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SYNTHESIS OF DAUNOSAMINE*

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ABSTRACT

The rearrangement of methyl 3-azido-2-*S*-benzyl-3-deoxy-2-thio-α-D-altropyranoside (**3**) in methanol to give methyl 3-azido-2-*S*-benzyl-3-deoxy-2-thio-αβ-D-altrofuranoside (**4a**) was catalysed by Amberlite CG-120(H^+) resin. Partial benzoylation of **4a** gave the 6-*O*-benzoyl derivative (**4b**), the 5-*O*-toluene-*p*-sulphonyl derivative (**4c**) of which was converted into methyl 5,6-anhydro-3-azido-2-*S*-benzyl-3-deoxy-2-thio-αβ-L-galactofuranoside (**7**) with methanolic sodium methoxide. Reduction of **7** with lithium aluminium hydride gave the 3,6-dideoxy sugar (**8a**) which, with Raney nickel, gave methyl 3-amino-2,3,6-trideoxy-αβ-L-*lyxo*-hexofuranoside (**9**). Acid hydrolysis of **9** gave 3-amino-2,3,6-trideoxy-L-*lyxo*-hexose (daunosamine) which is a component of the antibiotic daunomycin.

INTRODUCTION

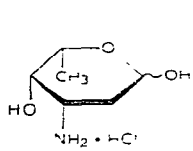
Daunosamine (**1**, 3-amino-2,3,6-trideoxy-L-*lyxo*-hexose) which is a component of a cytotoxic antibiotic daunomycin, was isolated as its hydrochloride by Arcamone *et al.*[2] and synthesized from L-rhamnose by Goodman *et al.*[3]. We have found that hexopyranoside derivatives having an *S*-substituent at C-2 can be isomerized to the corresponding furanosides[1,4], indicating that L sugars can be obtained from D-glucose. For example, L-rhodinose (2,3,6-trideoxy-L-*threo*-hexose), which is a component of the antibitoic rhodomycin or streptolydigin, was synthesised from methyl 2,3-dideoxy-2,3-epithio-α-D-mannofuranoside derived from D-glucose[5]. We now report on the isomerization of methyl 3-azido-2-*S*-benzyl-4,6-*O*-benzylidene-3-deoxy-2-thio-α-D-altropyranoside (**2**) and the synthesis therefrom of **1**.

RESULTS AND DISCUSSION

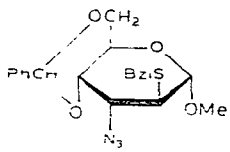
Goodman *et al.*[6] reported that syrupy methyl 3-azido-2-*S*-benzyl-3-deoxy-2-thio-α-D-altropyranoside (**3a**, $[\alpha]_D$ +61°) was obtained on treatment of **2** with

*Thio Sugars: Part V[1].

Amberlite CG-120(H^+) resin in 90% methanol. In our hands, this procedure gave a syrup ($[\alpha]_D$ +52°) which contained three components (t.l.c.). Chromatography of the mixture gave 1,6-anhydro-3-azido-2-*S*-benzyl-3-deoxy-2-thio-β-D-altropyranose (**5a**, 1.2%), 3-azido-2-*S*-benzyl-3-deoxy-2-thio-D-altrose (**6**, 8.3%), and a syrup (*A*, 86.5%; $[\alpha]_D$ +62°). The structure of **5a** was confirmed by the fact that the monobenzoate (**5b**) had a p.m.r. spectrum similar to that of 1,6-anhydride derivatives[1]. The $[\alpha]_D$ value of *A* is similar to that of **3a** reported by Goodman *et al.*, but formaldehyde was liberated on oxidation[4] of *A* with sodium metaperiodate, indicating that it is, at least partly, a furanoside structure. Hydrolysis of **2** with oxalic acid in 80% acetone gave a syrup (*B*, $[\alpha]_D$ +45°), the i.r. spectrum of which was similar to that of *A*, but formaldehyde was not formed on oxidation with sodium metaperiodate. Therefore, *B* is **3a**, from which the 6-benzoate (**3b**) was obtained. Hydrolysis of **3a** with the resin in water gave **6** as main product.



1



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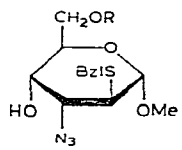
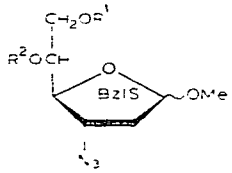
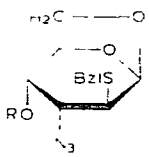


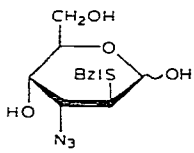
3a R = H
3b R = Ac



4a R^1 = R^2 = H
4b R^1 = Bz, R^2 = H
4c R^1 = Bz, R^2 = Ts



5a R = H
5b R = Bz



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The $[\alpha]_D$ value of *A* increased (+62°→+71.5°) with increase in reaction time (15→255 h). The p.m.r. spectrum of *A* showed doublets for the anomeric protons of α- and β-furanoside at δ 4.75 ($J_{1,2}$ 1.5 Hz) and 4.53 ($J_{1,2}$ 4.5 Hz), together with a singlet at δ 4.63 for H-1 in **3a**. Thus, *A* is a mixture of **3a** and its furanoside isomers, the proportion of which varies according to the reaction time. Syrupy *A*, obtained on reaction for 255 h, was fractionated by chromatography. Eluted first was a syrup ($[\alpha]_D$ +97°) which was identified as methyl 3-azido-2-*S*-benzyl-3-deoxy-2-thio-αβ-D-altrofuranoside (**4a**), because the p.m.r. spectrum contained doublets for anomeric protons at δ 4.75 (α-furanoside) and 4.53 (β-furanoside); there was no signal at δ 4.63 (α-pyranoside). The yields of **5a**, **6**, and *A* are shown in Table I for each reaction time. Thus, during the isomerization **3a**→**4a**, **3a** was also transformed into **5a** and **6**.

TABLE I

THE YIELDS OF PRODUCTS ON TREATMENT OF METHYL 3-AZIDO-2-*S*-BENZYL-4,6-*O*-BENZYLIDENE-3-DEOXY-2-THIO-α-D-ALTROPYRANOSIDE (**2**) WITH AMBERLITE CG-120(H^+) RESIN IN 80% METHANOL AT 55°

Reaction time (h)	*Yield of products* (%)		
	5a	**6**	*Syrup* A
15	1.2	8.3	86.5
55	7.1	11.0	83.1
100	8.7	9.9	81.4
156	9.4	9.4	82.6
200	13.7	8.2	71.2
255	12.6	5.0	71.1

Benzoylation of *A* gave the benzoate **3b** and methyl 3-azido-6-*O*-benzoyl-2-*S*-benzyl-3-deoxy-2-thio-αβ-D-altrofuranoside (**4b**, $[\alpha]_D$ +56°). The p.m.r. spectrum of **4b** contained doublets for anomeric protons at δ 4.57 (*J* 4.5 Hz) and 4.77 (*J* 1.5 Hz). Table II shows the yields of **3b** and **4b** on benzoylation of *A* obtained from various reaction times of **2** with the resin; the proportion of **4a** in *A* increases with increase in reaction time. Tosylation of **4b** gave syrupy methyl 3-azido-6-*O*-benzoyl-2-*S*-benzyl-3-deoxy-5-*O*-toluene-*p*-sulphonyl-2-thio-αβ-D-altrofuranoside (**4c**) in quantitative yield. Treatment of **4c** with sodium methoxide gave syrupy methyl 5,6-anhydro-3-azido-2-*S*-benzyl-3-deoxy-2-thio-αβ-L-galactofuranoside (**7**, 96.8%; $[\alpha]_D$ +81°), which had an i.r. band at 3050 cm^{-1} (terminal epoxymethylene group) but no absorption (*cf.* **4c**) at 1720 (C=O), 1185 and 1175 cm^{-1} (SO_2). The formation of **7** confirmed that **4a** has a furanoid structure.

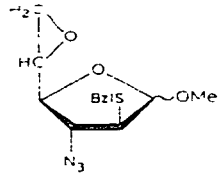
TABLE II

THE YIELDS OF BENZOYLATION PRODUCTS FROM *A*[a]

Reaction time (h) for obtaining syrup A	*Yield of products* (%)	
	3b	**4b**
15	35.3	0.4
55	59.5	20.0
100	50.2	38.1
156	50.0	47.2
255	51.9	43.2

[a]Obtained from **2** by methanolysis with Amberlite CG-120(H^+) resin for various reaction times.

Treatment of **7** with lithium aluminium hydride gave syrupy methyl 3-amino-2-*S*-benzyl-3,6-dideoxy-2-thio-αβ-L-galactofuranoside (**8a**, 72.2%; $[\alpha]_D$ −29°), the p.m.r. spectrum of which contained doublets at δ 4.54 (*J* 4.5 Hz) and 4.77 (*J* 1.5 Hz) for anomeric protons. Benzoylation of **8a**, followed by chromatography, gave methyl



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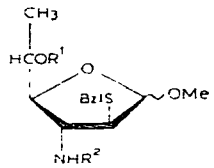
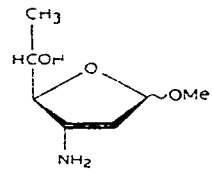


8a $R^1 = R^2 = H$
8b $R^1 = R^2 = Bz$ (β anomer)
8c $R^1 = R^2 = Bz$ (α anomer)
8d $R^1 = H, R^2 = Ac$ (β anomer)
8e $R^1 = H, R^2 = Ac$ (α anomer)



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3-benzamido-5-*O*-benzoyl-2-*S*-benzyl-3,6-dideoxy-2-thio-β-L-galactofuranoside (**8b**, m.p. 147–148°, $[\alpha]_D$ +60°) and methyl 3-benzamido-5-*O*-benzoyl-2-*S*-benzyl-3,6-dideoxy-2-thio-α-L-galactofuranoside (**8c**, m.p. 205–206°, $[\alpha]_D$ −37°) in yields of 70 and 19.9%, respectively. The p.m.r. spectra of **8b** and **8c** showed terminal methyl proton signals (δ 1.45 and 1.42, respectively). Acetylation of **8a**, followed by chromatography, gave syrupy methyl 3-acetamido-2-*S*-benzyl-3,6-dideoxy-2-thio-β-L-galactofuranoside (**8d**, $[\alpha]_D$ +96°) and methyl 3-acetamido-2-*S*-benzyl-3,6-dideoxy-2-thio-α-L-galactofuranoside (**8e**, m.p. 190–191.5°, $[\alpha]_D$ −96.5°) in yields of 64.2 and 19.2%, respectively. The structures of **8d** and **8e** were determined by p.m.r. spectroscopy.

From the foregoing results, it is clear that the reductive opening of the 5,6-epoxy ring of **7** occurred between C-6 and the attached oxygen atom. Treatment of **8a** with Raney nickel gave syrupy methyl 3-amino-2,3,6-trideoxy-αβ-L-*lyxo*-hexofuranoside (**9**, 48.3%; $[\alpha]_D$ −17°); the anomers could be separated by t.l.c. Furthermore, **9** (35.5%) was obtained by treatment of **7** with Raney nickel under hydrogen.

Hydrolysis of **9** with 0.2M hydrochloric acid gave daunosamine hydrochloride (**1**).

EXPERIMENTAL

General methods. — Melting points are uncorrected. Specific rotations were measured by an automatic polarimeter DIP-SL (JASCO). I.r. spectra were recorded with a DS-701 type (JASCO) instrument, and p.m.r. spectra with a JNM-C-60H (JEOL) spectrometer. Column chromatography was performed on 100-mesh silicic acid (Mallinckrodt Chem. Co.) with the solvent system specified. Amberlite CG-120(H^+) resin was prepared in the usual way.

Hydrolysis of methyl 3-azido-2-S-benzyl-4,6-O-benzylidene-3-deoxy-2-thio-α-D-altropyranoside (**2**). — (*a*) *With Amberlite CG-120(H^+) resin.* A mixture of resin (9.2 g) and a solution of **2** (2 g) in 80% methanol (200 ml) was stirred for 15 h at 55°, cooled, filtered through Celite, and concentrated *in vacuo*. The resulting syrup, $[\alpha]_D^{26}$ +52° (*c* 0.1, chloroform), was chromatographed with chloroform–ethyl acetate (4:1). Eluted first was 1,6-anhydro-3-azido-2-*S*-benzyl-3-deoxy-2-thio-β-D-altopyranose (**5a**.

m.p. 90–95°). Recrystallization from benzene–light petroleum gave colourless needles (17.1 mg, 1.2%), m.p. 99.5–100.5°, $[\alpha]_D^{27.5}$ −33.5° (*c* 0.95, chloroform); ν_{max}^{KBr} 3480 (OH), 2100 (N_3), and 710 cm^{-1} (phenyl). P.m.r. data δ 2.45 (broad, 1 H, OH), 2.84 (q, 1 H, $J_{1,2}$ 0.7, $J_{2,3}$ 10.6 Hz, H-2), 3.49 (q, 1 H, $J_{2,3}$ 10.6, $J_{3,4}$ 3.7 Hz, H-3), 3.89 (s, 2 H, CH_2-S), 4.48 (m, 1 H, H-5), and 5.27 (d, 1 H, $J_{1,2}$ 0.7 Hz, H-1).

Anal. Calc. for $C_{13}H_{15}N_3O_3S$: C, 53.24; H, 5.16; N, 14.33. Found: C, 53.33; H, 5.21; N, 14.37.

Eluted second was syrupy *A* (1.358 g, 86.5%; $[\alpha]_D^{17}$ +62°) which was a mixture of methyl 3-azido-2-*S*-benzyl-3-deoxy-2-thio-α-D-altropyranoside (**3a**) and methyl 3-azido-2-*S*-benzyl-3-deoxy-2-thio-αβ-D-altrofuranoside (**4a**).

Eluted third was 3-azido-2-*S*-benzyl-3-deoxy-2-thio-D-altrose (**6**) isolated as colourless needles (132.9 mg, 8.3%), m.p. 79–81°, $[\alpha]_D^{15}$ −56°→+2° (equil., *c* 0.27, methanol); ν_{max}^{KBr} 3400–3000 (OH), 2110 (N_3), and 715 cm^{-1} (phenyl). P.m.r. data: δ 3.35 (s, shifted to low field on addition of D_2O, OH of crystal water), 4.93 (q, 1 H, collapsed into a doublet on addition of D_2O, *J* 6 Hz, $J_{1,2}$ 1.5 Hz, H-1), and 6.62 (d, 1 H, disappeared on addition of D_2O, *J* 6 Hz, HO-1).

Anal. Calc. for $C_{13}H_{17}N_3O_4S \cdot H_2O$: C, 47.41; H, 5.82; N, 12.76. Found: C, 47.40; H, 5.83, N, 12.60.

The yields of **5a**, **6**, and *A* obtained on treatment of **2** (5 g) with Amberlite CG-120(H^+) resin in 80% methanol (500 ml) for various reaction times are listed in Table I.

(*b*) *With oxalic acid.* Oxalic acid (3 g) was added to a solution of **2** (1 g) in 80% acetone (100 ml). The mixture was boiled under reflux for 8 h and then cooled, neutralised ($BaCO_3$), filtered, and concentrated *in vacuo*. The syrupy residue was eluted from silicic acid with chloroform–ethyl acetate (1:1) to give **2** (300 mg, 30%), followed by syrupy methyl 3-azido-2-*S*-benzyl-3-deoxy-2-thio-α-D-altropyranoside (**3a**; 460 mg, 58.5%), $[\alpha]_D^{26}$ +45° (*c* 0.5, chloroform); ν_{max}^{liquid} 3550 (OH), 2110 (N_3), and 710 cm^{-1} (phenyl). P.m.r. data: δ 2.30 (s, 2 H, disappeared on addition of D_2O, OH), 3.01 (d, 1 H, $J_{2,3}$ 3 Hz, H-2), 3.71 (s, 3 H, OMe), 3.80 (s, 2 H, CH_2-S), and 4.63 (s, 1 H, H-1).

Anal. Calc. for $C_{14}H_{19}N_3O_4S$: C, 51.67; H, 5.88; N, 12.91. Found: C, 51.59; H, 6.04; N, 12.54.

1,6-Anhydro-3-azido-4-O-benzoyl-2-S-benzyl-3-deoxy-2-thio-β-D-altropyranose (**5b**). — Conventional treatment of **5a** (100 mg) with benzoyl chloride (75 mg) in pyridine (1 ml) gave a syrupy product which was eluted from silicic acid with chloroform to give **5b** (141.8 mg), m.p. 96–98°. Recrystallization from light petroleum gave colourless needles (110.8 mg, 82.1%), m.p. 99–100°, $[\alpha]_D^{23.5}$ −181° (*c* 0.59, chloroform); ν_{max}^{KBr} 2100 (N_3), 1740 (C=O), and 710 cm^{-1} (phenyl). P.m.r. data: δ 3.01 (d, 1 H, $J_{2,3}$ 10.6 Hz, H-2), 3.69 (q, 1 H, $J_{2,3}$ 10.6, $J_{3,4}$ 3.7 Hz, H-3), 4.78 (m, 1 H, H-5), 5.26 (q, 1 H, $J_{3,4}$ 3.7, $J_{4,5}$ 2.2 Hz, H-4), and 5.42 (s, 1 H, H-1).

Anal. Calc. for $C_{20}H_{19}N_3O_4S$: C, 60.45; H, 4.82; N, 10.58. Found: C, 60.21; H, 5.04; N, 10.48.

Methyl 3-azido-6-O-benzoyl-2-S-benzyl-3-deoxy-2-thio-α-D-altropyranoside (**3b**). — Conventional treatment of **3a** (91 mg) with benzoyl chloride–pyridine, followed by purification of the crude product by chromatography, gave **3b**, m.p. 95–105°. Recrystallization from methanol gave needles (104.5 mg, 79%), m.p. 110–111°, $[\alpha]_D^{26}$ +49° (*c* 0.5, chloroform); ν_{max}^{liquid} 3510 (OH), 2110 (N_3), 1710 (C=O), and 710 cm^{-1} (phenyl). P.m.r. data δ 2.45 (b, 1 H, OH), 3.30 (s, 3 H, OMe), 3.80 (s, 2 H, CH_2-S), 4.55 (s, 2 H, H-6,6'), and 4.69 (s, 1 H, H-1).

Anal. Calc. for $C_{21}H_{23}N_3O_5S$: C, 58.73; H, 5.40; N, 9.78. Found: C, 58.84; H, 5.51; N, 9.64.

Benzoylation of A (*mixture of* **3a** *and* **4a**). — Conventional treatment of *A* (2.8 g, obtained on treatment with the resin for 255 h), with purification by chromatography (elution with chloroform), gave first the syrupy dibenzoate of **3a** and **4a** (0.9 g, 19.6%), followed by syrupy methyl 3-azido-6-*O*-benzoyl-2-*S*-benzyl-3-deoxy-2-thio-αβ-D-altrofuranoside (**4b**; 1.92 g, 51.9%), $[\alpha]_D^{13}$ +56° (*c* 0.28, chloroform); ν_{max}^{liquid} 3510 (OH), 2100 (N_3), 1720 (C=O), and 710 cm^{-1} (phenyl). P.m.r. data δ 3.28 (s, OMe), 3.83 (s, CH_2-S), 4.57 (d, $J_{1,2}$ 4.5 Hz, H-1 of β anomer), and 4.77 (d, $J_{1,2}$ 1.5 Hz, H-1 of α anomer).

Anal. Calc. for $C_{21}H_{23}N_3O_5S$: C, 58.73; H, 5.40; N, 9.78. Found: C, 59.12; H, 5.27; N, 9.60.

Eluted third was **3b**. Recrystallization from methanol gave needles (1.60 g, 43.2%), m.p. 110–111°.

The yields of **3b** and **4b** obtained by benzoylation of *A*, obtained on treatment of **2** with the resin for different reaction times, are listed in Table II.

Methyl 5,6-anhydro-3-azido-2-S-benzyl-3-deoxy-2-thio-αβ-L-galactofuranoside (**7**). — Conventional treatment of **4b** (630 mg) with toluene-*p*-sulphonyl chloride (1.5 g) and pyridine (10 ml) gave a syrupy product which was eluted from silicic acid with chloroform to give syrupy 3-azido-6-*O*-benzoyl-2-*S*-benzyl-3-deoxy-5-*O*-toluene-*p*-sulphonyl-2-thio-αβ-D-altrofuranoside (**4c**); ν_{max}^{liquid} 2100 (N_3), 1720 (C=O), 1185, 1175 (SO_2), and 710 cm^{-1} (phenyl). Methanolic sodium methoxide (3 ml, from 120 mg of sodium) was added to a precooled solution of **4c** in chloroform (50 ml). The mixture was stored for 4 h and then poured into ice–water (30 ml). The chloroform layer was washed with water, dried (Na_2SO_4), and concentrated. The syrupy residue was eluted from silicic acid with benzene to give **7** as a colourless syrup (435.5 mg, 96.8%), $[\alpha]_D^{26}$ +80° (*c* 0.5, chloroform); ν_{max}^{liquid} 3050 (terminal epoxymethylene group), 2100 (N_3), and 700 cm^{-1} (phenyl).

Anal. Calc. for $C_{14}H_{17}N_3O_3S$: C, 54.72; H, 5.58; N, 13.68. Found: C, 54.77; H, 5.72; N, 13.55.

Hydrolysis of methyl 3-azido-2-S-benzyl-3-deoxy-2-thio-α-D-altropyranoside (**3a**). — A mixture of Amberlite CG-120(H^+) resin (460 mg) and a solution of **3a** (98.4 mg) in water (20 ml) was stirred for 17 h at 55° and then cooled, filtered through Celite, and concentrated. The syrupy residue (64.7 mg) was eluted from silicic acid with chloroform–ethyl acetate (4:1) to give first **5a** (4.4 mg, 4.5%), m.p. 98–99°, then *A* (**3a** and **4a**, 3.9 mg, 4.0%), and finally **6** (29.5 mg, 30.0%), m.p. 79–81°.

Methyl 3-amino-2-S-benzyl-3,6-dideoxy-2-thio-αβ-L-galactofuranoside (**8a**). — Lithium aluminium hydride (200 mg) was added to a solution of **7** (769.9 mg) in tetrahydrofuran (20 ml). The mixture was boiled under reflux for 1 h, and then cooled and poured into ice–water (20 ml). 2M Potassium hydroxide was added until all insoluble material had disappeared. The solution was extracted with chloroform, and the extract was washed with water, dried (Na_2SO_4), and concentrated *in vacuo*. The syrupy residue (820 mg) was eluted from silicic acid with chloroform–methanol (9.5:0.5) to give **8a** as a colourless syrup (559.3 mg, 72.2%), $[\alpha]_D^{17}$ −29° (*c* 1, chloroform); ν_{max}^{liquid} 3600–3200 (OH, NH_2) and 700 cm^{-1} (phenyl). P.m.r. data: δ 1.18 (d, $J_{5,6}$ 6 Hz, Me-6 of α anomer), 1.25 (d, $J_{5,6}$ 6 Hz, Me-6 of β anomer), 1.91 (s, OH and NH_2), 3.32 (s, OMe), 3.81 (s, CH_2-S), 4.54 (d, $J_{1,2}$ 4.5 Hz, H-1 of α anomer), and 4.77 (d, $J_{1,2}$ 1.5 Hz, H-1 of β anomer).

Methyl 3-benzamido-5-O-benzoyl-2-S-benzyl-3,6-dideoxy-2-thio-β-L-galactofuranoside (**8b**) *and -α-L-galactofuranoside* (**8c**). — Conventional treatment of **8a** with benzoyl chloride in pyridine, followed by fractionation of the product on silicic acid by elution with chloroform, gave first **8b**, m.p. 112–113°. Recrystallization from 60% ethanol gave colourless needles (182.4 mg, 70.7%), m.p. 147–148°, $[\alpha]_D^{19}$ +60° (*c* 0.25, chloroform); ν_{max}^{Nujol} 3300, 1690, 1640, 1555 (NH–C=O), 1730 (C=O), and 705 cm^{-1} (phenyl). P.m.r. data: δ 1.45 (d, 3 H, $J_{5,6}$ 6 Hz, Me-6), 3.33 (s, 3 H, OMe), 3.69 (s, 2 H, CH_2-S), and 4.93 (d, 1 H, $J_{1,2}$ 1.5 Hz, H-1).

Anal. Calc. for $C_{28}H_{29}NO_5S$: C, 68.40; H, 5.94; N, 2.84. Found: C, 68.53; H, 5.93; N, 2.77.

Eluted second was **8c**, m.p. 190–195°. Recrystallization from acetone gave colourless needles (51.9 mg, 19.9%), m.p. 205–206°, $[\alpha]_D^{19}$ −37° (*c* 0.24, acetone); ν_{max}^{Nujol} 3240, 1640, 1540 (NH–C=O), 1730 (C=O), and 700 cm^{-1} (phenyl). P.m.r. data: δ 1.42 (d, 3 H, $J_{5,6}$ 6 Hz, Me-6), 3.37 (s, 3 H, OMe), 3.88 (s, 2 H, CH_2-S), and 4.81 (d, 1 H, $J_{1,2}$ 4.5 Hz, H-1).

Anal. Calc. for $C_{28}H_{29}NO_5S$: C, 68.40; H, 5.94; N, 2.84. Found: C, 68.52; H, 5.70; N, 2.71.

Methyl 3-acetamido-2-S-benzyl-3,6-dideoxy-2-thio-β-L-galactofuranoside (**8d**) *and -α-L-galactofuranoside* (**8e**). — Conventional treatment of **8a** (100 mg) with acetic anhydride in pyridine and fractionation of the product by elution from silicic acid with chloroform–methanol (9.5:0.5) gave, first, syrupy **8d** (73.5 mg, 64.2%). Purification by chromatography gave a colourless syrup, $[\alpha]_D^{20.5}$ +96° (*c* 0.25, chloroform): ν_{max}^{liquid} 3400 (OH), 3300, 1655, 1550 (NH–C=O), and 700 cm^{-1} (phenyl). P.m.r. data: δ 1.25 (d, 3 H, $J_{5,6}$ 6 Hz, Me-6), 1.95 (s, 3 H, NAc), 2.58 (s, 1 H, OH), 2.88 (q, 1 H, $J_{1,2}$ 1.5, $J_{2,3}$ 3 Hz, H-2), 3.33 (s, 3 H, OMe), 3.84 (s, 2 H, CH_2-S), and 4.79 (d, 1 H, $J_{1,2}$ 1.5 Hz, H-1).

Anal. Calc. for $C_{16}H_{22}NO_4S$: C, 59.23; H, 6.83; N, 4.31. Found: C, 59.34; H, 7.07; N, 4.40.

Eluted second was **8e** (34.1 mg, 29.8%), m.p. 175–181°. Recrystallization from chloroform–light petroleum gave colourless needles, m.p. 190.5–191.5°, $[\alpha]_D^{20.5}$ −97 (*c* 0.25, chloroform); ν_{max}^{Nujol} 3500 (OH), 3240, 1650, 1550 (NH–C=O), and 720 cm^{-1}

(phenyl). P.m.r. data: δ 1.18 (d, 3 H, $J_{5,6}$ 6 Hz, Me-6), 1.90 (s, 3 H, NAc), 2.20 (s, 1 H, OH), 3.14 (q, 1 H, $J_{1,2}$ 4.5 Hz, H-2), 3.79 (s, 2 H, CH_2-S), and 4.61 (d, 1 H, $J_{1,2}$ 4.5 Hz, H-1).

Anal. Calc. for $C_{16}H_{22}NO_4S$: C, 59.23; H, 6.83; N, 4.31. Found: C, 59.06; H, 7.05; N, 4.23.

*Methyl 3-amino-2,3,6-trideoxy-αβ-*L-lyxo*-hexofuranoside* (**9**). — (*a*) To a suspension of Raney nickel W_4 (2 ml) in *p*-dioxane (9 ml) was added **8a** (187 mg). The mixture was heated on a boiling water-bath for 1 h and then cooled, filtered through Celite, and concentrated *in vacuo*. The syrupy residue (75 mg) was eluted from silicic acid with chloroform–methanol (3:1) to give **9** as a colourless syrup (62.8 mg, 48.3%), $[\alpha]_D^{22}$ −17° (*c* 1.3, methanol).

Anal. Calc. for $C_7H_{15}NO_3$: C, 52.15; H, 9.83; N, 8.61. Found: C, 51.83; H, 9.53; N, 8.27.

(*b*) To a suspension of Raney nickel (8 ml) in *p*-dioxane (15 ml) was added **7** (483 mg). The mixture was shaken under a stream of hydrogen for 2.5 h, filtered through Celite, and concentrated *in vacuo*. The syrupy residue was purified by chromatography with ethyl acetate–methanol (3:1) to give **9** as colourless syrup (90 mg, 35.5%).

Daunosamine hydrochloride (*3-amino-2,3,6-trideoxy-*L-lyxo*-hexose hydrochloride*) (**1**). — A solution of **9** (30 mg) in 0.2M hydrochloric acid (1 ml) was stored for 84 h at room temperature and then concentrated *in vacuo* to dryness. A solution of the resulting light-brown crystals in methanol (2 ml) was treated with charcoal, filtered, concentrated to ~1 ml, and treated with acetone to give white powdery crystals of **1** (23 mg, 67.4%), m.p. 166–168° (dec.), $[\alpha]_D^{27}$ −52.5° (*c* 0.25, water); lit.[2] m.p. 168° (dec.), $[\alpha]_D$ −54.5°; lit.[3] m.p. 160° (dec.), $[\alpha]_D$ −54.2°.

Anal. Calc. for $C_6H_{13}NO_3 \cdot HCl$: C, 39.24; H, 7.68; N, 7.63. Found: C, 39.47; H, 7.54; N, 7.34.

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