# Studies on Aminosugars. XXVII. Synthesis of Several Glycosides Containing (6-Amino-6-deoxy-D-glucopyranosyl)-2-deoxystreptamine[1]

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Racemic *O*-isopropylidene derivative of *N,N'*-diethoxycarbonyl-2-deoxystreptamine was glycosidized with 6-azido-2,3,4-tri-*O*-benzyl-6-deoxy-α-D-glucopyranosyl chloride to afford two kinds of positional isomers of α-glucoside, which led to 4-*O*-(6-amino-6-deoxy-α-D-glucopyranosyl)- and 6-*O*-(6-amino-6-deoxy-α-D-glucopyranosyl)-2-deoxystreptamine. In a similar manner, 4-*O*-(6-amino-6-deoxy-α and β-D-glucopyranosyl)-6-*O*-(α-D-glucopyranosyl)-2-deoxystreptamines and 4-*O*-(6-amino-6-deoxy-α and β-D-glucopyranosyl)-6-*O*-(6-amino-6-deoxy-α-D-glucopyranosyl)-2-deoxystreptamines were synthesized.

A number of chemotherapeutically useful compounds of 2-deoxystreptamine aminoglycosides have been obtained from the metabolites of microorganisms. The compounds include neomycins, kanamycins, paromomycins and gentamicins. In order to investigate the relationship between structure and antibiotic activity, the structural modification of either the aminocyclitol[2] or the sugar moiety[3,4] has been made. It appears so far that alterations have a profound effect on antibiotic activity and that the 2-deoxystreptamine moiety plays an important role in exhibiting activity. We have recently reported the total syntheses of kanamycin A,[5] B,[6] and C[7] as well as the syntheses of paromamine[8] and neamine.[4c] In relation to these syntheses, we were interested in altering the sugar moieties of kanamycin, and reported[9] the syntheses of the positional isomers of α-D-glucosyl-2-deoxystreptamines as a basic experiment of the syntheses of α-glycosides of 2-deoxystreptamine.

2-Deoxystreptamine has three hydroxyl groups at C-4,5, and 6, and there exist three kinds of 2-deoxystreptamine glycosides. As for the glycosyl components of 4-*O*-glycosyl-2-deoxystreptamines, 2-amino-2-deoxy-D-glucose (in kanamycin C, paromomycins, and gentamicin A), 6-amino-6-deoxy-D-glucose (in kanamycin A), 2,6-diamino-2,6-dideoxy-D-glucose (in kanamycin B, neomycins, and neamine), and partially substituted 2,6-diamino-2,3,4,6-tetradeoxy-D-glucose (in gentamicin $C_1$, $C_2$, and $C_{1a}$) are found. They are attached to the 2-deoxystreptamine with an α-glucosidic linkage. As for the glycosyl component of 6-*O*-glycosyl-2-deoxystreptamines, 3-amino-3-deoxysugars such as 3-amino-3-deoxy-D-glucose (in kanamycins), gentosamine[10] (in gentamicin A) and garosamine[11] (in gentamicin C) are found. They are also linked to the 2-deoxystreptamine with an α-linkage. As for the glycosyl component of 5-*O*-glycosyl-2-deoxystreptamines, only D-ribose is found, linked with β-linkage, in paromomycins, neomycins, and vistamycin.[12] On the other hand, 5-*O*-(2-amino-2-deoxy-α-D-glucopyranosyl)-2-deoxystreptamine[3,13] was synthesized and found to have antibacterial activity against mycobacteria.

This paper reports the synthesis of 4-*O*- and 6-*O*-(6-amino-6-deoxy-α-D-glucopyranosyl)-2-deoxystreptamine (**7a** and **7b**), 4,6-di-*O*-(6-amino-6-deoxy-α-D-glucopyranosyl)-2-deoxystreptamine (**20**) and 4-*O*-(6-amino-6-deoxy-α-D-glucopyranosyl)-6-*O*-(α-D-glucopyranosyl)-2-deoxystreptamine (**14**). In addition some derivatives containing β-glycosidic linkages are described. Since 4-*O*-(6-amino-6-deoxy-α-D-glucopyranosyl)-2-deoxystreptamine moiety[14] is considered to be the origin of the antibacterial activity of kanamycin A and 3-amino-3-deoxy-D-glucose moiety attached to C-6 of 2-deoxystreptamine is considered the enhacing factor of the activity, the latter moiety has been changed.

*Synthesis of Glucosides.* 6-Azido-2,3,4-tri-*O*-benzyl-

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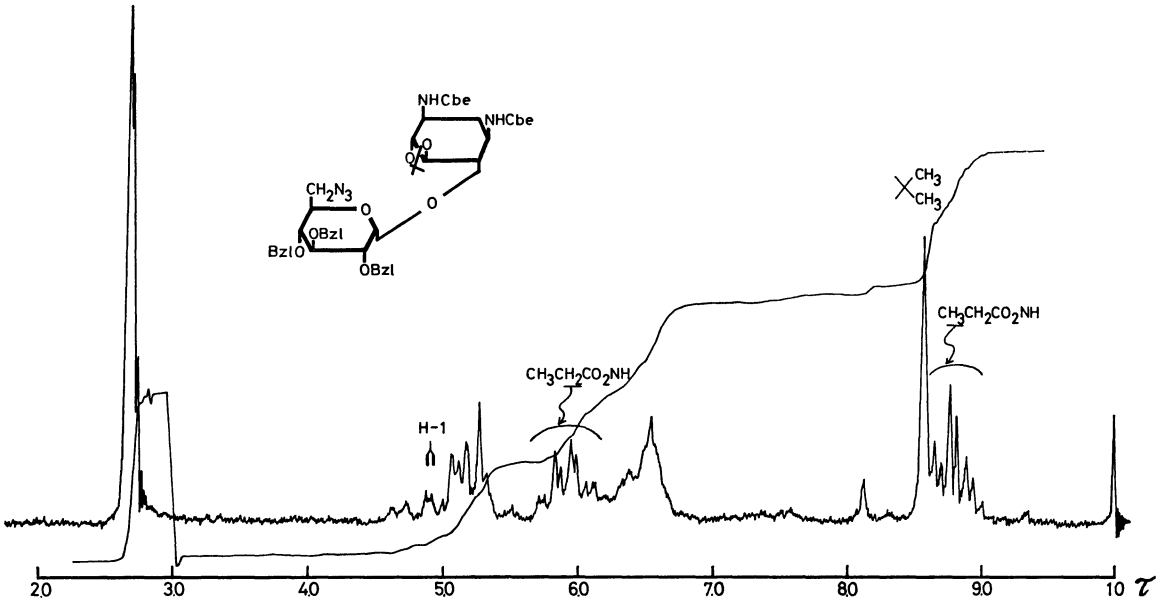
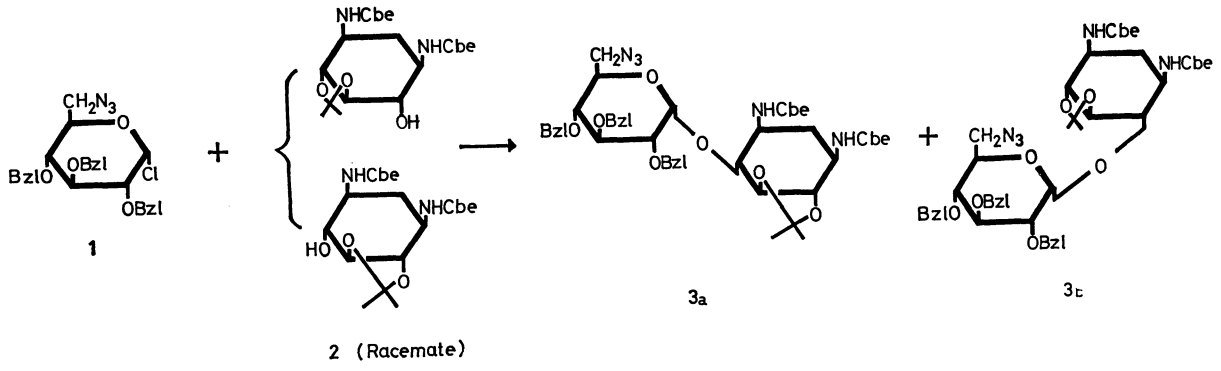
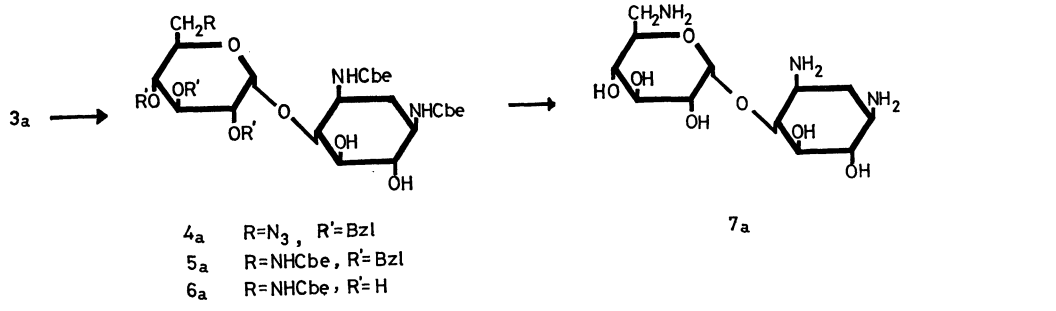
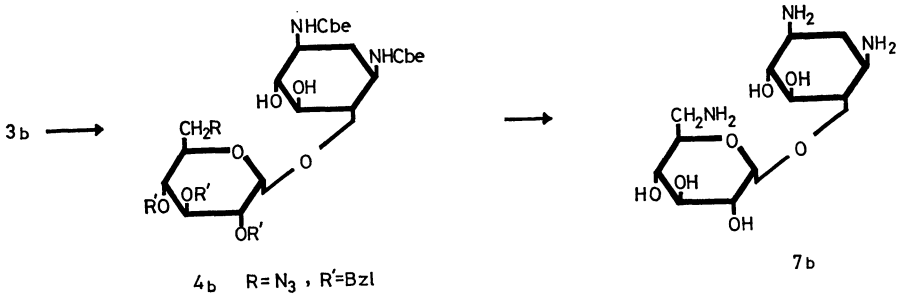



Fig 1. The NMR spectrum of **3b** in $CDCl_3$.




Bzl=$CH_2C_6H_5$ , Cbe=$CO_2C_2H_5$

Chart 1.

6-deoxy-α-D-glucopyranosyl chloride (**1**)[15] was condensed with a racemic mixture (**2**) of *N,N'*-diethoxycarbonyl-4,5- and 5,6-*O*-isopropylidene-2-deoxystreptamine[9] in dry benzene-dioxane in the presence of mercuric cyanide and freshly prepared Drierite (Chart 1). The azide derivative of glycosyl chloride has been found to be more suitable for glycosidation than the acylamino or aryloxycarbonylamino derivatives of glycosyl halides, since the azide derivatives is more stable and easily hydrogenated into an amino derivative. Solvents, completely dried, were indispensable for the condensation. Benzene was dried over lithium aluminum hydride and dioxane was dried with sodium metal under reflux. The condensation products were purified by column chromatography. The main product ($R_f$ 0.51) was still proved to be a mixture of two products. The major product in the mixture was isolated by recrystallization from ethanol-aqueous ammonia in a yield of 40%. The compound was proved to be 6-*O*-(6-azido-2,3,4-tri-*O*-benzyl-6-deoxy-α-D-glucopyranosyl)-*N,N'*-diethoxycarbonyl-4,5-*O*-isopropylidene-2-deoxystreptamine (**3b**) by its IR, NMR (Fig. 1) and elemental analysis and by the fact that it was led to 6-*O*-(6-amino-6-deoxy-α-D-glucopyranosyl)-2-deoxystreptamine.

The mother liquor of the recrystallization described above contained the 4-*O*-isomer, namely 4-*O*-(6-azide-2,3,4-tri-*O*-benzyl-6-deoxy-α-D-glucopyranosyl)-*N,N'*-diethoxycarbonyl-5,6-*O*-isopropylidene-2-deoxystreptamine (**3a**) accompanied by **3b**. Since the difficulty in separation of **3a** from **3b** remained, the isopropylidene groups were removed by acid and the deacetonated mixture (**4a** and **4b**) was chromatographed on silica gel to give **4a** and **4b** in yields of 12 and 48% (including that from **3b** obtained by recrystallization) based on **2**, respectively. It is noteworthy that we came across a low yield of 4-*O*-glucosides in the preparation of 4-*O*-(2,3,4,6-tetra-*O*-benzyl-α-D-glucopyranosyl)-*N,N'*-diethoxycarbonyl-5,6-*O*-isopropylidene-2-deoxystreptamine.[9] Since 4,6-di-*O*-glucosides (**9** and **16**) were prepared in good yields (60—70%) from mono-6-*O*-glucosides (**8** and **4b**) and **1**, the low yields of 4-*O*-glucosides may be not due to the intrinsic nature of $C_4$-OH, but to the presence of a 5,6-*O*-isopropylidene group.

Azide groups of **4a** and **4b** were reduced with Raney nickel and hydrogen to the amino groups, which were ethoxycarbonylated to give 4-*O*- and 6-*O*-(2,3,4-tri-*O*-benzyl-6-deoxy-6-ethoxycarbonylamido-α-D-glucopyranosyl)-*N,N'*-diethoxycarbonyl-2-deoxystreptamine (**5a** and **5b**), respectively. The subsequent debenzylation with palladium black and hydrogen gave 4-*O*- and 6-*O*-(6-deoxy-6-ethoxycarbonylamido-α-D-glucopyranosyl)-*N,N'*-diethoxycarbonyl-2-deoxystreptamine (**6a** and **6b**) respectively. When simultaneous reduction and debenzylation of **4a** or **4b** were performed by use of palladium black and hydrogen, several undeterminable products were obtained. The reaction was not pursued any further. However, Ainsworth's work suggests[16] that the amino groups liberated are damaged during the reaction. Treatment of **6a** and **6b** with hot 1N barium hydroxide gave 4-*O*- and 6-*O*-(6-amino-6-deoxy-α-D-glucopyranosyl)-2-deoxystreptamine (**7a** and **7b**), respectively, in good yields.

6-*O*-(2,3,4,6-Tetra-*O*-benzyl-α-D-glucopyranosyl)-*N,N'*-diethoxycarbonyl-2-deoxystreptamine[9] (**8**) and **1** were condensed to give 4-*O*-(6-azide-2,3,4-tri-*O*-benzyl-6-deoxy-α- and β-D-glucopyranosyl)-6-*O*-(2,3,4,6-tetra-*O*-benzyl-α-D-glucopyranosyl)-*N,N'*-diethoxycarbonyl-2-deoxystreptamine (**9** and **10**) in yields of 71 and 10%, respectively (Chart 2). In order to determine whether the newly formed glycosides **9** and **10** are a 4-*O*-glycoside or 5-*O*-glycoside, the end products (**14** and **15**) derived from them were oxidized with periodate and followed by acidic hydrolysis. Paper chromatography of

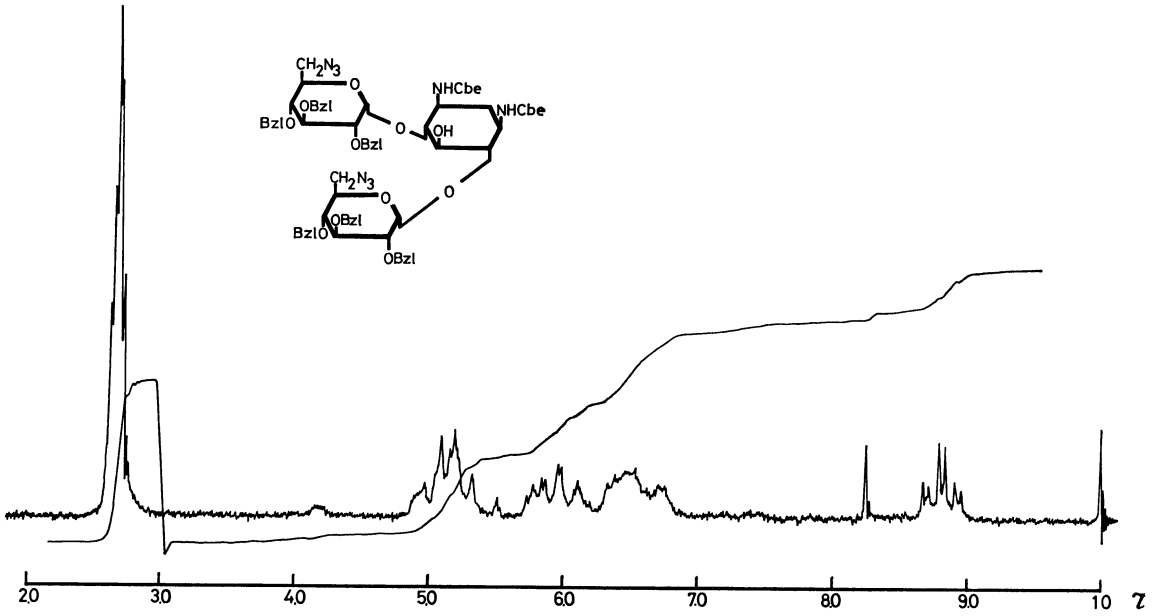



Fig 2. The NMR spectrum of **16** in $CDCl_3$.

15) S. Umezawa, Y. Takagi, and T. Tsuchiya, the details will be published elesewhere.

16) C. Ainsworth, *J. Amer. Chem. Soc.*, **78**, 1635 (1956).

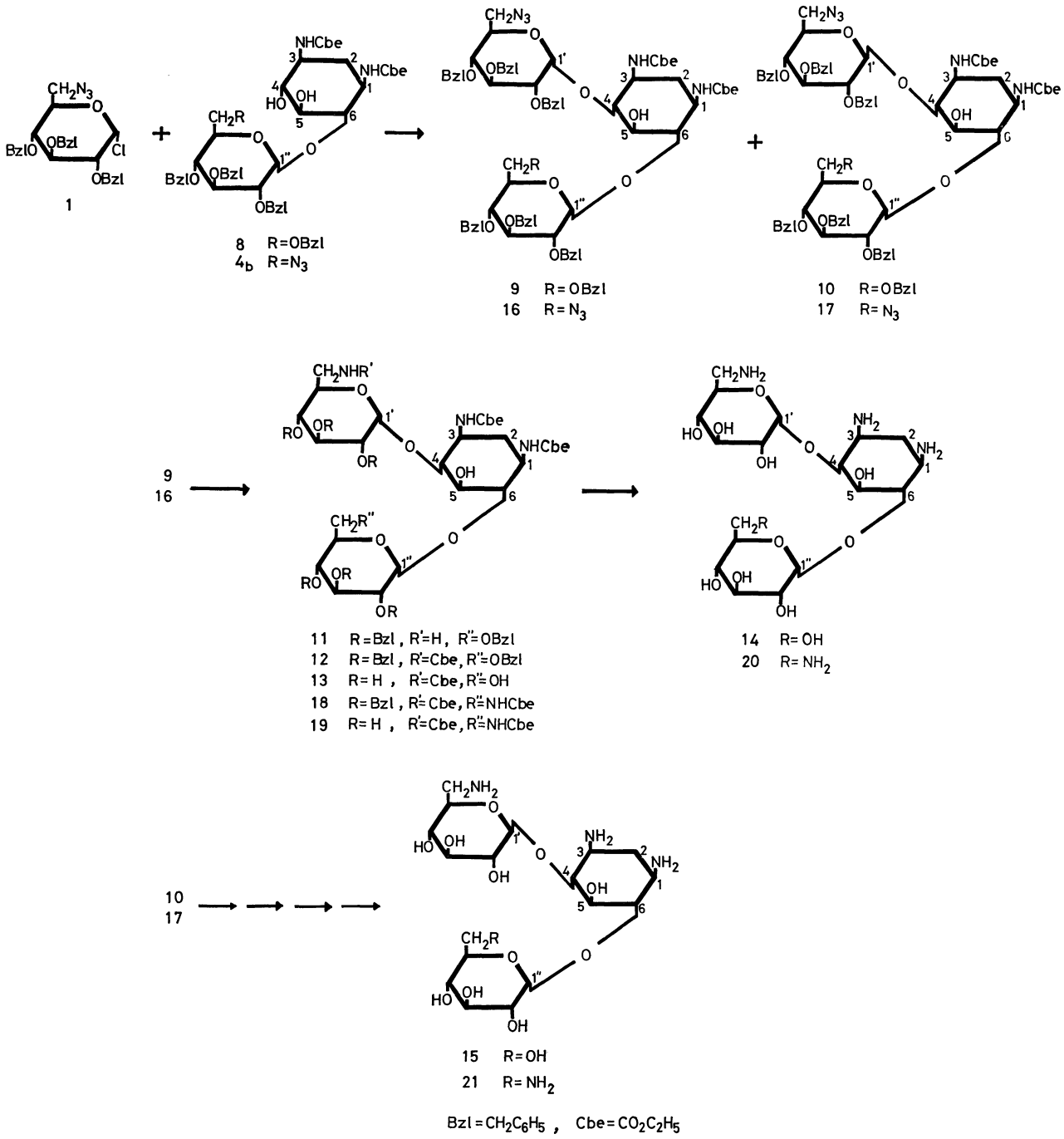



Chart 2.

the hydrolyzates showed the presence of 2-deoxystreptamine, indicating both **9** and **10** are 4,6-di-*O*-glycosides. The main product **9** was reduced with Raney nickel and hydrogen to give 4-*O*-(6-amino-2,3,4-tri-*O*-benzyl-6-deoxy-α-D-glucopyranosyl)-6-*O*-(2,3,4,6-tetra-*O*-benzyl-α-D-glucopyranosyl)-*N*,*N'*-diethoxycarbonyl-2-deoxystreptamine (**11**), which was then *N*-ethoxycarbonylated to give a tri-*N*-ethoxycarbonyl derivative (**12**). Subsequent debenzylation gave **13** and deethoxycarbonylation the final product, 4-*O*-(6-amino-6-deoxy-α-D-glucopyranosyl)-6-*O*-(α-D-glucopyranosyl)-2-deoxystreptamine (**14**). The corresponding β-isomer, 4-*O*-(6-amino-6-deoxy-β-D-glucopyranosyl)-6-*O*-(α-D-glucopyranosyl)-deoxystreptamine (**15**) was similarly prepared, starting from **10**.

A similar scheme was also carried out for the preparation of 4-*O*-(6-amino-6-deoxy-α and β-D-glucopyranosyl)-6-*O*-(6-amino-6-deoxy-α-D-glucopyranosyl)-2-deoxystreptamine (**20** and **21**) starting from **4b** and **1** (Chart 2). The NMR spectrum of a condensation product, 4,6-di-*O*-(6-azido-2,3,4-tri-*O*-benzyl-6-deoxy-D-glucopyranosyl)-*N*,*N'*-diethoxycarbonyl-2-deoxystreptamine (**16**) is shown in Fig 2.

The characteristic features of the above mentioned synthesis and that reported previously[9] are: 1) α-glucoside is the main product and the yield of β-isomer is very low, even though it is formed, 2) 4-O and 6-O positional isomers are successfully separated by recrys-

Table 1. Antibacterial spectra **7a**, **7b**, **14**, and **20**

| Test organisms[a] | Minimal inhibitory concentration (mcg/ml) | | | |
|---|---|---|---|---|
| | **7a** | **7b** | **14** | **20** |
| *Staphylococcus aureus* FDA 209 F | 50 | >100 | 100 | 100 |
| *Staphylococcus auleus* Smith | 6.25 | >100 | 12.5 | 6.25 |
| *Escherichia coli* NIHJ | 50 | >100 | 100 | 100 |
| *Sarcina lutea* PCI 1001 | >100 | >100 | >100 | >100 |
| *Salmonella typhosa* T-63 | 25 | >100 | 50 | 50 |
| *Proteus vulgaris* OX19 | 25 | >100 | 25 | 100 |
| *Bacillus subtilis* NRRL B-558 | 12.5 | >100 | 12.5 | 25 |
| *Pseudomonas aeruginosa* A3 | >100 | >100 | >100 | >100 |
| *Mycobacterium smegmatis* ATCC 607 | 25 | >100 | 50 | 25 |

a) Nutrient agar, 37°C, 18 hr.

tallization or by column chromatography of either the condensed products or the deacetonation products.

*Structural assignment.* α-glucosidic structures of 4-*O*- and 6-*O*-(6-amino-6-deoxy-α-D-glucopyranosyl)-2-deoxystreptamine (**7a** and **7b**, respectively) were proved by their specific rotations ($[\alpha]_D^{20}$ +89° as **7a**·dihydrochloride and +82° as **7b**·dihydrochloride) and coupling constants (each ~3 Hz) of anomeric protons in their NMR spectra.

Assignment of 4-*O*- and 6-*O*-glycoside to **7a** and **7b**, respectively, were performed by the determination of the values of $\Delta$[M] in tetramminecopper(II) sulfate solutions (**TACu**).[17] The $\Delta$[M] values of **7a** and **7b** were +645° and −230° respectively. The former was in accord with that (+640°) of natural 4-*O*-(6-amino-6-deoxy-α-D-glucopyranosyl)-2-deoxystreptamine,[13] and the sign and the absolute value of the $\Delta$[M] indicated that **TACu** formed a complex between C-1 $NH_2$ and C-6 OH in deoxystreptamine moiety. Since methyl 6-amino-6-deoxy-α-D-glucopyranoside shows $\Delta$[M]+80°[17] indicating that the C-6 amino group gives almost no effect on the $\Delta$[M] value, the above assignment for **7a** is substantiated. On the other hand, $\Delta$[M]−230° of **7b** is anomalously low in absolute value. However, the deviation from the normal value (900—700°) will be interpreted by considering the steric state of **7b**. If 6-amino-6-deoxy-D-glucose and 2-deoxystreptamine moieties of **7a** and **7b** are situated as far as possible from each other as seen in kanamycin, which is indicated by X-ray crystallographic analysis,[18] the C-6 amino groups of **7a** and **7b**, can come near the C-3 $NH_2$ and C-5 OH groups, respectively, of 2-deoxystreptamine moiety. Thus the anomalous $\Delta$[M] value of **7b**, can be explained by assuming the complexing between C-5 OH in 2-deoxystreptamine moiety and C-6 $NH_2$ group in sugar moiety occurs and the value of $\Delta$[M] attributable to the complexing is fairly large and the sign is positive.

*Antibiotic Activity.* The antibacterial activities of synthetic compounds **7a**, **7b**, **14**, **15**, **20**, and **21** were tested. It is particularly noteworthy that the 4-*O*-isomer (**7a**), which was proved to be the same as the natural origin,[14] has antibacterial activity (Table 1), while the 6-*O*-isomer (**7b**) has no antibacterial activity. **7a**, **14**, and **20** which contain 4-*O*-(6-amino-6-deoxy-α-D-glucopyranosyl)-2-deoxystreptamine have antibacterial activity, even though it is low. This shows that 3-amino-3-deoxy-D-glucose moiety attached to C-6 OH of 2-deoxystreptamine especially enhances the activity of 4-*O*-(6-amino-6-deoxy-α-D-glucopyranosyl)-2-deoxystreptamine moiety. Since 6-*O*-(3-amino-3-deoxy-α-D-glucopyranosyl)-2-deoxystreptamine have no antibacterial activity, this conclusion may be substantiated.

It has been confirmed that **15** and **21** which contain 4-*O*-(6-amino-6-deoxy-β-D-glucopyranosyl)-2-deoxystreptamine show no antibacterial activities, indicating that the α-glucosidic linkage at C-4 of 2-deoxystreptamine is indispensable for exhibiting antibacterial activity.

## Experimental

The NMR spectra were measured with a Varian A-60D spectrometer. Tetramethylsilane ($\tau$ 10.00; for the solutions other than deuterium oxide) and sodium 4,4-dimethyl-4-silapentane-1-sulfonate ($\tau$ 10.00; for the solutions of deuterium oxide) were used as internal standards. Thin-layer chromatography (tlc) was carried out on microscope slides coated with silica gel, and the spots were visualized with sulfuric acid. Paper chromatography (ppc) was carried out on Toyo Roshi No. 50 paper.

*6-O-(6-Azido-2,3,4-tri-O-benzyl-6-deoxy-α-D-glucopyranosyl)-N,N′-diethoxycarbonyl-4,5-O-isopropylidene-2-deoxystreptamine (**3b**,) and a Mixture of **3b** and 4-O-(6-Azido-2,3,4-tri-O-benzyl-6-deoxy-α-D-glucopyranosyl)-N,N′-diethoxycarbonyl-5,6-O-isopropylidene-2-deoxystreptamine (**3a**).* A mixture of **1** syrup, ($[\alpha]_D^{24}$+119° (*c* 1, $CHCl_3$), 8.3 g, 17 mmol) and freshly prepared Drierite (7 g) in dry benzene-dioxane (4:1, 75 ml)[19] was heated at 60°C under stirring for 30 min, and **2** (racemic mixture, 3.76 g, 11 mmol) and well dried powder mercuric cyanide (9 g) were added to the mixture, which was refluxed for 26 hr under vigorous stirring. The reaction mixture was filtered and the residue was washed with chloroform. The filtrate and the washings combined were evaporated to

17) S. Umezawa, T. Tsuchiya, and K. Tatsuta, This Bulletin, **39**, 1235 (1966).

18) G. Koyama, Y. Iitaka, K. Maeda, and H. Umezawa, *Tetrahedron Lett.*, **1968**, 1875.

19) Benzene and dioxane were dried strictly as follows: benzene was distilled with a fractionating column and the main portion was dried over lithium aluminum hydride. After storage for several days, the upper layer was taken for use. Dioxane was distilled and the main portion was refluxed with sodium metal for several hours and used immediately.

give a syrup, which was dissolved in chloroform and the solution was washed with 2% sodium bicarbonate solution and water. The solution was dried over sodium sulfate and evaporated. The syrup (~14 g) was chromatographed on a column (45×410 mm) of alumina (E. Merck AG, 650 g) with benzene - acetone (5:1). The condensation product was eluted, after the chloride (**I**) remained eluted, giving a paleyellow syrup (~12 g). On tlc with chloroform - ethyl acetate (3:1), the syrup showed two spots of $R_f$ 0.50 (major) and 0.37 (minor). One fourth of the syrup was chromatographed on a column (35×315 mm) of silica gel (Wako Gel, 130 g) with chloroform-ethyl acetate (3:1) and the portion (360—460 ml) containing the major product ($R_f$ 0.50) was evaporated to give a syrup (1.58 g). The syrup, however, on tlc with benzene - acetone (5:1), showed still two spots of $R_f$ 0.51 (major) and 0.60 (minor). Further chromatography on a column (28×530 mm) of silica gel (Wako Gel, 150 g) with benzene - acetone (5:1) gave a syrup ($R_f$ 0.51, **3a**+**3b**, 1.4 g). Recrystallization from ethanol containing a small quantity of aqueous ammonia gave crystals of **3b**, 0.88 g (47%), mp 184.5—185.5°C, $[\alpha]_D^{16}$+48° (*c* 1, chloroform); IR (KBr): 2100 ($N_3$), 1695 (amide I), 1540 $cm^{-1}$ (amide II); NMR ($CDCl_3$): $\tau$ 8.83 and 8.78 (3H, t. each, *J* 7 Hz, $CH_2C\underline{H}_3$), 8.58 (6H, s., isopropylidene), 2.67, 2.68, and 2.71 (5H s. each, $OCH_2C_6\underline{H}_5$).

Found: C, 63.07; H, 6.87; N, 8.50%. Calcd for $C_{42}H_{53}N_5O_{11}$: C, 62.75; H, 6.65; N, 8.71%.

Evaporation of the mother liquor gave a syrup (0.5 g) which was still a mixture of **3a** and **3b**.

*4-O-(6-Azido-2,3,4-tri-O-benzyl-6-deoxy-α-D-glucopyranosyl)-N,N'-diethoxycarbonyl-2-deoxystreptamine (**4a**) and 6-O-(6-Azido-2,3,4-tri-O-benzyl-6-deoxy-α-D-glucopyranosyl)-N,N'-diethoxycarbonyl-2-deoxystreptamine (**4b**).* *a) From the mixture of **3a** and **3b**:* A solution of the mixture (1.94 g) in 80% acetic acid (10 ml) was heated at 90°C for 20 min and poured into water. The resulting precipitate (1.78 g) was chromatographed on a column of silica gel (Mallinckrodt, 200 g) with benzene-methyl ethyl ketone (3:1). **4a** ($R_f$ 0.17 on tlc with the same solvent system) was obtained from the early fractions, yield 1.08 g (12.3%, based on one-half of **2**). From the late fractions, **4b** ($R_f$ 0.12) was obtained, yield 0.55 g. **4a** was recrystallized from acetone to give needles, but not **4b**.

*b) **4b** from **3b**:* The crystalline **3b** (3.2 g) was treated as above to give **4b** quantitatively, yield, 3.12 g. Total yield of **4b** by a) and b) was 48% based on one-half of **2**.

Compound **4a**: mp 218—219°C, $[\alpha]_D^{26}$+74.3° (*c* 1, chloroform); IR (KBr): 2100 ($N_3$), 1690, 1540 $cm^{-1}$; NMR (in $CDCl_3$ containing $D_2O$): $\tau$ 8.80 and 8.78 (3H t. each, *J* 7 Hz, $CH_2C\underline{H}_3$), 6.1—6.7 (11H, skeleton protons), 5.89 and 5.86 (2H q. each, *J* 7 Hz, $C\underline{H}_2CH_3$), 5.35 (1H, d., *J* 11 Hz) and 5.08 (1H d., *J* 11 Hz) forming an AB quartet ($OC\underline{H}_2C_6H_5$ at C-2(?)), 5.17 and 5.08 (2H s. each, $OC\underline{H}_2C_6H_5$ at C-3 and C-4), 5.00 (1H, d., *J* 3 Hz, H-1'[20]), 2.69 (5H s., $OC\underline{H}_2C_6H_5$), 2.65 (10H s., $OC\underline{H}_2C_6H_5$).

Found: C, 61.56; H, 6.43; N, 8.86%. Calcd for $C_{39}H_{49}N_5O_{11}$: C, 61.32; H, 6.47; N, 9.17%.

Compound **4b**: mp 178—179°C $[\alpha]_D^{22}$+38° (*c* 0.5, chloroform); IR: a similar pattern with that of **4a**; NMR (in $CDCl_3$ containing $D_2O$): $\tau$ 8.85 and 8.76 (3H t. each, *J* 7 Hz, $CH_2C\underline{H}_3$), 6.1—6.7 (11H, skeleton protons), 5.92 and 5.85 (2H q. each, *J* 7 Hz, $C\underline{H}_2CH_3$), 4.9—5.5 (~7 H m.), 2.67, 2.63 and 2.61 (each 5H s., $OCH_2C_6\underline{H}_5$).

Found: C, 61.18; H, 6.21; N, 8.87%. Calcd for $C_{39}H_{49}N_5O_{11}$: C, 61.32; H, 6.47; N, 9.17%.

*4-O-(2,3,4-Tri-O-benzyl-6-deoxy-6-ethoxycarbonylamido-α-D-glucopyranosyl)-N,N'-diethoxycarbonyl-2-deoxystreptamine (**5a**).* Compound **4a** (0.40 g) was dissolved in aqueous ethanol (1:16, 8.5 ml) by heating and the solution was hydrogenated with Raney nickel (T-4) and hydrogen under 50 lb/sq. inch pressure at 40—45°C for 12 hr. On tlc with benzene-methyl ethyl ketone (2:1), **4a** ($R_f$ 0.3) disappeared and a product ($R_f$ 0) appeared. Filtration and evaporation of the solution gave a solid (0.38 g), which was dissolved in acetone (5 ml), and water (5 ml) was added under vigorous stirring to the solution. To the resulting suspension, anhydrous sodium carbonate (0.42 g) was added and after agitation for a while, carboethoxy chloride (0.28 g) was added slowly. After agitation was continued for 30 min, a product ($R_f$ 0.15) appeared on tlc. The solution was evaporated to give a residue, which was dissolved in chloroform and the solution was washed with water. Drying over sodium sulfate and evaporation gave a residue (0.41 g). Recrystallization from equeous ethanol gave a colorless solid, 0.36 g (86%), mp 198—199°C, $[\alpha]_D^{23}$+24° (*c* 0.7, chloroform); IR: no peak near ~2100 $cm^{-1}$ ($N_3$) was observed; NMR (in pyridine-$d_5$ containing small amount of $D_2O$): $\tau$ 8.80 (9H t., *J* 7 Hz, $CH_2C\underline{H}_3$), 2.65 (15H s., $OCH_2C_6\underline{H}_5$).

Found: C, 62.32; H, 6.91; N, 5.06%. Calcd for $C_{42}H_{55}N_3O_{13}$: C, 62.28; H, 6.85; N, 5.19%.

*6-O-(2,3,4-Tri-O-benzyl-6-deoxy-6-ethoxycarbonylamido-α-D-glucopyranosyl)-N,N'-diethoxycarbonyl-2-deoxystreptamine (**5b**).* A solution of **4b** (0.23 g) in aqueous ethanol (1:20, 10.5 ml) was hydrogenated for 20 hr as in the procedure for **4a** and the reduction product (0.21 g, $R_f$ 0 with benzene-acetone 2:1) was allowed to react with carboethoxy chloride to give **5b** (0.21 g). Recrystallized from aqueous ethanol; a colorless solid 0.18 g (74%), mp 243—244°C, $[\alpha]_D^{26}$ +24° (*c* 0.6, acetone); NMR (in pyridine-$d_5$ containing small amount of $D_2O$): $\tau$ 8.87 and 8.82 (6H and 3H t. respectively, $CH_2C\underline{H}_3$), 4.05 (1H d., *J* 3 Hz, H-1''), 2.4—2.6 (15H m., $OCH_2C_6\underline{H}_5$).

*4-O-(6-Deoxy-6-ethoxycarbonylamido-α-D-glucopyranosyl)-N,N'-diethoxycarbonyl-2-deoxystreptamine (**6a**).* Compound **5a** (0.31 g) was dissolved in a mixture of ethanol (11 ml) and water (4 ml) by heating. After addition of several drops of acetic acid, the solution was hydrogenated with freshly prepared palladium black and hydrogen under 50 lb/sq. inch pressure at 40—45°C for 12 hr. On tlc with benzene-methanol (4:1), **5a** ($R_f$ 0.6) disappeared and a product ($R_f$ 0.2) appeared. Filtration and evaporation of the solution gave a solid, which was treated with aqueous acetone (2:1) to give an amorphous solid, 0.20 g (97%), mp 266—267°C, $[\alpha]_D^{20}$+44° (*c* 0.7, aqueous ethanol 1:1); IR (KBr): 3200—3500, 1695, and 1545 $cm^{-1}$; NMR (in a mixture of $D_2O$ and pyridine-$d_5$ of approximately 1:1): $\tau$ 8.90 (9H t., *J* 7 Hz, $CH_2C\underline{H}_3$), 6.8—6.3 (11H, skeleton protons), 6.01 (6H q., *J* 7 Hz, $C\underline{H}_2CH_3$), 4.82 (1H, d., *J* 3 Hz, H-1'). No benzyl protons were observed. Found: C, 46.44; H, 7.24; N, 7.55%. Calcd for $C_{21}H_{37}N_3O_{11}$: C, 46.75; H, 6.91; N, 7.79%.

*6-O-(6-Deoxy-6-ethoxycarbonylamido-α-D-glucopyranosyl)-N,N'-diethoxycarbonyl-2-deoxystreptamine (**6b**).* **6b** was prepared from **5b** likewise as described above and the product was reprecipitated from aqueous acetone (3:1), yield 97%. Mp 242.5—244°C, $[\alpha]_D^{20}$+67° (*c* 0.6, aqueous ethanol 1:1); NMR (in a mixture of $D_2O$ and pyridine-$d_5$ of approximately 1:1): $\tau$ 8.90, 8.87, and 8.82 (3H t. each, *J* 7 Hz, $CH_2C\underline{H}_3$), 6.4—5.6 (~17 H), 4.43 (1H d., *J* 3 Hz, H-1'').

Found: C, 46.83; H, 6.91; N, 7.42%. Calcd for $C_{21}H_{37}N_3O_{13}$: C, 46.75; H, 6.91; N, 7.79%.

*4-O-(6-Amino-6-deoxy-α-D-glucopyranosyl)-2-deoxystreptamine (**7a**).* A solution of **6a** (0.14 g) in 1N barium hydroxide

20) The anomeric hydrogen of a glycoside moiety attached to C-4 and C-6 of 2-deoxystreptamine is designated as H-1' and H-1'' respectively; See Ref. 4e.

(6 ml) was heated at 90°C for 5 hr and the resulting solution was neutralized with carbon dioxide. The suspension was boiled for a while, centrifuged, and the upper layer was filtered. The residue was washed with boiling water several times. The filtrate and washings combined were evaporated. The resulting residue was dissolved in water and the solution was filtered and the filtrate was evaporated. The procedure was repeated twice more. The residue was charged on a column (10×140 mm) of Amberlite IRC 50 ($NH_4^+$ form) and after washing with water developed with 0.1N ammonia. The portion (70—160 ml) containing **7a** was evaporated to give a colorless solid, 0.06 g (69%). An aqueous solution of the product was neutralized with hydrochloric acid to pH 3 and the solution was concentrated. Addition of acetone gave **7a**·dihydrochloride, $[\alpha]_D^{22}$+89° (*c* 0.3, water), $[\alpha]_{436}^{22}$+153° (*c* 0.3, water), $[\alpha]_{436TACu}^{22}$ +316° (*c* 0.3, TACu), $\Delta[M]_{TACu}^{22}$[16] +645°; $R_{f\,2\text{-deoxystreptamine}}$ 0.38 (ppc with *n*-butanol-pyridine-water-acetic acid 6:4:3:1) IR spectrum was quite the same as that obtained from the natural antibiotic.[14] NMR (in $D_2O$): $\tau$ 8.75 (1H q., $J\sim12$ Hz, $H_{ax}$-2), 7.97 (1H double triplets, $J\sim3$ and $\sim12$ Hz, $H_{eq}$-2), 4.73 (1H d., $J\sim3$ Hz, H-1′)

Found: C, 36.34; H, 7.21; Cl, 17.51%. Calcd for $C_{12}H_{25}N_3O_7\cdot2HCl$: C, 36.37; H, 6.87; Cl, 17.89%.

The value of $\Delta[M]_{TACu}^{22}$ corresponded to that (+640°) of the natural product.

*6-O-(6-Amino-6-deoxy-α-D-glucopyranosyl)-2-deoxystreptamine (7b).* **6b** was treated similarly as in the procedure for **7a** yielding **7b**, yield 65%. Dihydrochloride, $[\alpha]_D^{22}$+82° (*c* 0.3, water), $[\alpha]_{436}^{22}$+150° (*c* 0.3, water), $[\alpha]_{436(TACu)}^{22}$+92° (*c* 0.3, TACu), $\Delta[M]_{TACu}$ −230°; $R_{f\,2\text{-deoxysteptamine}}$ 0.45 (ppc with *n*-butanol-pyridine-water-acetic acid); The IR spectra of **7b** was the same as that of **7a**. NMR (in $D_2O$): $\tau$ 8.53 (1H q., $J\sim12$ Hz, $H_{ax}$-2), 7.83 (1H double triplet, $J\sim3$ and $\sim12$ Hz, $H_{eq}$-2), 4.87 (1H, d., $J\sim3$ Hz, H-1″).

Found: C, 36.54; H, 7.03; Cl, 17.42%. Calcd for $C_{12}H_{25}N_3O_7$ 2HCl: C, 36.37; H, 6.87; Cl, 17.89%.

*4-O-(6-Azido-2,3,4-tri-O-benzyl-6-deoxy-α- and β-D-glucopyranosyl)-6-O-(2,3,4,6-tetra-O-benzyl-α-D-glucopyranosyl)-N,N′-diethoxycarbonyl-2-deoxystreptamine (9 and 10, respectively).*

A mixture of **1** (1.21 g, 2.4 mmol) and freshly prepared Drierite (1.5 g) in anhydrous benzene-dioxane (3:1, 20 ml) was heated at 60°C under stirring for 30 min and **8**[9] (1.35 g, 1.6 mmol) and well dried mercuric cyanide (1.24 g) were added to the mixture, which was refluxed for 10 hr under vigorous striring. Mercuric cyanide (1.24 g) was again added and the reaction was further continued for 10 hr. The mixture was filtered and the residue was washed with chloroform. The filtrate and washings combined were evaporated to give a syrup which was dissolved in chloroform. The solution was washed with water, dried over sodium sulfate and evaporated to give a thick syrup (2.3 g). On tlc with benzene-acetone (10:1), the syrup showed four spots of $R_f$ 0.43 (major), 0.33 (minor), 0.28 (minor), and 0.20 (minor). The syrup was chromatographed on a column (27×330 mm) of silica gel (Mallinckrodt, 120 g) with benzene-acetone (10:1), and the fractions of 200—300 ml and 360—450 ml containing the major ($R_f$ 0.43) and minor ($R_f$ 0.20) products were evaporated to give solids, respectively (**9**, 1.50 g, 71% based on **8**; **10**, 0.33 g, 16% based on **8**). **10** was recrystallized from ethanol, but not **9**. Compound **9**: mp 53—57°C, $[\alpha]_D^{20}$+80° (*c* 0.8, acetone); IR (KBr): 2100 $cm^{-1}$ ($N_3$); NMR (in $CDCl_3$): $\tau$ 8.86 and 8.83 (3H t. each $J\sim7$ Hz, $CH_2C\underline{H}_3$, overlapped with peaks of $H_{ax}$-2), 5.7—6.8 ($\sim$21H, skeleton protons and $C\underline{H}_2CH_3$), 4.8—5.7 ($\sim$17H; seven $OC\underline{H}_2C_6H_5$, two anomeric protons and one amide proton (?)), 4.0 (1H, amide proton), 2.55—2.75 (35H, five singlets, seven $OCH_2C_6\underline{H}_5$).

Found: C, 68.44; H, 6.43; N, 5.51%. Calcd for $C_{73}H_{83}N_5O_{16}$: C, 68.15; H, 6.50; N, 5.44%.

Compound **10**: mp 176—176.5°C, $[\alpha]_D^{20}$+82° (*c* 0.7 acetone); IR (KBr): 2120 $cm^{-1}$ ($N_3$); NMR (in $CDCl_3$): $\tau$ 8.86 and 8.84 (3H t. each), 5.7—6.8 ($\sim$21H), 4.95—5.7 ($\sim$16H), 4.80 (1H d., $J\sim3$ Hz), 3.7 (1H, amide proton), 2.6—2.75 (35H).

Found: C, 68.01; H, 6.64: N, 5.35%. Calcd for $C_{73}H_{83}N_5O_{16}$: C, 68.15; H, 6.50; N, 5.44%.

*4-O-(6-Amino-2,3,4-tri-O-benzyl-6-deoxy-α-D-glucopyranosyl)-6-O-(2,3,4,6-tetra-O-benzyl-α-D-glucopyranosyl)-N,N′-diethoxycarbonyl-2-deoxystreptamine (11).* Compound **9** (0.65 g) was dissolved in hot aqueous ethanol (16:1, 8.5 ml) and the solution was hydrogenated with Raney nickel (T-4) and hydrogen under a pressure of 50 lb/sq. inch at 40—45°C for 5 hr. On tlc with benzene-acetone (1:1), **9** ($R_f$ 0.94) disappeared and a product ($R_f$ 0.61) appeared. Filtration and evaporation of the solution gave a colorless solid (0.56 g), which was recrystallized from ethanol to give crystals of **11** (0.51 g, 80%), mp 130—131°C, $[\alpha]_D^{22}$+59° (*c* 0.8, $CHCl_3$); IR (KBr): no peak near 2100 $cm^{-1}$ ($N_3$). NMR (in $CDCl_3$): $\tau$ 8.83 and 8.80 (3H t. each, $J$ 7 Hz, $CH_2C\underline{H}_3$ overlapped with $H_{ax}$-2 peaks), $\sim$7.9 (1H unresolved m. $H_{eq}$-2), 6.9—7.5 (3H m., $NH_2$ and OH), 5.7—6.9 (21H, skeleton protons and $C\underline{H}_2CH_3$), 5.0—5.65 (14H, seven $OC\underline{H}_2C_6H_5$), 4.95 (1H d., $J\sim3$ Hz, anomeric proton at 1″ (?)), 4.78 (1H d., $J\sim3$ Hz, anomeric proton at 1′ (?)), 4.28 and 3.96 (1H each, amide protons), 2.6—2.75 (35H four singlets, seven $OCH_2C_6\underline{H}_5$).

Found: C, 69.26; H, 6.71; N, 3.61%. Calcd for $C_{73}H_{85}N_3O_{16}$: C, 69.56; H, 6.80; N, 3.33%.

*4-O-(2,3,4-Tri-O-benzyl-6-deoxy-6-ethoxycarbonylamido-α-D-glucopyranosyl)-6-O-(2,3,4,6-tetra-O-benzyl-α-D-glucopyranosyl)-N,N′-diethoxycarbonyl-2-deoxystreptamine (12).* Water (5 ml) and sodium carbonate (0.22 g) were added to a solution of **11** (0.34 g) in acetone (5 ml), under vigorous stirring, and carboethoxy chloride (0.15 g) was added to the resulting suspension. The reaction was continued under stirring for 30 min at room temperature. On tlc with benzene-acetone (3:1), the starting material **11** ($R_f$ 0.13) disappeared and a product ($R_f$ 0.75) appeared. The solution was evaporated and the residue was dissolved in chloroform. The solution was washed with water, dried over sodium sulfate and evaporated to give a thick syrup of **12**; 0.37 g (97%), $[\alpha]_D^{20}$+54°C (*c* 1.2, acetone); NMR (in $CDCl_3$): $\tau$ 8.85, 8.82, and 8.77 (3H t. each $CH_2C\underline{H}_3$, overlapped with $H_{ax}$-2 peaks), $\sim$8.0 (1H m., $H_{eq}$-2), 5.65 $\sim$6.7 (23H), 4.7—5.6 (17H), 3.95 (1H), 2.55—2.7 (35H, seven $OC\underline{H}_2C_6\underline{H}_5$).

Found: C, 68.67; H, 6.76; N, 3.44%. Calcd for $C_{76}H_{89}N_3O_{18}$: C, 68.50; H, 6.73; N, 3.15%.

*4-O-(6-Deoxy-6-ethoxycarbonylamido-α-D-glucopyranosyl)-6-O-(α-D-glucopyranosyl)-N,N′-diethoxycarbonyl-2-deoxystreptamine (13).* A solution of **12** (0.33 g) in aqueous ethanol (1:7, 16 ml) containing several drops of acetic acid was hydrogenated with palladium black and hydrogen under 50 lb/sq. inch pressure at 40—45°C for 15 hr. Filtration and evaporation of the solution gave a residue. Recrystallization was accomplished by dissolving the residue in aqueous ethanol (1:1, 8 ml) with subsequent addition of acetone; 0.15 g (84%), mp 164.5—165.5°C, $[\alpha]_D^{20}$+88° (*c* 0.5, aqueous ethanol 1:1); IR (KBr): 1690 (sharp), 1545 $cm^{-1}$; NMR (in pyridine-$d_5$ containing small amount of $D_2O$): $\tau$ 8.75, 8.72 and 8.69 (3H t. each, $CH_2C\underline{H}_3$), $\sim$7.7 (1H, $H_{ex}$-2), 5.35—6.3 ($\sim$23H), 4.2—4.7 (overlapped with DOH).

Found: C, 45.03; H, 6.82; N, 6.15%. Calcd for $C_{27}H_{47}N_3O_{18}\cdot H_2O$: C, 45.05; H, 6.86; N, 5.84%.

*4-O-(6-Amino-6-deoxy-α-D-glucopyranosyl)-6-O-(α-D-gluco-*

*pyranosyl)-2-deoxystreptamine (14).* A solution of **13** (0.14 g) in 1N barium hydroxide (6 m*l*) was heated at 90°C for 5 hr and then neutralized with carbon dioxide. A product ($R_{f\,2\text{-deoxystreptamine}}$ 0.32) appeared on paper chromatography with *n*-butanol – pyridine – water – acetic acid (6:4:3:1). By a similar procedure to that for **7a**, a crude product was obtained. The product was passed through a short column (11×40 mm) of Sephadex G 10 and the fraction containing the product was concentrated to a small volume which was again passed through a short column of Dowex 1×2 (OH form, 0.5 m*l*). The solution obtained was evaporated to give a colorless solid (88 mg), which was purified by dissolving in a mixture of water, methanol and ethanol with subsequent addition of acetone; a hygroscopic solid, 79 mg (82%), $[\alpha]_D^{22}$ +135° (*c* 0.5, water), NMR (in $D_2O$): $\tau$ 8.3—9.0 (1H unresolved m., $H_{ax}$-2), 7.85—8.2 (1H unresolved m., $H_{eq}$-2), 5.8—7.3 (~17H, skeleton protons), 4.87 (1H d., $J$~3 Hz, H-1″), 4.55 (1H d., $J$~3 Hz, H-1′).

Found: C, 44.35; H, 7.21; N, 8.36%. Calcd for $C_{18}H_{35}N_3O_{12}$: C, 44.53; H, 7.27; N, 8.66%.

*4-O-(6-Amino-6-deoxy-β-D-glucopyranosyl)-6-O-(α-D-glucopyranosyl)-2-deoxystreptamine (15).* Compound **10** (0.17 g) was reduced with Raney nickel and hydrogen and the amino derivative formed (0.15 g, $R_f$ 0 on tlc with benzene - acetone (10:1) was acylated with carboethoxy chloride to give the corresponding hepta-*O*-benzyl-tri-*N*-ethoxycarbonyl derivative ($R_f$ 0.24) accompanied by a by-product ($R_f$ 0.1). The main product was isolated by column chromatography on silica gel with benzene-acetone (10:1). After being debenzylated with palladium black and hydrogen, the product was hydrolyzed with 1N barium hydroxide and the product was purified by a similar procedure as in the preparation of **14** to give the final product **15** (30 mg, 47%), $[\alpha]_D^{22}$ +63° (*c* 0.6, water): NMR spectrum (in $D_2O$) of **15** showed a similar pattern to that of **14** except for the peaks of one of anomeric protons: $\tau$ 5.37 (1H d., $J$~7 Hz, $H_{ax}$-1′), 4.87 (1H d., $J$~3 Hz, $H_{eq}$-1″)

Found: C, 44.64; H, 7.33%. Calcd for $C_{18}H_{35}N_3O_{12}$: C, 44.53; H, 7.27%.

*4,6-Di-O-(6-azido-2,3,4-tri-O-benzyl-6-deoxy-α-D-glucopyranosyl)-N,N′-diethoxycarbonyl-2-deoxystreptamine (16) and 4-O-(6-Azido-2,3,4-tri-O-benzyl-6-deoxy-β-D-glucopyranosyl)-6-O-(6-azido-2,3,4-tri-O-benzyl-6-deoxy-α-D-glucopyranosyl)-N,N′-diethoxycarbonyl-2-deoxystreptamine (17).* A mixture of **1** (1.7 g, 3.5 mmole) and freshly prepared Drierite (1.5 g) in dry benzene-dioxane (3:1, 20 m*l*) was heated at 60°C for 30 min under stirring, and **4b** (1.88 g, 2.5 mmol) and well dried powder mercuric cyanide (1.9 g) were added. The mixture was refluxed under stirring. The reaction was monitored by tlc with benzene - acetone (20:1). After 6 hr mercuric cyanide (1.9 g) was again added. After 10 hr mercuric cyanide (1.9 g) was further added and the reaction was continued for 10 hr (26 hr in total). The mixture was filtered and treatment was carried out as in the preparation of **3a** to give a syrup. On tlc with benzene - acetone (20:1) the syrup showed three spots of $R_f$ 0.16 (**16**), 0.1 and 0.04 (**17**). The syrup was chromatographed on a column (35×330 mm) of silica gel (Mallinckrodt, 150 g) with benzene-acetone (20:1) and the fractions of 240—360 m*l* and 510—960 m*l* were evaporated to give a solid, 1.8 g (**16**, 60%) and 0.58 g (**17**, 19%), respectively. Both **16** and **17** were recrystallized from ethanol.

Compound **16**: mp 158—159°C $[\alpha]_D^{22}$ +91° (*c* 0.9, chloroform); IR (KBr): 2100 $cm^{-1}$ ($N_3$); NMR (in $CDCl_3$): $\tau$ 8.85 and 8.81 (3H t. each, $CH_2C\underline{H}_3$), 5.6—6.8 (~21H), 4.8—5.5 (~15H), 4.15 (1H), 2.55—2.7 (30H, five singlets, six $OCH_2C_6\underline{H}_5$).

Found: C, 64.70; H, 6.29; N, 9.50%. Calcd for $C_{66}H_{76}N_8O_{15}$: C, 64.90; H, 6.27; N, 9.18%.

Compound **17**: mp 185.5—186.5°C, $[\alpha]_D^{22}$ +62° (*c* 0.7, chloroform); IR (KBr): 2100 $cm^{-1}$ ($N_3$).

Found: C, 65.13; H, 6.12; N, 8.94%. Calcd for $C_{66}H_{76}N_8O_{15}$: C, 64.90; H, 6.27; N, 9.18%.

*4,6-Di-O-(6-ethoxycarbonylamido-2,3,4-tri-O-benzyl-6-deoxy-α-D-gluco-pyranosyl)-N,N′-diethoxycarbonyl-2-deoxystreptamine (18).* Compound **16** (0.7 g) was dissolved in hot aqueous ethanol 1:11, 9 m*l*) and hydrogenated with Raney nickel and hydrogen under the pressure of 50 lb/sq. inch at 40—45°C for 14 hr. On tlc with benzene - acetone (20:1), the starting material ($R_f$ 0.28) disappeared and a product ($R_f$ 0) appeared. Filtration and evaporation of the solution gave a solid (0.64 g) which was treated with carboethoxy chloride (0.32 g) in a similar manner as described in the preparation of **5a** to give a crude solid (0.70 g). The product was passed through a column (25×65 mm) of silica gel (Mallinckrodt, 12 g) with the aid of benzene-acetone (5:1). From the fraction of 30—130 m*l*, the final product was obtained as a syrup (0.65 g, 86%) which crystallized on standing, mp 79—81°C, $[\alpha]_D^{23}$ +36° (*c* 0.9, chloroform); NMR (in $CDCl_3$): $\tau$ 8.86, 8.82, 8.80, and 8.77 (3H t. each, $CH_2C\underline{H}_3$), 2.6—2.73 (30H, $OCH_2C_6\underline{H}_5$).

Found: C, 66.05; H, 6.58; N, 4.25%. Calcd for $C_{72}H_{88}N_4O_{19}$: C, 65.84; H, 6.75; N, 4.27%.

*4,6-Di-O-(6-ethoxycarbonylamido-6-deoxy-α-D-glucopyranosyl)-N,N′-diethoxycarbonyl-2-deoxystreptamine (19).* Compound **18** (0.5 g) was dissolved in hot aqueous ethanol (3.5:10, 13.5 m*l*) and hydrogenated with palladium black and hydrogen. On tlc with benzene - methanol (4:1), **18** ($R_f$ 0.78) disappeared and a product ($R_f$ 0.2) appeared. Filtration and evaporation of the solution gave **19** which was recrystallized from aqueous ethanol (1:1), 0.25 g (97%); mp 282—283°C, $[\alpha]_D^{20}$+73° (*c* 0.8, aqueous ethanol 1:1); NMR (in pyridine-$d_6$ containing a little $D_2O$): $\tau$ 8.79, 8.77, 8.72, and 8.70 (3H t. each, $J$ 7 Hz, $CH_3C\underline{H}_2$)

Found: C, 46.37; H, 6.90; N, 6.98%. Calcd for $C_{30}H_{52}N_4O_{19}$: C, 46.63; H, 6.78; N, 7.25%.

*4,6-Di-O-(6-amino-6-deoxy-α-D-glucopyranosyl)-2-deoxystreptamine (20).* Compound **19** was hydrolyzed in a smilar manner as in the preparation of **7a** and **20** was obtained in 75% yield; $[\alpha]_D^{23}$ +138° (*c* 0.5, water); NMR (in $D_2O$): $\tau$ 4.88 (1H d., $J$~3 Hz, H-1″), 4.58 (1H d., $J$~3 Hz, H-3′).

Found: C, 44.78; H, 7.33%. Calcd for $C_{18}H_{36}N_4O_{11}$: C, 44.62; H, 7.49%.

*4-O-(6-Amino-6-deoxy-β-D-glucopyranosyl)-6-O-(6-amino-6-deoxy-α-D-glucopyranosyl)-2-deoxystreptamine (21).* Compound **17** was hydrogenated with Raney nickel and the corresponding amino compound was *N*-ethoxycarbonylated. The product had $R_f$ 0.44 on tlc with benzene - acetone (5:1). Debenzylation and deethoxycarbonylation were accomplished by similar procedures as in the preparation of **15** to give the final product **21** in 59% yield (based on **17**); $R_{f\,2\text{-deoxystreptamine}}$ 0.23 (ppc with *n*-butanol - pyridine - water - acetic acid 6:4:3:1), $[\alpha]_D^{22}$ +65° (*c* 0.7, water); NMR (in $D_2O$): $\tau$ 5.37 (1H d., $J$ 7 Hz, $H_{ax}$-1′), 4.87 (1H d., $J$~3 Hz, $H_{eq}$-1″).

Found: C, 44.91; H, 7.39%. Calcd for $C_{18}H_{36}N_4O_{11}$: C, 44.62; H, 7.49%.

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