GLYCOPEPTIDES

COMMUNICATION 14. SYNTHESIS OF O-(AMINO-ACYL) DERIVATIVES OF ARABINOSE AND MANNITOL

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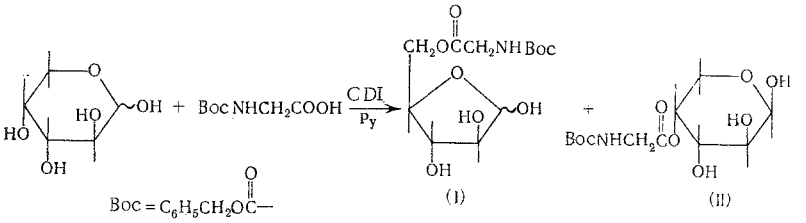
UDC 542.91 + 547.917 + 547.466

In the development of work on the synthesis of compounds modeling natural glycopeptides we have previously reported on the synthesis of O-(amino-acyl) derivatives of ribose and some hexoses [1-4] and presented data on the stability of various O-(amino-acyl) derivatives of glucose to hydrolysis and hydroxylaminolysis [5,6].

In this paper we describe the synthesis of 5-O-, 4-O-, and 2-O-glycyl-D-arabinoses, 1-O-glycyl-D-mannitol, and 3-O-glycyl-D-glucose. The results obtained in the synthesis of these compounds made it possible to determine the limits of the applicability of the carbodiimide (CDI) method: the effect of the nature of the carbohydrate and, in particular, its selectivity in the O-(amino-acylation) of carbohydrates. The following study of the chemical behavior of new O-(amino-acyl) derivatives, e.g., of the stability of the ester link, makes it possible to compose a picture of the effect of the nature of the carbohydrate and the position of the O-(amino-acyl) group in the monosaccharide molecule on the properties of natural glycopeptides.

The condensation of D-arabinose with N-(benzyloxycarbonyl) glycine was conducted in presence of dicyclohexylcarbodiimide in dry pyridine at -7°. Chromatographic study of the reaction mixture showed the presence of at least two mono(amino-acyl) derivatives together with small amounts of what was probably a diacyl derivative of arabinose. By the extraction procedure developed earlier (1,4] the starting substances and the diacyl derivatives were readily separated from the mono(amino-acyl) derivatives of arabinose. In paper chromatography in system 3 (see Experimental) the mono(amino-acyl) fraction gave two spots with R_f 0.69 and 0.77; ratio about 1 : 2.5. These substances were separated by partition chromatography on cellulose. Periodate oxidation showed that the substance with R_f 0.69, which was obtained in the smaller amount, was 5-O-[N-(benzyloxycarbonyl) glycyl]-D-arabinose (I) (3 molecular proportions of periodic acid were consumed, and 3 mol.prop. of formic acid were formed). The substance with R_f 0.77 was probably a mixture of isomeric mono(amino-acyl) derivatives of arabinose in which secondary hydroxyls were substituted. The mixture crystallized partially after a long time; the crystalline compound isolated was investigated, and the oily residue was not studied. Periodate oxidation of the crystalline compound showed unequivocally (2 mol.prop. of periodic acid were consumed, and 2 mol.prop. of formic acid were formed) that this substance was 4-O-[N-(benzyloxycarbonyl) glycyl]-D-arabinose (II). The negative rotation angle of (II) diminishes in methanolic solution which enables us to assign (II) to the B-D-arabinose series.

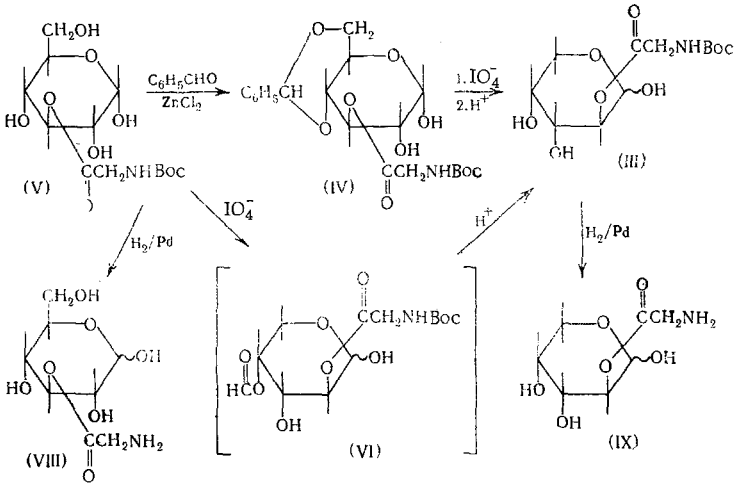


(I) (II)

We did not succeed in selecting conditions for the O-(amino-acylation) of arabinose under which the main reaction product would be the product of the amino-acylation of the primary hydroxy group (I). Thus,

Institute of Chemistry of Natural Products, Academy of Sciences, USSR. Translated from Izvestiya Akademii Nauk SSSR, Seriya Khimicheskaya, pp. 1772-1779, No. 10, October, 1966. Original article submitted May 28, 1964.

lowering the temperature from 20 to -20° raised the yield of (I) somewhat, but the amount of the products of the amino-acylation of the secondary hydroxy groups of arabinose remained predominant. Our results on the condensation of D-xylose with N-(benzyloxycarbonyl) glycine in presence of dicyclohexylcarbodiimide show that in this case a mixture of isomeric mono(amino-acylation) derivative is again obtained which in paper chromatography gives two spots with R_f 0.75 and 0.83 (system 3); ratio about 1 : 3.5. By preparative partition chromatography on cellulose these substances were separated and isolated in the form of amorphous powders. The periodate oxidation of these substances went much more slowly than in the case of the corresponding derivatives of other monosaccharides, and as a result of overoxidation processes it did not give a decisive answer on the structures of these substances. The substance with R_f 0.83 was probably a mixture of products of the mono(amino-acylation) of the secondary hydroxyls of xylose, whereas the substance with R_f 0.75, which was obtained in the smaller amount, was probably 5-O-[N-(benzyloxycarbonyl) glycyl]-D-xylose.



Thus, the carbodiimide method of condensing N-(benzyloxycarbonyl) glycine with arabinose or xylose, unlike the similar condensation with ribose [4] or hexoses [1-4], gives a mixture of products of the amino-acylation of the secondary hydroxyls, which is probably related to the existence of these monosaccharides in solution predominantly in the pyranose form. However, with the development of sufficently convenient methods for the separation of these mixtures the most varied O-(amino-acyl) derivatives may be obtained, including derivatives of furanose forms of these monosaccharides, which again demonstrates the universality of the carbodiimide method. In connection with our subsequent work on the determination of the effect of the position of the O-(amino-acyl) group in the monosaccharide molecule on the stability of the ester link, we also synthesized 2-O-[N-(benzyloxycarbonyl) glycyl]-D-arabinose (III), which was prepared by the periodate oxidation of 4,6-O-benzylidene-3-O-[N-(benzyloxycarbonyl) glycyl]-D-glucose (IV) or 3-O-[N-(benzyloxycarbonyl) glycyl]-D-glucose (V), which we have described earlier [2].

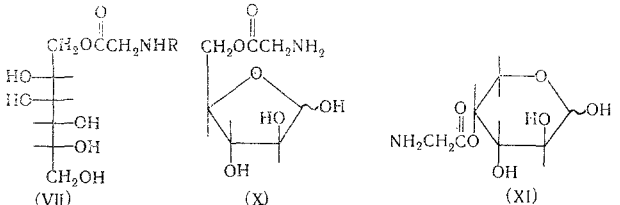
The periodate oxidation of (IV) was conducted in 55% methanol for three days and, without isolation in the pure state, the oxidation product was hydrolyzed with hydrochloric acid to (III). After partition chromatography on cellulose (III) was obtained in 54% yield as an amorphous powder. The structure of (III) was proved unequivocally by the fact that after the acid or alkaline hydrolysis of (III) arabinose was identified, and also by periodate oxidation (2 mol.prop. of periodic acid were consumed). The second method of synthesizing (III) proved to be considerably more convenient. It was found that (V) is oxidized quantitatively in the course of 90 minutes with the absorption of 1 mol.prop. of sodium periodate, and further oxidation goes extremely slowly. In the oxidation only the bond between the C-1 and C-2 atoms of glucose is broken, and probably 2-O-[N-(benzyloxycarbonyl)-glycyl]-4-O-formyl-D-arabinose (VI), which does not contain an a-glycol grouping, is formed. Without isolation in the pure state (VI) was subjected to acid hydrolysis and gave a 71% yield of (III), which was completely identical in its constants to the substance obtained by the first method. Confirmation of the quantitative cleavage of the bond between C-1 and C-2 atoms in (V) is provided by the fact that after the hydrolysis of (VI) only one monosaccharide – arabinose – was identified by paper chromatography. An analogous course of periodate oxidation is described in the literature for 3-deoxyhexoses [7,8].

We must point out that the synthesis of (V) by the acid hydrolysis of its 1,2:5,6-di-O-isopropylidene derivative has been described by us previously very briefly [2]; it is associated with certain difficulties, which prevented Stroh and co-workers [9] from preparing (V) in an analogous way and merits more detailed examination. Chromatographic investigation of the products of the hydrolysis of 3-O-[N-(benzyloxycarbonyl) glycyl]-1,2:5,6-di-O-isopropylidene-D-glucose, which is readily prepared by the carbodiimide method, with 70% acetic acid or 40% formic acid at 20° showed that, apart from (V) and products of its hydrolysis, substances are formed which can be attributed to the partial acylation of (V) by acetic or formic acid (cf. [10]). When hydrochloric acid is used, hydrolysis at 70-100° is accompanied by the migration of the benzyloxycarbonyl) amino acyl group onto the primary hydroxy group, which is evidenced by the formation of the by-product 6-O-[N-(benzyloxycarbonyl) glycyl]-D-glucose, which we identified chromatographically. To avoid migration we carried out the hydrolysis with hydrochloric acid in aqueous acetone solution at 50° for 2.5 h. Moreover, earlier [2] for the removal of hydrochloric acid from the hydrolyzate we have used silver carbonate, but the excess of silver carbonate can bring about a fairly appreciable migration of the acyl group, and therefore we have preferred to remove hydrochloric acid by extraction (see Experimental). However, even under the best conditions found, as well as the hydrolysis of isopropylidene groups, hydrolysis of the ester link occurs also and the yield of crystalline (V) is 35%.

In benzaldehyde solution in presence of zinc chloride (V) is converted very smoothly in 81% yield into (IV), which has the same melting point as the sample prepared previously [1,2]. Data on the direction of the mutarotation of solutions of crystalline (IV) and (V) enable us to assign them to the α-D-glucopyranose series.

For use in work on the determination of the effect of the presence of an open carbohydrate chain on the stability of O-(amino-acyl) derivatives we synthesized 1-O-[N-(benzyloxycarbonyl) glycyl]-D-mannitol (VIIa). (VIIa) was synthesized by the carbodiimide method described for monosaccharides [1-4]. In view of the poor solubility of mannitol in dry pyridine the reaction was conducted in dilute solution, which probably lowered the yield of (VIIa), which was 17%. The structure of (VIIa), which was isolated in the crystalline state, followed unequivocally from the results of periodate oxidation (4 mol.prop. of periodic acid were consumed, and 3 mol.prop. of formic acid were formed).

As indicated above, the structures of (I) - (III) and (VII) were confirmed by periodate oxidation. Since after an excessively long time periodate oxidation led to a high consumption of oxidant, we checked the consumption of periodic acid periodically during the oxidation. To determine the consumption of periodic acid we carried out titration with sodium arsenite in presence of excess of sodium bicarbonate with cooling with ice, and this gave results of good reproducibility. Data on periodic acid consumption as a function of oxidation time are presented in Table 1 (see Experimental) and show that in the oxidation of the O-(amino-acyl) derivative (I), which is acylated on the primary hydroxy group, 3 mol.prop. of periodic acid are consumed rapidly, while in the oxidation of the derivatives with acylated secondary hydroxy groups (II) and (III) 2 mol.prop. of periodic acid are consumed rapidly, after which fairly slow oxidation occurs. We consider that the more marked overoxidation of (III) is probably to be explained by the formation of a malonaldehyde derivative, and as is well known, these are particularly prone to overoxidation.



Hydrogenolysis of the (benzyloxycarbonyl) amino acyl derivatives obtained, which was conducted, as described previously [1-4], over $Pd/BaSO_4$ in 75% methanol in presence of oxalic acid, gave the oxalates of the corresponding compounds containing a free amino group (VIIb) and (VIII)-(XI) in yields of up to 70%. In hydrogenolysis in water or methanol without the addition of acids rapid hydrolysis or alcoholysis of the

TABLE 1

Substance	HIO_4, mol.prop.				HCOOH, mol.prop.
	0.5 h	1 h	2 h	3 h	2 h
5-O-[N-(Benzyloxycarbonyl)glycyl]-D-arabinose	2.53	2.98	3.05	3.10	2.84
4-O-[N-(Benzyloxycarbonyl)glycyl]-D-arabinose	1.93	2.00	2.08	2.18	2.01
2-O-[N-(Benzyloxycarbonyl)glycyl]-D-arabinose	1.44	1.92	2.11	2.23	-
1-O-[N-(Benzyloxycarbonyl)glycyl]-D-mannitol	-	3.92	3.97	4.00	2.89

ester link occurred. More detailed data on the stability of the ester link in the compounds synthesized will be published in the future.

EXPERIMENTAL

Chromatography and electrophoresis were conducted on "M" chromatographic paper from Leningrad No. 2 factory. Chromatograms were produced by the ascending method. We used the following solvent systems for chromatography: isobutyl alcohol saturated with water (system 1); butyl alcohol–acetic acid–water, 4 : 1 : 5 (system 2); isobutyl alcohol–butyl acetate–water (system 3). Electrophoresis was conducted in buffers: pyridine (2 ml)–acetic acid (4 ml)–water (to 1 liter), pH, 4.3-4.5; pyridine (0.5 ml)–acetic acid (30 ml)–water (to 1 liter), pH 2.8-2.9. Spots were detected with the aid of silver nitrate, aniline phthalate, and ninhydrin.

Condensation of D-Arabinose with N-(Benzyloxycarbonyl) glycine. 3 g of D-arabinose and 2.1 g of N-(benzyloxycarbonyl) glycine were dissolved in 140 ml of dry pyridine, the solution was cooled to -7°, 2.5 g of dicyclohexylcarbodiimide was added, and the mixture was left at -7° for four days. Pyridine was vacuum-distilled off, and the residue was treated with a mixture of water (80 ml) and ether (50 ml). Crystals of 1,3-dicyclohexylurea were filtered off, the ether layer was separated, and the aqueous layer was extracted twice with ether. Two to three drops of acetic acid were added to the aqueous solution, and it was extracted six times further with ether. The aqueous solution was extracted eight times with butyl alcohol. The butyl alcohol solution was washed five times with water and vacuum-evaporated. The oily residue (1.8 g) was dissolved in 15 ml of isobutyl alcohol and applied to a column of cellulose (600 g) in system 1, and 600 ml of isobutyl alcohol was added to the column. When 100 ml of solvent had left the column, 250 ml of system 1 was added to the column, and then system 1 was added continuously at the rate at which solvent left the column (communicating vessels). Fractions containing only one substance with R_f 0.69 or 0.77 (system 3) were evaporated, and the mixed fractions were re-chromatographed. We obtained 0.5 g (14%) of (I) (R_f 0.60 in system 3) as an amorphous hygroscopic powder $[\alpha]_D^{20}$ −60.4° (c 0.5; water). Found %: C 52.78, 53.03; H 5.77, 5.76. $C_{15}H_{19}O_8N$. Calculated %: C 52.79; H 5.61.

The fractions containing the substance with R_f 0.77 (system 3) were evaporated. The residue, which crystallized partially on standing, was treated with chloroform, and the crystals were filtered off, washed with chloroform and a little ethyl acetate, and crystallized from a 1 : 1 mixture of ethyl acetate and ethanol. We obtained 0.36 g (10.8%) of (II) in the form of coloreless crystals of m.p. 158-159°, $[\alpha]_D^{20}$ — 73.3°, (c 0.35; water); $[\alpha]_D^{20}$ — 85.2° (after 5 min) → —46.1° (after 20 h – constant) (c 0.3; methanol). Found %: C 52.89, 52.93; H 5.62, 5.48. $C_{15}H_{19}O_8N$. Calculated %: C 52.79; H 5.61.

Condensation of D-Xylose with N-(Benzyloxycarbonyl)glycine. The procedure was similar to that in the condensation with D-arabinose, and we started from 3 g of D-xylose, 2.1 g of N-(benzyloxycarbonyl)glycine, and 2.5 g of dicyclohexylcarbodiimide in 85 ml of dry pyridine. After two partition-chromatography treatments on cellulose we obtained 0.96 g (28%) of an amorphous substance with R_f 0.83 (system 3), which was probably a mixture of isomeric products of amino-acylation on secondary hydroxy groups, and 0.29 g (8.5%) of a substance with R_f 0.75 (system 3) in the form of an amorphous colorless hygroscopic powder, which was probably 5-O-(N-benzyloxycarbonyl)glycyl]-D-xylose, $[\alpha]_D^{20}$ +10.2° (c 0.3; water). Found %: C 52.73, 53.02; H 5.62, 5.81. $C_{15}H_{19}O_8N$. Calculated %: C 52.79; H 5.61.

3-O-[N-(Benzyloxycarbonyl)glycyl]-α-D-glucose (V). 3.8 g of 3-O-N-(benzyloxy-carobonyl)glycyl]-1,2:5,6-di-O-isopropylidene-D-glucofuranose [2] was dissolved in 25 ml of acetone, the solution was heated to 50°, and in the course of 15 min 30 ml of dilute (1 : 9) hydrochloric acid was added

dropwise with stirring. The reaction mixture was heated further for 2.5 h at 50°, acetone was vacuum-distilled off, and 70 ml of water was added. The aqueous solution was extracted eight times with ether and then seven times with butyl alcohol. The butyl alcohol solution was washed repeatedly with eater until neutral. Butyl alcohol was vacuum-evaporated. The oily residue was dissolved in a little hot ethyl acetate and left in a refrigerator. The crystals precipitated were filtered off; yield 1.1 g (35%). After recrystallization from ethyl acetate we obtained colorless crystals of (V), m.p. 132-133° $[\alpha]_D^{20}$ + 64.7° (after 5 min) → + 37.8° (after 20 h – constant) (c 0.5; water). Found%: C 51.68; H 5.65, 5.68; $C_{16}H_{21}O_9N$. Calculated%: C 51.75; H 5.70.

4,6-O-Benzylidene-3-O-[N-(benzyloxycarbonyl)glycyl]-[α]-D-glucose (IV). 0.93 g of (V) was dissolved in 13 ml of freshly distilled benzaldehyde, 0.21 g of freshly fused zinc chloride was added, and the mixture was stirred vigorously for 2 h at room temperature. The reaction mixture was diluted with 50 ml of hexane, and the crystals formed were filtered off, washed repeatedly with hexane, and treated with 20 ml of 3% ammonium sulfate solution and 20 ml of ether. The crystals were filtered off and washed well with water and then ether; yield 0.93 g (81.5%). Recrystallization from alcohol gave colorless needles of (IV), m.p. 164-165°; $[\alpha]_D^{20}$ + 15.6° (after 10 min) → −1.6° (after 24 h – constant)(c 0.5; methanol). Found%: C 60.04, 60.00; H 5.67, 5.65; $C_{23}H_{25}O_9N$. Calculated%: C 60.13; H 5.48.

2-O-[N-(Benzyloxycarbonyl)glycyl]-D-arabinose (III). 0.5 g of (IV) was dissolved in 75 ml of methanol, the solution was cooled with ice, 63 ml of sodium periodate solution (7 g/liter) was added, and the mixture was left at room temperature in the dark for three days. 0.5 ml of ethylene glycol was added, after 2 h methanol was vacuum-distilled off, and 40 ml of water and 30 ml of ether was added. The aqueous solution was extracted twice with ether. The combined ether extracts were washed five times with water, and ether was evaporated. The residue was dissolved in 6.2 ml of acetone, the solution was heated to 45°, 5 ml of dilute (1 : 30) hydrochloric acid was added dropwise in the course of 10 min, and the mixture was heated for 1 h 50 min at 45°. Acetone was evaporated, the solution was diluted to 20 ml with water, and it was extracted with ether ten times. The aqueous solution was extracted eight times with butyl alcohol. The butyl alcohol solution was washed with water until neutral. Butyl alcohol was vacuum-evaporated, and the residue was subjected to partition chromatography on cellulose (75 g) in system 1. Fractions containing the substance with R_f 0.78 (system 3) were evaporated; yield 0.2 g (54%).

1.1 g of (V) was dissolved in sodium periodate solution (10 g/liter), and the solution was left at room temperature in the dark for 90 min. 0.5 ml of ethylene glycol was added, and the mixture was again left in the dark for 90 min. The solution obtained was extracted six times with butyl alcohol, and the extract was washed three times with water and vacuum-evaporated. The residue was dissolved in 12.5 ml of acetone, 10 ml of dilute (1 : 30) hydrochloric acid was added, and the mixture was heated at 45° for 90 min. Acetone was vacuum-distilled off. The aqueous solution was diluted to 50 ml and extracted 12 times with ether. The aqueous solution was extracted seven times with butyl alcohol. The butyl alcohol solution was washed with water until neutral, and butyl alcohol was vaccum-evaporated. We obtained 0.72 g (71.2%) of an amorphous hygroscopic powder, $[\alpha]_D^{20}$ −48.2° (c 0.35; water). Found%: C 52.92, 53.09; H 5.81, 5.85. $C_{15}H_{19}O_8N$. Calculated%: C 52.79; H 5.61.

By the paper chromatography in systems 1-3 of the acid hydrolyzate described above and of the alkaline hydrolyzate of (III) (1 mg of the substance, 0.15 ml of methanol, 0.03 ml of concentrated ammonia, 2 h) we identified only one monosaccharide – arabinose.

1-O-[N-(Benzyloxycarbonyl)glycyl]-D-mannitol (VIIa). 3 g of mannitol and 1.8 g of N-(benzyloxycarbonyl)glycine were dissolved in 1400 ml of dry pyridine, the solution was cooled to 5°, 2.2 g of dicyclohexylcarbodiimide was added, and the mixture was left at 5° for four days. Pyridine was vacuum-evaporated. The residue was treated with 80 ml of water and 50 ml of ether. The crystals were filtered off, the ether layer was separated, and the aqueous layer was extracted twice with ether. A few drops of acetic acid were added to the aqueous solution, and the solution was extracted eight times more with ether and then 15 times with water. Butyl alcohol was vacuum-distilled off. The crystalline residue was treated with a little ethyl acetate, filtered off, and recrystallized from a 1 : 1 mixture of ethyl acetate and methanol. We obtained 0.55 g (17%) of (VIIa) in the form of colorless crystals, m.p. 150-151°; $[\alpha]_D^{20}$ + 4.2° (c 0.5, methanol). Found%: C 51.52, 51.62; H 6.23, 6.09; $C_{16}H_{23}O_9N$. Calculated%: C 51.47; H 6.21.

Oxidation with Periodic Acid. 20-24 mg of the substance under investigation was dissolved in 35 ml of an acetate buffer of pH 4.3, 10 ml of sodium periodate solution (5.5 g/liter) was added, the volume was made up to 50 ml with water, and the mixture was left in the dark at room temperature.

5-ml samples were taken periodically, cooled with ice, and neutralized with 0.2-0.25 g of $NaHCO_3$ and 1.5 ml of cooled 4% $NaHCO_3$ solution; 0.5 g of potassium iodide was added, and the solution was titrated with sodium arsenite.

Two h after the start of the oxidation 0.1 ml of ethylene glycol was added to 20 ml of the solution being oxidized, the mixture was left in the dark for 90 min and then neutralized exactly with alkali, 0.2 ml of 4N HCl, 1 ml of saturated sodium acetate solution, and 2 ml of 4% mercuric chloride solution were added, and the mixture was boiled in a water bath in the dark for 90 min. The solution was cooled, and the precipitate was filtered off, washed with water, and dried to constant weight at 100°. From the weight of calomel we determined the amount of formic acid formed as a result of the oxidation. The results of the oxidation are presented in Table 1.

3-O-Glycyl-D-glucose (Oxalate) VIII). 185 mg of (V) was dissolved in 6 ml of 75% methanol, 60 mg of 5% palladium on barium sulfate and 38 mg of oxalic acid dihydrate were added, and hydrogenation was conducted for one h. Catalyst was separated by centrifugation, washed with a little 50% methanol, and again centrifuged. The solution obtained was filtered and diluted with a large amount of acetone. The precipitate formed was separated by centrifugation, dissolved in the least possible amount of water, and precipated with acetone. The precipitate was ground with dry acetone and then centrifuged, acetone was decanted, and residual acetone was removed in a vacuum. We obtained 94 mg (67%) of electrophoretically homogeneous (VIII) as a colorless amorphous hygroscopic powder, decomp. temp. 87-88°; $[\alpha]_D^{20}$ + 49° (c 1.0 water). Found %: C 38.31, 38.52; H 5.71, 5.72; $(C_8H_{15}O_7N)_2 \cdot (COOH)_2$. Calculated %: C 38.30; H 5.71.

1-O-Glycyl-D-mannitol (Oxalate) VIIb). This was prepared analogously to (VIII) from 186 mg of (VIIa) and 38 mg of oxalic acid dihydrate in 6 ml of 75% methanol. Yield 97 mg (69%) of a colorless amorphous hygroscopic powder with $[\alpha]_D^{20}$ + 4.8° (c 1.5; water). Found%: C 38.27, 38.33; H 6.41, 6.51; $(C_8H_{17}O_7N)_2 \cdot (COOH)_2$. Calculated%: C 38.03, 6.38.

5-O-Glycyl-D-arabinose (Oxalate). This was prepared analogously to (VIII) from 170 mg of (I) and 38 mg of oxalic acid dihydrate in 4 ml of 75% methanol. Yield 81.5 mg (65%) of a colorless amorphous hygroscopic powder with decomp. temp. 69-70°, $[\alpha]_D^{20}$ −66.7° (c 1.5, water). Found%: C 38.46, 38.48; H 5.86, 5.90; $(C_7H_{13}O_6N)_2 \cdot (COOH)_2$. Calculated%: C 38.10; H 5.60.

4-O-Glycyl-D-arabinose (Oxalate). This was prepared analogously to (VIII) from 170 mg of 4-O-[N-(benzyloxycarbonyl)glycyl]-D-arabinose and 38 mg of oxalic acid dihydrate in 10 ml of 75% methanol. Yield 80 mg (64%) of a colorless amorphous hygroscopic powder, decomp. temp. 82-83°; $[\alpha]_D^{20}$ −83.4° (c 1.5; water). Found%: C 37.86, 37.79; H 5.49, 5.65; $(C_7H_{13}O_6N)_2 \cdot (COOH)_2$. Calculated%: C 38.10; H 5.60.

2-O-Glycyl-D-arabinose (Oxalate). This was prepared analogously to (VIII) from 170 mg of (III) and 38 mg of oxalic acid in 5 ml of 75% methanol. Yield 80 mg (64%) of a colorless amorphous hygroscopic powder, $[\alpha]_D^{20}$ −65.4° (c 1.5; water). Found%: C 37.84, 37.76; H 5.81, 5.83; $(C_7H_{13}O_6N)_2 \cdot (COOH)_2$. Calculated%: C 38.10; H 5.60.

CONCLUSIONS

1. The previously developed carbodiimide method was extended to the synthesis of 5-O- and 4-O-[N-(benzyloxycarbonyl)glycyl]-D-mannitol.
2. By the periodate oxidation of 3-O-[N-(benzyloxycarbonyl)glycyl]-D-glucose or its 4,6-O-benzylidene derivative 2-O-[N-(benzyloxycarbonyl)glycyl-D-arabinose was obtained.
3. By the hydrogenolysis of the O-[(benzyloxycarbonyl) amino acyl] derivatives in presence of oxalic acid the corresponding O-(amino-acyl) derivatives were obtained as oxalates.

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All abbreviations of periodicals in the above bibliography are letter-by-letter transliterations of the abbreviations as given in the original Russian journal. *Some or all of this periodical literature may well be available in English translation.* A complete list of the cover-to-cover English translations appears at the back of the first issue of this year.
