THE ABSOLUTE CONFIGURATION OF DECILONITROSE, A SUGAR COMPONENT OF DECILORUBICIN, IS UNDOUBTEDLY 2,3,6-TRIDEOXY-3-*C*-METHYL-3-NITRO-L-*RIBO*-HEXOPYRANOSE

YOSHIO NISHIMURA, KIYOTO ISHII and SHINICHI KONDO

Institute of Microbial Chemistry,
3-14-23 Kamiosaki, Shinagawa-ku, Tokyo 141, Japan

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The absolute structure of decilonitrose, a sugar component of an antitumor antibiotic decilorubicin was decided to be 2,3,6-trideoxy-3-*C*-methyl-3-nitro-L-*ribo*-hexopyranose by synthesis of its methyl β-glycoside starting from L-rhamnose through the 3-ulose. In the synthetic route, any configurational ambiguities do not exist.

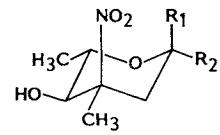
Decilonitrose (**1**), a new nitro branched-chain sugar, was observed as a sugar component in decilorubicin (**2**).[1] Methyl decilonitroside (**3**), $[\alpha]_D$ −13° ($CHCl_3$), was obtained by methanolysis of **2**. In the previous communication,[2] we reported its total synthesis and absolute configuration as methyl 2,3,6-trideoxy-3-*C*-methyl-3-nitro-β-L-*ribo*-hexopyranoside. Decilonitrose was also found in arugomycin (**4**), and its methanolysis afforded **3**, $[\alpha]_D$ −10° ($CHCl_3$).[3,4] In the recent article,[5] ZEECK *et al.* have reported the isolation of a methyl glycoside of a nitro branched-chain sugar, $[\alpha]_D$ −17.5° ($CHCl_3$), supposed to be **3** by methanolysis of viriplanin D, a photooxidation product of raw viriplanin. They concluded its absolute configuration as β-D-series by a misunderstanding application of HUDSON's isorotation rule[6] compared with methyl α-D-decilonitroside, $[\alpha]_D$ +141.8° ($CHCl_3$) (synthetic α-L-decilonitroside,[7] $[\alpha]_D$ −172°±3° ($CHCl_3$)). Their methyl α-D-glycoside was obtained by successive sequences of hydrazine reduction, methanolysis and peracid oxidation of viriplanin A[5] whose structure was not clarified. From these results they pointed out our methyl decilonitroside to be D-series.

In this paper, we want to verify our conclusion to be absolutely correct with the full experimental details and discussion.[8,9],† Key stages in our strategy followed YOSHIMURA's excellent procedure for the synthesis of evernitrose (**5**) and 3-*epi*-evernitrose (**6**) involved subsequent reactions of cyanomesylation of 3-ulose (**11**), reduction into spiro-aziridine, hydrogenolysis of the aziridine ring and oxidation to the nitro group[10] (Scheme 1). The synthesis of our key intermediate **11** began with methyl 2,6-dideoxy-β-L-*arabino*-hexopyranoside (**7**) which was synthesized starting from L-rhamnose.[11],†† Selective acylation of **7** with benzoyl chloride in pyridine afforded 3-*O*-benzoate **8** in a yield of 71%. Compound **8** was converted to 4-*O*-benzyl ether **10** by benzylation (benzyl chloride, NaH, *N*,*N*-dimethylformamide; **9**, 65% yield) followed by deacylation (sodium methoxide, methanol, 85% yield). Oxidation of **10** with CrO_3-pyridine in dichloromethane afforded **11** in a yield of 73%. Cyanomesylation of **11** was carried out by successive

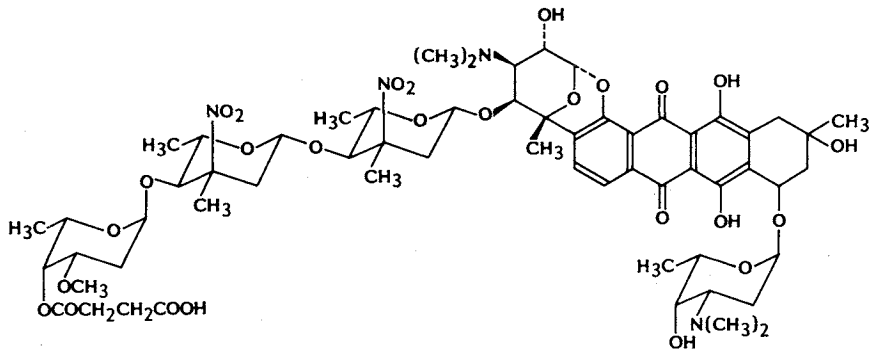
† The total synthesis and absolute configuration of **3** was presented with the full experimental details on the Annual Meeting of the Agricultural Chemical Society of Japan in 1983[8] and also described in detail in the Doctor Thesis by K. ISHII (University of Tokyo, 1983).[9]

†† Compound **7** was also prepared by the following method: Treatment of 1,5-anhydro-3,4-di-*O*-acetyl-2,6-dideoxy-L-*arabino*-hex-1-enitol (3,4-di-*O*-acetylrhamnal) with Br_2 in dichloromethane, and subsequent reaction with methanol and Ag_2CO_3, followed by hydrogenation with Pd-C in a mixture of methanol, water and triethylamine (5:4:1) under hydrogen at 3.5 kg/cm^2 afforded **7** (49% yield) and its α-anomer (16% yield).

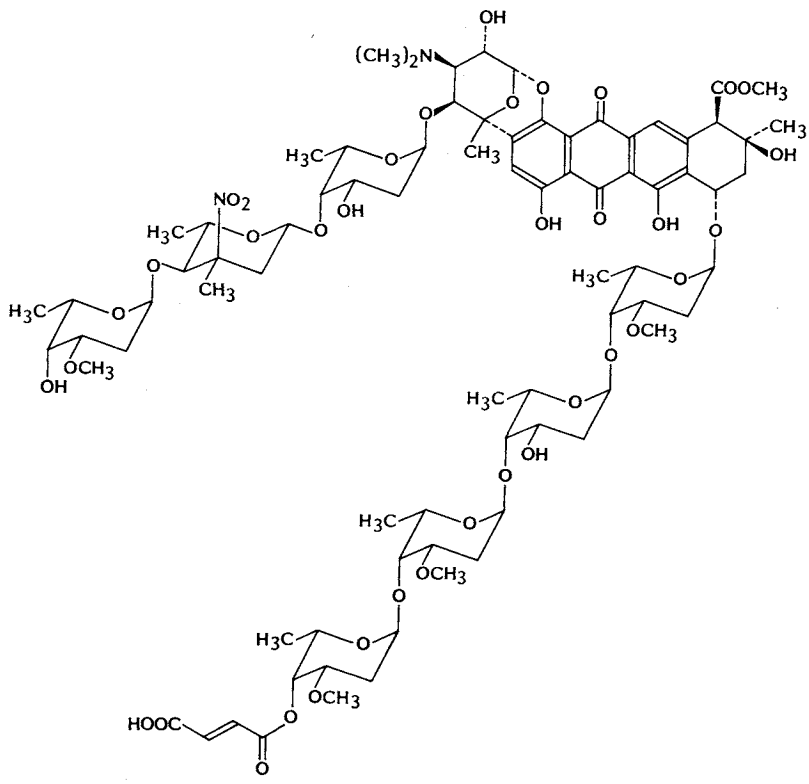
reaction of HCN and methanesulfonyl chloride in pyridine to give the 3-cyano-3-*O*-mesyl derivatives having L-*arabino* (**12**, 42% yield) and L-*ribo* (**13**, 23% yield) configurations. The stereochemistries of **12** and **13** were established at the later stage. Compounds **12** and **13** were transformed into the spiro-aziridine derivatives **14** and **15** by reduction with lithium aluminum hydride in 66% and 50% yields, respectively. Catalytic hydrogenation of **14** and **15** with Raney nickel catalyst gave the 3-amino-3-methyl derivatives having L-*ribo* (**16**, 83% yield, $[\alpha]_D$ +45.6° ($CHCl_3$)) and L-*arabino* (**17**, 86% yield,



Decilonitrose (**1**) R_1, R_2=H, OH
Methyl decilonitroside (**3**) R_1=H R_2=OCH_3



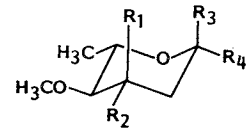
Decilorubicin (**2**)



Arugomycin[3,4] (**4**)

$[\alpha]_D$ +33.3° ($CHCl_3$)) configurations.

The absolute configurations of **16** and **17** were established by application of the TACu method:[12] **16** showed positive contribution ($\Delta[M]_{436(TACu)}$ +525°) and **17** showed negative ($\Delta[M]_{436(TACu)}$ −621°), clearly indicative of L-*ribo* and L-*arabino* configurations in **16** and **17**, respectively. Compounds **16** and **17** were also characterized as the *N*-acetyl derivatives **18** ($[\alpha]_D$ +11° ($CHCl_3$)) and **19** ($[\alpha]_D$ +12.4° ($CHCl_3$)), respectively. In ^{13}C NMR spectra of **18** and **19**, the former showed a singlet assigned to 3-*C*-methyl at δ 24.8 and the latter showed it at δ 18.3, clearly indicative an equatorial methyl and an axial one in **18** and **19**, respectively, in agreement with SATO's empirical rule.[13] Thus, the absolute configuration of **16** and **17** have been determined, and **16** is the desired compound for synthesis of **1**.



5 $R_1=CH_3$ $R_2=NO_2$ R_3, R_4=H, OH
6 $R_1=NO_2$ $R_2=CH_3$ R_3, R_4=H, OH
21 $R_1=NO_2$ $R_2=CH_3$ R_3=H $R_4=OCH_3$
22 $R_1=CH_3$ $R_2=NO_2$ R_3=H $R_4=OCH_3$

Oxidation of **16** with *m*-chloroperbenzoic acid in acetonitrile gave **3** (29% yield), which was identical with the natural **3** derived from decilorubicin in all respects. Therefore, the structure of **3** was absolutely clarified to be methyl 2,3,6-trideoxy-3-*C*-methyl-3-nitro-β-L-*ribo*-hexopyranoside. The β-L-*arabino* isomer (**20**, a colorless foam, $[\alpha]_D$ +41.7° ($CHCl_3$)) was also synthesized from **17** in 62% yield. The ^{13}C NMR chemical shift of the 3-equatorial methyl carbon in **3** (δ 25.2) is at lower field than that of the 3-axial one in **20** (δ 18.3). Such a behavior is also supportable the above conclusion in accordance with SATO's rule.[13] Moreover, **3** and **20** have the similar values and signs of specific rotation with those of methyl 3-*epi*-β-L-evernitroside (**21**) (−10.5° ($CHCl_3$)) and methyl β-L-evernitroside (**22**) (+33.6° ($CHCl_3$)),[10] respectively.

In conclusion the synthesis and the results described herein have provided the satisfactory evidence for the absolute-structure elucidation of decilonitrose (**1**).

Experimental

General

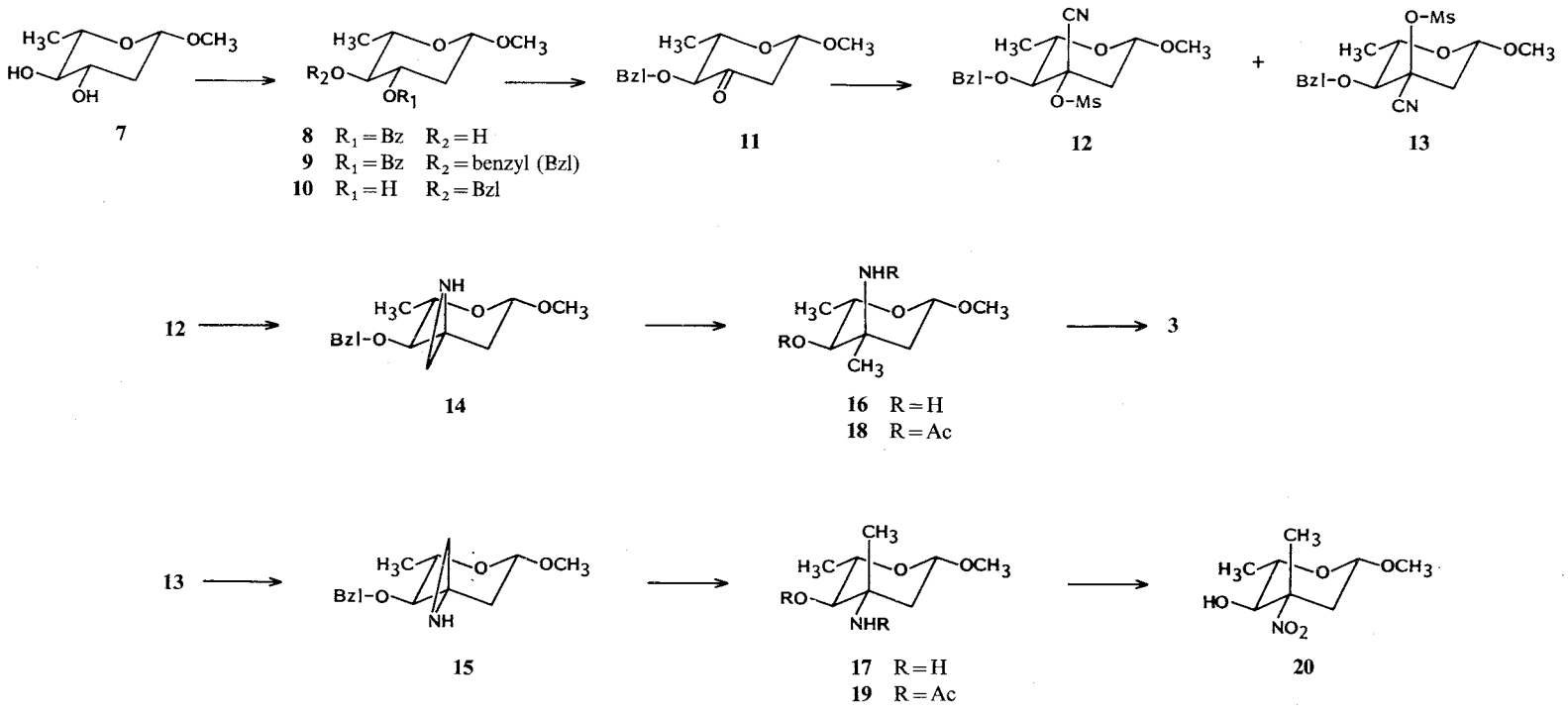
MP's were determined with a Yamato apparatus and are uncorrected. IR spectra were determined on a Hitachi Model 260-10 spectrophotometer. Optical rotations were measured with a Parkin-Elmer 241 polarimeter. The ^1H NMR spectra were recorded with Varian XL-100 and Varian EM-390 spectrometers. Chemical shifts are expressed in values (ppm) with TMS as an internal standard. Proton-noise decoupled FT-^{13}C NMR spectra were taken at 25.2 MHz on a Varian XL-100 spectrometer using TMS as a reference.

Methyl 3-*O*-Benzoyl-2,6-dideoxy-β-L-*arabino*-hexopyranoside (**8**)

To a solution of **7** (2 g) in pyridine (20 ml) was added benzoyl chloride (1.6 ml) at −50°C, and the mixture was stirred for 1 hour. After quenching with water, evaporation of the solvent gave an oil, which was subjected to a column chromatography on silica gel. Elution with toluene-ethyl acetate (20:1) gave an oil of **8** (2.32 g, 71%): $[\alpha]_D^{24}$ +26.8° (*c* 1.0, $CHCl_3$); IR ($CHCl_3$) cm^{-1} 3450, 2970 (sh), 2925, 2830 (sh), 1710, 1600, 1450; ^1H NMR (90 MHz, $CDCl_3$) δ 1.35 (3H, d, J=5.3 Hz, 5-CH_3), 1.77 (1H, dt, $J_{2_{ax},1}$=9.8 Hz and $J_{2_{ax},3}$=J_{gem}=12 Hz, 2-H_{ax}), 2.43 (1H, ddd, $J_{2_{eq},1}$=2.3 Hz, $J_{2_{eq},3}$=5.3 Hz and J_{gem}=12 Hz, 2-H_{eq}), 3.1~3.8 (2H, m, 4-H and 5-H), 3.50 (3H, s, 1-OCH_3), 4.51 (1H, dd, $J_{1,2_{ax}}$=9.8 Hz and $J_{1,2_{eq}}$=2.3 Hz, 1-H), 5.08 (1H, ddd, $J_{3,2_{eq}}$=5.3 Hz, $J_{3,2_{ax}}$=12 Hz and $J_{3,4}$=7.8 Hz, 3-H), 5.56 (1H, br s, OH), 7.2~8.3 (5H, m, phenyl).

Anal Calcd for $C_{14}H_{18}O_5$: C 63.14, H 6.81.
Found: C 63.08, H 6.71.

Scheme 1.


H3C
O
OCH3
HO
OH
7
R2O
OR1
8 R1=Bz R2=H
9 R1=Bz R2=benzyl (Bzl)
10 R1=H R2=Bzl
Bzl-O
O
11
CN
O-Ms
12
+
13
12
NH
14
NHR
RO
CH3
16 R=H
18 R=Ac
3
13
15
17 R=H
19 R=Ac
NO2
20

Methyl 3-*O*-Benzoyl-4-*O*-benzyl-2,6-dideoxy-β-L-*arabino*-hexopyranoside (**9**)

After **8** (10.5 g) was stirred in DMF (105 ml) with sodium hydride (1.42 g) at 0°C for 30 minutes, benzyl chloride (7.2 ml) was added to the mixture, and the mixture was stirred at room temperature for 1.5 hours. After quenching with water, evaporation of the solvent gave a solid, which was dissolved in chloroform. The chloroform solution was washed with water, dried over $MgSO_4$ and filtered. The filtrate was evaporated to give a foam, which was subjected to a column chromatography on silica gel. Elution with toluene-ethyl acetate (30:1) gave a colorless solid of **9** (9.2 g, 64%): MP 63~65°C; $[\alpha]_D^{24}$ +80.3° (*c* 1.0, $CHCl_3$); IR ($CHCl_3$) cm^{-1} 3000 (sh), 2930, 2870, 2830, 1715, 1600, 1450; ^1H NMR (90 MHz, $CDCl_3$) δ 1.34 (3H, d, J=5.3 Hz, 5-CH_3), 1.67 (1H, dt, $J_{2_{ax},1}$=9.8 Hz and $J_{2_{ax},3}=J_{gem}$=12.2 Hz, 2-H_{ax}), 2.45 (1H, ddd, $J_{2_{eq},1}$=2.3 Hz, $J_{2_{eq},3}$=5.3 Hz and J_{gem}=12.2 Hz, 2-H_{eq}), 3.1~3.8 (2H, m, 4-H and 5-H), 3.49 (3H, s, OCH_3), 4.44 (1H, dd, $J_{1,2_{eq}}$=2.3 Hz and $J_{1,2_{ax}}$=9.8 Hz, 1-H), 4.60 and 4.73 (2H, ABq, J=9.8 Hz, CH_2 of benzyl), 5.30 (1H, ddd, $J_{3,2_{eq}}$=5.3 Hz, $J_{3,4}$=8.5 Hz and $J_{3,2_{ax}}$=12.2 Hz, 3-H), 7.2~8.3 (10H, m, phenyl).

Anal Calcd for $C_{21}H_{24}O_5$: C 70.76, H 6.79.
Found: C 70.48, H 6.67.

Methyl 4-*O*-Benzyl-2,6-dideoxy-β-L-*arabino*-hexopyranoside (**10**)

Compound **9** (1.46 g) was dissolved in 1% methanol solution of sodium methoxide (140 ml), and the mixture was stirred at room temperature for 4 hours. After neutralization with Amberlyst A-15 (H^+) and filtration, the filtrate was evaporated to give a solid, which was dissolved in chloroform (200 ml). The solution was washed with $NaHCO_3$-saturated aqueous solution, dried over $MgSO_4$ and filtered. Evaporation of the filtrate gave a solid, which was crystallized from hexane to afford a colorless crystal of **10** (880 mg, 85%): MP 108°C; $[\alpha]_D^{24}$ +83° (*c* 0.2, $CHCl_3$); IR($CHCl_3$) cm^{-1} 3570 (sh), 2980 (sh), 2930, 2860 (sh), 2830, 1450, 1390; ^1H NMR (90 MHz, $CDCl_3$) δ 1.33 (3H, d, J=6.0 Hz, 5-CH_3), 1.56 (1H, dt, $J_{2_{ax},1}$=9.3 Hz and $J_{2_{ax},3}=J_{gem}$=12 Hz, 2-H_{ax}), 2.16 (1H, ddd, $J_{2_{eq},1}$=2.3 Hz, $J_{2_{eq},3}$=5.3 Hz and J_{gem}=12 Hz, 2-H_{eq}), 2.22 (1H, d, J=3.6 Hz, OH), 2.94 (1H, t, $J_{3,4}=J_{4,5}$=8.7 Hz, 4-H), 3.33 (1H, dq, $J_{5,4}$=8.7 Hz and J_{5,CH_3}=6.0 Hz, 5-H), 3.43 (3H, s, OCH_3), 3.5~4.0 (1H, m, 3-H), 4.37 (1H, dd, $J_{1,2_{eq}}$=2.3 Hz and $J_{1,2_{ax}}$=9.3 Hz, 1-H), 4.72 (2H, s, CH_2 of benzyl), 7.32 (5H, br s, phenyl).

Anal Calcd for $C_{14}H_{20}O_4$: C 66.64, H 7.99.
Found: C 66.50, H 8.05.

Methyl 4-*O*-Benzyl-2,6-dideoxy-β-L-*erythro*-3-hexulopyranoside (**11**)

To a solution of chromium(VI) oxide (3.9 g) in a mixture of dichloromethane (160 ml) and pyridine (10.8 ml) was added **10** (0.98 g), and the mixture was stirred at room temperature for 15 minutes. After addition of chloroform and filtration, the filtrate was washed with $NaHCO_3$-saturated aqueous solution and NaCl-saturated aqueous solution, dried over $MgSO_4$ and filtered. Evaporation of the filtrate gave a solid, which was crystallized from hexane to give a colorless crystal of **11** (714 mg, 73%): MP 83~84°C; $[\alpha]_D^{24}$ −108° (*c* 1.0, $CHCl_3$); IR ($CHCl_3$) cm^{-1} 3000 (sh), 2930, 2870, 2830, 1730, 1450, 1385, 1375, 1360; ^1H NMR (90 MHz, $CDCl_3$) δ 1.41 (3H, d, J=5.8 Hz, 5-CH_3), 2.56 (1H, dd, $J_{2_{ax},1}$=8.3 Hz and J_{gem}=13.5 Hz, 2-H_{ax}), 2.78 (1H, dd, $J_{2_{eq},1}$=3.8 Hz and J_{gem}=13.5 Hz, 2-H_{eq}), 3.51 (3H, s, OCH_3), 3.2~3.8 (2H, m, 4-H and 5-H), 4.56 (1H, dd, $J_{1,2_{ax}}$=3.8 Hz and $J_{1,2_{eq}}$=8.3 Hz, 1-H), 4.47 and 4.93 (2H, ABq, J=11.2 Hz, CH_2 of benzyl), 7.33 (5H, br s, phenyl).

Anal Calcd for $C_{14}H_{18}O_4$: C 67.18, H 7.25.
Found: C 67.16, H 7.03.

Methyl 4-*O*-Benzyl-3-*C*-cyano-2,3,6-trideoxy-3-*O*-mesyl-β-L-*arabino*-hexopyranoside (**12**) and Methyl 4-*O*-Benzyl-3-*C*-cyano-2,3,6-trideoxy-3-*O*-mesyl-β-L-*ribo*-hexopyranoside (**13**)

A solution of **11** (3.9 g) and an excess of hydrogen cyanide in pyridine (40 ml) was allowed to stand at room temperature overnight. After evaporation, to a solution of the resulting oil in pyridine (40 ml) was added methanesulfonyl chloride (2.0 ml), and the mixture was stirred at room temperature overnight. After quenching with water and evaporation, the resulting oil was dissolved in chloroform, and the solution was washed with water, dried over $MgSO_4$, and filtered. The filtrate was evaporated to give an oil, which was subjected to a column chromatography on silica gel. Elution with hexane-ether (3:1) gave an oil of **12** (2.35 g, 42%) and a colorless solid of **13** (1.27 g, 22.7%). **12**: $[\alpha]_D^{22}$ −22.8° (*c* 0.5, CH_2Cl_2); IR ($CHCl_3$)

cm^{-1} 1380, 1190; ^1H NMR (90 MHz, $CDCl_3$) δ 1.28 (3H, d, J=6.3 Hz, 5-CH_3), 2.13 (1H, dd, $J_{2_{ax},1}$=9.7 Hz and J_{gem}=13.7 Hz, 2-H_{ax}), 2.96 (3H, s, SO_2CH_3), 3.03 (1H, dd, $J_{2_{eq},1}$=2.3 Hz and J_{gem}=13.7 Hz, 2-H_{eq}), 3.35 (1H, d, $J_{4,5}$=9.3 Hz, 4-H), 3.45 (3H, s, OCH_3), 3.66 (1H, dq, $J_{5,4}$=9.3 Hz and J_{5,CH_3}=6.3 Hz, 5-H), 4.54 (1H, dd, $J_{1,2_{ax}}$=9.7 Hz and $J_{1,2_{eq}}$=2.3 Hz, 2-H_{eq}), 4.77 (2H, s, CH_2 of benzyl), 7.36 (5H, s, phenyl).

Anal Calcd for $C_{16}H_{21}NO_6S$: C 54.07, H 5.96, N 3.94, S 9.02.
Found: C 53.93, H 5.93, N 3.83, S 8.96.

13: MP 109°C; $[\alpha]_D^{22}$ −16.2° (*c* 0.5, CH_2Cl_2); IR ($CHCl_3$) cm^{-1} 1380, 1190; ^1H NMR (90 MHz, $CDCl_3$) δ 1.30 (3H, d, J=6.0 Hz, 5-CH_3), 2.04 (1H, dd, $J_{2_{ax},1}$=9.3 Hz and J_{gem}=14.5 Hz, 2-H_{ax}), 2.93 (1H, dd, $J_{2_{eq},1}$=2.3 Hz and J_{gem}=14.5 Hz, 2-H_{eq}), 3.12 (3H, s, SO_2CH_3), 3.47 (3H, s, OCH_3), 3.49 (1H, d, $J_{4,5}$=9.3 Hz, 4-H), 3.85 (1H, dq, $J_{5,4}$=9.3 Hz and J_{5,CH_3}=6 Hz, 5-H), 4.72 (1H, dd, $J_{1,2_{eq}}$=2.3 Hz and $J_{1,2_{ax}}$=9.3 Hz, 1-H), 4.76 and 5.03 (1H, ABq, J=10.5 Hz, CH_2 of benzyl), 7.33 (5H, s, phenyl).

Anal Calcd for $C_{16}H_{21}NO_6S$: C 54.07, H 5.96, N 3.94, S 9.02.
Found: C 53.81, H 5.89, N 3.90, S 8.78.

Aziridine-2-spiro-3′-(methyl 4-*O*-Benzyl-2,3,6-trideoxy-β-L-*ribo*-hexopyranoside) (**14**)

To a solution of **12** (1.75 g) in ether (50 ml) was added lithium aluminum hydride (0.56 g), and the mixture was refluxed with stirring. After successive addition of water (0.5 ml), 15% NaOH aqueous solution (0.5 ml) and water (0.5 ml), the resulting insoluble matter was filtered off and washed with ether. The filtrate and washings were combined and dried over $MgSO_4$, and filtered. Evaporation of the filtrate gave an oil, which was subjected to a column chromatography on silica gel. Elution with toluene - acetone (10 : 1) gave an oil of **14** (862 mg, 66%): $[\alpha]_D^{25}$ +17.6° (*c* 1.0, $CHCl_3$); IR ($CHCl_3$) cm^{-1} 3000, 2930, 2830, 1450, 1385, 1365, 1160, 1075; ^1H NMR (90 MHz, $CDCl_3$) δ 1.27 (3H, d, J=6.0 Hz, 5-CH_3), 1.44 (1H, dd, $J_{2_{eq},1}$=2.3 Hz and J_{gem}=13.5 Hz, 2-H_{eq}), 1.78 (2H, s, 3-CH_2), 1.97 (1H, dd, $J_{2_{ax},1}$=9.0 Hz and J_{gem}=13.5 Hz, 2-H_{ax}), 3.45 (3H, s, OCH_3), 3.2~3.7 (2H, m, 4-H and 5-H), 4.40 and 4.60 (2H, ABq, J=12 Hz, CH_2 of benzyl), 4.67 (1H, dd, $J_{1,2_{eq}}$=2.3 Hz and $J_{1,2_{ax}}$=9.0 Hz, 1-H), 7.30 (5H, br s, phenyl).

Anal Calcd for $C_{15}H_{21}NO_3$: C 68.41, H 8.04, N 5.32.
Found: C 68.23, H 7.88, N 5.20.

Aziridine-2-spiro-3′-(methyl 4-*O*-Benzyl-2,3,6-trideoxy-β-L-*arabino*-hexopyranoside) (**15**)

Procedures from **13** used were similar to those used for preparation of **14**; the yield was 50%: $[\alpha]_D^{24}$ +47.3° (*c* 1.0, $CHCl_3$); IR ($CHCl_3$) cm^{-1} 2975 (sh), 2930, 2870, 2830, 1450, 1380, 1360, 1310, 1160, 1070; ^1H NMR (90 MHz, $CDCl_3$) δ 1.35 (3H, d, J=6.0 Hz, 5-CH_3), 1.43 (1H, dd, $J_{2_{eq},1}$=2.4 Hz and J_{gem}=13.5 Hz, 2-H_{eq}), 1.95 (2H, br s, 3-CH_2), 2.05 (1H, ddd, $J_{2_{ax},1}$=9.6 Hz, J_{gem}=13.5 Hz and $J_{2_{ax},3\text{-}CH_2}$=1.5 Hz, 2-H_{ax}), 3.21 (1H, d, $J_{4,5}$=9.6 Hz, 4-H), 3.47 (3H, s, OCH_3), 3.2~3.7 (1H, m, 5-H), 4.46 (1H, dd, $J_{1,2_{ax}}$=9.6 Hz and $J_{1,2_{eq}}$=2.4 Hz, 1-H), 4.47 and 4.65 (2H, ABq, J=9.5 Hz, CH_2 of benzyl), 7.30 (5H, br s, phenyl).

Anal Calcd for $C_{15}H_{21}NO_3$: C 68.41, H 8.04, N 5.32.
Found: C 68.15, H 7.88, N 5.18.

Methyl 3-Amino-2,3,6-trideoxy-3-*C*-methyl-β-L-*ribo*-hexopyranoside (**16**)

A solution of **14** (50 mg) in methanol (1.2 ml) was stirred under hydrogen at 3.5 kg/cm^2 in the presence of Raney Ni (250 mg) for 18 hours, and then filtered. Evaporation of the filtrate gave an oil, which was subjected to a column chromatography on silica gel. Elution with chloroform - methanol (5 : 1) gave an oil of **16** (27.6 mg, 83%): $[\alpha]_D^{23}$ +45.6° (*c* 1.0, $CHCl_3$); $[\alpha]_{436}$ +80° (*c* 0.02, H_2O); $[\alpha]_{436(TACu)}$ +380° (*c* 0.01, H_2O); $\Delta[M]_{TACu}$ +525°; IR ($CHCl_3$) cm^{-1} 2960, 2930, 2840, 1450, 1380, 1320, 1165, 1135, 1075 (sh); ^1H NMR (90 MHz, $CDCl_3$ containing a drop of D_2O) δ 1.13 (3H, s, 3-CH_3), 1.27 (3H, d, J=6.0 Hz, 5-CH_3), 1.55 (1H, dd, $J_{2_{ax},1}$=9.0 Hz and J_{gem}=14 Hz, 2-H_{ax}), 1.83 (1H, dd, $J_{2_{eq},1}$=3.0 Hz and J_{gem}=14 Hz, 2-H_{eq}), 2.90 (1H, d, $J_{4,5}$=9.2 Hz, 4-H), 3.2~3.7 (1H, m, 5-H), 3.45 (3H, s, OCH_3), 4.53 (1H, dd, $J_{1,2H_{eq}}$=3.0 Hz and $J_{1,2H_{ax}}$=9.0 Hz, 1-H).

Methyl 3-Amino-2,3,6-trideoxy-3-*C*-methyl-β-L-*arabino*-hexopyranoside (**17**)

Procedures from **15** used were similar to those used for preparation of **16**; the yield was 86%: $[\alpha]_D^{25}$

+33.3° (*c* 1.0, $CHCl_3$); $[\alpha]_{436}$ +85° (*c* 0.02, H_2O); $[\alpha]_{436(TACu)}$ −270° (*c* 0.01, H_2O); $\Delta[M]_{TACu}$ −621°; IR ($CHCl_3$) cm^{-1} 2970, 2940, 2880, 1450, 1390, 1320, 1160, 1130, 1065; ^1H NMR (90 MHz, $CDCl_3$) δ 1.20 (3H, s, 3-CH_3), 1.33 (3H, d, J=6.0 Hz, 5-CH_3), 1.59 (1H, dd, $J_{2_{ax},1}$=9.7 Hz and J_{gem}=13.0 Hz, 2-H_{ax}), 1.95 (1H, dd, $J_{2_{eq},1}$=2.3 Hz and J_{gem}=13.0 Hz, 2-H_{eq}), 3.10, (1H, d, $J_{4,5}$=9.8 Hz, 4-H), 3.50 (3H, s, OCH_3), 3.2~3.7 (1H, m, 5-H), 4.50 (1H, dd, $J_{1,2_{ax}}$=9.7 Hz and $J_{1,2_{eq}}$=2.3 Hz, 1-H).

Methyl 3-Acetamido-4-*O*-acetyl-2,3,6-trideoxy-3-*C*-methyl-β-L-*ribo*-hexopyranoside (**18**)

To a solution of **16** (9 mg) in pyridine (0.1 ml) was added acetic anhydride (0.05 ml), and the mixture was allowed to stand at room temperature overnight. After quenching with water, evaporation of the solvent gave an oil. The oil was subjected to the preparative TLC of silica gel with toluene-acetone (3:1) to give an oil of **18** (13 mg, 69%): $[\alpha]_D^{23}$ +11.0° (*c* 0.5, $CHCl_3$); IR ($CHCl_3$) cm^{-1} 3430, 2975, 2930, 2870, 2840, 1750, 1680, 1510, 1445; ^1H NMR (90 MHz, $CDCl_3$) δ 1.22 (3H, d, J=6.0 Hz, 5-CH_3), 1.31 (3H, s, 3-CH_3), 1.45 (2H, ddd, $J_{2_{ax},1}$=9.5 Hz, J_{gem}=14.3 Hz and $J_{2_{ax},NH}$=1.5 Hz, 2-H_{ax}), 2.03 (3H, s, NAc), 2.16 (3H, s, OAc), 3.43 (1H, dd, $J_{2_{eq},1}$=2.2 Hz and J_{gem}=14.3 Hz, 2-H_{eq}), 3.48 (3H, s, OCH_3), 3.78 (1H, dq, $J_{5,4}$=9.7 Hz and J_{5,CH_3}=6.0 Hz, 5-H), 4.54 (1H, dd, $J_{1,2_{ax}}$=9.5 Hz and $J_{1,2_{eq}}$=2.2 Hz, 1-H), 4.63 (1H, d, $J_{4,5}$=9.7 Hz, 4-H); ^{13}C NMR (25.2 MHz, $CDCl_3$) δ 17.8 (q, C-6), 20.8 (q, acetyl CH_3), 24.1 (q, acetyl CH_3), 24.8 (q, 3-CH_3), 38.5 (t, C-2), 56.0 (s, C-3), 56.5 (q, OCH_3), 68.2 (d, C-5), 78.0 (d, C-4), 99.7 (d, C-1), 169.3 (s, C=O), 170.2 (s, C=O).

Anal Calcd for $C_{12}H_{21}NO_5$: C 55.58, H 8.16, N 5.40.
Found: C 55.54, H 7.89, N 5.33.

Methyl 3-Acetamido-4-*O*-acetyl-2,3,6-trideoxy-3-*C*-methyl-β-L-*arabino*-hexopyranoside (**19**)

Procedures from **17** used were similar to those used for preparation of **18**; the yield was 87%: MP 168°C (dec); $[\alpha]_D^{23}$ +12.4° (*c* 1.0, $CHCl_3$); IR ($CHCl_3$) cm^{-1} 3430, 2980, 2930, 2875, 2830, 1720, 1680, 1520, 1450; ^1H NMR (90 MHz, $CDCl_3$) δ 1.22 (3H, d, J=6.0 Hz, 5-CH_3), 1.53 (3H, s, 3-CH_3), 1.78 (1H, dd, $J_{2_{ax},1}$=9.8 Hz and J_{gem}=13.5 Hz, 2-H_{ax}), 1.87 (3H, s, NAc), 2.16 (3H, s, OAc), 2.75 (1H, dd, $J_{2_{eq},1}$=2.3 Hz and J_{gem}=13.5 Hz, 2-H_{eq}), 3.46 (3H, s, OCH_3), 3.72 (1H, dq, $J_{5,4}$=9.7 Hz and J_{5,CH_3}=6.0 Hz, 5-H), 4.49 (1H, dd, $J_{1,2_{ax}}$=9.8 Hz and $J_{1,2_{eq}}$=2.3 Hz, 1-H), 4.67 (1H, d, $J_{4,5}$=9.7 Hz, 4-H); ^{13}C NMR (25.2 MHz, $CDCl_3$) δ 17.8 (q, C-6), 18.3 (q, 3-CH_3), 21.0 (q, acetyl CH_3), 24.5 (q, acetyl CH_3), 41.9 (t, C-2), 56.3 (s, C-3), 56.5 (q, OCH_3), 68.1 (d, C-5), 78.3 (d, C-4), 99.7 (d, C-1), 169.5 (s, C=O), 172.3 (s, C=O).

Anal Calcd for $C_{12}H_{21}NO_5$: C 55.58, H 8.16, N 5.40.
Found: C 55.52, H 7.94, N 5.21.

Methyl 2,3,6-Trideoxy-3-*C*-methyl-3-nitro-β-L-*ribo*-hexopyranoside (Methyl β-Decilonitroside, **3**)

To a solution of **16** (40 mg) in acetonitrile (2 ml) was added dropwise a solution of *m*-chloroperbenzoic acid (120 mg) in acetonitrile (8 ml), and the mixture was stirred at 25°C for 25 minutes. After quenching with 10% sodium thiosulfate aqueous solution and extraction with dichloromethane, the extract was washed with $NaHCO_3$-saturated aqueous solution and water, dried over $MgSO_4$, and filtered. Evaporation of the filtrate gave an oil, which was subjected to the preparative TLC of silica gel with dichloromethane to give a foam of **3** (13.8 mg, 29%, easily sublimes under a reduced pressure): $[\alpha]_D^{25}$ −12.0° (*c* 0.2, $CHCl_3$) (natural **3**, −13° (*c* 0.2, $CHCl_3$)[2]; IR ($CHCl_3$) cm^{-1} 2975, 2925, 2840, 1540, 1445, 1425, 1400, 1380, 1350, 1315, 1285, 1160, 1125, 1075; ^1H NMR (90 MHz, $CDCl_3$) δ 1.37 (3H, d, J=6.0 Hz, 5-CH_3), 1.72 (3H, s, 3-CH_3), 1.77 (1H, dd, $J_{2_{ax},1}$=9.4 Hz and J_{gem}=14.7 Hz, 2-H_{ax}), 2.73 (1H, dd, $J_{2_{eq},1}$=2.0 Hz and J_{gem}=14.7 Hz, 2-H_{eq}), 2.9~3.5 (2H, m, 4-H and 4-OH), 3.48 (3H, s, OCH_3), 3.70 (1H, dq, $J_{5,4}$=9.0 Hz and J_{5,CH_3}=6.0 Hz, 5-H), 4.50 (1H, dd, $J_{1,2_{ax}}$=9.4 Hz and $J_{1,2_{eq}}$=2.0 Hz, 1-H); ^{13}C NMR (25.2 MHz, $CDCl_3$) δ 18.3 (q, C-6), 25.2 (q, 3-CH_3), 41.7 (t, C-2), 56.5 (q, OCH_3), 71.1 (d, C-5), 77.0 (d, C-4), 89.6 (s, C-3), 98.6 (d, C-1).

Methyl 2,3,6-Trideoxy-3-*C*-methyl-3-nitro-β-L-*arabino*-hexopyranoside (**20**)

Procedures from **17** used were similar to those used for preparation of **3**; the yield was 62%: $[\alpha]_D^{25}$ +41.7° (*c* 1.0, $CHCl_3$); IR ($CHCl_3$) cm^{-1} 3580, 3370 (sh), 2970, 2940, 2870, 2830, 1540, 1450, 1390, 1365, 1350, 1320, 1165, 1120; ^1H NMR (90 MHz, $CDCl_3$) δ 1.38 (3H, d, J=6.0 Hz, 5-CH_3), 1.69 (3H, s, 3-CH_3), 2.12 (1H, dd, $J_{2_{ax},1}$=9.0 Hz and J_{gem}=13.5 Hz, 2-H_{ax}), 2.38 (1H, dd, $J_{2_{eq},1}$=2.3 Hz and J_{gem}=13.5 Hz,

2-H_{eq}), 3.0 (1H, br s, 4-OH), 3.45 (1H, dq, $J_{5,4}=9.0$ Hz and $J_{5,CH_3}=6.0$ Hz, 5-H), 3.48 (3H, s, OCH_3), 3.94 (1H, br d, $J_{4,5}=9.0$ Hz, 4-H), 4.48 (1H, dd, $J_{1,2_{eq}}=2.3$ Hz and $J_{1,2_{ax}}=9.0$ Hz, 1-H); ^{13}C NMR (25.2 MHz, $CDCl_3$), 18.1 (q, 3-CH_3 or C-6), 18.3 (q, C-6 or 3-CH_3), 41.4 (t, C-2), 56.5 (q, OCH_3), 70.5 (d, C-5), 74.6 (d, C-4), 89.3 (s, C-3), 99.1 (d, C-1).

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