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SYNTHESIS OF BRANCHED-CHAIN SUGARS: A STEREOSELECTIVE ROUTE TO SIBIROSAMINE, KANSOSAMINE, AND VINELOSE FROM A COMMON PRECURSOR

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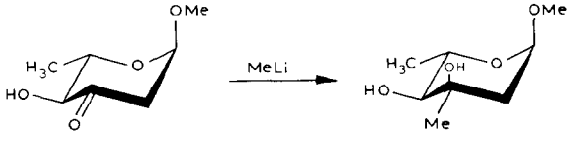
ABSTRACT

Methyl 4,6-dideoxy-3-*C*-methyl-4-(*N*-methyl-*N*-phenylsulfonylamino)-α-L-mannopyranoside and methyl 4-amino-4,6-dideoxy-3-*C*-methyl-α-L-mannopyranoside, derivatives of the branched-chain amino sugars sibirosamine and kansosamine, respectively, were synthesized by nucleophilic ring-opening of methyl 3,4-anhydro-6-deoxy-3-*C*-methyl-α-L-talopyranoside. Catalytic reduction of methyl 6-deoxy-2,3-*O*-isopropylidene-3-*C*-methyl-α-L-*lyxo*-hexopyranosid-4-ulose gave the axial alcohol methyl 6-deoxy-2,3-*O*-isopropylidene-3-*C*-methyl-α-L-talopyranoside, a known precursor to vinelose.

INTRODUCTION

The control of stereochemistry at tertiary centers is a common problem in the synthesis[1] of branched-chain sugars. For 3-*C*-methyl-branched sugars, syntheses based on nucleophilic additions to hexopyranosid-3-uloses have been the most successful in cases where the branching methyl group is equatorial in the favored pyranose form, as exemplified by the synthesis of methyl α-L-mycaroside (**1**), reported by Thiem and Elvers[2]. The usual preference for equatorial attack on the carbonyl group has prompted the development of alternative methods for the synthesis of branched-chain sugars in which the 3-*C*-methyl group is axial. Stereoselective routes based on oxymercuration of 3-*C*-methylene sugars[3], alkylation of enolates derived from ketoses[4], and intramolecular cyclization of allylic urethans[5], have been reported. We have recently described a stereoselective synthesis of nogalose (**2**) from L-rhamnose *via* methyl 2,5-di-*O*-benzyl-6-deoxy-3-*C*-methyl-α-L-



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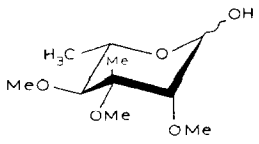

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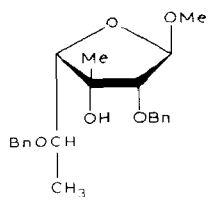

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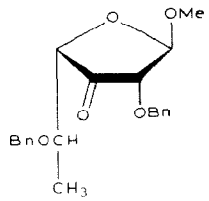

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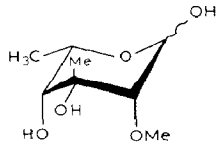

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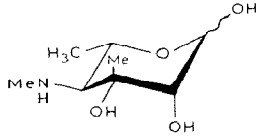

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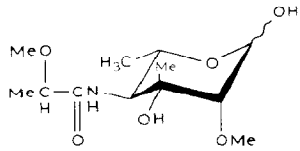

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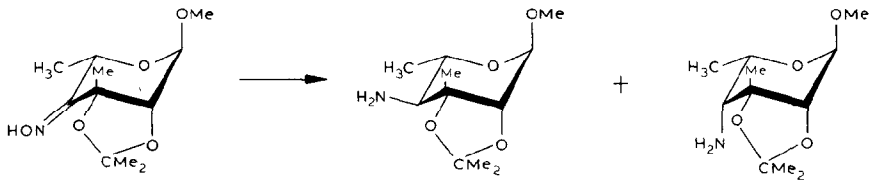
mannofuranoside[6] (**3**). The branching methyl group in **2** was introduced, with complete stereoselectivity, by the addition of methylmagnesium iodide to an aldosulose in its aldofuranosidic form, namely, methyl 2,5-di-*O*-benzyl-6-deoxy-α-L-*arabino*-hexofuranosid-3-ulose (**4**). In the note[6] describing the synthesis of nogalose, we suggested that furanoside **3** could also be used as a precursor to the L-sugars vinelose[7] (**5**), sibirosamine[8] (**6**), and *N*-acylkansosamine[9] (**7**), all of which possess the same configurations at C-2 and C-3 as **3**, with *trans*-diaxial groups at these positions. Considering the level of interest in the synthesis of branched-chain sugars, the development of a general approach to **5, 6,** and **7** from a single intermediate seemed worthy of investigation. We now describe a regio- and stereoselective route to the amino sugars sibirosamine and kansosamine, based on the nucleophilic ring-opening of a branched-chain, anhydro sugar. The synthesis of a known precursor to vinelose is also described.

RESULTS AND DISCUSSION

Acidic methanolysis of the antibiotic sibiromycin gave methyl sibirosaminide, the structure of which was initially assigned[8] as methyl 4,6-dideoxy-3-*C*-methyl-4-(methylamino)-β-D-altropyranoside by Mesentsev and Kuljaeva in 1973. Parker and Babine[10] revised the structure of sibirosamine to 4,6-dideoxy-3-*C*-methyl-4-(methylamino)-L-mannopyranose (**6**) in 1982. Several syntheses of compounds isomeric with **6** have been reported[11], and the routes described recently by Yoshimura *et al.*[12] (from L-rhamnose) and Rapoport *et al.*[13] (from L-allothreonine) give products having the L-*manno* configurations. In both of these routes, however, the formation of undesired isomers or other side-products was observed. For example, oxime[12] (**8**) underwent reduction with lithium aluminum hydride to give a 1:1 mixture of the epimeric amines **9** and **10**. The introduction of the amino group into **9**



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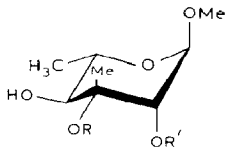
via the oxime suggested to us that a related approach, based on the reductive amination of hexos-3-ulose **14**, or its derivatives **13** and **15**, might also be feasible. This approach seemed potentially versatile, because access to both **6** and **7** would be provided by the choice of amine.

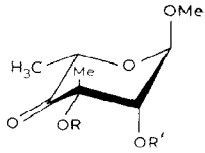
Furanoside **3** was converted[6] into methyl 6-deoxy-3-*C*-methyl-α-L-manno-pyranoside (**11**), which gave the isopropylidene acetal **12** on treatment with acetone and Dowex 50 (H^+) resin. Oxidation of **12** by Swern's method gave hexos-3-ulose **13**. Removal of the isopropylidene group[14] gave the hydroxy ketone **14**. Cyclic carbonate **15** was prepared by treatment of **11** with 1,1′-carbonyldiimidazole followed by oxidation. Reductive aminations of **13, 14,** and **15** were attempted using a variety of procedures. Despite the utility of the cyanoborohydride-based reductive amination (Borch procedure[15]) and related synthetic methods[16], we were unable to obtain satisfactory yields of amines by these reactions. Attempted catalytic and dissolving-metal reductions of preformed imines of **14** or its derivatives also failed to provide amino sugars as the major products. Reduction of **13** with hydrogen at 505 kPa in the presence of platinum oxide gave exclusively alcohol **16**, with the L-*talo* configuration. Compound **16** had been synthesized by Klemer and Stegt[17], and converted into L-vinelose (**5**), a branched-chain sugar isolated from the lipopolysaccharide of *Azotobacter vinelandii*.

The results of our attempted reductive aminations of branched-chain hexos-3-uloses illustrate the difficulty of conducting functional-group transformations adjacent to tertiary centers in monosaccharides. Not surprisingly, an attempted nucleophilic displacement of mesylate **17** was also unsuccessful. In considering alternative routes to amino sugars **6** and **7**, we chose a strategy based on the nucleophilic ring-opening of anhydro sugar **21**. This approach required that **21** should undergo ring-opening in the *trans*-diequatorial sense, in preference to the stereoelectronically favored *trans*-diaxial mode. We were encouraged by recent studies[18] in which *trans*-diequatorial ring-opening was observed for the reaction of anhydro sugar **18** with tetraethylammonium azide. The synthesis of **21**, and its successful conversion into derivatives of **6** and **7**, are described herein.

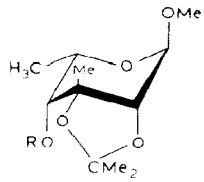
Treatment of **12** with methanesulfonyl chloride in pyridine gave **19**, from which the isopropylidene group was removed by acid hydrolysis, to give **20** in 88% overall yield. In the workup of the hydrolysis, neutralization of the acid was done carefully in order to avoid the formation of a mixture of **20** and **21**. The conversion of **20** into **21** was then conducted with methanolic potassium hydroxide. Anhydro



11 R = R′ = H
12 R, R′ = Me_2C



13 R, R′ = Me_2C
14 R = R′ = H
15 R, R′ = CO

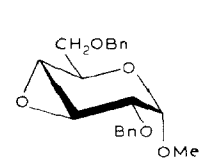


16 R = H
17 R = OMs
Ms = $MeSO_2$

sugar **21**, obtained as a syrup in 66% yield, was used without further purification in the subsequent steps. Reaction of **21** with either sodium *N*-methyl-*N*-phenylsulfonylamide or tetraethylammonium azide gave, respectively, sulfonamide **22** (63% yield) or azide **23** (55% yield) as single isomers. The physical constants of and ^{1}H-n.m.r.-spectral data for **22** were in complete agreement with those reported by Rapoport *et al.*[13]. Because compound **22** was converted in two steps into L-sibirosamine, the route described here constitutes a formal synthesis of this amino sugar.

Catalytic reduction of azide **23** gave methyl 4-amino-4,6-dideoxy-3-*C*-methyl-α-L-mannopyranoside (**24**). The isopropylidene derivative of **24**, namely **9**, was recently converted[12] into *N*-acylkansosamine by Yoshimura and co-workers. *N*-Acylkansosamine (**7**) had been isolated[9] from the antigenic lipopolysaccharide of *Mycobacterium kansasii*, and assigned the structure of 4,6-dideoxy-4-[(*R*)-2-methoxypropanamido]-3-*C*-methyl-2-*O*-methyl-L-mannopyranose on the basis of extensive spectroscopic analysis and synthesis[19].

The syntheses of amino sugar derivatives **22** and **24** described herein respectively require fourteen and fifteen steps from L-rhamnose. The tertiary center is established by nucleophilic addition to furanosid-3-ulose **4**, and the nitrogen func-



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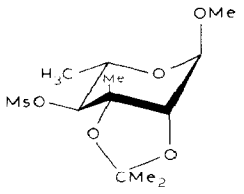

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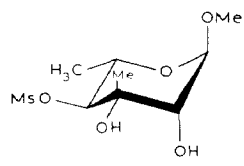

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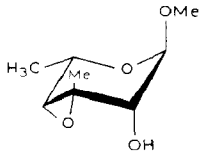

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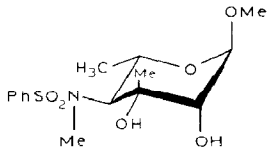

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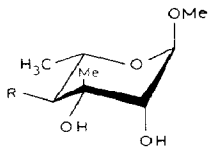

23 R = N_3
24 R = NH_2

tionality at the adjacent C-4 atom is introduced by ring-opening reactions of anhydro sugar **21**. Both of these key synthetic operations proceed with complete regio- and stereo-selectivity, further demonstrating the utility of **3** as a precursor to branched-chain sugars that contain an axial methyl group.

EXPERIMENTAL

General procedures. — Melting points were determined on a Thomas–Hoover melting-point apparatus and are uncorrected. Optical rotations were determined with a Perkin–Elmer 241 polarimeter. The progress of reactions was monitored by thin-layer chromatography using aluminum-supported plates of silica gel 60 (0.2 mm, F-254, E. Merck). Solvent systems are indicated in volume:volume ratios, along with the R_F value. Components were detected by observation under short-wavelength ultraviolet light, or by spraying with concentrated sulfuric acid and charring with a heat gun. Flash chromatography was performed on silica gel 60 (230–400 mesh) or Florisil (60–100 mesh). Infrared spectra were recorded with a Perkin–Elmer 299 infrared spectrophotometer or an Analect FX-6130 infrared spectrophotometer. ^{1}H-N.m.r. and ^{13}C-n.m.r. spectra were recorded with a Varian XL-200 spectrometer at 200 and 50.3 MHz, respectively. Chemical shifts for ^{1}H resonances are recorded relative to tetramethylsilane (0.0) or deuterated chloroform (7.27). Chemical shifts for ^{13}C-n.m.r. spectra were recorded relative to tetramethylsilane (0.0) or deuterated chloroform (76.91). High-resolution mass spectra were recorded with a VG-7070H spectrometer at the Mass Spectrometry Center, University of Pennsylvania, under c.i. conditions with either isobutane or ammonia.

*Methyl 6-deoxy-2,3-*O*-isopropylidene-3-*C*-methyl-α-*L*-mannopyranoside* (**12**). — A mixture of methyl α-L-evalopyranoside* (**11**; 3.0 g, 16.0 mmol), Dowex 50 (H^+) resin, and copper sulfate (1.88 g, 12.0 mmol) was stirred in acetone (60 mL) for 45 min at room temperature, and filtered. Evaporation of the filtrate left a residue that was dissolved in chloroform and the solution washed with saturated sodium hydrogencarbonate solution. The aqueous phase was separated, and extracted with chloroform, and the extracts were combined, dried (magnesium sulfate), and evaporated, to give 3.36 g (93%) of **12**, which was recrystallized from chloroform–hexane. Compound **12** had R_F 0.57 (ethyl acetate); m.p. 91–92°, $[\alpha]_D^{20}$ −56° (*c* 0.9, $CHCl_3$); ^{1}H-n.m.r.: δ 4.88 (bs, 1 H, H-1), 3.90 (bs, 1 H, H-2), 3.7–3.5 (m, 2 H, H-4,5), 3.40 (s, 3 H, OCH_3), 2.15 (bs, O*H*), 1.52 (s, 3 H, C-CH_3), 1.38 (s, 3 H, C-CH_3), 1.36 (s, 3 H, CH_3-3), and 1.31 (d, 3 H, $J_{5,6}$ 6 Hz, H-6).

Anal. Calc. for $C_{11}H_{20}O_5$: C, 56.88; H, 8.68. Found: C, 56.75; H, 8.56.

*Methyl 6-deoxy-2,3-*O*-isopropylidene-3-*C*-methyl-α-*L*-lyxo-hexopyranosid-4-ulose* (**13**). — To a solution of dry dimethyl sulfoxide (2.05 mL, 29 mmol) in dry

*The anomeric configuration of methyl evalopyranoside (**11**), synthesized[6] from **3** has been reassigned[19a] as α on the basis of X-ray crystallographic and n.m.r. analysis.

dichloromethane (29 mL) at −65° was added a solution of trifluoroacetic anhydride (3.05 mL, 22 mmol) in dichloromethane (7.3 mL) dropwise with stirring. The mixture was stirred for 10 min, and then a solution of **12** (3.36 g, 14 mmol) in dichloromethane (32 mL) was added dropwise while the temperature was maintained below −65°. After 30 min, triethylamine (5.9 mL, 43 mmol) was added dropwise. The mixture was allowed to warm to room temperature, and washed successively with saturated ammonium chloride solution and water, dried (magnesium sulfate), and evaporated, to give 2.40 g (72%) of crude **13**; R_F 0.63 (ethyl acetate); $[\alpha]_D^{20}$ −85° (*c* 0.20, $CHCl_3$), lit.[4] $[\alpha]_D^{20}$ −110.8° (*c* 0.8, $CHCl_3$); $\nu_{max}^{thin\ film}$ 1738 cm^{-1}; the ^{1}H-n.m.r. spectrum of **13** was identical[4] with that reported. Compound **13** was used without purification.

*Methyl 2,3-O-carbonyl-6-deoxy-3-C-methyl-α-*L*-lyxo-hexopyranosid-4-ulose* (**15**). — A solution of **11** (0.150 g, 0.78 mmol), and 1,1′-carbonyldiimidazole (0.15 g, 925 μmol) in benzene (4.5 mL) was boiled and stirred under reflux for 4.3 h, and then stirred for 18 h at room temperature. Additional 1,1′-carbonyldiimidazole (0.12 g) was added in portions, and the progress of the reaction was carefully monitored (R_F 0.24, 4.5:1 chloroform–ethyl acetate). The mixture was partitioned between ether and water, and the organic phase was separated, dried (magnesium sulfate), and evaporated, to give 0.136 g (80%) of **14**, which was purified by flash chromatography. The syrupy product gave crystals that had m.p. 90–95°, $[\alpha]_D^{20}$ −58° (*c* 1.8, $CHCl_3$); $\nu_{max}^{CHCl_3}$ 1805 cm^{-1}; ^{1}H-n.m.r.: δ 4.91 (bs, 1 H, H-1), 4.30 (bs, 1 H, H-2), 3.77 (m, 1 H, H-5), 3.61 (d, 1 H, $J_{4,5}$ 8 Hz, H-4), 3.44 (s, 3 H, OCH_3), 1.58 (s, 3 H, CH_3-3), 1.35 (d, 3 H, $J_{5,6}$ 6 Hz, H-6).

Anal. Calc. for $C_9H_{14}O_6$: C, 49.54; H, 6.47. Found: C, 49.59; H, 6.42.

Oxidation of 25 mg (115 μmol) of the product (**14**) was conducted as described for the preparation of **13**. There was obtained 21 mg (83%) of syrupy **15** which displayed the following characteristics: R_F 0.55 (4.5:1 chloroform–ethyl acetate); $[\alpha]_D^{20}$ −70° (*c* 1.0, $CHCl_3$); $\nu_{max}^{CHCl_3}$ 1815 and 1750 cm^{-1}; ^{1}H-n.m.r.: δ 4.82 (bs, 1 H, H-1), 4.38 (bs, 1 H, H-2), 4.24 (m, 1 H, H-5), 3.44 (s, 3 H, OCH_3), 1.52 (s, 3 H, CH_3-3), and 1.44 (d, 3 H, $J_{5,6}$ 6 Hz, H-6).

Anal. Calc. for $C_9H_{12}O_6$: C, 50.00; H, 5.55. Found: C, 49.58; H, 5.81.

*Methyl 6-deoxy-2,3-O-isopropylidene-3-C-methyl-α-*L*-talopyranoside* (**16**). — A mixture of **13** (0.482 g, 2.10 mmol), platinum oxide (0.12 g, 0.53 mmol), and ethanol (3 mL) was shaken under hydrogen at 506 kPa in a Parr apparatus for 2 days. The solids were removed by centrifugation, and the supernatant liquor was evaporated, to give 0.374 g (77%) of syrupy **16**; R_F 0.5 (6:1 chloroform–acetonitrile); $[\alpha]_D^{20}$ −56.0° (*c* 0.56, $CHCl_3$), lit.[17] $[\alpha]_D^{20}$ −55.0° (*c* 1.0, $CHCl_3$). The ^{1}H-n.m.r. spectrum of **16** was identical with that reported[17].

*Methyl 6-deoxy-2,3-O-isopropylidene-3-C-methyl-4-O-(methylsulfonyl)-α-*L*-talopyranoside* (**17**). — Compound **17** was prepared from **16** by using the procedure described next for **19**. From 0.416 g (1.79 mmol) of **16** there was obtained 0.565 g (quantitative) of crystalline **17**, which displayed the following characteristics: m.p. 115–120°, $[\alpha]_D^{20}$ −37° (*c* 1.0, $CHCl_3$); ^{1}H-n.m.r.: δ 4.96 (bs, 1 H, H-1), 4.16 (bs, 1

H,. H-4), 4.00 (m, 1 H, H-5), 3.76 (bs, 1 H, H-2), 3.39 (s, 3 H, OCH_3), 3.08 (s, 3 H, CH_3OS), 1.57 (s, 3 H, CH_3-C), 1.45 (s, 3 H, CH_3-3), 1.39 (s, 3 H, CH_3-C), and 1.36 (d, 3 H, $J_{5,6}$ 7 Hz, H-6).

*Methyl 6-deoxy-2,3-*O*-isopropylidene-3-*C*-methyl-4-*O*-(methylsulfonyl)-α-*L*-mannopyranoside* (**19**). — To a solution of **12** (1.47 g, 6.34 mmol) in pyridine (15 mL) at 0° was added methanesulfonyl chloride (2.54 mL, 32.8 mmol) dropwise with stirring. The mixture was stirred for 2 h at room temperature, and water (2.5 mL) was added. Chloroform (200 mL) was added, and the organic phase was washed with water (7 × 50 mL), dried (calcium chloride), and evaporated, to give 1.85 g (94%) of crystalline **19**. Compound **19** had R_F 0.63 (6:1 chloroform–acetonitrile); m.p. 168–170°, $[\alpha]_D^{20}$ −28° (*c* 0.55, $CHCl_3$); ^{1}H-n.m.r.: δ 4.88 (bs, 1 H, H-1), 4.55 (d, 1 H, $J_{4,5}$ 10 Hz, H-4), 3.89 (bs, 1 H, H-2), 3.80 (m, 1 H, H-5), 3.39 (s, 3 H, OCH_3), 3.18 (s, 3 H, SCH_3), 1.58 (s, 3 H, C-CH_3), 1.38 (s, 3 H, CH_3-3), 1.36 (s, 3 H, C-CH_3), and 1.34 (d, 3 H, $J_{5,6}$ 6 Hz, H-6); *exact mass* calc. for ($C_{12}H_{23}O_7S$ + H): 311.1164; found: 311.1163.

*Methyl 6-deoxy-3-*C*-methyl-4-*O*-(methylsulfonyl)-α-*L*-mannopyranoside* (**20**). — A solution of **19** (1.85 g, 5.97 mmol) in 0.4M HCl in methanol was boiled and stirred under reflux for 24 h, cooled to room temperature, and the acid neutralized by the addition of solid sodium carbonate (1.0 g). The mixture was filtered, and the filtrate was dried (magnesium sulfate) and evaporated, to give 1.54 g (96%) of syrupy **20**. Compound **20** had R_F 0.18 (6:1 chloroform–acetonitrile); $[\alpha]_D^{20}$ −44.0° (*c* 0.25, $CHCl_3$); ^{1}H-n.m.r.: δ 4.77 (bs, 1 H, H-1), 4.56 (d, 1 H, $J_{4,5}$ 10 Hz, H-4), 3.84 (m, 1 H, H-5), 3.70 (bs, 1 H, H-2), 3.42 (s, 3 H, OCH_3), 3.22 (s, 3 H, SCH_3), 2.45 (s, 2 H, 2 O*H*), 1.40 (s, 3 H, CH_3-3), and 1.39 (d, 3 H, $J_{5,6}$ 6 Hz, H-6); *exact mass* calc. for ($C_9H_{18}O_7S$ + NH_4): 288.1117; found: 288.1094.

*Methyl 3,4-anhydro-6-deoxy-3-*C*-methyl-α-*L*-talopyranoside* (**21**). — A mixture of **20** (1.51 g, 5.59 mmol), potassium hydroxide (0.488 g, 8.71 mmol), and methanol (40 mL) was stirred for 20 min at room temperature, and evaporated. Chloroform (60 mL) was added, and the mixture was washed with water. The organic phase was dried (magnesium sulfate), and evaporated, to give 0.64 g (66%) of syrupy **21**; R_F 0.38 (6:1 chloroform–acetonitrile); $[\alpha]_D^{20}$ −23° (*c* 0.18, $CHCl_3$); ^{1}H-n.m.r.: δ 4.46 (bs, 1 H, H-1), 4.06 (m, 1 H, H-5), 3.56 (bs, 1 H, H-2), 3.40 (s, 3 H, OCH_3), 3.08 (bs, 1 H, H-4), 2.06 (bs, 1 H, O*H*), 1.50 (s, 3 H, CH_3-3), and 1.34 (d, 3 H, $J_{5,6}$ 6 Hz, H-6).

*Methyl 4,6-dideoxy-3-*C*-methyl-4-(*N*-methyl-*N*-phenylsulfonylamino)-α-*L*-mannopyranoside* (**22**). — Sodium *N*-methyl-*N*-phenylsulfonylamide (1.12 g, 5.8 mmol) was added to a solution of **21** (0.175 g, 1.0 mmol) in dry *N,N*-dimethylformamide (2 mL), and the mixture was stirred for 6 d at 100°. Potassium hydroxide solution (10%) was added to the cooled mixture, which was then shaken, and extracted with dichloromethane (20 mL). The organic phase was separated, washed successively with 10% potassium hydroxide solution and water, dried (magnesium sulfate), and evaporated, to give 0.219 g (63%) of crystalline **22**, which was purified by flash chromatography using 1:1 ethyl acetate–petroleum ether as the eluant.

Compound **22** had R_F 0.15 (2:1 chloroform–acetonitrile); m.p. 115–117° (lit.[13] m.p. 115–116°), $[\alpha]_D^{20}$ −76° (*c* 2.1, CH_3OH) lit.[13] $[\alpha]_D^{23}$ −89.3° (*c* 1.8, CH_3OH). The ^{1}H-n.m.r. spectrum of **22** matched that reported[13]; ^{13}C-n.m.r.: δ 138.3, 133.2, 129.3, 127.4, 100.4, 74.6, 72.8, 63.5, 62.7, 55.4, 32.1, 22.1, and 18.2. The value of 168 Hz measured for $J_{C\text{-}1,H}$ in the ^{1}H-coupled, ^{13}C-n.m.r. spectrum indicated[20] the α anomer.

*Methyl 4-azido-4,6-dideoxy-3-*C*-methyl-α-*L*-mannopyranoside* (**23**). — Sodium azide (2.77 g, 42.6 mmol) was added to a solution of **21** (0.741 g, 4.26 mmol) in dry *N,N*-dimethylformamide (4.5 mL) containing tetraethylammonium chloride (3.53 g, 21.3 mmol), and the mixture was stirred for 6 d at 85°. Water (60 mL) was added to the cooled mixture, which was then extracted with dichloromethane (45 mL). The organic phase was separated, washed with water (45 mL), dried (magnesium sulfate), and evaporated, to give 0.46 g (50%) of syrupy **23**; R_F 0.3 (6:1 chloroform–acetonitrile); $\nu_{max}^{thin\ film}$ 2113 cm^{-1}; ^{1}H-n.m.r.: δ 4.74 (bs, 1 H, H-1), 3.6–3.0 (m, 3 H, H-2,4,5), 3.38 (s, 3 H, OCH_3), 2.60 (bs, 2 H, 2 *OH*), 1.38 (s, 3 H, CH_3-3), and 1.34 (d, 3 H, $J_{5,6}$ 6 Hz, H-6); *exact mass* calc. for $C_8H_{15}N_3O_4$ + NH_4): 235.1406, Found: 235.1380.

*Methyl 4-amino-4,6-dideoxy-3-*C*-methyl-α-*L*-mannopyranoside* (**24**). — A mixture of azide **23** (0.46 g, 2.12 mmol), 10% palladium–charcoal (55 mg), and ethanol (4 mL) was shaken under hydrogen at a pressure of 506 kPa in a Parr apparatus for 4 h. Solids were removed by centrifugation, and the supernatant liquor was evaporated, to give 0.34 g (84%) of syrupy **24**; R_F 0.4 (methanol); $[\alpha]_D^{20}$ −48.9° (*c* 1.1, CH_3OH); ^{1}H-n.m.r. (acetone-d_6): δ 4.69 (bs, 1 H, H-1), 4.01 (m, 1 H, $J_{4,5}$ 9.8 Hz, H-5), 3.66 (d, 1 H, $J_{4,5}$ 9.5 Hz, H-4), 3.43 (bs, 1 H, H-2), 3.34 (s, 3 H, OCH_3), 2.20 (bs, 4 H, NH_2, *OH*), 1.32 (s, 3 H, CH_3-3), and 1.02 (d, 3 H, $J_{5,6}$ 6 Hz, H-6); *exact mass* calc. for ($C_8H_{17}NO_4$ + H): 192.1236, found: 192.1222.

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