Synthesis of β-D-galactopyranosylamine derivatives with the terminal amino group in the spacer as mono-, di-, and trivalent ligands of galectins

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Glycoclusters were obtained by N-alkylation of *N*-glycyl-β-D-galactopyranosylamine with *N*-chloroacetyl derivatives of β-D-galactopyranosylamine and *N,N´´*-iminodiacetyl-di-β-D-galactopyranosylamine. The glycoclusters with two and three galactopyranosylamine residues and the monovalent ligand *N*-diglycyl-β-D-galactopyranosylamine with an amino group in the spacer are suitable for subsequent conjugation with carboxyl-containing physiologically active compounds.

Key words: glycoclusters, polyvalent ligands, *N*-glycyl-β-D-galactopyranosylamine, *N*-chloroacetyl-β-D-galactopyranosylamine.

Some tumor cells are known to have an increased surface concentration of galectins (the proteins capable of binding β-D-galactose-containing glycoconjugates).[1] This feature of tumor cells was successfully used for targeted delivery of glycoconjugates to breast carcinoma cells.[2] One of accessible ligands of galectins is the disaccharide lactose with the terminal O-linked β-D-galactose residue. Earlier, we developed methods for the synthesis of mono-, di-, and trivalent ligands of galectins, lactosylamine derivatives,[3,4] and obtained some monovalent glycoconjugates of polyhedral boron compounds (with *ortho*-carboranylacetic acid as an example),[5] which are potential agents for boron neutron capture therapy of cancer.

The goal of the present work was to obtain similar ligands of galectins from β-galactopyranosylamine and compare the efficacies of galectin binding to glycoconjugates containing O- and N-linked β-D-galactose residues.

One of the starting compounds for the synthesis of the ligands was *N*-glycyl-β-D-galactopyranosylamine (**1**) prepared earlier[6] from β-D-galactosylamine (here we synthesized this compound in a new, more efficient way[7]). It is thought that the spacer linking a carbohydrate with a physiologically active compound should be long enough in order not to hinder an interaction of the carbohydrate with the lectin.[8] For this reason, the spacer in compound **1** was lengthened by coupling with *N*-benzyloxycarbonylglycine (**2**) in the presence of *N,N´´*-dicyclohexylcarbodiimide (DCC) and *N*-hydroxysuccinimide (NHS). Hydrogenolysis of the resulting compound **3** gave the monovalent ligand *N*-diglycyl-β-D-galactopyranosylamine (**4**) with a spacer consisting of seven atoms with a terminal amino group (Scheme 1).

N-Alkylation of amino compound **1** with *N*-chloroacetyl-β-D-galactopyranosylamine (**5**)[9] in aqueous MeOH in the presence of Pr^i_2EtN gave *N,N´´*-iminodiacetyl-di-β-D-galactopyranosylamine (**6**). Imino compound **6** was further used to both lengthen the spacer and obtain a trivalent ligand. The spacer was lengthened by condensation of compound **6** with a twofold excess of *N*-benzyloxycarbonylglycylglycine (**7**), DCC, and NHS in DMSO—DMF (10 : 1) at 15 °C. Few *O*-acyl groups in N-acylated product **8** were removed by treatment with Et_3N in aqueous MeOH. Divalent ligand **9** was obtained upon N-deprotection of compound **8** by hydrogenolysis over Pd/C.

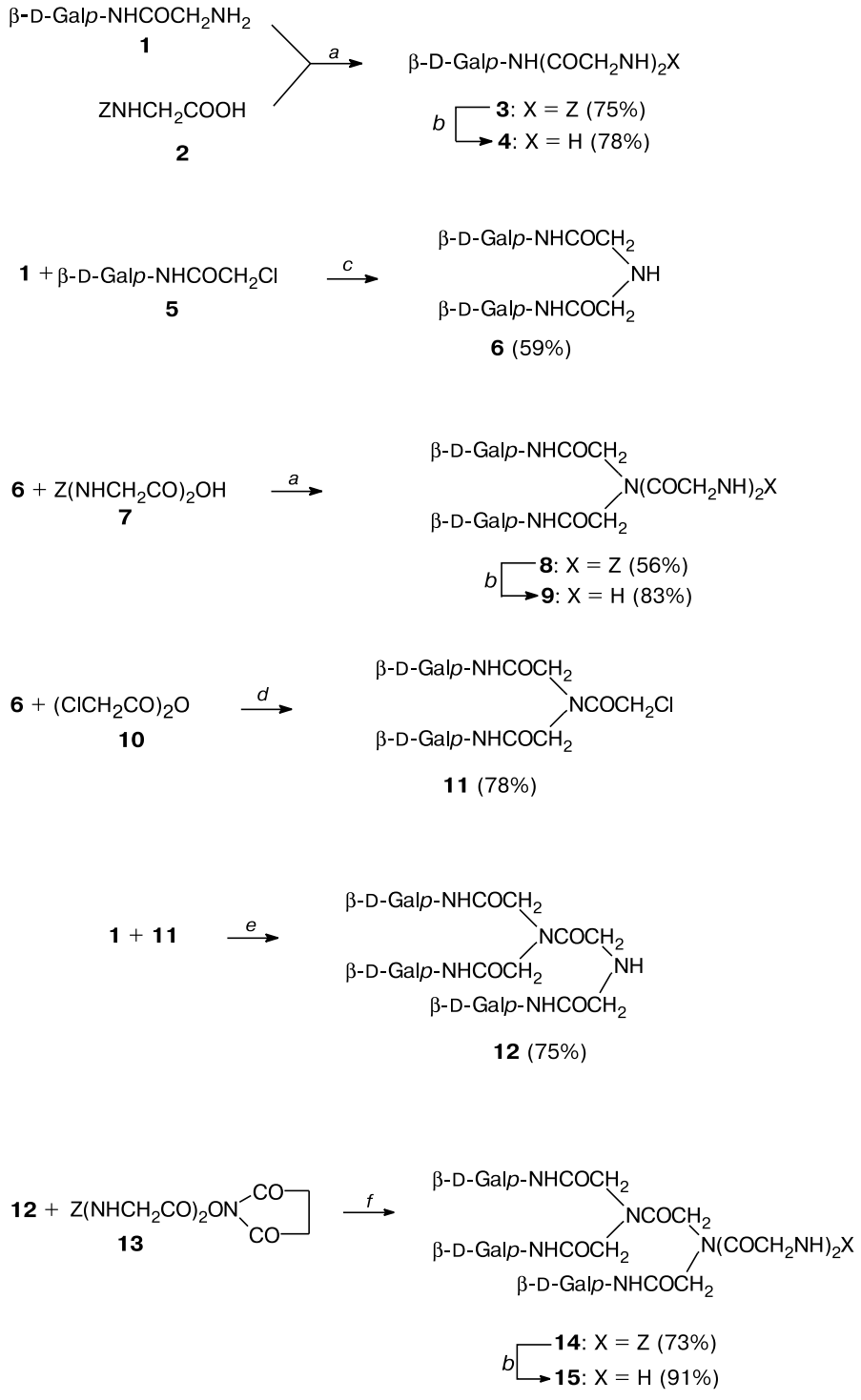
To obtain a precursor of a trivalent ligand, we carried out N-chloroacetylation of imino compound **6** with chloroacetic anhydride (**10**) (twofold excess) in dry DMF. Few *O*-acyl groups in the N-acylated product were removed by treatment with Et_3N in aqueous MeOH to yield compound **11**. N-Alkylation of amino compound **1** with *N*-chloroacetyl compound **11** gave imino compound **12**. The spacer in compound **12** was lengthened by a reaction with an activated ester of acid **7**, namely, the NHS ester of *N*-benzyloxycarbonylglycylglycine (**13**). The yield of compound **14** was higher than that achieved in a reaction of acid **7** with DCC and NHS. Hydrogenolysis of the N-protecting group in compound **14** gave the target trivalent ligand **15**.

Published in Russian in *Izvestiya Akademii Nauk. Seriya Khimicheskaya,* No. 11, pp. 2369—2373, November, 2008.

1066-5285/08/5711-2418

The structures of the compounds obtained were confirmed by data from elemental analysis and NMR spectra. The ^{1}H NMR spectra of all compounds with one, two, and three β-galactosylamine residues contain signals for the H(2)—H(6) protons of the galactose residues at δ 3.60—4.00, which were not analyzed by us any further.

Scheme 1



Z = $PhCH_2OCO$

Reagents and conditions: *a*, DCC, NHS, DMSO; *b*, H_2, Pd/C, H_2O; *c*, Pr^i_2EtN, MeOH—H_2O (3 : 2); *d*, DMF; *e*, Pr^i_2EtN, DMSO; *f*, DMSO—DMF (2 : 3)

The spectra show some distinctions in the character and number of the signals for the H(1) protons in compounds with two (except for **6**) and three galactosylamine residues. The spectra of compounds **8**, **9**, and **11** each containing two β-galactose residues exhibit two doublets with Δδ 0.05—0.07 ppm. The spectra of compounds containing three β-galactose residues show a doublet and a double-intensity doublet with Δδ 0.04 ppm (**12**) and multiplets at δ 4.89—5.02 (**14**) and 4.94—5.06 (**15**).

The signals for the CH_2 protons of the spacer appear in a wide range (δ_H 3.44—5.20). Part of these signals (mainly broadened singlets) in the spectra of compounds **3**, **4**, **6**, **8**, **9**, and **11** were assigned to particular CH_2 groups (see Experimental) from both the literature[3,5,6,9] and our experimental data (appearance or disappearance of the signals as the result of the reactions). We did not assign the signals to particular CH_2 groups in compounds **14** and **15** (except for CH_2Ph and CH_2NH_2, respectively) because the CH_2 protons produced a complex spectrum with numerous signals. The presence of many signals for the CH_2 protons and a multiplet for the H(1) protons of three β-galactose residues in the spectra of compounds **14** and **15**, as in analogous lactosylamine derivatives,[4] is attributable to the formation of rotamers because of the presence of two disubstituted amide groups (see Ref. 10 and references therein).

The structure of trivalent ligand **15** was additionally confirmed by its ^{13}C NMR spectrum. The spectrum shows signals for six carbon atoms of three β-D-galactopyranosylamine residues and low-intensity signals for the CH_2 and CO carbon atoms: four signals (including two broadened ones) due to six CH_2 groups and six signals due to six CO groups.

Thus, using the previously developed methods, we obtained mono-, di-, and trivalent ligands of galectins, β-galactopyranosylamine derivatives, with the terminal amino group in the spacer. These ligands are suitable for conjugation with carboxyl-containing physiologically active compounds. The compounds obtained will allow further investigations (see Ref. 5 and references therein) aimed at the synthesis of new mono- and polyvalent glycoconjugates of polyhedral boron compounds, which are of interest as potential agents for boron neutron capture therapy of cancer.

Experimental

^1H and ^{13}C NMR spectra were recorded in D_2O at 24 °C on a Bruker WM-250 spectrometer (250 (^1H) and 62.7 MHz (^{13}C)) with acetone as the external standard. Optical rotation was measured on a PU-07 polarimeter (Russia). The course of the reactions and the isolation of products were monitored by electrophoresis (30 V cm^{-1}, 1 h) on Filtrak FN1 paper in pyridinium acetate buffer (0.025 *M* Py, pH 4.5). The products were visualized with ninhydrin and the sequence of reagents KIO_4—$AgNO_3$—KOH (see Ref. 11). Water was determined according to the Fischer method. Column chromatography on silica gel S-18 was monitored by UV absorption at 206 and 260 nm.

***N*-(*N*-Benzyloxycarbonyldiglycyl)-β-D-galactopyranosylamine (3).** A mixture of *N*-glycyl-β-D-galactopyranosylamine (**1**) (0.35 g, 1.5 mmol), *N*-benzyloxycarbonylglycine (**2**) (0.32 g, 1.5 mmol), and NHS (0.19 g, 1.65 mmol) was dissolved in dry DMSO (10 mL) heated to 50 °C. The resulting solution was cooled to 15 °C and DCC (0.37 g, 1.8 mmol) was added. The reaction mixture was stirred for 45 min and kept at 20 °C for 20 h. The precipitate of *N*,*N*′-dicyclohexylurea was filtered off and washed with DMSO (2×0.75 mL). The filtrate was added to stirred Et_2O (120 mL) and the clarified liquid was decanted from an oily precipitate. The precipitate was repeatedly triturated with Et_2O (25 mL each portion) into a viscous mass, which was repeatedly treated with acetone (15 mL each portion). The resulting powder was filtered off, dried, and dissolved in water (1 mL). Methanol (5×3 mL) was added with stirring and heating to 40 °C. The solution was kept at 5 °C for 48 h. The precipitate that formed was filtered off, washed with MeOH and Et_2O, and dried. The yield of compound **3** was 0.48 g (75%), an amorphous solid, $[\alpha]_D^{21}$ +10.2 (*c* 1, H_2O). Found (%): C, 50.01; H, 6.06; N, 9.84. $C_{18}H_{25}N_3O_9$. Calculated (%): C, 50.58; H, 5.90; N, 9.83. ^1H NMR, δ: 3.62—3.83 (m, 5 H); 3.92 (s, 2 H, $CH_2NCOC\underline{H}_2$); 3.98 (br.s, 1 H, H(4)); 4.02 (s, 2 H, $C\underline{H}_2NHCOCH_2$); 4.95 (d, 1 H, H(1), *J* = 9.0 Hz); 5.17 (s, 2 H, CH_2Ph); 7.44 (br.s, 5 H, Ph).

***N*-Diglycyl-β-D-galactopyranosylamine (4).** 10% Pd/C (0.21 g) was added under argon to a solution of compound **3** (0.415 g, 0.97 mmol) in water (10 mL). Hydrogenation was carried out by passing a weak flow of H_2 through the vigorously stirred mixture at 20 °C for 8 h. The reaction mixture was filtered through silica gel C-18 (4 g). The sorbent was washed with water (80 mL) and the solution was concentrated to a syrup, which partially crystallized. The syrup was kept at 5 °C for 16 h. Then MeOH (5 mL) was added to the resulting crystalline solid and the precipitate was filtered off, washed with MeOH and Et_2O, and dried. The yield of compound **4** was 0.22 g (78%), m.p. 165—166 °C, $[\alpha]_D^{18}$ +12.2 (*c* 1, H_2O). Found (%): C, 40.47; H, 6.61; N, 13.84. $C_{10}H_{19}N_3O_7$. Calculated (%): C, 40.95; H, 6.53; N, 14.33. ^1H NMR, δ: 3.48 (s, 2 H, $C\underline{H}_2NH_2$); 3.61—3.83 (m, 5 H); 3.97 (m, 1 H, H(4)); 4.03 (s, 2 H, CH_2N); 4.95 (d, 1 H, H(1), *J* = 9.0 Hz).

***N*,*N*-Bis[*N*-(β-D-galactopyranosyl)carbamoylmethyl]amine (6).** A mixture of compound **1** (0.82 g, 3.47 mmol) and *N*-chloroacetyl-β-D-galactopyranosylamine (**5**) (0.89 g, 3.49 mmol) in 60% aqueous MeOH (13 mL) and Pr^i_2EtN (0.66 mL, 3.88 mmol) was heated with periodical stirring in a screw-capped test tube at 70 °C for 20 h. The reaction mixture was diluted with water (10 mL) and concentrated to 10 mL. The residue was diluted with water (15 mL), stirred with the anion exchange resin Dowex 1w×8 (OH^-) (18 mL) for 10 min, and again diluted with water (50 mL). The liberated Pr^i_2EtN was codistilled with water, while concentrating the suspension to 35 mL. The resin was filtered off and washed with water (150 mL). The filtrate and the aqueous eluate were concentrated to 50 mL and stirred with the cation exchange resin Dowex 50w×8 (H^+) (30 mL) for 1 h. The resin was filtered off, washed with water (300 mL) and 0.5 *M* aqueous pyridine (250 mL). The latter eluate was evaporated to dryness. The residue was dissolved in water (3 mL). Then MeOH (40 mL) was added with

stirring and the solution was kept at 5 °C for 16 h. The precipitate that formed was filtered off, washed with MeOH and Et_2O, and dried. The yield of compound **6** was 0.95 g (59%), an amorphous solid, $[\alpha]_D^{21}$ +16.2 (*c* 1, H_2O). Found (%): C, 41.59; H, 6.84; N, 8.61; H_2O, 2.35. $C_{16}H_{29}N_3O_{12} \cdot 0.5H_2O$. Calculated (%): C, 41.38; H, 6.51; N, 9.05; H_2O, 1.94. ^{1}H NMR, δ: 3.46 (s, 4 H, 2 CH_2N); 3.61—3.83 (m, 10 H); 3.98 (br.s, 2 H, 2 H(4)); 4.96 (d, 2 H, 2 H(1), *J* = 9.0 Hz).

***N*-(*N*-Benzyloxycarbonyldiglycyl)-*N*,*N*-bis[*N*-(β-D-galactopyranosyl)carbamoylmethyl]amine (8).** A mixture of compound **6** (0.228 g, 0.5 mmol), *N*-benzyloxycarbonylglycylglycine (**7**) (0.266 g, 1 mmol), and NHS (0.134 g, 1.16 mmol) was dissolved in dry DMSO (1.7 mL) and DMF (0.17 mL). The solution was cooled to 10 °C and DCC (0.27 g, 1.31 mmol) was added. The reaction mixture was stirred for 45 min and then kept at 15 °C for 60 h. The precipitate of *N*,*N*′-dicyclohexylurea was filtered off and washed with DMSO (2×0.5 mL). The filtrate was added to stirred Et_2O (35 mL) and the clarified liquid was decanted from the oily precipitate. The precipitate was repeatedly triturated with Et_2O (10 mL each portion) into a viscous mass, which was repeatedly treated with hot acetone (10 mL each portion). The resulting powder was filtered off, washed with Et_2O, dried, and dissolved in a mixture of water (2.5 mL) and MeOH (2.5 mL). The solution was kept with Et_3N (0.5 mL) at 20 °C for 3 h, diluted with MeOH (10 mL), and concentrated to 1 mL. The procedure was repeated twice. In the last run, the solution was concentrated to dryness. The residue was washed with Pr^iOH (5×7 mL) and Et_2O, dried, dissolved in water (5 mL), and filtered through silica gel C-18 (10 g). The sorbent was washed with water (300 mL), 10% aqueous MeOH (220 mL), and 20% aqueous MeOH (200 mL). The water—methanol fractions were concentrated to dryness. The residue was dissolved with heating in MeOH (5 mL) and the solution was kept at 5 °C for 16 h. The precipitate that formed was filtered off, washed with MeOH and Et_2O, and dried. The yield of compound **8** was 0.2 g (56%), m.p. 164—165 °C, $[\alpha]_D^{21}$ +11.5 (*c* 1, H_2O). Found (%): C, 45.95; H, 6.20; N, 9.40; H_2O, 3.37. $C_{28}H_{41}N_5O_{16} \cdot 1.5H_2O$. Calculated (%): C, 46.03; H, 6.07; N, 9.58; H_2O, 3.70. ^{1}H NMR, δ: 3.61—3.83 (m, 10 H); 3.92 (br.s, 2 H, $CH_2NCOC\underline{H}_2$); 3.99 (br.s, 2 H, 2 H(4)); 4.12—4.27 (m, 4 H, 2 CH_2); 4.41 (m, 2 H, CH_2); 4.96 (d, 1 H, H(1), *J* = 9.0 Hz); 5.03 (d, 1 H, H(1), *J* = 9.0 Hz); 5.18 (s, 2 H, CH_2Ph); 7.46 (br.s, 5 H, Ph).

***N*-(Diglycyl)-*N*,*N*-bis[*N*-(β-D-galactopyranosyl)carbamoylmethyl]amine (9).** 10% Pd/C (0.07 g) was added under argon to a solution of compound **8** (0.135 g, 0.185 mmol) in water (3.5 mL). Hydrogenation was carried out by passing a weak flow of H_2 through the vigorously stirred mixture at 20 °C for 8 h. The reaction mixture was filtered through silica gel C-18 (2 g). The sorbent was washed with water (70 mL) and the solution was concentrated to 0.5 mL. Methanol (10 mL) was added dropwise with stirring at 50 °C and the solution was kept at 5 °C for 16 h. The precipitate that formed was filtered off, washed with MeOH and Et_2O, and dried. The yield of compound **9** was 0.09 g (83%), an amorphous solid, $[\alpha]_D^{18}$ +13.7 (*c* 1, H_2O). Found (%): C, 40.75; H, 6.73; N, 11.40; H_2O, 2.83. $C_{20}H_{35}N_5O_{14} \cdot H_2O$. Calculated (%): C, 40.88; H, 6.35; N, 11.92; H_2O, 3.07. ^{1}H NMR, δ: 3.44 (br.s, 2 H, $C\underline{H}_2NH_2$); 3.61—3.83 (m, 10 H); 3.97 (br.s, 2 H, 2 H(4)); 4.18 (m, 4 H, 2 CH_2); 4.38 (br.s, 2 H, CH_2); 4.93 (d, 1 H, H(1), *J* = 9.0 Hz); 4.98 (d, 1 H, H(1), *J* = 9.0 Hz).

***N*-(Chloroacetyl)-*N*,*N*-bis[*N*-(β-D-galactopyranosyl)carbamoylmethyl]amine (11).** A suspension of compound **6** (0.685 g, 1.47 mmol) in dry DMF (7 mL) was heated at 70 °C to homogenization and cooled with ice. Chloroacetic anhydride (**10**) (0.311 g, 1.8 mmol) was added and the mixture was stirred at 0 °C for 3 h. Then another portion of anhydride **10** (0.178 g, 1.04 mmol) was added with stirring and the mixture was kept at 0 °C for 3 h. The mixture was diluted with MeOH (10 mL) and kept at 20 °C for 2 h. Then Et_2O (70 mL) was added with stirring and the mixture was kept at 5 °C for 16 h. The gel-like precipitate that formed was filtered off, washed with MeOH—Et_2O (2 : 1), MeOH—Et_2O (1 : 1), and Et_2O, and dried. The residue was dissolved in water (3 mL), MeOH (3 mL) containing Et_3N (0.6 mL) was added, and the solution was kept at 20 °C for 3 h. The precipitate that formed was diluted with MeOH (9 mL), filtered off, washed with 80% aqueous MeOH, then MeOH, and Et_2O, and dried. The residue was heated in water (5 mL) to homogenization. The resulting solution was diluted with MeOH (25 mL), heated to homogenization, and kept at 5 °C for 16 h. The precipitate that formed was filtered off, washed with 80% aqueous MeOH, then MeOH, and Et_2O, and dried. The yield of compound **11** was 0.63 g (78%), an amorphous solid, $[\alpha]_D^{21}$ +15.4 (*c* 1, H_2O). Found (%): C, 39.19; H, 6.06; Cl, 6.39; N, 7.55; H_2O, 3.47. $C_{18}H_{30}ClN_3O_{13} \cdot H_2O$. Calculated (%): C, 39.31; H, 5.86; Cl, 6.45; N, 7.64; H_2O, 3.27. ^{1}H NMR, δ: 3.60—3.82 (m, 10 H); 3.97 (m, 2 H, 2 H(4)); 4.23, 4.32 (AB system, 2 H, CH_2Cl, *J* = 17.2 Hz); 4.48 (br.s, 2 H, CH_2); 4.50 (br.s, 2 H, CH_2); 4.93 (d, 1 H, H(1), *J* = 9.0 Hz); 4.98 (d, 1 H, H(1), *J* = 9.0 Hz).

***N*-[*N*-(β-D-Galactopyranosyl)carbamoylmethyl]-*N*-{*N*,*N*-bis[*N*-(β-D-galactopyranosyl)carbamoylmethyl]carbamoylmethyl}amine (12).** A mixture of compound **1** (0.44 g, 1.86 mmol), chloroacetyl derivative **11** (0.5 g, 0.91 mmol) in dry DMSO (5.6 mL), and Pr^i_2EtN (0.161 mL, 0.95 mmol) was heated in a screw-capped test tube at 70 °C for 16 h. On cooling to 20 °C, Et_2O (50 mL) was added with stirring. The clarified liquid was decanted from the oily precipitate. The precipitate was repeatedly triturated with Et_2O (15 mL each portion) into a viscous mass, which was dissolved in water (50 mL). The solution was stirred with the cation exchange resin Dowex 50w×2 (H^+) (50 mL) for 1 h. The resin was filtered off and washed with water (500 mL) and 0.5 *M* aqueous pyridine (500 mL). The pyridine eluate (250 mL) containing the target product was evaporated to dryness. The residue was dissolved in water (3 mL) and then MeOH (30 mL) was added with stirring. The mixture was kept at 5 °C for 16 h. The precipitate that formed was filtered off, washed with MeOH and Et_2O, and dried. The yield of compound **12** was 0.51 g (75%), an amorphous solid, $[\alpha]_D^{21}$ +16.6 (*c* 1, H_2O). Found (%): C, 41.65; H, 6.46; N, 9.10; H_2O, 2.13. $C_{26}H_{45}N_5O_{19} \cdot H_2O$. Calculated (%): C, 41.65; H, 6.32; N, 9.34; H_2O, 2.40. ^{1}H NMR, δ: 3.41 (s, 2 H, CH_2NH); 3.58 (s, 2 H, CH_2NH); 3.61—3.82 (m, 15 H); 3.97 (m, 3 H, 3 H(4)); 4.14, 4.25 (AB system, 2 H, CH_2N, *J* = 27.5 Hz); 4.31 (br.s, 2 H, CH_2N); 4.94 (d, 2 H, 2 H(1), *J* = 9.0 Hz); 4.98 (d, 1 H, H(1), *J* = 9.0 Hz).

***N*-(*N*-Benzyloxycarbonyldiglycyl)-*N*-[*N*-(β-D-galactopyranosyl)carbamoylmethyl]-*N*-{*N*,*N*-bis[*N*-(β-D-galactopyranosyl)-carbamoylmethyl]carbamoylmethyl}amine (14).** Compound **12** (0.22 g, 0.29 mmol) was dissolved at 50 °C in dry DMSO (1.2 mL). On cooling to 15 °C, a solution of *N*-hydroxysuccinimide ester of *N*-benzyloxycarbonylglycylglycine (**13**) (0.218 g,

0.6 mmol) in DMF (1.8 mL) was added. The reaction mixture was kept at 20 °C for 60 h. Another portion of DMF (0.9 mL) containing compound **13** (0.11 g, 0.3 mmol) was added. The mixture was kept at 20 °C for an additional 24 h and added to stirred Et_2O (50 mL). The clarified liquid was decanted from the oily precipitate. The precipitate was repeatedly triturated with Et_2O (10 mL each portion) into a viscous mass, which was repeatedly treated with hot acetone (10 mL each portion). The resulting powder was filtered off, dried, and dissolved in a mixture of water (5 mL) and MeOH (5 mL). The solution was treated with Et_3N (1 mL) at 20 °C for 3 h, diluted with MeOH (15 mL), and concentrated to 2 mL. The procedure was repeated twice. In the last run, the solution was concentrated to dryness. The residue was dissolved in MeOH (10 mL). Then Pr^iOH (10 mL) was added with stirring and the mixture was kept at 5 °C for 16 h. The precipitate that formed was filtered off, washed with MeOH—Pr^iOH (1 : 1) and Et_2O, and dried. The residue was dissolved in water (5 mL) and filtered through silica gel C-18 (20 g). The sorbent was washed with water (600 mL) and 25% aqueous MeOH (400 mL). The water—methanol fractions were concentrated to dryness. The yield of compound **14** was 0.22 g (73%), an amorphous solid, $[\alpha]_D^{23}$ + 10.3 (*c* 0.5, H_2O). Found (%): C, 43.72; H, 6.28; N, 9.34; H_2O, 5.68. $C_{38}H_{57}N_7O_{23} \cdot 3H_2O$. Calculated (%): C, 44.14; H, 6.14; N, 9.48; H_2O, 5.23. ^{1}H NMR, δ: 3.60—3.83 (m, 15 H); 3.92 (s, 2 H, CH_2); 3.98 (m, 3 H, 3 H(4)); 4.04—4.47 (m, 9 H); 4.56 (br.s, 1 H); 4.89—5.02 (m, 3 H, 3 H(1)); 5.18 (s, 2 H, CH_2Ph); 7.45 (br.s, 5 H, Ph).

***N*-(Diglycyl)-*N*-[*N*-(β-D-galactopyranosyl)carbamoylmethyl]-*N*-{*N*,*N*-bis[*N*-(β-D-galactopyranosyl)carbamoylmethyl]carbamoylmethyl}amine (15)** was obtained from compound **14** (0.188 g, 0.182 mmol) by hydrogenolysis in the presence of 10% Pd/C (0.11 g) as described for compound **9**. The yield of compound **15** was 0.14 g (91%), an amorphous solid, $[\alpha]_D^{15}$ + 12.7 (*c* 1, H_2O). Found (%): C, 42.53; H, 6.19; N, 11.46. $C_{30}H_{51}N_7O_{21}$. Calculated (%): C, 42.60; H, 6.08; N, 11.59. ^{1}H NMR, δ: 3.53 (br.s, 2 H, CH_2NH_2); 3.63—3.84 (m, 15 H); 3.99 (m, 3 H, 3 H(4)); 4.10—4.46 (m, 7 H); 4.58 (br.s, 1 H); 4.94—5.06 (m, 3 H, 3 H(1)). ^{13}C NMR, δ: 42.3 (CH_2NH_2); 44.9 (CH_2NH); 52.9 (br.s, CH_2NCH_2); 53.2 (br.s, CH_2NCH_2); 62.5 (C(6)); 70.2 (C(4)): 70.9 (C(2)); 74.9 (C(3)); 78.3 (C(5)); 81.3 (C(1)); 172.6; 172.8; 173.2; 173.4; 173.5; 173.7 (6 CO).

This work was financially supported by the Russian Foundation for Basic Research (Project No. 07-03-00120).

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Received May 22, 2008