.97 (d, 1H, $J = 10.8$ Hz), 3.56 (dd, 1H, $J = 4$ Hz, $J = 7.6$ Hz), 1.38 (d, 3H, $J = 6.4$ Hz). **^{13}C (100 MHz, CDCl_3):** δ 151.3, 144.4, 138.3, 138.0, 128.5, 128.4, 128.4, 128.0, 127.9, 127.7, 109.4, 87.3, 79.3, 75.5, 74.2, 73.7, 73.2, 66.1, 17.1. **Low-resolution MS** (EI): m/z : 366 (M^+), **HRMS** (ESI) calcd for $\text{C}_{23}\text{H}_{26}\text{O}_4+\text{Na}$ 389.1729, found 389.1729.

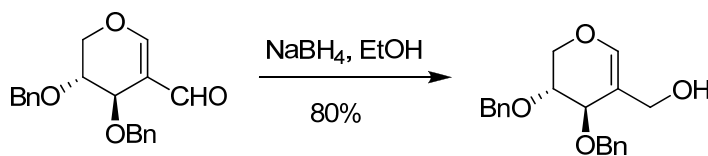


Compound 17 β : ^1H (500 MHz, CDCl_3): δ 9.83 (t, 1H, $J = 2.5$ Hz), 7.29-7.39 (m, 10H), 5.33 (d, 1H, $J = 1.5$ Hz), 4.94 (d, 1H, $J = 1.5$ Hz), 4.76 (d, 1H, $J = 11.5$ Hz), 4.69 (d, 1H, $J = 11.5$ Hz), 4.63 (d, 1H, $J = 11$ Hz), 4.29 (dd, 1H, $J = 5$ Hz, $J = 8$ Hz), 4.06 (dt, 1H, $J = 1.5$ Hz, $J = 8.5$ Hz), 3.54 (dd, 1H, $J = 6$ Hz, $J = 9$ Hz), 3.13 (t, 1H, $J = 9$ Hz), 2.82 (ddd, 1H, $J = 2.5$ Hz, $J = 8$ Hz, $J = 16.5$ Hz), 2.75 (ddd, 1H, $J = 2$ Hz, $J = 5$ Hz, $J = 16.5$ Hz), 1.26 (d, 3H, $J = 6$ Hz). ^{13}C (125 MHz, CDCl_3): δ 200.6, 144.0, 138.2, 138.0, 128.5, 128.4, 128.0, 127.7, 107.6, 85.6, 84.1, 75.7, 75.1, 73.3, 72.3, 45.3, 18.3. **Low-resolution MS** (EI): m/z : 366 (M^+), **HRMS** (ESI) calcd for $\text{C}_{23}\text{H}_{26}\text{O}_4 + \text{Na}$ 389.1729, found 389.1729.



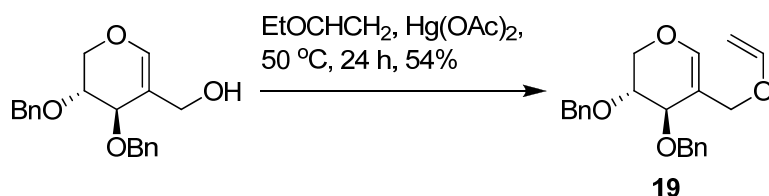
Compound 18 α : ^1H (400 MHz, CDCl_3): δ 7.30-7.41 (m, 10H), 5.26 (s, 1H), 5.10 (s, 1H), 4.88 (d, 1H, $J = 11.2$ Hz), 4.74 (d, 1H, $J = 11.6$ Hz), 4.67 (d, 1H, $J = 11.6$ Hz), 4.63 (d, 1H, $J = 11.2$ Hz), 4.53 (dd, 1H, $J = 4.8$ Hz, $J = 9.6$ Hz), 4.20 (d, 1H, $J = 7.6$ Hz), 3.77-3.83 (m, 3H), 3.21 (t, 1H, $J = 8.4$ Hz), 2.12-2.18 (m, 1H), 1.73-1.80 (m, 1H). ^{13}C (100 MHz, CDCl_3): δ 144.5, 138.2, 138.1, 128.5, 128.4, 128.0, 127.8, 127.7, 110.4, 85.5, 80.9, 76.4, 74.5, 72.8, 69.8, 60.6, 33.2, 18.5. **Low-resolution MS** (EI): m/z : 368 (M^+), **HRMS** (ESI) calcd for $\text{C}_{23}\text{H}_{28}\text{O}_4 + \text{Na}$ 391.1886, found 391.1885.

Compound 18 β : Not able to resolve in column chromatography and obtained along with **18 α** .

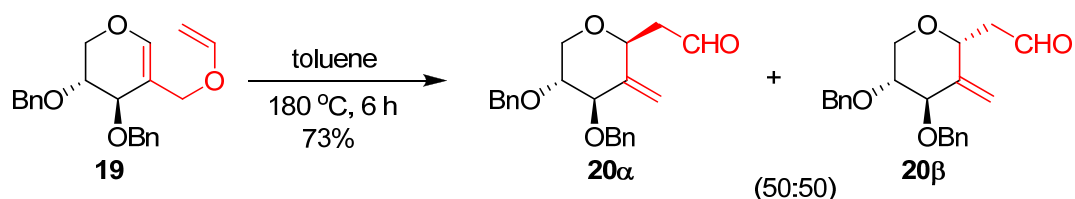


2-Hydroxymethyl-3,4-di-O-benzyl-D-xylal: ^1H (400 MHz, CDCl_3): δ 7.30-7.39 (m, 10H), 6.61 (s, 1H), 4.66 (d, 1H, $J = 12.4$ Hz), 4.63 (d, 2H, $J = 11.2$ Hz), 4.57 (d, 1H, $J = 11.6$ Hz), 4.15-4.10 (m, 1H), 4.08 (d, 1H, $J = 12$ Hz), 3.97-4.01 (m, 2H), 3.90 (dd, 1H, $J = 1.6$ Hz, $J = 12$ Hz), 3.71

(m, 1H), 2.10 (bs, 1H). ^{13}C (125 MHz, CDCl_3): δ 145.0, 137.8, 137.6, 128.4, 128.2, 127.9, 127.8, 127.7, 111.3, 71.7, 71.6, 70.9, 70.6, 63.4, 62.4.

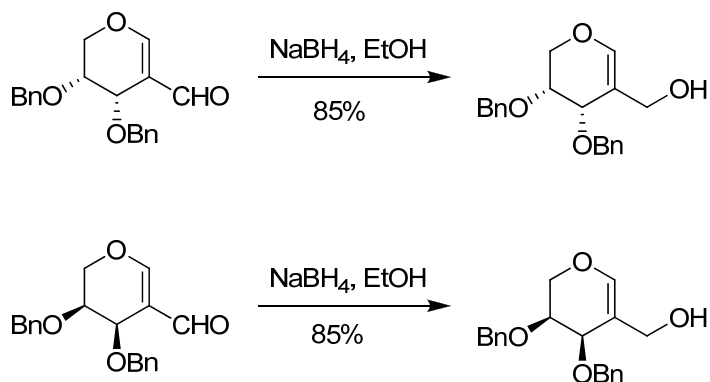


Compound 19: ^1H (400 MHz, CDCl_3): δ 7.24-7.29 (m, 10H), 6.60 (s, 1H), 6.39 (dd, 1H, $J = 6.8\text{ Hz}$, 14 Hz), 4.57 (bs, 2H), 4.54 (d, 1H, $J = 11.6\text{ Hz}$), 4.47 (d, 1H, $J = 11.6\text{ Hz}$), 4.25 (d, 1H, $J = 7.2\text{ Hz}$), 4.17 (d, 1H, $J = 14.4\text{ Hz}$), 4.12 (d, 1H, $J = 11.6\text{ Hz}$), 3.96-3.98 (m, 2H), 3.86-3.93 (m, 2H), 3.64 (s, 1H). ^{13}C (100 MHz, CDCl_3): δ 151.4, 146.1, 138.1, 137.9, 128.5, 128.5, 128.0, 127.9, 127.8, 108.0, 87.0, 71.9, 71.7, 71.0, 69.5, 67.2, 63.9. **Low-resolution MS** (EI): m/z : 352 (M^+), **HRMS** (ESI) calcd for $\text{C}_{22}\text{H}_{24}\text{O}_4 + \text{Na}$ 375.1573, found 375.1573.

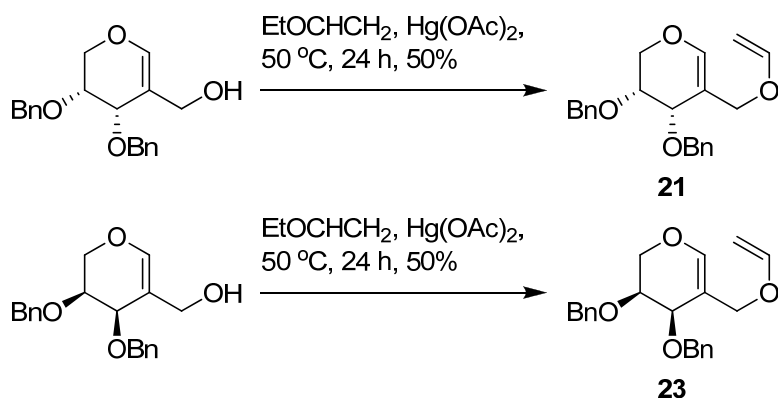


Compound 20 α : Not resolved in column chromatography and obtained along with **20 β** .

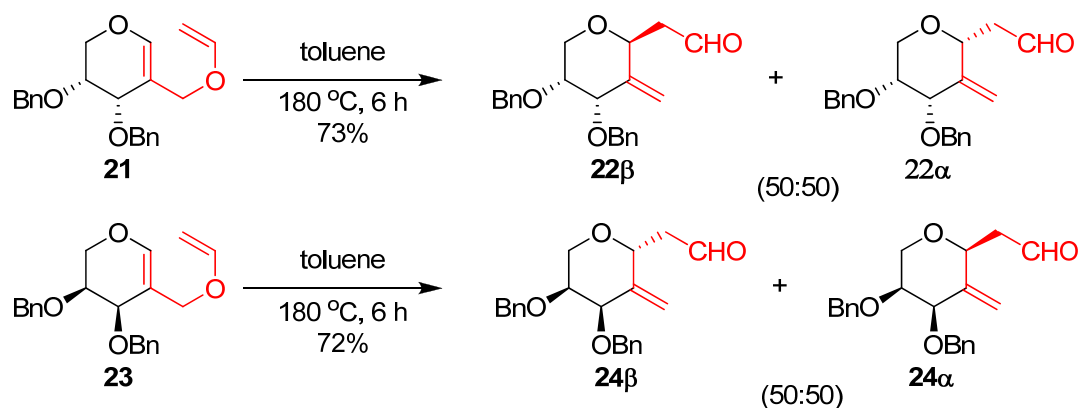
Compound 20 β : ^1H (500 MHz, CDCl_3): δ 9.84 (t, 1H, $J = 2\text{ Hz}$), 7.27-7.36 (m, 10H), 5.14 (s, 1H), 5.12 (s, 1H), 4.66 (dd, 1H, $J = 4.5\text{ Hz}$, $J = 8\text{ Hz}$), 4.55-4.67 (m, 3H), 4.33 (d, 1H, $J = 12\text{ Hz}$), 3.91-4.01 (m, 3H), 3.55-3.56 (m, 1H), 2.85 (ddd, 1H, $J = 2.5\text{ Hz}$, $J = 8.5\text{ Hz}$, $J = 16.5\text{ Hz}$), 2.74 (ddd, 1H, $J = 1.5\text{ Hz}$, $J = 4.5\text{ Hz}$, $J = 16.5\text{ Hz}$). ^{13}C (125 MHz, CDCl_3): δ 200.4, 142.9, 138.2, 128.4, 127.8, 109.6, 82.5, 79.2, 73.2, 73.1, 73.0, 67.4, 45.3. **Low-resolution MS** (EI): m/z : 352 (M^+), **HRMS** (ESI) calcd for $\text{C}_{22}\text{H}_{24}\text{O}_4 + \text{Na}$ 375.1573, found 375.1573.



2-Hydroxymethyl-3,4-di-O-benzyl-D-arabinal and 2-Hydroxymethyl-3,4-di-O-benzyl-L-arabinal: ^1H (400 MHz, CDCl_3): δ 7.26-7.37, (m, 10H), 6.41 (s, 1H), 4.94 (d, 1H, $J = 11.6$ Hz), 4.70 (bs, 2H), 4.65 (d, 1H, $J = 11.2$ Hz), 4.23 (d, 1H, $J = 2.8$ Hz), 3.92-4.03 (m, 4H), 3.78-3.82 (m, 1H). ^{13}C (100 MHz, CDCl_3): δ 144.6, 138.5, 137.9, 128.5, 128.4, 128.2, 127.8, 127.7, 127.5, 111.7, 74.1, 73.7, 71.5, 69.6, 62.7, 61.7.

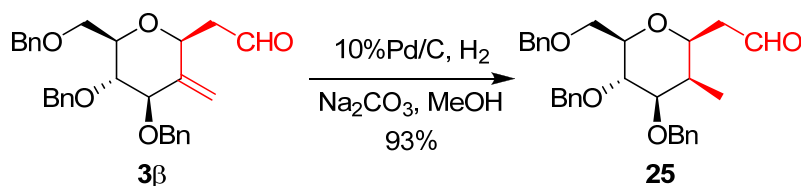


Compounds 21 and 23: ^1H (400 MHz, CDCl_3): δ 7.27-7.37, (m, 10H), 6.46 (s, 1H), 6.36 (dd, 1H, $J = 6.8$ Hz, $J = 14$ Hz), 4.91 (d, 1H, $J = 11.6$ Hz), 4.72 (d, 1H, $J = 12$ Hz), 4.68 (d, 1H, 11.2 Hz), 4.65 (d, 1H, $J = 11.6$ Hz), 4.17-4.35 (m, 3H), 4.93-4.06 (m, 4H), 3.80-3.85 (m, 1H). ^{13}C (100 MHz, CDCl_3): δ 151.3, 138.6, 137.9, 128.5, 128.3, 128.2, 127.9, 127.7, 127.6, 108.6, 87.2, 74.4, 74.0, 71.7, 68.7, 66.5, 62.9. **Low-resolution MS** (EI): m/z : 352 (M^+), **HRMS** (ESI) calcd for $\text{C}_{22}\text{H}_{24}\text{O}_4 + \text{Na}$ 375.1573, found 375.1573.



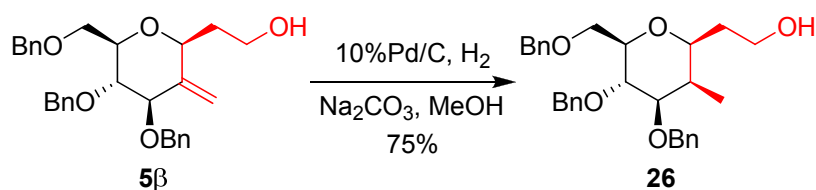
Compounds 22β and 24β: ^1H (500 MHz, CDCl_3): δ 9.79 (dd, 1H, $J = 2$ Hz, $J = 3$ Hz), 7.28-7.39 (m, 10H), 5.04 (s, 1H), 4.99 (s, 1H), 4.67 (d, 1H, $J = 12.5$ Hz), 4.60 (t, 1H, $J = 7$ Hz), 4.58 (d, 1H, $J = 12$ Hz), 4.49 (d, 1H, $J = 12$ Hz), 4.42 (d, 1H, $J = 12.5$ Hz), 4.21 (d, 1H, $J = 3$ Hz), 3.96 (t, 1H, $J = 11$ Hz), 3.83 (dd, 1H, $J = 5$ Hz, $J = 11$ Hz), 3.57 (ddd, 1H, $J = 3$ Hz, $J = 5$ Hz, $J = 10.5$ Hz), 2.67-2.70 (m, 2H). ^{13}C (125 MHz, CDCl_3): δ 200.7, 142.8, 138.0, 128.4, 128.3, 127.9, 127.7, 127.6, 127.5, 113.7, 76.9, 76.0, 70.7, 69.4, 69.2, 65.0, 44.8. **Low-resolution MS** (EI): m/z : 352 (M^+), **HRMS** (ESI) calcd for $\text{C}_{22}\text{H}_{24}\text{O}_4 + \text{Na}$ 375.1573, found 375.1573.

Compound 22α and 24α: ^1H (400 MHz, CDCl_3): δ 9.81 (t, 1H, $J = 2$ Hz), 7.27-7.35 (m, 10H), 5.33 (s, 1H), 5.11 (s, 1H), 4.68 (s, 2H), 4.64 (d, 1H, $J = 12.4$ Hz), 4.49 (d, 1H, $J = 12.4$ Hz), 4.44 (dd, 1H, $J = 4.8$ Hz, $J = 8$ Hz), 4.06-4.07 (m, 1H), 4.03 (dd, 1H, $J = 5.2$ Hz, $J = 12.4$ Hz), 3.70-3.72 (m, 1H), 3.56 (dd, 1H, $J = 2.4$ Hz, $J = 12$ Hz), 3.07 (ddd, 2H, $J = 8.4$ Hz, $J = 16.8$ Hz), 2.81 (ddd, 1H, $J = 2$ Hz, $J = 8.4$ Hz, $J = 16.8$ Hz). ^{13}C (100 MHz, CDCl_3): δ 200.7, 141.8, 138.2, 137.9, 128.4, 128.3, 127.9, 127.8, 127.8, 127.6, 127.5, 111.7, 78.1, 74.5, 73.0, 71.2, 70.5, 64.8, 45.5. **Low-resolution MS** (EI): m/z : 352 (M^+), **HRMS** (ESI) calcd for $\text{C}_{22}\text{H}_{24}\text{O}_4 + \text{Na}$ 375.1573, found 375.1573.

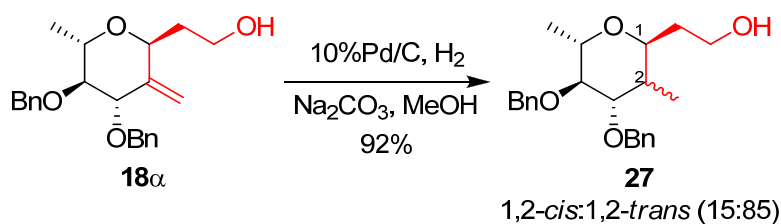


Compound 25: ^1H (400 MHz, CDCl_3): δ 9.82 (t, 1H, $J = 1.6$ Hz), 7.19-7.41 (m, 15H), 4.90 (d, 1H, $J = 10.8$ Hz), 4.70 (d, 1H, $J = 11.6$ Hz), 4.57 (d, 1H, $J = 11.6$ Hz), 4.56 (d, 1H, $J = 11.6$

Hz), 4.53 (d, 1H, $J = 12.0$ Hz), 4.49 (d, 1H, $J = 12.0$ Hz), 4.01-4.04 (m, 1H), 3.66-3.76 (m, 4H), 3.46 (dt, 1H, $J = 2.8$ Hz, $J = 9.6$ Hz), 2.77 (dd, 1H, $J = 8.8$ Hz, $J = 16.0$ Hz), 2.50 (dd, 1H, $J = 4.4$ Hz, $J = 16.0$ Hz), 2.25-2.28 (m, 1H), 1.05 (d, 3H, $J = 7.2$ Hz). **^{13}C (100 MHz, CDCl_3)**: δ 200.8, 138.5, 138.4, 138.3, 128.4, 128.3, 128.0, 127.9, 127.6, 83.8, 79.7, 75.1, 74.0, 73.4, 73.3, 70.8, 69.3, 46.4, 35.9, 6.5. **Low-resolution MS** (EI): m/z : 474 (M^+). **HRMS** (ESI) calcd for $\text{C}_{30}\text{H}_{34}\text{O}_5+\text{Na}$ 497.2304, Found: 497.2304.

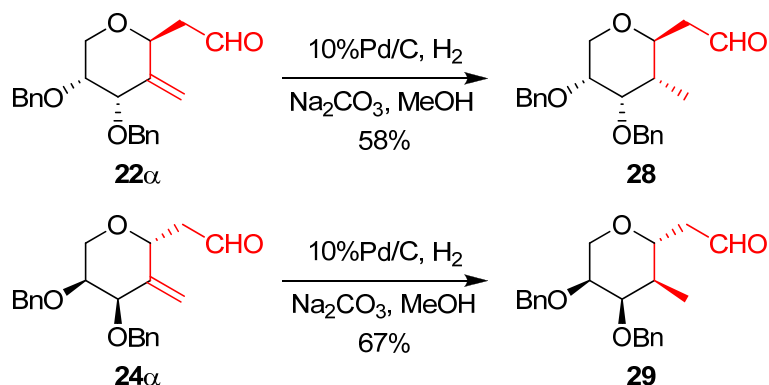


Compound 26: **^1H (500 MHz, CDCl_3)**: δ 7.20-7.40 (m, 15H), 4.89 (d, 1H, $J = 11.0$ Hz), 4.69 (d, 1H, $J = 11.5$ Hz), 4.59 (d, 1H, $J = 12.0$ Hz), 4.55 (d, 1H, $J = 11.5$ Hz), 4.54 (d, 1H, $J = 12.0$ Hz), 4.50 (d, 1H, $J = 11.0$ Hz), 3.81-3.83 (m, 2H), 3.65-3.72 (m, 3H), 3.63 (dd, 1H, $J = 6.0$ Hz, $J = 11.5$ Hz), 3.57 (t, 1H, $J = 9.5$ Hz), 3.47 (ddd, 1H, $J = 2.0$ Hz, $J = 6.0$ Hz, $J = 9.5$ Hz), 2.66 (bs, 1H), 2.17-2.20 (m, 1H), 2.01-2.06 (m, 1H), 1.53-1.56 (m, 1H), 1.05 (d, 3H, $J = 7.0$ Hz). **^{13}C (100 MHz, CDCl_3)**: δ 138.5, 138.4, 138.2, 128.4, 128.3, 128.3, 128.0, 127.7, 127.6, 127.5, 127.5, 83.9, 79.3, 78.9, 75.0, 74.5, 73.3, 70.6, 69.7, 61.9, 36.6, 34.5, 6.6. **Low-resolution MS** (EI): m/z : 476 (M^+). **HRMS** (ESI) calcd for $\text{C}_{30}\text{H}_{36}\text{O}_5+\text{Na}$ 499.2461, Found: 499.2461.



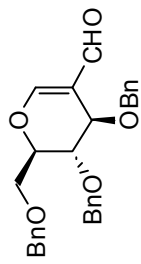
Compound 27 (for 1,2-*trans* compound): **^1H (400 MHz, CDCl_3)**: δ 7.28-7.37 (m, 10H), 4.4.72 (d, 1H, $J = 11.6$ Hz), 4.59 (d, 1H, $J = 11.6$ Hz), 4.58 (d, 1H, $J = 12.0$ Hz), 4.53 (d, 1H, $J = 12.0$ Hz), 3.85-3.95 (m, 2H), 3.78 (t, 2H, $J = 6.0$ Hz), 3.66 (dd, 1H, $J = 4.4$ Hz, $J = 5.6$ Hz), 3.35 (t, 1H, $J = 5.6$ Hz), 2.07-2.11 (m, 1H), 1.96-1.99 (m, 1H), 1.65-1.70 (m, 1H), 1.35 (d, 3H, $J = 6.8$

Hz), 1.05 (d, 1H, $J = 7.2$ Hz). ^{13}C (100 MHz, CDCl_3): δ 138.4, 138.4, 128.5, 128.4, 128.3, 127.9, 127.8, 127.7, 78.9, 77.8, 74.2, 73.3, 71.6, 69.8, 61.4, 35.6, 33.3, 17.8, 13.5. **Low-resolution MS** (EI): m/z : 370 (M^+), **HRMS** (ESI) calcd for $\text{C}_{23}\text{H}_{30}\text{O}_4+\text{Na}$ 393.2042, found 393.2046.

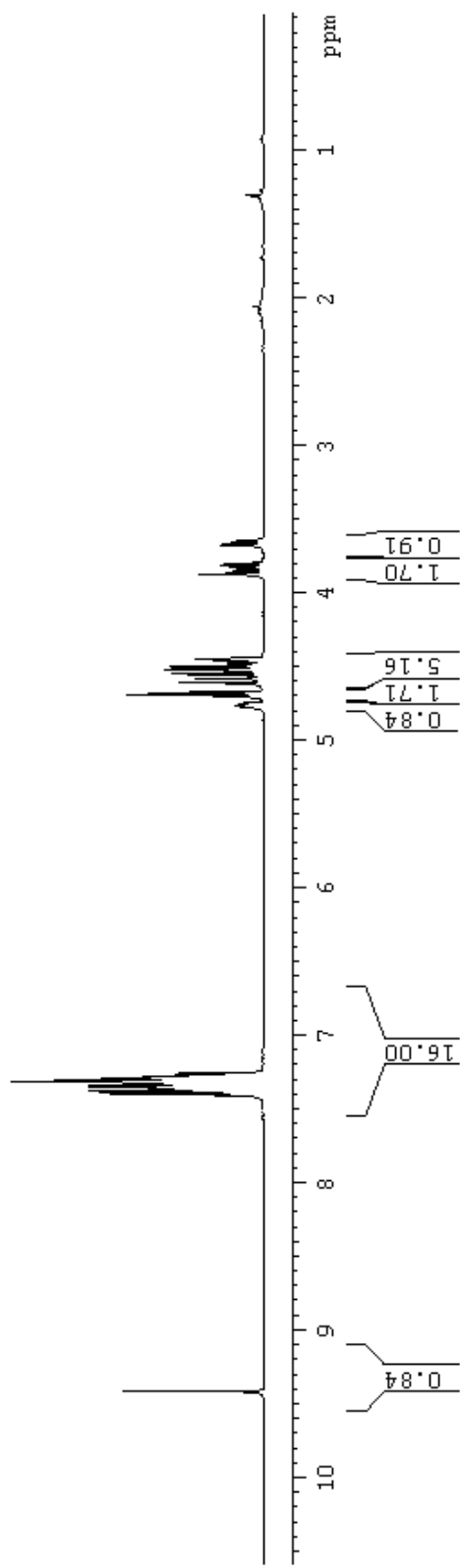


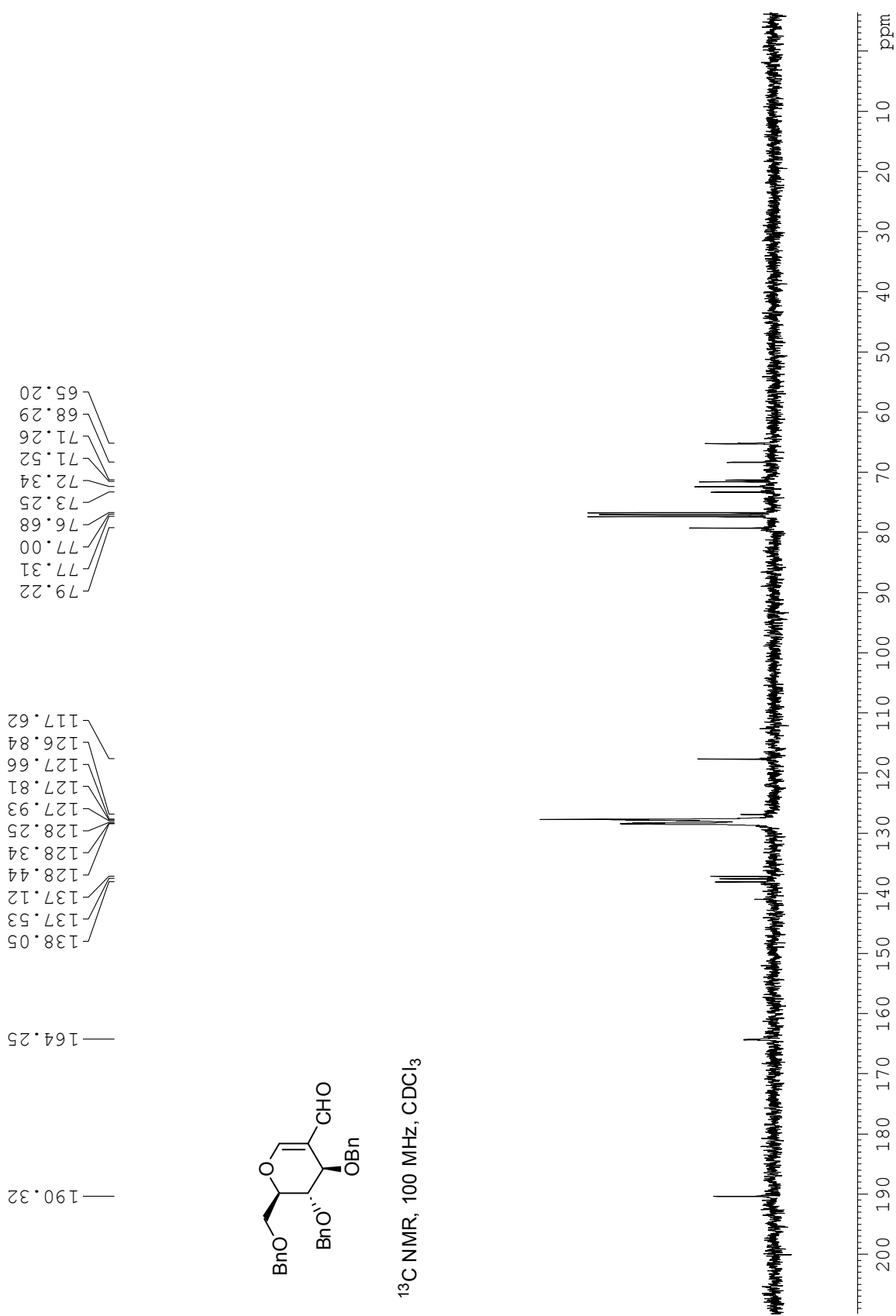
Compounds 28 and 29: ^1H (500 MHz, CDCl_3): δ 9.76 (dd, 1H, $J = 1.5$ Hz, $J = 4.0$ Hz), 7.29-7.40 (m, 10H), 5.03 (d, 1H, $J = 11.5$ Hz), 4.60-4.65 (m, 3H), 3.99 (td, 1H, $J = 3.0$ Hz, $J = 9.5$ Hz), 3.79-3.85 (m, 3H), 3.59 (ddd, 1H, $J = 2.5$ Hz, $J = 7.0$ Hz, $J = 9.0$ Hz), 2.54 (ddd, 1H, $J = 1.5$ Hz, $J = 3.5$ Hz, $J = 15.5$ Hz), 2.32 (ddd, 1H, $J = 3.5$ Hz, $J = 9.5$ Hz, $J = 15.5$ Hz), 1.58-1.62 (m, 1H), 0.94 (d, 3H, $J = 7.0$ Hz). ^{13}C (125 MHz, CDCl_3): δ 201.8, 139.1, 138.4, 128.5, 128.4, 128.2, 127.8, 127.7, 127.5, 127.4, 127.3, 77.6, 74.7, 72.7, 71.3, 64.5, 46.8, 40.2, 14.0. **Low-resolution MS** (EI): m/z : 354 (M^+), **HRMS** (ESI) calcd for $\text{C}_{22}\text{H}_{26}\text{O}_4+\text{Na}$ 377.1729, found 377.1729.

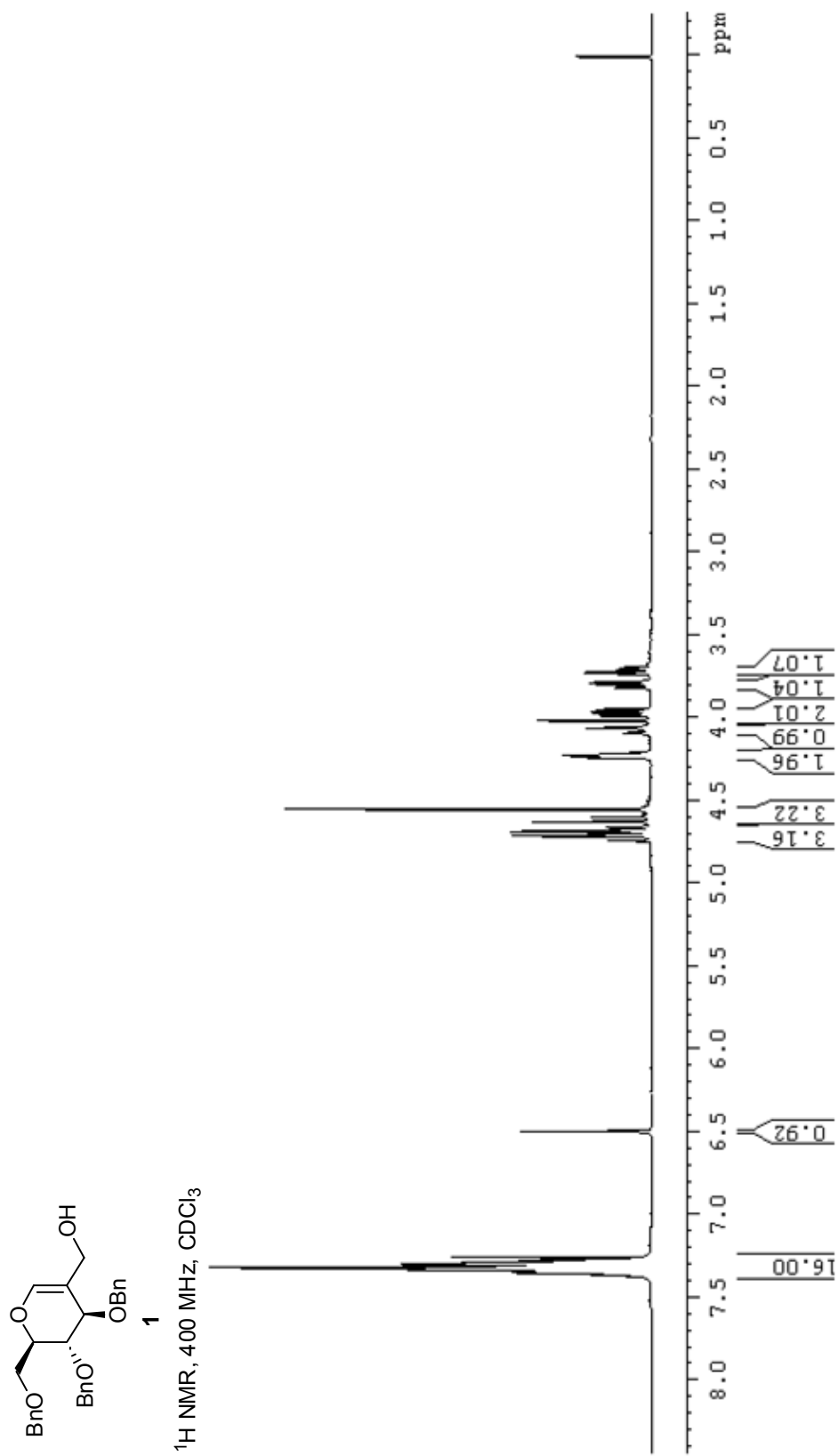
4. NMR spectra of Compounds

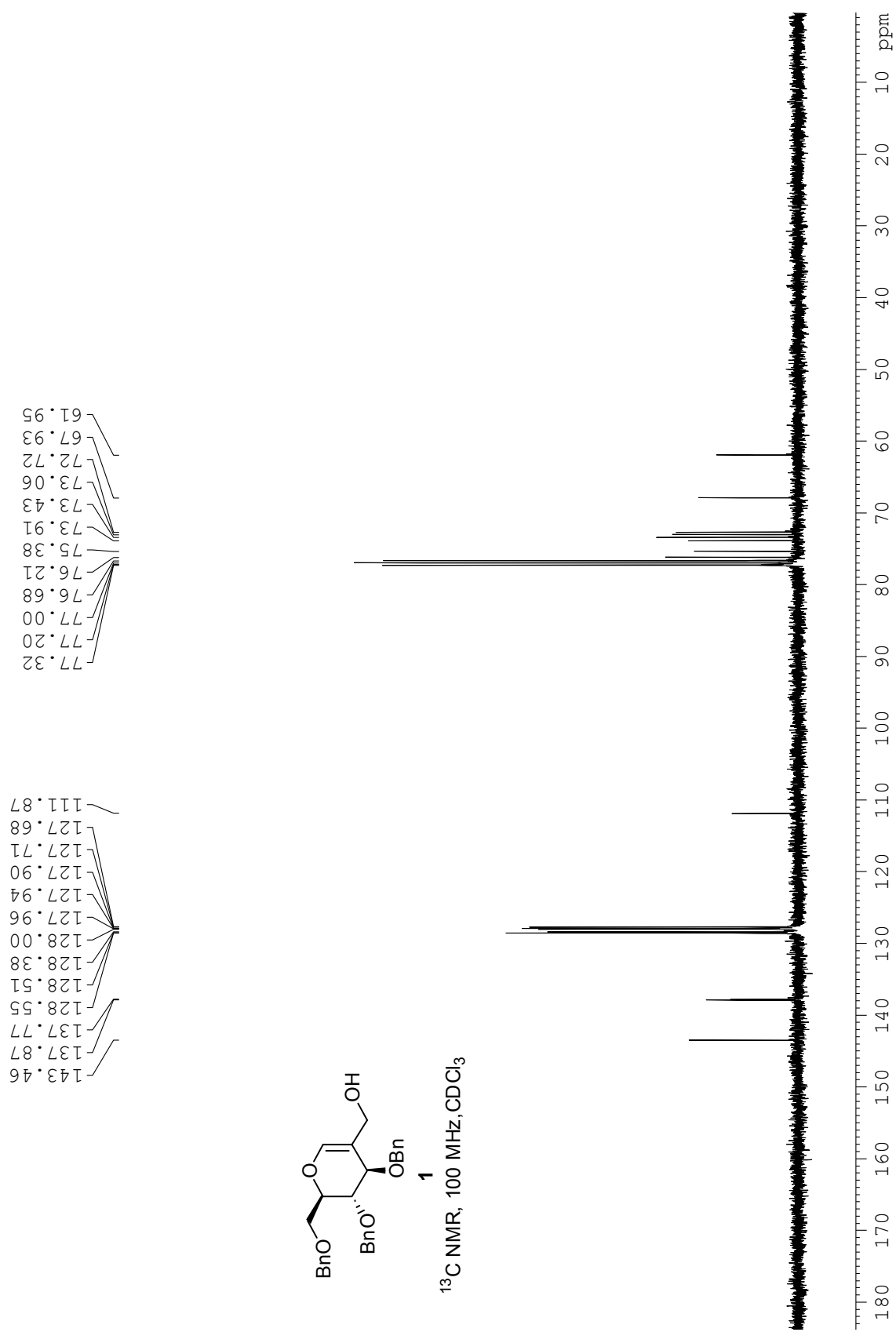


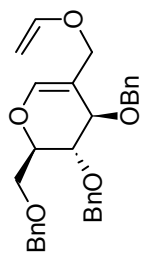
^1H NMR, 400 MHz, CDCl_3





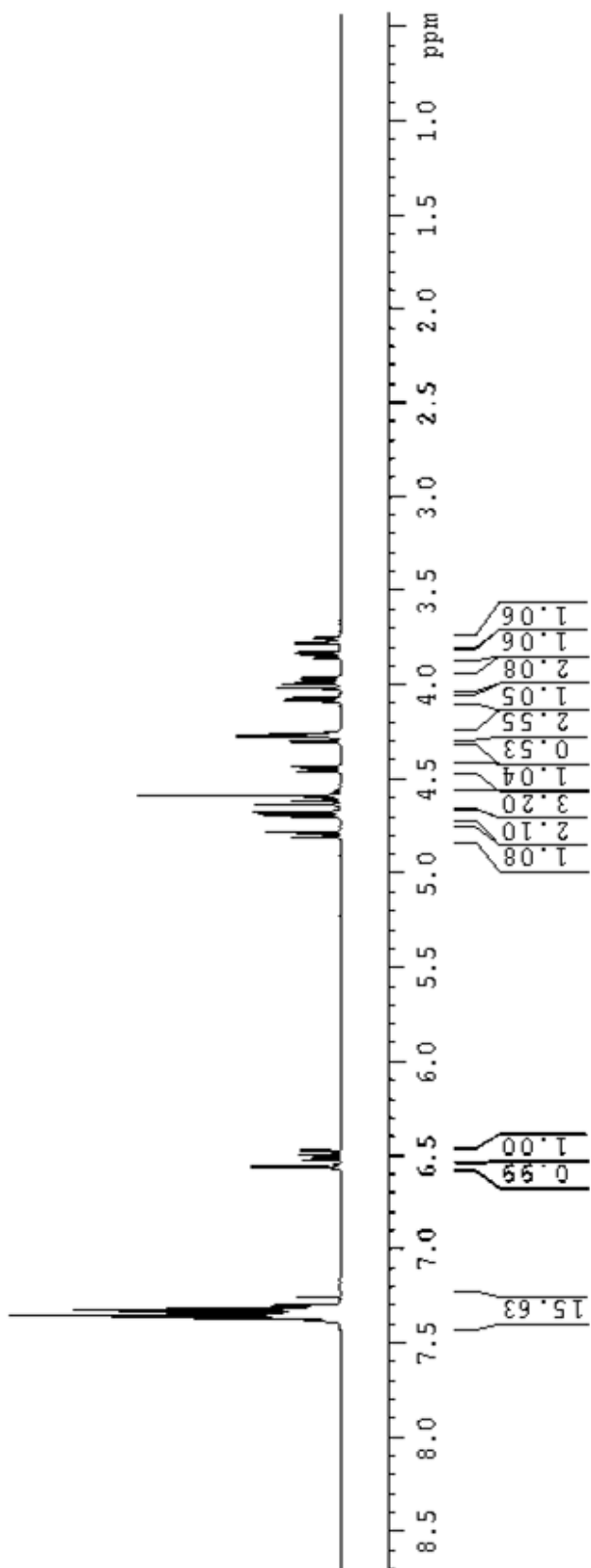


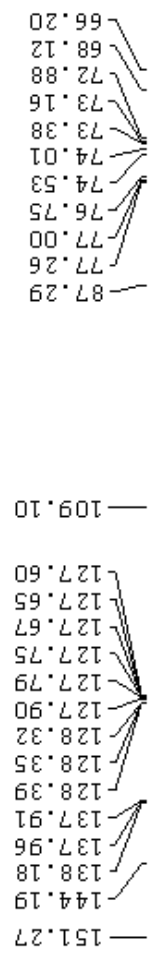




2

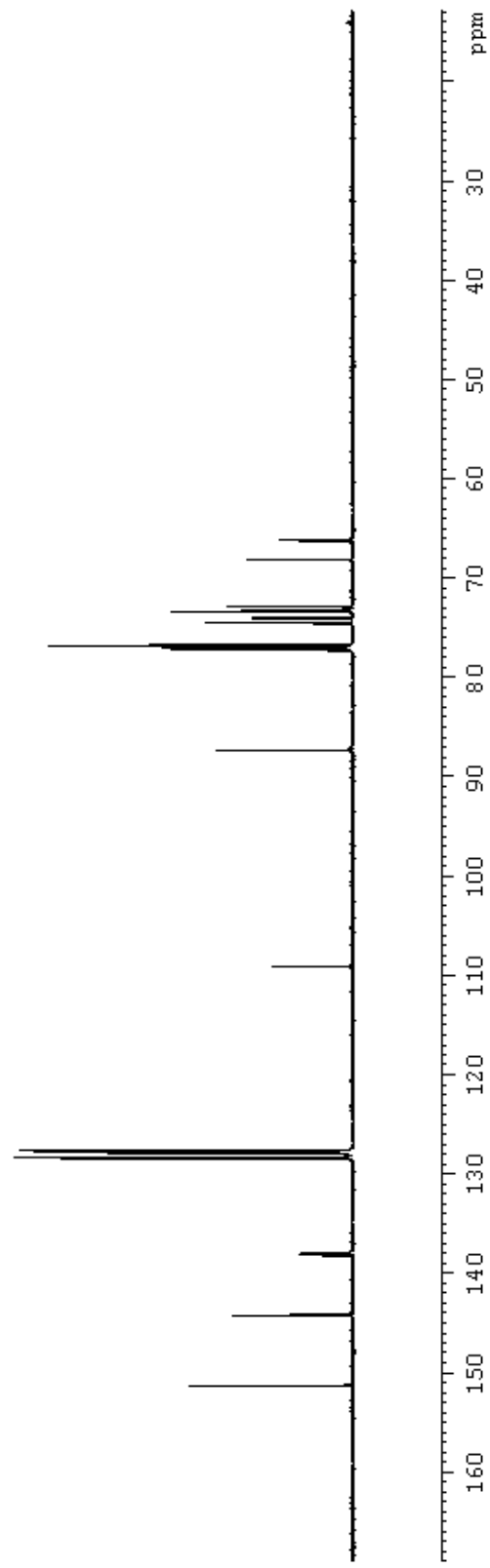
¹H NMR, 500 MHz, CDCl₃

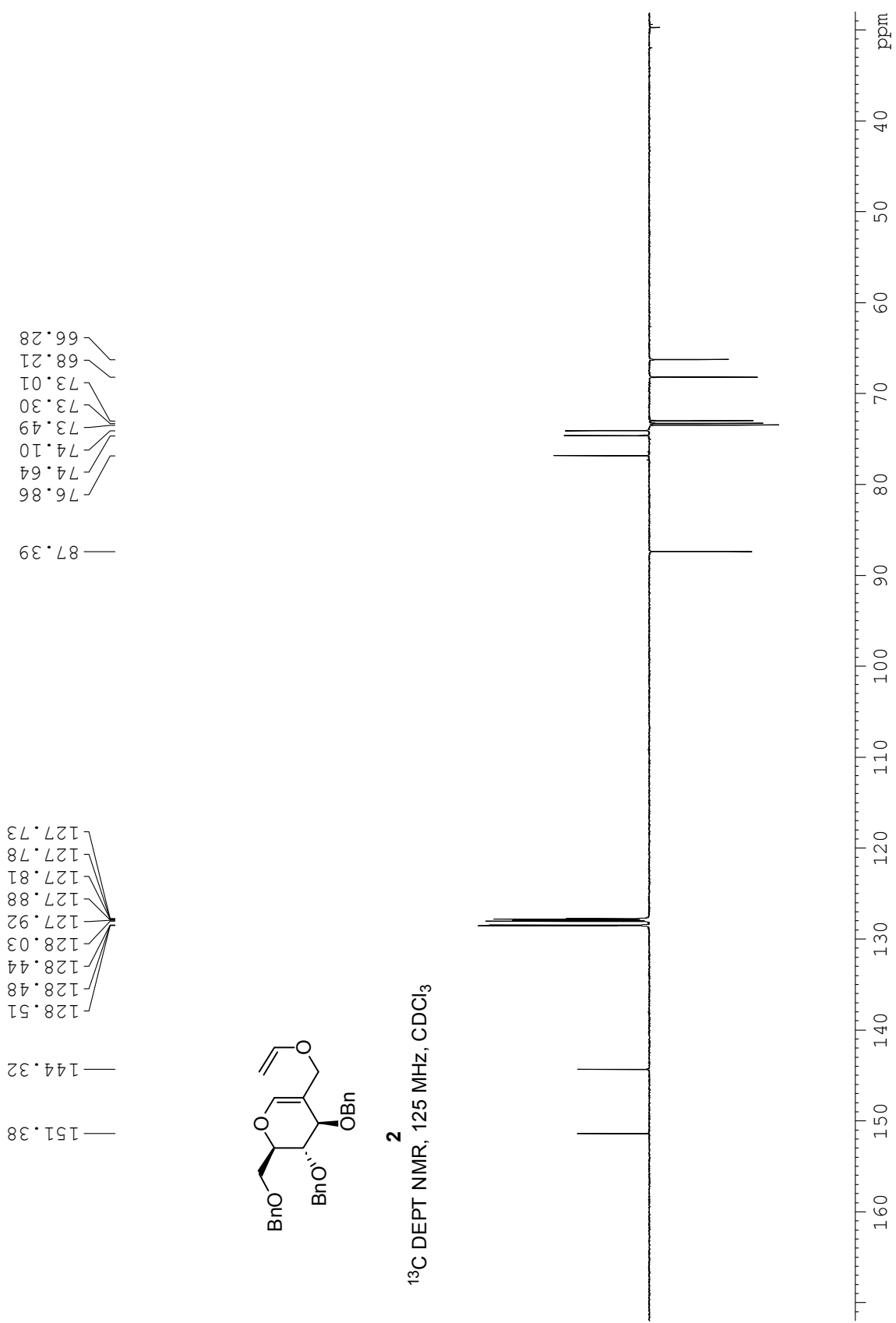


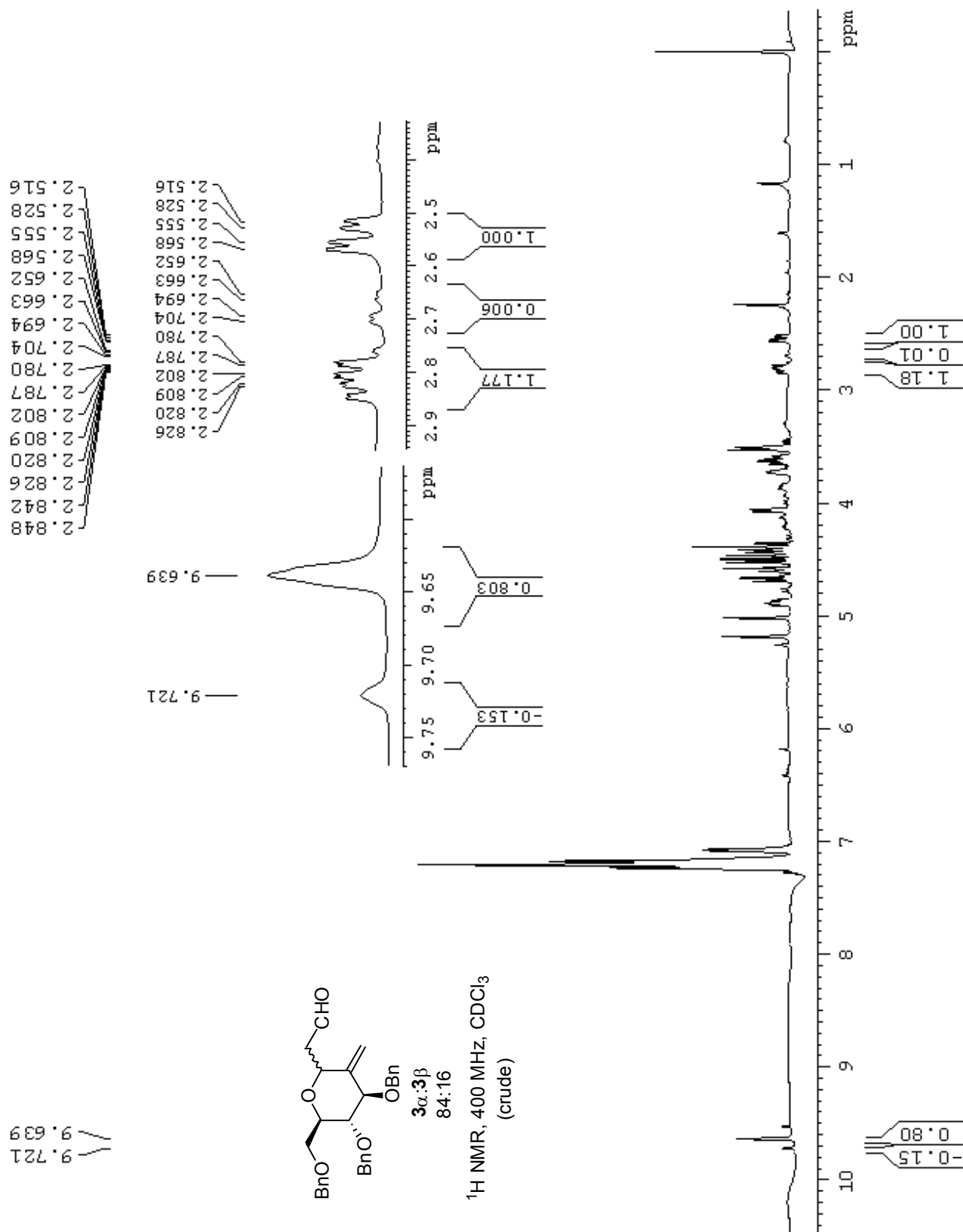


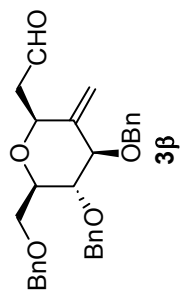
2

^{13}C NMR, 125 MHz, CDCl_3

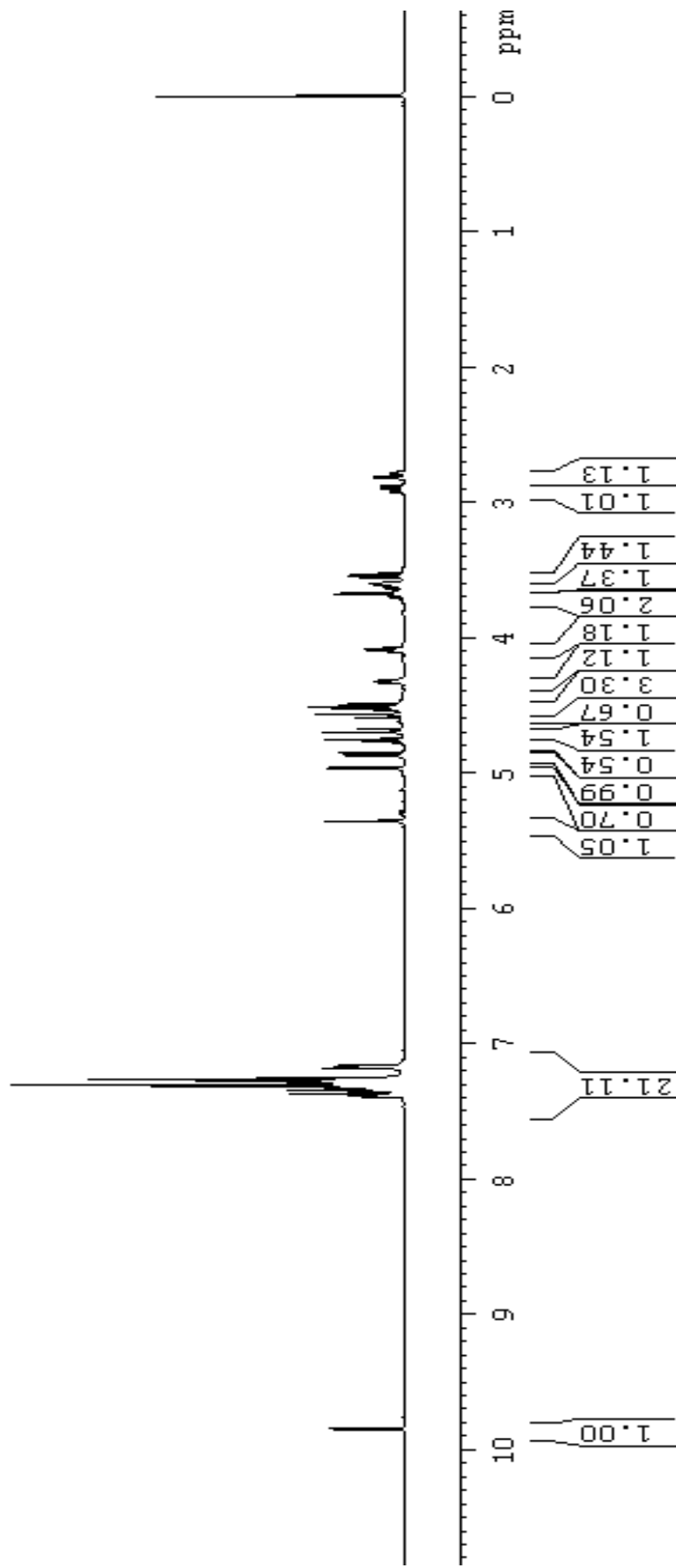


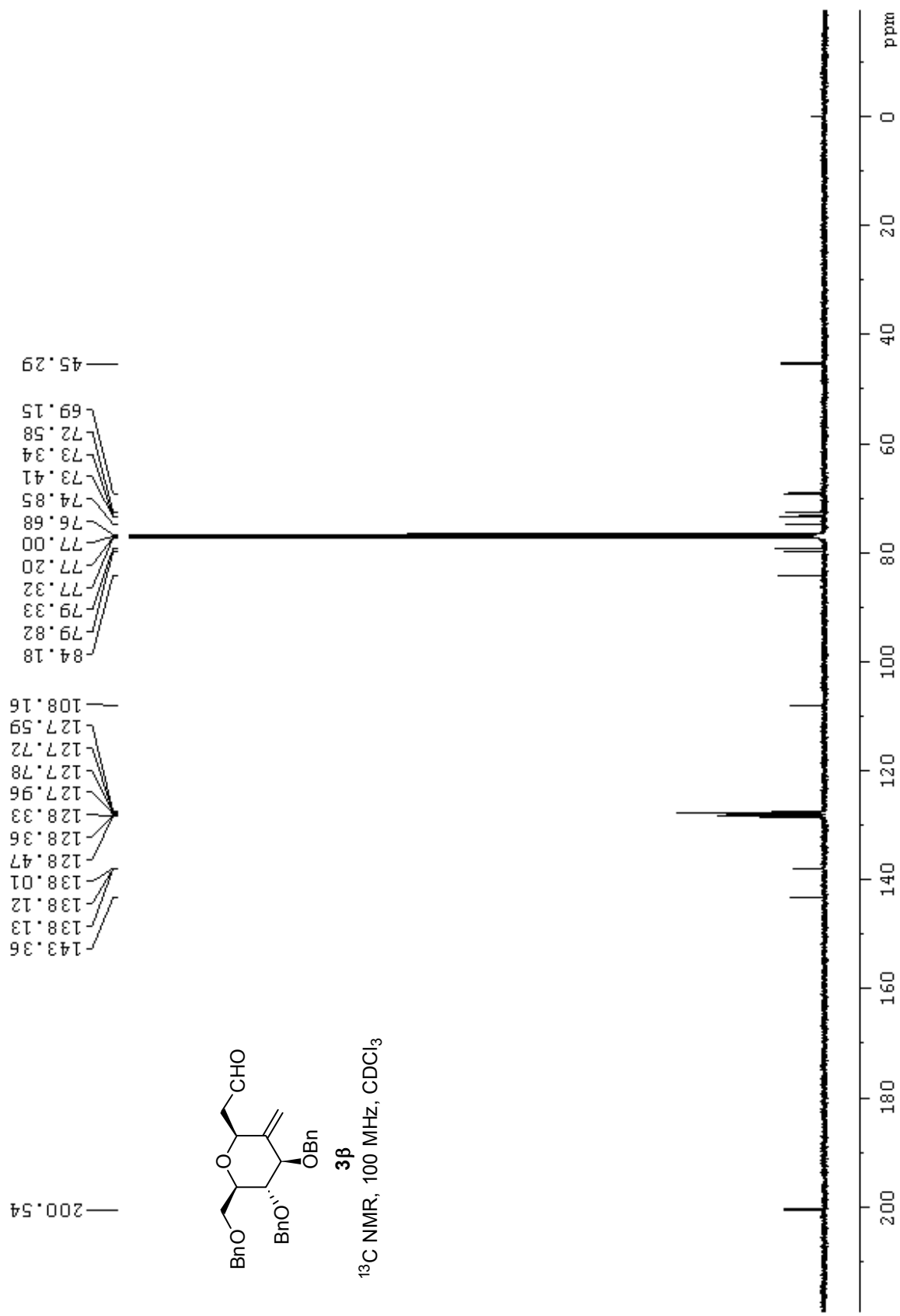


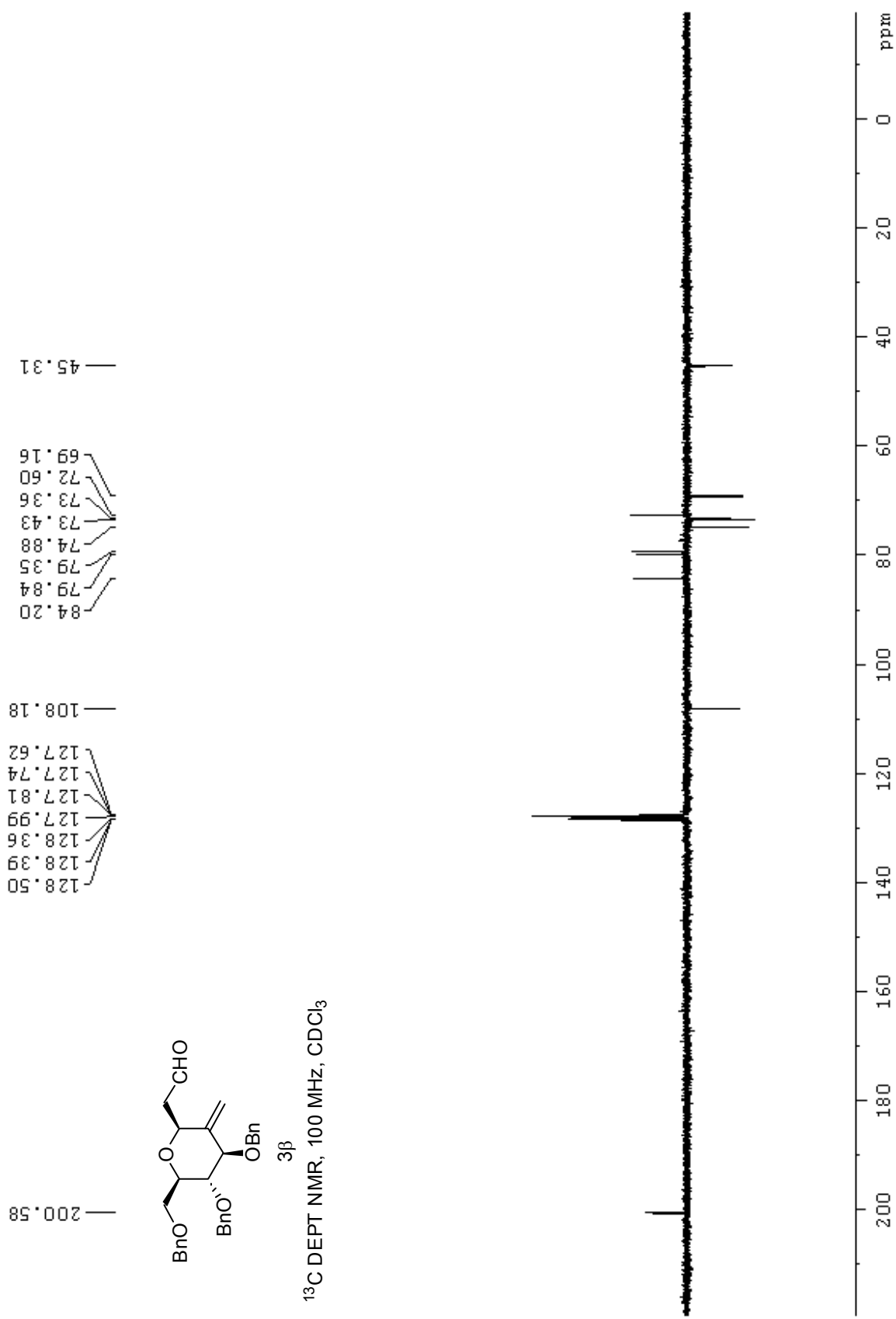


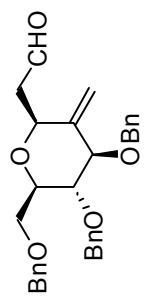


^1H NMR, 500 MHz, CDCl_3

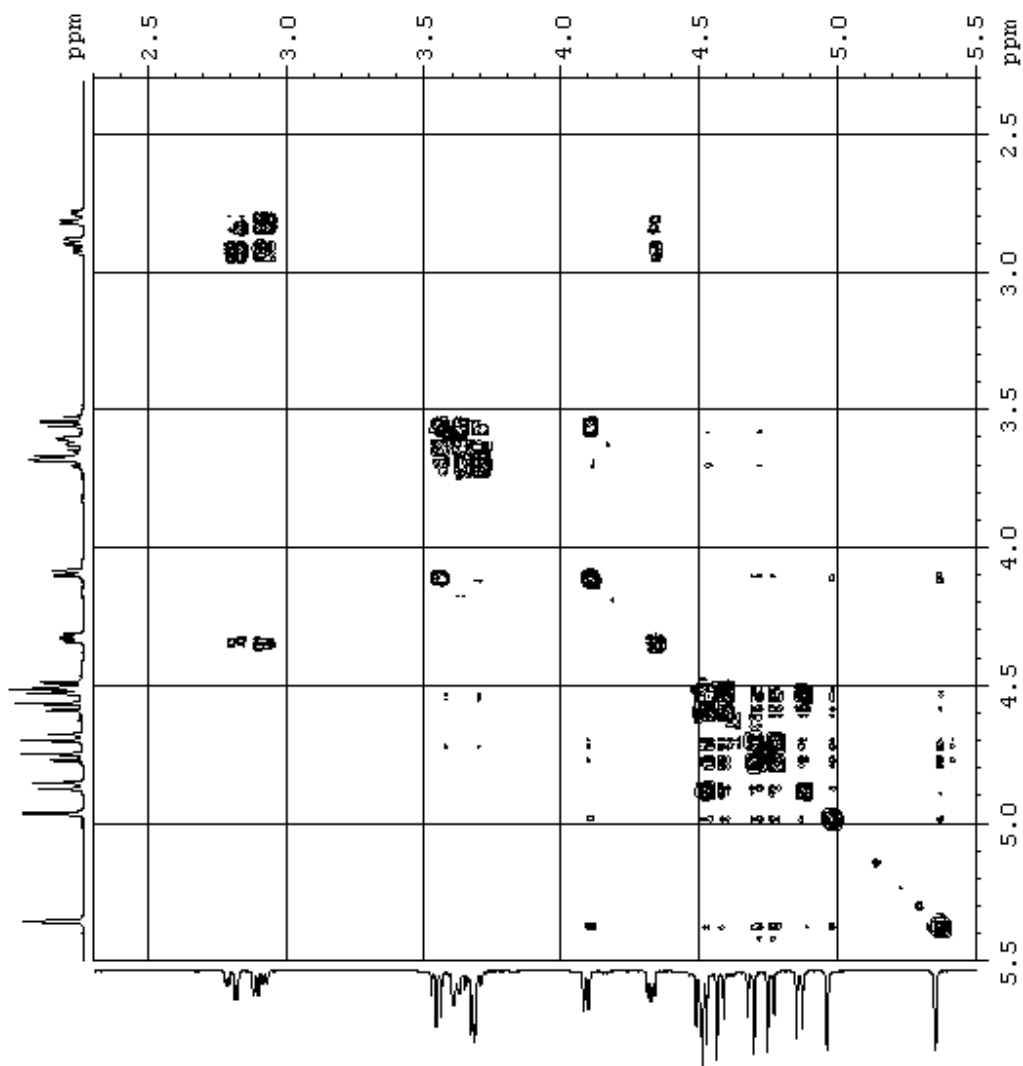


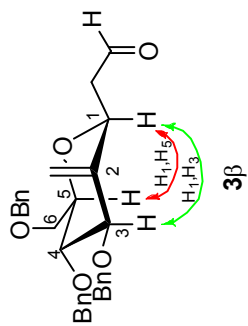
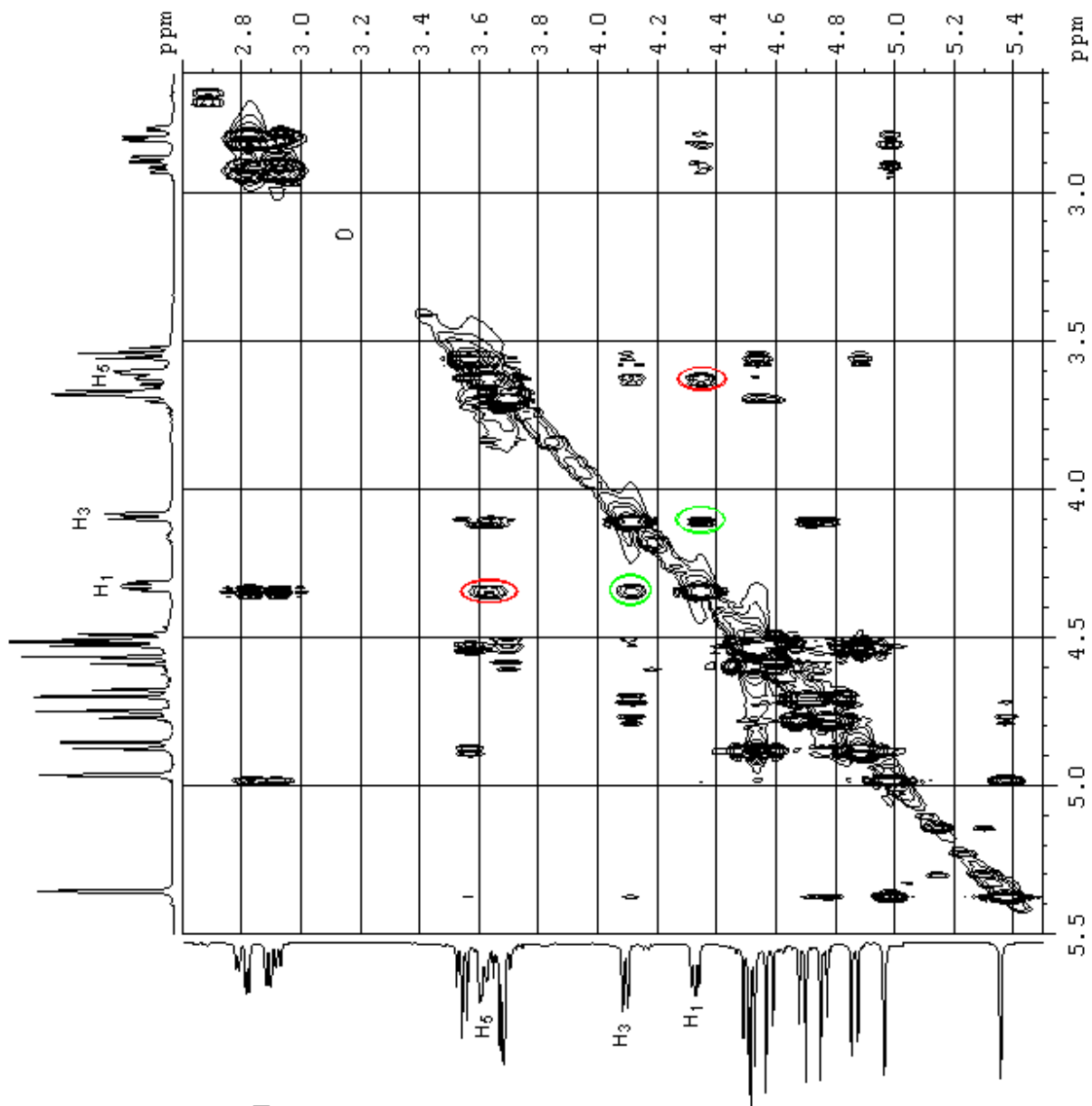




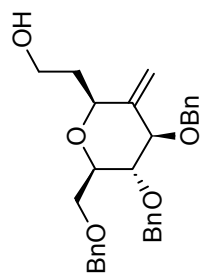


$^1\text{H-}^1\text{H}$ COSY, 500M Hz, CDCl_3



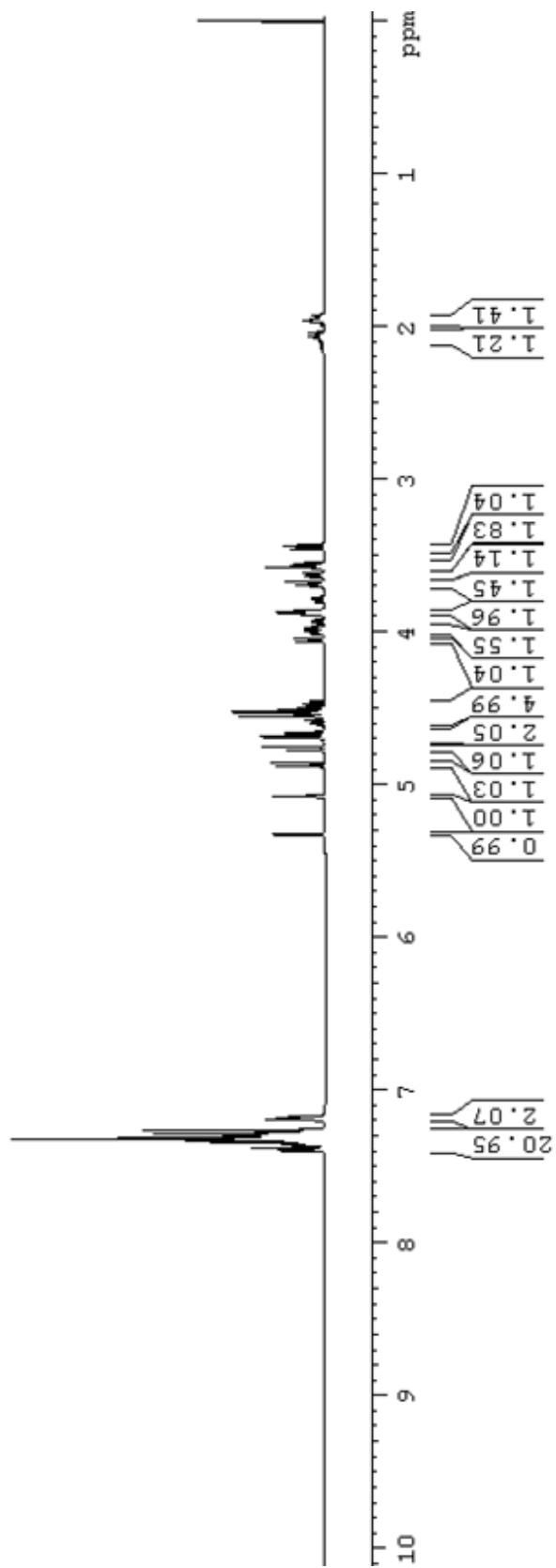


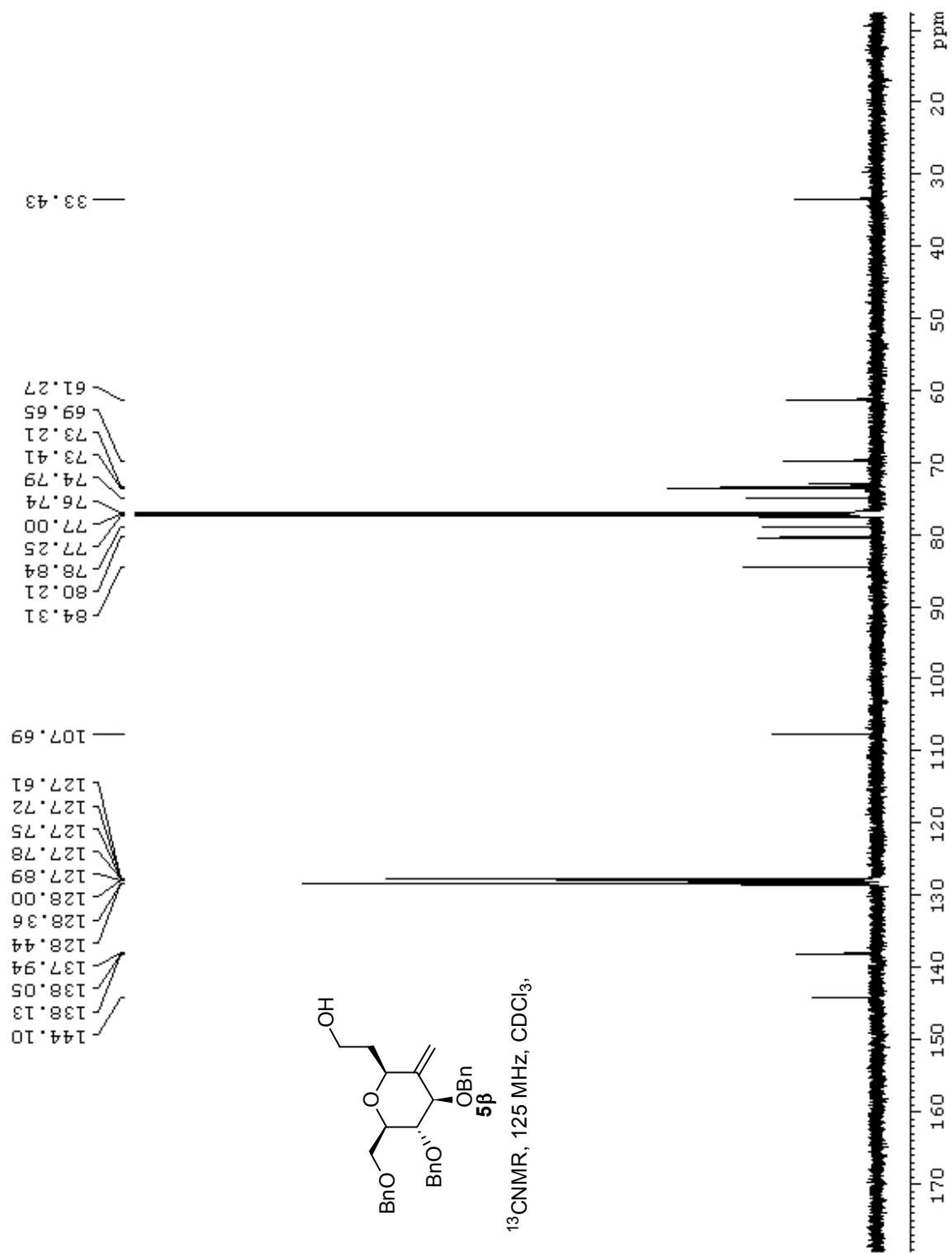
^1H - ^1H NOESY, 500 MHz

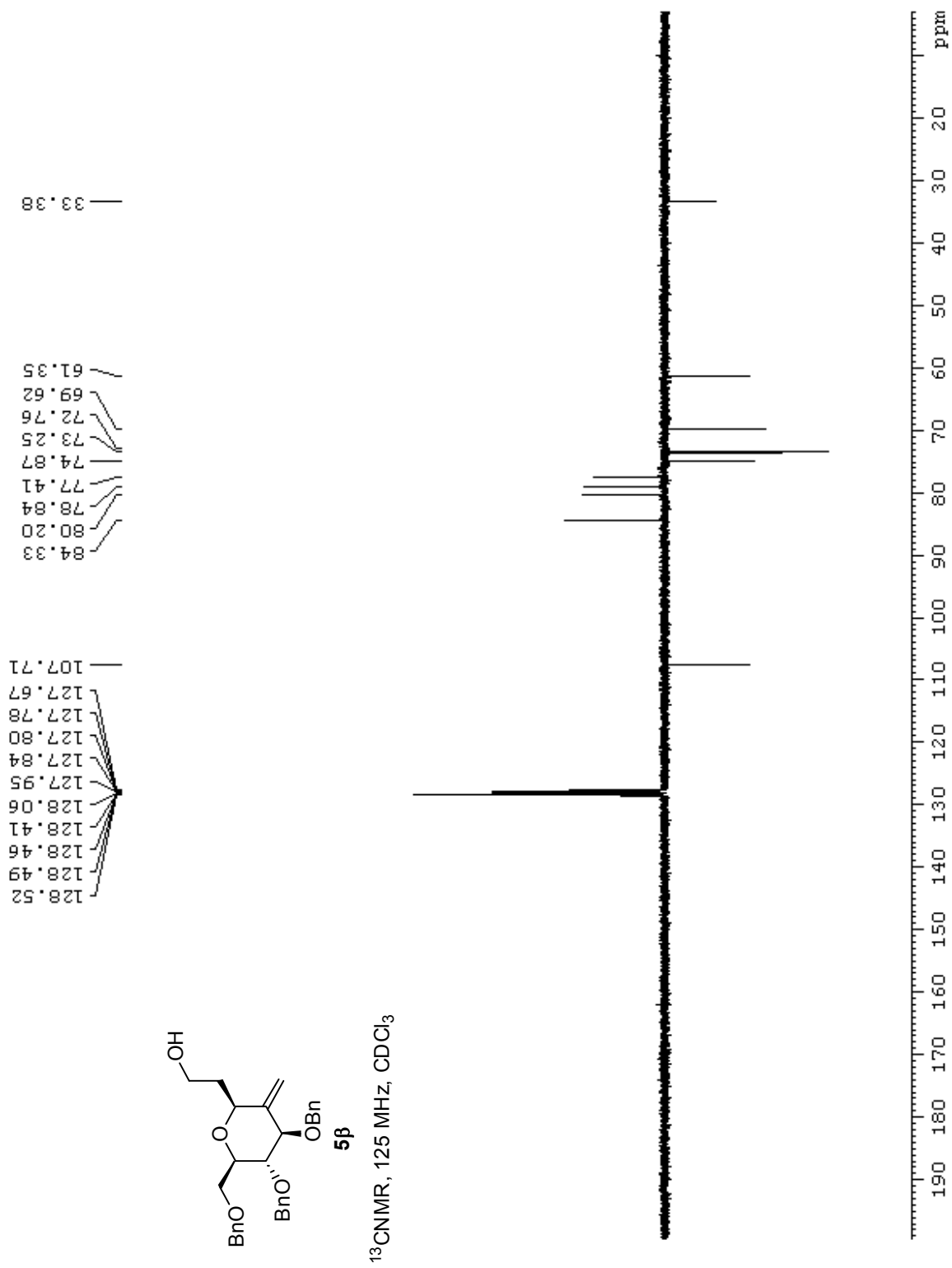


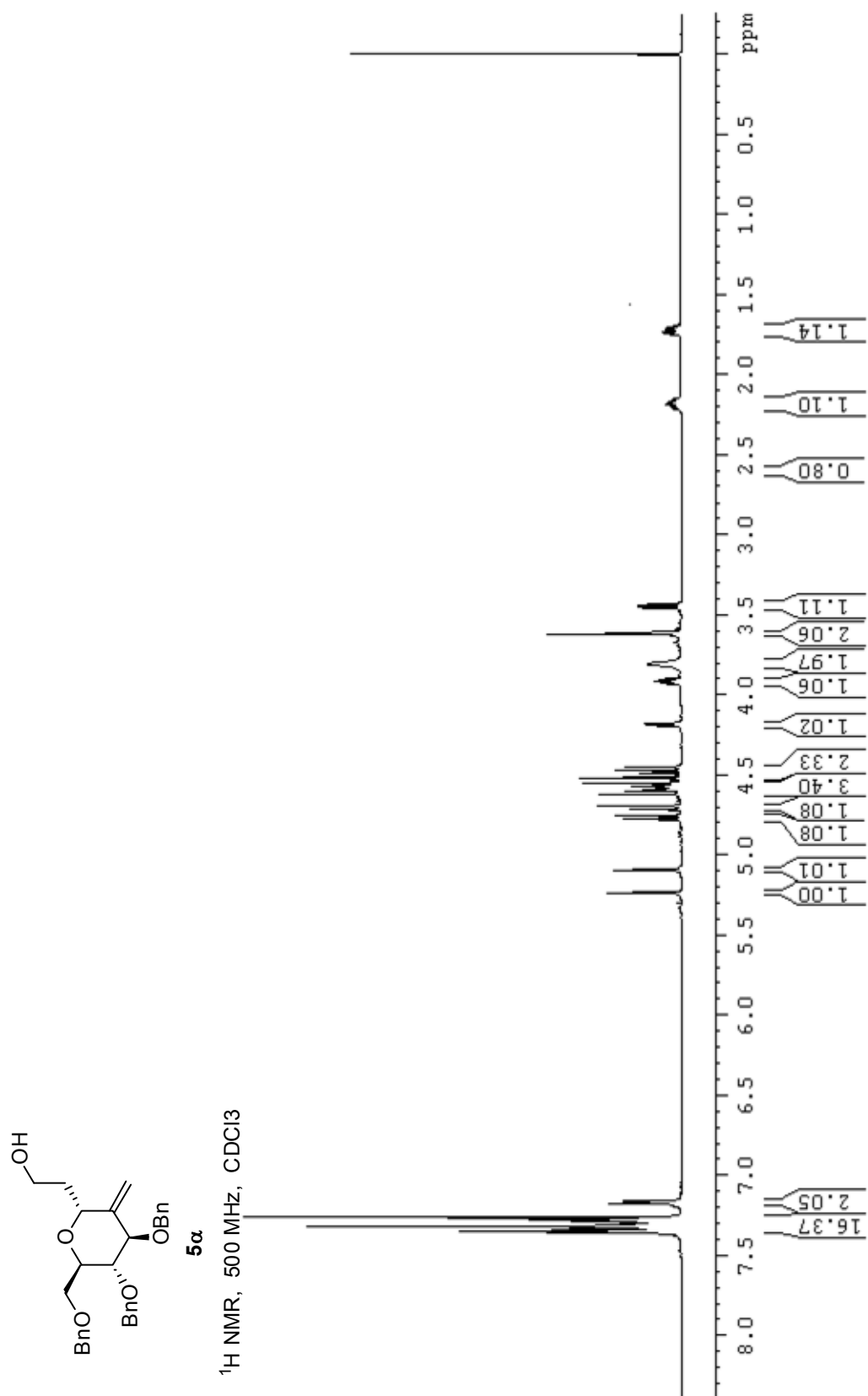
5 β

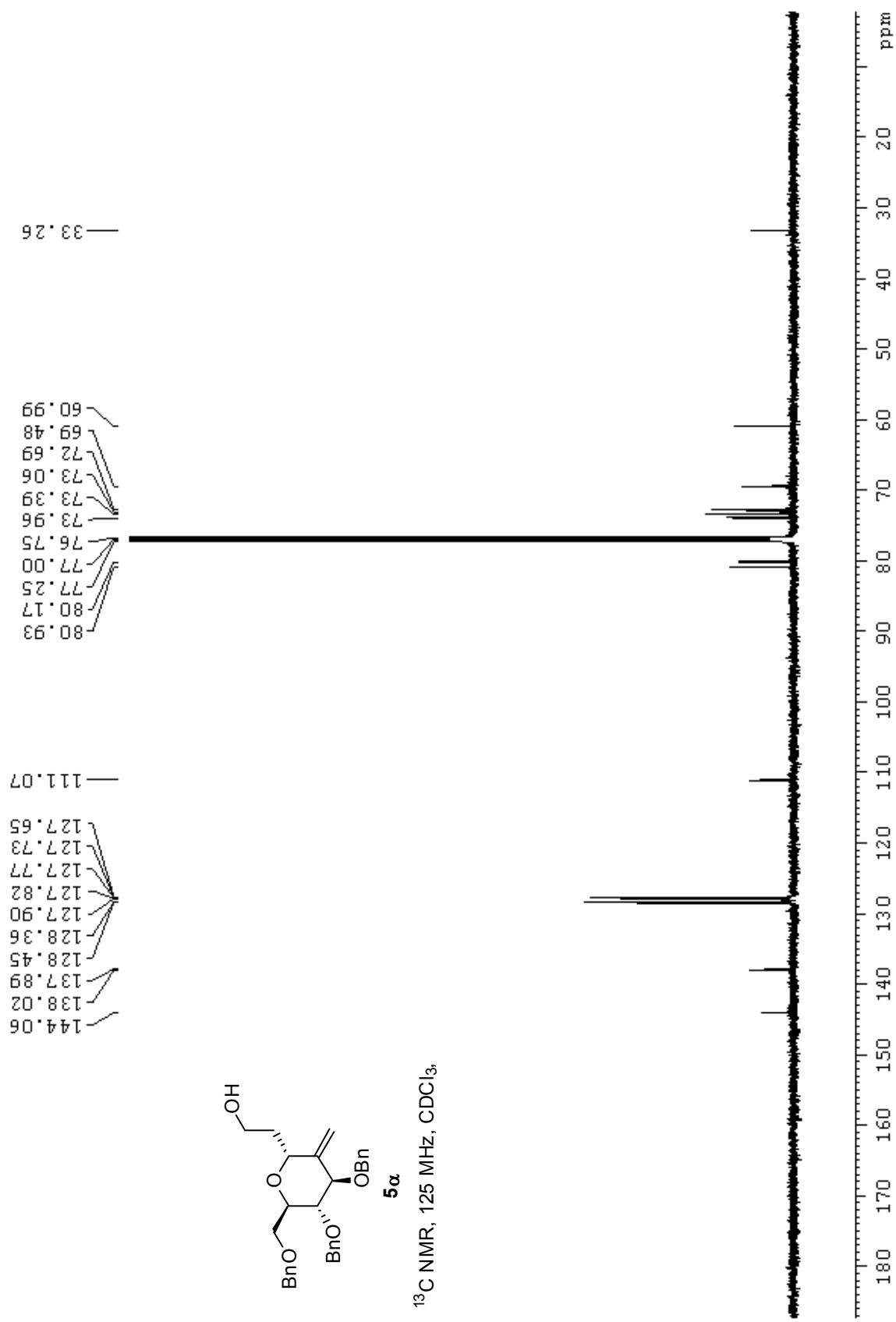
^1H NMR, 500 MHz, CDCl_3

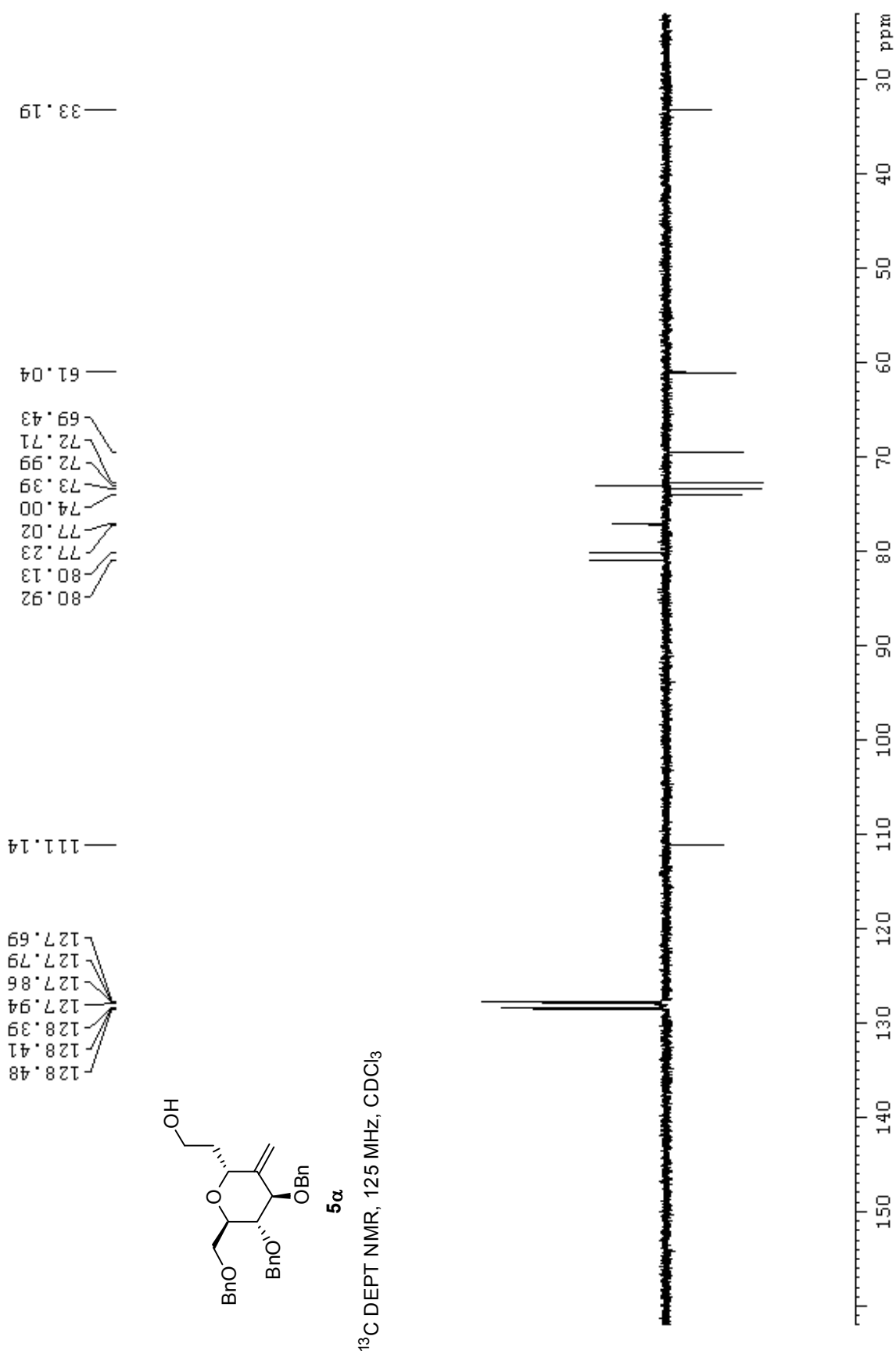


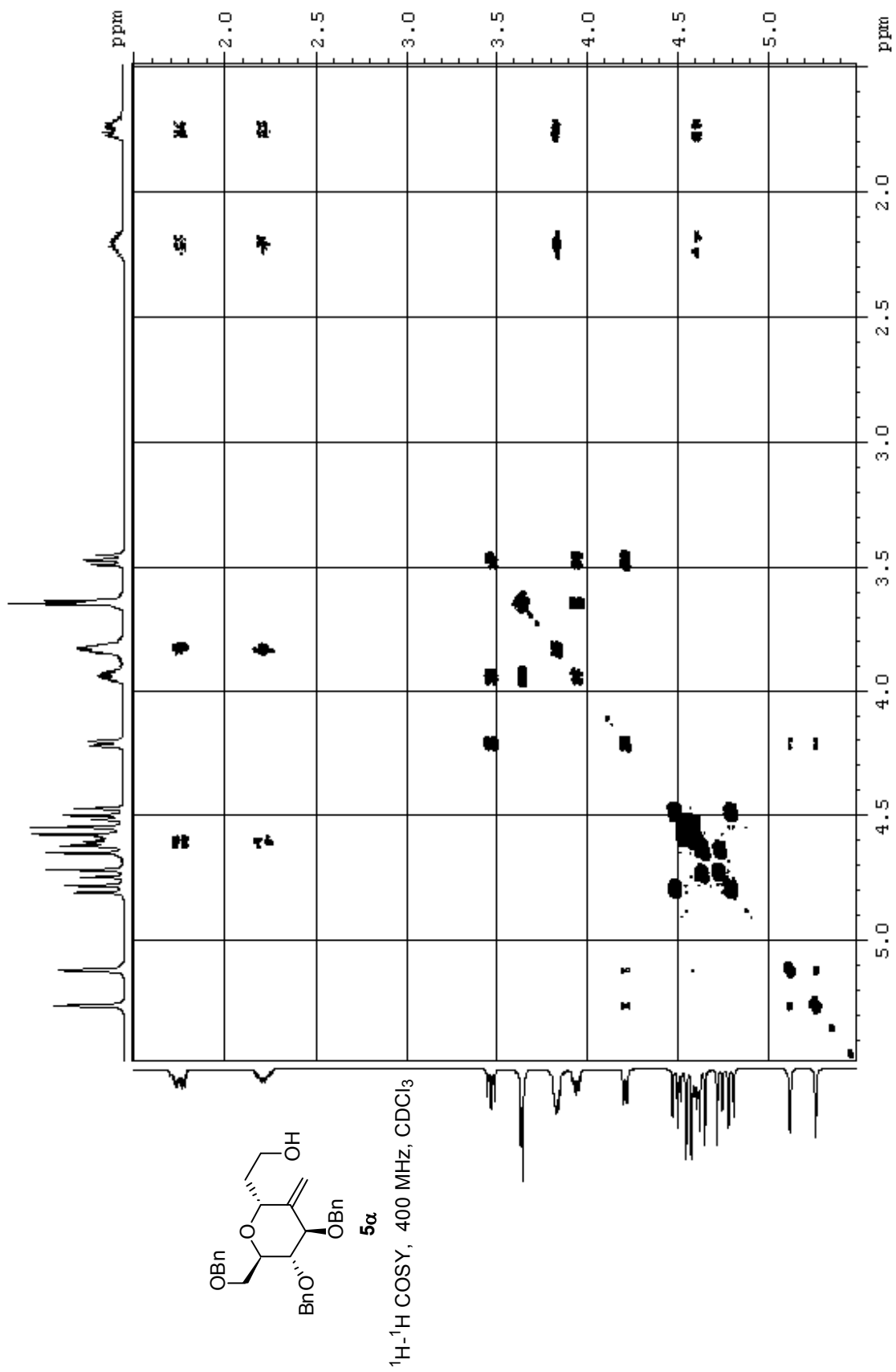


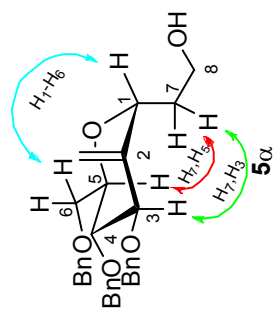
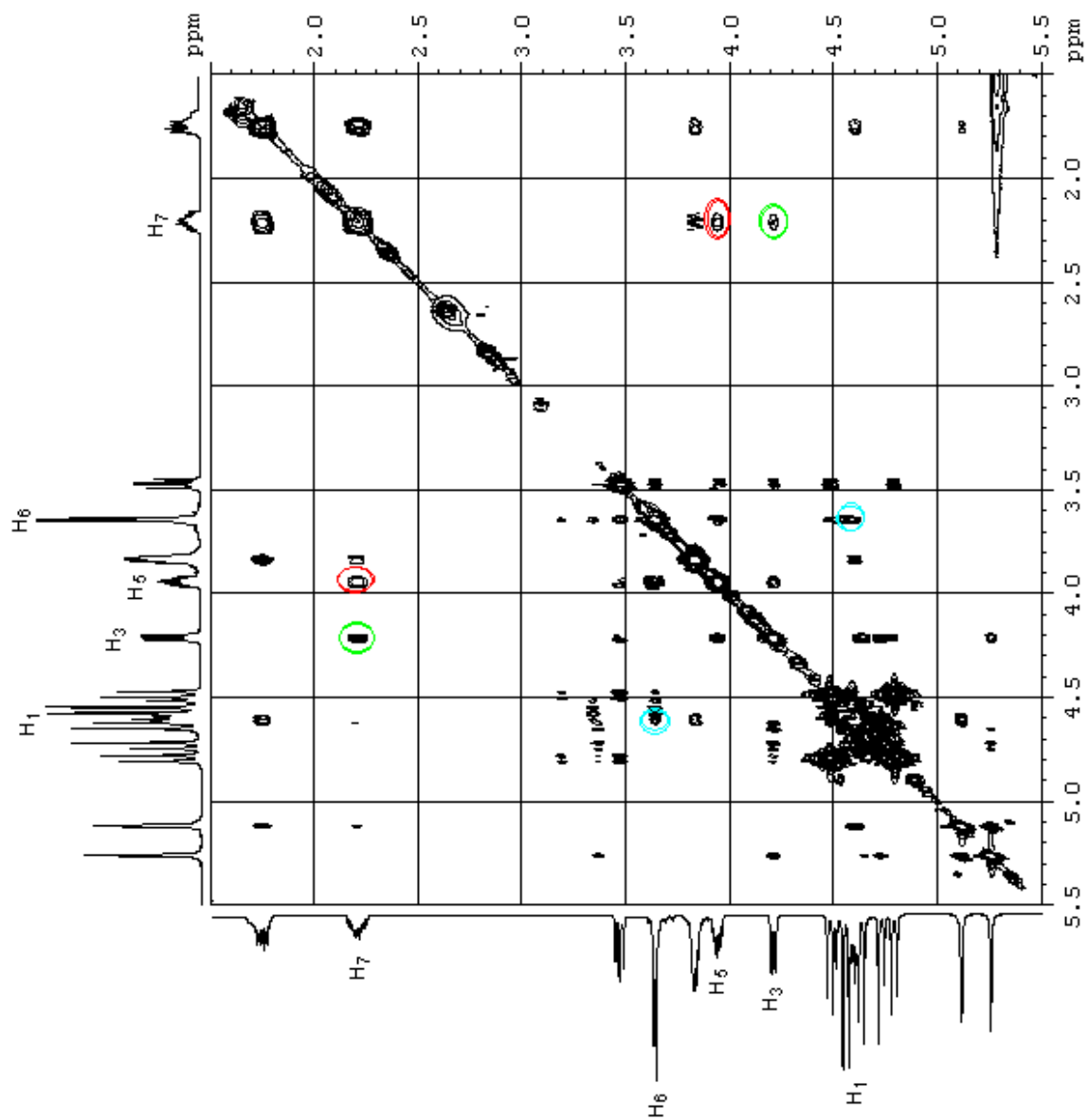




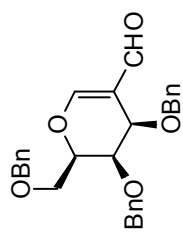




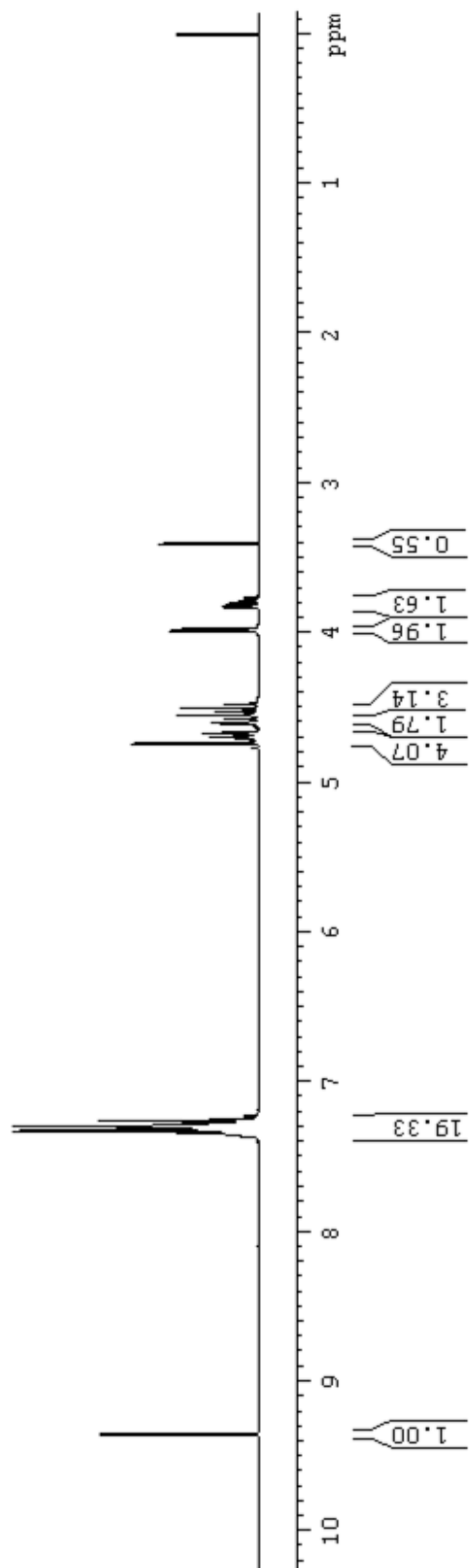


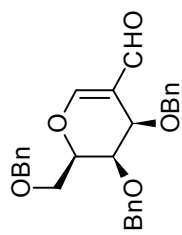


^1H - ^1H NOESY, 500 MHz

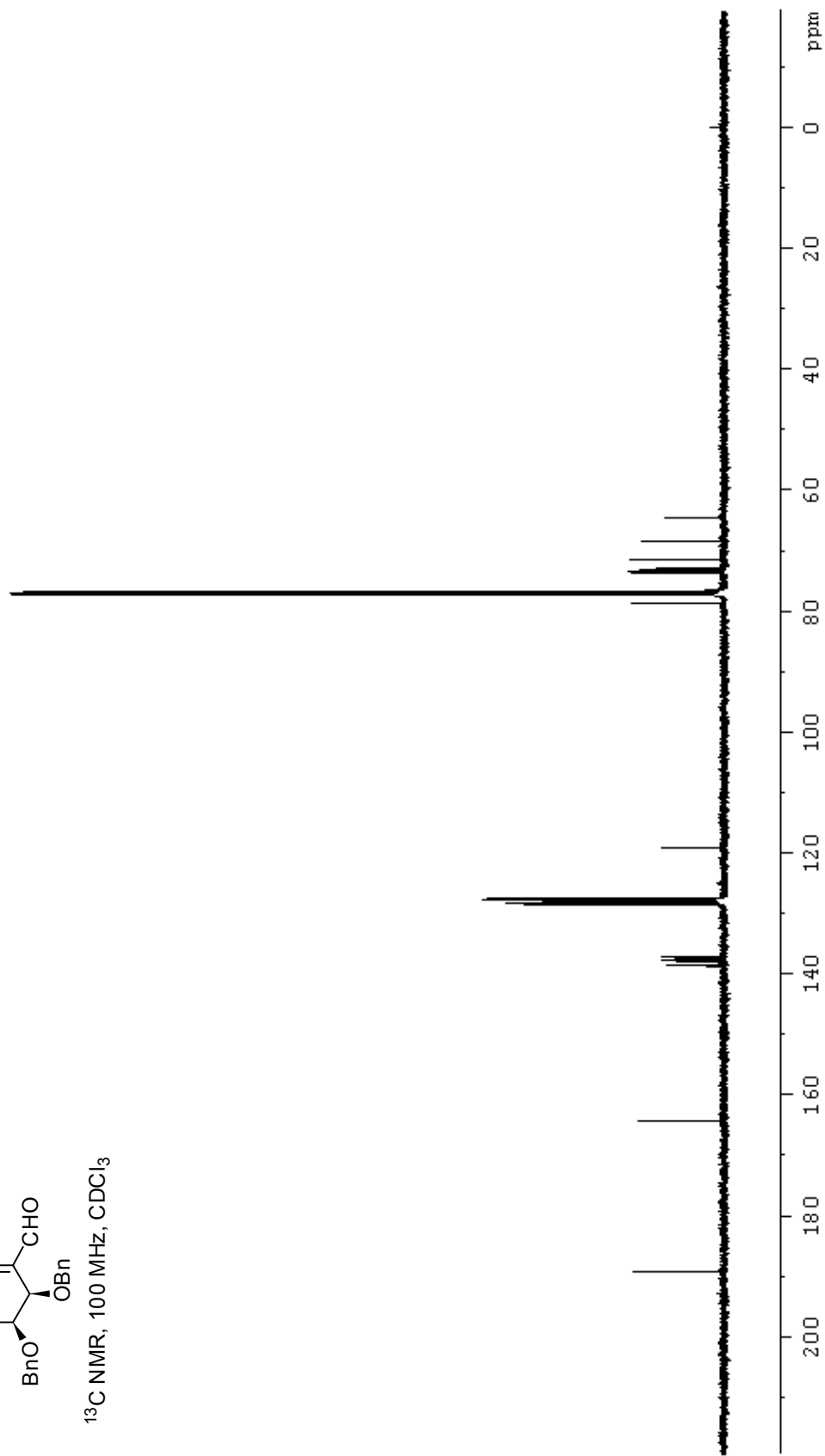


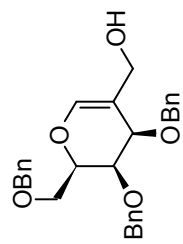
^1H NMR, 400 MHz, CDCl_3



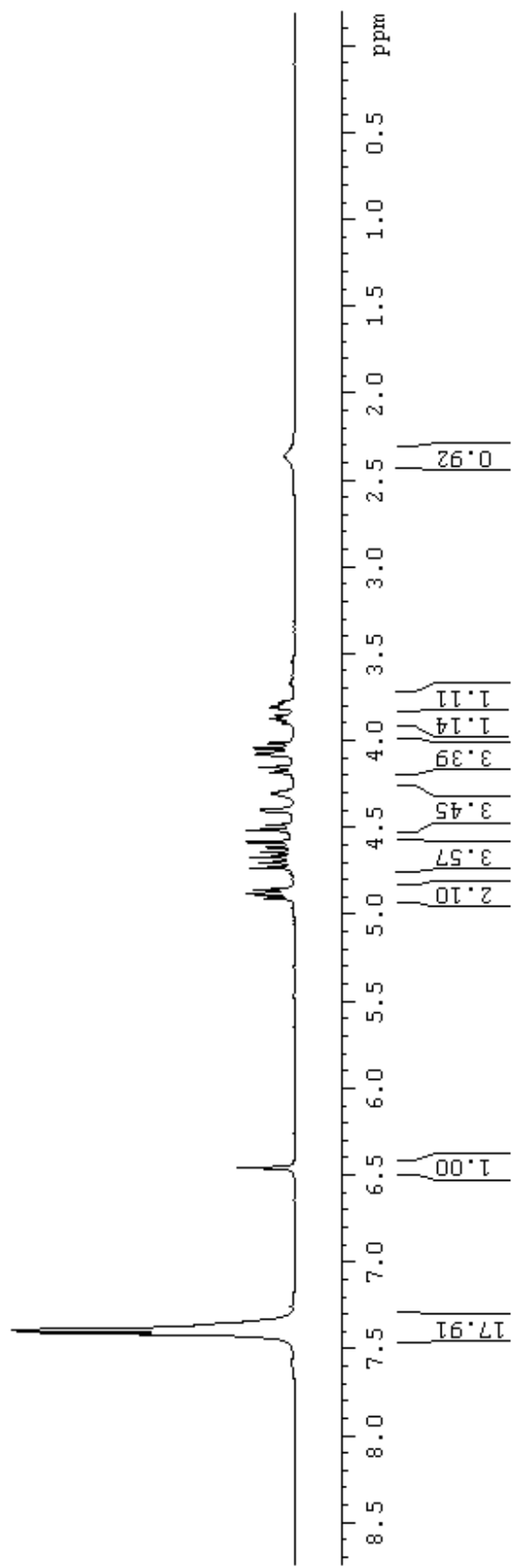


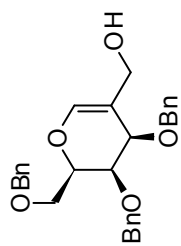
^{13}C NMR, 100 MHz, CDCl_3



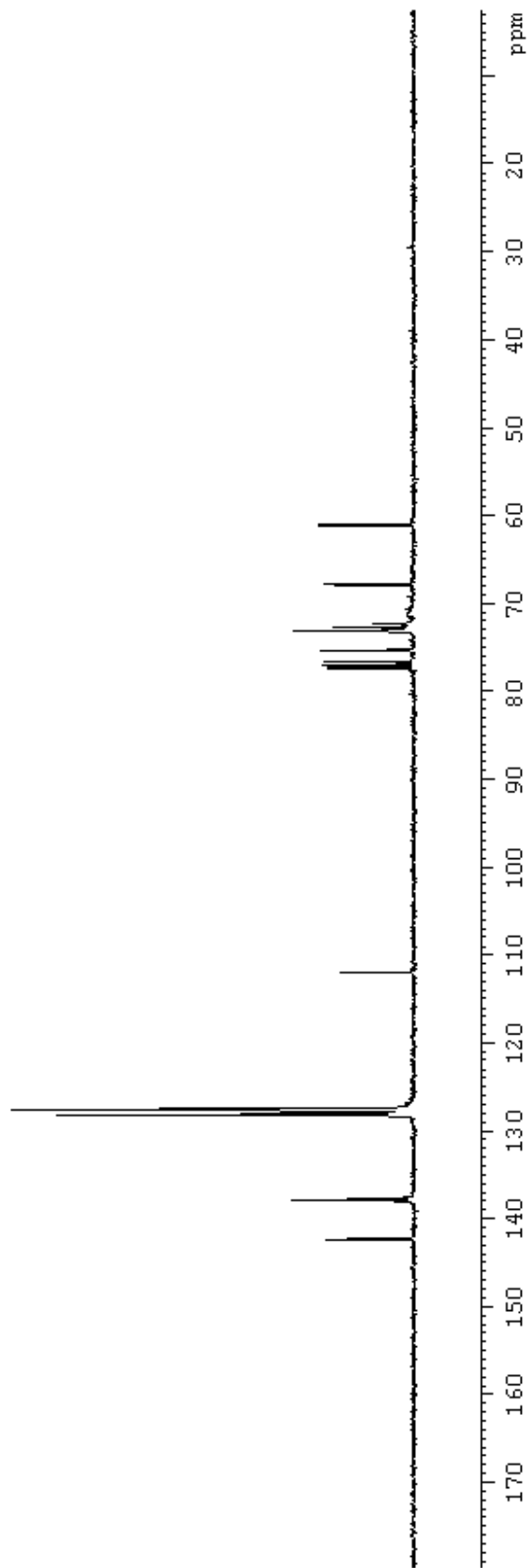


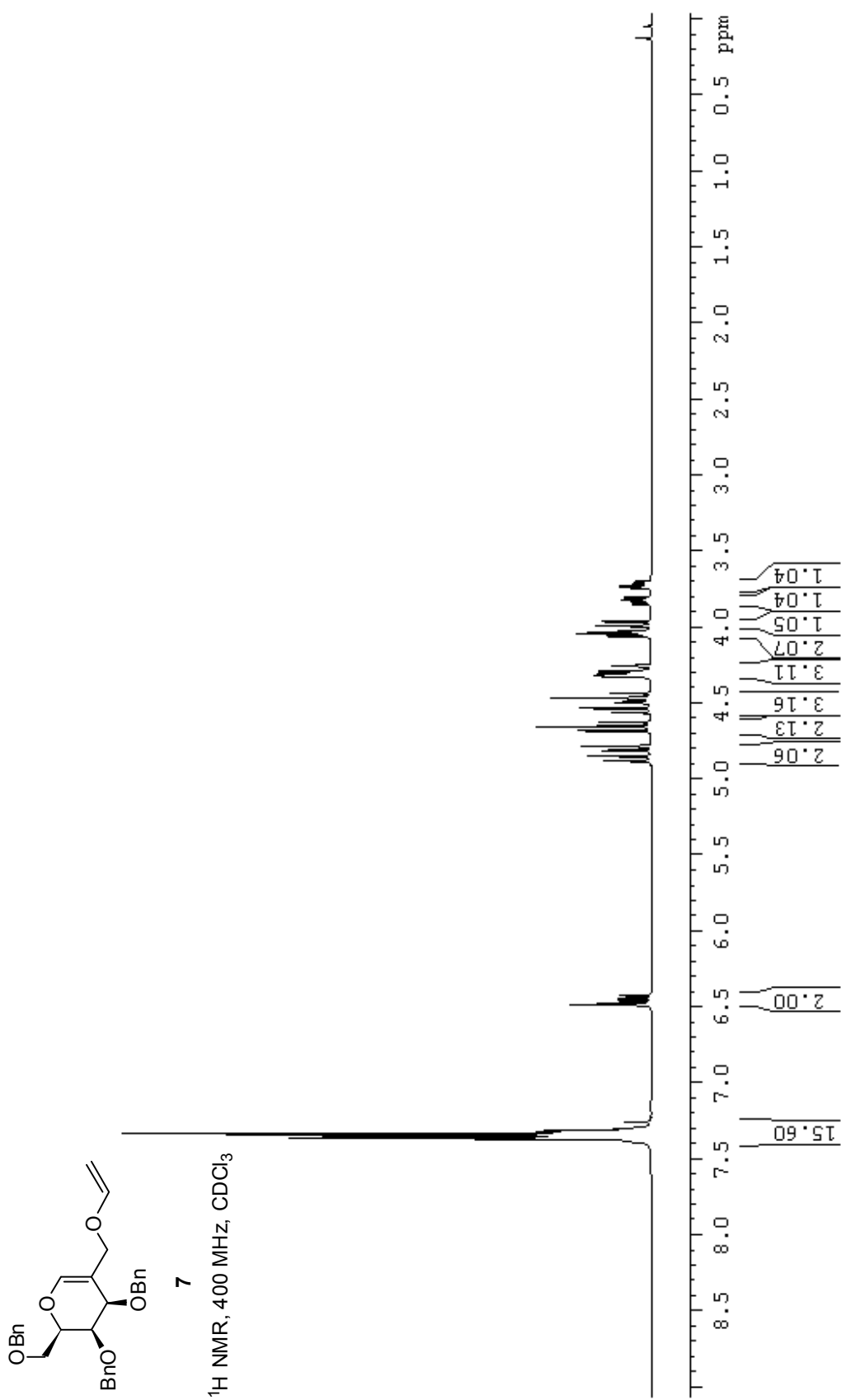
^1H NMR, 400 MHz, CDCl_3

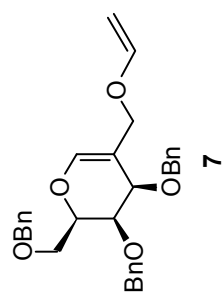




¹³C NMR, 100 MHz, CDCl₃

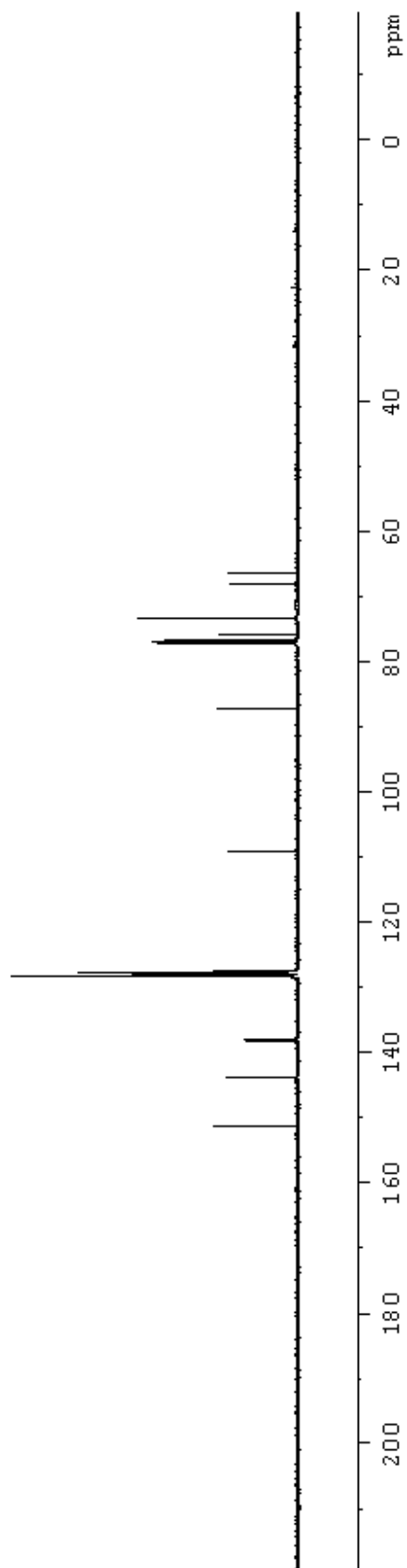


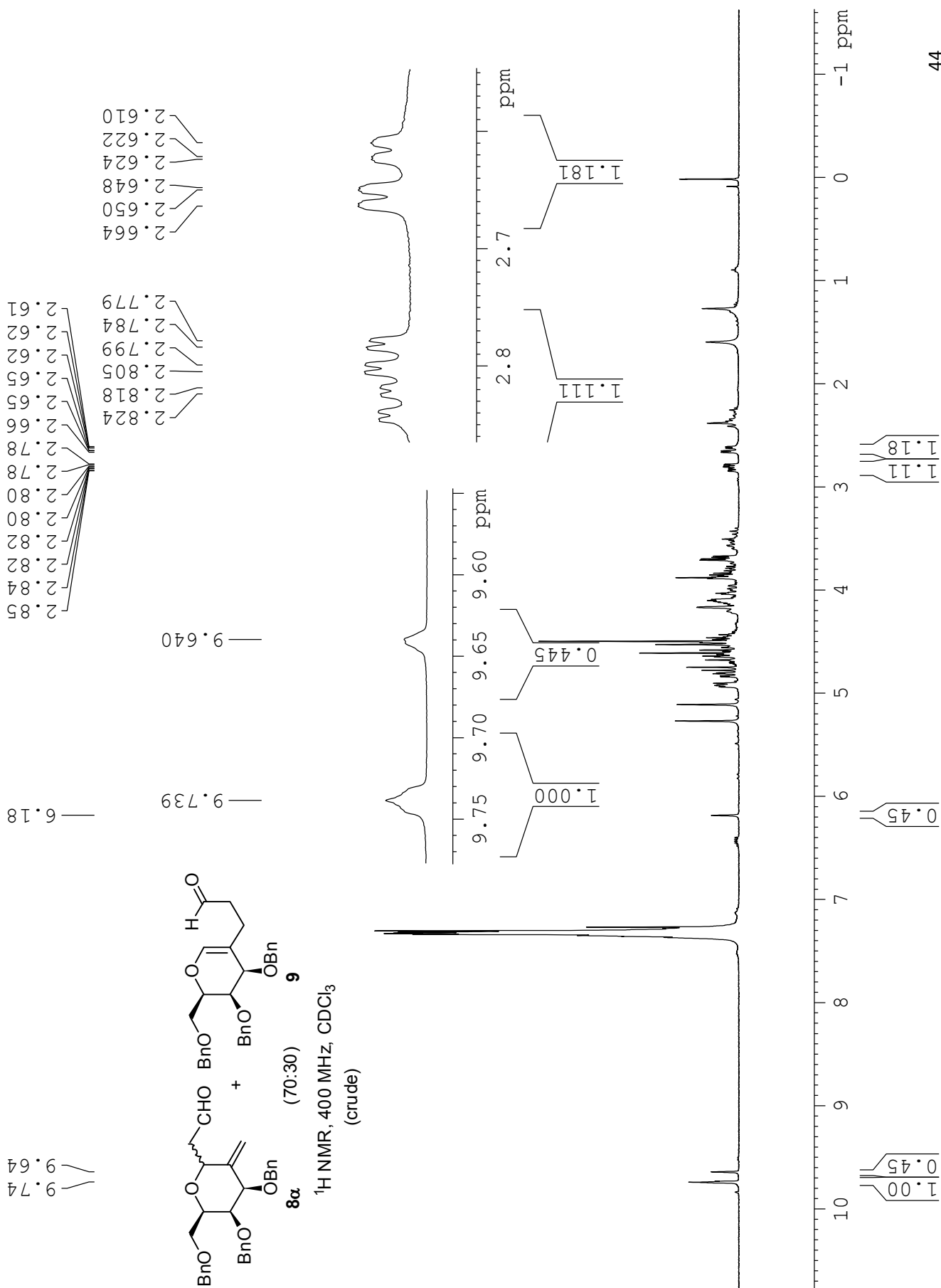


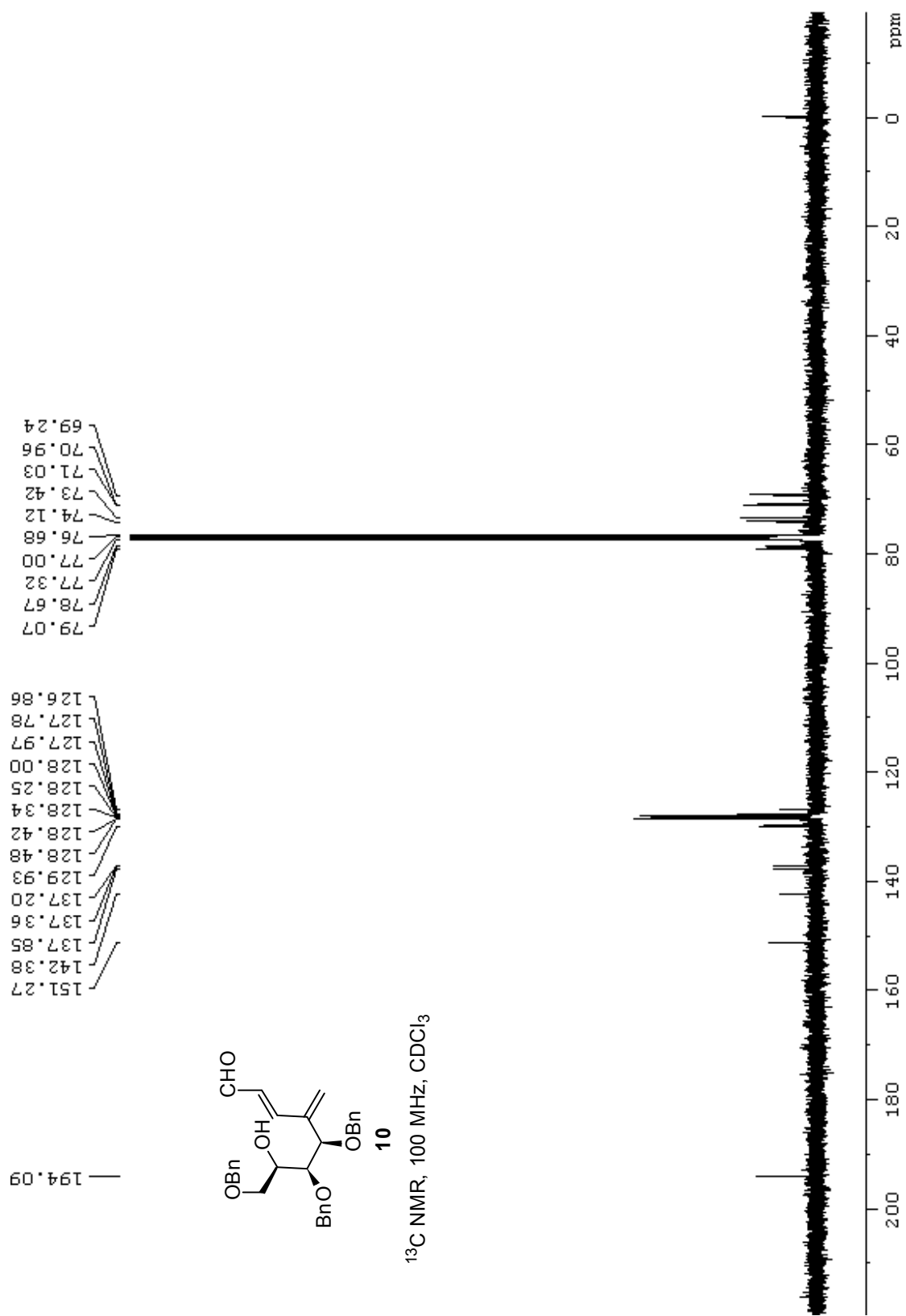


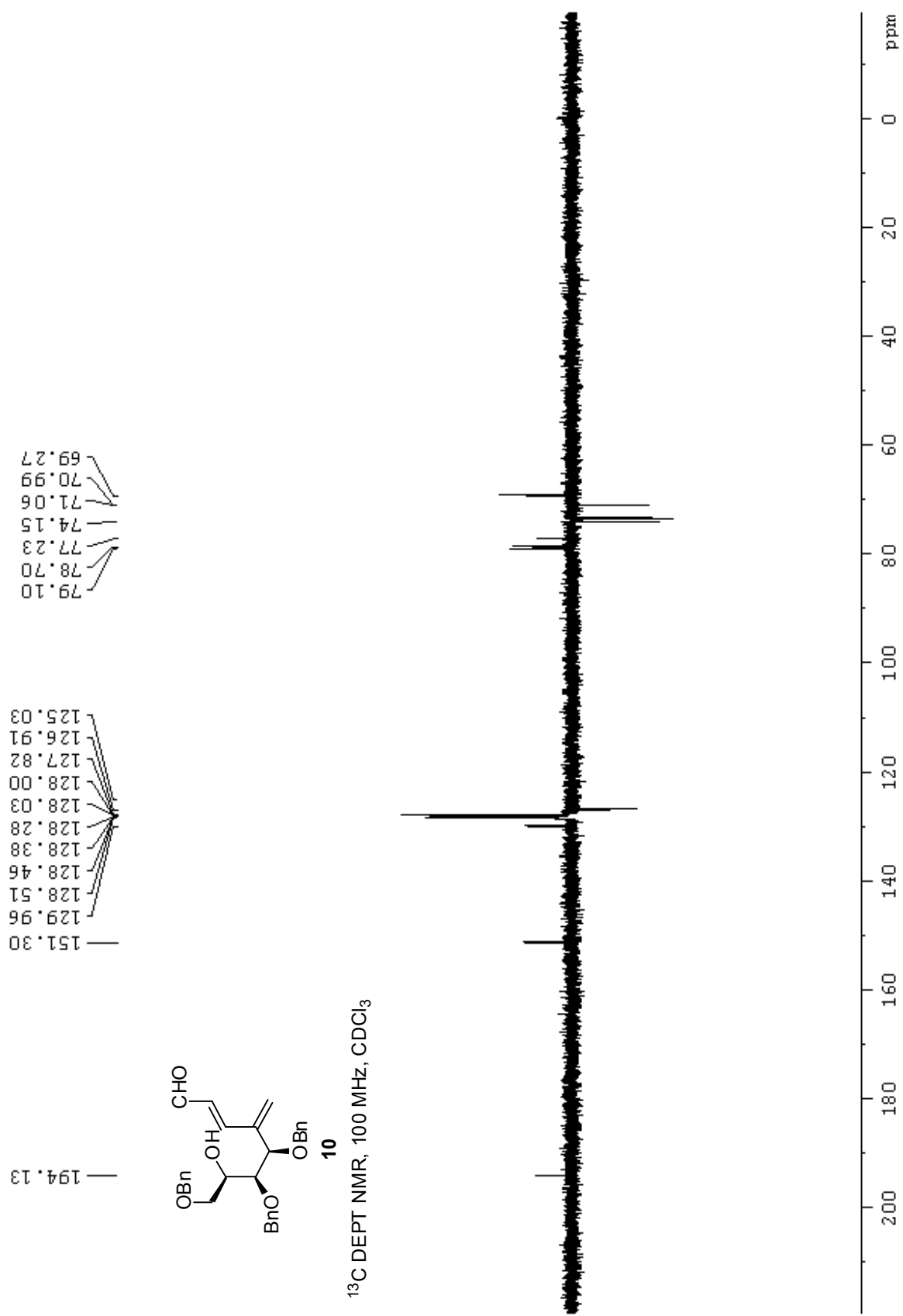
¹³C NMR, 100 MHz, CDCl₃

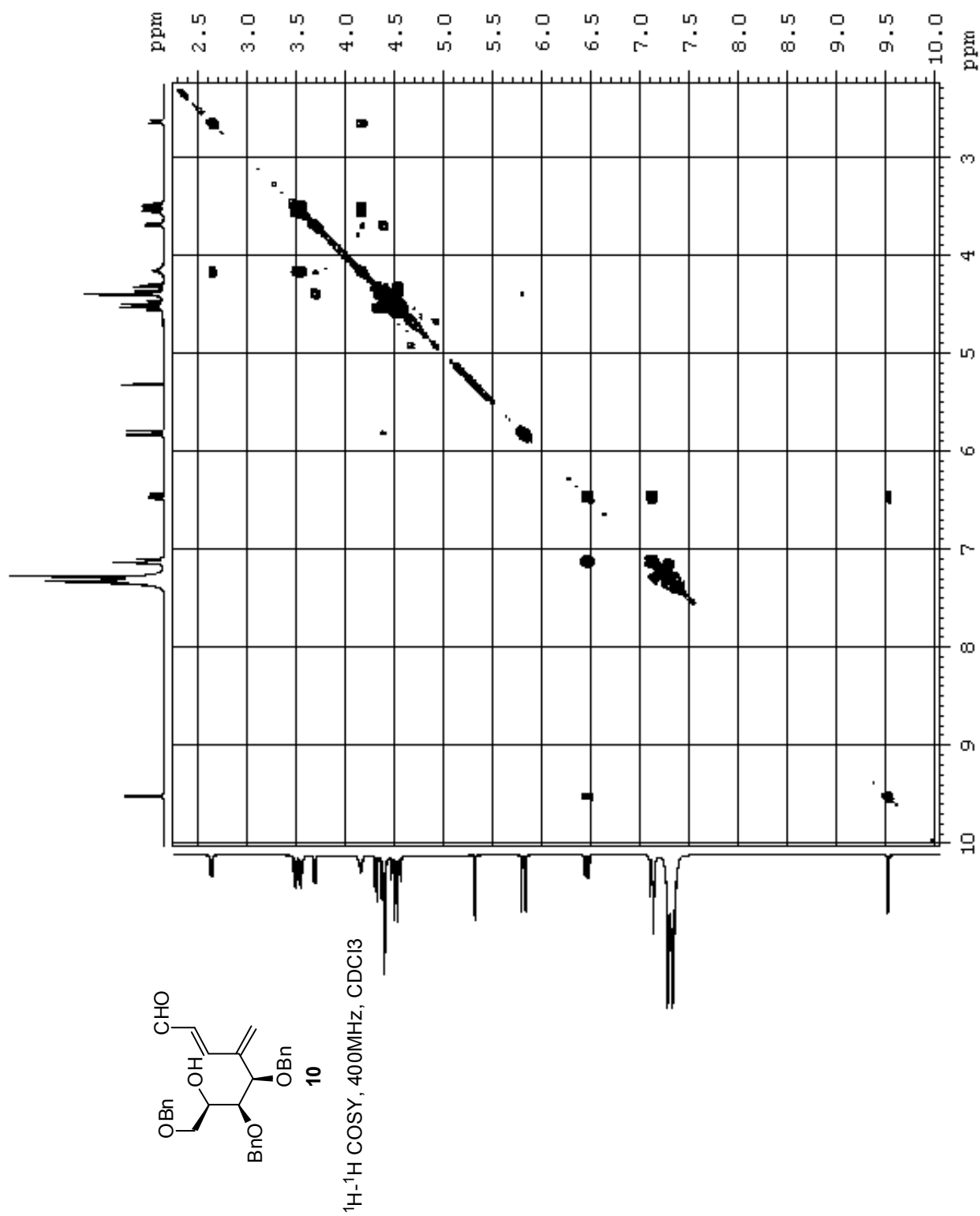
151.31
143.74
138.34
138.11
137.88
128.31
127.92
127.83
127.81
127.71
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127.60
109.19
87.22
77.32
77.00
76.68
75.83
73.33
68.07
66.36

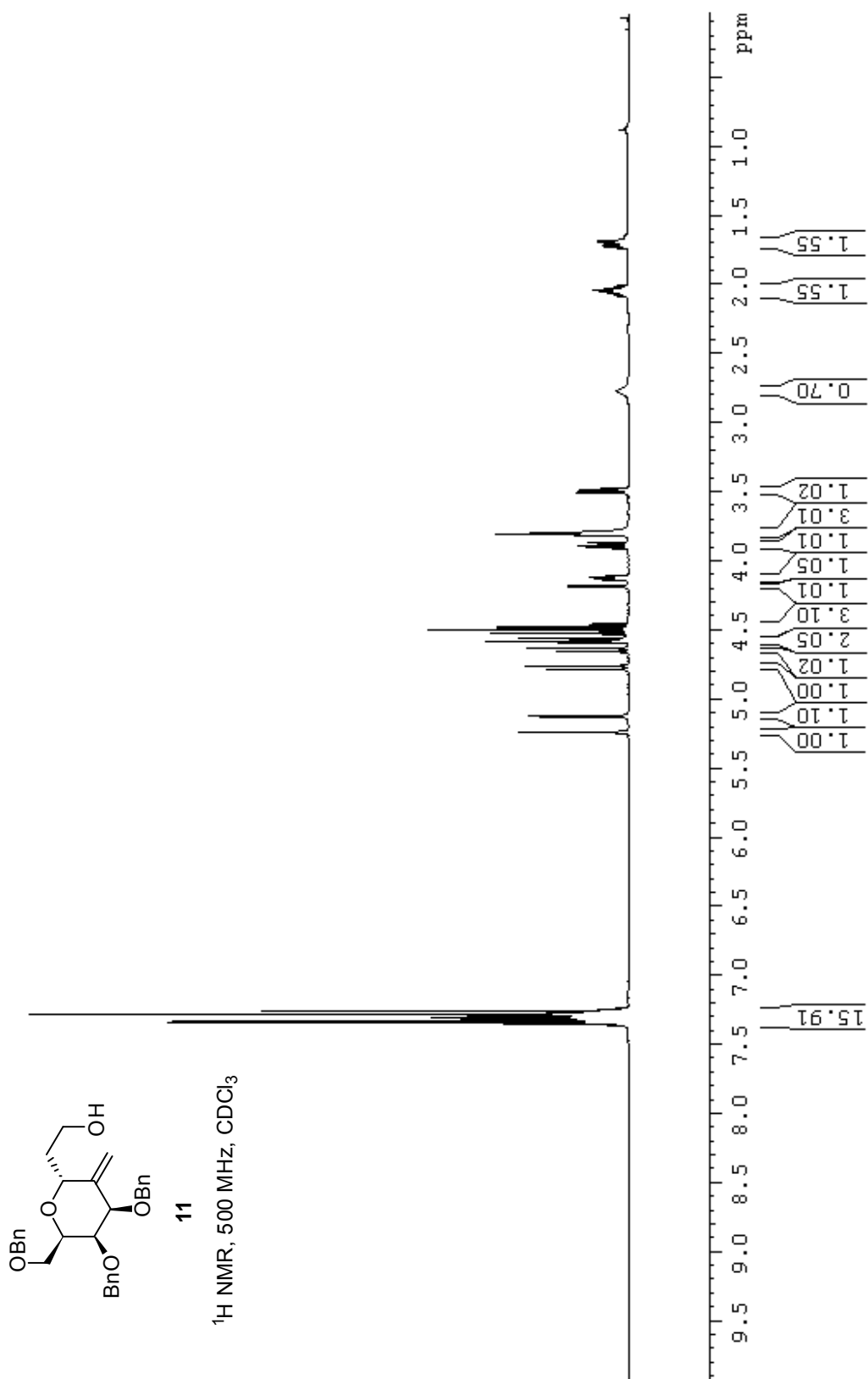


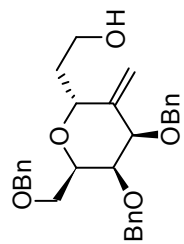






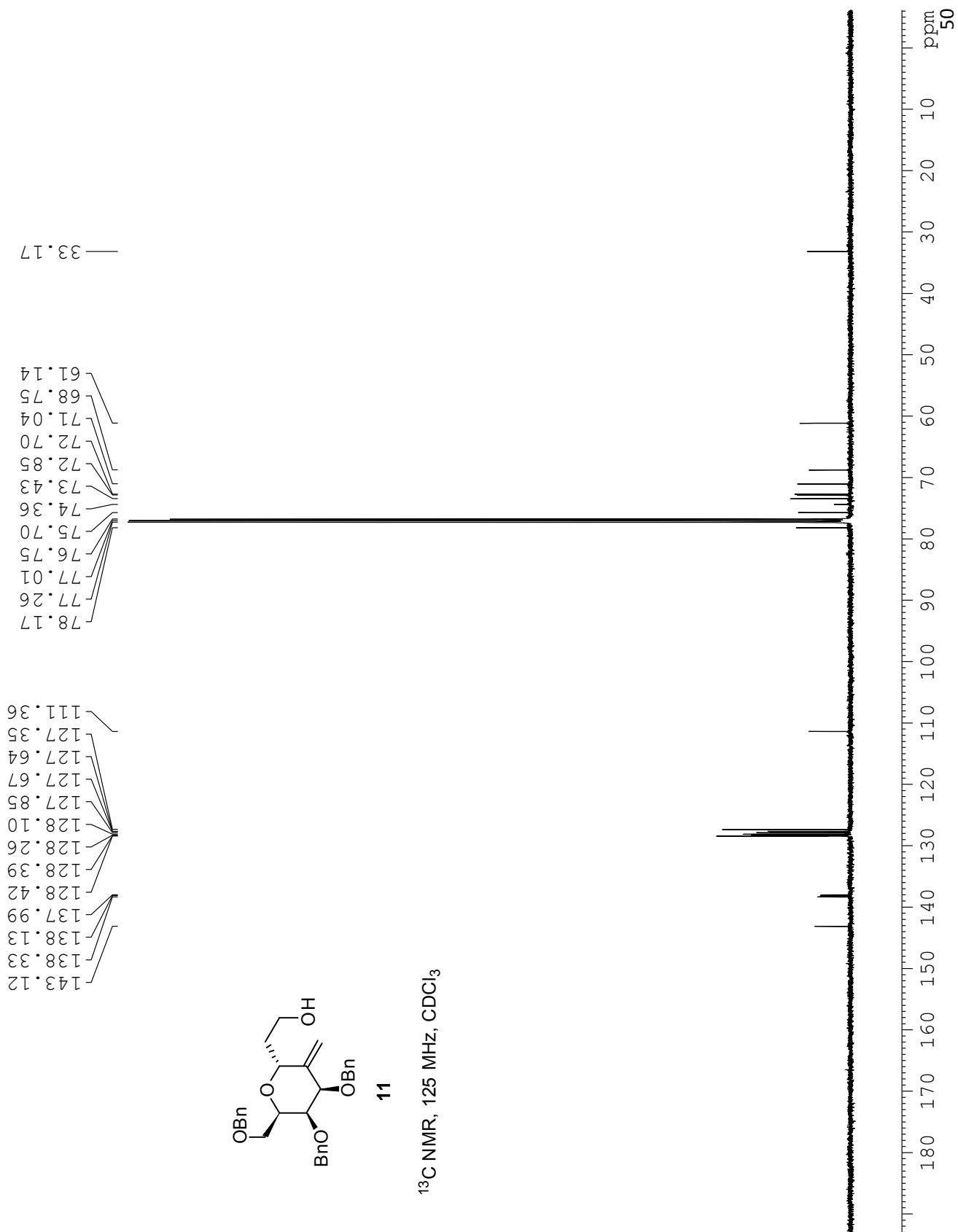


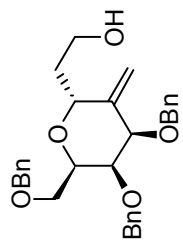




11

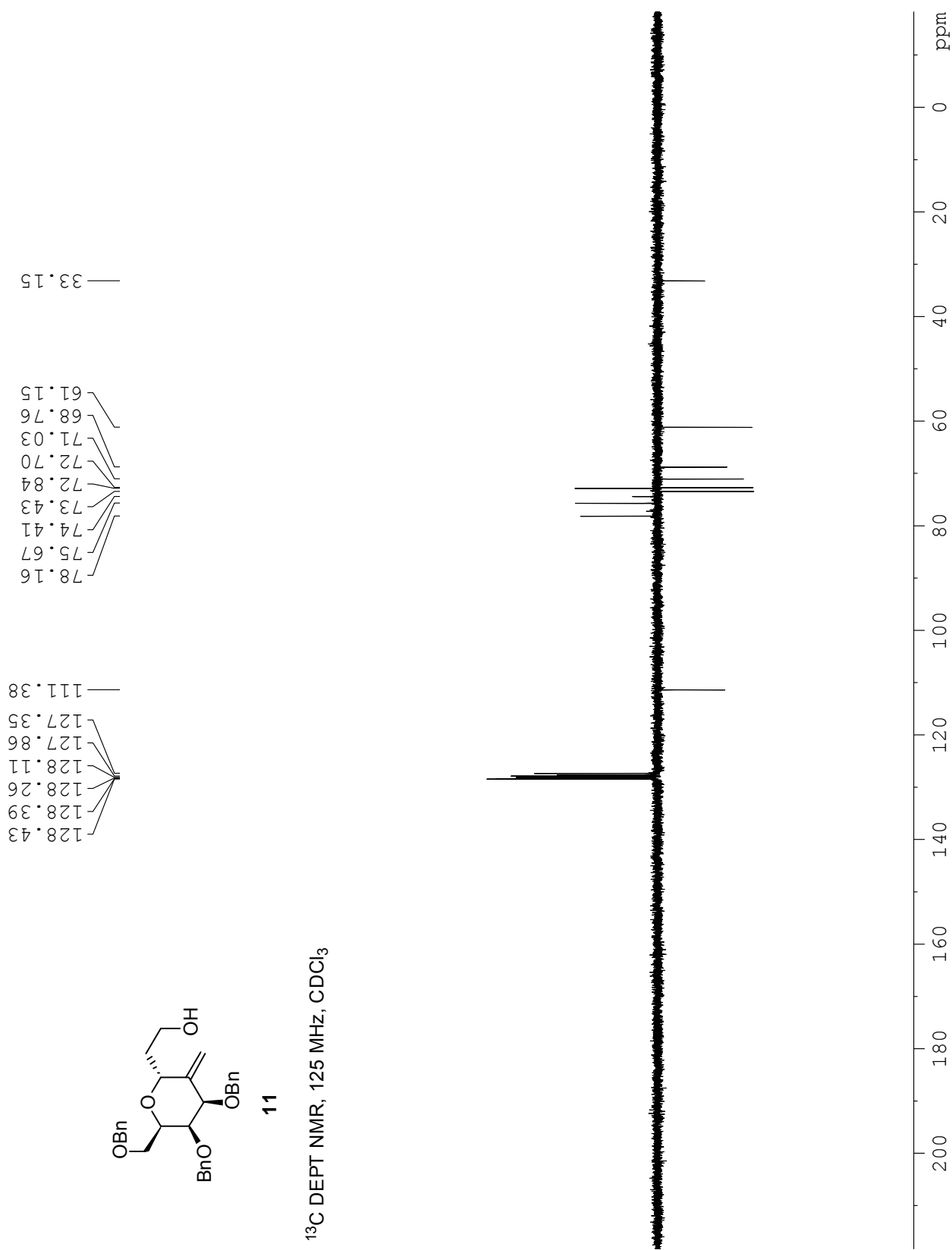
^{13}C NMR, 125 MHz, CDCl_3

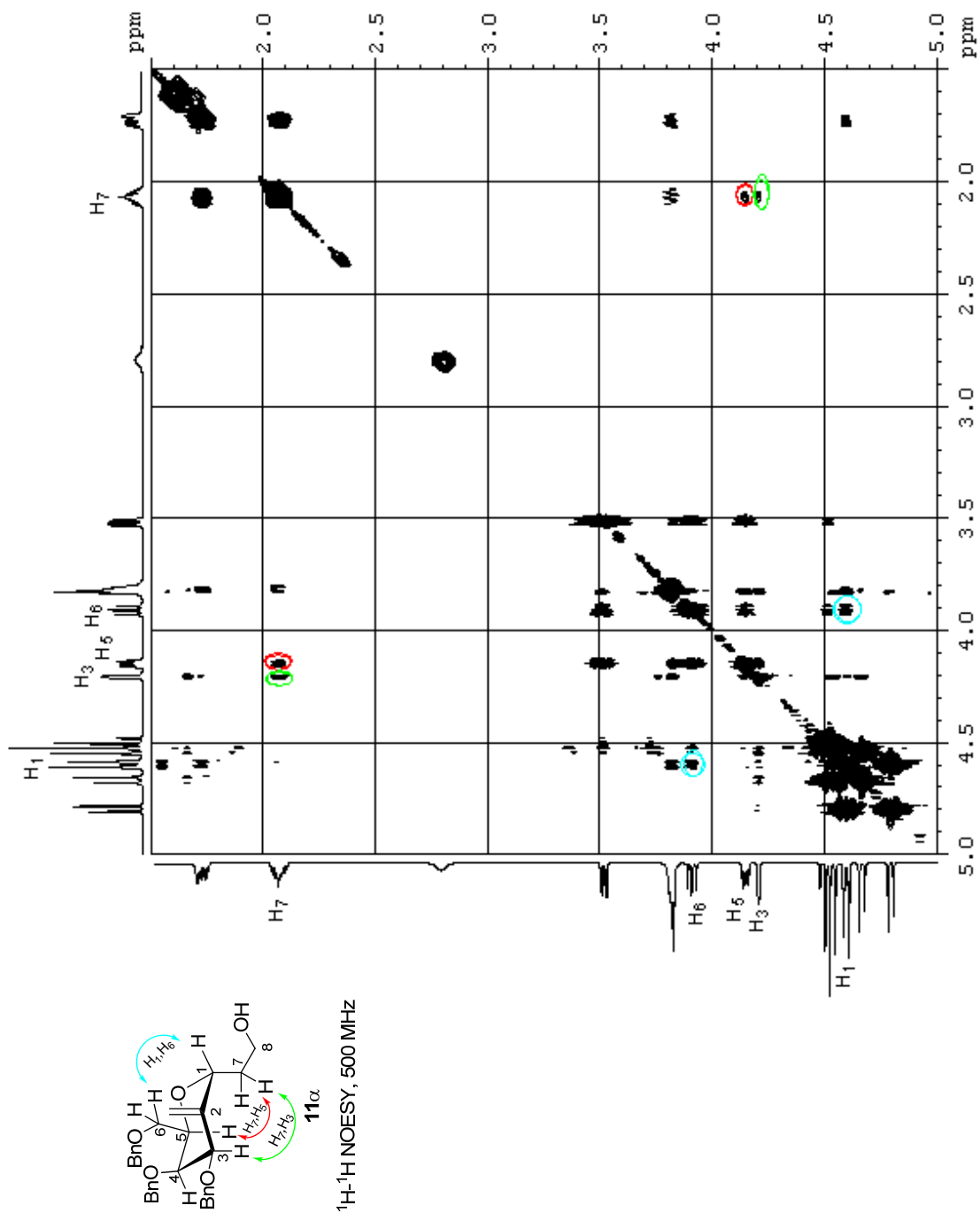


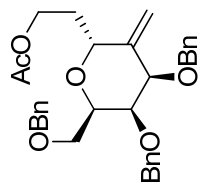


11

¹³C DEPT NMR, 125 MHz, CDCl₃

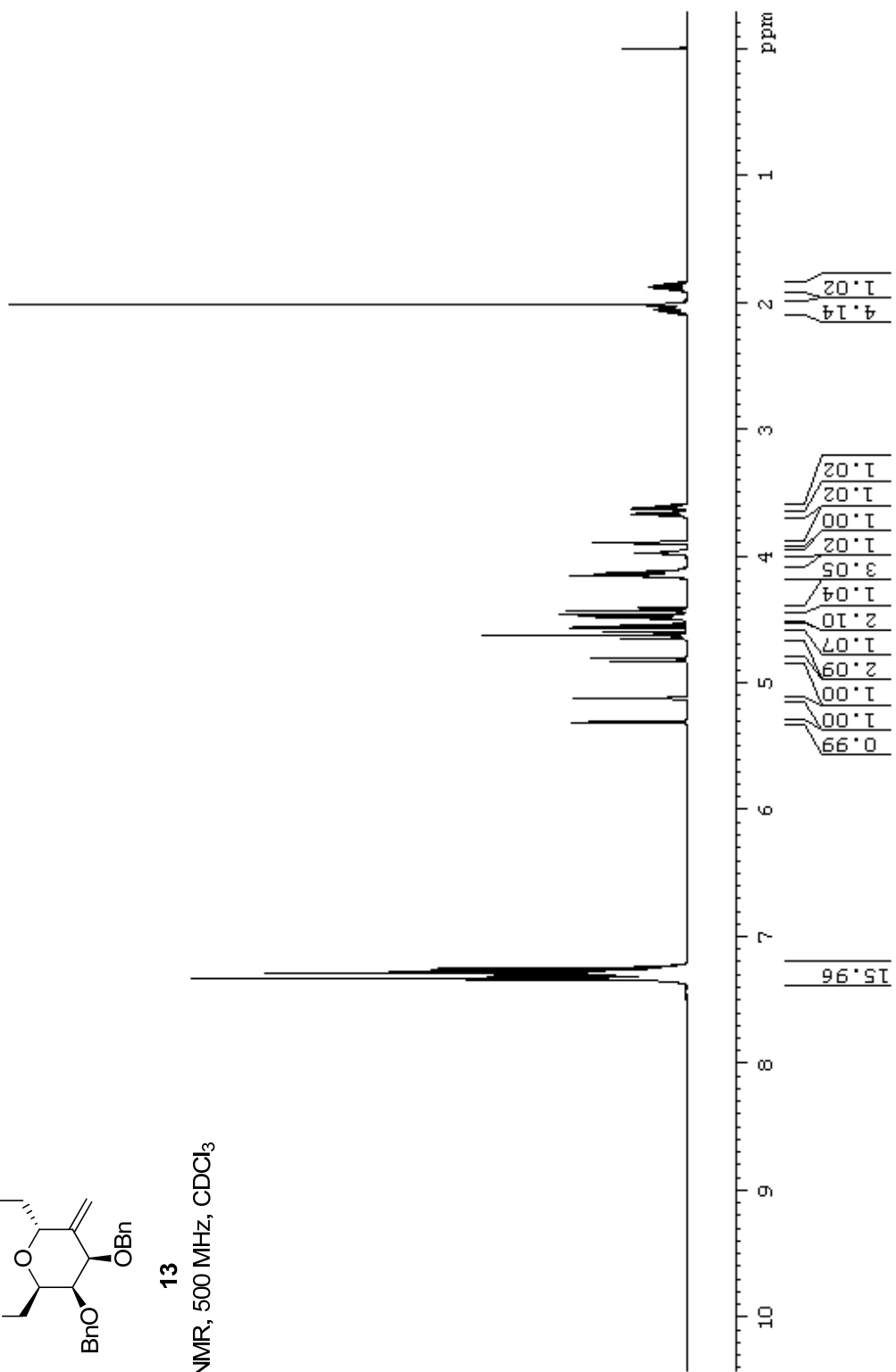


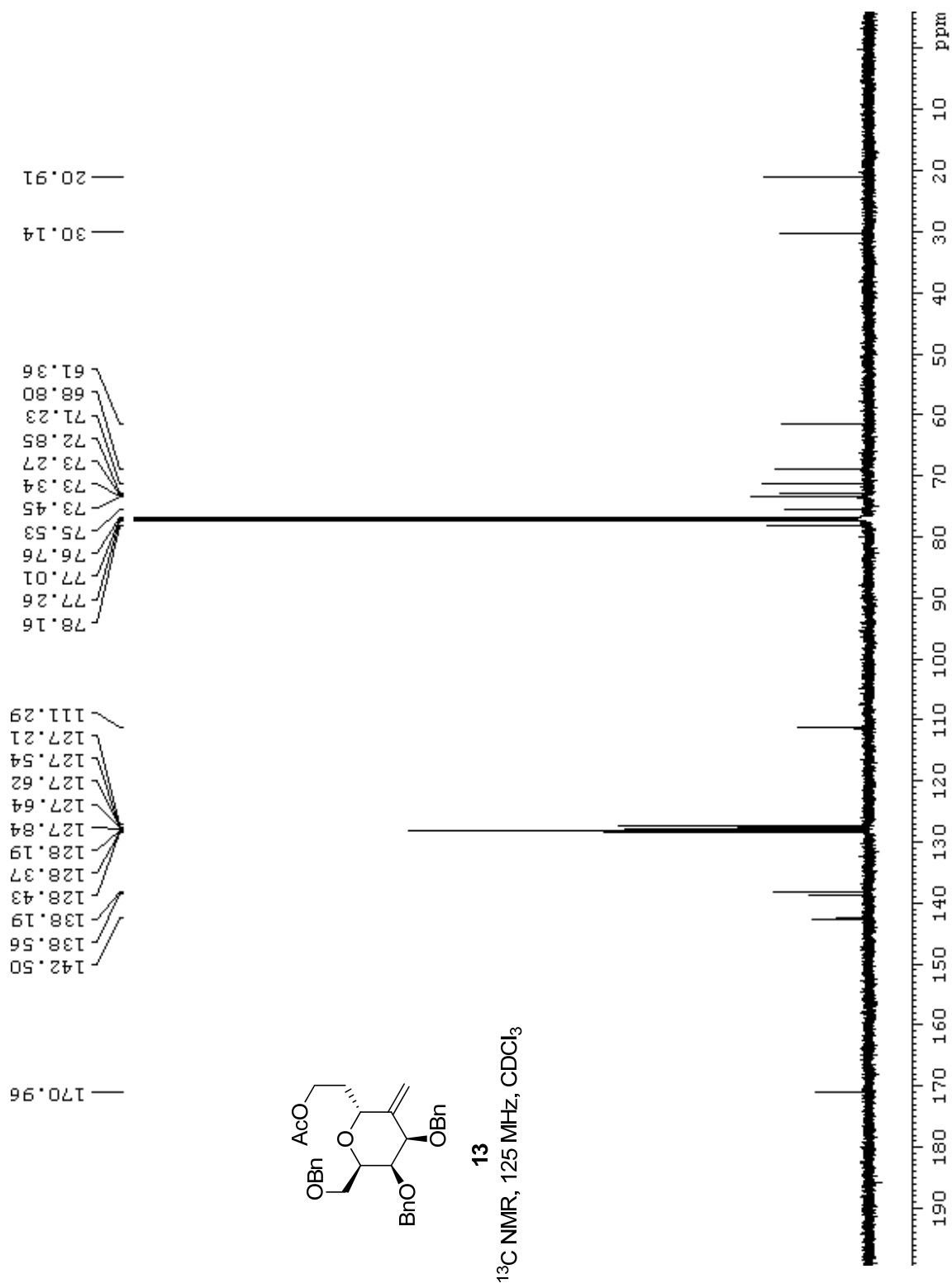


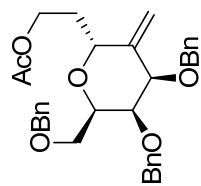


13

$^1\text{H NMR}$, 500 MHz, CDCl_3

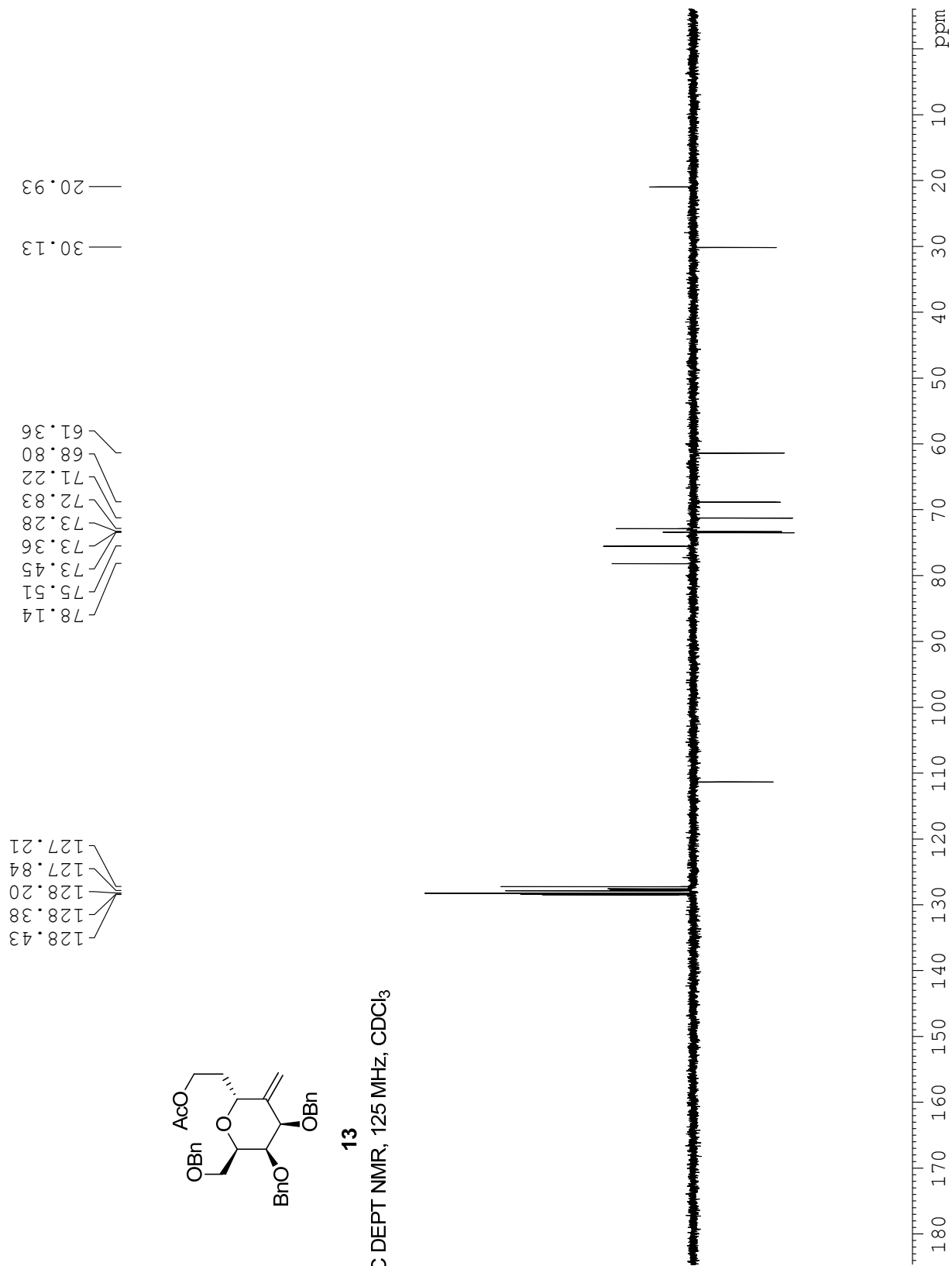


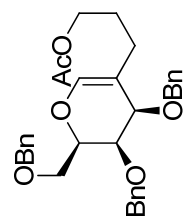




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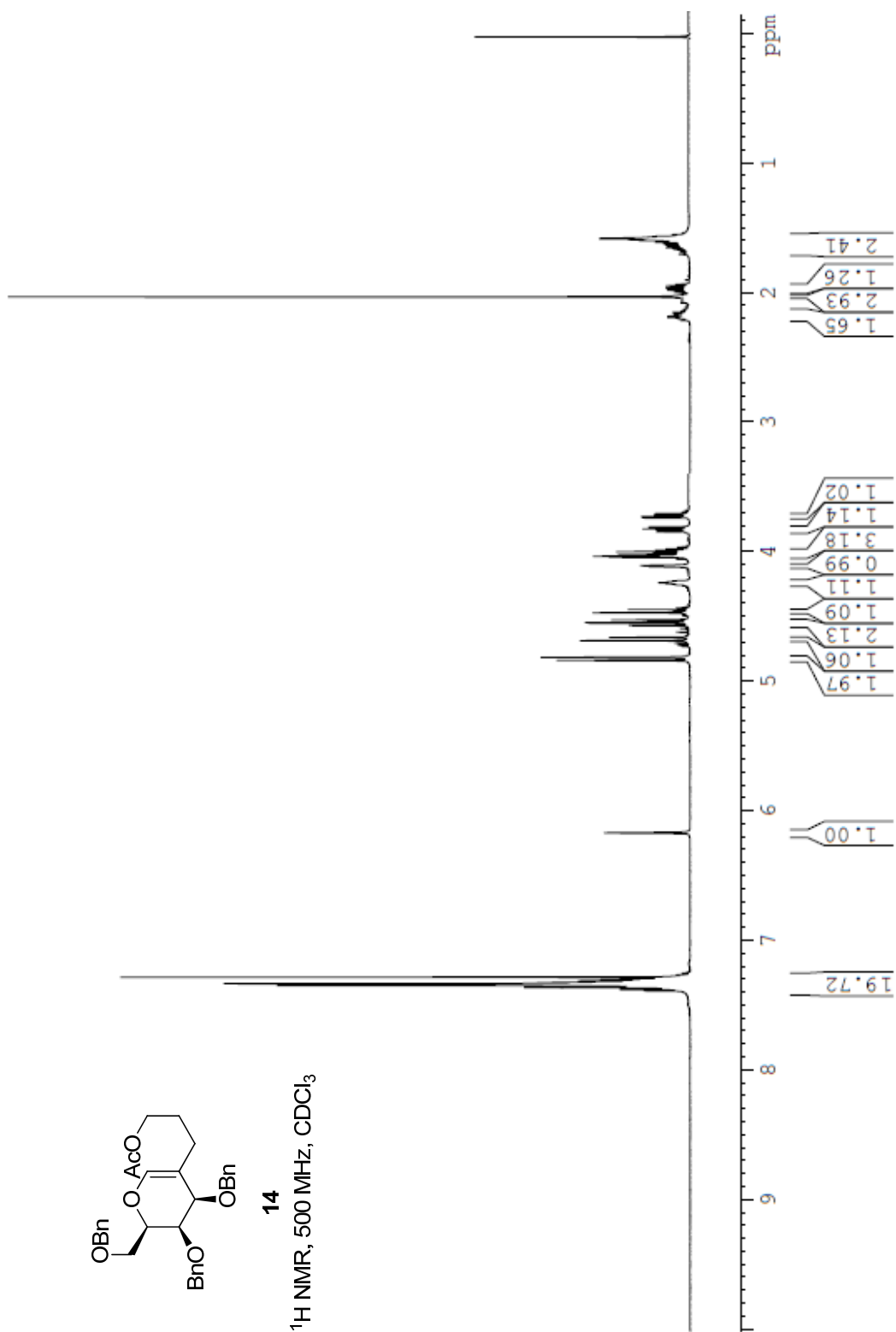
¹³C DEPT NMR, 125 MHz, CDCl₃

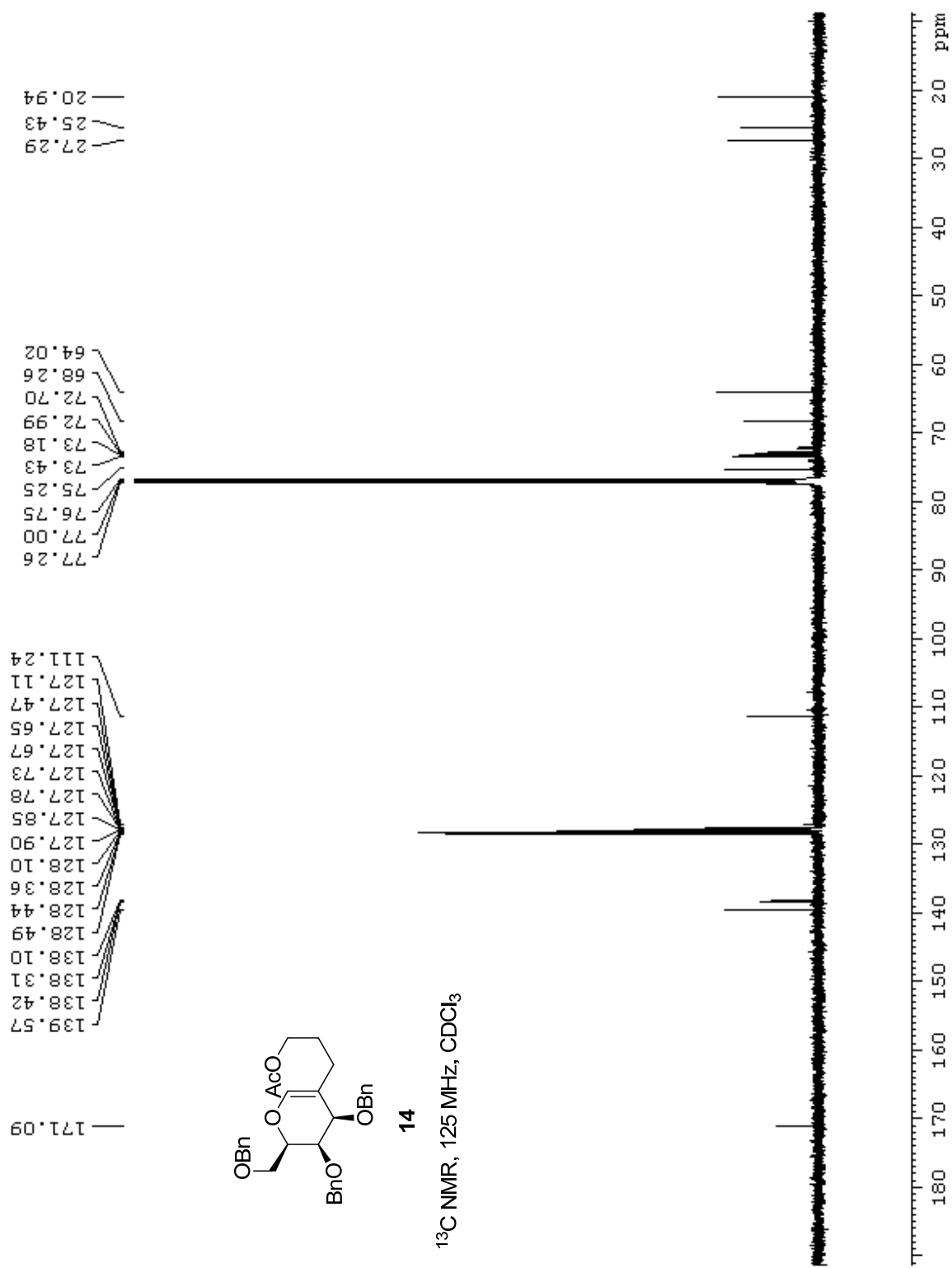


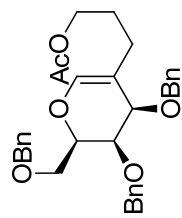


14

¹H NMR, 500 MHz, CDCl₃

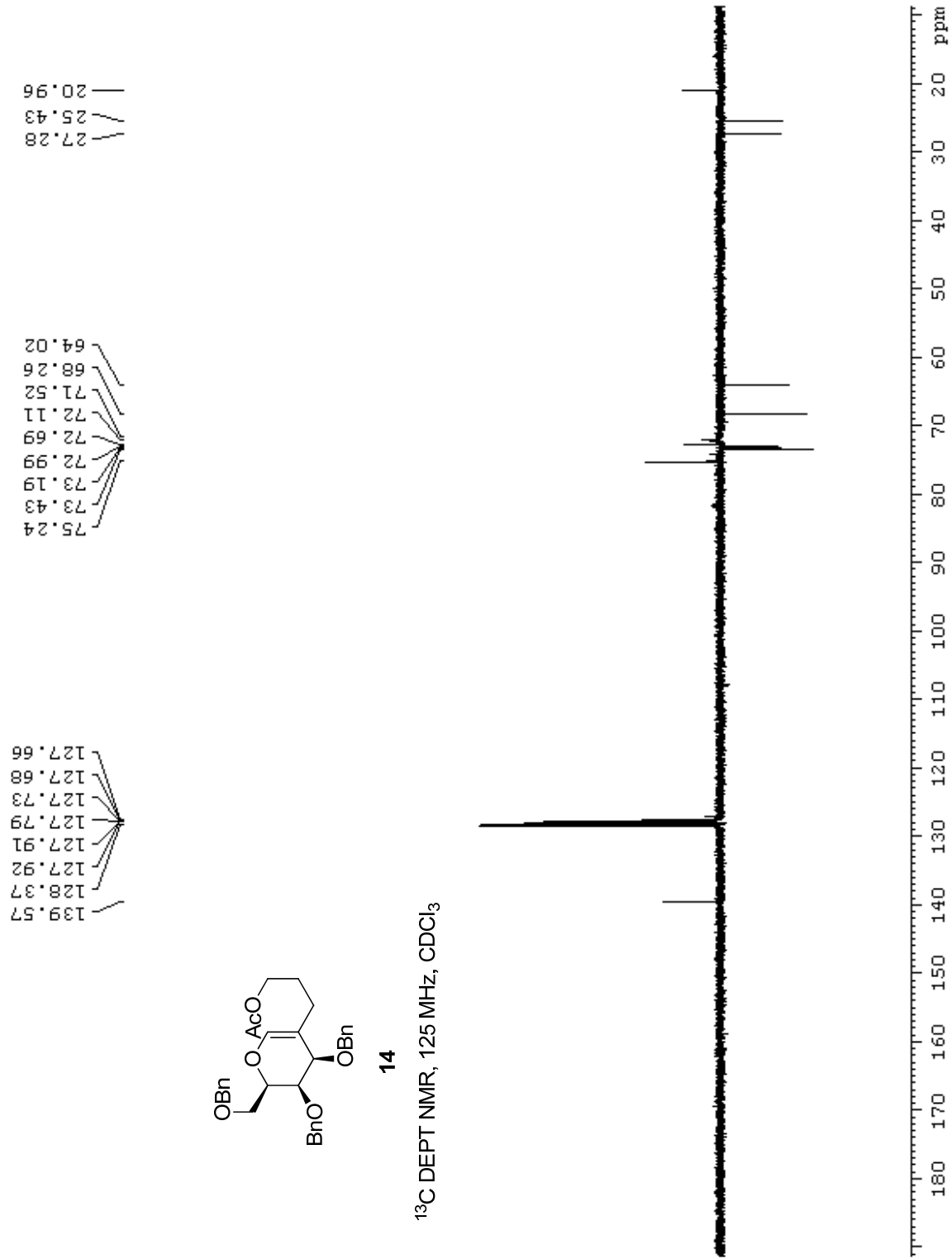


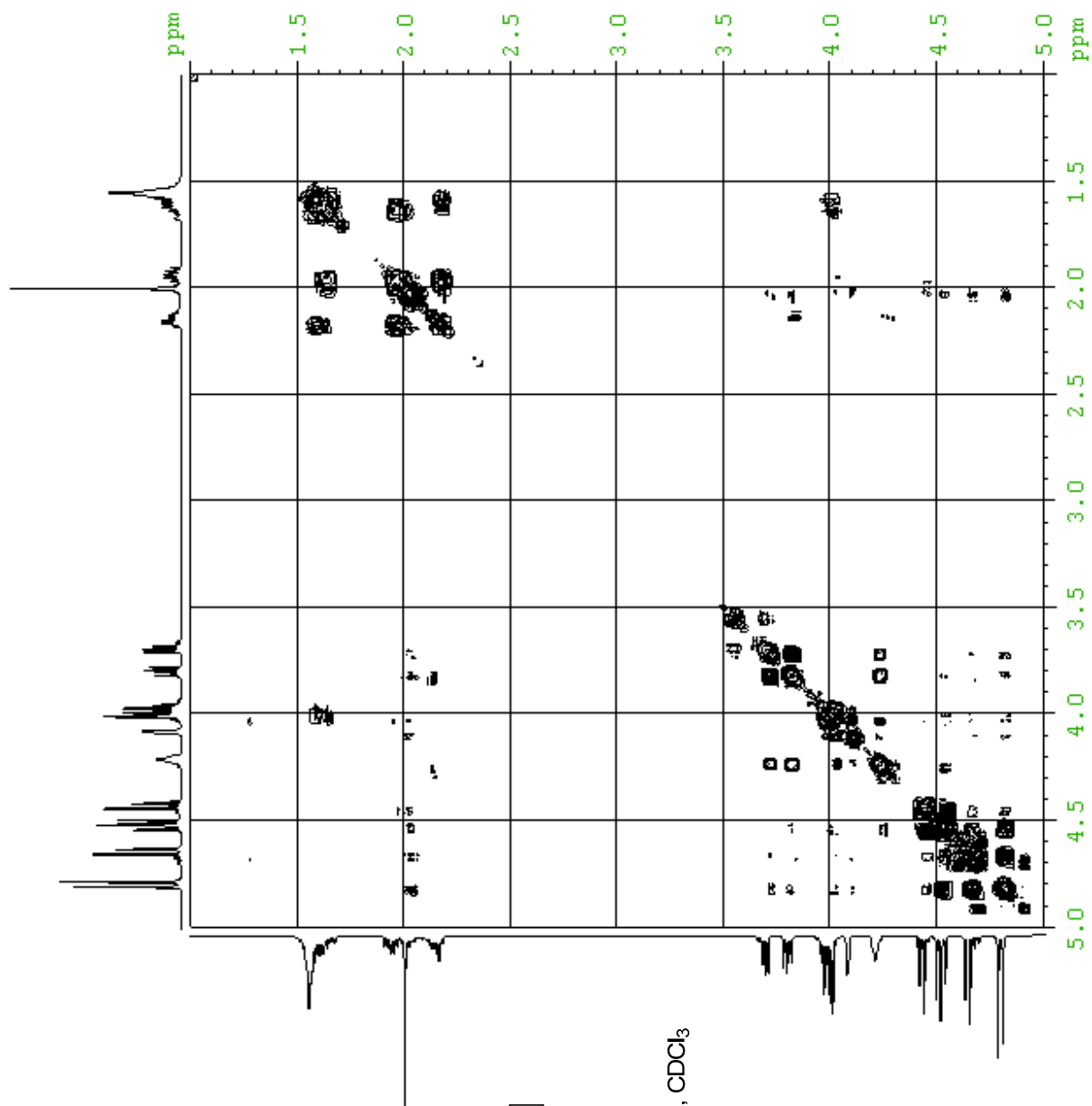




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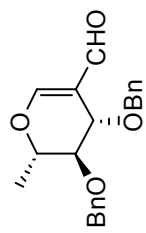
^{13}C DEPT NMR, 125 MHz, CDCl_3



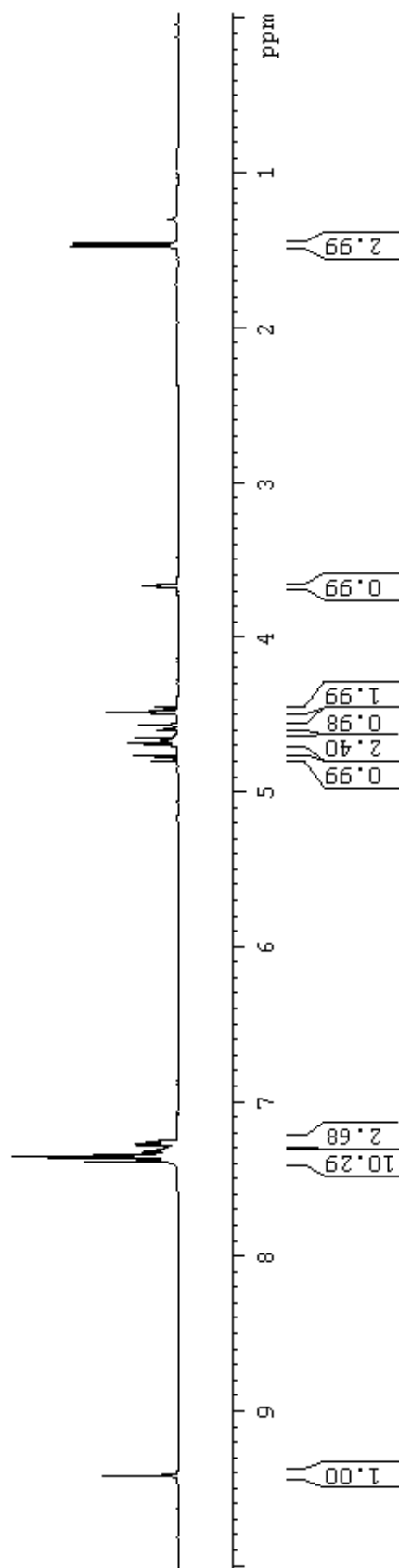


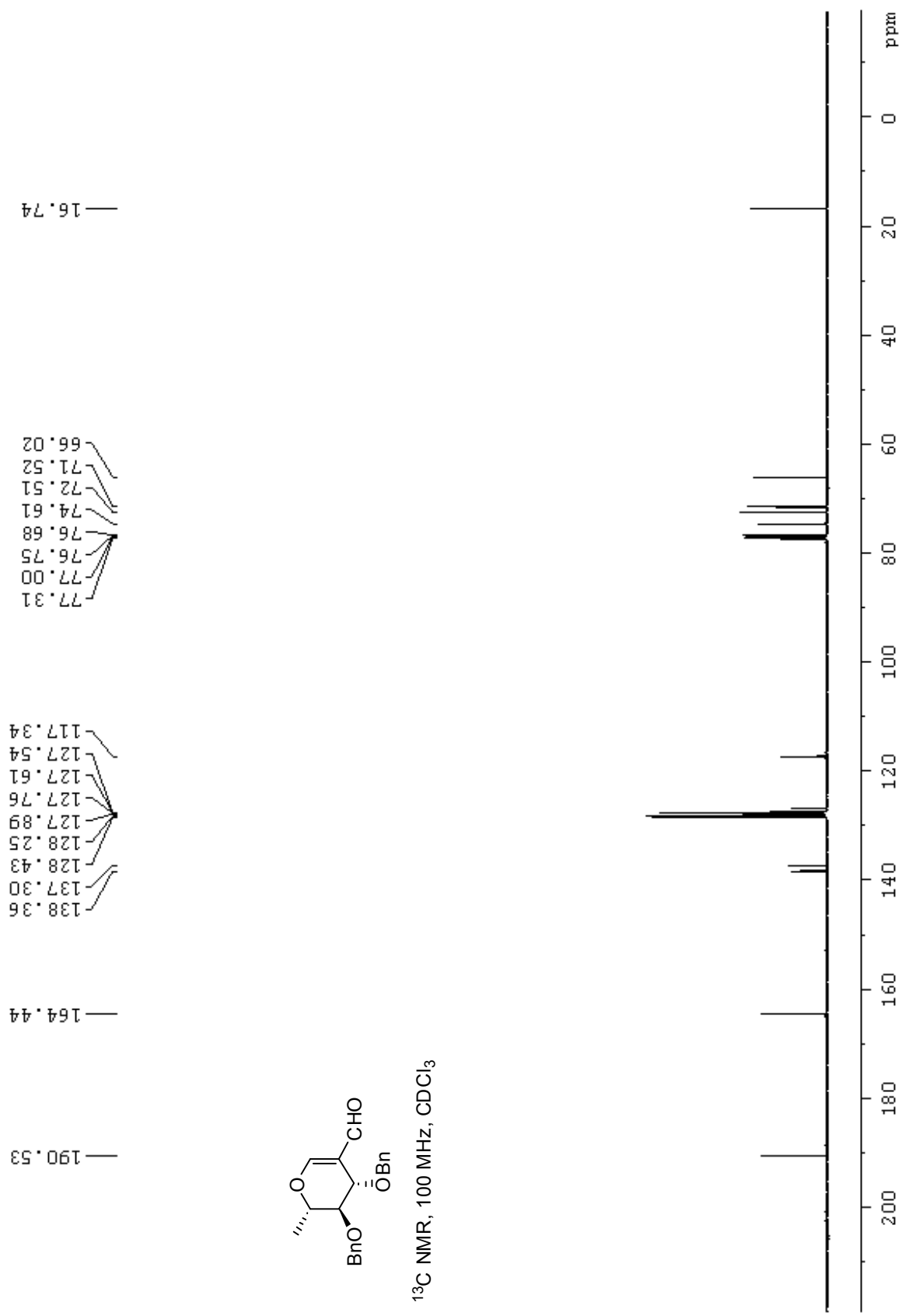
14

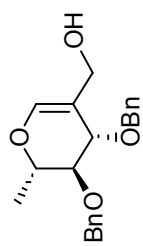
^1H - ^1H COSY, 500 MHz, CDCl_3



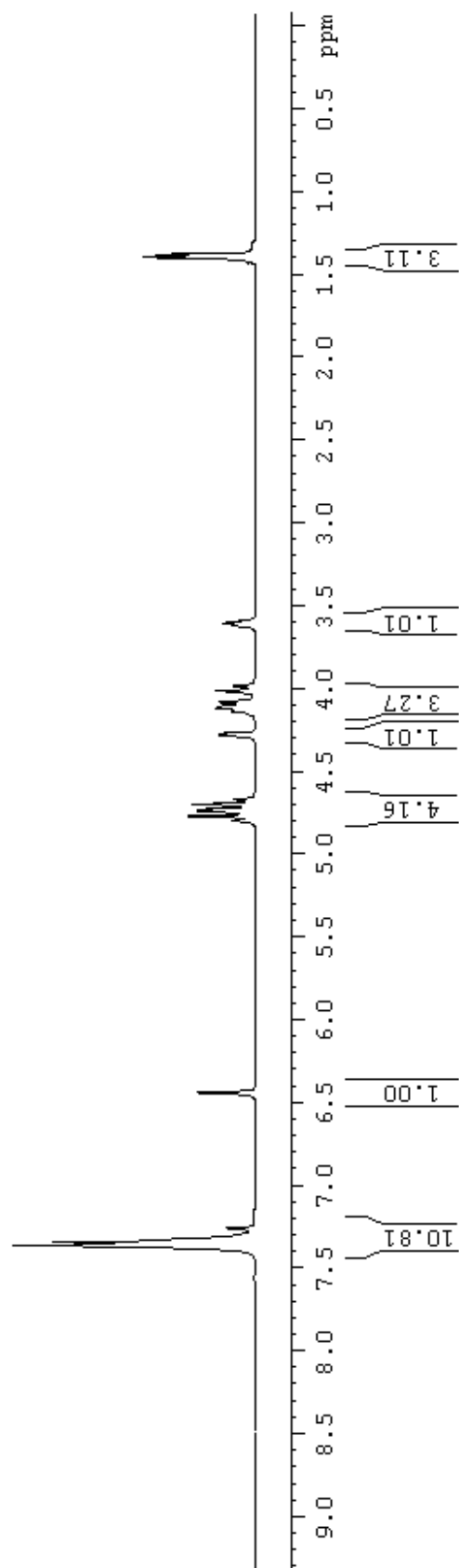
^1H NMR, 400 MHz, CDCl_3

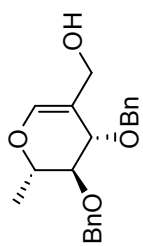




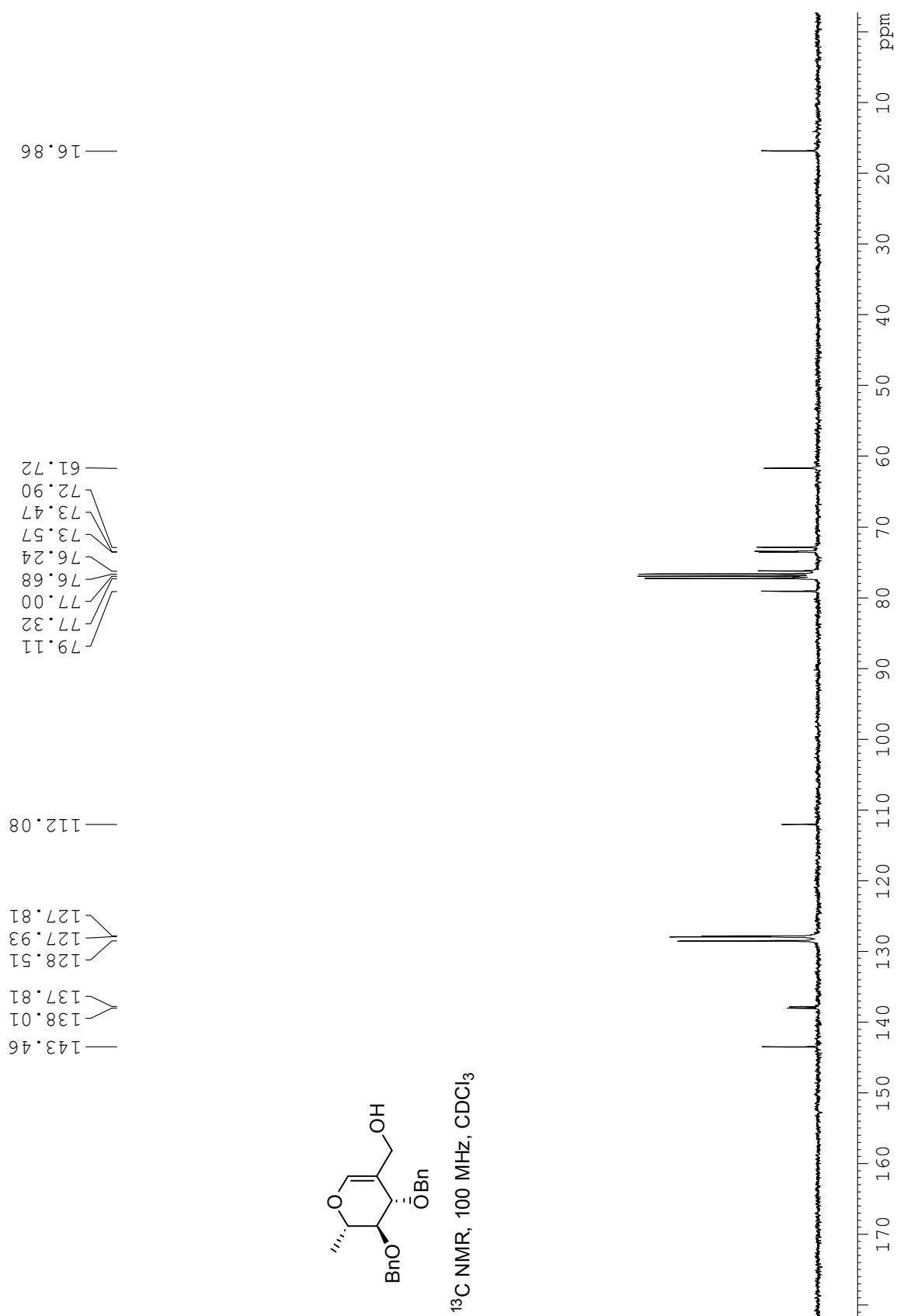


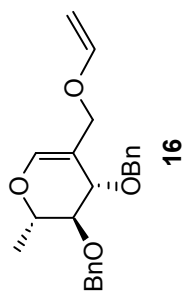
^1H NMR, 400 MHz, CDCl_3 ,



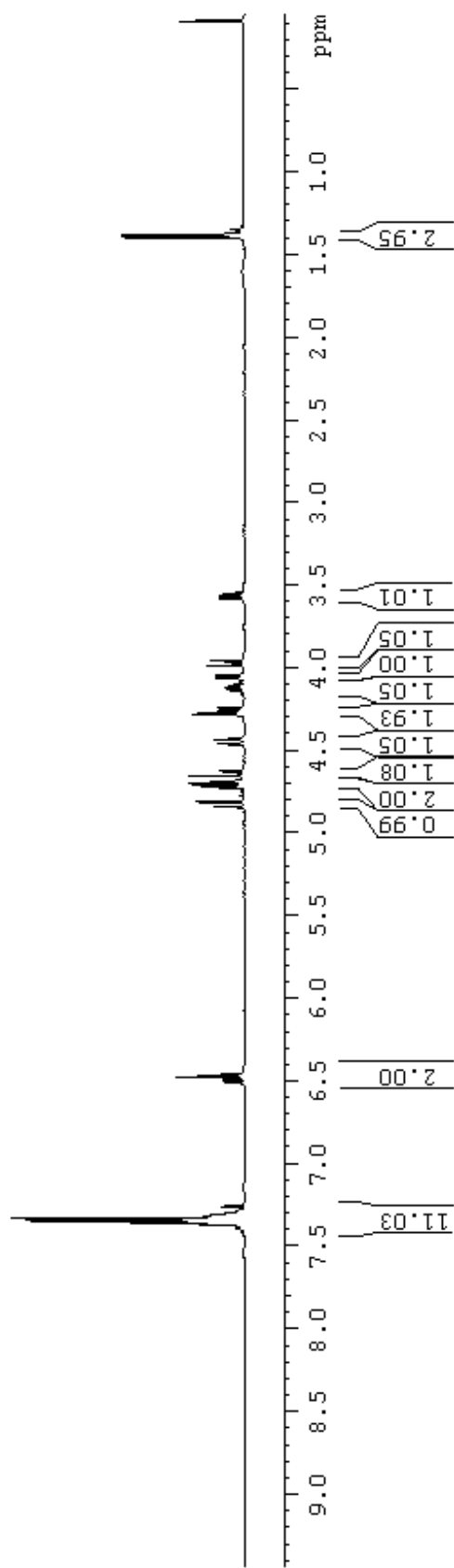


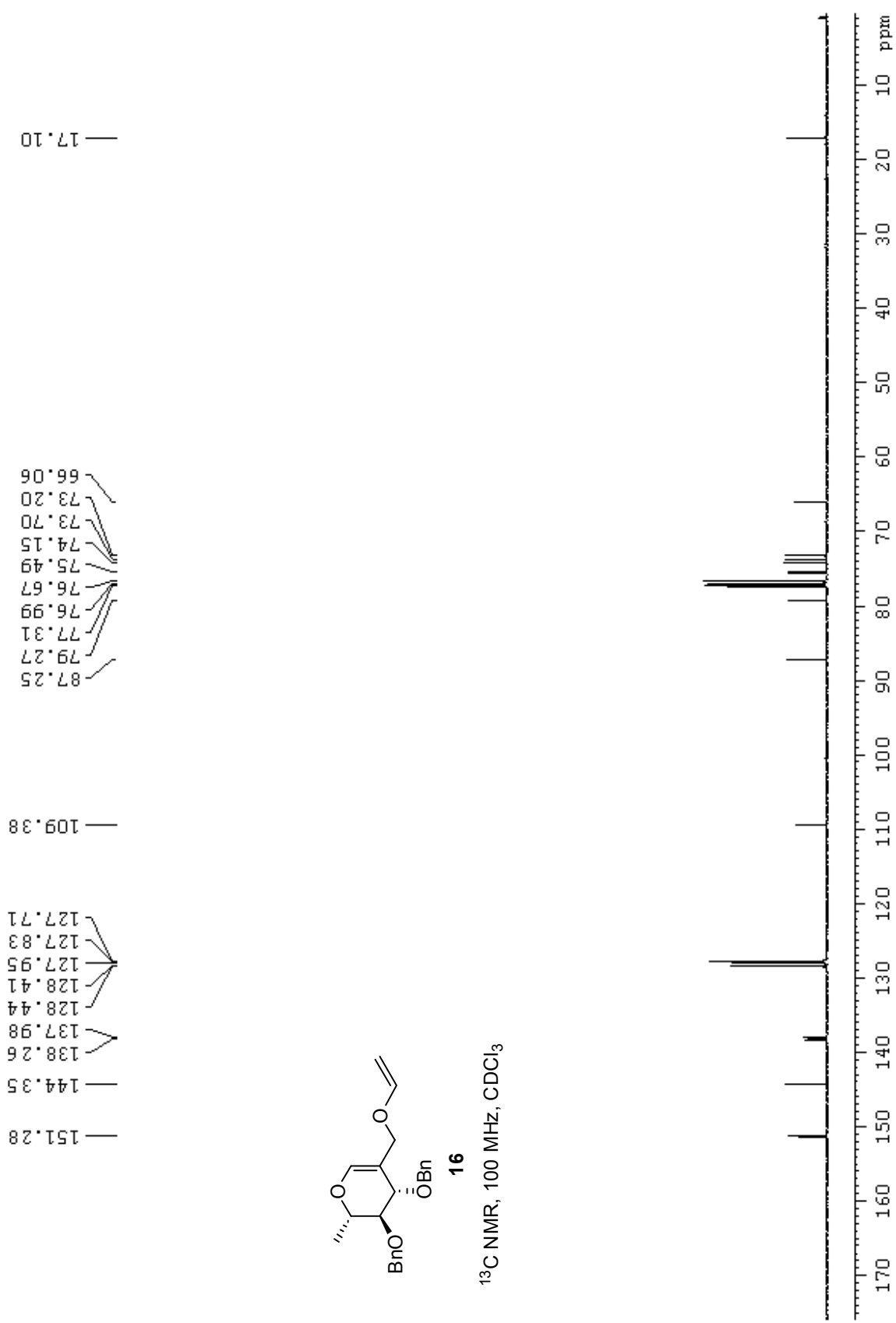
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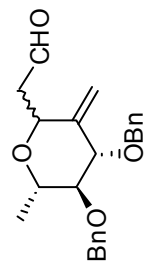




¹H NMR, 400 MHz, CDCl₃

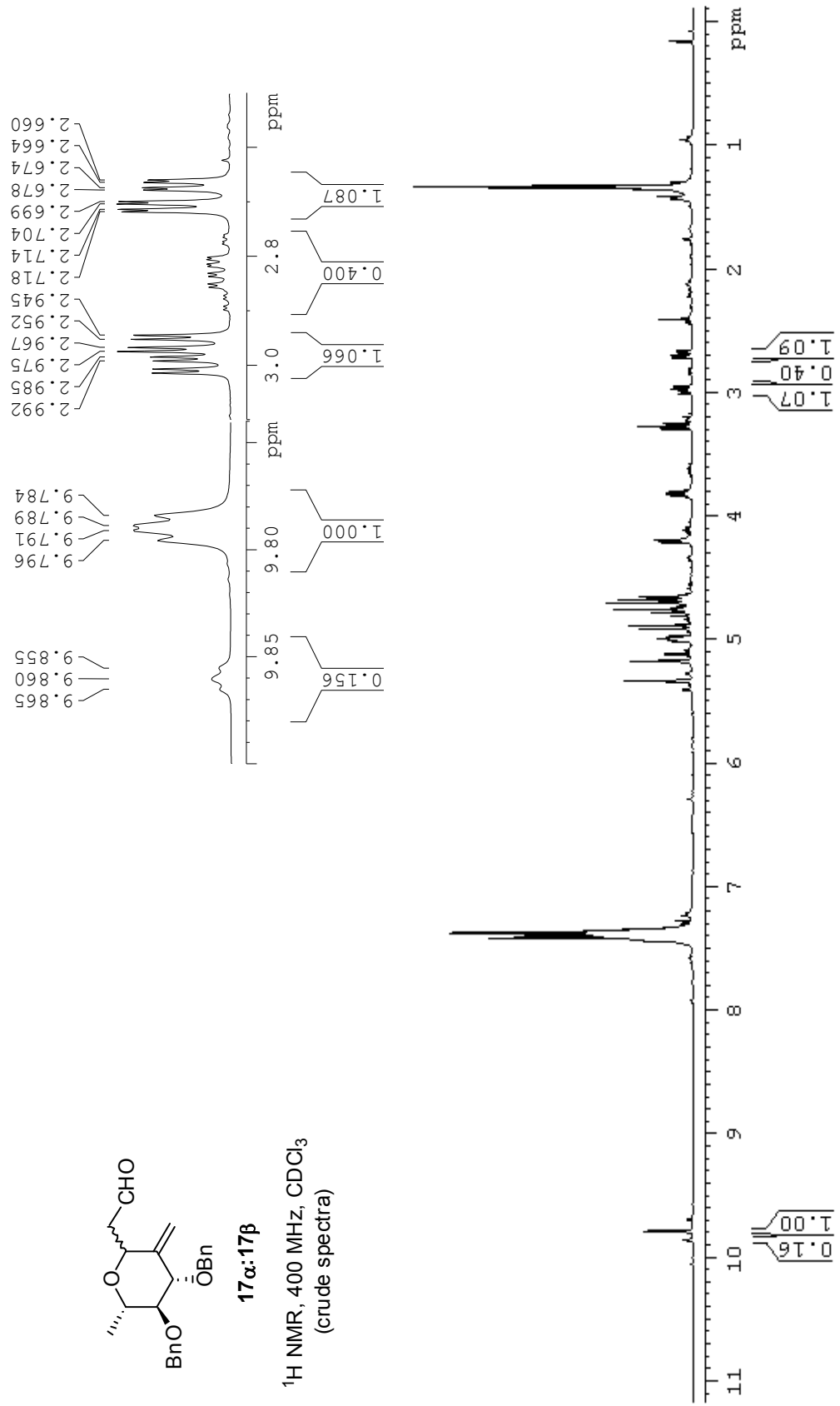


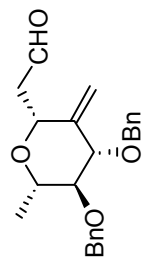




17α:17β

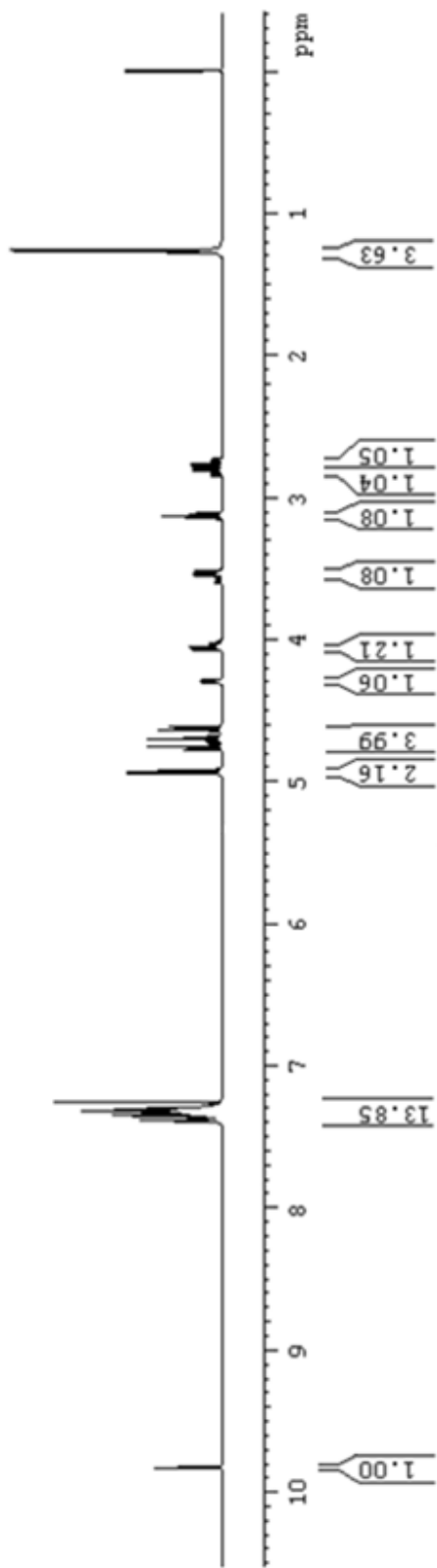
¹H NMR, 400 MHz, CDCl₃
(crude spectra)

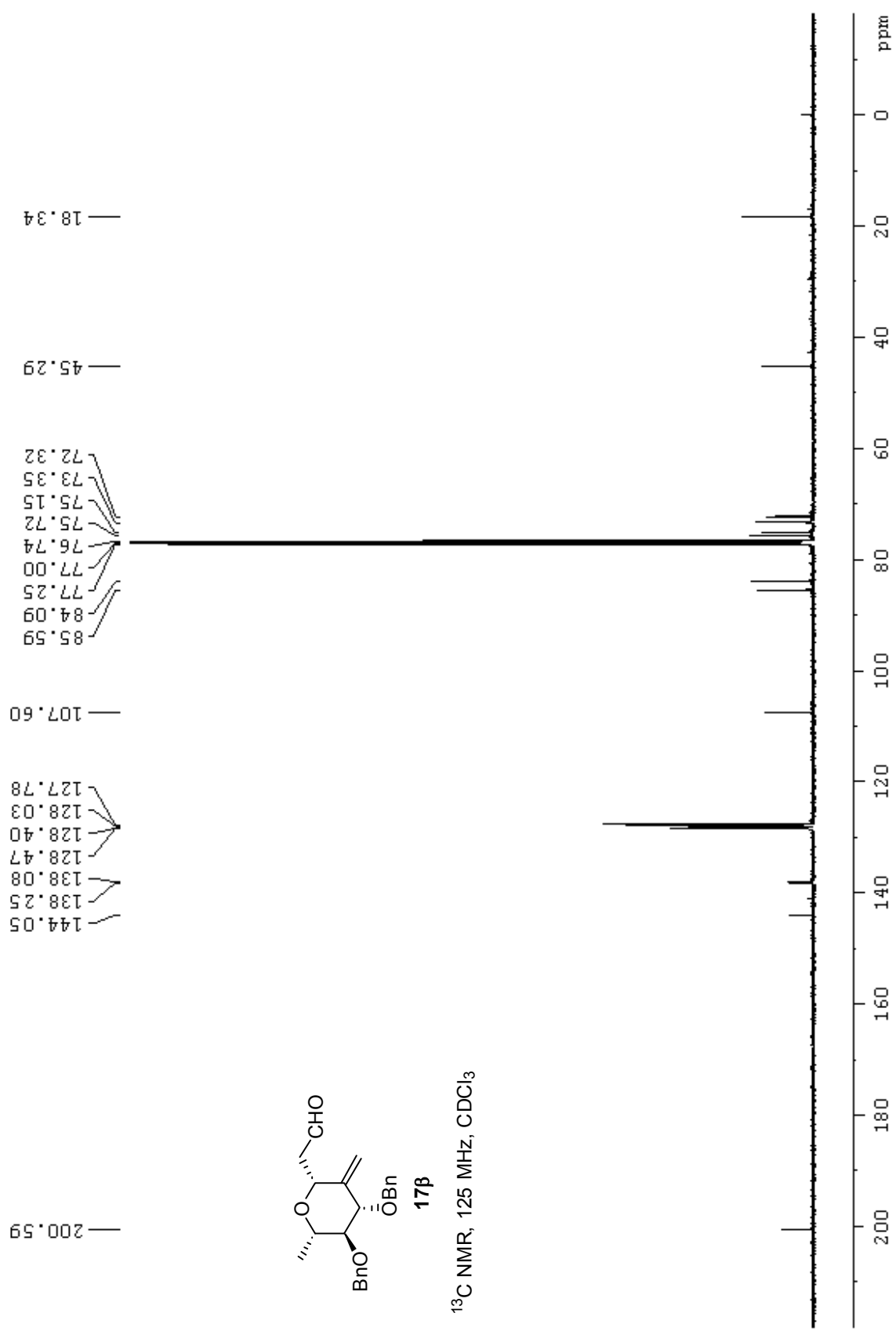


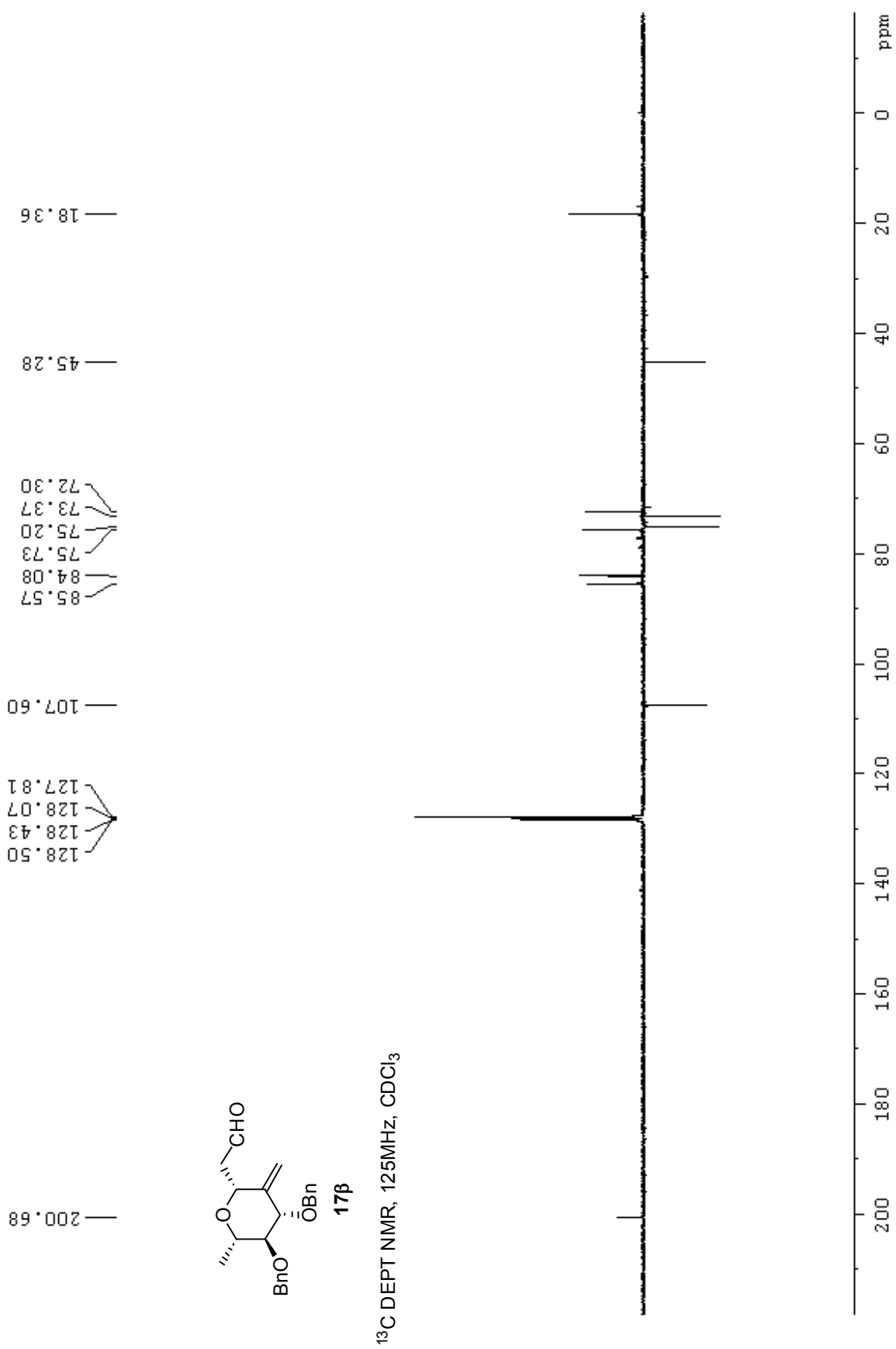


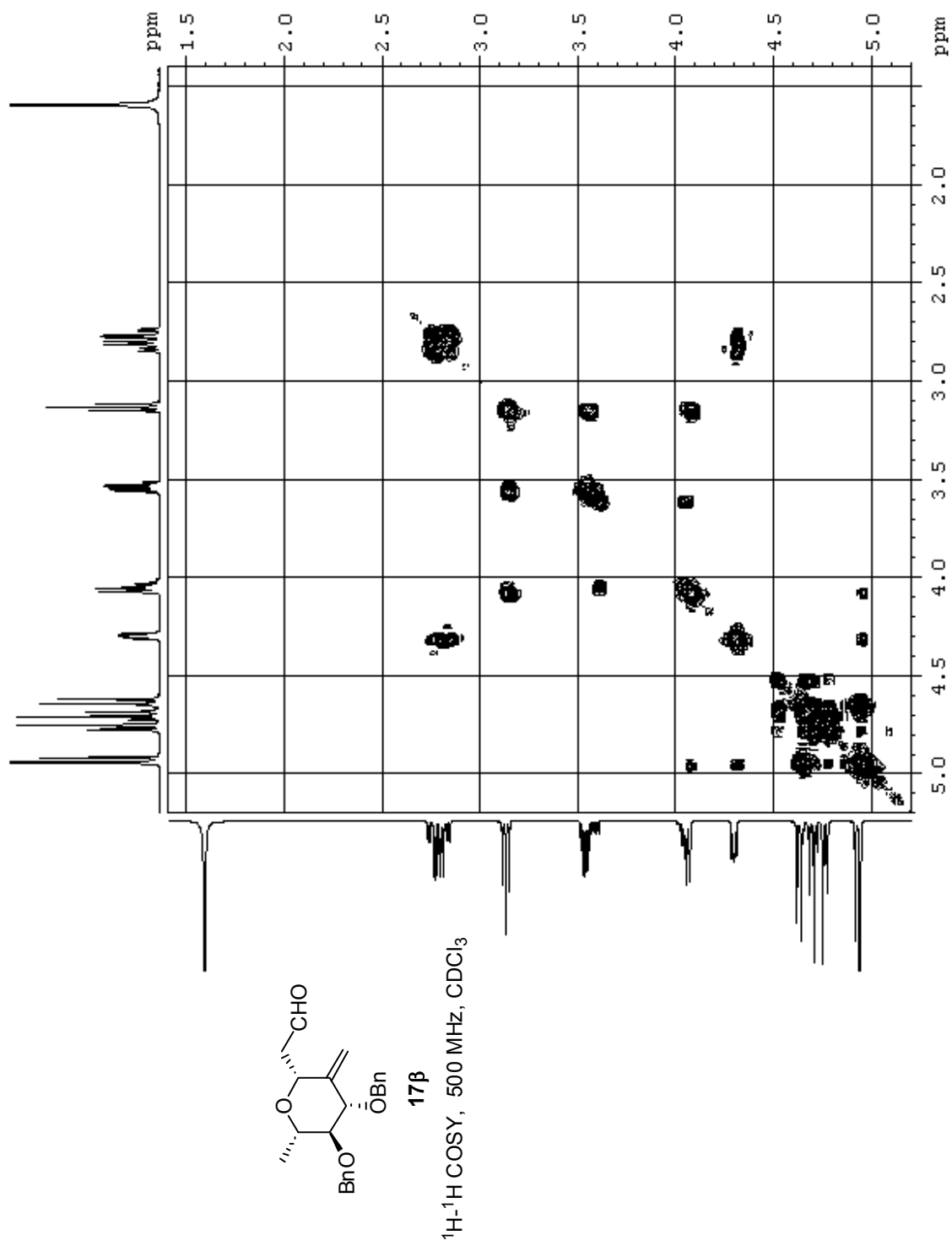
17β

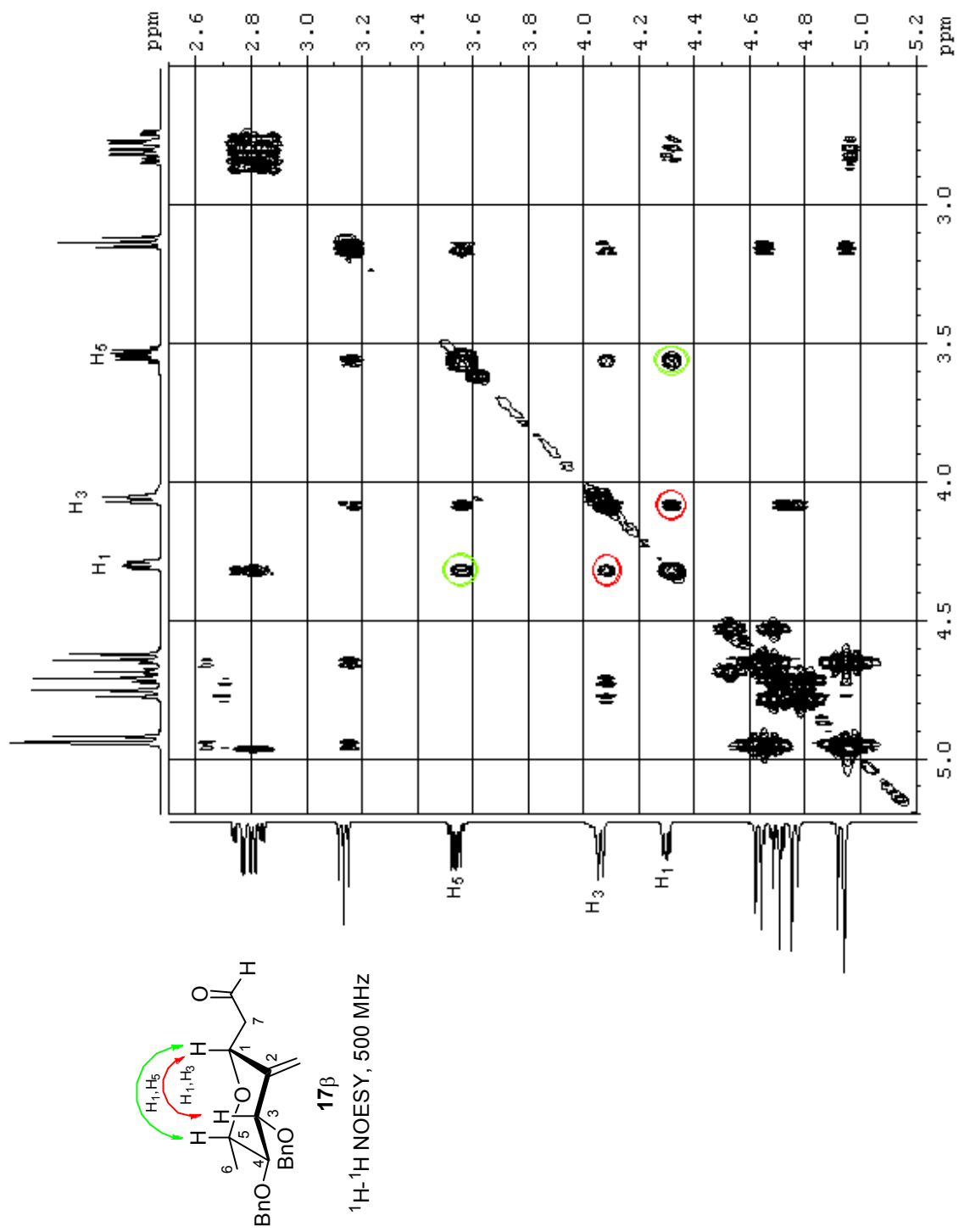
¹H NMR, 500 MHz, CDCl₃

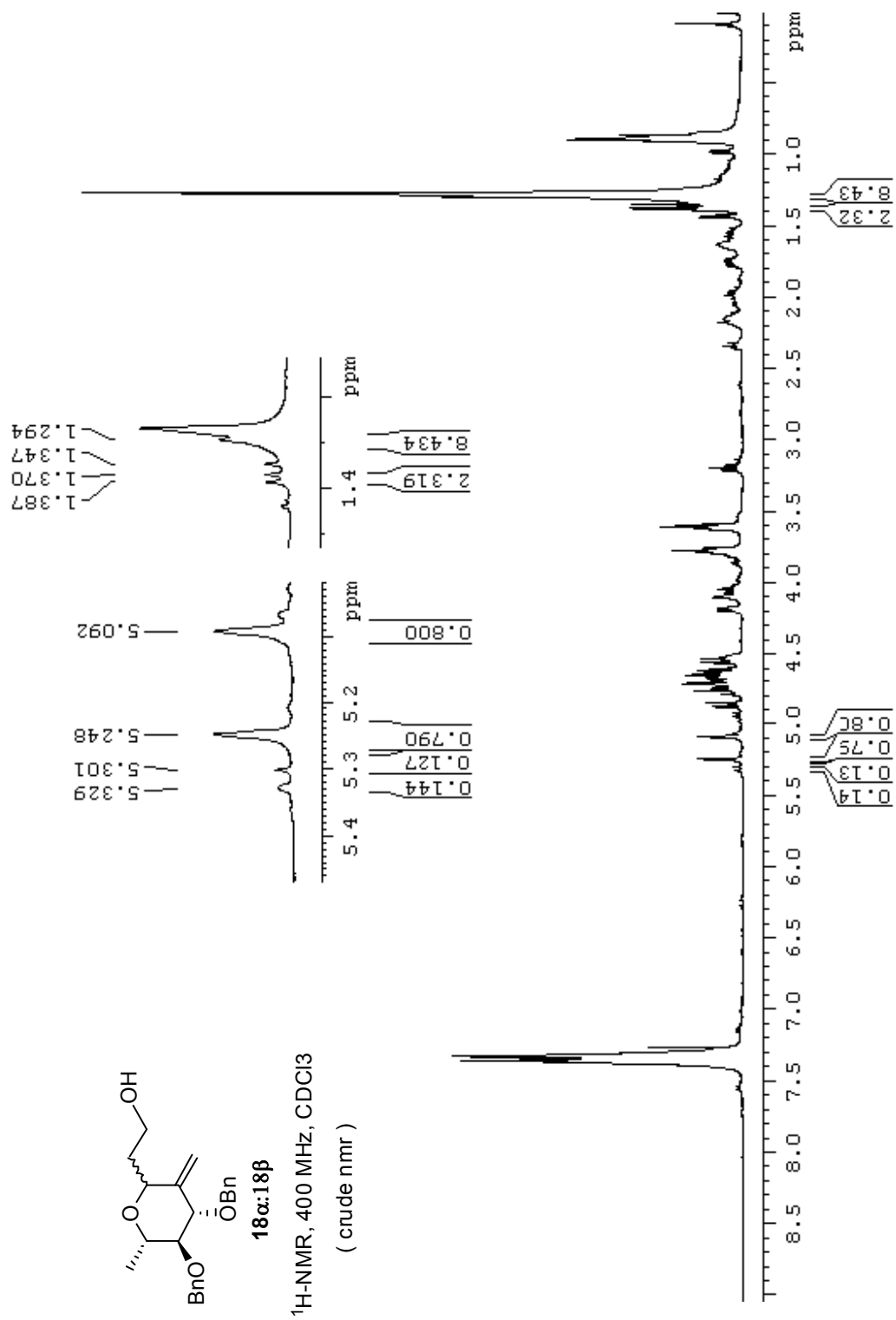


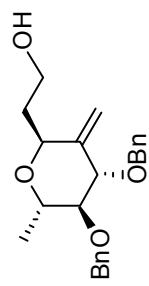






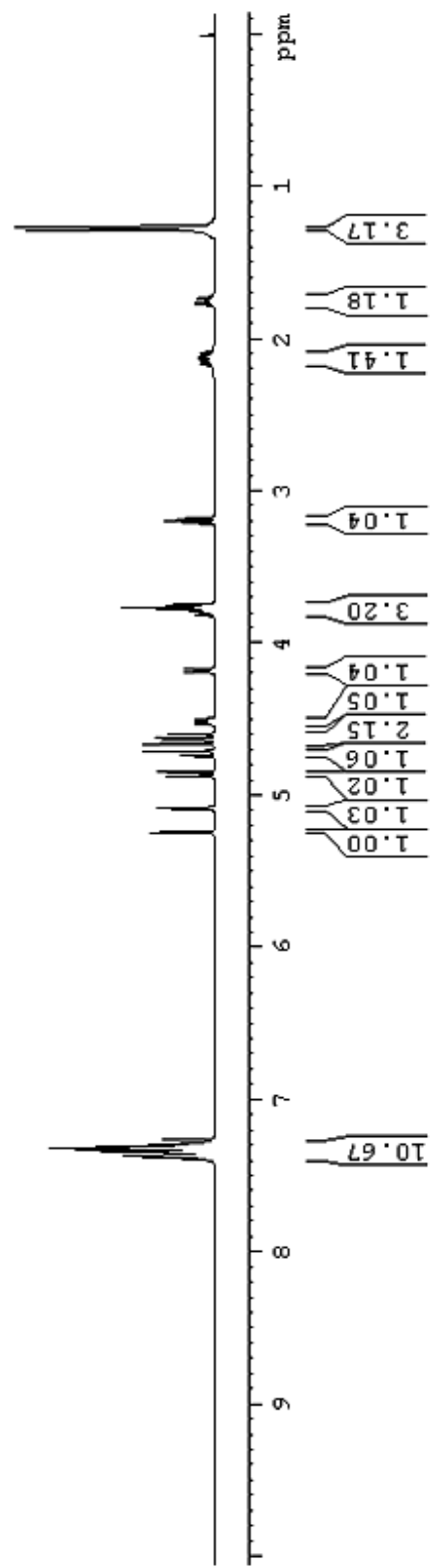


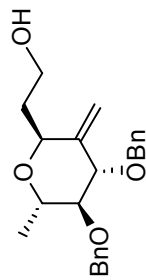




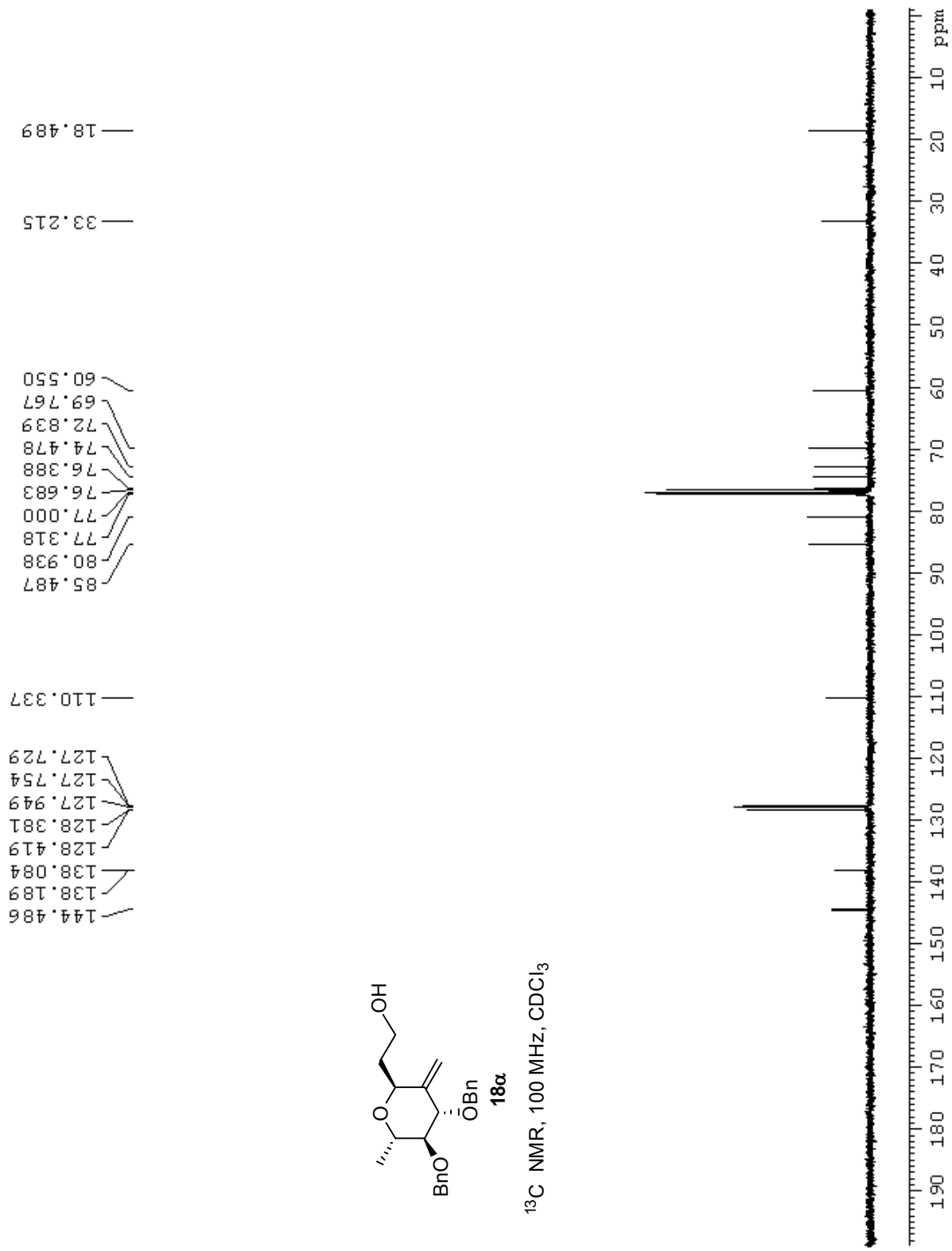
18α

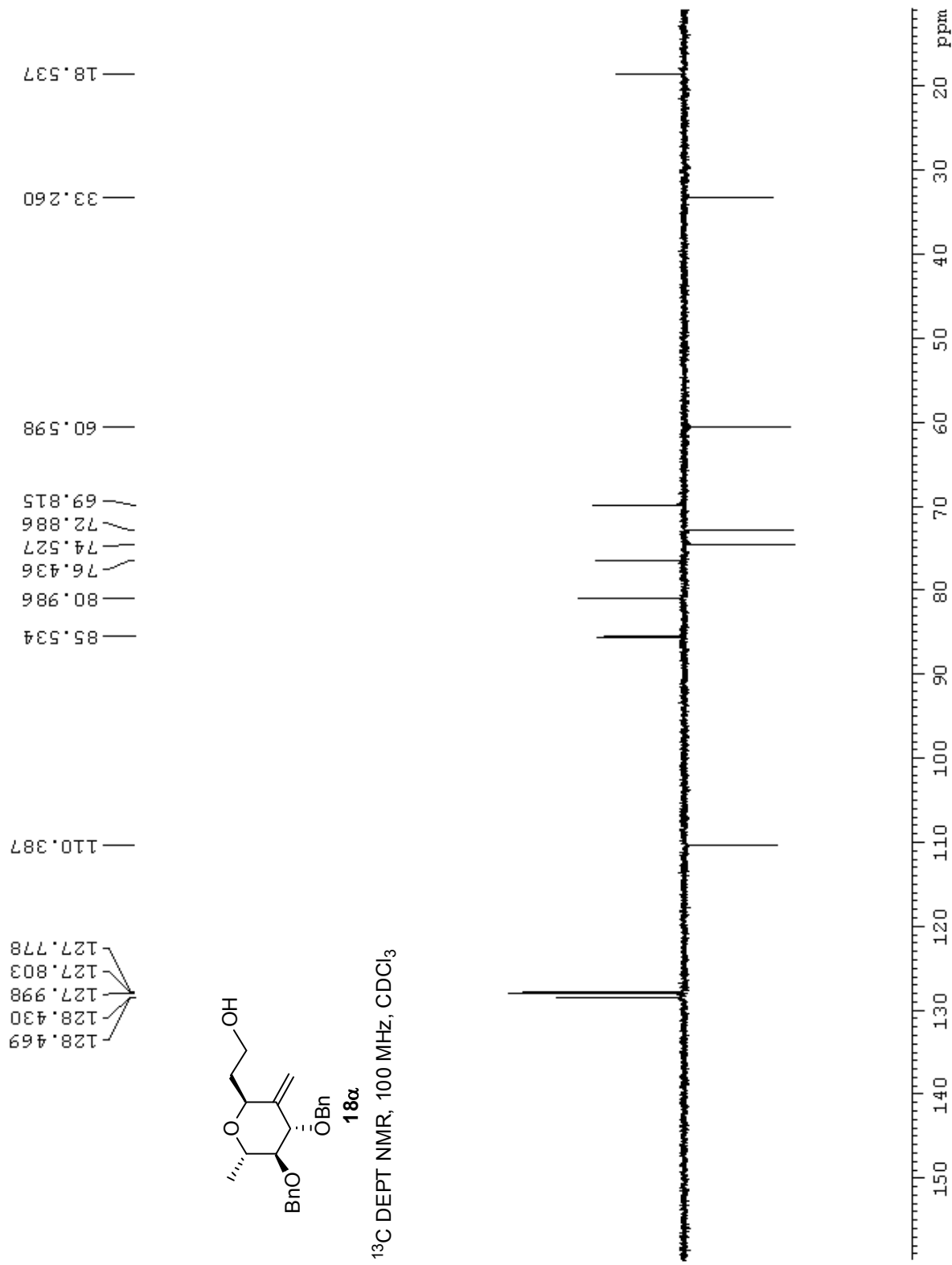
¹H NMR, 400 MHz, CDCl₃

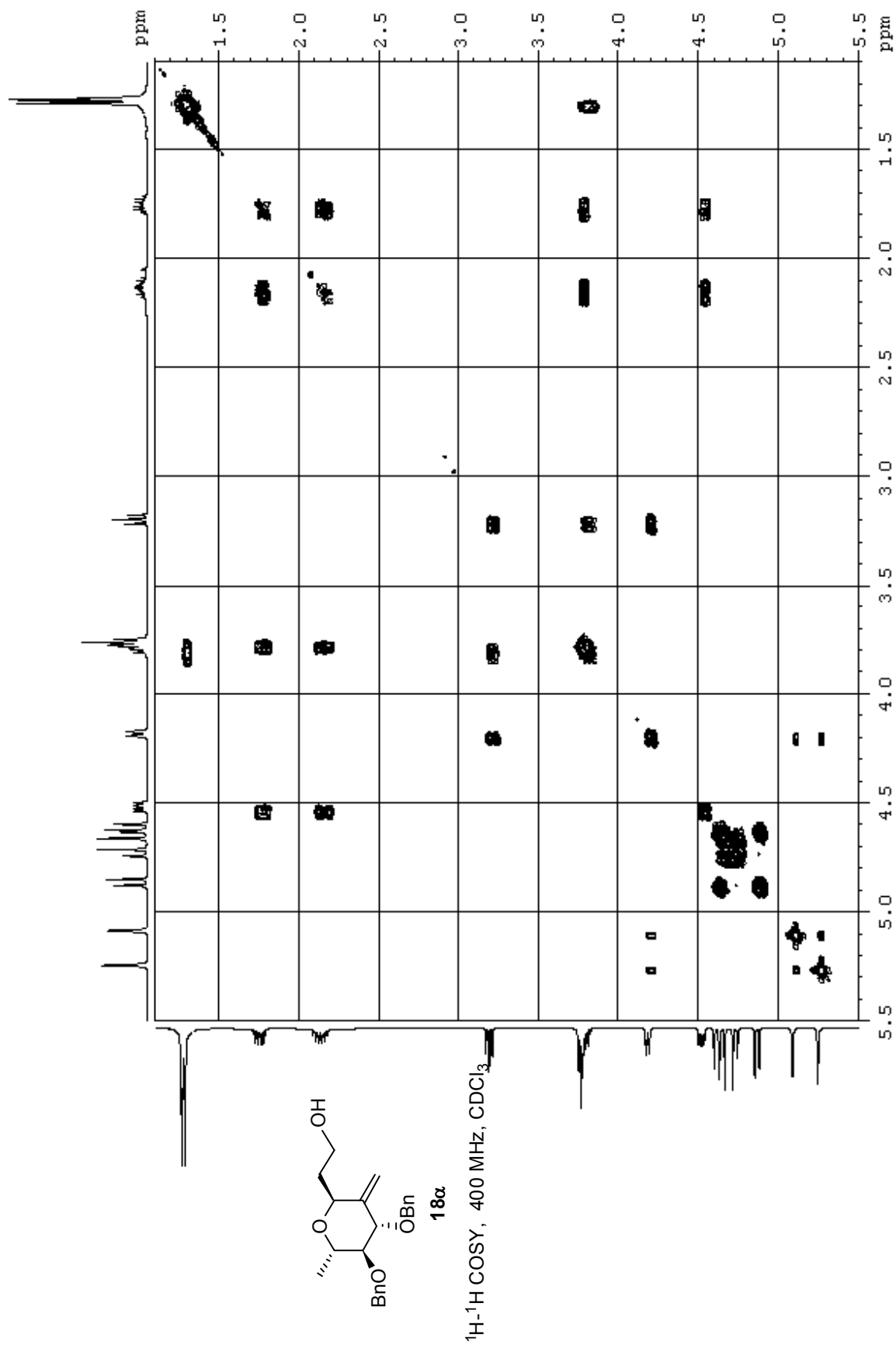


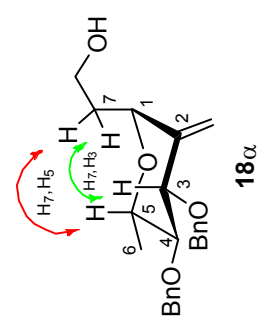
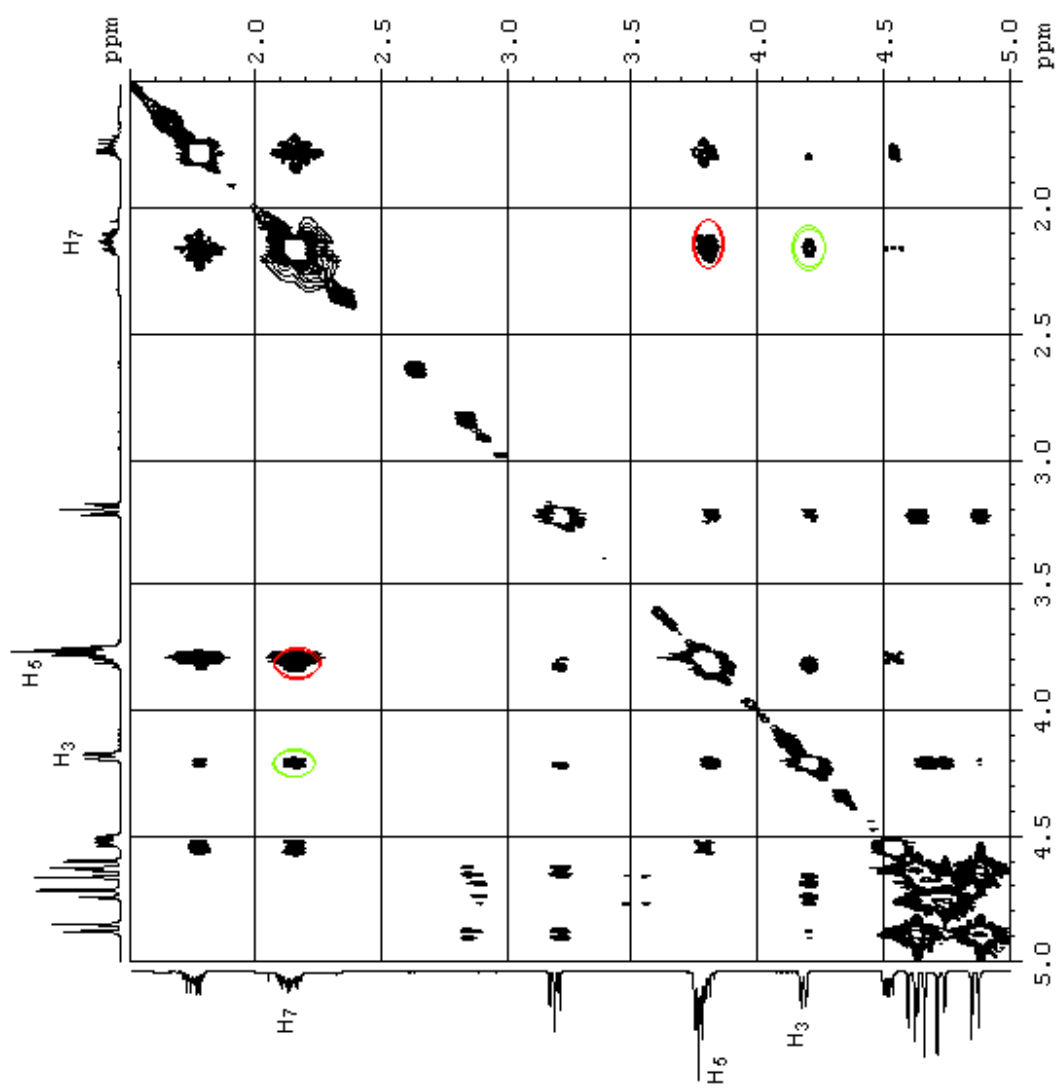


^{13}C NMR, 100 MHz, CDCl_3

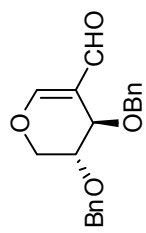




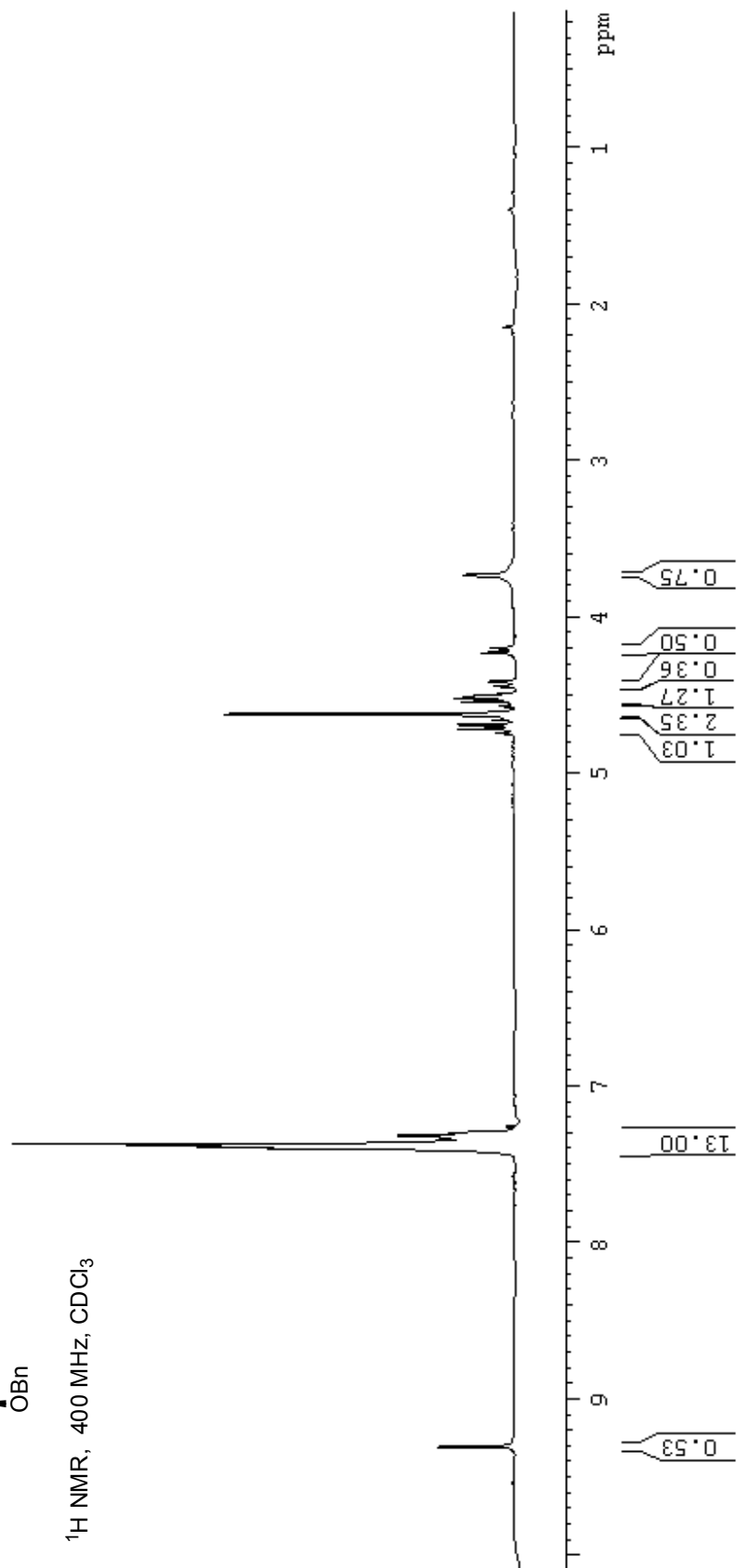


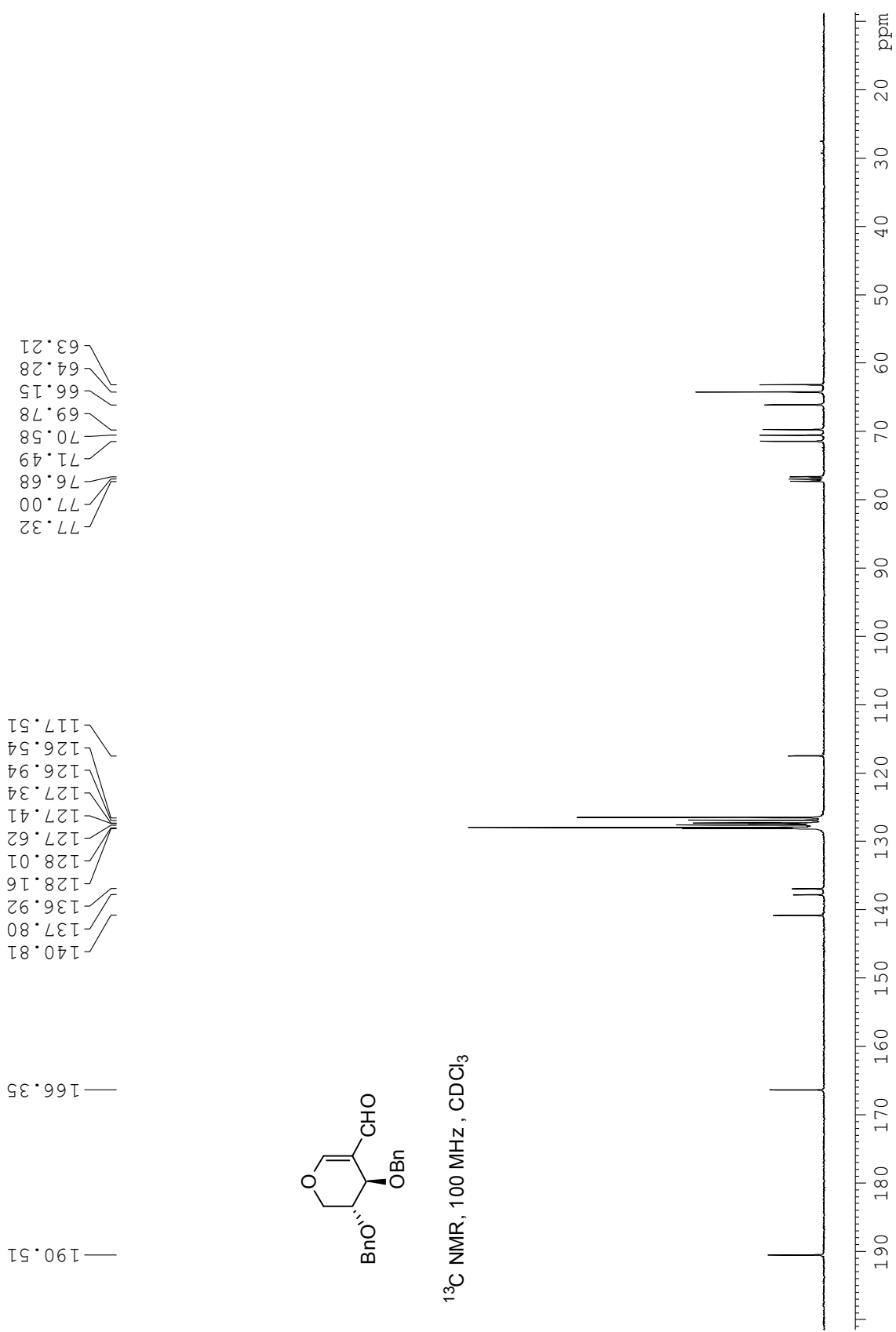


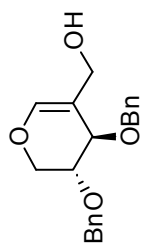
^1H - ^1H NOESY, 400 MHz



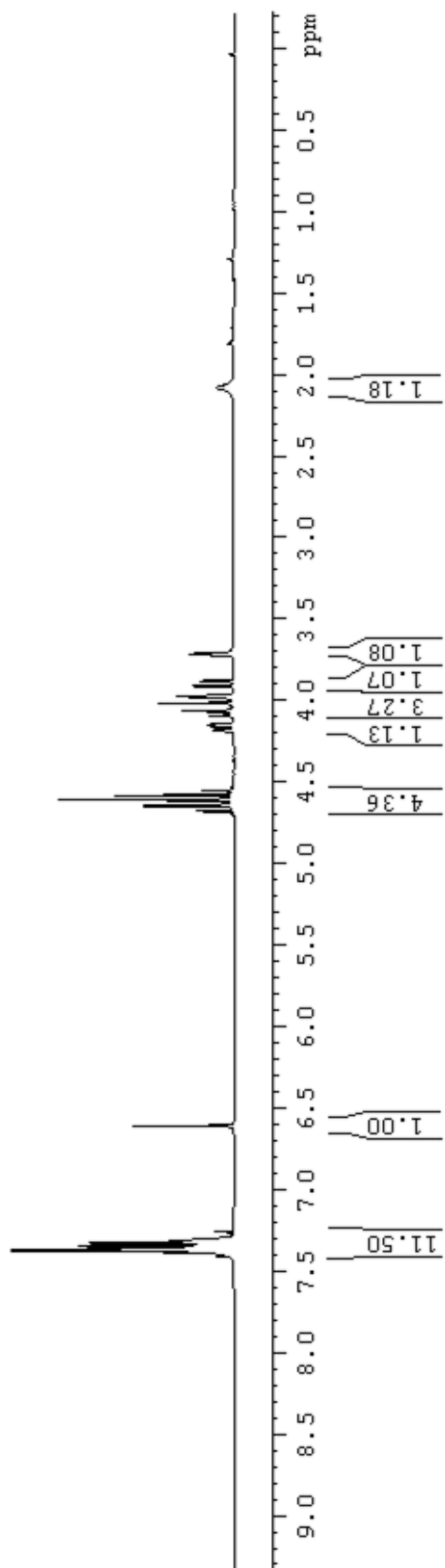
^1H NMR, 400 MHz, CDCl_3

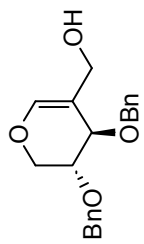




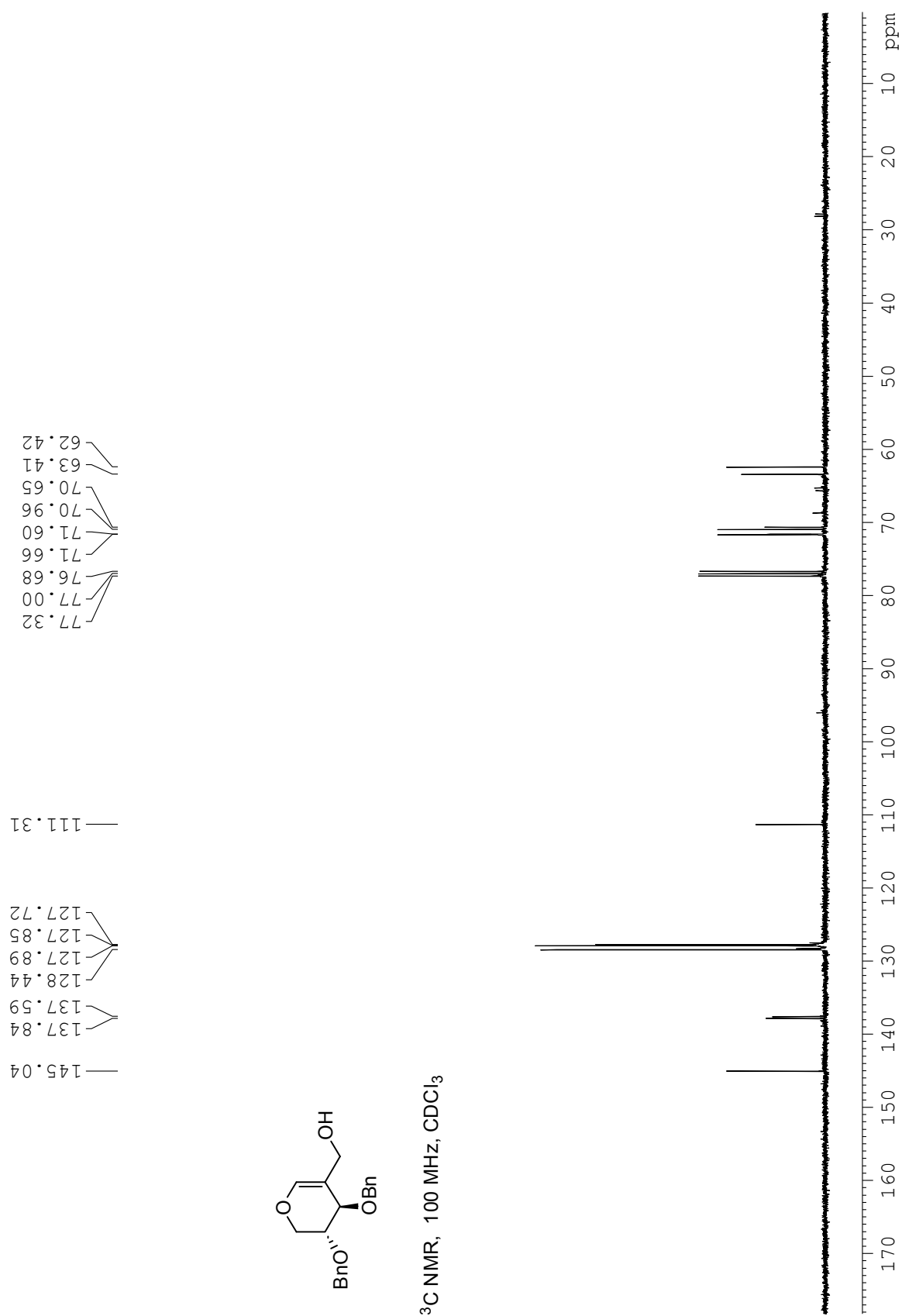


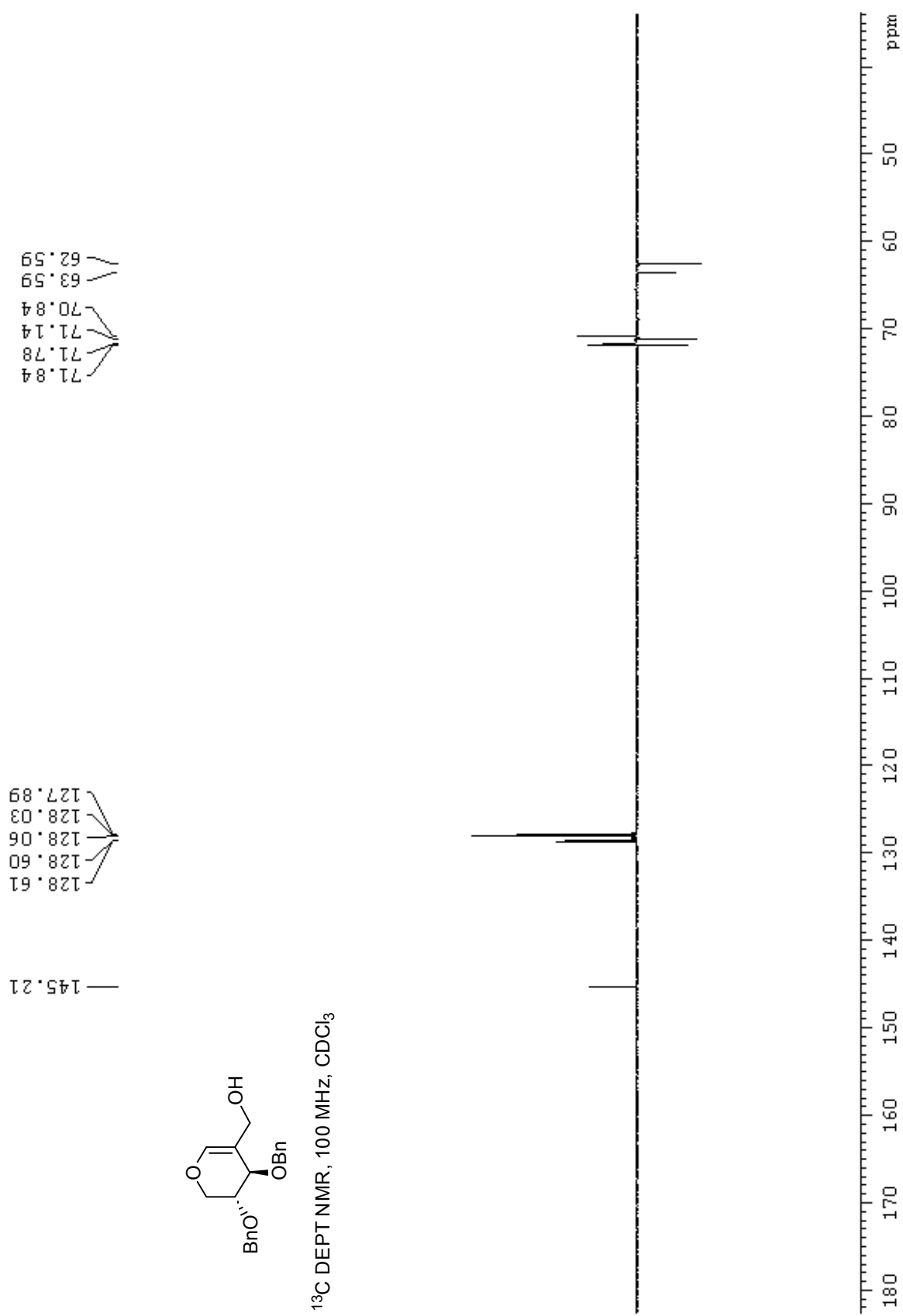
¹H NMR, 400 MHz, CDCl₃

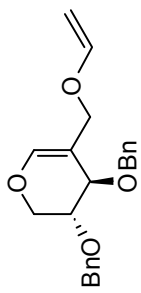




¹³C NMR, 100 MHz, CDCl₃

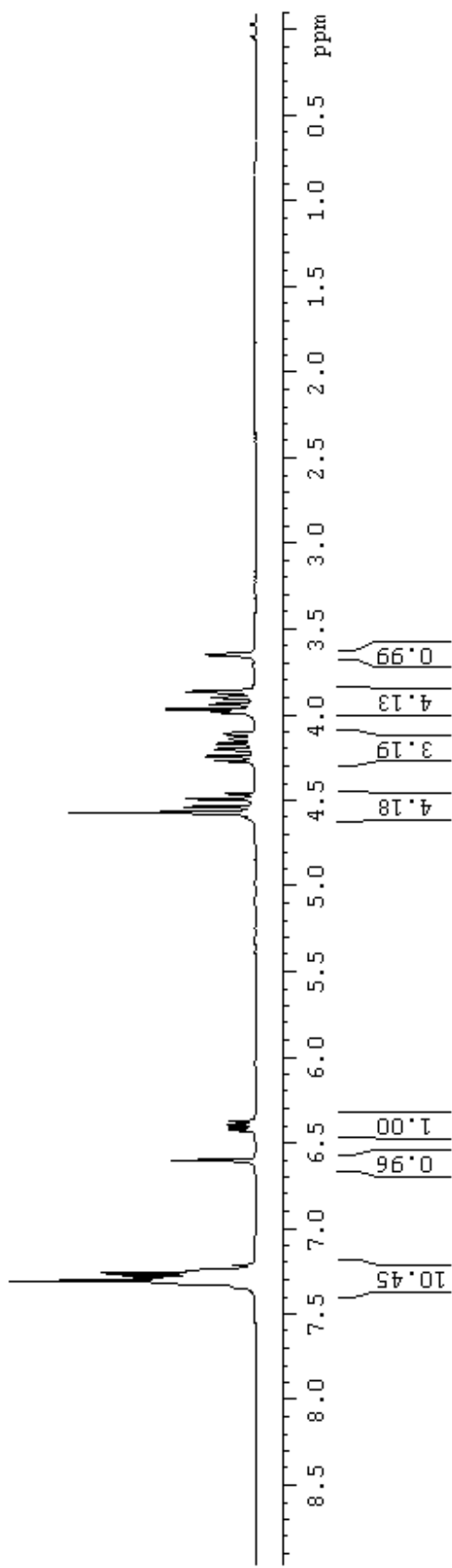


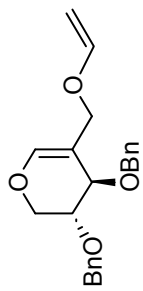




19

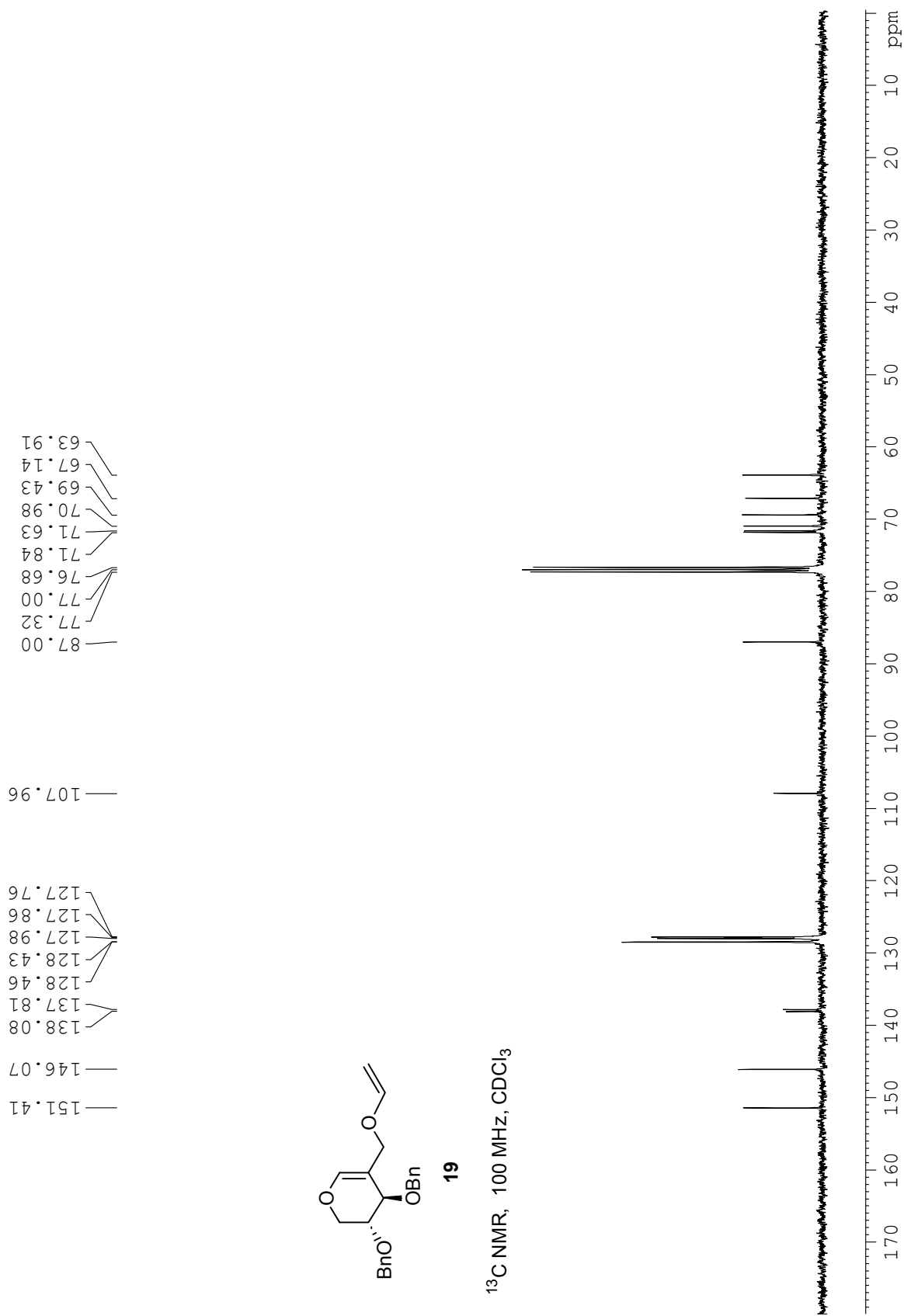
¹H NMR, 400 MHz, CDCl₃

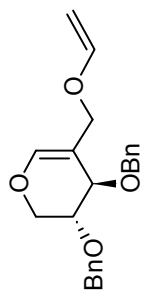




19

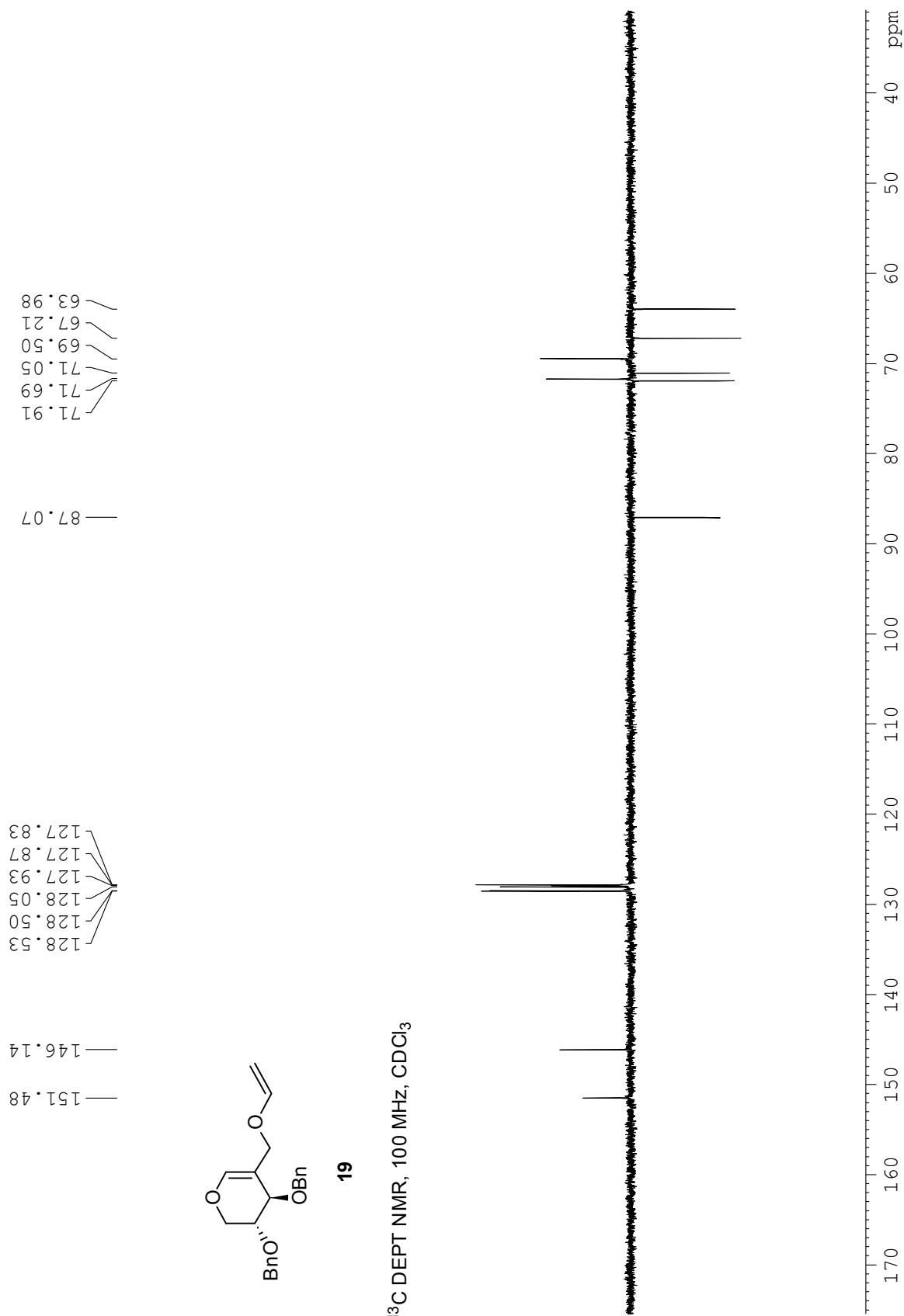
^{13}C NMR, 100 MHz, CDCl_3

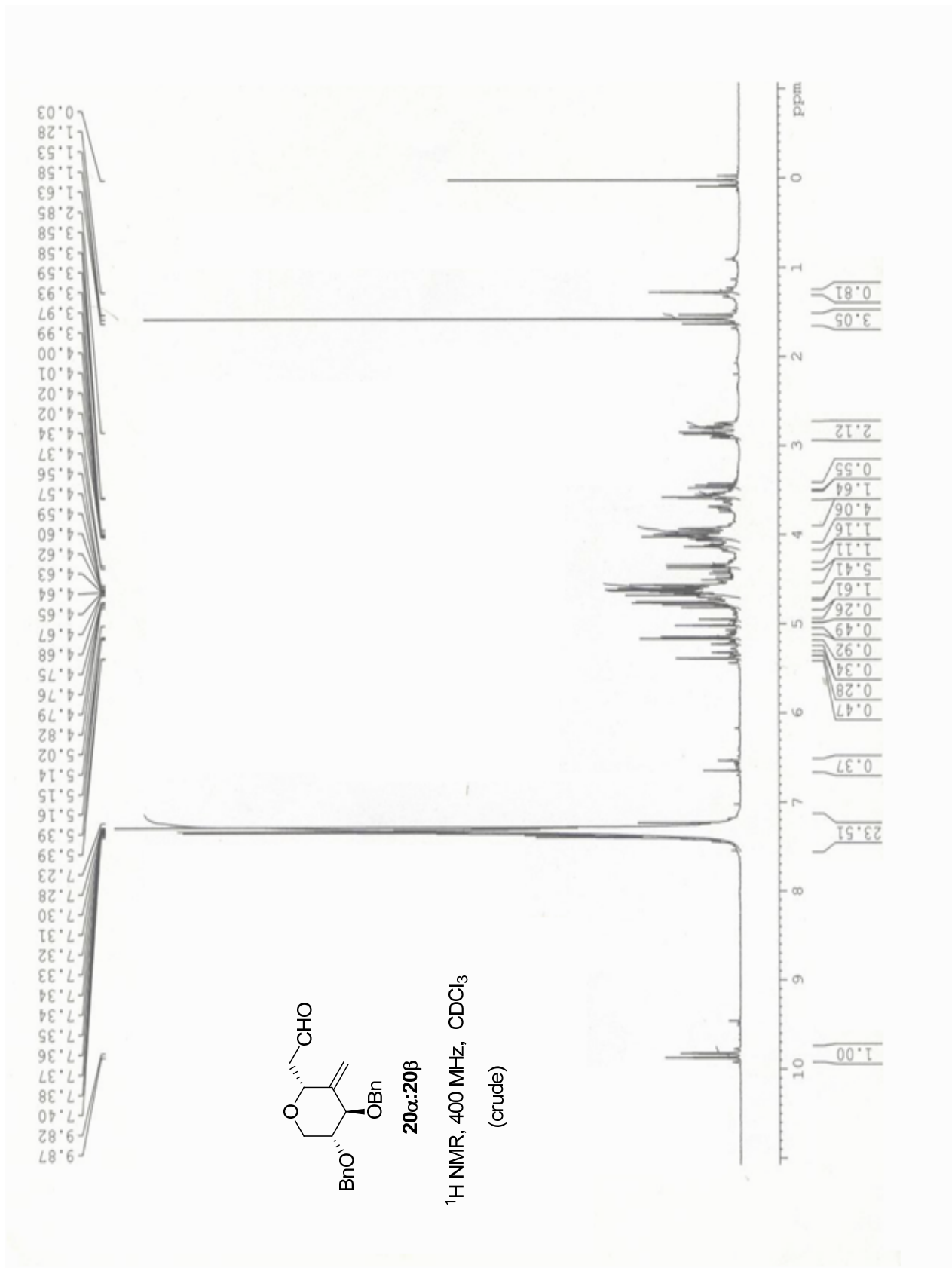


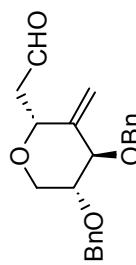


19

^{13}C DEPT NMR, 100 MHz, CDCl_3

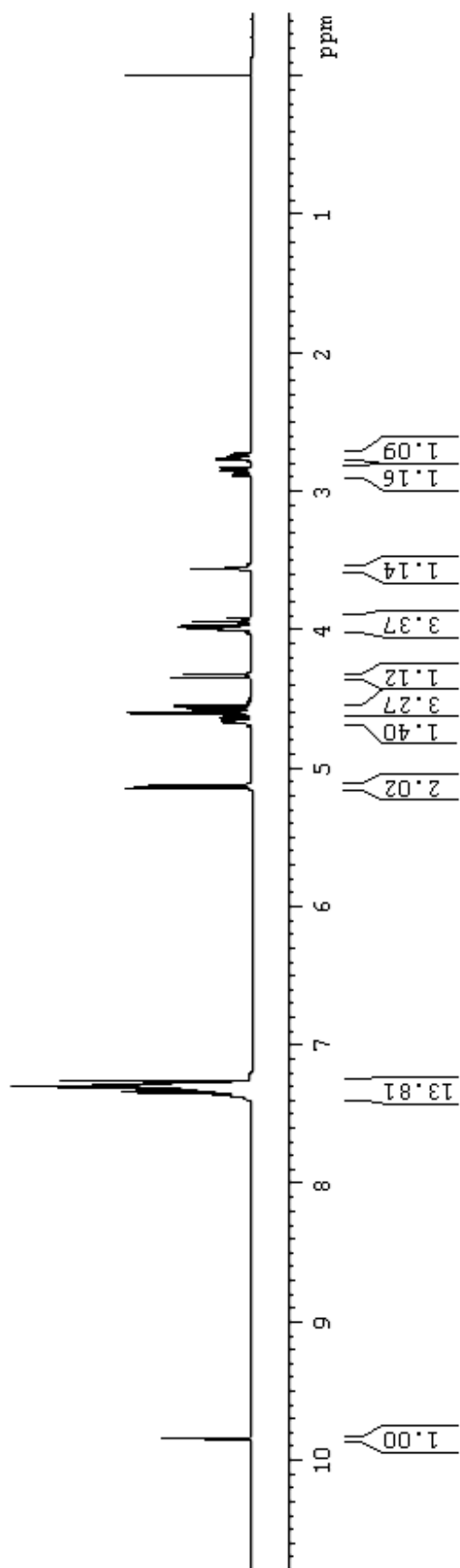


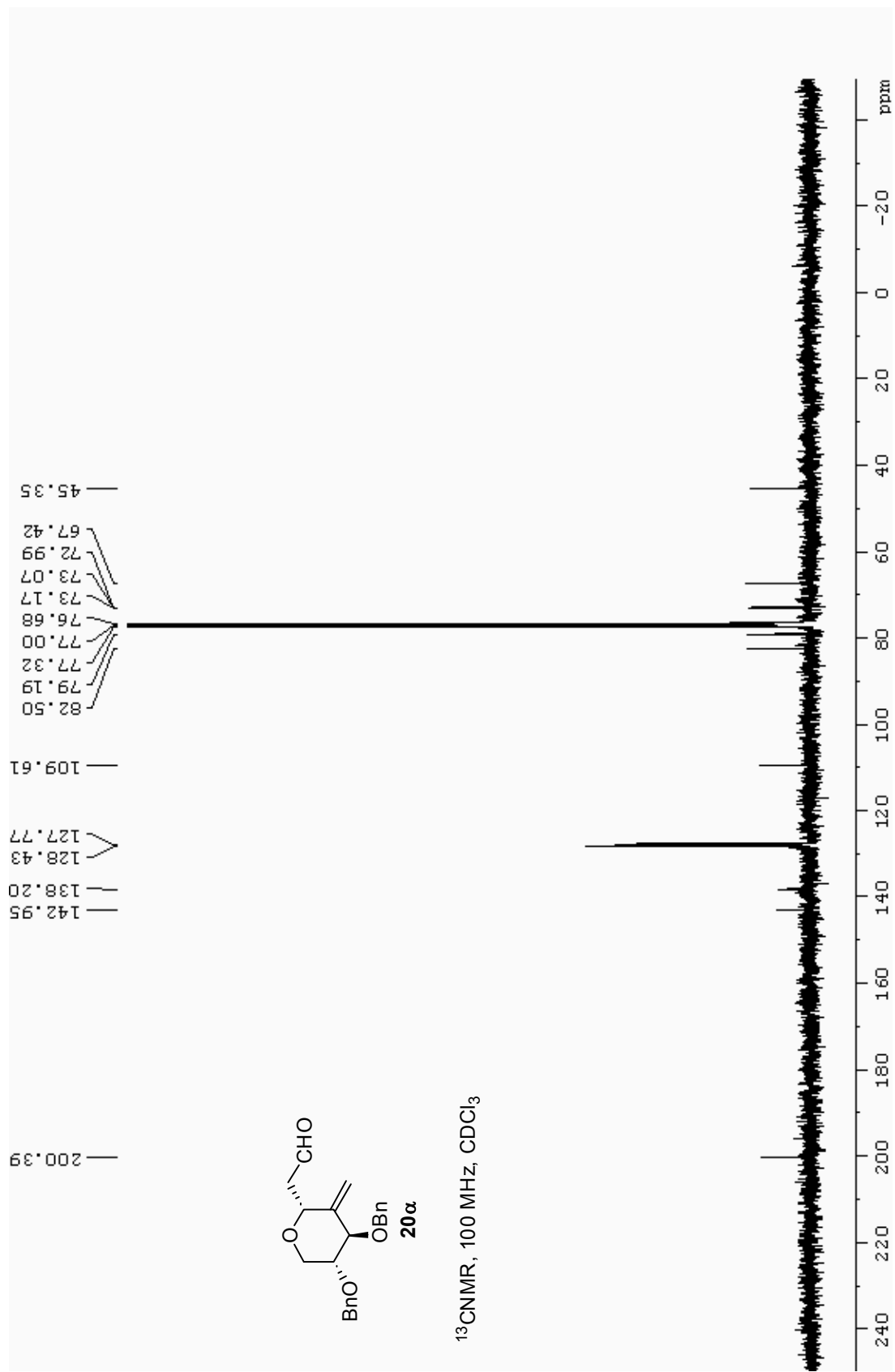


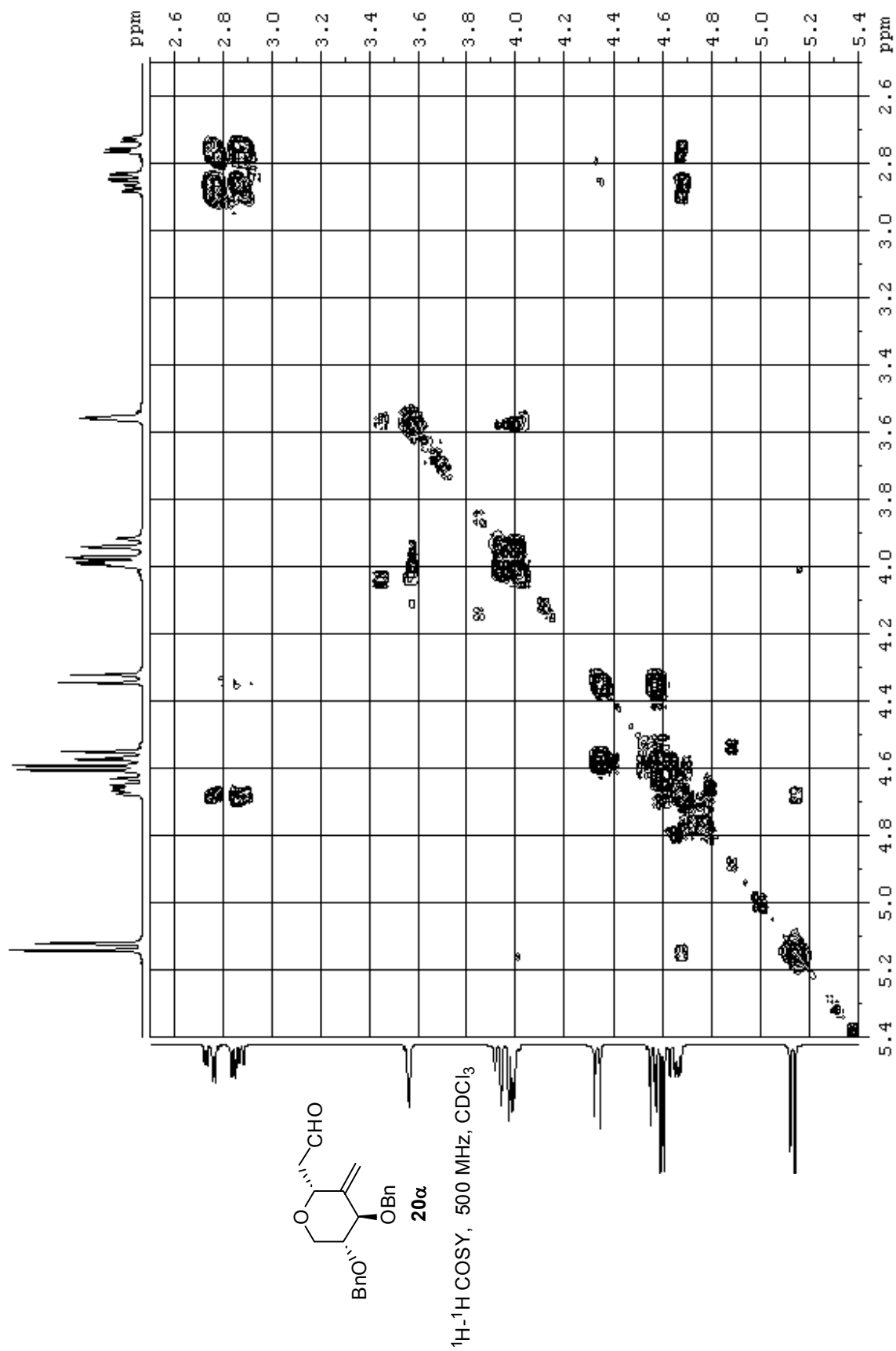


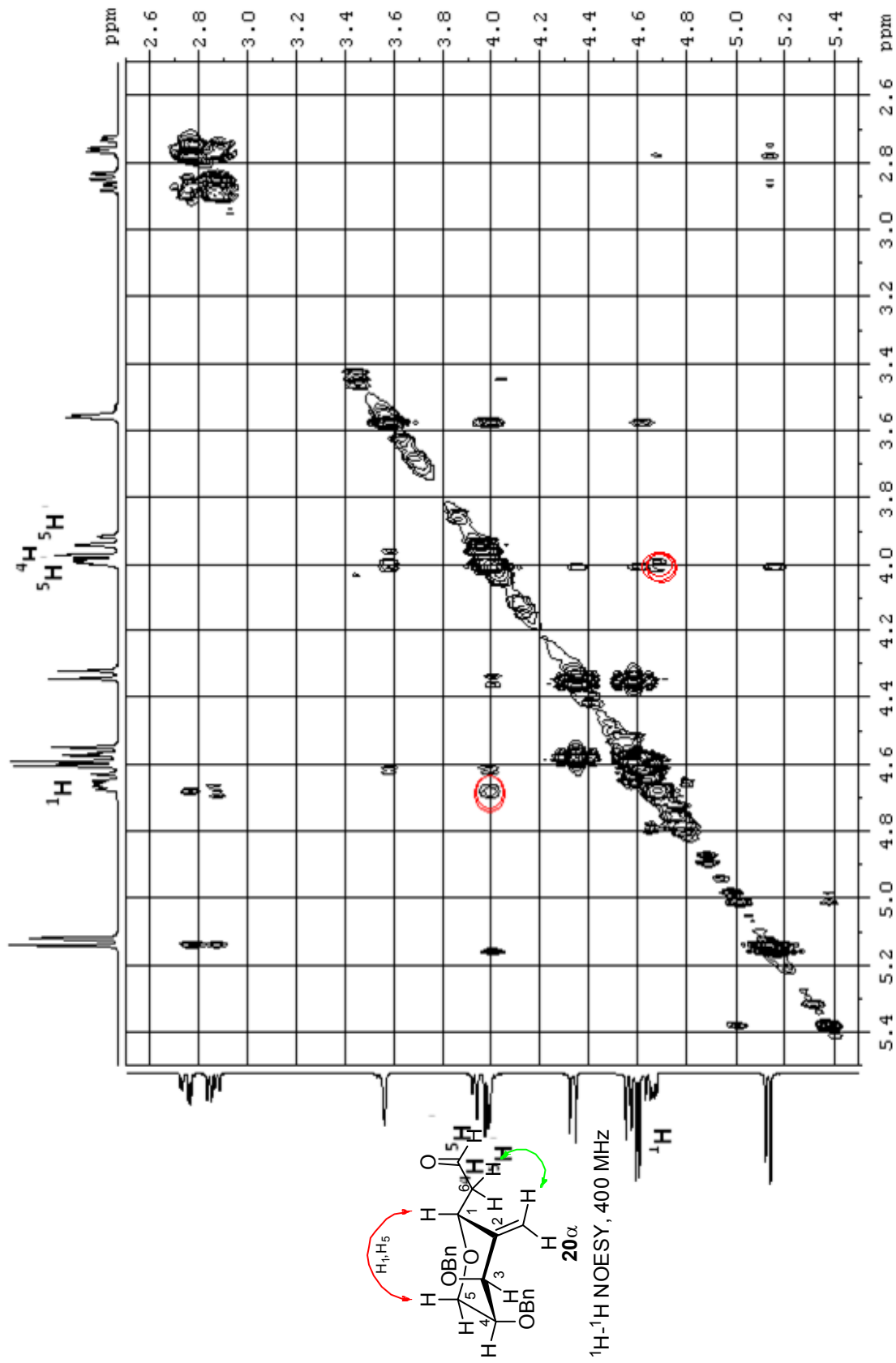
20α

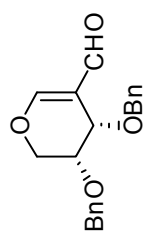
¹H NMR, 500 MHz, CDCl₃



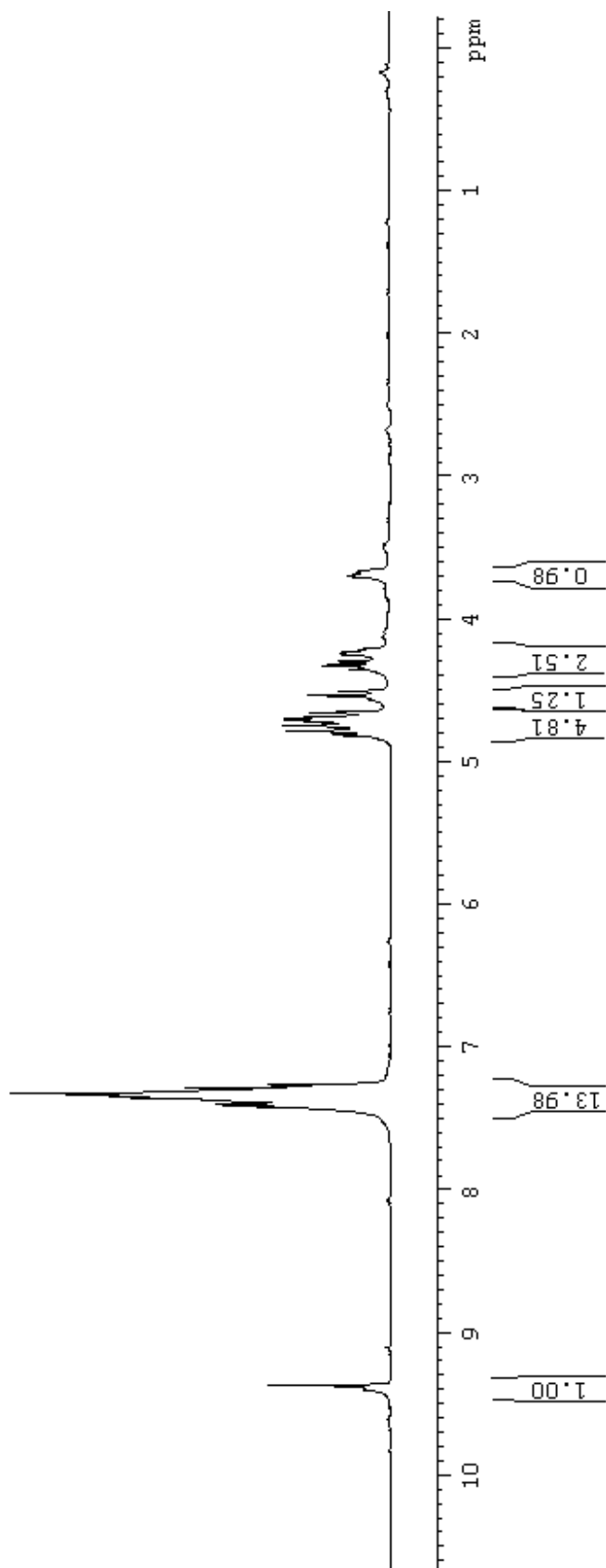


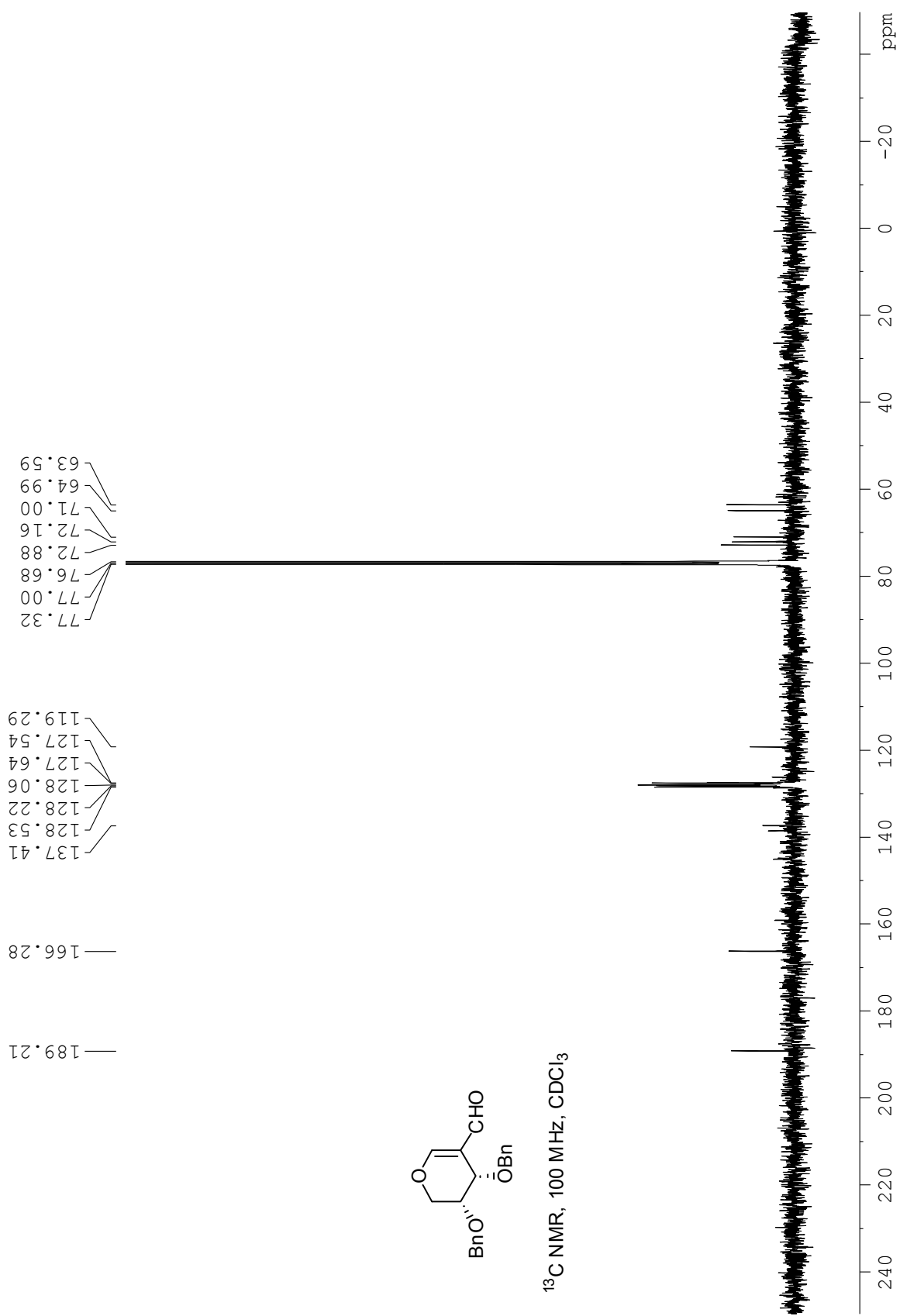


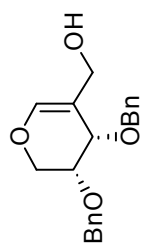




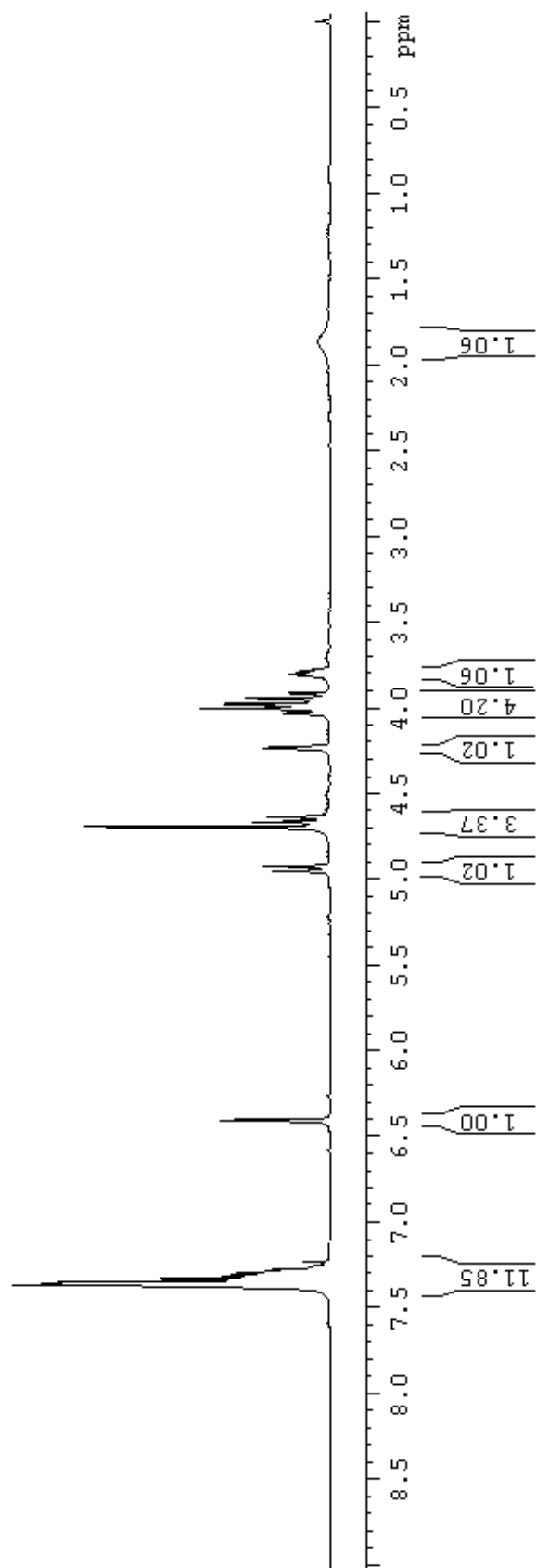
^1H NMR, 400 MHz, CDCl_3

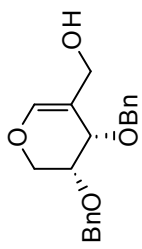






^1H NMR, 400 MHz, CDCl_3



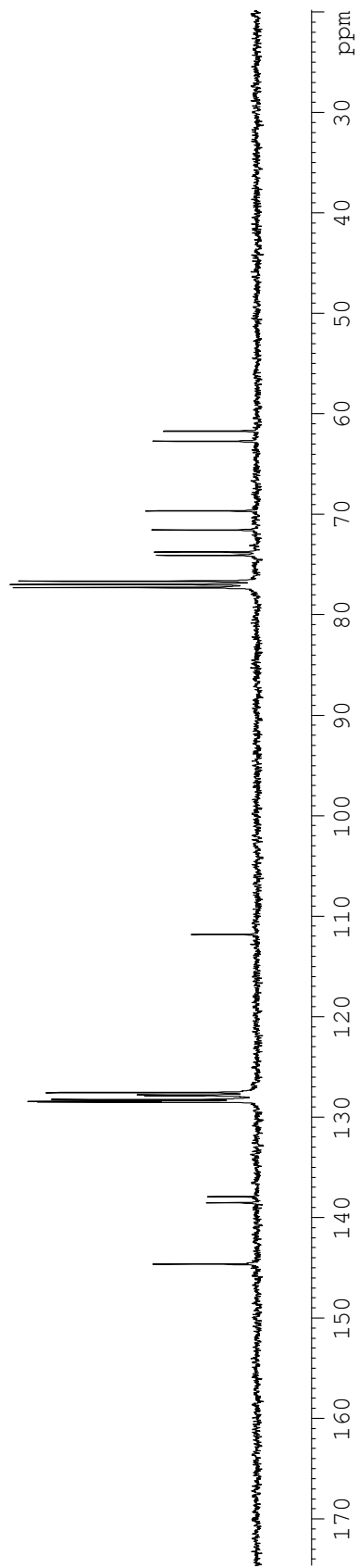


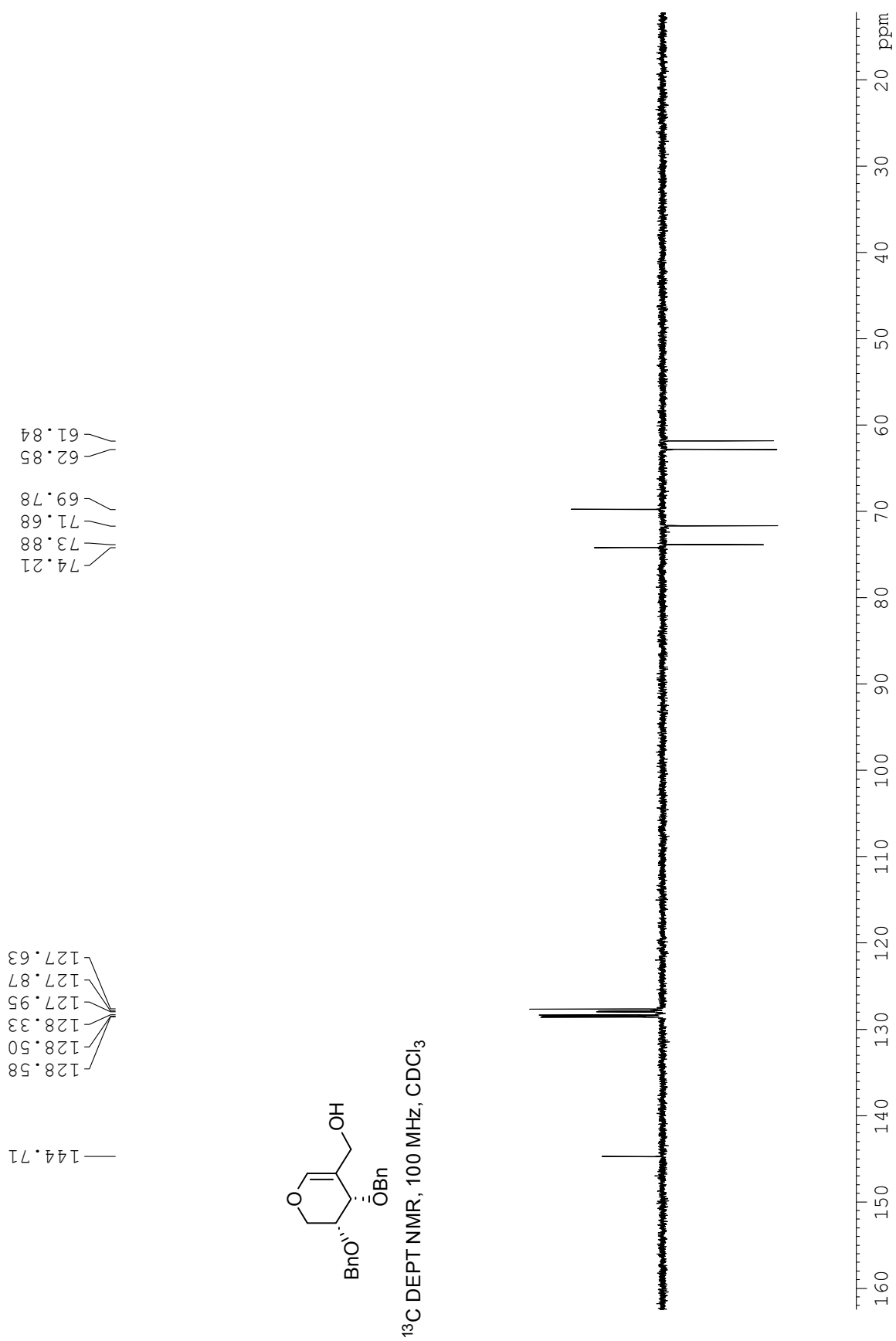
^{13}C NMR, 100 MHz, CDCl_3

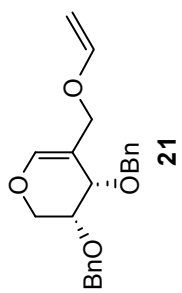
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74.11
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71.58
69.68
62.75
61.75

111.79

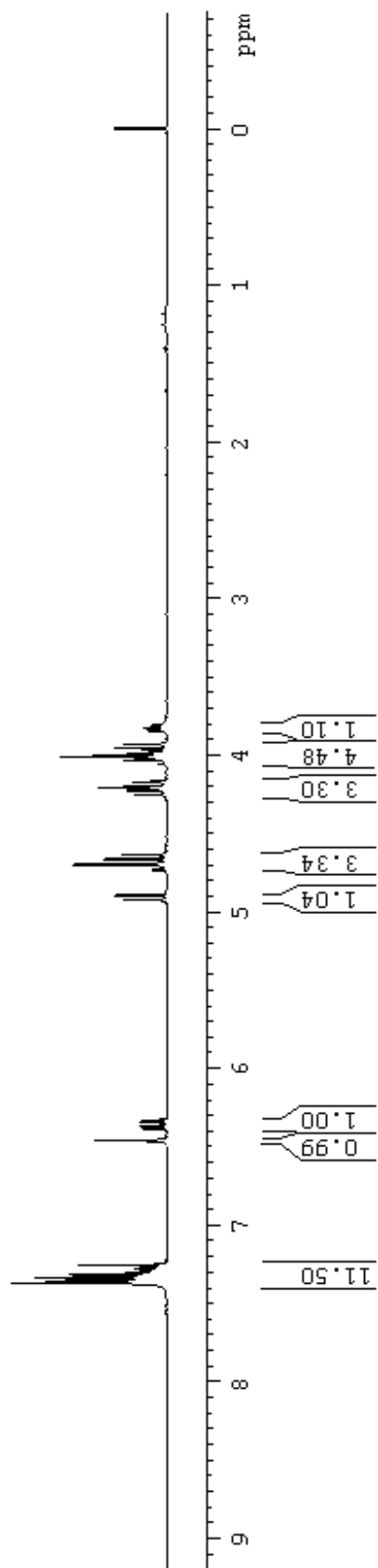
144.61
138.51
137.90
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128.41
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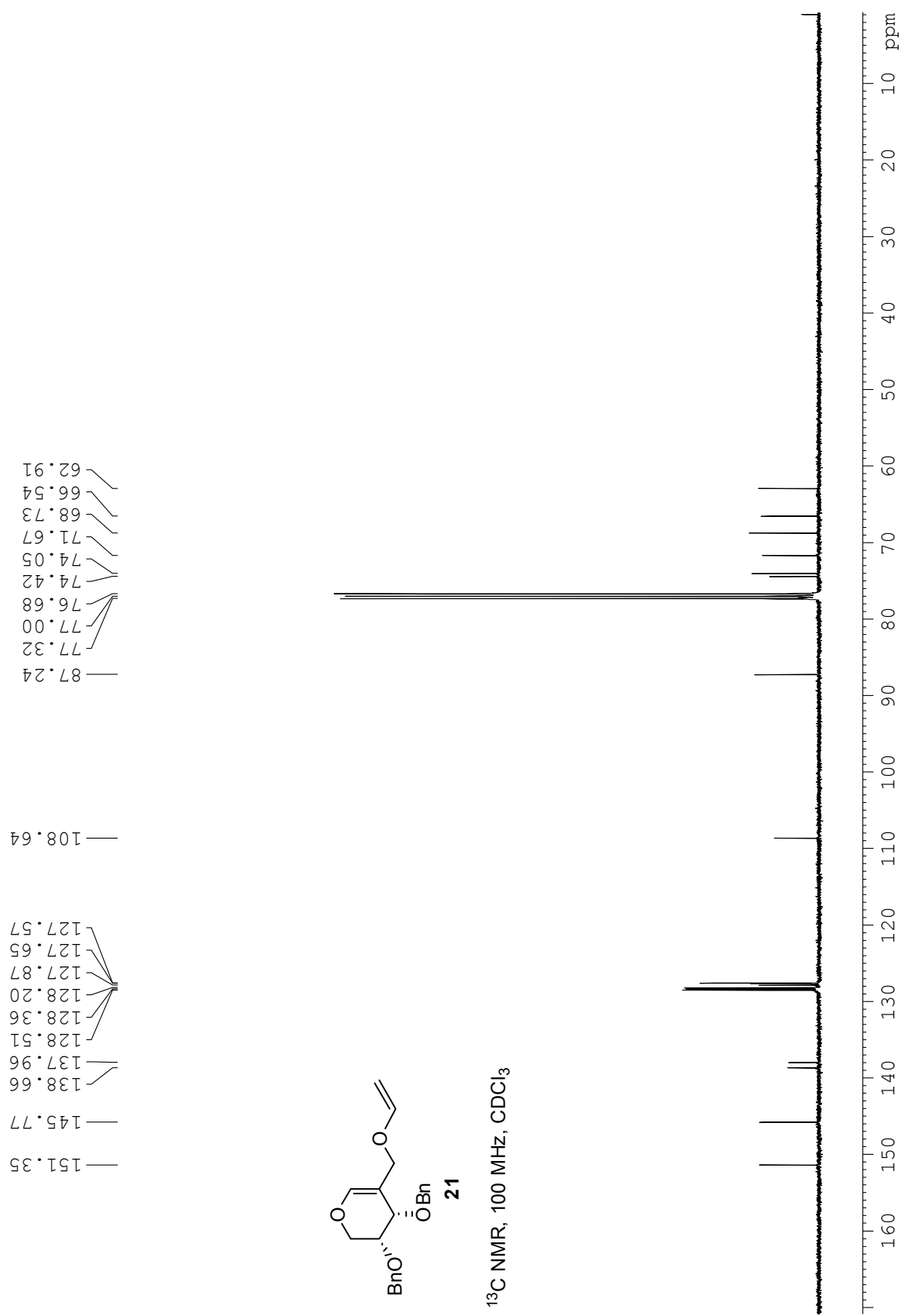


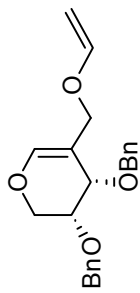




¹H NMR, 400 MHz, CDCl₃

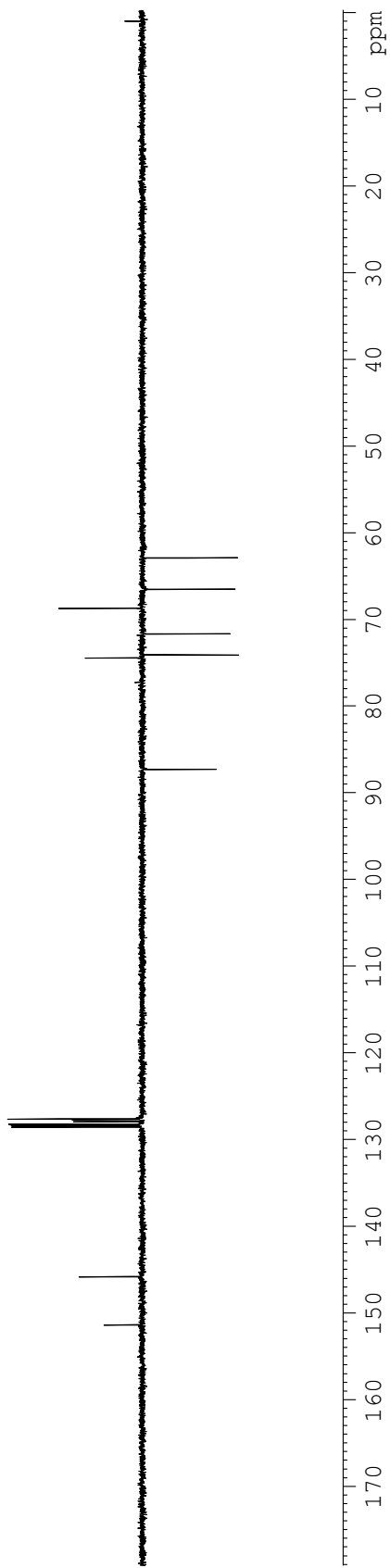


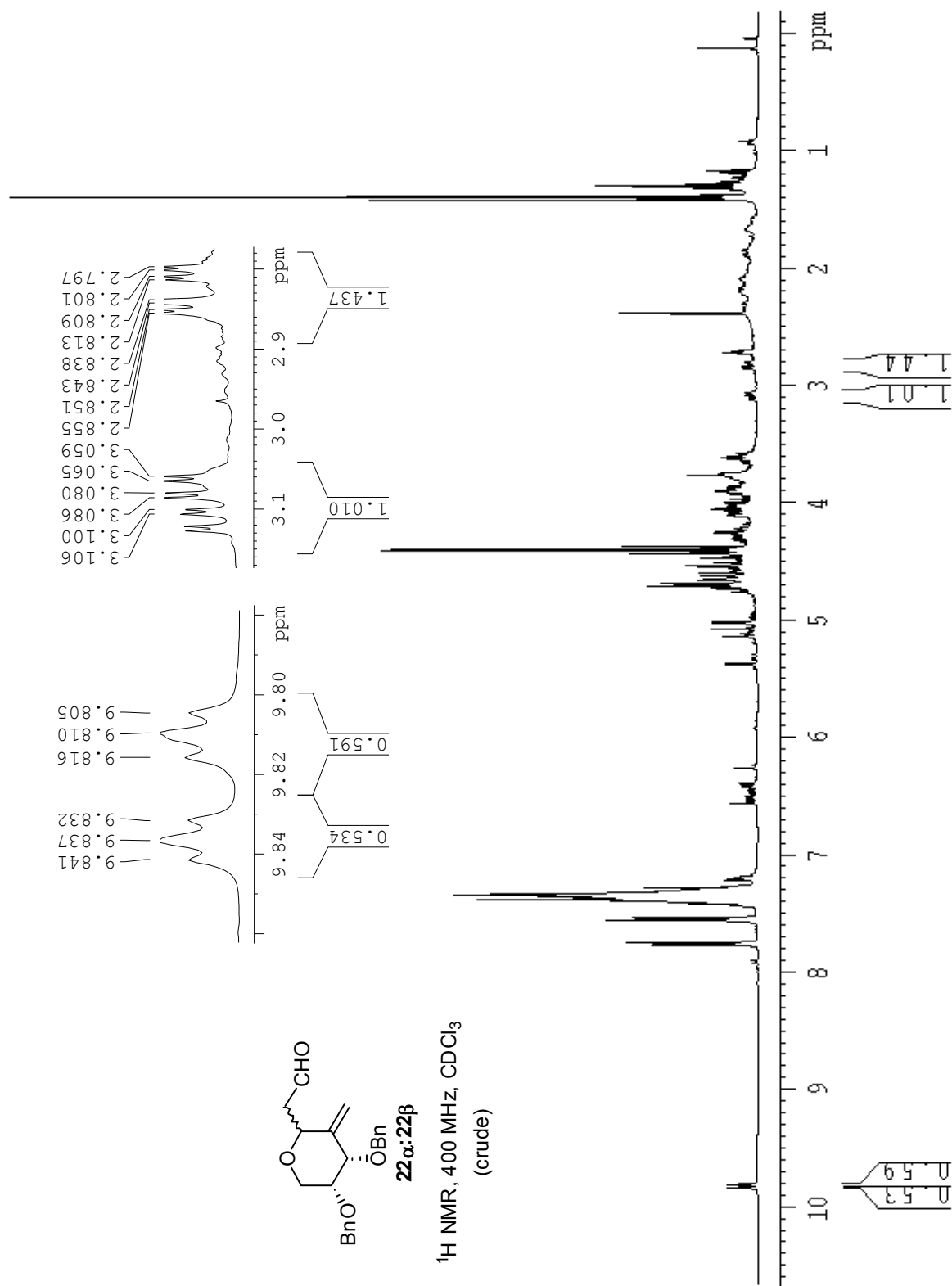


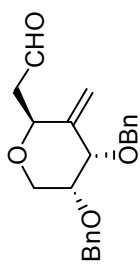


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^{13}C DEPT NMR, 100 MHz, CDCl_3

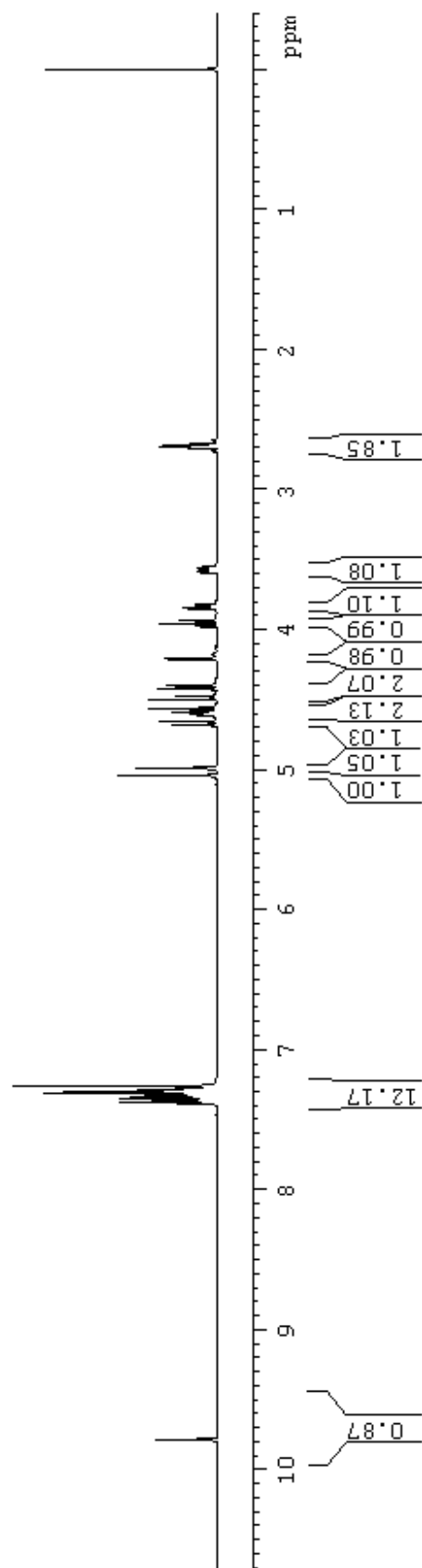


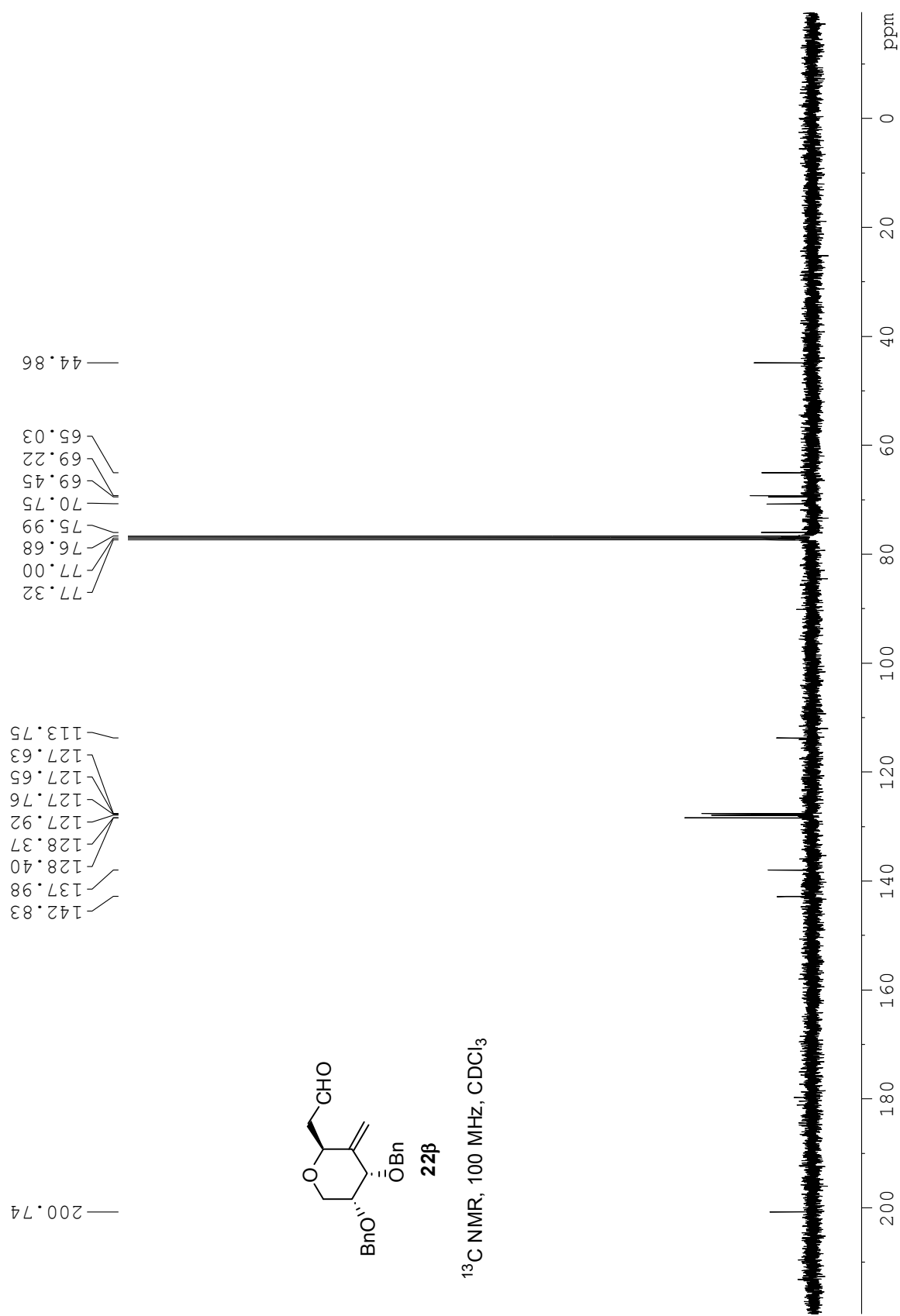


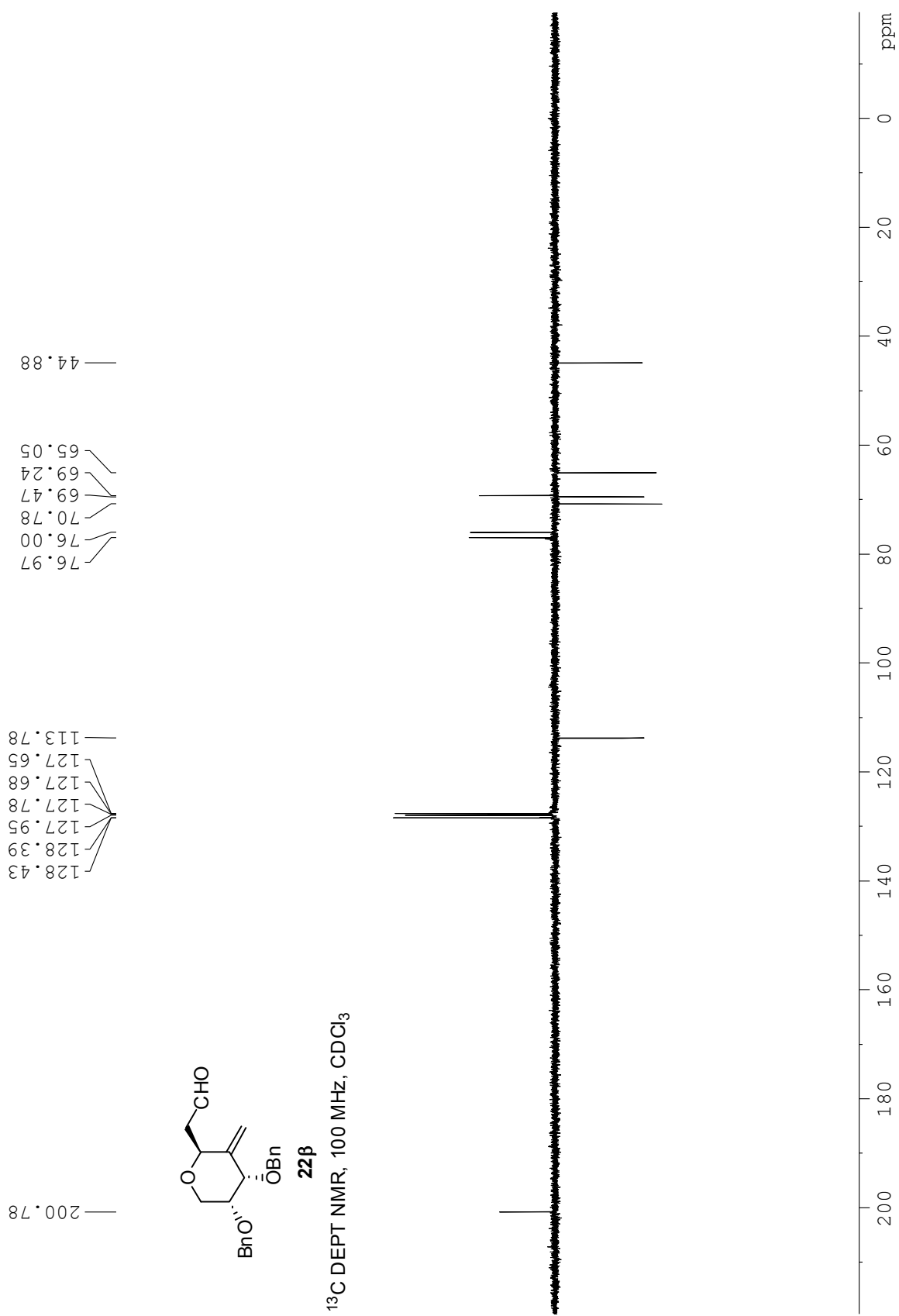


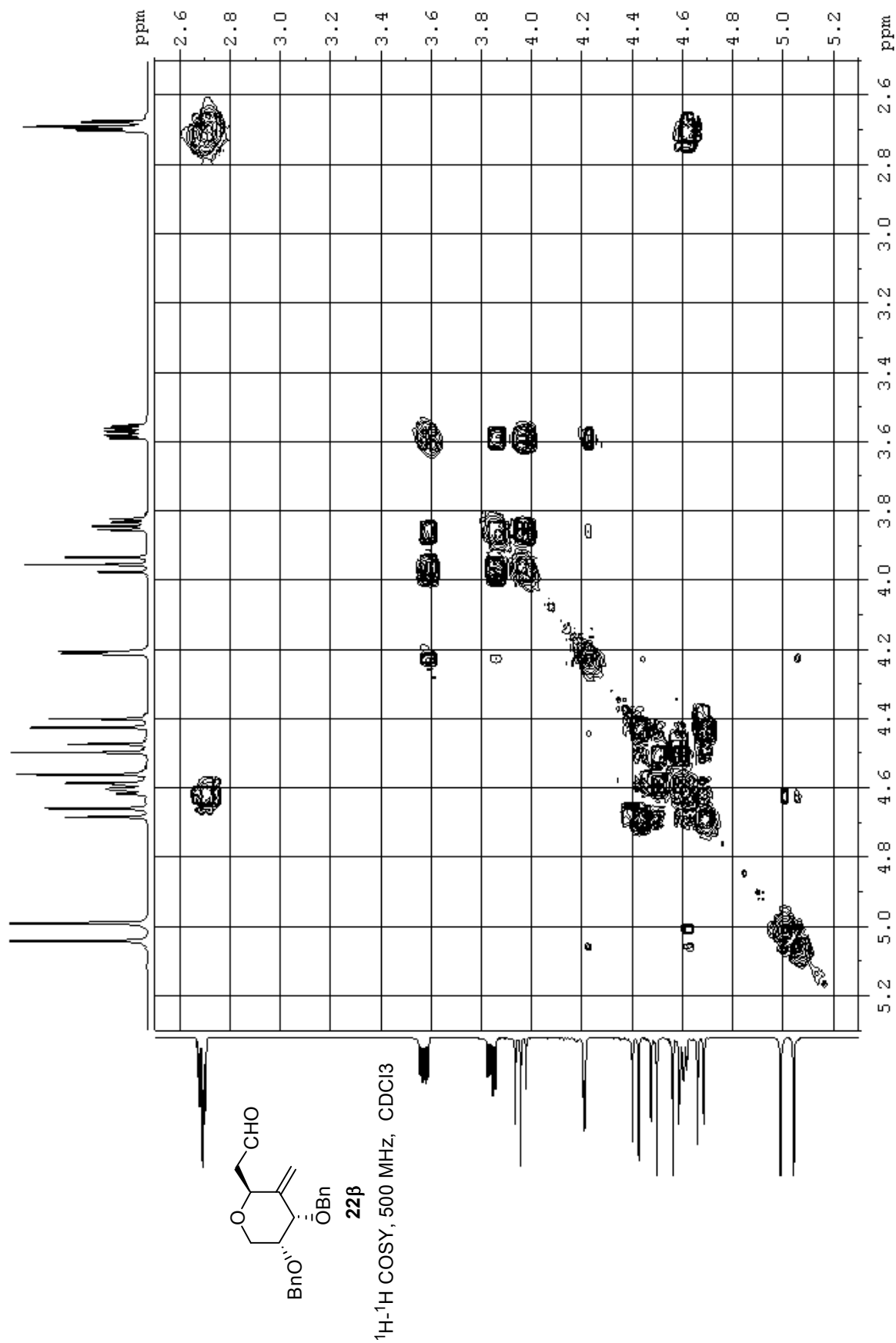
22β

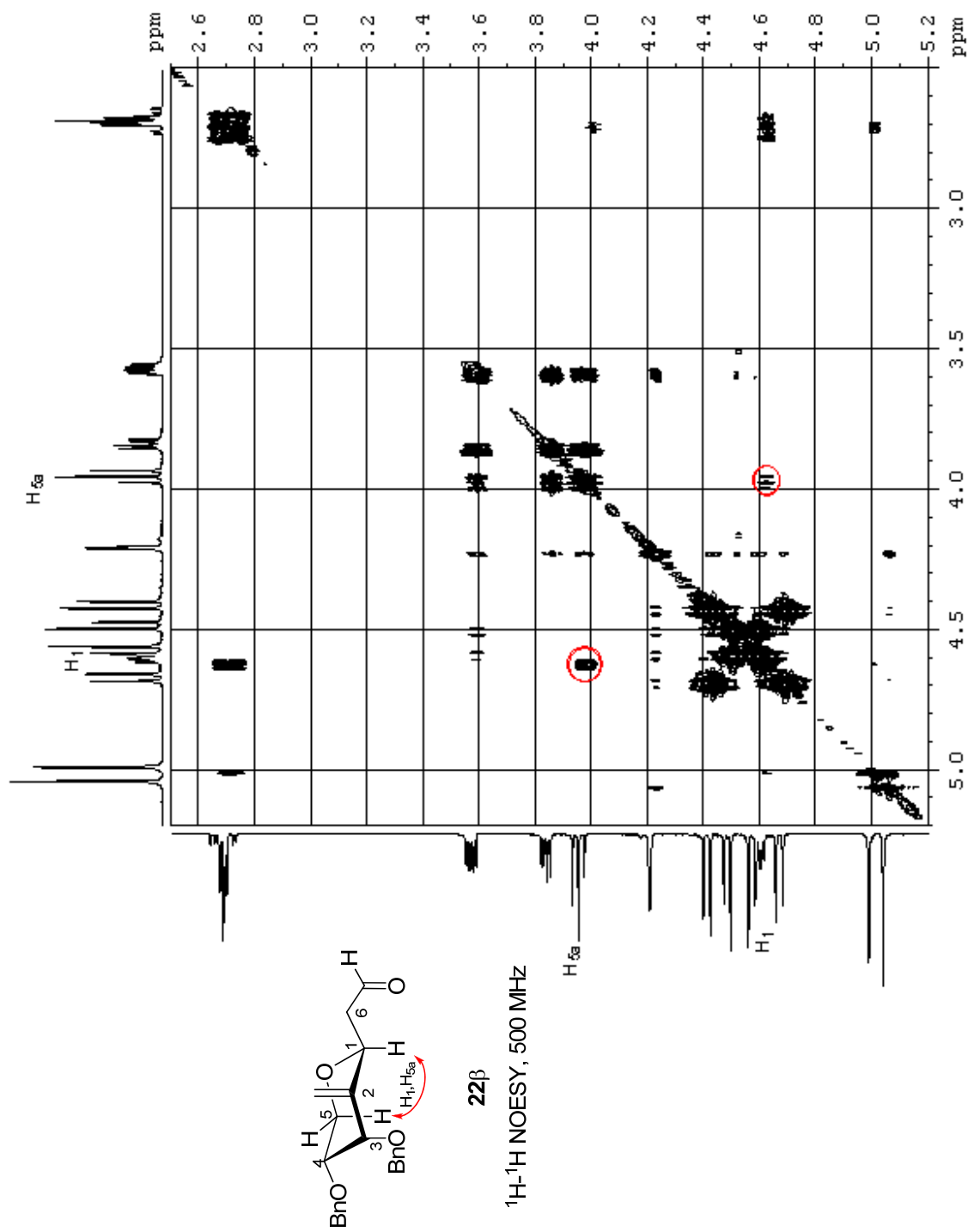
¹H NMR, 500 MHz, CDCl₃

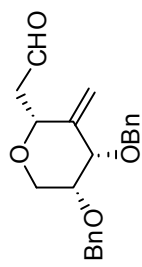






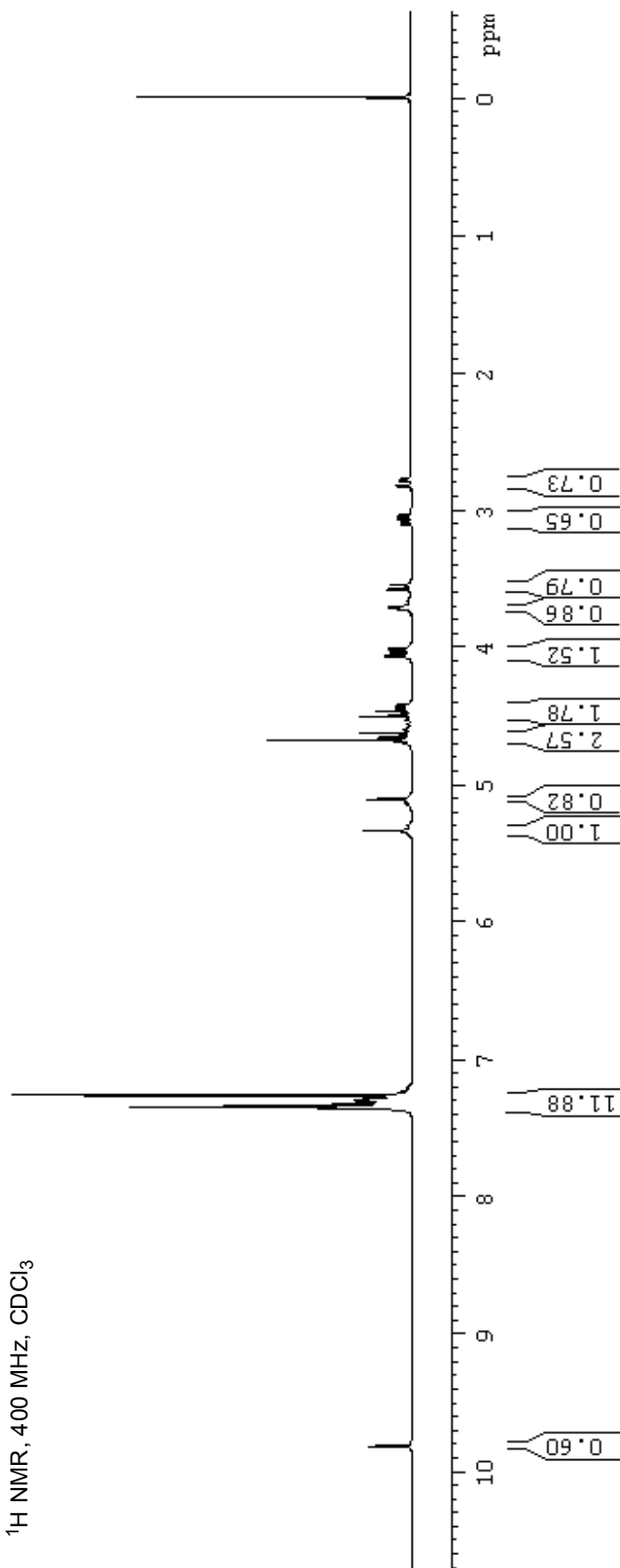


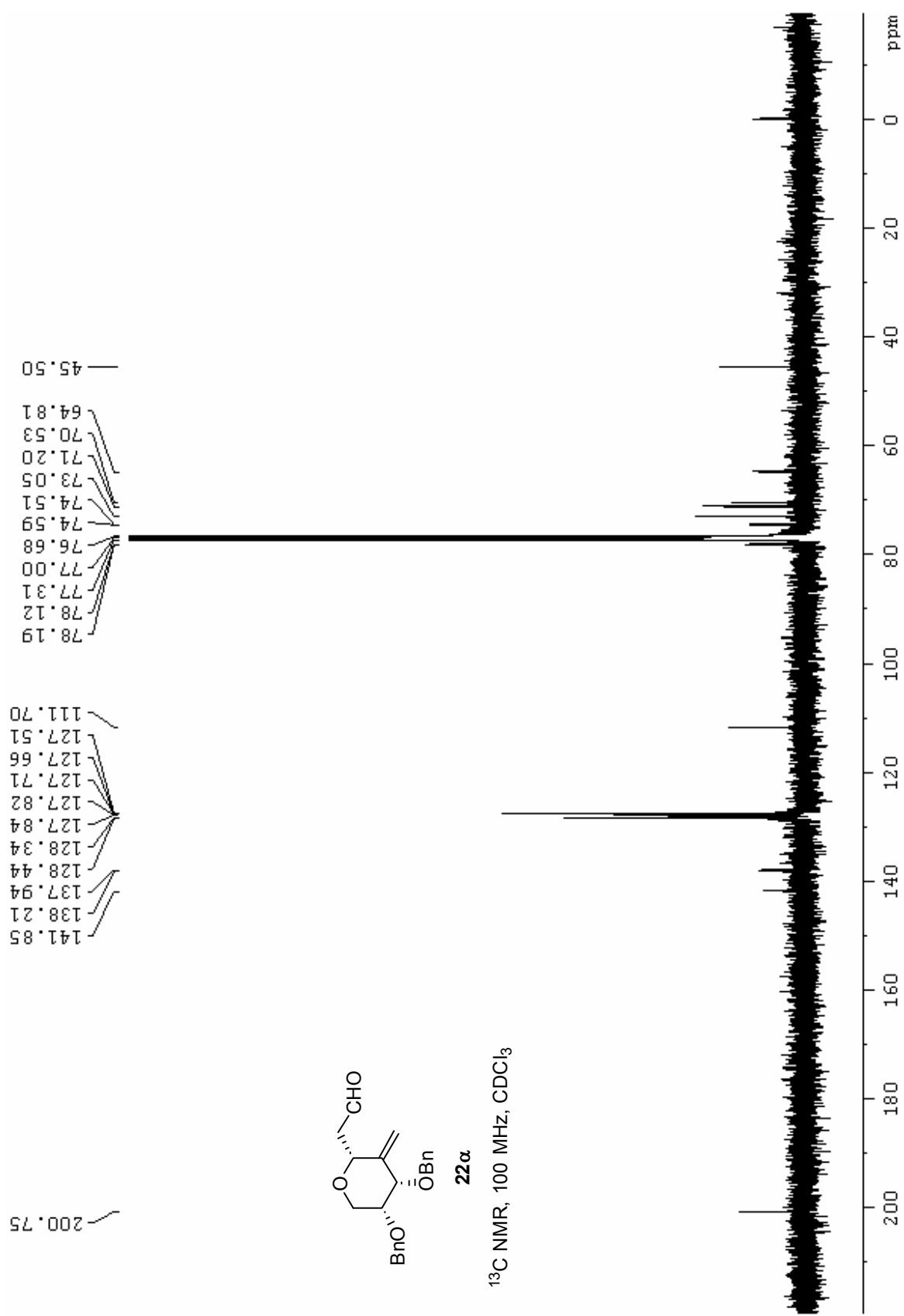


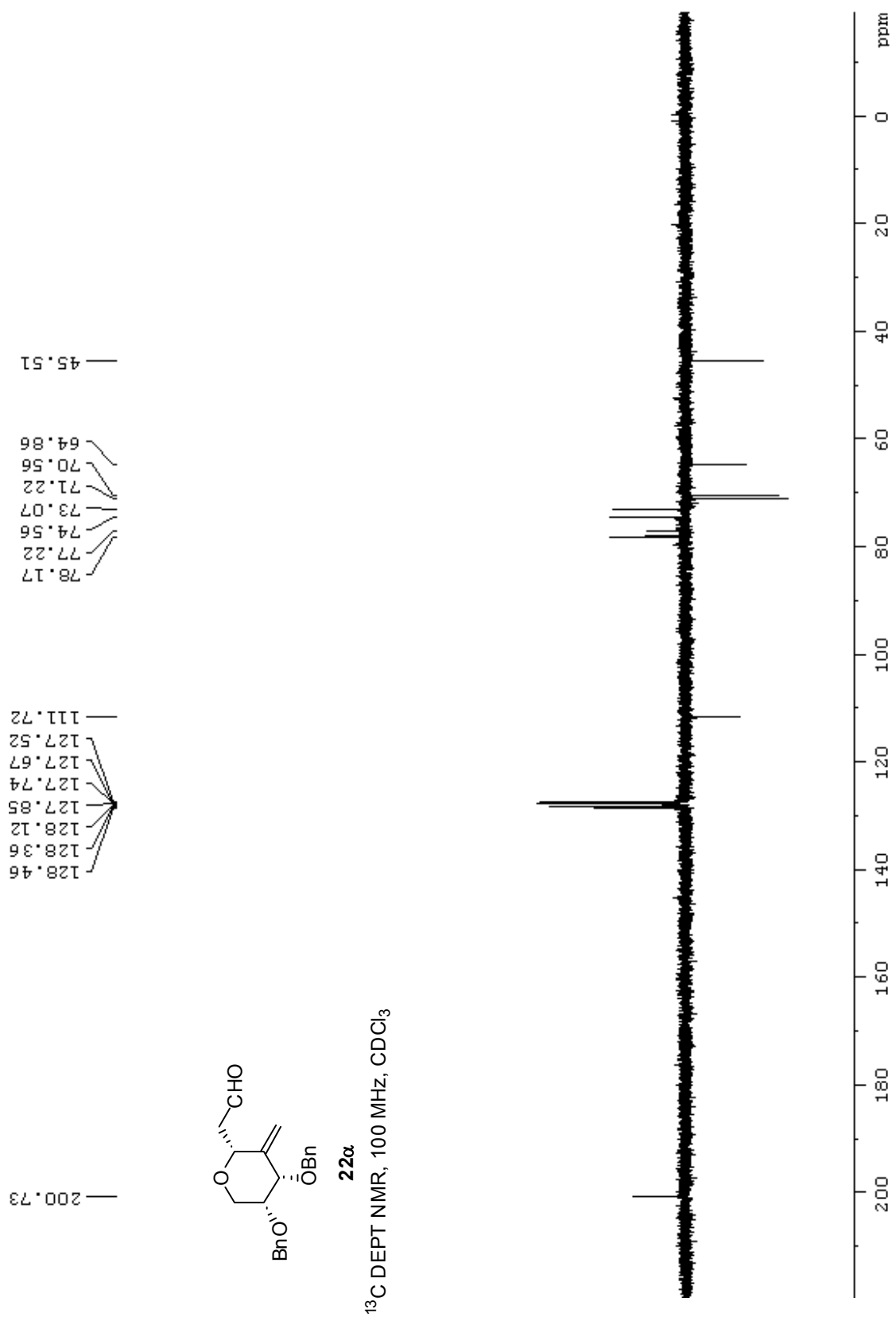


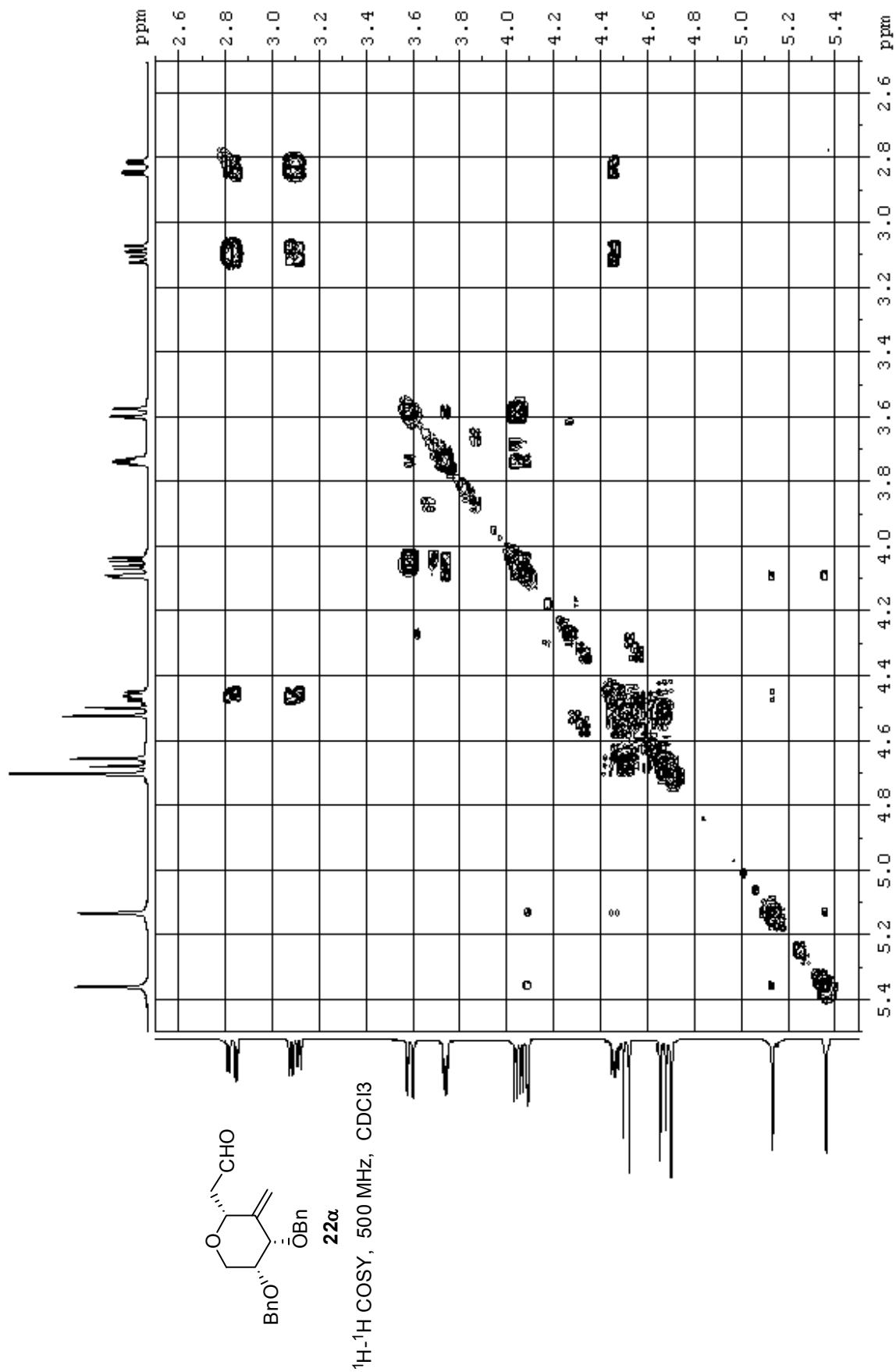
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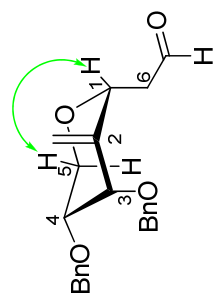
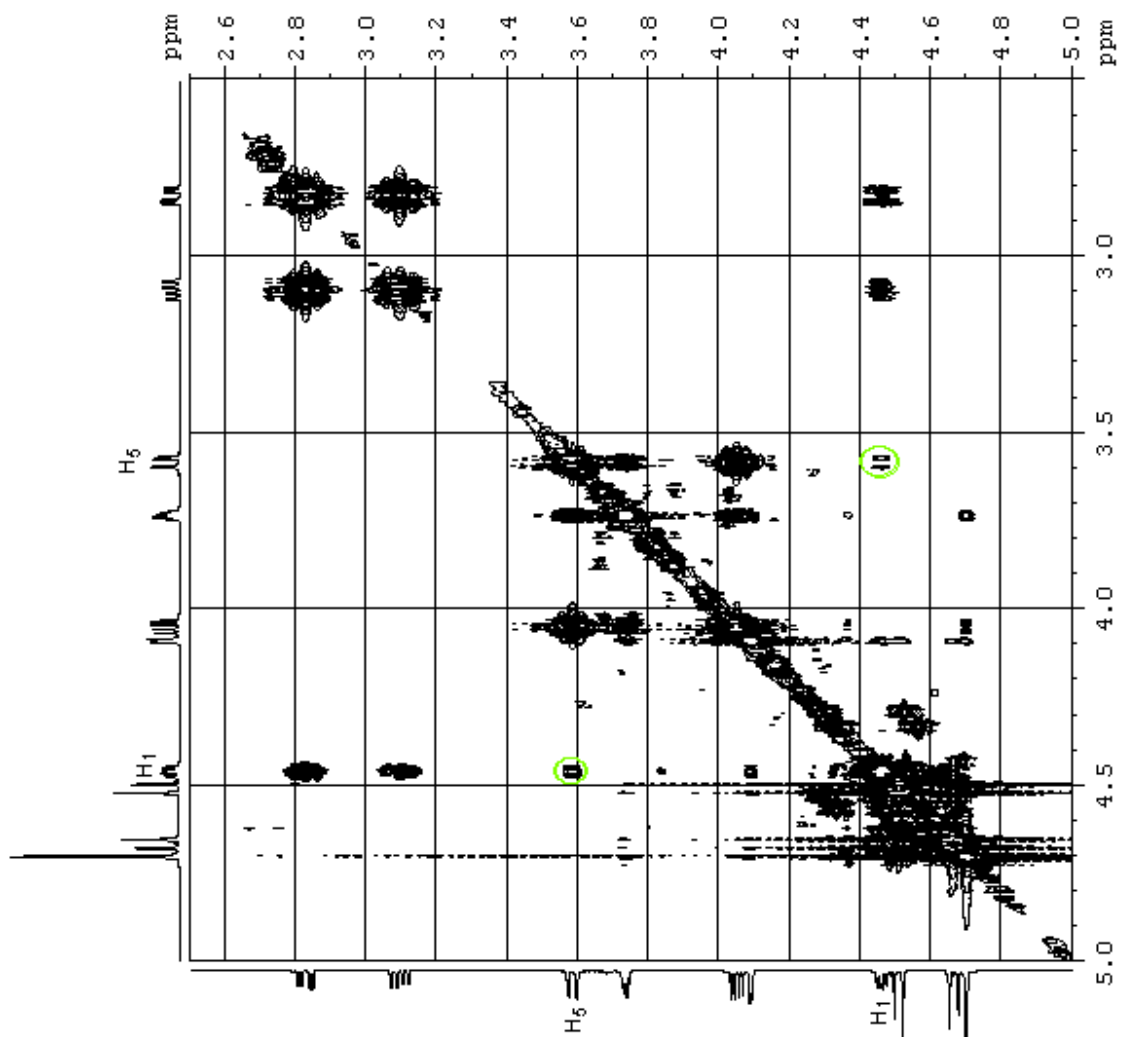
¹H NMR, 400 MHz, CDCl₃





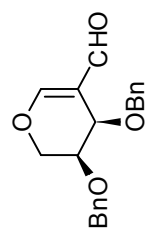




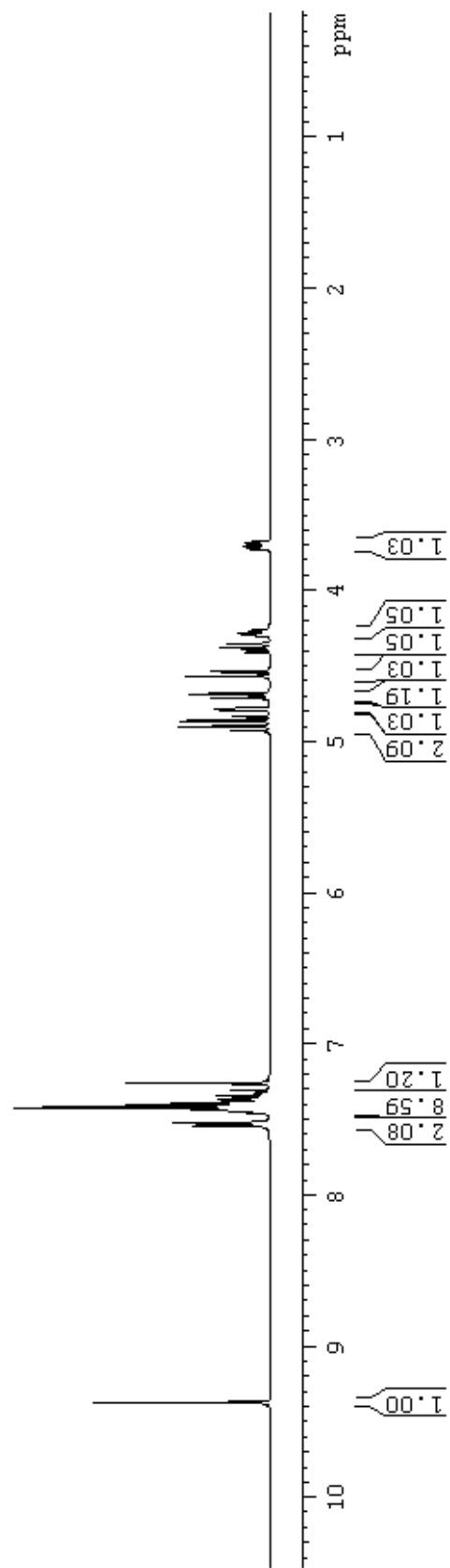


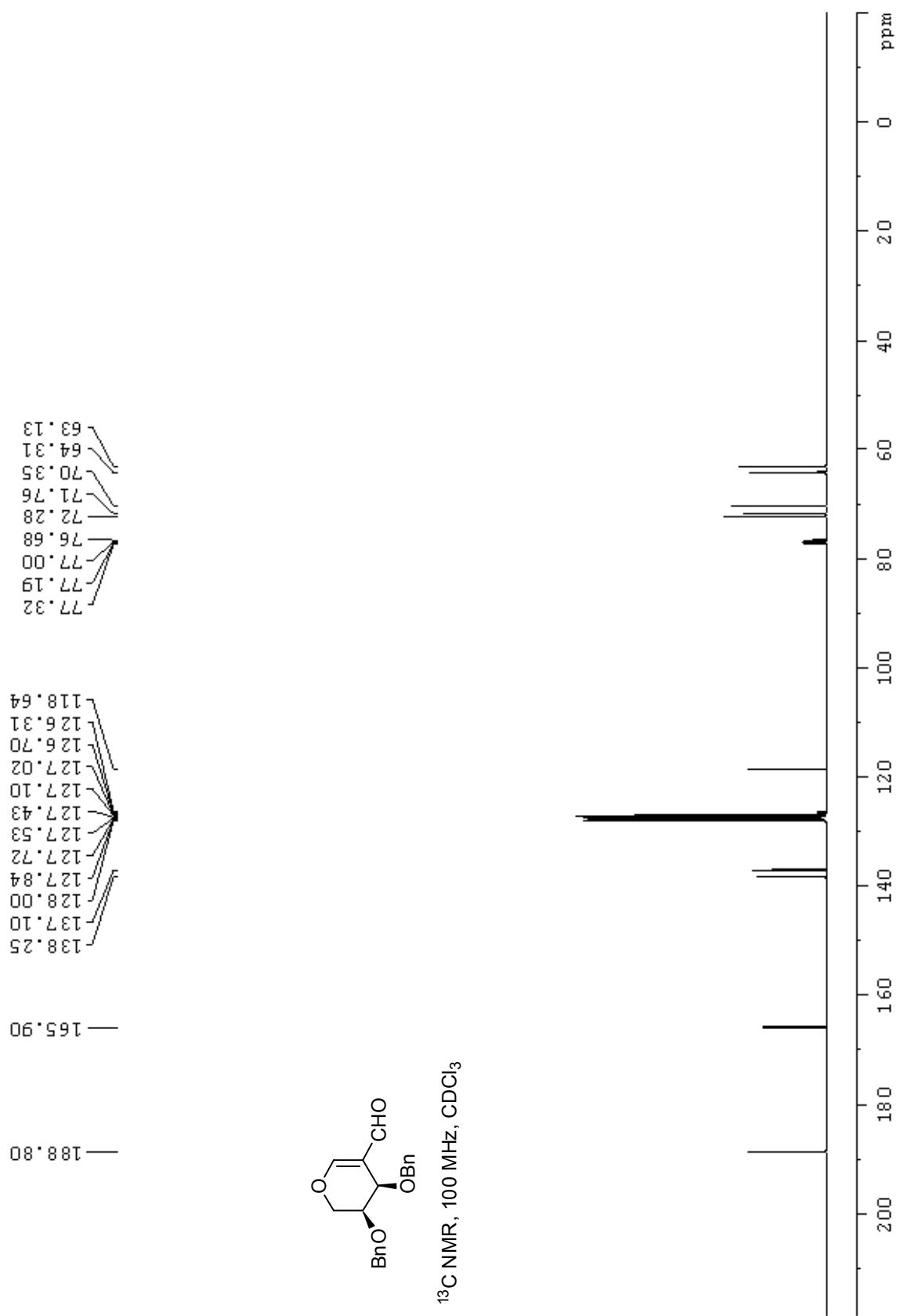
22α

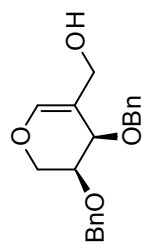
^1H - ^1H NOESY, 500 MHz



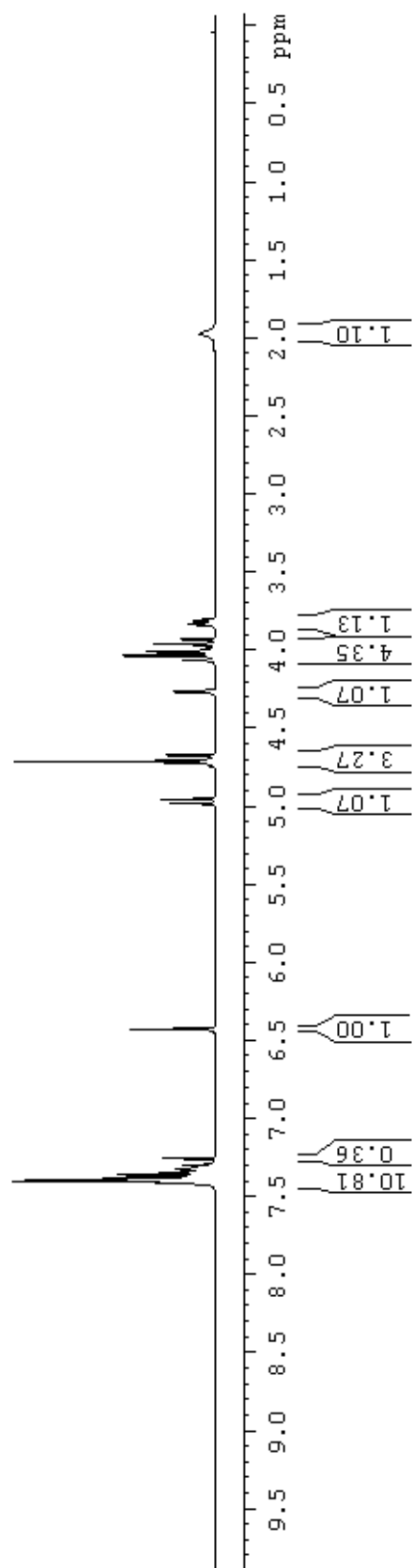
^1H NMR, 400 MHz, CDCl_3

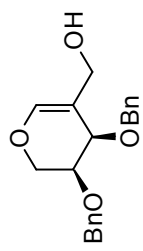




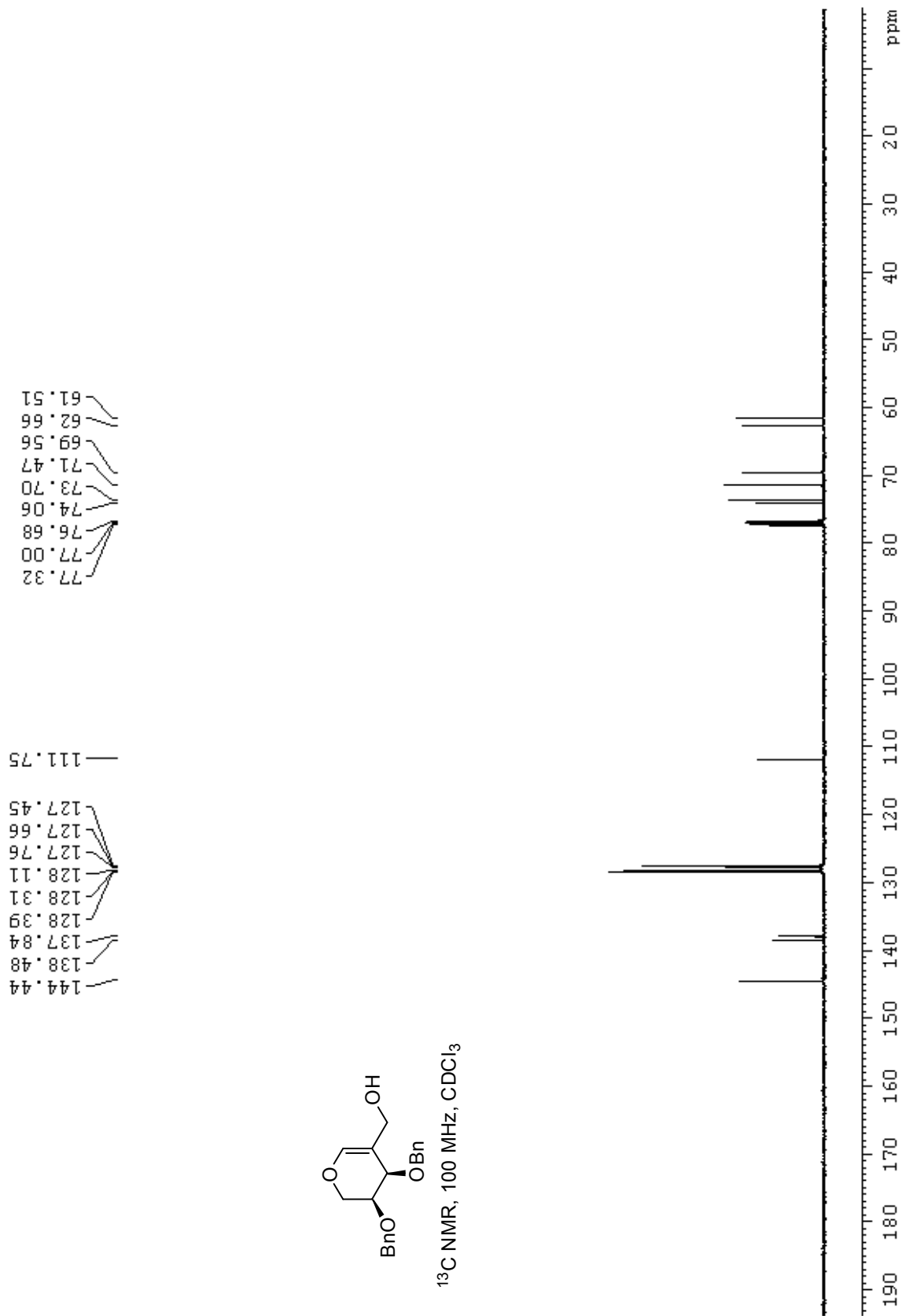


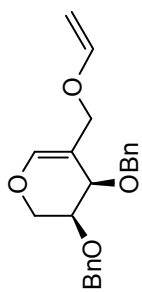
^1H NMR, 400 MHz, CDCl_3





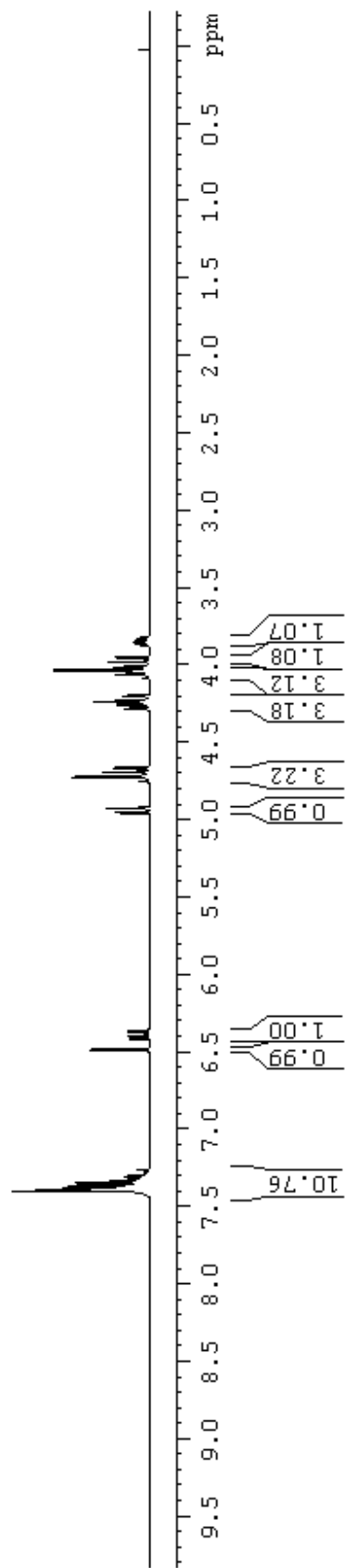
^{13}C NMR, 100 MHz, CDCl_3

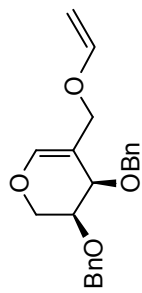




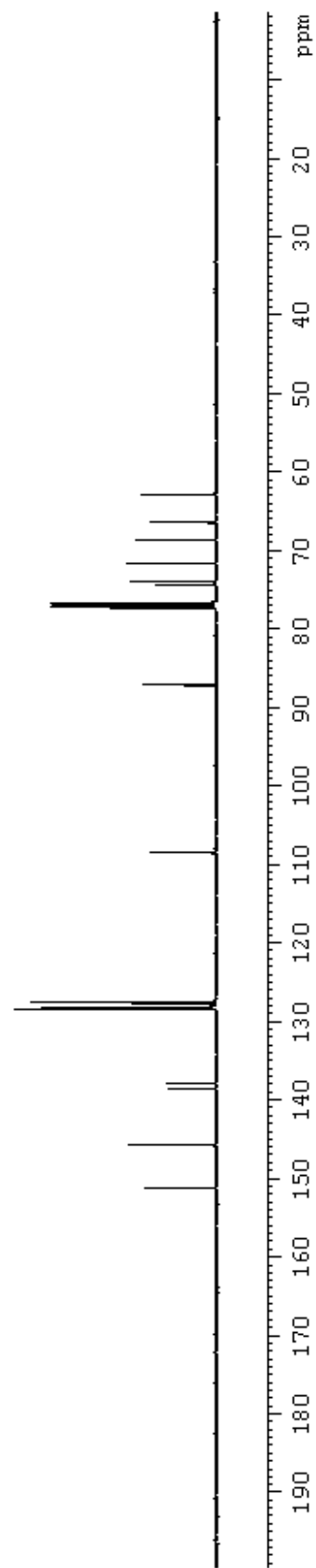
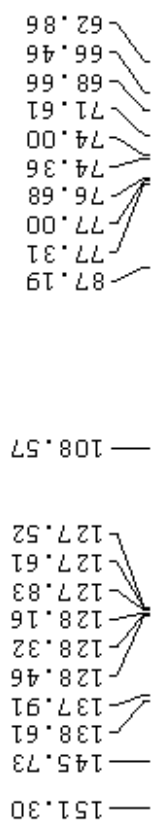
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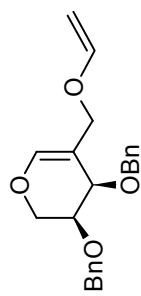
^1H NMR, 400 MHz, CDCl_3





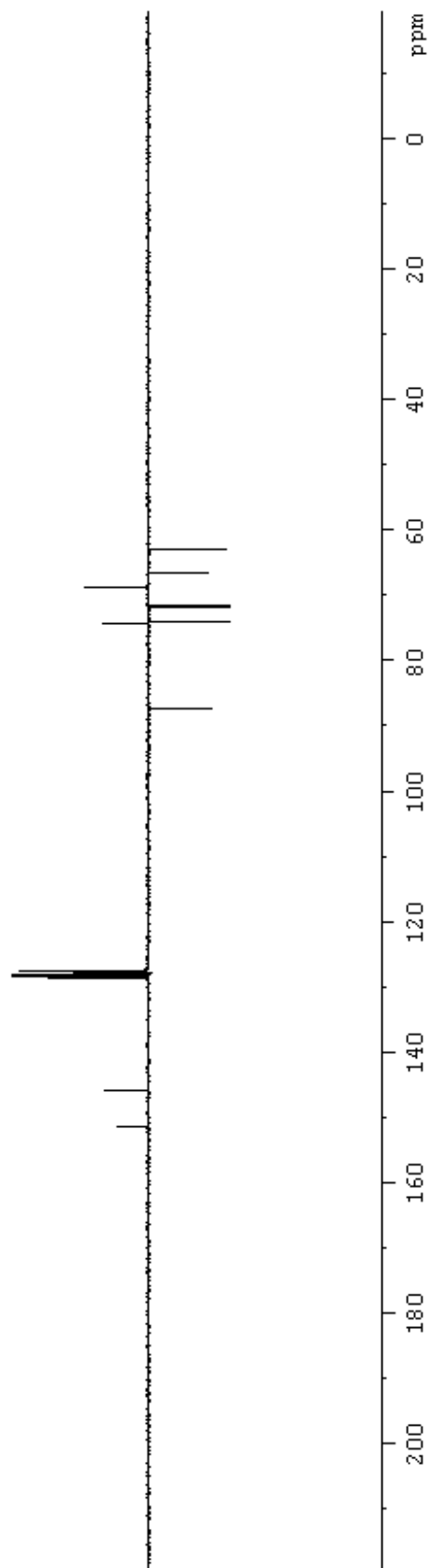
¹³C NMR, 100 MHz, CDCl₃

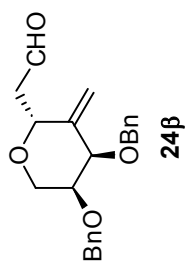




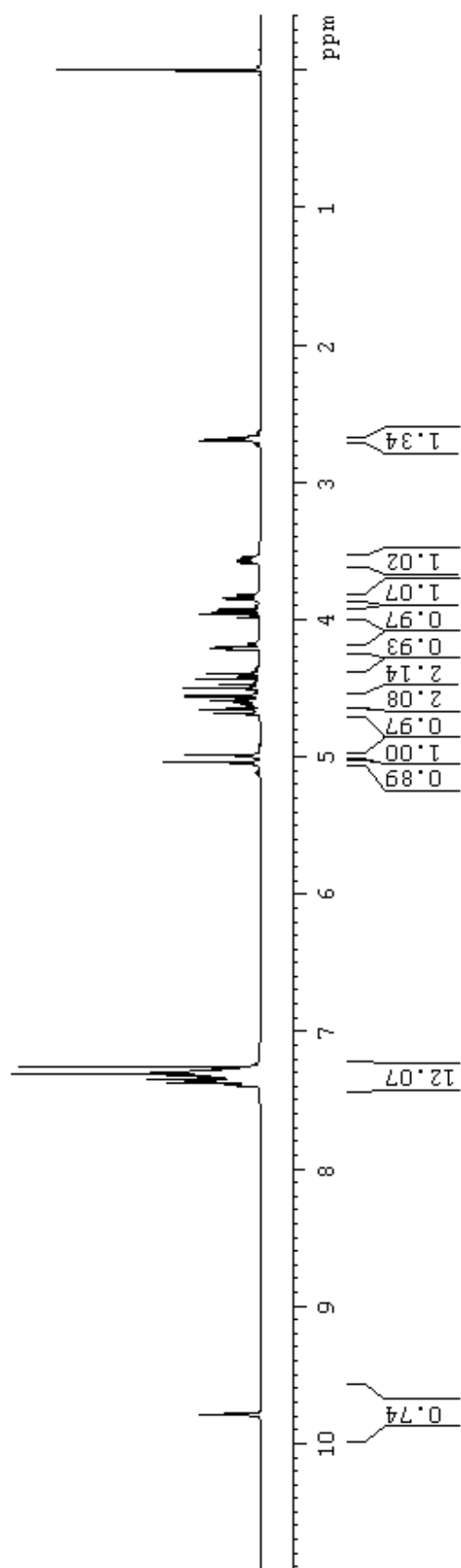
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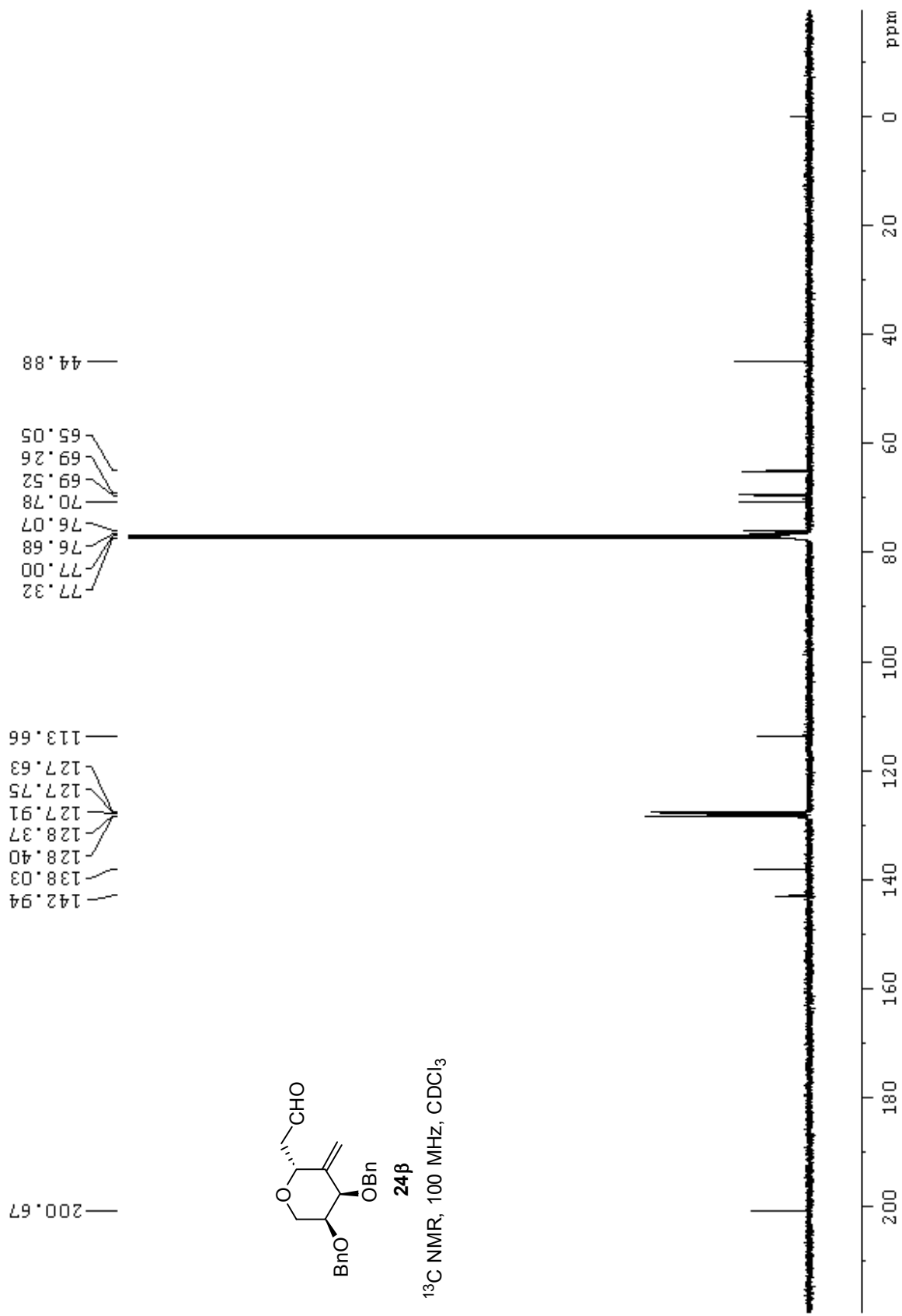
^{13}C DEPT NMR, 100 MHz, CDCl_3

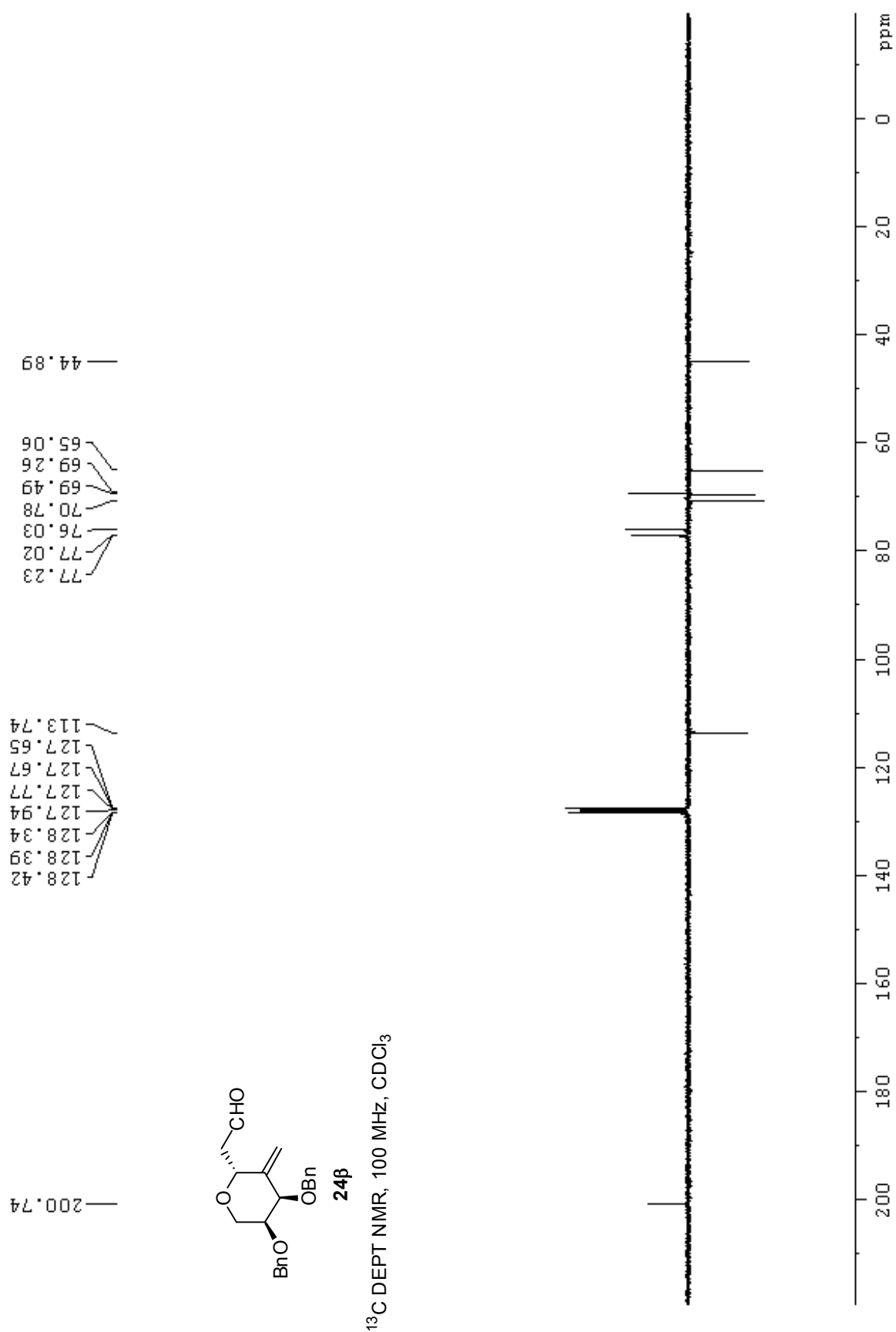


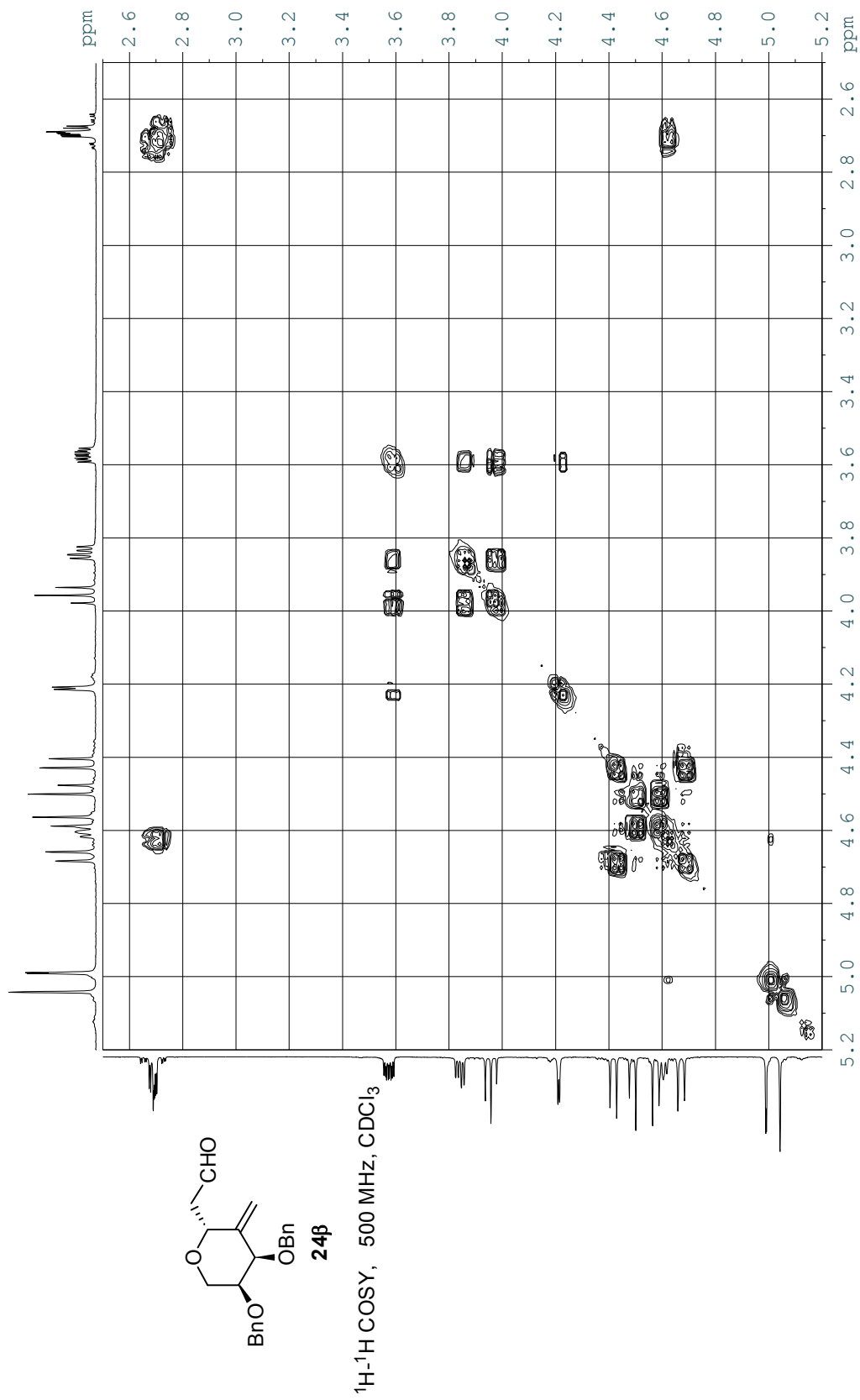


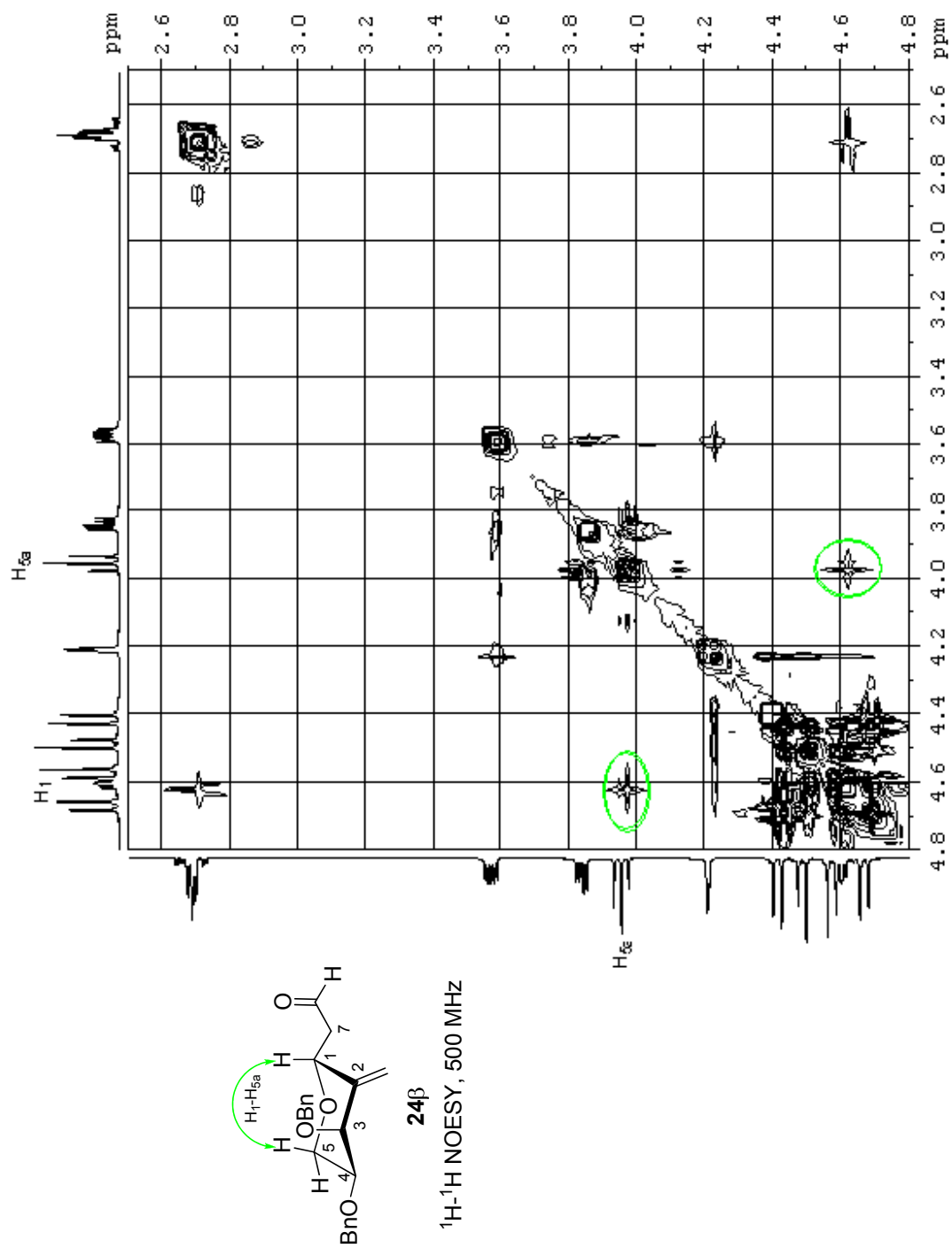
^1H NMR, 400 MHz, CDCl_3

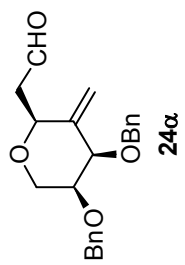




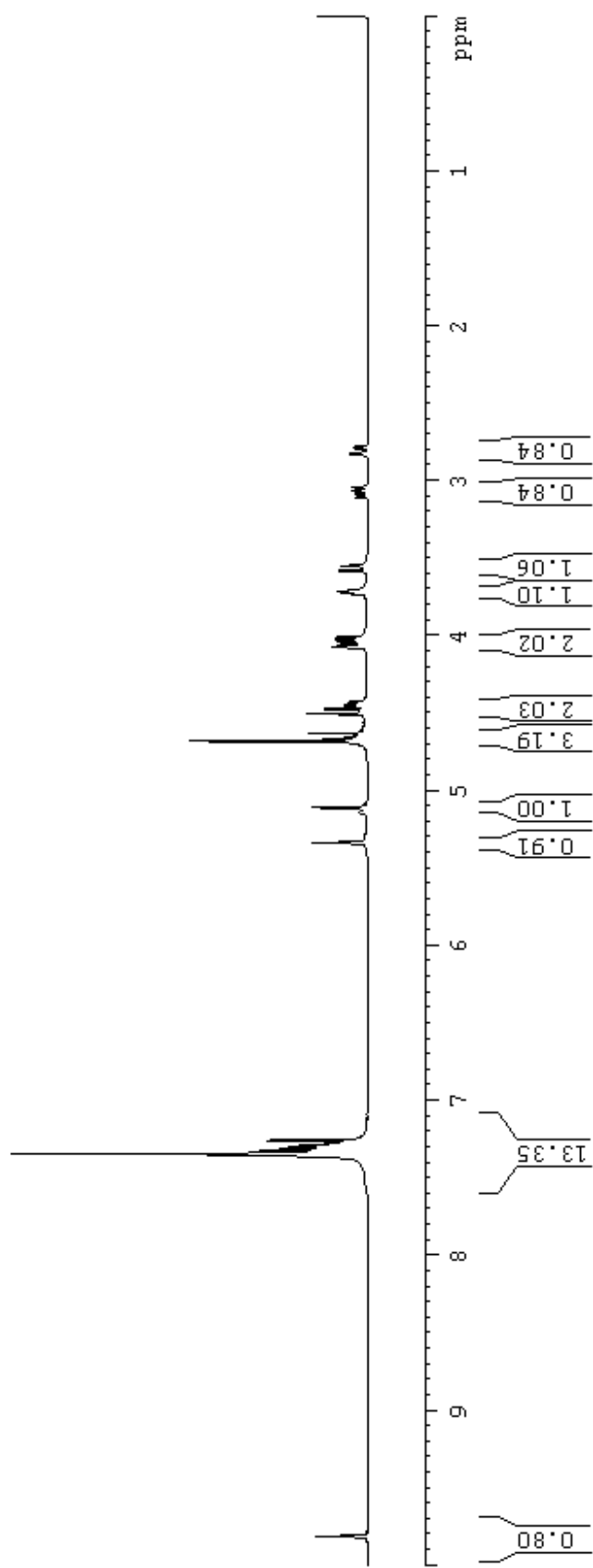


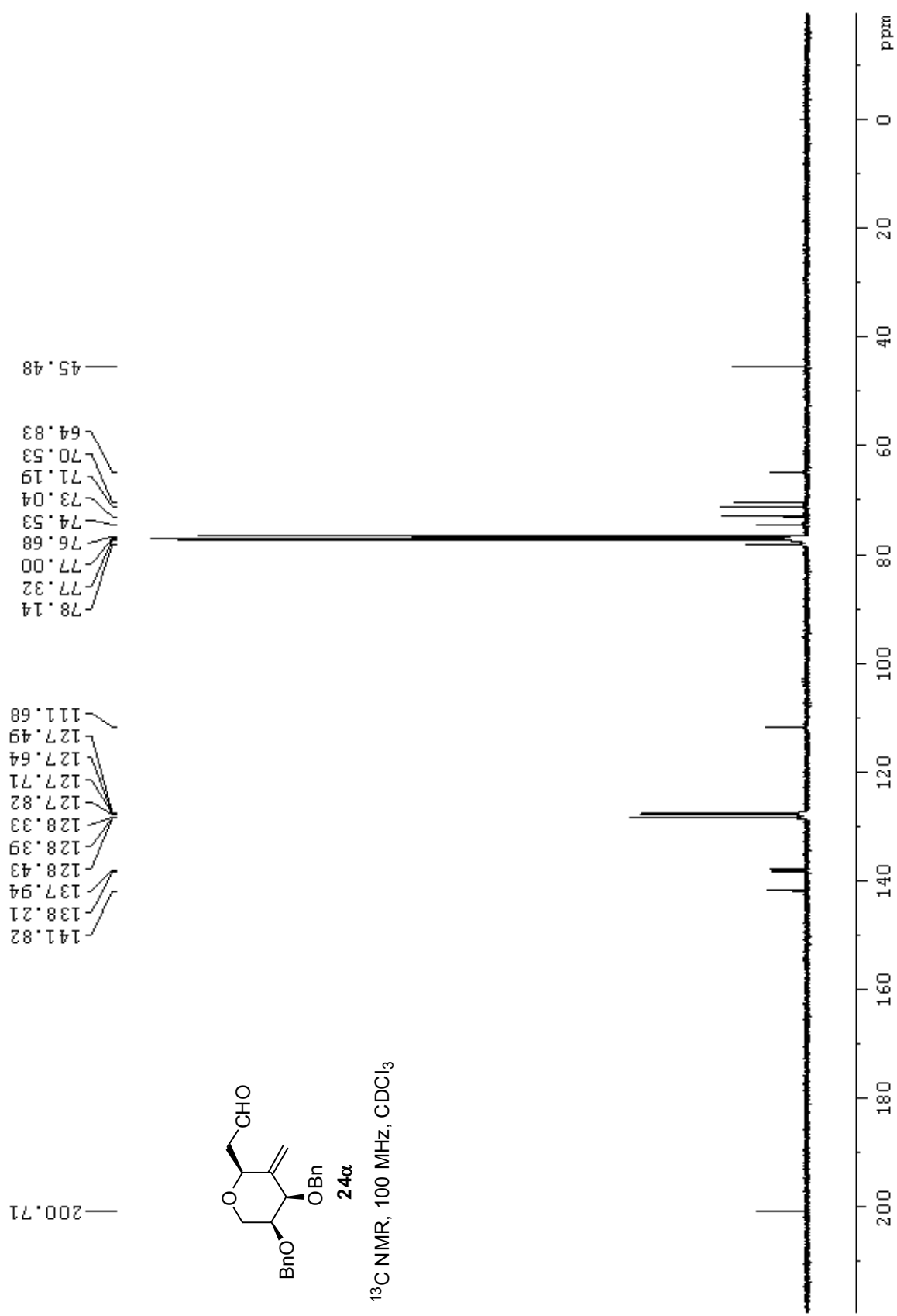


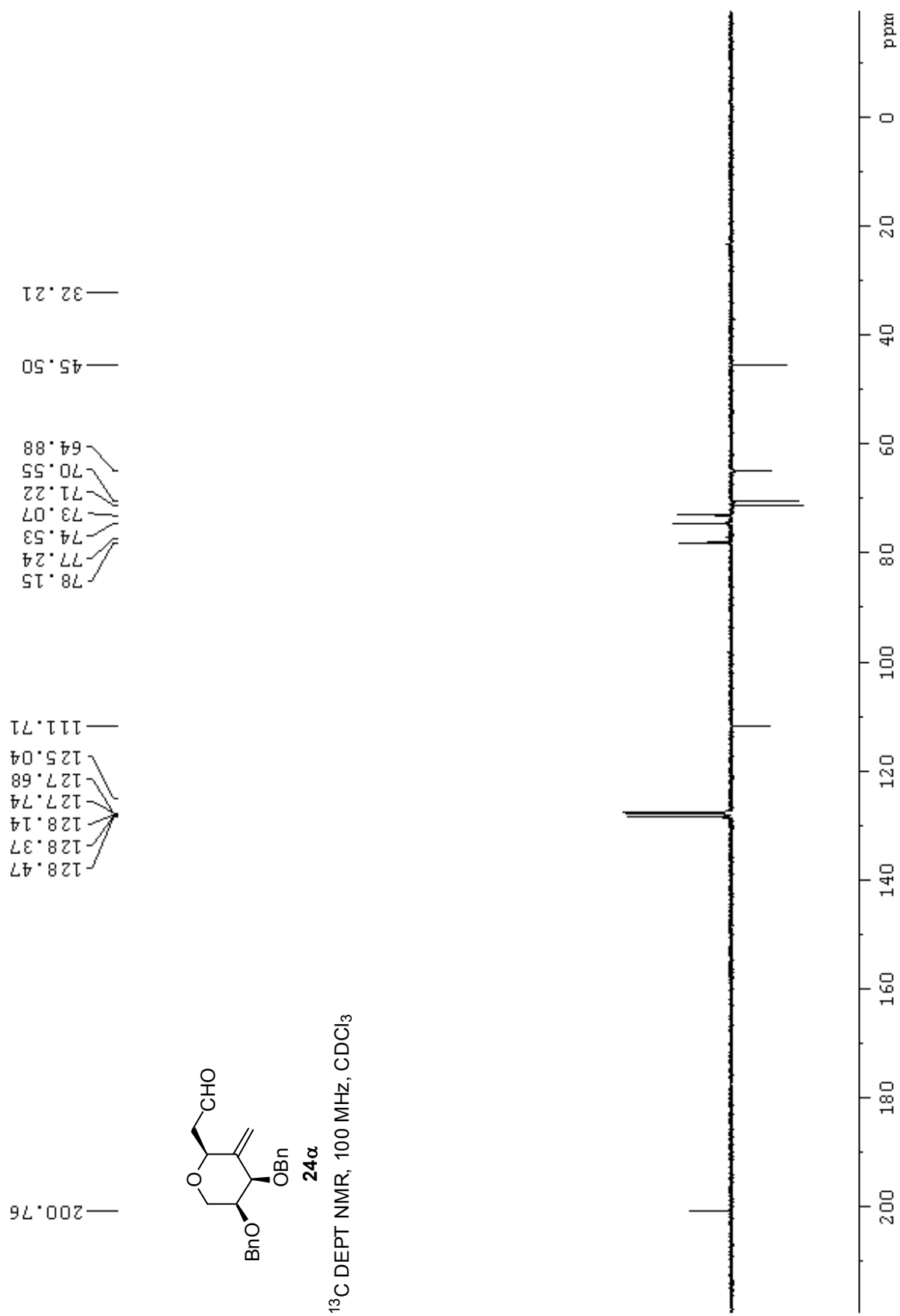


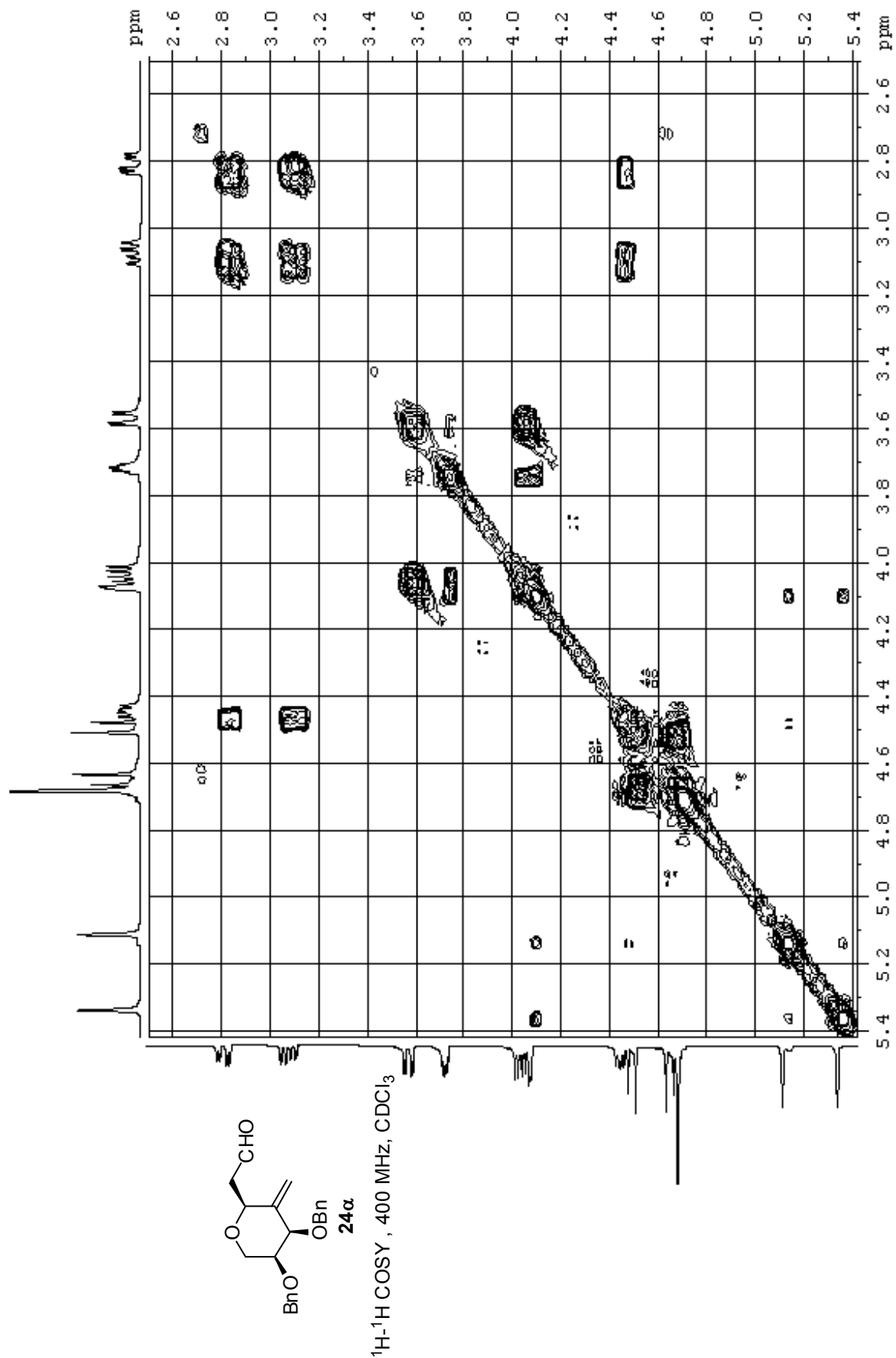


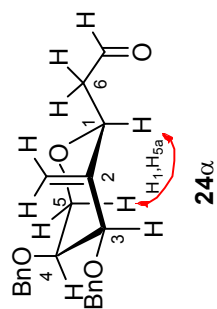
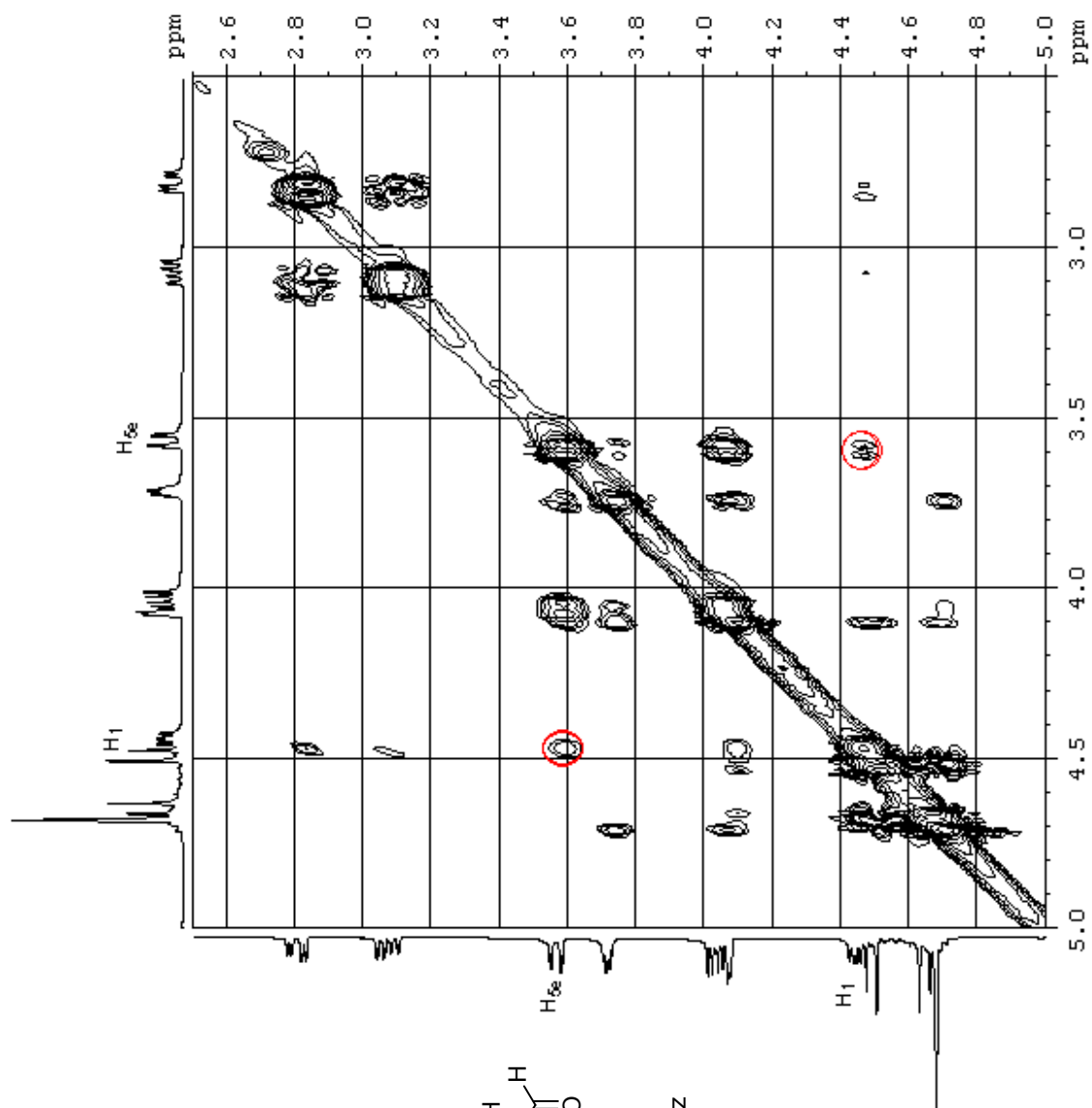
¹H NMR, 400 MHz, CDCl₃



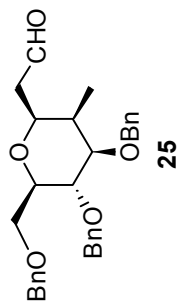




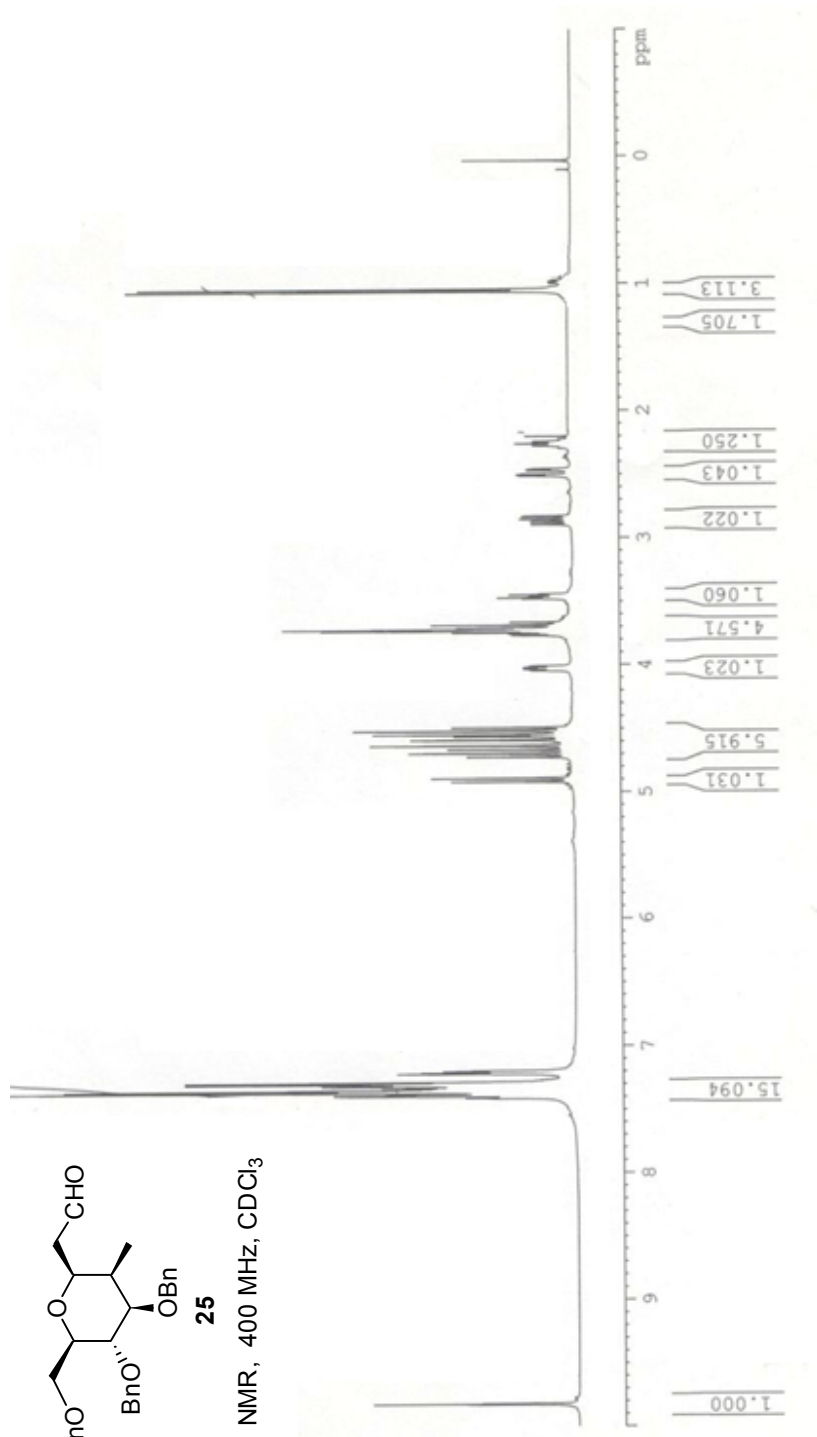


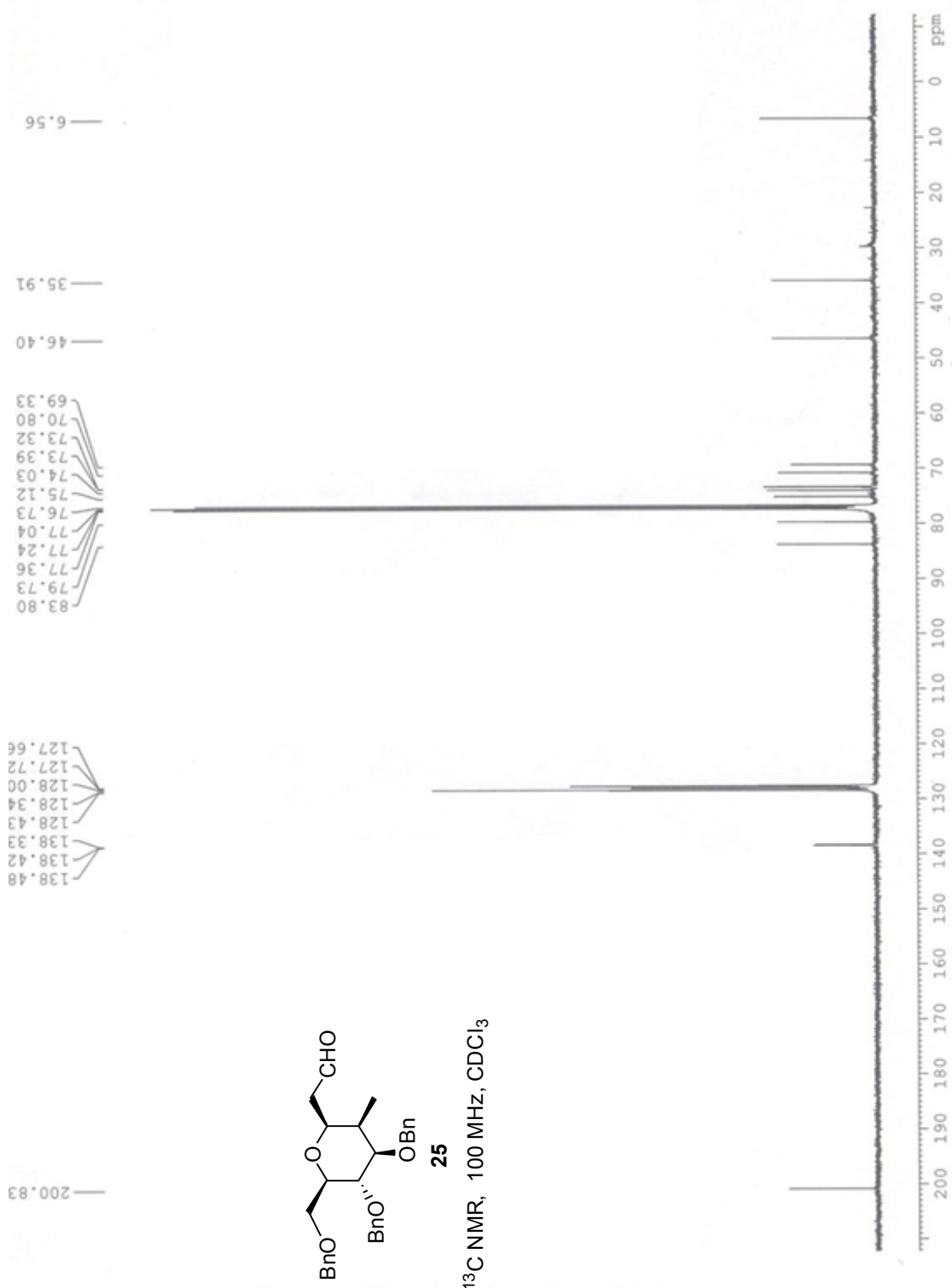


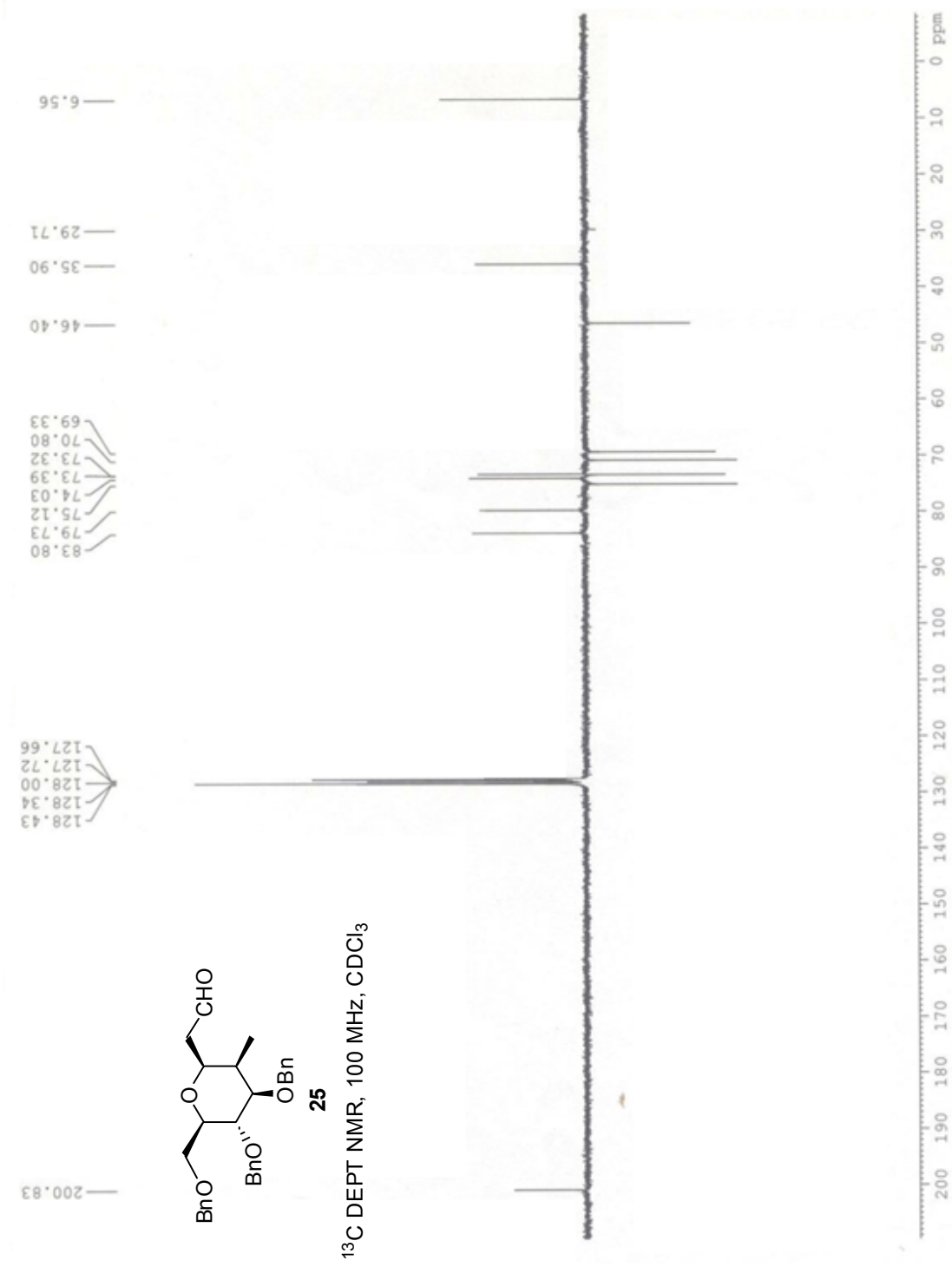
^1H - ^1H NOESY, 400 MHz

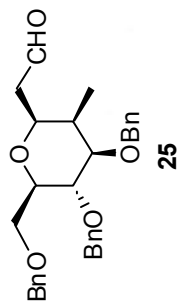
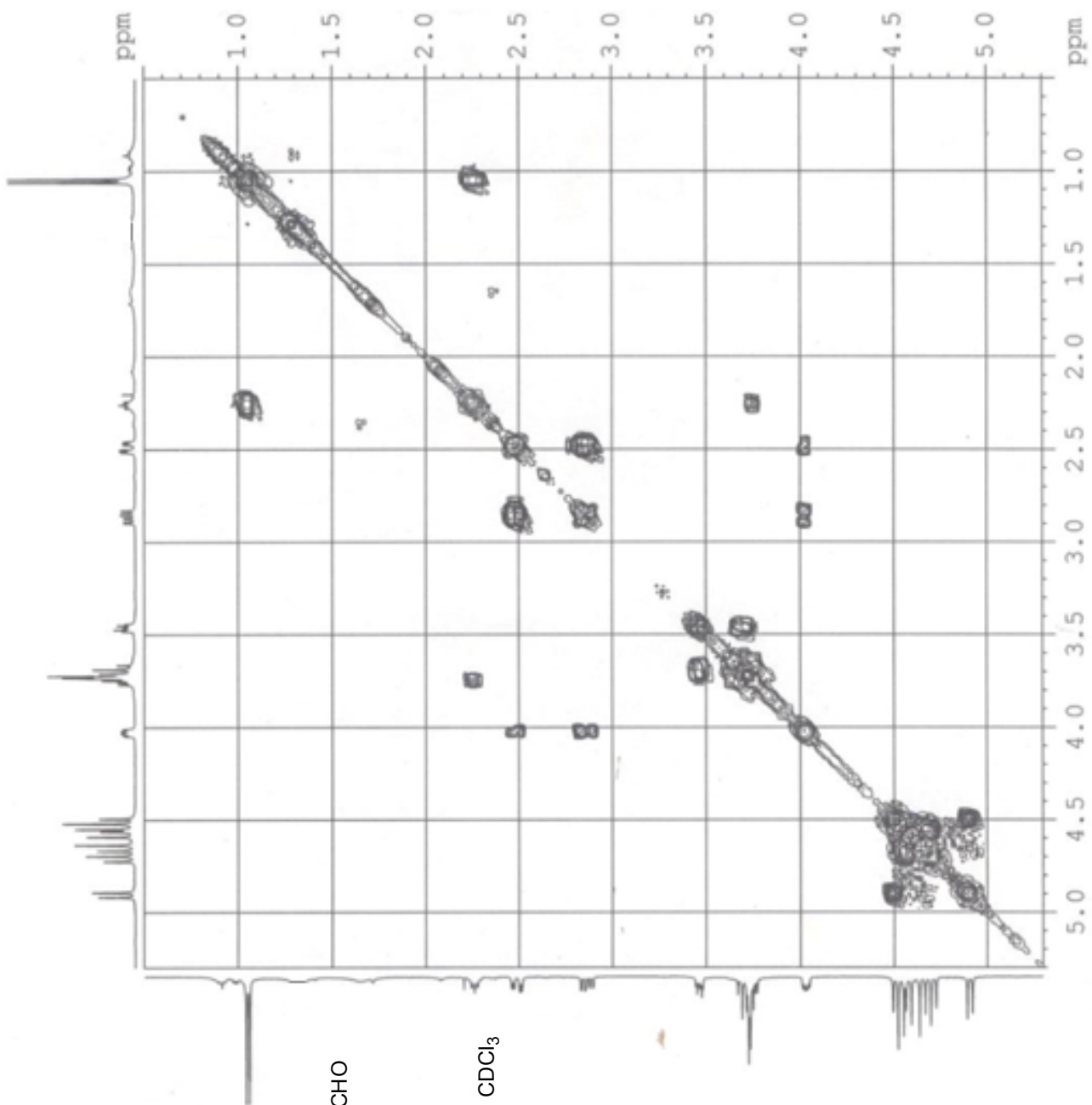


^1H NMR, 400 MHz, CDCl_3

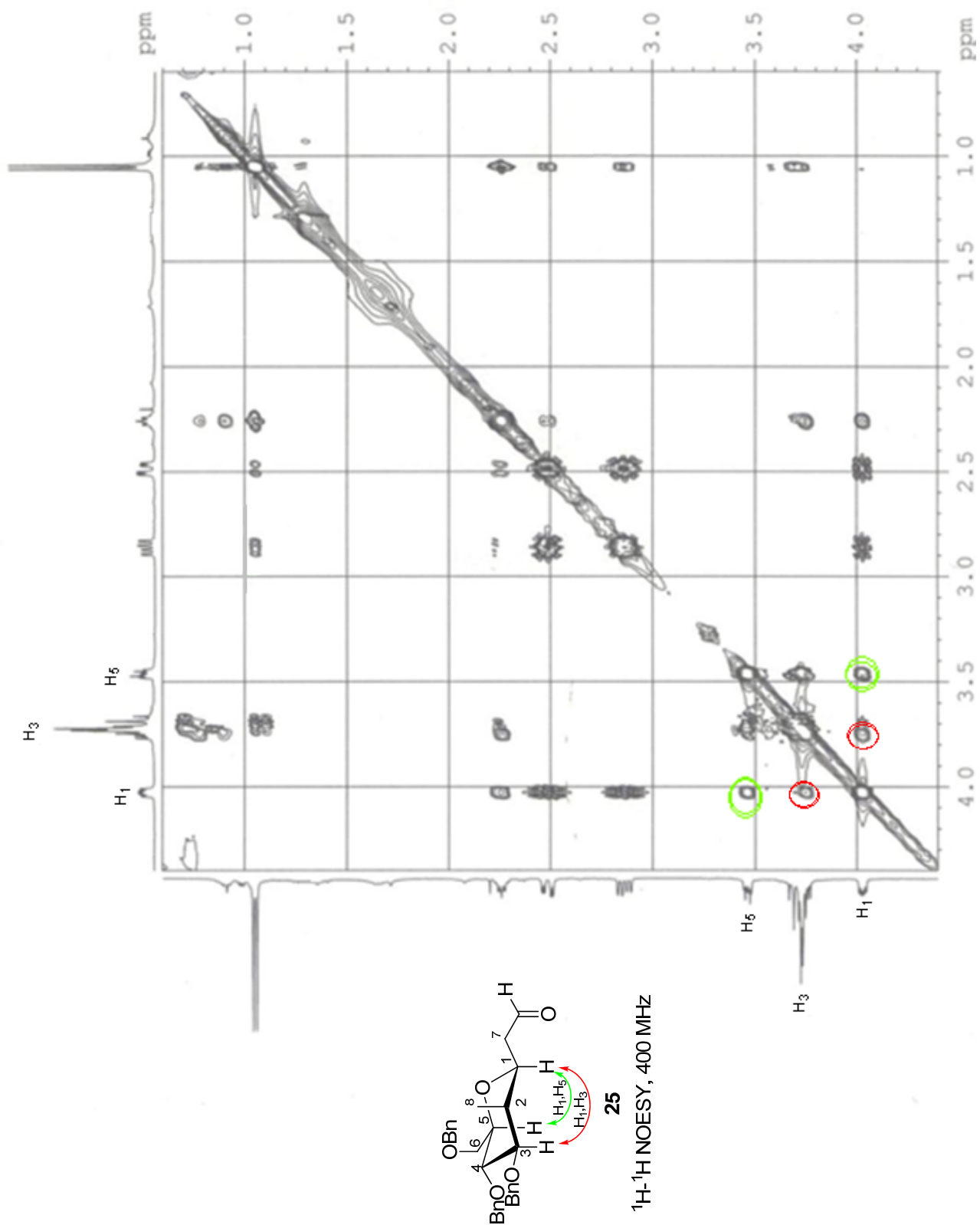


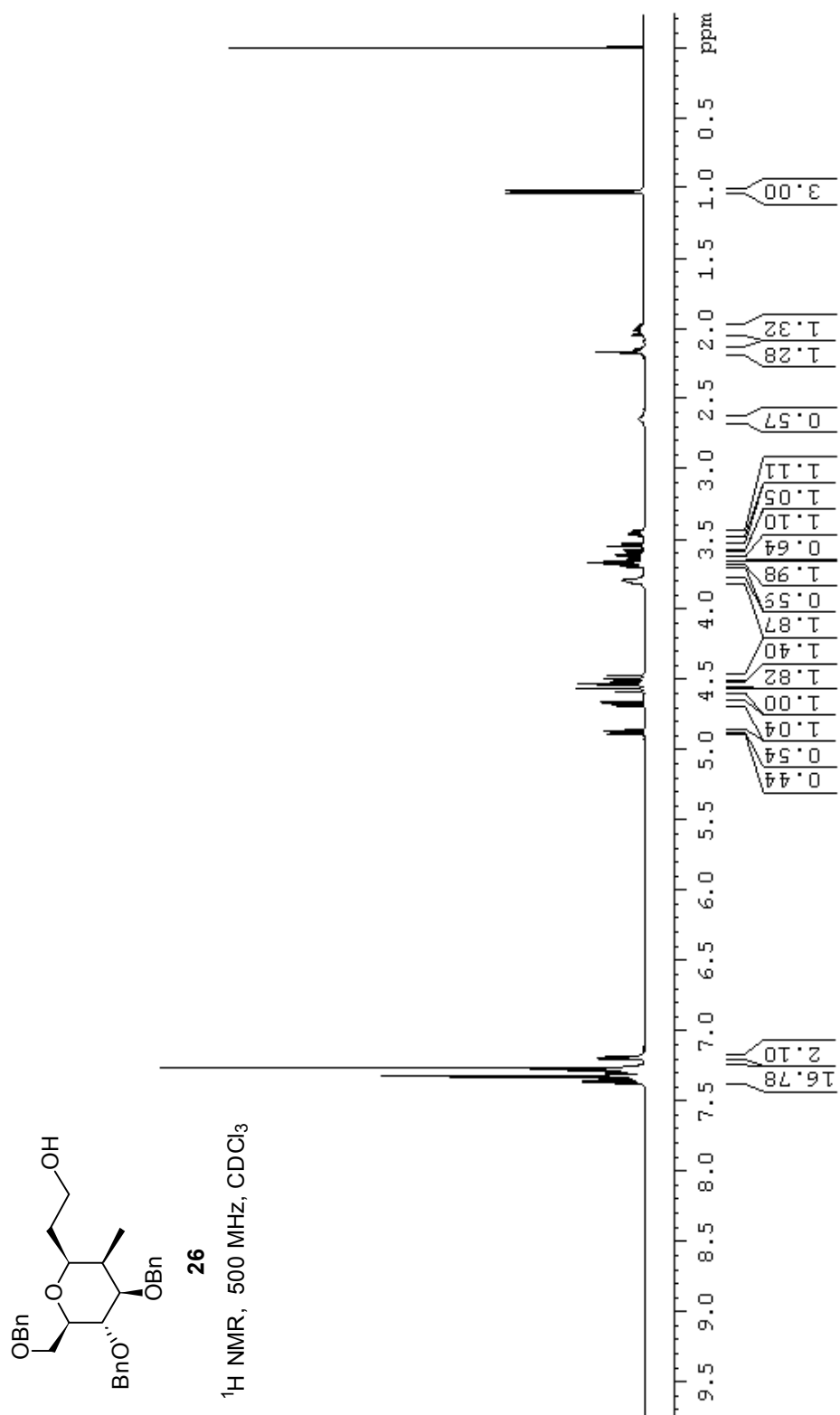


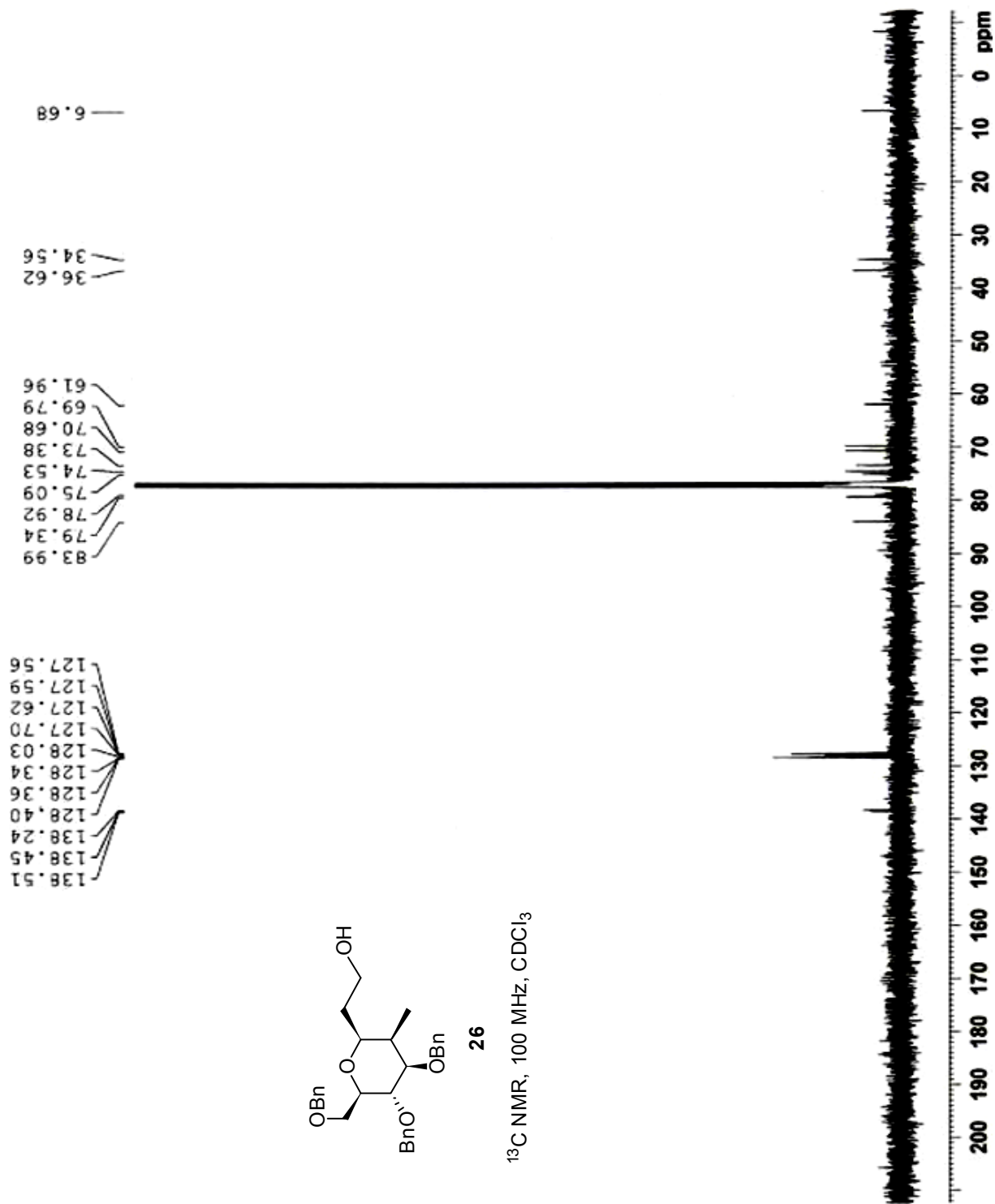


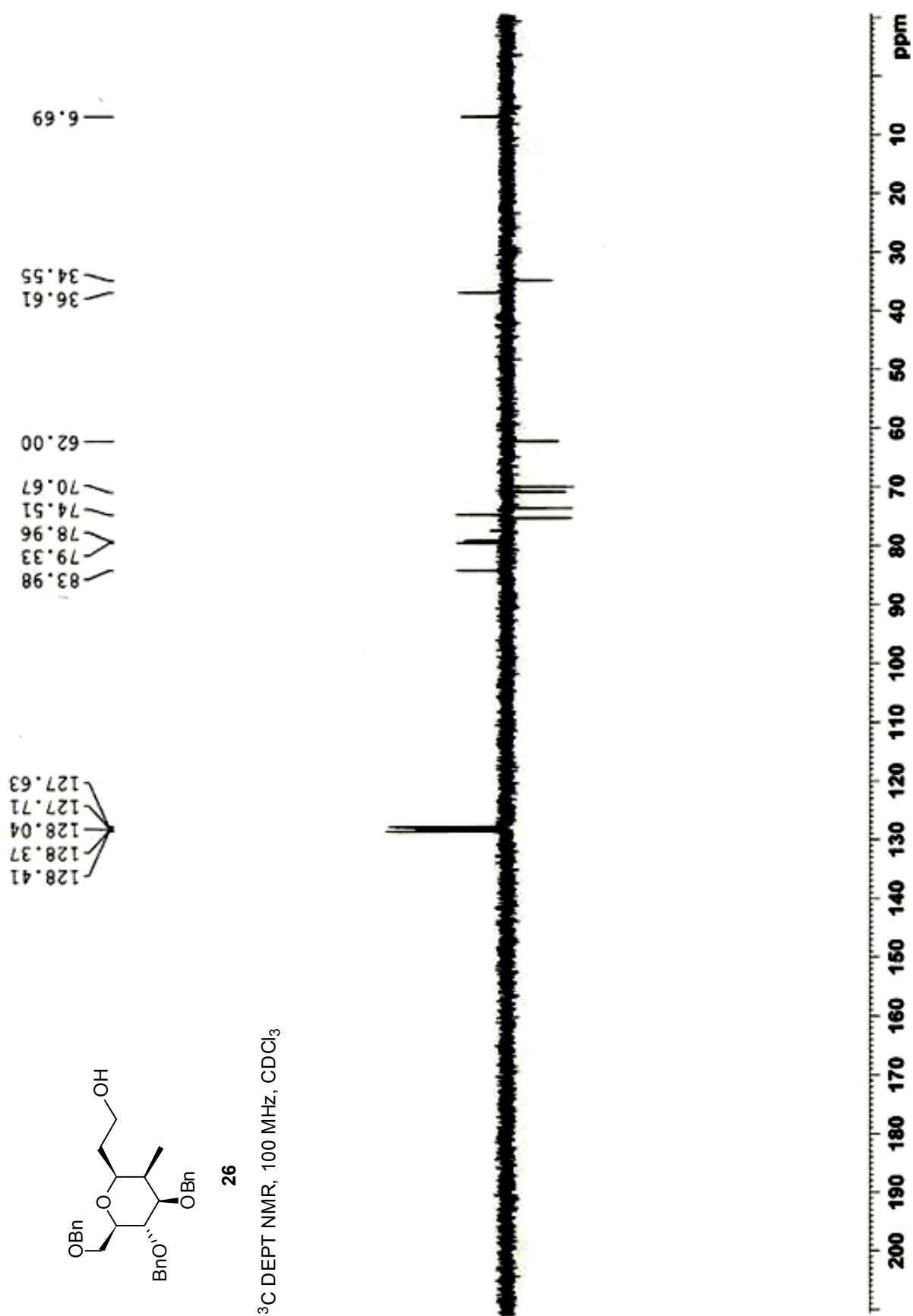


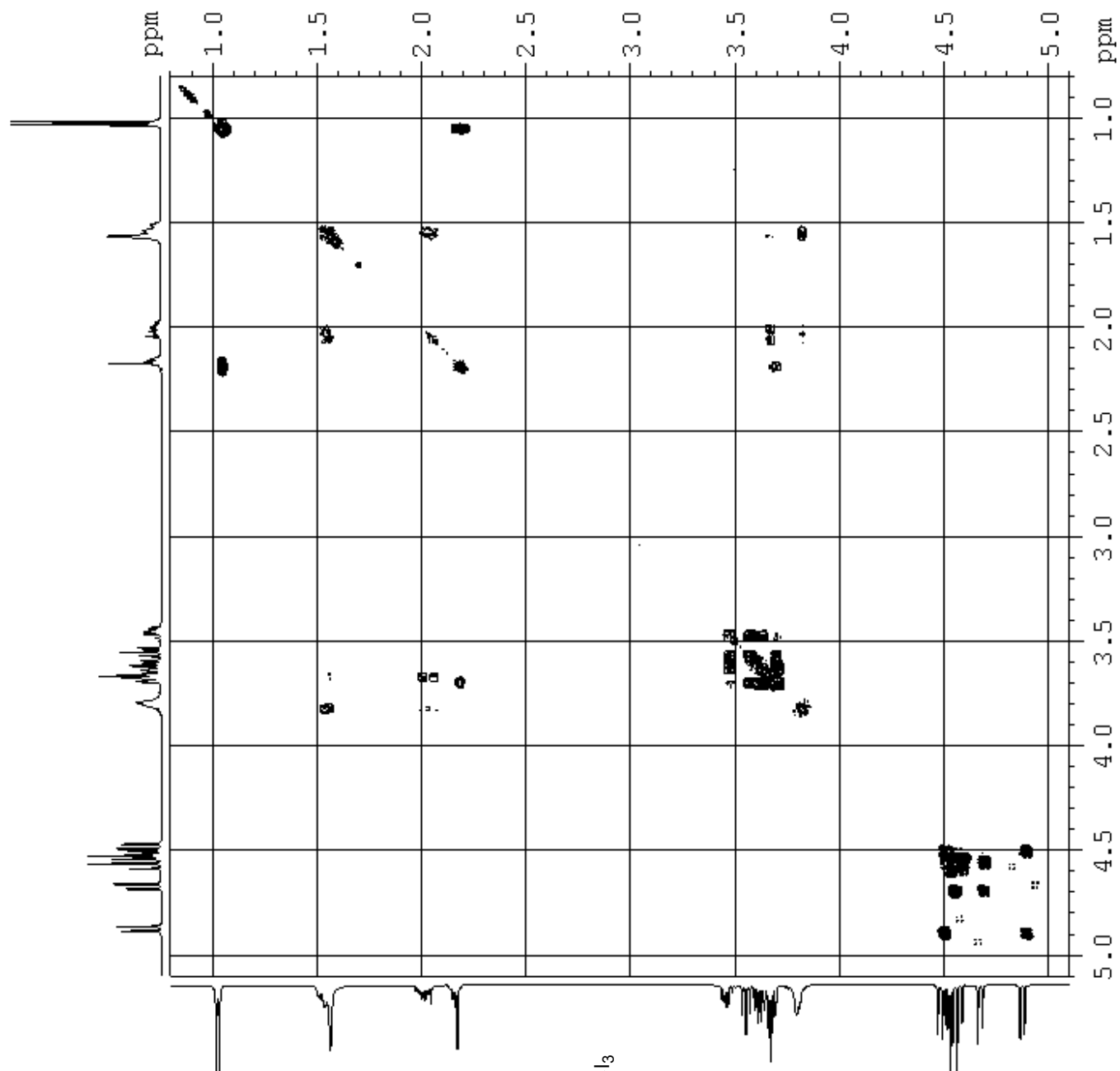
^1H - ^1H COSY, 400 MHz, CDCl_3





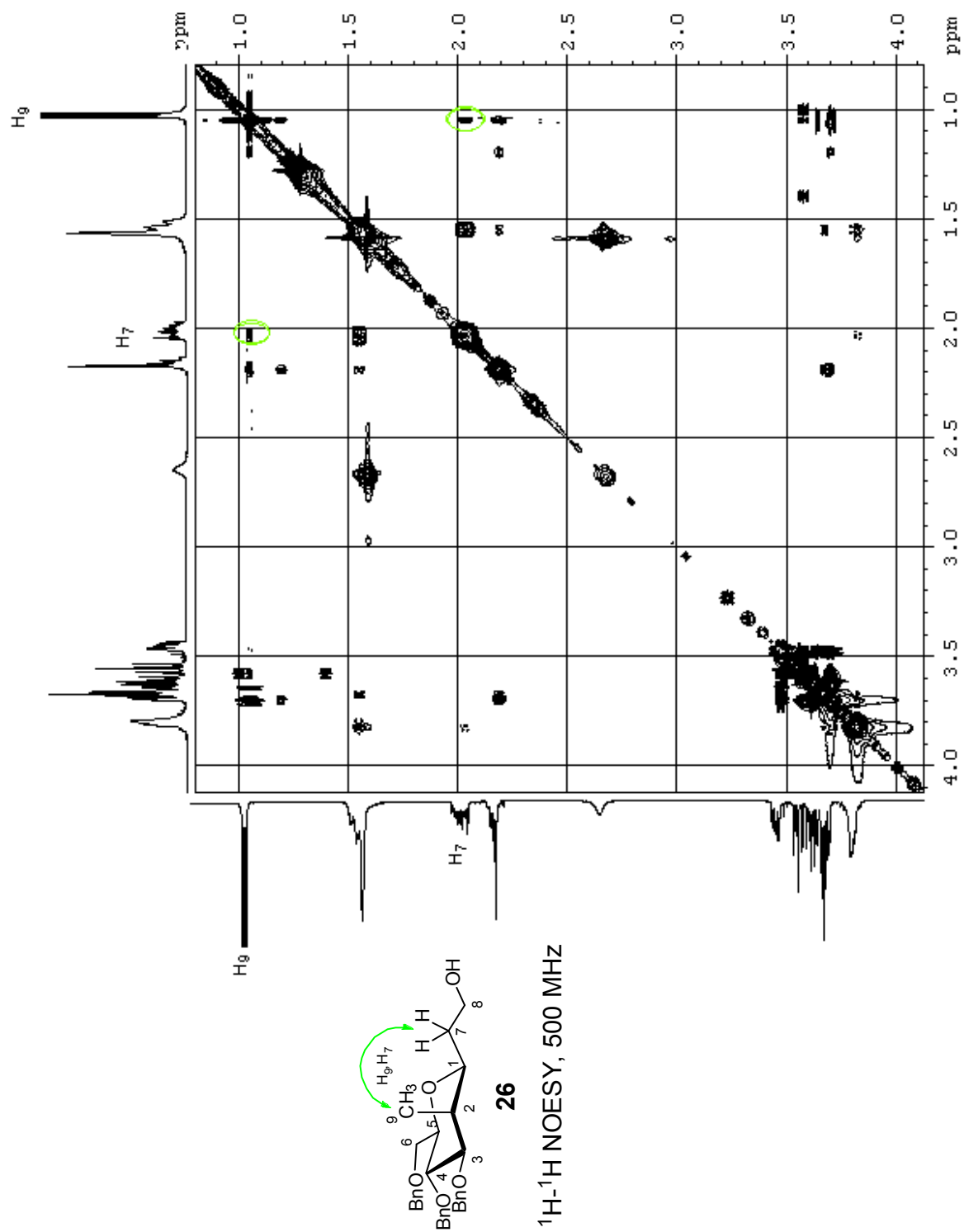


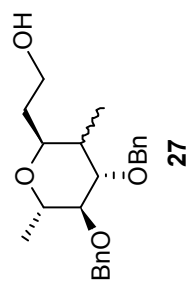




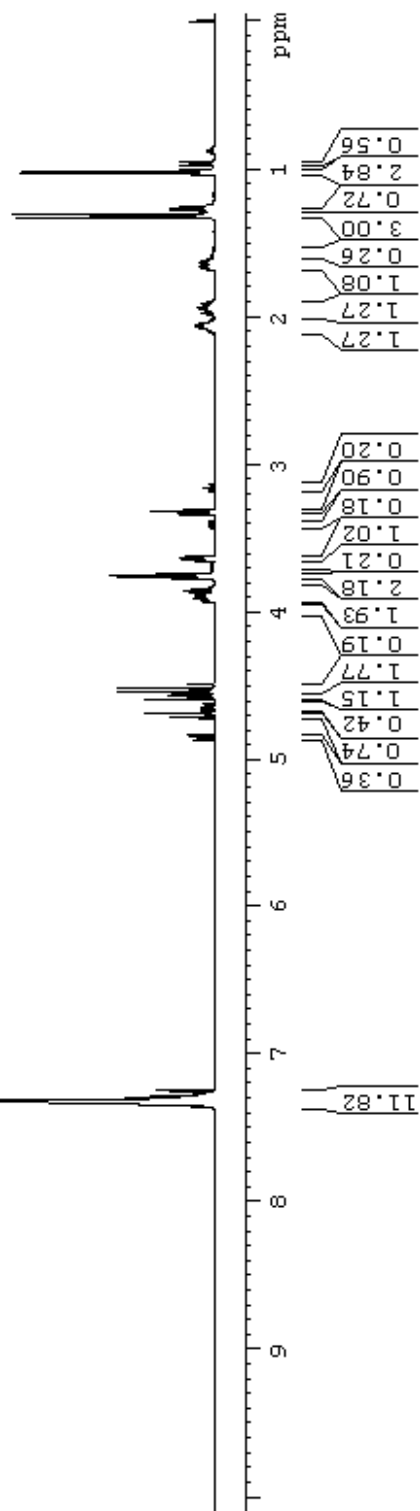
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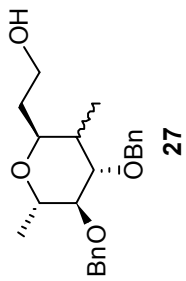
^1H - ^1H COSY, 500 MHz, CDCl_3



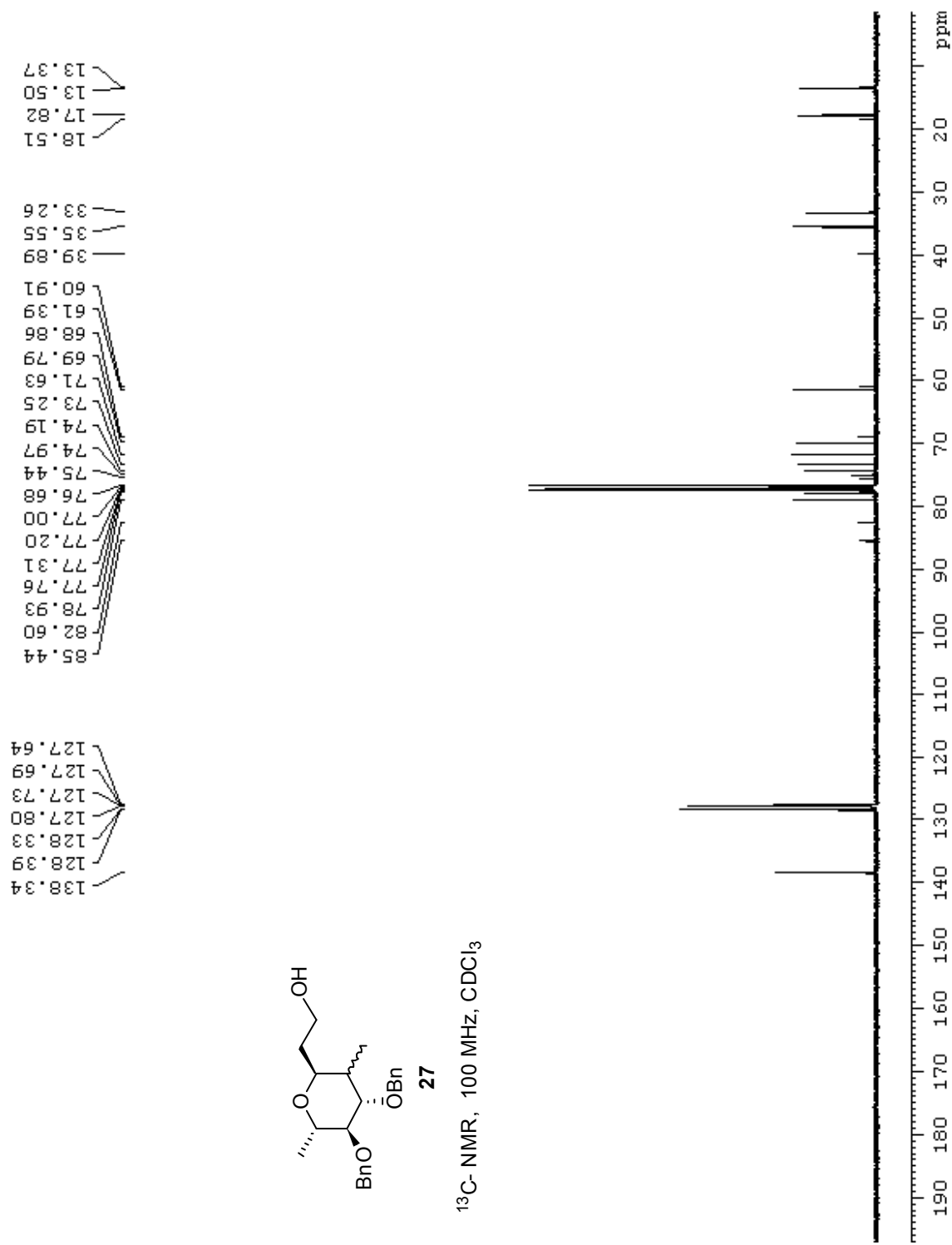


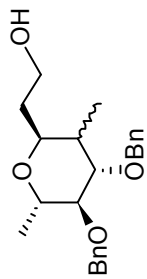
¹H-NMR, 400 MHz, CDCl₃





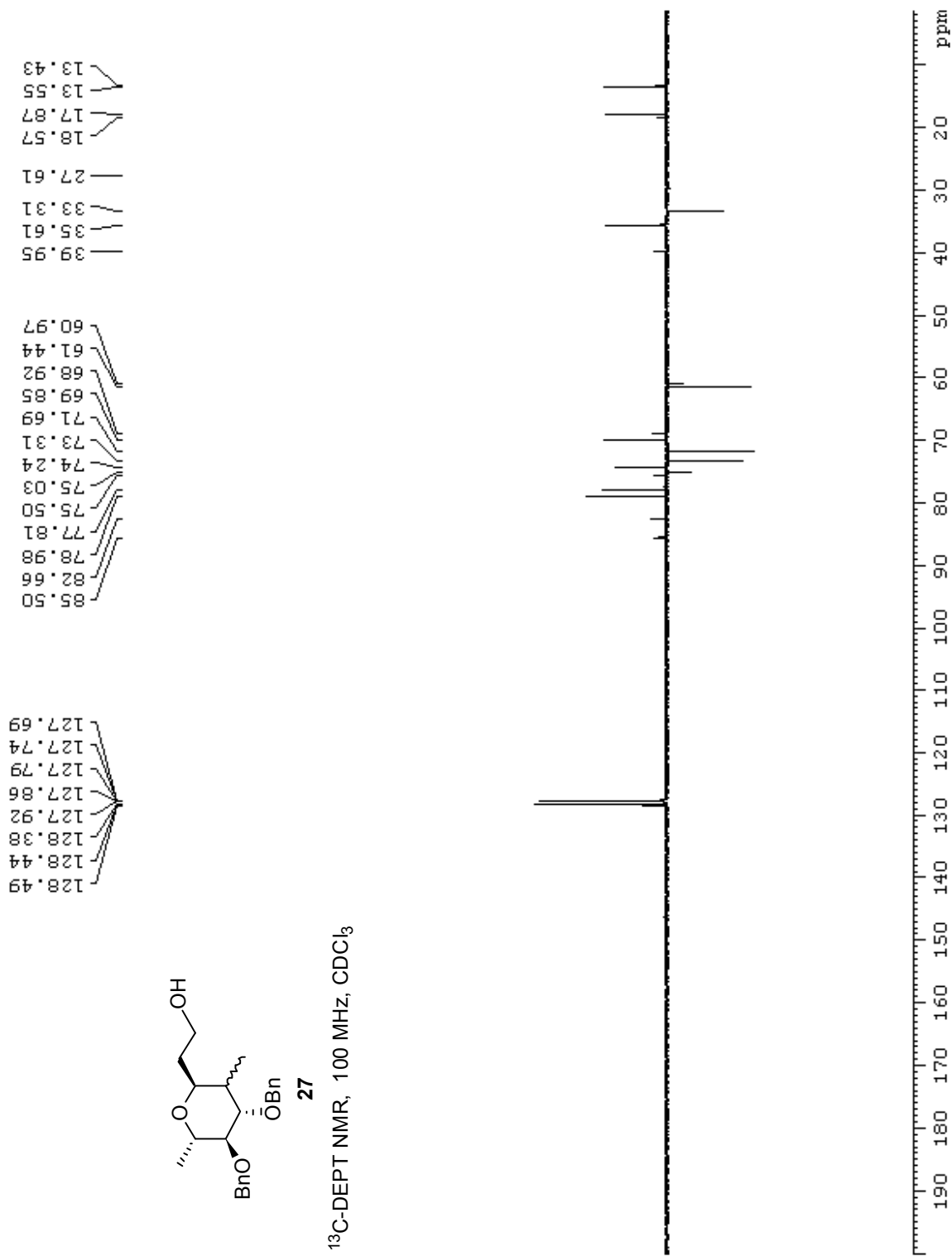
^{13}C -NMR, 100 MHz, CDCl_3

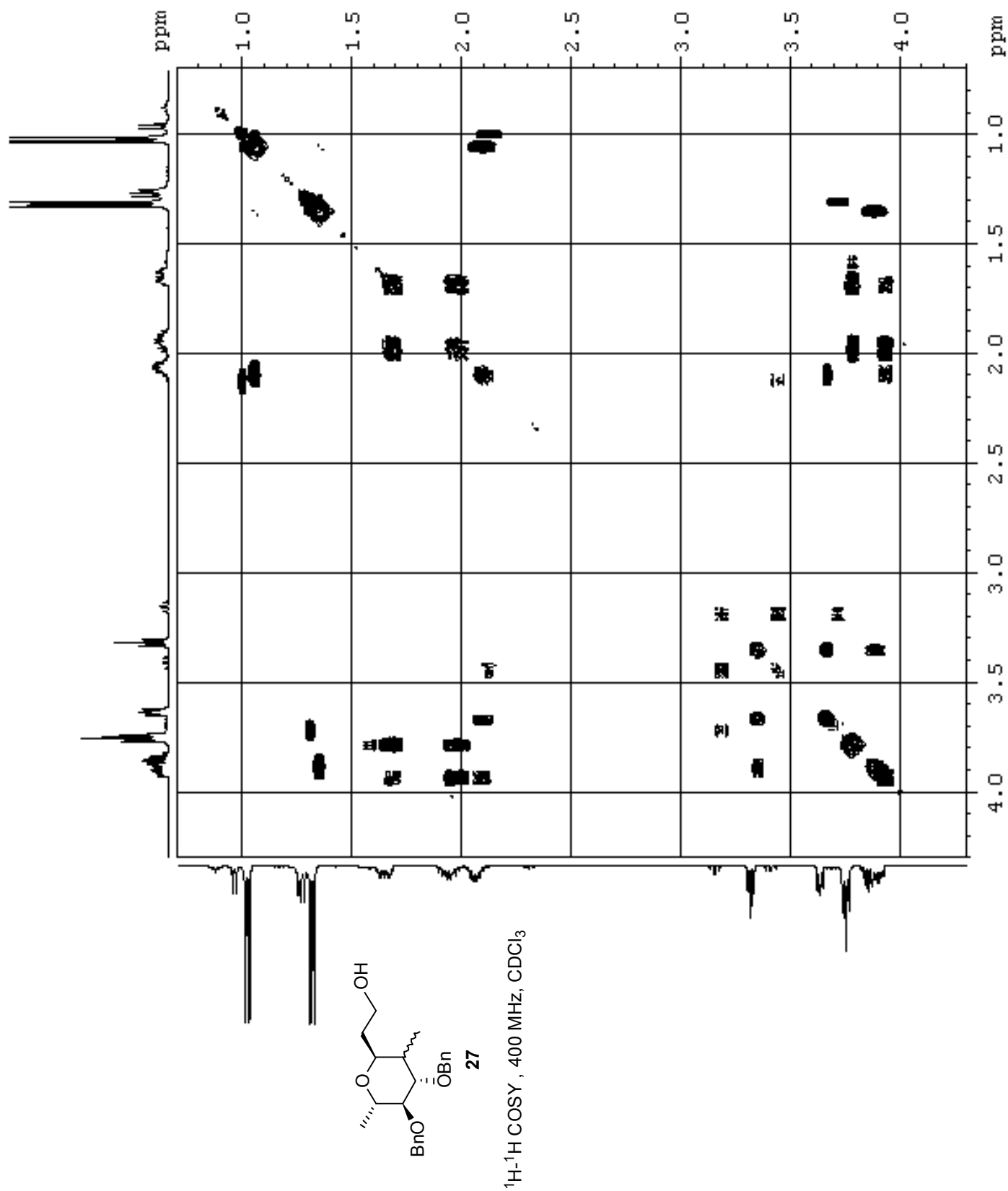


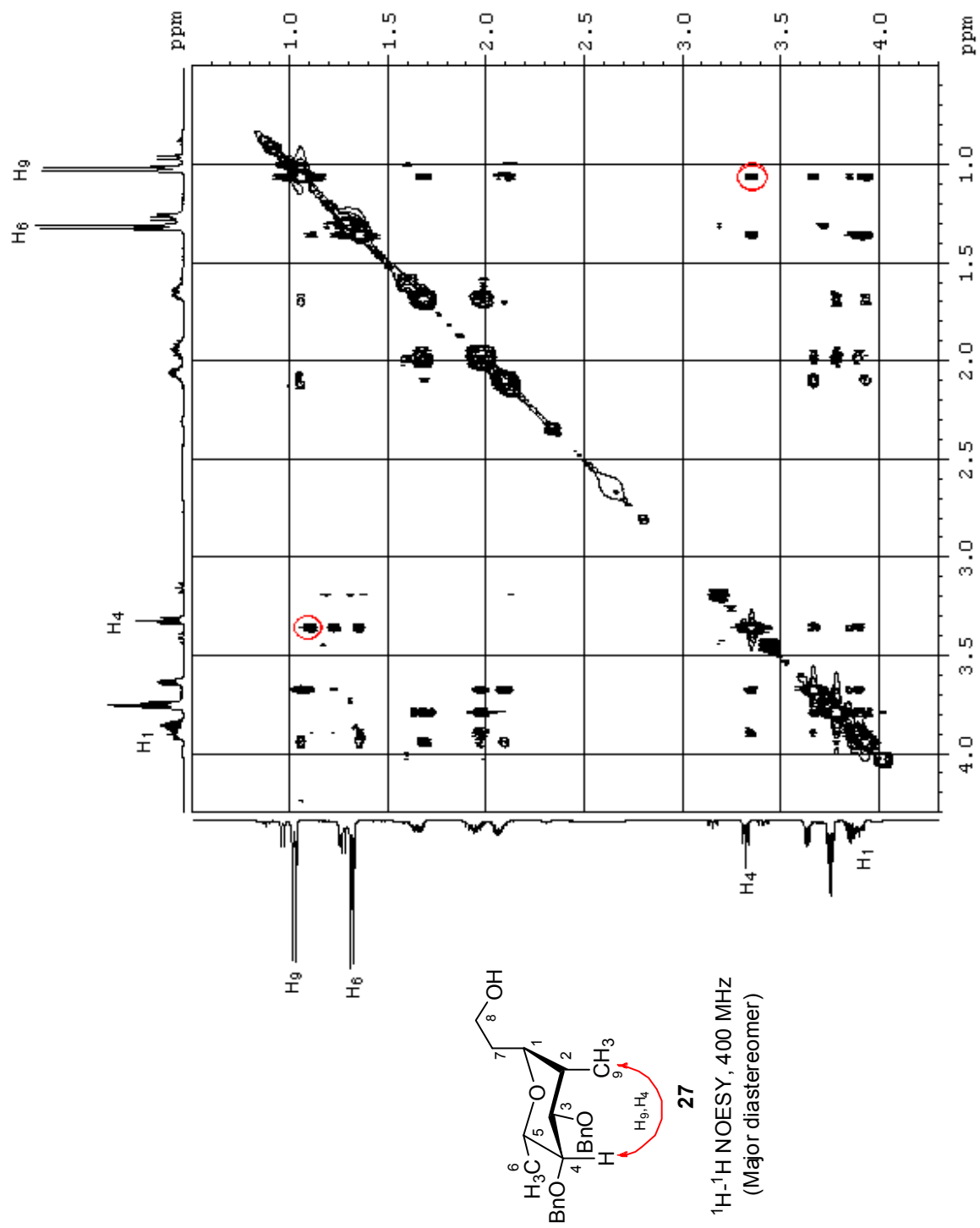


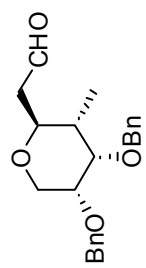
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^{13}C -DEPT NMR, 100 MHz, CDCl_3



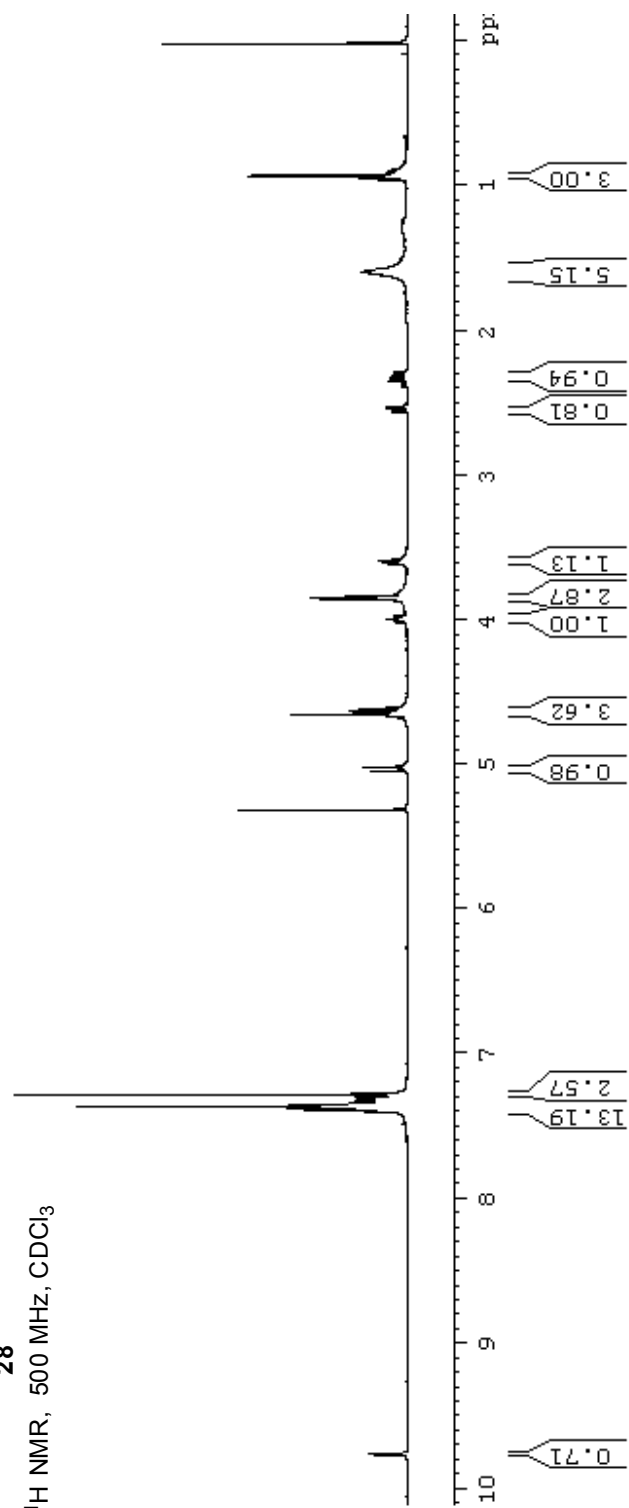


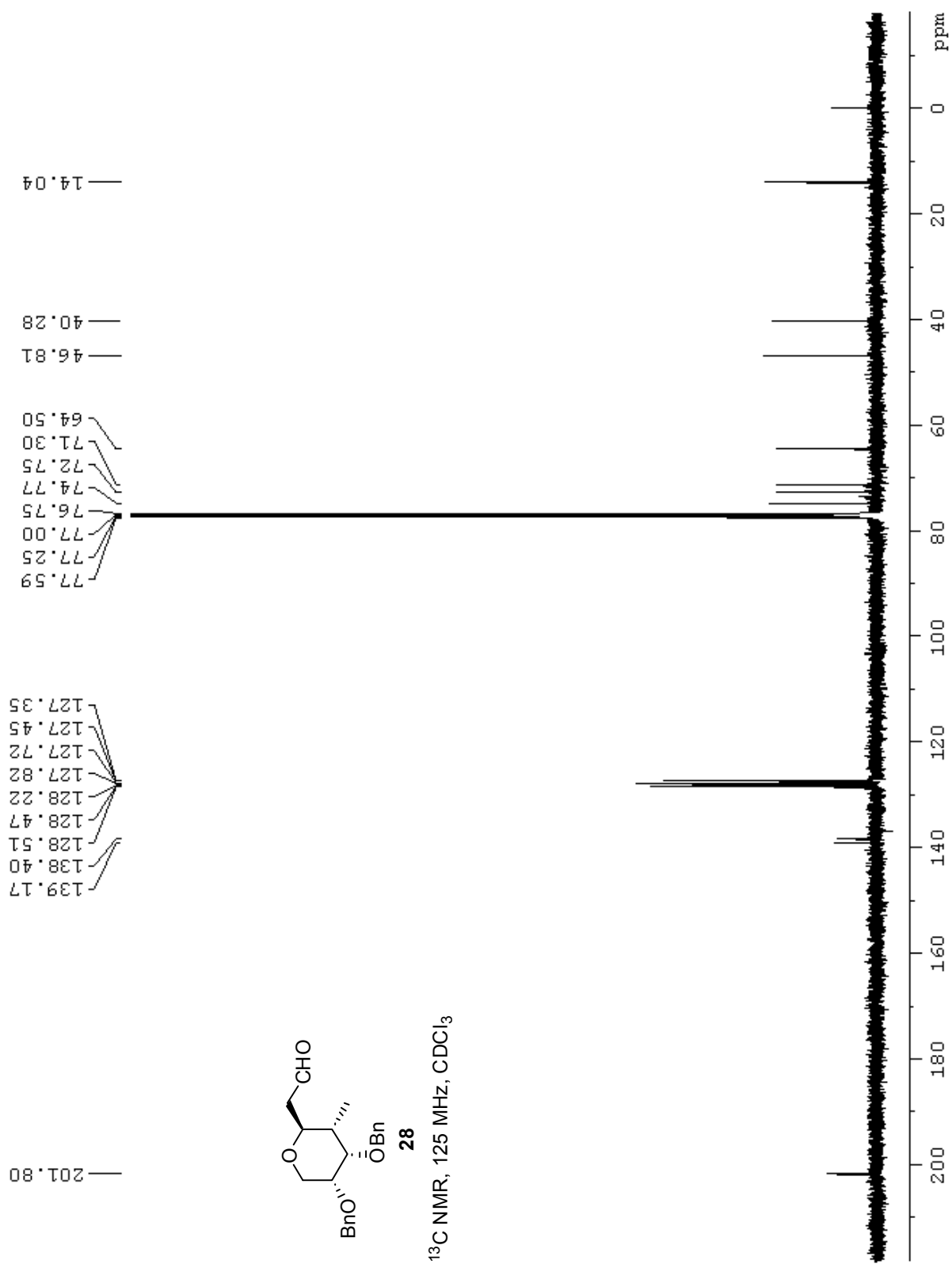


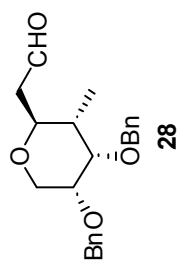
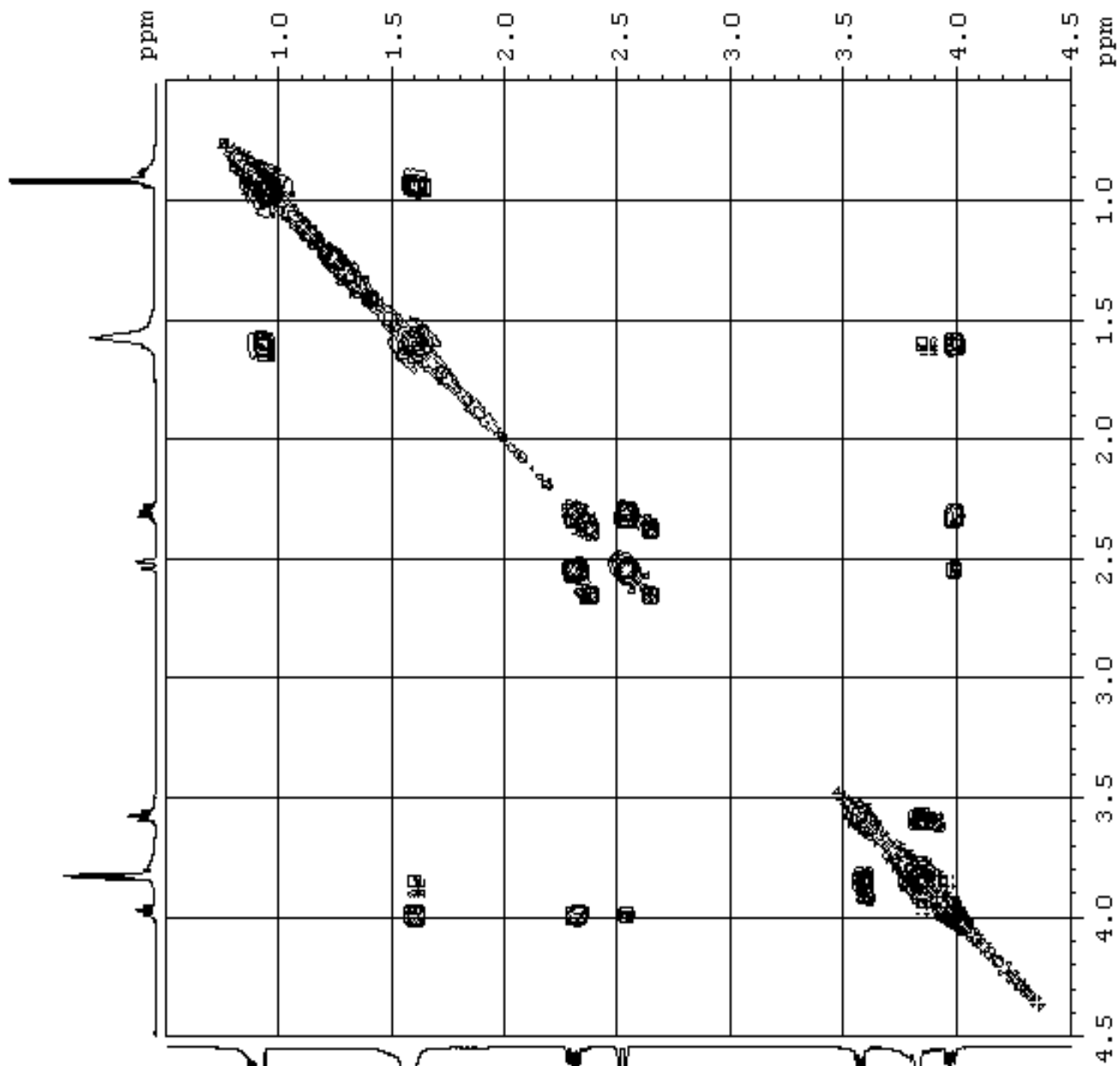


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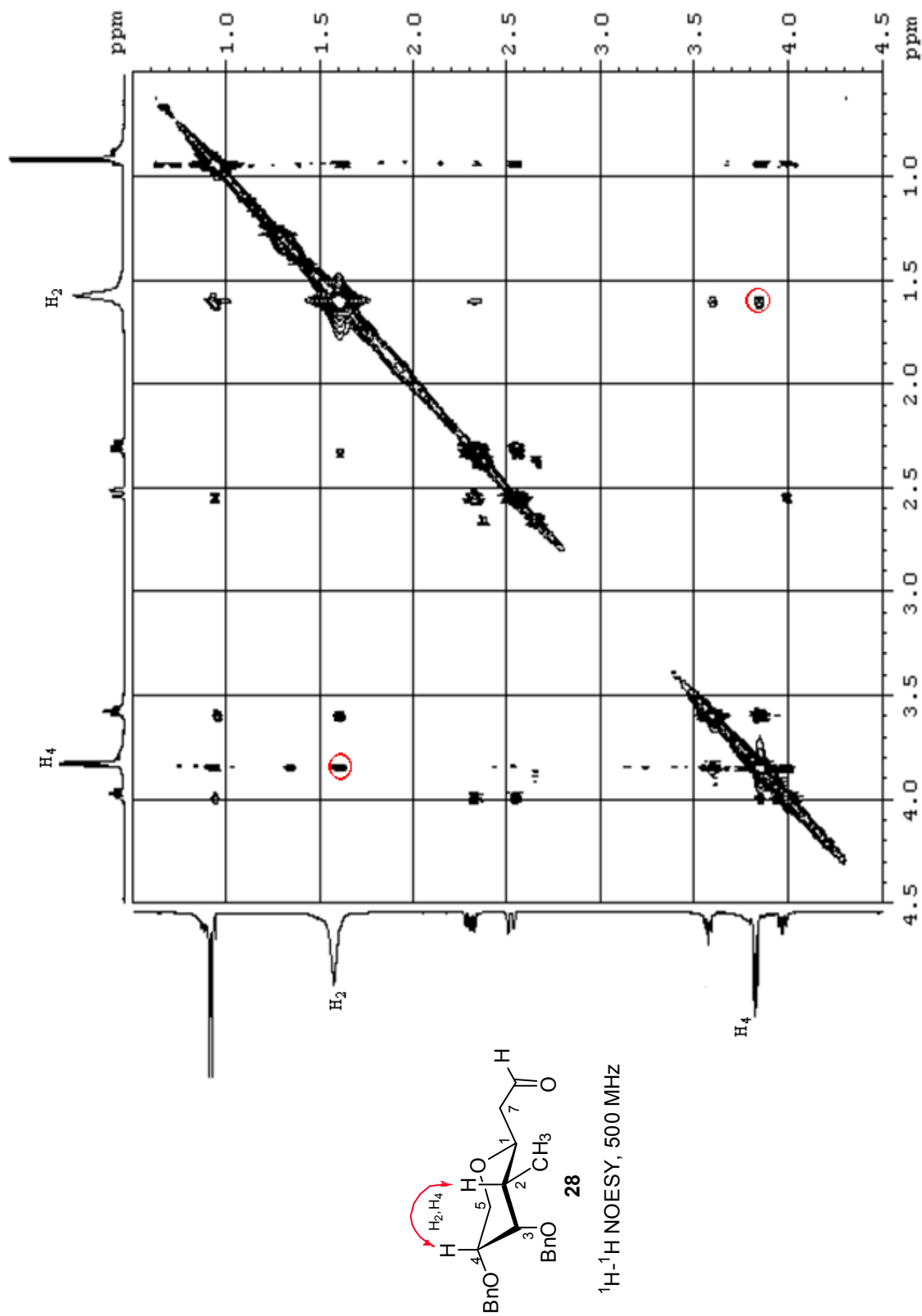
^1H NMR, 500 MHz, CDCl_3

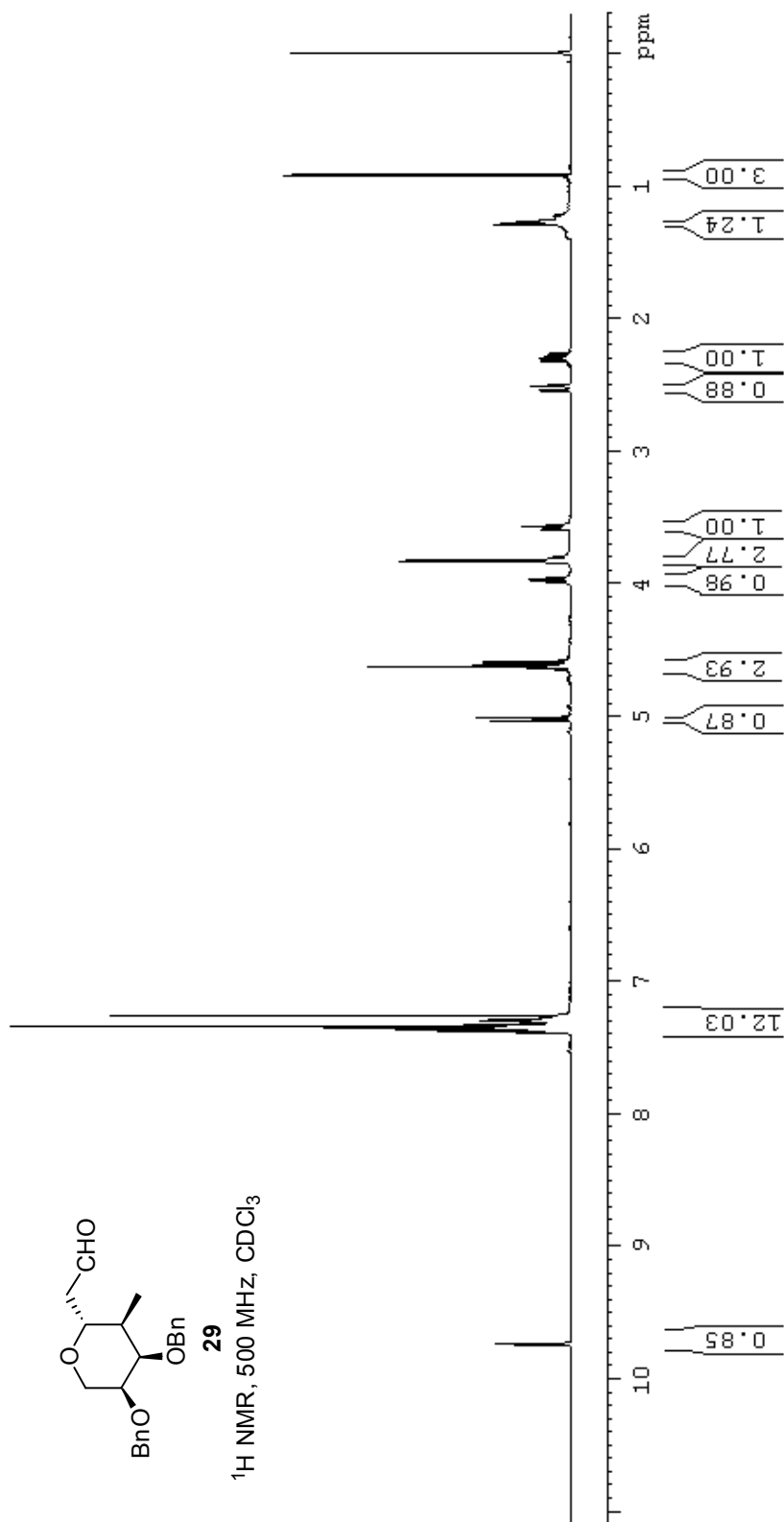


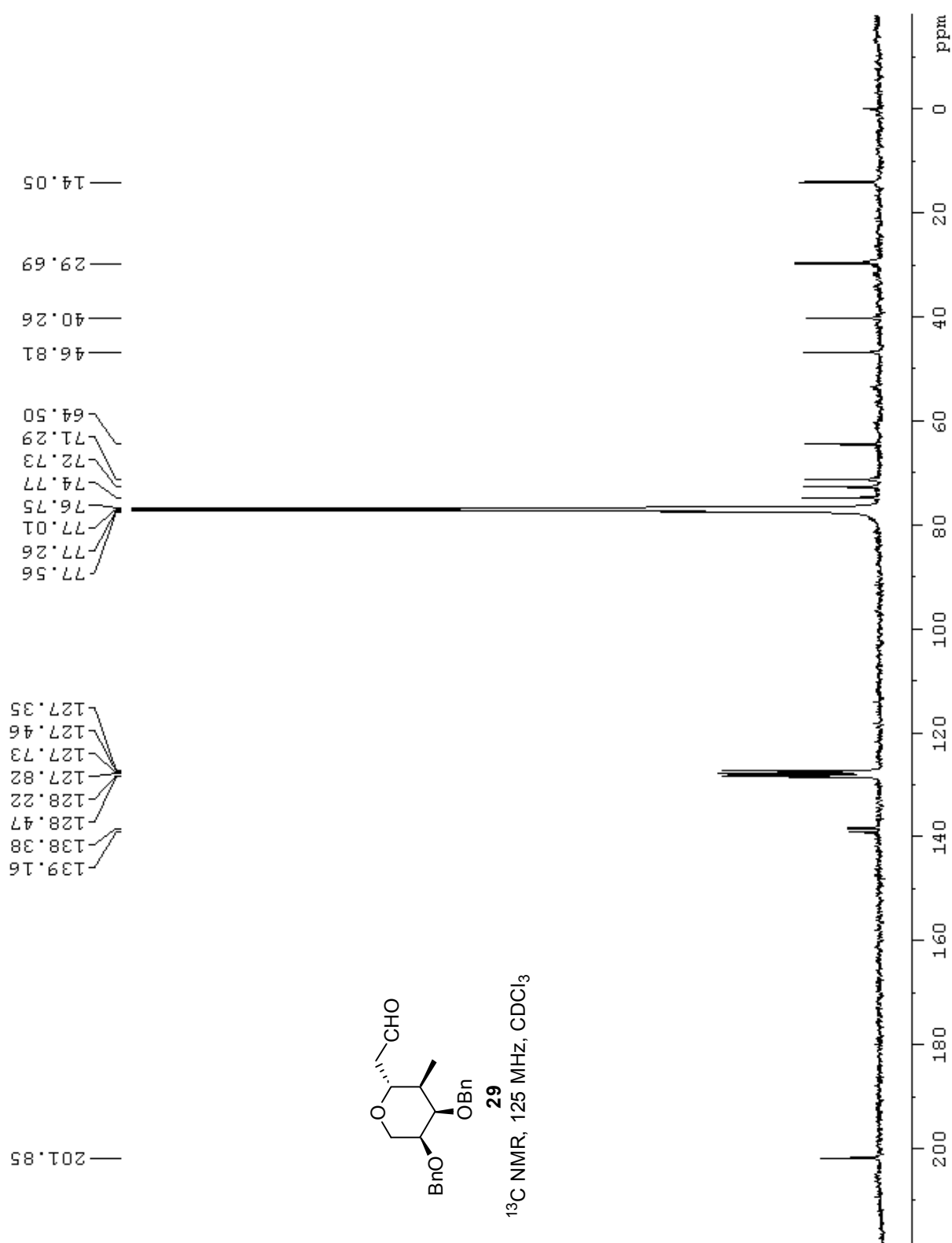


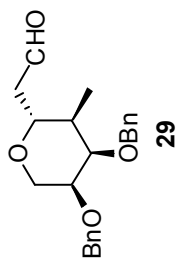


^1H - ^1H COSY, 500 MHz, CDCl_3









¹³C DEPT NMR, 125 MHz, CDCl₃

