

**Q1** Tethered derivatives of D-glucose and pentacyclic triterpenes for homo/heterobivalent inhibition of glycogen phosphorylase

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**Q2** Low micromolar inhibitors ( $\text{IC}_{50}$  40–70  $\mu\text{M}$ ) were found among the heterobivalent compounds studied, while homobivalent derivatives proved inactive in assays against rabbit muscle glycogen phosphorylase a or b.

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# Tethered derivatives of D-glucose and pentacyclic triterpenes for homo/heterobivalent inhibition of glycogen phosphorylase†

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Received (in Montpellier, France) 27th October 2009, Accepted 25th January 2010

First published as an Advance Article on the web

DOI: 10.1039/b9nj00602h

Propargyl esters of the C-28 carboxylic acids of pentacyclic triterpenes (oleanolic, ursolic, and maslinic acids) were coupled with 2,3,4,6-tetra-*O*-acetyl- $\beta$ -D-glucopyranosyl azide as well as *N*-( $\omega$ -azido-[C-2, C-6, and C-11]alkanoyl)- $\beta$ -D-glucopyranosylamines under conditions of copper(i)-catalyzed azide-alkyne cycloaddition (CuAAC) to give tethered D-glucose-triterpene heteroconjugates. The *O*-acetyl protecting groups were removed by base-catalyzed hydrolysis. *N*-( $\omega$ -Azido-[C-2, C-6, C-11, and C-16]alkanoyl)- $\beta$ -D-glucopyranosylamines were also tethered by 1,7-octadiyne under CuAAC conditions to furnish D-glucose homoconjugates. *O*-Deacetylation was carried out by the Zemplén protocol. The new compounds were assayed against rabbit muscle glycogen phosphorylase (RMGP) a or b enzymes. Some of the heteroconjugates inhibited the enzyme in the low micromolar range (IC<sub>50</sub> values 40–70  $\mu$ M), while the homoconjugates proved inefficient as inhibitors.

## Introduction

Type 2 diabetes mellitus has become a widespread disease afflicting a very large proportion of the population all over the world.<sup>1–3</sup> The diseased state is associated with disorders in glucose metabolism by the liver and periphery resulting in elevated blood glucose levels which, in turn, are responsible for fatal long-term complications.<sup>1,4</sup> An ideal anti-diabetic agent should be capable of lowering blood glucose in both fed and fasted states. Control of the hepatic glycogen metabolism is one of the key events through which insulin maintains blood glucose homeostasis. Among other means for influencing glucose production in the liver, inhibition of glycogen phosphorylase (GP), the rate-limiting enzyme of glycogen degradation, has been regarded as a promising therapeutic approach to the treatment of type 2 diabetes.<sup>5,6</sup> Some GP inhibitors have shown efficacy in lowering blood glucose in animal models and clinical trials.<sup>7,8</sup> In the liver and muscle isoforms of GP enzymes, six binding sites have been identified by X-ray crystallographic studies of enzyme-inhibitor complexes: the catalytic, the inhibitor, the allosteric,

the glycogen storage, and the new allosteric sites,<sup>6,9</sup> as well as the recently discovered benzimidazol site.<sup>10</sup>

Among the large variety of compounds tested as GP inhibitors, the most populated class is that of D-glucose derivatives,<sup>11,12</sup> which bind primarily to the catalytic site of the enzyme, as proven by several X-ray crystallographic investigations.<sup>9</sup> These glucose analogue inhibitors of GP are characterized by maintaining an intact hexopyranoid sugar ring with the full OH substitution pattern of D-glucose configuration, thus resembling the non-reducing end of the natural substrate glycogen. The modifications are located at the anomeric centre as spirocycles, as well as  $\beta$ -NHCOR,  $\beta$ -NHCONHCOR, and  $\beta$ -C-heterocyclic substituents, just to mention the most efficient ones.<sup>5,6</sup>

Pentacyclic triterpenes like **1–3** and related compounds have been reported to represent a new class of glycogen phosphorylase inhibitors.<sup>13–15</sup> X-Ray crystallographic studies revealed the molecular basis of their inhibitory effect, demonstrating that pentacyclic triterpenes such as asiatic and maslinic acids bind to GP at the allosteric site.<sup>16</sup> Oleanolic acid (**1**, OA), ursolic acid (**2**, UA) and maslinic acid (**3**, MA) have recently attracted much attention due to their broad biological activities such as protection of the liver against toxic injury, anti-inflammation, anti-HIV, antitumor, antioxidation, anti-hyperglycemia and cardiovascular activities.<sup>17</sup>

Inhibitors having the potential to bind to more than one site of an enzyme may be significantly more efficient than those with a single binding group (for some tentatively selected examples of bi- or trivalent enzyme inhibitors see ref. 18–23). This principle is well known in the interactions of multivalent carbohydrate derivatives with various proteins, and is frequently called the glycoside cluster effect in that field.<sup>24</sup> Trivalent glucose analogues have very recently been tested for GP inhibition to show a slightly better effect than

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† Electronic supplementary information (ESI) available: Copies of <sup>1</sup>H NMR and <sup>13</sup>C NMR spectra. See DOI: 10.1039/b9nj00602h

1 that of derivatives with a single sugar unit.<sup>25</sup> Homobivalent  
 Q4 indolcarboxamide<sup>26</sup> as well as cinnamic acid<sup>27,28</sup> derivatives  
 proved very efficient inhibitors of GP.

5 With these preliminaries in mind, we envisaged conjugation  
 Q5 of triterpenes and D-glucose in such a way that both could  
 bind to the site to which they bind on their own, thus  
 providing the first potentially heterobivalent inhibitors of  
 GP. The recently reported triterpene–glucose conjugates were  
 10 not capable of this because the sugar parts were attached to  
 the triterpene *via* the C-6 position.<sup>29</sup> Furthermore, some new  
 bivalent glucose derivatives are also reported.

## Results and discussion

### 15 Syntheses

The new triterpene glycoconjugates were designed to include  
 oleanolic, ursolic, and maslinic acids (**1–3**) on one hand and  
*N*-acyl-β-D-glucopyranosylamines on the other, by connecting  
 them *via* linker chains of different length. The Cu(I)-catalyzed  
 20 azide–alkyne cycloaddition<sup>30</sup> (CuAAC) was chosen as the  
 linking methodology. The syntheses are summarized in  
 Schemes 1–5.

Direct esterification of oleanolic acid **1**, ursolic acid **2**, and  
 25 maslinic acid **3** with propargyl bromide (Scheme 1) afforded  
 alkynes **4**,<sup>29</sup> **5**, and **6**, respectively, in excellent yields.

*N*-Acyl-β-D-glucopyranosylamines with a terminal azide  
 group were synthesized from per-*O*-acetylated-β-D-gluco-  
 pyranosyl azide<sup>32</sup> **7** (Scheme 2). ω-Bromoalkanoyl derivatives  
 8–11 were obtained by a ‘Staudinger reaction’ of **7** with PMe<sub>3</sub>,  
 30 resulting in an intermediate phosphinimine which, without  
 being isolated, was reacted<sup>33</sup> with the corresponding  
 ω-bromoalkanoic acid. Subsequent substitution with NaN<sub>3</sub>  
 in DMF gave compounds **12–15**, respectively. Practically each

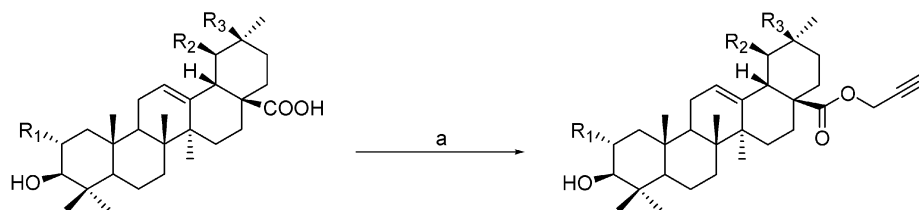
synthetic step furnished the corresponding product in very  
 good yield.

To perform the CuAAC, an alkyne **4–6** and an azide **7** or  
 12–14 each were dissolved in CH<sub>2</sub>Cl<sub>2</sub>–H<sub>2</sub>O, followed by the  
 addition of a catalytic amount of sodium L-ascorbate and  
 5 CuSO<sub>4</sub>·5H<sub>2</sub>O. The ‘click reactions’ proceeded very well at  
 room temperature to afford β-D-glucopyranosyl-1,2,3-triazoles  
 16–18 (Scheme 3) and the tethered compounds **22–30**  
 (Scheme 4) in good to excellent yields. The *O*-acetyl groups  
 were cleaved with 4 N NaOH/MeOH to give the corresponding  
 10 deprotected compounds **19–21** (Scheme 3) and **31–37**,  
 respectively (Scheme 4). During deprotection of **28** the desired  
 compound was not obtained; instead compound **38** could be  
 isolated as a result of cleavage of the glucosylamide bond.

For bivalent glucose derivatives the *N*-(ω-azidoalkanoyl)-β-  
 15 D-glucopyranosylamines **12–15** were reacted with 1,7-octa-  
 diyne (**43**) under CuAAC conditions (Scheme 5). The reactions  
 proceeded smoothly to give good to excellent yields of the  
 coupled derivatives **44–47**, which were deprotected under  
 Zemplén conditions to give compounds **48–51** in similarly  
 20 good yields. In order to make comparisons with monovalent  
 glucose derivatives, azides **12** and **13** were deprotected by the  
 Zemplén protocol to **39** and **41**, respectively, which were  
 further reduced to the ω-amino compounds **40** and **42**.

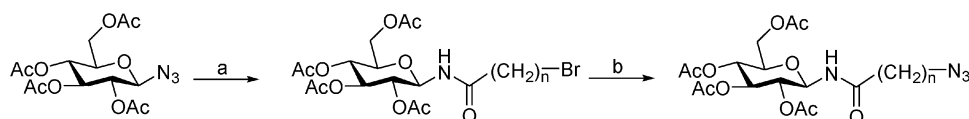
### Glycogen phosphorylase inhibition

The above-synthesized derivatives were evaluated in enzyme  
 inhibition assays described previously<sup>35,36</sup> against rabbit  
 muscle glycogen phosphorylase a (RMGP<sub>a</sub>) or b (RMGP<sub>b</sub>)  
 which shared considerable sequence similarity with human  
 liver GP (Schemes 1 and 3–5, and Charts 1 and 2. As we found  
 30 previously,<sup>36</sup> inhibitions of a and b forms of GP showed  
 acceptable similarity.



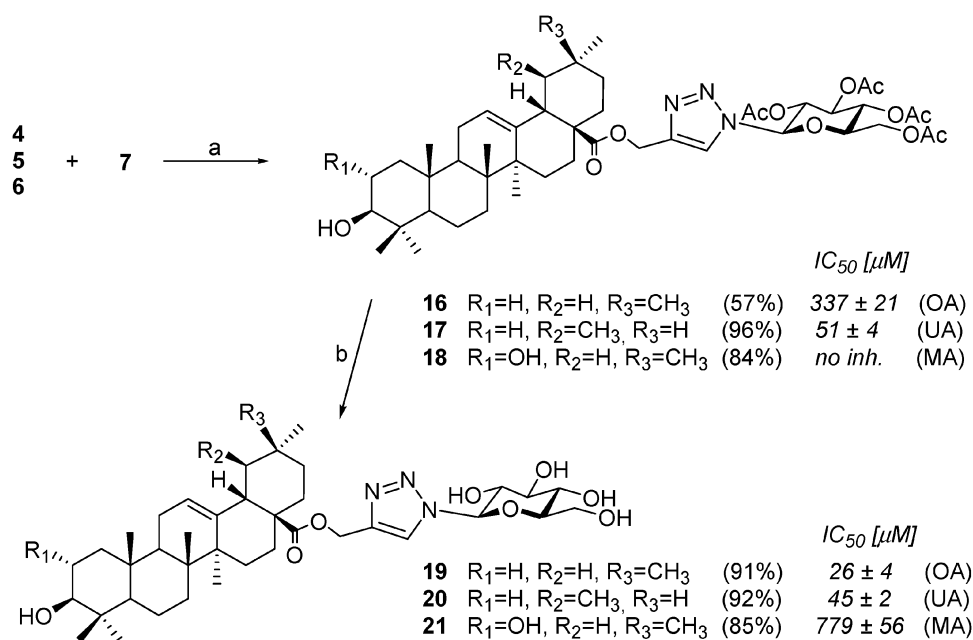
	<i>IC</i> <sub>50</sub> [μM]	R <sup>1</sup>	R <sup>2</sup>	R <sup>3</sup>	Yield [%]	<i>IC</i> <sub>50</sub> [μM]
<b>1</b> (oleanolic acid, OA)	14 <sup>14</sup>	H	H	CH <sub>3</sub>	<b>4</b>	405 ± 30
<b>2</b> (ursolic acid, UA)	9 <sup>13</sup>	H	CH <sub>3</sub>	H	<b>5</b>	no inh.
<b>3</b> (maslinic acid, MA)	28 <sup>31</sup>	OH	H	CH <sub>3</sub>	<b>6</b>	no inh.

Scheme 1 Reagents and conditions: (a) K<sub>2</sub>CO<sub>3</sub>, propargyl bromide, DMF, rt. Inhibition of RMGP<sub>a</sub> (*IC*<sub>50</sub> [μM], values are means of three experiments).

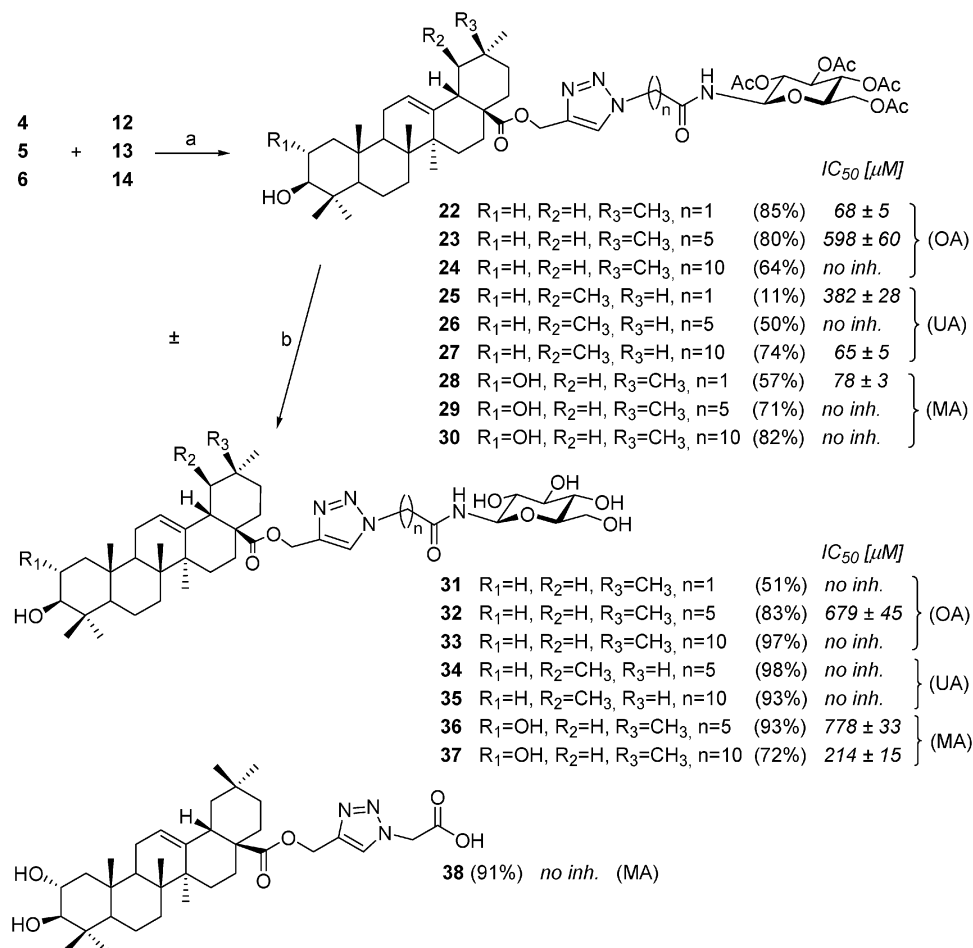


	<i>n</i>	Yield [%]
<b>8</b> not isolated	1	<b>12</b> (63%)
<b>9</b> (93%)	5	<b>13</b> (85%)
<b>10</b> (64%)	10	<b>14</b> (88%)
<b>11</b> (76%)	15	<b>15</b> (81%)

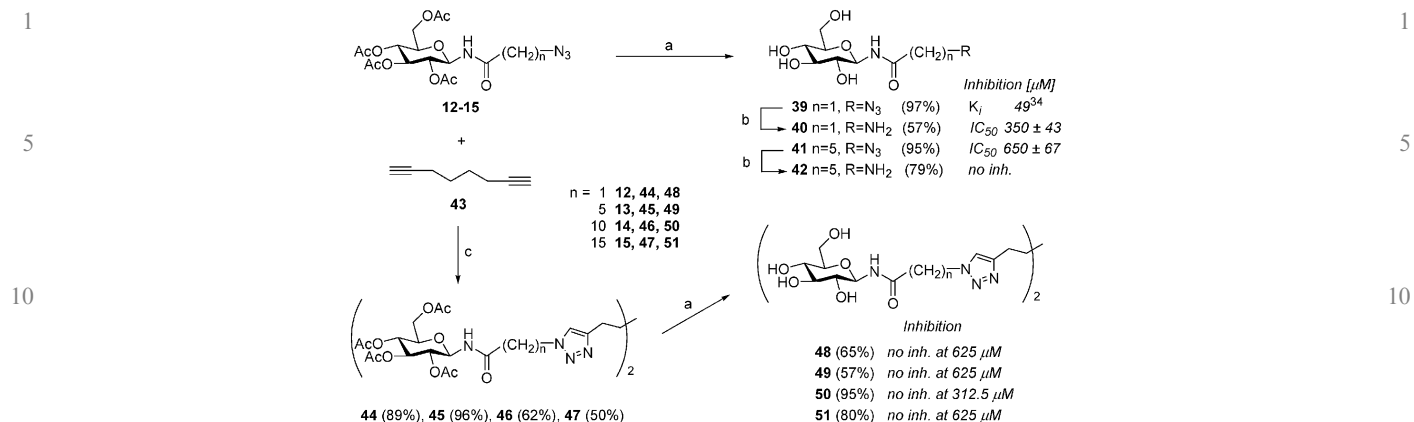
Scheme 2 Reagents and conditions: (a) PMe<sub>3</sub>, Br-(CH<sub>2</sub>)<sub>n</sub>-COOH, CH<sub>2</sub>Cl<sub>2</sub>, rt; (b) NaN<sub>3</sub>, DMF, rt.



**Scheme 3** Reagents and conditions: (a) CuSO<sub>4</sub>, sodium L-ascorbate, CH<sub>2</sub>Cl<sub>2</sub>-H<sub>2</sub>O, rt; (b) NaOH, MeOH, rt. Inhibition of RMGPα (*IC*<sub>50</sub> [ $\mu$ M], values are means of three experiments).



**Scheme 4** Reagents and conditions: (a) CuSO<sub>4</sub>, sodium L-ascorbate, CH<sub>2</sub>Cl<sub>2</sub>-H<sub>2</sub>O, rt; (b) NaOH, MeOH, rt. Inhibition of RMGPα (*IC*<sub>50</sub> [ $\mu$ M], values are means of three experiments).



15 **Scheme 5** Reagents and conditions: (a) cat. NaOMe, MeOH rt.; (b) RANEY<sup>®</sup>-Ni, H<sub>2</sub>, MeOH, 70 °C; (c) CuSO<sub>4</sub>, L-ascorbic acid, CH<sub>2</sub>Cl<sub>2</sub>-H<sub>2</sub>O, rt. Inhibition of RMGPb. 15

20 Inhibition by compounds tested against RMGPb

20  
25  
30

R	$IC_{50}$ [ $\mu\text{M}$ ]
1	H 14 <sup>14</sup>
52	Et no inh. <sup>14</sup>
53	Allyl no inh. <sup>14</sup>
54	Bn 461 <sup>14</sup>

55 1.14<sup>29</sup>

20 The assay results showed that propargylation of the C-28 carboxyl depressed the GPa enzyme inhibitory activity (compare 1–3 to 4–6 in Scheme 1). This observation is similar to the effect of other esterifications of OA (52–54, Chart 1) resulting in a significant loss of activity.<sup>14</sup>

25 In the sugar-coupled series (Schemes 3 and 4) the activities of OA derivatives were generally better than those of the derivatives of UA and MA (19 vs. 20 and 21; 22 vs. 25 and 28; 23 vs. 26 and 29; 32 vs. 34 and 36). Deprotection of the sugar part in the 1- $\beta$ -D-glucopyranosyl-1,2,3-triazole series (Scheme 3) gave better inhibitors with OA (16 vs. 19) and MA (18 vs. 21), while no significant change was observed with UA (17 vs. 20). Appending the sugar to the triazole via the C-6 position as in 55 (Chart 1) gave a very good inhibitor, although the *O*-peracetylated analogue had no activity at all.<sup>29</sup>

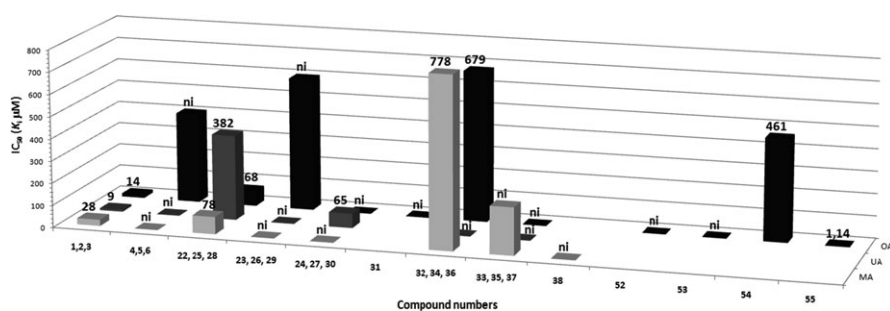
35 Inhibition by compounds tested against RMGPb

35  
40  
45

Compound	$K_i$ [ $\mu\text{M}$ ]
56	14 <sup>37</sup> 26 <sup>39</sup>
57	180 <sup>38</sup>

**Chart 1**

35 The effect of the length of the linker between the sugar and the triterpene parts was studied in the  $\omega$ -triazolylalkanoyl-amide series (Scheme 4): with OA (22 vs. 23 and 24) and MA (28 vs. 29 and 30) derivatives the one-carbon linkage was significantly better than the longer ones, while among the UA compounds an opposite effect (27 vs. 25 and 26) was observed. Removal of the *O*-acetyl protecting groups in the  $\omega$ -triazolylalkanoyl-amide series (Scheme 4, 31–37) brought about no obvious difference. Comparison of 19 with the hydroxy-methyl-triazole 56 shows that the presence of the OA moiety makes the inhibition somewhat better. However, 56 binds to the catalytic site,<sup>37</sup> while 19 can be expected to occupy the allosteric site.<sup>29</sup> Thus, the comparable inhibitory activities may



**Chart 2** ni = no inhibition.

1 not be directly relevant, except in the as-yet unproven case of a  
dual binding mode which could be expected to occur between  
two enzyme dimers.<sup>25</sup> Similar considerations may apply to a  
comparison of **31** and **57**.

5 In cases of bivalent glucose derivatives **48–51** (Scheme 5) no  
inhibition could be observed. Study of analogous monovalent  
compounds revealed that with an azide as endgroup (**39**, **41**)  
the inhibitory activity was moderate and decreased with the  
length of the linker. Bivalent compound **48** can also be  
10 compared with the monovalent triazole **57**<sup>38</sup> (Chart 1) to  
show that the dimeric structures seem to be too large to  
occupy the catalytic site, and no other interactions exist with  
the enzyme. In the presence of amine endgroups (**40**, **42**) the  
inhibition was much weaker, and with the longer linker chain  
15 no effect was detected.

## Conclusions

Copper(i)-catalyzed azide–alkyne cycloaddition – ‘click  
chemistry’ – proved suitable for the synthesis of conjugates  
20 of pentacyclic triterpenes and D-glucose derivatives as new,  
potentially heterobivalent inhibitors of glycogen phosphorylase.  
Compounds **17** (IC<sub>50</sub> = 51 μM), **19** (IC<sub>50</sub> = 26 μM), **20**  
(IC<sub>50</sub> = 45 μM), **22** (IC<sub>50</sub> = 68 μM), **27** (IC<sub>50</sub> = 65 μM) and  
**25** (IC<sub>50</sub> = 78 μM) were the most potent inhibitors of  
RMGPa. Homobivalent glucose derivatives proved inefficient  
in RMGPb inhibition assays. The monovalent analogues of  
both triterpenes and glucose derivatives proved generally more  
efficient than the bivalent compounds.

## Experimental

### General methods

35 All commercially available solvents and reagents were used  
without further purification. Melting points were measured on  
a RY-1 or on a Kofler hot-stage melting point apparatus.  
Column chromatography was carried out on E. Merck Silica  
Gel 60 (230–400 mesh), on silica gel (200–300 mesh, Qindao  
Ocean Chemical Company, China), or Kieselgel 60 (Merck,  
40 particle size 0.063–0.200 mm). IR spectra were recorded on  
Shimadzu FTIR-8400S spectrometer. <sup>1</sup>H- and <sup>13</sup>C-NMR spectra  
were measured on Bruker AV-300 (300/75 MHz for <sup>1</sup>H/<sup>13</sup>C),  
Bruker 360 (360/90 MHz for <sup>1</sup>H/<sup>13</sup>C) or Avance DRX 500  
(500/125 MHz for <sup>1</sup>H/<sup>13</sup>C) spectrometers. Chemical shifts are  
45 reported as values from an internal tetramethylsilane standard.  
TLC was performed on DC-Alurolle Kieselgel 60 F254 (Merck),  
and the plates were visualised under UV light and by gentle  
heating. Mass spectral data were obtained on Agilent 1100  
LC/DAD/MSD or Q-ToF Micro MS/MS spectrometers. Optical  
50 rotations were measured using a Perkin-Elmer 141 or a Perkin-  
Elmer 241 polarimeters at rt. PMe<sub>3</sub> (1 M solution in toluene) and  
1,7-octadiyne were purchased from Sigma-Aldrich.

### Syntheses

#### 55 General procedure I for the propargylation of oleanolic acid, ursolic acid or maslinic acid

To a solution of a carboxylic acid (**1** or **2** or **3**, 2.2 mmol) in  
DMF (5 mL), was added propargyl bromide (2.4 mmol) and

K<sub>2</sub>CO<sub>3</sub> (4.4 mmol). The reaction mixture was stirred at rt  
1 for 18 h, then concentrated. The residue was diluted with  
EtOAc (50 mL), washed successively with 1 N HCl, water,  
satd. aq. NaHCO<sub>3</sub>, water and brine, dried (MgSO<sub>4</sub>), filtered  
and concentrated. The residue was purified by column  
5 chromatography.

**Propargyl 3β-hydroxyolean-12-en-28-oate (4)**<sup>29</sup>. Prepared  
from **1** (1 g, 2.2 mmol) and propargyl bromide (0.27 mL,  
2.4 mmol) according to General procedure I. The residue was  
10 purified by column chromatography (EtOAc–hexane, 1 : 6).  
Yield: 1.05 g, 97%, white solid, mp 121–122 °C; R<sub>f</sub> = 0.33  
(EtOAc–hexane, 1 : 4); [α]<sub>D</sub> = +67.9 (c = 0.50, CH<sub>2</sub>Cl<sub>2</sub>). IR  
(KBr, cm<sup>-1</sup>): 3308, 2945, 2866, 1731, 1157, 1032, 739; <sup>1</sup>H  
NMR (300 MHz, CDCl<sub>3</sub>): δ 0.74, 0.77, 0.92, 0.98, 1.13 (5 s,  
15 each 3H, 5 × CH<sub>3</sub>), 0.90 (s, 6H, 2 × CH<sub>3</sub>), 0.71–2.04 (m, 22H),  
2.41 (t, 1H, J = 2.6 Hz, CH), 2.87 (dd, 1H, J = 4.1, 9.5 Hz,  
H-18), 3.21 (dd, 1H, J = 5.1, 10.7 Hz, H-3), 4.56 (dd, 1H, J =  
2.6, 15.4 Hz, CO<sub>2</sub>CH<sub>2</sub>), 4.68 (dd, 1H, J = 2.6, 15.4 Hz,  
CO<sub>2</sub>CH<sub>2</sub>), 5.30 (t, 1H, J = 3.5 Hz, H-12); <sup>13</sup>C NMR  
20 (75 MHz, CDCl<sub>3</sub>): δ 15.3, 15.6, 17.1, 18.3, 23.0, 23.4, 23.6,  
25.8, 27.2, 27.7, 28.1, 30.7, 32.2, 32.8, 33.1, 33.8, 37.0, 38.5,  
38.8, 39.4, 41.3, 41.7, 45.9, 46.8, 47.6, 51.6, 55.2, 74.4, 78.1,  
79.0, 122.63, 143.4, 176.8. ESI-MS (positive mode) m/z: 517.3  
[M + Na]<sup>+</sup>.

**Propargyl 3β-hydroxyurs-12-en-28-oate (5)**. Prepared from **2**  
(2.0 g, 4.4 mmol) and propargyl bromide (0.54 mL, 4.8 mmol)  
according to General procedure I. The residue was purified by  
column chromatography (EtOAc–hexane, 1 : 5). Yield: 2.0 g,  
93%, white solid, mp 129–131 °C; R<sub>f</sub> = 0.48 (EtOAc–hexane,  
30 1 : 5). IR (KBr, cm<sup>-1</sup>): 3309, 2927, 2871, 1729, 1454, 1383,  
1221, 1167, 1139, 1106, 1032, 996, 757, 667; <sup>1</sup>H NMR  
(300 MHz, CDCl<sub>3</sub>): δ 0.76, 0.77, 0.91, 0.95, 0.98, 1.08  
(6 s, each 3H, 6 × CH<sub>3</sub>), 0.87 (d, 3H, J = 6.4 Hz, CH<sub>3</sub>),  
0.75–2.10 (m, 22H), 2.26 (d, 1H, J = 11.3 Hz, H-18), 2.41  
35 (t, 1H, J = 2.4 Hz, CH), 3.20 (dd, 1H, J = 5.1, 10.7 Hz, H-3),  
4.57 and 4.65 (dd, each 1H, J = 2.5, 15.6 Hz, COOCH<sub>2</sub>), 5.27  
(1H, t, J = 3.6 Hz, H-12); <sup>13</sup>C NMR (75 MHz, CDCl<sub>3</sub>): δ 5.5,  
15.6, 17.0, 17.2, 18.3, 21.1, 23.3, 23.5, 24.6, 27.3, 28.0, 28.1,  
30.6, 33.1, 36.4, 37.0, 38.67, 38.75, 38.8, 39.1, 39.6, 42.1, 47.6,  
40 48.2, 51.6, 52.8, 55.3, 74.3, 78.1, 79.0, 125.9, 137.8, 176.6.  
ESI-MS (positive mode) m/z: 495.4 [M + H]<sup>+</sup>.

**Propargyl 2α,3β-dihydroxyolean-12-en-28-oate (6)**. Prepared  
from **3** (1.4 g, 3.0 mmol) and propargyl bromide (0.37 mL,  
3.3 mmol) according to General procedure I. The residue was  
purified by column chromatography (EtOAc–hexane, 1 : 5).  
Yield: 1.3 g, 87%, white solid, mp 233–234 °C; R<sub>f</sub> = 0.69  
(EtOAc–hexane, 1 : 5). IR (KBr, cm<sup>-1</sup>): 3394, 3309, 2946,  
1729, 1463, 1388, 1364, 1259, 1217, 1157, 1121, 1049, 1033,  
995, 758, 669, 633; <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 0.74, 0.82,  
0.90, 0.92, 0.98, 1.03, 1.13 (7 s, each 3H, 7 × CH<sub>3</sub>), 0.75–2.01  
(m, 20H), 2.41 (t, 1H, J = 2.4 Hz, CH), 2.87 (dd, 1H, J = 4.3,  
13.7 Hz, H-18), 3.01 (d, 1H, J = 9.5 Hz, H-3), 3.65–3.73  
(m, 1H, H-2), 4.57 and 4.69 (dd, each 1H, J = 2.4, 15.6 Hz,  
COOCH<sub>2</sub>), 5.31 (t, 1H, J = 3.5 Hz, H-12); <sup>13</sup>C NMR  
(75 MHz, CDCl<sub>3</sub>): δ 16.6, 16.7, 17.2, 18.4, 23.0, 23.5, 23.6,  
25.9, 27.7, 28.6, 30.7, 32.2, 32.7, 33.1, 33.9, 38.3, 39.2,  
39.5, 41.3, 41.8, 45.9, 46.5, 46.8, 47.6, 51.6, 55.4, 69.0, 74.4,

1 78.1, 84.0, 122.5, 143.5, 176.8. ESI-MS (positive mode)  $m/z$ :  
533.4 [M + Na]<sup>+</sup>.

5 **General procedure II for the preparation of *N*-( $\omega$ -bromoalkanyl)-  
2,3,4,6-tetra-*O*-acetyl- $\beta$ -D-glucopyranosylamines (9–11)**

2,3,4,6-Tetra-*O*-acetyl- $\beta$ -D-glucopyranosyl azide (**7**, 0.10 g,  
0.27 mmol) was dissolved in dry CH<sub>2</sub>Cl<sub>2</sub> (3 mL). To the  
solution Me<sub>3</sub>P (1.1 equiv. of a 1 M solution in toluene) was  
added in one portion. The mixture was stirred at rt. until  
nitrogen evolution had ceased and TLC (EtOAc–hexane, 1 : 1)  
had indicated complete transformation of the azide. This  
solution was then reacted with an  $\omega$ -bromoalkanoic acid  
(1.1 equiv., as indicated with the particular compounds) till  
the disappearance of the iminophosphorane (TLC, EtOAc–  
hexane, 1 : 1). Then, it was diluted with CH<sub>2</sub>Cl<sub>2</sub> (5 mL) and  
washed with satd. aq. NaHCO<sub>3</sub> solution (2 × 5 mL). The  
organic phase was dried over MgSO<sub>4</sub> and the solvent was  
removed under diminished pressure. The crude product was  
purified by column chromatography.

***N*-(6-Bromohexanoyl)-2,3,4,6-tetra-*O*-acetyl- $\beta$ -D-glucopyrano-  
sylamine (**9**).** Prepared from **7** (0.50 g 1.34 mmol) according to  
General procedure II. The residue was purified by column  
chromatography (EtOAc–hexane, 1 : 1). Yield: 0.65 g, 93%,  
colourless oil,  $R_f$  = 0.35 (EtOAc–hexane, 1 : 1);  $[\alpha]_D^{25}$  = +22  
( $c$  = 0.59, CHCl<sub>3</sub>); <sup>1</sup>H NMR (360 MHz, CDCl<sub>3</sub>):  $\delta$ (ppm)  
1.42–1.47 (m, 2H, CH<sub>2</sub>), 1.60–1.63 (m, 2H, CH<sub>2</sub>), 1.83–1.90  
(m, 2H, CH<sub>2</sub>), 2.02, 2.04, 2.06, 2.08 (4s, 12H, 4 × OCOCH<sub>3</sub>),  
2.21–2.27 (m, 2H, CH<sub>2</sub>), 3.39–3.43 (m, 2H, CH<sub>2</sub>), 3.86 (ddd,  
1H,  $J$  = 1.2, 2.6, 10.6 Hz, H-5), 4.08 (dd, 1H,  $J$  = 1.2,  
11.9 Hz, H-6b), 4.32 (dd, 1H,  $J$  = 2.6, 11.9 Hz, H-6a), 4.93,  
5.06, 5.29, 5.32 (4 pseudo t, 4H,  $J$  = 9.2, 10.6 Hz in each, H-1,  
H-2, H-3, H-4), 6.63 (d, 1H,  $J$  = 9.2 Hz, NH); <sup>13</sup>C NMR  
(90 MHz, CDCl<sub>3</sub>):  $\delta$  (ppm) 20.3 (3), 20.5 (4 × OCOCH<sub>3</sub>), 23.9,  
27.3, 32.0, 33.3, 35.9 (5 × CH<sub>2</sub>), 61.5 (C-6), 67.9, 70.4, 72.5,  
73.2 (C-2, C-3, C-4, C-5), 77.7 (C-1), 169.3, 169.6, 170.4,  
170.5 (4 × OCOCH<sub>3</sub>), 172.8 (NHCO). Anal. calcd. for  
C<sub>20</sub>H<sub>30</sub>BrNO<sub>10</sub> (524.37): C 45.81, H 5.77, N 2.67. Found: C  
45.64, H 5.94, N 2.59.

***N*-(11-Bromoundecanoyl)-2,3,4,6-tetra-*O*-acetyl- $\beta$ -D-glucopy-  
ranosylamine (**10**).** Prepared from **7** (5.0 g 13.4 mmol)  
according to General procedure II. The residue was purified  
by column chromatography (EtOAc–hexane, 1 : 1). Yield:  
5.13 g, 64%, white crystalline product, mp 61–63 °C;  $[\alpha]_D^{25}$  =  
+15 ( $c$  = 0.38, CHCl<sub>3</sub>); <sup>1</sup>H NMR (360 MHz, CDCl<sub>3</sub>):  $\delta$ (ppm)  
1.28 (bs, 10H, 5 × CH<sub>2</sub>), 1.40–1.45 (m, 2H, CH<sub>2</sub>), 1.57–1.50  
(m, 2H, CH<sub>2</sub>), 1.80–1.86 (m, 2H, CH<sub>2</sub>), 2.02, 2.04, 2.06, 2.08  
(4 s, 12H, 4 × OCOCH<sub>3</sub>), 2.17–2.21 (m, 2H, CH<sub>2</sub>), 3.38–3.43  
(m, 2H, CH<sub>2</sub>), 3.85 (ddd, 1H,  $J$  = 1.2, 2.6, 10.6 Hz, H-5), 4.07  
(dd, 1H,  $J$  = 1.2, 11.9 Hz, H-6b), 4.32 (dd, 1H,  $J$  = 2.6, 11.9  
Hz, H-6a), 4.93, 5.06, 5.27, 5.32 (4 pseudo t, 4H,  $J$  = 9.2, 10.6  
Hz in each, H-1, H-2, H-3, H-4), 6.51 (d, 1H,  $J$  = 9.2 Hz,  
NH); <sup>13</sup>C NMR (90 MHz, CDCl<sub>3</sub>):  $\delta$  (ppm) 20.4(3), 20.5  
(4 × OCOCH<sub>3</sub>), 24.8, 25.0, 27.9, 28.4, 28.8, 29.0, 29.1, 32.5,  
33.7, 36.3 (10 × CH<sub>2</sub>), 61.5 (C-6), 67.9, 70.4, 72.5, 73.3  
(C-2, C-3, C-4, C-5), 77.8 (C-1), 169.3, 169.6, 170.4, 170.6  
(4 × OCOCH<sub>3</sub>), 173.3 (NHCO). Anal. calcd. for C<sub>25</sub>H<sub>40</sub>BrNO<sub>10</sub>

(594.50): C 50.51, H 6.78, N 2.36. Found: C 50.64, H 6.91,  
N 2.49.

***N*-(16-Bromohexadecanoyl)-2,3,4,6-tetra-*O*-acetyl- $\beta$ -D-glucopy-  
ranosylamine (**11**).** Prepared from **7** (0.50 g 1.34 mmol)  
according to General procedure II. The residue was purified  
by column chromatography (EtOAc–hexane, 1 : 1). Yield:  
0.68 g, 76%, white crystalline product, mp 91–93 °C;  $[\alpha]_D^{25}$  =  
+10 ( $c$  = 0.20, CHCl<sub>3</sub>); <sup>1</sup>H NMR (360 MHz, CDCl<sub>3</sub>):  $\delta$ (ppm)  
1.28 (m, 18H, 9 × CH<sub>2</sub>), 1.36–1.39 (m, 2H, CH<sub>2</sub>), 1.48–1.52  
(m, 2H, CH<sub>2</sub>), 1.57–1.61 (m, 2H, CH<sub>2</sub>), 1.84–1.88 (m, 2H,  
CH<sub>2</sub>), 2.03, 2.04, 2.06, 2.08 (4 s, 12H, 4 × OCOCH<sub>3</sub>),  
2.27–2.31 (m, 2H, CH<sub>2</sub>), 3.36–3.40 (m, 2H, CH<sub>2</sub>), 3.87  
(ddd, 1H,  $J$  = 1.2, 2.6, 10.6 Hz, H-5), 4.06 (dd, 1H,  $J$  =  
1.2, 11.9 Hz, H-6b), 4.35 (dd, 1H,  $J$  = 2.6, 11.9 Hz, H-6a),  
4.98, 5.22, 5.27, 5.32 (4 pseudo t, 4H,  $J$  = 9.2, 10.6 Hz in each,  
H-1, H-2, H-3, H-4), 6.50 (d, 1H,  $J$  = 9.2 Hz, NH); <sup>13</sup>C NMR  
(90 MHz, CDCl<sub>3</sub>):  $\delta$  (ppm) 20.2 (3), 20.3 (4 × OCOCH<sub>3</sub>), 23.0,  
23.4, 24.8, 25.0, 26.0, 26.3, 28.1, 28.8, 29.0, 29.3, 29.4, 32.0,  
33.8, 34.5, 36.2, (16 × CH<sub>2</sub>), 61.7 (C-6), 68.1, 71.2, 72.5, 74.3  
(C-2, C-3, C-4, C-5), 76.8 (C-1), 169.3, 169.6, 170.4, 170.6  
(4 × OCOCH<sub>3</sub>), 172.3 (NHCO). Anal. calcd. for  
C<sub>30</sub>H<sub>50</sub>BrNO<sub>10</sub> (664.64): C 54.22, H 7.58, N 2.11. Found: C  
54.11, H 7.72, N 2.29.

**General procedure III for the preparation of *N*-( $\omega$ -azidoalkanyl)-  
2,3,4,6-tetra-*O*-acetyl- $\beta$ -D-glucopyranosylamines (12–15)**

An *N*-( $\omega$ -bromoalkanyl)-2,3,4,6-tetra-*O*-acetyl- $\beta$ -D-glucopyra-  
nosylamine (**9–11**) was dissolved in dry DMSO (15 mL/mmol).  
To the solution NaN<sub>3</sub> (2 equiv.) was added in one portion.  
The mixture was stirred at rt until the disappearance of the starting  
bromide (TLC EtOAc–hexane 1 : 1). The solution was diluted  
with water (150 mL), washed with Et<sub>2</sub>O (5 × 25 mL) and water  
(1 × 25 mL), dried over MgSO<sub>4</sub> and the solvent was removed  
under diminished pressure. The crude product was purified by  
column chromatography or crystallisation.

***N*-Azidoacetyl-2,3,4,6-tetra-*O*-acetyl- $\beta$ -D-glucopyranosylamine  
(**12**).** To a solution of azide **7** (0.20 g, 0.54 mmol) in dry  
CH<sub>2</sub>Cl<sub>2</sub> (3 mL), PMe<sub>3</sub> (0.54 mL of a 1 M solution in toluene)  
was added in one portion. The mixture was stirred at rt until  
nitrogen evolution had ceased, and TLC (EtOAc–hexane, 1 : 1)  
had indicated complete transformation of **7** (approx. 15 min).  
This soln was then reacted with bromoacetic acid (0.082 g,  
0.59 mmol). When TLC (EtOAc–hexane, 1 : 1) showed no  
more change (conversions were incomplete), the solvent was  
evaporated, and the pale yellow oil was dissolved in CH<sub>2</sub>Cl<sub>2</sub>  
(30 mL) and extracted with satd. aq. NaHCO<sub>3</sub> solution  
(2 × 30 mL). The organic phase was dried over MgSO<sub>4</sub>,  
concentrated under diminished pressure, then the residue  
(0.20 g) was dissolved in dry DMF (3 ml) and NaN<sub>3</sub> (0.056 g,  
0.82 mmol) was added. The reaction mixture was stirred at rt  
for 2 h (TLC, EtOAc–hexane, 1 : 1). The mixture was then  
diluted with water (20 mL) and extracted with Et<sub>2</sub>O (5 × 30 mL).  
The combined organic phase was dried over MgSO<sub>4</sub> and the  
solvent was removed under diminished pressure. The obtained  
syrup was purified by column chromatography (EtOAc–  
hexane, 4 : 6) to give **12** as white crystals: 0.15 g, 63%, calcd  
for **7**; mp 150–152 °C,  $[\alpha]_D^{25}$  = +39 ( $c$  = 0.21, CHCl<sub>3</sub>),



1 (lit.<sup>40</sup>  $[\alpha]_{\text{D}} +4.1$  ( $c = 1$ ,  $\text{CHCl}_3$ );  $^1\text{H}$  NMR (360 MHz,  $\text{CDCl}_3$ ):  $\delta$  (ppm) 2.03, 2.04, 2.07, 2.09 (4s, 12H,  $4 \times \text{OCOCH}_3$ ), 3.85 (ddd, 1H,  $J = 2.6, 4.0, 9.2$  Hz, H-5), 3.93–4.11 (m, 3H, H-6b,  $\text{CH}_2$ ), 4.30 (dd, 1H  $J = 2.6, 13.2$  Hz, H-6a), 4.99, 5.08, 5.24, 5.33 (4 pseudo t, 4H,  $J = 9.2, 10.6$  Hz in each, H-1, H-2, H-3, H-4), 7.19 (d, 1H,  $J = 9.2$  Hz, NH);  $^{13}\text{C}$  NMR (90 MHz,  $\text{CDCl}_3$ ):  $\delta$  (ppm) 20.6, 20.5 ( $4 \times \text{OCOCH}_3$ ), 52.4 ( $\text{CH}_2$ ), 61.5 (C-6) 67.9, 70.3, 72.5, 73.6 (C-2, C-3, C-4, C-5), 78.0 (C-1), 167.5, 169.5, 169.8, 170.5 ( $4 \times \text{OCOCH}_3$ ), 170.8 (NHCO). Anal. calcd. for  $\text{C}_{16}\text{H}_{22}\text{N}_4\text{O}_{10}$  (430.37): C, 44.65; H, 5.15; N, 13.02; Found: C, 44.53; H, 5.22; N, 13.12.

***N*-(6-Azidohexanoyl)-2,3,4,6-tetra-*O*-acetyl- $\beta$ -D-glucopyranosylamine (13).** Prepared from **9** (2.00 g, 3.81 mmol) according to General procedure III. Yield: 1.57 g, 85%, white crystalline product, mp 135–137 °C;  $[\alpha]_{\text{D}} = +37$  ( $c = 0.34$ ,  $\text{CHCl}_3$ );  $^1\text{H}$  NMR (360 MHz,  $\text{CDCl}_3$ ):  $\delta$ (ppm) 1.36–1.44 (m, 2H,  $\text{CH}_2$ ), 1.57–1.68 (m, 4H,  $2 \times \text{CH}_2$ ), 2.02, 2.04, 2.05, 2.08 (4 s, 12H,  $4 \times \text{OCOCH}_3$ ), 2.18–2.24 (m, 2H,  $\text{CH}_2$ ), 3.24–3.29 (m, 2H,  $\text{CH}_2$ ), 3.84 (ddd, 1H,  $J = 1.2, 2.6, 10.6$  Hz, H-5), 4.08 (dd, 1H,  $J = 1.1, 11.9$  Hz, H-6b), 4.31 (dd, 1H,  $J = 11.9, 4.0$  Hz, H-6a), 4.92, 5.06, 5.28, 5.31 (4 pseudo t, 4H,  $J = 9.2, 10.6$  Hz in each, H-1, H-2, H-3, H-4), 6.57 (d, 1H,  $J = 9.2$  Hz, NH);  $^{13}\text{C}$  NMR (90 MHz,  $\text{CDCl}_3$ ):  $\delta$  (ppm) 20.4 (3), 20.5 ( $4 \times \text{OCOCH}_3$ ), 24.4, 26.0, 28.4, 36.1, 51.0 ( $5 \times \text{CH}_2$ ), 61.5 (C-6), 68.0, 70.4, 73.4, 72.6 (C-2, C-3, C-4, C-5), 77.9 (C-1), 169.5, 169.7, 170.5, 170.8 ( $4 \times \text{OCOCH}_3$ ), 173.0 (NHCO). Anal. calcd. for  $\text{C}_{20}\text{H}_{30}\text{N}_4\text{O}_{10}$  (486.48): C 49.38, H 6.22, N 11.52. Found: C 49.46, H 6.14, N 11.59.

***N*-(11-Azidoundecanoyl)-2,3,4,6-tetra-*O*-acetyl- $\beta$ -D-glucopyranosylamine (14).** Prepared from **10** (1.00 g, 1.69 mmol) according to General procedure III. Yield: 0.83 g, 88%, white crystalline product, mp 68–70 °C;  $[\alpha]_{\text{D}} = +13$  ( $c = 0.22$ ,  $\text{CHCl}_3$ );  $^1\text{H}$  NMR (360 MHz,  $\text{CDCl}_3$ ):  $\delta$ (ppm) 1.25–1.31 (m, 14H,  $7 \times \text{CH}_2$ ), 1.46–1.50 (m, 2H,  $\text{CH}_2$ ), 2.02, 2.04, 2.05, 2.08 (4 s, 12H,  $4 \times \text{OCOCH}_3$ ), 2.20–2.25 (m, 2H,  $\text{CH}_2$ ), 2.52–2.56 (m, 2H,  $\text{CH}_2$ ), 3.17 (ddd, 1H,  $J = 1.2, 2.6, 10.6$  Hz, H-5), 3.31 (dd, 1H,  $J = 1.1, 11.9$  Hz, H-6b), 3.53 (dd, 1H,  $J = 4.0, 11.9$  Hz, H-6a), 4.22, 4.29, 4.56, 4.61 (4 pseudo t, 4H,  $J = 9.2, 10.6$  Hz in each, H-1, H-2, H-3, H-4), 7.49 (d, 1H,  $J = 9.2$  Hz, NH);  $^{13}\text{C}$  NMR (90 MHz,  $\text{CDCl}_3$ ):  $\delta$  (ppm) 20.4 (3), 20.5 ( $4 \times \text{OCOCH}_3$ ), 25.0, 26.4, 27.9, 28.0, 28.2, 28.3, 30.1, 32.4, 35.0, 50.2 ( $10 \times \text{CH}_2$ ), 60.9 (C-6), 67.1, 69.6, 72.2, 72.4 (C-2, C-3, C-4, C-5), 77.9 (C-1), 168.5, 168.6, 168.7, 169.3 ( $4 \times \text{OCOCH}_3$ ), 173.0 (NHCO). Anal. calcd. for  $\text{C}_{25}\text{H}_{40}\text{N}_4\text{O}_{10}$  (556.62): C 53.95, H 7.24, N 10.07. Found: C 53.76, H 7.04, N 10.19.

***N*-(16-Azidohexadecanoyl)-2,3,4,6-tetra-*O*-acetyl- $\beta$ -D-glucopyranosylamine (15).** Prepared from **11** (0.4 g, 0.60 mmol) according to General procedure III. Yield: 0.30 g, 81%, white crystalline product, mp 92–94 °C;  $[\alpha]_{\text{D}} = +16$  ( $c = 0.22$ ,  $\text{CHCl}_3$ );  $^1\text{H}$  NMR (360 MHz,  $\text{CDCl}_3$ ):  $\delta$ (ppm) 1.24–1.28 (m, 18H,  $9 \times \text{CH}_2$ ), 1.36–1.39 (m, 2H,  $\text{CH}_2$ ), 1.47–1.50 (m, 2H,  $\text{CH}_2$ ), 1.56–1.61 (m, 2H,  $\text{CH}_2$ ), 1.84–1.87 (m, 2H,  $\text{CH}_2$ ), 2.02, 2.04, 2.07, 2.08 (4s, 12H,  $4 \times \text{OCOCH}_3$ ), 2.27–2.31 (m, 2H,  $\text{CH}_2$ ), 3.38–3.41 (m, 2H,  $\text{CH}_2$ ), 3.21 (ddd, 1H,  $J = 1.2, 2.6, 10.6$  Hz, H-5), 3.29 (1H, dd,  $J = 1.1, 11.9$  Hz, H-6b),

3.52 (dd, 1H,  $J = 4.0, 11.9$  Hz, H-6a), 4.20, 4.25, 4.71, 4.60 (4 pseudo t, 4H,  $J = 9.2, 10.6$  Hz, in each, H-1, H-2, H-3, H-4), 7.48 (d, 1H,  $J = 9.2$  Hz, NH);  $^{13}\text{C}$  NMR (90 MHz,  $\text{CDCl}_3$ ):  $\delta$  (ppm) 20.4 (3), 20.5 ( $4 \times \text{OCOCH}_3$ ), 23.3, 23.4, 3 24.8, 26.0, 27.1, 27.6, 28.2, 28.5, 29.0, 29.7, 30.4, 31.9, 33.8, 36.5, 49.2 ( $15 \times \text{CH}_2$ ), 61.5 (C-6), 68.3, 70.0, 72.1, 72.5 (C-2, C-3, C-4, C-5), 78.7 (C-1), 168.5, 168.6, 168.7, 169.3 ( $4 \times \text{OCOCH}_3$ ), 172.1 (NHCO). Anal. calcd. for  $\text{C}_{30}\text{H}_{50}\text{N}_4\text{O}_{10}$  (626.75): C 57.49, H 8.04, N 8.94. Found: C 57.23, H 8.24, N 8.82.

#### General procedures IV for the CuAAC ‘click’ reaction

(a). To a solution of an alkyne (0.27 mmol) and an azide (0.27 mmol) in  $\text{CH}_2\text{Cl}_2$  (2 mL) and  $\text{H}_2\text{O}$  (2 mL), was added  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$  (0.32 mmol) and Na-L-ascorbate (0.64 mmol). The resulting solution was stirred for 12 h at rt. The reaction mixture was diluted with  $\text{H}_2\text{O}$  (10 mL), then extracted with  $\text{CH}_2\text{Cl}_2$  ( $3 \times 10$  mL). The combined organic layer was dried over  $\text{MgSO}_4$ , filtered, and concentrated. The residue was purified by column chromatography.

(b). An *N*-( $\omega$ -azidoalkanoyl)-2,3,4,6-tetra-*O*-acetyl- $\beta$ -D-glucopyranosylamine (0.46 mmol) was added to a 1 : 1 (v/v) mixture of  $\text{CH}_2\text{Cl}_2$  and water (10 mL/mmol). To the solution 1,7-octadiyne (**43**, 1.0 equiv.),  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$  (5 mol%) and L-ascorbic acid (15 mol%) were added. The mixture was heated at 50 °C until complete transformation of the starting azide (TLC, EtOAc). The solution was diluted with water (25 mL) and extracted with  $\text{CH}_2\text{Cl}_2$  ( $5 \times 12$  mL). The organic phase was dried over  $\text{MgSO}_4$  and the solvent was removed under diminished pressure. The crude product was purified by column chromatography or crystallisation.

#### General procedure V for *O*-deacetylation

To a solution or suspension of an *O*-peracetylated compound (0.081 mmol) in MeOH (3 mL) was added 4 N aq. NaOH (0.4 mL), then stirred at rt for 1 h, and neutralized with 1 N HCl (1.8 mL). The mixture was concentrated *in vacuo* and the residue was taken up in EtOAc (50 mL), washed successively with 1 N HCl ( $3 \times 15$  mL), water ( $3 \times 15$  mL) and brine ( $3 \times 15$  mL), dried ( $\text{Na}_2\text{SO}_4$ ), filtered and concentrated. The residue was purified by column chromatography.

**[1-(2,3,4,6-Tetra-*O*-acetyl- $\beta$ -D-glucopyranosyl)-1*H*-1,2,3-triazol-4-ylmethyl] 3 $\beta$ -hydroxyolean-12-en-28-oate (16).** Prepared from **4** (0.13 g, 0.27 mmol) and **7** (0.10 g, 0.27 mmol) according to General procedure IVa. The residue was purified by column chromatography (EtOAc–hexane, 1 : 1). Yield: 0.13 g, 57%, white solid, mp 124–125 °C.  $R_f = 0.13$  (EtOAc–hexane, 1 : 2). IR (KBr,  $\text{cm}^{-1}$ ): 2947, 2869, 1757, 1460, 1369, 1227, 1036, 758;  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  0.66, 0.78, 0.89, 0.90, 0.91, 0.99, 1.13 (7 s, each 3H,  $7 \times \text{CH}_3$ ), 0.67–2.09 (m, 22H), 1.86, 2.03, 2.07, 2.09 (4 s, each 3H,  $4 \times \text{OCOCH}_3$ ), 2.86 (dd, 1H,  $J = 3.8, 13.9$  Hz, H-18), 3.18–3.23 (m, 1H, H-3), 3.96–4.02 (m, 1H, H-5-Glc), 4.11–4.16 (m, 1H, H-6a-Glc), 4.33 (dd, 1H,  $J = 4.8, 12.6$  Hz, H-6b-Glc), 5.17 (s, 2H,  $\text{COOCH}_2$ ), 5.21–5.27 (m, 1H, H-2-Glc), 5.31 (t, 1H,  $J = 3.3$  Hz, H-12), 5.39–5.43 (m, 2H, overlapping, H-3-Glc and H-4-Glc), 5.84–5.87 (m, 1H, H-1-Glc), 7.81 (s, 1H, NCH);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):

1  $\delta$  15.3, 15.6, 16.9, 18.4, 20.1, 20.5, 20.6, 23.0, 23.4, 23.6, 25.9,  
27.2, 27.7, 28.1, 29.7, 30.7, 32.2, 32.7, 33.1, 33.9, 37.1, 38.5,  
38.8, 39.3, 41.4, 41.8, 45.9, 46.7, 47.6, 55.3, 57.4, 61.5, 67.7,  
70.3, 72.6, 75.3, 79.0, 85.9, 122.0, 122.5, 143.7, 144.0, 168.6,  
5 169.3, 169.9, 170.4, 177.4. ESI-MS (positive mode)  $m/z$ : 890.8  
[M + Na]<sup>+</sup>.

10 **[1-(2,3,4,6-Tetra-O-acetyl- $\beta$ -D-glucopyranosyl)-1H-1,2,3-triazol-  
4-ylmethyl] 3 $\beta$ -hydroxyurs-12-en-28-oate (17).** Prepared from **5**  
(0.13 g, 0.27 mmol) and **7** (0.10 g, 0.27 mmol) according to  
General procedure IVa. The residue was purified by column  
chromatography (EtOAc–hexane, 1:2). Yield: 0.22 g, 96%,  
white solid, mp 120–122 °C.  $R_f$  = 0.20 (EtOAc–hexane, 1:2);  
IR (KBr, cm<sup>-1</sup>): 2932, 2872, 1757, 1456, 1376, 1228, 1104; <sup>1</sup>H  
15 NMR (300 MHz, CDCl<sub>3</sub>):  $\delta$  0.72, 0.81, 0.94, 0.97, 1.01, 1.11  
(6 s, each 3H, 6  $\times$  CH<sub>3</sub>), 0.89 (d, 3H,  $J$  = 6.3 Hz, CH<sub>3</sub>),  
0.72–2.13 (m, 22H), 1.89, 2.06, 2.10, 2.13 (4 s, each 3H, 4  $\times$   
OCOCH<sub>3</sub>), 2.25 (d, 1H,  $J$  = 10.8 Hz, H-18), 3.25 (dd, 1H,  $J$  =  
4.3, 10.7 Hz, H-3), 4.00–4.04 (m, 1H, H-5-Glc), 4.14–4.19  
20 (m, 1H, H-6a-Glc), 4.35 (dd, 1H,  $J$  = 4.5, 12.7 Hz, H-6b-Glc),  
5.17 and 5.18 (2 d, each 1H,  $J$  = 12.8 Hz, COOCH<sub>2</sub>),  
5.23–5.30 (m, 2H, overlapping, H-12 and H-2-Glc),  
5.40–5.48 (m, 2H, overlapping, H-3-Glc and H-4-Glc), 5.90  
25 (d, 1H,  $J$  = 9.2 Hz, H-1-Glc), 7.82 (s, 1H, NCH); <sup>13</sup>C NMR  
(75 MHz, CDCl<sub>3</sub>):  $\delta$  15.5, 15.6, 19.96, 17.0, 18.4, 20.1, 20.5,  
20.6, 21.1, 23.3, 23.6, 24.2, 27.3, 28.1, 28.2, 30.6, 33.0, 36.4,  
37.0, 38.7, 38.8, 38.82, 39.1, 39.6, 42.1, 47.6, 48.1, 52.9, 55.3,  
57.3, 61.5, 67.8, 70.4, 72.7, 75.3, 79.1, 86.9, 122.0, 125.8, 138.1,  
144.1, 168.6, 169.3, 169.9, 177.3. ESI-MS (positive mode)  $m/z$ :  
30 890.8 [M + Na]<sup>+</sup>.

35 **[1-(2,3,4,6-Tetra-O-acetyl- $\beta$ -D-glucopyranosyl)-1H-1,2,3-triazol-  
4-ylmethyl] 2 $\alpha$ ,3 $\beta$ -dihydroxyolean-12-en-28-oate (18).** Prepared  
from **6** (0.14 g, 0.27 mmol) and **7** (0.10 g, 0.27 mmol) according  
to General procedure IVa. The residue was purified by column  
chromatography (EtOAc–hexane, 1:1). Yield: 0.20 g, 84%,  
white solid, mp 158–160 °C,  $R_f$  = 0.17 (EtOAc–hexane, 1:1);  
IR (KBr, cm<sup>-1</sup>): 3395, 2948, 1758, 1460, 1368, 1227, 1101,  
1037, 758; <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>):  $\delta$  0.69, 0.85, 0.92,  
0.94, 1.00, 1.06, 1.15 (7 s, each 3H, 7  $\times$  CH<sub>3</sub>), 0.69–2.12  
40 (m, 20H), 1.88, 2.06, 2.10, 2.12 (4 s, each 3H, 4  $\times$  OCOCH<sub>3</sub>),  
2.89 (dd, 1H,  $J$  = 3.1, 13.2 Hz, H-18), 3.05 (d, 1H,  $J$  = 9.5 Hz,  
H-3 $\alpha$ ), 3.68–3.76 (m, 1H, H-2 $\beta$ ), 4.00–4.04 (m, 1H, H-5-Glc),  
4.14–4.18 (m, 1H, H-6a-Glc), 4.35 (dd, 1H,  $J$  = 4.8, 12.6 Hz,  
45 H-6b-Glc), 5.19 and 5.20 (2 d, each 1H,  $J$  = 12.9 Hz,  
COOCH<sub>2</sub>), 5.24–5.30 (m, 1H, H-2-Glc), 5.34 (brs, 1H,  
H-12), 5.43–5.46 (m, 2H, H-3-Glc and H-4-Glc), 5.90  
50 (d, 1H,  $J$  = 9.2 Hz, H-1-Glc), 7.84 (s, 1H, NCH); <sup>13</sup>C NMR  
(75 MHz, CDCl<sub>3</sub>):  $\delta$  16.9, 17.0, 17.2, 18.6, 20.3, 20.7, 20.9,  
23.3, 23.7, 23.9, 26.1, 27.9, 28.8, 30.9, 32.4, 32.9, 33.3, 34.1,  
38.6, 39.3, 39.4, 39.7, 41.6, 42.0, 46.1, 46.7, 47.0, 47.9, 55.6,  
57.6, 61.8, 68.0, 69.2, 70.6, 72.9, 75.5, 77.4, 84.2, 86.1, 122.2,  
122.6, 144.0, 144.3, 168.9, 169.5, 170.1, 170.6, 177.7. ESI-MS  
(positive mode)  $m/z$ : 906.4 [M + Na]<sup>+</sup>.

55 **[1-( $\beta$ -D-Glucopyranosyl)-1H-1,2] 3 $\beta$ -hydroxyolean-12-en-28-  
oate (19).** Prepared from **16** (0.07 g, 0.08 mmol) according to  
General procedure V. The residue was purified by column  
chromatography (EtOAc). Yield: 0.05 g, 91%, white solid,  
mp 178–180 °C,  $R_f$  = 0.13 (EtOAc);  $[\alpha]_D$  = +45 ( $c$  = 0.05,

MeOH); IR (KBr, cm<sup>-1</sup>): 3424, 2942, 1712, 1636, 1052, 1033, 1016, 772; <sup>1</sup>H NMR (300 MHz, C<sub>5</sub>D<sub>5</sub>N):  $\delta$  0.82, 0.85, 0.89, 0.93, 1.01, 1.17, 1.21 (7 s, each 3H, 7  $\times$  CH<sub>3</sub>), 0.82–1.92 (m, 22H), 3.08–3.11 (m, 1H, H-18), 3.39–3.44 (m, 1H, H-3), 4.20–4.22 (m, 1H, H-5-Glc), 4.27–4.41 (m, 3H, overlapping, H-6a-Glc, H-6b-Glc, H-4-Glc), 4.50 (m, 1H, H-2-Glc), 4.79 (t, 1H,  $J$  = 8.9, 8.9 Hz, H-3-Glc), 5.40 (s, 1H, H-12), 5.47–5.57 (m, 2H, COOCH<sub>2</sub>), 6.35 (d, 1H,  $J$  = 9.2 Hz, H-1-Glc), 8.64 (s, 1H, NCH); <sup>13</sup>C NMR (75 MHz, C<sub>5</sub>D<sub>5</sub>N):  $\delta$  15.7, 16.6, 17.4, 18.8, 23.4, 23.6, 23.8, 26.0, 28.1, 28.8, 30.8, 32.7, 33.1, 33.2, 34.0, 37.4, 39.0, 39.4, 39.8, 41.9, 42.1, 46.1, 47.0, 48.1, 55.9, 58.2, 62.4, 71.1, 73.9, 78.2, 79.1, 82.0, 89.6, 123.0, 124.1, 143.5, 144.0, 177.4. ESI-MS (positive mode)  $m/z$ : 744.3 [M + HCOO]<sup>+</sup>; HRMS (MALDI)  $m/z$  = C<sub>39</sub>H<sub>61</sub>N<sub>3</sub>O<sub>8</sub> [M + Na]<sup>+</sup> calcd. 722.4356, found 722.4371.

15 **1-( $\beta$ -D-Glucopyranosyl)-1H-1,2] 3 $\beta$ -hydroxyurs-12-en-28-  
oate (20).** Prepared from **17** (0.14 g, 0.17 mmol) according to  
General procedure V. The residue was purified by column  
chromatography (EtOAc). Yield: 0.11 g, 92%, white solid, mp  
20 160–162 °C,  $R_f$  = 0.16 (EtOAc);  $[\alpha]_D$  = +23 ( $c$  = 0.1,  
MeOH); IR (KBr, cm<sup>-1</sup>): 3381, 2923, 2869, 1723, 1454,  
1136, 1098, 1051, 1032, 1016, 772; <sup>1</sup>H NMR (300 MHz,  
C<sub>5</sub>D<sub>5</sub>N):  $\delta$  0.81 (d, 3H,  $J$  = 4.7 Hz, CH<sub>3</sub>), 0.83, 0.85, 0.89,  
0.97, 1.06, 1.17 (6 s, each 3H, 6  $\times$  CH<sub>3</sub>), 2.34 (d, 1H,  $J$  = 11.2 Hz,  
25 H-18), 0.75–1.94 (m, 22H), 3.38 (m, 1H, H-3), 4.09–4.17  
(m, 1H, H-5-Glc), 4.22–4.36 (m, 3H, H-4-Glc and H-6-Glc),  
4.46 (d, 1H,  $J$  = 10.8 Hz, H-2-Glc), 4.75 (t, 1H,  $J$  = 8.8, 8.8  
Hz, H-3-Glc), 5.33 (brs, 1H, H-12), 5.44 (s, 2H, COOCH<sub>2</sub>),  
6.33 (d, 1H,  $J$  = 9.2 Hz, H-1-Glc), 8.58 (s, 1H, NCH); <sup>13</sup>C  
30 NMR (75 MHz, C<sub>5</sub>D<sub>5</sub>N):  $\delta$  15.8, 16.6, 17.3, 18.8, 19.1, 21.2,  
23.7, 23.8, 24.6, 28.2, 28.8, 30.8, 33.5, 36.8, 37.3, 39.1,  
39.2, 39.3, 39.4, 40.0, 42.4, 48.1, 48.4, 53.4, 55.9, 58.1, 62.4,  
71.1, 73.9, 78.2, 79.1, 81.9, 89.6, 124.1, 126.2, 129.3, 138.6,  
143.5, 177.1. ESI-MS (positive mode)  $m/z$ : 744.5 [M +  
35 HCOO]<sup>+</sup>; HRMS (MALDI)  $m/z$  = C<sub>39</sub>H<sub>61</sub>N<sub>3</sub>O<sub>8</sub> [M +  
Na]<sup>+</sup> calcd. 722.4356, found 722.4365.

40 **1-( $\beta$ -D-Glucopyranosyl)-1H-1,2] 2 $\alpha$ ,3 $\beta$ -dihydroxyolean-12-  
en-28-oate (21).** Prepared from **18** (0.13 g, 0.15 mmol) according  
to General procedure V. The residue was purified by column  
chromatography (MeOH–CH<sub>2</sub>Cl<sub>2</sub>, 1:15). Yield: 0.09 g, 85%,  
white solid, mp 205–207 °C,  $R_f$  = 0.18 (MeOH–CH<sub>2</sub>Cl<sub>2</sub>,  
1:15);  $[\alpha]_D$  = +27 ( $c$  = 0.07, MeOH). IR (KBr, cm<sup>-1</sup>):  
45 3461, 2945, 2864, 1720, 1642, 1457, 1051, 1031, 1017, 772, 667;  
<sup>1</sup>H NMR (300 MHz, C<sub>5</sub>D<sub>5</sub>N):  $\delta$  0.82, 0.85, 0.88, 1.03, 1.07,  
1.15, 1.25 (7 s, each 3H, 7  $\times$  CH<sub>3</sub>), 0.82–2.26 (m, 20H),  
3.07–3.10 (m, 1H, H-18), 3.29 (d, 1H,  $J$  = 9.3 Hz, H-3 $\alpha$ ),  
4.09 (m, 1H, H-2 $\beta$ ), 4.23–4.31 (m, 1H, H-5-Glc), 4.34–4.42  
50 (m, 3H, overlapping, H-4-Glc and H-6a-Glc, and H-6b-Glc),  
4.52 (d, 1H,  $J$  = 11.0 Hz, H-2-Glc), 4.80 (t, 1H,  $J$  = 8.9, 8.9  
Hz, H-3-Glc), 5.37 (s, 1H, H-12), 5.52 (s, 2H, COOCH<sub>2</sub>), 6.38  
(d, 1H,  $J$  = 9.2 Hz, H-1-Glc), 8.65 (s, 1H, NCH); <sup>13</sup>C NMR  
(75 MHz, C<sub>5</sub>D<sub>5</sub>N):  $\delta$  17.0, 17.5, 17.7, 18.9, 23.4, 23.6, 23.9,  
26.0, 28.1, 29.3, 30.7, 32.7, 33.1, 33.2, 33.9, 38.6, 39.8, 41.9,  
42.1, 46.1, 47.0, 47.8, 48.1, 55.9, 58.2, 62.4, 68.6, 71.1, 73.9,  
79.1, 81.9, 83.9, 89.6, 122.9, 124.1, 143.5, 144.0, 177.4. ESI-MS  
(positive mode)  $m/z$ : 716.4 [M + H]<sup>+</sup>; HRMS (MALDI)  
55  $m/z$  = C<sub>39</sub>H<sub>61</sub>N<sub>3</sub>O<sub>9</sub> [M + Na]<sup>+</sup> calcd. 738.4306, found 738.4320.

1 **[1-(2,3,4,6-Tetra-*O*-acetyl- $\beta$ -D-glucopyranosylaminocarbonyl-**  
**methyl)-1*H*-1,2,3-triazol-4-ylmethyl] 3 $\beta$ -hydroxyolean-12-en-**  
**28-oate (22).** Prepared from **4** (0.11 g, 0.23 mmol) and **12**  
2 residue was purified by column chromatography (EtOAc-  
3 hexane, 1 : 1). Yield: 0.18 g, 85%, white solid, mp 146–148 °C,  
 $R_f = 0.21$  (EtOAc–hexane, 1 : 1); IR (KBr,  $\text{cm}^{-1}$ ): 2947, 2872,  
4 1755, 1552, 1463, 1374, 1230, 1175, 1159, 1045, 759, 667;  $^1\text{H}$   
NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  0.57, 0.78, 0.98, 1.11 (4 s, each  
5 3H,  $4 \times \text{CH}_3$ ), 0.89 (s, 9H,  $3 \times \text{CH}_3$ ), 0.57–2.10 (m, 22H), 2.01,  
6 2.02, 2.03, 2.08 (4 s, each 3H,  $4 \times \text{OCOCH}_3$ ), 2.82–2.85 (1H, m,  
H-18), 3.20 (dd, 1H,  $J = 5.0, 10.4$  Hz, H-3), 3.78–3.83 (m, 1H,  
H-5-Glc), 4.07 (dd, 1H,  $J = 2.1, 12.6$  Hz, H-6a-Glc), 4.28  
7 (dd, 1H,  $J = 4.3, 12.5$  Hz, H-6b-Glc), 4.90 (t, 1H,  $J = 9.6, 9.6$  Hz,  
H-4-Glc), 4.94–5.32 (m, 8H, overlapping,  $\text{NCH}_2$ ,  $\text{COOCH}_2$ ,  
8 H-1-Glc, H-2-Glc, H-3-Glc, H-12), 6.78 (d, 1H,  $J = 8.7$  Hz,  
OH), 7.69 (s, 1H, NCH);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  15.4,  
9 15.6, 16.7, 18.3, 20.5, 20.7, 23.0, 23.4, 23.6, 26.0, 27.2, 27.6,  
28.1, 30.6, 32.3, 32.7, 33.0, 33.8, 37.0, 38.4, 38.7, 39.3, 41.3,  
10 41.7, 45.8, 46.7, 47.5, 52.5, 55.2, 57.3, 61.5, 68.0, 70.3, 72.4,  
73.8, 78.5, 79.0, 122.5, 125.4, 143.5, 143.9, 165.4, 169.4, 169.8,  
11 170.5, 171.0, 177.6. ESI-MS (positive mode)  $m/z$ : 947.6  
[M + Na] $^+$ . HRMS (MALDI)  $m/z = \text{C}_{45}\text{H}_{72}\text{N}_4\text{O}_{10}$   
[M + Na] $^+$  calcd. 852.0638, found 851.5158.

12 **[1-(2,3,4,6-Tetra-*O*-acetyl- $\beta$ -D-glucopyranosylaminocarbonyl-**  
**pentyl)-1*H*-1,2,3-triazol-4-ylmethyl] 3 $\beta$ -hydroxyolean-12-en-**  
**28-oate (23).** Prepared from **4** (0.10 g, 0.21 mmol) and **13** (0.10 g,  
0.21 mmol) according to General procedure IVa. The residue  
13 was purified by column chromatography (EtOAc–hexane,  
1 : 1). Yield: 0.16 g, 80%, white solid, mp 99–100 °C,  $R_f =$   
14 0.12 (EtOAc–hexane, 1 : 1); IR (KBr,  $\text{cm}^{-1}$ ): 2947, 2866, 1755,  
15 1537, 1463, 1367, 1229, 1176, 1039, 757, 667;  $^1\text{H}$  NMR  
(300 MHz,  $\text{CDCl}_3$ ):  $\delta$  0.55, 0.77, 0.89, 0.97, 1.11 (5 s, each  
16 3H,  $5 \times \text{CH}_3$ ), 0.88 (s, 6H,  $2 \times \text{CH}_3$ ), 0.55–2.07 (m, 28H), 2.02,  
17 2.03, 2.04, 2.07 (4 s, each 3H,  $4 \times \text{OCOCH}_3$ ), 2.14–2.18  
(m, 2H,  $\text{CH}_2\text{CO}$ ), 2.82–2.85 (m, 1H, H-18), 3.20 (dd, 1H,  
18  $J = 4.9, 10.6$  Hz, H-3), 3.79–3.84 (m, 1H, H-5-Glc), 4.07  
(dd, 1H,  $J = 2.1, 12.5$  Hz, H-6a-Glc), 4.28–4.34 (m, 3H,  
19 overlapping,  $\text{NCH}_2$  and H-6b-Glc), 4.90 (t, 1H,  $J = 9.7,$   
9.7 Hz, H-4-Glc), 5.06 (t, 1H,  $J = 9.7, 9.7$  Hz, H-3-Glc), 5.20  
(s, 2H,  $\text{COOCH}_2$ ), 5.24–5.34 (m, 3H, overlapping, H-12, H-1-  
20 Glc and H-12'), 6.23 (d, 1H,  $J = 9.2$  Hz, NH), 7.56 (s, 1H,  
NCH);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  15.3, 15.6, 16.7, 18.3,  
21 20.6, 20.66, 20.7, 22.9, 23.4, 23.6, 24.2, 25.8, 25.9, 27.2, 27.6,  
28.1, 29.9, 30.6, 32.3, 32.7, 33.0, 33.8, 36.0, 37.0, 38.4, 38.7,  
22 39.3, 41.3, 41.7, 45.8, 46.7, 47.5, 49.9, 55.2, 57.4, 61.6, 68.1,  
70.7, 72.6, 73.6, 77.2, 78.2, 79.0, 122.4, 123.9, 143.1, 143.6,  
23 169.5, 169.8, 170.6, 171.1, 172.7, 177.8. ESI-MS (positive  
24 mode)  $m/z$ : 1003.5 [M + Na] $^+$ .

25 **[1-(2,3,4,6-Tetra-*O*-acetyl- $\beta$ -D-glucopyranosylaminocarbonyl-**  
**decyl)-1*H*-1,2,3-triazol-4-ylmethyl] 3 $\beta$ -hydroxyolean-12-en-**  
**28-oate (24).** Prepared from **4** (0.09 g, 0.18 mmol) and **14**  
26 (0.10 g, 0.18 mmol) according to General procedure IVa.  
The residue was purified by column chromatography (EtOAc–  
27 hexane, 1 : 1). Yield: 0.12 g, 64%, white solid, mp 90–92 °C,  
 $R_f = 0.22$  (EtOAc–hexane, 1 : 1); IR (KBr,  $\text{cm}^{-1}$ ): 3359, 2922,  
28 2860, 1744, 1693, 1364, 1220, 1049, 1032, 772;  $^1\text{H}$  NMR

(300 MHz,  $\text{CDCl}_3$ ):  $\delta$  0.52, 0.77, 0.87, 0.88, 0.90, 0.98, 1.11  
29 (7 s, each 3H,  $7 \times \text{CH}_3$ ), 0.52–2.07 (m, 38H), 2.02, 2.03, 2.04,  
30 2.07 (4 s, each 3H,  $4 \times \text{OCOCH}_3$ ), 2.13–2.23 (m, 2H,  $\text{CH}_2\text{CO}$ ),  
2.82 (m, 1H, H-18), 3.20 (dd, 1H,  $J = 5.0, 10.9$  Hz, H-3),  
31 3.80–3.85 (m, 1H, H-5-Glc), 4.07 (dd, 1H,  $J = 1.9, 12.5$  Hz,  
H-6a-Glc), 4.28–4.34 (m, 3H, overlapping, H-6b-Glc and  
32  $\text{NCH}_2$ ), 4.91 (pseudo t, 1H,  $J = 9.6, 9.7$  Hz, H-4-Glc), 5.06  
(pseudo t, 1H,  $J = 9.6, 9.7$  Hz, H-3-Glc), 5.18 (s, 2H,  
33  $\text{COOCH}_2$ ), 5.22–5.34 (m, 3H, overlapping, H-12 and H-1-  
Glc, H-2-Glc), 6.30 (d, 1H,  $J = 9.3$  Hz, NH), 7.56 (s, 1H, s,  
34 NCH);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  15.4, 15.6, 16.8, 18.3,  
20.5, 20.6, 20.7, 23.0, 23.4, 23.6, 25.1, 25.8, 26.5, 27.2, 27.7,  
35 28.1, 29.0, 29.1, 29.2, 29.3, 29.33, 30.2, 30.7, 32.4, 32.7, 33.0,  
33.9, 36.6, 37.1, 38.5, 38.8, 39.4, 41.4, 41.7, 45.9, 46.8, 47.6,  
36 50.4, 55.2, 57.5, 61.7, 68.3, 70.7, 72.8, 73.6, 77.2, 78.2, 79.0,  
37 122.4, 123.9, 143.1, 169.5, 170.0, 170.5, 171.0, 173.3, 177.8.  
ESI-MS (positive mode)  $m/z$ : 1073.9 [M + Na] $^+$ .

38 **[1-(2,3,4,6-Tetra-*O*-acetyl- $\beta$ -D-glucopyranosylaminocarbonyl-**  
**methyl)-1*H*-1,2,3-triazol-4-ylmethyl] 3 $\beta$ -hydroxyurs-12-en-**  
**28-oate (25).** Prepared from **5** (0.11 g, 0.23 mmol) and **12**  
39 (0.10 g, 0.23 mmol) according to General procedure IVa.  
The residue was purified by column chromatography (EtOAc–  
40 hexane, 1 : 1). Yield: 0.024 g, 11%, white solid, mp 116–118 °C,  
 $R_f = 0.21$  (EtOAc–hexane, 1 : 1);  $[\alpha]_D = +29$  ( $c = 0.05,$   
41  $\text{CHCl}_3$ ). IR (KBr,  $\text{cm}^{-1}$ ): 3340, 2947, 2871, 1756, 1454, 1377,  
1230, 1046, 1033, 997, 758;  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$   
42 0.60, 0.78, 0.91, 0.93, 0.98, 1.06 (6 s, each 3H,  $6 \times \text{CH}_3$ ), 0.83  
(d, 3H,  $J = 6.4$  Hz,  $\text{CH}_3$ ), 0.60–2.01 (m, 22H), 2.01, 2.03, 2.08  
43 (s, 12 H,  $4 \times \text{OCOCH}_3$ ), 2.20 (d, 1H,  $J = 11.3$  Hz, H-18), 3.22  
(dd, 1H,  $J = 4.9, 10.8$  Hz, H-3), 3.78–3.83 (m, 1H, H-5-Glc),  
44 4.08 (dd, 1H,  $J = 1.9, 12.7$  Hz, H-6a-Glc), 4.28 (dd, 1H,  $J =$   
4.3, 12.6 Hz, H-6b-Glc), 4.87 (pseudo t, 1H,  $J = 9.5, 9.6$  Hz,  
45 H-4-Glc), 4.99–5.09 (m, 3H, overlapping,  $\text{NCH}_2\text{CO}$  and H-2-  
Glc), 5.16 (d, 1H,  $J = 12.7$  Hz,  $\text{COOCH}_2$ ), 5.19 (d, 1H,  $J =$   
46 12.7 Hz,  $\text{COOCH}_2$ ), 5.22–5.23 (m, 2H, overlapping, H-1-Glc  
and H-12), 5.29 (pseudo t, 1H,  $J = 9.5, 9.6$  Hz, H-3-Glc), 6.75  
(d, 1H,  $J = 8.7$  Hz, NH), 7.68 (s, 1H, NCH);  $^{13}\text{C}$  NMR  
(75 MHz,  $\text{CDCl}_3$ ):  $\delta$  15.5, 15.6, 16.9, 17.0, 18.3, 20.5, 20.7,  
47 21.1, 23.3, 23.5, 24.2, 27.3, 28.0, 28.2, 30.6, 33.0, 36.6, 37.0,  
48 38.7, 38.76, 38.84, 39.1, 39.6, 42.1, 47.6, 48.2, 52.6, 52.9, 55.3,  
57.2, 61.6, 68.1, 70.4, 72.5, 73.9, 78.5, 79.1, 125.3, 125.8, 138.0,  
49 144.0, 165.3, 169.4, 169.8, 170.5, 171.0, 177.4. ESI-MS  
(positive mode)  $m/z$ : 947.0 [M + Na] $^+$ .

50 **[1-(2,3,4,6-Tetra-*O*-acetyl- $\beta$ -D-glucopyranosylaminocarbonyl-**  
**pentyl)-1*H*-1,2,3-triazol-4-ylmethyl] 3 $\beta$ -hydroxyurs-12-en-**  
**28-oate (26).** Prepared from **5** (0.10 g, 0.21 mmol) and **13**  
51 (0.10 g, 0.21 mmol) according to General procedure IVa.  
The residue was purified by column chromatography (EtOAc–  
52 hexane, 1 : 1). Yield: 0.10 g, 50%, white solid, mp 102–104 °C,  
 $R_f = 0.56$  (EtOAc–hexane, 2 : 1); IR (KBr,  $\text{cm}^{-1}$ ): 3352, 2940,  
53 2870, 1754, 1534, 1455, 1377, 1228, 1043, 756, 666;  $^1\text{H}$  NMR  
(300 MHz,  $\text{CDCl}_3$ ):  $\delta$  0.59, 0.77, 0.90, 0.93, 0.98, 1.06 (6 s, each  
54 3H,  $6 \times \text{CH}_3$ ), 0.83 (d,  $J = 6.4$  Hz, 3H,  $\text{CH}_3$ ), 0.59–2.00  
(m, 28H), 2.02, 2.03, 2.04, 2.08 (4 s, each 3H,  $4 \times \text{OCOCH}_3$ ),  
55 2.14–2.23 (m, 3H, overlapping, H-18 and  $\text{CH}_2\text{CON}$ ), 3.21  
(dd, 1H,  $J = 4.0, 10.1$  Hz, H-3), 3.79–3.84 (m, 1H, H-5-  
Glc), 4.07 (dd, 1H,  $J = 2.1, 12.7$  Hz, H-6a-Glc), 4.29–4.34



**Q9** [3-Triazol-4-ylmethyl,1-(β-D-glucopyranosylaminocarbonylmethyl)-1H-1,2] 3β-hydroxyolean-12-en-28-oate (31). Prepared from **22** (0.13 g, 0.14 mmol) according to General procedure V. The residue was purified by column chromatography (MeOH-CH<sub>2</sub>Cl<sub>2</sub>, 1:15). Yield: 0.055 g, 51%, white solid, mp 197–199 °C, *R<sub>f</sub>* = 0.09 (MeOH-CH<sub>2</sub>Cl<sub>2</sub>, 1:10); [α]<sub>D</sub> = +37 (*c* = 0.11, MeOH); IR (KBr, cm<sup>-1</sup>): 3407, 2943, 2860, 1705, 1556, 1389, 1161, 1059, 1032, 1018, 772; <sup>1</sup>H NMR (300 MHz, C<sub>5</sub>D<sub>5</sub>N): δ 0.80, 0.90, 1.03, 1.19, 1.24 (5 s, each 3H, 5 × CH<sub>3</sub>), 0.88 (s, 6H, 2 × CH<sub>3</sub>), 0.80–1.96 (m, 22H), 3.13 (d, 1H, *J* = 10.3 Hz, H-18), 3.43 (t, 1H, *J* = 7.8 Hz, H-3), 4.02–4.11 (m, 2H, overlapping, H-5-Glc and H-6a-Glc), 4.25–4.27 (m, 2H, overlapping, H-4-Glc and H-2-Glc), 4.37 (dd, 1H, *J* = 4.3, 11.8 Hz, H-6b-Glc), 4.49 (d, 1H, *J* = 11.5 Hz, H-1'), 5.43 (s, 1H, H-12), 5.48 (s, 2H, NCH<sub>2</sub>CO), 5.62 (s, 2H, COOCH<sub>2</sub>), 5.97 (t, 1H, *J* = 8.9, 8.9 Hz, H-3-Glc), 8.40 (s, 1H, NCH), 10.60 (d, 1H, *J* = 8.8 Hz, NH); <sup>13</sup>C NMR (75 MHz, C<sub>5</sub>D<sub>5</sub>N): δ 15.6, 16.5, 17.1, 18.7, 23.3, 23.6, 23.7, 26.0, 28.0, 28.1, 28.7, 29.9, 30.7, 32.7, 33.05, 33.1, 33.9, 37.3, 38.9, 39.3, 39.7, 41.9, 42.0, 46.1, 46.9, 48.0, 52.7, 55.8, 58.0, 62.4, 71.5, 74.5, 78.1, 79.5, 80.3, 81.5, 123.1, 123.8, 126.7, 135.8, 143.5, 144.0, 150.2, 166.9, 177.3. ESI-MS (negative mode) *m/z*: 755.5 [M - H]<sup>+</sup>; HRMS (MALDI) *m/z* = C<sub>41</sub>H<sub>64</sub>N<sub>4</sub>O<sub>9</sub> [M + Na]<sup>+</sup> calcd. 779.4571, found 779.4594.

[3-Triazol-4-ylmethyl,1-(β-D-glucopyranosylaminocarbonylpentyl)-1H-1,2] 3β-hydroxyolean-12-en-28-oate (32). Prepared from **23** (0.11 g, 0.11 mmol) according to the general procedure V. The residue was purified by column chromatography (MeOH-CH<sub>2</sub>Cl<sub>2</sub>, 1:15). Yield: 0.076 g, 83%, white solid, mp 164–166 °C, *R<sub>f</sub>* = 0.25 (MeOH-CH<sub>2</sub>Cl<sub>2</sub>, 1:10); [α]<sub>D</sub> = +42 (*c* = 0.06, MeOH); IR (KBr, cm<sup>-1</sup>): 3367, 2939, 2864, 1725, 1663, 1382, 1053, 1032, 1013, 773; <sup>1</sup>H NMR (300 MHz, C<sub>5</sub>D<sub>5</sub>N): δ 0.81, 0.94, 1.05, 1.20, 1.24 (5 s, each 3H, 5 × CH<sub>3</sub>), 0.89 (s, 6H, 2 CH<sub>3</sub>), 0.81–1.93 (m, 28H), 2.41 (t, 2H, *J* = 7.3 Hz, CH<sub>2</sub>CO), 3.15 (d, 1H, *J* = 13.3 Hz, H-18), 3.45 (brs, 1H, H-3), 4.05–4.13 (m, 2H, H-5-Glc and H-6a-Glc), 4.23–4.30 (m, 4H, H-2-Glc, H-4-Glc and NCH<sub>2</sub>), 4.37 (dd, 1H, *J* = 4.6, 11.8 Hz, H-6b-Glc), 4.48 (d, 1H, *J* = 11.8 Hz, H-1-Glc), 5.43 (s, 1H, H-12), 5.53 and 5.54 (2 d, each 1H, *J* = 12.6 Hz, COOCH<sub>2</sub>), 6.01 (t, 1H, *J* = 9.0, 9.0 Hz, H-3-Glc), 8.13 (s, 1H, NCH), 9.62 (d, 1H, *J* = 9.1 Hz, NH); <sup>13</sup>C NMR (75 MHz, C<sub>5</sub>D<sub>5</sub>N): δ 15.6, 16.5, 17.2, 18.8, 23.3, 23.6, 23.8, 25.1, 26.0, 26.4, 28.0, 28.1, 28.8, 30.3, 30.7, 32.8, 33.1, 33.2, 33.9, 36.3, 37.3, 39.0, 39.4, 39.7, 41.9, 42.0, 46.1, 47.0, 48.0, 50.0, 55.8, 58.1, 62.7, 71.8, 74.6, 78.1, 79.7, 80.1, 81.3, 123.0, 124.6, 143.4, 144.0, 173.6, 177.4. ESI-MS (negative mode) *m/z*: 811.4 [M - H]<sup>+</sup>; HRMS (MALDI) *m/z* = C<sub>45</sub>H<sub>72</sub>N<sub>4</sub>O<sub>9</sub> [M + Na]<sup>+</sup> calcd. 835.5197, found 835.5203.

[3-Triazol-4-ylmethyl,1-(β-D-glucopyranosylaminocarbonyldecyl)-1H-1,2] 3β-hydroxyolean-12-en-28-oate (33). Prepared from **24** (0.083 g, 0.08 mmol) according to General procedure V. The residue was purified by column chromatography (MeOH-CH<sub>2</sub>Cl<sub>2</sub>, 1:20). Yield: 0.068 g, 97%, white solid, mp 195–196 °C, *R<sub>f</sub>* = 0.27 (MeOH-CH<sub>2</sub>Cl<sub>2</sub>, 1:15); [α]<sub>D</sub> = +31 (*c* = 0.1, MeOH); IR (KBr, cm<sup>-1</sup>): 3392, 2928, 1727, 1463, 1386, 1158, 1123, 1050, 1032, 1012, 756, 697; <sup>1</sup>H NMR (300 MHz, C<sub>5</sub>D<sub>5</sub>N): δ 0.59, 0.86, 1.04, 1.10 (4 s, each 3H,

4 × CH<sub>3</sub>), 0.74 (s, 9H, 3 × CH<sub>3</sub>), 0.59–1.95 (m, 38H), 2.36 (t, 2H, *J* = 7.3 Hz, CH<sub>2</sub>CON), 2.94 (dd, 1H, *J* = 3.6, 10.0 Hz, H-18), 3.28 (t, 1H, *J* = 8.0 Hz, H-3), 3.92–3.93 (m, 2H, overlapping, H-5-Glc and H-6a-Glc), 4.04–4.10 (m, 3H, m, overlapping, NCH<sub>2</sub> and H-6b-Glc), 4.26–4.38 (m, 3H, m, overlapping, H-2-Glc, H-3-Glc, and H-4-Glc), 5.26 (s, 1H, H-12), 5.42 (d, 1H, *J* = 14.1 Hz, COOCH<sub>2</sub>), 5.46 (d, 1H, *J* = 14.1 Hz, COOCH<sub>2</sub>), 5.63 (d, 1H, *J* = 8.6 Hz, H-1-Glc), 8.18 (s, 1H, NCH), 9.67 (d, 1H, *J* = 8.8 Hz, NH); <sup>13</sup>C NMR (75 MHz, C<sub>5</sub>D<sub>5</sub>N): δ 15.7, 16.6, 17.3, 18.8, 23.4, 23.7, 23.8, 25.9, 26.0, 26.7, 28.1, 28.8, 29.2, 29.6, 29.64, 29.7, 30.6, 30.8, 32.8, 33.1, 33.2, 34.0, 36.9, 37.4, 39.0, 39.4, 39.8, 41.9, 42.1, 46.1, 47.0, 48.0, 50.3, 55.8, 58.1, 62.7, 71.8, 74.5, 78.1, 79.6, 80.0, 81.4, 122.8, 124.7, 143.4, 144.0, 174.1, 177.4. ESI-MS (positive mode) *m/z*: 917.5 [M + Cl]<sup>+</sup>; HRMS (MALDI) *m/z* = C<sub>50</sub>H<sub>82</sub>N<sub>4</sub>O<sub>9</sub> [M + Na]<sup>+</sup> calcd. 905.5980, found 905.6013.

[3-Triazol-4-ylmethyl,1-(β-D-glucopyranosylaminocarbonylpentyl)-1H-1,2] 3β-hydroxyurs-12-en-28-oate (34). Prepared from **26** (0.065 g, 0.07 mmol) according to General procedure V. The residue was purified by column chromatography (MeOH-CH<sub>2</sub>Cl<sub>2</sub>, 1:20). Yield: 0.053 g, 98%, white solid, mp 214–216 °C, *R<sub>f</sub>* = 0.67 (MeOH-CH<sub>2</sub>Cl<sub>2</sub>, 1:15); [α]<sub>D</sub> = +26 (*c* = 0.1, MeOH). IR (KBr, cm<sup>-1</sup>): 3386, 2924, 2869, 1724, 1657, 1456, 1392, 1049, 1032, 1017; <sup>1</sup>H NMR (300 MHz, C<sub>5</sub>D<sub>5</sub>N): δ 0.83, 0.91, 0.94, 1.04, 1.13, 1.23 (6 s, each 3H, 6 × CH<sub>3</sub>), 0.88 (d, 3H, *J* = 3.9 Hz, CH<sub>3</sub>), 0.83–2.00 (m, 28H), 2.39–2.47 (m, 3H, overlapping, H-18 and CH<sub>2</sub>CON), 3.44 (dd, 1H, *J* = 6.1, 9.8 Hz, H-3), 4.04 (m, 1H, H-5-Glc), 4.16 (t, 1H, *J* = 9.8, 9.8 Hz, H-4-Glc), 4.24–4.45 (m, 6H, overlapping, NCH<sub>2</sub>, H-2-Glc, H-3-Glc and H-6a-Glc, H-6b-Glc), 5.40 (s, 1H, H-12), 5.50 (s, 2H, COOCH<sub>2</sub>), 5.96 (1H, overlapping, H-1'), 8.13 (s, 1H, NCH), 9.69 (d, 1H, *J* = 8.2 Hz, NH); <sup>13</sup>C NMR (75 MHz, C<sub>5</sub>D<sub>5</sub>N): δ 15.8, 16.6, 17.3, 18.8, 21.2, 23.7, 23.8, 24.6, 25.1, 26.4, 28.1, 28.4, 28.8, 30.0, 30.3, 30.8, 33.5, 36.4, 37.0, 37.3, 39.1, 39.2, 39.3, 39.4, 40.0, 42.4, 48.0, 48.4, 50.1, 53.4, 55.8, 58.0, 62.7, 71.8, 74.5, 78.2, 79.6, 80.0, 81.3, 124.6, 126.2, 138.6, 143.3, 173.7, 177.1. ESI-MS (positive mode) *m/z*: 847.5 [M + Cl]<sup>+</sup>. HRMS (MALDI) *m/z* = C<sub>45</sub>H<sub>72</sub>N<sub>4</sub>O<sub>9</sub> [M + Na]<sup>+</sup> calcd. 835.5197, found 835.5206.

[3-Triazol-4-ylmethyl,1-(β-D-glucopyranosylaminocarbonyldecyl)-1H-1,2] 3β-hydroxyurs-12-en-28-oate (35). Prepared from **27** (0.10 g, 0.1 mmol) according to General procedure V. The residue was purified by column chromatography (MeOH-CH<sub>2</sub>Cl<sub>2</sub>, 1:12). Yield: 0.078 g, 93%, white solid, mp 199–200 °C, *R<sub>f</sub>* = 0.12 (MeOH-CH<sub>2</sub>Cl<sub>2</sub>, 1:15); [α]<sub>D</sub> = +32 (*c* = 0.06, MeOH); IR (KBr, cm<sup>-1</sup>): 3409, 2924, 2861, 1726, 1662, 1453, 1382, 1052, 1032, 1013. <sup>1</sup>H NMR (300 MHz, C<sub>5</sub>D<sub>5</sub>N): δ 0.81, 0.91, 0.94, 1.03, 1.13, 1.23 (6 s, each 3H, 6 × CH<sub>3</sub>), 0.88 (d, 3H, *J* = 3.6 Hz, CH<sub>3</sub>), 0.81–1.99 (m, 38H), 2.43–2.49 (m, 3H, overlapping, H-18 and CH<sub>2</sub>CON), 3.44 (dd, 1H, *J* = 6.8, 9.7 Hz, H-3), 4.04 (m, 1H, H-5-Glc), 4.14 (t, 1H, *J* = 8.8, 8.8 Hz, H-4-Glc), 4.21–4.33 (m, 2H, NCH<sub>2</sub>), 4.35–4.47 (m, 3H, overlapping, H-3-Glc, H-2-Glc and H-1-Glc), 5.39 (brs, 1H, H-12), 5.51 and 5.52 (2 d, each 1H, *J* = 12.5 Hz, COOCH<sub>2</sub>), 8.19 (s, 1H, NCH),

1 9.62 (d, 1H,  $J = 9.0$  Hz, NH);  $^{13}\text{C}$  NMR (75 MHz,  $\text{C}_5\text{D}_5\text{N}$ ):  $\delta$  15.8, 16.6, 17.3, 17.4, 18.8, 21.2, 23.7, 23.8, 24.6, 26.0, 26.8, 28.2, 28.5, 28.9, 29.3, 29.6, 29.67, 29.7, 30.0, 30.6, 30.8, 33.5, 36.9, 37.0, 37.4, 39.2, 39.3, 39.4, 40.0, 42.4, 48.0, 48.4, 50.3, 53.4, 55.9, 58.1, 62.8, 71.9, 74.6, 78.2, 79.7, 80.0, 81.4, 124.7, 126.2, 143.4, 174.1, 177.2. ESI-MS (positive mode)  $m/z$ : 927.5  $[\text{M} + \text{HCOO}]^+$ ; HRMS (MALDI)  $m/z = \text{C}_{50}\text{H}_{82}\text{N}_4\text{O}_9$   $[\text{M} + \text{Na}]^+$  calcd. 905.5980, found 905.6004.

10 **[3-Triazol-4-ylmethyl,1-( $\beta$ -D-glucopyranosylaminocarbonyl-pentyl)-1H-1,2] 2 $\alpha$ ,3 $\beta$ -dihydroxyolean-12-en-28-oate (36).** Prepared from **29** (0.10 g, 0.1 mmol) according to General procedure V. The residue was purified by column chromatography (MeOH– $\text{CH}_2\text{Cl}_2$ , 1:10). Yield: 0.075 g, 93%, white solid, mp 180–182 °C,  $R_f = 0.09$  (MeOH– $\text{CH}_2\text{Cl}_2$ , 1:15);  $[\alpha]_D = +23$  ( $c = 0.05$ , MeOH); IR (KBr,  $\text{cm}^{-1}$ ): 3369, 2944, 2873, 1725, 1664, 1546, 1461, 1260, 1159, 1122, 1049, 1033;  $^1\text{H}$  NMR (300 MHz,  $\text{C}_5\text{D}_5\text{N}$ ):  $\delta$  0.79, 0.90, 1.02, 1.09, 1.16 (5 s, each 3H,  $5 \times \text{CH}_3$ ), 0.87 (s, 6H,  $2 \times \text{CH}_3$ ), 0.79–2.30 (m, 26H), 2.40 (t, 2H,  $J = 7.3$  Hz,  $\text{CH}_2\text{CON}$ ), 3.11 (dd, 1H,  $J = 4.2$ , 13.5 Hz, H-18), 3.37 (d, 1H,  $J = 9.3$  Hz, H-3 $\alpha$ ), 4.10 (m, 1H, H-2 $\beta$ ), 4.15–4.49 (m, 6H, overlapping, H-1-Glc, H-2-Glc, H-4-Glc, H-5-Glc and H-6-Glc), 5.38 (s, 1H, H-12), 5.52 (s, 2H,  $\text{COOCH}_2$ ), 5.99 (t, 1H,  $J = 9.0$ , 9.0 Hz, H-3-Glc), 8.11 (s, 1H, NCH), 9.62 (d, 1H,  $J = 9.0$  Hz, NH);  $^{13}\text{C}$  NMR (75 MHz,  $\text{C}_5\text{D}_5\text{N}$ ):  $\delta$  16.9, 17.3, 17.7, 18.9, 23.4, 23.7, 23.9, 25.1, 26.0, 26.5, 28.0, 29.3, 30.0, 30.4, 36.4, 38.6, 39.8, 41.9, 42.1, 46.1, 47.0, 47.8, 48.1, 50.0, 55.9, 58.2, 62.8, 68.6, 71.8, 74.6, 79.7, 80.0, 81.3, 83.8, 122.9, 124.6, 143.3, 144.0, 173.6, 177.4. ESI-MS (positive mode)  $m/z$ : 873.5  $[\text{M} + \text{HCOO}]^+$ ; HRMS (MALDI)  $m/z = \text{C}_{45}\text{H}_{72}\text{N}_4\text{O}_{10}$   $[\text{M} + \text{Na}]^+$  calcd. 851.5146, found 851.5158.

35 **[3-Triazol-4-ylmethyl,1-( $\beta$ -D-glucopyranosylaminocarbonyl-decyl)-1H-1,2] 2 $\alpha$ ,3 $\beta$ -dihydroxyolean-12-en-28-oate (37).** Prepared from **30** (0.11 g, 0.1 mmol) according to General procedure V. The residue was purified by column chromatography (MeOH– $\text{CH}_2\text{Cl}_2$ , 1:15). Yield: 0.065 g, 72%, white solid, mp 163–165 °C,  $R_f = 0.18$  (MeOH– $\text{CH}_2\text{Cl}_2$ , 1:15);  $[\alpha]_D = +33$  ( $c = 0.07$ , MeOH), IR (KBr,  $\text{cm}^{-1}$ ): 3377, 2923, 2861, 1725, 1053, 1032, 1015, 772;  $^1\text{H}$  NMR (300 MHz,  $\text{C}_5\text{D}_5\text{N}$ ):  $\delta$  0.79, 1.04, 1.10, 1.18 (4 s, each 3H,  $4 \times \text{CH}_3$ ), 0.89 (s, 9H,  $3 \times \text{CH}_3$ ), 0.79–2.30 (m, 36H), 2.48 (t, 2H,  $J = 7.5$  Hz,  $\text{CH}_2\text{CON}$ ), 3.12 (dd, 1H,  $J = 3.8$ , 9.9 Hz, H-18), 3.38 (d, 1H,  $J = 9.2$  Hz, H-3 $\alpha$ ), 4.05 (m, 1H, H-2 $\beta$ ), 4.07–4.51 (m, 8H, overlapping, H-1-Glc, H-2-Glc, H-4-Glc, H-5-Glc, H-6-Glc and  $\text{NCH}_2$ ), 5.40 (s, 1H, H-12), 5.54 and 5.57 (2 d, each 1H,  $J = 12.6$  Hz,  $\text{COOCH}_2$ ), 6.03 (t, 1H,  $J = 9.0$ , 9.0 Hz, H-3-Glc), 8.12 (s, 1H, NCH), 9.61 (d, 1H,  $J = 8.9$  Hz, NH);  $^{13}\text{C}$  NMR (75 MHz,  $\text{C}_5\text{D}_5\text{N}$ ):  $\delta$  17.0, 17.3, 17.7, 18.9, 23.4, 23.9, 25.95, 26.0, 26.8, 28.0, 29.3, 29.4, 29.6, 29.66, 29.7, 30.0, 30.6, 30.8, 32.8, 33.1, 34.0, 36.9, 38.6, 39.9, 41.9, 42.1, 46.1, 47.0, 47.8, 48.1, 50.3, 55.9, 58.2, 62.8, 68.6, 71.9, 74.7, 79.8, 80.1, 81.4, 83.9, 122.9, 124.7, 143.4, 144.1, 174.0, 177.4. ESI-MS (positive mode)  $m/z$ : 943.6  $[\text{M} + \text{HCOO}]^+$ ; HRMS (MALDI)  $m/z = \text{C}_{50}\text{H}_{82}\text{N}_4\text{O}_{10}$   $[\text{M} + \text{Na}]^+$  calcd. 921.5929, found 921.5937.

55 **2-[2,3-Triazol-1-yl,3 $\beta$ -dihydroxyolean-12-en-28-carboxyloxy-methyl)-1H-1,4-(2 $\alpha$ ) acetic acid (38).** Prepared from **28** (0.084 g,

0.09 mmol) according to General procedure V. The residue was purified by column chromatography (MeOH– $\text{CH}_2\text{Cl}_2$ , 1:10). Yield: 0.05 g, 91%, white solid, mp 225–227 °C,  $R_f = 0.06$  (MeOH– $\text{CH}_2\text{Cl}_2$ , 1:15);  $[\alpha]_D = +82$  ( $c = 0.06$ , MeOH); IR (KBr,  $\text{cm}^{-1}$ ): 3403, 2940, 2862, 1724, 1450, 1386, 1229, 1159, 1050, 1033;  $^1\text{H}$  NMR (300 MHz,  $\text{C}_5\text{D}_5\text{N}$ ):  $\delta$  0.84, 1.02, 1.07, 1.13, 1.17 (5 s, each 3H,  $5 \times \text{CH}_3$ ), 0.87 (s, 6H,  $2 \times \text{CH}_3$ ), 0.84–2.22 (m, 20H), 3.12 (dd, 1H,  $J = 3.7$ , 13.5 Hz, H-18), 3.37 (d, 1H,  $J = 9.4$  Hz, H-3 $\alpha$ ), 4.06–4.14 (m, 1H, H-2 $\beta$ ), 5.40 (s, 1H, H-12), 5.54 (s, 2H,  $\text{NCH}_2\text{CO}$ ), 5.64 (s, 2H,  $\text{COOCH}_2$ ), 5.67 (s, 2H,  $\text{COOCH}_2$ ), 8.45 (s, 1H, NCH);  $^{13}\text{C}$  NMR (75 MHz,  $\text{C}_5\text{D}_5\text{N}$ ):  $\delta$  16.9, 17.3, 17.7, 18.9, 23.4, 23.7, 23.9, 26.0, 28.1, 29.3, 30.0, 30.8, 32.7, 33.1, 34.0, 38.6, 39.8, 39.9, 41.9, 42.1, 46.1, 47.0, 47.8, 48.1, 52.3, 55.9, 58.2, 68.6, 83.9, 122.6, 126.3, 143.5, 144.0, 177.4. ESI-MS (positive mode)  $m/z$ : 634.9  $[\text{M} + \text{Na}]^+$ ; HRMS (MALDI)  $m/z = \text{C}_{35}\text{H}_{53}\text{N}_3\text{O}_6$   $[\text{M} + \text{Na}]^+$  calcd. 634.3832, found 634.3845.

### General procedure VI for the Zemlén-deacetylation

To a solution of an *O*-acetyl-protected compound in dry MeOH 1–2 drops of a  $\sim 1$  M methanolic NaOMe solution were added, and the reaction mixture was kept at rt until completion of the transformation (TLC,  $\text{CHCl}_3$ –MeOH, 1:1). Amberlyst 15 ( $\text{H}^+$  form) was then added to remove sodium ions, the resin was filtered off, and the solvent removed *in vacuo*. If the residue was chromatographically non-uniform it was purified by column chromatography or crystallisation.

### General procedure VII for reduction

An *N*-( $\omega$ -azidoalkanoyl)- $\beta$ -D-glucopyranosyl-amine was dissolved in dry MeOH (12 mL/mmol). To the solution RANEY<sup>®</sup>-Ni ( $\sim 2$  mmol) was added, and  $\text{H}_2$  gas was bubbled through the mixture at 70 °C until the complete transformation of the starting azide TLC ( $\text{CHCl}_3$ –MeOH, 1:1). The solution was filtered over a Celite pad and the solvent was removed *in vacuo*.

***N*-Azidoacetyl- $\beta$ -D-glucopyranosylamine (39).** Prepared from **12** (0.10 g, 0.23 mmol) according to General procedure VI. The residue was purified by column chromatography ( $\text{CHCl}_3$ –MeOH, 7:3). Yield: 0.058 g, 95%, colourless oil,  $R_f = 0.34$  ( $\text{CHCl}_3$ –MeOH, 7:3);  $[\alpha]_D = -12$  ( $c = 0.22$ , MeOH), (lit.<sup>40</sup>  $[\alpha]_D = -61$  ( $c = 1$ ,  $\text{H}_2\text{O}$ ));  $^1\text{H}$  NMR (360 MHz,  $\text{CD}_3\text{OD}$ ):  $\delta$ (ppm) 3.29–3.37 (m, 3H, H-3, H-4, H-5), 3.44 (t, 1H,  $J = 9.2$ , 9.2 Hz, H-2), 3.68 (dd, 1H,  $J = 4.0$ , 11.9 Hz, H-6b), 3.83–3.99 (m, 3H,  $\text{CH}_2$ , H-6a), 4.95 (d, 1H,  $J = 9.2$  Hz, H-1).  $^{13}\text{C}$  NMR (90 MHz,  $\text{D}_2\text{O}$ ):  $\delta$ (ppm) 52.8 ( $\text{CH}_2$ ), 62.6 (C-6), 71.2, 73.8, 78.8, 79.7 (C-2, C-3, C-4, C-5), 81.0 (C-1), 171.3 (CONH). Analysis: Calcd for  $\text{C}_8\text{H}_{14}\text{N}_4\text{O}_6$  (262.22): C, 36.64; H, 5.38; N, 21.37. Found: C, 36.73; H, 5.42; N, 21.25.

***N*-Glycyl- $\beta$ -D-glucopyranosylamine (40).** Prepared from **39** (0.097 g, 0.37 mmol) according to General procedure VII. Yield: 0.07 g, 79%, amorphous oil,  $R_f = 0.16$  (MeOH);  $[\alpha]_D = +34$  ( $c = 0.08$ , DMSO);  $^1\text{H}$  NMR (360 MHz,  $\text{CD}_3\text{OD}$ ):  $\delta$ (ppm) 3.48–3.61 (m, 6H, H-2, H-3, H-4, H-5,  $\text{CH}_2$ ), 3.76 (dd, 1H,  $J = 5.3$ , 11.9 Hz, H-6a), 3.90 (dd, 1H,  $J = 1.2$ , 11.9 Hz, H-6b), 5.04 (d, 1H,  $J = 9.2$  Hz, H-1).  $^{13}\text{C}$  NMR (90 MHz,

1 D<sub>2</sub>O):  $\delta$ (ppm) 44.1 (CH<sub>2</sub>), 62.6 (C-6), 69.8, 72.4, 77.1, 78.2 (C-2, C-3, C-4, C-5), 79.9 (C-1), 176.5 (CONH). Analysis: Calcd for C<sub>8</sub>H<sub>16</sub>N<sub>2</sub>O<sub>6</sub> (236.22): C, 40.68; H, 6.83; N, 11.86. Found: C, 40.75; H, 6.68; N, 11.79.

5 **N-(6-Azidohexanoyl)- $\beta$ -D-glucopyranosylamine (41)**. Prepared from **13** (0.50 g, 1.03 mmol) according to General procedure VI. The residue was purified by column chromatography (CHCl<sub>3</sub>-MeOH, 7:3). Yield: 0.31 g (97%) colourless oil,  $R_f$  = 0.66 (CHCl<sub>3</sub>-MeOH, 7:3);  $[\alpha]_D^{25}$  = +13 ( $c$  = 0.22, MeOH); <sup>1</sup>H NMR (360 MHz, MeOD):  $\delta$ (ppm) 1.42–1.49 (m, 2H, CH<sub>2</sub>), 1.60–1.72 (m, 4H, CH<sub>2</sub>), 2.25–2.32 (m, 2H, CH<sub>2</sub>), 3.36–3.24 (m, 5H, H-3, H-4, H-5, CH<sub>2</sub>), 3.44 (pseudo t, 1H,  $J$  = 7.9, 9.2 Hz, H-2), 3.69 (dd, 1H,  $J$  = 5.3, 11.9 Hz, H-6b), 3.85 (dd, 1H,  $J$  = 1.2, 11.9 Hz, H-6a), 4.92 (d, 1H,  $J$  = 7.9 Hz, H-1); <sup>13</sup>C NMR (90 MHz, MeOD):  $\delta$  (ppm) 26.0, 27.4, 29.6, 36.9, 52.3 (5  $\times$  CH<sub>2</sub>), 62.6 (C-6), 71.4, 73.9, 79.0, 79.5 (C-2, C-3, C-4, C-5), 80.9 (C-1), 177.0 (NHCO); Anal. calcd. for C<sub>12</sub>H<sub>22</sub>N<sub>4</sub>O<sub>6</sub> (318.33): C 45.28, H 6.97, N 17.60. Found: C 45.36, H 6.84, N 17.49.

25 **N-(6-Amino hexanoyl)- $\beta$ -D-glucopyranosylamine (42)**. Prepared from **41** (0.18 g 0.57 mmol) according to General procedure VII. Yield: 0.09 g (57%) colourless oil,  $R_f$  = 0.05 (MeOH);  $[\alpha]_D^{25}$  = +11 ( $c$  = 0.15, MeOH); <sup>1</sup>H NMR (360 MHz, MeOD):  $\delta$ (ppm) 1.34–1.38 (m, 2H, CH<sub>2</sub>), 1.47–1.51 (m, 2H, CH<sub>2</sub>), 1.60–1.64 (m, 2H, CH<sub>2</sub>), 2.21–2.27 (m, 2H, CH<sub>2</sub>), 2.62–2.68 (m, 2H, CH<sub>2</sub>), 3.23–3.35 (m, 3H, H-3, H-4, H-5), 3.38 (t, 1H,  $J$  = 7.9, 7.9 Hz, H-2), 3.62 (dd, 1H,  $J$  = 5.3, 11.9 Hz, H-6a), 3.81 (dd, 1H,  $J$  = 1.2, 11.9 Hz, H-6a), 4.84 (d, 1H,  $J$  = 7.9 Hz, H-1); <sup>13</sup>C NMR (MeOD, 90 MHz):  $\delta$  (ppm) 26.2, 27.4, 32.4, 36.9, 41.9 (5  $\times$  CH<sub>2</sub>), 62.7 (C-6), 71.4, 73.9, 79.0, 79.7 (C-2, C-3, C-4, C-5), 81.0 (C-1), 177.2 (NHCO). Anal. calcd. for C<sub>12</sub>H<sub>24</sub>N<sub>4</sub>O<sub>6</sub> (292.33): C 49.30, H 8.28, N 9.58. Found: C 49.36, H 8.18, N 9.45.

35 **1,4-Bis-[1-(2,6-tetra-*O*-acetyl- $\beta$ -D-glucopyranosylaminocarbonyl-methyl)-1*H*-1,3-triazol-4-yl]butane (44)**. Prepared from **12** (0.30 g 0.41 mmol) according to General procedure IVb. The residue was purified by column chromatography (EtOAc). Yield: 0.10 g, 89%, white crystalline product, mp 197–199 °C,  $[\alpha]_D^{25}$  = +35 ( $c$  = 0.20, DMSO); <sup>1</sup>H NMR (360 MHz, DMSO-*d*<sub>6</sub>):  $\delta$ (ppm) 1.64 (brs, 4H, 2  $\times$  CH<sub>2</sub>), 1.93, 1.95, 1.99, 2.00 (4s, 24H, 8  $\times$  OCOCH<sub>3</sub>), 2.65 (brs, 4H, 2  $\times$  CH<sub>2</sub>), 3.96–4.16 (m, 6H, 2  $\times$  H-5-Glc, 2  $\times$  H-6a-Glc, 2  $\times$  H-6b-Glc), 5.07 (brs, 4H, 2  $\times$  CH<sub>2</sub>), 4.86, 4.92, 5.34, 5.42 (4t, 8 H,  $J$  = 9.2, 9.2 Hz in each, 2 H-1-Glc, 2  $\times$  H-2-Glc, 2  $\times$  H-3-Glc, 2  $\times$  H-4-Glc), 7.78 (s, 2H, 2 triazole CH), 9.20 (d, 2H,  $J$  = 9.2 Hz, 2  $\times$  NH); <sup>13</sup>C NMR (90 MHz, DMSO-*d*<sub>6</sub>):  $\delta$ (ppm) 20.3, 20.5, (8  $\times$  OCOCH<sub>3</sub>), 24.7, 28.4, 51.3 (6  $\times$  CH<sub>2</sub>), 61.6 (2  $\times$  C-6-Glc), 67.7, 70.5, 72.1, 72.7 (2 C-2-Glc, 2  $\times$  C-3-Glc, 2  $\times$  C-4-Glc, 2  $\times$  C-5-Glc), 76.8 (2  $\times$  C-1-Glc), 123.4 (2 triazole C-5), 146.4 (2 triazole C-4), 166.4 (2  $\times$  CONH), 169.2, 169.3, 169.5, 170.0 (8  $\times$  OCOCH<sub>3</sub>). Anal. calcd. for C<sub>40</sub>H<sub>54</sub>N<sub>8</sub>O<sub>20</sub> (966.92): C, 49.69; H, 5.63; N, 11.59; Found: C, 49.59; H, 5.71; N, 11.67.

55 **1,4-Bis-[1-(2,6-tetra-*O*-acetyl- $\beta$ -D-glucopyranosylaminocarbonyl-pentyl)-1*H*-1,3-triazol-4-yl]butane (45)**. Prepared from **13** (0.20 g, 0.41 mmol) according to General procedure IVb.

The residue purified by column chromatography (EtOAc-MeOH, 95:5). Yield: 0.21 g, 96%, colourless oil,  $R_f$  = 0.32 (EtOAc);  $[\alpha]_D^{25}$  = +16 ( $c$  = 0.16, CHCl<sub>3</sub>); <sup>1</sup>H NMR (360 MHz, CDCl<sub>3</sub>):  $\delta$ (ppm) 1.16–1.30 (m, 4H, 2  $\times$  CH<sub>2</sub>), 1.62–1.74 (m, 4H, 2  $\times$  CH<sub>2</sub>), 1.85–1.91 (m, 4H, 2  $\times$  CH<sub>2</sub>), 2.01, 2.03, 2.04, 2.07 (4 s, 24H, 8  $\times$  OCOCH<sub>3</sub>), 2.18–2.22 (m, 4H, 2  $\times$  CH<sub>2</sub>), 2.52–2.56 (m, 2H, CH<sub>2</sub>), 2.72–2.76 (m, 4H, 2  $\times$  CH<sub>2</sub>), 3.84 (ddd, 2H,  $J$  = 1.1, 2.6, 10.6 Hz, 2  $\times$  H-5-Glc), 4.13–4.07 (m, 4H, 2  $\times$  CH<sub>2</sub>), 4.27–4.31 (m, 6H, 2  $\times$  H-6a-Glc, 2  $\times$  H-6b-Glc, CH<sub>2</sub>), 5.28, 5.24, 5.06, 4.93 (4 pseudo t, 8H,  $J$  = 9.2, 10.6 Hz in each, 2  $\times$  H-1-Glc, 2  $\times$  H-2-Glc, 2  $\times$  H-3-Glc, 2  $\times$  H-4-Glc), 6.57 (d, 2H,  $J$  = 7.9 Hz, 2  $\times$  NH), 7.34 (s, 2H, 2 triazole CH); <sup>13</sup>C NMR (90 MHz, CDCl<sub>3</sub>):  $\delta$  (ppm) 20.3, 20.4, (8  $\times$  OCOCH<sub>3</sub>), 24.1, 25.1, 25.7, 28.6, 29.7, 35.7, 49.5 (14  $\times$  CH<sub>2</sub>), 61.6 (2  $\times$  C-6-Glc), 68.0, 70.4, 72.7, 73.3 (2  $\times$  C-2-Glc, 2  $\times$  C-3-Glc, 2  $\times$  C-4-Glc, 2  $\times$  C-5-Glc), 77.8 (2  $\times$  C-1-Glc), 120.6 (2 triazole C-5), 147.7 (2 triazole C-4), 169.4, 169.6, 170.0, 170.4 (8  $\times$  OCOCH<sub>3</sub>), 172.9 (2  $\times$  NHCO). Anal. calcd. for C<sub>48</sub>H<sub>70</sub>N<sub>8</sub>O<sub>20</sub> (1079.13): C 53.43, H 6.54, N 10.38. Found: C 53.49, H 6.62, N 10.45.

25 **1,4-Bis-[1-(2,6-tetra-*O*-acetyl- $\beta$ -D-glucopyranosylaminocarbonyl-decyl)-1*H*-1,3-triazol-4-yl]butane (46)**. Prepared from **14** (0.20 g 0.36 mmol) according to General procedure IVb. The residue purified by column chromatography (EtOAc). Yield: 0.136 g, 62%, colourless oil;  $[\alpha]_D^{25}$  = +7 ( $c$  = 0.62, CHCl<sub>3</sub>); <sup>1</sup>H NMR (CDCl<sub>3</sub>, 90 MHz):  $\delta$  (ppm) 1.26 (brs, 24H, 12  $\times$  CH<sub>2</sub>), 1.56–1.59 (m, 4H, 2  $\times$  CH<sub>2</sub>), 1.73–1.78 (m, 4H, 2  $\times$  CH<sub>2</sub>), 1.85–1.89 (m, 4H, 2  $\times$  CH<sub>2</sub>), 2.02, 2.03, 2.04, 2.08 (4s, 24H, 8  $\times$  OCOCH<sub>3</sub>), 2.10–2.25 (m, 4H, 2  $\times$  CH<sub>2</sub>), 2.73–2.76 (m, 4H, 2  $\times$  CH<sub>2</sub>), 3.83 (m, 2H,  $J$  = 2.4, 4.3, 9.9 Hz, 2  $\times$  H-5-Glc), 4.08 (dd, 2H,  $J$  = 2.3, 12.3 Hz, 2  $\times$  H-6b-Glc), 4.27–4.34 (m, 6H, 2  $\times$  H-6a-Glc, 2  $\times$  CH<sub>2</sub>), 4.93, 5.06, 5.27, 5.31 (4 pseudo t, 8 H,  $J$  = 9.6, 9.9 Hz in each, 2  $\times$  H-1-Glc, 2  $\times$  H-2-Glc, 2  $\times$  H-3-Glc, 2  $\times$  H-4-Glc), 6.42 (d, 2H,  $J$  = 9.2 Hz, 2  $\times$  NH), 7.28 (s, 2H, 2 triazole CH); <sup>13</sup>C NMR (90 MHz, CDCl<sub>3</sub>):  $\delta$  (ppm) 20.4, 20.5, 20.6 (8  $\times$  OCOCH<sub>3</sub>), 25.0, 25.3, 26.3, 28.7, 28.8, 28.9, 29.0, 29.1, 29.2, 29.6, 30.2, 50.0, (24  $\times$  CH<sub>2</sub>), 61.6 (2  $\times$  C-6-Glc), 68.1, 70.5, 72.6, 73.4 (2 C-2-Glc, 2  $\times$  C-3-Glc, 2  $\times$  C-4-Glc, 2  $\times$  C-5-Glc), 78.0 (2  $\times$  C-1-Glc), 120.4 (2 triazole C-5), 147.8 (2 triazole C-4), 169.5, 169.8, 170.5, 170.8 (8  $\times$  OCOCH<sub>3</sub>), 173.4 (2  $\times$  CONH). Anal. calcd. for C<sub>58</sub>H<sub>90</sub>N<sub>8</sub>O<sub>20</sub> (1219.38): C, 57.13; H, 7.44; N, 9.19; Found: C, 57.22; H, 7.32; N, 9.30.

45 **1,4-Bis-[1-(2,6-tetra-*O*-acetyl- $\beta$ -D-glucopyranosylaminocarbonyl-pentadecyl)-1*H*-1,3-triazol-4-yl]butane (47)**. Prepared from **15** (0.30 g 0.41 mmol) according to General procedure IV. The residue purified by column chromatography (EtOAc). Yield: 0.28 g, 50%, white crystalline product, mp 144–146 °C;  $[\alpha]_D^{25}$  = +14 ( $c$  = 0.24, CHCl<sub>3</sub>); <sup>1</sup>H NMR (360 MHz, CDCl<sub>3</sub>):  $\delta$ (ppm) 1.20–1.35 (m, 26H, 13CH<sub>2</sub>), 1.40–1.50 (m, 8H, 2  $\times$  CH<sub>2</sub>), 1.60–1.77 (m, 8H, 2  $\times$  CH<sub>2</sub>), 1.82–1.90 (m, 8H, 2  $\times$  CH<sub>2</sub>), 2.02, 2.03, 2.05, 2.06 (4 s, 24H, 8  $\times$  OCOCH<sub>3</sub>), 2.32–2.27 (m, 2H, CH<sub>2</sub>), 2.60–2.52 (m, 4H, 2  $\times$  CH<sub>2</sub>), 2.73–2.80 (m, 2H, CH<sub>2</sub>), 3.70 (ddd, 2H,  $J$  = 1.1, 2.6, 10.6 Hz, 2  $\times$  H-5-Glc), 4.11–4.20 (m, 8H, 4 CH<sub>2</sub>), 4.37–4.44 (m, 4H, 2  $\times$  H-6a-Glc, 2  $\times$  H-6b-Glc), 4.94, 5.00, 5.11, 5.19 (4 pseudo t, 8H,  $J$  = 9.2, 10.6 Hz in each, 2  $\times$  H-1-Glc, 2  $\times$  H-2-Glc, 2  $\times$  H-3-Glc, 2  $\times$  H-4-Glc),

1 6.73 (d, 2H,  $J = 7.9$  Hz, 2 NH), 7.34 (s, 2H, 2 triazole CH);  $^{13}\text{C}$  NMR (90 MHz,  $\text{CDCl}_3$ ):  $\delta$  (ppm) 20.4, 20.5 (8  $\times$   $\text{OCOCH}_3$ ), 22.1, 22.5, 23.0, 23.6, 24.8, 25.1, 25.8, 26.1, 26.6, 27.0, 27.5, 29.8, 30.7, 31.7, 35.7, 36.7, 50.1 (32  $\times$   $\text{CH}_2$ ), 60.6 (2  $\times$  C-6-Glc), 69.3, 71.0, 72.0, 72.8 (2  $\times$  C-2-Glc, 2  $\times$  C-3-Glc, 2  $\times$  C-4-Glc, 2  $\times$  C-5-Glc), 77.6 (2  $\times$  C-1-Glc), 121.0 (2 triazole C-5), 146.6 (2 triazole C-4), 169.4, 169.6, 169.9, 170.1 (8  $\times$   $\text{OCOCH}_3$ ), 171.8 (2  $\times$   $\text{HHCO}$ ). Anal. calcd. for  $\text{C}_{68}\text{H}_{110}\text{N}_8\text{O}_{20}$  (1359.68): C, 60.07; H, 8.15; N, 8.24; Found: C, 60.16; H, 8.22; N, 8.33.

**Q10** **1,4-Bis-[1-( $\beta$ -D-glucopyranosylaminocarbonylmethyl)-1H-1,3-triazol-4-yl],2]butane (48).** Prepared from **44** (0.10 g, 0.10 mmol) according to General procedure VI. Yield: 0.042 g, 65%, white crystalline product, mp 235–236 °C,  $[\alpha]_{\text{D}} = 42$  ( $c = 0.22$ , DMSO);  $^1\text{H}$  NMR (360 MHz,  $\text{D}_2\text{O}$ ):  $\delta$  (ppm) 1.64 (brs, 4H, 2  $\times$   $\text{CH}_2$ ), 2.70 (brs, 4H, 2  $\times$   $\text{CH}_2$ ), 3.39–3.57 (8H, m, 2  $\times$  H-2-Glc, 2  $\times$  H-3-Glc, 2  $\times$  H-4-Glc, 2  $\times$  H-5-Glc), 3.71 (dd, 2H,  $J = 5.3$  11.9 Hz, 2  $\times$  H-6b-Glc), 5.01 (d, 2H,  $J = 9.2$  Hz, 2  $\times$  H-1-Glc), 3.85 (dd, 2H,  $J = <1$ , 11.9 Hz, 2  $\times$  H-6a-Glc), 5.24–5.27 (s, 4H, 2  $\times$   $\text{CH}_2$ ), 7.73 (s, 2H, triazole CH);  $^{13}\text{C}$  NMR (90 MHz, DMSO- $d_6$ ):  $\delta$  (ppm) 24.7, 28.4, 51.5 (6  $\times$   $\text{CH}_2$ ), 60.8 (2  $\times$  C-6-Glc), 69.9, 72.6, 77.3, 78.7 (2  $\times$  C-2-Glc, 2  $\times$  C-3-Glc, 2  $\times$  C-4-Glc, 2  $\times$  C-5-Glc), 79.7 (2  $\times$  C-1-Glc), 123.5 (2 triazole C-5), 146.5 (2 triazole C-4), 166.1 (2  $\times$   $\text{CONH}$ ). Anal. calcd. for  $\text{C}_{24}\text{H}_{38}\text{N}_8\text{O}_{12}$  (630.62): C, 45.71; H, 6.07; N, 17.77; Found: C, 45.80; H, 5.97; N, 17.54.

**1,4-Bis-[1-( $\beta$ -D-glucopyranosylaminocarbonylpentyl)-1H-1,3-triazol-4-yl],2]butane (49).** Prepared from **45** (0.21 g 0.19 mmol) according to General procedure VI. Yield: 0.09 g, 66%, white crystalline product, mp: 150–152 °C;  $[\alpha]_{\text{D}} = +14$  ( $c = 0.12$ , MeOH);  $^1\text{H}$  NMR (360 MHz,  $\text{D}_2\text{O}$ ):  $\delta$  (ppm) 1.20–1.25 (m, 4H, 2  $\times$   $\text{CH}_2$ ), 1.52–1.64 (m, 8H, 4  $\times$   $\text{CH}_2$ ), 1.80–1.88 (m, 4H, 2  $\times$   $\text{CH}_2$ ), 2.22–2.28 (m, 4H, 2  $\times$   $\text{CH}_2$ ), 2.66–2.70 (m, 4H, 2  $\times$   $\text{CH}_2$ ), 3.33–3.42 (m, 6H, 2  $\times$  H-3-Glc, 2  $\times$  H-4-Glc,  $\text{CH}_2$ ), 3.50 (ddd, 2H,  $J = 1.2, 5.3, 9.2$  Hz, 2  $\times$  H-5-Glc), 3.52 (t, 2H,  $J = 9.2, 9.2$  Hz, 2  $\times$  H-2-Glc), 3.70 (dd, 2H,  $J = 5.3, 11.9$  Hz, 2  $\times$  H-6b-Glc), 3.85 (dd, 2H,  $J = 1.2, 11.9$  Hz, 2  $\times$  H-6a-Glc), 4.31–4.37 (m, 4H, 2  $\times$   $\text{CH}_2$ ), 4.91 (d, 2H,  $J = 9.2$  Hz, 2  $\times$  H-1-Glc), 7.82 (s, 2H, 2 triazole CH);  $^{13}\text{C}$  NMR (90 MHz,  $\text{D}_2\text{O}$ ):  $\delta$  (ppm) 24.0, 24.1, 25.2, 27.8, 29.1, 35.6, 50.4 (14  $\times$   $\text{CH}_2$ ), 60.7 (2  $\times$  C-6-Glc), 69.4, 71.9, 76.7, 77.7 (2  $\times$  C-2-Glc, 2  $\times$  C-3-Glc, 2  $\times$  C-4-Glc, 2  $\times$  C-5-Glc), 79.4 (2  $\times$  C-1-Glc), 123.8 (2 triazole C-5), 146.2 (2 triazole C-4), 178.1 (2  $\times$   $\text{NHCO}$ ). Anal. calcd. for  $\text{C}_{32}\text{H}_{54}\text{N}_8\text{O}_{12}$  (742.83): C 51.74, H 7.33, N 15.08. Found: C 51.69, H 7.25, N 15.02.

**1,4-Bis-[1-( $\beta$ -D-glucopyranosylaminocarbonyldecyl)-1H-1,3-triazol-4-yl],2]butane (50).** Prepared from **46** (0.07 g, 0.06 mmol) according to General procedure VI. Precipitated from the reaction mixture. Yield: 0.048 g, 95%, white amorphous product;  $[\alpha]_{\text{D}} = +16$  ( $c = 0.37$ , DMSO);  $^1\text{H}$  NMR (360 MHz, DMSO- $d_6 + \text{D}_2\text{O}$ ):  $\delta$  (ppm) 1.20 (brs, 24H, 12  $\times$   $\text{CH}_2$ ), 1.45, 1.60, 1.75, 2.06, 2.60 (5 brs, 20H, 10  $\times$   $\text{CH}_2$ ), 3.00–3.19 (m, 8H, 2  $\times$  H-2-Glc, 2  $\times$  H-3-Glc, 2  $\times$  H-4-Glc, 2  $\times$  H-5-Glc), 3.38 (dd, 2H,  $J = 4.6, 11.6$  Hz, 2  $\times$  H-6b-Glc), 3.61 (dd, 2H,  $J < 1.0, 11.2$  Hz, 2  $\times$  H-6a-Glc), 4.23–4.27 (m, 4H, 2  $\times$   $\text{CH}_2$ ), 4.68 (d, 2H,  $J = 8.9$  Hz, 2  $\times$  H-1-Glc), 7.80 (s, 2H, 2 triazole CH);  $^{13}\text{C}$  NMR (90 MHz, DMSO- $d_6 + \text{D}_2\text{O}$ ):

$\delta$  (ppm) 24.8, 25.0, 25.9, 28.4, 28.5, 28.9, 29.7, 35.5, 49.2 (24  $\times$   $\text{CH}_2$ ), 60.9 (2  $\times$  C-6-Glc), 69.9, 72.3, 77.4, 78.4 (2  $\times$  C-2-Glc, 2  $\times$  C-3-Glc, 2  $\times$  C-4-Glc, 2  $\times$  C-5-Glc), 79.4 (2  $\times$  C-1-Glc), 121.7 (2 triazole C-5), 146.8 (2 triazole C-4), 173.0 (2  $\times$   $\text{CONH}$ ). Anal. calcd. for  $\text{C}_{42}\text{H}_{74}\text{N}_8\text{O}_{12}$  (883.08): C, 57.12; H, 8.45; N, 12.69; Found: C, 57.23; H, 8.56; N, 12.58.

**1,4-Bis-[1-( $\beta$ -D-glucopyranosylaminocarbonylpentadecyl)-1H-1,2,3-triazol-4-yl],2]butane (51).** Prepared from **47** (0.2 g, 0.147 mmol) according to General procedure VI. Yield: 0.12 g, 80%, white crystalline product, mp 158–160 °C;  $[\alpha]_{\text{D}} = +25$  ( $c = 0.20$ , MeOH);  $^1\text{H}$  NMR (360 MHz,  $\text{D}_2\text{O}$ ):  $\delta$  (ppm) 1.19–1.32 (m, 30H, 15  $\times$   $\text{CH}_2$ ), 1.49–1.70 (m, 4H, 2  $\times$   $\text{CH}_2$ ), 1.91–1.98 (m, 4H, 2  $\times$   $\text{CH}_2$ ), 2.18–2.38 (m, 8H, 4  $\times$   $\text{CH}_2$ ), 2.51–2.90 (m, 20H, 10  $\times$   $\text{CH}_2$ ), 3.32–3.39 (m, 4H, 2  $\times$  H-3-Glc, 2  $\times$  H-4-Glc), 3.45 (ddd, 2H,  $J = 1.2, 5.3, 9.2$  Hz, 2  $\times$  H-5-Glc), 3.49 (t, 2H,  $J = 9.2, 9.2$  Hz, 2  $\times$  H-2-Glc), 3.79 (dd, 2H,  $J = 5.3, 11.9$  Hz, 2  $\times$  H-6b-Glc), 3.87 (2H, dd,  $J = 1.2, 11.9$  Hz, 2  $\times$  H-6a-Glc), 4.41–4.47 (m, 4H, 2  $\times$   $\text{CH}_2$ ), 5.01 (d, 2H,  $J = 9.2$  Hz, 2  $\times$  H-1-Glc), 7.67 (s, 2H, 2 triazole CH);  $^{13}\text{C}$  NMR (90 MHz,  $\text{D}_2\text{O}$ ):  $\delta$  (ppm) 21.7, 22.9, 23.3, 24.1, 24.8, 25.3, 25.8, 27.1, 27.6, 28.1, 29.5, 31.2, 32.0, 33.1, 36.7, 37.4, 51.2 (34  $\times$   $\text{CH}_2$ ), 61.5 (2  $\times$  C-6-Glc), 69.0, 72.1, 76.3, 77.3 (2  $\times$  C-2-Glc, 2  $\times$  C-3-Glc, 2  $\times$  C-4-Glc, 2  $\times$  C-5-Glc), 78.1 (2  $\times$  C-1-Glc), 121.5 (2 triazole C-5), 146.5 (2 triazole C-4), 179.3 (2  $\times$   $\text{NHCO}$ ). Anal. calcd. for  $\text{C}_{52}\text{H}_{94}\text{N}_8\text{O}_{12}$  (1023.38): C, 61.06; H, 9.26; N, 10.95; Found: C, 61.13; H, 9.36; N, 10.88.

#### Enzyme assays

**(a) Against RMGP<sub>a</sub>.** The inhibitory activity of the prepared compounds against rabbit muscle glycogen phosphorylase a (RMGP<sub>a</sub>) was monitored using microplate reader (BIO-RAD) based on the published method.<sup>35</sup> In brief, GP<sub>a</sub> activity was measured in the direction of glycogen synthesis by the release of phosphate from glucose-1-phosphate. Each prepared compound was dissolved in DMSO and diluted to different concentrations for  $\text{IC}_{50}$  determination. The enzyme was added into 100  $\mu\text{L}$  of buffer containing 50 mM Hepes (pH = 7.2), 100 mM KCl, 2.5 mM  $\text{MgCl}_2$ , 0.5 mM glucose-1-phosphate, 1 mg/ml glycogen and the test compound in 96-well microplates (Costar). After the addition of 150  $\mu\text{L}$  of 1 M HCl containing 10 mg/ml ammonium molybdate and 0.38 mg/ml malachite green, reactions were run at 22 °C for 25 min, and then the phosphate absorbance was measured at 655 nm. The  $\text{IC}_{50}$  values were estimated by fitting the inhibition data to a dose-dependent curve using a logistic derivative equation.

**(b) Against RMGP<sub>b</sub>.** Glycogen phosphorylase b (RMGP<sub>b</sub>) was prepared from rabbit skeletal muscle according to the method of Fischer and Krebs,<sup>41</sup> using dithiothreitol instead of L-cysteine, and recrystallized at least three times before use. Kinetic experiments were performed in the direction of glycogen synthesis using RMGP<sub>b</sub> as described.<sup>36,42</sup>  $\text{IC}_{50}$  values were determined in the presence of 4 mM  $\alpha$ -D-glucose-1-phosphate, 1 mM AMP, 1% glycogen and varying concentrations of the inhibitor.<sup>43</sup> Inhibitors were dissolved in dimethyl sulfoxide (DMSO) and diluted in the assay buffer (50 mM triethanolamine, 1 mM EDTA and 1 mM dithiothreitol) so that the DMSO concentration in the assay should



1 be lower than 1%. The means of standard errors for all  
calculated kinetic parameters averaged to less than 10%.

## Acknowledgements

5 HBS thanks financial support by National Natural Science  
Foundation of China (Grants 30672523 and 90713037),  
research grants from Chinese Ministry of Education (Grants  
706030 and 20050316008) and the program for New Century  
10 Excellent Talents in University (NCET-05-0495). In Hungary  
this research was supported by the National Office for  
Research and Technology as well as the Hungarian Scientific  
Research Fund (Grants NI-61336, NK-68578, and  
CK-77712). The authors also thank NORT (Hungary, CHN-  
15 25/05) and the Program for Chinese–Hungarian Scientific and  
Technological Cooperation (China, No. CHN-7/2006) for  
supporting this bilateral R&D project.

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