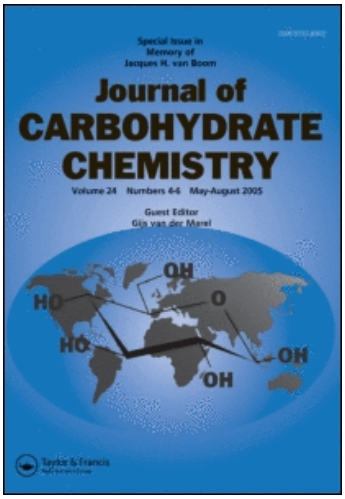

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Synthesis of Octyl β-D-Glucopyranoside-aminobutyric (GABA) and Aminohydroxybutyric (GABOB) Conjugates

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SYNTHESIS OF OCTYL β-D-GLUCOPYRANOSIDE-AMINOBUTYRIC (GABA) AND AMINOHYDROXYBUTYRIC (GABOB) CONJUGATES

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ABSTRACT

The syntheses of octyl β-D-glucopyranoside-GABA and GABOB conjugates are presented. The selectively protected octyl-β-D-glucopyranoside and γ-aminobutyric acids were coupled with *N,N'*-dicyclohexylcarbodiimide. ^{1}H and ^{13}C NMR spectroscopy were used to verify the proposed structures.

INTRODUCTION

The transport of several chemical substances from the bloodstream into the brain occurs at a slower rate than into other organs in the body. The endothelial cells of brain capillaries prevent many substances in the blood from diffusing through to brain tissue.[1] Neuronal membranes are characterized by high levels of sphingolipid, cholesterol, saturated and unsaturated fatty acids. These compounds insulate the neuronal tissue from its surrounding milieu, especially substances in which the hydrophilic-hydrophobic forces are not optimally balanced. γ-aminobutyric acid (GABA) and γ-aminohydroxybutyric acid (GABOB) are constituents of the mammalian brain and are believed to be inhibitory neurotransmitters or neuromodulators.[2-5] Their difficulty in permeating neuronal membranes is most likely due to an unsuitable balance of hydrophilic-hydrophobic forces in their molecular structures.

Numerous attempts have been made to increase the permeability of neurotransmitters through the blood-brain barrier. Promising methods are based both on coupling the neurotransmitters to peptides able to cross the endothelial cell blood-brain barrier[6] and on the synthesis of neurotransmitters steroid and glycerol lipid esters.[7-9]

The present work describes the synthesis of octyl β-D-glucopyranoside-GABA and GABOB conjugates as simple models of natural glycolipids. These conjugates represent examples of a new class of alkyl glucoside carriers. These carriers are non-ionic and their hydrophobic-hydrophilic characteristics can be modulated by varying the polarity of the head group and aliphatic chain.[10] The ability of such conjugates to form self-assemblies such as micelles and vesicles depends on the nature of the glycosidic aliphatic chain, while the dimension of the microaggregate rests mainly on the configuration at the anomeric center.[11,12]

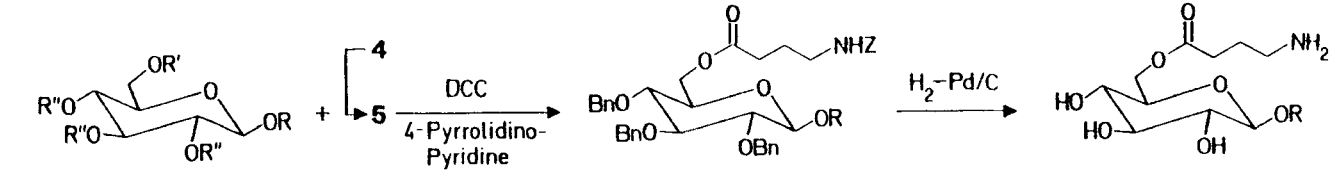
RESULTS AND DISCUSSION

According to the scheme, building blocks **1**,**2**,**3** selectively protected in 2,3,4 positions, and the aminobutyric acids **5** and **12** regioselectively protected on amino and hydroxyl groups, respectively, were prepared for the synthesis of **7** and **14**.

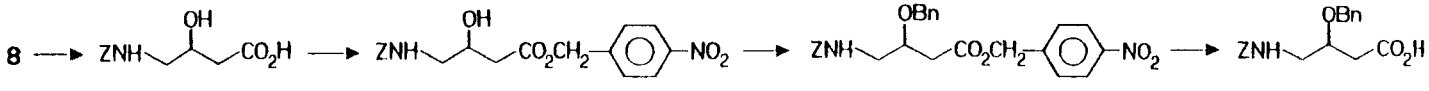
The synthesis of octyl 2,3,4 tri-*O*-benzyl-β-D-glucopyranoside **3** was accomplished in good yield (72%) as previously reported.[10] The regioselective protection of the amino group of GABA and GABOB by benzyl chloroformate led to **5** and **9** in yield of 84% and 83%, respectively.[14] This procedure was chosen to simultaneously remove carbobenzyloxy and benzyl groups by catalytic hydrogenolysis.

The coupling reaction of **3** and **5** was carried out in the presence of *N*,*N*'-dicyclohexylcarbodiimide (DCC) as the coupling agent and 4-pyrrolidinopyridine as the catalyst.[15]

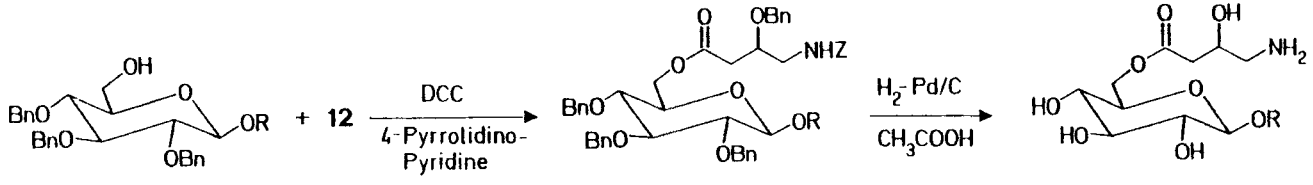
In the synthesis of **12**, amino, hydroxyl and carboxyl groups had to be selectively protected. In our hands the conventional method of hydroxyl groups protection by benzyl bromide was unsuccessful because it was not selective between the carboxyl and hydroxyl groups and the benzyl ester was not removable under the mild conditions needed to preserve the carbobenzyloxy protective group. The strategy we adopted began with the protection of the amino and carboxyl group by carbobenzyloxy and *p*-nitrobenzyl groups. Following literature methods for protection of some carbohydrates and hydroxyacids,[16,17] **10** was converted to **11** in 81% yield by using benzyl 2,2,2-trichloroacetimidate under weak acid conditions. The ester **11** was converted to the acid **12** which was then coupled with the alkyl glucoside **3** in the presence of DCC. The initial attempt at catalytic debenzylation of **13** in methanol/ethyl acetate (1:1) in a hydrogen atmosphere with palladium on carbon catalyst rise to by-products probably due to the formation of a five member lactam as a result of the cleavage of the amino butyric



1-2-3 6 7



9 10 11 12



3 13 14

1: R = $CH_3(CH_2)_7$, R' = R'' = H ; **2**: R' = $(C_6H_5)_3C$, R'' = H ; **3**: R' = H , R'' = Bn = $C_6H_5CH_2$–

4: = $H_2N(CH_2)_4CO_2H$; **5**: = $ZNH(CH_2)_4CO_2H$, Z = $C_6H_5CH_2OCO$; **8**: = H_2N–CH(OH)–CH_2CO_2H

acid residue. The addition of a stoichiometric quantity acetic acid to the solvent employed, (methanol/ethyl acetate), to protonize the amino group hindered the secondary aminolysis reaction. Deprotonation of the adduct was easily accomplished with ion exchange resin. In the table are shown the ^{13}C NMR data of the final products 7 and **14** in comparison to the *O*-β-octylglucopyranoside **1**.

EXPERIMENTAL

General methods. Melting points were determined in open-end capillaries with a Buchi 512 melting-point apparatus and are uncorrected. Optical rotations were measured at 23°C with a Jasco DIP-360 digital polarimeter. Infrared spectra were obtained on Bruker IFS 66 FTIR spectrometer (KBr pellets) and 16-100 scans were taken with a resolution of 2 cm^{-1}.^1H (500 MHz) and ^{13}C NMR (125.7 MHz) spectra were recorded with a Bruker AMX 500 spectrometer. For the acquisition of the Cosy spectra, a spectral window of 4500 Hz was used with 1024 data points for 256 increments. The data were zero-filled and transformed with a sine-hell function. ^1H-^{13}C correlation (HMQC) experiments were acquired using a spectral width of 4500 Hz with 1024 data points for 128 increments. The data were zero-filled in the evolution domain providing a matrix of 2Kx512. A shifted sine-hell function was used prior to the Fourier transformation. The samples (10 or 50 mg) were dissolved in CD_3OD or $CDCl_3$ (0.5-1.5 mL) and the spectra recorded at 25°C. The values of chemical shifts (δ) are given in ppm.

The following reference signals were used: $(CH_3)_4Si$, δ 0.0 (^1H in $CDCl_3$); $CDCl_3$, δ 77.0 (^{13}C in $CDCl_3$); CD_3OD, δ 49.0 (^{13}C in CD_3OD). The ^1H signals were assigned by homonuclear correlation spectroscopy (Cosy)[18] while ^{13}C signals were assigned by ^1H-^{13}C inverse correlation spectroscopy.[19] MS-ESI spectra was obtained in a TSQ 700 Finnigan-Mat instrument.

TABLE ^{13}C NMR CHEMICAL SHIFTS OF OCTYL GLUCOSIDE CARRIER (1) AND ITS GABA (7) AND GABOB (14) CONJUGATES

ENTRY	PRODUCTS		
	1	7	14
CH_3	14.4	14.4	14.4
CH_2 (2)	23.6	23.3	23.6
CH_2 (3)	32.9	32.9	32.9
CH_2 (4)	30.3-30.7	30.3-31.2	30.3-30.7
CH_2 (5)	30.3-30.7	30.3-31.2	30.3-30.7
CH_2 (6)	27.0	27.0	27.0
CH_2 (7)	30.3-30.7	30.3-31.2	30.3-30.7
CH_2O (8)	71.5	71.5	71.6
CH_2CO	-	30.3-31.2	41.0
CH_2NH_2	-	43.5	52.6
CH_2 (GABA)	-	23.6	-
CH_2 (GABOB)	-	-	67.8
C-1 glc	104.3	104.2	104.2
C-2 glc	74.9	75.0	75.0
C-3 glc	78.0	78.0	77.9
C-4 glc	70.8	70.8	70.9
C-5 glc	77.8	77.7	77.7
C-6 glc	62.7	62.6	62.6
COO	-	183.2	180.1

All reactions were followed by thin layer chromatography (TLC) on precoated silica gel plates (Merck Kiesel Gel 60 F_{254}) eluted with several solvent mixtures and the compounds were detected by spraying with 2N sulfuric acid in ethanol and by 0.3 g ninhydrin in 100 mL of 1-butanol after addition of 3 mL of glacial acetic acid.

Flash and column chromatography were carried out on silica gel (9385 Merck) and silica gel (Merck Kiesel Gel 60), respectively. The elemental analysis obtained for syrupy and amorphous products was not satisfactory. After purification, products purity was ascertained by TLC and NMR spectroscopy.

GABA and GABOB are commercial products and were used without any further purification: GABA: mp 200-205°C dec.; GABOB: mp 217°C dec., $[\alpha]_{546}$ -11.38 (*c*3.5,water), $[\alpha]_D$-1.5 (*c*3.5,water). Literature values: GABA mp 202°C; GABOB mp 202-205°C dec, $[\alpha]_{546}$ -8.49 (*c*3.5,water).[20] In order to gain insight into the optical purity of the commercial GABOB in our hands, mono and two-dimensional ^1H NMR experiments were carried out in the presence of a chiral shift reagent,tris[3(trifluoromethylhydroxymethylene)-d-camphorato]europium(III).[21]

The presence in the ^1H NMR spectrum of a single set of proton signals proved the enantiomeric purity of the product.

All solvents and reagents were commercial reagent grade and were purified and dried using standard procedures.

Octyl 2,3,4-tri-*O*-benzyl-β-D-glucopyranoside(3). As in a previous work,[10] **3** was obtained by reacting a mixture of **2** (3.3 g, 6.17 mmol), benzyl bromide (7.18 mL, 61.7 mmol) and sodium hydride (1.47 g, 61.7 mmol) in dry dimethylformamide (50 mL) at room temperature for 36 h with magnetic stirring. To the benzylated crude product (15 g) *in* methanol (100 mL) was added 37% (w/w) HCl (0.5 mL) to give **3** (2.5 g, 72%); R_f=0.29 (hexane/ethyl acetate 2:1); mp

69-70°C; ^{13}C NMR ($CDCl_3$): δ 14.7 (CH_3), 23.3 (CH_2-2), 26.8 (CH_2-6), 29.9-30.4 (CH_2-4, CH_2-5, CH_2-7), 32.5 (CH_2-3), 62.6 (C-6 glc.), 71.1 (CH_2O-8), 75.5-76.3 (C-4 glc., $PhCH_2O$), 82.9 (C-5 glc.), 85.1 (C-3 glc.), 104.3 (C-1 glc.), 128.3-128.7 (CH_{arom} phenyl), 138.6, 139.0, 139.2 (C_{arom} phenyl).

***N*-Benzyloxycarbonyl-4-aminobutyric acid** (5). To a solution of 4-aminobutyric acid (GABA) **4** (8 g, 77.67 mmol) in 2N NaOH (50 mL) cooled in an ice-water bath, benzyl chloroformate (11.1 mL, 7.44 mmol) and 2N NaOH (23.5 mL) were alternatly added in several portions with magnetic stirring. The reaction temperature was kept between 5-10°C during the addition of the reagents (30 min), after which it was raised to room temperature and the reaction stirred for an additional 30 min. The alkaline solution was extracted by ethyl ether (2x50 mL) and the aqueous layer, cooled at 5°C, was acidified by 5N HCl at pH 2. An oil which separated was triturated with ethyl acetate to give a crystalline mass. The product was recrystallized from diisopropyl ether (15.5 g, 84%); R_f=0.2 (methanol/ethylacetate 1:1); mp 59-60°C; $[\alpha]_D$ + 23.5 (*c*1,chloroform); ^{13}C NMR ($CDCl_3$): δ 24.7 (CH_2), 31.0 (CH_2CO_2H), 40.1 (CH_2NH), 66.6 (CH_2O), 128.8-128.4 (CH_{arom} phenyl), 136.3 (C_{arom} phenyl), 156.7 (OCONH), 178.2 (CH_2CO_2H).

Anal. Calcd for C_{12} H_{15} NO_4 : C, 60.76; H, 6.33; N, 5.91. Found C, 60.90; H, 6.40; N, 5.77.

Octyl 2,3,4-tri-*O*-benzyl-6-*O*-(*N*-benzyloxycarbonyl-4'-aminobutyryl)-β-D-glucopyranoside(6). 4-Pyrrolidinopyridine (190.4 mg,1.28 mmol) was added with magnetic stirring to a solution of **3** (755.5 mg, 1.34 mmol) and of **5** (190.4 mg, 2.57 mmol) in dichloromethane (10 mL). The mixture was then cooled to 0°C and DCC (517.36 mg, 2.57 mmol) in dichloromethane (5 mL) was added dropwise. The mixture left to reach room temperature was then stirred for 24 h and then filtered through celite. The filtrate was first washed with water (2x30 mL), then with a 5% aqueous acetic acid solution (2x30 mL) and, again, with water

(2x20mL). The organic layer was dried with Na_2SO_4 and concentrated at 10^{-2} torr. The residue was purified by silica gel chromatography (ethyl ether/petroleum ether 1:1) to yield **6** (0.8 g, 76%); R_f=0.35 (ethyl ether/petroleum ether 1:1); ^{13}C NMR ($CDCl_3$): δ 14.6 (CH_3), 23.2 (CH_2-2), 25.6 (CH_2 of GABA), 26.6 (CH_2-6), 29.7-30.2 (CH_2-4, CH_2-5, CH_2-7), 31.7-32.3 (CH_2-3, CH_2CO), 40.7 (CH_2NH), 63.5 (C-6 glc.), 67.0 ($PhCH_2O$), 70.7 (CH_2O-8), 73.2-76.2 (C-4 glc., $PhCH_2O$), 77.9 (C-2 glc.), 85.0 (C-3 glc.), 104.1 (C-1 glc.), 128.1-128.9 (CH_{arom} phenyl), 137.1-138.9 (C_{arom} phenyl), 156.9 (OCON), 173.3 (CH_2CO_2).

Octyl 6-*O*-(4'-aminobutyryl)-β-D-glucopyranoside(7). A solution of **6** (1.3 g, 1.66 mmol) in 50 mL of methanol-ethyl acetate (1:1) was stirred under H_2 pressure (3 bar) in the presence of 10% palladium on carbon (400 mg) at room temperature for 36 h. The mixture was filtered through celite and the solvent evaporated in vacuo to give crude **7** which was purified on silica gel, first eluting with ethyl acetate and then methanol. Further purification of the residue by filtration through charcoal afforded **7** as an oil (0.5 g, 80%); R_f=0.15 (ethyl acetate); IR: 3374(ν_{OH}), 2925, 2855(ν_{CH2}, ν_{CH3}), 1730(ν_{CO}), 1667(δ_{NH}), 1078, 1028(ν_{COC}) cm^{-1}; MS m/z 378.5 $[M+H]^+$, 400.2$[M+Na]^+$; the ^1H (CD_3OD) NMR data are shown in the following table:

H1	H2	H3	H4	H5	H6
4.25	3.16	3.26	3.27	3.34	3.86
-	-	-	-	-	3.67
CH_2 (GABA)	CH_2N	CH_2CO	CH_2-O	$(CH_2)_n$	CH_3
2.12	3.39	2.28	3.89	1.29-1.33	0.90
-	-	-	3.53	1.37,1.61	-

***N*-Benzyloxycarbonyl-4-amino-3-hydroxybutyric acid (9).** To a solution of 4-amino-3-hydroxybutyric acid (GABOB) **8** (20 g, 167 mmol) in 1N NaOH/dioxane 1:1 (200 mL) cooled in an ice-water bath, benzyl chloroformate (35.7 mL, 251.6 mmol) and 60% (w/w) aqueous NaOH were alternatively added in several portions, with magnetic stirring. The reaction temperature was kept between 0-5°C during the addition of the reagents (30 min). The solution was concentrated in vacuo, extracted with diisopropyl ether (2x50 mL) and the aqueous layer, cooled at 5°C, was acidified by 37% HCl at pH 2. An oil was separated, and then extracted with ethyl acetate (500 mL) and the organic layer dried with Na_2SO_4. Evaporation of the solvent afforded an oil which was crystallized from ethyl acetate to yield **9** (35.6 g, 84%); R_f 0.42 (ethyl acetate/methanol 1:1); mp 159°C; $[\alpha]_D$ +1.75 (*c*1 methanol); ^{13}C NMR (CD_3OD): δ 40.7 ($\mathbf{C}H_2CO_2H$), 45.8 ($\mathbf{C}H_2NH$), 67.0 (**C**HOH), 67.8 ($PhCH_2O$), 127.9-128.8 ($\mathbf{C}H_{arom}$ phenyl), 136.5 ($\mathbf{C}_{arom}$ phenyl), 158.4 (OCON), 177.9 (CH_2CO_2H).

***p*-Nitrobenzyl(*N*-benzyloxycarbonyl-4-amino-3-hydroxy) butyrate(10).** To a suspension of **9** (8.5 g, 33.57 mmol) in ethyl acetate (150 mL) were added triethylamine (6.8 mL, 50.35 mmol) and 4-nitrobenzyl chloride (10.8 g, 50.35 mmol) with magnetic stirring. The mixture was heated at reflux for 8 h and, after cooling to room temperature, the solution was neutralized with 2N HCl (16.8 mL, 33.57 mmol). The reaction mixture was washed with water (2x100 mL), saturated aqueous $NaHCO_3$ solution and again with water (2x100 mL). The organic layer was dried with Na_2SO_4 and concentrated to give a crude product which was recrystallized from hexane/ethyl acetate 1:1 to yield **10** (9.1 g, 70%); R_f=0.35 (hexane/ethyl acetate, 1:1); mp 64 °C $[\alpha]_D$ +1.95 (*c*1 $CHCl_3$); ^{13}C NMR ($CDCl_3$): δ 38.5 ($\mathbf{C}H_2CO_2$) 45.8 ($\mathbf{C}H_2NH$), 64.9 (p-NO_2-Ph$\mathbf{C}H_2O$), 66.8 (**C**HOH), 67.3 ($PhCH_2O$), 123.6 (**C**-3, **C**-5$_{arom}$ of $C_6H_4NO_2$), 127.9-128.4 ($\mathbf{C}H_{arom}$ phenyl), 136.1, 142.6, 147.5 ($\mathbf{C}_{arom}$ phenyl), 157.0 (OCON), 171.6 ($CH_2\mathbf{C}O_2CH_2C_6H_4NO_2$).

Anal. Calcd for $C_{19}H_{20}N_2O_7$: C, 58.76; H, 5.15; N, 7.22. Found: C, 58.79; H, 5.29; N, 7.18.

***p*-Nitrobenzyl(*N*-benzyloxycarbonyl-4-amino-3-benzyloxy) butyrate(11).** To a solution of **10** (10 g, 25.84 mmol) in dichloromethane (120 mL) was added benzyl 2,2,2-trichloroacetimidate (7.2 g, 28.42 mmol) in cyclohexane (100 mL). The solution was cooled to 0°C and triflic acid (0.52 mL) was added in one portion under nitrogen. The solution was stirred at 0°C for 2 h and then at room temperature for 16 h. Another portion of benzyl 2,2,2-trichloroacetimidate (3.6 g, 14.21 mmol) was added and the reaction mixture was stirred for 4 h. The mixture was filtered through celite,washed first with saturated aqueous $NaHCO_3$ solution (3x100 mL) and then with water (2x100 mL). The organic layer was dried with Na_2SO_4 and evaporation of the solvent yielded an oil which was purified by silica gel chromatography (toluene/ethyl acetate 9:1) affording **11** as an oil (10 g, 81%); R_f=0.23 (toluene/ethyl acetate 9:1); ^{13}C NMR ($CDCl_3$): δ 37.3 ($\mathbf{C}H_2CO_2$), 43.4 ($\mathbf{C}H_2NH$), 64.8 (*p*-NO_2-Ph$\mathbf{C}H_2O$), 66.7 ($\mathbf{C}HOCH_2Ph$), 71.9, 74.6 (Ph$\mathbf{C}H_2O$), 123.6 (**C**-3, **C**-5$_{arom}$ of $C_6H_4NO_2$), 127.6-128.9 ($\mathbf{C}H_{arom}$ phenyl), 136.2, 137.5, 142.8, 147.5 ($\mathbf{C}_{arom}$ phenyl), 156.5 (OCONH), 170.5 ($CH_2\mathbf{C}O_2CH_2C_6H_4NO_2$).

Anal. Calcd for $C_{26}H_{26}O_7N_2$: C, 65.27; H, 5.44; N, 5.86. Found: C, 65.40, H, 5.35; N, 5.94.

***N*-Benzyloxycarbonyl-4-amino-3-benzyloxybutyric acid(12).** To a solution of **11** (10 g, 20.96 mmol) in dioxane/water 4:1 (400 mL) was added 2N NaOH (25 mL) and the solution stirred at room temperature for 2 h. The mixture was neutralized with 2N HCl (pH 7.0) and the solvent evaporated in vacuo. The aqueous residue was washed with ethyl ether (3x50 mL) and then acidified with 37% HCl (pH 2.0). The precipitated oil was extracted with ethyl acetate (3x50 mL) and the organic layer dried with Na_2SO_4. The solvent was evaporated, the oil residue was dissolved in dichloromethane and purified through charcoal to yield a colorless oil

(5.5 g, 77%); R_f=0.15 (toluene/ethyl acetate 1:1); ^{13}C NMR ($CDCl_3$): δ 37.0 (CH_2CO_2H), 43.5 (CH_2NH), 66.9 ($CHOCH_2Ph$), 71.9, 74.3 ($PhCH_2O$), 127.8-128.4 (CH_{arom} phenyl), 136.2, 137.5 (C_{arom} phenyl), 156.6 (OCON), 175.7 (CH_2CO_2H).

Octyl 2,3,4-tri-*O*-benzyl-6-*O*-(*N*-benzyloxycarbonyl-4'-amino-3'-benzyloxybutyryl)-β-D-glucopyranoside (13). To a mixture of **3** (1 g, 1.77 mmol), **12** (1.2 g, 3.56 mmol) and 4-pyrrolidinopyridine (0.262 g, 1.77 mmol) in dichloromethane (10 mL) cooled at 0°C was added dropwise DCC (0.73 g, 3.55 mmol) in dichloromethane (10 mL). After standing at room temperature for 24 h under stirring the reaction mixture was filtered through celite and washed with water (2x50 mL). The filtrate was dried with Na_2SO_4 the solvent was evaporated and the residue purified by gel chromatography (ethyl ether/petroleum ether 1:2) to give **13** as a pale oil (1.25 g, 79%); R_f=0.13 (diisopropyl ether/petroleum ether 1:1); ^{13}C NMR ($CDCl_3$): δ 14.7 (CH_3), 23.3 (CH_2-2), 26.8 (CH_2-6), 29.9-30.4 (CH_2-4, CH_2-5, CH_2-7), 32.5 (CH_2-3), 38.2 (CH_2CO), 44.4 (CH_2NH), 64.0 (C-6 glc.), 67.4 ($PhCH_2O$), 70.9 (CH_2O-8), 72.6 ($PhCH_2O$), 73.4 (C-5 glc.), 75.2 (CHO of GABOB), 75.5-76.3 ($PhCH_2O$), 78.3 (C-4 glc.), 82.9 (C-2 glc.), 85.3 (C-3 glc.), 104.3 (C-1 glc.), 128.3-129.1 (CH_{arom} phenyl), 137.2, 138.4, 139.0, 139.2 (C_{arom} phenyl), 157.1 (OCON), 171.4 (CH_2CO_2).

Anal. Calcd for $C_{54}H_{64}NO_{10}$: C, 73.14; H, 7.22; N, 1.58. Found: C, 73.04; H, 7.29; N, 1.58.

Octyl 6-*O*-(4'-amino-3'-hydroxybutyryl)-β-D-glucopyranoside (14). A solution of **13** (100 mg, 0.113 mmol) in 50 mL of methanol/ethyl acetate 1:1 was stirred under H_2 pressure (4 bar) in the presence of glacial acetic acid (5 mL) and 10% palladium on carbon (50 mg) for 24 h at room temperature. The mixture was filtered through celite and the solvent evaporated in vacuo. The residue was dissolved with water, washed with ethyl ether (2x50 mL) and lyophilized to give an amorphous pale colored mass. The product was dissolved in methanol and treated for 16 h at room temperature under stirring with ion exchange resin (Amberlist A-21).

After filtration, evaporation of the solvent gave the crude product **14** which was purified by flash-chromatography (15x5 cm). Successive elution with ethyl acetate and then with methanol yielded **14** (35 mg, 79%); Rf=0.1 (ethyl acetate); IR: 3356 (ν_{OH}), 2954, 2856 (ν_{CH2}, ν_{CH3}), 1674 (ν_{CO}), 1598 (δ_{NH}), 1076, 1036 (ν_{COC}) cm^{-1}; MS m/z 394.1 $[M+H]^+$, 416.3$[M+Na^+]$; the ^1H (CDO_3D) NMR data are shown in the following table:

H1	H2	H3	H4	H5	H6
4.25	3.17	3.36	3.39	3.27	3.86
-	-	-	-	-	3.70
CHOH	CH_2N	CH_2CO	CH_2O	$(CH_2)_n$	CH_3
4.51	3.63	2.62	3.90	1.61,1.37	0.90
-	3.24	2.18	3.53	1.36-1.26	-

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