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REACTION OF DERIVATIVES OF METHYL 2,3-*O*-BENZYLIDENE-6-DEOXY-α-L-MANNOPYRANOSIDE WITH BUTYLLITHIUM: SYNTHESIS OF METHYL 2,6-DIDEOXY-4-*O*-METHYL-α-L-*erythro*-HEXOPYRANOSID-3-ULOSE*

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ABSTRACT

Methyl 2,3-*O*-benzylidene-6-deoxy-α-L-mannopyranoside (**2**) reacted with butyllithium to give a mixture of 1,5-anhydro-3-*C*-butyl-1,2,6-trideoxy-L-*ribo*-hex-1-enitol (**3**) and its L-*arabino* analogue (**4**), together with methyl 2,3,6-trideoxy-α-L-*erythro*-hex-2-enopyranoside (**5**). In contrast, the 4-*O*-methyl analogue (**8**) of **2** was converted by butyllithium into methyl 2,6-dideoxy-4-*O*-methyl-α-L-*erythro*-hexopyranosid-3-ulose (**9**), which was further characterized as its oxime **10**. The 4-*O*-benzyl analogue of **8**, obtained as two separate diastereoisomers (**6** and **7**) differing in configuration at C-2 of the dioxolane ring, gave a complex mixture of products on treatment with butyllithium.

INTRODUCTION

This work[1] is concerned with evaluation of the scope of the useful synthetic reaction of Klemer and Rodemeyer[2] whereby methyl 2,3:4,6-di-*O*-benzylidene-α-D-mannopyranoside is converted by action of butyllithium into methyl 4,6-*O*-benzylidene-2-deoxy-α-D-*erythro*-hexopyranosid-3-ulose; this reaction has been utilized in a high-yielding synthesis[3] of daunosamine (3-amino-2,3,6-trideoxy-L-*lyxo*-hexose) and its 5-epimer[4] (D-ristosamine). Daunosamine is the carbohydrate constituent of the anthracycline antibiotics daunorubicin and adriamycin. Both of these antibiotics, adriamycin in particular, have shown promise as anticancer agents in clinical use[5,6], although a disadvantage of adriamycin is the cardiotoxic behavior manifested at dose-levels most effective in treating tumors.

This investigation is part of a program designed to afford practical syntheses of daunosamine and its stereochemical variants, for coupling to appropriate aglycons to furnish analogues of adriamycin for antitumor evaluation. As the generality of the reaction of butyllithium with 5-membered benzylidene acetal rings has not been

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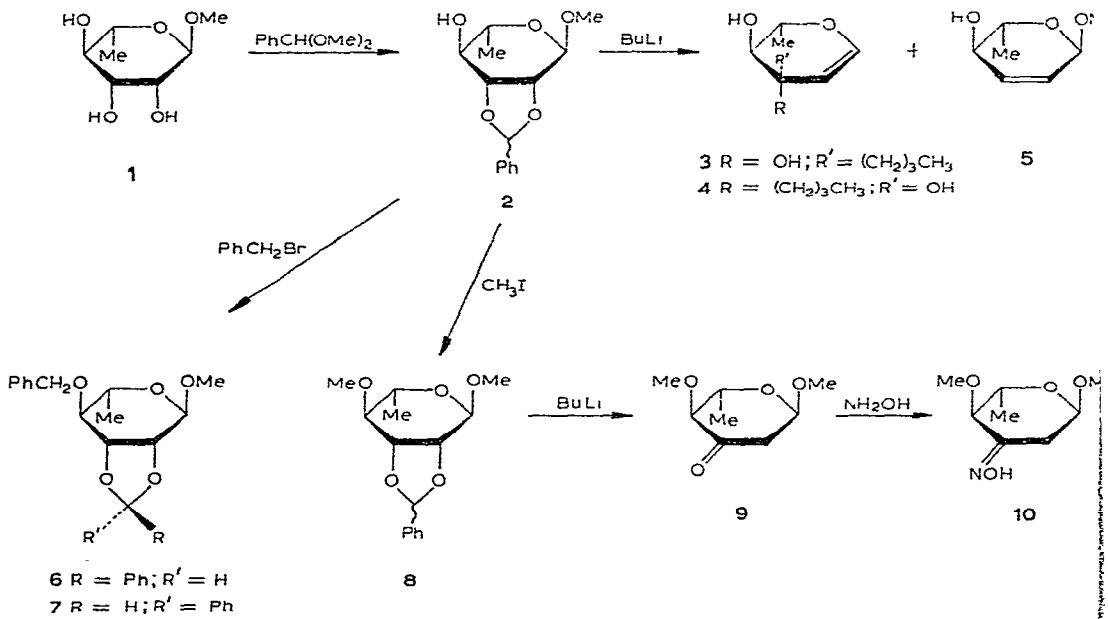
established, the behavior of methyl 2,3-*O*-benzylidene-6-deoxy-α-L-mannopyranoside (methyl 2,3-*O*-benzylidene-α-L-rhamnopyranoside, **2**) with the reagent was of interest; succesful generation of the requisite 2-deoxy 3-keto product would permit a simple and direct access, *via* an oximation–reduction sequence, to the L-*ribo* and L-*arabino* analogues (ristosamine[7] and acosamine[8], respectively) of daunosamine.

DISCUSSION

Methyl α-L-rhamnopyranoside (**1**) was benzylidenated with α,α-dimethoxytoluene by the general procedure previously used[3,9], to give the 2,3-benzylidene acetal **2** as a syrup that migrated as a single spot in t.l.c. The n.m.r. spectrum (Table I) of the product showed two signals of equal intensity for the benzylic, anomeric, and methoxyl protons, indicating that compound **2** was a mixture of two forms diastereoisomeric at the acetal position of the dioxolane ring.



Treatment of the acetal **2** with a 3-molar excess of butyllithium in tetrahydrofuran at −30° gave no reaction, but at 0° **2** was converted into a mixture of three new products that were isolated by t.l.c., together with unreacted starting material. One product was a syrup that appeared to be methyl 2,3,6-trideoxy-α-L-*erythro*-hex-2-enopyranoside (**5**), as determined from a detailed analysis of its n.m.r. spectrum and by comparison with n.m.r. data recorded in the literature[10] for the D enantiomer. This compound presumably arises from the 4-oxyanion of **2** by abstraction of the acetal hydrogen atom and subsequent elimination[11] of a benzoate anion.

TABLE I

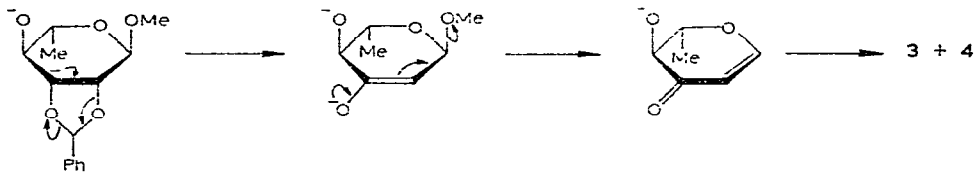
100-MHz N.M.R. SPECTRAL DATA FOR COMPOUNDS 2–10

Compound[a]	*Chemical shifts (δ)*[b] *(first-order couplings, Hz, in parentheses)*												
	H-1 ($J_{1,2e}$)	*H-2e* ($J_{2e,2a}$)	*H-2a* ($J_{1,2a}$)	*H-3* ($J_{2e,3}$)	*H-4* ($J_{3,4}$)	*H-5* ($J_{4,5}$)	*H-6* ($J_{5,6}$)	*Aryl*	*PhCH*	*PhCH₂*	*OMe*	*OH*	*Butyl*
2[c]	4.89d (1.0) 4.96d (1.0)	←———		3.25–4.50m		———→	1.22d (6.0) 1.28d (6.0)	7.20–7.60m	5.86s 6.09s		3.33s 3.36s	2.95s	
3 (or 4)	6.37d (6.0)	4.78d			3.28t	3.73dq (10.0)	1.36d (6.0)					2.54d (10.0) 1.94s	0.60–1.80m
4 (or 3)	6.22d (6.3)	4.67d			3.63d	3.97dq (10.0)	1.33d (6.0)					3.33s 2.47s	0.70–1.80m
5[d]	4.82dd (1.0)	5.93dd		5.70ddd[e] (10.3)	3.50——3.90m (2.0)		1.29d (6.0)				3.40s	2.72s	
6[d]	4.90s	4.11d		5.59dd (5.8)	3.33dd (7.0)	3.74dq (10.0)	1.31d (6.0)	7.20–7.60m	6.05s	4.83q	3.34s		
7[d]	4.98s	4.19d		4.40t (6.5)	3.24dd (6.5)	3.73dq (10.0)	1.24d (6.0)	7.10–7.60m	5.89s	4.68q	3.36s		
8[c]	4.96d (1.0) 4.89d (1.0)	←———		2.80–4.55m		———→	1.23d (6.0) 1.30d (7.0)	7.15–7.65m	6.14s 5.87s		3.44s, 3.32s 3.56s, 3.55s		
9	5.01dd (1.5)	2.52dd (14.0)	2.75dd (4.3)		3.40d	3.91dq (9.3)	1.35d (6.0)				3.50s, 3.31s		
10	4.30dd (2.8)	3.18dd (15.0)	2.46dd (4.5)		3.41d	3.91dq (8.0)	1.28d (6.3)				3.46s, 3.33s	9.48s	

[a]In chloroform-*d*. [b]Signal multiplicities: d, doublet; m, multiplet; q, quartet; s, singlet; t, triplet. [c]Two diastereoisomers present. [d]Assignments confirmed by spin decoupling. [e]Long-range coupling $J_{1,3}$ 2.5 Hz.

The other two products were obtained crystalline and are isomers having the molecular formula $C_{10}H_{18}O_3$. When the reaction was conducted at room temperature with **2** and a larger excess of butyllithium, these two compounds were the only products isolated, the isomer having m.p. 88–89° being obtained in 17% yield and the one melting at 67–68° in 44% yield. Both compounds showed infrared absorption for a glycal type of system, and their n.m.r. (Table I) and mass (Table II) spectra showed that the methoxyl group was absent but that a *C*-butyl group was present. Detailed analysis of the n.m.r. and mass spectra indicated that these compounds were 1,5-anhydro-3-*C*-butyl-1,2,6-trideoxy-L-*arabino*-hex-1-enitol (**3**) and its L-*ribo* epimer (**4**). Individual attribution of the two compounds was not undertaken, nor was degradative proof secured for the stereochemistry assigned at C-4 and C-5.

It appears probable that **3** and **4** arise from the 4-oxyanion of **2** by initial abstraction of H-3 and release of benzaldehyde to give the enolate of the desired 2-deoxy 3-ketone, which undergoes subsequent elimination of methoxide ion to give the 1-ene-3-one (Scheme 1). The latter would react at once with butyllithium to produce the observed tertiary alcohols **3** and **4**.



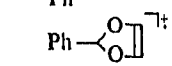
Scheme 1

The failure of **2** to afford the 2-deoxy 3-ketone on treatment with butyllithium may be ascribed to the presence of the 4-hydroxyl group; the 4-oxyanion formed on initial reaction with the reagent would impede abstraction of a second proton, necessitating more-vigorous reaction conditions and leading to the observed elimination-products. It was considered that etherified derivatives of **2** would more closely resemble the fully protected derivative used in the preceding work[3], and accordingly, the 4-benzyl and 4-methyl ethers of **2** were prepared.

Benzylation[12] of **2** gave an 87% yield of the 4-benzyl ether, which was produced as a mixture of diastereoisomers separable by column chromatography into the crystalline (*2'S*) isomer **6** and the syrupy (*2'R*) isomer **7**. The configurational assignments for **6** and **7** are based on the n.m.r. spectroscopic method of Foster and coworkers[13], who showed that the benzylic proton (H-2) in 2-phenyldioxolane derivatives resonates at high field when it is *cis* to protons at C-4 and C-5, whereas it resonates at lower field when H-2 is *cis* to substituents at C-4 and C-5. The crystalline product was assigned as the *2'S* isomer because the benzylidene proton (H-2') resonated at δ 6.05, whereas the syrup showed the H-2' resonance at higher field (δ 5.89).

TABLE II

MASS-SPECTRAL DATA FOR COMPOUNDS 2–4 AND 6–10

m/e *of principal fragments* (% *of base peak*)				*Assignment*	m/e *of principal fragments* (% *of base peak*)				*Assignment*
2	**6**	**7**	**8**		**3**	**4**	**9**	**10**	
267(0.7)	357(0.1)	357(0.7)	281(1.2)	M+1	187(0.1)	187(0.2)	175(0.25)	190(0.1)	M+1
266(5)	356(0.7)	356(3)	280(7)	$M^{\ddagger}$	186(1.5)	186(1.25)	174(3)	189(0.1)	$M^{\ddagger}$
265(2)	355(0.04)	355(0.2)	279(0.85)	M−1			173(0.1)	188(0.25)	M−1
235(3)	325(0.3)	325(1.1)	249(3.9)	M−MeO·	129(100)	129(100)			$M-C_4H_9\cdot$
234(1.1)	324(0.06)	324(0.05)	248(1)	M−MeOH	111(12)	111(10.5)			$M-C_4H_9\cdot-H_2O$
206(0.4)			220(0.4)	$M-HCO_2Me$	168(4)	168(6)			$M-H_2O$
160(1.1)	250(0.3)	250(0.9)	174(0.3)	M−PhCHO	153(4.5)	153(5)			$M-H_2O-Me\cdot$
189(0.4)	279(0.02)	279(0.02)	203(0.4)	M−Ph·	128(0.2)	128(0.2)			$M-C_4H_{10}$
143(1.9)	233(0.3)	233(0.5)	157(0.5)	$M-Ph\cdot-HCO_2H$	110(0.7)	110(1)			$M-C_4H_{10}-Me\cdot$
159(2.5)	249(1.1)	249(4.5)	173(0.6)	$M-H\cdot-PhCHO$			143(10)	158(14.5)	M−MeO·
143(1.9)	233(0.3)	233(0.5)	157(0.5)	$M-H\cdot-PhCO_2H$			111(0.5)	126(9.5)	M−MeO·−MeOH
106(18.5)	106(3)	106(1.5)	106(11.5)	$PhCHO^{\ddagger}$			130(40)	145(100)	M−MeCHO
105(60)	105(11.5)	105(7)	105(36)	$PhCO^{+}$			72(100)		$MeOC^4H=C^3=O^{\ddagger}$
91(50)	91(100)	91(100)	91(36)	$PhCH_2^{+}$			72(100)		$MeC^5H=C^4HOMe^{\ddagger}$
77(30)	77(7)	77(4)	77(26)	Ph^{+}			42(5)		$CH_2CO^{\ddagger}$
148(100)	148(30)	148(24)	148(100)				146(0.03)		M−CO

Butyllithium failed to effect a straightforward transformation of the benzylated acetal **6** in tetrahydrofuran or in benzene; at low temperature (−30°), no reaction was evident, and more-vigorous conditions led to a complex mixture of products. It was concluded that the reagent probably acts by initial abstraction of a proton from the benzyl group, again impeding removal of a second proton from the dioxolane ring. Accordingly, the 4-methyl ether (**8**) of **2** was prepared to furnish a compound free of such labile hydrogen atoms.

The methyl ether **8** reacted readily with butyllithium at −30° and the reaction was complete after 30 min. The major product, isolated crystalline in 40% yield, was the desired 2-deoxy 3-ketone **9**; it was first obtained by chromatography but it could also be isolated directly from the reaction mixture. The assigned structure **9** is fully supported by n.m.r. and mass-spectral data. Hydroxylamine converted[14] **9** into the corresponding, crystalline oxime **10** in 87.5% yield.

Further details of n.m.r.- and mass-spectral assignments on new compounds described in this work are recorded in Tables I and II.

The foregoing results verify, by the conversion **8**→**9**, that the synthesis of a deoxy ketone in one step from a vicinal benzylidene acetal is feasible in systems other than the one first reported[2,3]. The present results indicate that hydroxylated precursors or their benzyl ethers are not suitable for the reaction.

The ready access to the oxime **10** provided by this synthesis offers the potential for a convenient preparation, by reduction followed by hydrolysis, of 3-amino-2,3,6-trideoxy-4-*O*-methyl-L-*ribo*-hexose and its *arabino* epimer (actinosamine[8]), with the former preponderating. Demethylation of the products with boron trichloride[15] would be expected to yield the corresponding unsubstituted amino sugars (ristosamine[7] and acosamine[8]).

EXPERIMENTAL

General methods. — Evaporations were performed under diminished pressure. Melting points were determined with a Thomas–Hoover apparatus and are uncorrected. A Perkin–Elmer Model 141 polarimeter and 1-dm tubes were used for measurement of specific rotations. I.r. spectra were recorded with a Perkin–Elmer Model 137 "Infracord" i.r. spectrometer. N.m.r. spectra were recorded at 100 MHz with a Varian HA-100 spectrometer; chemical shifts refer to an internal standard of tetramethylsilane ($\delta = 0.00$), and are recorded, together with spin-coupling values (Hz), in Table I. T.l.c. was performed with Silica Gel G (E. Merck, Darmstadt, Germany) activated at 120°. Solvent volumes are v/v, petroleum ether refers to the fraction boiling at 30–60°. Detection was by u.v. light and with sulfuric acid. Column chromatography was conducted with silica gel Merck No. 7734 (0.063–0.200 mm). Microanalyses were performed by W. N. Rond. Mass spectra were recorded by C. R. Weisenberger wih an AEI MS-9 double-focusing, high-resolution spectrometer operating at an ionizing potential of 70 eV and an accelerating potential of 8 kV; the source temperature (direct-inlet system) was 150°. Data and probable

assignments are recorded in Table II. X-Ray powder diffraction data give interplanar spacings, Å, for CuKα radiation. The camera diameter was 114.59 mm. Relative intensities were estimated visually: m, moderate; s, strong; v, very; w, weak. The strongest lines are numbered (1, strongest); double numbers indicate approximately equal intensities.

Methyl α-L-rhamnopyranoside (**1**). — This compound was prepared by an adaptation of the procedure of Smith *et al.*[16]. A mixture of L-rhamnose hydrate (59 g), anhydrous methanol (875 ml), and Amberlite IR-120 (H^+) resin (59 g, previously washed with methanol and kept under anhydrous methanol for 24 h) was boiled under reflux with the condensate passing through a Soxhlet apparatus containing molecular sieves (Linde, type 3A). After 16 h, t.l.c. (6:3:1 dichloromethane–ethyl acetate–ethanol) showed that no starting material remained and that a component having faster mobility than **1** had disappeared. Crystallization from ethyl acetate[17] gave **1** (48 g, 75%), m.p. 107–109°, $[\alpha]_D^{25}$ −79° (*c* 2, methanol) (lit.[18] m.p. 108–109°, $[\alpha]_D$ −62.5° in water).

Methyl 2,3-O-benzylidene-6-deoxy-α-L-mannopyranoside (**2**). — By the benzylidenation procedure previously used[3,9], a mixture of **1** (5 g, 28 mmoles), α,α-dimethoxytoluene (5 g, 33 mmoles), and *p*-toluenesulfonic acid monohydrate (0.1 g) in *N,N*-dimethylformamide (30 ml), contained in a 100-ml flask fitted with an air condenser attached to a water aspirator, was stirred for 5 h at 70–75°. After this time, no starting material remained (t.l.c., 3:2 petroleum ether–ether) and the mixture was poured into ice–aqueous sodium hydrogen carbonate. The syrupy product was extracted with chloroform and the extract was washed with water, dried (magnesium sulfate), and evaporated to give **2** as a chromatographically homogeneous (t.l.c.) syrup; yield 9.2 g (96%). This product could be used without further purification.

An analytically pure sample of **2** was obtained by distillation; b.p. 170–185° (0.01 torr), $[\alpha]_D^{22}$ −21° (*c* 3.2, chloroform).

Anal. Calc. for $C_{14}H_{18}O_5$ (266.296): C, 63.16; H, 6.77. Found: C, 62.95; H, 7.08.

Methyl 4-O-benzyl-2,3-O-(2′S)-benzylidene-6-deoxy-α-L-mannopyranoside (**6**) *and its 2′R isomer* (**7**). — The acetal **2** (4.0 g, 15 mmoles) was benzylated in *N,N*-dimethylformamide by use of sodium hydride and α-bromotoluene according to a standard procedure[12]. The product was shown by t.l.c. (9:1 petroleum ether–ether) to be free from starting material and to contain two faster-migrating components of similar mobility. These were separated on a column of silica gel that was eluted with 19:1 petroleum ether–ether. The faster-migrating component crystallized and was recrystallized from petroleum ether to give **6** (1.53 g), m.p. 96–97°, $[\alpha]_D^{25}$ −70° (*c* 1, chloroform); X-ray powder diffraction data: 11.47 s (1), 8.42 m, 5.94 s, 5.55 s (3,3), 4.62 w, 4.46 s (2), 4.20 m, 4.02 m, 3.83 w, 3.71 w, 3.53 s (3,3), and 3.32 m.

Anal. Calc. for $C_{21}H_{24}O_5$ (356.422): C, 70.79; H, 6.74. Found: C, 70.66; H, 7.01.

The slower-moving component, which was homogeneous by t.l.c. (4:1 petroleum ether–ether), was syrupy **7** (0.68 g); $[\alpha]_D^{25}$ −34° (*c* 1.7, chloroform).

Anal. Calc. for $C_{21}H_{24}O_5$ (356.422): C, 70.79; H, 6.74. Found: C, 71.25; H, 6.94.

The total yield of **6** and **7** recovered from the column was 4.6 g (86%).

Methyl 2,3-O-benzylidene-6-deoxy-4-O-methyl-α-L-mannopyranoside (**8**). — The acetal **2** (10 g, 38 mmoles) in *N,N*-dimethylformamide was methylated with sodium hydride and methyl iodide by a standard procedure[12]. The syrupy product was distilled to give pure **8** as a mixture of diastereoisomers at C-2′; yield 7.5 g (71%), b.p. 110–123° (0.03 torr), $[\alpha]_D^{25}$ −40° (*c* 2.5, chloroform); R_F 0.58 and 0.52 (4:1 petroleum ether–ether).

Anal. Calc. for $C_{15}H_{20}O_5$ (280.323): C, 64.29; H, 7.14. Found: C, 64.24; H, 7.09.

Reaction of methyl 2,3-O-benzylidene-6-deoxy-α-L-mannopyranoside (**2**) *with butyllithium.* — A solution of **2** (2 g, 7.5 mmoles) in commercial abs. tetrahydrofuran (75 ml), kept under nitrogen, was cooled to −30°. Butyllithium in hexane (2.4M, 10 ml, 24 mmoles) was added and the temperature was maintained below −30°. After 1.5 h, t.l.c. (3:2 petroleum ether–ether) showed that only **2** was present. The mixture was allowed to warm to 0° and was kept for 1 h at this temperature, whereupon t.l.c. (3:2 petroleum ether–ether) showed the presence of starting material (R_F 0.45, major) and two slower-migrating components having R_F 0.21 and 0.15. No further change was detected by t.l.c. during the next 3 h, and the mixture was then poured into ice–water (40 ml) containing ammonium chloride (5 g). The mixture was extracted with chloroform and the extract was washed with water, dried (magnesium sulfate), and evaporated *in vacuo*. The resulting syrup was placed on a column of silica gel, and elution with the t.l.c. solvent gave the separate components having R_F 0.45, 0.21, and 0.15.

The component having R_F 0.45 (0.34 g) partially crystallized, and the crystalline product was filtered off to give a compound (53 mg) having a slightly lower R_F value (0.40). T.l.c. examination of the filtrate showed that only the starting material **2** (R_F 0.45) was present. Recrystallization of the solid from petroleum ether gave *1,5-anhydro-3-C-butyl-1,2,6-trideoxy-*L-arabino(or L-ribo)*-hex-1-enitol* (**3** or **4**); m.p. 88–89°, $[\alpha]_D^{25}$ −110° (*c* 0.7, chloroform); ν_{max}^{KBr} 3350 (OH), 1660 cm^{-1} (C=C); X-ray powder diffraction data: 14.36 m (2), 10.33 m (1,1,1), 9.30 w, 8.38 m (1,1,1), 7.37 w, 6.53 w, 5.75 m (1,1,1), 5.04 m, 4.84 m, 4.54 m, 4.20 m, 4.07 w, and 3.83 m.

Anal. Calc. for $C_{10}H_{18}O_3$ (186.252): C, 64.50; H, 9.67. Found: C, 63.97; H, 9.97.

The component having R_F 0.21 was obtained as a syrup; yield 0.11 g, identified as *methyl 2,3,6-trideoxy-α-L-*erythro*-hex-2-enopyranoside* (**5**), $[\alpha]_D^{25}$ −115° (*c* 0.66, chloroform).

The component having R_F 0.15 (0.11 g) crystallized and was recrystallized from petroleum ether to give *1,5-anhydro-3-C-butyl-1,2,6-trideoxy-*L-ribo(*or* L-arabino)*-hex-1-enitol* (**4** or **3**); m.p. 67–68°, $[\alpha]_D^{25}$ −88° (*c* 1, chloroform); ν_{max}^{KBr} 3400 (OH), 1650 cm^{-1} (C=C); X-ray powder diffraction data: 12.99 m (2), 7.43 w, 5.52 m, 5.32 w, 4.82 s (1), 3.87 m (3), 3.62 m, and 3.46 w.

Anal. Calc. for $C_{10}H_{18}O_3$ (186.252): C, 64.50; H, 9.67. Found: C, 64.80; H, 9.92.

In a second experiment, a solution of **2** (2 g, 7.5 mmoles) in commercial abs. tetrahydrofuran (75 ml) under nitrogen was treated at room temperature with butyllithium in hexane (2.4M, 10 ml, 24 mmoles). Additional quantities of butyllithium in hexane (portions of 5 ml, 12 mmoles) were added after 1 and 2 h. After 3 h, no starting acetal **2** was evident by t.l.c., and only two products (R_F 0.40 and 0.15) were observed. These products gave distinctive purple spots when the t.l.c. plates were sprayed with 10% sulfuric acid in ethanol and then heated, whereas the starting material gave a brownish-black spot. The product mixture was processed as in the preceding experiment, and column chromatography gave **3** (or **4**) (m.p. 88–89°, 0.24 g, 17%) and **4** (or **3**) (m.p. 67–68°, 0.62 g, 44%), identical with samples prepared by the first procedure.

*Methyl 2,6-dideoxy-4-*O*-methyl-α-*L*-*erythro*-hexopyranosid-3-ulose* (**9**). — A solution of the acetal **8** (0.56 g, 2 mmoles) in commercial abs. tetrahydrofuran (15 ml) under nitrogen was cooled to −30°. Butylithium in hexane (2.5M, 2 ml, 5 mmoles) was added and the temperature was kept below −30°. After 0.5 h, t.l.c. (4:1 petroleum ether–ether) showed no remaining **8** (R_F 0.58 and 0.52), but six other components were present, the strongest one having R_F 0.21. The mixture was processed as in the preceding experiments and the syrupy product was placed on a column of silica gel. Elution with 4:1 petroleum ether–ether gave the components having R_F 0.21 (33 mg) and R_F 0.17 (140 mg, 40%). None of the other components observed by t.l.c. were isolated in appreciable yield. The component having R_F 0.17 crystallized and was recrystallized from petroleum ether to give pure **9**; m.p. 71–72°, $[\alpha]_D^{25}$ −301° (*c* 1, chloroform); ν_{max}^{KBr} 1735 cm^{-1} (C=O); X-ray powder diffraction data: 10.91 m, 9.60 m, 7.43 s (2), 6.75 s (3), 4.74 m, 4.24 vs (1), 3.96 m, 3.72 m, 3.53 m, 3.39 m, 3.25 m, 3.11 w, 2.96 w, 2.84 m, 2.76 m, and 2.62 m.

Anal. Calc. for $C_8H_{14}O_4$ (174.199): C, 55.17; H, 8.05. Found: C, 55.36; H, 8.12.

In subsequent experiments, the ketone **9** could be isolated directly in 26% yield, without chromatography, by adding petroleum ether to the syrupy product and cooling the solution in Dry Ice. The product crystallized and could be recovered by filtration of the cold mixture. Evaporation of the filtrate and column chromatography of the residue afforded a further 14% of **9**.

*Methyl 2,6-dideoxy-4-*O*-methyl-α-*L*-*erythro*-hexopyranosid-3-ulose oxime* (**10**). — The ketone **9** (200 mg, 1.15 mmoles) was oximated by the general procedure previously described[14] to give **10**; yield 0.19 g (87.5%), m.p. 108–109°, $[\alpha]_D^{25}$ −280° (*c* 0.8, chloroform); ν_{max}^{KBr} 3330 (OH), 1670 cm^{-1} (C=N); X-ray powder diffraction data: 7.76 vs (2), 6.94 w, 6.28 s (4), 5.17 m, 4.36 vs (1), 4.15 m, 3.96 m, 3.79 s, 3.73 vs (3), 3.10 w, 2.88 m, 2.59 s, 2.22 w, 2.11 m, and 1.98 m.

Anal. Calc. for $C_8H_{15}NO_4$ (189.214): C, 50.79; H, 7.94; N, 7.41. Found: C, 50.57; H, 7.80; N, 7.38.

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