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Synthesis of Sterically Congested Carbamates of Carbohydrates through Organic Base Catalysis

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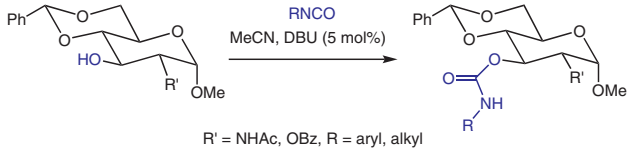

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Abstract 4,6-*O*-Benzylidene acetal protected α-methoxy D-glucose and D-glucosamine are useful building blocks for the syntheses of carbohydrate derivatives and functional molecular assemblies. In this research, we have developed a general method for the preparation of C-3 carbamate derivatives of densely functionalized glucose and glucosamine with isocyanates using organic bases as catalysts. Without a suitable catalyst, the C-3 hydroxy group of the glucosamine derivative could not be converted into the corresponding carbamates when treated with isocyanates. Several organic bases were screened as the catalysts for the reactions, and we discovered that 5.0 mol% of 1,8-diazabicyclo[5.4.0]undec-7-ene (DBU) was an effective catalyst for the carbamoylation reaction. A library of both alkyl and aryl carbamate derivatives of the two sterically congested carbohydrates have been effectively synthesized using the current method.

Key words carbamates, isocyanates, glucosamine, glucose, organocatalysis

Carbamates or urethanes make up an important class of compounds in pharmaceutics and for the preparation of polymeric materials.[1] Organic carbamates are essential functional groups of many biologically active compounds and pharmaceutics and they are also important synthetic intermediates.[2–7] Cyclic carbamates, such as oxazolidinones formed by glucosamine derivatives, have shown great applications in glycosylation reactions for carbohydrate synthesis.[8,9] The synthesis of carbamates typically involves reactions of alcohols with isocyanates or isocyanate precursors by using certain catalysts. Many methods have been developed using carboxylic acids or their derivatives as precursors through Hoffman or Curtius rearrangement reactions, to produce isocyanate intermediates *in situ*, and followed by addition of alcohols to form urethanes.[10–12] In recent years, precursors such as ureas have also been used to prepare these carbamates.[13] Carbonyldiimidazole (CDI) has been used as a convenient reagent for the carbonylation of amino alcohols to form carbamates.[14–16] Ethyl 1*H*-imidazole-1-carboxylate derived from CDI has been shown to selectively acylate indoles and oxazolidinones to form *N*-aryl carbamates.[17] CDI has also been used in Lossen's rearrangement of various hydroxamic acids to the corresponding isocyanate intermediates, which were then converted into carbamates.[18] The trichloroacetamide group has been converted into isocyanate *in situ*, followed by treatment with alcohols to afford the corresponding carbamates.[19] Trifluoroacetamide intermediates have been converted into cyclic carbamate oxazinanones as well.[20] Recently, carbon dioxide has been used as a carbonylation source under different conditions for the synthesis of carbamates.[21–23] 1,8-Diazabicyclo[5.4.0]undec-7-ene (DBU) is a versatile reagent that is useful for many synthetic applications.[24] Besides being an organic base, DBU also functions as a nucleophile and has been used as a nucleophilic catalyst for reactions of amines with CO_2 or carbonates to form various carbamate derivatives.[22,23,25]

The structures of several commonly used organic bases are shown in Figure 1. These include 4-(dimethylamino)pyridine (DMAP), 1,8-diazabicyclo[5.4.0]undec-7-ene (DBU), and 1,4-diazabicyclo[2.2.2]octane (DABCO). Among these three organic bases, DBU is the strongest organic base and it has a lower nucleophilicity than DABCO. The nucleophilicity order of these three bases is DMAP < DBU < DABCO; the basicity order is different: DABCO < DMAP < DBU.[26] These organic bases have been used for the synthesis of *N*-aryl carbamates from amines and carbonates, and it was found that DBU is moderately effective, but DMAP and DABCO were unable to catalyze the carbamate formation.[27] Both DBU and DABCO have been utilized as organocatalysts for the synthesis of polyurethane.[28,29] Other amidine and guanidine derivatives such as 1,5-diazabicyclo[4.3.0]non-5-ene

(DBN) and 1,5,7-triazabicyclo[4.4.0]dec-5-ene (TBD) have been shown to be effective organocatalysts for the synthesis of polyurethanes.[29]

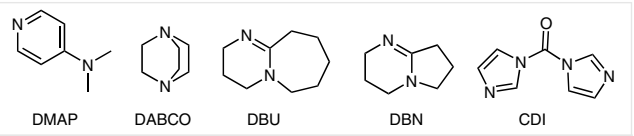
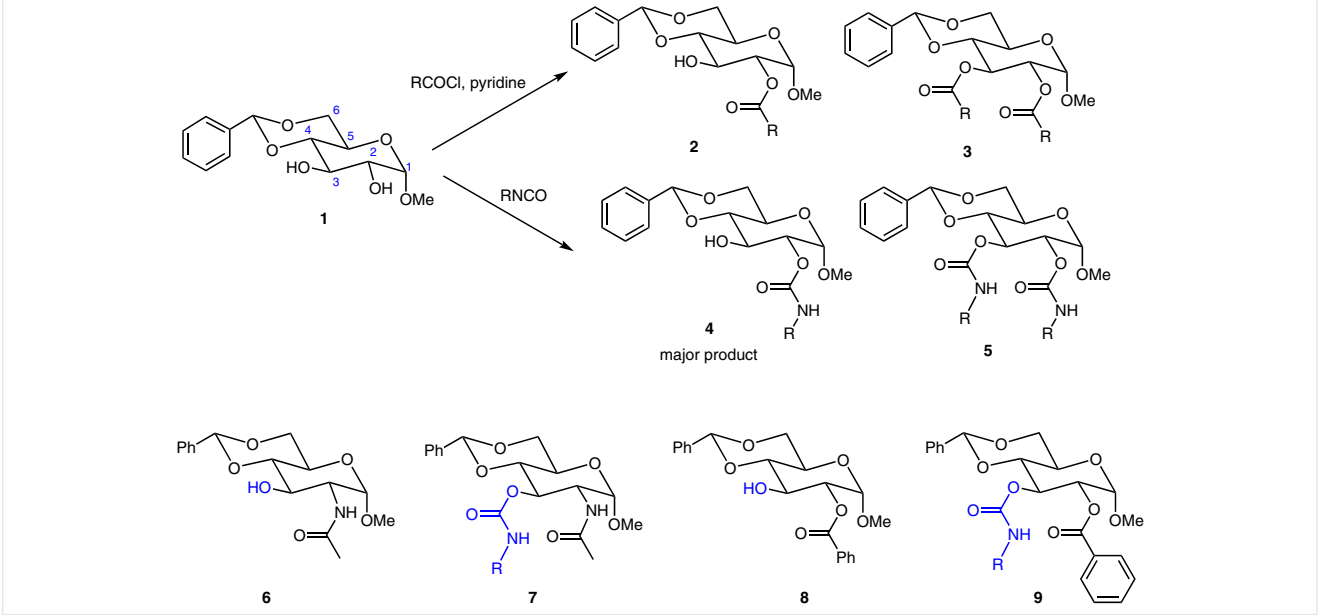


Figure 1 Structures of organic bases and reagents useful for carbamate formation

The preparation of carbamates from non-hindered alcohols and isocyanates is usually straightforward; in general, stirring the isocyanates and alcohols together with trimethylamine is sufficient to produce the carbamates in good yields. For hindered alcohols, such as *tert*-butyl alcohol and secondary isocyanates, the reactions typically have poor conversions and require higher temperatures or the use of organic bases or tin complexes as catalysts. In the course of the synthesis and study of monosaccharide-based self-assembling materials, we found that various carbamate derivatives are effective low-molecular-weight gelators.[30] As shown in Scheme 1, the 3-hydroxy groups of glucose or glucosamine derivatives are not as readily acylated or derivatized as the 2-hydroxy groups. When compound **1** is used as the starting material, esterification typically leads to the formation of 2-ester **2**, 2,3-diester **3**, and a small amount of 3-ester, with the 2-acyl derivative as the major product.[31,32] When isocyanate (1 equiv) is used as the reagent, the 2-carbamate **4** is obtained as the major product along with a small amount of dicarbamate **5**.[30] This indicates that the 3-hydroxy group of the glucose derivatives is more sterically hindered and less reactive in comparison to the 2-hydroxy group. For the acylation or carbamoylation of the 3-hydroxy group of the sugar derivative, more vigorous reaction conditions are typically required.

Because of the potential applications of carbamate derivatives as self-assembled functional materials and as useful synthetic intermediates for multistep synthesis and biologically active compounds, we are interested in developing general procedures that are effective for the introduction of the carbamate functional group to densely protected glucose and glucosamine derivatives. As shown in Scheme 1, we used the *N*-acetyl-D-glucosamine derivative **6** as the starting material to study its functionalization to afford 3-carbamate derivative **7**. To show the generality of the method, we also used a 2-benzoate glucose derivative **8** as the starting material to prepare the 3-carbamate derivative **9**.

To synthesize a variety of different carbamate derivatives of the highly functionalized monosugars with general structures of **7** and **9**, we studied the effectiveness of a few common organic bases as catalysts. Several alcohols were initially used as the substrates for the preparation of their corresponding carbamates with phenyl isocyanate in acetonitrile and by using DBU and DABCO as the catalysts. The structures of the alcohols and the screening results are included in the Supporting Information (SI; Table S1). Three alcohols were initially used as the substrates for the test reaction: triethylene glycol, decane-1,10-diol, and *tert*-butyl alcohol. As shown in the SI (Table S1), both DBU and DABCO (5 mol%) were effective at catalyzing the reactions to full conversion in 2 hours; the corresponding dicarbamates



Scheme 1 Selective acylation of 4,6-*O*-benzylidene methyl α-D-glucopyranoside and the structures of the targeted 3-carbamate sugar derivatives **7** and **9** and their precursors

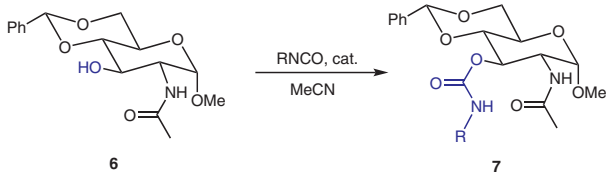
were obtained in excellent yields (~90%). We also tested the reaction of the tertiary alcohol *tert*-butyl alcohol with phenyl isocyanate, and the reactions also gave good yields. When phenyl isocyanate was changed to 4-methoxyphenyl isocyanate, the reactions required a longer time and the yields were also lower for both catalysts, DABCO giving 76% yield and DBU only giving 52% yield. For the reactions of benzyl alcohol with the secondary cyclohexyl isocyanate, good yields of the cyclohexyl carbamates were obtained when DBU (10 mol%) was used as the catalyst. The encouraging results for *tert*-butyl alcohol and cyclohexyl isocyanate when using DBU or DABCO indicated that similar conditions could be applied to sterically hindered sugar alcohols such as compounds **6** and **8**.

Several different reaction conditions were tested when using the *N*-acetyl glucosamine derivative **6** (Table 1). The full list of reactions screened for aliphatic isocyanates and phenyl isocyanate are shown in the SI (Tables S2 and S3). A few key entries are included in Table 1. Alkyl isocyanates were tested first in the presence of several different bases as the catalysts. For hexyl isocyanate, without catalyst or in the presence of either K_2CO_3 or DMAP at room temperature, no product formation resulted; when DBU (0.30 equiv) was used, the starting material was fully converted and the desired carbamate was obtained in 81% isolated yield. The lower isolated yield was possibly due to difficulties in removing the urea byproduct, and DBU may also affect product extraction into the organic phase. For benzyl isocyanate, the use of DMAP could only improve the conversion to 30% at higher temperature. For heptyl isocyanate, at room temperature in acetonitrile, none of the following bases afforded any product formation: triethylamine, DMAP, NMI, and K_2CO_3. When DMAP was used at 60 °C for 24 hours, only 25% conversion to carbamate **7** resulted. Only DBU was effective in catalyzing the reaction to full conversion and afforded the heptyl carbamate in 87% isolated yield.

As shown in Table 1 and in the SI (Table S3), phenyl isocyanate was significantly more reactive compared to the alkyl isocyanates. Without catalyst at r.t. and in the presence of DMAP (0.15 equiv) as catalyst in THF, no product was obtained. However, the use of DMAP as catalyst in acetonitrile led to full conversion in 5 hours. Several other organic bases besides DMAP were also screened. NMI only led to 20% conversion at 50 °C overnight; DABCO and hexamethylenetetramine (HMTA) were not effective either, leading to complex mixtures. DBN afforded better conversion; the use of DBN (0.10 equiv) at r.t. for 12 hours led to 60% conversion to the product. When DBU was used as the catalyst, the reaction afforded clean conversion to the desired product, similar to the alkyl carbamate synthesis.

Therefore, DBU was chosen as the main catalyst to be optimized for the reaction to synthesize sugar carbamate derivatives. Interestingly, we found that the order of reagent addition makes a big difference to the effectiveness of the carbamate synthesis. If DBU was added together with the alcohol and isocyanate, the reaction did not proceed to give full conversion with one equivalent PhNCO. The sugar alcohol **6** was added first followed by acetonitrile as the solvent and DBU (20 mol%) as the catalyst, and the mixture was stirred for 15–30 minutes. Then the phenyl isocyanate was added in two batches of 0.5 equivalent; this led to about 77% of the starting material being converted into the carbamate; adding one more equivalent of PhNCO afforded full conversion and an isolated yield of 81%. However, if the DBU catalyst was added later, after mixing of the isocyanate and alcohol for 15 minutes, typically the reaction with one equivalent of aryl isocyanate occurs readily within 1 hour to afford the desired carbamates in full conversion and more than 90% isolated yield. The optimum amount of DBU catalyst was also tested: 0.3, 0.2, 0.1, 0.05, and 0.02 equivalents of DBU were all effective in catalyzing the reaction to full conversion within 1 hour. The carbamate products were obtained in over 90% isolated yields when using 5.0 and 2.0 mol% of DBU, but further reduction of DBU to 1 mol% was

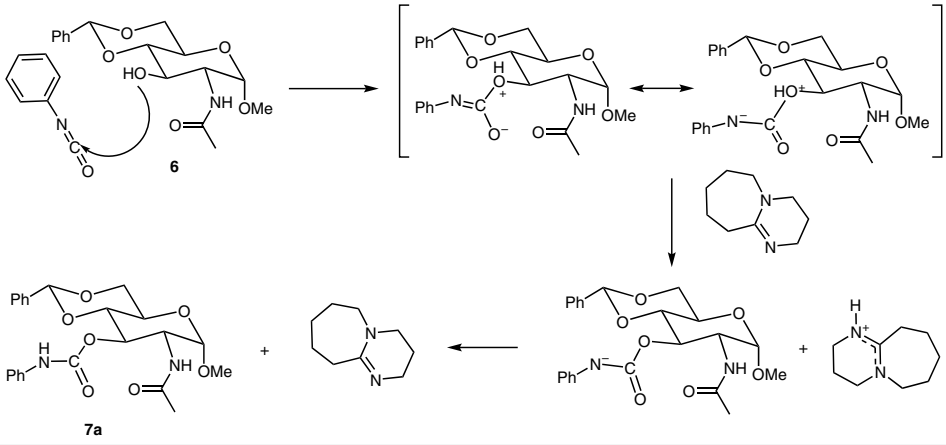
Table 1 Optimization of the Reaction Conditions for the Preparation of Carbamate Derivatives **7**[a]



6 7

Entry	Cat. (equiv)[b]	R	RNCO (equiv)	Temp, time[c]	Conversion (%)[d]
1	DMAP (0.10)	Bn	1.5	60 °C, 18 h	30
2	DBU (0.30)	Bn	1.5	r.t., 2 h	83
3	DMAP (0.20)	heptyl	1.5	60 °C, 24 h	31 (25)[e]
4	NMI (0.20)	heptyl	1.5	r.t., 12 h	NR[f]
5	**DBU (0.30)**	**heptyl**	**2.0**	**r.t., 2 h**	**87**
6	DMAP (0.15)	Ph	1.5	r.t., 5 h	100 (77)
7	NMI (0.10)	Ph	1.1	50 °C, 12 h	29 (20)
8	DBN (0.10)	Ph	1.5	r.t., 12 h	60
9	DBU (0.30)	Ph	1.1	r.t., 1 h	100
10	**DBU (0.05)**	**Ph**	**1.1**	**r.t., 1 h**	**100 (90)**
11	DBU (0.02)	Ph	1.1	r.t., 1 h	100 (93)

[a] Reaction conditions: **6** (75 mg, 0.232 mmol, 1 equiv), RNCO (1.0–2.0 equiv), cat. (0.02–0.30 equiv), anhyd MeCN (3 mL).
[b] DMAP = 4-(dimethylamino)pyridine; NMI = 1-methylimidazole; DBN = 1,5-diazabicyclo[4.3.0]non-5-ene; DBU = 1,8-diazabicyclo[5.4.0]undec-7-ene; DABCO = 1,4-diazabicyclo[2.2.2]octane.
[c] The reaction mixture was stirred at elevated temperature only after no reaction occurred at r.t. for 12 h.
[d] Conversion determined by ^{1}H NMR spectroscopy.
[e] Isolated yield given in parentheses.
[f] NR = no reaction.



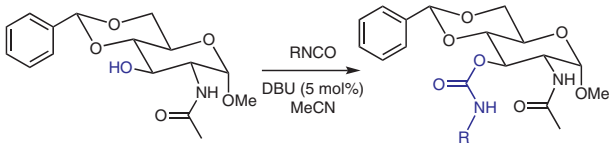
Scheme 2 Proposed mechanism of the reaction

not effective. On the basis of these findings, DBU (5.0 mol%) was selected as the catalyst for the synthesis of other carbamates.

The different reaction outcomes due to the order of reagent addition could possibly be rationalized. DBU is a strong base and when it is added first with the alcohol, it may deprotonate (or partially deprotonate) the 3-OH group and the 2-NHAc group. The deprotonation of the 3-OH should lead to product formation. On the other hand, deprotonation of NHAc or forming a hydrogen bond with the amide will hinder the reaction. Another possible reason is that DBU forms complexes with the isocyanates through nucleophilic attack; if the nucleophilic adduct is too stable, this will also hinder the formation of product. It has been shown that DBU can function both as a base and as a nucleophilic catalyst for carbamate synthesis; DBU can form a cyclic adduct with two equivalents of BnNCO.[28,29] However, if DBU is added later, it is more likely that it will function mainly as a base and not as a nucleophile (Scheme 2). The sugar alcohol **6** will react with the isocyanate first and form an unstable and reversible intermediate, so that adding DBU at this stage will accelerate the proton transfer of the intermediate leading to product formation. Since the intermediate is more acidic, DBU will function mostly as a base, and the amide will not interfere with the reaction. Further studies are necessary to confirm this hypothesis.

Using the optimized conditions and DBU as the catalyst, we synthesized a library of sugar carbamate derivatives as shown in Table 2. The majority of aryl isocyanates were converted smoothly into the desired product when 1.1 equivalents of the isocyanates were used (entries 1–3 and 5), except for 4-nitrophenyl isocyanate (entry 4). For this compound, only 35% conversion was observed when DBU (5 mol%) was used and after stirring for 1 hour; the addition of an extra 1 equivalent of isocyanate did not improve the conversion. However, the reaction proceeded in 78% conversion when DBU (10 mol%) and 4-nitrophenyl isocyanate (2 equiv) were used. The reason that the catalyst did not perform well with this substrate is probably due to the presence of the electron-withdrawing nitro group, which increases the electrophilicity of the isocyanate and makes it more reactive towards nucleophilic attack. The DBU catalyst probably acted more like a nucleophile and formed a stable complex with the isocyanate, which deactivates the catalyst. The presence of the 2-NHAc also affected the reaction significantly. Aliphatic isocyanates usually react slower than aryl isocyanates due to both steric and electronic fac-

Table 2 Synthesis of 3-*O*-Carbamates **7** of Glucosamine Derivatives[a]



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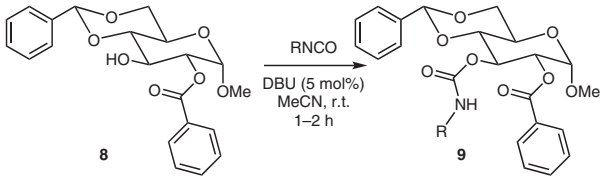
Entry	DBU (equiv)	R	RNCO (equiv)	Product	Conversion (%)[b]	Yield (%)
1	0.05	Ph	1.1	**7a**	100	90
2	0.05	4-MeOC$_6$H$_4$	1.1	**7b**	100	89
3	0.05	4-BrC$_6$H$_4$	1.5	**7c**	100	91
4	0.10	4-O$_2$NC$_6$H$_4$	2.0	**7d**	78	71
5	0.05	2-Naph	1.1	**7e**	100	87
6	0.05	Bn	1.1	**7f**	100	89
7	0.05	pentyl	2.1	**7g**	100	87
8	0.05	hexyl	2.1	**7h**	100	89
9	0.05	heptyl	2.1	**7i**	100	86
10	–[c]	Cy	2.5	**7j**	100	86

[a] Reaction conditions: **6** (1 equiv), RNCO, DBU, MeCN.
[b] Conversion determined by ^{1}H NMR spectroscopy.
[c] DABCO (0.40 equiv) used instead of DBU.

tors. Benzyl isocyanate (1.1 equiv) and linear alkyl isocyanates (2.0 equiv) reacted smoothly with the sugar derivative **6** when using 5.0 mol% DBU as the catalyst. The secondary cyclohexyl isocyanate was very sluggish under the same conditions; DBU (5 mol%) with CyNCO (1 equiv) at room temperature gave only 33% conversion, and no further conversion was observed with additional catalyst and isocyanate at higher temperature. DABCO, on the other hand, produced satisfactory results, leading to the corresponding carbamate in 86% isolated yield (entry 10).

To test the generality of the method, the glucose-derived benzoate **8** was subjected to similar reaction conditions using DBU (5 mol%) as catalyst. Unlike the reactions of glucosamine derivative **6**, the reactions with the 2-benzoyl glucose derivative **8** proceeded smoothly to the corresponding carbamate derivatives in excellent yields. As shown in Table 3, DBU (5.0 mol%) was sufficient for catalyzing the reaction, and typically the reactions with the isocyanates (1.1 equiv) occurred readily in 1–2 hours at room temperature to afford the desired carbamates in full conversion and more than 90% isolated yield. Both aromatic and aliphatic isocyanates were converted smoothly into the desired carbamates, including cyclohexyl isocyanate and 4-nitrophenyl isocyanate. The reactivity difference in the two sugar derivatives is interesting and this is useful for further selectively functionalization on different sugars.

Table 3 Synthesis of 3-Carbamates of Benzoate-Protected Glucose Derivatives **9**[a]



8 9

100% conversion for all RNCO listed based on ^{1}H NMR spectra

Entry	R	Product	Yield (%)
1[b]	Ph	**9a**	0
2	Ph	**9a**	90
3	4-MeOC$_6$H$_4$	**9b**	85
4	4-BrC$_6$H$_4$	**9c**	86
5	4-O$_2$NC$_6$H$_4$	**9d**	85
6	2-Naph	**9e**	84
7	Bn	**9f**	87
8[c]	pentyl	**9g**	87
9	hexyl	**9h**	87
10	heptyl	**9i**	89
11	Cy	**9j**	90

[a] Reaction conditions: **8** (1 equiv), RNCO (1.1 equiv), DBU (0.05 equiv), MeCN, r.t., 1–2 h.
[b] No DBU used.
[c] RNCO (2.1 equiv) used.

In an attempt to account for the reactivity differences between the two sugar alcohols, we carried out a molecular modeling study for the structures of the two compounds by using Chem3D. The energy-minimized conformations of compounds **6** and **8** are shown in Figure 2. In compound **6**, the amide NH group forms an intramolecular hydrogen bond with the anomeric oxygen with an estimated bond length of 2.33 Å; this leads to a more rigid steric environment for the formation of alkyl carbamates at the 3-position. The amide NH may also participate in hydrogen bonding with DBU and isocyanate. The 3-hydroxy group in compound **6** also forms a hydrogen bond with the 4-oxygen, with a bond length of 2.45 Å; the estimated pK_a value of compound **6** is 12.6. In comparison, the 3-OH of the glucose derivative **8** forms a stronger hydrogen bond with the carbonyl group of the 2-benzonate with a bond length of 1.89 Å, and a pK_a value of 12.4, which is slightly more acidic than that of compound **6**. The difference in the acidity and hydrogen bonding patterns in the two molecules could account for their reactivity differences with isocyanates. The glucosamine derivative **6** was more sluggish in the reactions with isocyanates due to the reduced nucleophilicity of the 3-hydroxy group and the 2-NHAc group interfering with the reaction.

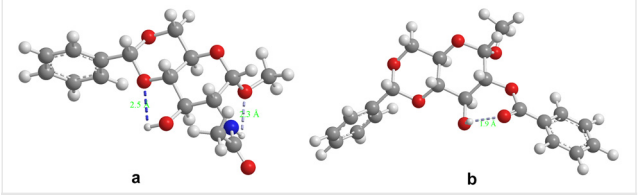
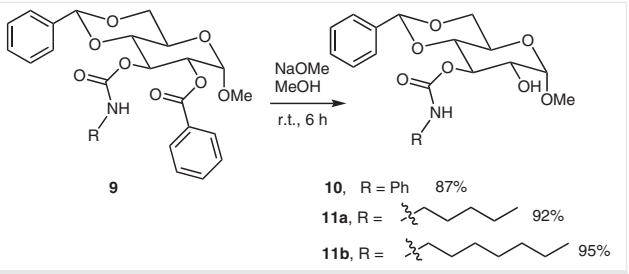


Figure 2 The energy-minimized structures of compounds **6** (a) and **8** (b)

The facile synthesis of 3-*O*-carbamates from the 2-*O*-benzoate of glucose derivative **8** allows us to access a class of useful hydrogelators and organogelators. The 2-benzoate can be selectively removed in the presence of the carbamate with sodium methoxide and methanol, leading to the mono-3-carbamate glucose derivatives. As a proof of the method, we selected compounds **9a**, **9g**, and **9i** and treated them with NaOMe in methanol (Scheme 3). The benzoyl group was removed selectively to afford the corresponding 3-carbamate derivatives **10** and **11**. The 3-pentyl and 3-heptyl carbamate derivatives **11a** and **11b** were previously found to be effective gelators,[32] and they were synthesized by reacting the diol **1** with pentyl and heptyl isocyanate, respectively, in a one-pot reaction, as the minor products. Due to the lengthy chromatography required for the isolation of the 2-*O*-carbamate and 3-*O*-carbamate products, the one-pot method was only suitable for compound screening, but not for scaling up the 3-carbamates to practical quantities. In contrast, the current method affords products **11a** and **11b** in excellent yields in two steps, as shown in

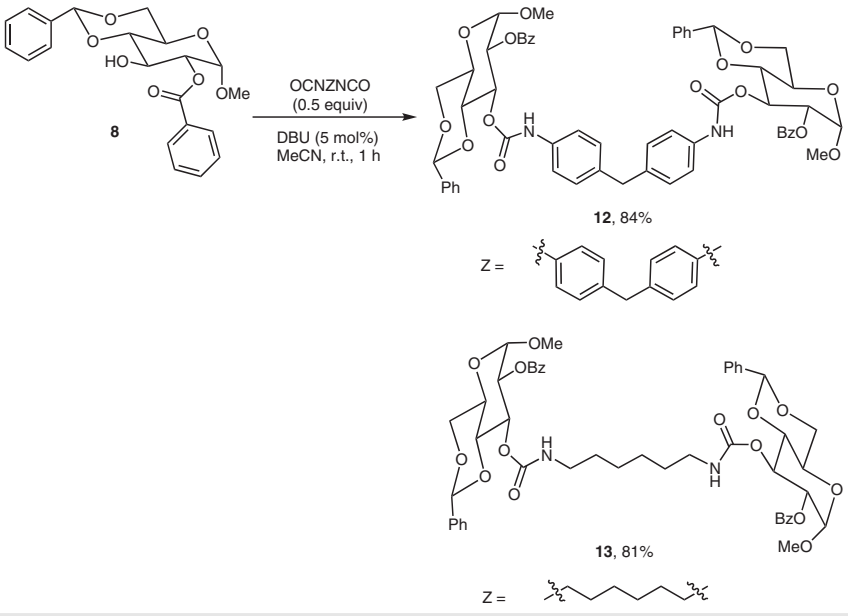
Scheme 3. Since 3-*O*-carbamate **9** can be synthesized in high yields and the deprotection reaction also proceeds in quantitative conversion to the 3-*O*-carbamate **10** as the only product, this method can be used for the effective synthesis of carbohydrate derivatives containing 2-hydroxy-3-*O*-carbamate functional groups in higher yields with more straightforward purifications.



Scheme 3 Debenzoylation reaction to synthesize the 3-carbamate derivatives

To expand the scope of the carbamate syntheses, bis-isocyanates were used to react with the corresponding glucose 2-*O*-benzoate **8** to synthesize several dimeric carbamates. As shown in Scheme 4, for both an alkyl and an aryl isocyanate, the reactions proceeded in excellent yields to produce the corresponding dimeric carbamates **12** and **13**. This can be expected because of the excellent conversion obtained for the monomeric carbamates. This type of bis-urethanes have shown numerous applications, for instance, 4,4′-methylenebis(*p*-phenyl isocyanate) and 1,6-diisocyanatohexane have been used for the preparation of thermoplastic medical polyurethanes,[33,34] and the bis-carbamates prepared from 1,6-diisocyanatohexane have shown applications as organogelators as well.[35,36] We therefore expect that the sugar based bis-urethanes will also have interesting material properties.

We have synthesized a library of sterically congested carbamate derivatives from protected glucose and glucosamine. These sugar derivatives contain a 4,6-*O*-benzylidene acetal protective group and the 2-position is acetylated or benzoylated and only the 3-OH is unfunctionalized. The syntheses of the carbamates were carried out by using DBU (5.0 mol%) as the organocatalyst. For the glucose group, the corresponding carbamates were obtained effectively in about one hour in quantitative conversions; dimeric carbamates were also synthesized in excellent isolated yields. The method is useful since only a catalytic amount of DBU was used and the reaction can tolerate steric hindrance in the substrates. When the *N*-acetyl-D-glucosamine derivative is used as the substrate, typically two equivalents of alkyl isocyanate were required for full conversion into the corresponding carbamates. We also showed that the benzoate protective group at the C-2 position could be removed selectively to afford the 3-carbamate derivatives in excellent yields. The self-assembling properties of these carbamoyl carbohydrates are currently being investigated and will be reported in due course. A carbamate function introduced at a specific position on carbohydrates could affect the outcome of glycosylation reactions and has applications in carbohydrate synthesis. The synthesis of these sugar derivatives by a feasible and practical method provides an easy access to regioselective functionalization of glucose or glucosamine derivatives. In addition, the method developed



Scheme 4 Synthesis of dimeric carbamate glucose derivatives **12** and **13**

should be applicable to other sterically hindered systems and more complex compounds that require mild carbamoylation conditions.

Reagents and solvents were used as received from the suppliers. All purifications were conducted by flash chromatography using 230–400 mesh silica gel obtained from Natland International Corporation. ^{1}H NMR and proton-decoupled ^{13}C NMR spectra were obtained on Bruker 400 MHz spectrometers of samples in DMSO-d_6 or $CDCl_3$. The chemical shifts were reported by using $CDCl_3$/DMSO-d_6 as internal standard at δ = 7.26/2.50 (^{1}H NMR) and at δ = 77.00/39.50 (^{13}C NMR), respectively. 2D NMR experiments (HSQC, COSY) were also conducted on a 400 MHz Bruker NMR spectrometer to assist the ^{1}H and ^{13}C signal assignment. Melting point measurements were carried out by using a Fisher Jones melting point apparatus. The molecular mass was measured by using LCMS on an Agilent 6120B Single Quad Mass spectrometer and LC1260 system with ESI in positive ionization mode. Screening reactions for triethylene glycol, decane-1,10-diol, *tert*-butyl alcohol, and benzyl alcohol with isocyanates and the ^{1}H and ^{13}C NMR spectra of all intermediates and final products are provided in the Supporting Information (SI).

Carbamate Derivatives 7; General Procedure

Compound **6** (75 mg, 0.232 mmol, 1 equiv) and anhyd MeCN (3 mL) were added to a 50 mL round-bottom flask, followed by the appropriate isocyanate. The reaction mixture was stirred for 15 min at r.t., after which DBU (5.0 mol%; 0.05 mL of a 1 mL stock solution in anhyd MeCN containing 1 equiv DBU) was added to the reaction mixture. The mixture was stirred at r.t. for 1 h, after which the ^{1}H NMR spectrum showed full conversion. The mixture was concentrated using a rotavap under vacuum and the residue was treated with H_2O (5.0 mL) and extracted with EtOAc (3 × 20 mL). The combined organic phase was dried over anhyd Na_2SO_4. The solvent was removed using a rotavap to afford the crude product, which was purified by flash chromatography (silica gel, 100% hexanes to 60% EtOAc/hexanes). All compounds **7a–j** were synthesized by the same method unless otherwise noted.

Methyl 2-Acetamido-4,6-*O*-benzylidene-2-deoxy-3-*O*-(phenylcarbamoyl)-α-D-glucopyranoside (7a)

Phenyl isocyanate (0.028 mL, 0.255 mmol, 1.1 equiv) was used.

Yield: 90 mg (90%); R_f = 0.3 (60% EtOAc/hexanes); white solid; mp 241.0–243.0 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.50–7.46 (m, 2 H), 7.35–7.30 (m, 3 H), 7.29–7.21 (m, 4 H), 7.07–6.99 (m, 1 H), 6.87 (s, 1 H, NHPh), 6.19 (d, *J* = 9.4 Hz, 1 H, NHAc), 5.57 (s, 1 H), 5.32 (t, *J* = 10.0 Hz, 1 H, H-3), 4.79 (d, *J* = 3.6 Hz, 1 H, H-1), 4.47–4.40 (m, 1 H, H-2), 4.34 (dd, *J* = 10.2, 4.7 Hz, 1 H, H-6$_a$), 4.01–3.93 (m, 1 H, H-5), 3.84 (t, *J* = 10.2 Hz, 1 H, H-6$_b$), 3.78 (t, *J* = 10.2 Hz, 1 H, H-4), 3.46 (s, 3 H), 1.97 (s, 3 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 170.6, 153.3, 137.5, 136.8, 129.2, 128.9, 128.2, 126.3, 123.5, 118.7, 101.9, 99.2 (*C*-1), 79.3 (*C*-4), 71.1 (*C*-3), 69.0 (*C*-6), 63.0 (*C*-5), 55.4 (OCH_3), 52.9 (*C*-2), 23.2.

LC-MS (ESI+): *m*/*z* [M + H]$^+$ calcd for $C_{23}H_{27}N_2O_7$: 443.2; found: 443.2.

Methyl 2-Acetamido-4,6-*O*-benzylidene-2-deoxy-3-*O*-(4-methoxyphenylcarbamoyl)-α-D-glucopyranoside (7b)

4-Methoxyphenyl isocyanate (0.029 mL, 0.255 mmol, 1.1 equiv) was used.

Yield: 97 mg (89%); R_f = 0.3 (60% EtOAc/hexanes); white solid; mp 238.0–240.0 °C.

^{1}H NMR (400 MHz, DMSO-d_6): δ = 9.45 (s, 1 H, NHAr), 8.00 (d, *J* = 9.4 Hz, 1 H, NHAc), 7.40–7.29 (m, 7 H), 6.86–6.80 (m, 2 H), 5.65 (s, 1 H), 5.15 (t, *J* = 9.9 Hz, 1 H, H-3), 4.69 (d, *J* = 3.5 Hz, 1 H, H-1), 4.28–4.19 (m, 2 H, H-6$_a$, H-2), 3.89–3.73 (m, 3 H, H-6$_b$, H-4, H-5), 3.69 (s, 3 H, ArOCH_3), 3.38 (s, 3 H, OCH_3), 1.81 (s, 3 H).

^{13}C NMR (100 MHz, DMSO-d_6): δ = 169.6, 154.8, 153.1, 137.3, 132.0, 128.9, 128.0, 126.0, 119.8, 113.9, 100.4, 98.9 (*C*-1), 79.2 (*C*-4), 69.6 (*C*-3), 67.8 (*C*-6), 62.7 (*C*-5), 55.1 (ArOCH_3), 55.0 (OCH_3), 51.7 (*C*-2), 22.3.

LC-MS (ESI+): *m*/*z* [M + H]$^+$ calcd for $C_{24}H_{29}N_2O_8$: 473.2; found: 473.2.

Methyl 2-Acetamido-4,6-*O*-benzylidene-3-*O*-(4-bromophenylcarbamoyl)-2-deoxy-α-D-glucopyranoside (7c)

4-Bromophenyl isocyanate (46 mg, 0.232 mmol, 1 equiv) was added first. The ^{1}H NMR spectrum showed only 70% conversion after 1 h stirring. Then more 4-bromophenyl isocyanate (23 mg, 0.116 mmol, 0.5 equiv) was added and the mixture was stirred for another 1 h at r.t. The ^{1}H NMR spectrum showed full conversion.

Yield: 109 mg (91%); R_f = 0.4 (60% EtOAc/hexanes); white solid, mp 235.0–237.0 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.48–7.42 (m, 2 H), 7.35–7.28 (m, 5 H), 7.13 (d, *J* = 8.9 Hz, 2 H), 6.86 (s, 1 H, NHAr), 6.10 (d, *J* = 9.4 Hz, 1 H, NHAc), 5.54 (s, 1 H, PhC*H*), 5.26 (t, *J* = 10.0 Hz, H-3), 4.75 (d, *J* = 3.6 Hz, 1 H, H-1), 4.45–4.37 (m, 1 H, H-2), 4.32 (dd, *J* = 10.3, 4.7 Hz, 1 H, H-6$_a$), 3.98–3.90 (m, 1 H, H-5), 3.38 (t, *J* = 10.3 Hz, 1 H, H-6$_b$), 3.75 (t, *J* = 10.0 Hz, 1 H, H-4), 3.44 (s, 3 H, OCH_3), 1.94 (s, 3 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 170.5, 153.1, 136.8, 136.6, 131.9, 129.2, 128.3, 126.3, 120.2, 116.1, 102.0 (PhCH), 99.2 (C-1), 79.2 (C-4), 71.4 (C-3), 68.9 (C-6), 62.9 (C-5), 55.5 (OCH_3), 52.7 (C-2), 23.2.

LC-MS (ESI+): *m*/*z* [M + H]$^+$ calcd for $C_{23}H_{26}N_2O_7Br$: 521.1; found: 521.0.

Methyl 2-Acetamido-4,6-*O*-benzylidene-2-deoxy-3-*O*-(4-nitrophenylcarbamoyl)-α-D-glucopyranoside (7d)

4-Nitrophenyl isocyanate (38 mg, 0.232 mmol, 1 equiv) was added first. Then DBU (0.023 mmol, 0.1 equiv) was added to the mixture. The ^{1}H NMR spectrum showed only 50% conversion after 1 h stirring. More 4-nitrophenyl isocyanate (38 mg, 0.232 mmol, 1 equiv) was then added and the mixture was stirred for another 1 h at r.t. The ^{1}H NMR spectrum showed 78% conversion.

Yield: 80 mg (71%); R_f = 0.25 (60% EtOAc/hexanes); yellow solid; mp 241.0–243.0 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.02 (d, *J* = 9.2 Hz, 2 H), 7.95 (s, 1 H, NHAr), 7.46–7.40 (m, 2 H), 7.33 (d, *J* = 9.2 Hz, 2 H), 7.28–7.23 (m, 3 H), 6.25 (d, *J* = 9.6 Hz, 1 H, NHAc), 5.54 (s, 1 H, PhC*H*), 5.29 (t, *J* = 10.1 Hz, 1 H, H-3), 4.76 (d, *J* = 3.6 Hz, 1 H, H-1), 4.50–4.43 (m, 1 H, H-2), 4.34 (dd, *J* = 10.3, 4.8 Hz, 1 H, H-6$_a$), 4.00–3.92 (m, 1 H, H-5), 3.86–3.75 (m, 2 H, H-6$_b$, H-4), 3.46 (s, 3 H, OCH_3), 1.95 (s, 3 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 170.6, 152.8, 143.8, 142.9, 136.6, 129.4, 128.3, 126.3, 124.8, 117.6, 102.1 (PhCH), 99.2 (C-1), 79.3 (C-4), 71.9 (C-3), 68.9 (C-6), 62.9 (C-5), 55.5 (OCH_3), 52.5 (C-2), 23.2.

LC-MS (ESI+): *m*/*z* [M + H]$^+$ calcd for $C_{23}H_{26}N_3O_9$: 488.2; found: 488.2.

Methyl 2-Acetamido-4,6-*O*-benzylidene-2-deoxy-3-*O*-(1-naphthylcarbamoyl)-α-D-glucopyranoside (7e)

1-Naphthyl isocyanate (0.036 mL, 0.255 mmol, 1.1 equiv) was used.

Yield: 99 mg (87%); R_f = 0.3 (60% EtOAc/hexanes); white solid; mp 263.0–265.0 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.88–7.65 (m, 4 H), 7.52–7.42 (m, 5 H), 7.38–7.32 (m, 3 H), 7.02 (s, 1 H, NHAr), 6.04 (d, *J* = 9.4 Hz, 1 H, NHAc), 5.57 (s, 1 H, PhCH), 5.34 (t, *J* = 10.1 Hz, H-3), 4.78 (d, *J* = 3.6 Hz, 1 H, H-1), 4.47–4.38 (m, 1 H, H-2), 4.32 (dd, *J* = 10.1, 4.7 Hz, 1 H, H-6_a), 3.98–3.90 (m, 1 H, H-5), 3.86–3.74 (m, 2 H, H-6_b, H-4), 3.43 (s, 3 H, OCH_3), 1.95 (s, 3 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 170.4, 154.5, 137.0, 134.1, 132.1, 129.1, 128.6, 128.3, 126.4, 126.3, 126.1, 125.6, 120.7, 101.7 (PhCH), 99.2 (C-1), 79.2 (C-4), 71.6 (C-3), 69.0 (C-6), 63.0 (C-5), 55.4 (OCH_3), 52.9 (C-2), 23.3.

LC-MS (ESI+): *m*/*z* [M + H]$^+$ calcd for $C_{27}H_{29}N_2O_7$: 493.2; found: 493.2.

Methyl 2-Acetamido-3-*O*-(benzylcarbamoyl)-4,6-*O*-benzylidene-2-deoxy-α-D-glucopyranoside (7f)

Benzyl isocyanate (0.032 mL, 0.255 mmol, 1.1 equiv) was added.

Yield: 94 mg (89%); R_f = 0.3 (60% EtOAc/hexanes); white solid; mp 244.0–246.0 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.50–7.43 (m, 2 H), 7.38–7.33 (m, 3 H), 7.25–7.19 (m, 5 H), 6.00 (d, *J* = 9.0 Hz, 1 H, NHAc), 5.52 (s, 1 H), 5.22 (t, *J* = 10.1 Hz, 1 H, H-3), 5.16 (t, *J* = 5.9 Hz, 1 H, $PhCH_2NH$), 4.74 (d, *J* = 3.5 Hz, 1 H, H-1), 4.41–4.24 (m, 4 H, $PhCH_2NH$, H-2, H-6_a), 3.94–3.85 (m, 1 H, H-5), 3.78 (t, *J* = 10.2 Hz, 1 H, H-6_b), 3.68 (t, *J* = 9.5 Hz, 1 H, H-4), 3.40 (s, 3 H, OCH_3), 1.89 (s, 3 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 170.2, 156.6, 138.2, 137.1, 129.1, 128.6, 128.2, 127.4, 127.2, 126.3, 101.7, 99.1 (C-1), 79.3 (C-4), 71.0 (C-3), 68.9 (C-6), 62.9 (C-5), 55.3 (OCH_3), 53.0 (C-2), 45.0 ($PhCH_2NH$), 23.1.

LC-MS (ESI+): *m*/*z* [M + H]$^+$ calcd for $C_{24}H_{29}N_2O_7$: 457.2; found: 457.2.

Methyl 2-Acetamido-4,6-*O*-benzylidene-2-deoxy-3-*O*-(pentylcarbamoyl)-α-D-glucopyranoside (7g)

Pentyl isocyanate (0.033 mL, 0.255 mmol, 1.1 equiv) was added first. The ^{1}H NMR spectrum showed only 40% conversion after 1 h stirring. More pentyl isocyanate (0.030 mL, 0.232 mmol, 1 equiv) was then added and the mixture was stirred for another 1 h at r.t., after which the ^{1}H NMR spectrum showed 100% conversion.

Yield: 88 mg (87%); R_f = 0.3 (60% EtOAc/hexanes); white solid; mp 222.0–224.0 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.50–7.43 (m, 2 H), 7.38–7.31 (m, 3 H), 6.05 (d, *J* = 8.9 Hz, 1 H, NHAc), 5.52 (s, 1 H), 5.17 (t, *J* = 10.0 Hz, 1 H, H-3), 4.85–4.70 (m, 2 H, H-1, CH_2NH), 4.33–4.20 (m, 2 H, H-2, H-6_a), 3.93–3.83 (m, 1 H, H-5), 3.78 (t, *J* = 10.2 Hz, 1 H, H-6_b), 3.66 (t, *J* = 9.5 Hz, 1 H, H-4), 3.39 (s, 3 H, OCH_3), 3.22–3.05 (m, 2 H, CH_2NH), 1.97 (s, 3 H), 1.51–1.39 (m, 2 H), 1.34–1.17 (m, 4 H), 0.87 (t, *J* = 6.8 Hz, 3 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 170.2, 156.5, 137.1, 129.1, 128.2, 126.3, 101.6, 99.1 (C-1), 79.3 (C-4), 70.6 (C-3), 69.0 (C-6), 62.9 (C-5), 55.3 (OCH_3), 53.2 (C-2), 41.1 (CH_2NH), 29.5, 28.8, 23.2, 22.3, 13.9.

LC-MS (ESI+): *m*/*z* [M + H]$^+$ calcd for $C_{22}H_{33}N_2O_7$: 437.2; found: 437.2.

Methyl 2-Acetamido-4,6-*O*-benzylidene-2-deoxy-3-*O*-(hexylcarbamoyl)-α-D-glucopyranoside (7h)

Hexyl isocyanate (0.038 mL, 0.255 mmol, 1.1 equiv) was added first. The ^{1}H NMR spectrum showed 53% conversion after 1 h stirring, and more hexyl isocyanate (0.030 mL, 0.232 mmol, 1 equiv) was then added to the mixture, which was stirred for another 1 h at r.t. The ^{1}H NMR spectrum showed 100% conversion.

Yield: 93 mg (89%); R_f = 0.3 (60% EtOAc/hexanes); white solid; mp 204.0–206.0 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.48–7.44 (m, 2 H), 7.37–7.32 (m, 3 H), 6.05 (d, *J* = 8.9 Hz, 1 H, NH), 5.52 (s, 1 H), 5.17 (t, *J* = 10.1 Hz, 1 H, H-3), 4.80–4.72 (m, 2 H, NH, H-1), 4.32–4.21 (m, 2 H, H-6_a, H-2), 3.92–3.84 (m, 1 H, H-5), 3.78 (t, *J* = 10.2 Hz, 1 H, H-6_b), 3.66 (t, *J* = 9.5 Hz, 1 H, H-4), 3.39 (s, 3 H, OCH_3), 3.20–3.05 (m, 2 H, $NHCH_2$), 1.97 (s, 3 H), 1.49–1.40 (m, 2 H), 1.31–1.20 (m, 6 H), 0.86 (t, *J* = 6.9 Hz, 3 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 170.2, 156.5, 137.1, 129.1, 128.2, 126.3, 101.6, 99.1 (C-1), 79.3 (C-4), 70.6 (C-3), 69.0 (C-6), 62.9 (C-5), 55.3 (OCH_3), 53.2 (C-2), 41.1 ($NHCH_2CH_2$), 31.4, 29.8 ($NHCH_2CH_2$), 26.3, 23.2, 22.5, 14.0.

LC-MS (ESI+): *m*/*z* [M + H]$^+$ calcd for $C_{23}H_{35}N_2O_7$: 451.2; found: 451.2.

Methyl 2-Acetamido-4,6-*O*-benzylidene-2-deoxy-3-*O*-(heptylcarbamoyl)-α-D-glucopyranoside (7i)

Heptyl isocyanate (0.040 mL, 0.255 mmol, 1.1 equiv) was added first. The ^{1}H NMR spectrum showed 60% conversion after 1 h, so that more heptyl isocyanate (0.036 mL, 0.232 mmol, 1 equiv) was added and the mixture was stirred for another 1 h at r.t. The ^{1}H NMR spectrum showed 100% conversion.

Yield: 93 mg (86%); R_f = 0.4 (60% EtOAc/hexane); white solid; mp 194.0–196.0 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.48–7.44 (m, 2 H), 7.37–7.32 (m, 3 H), 6.05 (d, *J* = 9.0 Hz, 1 H, NHAc), 5.52 (s, 1 H), 5.17 (t, *J* = 10.0 Hz, 1 H, H-3), 4.81–4.72 (m, 2 H, H-1, CH_2NH), 4.32–4.21 (m, 2 H, H-2, H-6_a), 3.92–3.84 (m, 1 H, H-5), 3.78 (t, *J* = 10.2 Hz, 1 H, H-6_b), 3.66 (t, *J* = 9.5 Hz, 1 H, H-4), 3.40 (s, 3 H, OCH_3), 3.22–3.04 (m, 2 H, CH_2NH), 1.97 (s, 3 H), 1.50–1.40 (m, 2 H), 1.33–1.17 (m, 8 H), 0.86 (t, *J* = 6.9 Hz, 3 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 170.2, 156.5, 137.1, 129.1, 128.2, 126.3, 101.6, 99.1 (C-1), 79.3 (C-4), 70.6 (C-3), 69.0 (C-6), 62.9 (C-5), 55.3 (OCH_3), 53.2 (C-2), 41.1 (CH_2NH), 31.7, 29.8, 28.9, 26.6, 23.2, 22.6, 14.0.

LC-MS (ESI+): *m*/*z* [M + H]$^+$ calcd for $C_{24}H_{37}N_2O_7$: 465.2; found: 465.2.

Methyl 2-Acetamido-4,6-*O*-benzylidene-3-*O*-(cyclohexylcarbamoyl)-2-deoxy-α-D-glucopyranoside (7j)

Cyclohexyl isocyanate (0.045 mL, 0.348 mmol, 1.5 equiv) was added first, followed by DABCO (10.4 mg, 0.093 mmol, 0.4 equiv). The reaction mixture was stirred for 1 h at r.t., after which the ^{1}H NMR spectrum showed 0% conversion. The reaction mixture was then refluxed for 20 h, after which the ^{1}H NMR spectrum showed 78% conversion. Additional cyclohexyl isocyanate (0.030 mL, 0.232 mmol, 1.0 equiv) was then added and the mixture was refluxed for another 5 h; this time the ^{1}H NMR spectrum showed 94% conversion.

Yield: 89 mg (86%); R_f = 0.4 (60% EtOAc/hexanes); white solid; mp 236.0–238.0 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.49–7.43 (m, 2 H), 7.38–7.32 (m, 3 H), 6.06 (d, *J* = 8.6 Hz, 1 H, NHAc), 5.52 (s, 1 H), 5.16 (t, *J* = 10.0 Hz, 1 H, H-3), 4.78–4.66 (m, 2 H, H-1, CyNH), 4.31–4.21 (m, 2 H, H-2, H-6_a), 3.92–3.84 (m, 1 H, H-5), 3.78 (t, *J* = 10.2 Hz, 1 H, H-6_b), 3.65 (t, *J* = 9.2 Hz, 1 H, H-4), 3.47–3.36 (m, 4 H, CH in cyclohexyl, OCH_3), 1.97 (s, 3 H), 1.94–1.02 (m, 10 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 170.2, 155.6, 137.1, 129.1, 128.2, 126.3, 101.6, 99.1 (C-1), 79.3 (C-4), 70.4 (C-3), 69.0 (C-6), 62.9 (C-5), 55.3 (OCH_3), 53.2 (C-2), 50.0 (CH in cyclohexyl), 33.2, 32.9, 25.4, 24.7, 24.6, 23.3.

LC-MS (ESI+): *m*/*z* [M + H]$^+$ calcd for $C_{23}H_{33}N_2O_7$: 449.2; found: 449.2.

Carbamates 9 from Protected Glucose 8; General Procedure

Compound **8** (45 mg or 75 mg, 1 equiv) and anhyd MeCN (3 mL) were added to a 50 mL round-bottom flask, followed by the appropriate isocyanate (1.1 equiv). The mixture was stirred for 15 min at r.t., then DBU (5.0 mol%; 0.05 mL of a 1 mL stock solution in anhyd MeCN containing 1 equiv DBU) was added to the reaction mixture. The resulting mixture was stirred at r.t. for 1 h, after which the ^{1}H NMR spectrum showed full conversion. The mixture was concentrated using a rotavap under vacuum and the residue was treated with H_2O (5.0 mL) and extracted with EtOAc (3 × 20 mL). The combined organic phase was dried over anhyd Na_2SO_4. The solvent was removed using a rotavap to afford the crude product, which was purified by flash chromatography (silica gel, 100% hexanes to 60% EtOAc/hexanes). All compounds **9a–j** were synthesized by the same method unless otherwise noted.

Methyl 2-*O*-Benzoyl-4,6-*O*-benzylidene-3-*O*-(phenylcarbamoyl)-α-D-glucopyranoside (9a)

Compound **8** (45 mg, 0.116 mmol, 1 equiv) and phenyl isocyanate (0.016 mL, 0.128 mmol, 1.1 equiv) were used.

Yield: 52 mg (90%); R_f = 0.2 (20% EtOAc/hexanes); white solid; mp 156.0–158.0 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.10–8.04 (m, 2 H), 7.56–7.44 (m, 3 H), 7.42–7.27 (m, 7 H), 7.25–7.20 (m, 2 H), 7.05–6.98 (m, 1 H), 6.56 (s, 1 H, N*H*Ar), 5.77 (t, *J* = 9.8 Hz, 1 H, H-3), 5.56 (s, 1 H, PhC*H*), 5.17–5.08 (m, 2 H, H-1, H-2), 4.36 (dd, *J* = 10.3, 4.9 Hz, 1 H, H-6_a), 4.09–4.00 (m, 1 H, H-5), 3.84 (t, *J* = 10.3 Hz, 1 H, H-6_b), 3.78 (t, *J* = 9.8 Hz, 1 H, H-4), 3.42 (s, 3 H, OCH_3).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 166.2, 152.3, 137.5, 136.9, 133.5, 130.1, 129.1, 128.9, 128.5, 128.2, 126.3, 123.5, 118.8, 101.8 (PhCH), 97.9 (C-1), 79.3 (C-4), 72.8 (C-2), 70.1 (C-3), 68.9 (C-6), 62.6 (C-5), 55.5 (OCH$_3$).

LC-MS (ESI+): *m*/*z* [M + H]$^+$ calcd for $C_{28}H_{28}NO_8$: 506.2; found: 506.2.

Methyl 2-*O*-Benzoyl-4,6-*O*-benzylidene-3-*O*-(4-methoxyphenylcarbamoyl)-α-D-glucopyranoside (9b)

Compound **8** (45 mg, 0.116 mmol, 1 equiv) and 4-methoxyphenyl isocyanate (0.017 mL, 0.128 mmol, 1.1 equiv) were used.

Yield: 53 mg (85%); R_f = 0.3 (25% EtOAc/hexanes); white solid; mp 192.0–194.0 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.10–8.05 (m, 2 H), 7.57–7.51 (m, 1 H), 7.50–7.45 (m, 2 H), 7.44–7.38 (m, 2 H), 7.37–7.32 (m, 3 H), 7.16 (d, *J* = 8.8 Hz, 2 H), 6.80–6.75 (m, 2 H), 6.40 (s, 1 H, N*H*Ar), 5.75 (t, *J* = 9.8 Hz, 1 H, H-3), 5.56 (s, 1 H, PhC*H*), 5.14 (d, *J* = 3.7 Hz, 1 H, H-1), 5.12–5.07 (m, 1 H, H-2), 4.35 (dd, *J* = 10.2, 4.8 Hz, 1 H, H-6_a), 4.07–3.99 (m, 1 H, H-5), 3.87–3.73 (m, 5 H, H-6_b, H-4, ArOCH_3), 3.42 (s, 3 H, OCH_3).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 166.2, 156.1, 152.7, 136.9, 133.5, 130.6, 130.1, 129.2, 129.1, 128.5, 128.2, 126.3, 120.9, 114.1, 101.8 (PhCH), 97.9 (C-1), 79.4 (C-4), 72.8 (C-2), 70.1 (C-3), 69.0 (C-6), 62.6 (C-5), 55.50 (OCH$_3$), 55.47 (ArOCH$_3$).

LC-MS (ESI+): *m*/*z* [M + H]$^+$ calcd for $C_{29}H_{30}NO_9$: 536.2; found: 536.2.

Methyl 2-*O*-Benzoyl-4,6-*O*-benzylidene-3-*O*-(4-bromophenylcarbamoyl)-α-D-glucopyranoside (9c)

Compound **8** (75 mg, 0.202 mmol, 1 equiv) and 4-bromophenyl isocyanate (44 mg, 0.222 mmol, 1.1 equiv) were used.

Yield: 101 mg (86%); R_f = 0.5 (25% EtOAc/hexanes); white solid; mp 100.0–102.0 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.08–8.04 (m, 2 H), 7.57–7.52 (m, 1 H), 7.46–7.37 (m, 4 H), 7.32–7.26 (m, 5 H), 7.12–7.06 (m, 2 H), 6.60 (s, 1 H, N*H*), 5.75 (t, *J* = 9.4 Hz, 1 H, H-3), 5.55 (s, 1 H, PhC*H*), 5.15–5.10 (m, 2 H, H-1, H-2), 4.36 (dd, *J* = 10.3, 4.8 Hz, 1 H, H-6_a), 4.08–4.01 (m, 1 H, H-5), 3.85 (t, *J* = 10.3 Hz, 1 H, H-6_b), 3.78 (t, *J* = 9.4 Hz, 1 H, H-4), 3.43 (s, 3 H, OCH_3).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 166.2, 152.1, 136.7, 136.6, 133.6, 131.8, 130.0, 129.2, 129.0, 128.5, 128.2, 126.3, 120.3, 116.0, 101.9 (PhCH), 97.9 (C-1), 79.3 (C-4), 72.6 (C-2), 70.4 (C-3), 68.9 (C-6), 62.6 (C-5), 55.6 (OCH$_3$).

LC-MS (ESI+): *m*/*z* [M + H]$^+$ calcd for $C_{28}H_{27}BrNO_8Br$: 584.1; found: 584.1.

Methyl 2-*O*-Benzoyl-4,6-*O*-benzylidene-3-*O*-(4-nitrophenylcarbamoyl)-α-D-glucopyranoside (9d)

Compound **8** (75 mg, 0.202 mmol, 1 equiv) and 4-nitrophenyl isocyanate (36 mg, 0.222 mmol, 1.1 equiv) were used.

Yield: 94 mg (85%); R_f = 0.25 (25% EtOAc/hexanes); off-white solid; mp 111.0–113.0 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.08–8.00 (m, 4 H), 7.58–7.51 (m, 1 H), 7.44–7.37 (m, 4 H), 7.31–7.27 (m, 2 H), 7.24–7.18 (m, 3 H), 7.03 (s, 1 H, N*H*), 5.78 (t, *J* = 9.7 Hz, 1 H, H-3), 5.55 (s, 1 H, PhC*H*), 5.20–5.13 (m, 2 H, H-2, H-1), 4.38 (dd, *J* = 10.4, 4.8 Hz, 1 H, H-6_a), 4.12–4.04 (m, 1 H, H-5), 3.91–3.79 (m, 2 H, H-6_b, H-4), 3.46 (s, 3 H, OCH_3).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 166.1, 151.6, 143.3, 143.0, 136.5, 133.7, 130.0, 129.3, 128.9, 128.6, 128.3, 126.3, 124.8, 117.8, 102.1 (PhCH), 97.9 (C-1), 79.3 (C-4), 72.4 (C-2), 70.9 (C-3), 68.9 (C-6), 62.5 (C-5), 55.6 (OCH$_3$).

LC-MS (ESI+): *m*/*z* [M + H]$^+$ calcd for $C_{28}H_{27}N_2O_{10}$: 551.2; found: 551.2.

Methyl 2-*O*-Benzoyl-4,6-*O*-benzylidene-3-*O*-(1-naphthylcarbamoyl)-α-D-glucopyranoside (9e)

Compound **8** (75 mg, 0.202 mmol, 1 equiv) and 1-naphthyl isocyanate (0.033 mL, 0.222 mmol, 1.1 equiv) were added.

Yield: 94 mg (84%); R_f = 0.5 (25% EtOAc/hexanes); white solid; mp 93.0–95.0 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.14–8.09 (m, 2 H), 7.82–7.78 (m, 1 H), 7.69–7.62 (m, 3 H), 7.54–7.49 (m, 3 H), 7.42–7.33 (m, 7 H), 7.26–7.22 (m, 1 H), 6.83 (s, 1 H, N*H*), 5.83 (t, *J* = 9.6 Hz, 1 H, H-3), 5.59 (s, 1 H, PhC*H*), 5.18–5.11 (m, 2 H, H-1, H-2), 4.36 (dd, *J* = 10.2, 4.8 Hz, 1 H, H-6_a), 4.10–4.01 (m, 1 H, H-5), 3.89–3.76 (m, 2 H, H-6_b, H-4), 3.43 (s, 3 H, OCH_3).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 166.2, 153.5, 137.0, 134.0, 133.5, 132.2, 130.1, 129.14, 129.07, 128.5, 128.2, 126.3, 126.1, 125.9, 125.6, 120.7, 101.7 (PhCH), 97.9 (C-1), 79.3 (C-4), 72.7 (C-2), 70.5 (C-3), 68.9 (C-6), 62.6 (C-5), 55.5 (OCH$_3$).

LC-MS (ESI+): *m*/*z* [M + H]$^+$ calcd for $C_{32}H_{30}NO_8$: 556.2; found: 556.2.

Methyl 2-*O*-Benzoyl-3-*O*-(benzylcarbamoyl)-4,6-*O*-benzylidene-α-D-glucopyranoside (9f)

Compound **8** (75 mg, 0.202 mmol, 1 equiv) and benzyl isocyanate (0.030 mL, 0.222 mmol, 1.1 equiv) were used.

Yield: 91 mg (87%); R_f = 0.6 (40% EtOAc/hexanes); white solid; mp 62.0–64.0 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.14–8.07 (m, 2 H), 7.63–7.57 (m, 1 H), 7.53–7.43 (m, 4 H), 7.40–7.35 (m, 3 H), 7.17–7.10 (m, 1 H), 7.09–7.00 (m, 4 H), 5.73 (t, *J* = 9.8 Hz, 1 H, H-3), 5.55 (s, 1 H, PhC*H*), 5.13–5.03

(m, 2 H, H-1, H-2), 4.92 (t, *J* = 5.6 Hz, 1 H, N*H*), 4.37–4.21 (m, 3 H, H-6_a, PhCH_2), 4.06–3.97 (m, 1 H, H-5), 3.81 (t, *J* = 10.3 Hz, 1 H, H-6_b), 3.72 (t, *J* = 9.8 Hz, 1 H, H-4), 3.41 (s, 3 H, OCH_3).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 166.1, 155.5, 138.3, 137.1, 133.4, 130.1, 129.3, 129.1, 128.5, 128.4, 128.2, 127.22, 127.18, 126.3, 101.7 (PhCH), 97.9 (C-1), 79.5 (C-4), 72.7 (C-2), 70.0 (C-3), 69.0 (C-6), 62.5 (C-5), 55.5 (OCH_3), 45.0 (PhCH_2).

LC-MS (ESI+): *m*/*z* [M + H]$^+$ calcd for $C_{29}H_{30}NO_8$: 520.2; found: 520.2.

Methyl 2-*O*-Benzoyl-4,6-*O*-benzylidene-3-*O*-(pentylcarbamoyl)-α-D-glucopyranoside (9g)

Compound **8** (45 mg, 0.116 mmol, 1 equiv) and pentyl isocyanate (0.017 mL, 0.128 mmol, 1.1 equiv) were added first. The ^{1}H NMR spectrum showed 55% conversion after 1 h stirring. Additional pentyl isocyanate (0.015 mL, 0.116 mmol, 1 equiv) was added and the mixture was stirred for another 1 h at r.t., at which time the ^{1}H NMR spectrum showed 100% conversion.

Yield: 49 mg (87%); R_f = 0.3 (20% EtOAc/hexanes); colorless solid; mp 75.0–77.0 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.12–8.06 (m, 2 H), 7.60–7.54 (m, 1 H), 7.51–7.42 (m, 4 H), 7.39–7.33 (m, 3 H), 5.66 (t, *J* = 9.8 Hz, 1 H, H-3), 5.54 (s, 1 H, PhC*H*), 5.09 (d, *J* = 3.6 Hz, 1 H, H-1), 5.07–5.00 (m, 1 H, H-2), 4.58 (s, 1 H, N*H*CH_2), 4.33 (dd, *J* = 10.3, 4.8 Hz, 1 H, H-6_a), 4.05–3.96 (m, 1 H, H-5), 3.81 (t, *J* = 10.3 Hz, 1 H, H-6_b), 3.70 (t, *J* = 9.8 Hz, 1 H, H-4), 3.40 (s, 3 H, OCH_3), 3.11–2.98 (m, 2 H, NHCH_2), 1.34–1.24 (m, 2 H), 1.21–1.06 (m, 4 H), 0.75 (t, *J* = 6.8 Hz, 3 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 166.2, 155.3, 137.0, 133.4, 130.1, 129.3, 129.0, 128.4, 128.2, 126.3, 101.7 (PhCH), 97.9 (C-1), 79.5 (C-4), 72.9 (C-2), 69.6 (C-3), 68.9 (C-6), 62.6 (C-5), 55.4 (OCH_3), 41.0 (NHCH_2), 29.4, 28.6, 22.1, 13.8.

LC-MS (ESI+): *m*/*z* [M + H]$^+$ calcd for $C_{27}H_{34}NO_8$: 500.2; found: 500.2.

Methyl 2-*O*-Benzoyl-4,6-*O*-benzylidene-3-*O*-(hexylcarbamoyl)-α-D-glucopyranoside (9h)

Compound **8** (45 mg, 0.116 mmol, 1 equiv) and hexyl isocyanate (0.019 mL, 0.128 mmol, 1.1 equiv) were added.

Yield: 52 mg (87%); wax-like solid; R_f = 0.35 (20% EtOAc/hexanes).

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.11–8.06 (m, 2 H), 7.60–7.54 (m, 1 H), 7.52–7.42 (m, 4 H), 7.39–7.32 (m, 3 H), 5.67 (t, *J* = 9.7 Hz, 1 H, H-3), 5.54 (s, 1 H, PhC*H*), 5.09 (d, *J* = 3.6 Hz, 1 H, H-1), 5.07–5.01 (m, 1 H, H-2), 4.58 (s, 1 H, N*H*CH_2), 4.33 (dd, *J* = 10.2, 4.8 Hz, 1 H, H-6_a), 4.04–3.96 (m, 1 H, H-5), 3.81 (t, *J* = 10.3 Hz, 1 H, H-6_b), 3.70 (t, *J* = 9.7 Hz, 1 H, H-4), 3.40 (s, 3 H, OCH_3), 3.11–2.96 (m, 2 H, NHCH_2), 1.35–1.23 (m, 2 H), 1.20–1.03 (m, 6 H), 0.79 (t, *J* = 6.8 Hz, 3 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 166.2, 155.3, 137.1, 133.4, 130.1, 129.3, 129.0, 128.4, 128.2, 126.3, 101.7 (PhCH), 97.9 (C-1), 79.5 (C-4), 72.9 (C-2), 69.6 (C-3), 69.0 (C-6), 62.6 (C-5), 55.4 (OCH_3), 41.0 (NHCH_2), 31.3, 29.7, 26.2, 22.4, 13.9.

LC-MS (ESI+): *m*/*z* [M + H]$^+$ calcd for $C_{28}H_{36}NO_8$: 514.2; found: 514.2.

Methyl 2-*O*-Benzoyl-4,6-*O*-benzylidene-3-*O*-(heptylcarbamoyl)-α-D-glucopyranoside (9i)

Compound **8** (75 mg, 0.202 mmol, 1 equiv) and heptyl isocyanate (0.036 mL, 0.222 mmol, 1.1 equiv) were added.

Yield: 95 mg (89%); wax-like solid; R_f = 0.6 (25% EtOAc/hexanes).

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.11–8.06 (m, 2 H), 7.59–7.54 (m, 1 H), 7.50–7.42 (m, 4 H), 7.37–7.31 (m, 3 H), 5.66 (t, *J* = 9.7 Hz, 1 H, H-3), 5.54 (s, 1 H, PhC*H*), 5.10 (d, *J* = 3.6 Hz, 1 H, H-1), 5.07–5.01 (m, 1 H, H-2), 4.65–4.58 (m, 1 H, N*H*), 4.33 (dd, *J* = 10.2, 4.8 Hz, 1 H, H-6_a), 4.05–3.96 (m, 1 H, H-5), 3.81 (t, *J* = 10.2 Hz, 1 H, H-6_b), 3.71 (t, *J* = 9.7 Hz, 1 H, H-4), 3.40 (s, 3 H, OCH_3), 3.08–2.95 (m, 2 H, NHCH_2), 1.31–1.16 (m, 4 H), 1.13–1.03 (m, 6 H), 0.83 (t, *J* = 7.2 Hz, 3 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 166.2, 155.3, 137.0, 133.4, 130.1, 129.3, 129.0, 128.4, 128.2, 126.3, 101.7 (PhCH), 97.9 (C-1), 79.4 (C-4), 72.9 (C-2), 69.6 (C-3), 68.9 (C-6), 62.6 (C-5), 55.4 (OCH_3), 41.0 (NHCH_2), 31.6, 29.7, 28.8, 26.5, 22.5, 14.0.

LC-MS (ESI+): *m*/*z* [M + H]$^+$ calcd for $C_{29}H_{38}NO_8$: 528.3; found: 528.3.

Methyl 2-*O*-Benzoyl-4,6-*O*-benzylidene-3-*O*-(cyclohexylcarbamoyl)-α-D-glucopyranoside (9j)

Compound **8** (75 mg, 0.202 mmol, 1 equiv) and cyclohexyl isocyanate (0.029 mL, 0.222 mmol, 1.1 equiv) were added.

Yield: 93 mg (90%); R_f = 0.5 (25% EtOAc/hexanes); white solid; mp 82.0–84.0 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.11–8.07 (m, 2 H), 7.59–7.54 (m, 1 H), 7.51–7.41 (m, 4 H), 7.38–7.32 (m, 3 H), 5.66 (t, *J* = 9.8 Hz, 1 H, H-3), 5.54 (s, 1 H, PhC*H*), 5.10 (d, *J* = 3.7 Hz, 1 H, H-1), 5.08–5.00 (m, 1 H, H-2), 4.55–4.45 (m, 1 H, N*H*CH), 4.33 (dd, *J* = 10.3, 4.8 Hz, 1 H, H-6_a), 4.04–3.96 (m, 1 H, H-5), 3.81 (t, *J* = 10.3 Hz, 1 H, H-6_b), 3.70 (t, *J* = 9.8 Hz, 1 H, H-4), 3.44–3.33 (m, 4 H, OCH_3, NHC*H*), 1.89–1.77 (m, 1 H), 1.57–1.42 (m, 3 H), 1.34–1.11 (m, 3 H), 1.10–0.96 (m, 2 H), 0.91–0.77 (m, 1 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 166.2, 154.5, 137.1, 133.4, 130.1, 129.3, 129.0, 128.4, 128.2, 126.3, 101.7 (PhCH), 98.0 (C-1), 79.5 (C-4), 72.9 (C-2), 69.5 (C-3), 69.0 (C-6), 62.6 (C-5), 55.4 (OCH_3), 49.8 (NHCH), 33.0, 25.4, 24.6, 24.5.

LC-MS (ESI+): *m*/*z* [M + H]$^+$ calcd for $C_{28}H_{34}NO_8$: 512.2; found: 512.2.

Compounds 10 and 11; General Procedure

In a scintillation vial, compound **9** (1 equiv) was dissolved in anhyd MeOH; addition of NaOMe (0.5 equiv) followed. The reaction mixture was stirred at r.t. for 6 h. The ^{1}H NMR spectrum showed full conversion. Solvent was removed by a rotavap to afford the crude product, which was purified by column chromatography (silica gel, hexanes/EtOAc, 9:1 to hexanes/EtOAc/MeOH, 70:30:1); this afforded the desired product as a white solid.

Methyl 4,6-*O*-Benzylidene-3-*O*-(phenylcarbamoyl)-α-D-glucopyranoside (10)

Compound **9a** (20 mg, 0.040 mmol, 1 equiv) and NaOMe (1.1 mg, 0.020 mmol, 0.5 equiv) were added.

Yield: 13 mg (87%); R_f = 0.5 (5% MeOH/DCM); white solid; mp 215.0–217.0 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.49–7.44 (m, 2 H), 7.39–7.28 (m, 7 H), 7.09–7.03 (m,1 H), 6.68 (s, 1 H), 5.51 (s, 1 H), 5.27 (t, *J* = 9.6 Hz, 1 H), 4.83 (d, *J* = 3.8 Hz, 1 H), 4.35–4.29 (m, 1 H), 3.95–3.87 (m, 1 H), 3.81–3.67 (m, 2 H), 3.63 (t, *J* = 9.6 Hz, 1 H), 3.49 (s, 3 H), 2.56–2.50 (m, 1 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 155.4, 137.6, 137.0, 129.1, 129.0, 128.3, 126.3, 123.7, 118.9, 101.7, 100.3, 78.7, 73.6, 72.2, 69.0, 62.8, 55.6.

LC-MS (ESI+): *m*/*z* [M + H]$^+$ calcd for $C_{21}H_{24}NO_7$: 402.2; found: 402.2.

Methyl 4,6-*O*-Benzylidene-3-*O*-(pentylcarbamoyl)-α-D-glucopyranoside (11a)

Compound **9g** (50 mg, 0.100 mmol, 1 equiv) and NaOMe (2.7 mg, 0.050 mmol, 0.5 equiv) were added.

Yield: 35 mg (92%); R_f = 0.45 (5% MeOH/DCM); white solid; mp 186.0–188.0 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.49–7.44 (m, 2 H), 7.37–7.33 (m, 3 H), 5.50 (s, 1 H), 5.15 (t, *J* = 9.7 Hz, 1 H), 4.83–4.72 (m, 2 H), 4.33–4.26 (m, 1 H), 3.92–3.83 (m, 1 H), 3.75 (t, *J* = 10.3 Hz, 1 H), 3.69–3.61 (m, 1 H), 3.56 (t, *J* = 9.7 Hz, 1 H), 3.46 (s, 3 H), 3.22–3.12 (m, 2 H), 2.90–2.79 (m, 1 H), 1.54–1.43 (m, 2 H), 1.35–1.21 (m, 4 H), 0.87 (t, *J* = 6.5 Hz, 3 H).

Methyl 4,6-*O*-Benzylidene-3-*O*-(heptylcarbamoyl)-α-D-glucopyranoside (11b)

Compound **9i** (50 mg, 0.095 mmol, 1 equiv) and NaOMe (2.6 mg, 0.048 mmol, 0.5 equiv) were added.

Yield: 38 mg (95%); R_f = 0.5 (5% MeOH/DCM); white solid; mp 180.0–182.0 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.49–7.43 (m, 2 H), 7.38–7.32 (m, 3 H), 5.49 (s, 1 H), 5.15 (t, *J* = 9.7 Hz, 1 H), 4.82–4.72 (m, 2 H), 4.33–4.26 (m, 1 H), 3.91–3.83 (m, 1 H), 3.75 (t, *J* = 10.2 Hz, 1 H), 3.70–3.62 (m, 1 H), 3.56 (t, *J* = 9.7 Hz, 1 H), 3.46 (s, 3 H), 3.22–3.11 (m, 2 H), 2.82 (d, *J* = 8.5 Hz, 1 H), 1.52–1.40 (m, 2 H), 1.35–1.17 (m, 8 H), 0.86 (t, *J* = 6.9 Hz, 3 H).

Dicarbamate Compound 12

Compound **8** (90 mg, 0.232 mmol, 1 equiv) and 4,4′-methylenediphenyl diisocyanate (29 mg, 0.116 mmol, 0.5 equiv) were stirred under the reaction conditions.

Yield: 100 mg (84%); R_f = 0.5 (40% EtOAc/hexanes); off-white solid; mp 150.0–152.0 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.09–8.02 (m, 4 H), 7.54–7.43 (m, 6 H), 7.40–7.35 (m, 4 H), 7.33–7.28 (m, 6 H), 7.14 (d, *J* = 8.4 Hz, 4 H), 6.97 (d, *J* = 8.4 Hz, 4 H), 6.51 (s, 2 H), 5.76 (t, *J* = 9.8 Hz, 2 H, H-3), 5.55 (s, 2 H, PhC*H*), 5.15–5.07 (m, 4 H, H-1, H-2), 4.38–4.32 (m, 2 H, H-6_a), 4.07–3.99 (m, 2 H, H-5), 3.87–3.73 (m, 6 H, H-6_b, CH_2, H-4), 3.42 (s, 6 H, OCH_3).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 166.2, 152.3, 136.9, 136.3, 135.6, 133.5, 130.0, 129.2, 129.1, 128.5, 128.2, 126.2, 119.1, 101.8 (PhCH), 97.9 (C-1), 79.3 (C-4), 72.7 (C-2), 70.1 (C-3), 68.9 (C-6), 62.6 (C-5), 55.5 (OCH_3), 40.5 (CH_2).

LC-MS (ESI+): *m*/*z* [M + H]$^+$ calcd for $C_{57}H_{55}N_2O_{16}$: 1023.4; found: 1023.4.

Dicarbamate Compound 13

Compound **8** (90 mg, 0.232 mmol, 1 equiv) and 1,6-diisocyanatohexane (0.019 mL, 0.116 mmol, 0.5 equiv) were added.

Yield: 88 mg (81%); R_f = 0.5 (40% EtOAc/hexanes); white solid; mp 118.0–120.0 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.11–8.04 (m, 4 H), 7.59–7.52 (m, 2 H), 7.47–7.35 (m, 8 H), 7.32–7.27 (m, 6 H), 5.66 (t, *J* = 9.5 Hz, 2 H, H-3), 5.49 (s, 2 H, PhC*H*), 5.14–5.06 (m, 4 H, H-2, H-1), 4.64–4.51 (m, 2 H, N*H*), 4.36–4.29 (m, 2 H, H-6_a), 4.06–3.97 (m, 2 H, H-5), 3.84 (t, *J* = 10.2 Hz, 2 H, H-6_b), 3.74 (t, *J* = 9.5 Hz, 2 H, H-4), 3.41 (s, 6 H, OCH_3), 2.95–2.78 (m, 2 H), 2.69–2.53 (m, 2 H), 1.13–0.79 (m, 8 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 166.1, 155.3, 137.0, 133.4, 130.1, 129.3, 129.1, 128.5, 128.2, 126.3, 101.8 (PhCH), 97.9 (C-1), 79.4 (C-4), 72.7 (C-2), 69.5 (C-3), 68.9 (C-6), 62.6 (C-5), 55.4 (OCH_3), 40.6, 28.8, 25.9.

LC-MS (ESI+): *m*/*z* [M + H]$^+$ calcd for $C_{50}H_{57}N_2O_{16}$: 941.4; found: 941.4.

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Supporting Information

Supporting information for this article is available online at https://doi.org/10.1055/s-0037-1612425.

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