  Bull. Chem. Soc. Jpn., 57, 2538—2542 (1984) [Vol. 57, No. 9

Branched-chain Sugars. XXXVI. A New Synthesis of Methyl 4-*O*-Benzoyl-3-benzoylamino-2,3,6-trideoxy-3-*C*-methyl-α-L-*xylo*-hexopyranoside, a Derivative of the Branched-chain Amino Sugar of Antibiotic A35512B[1]

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(Received April 16, 1984)

The title compound was synthesized from methyl 4-*O*-benzyl-2,6-dideoxy-β-L-*threo*-hexopyranosid-3-ulose (**19**) through cyanomesylation, reductive spiro aziridine formation, and reductive ring-opening. When (2-methoxyethoxymethyl) group was used as the protecting group at *O*-4 of the above intermediate, it could not be removed at the final stage.

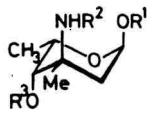
3-Amino-2,3,6-trideoxy-3-*C*-methyl-L-*xylo*-hexopyranose (**1**)[2] was found as a component of the new Gram-positive antibiotic, A35512B,[3] and characterized as the title compound (**2**).[2] In the preceding paper,[1] we have synthesized L-rubranitrose (**4**), having fundamentally the same configuration with **1**, from D-glucose. This paper describes a facile synthesis of **2** through a similar pathway. The first synthesis of **2** was accomplished from a non-carbohydrate diol obtained by fermentation of α-methylcinnamaldehyde with bakers' yeast.[4] In latter, *N*-acetyl derivative of **2** was obtained from its 4-epimeric derivative (**5**) by inversion,[5] which was derived from L-rhamnose.

Results and Discussion

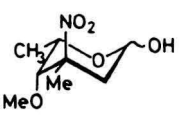
In the synthesis of **4**, the coincidental migration of benzoyl group in methyl 6-bromo-2,6-dideoxy-4-*O*-benzoyl-α-D-*ribo*-hexopyranoside (**6**) with the introduction of methyl group on *O*-4, and the conversion of D-sugar to L-sugar were utilized. In the similar way, treatment of **6** with benzyl bromide and silver(I) oxide in *N*,*N*-dimethylformamide (DMF) in the dark gave the corresponding 3-*O*-benzoyl-4-*O*-benzyl derivative (**7**) in 92% yield. However, treatment of **7** in dry pyridine with silver(I) fluoride gave the 5-enopyranoside (**8**) and fluorine-substituted derivative of **7** in the ratio of 2:3, and catalytic hydrogenation of the unsaturated bond of **8** was undesirably accompanied with hydrogenolysis of 4-*O*-benzyl group to give methyl 3-*O*-benzoyl-2,6-dideoxy-β-L-*lyxo*-hexopyranoside (**9**) in 32% overall yield. Partial benzoylation of methyl 2,6-dideoxy-β-L-*lyxo*-hexopyranoside[6] gave also **9** in 85% yield, together with a small amount of the 4-benzoate (**10**) and 3,4-dibenzoate.

As was observed in the case of **6**, the benzoyl migration in equatorially oriented benzoyloxy group of **9** to the vicinal axial hydroxyl group took place very easily. Thus, the treatment of **9** with silver(I) fluoride in pyridine or with silver(I) oxide in DMF gave the corresponding 4-benzoate (**10**) quantitatively, and therefore, benzylation of **9** under the above conditions gave mainly the corresponding 4-*O*-benzoyl-3-*O*-benzyl derivative, which was confirmed by hydrogenolysis of the product into **10**. Similarly, reaction of **9** in dichloromethane with (2-methoxyethoxymethyl) chloride in the presence of *N*,*N*-diisopropylethylamine gave the corresponding 4-*O*-benzoyl-3-*O*-(2-methoxyethoxymethyl) (**11**) and 3-*O*-benzoyl-4-*O*-(2-methoxyethoxymethyl) (**12**) derivatives in the ratio of 1:1, and the mixture was *O*-debenzoylated into the corresponding 3-*O*-(2-methoxyethoxymethyl) (**13**) and 4-*O*-(2-methoxyethoxymethyl) (**14**) derivatives. These acyl migration are undesirable in the present synthesis.

Now, the reaction was accomplished under the conditions by the use of (2-methoxyethoxymethyl) triethylammonium chloride[7] to give **12** exclusively, which was then *O*-debenzoylated into **14** in 88% yield. Oxidation of **10** and **14** with pyridinium chlorochromate gave the corresponding pyranosid-3-uloses (**17** and **18**) in 91% and 98% yields, respectively. One-flask cyanomesylation of **17** and **18** under kinetic conditions[8] gave 4-*O*-benzoyl (**20**) and 4-*O*-(β-methoxyethoxymethyl) (**21**) derivatives of methyl 3-*C*-cyano-2,6-dideoxy-3-*O*-methylsulfonyl-β-L-*lyxo*-hexopyranoside in 35 and 73% yields, respectively. Reduction of **21** with lithium aluminium hydride gave the corresponding spiro aziridine (**23**) in 65% yield, which was then converted into methyl 3-benzoylamino-2,3,6-trideoxy-4-*O*-(2-methoxyethoxymethyl)-3-*C*-methyl-β-L-*xylo*-hexopyranoside



1 $R^1=R^2=R^3=H$
2 $R^1=Me, R^2=R^3=Bz$
3 $R^1=Me, R^2=Bz, R^3=H$



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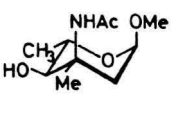

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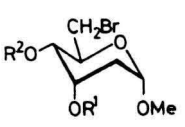
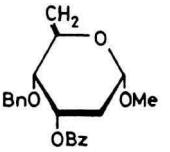


6 $R^1=H, R^2=Bz$
7 $R^1=Bz, R^2=Bn$



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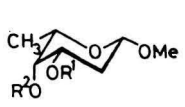
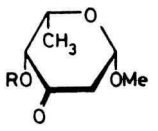


9 R^1=Bz, R^2=H
10 R^1=H, R^2=Bz
11 R^1=MEM, R^2=Bz
12 R^1=Bz, R^2=MEM
13 R^1=MEM, R^2=H
14 R^1=H, R^2=MEM
15 R^1=Bz, R^2=Bn
16 R^1=H, R^2=Bn



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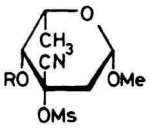
18 R=MEM
19 R=Bn



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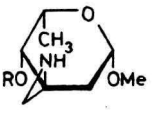

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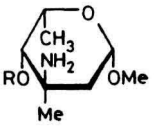

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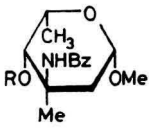
26 R=Bn



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28 R=Bn

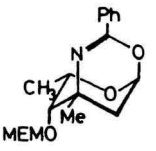

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Table 1. ^{13}C-NMR chemical shifts (δ)[a] of **2**, **27**, and **28**

Carbons	2	27[b]	28
C-1	98.66	98.91	98.93
C-2	36.95	39.75	38.34
C-3	53.64	57.60	58.03
C-4	70.33	76.72	76.61
C-5	63.12	69.26	69.62
C-6	17.07	17.42	17.23
C-Me	22.76	23.45	23.35
O-Me	55.37	56.17	56.13
C=O	116.01	167.01	167.15
	165.58		

a) Data for benzene-carbons were omitted. b) (2-methoxyethoxymethyl) carbons from the terminal: 59.04, 68.48, 71.73, and 98.05 respectively.

(**27**) through hydrogenolysis into the corresponding methyl-branched amino sugar (**25**) followed by *N*-benzoylation. However, the 4-*O*-(2-methoxyethoxymethyl) group of **27** could not be removed. Treatment of **27** with 2-propanethiol and boron trifluoride etherate[9] gave unchanged **27**, and with zinc(II) chloride[7] in dichloromethane or with 1.5 M (1 M=1 mol dm^{-3}) methanolic hydrogen chloride[10] gave 8-(2-methoxyethoxymethoxy)-7-methyl-3-phenyl-4,6-dioxa-2-azabicyclo[3.3.1]non-2-ene (**29**) in 63 and 60% yields, respectively.

From the aforementioned result, benzyl group was chosen as the protecting group. Benzylation[11] of **9** with benzyl trichloroacetimidate and trifluoromethanesulfonic acid[12] was successfully proceeded to give the corresponding 4-*O*-benzyl derivative (**15**) in 62% yield, which was then debenzoylated to give **16**. Oxidation of **16** with pyridinium chlorochromate gave the corresponding pyranosid-3-ulose (**19**) in 84% yield. Cyanomesylation of **19** gave **22** in 65% yield, which was converted into the corresponding methyl-branched amino sugar (**26**) *via* the spiro aziridine derivative (**24**). Benzoylation of **26** in methanol gave the corresponding *N*-benzoyl derivative (**28**) quantitatively. Hydrogenolysis of **28** in methanol in the presence of palladium–carbon, followed by *O*-benzoylation of the product (**3**) in pyridine, was unexpectedly accompanied by anomerization to give **2** in 65% yield. This anomerization under neutral conditions was confirmed by repeated experiments. Physical constants of **2** thus obtained were identical with those reported for the sample obtained from antibiotic A35512B (see Experimental). In Table 1, ^{13}C-NMR data of **2**, **27**, and **28** were summarized. The results indicate the presence of an equatorially oriented methyl-group in these compounds,[13] and the substituent effects observed are rational to those have been reported.[14]

Experimental

Melting points are uncorrected. Optical rotations were measured with a JASCO DIP-4 polarimeter in chloroform, and ^{1}H and ^{13}C-NMR were recorded in chloroform-*d* with JEOL PS-100 and JEOL FX-90Q spectrometers, respectively, with tetramethylsilane as an internal standard, unless otherwise stated. Chemical shifts and coupling constants were recorded in δ (ppm) and Hz units, respectively, and IR frequencies in cm^{-1}.

*Methyl 3-O-Benzoyl-4-O-benzyl-6-bromo-2,6-dideoxy-α-*D*-ribo-hexopyranoside (7).* To a solution of methyl 4-*O*-benzoyl-6-bromo-2,6-dideoxy-α-D-*ribo*-hexopyranoside (1.61 g, 4.67 mmol) in *N*,*N*-dimethylformamide (10 ml) was added benzyl bromide (0.95 g, 5.61 mmol) and silver(I) oxide (1.32 g, 5.61 mmol), and the mixture was stirred in the dark for 24 h, filtered (after checking the consumption of the starting meterial with TLC), and the filtrate was evaporated. Purification of the residual sirup on a silica-gel column (benzene: acetone 16:1) gave **7** as a pale yellow sirup (1.87 g, 92.2%). $[\alpha]_D$ +65° (*c* 1.2); NMR: δ=8.27—7.96 and 7.86—7.04 (m, 10H, Bz and Ph), 5.79 (dt, 1H, $J_{3,4}$=3.0, H-3), 4.85 (dd, 1H, $J_{1,2a}$=4.0, $J_{1,2e}$=1.4, H-1), 4.79 and 4.47 (ABq, 2H, J_{gem}=11.0, CH_2Ph), 4.36 (m, 1H, H-5), 3.85—3.40 (m, 3H, H-4, 6, and 6'), 3.46 (s, 3H, OMe), 2.30 (ddd, 1H, $J_{2a,3}$=4.0, $J_{2a,2e}$=16.0, H-2a) and 2.00 (dt, 1H, H-2e).

Anal. ($C_{21}H_{23}O_4Br$) C, H, Br.

*Methyl 3-O-Benzoyl-2,6-dideoxy-β-*L*-lyxo-hexopyranoside (9).* i) A suspension of **7** (1.76 g, 4.2 mmol) and powdered dry silver(I) fluoride (1.55 g, 12.2 mmol) in dry pyridine (30 ml) was stirred for 40 h in the dark, poured into cold water, and then extracted with chloroform. The organic

layer was filtered, and evaporated. The residual yellow sirup contains 3-*O*-benzoyl-4-*O*-benzyl-2,6-dideoxy-α-D-*erythro*-hex-5-enopyranoside (**8**) and the substitution product; 6-fluoro-6-deoxy drivative in the ratio of 2:3. The mixture in methanol (20 ml) containing a few drops of acetic acid was hydrogenated in the presence of 10% palladium-carbon (200 mg) overnight. After monitering the disappearance of **8**, the usual work-up of the reaction mixture and purification of the product on a silica-gel column gave **9** (362 mg, 32.4%) as a yellow sirup. $[\alpha]_D$ −8.6° (*c* 1.4); NMR: δ=8.2—8.0 and 7.7—7.3 (m, 5H, Bz), 5.11 (ddd, 1H, $J_{2a,3}$=12.0, $J_{2e,3}$=6.0, H-3), 4.48 (dd, 1H, $J_{1,2a}$=8.6, $J_{1,2e}$=3.6, H-1), 3.83 (d, 1H, $J_{3,4}$=3.0, H-4), 3.65 (q, 1H, $J_{5,6}$=7.0, H-5), 3.53 (s, 3H, OMe), 2.20 (bs, 1H, OH), 2.17 (ddd, 1H, $J_{2a,2e}$=12.0, H-2e), 1.98 (dt, 1H, H-2a) and 1.35 (d, 3H, H-6).

Anal. ($C_{14}H_{18}O_5$) C, H.

ii) To a solution of methyl 2,6-dideoxy-β-L-*lyxo*-hexopyranoside[6] (4.93 g, 30.4 mmol) in dry pyridine (40 ml) was added benzoyl chloride (4.53 g, 32.2 mmol) dropwise at 0 °C, and the resulting solution was stirred overnight at room temperature. The usual work-up of the reaction mixture and purification of the product on a silica-gel column (benzene–acetone 8:1) gave **9** in 85.0% (6.88 g) yield. The residual part included 4-*O*-benzoyl (**10**) and 3,4-di-*O*-benzoyl derivatives.

Methyl 4-O-Benzoyl-2,6-dideoxy-β-L-lyxo-hexopyranoside (10). A suspension of **9** (130 mg, 0.488 mmol) and silver(I) oxide (2 g, 8.63 mmol) in DMF (20 ml) was stirred for 2 d at room temperature in the dark, and then filtered. The usual work-up of the filtrate gave **10** (130 mg) quantitatively. Mp. 122—124 °C (hexane–ethanol 1:1); $[\alpha]_D$ +30.3° (*c* 1.1). NMR: δ=8.3—8.0 and 7.7—7.3 (m, 5H, Bz), 5.26 (dd, 1H, $J_{3,4}$=4.0, $J_{4,5}$=1.0, H-4), 4.42 (dd, 1H, $J_{1,2a}$=9.5, $J_{1,2e}$=2.4, H-1), 4.03 (ddd, 1H, $J_{2a,3}$=12.2, $J_{2e,3}$=5.4, H-3), 3.72 (dq, $J_{5,6}$=6.7, H-5), 3.53 (s, 3H, OMe), 2.88 (bs, 1H, OH), 2.07 (ddd, 1H, $J_{2a,2e}$=12.0, H-2e), 1.84 (dt, 1H, H-2a) and 1.28 (d, 3H, H-6).

Anal. ($C_{14}H_{18}O_5$) C, H.

(2-Methoxyethoxy) methylation of 9. i) A solution of **9** (172.5 mg, 0.648 mmol), (2-methoxyethoxymethyl) chloride (143 mg, 1.15 mmol), and *N,N*-diisopropylethylamine (167 mg, 1.29 mmol) in dichloromethane (10 ml) was stirred at room temperature overnight. The usual work-up of the reaction mixture gave a 1:1 mixture (226.8 mg) of methyl 4-*O*-benzoyl-2,6-dideoxy-3-*O*-(2-methoxyethoxymethyl)-β-L-*lyxo*-hexopyranoside (**11**) and its regioisomer (**12**) in 98.8% yield, which could not be separated in a pure state. Therefore, a solution of the mixture (226.8 mg) in methanol (10 ml) containing sodium (30 mg, 1.30 mmol) was stirred overnight at room temperature. The usual work-up of the reaction mixture gave a mixture (138.1 mg) of the corresponding 3-*O*-(2-methoxyethoxymethyl) (**13**) and 4-*O*-(2-methoxyethoxymethyl) (**14**) derivatives in 86.2% yield. Separation of the products on a silica-gel column (benzene–acetone 19:1) gave only a small amount of pure samples.

13: mp. 65—66 °C (hexane–ethanol 1:1); $[\alpha]_D$−10.0° (*c* 0.9); NMR: δ=4.97 and 4.66 (ABq, 2H, J_{AB}=7.0, OCH_2O), 4.78 (dd, 1H, $J_{1,2a}$=3.0, $J_{1,2e}$=0.7, H-1), 4.12—3.72 (m, 3H, H-3, 4, and 5), 3.72—3.47 (m, 4H, OCH_2CH_2O), 3.40 (s, 3H, OMe), 3.33 (s, 3H, OMe in MEM), 1.92 (dd, 1H, $J_{2a,2e}$=9.0, H-2e), 1.82 (dd, 1H, H-2a), 1.32 (s, 1H, OH) and 1.23 (d, 3H, H-6).

Anal. ($C_{11}H_{22}O_6$) C, H.

14: mp 90—91 °C (hexane–ethanol 1:1); $[\alpha]_D$−38.3° (*c* 1.1); NMR: δ=4.94 and 4.68 (ABq, 2H, J_{AB}=7.0, OCH_2O), 4.32 (dd, 1H, $J_{1,2a}$=9.6, $J_{1,2e}$=2.5, H-1), 3.91 (ddd, 1H, $J_{2a,3}$=9.6, $J_{2e,3}$=5.0, H-3), 3.56 (q, 1H, $J_{5,6}$=6.6, H-5), 3.54 (d, 1H, $J_{3,4}$=4.0, H-4), 3.47 (s, 3H, OMe), 3.76—3.48 (m, 4H, OCH_2CH_2O), 3.36 (s, 3H, OMe in MEM), 1.98 (ddd, 1H, $J_{2a,2e}$=12.0, H-2e), 1.67 (dt, 1H, H-2a), 1.92 (bs, 1H, OH), and 1.29 (d, 3H, H-6).

Anal. ($C_{11}H_{22}O_6$) C, H.

ii) A solution of **9** (162 mg, 0.608 mmol) and (2-methoxyethoxymethyl) trimethylammonium chloride (452 mg, 2.00 mmol) in acetonitrile (10 ml) was refluxed for 3h. The usual work-up of the mixture and purification of the product on a silica-gel column (benzene–acetone 19:1) gave sirupy **12** (215.6 mg) in quantitative yield. $[\alpha]_D$ +43.7° (*c* 1.5); NMR: δ=8.16—7.98 and 7.62—7.30 (m, 5H, Bz), 5.15 (ddd, 1H, $J_{2a,3}$=11.0, $J_{2e,3}$=6.0, H-3), 4.98 and 4.85 (ABq, J_{AB}=7.0, OCH_2O), 4.50 (dd, 1H, $J_{1,2a}$=8.0, $J_{1,2e}$=4.0, H-1), 3.91 (bd, $J_{3,4}$=3.0, H-4), 3.82 (q, 1H, $J_{5,6}$=6.6, H-5), 3.80—3.36 (m, 4H, OCH_2CH_2O), 3.52 (s, 3H, OMe), 3.28 (s, 3H, OMe in MEM), 2.16 (dt, 1H, $J_{2a,2e}$=11.0, H-2a), 2.03 (ddd, 1H, H-2e), and 1.37 (d, 3H, H-6).

Anal. ($C_{18}H_{26}O_7$) C, H.

O-Debenzoylation of thus obtained **12** (204 mg) with sodium methoxide by the aforementioned method gave **14** (126.1 mg) in 87.5% yield.

Methyl 3-O-Benzoyl-4-O-benzyl-2,6-dideoxy-β-L-lyxo-hexopyranoside (15). A solution of **9** (475 mg, 1.78 mmol) and benzyl trichloroacetimidate (1.35 g, 5.66 mmol) in cyclohexane (12 ml) and dichloromethane (6 ml) containing trifluoromethanesulfonic acid catalyst (0.72 ml of 0.435 M dichloromethane solution) was stirred for 3 d at room temperature. The usual work-up of the mixture and purification of the product on a silica-gel column (benzene–acetone 19:1) gave **15** (395 mg) as a sirup in 62.2% yield. $[\alpha]_D$ −2.4° (*c* 0.95); NMR: δ=8.16—7.96 and 7.68—7.20 (m, 10H, Bn and Bz), 5.18 (ddd, $J_{2a,3}$=11.5, $J_{2e,3}$=6.0, H-3), 4.82 and 4.62 (ABq, 2H, J_{AB}=12.0, CH_2Ph), 4.48 (dd, 1H, $J_{1,2a}$=8.4, $J_{1,2e}$=3.0, H-1), 3.68 (dd, 1H, $J_{3,4}$=3.0, H-4), 3.62 (dq, 1H, $J_{4,5}$=1.4, $J_{5,6}$=6.2, H-5), 3.53 (s, 3H, OMe), 2.26 (dt, 1H, $J_{2a,2e}$=11.5, H-2a), 2.07 (ddd, 1H, H-2e), and 1.29 (d, 3H, H-6).

Anal. ($C_{21}H_{24}O_5$) C, H.

Methyl 4-O-Benzyl-2,6-dideoxy-β-L-lyxo-hexopyranoside(16). A solution of **15** (350 mg, 0.982 mmol) in methanol (15 ml) containing sodium (40 mg, 1.74 mmol) was stirred overnight at room temperature. The usual work-up of the mixture and purification of the product on a silica-gel column (benzene–acetone 8:1) gave **16** (220 mg) in 88.7% yield. Mp. 63.5—64.0 °C (hexane–ethanol 1:1); $[\alpha]_D$ −9.5° (*c* 1.3); NMR: δ=7.52—7.20 (bs, 5H, Bn), 4.84 and 4.64 (ABq, 2H, J_{AB}=12.0, CH_2Ph), 4.49 (dd, 1H, $J_{1,2a}$=9.5, $J_{1,2e}$=2.6, H-1), 3.68 (ddd, $J_{2a,3}$=12.0, $J_{2e,3}$=5.4, H-3), 3.39 (dq, 1H, $J_{5,6}$=6.9, H-5), 3.48 (s, 3H, OMe), 3.42 (dd, $J_{3,4}$=3.0, $J_{4,5}$=1.4, H-4), 2.00 (bs, 1H, OH), 1.96 (ddd, 1H, $J_{2a,2e}$=9.6, H-2a), 1.68 (dt, 1H, H-2e), and 1.35 (d, 3H, H-6).

Anal. ($C_{14}H_{20}O_4$) C, H.

Oxidation of 10, 14, and 16 into the Corresponding Pyranosid-3-uloses. A suspension of **10** (435 mg, 1.63 mmol), pyridinium chlorochromate (PCC) (800 mg, 3.71 mmol) and a small amount of molecular sieves 3A in dichloromethane (15 ml) was stirred at room temperature overnight, and then filtered. The usual work-up of the filtrate, and purification of the product on a silica-gel column (benzene–acetone 8:1) gave methyl 4-*O*-benzyl-2,6-dideoxy-β-L-threohexopyranosid-3-ulose (**17**; 392 mg, 90.8%) as a sirup. $[\alpha]_D$ +20.0° (*c* 1.5); NMR: δ=8.2—8.0 and 7.7—7.3 (m, 5H, Bz), 5.35 (d, 1H, $J_{4,5}$=4.2, H-4), 4.87 (t, 1H, $J_{1,2a}$=$J_{1,2e}$=4.7, H-1), 4.24 (dq, $J_{5,6}$=6.8, H-5), 3.50 (s, 3H, OMe), 2.83 (d, 2H, H-2a and 2e) and 1.46 (d, 3H, H-6).

Anal. ($C_{14}H_{16}O_5$) C, H.

A similar oxidation of **14** (512 mg, 2.05 mmol) with PCC (912 mg, 4.23 mmol) gave the corresponding 3-ulose (**18**: 498 mg, 98.1%) as a sirup. $[\alpha]_D$ +27° (*c* 7.9); IR : 1740 cm^{-1} (C=O); NMR: δ=4.77 (s, 2H, OCH_2O), 4.63 (dd, 1H, $J_{1,2a}$=7.5, $J_{1,2e}$=3.4, H-1), 3.86 (bs, 1H, $J_{2e,4}$=1.4, H-4), 3.71 (q, $J_{5,6}$=6.2, H-5), 3.84—3.52 (m, 4H, OCH_2CH_2O), 3.53 (s, 3H, OMe), 3.39 (s, 3H, OMe in MEM), 2.90 (dd, 1H, $J_{2a,2e}$=

13.4, H-2a), 2.60 (ddd, 1H, H-2e), and 1.41 (d, 3H, H-6).

Anal. ($C_{11}H_{20}O_6$) C, H.

Oxidation of **16** (737 mg, 2.92 mmol) with PCC (1.50 g, 6.96 mmol) gave the product (**19**) (614 mg, 84.0%) as a sirup. $[\alpha]_D$ +40.4° (*c* 4.4); IR: 1740 cm^{-1} (C=O); NMR: δ=7.48—7.20 (m, 5H, Ph), 4.56 (dd, 1H, $J_{1,2a}$=8.0, $J_{1,2e}$=3.0; H-1), 4.68 and 4.36 (ABq, 2H, J_{AB}=12.0, CH_2Ph), 3.71 (dq, 1H, $J_{5,6}$=6.6, H-5), 3.51 (s, 3H, OMe), 3.46 (bd, 1H, $J_{4,5}$=2.0, H-4), 2.93 (dd, $J_{2a,2e}$=13.6, H-2a), 2.57 (ddd, 1H, $J_{2e,4}$=1.4, H-2e), and 1.37 (d, 3H, H-6).

Anal. ($C_{14}H_{18}O_4$) C, H.

Cyanomesylation of 17, 18, and 19. A solution of **17** (370 mg, 1.40 mmol) and hydrogen cyanide (50 mg, 1.85 mmol) in dry pyridine (8 ml) was stirred overnight at room temperature, and then methanesulfonyl chloride (964 mg, 8.42 mmol) was added to it. The reaction mixture was further stirred for 2 d at room temperature, poured into ice-water, and then extracted with chloroform. The usual work-up of the extract and purification of the product on a silica-gel column (benzene–acetone 19:1) gave methyl 4-*O*-benzoyl-3-*C*-cyano-2,6-dideoxy-3-*O*-methylsulfonyl-β-L-*lyxo*-hexopyranoside (**20**, 180 mg) as a sirup in 35% yield. NMR: δ=8.2—8.0 and 7.7—7.3 (m, 5H, Bz), 5.71 (s, 1H, H-4), 4.80 (dd, 1H, $J_{1,2a}$=9.3, $J_{1,2e}$=2.0, H-1), 4.22 (q, 1H, $J_{5,6}$=6.0, H-5), 3.61 (s, 3H, OMe), 3.20 (s, 3H, SMe), 2.84 (dt, 1H, $J_{2a,2e}$=12.5, $J_{2e,4}$=2.0, H-2e), 2.46 (dd, 1H, H-2a), and 1.33 (d, 3H, H-6).

Anal. ($C_{16}H_{19}O_7NS$) C, H, N.

Cyanomesylation of **18** (550 mg, 2.22 mmol) with hydrogen cyanide (200 mg, 7.40 mmol) and methanesulfonyl chloride (1382 mg, 12.06 mmol) in dry pyridine (10 ml) as above and purification of the product on a silica-gel column (benzen–acetone 14:1) gave the product (**21**, 570 mg) as a sirup in 72.8% yield. $[\alpha]_D$ +14.8° (*c* 1.3); NMR: δ=4.96 and 4.84 (ABq, 2H, J_{AB}=7.0, OCH_2O), 4.57 (dd, 1H, $J_{1,2a}$=9.2, $J_{1,2e}$=2.5, H-1), 3.95 (q, 1H, $J_{5,6}$=6.2, H-5), 3.92 (bs, 1H, H-4), 3.90—3.56 (m, 4H, OCH_2CH_2O), 3.54 (s, 3H, OMe), 3.39 (s, 3H, OMe in MEM) 3.25 (s, 3H, SMe), 2.67 (ddd, $J_{2a,2e}$=13.0, $J_{2e,4}$=1.0, H-2e), 2.31 (dd, 1H, H-2a), and 1.37 (d, 3H, H-6).

Anal. ($C_{13}H_{23}O_8NS$) C, H, N.

In a similar way, **19** (602 mg, 2.41 mmol) was cyanomesylated to give **22** (614 mg) as a sirup in 65.4% yield. $[\alpha]_D$ −4.95° (*c* 1.2); NMR: δ=7.6—7.2 (bs, 5H, Bn), 4.94 and 4.74 (ABq, 2H, J_{AB}=11.0, CH_2Ph), 4.59 (dd, 1H, $J_{1,2a}$=8.6, $J_{1,2e}$=3.0, H-1), 3.89 (q, 1H, $J_{5,6}$=6.4, H-5), 3.85 (s, 1H, H-4), 3.51 (s, 3H, OMe), 3.16 (s, 3H, SMe), 2.59 (dd, 1H, $J_{2a,2e}$= 12.4, H-2e), 2.40 (dd, 1H, H-2a), and 1.25 (d, 3H, H-6).

Anal. ($C_{16}H_{21}O_6NS$) C, H, N, S.

Spiro Aziridine Formation from 21 and 22. A suspension of **21** (447 mg, 1.26 mmol) and lithium aluminium hydride (72.0 mg, 1.90 mmol) in dry ether (55 ml) was refluxed for 2 h, and then a small amount of water was added to the reaction mixture. The mixture was filtered, and the ether solution was washed with water, dried, and evaporated. The residue was purified on a silica-gel column (ethyl acetate–ethanol 5:1) to give spiro [aziridine-2,3′-(methyl 2,3,6-trideoxy-4-*O*-(2-methoxyethoxymethyl)-β-L-*xylo*-hexopyranoside)] (**23**, 216 mg) as a sirup in 65.3% yield. $[\alpha]_D$ 0° (*c* 1.3); NMR: δ=4.88 and 4.66 (ABq, 2H, J_{AB}= 7.0, OCH_2O), 4.53 (dd, 1H, $J_{1,2a}$=9.6, $J_{1,2e}$=2.0, H-1), 3.85 (dq, 1H, $J_{5,6}$=7.0, $J_{4,5}$=1.4, H-5), 3.8—3.5 (m, 4H, OCH_2CH_2O), 3.68 (bs 1H, H-4), 3.49 (s, 3H, OMe), 3.37 (s, 3H, OMe in MEM), 2.75 (bs, 1H, NH), 2.31 (dd, 1H, $J_{2a,2e}$=13.8, H-2a), 1.07 (ddd, 1H, $J_{2e,4}$=1.3, H-2e), 1.95 and 1.75 (each s, 2H, CH_2N) and 1.29 (d, 3H, H-6).

Anal. ($C_{12}H_{23}O_5N$) C, H, N.

Similarly, **22** (460 mg, 1.29 mmol) was converted into the corresponding sirupy spiro aziridine (**24**, 210 mg) as above in 61.7% yield. $[\alpha]_D$ 0° (*c* 1.1); NMR: δ=7.5—7.2 (bs, 5H, Bn), 4.76 and 4.58 (ABq, 2H, J_{AB}=12.0, CH_2Ph), 4.60 (dd, 1H, $J_{1,2a}$=9.4, $J_{1,2e}$=2.4, H-1), 3.90 (dq, $J_{5,6}$=6.4, $J_{4,5}$=1.6, H-5), 3.53 (s, 3H, OMe), 2.55 (bs, 1H, H-4), 2.54 (bs, 1H, NH), 2.44 (dd, $J_{2a,2e}$=13.2, H-2a), 1.08 (ddd, 1H, $J_{2e,4}$=1.0, H-2e), 1.77 and 1.74 (each s, 2H, CH_2N) and 1.34 (d, 3H, H-6).

Anal. ($C_{15}H_{21}O_3N$) C, H, N.

*4-O-(2-Methoxyethoxymethyl) (27) and 4-O-Benzyl (28) Derivatives of Methyl 3-Benzoylamino-2,3,6-trideoxy-3-C-methyl-β-*L-xylo-*hexopyranoside.* A solution of **23** (180 mg, 0.689 mmol) in methanol (150 ml) was hydrogenolyzed in the presence of Raney nickel W-4 (2 ml) under 110 atm hydrogen at room temperature for 3 d and then filtered. The filtrate was evaporated, and the residue was benzoylated in pyridine (10 ml) with benzoyl chloride (226 mg, 1.61 mmol) in the usual manner to give sirupy **27** in 48.8% overall yield, after purification on a silica-gel column (benzene–acetone 8:1). $[\alpha]_D$ −18.8° (c 0.75); NMR: δ=7.76—7.56 and 7.48—7.30 (m, 5H, Bz), 5.85 (bs, 1H, NH), 4.92 and 4.82 (ABq, 2H, J_{AB}=6.5, OCH_2O), 4.58 (dd, 1H, $J_{1,2a}$=7.6, $J_{1,2e}$=4.7, H-1), 4.19 (bs, 1H, H-4), 3.93 (bq, 1H, $J_{5,6}$=6.4, H-5), 3.86—3.52 (m, 4H, OCH_2CH_2O), 3.51 (s, 3H, OMe), 3.40 (s, 3H, OMe in MEM), 1.70—2.00 (m, 2H, H-2e and 2a), 1.59 (s, 3H, CMe), and 1.30 (d, 3H, H-6).

Anal. ($C_{19}H_{29}O_6N$), C, H, N.

In a similar manner, **24** (190 mg, 0.722 mmol) was converted into **28** (193 mg) in 72.2% yield. Sirup; $[\alpha]_D$ −23.4° (*c* 1.6); NMR: 7.84—7.68 and 7.60—7.20 (m, 10H, Bn and Bz), 5.91 (bs, 1H, NH), 4.84 and 4.70 (ABq, 2H, J_{AB}=11.6, CH_2Ph), 4.60 (dd, 1H, $J_{1,2a}$=9.4, $J_{1,2e}$=3.0, H-1), 4.24 (bs, 1H, $J_{4,5}$=1.0, H-4), 3.95 (dq, $J_{5,6}$=6.4, H-5), 3.50 (s, 3H, OMe), 2.00 (dd, $J_{2a,2e}$=14.0, H-2a), 1.76 (ddd, 1H, $J_{2e,4}$=1.0, H-2e), 1.62 (s, 3H, CMe), and 1.32 (d, 3H, H-6).

Anal. ($C_{22}H_{27}O_4N$) C, H, N.

Attempted O-De (2-methoxyethoxy) methylation of 27. i) A solution of **27** (20 mg, 0.054 mmol) and zinc(II) bromide (64.5 mg, 0.286 mmol) in dichloromethane (2 ml) was stirred at room temperature overnight. The reaction mixture was washed with sodium hydrogencarbonate solution, and the usual work up, and purification of the product on a preparative TLC (benzene–acetone 14:1) gave 8-(2-methoxyethoxymethoxy)-7-methyl-3-phenyl-4,6-dioxa-2-azabicyclo[3.3.1]-non-2-ene (**29**) as a sirup in 63.3% (11.6 mg) yield. $[\alpha]_D$ −35° (*c* 1.3); NMR: δ=8.00—7.84 and 7.48—7.20 (m, 5H, Ph), 5.61 (t, 1H, $J_{1,2a}$=$J_{1,2e}$=2.0, H-1), 4.84 (s, 2H, OCH_2O), 3.90 (dq, 1H, $J_{5,6}$=6.7, $J_{4,5}$=1.8, H-5), 3.48 (bs, 1H, H-4), 3.84—3.44 (m, 4H, OCH_2CH_2O), 3.40 (s, 3H, OMe in MEM), 2.25 (dd, 1H, $J_{2a,2e}$=13.2, H-2a), 1.40 (s, 3H, CMe), 1.41 (dt, 1H, $J_{2e,4}$=1.4, H-2e), 1.20 (d, 3H, H-6).

Anal. ($C_{18}H_{25}O_5N$) C, H, N.

ii) Treatment of **27** (20 mg, 0.054 mmol) with 1.5 M hydrochloric acid in methanol (5.0 ml) for 15 min refluxing temperature gave also **29** (10.0 mg) in 59.6% yield.

*Methyl 4-O-Benzoyl-3-benzoylamino-2,3,6-trideoxy-3-C-methyl-α-*L-xylo-*hexopyranoside (2).* A solution of **28** (102 mg, 0.276 mmol) in methanol (20 ml) was hydrogenated overnight at room temperature in the presence of 10% palladium–carbon (100 mg), and then filtered. The filtrate was evaporated, and the dried residue was treated with benzoyl chloride (359 mg, 2.55 mmol) in pyridine (10 ml) at room temperature overnight. The usual work-up of the reaction mixture, and purification of the product on a silica-gel column (benzene–acetone 8:1) gave **2** (69.1 mg) in 65.3% yield.

Mp. 178—179°C (hexane–ethanol 1:1); $[\alpha]_D$ −191° (*c* 1.0, MeOH); MS: *m/z* 383 (M^+ for $C_{22}H_{25}O_5N$), 351 (M^+-CH_3OH); UV (EtOH): 231, 270, and 280 nm; CD: $\Delta\varepsilon$ 238.5=−11.3 (θ=−23.3 °M); NMR: δ=8.24—8.04, 7.90—7.80, and 7.64—7.35 (m, 10H, 2×Bz), 7.90 (bs, 1H, NH), 5.93 (bs, 1H, $J_{4,5}$=1.0, H-4), 5.00 (bd, 1H, $J_{1,2a}$=3.5, H-1), 4.33 (dq, $J_{5,6}$=6.5, H-5), 3.52

(s, 3H, OMe), 2.19 (dd, $J_{2a,2e}$=14.5, H-2a), 1.87 (bd, 1H, H-2e), 1.60 (s, 3H, CMe), and 1.15 (d, 1H, H-6). These data are identical with those of reported.[2]

Anal. ($C_{22}H_{25}O_5N$) C, H, N.

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