Supporting Information

Glycopeptide Self-Assembly Modulated by Glycan Stereochemistry through Glycan-Aromatic Interactions

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I. EXTENDED DATA

Figure S1. Screening gelation ability of galactosyl peptides with different glycosylation sites or alanine mutations. Glycopeptide structures and macroscopic images of solutions (glycopeptides **1, 7, 9**), precipitations (glycopeptides **2, 3, 5, 6, 8**) and hydrogel (glycopeptides **10**) formed in 10 mM phosphate buffer (0.25%, *w/w*, pH = 7.4) after a heating-cooling operation.

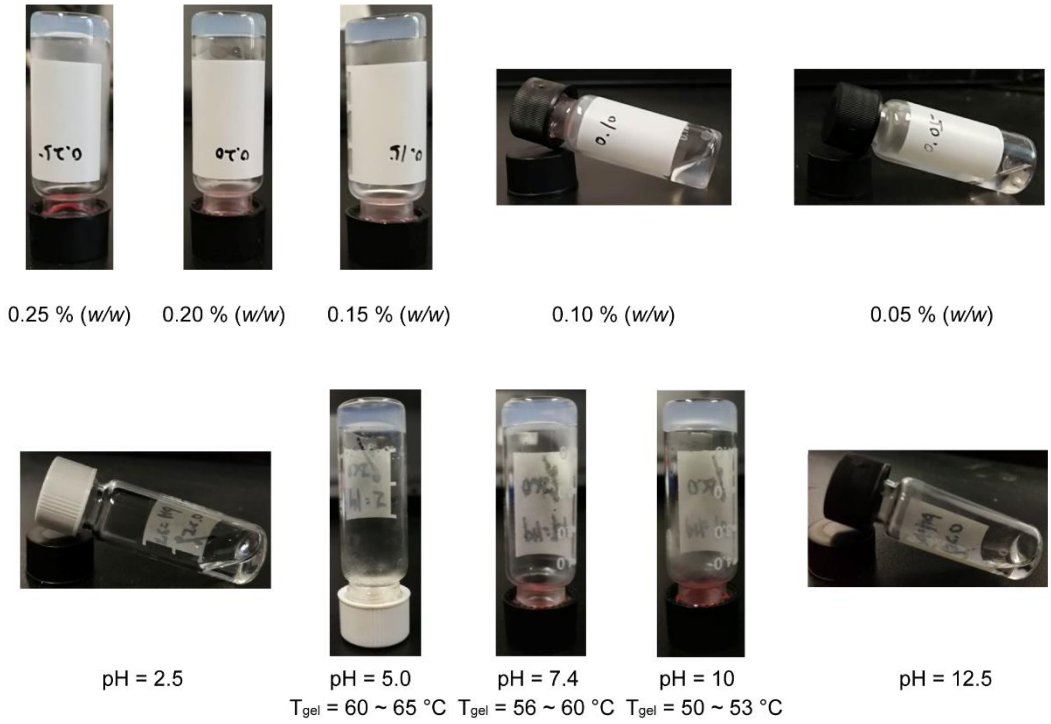


Figure S2. Critical gelation concentration (cgc), morphology under various pH, and melting points of hydrogels derived from glycopeptide **4**. Top, macroscopic images of glycopeptides **4** hydrogels formed in 10 mM phosphate buffer (0.25%, *w/w*, pH = 7.4) with different concentration, showing that the cgc of glycopeptide **4** is 0.15% (*w/w*). Bottom, macroscopic images of glycopeptides **4** hydrogels (0.25%, *w/w*) under different pH conditions. The hydrogel could keep stable at pH from 5 to 10 and deassembly in highly acidic (pH = 2.5) or basic conditions (pH = 12.5). T_{gel} represents the melting points of hydrogel under the corresponding pH, indicating that slightly acidic condition could increase the thermostability.

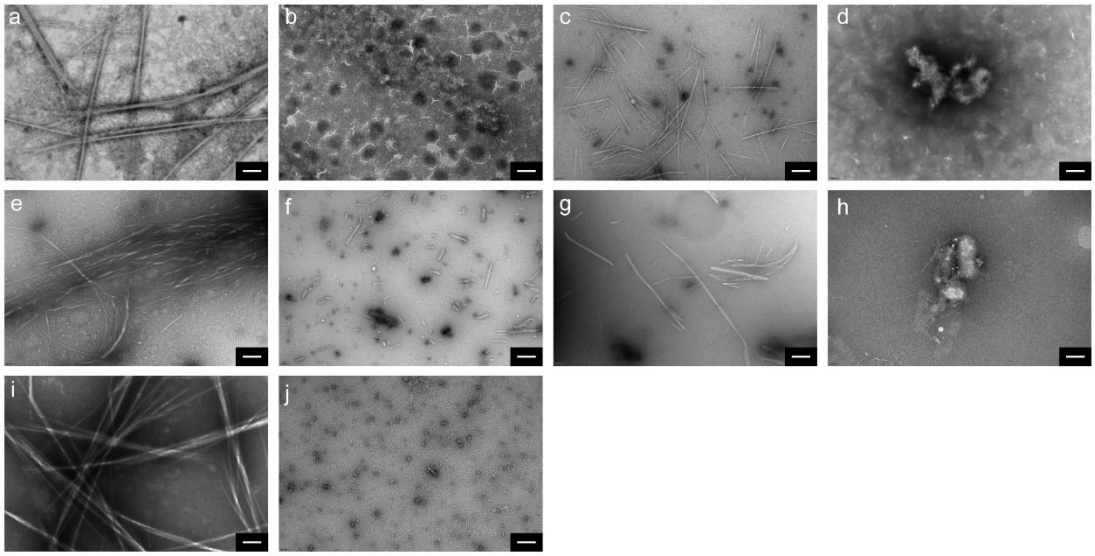


Figure S3. TEM images of glycopeptides **18** (a), **19** (b), **20** (c), **21** (d), **22** (e), **23** (f), **24** (g), **25** (h) and **26** (i) and **27** (j) in phosphate buffer after a heating-cooling procedure. (a), (c), (e), (f), (g) and (i) show the nanofiber structures. (b), (d), (h) and (j) show the irregular aggregates. Notably, although glycopeptide **23** with α-D-Fuc modification could not form hydrogel, short nanofibers could be observed. Scale bars: 200 nm

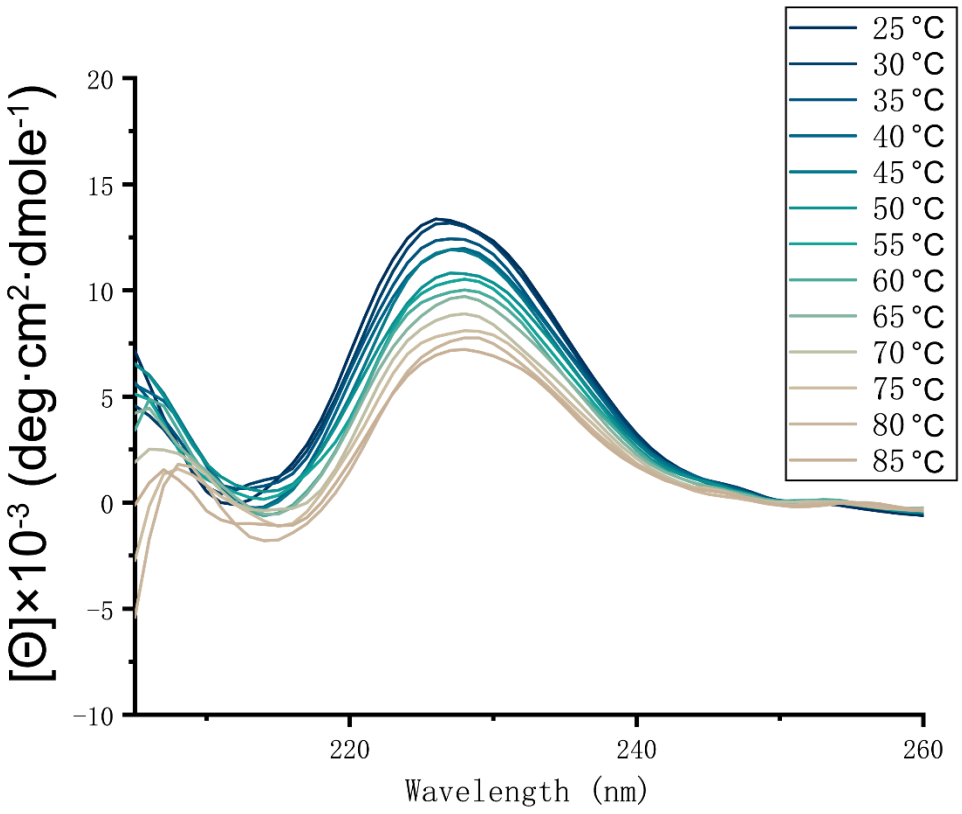


Figure S4. CD spectra of glycopeptide **4** over a temperature ramp from 25 ℃ to 85 ℃. The peak signals around 227 nm weaken with the increase of temperature. Notably, the melting temperature cannot be obtained by ploting the molar ellipticity [Θ] at 227 nm as the temperature increases.

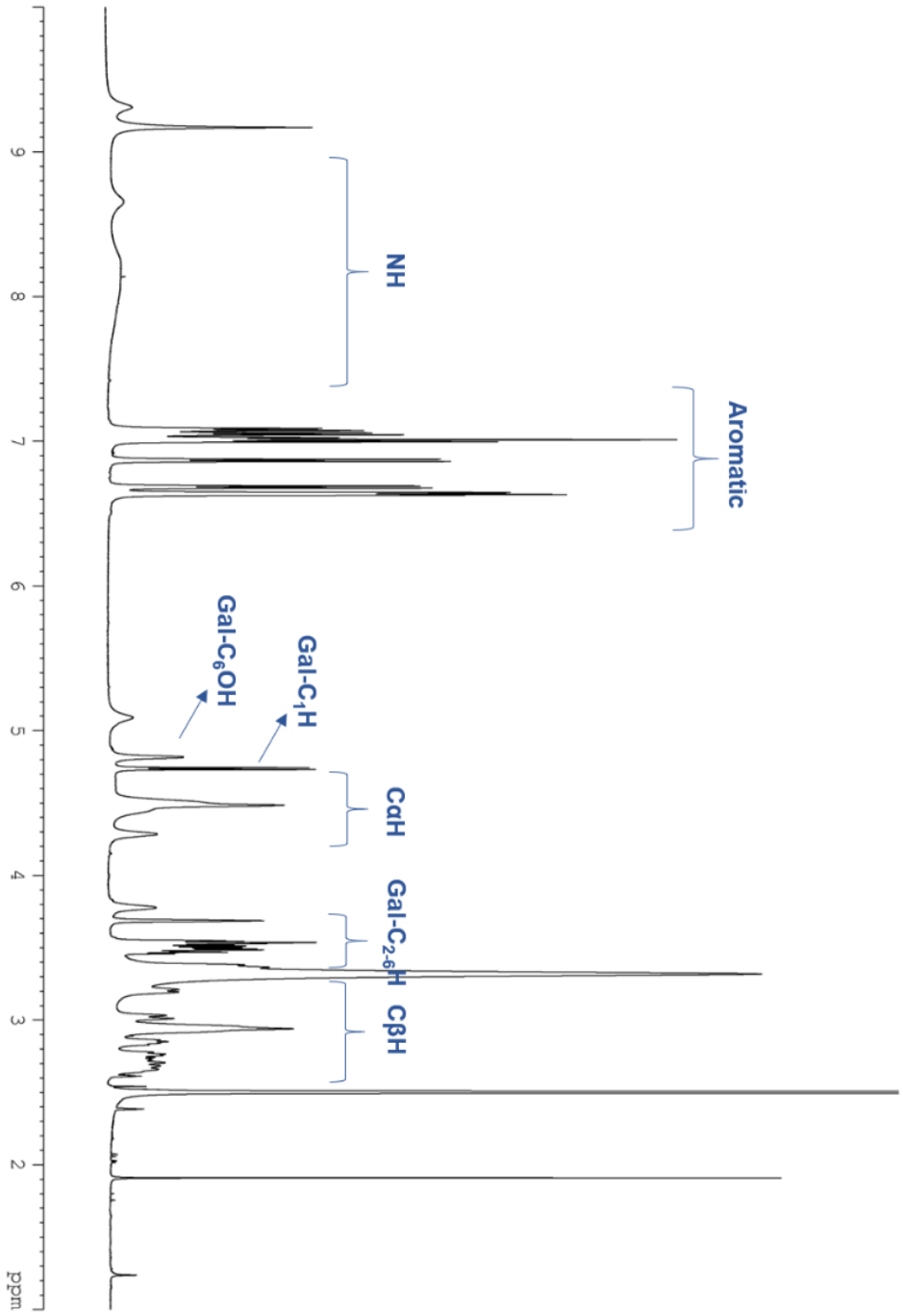


Figure S5. ^{1}H NMR Spectrum of glycopeptide **4** (600 MHz, DMSO-d^{6}). The characteristic regions are shown on the spectrum including NH (signals of amide bond protons), Aromatic (signals of tyrosine phenol protons), CαH (signals of amino acid α protons), CβH (signal of amino acid β protons) and Gal (signal of galactose protons).

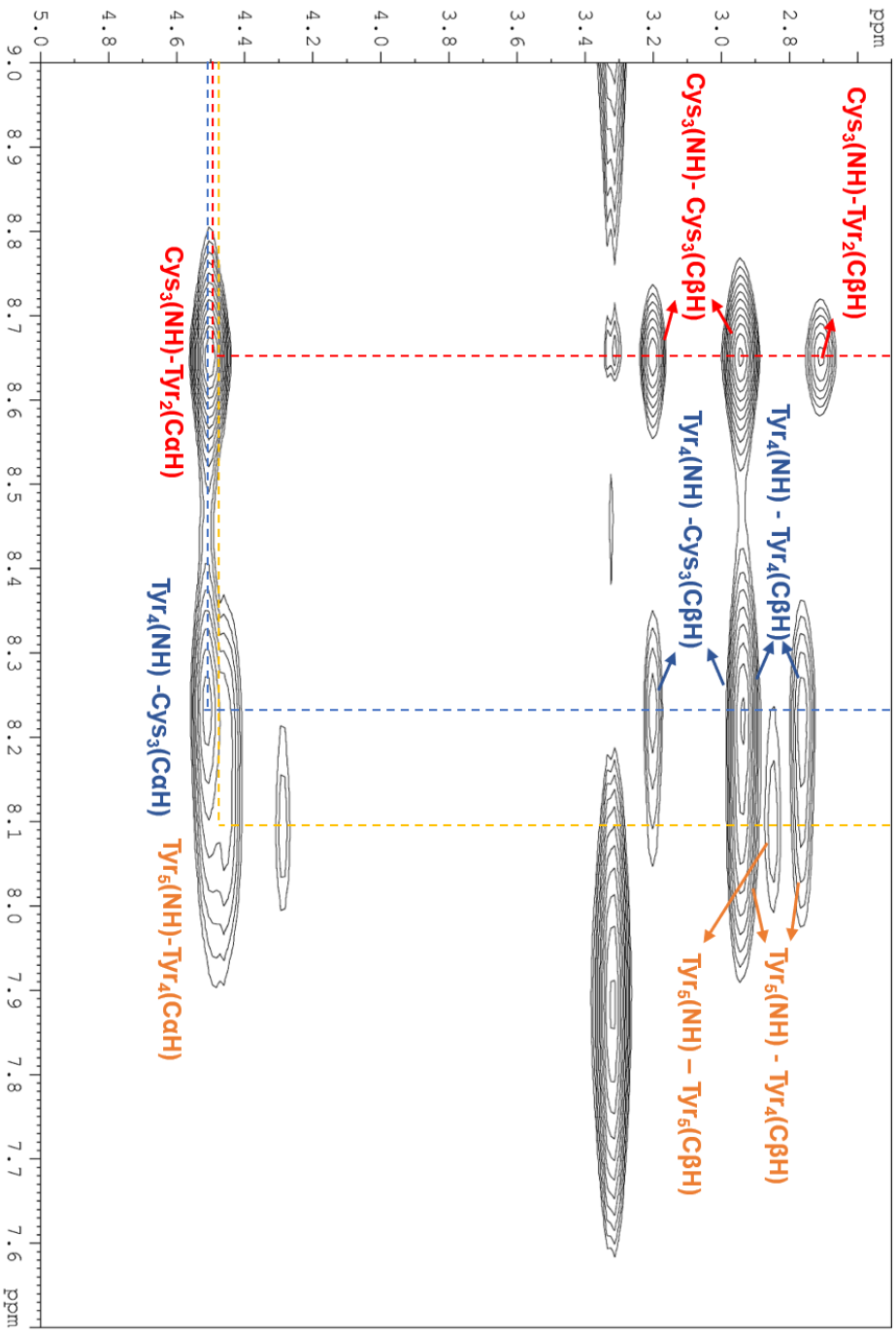


Figure S6. The NH-CαH&CβH fingerprint region of NOESY spectrum, highlighting the correlation peaks between amide and either α- or β-protons of Tyr_2, Cys_3, Tyr_4 and Tyr_5 (600 MHz, DMSO-d^6).

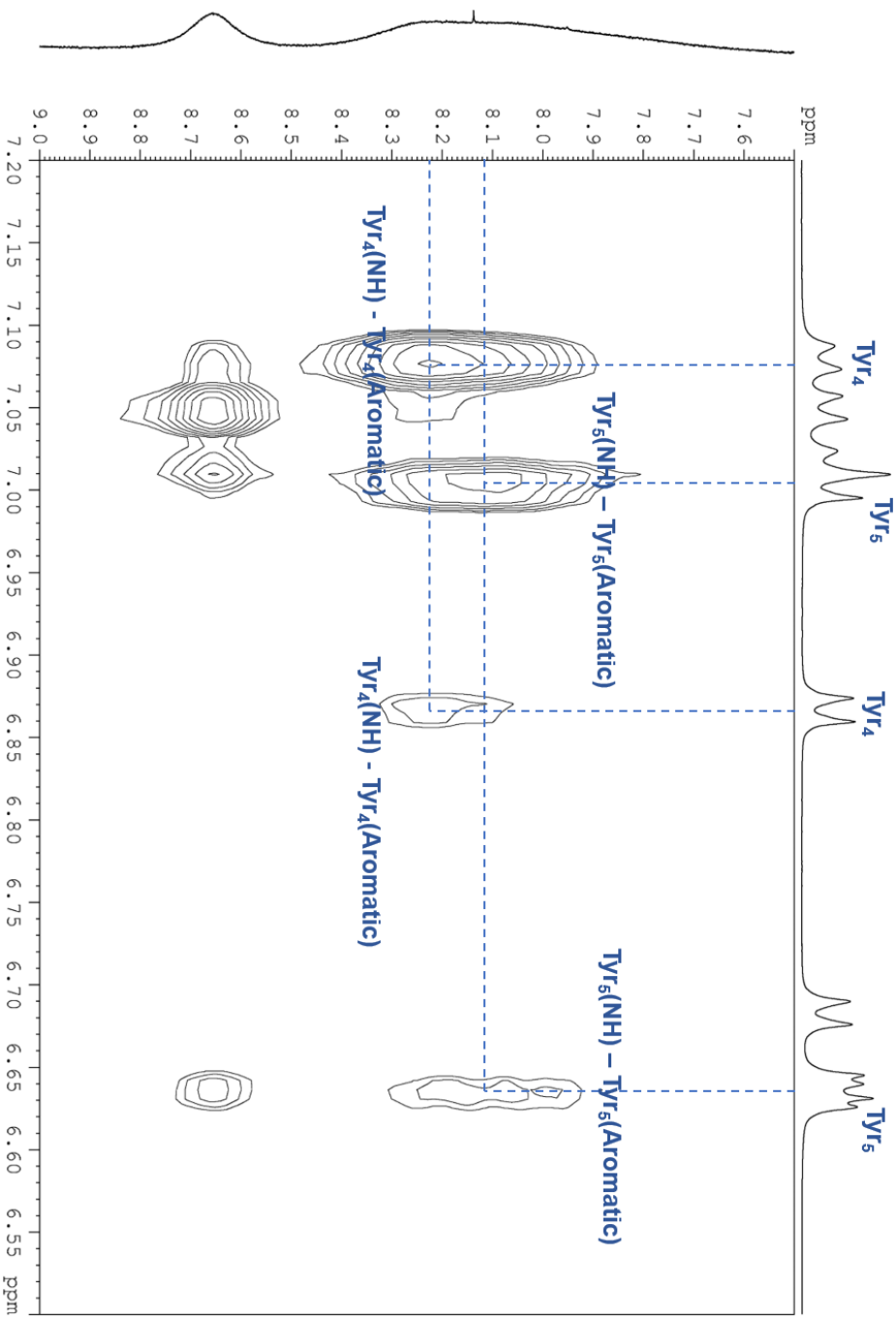


Figure S7. Selected region of 2D ^{1}H, ^{1}H NOESY spectrum of glycopeptide **4**, highlighting the correlation peaks between amide and aromatic protons (600 MHz, DMSO-d^{6}).

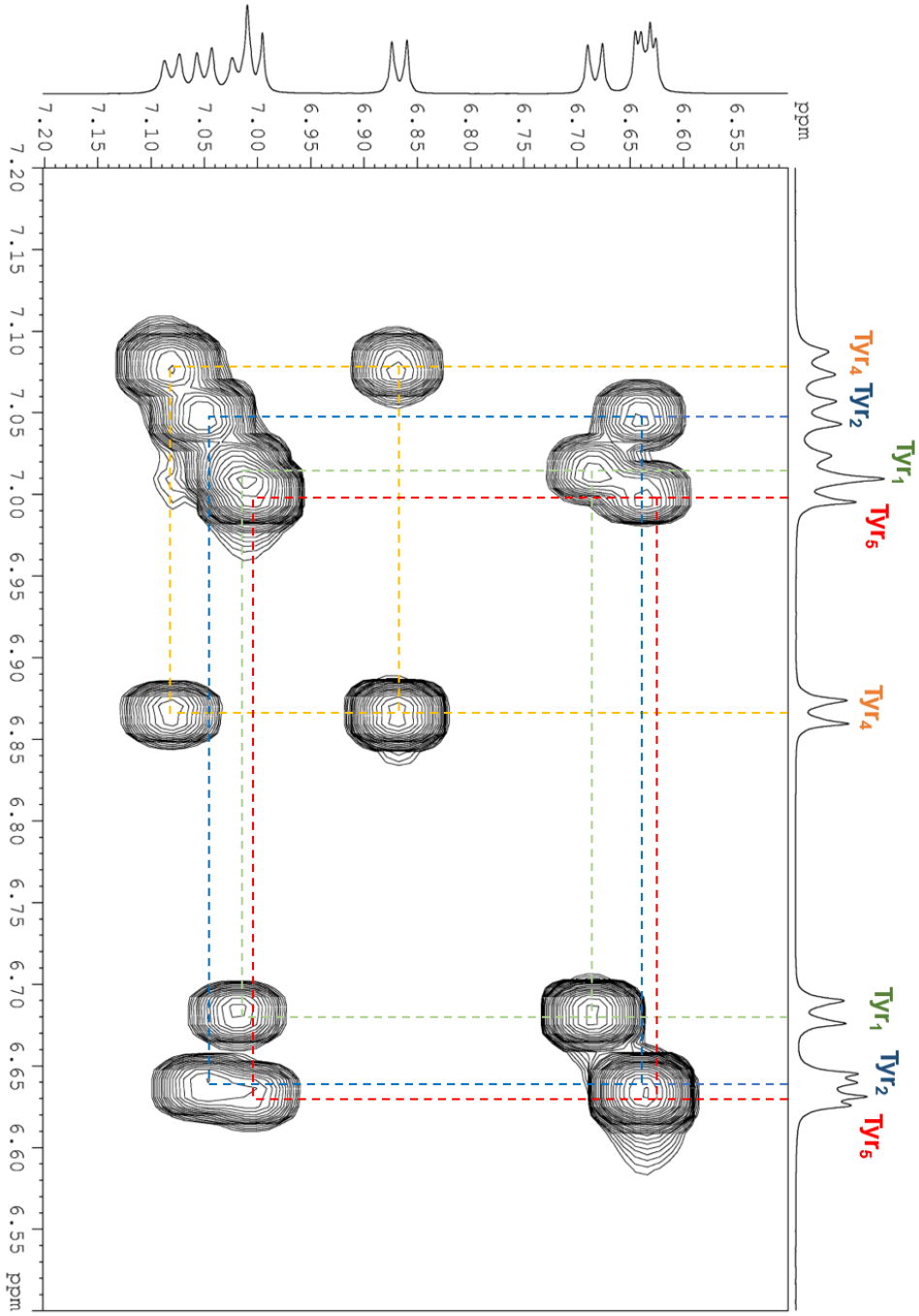


Figure S8. Selected region of 2D ^{1}H, ^{1}H NOESY spectrum of glycopeptide **4**, demonstrating the assigned tyrosine phenol protons (600 MHz, DMSO-d^{6}).

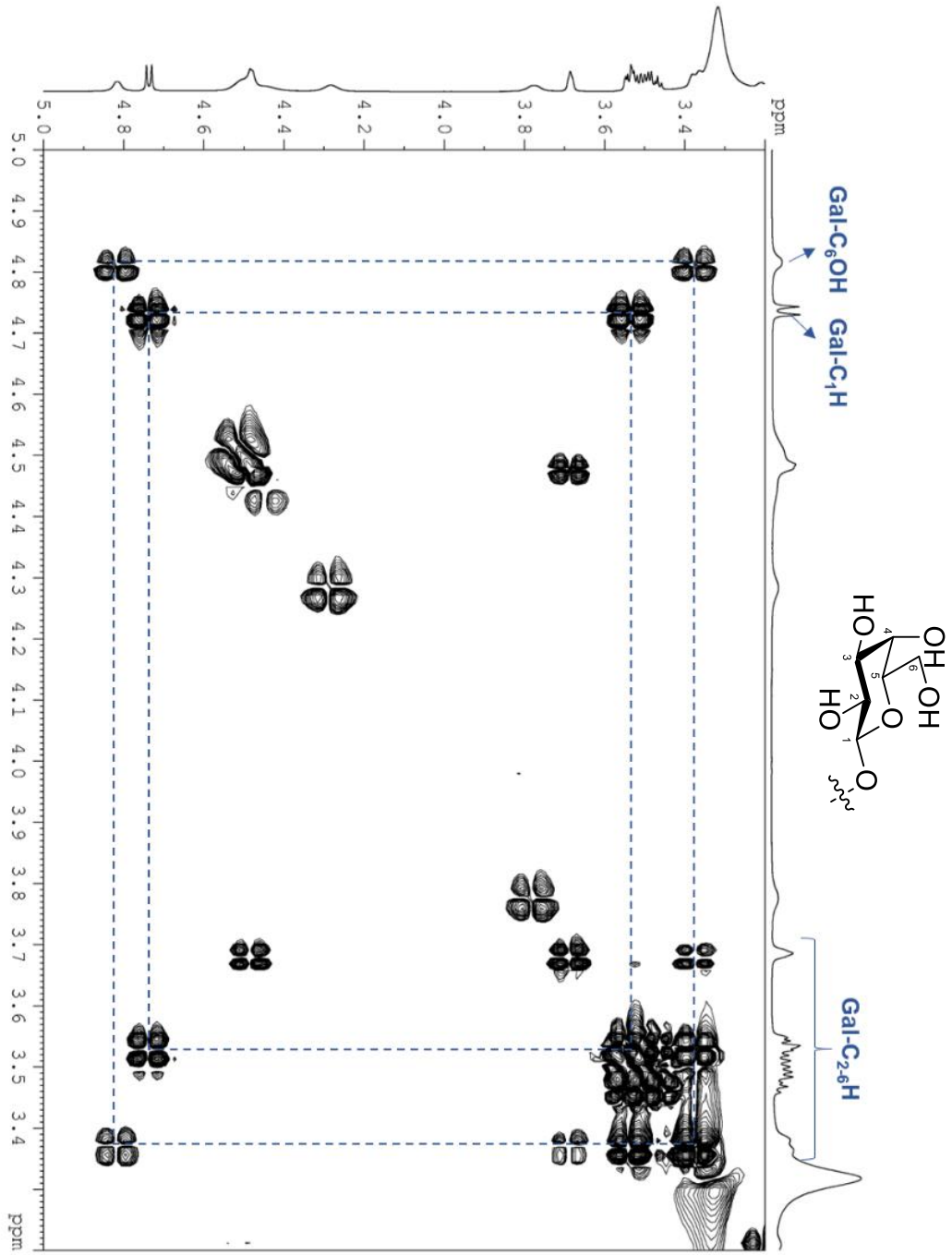


Figure S9. Selected region of 2D ^{1}H, ^{1}H DQF-COSY spectrum of glycopeptide **4**, highlighting the correlation peaks between galactose protons (600 MHz, DMSO-d^{6}). Of note, $C_{2\text{-}5}$ protons could not be fully distinguished due to the overlapping signals.

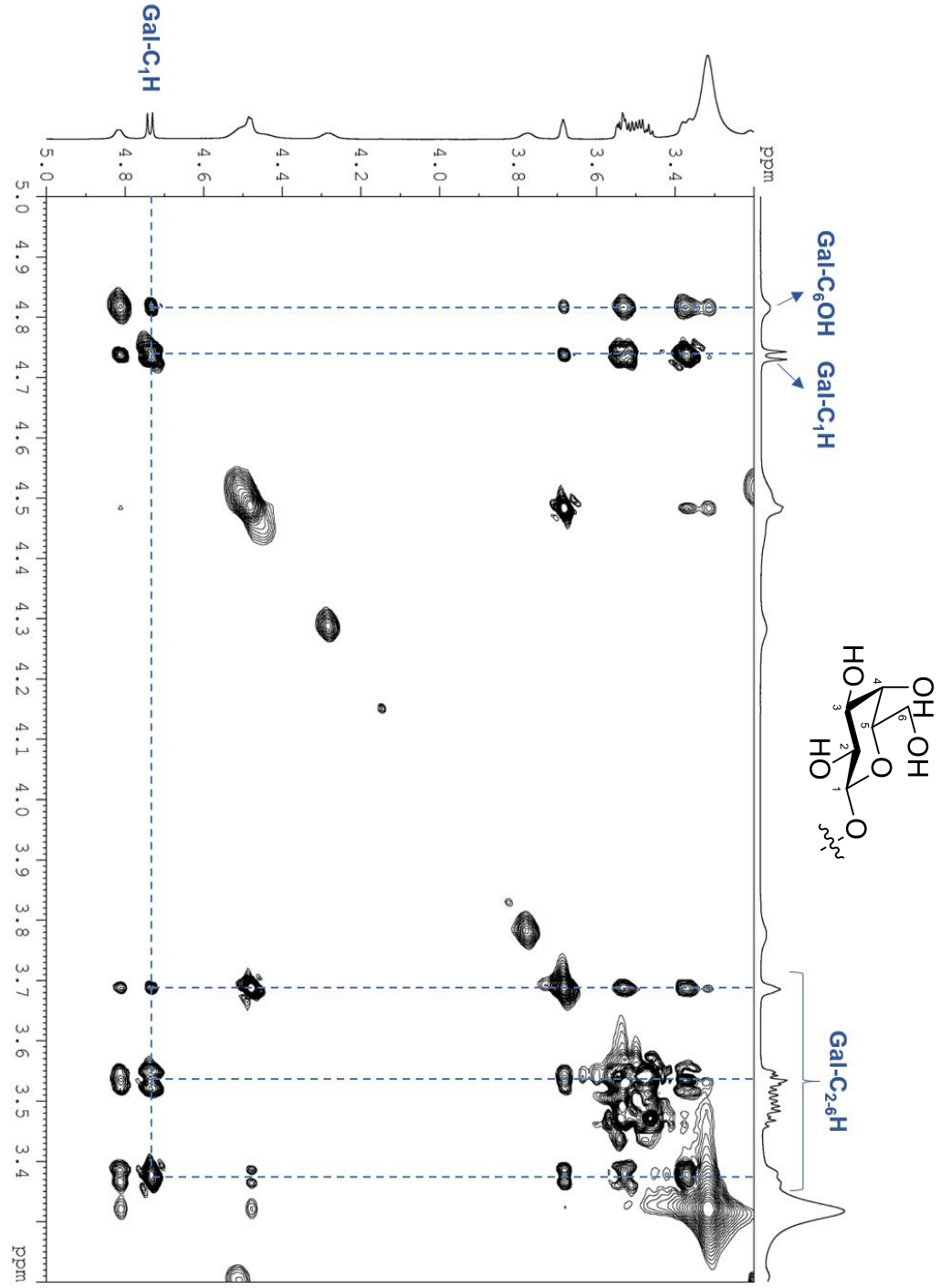


Figure S10. Selected region of 2D ^{1}H, ^{1}H TOCSY spectrum of glycopeptide **4** highlighting the correlation peaks of between C_1H and the other protons on the galactose (600 MHz, DMSO-d^6). The results of TOCSY spectrum are consistent with the signal assignment of galactose from DQF-COSY spectrum as shown in **Figure S9**.

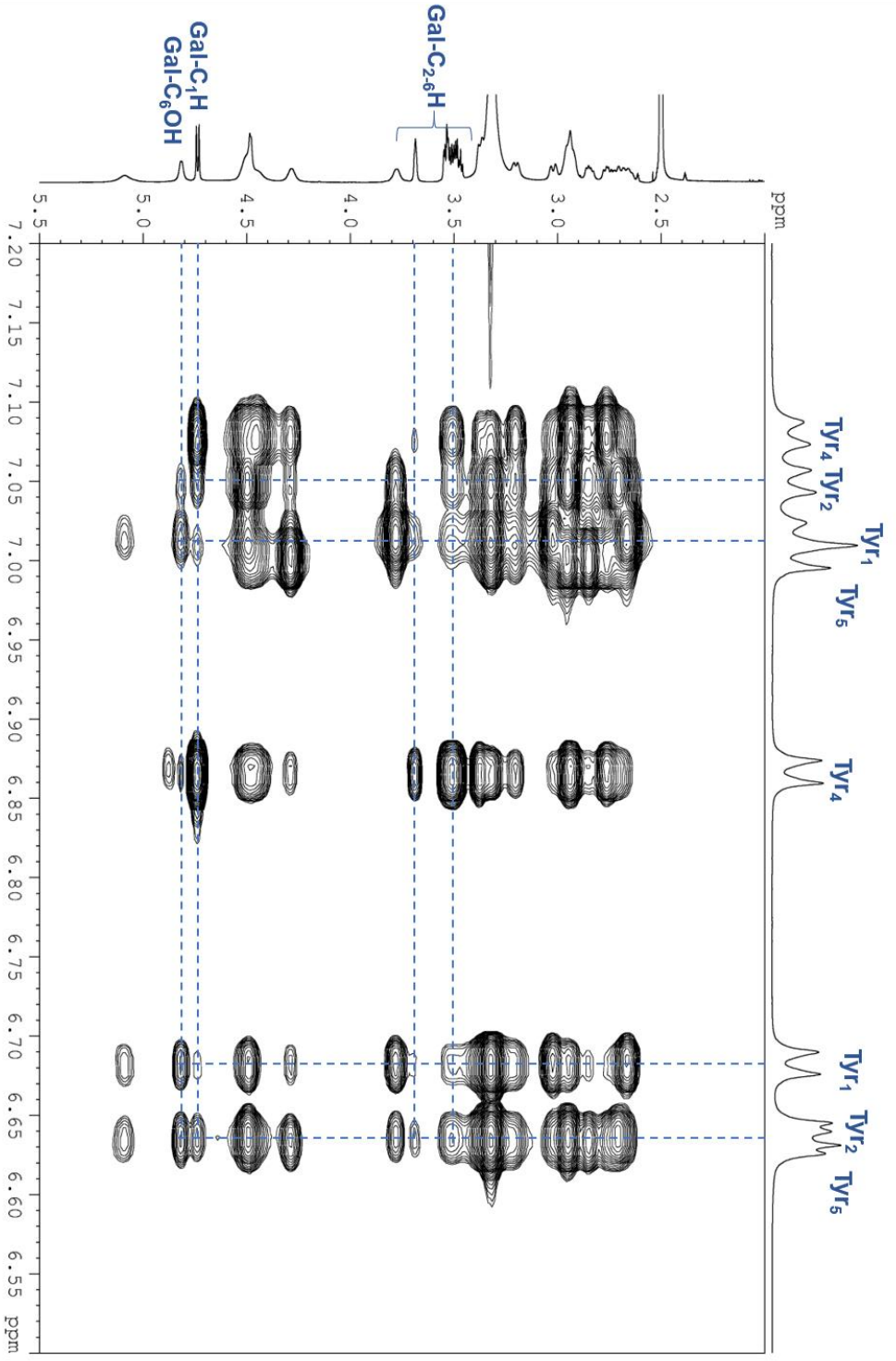


Figure S11. Selected region of 2D ^{1}H, ^{1}H NOESY spectrum of glycopeptide **4**, indicating the potential interactions between galactose and the aromatic residues of Tyr_1 and Tyr_2. The nOe highlighted in the figure suggests the close proximity between galactose and the aromatics of Tyr_1 and Tyr_2.

Table S1. Crystal parameters, data collection, and structure refinement

	[YYCY(β-Gal)Y]$_2$ **4**
Data collection	
Wavelength(Å)	1.54191
Space group	$F4_132$
Unit cell	
a, b, c (Å)	72.837, 72.837, 72.837
α, β, γ (°)	90.000, 90.000, 90.000
Resolution range (Å)	50-1.55(1.61-1.55)[h]
Unique reflections	2694(256)
R_{merge}[a]	0.078
$I/\sigma(I)$	54.2(17)
Completeness (%)	100.0(100.0)
Average redundancy	72.6(63.0)
Structure Refinement	
Resolution range (Å)	25.752-1.552
No. of unique reflections	2682
R_{work}[b]/R_{free}[c]	0.2344/0.2495
Number of atoms	
Peptide	107
Ligand/ion	28
Water	3
Average B-factor (Å^2)	
Peptide	16.7
Ligand/ion	24.0
Water	24.4
RMS[d] bond length (Å)	0.0069
RMS bond angles (°)	1.02

Outliers	0.00
Favored	100.00%
MolProbity clashscore[f]/score percentile	4.2/97th percentile* (N=698, 1.552Å ± 0.25Å)
MolProbity score[g]/score percentile	1.20/98th percentile* (N=6635, 1.552Å ± 0.25Å)
Protein Data Bank entry	7C0N

[a] $R_{merge} = \sum_{hkl}\sum_i|I_i(hkl) - \langle I(hkl)\rangle|/\sum_{hkl}\sum_i|I_i(hkl)$, where $I_i(hkl)$ is the intensity of an observation and $\langle I(hkl)\rangle$ is the mean value for its unique reflection. Summations are over all reflections.

[b] $R_{work} = \sum_h|F_o(h) - F_c(h)|/\sum_h|F_o(h)$, where F_o and F_c are the observed and calculated structure factor amplitudes, respectively.

[c] R_{free} was calculated with 5% of the data excluded from the refinement.

[d] RMS, root mean square of ideal values.

[e] The categories were defined by Molprobity.

[f] The number of serious steric overlaps (> 0.4 Å) per 1000 atoms.

[g] MolProbity score combines the clashscore, rotamer, and Ramachandran evaluations into a single score, normalized to be on the same scale as X-ray resolution.

[h] The values in parentheses refer to statistics in the highest bin.

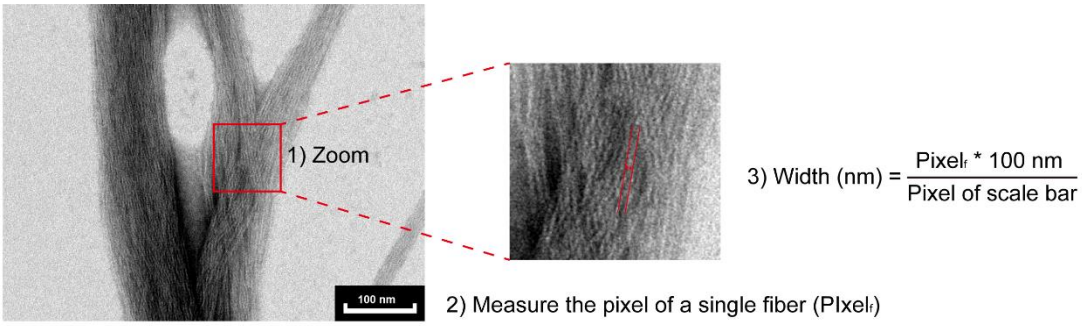


Figure S12. Protocols for measuring the width of single fibers from TEM image of glycopeptide **4**-derived sample.

Table S2. Width of fibrils derived from glycopeptide 4 on TEM images

Pixel[a]	**Width (nm)**[b]	**Pixel**	**Width (nm)**
4.55	1.900267	6.97	2.910959
4.24	1.770799	6.38	2.664551
6.06	2.530905	4.81	2.008854
5.81	2.426495	5.54	2.313732
4.66	1.946208	6.43	2.685433
4.94	2.063147	4.78	1.996325
4.65	1.942031	5.13	2.142499
4.53	1.891914	5.54	2.313732
6.65	2.777314	6.05	2.526729
6.71	2.802372	5.58	2.330438
5.93	2.476612	**Ave. ±Std.**	2.31 ±0.34

[a] The pixel data was obtained by measuring the width of single nanofibril on TEM images of the hydrogel derived from glycopeptide **4**.

[b] Calculated based on the pixel data and image scale of TEM images.

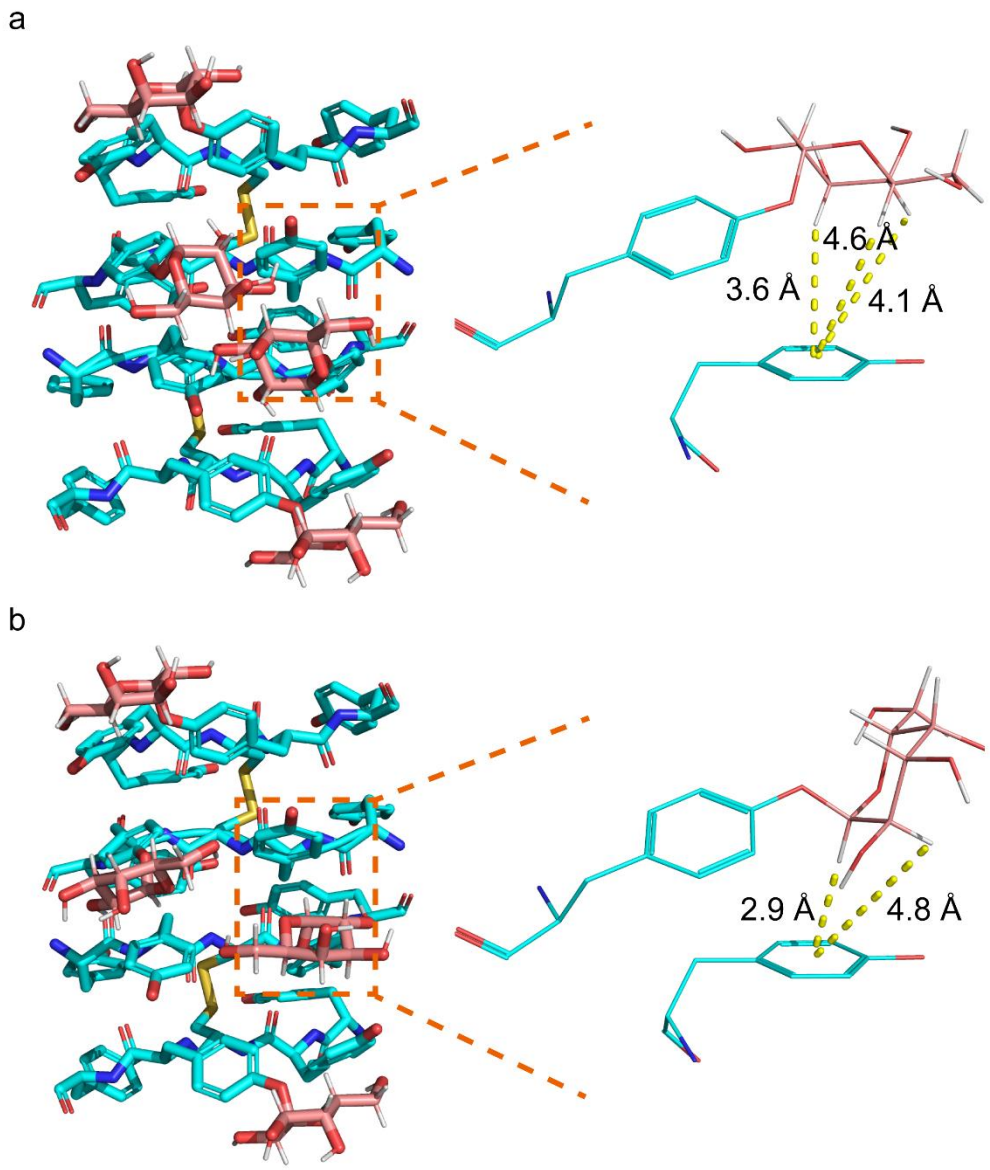


Figure S13. Comparison of either α- or β-face of α-Gal interacting with tyrosine residue, demonstrating α-glycosidic linkage blocks the interaction at α-face. (a) The working model of α-face interaction (left) and CH-aromatic distance of α-face (right) under the α-glycosidic linkage. (b) The working model of β-face interaction (left) and CH-aromatic distance of β-face (right) under the α-glycosidic linkage. Notably, comparing with β-face interaction, α-face interaction would generally enlarge the distance between glycan hydrogens and aromatics.

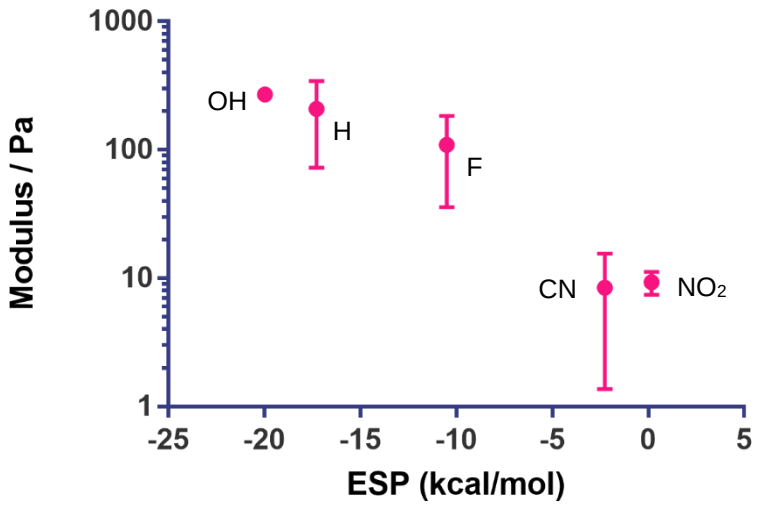


Figure S14. Correlations between normalized storage modulus (G′) of glycopeptides (**4**, **S90**, **S92**, **S94** and **S96**) and the electrostatic surface potential (ESP) values of the corresponding 4-substituent on aryl ring. Data for ESP plot are listed in **Table S3**.

Table S3. The data of electrostatic surface potential (ESP) and storage modulus G′ utilized in figure S14.

4-substituent group	ESP / (kcal/mol)[a]	G′ / Pa[b]		
OH	-19.95	264.742	308.031	237.702
H	-17.28	58.825	386.763	179.279
F	-10.50	25.764	97.560	205.170
CN	-2.26	1.999	5.045	18.305
NO_2	0.15	11.299	6.782	9.807

[a] Minimized conformations were generated from Density Functional Theory (B3LYP/6-311+g(d,p)) calculations in the gas phase using Gaussian09.[S1] The electrostatic surface potentials (ESPs) calculated at the M06-2X/cc-pVTZ level at isovalue 0.002 with Multiwfn.[S2]

[b]The rheology data were collected as Methods indicated under the condition of angular frequency (ω) = 1 rad/s

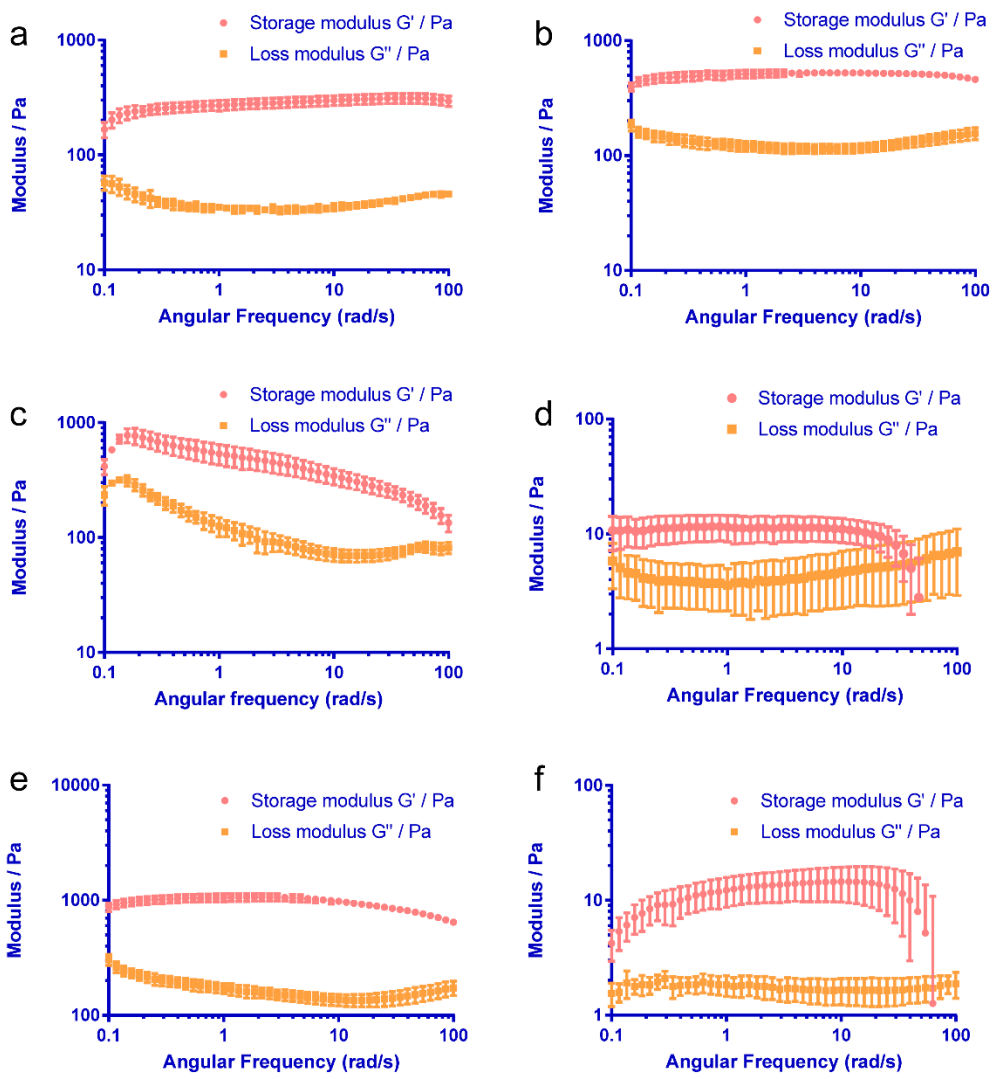


Figure S15. Rheology data for hydrogels that derived from glycopeptides **4** (a), **12** (b), **13** (c), **14** (d), **16** (e) and **17** (f) prepared in 10 mM phosphate buffer (0.25%, *w/w*, pH = 7.4).

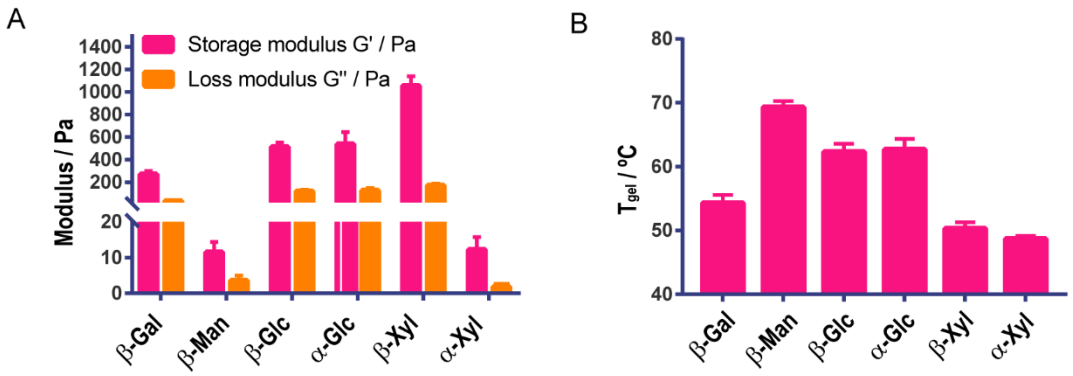


Figure S16. Representative physical properties of hydrogels generated from glycopeptides with different stereochemistries of the appended glycans. (a) Storage modulus and loss modulus (angular frequency ω = 1), and **(**b**)** Melting points, of hydrogels prepared from glycopeptides **4**, **12**, **13**, **14**, **16** and **17** in 10 mM phosphate buffer (0.25%, *w/w*).

Table S4. The data of storage modulus (G′) and loss modulus (G′′) utilized in Figure S16a.

Glycopeptide	Storage modulus (G′) /Pa			Loss modulus (G′′) /Pa		
4	264.742	308.031	237.702	35.0136	35.5408	34.974
12	490.975	568.242	475.602	112.101	137.235	112.524
13	686.270	481.395	442.964	158.533	105.268	112.306
14	12.205	14.639	7.570	3.249	5.440	1.996
16	958.557	1163.580	1041.860	150.556	192.403	169.486
17	17.247	9.987	9.463	2.333	1.441	1.725

Table S5. The data of melting points utilized in Figure S16b.

Glycopeptide	Melting point (T_{gel}) / ℃		
4	54	53	56
12	64	62	61
13	65	61	62
14	70	68	70
16	49	51	51
17	49	49	48

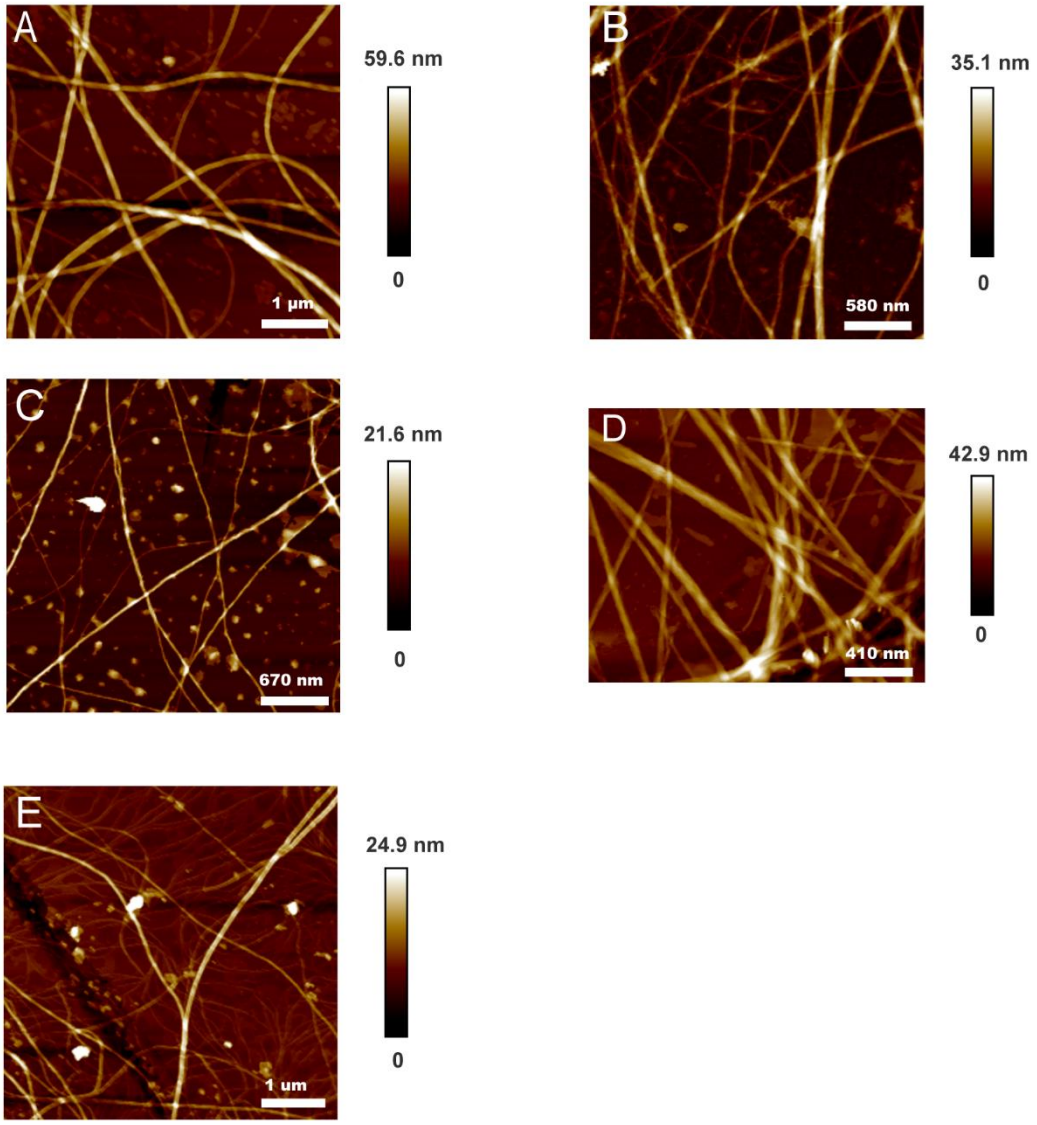


Figure S17. AFM images of glycopeptide hydrogels. AFM images of hydrogels that are prepared from glycopeptides **4** (a), **12** (b), **13** (c), **14** (d) and **16** (e).

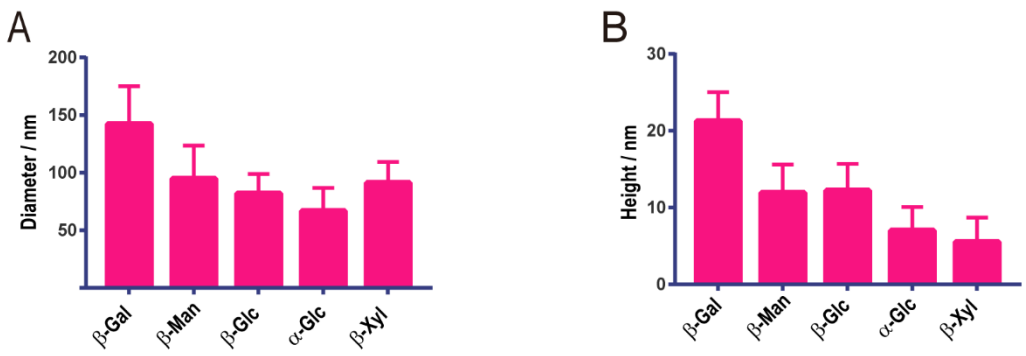


Figure S18. AFM images analyzation data of horizontal and vertical distances. Horizontal distances (a) and vertical distances (b) of nanobundles with different glycan stereochemistry determined by AFM measurements. Data for horizontal distance and vertical distance are listed in **Table S6** and **S7**.

Table S6. The data of horizontal distances measured in AFM images utilized in Figure S18a.

Glycopeptide	4	12	13	14	16
Horizontal distance / nm	140	98	53	61	73
	120	72	92	101	108
	121	80	40	69	109
	217	69	66	63	82
	133	114	53	107	106
	179	99	56	74	64
	140	109	69	64	64
	140	73	71	74	64
	148	82	43	67	85
	150	82	57	73	106
	106	60	43	105	65
	195	60	48	104	131
	97	71	79	117	109
	141	65	63	134	87
	135	79	79	160	109
	189	118	95	107	90
	175	76	95	104	90
	97	84	47	104	90
	117	67	111	63	96
	109	84	79	146	96

Table S7. The data of vertical distances measured in AFM images utilized in Figure S18b.

Glycopeptide	4	12	13	14	16
Vertical distance / nm	21.87	16.73	4.49	9.27	4.44
	20.23	12.30	11.42	16.35	11.33
	22.02	12.03	4.84	11.79	12.37
	25.31	8.88	7.74	6.56	7.32
	22.14	18.62	8.90	17.50	4.76
	18.96	19.025	10.27	14.14	2.54
	24.00	12.73	11.40	5.90	2.33
	27.00	11.63	4.385	10.10	1.93
	26.4.0	11.95	2.59	10.50	3.20
	24.43	11.85	2.60	14.38	1.81
	18.25	9.51	3.13	18.70	8.56
	22.67	9.51	10.24	12.56	7.44
	20.57	6.35	5.24	14.358	7.23
	21.82	12.20	4.70	11.50	3.65
	20.58	14.35	9.14	17.09	5.45
	25.60	15.50	9.75	10.92	7.11
	17.92	15.40	12.09	7.91	8.45
	12.34	11.02	5.28	11.10	7.33
	13.89	7.6	5.35	6.06	1.24
	19.27	7.23	6.45	12.11	2.50

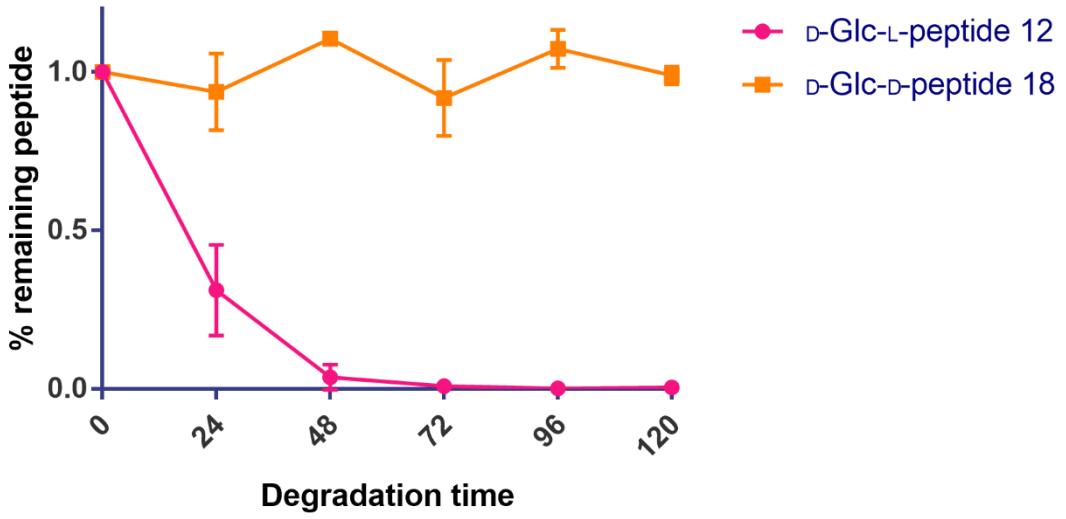


Figure S19. Peptide integrity in protease assay. Hydrogels prepared from D-peptide **28** resisted enzymatic hydrolysis over 5 days. In contrast, only trace amount (3.6 ± 4.1 %) of L-glycopeptide **12** could be detected after 48 h.

II. GENERAL INFROMATION

2.1 Materials and Methods

All commercial materials (Aldrich, GL Biochem, TCI, Acros, J&K, *etc.*) were used without further purification. All solvents were reagent grade or HPLC grade (Fisher, Sigma, Across, Oceanpak). Anhydrous tetrahydrofuran, diethyl ether, dichloromethane, toluene and *N,N*-dimethyl formamide were purified and dried by passing through a PURE SOLV® solvent purification system (Innovative Technology, Inc.). Analytical thin layer chromatography was performed using Merck TLC silica gel 60-F254 glass plates. Flash chromatography was performed using 200-300 mesh silica gel (Qingdao Haiyang Chemical Co., Ltd.). Filtration for crude peptide was performed using a Bulk GHP Acrodisc® 13 mm syringe filter with 0.22 μm GHP membrane. Yields refer to chromatographically and spectroscopically pure materials unless otherwise stated. Ultra-pure argon (⩾99.999%) was used when inert reaction conditions were required.

^{1}H NMR spectra were recorded on Bruker Avance III 400 MHz at ambient temperature with $CDCl_3$ (Cambridge Isotope Laboratories, Inc.) as the solvent unless otherwise stated. ^{13}C NMR spectra were recorded at 100.0 MHz at ambient temperature with $CDCl_3$ as the solvent unless otherwise stated. Chemical shifts are reported in parts per million relative to $CDCl_3$ (^{1}H, δ 7.26; ^{13}C, δ 77.0), DMSO-d_6 (^{1}H, δ 2.50; ^{13}C, δ 39.5), CD_3OD (^{1}H, δ 3.31; ^{13}C, δ 49.0), acetone-d_6 (^{1}H, δ 2.05; ^{13}C, δ 206.7, 29.9). Data for ^{1}H NMR are reported as follows: chemical shift, integration, multiplicity (app = apparent, par obsc = partially obscure, ovrlp = overlapping, s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet) and coupling constants (*J* Hz). All ^{13}C NMR spectra were recorded with complete proton decoupling. High-resolution mass spectra were obtained in the Chemical Instrumentation Center, Peking University Health Center using a Waters Q-TOF mass spectrometer (Xevo G2 Q-TQF). Low-resolution mass spectra analyses were performed with a Waters SQD mass spectrometer (Alliance

e2695-SQD). Optical rotations were recorded on an AUTOPOL III digital polarimeter at 589 nm and are recorded as $[\alpha]_D^{25}$ (concentration in grams/100 mL solvent).

2.2 HPLC analysis and purification

All HPLC separations involved a mobile phase of 0.05% (*v/v*) TFA in water (solvent A) and 0.04% (*v/v*) TFA in acetonitrile (solvent B).

Analytical LC-MS analyses were performed using a Water Alliance e2695 Separations Module equipped with an Agilent C18 column (5.0 μm, 4.6 × 150 mm, 0.4 mL/min), a Water 2489 UV/Visible (UV/Vis) Detector and a Waters SQD mass spectrometer (Alliance e2695-SQD). The wavelengths of UV-detector were set to 210 nm and 220 nm.

Analytical HPLC separations were performed using an Agilent Technologies 1260 Infinity LC system.

Preparative HPLC separations were performed using a two Shimadzu LC-20AR semi-preparative solvent delivery units, a Shimadzu SPD-20A UV detector and a Shimadzu CBM-20A system controller equipped with a Dr. Maisch ReproSil 300 C18 column (5.0 μm, 20 × 250 mm) at a flow rate of 12 mL/min. The wavelengths of UV-detector were set to 210 and 220 nm.

III. METHODS

Gel Preparation: The gels were prepared in a 4 ml vial by heating a solution of the corresponding glycopeptide in 10 mM phosphate buffer (pH = 7.4, 400 μL) to 85 °C in a water bath with gently shaking. When the suspension turns to a clear solution (~ 2 min), the vial was allowed to cool to rt in air for all cases, except for the case of β-Man-containing glycopeptide **14** which requires gradually cooling from 85 ℃ to rt in the heated water bath. The formation of hydrogels was confirmed by inversion of the vial.

Fourier Transform Infrared Spectroscopy (FTIR): FTIR spectrum of glycopeptide **4** was recorded on a Nicolet iS50 FTIR spectrometer from 400 to 4000 cm^{-1}. The powder of glycopeptide **4** was tested by KBr Pellet Method. The glycopeptide **4** hydrogel in 10 mM phosphate buffer at pD 7.4 (1%, *w/w*) was sandwiched between two diamond plate windows (spacer < 0.1 mm), followed by testing on the spectrometer.

ThT Test: The glycopeptide **4** was suspended in 10 mM phosphate buffer at different concentrations (0-1 mM). Freshly prepared ThT (20 μM) was added and the mixture was put in dark for 24 h. Then, fluorescence emission spectra were collected using a Hitachi F-7000 fluorescence spectrometer with excitation at 440 nm and emission at 484 nm.

Variable Temperature Circular Dichroism: Circular dichroism (CD) spectra were measured on a BioLogic MOS-450 Spectrometer with a 1 cm pathlength cell containing 2 ml of 100 μM glycopeptide **4** in 10 mM phosphate buffer equipped with a temperature probe. With the increase of the temperature, the spectrums could be obtained at 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80 and 85 ℃.

Nuclear Magnetic Resonance (NMR) Spectroscopy of Glycopeptide 4: The glycopeptide **4** was dissolved at 1.5 mM in 0.45 ml of DMSO-d_6 (Cambridge Isotope Laboratories, Inc.). Phasesensitive 2D experiments were performed including double quantum-filtered correlation spectroscopy (DQF-COSY), total correlation spectroscopy (TOCSY) and NOE spectroscopy (NOESY), using 2D phase incrementation. The NMR spectra were recorded on a Bruker Avance 600 MHz spectrometer operated at 600 MHz for ^{1}H and 150 MHz for ^{13}C.

Glycopeptide 4 Crystallization and Cry Protection: The purified glycopeptide $[YYCY(\beta\text{-Gal})Y]_2$ (**4**) was dissolved in methanol/water(1:1, *v/v*) at 2.5 mM concentration for screening crystallization conditions. Initial screen was performed at 20˚C by the sitting-drop vapor-diffusion method. The crystals were obtained in condition that consists of 20% *w/v* polyethylene glycol 1000, 0.1 M sodium phosphate dibasic/ citric acid pH 4.2, 0.2 M lithium sulfate. After a round of refinement of the initial conditions with variation of the precipitants using the sitting-drop vapor-diffusion method, diffraction-quality crystals appeared over a reservoir consisting of 40% *w/v* polyethylene glycol 1000, 0.1 M sodium phosphate dibasic/ citric acid pH 4.2, 0.2 M lithium sulfate. Single crystals were collected with loops, cryoprotected by dipping the crystal in the reservoir solution supplemented with 26%(v/v) glycerol and flash-frozen in liquid nitrogen.

Structure Determination and Refinement: X-ray diffraction data were collected at 100 K in a liquid nitrogen stream, using beamline BL17B1 with a Rayonix MX300 CCD detector at the Shanghai Synchrotron Radiation Facility (SSRF). At the BL17B1 beamline, the data sets were collected at the wavelength of 1.54191 Å, rotation interval 1˚/image. A total of 360 images were collected for crystals $[YYCY(\beta\text{-Gal})Y]_2$ **4**. The data sets were processed and scaled using HKL2000.[S3] Phases were calculated with PHENIX.Autosol[S4] using the S-SAD (single-wavelength anomalous diffraction) method. Initial model was built with PHENIX.Autobuild and refined with PHENIX.Refine. Final model was established with multiple rounds of manual modeling in Coot[S5] and refinement with Refmac5 in CCP4[S6] and checked using the program MolProbity[S7] and PROCHECK[S8]. Data collection and refinement statistics are listed in **Table S1**.

Transmission Electron Microscopy (TEM): 3μL of prepared hydrogel or suspension was loaded onto the copper grids of carbon support films (200 mesh) for 1 min. Excess gel was removed by blotting with a filter paper, followed by the addition of 3μL negative stain (2% aqueous phosphotungstic acid) and stained for 1 min. After removing the remaining liquid with a filter paper, copper grids were allowed to dry on air overnight. Then, copper grids were directly imaged on transmission electron microscope (JEM-1400 PLUS).

Rheology Test: Oscillatory rheology experiments were conducted on a TA DHR-2 rheometer with parallel-plate geometry (40 mm diameter). Hydrogel (0.25%, *w/w*, in 10 mM phosphate buffer, pH = 7.4) was prepared *in situ* using an integrated electrical heater to 85 ℃ with a solvent trap, followed by cooling down to rt slowly. The gap was set at 290 μm for the measurements and the frequency sweeps were carried out between 0.1 and 100 rad/s. The measurements were repeated three times to ensure reproducibility.

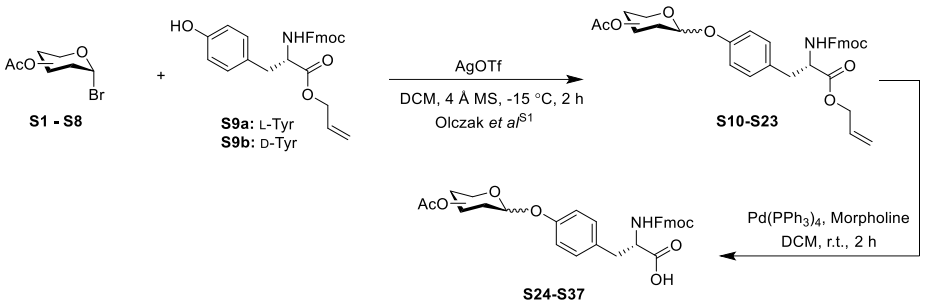
Melting Point Test: The melting points of glycopeptide hydrogels (0.25%, *w/w*) were determined by the vial inversion method. 4 ml vials with prepared hydrogels were inverted and submerged in a water bath. The water bath was heated to increase temperature slowly (1-2 ℃/min) by a heating magnetic whisk. The gently stirring of a magnetic stir bar was needed to promote the thermal equilibrium. The melting points were assessed by the temperature where the hydrogel dropped off. The measurements were repeated three times to ensure reproducibility.

Atomic Force Microscopy (AFM): Prepared glycopeptide hydrogel (0.5%, *w/w*, 250 μL) was added to water (1.75 mL) and mixed well. The suspension (50 μL) was dropped on a clean surface of commercial mica sheet. The sample was dried at 37 ℃ for overnight. All AFM spectra were recorded on a Bluker Resolve atomic force microscopy. Measurements were carried out using SNL-A/C cantilevers with a spring constant of 0.4 N/m under the ScanAsyst-Air mode.

Protease Assay[S9]: 0.25 ml of hydrogel (0.5 %, *w/w*) was prepared from each peptide in 15 ml-Falcon tubes according to the described Method for gel preparation. 4.75 ml of PBS buffer (pH = 7.4) containing a large excess (2 mg) of recombinant proteinase K from Pichia pastoris (Merck–CB539480 – ≥30 U/mg) were gently added on top. The tubes were incubated at 37 ℃, and at the selected timepoints, 2 ml of NaOH (1 M) were added to completely disassemble the gel and inhibit further protease activity prior to HPLC analysis. Average and standard deviation values (n=3) were calculated and plotted.

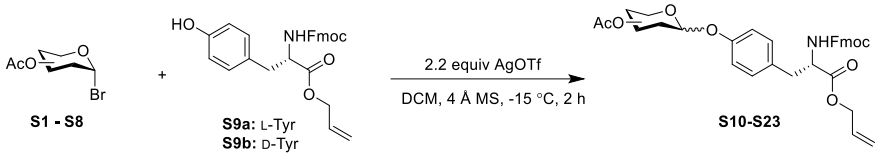
IV. SYNTHESIS AND CHARACTERIZATION OF GLYCOSYLATED TYROSINES

4.1 Preparation of glycosylated tyrosine building blocks S24-S37:



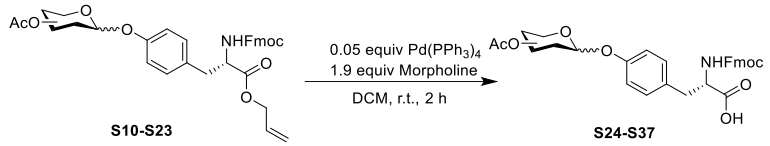
Scheme S1. Synthesis of glycosylated tyrosine building blocks **S24-S37**

General procedure A



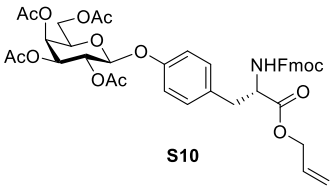
N-Fmoc-tyrosine allyl ester **S9a** or **S9b** (1.0 equiv) was co-evaporated with toluene (×3) and dried *in vacuo* for 1 h. To the round-bottom flask was added anhydrous DCM, freshly activated 4 Å MS, and AgOTf (2.2 equiv) under an argon atmosphere, and the mixture was stirred at r.t. in dark for 1 h. The resulting mixture was then cooled to -15 ℃, followed by the addition of a solution of the corresponding glycosyl bromide (**S1-S8**, 2.0 equiv) in anhydrous DCM dropwise. The reaction was allowed to stir at -15 ℃ until completed consumption of starting material as indicated by TLC (~ 2 h), and the mixture was then filtered through Celite. The filtrate was washed with a saturated solution of $NaHCO_3$ (×3), water (×1), and brine (×1), dried over $MgSO_4$, and filtered over a sintered funnel. The filtrate was concentrated *in vacuo* and the resulting crude mixture was purified using flash chromatography.[S10]

General procedure B



Tyrosine *O*-pyranoside derivative (**S10-S23**, 1.0 equiv) and $Pd(PPh_3)_4$ (5 mol%) were dissolved in anhydrous DCM under an argon atmosphere, followed by the addition of morpholine (1.9 equiv) at room temperature dropwise. The resulting mixture was allowed to stir at room temperature until completed consumption of starting material as indicated by TLC (~ 2 h), and the reaction was then diluted with EtOAc, washed with 1 M aqueous HCl (×3), water (×1), and brine (×1), dried over $MgSO_4$, and filtered over a sintered funnel. The filtrate was concentrated *in vacuo* and the resulting crude mixture was purified using flash chromatography.

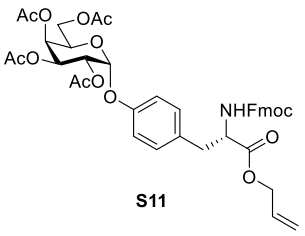
***N*-Fmoc-L-tyrosine (2,3,4,6-tetra-*O*-acetyl-β-D-galactopyranoside)-OAllyl (S10)**



S10

The title compound was obtained by reacting galactosyl bromide **S1** (6.5 g, 15.69 mmol) with acceptor **S9a** (3.5 g, 7.85 mmol) following General Procedure A described above. Purification of the crude products (α/β = 1:8.8) using silica gel column chromatography eluting with petroleum ether/EtOAc (4:1 to 3:1) afforded pure β-anomer **S10** as a yellow syrup (4.7 g, 77% yield). Analytical data for **S10** was in accordance with those reported previously.[S11, S12]

***N*-Fmoc-L-tyrosine (2,3,4,6-tetra-*O*-acetyl-α-D-galactopyranoside)-OAllyl (S11)**

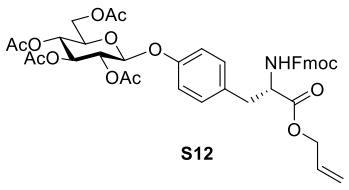


S11

The title compound was obtained by reacting galactosyl bromide **S1** (6.5 g, 15.69 mmol) and acceptor **S9a** (3.5 g, 7.85 mmol) following General Procedure A described above. Purification of the crude products (α/β = 1:8.8) using silica gel column chromatography eluting with petroleum ether/EtOAc (4:1 to 3:1) afforded pure α-anomer **S11** as a yellow syrup (547 mg, 9% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.78 (d, *J* = 7.5 Hz, 2H), 7.60-7.52 (m, 2H), 7.42

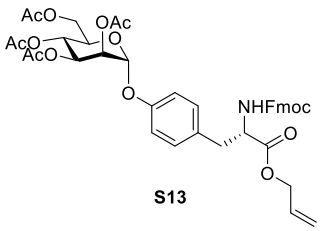
(t, *J* = 7.5 Hz, 2H), 7.35-7.28 (m, 2H), 7.01 (d, *J* = 8.7 Hz, 2H), 6.96 (d, *J* = 8.7 Hz, 2H), 5.89 (ddd, *J* = 22.6, 12.8, 5.6 Hz, 1H), 5.72 (d, *J* = 3.5 Hz, 1H), 5.56 (dd, *J* = 10.8, 3.5 Hz, 1H), 5.52-5.49 (m, 1H), 5.37-5.20 (m, 4H), 4.70-4.60 (m, 1H), 4.47 (dd, *J* = 10.7, 6.9 Hz, 1H), 4.36 (dd, *J* = 10.7, 6.9 Hz, 1H), 4.27 (t, *J* = 6.6 Hz, 1H), 4.21 (t, *J* = 6.9 Hz, 1H), 4.11-4.00 (m, 2H), 3.08 (ddd, *J* = 26.3, 14.0, 5.6 Hz, 2H), 2.17 (s, 3H), 2.07 (s, 3H), 2.03 (s, 3H), 1.93 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 171.2, 170.5, 170.4, 170.3, 170.2, 155.6, 155.6, 143.9, 143.8, 141.5, 131.5, 130.7, 130.3, 127.9, 127.2, 125.2, 125.1, 120.2, 120.1, 119.4, 116.9, 95.0, 68.0, 67.9, 67.6, 67.2, 67.0, 66.3, 61.5, 54.9, 47.3, 37.5, 20.9, 20.8, 20.8, 20.7; HRMS-ESI (*m/z*): $[M+H]^+$ calcd for $C_{41}H_{44}NO_{14}$, 774.2762; found, 774.2770. $[\alpha]^{25}_D$ = +80 °(*c* = 0.10, MeOH).

***N*-Fmoc-L-tyrosine (2,3,4,6-tetra-*O*-acetyl-β-D-glucopyranoside)-OAllyl (S12)** The title compound was obtained by reacting glucosyl bromide **S2** (2.8 g, 6.76 mmol) with acceptor **S9a** (1.5 g, 3.38 mmol) following General Procedure A described above. Purification of the crude product (β only) using silica gel column chromatography eluting with toluene/EtOAc (5:1) afforded pure β-anomer **S12** as a yellow syrup (2.0 g, 76% yield). Analytical data for **S12** was in accordance with those reported previously.[S11]



S12

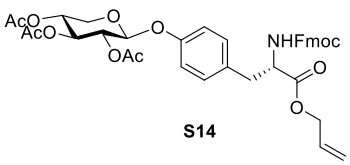
***N*-Fmoc-L-tyrosine (2,3,4,6-tetra-*O*-acetyl-α-D-mannopyranoside)-OAllyl (S13)** The title compound was obtained by reacting mannosyl bromide **S3** (370 mg, 0.90 mmol) with acceptor **S9a** (200 mg, 0.45 mmol) following General Procedure A described above. Purification of the crude product (α only) using silica gel column chromatography eluting with toluene/EtOAc (5:1) afforded pure α-anomer **S13** as a yellow syrup (313 mg, 90% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.77 (d, *J* = 7.5 Hz, 2H), 7.60-7.52 (m, 2H), 7.40 (t, *J* = 7.5 Hz, 2H), 7,31 (t, *J* = 7.5 Hz), 7.05-6.95 (m, 4H), 5.88 (ddd, *J* = 22.6, 10.9,



S13

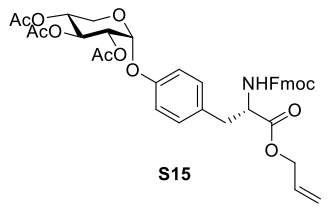
5.7 Hz, 1H) 5.55 (dd, *J* = 10.2, 3.6 Hz, 1H), 5.47 (d, *J* = 1.8 Hz, 1H), 5.43 (dd, *J* = 3.6, 1.8 Hz, 1H), 5.40-5.33 (m, 2H), 5.27 (dd, *J* = 16.8, 6.7 Hz, 2H), 4.66 (dd, *J* = 7.6, 5.8 Hz, 1H) 4.61 (d, *J* = 5.6 Hz, 2H), 4.46 (dd, *J* = 5.3, 7.0 Hz, 1H), 4.28 (dd, *J* = 6.2, 5.3 Hz, 1H), 4.20 (t, *J* = 7.0 Hz, 1H), 4.10-4.01 (m, 2H), 3.15-3.02 (m, 2H), 2.20 (s, 3H), 2.05 (s, 3H), 2.04 (s, 3H), 2.02 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 171.2, 170.6, 170.1, 169.8, 155.6, 155.0, 143.9, 143.8, 141.5, 131.5, 130.7, 130.4, 127.9, 127.2, 125.2, 125.1, 120.1, 120.1, 119.4, 116.7, 96.1, 69.5, 69.3, 69.0, 67.0, 66.3, 66.0, 62.2, 54.9, 47.3, 37.5, 21.0, 20.8, 20.8; $^{1}J_{C1\text{-}H1}$ = 173.9 Hz; HRMS-ESI (*m/z*): $[M+NH_4]^+$ calcd for $C_{41}H_{47}N_2O_{14}$, 791.3027; found, 791.3030. $[\alpha]^{25}_D$ = +24 °(*c* = 0.10, MeOH).

***N*-Fmoc-L-tyrosine (2,3,4-tri-*O*-acetyl-β-D-xylopyranoside)-OAllyl (S14)** The title compound was obtained by reacting xylosyl bromide **S4** (1.9 g, 5.56 mmol) with acceptor **S9a** (1.2 g, 2.78 mmol) following General Procedure A described above. Purification of the crude products (α/β = 1:3) using silica gel column chromatography eluting with toluene/EtOAc (15:1 to 12:1) afforded pure β-anomer **S14** as a yellow syrup (722 mg, 37% yield) ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.77 (d, *J* = 7.5 Hz, 2H), 7.60-7.51 (m, 2H), 7.41 (t, *J* = 7.5 Hz, 2H), 7.31 (t, *J* = 7.5 Hz, 2H), 7.03 (d, *J* = 8.3 Hz, 2H), 6.90 (d, *J* = 8.3 Hz, 2H), 5.88 (ddd, *J* = 22.6, 10.9, 5.6 Hz, 1H) 5.36-5.23 (m, 3H), 5.21 (d, *J* = 7.8 Hz, 2H), 5.16 (dd, *J* = 8.2, 6.0 Hz, 1H), 5.09 (d, *J* = 6.0 Hz, 1H), 5.04-4.97 (m, 1H), 4.70-4.59 (m, 3H) , 4.45 (dd, *J* = 10.8, 7.0 Hz, 1H), 4.33 (dd, *J* = 10.7, 7.0 Hz, 1H), 4.22-4.15 (m, 2H), 3.46 (dd, *J* = 12.2, 7.8 Hz, 1H), 3.12 (ddd, *J* = 26.3,14.0, 5.8 Hz, 2H), 2.09 (s, 3H), 2.08 (s, 3H), 2.07 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 171.2, 170.1 169.9, 169.5, 155.8, 155.6, 143.8, 141.4, 131.4, 130.6, 130.4, 127.8, 127.2, 125.2, 125.1, 120.1, 120.1, 119.3, 117.1, 98.6, 70.8, 70.2, 68.6, 67.0, 66.2, 61.9, 54.9, 47.2, 37.5, 29.8, 20.9, 20.9, 20.8; HRMS-ESI (*m/z*): $[M+NH_4]^+$ calcd for $C_{38}H_{43}N_2O_{12}$, 719.2816; found, 719.2814. $[\alpha]^{25}_D$ = -28 °(*c* = 0.10, MeOH).



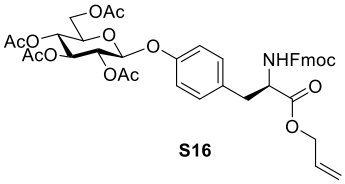
S14

***N*-Fmoc-L-tyrosine (2,3,4-tri-*O*-acetyl-α-D-xylopyranoside)-OAllyl (S15)** The title compound was obtained by reacting xylosyl bromide **S4** (1.9 g, 5.56 mmol) with acceptor **S9a** (1.2 g, 2.78 mmol) following General Procedure A described above. Purification of the crude products (α/β = 1:3) using silica gel column chromatography eluting with toluene/EtOAc (15:1 to 12:1) afforded pure α-anomer **S15** as a yellow syrup (229 mg, 12% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.77 (d, *J* = 7.5 Hz, 2H), 7.60-7.52 (m, 2H), 7.41 (t, *J* = 7.5 Hz, 2H), 7.35-7.28 (m, 2H), 7.05-6.92 (m, 4H), 5.88 (ddd, *J* = 22.7, 11.2, 5.3 Hz, 1H), 5.70 (t, *J* = 9.9 Hz, 1H), 5.64 (d, *J* = 3.5 Hz, 1H), 5.38-5.17 (m, 3H), 5.10-5.01 (m, 1H), 4.98 (dd, *J* = 10.1, 3.5 Hz, 1H), 4.66 (dd, *J* = 13.5, 5.3 Hz, 1H), 4.63 (d, *J* = 5.8 Hz, 2H), 4.47 (dd, *J* = 10.1, 6.7 Hz, 1H), 4.36 (dd, *J* = 10.6, 6.7 Hz, 1H), 4.21 (t, *J* = 6.9 Hz, 1H), 3.84 (dd, *J* = 10.6, 5.8 Hz, 1H), 3.68 (t, *J* = 11.0 Hz, 1H), 3.15-3.02 (m, 2H), 2.08 (s, 3H), 2.06 (s, 3H), 2.04 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 171.1, 170.2, 170.1, 169.9, 155.5, 155.3, 143.9, 143.7, 141.3, 131.4, 130.6, 130.0, 127.8, 127.1, 125.1, 125.0, 120.0, 120.0, 119.3, 116.6, 94.2, 70.6, 69.5, 69.2, 66.9, 66.1, 59.0, 54.8, 47.2, 37.4, 20.8, 20.7, 20.7; HRMS-ESI (*m/z*): $[M+ NH_4]^+$ calcd for $C_{38}H_{43}N_2O_{12}$, 719.2816; found, 719.2809. $[\alpha]^{25}_D$ = +52 °(*c* = 0.10, MeOH).



S15

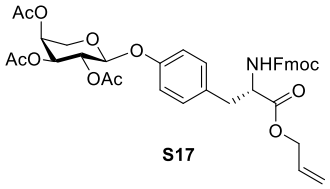
***N*-Fmoc-D-tyrosine (2,3,4,6-tetra-*O*-acetyl-β-D-glucopyranoside)-OAllyl (S16)** The title compound was obtained by reacting glucosyl bromide **S2** (1.0 g, 2.40 mmol) with acceptor **S9b** (530 mg, 1.21 mmol) following General Procedure A described above. Purification of the crude product (β only) using silica gel column chromatography eluting with petroleum ether/EtOAc (3:1) afforded pure β-anomer **S16** as a yellow syrup (729 mg, 78% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.78 (d, *J* = 7.5 Hz, 2H), 7.60-7.52 (m, 2H), 7.41 (t, *J* = 7.5 Hz, 2H), 7.31 (t, *J* = 7.5 Hz, 2H), 7.04 (d, *J* = 8.2 Hz, 2H), 6.88 (d, *J* = 8.2 Hz, 2H), 5.88 (ddd, *J* = 22.8, 11.1, 5.3 Hz, 1H), 5.38-5.19 (m, 5H), 5.19-5.10 (m, 1H), 4.89 (d, *J* = 5.3 Hz, 1H), 4.72-4.58 (m, 3H), 4.46 (dd, *J* = 10.6, 6.8 Hz, 1H), 4.33-4.22 (m, 2H), 4.17-4.11 (m, 2H), 3.80-



S16

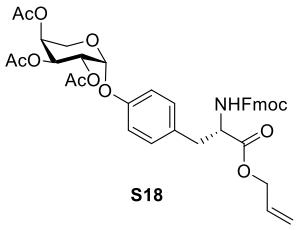
3.72 (m, 1H), 3.08 (ddd, *J* = 44.5, 14.0, 6.0 Hz, 2H), 2.07-1.98 (m, 12H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 171.3, 170.7, 170.3, 169.5, 169.4, 156.1, 155.6, 144.0, 143.8, 141.5, 141.4, 131.5, 130.8, 130.7, 127.9, 127.9, 127.2, 127.2, 125.3, 125.1, 120.2, 120.2, 119.4, 117.2, 99.2, 72.8, 72.1, 71.2, 68.4, 67.1, 66.3, 62.0, 55.0, 47.3, 37.8, 20.8, 20.7, 20.7; HRMS-ESI (*m/z*): $[M+Na]^+$ calcd for $C_{41}H_{43}NO_{14}Na$, 796.2581; found, 796.2587. $[\alpha]^{25}_D$ = +8 º(*c* = 0.10, MeOH).

***N*-Fmoc-L-tyrosine (2,3,4-tri-*O*-acetyl-β-L-arabinoside)-OAllyl (S17)** The title compound was obtained by reacting arabinosyl bromide **S5** (638 mg, 2.66 mmol) with acceptor **S9a** (591 mg, 1.33 mmol) following General Procedure A described above. Purification of the crude product (α/β = 3.8:1) using silica gel column chromatography eluting with petroleum ether/EtOAc (5:1) afforded pure β-anomer **S17** as a yellow syrup (400 mg, 50% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.77 (d, *J* = 7.5 Hz, 2H), 7.60-7.52 (m, 2H), 7.40 (t, *J* = 7.5 Hz, 2H), 7.31 (t, *J* = 7.5 Hz, 2H), 7.04 (d, *J* = 8.2 Hz, 2H), 6.91(d, *J* = 8.2 Hz, 2H), 5.88 (ddd, *J* = 22.8, 11.1, 5.3 Hz, 1H), 5.41 (dd, *J* = 8.9, 6.4 Hz, 1H), 5.36-5.23 (m, 4H), 5.13 (dd, *J* = 8.9, 3.5 Hz, 1H), 4.99 (d, *J* = 6.4 Hz, 1H), 4.70-4.57 (m, 3H), 4.44 (dd, *J* = 10.4, 6.8 Hz, 1H), 4.32 (dd, *J* = 10.4, 7.0 Hz, 1H), 4.19 (t, *J* = 7.0 Hz, 1H), 4.06 (dd, *J* = 12.9, 3.9 Hz, 1H), 3.65 (d, *J* = 12.9 Hz,1H), 3.08 (ddd, *J* = 32.0, 14.0, 5.6 Hz, 2H), 2.14 (s, 3H), 2.07 (s, 6H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 171.3, 170.3, 170.2, 169.5, 156.0, 155.6, 143.9, 141.4, 141.4, 131.5, 130.6, 130.5, 127.8, 127.2, 125.2, 125.1, 120.1, 120.1, 119.3, 117.2, 99.1, 69.9, 69.1, 67.3, 67.1, 66.2, 62.8, 54.9, 47.3, 37.6, 20.9, 20.8, 20.8; HRMS-ESI (*m/z*): $[M+NH_4]^+$ calcd for $C_{38}H_{43}N_2O_{12}$, 719.2816; found, 719.2824. $[\alpha]^{25}_D$ = -16 º(*c* = 0.10, MeOH).



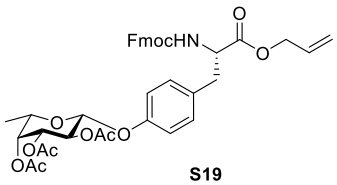
S17

***N*-Fmoc-L-tyrosine (2,3,4-tri-*O*-acetyl-α-L-arabinoside)-OAllyl (S18)** The title compound was obtained by reacting arabinosyl bromide **S5** (638 mg, 2.66 mmol) with acceptor **S9a** (591 mg, 1.33 mmol) following General Procedure A described above. Purification of the crude product (α/β = 3.8:1) using silica gel column chromatography eluting with petroleum ether/EtOAc (5:1) afforded pure α-anomer **S18** as a yellow syrup (120 mg, 13% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.76 (d, *J* = 7.5 Hz, 2H), 7.60-7.53 (m, 2H), 7.40 (t, *J* = 7.5 Hz, 2H), 7.31 (t, *J* = 7.5 Hz, 2H), 7.02 (d, *J* = 8.5 Hz, 2H), 6.96(d, *J* = 8.5 Hz, 2H), 5.88 (ddd, *J* = 22.8, 11.1, 5.3 Hz, 1H), 5.73 (d, *J* = 3.5 Hz, 1H), 5.57 (dd, *J* = 10.8, 3.5 Hz, 1H), 5.42-5.39 (m, 1H), 5.37-5.23 (m, 4H), 4.71-4.50 (m, 3H), 4.46 (dd, *J* = 10.8, 7.0 Hz, 1H), 4.36 (dd, *J* = 10.4, 7.0 Hz, 1H), 4.20 (t, *J* = 7.0 Hz, 1H), 4.00 (d, *J* = 13.2 Hz, 1H), 3.71 (dd, *J* = 13.2 1.8 Hz,1H), 3.08 (ddd, *J* = 32.0, 14.0, 5.6 Hz, 2H), 2.17 (s, 3H), 2.06 (s, 3H), 2.05 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 171.2, 170.5, 170.4, 170.2, 155.6, 144.0, 143.8, 141.4, 131.5, 130.7, 130.1, 127.9, 127.2, 125.2, 125.1, 120.1, 120.1, 119.3, 117.0, 116.7, 95.1, 69.0, 68.1, 67.2, 67.0, 66.2, 61.3, 54.9, 47.3, 37.5, 21.0, 20.9, 20.8; HRMS-ESI (*m/z*): $[M+NH_4]^+$ calcd for $C_{38}H_{43}N_2O_{12}$, 719.2816; found, 719.2809. $[\alpha]^{25}_D$ = +32 º(*c* = 0.10, MeOH).



S18

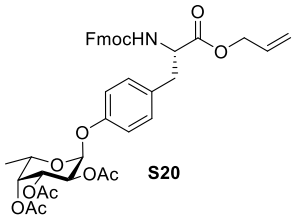
***N*-Fmoc-L-tyrosine (2,3,4-tri-*O*-acetyl-β-L-fucoside)-OAllyl (S19)** The title compound was obtained by reacting L-fucosyl bromide **S6** (289 mg, 0.82 mmol) with acceptor **S9a** (182 mg, 0.41 mmol) following General Procedure A described above. Purification of the crude product (α/β = 1:2) using silica gel column chromatography eluting with petroleum ether/EtOAc (4:1) afforded pure β-anomer **S19** as a yellow syrup (120 mg, 40% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.77 (dd, *J* = 7.3, 3.2 Hz, 2H), 7.57 (d, *J* = 7.5 Hz, 2H), 7.40 (t, *J* = 7.5 Hz, 2H), 7.31 (t, *J* = 7.5 Hz, 2H), 7.04 (d, *J* = 8.5 Hz, 2H), 6.89 (d, *J* = 8.5 Hz, 2H), 5.88 (ddd, *J* = 22.8, 11.1, 5.3 Hz, 1H), 5.42 (dd, *J* = 10.5, 8.0 Hz, 1H), 5.36-5.22 (m, 4H), 5.03 (dd, *J* = 10.5, 3.2 Hz, 1H), 4.86 (d, *J* = 8.0 Hz, 1H), 4.71-4.53 (m, 3H), 4.46 (dd, *J* = 10.5, 6.9 Hz,



S19

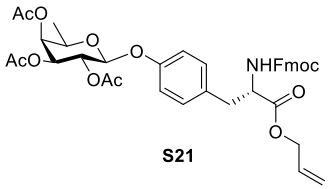
1H), 4.29 (dd, *J* = 10.5, 7.2 Hz, 1H), 4.15 (t, *J* = 6.9 Hz, 1H), 3.84 (dd, *J* = 12.6, 6.2 Hz, 1H), 3.07 (ddd, *J* = 42.4, 14.0, 5.6 Hz, 2H), 2.19 (s, 3H), 2.00 (s, 6H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 170.8, 170.3, 169.6, 156.4, 155.6, 144.0, 143.8, 141.4, 141.4, 131.5, 130.6, 130.4, 127.9, 127.2, 127.2, 125.3, 125.1, 120.2, 120.1, 119.3, 117.0, 99.6, 77.4, 71.3, 70.1, 69.5,68.8, 67.1, 66.2, 55.0, 47.3, 37.7, 20.8, 20.8, 20.7, 16.2; HRMS-ESI (*m/z*): $[M+NH_4]^+$ calcd for $C_{39}H_{45}N_2O_{12}$, 733.2972; found, 733.2975. $[\alpha]^{25}_D$ = -36 º(*c* = 0.10, MeOH).

***N*-Fmoc-L-tyrosine (2,3,4-tri-*O*-acetyl-α-L-fucoside)-OAllyl (S20)** The title compound was obtained by reacting L-fucosyl bromide **S6** (289 mg, 0.82 mmol) with acceptor **S9a** (182 mg, 0.41 mmol) following General Procedure A described above. Purification of the crude product ((α/β = 1:2) using silica gel column chromatography eluting with petroleum ether/EtOAc (4:1) afforded pure α-anomer **S20** as a yellow syrup (58 mg, 20% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.77 (d, *J* = 7.5 Hz, 2H), 7.57 (t, *J* = 7.5 Hz, 2H), 7.40 (t, *J* = 7.5 Hz, 2H), 7.31 (t, *J* = 7.5 Hz, 2H), 7.01 (d, *J* = 8.5 Hz, 2H), 6.96(d, *J* = 8.5 Hz, 2H), 5.88 (ddd, *J* = 22.8, 11.1, 5.3 Hz, 1H), 5.70 (d, *J* = 3.3 Hz, 1H), 5.58 (dd, J = 10.8, 3.3 Hz, 1H), 5.38-5.22 (m, 5H), 4.79-4.60 (m, 3H), 4.47 (dd, *J* = 10.4 6.7 Hz, 1H), 4.40-4.32 (m, 1H), 4.29-4.17 (m, 2H), 3.16-3.00 (m, 2H), 2.19 (s, 3H), 2.05 (s, 3H), 2.03 (s, 3H), 1.11 (d, *J* = 6.4 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 171.2, 170.6, 170.5, 170.2, 155.8, 155.6, 143.9, 143.8, 141.4, 131.5, 130.7, 129.9, 127.8, 127.1, 125.1, 125.1, 120.1, 120.1, 119.2, 116.7, 94.9, 71.0, 68.0, 67.9, 66.9, 66.2, 65.5, 54.9, 47.2, 37.4, 20.8, 20.8, 20.7, 15.9; HRMS-ESI (*m/z*): $[M+NH_4]^+$ calcd for $C_{39}H_{45}N_2O_{12}$, 733.2972; found, 733.2968. $[\alpha]^{25}_D$ = -92 º(*c* = 0.10, MeOH).

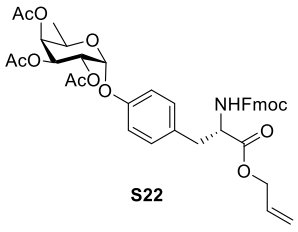


S20

***N*-Fmoc-L-tyrosine (2,3,4-tri-*O*-acetyl-β-D-fucoside)-OAllyl (S21)** The title compound was obtained by reacting D-fucosyl bromide **S7** (777 mg, 2.20 mmol) with acceptor **S9a** (486 mg, 1.10 mmol) following General Procedure A described above. Purification of the crude product (α/β = 4:1) using silica gel column chromatography eluting with petroleum ether/EtOAc (5:1) afforded pure β-anomer **S21** as a yellow syrup (411 mg, 52% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.77 (d, *J* = 7.5 Hz, 2H), 7.60-7.52 (m, 2H), 7.40 (t, *J* = 7.5 Hz, 2H), 7.31 (t, *J* = 7.5 Hz, 2H), 7.03 (d, *J* = 8.2 Hz, 2H), 6.90(d, *J* = 8.2 Hz, 2H), 5.88 (ddd, *J* = 22.7, 11.2, 5.3 Hz, 1H), 5.44 (dd, *J* = 10.5, 8.0 Hz, 1H), 5.35-5.23 (m, 4H), 5.07 (dd, *J* = 10.5, 3.5 Hz, 1H), 4.93 (d, *J* = 8.0 Hz, 1H), 4.71-4.53 (m, 3H), 4.44 (dd, *J* = 10.5, 7.0 Hz, 1H), 4.32 (dd, *J* = 10.4, 7.0 Hz, 1H), 4.19 (t, *J* = 7.0 Hz, 1H), 3.84 (dd, *J* = 12.8, 6.2 Hz, 1H), 3.09 (ddd, *J* = 32.0, 14.0, 5.6 Hz, 2H), 2.19 (s, 3H), 2.04 (s, 3H), 2.01 (s, 3H), 1.23 (d, *J* = 6.4 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 171.3, 170.8, 170.3, 169.6, 156.4, 155.6, 143.9, 141.4, 131.5, 130.6, 130.5, 127.9, 127.2, 125.3, 125.2, 120.1, 119.3, 117.3, 99.8, 77.4, 71.4, 70.2, 69.6, 68.9, 67.1, 66.3, 54.9, 47.3, 37.6, 20.9, 20.8, 20.7, 16.2; HRMS-ESI (*m/z*): $[M+NH_4]^+$ calcd for $C_{39}H_{45}N_2O_{12}$, 733.2972; found, 733.2968. $[\alpha]^{25}_D$ = -16 °(*c* = 0.10, MeOH).

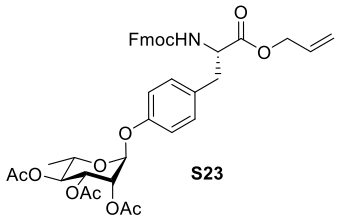


***N*-Fmoc-L-tyrosine (2,3,4-tri-*O*-acetyl-α-D-fucoside)-OAllyl (S22)** The title compound was obtained by reacting D-fucosyl bromide **S7** (777 mg, 2.20 mmol) with acceptor **S9a** (486 mg, 1.10 mmol) following General Procedure A described above. Purification of the crude product (α/β = 4:1) using silica gel column chromatography eluting with petroleum ether/EtOAc (5:1) afforded pure α-anomer **S22** as a yellow syrup (104 mg, 13% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.77 (d, *J* = 7.5 Hz, 2H), 7.60-7.52 (m, 2H), 7.41 (t, *J* = 7.5 Hz, 2H), 7.35-7.28 (m, 2H), 7.02 (d, *J* = 8.5 Hz, 2H), 6.96(d, *J* = 8.5 Hz, 2H), 5.89 (ddd, *J* = 22.7, 11.0, 5.3 Hz, 1H), 5.70 (d, *J* = 3.6 Hz, 1H), 5.57 (dd, J = 11.0, 3.6 Hz, 1H), 5.37-5.22 (m, 5H), 4.72-4.56 (m, 3H), 4.46 (dd, *J* = 11.0, 7.0 Hz, 1H), 4.35 (dd, *J* = 10.5, 7.0 Hz, 1H), 4.24-4.16 (m, 2H), 3.08



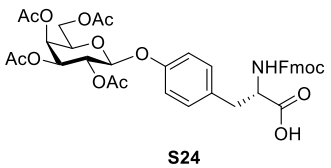
(ddd, *J* = 32.0, 14.0, 5.6 Hz, 2H), 2.19 (s, 3H), 2.06 (s, 3H), 2.03 (s, 3H), 1.09 (d, *J* = 6.5 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 171.2, 170.6, 170.5, 170.2, 155.8, 155.6, 143.9, 143.8, 141.4, 131.5, 130.7, 129.9, 129.1, 128.3, 127.9, 127.2, 125.4, 125.2, 125.1, 120.1, 120.1, 119.3, 116.6, 94.9, 77.4, 71.1, 68.0, 67.9, 67.0, 66.2, 65.5, 61.3, 54.9, 47.3, 37.5, 20.9, 20.8, 20.7, 16.0; HRMS-ESI (*m/z*): $[M+NH_4]^+$ calcd for $C_{39}H_{45}N_2O_{12}$, 733.2972; found, 733.2966. $[\alpha]^{25}_D$ = +52 º(*c* = 0.10, MeOH).

***N*-Fmoc-L-tyrosine (2,3,4-tri-*O*-acetyl-α-L-rhamnoside)-OAllyl (S23)** The title compound was obtained by reacting rhamnosyl bromide **S8** (692 mg, 1.96 mmol) with acceptor **S9a** (432 mg, 0.98 mmol) following General Procedure A described above. Purification of the crude product (α only) using silica gel column chromatography eluting with petroleum ether/EtOAc (3:1) afforded pure α-anomer **S23** as a yellow syrup (580 mg, 83% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.77 (d, *J* = 7.5 Hz, 2H), 7.60-7.52 (m, 2H), 7.40 (t, *J* = 7.5 Hz, 2H), 7.31 (t, *J* = 7.5 Hz, 2H), 7.06-6.94 (m, 4H), 5.88 (ddd, *J* = 22.8, 11.1, 5.3 Hz, 1H), 5.51 (dd, *J* = 10.1 3.4 Hz, 1H), 5.44-4.38 (m, 2H), 5.35-5.22 (m, 3H), 5.15 (t, *J* = 10.1 Hz, 1H), 4.71-4.51 (m, 3H), 4.46 (dd, *J* = 10.6, 7.2 Hz, 1H), 4.36 (dd, *J* = 10.6, 7.0 Hz, 1H), 4.21 (t, *J* = 7.0 Hz, 1H), 4.03-3.92 (m, 1H), 3.15-3.01 (m, 2H), 2.19 (s, 3H), 2.06 (s, 3H), 2.03 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 171.1, 170.0, 169.9, 155.5, 155.1, 143.9, 143.7, 141.3, 131.4, 130.5, 130.0, 127.7, 127.1, 125.1, 125.0, 120.0, 120.0, 119.1, 116.5, 95.9, 71.0, 69.7, 69.0, 67.2, 66.9, 66.1, 54.9, 47.2, 37.4, 20.8, 20.7, 20.7, 17.4; HRMS-ESI (*m/z*): $[M+NH_4]^+$ calcd for $C_{39}H_{45}N_2O_{12}$, 733.2972; found, 733.2982. $[\alpha]^{25}_D$ = -44 º(*c* = 0.10, MeOH).



S23

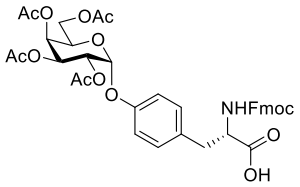
***N*-Fmoc-L-tyrosine (2,3,4,6-tetra-*O*-acetyl-β-D-galactopyranoside)-OH (S24)** The title compound was obtained by reacting tyrosine *O*-galactopyranoside derivative **S10** (4.7 g, 6.05 mmol) following General Procedure B described above. Purification of the crude product using silica gel column chromatography eluting with



S24

petroleum ether/EtOAc/AcOH (50:50:1) afforded **S24** as a white solid (4.4 g, 98% yield). Analytical data for **S24** was in accordance with those reported previously.[S11, S13]

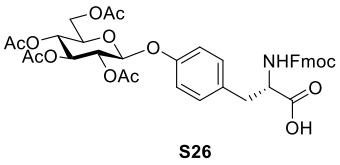
***N*-Fmoc-L-tyrosine (2,3,4,6-tetra-*O*-acetyl-α-D-galactopyranoside)-OH (S25)** The



S25

title compound was obtained by reacting tyrosine *O*-galactopyranoside derivative **S11** (550 mg, 0.71 mmol) following General Procedure B described above. Purification of the crude product using silica gel column chromatography eluting with petroleum ether/EtOAc/AcOH (50:50:1) afforded **S25** as a white solid (493 mg, 95% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.77 (d, *J* = 7.5 Hz, 2H), 7.58-7.49 (m, 2H), 7.40 (t, *J* = 7.5 Hz, 2H), 7.30 (t, *J* = 7.5 Hz, 2H), 7.06 (d, *J* = 8.3 Hz, 2H), 6.97 (d, *J* = 8.3 Hz, 2H), 5.73 (d, *J* = 3.3 Hz, 1H), 5.55 (dd, *J* = 10.8, 3.3 Hz, 1H), 5.51-5.46 (m, 1H), 5.27 (dd, *J* = 10.6, 2.9 Hz, 2H), 4.65 (dd, *J* = 13.4, 6.0 Hz, 1H), 4.49-4.41 (m, 1H), 4.36 (dd, *J* = 10.6, 6.6 Hz, 1H), 4.28-4.16 (m, 2H), 4.04 (d, *J* = 6.6 Hz, 2H), 3.16 (dd, *J* = 14.0, 5.0 Hz, 1H), 3.05 (dd, *J* = 14.0, 5.0 Hz, 1H), 2.16 (s, 3H), 2.06 (s, 3H), 2.03 (s, 3H), 1.91 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 174.9, 170.6, 170.4, 170.3, 155.9, 155.5, 143.8, 143.7, 141.5, 130.7, 130.3, 127.9, 127.2, 125.2, 125.1, 120.2, 117.0, 94.9, 68.0, 67.9, 67.7, 67.2, 67.1, 61.5, 54.7, 47.2, 37.1, 20.9, 20.8, 20.8, 20.7; HRMS-ESI (*m/z*): $[M+H]^+$ calcd for $C_{38}H_{40}NO_{14}$, 734.2449; found, 734.2455. $[\alpha]^{25}_D$ = +88 °(*c* = 0.10, MeOH).

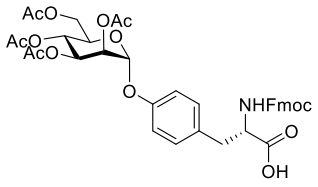
***N*-Fmoc-L-tyrosine (2,3,4,6-tetra-*O*-acetyl-β-D-glucopyranoside)-OH (S26)** The



S26

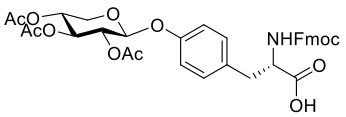
title compound was obtained by reacting tyrosine *O*-glucopyranoside derivative **S12** (2.0 g, 2.57 mmol) following General Procedure B described above. Purification of the crude product using silica gel column chromatography eluting with petroleum ether /EtOAc/AcOH (33:66:1) afforded **S26** as a white solid (1.8 g, 94% yield). Analytical data for **S26** was in accordance with those reported previously.[S10, S12]

***N*-Fmoc-L-tyrosine (2,3,4,6-tetra-*O*-acetyl-α-D-mannopyranoside)-OH (S27)** The title compound was obtained by reacting tyrosine *O*-mannopyranoside derivative **S13** (310 mg, 0.41) following General Procedure B described above. Purification of the crude product using silica gel column chromatography eluting with petroleum ether /EtOAc/AcOH (33:66:1) afforded **S27** as a white solid (264 mg, 89% yield). ^{1}H NMR (400 MHz, CD_3OD) δ 7.74 (d, *J* = 7.5 Hz, 2H), 7.54 (d, *J* = 7.5 Hz, 1H), 7.48 (d, *J* = 7.5 Hz, 1H), 7.38-7.31 (m, 2H), 7.30-7.22 (m, 2H), 7.18 (d, 8.6 Hz, 2H), 7.00 (d, *J* = 8.6 Hz, 2H), 5.45-5.37 (m, 3H), 5.26 (t, *J* = 9.9, 1H), 4.87 (br, 2H), 4.44 (dd, *J* = 9.9, 4.7 Hz, 1H), 4.31 (dd, *J* = 9.2, 5.3 Hz, 1H), 4.14-4.04 (m, 3H), 3.94-3.84 (m, 2H), 3.19 (dd, 14.1, 4.7 Hz, 1H), 2.88 (dd, *J* = 14.1, 9.9 Hz, 1H), 2.14 (s, 3H), 2.03 (s, 3H), 1.98 (s, 3H), 1.91 (m, 3H); ^{13}C NMR (100 MHz, CD_3OD) δ 173.7, 170.8, 170.2, 170.1, 170.1, 156.9, 154.5, 143.9, 143.7, 141.1, 141.1, 131.9, 130.2, 127.4, 126.8, 125.0, 124.8, 119.6, 116.4, 95.8, 69.2, 69.1, 69.0, 66.6, 65.7, 61.8, 55.3, 36.4, 19.3, 19.2; HRMS-ESI (*m/z*): $[M+H]^+$ calcd for $C_{38}H_{43}N_2O_{14}$, 751.2714; found, 751.2717. $[\alpha]^{25}_D$ = +40 °(*c* = 0.10, MeOH).



S27

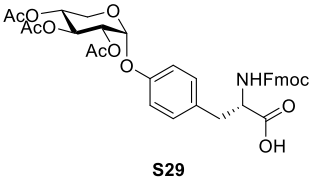
***N*-Fmoc-L-tyrosine (2,3,4-tri-*O*-acetyl-β-D-xylopyranoside)-OH (S28)** The title compound was obtained by reacting tyrosine *O*-xylopyranoside derivative **S14** (720 mg, 1.03 mmol) following General Procedure B described above. Purification of the crude product using silica gel column chromatography eluting with petroleum ether /EtOAc/AcOH (50:50:1) afforded **S28** as a white solid (668 mg, 98% yield). ^{1}H NMR (400 MHz, DMSO-d_6) δ 12.81 (br, 1H), 7.88 (d, *J* = 7.5 Hz, 2H), 7.65 (t, *J* = 7.5 Hz, 2H), 7.46-7.18 (m, 6H), 6.90 (d, *J* = 8.6 Hz, 2H), 5.41 (d, *J* = 7.4 Hz, 1H), 5.30 (t, *J* = 9.2 Hz, 1H), 5.02 (dd, *J* = 9.2, 7.4 Hz, 1H), 4.93 (td, *J* = 9.2, 5.4 Hz, 1H), 4.24-4.08 (m, 4H), 3.99 (dd, *J* = 11.5, 5.4 Hz, 1H), 3.66 (dd, *J* = 11.5, 9.8 Hz, 1H), 3.03 (dd, *J* = 13.7, 4.1 Hz, 1H), 2.81 (dd, 13.7s, 10.8 Hz, 1H), 2.01 (s, 3H), 2.00 (s, 3H), 1.99 (s, 3H); ^{13}C NMR (100 MHz, DMSO-d_6) δ 173.8, 170.0, 170.0, 169.6, 156.4,



S28

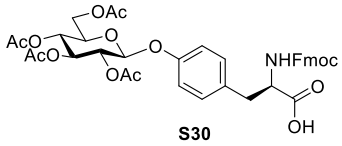
155.4, 144.2, 141.1, 132.9, 130.8, 128.1, 127.5, 125.8, 125.7, 120.6, 116.7, 98.2, 71.6, 70.9, 68.9, 66.0, 62.0, 56.1, 47.0, 36.1, 21.0, 20.9, 20.8; HRMS-ESI (*m/z*): $[M+NH_4]^+$ calcd for $C_{35}H_{39}N_2O_{12}$, 679.2503; found, 679.2496. $[\alpha]^{25}_D$ = -28 °(*c* = 0.10, MeOH).

***N*-Fmoc-L-tyrosine (2,3,4-tri-*O*-acetyl-α-D-xylopyranoside)-OH (S29)** The title compound was obtained by reacting tyrosine *O*-xylopyranoside derivative **S15** (229 mg, 0.33 mmol) following General Procedure B described above. Purification of the crude product using silica gel column chromatography eluting with petroleum ether /EtOAc/AcOH (50:50:1) afforded **S29** as a white solid (187 mg, 90% yield). ^{1}H NMR (400 MHz, DMSO-d_6) δ 12.76 (br, 1H), 7.87 (d, *J* = 7.5 Hz, 2H), 7.67-7.62 (m, 2H), 7.45-7.20 (m, 6H), 7.02 (d, *J* = 8.5 Hz, 2H), 5.76 (d, *J* = 3.6 Hz, 1H), 5.49 (t, *J* = 9.8 Hz, 1H), 5.08-4.97 (m, 2H), 4.25-4.10 (m, 4H), 3.77 (dd, *J* = 11.0, 5.9 Hz, 1H), 3.53 (t, *J* = 11.0 Hz, 1H), 3.05 (dd, 13.9, 3.6 Hz, 1H), 2.83 (dd, *J* = 13.9, 11.0 Hz, 1H), 2.03 (s, 3H), 2.01 (s, 3H), 2.00 (s, 3H); ^{13}C NMR (100 MHz, DMSO-d_6) δ 173.4, 169.8, 169.6, 156.0, 154.2, 143.8, 143.8, 140.7, 140.7, 132.4, 130.4, 127.6, 127.1, 125.3. 125.3, 120.1, 116.6, 93.9, 69.7, 69.0, 68.3, 65.6, 58.6, 55.6, 46.6, 35.6, 20.5, 20.4; HRMS-ESI (*m/z*): $[M+NH_4]^+$ calcd for $C_{35}H_{39}N_2O_{12}$, 679.2503; found, 679.2498. $[\alpha]^{25}_D$ = +72 °(*c* = 0.10, MeOH).



S29

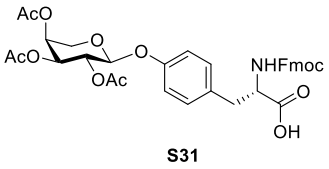
***N*-Fmoc-D-tyrosine (2,3,4,6-tetra-*O*-acetyl-β-D-glucopyranoside)-OH (S30)** The title compound was obtained by reacting tyrosine *O*-glucopyranoside derivative **S16** (729 mg, 0.94 mmol) following General Procedure B described above. Purification of the crude product using silica gel column chromatography eluting with petroleum ether /EtOAc/AcOH (50:50:1) afforded **S30** as a white solid (680 mg, 96% yield). ^{1}H NMR (400 MHz, acetone-d_6) δ 7.87 (dd, *J* = 7.5, 3.3 Hz, 2H), 7.66 (dd, *J* = 11.4, 7.5 Hz, 2H), 7.46-7.23 (m, 6H), 6.96 (d, *J* = 8.4 Hz, 2H), 6.71 (d, *J* = 8.7 Hz, 1H), 5.32 (t, *J* = 9.3 Hz, 1H), 5.20-5.04 (m, 3H), 4.52 (m, 1H), 4.35 (dd, *J* = 10.3, 6.9 Hz,



S30

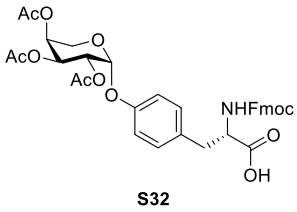
1H), 4.26 (dd, *J* = 12.2, 5.5 Hz, 1H), 4.23-4.03 (m, 4H), 3.23 (dd, *J* = 13.9, 4.6 Hz, 1H), 2.99 (dd, *J* = 13.9, 9.3 Hz, 1H), 2.03 (s, 3H), 2.01 (s, 3H), 1.97 (s, 3H), 1.94 (s, 3H); ^{13}C NMR (100 MHz, acetone-d_6) δ 173.3, 170.7, 170.3, 170.1, 169.8, 156.9, 156.8, 145.2, 144.9, 142.1, 133.0, 131.4, 128.6, 128.0, 128.0, 126.4, 126.1, 120.9, 120.9, 117.5, 99.5, 73.4, 72.6, 71.9, 69.3, 67.2, 62.7, 56.3, 48.0, 37.6, 29.9, 20.7, 20.7, 20.6, 20.5; HRMS-ESI (*m/z*): $[M+H]^+$ calcd for $C_{38}H_{40}NO_{14}$, 734.2449; found, 734.2444. $[\alpha]^{25}_D$ = 0 º(*c* = 0.10, MeOH).

***N*-Fmoc-L-tyrosine (2,3,4-tri-*O*-acetyl-β-L-arabinoside)-OH (S31)** The title compound was obtained by reacting tyrosine *O*-arabinoside derivative **S17** (330 mg, 0.48 mmol) following General Procedure B described above. Purification of the crude product using silica gel column chromatography eluting with petroleum ether /EtOAc/AcOH (50:50:1) afforded **S31** as a white solid (300 mg, 97% yield). ^{1}H NMR (400 MHz, CD_3OD) δ 7.76 (d, *J* = 7.5 Hz, 2H), 7.58-7.53 (m, 2H), 7.36 (t, *J* = 7.5 Hz, 2H), 7.27 (t, *J* = 7.5 Hz, 2H), 7.18 (d, *J* = 8.6 Hz, 2H), 6.88 (d, *J* = 8.6 Hz, 2H), 5.32-5.20 (m, 2H), 5.11 (dd, *J* = 9.6, 3.5 Hz, 1H), 4.93 (d, *J* = 7.3 Hz, 1H), 4.43 (dd, *J* = 9.6, 4.4 Hz, 1H), 4.29 (dd, *J* = 10.0, 6.4 Hz, 1H), 4.13-4.01 (m, 2H), 3.87 (dd, *J* = 13.1, 2.8 Hz, 1H), 3.60 (d, *J* = 13.1 Hz, 1H), 3.19 (dd, *J* = 14.0, 4.4 Hz, 1H), 2.87 (dd, *J* = 14.0, 10.0 Hz, 1H), 2.10 (s, 3H), 1.99 (s, 3H), 1.96 (s, 3H); ^{13}C NMR (100 MHz, CD_3OD) δ 173.7, 170.5, 170.2, 169.9, 156.9, 155.8, 143.9, 143.7, 141.1, 141.1, 132.4, 132.0, 131.7, 131.6, 130.2, 128.6, 128.5, 127.4, 126.8, 126.8, 125.1, 124.9, 119.6, 116.7, 99.2, 70.3, 69.0, 67.9, 66.6, 63.0, 55.4, 36.6, 19.4, 19.3, 19.2; HRMS-ESI (*m/z*): $[M+NH_4]^+$ calcd for $C_{35}H_{39}N_2O_{12}$, 679.2503; found, 679.2494. $[\alpha]^{25}_D$ = -12 º(*c* = 0.10, MeOH).



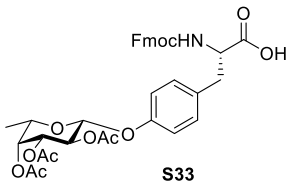
S31

***N*-Fmoc-L-tyrosine (2,3,4-tri-*O*-acetyl-α-L-arabinoside)-OH (S32)** The title compound was obtained by reacting tyrosine *O*-arabinoside derivative **S18** (100 mg, 0.15 mmol) following General Procedure B described above. Purification of the crude product using silica gel column chromatography eluting with petroleum ether /EtOAc/AcOH (50:50:1) afforded **S32** as a white solid (90 mg, 96% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.76 (d, *J* = 7.5 Hz, 2H), 7.62-7.52 (m, 2H), 7.40 (t, *J* = 7.5 Hz, 2H), 7.30 (t, *J* = 7.5 Hz, 2H), 7.04 (d, *J* = 8.5 Hz, 2H), 6.93 (d, *J* = 8.5 Hz, 2H), 5.72 (d, *J* = 3.5 Hz, 1H), 5.56 (dd, *J* = 10.8, 3.5 Hz, 1H), 5.39 (br, 1H), 5.32 (dd, *J* = 10.8, 3.5 Hz, 1H), 4.70-4.61 (m, 1H), 4.46 (dd, *J* = 10.6, 7.0 Hz, 1H), 4.34 (dd, *J* = 10.6, 7.0 Hz, 1H), 4.19 (t, *J* = 6.9 Hz, 1H), 3.97 (d, *J* = 13.1 Hz, 1H), 3.68 (d, *J* =13.1 Hz, 1H), 3.11 (ddd, *J* = 42.1, 13.9, 5.5 Hz, 2H), 2.17 (s, 3H), 2.05 (s, 6H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 174.1, 170.5, 170.4, 170.2, 155.7, 155.4, 143.8, 143.7, 141.3, 131.7, 130.7, 130.1, 127.8, 127.1, 125.1. 125.0, 120.0, 116.5, 94.9, 68.9, 68.0, 67.2, 67.0, 61.2, 54.6, 47.2, 37.0, 20.9, 20.7; HRMS-ESI (*m/z*): $[M+NH_4]^+$ calcd for $C_{35}H_{39}N_2O_{12}$, 679.2503; found, 679.2504. $[\alpha]^{25}_D$ = +16 °(*c* = 0.10, MeOH).



S32

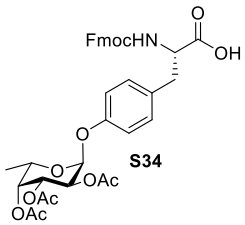
***N*-Fmoc-L-tyrosine (2,3,4-tri-*O*-acetyl-β-L-fucoside)-OH (S33)** The title compound was obtained by reacting tyrosine *O*-L-fucoside derivative **S19** (120 mg, 0.17 mmol) following General Procedure B described above. Purification of the crude product using silica gel column chromatography eluting with petroleum ether /EtOAc/AcOH (50:50:1) afforded **S33** as a white solid (94 mg, 83% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.77 (d, *J* = 7.5 Hz, 2H), 7.59-7.53 (m, 2H), 7.40 (t, *J* = 7.5 Hz, 2H), 7.34-7.27 (m, 2H), 7.08 (d, *J* = 8.6 Hz, 2H), 6.89 (d, *J* = 8.6 Hz, 2H), 5.41 (dd, *J* = 10.7, 7.8 Hz, 2H), 5.31 (d, *J* = 8.1 Hz, 1H), 5.26 (d, *J* = 3.3 Hz, 1H), 5.03 (dd, *J* = 10.7, 3.3 Hz, 1H), 4.85 (d, *J* = 8.1 Hz, 1H), 4.73-4.63 (m, 1H), 4.47 (dd, *J* = 10.7, 6.9 Hz, 1H), 4.29 (dd, *J* = 10.4, 7.1 Hz, 1H), 4.14 (t, *J* = 6.9 Hz, 1H), 3.84-3.77 (m, 1H), 3.11 (ddd, *J* = 61.2, 13.9, 5.7 Hz, 1H), 2.19 (s, 3H), 2.01 (s, 3H), 1.99 (s, 3H), 1.23 (d, *J* = 6.4 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 170.4, 169.7, 156.4, 155.9, 144.0,



S33

143.8, 141.5, 141.4, 138.0, 131.7, 131.6, 130.7, 130.4, 129.2, 128.3, 127.9, 127.2, 125.4, 125.3, 125.1, 120.2, 120.2 117.1, 99.6, 77.4,71.3, 70.2, 69.5, 68.8, 67.2, 54.7, 47.3, 37.3, 20.8, 20.8, 2.07, 16.2; HRMS-ESI (*m/z*): $[M+NH_4]^+$ calcd for $C_{36}H_{41}N_2O_{12}$, 693.2659; found, 693.2661. $[\alpha]^{25}_D$ = -28 º(*c* = 0.10, MeOH).

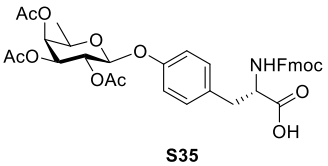
***N*-Fmoc-L-tyrosine (2,3,4-tri-*O*-acetyl-α-L-fucoside)-OH (S34)** The title compound



S34

was obtained by reacting tyrosine *O*-L-fucoside derivative **S20** (58 mg, 0.08 mmol) following General Procedure B described above. Purification of the crude product using silica gel column chromatography eluting with petroleum ether /EtOAc/AcOH (50:50:1) afforded **S34** as a white solid (51 mg, 93% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.77 (d, *J* = 7.5 Hz, 2H), 7.57 (d, *J* = 7.5 Hz, 2H), 7.41 (t, *J* = 7.5 Hz, 2H), 7.31 (t, *J* = 7.5 Hz, 2H), 7.06 (d, *J* = 8.5 Hz, 2H), 6.97 (d, *J* = 8.5 Hz, 2H), 5.72 (d, *J* = 3.3 Hz, 1H), 5.59 (dd, *J* = 10.9, 3.3 Hz, 1H), 5.40-5.25 (m, 3H), 4.71-4.62 (m, 1H), 4.48 (dd, *J* = 10.4, 6.7 Hz, 1H), 4.37 (dd = 10.4, 6.7 Hz, 1H), 4.30-4.13 (m, 2H), 3.12 (ddd, 37.0, 13.9, 5.4 Hz, 2H), 2.20 (s, 3H), 2.04 (s, 6H), 1.10 (d, *J* = 6.4 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 174.9, 170.8, 170.7, 170.3, 155.8, 154.2, 143.9, 143.8, 141.4, 138.0, 130.7, 130.0, 129.1, 128.3, 127.9, 127.1, 125.4. 125.2, 125.1, 120.1, 116.7, 94.9, 71.1, 68.1, 67.9, 67.0, 65.5, 54.7, 47.3, 37.0, 20.8, 20.8, 20.7, 16.0; HRMS-ESI (*m/z*): $[M+NH_4]^+$ calcd for $C_{36}H_{41}N_2O_{12}$, 693.2659; found, 693.2659. $[\alpha]^{25}_D$ = -68 °(*c* = 0.10, MeOH).

***N*-Fmoc-L-tyrosine (2,3,4-tri-*O*-acetyl-β-D-fucoside)-OH (S35)** The title compound

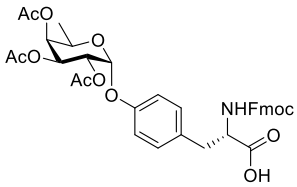


S35

was obtained by reacting tyrosine *O*-D-fucoside derivative **S21** (360 mg, 0.50 mmol) following General Procedure B described above. Purification of the crude product using silica gel column chromatography eluting with petroleum ether /EtOAc/AcOH (50:50:1) afforded **S35** as a white solid (320 mg, 95% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.76 (d, *J* = 7.5 Hz, 2H), 7.59-7.49 (m, 2H), 7.40 (t, *J* = 7.5 Hz, 2H), 7.30 (t, *J* = 7.5 Hz, 2H), 7.08 (d, *J* = 8.2 Hz, 2H), 6.90 (d, *J* = 8.2 Hz, 2H),

5.43 (dd, *J* = 10.4, 8.2 Hz, 2H), 5.31 (d, *J* = 8.2 Hz, 1H), 5.26 (d, *J* = 3.0 Hz, 1H), 5.08 (dd, *J* = 10.4, 3.4 Hz, 1H), 4.93 (d, *J* = 7.9 Hz, 1H), 4.72-4.64 (m, 2H), 4.44 (dd, *J* = 10.2, 7.0 Hz, 1H), 4.31 (dd, *J* = 10.2, 7.0 Hz, 1H), 4.17 (t, *J* = 7.0 Hz, 1H), 3.81 (q, *J* = 6.5 Hz, 1H), 3.12 (ddd, *J* = 55.3, 15.5, 4.7 Hz, 2H), 2.18 (s, 3H), 2.01 (s, 6H), 1.20 (d, *J* = 6.4 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 175.1, 170.9, 170.4, 169.7, 156.4, 155.9, 143.8, 141.4, 130.6, 130.5, 127.9, 127.2, 125.2, 125.1, 120.1, 117.3, 99.6, 77.4, 71.3, 70.2, 69.5, 68.9, 67.1, 54.7, 47.2, 37.1, 20.8, 20.8, 20.7, 16.2; HRMS-ESI (*m/z*): $[M+NH_4]^+$ calcd for $C_{36}H_{41}N_2O_{12}$, 693.2659; found, 693.2660. $[\alpha]^{25}_D$ = -16 º(*c* = 0.10, MeOH).

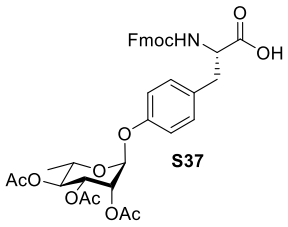
***N*-Fmoc-L-tyrosine (2,3,4-tri-*O*-acetyl-α-D-fucoside)-OH (S36)** The title compound



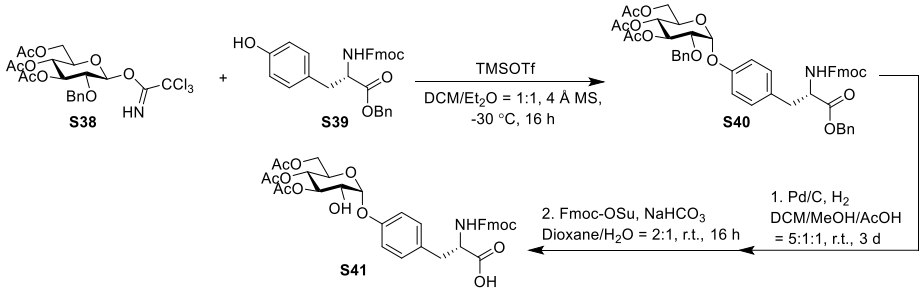
S36

was obtained by reacting tyrosine *O*-D-fucoside derivative **S22** (75 mg, 0.11 mmol) following General Procedure B described above. Purification of the crude product using silica gel column chromatography eluting with petroleum ether /EtOAc/AcOH (50:50:1) afforded **S36** as a white solid (70 mg, 98% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.77 (d, *J* = 7.5 Hz, 2H), 7.59-7.49 (m, 2H), 7.40 (t, *J* = 7.5 Hz, 2H), 7.33-7.27 (m, 2H), 7.06 (d, *J* = 8.0 Hz, 2H), 6.96 (d, *J* = 8.0 Hz, 2H), 5.70 (d, *J* = 3.3 Hz, 1H), 5.56 (dd, *J* = 10.8, 3.3 Hz, 1H), 5.35-5.24 (m, 3H), 4.71-4.63 (m, 1H), 4.45 (dd, *J* = 10.4, 7.2 Hz, 1H), 4.34 (dd, *J* = 10.4, 6.9 Hz, 1H), 4.22-4.14 (m, 2H), 3.11 (ddd, *J* = 51.9, 14.0, 5.6 Hz, 1H), 2.18 (s, 3H), 2.05 (s, 3H), 2.04 (s, 3H), 1.06 (d, *J* = 6.4 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 175.0, 170.8, 170.7, 170.4, 155.9, 155.8, 143.9, 143.7, 141.4, 130.7, 129.9, 127.6, 127.9, 127.2, 125.1, 120.1, 116.7, 94.9, 77.4, 71.1, 68.1, 67.9, 67.1, 65.5, 54.7, 47.2, 37.1, 20.9, 20.8, 20.7, 15.9; HRMS-ESI (*m/z*): $[M+NH_4]^+$ calcd for $C_{36}H_{41}N_2O_{12}$, 693.2659; found, 693.2661. $[\alpha]^{25}_D$ = +52 °(*c* = 0.10, MeOH).

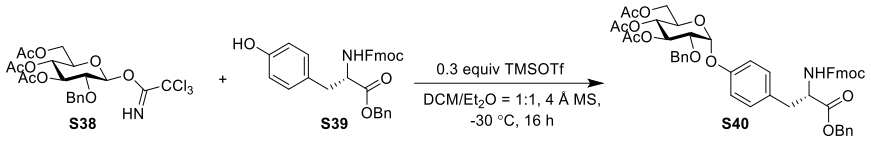
***N*-Fmoc-L-tyrosine (2,3,4-tri-*O*-acetyl-α-L-Rhamnoside)-OH (S37)** The title compound was obtained by reacting tyrosine *O*-L-rhamnoside derivative **S23** (416 mg, 0.58 mmol) following General Procedure B described above. Purification of the crude product using silica gel column chromatography eluting with petroleum ether /EtOAc/AcOH (50:50:1) afforded **S37** as a white solid (379 mg, 96% yield). ^{1}H NMR (400 MHz, CD_3OD) δ 7.74 (d, *J* = 7.5 Hz, 2H), 7.53 (t, *J* = 6.7 Hz, 2H), 7.34 (t, *J* = 7.5 Hz, 2H), 7.30-7.21 (m, 2H), 7.17 (d, *J* = 8.4 Hz, 2H), 6.98 (d, *J* = 8.4 Hz, 2H), 5.44-5.36 (m, 3H), 5.06 (t, *J* = 10.4 Hz, 1H), 4.43 (dd, *J* = 9.4, 4.5 Hz, 1H), 4.28 (dd, *J* = 10.4, 7.1 Hz, 1H), 4.15 (dd, *J* = 10.4, 7.1 Hz, 1H), 4.11-4.05 (m, 1H), 3.95-3.84 (m, 1H), 3.17 (dd, *J* = 14.0, 4.7 Hz, 1H), 2.89 (dd, *J* = 14.0, 9.7 Hz, 1H), 2.13 (s, 3H), 2.02 (s, 3H), 1.98 (s, 3H), 1.04 (d, *J* = 6.3 Hz, 3H); ^{13}C NMR (100 MHz, CD_3OD) δ 175.0, 171.6, 171.6, 171.6, 158.2, 156.1, 145.1, 142.5, 133.0, 131.6, 128.7, 128.1, 126.3, 126.2, 120.9, 117.6, 97.2, 71.9, 70.7, 70.5, 68.3, 67.9, 56.7, 48.3, 37.8, 20.7, 20.6, 17.7; HRMS-ESI (*m/z*): $[M+NH_4]^+$ calcd for $C_{36}H_{41}N_2O_{12}$, 693.2659; found, 693.2668. $[\alpha]^{25}_D$ = -44 º(*c* = 0.10, MeOH).



4.2 Preparation of Fmoc-Tyr(α- Ac$_3$Glc)-OH (S41):

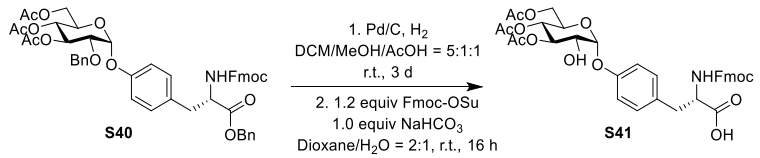


Scheme S2. Synthesis of Fmoc-Tyr(α-Ac$_3$Glc)-OH (**S41**)



To a solution of 3,4,6-tri-*O*-acetyl-2-*O*-benzyl-β-D-glucopyranose trichloroacetimidate **(38)** [S14] (472 mg, 0.96 mmol, 1.0 equiv) and *N*-Fmoc-L-tyrosine benzyl ester **(S39)** (775

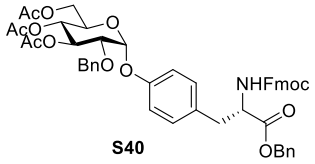
mg, 1.43 mmol, 1.5 equiv) in anhydrous DCM/Et_2O (20 mL/20 mL) was added freshly activated 4 Å MS (1g) under an argon atmosphere. The resulting mixture was allowed to stir at r.t for 1 h, then cooled to -30 ℃ followed by the addition of TMSOTf (56 μL, 0.29 mmol, 0.3 equiv) dropwise. The reaction was allowed to stir at -30 ℃ for 16 h, and the mixture was then filtered through Celite. The filtrate was washed with a saturated solution of $NaHCO_3$ (50 ml×1), water (50 ml×1) and brine (50 ml×1), dried over $MgSO_4$, and filtered over a sintered funnel. The filtrate was concentrated *in vacuo* and purification of the crude product using silica gel column chromatography eluting with Toluene/EtOAc (9:1) afforded compound **S40** as a colorless oil (683 mg, 82%, α/β = 13:1).



To a solution of compound **S40** (680 mg, 0.78 mmol, 1.0 equiv) in DCM/MeOH/AcOH (40 ml/8 ml/8 ml), Pd/C (340 mg, 10% Pd) was added under an argon atmosphere. The flask was then closed with a septum and purged with H_2 (1 atm) for 15 minutes. The mixture was allowed to stir at r.t. for 3 d under a H_2 atmosphere (1 atm). Upon completion, the resulting mixture was filtered through a nylon syringe equipped with a 0.45 μm filter, and evaporated to afford a white solid.

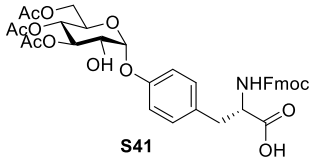
The crude residue was co-evaporated with toluene (×3) and dried *in vacuo* for 1 h, then dissolved in dioxane/H_2O (7 ml/3.5 ml), followed by the addition of Fmoc-OSu (317 mg, 0.94 mmol, 1.2 equiv) and $NaHCO_3$ (66 mg, 0.78 mmol, 1.0 equiv). The reaction was allowed to stir at r.t. for 16 h and quenched with 1 M aqueous HCl to adjust pH to ~1. The resulting mixture was transferred to a 125 ml extraction funnel, diluted with 25 ml of water and then extracted with EtOAc (25 ml×3). The organic phase was combined, dried over $MgSO_4$, filtered over a sintered funnel and concentrated to dryness. The crude mixture of two anomers was then purified by flash chromatography (Toluene/EtOAc/AcOH = 66/33/1), and monitored using analytical HPLC ($t_{R\alpha}$ = 23.2 min, $t_{R\beta}$ = 23.9 min, Agilent C18 column, 40 to 60% solvent B

gradient over 30 min), as the α- and β-anomers could not be completely separated on TLC. The fractions containing desired product in an α/β ratio greater than 20:1 were combined to afford pure **S41** as a white solid (251 mg, 46%, α/β > 20:1).

***N*-Fmoc-L-tyrosine (2-*O*-benzyl-3,4,5-tri-*O*-acetyl-α-D-glucopyranoside)-OBn (S40)** 

S40

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.77 (d, *J* = 7.5 Hz, 2H), 7.60-7.53 (m, 2H), 7.44-7.26 (m, 14H), 6.93 (d, *J* = 8.6 Hz, 2H), 6.88 (d, *J* = 8.6 Hz, 2H), 5.65 (t, *J* = 9.6 Hz, 1H), 5.40 (d, *J* = 3.5 Hz, 1H), 5.28 (d, *J* = 8.3 Hz, 1H), 5.22 (d, *J* = 12.1 Hz, 1H), 5.14 (d, *J* = 12.1 Hz, 1H), 5.07 (t, *J* = 9.9 Hz, 1H), 4.75-4.67 (m, 1H), 4.63 (dd, 16.9, 12.4 Hz, 1H), 4.47 (dd, *J* = 10.6, 7.0 Hz, 1H), 4.37 (dd, *J* = 10.6, 7.0 Hz, 1H), 4.27 (dd, *J* = 12.4, 4.2 Hz, 1H), 4.21 (t, *J* = 6.8 Hz, 1H), 4.08-4.00 (m, 1H), 3.94 (dd, *J* = 12.4, 1.5 Hz, 1H), 3.72 (dd, 9.9, 3.5 Hz, 1H), 3.15-3.01 (m, 2H), 2.06 (s, 3H), 2.04 (s, 3H), 2.02 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 171.3, 170.5 170.3, 169.9, 155.5, 143.8, 143.7, 141.4, 141.3, 137.5, 135.0, 130.6, 129.8, 128.7, 128.6, 128.1, 127.8, 127.1, 125.1, 125.0, 120.1, 116.7, 95.1, 76.5, 73.1, 71.8, 68.4, 67.9, 67.4, 66.9, 61.7, 54.8, 47.2, 37.3, 20.9, 20.7; HRMS-ESI (*m/z*): $[M+NH_4]^+$ calcd for $C_{50}H_{53}N_2O_{13}$, 889.3548; found, 889.3565. $[\alpha]^{25}_D$ = +48 °(*c* = 0.10, MeOH).

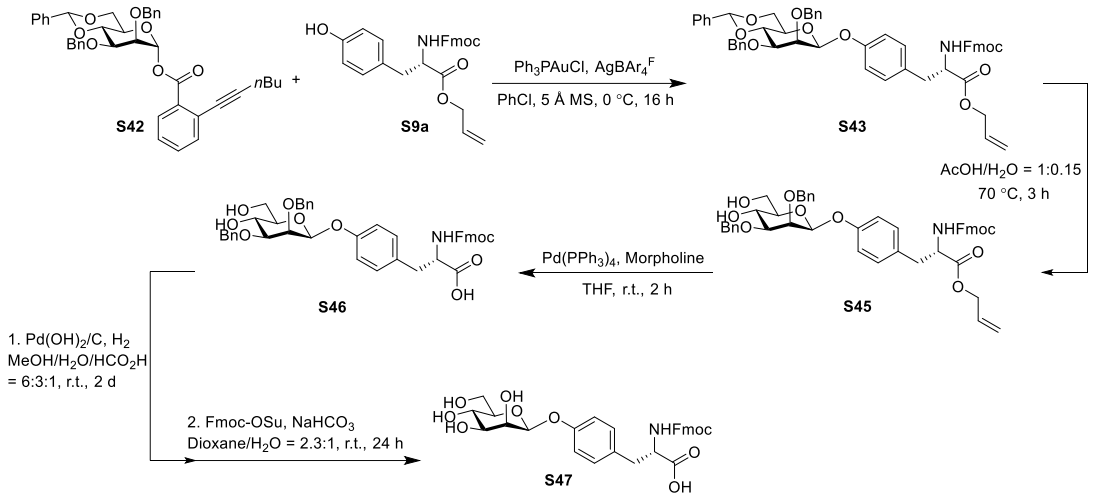
***N*-Fmoc-L-tyrosine (3,4,5-tri-*O*-acetyl-α-D-glucopyranoside)-OH (S41)** 

S41

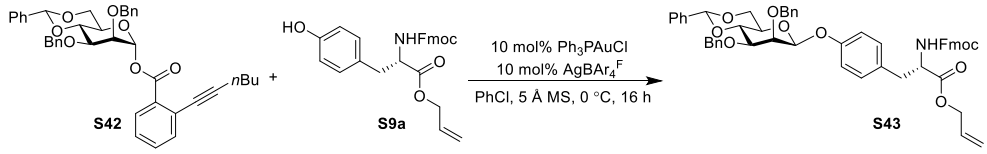
^{1}H NMR (400 MHz, CD_3OD) δ 7.77 (d, *J* = 7.5 Hz, 2H), 7.55 (dd, *J* = 23.1, 7.5 Hz, 2H), 7.38 (td, *J* = 7.5, 3.7 Hz, 2H), 7.32-7.25 (m, 2H), 7.20 (d, *J* = 8.5 Hz, 2H), 7.08 (d, *J* = 8.5 Hz, 2H), 5.46 (d, *J* = 3.6 Hz, 1H), 5.42 (t, *J* = 9.6 Hz, 1H), 4.96 (t, *J* = 9.8 Hz, 1H), 4.43 (dd, *J* = 9.6, 4.6 Hz, 1H), 4.38-4.29 (m, 1H), 4.18-4.08 (m, 3H), 3.96-3.79 (m, 3H), 3.19 (dd, 13.9, 4.5 Hz, 1H), 2.89 (dd, *J* = 13.9, 9.8 Hz, 1H), 2.66 (s, 1H), 2.06 (s, 3H), 2.01 (s, 3H), 1.92 (s, 3H); ^{13}C NMR (100 MHz, CD_3OD) δ 173.7, 173.5, 170.8, 170.1, 156.9, 155.5, 143.9, 143.7, 141.1, 141.1, 131.7, 130.1, 127.4, 126.8, 125.0, 124.8, 119.5, 116.6, 97.2, 72.9, 69.7, 68.7, 68.0, 66.6, 61.8, 55.4, 46.9, 36.4, 24.9, 19.4, 19.3, 19.2; HRMS-ESI (*m/z*): $[M+H]^+$ calcd for $C_{36}H_{38}NO_{13}$, 692.2343; found, 692.2338. $[\alpha]^{25}_D$ =

+84 °(*c* = 0.10, MeOH).

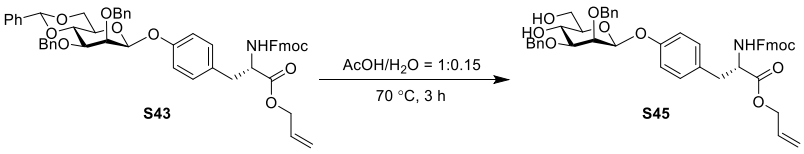
4.3 Preparation of Fmoc-Tyr(β-Man)-OH (S47):



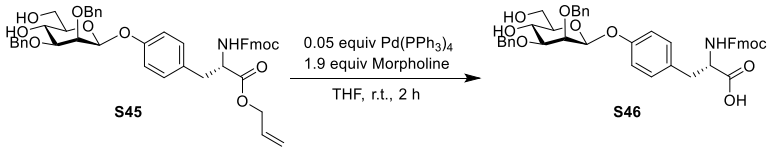
Scheme S3. Synthesis of Fmoc-Tyr(β-Man)-OH (**S47**)



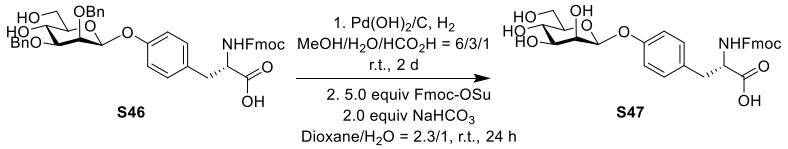
A mixture of the 2,3-di-*O*-benzyl-4,6-*O*-benzylidene-D-mannopyranosyl ortho-hexynylbenzoate **(S42)**[S15] (246 mg, 0.42 mmol, 1.0 equiv), *N*-Fmoc-L-tyrosine Allyl ester **(S9a)** (369 mg, 0.83 mmol, 2.0 equiv), 5 Å MS (850 mg), and Ph_3PAuCl (21 mg, 0.04 mmol, 10 mol%) in PhCl (16 ml) were stirred for 30 min at 0 ℃ under an argon atmosphere. A solution of $AgBAr_4^F$ in Et_2O (150 μL × 0.28 M, 0.04 mmol, 10 mol%) was then added. The reaction was allowed to stir at 0 ℃ for 16 h. Ph_3P (50 mg) was added. The mixture was filtered through Celite and the filtrate was concentrated *in vacuo*. Purification of the crude products (α/β = 1:2.2) using silica gel column chromatography eluting with Toluene/EtOAc (30:1 to 25:1) afforded the pure α-anomer **S44** as a colorless oil (86 mg, 23.6%) and the pure β-anomer **S43** as a white solid (188 mg, 52%).



Compound **S43** (188 mg, 0.22 mmol, 1.0 equiv) was dissolved in acetic acid (2.5 ml), followed by the addition of H_2O (375 μl) dropwise with stirring. The reaction mixture was then heated at 70 ℃ for 3 h. Upon completion, the resulting mixture was concentrated *in vacuo*. Purification of the crude product using silica gel column chromatography eluting with petroleum ether /EtOAc (1:1 to 1:2) afforded product **S45** as a white solid (144 mg, 90%).



Compounds **S45** (75 mg, 0.10 mmol, 1.0 equiv) and $Pd(PPh_3)_4$ (6 mg, 0.005 mmol, 5 mol%) were dissolved in 2 ml of anhydrous THF under an argon atmosphere, followed by the addition of morpholine (16 μl, 0.18 mmol, 1.8 equiv) at r.t. dropwise. The reaction was allowed to stir at r.t. for 2 h until completed consumption of starting material as indicated by TLC. The solution was then concentrated *in vacuo* and dissolved in EtOAc (10 ml), washed with 1 M aqueous HCl (10 ml ×3), water (10 ml ×1) and brine (10 ml ×1), dried over $MgSO_4$, and evaporated to dryness. Purification of the crude product using silica gel column chromatography eluting with DCM/CH_3OH/AcOH (100:2:1) afforded product **S46** as a white solid (66 mg, 92%).

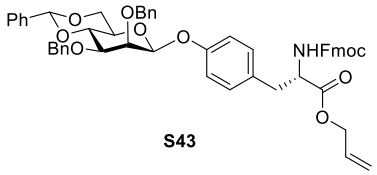


To a solution of compound **S46** (81 mg, 0.11 mmol, 1.0 equiv) in MeOH/H_2O/HCO_2H (4.5 ml/2.25 ml/0.75 ml), $Pd(OH)_2$/C (108 mg, 20% loading) was added to the mixture under an argon atmosphere. The flask was then closed with a septum and purged with H_2 (1 atm) for 15 minutes. The mixture was allowed to stir at r.t. for 2 d under a H_2 atmosphere (1 atm). Upon completion, the resulting mixture was filtered through a

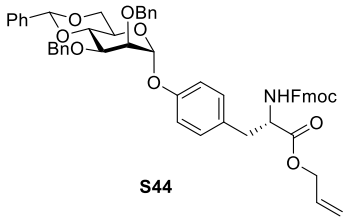
nylon syringe equipped with a 0.45 μm filter, and evaporated to afford a white solid.

The crude residue was co-evaporated with toluene (×3) and dried *in vacuo* for 1 h, then dissolved in dioxane/H_2O (4.6 ml/2 ml), followed by the addition of Fmoc-OSu (184 mg, 0.55 mmol, 5.0 equiv) and $NaHCO_3$ (18 mg, 0.22 mmol, 2.0 eqiuv). The reaction was allowed to stir at r.t. for 24 h and quenched with 1 M aqueous HCl to adjust pH to ~1. The resulting mixture was transferred to a 50 ml extraction funnel, diluted with 15 ml of water and then extracted with EtOAc (15 ml×3). The organic phase was combined, dried over $MgSO_4$, filtered over a sintered funnel and concentrated to dryness. Purification of crude product using silica gel column chromatography eluting with DCM/MeOH/AcOH (80:20:1) afforded product **S47** as a white solid (50 mg, 80%).

***N*-Fmoc-L-tyrosine (2,3-di-*O*-benzyl-4,6-*O*-benzylidene -β-D-mannopyranoside)-OAllyl (S43)** ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.76 (d, *J* = 7.5 Hz, 2H), 7.61-7.49 (m, 6H), 7.44-7.27 (m, 15H), 7.04 (d, *J* = 8.2 Hz, 2H), 6.90 (d, *J* = 8.2 Hz, 2H), 5.90 (ddd, *J* = 22.7, 11.0, 5.3 Hz, 1H), 5.65 (s, 1H), 5.38-5.21 (m, 3H), 5.11-5.95 (m, 3H), 4.78 (d, *J* = 12.5 Hz, 1H), 4.72-4.61 (m, 3H), 4.45 (dd, *J* = 10.6, 7.0 Hz, 1H), 4.37-4.27 (m, 3H), 4.20 (t, *J* = 7.0 Hz, 1H), 4.07 (d, *J* = 2.9 Hz, 1H), 3.96 (t, *J* = 10.3 Hz, 1H), 3.67 (dd, *J* = 9.7, 2.9 Hz, 1H), 3.49-3.38 (m, 1H), 3.10 (ddd, *J* = 36.4, 14.1, 5.7 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 171.2, 155.6, 155.2, 144.0, 143.8, 141.5, 138.7, 138.0, 137.7, 131.5, 130.6, 129.7, 129.0, 128.6, 128.5, 128.3, 128.2, 128.0, 127.9, 127.7, 127.7, 127.2, 126.2, 125.2, 125.1, 120.1, 119.3, 116.5, 101.6, 97.5, 79.1, 76.4, 76.3, 73.9, 73.5, 68.8, 67.0, 66.2, 65.0, 55.0, 47.3, 37.5; $^1J_{C1\text{-}H1}$ = 156.9 Hz; HRMS-ESI (*m/z*): $[M+NH_4]^+$ calcd for $C_{54}H_{55}N_2O_{10}$, 891.3857; found, 891.3856. $[\alpha]^{25}_D$ = -44 °(*c* = 0.10, MeOH).



S43

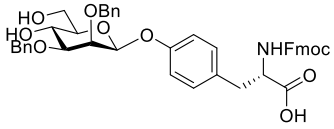
***N*-Fmoc-L-tyrosine (2,3-di-*O*-benzyl-4,6-*O*-benzylidene-α-D-mannopyranoside)-OAllyl (S44)** 

S44

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.79 (d, *J* = 7.5 Hz, 2H), 7.63-7.49 (m, 4H), 7.46-7.28 (m, 17H), 7.03 (d, *J* = 8.2 Hz, 2H), 6.91 (d, *J* = 8.2 Hz, 2H), 5.90 (ddd, *J* = 22.3, 10.8, 5.5Hz, 1H), 5.68 (s, 1H), 5.50 (s, 1H), 5.39-5.24 (m, 3H), 4.92 (t, *J* = 12.2 Hz, 2H), 4.80 (d, *J* = 12.2 Hz, 1H), 4.75 (d, *J* = 12.2 Hz, 1H), 4.72-4.62 (m, 3H), 4.48 (dd, *J* = 10.6, 7.3 Hz, 1H), 4.40 (d, *J* = 8.0 Hz, 1H), 4.35 (d, *J* = 9.4 Hz, 1H), 4.27-4.16 (m, 3H), 4.05-4.01 (m, 1H), 3.98-3.81 (m, 2H), 3.18-3.03 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 171.2, 155.6, 155.2, 144.0, 143.8, 141.5, 138.7, 138.0, 137.7, 131.5, 130.6, 129.7, 129.0, 128.6, 128.5, 128.3, 128.2, 128.0, 127.9, 127.7, 127.7, 127.2, 126.2, 125.2, 125.1, 120.1, 119.3, 116.5, 101.6, 97.5, 79.1, 76.4, 76.3, 73.9, 73.4, 68.8, 67.0, 66.2, 65.0, 55.0, 47.3, 37.5; $^1J_{C1\text{-}H1}$ = 170.8 Hz; HRMS-ESI (*m/z*): $[M+NH_4]^+$ calcd for $C_{54}H_{55}N_2O_{10}$, 891.3857; found, 891.3868. $[\alpha]^{25}_D$ = +28 °(*c* = 0.10, MeOH).

***N*-Fmoc-L-tyrosine (2,3-di-*O*-benzyl-β-D-mannopyranoside)-OAllyl (S45)** ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.77 (d, *J* = 7.5 Hz, 2H), 7.61-7.46 (m, 4H), 7.43-7.27 (m, 12H), 7.04 (d, *J* = 8.3 Hz, 2H), 6.91 (d, *J* = 8.3 Hz, 2H), 5.91 (ddd, *J* = 22.6, 10.8, 5.3 Hz, 1H), 5.39-5.25 (m, 3H), 5.05 (d, *J* = 12.2 Hz, 1H), 4.99 (s, 1H), 4.90 (d, *J* = 12.2 Hz, 1H), 4.73-4.60 (m, 3H), 4.55 (d, *J* = 11.9 Hz, 1H), 4.45 (dd, *J* = 10.5, 7.2 Hz, 1H), 4.38 (d, *J* = 11.9 Hz, 1H), 4.33 (dd, *J* = 10.5, 7.2 Hz, 1H), 4.20 (t, *J* = 7.0 Hz, 1H), 4.08-4.00 (m, 2H), 3.98-3.90 (m, 1H), 3.87-3.78 (m, 1H), 3.46-3.35 (m, 2H), 3.10 (ddd, *J* = 36.3, 14.0, 5.8 Hz, 2H), 2.71 (d, *J* = 2.7 Hz, 1H), 2.35 (t, *J* = 6.6 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 171.3, 156.2, 155.6, 143.9, 141.4, 138.3, 137.6, 131.5, 130.6, 129.9, 128.7, 128.5, 128.4, 128.1, 127.9, 127.8, 127.2, 125.3, 125.2, 120.1, 120.1, 119.3, 116.2, 99.3, 81.4, 76.3, 74.5, 73.6, 71.4, 67.2, 67.0, 66.2, 62.9, 54.9, 47.2, 37.5; HRMS-ESI (*m/z*): $[M+NH_4]^+$ calcd for $C_{47}H_{51}N_2O_{10}$, 803.3544; found, 803.3539. $[\alpha]^{25}_D$ = -120 °(*c* = 0.10, MeOH).

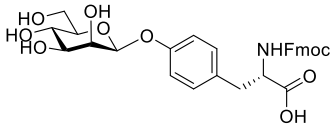
***N*-Fmoc-L-tyrosine (2,3-di-*O*-benzyl-β-D-mannopyranoside)-OH (S46)** ^{1}H NMR



S46

(400 MHz, DMSO-d_6) δ 12.75 (s, 1H), 7.88 (d, J = 7.5 Hz, 2H), 7.73-7.63 (m, 2H), 7.46-7.23 (m, 14H), 7.20 (d, J = 8.3 Hz, 2H), 6.93 (d, J = 8.3 Hz, 2H), 5.22-5.10 (m, 2H), 4.90 (d, J = 12.1 Hz, 1H), 4.77 (d, J = 12.1 Hz, 1H), 4.69-4.57 (m, 3H), 4.26-4.08 (m, 5H), 3.74-3.25 (m, 5H), 3.04 (dd, J = 13.5, 3.8 Hz, 1H), 2.83 (dd, J = 13.5, 10.7 Hz, 1H), 2.54 (s, 1H); ^{13}C NMR (100 MHz, DMSO-d_6) δ 173.4, 155.9, 155.6, 143.8, 143.7, 140.7, 140.7, 139.2, 139.0, 131.2, 130.1, 128.1, 128.0, 127.6, 127.4, 127.2, 127.1, 125.3, 125.2, 120.1, 115.6, 98.2, 81.3, 77.6, 75.7, 74.0, 70.8, 65.9, 65.6, 60.8, 55.7, 46.6, 40.4, 40.4, 35.7, 29.0; HRMS-ESI (*m/z*): $[M+NH_4]^+$ calcd for $C_{44}H_{47}N_2O_{10}$, 763.3231; found, 763.3224. $[\alpha]^{25}_D$ = -48 °(*c* = 0.10, MeOH).

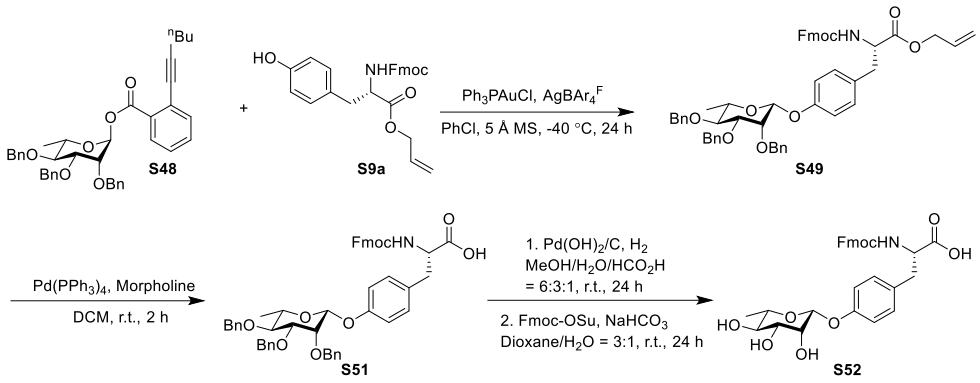
***N*-Fmoc-L-tyrosine (β-D-mannopyranoside)-OH (S47)** ^{1}H NMR (400 MHz,



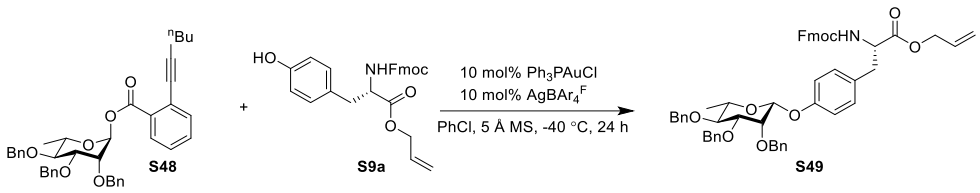
S47

D_2O/CD_3OD/DMF-d^7 = 10/2/5) δ 7.89 (d, J = 7.3 Hz, 2H), 7.71-7.35 (m., 6H), 7.18 (d, J = 7.5 Hz, 2H), 6.96 (d, J = 7.5 Hz, 2H), 5.06 (br, 1H), 4.48-4.01 (m, 6H), 3.94-3.62 (m, 5H), 3.42 (br, 1H), 3.16 (d, J = 12.0 Hz, 1H), 2.95-2.86 (m, 1H); ^{13}C NMR (100 MHz, D_2O/CD_3OD/DMF-d^7 = 10/2/5) δ 156.8, 155.5, 143.8, 143.7, 140.9, 132.1, 130.5, 128.0, 127.4, 127.4, 125.3, 125.1 120.0, 116.1, 98.0, 76.6, 73.2, 70.9, 66.6, 66.3, 60.9, 46.9, 37.2; HRMS-ESI (*m/z*): $[M+NH_4]^+$ calcd for $C_{30}H_{35}N_2O_{10}$, 583.2292; found, 583.2291 . $[\alpha]^{25}_D$ = -44 °(*c* = 0.10, MeOH/H_2O = 1:1)

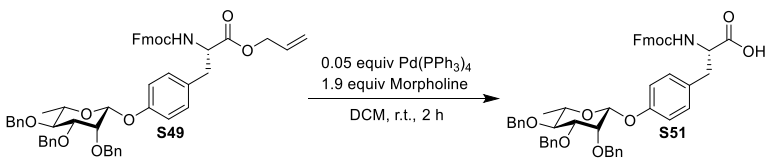
4.4 Preparation of Fmoc-Tyr(β-Rha)-OH (S52):



Scheme S4. Synthesis of Fmoc-Tyr(β-Rha)-OH (**S52**)

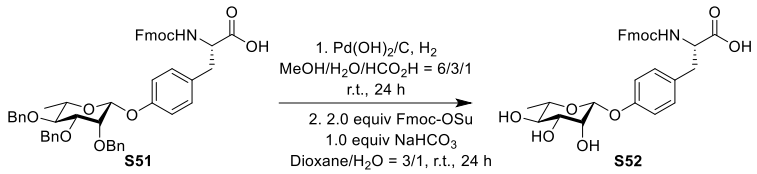


A mixture of the 2,3,4-tri-*O*-benzyl-D-rhamnosyl ortho-hexynylbenzoate **(S48)** [S16] (505 mg, 0.82 mmol, 1.0 equiv), *N*-Fmoc-L-tyrosine Allyl ester **(S9a)** (721 mg, 1.63 mmol, 2.0 equiv), 5 Å MS (1600 mg), and Ph_3PAuCl (40 mg, 0.08 mmol, 10 mol%) in PhCl (32 ml) were stirred for 30 min at -40 ℃ under an argon atmosphere. A solution of $AgBAr_4^F$ in Et_2O (180 μL × 0.45 M, 0.08 mmol, 10 mol%) was then added. The reaction was allowed to stir at -40 ℃ for 24 h. Ph_3P (98 mg) was added. The mixture was filtered through Celite and the filtrate was concentrated *in vacuo*. Purification of the crude products (α/β = 5:1) using silica gel column chromatography eluting with Toluene/EtOAc (50:1 to 30:1) afforded the pure α-anomer **S50** as a colorless oil (343 mg, 49%) and the pure β-anomer **S49** as a yellow oil (69 mg, 10%).



Compounds **S49** (69 mg, 0.08 mmol, 1.0 equiv) and $Pd(PPh_3)_4$ (5 mg, 0.005 mmol, 5 mol%) were dissolved in 2 ml of anhydrous DCM under an argon atmosphere, followed

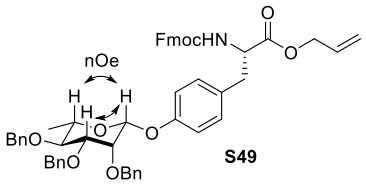
by the addition of morpholine (13 μl, 0.15 mmol, 1.9 equiv) at r.t. dropwise. The reaction was allowed to stir at r.t. for 2 h until completed consumption of starting material as indicated by TLC. The solution was then concentrated *in vacuo* and dissolved in EtOAc (10 ml), washed with 1 M aqueous HCl (10 ml ×3), water (10 ml ×1) and brine (10 ml ×1), dried over $MgSO_4$, and evaporated to dryness. Purification of the crude product using silica gel column chromatography eluting with petroleum ether/EtOAc /AcOH (66:33:1) afforded product **S51** as a white solid (58 mg, 89%).



To a solution of compound **S51** (58 mg, 0.07 mmol, 1.0 equiv) in $MeOH/H_2O/HCO_2H$ (4.5 ml/2.25 ml/0.75 ml), $Pd(OH)_2/C$ (77 mg, 20% loading) was added to the mixture under an argon atmosphere. The flask was then closed with a septum and purged with H_2 (1 atm) for 15 minutes. The mixture was allowed to stir at r.t. for 24 h under a H_2 atmosphere (1 atm). Upon completion, the resulting mixture was filtered through a nylon syringe equipped with a 0.45 μm filter, and evaporated to afford a white solid.

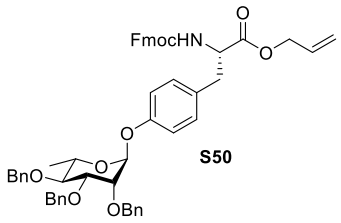
The crude residue was co-evaporated with toluene (×3) and dried *in vacuo* for 1 h, then dissolved in dioxane/H_2O (3 ml/1 ml), followed by the addition of Fmoc-OSu (48 mg, 0.14 mmol, 2.0 equiv) and $NaHCO_3$ (6 mg, 0.07 mmol, 1.0 eqiuv). The reaction was allowed to stir at r.t. for 24 h and quenched with 1 M aqueous HCl to adjust pH to ~1. The resulting mixture was transferred to a 50 ml extraction funnel, diluted with 15 ml of water and then extracted with EtOAc (15 ml ×3). The organic phase was combined, dried over $MgSO_4$, filtered over a sintered funnel and concentrated to dryness. Purification of crude product using silica gel column chromatography eluting with DCM/MeOH/AcOH (90:10:1) afforded product **S52** as a white solid (29 mg, 74%).

***N*-Fmoc-L-tyrosine (2,3,4,-tri-*O*-benzyl -β-D-rhamnoside)-OAllyl (S49)** ^{1}H NMR



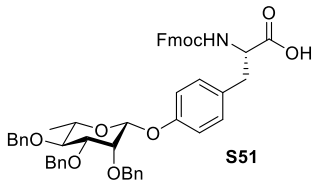
(400 MHz, $CDCl_3$) δ 7.78 (d, *J* = 7.5 Hz, 2H), 7.62-7.52 (m, 4H), 7.45-7.28 (m, 17H), 7.05 (d, *J* = 8.2 Hz, 2H), 6.90 (d, *J* = 8.2 Hz, 2H), 5.90 (ddd, *J* = 22.9, 10.8, 4.3 Hz, 1H), 5.40-5.24 (m, 3H), 5.11-4.97 (m, 3H), 4.89 (s, 1H), 4.73-4.67 (m, 2H), 4.64 (d, *J* = 5.8 Hz, 2H), 4.55 (q, *J* = 11.7 Hz, 2H), 4.47 (dd, *J* = 10.6, 7.0 Hz, 1H), 4.34 (dd, *J* = 10.6, 7.0 Hz, 1H), 4.20 (t, *J* = 7.0 Hz, 1H), 4.04 (d, *J* = 2.1 Hz, 3H), 3.72 (t, *J* = 9.2 Hz, 1H), 3.52 (dd, *J* = 9.2, 2.1 Hz, 3H), 3.49-3.40 (m, 1H), 3.10 (ddd, *J* = 30.2, 13.9, 5.8 Hz, 2H), 1.44 (d, *J* = 6.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 171.3, 156.6, 155.6, 143.9, 141.4, 138.7, 138.6, 138.2, 131.5, 130.5, 129.5, 128.6, 128.5, 128.5, 128.3, 128.2, 127.8, 127.8, 127.7, 127.7, 127.2, 125.3, 125.2, 120.1, 119.3, 116.4, 99.2, 82.1, 80.0, 75.6, 74.4, 74.4, 72.1, 71.8, 67.1, 66.2, 55.0, 47.3, 37.7, 18.2; HRMS-ESI (*m/z*): $[M+NH_4]^+$ calcd for $C_{54}H_{57}N_2O_9$, 877.4064; found, 877.4069. $[\alpha]^{25}_D$ = +12 °(*c* = 0.10, MeOH)

***N*-Fmoc-L-tyrosine (2,3,4,-tri-*O*-benzyl -α-D-rhamnoside)-OAllyl (S50)** ^{1}H NMR



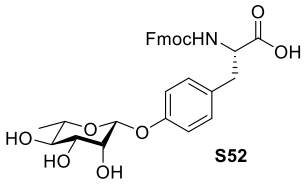
(400 MHz, $CDCl_3$) δ 7.80 (d, *J* = 7.5 Hz, 2H), 7.60 (m, 2H), 7.46-7.28 (m, 19H), 7.02 (d, *J* = 8.4 Hz, 2H), 6.93 (d, 8.4 Hz, 2H), 5.90 (ddd, *J* = 22.9, 10.8, 5.5Hz, 1H), 5.47 (s, 1H), 5.38-5.24 (m, 3H), 5.00 (d, *J* = 10.8 Hz, 1H), 4.88 -4.62 (m, 7H), 4.50 (dd, *J* = 10.6, 7.0 Hz, 1H), 4.39 (dd, *J* = 10.6, 6.7 Hz, 1H), 4.24 (t, *J* = 6.9 Hz, 1H), 4.09 (dd, *J* = 9.2, 3.0 Hz, 1H), 3.97 (t, *J* = 2.4 Hz, 1H), 3.87-3.69 (m, 2H), 3.16-3.03 (m 2H), 1.34 (d, *J* = 6.1 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 171.3, 155.6, 143.9, 143.8, 141.4, 138.6, 138.6, 138.2, 131.5, 130.5, 129.3, 128.5, 128.5, 128.1, 128.0, 127.9, 127.8, 127.8, 127.7, 127.2, 125.2, 125.1, 120.1, 120.1, 119.3, 116.5, 96.4, 80.5, 80.0, 75.5, 74.9, 73.1, 72.5, 68.9, 67.0, 66.2, 55.0, 47.3, 37.5, 18.2; HRMS-ESI (*m/z*): $[M+NH_4]^+$ calcd for $C_{54}H_{57}N_2O_9$, 877.4064; found, 877.4072. $[\alpha]^{25}_D$ = -36 °(*c* = 0.10, MeOH)

***N*-Fmoc-L-tyrosine (2,3,4,-tri-*O*-benzyl -β-D-rhamnoside)-OH (S51)** ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.75 (d, *J* = 7.5 Hz, 2H), 7.59-7.49 (m, 4H), 7.44-7.27 (m, 17H), 7.07 (d, *J* = 8.2 Hz, 2H), 6.89 (d, *J* = 8.2 Hz, 2H), 5.26 (d, *J* = 8.2 Hz, 1H), 5.08-4.94 (m, 3H), 4.86 (s, 1H), 4.73-4.63 (m, 2H), 4.53 (q, *J* = 11.9 Hz, 2H), 4.45 (dd, *J* = 10.2, 7.2 Hz, 1H), 4.33 (dd, *J* = 10.2, 7.0 Hz, 1H), 4.17 (t, *J* = 7.0 Hz, 1H), 4.01 (d, *J* = 2.5 Hz, 1H), 3.70 (t, *J* = 9.3 Hz, 1H), 3.50 (dd, *J* = 9.3, 2.5 Hz, 1H), 3.47-3.38 (m, 1H), 3.10 (ddd, *J* = 49.3, 13.9, 5.5 Hz, 2H), 1.41 (d, *J* = 5.9 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 175.4, 156.5, 155.9, 143.8, 141.4, 138.6, 138.5, 138.2, 130.5, 129.5, 128.6, 128.5, 128.5, 128.3, 128.2, 127.9, 127.8, 127.7, 127.7, 127.2, 125.3, 125.2, 120.1, 116.5, 99.1, 80.1, 80.0, 77.4, 75.6, 74.5, 74.4, 72.1, 71.8, 67.2, 54.7, 47.3, 37.2, 18.2; HRMS-ESI (*m/z*): $[M+NH_4]^+$ calcd for $C_{51}H_{53}N_2O_9$, 837.3751; found, 837.3749. $[\alpha]^{25}_D$ = +28 °(*c* = 0.10, MeOH)



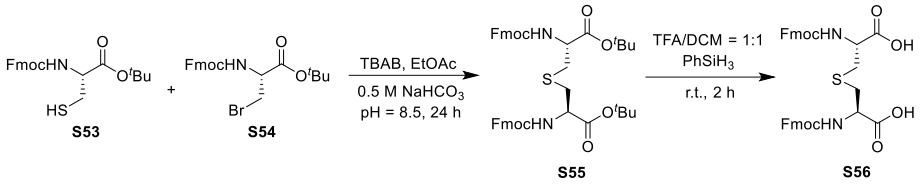
S51

***N*-Fmoc-L-tyrosine (β-D-rhamnoside)-OH (S52)** ^{1}H NMR (400 MHz, CD_3OD) δ 7.78 (d, *J* = 7.5 Hz, 2H), 7.64-7.54 (dd, *J* = 16.8, 7.5 Hz, 2H), 7.42-7.24 (m, 4H), 7.16 (d, *J* = 8.5 Hz, 2H), 6.88 (d, *J* = 8.5 Hz, 2H), 4.81 (s, 1H), 4.44 (dd, *J* = 9.6, 4.5 Hz, 1H), 4.35 (dd, *J* = 10.5, 6.6 Hz, 1H), 4.08 (dd, *J* = 10.5, 7.5 Hz, 1H), 4.00 (t, *J* = 6.9 Hz, 1H), 3.86 (d, *J* = 2.1 Hz, 1H), 3.42-3.33 (m, 2H), 3.29-3.14 (m, 2H), 2.87 (dd, *J* = 14.0, 9.7 Hz, 1H), 2.31 (s, 1H), 1.29 (d, *J* = 6.1 Hz, 3H); ^{13}C NMR (100 MHz, CD_3OD) δ 157.5, 145.5, 145.0, 142.5, 132.5, 131.4, 128.8, 128.2, 126.6, 126.2, 120.9, 117.2, 99.3, 74.8, 73.6, 72.5, 68.0, 38.3, 30.7, 18.0; HRMS-ESI (*m/z*): $[M+NH_4]^+$ calcd for $C_{30}H_{35}N_2O_9$, 567.2343; found, 567.2347. $[\alpha]^{25}_D$ = +24 °(*c* = 0.10, MeOH)

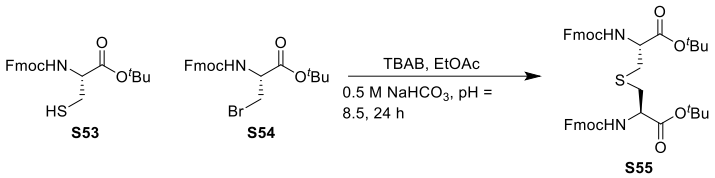


S52

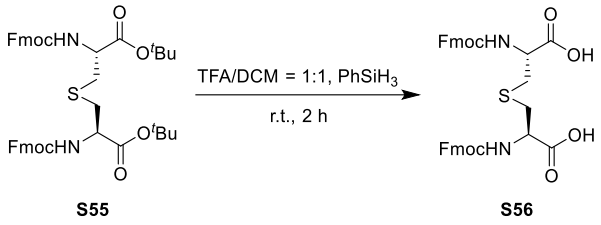
4.5 Preparation of lanthionine-derived building block:



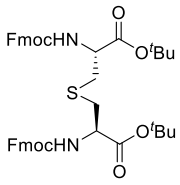
Scheme S5. Synthesis of lanthionine building block **S56**



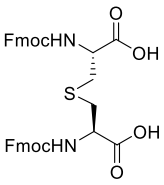
Tetrabutylammonium bromide (355 mg, 1.10 mmol, 4.0 equiv) was added to 3 ml of 0.5 M $NaHCO_3$ (pH was adjusted to 8.5 with 10% Na_2CO_3) and stirred for 5 min. This solution was transferred to the solution of compound **S53**[S17] (110 mg, 0.27 mmol, 1.0 equiv) and **S54**[S18] (123 mg, 0.27 mmol, 1 equiv) in EtOAc (3 ml). The resulting biphasic mixture was stirred vigorously at 25 ℃ for 24 h. The organic layer was separated and washed with water (10 ml×1) and brine (10 ml×1), dried over $MgSO_4$, filtered over a sintered funnel and concentrated *in vacuo*. Purification of crude product using silica gel column chromatography eluting with petroleum ether/EtOAc (5:1) afforded the product **S55** as a colorless solid (154 mg, 73%).



To a solution of **S55** (153.7 mg, 0.2 mmol, 1.0 equiv) in DCM (4 ml), TFA (4 ml) was added dropwise, followed by the addition of $PhSiH_3$ (25 μl, 0.2 mmol, 1.0 equiv). The reaction was allowed to stir for 2 h at r.t.. TFA was then removed under a nitrogen atmosphere. Purification of crude product using silica gel column chromatography eluting with petroleum ether/EtOAc/AcOH (66:33:1) afforded the product **S56** as a white solid (128 mg, 98%).

Di-*tert*-butyl 3,3'-thio(2*R*,2'*R*)-bis(2-((((9H-fluoren-9-yl)methoxy) carbonyl) amino) propanoate) (S55) 
S55

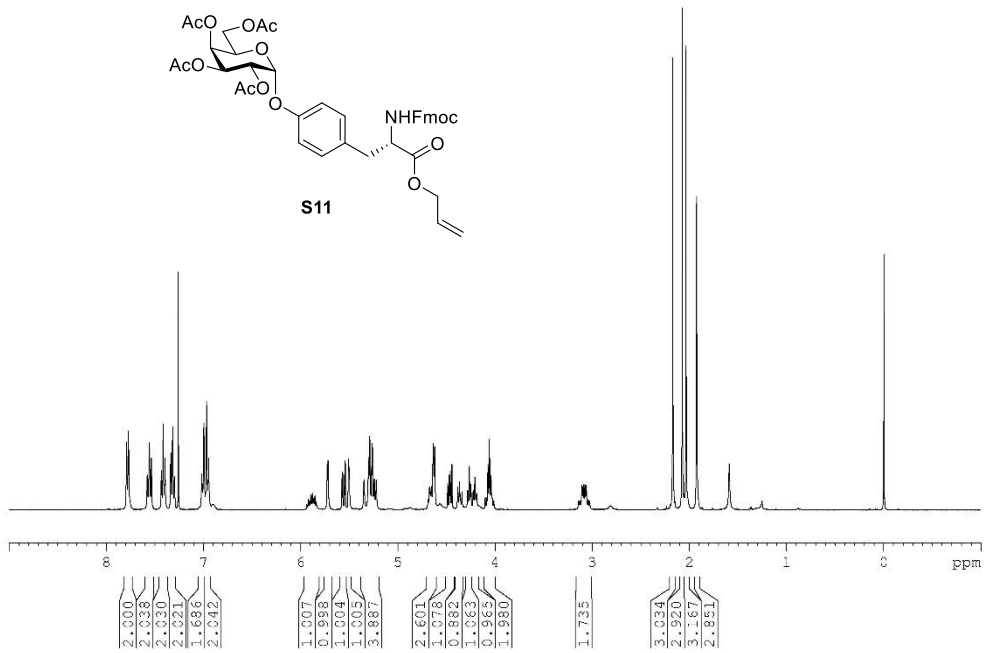
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.75 (d, *J* = 7.4 Hz, 4H), 7.59 (d, *J* = 7.4 Hz, 4H), 7.38 (d, 7.4 Hz, 4H), 7.29 (t, *J* = 7.4 Hz, 4H), 5.71 (d, *J* = 7.3 Hz, 2H), 4.55-4.45 (m, 2H), 4.38 (d, *J* = 7.0Hz, 4H), 4.21 (t, *J* = 7.0 Hz, 2H), 3.03 (d, *J* = 3.5 Hz, 4H), 1.48 (s, 18H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 169.6, 155.9, 144.0, 143.9, 141.4, 127.8, 127.2, 125.3, 120.1, 83.2, 67.3, 54.5, 47.2, 35.9, 28.1; HRMS-ESI (*m/z*): $[M+H]^+$ calcd for $C_{44}H_{49}N_2O_8S$, 765.3210; found, 765.3206. $[\alpha]^{25}_D$ = -20 °(*c* = 0.10, MeOH).

(2*R*,2'*R*)-3,3'-thiobis(2-((((9H-fluoren-9-yl)methoxy)carbonyl)amino) propanoic acid) (S56) 
S56

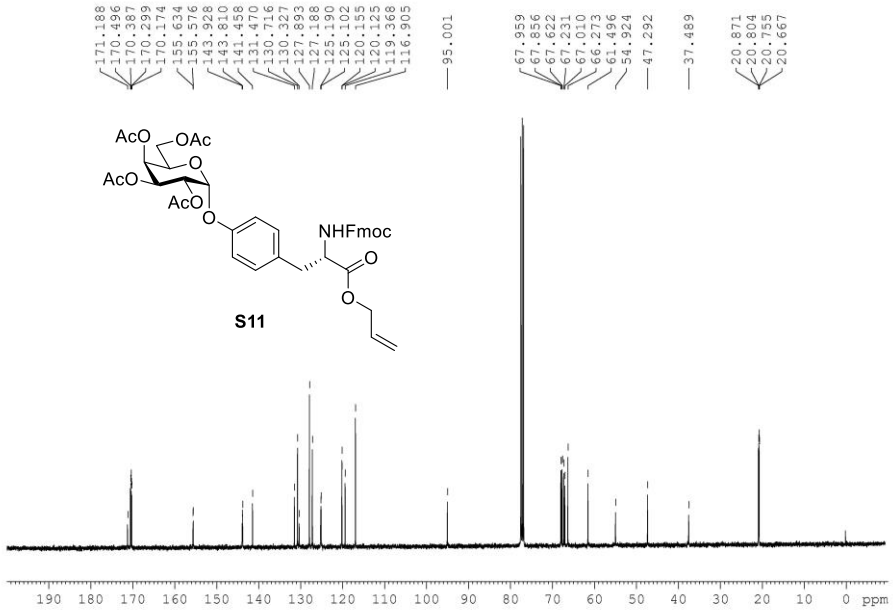
^{1}H NMR (400 MHz, DMSO-d_6) δ 7.88 (d, *J* = 7.5 Hz, 4H), 7.74-7.69 (m, 4H), 7.41 (t, *J* = 7.5 Hz, 4H), 7.32 (t, *J* = 7.5 Hz, 4H), 4.33-4.11 (m, 8H), 2.98 (dd, *J* = 13.6, 4.4 Hz, 2H), 2.79 (dd, *J* = 13.6, 9.9 Hz, 2H); ^{13}C NMR (100 MHz, DMSO-d_6) δ 172.2, 156.0, 143.8, 140.7, 127.6, 127.1, 125.3, 125.3, 120.1, 65.8, 53.8, 46.6, 32.8; HRMS-ESI (*m/z*): $[M+H]^+$ calcd for $C_{36}H_{33}N_2O_8S$, 653.1958; found, 653.1948. $[\alpha]^{25}_D$ = -24 °(*c* = 0.10, MeOH).

V. NMR SPECTRA OF UNNATURAL AMINO ACIDS AND DERIVATIVES

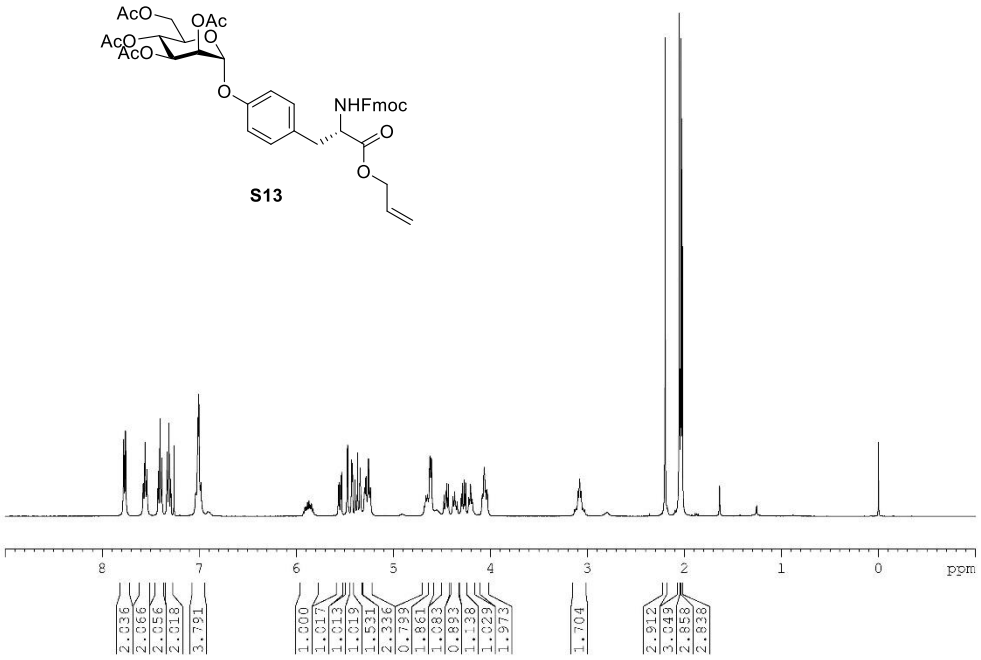
Compound S11 - ^{1}H NMR Spectrum - $CDCl_3$, 400 MHz



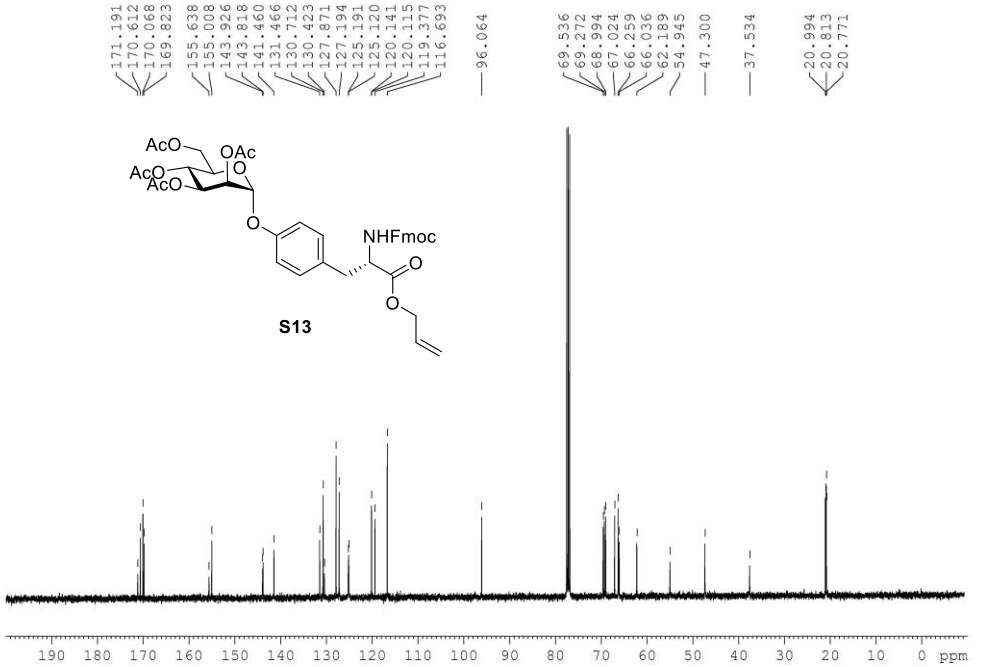
Compound S11 – ^{13}C NMR Spectrum - $CDCl_3$, 100 MHz



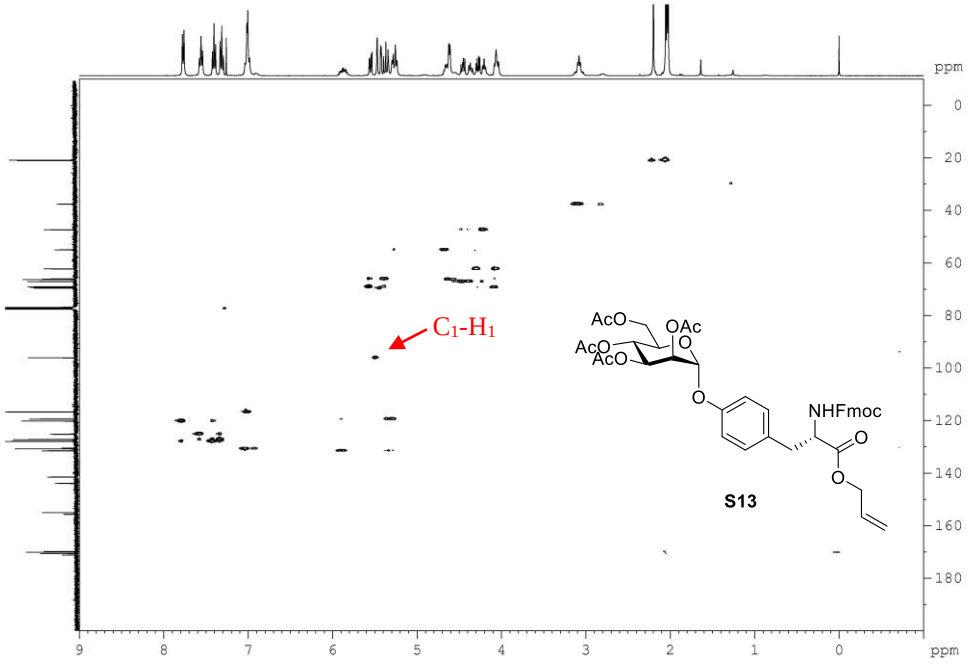
Compound S13 - ^{1}H NMR Spectrum - $CDCl_3$, 400 MHz



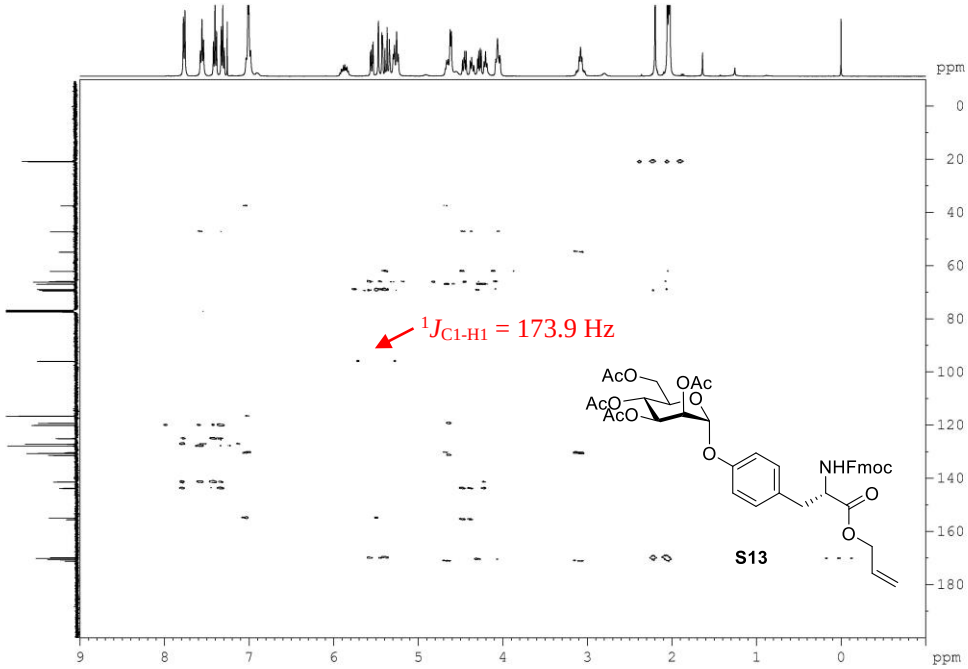
Compound S13 – ^{13}C NMR Spectrum - $CDCl_3$, 100 MHz



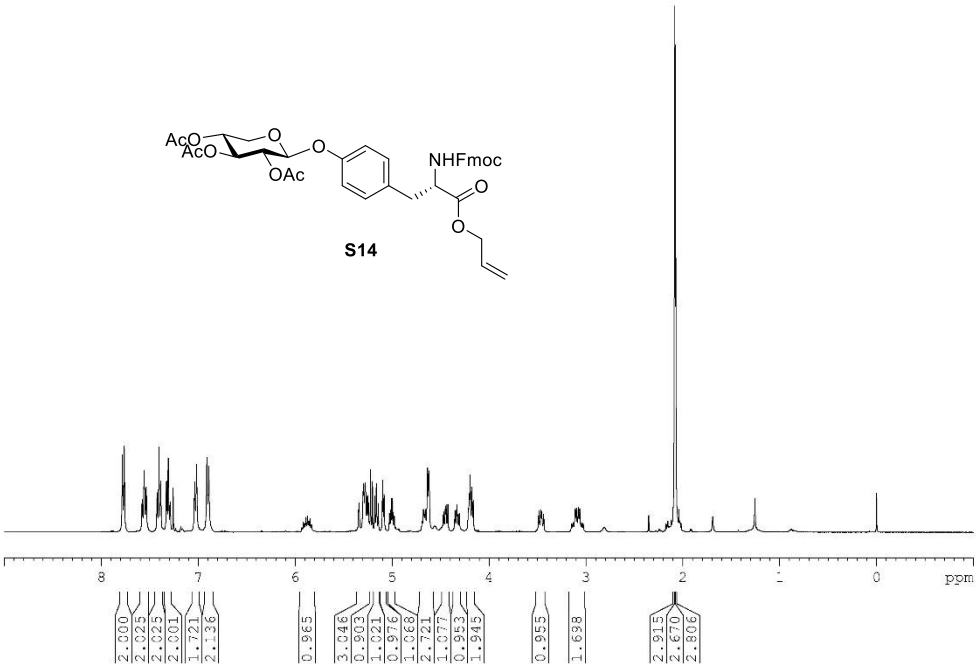
Compound S13 - HSQC NMR Spectrum - $CDCl_3$, 400 MHz



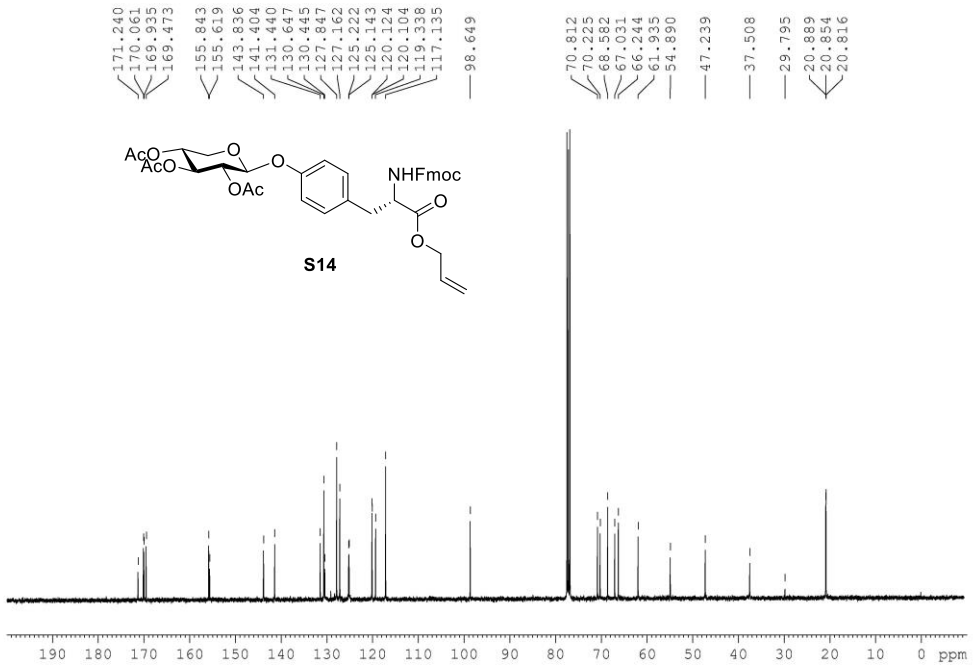
Compound S13 - HMBC NMR Spectrum - $CDCl_3$, 400 MHz



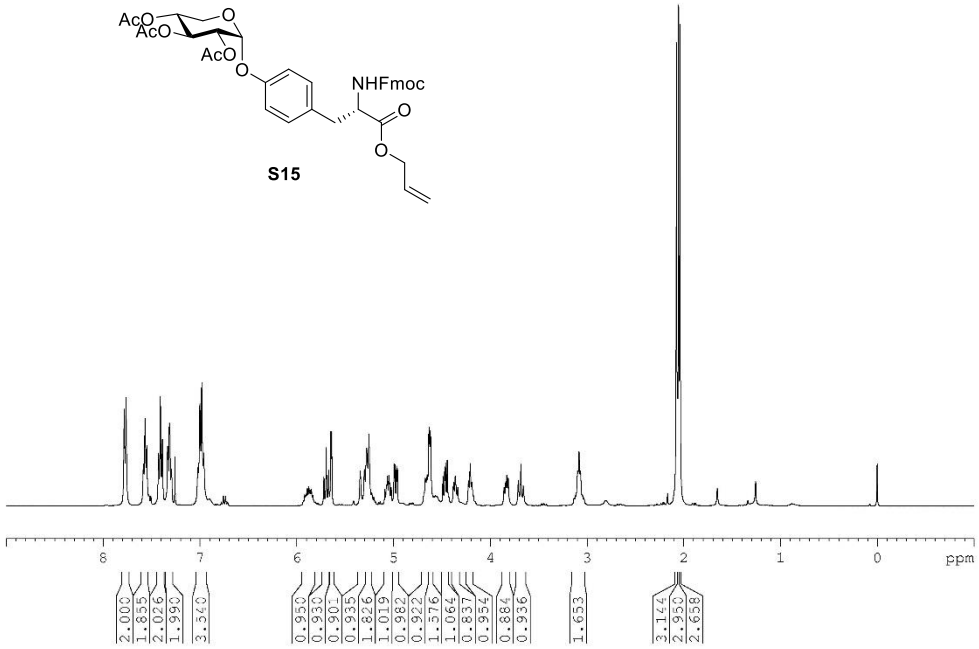
Compound S14 - ^{1}H NMR Spectrum - $CDCl_3$, 400 MHz



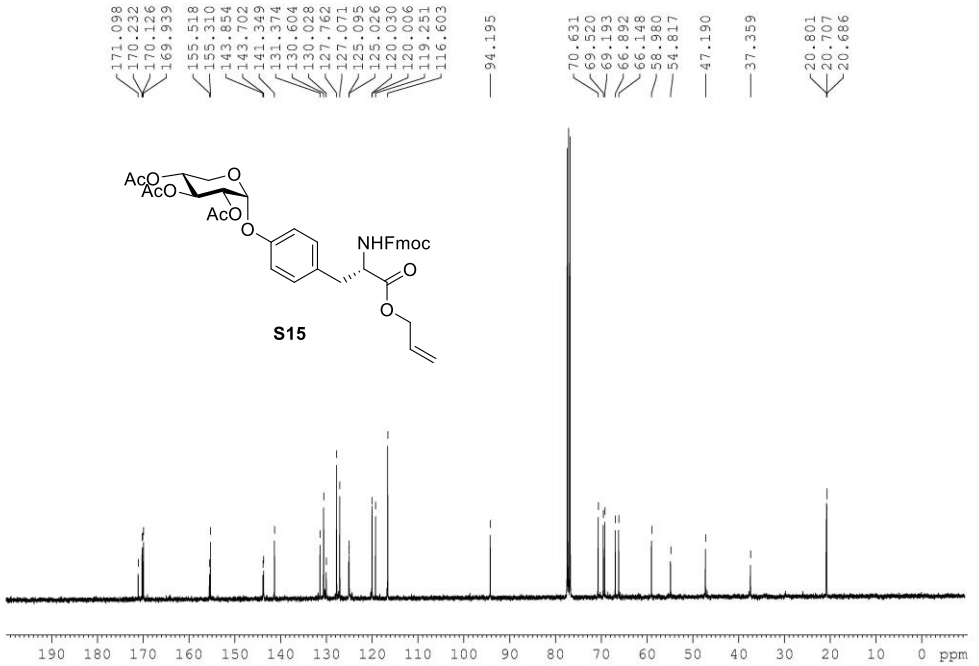
Compound S14 – ^{13}C NMR Spectrum - $CDCl_3$, 100 MHz



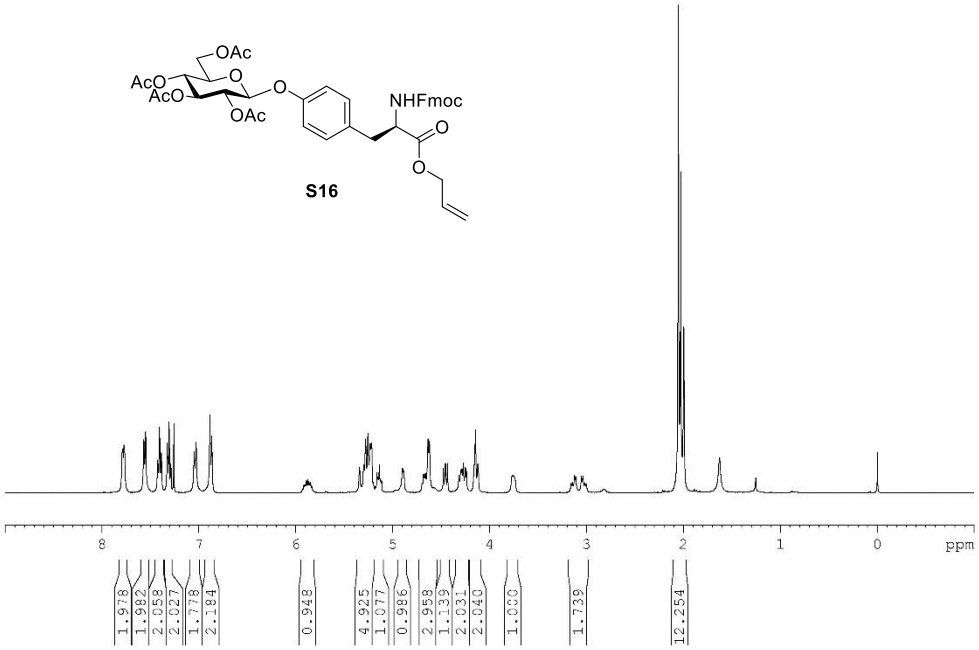
Compound S15 - ^{1}H NMR Spectrum - $CDCl_3$, 400 MHz



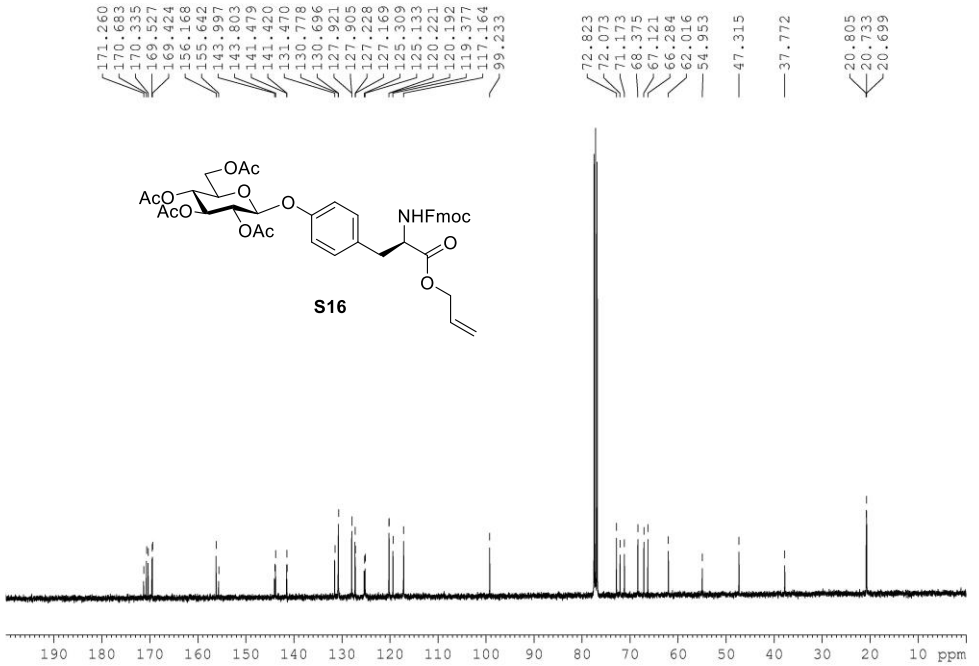
Compound S15 – ^{13}C NMR Spectrum - $CDCl_3$, 100 MHz



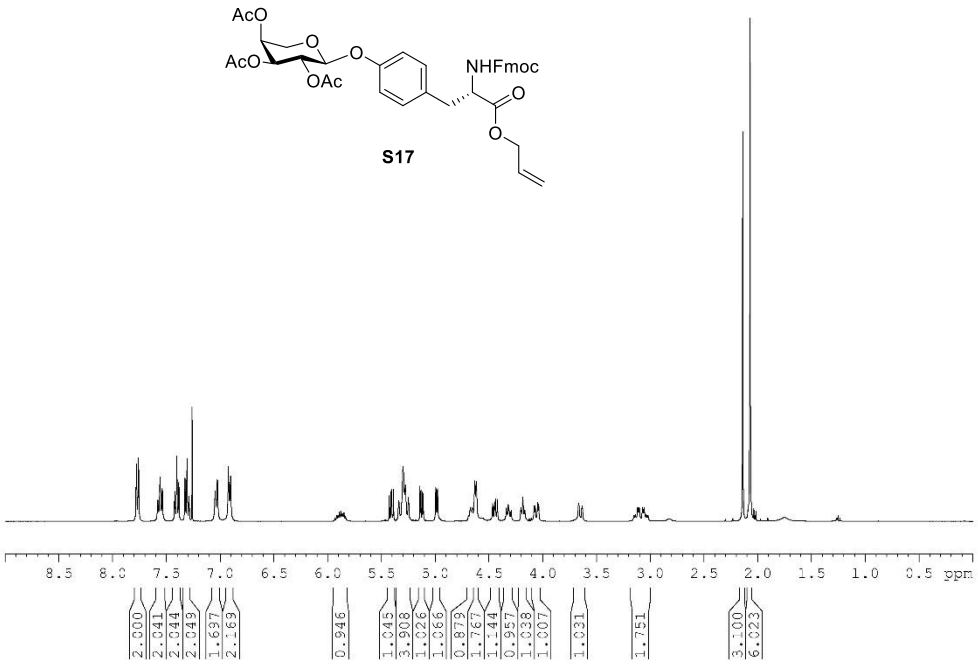
Compound S16 - ^{1}H NMR Spectrum – $CDCl_3$, 400 MHz



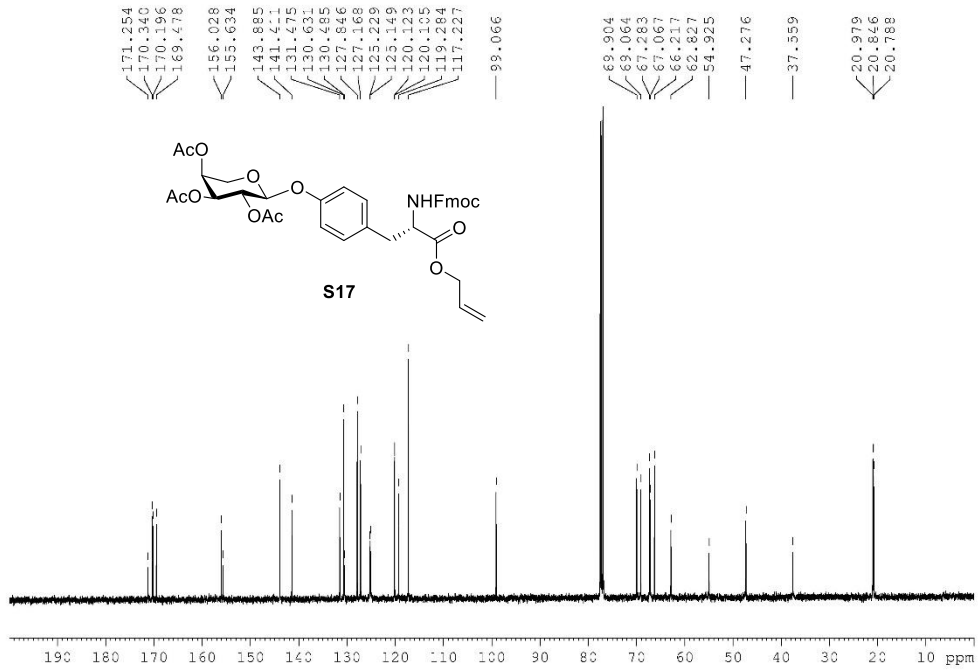
Compound S16 – ^{13}C NMR Spectrum - $CDCl_3$, 100 MHz



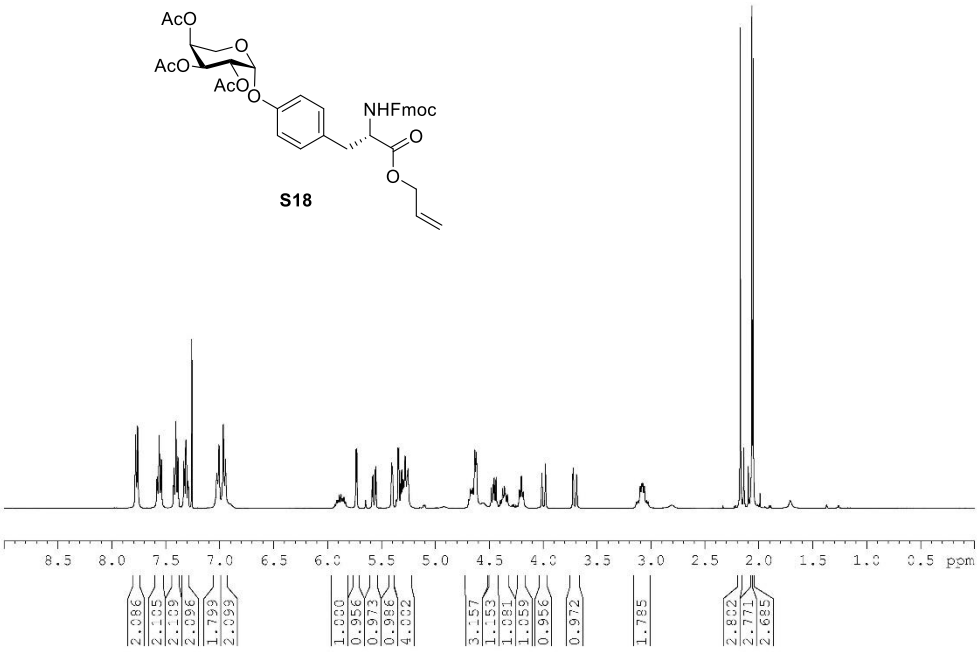
Compound S17 - ^{1}H NMR Spectrum – $CDCl_3$, 400 MHz



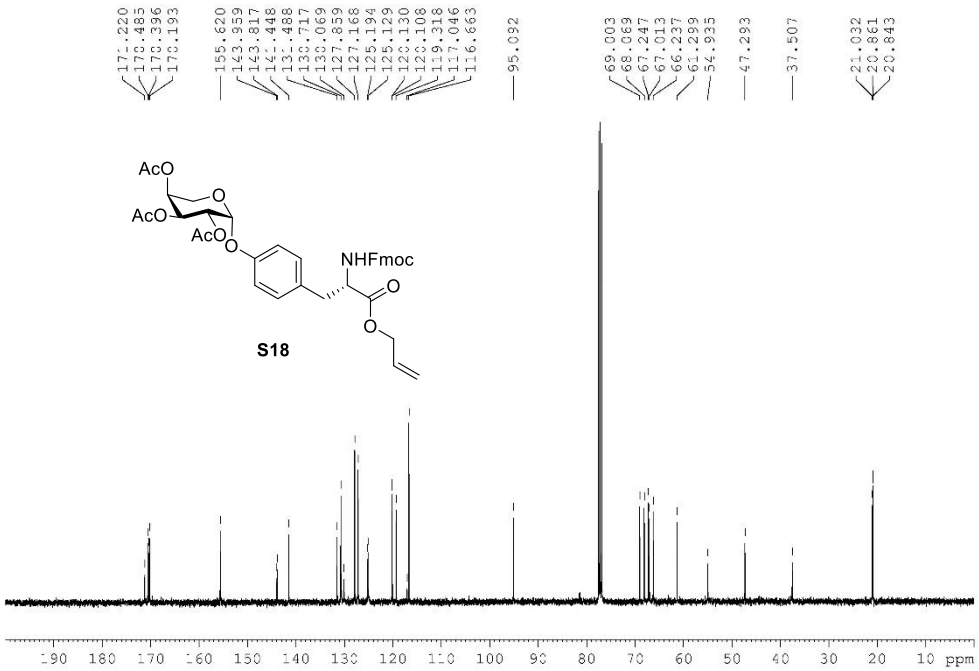
Compound S17 – ^{13}C NMR Spectrum - $CDCl_3$, 100 MHz



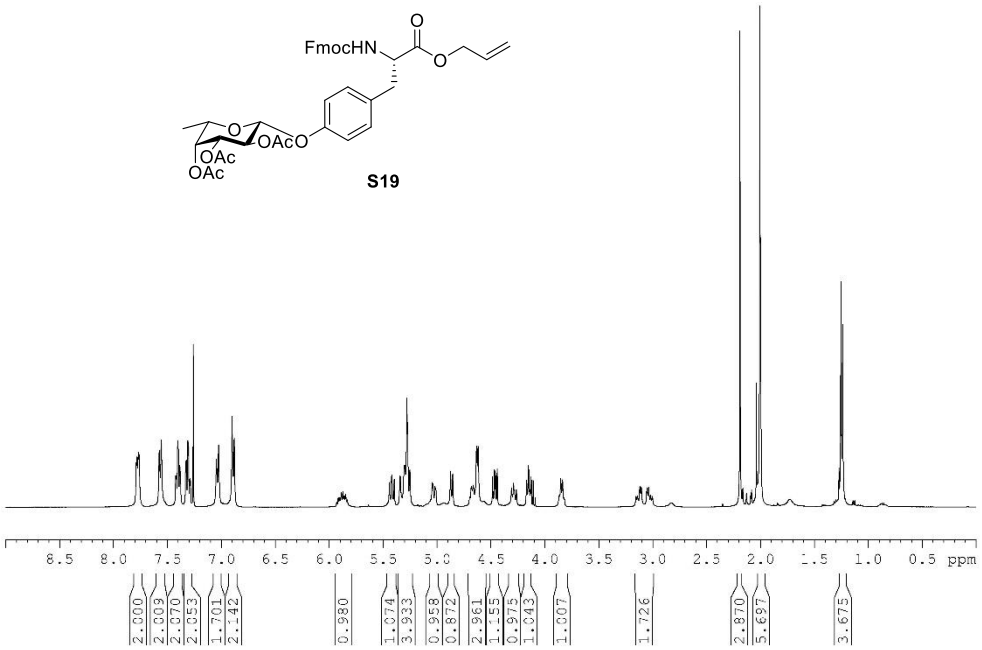
Compound S18 - ^{1}H NMR Spectrum – $CDCl_3$, 400 MHz



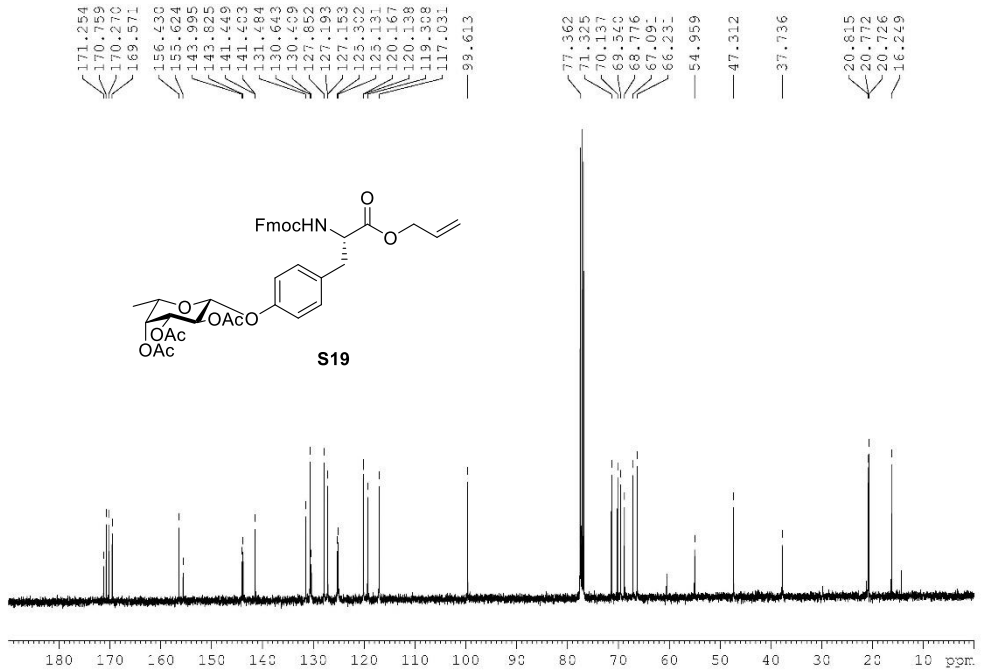
Compound S18 – ^{13}C NMR Spectrum - $CDCl_3$, 100 MHz



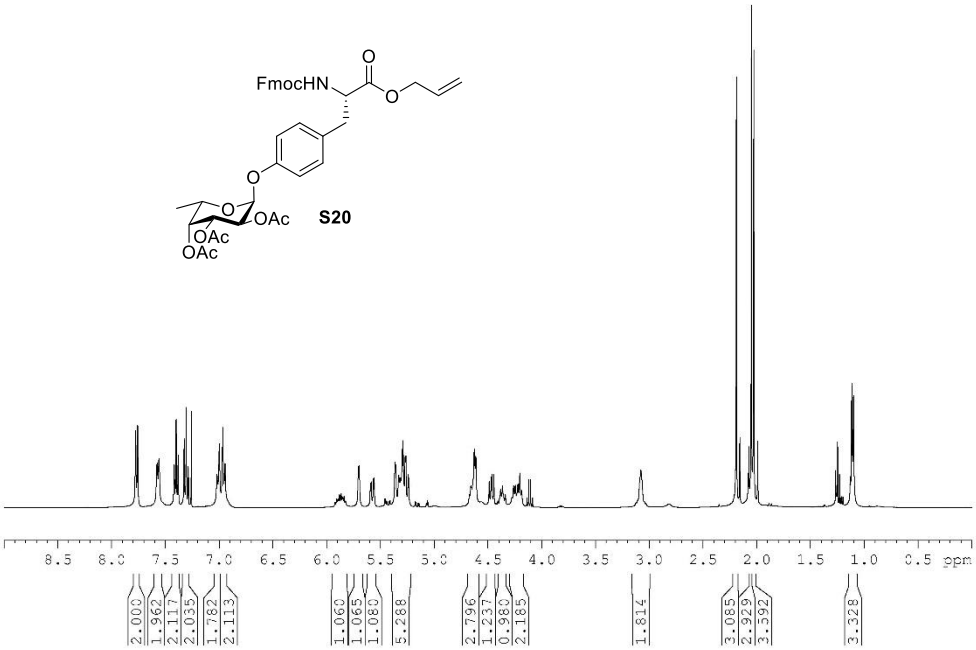
Compound S19 - ^{1}H NMR Spectrum – $CDCl_3$, 400 MHz



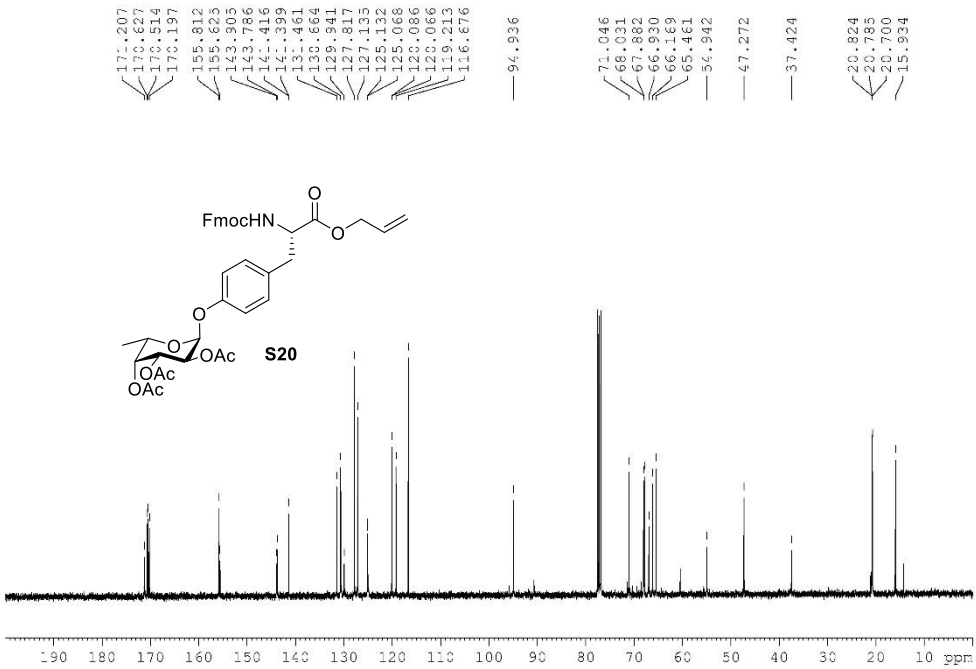
Compound S19 – ^{13}C NMR Spectrum - $CDCl_3$, 100 MHz



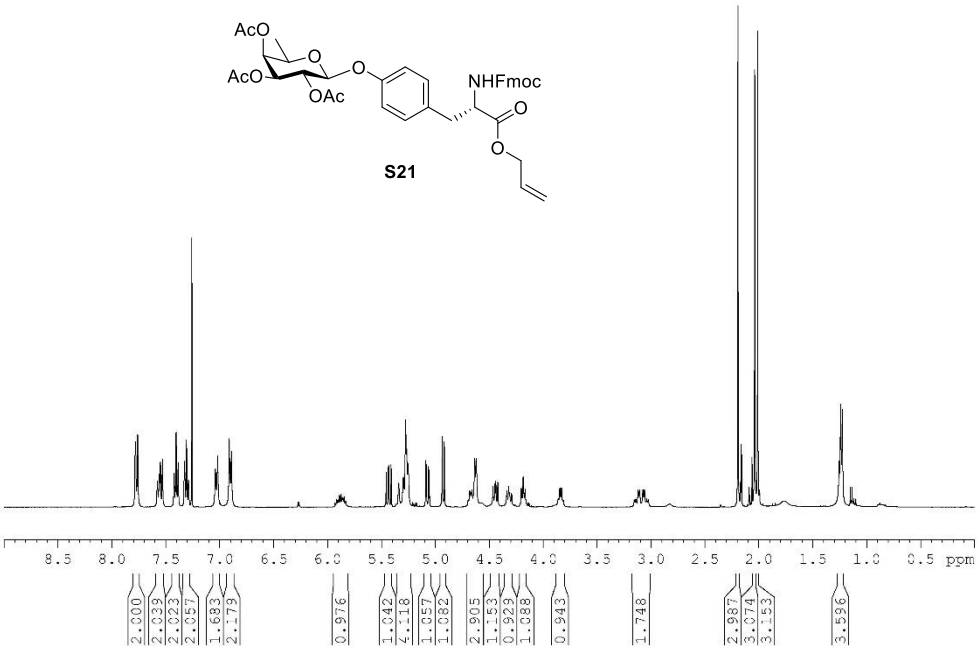
Compound S20 - ^{1}H NMR Spectrum – $CDCl_3$, 400 MHz



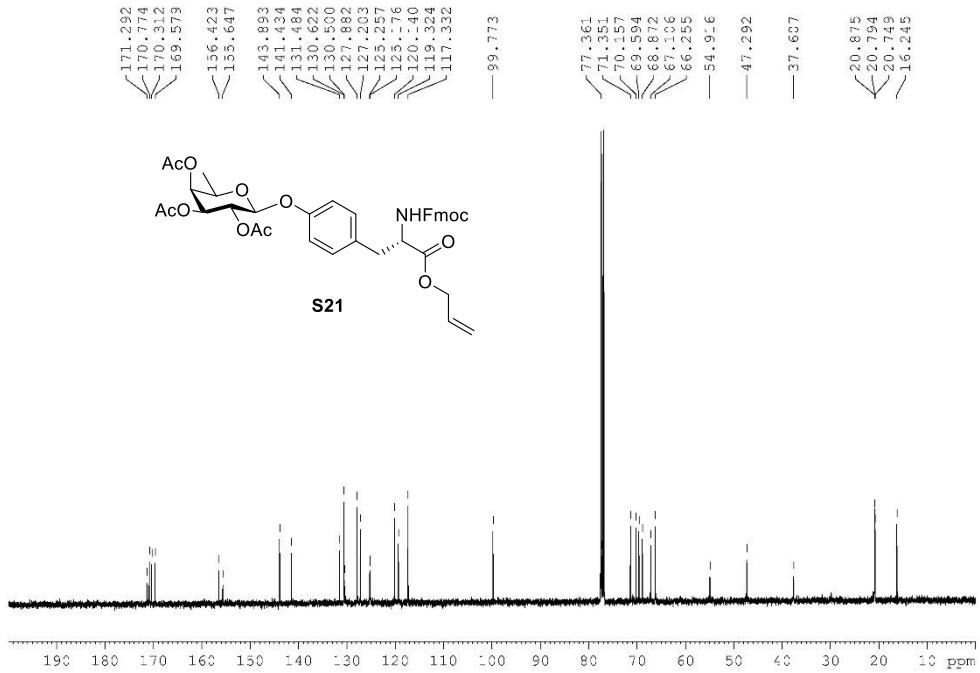
Compound S20 – ^{13}C NMR Spectrum - $CDCl_3$, 100 MHz



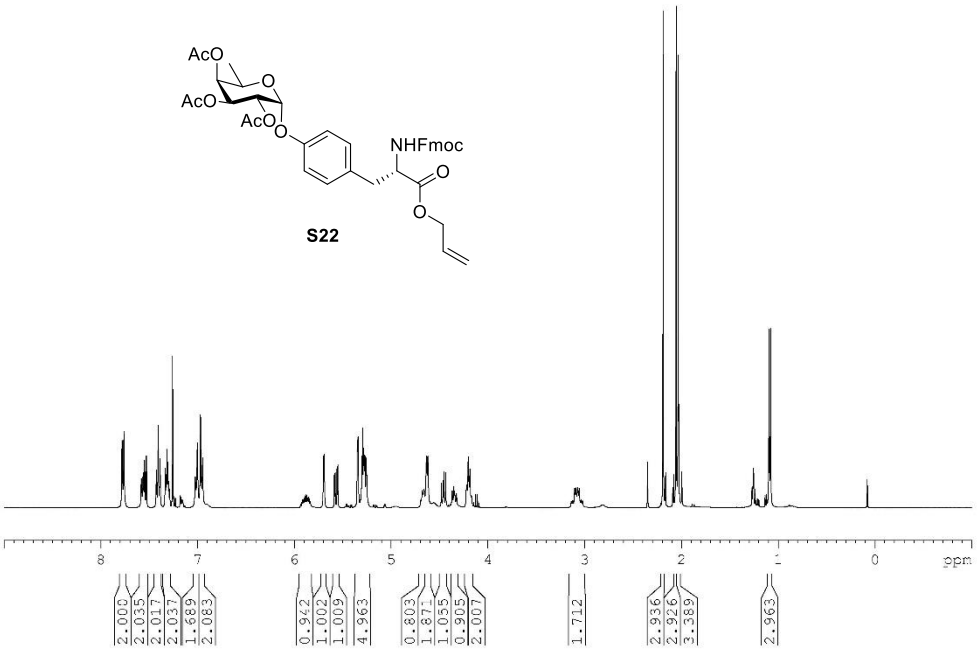
Compound S21 - ^{1}H NMR Spectrum – $CDCl_3$, 400 MHz



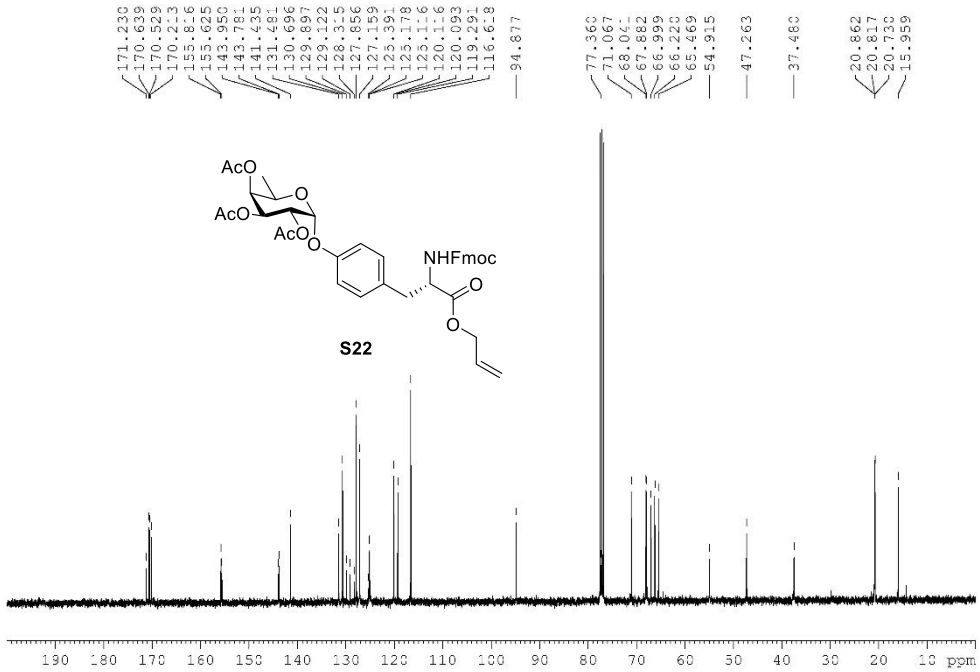
Compound S21 – ^{13}C NMR Spectrum - $CDCl_3$, 100 MHz



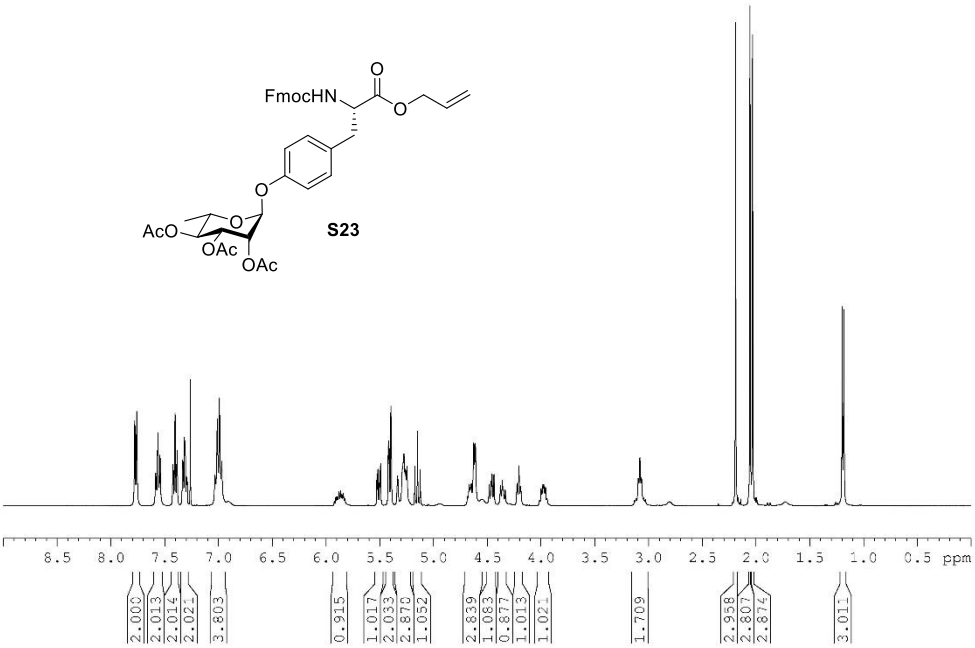
Compound S22 - ^{1}H NMR Spectrum – $CDCl_3$, 400 MHz



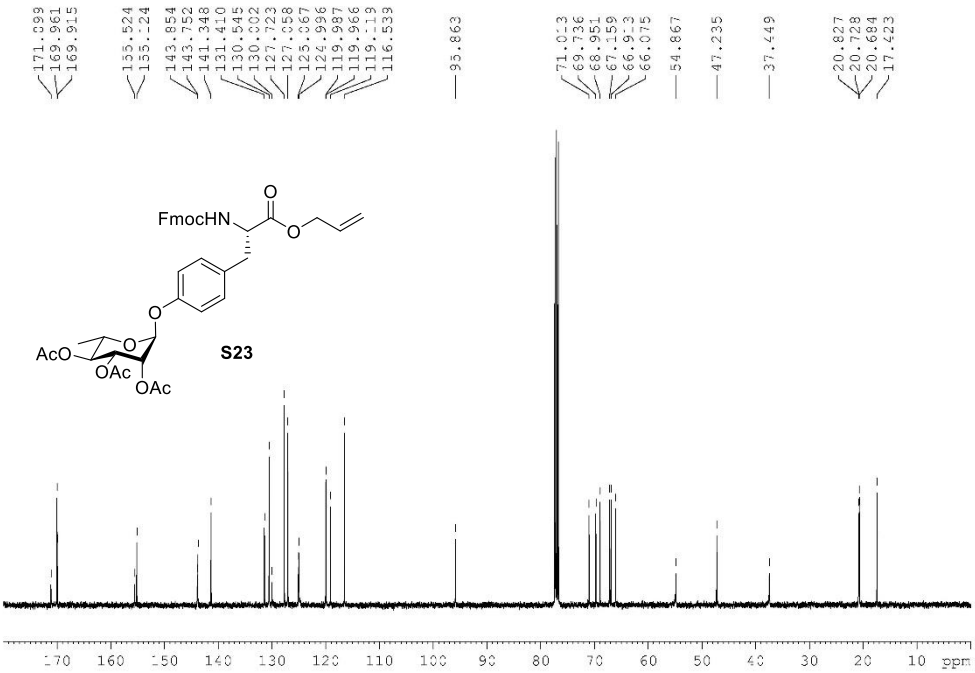
Compound S22 – ^{13}C NMR Spectrum - $CDCl_3$, 100 MHz



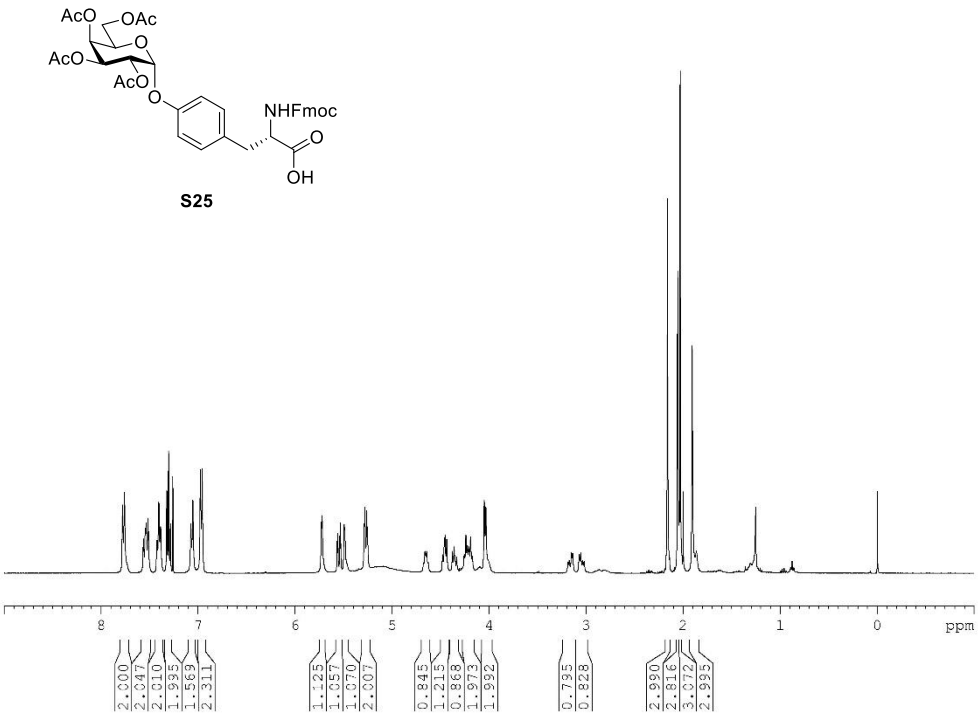
Compound S23 - ^{1}H NMR Spectrum – $CDCl_3$, 400 MHz



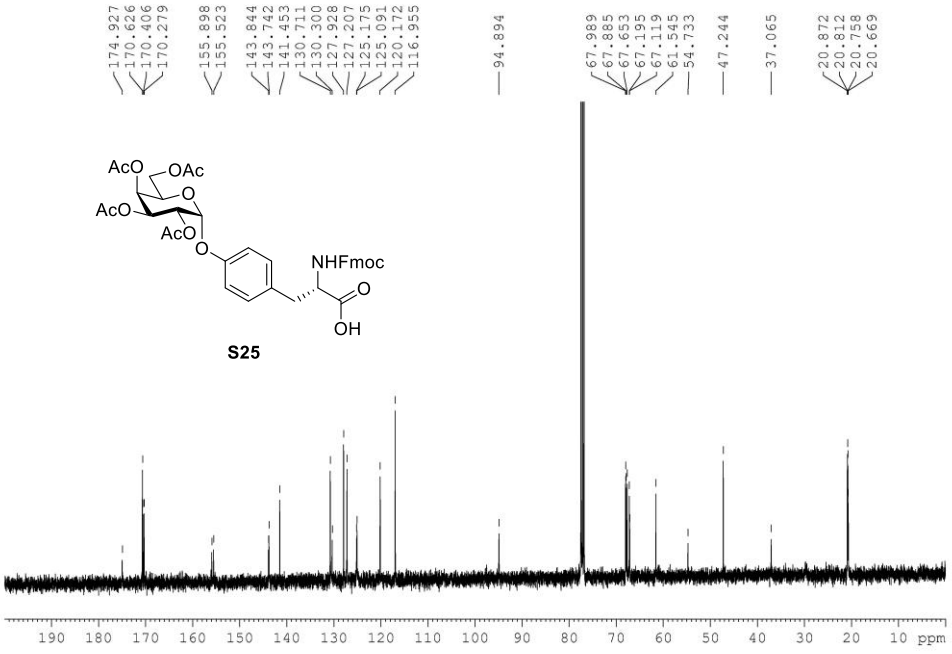
Compound S23 – ^{13}C NMR Spectrum - $CDCl_3$, 100 MHz



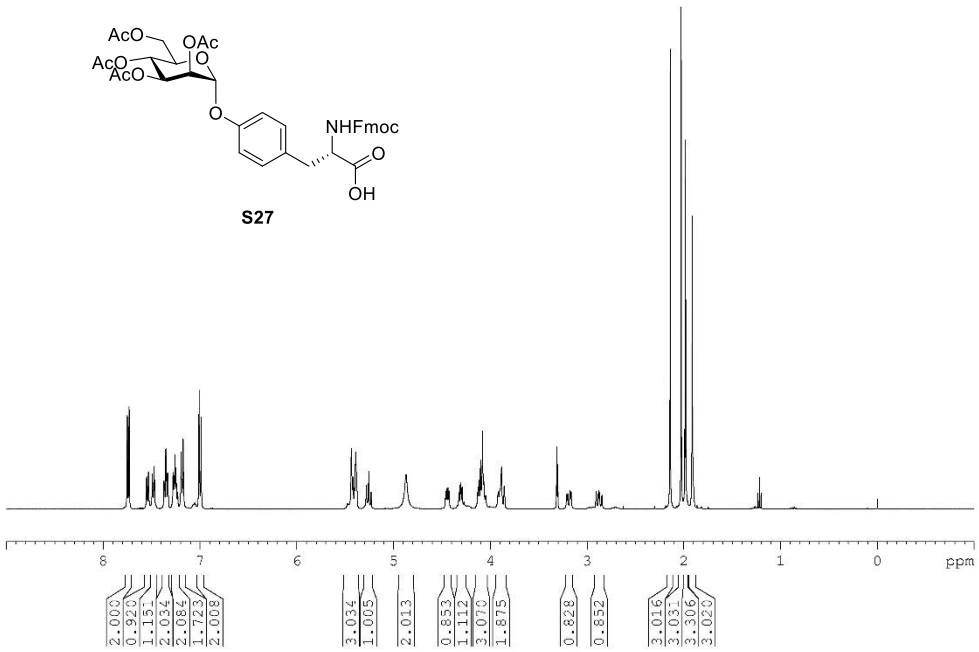
Compound S25 - ^{1}H NMR Spectrum – $CDCl_3$, 400 MHz



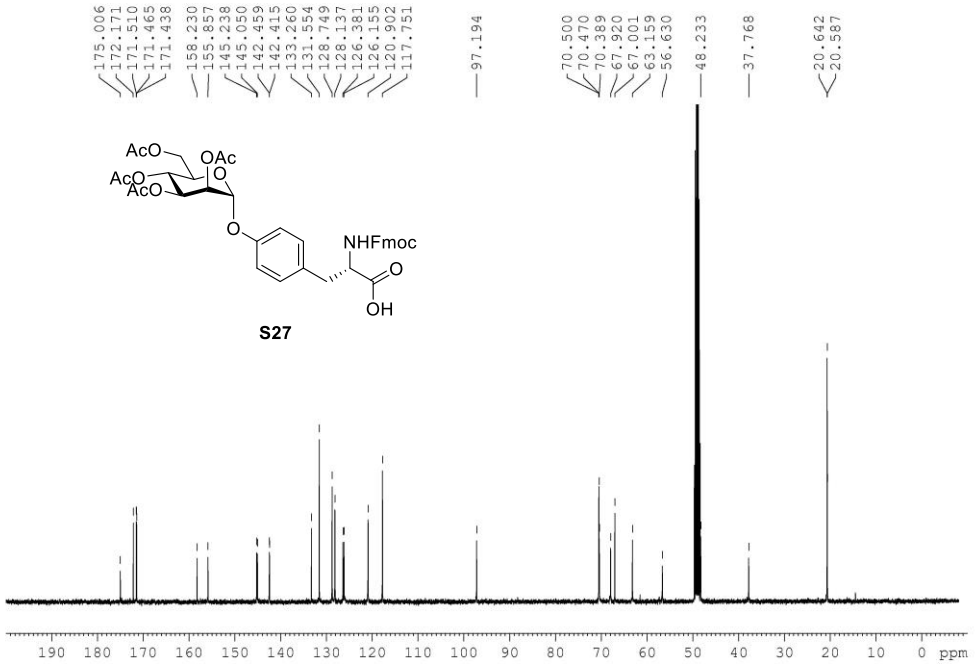
Compound S25 – ^{13}C NMR Spectrum - $CDCl_3$, 100 MHz



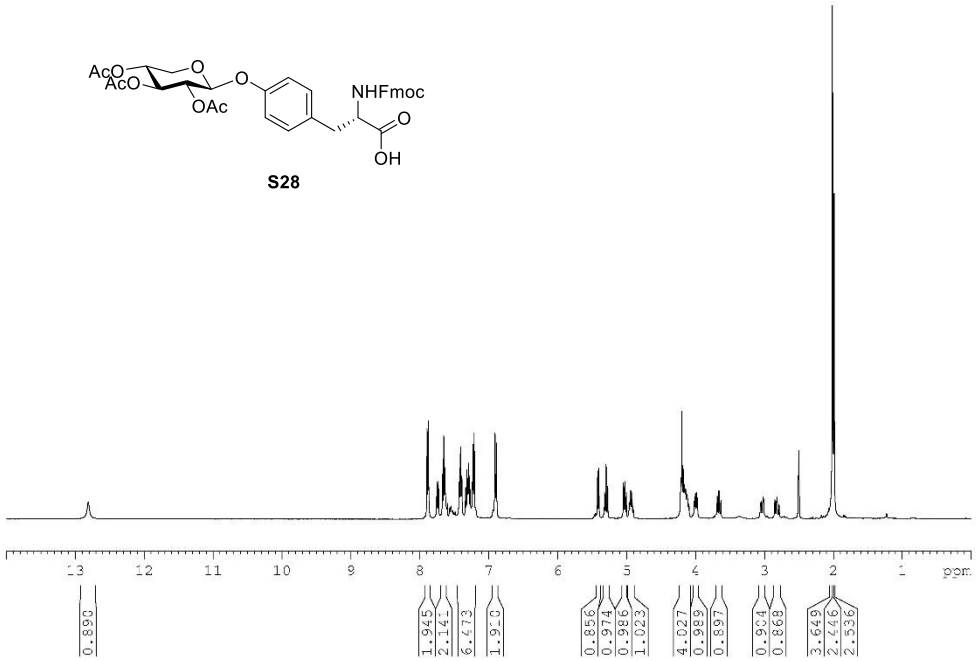
Compound S27 - ^{1}H NMR Spectrum – CD_3OD, 400 MHz



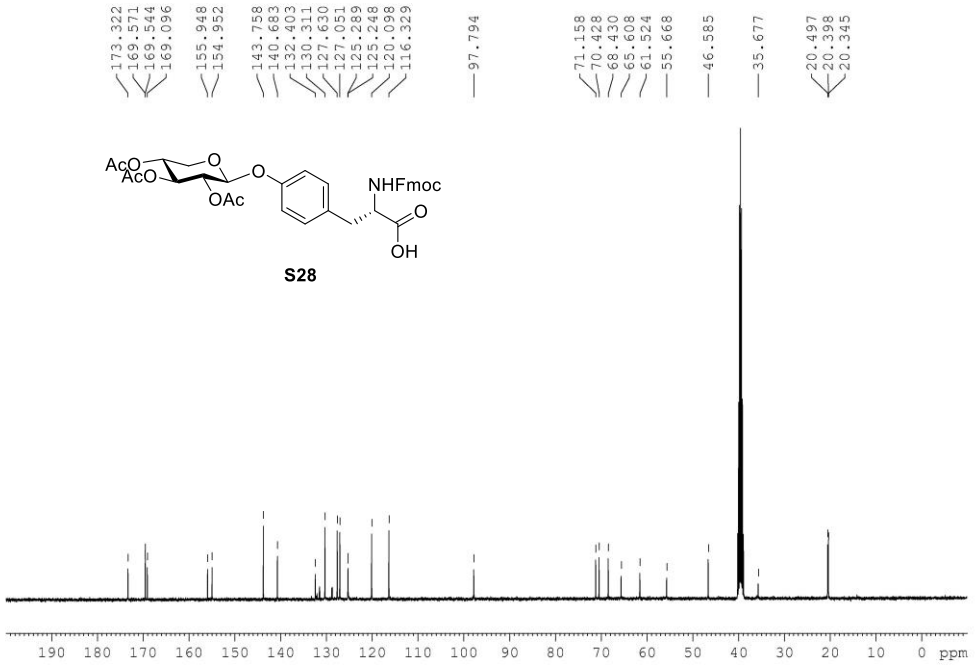
Compound S27 – ^{13}C NMR Spectrum - CD_3OD, 100 MHz



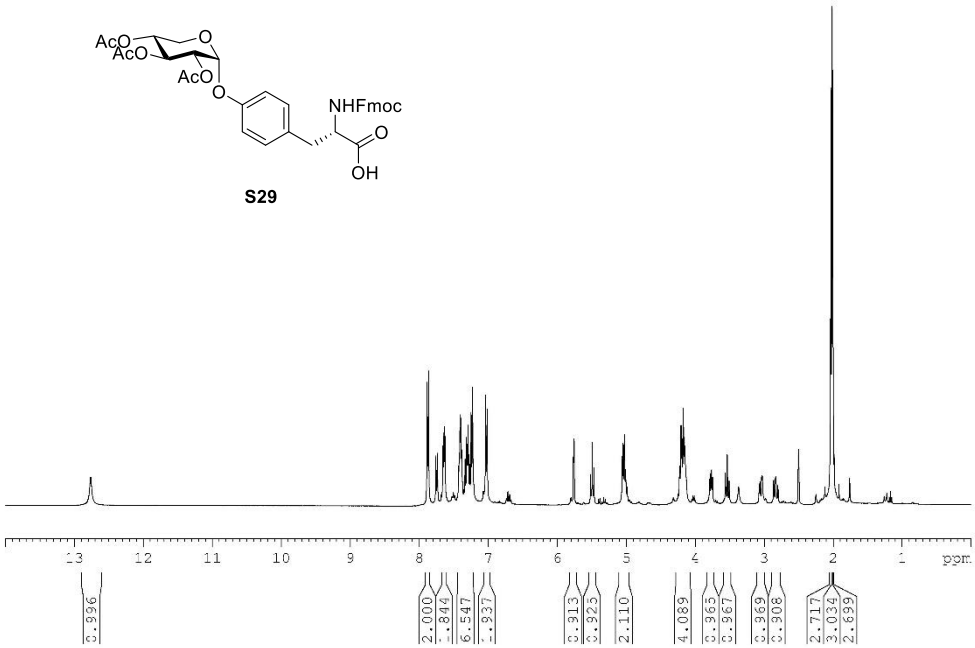
Compound S28 - ^{1}H NMR Spectrum – DMSO-d^{6}, 400 MHz



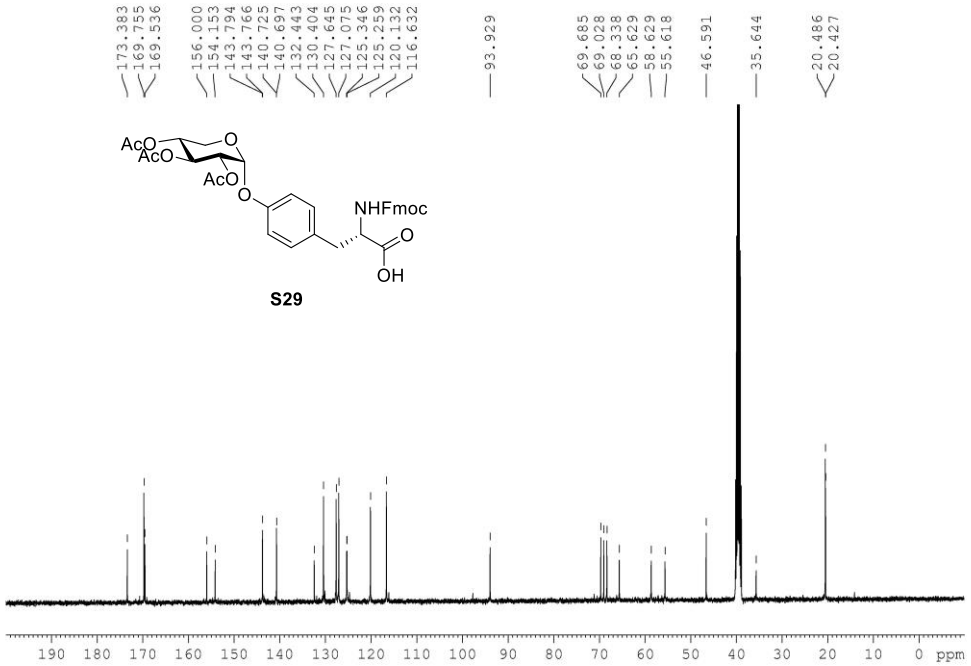
Compound S28 – ^{13}C NMR Spectrum – DMSO-d^{6}, 100 MHz



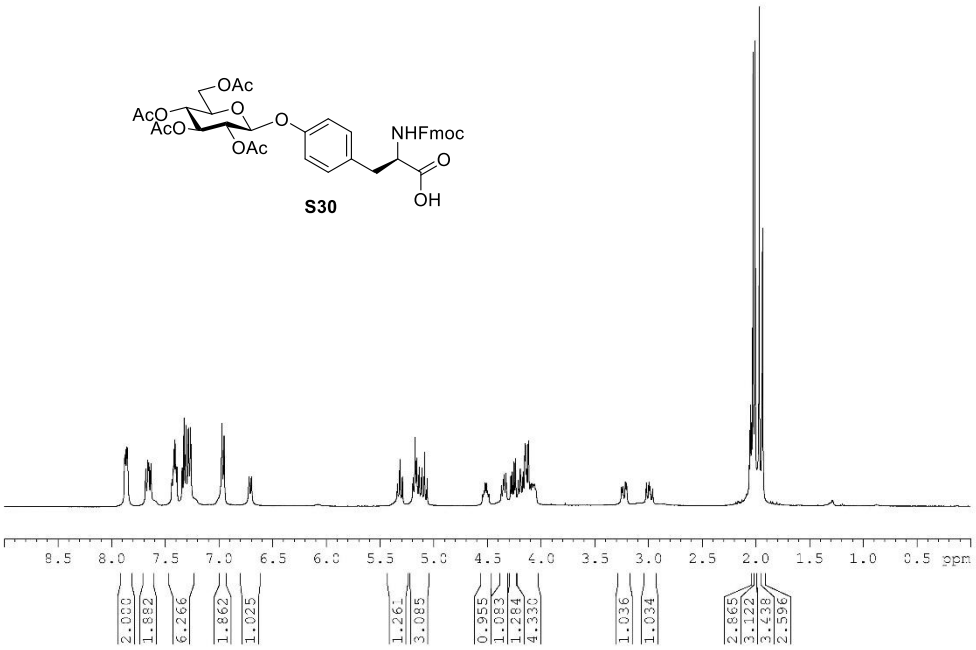
Compound S29 - ^{1}H NMR Spectrum – DMSO-d^{6}, 400 MHz



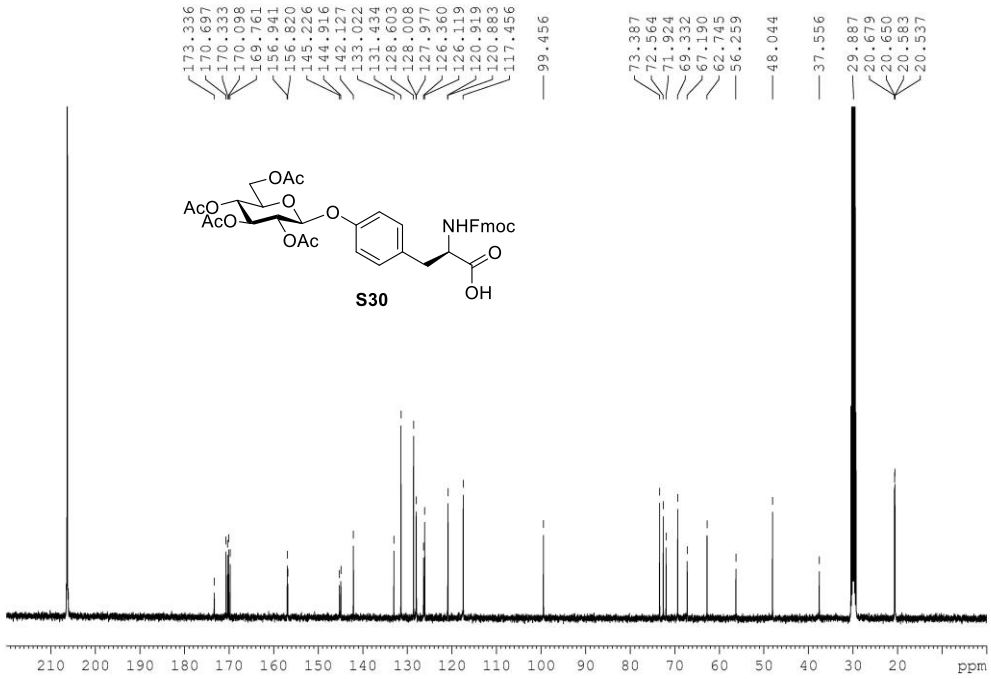
Compound S29 – ^{13}C NMR Spectrum – DMSO-d^{6}, 100 MHz



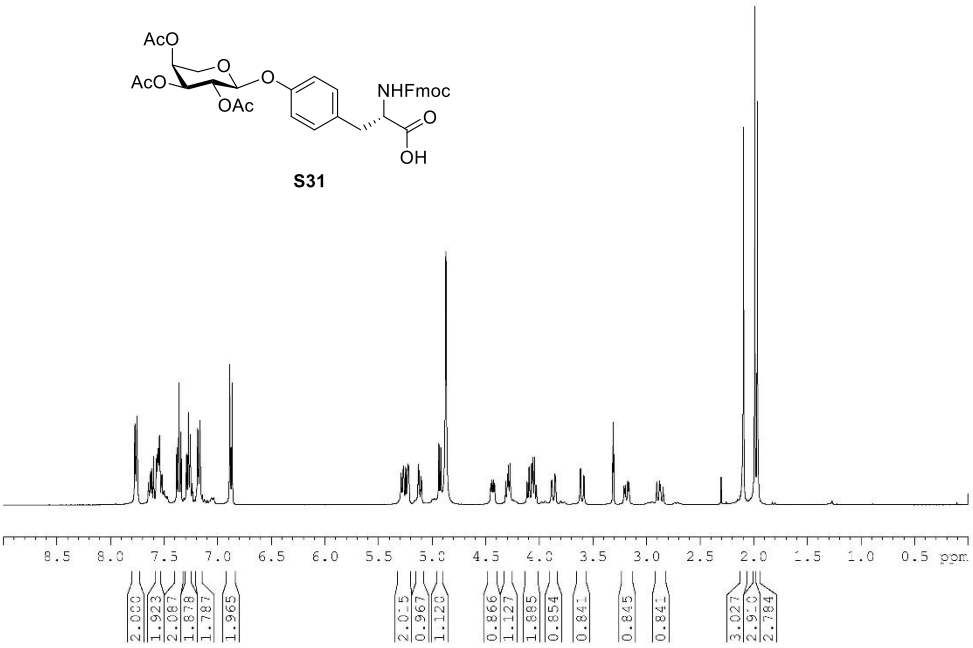
Compound S30 - ^{1}H NMR Spectrum – Acetone-d^6, 400 MHz



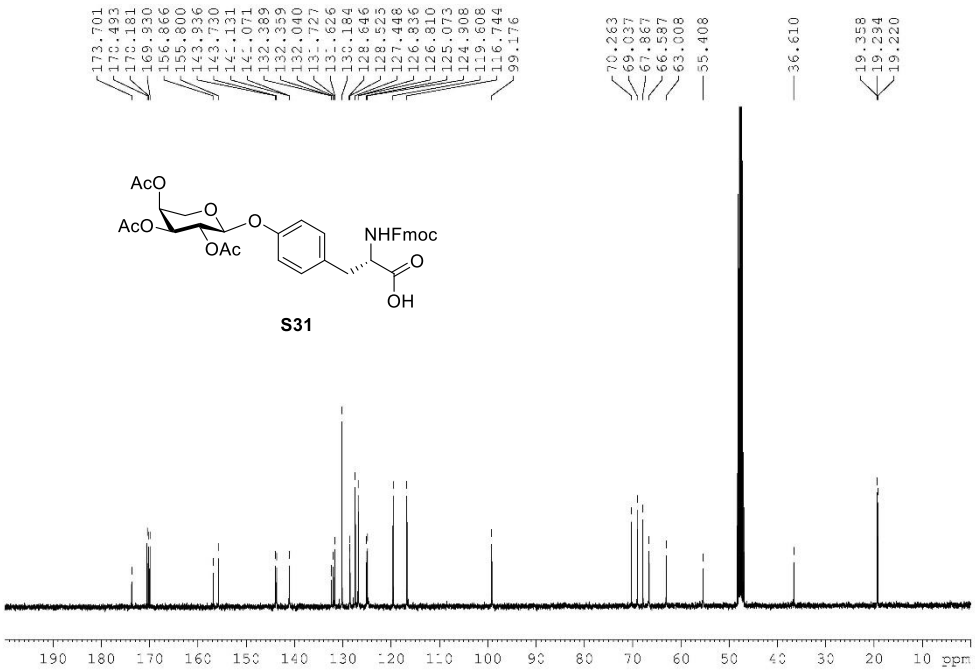
Compound S30 – ^{13}C NMR Spectrum – Acetone -d^6, 100 MHz



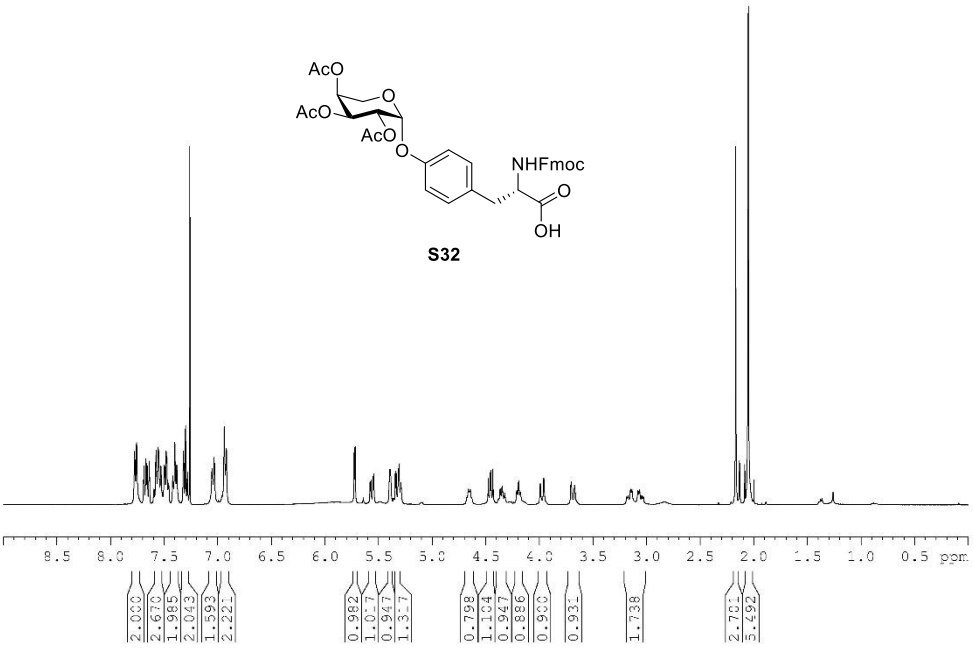
Compound S31 - ^{1}H NMR Spectrum – CD_3OD, 400 MHz



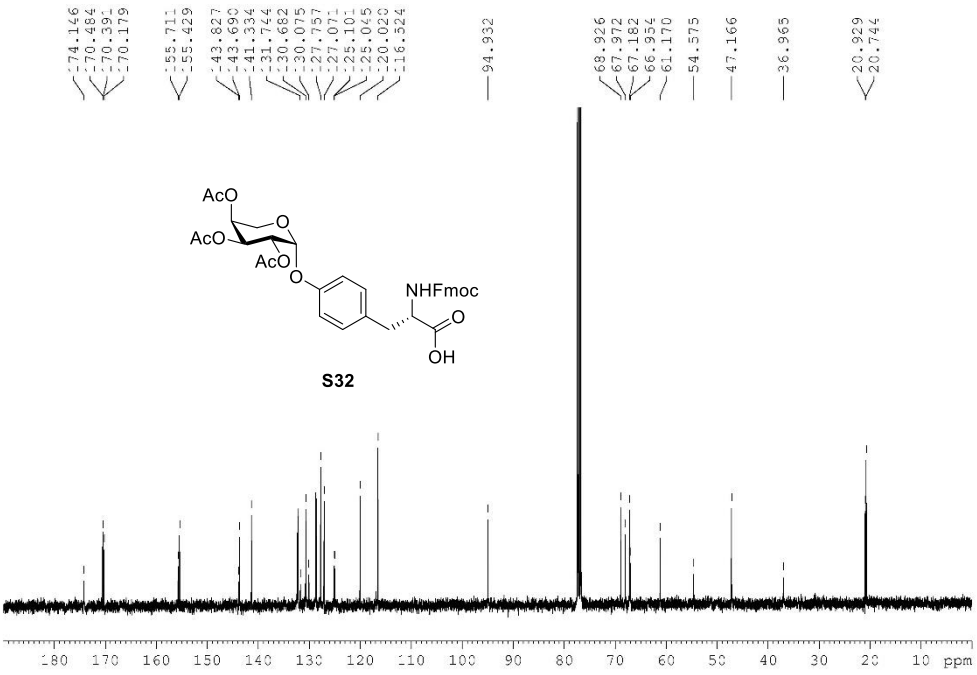
Compound S31 – ^{13}C NMR Spectrum – CD_3OD, 100 MHz



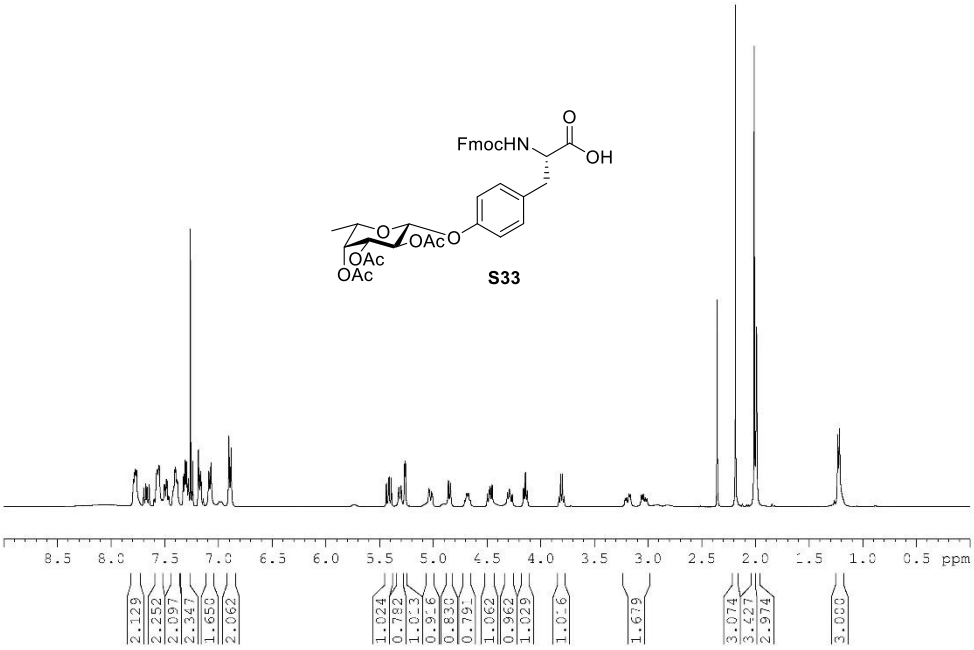
Compound S32 - ^{1}H NMR Spectrum – $CDCl_3$, 400 MHz



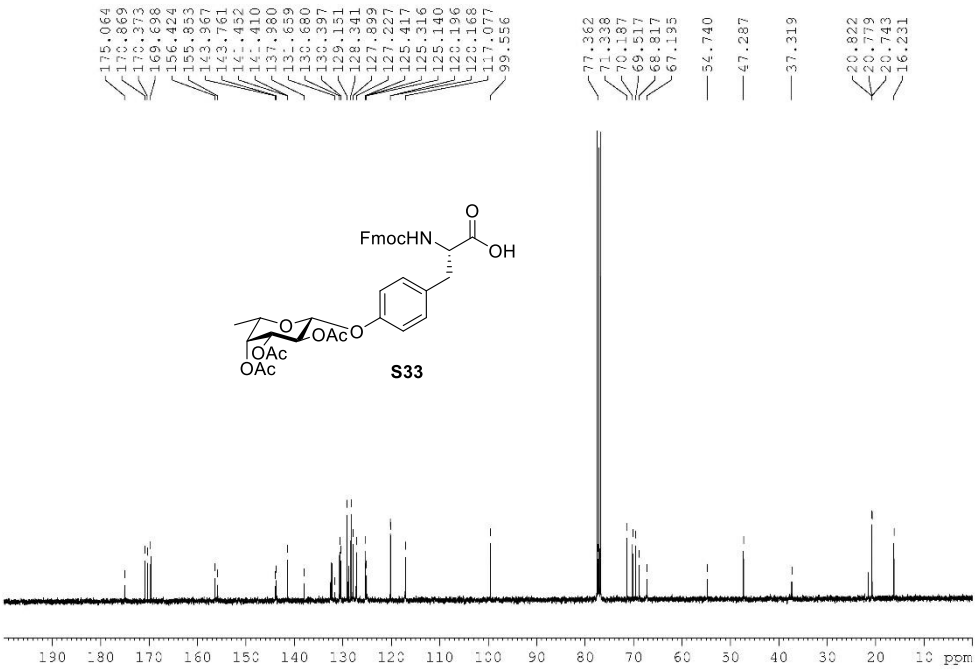
Compound S32 – ^{13}C NMR Spectrum – $CDCl_3$, 100 MHz



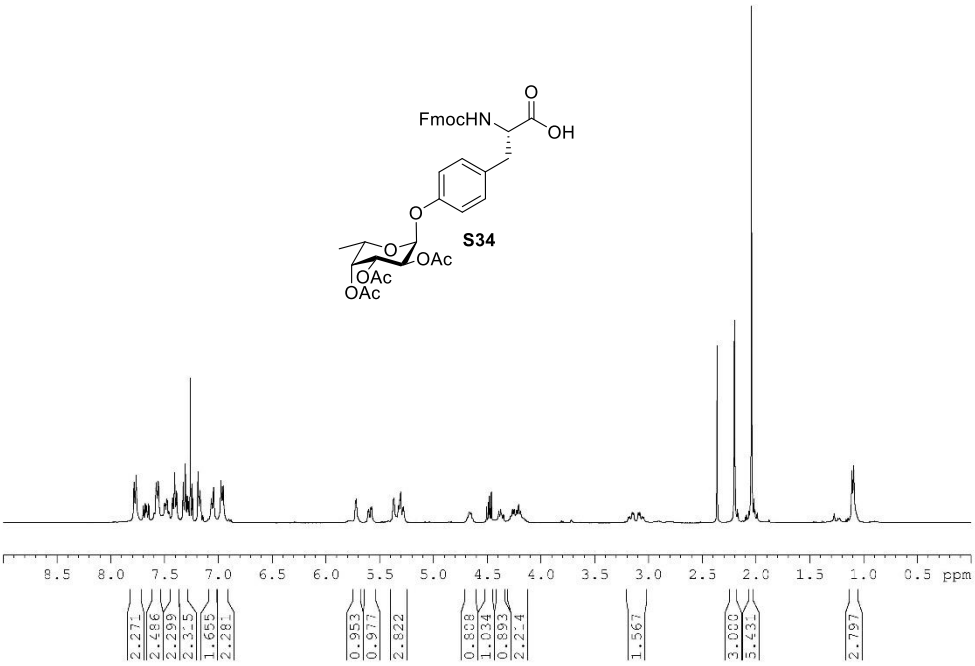
Compound S33 - ^{1}H NMR Spectrum – $CDCl_3$, 400 MHz



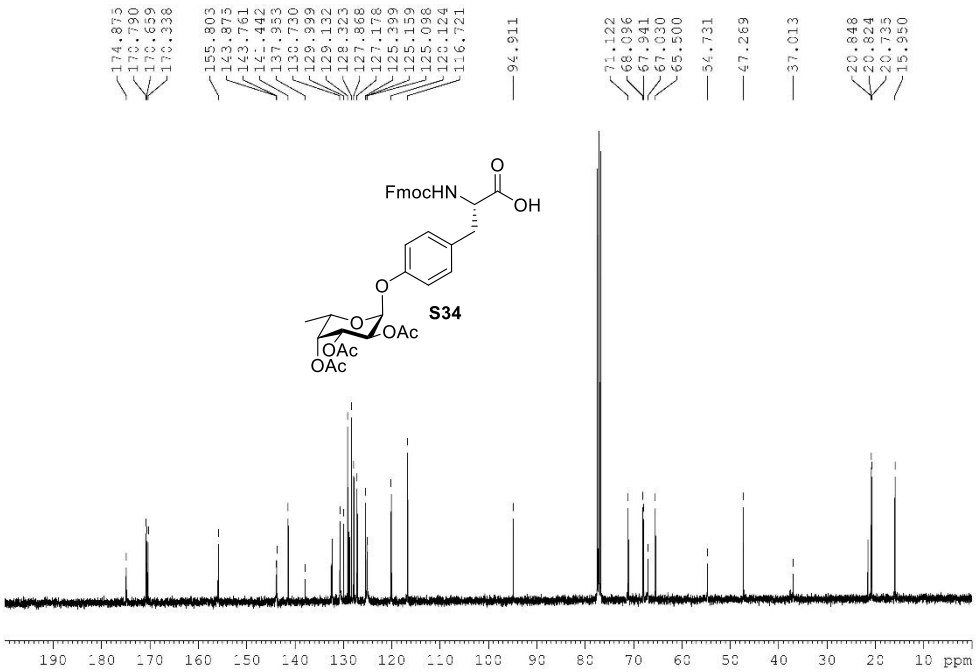
Compound S33 – ^{13}C NMR Spectrum – $CDCl_3$, 100 MHz



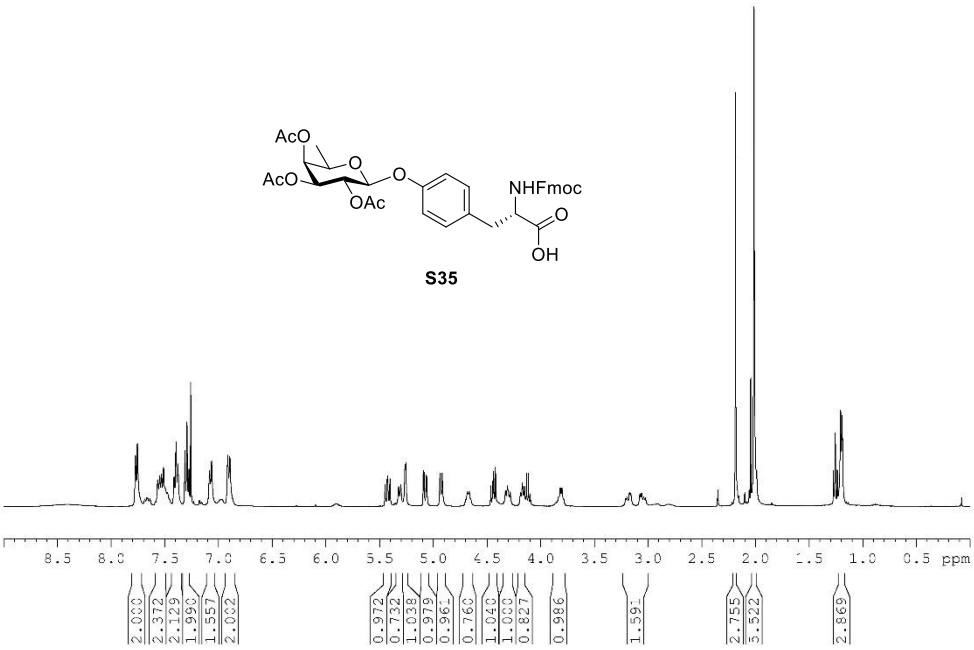
Compound S34 - ^{1}H NMR Spectrum – $CDCl_3$, 400 MHz



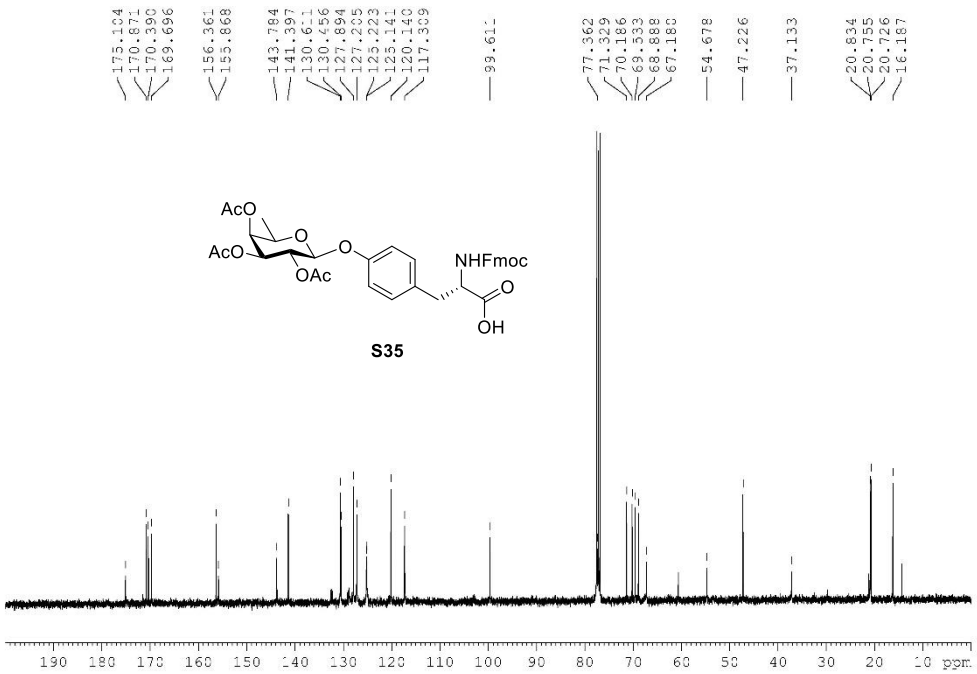
Compound S34 – ^{13}C NMR Spectrum – $CDCl_3$, 100 MHz



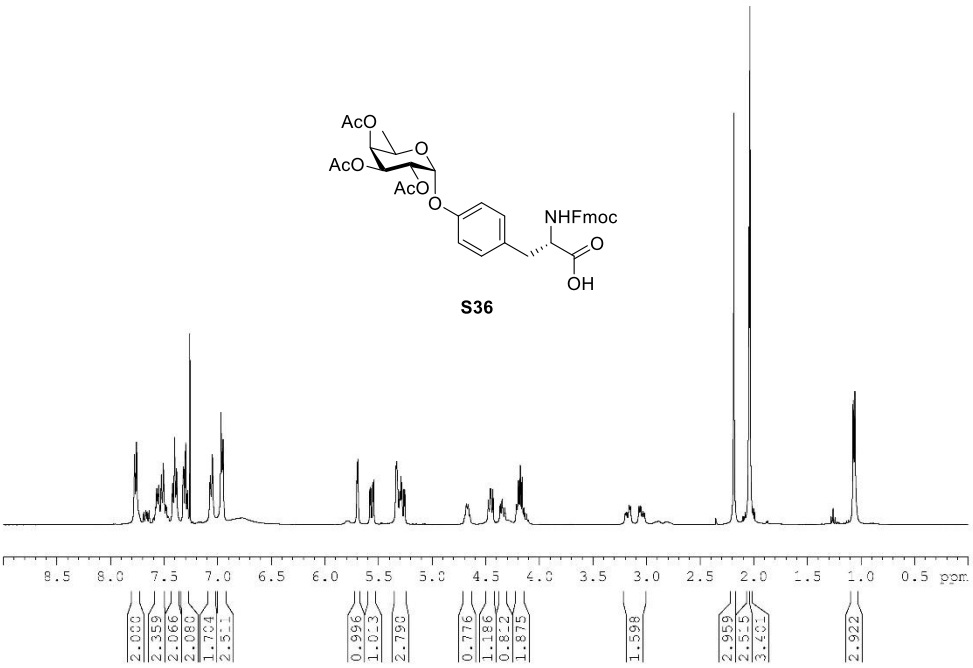
Compound S35 - ^{1}H NMR Spectrum – $CDCl_3$, 400 MHz



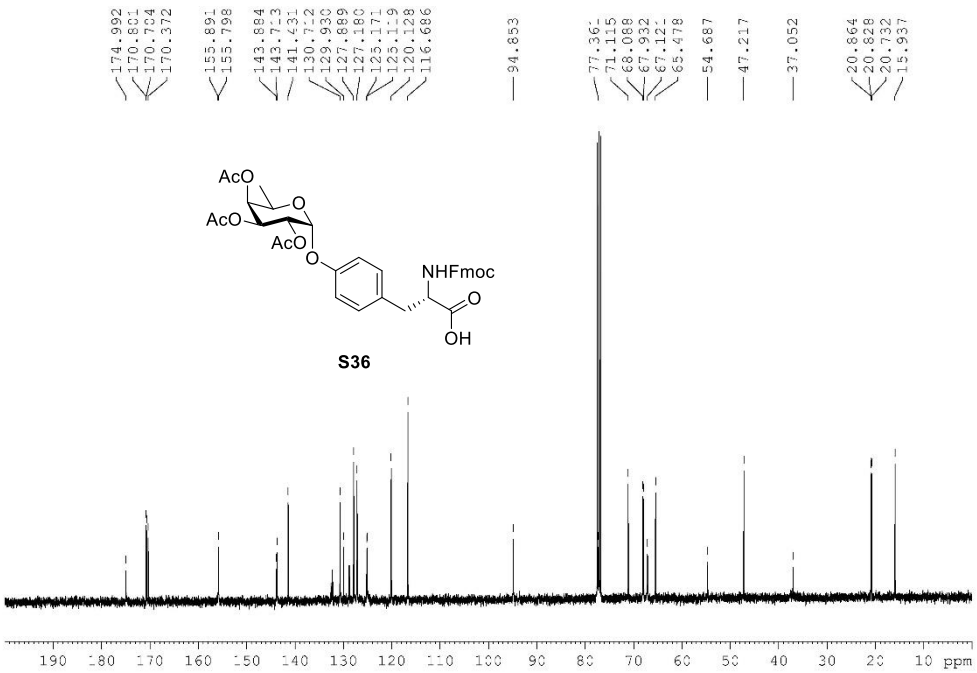
Compound S35 – ^{13}C NMR Spectrum – $CDCl_3$, 100 MHz



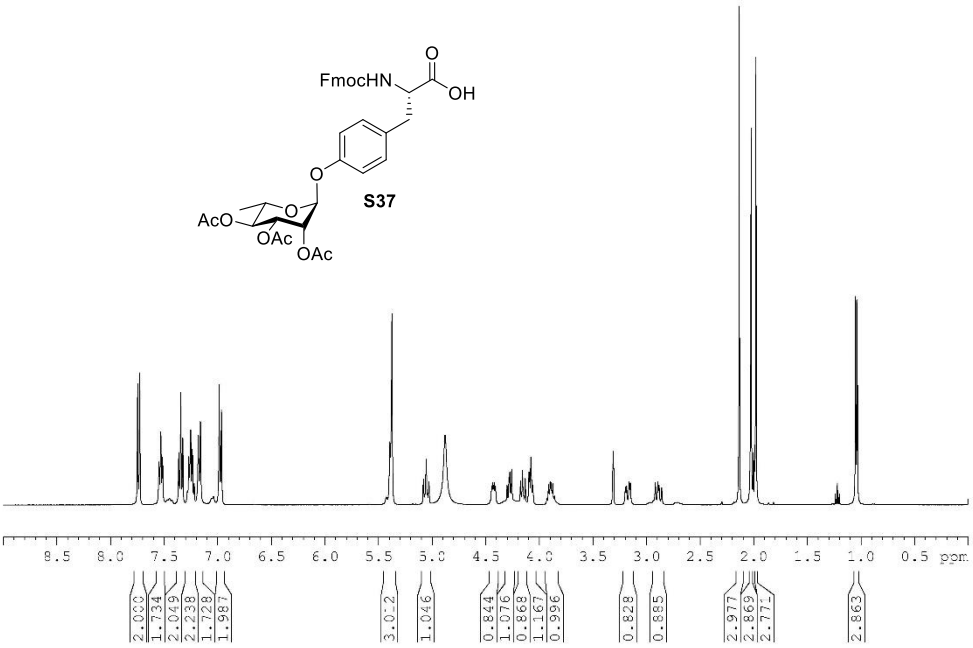
Compound S36 - ^{1}H NMR Spectrum – $CDCl_3$, 400 MHz



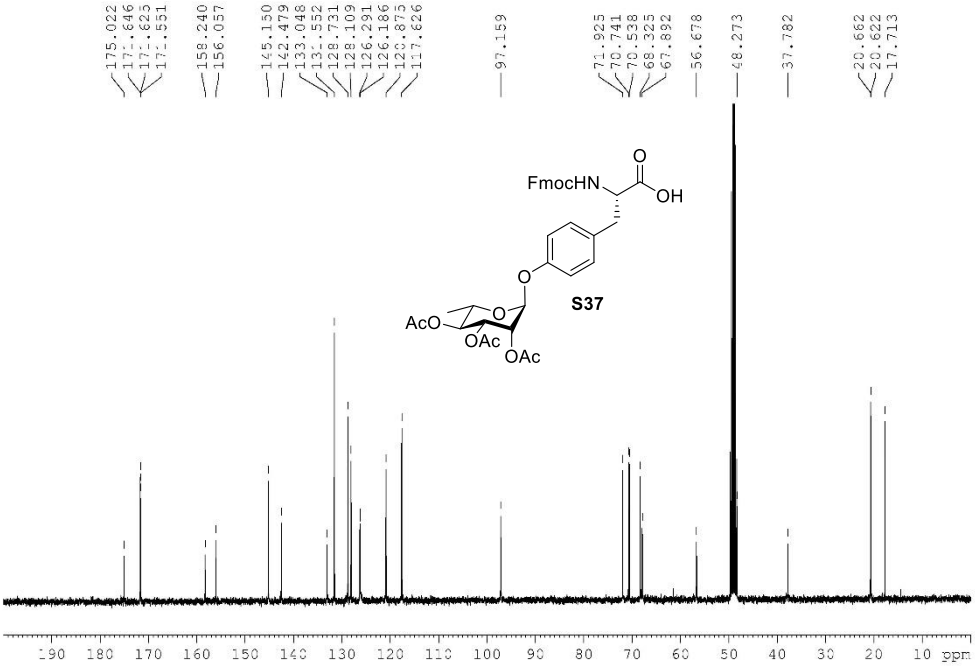
Compound S36 – ^{13}C NMR Spectrum – $CDCl_3$, 100 MHz



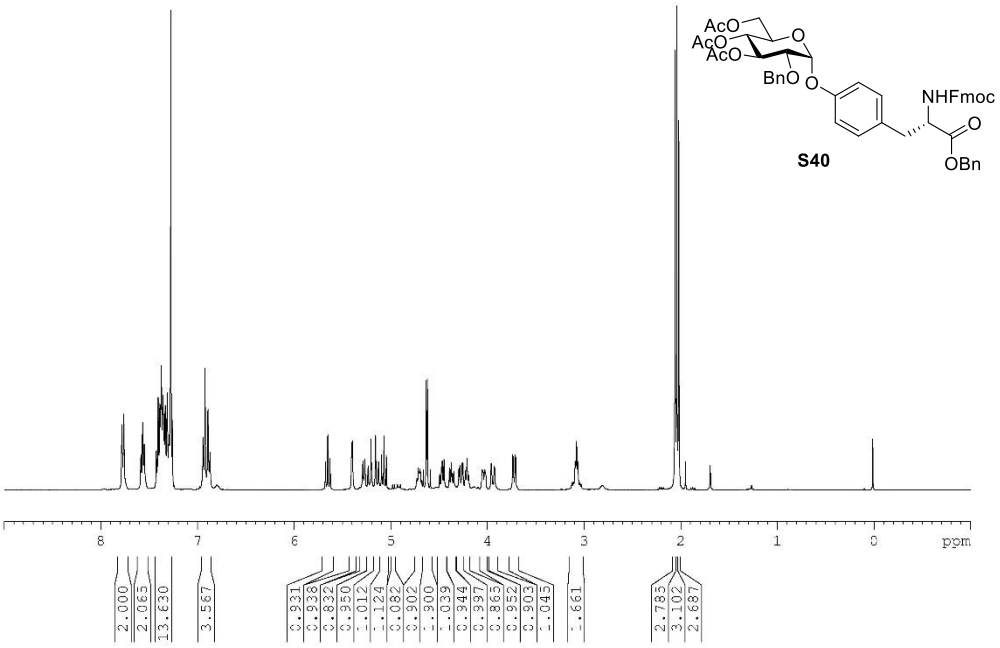
Compound S37 - ^{1}H NMR Spectrum – $CDCl_3$, 400 MHz



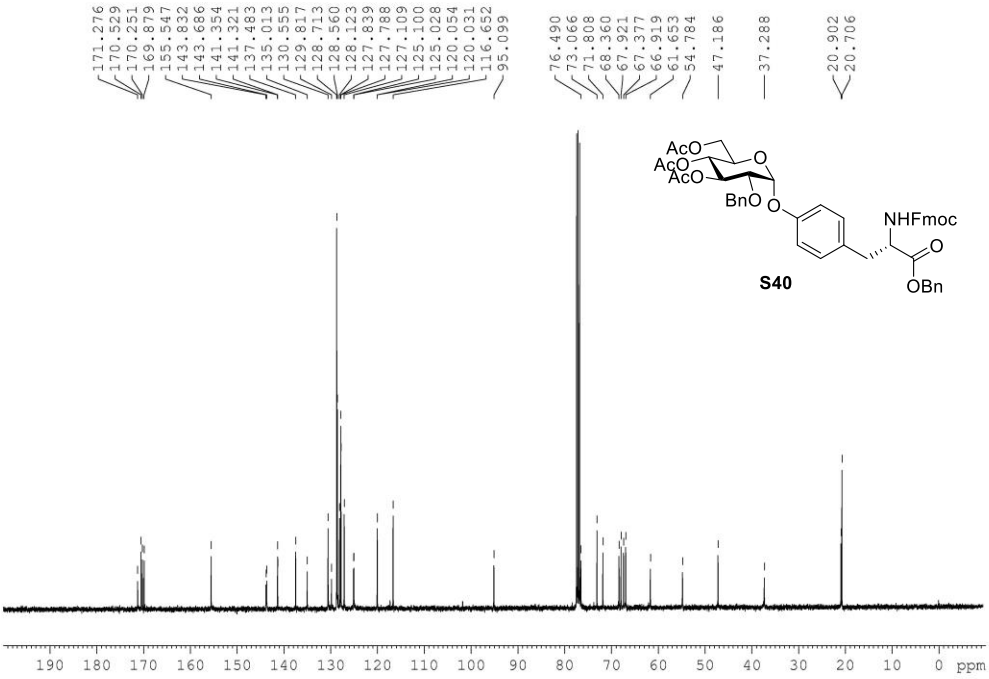
Compound S37 – ^{13}C NMR Spectrum – $CDCl_3$, 100 MHz



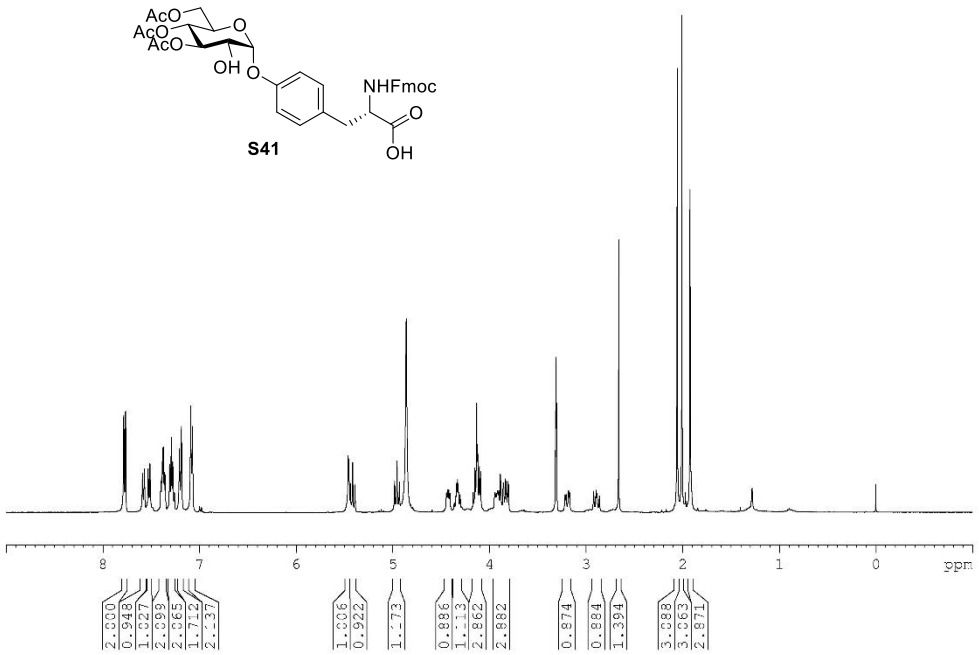
Compound S40 - ^{1}H NMR Spectrum – $CDCl_3$, 400 MHz



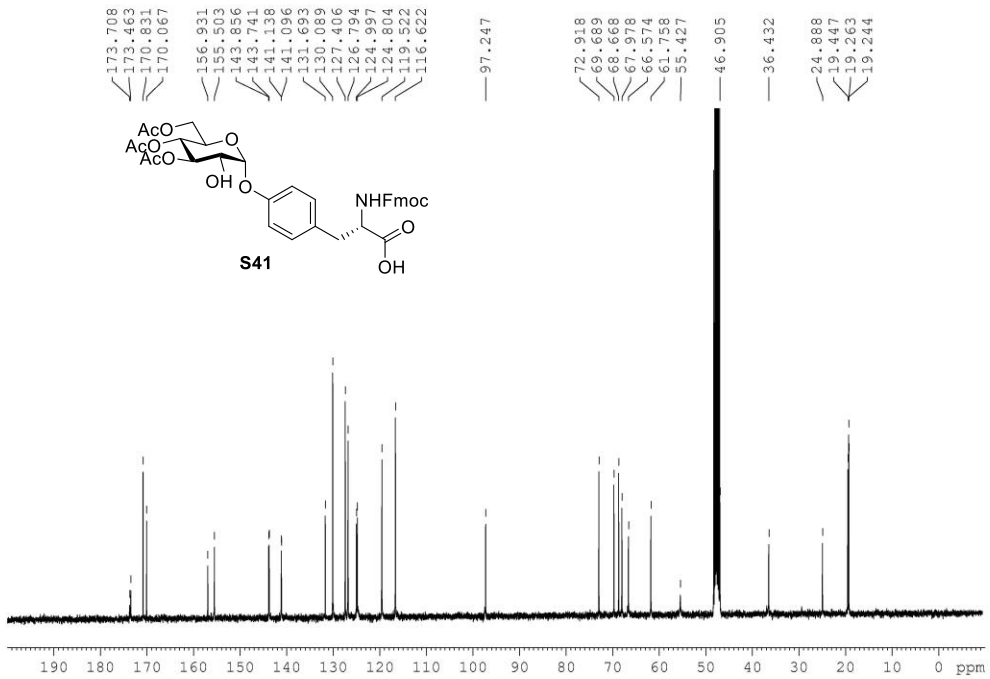
Compound S40 – ^{13}C NMR Spectrum – $CDCl_3$, 100 MHz



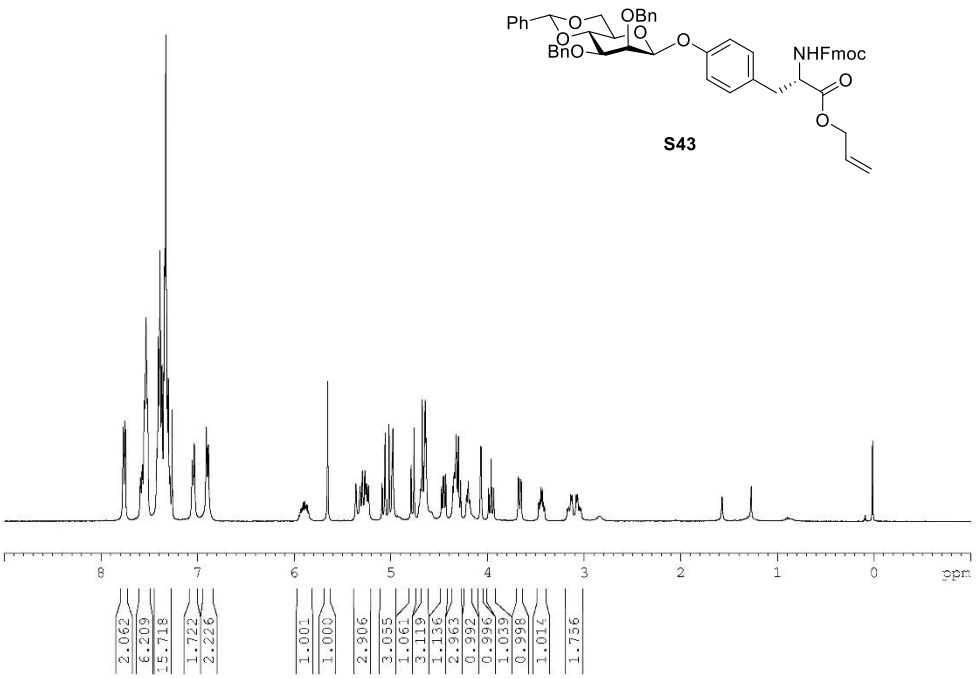
Compound S41 - ^{1}H NMR Spectrum – CD_3OD, 400 MHz



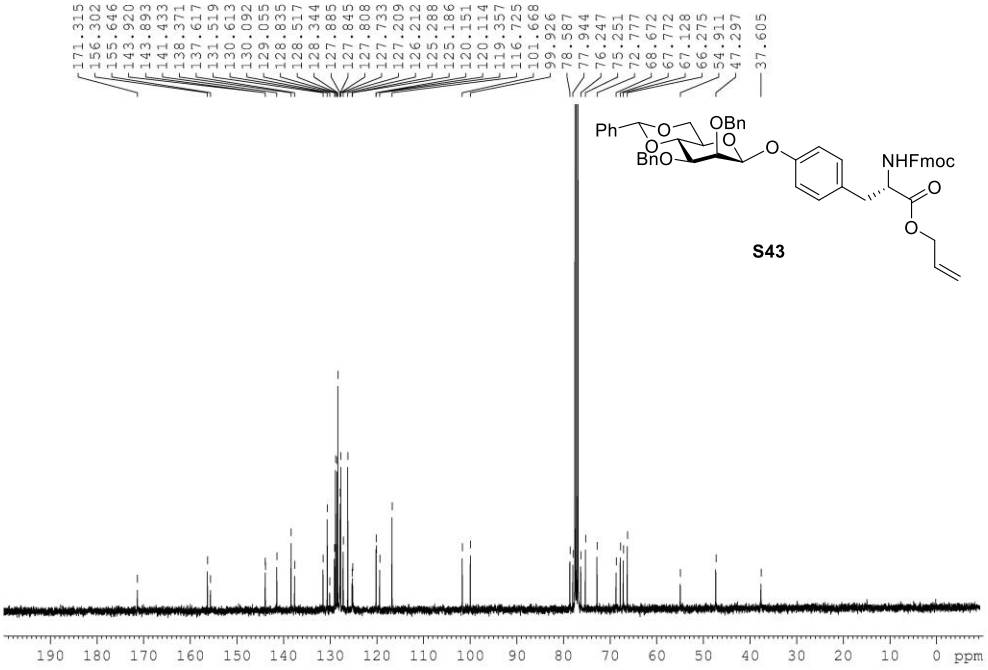
Compound S41 – ^{13}C NMR Spectrum – CD_3OD, 100 MHz



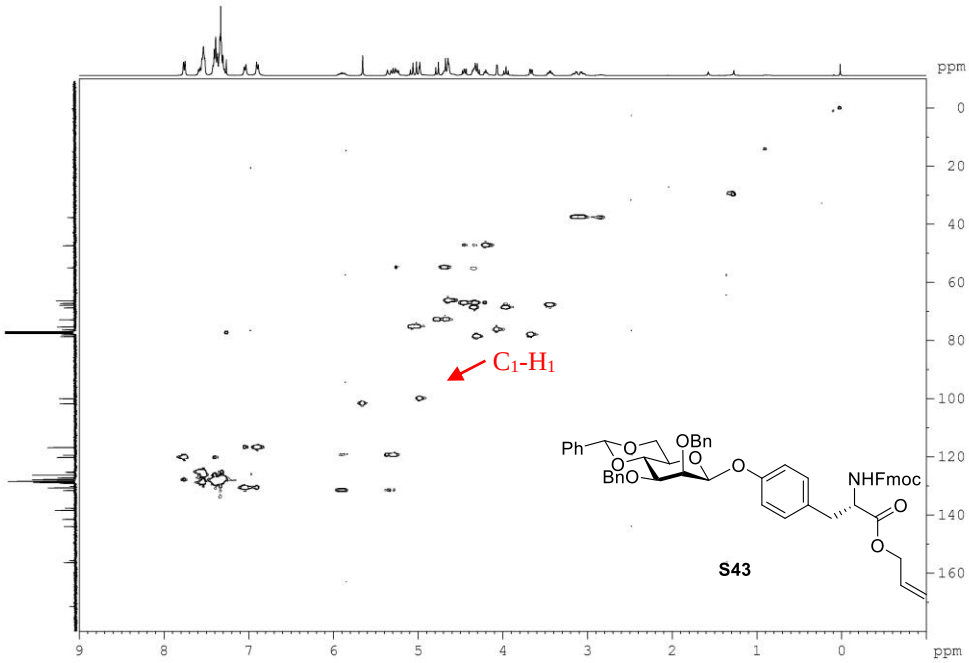
Compound S43 - ^{1}H NMR Spectrum – $CDCl_3$, 400 MHz



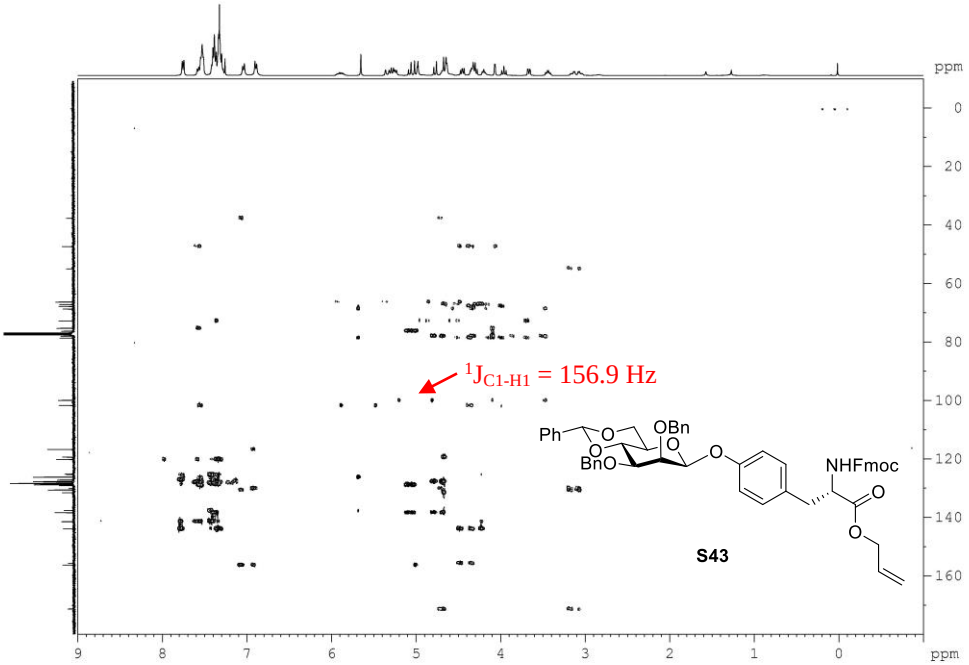
Compound S43 – ^{13}C NMR Spectrum – $CDCl_3$, 100 MHz



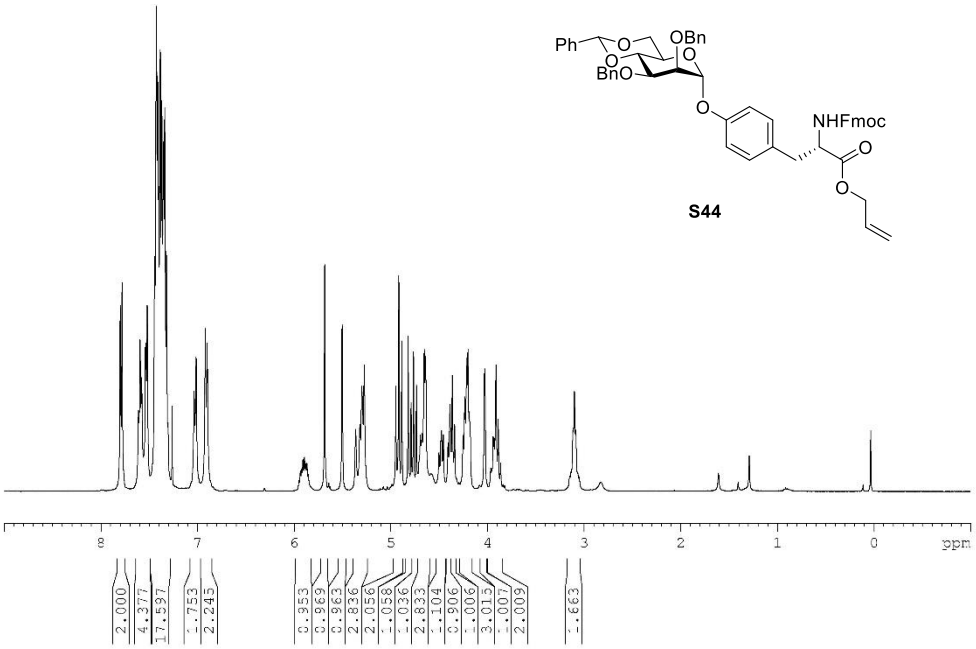
Compound S43 - HSQC NMR Spectrum – $CDCl_3$, 400 MHz



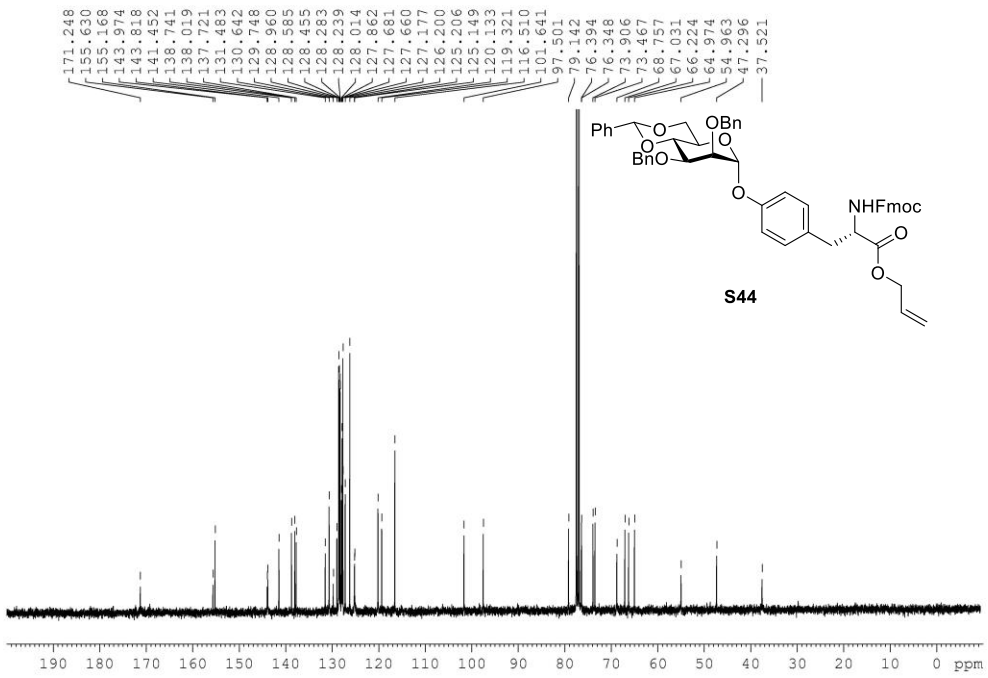
Compound S43 - HMBC NMR Spectrum – $CDCl_3$, 400 MHz



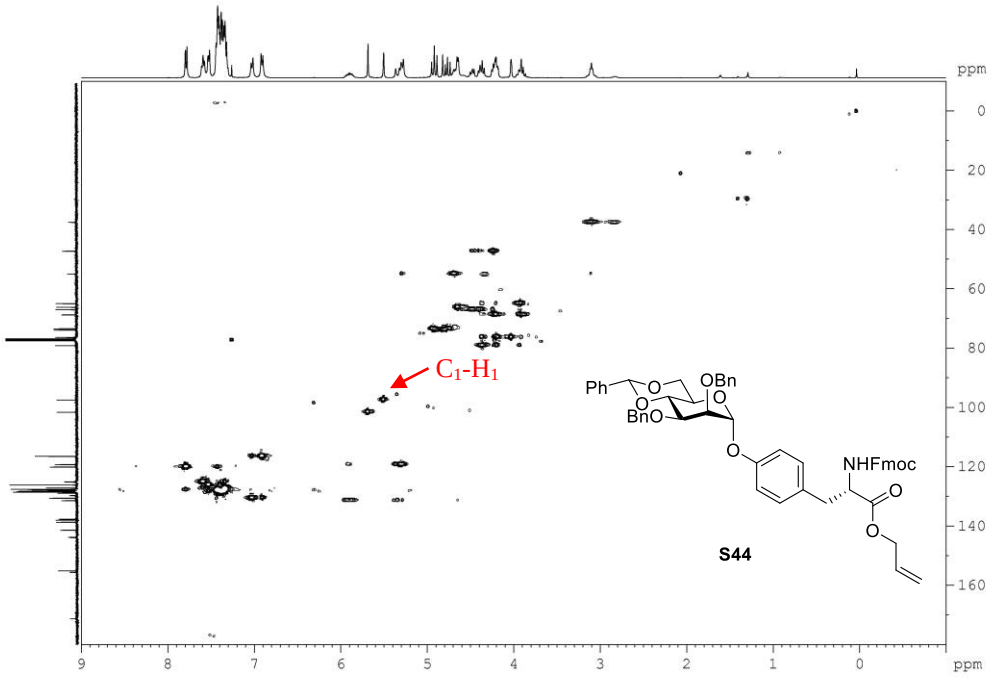
Compound S44 - ^{1}H NMR Spectrum – $CDCl_3$, 400 MHz



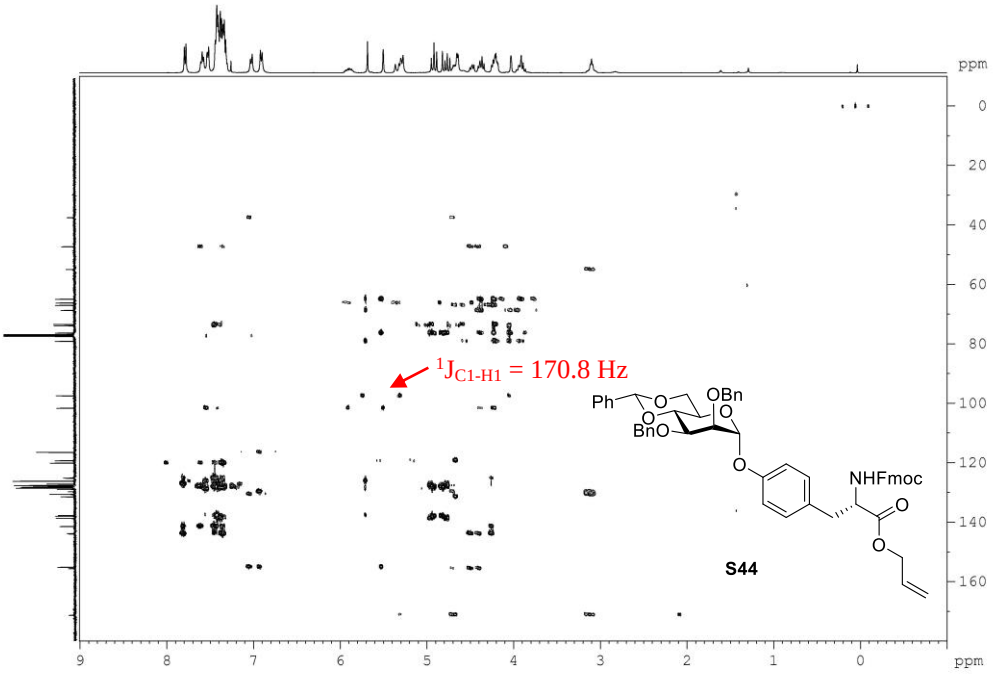
Compound S44 – ^{13}C NMR Spectrum – $CDCl_3$, 100 MHz



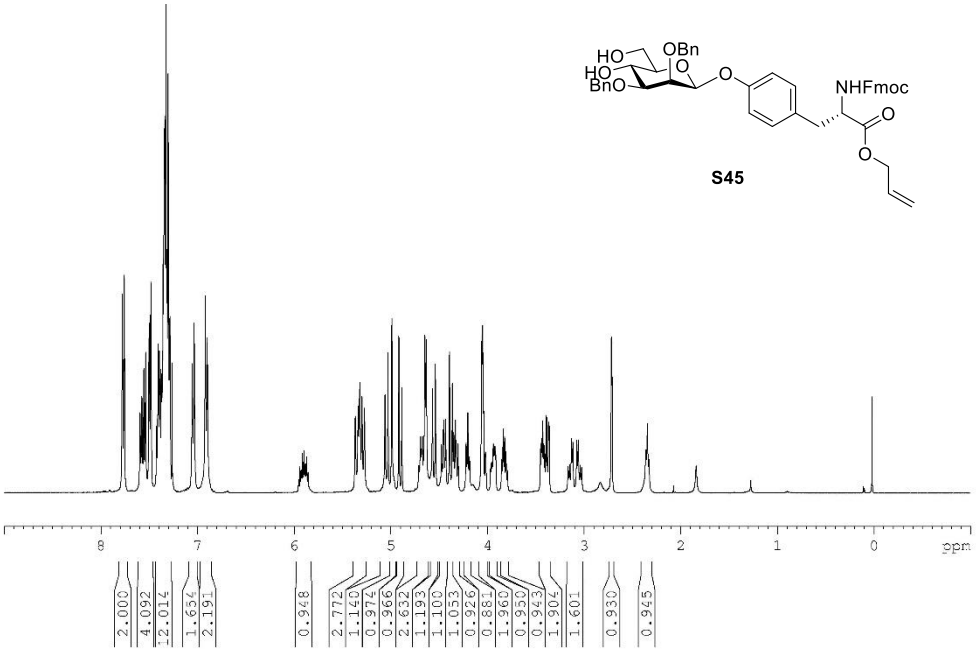
Compound S44 - HSQC NMR Spectrum – $CDCl_3$, 400 MHz



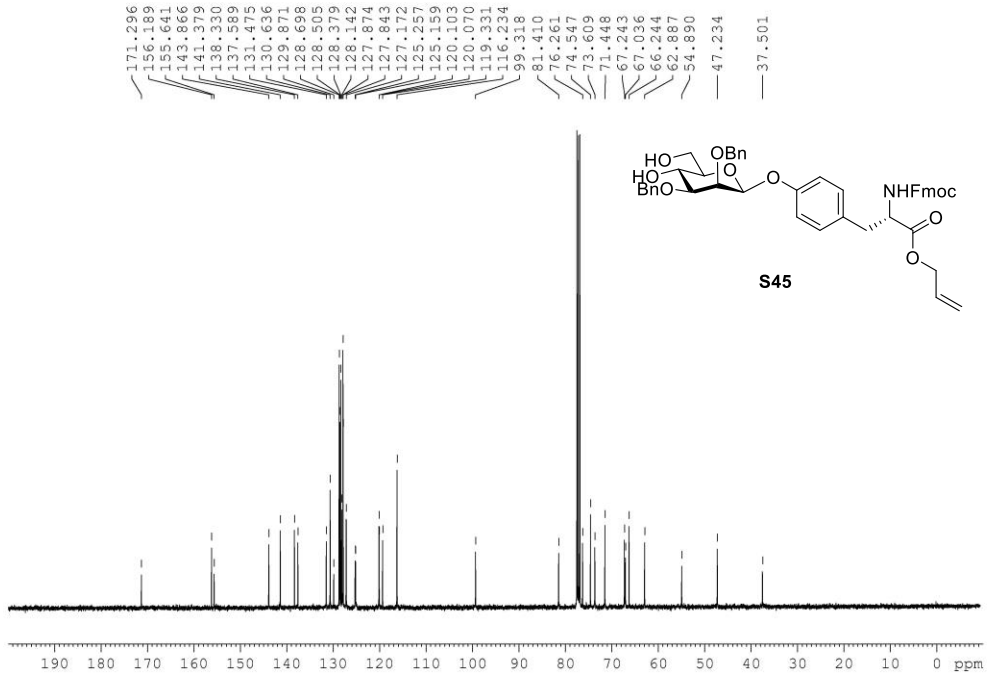
Compound S44 - HMBC NMR Spectrum – $CDCl_3$, 400 MHz



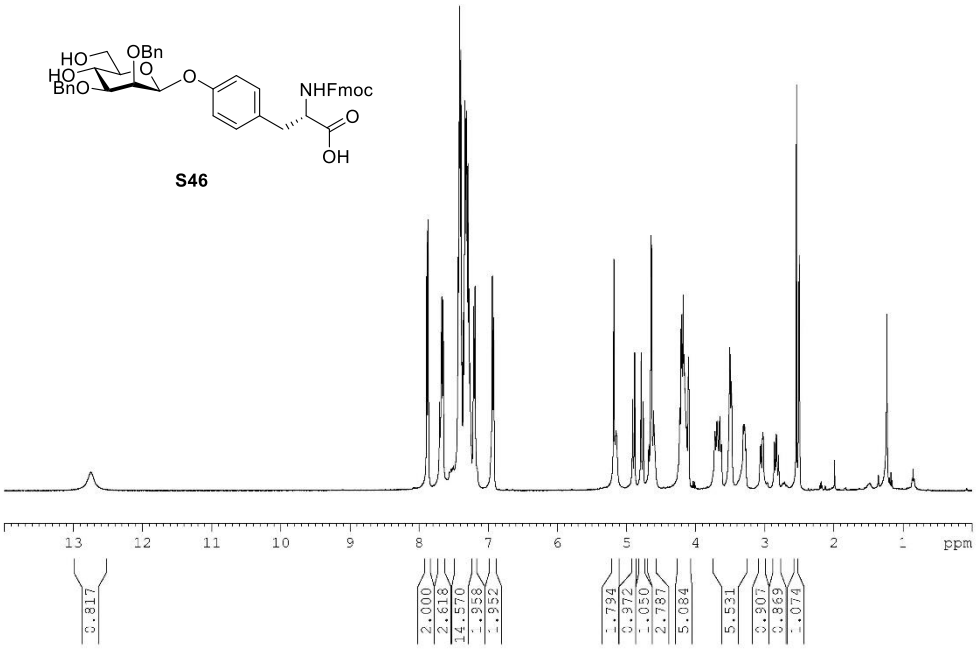
Compound S45 - ^{1}H NMR Spectrum – $CDCl_3$, 400 MHz



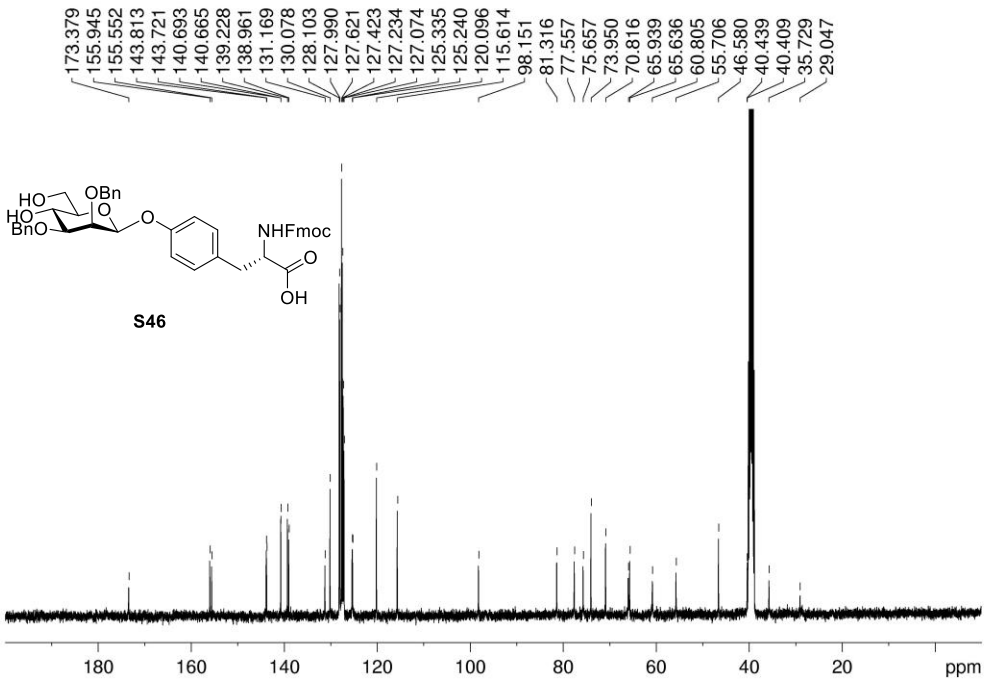
Compound S45 – ^{13}C NMR Spectrum – $CDCl_3$, 100 MHz



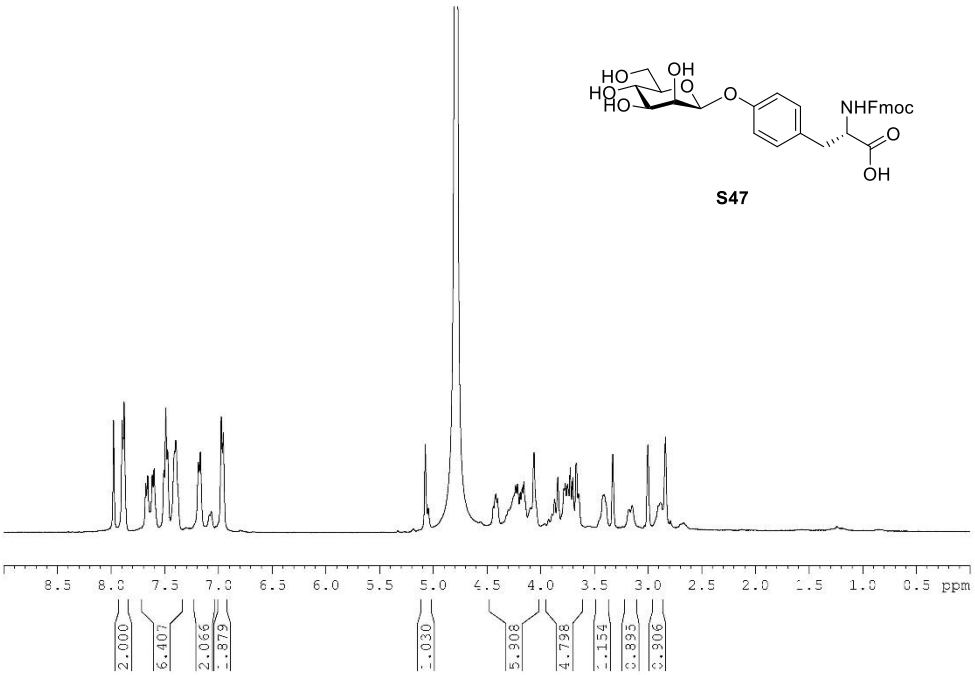
Compound S46 - ^{1}H NMR Spectrum – DMSO-d^{6}, 400 MHz



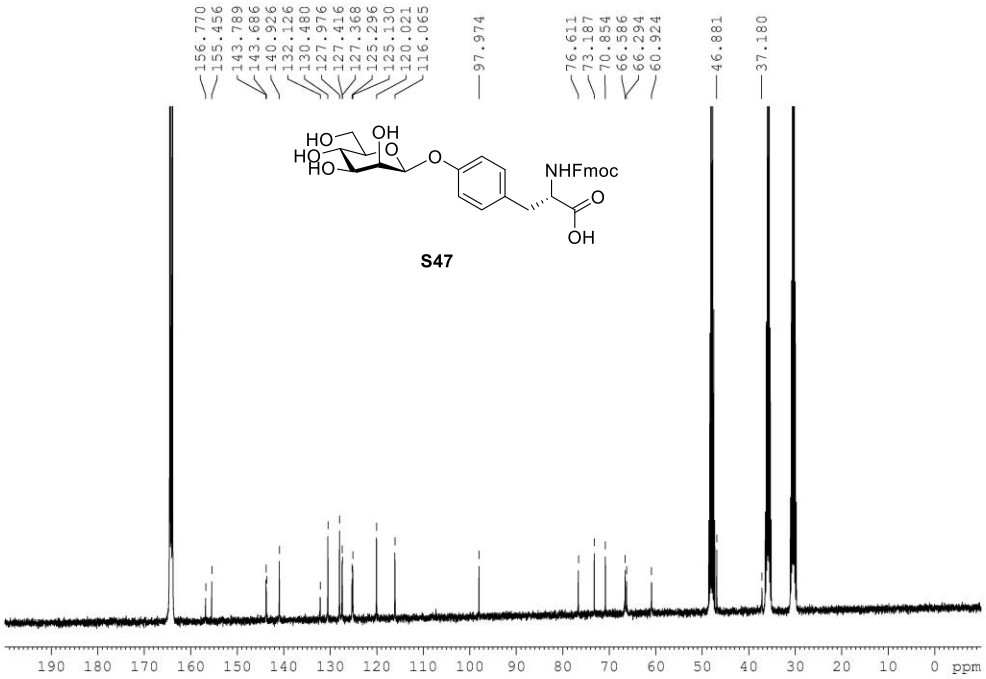
Compound S46 – ^{13}C NMR Spectrum – DMSO-d^{6}, 100 MHz



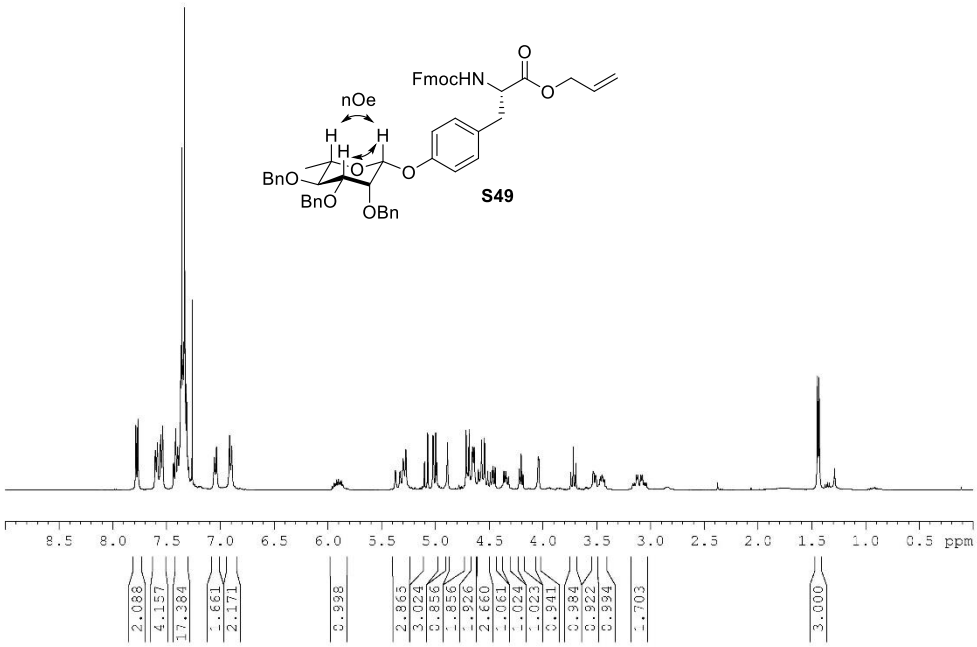
Compound S47 - ^{1}H NMR Spectrum – $D_2O/CD_3OD/DMF$-d^7 = 10/2/5, 400 MHz



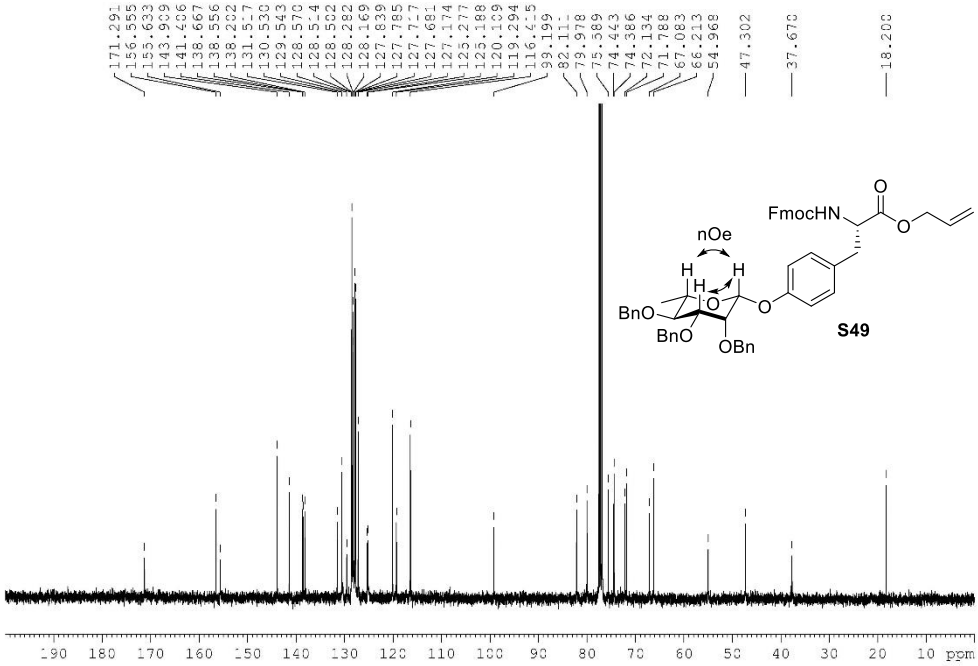
Compound S47 – ^{13}C NMR Spectrum –$D_2O/CD_3OD/DMF$-d^7 = 10/2/5, 100 MHz



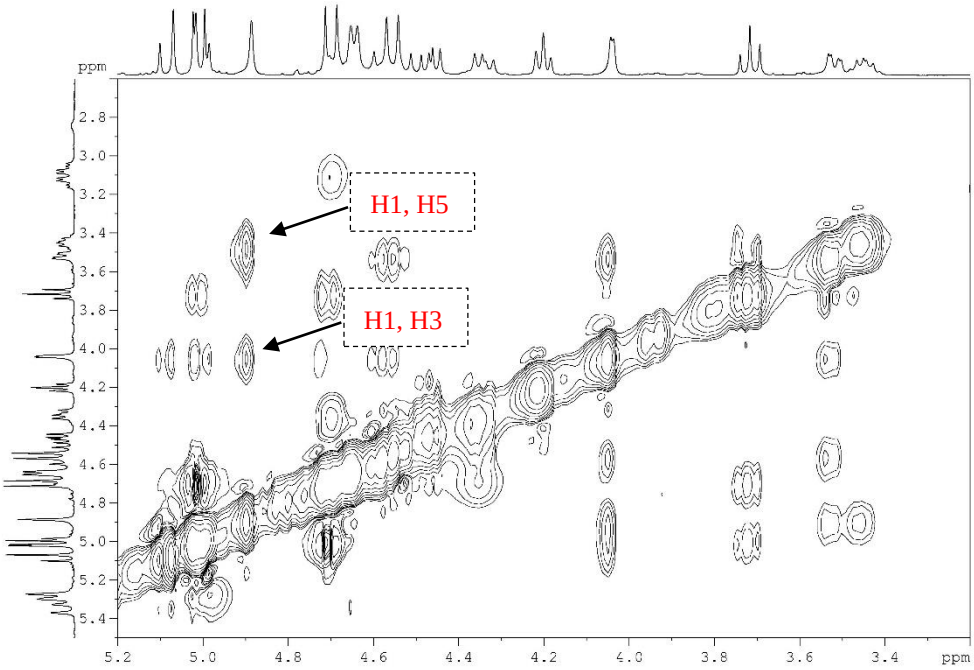
Compound S49 - ^{1}H NMR Spectrum – $CDCl_3$, 400 MHz



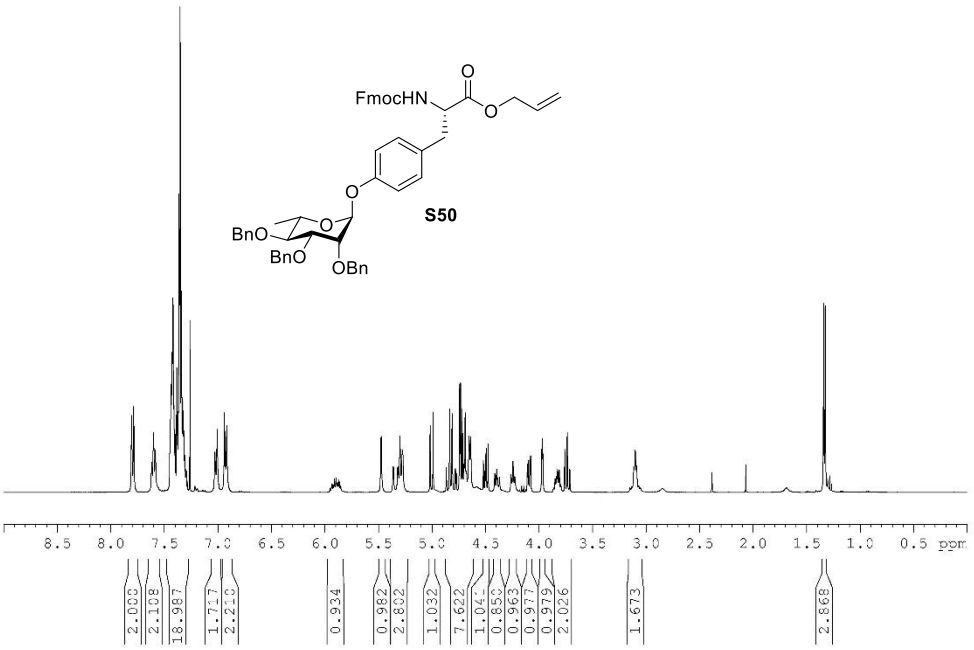
Compound S49 – ^{13}C NMR Spectrum –$CDCl_3$, 400 MHz



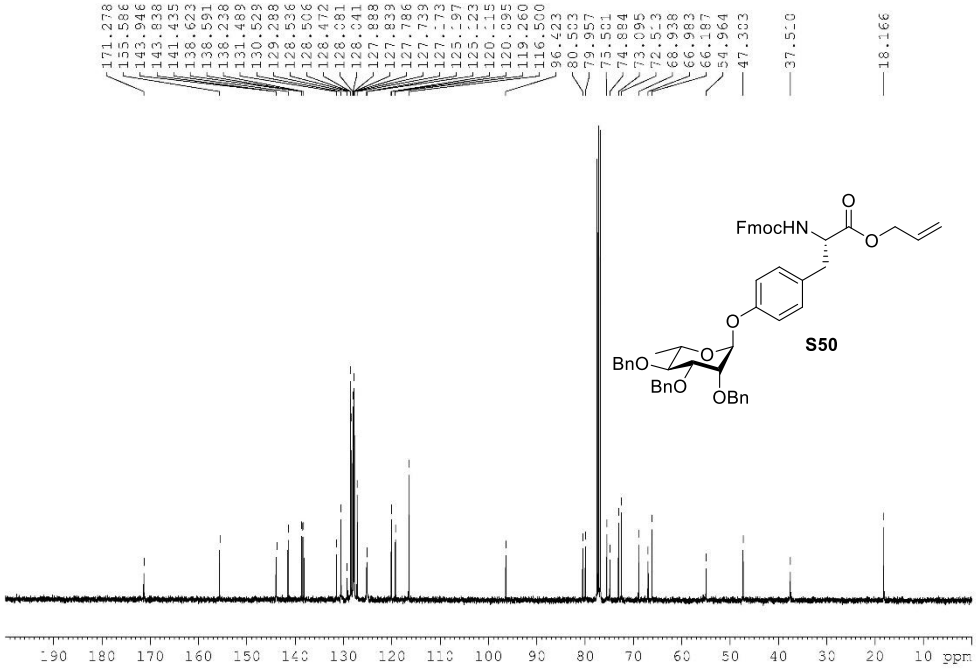
Compound S49 - NOESY NMR Spectrum – $CDCl_3$, 400 MHz



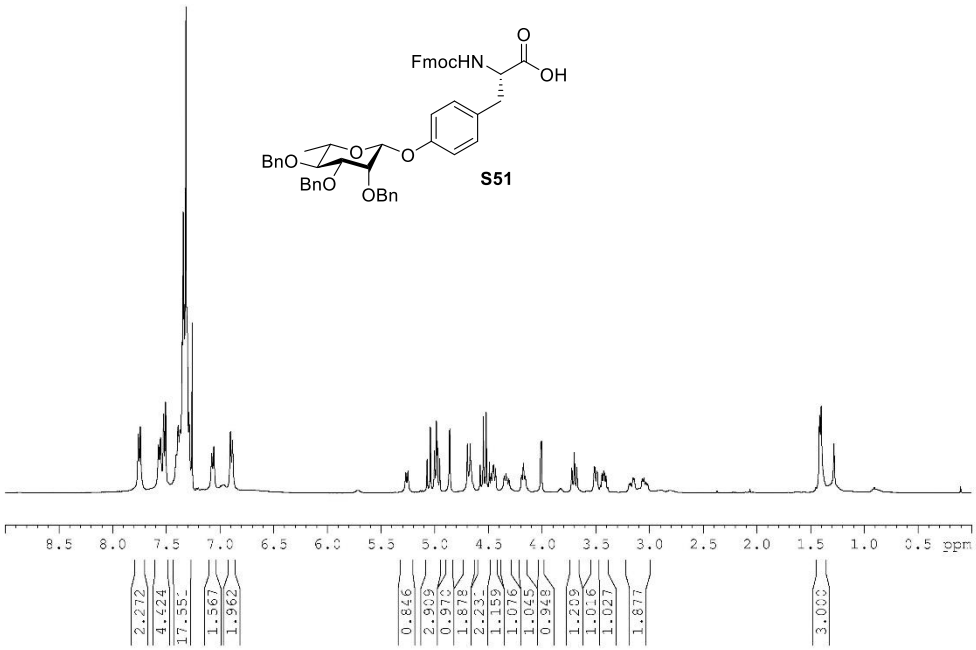
Compound S50 - ^1H NMR Spectrum – $CDCl_3$, 400 MHz



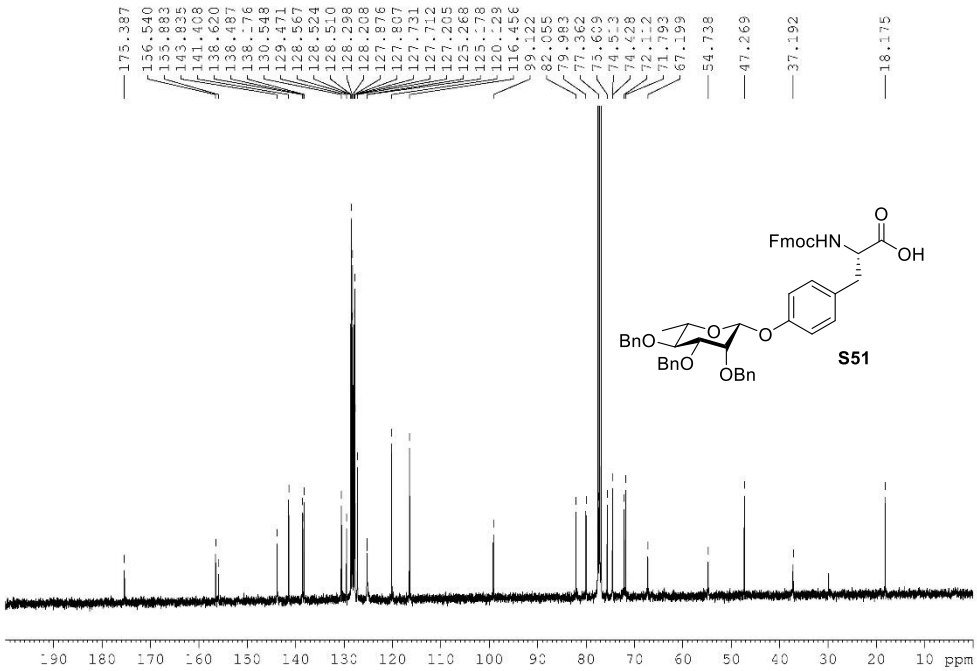
Compound S50 – ^{13}C NMR Spectrum –$CDCl_3$, 400 MHz



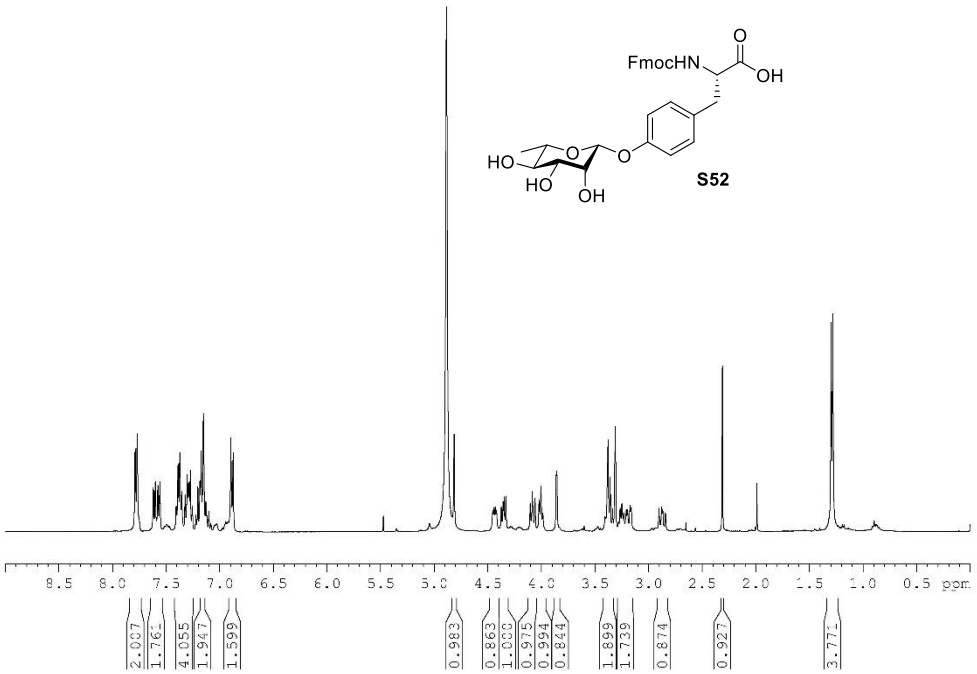
Compound S51 - ^{1}H NMR Spectrum – $CDCl_3$, 400 MHz



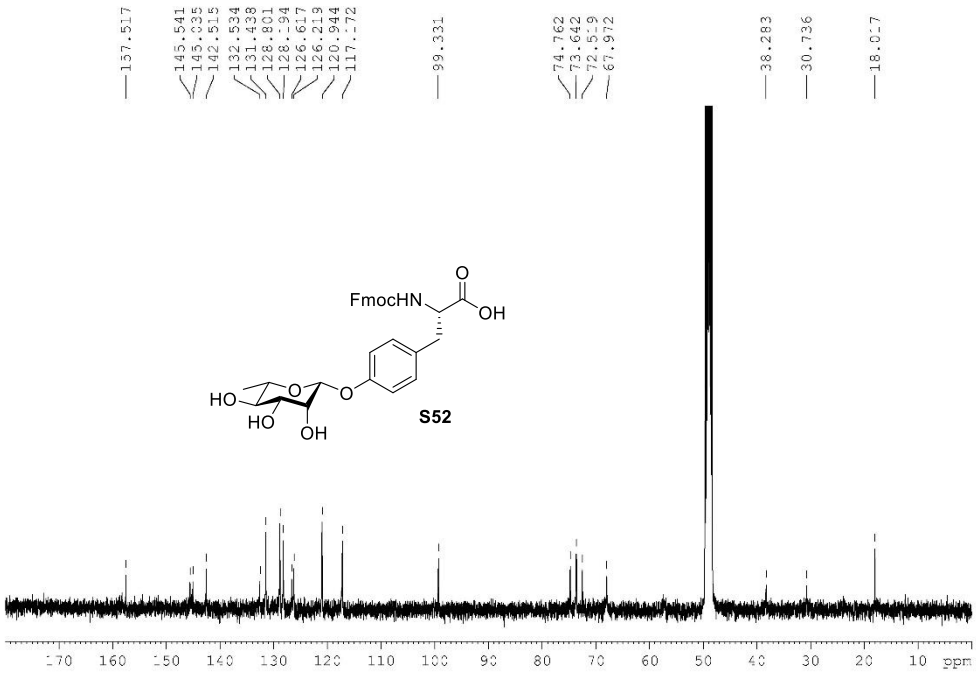
Compound S51 – ^{13}C NMR Spectrum –$CDCl_3$, 400 MHz



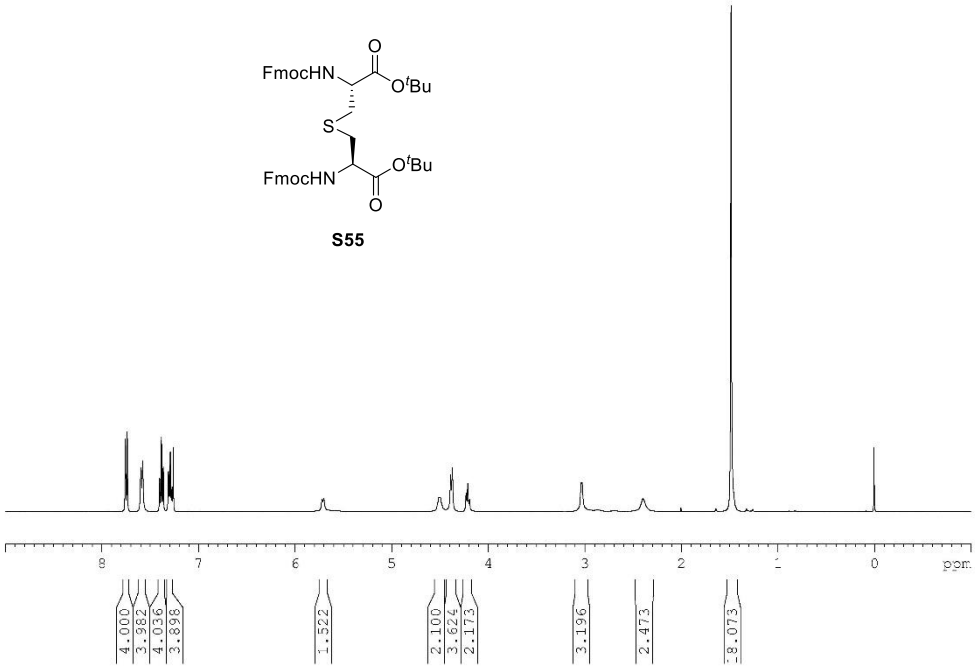
Compound S52 - ^{1}H NMR Spectrum – CD_3OD, 400 MHz



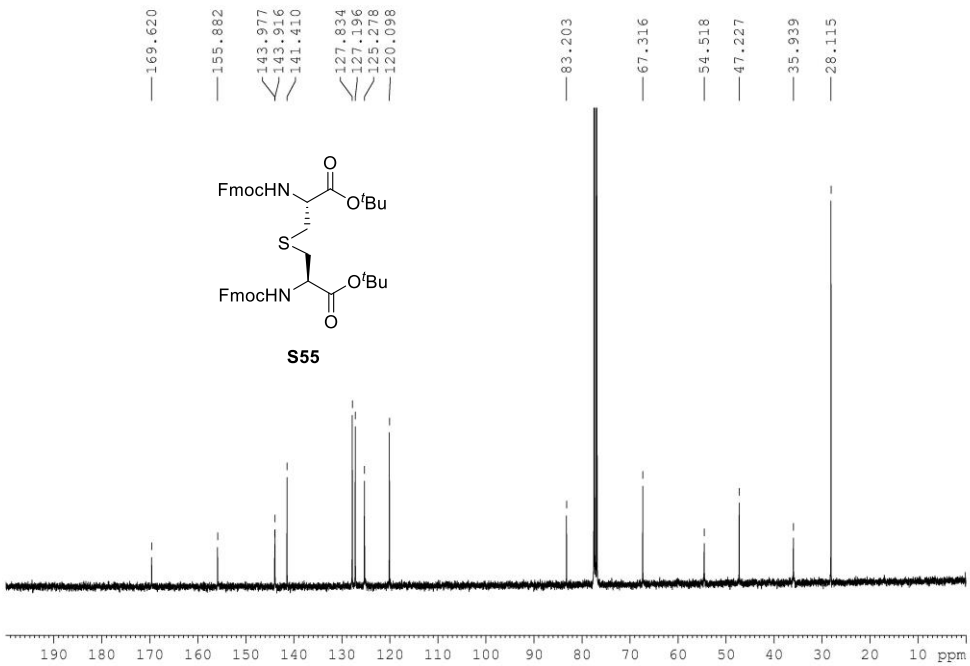
Compound S52 – ^{13}C NMR Spectrum –CD_3OD, 400 MHz



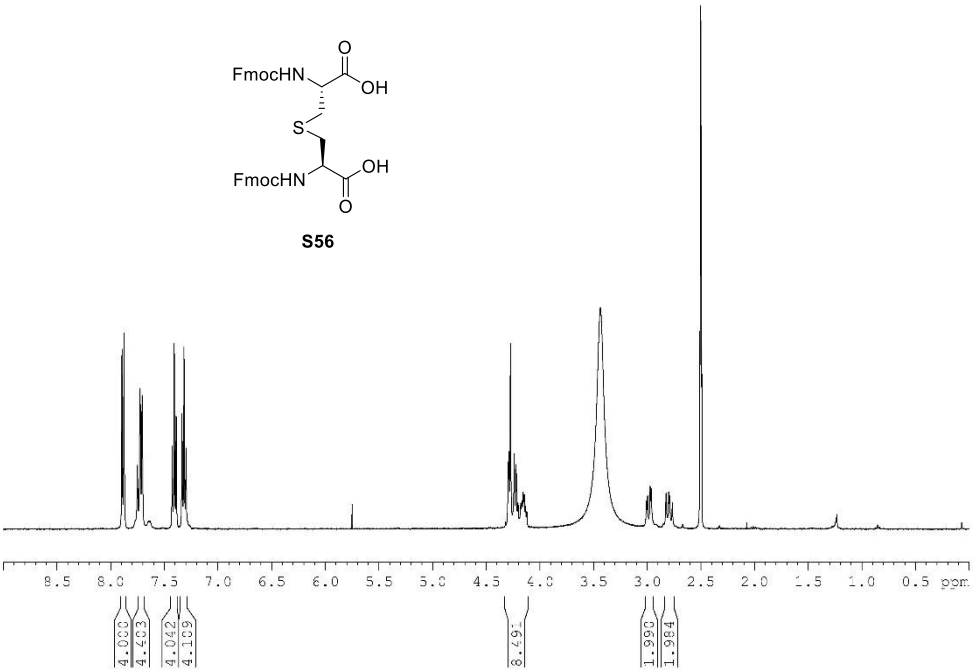
Compound S55 - ^{1}H NMR Spectrum – $CDCl_3$, 400 MHz



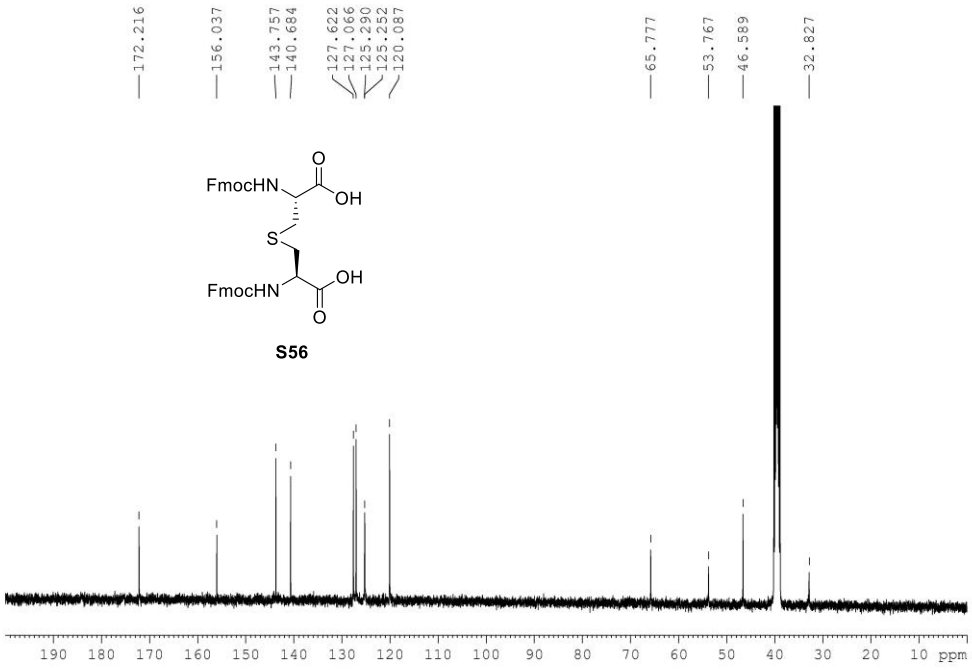
Compound S55 – ^{13}C NMR Spectrum – $CDCl_3$, 100 MHz



Compound S56 - ^{1}H NMR Spectrum – DMSO-d^6, 400 MHz



Compound S56 – ^{13}C NMR Spectrum – DMSO-d^6, 100 MHz



VI. GENERAL PROCEDURES FOR PEPTIDE SYNTHESIS

6.1 Solid-phase peptide synthesis

Pre-load an amino acid to 2-chlorotritylchloride resin[S19]

To a mixture of Fmoc-amino acid (1.0 equiv) and 2-chlorotritylchloride resin was added dry DCM (approx. 10 mL per gram of resin) and DIEA (4.0 equiv). The reaction was agitated for 2 hours. The resin was collected and washed with 17/2/1 (*v/v/v*) of DCM/MeOH/DIEA (× 3), DCM (× 3), DMF (× 2), DCM (× 3), and dried *in vacuo* for 12 hours before the loading test.

Determination of resin loading[S20]

Dry Fmoc amino-acid resin (W_{resin} = approx. 5 μmol with respect to Fmoc) was weighted into a clean test tube, followed by the addition of 2 mL of 2% DBU in DMF. The mixture was agitated gently for 30 min, and then diluted to 10 mL with CH_3CN. 2 mL of the resulting solution was taken out and diluted to 25 mL in a 50 mL centrifuge tube as the test solution. A reference solution was prepared in the same manner without the addition of resin.

The silica UV cell was filled with reference solution to blank the U.V. spectrophotometer. The solution in the silica UV cell was changed to the test solution after washing with the test solution for three times. The optical density at 304 nm was recorded for three times and the average value was calculated as Abs_{sample}. The Fmoc loading of resin could be calculated using the equation below:

$$\text{Fmoc loading: mmol/g} = Abs_{sample} * 125/(\varepsilon_{304\ nm} * W_{resin})$$

The extinction coefficient of dibenzofulvene at 304 nm is $\varepsilon_{304\ nm} = 7624\ M^{-1}cm^{-1}$.

Glycopeptide synthesis

Glycopeptides were synthesized under standard Fmoc protocols manually using DMF as solvent, deblocking for 5 min (×2) in piperidine/DBU/DMF (2:2:96, *v/v/v*). Excess Fmoc amino acids (4.0 equiv) and coupling reagent (HATU, 4.0 equiv) were employed

for each cycle (20 min), DIEA (6.0 equiv) was used as base in the coupling steps. An extra coupling cycle was needed for the installation the residues located at the sites right after the glycosylated amino acids.

For the steps of coupling glycosylated amino acids and the lanthionine building block **S56**, the corresponding Fmoc amino acids (0.6 equiv for **S56**, and 1.2 equiv for other glycosylated amino acids), HATU (1.2 equiv) and DIEA (2.4 equiv) were employed for each cycle (2 h × 2).

6.2 Preparation of peptidyl acids

Upon completion of the Fmoc removal of solid-phase peptide synthesis, the peptides on resin were treated with a solution of hydrazine hydrate in DMF (5:95, *v/v*) for 16 h at room temperature to remove the acetyl groups on the carbohydrates, where approx. 1 mL solution was needed for the synthetic scale of 0.01 mmol. For β-Mannosyl peptide **S74** and β-Rhamnosyl peptide **S90**, this step for removing acetyl group was not necessary because there was no protecting group on mannose in the Fmoc-Tyr(β-Man)-OH building block (**S47**, *cf.* Page 52, Section 4.3) and Fmoc-Tyr(β-Rha)-OH building block (**S52**, *cf.* Page 57, Section 4.4). For β-GalNAc peptide **18,** β-Arabinosyl peptide **20**, β-D-Fucosyl peptide **22**, α-D-Fucosyl peptide **23** and β-L-Fucosyl peptide **26**, the glycosidic bonds were not stable under hydrazine hydrate treatment. These peptides were directly cleaved from resin bearing acetyl group and conducted liquid-phase deprotection following procedure **6.4**.

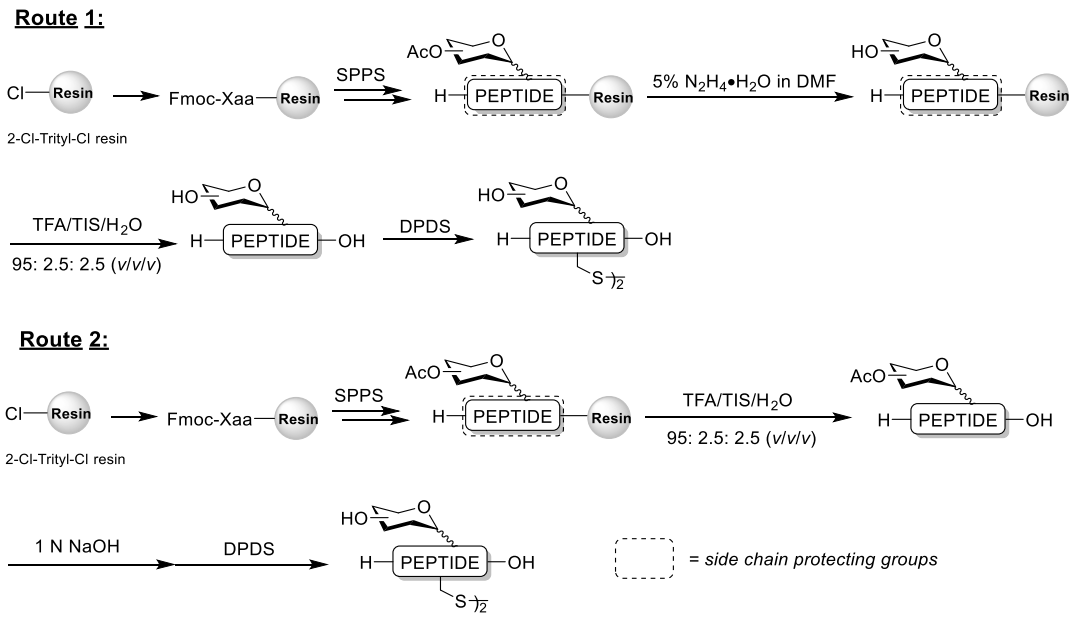
Resin cleavage and global deprotection was performed in a cocktail solution of TFA/H_2O/TIPS (95:2.5:2.5, *v/v/v*) for 2 h. The resin was then removed by filtration, and the filtrate was concentrated under a nitrogen atmosphere. The resulting residue was washed with cold diethyl ether to give a white solid, which was then dissolved in a mixture of acetonitrile and water containing 5% of acetic acid. The resulting solution was ready for HPLC purification after filtration.

6.3 Preparation of dimerized glycopeptides

The purified glycopeptide monomer (0.05 mmol) with a free cysteine was dissolved in CH_3CN/H_2O (2 ml/2 ml) at 37 ℃, followed by the addition of a solution of dipyridine disulfide (DPDS, 5.5 mg, 0.025 mmol) in 0.4 ml of MeOH. The reaction was monitored by LCMS and upon full conversion, the solution was diluted with 2 ml of H_2O containing 5% of acetic acid, and then purified using preparative HPLC.

6.4 Liquid-phase deprotection

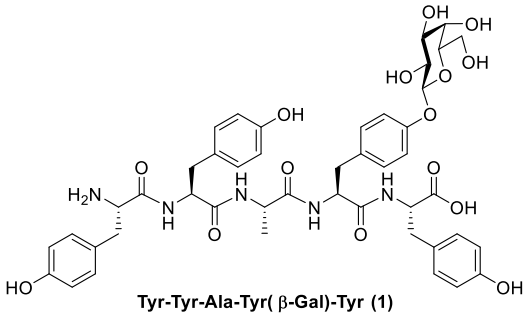
The lyophilized powder of glycopeptides bearing acetyl groups was dissolved in 1 N NaOH aqueous solution with a concentration of 5 mg/ml and stirred under r.t. for 1 h. Trifluoroacetic acid was used to neutralize the pH and the solution was dried under lyophilization overnight. The obtained powder could be directed used in dimerization following procedure **6.3**.



Scheme S6. Preparation of dimerized glycopeptides

VII. PREPARATION AND CHARACTERIZATION OF GLYCOPEPTIDES

Glycopeptide 1



Chemical Formula: $C_{45}H_{53}N_5O_{15}$
Exact Mass: 903.3
Molecular Weight: 903.9

Glycopeptide **1** was prepared following the General Procedures **6.1** and **6.2** described above on a 0.02 mmol scale. Purification of the crude peptide using preparative HPLC (10 to 30% solvent B over 30 min, Dr. Maisch ReproSil 300 C18 column) afforded peptide **1** as a white solid after lyophilization (4.6 mg, 27%). Analytical HPLC: t_R = 19.6 min (10 to 30% solvent B over 30 min, Agilent C18 column); ESI-MS (*m/z*): $[M+H]^+$ calcd for $C_{45}H_{54}N_5O_{15}$: 904.9 (average isotope), $[M\text{-}Gal+H]^+$: 741.8; found 904.0, 742.0.

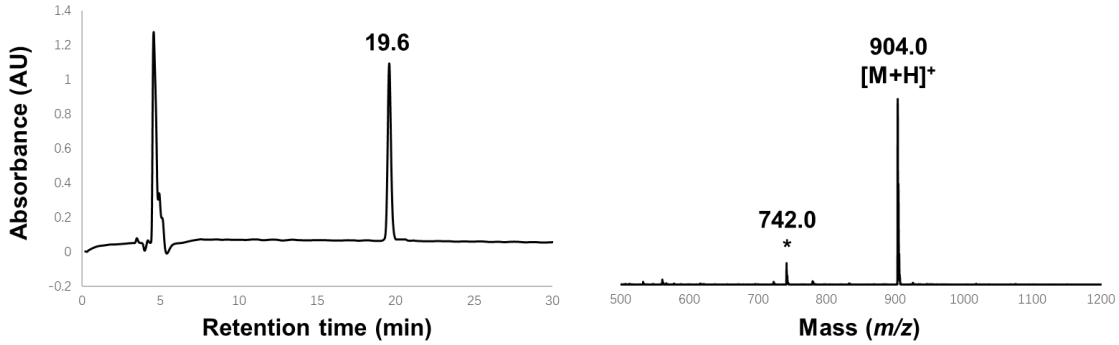
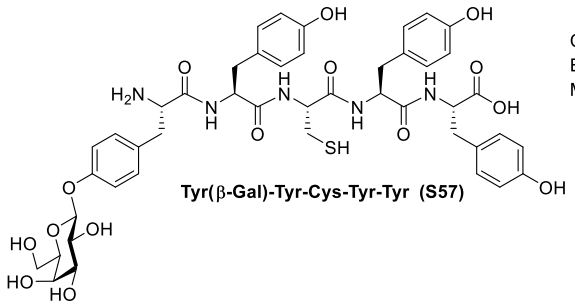


Figure S20. Left: UV trace from LC-MS analysis of glycopeptide **1**; Right: ESI-MS data of glycopeptide **1**. *Signal denotes the mass of $[M\text{-}Gal+H]^+$ corresponding to the galactose-cleaved species generated during ionization in the mass spectrometer.

Glycopeptide S57



Chemical Formula: $C_{45}H_{53}N_5O_{15}S$
Exact Mass: 935.3
Molecular Weight: 936.0

Glycopeptide **S57** was prepared following the General Procedures **6.1** and **6.2** described above on a 0.05 mmol scale. Purification of the crude peptide using preparative HPLC (10 to 30% solvent B over 30 min, Dr. Maisch ReproSil 300 C18 column) afforded peptide **S57** as a white solid after lyophilization (27.5 mg, 59%). Analytical HPLC: t_R = 22.7 min (10 to 30% solvent B over 30 min, Agilent C18 column); ESI-MS (*m/z*): $[M+H]^+$ calcd for $C_{45}H_{54}N_5O_{15}S$: 937.0 (average isotope), $[M\text{-}Gal+H]^+$: 773.9; found 936.3, 774.3.

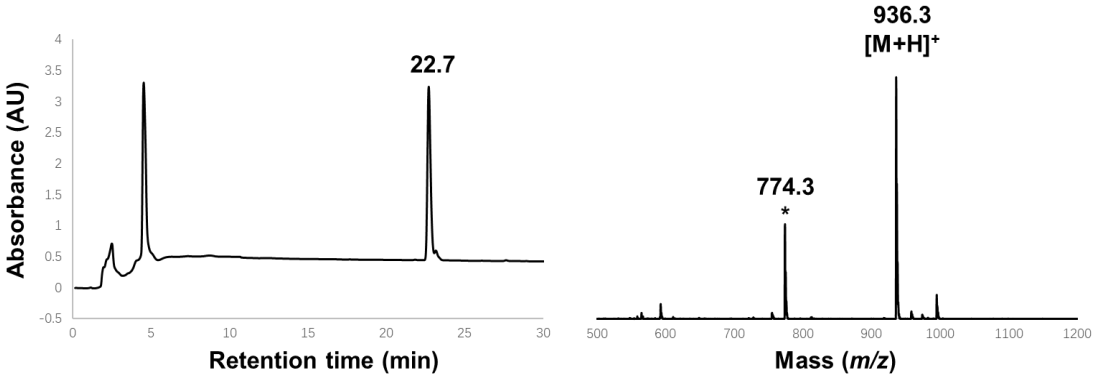
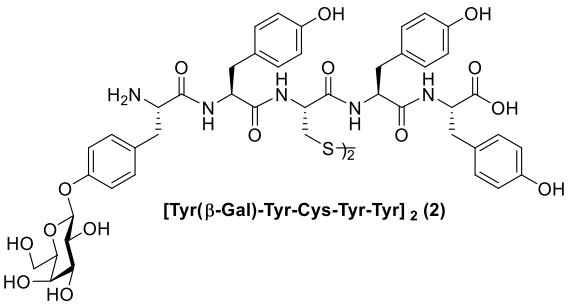


Figure S21. Left: UV trace from LC-MS analysis of glycopeptide **S57**; Right: ESI-MS data of glycopeptide **S57**. *Signal denotes the mass of $[M\text{-}Gal+H]^+$ corresponding to the galactose-cleaved species generated during ionization in the mass spectrometer.

Glycopeptide 2



Chemical Formula: $C_{90}H_{104}N_{10}O_{30}S_2$
Exact Mass: 1868.6
Molecular Weight: 1870.0

Glycopeptide **2** was prepared following the General Procedure **6.3** described above. Purification of the crude peptide using preparative HPLC (10 to 35% solvent B over 30 min, Dr. Maisch ReproSil 300 C18 column) afforded peptide **2** as a white solid after lyophilization (21.3 mg, 78%). Analytical HPLC: t_R = 23.7 min (10 to 35% solvent B over 30 min, Agilent C18 column); ESI-MS (*m/z*): $[M+H]^+$ calcd for $C_{90}H_{105}N_{10}O_{30}S_2$: 1871.0 (average isotope), $[M+2H]^{2+}$: 936.0, $[M\text{-}Gal+2H]^{2+}$: 854.4, $[M\text{-}2Gal+2H]^{2+}$: 772.8; found 936.0, 854.5, 773.5.

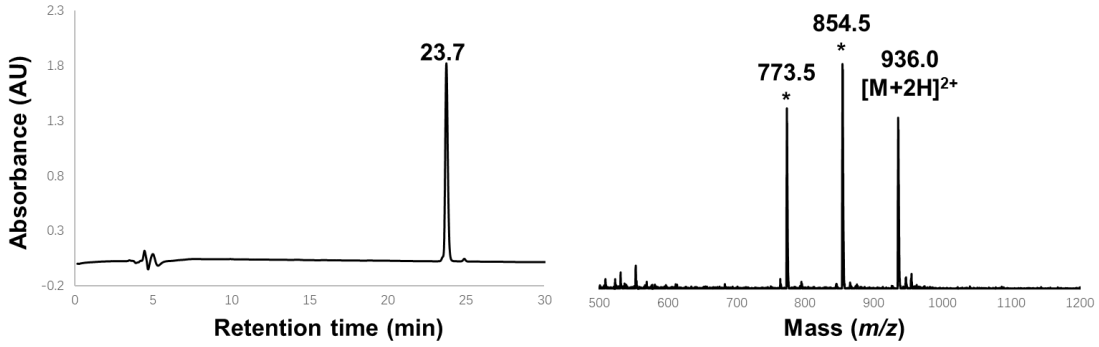
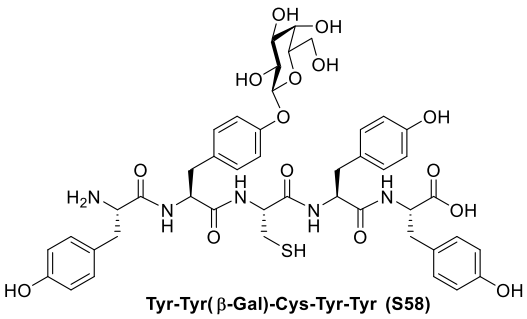


Figure S22. Left: UV trace from LC-MS analysis of glycopeptide **2**; Right: ESI-MS data of glycopeptide **2**. *Signals denote the mass of $[M\text{-}Gal+2H]^{2+}$ and $[M\text{-}2Gal+2H]^{2+}$ corresponding to the singly or doubly galactose-cleaved species respectively, generated during ionization in the mass spectrometer.

Glycopeptide S58



Chemical Formula: $C_{45}H_{53}N_5O_{15}S$
Exact Mass: 935.3
Molecular Weight: 936.0

Glycopeptide **S58** was prepared following the General Procedures **6.1** and **6.2** described above on a 0.05 mmol scale. Purification of the crude peptide using preparative HPLC (10 to 30% solvent B over 30 min, Dr. Maisch ReproSil 300 C18 column) afforded peptide **S58** as a white solid after lyophilization (38.0 mg, 81%). Analytical HPLC: t_R = 22.8 min (10 to 30% solvent B over 30 min, Agilent C18 column); ESI-MS (*m/z*): $[M+H]^+$ calcd for $C_{45}H_{54}N_5O_{15}S$: 937.0 (average isotope), $[M\text{-}Gal+H]^+$: 773.9; found 936.3, 774.4.

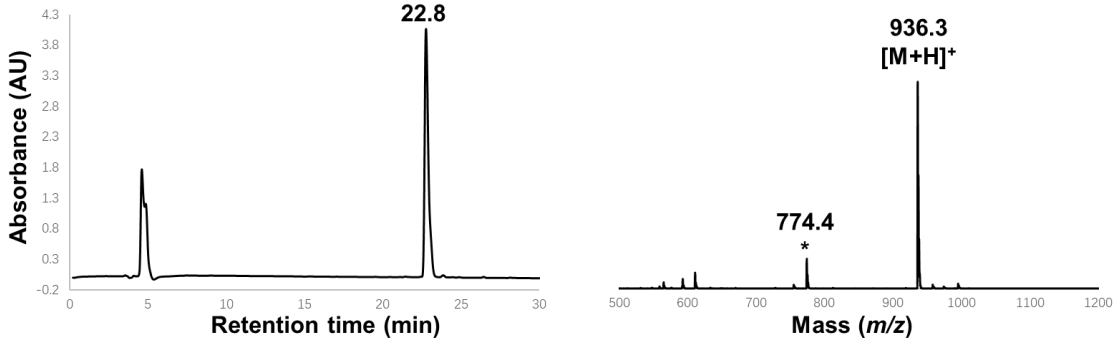
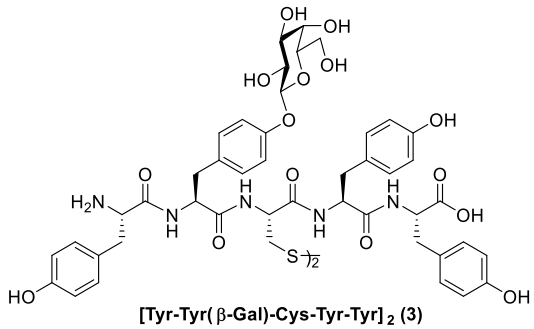


Figure S23. Left: UV trace from LC-MS analysis of glycopeptide **S58**; Right: ESI-MS data of glycopeptide **S58**. *Signal denotes the mass of $[M\text{-}Gal+H]^+$ corresponding to the galactose-cleaved species generated during ionization in the mass spectrometer.

Glycopeptide 3



Chemical Formula: $C_{90}H_{104}N_{10}O_{30}S_2$
Exact Mass: 1868.6
Molecular Weight: 1870.0

Glycopeptide **3** was prepared following the General Procedure **6.3** described above. Purification of the crude peptide using preparative HPLC (10 to 35% solvent B over 30 min, Dr. Maisch ReproSil 300 C18 column) afforded peptide **3** as a white solid after lyophilization (24.7 mg, 65%). Analytical HPLC: t_R = 22.8 min (10 to 35% solvent B over 30 min, Agilent C18 column); ESI-MS (*m/z*): $[M+H]^+$ calcd for $C_{90}H_{105}N_{10}O_{30}S_2$: 1871.0 (average isotope), $[M+2H]^{2+}$: 936.0, $[M\text{-}Gal+2H]^{2+}$: 854.4, $[M\text{-}2Gal+2H]^{2+}$: 772.8; found 935.7, 854.6, 773.5.

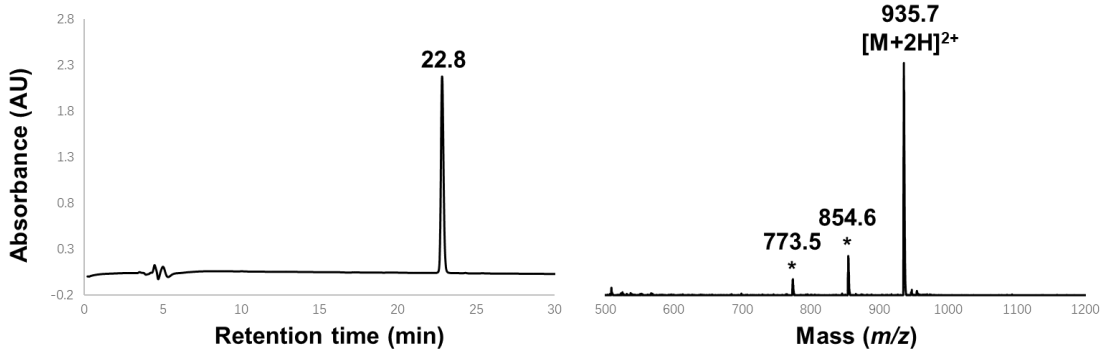
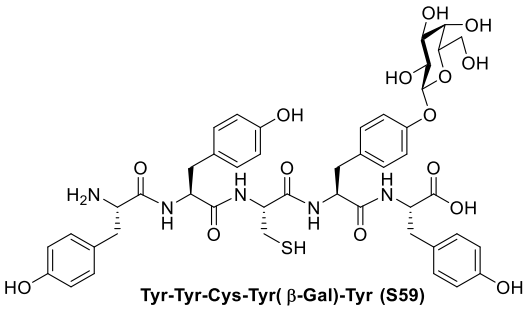


Figure S24. Left: UV trace from LC-MS analysis of glycopeptide **3**; Right: ESI-MS data of glycopeptide **3**. *Signals denote the mass of $[M\text{-}Gal+2H]^{2+}$ and $[M\text{-}2Gal+2H]^{2+}$ corresponding to the singly or doubly galactose-cleaved species respectively, generated during ionization in the mass spectrometer.

Glycopeptide S59



Chemical Formula: $C_{45}H_{53}N_5O_{15}S$
Exact Mass: 935.3
Molecular Weight: 936.0

Glycopeptide **S59** was prepared following the General Procedures **6.1** and **6.2** described above on a 0.10 mmol scale. Purification of the crude peptide using preparative HPLC (10 to 30% solvent B over 30 min, Dr. Maisch ReproSil 300 C18 column) afforded peptide **S59** as a white solid after lyophilization (43.1 mg, 46%). Analytical HPLC: t_R = 18.1 min (5 to 50% solvent B over 30 min, Agilent C18 column); ESI-MS (*m/z*): $[M+H]^+$ calcd for $C_{45}H_{54}N_5O_{15}S$: 937.0 (average isotope), $[M\text{-}Gal+H]^+$: 773.9; found 936.8, 774.7.

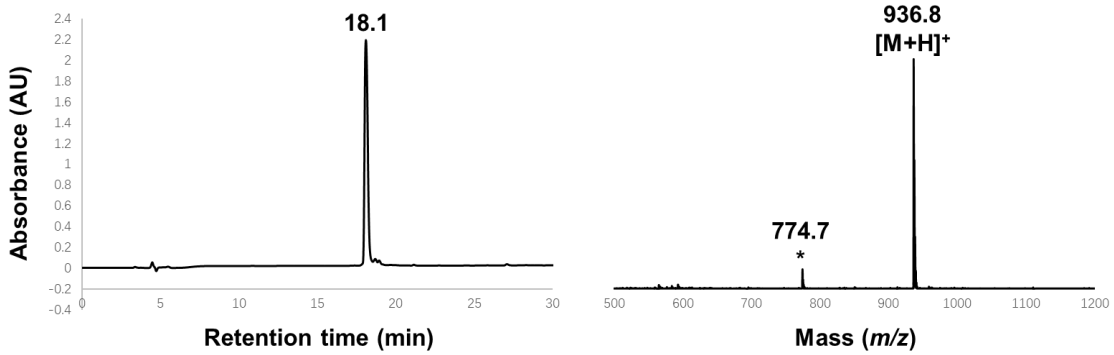
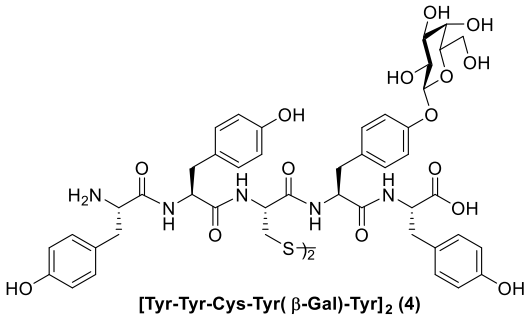


Figure S25. Left: UV trace from LC-MS analysis of glycopeptide **S59**; Right: ESI-MS data of glycopeptide **S59**. *Signal denotes the mass of $[M\text{-}Gal+H]^+$ corresponding to the galactose-cleaved species generated during ionization in the mass spectrometer.

Glycopeptide 4



Chemical Formula: $C_{90}H_{104}N_{10}O_{30}S_2$
Exact Mass: 1868.6
Molecular Weight: 1870.0

Glycopeptide **4** was prepared following the General Procedure **6.3** described above. Purification of the crude peptide using preparative HPLC (10 to 35% solvent B over 30 min, Dr. Maisch ReproSil 300 C18 column) afforded peptide **4** as a white solid after lyophilization (35.8 mg, 77%). Analytical HPLC: t_R = 19.7 min (5 to 50% solvent B over 30 min, Agilent C18 column); ESI-MS (*m/z*): $[M+H]^+$ calcd for $C_{90}H_{105}N_{10}O_{30}S_2$: 1871.0 (average isotope), $[M+2H]^{2+}$: 936.0, $[M\text{-}Gal+2H]^{2+}$: 854.4, $[M\text{-}2Gal+2H]^{2+}$: 772.8; found 935.9, 854.3, 773.3.

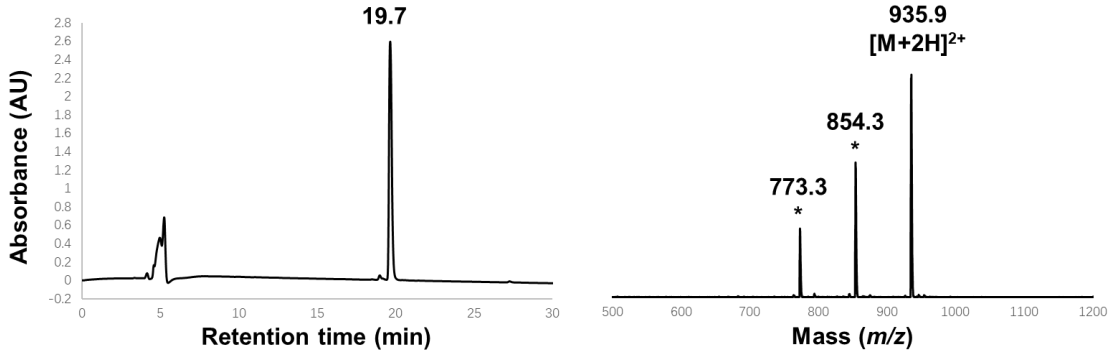
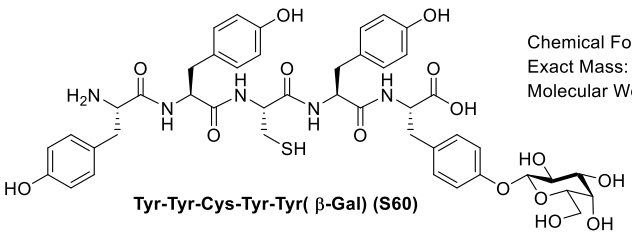


Figure S26. Left: UV trace from LC-MS analysis of glycopeptide **4**; Right: ESI-MS data of glycopeptide **4**. *Signals denote the mass of $[M\text{-}Gal+2H]^{2+}$ and $[M\text{-}2Gal+2H]^{2+}$ corresponding to the singly or doubly galactose-cleaved species respectively, generated during ionization in the mass spectrometer.

Glycopeptide S60



Chemical Formula: $C_{45}H_{53}N_5O_{15}S$
Exact Mass: 935.3
Molecular Weight: 936.0

Glycopeptide **S60** was prepared following the General Procedures **6.1** and **6.2** described above on a 0.03 mmol scale. Purification of the crude peptide using preparative HPLC (10 to 30% solvent B over 30 min, Dr. Maisch ReproSil 300 C18 column) afforded peptide **S60** as a white solid after lyophilization (43.1 mg, 46%). Analytical HPLC: t_R = 19.1 min (5 to 50% solvent B over 30 min, Agilent C18 column); ESI-MS (*m/z*): $[M+H]^+$ calcd for $C_{45}H_{54}N_5O_{15}S$: 937.0 (average isotope), $[M\text{-}Gal+H]^+$: 773.9; found 936.1, 774.1.

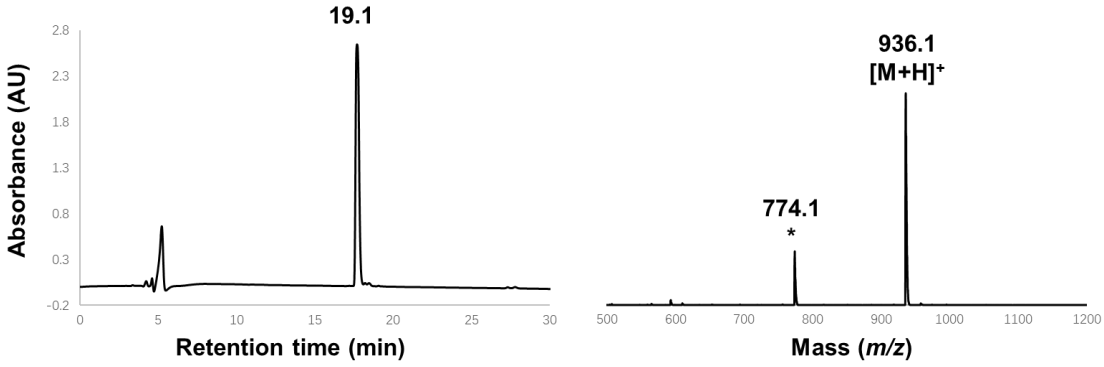
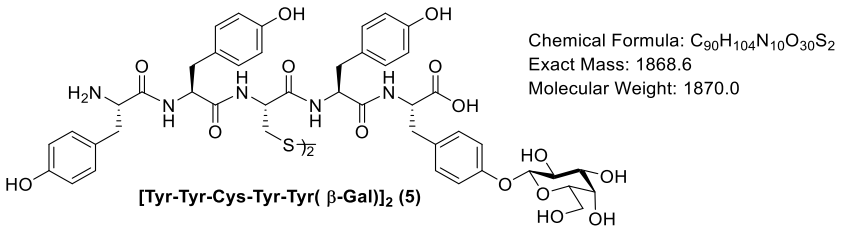


Figure S27. Left: UV trace from LC-MS analysis of glycopeptide **S60**; Right: ESI-MS data of glycopeptide **S60**. *Signal denotes the mass of $[M\text{-}Gal+H]^+$ corresponding to the galactose-cleaved species generated during ionization in the mass spectrometer.

Glycopeptide 5



Glycopeptide **5** was prepared following the General Procedure **6.3** described above. Purification of the crude peptide using preparative HPLC (10 to 35% solvent B over 30 min, Dr. Maisch ReproSil 300 C18 column) afforded peptide **5** as a white solid after lyophilization (35.8 mg, 77%). Analytical HPLC: t_R = 19.0 min (5 to 50% solvent B over 30 min, Agilent C18 column); ESI-MS (*m/z*): $[M+H]^+$ calcd for $C_{90}H_{105}N_{10}O_{30}S_2$: 1871.0 (average isotope), $[M+2H]^{2+}$: 936.0, $[M\text{-}Gal+2H]^{2+}$: 854.4, $[M\text{-}2Gal+2H]^{2+}$: 772.8; found 935.3, 854.4, 773.3.

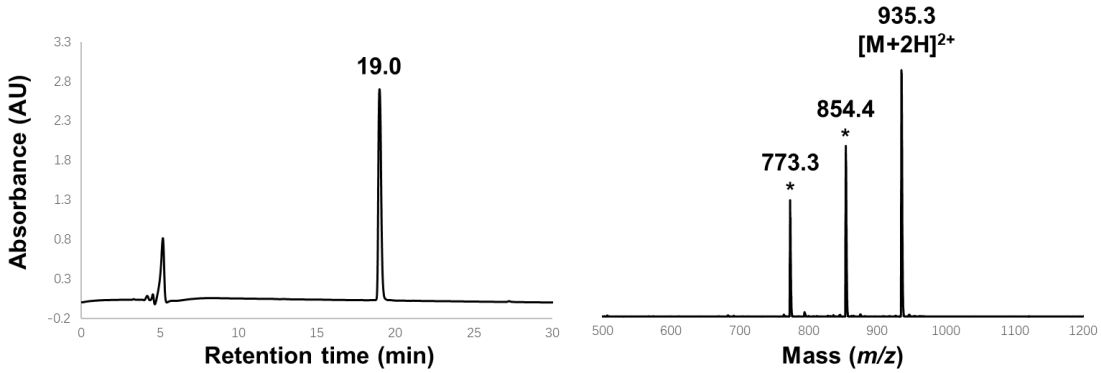
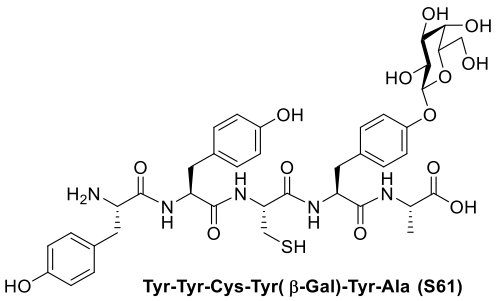


Figure S28. Left: UV trace from LC-MS analysis of glycopeptide **5**; Right: ESI-MS data of glycopeptide **5**. *Signals denote the mass of $[M\text{-}Gal+2H]^{2+}$ and $[M\text{-}2Gal+2H]^{2+}$ corresponding to the singly or doubly galactose-cleaved species respectively, generated during ionization in the mass spectrometer.

Glycopeptide S61



Chemical Formula: $C_{39}H_{49}N_5O_{14}S$
Exact Mass: 843.3
Molecular Weight: 843.9

Glycopeptide **S61** was prepared following the General Procedures **6.1** and **6.2** described above on a 0.02 mmol scale. Purification of the crude peptide using preparative HPLC (10 to 30% solvent B over 30 min, Dr. Maisch ReproSil 300 C18 column) afforded peptide **S61** as a white solid after lyophilization (16.5 mg, 98%). Analytical HPLC: t_R = 16.0 min (10 to 30% solvent B over 30 min, Agilent C18 column); ESI-MS (*m/z*): $[M+H]^+$ calcd for $C_{39}H_{50}N_5O_{14}S$: 844.9 (average isotope), $[M\text{-}Gal+H]^+$: 681.8; found 843.9, 681.9.

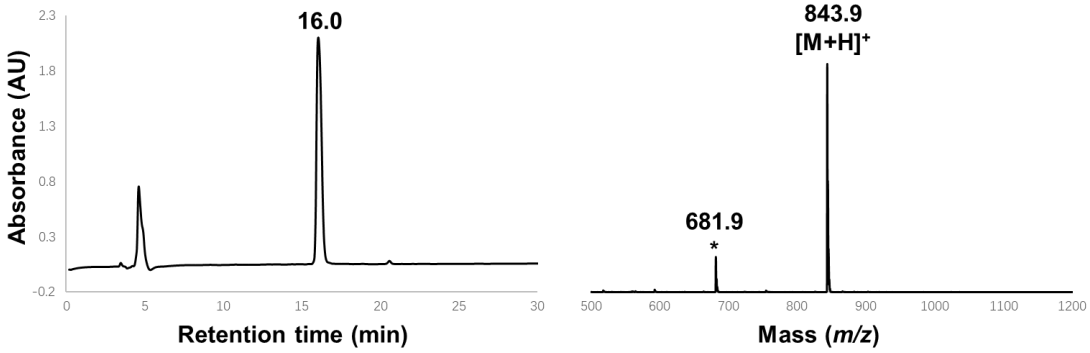
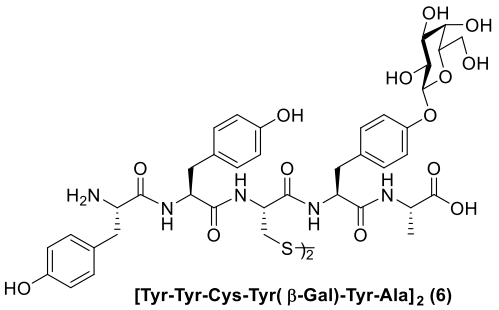


Figure S29. Left: UV trace from LC-MS analysis of glycopeptide **S61**; Right: ESI-MS data of glycopeptide **S61**. *Signal denotes the mass of $[M\text{-}Gal+H]^+$ corresponding to the galactose-cleaved species generated during ionization in the mass spectrometer.

Glycopeptide 6



Chemical Formula: $C_{78}H_{96}N_{10}O_{28}S_2$
Exact Mass: 1684.6
Molecular Weight: 1685.8

Glycopeptide **6** was prepared following the General Procedure **6.3** described above. Purification of the crude peptide using preparative HPLC (10 to 35% solvent B over 30 min, Dr. Maisch ReproSil 300 C18 column) afforded peptide **6** as a white solid after lyophilization (13.2 mg, 80%). Analytical HPLC: t_R = 18.4 min (10 to 35% solvent B over 30 min, Agilent C18 column); ESI-MS (*m/z*): $[M+H]^+$ calcd for $C_{78}H_{97}N_{10}O_{28}S_2$: 1686.8 (average isotope), $[M+2H]^{2+}$: 843.9, $[M\text{-}Gal+2H]^{2+}$: 762.3, $[M\text{-}2Gal+2H]^{2+}$: 680.8; found 843.4, 762.2, 681.2.

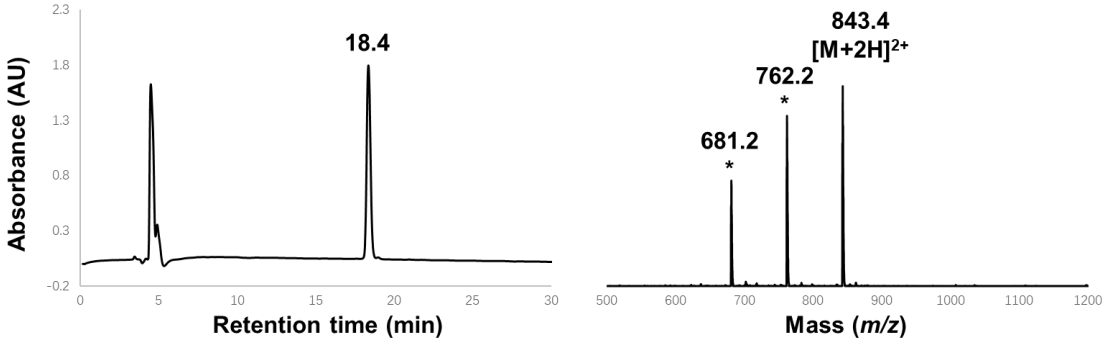
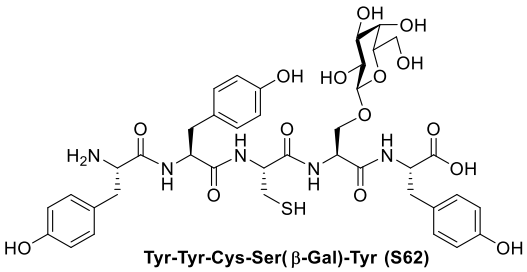


Figure S30. Left: UV trace from LC-MS analysis of glycopeptide **6**; Right: ESI-MS data of glycopeptide **6**. *Signals denote the mass of $[M\text{-}Gal+2H]^{2+}$ and $[M\text{-}2Gal+2H]^{2+}$ corresponding to the singly or doubly galactose-cleaved species respectively, generated during ionization in the mass spectrometer.

Glycopeptide S62



Chemical Formula: $C_{39}H_{49}N_5O_{15}S$
Exact Mass: 859.3
Molecular Weight: 859.9

Glycopeptide **S62** was prepared following the General Procedures **6.1** and **6.2** described above on a 0.02 mmol scale. Purification of the crude peptide using preparative HPLC (10 to 30% solvent B over 30 min, Dr. Maisch ReproSil 300 C18 column) afforded peptide **S62** as a white solid after lyophilization (5.93 mg, 35%). Analytical HPLC: t_R = 18.9 min (10 to 30% solvent B over 30 min, Agilent C18 column); ESI-MS (*m/z*): $[M+H]^+$ calcd for $C_{39}H_{50}N_5O_{15}S$: 860.9 (average isotope), $[M\text{-}Gal+H]^+$: 697.8; found 859.9, 697.9.

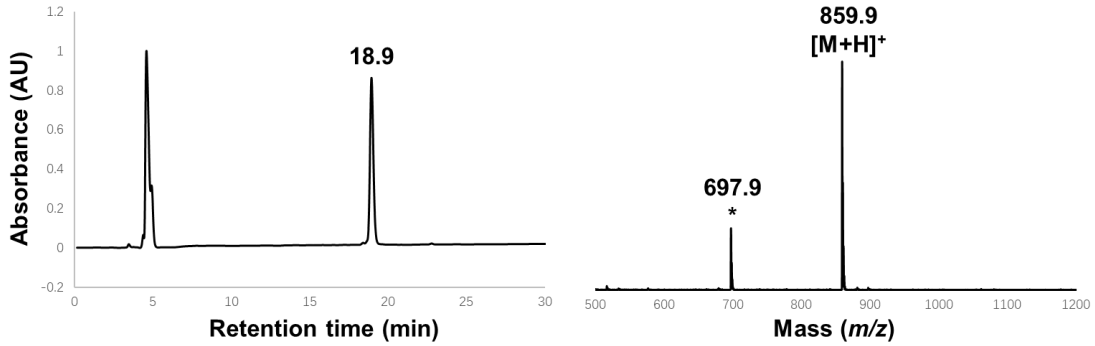
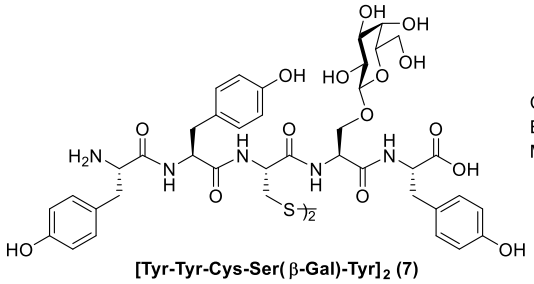


Figure S31. Left: UV trace from LC-MS analysis of glycopeptide **S62**; Right: ESI-MS data of glycopeptide **S62**. *Signal denotes the mass of $[M\text{-}Gal+H]^+$ corresponding to the galactose-cleaved species generated during ionization in the mass spectrometer.

Glycopeptide 7



Chemical Formula: $C_{78}H_{96}N_{10}O_{30}S_2$
Exact Mass: 1716.6
Molecular Weight: 1717.8

Glycopeptide **7** was prepared following the General Procedure **6.3** described above. Purification of the crude peptide using preparative HPLC (10 to 35% solvent B over 30 min, Dr. Maisch ReproSil 300 C18 column) afforded peptide **7** as a white solid after lyophilization (4.2 mg, 70%). Analytical HPLC: t_R = 19.5 min (10 to 35% solvent B over 30 min, Agilent C18 column); ESI-MS (*m/z*): $[M+H]^+$ calcd for $C_{78}H_{97}N_{10}O_{30}S_2$: 1718.8 (average isotope), $[M+2H]^{2+}$: 859.9, $[M\text{-}Gal+2H]^{2+}$: 778.3, $[M\text{-}2Gal+2H]^{2+}$: 696.8; found 859.3, 778.3, 697.2.

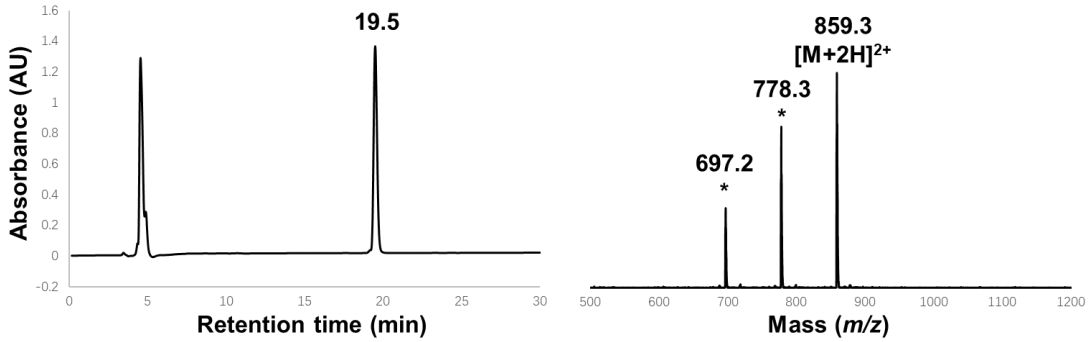
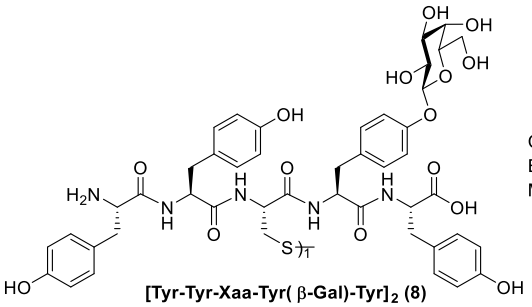


Figure S32. Left: UV trace from LC-MS analysis of glycopeptide **7**; Right: ESI-MS data of glycopeptide **7**. *Signals denote the mass of $[M\text{-}Gal+2H]^{2+}$ and $[M\text{-}2Gal+2H]^{2+}$ corresponding to the singly or doubly galactose-cleaved species respectively, generated during ionization in the mass spectrometer.

Glycopeptide 8



Chemical Formula: $C_{90}H_{104}N_{10}O_{30}S$
Exact Mass: 1836.7
Molecular Weight: 1837.9

Xaa = lanthionine (Ala-S-Ala)

Glycopeptide **8** was prepared following the General Procedures **6.1** and **6.2** described above on a 0.04 mmol scale. Purification of the crude peptide using preparative HPLC (10 to 35% solvent B over 30 min, Dr. Maisch ReproSil 300 C18 column) afforded peptide **8** as a white solid after lyophilization (17.9 mg, 25%). Analytical HPLC: t_R = 19.1 min (5 to 50% solvent B over 30 min, Agilent C18 column); ESI-MS (*m/z*): $[M+H]^+$ calcd for $C_{90}H_{105}N_{10}O_{30}S$: 1838.9 (average isotope), $[M+2H]^{2+}$: 920.0, $[M\text{-}Gal+2H]^{2+}$: 838.4, $[M\text{-}2Gal+2H]^{2+}$: 756.8; found 919.8, 838.8.

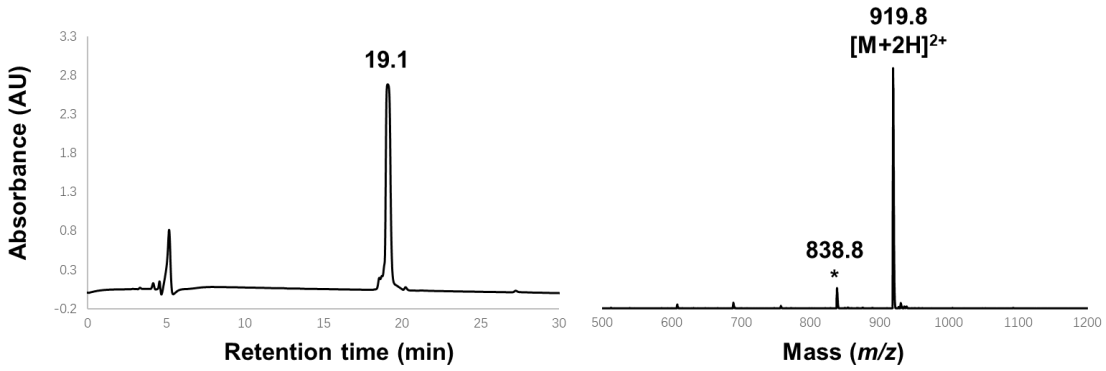
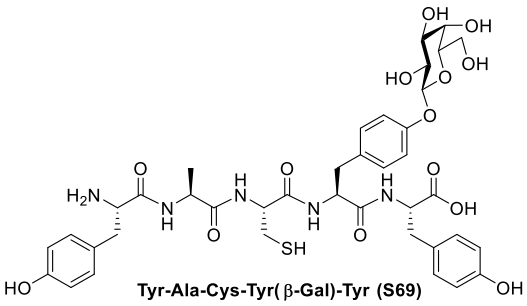


Figure S33. Left: UV trace from LC-MS analysis of glycopeptide **8**; Right: ESI-MS data of glycopeptide **8**. *Signal denotes the mass of $[M\text{-}Gal+2H]^{2+}$ corresponding to the singly galactose-cleaved species generated during ionization in the mass spectrometer.

Glycopeptide S69



Chemical Formula: $C_{39}H_{49}N_5O_{14}S$
Exact Mass: 843.3
Molecular Weight: 843.9

Glycopeptide **S69** was prepared following the General Procedures **6.1** and **6.2** described above on a 0.02 mmol scale. Purification of the crude peptide using preparative HPLC (10 to 30% solvent B over 30 min, Dr. Maisch ReproSil 300 C18 column) afforded peptide **S69** as a white solid after lyophilization (4.6 mg, 27%). Analytical HPLC: t_R = 18.6 min (10 to 30% solvent B over 30 min, Agilent C18 column); ESI-MS (*m/z*): $[M+H]^+$ calcd for $C_{39}H_{50}N_5O_{14}S$: 844.9 (average isotope), $[M\text{-}Gal+H]^+$: 681.8; found 843.9, 684.0.

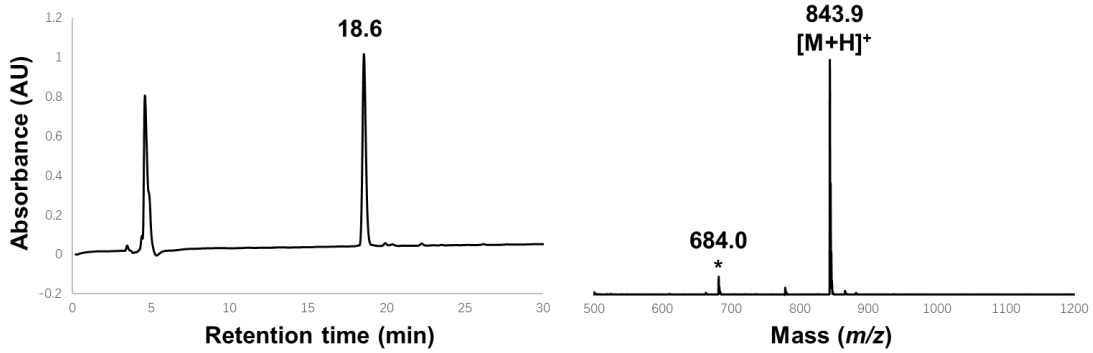
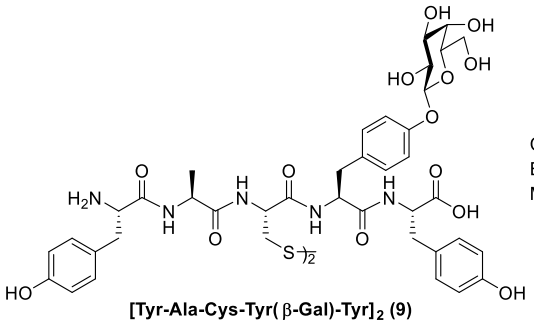


Figure S34. Left: UV trace from LC-MS analysis of glycopeptide **S69**; Right: ESI-MS data of glycopeptide **S69**. *Signal denotes the mass of $[M\text{-}Gal+H]^+$ corresponding to the galactose-cleaved species generated during ionization in the mass spectrometer.

Glycopeptide 9



Chemical Formula: $C_{78}H_{96}N_{10}O_{28}S_2$
Exact Mass: 1684.6
Molecular Weight: 1685.8

Glycopeptide **9** was prepared following the General Procedure **6.3** described above. Purification of the crude peptide using preparative HPLC (10 to 35% solvent B over 30 min, Dr. Maisch ReproSil 300 C18 column) afforded peptide **9** as a white solid after lyophilization (3.7 mg, 82%). Analytical HPLC: t_R = 19.6 min (10 to 35% solvent B over 30 min, Agilent C18 column); ESI-MS (*m/z*): $[M+H]^+$ calcd for $C_{78}H_{97}N_{10}O_{28}S_2$: 1686.8 (average isotope), $[M+2H]^{2+}$: 843.9, $[M\text{-}Gal+2H]^{2+}$: 762.3, $[M\text{-}2Gal+2H]^{2+}$: 680.8; found 843.2, 762.1, 681.2.

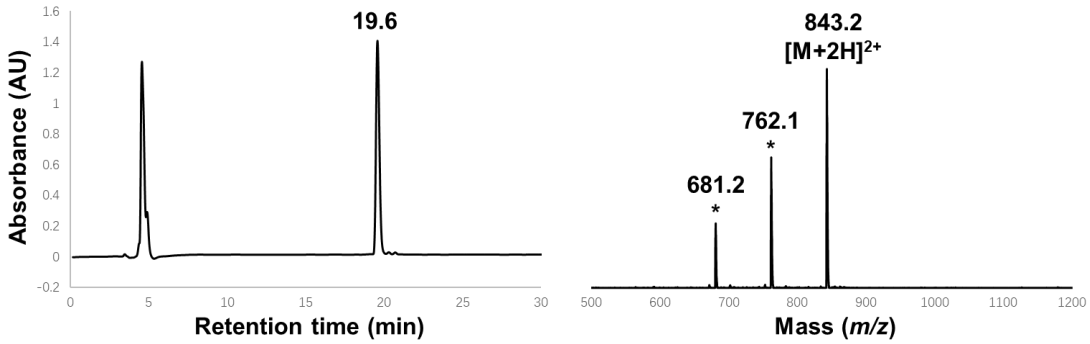
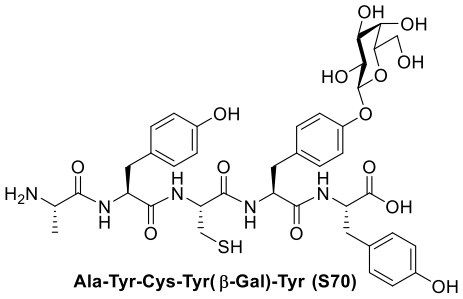


Figure S35. Left: UV trace from LC-MS analysis of glycopeptide **9**; Right: ESI-MS data of glycopeptide **9**. *Signals denote the mass of $[M\text{-}Gal+2H]^{2+}$ and $[M\text{-}2Gal+2H]^{2+}$ corresponding to the singly or doubly galactose-cleaved species respectively, generated during ionization in the mass spectrometer.

Glycopeptide S70



Chemical Formula: $C_{39}H_{49}N_5O_{14}S$
Exact Mass: 843.3
Molecular Weight: 843.9

Glycopeptide **S70** was prepared following the General Procedures **6.1** and **6.2** described above on a 0.02 mmol scale. Purification of the crude peptide using preparative HPLC (10 to 30% solvent B over 30 min, Dr. Maisch ReproSil 300 C18 column) afforded peptide **S70** as a white solid after lyophilization (4.5 mg, 27%). Analytical HPLC: t_R = 18.7 min (10 to 30% solvent B over 30 min, Agilent C18 column); ESI-MS (*m/z*): $[M+H]^+$ calcd for $C_{39}H_{50}N_5O_{14}S$: 844.9 (average isotope), $[M\text{-}Gal+H]^+$: 681.8; found 844.9, 684.1.

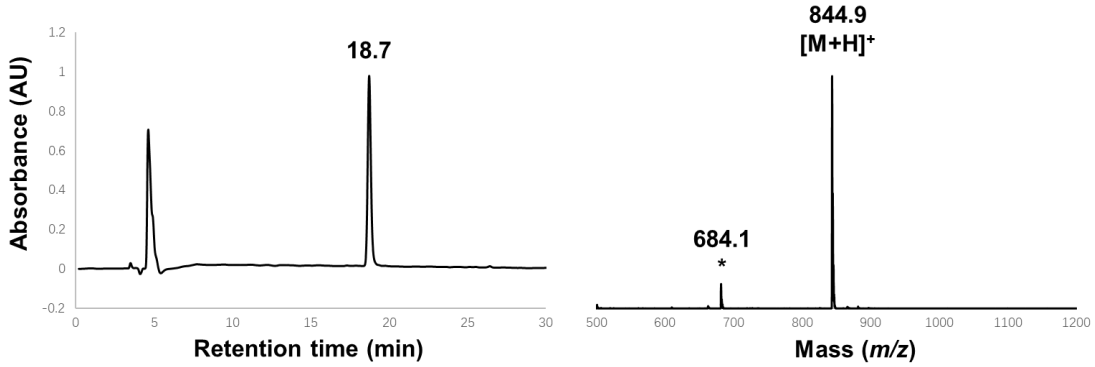
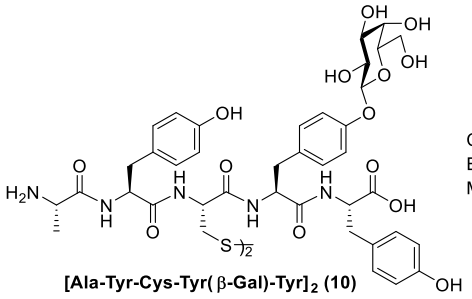


Figure S36. Left: UV trace from LC-MS analysis of glycopeptide **S70**; Right: ESI-MS data of glycopeptide **S70**. *Signal denotes the mass of $[M\text{-}Gal+H]^+$ corresponding to the galactose-cleaved species generated during ionization in the mass spectrometer.

Glycopeptide 10



Chemical Formula: $C_{78}H_{96}N_{10}O_{28}S_2$
Exact Mass: 1684.6
Molecular Weight: 1685.8

Glycopeptide **10** was prepared following the general procedure **6.3** described above. Purification of the crude peptide using preparative HPLC (10 to 35% solvent B over 30 min, Dr. Maisch ReproSil 300 C18 column) afforded peptide **10** as a white solid after lyophilization (3.4 mg, 75%). Analytical HPLC: t_R = 19.9 min (10 to 35% solvent B over 30 min, Agilent C18 column); ESI-MS (*m/z*): $[M+H]^+$ calcd for $C_{78}H_{97}N_{10}O_{28}S_2$: 1686.8 (average isotope), $[M+2H]^{2+}$: 843.9, $[M\text{-}Gal+2H]^{2+}$: 762.3, $[M\text{-}2Gal+2H]^{2+}$: 680.8; found 843.3, 762.1, 681.7.

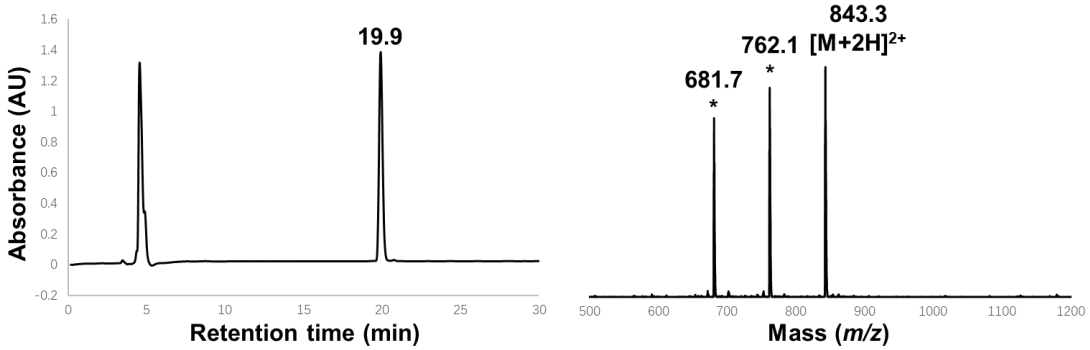
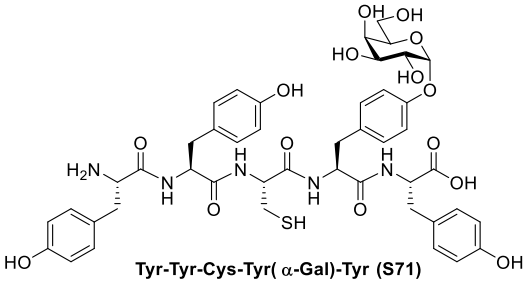


Figure S37. Left: UV trace from LC-MS analysis of glycopeptide **10**; Right: ESI-MS data of glycopeptide **10**. *Signals denote the mass of $[M\text{-}Gal+2H]^{2+}$ and $[M\text{-}2Gal+2H]^{2+}$ corresponding to the singly or doubly galactose-cleaved species respectively, generated during ionization in the mass spectrometer.

Glycopeptide S71



Chemical Formula: $C_{45}H_{53}N_5O_{15}S$
Exact Mass: 935.3
Molecular Weight: 936.0

Glycopeptide **S71** was prepared following the General Procedures **6.1** and **6.2** described above on a 0.05 mmol scale. Purification of the crude peptide using preparative HPLC (10 to 30% solvent B over 30 min, Dr. Maisch ReproSil 300 C18 column) afforded peptide **S71** as a white solid after lyophilization (23.7 mg, 51%). Analytical HPLC: t_R = 18.2 min (5 to 50% solvent B over 30 min, Agilent C18 column); ESI-MS (*m/z*): $[M+H]^+$ calcd for $C_{45}H_{54}N_5O_{15}S$: 937.0 (average isotope), $[M\text{-}Gal+H]^+$: 773.9; found 935.8, 773.9.

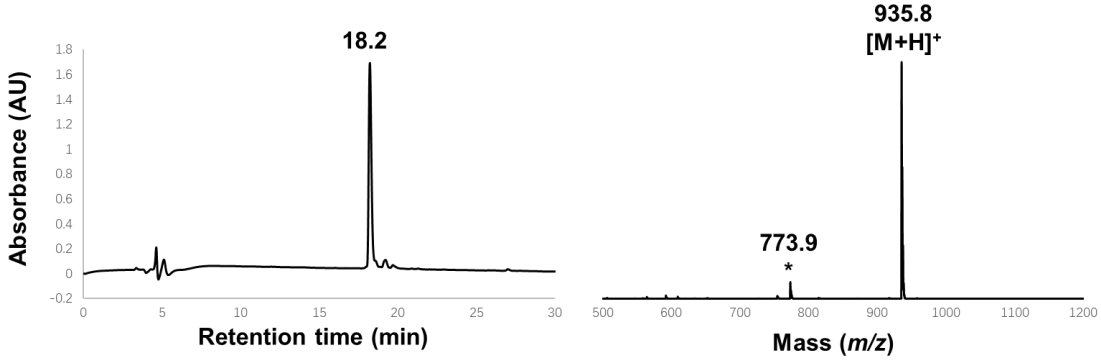
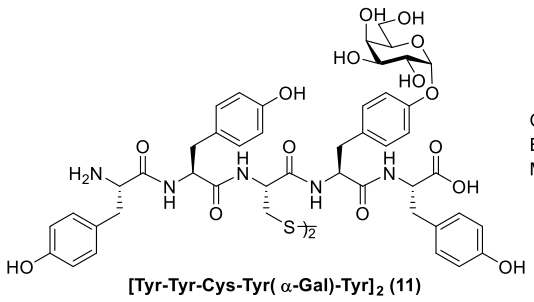


Figure S38. Left: UV trace from LC-MS analysis of glycopeptide **S71**; Right: ESI-MS data of glycopeptide **S71**. *Signal denotes the mass of $[M\text{-}Gal+H]^+$ corresponding to the galactose-cleaved species generated during ionization in the mass spectrometer.

Glycopeptide 11



Chemical Formula: $C_{90}H_{104}N_{10}O_{30}S_2$
Exact Mass: 1868.6
Molecular Weight: 1870.0

Glycopeptide **11** was prepared following the General Procedure **6.3** described above. Purification of the crude peptide using preparative HPLC (10 to 35% solvent B over 30 min, Dr. Maisch ReproSil 300 C18 column) afforded peptide **11** as a white solid after lyophilization (12 mg, 70%). Analytical HPLC: t_R = 19.2 min (5 to 50% solvent B over 30 min, Agilent C18 column); ESI-MS (*m/z*): $[M+H]^+$ calcd for $C_{90}H_{105}N_{10}O_{30}S_2$: 1871.0 (average isotope), $[M+2H]^{2+}$: 936.0, $[M\text{-}Gal+2H]^{2+}$: 854.4, $[M\text{-}2Gal+2H]^{2+}$: 772.8; found 935.6, 854.6, 773.6.

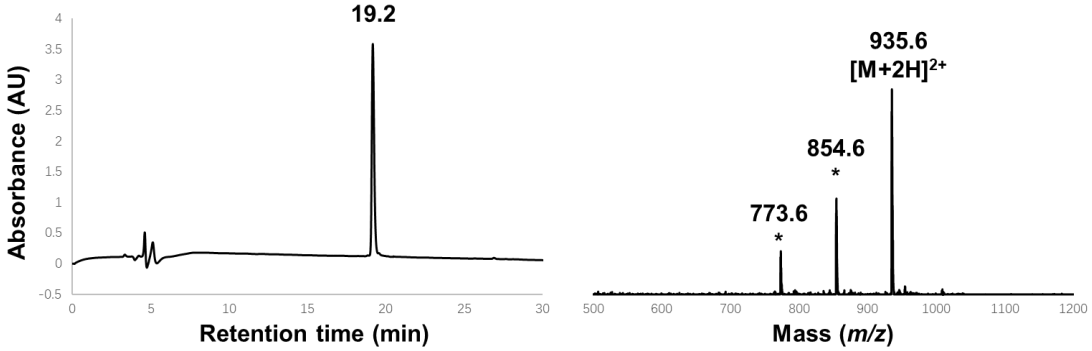
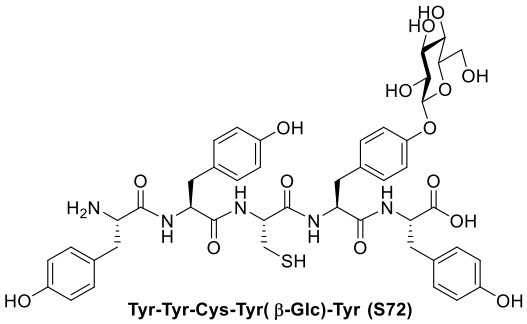


Figure S39. Left: UV trace from LC-MS analysis of glycopeptide **11**; Right: ESI-MS data of glycopeptide **11**. *Signals denote the mass of $[M\text{-}Gal+2H]^{2+}$ and $[M\text{-}2Gal+2H]^{2+}$ corresponding to the singly or doubly galactose-cleaved species respectively, generated during ionization in the mass spectrometer.

Glycopeptide S72



Chemical Formula: $C_{45}H_{53}N_5O_{15}S$
Exact Mass: 935.3
Molecular Weight: 936.0

Glycopeptide **S72** was prepared following the General Procedures **6.1** and **6.2** described above on a 0.02 mmol scale. Purification of the crude peptide using preparative HPLC (10 to 30% solvent B over 30 min, Dr. Maisch ReproSil 300 C18 column) afforded peptide **S72** as a white solid after lyophilization (12.7 mg, 68%). Analytical HPLC: t_R = 18.4 min (5 to 50% solvent B over 30 min, Agilent C18 column); ESI-MS (*m/z*): $[M+H]^+$ calcd for $C_{45}H_{54}N_5O_{15}S$: 937.0 (average isotope), $[M\text{-}Glc+H]^+$: 773.9; found 937.0, 774.8.

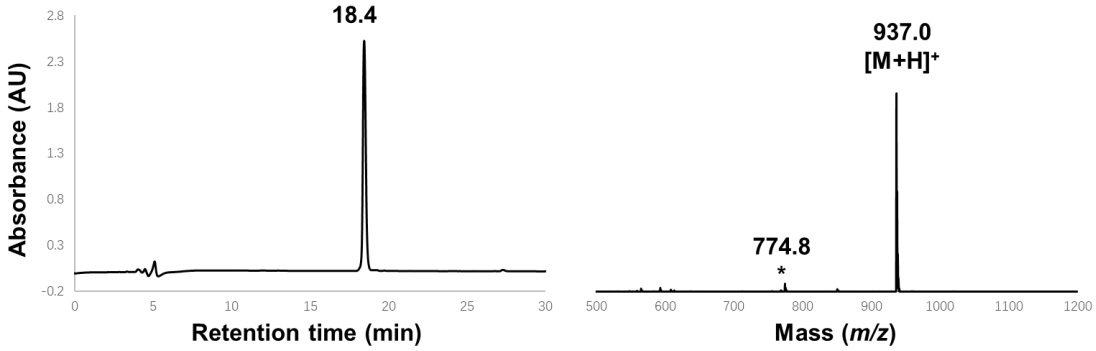
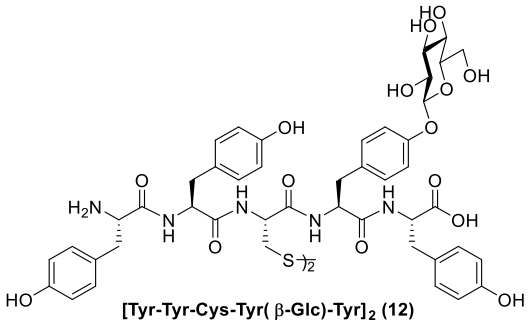


Figure S40. Left: UV trace from LC-MS analysis of glycopeptide **S72**; Right: ESI-MS data of glycopeptide **S72**. *Signal denotes the mass of $[M\text{-}Glc+H]^+$ corresponding to the glucose-cleaved species generated during ionization in the mass spectrometer.

Glycopeptide 12



Chemical Formula: $C_{90}H_{104}N_{10}O_{30}S_2$
Exact Mass: 1868.6
Molecular Weight: 1870.0

Glycopeptide **12** was prepared following the General Procedure **6.3** described above. Purification of the crude peptide using preparative HPLC (10 to 35% solvent B over 30 min, Dr. Maisch ReproSil 300 C18 column) afforded peptide **12** as a white solid after lyophilization (37.8 mg, 81%). Analytical HPLC: t_R = 19.8 min (5 to 50% solvent B over 30 min, Agilent C18 column); ESI-MS (*m/z*): $[M+H]^+$ calcd for $C_{90}H_{105}N_{10}O_{30}S_2$: 1871.0 (average isotope), $[M+2H]^{2+}$: 936.0, $[M\text{-}Glc+2H]^{2+}$: 854.4, $[M\text{-}2Glc+2H]^{2+}$: 772.8; found 936.0, 854.8.

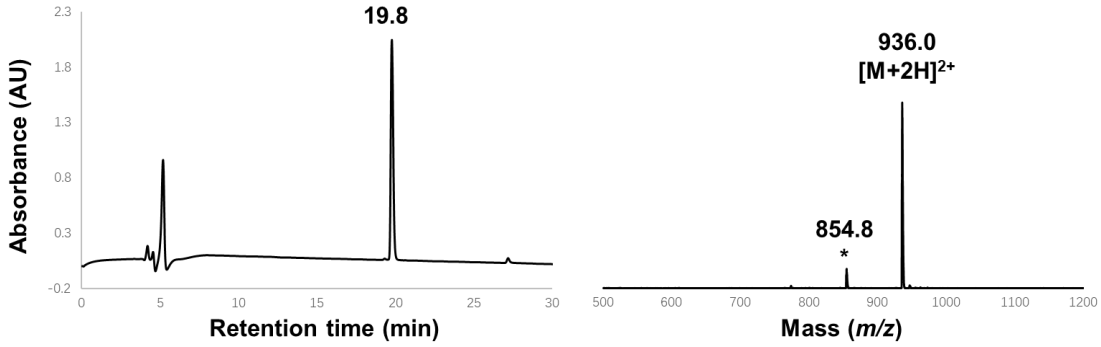
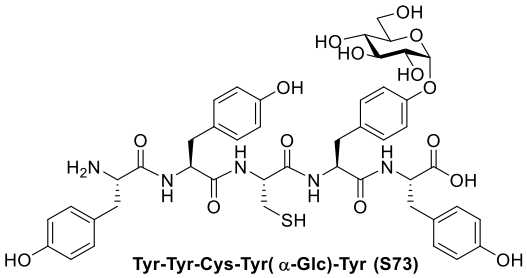


Figure S41. Left: UV trace from LC-MS analysis of glycopeptide **12**; Right: ESI-MS data of glycopeptide **12**. *Signal denotes the mass of $[M\text{-}Glc+2H]^{2+}$ corresponding to the singly glucose-cleaved species generated during ionization in the mass spectrometer.

Glycopeptide S73



Chemical Formula: $C_{45}H_{53}N_5O_{15}S$
Exact Mass: 935.3
Molecular Weight: 936.0

Glycopeptide **S73** was prepared following the General Procedures **6.1** and **6.2** described above on a 0.06 mmol scale. Purification of the crude peptide using preparative HPLC (10 to 30% solvent B over 30 min, Dr. Maisch ReproSil 300 C18 column) afforded peptide **S73** as a white solid after lyophilization (25.6 mg, 55%). Analytical HPLC: t_R = 18.1 min (5 to 50% solvent B over 30 min, Agilent C18 column); ESI-MS (*m/z*): $[M+H]^+$ calcd for $C_{45}H_{54}N_5O_{15}S$: 937.0 (average isotope), $[M\text{-}Glc+H]^+$: 773.9; found 936.8, 773.9.

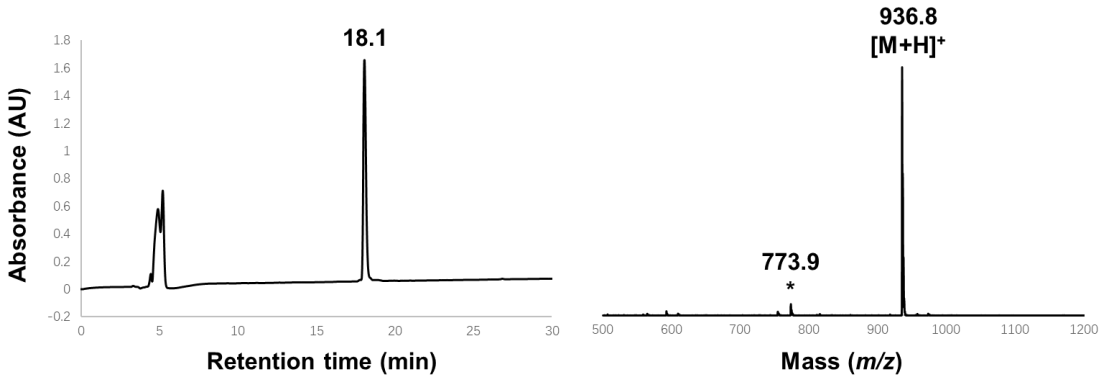
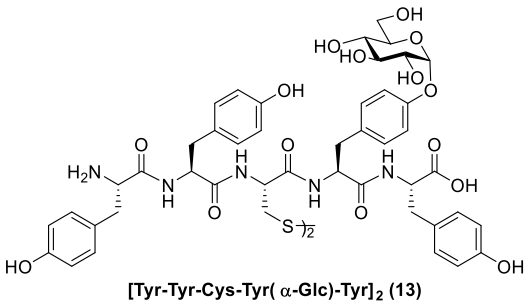


Figure S42. Left: UV trace from LC-MS analysis of glycopeptide **S73**; Right: ESI-MS data of glycopeptide **S73**. *Signal denotes the mass of $[M\text{-}Glc+H]^+$ corresponding to the glucose-cleaved species generated during ionization in the mass spectrometer.

Glycopeptide 13



Chemical Formula: $C_{90}H_{104}N_{10}O_{30}S_2$
Exact Mass: 1868.6
Molecular Weight: 1870.0

Glycopeptide **13** was prepared following the General Procedure **6.3** described above. Purification of the crude peptide using preparative HPLC (10 to 35% solvent B over 30 min, Dr. Maisch ReproSil 300 C18 column) afforded peptide **13** as a white solid after lyophilization (11.1 mg, 77%). Analytical HPLC: t_R = 19.3 min (15 to 30% solvent B over 30 min, Agilent C18 column); ESI-MS (*m/z*): $[M+H]^+$ calcd for $C_{90}H_{105}N_{10}O_{30}S_2$: 1871.0 (average isotope), $[M+2H]^{2+}$: 936.0, $[M\text{-}Glc+2H]^{2+}$: 854.4, $[M\text{-}2Glc+2H]^{2+}$: 772.8; found 935.5, 854.5, 773.4.

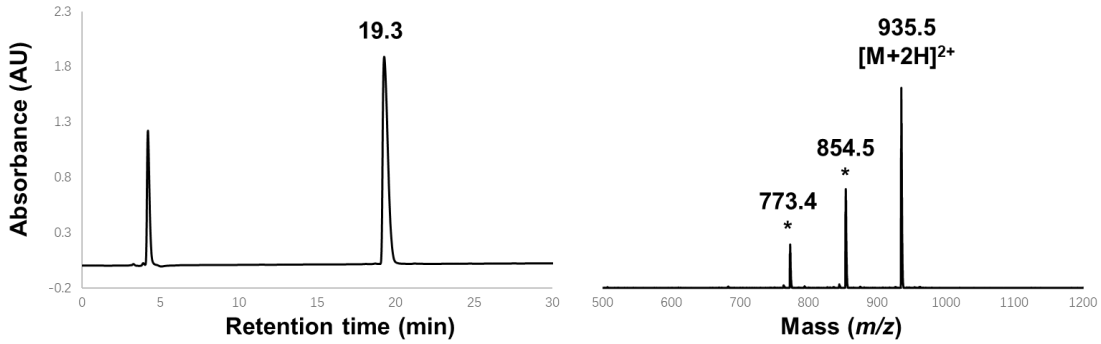
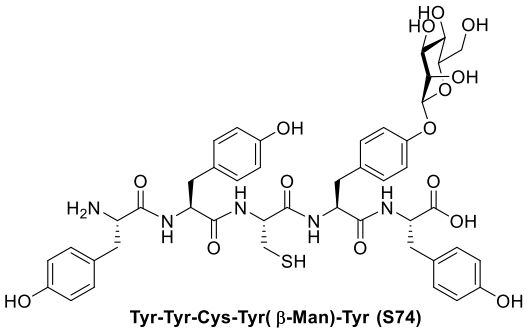


Figure S43. Left: UV trace from LC-MS analysis of glycopeptide **13**; Right: ESI-MS data of glycopeptide **13**. *Signals denote the mass of $[M\text{-}Glc+2H]^{2+}$ and $[M\text{-}2Glc+2H]^{2+}$ corresponding to the singly or doubly glucose-cleaved species respectively, generated during ionization in the mass spectrometer.

Glycopeptide S74



Chemical Formula: $C_{45}H_{53}N_5O_{15}S$
Exact Mass: 935.3
Molecular Weight: 936.0

Glycopeptide **S74** was prepared following the General Procedures **6.1** and **6.2** described above on a 0.05 mmol scale. Purification of the crude peptide using preparative HPLC (10 to 30% solvent B over 30 min, Dr. Maisch ReproSil 300 C18 column) afforded peptide **S74** as a white solid after lyophilization (37.2 mg, 79%). Analytical HPLC: t_R = 19.6 min (10 to 35% solvent B over 30 min, Agilent C18 column); ESI-MS (*m/z*): $[M+H]^+$ calcd for $C_{45}H_{54}N_5O_{15}S$: 937.0 (average isotope), $[M\text{-Man}+H]^+$: 773.9; found 935.9, 774.8.

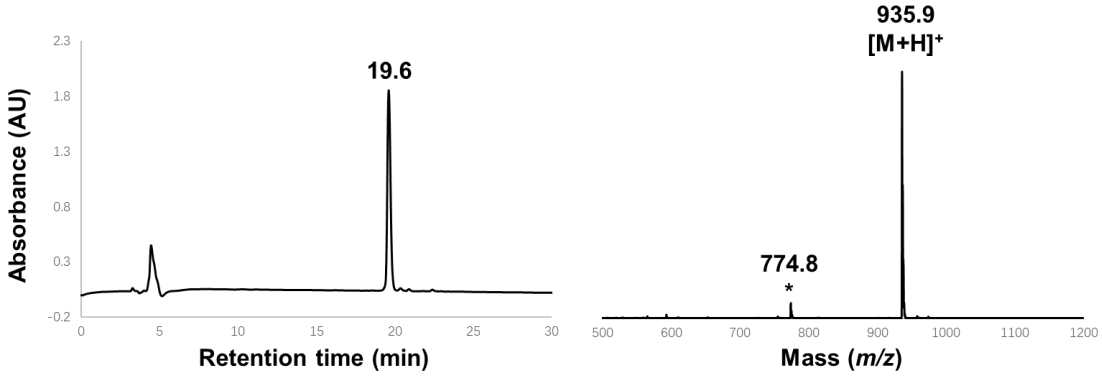
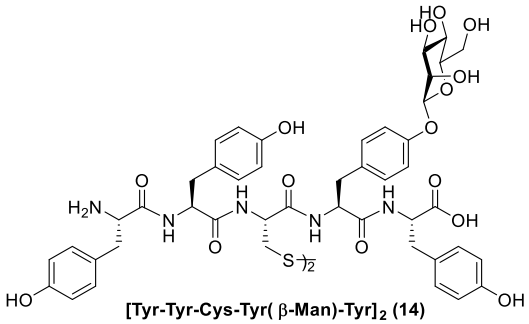


Figure S44. Left: UV trace from LC-MS analysis of glycopeptide **S74**; Right: ESI-MS data of glycopeptide **S74**. *Signal denotes the mass of $[M\text{-Man}+H]^+$ corresponding to the mannose-cleaved species generated during ionization in the mass spectrometer.

Glycopeptide 14



Chemical Formula: $C_{90}H_{104}N_{10}O_{30}S_2$
Exact Mass: 1868.6
Molecular Weight: 1870.0

Glycopeptide **14** was prepared following the General Procedure **6.3** described above. Purification of the crude peptide using preparative HPLC (10 to 35% solvent B over 30 min, Dr. Maisch ReproSil 300 C18 column) afforded peptide **14** as a white solid after lyophilization (7.9 mg, 76%). Analytical HPLC: t_R = 22.5 min (10 to 35% solvent B over 30 min, Agilent C18 column); ESI-MS (*m/z*): $[M+H]^+$ calcd for $C_{90}H_{105}N_{10}O_{30}S_2$: 1871.0 (average isotope), $[M+2H]^{2+}$: 936.0, $[M\text{-}Man+2H]^{2+}$: 854.4, $[M\text{-}2Man+2H]^{2+}$: 772.8; found 935.6, 854.1, 773.1.

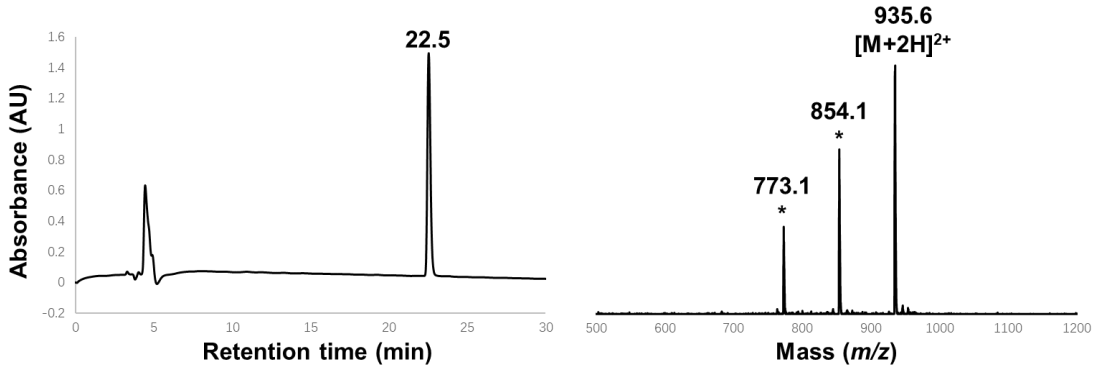
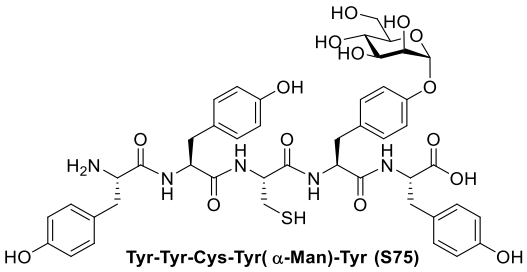


Figure S45. Left: UV trace from LC-MS analysis of glycopeptide **14**; Right: ESI-MS data of glycopeptide **14**. *Signals denote the mass of $[M\text{-}Man+2H]^{2+}$ and $[M\text{-}2Man+2H]^{2+}$ corresponding to the singly or doubly mannose-cleaved species respectively, generated during ionization in the mass spectrometer.

Glycopeptide S75



Chemical Formula: $C_{45}H_{53}N_5O_{15}S$
Exact Mass: 935.3
Molecular Weight: 936.0

Glycopeptide **S75** was prepared following the General Procedures **6.1** and **6.2** described above on a 0.02 mmol scale. Purification of the crude peptide using preparative HPLC (10 to 30% solvent B over 30 min, Dr. Maisch ReproSil 300 C18 column) afforded peptide **S75** as a white solid after lyophilization (10.1 mg, 54%). Analytical HPLC: t_R = 19.0 min (5 to 50% solvent B over 30 min, Agilent C18 column); ESI-MS (*m/z*): $[M+H]^+$ calcd for $C_{45}H_{54}N_5O_{15}S$: 937.0 (average isotope), $[M\text{-Man}+H]^+$: 773.9; found 936.1, 774.2.

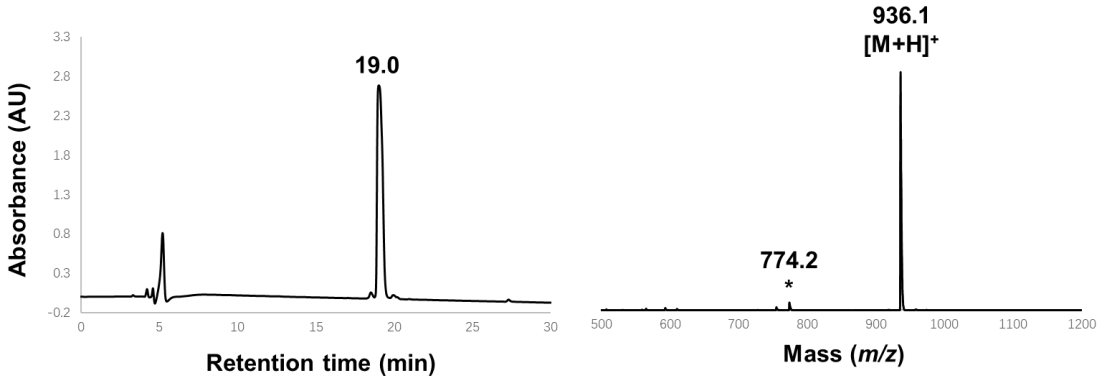
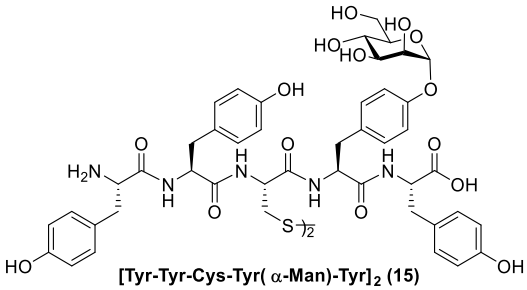


Figure S46. Left: UV trace from LC-MS analysis of glycopeptide **S75**; Right: ESI-MS data of glycopeptide **S75**. *Signal denotes the mass of $[M\text{-Man}+H]^+$ corresponding to the mannose-cleaved species generated during ionization in the mass spectrometer.

Glycopeptide 15



Chemical Formula: $C_{90}H_{104}N_{10}O_{30}S_2$
Exact Mass: 1868.6
Molecular Weight: 1870.0

Glycopeptide **15** was prepared following the General Procedure **6.3** described above. Purification of the crude peptide using preparative HPLC (10 to 35% solvent B over 30 min, Dr. Maisch ReproSil 300 C18 column) afforded peptide **15** as a white solid after lyophilization (6.2 mg, 61%). Analytical HPLC: t_R = 22.0 min (5 to 50% solvent B over 30 min, Agilent C18 column); ESI-MS (*m/z*): $[M+H]^+$ calcd for $C_{90}H_{105}N_{10}O_{30}S_2$: 1871.0 (average isotope), $[M+2H]^{2+}$: 936.0, $[M\text{-}Man+2H]^{2+}$: 854.4, $[M\text{-}2Man+2H]^{2+}$: 772.8; found 935.7, 854.3, 773.3.

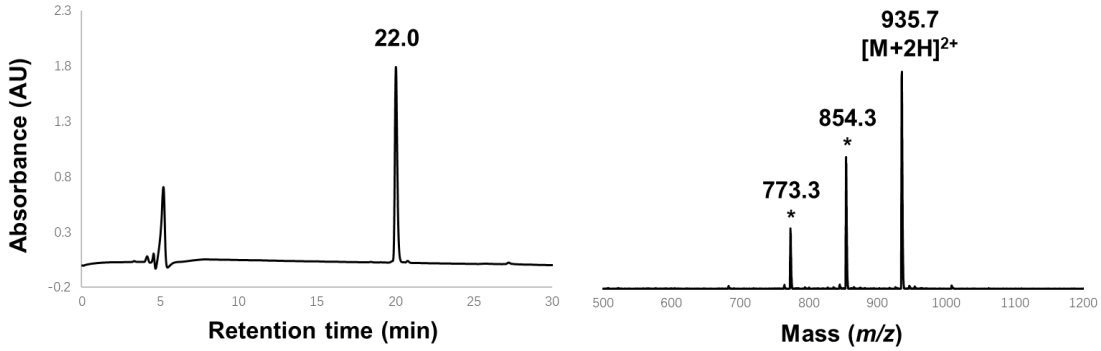
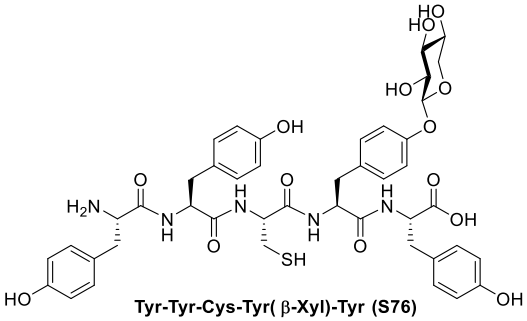


Figure S47. Left: UV trace from LC-MS analysis of glycopeptide **15**; Right: ESI-MS data of glycopeptide **15**. *Signals denote the mass of $[M\text{-}Man+2H]^{2+}$ and $[M\text{-}2Man+2H]^{2+}$ corresponding to the singly or doubly mannose-cleaved species respectively, generated during ionization in the mass spectrometer.

Glycopeptide S76



Chemical Formula: $C_{44}H_{51}N_5O_{14}S$
Exact Mass: 905.3
Molecular Weight: 906.0

Glycopeptide **S76** was prepared following the General Procedures **6.1** and **6.2** described above on a 0.05 mmol scale. Purification of the crude peptide using preparative HPLC (10 to 30% solvent B over 30 min, Dr. Maisch ReproSil 300 C18 column) afforded peptide **S76** as a white solid after lyophilization (27.7 mg, 61%). Analytical HPLC: t_R = 19.6 min (15 to 25% solvent B over 30 min, Agilent C18 column); ESI-MS (*m/z*): $[M+H]^+$ calcd for $C_{44}H_{52}N_5O_{14}S$: 907.0 (average isotope), $[M\text{-Xyl}+H]^+$: 773.9; found 905.7, 773.9.

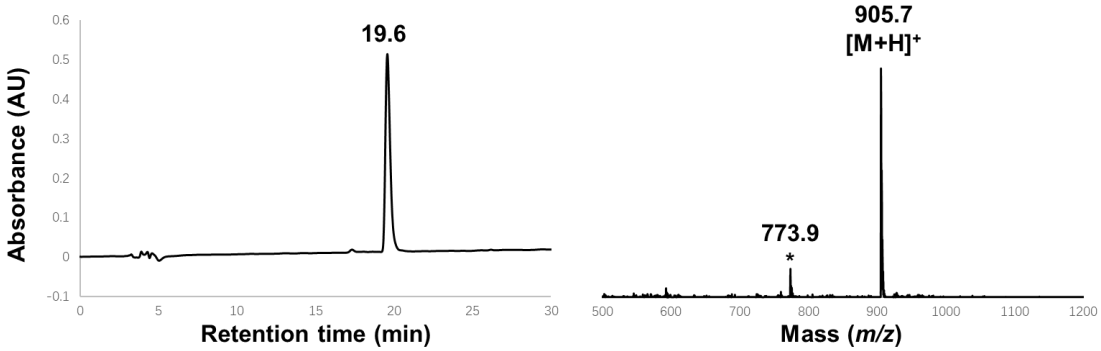
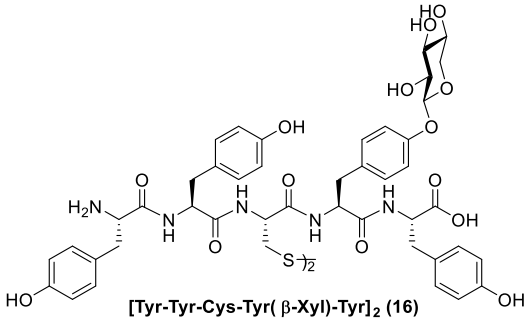


Figure S48. Left: UV trace from LC-MS analysis of glycopeptide **S76**; Right: ESI-MS data of glycopeptide **S76**. *Signal denotes the mass of $[M\text{-Xyl}+H]^+$ corresponding to the xylose-cleaved species generated during ionization in the mass spectrometer.

Glycopeptide 16



Chemical Formula: $C_{88}H_{100}N_{10}O_{28}S_2$
Exact Mass: 1808.6
Molecular Weight: 1809.9

Glycopeptide **16** was prepared following the General Procedure **6.3** described above. Purification of the crude peptide using preparative HPLC (10 to 35% solvent B over 30 min, Dr. Maisch ReproSil 300 C18 column) afforded peptide **16** as a white solid after lyophilization (22.3 mg, 78%). Analytical HPLC: t_R = 20.4 min (10 to 40% solvent B over 30 min, Agilent C18 column); ESI-MS (*m/z*): $[M+H]^+$ calcd for $C_{88}H_{101}N_{10}O_{28}S_2$: 1810.9 (average isotope), $[M+2H]^{2+}$: 906.0, $[M\text{-}Xyl+2H]^{2+}$: 839.4, $[M\text{-}2Xyl+2H]^{2+}$: 772.8; found 905.2, 839.3, 773.1.

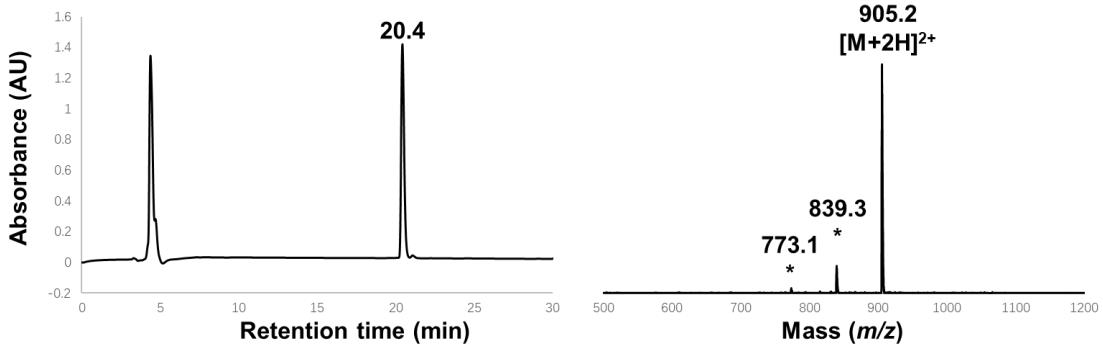
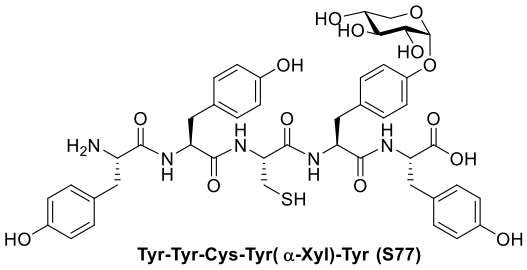


Figure S49. Left: UV trace from LC-MS analysis of glycopeptide **16**; Right: ESI-MS data of glycopeptide **16**. *Signals denote the mass of $[M\text{-}Xyl+2H]^{2+}$ and $[M\text{-}2Xyl+2H]^{2+}$ corresponding to the singly or doubly xylose-cleaved species respectively, generated during ionization in the mass spectrometer.

Glycopeptide S77



Chemical Formula: $C_{44}H_{51}N_5O_{14}S$
Exact Mass: 905.3
Molecular Weight: 906.0

Glycopeptide **S77** was prepared following the General Procedures **6.1** and **6.2** described above on a 0.05 mmol scale. Purification of the crude peptide using preparative HPLC (10 to 30% solvent B over 30 min, Dr. Maisch ReproSil 300 C18 column) afforded peptide **S77** as a white solid after lyophilization (31.6 mg, 55%). Analytical HPLC: t_R = 20.2 min (15 to 25% solvent B over 30 min, Agilent C18 column); ESI-MS (*m/z*): $[M+H]^+$ calcd for $C_{44}H_{52}N_5O_{14}S$: 907.0 (average isotope), $[M\text{-}Xyl+H]^+$: 773.9; found 905.8, 774.0.

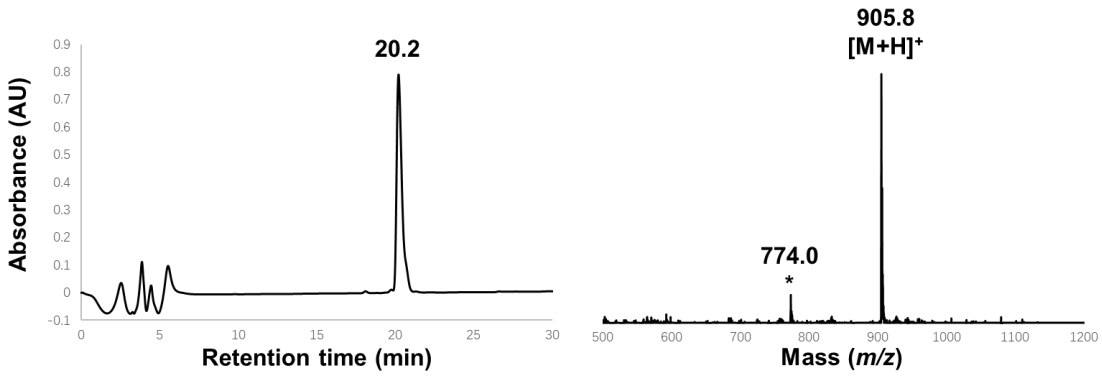
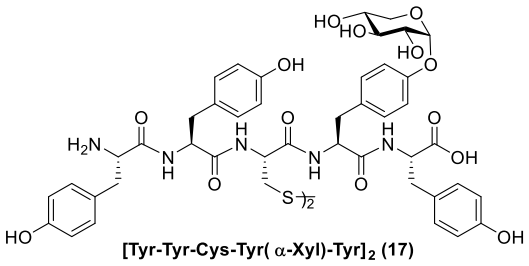


Figure S50. Left: UV trace from LC-MS analysis of glycopeptide **S77**; Right: ESI-MS data of glycopeptide **S77**. *Signal denotes the mass of $[M\text{-}Xyl+H]^+$ corresponding to the xylose-cleaved species generated during ionization in the mass spectrometer.

Glycopeptide 17



Chemical Formula: $C_{88}H_{100}N_{10}O_{28}S_2$
Exact Mass: 1808.6
Molecular Weight: 1809.9

Glycopeptide **17** was prepared following the General Procedure **6.3** described above. Purification of the crude peptide using preparative HPLC (10 to 35% solvent B over 30 min, Dr. Maisch ReproSil 300 C18 column) afforded peptide **17** as a white solid after lyophilization (31.3 mg, 85%). Analytical HPLC: t_R = 23.6 min (10 to 40% solvent B over 30 min, Agilent C18 column); ESI-MS (*m/z*): $[M+H]^+$ calcd for $C_{88}H_{101}N_{10}O_{28}S_2$: 1810.9 (average isotope), $[M+2H]^{2+}$: 906.0, $[M\text{-}Xyl+2H]^{2+}$: 839.4, $[M\text{-}2Xyl+2H]^{2+}$: 772.8; found 905.3, 838.8.

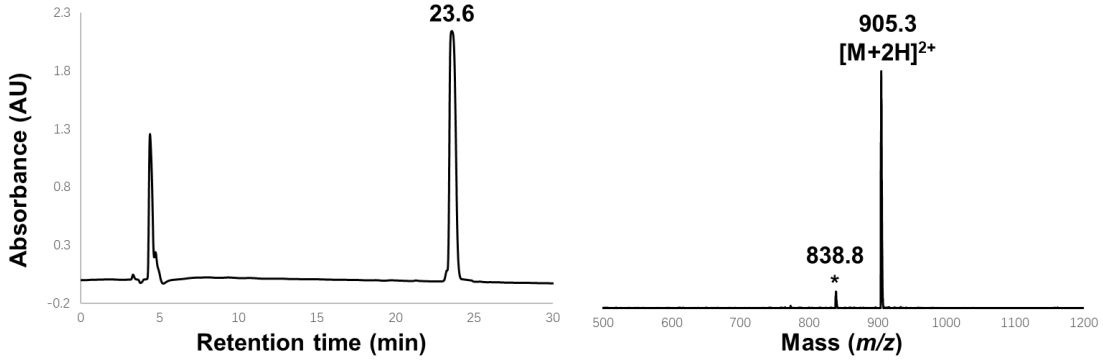
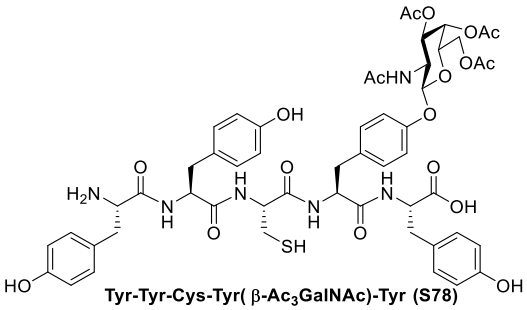


Figure S51. Left: UV trace from LC-MS analysis of glycopeptide **17**; Right: ESI-MS data of glycopeptide **17**. *Signal denotes the mass of $[M\text{-}Xyl+2H]^{2+}$ corresponding to the singly xylose-cleaved species generated during ionization in the mass spectrometer.

Glycopeptide S78



Tyr-Tyr-Cys-Tyr(β-Ac_3GalNAc)-Tyr (S78)

Chemical Formula: $C_{53}H_{62}N_6O_{18}S$
Exact Mass: 1102.4
Molecular Weight: 1103.2

Glycopeptide **S78** was prepared following the General Procedures **6.1** and **6.2** described above on a 0.02 mmol scale. Fmoc-Tyr(β-Ac_3GalNAc)-OH and Fmoc-Tyr(α-Ac_3GalNAc)-OH were synthesized following the synthetic procedures reported previously.[S21] Purification of the crude peptide using preparative HPLC (10 to 50% solvent B over 30 min, Dr. Maisch ReproSil 300 C18 column) afforded peptide **S78** as a white solid after lyophilization (9.5 mg, 43%). Analytical HPLC: t_R = 22.0 min (10 to 50% solvent B over 30 min, Agilent C18 column); ESI-MS (*m/z*): $[M+H]^+$ calcd for $C_{53}H_{63}N_6O_{18}S$: 1104.2 (average isotope), $[M\text{-}Ac_3GalNAc+H]^+$: 773.9; found 1103.4, 774.3.

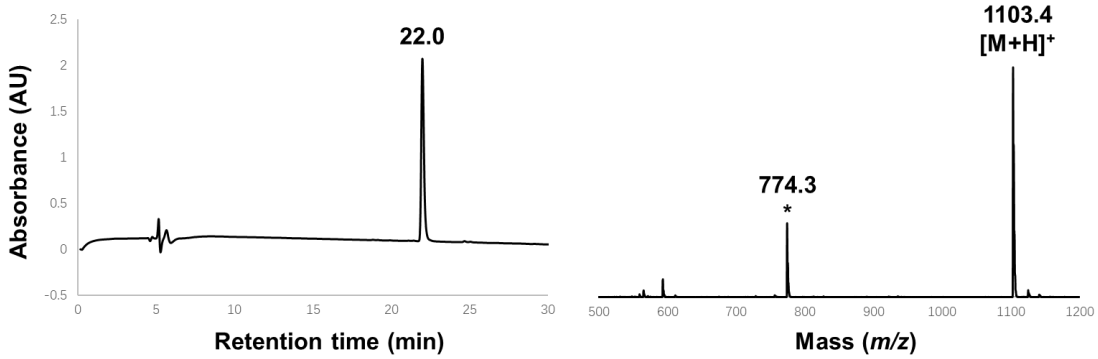
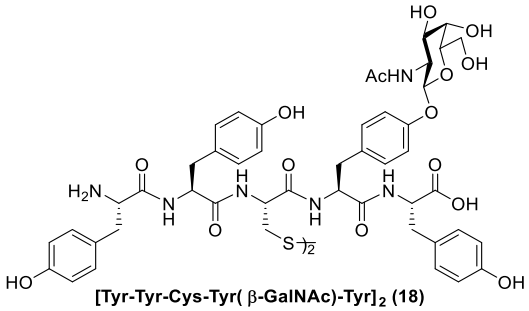


Figure S52. Left: UV trace from LC-MS analysis of glycopeptide **S78**; Right: ESI-MS data of glycopeptide **S78**. *Signal denotes the mass of $[M\text{-}Ac_3GalNAc+H]^+$ corresponding to the GalNAc-cleaved species generated during ionization in the mass spectrometer.

Glycopeptide 18



Chemical Formula: $C_{94}H_{110}N_{12}O_{30}S_2$
Exact Mass: 1950.7
Molecular Weight: 1952.1

Glycopeptide **18** was prepared following the General Procedure **6.4** described above. Purification of the crude peptide using preparative HPLC (10 to 35% solvent B over 30 min, Dr. Maisch ReproSil 300 C18 column) afforded peptide **18** as a white solid after lyophilization (5.8 mg, 69%). Analytical HPLC: t_R = 21.0 min (10 to 35% solvent B over 30 min, Agilent C18 column); ESI-MS (*m/z*): $[M+H]^+$ calcd for $C_{94}H_{111}N_{12}O_{30}S_2$: 1953.1 (average isotope), $[M+2H]^{2+}$: 977.0, $[M\text{-GalNAc}+2H]^{2+}$: 875.0, $[M\text{-}2GalNAc+2H]^{2+}$: 772.8; found 976.6, 875.2.

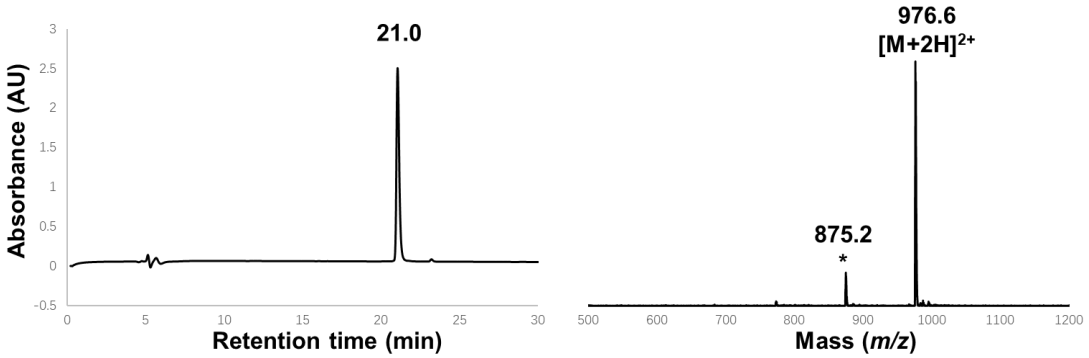
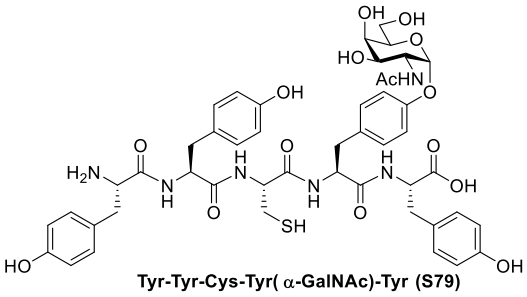


Figure S53. Left: UV trace from LC-MS analysis of glycopeptide **18**; Right: ESI-MS data of glycopeptide **18**. *Signal denotes the mass of $[M\text{-GalNAc}+2H]^{2+}$ corresponding to the singly GalNAc-cleaved species generated during ionization in the mass spectrometer.

Glycopeptide S79



Chemical Formula: $C_{47}H_{56}N_6O_{15}S$
Exact Mass: 976.3
Molecular Weight: 977.0

Glycopeptide **S79** was prepared following the General Procedures **6.1** and **6.2** described above on a 0.02 mmol scale. Purification of the crude peptide using preparative HPLC (10 to 35% solvent B over 30 min, Dr. Maisch ReproSil 300 C18 column) afforded peptide **S79** as a white solid after lyophilization (14.0 mg, 67%). Analytical HPLC: t_R = 18.5 min (10 to 35% solvent B over 30 min, Agilent C18 column); ESI-MS (*m/z*): $[M+H]^+$ calcd for $C_{47}H_{57}N_5O_{15}S$: 978.0 (average isotope), $[M\text{-GalNAc}+H]^+$: 773.9; found 977.3, 774.4.

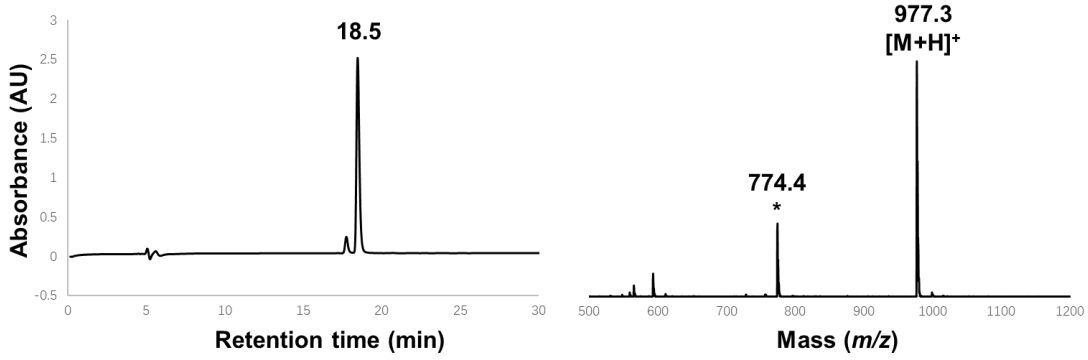
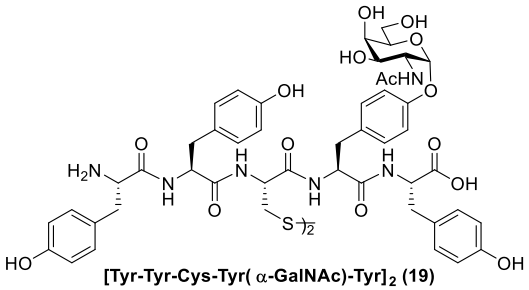


Figure S54. Left: UV trace from LC-MS analysis of glycopeptide **S79**; Right: ESI-MS data of glycopeptide **S79**. *Signal denotes the mass of $[M\text{-GalNAc}+H]^+$ corresponding to the GalNAc-cleaved species generated during ionization in the mass spectrometer.

Glycopeptide 19



Chemical Formula: $C_{94}H_{110}N_{12}O_{30}S_2$
Exact Mass: 1950.7
Molecular Weight: 1952.1

Glycopeptide **19** was prepared following the General Procedure **6.3** described above. Purification of the crude peptide using preparative HPLC (10 to 35% solvent B over 30 min, Dr. Maisch ReproSil 300 C18 column) afforded peptide **19** as a white solid after lyophilization (5.5 mg, 763%). Analytical HPLC: t_R = 20.8 min (10 to 35% solvent B over 30 min, Agilent C18 column); ESI-MS (*m/z*): $[M+H]^+$ calcd for $C_{94}H_{111}N_{12}O_{30}S_2$: 1953.1 (average isotope), $[M+2H]^{2+}$: 977.0, $[M\text{-GalNAc}+2H]^{2+}$: 875.0, $[M\text{-}2GalNAc+2H]^{2+}$: 772.8; found 976.6, 875.0.

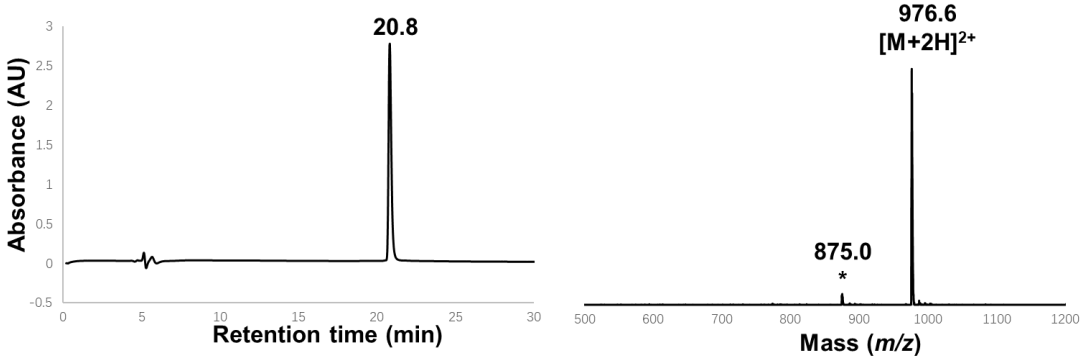
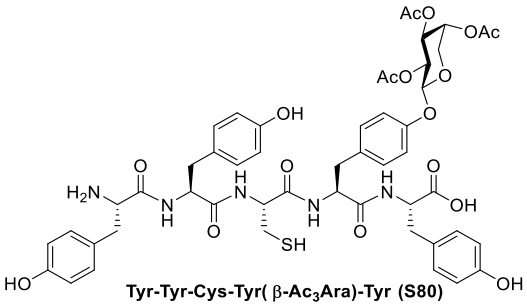


Figure S55. Left: UV trace from LC-MS analysis of glycopeptide **19**; Right: ESI-MS data of glycopeptide **19**. *Signal denotes the mass of $[M\text{-GalNAc}+2H]^{2+}$ corresponding to the singly GalNAc-cleaved species generated during ionization in the mass spectrometer.

Glycopeptide S80



Tyr-Tyr-Cys-Tyr(β-Ac_3Ara)-Tyr (S80)

Chemical Formula: $C_{50}H_{57}N_5O_{17}S$
Exact Mass: 1031.3
Molecular Weight: 1032.1

Glycopeptide **S80** was prepared following the General Procedures **6.1** and **6.2** described above on a 0.03 mmol scale. Purification of the crude peptide using preparative HPLC (10 to 50% solvent B over 30 min, Dr. Maisch ReproSil 300 C18 column) afforded peptide **S80** as a white solid after lyophilization (20.1 mg, 65%). Analytical HPLC: t_R = 24.8 min (5 to 60% solvent B over 30 min, Agilent C18 column); ESI-MS (*m/z*): $[M+H]^+$ calcd for $C_{50}H_{57}N_5O_{17}S$: 1033.1 (average isotope), $[M\text{-}Ac_3Ara+H]^+$: 773.9; found 1032.3, 774.4.

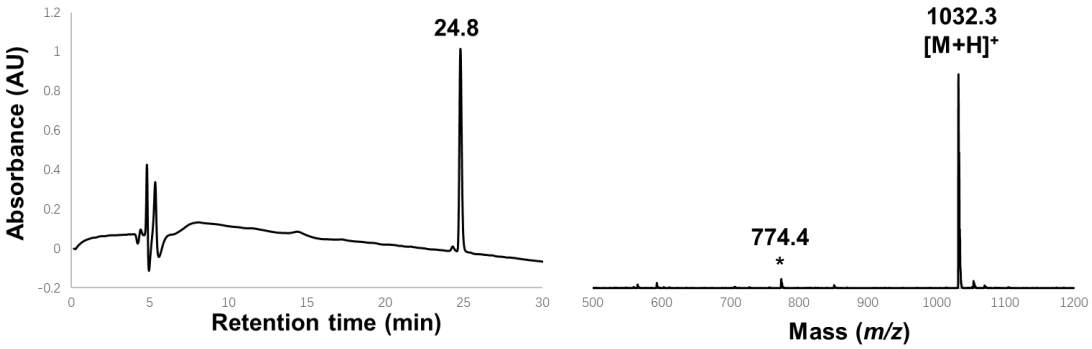
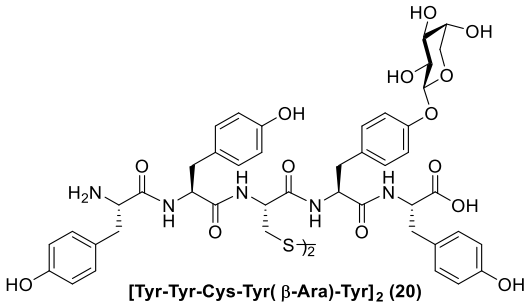


Figure S56. Left: UV trace from LC-MS analysis of glycopeptide **S80**; Right: ESI-MS data of glycopeptide **S80**. *Signal denotes the mass of $[M\text{-}Ac_3Ara+H]^+$ corresponding to the xylose-cleaved species generated during ionization in the mass spectrometer.

Glycopeptide 20



Chemical Formula: $C_{88}H_{100}N_{10}O_{28}S_2$
Exact Mass: 1808.6
Molecular Weight: 1809.9

Glycopeptide **20** was prepared following the General Procedure **6.4** described above. Purification of the crude peptide using preparative HPLC (10 to 35% solvent B over 30 min, Dr. Maisch ReproSil 300 C18 column) afforded peptide **20** as a white solid after lyophilization (28.0 mg, 81%). Analytical HPLC: t_R = 21.3 min (10 to 35% solvent B over 30 min, Agilent C18 column); ESI-MS (*m/z*): $[M+H]^+$ calcd for $C_{88}H_{101}N_{10}O_{28}S_2$: 1810.9 (average isotope), $[M+2H]^{2+}$: 906.0, $[M\text{-}Xyl+2H]^{2+}$: 839.4, $[M\text{-}2Xyl+2H]^{2+}$: 772.8; found 905.6, 839.8, 773.7.

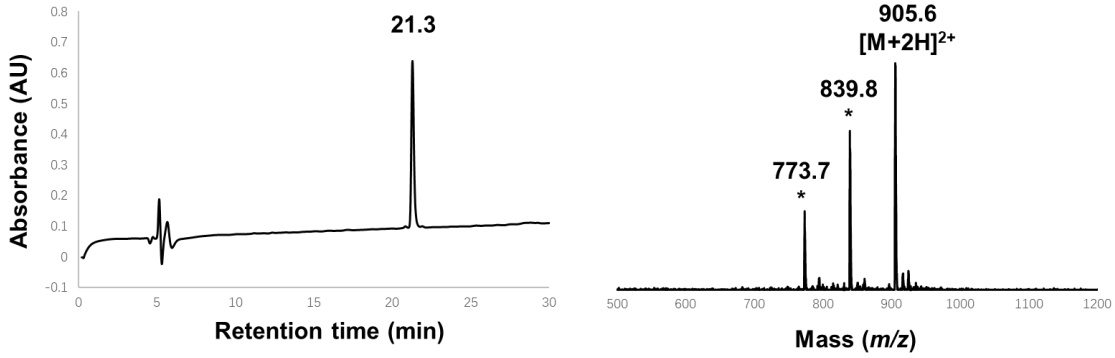
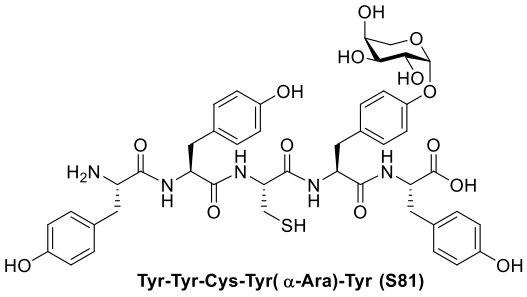


Figure S57. Left: UV trace from LC-MS analysis of glycopeptide **20**; Right: ESI-MS data of glycopeptide **20**. *Signals denote the mass of $[M\text{-}Ara+2H]^{2+}$ and $[M\text{-}2Ara+2H]^{2+}$ corresponding to the singly or doubly arabinose-cleaved species respectively, generated during ionization in the mass spectrometer.

Glycopeptide S81



Chemical Formula: $C_{44}H_{51}N_5O_{14}S$
Exact Mass: 905.3
Molecular Weight: 906.0

Glycopeptide **S81** was prepared following the General Procedures **6.1** and **6.2** described above on a 0.03 mmol scale. Purification of the crude peptide using preparative HPLC (10 to 35% solvent B over 30 min, Dr. Maisch ReproSil 300 C18 column) afforded peptide **S81** as a white solid after lyophilization (20.0 mg, 74%). Analytical HPLC: t_R = 18.5 min (10 to 35% solvent B over 30 min, Agilent C18 column); ESI-MS (*m/z*): $[M+H]^+$ calcd for $C_{44}H_{52}N_5O_{14}S$: 907.0 (average isotope), $[M\text{-}Xyl+H]^+$: 773.9; found 906.3, 774.5.

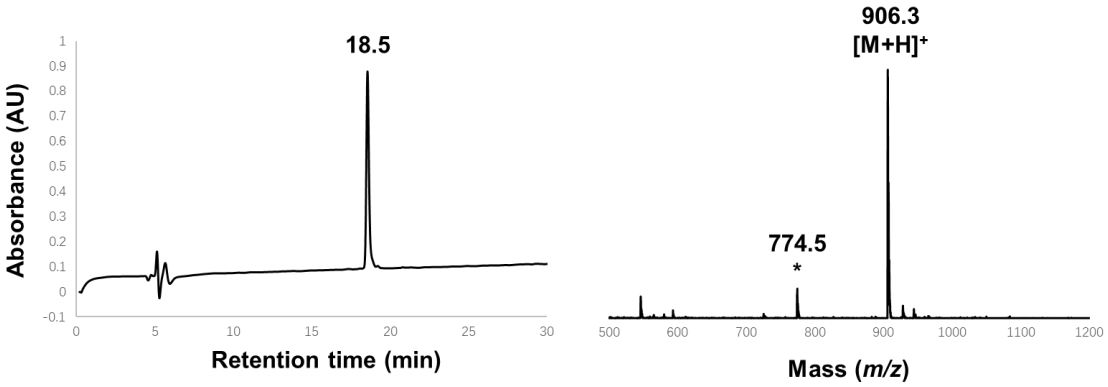
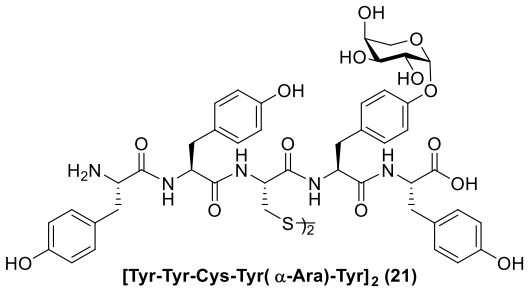


Figure S58. Left: UV trace from LC-MS analysis of glycopeptide **S81**; Right: ESI-MS data of glycopeptide **S81**. *Signal denotes the mass of $[M\text{-}Ara+H]^+$ corresponding to the arabinose-cleaved species generated during ionization in the mass spectrometer.

Glycopeptide 21



Chemical Formula: $C_{88}H_{100}N_{10}O_{28}S_2$
Exact Mass: 1808.6
Molecular Weight: 1809.9

Glycopeptide **21** was prepared following the General Procedure **6.3** described above. Purification of the crude peptide using preparative HPLC (10 to 35% solvent B over 30 min, Dr. Maisch ReproSil 300 C18 column) afforded peptide **21** as a white solid after lyophilization (31.1 mg, 76%). Analytical HPLC: t_R = 21.4 min (10 to 35% solvent B over 30 min, Agilent C18 column); ESI-MS (*m/z*): $[M+H]^+$ calcd for $C_{88}H_{101}N_{10}O_{28}S_2$: 1810.9 (average isotope), $[M+2H]^{2+}$: 906.0, $[M\text{-}Ara+2H]^{2+}$: 839.4, $[M\text{-}2Ara+2H]^{2+}$: 772.8; found 905.6, 839.6, 773.7.

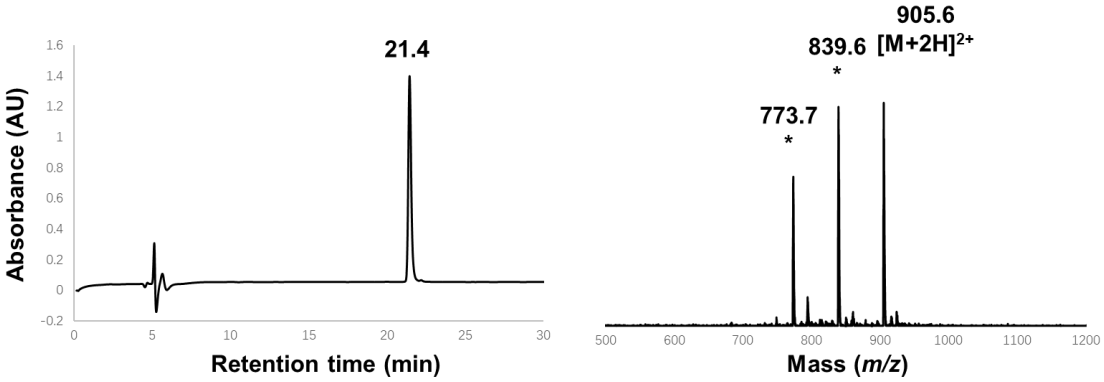
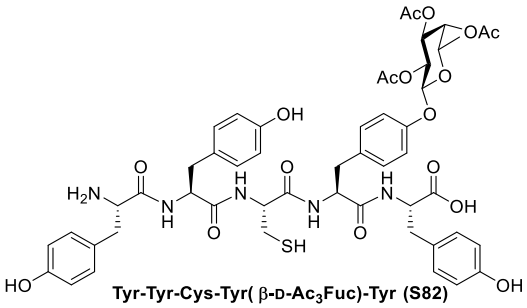


Figure S59. Left: UV trace from LC-MS analysis of glycopeptide **21**; Right: ESI-MS data of glycopeptide **21**. *Signal denotes the mass of $[M\text{-}Ara+2H]^{2+}$ and $[M\text{-}2Ara+2H]^{2+}$ corresponding to the singly or doubly arabinose-cleaved species respectively generated during ionization in the mass spectrometer.

Glycopeptide S82



Tyr-Tyr-Cys-Tyr(β-D-Ac_3Fuc)-Tyr (S82)

Chemical Formula: $C_{51}H_{59}N_5O_{17}S$
Exact Mass: 1045.4
Molecular Weight: 1046.1

Glycopeptide **S82** was prepared following the General Procedures **6.1** and **6.2** described above on a 0.03 mmol scale. Purification of the crude peptide using preparative HPLC (10 to 35% solvent B over 30 min, Dr. Maisch ReproSil 300 C18 column) afforded peptide **S82** as a white solid after lyophilization (25.8 mg, 82%). Analytical HPLC: t_R = 27.0 min (10 to 50% solvent B over 30 min, Agilent C18 column); ESI-MS (*m/z*): $[M+H]^+$ calcd for $C_{51}H_{60}N_5O_{17}S$: 1047.1 (average isotope), $[M\text{-}Ac_3Fuc+H]^+$: 773.9; found 1046.4, 774.3.

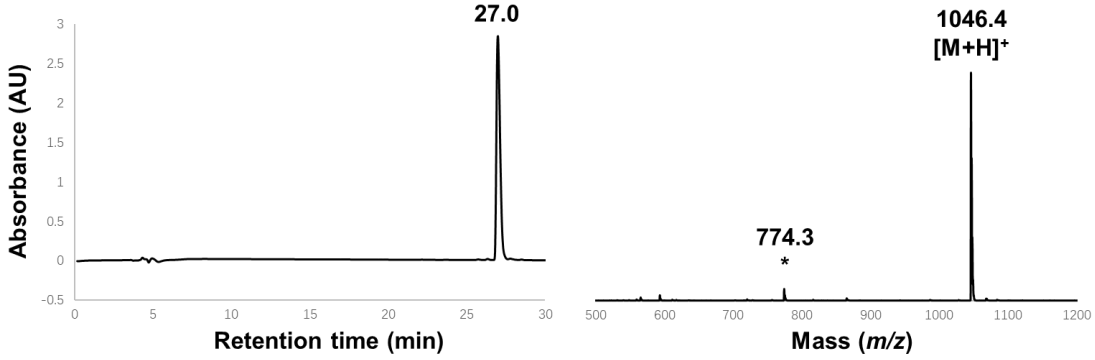
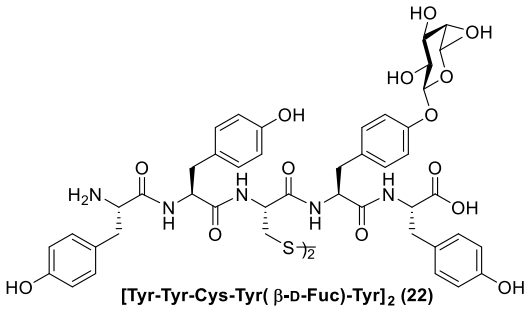


Figure S60. Left: UV trace from LC-MS analysis of glycopeptide **S82**; Right: ESI-MS data of glycopeptide **S82**. *Signal denotes the mass of $[M\text{-}Ac_3Fuc+H]^+$ corresponding to the fucose-cleaved species generated during ionization in the mass spectrometer.

Glycopeptide 22



Chemical Formula: $C_{90}H_{104}N_{10}O_{28}S_2$
Exact Mass: 1836.6
Molecular Weight: 1838.0

Glycopeptide **22** was prepared following the General Procedure **6.4** described above. Purification of the crude peptide using preparative HPLC (10 to 35% solvent B over 30 min, Dr. Maisch ReproSil 300 C18 column) afforded peptide **22** as a white solid after lyophilization (6.5 mg, 56%). Analytical HPLC: t_R = 22.4 min (10 to 35% solvent B over 30 min, Agilent C18 column); ESI-MS (*m/z*): $[M+H]^+$ calcd for $C_{90}H_{105}N_{10}O_{28}S_2$: 1839.0 (average isotope), $[M+2H]^{2+}$: 920.0, $[M\text{-}Fuc+2H]^{2+}$: 846.5, $[M\text{-}2Fuc+2H]^{2+}$: 772.8; found 919.7, 846.6, 773.6.

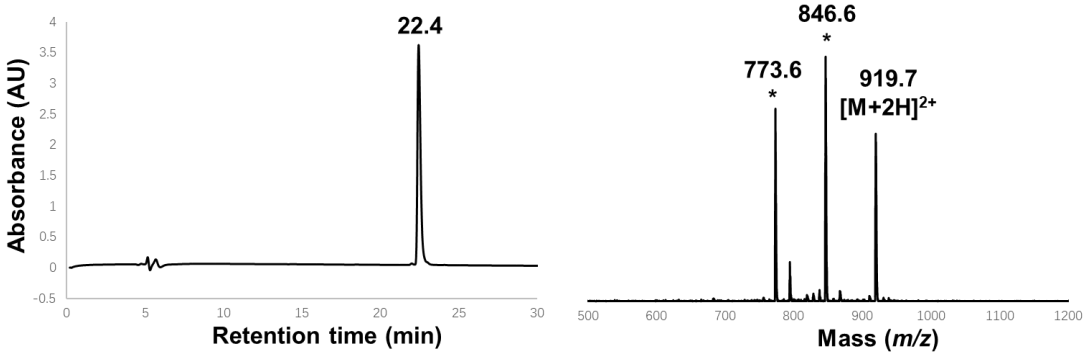
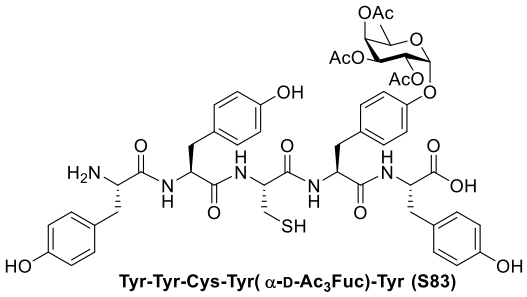


Figure S61. Left: UV trace from LC-MS analysis of glycopeptide **22**; Right: ESI-MS data of glycopeptide **22**. *Signals denote the mass of $[M\text{-}Fuc+2H]^{2+}$ and $[M\text{-}2Fuc+2H]^{2+}$ corresponding to the singly or doubly fucose-cleaved species respectively, generated during ionization in the mass spectrometer.

Glycopeptide S83



Chemical Formula: $C_{51}H_{59}N_5O_{17}S$
Exact Mass: 1045.4
Molecular Weight: 1046.1

Glycopeptide **S83** was prepared following the General Procedures **6.1** and **6.2** described above on a 0.03 mmol scale. Purification of the crude peptide using preparative HPLC (10 to 50% solvent B over 30 min, Dr. Maisch ReproSil 300 C18 column) afforded peptide **S83** as a white solid after lyophilization (27.7 mg, 85%). Analytical HPLC: t_R = 27.3 min (10 to 50% solvent B over 30 min, Agilent C18 column); ESI-MS (*m/z*): $[M+H]^+$ calcd for $C_{51}H_{60}N_5O_{17}S$: 1047.1 (average isotope), $[M\text{-}Fuc+H]^+$: 773.9; found 1046.4, 774.4.

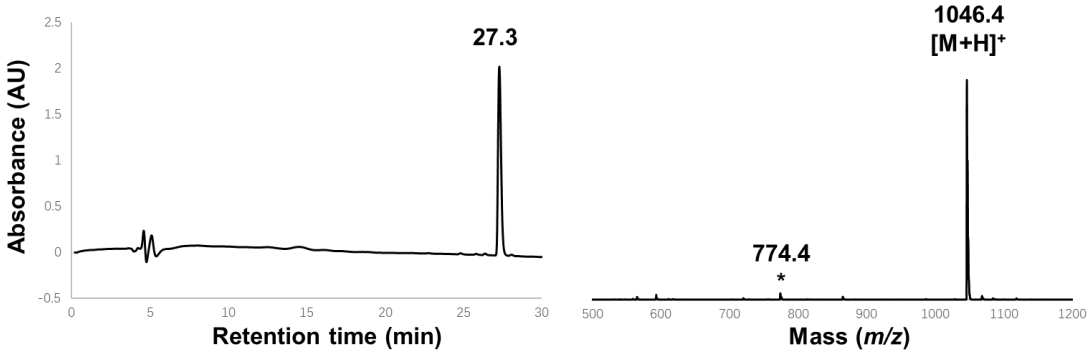
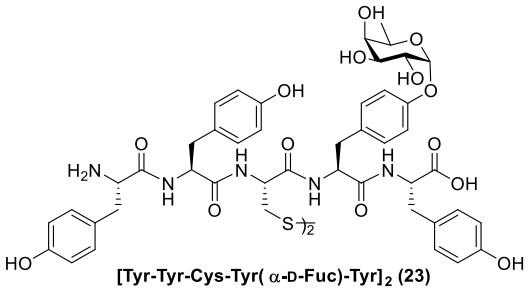


Figure S62. Left: UV trace from LC-MS analysis of glycopeptide **S83**; Right: ESI-MS data of glycopeptide **S83**. *Signal denotes the mass of $[M\text{-}Ac_3Fuc+H]^+$ corresponding to the fucose-cleaved species generated during ionization in the mass spectrometer.

Glycopeptide 23



Chemical Formula: $C_{90}H_{104}N_{10}O_{28}S_2$
Exact Mass: 1836.6
Molecular Weight: 1838.0

Glycopeptide **23** was prepared following the General Procedure **6.4** described above. Purification of the crude peptide using preparative HPLC (10 to 35% solvent B over 30 min, Dr. Maisch ReproSil 300 C18 column) afforded peptide **23** as a white solid after lyophilization (4.7 mg, 67%). Analytical HPLC: t_R = 17.7 min (10 to 50% solvent B over 30 min, Agilent C18 column); ESI-MS (*m/z*): $[M+H]^+$ calcd for $C_{90}H_{105}N_{10}O_{28}S_2$: 1839.0 (average isotope), $[M+2H]^{2+}$: 920.0, $[M\text{-}Fuc+2H]^{2+}$: 846.5, $[M\text{-}2Fuc+2H]^{2+}$: 772.8; found 919.7, 846.6, 773.6.

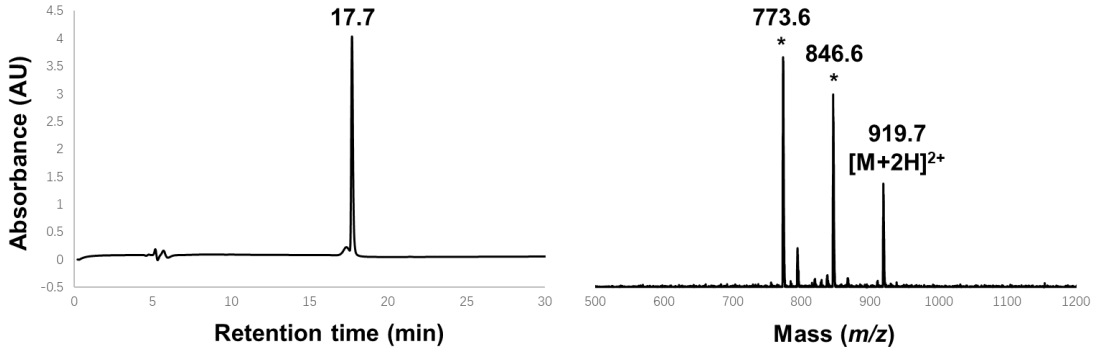
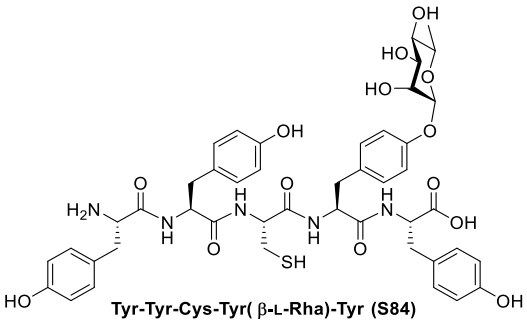


Figure S63. Left: UV trace from LC-MS analysis of glycopeptide **23**; Right: ESI-MS data of glycopeptide **23**. *Signals denote the mass of $[M\text{-}Fuc+2H]^{2+}$ and $[M\text{-}2Fuc+2H]^{2+}$ corresponding to the singly or doubly fucose-cleaved species respectively, generated during ionization in the mass spectrometer.

Glycopeptide S84



Chemical Formula: $C_{45}H_{53}N_5O_{14}S$
Exact Mass: 919.3
Molecular Weight: 920.0

Glycopeptide **S84** was prepared following the General Procedures **6.1** and **6.2** described above on a 0.03 mmol scale. Purification of the crude peptide using preparative HPLC (10 to 35% solvent B over 30 min, Dr. Maisch ReproSil 300 C18 column) afforded peptide **S84** as a white solid after lyophilization (16.6 mg, 60%). Analytical HPLC: t_R = 21.5 min (10 to 35% solvent B over 30 min, Agilent C18 column); ESI-MS (*m/z*): $[M+H]^+$ calcd for $C_{45}H_{54}N_5O_{14}S$: 921.0 (average isotope), $[M\text{-Rha}+H]^+$: 773.9; found 920.4, 774.3.

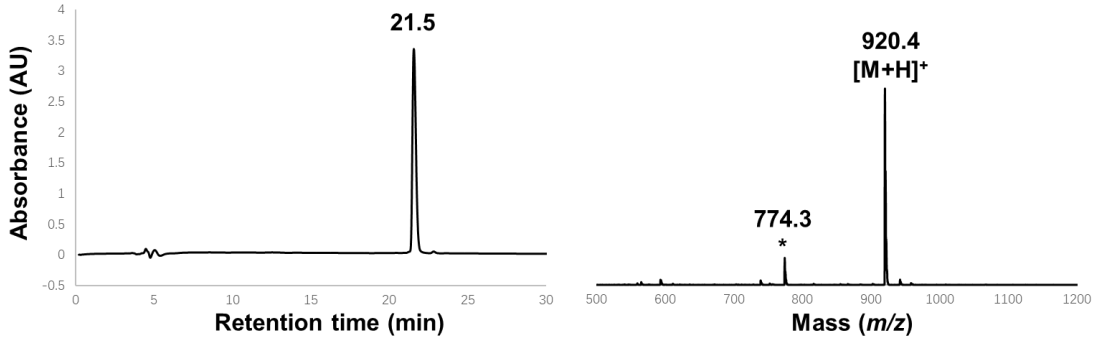
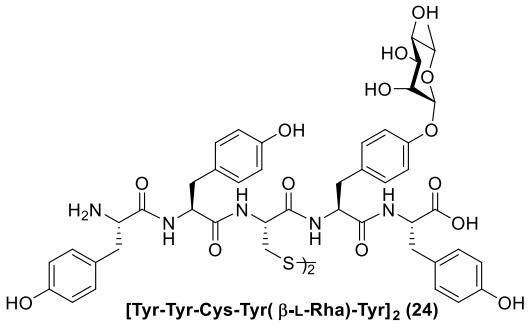


Figure S64. Left: UV trace from LC-MS analysis of glycopeptide **S84**; Right: ESI-MS data of glycopeptide **S84**. *Signal denotes the mass of $[M\text{-Rha}+H]^+$ corresponding to the fucose-cleaved species generated during ionization in the mass spectrometer.

Glycopeptide 24



Chemical Formula: $C_{90}H_{104}N_{10}O_{28}S_2$
Exact Mass: 1836.6
Molecular Weight: 1838.0

Glycopeptide **24** was prepared following the General Procedure **6.3** described above. Purification of the crude peptide using preparative HPLC (10 to 35% solvent B over 30 min, Dr. Maisch ReproSil 300 C18 column) afforded peptide **24** as a white solid after lyophilization (13.6 mg, 82%). Analytical HPLC: t_R = 24.2 min (10 to 35% solvent B over 30 min, Agilent C18 column); ESI-MS (*m/z*): $[M+H]^+$ calcd for $C_{90}H_{105}N_{10}O_{28}S_2$: 1839.0 (average isotope), $[M+2H]^{2+}$: 920.0, $[M\text{-}Fuc+2H]^{2+}$: 846.5, $[M\text{-}2Fuc+2H]^{2+}$: 772.8; found 919.8, 846.6, 773.5.

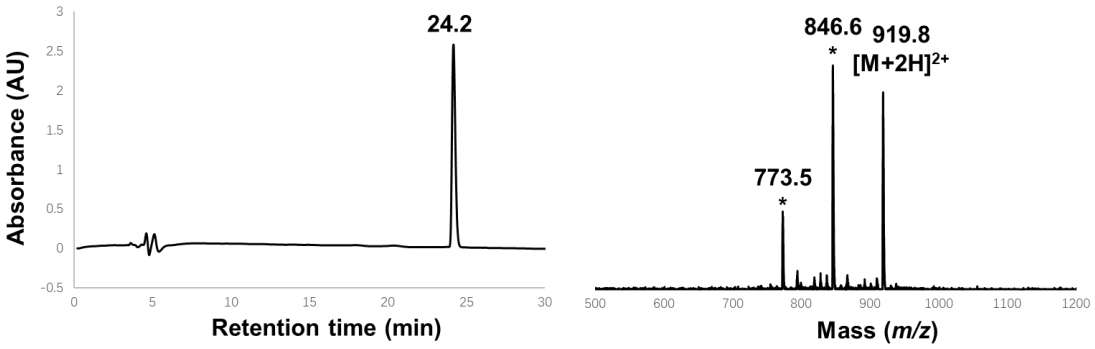
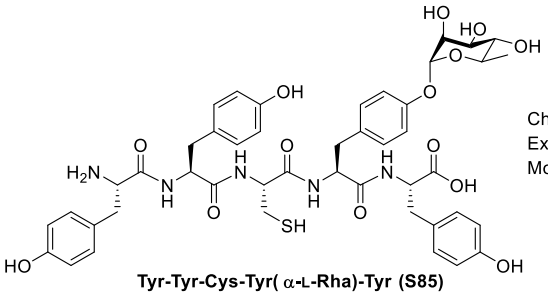


Figure S65. Left: UV trace from LC-MS analysis of glycopeptide **24**; Right: ESI-MS data of glycopeptide **24**. *Signals denote the mass of $[M\text{-}Rha+2H]^{2+}$ and $[M\text{-}2Rha+2H]^{2+}$ corresponding to the singly or doubly rhamnose-cleaved species respectively, generated during ionization in the mass spectrometer.

Glycopeptide S85



Chemical Formula: $C_{45}H_{53}N_5O_{14}S$
Exact Mass: 919.3
Molecular Weight: 920.0

Glycopeptide **S85** was prepared following the General Procedures **6.1** and **6.2** described above on a 0.05 mmol scale. Purification of the crude peptide using preparative HPLC (10 to 35% solvent B over 30 min, Dr. Maisch ReproSil 300 C18 column) afforded peptide **S85** as a white solid after lyophilization (32.3 mg, 70%). Analytical HPLC: t_R = 20.4 min (10 to 35% solvent B over 30 min, Agilent C18 column); ESI-MS (*m/z*): $[M+H]^+$ calcd for $C_{45}H_{54}N_5O_{14}S$: 921.0 (average isotope), $[M\text{-Rha}+H]^+$: 773.9; found 920.4, 774.2.

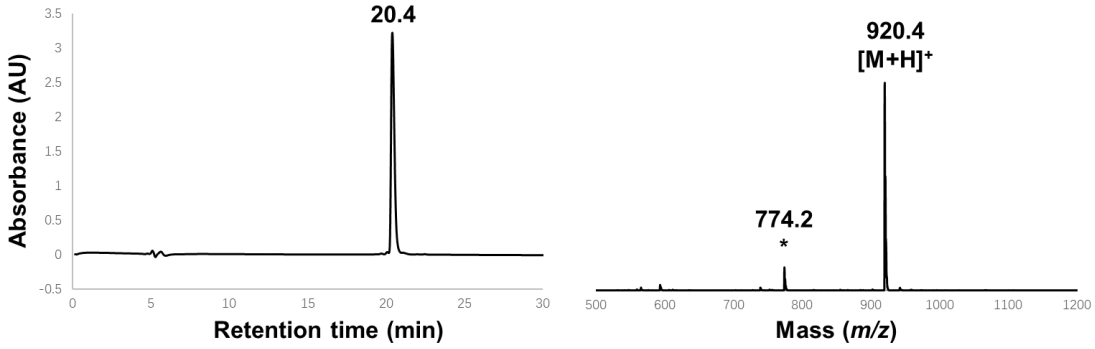
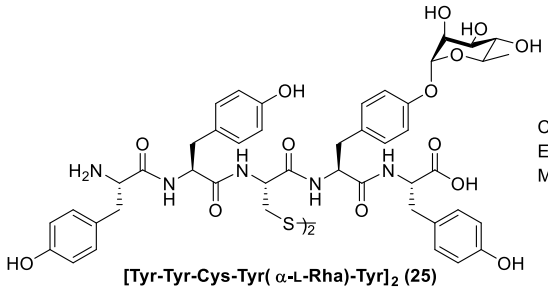


Figure S66. Left: UV trace from LC-MS analysis of glycopeptide **S85**; Right: ESI-MS data of glycopeptide **S85**. *Signal denotes the mass of $[M\text{-Rha}+H]^+$ corresponding to the Rhamnose-cleaved species generated during ionization in the mass spectrometer.

Glycopeptide 25



Chemical Formula: $C_{90}H_{104}N_{10}O_{28}S_2$
Exact Mass: 1836.6
Molecular Weight: 1838.0

Glycopeptide **25** was prepared following the General Procedure **6.3** described above. Purification of the crude peptide using preparative HPLC (10 to 35% solvent B over 30 min, Dr. Maisch ReproSil 300 C18 column) afforded peptide **25** as a white solid after lyophilization (29.6 mg, 92%). Analytical HPLC: t_R = 18.1 min (10 to 35% solvent B over 30 min, Agilent C18 column); ESI-MS (*m/z*): $[M+H]^+$ calcd for $C_{90}H_{105}N_{10}O_{28}S_2$: 1839.0 (average isotope), $[M+2H]^{2+}$: 920.0, $[M\text{-}Rha+2H]^{2+}$: 846.5, $[M\text{-}2Rha+2H]^{2+}$: 772.8; found 919.6, 846.6, 773.5.

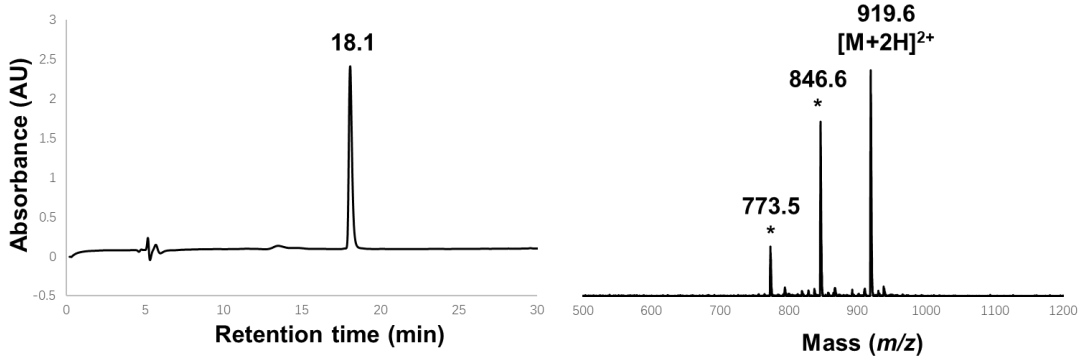
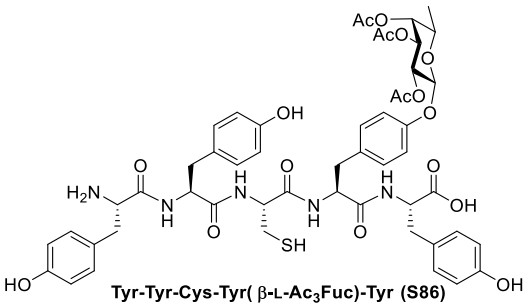


Figure S67. Left: UV trace from LC-MS analysis of glycopeptide **25**; Right: ESI-MS data of glycopeptide **25**. *Signals denote the mass of $[M\text{-}Rha+2H]^{2+}$ and $[M\text{-}2Rha+2H]^{2+}$ corresponding to the singly or doubly rhamnose-cleaved species respectively, generated during ionization in the mass spectrometer.

Glycopeptide S86



Tyr-Tyr-Cys-Tyr(β-L-Ac_3Fuc)-Tyr (S86)

Chemical Formula: $C_{51}H_{59}N_5O_{17}S$
Exact Mass: 1045.4
Molecular Weight: 1046.1

Glycopeptide **S86** was prepared following the General Procedures **6.1** and **6.2** described above on a 0.03 mmol scale. Purification of the crude peptide using preparative HPLC (10 to 35% solvent B over 30 min, Dr. Maisch ReproSil 300 C18 column) afforded peptide **S86** as a white solid after lyophilization (22.6 mg, 75%). Analytical HPLC: t_R = 26.0 min (10 to 50% solvent B over 30 min, Agilent C18 column); ESI-MS (*m/z*): $[M+H]^+$ calcd for $C_{51}H_{60}N_5O_{17}S$: 1047.1 (average isotope), $[M\text{-}Ac_3Fuc+H]^+$: 773.9; found 1046.4, 774.5.

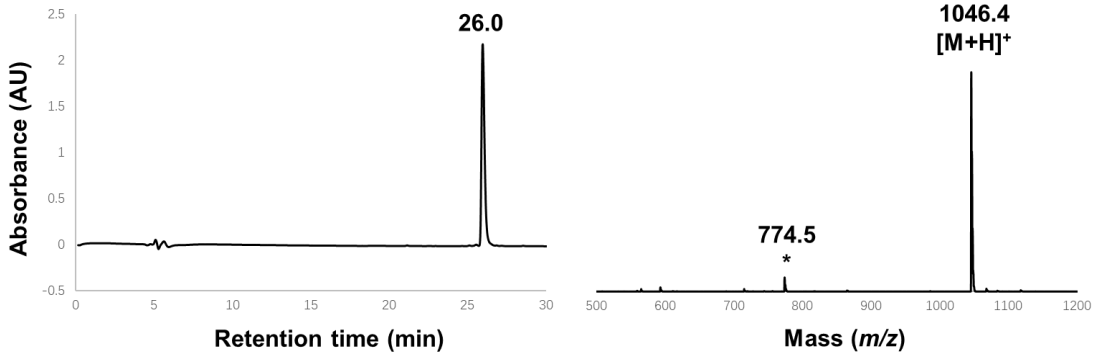
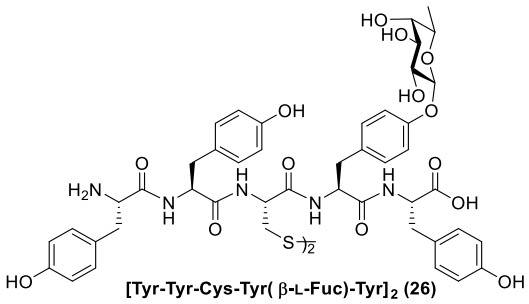


Figure S68. Left: UV trace from LC-MS analysis of glycopeptide **S86**; Right: ESI-MS data of glycopeptide **S86**. *Signal denotes the mass of $[M\text{-}Ac_3Fuc+H]^+$ corresponding to the fucose-cleaved species generated during ionization in the mass spectrometer.

Glycopeptide 26



Chemical Formula: $C_{90}H_{104}N_{10}O_{28}S_2$
Exact Mass: 1836.6
Molecular Weight: 1838.0

Glycopeptide **26** was prepared following the General Procedure **6.4** described above. Purification of the crude peptide using preparative HPLC (10 to 35% solvent B over 30 min, Dr. Maisch ReproSil 300 C18 column) afforded peptide **26** as a white solid after lyophilization (5 mg, 24%). Analytical HPLC: t_R = 22.0 min (10 to 35% solvent B over 30 min, Agilent C18 column); ESI-MS (*m/z*): $[M+H]^+$ calcd for $C_{90}H_{105}N_{10}O_{28}S_2$: 1839.0 (average isotope), $[M+2H]^{2+}$: 920.0, $[M\text{-}Fuc+2H]^{2+}$: 846.5, $[M\text{-}2Fuc+2H]^{2+}$: 772.8; found 919.7, 846.6, 773.6.

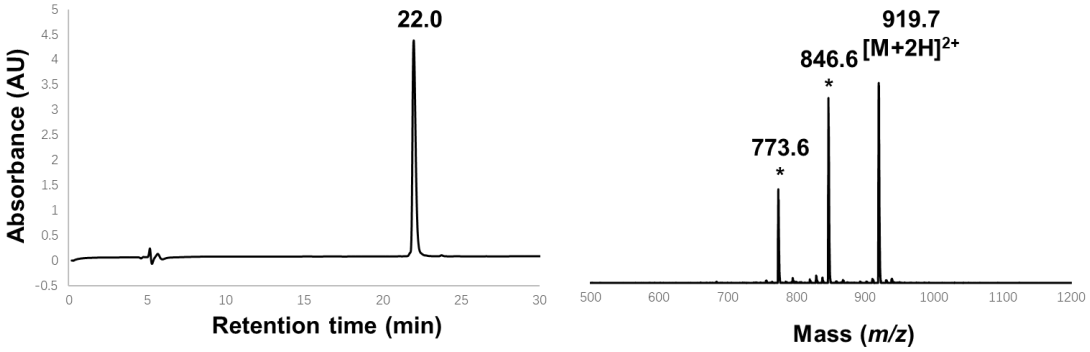
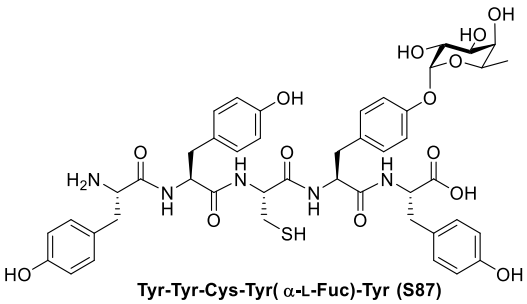


Figure S69. Left: UV trace from LC-MS analysis of glycopeptide **26**; Right: ESI-MS data of glycopeptide **26**. *Signals denote the mass of $[M\text{-}Fuc+2H]^{2+}$ and $[M\text{-}2Fuc+2H]^{2+}$ corresponding to the singly or doubly fucose-cleaved species respectively, generated during ionization in the mass spectrometer.

Glycopeptide S87



Chemical Formula: $C_{45}H_{53}N_5O_{14}S$
Exact Mass: 919.3
Molecular Weight: 920.0

Glycopeptide **S87** was prepared following the General Procedures **6.1** and **6.2** described above on a 0.04 mmol scale. Purification of the crude peptide using preparative HPLC (10 to 35% solvent B over 30 min, Dr. Maisch ReproSil 300 C18 column) afforded peptide **S87** as a white solid after lyophilization (7.3 mg, 21%). Analytical HPLC: t_R = 20.4 min (10 to 35% solvent B over 30 min, Agilent C18 column); ESI-MS (*m/z*): $[M+H]^+$ calcd for $C_{45}H_{54}N_5O_{14}S$: 921.0 (average isotope), $[M\text{-}Fuc+H]^+$: 773.9; found 920.3, 774.3.

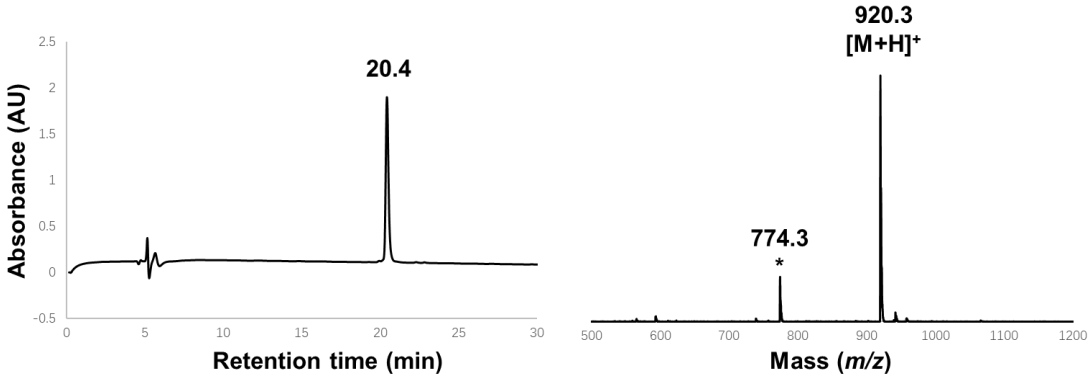
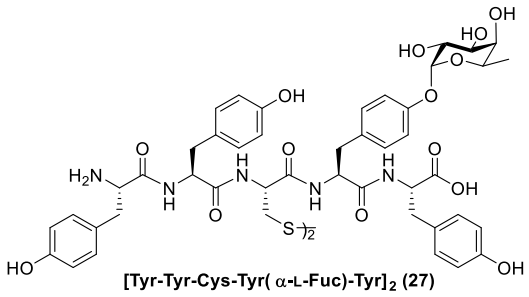


Figure S70. Left: UV trace from LC-MS analysis of glycopeptide **S87**; Right: ESI-MS data of glycopeptide **S87**. *Signal denotes the mass of $[M\text{-}Fuc+H]^+$ corresponding to the fucose-cleaved species generated during ionization in the mass spectrometer.

Glycopeptide 27



Chemical Formula: $C_{90}H_{104}N_{10}O_{28}S_2$
Exact Mass: 1836.6
Molecular Weight: 1838.0

Glycopeptide **27** was prepared following the General Procedure **6.3** described above. Purification of the crude peptide using preparative HPLC (10 to 35% solvent B over 30 min, Dr. Maisch ReproSil 300 C18 column) afforded peptide **27** as a white solid after lyophilization (5.5 mg, 76%). Analytical HPLC: t_R = 22.0 min (10 to 35% solvent B over 30 min, Agilent C18 column); ESI-MS (*m/z*): $[M+H]^+$ calcd for $C_{90}H_{105}N_{10}O_{28}S_2$: 1838.0 (average isotope), $[M+2H]^{2+}$: 920.0, $[M\text{-}Fuc+2H]^{2+}$: 846.5, $[M\text{-}2Fuc+2H]^{2+}$: 772.8; found 920.1, 846.6, 773.7.

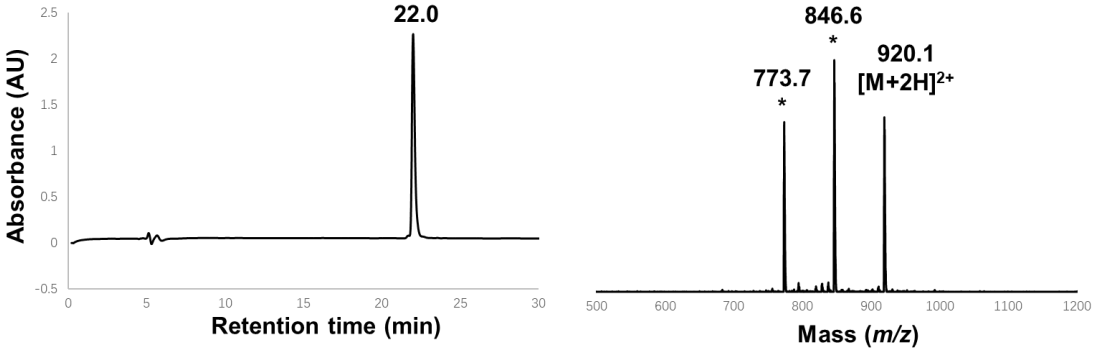
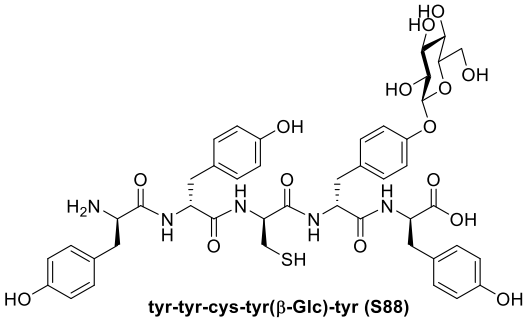


Figure S71. Left: UV trace from LC-MS analysis of glycopeptide **27**; Right: ESI-MS data of glycopeptide **27**. *Signals denote the mass of $[M\text{-}Fuc+2H]^{2+}$ and $[M\text{-}2Fuc+2H]^{2+}$ corresponding to the singly or doubly fucose-cleaved species respectively, generated during ionization in the mass spectrometer.

Glycopeptide S88



Chemical Formula: $C_{45}H_{53}N_5O_{15}S$
Exact Mass: 935.3
Molecular Weight: 936.0

Glycopeptide **S88** was prepared following the General Procedures **6.1** and **6.2** described above on a 0.05 mmol scale. Purification of the crude peptide using preparative HPLC (10 to 35% solvent B over 30 min, Dr. Maisch ReproSil 300 C18 column) afforded peptide **S88** as a white solid after lyophilization (27.4 mg,59%). Analytical HPLC: t_R = 20.0 min (10 to 35% solvent B over 30 min, Agilent C18 column); ESI-MS (*m/z*): $[M+H]^+$ calcd for $C_{45}H_{54}N_5O_{15}S$: 937.0 (average isotope), $[M\text{-}Glc+H]^+$: 773.9 ; found 936.1, 774.1.

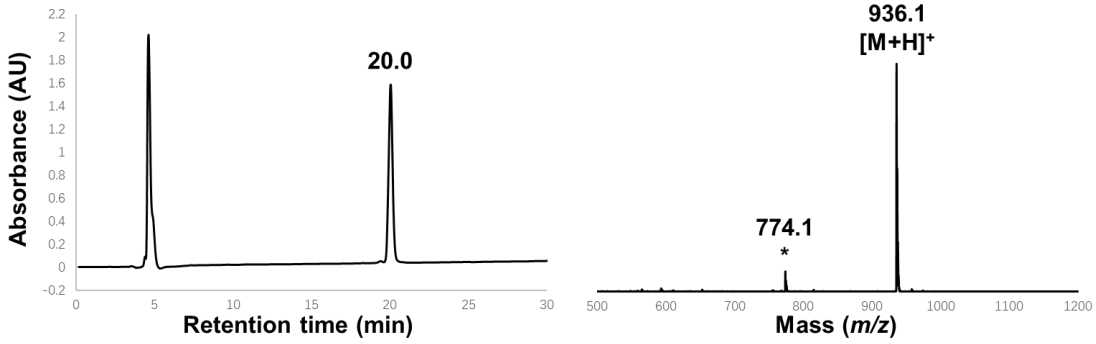
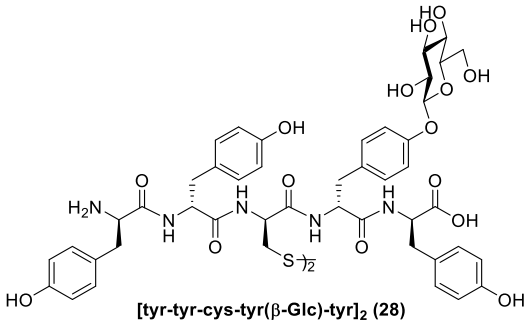


Figure S72. Left: UV trace from LC-MS analysis of glycopeptide **S88**; Right: ESI-MS data of glycopeptide **S88**. *Signal denotes the mass of $[M\text{-}Glc+H]^+$ corresponding to the glucose-cleaved species generated during ionization in the mass spectrometer.

Glycopeptide 28



Chemical Formula: $C_{90}H_{104}N_{10}O_{30}S_2$
Exact Mass: 1868.6
Molecular Weight: 1870.0

Glycopeptide **28** was prepared following the General Procedure **6.3** described above. Purification of the crude peptide using preparative HPLC (10 to 35% solvent B over 30 min, Dr. Maisch ReproSil 300 C18 column) afforded peptide **28** as a white solid after lyophilization (23.0 mg, 84%). Analytical HPLC: t_R = 23.3 min (10 to 35% solvent B over 30 min, Agilent C18 column); ESI-MS (*m/z*): $[M+H]^+$ calcd for $C_{90}H_{105}N_{10}O_{30}S_2$: 1871.0 (average isotope), $[M+2H]^{2+}$: 936.0, $[M\text{-}Glc+2H]^{2+}$: 854.4, $[M\text{-}2Glc+2H]^{2+}$: 772.8; found 936.0, 854.5, 773.6.

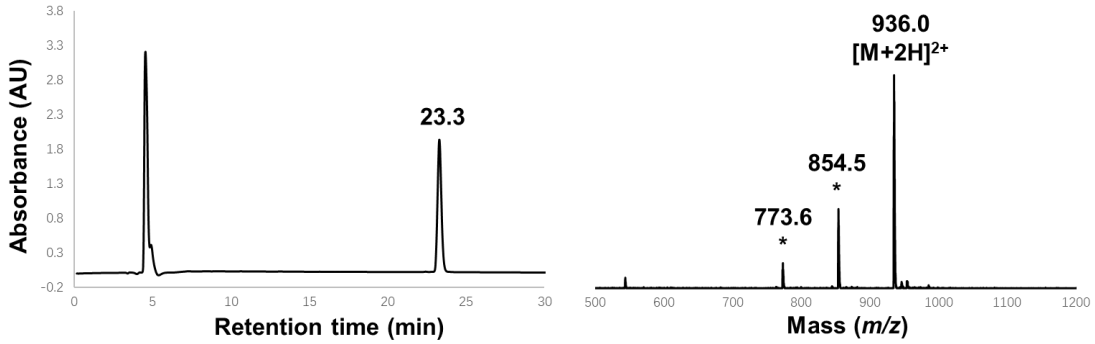
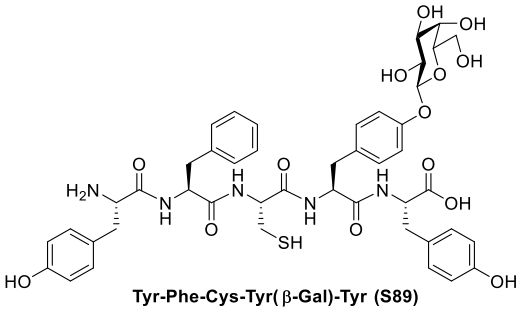


Figure S73. Left: UV trace from LC-MS analysis of glycopeptide **28**; Right: ESI-MS data of glycopeptide **28**. *Signals denote the mass of $[M\text{-}Glc+2H]^{2+}$ and $[M\text{-}2Glc+2H]^{2+}$ corresponding to the singly or doubly glucose-cleaved species respectively, generated during ionization in the mass spectrometer.

Glycopeptide S89



Chemical Formula: $C_{45}H_{53}N_5O_{14}S$
Exact Mass: 919.3
Molecular Weight: 920.0

Glycopeptide **S89** was prepared following the General Procedures **6.1** and **6.2** described above on a 0.05 mmol scale. Purification of the crude peptide using preparative HPLC (10 to 30% solvent B over 30 min, Dr. Maisch ReproSil 300 C18 column) afforded peptide **S89** as a white solid after lyophilization (32.3 mg, 70%). Analytical HPLC: t_R = 25.0 min (10 to 30% solvent B over 30 min, Agilent C18 column); ESI-MS (*m/z*): $[M+H]^+$ calcd for $C_{45}H_{54}N_5O_{14}S$: 921.0 (average isotope), $[M\text{-}Gal+H]^+$: 757.9,; found 920.4, 758.2.

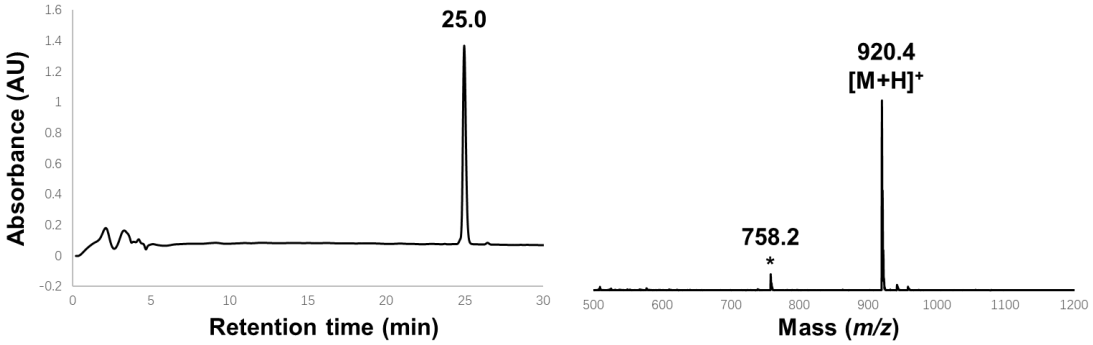
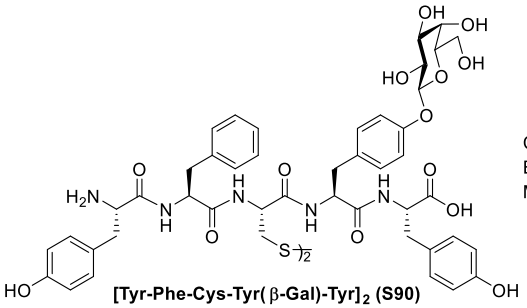


Figure S74. Left: UV trace from LC-MS analysis of glycopeptide **S89**; Right: ESI-MS data of glycopeptide **S89**. *Signal denotes the mass of $[M\text{-}Gal+H]^+$ corresponding to the galactose-cleaved species generated during ionization in the mass spectrometer.

Glycopeptide S90



Chemical Formula: $C_{90}H_{104}N_{10}O_{28}S_2$
Exact Mass: 1836.6
Molecular Weight: 1838.0

Glycopeptide **S90** was prepared following the General Procedure **6.3** described above. Purification of the crude peptide using preparative HPLC (10 to 35% solvent B over 30 min, Dr. Maisch ReproSil 300 C18 column) afforded peptide **S90** as a white solid after lyophilization (26.1 mg, 81%). Analytical HPLC: t_R = 25.7 min (10 to 35% solvent B over 30 min, Agilent C18 column); ESI-MS (*m/z*): $[M+H]^+$ calcd for $C_{90}H_{105}N_{10}O_{28}S_2$: 1839.0 (average isotope), $[M+2H]^{2+}$: 920.0, $[M\text{-}Gal+2H]^{2+}$: 838.4, $[M\text{-}2Gal+2H]^{2+}$: 756.8; found 919.7, 838.6, 757.7.

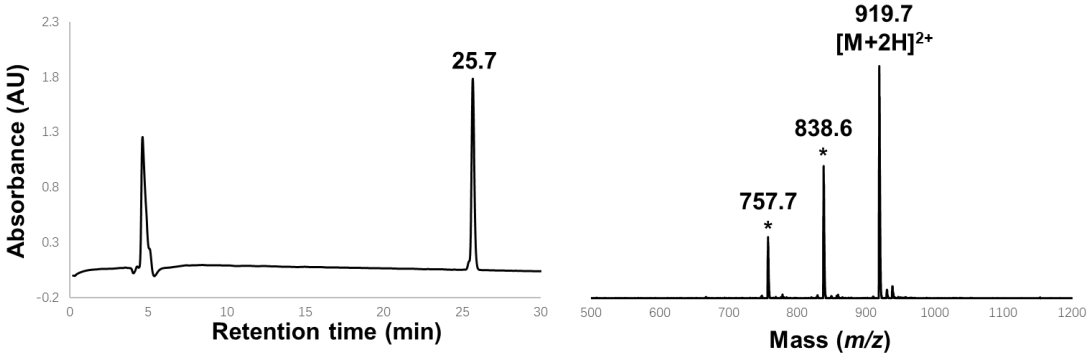
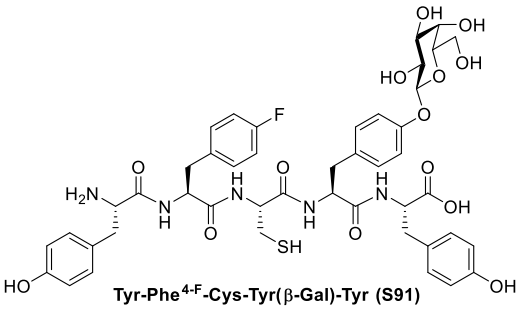


Figure S75. Left: UV trace from LC-MS analysis of glycopeptide **S90**; Right: ESI-MS data of glycopeptide **S90**. *Signals denote the mass of $[M\text{-}Gal+2H]^{2+}$ and $[M\text{-}2Gal+2H]^{2+}$ corresponding to the singly or doubly galactose-cleaved species respectively, generated during ionization in the mass spectrometer.

Glycopeptide S91



Chemical Formula: $C_{45}H_{52}FN_5O_{14}S$
Exact Mass: 937.3
Molecular Weight: 938.0

Glycopeptide **S91** was prepared following the General Procedures **6.1** and **6.2** described above on a 0.05 mmol scale. Purification of the crude peptide using preparative HPLC (10 to 35% solvent B over 30 min, Dr. Maisch ReproSil 300 C18 column) afforded peptide **S91** as a white solid after lyophilization (33.6 mg, 72%). Analytical HPLC: t_R = 23.4 min (10 to 35% solvent B over 30 min, Agilent C18 column); ESI-MS (*m/z*): $[M+H]^+$ calcd for $C_{45}H_{53}FN_5O_{14}S$: 939.0 (average isotope), $[M\text{-}Gal+H]^+$: 775.8; found 938.4, 776.3.

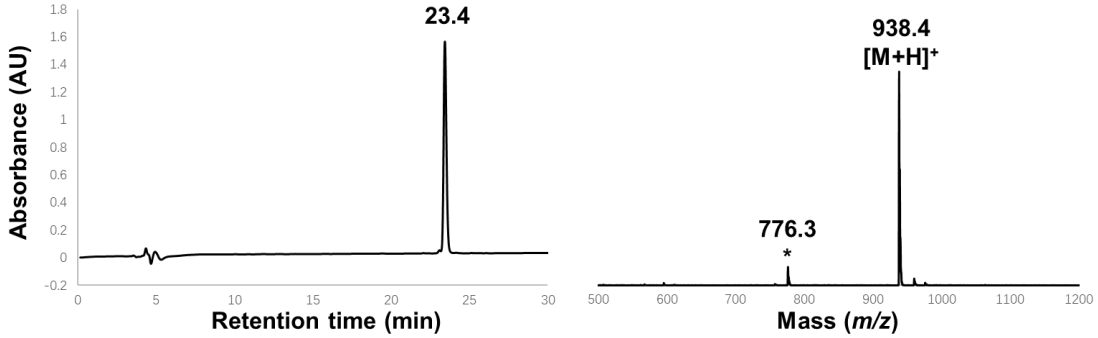
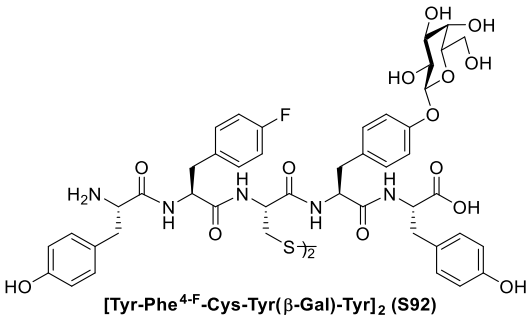


Figure S76. Left: UV trace from LC-MS analysis of glycopeptide **S91**; Right: ESI-MS data of glycopeptide **S91**. *Signal denotes the mass of $[M\text{-}Gal+H]^+$ corresponding to the galactose-cleaved species generated during ionization in the mass spectrometer.

Glycopeptide S92



Chemical Formula: $C_{90}H_{102}F_2N_{10}O_{28}S_2$
Exact Mass: 1872.6
Molecular Weight: 1874.0

Glycopeptide **S92** was prepared following the General Procedure **6.3** described above. Purification of the crude peptide using preparative HPLC (10 to 35% solvent B over 30 min, Dr. Maisch ReproSil 300 C18 column) afforded peptide **S92** as a white solid after lyophilization (30.1 mg, 90%). Analytical HPLC: t_R = 26.7 min (10 to 35% solvent B over 30 min, Agilent C18 column); ESI-MS (*m/z*): $[M+H]^+$ calcd for $C_{90}H_{103}F_2N_{10}O_{28}S_2$: 1875.0 (average isotope), $[M+2H]^{2+}$: 938.0, $[M\text{-}Gal+2H]^{2+}$: 856.4, $[M\text{-}2Gal+2H]^{2+}$: 774.8; found 937.7, 856.6, 775.6.

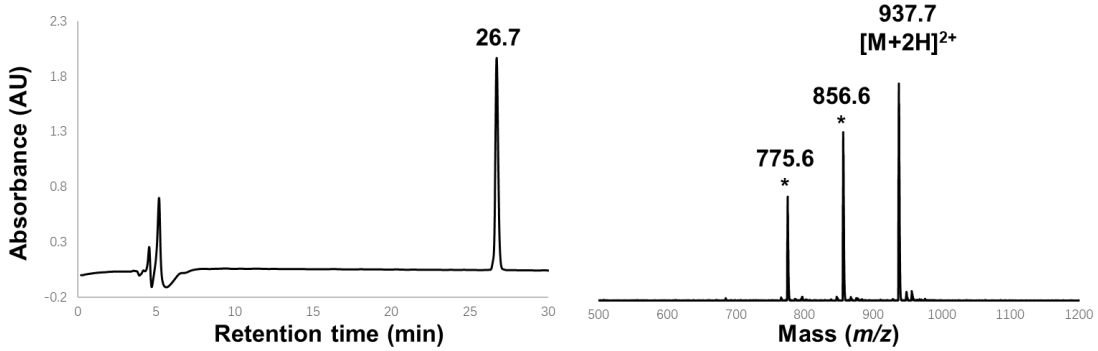
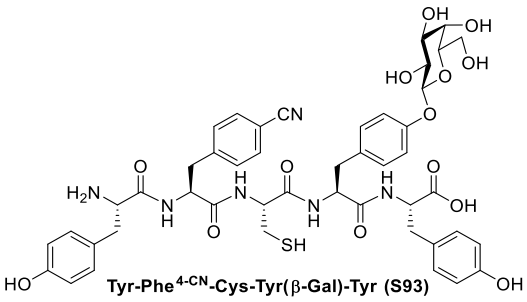


Figure S77. Left: UV trace from LC-MS analysis of glycopeptide **S92**; Right: ESI-MS data of glycopeptide **S92**. *Signals denote the mass of $[M\text{-}Gal+2H]^{2+}$ and $[M\text{-}2Gal+2H]^{2+}$ corresponding to the singly or doubly galactose-cleaved species respectively, generated during ionization in the mass spectrometer.

Glycopeptide S93



Chemical Formula: $C_{46}H_{52}N_6O_{14}S$
Exact Mass: 944.3
Molecular Weight: 945.0

Glycopeptide **S93** was prepared following the General Procedures **6.1** and **6.2** described above on a 0.05 mmol scale. Purification of the crude peptide using preparative HPLC (10 to 40% solvent B over 30 min, Dr. Maisch ReproSil 300 C18 column) afforded peptide **S93** as a white solid after lyophilization (26.3 mg, 56%). Analytical HPLC: t_R = 20.6 min (10 to 35% solvent B over 30 min, Agilent C18 column); ESI-MS (*m/z*): $[M+H]^+$ calcd for $C_{46}H_{52}N_6O_{14}S$: 946.0 (average isotope), $[M\text{-}Gal+H]^+$: 782.9; found 945.3, 784.3.

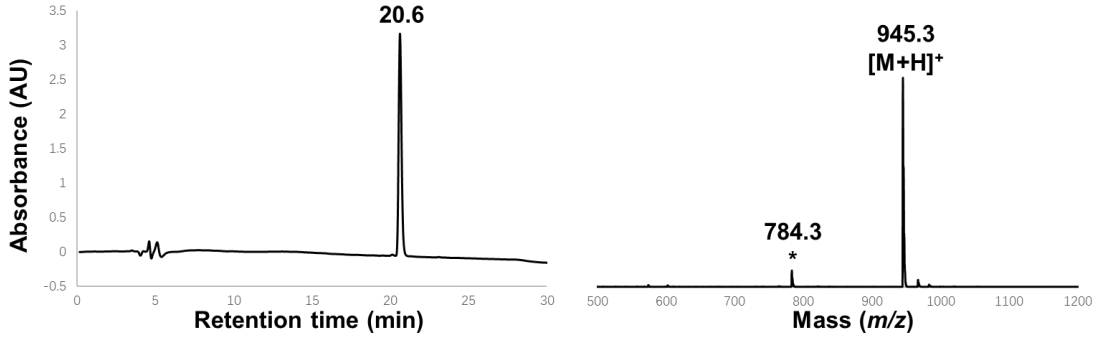
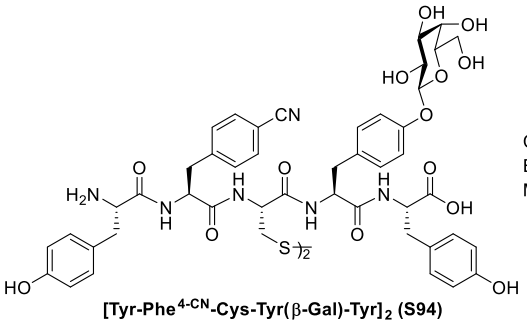


Figure S78. Left: UV trace from LC-MS analysis of glycopeptide **S93**; Right: ESI-MS data of glycopeptide **S93**. *Signal denotes the mass of $[M\text{-}Gal+H]^+$ corresponding to the galactose-cleaved species generated during ionization in the mass spectrometer.

Glycopeptide S94



Chemical Formula: $C_{92}H_{102}N_{12}O_{28}S_2$
Exact Mass: 1886.6
Molecular Weight: 1888.0

Glycopeptide **S94** was prepared following the General Procedure **6.3** described above. Purification of the crude peptide using preparative HPLC (10 to 40% solvent B over 30 min, Dr. Maisch ReproSil 300 C18 column) afforded peptide **S94** as a white solid after lyophilization (24.1 mg, 92%). Analytical HPLC: t_R = 22.4 min (10 to 40% solvent B over 30 min, Agilent C18 column); ESI-MS (*m/z*): $[M+H]^+$ calcd for $C_{92}H_{103}N_{12}O_{28}S_2$: 1889.0 (average isotope), $[M+2H]^{2+}$: 945.0, $[M\text{-}Gal+2H]^{2+}$: 863.4, $[M\text{-}2Gal+2H]^{2+}$: 781.9; found 944.6, 863.4, 782.5.

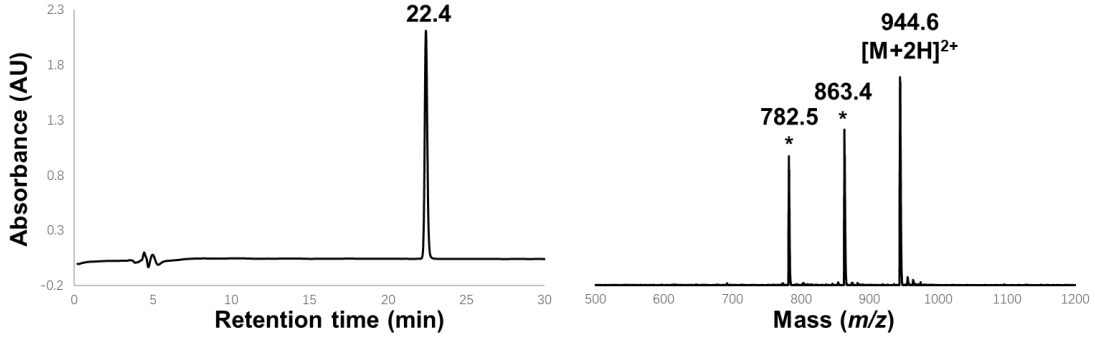
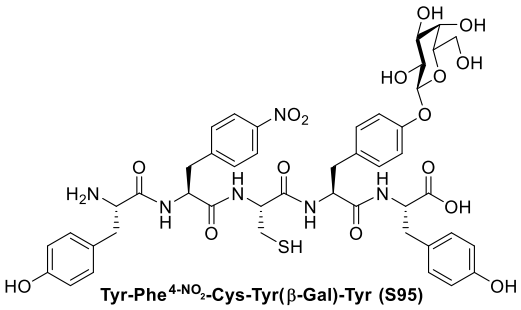


Figure S79. Left: UV trace from LC-MS analysis of glycopeptide **S94**; Right: ESI-MS data of glycopeptide **S94**. *Signals denote the mass of $[M\text{-}Gal+2H]^{2+}$ and $[M\text{-}2Gal+2H]^{2+}$ corresponding to the singly or doubly galactose-cleaved species respectively, generated during ionization in the mass spectrometer.

Glycopeptide S95



Chemical Formula: $C_{45}H_{52}N_6O_{16}S$
Exact Mass: 964.3
Molecular Weight: 965.0

Glycopeptide **S95** was prepared following the General Procedures **6.1** and **6.2** described above on a 0.05 mmol scale. Purification of the crude peptide using preparative HPLC (10 to 40% solvent B over 30 min, Dr. Maisch ReproSil 300 C18 column) afforded peptide **S95** as a white solid after lyophilization (39.9 mg, 82%). Analytical HPLC: t_R = 20.6 min (10 to 40% solvent B over 30 min, Agilent C18 column); ESI-MS (*m/z*): $[M+H]^+$ calcd for $C_{45}H_{53}N_6O_{16}S$: 966.0 (average isotope), $[M\text{-Gal}+H]^+$: 802.9; found 965.2, 803.2.

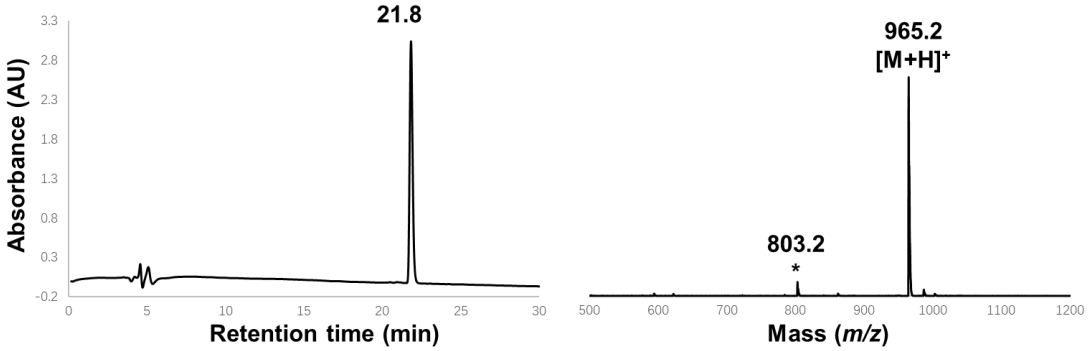
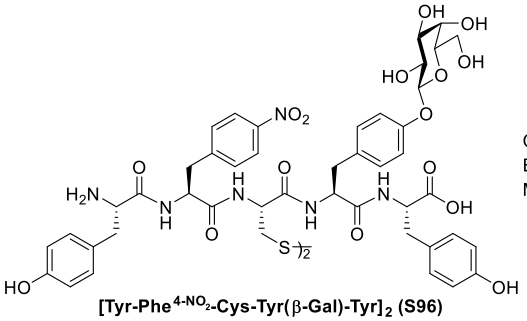


Figure S80. Left: UV trace from LC-MS analysis of glycopeptide **S95**; Right: ESI-MS data of glycopeptide **S95**. *Signal denotes the mass of $[M\text{-Gal}+H]^+$ corresponding to the galactose-cleaved species generated during ionization in the mass spectrometer.

Glycopeptide S96



Chemical Formula: $C_{90}H_{102}N_{12}O_{32}S_2$
Exact Mass: 1926.6
Molecular Weight: 1928.0

Glycopeptide **S96** was prepared following the General Procedure **6.3** described above. Purification of the crude peptide using preparative HPLC (10 to 40% solvent B over 30 min, Dr. Maisch ReproSil 300 C18 column) afforded peptide **S96** as a white solid after lyophilization (32.4 mg, 82%). Analytical HPLC: t_R = 22.8 min (10 to 40% solvent B over 30 min, Agilent C18 column); ESI-MS (*m/z*): $[M+H]^+$ calcd for $C_{90}H_{103}N_{12}O_{32}S_2$: 1929.0 (average isotope), $[M+2H]^{2+}$: 965.0, $[M\text{-}Gal+2H]^{2+}$: 883.4, $[M\text{-}2Gal+2H]^{2+}$: 801.8; found 964.5, 883.6, 802.5.

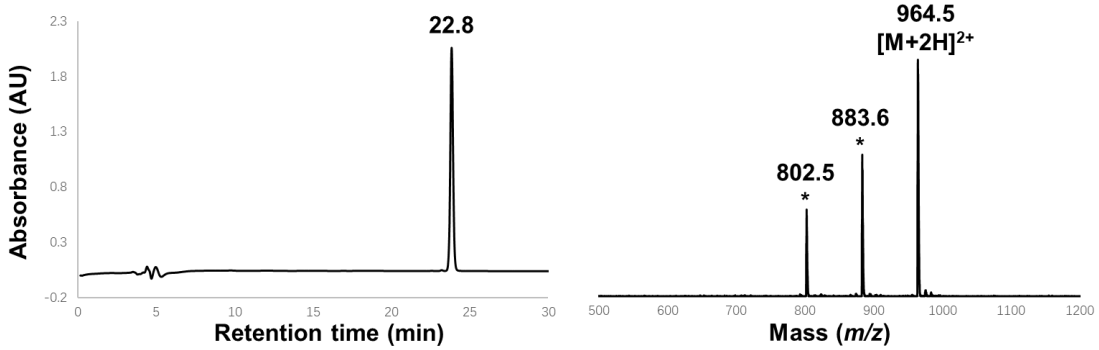


Figure S81. Left: UV trace from LC-MS analysis of glycopeptide **S96**; Right: ESI-MS data of glycopeptide **S96**. *Signals denote the mass of $[M\text{-}Gal+2H]^{2+}$ and $[M\text{-}2Gal+2H]^{2+}$ corresponding to the singly or doubly galactose-cleaved species respectively, generated during ionization in the mass spectrometer.

References

(S1) Frisch, M. J.; Trucks, G. W.; Schlegel, H. B.; Scuseria, G. E.; Robb, M. A.; Cheeseman, J. R.; Scalmani, G.; Barone, V.; Petersson, G. A.; Nakatsuji, H.; Li, X.; Caricato, M.; Marenich, A. V.; Bloino, J.; Janesko, B. G.; Gomperts, R.; Mennucci, B.; Hratchian, H. P.; Ortiz, J. V.; Izmaylov, A. F.; Sonnenberg, J. L.; Williams-Young, D.; Ding, F.; Lipparini, F.; Egidi, F.; Goings, J.; Peng, B.; Petrone, A.; Henderson, T.; Ranasinghe, D.; Zakrzewski, V. G.; Gao, J.; Rega, N.; Zheng, G.; Liang, W.; Hada, M.; Ehara, M.; Toyota, K.; Fukuda, R.; Hasegawa, J.; Ishida, M.; Nakajima, T.; Honda, Y.; Kitao, O.; Nakai, H.; Vreven, T.; Throssell, K.; Montgomery, J. A., Jr.; Peralta, J. E.; Ogliaro, F.; Bearpark, M. J.; Heyd, J. J.; Brothers, E. N.; Kudin, K. N.; Staroverov, V. N.; Keith, T. A.; Kobayashi, R.; Normand, J.; Raghavachari, K.; Rendell, A. P.; Burant, J. C.; Iyengar, S. S.; Tomasi, J.; Cossi, M.; Millam, J. M.; Klene, M.; Adamo, C.; Cammi, R.; Ochterski, J. W.; Martin, R. L.; Morokuma, K.; Farkas, O.; Foresman, J. B.; Fox, D. J. *Gaussian 09*, revision D.01; Gaussian, Inc.: Wallingford, CT, 2016.

(S2) Lu, T; Chen, F. Multiwfn: A multifunctional wavefunction analyzer. *J. Comput. Chem.*, **2012**, *33*, 580-592.

(S3) Otwinowski, Z. M.; Wladek, M. Processing of X-ray diffraction data collected in oscillation mode. *Methods Enzymol*. **1997**, *276*, 307-326.

(S4) Adams, P. D.; Afonine, P. V.; Bunkoczi, G.; Chen, V. B.; Davis, I. W.; Echols, N.; Headd, J. J.; Hung, L.-W.; Kapral, G. J.; Grasse-Kunstleve, R. W.; McCoy, A. J.;Moriarty, N. W.; Oeffner, R.; Read, R. J.; Richardson, D. C.; Richardson, J. S.; Terwilliger, T. C.; Zwart, P. H. PHENIX: a comprehensive Python-based system for macromolecular structure solution. *Acta. Crystallogr. D. Biol. Crystallogr.* **2010**, *66*, 213-221.

(S5) Emsley, P.; Lohkamp, B.; Scott, W. G.; Cowtan K. Features and development of Coot. *Acta. Crystallogr. D. Biol. Crystallogr.* **2010**, *66*, 486-501.

(S6) Winn, M. D.; Ballard, C. C.; Cowtan, K. D.; Dodson, E. J.; Emsley, P.; Evans, P. R.; Keegan, R. M.; Krissinel, E. B.; Leslie, A. G. W.; McCoy, A.; McNicholas, S. J.; Murshudov, G. N.; Pannu, N. S.; Potterton, E. A.; Powell, H. R.; Read, R. J.; Vagin, A.; Wilson, K. S. Overview of the CCP4 suite and current developments. *Acta. Crystallogr. D. Biol. Crystallogr.* **2011**, *67*, 235-242.

(S7) Davis, I. W.; Leaver-Fay, A.; Chen, V. B.; Block, J. N.; Kapral, G. J.; Wang, X.; Murray, L. W.; Arendall, W. B. III; Snoeyink, J.; Richardson, J. S.; Richardson, D. C. MolProbity: all-atom contacts and structure validation for proteins and nucleic acids. *Nucleic Acids Res.* **2007**, *35*, W375-383.

(S8) Laskowski, R. A.; MacArthur, M. W.; Moss, D. S.; Thornton, J. M. PROCHECK: a program to check the stereochemicai quality of protein structures. *J. Appl. Crystallogr.* **1993**, *26*, 283-291.

(S9) Garcia, A. M.; Iglesias, D.; Parisi, E.; Styan, K. E.; Waddington, L. J.; Deganutti, C.; De Zorzi, R.; Grassi, M.; Melchionna, M.; Vargiu, A.V.; Marchesan, S. Chirality effects on peptide self-assembly unraveled from molecules to materials. *Chem* **2018**, *4*, 1862-1876.

(S10) Fichna, J.; Mazur, M.; Grzywacz, D.; Kamysz, W.; Perlikowska, R.; Piekielna, J.; Sobczak, M.; Salaga, M.; Toth, G.; Janecka, A.; Chen, C.; Olczak, J. Novel glycosylated endomorphin-2 analog produces potent centrally-mediated antinociception in mice after peripheral administration. *Bioorg. Med. Chem. Lett.* **2013**, *23*, 6673-6676.

(S11) Lin, H.; Thayer, D. A.; Wong, C. H.; Walsh, C.T. Macrolactamization of glycosylated peptide thioesters by the thioesterase domain of tyrocidine synthetase. *Chem. Biol.* **2004**, *11*, 1635-1642.

(S12) Wang, S.; Dupin, L., Noel, M.; Carroux, C. J.; Renaud, L.; Gehin, T.; Meyer, A.; Souteyrand, E.; Vasseur, J.-J.; Vergoten, G. *et al*. Toward the rational design of galactosylated glycoclusters that target *pseudomonas aeruginosa* lectin A (LecA): influence of linker arms that lead to low-nanomolar

multivalent ligands. *Chem. Eur. J.* **2016**, *22*, 1-11.
(S13) Yao, N.; Fung, G.; Malekan, H.; Ye, L.; Kurth, M. J.; Lam, K. S. Facile synthesis of glycosylated Fmoc amino acid building blocks assisted by microwave irradiation. *Carbohydr. Res.* **2010**, *345*, 2277-2281.
(S14) Pelletier, G.; Zwicker, A.; Allen, C. L.; Schepartz, A.; Miller, S. J. Aqueous Glycosylation of Unprotected Sucrose Employing Glycosyl Fluorides in the Presence of Calcium Ion and Trimethylamine. *J. Am. Chem. Soc.* **2016**, *138*, 3175-3182.
(S15) Zhu, Y.; Yu, B. Highly stereoselective beta-mannopyranosylation via the 1-alpha-glycosyloxy-isochromenylium-4-gold(I) intermediates. *Chemistry* **2015**, *21*, 8771-8780.
(S16) Zhu, Y.; Shen, Z.; Li, W.; Yu, B. Stereoselective synthesis of β-rhamnopyranosides via gold(I)-catalyzed glycosylation with 2-alkynyl-4-nitro-benzoate donors. *Org. Biomol. Chem.* **2016**, *14*, 1536-1539.
(S17) Pattabiraman, V. R.; McKinnie, S. M.; Vederas, J. C. Solid-supported synthesis and biological evaluation of the lantibiotic peptide bis(desmethyl) lacticin 3147 A2. *Angew. Chem. Int. Ed. Engl.* **2008**, *47*, 9472-9475.
(S18) Picha, J.; Budesinsky, M.; Machackova, K.; Collinsova, M.; Jiracek, J. Optimized syntheses of Fmoc azido amino acids for the preparation of azidopeptides. *J. Pept. Sci.* **2017**, *23*, 202-214.
(S19) Peptide Synthesis, 2010/2011 Catalog, Merck.
(S20) Gude, M.; Ryf, J.; White, P. D. An accurate method for the quantitation of Fmoc-derivatized solid phase supports. *Lett. Pept. Sci.* **2002**, *9*, 203-206
(S21) Wang, P.; Nilsson, J.; Brinkmalm, G.; Larson, G.; Huang, X. Synthesis aided structural determination of amyloid-β(1–15) glycopeptides, new biomarkers for Alzheimer's disease. *Chem. Commun.*, **2014**, *50*, 15067-15070