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A SYNTHESIS OF METHYL 4,6-DIDEOXY-3-*C*-METHYL-4-(*N*-METHYLACETAMIDO)-α-D-ALTROPYRANOSIDE, THE 3-EPIMER OF (METHYL *N*-ACETYLSIBIROSAMINIDE)*,†

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ABSTRACT

The oxirane ring of 1,6:3,4-dianhydro-β-D-talopyranose reacted at C-4 with methylamine, and the product, further processed gave a 3-deoxy-*C*-3-methylene derivative. Iodonium ion-induced cyclisation led to an iodooxazolidinone, and deiodination, followed by hydrolysis and *N*-acetylation, to the title compound.

INTRODUCTION

The development of a simple and general procedure for obtaining a *cis*-hydroxy-amino configuration, particularly applicable to syntheses of aminodeoxy sugars, is of interest to us[1–4]. The procedure of Baker and Schaub[5], in which a derivative having a *trans*-hydroxyamino configuration (**1**) is transformed into its *cis* counterpart (**3**), has enjoyed a remarkable success where the hydroxyl group being inverted is secondary (*i.e.*, R = H). However, where the hydroxyl group is tertiary (*e.g.*, R = CH_3), the formation of the crucial intermediate **2** is difficult as an SN2 displacement at a tertiary centre is required. The synthesis of garosamine has shown that it is possible to obtain both a *cis*-hydroxyamino configuration as well as a tertiary hydroxyl centre simultaneously[4]. Thus we turned our attention to another sugar, 3-*epi*-sibirosamine, in which a similar structural relationship exists.

Sibiromycin[6], a member of the pyrrolo[1,4]benzodiazepene class of antibiotics, exhibits both antimicrobial[6] and antitumor[7] activities. The structure of the

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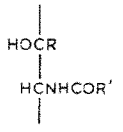
sugar component, obtained as the methyl glycoside, was reported to be methyl 4,6-dideoxy-3-*C*-methyl-4-(*N*-methylacetamido)-β-D-altropyranoside[8] (**5**). Two syntheses of **5** had been reported[9,10] prior to our own, and our final product was found identical to that of Dyong and Schulte[9] (*vide infra*). However, Parker and Babine[11] subsequently prepared the antibiotic sibiromycin by fermentation, and found that the sugar obtained therefrom by hydrolysis was different from the compound synthesized by Dyong and Schulte[9]. Parker and Babine established, by synthesis, that the correct stereorelationship was as in **6**, and subsequently showed that the sugar has the L configuration[12]. Thus, all three earlier syntheses[2,9,10] had furnished the 3-epimer **5**.



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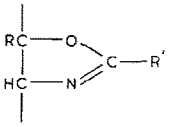

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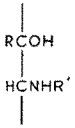

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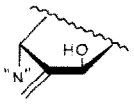

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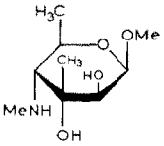

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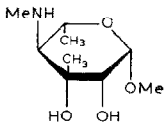

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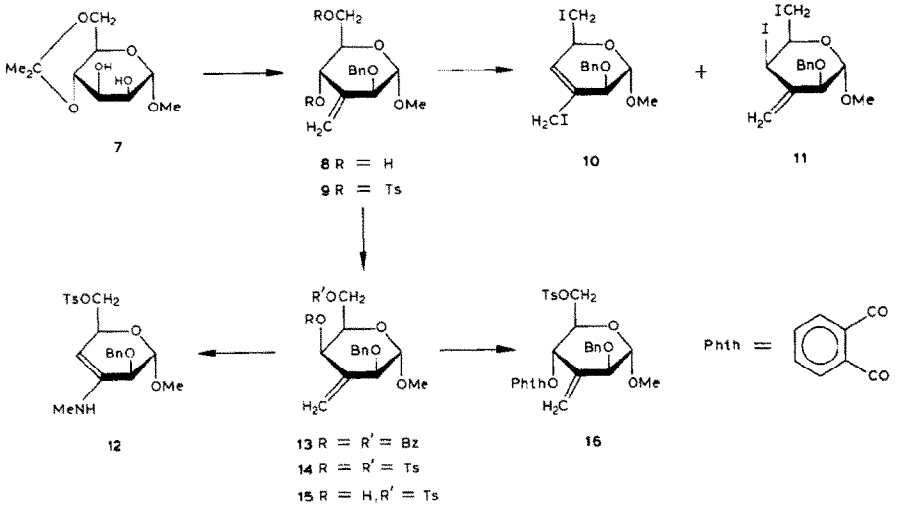
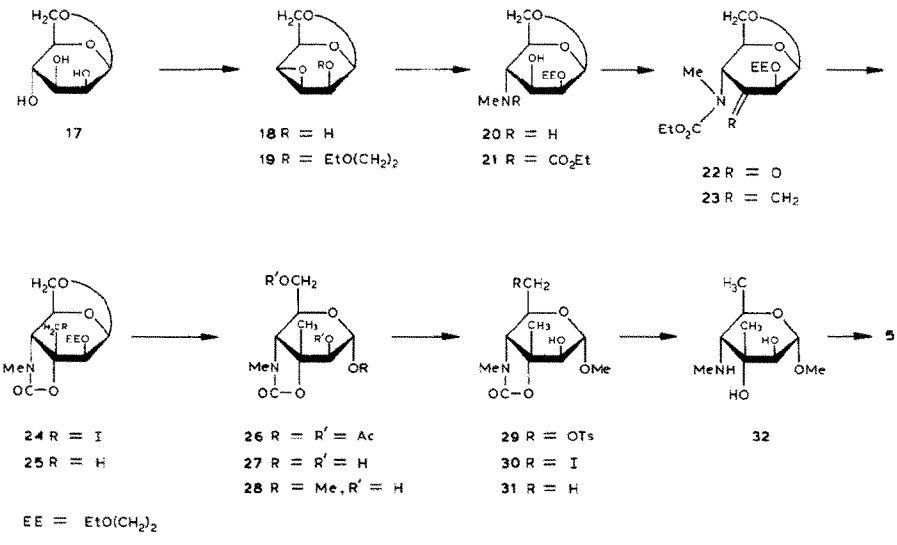
RESULTS AND DISCUSSION

Application of the hydroxyamination reaction developed earlier[4] required an allylamine segment (**4**), and a D-mannopyranose derivative was most appropriate precursor in view of the C-2 configuration. Two approaches were examined. In the first, the amino group was introduced prior to the exocyclic methylene group, and in the second the order was reversed. The first was patterned after the synthesis of holacosamine[1,3], and required two SN2 displacements at C-4 to introduce the nitrogen substituent in the desired orientation. Methyl 4,6-*O*-isopropylidene-α-D-mannopyranoside (**7**) was converted into the olefinic disulfonate **8** in several steps. Treatment of **8** with sodium iodide gave **10** by SN2'-displacement exclusively, whereas the procedure of Landauer and Rydon[13] gave a 1:1 mixture of **10** and **11**, but in low yield. Alternatively, the diol **9** was epimerized at C-4 to give the dibenzoate **13**, but the corresponding di-*p*-toluenesulfonate **14** underwent ammonolysis exclusively by an SN2'-displacement to give **12**. Amination[14] of the 6-*p*-toluenesulfonate **15** did afford the phthalimide **16** as the sole product in excellent yield, but this sequence of reaction required too many steps to be considered further.

The second approach started from 1,6:3,4-dianhydro-β-D-talopyranose (**18**), whose synthesis from 1,6-anhydro-β-D-mannopyranose was known[15]. The 1-



ethoxyethyl derivative (**19**) reacted with methylamine at 140° to give the amino alcohol **20** (94%), and the urethan **21** was subsequently prepared in 93% yield. Oxidation with chromium trioxide[16] gave the best results and the resulting ketone **22** (which could be stored in the refrigerator for one month without decomposition) was used in the next step without purification. Ketones bearing vicinal oxygen or nitrogen, or both substituents are poor candiates for methylation by the Wittig procedure[17], and **22** proved to be no exception; nine products (t.l.c.) were formed, none of which being the olefin **23**. Among various methylenation procedures[18–20], the best results were obtained by treatment with methylene iodide and magnesium amalgam[21], and, although the optimum yield of **23** was only 35%, we did succeed in reducing the amount of mercury needed to 1/6th of the prescribed[21,22] quantity.



Iodonium ion-induced cyclization of **23** afforded the oxazolidinone **24** more conveniently than the comparable reaction in the synthesis of holacosamine[1,3]. This result is deemed to reflect the greater reactivity of the exocyclic double-bond in **23** *vis-a-vis* the endocyclic double-bond in the latter compound[1,3]. De-iodination with tri-1-butyltin hydride[23] to give **25** required a free-radical initiator, dibenzoyl peroxide. Conventional conditions of solvolysis[24] (0.5% sulfuric acid in acetic anhydride, 0.5% hydrochloric acid, or boron trifluoride–benzyl alcohol) failed to open the 1,6-anhydro ring of **25**, but the comparatively drastic conditions (10% sulfuric acid in acetic anhydride) afforded a nearly quantitative yield of the triacetate **26**, which was converted into the crystalline methyl α-D-altroside **28** by way of **27**. The 6-deoxy-6-iodo precursor **30**, required for deoxygenation at C-6, could be obtained from **28** by the procedure of Mitsunobu[14]; but owing to the low yield (53%) the conventional two-step route *via* the sulfonate **29** was preferred (73% overall yield). Reduction to **31**, followed by alkaline hydrolysis gave the aminodiol **32**, and *N*-acetylation the desired methyl 4,6-dideoxy-3-*C*-methyl-4-(*N*-methylacetamido)-α-D-altropyranoside (methyl *N*-acetyl-3-*epi*-sibirosaminide, **5**). This compound had a 400-MHz ^{1}H-n.m.r. spectrum and melting point (141–143°) similar to those of a sample[9] obtained from Professor Dyong's laboratory.

EXPERIMENTAL

General methods. — Melting points were determined in capillary tubes with a Büchi Model 510 and are uncorrected. Optical rotations were measured with a Perkin–Elmer 241 polarimeter. I.r. spectra were recorded with either a Beckman IR-10 or a Perkin–Elmer 298 spectrometer; solid samples were smeared on sodium chloride plates and solutions were placed in sodium chloride cells. ^{1}H-N.m.r. spectra were recorded for deuteriochloroform solutions with internal tetramethylsilane as the standard, unless otherwise stated, with one of the following spectrometers: Varian T-60, Bruker WP-80, or Bruker WH-400; coupling constants were measured directly from the spectra or calculated from the peak listings. T.l.c. was performed on aluminum plates precoated with silica gel (HF-254, 0.2-mm thickness) containing a fluorescent indicator (E. Merck, No. 5539). The chromatograms were viewed under u.v. light (254 nm), after being sprayed with concentrated sulfuric acid and heated until charring occurred. Column chromatography was carried out on silica gel (E. Merck; 70–230 or 230–500 mesh A.S.T.M.). Elemental analyses were performed by Guelph Chemical Labs, Guelph, Ontario and by Dr. F. Kasler, Department of Chemistry, University of Maryland.

1,6:3,4-Dianhydro-2-O-(1-ethoxyethyl)-β-D-talopyranose (**19**). — To a solution of 1,6:3,4-dianhydro-β-D-talopyranose[25] (**18**, 2.2 g, 15 mmol) and pyridinium *p*-toluenesulfonate[26] (150 mg, 0.2 mmol) in dry dichloromethane (15 mL) was added, at 23° under argon, ethyl vinyl ether (2 mL, 21 mmol). The mixture was stirred for 2 h, the reaction quenched with triethylamine (0.2 mL, 1.4 mmol), and the solution washed with a saturated, aqueous sodium chloride solution, dried

(Na_2SO_4) and evaporated *in vacuo* to yield an oil. Kugelrohr distillation (25 Pa, b.p. 90°) afforded **19** (3.0 g, 91%) as a colorless oil, $[\alpha]_D^{23}$ −18.8° (*c* 1.5, chloroform); t.l.c. (19:1 dichloromethane–methanol) R_F 0.79; ^{1}H-n.m.r. (80 MHz): δ 1.21 (t, 3 H, *J* 7 Hz, OCHC*H*$_3$), 1.34 [dd, 3 H, *J*1.4, 5.5 Hz, OCH(C*H*$_3$)O], 3.22–3.38 (m, 1 H, H-3), 3.47–3.80 (m, 4 H, H-4,6,8,8), 3.91 (5, 1 H, *J* 3.5 Hz, H-2), 4.10 (d, 1 H, *J* 6.5 Hz, H-6), 4.80 (t, 1 H, *J* 4.5 Hz, H-5), 6.04 (dq, 1 H, *J* 3.2, 5.5 Hz, H-7), and 5.33 (bd, 1 H, H-1).

Anal. Calc. for $C_{10}H_{16}O_5$: C, 55.55; H, 7.46. Found: C, 55.65; H, 7.30.

*1,6-Anhydro-4-deoxy-2-*O*-(1-ethoxyethyl)-4-(*N*-methylamino)-β-*D*-manno-pyranose* (**20**). — A solution of **19** (5.0 g, 23 mmol) in absolute ethanol (100 mL) was saturated with methylamine, and the mixture heated in a Parr bomb for 2 h at 140°, cooled, and evaporated *in vacuo* to give a dark oil. Purification by medium-pressure chromatography on silica gel (93:7 dichloromethane–methanol R_F 0.38) afforded **20** (5.2 g, 94%) as a colorless oil; ^{1}H-n.m.r. (80 MHz): δ 1.24 (t, 3 H, OCH$_2$C*H*$_3$), 1.37 [d, 3 H, *J* 5.4 Hz, OCH(C*H*$_3$)O], 2.24 (bs, 1 H, OH), 2.53 (s, 3 H, NCH$_3$), 2.79 (s, 1 H, H-4), 3.49–3.93 (m, 4 H, H-6,6,8,8), 3.94–4.04 (m, 1 H, H-2), 4.34 (d, 1 H, *J* 7 Hz, H-5), 4.52 (bd, 1 H, *J* 5.0 Hz, H-3), 4.87 (q, 1 H, *J* 5.3 Hz, H-7), and 5.37 (bd, 1 H, *J* 1.5 Hz, H-1).

Anal. Calc. for $C_{11}H_{11}NO_5$: C, 53.43; H, 8.56. Found: C, 53.57; H, 8.57.

*1,6-Anhydro-4-deoxy-4-(*N*-ethoxycarbonyl-*N*-methylamino)-2-*O*-(1-ethoxy-ethyl)-α-*D*-mannopyranose* (**21**). — A solution of **20** (4.0 g, 16 mmol) in dichloromethane (25 mL) containing triethylamine (1.45 mL, 20 mmol) was cooled to 0°, and ethyl chloroformate (1.72 mL, 18 mmol) was added dropwise over a period of 5 min. The mixture was stirred under anhydrous conditions for 30 min, the reaction quenched with methanol (1 mL), and the solution washed with sodium chloride solution, dried (Na_2SO_4), and evaporated *in vacuo*. Purification by medium-pressure chromatography on silica gel [17:3 diethyl ether–petroleum ether (30–60°)] afforded **21** (4.80 g, 93%) as a viscous, colorless oil; $[\alpha]_D^{23}$ −74.7° (*c* 2.0, chloroform); t.l.c. (97:3 dichloromethane–methanol) R_F 0.52; $\nu_{max}^{CHCl_3}$ 3540, 2900, and 1680 cm^{-1} (urethane); ^{1}H-n.m.r. (80 MHz): δ 1.19–1.48 [m, 9 H, CO$_2$CH$_2$C*H*$_3$, OCH$_2$C*H*$_3$, OCH[C*H*$_3$]O], 3.07 (s, 3 H, NCH$_3$), 3.15–3.28 (m, 1 H, OH), 3.41–4.64 (m, 10 H, CO$_2$C*H*$_2$CH$_3$, OC*H*$_2$CH$_3$, H-2,3,4,4,6,6), 4.95 (q, 1 H, H-7), and 5.43 (bs, 1 H, H-1); *m/z* 319 (M^+).

*1,6-Anhydro-4-deoxy-4-(*N*-ethoxycarbonyl-*N*-methylamino)-2-*O*-(1-ethoxy-ethyl)-β-*D*-*arabino*-hexopyranos-3-ulose* (**22**). — To a solution of pyridine (13.3 g, 168 mmol) in dichloromethane (100 mL), at 23° under argon, was added chromium trioxide (8.4 g, 84 mmol). The mixture was stirred for 30 min, and Celite (~8 g) was added, followed by **21** (4.4 g, 14 mmol). After 1 h, the mixture was poured into diethyl ether (200 mL), and filtered through a funnel containing a bed of Florisil covered by a layer of Celite. The clear filtrate was evaporated *in vacuo* to afford 22 (3.6 g, 82%) as a colorless oil; t.l.c. (49:1 dichloromethane–methanol) R_F 0.56; $\nu_{max}^{CHCl_3}$ 2960, 2920, 2898, 1730, 1720 (ketone), and 1690 cm^{-1} (urethane); ^{1}H-n.m.r. (80 MHz): δ 1.03–1.44 [m, 9 H, CO$_2$CH$_2$C*H*$_3$, OCH$_2$C*H*$_3$, OCH(C*H*$_3$)O], 3.01 (s,

3 H, NCH_3), 3.33–4.40 (m, 9 H, $CO_2CH_2CH_3$, OCH_2CH_3, H-4,5,6,6), 4.85 (bs, 1 H, H-2), 4.98–5.17 (m, 1 H, H-7), and 5.67 (bs, 1 H, H-1). An attempt to further purify this oil by chromatography on silica gel resulted in extensive decomposition.

*1,6-Anhydro-3,4-deoxy-4-(*N*-ethoxycarbonyl-*N*-methylamino)-2-*O*-(1-ethoxyethyl)-3-*C*-methylene-α-*D*-arabino-hexopyranose* (**23**). — The following modification of the published procedure[21,22] was applied. To triply distilled mercury (28 g) in a 250-mL. three-neck flask fitted with an overhead mechanical stirrer was added, under argon, magnesium turnings (328 mg) that had been washed with 0.25M HCl, water, ethanol, and ether, respectively, and dried at 110° for 15 min. After the magnesium turnings had completely dissolved in the mercury (~30 min), 1:1 dry benzene–dry diethyl ether (10 mL) was added, and the mixture cooled to −10°. To this was added methylene iodide (0.24 mL, 3 mmol) in 1:1 benzene–diethyl ether (10 mL) over a period of 5 min, and the mixture was stirred for an additional 5 min. Ketone **22** (1.0 g, 3 mmol) in 1:1 benzene–diethyl ether (100 mL) was added as rapidly as possible. After 1 h, the reaction was quenched with saturated ammonium chloride solution (50 mL), and the suspension transferred to a separatory funnel. The mercury was drawn off, and the organic layer washed with a saturated aqueous sodium chloride solution, dried (Na_2SO_4), and evaporated *in vacuo* to afford an oil that was fractionated by medium-pressure chromatography on silica gel (diethyl ether) to give **23** (317 mg, 32%) as a clear oil, $[\alpha]_D^{23}$ −36.0° (*c* 0.2, chloroform); t.l.c. (diethyl ether) R_F 0.50; $\nu_{max}^{CHCl_3}$ 2870, and 1660 cm^{-1} (urethane); ^{1}H-n.m.r. (80 MHz): δ 1.28 (t, 3 H, $CO_2CH_2CH_3$), 1.65 (bs, 1 H, OH), 2.97 (s, 3 H, NCH_3), 3.71–3.80 (m, 1 H, H-4), 4.20 (bq, 3 H, $CO_2CH_2CH_3$, H-2), 4.64–4.75 (m, 2 H, H-6,6), 5.37–5.45 (m, 2 H, $C{=}CH_2$), and 5.82 (bs, 1 H, H-1); *m/z* 315 (M^+).

*3-*N*-Methyl-[1,6-anhydro-4-deoxy-2-*O*-(1-ethoxyethyl)-3-*C*-iodomethyl-β-*D*-altropyrano]-[3,4-d]-1,3-oxazolidin-2-one* (**24**). — A solution of **23** (0.495 g, 1.6 mmol) and iodonium di(2,4,6-trimethylpyridine) perchlorate[27] (0.715 g, 2.0 mmol) in dichloromethane (15 mL) was stirred for 12 h at 23° in the dark. The solvent was removed *in vacuo* and the resulting mixture chromatographed on silica gel (diethyl ether, R_F 0.50) to yield an oil that crystallized. Recrystallization from dichloromethane–hexane afforded **24** (0.456 g, 68%), m.p. 136–138°, $[\alpha]_D^{23}$ −11.3° (*c* 0.3, chloroform); $\nu_{max}^{CHCl_3}$ 3540 (carbonyl overtone), 3400, and 1775 cm^{-1} (urethane); ^{1}H-n.m.r. (80 MHz): δ 1.10–1.47 [m, 6 H, OCH_2CH_3, $OCH(CH_3)O$], 3.00 (s, 3 H, NCH_3), 3.41–4.12 (m, 8 H, H-4,5,6,6, CH_2I, OCH_2CH_3), 4.68 (bd, 1 H, H-2), 4.86 (q, 1 H, H-7), and 5.31 (dd, 1 H, H-1).

*3-*N*-Methyl-[1,6-anhydro-4-deoxy-2-*O*-(1-ethoxyethyl)-3-*C*-methyl-α-*D*-altropyrano]-[3,4-d]-1,3-oxazolidin-2-one* (**25**). — To a solution of **24** (0.228 g, 0.54 mmol) and benzoyl peroxide (10 mg) in dry benzene (10 mL), under an atmosphere of argon, was added tri-1-butyltin hydride (0.25 mL, 0.79 mmol). The mixture was boiled at reflux for 30 min, cooled, and evaporated *in vacuo*. The resulting oil was dissolved in acetonitrile and the solution washed two times with hexane. Removal of the acetonitrile *in vacuo*, followed by medium-pressure chromatog-

raphy on silica gel (24:1 diethyl ether–methanol R_F 0.38) yielded an oil that crystallized. Recrystallization from dichloromethane–hexane afforded **25** (0.150 g, 88%), m.p. 114–115°, $[\alpha]_D^{23}$ −77.5° (*c* 0.3, chloroform); $\nu_{max}^{CHCl_3}$ 3530 (carbonyl overtone), 3400, and 1765 cm^{-1} (urethan); ^{1}H-n.m.r. (80 MHz): δ 1.21 (3 H, *J* 6.8 Hz, OCH_2CH_3), 1.38 [d, 3 H, *J* 5.5 Hz, $OCH(CH_3)O$], 1.58 (s, 3 H, CH_3), 2.92 (s, 3 H, NCH_3), 3.42 (s, 1 H, H-4), 3.48–4.00 (m, 5 H, OCH_2CH_3, H-5,6,6), 4.67 (bs, 1 H, H-2), 4.89 (q, 1 H, *J* 5.5 Hz, H-7), and 4.42 (dd, 1 H, *J* 1.8, 7.0 Hz, H-1).

Anal. Calc. for $C_{13}H_{21}O_6N$: C, 54.29; H, 7.59; N, 4.78. Found: C, 54.35; H, 7.37; N, 4.88.

*Methyl-3-*N*-(1,2,6-tri-*O*-acetyl-4-deoxy-3-*C*-methyl-α,β-*D*-altropyrano)-[3,4-d]-1,3-oxazolidin-2-one* (**26**). — A solution of **25** (149 mg, 0.5 mmol) in 1:9 sulfuric acid–acetic anhydride (0.5 mL) was kept for 0.5 h at 23°. The mixture was diluted with ice–water (5 mL) and extracted with dichloromethane (3 × 5 mL). The dichloromethane fractions were combined, washed with a saturated, aqueous sodium chloride solution, dried (Na_2SO_4), and evaporated *in vacuo* to yield an oil. Purification by medium-pressure chromatography on silica gel (49:1 dichloromethane–methanol, R_F 0.50) afforded **26** (155 mg, 93%) as a colorless oil; $\nu_{max}^{CHCl_3}$ 3505 (carbonyl overtone), 3485, and 1755 cm^{-1} (urethane and acetate); ^{1}H-n.m.r. (80 MHz): δ 1.56 (s, 3 H, CH_3), 2.00-2.23 (m, 9 H, 3 $COCH_3$), 2.93 (s, 3 H, NCH_3), and 3.30–3.51 (m, 1 H, H-1); *m/z* 360 (M^+ + 1) and 359 (M^+).

*3-*N*-Methyl-(methyl 4-deoxy-3-*C*-methyl-α-*D*-altropyranosido)-[3,4-*d*]-1,3-oxazolidin-2-one* (**28**). — A solution of **26** (150 mg, 0.9 mmol) and sodium methoxide (10 mg, 0.2 mmol) in methanol (3 mL) was stirred for 45 min at 23°. Diethyl ether (5 mL) was added and the mixture filtered through Celite. The filtrate was evaporated *in vacuo* to afford crude **27** (84 mg, 84%) as a clear oil, which, without further purification, was dissolved in dry methanol and boiled at reflux under argon in the presence of Dowex 50 (H^+) resin (~200 mg) for 18 h. The resin was removed by filtration and the filtrate evaporated *in vacuo* to afford an oil that crystallized. Recrystallization from methanol–diethyl ether afforded **28** (83 mg, 93%) as granular crystals, m.p. 200–201°, $[\alpha]_D^{23}$ −36.0° (*c* 0.2, chloroform); t.l.c. (9:1 dichloromethane–methanol) R_F 0.51; $\nu_{max}^{CHCl_3}$ 3670, 3585, 3370 (OH), 2910, and 1750 cm^{-1} (urethane); ^{1}H-n.m.r. (80 MHz): δ 1.53 (s, 3 H, CH_3), 2.63 (bs, 2 H, OH), 2.86 (s, 3 H, NCH_3), 3.18–4.12 (m, 8 H, H-2,4,5,6,6, OMe), and 4.50 (d, 1 H, H-1).

Anal. Calc. for $C_{10}H_{17}NO_6$: C, 48.58; H, 6.93; N, 5.66. Found: C, 48.58; H, 7.04; N, 5.90.

*3-*N*-Methyl-(methyl 4,6-dideoxy-6-iodo-3-*C*-methyl-α-*D*-altropyranosido)-[3,4-d]-1,3-oxazolidin-2-one* (**30**). — (*a*). To a solution of **28** (130 mg, 0.5 mmol) and triphenylphosphine (157 mg, 0.6 mmol) in freshly distilled benzene (2 mL), under argon at 23°, was added with a syringe diethyl azodicarboxylate (105 mg, 0.6 mmol) in benzene (2 mL). After 3 min, methyl iodide (0.06 mL, 1.0 mmol) was added. The mixture was stirred for 1 h, and then evaporated *in vacuo*. The residue was passed through a column of silica gel (19:1 dichloromethane–methanol) to give

a clear oil that crystallized. Recrystallization from dichloromethane–hexane afforded **30** (94 mg, 53%), m.p. 175–176.5°, $[\alpha]_D^{23}$ +76.7° (*c* 0.5, chloroform); t.l.c. (19:1 dichloromethane–methanol) R_F 0.5; $\nu_{max}^{CHCl_3}$ 3505 (OH), 3405 (OH), 2925, 2850, and 1765 cm^{-1} (cyclic urethan); ^{1}H-n.m.r. (89 MHz): δ 1.51 (s, 3 H, CH_3), 2.40 (d, 1 H, OH), 2.88 (s, 3 H, NCH_3), 3.11–3.94 (m, 8 H, H-2,4,5,6,6, OMe), and 4.53 (d, 1 H, *J* 6.1 Hz, H-1).

Anal. Calc. for $C_{10}H_{16}INO_5$: C, 33.63; H, 4.52; I, 35.53; N, 3.92. Found: C, 33.32; H, 4.23; I, 35.30; N, 3.43.

(*b*). To a solution of **28** (241 mg, 1.0 mmol) in dry pyridine (5 mL) under argon at 0° was added *p*-toluenesulfonyl chloride (229 mg, 1.2 mmol). The mixture was stirred for 2 h, the reaction quenched with methanol, and the solution poured into ice-cold 0.25M hydrochloric acid (10 mL) and extracted with dichloromethane (1 × 15, 2 ×7 mL). The dichloromethane fractions were combined, washed with a saturated, aqueous sodium chloride solution, dried, and evaporated *in vacuo* to yield an oil. Purification by medium-pressure chromatography on silica gel (diethyl ether, R_F 0.65) afforded **29** (348 mg, 85%) as a colorless oil, *m/z* 370 ($M^+ - OCH_3$). A solution of **29** (300 mg, 0.7 mmol) and sodium iodide (150 mg, 1 mmol) in dry acetone (10 mL) was boiled under reflux and anhydrous conditions for 3 h. The mixture was cooled and evaporated *in vacuo*. The resulting residue was dissolved in sodium chloride solution and the solution extracted with dichloromethane (1 × 15, 2 × 10 mL). The dichloromethane fractions were combined, washed with a saturated, aqueous sodium chloride solution, dried (Na_2SO_4), and evaporated *in vacuo* to afford **30** (222 mg, 83%) as a crystalline material. This product showed i.r. and n.m.r. spectra, and m.p. that were identical to those of the compound described under (*a*).

3-N-*Methyl-(methyl 4,6-dideoxy-3*-C-*methyl-α*-D-*altropyranosido)*-[*3,4*-d]-*1,3-oxazolidin-2-one* (**31**). — To a solution of **30** (82 mg, 0.2 mmol) in dry benzene (5 mL) under argon was added tri-1-butyltin hydride (82 mg, 0.3 mmol) and a catalytic amount of benzoyl peroxide (5 mg). The reaction mixture was boiled under reflux for 30 min, cooled, and evaporated *in vacuo* to give a clear oil. This was dissolved in acetonitrile (10 mL) and the solution washed with hexane (3 × 5 mL). Acetonitrile was removed *in vacuo* to afford an oil that crystallized. Recrystallization from diethyl ether–hexane afforded **31** (42 mg, 79%) as needles, m.p. 176–177°, $[\alpha]_D^{23}$ +93.7° (*c* 0.4, chloroform); t.l.c. (diethyl ether) R_F 0.41; $\nu_{max}^{CHCl_3}$ 3575 (OH), 3390 (OH), 2910, 2830, and 1745 cm^{-1} (urethan); ^{1}H-n.m.r. (80 MHz): δ 1.38 (d, 3 H, *J* 6.1 Hz, CH_3-5), 1.49 (s, 3 H, CH_3-3), 2.46 (d, 1 H, *J* 3.7 Hz, OH), 2.86 (s, 3 H, NCH_3), 3.23 (d, 1 H, *J* 8.8 Hz, H-4), 3.44 (s, 3 H, OCH_3), 3.85–4.04 (m, 2 H, H-2,5), and 4.45 (d, 1 H, *J* 6.6 Hz, H-1).

Anal. Calc. for $C_{10}H_{17}NO_5$: C, 51.94; H, 7.41; N, 6.06. Found: C, 51.66; H, 7.50; N, 5.93.

Methyl 4,6-dideoxy-3-C-*methyl-4-(*N-*methylacetamido)-α*-D-*altropyranoside* (**5**). — A solution of **31** (32 mg, 0.14 mmol) in potassium hydroxide (4 mL) was boiled under reflux for 1 h. The mixture was cooled, and evaporated to dryness *in*

vacuo to yield a precipitate from which **32** was extracted with hot ethyl acetate (2 × 10 mL). The ethyl acetate fractions were combined and evaporated *in vacuo* to yield an oil that was dissolved in dry methanol (1 mL) containing acetic anhydride (4 drops). After 2 h, the mixture was concentrated *in vacuo* and the residue dissolved in sodium chloride solution (2 mL). The solution was extracted with dichloromethane. The fractions were combined, washed with a saturated, aqueous sodium chloride solution, dried (Na_2SO_4), and evaporated *in vacuo* to afford a crystalline material. Recrystallization from dichloromethane–hexane afforded **5** (24 mg, 70%), m.p. 141–143° (mixed m.p. 141–143°; lit.[9] m.p. 141–143°); $[\alpha]_D^{23}$ +146.4° (*c* 0.05, chloroform) {lit.[9] $[\alpha]_D^{23}$ +153.3° (*c* 0.24, chloroform)}; t.l.c. (47:3 dichloromethane–methanol) R_F 0.53; $\nu_{max}^{CHCl_3}$ 3570 (OH), 3460, 2920, and 1630 cm^{-1} (urethan); ^{1}H-n.m.r. (400 MHz): δ 1.15–1.50 (m, 6 H, 2 C-CH_3), 1.62 (6 s, 2 H, OH), 2.14 (2 s, 3 H, CH_3CO), 3.02 (2 s, 3 H, NCH_3), 3.48 (2, 3 H, OCH_3), 4.15 (dq, 1 H, H-5), 4.61 (d, 1 H, *J* 10.5 Hz, H-4), and 4.71 (d, 1 H, *J* 3.7 Hz, H-1); *m/z* 248 ($M^+ + 1$) and 247 (M^+).

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