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# Design, Synthesis and Biological Evaluation of Aryl-substituted Sialyl Lewis X Mimetics Prepared Via Cross-metathesis of *C*-Fucopeptides

Christoph M. Huwe,[a] Thomas J. Woltering,[a] Jan Jiricek,[a] Gabriele Weitz-Schmidt[b] and Chi-Huey Wong[a,*]

[a]*Department of Chemistry and Skaggs Institute of Chemical Biology, The Scripps Research Institute, 10550 North Torrey Pines Road, La Jolla, CA 92037, USA*

[b]*Novartis Pharma AG, CH-4002 Basel, Switzerland*

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**Abstract**—Several aryl substituted *C*-fucopeptides have been developed as sialyl Lewis X mimetics. Although the compounds have a much simpler structure compared to $SLe^x$, up to 3-times higher binding affinity toward E-selectin and >1000 times toward P-selectin was observed. Furthermore, a convenient strategy for generating a number of analogues from a $SLe^x$ mimetic template at a very late stage of the synthesis was introduced, using a ruthenium catalyzed cross olefin metathesis under benchtop conditions.


## Introduction

The tetrasaccharide sialyl Lewis x ($SLe^x$, **1**, Figure 1), a terminal unit of cell-surface glycoproteins and glycolipids, has been identified as a common ligand for E-, P- and L-selectin,[1] albeit with some differences in the bound conformation.[2] The carbohydrate-protein recognition between $SLe^x$ and E- or P-selectin mediates the early stage of inflammatory response, leading to the rolling of leukocytes on endothelial cells, followed by the recruitment of leukocytes to inflamed tissue. Inhibition of this carbohydrate–protein interaction has therefore been considered as a new therapeutic approach for the treatment of inflammatory diseases as well as metastasis and angiogenesis.[1] Since the binding affinity of $SLe^x$ is relatively low and it is orally inactive and unstable in the bloodstream, the search for $SLe^x$ mimetics[3] has been of current interest, especially for compounds with simpler structure, higher binding affinity, and resistance to glycosidases, i.e. fucosidase and sialidase. Based on the structure–activity relationship studies, the functional groups essential for selectin binding are depicted in Figure 1.[4] Recently, a new binding site in the selectins for aromatic or hydrophobic groups has been proposed, since replacement of the acetamide group in $SLe^x$ (**1**) by a benzamide (**2**) or naphtamide (**3**) resulted in a 3.3- and 12.5-fold increase in activity against E-selectin, respectively,[5] and several $SLe^x$ mimetics containing a hydrophobic group at the equivalent position also showed enhanced activities against the three selectins.[6] In this study, we have designed and synthesized a series of aryl substituted *C*-fucopeptides[7] as $SLe^x$ mimetics, which are stable against glycosidases and are expected to adopt the same favorable gauche conformation as the *O*-linked analogues[8] (Fig. 1). Thus, several $SLe^x$ mimetics (**13a,b; 18; 21**) bearing phenyl groups and a series of mimetics (**32a–g**) bearing different aromatic groups have been prepared. Many of the latter compounds can be quickly generated from a template molecule using a cross olefin metathesis reaction under normal benchtop conditions. The synthesized compounds, in spite of rather simple structure, exihibited up to 3-times better activity than $SLe^x$ against E-selectin and >1000 times better than $SLe^x$ against P-selectin.

## Results

The distance of the aromatic residue and the fucose moiety in $SLe^x$ derivatives **2** and **3** would demand the establishment of a two carbon spacer, making phenethyl ether **13** (**4**, $R^1 = Ph$, $R^2 = H$, $R^3 = CH_3$) the first target for synthesis (Scheme 1). 3-(Tri-*O*-benzyl-α-L-fucopyranosyl)-1-propene[7a] (**6**) served as starting material for the fucose part. It was planned to generate the epoxide and perform a regioselective ring opening with azide to obtain the 1,2-azido alcohol. Unfortunately, all attempts to achieve a highly diastereoselective reaction, either by

*Corresponding author. Tel.: +1-619-784-2487; fax: +1-619-784-2409; e-mail: wong@scripps.edu

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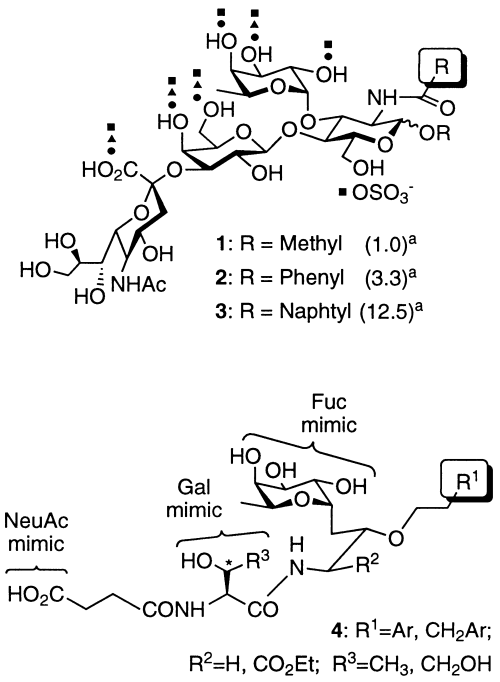


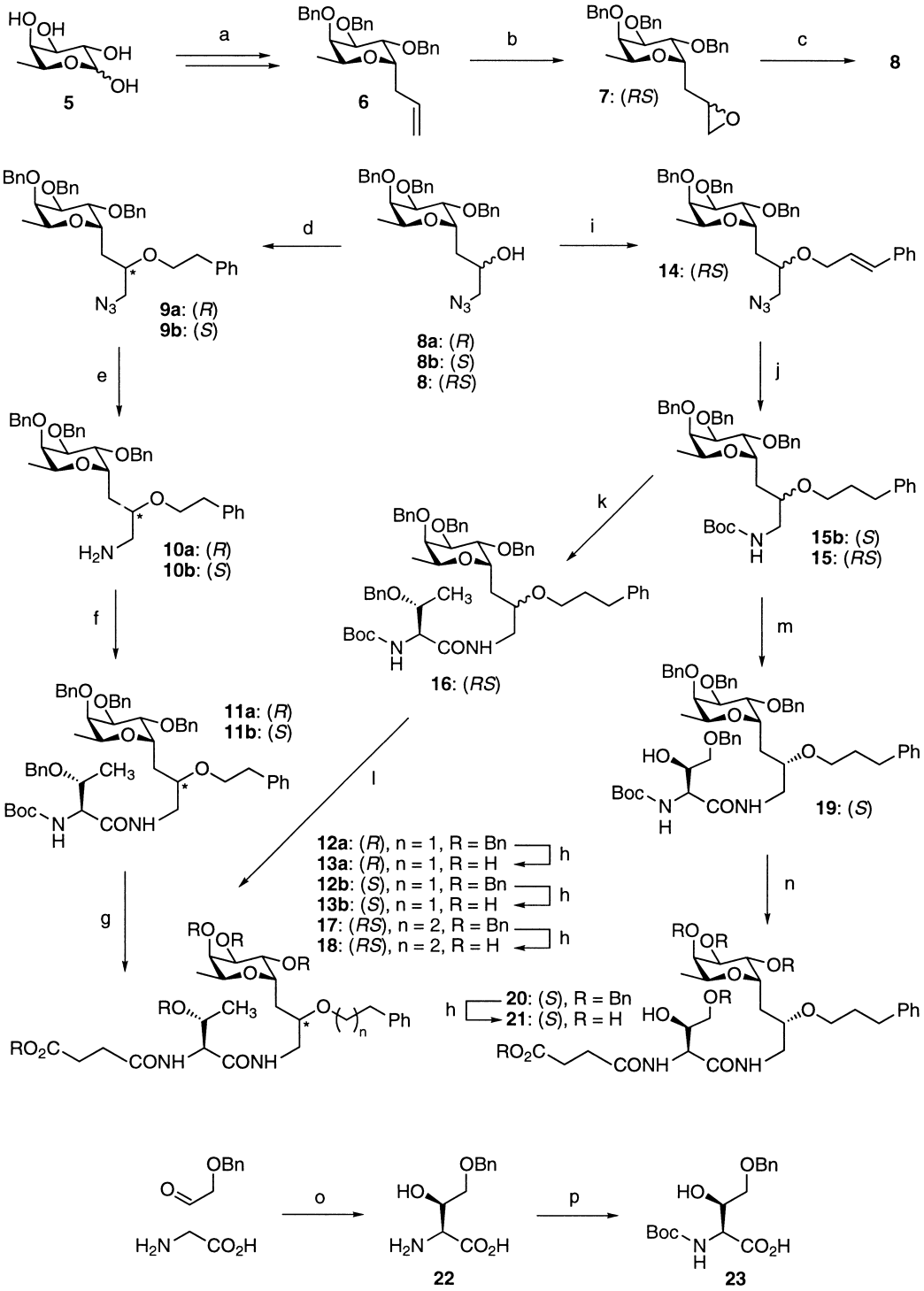

**Figure 1.** $SLe^x$ (**1**), the essential functional groups for its recognition by E- (●), P- (▲), and L- (■) selectin, aryl substituted $SLe^x$ analogues[5] (**2** and **3**), and designed $SLe^x$ mimetics (**4**) based on *C*-fucopeptides. [a]Relative binding affinities to E-selectin calculated from $IC_{50}$ values.

*Jacobsen* epoxidation or *Sharpless* AD-reaction, were not successful. Therefore, a non-selective epoxidation was employed to give epoxide **7** (MCPBA, $CH_2Cl_2$, 89%) which was then opened with sodium azide ($NaN_3$, $NH_4Cl$, EtOH, $H_2O$, 86%). Separation of the isomers by HPLC led to the chiral azido alcohols **8a** and **8b**[9] (Scheme 1). The attempted alkylation of the OH-group to establish the 2-phenylethyl ether turned out to be a difficult step. Alkylation under standard conditions (NaH, phenethyl bromide, $Bu_4NI$) resulted in a total recovery of the starting material. Several other conditions were tried, including etherification with the trichloroacetimidate of 2-phenylethanol under acidic conditions, and $Bu_3Sn$-ether formation followed by treatment with phenethyl bromide in the presence of $Bu_4NI$, but none of these methods gave any detectable amount of the desired 2-phenylethyl ether. Therefore, we sought for conditions in the presence of an excess of base and an alkylating reagent. Accordingly, employing phase transfer catalysis with 50% aqueous NaOH in neat 2-phenethyl bromide in the presence of $Bu_4NHSO_4$ for five days afforded the phenethyl ethers **9a** and **9b** in 9% and 18% yield, respectively (64% and 93% taking the still diastereomerically pure recovered starting material into consideration). Azides **9a** and **9b** were then reduced ($PPh_3$, $H_2O$, THF, 88% and 86%) and the resulting amines **10a** and **10b** were coupled with *N*-Boc-*O*-benzyl-L-threonine to afford compounds **11a** and **11b** (EDC, HOBT, NMM, $CH_2Cl_2$, 98% and 84%). Removal of the Boc protecting group (TFA, $CH_2Cl_2$) followed by coupling with monobenzyl succinate gave protected $SLe^x$ mimetics **12a** and **12b** (EDC, HOBT, NMM, $CH_2Cl_2$, 98% and 99%, two steps). The five benzyl groups were easily removed by catalytic hydrogenation (Pd-C, HOAc, $H_2O$) without affecting the stable phenethyl ether, giving pure mimetics **13a** and **13b** (90% and 83% yield). Evaluation of the biological activities of these compounds revealed an $IC_{50}$ of ~0.3 mM for **13a** and 0.19 mM for **13b**, thus showing a 1.7- and 2.6-times higher binding affinity toward E-selectin than $SLe^x$ ($IC_{50}$ 0.5 mM).

The difficulties in the preparation of the phenethyl ether led us to use the more accessible cinnamyl compound **18** (**4,** $R^1 = CH_2Ph$, $R^2 = H$, $R^3 = CH_3$) as the next target (Scheme 1). This time the diasteromeric mixture of azido alcohol **8** was alkylated with cinnamyl bromide to give cinnamyl ether **14** (NaH, THF, DMF, 79%), followed by chemoselective hydrogenation of the olefin and the azide in the presence of di-*tert*-butyldicarbonate ($Boc_2O$, $H_2$, Pd-C, EtOAc, 80%) for immediate protection of the resulting amine as the *tert*-butyl carbamate (**15**). In analogy to the synthesis of compounds **13a** and **13b**, Boc deprotection followed by coupling with *N*-Boc-*O*-benzyl-L-threonine (**16**, 85%, two steps), another Boc deprotection and coupling with monobenzyl succinate (**17**, 98%, two steps) and finally catalytic hydrogenation gave phenpropyl mimetic **18** (90%). Since the $IC_{50}$ of this compound (0.23 mM) was almost exactly in between **13a** and **13b**, it appeared that the one carbon extension had no major impact on the activity.

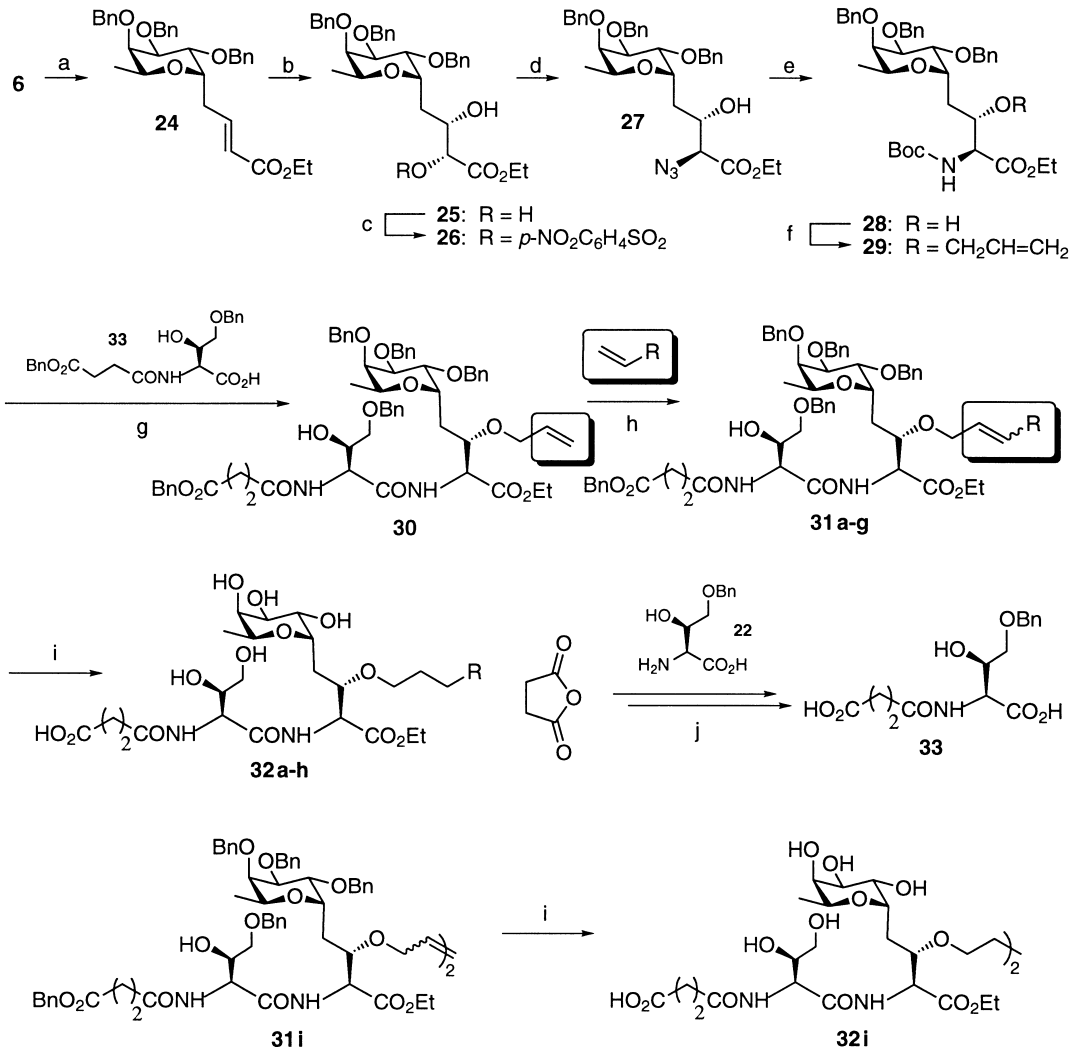
Since the unnatural dihydroxy amino acid **22**[10] proved to be a very good galactose mimic in earlier studies,[7,11] we incorporated it into another phenyl substituted $SLe^x$ mimetic **21** (**4**, $R^1 = CH_2Ph$, $R^2 = H$, $R^3 = CH_2OH$), an analogue of **18** (Scheme 1). Since the (*S*)-configuration[9] in the mimetics of type **13**, i.e. compound **13b**, showed slightly better inhibition, only the corresponding (*S*)-diastereomer was used. This time the separation of the diastereomers was carried out by simple flash-chromatography. Deprotection of **15b** (Scheme 1) and coupling with protected dihydroxy amino acid **23**[7a] (**19**, 62%, two steps), which is available from the L-threonine catalyzed condensation product of glycine and benzyloxyacetaldehyde[10] (**22**, Scheme 1), another deprotection and coupling with monobenzyl succinate (**20**, 65%, twosteps) and again catalytic hydrogenation (95%) gave mimetic **21**. No further increase of activity was observed, however.

So far, only phenyl groups had been incorporated into our mimetics, and as a next step we were looking for a quick way of synthesizing a series of mimetics **32** (**4**, $R^1 = CH_2Ar$, $R^2 = CO_2Et$, $R^3 = CH_2OH$) with a wide variety of aromatic residues in order to probe their influence on the observed biological activity. A divergent approach to these compounds was envisaged, i.e. these aromatic groups were introduced at a very late stage of the synthesis. To achieve this task, the use of a transition metal catalyzed cross metathesis reaction[12] between an almost inert allyl ether and different aromatic olefins appeared to be the reaction of choice. Finally, a more practical, convergent synthesis of the template was employed (Scheme 2). In order to obtain a



**Scheme 1.** *Conditions*: (a) Ref 7a (73% from L-fucose, 4 steps); (b) MCPBA, $CH_2Cl_2$, rt, 11 h (89%); (c) $NaN_3$, $NH_4Cl$, EtOH, $H_2O$, reflux, 1.5 h (86%); (d) 1. separation by HPCL; 2. $PhCH_2CH_2Br$, NaOH, $H_2O$, $Bu_4NHSO_4$, rt, 5 days (**9a**: 9%, **9b**: 18%); (e) $PPh_3$, $H_2O$, rt, 2.5 days (**10a**: 88%, **10b**: 86%); (f) *N*-Boc-*O*-benzyl-L-threonine, EDC, HOBT, NMM, DMF, −20 °C to rt, 38 h (**12a**: 98%, **12b**: 99%; two steps); (h) $H_2$, Pd-C, HOAc, $H_2O$, rt, 1–2 days (83–95%); (i) cinnamyl bromide, NaH, THF, DMF, 65 °C, 1 h (79%); (j) $Boc_2O$, $H_2$, Pd-C, EtOAc, rt, 2 days (80%); (k) 1. TFA, $CH_2Cl_2$, rt, 1 h; *N*-Boc-*O*-benzyl-L-threonine, EDC, HOBT, NMM, DMF, −20 °C to rt, 7 h (85%, two steps); (l) 1. TFA, $CH_2Cl_2$, rt, 1 h; 2. monobenzyl succinate, EDC, HOBT, NMM, DMF, −20 °C to rt, 12 h (98%, two steps); (m) 1. separation by flash chromatography; 2. **23**, EDC, HOBT, NMM, $CH_2Cl_2$, rt, 5 h (62%, two steps); (n) 1. TFA, $CH_2Cl_2$, rt, 1 h; 2. monobenzyl succinate, EDC, HOBT, NMM, DMF, rt, 4 h (65%, two steps); (o) ref 10 (L-threonine aldolase, 78%); (p) ref 7a (98%). EDC: 1-(3-dimethylaminopropyl)-3-ethyl-carbodiimide hydrochloride, HOBT: 1-hydroxybenzotriazole, MCPBA: *m*-chloroperbenzoic acid, NMM: *N*-methylmorpholine, TFA: trifluoroacetic acid.

stereochemically pure product and to have the option of future incorporation of the compounds into multivalent assemblies such as liposomes or polymers,[1,13] unsaturated ester **24** was used as starting material for the synthesis of mimetics related to **32**. As anticipated, compound **24**, easily available from **6** by ozonization and workup with dimethyl sulfide and *Horner–Wittig* chain elongation (88% overall), proved to be a viable



**Scheme 2.** *Conditions*: (a) 1. $O_3$, $CH_2Cl_2$, MeOH, −78 °C, then $Me_2S$, −78 °C to rt, 22 h; 2. $(EtO)_2POCH_2CO_2Et$, NaH, rt, 12 h (88% overall); (b) AD-mix α, $MeSO_2NH_2$, *t*-BuOH, $H_2O$, 4 °C, 48 h (86%, 93% *de*); (c) *p*-$NO_2C_6H_4SO_2Cl$, py, 4 °C, 25 h (88%); (d) $NaN_3$, DMF, 50 °C, 21 h (88%); (e) $Boc_2O$, $H_2$, Pd-C, EtOAc, rt, 18 h (85%); (f) $CH_2$-$CHCH_2OCO_2Me$, 2.5 mol% $Pd_2(dba)_3$, bdpb, THF, 65 °C, 4.25 h (88%); (g) 1. TFA, $CH_2Cl_2$, 0 °C, 1.5 h, then rt, 2 h; 2. **33**, EDC, HOBT, NMM, $CH_2Cl_2$, 0 °C to rt, 11 h (69%); (h) 2 equiv olefin, 5 mol% $Cl_2(PCy_3)_2RuCHPh$, $CH_2Cl_2$, reflux, 18–40 h (for yields see Table 1); (i) **31a,b,d,f,h**: $H_2$, $Pd(OH)_2$-C, EtOH, $H_20$, rt, 24 h; **31c,e,g**: cyclohexene, Pd-BaSO4, EtOH, 80 °C, 1–5 days (for yields see Table 1); (j) ref 11 (66%, 3 steps). dba: dibenzylideneacetone, bdpb: bis(diphenyl-phosphino)-butane, EDC: 1-(3-dimethylaminopropyl)-3-ethyl-carbodiimide hydrochloride, HOBT: 1-hydrobenzotriazole, NMM: *N*-methylmorphonline, TFA: trifluoroacetic acid.

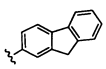
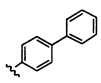
substrate for the *Sharpless* AD reaction, giving diol **25** in 86% yield and 93% *de*. Selective nosylation of the more reactive hydroxyl group (**26**, nosyl chloride, pyridine, 88%) and displacement of the nosylate with sodium azide ($NaN_3$, DMF, 88%) gave compound **27**. Catalytic hydrogenation of azide **27** in the presence of di-*tert*-butyldicarbonate ($Boc_2O$, $H_2$, Pd-C, EtOAc, 85%) yielded amino acid derivative **28**, which was finally *O*-allylated under essentially neutral conditions by means of palladium catalysis (allyl methyl carbonate, $Pd_2(dba)_3$, bdpb, 88%) to give sugar building block **29**. Using a different reaction sequence, i.e. *O*-allylation followed by reduction, only a poor yield of **29** had been obtained. The other building block, acid **33**, was available from succinic anhydride and amino acid **22** as described[11] (66%, three steps). Coupling of the two building blocks **29** and **33** (EDC, HOBT, $CH_2Cl_2$, NMM, 69%) finally gave mimetic precursor **30**, the template for the cross metathesis reactions (Scheme 2). While more studies have been reported for the related ring closing olefin metathesis[14] only few examples for the crossed metathesis reaction of terminal olefins have been published,[12a–c] including the selective molybdenium catalyzed cross-metathesis of styrenes with terminal olefins.[12h] Since we were aiming at a practical synthesis, we decided to employ the commercially available and much more stable ruthenium catalyst ($Cl_2P(Cy_3)_2RuCHPh$)[15] instead of the highly sensitive molybdenium catalyst[16] used in the model study.[12h] It turned out that, while the molybdenium catalyzed reactions are described[12h] to work well at room temperature, using ruthenium catalysis no reaction was observed under the same conditions. However, refluxing a dichloromethane solution of **30** and two equivalents of various aromatic olefins in the presence of 5 mol% $Cl_2P(Cy_3)_2RuCHPh$ usually gave moderate to good

yields of the metathesis products **31** (Scheme 2, Table 1). Electron-poor pentafluorostyrene on the other hand, showed a very slow reaction and reduced yield of the desired product (**31d**, 17%). In this case most of the starting material dimerized to give **31i** in 47% yield (Scheme 2). In all other cases, only traces of **31i** were detected (TLC). Allylbenzene was employed in order to synthesize a mimetic with an even longer linker between template and aromatic group (**31b**). Although lacking the stabilizing electronic effect of the aromatic group directly bound to the olefin, an acceptable yield of the desired metathesis product was obtained.[17] This result also demonstrates that besides aromatic olefins, a wide variety of other groups, for example, long alkyl chains which are known to enhance the binding affinity of $SLe^x$ mimetics,[7b] may be introduced using this methodology, providing more options for this divergent approach. In this study, the stereochemistry of the formed double bond was not important since the metathesis products were hydrogenated to reduce the double bond and at the same time to remove the benzyl protecting groups. However, it is notable that for activated aromatic or nonaromatic olefins (Table 1, **31b,c,d,i**) a *trans*/*cis* mixture was obtained, but for nonactivated aromatic olefins (Table 1, **31a,e,f,g**) only the *trans* double bond was detected ($^1$H NMR). As expected, the final deprotection of the metathesis products by catalytic hydrogenation, i.e. simultaneously removing four benzyl ethers and one benzyl ester, and hydrogenating one double bond, without destroying the aromatic group, proved to be nontrivial (Table 1). While standard conditions ($H_2$, $Pd(OH)_2$-C, EtOH, $H_2O$) worked most of the time, the anisyl (**31c**), biphenyl (**31g**) and the very labile naphthyl compound (**31e**) required more selective conditions for transfer hydrogenation[18] (cyclohexene, Pd-$BaSO_4$, EtOH) and close monitoring of the reaction (TLC) in order to avoid overhydrogenation. In addition to these compounds, template molecule **30** (Table 1, Entry h) and dimer **31i** were hydrogenated and tested[19] for E- and P-selectin binding. The results are summarized in Table 1.

## Discussion

Direct comparison of the phenyl compounds shows that incorporation of additional ester moiety, which is useful for the diastereomeric synthesis of compounds **31**, and for the preparation of multivalent structures, led to a reduced biological activity for **32a** (60% inhibition at 3mM) compared to compound **21** ($IC_{50}$ 0.3 mM) and other simpler structures such as **13a** ($IC_{50}$ 0.3 mM), **13b** ($IC_{50}$ 0.19 mM) and **18** ($IC_{50}$ 0.23 mM) in the E-selectin binding assay. Inside the series of compounds **31**, however, it was observed that while the naphtyl compound (**31e**) was inactive, the somewhat stretched fluorenyl (68% inhibition at 3mM) and especially biphenyl (87% inhibition at 3mM) derivatives showed increased activities compared to the phenyl parent structure (**32a**). Modification of the phenyl group gave less active anisyl (**32c**, 47% inhibition at 3mM) and pentafluorophenyl (**32d**, inactive) derivatives, so did dimerization (**32i**, inactive). Finally it was shown that homophenyl compound **32b** (58% inhibition at 3mM) was about equally active as the phenyl parent compound **32a**. However, even the best compound of this series, biphenyl

**Table 1.** Quick synthesis of $SLe^x$ mimetics bearing different aromatic groups by cross metathesis

| Entry | R | Yield (31) (%) | *trans*/*cis* | Yield (32) (%) | Inhibition at 3 mM[a] against E-selectin | $IC_{50}$ (μM)[b] against P-selectin |
|---|---|---|---|---|---|---|
| a |  | 74 | >95:5 | 78 | 60% | 4 |
| b |  | 65 | 75:25 | 76 | 58% | 2 |
| c |  | 79 | 87:13 | 57 | 47% | 5 |
| e |  | 17[c] | 70:30 | 67[c] | inactive | 12 |
| d |  | 71 | >95:5 | 21 | inactive | 1 |
| f |  | 70 | >95:5 | 68 | 65% | 1 |
| g |  | 73 | >95:5 | 52 | 87% | 1 |
| h | H | -[d] | -[d] | 81[d] | 52% | 302 |
| i | (see **31/32** i) | 47[c] | 75:25 | 54 | inactive | 217 |

[a]Determined in a cell-free assay[19a] for inhibition of E-selectin binding to polyacrylated-$SLe^a$ copolymer.
[b]Determined in a cell-free assay for inhibition of P-selectin binding to polylysine-$SLe^x$ copolymer.[19b]
[c]The dimerized starting material (**31i**) was isolated in 47% yield. In all other cases only traces of **31i** were detected (TLC).
[d]Prepared by hydrogenation of **30**.

derivative **32g** was only about two times more active than the reference compound **32h** (42% inhibition at 3mM) bearing only a propyl group instead of an arylpropyl moiety. A significant improvement in P-selectin binding was, however, observed when a hydrophobic group is incorporated into the mimetics (see Table 1), and many μM inhibitors for P-selectin are obtained. These results are consistent with the previous finding that P-selectin is more sensitive to hydrophobic interaction than is E-selectin.[6]

## Conclusion

We have prepared several aryl substituted $SLe^x$ mimetics based on *C*-fucopeptides, exhibiting up to 3-times higher binding affinity toward E-selectin than $SLe^x$ and >1000 times more active toward P-selectin than $SLe^x$, yet having a much simpler structure. In addition, we have introduced a convenient strategy for the diversification in structure of $SLe^x$ mimetics at a very late stage of the synthesis using cross olefin metathesis, thus providing a wide variety of derivatives for inhibition analysis. It is expected that this divergent strategy for the synthesis of $SLe^x$ mimetics is applicable to other templates.

## Experimental

### General information

All reactions except those involving $H_2O$ were performed in an argon atmosphere in dried glassware (torch, vacuum) unless otherwise noted, using solvents which were dried as follows. THF and $Et_2O$: distillation over sodium (indicator benzophenone), $CH_2Cl_2$: distillation over $CaH_2$. All other dry solvents were purchased from Aldrich. The following stationary phases were used for chromatography. Thin-layer chromatography: precoated glass TLC plates (Merck Silica $F_{254}$, 0.2 mm layer), flash chromatography: Mallinckroth Silica F60, 0.040–0.063 mm. The following spectrometers were used to record physical data. NMR: Bruker AMX 500 ($^1H$: 500 MHz, $^{13}C$: 125 MHz), Bruker AMX 400 ($^1H$: 400 MHz, $^{13}C$: 100 MHz), Bruker AC 250 ($^1H$: 250 MHz, $^{13}C$: 62.5 MHz). NMR spectra are reported in ppm against residual protic solvent ($CHCl_3$: $\delta_H$ = 7.24 ppm, $\delta_C$ = 77.0 ppm; $CD_3OD$: $\delta_H$ = 3.30 ppm, $\delta_C$ = 49.0 ppm; $D_2O$: $\delta_H$ = 4.80 ppm, $\delta_C$ ($CH_3CN$) = 1.7 ppm) as internal standard. Coupling constants *J* are given in Hz. FABMS: VG ZAB-ZSE (*m*-nitrobenzylalcohol matrix, NaI or CsI). ESI-MS: PE SCIEX API 100. Preparative HPLC separations were conducted on a Gilson HPLC system consisting of Pump 302, UV Detector 115, Manometric Module 802B and Dynamic Mixer 811B using a Whatman Partisil 10 (Magnum 9) Silica column.

### General procedure A (peptide coupling)

A solution of the amine, 1-hydroxybenzotriazole (HOBT), the carboxylic acid and *N*-methyl morpholine (NMM) in dry DMF or $CH_2Cl_2$ was cooled to −20 °C and 1-(3-dimethylaminopropyl)-3-ethylcarbodiimide hydrochloride (EDC) was added. The reaction mixture was stirred at −20 °C for 1 h, then allowed to reach rt overnight and stirring continued at rt. After the reaction was complete (TLC), the mixture was diluted with ethyl acetate and washed with 5% aqueous citric acid solution. The aqueous layer was extracted with ethyl acetate and the combined organic layers were washed with satd $NaHCO_3$-sol and brine, dried ($MgSO_4$) and evaporated. The residue was purified by flash chromatography on silica with EtOAc/hexanes to give the coupled compounds.

### General procedure B (Boc deprotection)

A solution of the Boc compound (1.4 mmol) in dry $CH_2Cl_2$ (1 mL) was treated with TFA (1 mL) at 0 °C and stirred for 1.5 h slowly reaching rt. The reaction mixture was then evaporated from $CHCl_3$ (twice, 15 mL each). The residue was taken up in MeOH (10 mL) and DOWEX 1X8-50 (Biorad, $OH^-$ form) was added until pH 8 was reached. The resin was filtered, washed with MeOH, the filtrate evaporated and the residue was used in the next step without further purification.

### General procedure C (final deprotection using $H_2$/Pd-C)

A solution of the benzyl protected compound in 80% aqueous HOAc was hydrogenated at 1 atm in the presence of Pd-C (Aldrich, 10% Pd) at rt until the reaction was complete (TLC). The mixture was then filtered through Celite, the residue washed with $H_2O$ and the filtrate evaporated. An aqueous solution of the residue was filtered through a Whatman Anotop inorganic membrane filter (Anotop 25, 0.2 μm) and lyophilized to give the completely deprotected compound as a white solid.

### General procedure D (cross metathesis reactions)

$Cl_2$ $(PCy_3)_2Ru$=CHPh (Strem, 10 mg, 12.5 mmol, 5 mol%) and **30** (250 mg, 250 mmol) were placed in a two-necked flask equipped with a reflux condenser, dissolved in dry $CH_2Cl_2$ (2 mL), the olefin added (500 mmol, 2 equiv) and the mixture gently refluxed (45 °C bath temperature) for 18–40 h. After that time the volatiles were removed and the residue purified by flash chromatography on silica with EtOAc/hexanes or EtOAc/toluene mixtures to give compounds **31** as yellowish foams.

### General procedure E (final deprotection using $H_2$/Pd $(OH)_2$-C)

To a solution of compounds **31** in EtOH and $H_2O$, $Pd(OH)_2$-C (20% Pd, Aldrich) was added and the mixture vigorously stirred in a hydrogen atmosphere overnight. If the reaction was still incomplete, another portion of the catalyst was added and the procedure repeated as above. The catalyst was then filtered (Celite), the residue washed with MeOH and $H_2O$, and the filtrate evaporated. The residue was purified by flash chromatography on silica with $H_2O/CH_3CN$ mixtures

to give compounds **32** as colorless glasses. These were then dissolved in $H_2O$ (and some $^tBuOH$ if neccessary), filtered through a Whatman Anotop 25 Plus inorganic membrane filter (0.2 μm) and lyophylized to give white powders.

### General procedure F (final deprotection using cyclo-hexene/Pd-$BaSO_4$)

To a solution of compounds **31** in dry EtOH, Pd-$BaSO_4$ (5% Pd, Aldrich) was added, the mixture degassed (by alternated application of slight vacuum and slight Ar pressure), cyclohexene added, and the mixture gently refluxed (85–90 °C bath temperature) for 1–5 days. The catalyst was then filtered (Celite), the residue washed with MeOH and continued as in General Procedure E.

**3-(Tri-*O*-benzyl-α-L-fucopyranosyl)-1-propene (6).** Prepared in 73% yield (four steps) from L-fucose as described.[7a]

**1,2-Epoxy-3-(tri-*O*-benzyl-α-L-fucopyranosyl)-propane (7).** A solution of **6** (7.0 g, 15.3 mmol) in $CH_2Cl_2$ (70 mL) was cooled to 0 °C, MCPBA (50%, 8.5 g, ca. 25 mmol) was added and the mixture stirred at rt for 11 h. The reaction was quenched with icewater, diluted with ether and the excess MCPBA was destroyed with $Na_2SO_3$ in satd $NaHCO_3$-sol. The organic layer was washed with satd $NaHCO_3$-sol (twice) and brine, dried ($MgSO_4$), and evaporated. The residue was purified by flash chromatography on silica with EtOAc/hexanes (1/4 to 1/2) to give **7** (6.43 g, 89%) as a colorless oil. Mixture of diastereomers in a 1/1 ratio. $^1H$ NMR (400 MHz, $CDCl_3$): δ 1.29 (d, 3H, $J$ = 6.6 Hz), 1.34 (d, 3H, $J$ = 6.7 Hz), 1.56 (ddd, 1H, $J$ = 3.8, 7.1, 14.5 Hz), 1.72 (dt, 1H, $J$ = 4.9, 14.7 Hz), 1.93 (ddd, 1H, $J$ = 4.6, 10.1, 14.6 Hz), 1.97 (ddd, 1H, $J$ = 5.5, 9.9, 16.6 Hz), 2.45 (dd, 1H, $J$ = 2.7, 5.0 Hz), 2.48 (dd, 1H, $J$ = 2.7, 5.0 Hz), 2.70 (dd, 1H, $J$ = 4.1, 5.0 Hz), 2.78 (dd, 1H, $J$ = 4.1, 4.8 Hz), 2.94 (m, 1H), 3.18 (m, 1H), 3.75–3.81 (m, 3H), 3.95 (dq, 1H, $J$ = 3.1, 6.6 Hz), 3.99 (dq, 1H, $J$ = 4.0, 6.5 Hz), 4.18 (dt, 1H, $J$ = 4.4, 9.8 Hz), 4.26 (brd, 1H, $J$ = 9.9 Hz), 4.50–4.77 (m, 6H), 7.25–7.36 (m, 15H).

**1-Azido-3-(tri-*O*-benzyl-α-L-fucopyranosyl)-2-propanol (8).** To a solution of **7** (5.90 g, 12.4 mmol) in EtOH and $H_2O$ (9/1, 25 mL) was added $NaN_3$ (4.04 g, 62.2 mmol) and $NH_4Cl$ (3.32 g, 62.2 mmol) and the resulting suspension was heated to reflux for 1.5 h. After cooling to rt, the reaction was diluted with ether, washed with $H_2O$ and brine, dried ($MgSO_4$), and evaporated. The residue was purified by flash chromatography on silica with EtOAc/hexanes (1/4 to 1/2) to give **8** (5.56 g, 86%) as a yellow oil. Separation of the diastereomers was performed by HPLC (2-propanol/hexane 0.5/99.5, 9 mL/min). Less polar diastereomer (*R*)-**8a**: $^1H$ NMR (400 MHz, $CDCl_3$): δ 1.34 (d, 3H, $J$ = 6.7 Hz), 1.53 (dt, 1H, $J$ = 4.0, 14.7 Hz), 1.90 (ddd, 1H, $J$ = 9.7, 10.8, 14.6 Hz), 3.23 (d, 2H, $J$ = 5.2 Hz), 3.58 (s, 1H), 3.67 (dd, 1H, $J$ = 3.6, 6.2 Hz), 3.76 (dd, 1H, $J$ = 2.9, 6.4 Hz), 3.81 (dd, 1H, $J$ = 3.0, 4.0 Hz), 3.91 (m, 1H), 4.08 (dq, 1H, $J$ = 4.1, 6.7 Hz), 4.21 (dt, 1H, $J$ = 2.7, 11.0 Hz), 4.67–4.77 (m, 6H), 7.25–7.36 (m, 15H). More polar diastereomer (*S*)-**8b**: $^1H$ NMR (400 MHz, $CDCl_3$): δ 1.31 (d, 3H, $J$ = 6.6 Hz), 1.62 (ddd, 1H, $J$ = 3.5, 8.3, 14.3 Hz), 1.87 (ddd, 1H, $J$ = 3.3, 9.9, 14.3 Hz), 2.72 (d, 1H, $J$ = 5.1 Hz), 3.28 (dd, 1H, $J$ = 2.4, 6.7 Hz), 3.33 (dd, 1H, $J$ = 4.5, 12.3 Hz), 3.76–3.78 (m, 3H), 3.94 (m, 2H), 4.27 (dt, 1H, $J$ = 3.2, 9.9 Hz), 4.53–4.78 (m, 6H), 7.27–7.36 (m, 15H). HRMS (FAB): $C_{30}H_{35}N_3O_5Cs$ (M + Cs), calcd 650.1631, found 650.1635.

**(*R*)-1-Azido-2-(2-phenethoxy)-3-(tri-*O*-benzyl-α-L-fucopyranosyl)propane (9a).** A two-phase system consisting of a solution of **8a** (281 mg, 543 μmol) in 2-bromoethylbenzene (4.1 mL) and 50% aq NaOH-sol (2.7 mL) was stirred for 10 days at rt in the presence of $Bu_4NI$ (30 mg, 81 μmol) and $Bu_4NHSO_4$ (30 mg, 88 μmol). After that time, the reaction mixture was diluted with $Et_2O$, washed with $H_2O$, 5% aqueous citric acid, satd $NaHCO_3$-sol and brine, dried ($MgSO_4$), and evaporated. The residue was purified by flash chromatography on silica with EtOAc/hexanes (0/1 to 1/1) to give **9a** (31.6 mg, 9%; 64% based on recovered starting material) as a yellow oil. $^1H$ NMR (400 MHz, $CDCl_3$): δ 1.24 (d, 3H, $J$ = 6.7 Hz), 1.67 (ddd, 1H, $J$ = 3.5, 7.7, 14.5 Hz), 1.92 (ddd, 1H, $J$ = 4.6, 10.6, 14.6 Hz), 2.86 (t, 2H, $J$ = 7.2 Hz), 3.20–3.27 (m, 2H), 3.49 (m, 1H), 3.64 (dt, 2H, $J$ = 1.9, 7.4 Hz), 3.67–3.74 (m, 3H), 3.86 (dq, 1H, $J$ = 3.2, 6.3 Hz), 4.05 (brd, 1H, $J$ = 10.4 Hz), 4.44–4.76 (m, 6H), 7.16–7.34 (m, 20H); $^{13}C$ NMR (100 MHz, $CDCl_3$): δ 15.25, 29.23, 36.69, 53.27, 67.15, 68.72, 70.72, 73.02, 73.08, 75.74, 76.03, 76.60, 76.67, 76.73, 126.20, 127.52, 127.59, 127.63, 127.85, 127.97, 128.09, 128.29, 128.32, 128.39, 128.96, 138.12, 138.49, 138.72. HRMS (FAB): $C_{38}H_{43}N_3O_5Cs$ (M + Cs), calcd 754.2257, found 754.2279.

**(*S*)-1-Azido-2-(2-phenethoxy)-3-(tri-*O*-benzyl-α-L-fucopyranosyl)propane (9b).** Prepared as described for **9a** using **8b** (207 mg, 400 μmol) in 2-bromoethylbenzene (3 mL) and 50% aq NaOH-sol (2 mL) for 5 days at rt in the presence of $Bu_4NHSO_4$ (22 mg, 65 μmol) to give **9b** (46.0 mg, 18%; 93% based on recovered starting material) as a yellow oil. $^1H$ NMR (400 MHz, $CDCl_3$): δ 1.26 (d, 3H, $J$ = 6.6 Hz), 1.62 (ddd, 1H, $J$ = 2.7, 9.2, 14.4 Hz), 1.76 (ddd, 1H, $J$ = 3.8, 10.8, 14.5 Hz), 2.89 (t, 2H, $J$ = 7.4 Hz), 3.17 (dd, 1H, $J$ = 5.5, 12.8 Hz), 3.35 (dd, 1H, $J$ = 4.0, 12.8 Hz), 3.52–3.62 (m, 1H), 3.67–3.83 (m, 5H), 3.90 (dq, 1H, $J$ = 3.6, 6.4 Hz), 4.19 (brdt, 1H, $J$ = 2.8, 10.7 Hz), 4.45–4.75 (m, 6H), 7.14–7.34 (m, 20H); $^{13}C$ NMR (100 MHz, $CDCl_3$): δ 15.31, 24.19, 31.03, 36.79, 54.46, 66.95, 68.82, 71.70, 73.07, 73.11, 75.71, 76.08, 76.81, 76.98, 126.26, 127.54, 127.59, 127.67, 127.84, 128.14, 128.20, 128.33, 128.41, 129.01, 138.21, 138.54, 138.62, 138.80. HRMS (FAB): $C_{38}H_{43}N_3O_5Cs$ (M + Cs), calcd 754.2257, found 754.2233.

**(*R*)-2-(2-Phenethoxy)-3-(tri-*O*-benzyl-α-L-fucopyranosyl)-1-propyl amine (10a).** To a solution of **9a** (29.1 mg, 46.8 μmol) in THF (0.5 mL) and $H_2O$ (1 drop) was added $PPh_3$ (15 mg, 57.2 μmol) and the mixture was stirred at rt for 60 h. The volatiles were removed to give, after flash chromatography on silica with MeOH/$CH_2Cl_2$/$NH_4OH$ (1/29/0.1 to 1/19/0.1), **10a** (24.4 mg, 88%) as a colorless oil. $^1H$ NMR (400 MHz, $CDCl_3$): δ 1.26 (d, 3H, $J$ = 6.5 Hz), 1.41 (brs, 2H), 1.57 (ddd, 1H,

$J$ = 3.4, 7.6, 14.2 Hz), 1.90 (ddd, 1H, $J$ = 4.6, 10.4, 14.7 Hz), 2.58 (dd, 1H, $J$ = 6.7, 13.3 Hz), 2.73 (dd, 1H, $J$ = 3.5, 13.4 Hz), 2.81 (ddd, 1H, $J$ = 4.8, 7.1, 14.0 Hz), 2.86 (ddd, 1H, $J$ = 4.1, 11.3, 14.8 Hz), 3.26 (dddd, 1H, $J$ = 3.4, 4.3, 6.8, 7.6 Hz), 3.56 (dt, 1H, $J$ = 7.3, 9.2 Hz), 3.69 (dt, 1H, $J$ = 7.0, 9.1 Hz), 3.73–3.76 (m, 3H), 3.91 (dq, 1H, $J$ = 3.2, 6.2 Hz), 4.04 (brd, 1H, $J$ = 10.1 Hz), 4.46–4.76 (m, 6H), 7.17–7.34 (m, 20H); $^{13}$C NMR (100 MHz, $CDCl_3$): δ 15.22, 29.21, 36.75, 44.47, 67.40, 68.67, 70.81, 73.05, 75.78, 76.77, 78.79, 126.17, 127.49, 127.55, 127.60, 127.81, 127.96, 128.09, 128.28, 128.31, 128.37, 128.91, 138.22, 138.53, 138.76, 139.05. HRMS (FAB): $C_{38}H_{46}NO_5$ (M + H), calcd 596.3376, found 596.3360.

**(*S*)-2-(2-Phenethoxy)-3-(tri-*O*-benzyl-α-L-fucopyranosyl)-1-propyl amine (10b).** Prepared as described for **10a** using **9b** (46 mg, 74 μmol), THF (0.5 mL), $H_2O$ (1 drop) and $PPh_3$ (24 mg, 91.5 μmol) for 30 h at rt to give, after flash chromatography on silica with $MeOH/CH_2Cl_2/NH_4OH$ (1/29/0.1 to 1/19/0.1), **10b** (38.1 mg, 86%) as a colorless oil. $^1$H NMR (400 MHz, $CDCl_3$): δ 1.27 (d, 3H, $J$ = 6.6), 1.58 (brs, 2H), 1.59 (m, 1H), 1.68 (ddd, 1H, $J$ = 3.8, 10.6, 14.4 Hz), 2.61 (brs, 1H), 2.83 (brs, 1H), 2.86 (t, 2H, $J$ = 7.0 Hz), 3.39 (m, 1H), 3.64–3.76 (m, 5H), 3.89 (dq, 1H, $J$ = 3.4, 6.0 Hz), 4.20 (dt, 1H, $J$ = 3.1, 10.4 Hz), 4.48–4.75 (m, 6H), 7.20–7.34 (m, 20H); $^{13}$C NMR (100 MHz, $CDCl_3$): δ 15.31, 30.60, 36.86, 45.38, 67.36, 68.67, 71.12, 72.88, 72.95, 73.07, 75.77, 76.98, 77.11, 78.11, 126.19, 127.49, 127.53, 127.62, 127.77, 128.03, 128.15, 128.29, 128.35, 128.91, 138.27, 138.53, 138.80, 139.00. HRMS (FAB): $C_{38}H_{45}NO_5Cs$ (M + Cs), calcd 728.2352, found 728.2333.

**(*R*)-1-(*O*-Benzyl-*N*-*tert*-butoxycarbonyl-L-threonine)-2-(2-phenethoxy)-3-(tri-*O*-benzyl-α-L-fucopyranosyl)propane (11a).** Compound **10a** (24 mg, 40.3 μmol) was coupled with *N*-Boc-*O*-benzyl-L-threonine (14.4 mg, 46.5 μmol) according to General Procedure A using EDC (9.4 mg, 49.0 μmol), HOBT (6.6 mg, 48.8 μmol), NMM (10 μL, 91 μmol) in DMF (0.7 mL) for 51 h to give, after flash chromatography on silica with EtOAc/hexanes (1/1.5), **11a** (34.9 mg, 98%) as a white solid. $^1$H NMR (400 MHz, $CDCl_3$): δ 1.15 (d, 3H, $J$ = 6.2 Hz), 1.27 (d, 3H, $J$ = 6.6 Hz), 1.44 (s, 9H), 1.56 (ddd, 1H, $J$ = 3.7, 6.9, 14.7 Hz), 1.84 (ddd, 1H, $J$ = 4.2, 10.2, 14.5 Hz), 2.72 (t, 2H, $J$ = 7.3 Hz), 3.27 (dt, 1H, $J$ = 5.7, 13.0 Hz), 3.41–3.48 (m, 2H), 3.49 (dt, 1H, $J$ = 7.3, 9.0 Hz), 3.57 (dt, 1H, $J$ = 7.4, 9.2 Hz), 3.65 (m, 1H), 3.69 (dd, 1H, $J$ = 2.8, 6.6 Hz), 3.73 (dd, 1H, $J$ = 2.8, 3.5 Hz), 3.88 (dq, 1H, $J$ = 3.8, 6.3 Hz), 4.12–4.15 (m, 2H), 4.24 (brd, 1H, $J$ = 5.0 Hz), 4.39–4.73 (m, 8H), 5.50 (d, 1H, $J$ = 7.0 Hz), 6.78 (brt, 1H, $J$ = 5.4 Hz), 7.11–7.33 (m, 25H). $^{13}$C NMR (100 MHz, $CDCl_3$): δ 15.11, 15.63, 28.31, 29.36, 36.57, 41.66, 57.60, 66.65, 68.83, 70.04, 71.55, 72.86, 72.88, 73.03, 74.84, 75.67, 76.55, 76.72, 79.94, 126.18, 127.52, 127.59, 127.71, 127.79, 127.91, 128.06, 128.29, 128.36, 128.89, 138.05, 138.12, 138.53, 138.72, 138.76, 155.81, 169.82. HRMS (FAB): $C_{54}H_{66}N_2O_9Cs$ (M + Cs), calcd 1019.3823, found 1019.3849.

**(*S*)-1-(*O*-Benzyl-*N*-*tert*-butoxycarbonyl-L-threonine)-2-(2-phenethoxy)-3-(tri-*O*-benzyl-α-L-fucopyranosyl)propane (11b).** Prepared as described for **11a** using **10b** (35.7 mg, 59.9 μmol), *N*-Boc-*O*-benzyl-L-threonine (14.4 mg, 46.5 μmol), EDC (13.8 mg, 72.0 μmol), HOBT (9.8 mg, 72.5 μmol), NMM (15 μL, 136 μmol) in DMF (1.0 mL) for 21 h to give, after flash chromatography on silica with EtOAc/hexanes (1/1.5), **11b** (44.7 mg, 84%) as a white solid. $^1$H NMR (400 MHz, $CDCl_3$): δ 1.14 (d, 3H, $J$ = 6.3 Hz), 1.24 (d, 3H, $J$ = 6.7 Hz), 1.44 (s, 9H), 1.62 (m, 1H), 1.71 (ddd, 1H, $J$ = 3.7, 10.9, 14.4 Hz), 2.74 (t, 2H, $J$ = 7.0 Hz), 3.26 (dt, 1H, $J$ = 5.5, 13.7 Hz), 3.42 (dt, 1H, $J$ = 4.2, 13.6 Hz), 3.52 (dq, 1H $J$ = 4.2, 8.9 Hz), 3.64 (t, 2H, $J$ = 7.0 Hz), 3.67 (m, 1H), 3.72 (dd, 1H, $J$ = 3.0, 3.1 Hz), 3.74 (m, 1H), 3.85 (brdq, 1H, $J$ = 3.2, 5.9 Hz), 4.13 (brdq, 1H, $J$ = 2.2, 6.2 Hz), 4.17–4.20 (m, 2H), 4.45–4.75 (m, 8H), 5.45 (d, 1H, $J$ = 7.0 Hz), 6.60 (t, 1H, $J$ = 5.3 Hz), 7.11–7.33 (m, 25H); $^{13}$C NMR (100 MHz, $CDCl_3$): δ 15.43, 15.63, 28.32, 30.75, 36.65, 42.52, 57.82, 67.41, 68.56, 70.93, 71.60, 72.98, 73.02, 73.13, 74.86, 74.99, 75.89, 76.92, 77.28, 79.98, 126.20, 127.46, 127.50, 127.60, 127.68, 127.74, 128.00, 128.04, 128.26. 128.32, 128.40, 128.85, 138.03, 138.30, 138.54, 138.79, 138.83, 155.75, 169.84. HRMS (FAB): $C_{54}H_{66}N_2O_9Cs$ (M + Cs), calcd 1019.3823, found 1019.3869.

**(*R*)-1-(3-*O*-Benzyl-2-monobenzyl-succinamidyl-L-threonine)-2-(2-phenethoxy)-3-(tri-*O*-benzyl-α-L-fucopyranosyl)-propane (12a).** Compound **11a** (34.9 mg, 39 μmol) was deprotected according to General Procedure B and coupled with monobenzylsuccinate (11.7 mg, 56.2 μmol) according to General Procedure A using EDC (11.4 mg, 59.5 μmol), HOBT (8.6 mg, 63.6 μmol), NMM (11 μL, 100 μmol) in DMF (0.9 mL) for 33 h to give, after flash chromatography on silica with EtOAc/hexanes (2/3 to 2/1), **12a** (37.0 mg, 98%) as a white solid. $^1$H NMR (400 MHz, $CDCl_3$): δ 1.10 (d, 3H, $J$ = 6.4 Hz), 1.27 (d, 3H, $J$ = 7.0 Hz), 1.57 (brddd, 1H, $J$ = 2.8, 6.4, 14.2 Hz), 1.86 (brddd, 1H, $J$ = 4.0, 10.4, 14.5 Hz), 2.45 (dt, 1H, $J$ = 7.0, 15.4 Hz), 2.50 (dt, 1H, $J$ = 6.4, 15.6 Hz), 2.64–2.76 (m, 4H), 3.30 (dt, 1H, $J$ = 5.9, 13.2 Hz), 3.42–3.46 (m, 2H), 3.51 (dt, 1H, $J$ = 7.0, 9.1 Hz), 3.56 (dt, 1H, $J$ = 7.2, 9.0 Hz), 3.67–3.72 (m, 3H), 3.88 (brdq, 1H, $J$ = 2.8, 6.1 Hz), 4.10 (dq, 1H, $J$ = 2.8, 6.4 Hz), 4.14 (brdt, 1H, $J$ = 3.3, 10.4 Hz), 4.41–4.73 (m, 9H), 5.09 (s, 2H), 6.58 (d, 1H, $J$ = 6.9 Hz), 6.83 (t, 1H, $J$ = 5.2 Hz), 7.10–7.33 (m, 30H); $^{13}$C NMR (100 MHz, $CDCl_3$): δ 15.16, 15.55, 29.35, 29.70, 30.74, 36.54, 41.76, 56.20, 66.54, 68.79, 70.05, 71.63, 72.86, 72.95, 73.03, 74.17, 75.64, 75.69, 76.63, 76.74, 126.18, 127.50, 127.54. 127.59, 127.80, 127.90, 128.16, 128.23, 128.23, 128.29, 128.36, 128.44, 128.54, 128.91, 135.74, 137.99, 138.16, 138.53, 138.73, 138.86, 169.30, 171.43, 172.63. HRMS (FAB): $C_{60}H_{68}N_2O_{10}Cs$ (M + Cs), calcd 1109.3928, found 1109.3976.

**(*S*)-1-(3-*O*-Benzyl-2-monobenzyl-succinamidyl-L-threonine)-2-(2-phenethoxy)-3-(tri-*O*-benzyl-α-L-fucopyranosyl)-propane (12b).** Prepared as described for **12a** using **11b** (44.7 mg, 50.4 μmol), monobenzylsuccinate (12.1 mg, 58.1 μmol), EDC (14.8 mg, 77.2 μmol), HOBT (9.1 mg, 67.3 μmol) and NMM (12 μL, 129 μmol) in DMF (1 mL) for 38 h to give **12b** (47.0 mg, 99%) as a white solid. $^1$H NMR (400 MHz, $CDCl_3$): δ 1.11 (d, 3H, $J$ = 6.4 Hz), 1.24 (d, 3H, $J$ = 6.5 Hz), 1.62 (brddd, 1H, $J$ = 2.2, 9.6, 14.3 Hz), 1.74 (ddd, 1H, $J$ = 3.2, 11.1, 14.3 Hz), 2.44–2.53

(m, 2H), 2.63–2.81 (m, 4H), 3.32 (dt, 1H, $J=5.6$, 13.6 Hz), 3.38 (dt, 1H, $J=5.3$, 13.8 Hz), 3.57 (dq, 1H, $J=3.8$, 9.1 Hz), 3.63–3.75 (m, 4H), 3.83 (m, 2H), 4.18 (dq, 1H, $J=2.7$, 6.4 Hz), 4.24 (brdt, 1H, $J=3.2$, 7.9 Hz), 4.43–4.78 (m, 9H), 5.03 (d, 1H, $J=12.3$ Hz), 5.13 (d, 1H, $J=12.4$ Hz), 6.54 (d, 1H, $J=7.1$ Hz), 6.83 (t, 1H, $J=5.6$ Hz), 7.13–7.34 (m, 30H); $^{13}$C NMR (100 MHz, $CDCl_3$): δ 15.67, 15.76, 29.39, 30.48, 30.84, 36.61, 42.81, 56.59, 66.64, 67.76, 68.26, 70.95, 71.73, 72.93, 72.97, 73.38, 74.12, 74.63, 76.20, 76.88, 77.72, 126.16, 127.42, 127.48, 127.58, 127.65, 127.80, 127.96, 128.08, 128.20, 128.25, 128.30, 128.34, 128.44, 128.54, 128.87, 135.65, 137.97, 138.34, 138.59, 138.82, 138.88, 169.31, 171.58, 172.85. HRMS (FAB): $C_{60}H_{68}N_2O_{10}Cs$ (M + Cs), calcd 1109.3928, found 1109.3914.

**(*R*)-1-(2-Monosuccinamidyl-L-threonine)-2-(2-phenethoxy)-3-(α-L-fucopyranosyl)propane (13a).** Prepared according to General Procedure C using **12a** (33.7 mg, 34.5 μmol) to give **13a** (16.3 mg, 90%). $^1$H NMR (400 MHz, $D_2O$): δ 1.09 (d, 3H, $J=6.4$ Hz), 1.16 (d, 3H, $J=6.3$ Hz), 1.64 (ddd, 1H, $J=4.1$, 7.6, 14.5 Hz), 1.75 (ddd, 1H, $J=4.6$, 10.8, 15.0 Hz), 2.54–2.63 (m, 4H), 2.77–2.89 (m, 2H), 3.22 (brddd, 1H, $J=5.4$, 10.9, 13.8 Hz), 3.41–3.49 (m, 2H), 3.56 (dt, 1H, $J=6.0$, 6.6 Hz), 3.62 (dd, 1H, $J=3.3$, 10.0 Hz), 3.68 (brd, 1H, $J=2.8$ Hz), 3.73 (dt, 1H, $J=6.9$, 9.9 Hz), 3.85 (dd, 1H, $J=6.4$, 9.8 Hz), 3.86 (m, 1H), 3.97 (brddd, 1H, $J=4.6$, 5.9, 10.5 Hz), 4.16 (dq, 1H, $J=4.3$, 6.4 Hz), 4.22 (d, 1H, $J=4.1$ Hz), 7.25–7.38 (m, 5H), 7.90 (t, 1H, $J=5.6$ Hz); $^{13}$C NMR (100 MHz, $D_2O$): δ 18.06, 21.28, 29.06, 33.22, 38.25, 44.05, 44.17, 61.66, 69.36, 69.71, 72.04, 73.30, 73.93, 74.82, 79.07, 128.95, 131.10, 131.48, 141.65, 174.68, 178.17, 180.91. HRMS (FAB): $C_{25}H_{38}N_2O_{10}Cs$ (M + Cs), calcd 659.1581, found 659.1562.

**(*S*)-1-(2-Monosuccinamidyl-L-threonine)-2-(2-phenethoxy)-3-(α-L-fucopyranosyl)propane (13b).** Prepared as described for **13a** using **12b** (47.0 mg, 48.1 μmol) to give **13b** (21.1 mg, 83%). $^1$H NMR (400 MHz, $D_2O$): δ 1.15 (d, 3H, $J=6.4$ Hz), 1.18 (d, 3H, $J=6.3$ Hz), 1.54 (brt, 1H, $J=11.6$ Hz), 1.79 (brt, 1H, $J=12.9$ Hz), 2.58 (s, 4H), 2.87 (t, 2H, $J=7.1$ Hz), 3.20 (brdt, 1H, $J=5.0$, 13.7 Hz), 3.39 (brdt, 1H, $J=4.7$, 13.8 Hz), 3.62 (m, 1H), 3.66 (dd, 1H, $J=3.0$, 10.1 Hz), 3.73 (brd, 1H, $J=2.9$ Hz), 3.77 (brdt, 2H, $J=6.89$, 10.8 Hz), 3.88 (dd, 1H, $J=6.2$, 10.0 Hz), 3.91 (m, 1H), 4.01 (m, 1H), 4.19 (d, 1H, $J=3.6$ Hz), 4.23 (brdq, 1H, $J=3.8$, 6.4 Hz), 7.25–7.38 (m, 5H), 7.98 (t, 1H, $J=5.7$ Hz); $^{13}$C NMR (100 MHz, $D_2O$): δ 18.05, 21.32, 29.23, 33.16, 38.02, 44.90, 45.01, 61.68, 69.24, 69.53, 69.95, 72.23, 73.45, 74.04, 74.14, 76.77, 128.92, 131.08, 131.39, 141.35, 174.87, 174.95, 178.22. HRMS (FAB): $C_{25}H_{38}N_2O_{10}Na$ (M + Na), calcd 549.2424, found 549.2412.

**1-Azido-2-(3-phenyl-2-propenoxy)-3-(tri-*O*-benzyl-α-L-fucopyranosyl)propane (14).** To a solution of **8** (1/1 mixture of diastereomers, 400 mg, 773 μmol) in THF (5 mL) and DMF (0.9 mL) were successively added NaH (95%, 56 mg, 2.33 mmol) and cinnamyl bromide (309 mg, 1.57 mmol). The mixture was heated to 65 °C for 1 h, cooled to rt, diluted with $Et_2O$, washed with $H_2O$ and brine, dried ($MgSO_4$), and evaporated. The residue was purified by flash chromatography on silica with EtOAc/hexanes (1/6 to 1/4) to give **14** (387 mg, 79%) as a yellow oil. Mixture of diastereomers in a 1/1 ratio. $^1$H NMR (400 MHz, $CDCl_3$): δ 1.24 (d, $J=6.6$ Hz) and 1.28 (d, $J=6.6$ Hz) (3H), 1.66–1.77 (m, 1H), 1.81 (ddd, $J=3.5$, 11.0, 14.5 Hz) and 1.99 (ddd, $J=4.6$, 10.6, 14.8 Hz) (1H), 3.24 (dd, $J=5.6$, 12.7 Hz) and 3.28 (dd, $J=6.1$, 13.2 Hz) (1H), 3.40 (dd, $J=3.9$, 12.8 Hz) and 3.32 (dd, $J=4.0$, 13.4 Hz) (1H), 3.60 (m) and 3.68 (m) (1H), 3.70–3.77 (m, 3H), 3.91 (brdq, 1H, $J=3.3$, 6.2 Hz), 4.10 (dt, $J=3.4$, 10.4 Hz) and 4.29 (m) (1H), 4.17 (d, $J=6.0$ Hz) and 4.23 (dd, $J=6.2$, 12.3 Hz) and 4.30 (dd, $J=6.2$, 12.3 Hz) (2H), 4.49–4.76 (m, 6H), 6.25 (dt, $J=6.0$, 15.8 Hz) and 6.29 (dt, $J=6.0$, 15.8 Hz) (1H), 6.56 (d, $J=15.8$ Hz) and 6.59 (d, $J=15.8$ Hz) (1H), 7.25–7.35 (m, 20H); $^{13}$C NMR (100 MHz, $CDCl_3$): δ 15.24, 29.42, 54.42, 54.64, 66.90, 68.76, 68.84, 70.15, 71.35, 72.93, 73.03, 75.37, 75.63, 75.74, 76.60, 76.87, 125.88, 126.53, 127.46, 127.50, 127.60, 127.67, 127.78, 127.82, 127.95, 128.05, 128.26, 128.36, 128.39, 128.49, 132.39, 132.58, 138.12, 138.46, 138.68. HRMS (FAB): $C_{39}H_{43}N_3O_5Cs$ (M + Cs), calcd 766.2257, found 766.2241.

***N*-(*tert*-Butoxycarbonyl)-2-(3-phenylpropoxy)-3-(tri-*O*-benzyl-α-L-fucopyranosyl)-1-propyl amine (15).** A solution of **14** (343 mg, 541 μmol) and $Boc_2O$ (149 mg, 683 μmol) in EtOAc (6.1 mL) was stirred in the presence of Pd-C (16.5 mg, Aldrich 10% Pd) for 48 h at rt under atmospheric hydrogen pressure. The mixture was then filtered through Celite, washed with EtOAc and the filtrate evaporated. The residue was purified by flash chromatography on silica with EtOAc/hexanes (1/4 to 1/3) resulting in partial resolution of the diastereomeric mixture to give **15** (307 mg, 80%) as a pale-yellow oil. (*R*)-**15a**: $^1$H NMR (400 MHz, $CDCl_3$): δ 1.31 (d, 3H, $J=6.6$ Hz), 1.43 (s, 9H), 1.59–1.65 (m, 1H), 1.84 (qui, 2H, $J=7.0$ Hz), 1.84–1.93 (m, 1H), 2.61–2.71 (m, 2H), 3.20 (dt, 1H, $J=5.5$, 13.7 Hz), 3.26 (dt, 1H, $J=5.1$, 13.8 Hz), 3.40 (t, 2H, $J=6.4$ Hz), 3.38–3.43 (m, 1H), 3.66–3.82 (m, 3H), 3.96 (brdq, 1H, $J=3.9$, 6.2 Hz), 4.19 (brd, 1H, $J=9.3$ Hz), 4.47–4.78 (m, 6H), 4.86 (brt, 1H, $J=5$ Hz), 7.15–7.35 (m, 20H); $^{13}$C NMR (100 MHz, $CDCl_3$): δ 15.04, 28.42, 29.55, 31.58, 32.37, 42.48, 66.57, 68.12, 72.87, 73.03, 75.58, 75.65, 76.41, 76.80, 79.04, 125.78, 127.51, 127.61, 127.82, 127.91, 128.26, 128.30, 128.34, 128.39, 128.42, 138.12, 138.54, 138.74, 141.89, 156.05. HRMS (FAB): $C_{44}H_{55}NO_7Cs$ (M + Cs), calcd 842.3033, found 842.3044. (*S*)-**15b**: $^1$H NMR (400 MHz, $CDCl_3$): δ 1.29 (d, 3H, $J=6.6$ Hz), 1.46 (s, 9H), 1.63 (brddd, 1H, $J=2.0$, 9.7, 14.5 Hz), 1.76 (ddd, 1H, $J=3.5$, 11.0, 14.6 Hz), 1.88 (qui, 2H, $J=7.2$ Hz), 2.64–2.72 (m, 2H), 3.16 (brdt, 1H, $J=5.2$, 13.6 Hz), 3.32 (brdt, 1H, $J=4.8$, 13.7 Hz), 3.41–3.67 (m, 3H), 3.73 (dd, 1H, $J=2.8$, 7.0 Hz), 3.78 (brt, 1H, $J=3.0$ Hz), 3.81 (m, 1H), 3.91 (m, 1H), 4.27 (brd, 1H, $J=10.8$ Hz), 4.52–4.78 (m, 7H), 7.20–7.36 (m, 20H); $^{13}$C NMR (100 MHz, $CDCl_3$): δ 15.39, 28.44, 30.94, 31.79, 32.47, 43.55, 67.27, 68.65, 69.31, 72.90, 72.99, 73.05, 75.19, 75.87, 76.98, 77.10, 79.12, 125.79, 127.47, 127.52, 127.62, 127.76, 128.05, 128.07, 128.29, 128.36, 128.42, 138.29, 138.56, 138.78, 141.95, 156.11. HRMS (FAB): $C_{44}H_{55}NO_7Cs$ (M + Cs), calcd 842.3033, found 842.3043.

**Compound 18. 15** (94 mg, 132 μmol, 1/1 mixture of diastereomers) was deprotected according to General Procedure B and coupled with *N*-Boc-*O*-benzyl-L-threonine (45 mg, 145 μmol) according to General Procedure A using EDC (29 mg, 152 μmol), HOBT (21 mg, 157 μmol) and NMM (32 μL, 290 μmol) in $CH_2Cl_2$ (1.5 mL) for 7 h to give **16** (101 mg, 85%) as a white solid. Another Boc removal according to General Procedure B followed by coupling with monobenzyl succinate (26 mg, 125 μmol) according to General Procedure A using EDC (25 mg, 131 μmol), HOBT (18.5 mg, 137 μmol) and NMM (20 μL, 182 μmol) in $CH_2Cl_2$ (1.3 mL) for 12 h to give **17** (109 mg, 98%) as a pale-yellow oil. Deprotection of **17** according to General Procedure C gave **18** (54 mg, 90%; 75% overall yield). $^1$H NMR (400 MHz, $D_2O$): δ 1.13–1.19 (m, 6H), 1.61 (m) and 1.75 (m) (1H), 1.86 (m, 3H), 2.57–2.67 (m, 6H), 3.28–4.28 (m, 12H), 7.28–7.36 (m, 5H); $^{13}$C NMR (100 MHz, $D_2O$): δ 18.08, 21.26, 21.35, 28.82, 33.03, 33.40, 33.89, 33.98, 45.03, 61.69, 69.25, 69.42, 69.56, 69.81, 70.01, 71.33, 72.13, 72.27, 73.98, 75.11, 76.51, 78.58, 128.50, 131.02, 131.10, 139.85, 175.06, 177.90, 178.13. HRMS (FAB): $C_{26}H_{40}N_2O_{10}Cs$ (M + Cs), calcd 673.1737, found 673.1712.

**Compound 19.** Compound **15b** (128 mg, 180 μmol) was deprotected according to General Procedure B and subsequently coupled to **23**[7a,10] (70 mg, 215 μmol) according to General Procedure A using EDC (42 mg, 219 μmol), HOBT (30 mg, 222 μmol) and NMM (25 μL, 227 μmol) in $CH_2Cl_2$ (2.0 mL) for 5.5 h to give, after flash chromatography on silica with EtOAc/hexanes (1/1), **19** (103 mg, 62%) as a yellow oil. $^1$H NMR (500 MHz, $CDCl_3$): δ 1.26 (d, 3H, $J$ = 6.5 Hz), 1.40 (s, 9H), 1.64 (m, 1H), 1.72 (ddd, 1H, $J$ = 3.5, 10.5, 14.0 Hz), 1.85 (qui, 2H, $J$ = 7.5 Hz), 2.63–2.67 (m, 2H), 3.27 (dt, 1H, $J$ = 5.5, 14.0 Hz), 3.41–3.56 (m, 5H), 3.61 (dd, 1H, $J$ = 5.5, 10.0 Hz), 3.70 (dd, 1H, $J$ = 2.5, 6.5 Hz), 3.73–3.76 (m, 3H), 3.89 (m, 1H), 3.97 (brqui, 1H, $J$ = 5.5 Hz), 4.20–4.22 (m, 2H), 4.49–4.73 (m, 8H), 5.63 (d, 1H, $J$ = 7.5 Hz), 6.69 (brs, 1H), 7.16–7.33 (m, 25H); $^{13}$C NMR (125 MHz, $CDCl_3$): δ 15.23, 28.17, 29.61, 31.65, 32.33, 42.23, 55.76, 67.16, 68.61, 69.26, 71.14, 71.49, 72.90, 73.44, 74.74, 75.66, 76.82, 80.12, 125.69, 127.34, 127.40, 127.50, 127.65, 127.68, 127.76, 127.90, 127.94, 128.18, 128.25, 128.31, 128.37, 137.51, 138.17, 138.43, 138.65, 141.82, 155.90, 170.74. MS (FAB): $C_{55}H_{68}N_2O_{10}Cs$ (M + Cs), calcd 1049, found 1049.

**Compound 20.** Compound **19** (103 mg, 112 μmol) was deprotected according to according to General Procedure B and subsequently coupled to monobenzyl succinate (26.6 mg, 128 μmol) according to General Procedure A using EDC (25 mg, 130 μmol), HOBT (18.2 mg, 135 μmol) and NMM (26 μL, 236 μmol) in $CH_2Cl_2$ (1.1 mL) for 4 h to give, after flash chromatography on silica with EtOAc/hexanes (1/1 to 3/2), **20** (73 mg, 65%) as a yellow oil. $^1$H NMR (500 MHz, $CDCl_3$): δ 1.24 (d, 3H, $J$ = 6.6 Hz), 1.61 (brdd, 1H, $J$ = 10.0, 12.9 Hz), 1.74 (ddd, 1H, $J$ = 3.2, 11.1, 14.3 Hz), 1.84 (qui, 2H, $J$ = 7.1 Hz), 2.35 (dt, 1H, $J$ = 6.8, 15.5 Hz), 2.40 (dt, 1H, $J$ = 6.3, 15.5 Hz), 2.61–2.66 (m, 4H), 3.29 (dt, 1H, $J$ = 5.6, 13.7 Hz), 3.35 (dt, 1H, $J$ = 5.2, 13.7 Hz), 3.43 (dt, 1H, $J$ = 6.6, 9.0 Hz), 3.51 (m, 1H), 3.54–3.58 (m, 2H), 3.65 (dd, 1H, $J$ = 5.1, 10.0 Hz), 3.69–3.73 (m, 3H), 3.80 (brs, 1H), 3.86 (brm, 1H), 4.02 (brqui, 1H, $J$ = 5.5 Hz), 4.24 (brd, 1Hd, $J$ = 11.0 Hz), 4.54 (dd, 1H, $J$ = 5.4, 7.7 Hz), 4.44–4.74 (m, 8H), 5.03 (d, 1H, $J$ = 12.3 Hz), 5.09 (d, 1H, $J$ = 12.4 Hz), 6.87 (d, 1H, $J$ = 7.7 Hz), 6.91 (t, 1H, $J$ = 5.7 Hz), 7.14–7.32 (m, 30H); $^{13}$C NMR (125 MHz, $CDCl_3$): δ 15.41, 29.27, 29.62, 30.68, 31.69, 32.33, 42.43, 55.19, 66.55, 67.32, 68.39, 69.40, 70.70, 71.56, 72.86, 73.07, 73.45, 74.53, 75.86, 76.85, 125.68, 127.30, 127.39, 127.49, 127.65, 127.76, 127.82, 127.93, 128.11, 128.17, 128.22, 128.25, 128.32, 128.35, 128.39, 128.48, 135.52, 137.53, 138.21, 138.48, 138.68, 141.85, 169.97, 171.85, 172.78. HRMS (FAB): $C_{61}H_{70}N_2O_{11}Cs$ (M + Cs), calcd 1139.4034, found 1139.4078.

**Compound 21.** Compound **20** (72.5 mg, 72 μmol) was deprotected according to General Procedure C to give 21 (38 mg, 95%). $^1$H NMR (500 MHz, $D_2O$): δ 1.14 (d, 3H, $J$ = 6.4 Hz), 1.58 (ddd, 1H, $J$ = 2.7, 10.4, 14.8 Hz), 1.79–1.85 (m, 3H), 2.46–2.56 (m, 4H), 2.63 (t, 2H, $J$ = 7.5 Hz), 3.29 (dt, 1H, $J$ = 5.4, 14.3 Hz), 3.33 (dt, 1H, $J$ = 5.2, 13.9 Hz), 3.48 (dt, 1H, $J$ = 6.6, 13.9 Hz), 3.56 (dd, 1H, $J$ = 6.1, 12.1 Hz), 3.57–3.73 (m, 5H), 3.76 (brq, 1H, $J$ = 6.1 Hz), 3.92 (m, 2H), 4.13 (ddd, 1H, $J$ = 2.7, 6.0, 11.7 Hz), 4.37 (d, 1H, $J$ = 7.2 Hz), 7.19–7.33 (m, 5H), 8.14 (t, 1H, $J$ = 6.0 Hz); $^{13}$C NMR (125 MHz, $CDCl_3$): δ 16.39, 27.62, 31.02, 31.70, 32.28, 43.16, 43.27, 56.21, 63.14, 67.88, 68.33, 70.36, 70.56, 71.64, 72.33, 72.47, 74.84, 126.79, 129.32, 129.37, 134.01, 172.47, 172.55, 175.54. MS (ESI): $C_{26}H_{41}N_2O_{11}$ (M + H), calcd 557, found 557; $C_{26}H_{39}N_2O_{11}$ (M–H), calcd 555, found 555.

**Ethyl (*E*)-4-(tri-*O*-benzyl-α-L-fucopyranosyl)-2-butenoate (24).** A solution of **6** (21.54 g, 47.00 mmol) in $CH_2Cl_2$ (285 mL) and MeOH (90 mL) was cooled to −78 °C. $O_3$ was bubbled through the solution until a blue color appeared, and then $O_2$ was bubbled until the solution became colorless. $NaHCO_3$ (8.2 g, 97.6 mmol) and dimethyl sulfide (24.5 mL, 470 mmol) were successively added to the reaction, and the mixture was stirred for 22 h at rt. The mixture was taken up in $Et_2O$, washed with water and brine and dried ($MgSO_4$). Removal of the solvent in vacuo gave the aldehyde (23.08 g, 100%) as a slightly yellow oil. To a suspension of 1.13 g (47 mmol) NaH in dry THF (300 mL) was added triethyl phosphonoacetate (10.3 mL, 51.7 mmol) at 0 °C and the mixture was stirred until it became a clear solution. Then the aldehyde (23.01 g, 47 mmol) was added slowly at 0 °C and the mixture was stirred vigorously at rt for 12 h. The mixture was quenched with water, taken up in ether (900 mL), washed with brine, and dried ($MgSO_4$). After removal of the solvent in vacuo the residue was purified by flash chromatography on silica with EtOAc/hexanes (1/5) to give **24** (22.0 g, 88%) as a yellow oil. $^1$H NMR (400 MHz, $CDCl_3$): δ 1.28 (t, 3H, $J$ = 7.1 Hz), 1.29 (d, 3H, $J$ = 6.6 Hz), 2.40 (dddd, 1H, $J$ = 1.3, 4.7, 6.5, 15.4 Hz), 2.52 (dddd, 1H, $J$ = 1.3, 7.1, 8.9, 15.5 Hz), 3.76–3.78 (m, 3H), 3.93 (dq, 1H, $J$ = 3.2, 6.5 Hz), 4.12 (ddd, 1H, $J$ = 3.0, 4.8, 9.0 Hz), 4.17 (q, 2H, $J$ = 7.2 Hz), 4.48–4.78 (m, 6H), 5.83 (dt, 1H, $J$ = 1.4, 15.7 Hz), 6.90 (dt, 1H, $J$ = 7.1, 15.6 Hz), 7.26–7.35 (m, 15H); $^{13}$C NMR (100 MHz, $CDCl_3$): δ 14.26, 15.15, 30.99, 60.16, 68.91,

69.66, 73.06, 73.10, 75.66, 76.55, 76.69, 123.07, 127.52, 127.59, 127.62, 127.78, 127.81, 127.85, 127.93, 128.02, 128.29, 128.38, 128.46, 138.46, 138.47, 138.63, 145.74, 166.38. HRMS (FAB): $C_{33}H_{38}O_6Cs$ (M + Cs), calcd 663.1723, found 663.1752.

**Ethyl (2*R*,3*S*)-2,3-dihydroxy-4-(tri-*O*-benzyl-α-L-fucopyranosyl)-butanoate (25).** A solution of AD-mix α (37.0 g, Aldrich) in *tert*-butanol (132 mL) and $H_2O$ (132 mL) was cooled to 0 °C, $MeSO_2NH_2$ (2.89 g, 30.4 mmol), potassium osmate (34.3 mg) and **24** (14.0 g, 26.4 mmol) were added and the heterogeneous mixture was stirred at 4 °C for 48 h. Sodium sulfite (39.6 g) was added at 4 °C and stirring was continued at rt for 30 min. Triple extraction with EtOAc was followed by washings with 1 N NaOH and brine. After drying ($MgSO_4$) and removal of the solvent in vacuo the residue was purified by flash chromatography on silica with EtOAc/hexanes (1/2 to 1/1) to give **25** (12.80 g, 86%, 93% *de*) as a colorless oil. $^1$H NMR (400 MHz, $CDCl_3$): δ 1.29 (t, 3H, $J$ = 7.2 Hz), 1.30 (d, 3H, $J$ = 6.5 Hz), 1.84 (ddd, 1H, $J$ = 3.4, 8.6, 14.7 Hz), 1.96 (ddd, 1H, $J$ = 4.1, 9.7, 14.7 Hz), 2.54 (d, 1H, $J$ = 7.9 Hz), 3.15 (d, 1H, $J$ = 6.1 Hz), 3.74–3.82 (m, 3H), 3.96 (dq, 1H, $J$ = 3.4, 6.6 Hz), 4.04–4.13 (m, 2H), 4.20–4.32 (m, 3H), 4.54–4.76 (m, 6H), 7.28–7.34 (m, 15H); $^{13}$C NMR (100 MHz, $CDCl_3$): δ 14.09, 15.27, 32.09, 61.90, 68.11, 68.91, 70.10, 73.00, 73.03, 73.23, 73.84, 75.74, 76.91, 77.00, 127.45, 127.51, 127.56, 127.78, 127.89, 127.93, 127.96, 128.00, 128.23, 128.27, 128.32, 128.34, 137.99, 138.44, 138.59, 173.24. HRMS (FAB): $C_{33}H_{40}O_8Cs$ (M + Cs), calcd 697.1778, found 697.1762.

**Ethyl (2*R*,3*S*)-3-hydroxy-2-(4-nitrobenzenesulfonyloxy)-4-(tri-*O*-benzyl-α-L-fucopyranosyl)-butanoate (26).** A solution of **25** (13.12 g, 23.26 mmol) in dry pyridine (78 mL) was cooled to 0 °C and 4-nitrobenzenesulfonyl chloride (5.31 g, 24 mmol, freshly recrystallized from hexane) was added. After standing for 25 h at 4 °C the mixture was poured onto ice and extracted with ether. After multiple washings with satd $CuSO_4$-sol, one washing with brine and drying (MgSO4), the solvent was removed in vacuo. The residual oil was purified by flash chromatography on silica with EtOAc/hexanes (1/2 to 1/1) to give **26** (15.4 g, 88%) as a pale-yellow foam. $^1$H NMR (400 MHz, $CDCl_3$): δ 1.19 (t, 3H, $J$ = 7.2 Hz), 1.29 (d, 3H, $J$ = 6.7 Hz), 1.72 (ddd, 1H, $J$ = 3.8, 9.2, 14.6 Hz), 1.90 (ddd, 1H, $J$ = 3.2, 9.4, 14.5 Hz), 2.65 (d, 1H, $J$ = 7.0 Hz), 3.71–3.80 (m, 3H), 3.92 (dq, 1H, $J$ = 3.9, 6.6 Hz), 4.09–4.19 (m, 2H), 4.23–4.32 (m, 2H), 4.46–4.78 (m, 6H), 4.97 (d, 1H, $J$ = 3.3 Hz), 7.24–7.34 (m, 15H), 8.13–8.30 (m, 4H); $^{13}$C NMR (100 MHz, $CDCl_3$): δ 13.96, 15.01, 32.16, 62.31, 67.14, 68.93, 69.37, 72.89, 73.06, 73.21, 75.29, 76.29, 76.71, 81.68, 124.16, 127.51, 127.63, 127.68, 127.87, 127.99, 128.14, 128.32, 128.39, 128.48, 128.50, 137.69, 138.33, 138.46, 142.00, 150.71, 166.60. HRMS (FAB): $C_{39}H_{43}NO_{12}SCs$ (M + Cs), calcd 882.1560, found 882.1578.

**Ethyl (2*S*,3*S*)-2-azido-3-hydroxy-4-(tri-*O*-benzyl-α-L-fucopyranosyl)-butanoate (27).** A solution of **26** (14.12 g, 18.85 mmol) and sodium azide (7.32 g, 112.54 mmol) in dry DMF (187 mL) was stirred at 50 °C for 21 h. The reaction mixture was poured into ice water and extracted three times with ether. The combined organic layers were washed with brine and dried ($MgSO_4$). After removal of the solvent in vacuo the residue was purified by flash chromatography on silica with EtOAc/hexanes (2/5) to give **27** (9.74 g, 88%) as a slightly yellow oil. $^1$H NMR (400 MHz, $CDCl_3$): δ 1.26 (d, 3H, $J$ = 6.7 Hz), 1.29 (t, 3H, $J$ = 7.1 Hz), 1.70 (ddd, 1H, $J$ = 3.7, 9.1, 14.6 Hz), 1.95 (ddd, 1H, $J$ = 2.6, 10.0, 14.7 Hz), 2.98 (d, 1H, $J$ = 6.2 Hz), 3.73 (dd, 1H, $J$ = 2.8, 6.6 Hz), 3.75 (t, 1H, $J$ = 3.0 Hz), 3.83 (dd, 1H, $J$ = 4.1, 6.8 Hz), 3.88 (dq, 1H, $J$ = 3.1, 6.6 Hz), 3.92 (d,1H, $J$ = 6.1 Hz), 4.11 (ddt, 1H, $J$ = 2.5, 6.2, 8.9 Hz), 4.25 (q, 2H, $J$ = 7.1 Hz), 4.29 (dt, 1H, $J$ = 3.8, 9.3 Hz), 4.52–4.77 (m, 6H), 7.25–7.34 (m, 15H); $^{13}$C NMR (100 MHz, $CDCl_3$): δ 14.14, 15.48, 30.73, 62.00, 66.09, 68.04, 68.87, 69.21, 73.07, 73.31, 73.33, 75.81, 76.59, 77.31, 127.49, 127.58, 127.64, 127.89, 127.99, 128.12, 128.28, 128.38, 128.42, 137.83, 128.43, 138.63, 168.86. HRMS (FAB): $C_{33}H_{39}N_3O_7Cs$ (M + Cs), calcd 722.1842, found 722.1855.

**Ethyl (2*S*,3*S*)-2-(*tert*-butyloxycarbonyl-amino)-3-hydroxy-4-(tri-*O*-benzyl-α-L-fucopyranosyl)-butanoate (28).** Compound **27** (9.70 g, 16.4 mmol) was dissolved in EtOAc (145 mL), di-*tert*-butyl dicarbonate (5.4 mL, 18.1 mmol) and Pd-C (485 mg, Aldrich) added, and the mixture vigorously stirred in a hydrogen atmosphere for 13 h. At this time another 200 mg Pd-C were added and stirring continued for 5 h to complete the reaction. The catalyst was then filtered (Celite) and the filtrate evaporated. The residue was purified by flash chromatograpy on silica with EtOAc/hexanes (1/4 to 1/2) to give **28** (9.22 g, 85%) as a white solid. $^1$H NMR (400 MHz, $CDCl_3$): δ 1.23 (t, 3H, $J$ = 7.1 Hz), 1.25 (d, 3H, $J$ = 6.5 Hz), 1.41 (s, 9H), 1.62 (m, 2H), 1.79 (broad, 1H), 3.71 (m, 2H), 3.82 (m, 2H), 4.03 (broad d, 1H, $J$ = 7.0 Hz), 4.18 (q, 2H, $J$ = 7.1 Hz), 4.30 (m, 2H), 4.51 (d, 1H, $J$ = 11.7 Hz), 4.58 (d, 1H, $J$ = 11.8 Hz), 4.61 (d, 1H, $J$ = 11.7 Hz), 4.66 (d, 1H, $J$ = 12.0 Hz), 4.71 (d, 1H, $J$ = 12.0 Hz), 4.74 (d, 1H, $J$ = 11.8 Hz), 5.34 (broad d, 1H, $J$ = 7.0 Hz), 7.22–7.34 (m, 15H); $^{13}$C NMR (100 MHz, $CDCl_3$): δ 14.09, 15.40, 28.17, 31.12, 58.64, 61.53, 68.69, 69.99, 72.95, 73.07, 73.14, 75.82, 76.60, 77.20, 80.16, 127.45, 127.48, 127.55, 127.75, 127.90, 127.93, 128.05, 128.22, 128.30, 137.99, 138.43, 138.60, 155.82, 170.64. HRMS (FAB): $C_{38}H_{49}NO_9Cs$ (M + Cs), calcd 796.2462, found 796.2440.

**Ethyl (2*S*,3*S*)-2-(*tert*-butyloxycarbonyl-amino)-3-allyloxy-4-(tri-*O*-benzyl-α-L-fucopyranosyl)-butanoate (29).** To a solution of tris(dibenzylideneacetone)-dipalladium(0) (430 mg, 0.47 mmol, 2.5 mol%) in dry THF (100 mL) were sucessively added 1,4-bis(diphenylphosphino)-butane (800 mg, 1.87 mmol, 10 mol%; color change from red to yellow) and a solution of allylmethylcarbonate (6.4 mL, 56.2 mmol) and **28** (12.44 g, 18.7 mmol) in dry THF (125 mL). The solution was stirred at 65–70 °C bath temperature (color change to greenish) for 8 h. After cooling, the volatiles were removed and the residue was purified by flash chromatography on silica with EtOAc/hexanes (1/6 to 1/2) to give **29** (11.59 g, 88%) as a yellowish oil. $^1$H NMR (400 MHz, $CDCl_3$): δ 1.22 (t, 3H, $J$ = 7.1 Hz), 1.23 (d, 3H, $J$ = 6.5 Hz), 1.42 (s, 9H), 1.66 (m, 2H), 3.67 (brdd, 1H, $J$ = 2.8, 7.3 Hz), 3.71 (brt,

1H, $J=3.1$ Hz), 3.81 (m, 3H), 4.00 (brdd, 1H, $J=5.8$, 12.3 Hz), 4.13 (m, 1H), 4.14 (q, 2H, $J=7.1$ Hz), 4.14 (broad d, 1H, $J=10.6$ Hz), 4.25 (broad d, 1H, $J=10.6$ Hz), 4.49 (m, 1H), 4.50 (d, 1H, $J=11.8$ Hz), 4.58 (d, 1H, $J=11.9$ Hz), 4.59 (d, 1H, $J=11.8$ Hz), 4.68 (s, 2H), 4.74 (d, 1H, $J=11.9$ Hz), 5.11 (brd, 1H, $J=10.4$ Hz), 5.23 (ddd, 1H, $J=1.5$, 1.5, 17.2 Hz), 5.86 (ddt, 1H, $J=5.6$, 10.4, 17.2 Hz), 7.24–7.33 (m, 15H)l; $^{13}$C NMR (100 MHz, $CDCl_3$): δ 14.10, 15.45, 28.24, 56.03, 61.36, 68.30, 71.56, 72.87, 72.95, 73.17, 75.63, 75.91, 76.50, 79.72, 117.14, 127.39, 127.42, 127.52, 127.68, 128.00, 128.06, 128.18, 128.26, 134.52, 138.16, 138.46, 138.67, 155.40, 170.65. HRMS (FAB): $C_{41}H_{53}NO_9Cs$ (M + Cs), calcd 836.2775, found 836.2789.

**Compound 30.** To a solution of **29** (4.75 g, 6.75 mmol) in dry $CH_2Cl_2$ (78 mL) were added trifluoroacetic acid (16 mL) at 0 °C. After stirring at this temperature for 1.5 h the mixture was warmed to rt and stirring continued for 2 h. Toluene (75 mL) was then added, the volatiles removed and the residue coevaporated with toluene (twice, 150 mL each). The residue was dissolved in MeOH (75 mL) and AG 1-X8 ion exchange resin (Biorad, $OH^-$ form) added portionwise until pH 8 was reached. The resin was filtered and the filtrate evaporated. To a solution of the residue and **33** (3.60 g, 8.71 mmol) in dry $CH_2Cl_2$ (23 mL) were added 1-hydroxybenzotriazole (HOBT, 1.09 g, 8.04 mmol) and *N*-methylmorpholine (1.5 mL, 13.4 mmol), and the mixture was cooled to 0 °C. At this temperature 1-(3-dimethylaminopropyl)-3-ethylcarbodiimide hydrochloride (EDC, 1.54 g, 8.04 mmol) was added portionwise, the mixture slowly warmed to rt (during several hours) and stirring continued at rt (11 h altogether). The reaction mixture was diluted with EtOAc (700 mL), washed with $H_2O$ (twice, 150 mL each) and brine (200 mL), dried ($MgSO_4$) and evaporated. The residue was purified by flash chromatography on silica with EtOAc/hexanes (1/1) to give **30** (4.67 g, 69%) as a white solid. $^1$H NMR (400 MHz, $CDCl_3$): δ 1.21 (d, 3H, $J=6.5$ Hz), 1.22 (t, 3H, $J=7.1$ Hz), 1.70 (m, 2H), 2.42 (m, 2H), 2.59 (dt, 1H, $J=6.1$, 17.5 Hz), 2.70 (dt, 1H, $J=7.2$, 17.5 Hz), 3.58 (dd, 1H, $J=5.1$, 9.9 Hz), 3.61–3.69 (m, 4H), 3.75–3.82 (m, 2H), 3.87 (dt, 1H, $J=3.6$, 9.5 Hz), 3.94–4.02 (m, 2H), 4.06–4.19 (m, 3H), 4.25 (dt, 1H, $J=3.9$, 9.8 Hz), 4.46 (d, 1H, $J=11.9$ Hz), 4.47 (d, 1H, $J=11.7$ Hz), 4.52 (d, 1H, $J=11.9$ Hz), 4.54 (d, 1H, $J=11.7$ Hz), 4.56 (d, 1H, $J=11.8$ Hz), 4.61 (m, 3H), 4.73 (d, 1H, $J=11.8$ Hz), 4.86 (dd, 1H, $J=3.7$, 8.3 Hz), 5.05 (d, 1H, $J=12.3$ Hz), 5.08 (d, 1H, $J=12.3$ Hz), 5.1 (brdd, 1H, $J=1.5$, 10.4 Hz), 5.21 (ddt, 1H, $J=1.5$, 1.5, 17.2 Hz), 5.83 (ddt, 1H, $J=5.7$, 10.4, 17.2 Hz), 6.78 (d, 1H, $J=7.4$ Hz), 7.20–7.33 (m, 26H). $^{13}$C NMR (100 MHz, $CDCl_3$): δ 14.10, 29.34, 30.75, 54.90, 55.22, 61.75, 66.53, 68.37, 71.46, 71.51, 71.62, 72.92, 73.21, 73.39, 75d.53, 75.89, 76.55, 117.28, 127.34, 127.44, 127.55, 127.71, 127.75, 127.81, 128.01, 128.20, 128.28, 128.30, 128.43, 128.52, 134.43, 135.68, 137.56, 138.19, 138.47, 138.68, 169.67, 170.01, 171.64, 172.60. HRMS (FAB): $C_{58}H_{68}N_2O_{13}Cs$ (M + Cs), calcd 1133.3774, found 1133.3734).

**Compound 31a.** Prepared according to General Procedure D using 57 μL styrene and EtOAc/hexanes (1/1 to 3/2) to give **31a** (198 mg, 74%). $^1$H NMR (400 MHz, $CDCl_3$): δ 1.18–1.24 (m, 6H), 1.73 (m, 2H), 2.40 (m, 2H), 2.58 (dt, 1H, $J=6.6$, 17.6 Hz), 2.69 (dt, 1H, $J=6.8$, 17.6 Hz), 3.38 (dd, 1H, $J=5.1$, 9.9 Hz), 3.62–3.70 (m, 4H), 3.80 (broad m, 2H), 3.94 (m, 1H), 4.00 (m, 1H), 4.09–4.20 (m, 3H), 4.24–4.32 (m, 2H), 4.44 (d, 1H, $J=11.9$ Hz), 4.48 (d, 1H, $J=11.2$ Hz), 4.51 (d, 1H, $J=11.7$ Hz), 4.55 (d, 1H, $J=11.8$ Hz), 4.56 (d, 1H, $J=11.9$ Hz), 4.59–4.64 (m, 3H), 4.73 (d, 1H, $J=11.8$ Hz), 4.92 (dd, 1H, $J=3.6$, 8.3 Hz), 5.04 (d, 1H, $J=12.3$ Hz), 5.07 (d, 1H, $J=12.3$ Hz), 6.21 (dt, 1H, $J=6.1$, 15.9 Hz), 6.45 (d, 1H, $J=15.9$ Hz), 6.78 (d, 1H, $J=7.3$ Hz), 7.17–7.27 (m, 31H); $^{13}$C NMR (100 MHz, $CDCl_3$): δ 14.07, 15.57, 29.30, 30.69, 54.81, 55.29, 61.75, 66.50, 68.33, 71.26, 71.37, 71.47, 72.90, 73.19, 73.34, 75.42, 75.86, 76.49, 125.61. 126.45, 127.31, 127.38, 127.49, 127.58, 127.70, 127.76, 127.99, 128.18, 128.27, 128.40, 128.46, 132.65, 135.64, 136.51, 137.53, 138.15, 138.43, 138.63, 169.69, 170.02, 171.66, 172.60. HRMS (FAB): $C_{64}H_{72}N_2O_{13}Cs$ (M + Cs), calcd 1209.4089, found 1209.4049.

**Compound 31b.** Prepared according to General Procedure D using 66 μL allylbenzene and EtOAc/hexanes (1/1) to give **31b** (178 mg, 65%). Mixture of stereoisomers in a 0.75/0.25 ratio. $^1$H NMR (400 MHz, $CDCl_3$): δ 1.16–1.24 (m, 6H), 1.61–1.74 (m, 2H), 2.32–2.44 (m, 2H), 2.57 (dt, 1H, $J=6.6$, 17.4 Hz), 2.68 (dt, 1H, $J=6.8$, 17.4 Hz), 3.31 (d, 1.5H, $J=6.7$ Hz), 3.38 (d, 0.5H, $J=7.3$ Hz), 3.54–3.71 (m, 5H), 3.77 (broad m, 2H), 3.86–4.01 (m, 3H), 4.06–4.18 (m, 3H), 4.22–4.32 (m, 1H), 4.42–4.57 (m, 5H), 4.60 (s, 2H), 4.62 (m, 1H), 4.72 (d, 1H, $J=11.8$ Hz), 4.87 (dd, 0.75H, $J=3.7$, 8.2 Hz), 4.95 (dd, 0.25H, $J=3.5$, 8.2 Hz), 5.04 (d, 1H, $J=12.5$ Hz), 5.07 (d, 1H, $J=12.5$ Hz), 5.55 (brdt, 0.75H, $J=6.2$, 15.3 Hz), 5.60 (brdt, 0.25H, $J=6.1$, 10.8 Hz), 5.69 (brdt, 0.25H, $J=7.4$, 10.8 Hz), 5.79 (brdt, 0.75H, $J=6.7$, 15.3 Hz), 6.79 (d, 1H, $J=7.3$ Hz), 7.11–7.32 (m, 31H); $^{13}$C NMR (100 MHz, $CDCl_3$): δ 14.06, 15.48, 28.79, 29.28, 29.62, 30.65, 33.70, 38.60, 54.60, 54.72, 55.20, 55.24, 61.70, 61.75, 65.82, 66.47, 68.33, 70.92, 71.43, 72.83, 72.88, 73.11, 73.32, 74.99, 75.30, 75.81, 76.49, 125.96, 126.00, 126.55, 127.31, 127.36, 127.41, 127.52, 127.70, 127.75, 127.96, 128.00, 128.17, 128.25, 128.33, 128.39, 128.48, 131.84, 133.13, 135.64, 137.53, 138.12, 138.43, 138.63, 139.83, 140.10, 169.66, 169.70, 170.05, 170.09, 171.61, 172.58. HRMS (FAB): $C_{65}H_{74}N_2O_{13}Cs$ (M + Cs), calcd 1223.4245, found 1223.4293.

**Compound 31c.** Prepared according to General Procedure D using 67 μL 4-vinylanisole and EtOAc/toluene (1/2) to give **31c** (201 mg, 73%). Mixture of stereoisomers in a 0.87/0.13 ratio. $^1$H NMR (400 MHz, $CDCl_3$): δ 1.17–1.24 (m, 6H), 1.70–1.75 (m, 2H), 2.35–2.46 (m, 2H), 2.58 (dt, 1H, $J=6.1$, 17.6 Hz), 2.67 (dt, 1H, $J=7.2$, 17.6 Hz), 3.57 (dd, 1H, $J=5.1$, 10.0 Hz), 3.62–3.71 (m, 4H), 3.76 (s, 3H), 3.74–3.83 (broad m, 2H), 3.94 (dt, 1H, $J=3.8$, 9.1 Hz), 4.00 (m, 1H), 4.08–4.19 (m, 3H), 4.21–4.32 (m, 2H), 4.44 (d, 1H, $J=11.9$ Hz), 4.48 (d, 1H, $J=11.6$ Hz), 4.51 (d, 1H, $J=11.8$ Hz), 4.54 (d, 1H, $J=11.6$ Hz), 4.56 (d, 1H, $J=11.9$ Hz), 4.60 (s, 2H), 4.62 (dd, 1H, $J=4.7$, 7.3 Hz), 4.73 (d, 1H, $J=11.8$ Hz), 4.86 (dd, 0.13H, $J=3.7$,

8.2 Hz), 4.91 (dd, 0.87H, $J=3.7$, 8.3 Hz), 5.04 (d, 1H, $J=12.3$ Hz), 5.07 (d, 1H, $J=12.3$ Hz), 6.07 (dt, 1H, $J=6.3$, 15.9 Hz), 6.48 (d, 1H, $J=15.9$ Hz), 6.76–6.82 (m, 2H), 7.20–7.35 (m, 29H); $^{13}$C NMR (100 MHz, $CDCl_3$): δ 14.06, 15.56, 29.29, 29.62, 30.68, 54.82, 55.17, 55.28, 61.71, 66.48, 68.32, 71.37, 71.45, 72.87, 73.15, 73.32, 75.23, 75.85, 76.49, 113.80, 123.28, 127.30, 127.39, 127.51, 127.69, 127.74, 127.97, 128.15, 128.17, 128.25, 128.38, 128.47, 129.27, 132.45, 135.64, 137.53, 138.15, 138.43, 138.63, 159.20, 169.68, 170.05, 171.64, 172.59. HRMS (FAB): $C_{65}H_{74}N_2O_{14}Cs$ (M + Cs), calcd 1239.4194, found 1239.4142.

**Compound 31d.** Prepared according to General Procedure D using 78 mg pentafluorostyrene and EtOAc/toluene (1/2) to give **31d** (50 mg, 17%). Mixture of stereoisomers in a 0.7/0.3 ratio. $^1$H NMR (400 MHz, $CDCl_3$): δ 1.20 (t, 3H, $J=7.0$ Hz), 1.23 (d, 3H, $J=6.8$ Hz), 1.69–1.79 (m, 2H), 2.36–2.49 (m, 2H), 2.53–2.73 (m, 2H), 3.58 (m, 1H), 3.62–3.70 (m, 4H), 3.80 (broad m, 2H), 3.94 (m, 1H), 4.00 (m, 1H), 4.10–4.19 (m, 3H), 4.24–4.35 (m, 2H), 4.43–4.57 (m, 5H), 4.61 (s, 2H), 4.62 (m, 1H), 4.73 (d, 1H, $J=11.8$), 4.90 (dd, 0.3H, $J=3.7$, 7.4), 4.92 (dd, 0.7H, $J=3.7$, 8.2), 5.06 (d, 1H, $J=12.4$), 5.07 (d, 1H, $J=12.4$), 6.20 (dt, 0.7H, $J=6.2$, 15.9), 6.50 (m, 0.6H), 6.54 (d, 0.7H, $J=15.9$), 6.78 (d, 0.7H, $J=7.5$), 6.80 (d, 0.3H, $J=8.6$), 7.18–7.38 (m, 26H). $^{13}$C NMR (100 MHz, $CDCl_3$): δ 14.09, 15.58, 29.32, 29.66, 30.71, 54.82, 54.89, 55.22, 55.28, 54.82, 54.88, 55.22, 55.28, 61.78, 61.86, 66.53, 68.35, 71.03, 71.28, 71.42, 71.48, 72.93, 73.21, 73.37, 75.42, 75.87, 76.38, 76.51, 125.61, 126.51, 127.33, 127.44, 127.56, 127.65, 127.72, 127.79, 128.01, 128.16, 128.21, 128.30, 128.42, 128.48, 128.50, 132.69, 135.65, 136.52, 137.40, 137.53, 138.10, 138.16, 138.41, 138.44, 138.64, 169.72, 169.81, 170.05, 171.68, 171.75, 172.63. HRMS (FAB): $C_{64}H_{67}F_5N_2O_{13}Cs$ (M + Cs), calcd 1299.3618, found 1299.3540.

**Compound 31e.** Prepared according to General Procedure D using 85 mg 2-vinylnaphtalene and EtOAc/toluene 1/2 to give **31e** (106 mg, 71%). $^1$H NMR (400 MHz, $CDCl_3$): δ 1.19 (t, 3H, $J=7.0$ Hz), 1.23 (d, 3H, $J=6.5$ Hz), 1.73–1.80 (m, 2H), 2.32–2.43 (m, 2H), 2.56 (dt, 1H, $J=6.1$, 17.4 Hz), 2.66 (dt, 1H, $J=6.9$, 17.4 Hz), 3.58 (dd, 1H, $J=5.1$, 9.9 Hz), 3.63–3.70 (m, 3H), 3.75–3.87 (m, 3H), 3.96–4.05 (m, 2H), 4.08–4.23 (m, 3H), 4.31–4.34 (m, 2H), 4.44 (d, 1H, $J=11.8$ Hz), 4.46 (d, 1H, $J=11.8$ Hz), 4.49 (d, 1H, $J=12.7$ Hz), 4.52 (d, 1H, $J=12.7$ Hz), 4.56 (d, 1H, $J=11.7$ Hz), 4.61 (s, 2H), 4.66 (dd, 1H, $J=5.0$, 7.0 Hz), 4.73 (d, 1H, $J=11.7$ Hz), 4.96 (dd, 1H, $J=3.4$, 8.1 Hz), 5.02 (d, 1H, $J=12.4$ Hz), 5.05 (d, 1H, $J=12.4$ Hz), 6.34 (dt, 1H, $J=6.0$, 15.8 Hz), 6.71 (d, 1H, $J=15.8$ Hz), 6.88 (d, 1H, $J=7.2$ Hz), 7.13–7.32 (m, 25H), 7.38–7.43 (m, 3H), 7.54 (brd, 1H, $J=8.5$ Hz), 7.66–7.76 (m, 4H). $^{13}$C NMR (100 MHz, $CDCl_3$): δ 14.03, 15.59, 21.35, 28.81, 29.23, 29.57, 30.60, 54.80, 55.27, 61.69, 66.42, 68.27, 71.24, 71.28, 71.39, 72.82, 72.86, 73.16, 73.28, 75.42, 75.84, 76.44, 123.51, 125.18, 125.76, 126.01, 126.09, 126.47, 127.25, 127.36, 127.48, 127.52, 127.64, 127.69, 127.91, 127.94, 128.06, 128.09, 128.13, 128.22, 128.33, 128.41, 128.91, 132.63, 132.91, 133.40, 133.96, 135.58, 137.49, 138.12, 138.38, 138.57, 169.71, 169.98, 171.66, 172.58. HRMS (FAB): $C_{68}H_{74}N_2O_{13}Cs$ (M + Cs), calcd 1295.4245, found 1259.4189.

**Compound 31f.** Prepared according to general procedure D using 96 mg vinylfluoren and EtOAc/hexanes (1/1 to 3/2) to give **31f** (204 mg, 70%). $^1$H NMR (400 MHz, $CDCl_3$): δ 1.18–1.24 (m, 6H), 1.76 (m, 2H), 2.36–2.43 (m, 2H), 2.57 (dt, 1H, $J=6.2$, 17.4 Hz), 2.67 (dt, 1H, $J=7.0$, 17.4 Hz), 3.58 (dd, 1H, $J=4.9$, 9.8 Hz), 3.63–3.70 (m, 3H), 3.82 (s, 2H), 3.76–3.86 (m, 3H), 3.97 (broad m, 1H), 4.03 (broad m, 1H), 4.42–4.50 (m, 3H), 4.28–4.35 (m, 2H), 4.44 (d, 1H, $J=11.8$ Hz), 4.47 (d, 1H, $J=11.8$ Hz), 4.50 (d, 1H, $J=11.9$ Hz), 4.53 (d, 1H, $J=11.8$ Hz), 4.56 (d, 1H, $J=11.9$ Hz), 4.61 (s, 2H), 4.64 (dd, 1H, $J=4.8$, 6.9 Hz), 4.74 (d, 1H, $J=11.8$ Hz), 4.94 (dd, 1H, $J=3.5$, 8.2 Hz), 5.02 (d, 1H, $J=12.7$ Hz), 5.05 (d, 1H, $J=12.7$ Hz), 6.25 (dt, 1H, $J=6.1$, 15.8 Hz), 6.62 (d, 1H, $J=15.8$ Hz), 6.90 (d, 1H, $J=7.1$ Hz), 7.18–7.40 (m, 29H), 7.50 (m, 2H), 7.65 (d, 1H, $J=7.9$ Hz), 7.71 (d, 1H, $J=7.5$ Hz). $^{13}$C NMR (100 MHz, $CDCl_3$): δ 14.07, 15.64, 29.27, 29.61, 30.65, 36.69, 54.83, 55.34, 61.71, 66.45, 68.24, 71.30, 71.38, 71.43, 72.84, 72.88, 73.23, 73.30, 75.29, 75.90, 76.43, 119.79, 122.87, 124.94, 124.99, 125.64, 126.61, 126.68, 127.27, 127.38, 127.51, 127.66, 127.71, 127.94, 127.99, 128.11, 128.15, 128.24, 128.36, 128.44, 133.07, 135.18, 135.61, 137.52, 138.16, 138.41, 138.61, 141.30, 143.40, 143.49, 169.69, 170.03, 171.66, 172.59. HRMS (FAB): $C_{71}H_{76}N_2O_{13}Cs$ (M + Cs), calcd 1297.4402, found 1297.4445.

**Compound 31g.** Prepared according to General Procedure D using 90 mg 4-vinylbiphenyl and EtOAc/toluene (1/2) to give **31g** (209 mg, 73%). $^1$H NMR (400 MHz, $CDCl_3$): δ 1.20 (t, 3H, $J=7.1$ Hz), 1.22 (d, 3H, $J=6.5$ Hz), 1.72–1.77 (m, 2H), 2.39 (m, 2H), 2.58 (dt, 1H, $J=6.4$, 17.4 Hz), 2.68 (dt, 1H, $J=6.8$, 17.4 Hz), 3.58 (dd, 1H, $J=5.1$, 10.0 Hz), 3.63–3.71 (m, 4H), 3.76–3.85 (broad m, 2H), 3.96 (m, 1H), 4.02 (m, 1H), 4.11–4.19 (m, 3H), 4.27–4.34 (m, 2H), 4.44 (d, 1H, $J=12.1$ Hz), 4.49 (d, 1H, $J=11.8$ Hz), 4.51 (d, 1H, $J=11.9$ Hz), 4.56 (d, 1H, $J=12.1$ Hz), 4.57 (d, 1H, $J=11.9$ Hz), 4.61 (s, 2H), 4.64 (dd, 1H, $J=4.8$, 7.3 Hz), 4.73 (d, 1H, $J=11.8$ Hz), 4.94 (dd, 1H, $J=3.7$, 8.3 Hz), 5.03 (d, 1H, $J=12.5$ Hz), 5.06 (d, 1H, $J=12.5$ Hz), 6.25 (dt, 1H, $J=6.1$, 15.9 Hz), 6.58 (d, 1H, $J=15.9$ Hz), 6.82 (d, 1H, $J=7.4$ Hz), 7.21–7.33 (m, 26H), 7.36–7.42 (m, 5H), 7.50 (brd, 2H, $J=8.3$ Hz), 7.56 (brd, 2H, $J=7.1$ Hz). $^{13}$C NMR (100 MHz, $CDCl_3$): δ 14.09, 15.61, 29.30, 30.69, 54.82, 55.30, 61.76, 66.49, 68.34, 71.29, 71.36, 71.47, 72.90, 73.19, 73.35, 75.45, 75.86, 76.50, 125.74, 126.85, 126.93, 127.13, 127.23, 127.31, 127.41, 127.54, 127.69, 127.76, 127.99, 128.16, 128.19, 128.27, 128.40, 128.48, 128.71, 132.17, 135.57, 135.63, 137.52, 138.16, 138.43, 138.63, 140.31, 140.58, 169.71, 170.02, 171.68, 172.61. HRMS (FAB): $C_{70}H_{76}N_2O^{13}Cs$ (M + Cs), calcd 1285.4402, found 1285.4459.

**Compound 31i.** Byproduct in the preparation of **31d**. 117 mg (47%); EtOAc/hexanes (1/1 to 2/1) mixture of stereoisomers in a 0.75/0.25 ratio. $^1$H NMR (400 MHz, $CDCl_3$): δ 1.15–1.24 (m, 12H), 1.66–1.75 (m, 4H), 2.37–2.58 (m, 6H), 2.66 (m, 2H), 3.55–3.68 (m, 8H), 3.76–3.87

(m, 6H), 3.94–4.50 (m, 8H), 4.10 (m, 4H), 4.18–4.27 (m, 2H), 4.39–4.56 (m, 10H), 4.61 (s, 4H), 4.71 (d, 2H, $J$ = 12.1 Hz), 4.75 (dd, 1.5H, $J$ = 3.1, 7.7 Hz), 4.84 (dd, 0.5H, $J$ = 3.3, 7.4 Hz), 4.90 (dd, 1.5H, $J$ = 3.2, 8.3 Hz), 4.99 (dd, 0.5H, $J$ = 2.4, 7.7 Hz), 5.01 (d, 2H, $J$ = 12.4 Hz), 5.04 (d, 2H, $J$ = 12.4 Hz), 5.63 (broad t, 0.5H, $J$ = 4.2 Hz), 5.69 (broad t, 1.5H, $J$ = 2.5 Hz), 7.19–7.31 (m, 52H), 7.45 (d, 1.5H, $J$ = 8.2 Hz), 7.66 (d, 0.5H, $J$ = 8.4 Hz). $^{13}$C NMR (100 MHz, $CDCl_3$): d 14.06, 15.49, 29.30, 29.62, 30.51, 54.75, 55.13, 55.27, 55.63, 61.59, 66.21, 66.36, 68.29, 70.56, 71.26, 71.33, 72.83, 73.11, 73.26, 75.70, 75.89, 76.52, 127.36, 127.39, 127.48, 127.65, 127.88, 127.93, 138.12, 128.16, 128.24, 128.27, 128.31, 128.44, 129.60, 135.72, 137.73, 138.18, 138.23, 138.47, 138.64, 169.75, 169.87, 171.88, 171.98, 172.69. HRMS (FAB): $C_{114}H_{132}N_4O_{26}Cs$ (M + Cs), calcd 2105.8184, found 2105.8298.

**Compound 32a.** Prepared according to General Procedure E using 90 mg (83.5 μmol) **31a**, 20 mg $Pd(OH)_2$-C, 8 mL EtOH, 2 mL $H_2O$ and $H_2O/CH_3CN$ (1/8) to give **32a** (41 mg, 78%). Mixture of amide isomers in a 0.9/0.1 ratio. $^1$H NMR (400 MHz, $CDCl_3$): δ 1.22 (d, 3H, $J$ = 6.4 Hz), 1.27 (t, 2.7H, $J$ = 7.1 Hz), 1.28 (t, 0.3H, $J$ = 7.1 Hz), 1.77–1.85 (m, 4H), 2.47–2.61 (m, 4H), 2.63 (t, 2H, $J$ = 7.9 Hz), 3.47 (dt, 1H, $J$ = 6.3, 9.0 Hz), 3.60–3.70 (m, 5H), 3.75 (m, 1H), 3.75 (m, 1H), 3.83–3.94 (m, 3H), 4.17 (m, 1H), 4.18 (q, 2H, $J$ = 7.1 Hz), 4.54 (d, 0.1H, $J$ = 6.6 Hz), 4.56 (d, 0.9H, $J$ = 6.6 Hz), 4.82 (d, 0.1H, $J$ = 5.0 Hz), 4.86 (d, 0.9H, $J$ = 4.9 Hz), 7.12 (brt, 1H, $J$ = 7.2 Hz), 7.17 (brd, 2H, $J$ = 7.2 Hz), 7.23 (brt, 2H, $J$ = 7.2 Hz). $^{13}$C NMR (100 MHz, $CDCl_3$): d 14.53, 16.82, 27.60, 31.69, 33.12, 33.37, 56.26, 56.51, 62.67, 64.15, 68.74, 69.58, 70.94, 72.08, 72.42, 72.73, 72.89, 77.37, 126.74, 129.32, 129.48, 143.39, 171.61, 172.33, 174.78. HRMS (FAB): $C_{29}H_{44}N_2O^{13}Cs$ (M + Cs), calcd 761.1898, found 761.1917.

**Compound 32b.** Prepared according to General Procedure E using 120 mg (110 mmol) **31b**, 20 mg $Pd(OH)_2$-C, 8 mL EtOH, 2 mL $H_2O$ and $H_2O/CH_3CN$ (1/8) to give **32b** (54 mg, 76%). Mixture of amide isomers in a 0.9/0.1 ratio. $^1$H NMR (400 MHz, $CDCl_3$): δ 1.22 (d, 2.7H, $J$ = 6.6 Hz), 1.23 (d, 0.3H, $J$ = 6.6 Hz), 1.24 (t, 2.7H, $J$ = 7.1 Hz), 1.28 (t, 0.3H, $J$ = 7.1 Hz), 1.46–1.56 (m, 2H), 1.60–1.70 (m, 2H), 1.73–1.87 (m, 2H), 2.46–2.63 (m, 4H), 2.58 (t, 2H, $J$ = 7.6 Hz), 3.48 (dt, 1H, $J$ = 6.3, 8.8 Hz), 3.59–3.69 (m, 5H), 3.75 (m, 1H), 3.82 (m, 1H), 3.86–3.93 (m, 2H), 4.11–4.21 (m, 3H), 4.54 (d, 1H, $J$ = 6.5 Hz), 4.81 (d, 0.1H, $J$ = 5.0 Hz), 4.82 (d, 0.9H, $J$ = 5.0 Hz), 7.12 (brt, 1H, $J$ = 7.3 Hz), 7.16 (brd, 2H, $J$ = 7.3 Hz), 7.23 (brt, 2H, $J$ = 7.3 Hz). $^{13}$C NMR (100 MHz, $CDCl_3$): δ 14.51, 16.81, 24.46, 27.50, 27.65, 27.79, 30.62, 31.40, 31.69, 34.54, 36.64, 38.86, 56.35, 56.53, 62.64, 64.10, 64.23, 68.71, 69.54, 71.61, 71.91, 72.03, 72.40, 72.72, 72.81, 77.41, 126.66, 129.26, 129.45, 143.69, 171.64, 172.28, 174.80. HRMS (FAB): $C_{30}H_{46}N_2O^{13}Cs$ (M + Cs), calcd 775.2054, found 775.2076.

**Compound 32c.** Prepared according to General Procedure F using 200 mg (180 μmol) **31c**, 20 mL EtOH, 600 mg Pd-$BaSO_4$, 1.2 mL cyclohexene and $H_2O/CH_3CN$ (1/8) to give 32c (68 mg, 57%). $^1$H NMR (400 MHz, $CDCl_3$): δ 1.22 (d, 3H, $J$ = 6.4 Hz), 1.27 (t, 3H, $J$ = 7.1 Hz), 1.74–1.84 (m, 4H), 2.52 (broad m, 4H), 2.57 (t, 2H, $J$ = 7.6 Hz), 3.45 (dt, 1H, $J$ = 6.2, 8.8 Hz), 3.60–3.77 (m, 6H), 3.74 (s, 3H), 3.82–3.95 (m, 3H), 4.17 (m, 1H), 4.18 (q, 2H, $J$ = 7.1 Hz), 4.57 (d, 1H, $J$ = 6.3 Hz), 4.85 (d, 1H, $J$ = 4.7 Hz), 6.79 (brd, 2H, $J$ = 8.6 Hz), 7.08 (brd, 2H, $J$ = 8.6 Hz). $^{13}$C NMR (100 MHz, $CDCl_3$): δ 14.52, 16.83, 27.56, 32.05, 32.42, 33.23, 55.60, 56.23, 56.60, 62.64, 64.17, 68.70, 69.57, 70.88, 72.06, 72.44, 72.75, 72.91, 77.31, 114.7, 130.35, 135.30, 159.20, 171.60, 172.33, 174.94. HRMS (FAB): $C_{30}H_{46}N_2O_{14}Cs$ (M + Cs), calcd 791.2003, found 791.2025.

**Compound 32d.** Prepared according to General Procedure E using 29 mg (24.8 μmol) **31d**, 10 mg $Pd(OH)_2$-C, 4 mL EtOH, 1 mL $H_2O$ and $H_2O/CH_3CN$ (1/8) to give **32d** (12 mg, 67%). Mixture of amide isomers in a 0.9/0.1 ratio. $^1$H NMR (400 MHz, $CDCl_3$): δ 1.21 (d, 0.3H, $J$ = 6.4 Hz), 1.22 (d, 2.7H, $J$ = 6.4 Hz), 1.26 (t, 0.3H, $J$ = 7.1 Hz), 1.28 (t, 2.7H, $J$ = 7.1 Hz), 1.62–1.86 (m, 6H), 2.50–2.62 (broad m, 4H), 3.43 (dt, 1H, $J$ = 6.7, 8.7 Hz), 3.59–3.70 (m, 5H), 3.76 (m, 1H), 3.79–3.84 (m, 1H), 3.86–3.90 (m, 2H), 4.13 (m, 1H), 4.19 (q, 2H, $J$ = 7.1 Hz), 4.53 (d, 1H, $J$ = 6.5 Hz), 4.81 (d, 0.9H, $J$ = 5.1 Hz), 4.84 (d, 0.1H, $J$ = 4.9 Hz). $^{13}$C NMR (100 MHz, $CDCl_3$): δ 14.54, 16.79, 27.50, 27.79, 28.46, 34.52, 34.98, 38.90, 56.40, 56.60, 62.64, 64.15, 72.08, 72.26, 72.84, 77.40, 171.67, 173.53. MS (ESI): $C_{29}H_{39}F_5N_2O_{13}Na$ (M + Na), calcd 741, found 741.

**Compound 32e.** Prepared according to General Procedure F using 50 mg (44.4 μmol) **31e**, 12 mL EtOH, 745 mg Pd-$BaSO_4$, 0.9 mL cyclohexene and $H_2O/CH_3CN$ (1/8) to give **32e** (6 mg, 21%). Mixture of amide isomers. $^1$H NMR (400 MHz, $CDCl_3$): δ 1.20–1.29 (m, 6H), 1.81–1.95 (m, 4H), 2.44–2.63 (broad m, 4H), 2.82 (t, 2H, $J$ = 7.7 Hz), 3.52 (dt, 1H, $J$ = 6.4, 9.0 Hz), 3.59–3.72 (m, 4H), 3.76 (m, 1H), 3.84–4.04 (broad m, 3H), 4.16 (q, 2H, $J$ = 7.1 Hz), 4.19 (m, 1H), 4.45–4.57 (m, 1H), 4.56 (d, 1H, $J$ = 6.4 Hz), 4.85 (d, 1H, $J$ = 4.7 Hz), 7.23–7.43 (m, 4H), 7.63 (s, 1H), 7.75 (d, 1H, $J$ = 8.6 Hz), 7.78 (brd, 1H, $J$ = 8.6 Hz). $^{13}$C NMR (100 MHz, $CDCl_3$): δ 14.52, 16.88, 32.95, 33.55, 56.37, 62.64, 68.78, 71.01, 72.95, 77.46, 126.08, 126.82, 127.45, 128.43, 128.50, 128.54, 128.87, 129.26, 140.99, 171.61, 172.41. HRMS (FAB): $C_{33}H_{46}N_2O^{13}Cs$ (M + Cs), calcd 811.2054, found 811.2084.

**Compound 32f.** Prepared according to General Procedure E using 100 mg (85.8 μmol) **31f**, 20 mg $Pd(OH)_2$-C, 9 mL EtOH, 2 mL $H_2O$ and $H_2O/CH_3CN$ (1/8) to give **32f** (42 mg, 68%). Mixture of amide isomers in a 0.9/0.1 ratio. $^1$H NMR (400 MHz, $CDCl_3$): δ 1.23 (d, 3H, $J$ = 6.5 Hz), 1.26 (t, 2.7H, $J$ = 7.1 Hz), 1.27 (t, 0.3H, $J$ = 7.1 Hz), 1.77–1.89 (m, 4H), 2.47–2.63 (m, 4H), 2.71 (t, 2H, $J$ = 7.7 Hz), 3.50 (dt, 1H, $J$ = 6.2, 8.9 Hz), 3.60–3.70 (m, 5H), 3.76 (m, 1H), 3.82 (s, 2H), 3.85–3.95 (m, 3H), 4.18 (q, 2H, $J$ = 7.1 Hz), 4.20 (m, 1H), 4.57 (d, 1H, $J$ = 6.6 Hz), 4.87 (d, 1H, $J$ = 4.8 Hz), 7.18 (d, 1H, $J$ = 7.6 Hz), 7.23 (dt, 1H, $J$ = 0.9, 7.4 Hz), 7.31 (t, 1H, $J$ = 7.4 Hz), 7.37 (s, 1H), 7.50 (d, 1H, $J$ = 7.4 Hz), 7.67 (d, 1H, $J$ = 7.6 Hz), 7.73 (d, 1H, $J$ = 7.4 Hz). $^{13}$C NMR (100 MHz, $CDCl_3$): δ 14.52, 16.85, 23.57, 24.96, 27.64, 28.20, 29.06, 31.75, 33.30, 33.40, 33.53, 37.51, 38.40,

41.33, 44.88, 56.31, 56.50, 62.67, 64.14, 68.76, 69.60, 70.95, 72.09, 72.44, 72.73, 72.88, 77.39, 120.45, 120.58, 123.54, 125.96, 126.17, 127.33, 127.70, 128.22, 140.70, 142.26, 142.95, 144.41, 144.78, 171.62, 172.34, 174.79, 175.82. HRMS (FAB): $C_{36}H_{44}N_2O^{13}Cs$ (M + Cs), calcd 849.2211, found 849.2243.

**Compound 32g.** Prepared according to General Procedure F using 190 mg (165 μmol) **31g**, 46 mL EtOH, 665 mg Pd-$BaSO_4$, 1.3 mL cyclohexene and $H_2O$/$CH_3CN$ (1/8) to give **32g** (61 mg, 52%). Mixture of amide isomers. $^1H$ NMR (400 MHz, $CDCl_3$): δ 1.21–1.33 (m, 6H), 1.81–1.88 (m, 4H), 2.45–2.75 (broad m, 4H), 2.69 (t, 2H, $J$ = 7.8 Hz), 3.50 (dt, 1H, $J$ = 6.3, 8.8 Hz), 3.59–3.79 (m, 6H), 3.84–4.04 (m, 3H), 4.18 (q, 2H, $J$ = 7.1 Hz), 4.19 (m, 1H), 4.51–4.58 (m, 1H), 7.26 (brd, 2H, $J$ = 8.1 Hz), 7.29 (brt, 1H, $J$ = 7.7 Hz), 7.40 (brt, 2H, $J$ = 7.7 Hz), 7.50 (brd, 2H, $J$ = 8.1 Hz), 7.57 (brd, 2H, $J$ = 7.7 Hz). $^{13}C$ NMR (100 MHz, $CDCl_3$): δ 14.54, 16.85, 27.71, 33.00, 33.05, 56.33, 56.64, 62.65, 68.78, 70.94, 72.95, 77.44, 127.81, 127,92, 128.01, 129.78, 130.04, 139.98, 142.44, 142.62, 171.62. HRMS (FAB): $C_{35}H_{48}N_2O^{13}Cs$ (M + Cs), calcd 837.2211, found 837.2246.

**Compound 32h.** Prepared according to General Procedure E using 100 mg (100 μmol) **13**, 20 mg $Pd(OH)_2$-C, 4 mL EtOH, 1 mL $H_2O$ and $H_2O$/$CH_3CN$ (1/5) to give **32h** (45 mg, 81%). $^1H$ NMR (400 MHz, $CDCl_3$): δ 0.89 (t, 3H, $J$ = 7.4 Hz), 1.22 (t, 3H, $J$ = 6.4 Hz), 1.28 (t, 3H, $J$ = 7.1 Hz), 1.52 (tq, 2H, $J$ = 6.4, 7.4 Hz), 1.79 (m, 2H), 2.54 (broad m, 4H), 3.42 (dt, 1H, $J$ = 6.5, 8.7 Hz), 3.58 (dt, 1H, $J$ = 6.5, 8.7 Hz), 3.61–3.70 (m, 4H), 3.76 (brq, 1H, $J$ = 6.4 Hz), 3.82 (m, 1H), 3.89 (broad m, 2H), 4.14 (m, 1H), 4.19 (q, 2H, $J$ = 7.1 Hz), 4.54 (d, 1H, $J$ = 5.9 Hz), 4.82 (d, 1H, $J$ = 5.0 Hz). $^{13}C$ NMR (100 MHz, $CDCl_3$): δ 10.26, 13.73, 16.07, 22.79, 25.94, 30.95, 55.41, 62.70, 63.32, 67.62, 67.73, 70.10, 71.34, 71.93, 72.13, 73.36, 76.10, 119.48, 171.37, 171.88, 175.31, 176.43. HRMS (FAB): $C_{23}H_{40}N_2O^{13}Cs$ (M + Cs), calcd 575.2428, found 575.2447.

**Compound 32i.** Prepared according to General Procedure E using 115 mg (58.2 μmol) **14i**, 20 mg $Pd(OH)_2$-C, 8 mL EtOH, 2 mL $H_2O$ and $H_2O$/$CH_2CN$ (1/3 to 1/2) to give **32i** (34 mg, 54%). $^1H$ NMR (400 MHz, $CDCl_3$): δ 1.22 (d, 6H, $J$ = 6.4 Hz), 1.28 (t, 6H, $J$ = 7.0 Hz), 1.55 (broad m, 4H), 1.79 (broad m, 4H), 2.54 (broad m, 8H), 3.44 (broad m, 2H), 3.60–3.69 (m, 10H), 3.74 (m, 2H), 3.82 (m, 2H), 3.87–3.94 (m, 4H), 4.13 (m, 2H), 4.20 (q, 4H, $J$ = 7.0 Hz), 4.58 (d, 2H, $J$ = 6.4 Hz), 4.88 (d, 2H, $J$ = 4.6 Hz). $^{13}C$ NMR (100 MHz, $CDCl_3$): δ 14.59, 16.86, 27.59, 27.79, 32.92, 56.15, 56.58, 62.68, 64.18, 68.76, 69.60, 71.34, 72.06, 72.50, 72.80, 73.03, 77.44, 171.65, 172.36, 175.57. MS (ESI): $C_{44}H_{74}N_4O_{26}Na$ (M + Na) calcd 1098, found 1098.

**(2*S*,3*R*)-4-Benzyloxy-3-hydroxy-2-monobenzylsuccinamidyl-butanoic acid (33).** Prepared in 61% yield (four steps) from benzyloxyacetaldehyde as described.[11] $^1H$ NMR (400 MHz, $CDCl_3$): δ 2.53–2.58 (m, 2H), 2.61–2.67 (m, 2H), 3.56 (dd, 1H, $J$ = 5.8, 10.1 Hz), 3.62 (dd, 1H, $J$ = 4.7, 10.1 Hz), 4.08 (ddd, 1H, $J$ = 4.7, 5.3, 5.8 Hz), 4.51 (d, 1H, $J$ = 11.9 Hz), 4.54 (d, 1H, $J$ = 11.9 Hz), 4.63 (d, 1H, $J$ = 5.3 Hz), 5.10 (s, 2H), 7.22–7.36 (m, 11H). $^{13}C$ NMR (100 MHz, $CDCl_3$): δ 30.22, 31.16, 56.44, 67.33, 71.68, 72.33, 74.26, 128.61, 128.83, 129.09, 129.29, 129.45, 137.40, 139.40, 172.94, 173.99, 174.14. HRMS (FAB): $C_{22}H_{25}NO_7Cs$ (M + Cs), calcd 416.1709, found 416.1721.

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