Studies on Aminosugars. XXVI. A New Method for the Simultaneous Protection of Amino and Hydroxyl Groups in Aminosugars and Aminocyclitols[1]

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(Received December 11, 1970)

2-Deoxystreptamine-1,6:3,4-dicarbamate (II), methyl 2-amino-2-deoxy-α-D-glucopyranoside-2,3-carbamate (VIII) and methyl 6-amino-6-deoxy-α-D-glucopyranoside-4,6-carbamate (X) were prepared by utilizing *p*-nitrophenoxycarbonyl chloride or phenoxycarbonyl chloride.

The simultaneous protection of amino and hydroxyl groups is useful in synthetic chemistry, and this has been performed in case of *cis* amino and hydroxyl groups in cyclic compounds as well as in adjacent amino and hydroxyl groups in open-chain compounds by protection in the form of oxazolidine,[2] 2-oxazoline,[3] and 2-oxazolidone.[4] However, since natural aminosugars and aminocyclitols often have *trans*-equatorial substituents, the simultaneous protection of *trans*-diequatorial amino and hydroxyl groups or *trans*-diequatorial aminomethyl (or hydroxymethyl) and hydroxyl (or amino) groups are often desired.

Recently, Miyai and Gross[5] prepared the 2,3-carbamate derivative of benzyl 2-amino-4,6-*O*-benzylidene-2-deoxy-β-D-glucopyranoside by use of *N,N'*-carbonyl-diimidazole in absolute tetrahydrofuran. In the course of our investigation[6] of synthesis of aminoglycosides we have found a successful protection of the above-described couples of amino and hydroxyl groups by utilizing *p*-nitrophenoxycarbonyl chloride (NPCC) or phenoxycarbonyl chloride (PCC). Brief report of some of our findings has been published earlier.[1] The characteristic features of our method lie in that 1) the protection is performed in one-step procedure in good yields, 2) in a medium containing water which is a requisite condition in dealing with aminosugars or aminocyclitols, and 3) couples of amino and hydroxyl groups are selectively protected in the presence of other hydroxyl groups.

As typical examples, we here described the preparation of 2-deoxystreptamine-1,6:3,4-dicarbamate (II), methyl 2-amino-2-deoxyl-α-D-glucopyranoside-2,3-carbamate (VIII), and methyl 6-amino-6-deoxy-α-D-glucopyranoside-4,6-carbamate (X) from 2-deoxystreptamine (I), methyl 2-amino-2-deoxy-α-D-glucopyranoside, and methyl 6-amino-6-deoxy-α-D-glucopyranoside, respectively.

An aqueous solution of deoxystreptamine (I) was treated with a cold solution of NPCC in acetone in the presence of appropriate amount of anion exchange resin (OH form) and subsequent solvent extraction followed by column chromatography gave a cyclic dicarbamate derivative (II) in a yield of 73%. Structural proof of II was performed on the basis of its elemental analysis, IR (Chart I) and NMR spectra. The absence of the absorption peak at ~1550 cm^{-1} (amide II) indicated the cyclic amide structure and the chair conformation as shown in Chart 2 was confirmed by the splitting pattern of H-2,2' signals in its NMR spectrum. Further confirmation was obtained from its mono-*O*-acetyl derivative (III), which gave *m/e* 256 (molecular ion) by mass spectroscopy and, in the NMR spectrum, large coupling constants (J=9.4—11.2 Hz) between H_1–H_{2a}(H_3–H_{2a}), H_3–H_4(H_1–H_6), and H_4–H_5(H_5–H_6)

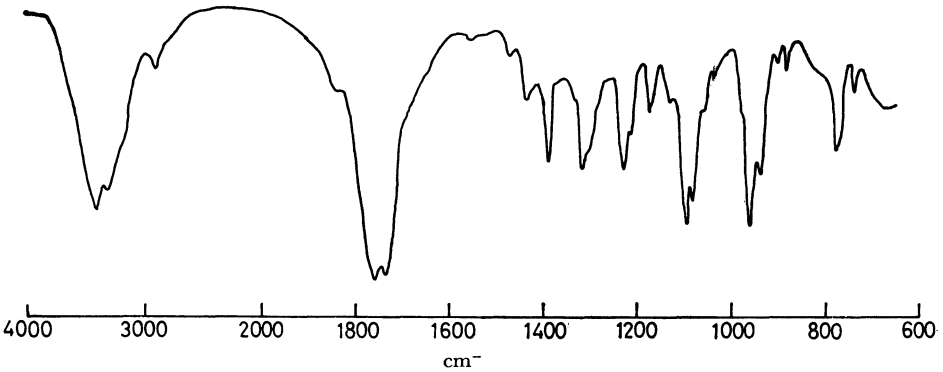


Chart 1. IR spectrum of 2-deoxystreptamine-1,6:3,4-dicarbamate (II).

1) Preliminary communication: S. Umezawa, T. Tsuchiya, Y. Takagi, This Bulletin, **43**, 1602 (1970).

2) See for example: E. D. Bergmann, *Chem. Rev.*, **53**, 309 (1953); G. E. McCasland and E. C. Horswill, *J. Amer. Chem. Soc.*, **73**, 3744, 3923 (1951); "Chemistry of Carbon Compounds," ed. by E.H. Rodd, Elsevier Publishing Co. (1957), IV-A, p. 372.

3) See for example: R. H. Wiley and L. L. Benett, Jr., *Chem. Rev.*, **44**, 447 (1949); W. M. zu Reckendorf, *Chem. Ber.*, **98**, 93 (1965); E.H. Rodd, *loc. cit.*, IV-A, p. 361; *ibid.*, I-F, p. 470 (1967).

4) See for example: P. H. Gross, K. Brendel, and H. K. Zimmerman, *Ann. Chem.*, **680**, 159 (1964); **681**, 225 (1965); K. Miyai, H. K. Zimmerman, and P. H. Gross, *J. Org. Chem.*, **34**, 1635 (1969); E.H. Rodd, *loc., cit.*, IV-A, p. 372.

5) K. Miyai and P. H. Gross, *J. Org. Chem.*, **34**, 1638 (1969).

6) Y. Nishimura, T. Tsuchiya, and S. Umezawa, This Bulletin, **43**, 2960 (1970).

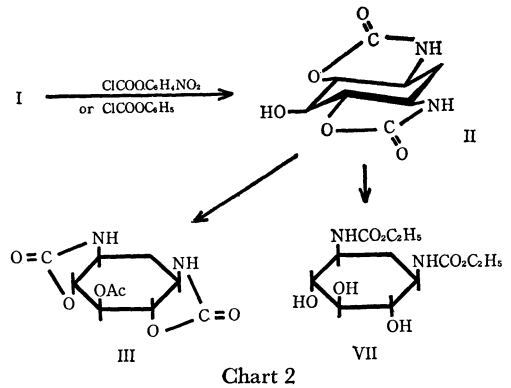


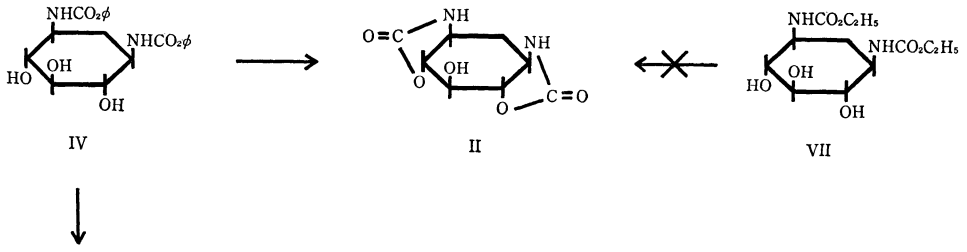
Chart 2

indicated the presence of all *trans*-axial protons. Compound II could also be prepared from I and PCC in the presence of anion-exchange resin or sodium carbonate, but the reaction required a longer period than that by NPCC.

When, however, I and PCC were brought into reaction in the presence of sodium hydrogen carbonate for a short period, *N*,*N*′-diphenoxycarbonyl-2-deoxystreptamine (IV) was formed. The spectroscopic data of its tri-*O*-acetyl derivative (V) and 4,5,6-tri-*O*-acetyl-*N*,*N*′-diacetyldeoxystreptamine (VI) support the structure for IV. When the solution of the compound IV in aqueous acetone was treated with a small amount of anion-exchange resin, IV was converted to a cyclic dicarbamate (II) in one hour in a yield of 81%. This result indicates that the reaction intermediate to II is IV, not an *O*-phenoxycarbonyl derivative.[7] Since *N*-ethoxycarbonyl derivative[6] (VII) of I could not be cyclized under the similar conditions, electron-withdrawing properties of phenyl and nitrophenyl groups may facilitate the cyclization.

We have found the properties of the cyclic carbamate group useful for synthetic purposes. When II was treated with barium hydroxide at 100°C, the carbamate groups were broken to give I; whereas, when II was refluxed in ethanol with a catalytic amount of sodium it was converted to VII in a yield of 77% (Chart 2). Thus, the protected hydroxyl group in a cyclic carbamate group could be made free leaving the amino group still protected.

By the similar treatment of methyl 2-amino-2-deoxy-α-D-glucopyranoside[8] with NPCC, a cyclic carbamate (VIII) was obtained in a yield of 78%. The structure was proved from its elemental analysis and spectroscopic data, and also from those of its di-*O*-acetyl derivative (IX) (Chart 3): The absence of any absorption peak near 1550 cm^{-1} in VIII and IX and the large coupling constants ($J_{2,3}$, $J_{3,4}$, and $J_{4,5}$=9—12Hz) of these compounds showed that both are cyclic carbamates of CI conformation, and these results exclude the pos-



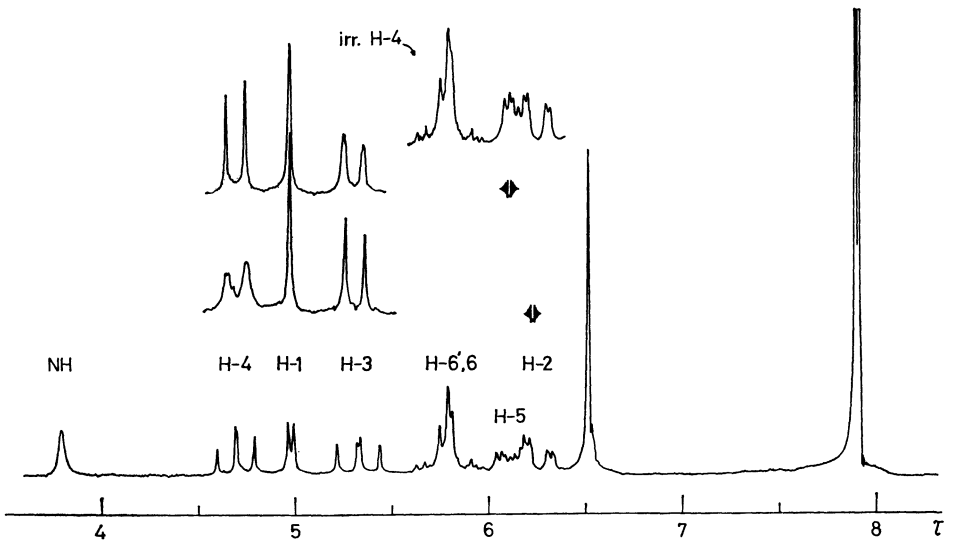
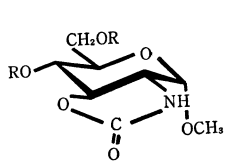


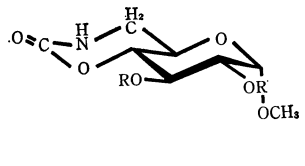
Chart 3. NMR spectrum of methyl 4,6-di-*O*-acetyl-2-amino-2-dexoy-α-D-glucopyranoside-2,3-carbamate (IX) in $CDCl_3$ at 100 MHz.

7) *Cf.* Ref. 5.

8) P. W. Austin, F. E. Hardy, J. G. Buchanan, and J. Baddiley, *J. Chem. Soc.*, **1963**, 5350.



Ⅷ R=H
Ⅸ R=Ac



X R=H
Ⅺ R=Ac

sibility of a 2,4-cyclic carbamate structure for the carbamate.

When similarly treated with NPCC, methyl α-D-glucopyranoside gave no reaction indicating that NPCC does not come into reaction with any hydroxyl group under a similar condition. This result also precludes the possibility of formation of an *O*-phenoxycarbonyl intermediate.

Methyl 6-amino-6-deoxy-α-D-glucopyranoside[9] was converted to 4,6-cyclic carbamate (X) in a yield of 78%. The structure was proved by its elemental analysis and spectroscopic data, and also from those of its di-*O*-acetyl derivative (XI), the CI conformation of these compounds being confirmed. These results exclude the possibility of 3,6-cyclic carbamate for the carbamate.

In glucopyranosides, the 2-*O*-, 3-*O*-, and 2,3-di-*O*-substituted derivatives was readily prepared *via* corresponding 4,6-*O*-benzylideneglucopyranosides, but the protecting method was not applicable in such case as 6-amino-6-deoxy-glucopyranosides. The above described cyclic carbamate method gives a solution for this problem.

Experimental

Thin-layer chromatography (tlc) was performed by the use of silica gel and the chromatograms were visualized by spraying with sulfuric acid. The NMR spectra were recorded with Varian A-60D and HA-100D spectrometers. Tetramethylsilane (τ 10.00; for the solutions other than deuterium oxide) and sodium 4,4′-diemthyl-4-silapentane-1-sulfonate (τ 10.00; for the solutions of deuterium oxide) were used as the internal standards.

2-Deoxystreptamine-1,6:3,4-dicarbamate (II). a) From 2-Deoxystreptamine (I) and p*-Nitrophenoxycarbonyl Chloride (NPCC) in the Presence of Dowex Resin:* To an ice-cold mixture of an aqueous solution (1 m*l*) of I (104 mg, 0.64 mmol) and wet Dowex 1×2 resin (OH form, 3.5 m*l*), a cold solution of NPCC (340 mg, 1.7 mmol) in acetone (3.4 m*l*) was added under stirring within several minutes and the mixture was stirred at that temperature for 1 hr. A weakly acidic yellow slurry resulted. Another Dowex resin (3.5 m*l*) and NPCC (340 mg) in acetone (3.4 m*l*) was added and stirring was continued for 1 hr in the cold. On tlc with acetone-ethyl acetate (2:1), three spots (R_f 0.95, 0.5, and 0) appeared; the first is a mixture of NPCC, *p*-nitrophenol, and some derivatives originated from NPCC, and the last a by-product, which gave R_f 0.35 on tlc with DMF. The mixture was extracted with ether to remove the first mixture (R_f 0.95) and the residual mixture was filtered off, washed with hot aqueous acetone (1:2). The combined filtrate and the washings were then evaporated to give a yellow solid (109 mg). The solid was chromatographed on a column of silica gel (1.4×18 cm) with DMF and the fraction containing II (R_f 0.5 with acetone-ethyl acetate 2:1) was evaporated to give a colorless solid (100 mg, 73%), which was recrystallized from aqueous methanol (1:1); mp >285°C.

Found: C, 41.14; H, 5.30; N, 12.35%. Calcd for $C_8H_{10}O_5N_2 \cdot H_2O$: C, 41.38; H, 5.21; N, 12.07%.

IR spectrum: 3410 (s), 3300, 2920 (w), 1760 (s), 1735 (s), 1470 (w), 1435, 1390, 1315, 1230, 1210, 1175, 1130 (w), 1095, 1085, 960 (s), 935, 905 (w), 885 (w), 775, 740 cm^{-1}. NMR spectrum (in DMSO-d_6 at 60 MHz): τ : 2.3 (2H s., disappeared on deuteration, NHCO), 4.0 (1H short-range multiplet, disappeared on deuteration, OH), 5.6—6.7 (5H m., H-1,3,4,5,6), 7.80 (1H double triplets H-2_e), 8.40 (1H q., H-2_a); $J_{1,2a}=J_{3,2a}=J_{2a,2e}=11$ Hz, $J_{1,2e}=J_{3,2e}=3$ Hz.

b) From I and Phenoxycarbonyl Chloride(PCC)in the Presence of of Dowex Resin: To an ice-cold mixture of an aqueous solution (2 m*l*) of I (108 mg, 0.67 mmol) and wet Dowex 1×2 resin (OH form, 4.1 m*l*), a cold solution of PCC (470 mg, 3.0 mmol) in acetone (4.2 m*l*) was added under stirring within several minutes, whereupon the resultant mixture became weakly acidic (pH 6) and gave a precipitate, which was proved to include compound II. After continuation of stirring at room temperature overnight followed by ice-cooling, Dowex resin (2.2 m*l*) and a cold solution of PCC (227 mg) in acetone (2 m*l*) were added successively, and the mixture (pH 5) was stirred at room temperature overnight. The resultant mixture (pH 6.5) gave almost no precipitation. On tlc with ethyl acetate-methanol (10:1), a spot (R_f 0.34, major) was accompanied with weak spots at R_f 0.56 and 0; the latter was ninhydrin-positive and the former faded as the reaction proceeded. Incidentally, compound II and the *N*, *N*′-diphenoxycarbonyl derivative (IV) of I gave almost identical R_f value with several developing solvent mixtures, and this made the determination of the reaction period by monitoring the tlc patterns difficult. The mixture was filtered and the resin was washed with hot aqueous acetone (1:2). On combining the filtrate and the washings, some solid precipitated. After filtration, the solution was treated with ether until the ethereal solution became negative for DQC reagent.[10] The aqueous suspension was concentrated to give a solid which was filtered off, washed with water until the washing became negative for ninhydrin reagent. Colorless solid (86 mg, 60%) was obtained and was identical with II obtained by method a) in its IR and NMR spectra.

c) From I and PCC in the Presence of Sodium Carbonate: To an ice-cold solution (5 m*l*) of I (200 mg 1.23 mmol) and sodium carbonate (160 mg), a cold solution of PCC (427 mg, 2.73 mmol) in acetone (8 m*l*) was added under stirring and the resultant suspension (pH ~8) was stirred at room temperature overnight, whereupon a clear solution (pH ~7.5) resulted. On tlc with ethyl acetate-methanol (10:1), a spot (R_f 0.34, major) appeared accompanied with minor spots of R_f 0.56 and 0. Sodium hydrogencarbonate (30 mg) was added and the mixture was again stirred overnight. The reaction mixture was treated with ether until the ethereal solution became negative for DQC reagent; the aqueous solution gave a precipitate. Filtration and washings with water gave II (193 mg, 73%).

d) From N,N′-*Diphenoxycarbonyl-2-deoxystreptamine (IV) in the Presence of Dowex Resin*: To a solution of IV (102 mg) in aqueous acetone (1:3, 10 m*l*), Dowex 1×2 resin (OH form, 0.1 m*l*) was added and the mixture was stirred at room tem-

9) F. Cramer, H. Otterbach, and H. Springmann, *Chem. Ber.*, **92**, 384 (1959).

10) This reagent was used for the detection of phenol liberated. A tlc plate spotted with a solution containing phenol is sprayed with 0.2% solution of 2,6-dichloroquinone chlorimide (DQC) in ethanol and the plate is exposed to the vapour of ammonia. Blue color appears.

perature for 1 hr. After neutralization with hydrochloric acid, the mixture was heated to 45°C to dissolve the precipitate, filtered, and the filtrate was evaporated to give a residue which was washed with ether and then with water to give a colorless solid (II) 43.5 mg (81%).

N N'-*Diphenoxycarbonyl-2-deoxystreptamine (IV).* To an ice-cold solution of I (508 mg, 3.13 mmol) and sodium hydrogencarbonate (658 mg, 7.82 mmol) in water (11 m*l*), a solution of PCC (1.22 g, 7.80 mmol) in acetone (18 m*l*) was dropped under stirring in 10 min and the mixture was stirred for more 30 min. After neutralization with hydrochloric acid the precipitate was filtered off, washed thoroughly with ether and with water to give a solid (IV), 716 mg (57%); mp > 295°C, R_f 0.33 (tlc with ethyl acetate - methanol 10:1).

Found: C, 59.57; H, 5.68; N, 6.83%. Calcd for $C_{20}H_{22}O_7N_2$: C, 59.69; H, 5.51; N, 6.96%.

IR spectrum: 3400, 3330, 3050 (w), 2930 (w), 2870 (w), 1710 (s, NHCOO), 1595 (w, phenyl), 1540 (s, amide II), 1495 (phenyl), 1340 (w), 1305, 1285, 1215 (s), 1150, 1115, 1075, 1030, 985, 960, 910, 855, 840, 790, 765, 715, 690 cm^{-1}. NMR spectrum (in DMSO-d_6 at 60 MHz): τ : 2.1—3.0 (12 H m., phenyl and NHCO).

This compound was unstable and attempted recrystallization from aqueous methanol caused partial convertion to II.

Preparation of N,N'-*Bis(ethoxycarbonyl)-2-deoxystreptamine (VII) from II.* To a suspension of II (78.4 mg) in dry ethanol (1.6 m*l*), 0.01 N sodium ethoxide in ethanol (1 m*l*) was added and the mixture was refluxed for 1.5 hr. On tlc with ethyl acetate - methanol (10:1), starting material (R_f 0.34) had disappeared and VII (R_f 0.23) and a product (R_f 0) appeared. When the solution was then allowed to stand at room temperature overnight, the product of R_f 0 almost disappeared and crude VII precipitated. The product was collected by centrifuge, washed with cold ethanol and then dissolved in water (0.7 m*l*) Additon of acetone (14 m*l*) gave some precipitates, which were removed by centrifuge, and the solution was evaporated to give a solid (VII), 86 mg (77%). The IR and NMR spectra of the product were superimposable with those of the authentic sample.[6] The product did not depress the melting point (218°C) when mixed with the authentic sample.

5-O-*Acetyl-2-deoxystreptamine-1,6:3,4-dicarbamate (III).* To a suspension of II (158 mg) in pyridine (3 m*l*) acetic anhydride (0.15 m*l*) was added and the mixture was stirred at room temperature for 3 hr. After addition of a drop of methanol, the clear solution was evaporated to give a residue, which was washed with cold water to give a chromatographically homogeneous solid, 143 mg (76%), R_f 0.57 (tlc with acetone - ethyl acetate 2:1). Recrystallized from aqueous acetone (1:2); mp 276°C (decomp.); molecular weight 256 (M^+, by mass spectrum).

Found: C, 47.03; H, 5.07; N, 10.46%. Calcd for $C_{10}H_{12}O_6N_2$: C, 46.88; H, 4.72; N, 10.93%.

IR spectrum: 3300 (νNH), 2930 (w), 1770 (s), 1735, 1475 (w), 1415, 1395, 1380, 1340, 1295, 1245 (acetyl ester), 1225, 1105, 1070, 1040, 980, 955, 925, 895, 870, 800, 775, 745 cm^{-1}. NMR spectrum (in DMSO-d_6 at 60 MHz): τ : 2.2 (2H s., NHCO), 4.45 (1H t., H-5), 5.91 (2H q., H-4,6), 6.30 (2H double triplets, H-1,3), 7.85 (1H double triplets, H-2$_e$), 7.90 (3H s., OAc), 8.40 (1H q., H-2$_a$); $J_{1,2a}=J_{3,2a}=J_{2a,2e}=11$ Hz, $J_{1,2e}=J_{3,2e}=3.2$ Hz, $J_{3,4}=J_{1,6}=11$ Hz, $J_{4,5}=J_{5,6}=9.4$ Hz. Irradiation at τ 5.91 caused the signals at τ 4.45 (H-5) to collapse to a singlet.

4,5,6-*Tri*-O-*acetyl*-N,N'-*diphenoxycarbonyl-2-deoxystreptamine (V).* To a solution of IV (74.3 mg) in pyridine (1.5 m*l*), acetic anhydride (0.21 m*l*) was added and the solution was allowed to stand overnight. After a slight precipitate was removed by filtration, the solution was coevaporated with toluene to give a solid, which was washed thoroughly with water to give a chromatographically homogeneous solid, 81.1 mg (83%), mp 192.5—194.5°C, R_f 0.52 (tlc with ether).

Found: C, 59.07; H, 5.31; N, 5.40%. Calcd for $C_{26}H_{28}O_{10}N_2$: C, 59.08; H, 5.34; N, 5.30%.

IR spectrum: 3420, 3350, 3080 (w), 2960 (w), 1760 (s), 1730, 1600 (w, phenyl), 1545 (sh, amide II), 1525 (amide II), 1500 (phenyl), 1385, 1365, 1310, 1260, 1235, 1205 (s), 1170 (w), 1065, 1030, 980, 920 (w), 895 (w), 845 (w), 790, 765, 720, 695 cm^{-1}. NMR spectrum (in DMSO-d_6 at 60 MHz): τ: 1.9—3.0 (12 H m., phenyl and NHCO), 7.99 (6H s., O(4,6)Ac), 8.03 (3H s., O(5)Ac).

4,5,6-*Tri*-O-*acetyl*-N,N'-*diacetyl-2-deoxystreptamine (VI).* This substance was prepared by the usual way from acetic anhydride and pyridine, mp >300°C (lit,[11] 340—350°C)

Found: C, 51.96; H, 6.80; N, 7.53%. Calcd for $C_{16}H_{24}O_8N_2$: C, 51.60; H, 6.50; N, 7.52%.

IR spectrum: 1750 (s); 1655 (s, sh), 1640 (s)(amide I); 1555 cm^{-1} (amide II). NMR spectrum[11,12] (in methanol-d_4-D_2O at 60 MHz): τ: 8.02 (9H s., OAc), 8.13 (6H s., NAc).

*Methyl 2-Amino-2-deoxy-α-*D*-glucopyranoside-2,3-carbamate (VIII).* To a solution of methyl 2-amino 2-deoxy-α-D-glucopyranoside (base, 616 mg, 3.19 mmol) in water (8 m*l*), wet Dowex 1×2 resin[13] (OH form, 100—200 mesh, 15.5 m*l*) was added and the mixture was ice-cooled. A cold solution of NPCC (1.63 g, 8.07 mmol) in acetone (16 m*l*) was added under vigorous stirring for 10 min, when the mixture became a viscous yellow slurry. After gentle stirring for 1 hr at room temperature, the slurry (pH ~7) was washed with ether and the resultant aqueous suspension was filtered and the residual mass was washed with hot water. The filtrate and the washings were combined and made acidic (pH ~3) by the addition of hydrochloric acid. The solution was extracted with ether to remove *p*-nitrophenol accompanied until the ethereal solution gave no yellow color when sodium hydroxide solution was added. The aqueous solution was then neutralized with Dowex 1×2 resin (OH form), filtered, and evaporated to give a solid (~650 mg). Since the solid still contained an impurity (tlc, R_f 0 with ethyl acetate - methanol 5:1), chromatography on a small column of silica gel (16 g) with ethyl acetate - methanol (5:1) was carried out and the fraction containing the carbamate (VIII, R_f 0.54) was evaporated and the residue was dried by coevaporation with ethanol and benzene. Hygroscopic solid was obtained; 542 mg (78%); $[\alpha]_D^{21}+110°$ (*c* 0.5, water).

Found: C, 43.76; H, 5.70; N, 6.61%. Calcd for $C_8H_{13}O_6N$: C, 43.83; H, 5.98; N, 6.39%.

IR spectrum: 3350 (s, broad), 2940, 1760 (s, broad), 1455, 1400 (broad), 1335, 1290, 1205, 1185, 1140, 1105, 1065, 1040, 1005, 945, 915, 785 cm^{-1}. NMR spectrum (in D_2O at 60 MHz): τ: 4.86 (1H d., H-1), 5.40 (1H q., H-3), 5.93 (1H t., H-4), 6.22 (1H q., H-2), 6.5 (3H s., OCH_3); $J_{1,2}=3$ Hz, $J_{2,3}=12$ Hz, $J_{3,4}=9.3$ Hz, $J_{4,5}=\sim 9$ Hz. Irradiation at τ 4.86 (H-1) caused the quartet at τ 6.22 (H-2) to collapse to a doublet ($J=\sim 12$ Hz).

*Methyl 4,6-Di-O-acetyl-2-amino-2-deoxy-α-*D*-glucopyranoside-2,3-carbamate (IX).* To a solution of VIII (202 mg) in

11) F. W. Lichtenthaler, *Chem. Ber.*, **96**, 2047 (1963).

12) M. Nakajima, A. Hasegawa, and N. Kurihara, *Ann. Chem.*, **689**, 235 (1965).

13) The aqueous suspension of the resin in a cylinder was set aside for a while and the volume of the resin was measured under pressing with a glass rod with a flat top having the same diameter with that of the cylinder.

pyridine (4 ml), acetic anhydride (0.3 ml) was added and the mixture was allowed to stand at room temperature overnight. On tlc, a single spot (R_f 0.67, with ethyl acetate) appeared. After a drop of water was added, the solution was evaporated and the residue was dissolved in chloroform. The solution was washed successively with potassium hydrogensulfate solution, water, sodium hydrogencarbonate solution and water, dried over sodium sulfate and coevaporated with benzene to give a hygroscopic solid, 219 mg (78%); $[\alpha]_D^{21}$ +94° (*c* 0.5, chloroform).

Found: C, 47.34; H, 5.77; N, 4.32%. Calcd for $C_{12}H_{17}O_8N$: C, 47.52; H, 5.65; N, 4.62%.

IR spectrum: 3400 (νNH), 2960, 1780 (s), 1750 (s), 1455, 1375, 1245 (s, ester), 1185, 1140, 1110, 1045 (s), 1005 (s), 940, 785, 755 cm^{-1}. NMR spectrum (in $CDCl_3$ at 100 MHz): τ: 3.8 (1H s., NHCO), 4.70 (1H q., H-4), 4.98 (1H d., H-1), 5.33 (1H q., H-3); 5.76 (H-6′) and 5.81 (H-6) (each 1H quartet forming in total the AB part of an ABX system); 6.10 (1H m., H-5), 6.25 (1H q., H-2), 6.52 (3H s., OCH_3), 7.90 and 7.92 (each 3H s., OAc); $J_{1,2}$=3 Hz, $J_{2,3}$=11.8 Hz, $J_{3,4}$=10 Hz, $J_{4,5}$=9.2 Hz, $J_{5,6}$=~3 Hz, $J_{5,6'}$=~4.5 Hz, $J_{6,6'}$=12.4 Hz. Irradiation at τ 5.33 (H-3) caused the quartet of H-2 to collapse to a doublet (J=~3 Hz) and the quartet of H-4 to a doublet (J=~9 Hz). Irradiation at τ 6.25 (H-2) caused the quartet of H-3 to collapse to a doublet (J=10 Hz), the doublet of H-1 to a singlet and the quartet of H-4 to an incomplete doublet. Irradiation at τ 6.10 (H-5) caused the quartet of H-4 to collapse to a doublet (J=10 Hz). Irradiation at τ 4.70 (H-4) caused the multiplet of H-5 to collapse to a quartet (J=~3 and ~4.5 Hz).

Methyl 6-Amino-6-deoxy-α-D-glucopyranoside-4,6-carbamate (X). To a solution of methyl 6-amino-6-deoxyl-α-D-glucopyranoside hydrochloride (715 mg, 3.11 mmol) in water (7 ml), wet Dowex 1×2 resin (OH form, 100—200 mesh, 18 ml, the volume was measured under pressing) was added and the mixture was ice-cooled. A cold solution of NPCC (1.63 g, 8.07 mmol) in acetone (16 ml) was added to the mixture under vigorous stirring for 40 min, when a viscous yellow slurry (pH~6) resulted. On tlc, a spot (R_f 0.85 with acetone-methanol 3:1) appeared. The slurry was made acidic (pH ~3) with hydrochloric acid and extracted with ether several times. The aqueous suspension was filtered, and the residual mass was washed with hot water. The combined filtrate and washings were neutralized with Dowex 1×2 resin (OH form), filtered, and evaporated to give a solid (~690 mg). This was dissolved in water (1.4 ml), filtered and concentrated almost to dryness. Addition of acetone gave colorless cystals, 529 mg (78%), mp 233—236°C, $[\alpha]_D^{26}$ +38.1° (*c* 0.7, water).

Found: C, 44.14; H, 6.01; N, 6.36%. Calcd for $C_8H_{13}O_6N$: C, 43.83; H, 5.98; N, 6.39%.

IR spectrum: 3430 (s), 3300, 2950 (w), 2900 (w), 1725 (s), 1660, 1495, 1460, 1405, 1385, 1370, 1320, 1280 (s), 1210, 1135, 1110, 1090, 1065, 1050, 1015, 995 (s), 945, 895, 855, 765 (s), 745, 710, 660 cm^{-1}. NMR spectrum (in D_2O at 60 MHz): τ: 5.09 (1H d., H-1), 6.54 (3H s., OCH_3); $J_{1,2}$= 3.2 Hz.

Methyl 2,3-Di-O-acetyl-6-amino-6-deoxy-α-D-glucopyranoside-4,6-carbamate (XI). To a solution of X (224 mg) in pyridine (5 ml), acetic anhydride (0.5 ml) was added and the mixture was allowed to stand at room temperature overnight. On tlc, a single spot (R_f 0.42 with ethyl acetate) appeared. Hereafter the solution was treated likewise as in the preparation of IX and a colorless solid (300 mg, 97%) was obtained. Recrystallization from chloroform-petroleum ether or from ethanol; mp 207—209°C, $[\alpha]_D^{21}$ +61.4° (*c* 0.8, chloroform).

Found: C, 47.80; H, 5.73; N, 4.68%. Calcd for $C_{12}H_{17}O_8N$: C, 47.52; H, 5.65; N, 4.62%.

IR spectrum: 3430 (w, NH), 2950 (w), 1760 (s), 1740 (s), 1715 (s), 1490, 1460, 1400, 1375 (s), 1270, 1240 (s, ester), 1220 (s, ester), 1195, 1180, 1160, 1145, 1095, 1075, 1055, 1000, 945, 920, 885, 850, 765, 755, 735, 680 cm^{-1}. NMR spectrum (in $CDCl_3$ at 100 MHz): τ: 3.2 (1H broad doublet in appearance, J=~3.5 Hz, NHCO), 4.42 (1H t., H-3), 5.03 (1H d., the signal in the higher field being strong, H-1), 5.13 (1H q., at τ 5.07, 5.11, 5.17, and 5.21, the signals at 5.07 and 5.17 being strong, H-2), 5.8—6.05 (2H m., H-4 and H-5 ?), 6.35—6.85 (2H m., H-6,6′ ?), 6.55 (3H s., OCH_3), 7.91 (6H s., OAc); $J_{1,2}$=3.5 Hz, $J_{2,3}$=9.7 Hz, $J_{3,4}$=~9.5 Hz. Irradiation at τ 3.2 caused the signals at τ 6.35—6.5 to change. Irradiation at τ 4.42 (H-3) caused the signals at τ 5.13 (H-2) to collapse to a doublet (J=~3.5 Hz) and the multiplet at τ 5.8—6.05 (which contained H-4) to change. Irradiation at τ 5.07 (H-1 and 2) or at τ 5.92 caused the signals at τ 4.42 (H-3) to collapse to a doublet (J=~9 Hz), respectively.

We are grateful to Dr. Hiroshi Naganawa of Institute of Microbial Chemistry for the measurements of NMR spectra at 100 MHz and to Mr. Saburo Nakada of our Laboratory for the elemental analysis.