Supporting Information

Of

The Interactions of Glycopolymers with Assemblies of Peptide Amphiphiles via Dynamic Covalent Bonding

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I. General Information

Materials.

Chemicals were purchased from J&K Chemical, TCI and GL Biochem (Shanghai) and used without further purification. DCM and DMF were purified by a solvent purification system (PS-MD, Innovative Technology, Inc.).

A549 cell lines and 1640 cell culture medium were afforded by Wuli Yang's group, Department of Macromolecular Science, Fudan University. Fetal bovine serum was from GIBCO BRL Life Technologies Inc. and MTS (3-(4,5-dimethylthiazol-2-yl)-5-(3-carboxymethoxyphenyl)-2-(4-sulfophenyl)-2H-tetrazolium) was from Promega Co.

Characterization.

^{1}H NMR and ^{13}C NMR spectra were taken on a 400 MHz Bruker instrument, and the acquired NMR data were analyzed with Bruker Topspin software. Chemical shift values were referenced using Tetramethylsilane (TMS).

TOCSY and NOESY spectra were taken on a 500 MHz Bruker instrument then the acquired 2D ^{1}H NMR data were analyzed with Bruker Topspin software as above.

Matrix Assisted Laser Desorption Ionization-Time of Flight (Maldi-TOF) Mass Spectrum was taken by AB SCIEX 5800 instrument.

Gel permeation chromatography (GPC) was carried out on a system comprising a Waters 1515 HPLC pump, Waters 2414 refractive index detector, TOSOH TSK gel α-3000 and α-2500 columns in series at 80 ^{o}C for DMF (0.2% LiBr, w/w) phase online test.

Transmission electron microscopy (TEM) images were taken with a Tecnai G2 instrument (200 kV) and JEOL TEM-2010 (80 kV). Cryo-TEM was performed on JEOL TEM-2100F (200 kV).

The cryofixation TEM sample prepared as followed procedure: the hydrophilic copper grid was put on a cupper cubic that half-immersed in liquid nitrogen. 2 μL of 7.5 mg/mL PA solution with or without PMan (25.0 mg/mL) were dropped on the cupper grid. Two samples were immediately frozen and put into lyophilizer to give the dry cryofixation TEM sample.

Atomic Force Microscope (AFM) was operated in air on a Bruker Multimode VIII SPM equipped with a J scanner. Experiments were performed in tapping mode with SNL tip. Sample (0.1 mL, 1.5 mg/mL PA solution) was dropped on freshly cleaved mica and solvent was removed by a pump for 4 h.

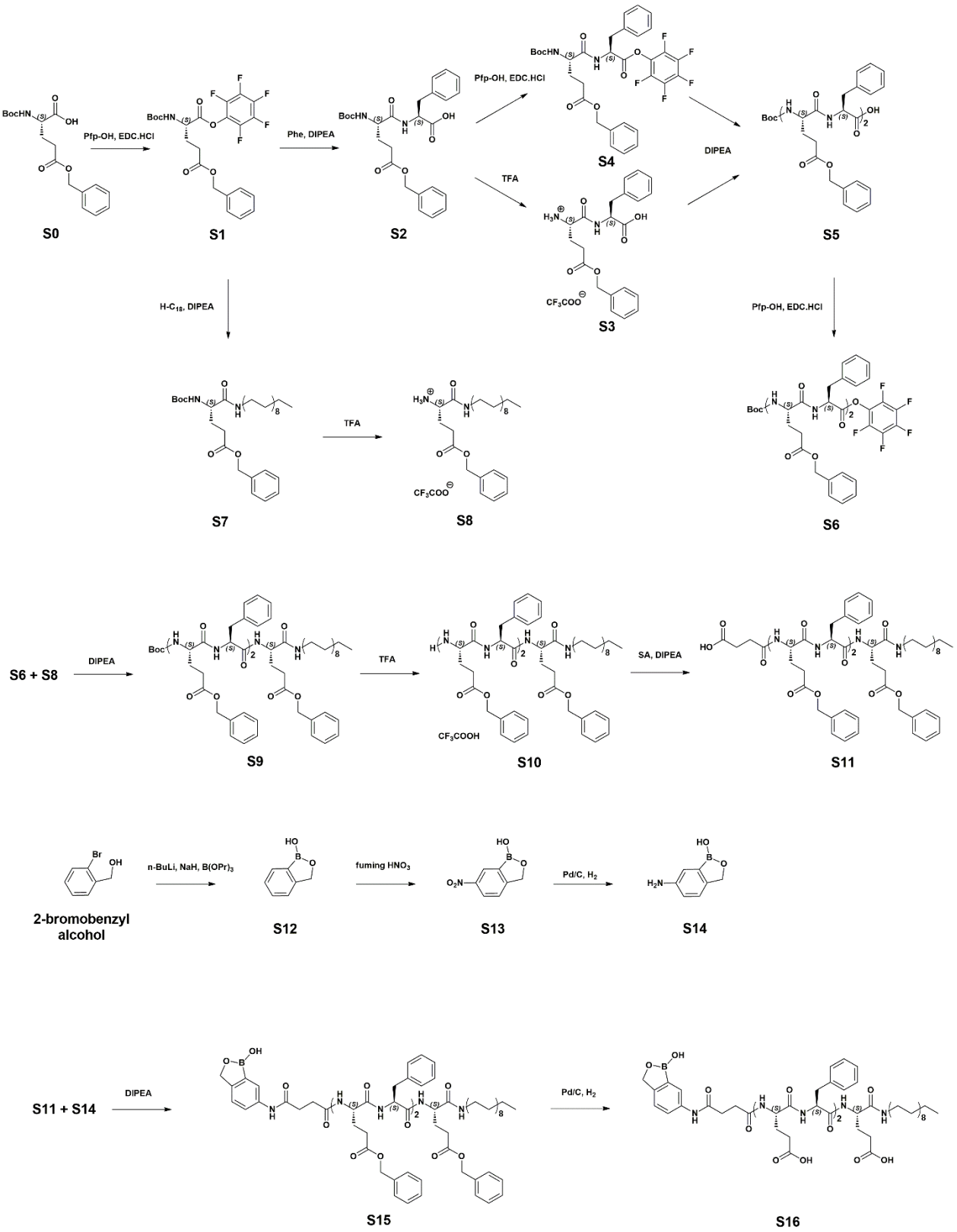
Fourier Transform Infrared (FT-IR) spectroscopy was obtained on a Nicolet 6700 spectrometer with a resolution of 4 cm^{-1} and 32 scans. FTIR samples were prepared by pressing PA solution of D_2O (5 wt%) with CaF_2.

Fluorescence Emission spectrum was obtained on a Fluorescence Lifetime Spectrometer QM 40.

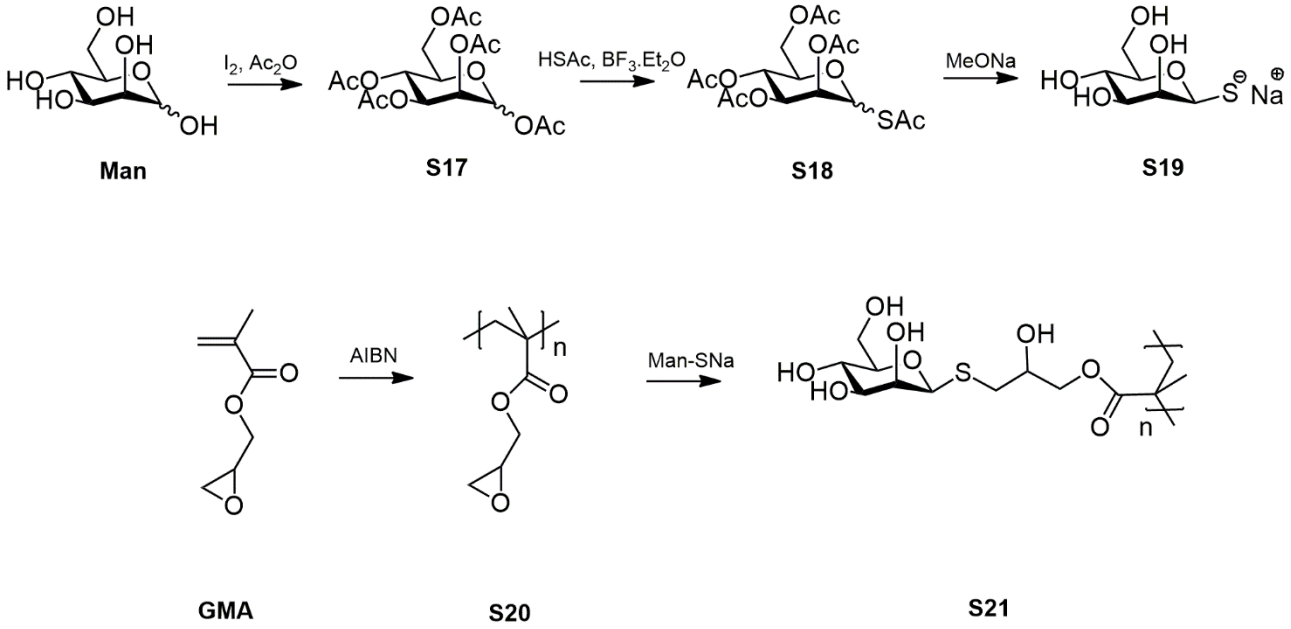
Circular dichroism (CD) CD measurements were performed on a JASCO J-815 spectropolarimeter with a 1-mm quartz cell (5 accumulations, continues scanning mode, scanning speed: 100 nm min^{-1}, data pitch: 0.5 nm, response: 1 s, band width: 2.0 nm). CD data are given as mean molar ellipticities based on assemble units.

Molecular Modeling Calculations. All calculations were performed using Gaussian 09. Density functional theory (DFT) calculations (SCF model) of Figure 1 used the B3LYP method with the 6-31++G** basis set. Geometry optimization of complexes of Table 1 used the same set.

II. PA and PMan Syntheses



Scheme S1. Synthesis of **PA**.



Scheme S2. Synthesis of **PMan**.

III. Molecular Weight Characterization

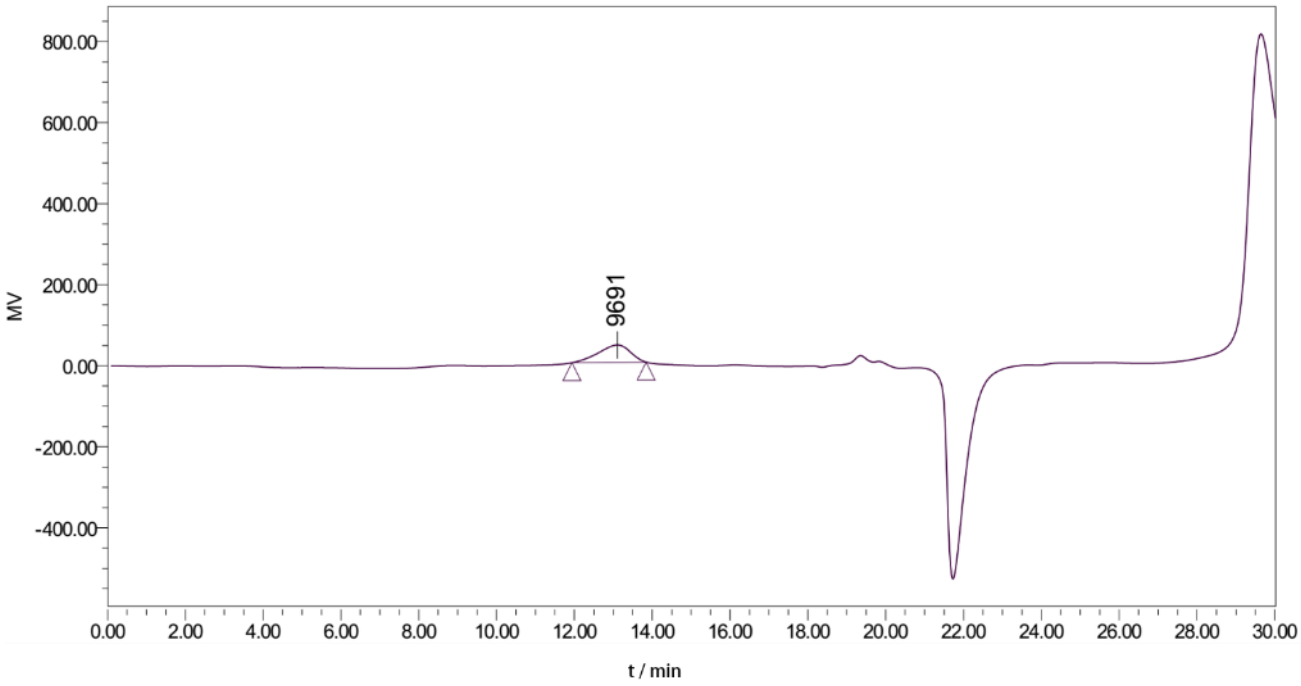


Figure S2. GPC Result of PGMA.

	M_n (Dal)	M_w (Dal)	M_z (Dal)	**PDI**	M_z/M_w
PGMA	1.0×10^4	1.3×10^4	1.7×10^4	1.3	1.7

Table S1. GPC result of PGMA.

IV. Transmission electron microscope (TEM) and cryo-TEM

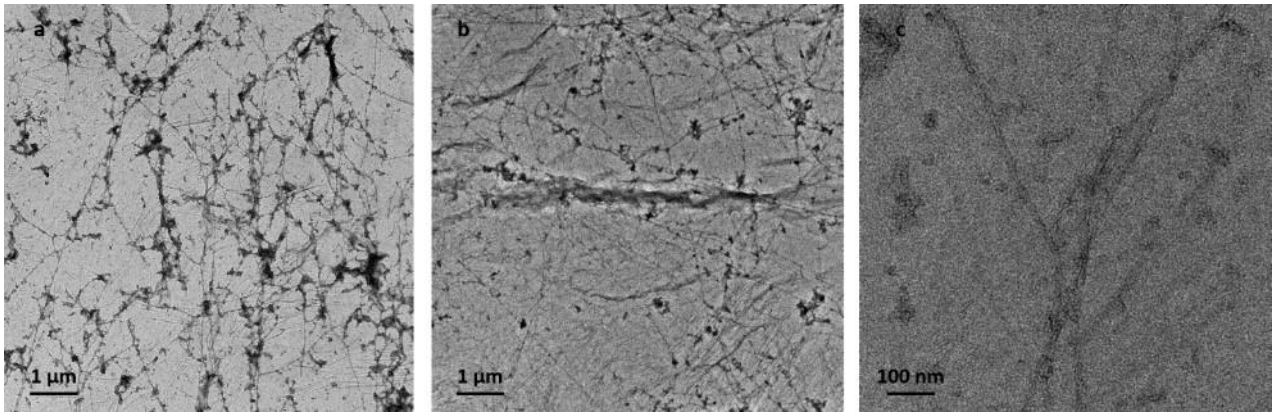


Figure S2. TEM images of **PAA**.

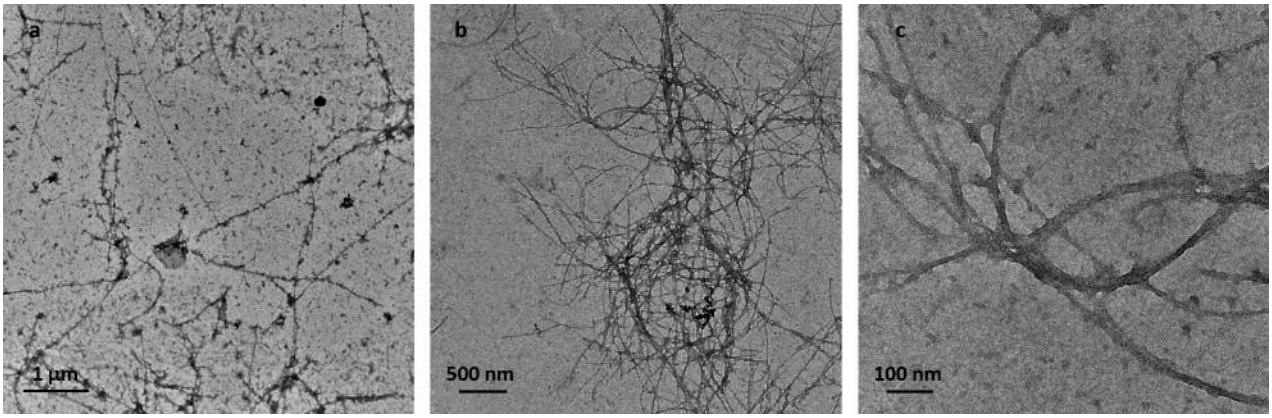
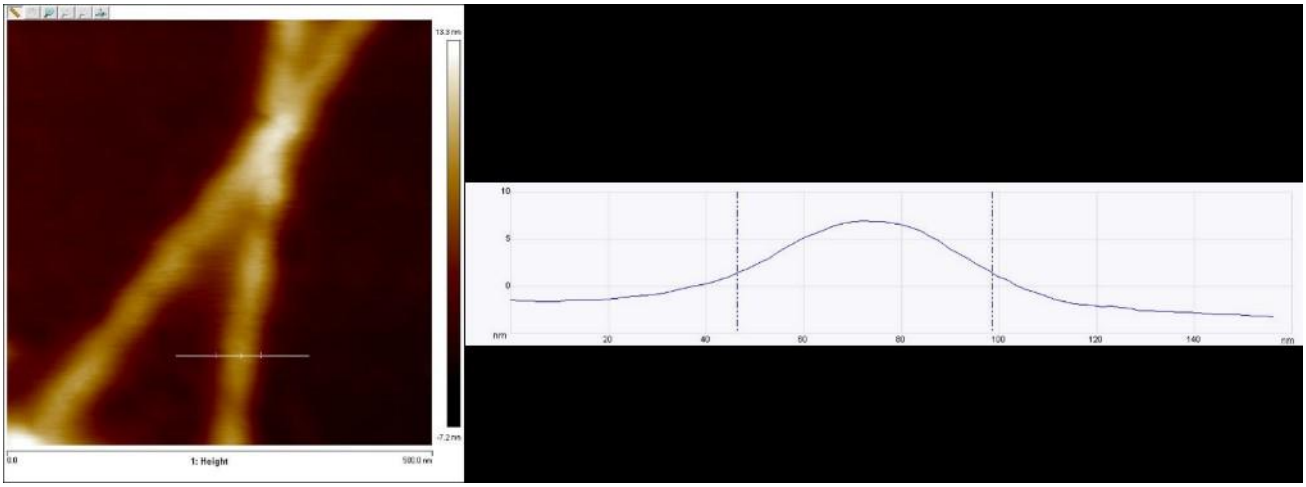


Figure S3. TEM images of **PAA/PMan**.

V. Atomic Force Microscope (AFM)

a



b

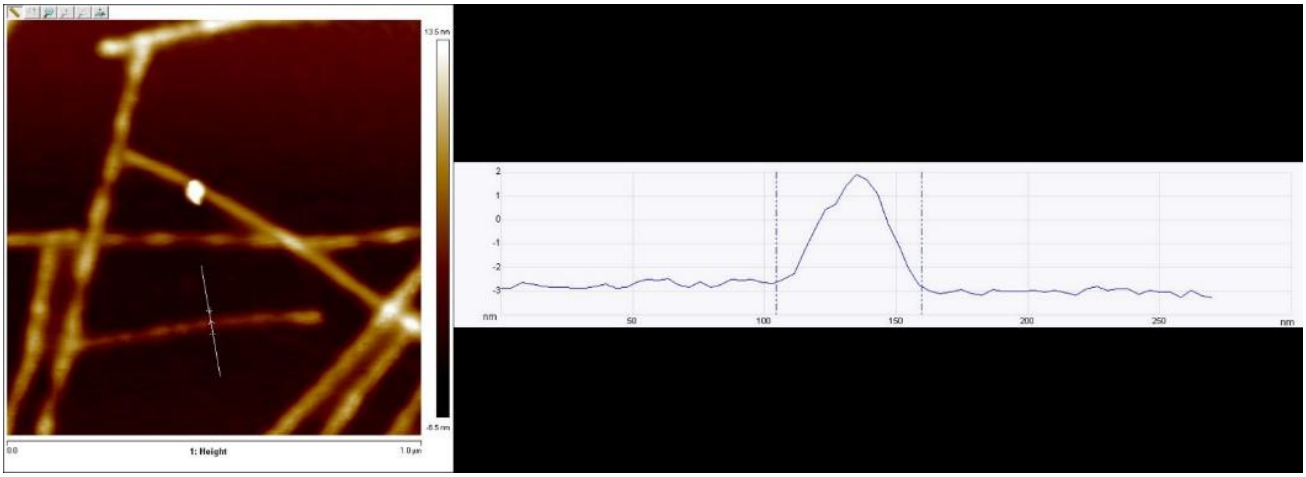


Figure S4. AFM images of **PAA**.

VI. Fourier Transform Infrared (FTIR) spectrum

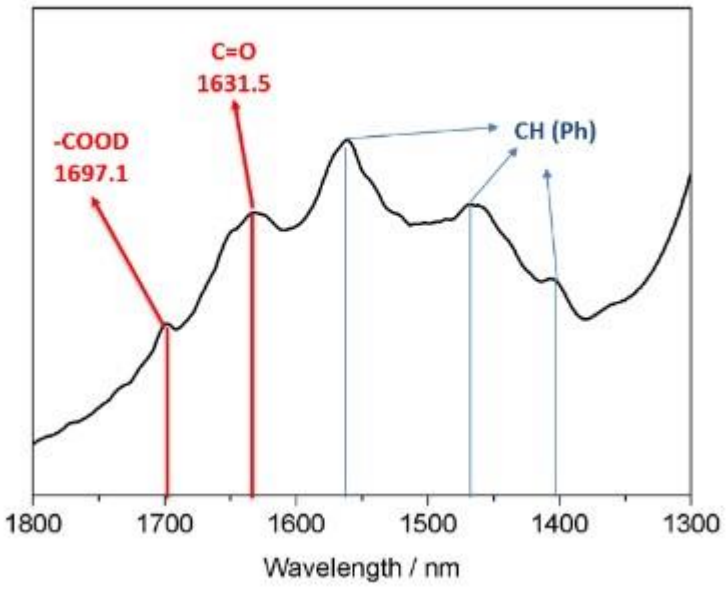


Figure S5 FT-IR spectra of **PAA** in PBS (pH 8, 5 wt%).

VII. Fluorescence Emission spectrum

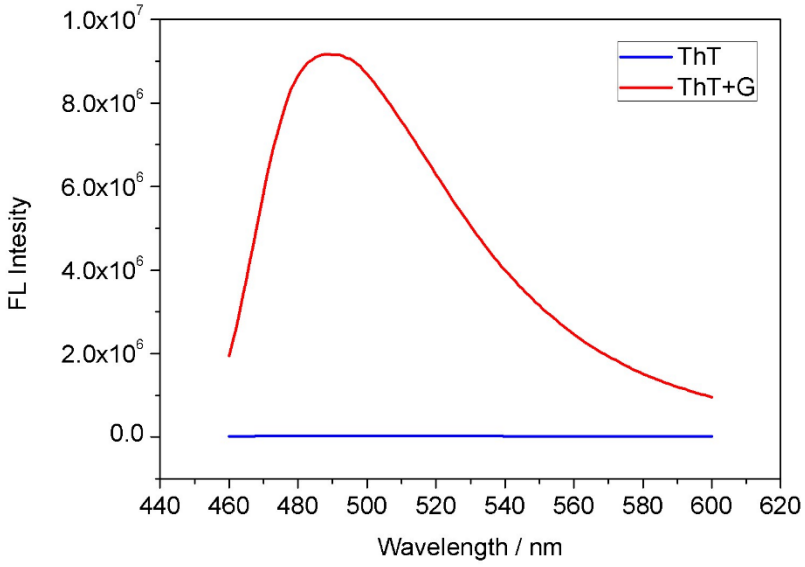


Figure S6. Fluorescence Emission spectra of **PAA** (5 mM) with (red line) and without (blue line) ThT (60 μM). λ = 440 nm.

VIII. Circular dichroism (CD)

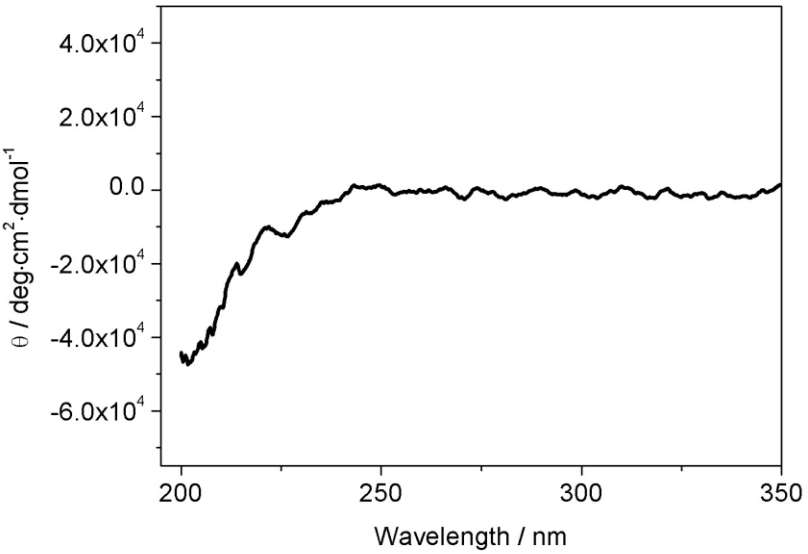


Figure S7. CD spectra of **PAA** in PBS (pH 8, 0.2 mg/mL).

IX. Total Correlation Spectroscopy (TOCSY)

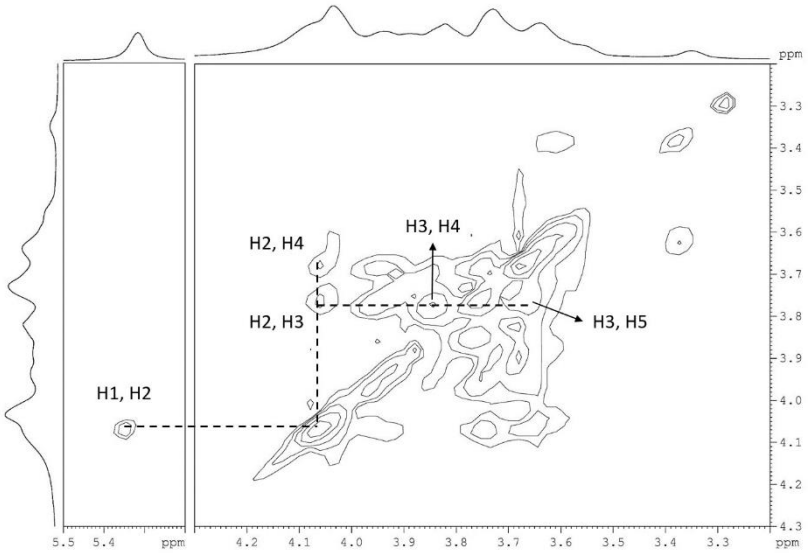


Figure S8. TOCSY spectrum of **PMan** in D_2O.

X. Nuclear Overhauser Effect Spectroscopy (NOESY)

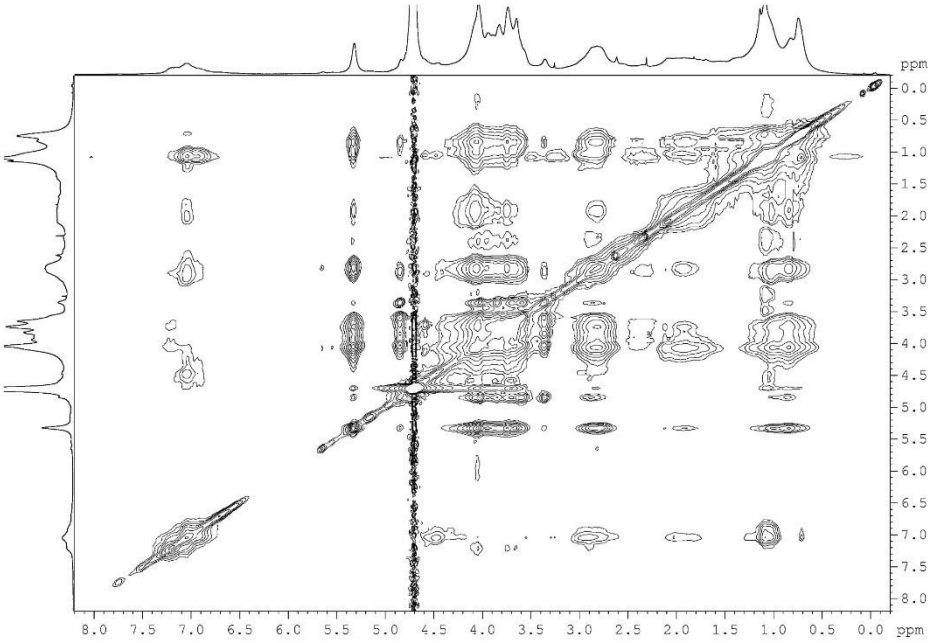


Figure S9. NOESY spectrum of **PAA/PMan**.

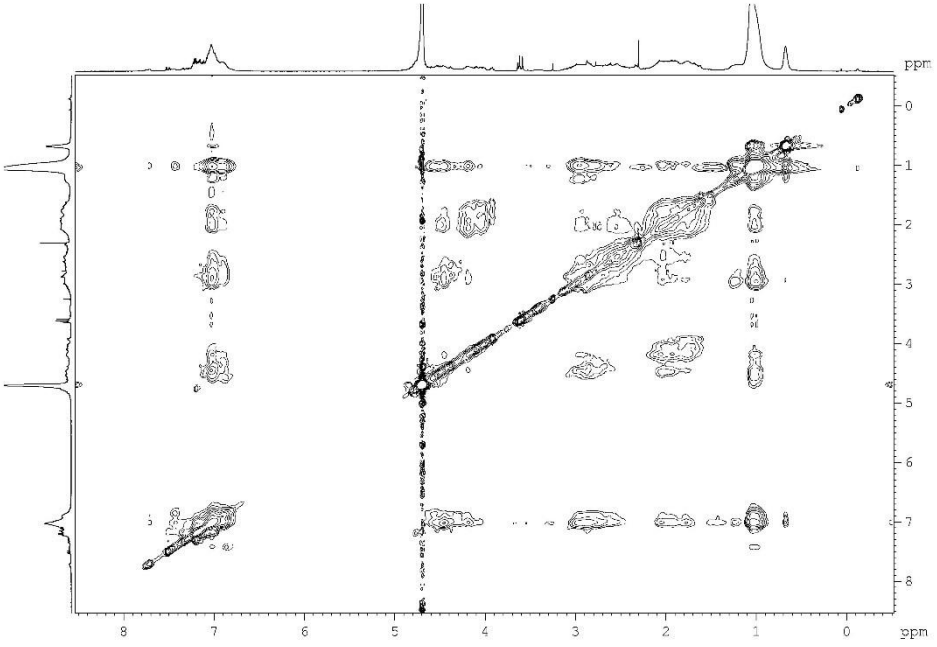


Figure S10. NOESY spectrum of **PAA**.

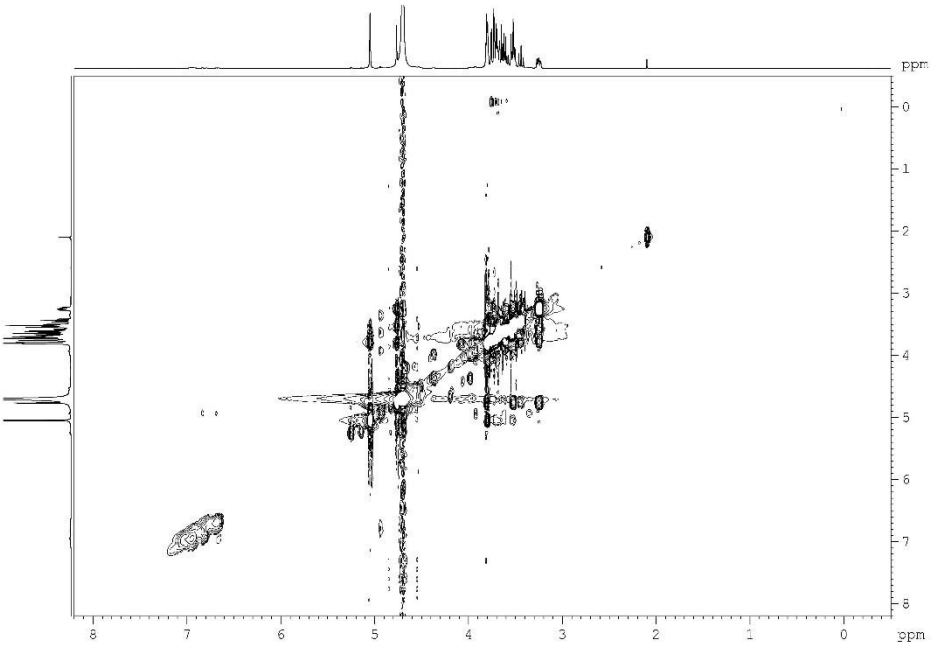


Figure S11. NOESY spectrum of ABOB/Man.

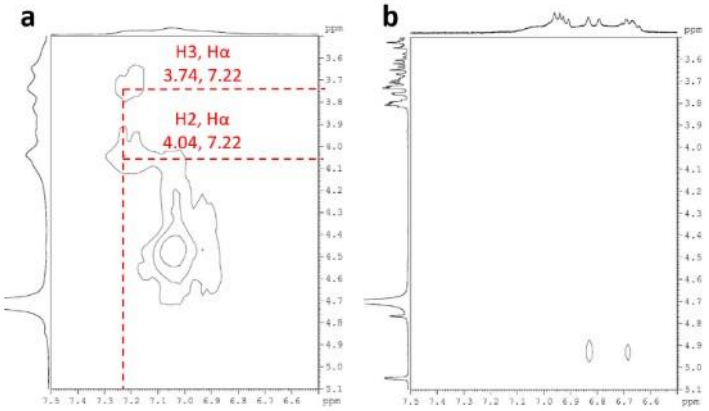


Figure S4 NOESY Spectrum of (a) **PAA/PMan** (13 mM/148 mM) and (b) ABOB/Man (13 mM/148 mM). Only **PAA/PMan** shows crossing peaks at the right region.

XI. Molecular Modeling Calculations

Table S2 Distance between H on benzene ring and mannose ring* (Å).

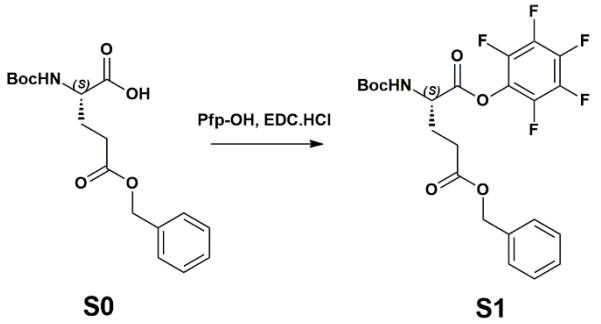
2,3-diol, α-aryl							
	H1	H2	H3	H4	H5	H6-1	H6-2
α-H	5.503	3.225	4.405	5.605	6.582	8.531	8.411
β-H	9.391	7.212	8.080	8.166	10.185	11.652	11.545
γ-H	8.988	7.095	7.642	6.865	9.408	10.433	10.362
2,3-diol, β-aryl							
	H1	H2	H3	H4	H5	H6-1	H6-2
α-H	5.824	5.173	5.004	2.420	5.450	5.598	5.613
β-H	9.577	8.205	8.406	6.571	9.558	9.792	9.902
γ-H	9.004	7.183	7.678	6.716	9.368	10.136	10.307
4,6-diol, α-aryl							
	H1	H2	H3	H4	H5	H6-1	H6-2
α-H	6.498	7.368	5.027	5.375	4.330	5.395	5.042
β-H	10.357	10.719	8.484	7.902	8.172	7.994	8.268
γ-H	9.828	9.941	8.021	6.633	7.749	6.798	7.565
4,6-diol, β-aryl							
	H1	H2	H3	H4	H5	H6-1	H6-2
α-H	6.190	6.240	5.491	2.525	4.878	4.225	2.510
β-H	10.097	9.816	8.627	6.218	8.453	7.882	6.474
γ-H	9.744	9.692	7.978	6.252	7.790	7.525	6.526

*H on benzene ring and mannose ring is actually on benzene ring of R1 and mannose ring of R2.

XII. Synthesis and Characterization

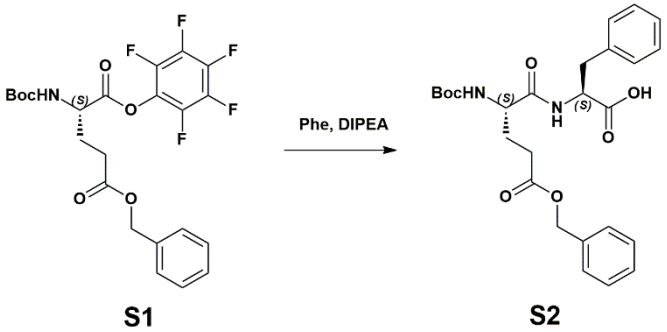
Synthesis of S1. Boc-Glu(Obzl)-OH (3.00 g, 8.89 mmol) and Pfp-OH (pentafluorophenol, 1.96 g, 10.67 mmol) were dissolved in DCM (80 mL), stirring and keeping this mixture at 0 ^{o}C for 30 min. Then EDC.HCl (2.05 g, 10.67 mmol) was added into the mixture, reacting overnight. When this reaction completed, the mixture was condensed and purified by column chromatography (DCM) to obtain S1 (with a little Pfp-OH, 4.26 g, ~80%).

^{1}H NMR (d_6-DMSO, 400MHz): δ 7.80-7.70 (d, 1H; N***H***, *J* = 5.7 Hz), 7.40-7.30 (m, 5H; Ar***H***), 5.14-5.11 (s, 2H; C$\boldsymbol{H_2}$), 4.44-4.36 (m, 1H; C***H***), 2.65-2.52 (m, 2H; C$\boldsymbol{H_2}$), 2.21-2.11 (m, 1H; C$\boldsymbol{H_2}$), 2.09-1.96 (m, 1H; C$\boldsymbol{H_2}$), 1.44-1.32 (t, 9H; C$\boldsymbol{H_3}$).



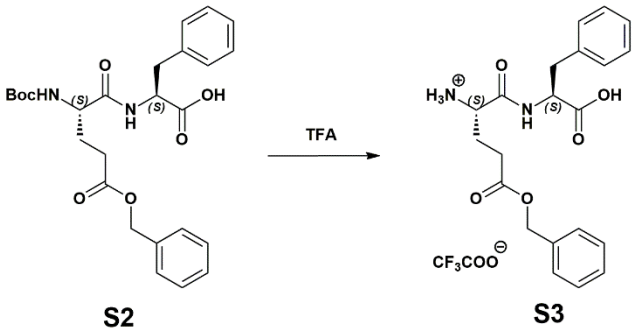
Synthesis of S2. Phe (phenylalanine, 1.31 g, 7.95 mmol), DIPEA (diisopropylethylamine, 4.2 mL, 23.84 mmol) and acetonitrile (4 drops) were added, dissolving in DCM at -15 ^{o}C for 30 min. Then S1 (in DCM, 4.00 g, < 7.95 mmol) was dropped into this mixture, stirring overnight. After this reaction the mixture was washed by $KHSO_4$ (aq, 10 wt %), condensed and purified by column chromatography (DCM : MeOH = 30 : 1) to get S2 (2.96 g, 77%).

^{1}H NMR (d_6-DMSO, 400MHz): δ 12.90-12.67 (s, 1H, COO***H***), 8.04-7.96 (d, 1H; N***H***, *J* = 6.3 Hz), 7.42-7.30 (m, 5H; Ar***H***), 7.27-7.12 (m, 5H; Ar***H***), 6.94-6.86 (d, 1H; N***H***, *J* = 6.7 Hz), 5.10-5.06 (d, 2H; C$\boldsymbol{H_2}$, *J* = 1.2 Hz), 4.49-4.38 (m, 1H; C***H***), 3.99-3.89 (q, 1H; C***H***), 3.10-3.01 (dd, 1H, C$\boldsymbol{H_2}$), 2.94-2.85 (dd, 1H, C$\boldsymbol{H_2}$), 2.35-2.27 (t, 2H; C$\boldsymbol{H_2}$), 1.89-1.78 (m, 1H; C$\boldsymbol{H_2}$), 1.78-1.66 (m, 1H; C$\boldsymbol{H_2}$), 1.44-1.16 (d, 9H; C$\boldsymbol{H_3}$, *J* = 51.4 Hz).



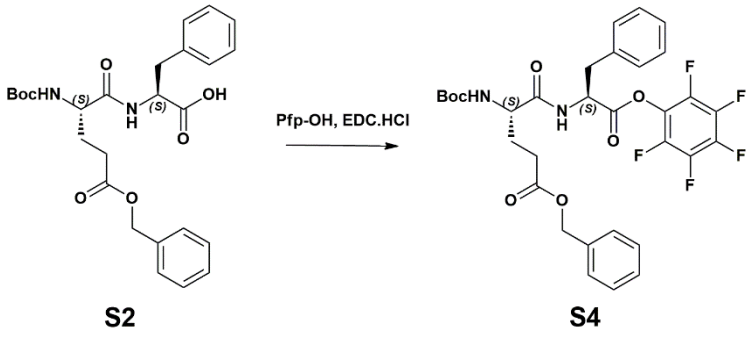
Synthesis of S3. S2 (1.46 g, 3.01 mmol) was dissolved in TFA (trifluoroacetic acid, 4.5 mL, 60.26 mmol) at 0 ^{o}C for 4 h. After the completion of this deprotection, MeOH (9.0 mL) was added into the mixture, stirring 3 h. This mixture was condensed to give S3 (1.54 g, 100%) without any purification.

^{1}H NMR (d_6-DMSO, 400MHz): δ 13.25-12.80 (s, 1H; COO***H***), 8.97-8.74 (dd, 1H; N***H***), 8.28-8.06 (s, 3H; N$\boldsymbol{H_3^+}$), 7.42-7.32 (m, 5H; Ar***H***), 7.32-7.18 (m, 6H; Ar***H*** + N***H***), 5.13-5.09 (d, 2H; C$\boldsymbol{H_2}$, *J* = 4.7 Hz), 4.58-4.44 (m, 1H; C***H***), 3.90-3.80 (s, 1H; C***H***), 3.63-3.57 (t, 1H, C$\boldsymbol{H_2}$), 3.15-3.06 (m, 1H, C$\boldsymbol{H_2}$), 3.00-2.89 (m, 1H; C$\boldsymbol{H_2}$), 2.48-2.33 (m, 1H; C$\boldsymbol{H_2}$), 2.11-1.93 (m, 2H; C$\boldsymbol{H_2}$).



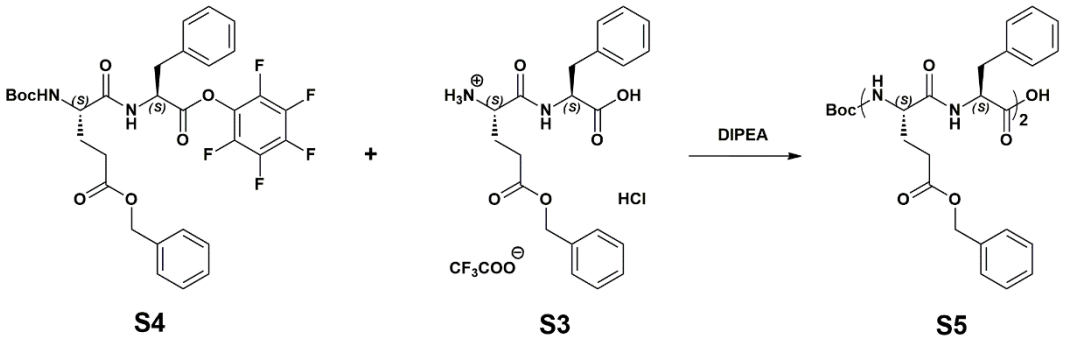
Synthesis of S4. S2 (1.30 g, 2.68 mmol) and Pfp-OH (0.59 g, 3.22 mmol) were dissolved in DCM (80 mL) at 0 ^{o}C for 30 min. And EDC.HCl (0.62 g, 3.22 mmol) was added into this mixture, stirring overnight. When this esterification was completed, the mixture was condensed and purified by column chromatography (DCM : MeOH = 100 : 1) to get S4 (with a little Pfp-OH, 1.78 g, ~80%).

^{1}H NMR (d_6-DMSO, 400MHz): δ 8.04-8.03 (dd, 1H; N***H***), 7.44-7.30 (m, 5H; Ar***H***), 7.27-7.05 (m, 5H; Ar***H***), 6.94-6.75 (dd, 1H; N***H***), 5.15-5.04 (m, 2H; C$\boldsymbol{H_2}$), 4.50-4.37 (m, 1H; C***H***), 4.05-3.90 (m, 1H; C***H***), 3.12-3.01 (m, 1H, C$\boldsymbol{H_2}$), 2.95-2.80 (m, 1H, C$\boldsymbol{H_2}$), 2.37-2.26 (t, 1H; C$\boldsymbol{H_2}$), 2.23-2.00 (m, 1H; C$\boldsymbol{H_2}$), 1.90-1.54 (m, 2H; C$\boldsymbol{H_2}$), 1.42-1.19 (m, 9H; C$\boldsymbol{H_3}$).



Synthesis of S5. S3 (0.65 g, < 1.00 mmol) and DIPEA (0.7 mL, 4.01 mmol) were dissolved in DCM (80 mL) at -15 ^{o}C for 30 min. Then S4 (in DCM, 0.50 g, 1.00 mmol) was dropped into the mixture slowly, reacting overnight. After the completion of this coupling, this mixture was washed by $KHSO_4$ (aq, 10 wt %), condensed and purified by column chromatography (DCM : MeOH = 30 : 1) to give S5 (0.51 g, 60%).

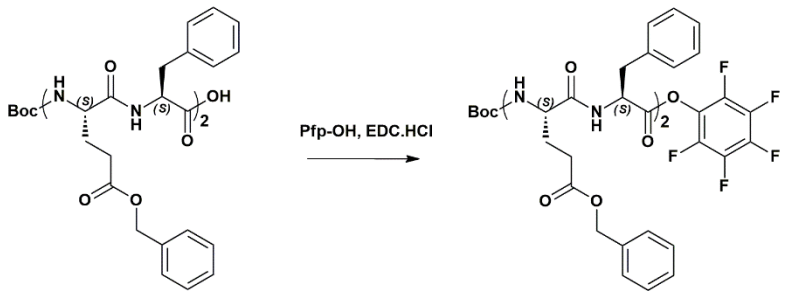
^{1}H NMR (d_6-DMSO, 400MHz): δ 12.85-12.60 (s, 1H, COO***H***), 8.34-7.72 (m, 3H; N***H***), 7.43-7.29 (m, 10H; Ar***H***), 7.28-7.06 (m, 10H; Ar***H***), 7.04-6.75 (m, 1H; N***H***), 5.10-5.04 (d, 4H; C$\boldsymbol{H_2}$, *J* = 5.6 Hz), 4.65-4.50 (m, 1H; C***H***), 4.48-4.28 (m, 2H; C***H***), 4.02-3.80 (m, 1H, C***H***), 3.12-3.02 (m, 1H, C$\boldsymbol{H_2}$), 3.00-2.85 (m, 2H; C$\boldsymbol{H_2}$), 2.77-2.67 (m, 1H; C$\boldsymbol{H_2}$), 2.40-2.30 (t, 1H; C$\boldsymbol{H_2}$), 2.28-2.15 (t, 2H; C$\boldsymbol{H_2}$), 2.13-1.53 (m, 5H; C$\boldsymbol{H_2}$), 1.40-1.13 (m, 9H; C$\boldsymbol{H_3}$).



S4 **S3** **S5**

Synthesis of S6. S5 (0.30 g, 0.35 mmol) and Pfp-OH (0.08 g, 0.42 mmol) were dissolved in DCM (80 mL) at 0 ^{o}C for 30 min. Then EDC.HCl (0.16 g, 0.85 mmol) was added into this mixture, stirring overnight. When this reaction was completed, the mixture was washed by pure water and evaporated to obtain S6 (with a little Pfp-OH, 0.38 g, ~80%).

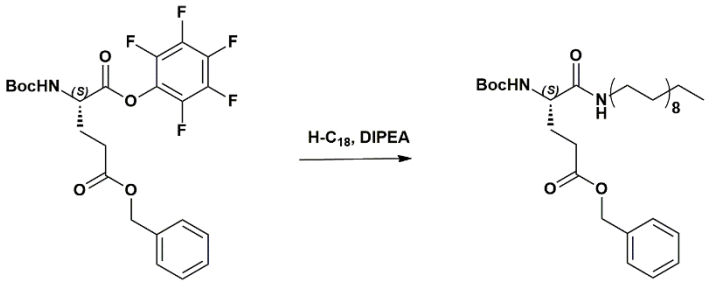
^{1}H NMR (d_6-DMSO, 400MHz): δ 8.95-7.70 (m, 2H; N***H***), 7.43-7.29 (m, 10H; Ar***H***), 7.45-6.89 (m, 20H; Ar***H***), 6.87-6.45 (m, 1H; N***H***), 5.16-5.00 (m, 4H; C$\boldsymbol{H_2}$), 4.95-4.70 (m, 1H; C***H***), 4.66-4.20 (m, 2H; C***H***), 4.05-3.80 (m, 1H, C***H***), 3.23-2.67 (m, 4H, C$\boldsymbol{H_2}$), 2.45-1.50 (m, 8H; C$\boldsymbol{H_2}$), 1.42-1.14 (m, 9H; C$\boldsymbol{H_3}$).



S5 **S6**

Synthesis of S7. H-C_{18} (n-octadecylamine, 0.40 g, 1.48 mmol) and DIPEA (0.8 mL, 4.45 mmol) were dissolved in DCM (60 mL) at -15 ^{o}C for 30 min. Then S1 (in DCM, 0.77 g, < 1.48 mmol) was dropped into this mixture, stirring overnight. When this coupling was completed, the mixture was washed by $KHSO_4$ (aq, 10 wt %), condensed and purified by column chromatography (DCM : MeOH = 50 : 1) to get S7 (0.67 g, > 80%).

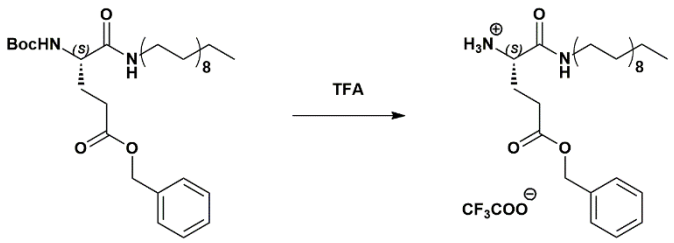
^{1}H NMR ($CDCl_3$, 400MHz): δ 7.35-7.23 (m, 5H; Ar***H***), 6.13-6.02 (s, 1H, N***H***), 5.23-5.13 (d, 1H, N***H***, *J* = 7.1 Hz), 5.08-5.04 (s, 2H; C***H*****$_2$**), 4.10-3.97 (d, 1H; C***H***, *J* = 5.2 Hz), 3.20-3.08 (q, 2H; C***H*****$_2$**), 2.54-2.43 (m, 1H, C***H*****$_2$**), 2.42-2.30 (m, 1H, C***H*****$_2$**), 2.12-2.00 (m, 1H; C***H*****$_2$**), 1.92-1.78 (m, 1H; C***H*****$_2$**), 1.47-1.32 (s, 9H; C***H*****$_3$**), 1.30-1.10 (s, 32H; C***H*****$_2$**), 0.85-0.77 (t, 3H; C***H*****$_3$**).



S1 **S7**

Synthesis of S8. S7 (0.67 g, 1.14 mmol) was dissolved in TFA (1.7 mL, 22.76 mmol) at 0 ^{o}C for 4 h. When this reaction was completed, MeOH (4 mL) was add into the mixture, stirring 4 h. Lastly the mixture was evaporated to obtain S8 (0.72 g, 100%).

^{1}H NMR (*d*$_6$-DMSO, 400MHz): δ 8.45-8.35 (t, 1H; N***H***), 8.23-8.07 (s, 3H; N***H*****$_3^+$**), 7.43-7.27 (m, 5H; Ar***H***), 5.15-5.05 (s, 2H; C***H*****$_2$**), 3.80-3.70 (d, 1H; C***H***, *J* = 5.4 Hz), 3.22-3.11 (m, 1H; C***H*****$_2$**), 3.09-2.98 (m, 1H, C***H*****$_2$**), 2.47-2.35 (m, 2H, C***H*****$_2$**), 2.07-1.93 (m, 2H; C***H*****$_2$**), 1.47-1.35 (m, 2H; C***H*****$_2$**), 1.33-1.17 (d, 30H; C***H*****$_2$**, *J* = 2.6 Hz), 0.90-0.80 (t, 3H; C***H*****$_3$**).

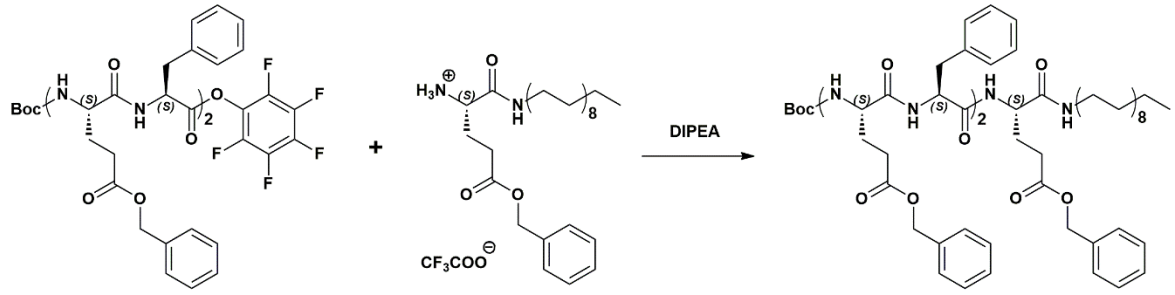


S7 **S8**

Synthesis of S9. S8 (0.72 g, 1.14 mmol) and DIPEA (0.6 mL, 3.41 mmol) were added in chloroform (70 mL) at -12

^{o}C for 30 min, then S6 (in chloroform, 1.20 g, < 1.14 mmol) was dropped into this mixture, stirring overnight. After the completion of this coupling, the mixture was washed by $KHSO_4$ (aq, 10 wt %), condensed and purified by column chromatography (DCM : MeOH = 50 : 1) to get S9 (1.20 g, 80%).

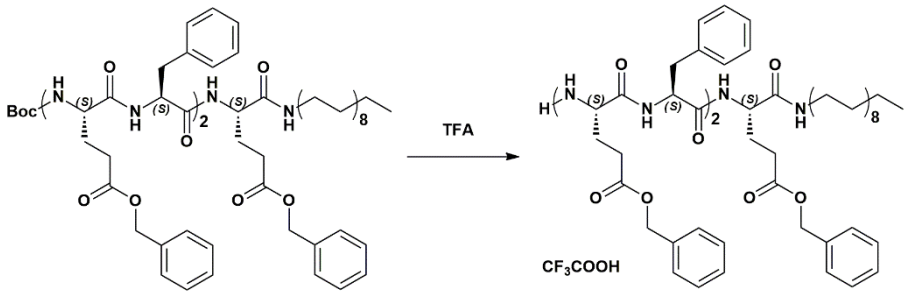
^{1}H NMR (d_6-DMSO, 400MHz): δ 8.40-7.90 (m, 3H; N***H***), 7.92-7.57 (m, 2H; N***H***), 7.56-6.96 (m, 25H; Ar***H***), 6.95-6.73 (m, 1H; N***H***), 5.29-4.95 (s, 6H; C***H₂***), 4.67-4.42 (m, 2H; C***H***), 4.36-4.15 (m, 2H; C***H***), 4.04-3.80 (m, 1H, C***H***), 3.17-2.89 (m, 4H, C***H₂***), 2.88-2.64 (m, 2H; C***H₂***), 2.44-1.56 (m, 12H; C***H₂***), 1.51-1.05 (m, 41H; C***H₂*** + C***H₃***), 0.94-0.78 (t, 9H; C***H₃***).



S6 **S8** **S9**

Synthesis of S10. S9 (0.49 g, 0.37 mmol) was dissolved in TFA (0.55 mL, 7.41 mmol) at 0 ^{o}C for 4 h. Then MeOH/chloroform (1 : 1) was added into this mixture at r.t. for 4 h. The mixture was evaporated to obtain S10 (0.50 g, 100%).

^{1}H NMR (d_6-DMSO, 400MHz): δ 8.60-8.28 (m, 3H, N***H***), 8.27-7.86 (m, 5H, N***H*** + N***H₃***$^+$), 7.50-7.05 (m, 25H; Ar***H***), 5.20-5.00 (m, 6H; C***H₂***), 4.71-4.46 (m, 2H; C***H***), 4.46-4.15 (m, 3H; C***H***), 3.19-2.89 (m, 4H; C***H₂***), 2.88-2.60 (m, 2H; C***H₂***), 2.42-2.14 (m, 3H; C***H₂***), 2.12-1.60 (m, 7H; C***H₂***), 1.50-1.10 (m, 32H, C***H₂***), 0.94-0.76 (t, 3H; C***H₃***).

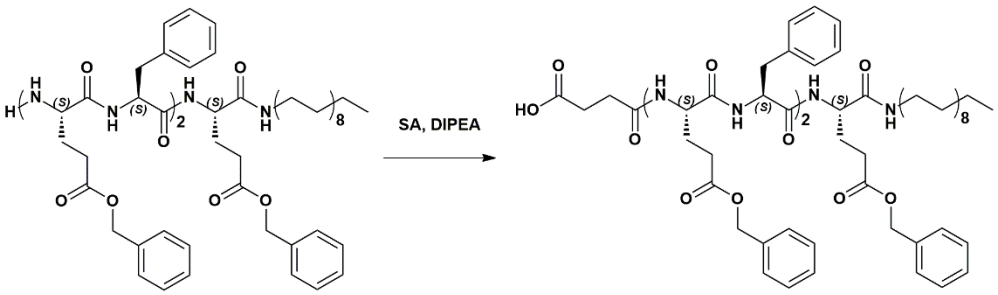


S9 **S10**

Synthesis of S11. S10 (0.32 g, 0.24 mmol) and DIPEA (0.13 mL, 0.72 mmol) was dissolved in chloroform (50 mL) at -15 ^{o}C for 30 min, then SA (Succine anhydride, 0.03 g, 0.29 mmol) was added into this solution, reacting overnight. After reaction the mixture was washed by $KHSO_4$ (aq, 10 wt%), condensed and obtained S11 (0.31 g,

80%).

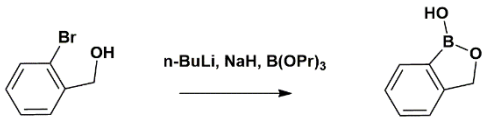
^{1}H NMR (d_6-DMSO, 400MHz): δ 12.17-12.03 (s, 1H, COO***H***), 8.35-8.13 (m, 1H, N***H***), 8.12-7.78 (m, 4H, N***H***), 7.75-7.57 (m, 1H; N***H***), 7.45-7.05 (m, 25H; Ar***H***), 5.12-5.00 (d, 6H; C***H*****$_2$**, *J* = 3.0 Hz), 4.58-4.40 (m, 2H; C***H***), 4.30-4.12 (m, 3H; C***H***), 3.10-2.90 (m, 4H; C***H*****$_2$**), 2.87-2.65 (m, 2H; C***H*****$_2$**), 2.45-2.10 (m, 9H; C***H*****$_2$**), 2.08-1.50 (m, 7H; C***H*****$_2$**), 1.45-1.10 (m, 32H, C***H*****$_2$**), 0.90-0.80 (t, 3H; C***H*****$_3$**).



S10 **S11**

Synthesis of S12. 2-bromobenzyl alcohol (7.10 g, 37.6 mmol) was dissolved in THF (50 mL) at 0 ^{o}C, then NaH (1.07 g, 45.2 mmol) was added into this mixture. After 1 h the mixture was cooled down to -78 ^{o}C and n-BuLi (18.0 mL, 45.2 mmol) was dropped into it. 1 h later, $B(OPr)_3$ (10.4 mL, 45.2 mmol) was added into the mixture, reacting at -78 ^{o}C for 6 h then recovering to room temperature gradually. When this reaction completed, the mixture was washed by sulfuric acid (2 M) to pH 2, extracted with ethyl acetate three times. Lastly this mixture was condensed and purified by column chromatography (PE : EAC = 4 : 1) to get S12 (2.12 g, 42%).

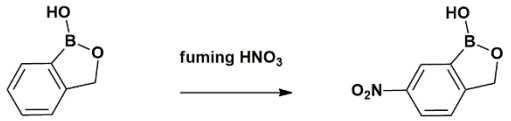
^{1}H NMR (d_6-DMSO, 400MHz): δ 9.20-9.13 (s, 1H, O***H***), 7.78-7.67 (dd, 1H, Ar***H***), 7.55-7.38 (m, 2H, Ar***H***), 7.37-7.30 (t, 1H, Ar***H***), 5.19-5.10 (s, 1H; C***H*****$_2$**), 5.05-4.95 (s, 1H; C***H*****$_2$**).



2-bromobenzyl alcohol **S12**

Synthesis of S13. Fuming HNO_3 (10.0 mL) was cooled down to -45 ^{o}C, then S12 (1.42 g, 10.6 mmol) was dropped into this mixture, reacting for 20 min. Then ice was added into it and the reaction was stirring at 0 ^{o}C for 2 h. This mixture was evaporated to obtain S13 (1.77 g, 93%).

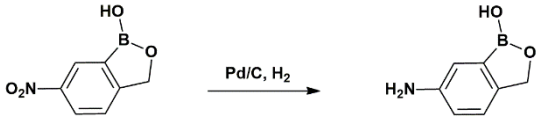
^{1}H NMR (d_6-DMSO, 400MHz): δ 9.63-9.55 (s, 1H, O***H***), 8.63-8.56 (d, 1H, Ar***H***, *J* = 2.2 Hz), 8.38-8.30 (dd, 1H, Ar***H***), 7.75-7.65 (d, 1H, Ar***H***, *J* = 8.4 Hz), 5.16-5.10 (s, 2H; C***H*****$_2$**).



S12 **S13**

Synthesis of S14. S13 (0.20 g, 1.1 mmol) was dissolved in methanol (30 mL) and DMAc (5 drops), then Pd/C (20 mg) was added into the mixture. After the replacement of H_2 this mixture was stirring overnight at room temperature in ordinary pressure. When this reaction completed, evaporated methanol under N_2 and obtained S14 (0.16 g, 70%).

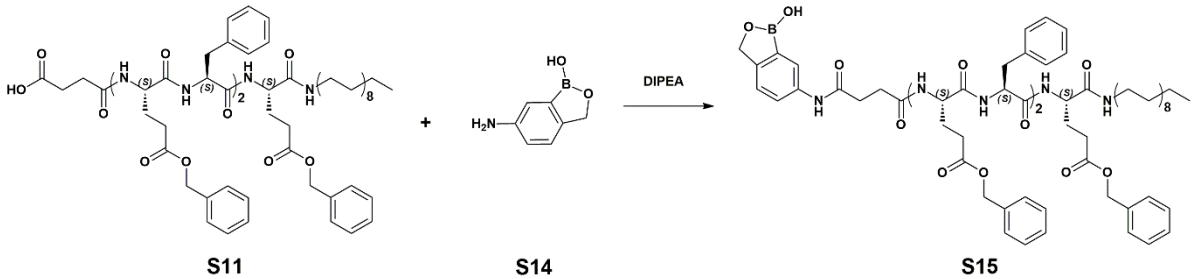
^{1}H NMR (d_6-DMSO, 400MHz): δ 9.70-9.45 (s, 1H, O***H***), 8.65-8.33 (d, 1H, Ar***H***, *J* = 2.0 Hz), 8.40-8.27 (dd, 1H, Ar***H***), 7.75-7.65 (d, 1H, Ar***H***, *J* = 8.4 Hz), 5.18-5.18 (s, 2H; C***H₂***).



S13 **S14**

Synthesis of S15. S11 (0.32 g, 0.24 mmol), S14 (0.10 g, 0.38 mmol) and DIPEA (0.13 g, 0.97 mmol) were dissolved in DMF (80 mL) at -15 ^{o}C for 30 min. Then EDC.HCl (0.09 g, 0.48 mmol) was added into this mixture, reacting overnight. The mixture was condensed (dealt with TFA) and purified by column chromatography (DCM : MeOH = 50 : 1) to get S15 (0.18 g, 51%, little residual TFA).

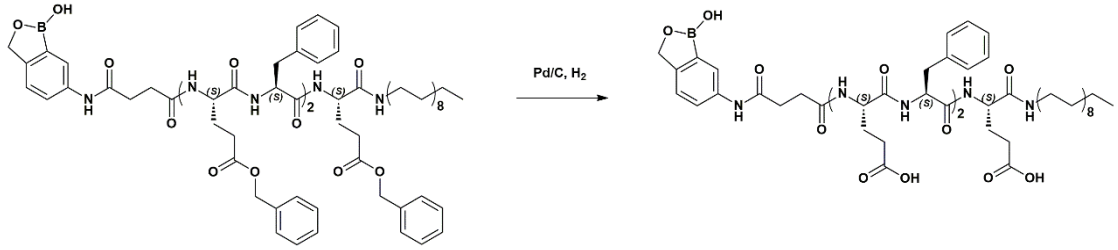
^{1}H NMR (d_6-DMSO, 400MHz): δ 9.23-9.12 (s, 1H, O***H***), 8.38-7.78 (m, 6H, N***H***), 7.75-7.57 (m, 1H, N***H***), 7.46-7.05 (m, 25H; Ar***H***), 5.09-5.02 (d, 6H; C***H₂***, *J* = 3.3 Hz), 4.95-4.88 (s, 2H; C***H₂***), 4.58-4.42 (m, 2H; C***H***), 4.30-4.14 (m, 3H; C***H***), 3.10-2.91 (m, 4H; C***H₂***), 2.88-2.65 (m, 2H; C***H₂***), 2.47-1.55 (m, 16H; C***H₂***), 1.45-1.10 (m, 32H, C***H₂***), 0.90-0.80 (t, 3H; C***H₃***).



S11 **S14** **S15**

Synthesis of S16. S15 (0.50 g, 0.34 mmol) was dissolved in methanol (3.0 mL) and ethyl acetate (8.0 mL), then

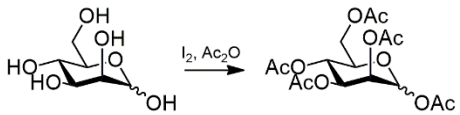
Pd/C (20 mg) was added into the mixture. After the replacement of H_2 this mixture was stirring overnight at room temperature in ordinary pressure. When this reaction completed, evaporated solvent under N_2 and obtained S16 (0.20 g, 50%). $[PA\text{-}H_2O+Na]^+$ in MALDITOF: 1186.62; Found: 1186.57.



S15 S16

Synthesis of S17. D-Mannose (10.0 g, 55.6 mmol) was dissolved in acetic anhydride (100.0 mL, 1.06 mol), then I_2 was added into this mixture, reacting overnight. When this reaction completed, ethyl acetate (60 mL) was added into the mixture. This mixture was washed by Na_2SO_3 (aq), $NaHCO_3$ (aq) and brine in turn. After the evaporation of solvent S17 was obtained (20.2 g, 90%).

^{1}H NMR (d_6-DMSO, 400MHz): δ 5.99-5.95 (d, 1H, C***H***, *J* = 1.7 Hz), 5.26-5.14 (m, 3H, C***H***), 4.23-4.09 (m, 2H, C***H***), 4.08-3.98 (m, 1H; C***H***), 2.78-2.16 (s, 3H; C***H*****$_3$**), 2.15-2.13 (s, 3H; C***H*****$_3$**), 2.04-2.03 (s, 3H; C***H*****$_3$**), 2.03-2.02 (s, 3H; C***H*****$_3$**), 1.97-1.95 (s, 3H; C***H*****$_3$**).



Man S17

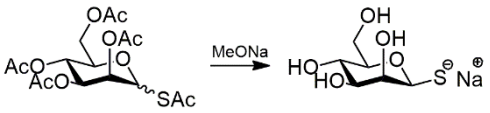
Synthesis of S18. S17 (2.00 g, 5.1 mmol) and thioglycolic acid (1.5 mL, 21.5 mmol) were dissolved in DCM (40 mL) at 0 ^{o}C for 30 min. Then $BF_3.Et_2O$ (4.0 mL, 31.5 mmol) was dropped into the mixture, reacting 36 h. After the reaction the mixture was washed by $NaHCO_3$ (aq) three times, condensed and purified by column chromatography (PE : EAC = 3 : 1) to get S18 (1.56 g, 75%).

^{1}H NMR (d_6-DMSO, 400MHz): δ 5.88-5.84 (d, 1H, C***H***, *J* = 1.7 Hz), 5.22-5.14 (m, 2H, C***H***), 5.00-4.92 (dd, 1H, C***H***), 4.21-4.13 (dd, 1H; C***H***), 4.05-3.97 (m, 1H; C***H***), 3.97-3.90 (m, 1H; C***H***), 2.49-2.46 (s, 3H; C***H*****$_3$**), 2.17-2.13 (s, 3H; C***H*****$_3$**), 2.05-2.02 (s, 3H; C***H*****$_3$**), 2.02-1.99 (s, 3H; C***H*****$_3$**), 1.97-1.94 (s, 3H; C***H*****$_3$**).

S17 S18

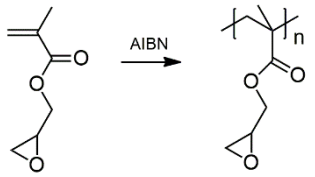
Synthesis of S19. S18 (0.55 g, 1.4 mmol) was dissolved in methanol (4.5 mL) at 0 °C for 20 min, then Na (81 mg, 1.5 mmol) was added into this mixture. After 4 h this mixture was evaporated and obtained S19 (0.41 g, 100%).

^{1}H NMR (D_2O, 400MHz): δ 5.49-5.45 (d, 1H, C***H***, *J* = 1.7 Hz), 4.36-4.30 (dd, 1H, C***H***), 4.20-4.14 (m, 1H, C***H***), 3.95-3.92 (dd, 1H; C***H***), 3.84-3.80 (dd, 2H; C***H₂***), 2.15-2.13 (s, 3H; C***H₃***), 2.04-2.03 (s, 3H; C***H₃***), 2.03-2.02 (s, 3H; C***H₃***), 1.97-1.95 (s, 3H; C***H₃***).



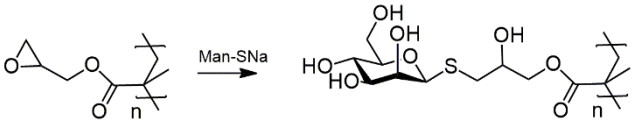
S18 **S19**

Synthesis of S20. GMA (1.0 mL, 7.7 mmol) and AIBN (0.20 g, 1.2 mmol) were dissolved in DMF (5.0 mL). After three times of freezing and thawing cycle, the mixture was heated to 70 °C for 55 min. The mixture precipitated in ethyl acetate for three times and S20 was obtained. (0.29 g, 27%)



GMA **S20**

Synthesis of S21. S19 (0.37 g, 1.69 mmol) and S20 (0.08 g, 0.56 mmol) were dissolved in DMF (40 mL), reacting at 65 °C for 2 d. After this reaction the mixture dialyzed in deionized water for eight times. Finally this sample was freeze-dried to get S21 (0.21 g, 100%).



S20 **S21**

XIII. ^{1}H and ^{13}C NMR spectra

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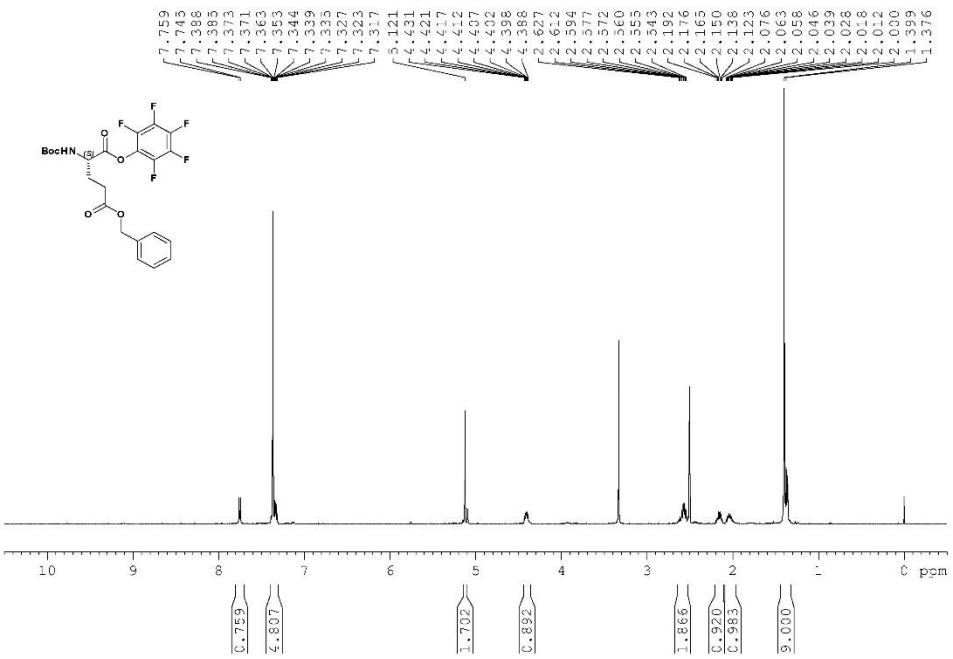

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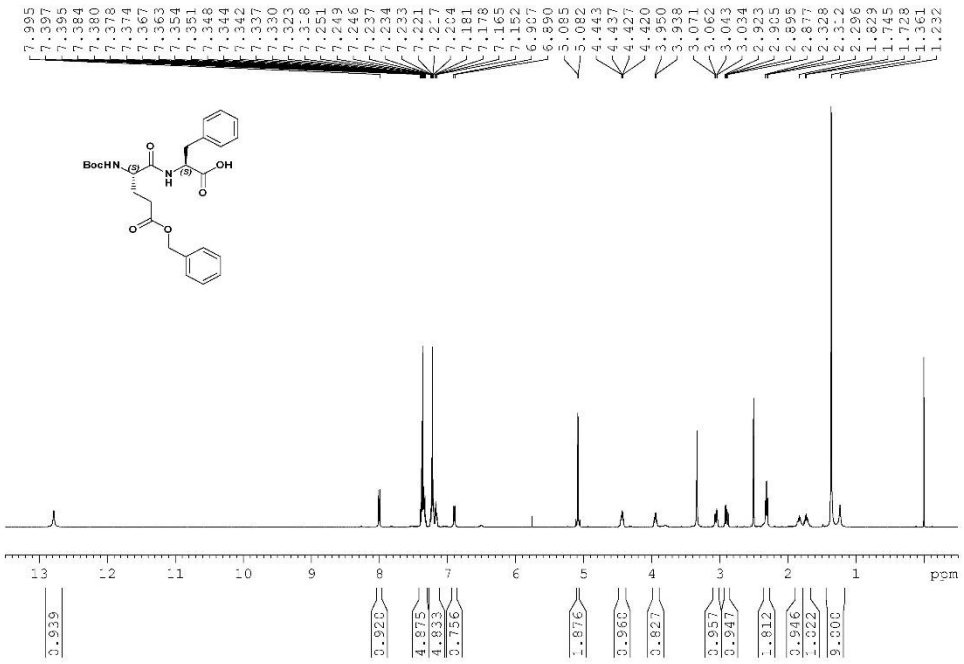

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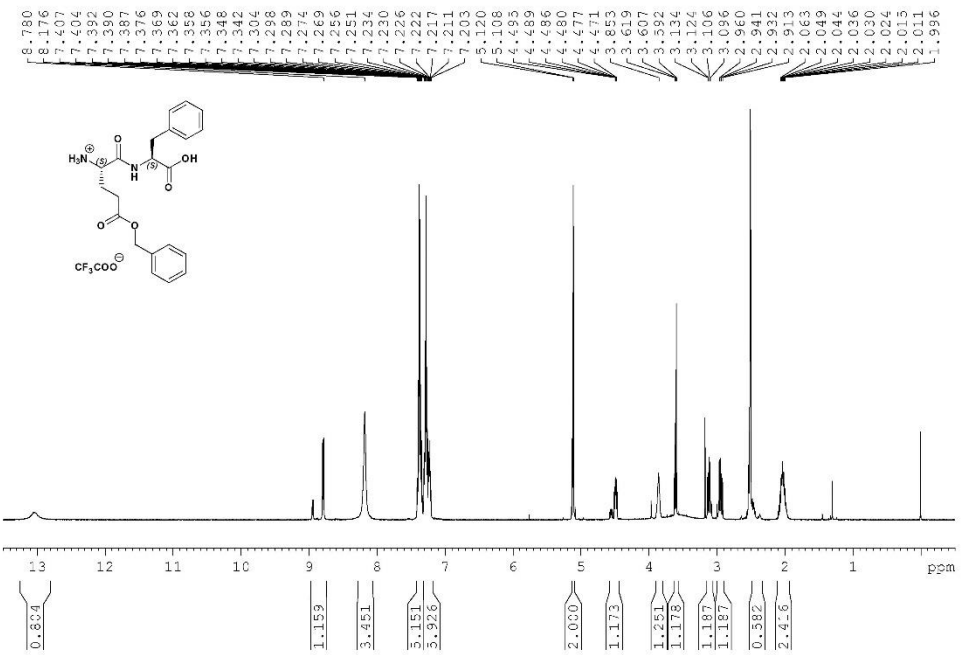

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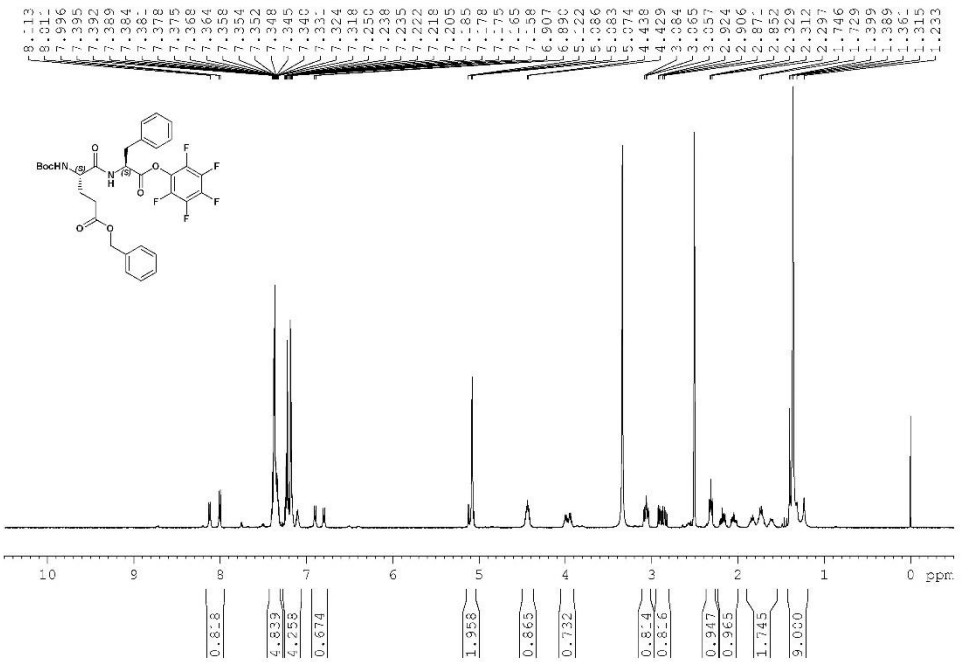

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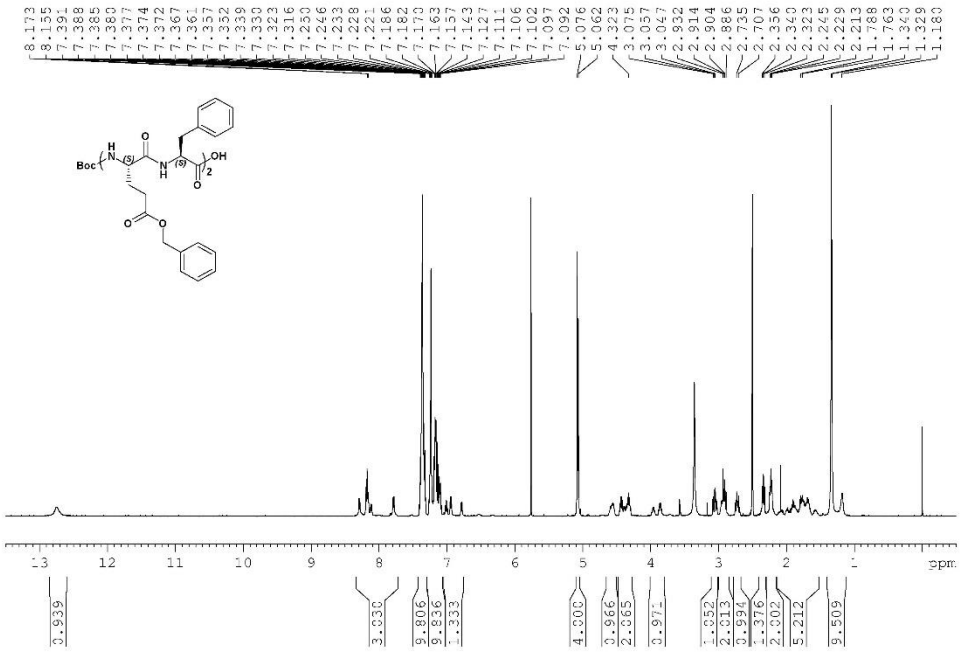

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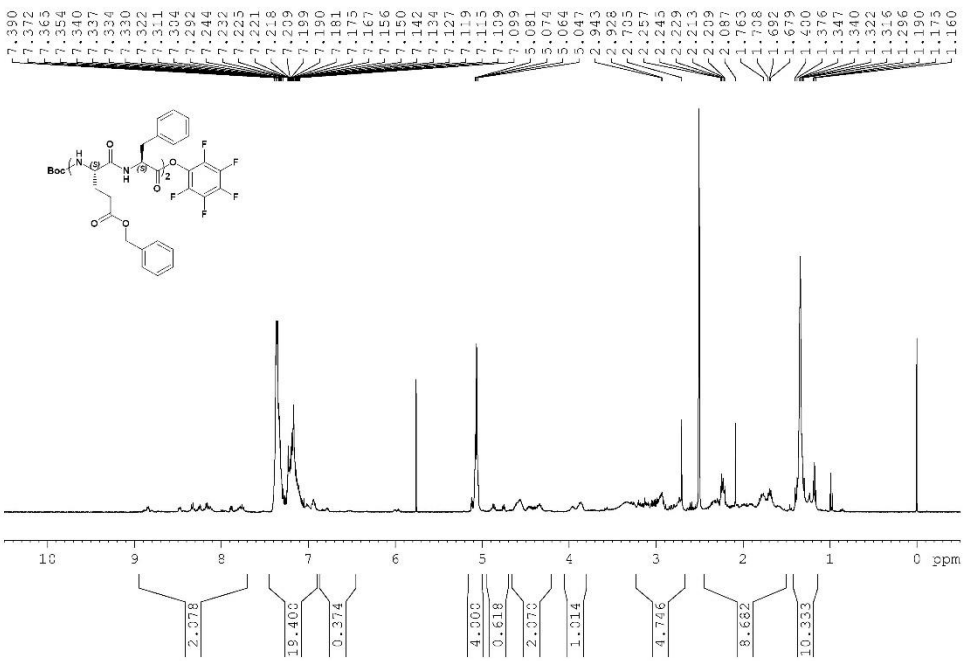

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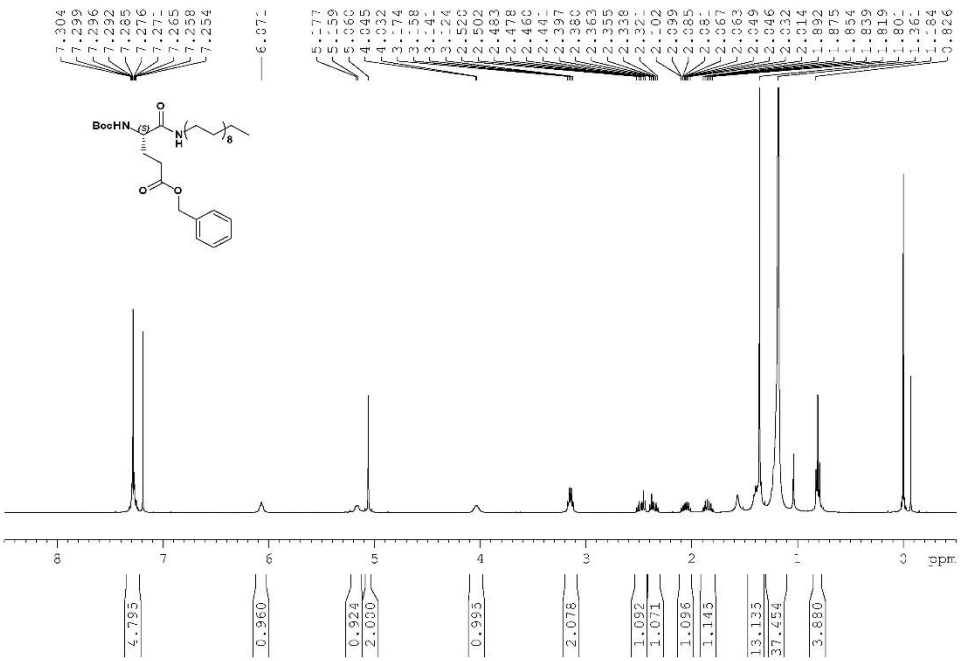

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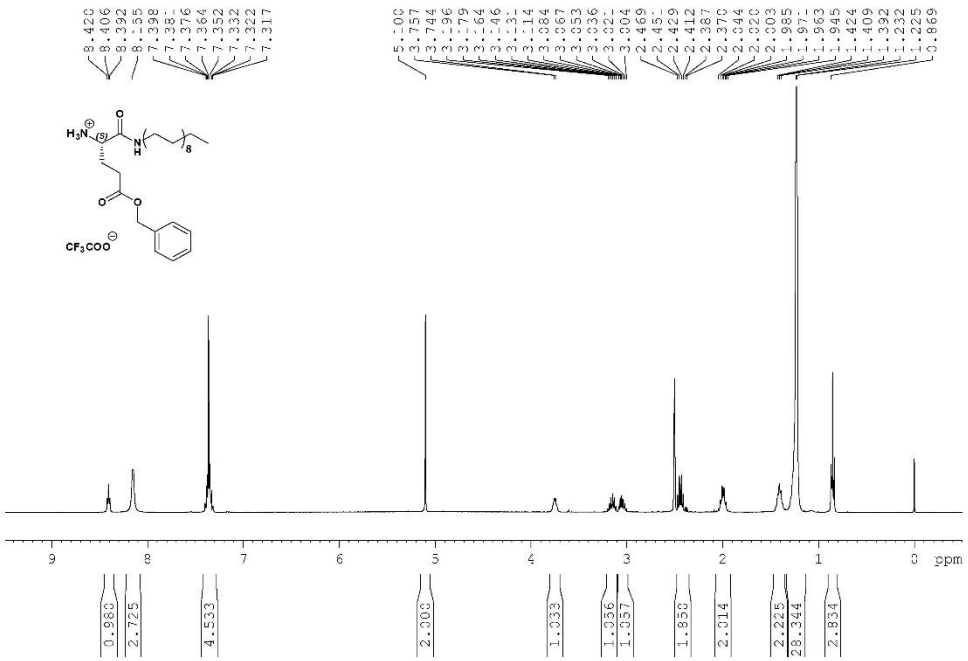

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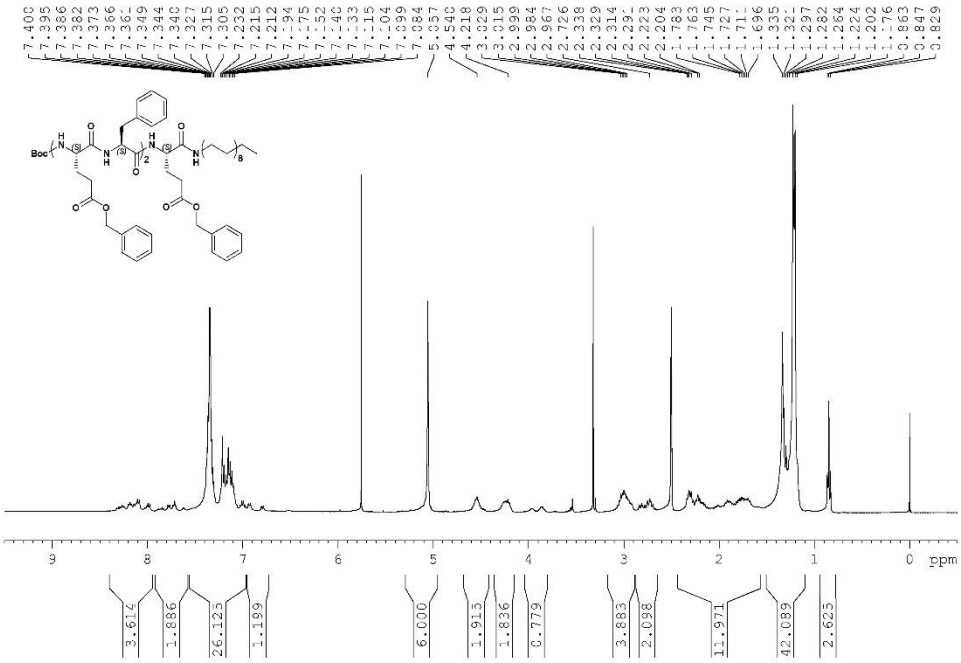

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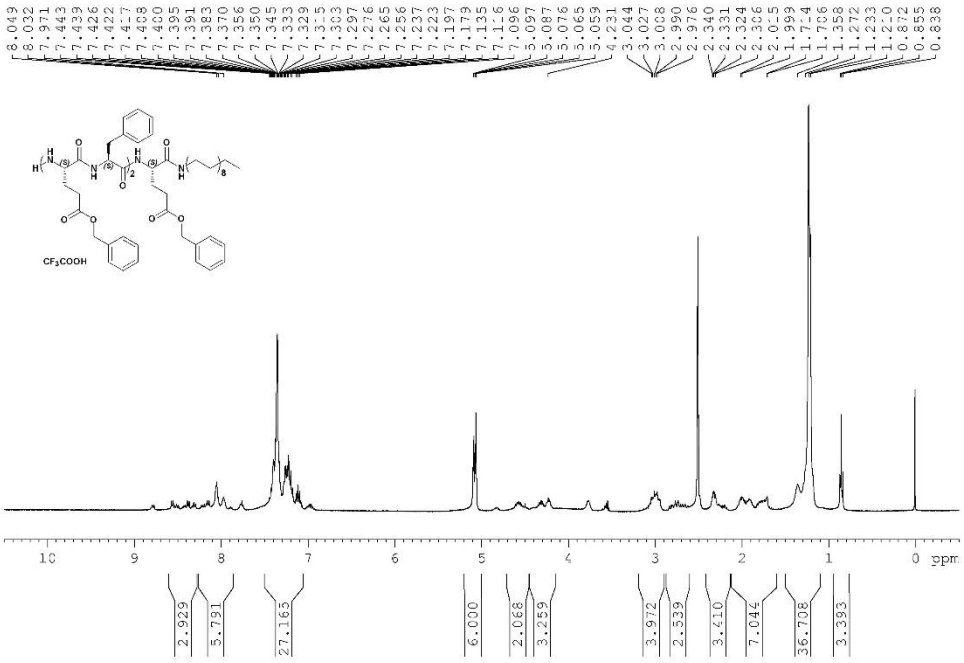

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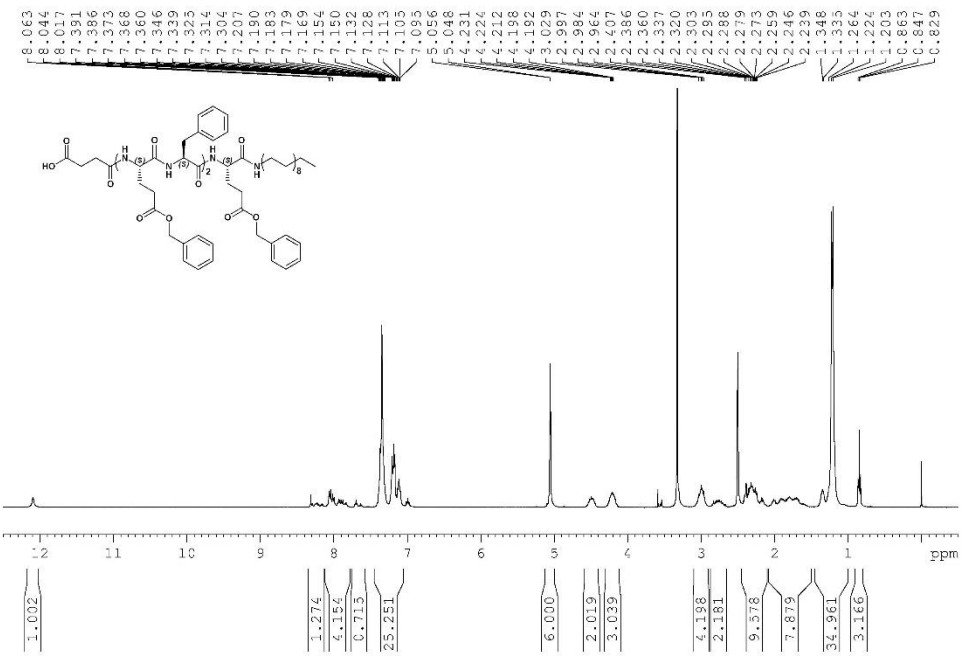

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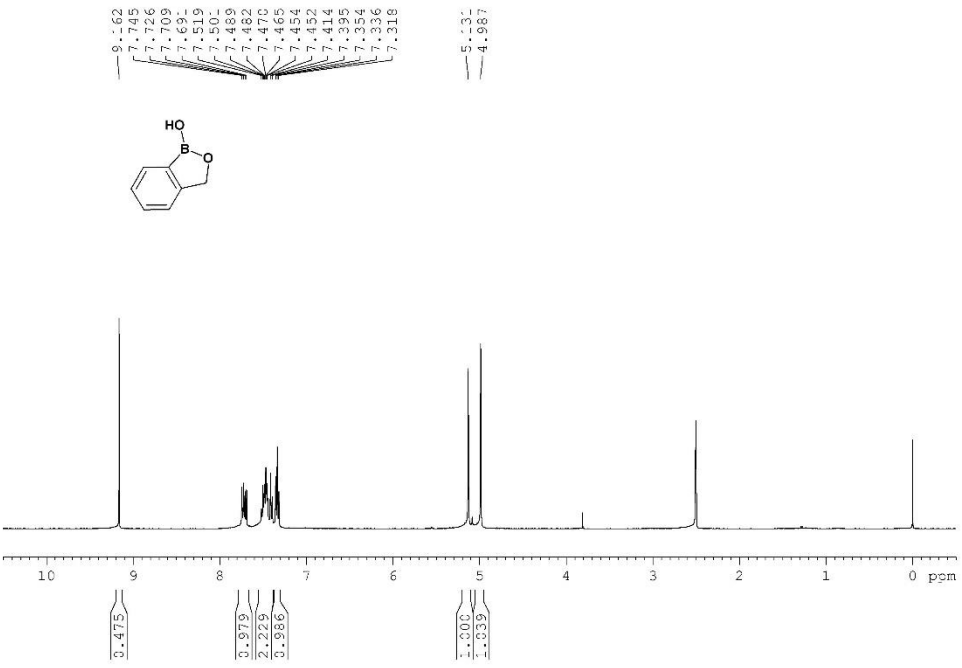

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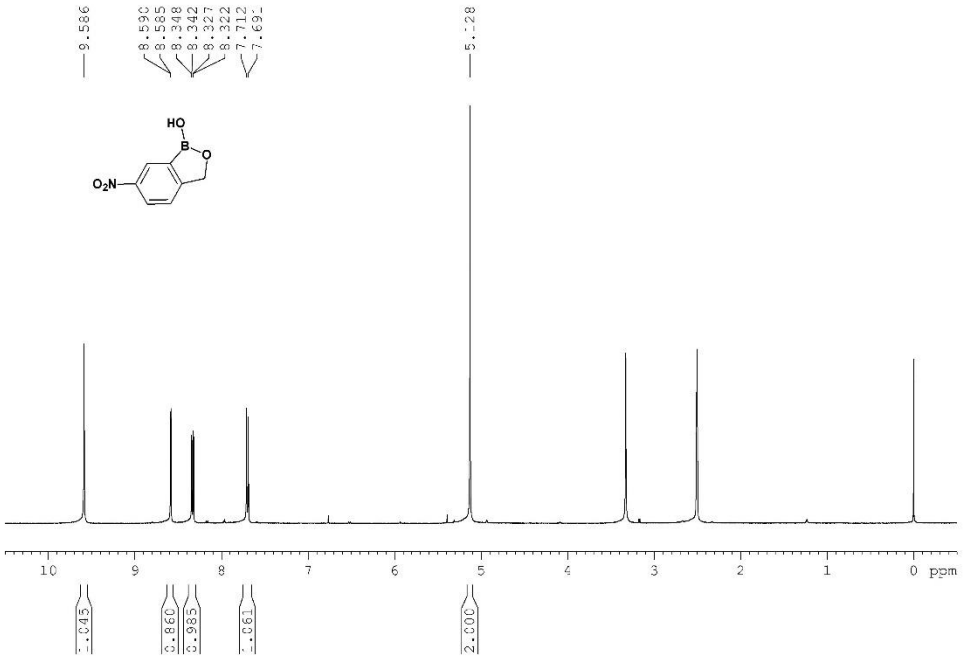
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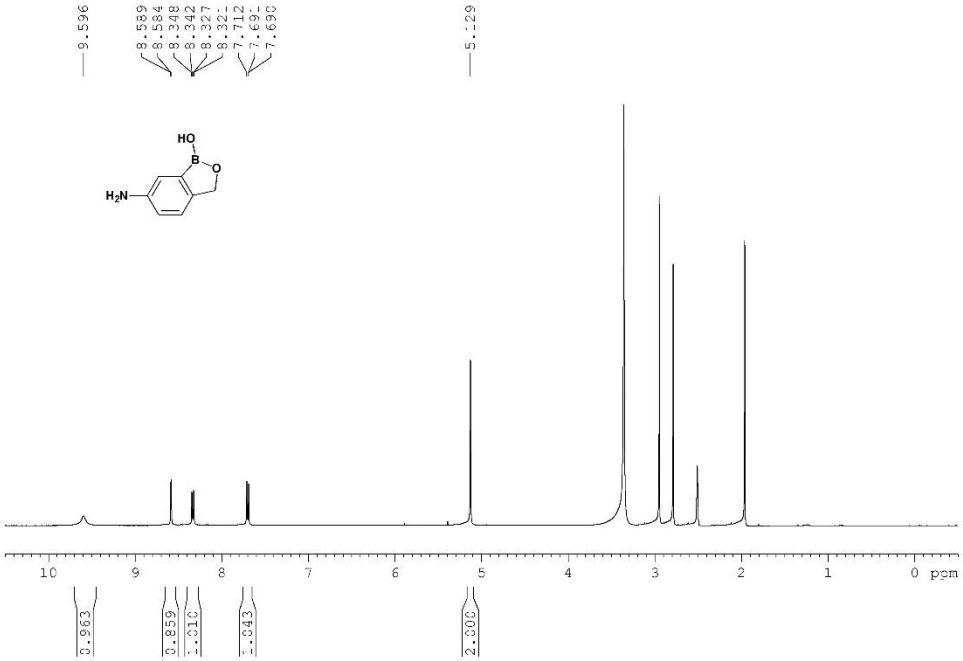
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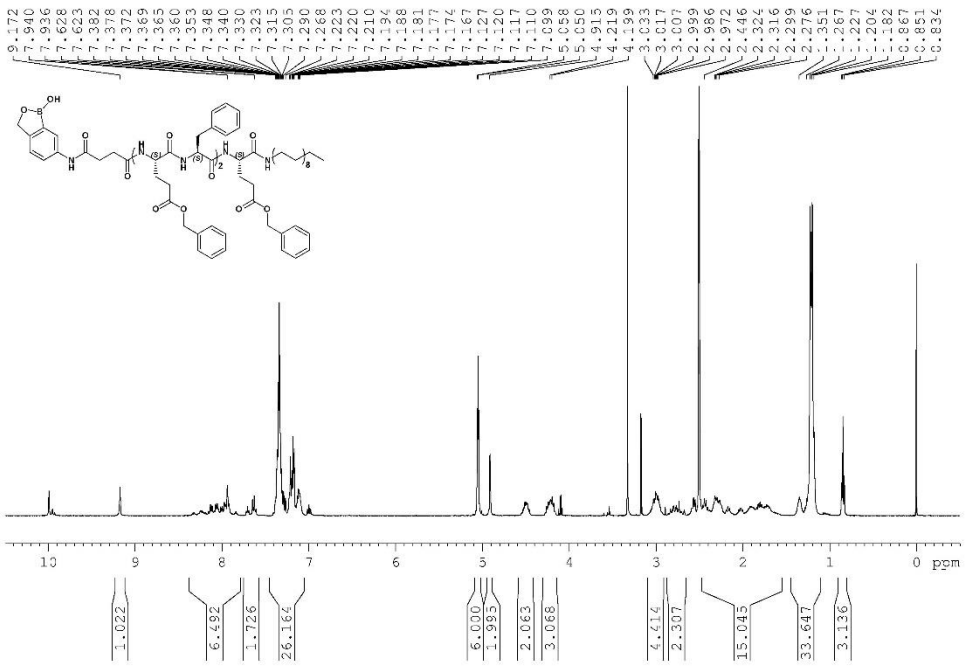
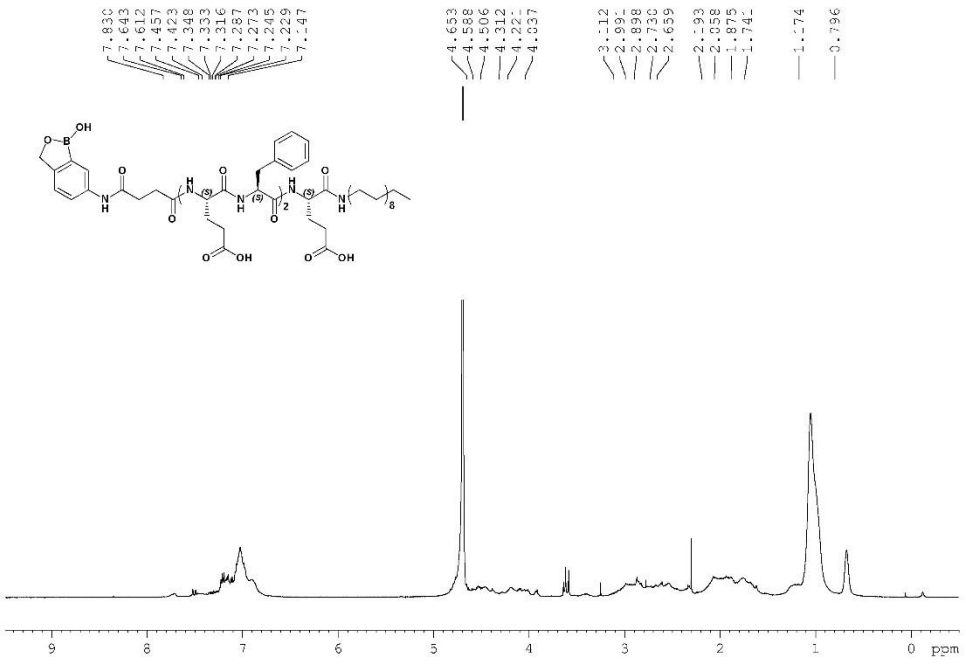
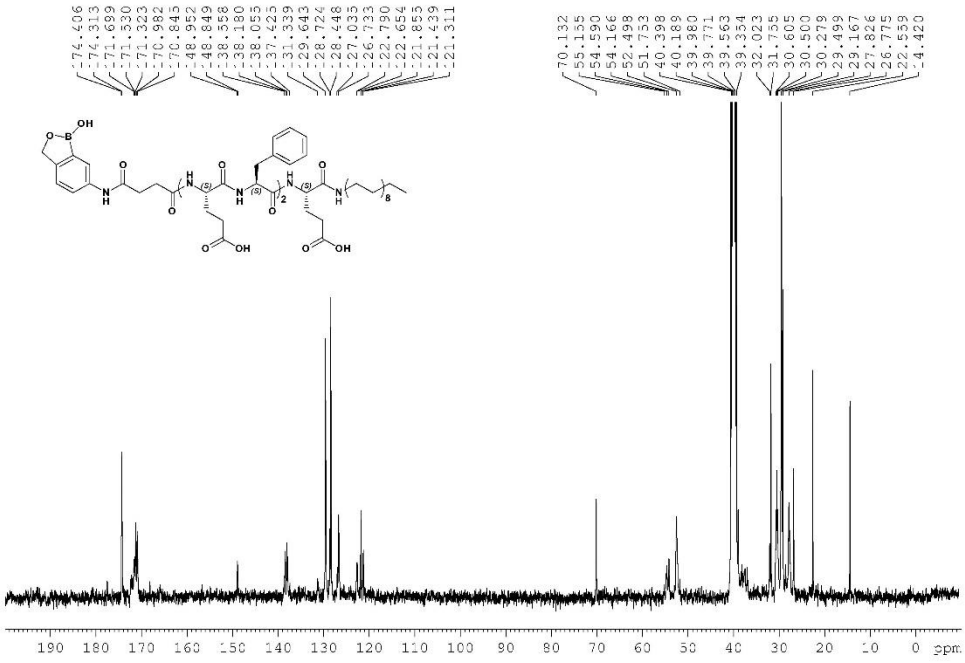
15.



16. (in D_2O)





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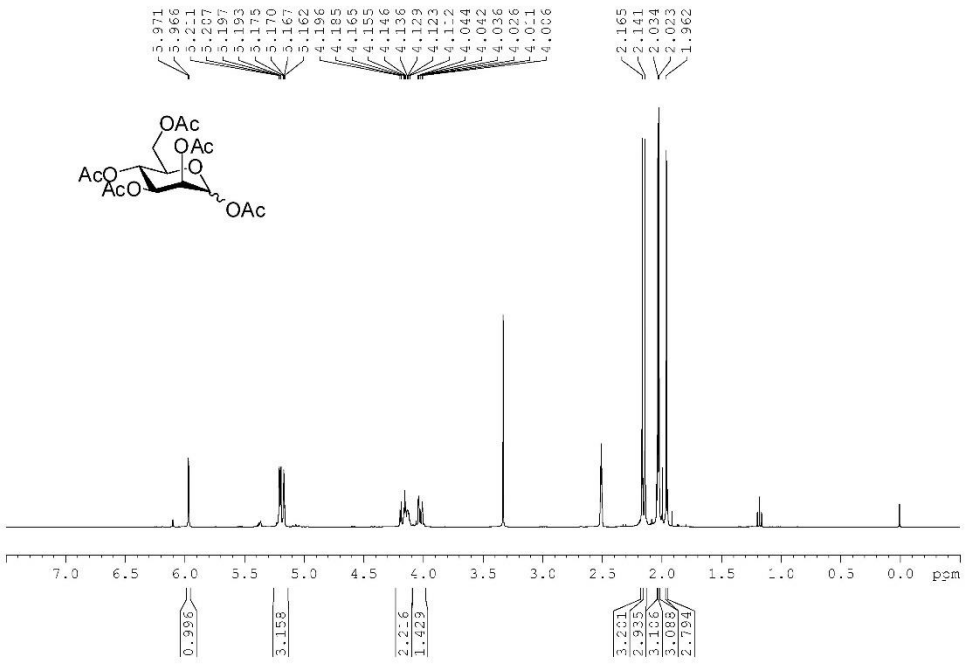

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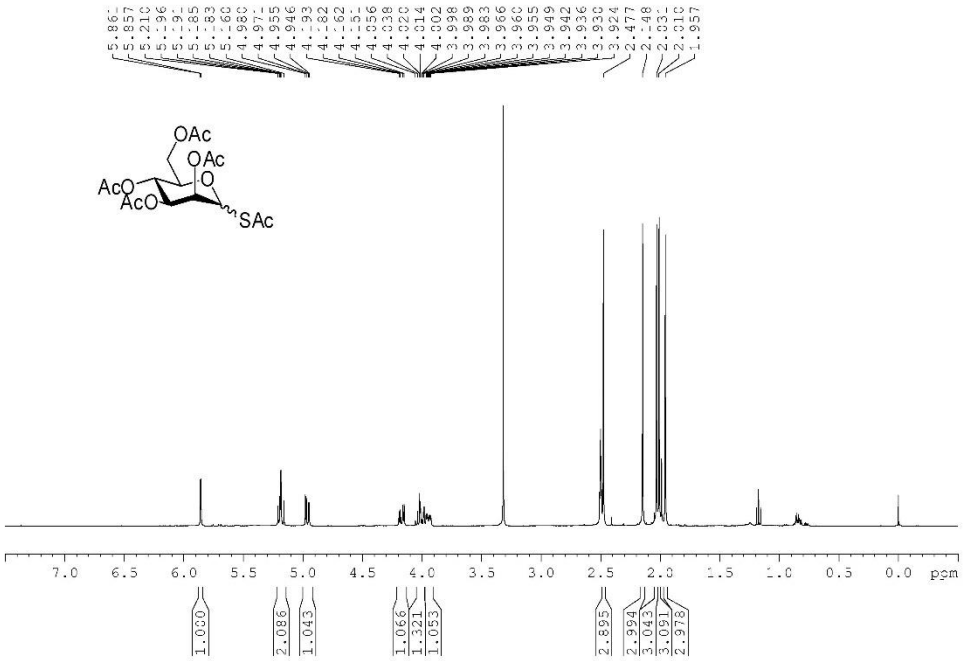

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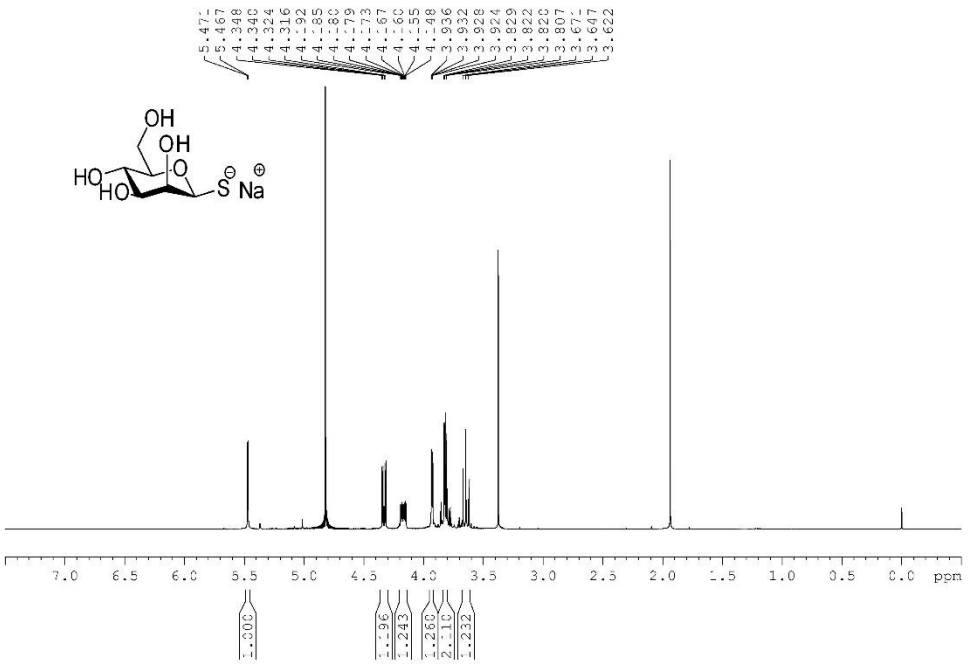

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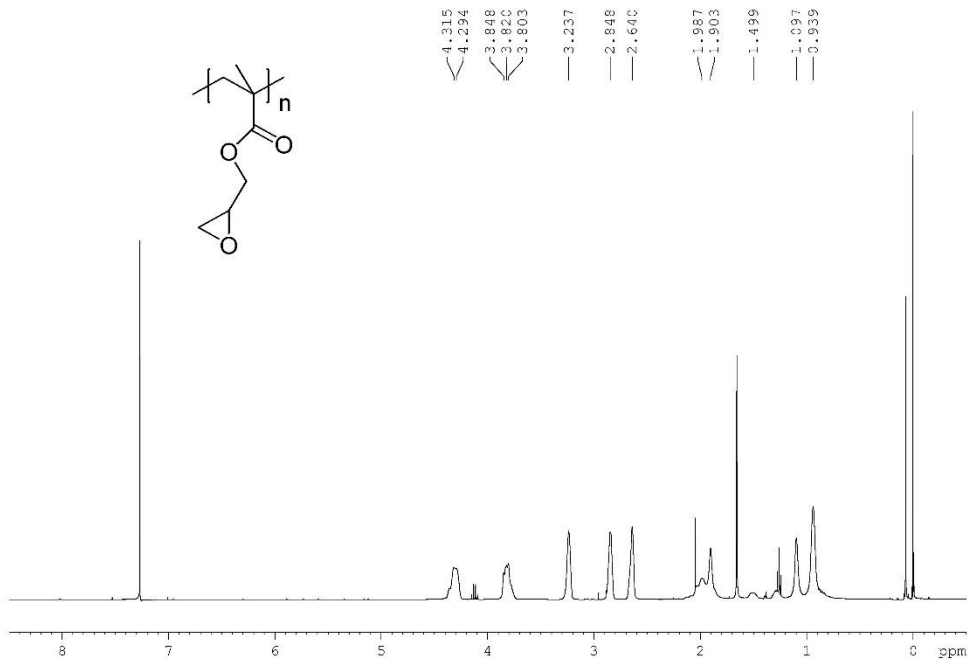
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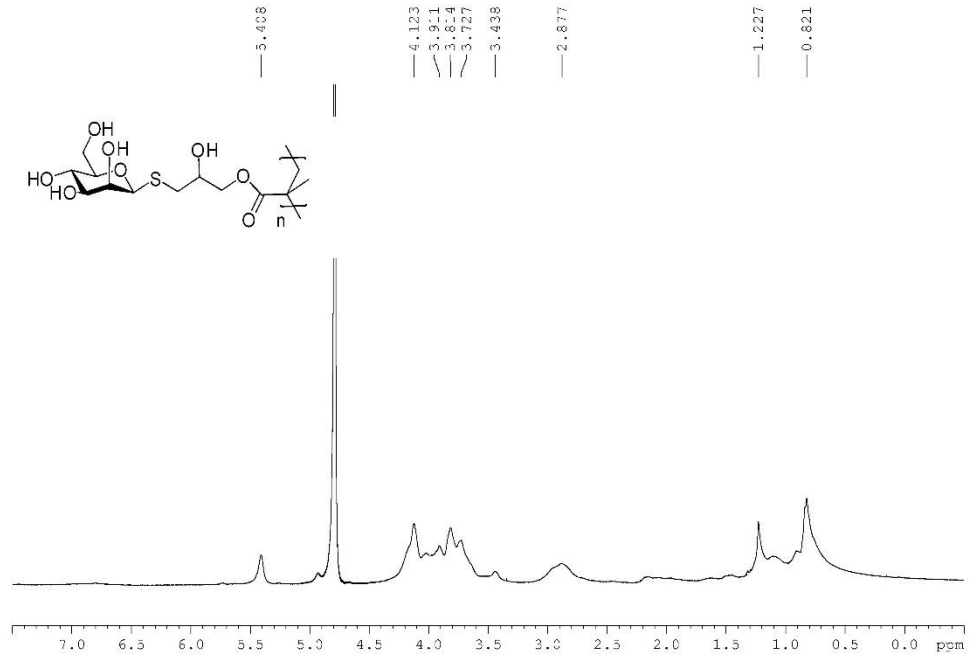
3.848
3.820
3.803
3.237
2.848
2.640
1.987
1.903
1.499
1.097
0.939
n
O
O
O
8
7
6
5
4
3
2
1
0
ppm

21.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4.123
3.941
3.814
3.727
3.438
2.877
1.227
0.821
OH
OH
OH
HO
HO
O
S
O
O
n
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
ppm