Electronic Supplementary Material (ESI) for Organic & Biomolecular Chemistry.

Supporting Information

Synthesis of Glycosylated Lanthanide Cyclen Complexes as Luminescent Probes for Glycosidase Enzymes

Helen M. Burke, Thorfinnur Gunnlaugsson* and Eoin. M. Scanlan*

I. Photophysical spectra and data

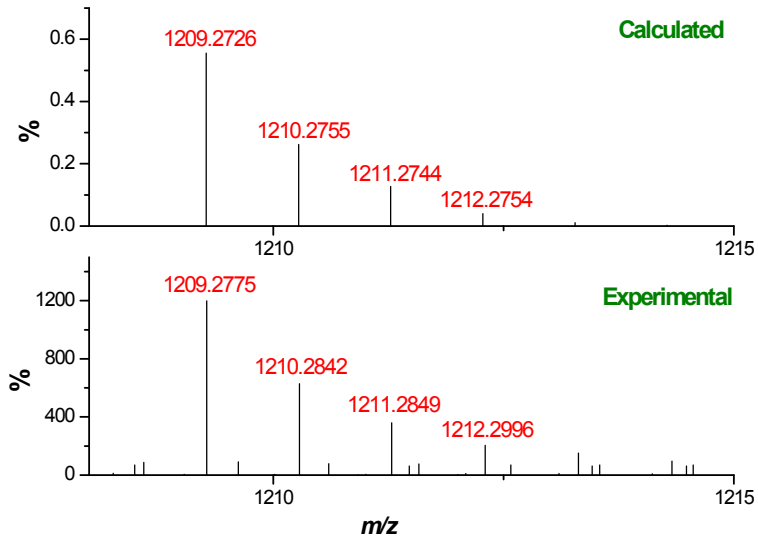


Figure S1 (a) Experimental and (b) calculated HRMS (MALDI+) spectra of [**1Tb**][2CF_3SO_3]$^+$. Calculated for $C_{37}H_{60}N_8O_{16}F_6S_2Tb$ *m/z* = 1209.2726 [M+2CF_3SO_3]$^+$. Found *m/z* = 1209.2775.

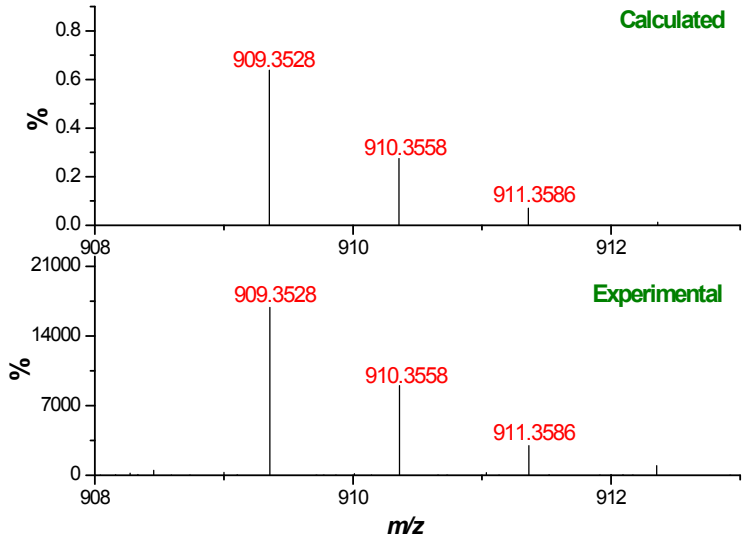


Figure S2 (a) Experimental and (b) calculated HRMS (MALDI+) spectra of [**2Tb**][2-H]$^+$. Calculated for $C_{35}H_{58}N_8O_{10}Tb$ *m/z* = 909.3529 [M-H]$^+$. Found *m/z* = 909.3560.

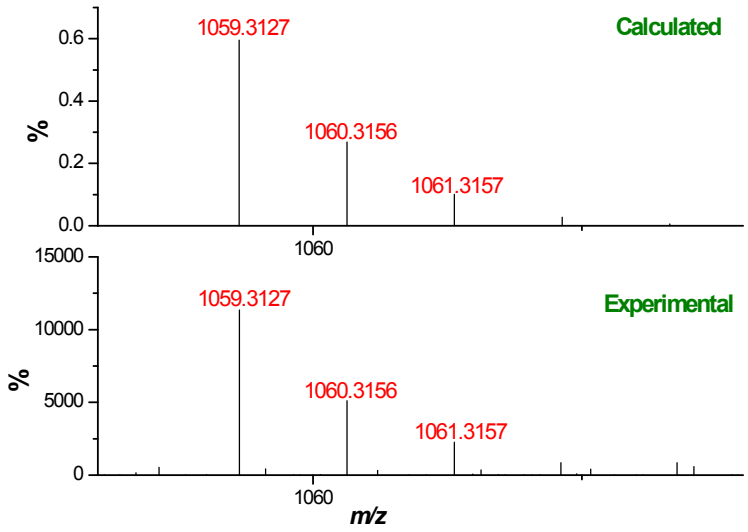


Figure S3 (a) Experimental and (b) calculated HRMS (MALDI+) spectra of [**3Tb**][CF_3SO_3]$^{2+}$. Calculated for $C_{36}H_{59}N_8O_{13}F_3STb$ *m/z* = 1059.3128 [M +CF_3SO_3]$^{2+}$. Found *m/z* = 1059.3160.

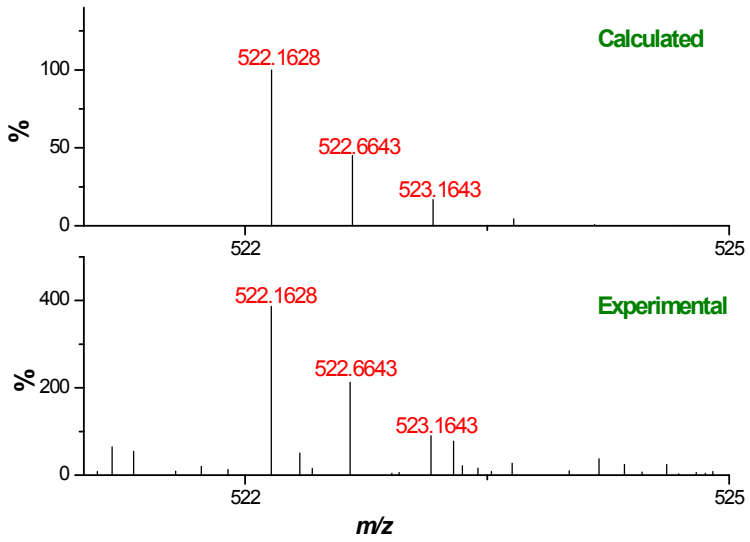


Figure S4 (a) Experimental and (b) calculated HRMS (ESI$^+$) spectra of [**4Tb**][CF_3SO_3]$^{2+}$. Calculated for $C_{36}H_{60}N_8O_{12}F_3STb$ *m/z* = 1044.3257 [M +CF_3SO_3]$^{2+}$. Found *m/z* = 1044.3254.

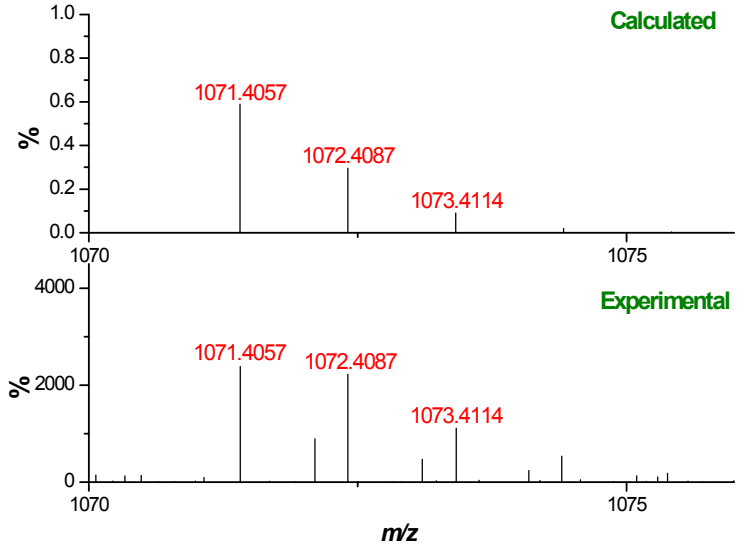


Figure S5 (a) Experimental and (b) calculated HRMS (MALDI+) spectra of [**5Tb**][2-H]$^+$. Calculated for $C_{41}H_{68}N_8O_{15}STb$ *m/z* = 1071.4058 [M–2H]$^+$. Found *m/z* = 1071.4077.

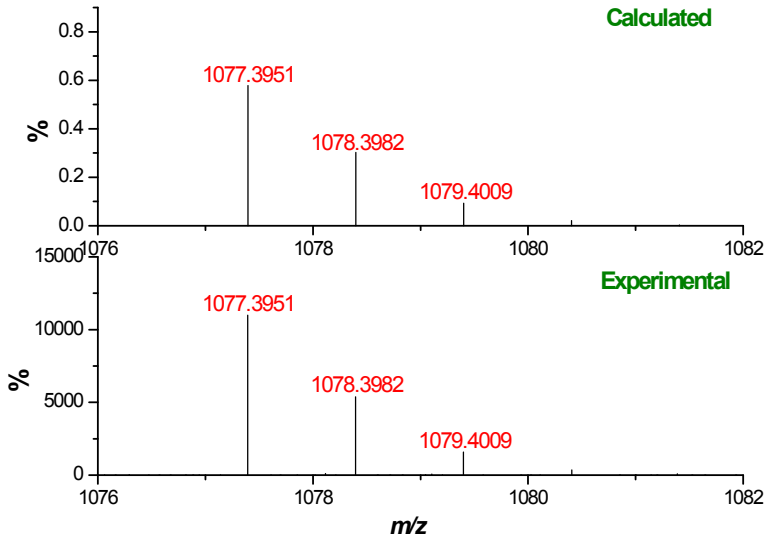


Figure S6 (a) Experimental and (b) calculated HRMS (MALDI+) spectra of [**6Tb**][2-H]$^+$. Calculated for $C_{43}H_{66}N_8O_{14}STb$ *m/z* = 1077.3952 [M–2H]$^+$. Found *m/z* = 1077.3922.

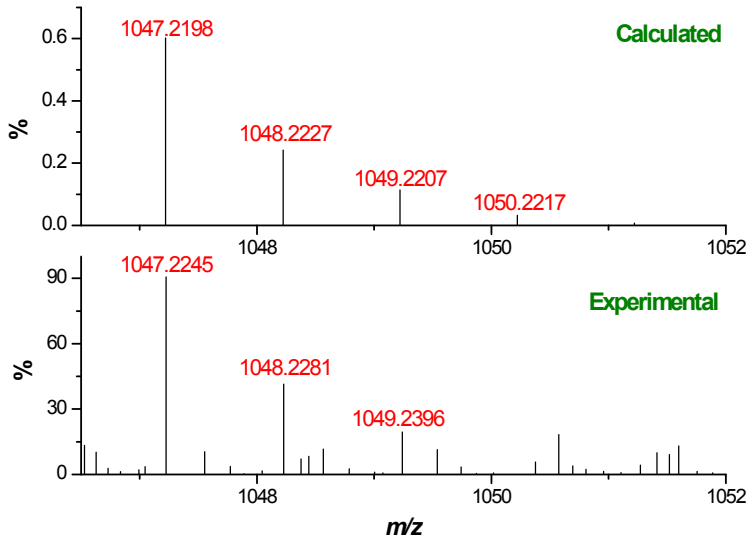


Figure S7 (a) Experimental and (b) calculated HRMS (MALDI+) spectra of [**7Tb**][$2CF_3SO_3$]$^+$. Calculated for $C_{31}H_{50}N_8O_{11}F_6S_2Tb$ *m/z* = 1047.2198 [M + $2CF_3SO_3$]$^+$. Found *m/z* = 1047.2245.

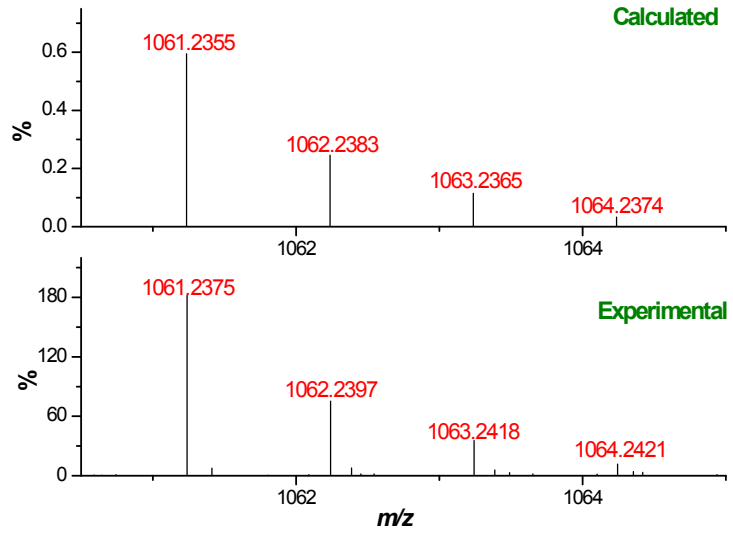


Figure S8 (a) Experimental and (b) calculated HRMS (MALDI+) spectra of [**8Tb**][$2CF_3SO_3$]$^+$. Calculated for $C_{32}H_{52}N_8O_{11}F_6S_2Tb$ *m/z* = 1061.2355 [M + $2CF_3SO_3$]$^+$. Found *m/z* = 1061.2375.

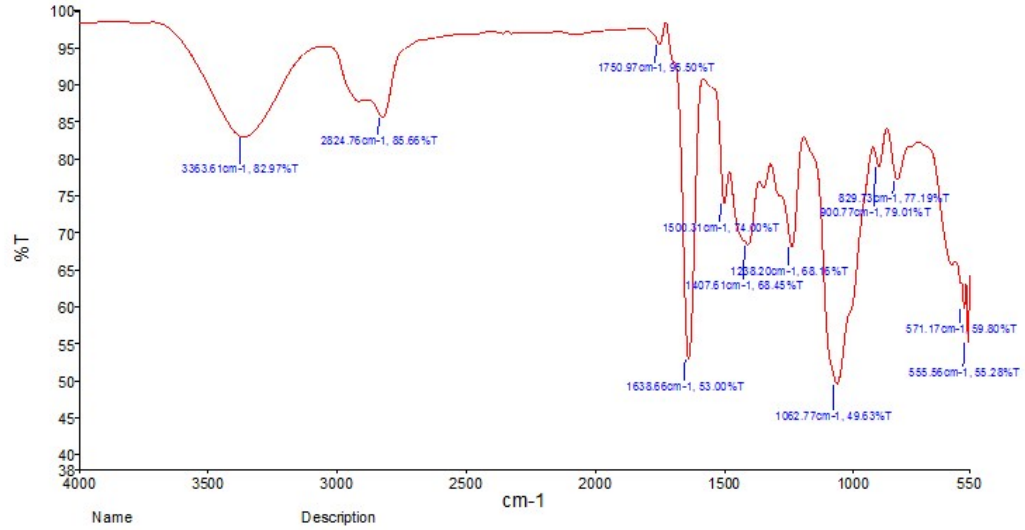


Figure S9 IR Spectrum of ligand **7**

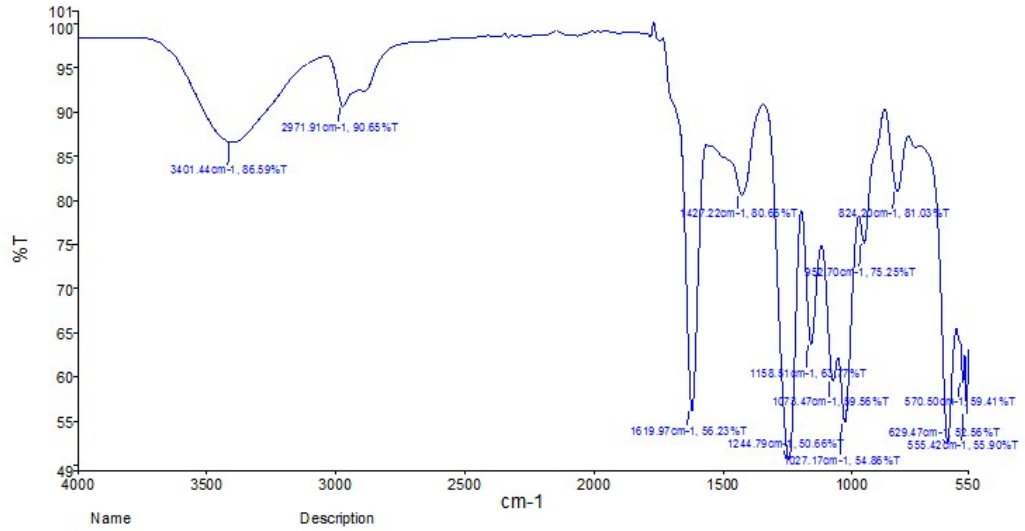
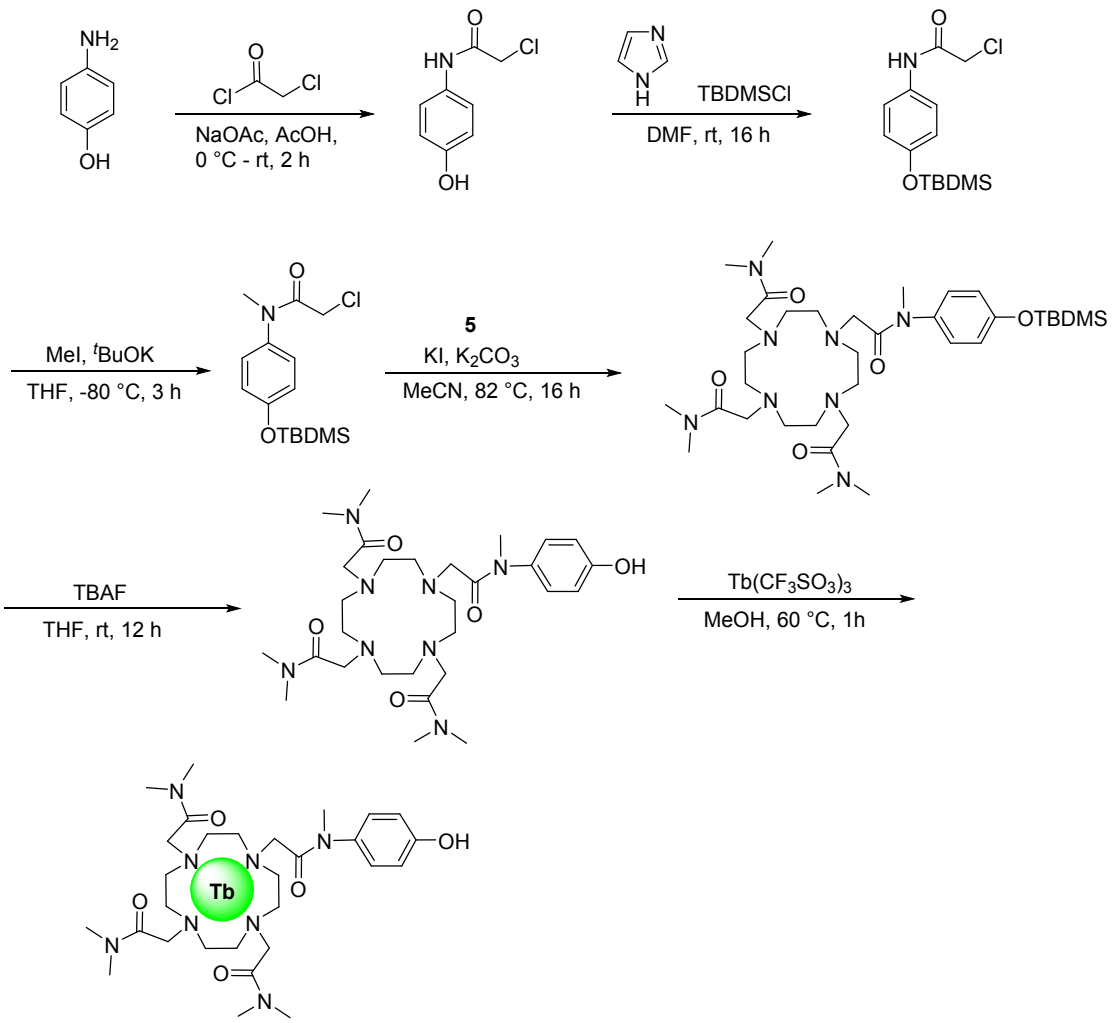
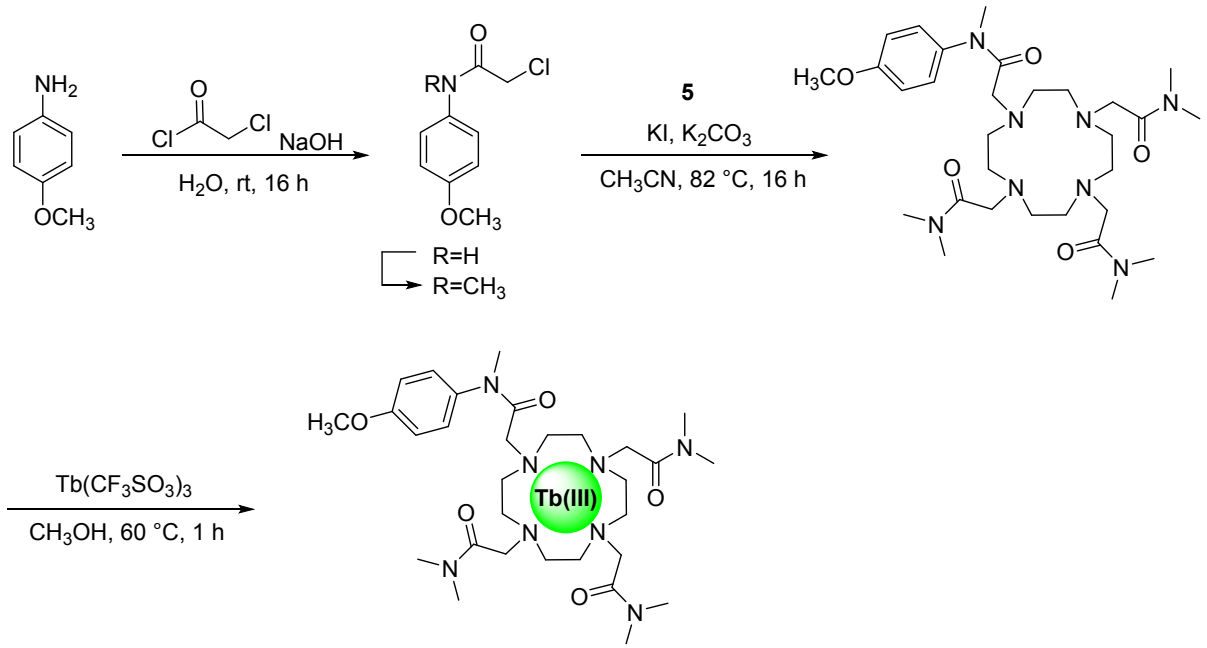


Figure S10 IR Spectrum of Tb(III) complex **1Tb**



Scheme S1 Synthetic strategy for synthesis of **7Tb**



Scheme S2 Synthetic strategy for synthesis of **8Tb**

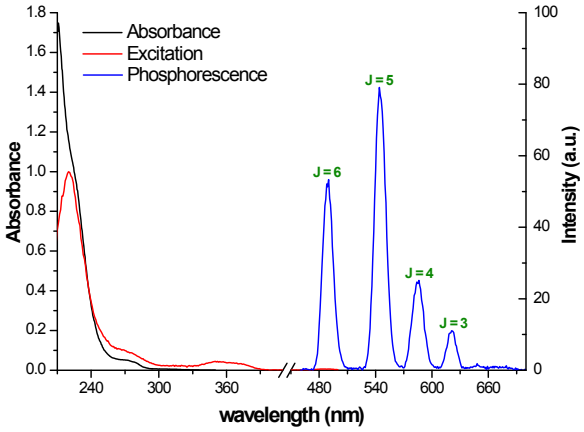


Figure S11 UV-Vis absorption (black), excitation (red), and sensitised Tb(III) luminescence spectra (blue) of **1Tb** (50 µM) in aqueous buffered solution (0.1M Tris-HCl, pH 7.4) using indirect excitation at 273 nm.

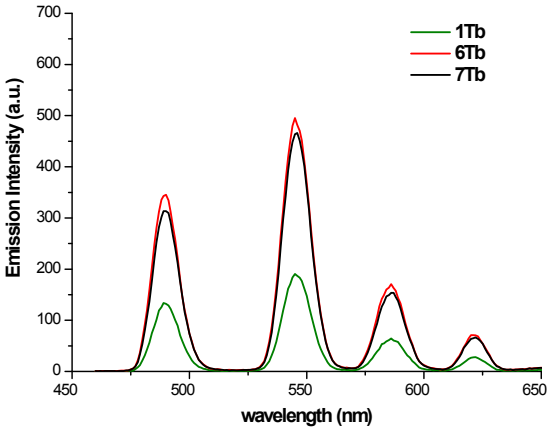


Figure S12 Lanthanide luminescence spectra of **1Tb** (green), **6Tb*** (red), **7Tb (black)** (1 mM) in aqueous buffered solution (0.1M Tris-HCl, pH 7.4) using indirect excitation at 273 nm. *10%EtOH added to aid solubility

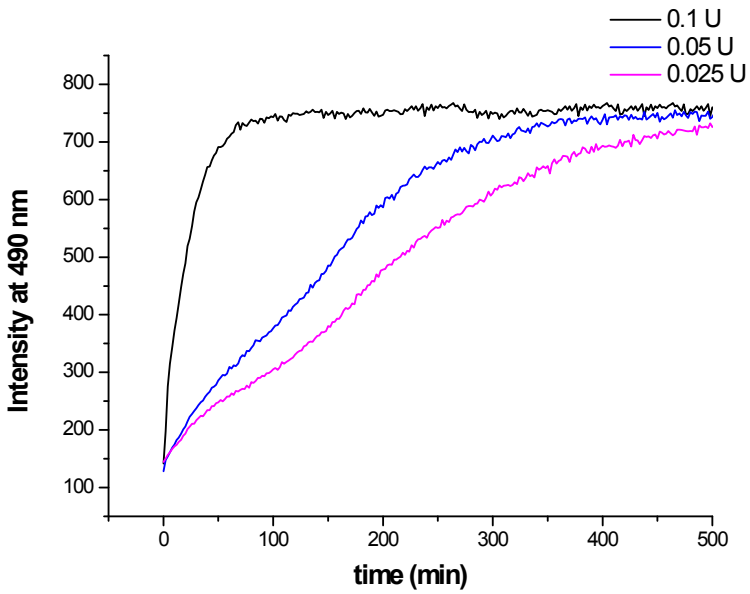


Figure S13 Lanthanide luminescence spectra of **1.Tb** (1 mM) in the presence of varying amounts of β-glucosidase (0.1 U – 0.025 U) in aqueous buffered solution (0.1M Tris-HCl, pH 7.4) using indirect excitation at 273 nm

Table S1 The lifetimes and the corresponding hydration states (*q*) of the Tb(III) complexes at concentrations of 1mM. Luminescence decay measured at 545 nm.

Complex	τ (D_2O)/ms	τ (H_2O)/ms	*q (±0.5)*
1.Tb[a]	1.19	0.93	0.89
1.Tb[b]	2.33	1.86	0.24
2.Tb[b]	2.34	1.77	0.39
3.Tb[b]	2.21	1.82	0.18
4.Tb[b]	1.56	1.27	0.44
5.Tb[b]	2.17	1.66	0.41
6.Tb[b,c]	2.36	1.64	0.62
7.Tb[b]	2.03	1.38	0.85

[a] Lifetime measured immediately

[b] Lifetime measured after 1 h standing in solution

[c] 10% MeOH and MeOD added to aid solubility

Hydration states of the Tb(III) complexes were determined by measuring their luminescence lifetimes in H_2O and D_2O, using the Parker-modified Horrock's equation

$q^{Ln(III)} = A\ \{(1/\tau_{H2O} - 1/\tau_{D2O}) - B - C)\}$,where for Tb(III), A = 5, B = 0.06, C = 0

II. ^{1}H, ^{13}C, and HSQC spectra for all new compounds

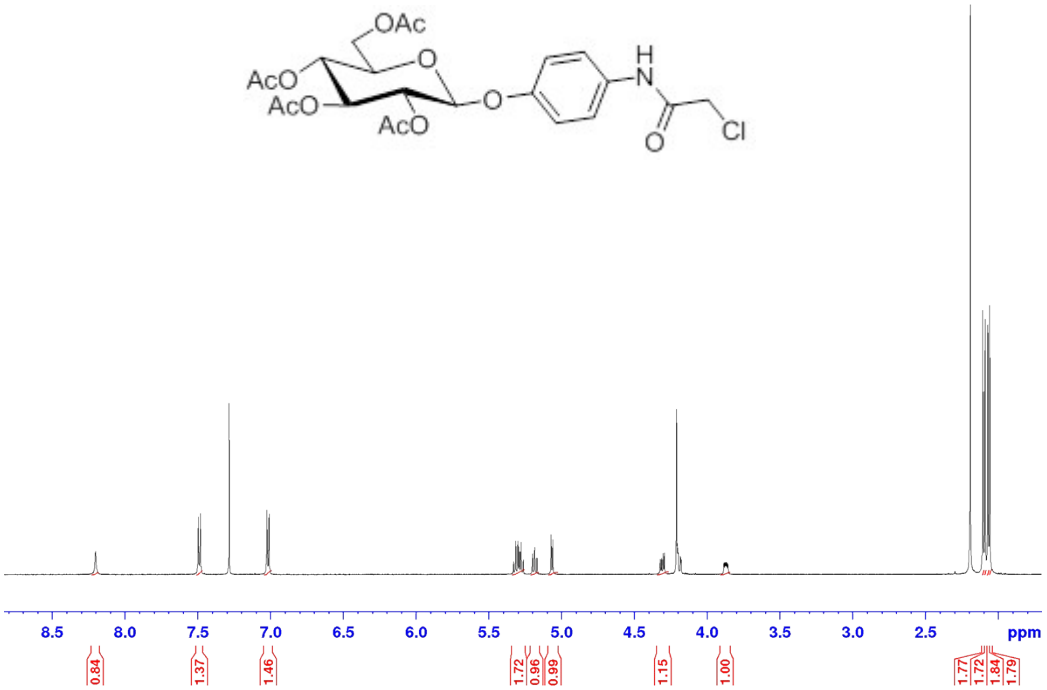


Figure S14 ^{1}H NMR Spectrum of **3**, $CDCl_3$, 400 MHz

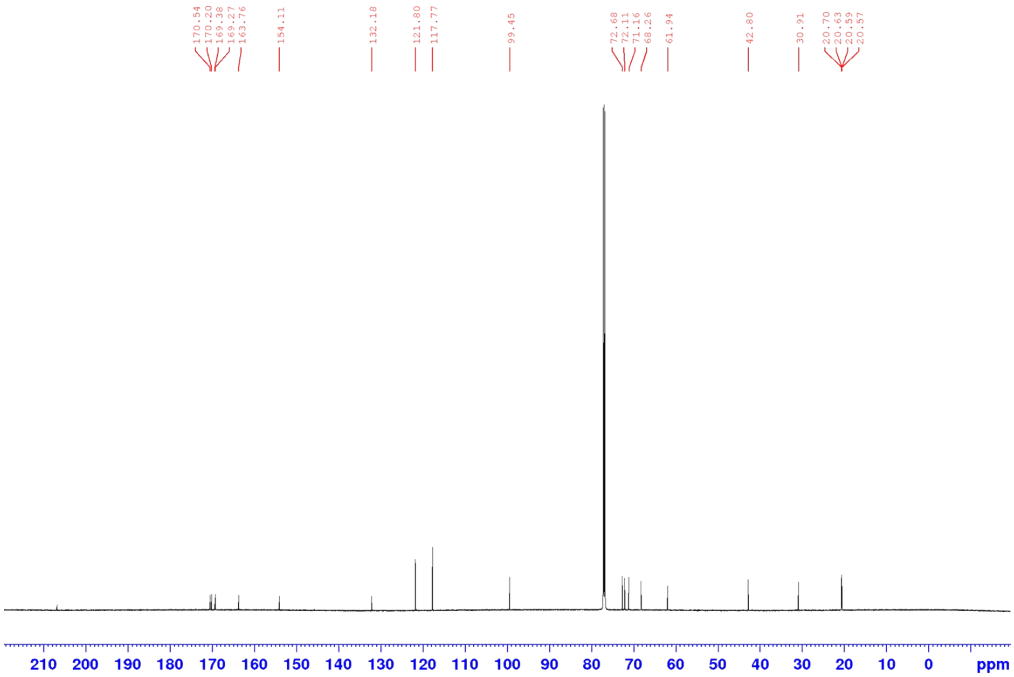


Figure S15 ^{13}C NMR Spectrum of **3**, $CDCl_3$, 101 MHz

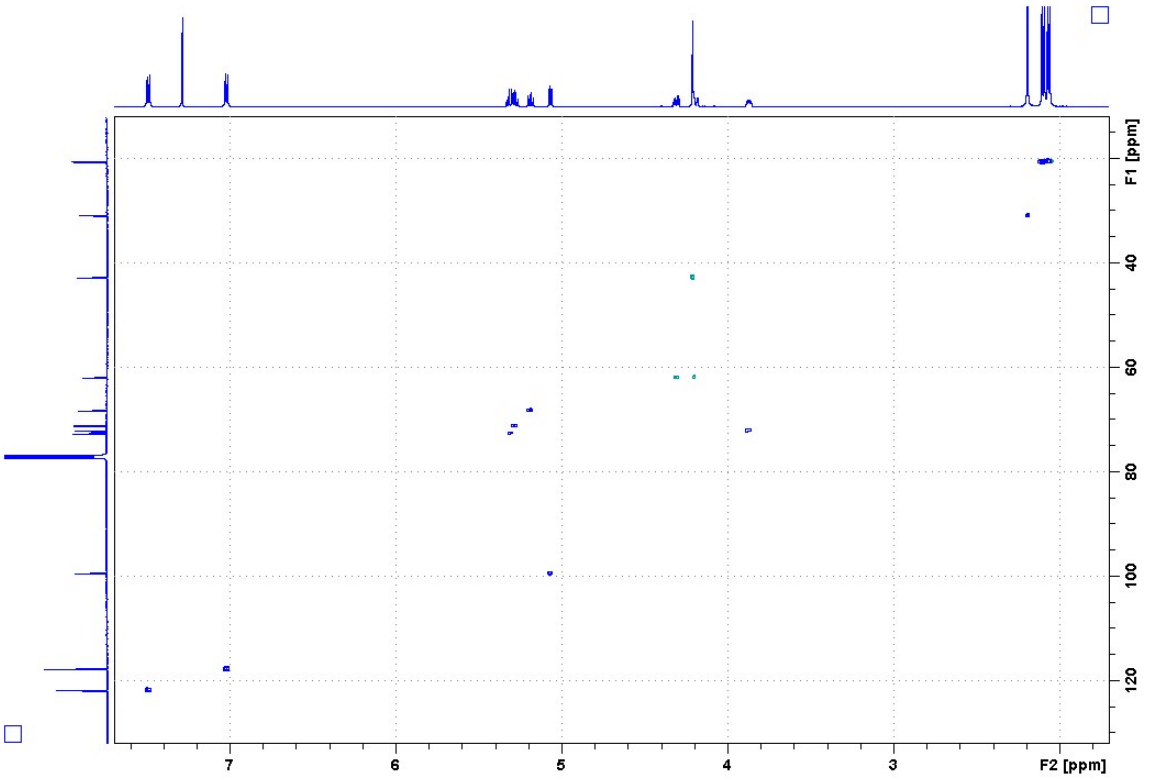


Figure S16 HSQC NMR Spectrum of **3**, $CDCl_3$, 101 MHz

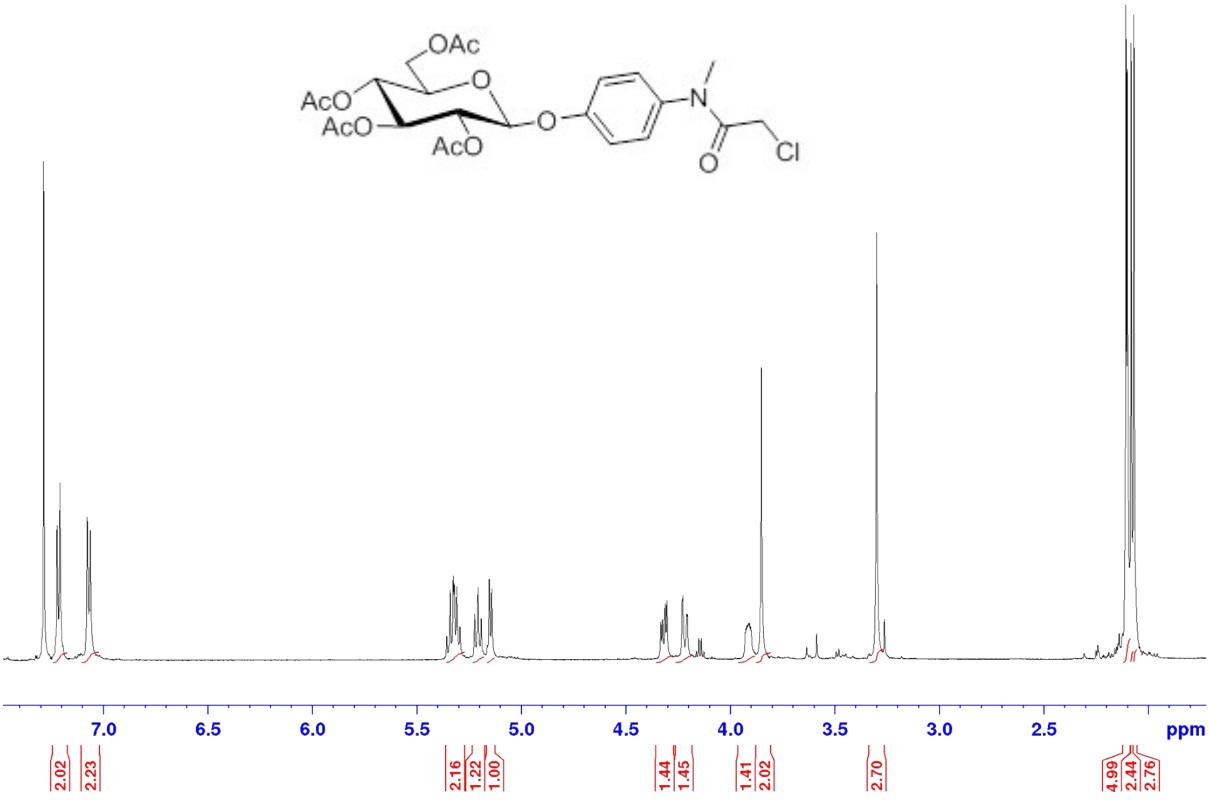


Figure S17 ^1H NMR Spectrum of **4**, $CDCl_3$, 600 MHz

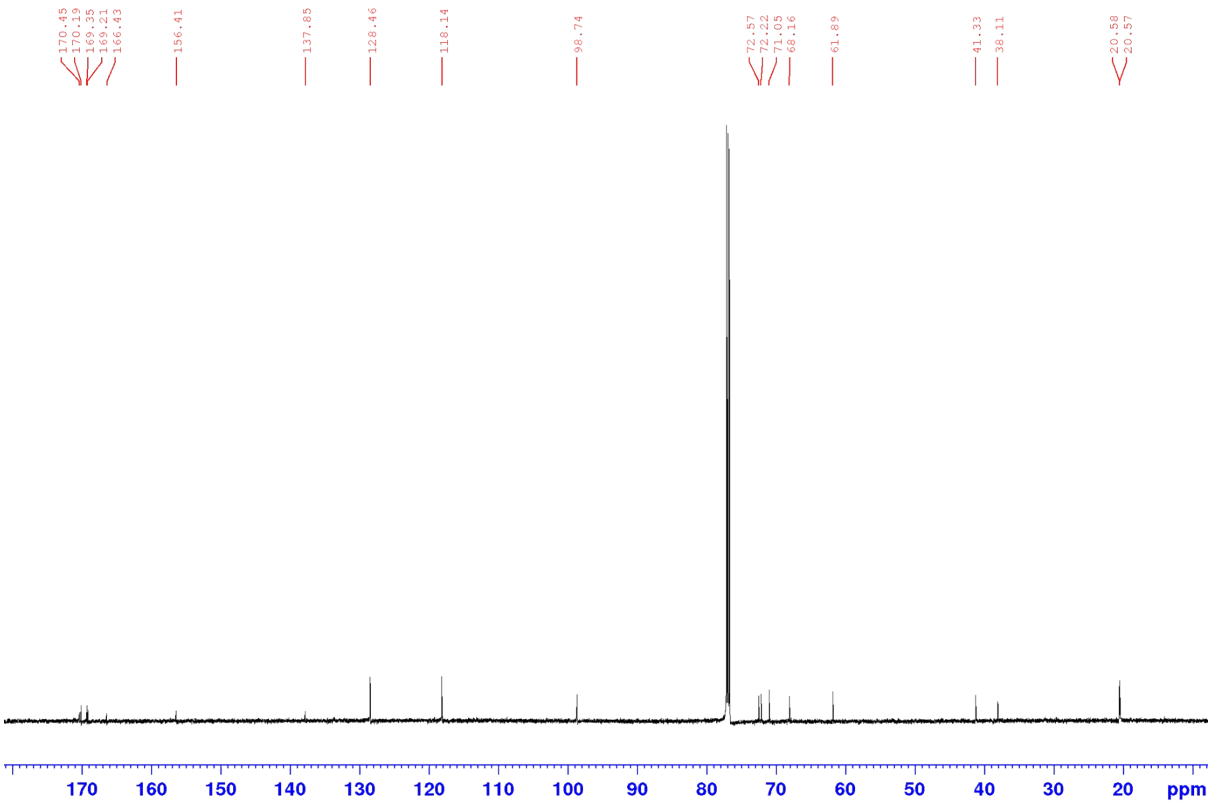


Figure S18 ^{13}C NMR Spectrum of **4**, $CDCl_3$, 101 MHz

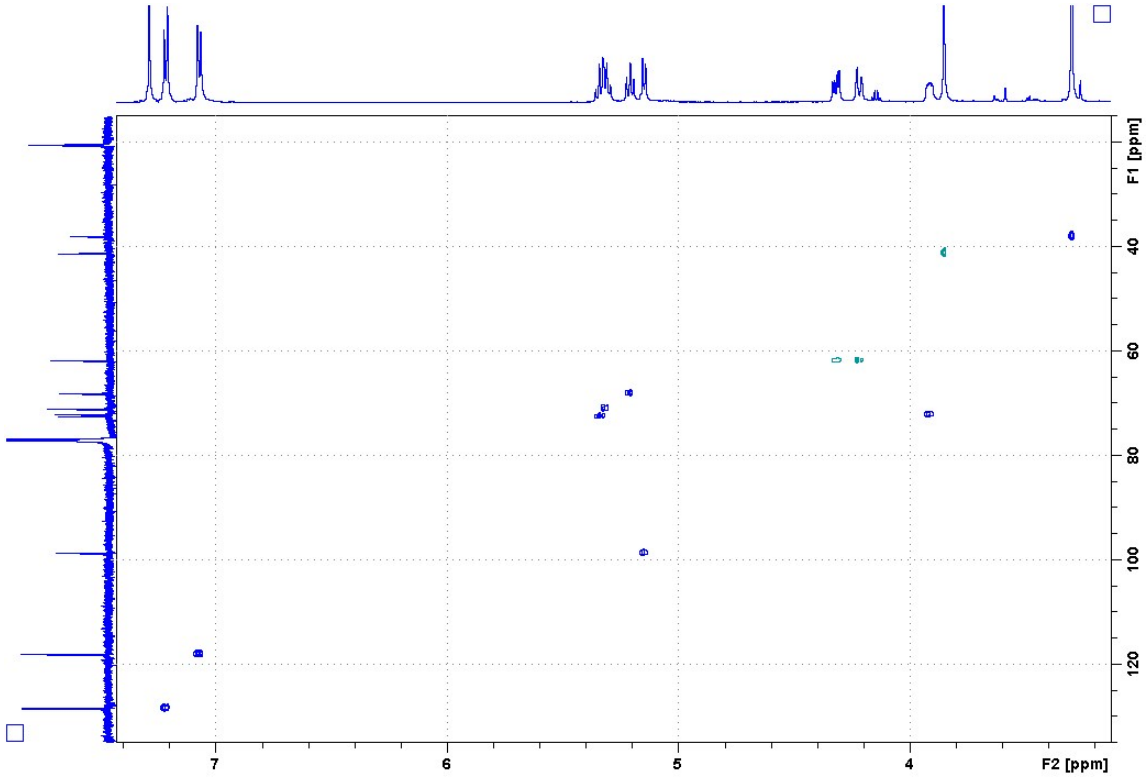


Figure S19 HSQC NMR Spectrum of **4**, $CDCl_3$, 101 MHz

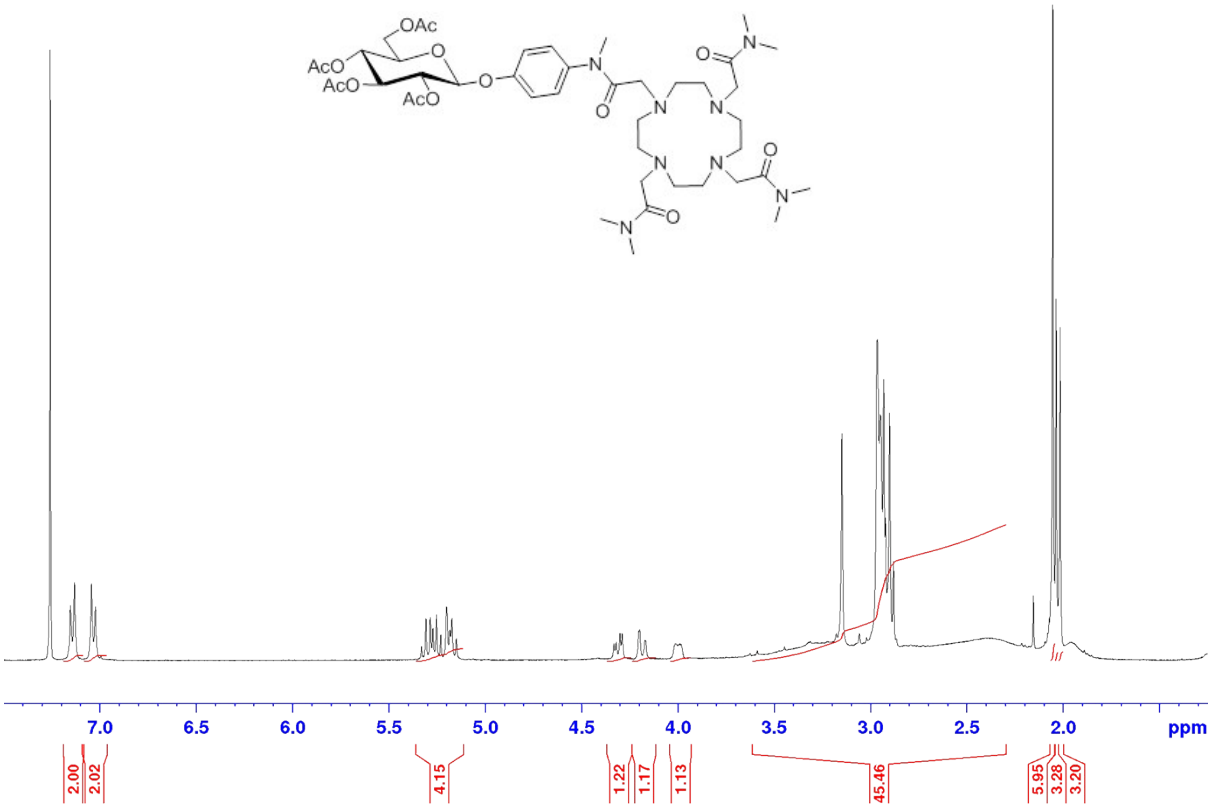


Figure S20 ^{1}H NMR Spectrum of **6**, $CDCl_3$, 600 MHz

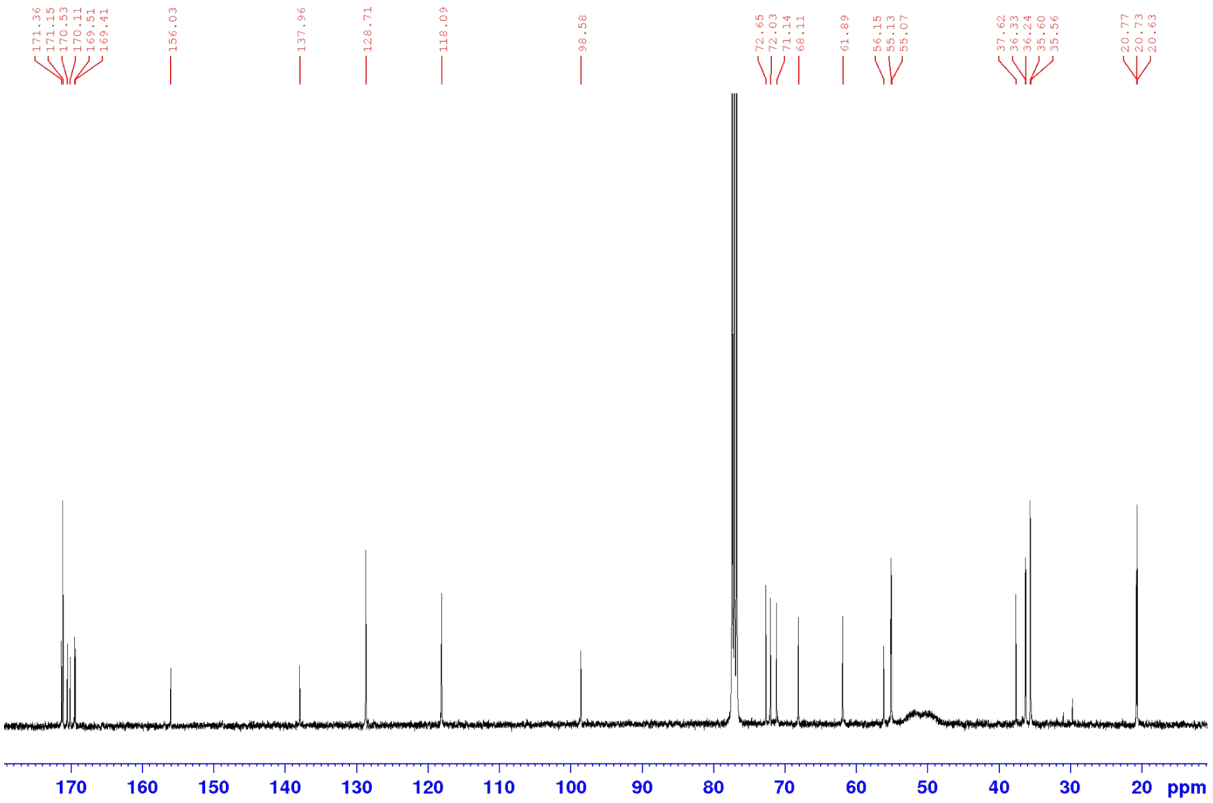


Figure S21 ^{13}C NMR Spectrum of **6**, $CDCl_3$, 101 MHz

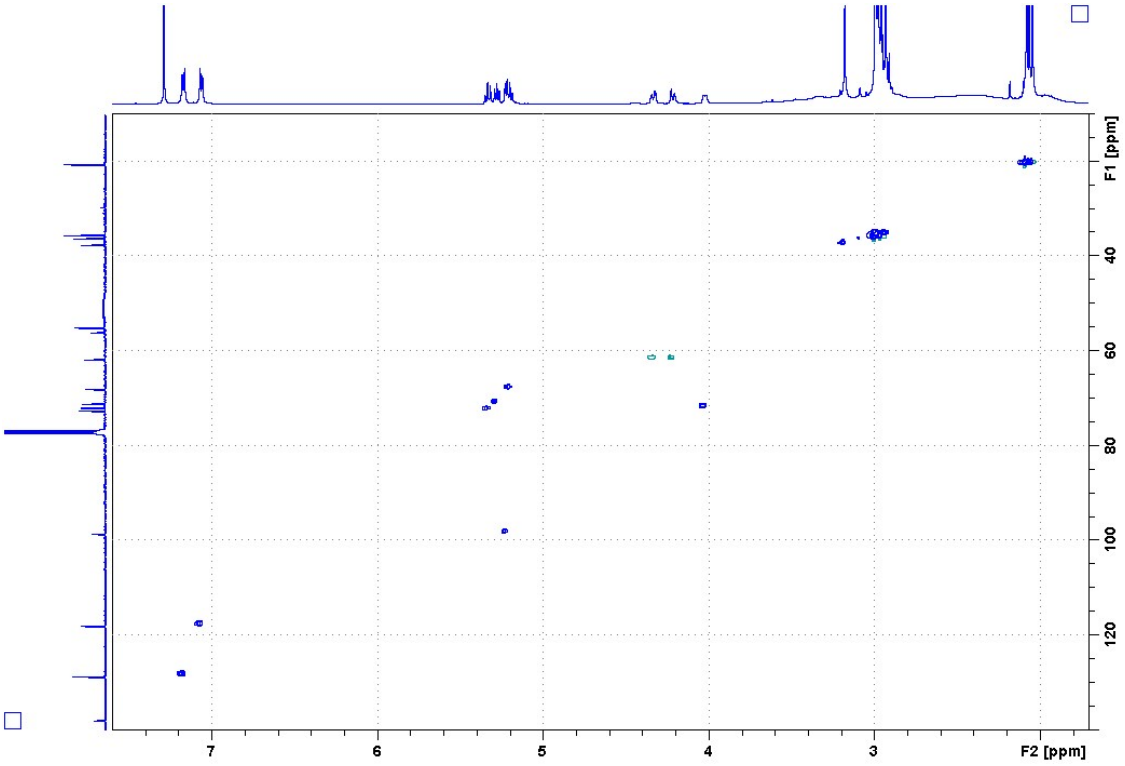


Figure S22 HSQC NMR Spectrum of **6**, $CDCl_3$, 101 MHz

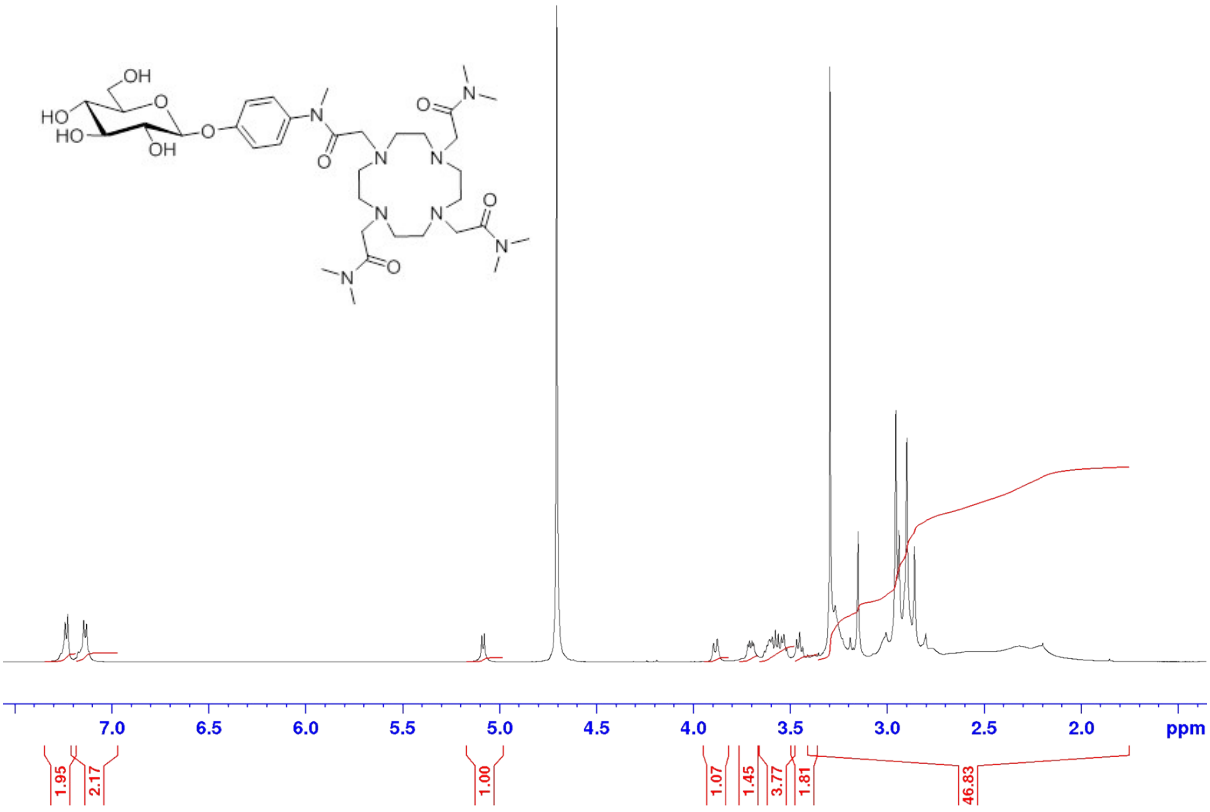


Figure S23 ^1H NMR Spectrum of **7**, D_2O, 600 MHz

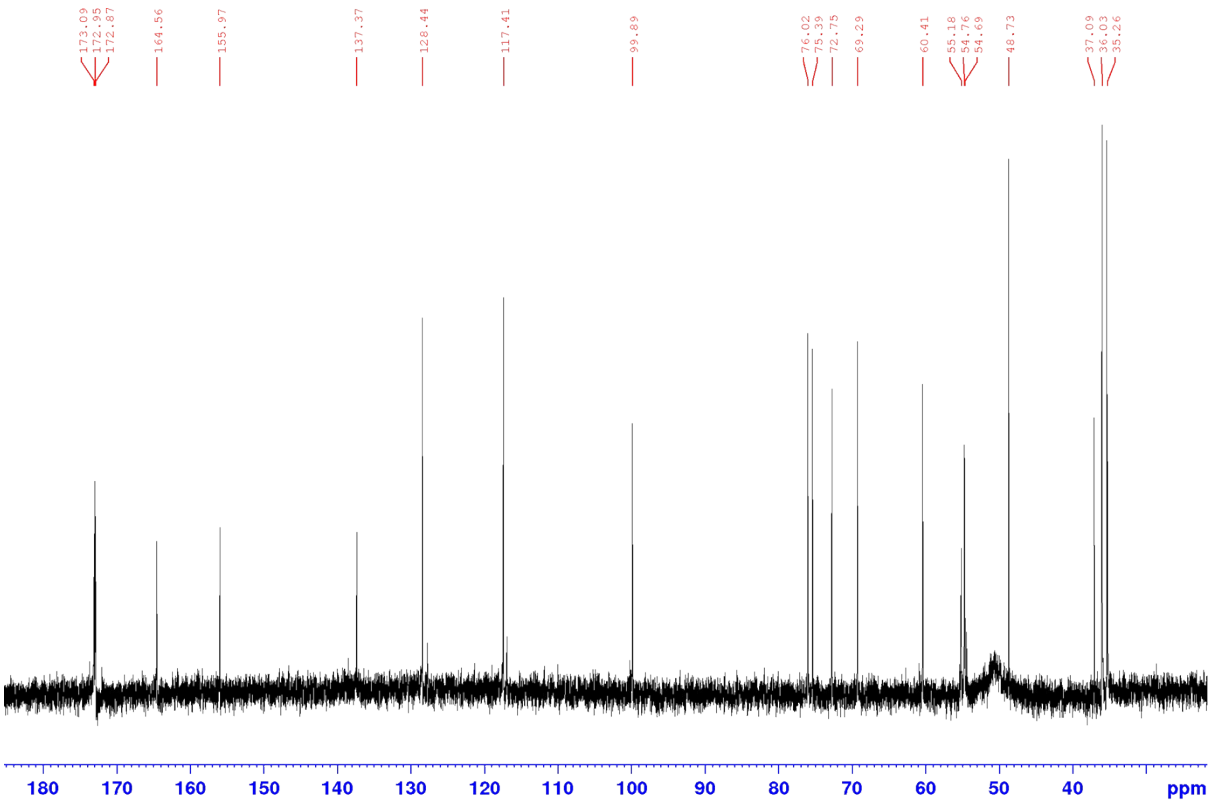


Figure S24 ^{13}C NMR Spectrum of **7**, D_2O, 101 MHz

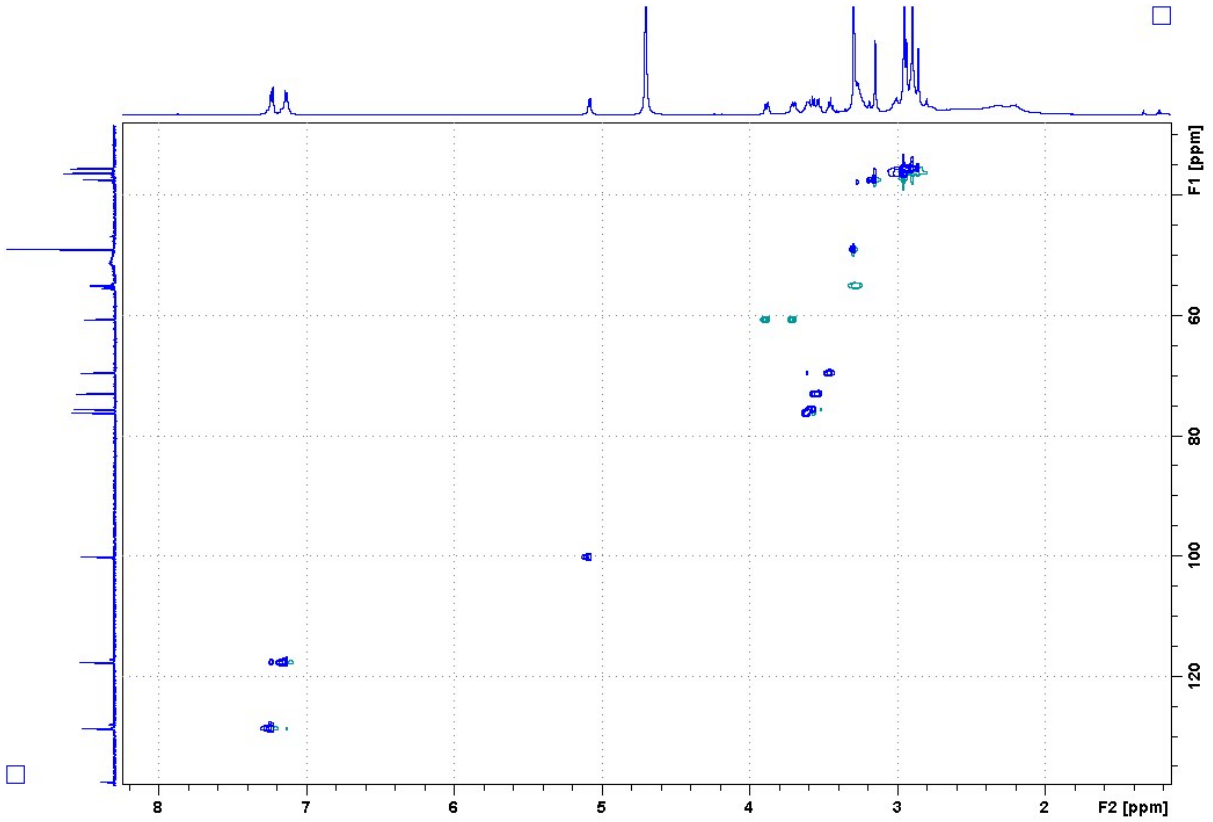


Figure S25 HSQC NMR Spectrum of **7**, D_2O, 101 MHz

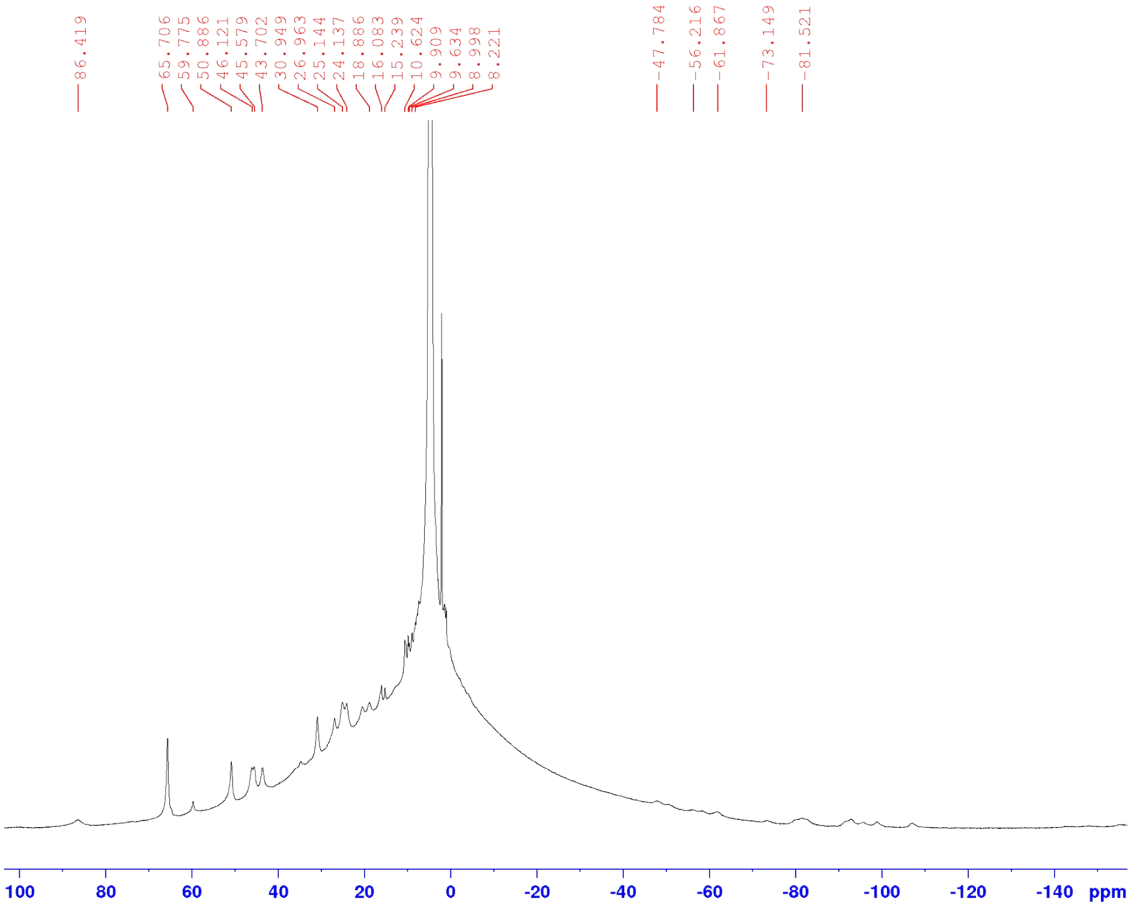


Figure S26 ^{1}H NMR Spectrum of **1Tb**, D_2O, 400 MHz

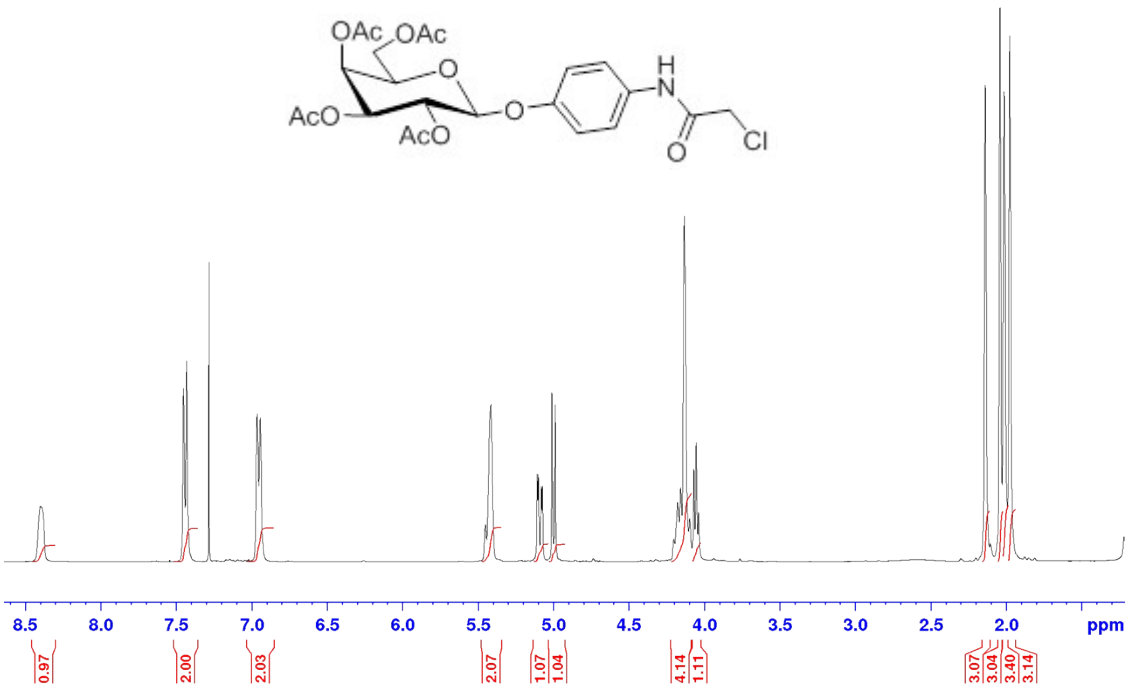


Figure S27 ^{1}H NMR Spectrum of **10**, $CDCl_3$, 400 MHz

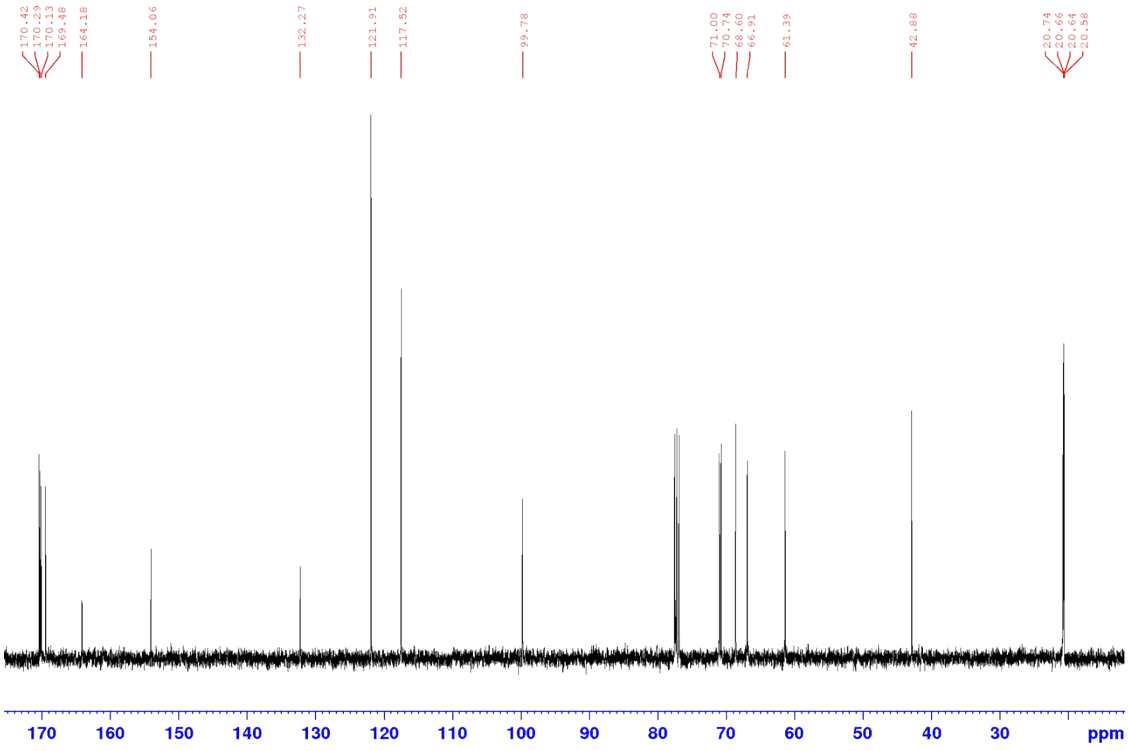


Figure S28 ^{13}C NMR Spectrum of **10**, $CDCl_3$, 101 MHz

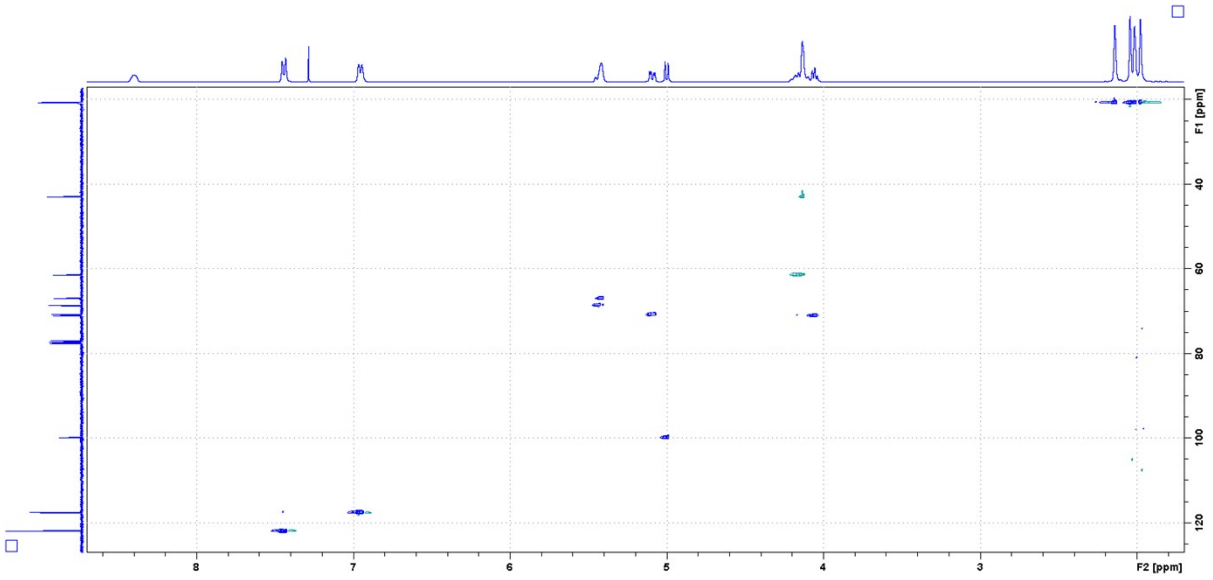


Figure S29 HSQC NMR Spectrum of **10**, $CDCl_3$, 101 MHz

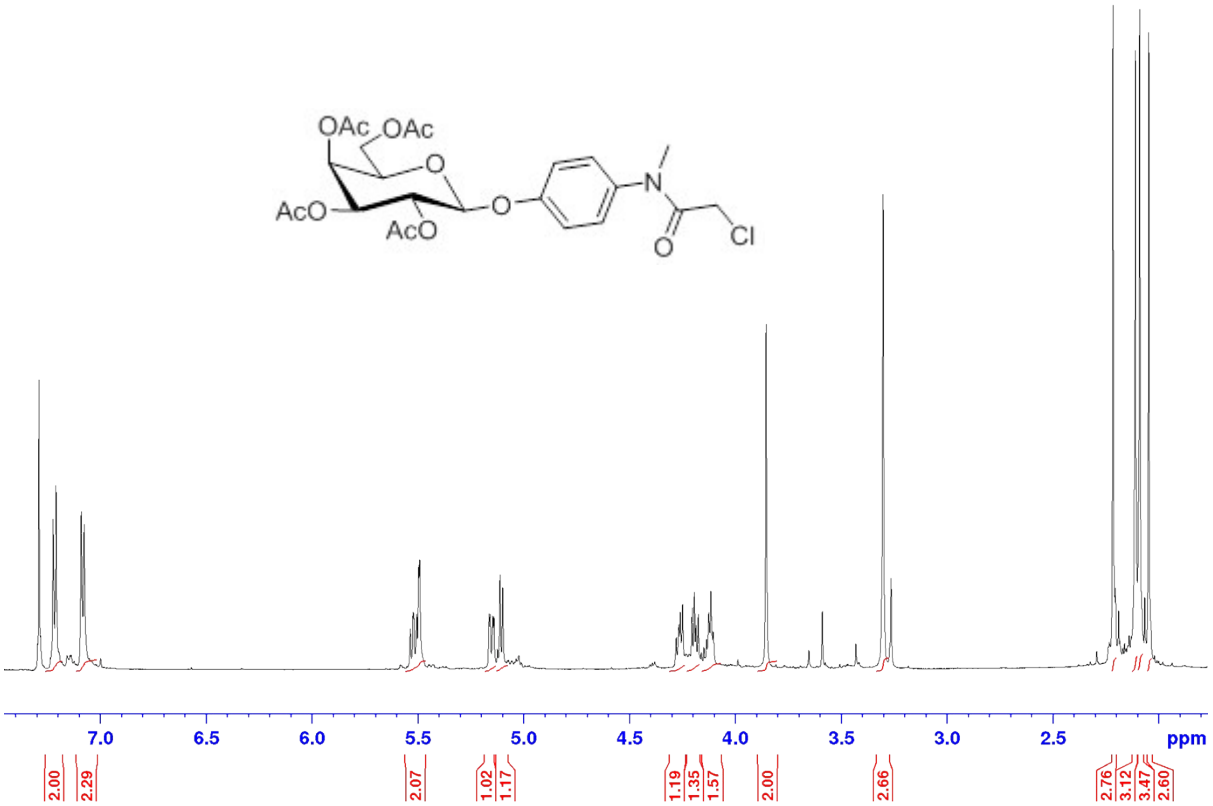


Figure S30 ^{1}H NMR Spectrum of **11**, $CDCl_3$, 400 MHz

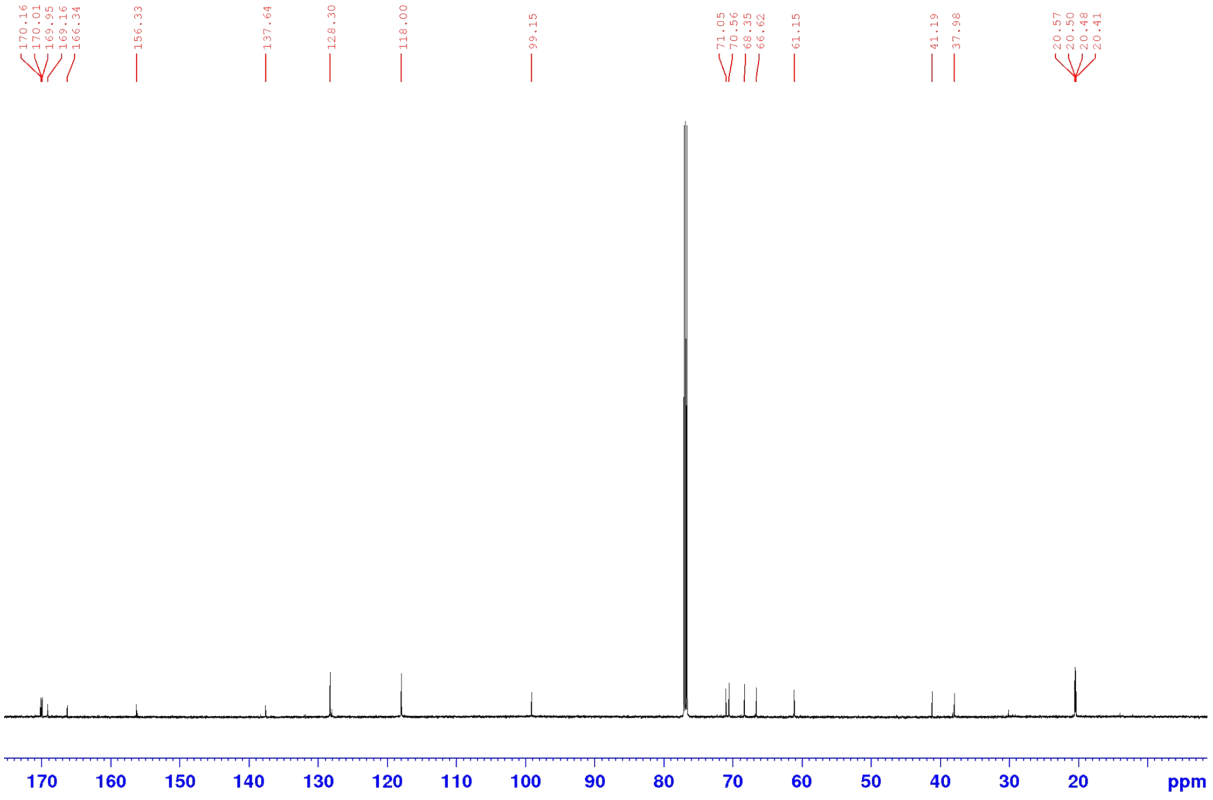


Figure S31 ^{13}C NMR Spectrum of **11**, $CDCl_3$, 101 MHz

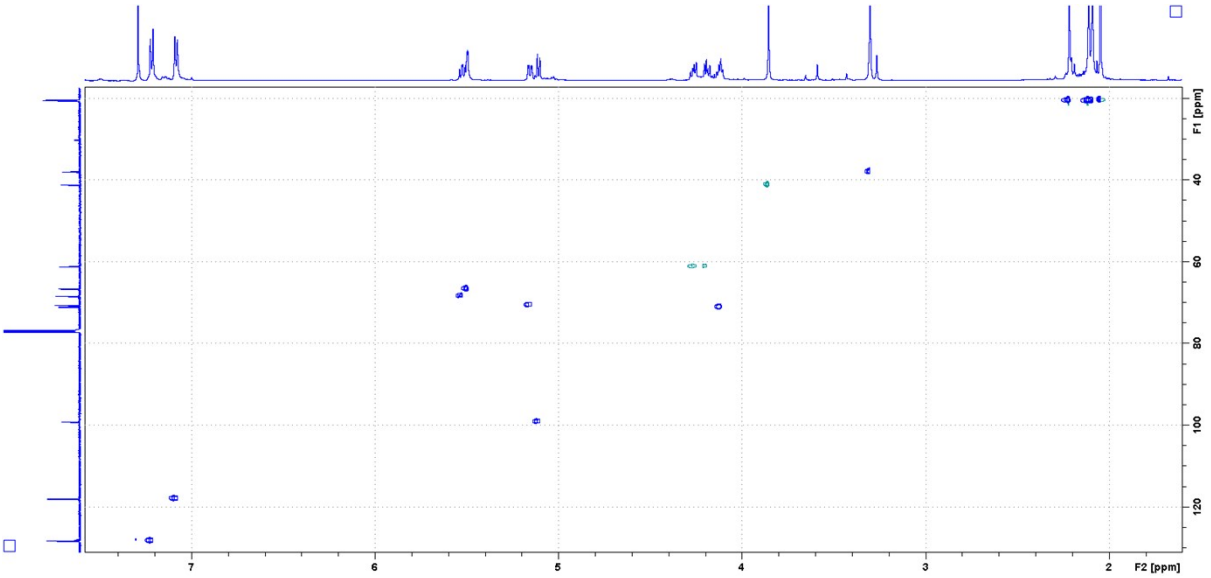


Figure S32 HSQC NMR Spectrum of **11**, $CDCl_3$, 101MHz

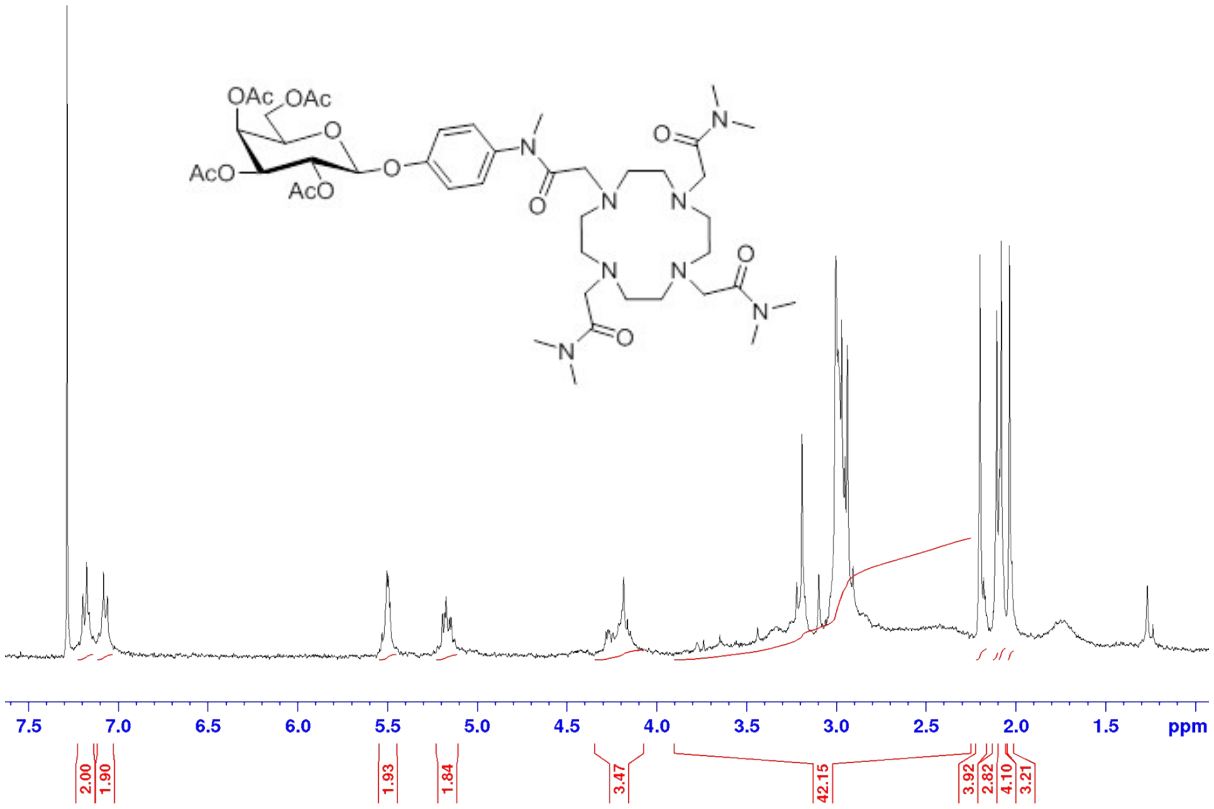


Figure S33 ^1H NMR Spectrum of **12**, $CDCl_3$, 400 MHz

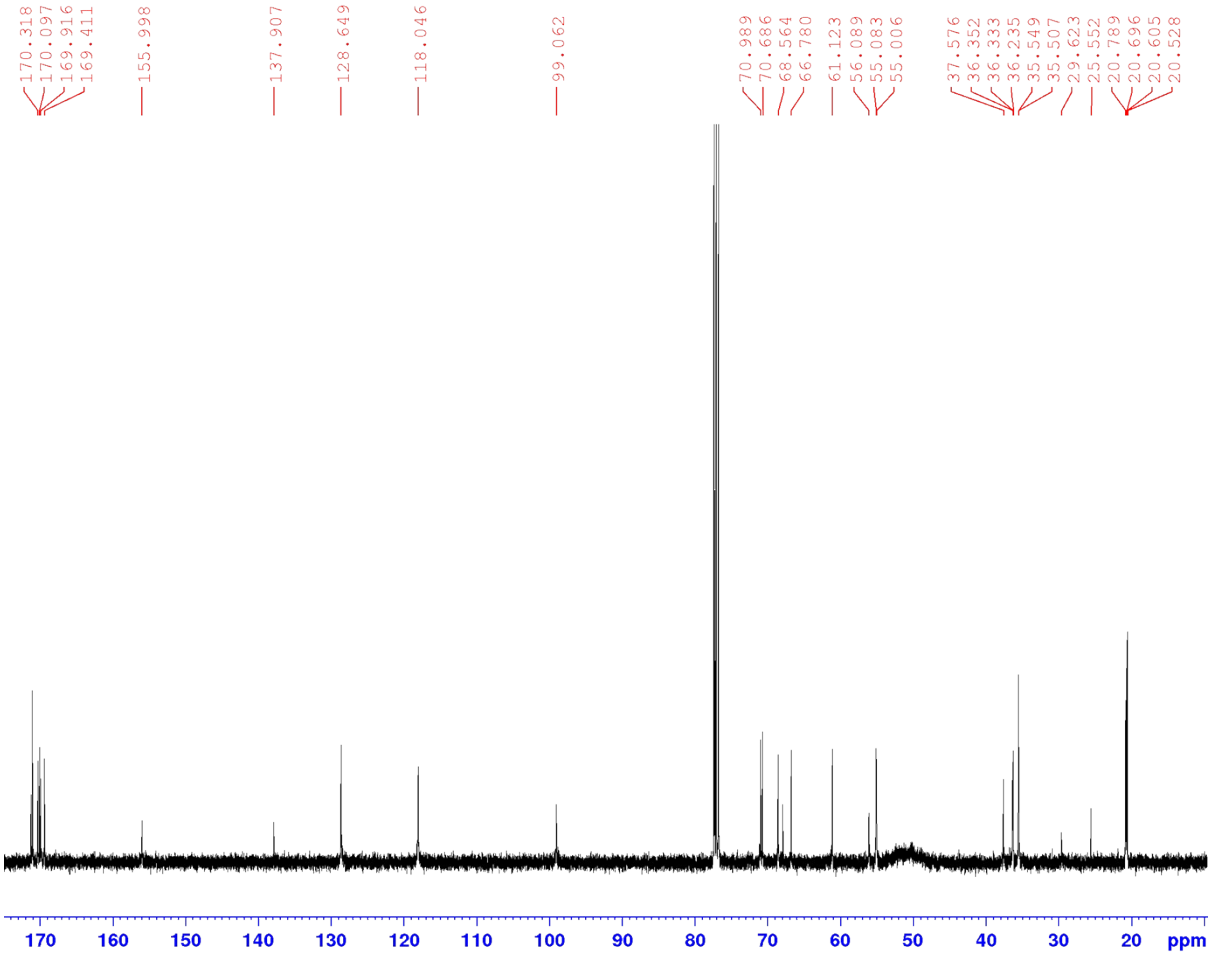


Figure S34 ^{13}C NMR Spectrum of **12**, $CDCl_3$, 101 MHz

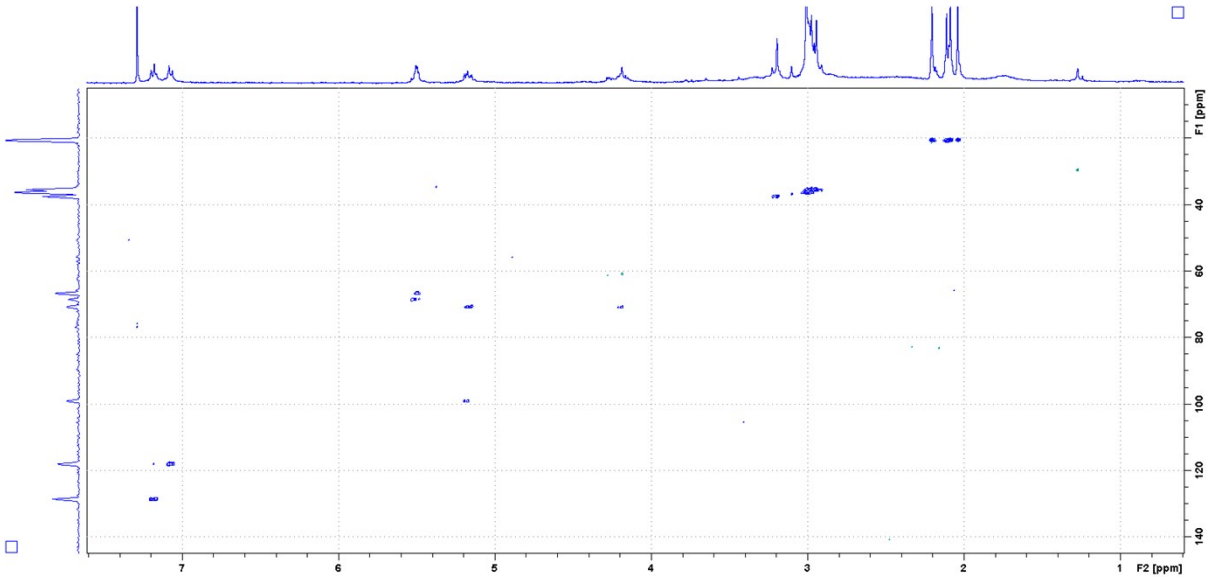


Figure S35 HSQC NMR Spectrum of **12**, $CDCl_3$, 101 MHz

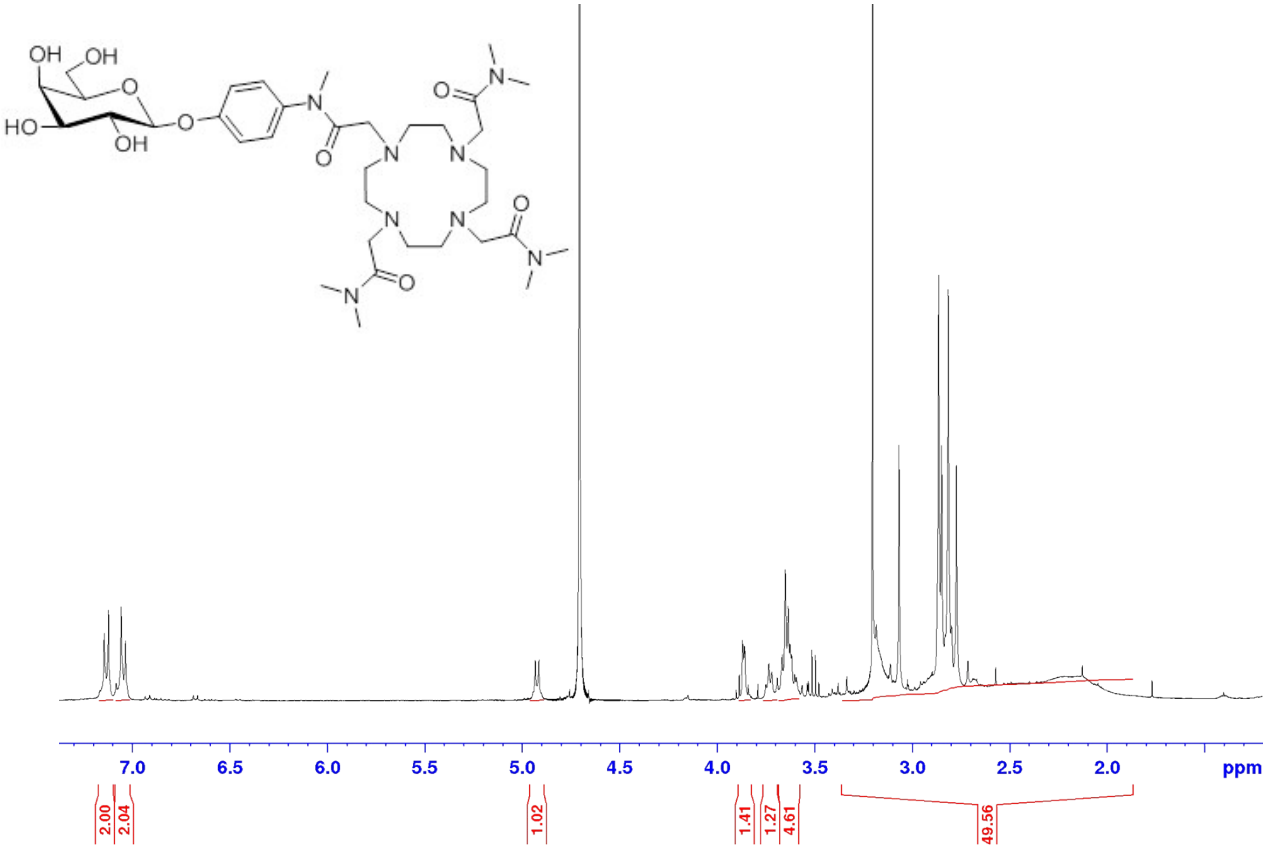


Figure S36 ^{1}H NMR Spectrum of **13**, D_2O 400 MHz

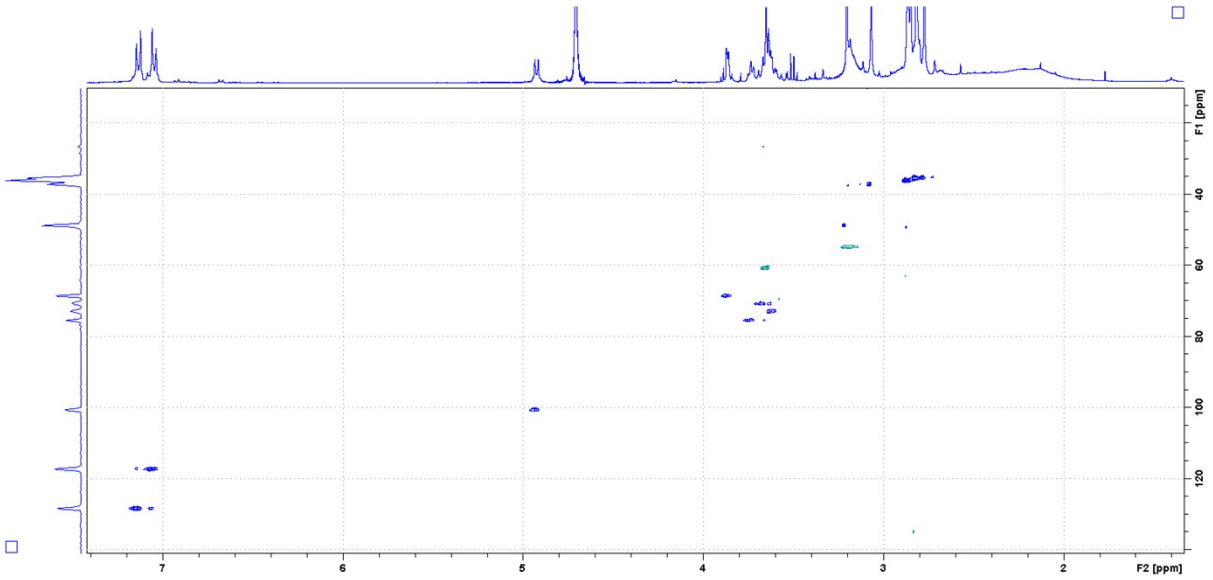


Figure S37 HSQC NMR Spectrum of **13**, D_2O 400 MHz

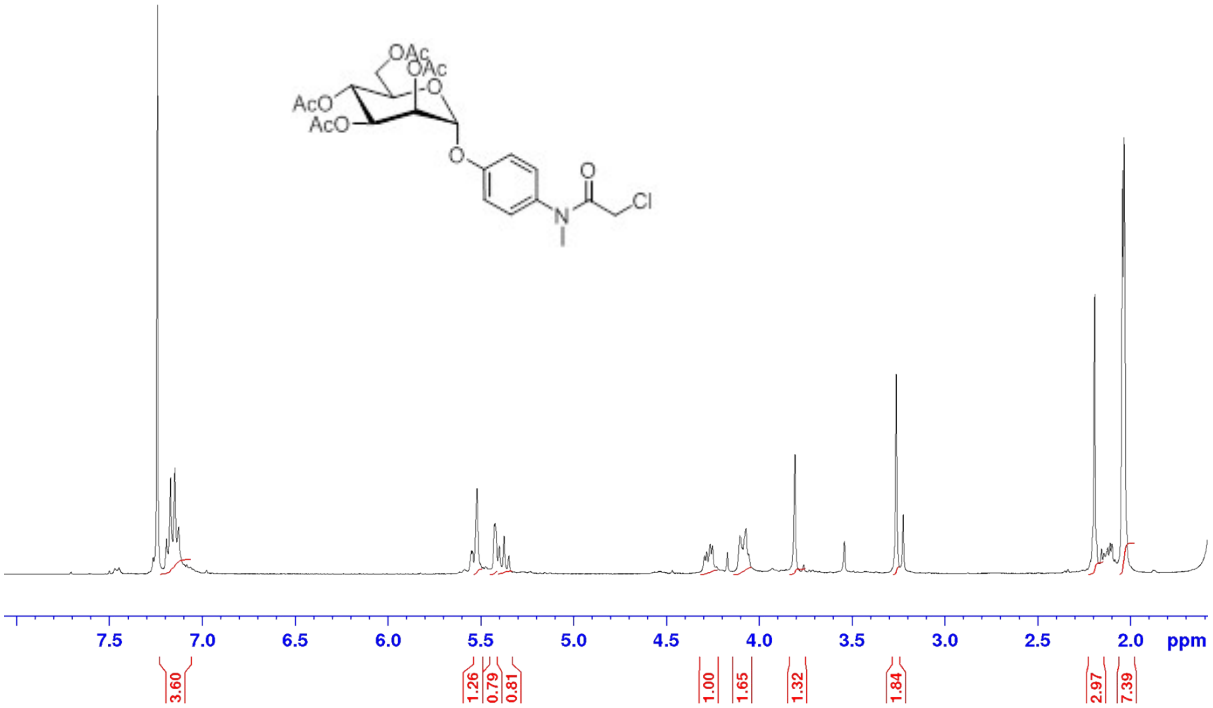


Figure S38 ^{1}H NMR Spectrum of **17**, $CDCl_3$, 600 MHz

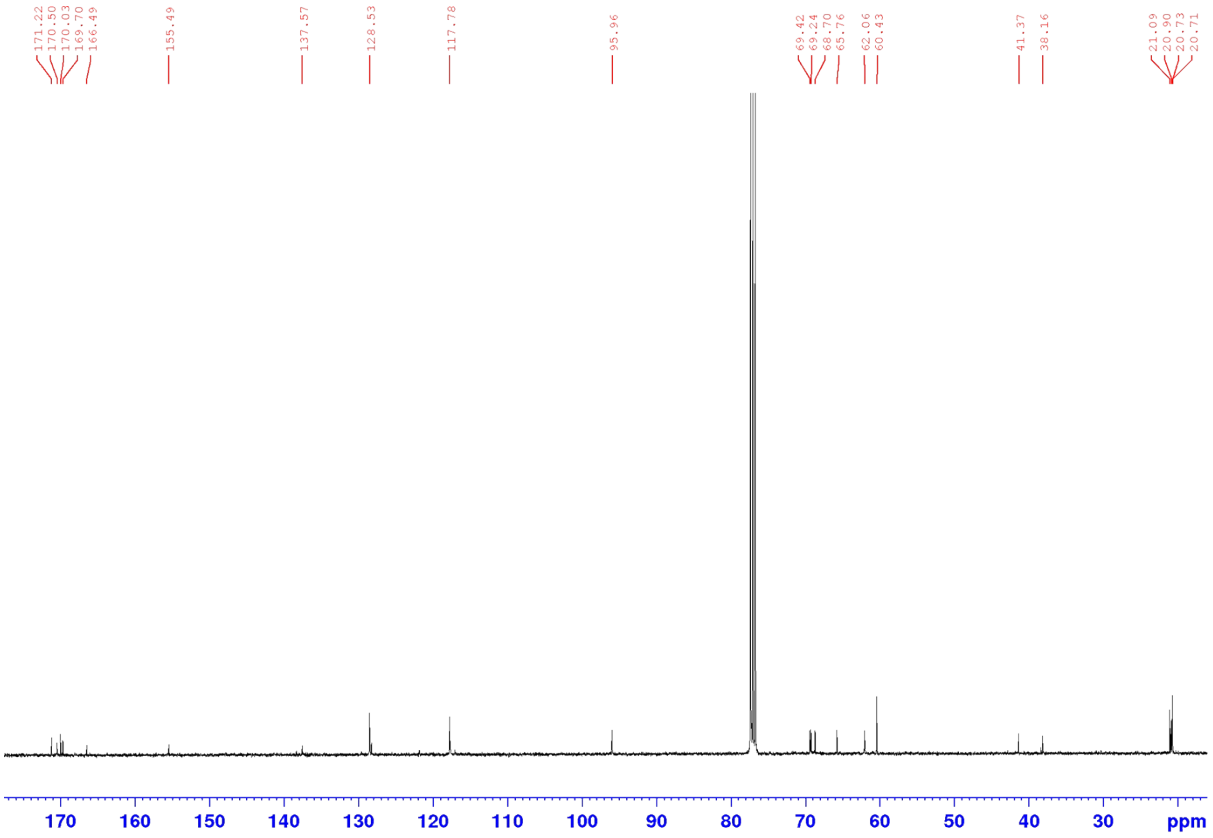


Figure S39 ^{13}C NMR Spectrum of **17**, $CDCl_3$, 101 MHz

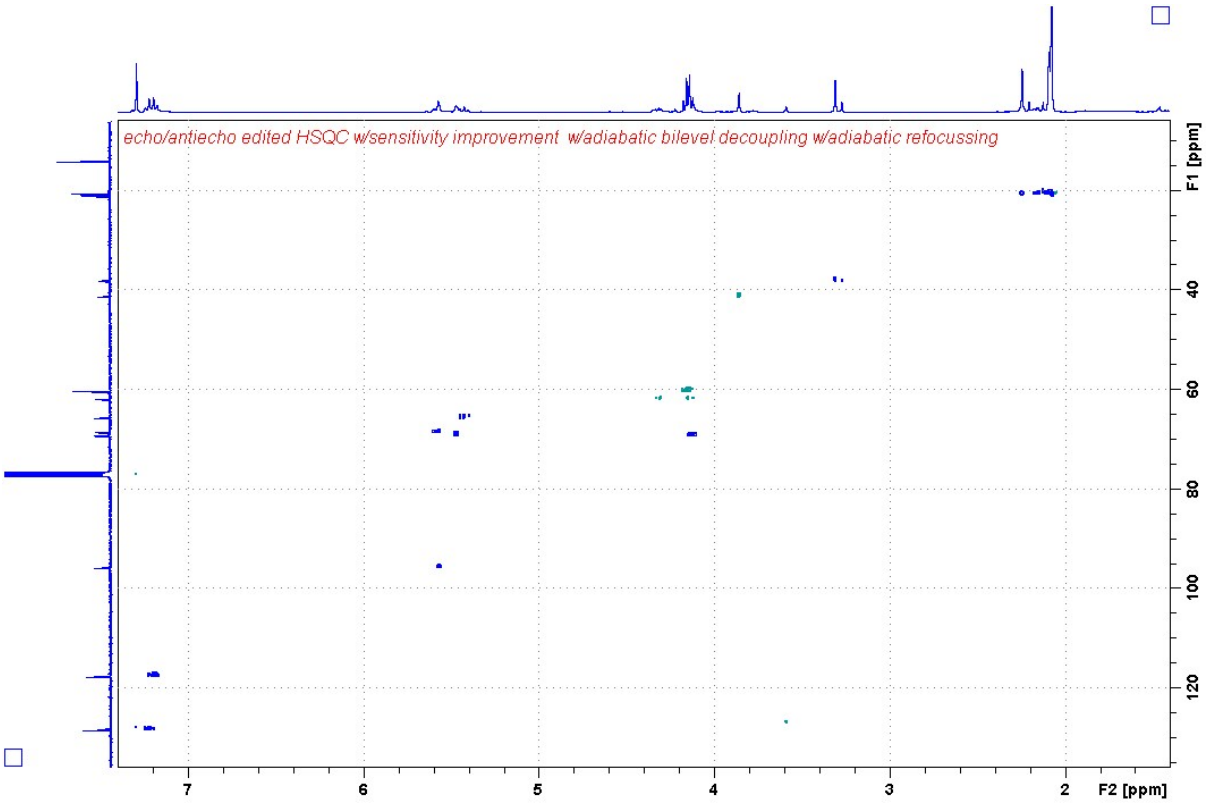


Figure S40 HSQC NMR Spectrum of **17**, $CDCl_3$, 101 MHz

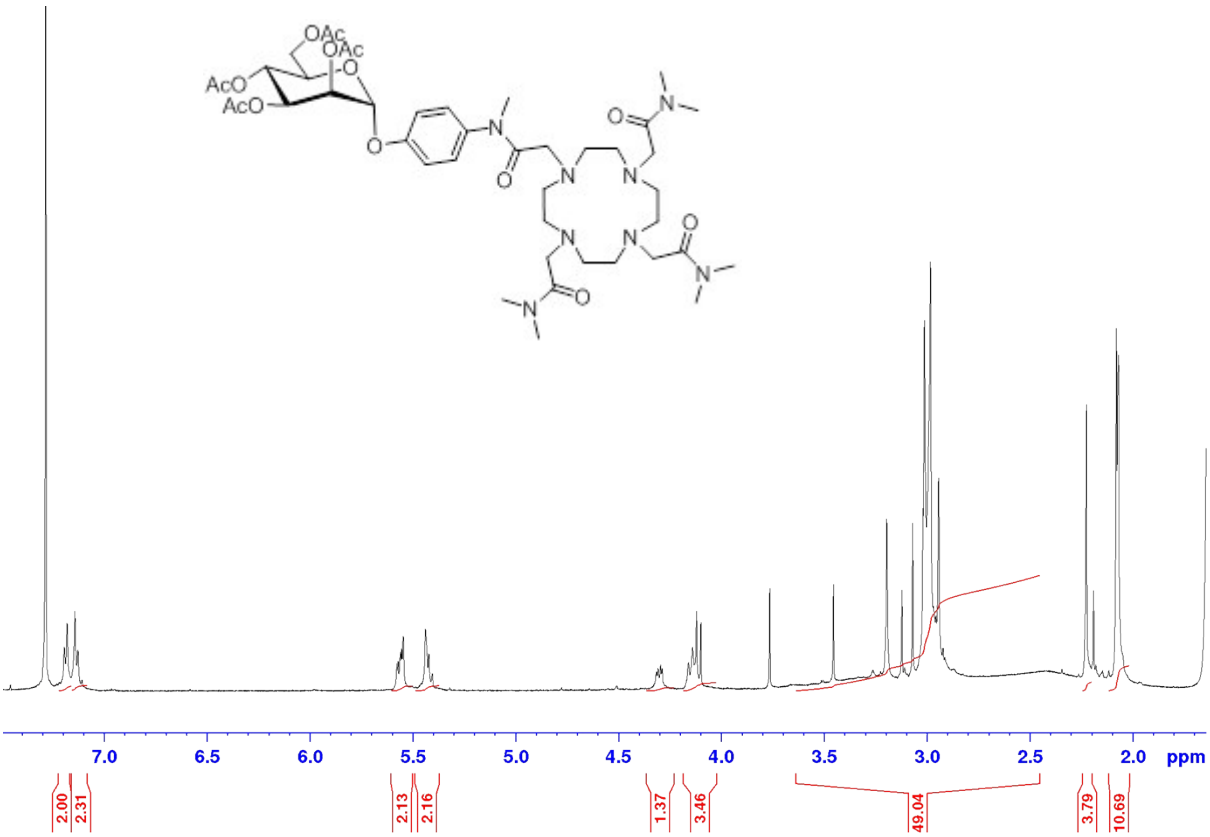


Figure S41 ^1H NMR Spectrum of **18**, $CDCl_3$, 600 MHz

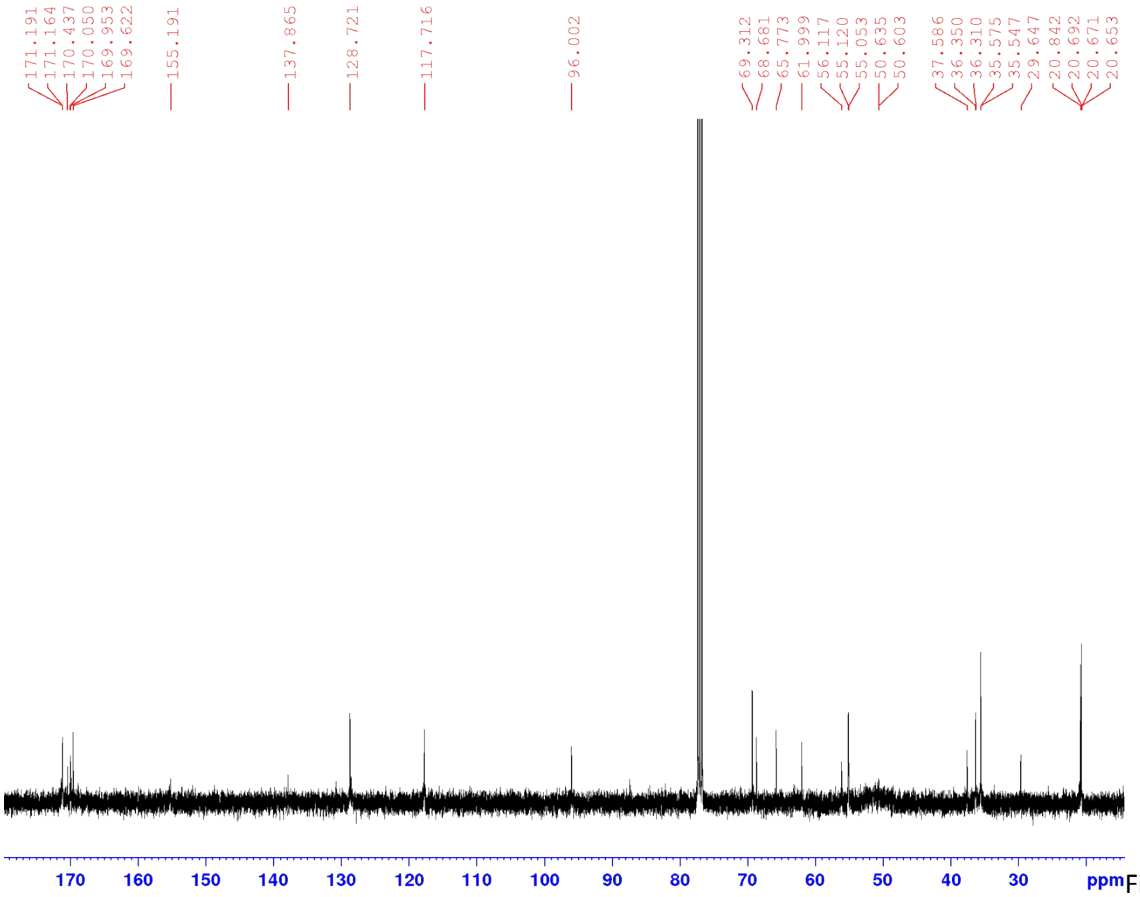


Figure S42 ^{13}C NMR Spectrum of **18**, $CDCl_3$, 101 MHz

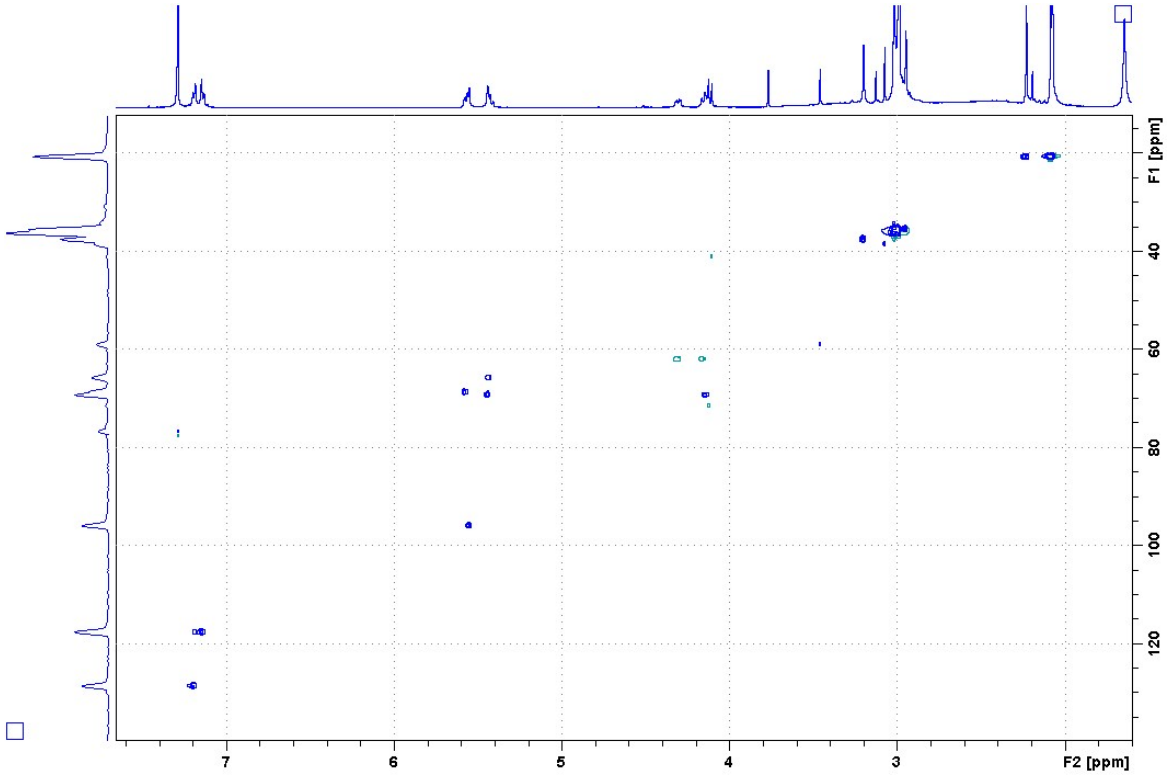


Figure S43 HSQC NMR Spectrum of **18**, $CDCl_3$, 101 MHz

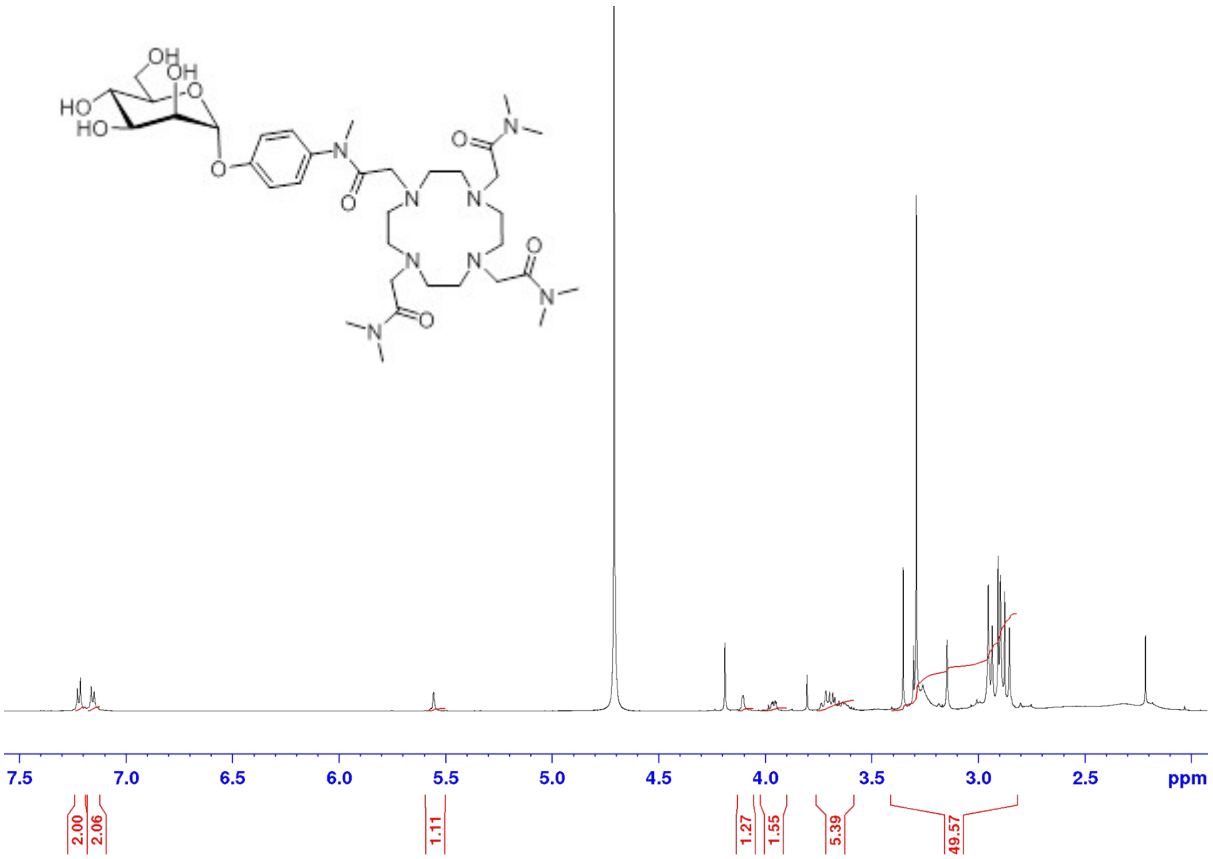


Figure S44 ^{1}H NMR Spectrum of **19**, D_2O, 600 MHz

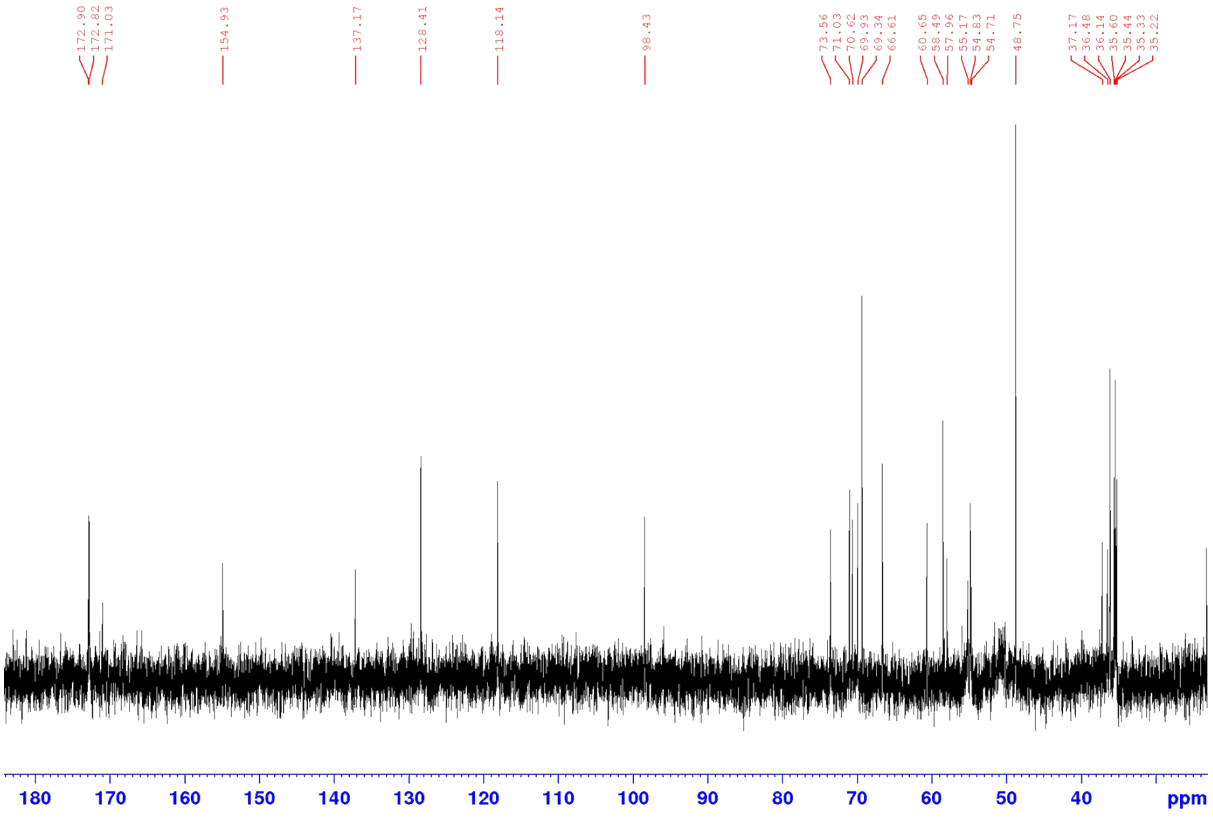


Figure S45 ^{13}C NMR Spectrum of **19**, D_2O, 101 MHz

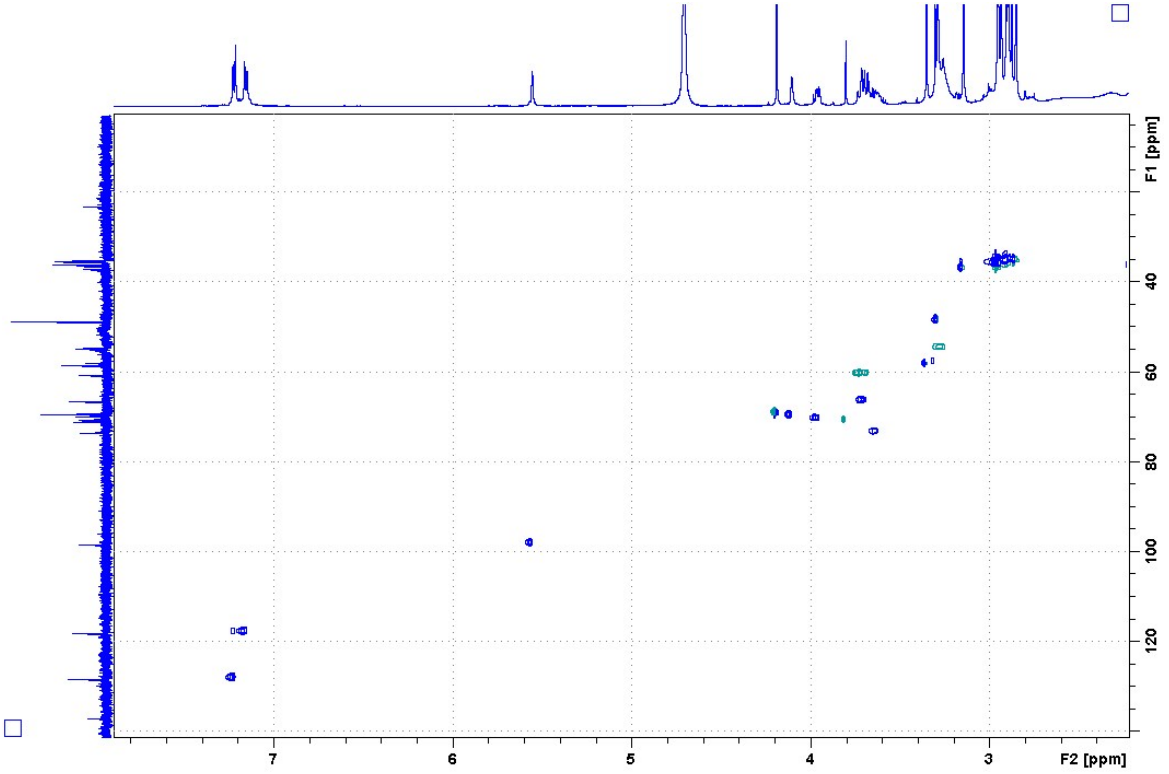


Figure S46 HSQC NMR Spectrum of **19**, $CDCl_3$, 101 MHz

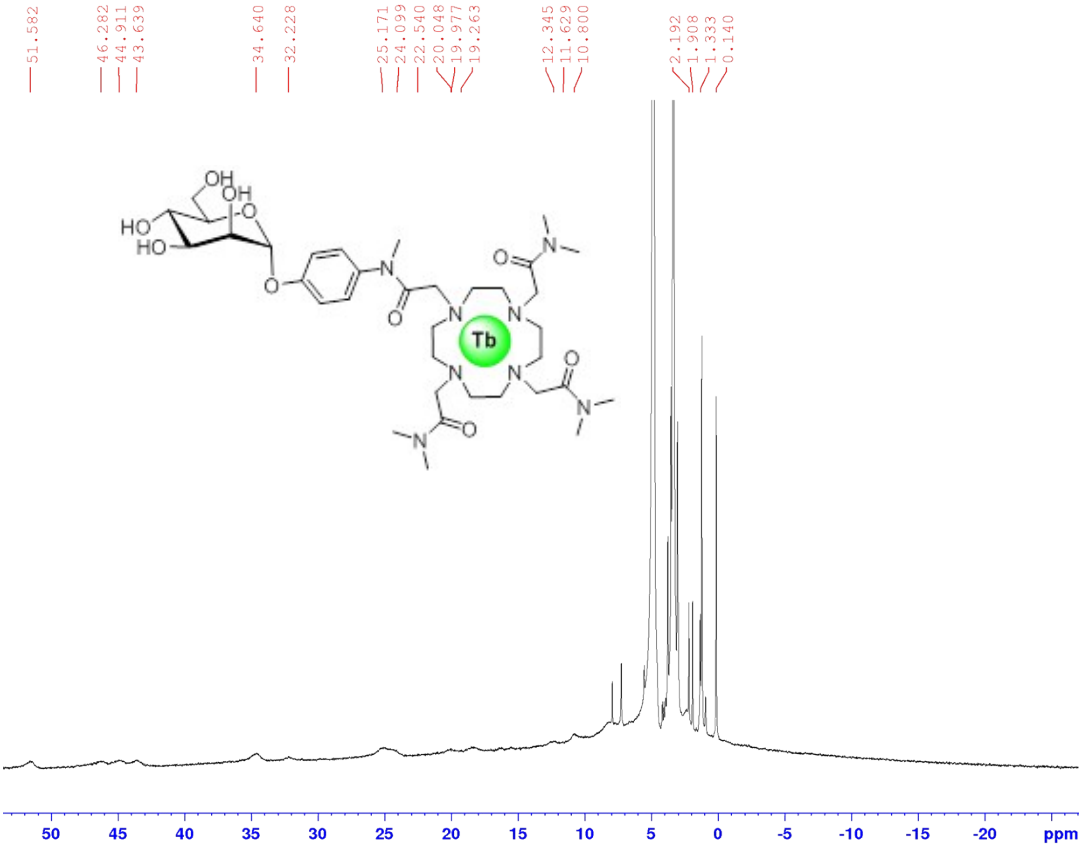


Figure S47 ^1H NMR Spectrum of **3Tb**, D_2O, 600 MHz

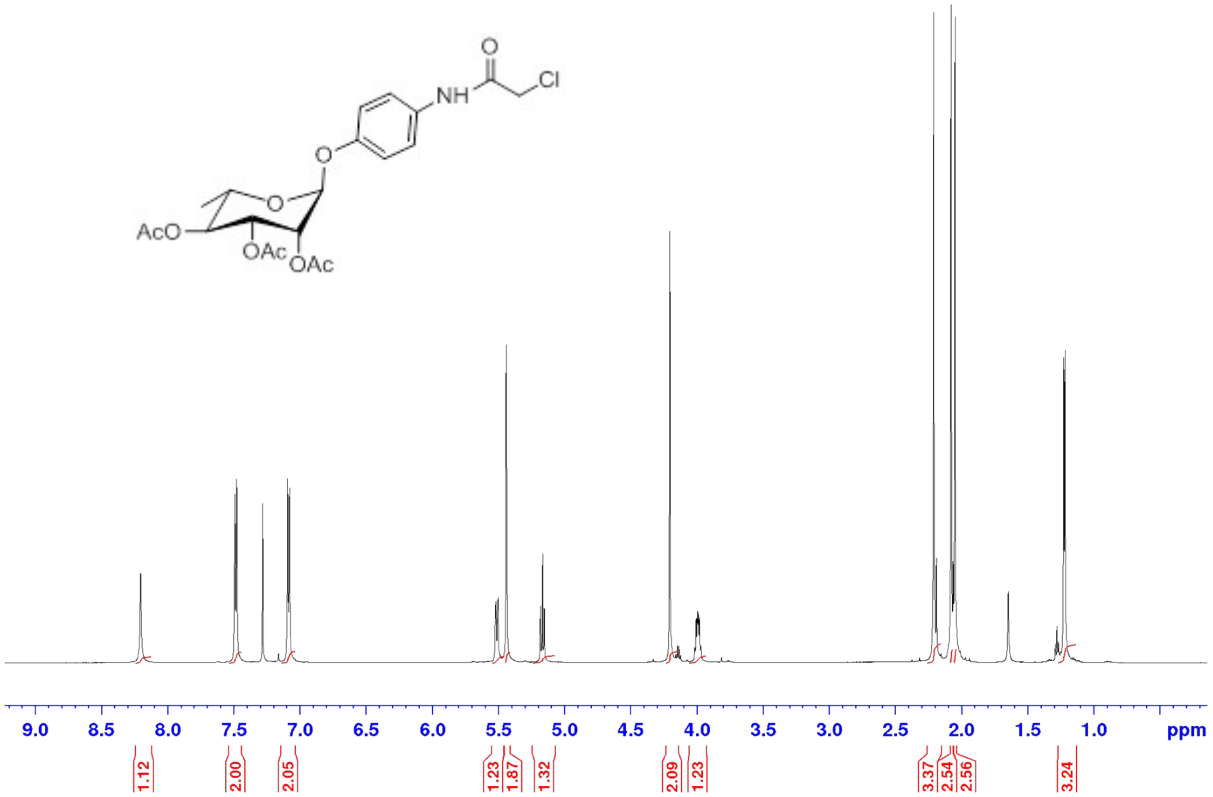


Figure S48 ^{1}H NMR Spectrum of **22**, $CDCl_3$, 600 MHz

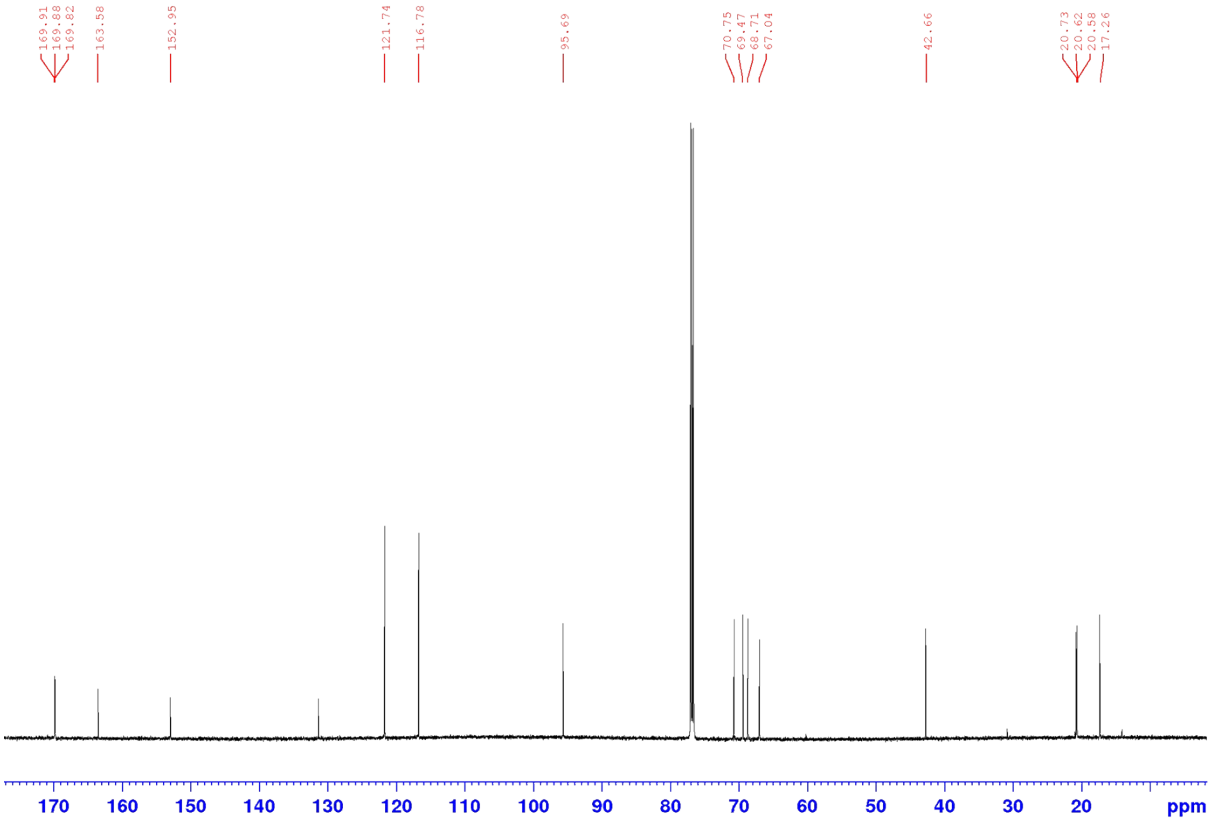


Figure S49 ^{13}C NMR Spectrum of **22**, $CDCl_3$, 101 MHz

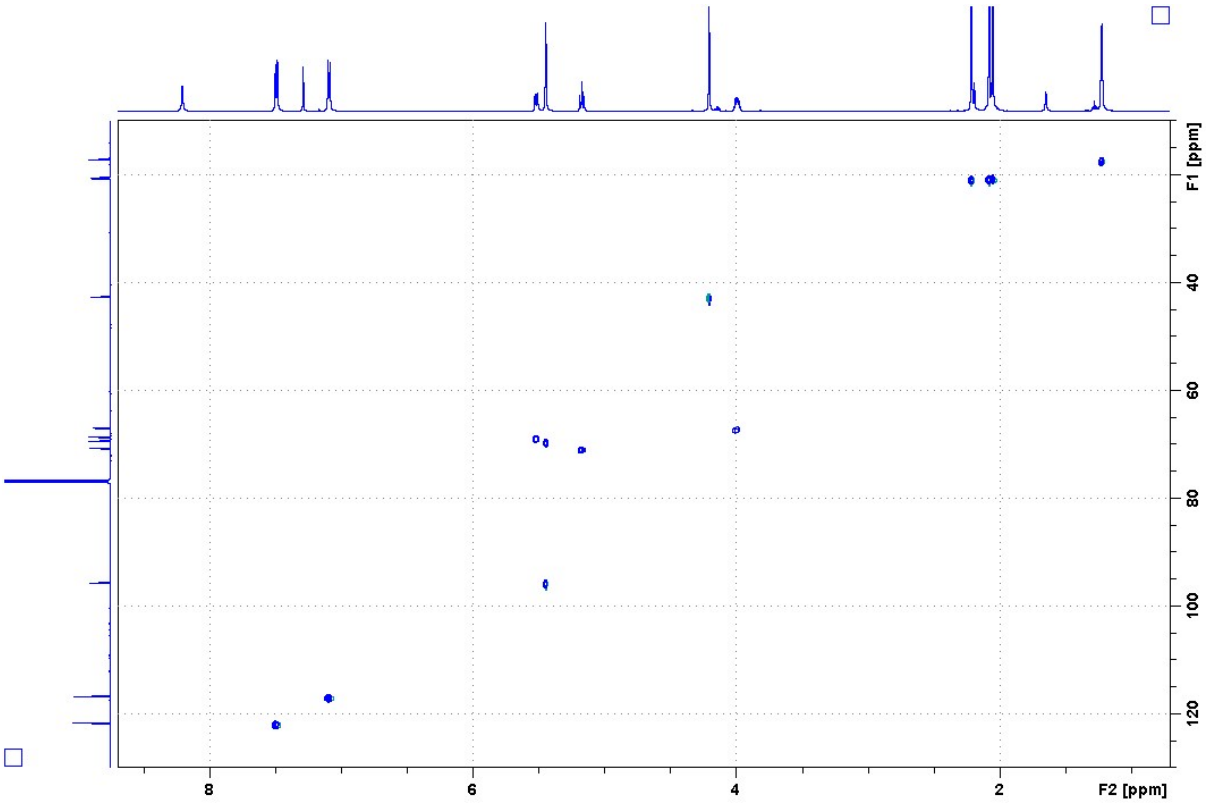


Figure S50 HSQC NMR Spectrum of **22**, $CDCl_3$, 101 MHz

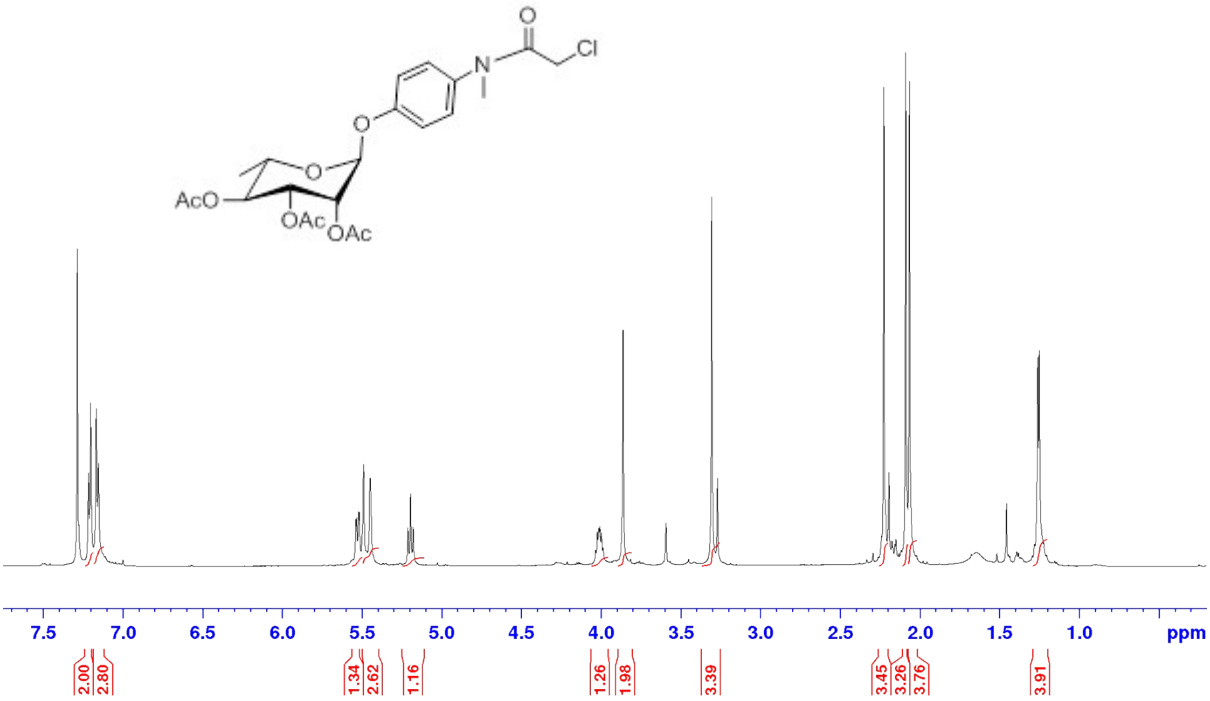


Figure S51 ^1H NMR Spectrum of **23**, $CDCl_3$, 600 MHz

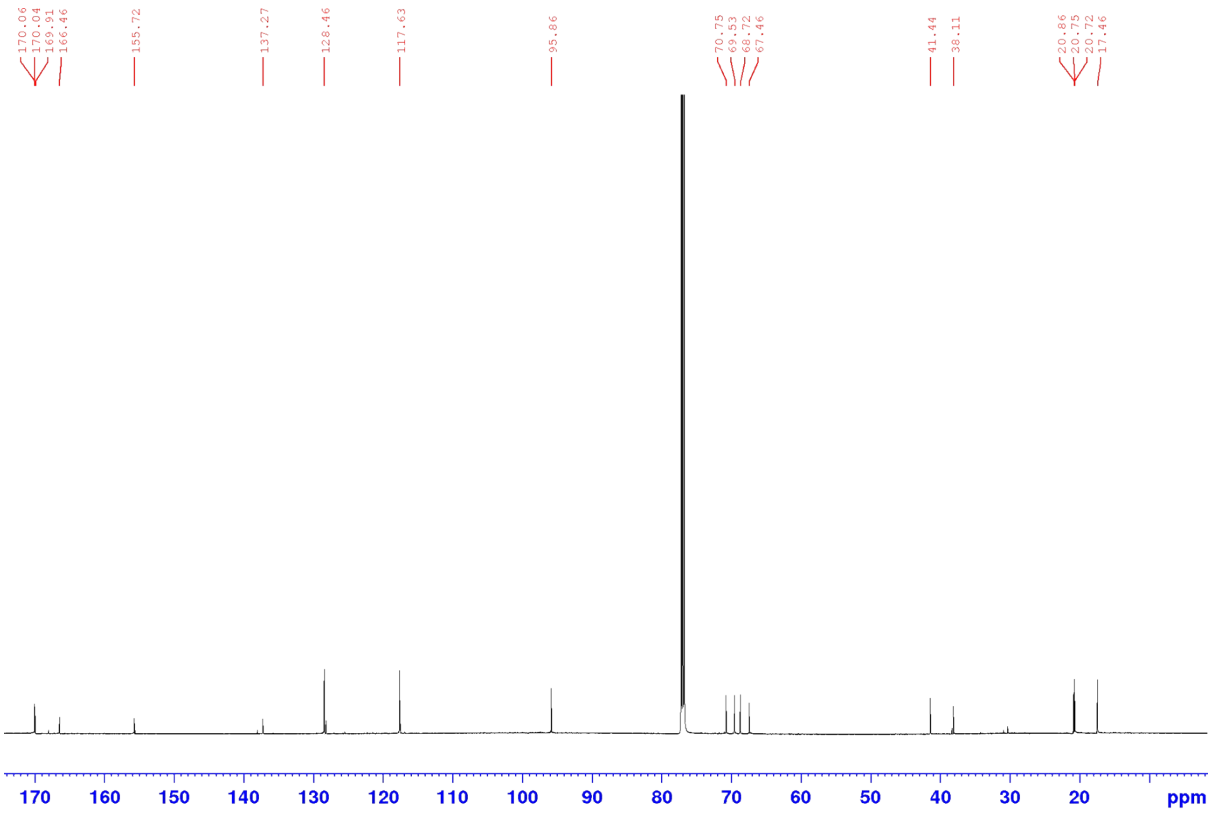


Figure S52 ^{13}C NMR Spectrum of **23**, $CDCl_3$, 101 MHz

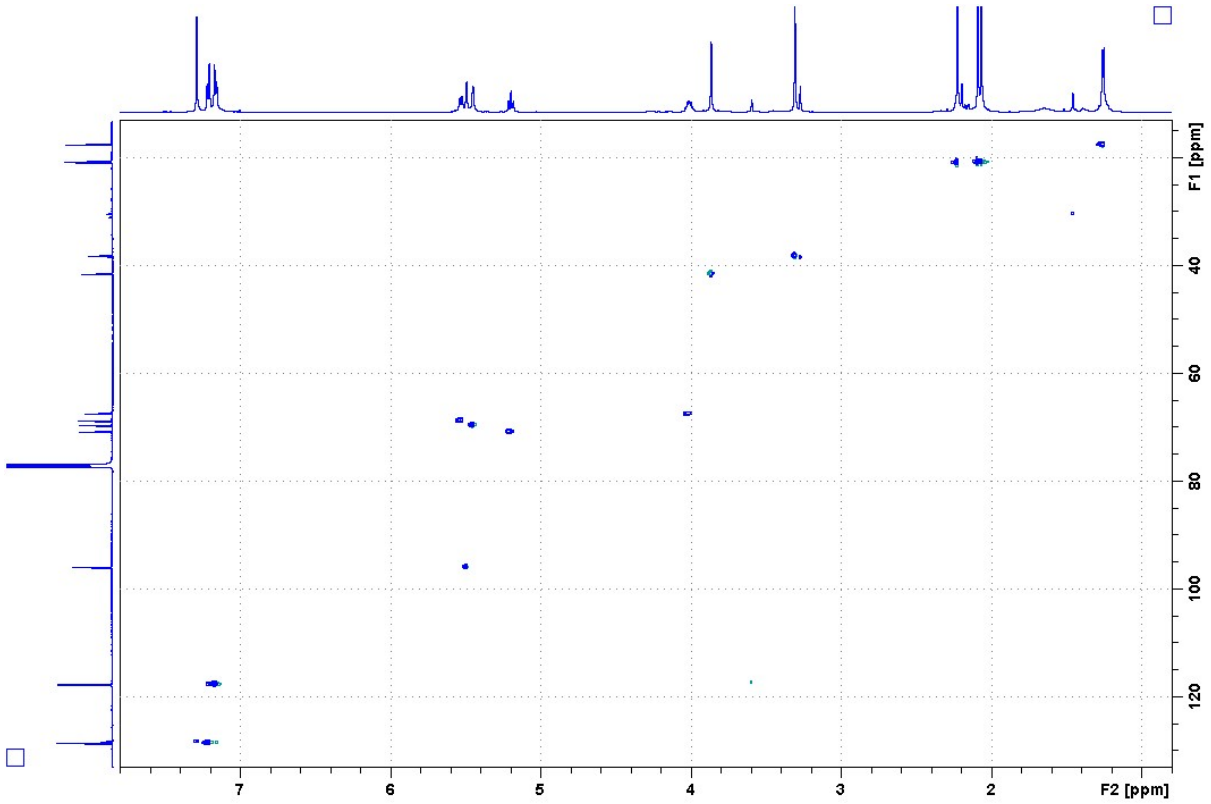


Figure S53 HSQC NMR Spectrum of **23**, $CDCl_3$, 101 MHz

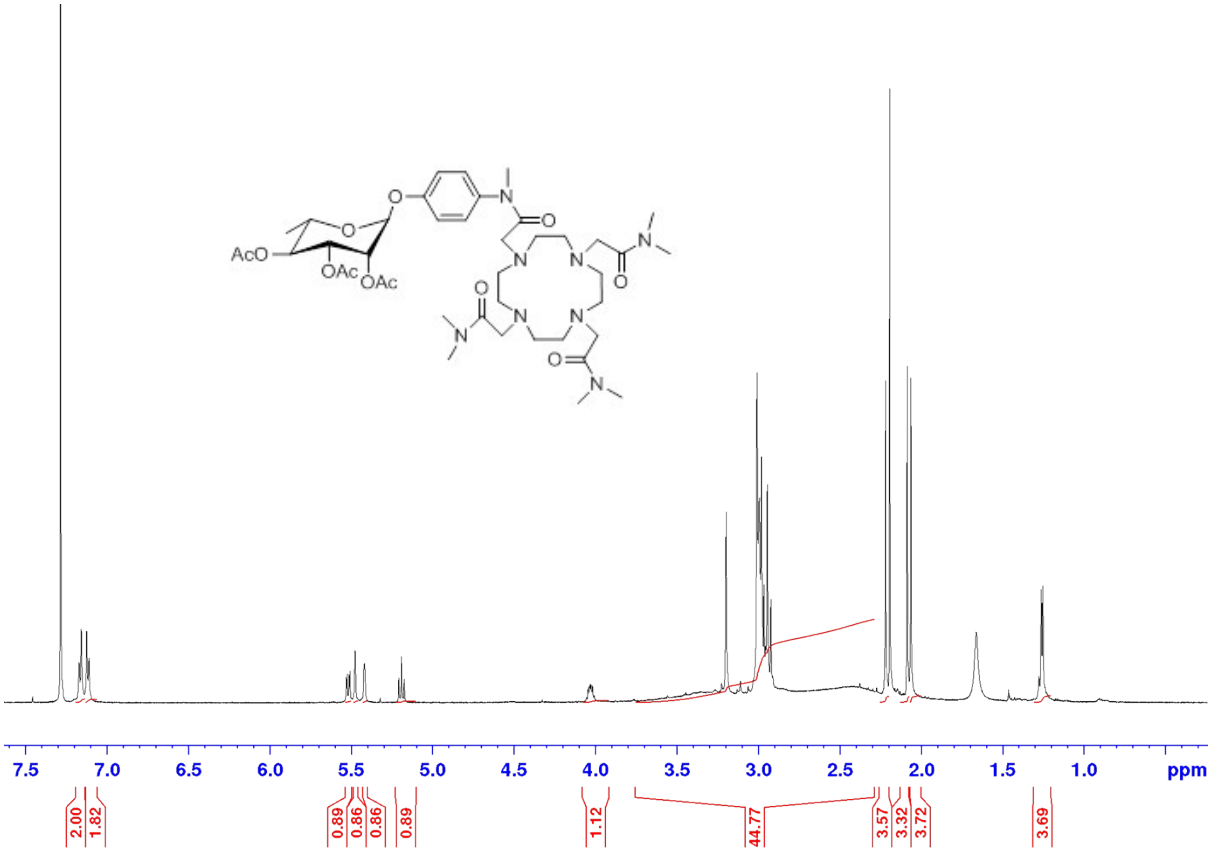


Figure S54 ^{1}H NMR Spectrum of **24**, $CDCl_3$, 600 MHz

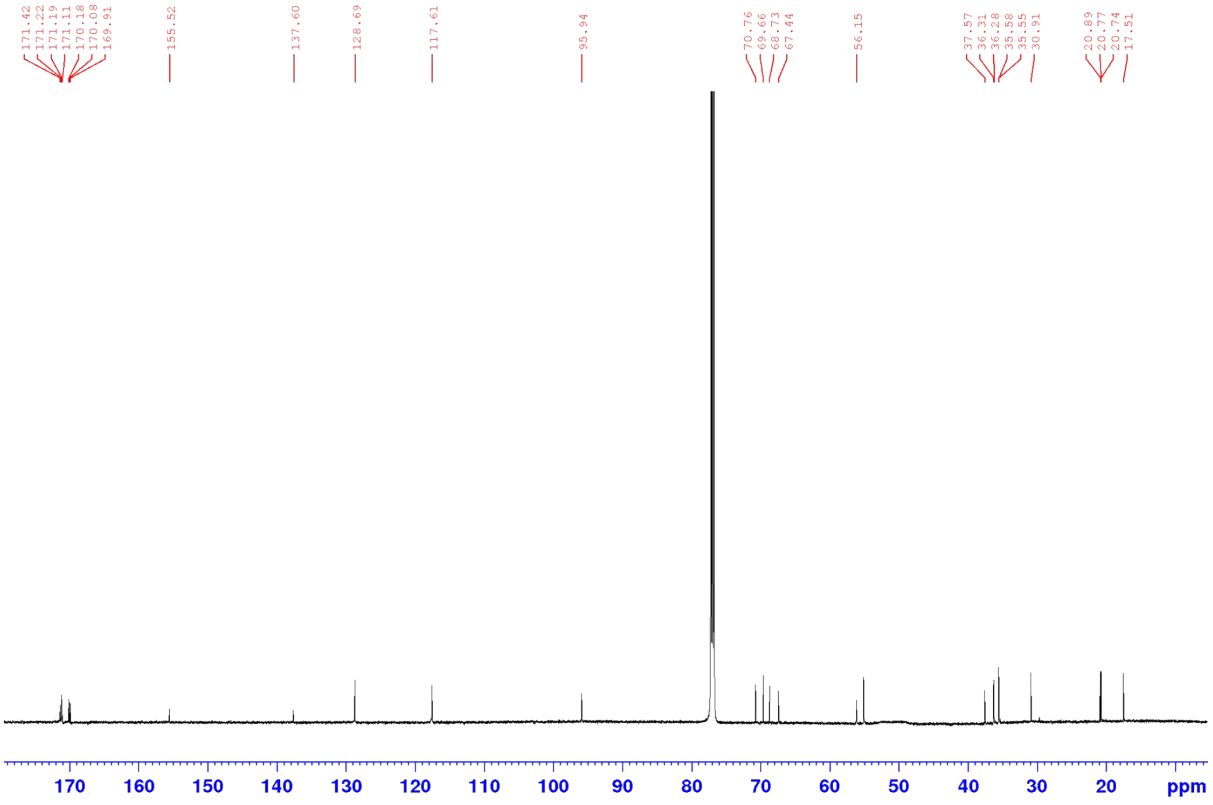


Figure S55 ^{13}C NMR Spectrum of **24**, $CDCl_3$, 101 MHz

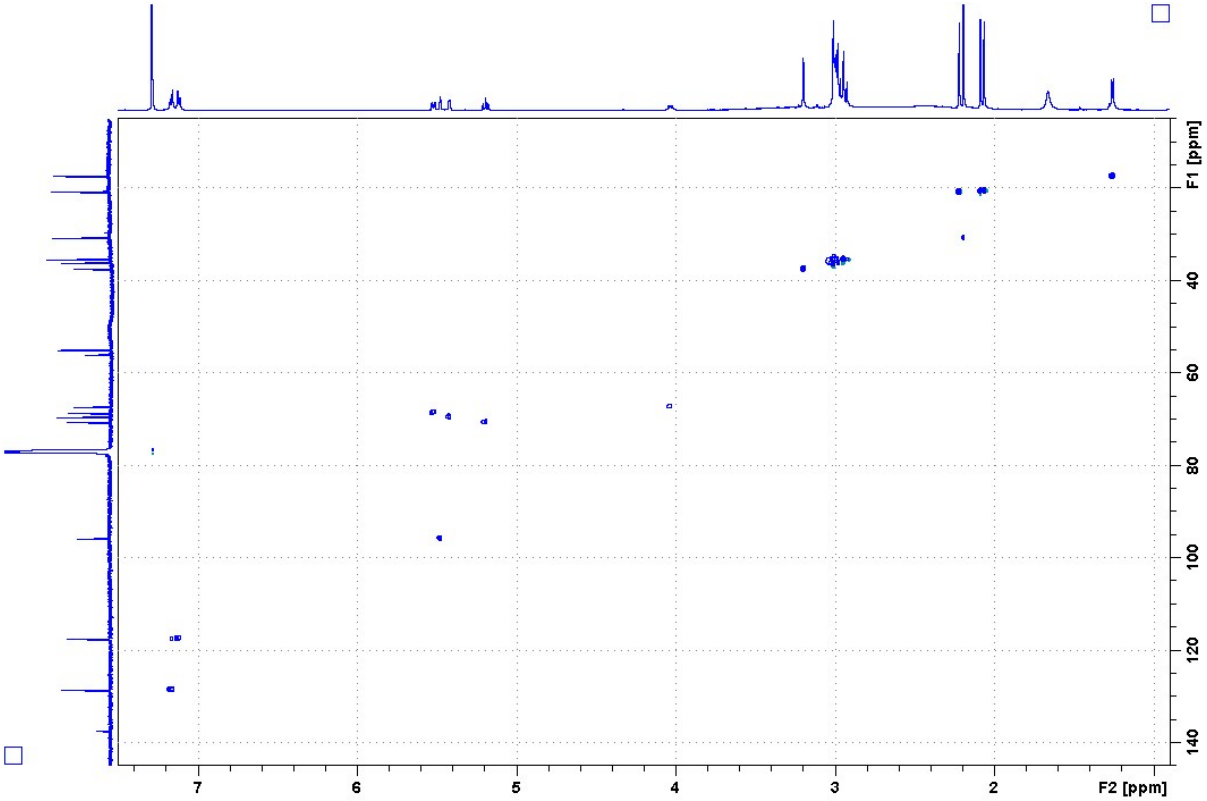


Figure S56 HSQC NMR Spectrum of **24**, $CDCl_3$, 101 MHz

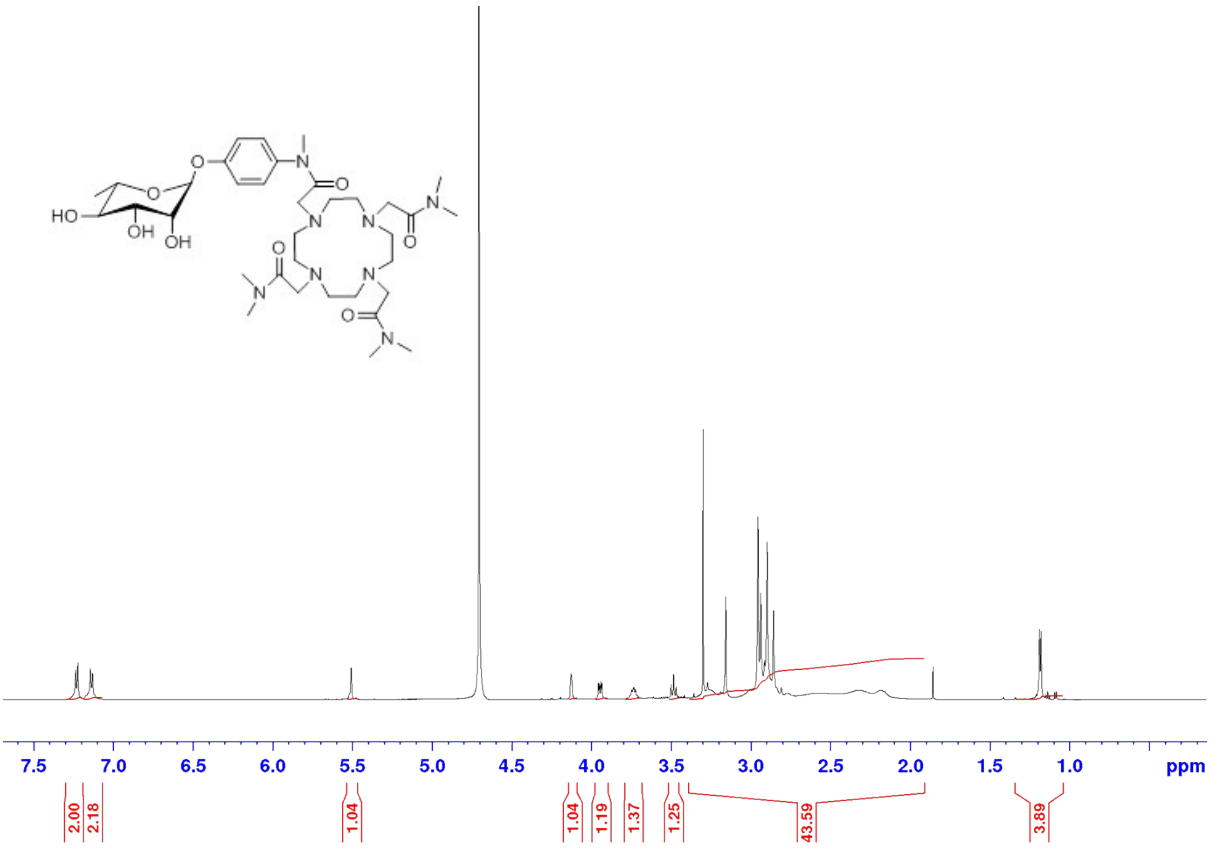


Figure S57 ^1H NMR Spectrum of **25**, D_2O, 600 MHz

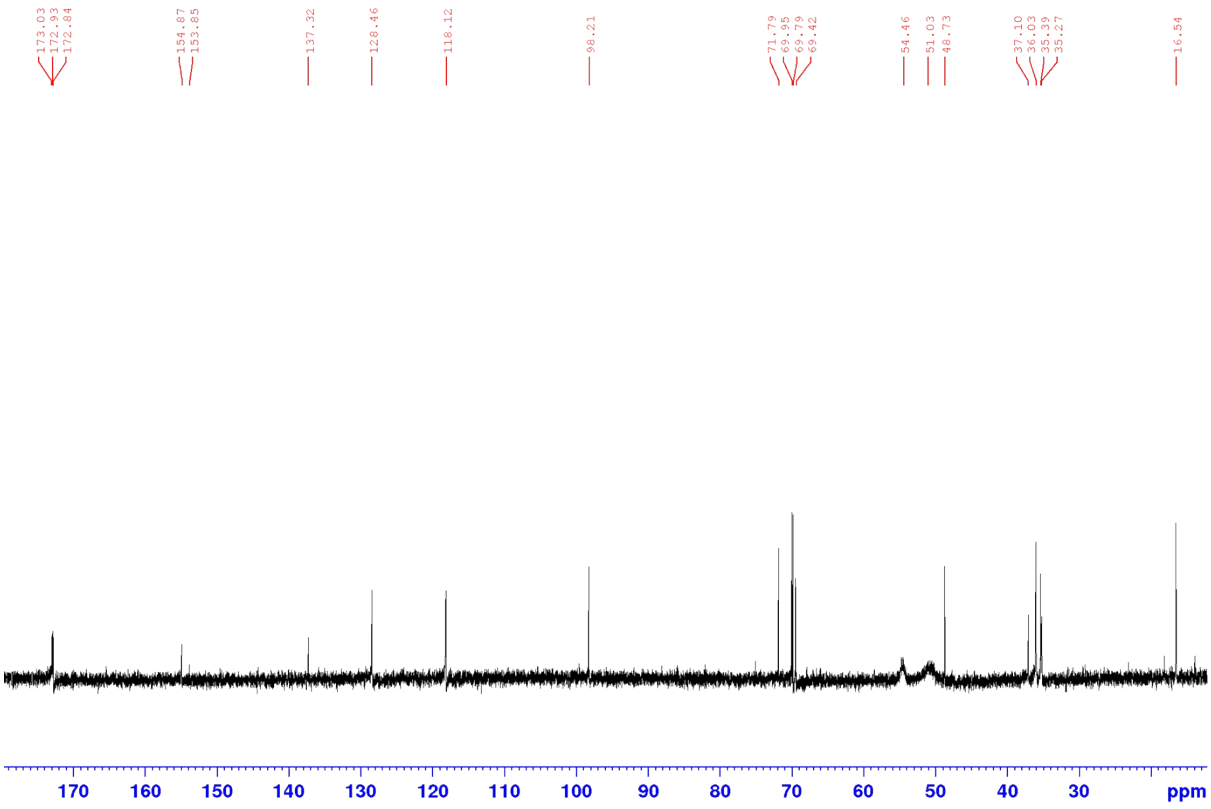


Figure S58 ^{13}C NMR Spectrum of **25**, D_2O, 101 MHz

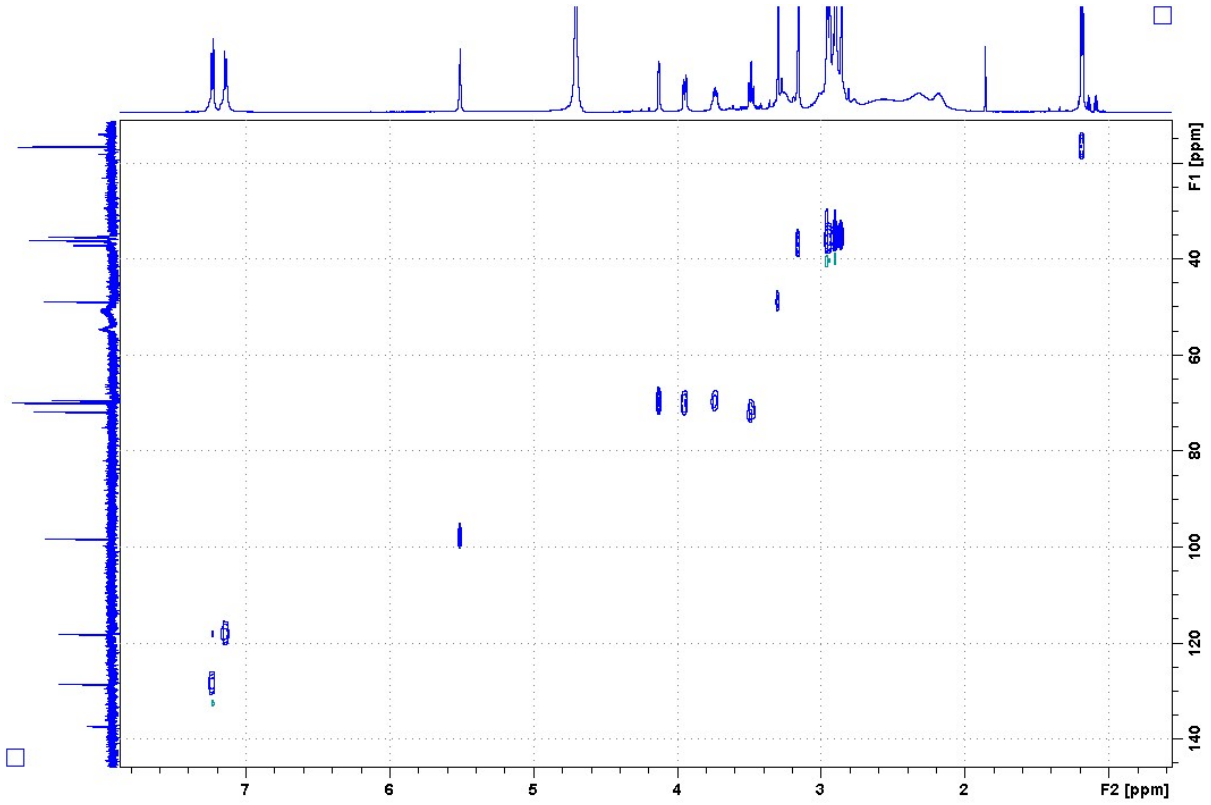


Figure S59 HSQC NMR Spectrum of **25**, D_2O, 101 MHz

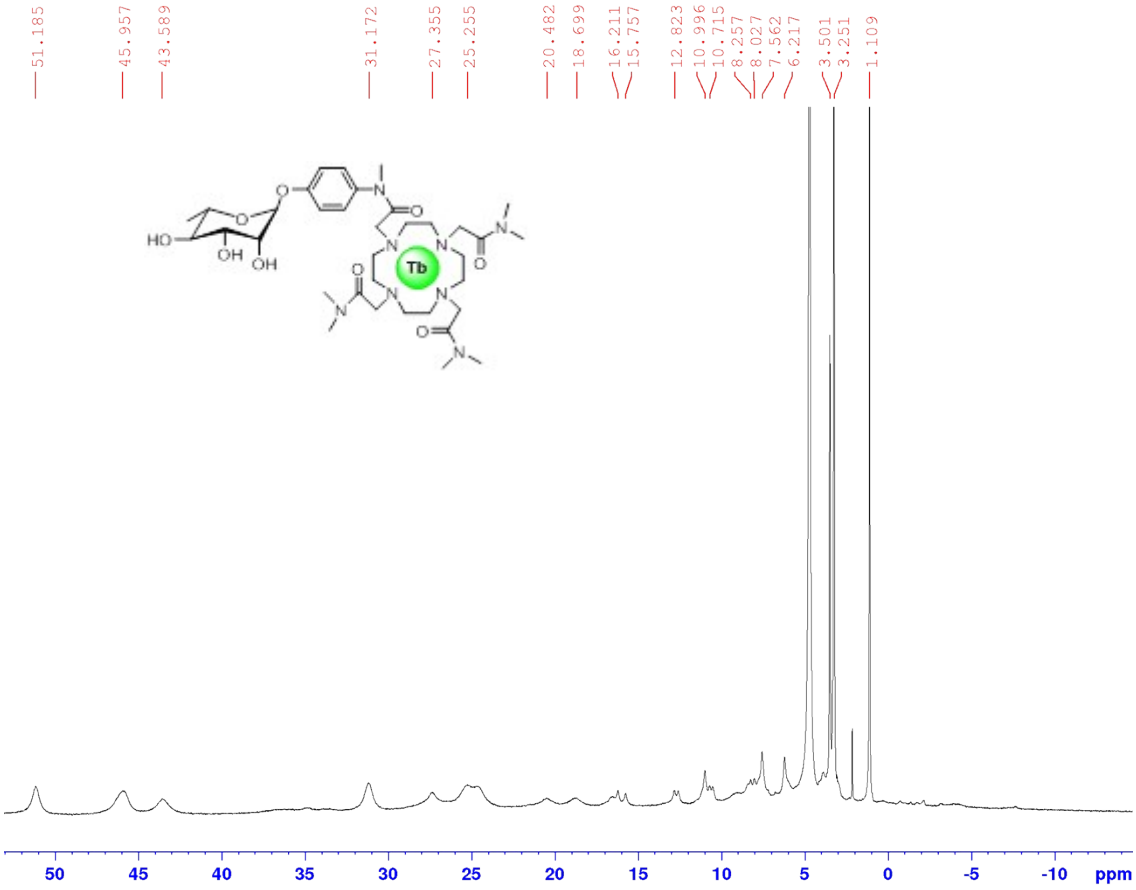


Figure S60 ^{1}H NMR Spectrum of **4Tb**, D_2O, 400 MHz

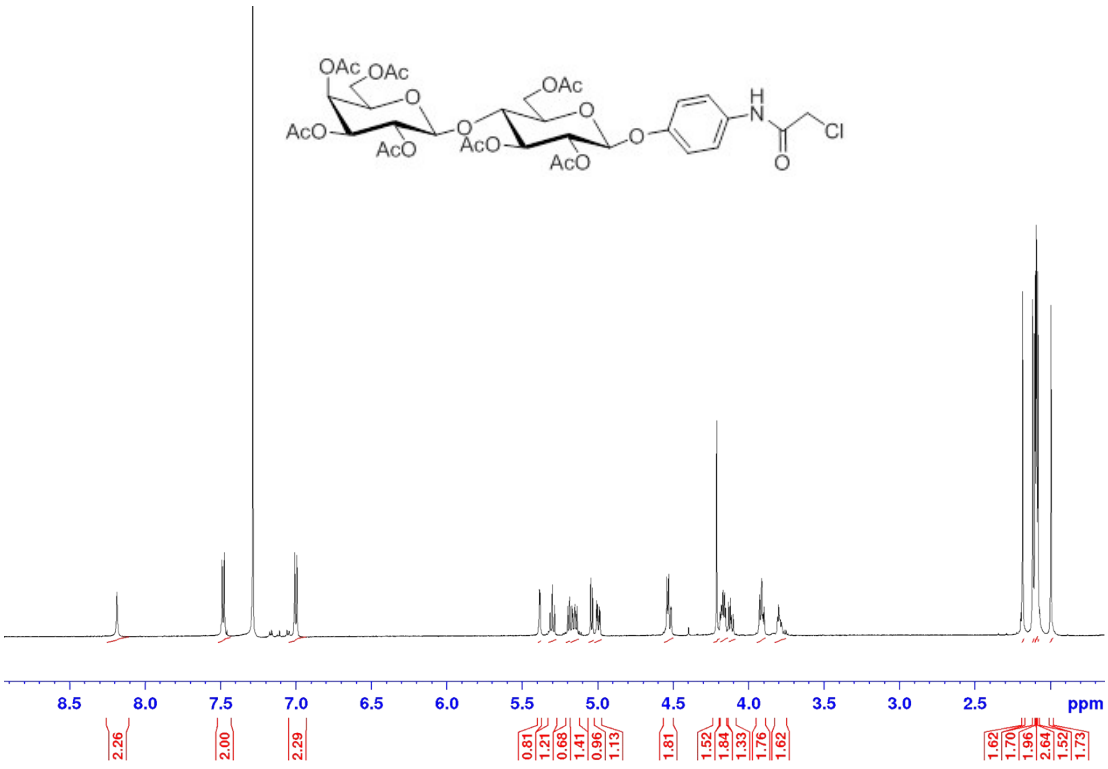


Figure S61 ^{1}H NMR Spectrum of **29**, $CDCl_3$, 600 MHz

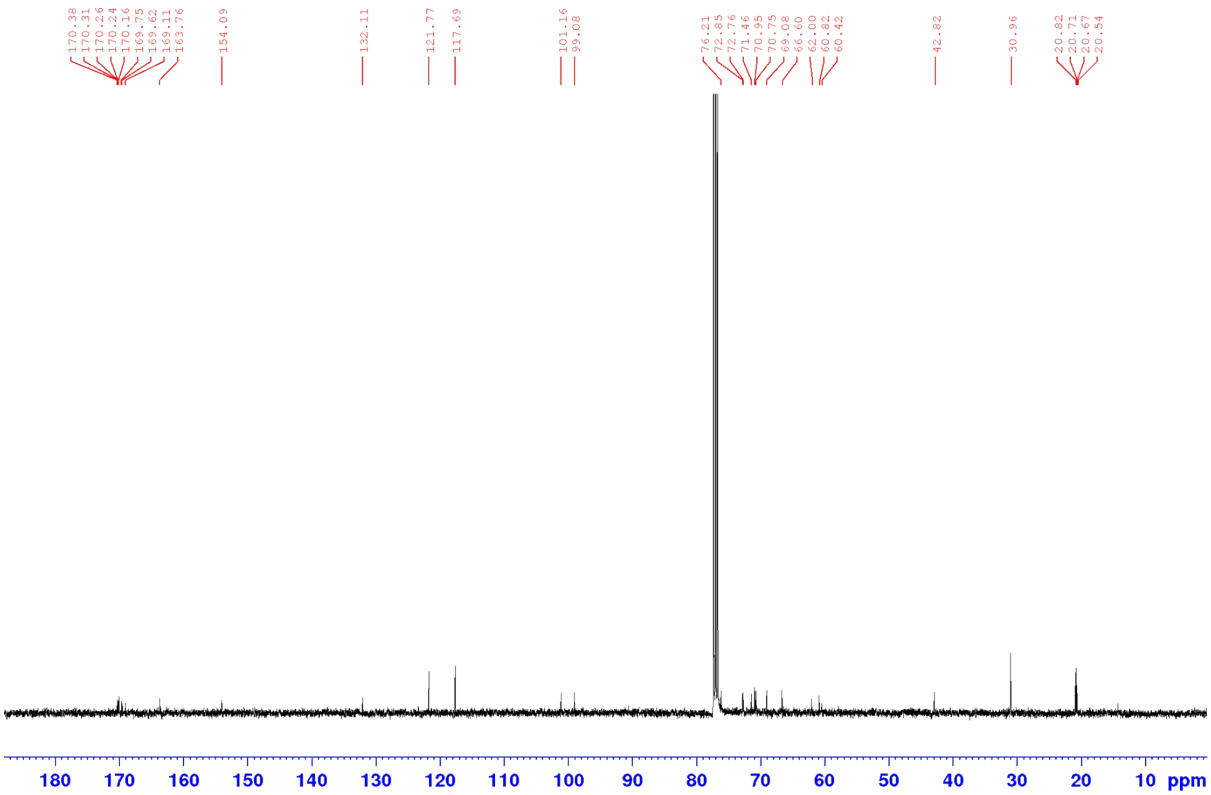


Figure S62 ^{13}C NMR Spectrum of **29**, $CDCl_3$, 101 MHz

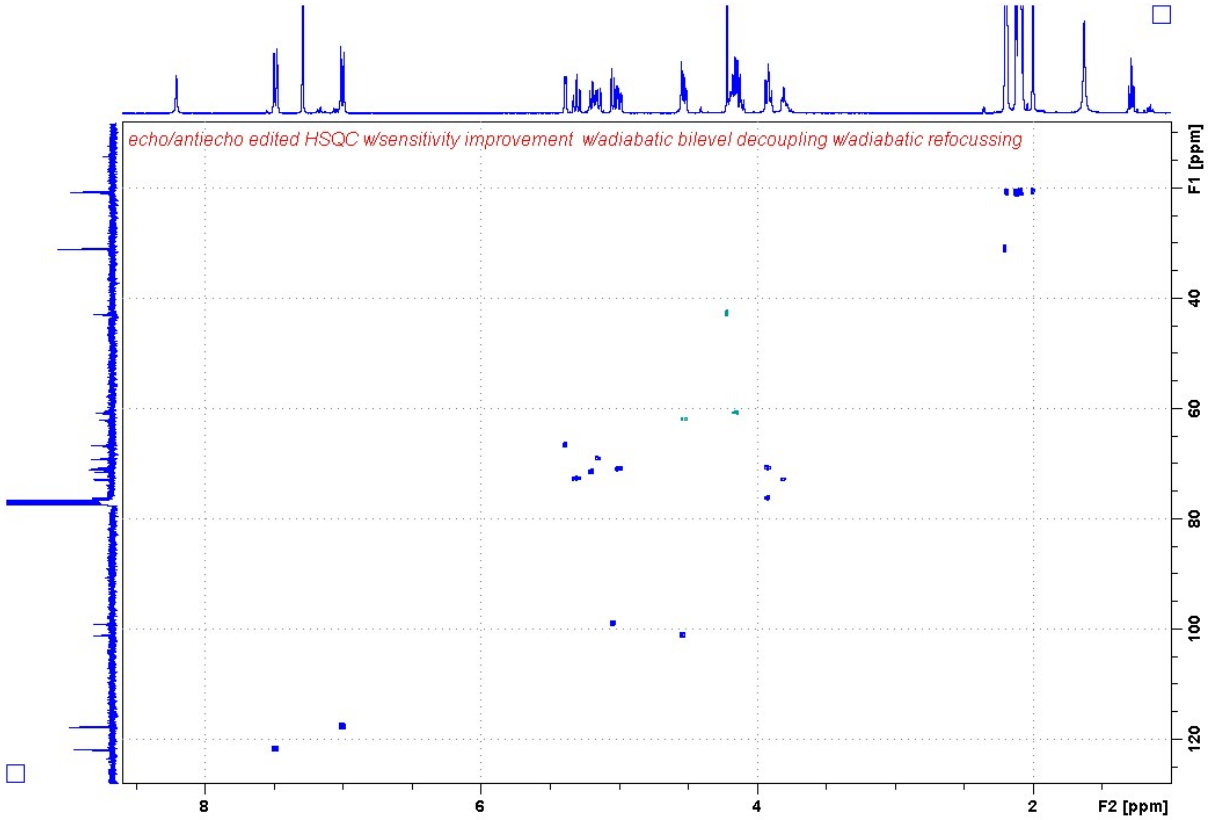


Figure S63 HSQC NMR Spectrum of **29**, $CDCl_3$, 101 MHz

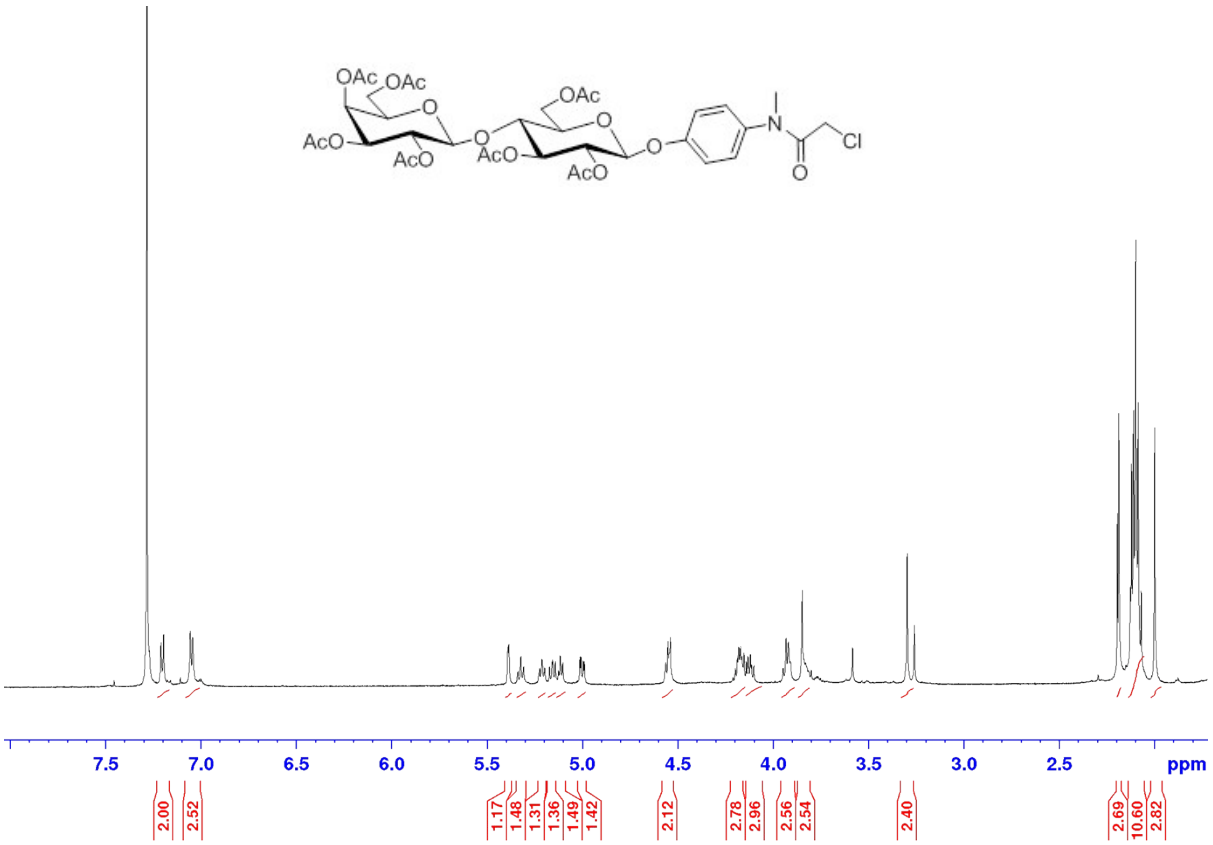


Figure S64 ^{1}H NMR Spectrum of **30**, $CDCl_3$, 600 MHz

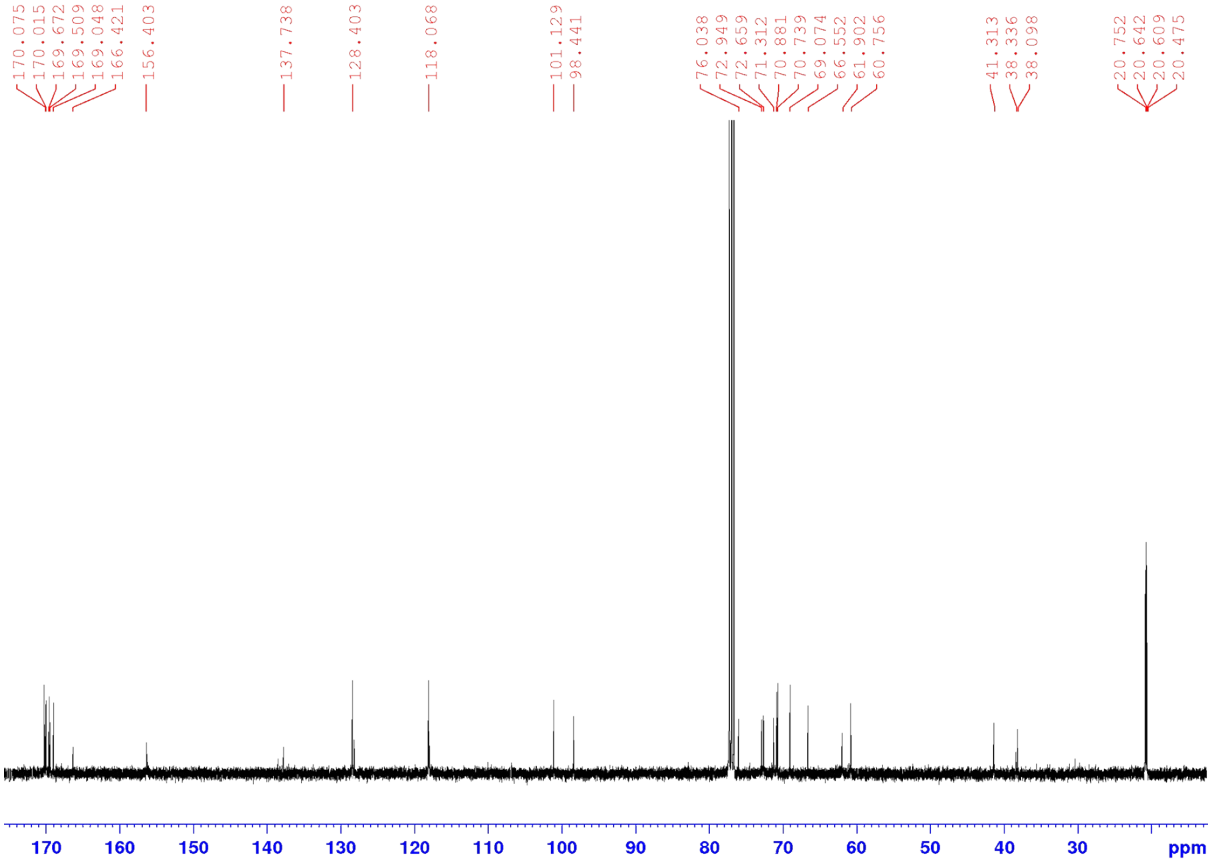


Figure S65 ^{13}C NMR Spectrum of **30**, $CDCl_3$, 101 MHz

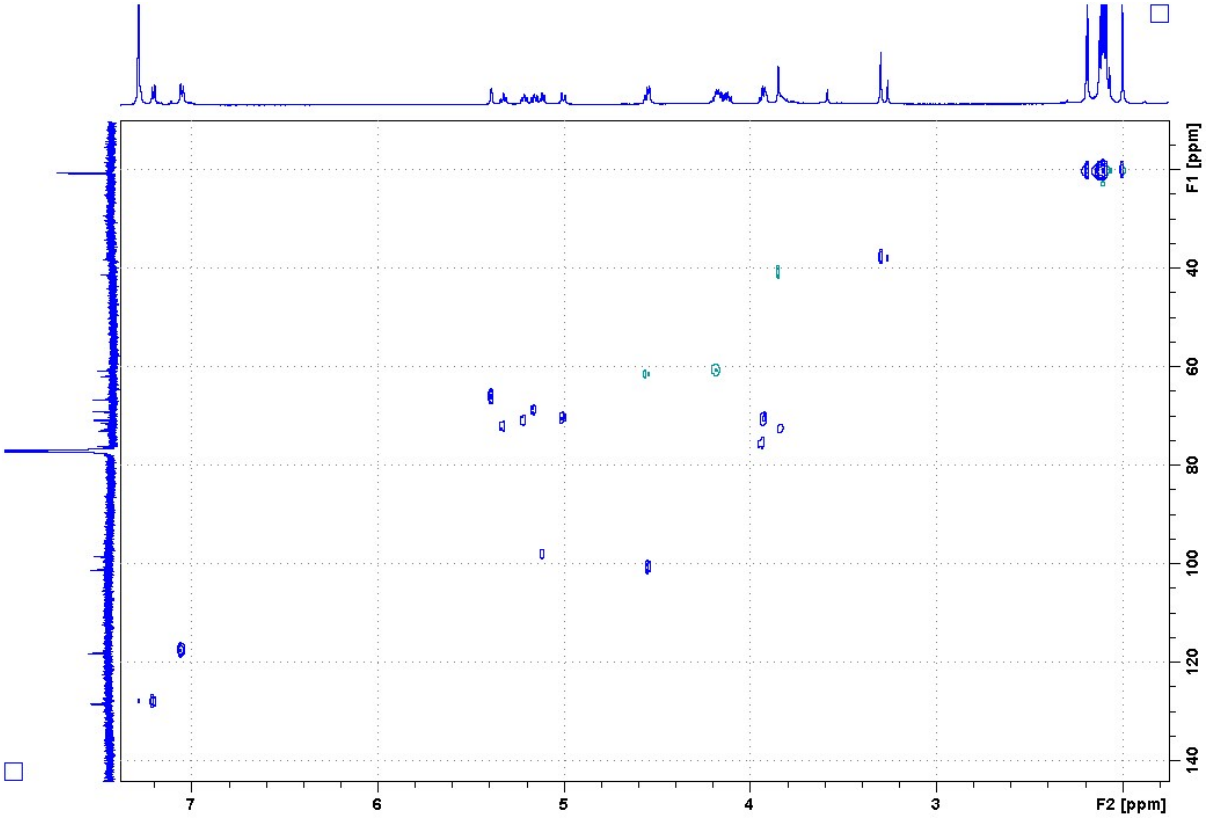


Figure S66 HSQC NMR Spectrum of **30**, $CDCl_3$, 101 MHz

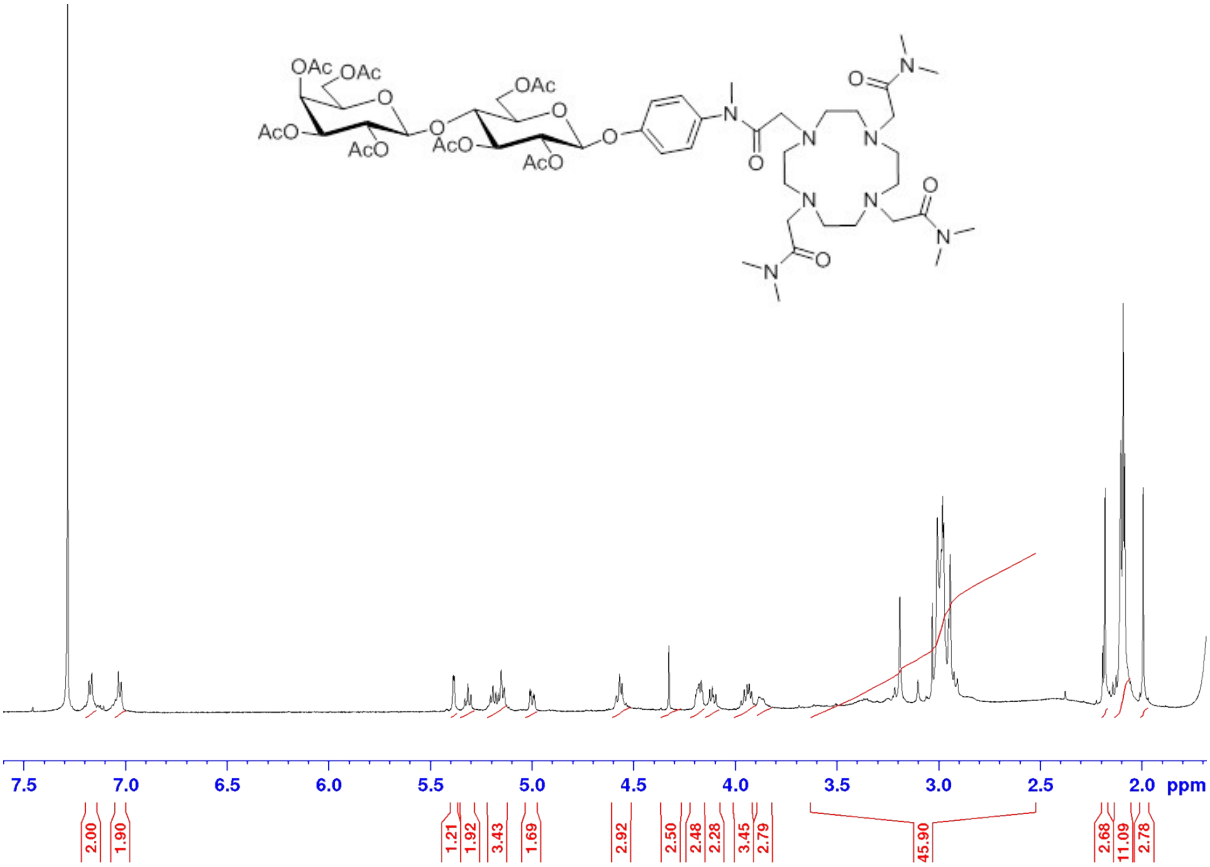


Figure S67 ^1H NMR Spectrum of **31**, $CDCl_3$, 600 MHz

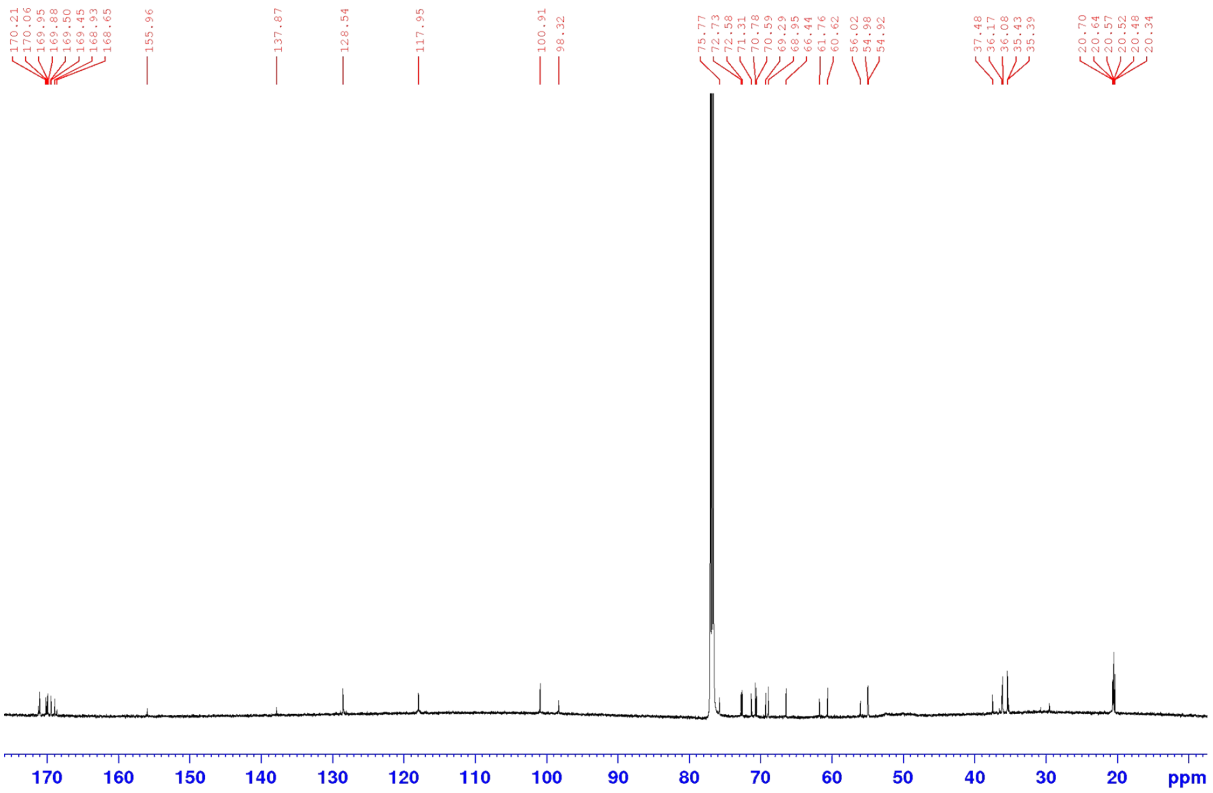


Figure S68 ^{13}C NMR Spectrum of **31**, $CDCl_3$, 101 MHz

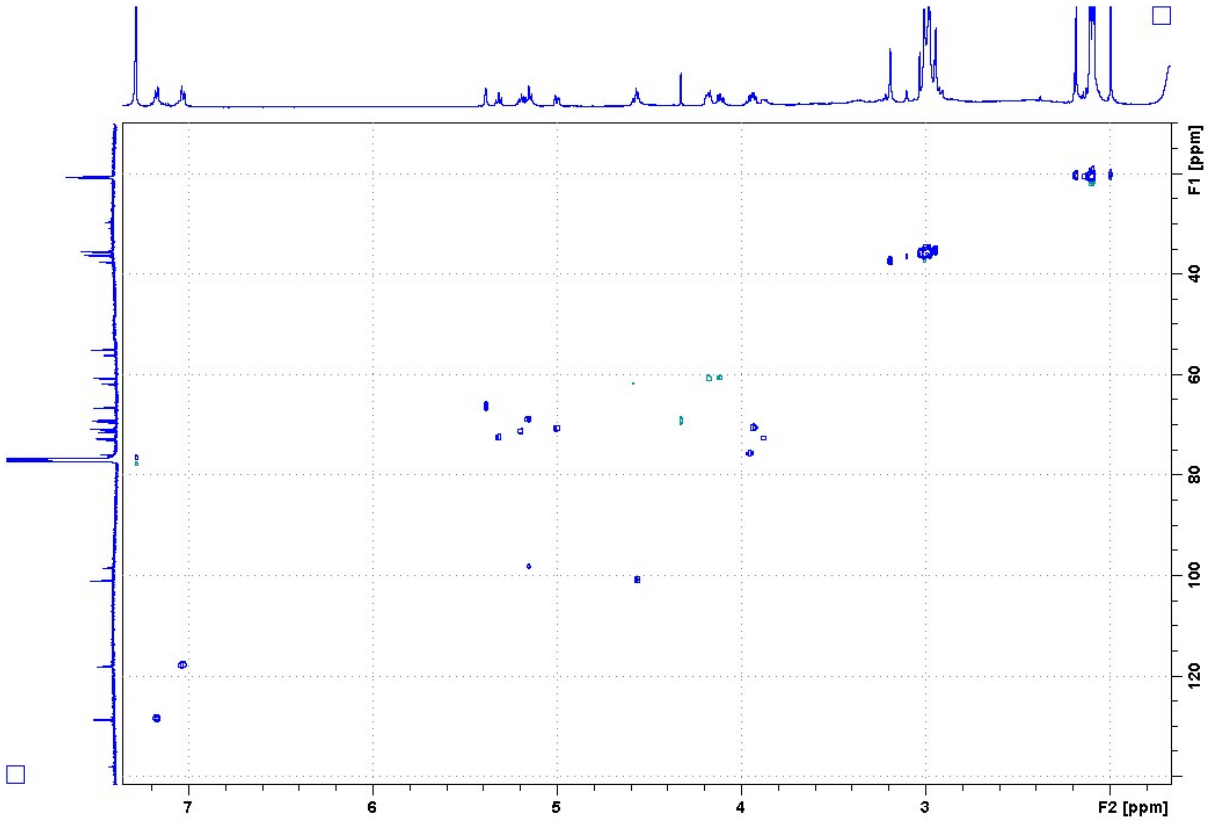


Figure S69 HSQC NMR Spectrum of **31**, $CDCl_3$, 101 MHz

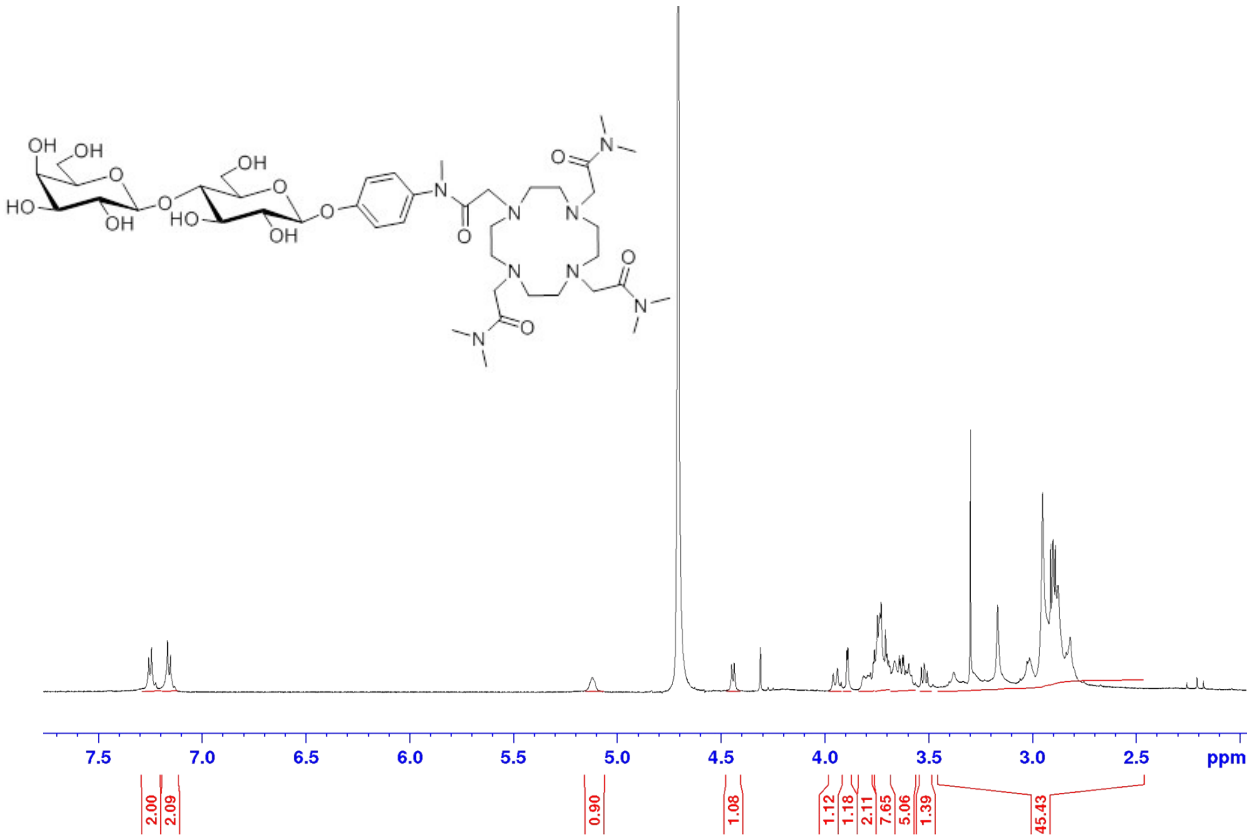


Figure S70 ^{1}H NMR Spectrum of **32**, $CDCl_3$, 600 MHz

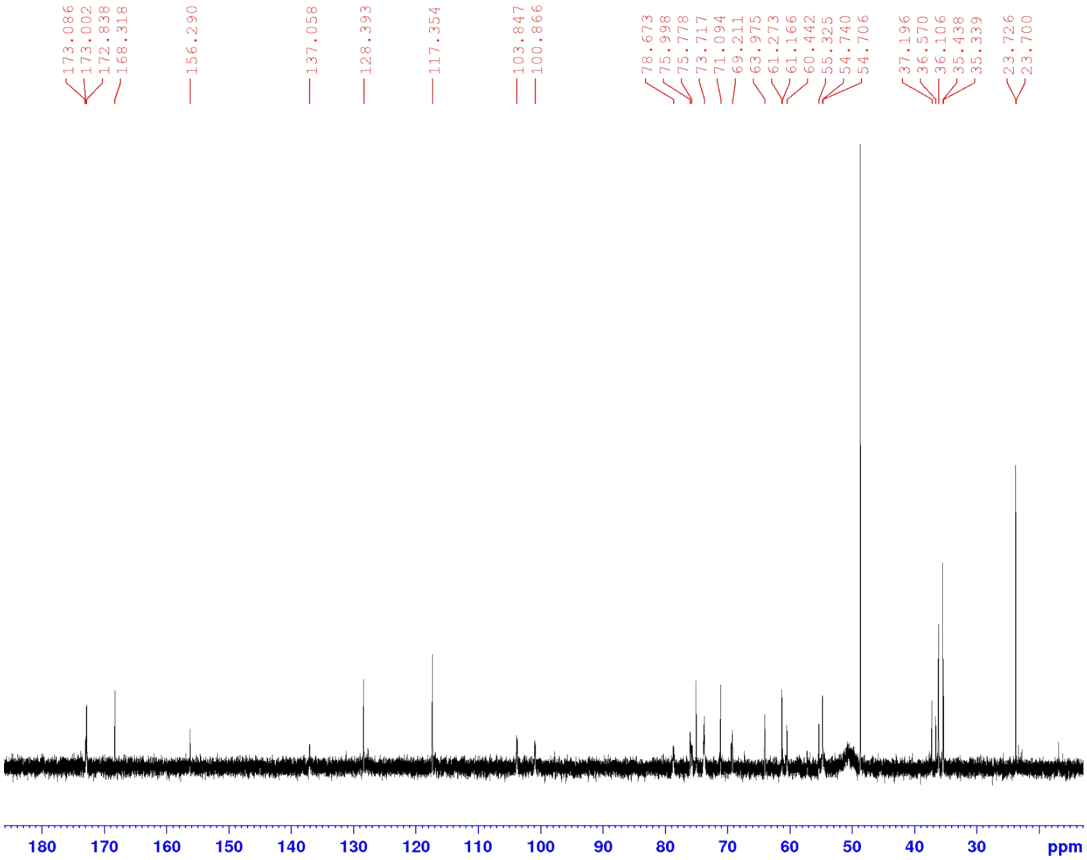


Figure S71 ^{13}C NMR Spectrum of **32**, $CDCl_3$, 101 MHz

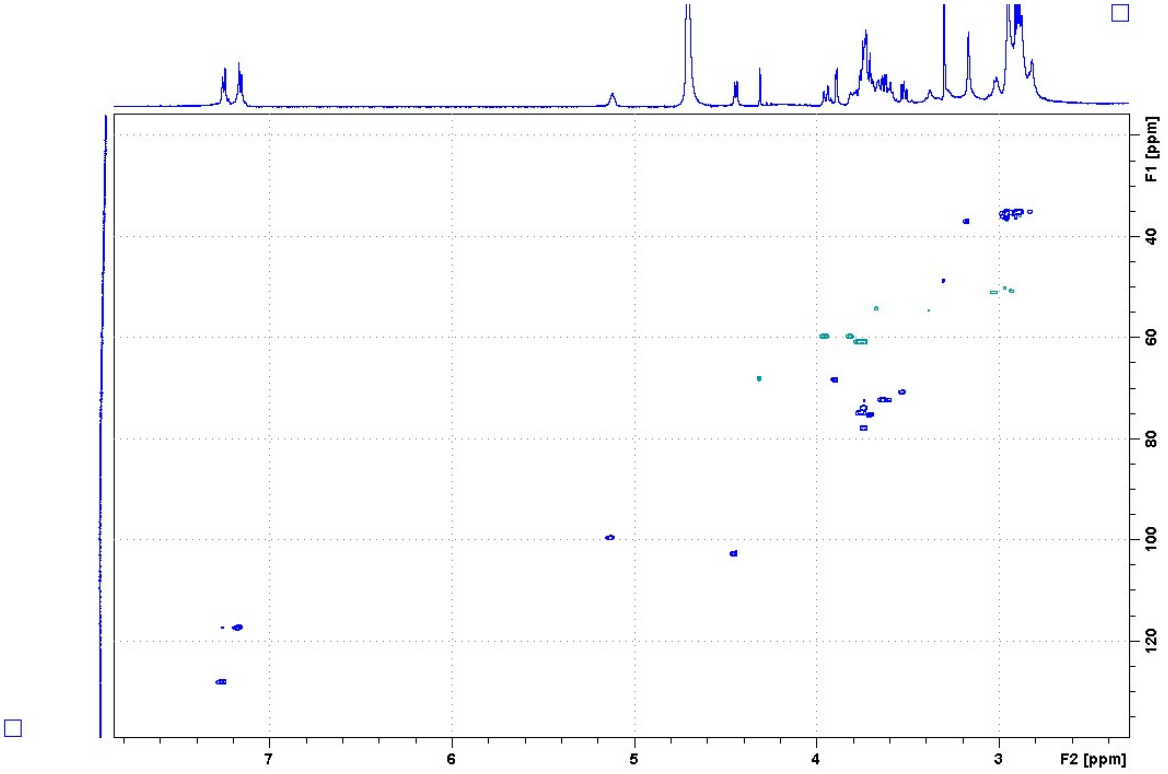


Figure S72 HSQC NMR Spectrum of **32**, $CDCl_3$, 101 MHz

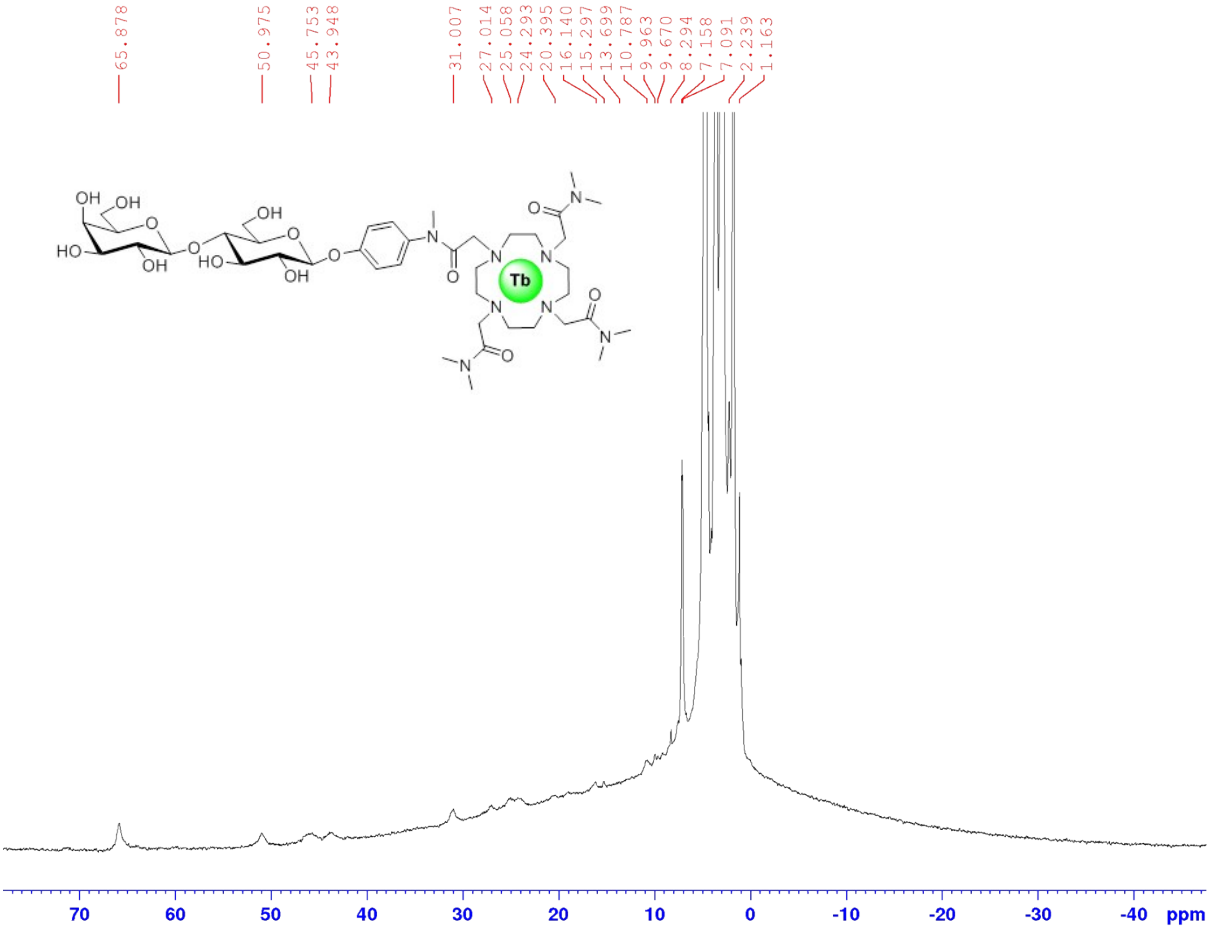


Figure S73 ^1H NMR Spectrum of **5Tb**, D_2O 400 MHz

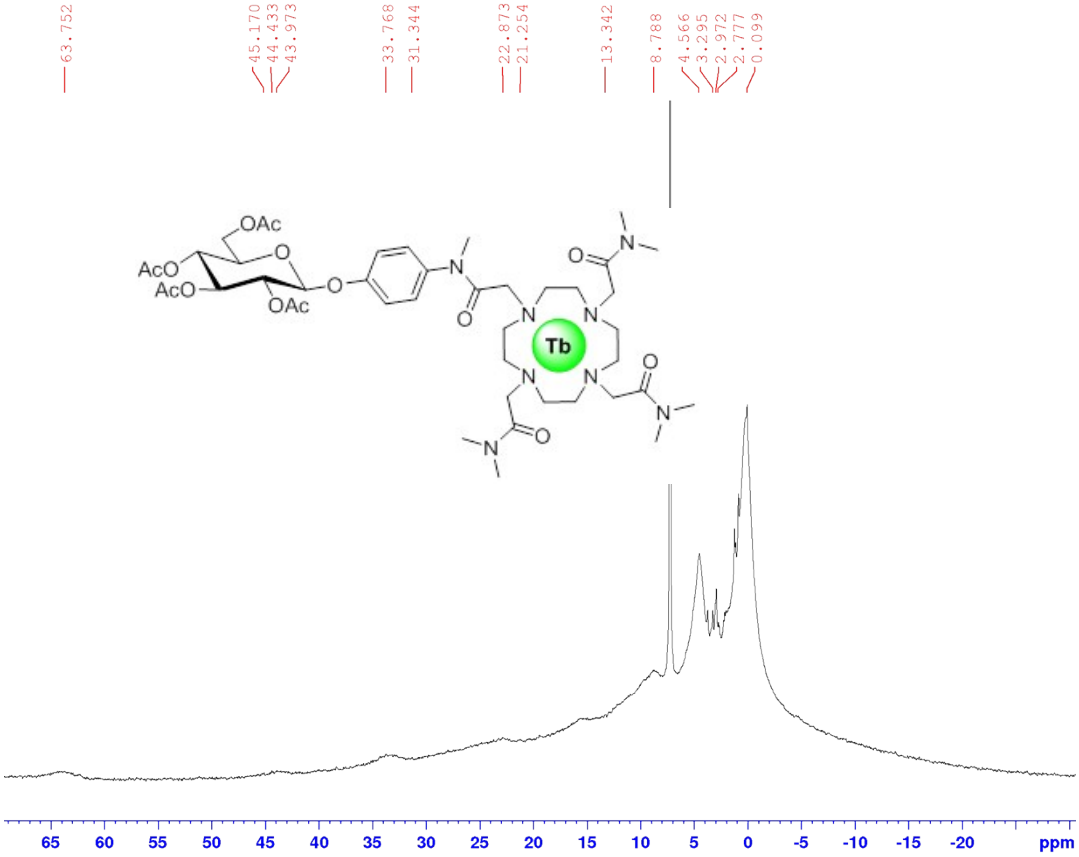


Figure S74 ^{1}H NMR Spectrum of **6Tb**, $CDCl_3$, 400 MHz

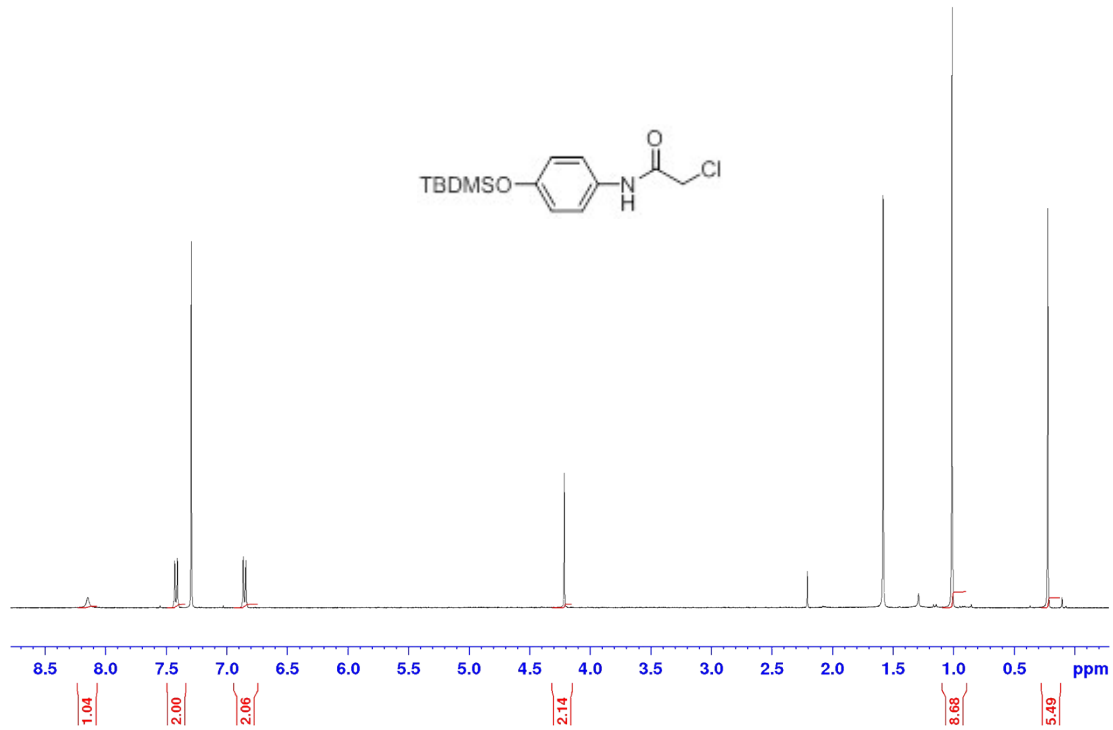


Figure S75 ^{1}H NMR Spectrum of **34**, $CDCl_3$, 400 MHz

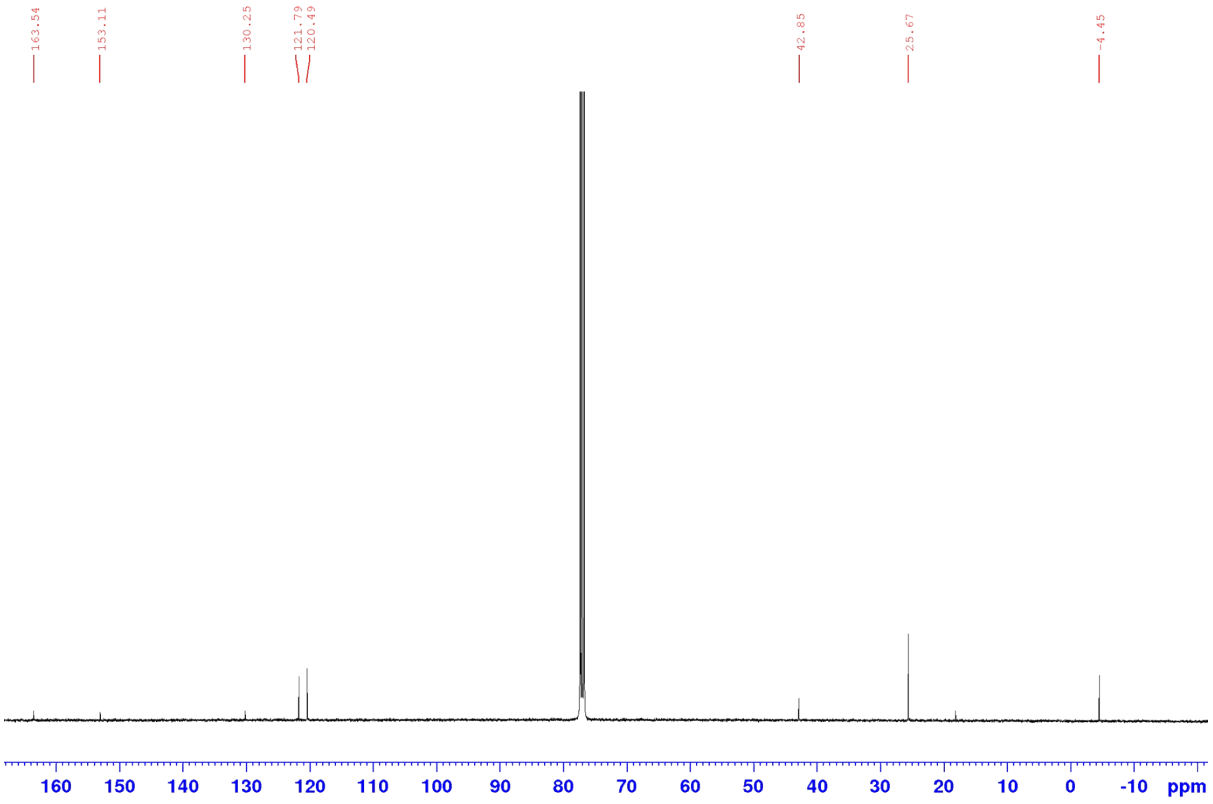


Figure S76 ^{13}C NMR Spectrum of **34**, $CDCl_3$, 101 MHz

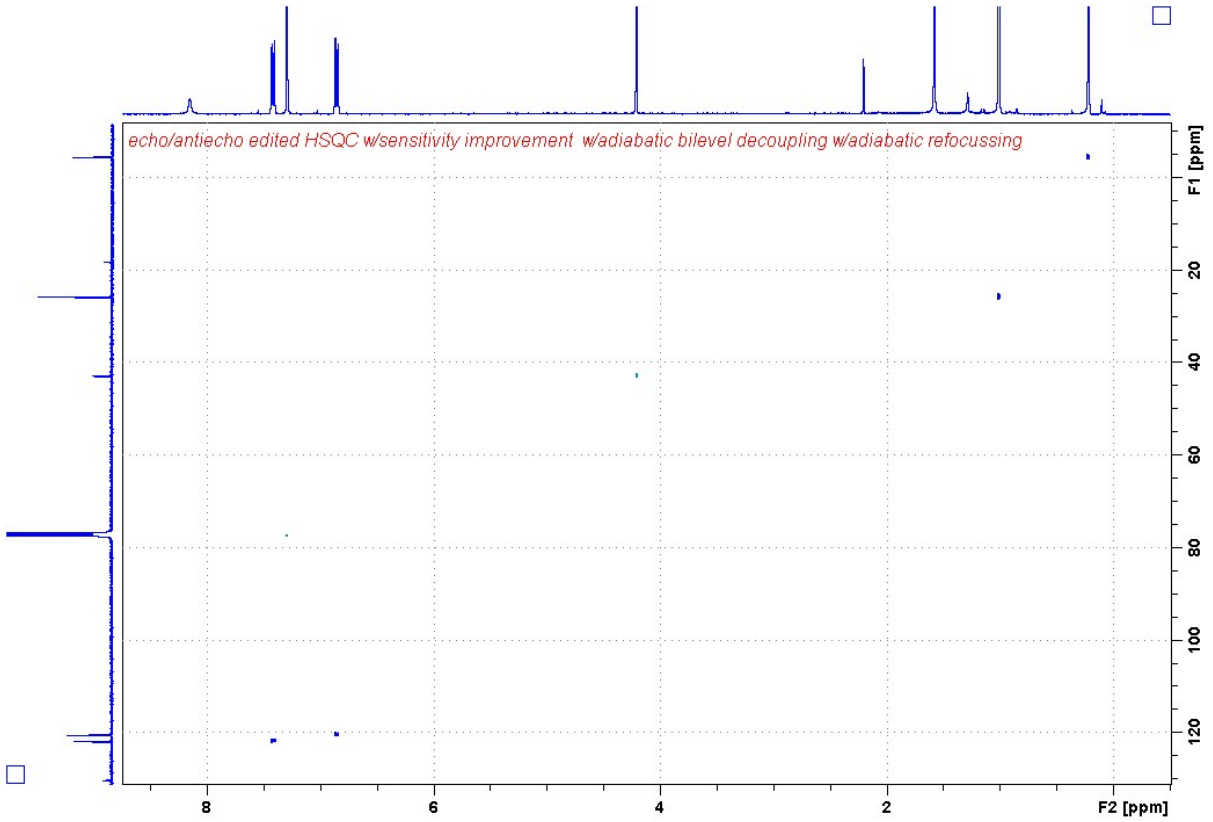


Figure S77 HSQC NMR Spectrum of **34**, $CDCl_3$, 101 MHz

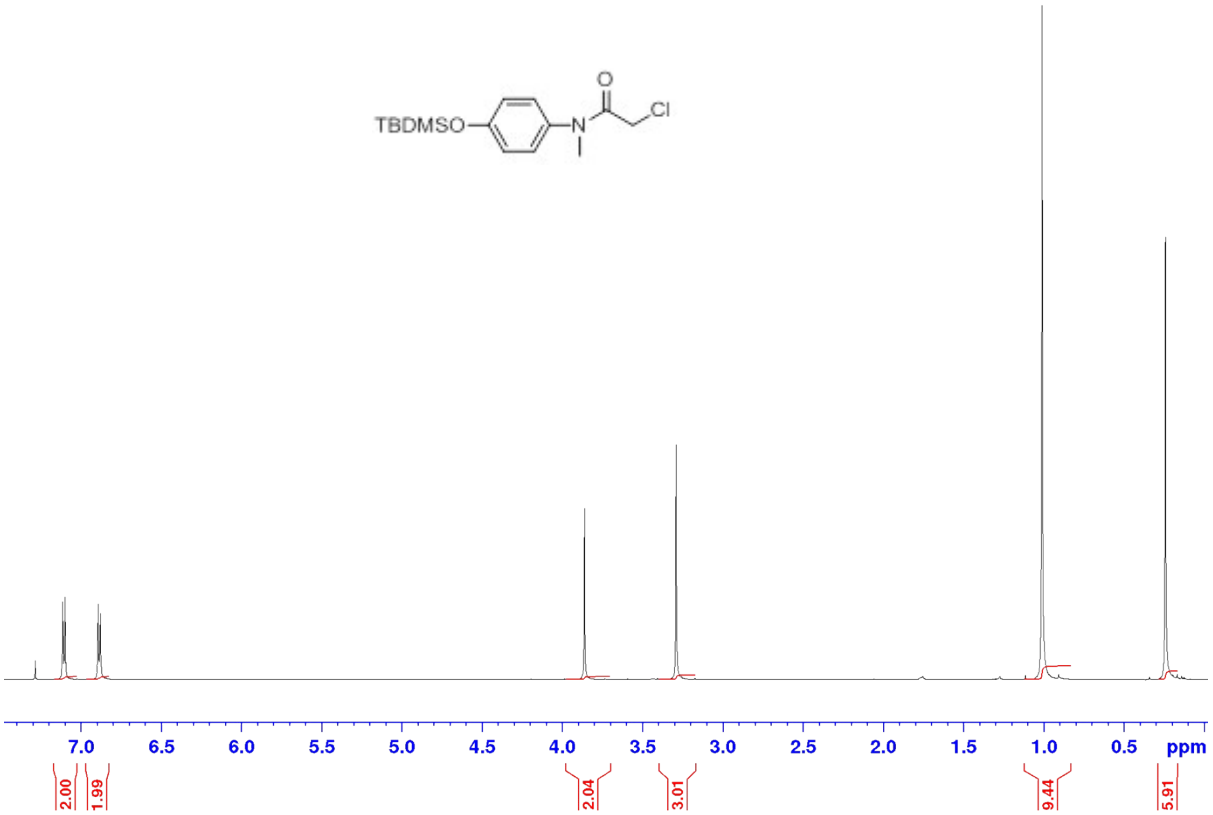


Figure S78 ^{1}H NMR Spectrum of **35**, $CDCl_3$, 400 MHz

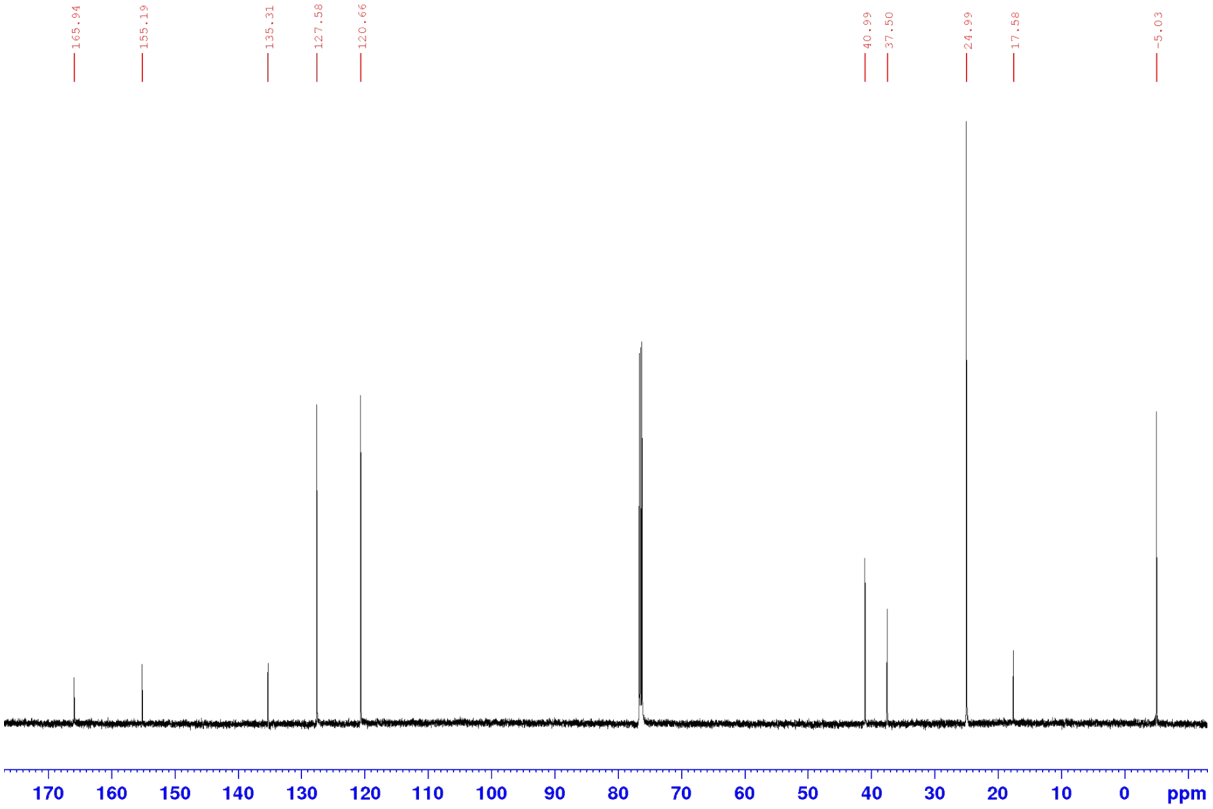


Figure S79 ^{13}C NMR Spectrum of **35**, $CDCl_3$, 101 MHz

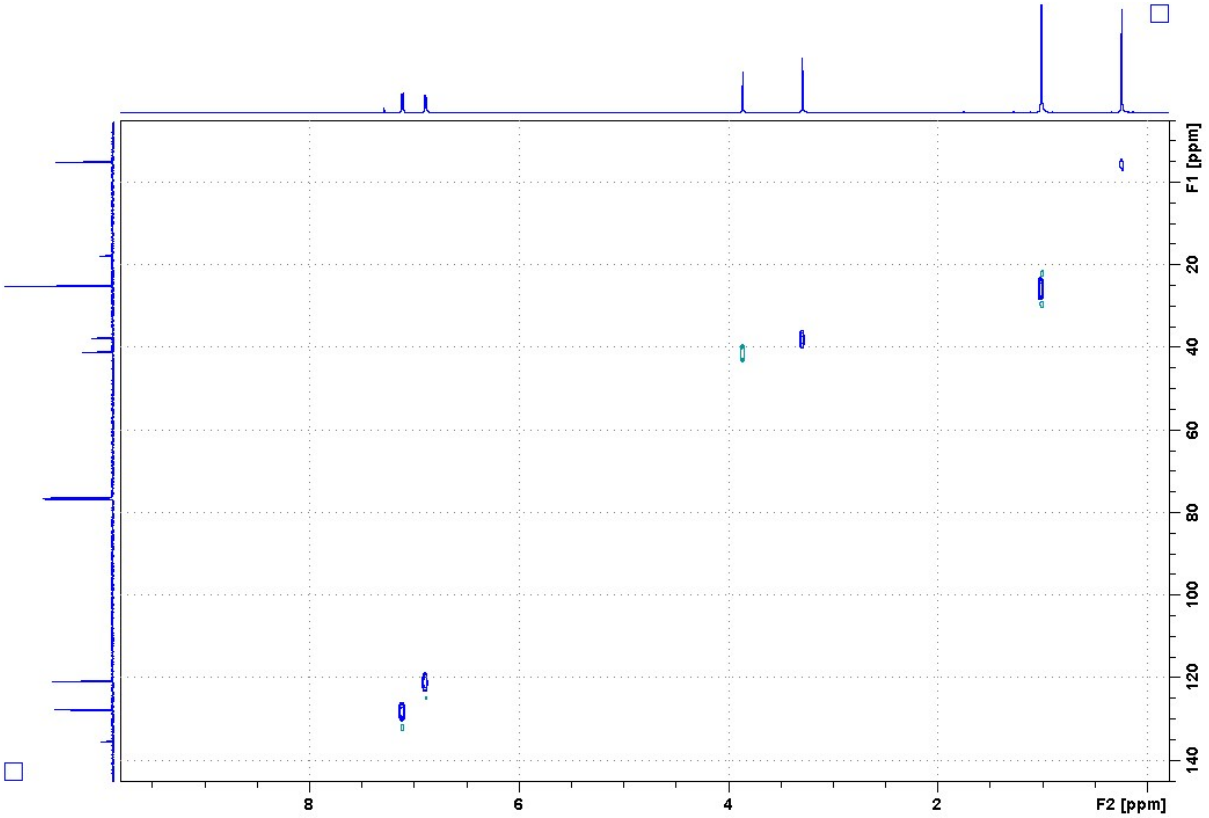


Figure S80 HSQC NMR Spectrum of **35**, $CDCl_3$, 101 MHz

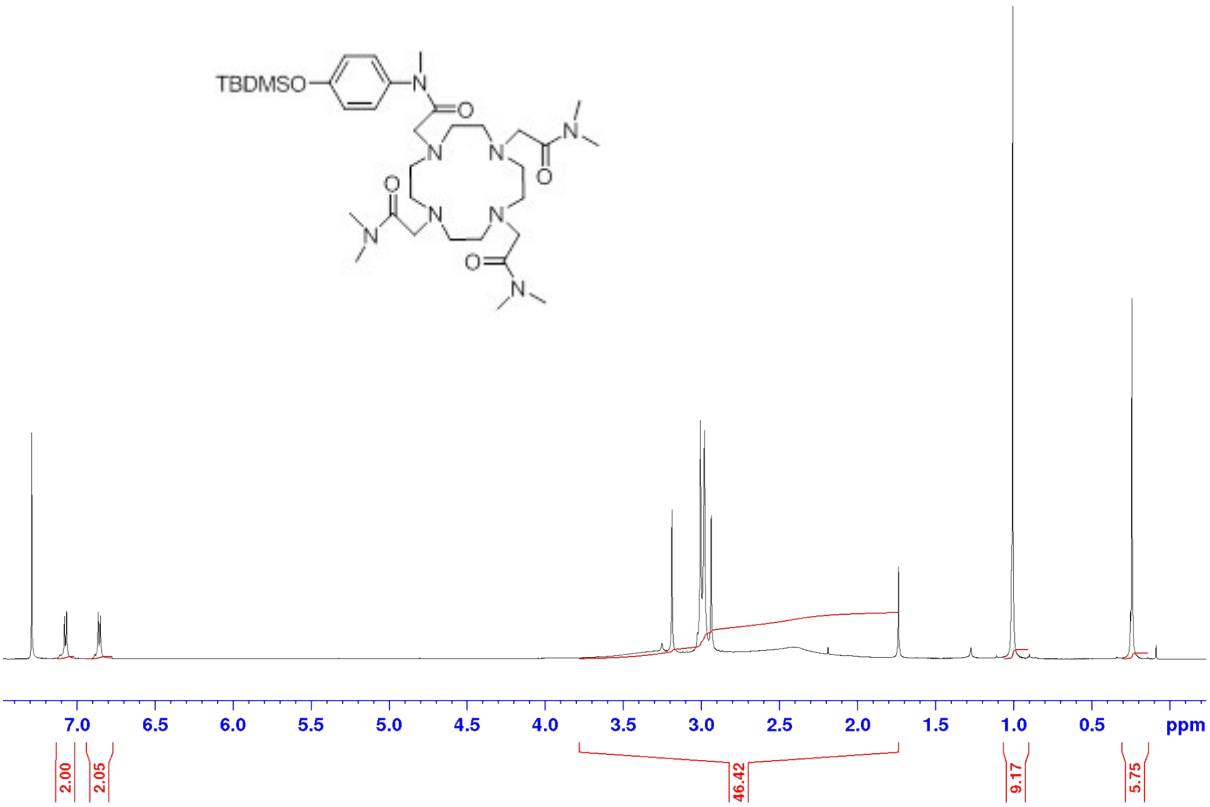


Figure S81 ^1H NMR Spectrum of **36**, $CDCl_3$, 400 MHz

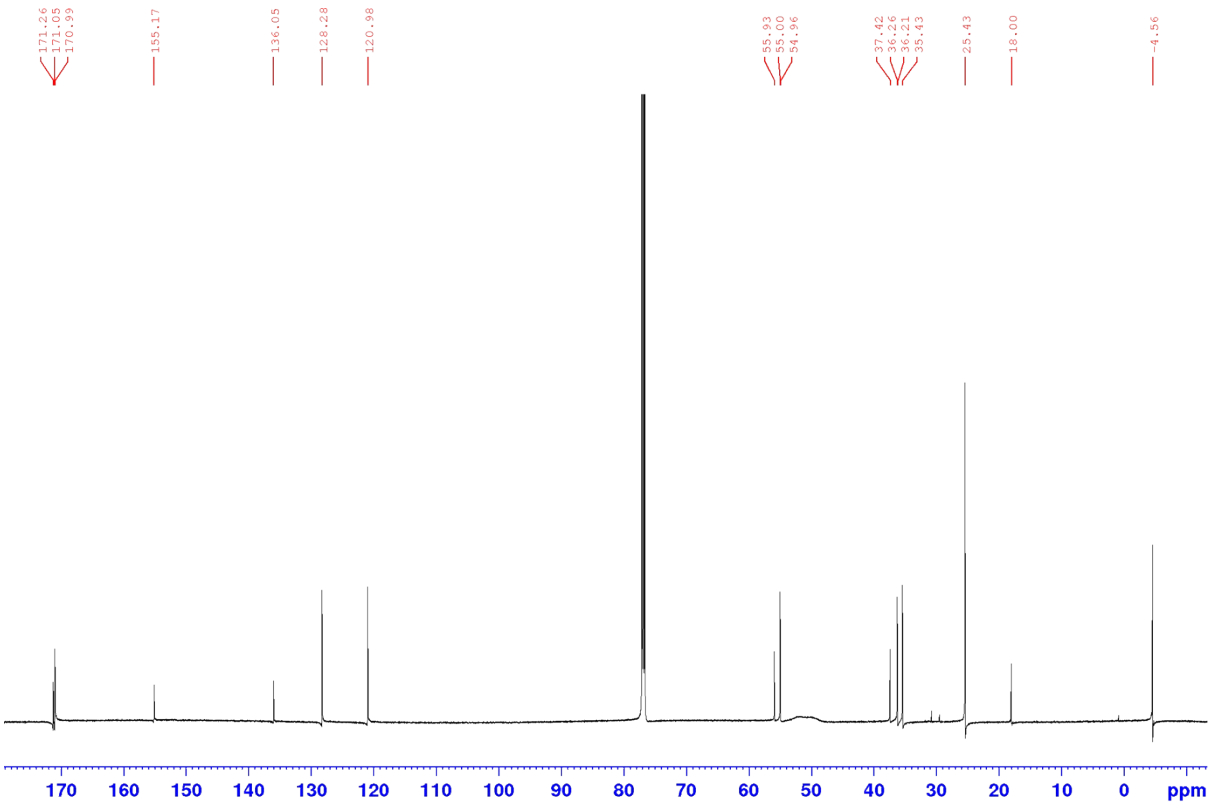


Figure S82 ^{13}C NMR Spectrum of **36**, $CDCl_3$, 101 MHz

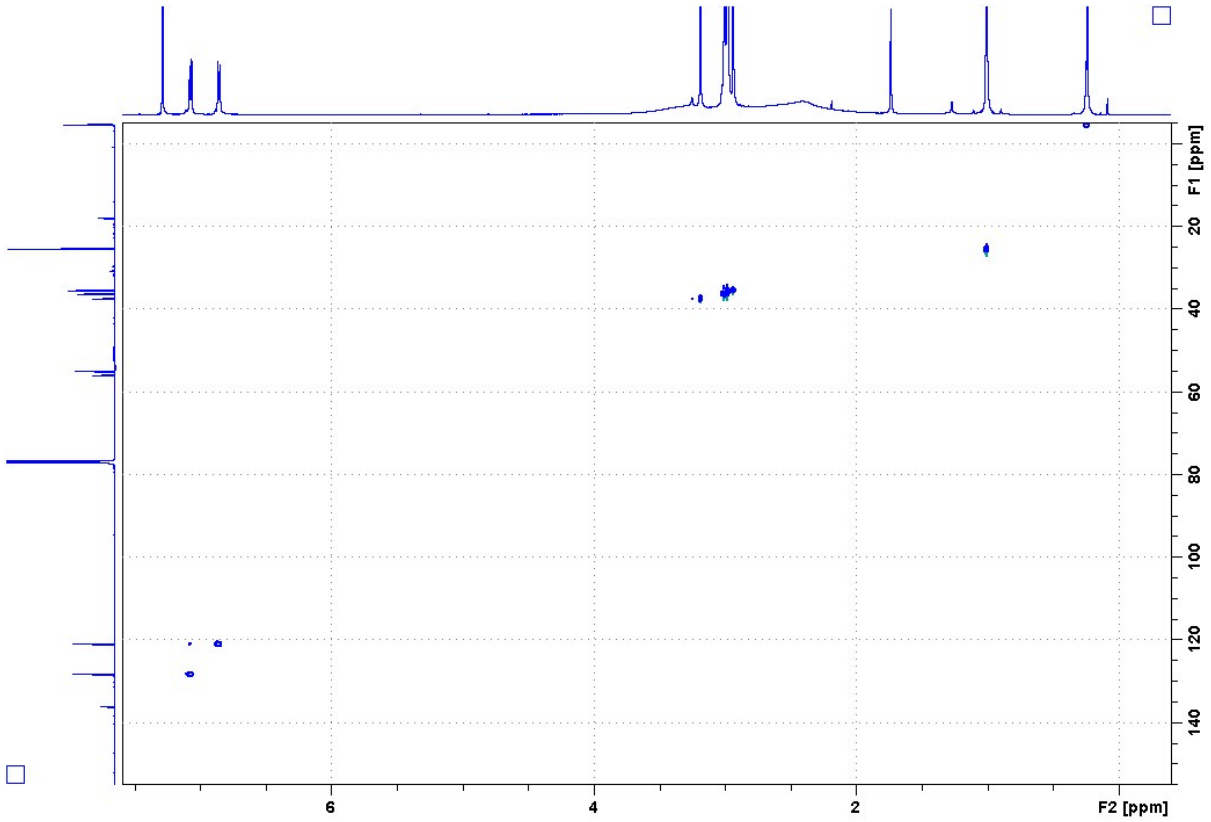


Figure S83 HSQC NMR Spectrum of **36**, $CDCl_3$, 101 MHz

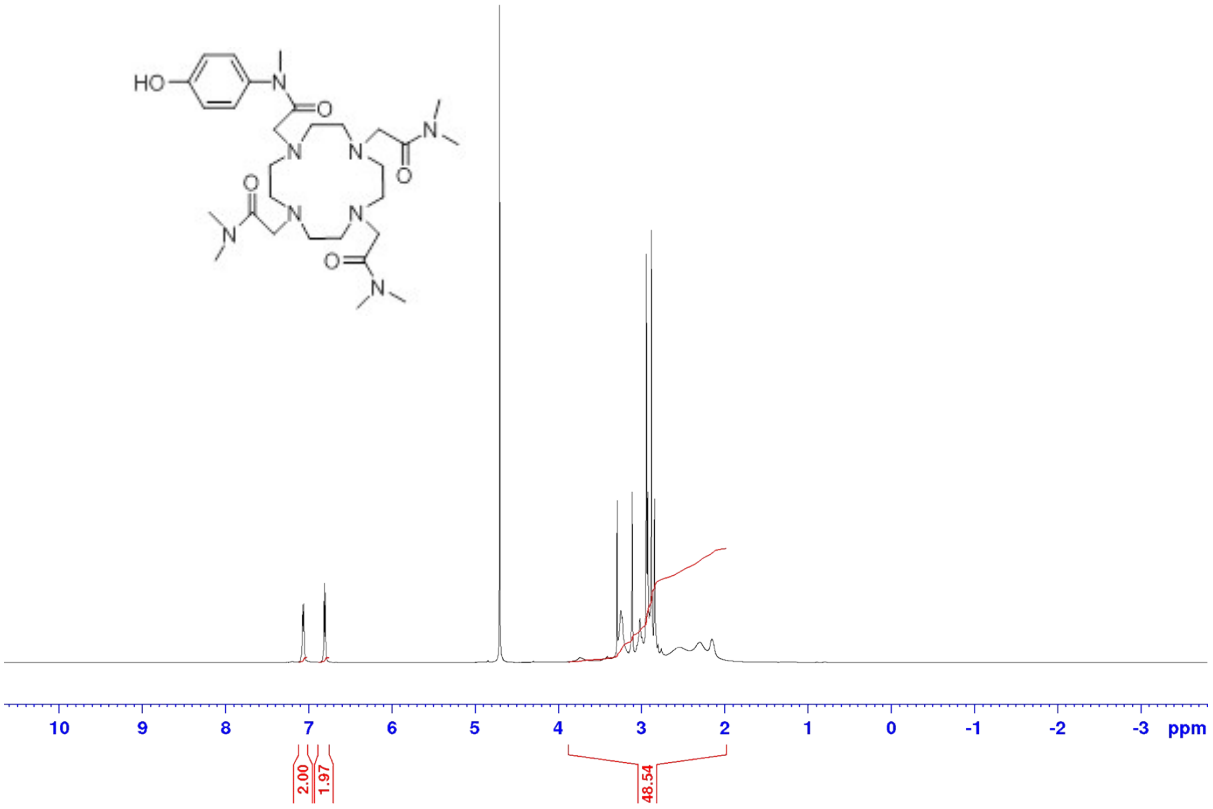


Figure S84 ^{1}H NMR Spectrum of **37**, D_2O, 400 MHz

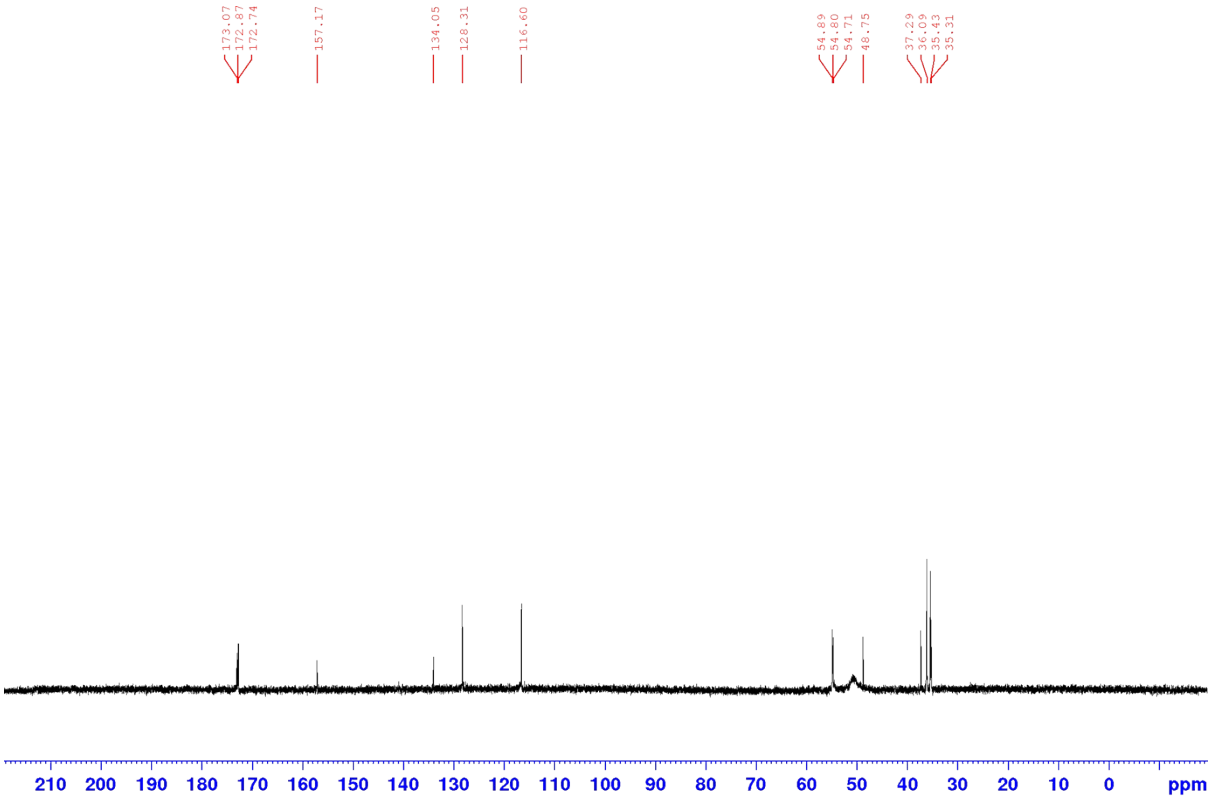


Figure S85 ^{13}C NMR Spectrum of **37**, D_2O, 101 MHz

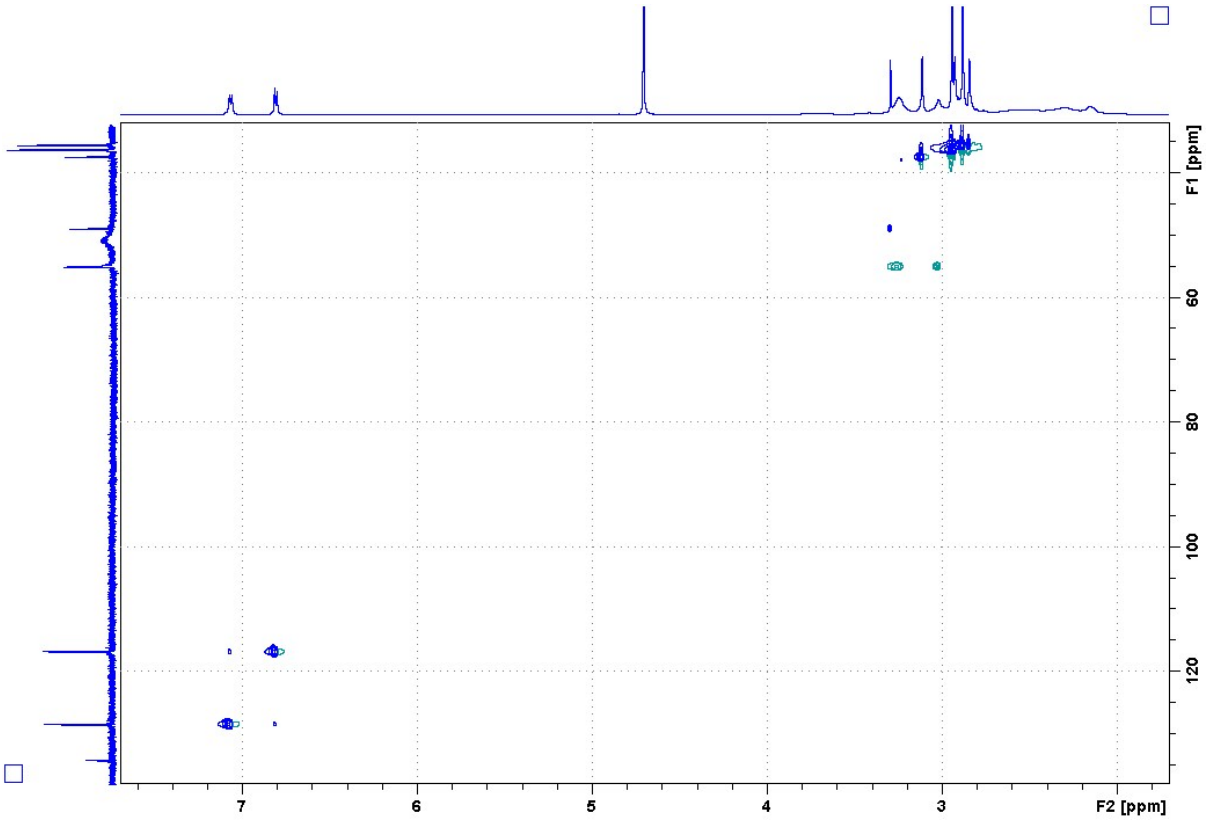


Figure S86 HSQC NMR Spectrum of **37**, D_2O, 101 MHz

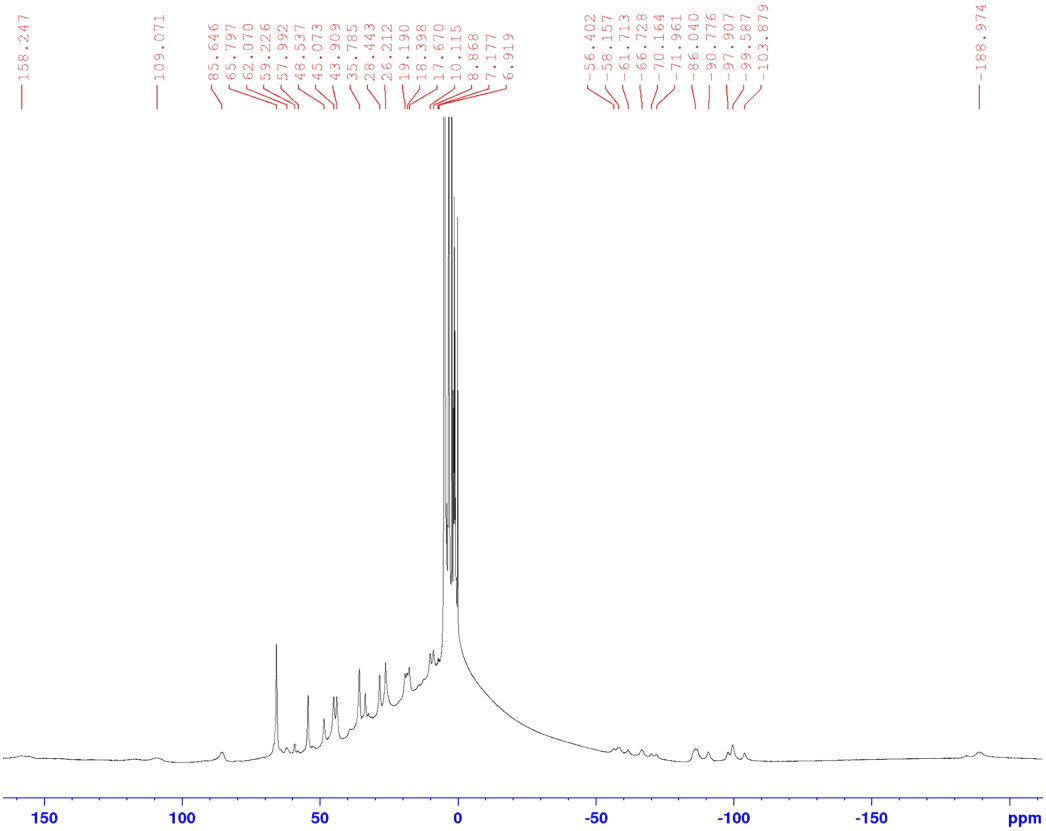


Figure S87 ^1H NMR Spectrum of **7Tb**, D_2O, 400 MHz

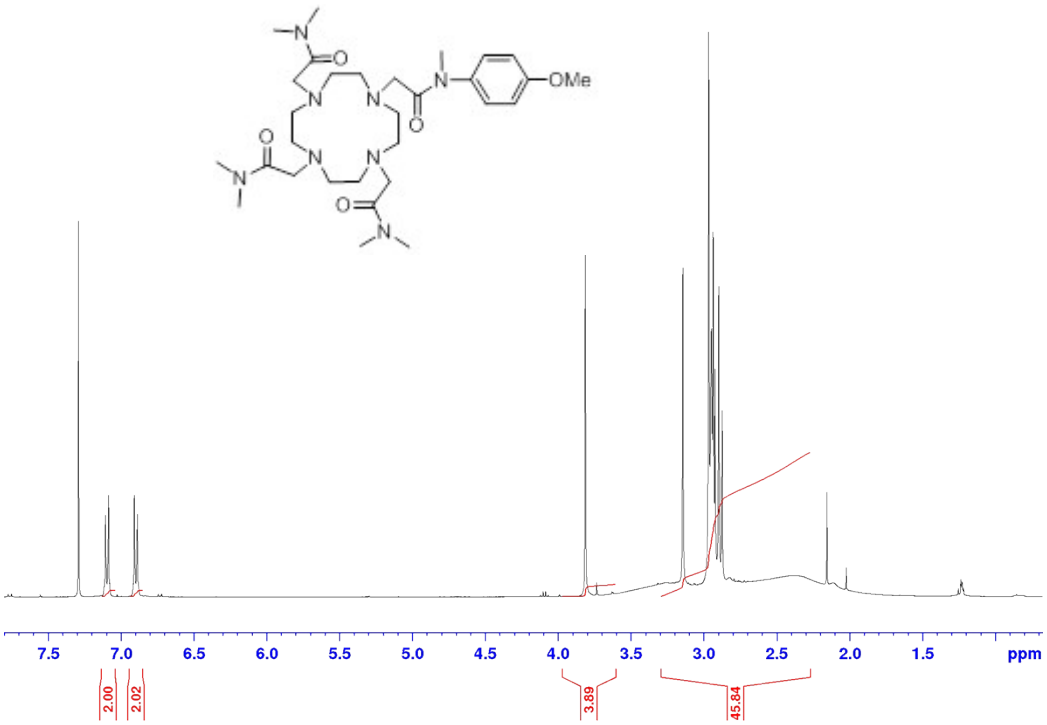


Figure S88 ^{1}H NMR Spectrum of **40**, $CDCl_3$, 400 MHz

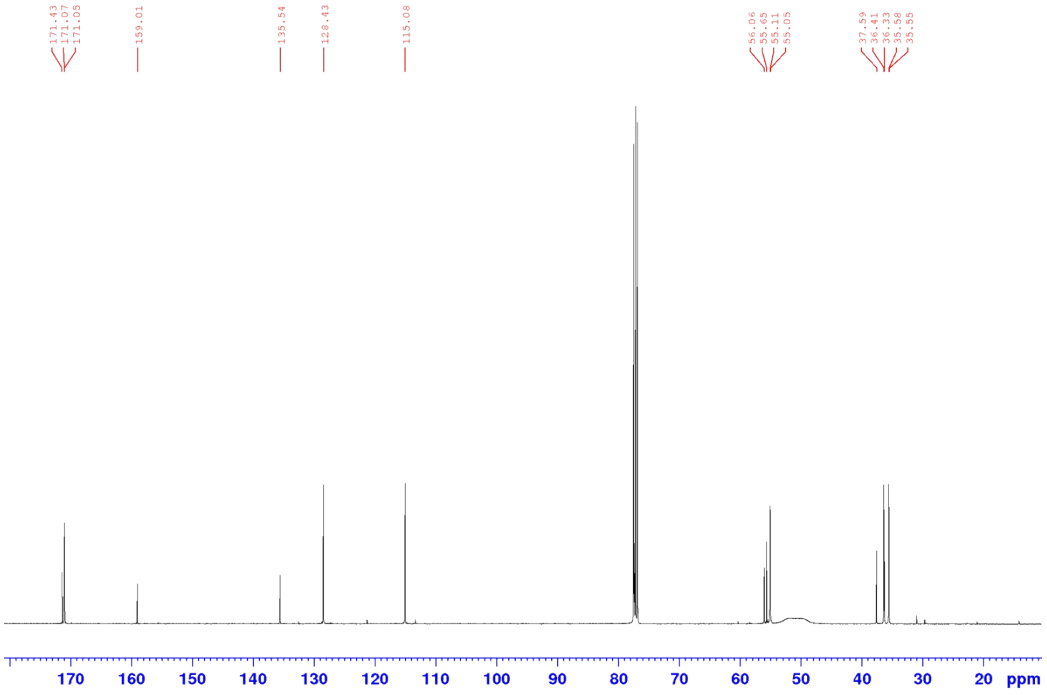


Figure S89 ^{13}C NMR Spectrum of **40**, $CDCl_3$, 101 MHz

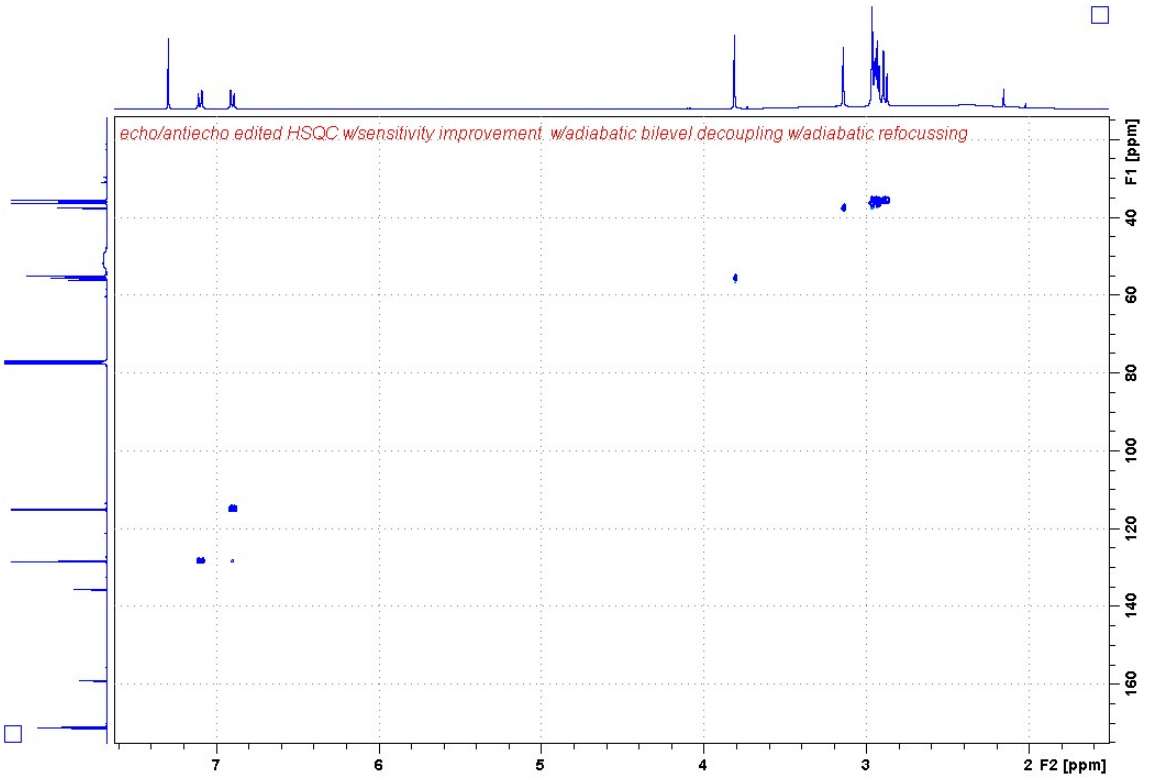


Figure S90 HSQC NMR Spectrum of **40**, $CDCl_3$, 101 MHz

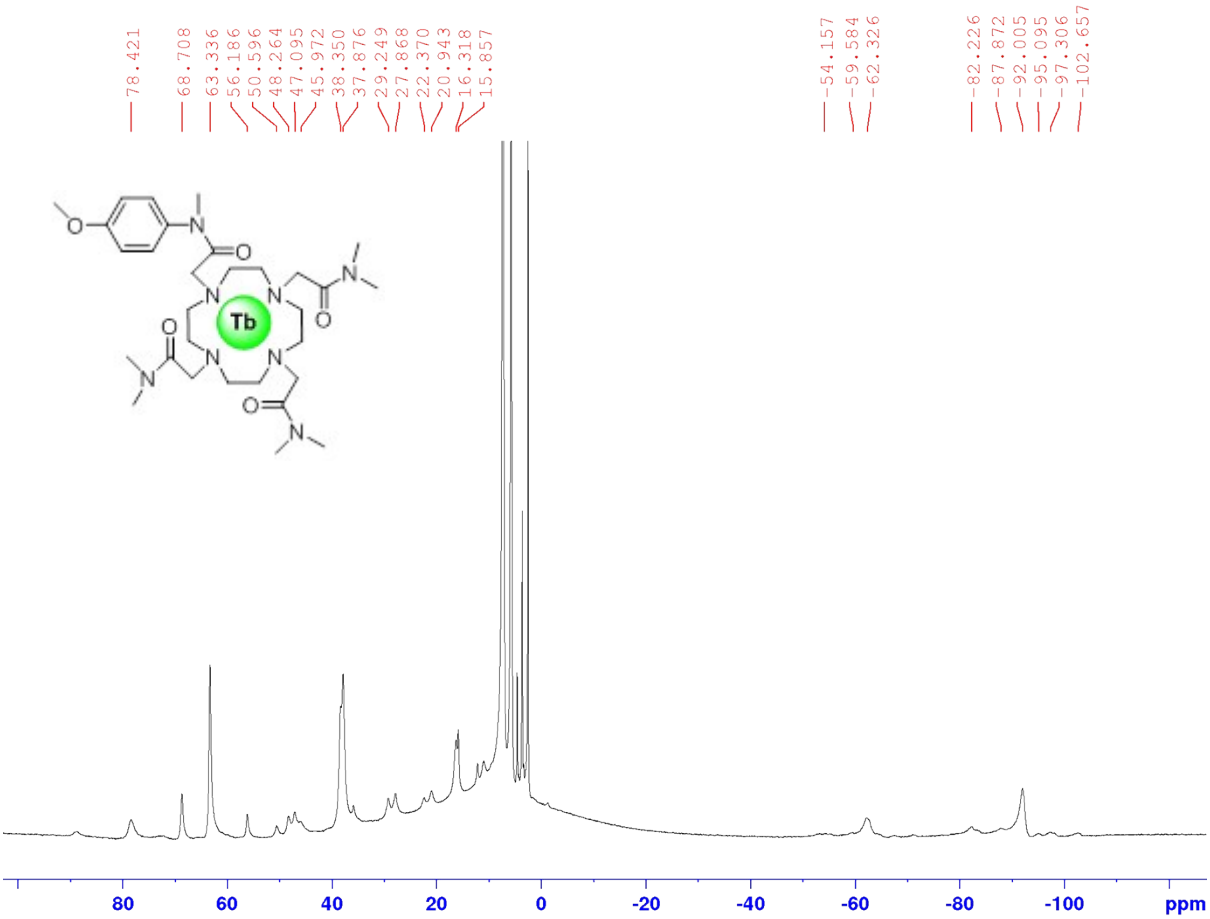


Figure S90 ^1H NMR Spectrum of **8Tb**, $CDCl_3$, 400 MHz