Supporting Information

Aziridine Carboxylate from D-Glucose: Synthesis of Polyhydroxylated Piperidine, Pyrrolidine Alkaloids and Study of their Glycosidase Inhibition

Dilip D. Dhavale,*[a] K. S. Ajish Kumar,[a] Vinod D. Chaudhari,[a] Tarun Sharma,[b] Sushma G. Sabharwal,[b] and J. PrakashaReddy[c]

[a]*Garware Research Centre, Department of Chemistry, University of Pune, Pune – 411 007, India,*
[b]*Division of Biochemistry, Department of Chemistry, University of Pune, Pune - 411 007, India*
[c]*Division of Organic Chemistry, National Chemical Laboratory, Pune-411 008, India*

ddd@chem.unipune.ernet.in

General Experimental Methods. Melting points were recorded with melting point apparatus and are uncorrected. IR spectra were recorded with FTIR as a thin film or in Nujol mull or using KBr pellets and are expressed in cm^{-1}. ^{1}H (300 MHz) and ^{13}C (75 MHz) NMR spectra were recorded using $CDCl_3$ or D_2O as a solvent. Chemical shifts were reported in δ unit (ppm) with reference to TMS as an internal standard and *J* values are given in Hz. Elemental analyses were carried out with C, H-analyzer. Optical rotations were measured using polarimeter at 25 °C. Thin layer chromatography was performed on pre-coated plates (0.25 mm, silica gel 60 F_{254}). Column chromatography was carried out with silica gel (100-200 mesh). The reactions were carried out in oven-dried glassware under dry N_2. Methanol, pyridine, THF, dichloromethane, were purified and dried before use. Distilled *n*-hexane and ethyl acetate were used for column chromatography. Bromine, trifluoroacetic acid and benzylchloroformate were purchased from Merck. 10% Pd-C was purchased from Aldrich and/or Fluka. After decomposition of the reaction with water, the work-up involves washing of combined organic layer with water, brine, drying over anhydrous sodium sulfate and evaporation of solvent at reduced pressure.

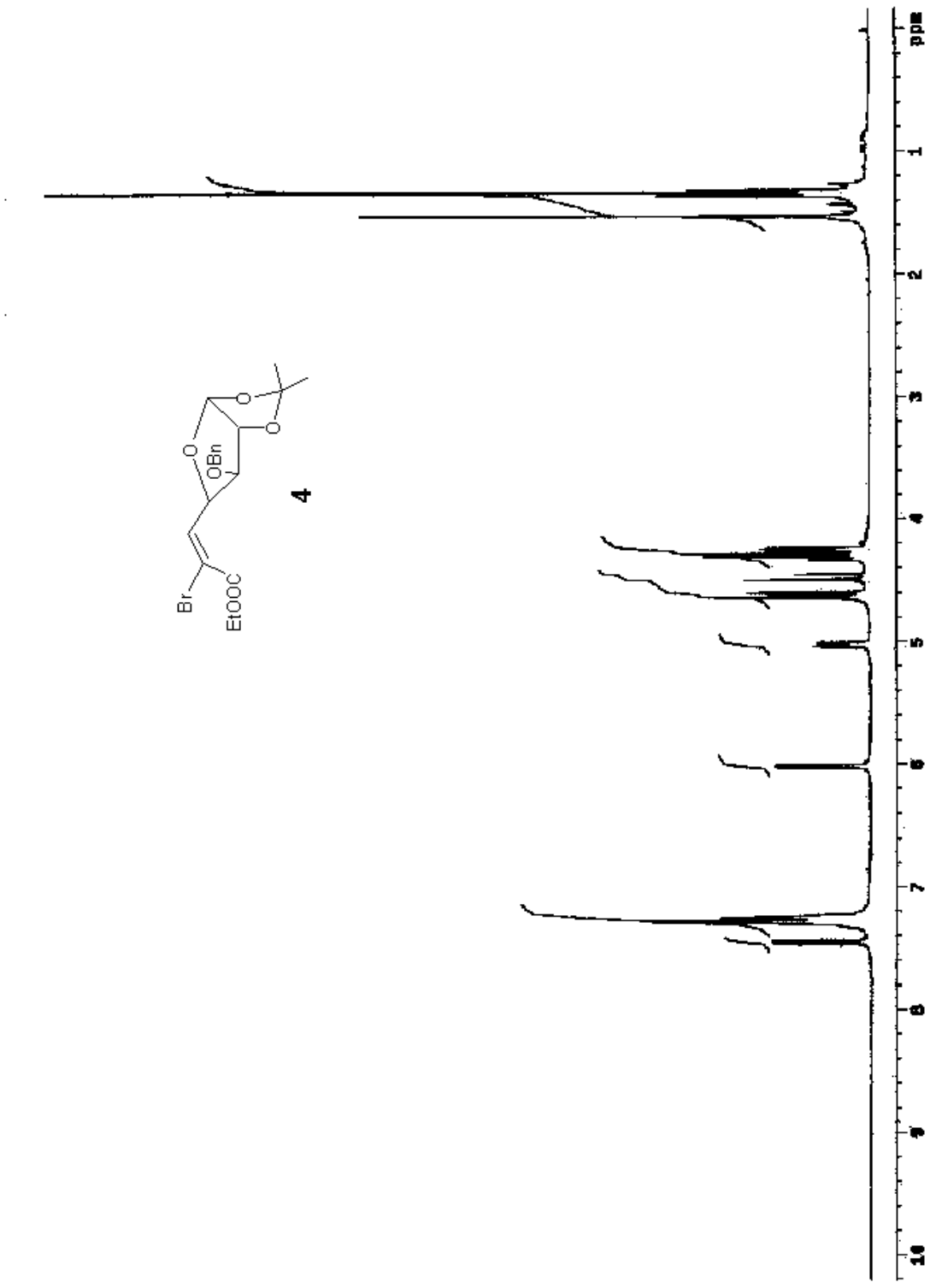


Figure 1: ^{1}H NMR (300 MHz, $CDCl_3$) spectrum of compound 4

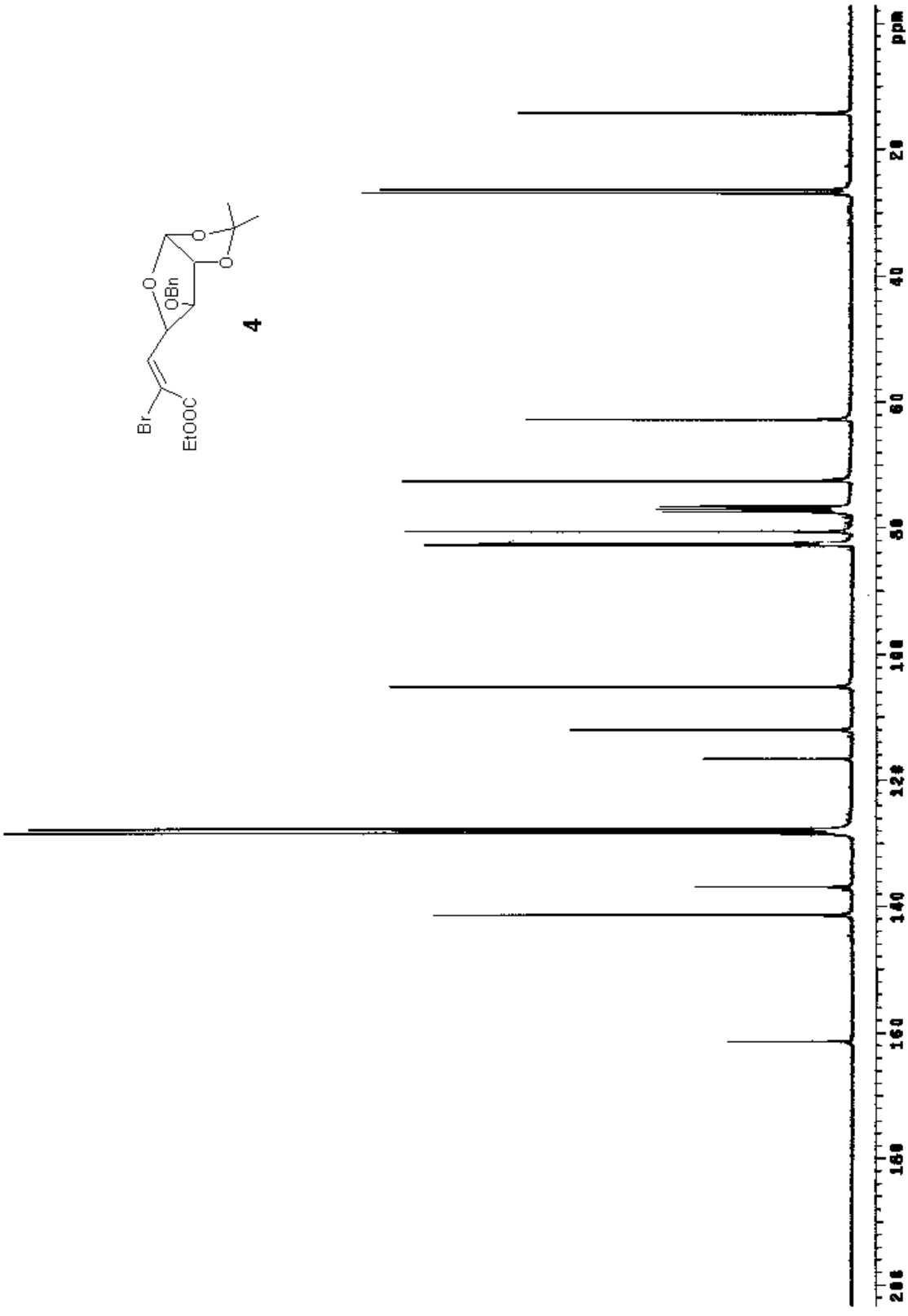


Figure 2: ^{13}C NMR (75 MHz, $CDCl_3$) spectrum of compound 4

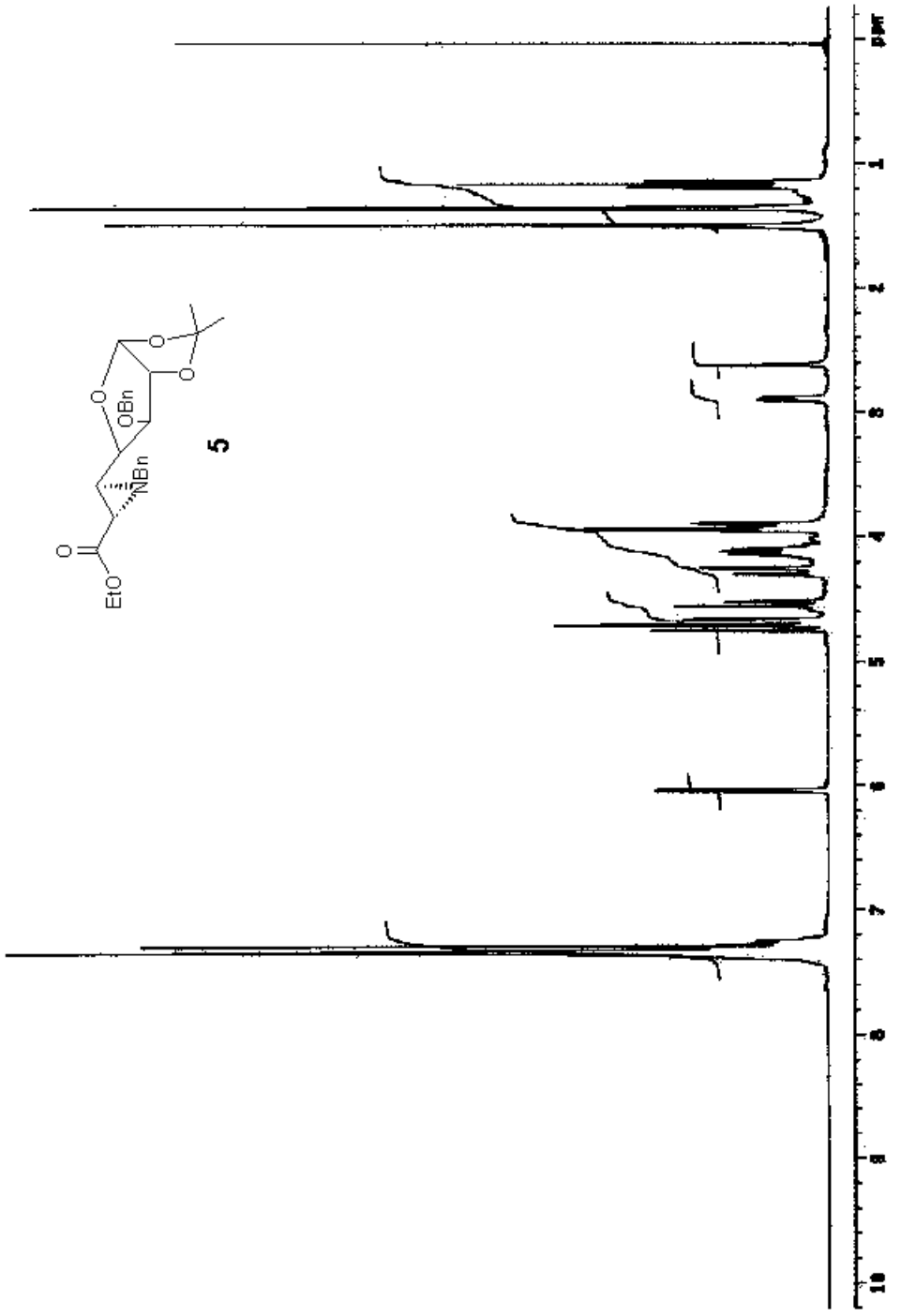


Figure 3: ^{1}H NMR (300 MHz, $CDCl_3$) spectrum of compound 5

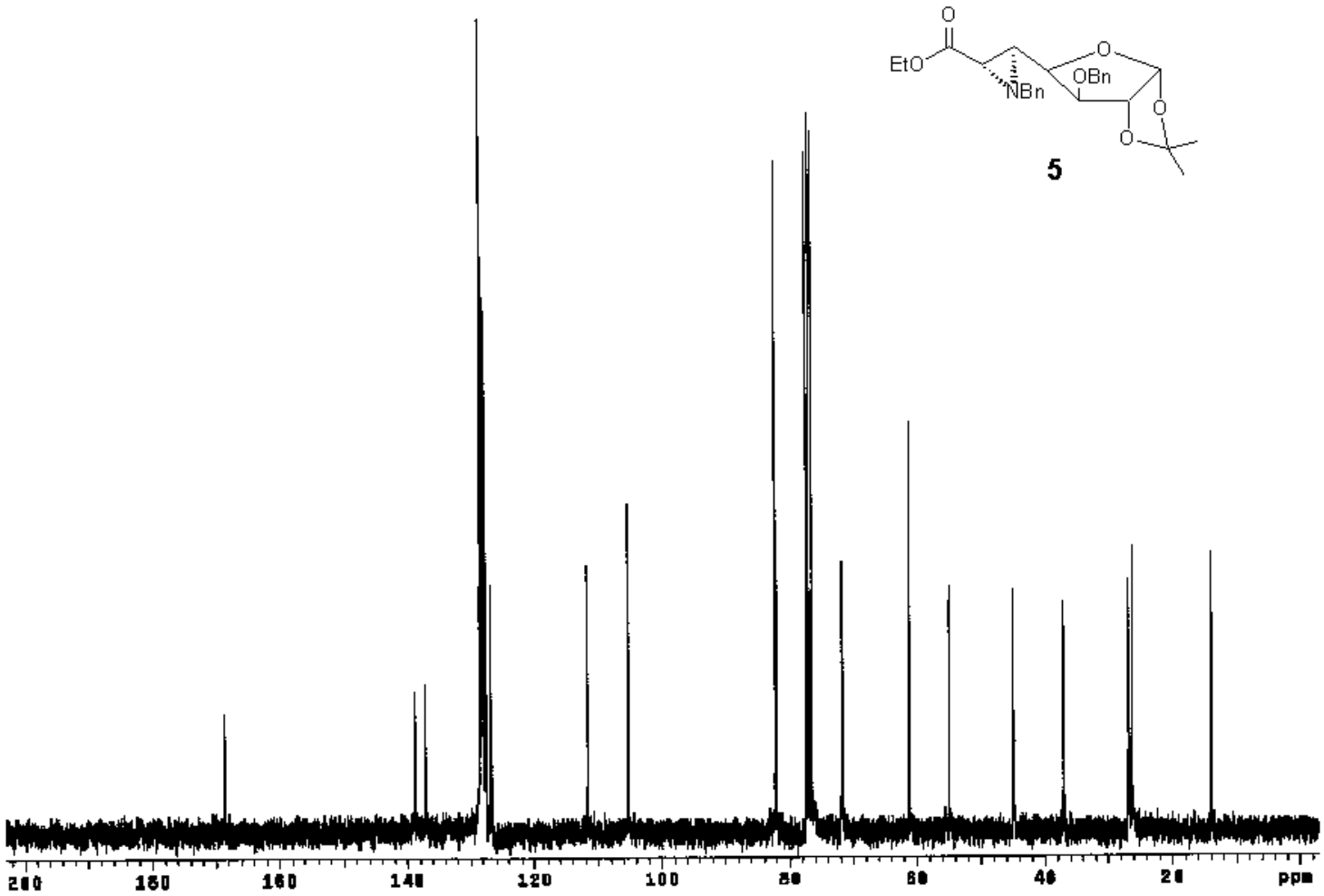


Figure 4: ^{13}C NMR (75 MHz, $CDCl_3$) spectrum of compound 5

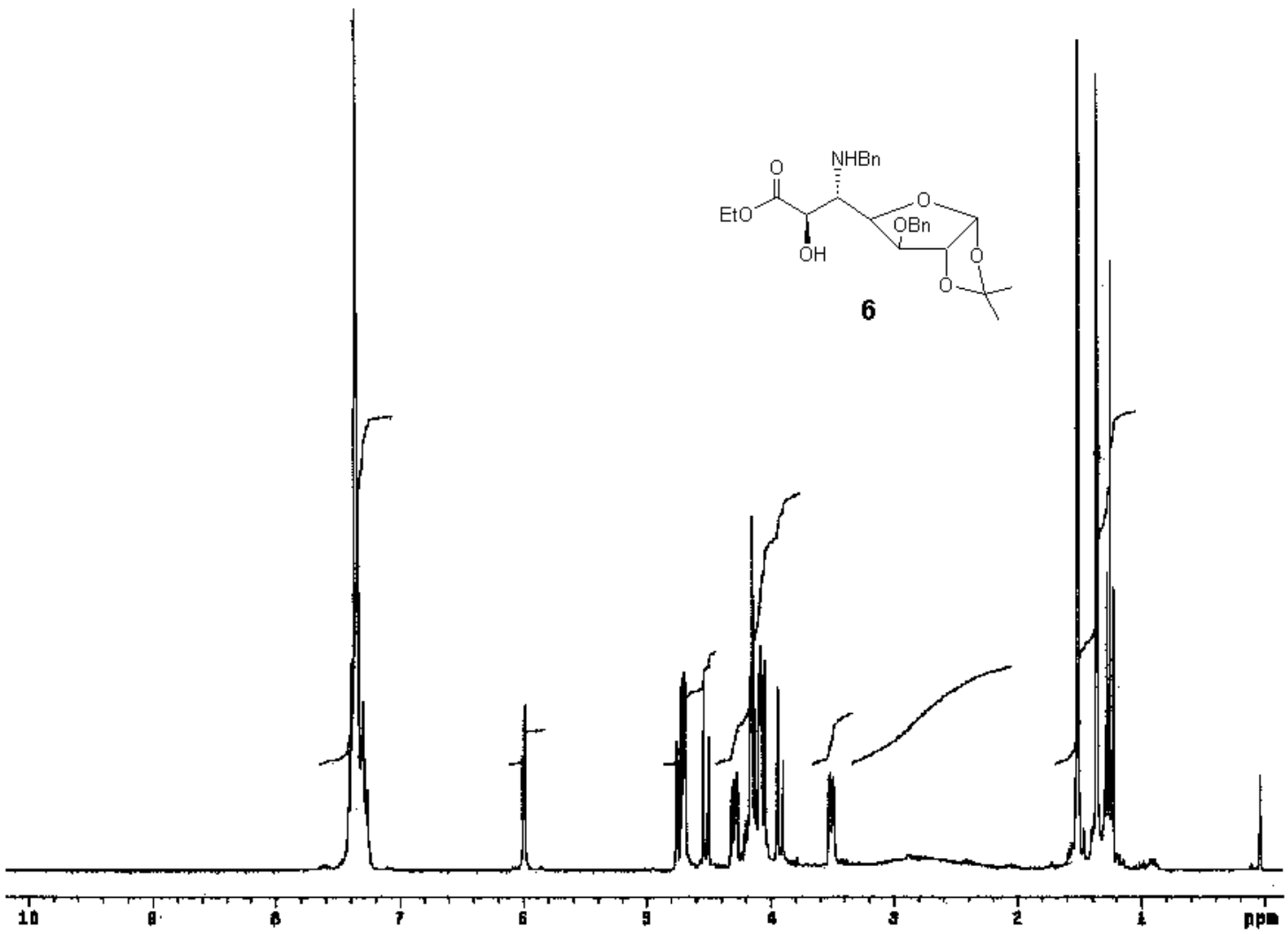


Figure 5: ^{1}H NMR (300 MHz, $CDCl_3$) spectrum of compound 6

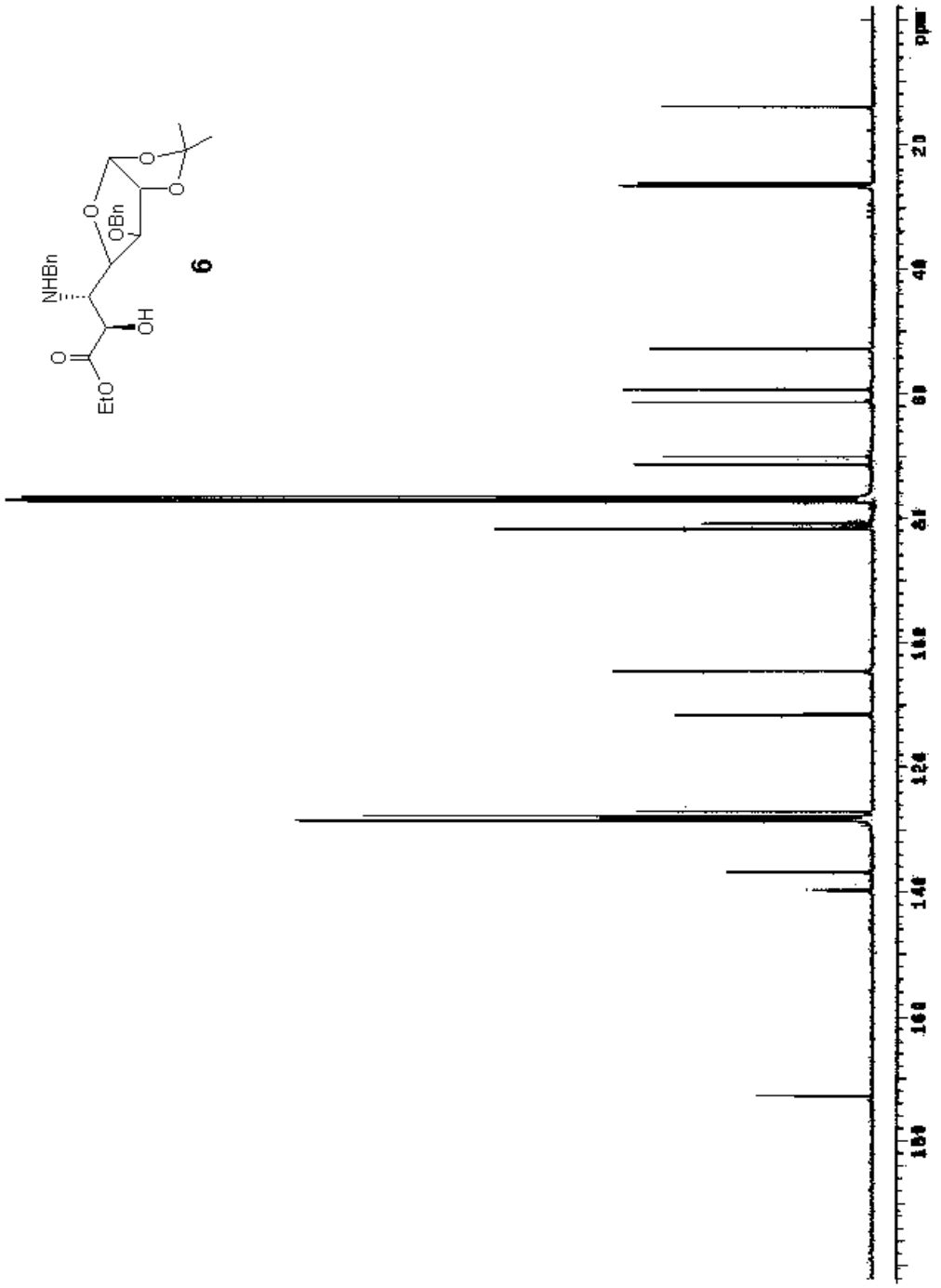


Figure 6: ^{13}C NMR (75 MHz, $CDCl_3$) spectrum of compound 6

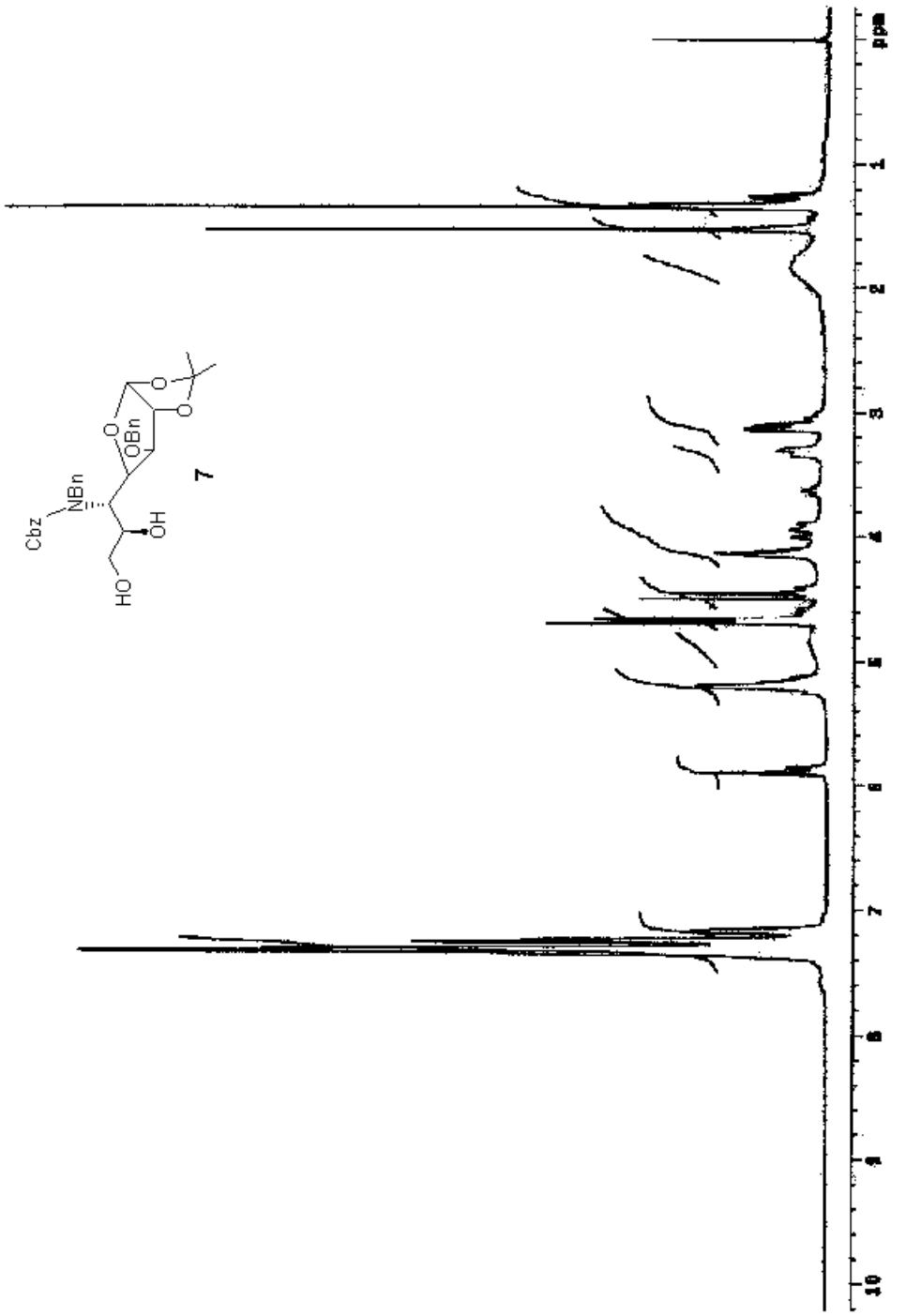


Figure 7: ^{1}H NMR (300 MHz, $CDCl_3$) spectrum of compound **7**

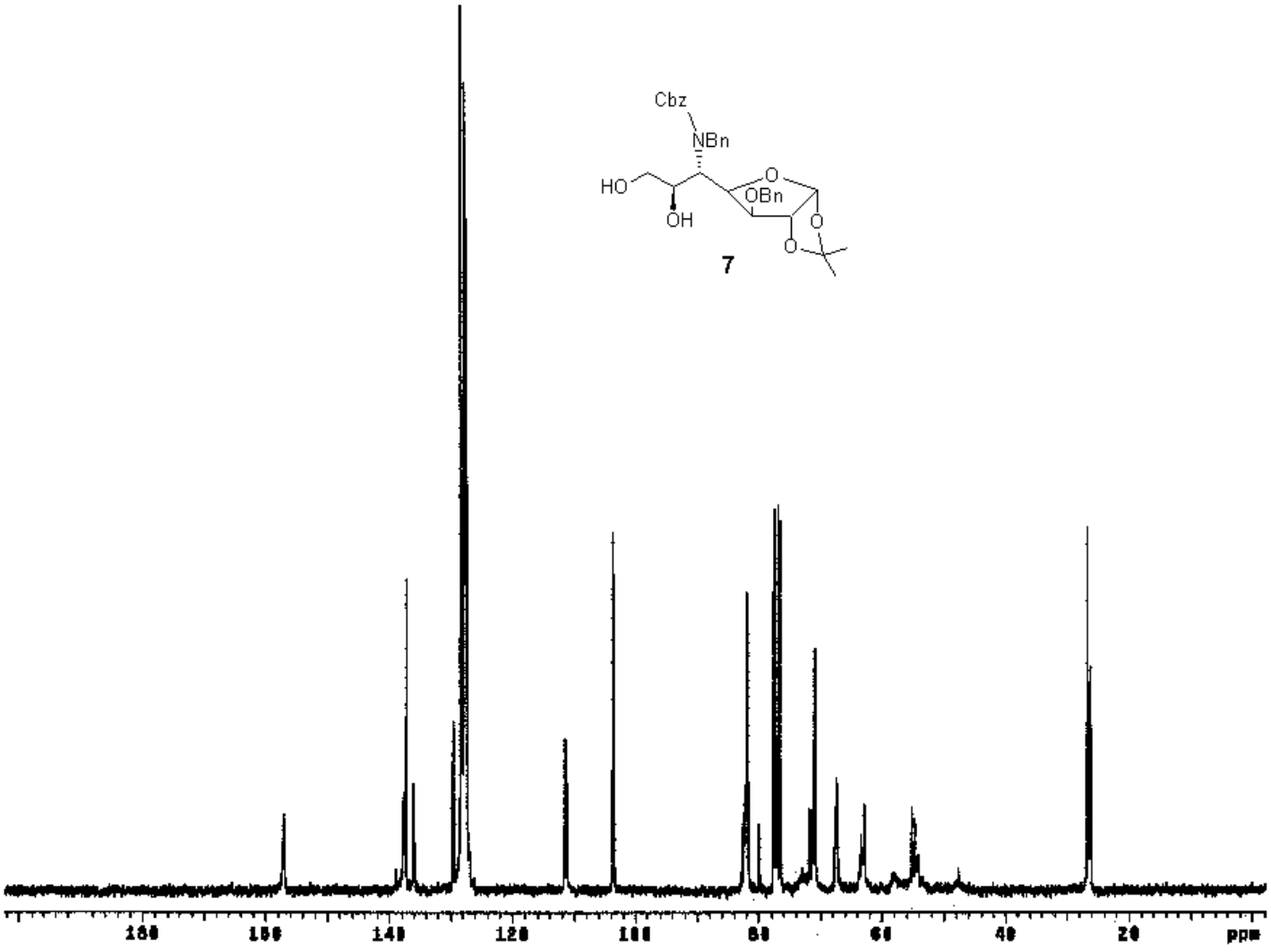


Figure 8: ^{13}C NMR (75 MHz, $CDCl_3$) spectrum of compound 7

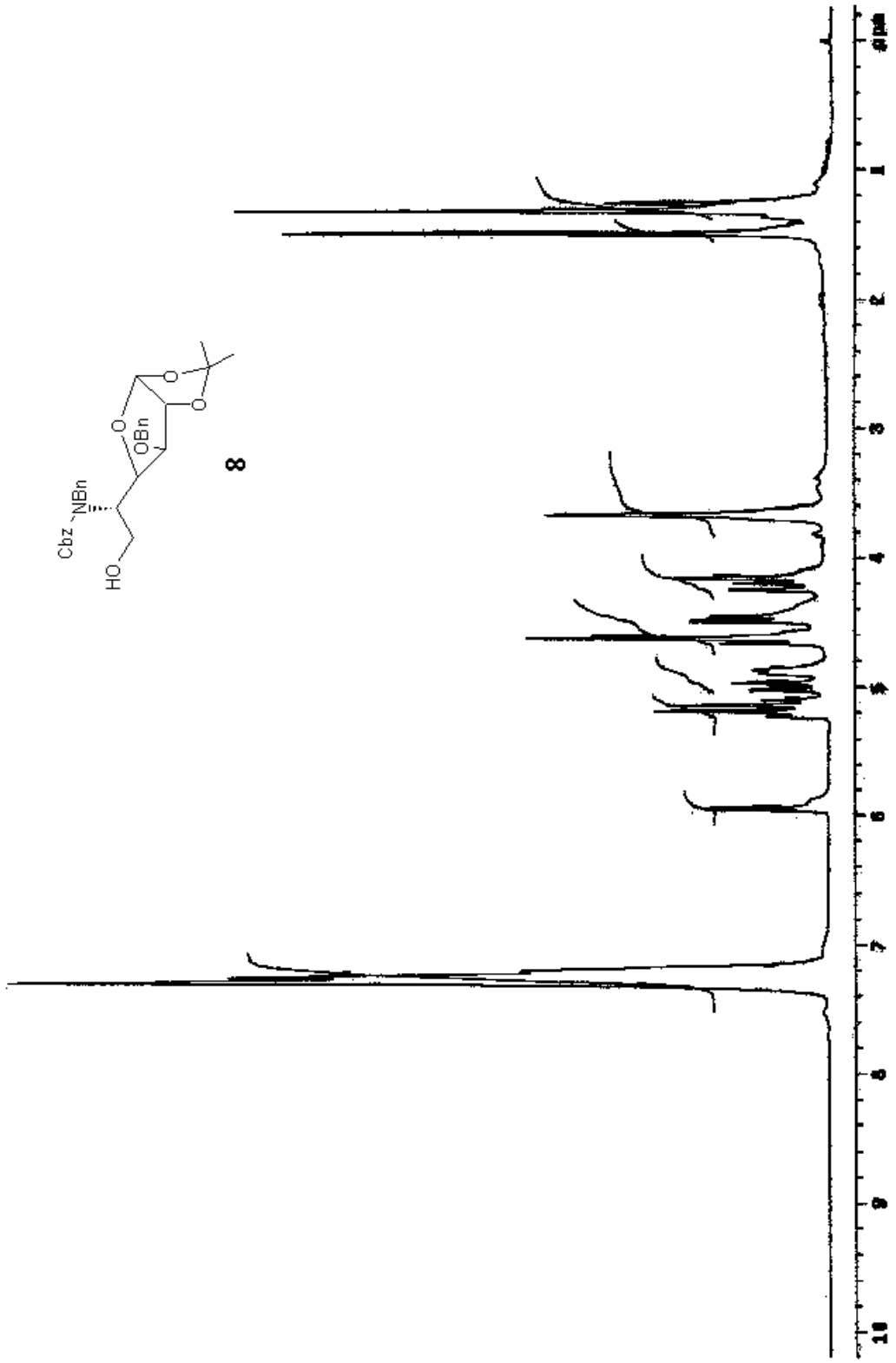


Figure 9: ^{1}H NMR (300 MHz, $CDCl_3$) spectrum of compound 8

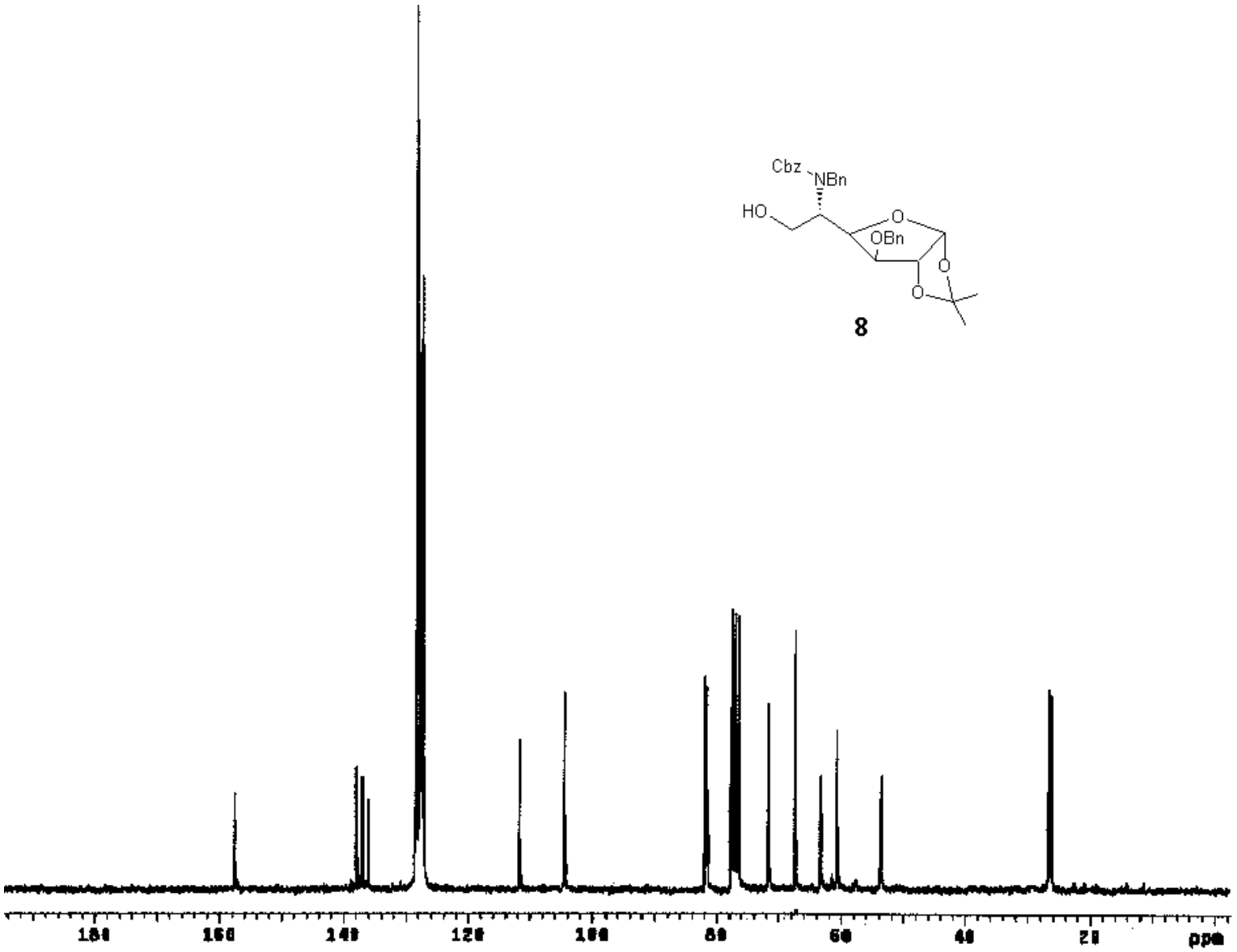


Figure 10: ^{13}C NMR (75 MHz, $CDCl_3$) spectrum of compound 8

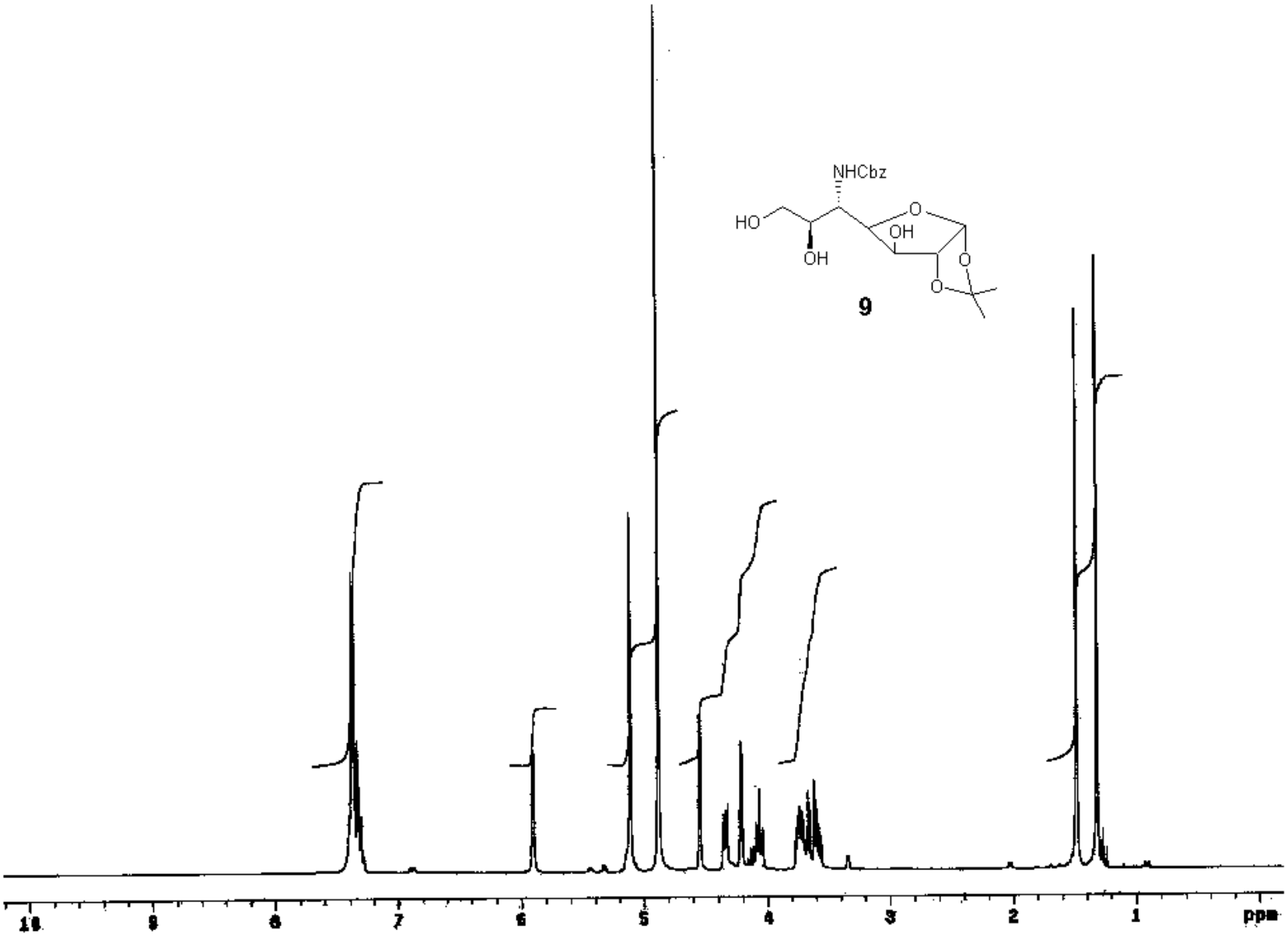


Figure 11: ^{1}H NMR (300 MHz, CD_3OD) spectrum of compound 9

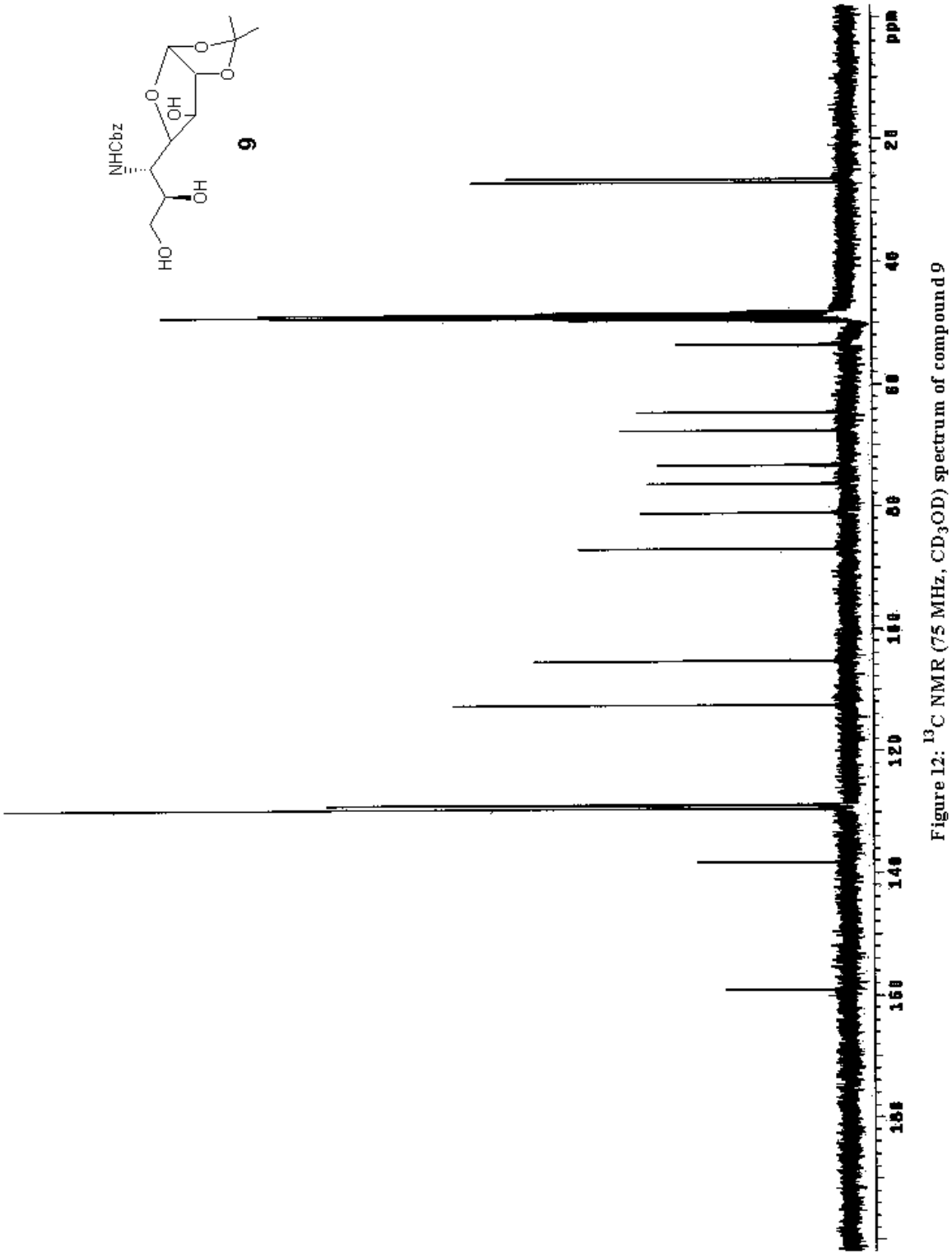


Figure 12: ^{13}C NMR (75 MHz, CD_3OD) spectrum of compound 9

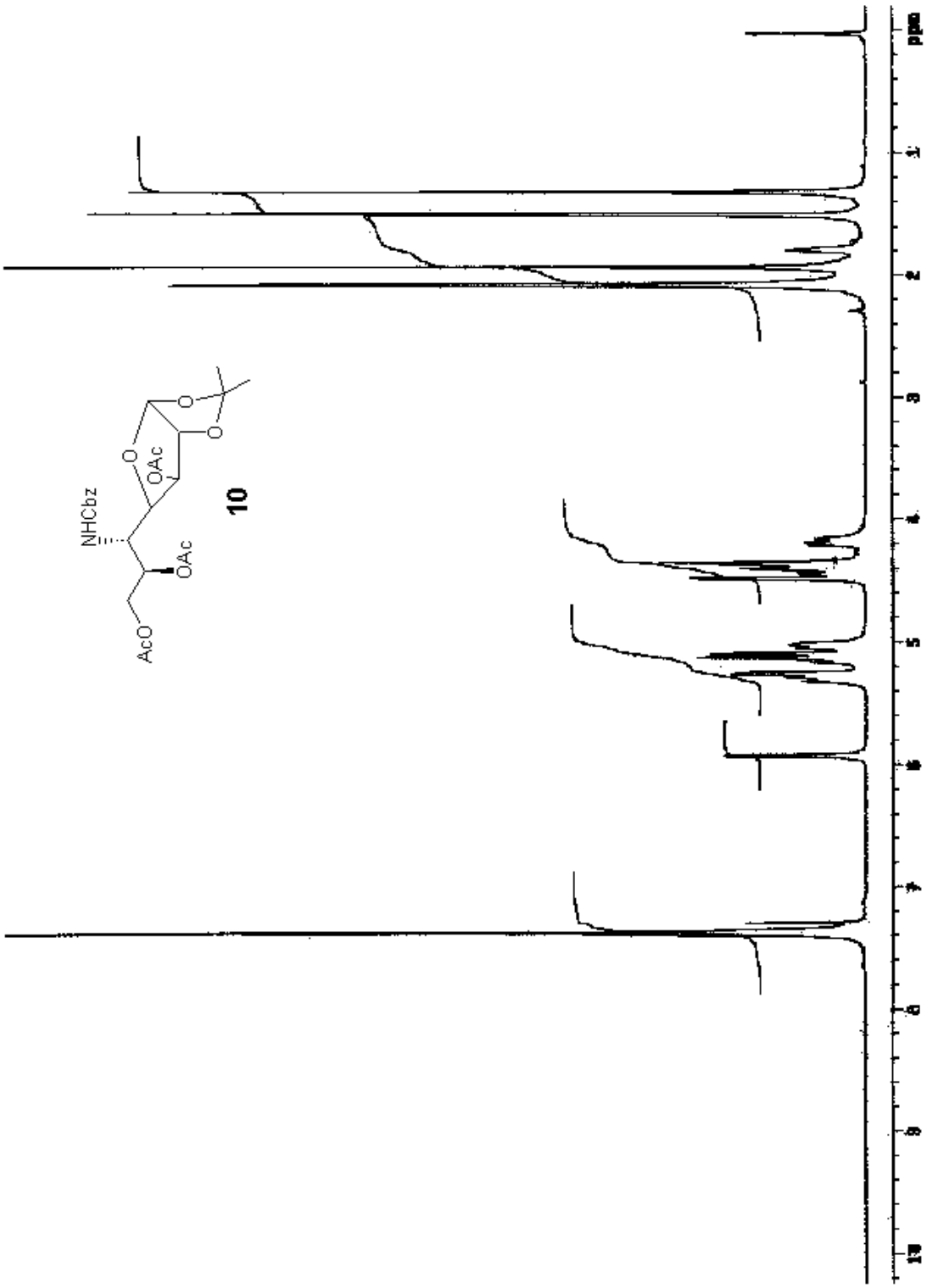


Figure 13: ^{1}H NMR (300 MHz, $CDCl_3$) spectrum of compound 10

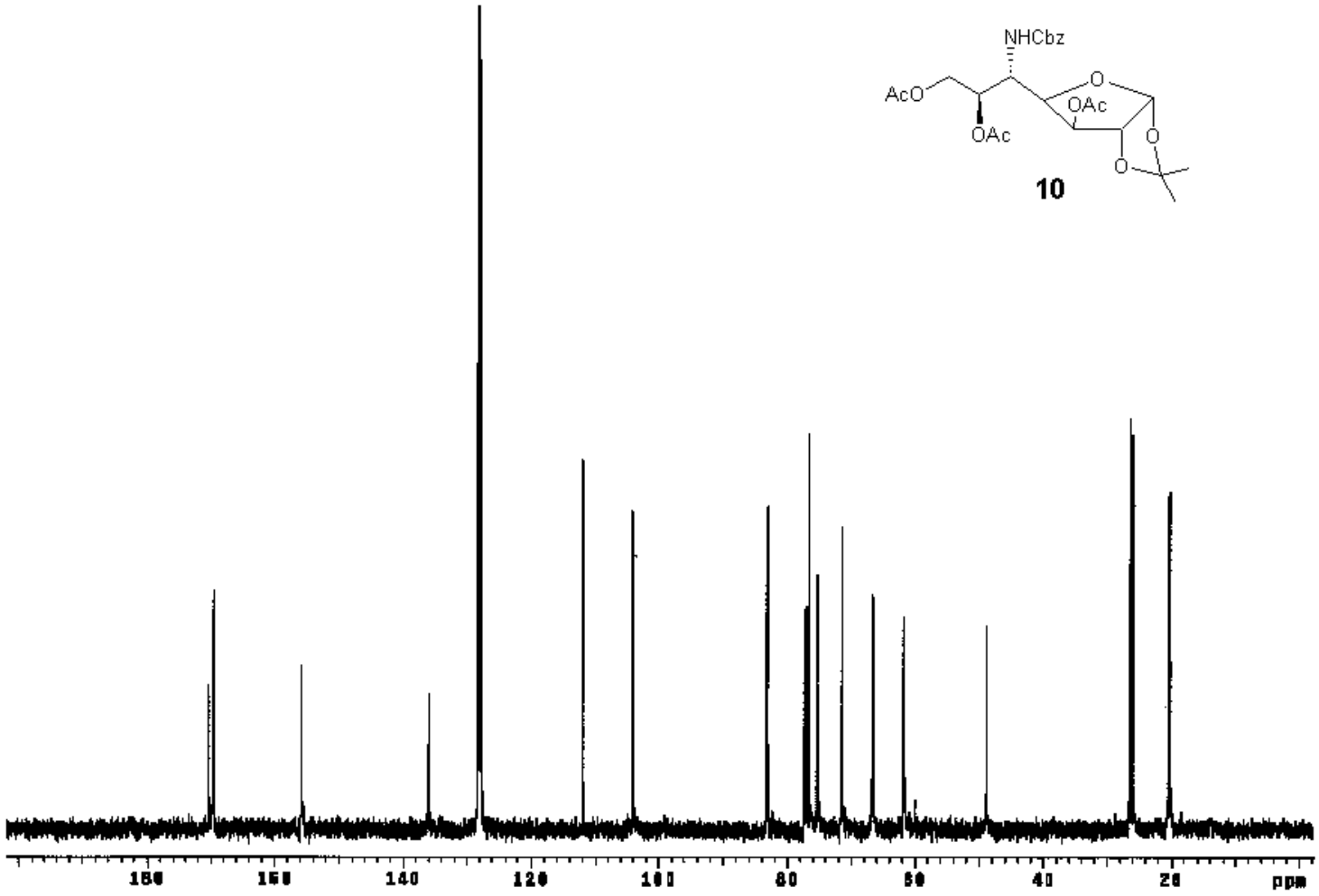


Figure 14: ^{13}C NMR (75 MHz, $CDCl_3$) spectrum of compound 10

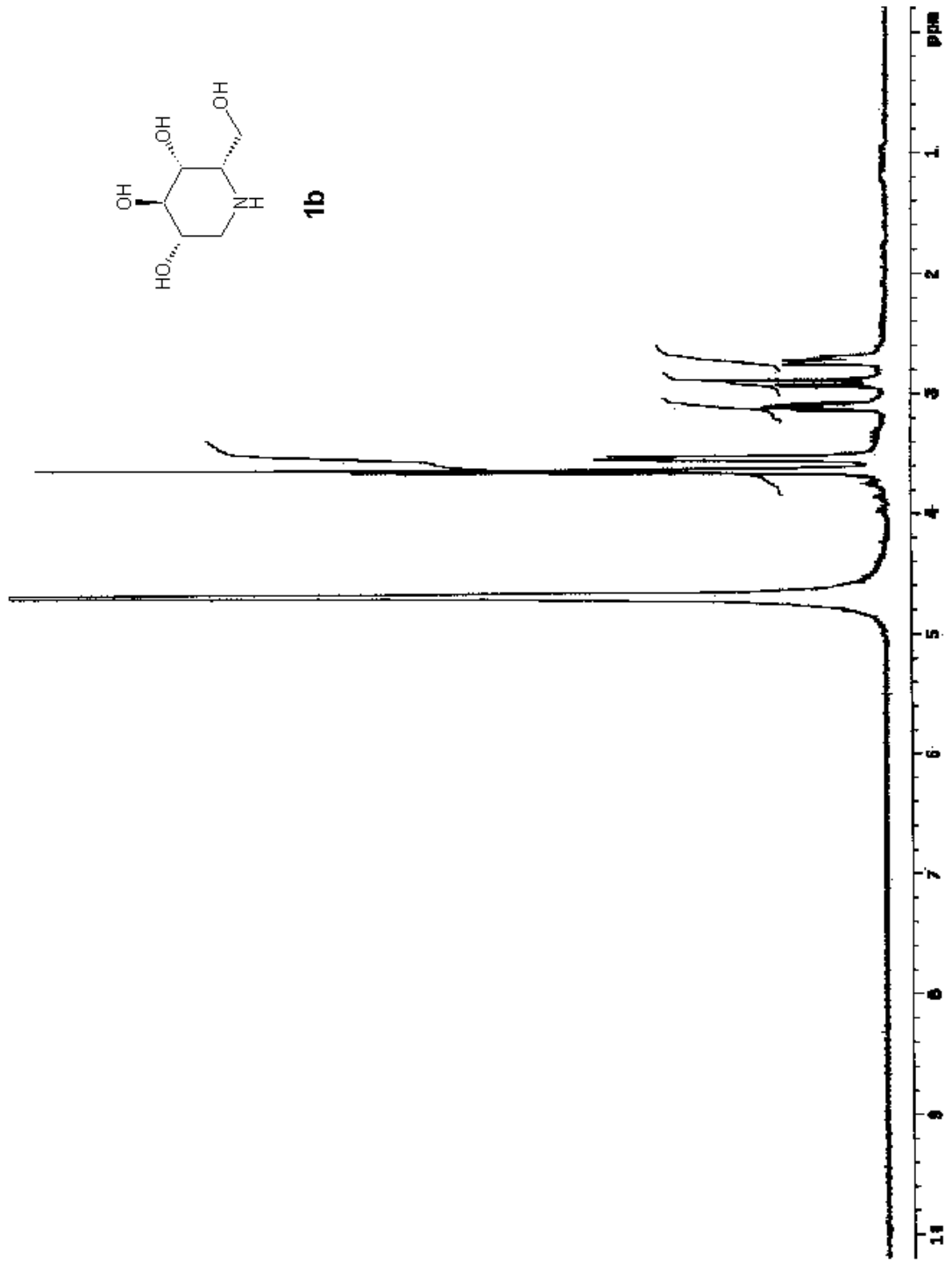
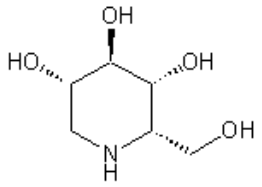


Figure 15: ^{1}H NMR (300 MHz, D_2O) spectrum of compound 1b



1b

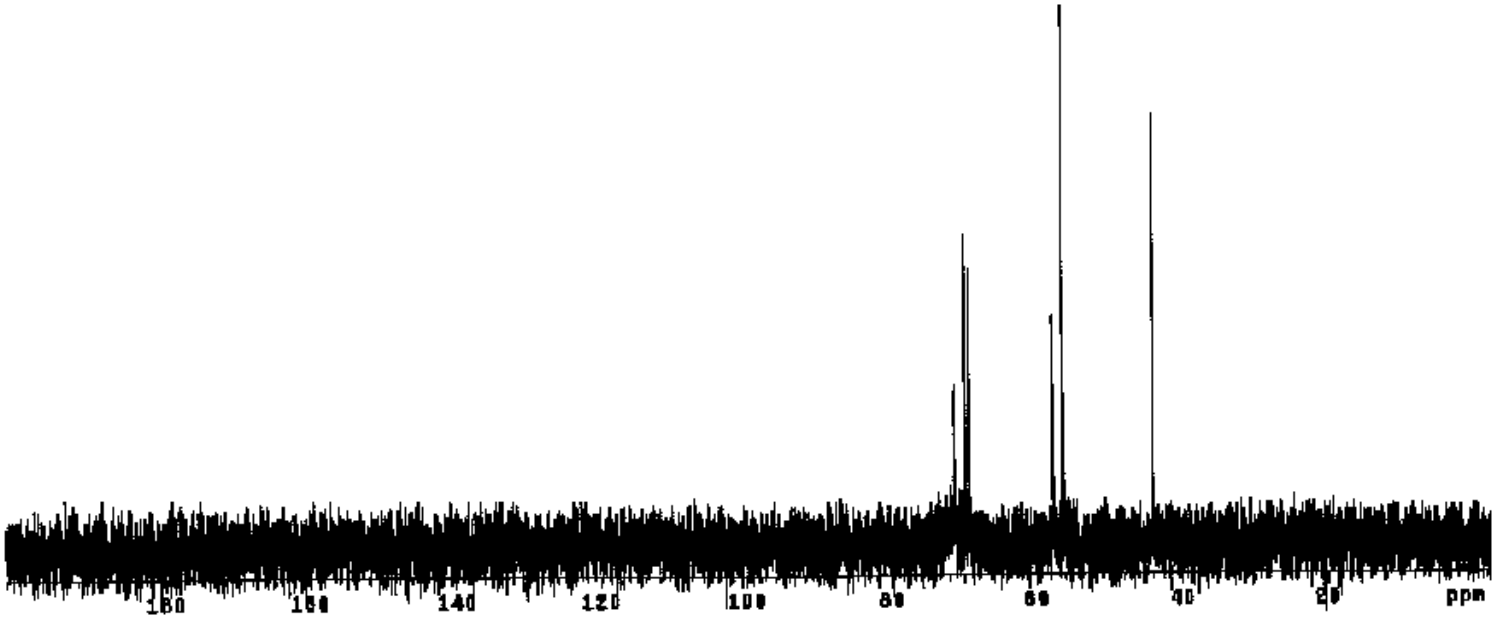


Figure 16: ^{13}C NMR (75 MHz, D_2O) spectrum of compound 1b

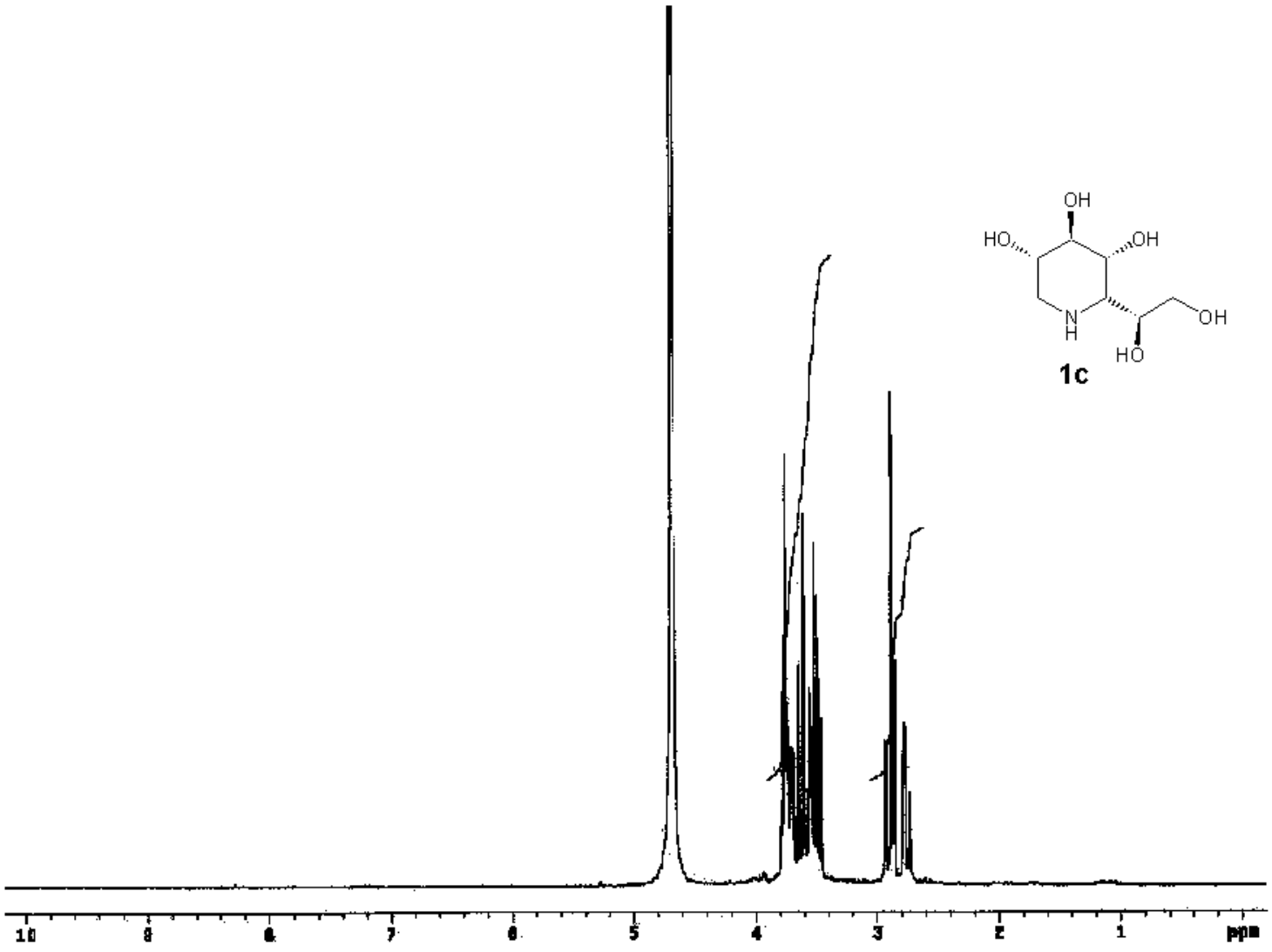
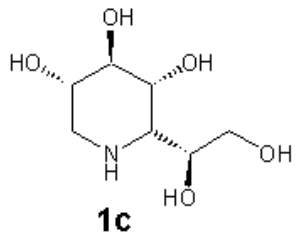


Figure 17: ^{1}H NMR (300 MHz, D_2O) spectrum of compound 1c



1c

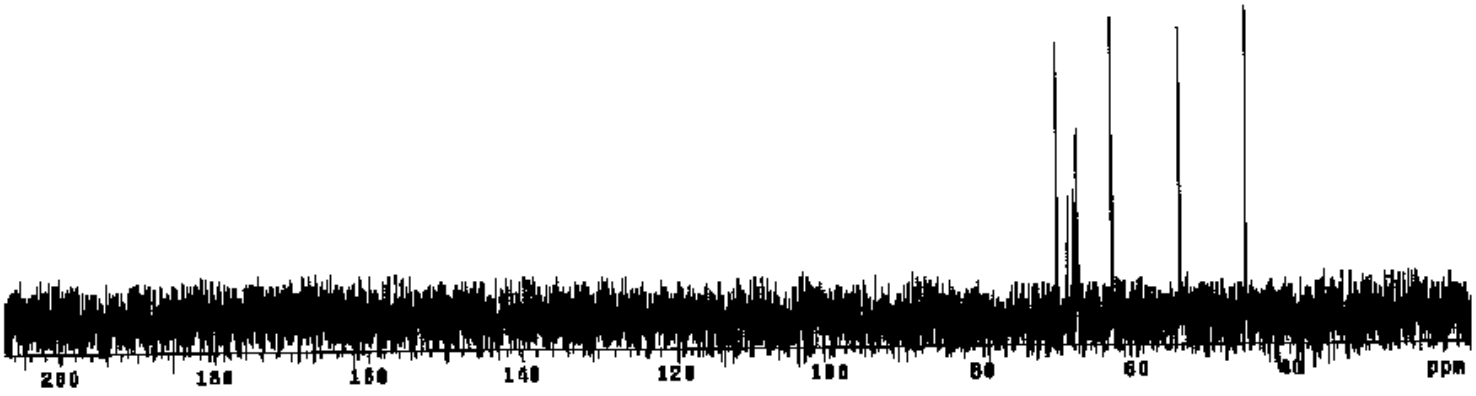


Figure 18: ^{13}C NMR (75 MHz, D_2O) spectrum of compound 1c

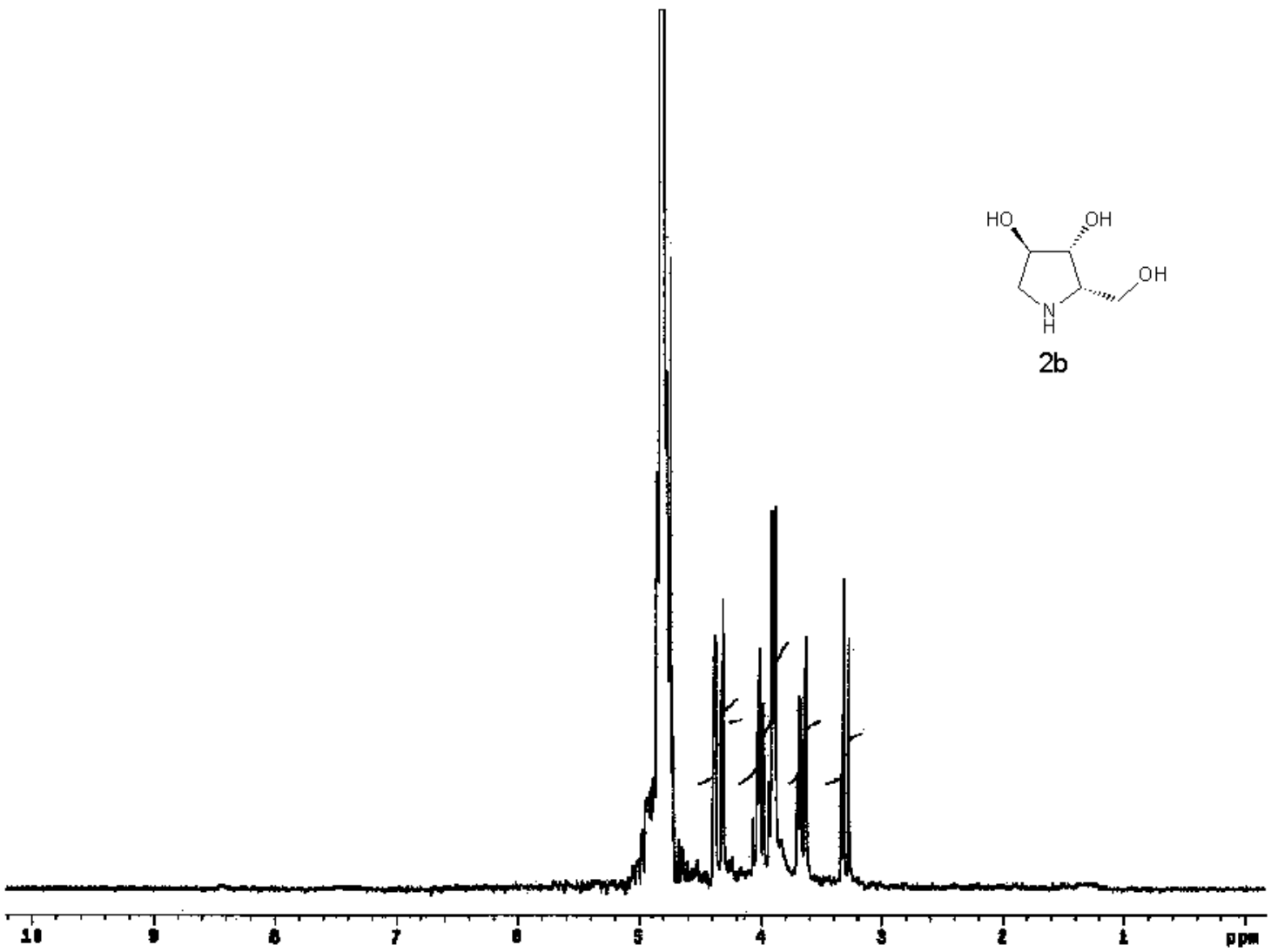
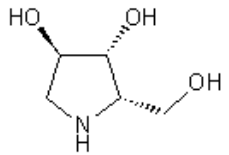


Figure 19: ^{1}H NMR (300 MHz, D_2O) spectrum of compound 2b



2b

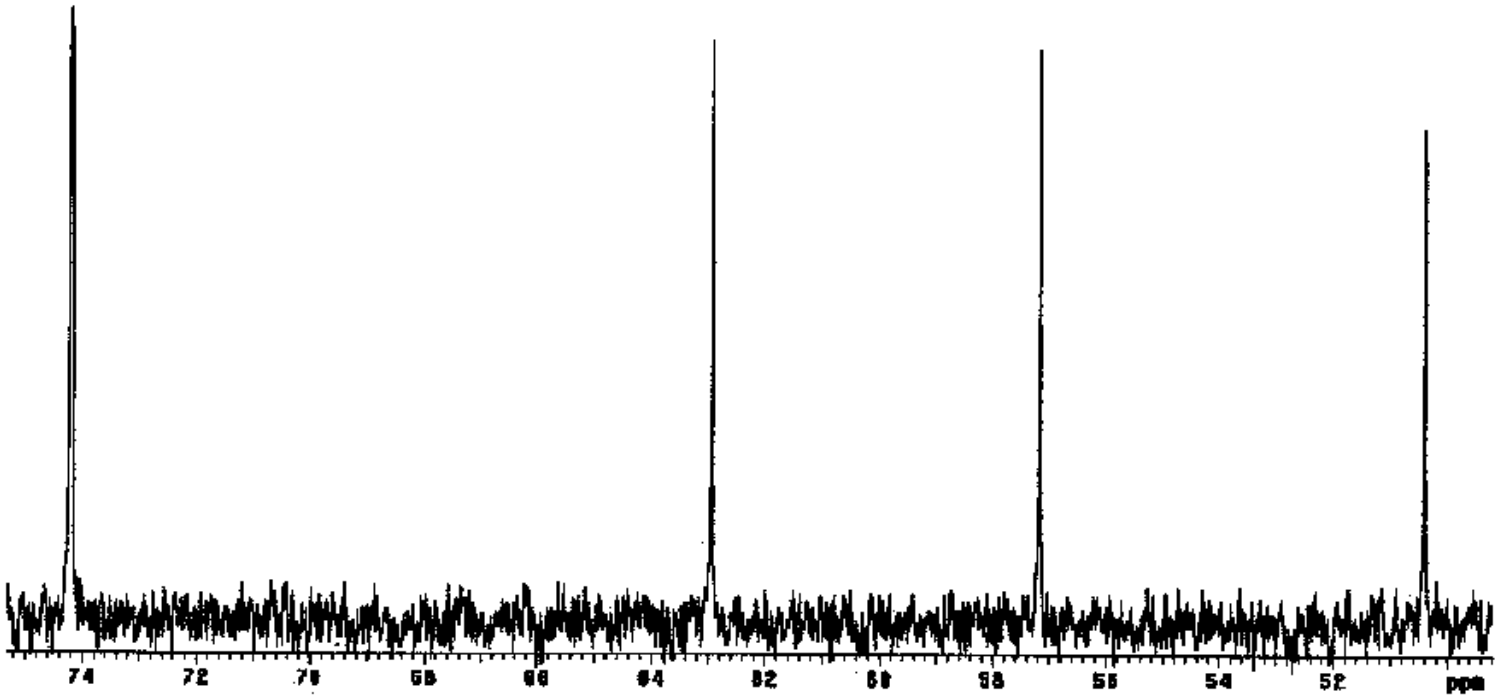


Figure 20: ^{13}C NMR (75 MHz, D_2O) spectrum of compound 2b

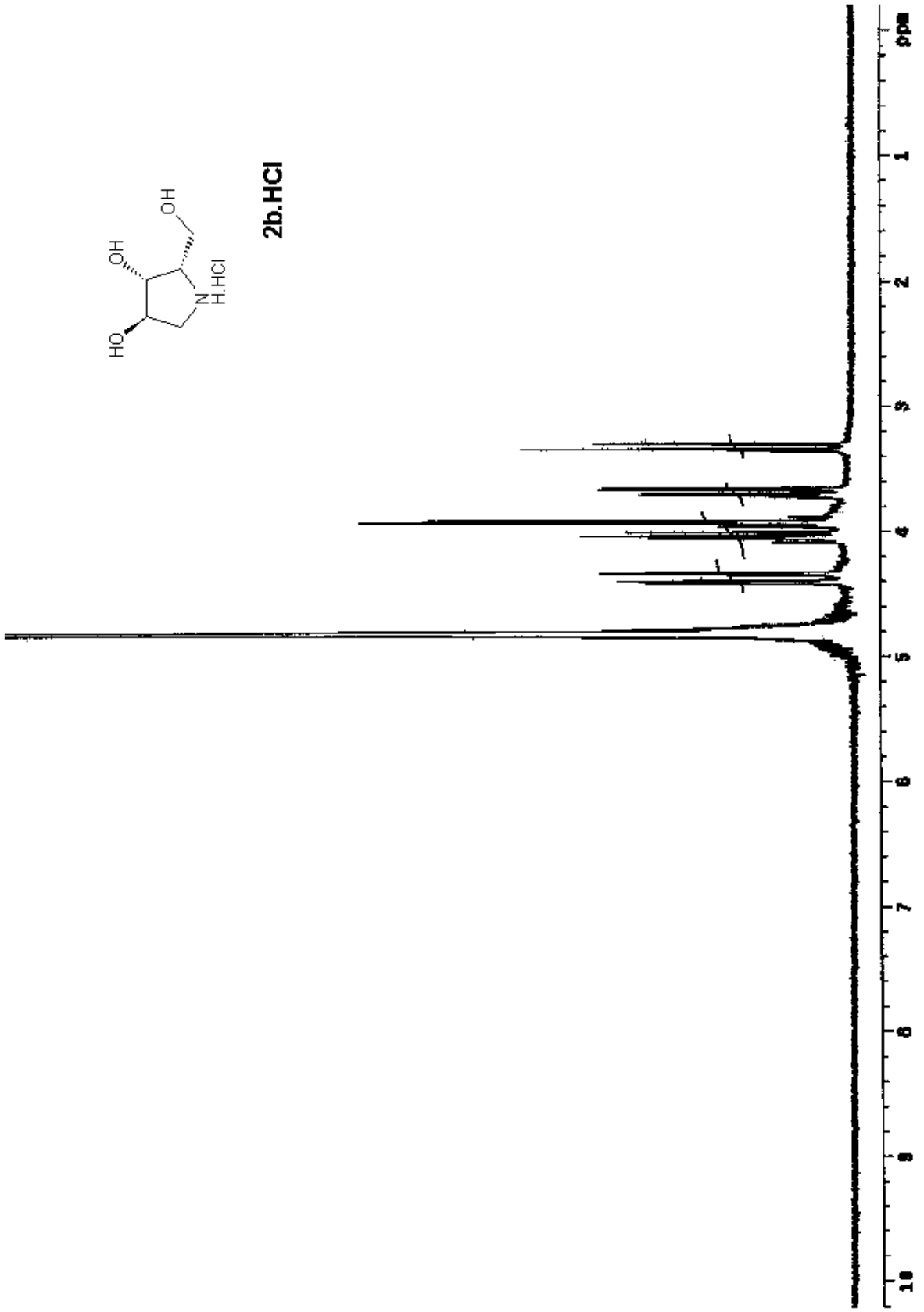
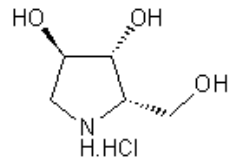


Figure 21: ^{1}H NMR (300 MHz, D_2O) spectrum of compound 2b.HCl



2b.HCl

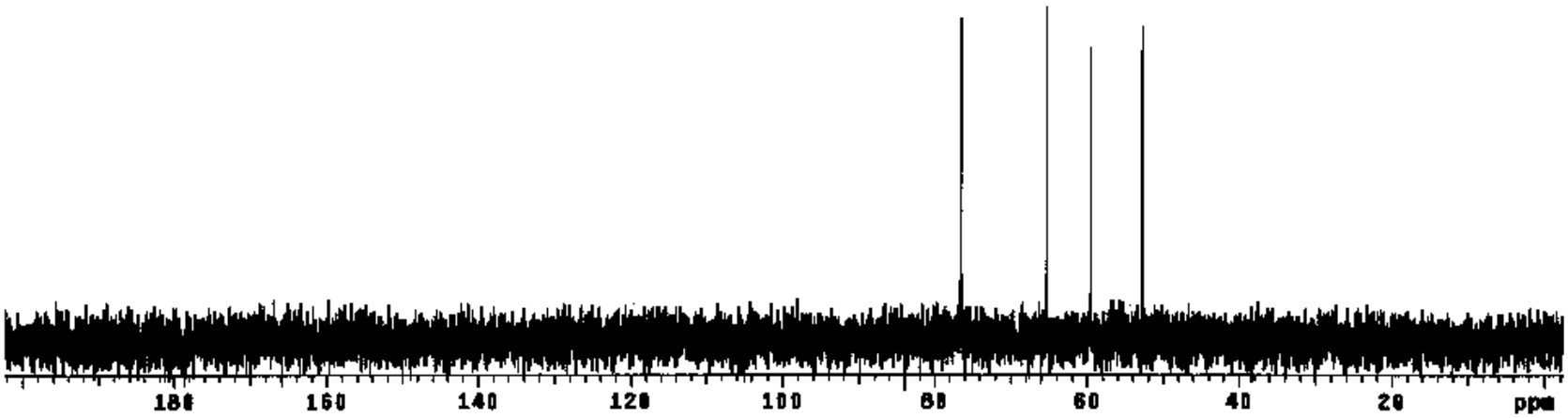


Figure 22: ^{13}C NMR (75 MHz, D_2O) spectrum of compound 2b.HCl

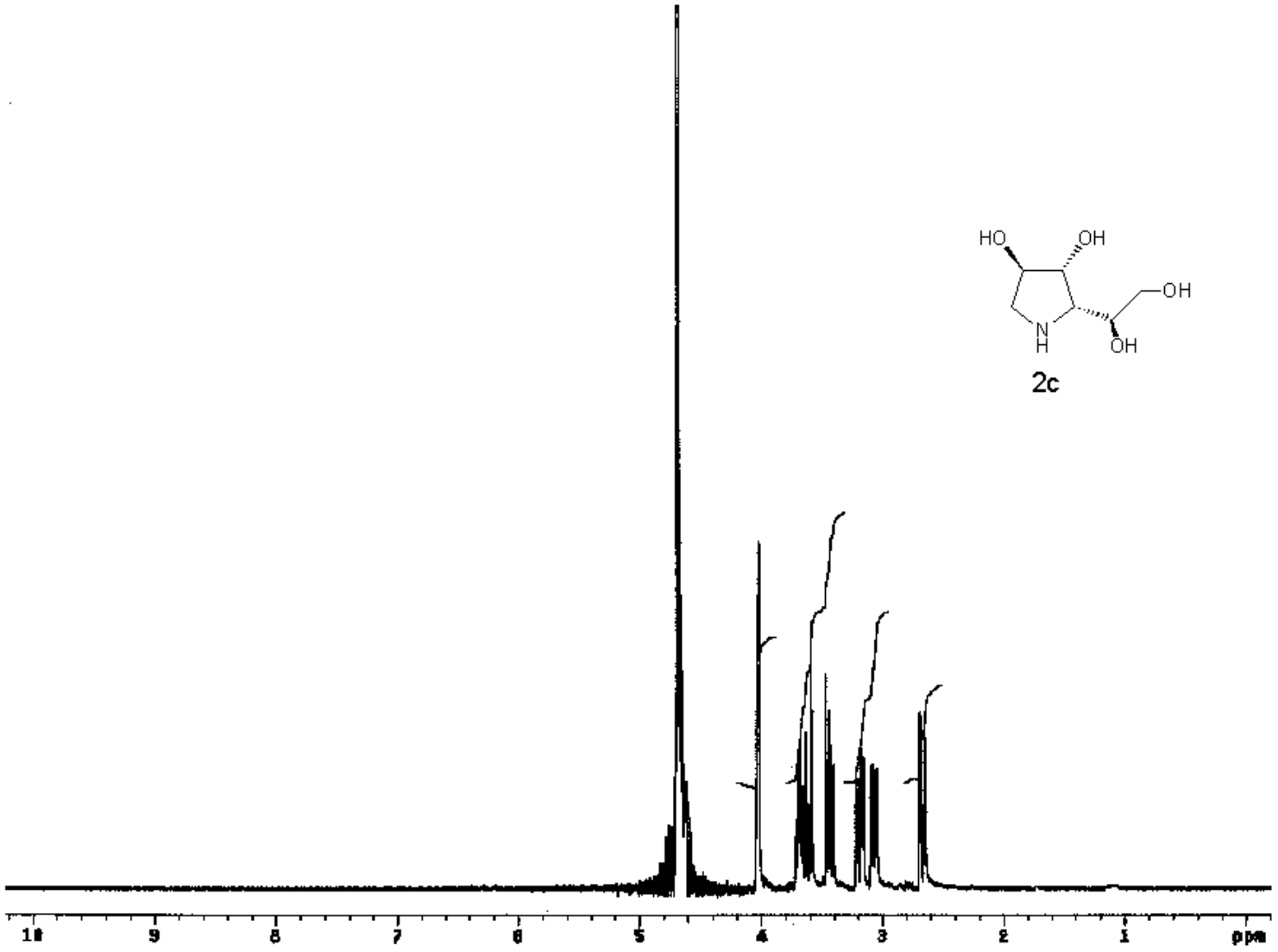
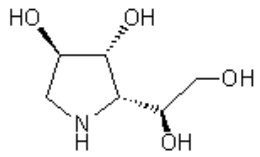


Figure 23: ^{1}H NMR (300 MHz, D_2O) spectrum of compound 2c



2c

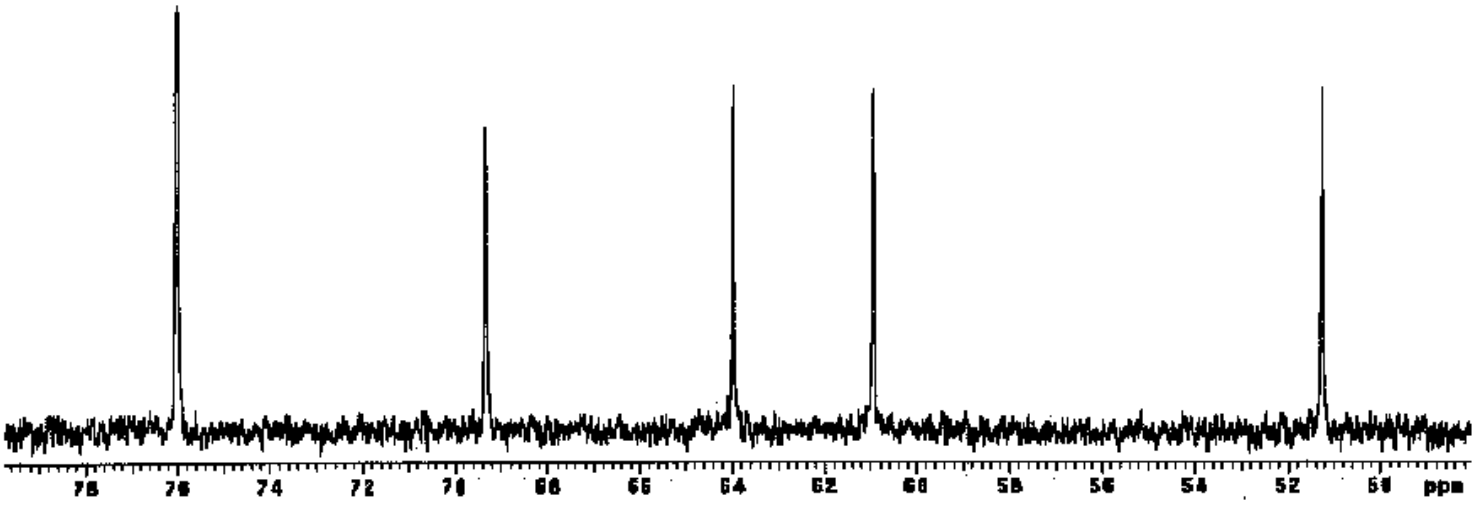


Figure 24: ^{13}C NMR (75 MHz, D_2O) spectrum of compound 2c

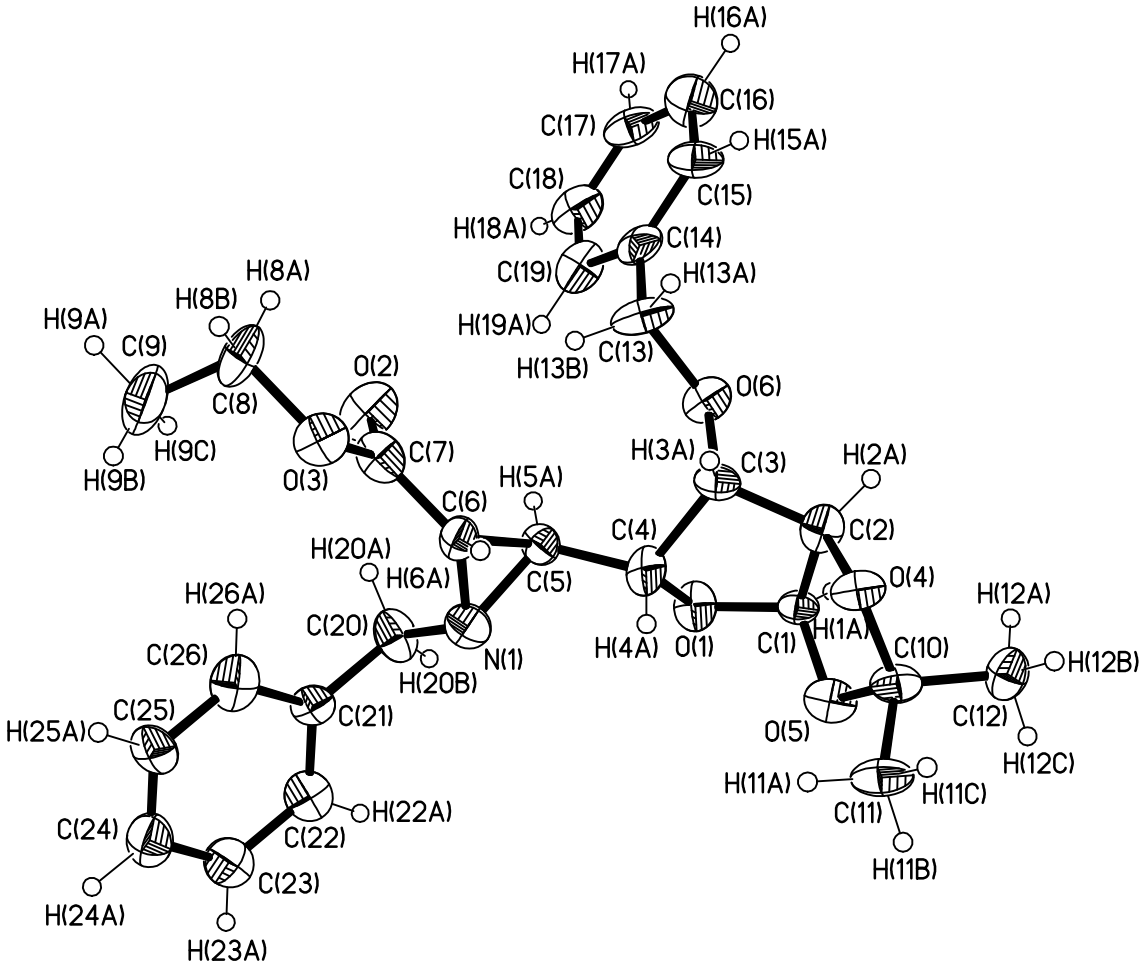


Table 1. Crystal data and structure refinement for aziridine ester **5**.

Identification code	test	
Empirical formula	C26 H31 N O6	
Formula weight	453.52	
Temperature	293(2) K	
Wavelength	0.71073 Å	
Crystal system	Monoclinic	
Space group	P2(1)	
Unit cell dimensions	a = 9.934(4) Å	α= 90°.
	b = 5.408(2) Å	β= 96.59(1)°.
	c = 22.042(1) Å	γ = 90°.

Volume	1176.3(8) $Å^3$
Z	2
Density (calculated)	1.280 Mg/m^3
Absorption coefficient	0.091 mm^{-1}
F(000)	484
Crystal size	0.35 x 0.25 x 0.20 mm^3
Theta range for data collection	1.86 to 23.28°.
Index ranges	-11<=h<=10, -5<=k<=6, -24<=l<=18
Reflections collected	5045
Independent reflections	3235 [R(int) = 0.0408]
Completeness to theta = 23.28°	99.4 %
Refinement method	Full-matrix least-squares on F^2
Data / restraints / parameters	3235 / 1 / 298
Goodness-of-fit on F^2	0.997
Final R indices [I>2sigma(I)]	R1 = 0.0631, wR2 = 0.1485
R indices (all data)	R1 = 0.0814, wR2 = 0.1554
Absolute structure parameter	1(2)
Largest diff. peak and hole	0.369 and -0.309 $e.Å^{-3}$

Table 2. Atomic coordinates (x 10^4) and equivalent isotropic displacement parameters ($Å^2$x 10^3) for aziridine ester **5**. U(eq) is defined as one third of the trace of the orthogonalized U^{ij} tensor.

	x	y	z	U(eq)
O(1)	1649(3)	607(6)	8523(1)	31(1)
O(2)	-1010(4)	-2289(7)	6509(2)	49(1)
O(3)	-605(3)	-6371(6)	6538(2)	36(1)
O(4)	1338(3)	-3183(6)	9625(2)	30(1)
O(5)	2889(3)	-268(6)	9453(1)	32(1)
O(6)	-1171(3)	-588(6)	8506(1)	32(1)
N(1)	1872(4)	-2293(7)	7279(2)	32(1)
C(1)	1659(4)	641(9)	9157(2)	28(1)
C(2)	556(5)	-1244(9)	9307(2)	30(1)
C(3)	-51(4)	-2152(9)	8690(2)	27(1)
C(4)	1110(4)	-1782(9)	8305(2)	28(1)
C(5)	796(4)	-1648(9)	7638(2)	29(1)
C(6)	683(4)	-3975(9)	7265(2)	31(1)
C(7)	-392(5)	-4040(10)	6736(2)	34(1)
C(8)	-1639(5)	-6697(10)	6026(2)	43(1)
C(9)	-1164(7)	-6092(15)	5436(3)	74(2)
C(10)	2582(4)	-2134(9)	9881(2)	31(1)
C(11)	3670(4)	-4116(10)	9906(3)	39(1)
C(12)	2462(5)	-1005(10)	10492(2)	36(1)
C(13)	-2265(4)	-1769(10)	8117(2)	36(1)
C(14)	-3303(4)	178(9)	7942(2)	32(1)
C(15)	-4457(4)	375(10)	8217(2)	36(1)
C(16)	-5393(6)	2266(12)	8057(3)	50(2)
C(17)	-5163(5)	3943(10)	7620(3)	41(1)
C(18)	-4013(6)	3763(10)	7337(3)	45(1)
C(19)	-3093(5)	1903(10)	7492(2)	37(1)
C(20)	2051(5)	-770(10)	6733(2)	36(1)
C(21)	2988(4)	-2003(9)	6344(2)	28(1)
C(22)	4266(5)	-1135(10)	6303(2)	40(1)
C(23)	5138(5)	-2193(11)	5938(3)	43(1)
C(24)	4716(5)	-4318(11)	5601(2)	43(1)
C(25)	3470(5)	-5252(10)	5642(2)	39(1)
C(26)	2606(5)	-4189(10)	6005(2)	40(1)

Table 3. Bond lengths [Å] and angles [°] for aziridine ester **5**.

O(1)-C(1)	1.396(5)
O(1)-C(4)	1.458(6)
O(2)-C(7)	1.206(6)
O(3)-C(7)	1.343(6)
O(3)-C(8)	1.446(6)
O(4)-C(10)	1.417(5)
O(4)-C(2)	1.438(6)
O(5)-C(1)	1.406(5)
O(5)-C(10)	1.438(6)
O(6)-C(3)	1.419(5)
O(6)-C(13)	1.453(5)
N(1)-C(5)	1.443(6)
N(1)-C(20)	1.485(6)
N(1)-C(6)	1.488(6)
C(1)-C(2)	1.560(7)
C(1)-H(1A)	0.9800
C(2)-C(3)	1.506(6)
C(2)-H(2A)	0.9800
C(3)-C(4)	1.522(6)
C(3)-H(3A)	0.9800
C(4)-C(5)	1.471(6)
C(4)-H(4A)	0.9800
C(5)-C(6)	1.500(7)
C(5)-H(5A)	0.9800
C(6)-C(7)	1.489(7)
C(6)-H(6A)	0.9800
C(8)-C(9)	1.471(8)
C(8)-H(8A)	0.9700
C(8)-H(8B)	0.9700
C(9)-H(9A)	0.9600
C(9)-H(9B)	0.9600
C(9)-H(9C)	0.9600
C(10)-C(12)	1.496(7)
C(10)-C(11)	1.518(7)
C(11)-H(11A)	0.9600
C(11)-H(11B)	0.9600
C(11)-H(11C)	0.9600

C(12)-H(12A)	0.9600
C(12)-H(12B)	0.9600
C(12)-H(12C)	0.9600
C(13)-C(14)	1.494(7)
C(13)-H(13A)	0.9700
C(13)-H(13B)	0.9700
C(14)-C(15)	1.361(6)
C(14)-C(19)	1.395(7)
C(15)-C(16)	1.400(8)
C(15)-H(15A)	0.9300
C(16)-C(17)	1.361(8)
C(16)-H(16A)	0.9300
C(17)-C(18)	1.367(8)
C(17)-H(17A)	0.9300
C(18)-C(19)	1.375(7)
C(18)-H(18A)	0.9300
C(19)-H(19A)	0.9300
C(20)-C(21)	1.493(7)
C(20)-H(20A)	0.9700
C(20)-H(20B)	0.9700
C(21)-C(22)	1.367(7)
C(21)-C(26)	1.427(7)
C(22)-C(23)	1.372(7)
C(22)-H(22A)	0.9300
C(23)-C(24)	1.407(8)
C(23)-H(23A)	0.9300
C(24)-C(25)	1.349(7)
C(24)-H(24A)	0.9300
C(25)-C(26)	1.366(7)
C(25)-H(25A)	0.9300
C(26)-H(26A)	0.9300

C(1)-O(1)-C(4)	107.5(3)
C(7)-O(3)-C(8)	116.1(4)
C(10)-O(4)-C(2)	107.4(3)
C(1)-O(5)-C(10)	108.1(3)
C(3)-O(6)-C(13)	114.5(4)
C(5)-N(1)-C(20)	118.4(4)
C(5)-N(1)-C(6)	61.5(3)

C(20)-N(1)-C(6)	119.4(4)
O(1)-C(1)-O(5)	111.5(4)
O(1)-C(1)-C(2)	106.2(4)
O(5)-C(1)-C(2)	105.5(4)
O(1)-C(1)-H(1A)	111.1
O(5)-C(1)-H(1A)	111.1
C(2)-C(1)-H(1A)	111.1
O(4)-C(2)-C(3)	109.9(4)
O(4)-C(2)-C(1)	103.1(3)
C(3)-C(2)-C(1)	103.9(4)
O(4)-C(2)-H(2A)	113.1
C(3)-C(2)-H(2A)	113.1
C(1)-C(2)-H(2A)	113.1
O(6)-C(3)-C(2)	106.5(4)
O(6)-C(3)-C(4)	112.5(4)
C(2)-C(3)-C(4)	102.1(4)
O(6)-C(3)-H(3A)	111.8
C(2)-C(3)-H(3A)	111.8
C(4)-C(3)-H(3A)	111.8
O(1)-C(4)-C(5)	108.3(4)
O(1)-C(4)-C(3)	101.9(4)
C(5)-C(4)-C(3)	118.5(4)
O(1)-C(4)-H(4A)	109.2
C(5)-C(4)-H(4A)	109.2
C(3)-C(4)-H(4A)	109.2
N(1)-C(5)-C(4)	116.8(4)
N(1)-C(5)-C(6)	60.7(3)
C(4)-C(5)-C(6)	120.1(4)
N(1)-C(5)-H(5A)	116.0
C(4)-C(5)-H(5A)	116.0
C(6)-C(5)-H(5A)	116.0
N(1)-C(6)-C(7)	121.8(4)
N(1)-C(6)-C(5)	57.8(3)
C(7)-C(6)-C(5)	116.8(4)
N(1)-C(6)-H(6A)	115.9
C(7)-C(6)-H(6A)	115.9
C(5)-C(6)-H(6A)	115.9
O(2)-C(7)-O(3)	123.3(5)
O(2)-C(7)-C(6)	126.3(5)

O(3)-C(7)-C(6)	110.4(4)
O(3)-C(8)-C(9)	113.0(5)
O(3)-C(8)-H(8A)	109.0
C(9)-C(8)-H(8A)	109.0
O(3)-C(8)-H(8B)	109.0
C(9)-C(8)-H(8B)	109.0
H(8A)-C(8)-H(8B)	107.8
C(8)-C(9)-H(9A)	109.5
C(8)-C(9)-H(9B)	109.5
H(9A)-C(9)-H(9B)	109.5
C(8)-C(9)-H(9C)	109.5
H(9A)-C(9)-H(9C)	109.5
H(9B)-C(9)-H(9C)	109.5
O(4)-C(10)-O(5)	105.1(4)
O(4)-C(10)-C(12)	111.4(4)
O(5)-C(10)-C(12)	110.4(4)
O(4)-C(10)-C(11)	108.5(4)
O(5)-C(10)-C(11)	108.5(4)
C(12)-C(10)-C(11)	112.6(4)
C(10)-C(11)-H(11A)	109.5
C(10)-C(11)-H(11B)	109.5
H(11A)-C(11)-H(11B)	109.5
C(10)-C(11)-H(11C)	109.5
H(11A)-C(11)-H(11C)	109.5
H(11B)-C(11)-H(11C)	109.5
C(10)-C(12)-H(12A)	109.5
C(10)-C(12)-H(12B)	109.5
H(12A)-C(12)-H(12B)	109.5
C(10)-C(12)-H(12C)	109.5
H(12A)-C(12)-H(12C)	109.5
H(12B)-C(12)-H(12C)	109.5
O(6)-C(13)-C(14)	106.9(4)
O(6)-C(13)-H(13A)	110.3
C(14)-C(13)-H(13A)	110.3
O(6)-C(13)-H(13B)	110.3
C(14)-C(13)-H(13B)	110.3
H(13A)-C(13)-H(13B)	108.6
C(15)-C(14)-C(19)	117.9(5)
C(15)-C(14)-C(13)	122.1(5)

C(19)-C(14)-C(13)	120.0(4)
C(14)-C(15)-C(16)	120.9(5)
C(14)-C(15)-H(15A)	119.5
C(16)-C(15)-H(15A)	119.5
C(17)-C(16)-C(15)	120.3(5)
C(17)-C(16)-H(16A)	119.9
C(15)-C(16)-H(16A)	119.9
C(16)-C(17)-C(18)	119.5(5)
C(16)-C(17)-H(17A)	120.2
C(18)-C(17)-H(17A)	120.2
C(17)-C(18)-C(19)	120.4(5)
C(17)-C(18)-H(18A)	119.8
C(19)-C(18)-H(18A)	119.8
C(18)-C(19)-C(14)	121.1(5)
C(18)-C(19)-H(19A)	119.5
C(14)-C(19)-H(19A)	119.5
N(1)-C(20)-C(21)	111.0(4)
N(1)-C(20)-H(20A)	109.4
C(21)-C(20)-H(20A)	109.4
N(1)-C(20)-H(20B)	109.4
C(21)-C(20)-H(20B)	109.4
H(20A)-C(20)-H(20B)	108.0
C(22)-C(21)-C(26)	116.3(5)
C(22)-C(21)-C(20)	122.0(5)
C(26)-C(21)-C(20)	121.7(4)
C(21)-C(22)-C(23)	123.3(5)
C(21)-C(22)-H(22A)	118.3
C(23)-C(22)-H(22A)	118.3
C(22)-C(23)-C(24)	118.8(5)
C(22)-C(23)-H(23A)	120.6
C(24)-C(23)-H(23A)	120.6
C(25)-C(24)-C(23)	119.3(5)
C(25)-C(24)-H(24A)	120.3
C(23)-C(24)-H(24A)	120.3
C(24)-C(25)-C(26)	121.7(5)
C(24)-C(25)-H(25A)	119.1
C(26)-C(25)-H(25A)	119.1
C(25)-C(26)-C(21)	120.6(5)
C(25)-C(26)-H(26A)	119.7

C(21)-C(26)-H(26A) 119.7

Symmetry transformations used to generate equivalent atoms:

Table 4. Anisotropic displacement parameters ($Å^2$x 10^3)for aziridine ester **5**. The anisotropic displacement factor exponent takes the form: $-2\pi^2[h^2a^{*2}U^{11} + ... + 2 h k a^* b^* U^{12}]$

	U^{11}	U^{22}	U^{33}	U^{23}	U^{13}	U^{12}
O(1)	45(2)	15(2)	33(2)	-4(2)	5(2)	-7(2)
O(2)	69(3)	20(2)	56(3)	-3(2)	-12(2)	12(2)
O(3)	43(2)	15(2)	47(2)	-1(2)	-2(2)	3(2)
O(4)	26(2)	16(2)	47(2)	3(2)	-1(2)	-1(1)
O(5)	32(2)	19(2)	45(2)	4(2)	4(2)	-2(2)
O(6)	32(2)	19(2)	43(2)	-6(2)	-4(2)	2(2)
N(1)	37(2)	25(2)	35(2)	-1(2)	6(2)	7(2)
C(1)	31(3)	15(3)	37(3)	-7(2)	3(2)	-2(2)
C(2)	29(2)	21(3)	38(3)	1(2)	4(2)	12(2)
C(3)	27(2)	16(3)	38(3)	0(2)	1(2)	7(2)
C(4)	36(3)	11(3)	36(3)	-4(2)	1(2)	-1(2)
C(5)	33(3)	15(3)	40(3)	-4(2)	4(2)	3(2)
C(6)	42(3)	17(3)	32(3)	-2(2)	0(2)	9(2)
C(7)	46(3)	18(3)	37(3)	-4(3)	6(3)	3(3)
C(8)	58(3)	20(3)	48(4)	-9(3)	-8(3)	1(3)
C(9)	82(5)	95(6)	44(4)	-29(4)	-2(3)	-15(4)
C(10)	23(2)	22(3)	46(3)	10(3)	1(2)	-7(2)
C(11)	27(3)	27(3)	61(3)	1(3)	-2(2)	2(2)
C(12)	38(3)	30(3)	40(3)	-1(3)	1(2)	-1(2)
C(13)	33(3)	24(3)	50(3)	0(3)	-2(2)	-2(2)
C(14)	26(3)	27(3)	40(3)	-1(2)	-6(2)	-8(2)
C(15)	30(3)	28(3)	51(3)	5(3)	5(2)	-4(3)
C(16)	38(3)	52(4)	59(4)	-13(3)	8(3)	5(3)
C(17)	32(3)	24(3)	64(4)	-3(3)	-8(3)	5(2)
C(18)	58(4)	24(3)	49(4)	3(3)	-10(3)	0(3)
C(19)	42(3)	25(3)	44(3)	1(3)	1(3)	-3(3)
C(20)	45(3)	23(3)	40(3)	4(3)	4(2)	3(2)
C(21)	28(3)	20(3)	36(3)	2(2)	2(2)	6(2)
C(22)	58(4)	23(3)	39(3)	0(2)	2(3)	-2(3)
C(23)	40(3)	39(4)	51(4)	5(3)	13(3)	1(3)
C(24)	49(3)	39(3)	42(3)	-2(3)	6(3)	16(3)

C(25)	51(3)	21(3)	47(3)	-3(3)	7(3)	6(3)
C(26)	46(3)	27(3)	49(3)	3(3)	8(3)	1(3)

Table 5. Hydrogen coordinates (x 10^4) and isotropic displacement parameters (Å^{2}x 10^3) for aziridine ester **5**

	x	y	z	U(eq)
H(1A)	1466	2301	9303	34
H(2A)	-115	-519	9548	35
H(3A)	-323	-3891	8703	33
H(4A)	1797	-3061	8409	33
H(5A)	209	-279	7481	35
H(6A)	835	-5523	7494	37
H(8A)	-2408	-5653	6084	52
H(8B)	-1946	-8401	6017	52
H(9A)	-1891	-6325	5114	112
H(9B)	-422	-7156	5369	112
H(9C)	-870	-4401	5439	112
H(11A)	3704	-4788	9505	58
H(11B)	3460	-5409	10179	58
H(11C)	4532	-3404	10051	58
H(12A)	1762	227	10453	54
H(12B)	3309	-253	10646	54
H(12C)	2239	-2267	10770	54
H(13A)	-2654	-3100	8335	43
H(13B)	-1930	-2450	7756	43
H(15A)	-4625	-761	8516	44
H(16A)	-6176	2377	8250	60
H(17A)	-5785	5201	7514	50
H(18A)	-3851	4904	7038	54
H(19A)	-2318	1793	7293	45
H(20A)	2414	834	6862	44
H(20B)	1177	-512	6496	44
H(22A)	4560	242	6534	48
H(23A)	5992	-1519	5915	51
H(24A)	5290	-5071	5351	52
H(25A)	3193	-6655	5418	47

H(26A)	1762	-4897	6031	48