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β-ELIMINATION IN ALDONOLACTONES. SYNTHESIS OF 3,6-DIDEOXY-L-*arabino*-HEXOSE (ASCARYLOSE)

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ABSTRACT

Benzoylation of L-rhamnono-1,5-lactone (**1**) with an excess of benzoyl chloride and pyridine for 16 h afforded 2,4-di-*O*-benzoyl-3,6-dideoxy-L-*erythro*-hex-2-enono-1,5-lactone (**2**). Catalytic hydrogenation of **2** was stereoselective and gave crystalline 2,4-di-*O*-benzoyl-3,6-dideoxy-L-*arabino*-hexono-1,5-lactone (**3**). Reduction of the lactone **3** with disiamylborane afforded 2,4-di-*O*-benzoyl-3,6-dideoxy-L-*arabino*-hexopyranose (**4**) which, on debenzoylation, gave 3,6-dideoxy-L-*arabino*-hexose (ascarylose) (**7**) in good overall yield. The sugar was identified as the corresponding alditol (ascarylitol) and by convertion into methyl 3,6-dideoxy-α-L-*arabino*-hexopyranoside (methyl ascaryloside, **6**).

INTRODUCTION

In previous papers, we have reported the formation of di- and tri-unsaturated derivatives on benzoylation of aldono-1,4-lactones[1–3]. When the reaction was applied to D-glucono-1,5-lactone, the mono-unsaturated derivative was obtained in excellent yield[4]. Catalytic hydrogenation was stereoselective and gave crystalline 2,4,6-tri-O-benzoyl-3-deoxy-D-*arabino*-hexono-1,5-lactone. The ease of formation of deoxy lactone derivatives *via* β-elimination reactions suggested application for the synthesis of deoxy sugars. Thus, 2-deoxy-D-*erythro*-pentose was obtained by oxidative degradation of 3-deoxy-D-*arabino*-hexono-lactone with ceric sulfate[5].

We now report a convenient synthesis of ascarylose** (**7**) in four steps from L-rhamnono-1,5-lactone (**1**). The deoxy group in C-3 is introduced through stereoselective hydrogenation of the 2-enonolactone obtained by benzoylation under conditions that favor β-elimination.

Ascarylose, the enantiomorph of tyvelose, is a component of the glycolipids

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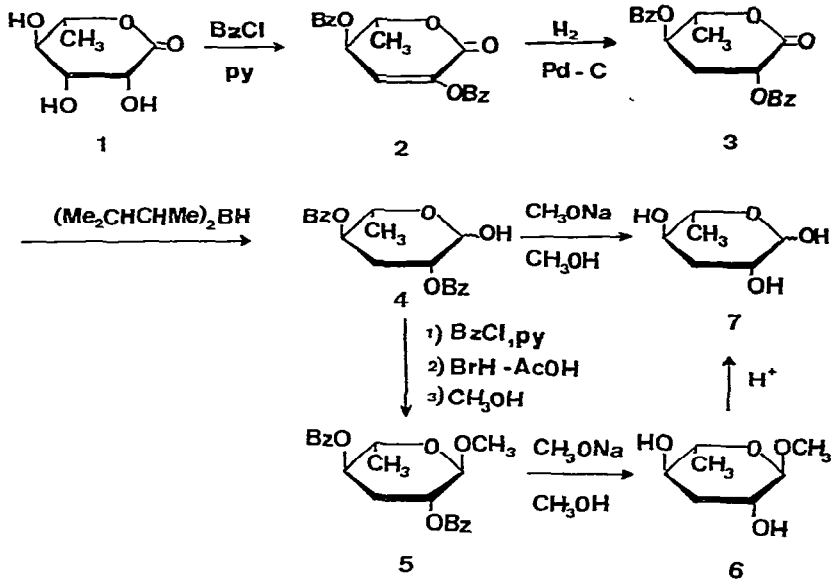
***Note added in proof.*— After the preparation of our manuscript, J.-C. Florent, C. Monneret, and Q. Khuong-Huu [*Carbohydr. Res.*, 56 (1977) 301–314] reported on the synthesis of crystalline ascarylose.



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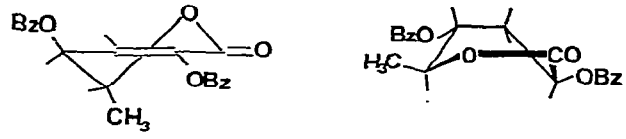

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ascarosides A, B, and C isolated from the eggs of a tapeworm (*Parascaris equorum*)[6-8], and has been characterized as a constituent of a specific lipopolysaccharide from *Pasteurella pseudotuberculosis*[9].

In general, 3,6-dideoxyhexoses occur at the nonreducing ends of lipopolysaccharides and constitute immunodominant groups of their respective antigenic determinants[10]. Because of their biological significance, several syntheses have been reported in recent years[11-13], but none of them deal with ascarylose. Monneret *et al.*[14] have recently described the synthesis of methyl 4-*O*-methylascaryloside in 27% yield from methyl α-L-rhamnopyranoside.

RESULTS AND DISCUSSION

L-Rhamnono-1,5-lactone (**1**), obtained by oxidation of L-rhamnose[15] with bromine, was benzoylated with a fourfold excess of benzoyl chloride and pyridine. Under these conditions, elimination of the benzoyloxy group β to the lactone carbonyl-group takes place, as already reported for D-glucono-1,5-lactone[4]. Aldono-1,4-

lactones may undergo multiple elimination to give the more-stabilized compound[1,3].

2,4-Di-*O*-benzoyl-3,6-dideoxy-L-*erythro*-hex-2-enono-1,5-lactone (**2**) was obtained crystalline in 87% yield. Its i.r. spectrum showed carbonyl absorptions at 1720 (benzoate C=O), 1730 (α,β-unsaturated 1,5-lactone), and 1735 cm^{-1} (vinyl benzoate C=O).

The ^{1}H-n.m.r. spectrum of **2** was in accordance with the postulated structure and suggested that the compound exists in the $^0H_5$ conformation (**8**). The observed value of 5 Hz for $J_{4,5}$ is more consistent with a *quasi*-diequatorial than with a *quasi*-diaxial orientation for these two protons. Similarly, a *quasi*-equatorial orientation for H-4 is supported by the observed value of 5 Hz for $J_{3,4}$, which corresponds to a dihedral angle of 45° between vicinal allylic and vinylic C-H protons[16]. Although both the 5-methyl and 4-benzoyl groups are *quasi*-axial in the $^0H_5$ conformation, there are no other substituents oriented unfavorably to the former group, and the latter, being an allylic ester, is probably *quasi*-axial, as in related glycal derivatives[17]. The fact that H-3 and H-5 in **2** are long-range coupled further supports the $^0H_5$ conformation assigned to the enono-lactone. Analogous derivatives in the D series are reported to exist mainly in the $^5H_0$ conformation, as for instance 2,4,6-tri-*O*-acetyl-3-deoxy-D-*erythro*-hex-2-enono-1,5-lactone[18], 2,4-di-*O*-acetyl-3-deoxy-D-*glycero*-hex-2-enono-1,5-lactone[18],and 2,4,6-tri-*O*-benzoyl-3-deoxy-D-*erythro*-hex-2-enono-1,5-lactone[4].

Catalytic hydrogenation of **2** over palladium was stereoselective and gave crystalline 2,4-di-*O*-benzoyl-3,6-dideoxy-L-*arabino*-hexono-1,5-lactone (**3**) in ~90% yield. This stereoselectivity may be explained by considering that the enono-1,5-lactone reacted in the $^0H_5$ conformation; the *quasi*-axial C-5 methyl group would then prevent attack from below the ring. In the case of 2,4,6-tri-*O*-benzoyl-3-deoxy-D-*erythro*-hex-2-enono-1,5-lactone, hydrogenation also occurred from the site of the *quasi*-axial, allylic, benzoyl group[4].

The ^{1}H-n.m.r. spectrum of **3** showed $J_{2,3}$ and $J_{2,3'}$ values of ~9 Hz, which suggest a distorted-boat conformation (**9**) for this compound. These large coupling-values require that H-2 should lie outside the dihedral angle enclosed by the AB protons at C-3. Both half-boat and half-chair conformations are compatible with the planar lactone group and have been proposed for 1,5-lactones[19]. The protons of the C-5 methyl group showed long-range coupling (J = 1 Hz) with H-4.

The configuration at C-2 in compound **3** was established by reduction with lithium aluminum hydride to the corresponding alditol, which was indistinguishable from an authentic sample of ascarylitol (3,6-dideoxy-L-*arabino*-hexitol). On the other hand, debenzoylation of **3** by sodium methoxide afforded ascarylonolactone as a syrup which, on treatment with phenylhydrazine, gave a dextrorotatory 3,6-dideoxyhexonic acid phenylhydrazide. According to Hudson's rule[20], the positive value should indicate that the 2-hydroxyl group is on the right-hand side in the Fischer projection. Fouquey *et al.*[7] obtained ascarylonolactone as a syrup by oxidation of ascarylose with nitric acid.

2,4-Di-*O*-benzoyl-3,6-dideoxy-L-*arabino*-hexono-1,5-lactone (**3**) was reduced

with disiamylborane in tetrahydrofuran to afford 2,4-di-*O*-benzoyl-3,6-dideoxy-L-*arabino*-hexopyranose (**4**) as a syrup in almost quantitative yield. This reagent has been used to reduce tetra-*O*-acylhexono-1,4-lactones to the corresponding tetra-*O*-acylhexofuranoses without affecting the protecting ester groups[21]. Kohn *et al.*[22] found disiamylborane to be the most effective dialkylborane for reduction of the lactones. This method was developed as a general procedure for the synthesis of furanose derivatives of aldoses and has not been used before for 1,5-aldono-lactones.

The benzoylated aldohexose **4** could not be induced to crystallize. Its ^{1}H-n.m.r. spectrum showed $J_{1,2}$ = 1.5 Hz and $J_{2,3e}$ and $J_{2,3a}$ = 5 Hz, values consistent with the proposed structure.

Direct debenzoylation with sodium methoxide in methanol for 0.5 h at 0° afforded a syrup having $R_{Rhamnose}$ of 1.29 (6:4:3, 1-butanol–pyridine–water), comparable to that reported for ascarylose[10] (**7**). When a longer reaction time with methoxide at room temperature was used, compounds of greater mobility were detected on the chromatograms together with ascarylose. The sugar was identified by reduction to ascarylitol. In another experiment, 2,4-di-*O*-benzoyl-3,6-dideoxy-L-*arabino*-hexopyranose (**4**) was converted into methyl 2,4-di-*O*-benzoyl-3,6-dideoxy-α-L-*arabino*-hexopyranoside (**5**) through treatment with methanol of the corresponding bromide, following the procedure described by Ness *et al.*[23] for methyl α-L-rhamnopyranoside. Debenzoylation of **5** afforded methyl 3,6-dideoxy-α-L-*arabino*-hexopyranoside (**6**), which showed the same melting point as the enantiomer, methyl 3,6-dideoxy-α-D-*arabino*-hexopyranoside[24,14], and an optical rotation comparable in magnitude but opposite in sign. Hydrolysis of the methyl glycoside (**6**) afforded ascarylose (**7**).

In order to confirm the stereoselectivity of the catalytic-hydrogenation step and the utility of the synthetic route proposed, an experiment was performed in which the hydrogenation mixture was treated with disiamylborane, debenzoylated, and reduced with sodium borohydride to the alditols, without isolation of intermediates. Gas–liquid chromatographic examination of the acetates showed a main peak corresponding to 3,6-dideoxy-L-*arabino*-hexitol (ascarylitol) and a small one having a very similar retention-time, which most probably corresponds to 3,6-dideoxy-L-*ribo*-hexitol (the enantiomer of paratitol). Unfortunately no authentic sample was available for comparison. The epimers were formed in 93:7 ratio. The overall yield with respect to the enono-lactone was 66%, as determined by comparison with the response for an authentic sample of ascarylitol acetate.

When platinum oxide was used as catalyst for the hydrogenation, a 63:37 ratio for the epimers was determined by electronic integration. Hough *et al.*[25] also found less selectivity when the catalytic reduction of 1,2,3,4-tetra-*O*-acetyl-6-deoxy-β-D-*xylo*-hex-5-enopyranose was performed in the presence of platinum oxide.

All attempts to obtain the sugar in crystalline form failed. Fouquey *et al.*[6], in the first isolation of ascarylose from the ascarosides A, B, and C, described this sugar as a syrup, but, in a footnote, it is reported that they had obtained crystals. In a following paper[7], the same authors reported that they had failed to crystallize ascarylose. However, in another publication[26] they tabulated the sugar as having a

melting point in accord with that of the enantiomer, tyvelose. Davies[9] isolated ascarylose as a component of a lipopolysaccharide from *Pasteurella pseudotuberculosis*, but was unable to crystallize the sugar. In contrast, the enantiomer tyvelose (natural and synthetic) has always been described crystalline[11,14,26].

Recently, Monneret *et al.*[14] have reported the synthesis of methyl 4-*O*-methyl-ascaryloside, which was identified through conversion to ascarylitol, but they did not describe the free sugar.

This convenient procedure for the synthesis of ascarylose, whose key step is the stereoselective hydrogenation of the enono-lactone, demonstrates further the utility of the β-elimination reaction in aldonolactones for the synthesis of biologically important sugars.

EXPERIMENTAL

General methods. — Evaporations were conducted under diminished pressure at a bath temperature below 60°. Melting points were determined with a Fisher–Johns apparatus and are uncorrected. Optical rotations were recorded with a Perkin–Elmer 141 polarimeter, and i.r. spectra with a Perkin–Elmer Model 421 spectrophotometer. ^{1}H-N.m.r. spectra were determined with a Varian A-60 spectrometer in chloroform-*d* solution, with tetramethylsilane as internal reference; the apparent coupling-constants (Hz) reported are the directly observed line-spacings. T.l.c. was performed on Silica Gel G (Merck). The following solvent systems were used: (*a*) 19:1 benzene–ethyl acetate and (*b*) 19:1 benzene–2-propanol. Detection was effected with iodine vapour. Paper chromatography was conducted by the descending method on Whatman No 1 paper with the following solvent-systems: (*A*) 6:4:3 1-butanol–pyridine–water and (*B*) 5:1:4 1-butanol–ethanol–water. Detection was effected with: (*a*) silver nitrate–sodium hydroxide[27], (*b*) *p*-anisidine hydrochloride[28], and (*c*) hydroxylamine–ferric chloride[29]. G.l.c. was effected with a Hewlett–Packard 5830 A gas chromatograph equipped with glass columns (183 × 0.3 cm) packed with 3% ECNSS-M on Gaschrom Q, with nitrogen at a flow rate of 31 mL.min^{-1}; T_i 250°; T_d 250°; T_c 170°. L-Rhamnono-1,5-lactone (**1**) was obtained by oxidation of L-rhamnose with bromine as already described[15].

2,4-Di-O-benzoyl-3,6-dideoxy-L-erythro-*hex-2-enono-1,5-lactone* (**2**). — L-Rhamnono-1,5-lactone (**1**) (1.82 g) was suspended in anhydrous pyridine (25 mL) and benzoyl chloride (10 mL) was slowly added. The mixture was shaken for 16 h at room temperature and then poured with stirring into 250 mL of ice–water. After 3 h, the product was extracted with dichloromethane, and the extract was washed successively with saturated aqueous sodium hydrogencarbonate and water until pH 7 was reached, dried (magnesium sulfate), and evaporated *in vacuo* with the addition of toluene to remove residual pyridine. Benzoic acid was then removed by sublimation at 80–90° under diminished pressure. The product (2.56 g) crystallized upon addition of ethanol and was homogeneous by t.l.c. A second crop of crystals (0.85 g) was obtained from the mother liquors; total yield: 3.41 g (87%). Compound **2**

was recrystallized from ethanol, whereupon it had m.p. 108–110°, $[\alpha]_D^{20}$ −93° (*c* 1.0, chloroform); R_F 0.46 (solvent *a*); ν_{max}^{Nujol} 1735 (vinyl benzoate), 1730 (α,β-unsaturated 1,5-lactone), 1720 (benzoate C=O), 1665 (C=C, conj.), 1590 and 1580 cm^{-1} (C=C, aromatic); ^{1}H-n.m.r. data: δ 7.25–8.25 (m, 10 H, 2 BzO), 6.77 (q, $J_{3,4}$ 5, $J_{3,5}$ 1 Hz, H-3), 5.77 (t, $J_{3,4}$ 5, $J_{4,5}$ 5 Hz, H-4), 4.96 (m, H-5), and 1.6 (d, $J_{5,6}$ 6 Hz, -CH_3).

Anal. Calc. for $C_{20}H_{16}O_6$: C, 68.18; H, 4.54. Found: C, 68.05; H, 4.74.

*2,4-Di-*O*-benzoyl-3,6-dideoxy-*L-arabino-*hexono-1,5-lactone* (**3**). — A solution of **2** (2.74 g) in ethyl acetate (150 mL) was hydrogenated over 10% palladium–charcoal (200 mg) at atmospheric pressure and 0° until **2** was no longer observed by t.l.c. The filtered solution was evaporated, and compound **3** crystallyzed upon addition of ethanol (2.61 g; 95%). The product was recrystallized from ethanol to give m.p. 85–87°; $[\alpha]_D^{20}$ +18.2° (*c* 1.0, chloroform); R_F 0.39 (solvent *a*); ν_{max}^{Nujol} 1755 (1,5-lactone), 1710 cm^{-1} (benzoate C=O); p.m.r. data: δ (p.p.m) 7.2–8.2 (m, 10 H, 2 BzO), 5.85 (t, $J_{2,3}$ 9, $J_{2,3'}$ 9 Hz, H-2), 5.25 (m, H-4), 4.8 (m, H-5), 2.6 (m, H-3,3'), 1.5 (q, $J_{5,6}$ 6 Hz, $J_{4,6}$ 1 Hz, 3 H, -CH_3).

Anal. Calc. for $C_{20}H_{18}O_6$: C, 67.79; H, 5.08; Found: C, 67.67; H, 5.28.

Compound **3** was debenzoylated with sodium methoxide 0.1M in methanol to give a syrup which, on paper chromatography [solvent *B*, reagents (*a*) and (*c*)], gave only one spot. It showed $[\alpha]_D^{20}$ −0.6 (10 min) → +8.6° (24 h, equilibrium, *c* 1.6, water); ν_{max}^{film} 1760 cm^{-1} (lactone C=O).

Anal. Calc. for $C_6H_{10}O_4$: C, 49.31; H, 6.84. Found: C, 49.40; H, 7.03.

Treatment of the foregoing product with an equal amount of phenylhydrazine gave 3,6-dideoxy-L-*arabino*-hexonic acid phenylhydrazide which, on recrystallization from methanol–ether, had m.p. 170–172°, $[\alpha]_D^{20}$ +51° (*c* 0.5, water); ν_{max}^{Nujol} 3300–3000 (O-H, N-H), 1660 (-CO-N), and 1570 cm^{-1} (C_6H_5).

Anal. Calc. for $C_{12}H_{18}N_2O_4$: C, 56.69; H, 7.09; N, 11.02. Found: C, 56.75; H, 7.13; N, 11.22.

*3,6-Dideoxy-*L-arabino-*hexitol* (*ascarylitol*). — Compound **3** (0.3 g) was reduced with excess lithium aluminum hydride (0.160 g) in ether (25 mL) for 18 h at ~20° with stirring. The excess of reductant was decomposed by careful addition of water, and the solution was filtered and concentrated. The aqueous solution was decationized with Dowex 50 (H^+ form) and evaporated to a syrup that crystallized upon addition of acetone (yield, 38 mg, 30%). It showed m.p. and mixed m.p. 112–114°; $[\alpha]_D^{20}$ +40° (*c* 0.3, water); lit.[26] m.p. 114–115°, $[\alpha]_D^{20}$ +35° (water); lit.[9] 112–113°; $[\alpha]_D$ +38 ± 3° (water). The i.r. spectrum was indistinguishable from that given by an authentic sample.

*2,4-Di-*O*-benzoyl-*L-arabino-*hexopyranose* (**4**). — 2,4-Di-*O*-benzoyl-3,6-dideoxy-L-*arabino*-hexono-1,5-lactone (**3**) was reduced with disiamylborane according to the procedure described by Kohn *et al.*[21]. To a solution containing 22 mmol of freshly prepared bis-(3-methyl-2-butyl)borane[21] under a nitrogen atmosphere, 1.91 g (5.4 mmol) of **3** in 5 mL tetrahydrofuran were added. After stirring for 20 h at room temperature, 1.5 mL of water were slowly added. The solution was stirred for 0.5 h

and, after cooling to 0°, 3 mL of 30% hydrogen peroxide was slowly added. The pH of the solution was kept between 7 and 8 with 3M sodium hydroxide. The solution was evaporated in order to remove tetrahydrofuran and extracted several times with dichloromethane. The organic layer was washed with water, dried (magnesium sulfate) and concentrated to a syrup that could not be induced to crystallize. It was purified by dissolution in methanol and precipitation with water. This procedure was repeated thrice. The resulting syrup (1.82 g, 95% yield) was homogeneous by t.l.c., R_F 0.24 (solvent *a*), R_F 0.38 (solvent *b*). It showed $[\alpha]_D^{20}$ +60.6° (*c* 0.4, chloroform); ^{1}H-N.m.r. data: δ 7.2–8.2 (m, 10 H, 2BzO), 5.3 (d, $J_{1,2}$ 1.5 Hz, H-1), 5.05 (m, H-2), 4.2 (m, H-4), 3.7 (m, H-5), 3.2 (broad, disappeared on deuteration, -OH), 2.1–2.6 (m, H-3a, H-3e), and 1.25 (d, $J_{5,6}$ 6 Hz, 3 H, $-CH_3$).

Anal. Calc. for $C_{20}H_{20}O_6$: C, 67.41; H, 5.61. Found: C, 67.61; H, 5.86.

*Methyl 2,4-di-O-benzoyl-3,6-dideoxy-α-*L-arabino-*hexopyranoside* (**5**). — 2,4-Di-*O*-benzoyl-3,6-dideoxy-L-*arabino*-hexopyranose (**4**) (0.6 g) was dissolved in pyridine (1 mL) and 0.4 mL of benzoyl chloride was added with external cooling. The mixture was shaken for 2 h at room temperature; poured into ice–water, and extracted with dichloromethane. The organic layer was successively washed with saturated aqueous sodium hydrogencarbonate and water until neutrality, dried (magnesium sulfate), and evaporated to a syrup (0.75 g) which, on t.l.c., showed greater mobility than the original product (R_F 0.76, solvent *b*).

To a solution of the tribenzoate (0.75 g) in 1 mL of acetic acid was added 3.5 mL of hydrogen bromide in acetic acid (~32% HBr). After 24 h at room temperature, dichloroethane was added, and the resulting solution washed successively with ice–water, saturated aqueous sodium hydrogencarbonate, and ice–water, dried (magnesium sulfate), and evaporated to a syrup (0.54 g) that was dissolved in 10 mL of abs. methanol and kept for three days at 5°. The mixture showed by t.l.c. a main product that was purified by column chromatography on silica gel G, using benzene with increasing concentrations of ethyl acetate as eluent. The product having R_F 0.55 (solvent *a*) was isolated as a chromatographically pure syrup (0.2 g, 40%). It showed $[\alpha]_D^{20}$ +25° (*c* 1.1, chloroform). Haga *et al.*[24] reported $[\alpha]_D$ −22.9° (chloroform) for the enantiomer, methyl 2,4-di-*O*-benzoyl-3,6-dideoxy-α-D-*arabino*-hexopyranoside.

*Methyl 3,6-dideoxy-α-*L-arabino-*hexopyranoside* (**6**). — The benzoate **5** (80 mg) was debenzoylated by treatment with 0.1M sodium methoxide in methanol (10 mL). The solution was kept for 4 h at room temperature; decationized with Dowex-50 (H^+ form), and evaporated to a syrup, which was dissolved in water and extracted with benzene in order to remove methyl benzoate. The aqueous layer was evaporated to a syrup (26 mg) that crystallized from 1:1 acetone–hexane; m.p. 82–84°, $[\alpha]_D^{20}$ −101° (*c* 0.8, water). Hage *et al.*[24] reported m.p. 82–84°, $[\alpha]_D$ +102.7° (water) for the enantiomer, methyl 3,6-dideoxy-α-D-*arabino*-hexopyranoside.

*3,6-Dideoxy-*L-arabino-*hexose* (*ascarylose*) (**7**). — (*a*) *From 2,4-di-*O*-benzoyl-3,6-dideoxy-*L-arabino-*hexopyranose* (**4**). — Compound **4** (215 mg) was dissolved in chloroform (5 mL) and sodium methoxide in methanol (5 mL, 0.5 M was added.) After stirring for 0.5 h at 0°, water was added, the organic layer was separated, and

extracted thrice with water. The aqueous solution, freed from methyl benzoate, was decationized with Dowex-50 (H^+ form) and evaporated to a syrup (86 mg, 90%). Paper chromatography showed a single spot detected with reagents (*a*) and (*b*); R_{Rh} 1.29 (solvent *A*) (lit.[10] R_{Rh} 1.29); and R_{Rh} 1.9 (solvent *B*). The chromatographically homogeneous syrup was distilled (100°/0.01 mmHg). The product showed $[\alpha]_D^{20}$ −23.6° (*c* 1.0, water); lit.[7,10] $[\alpha]_D$ −25°; lit.[9] $[\alpha]_D$ −20° (water). The aldose (50 mg) was dissolved in water (10 mL) and treated overnight with an excess of sodium borohydride (200 mg) at room temperature. The solution was acidified with acetic acid, decationized with Dowex-50 (H^+ form), and evaporated thrice with the addition of methanol to eliminate boric acid. The resulting syrup crystallized upon addition of acetone. The precipitate showed chromatographic behavior (paper chromatography, solvents *A* and *B*; g.l.c. of the acetates) indistinguishable from that of an authentic sample of ascarylitol. Upon recrystallization, it had m.p. and mixed m.p. 112–113°; lit.[10] 114–115°; lit.[9] 112–113°.

(*b*) *From methyl 3,6-dideoxy-α-*L-arabino-*hexopyranoside* (**6**). — Compound **6** (35 mg) was boiled under reflux with 0.1 M sulfuric acid during 3 h. The cooled solution was neutralized with De-Acidite G (OH^- form) and concentrated to a syrup (31 mg, 88%) having the same chromatographic properties and physical constants as just reported.

G.l.c. determination of the yield of ascarylose. — A solution of 2,4-di-*O*-benzoyl-3,6-dideoxy-L-*erythro*-hex-2-enono-1,5-lactone (**2**, 41 mg) in ethyl acetate (5 mL) was hydrogenated over palladium–charcoal until **2** could not longer be detected by t.l.c. The solution was filtered and concentrated to a syrup (41 mg) that was reduced with disiamylborane and debenzoylated as already described. After elimination of methyl benzoate and decationization, the product was reduced with sodium borohydride (40 mg) in water (3 mL) for 20 h. The solution was decationized with Dowex-50 (H^+ form) and evaporated thrice with the addition of methanol. The syrup was acetylated with 1 mL of 1:1, v/v acetic anhydride–pyridine. G.l.c. of the acetates showed two peaks with *T* 1.38 and 1.54, respectively (relative to 1,2,3,4-tetra-*O*-acetylerythritol), in a molar relation of 93:7. The main peak corresponded to ascarylitol acetate, by comparison with an authentic sample.

The overall yield for 1,2,4,5-tetra-*O*-acetylascarylitol with respect to 2,4-di-*O*-benzoyl-3,6-dideoxy-L-*erythro*-hex-2-enono-1,5-lactone (**2**) was calculated as 66% by electronic integration.

*Determination of the relative proportion of the epimers formed by catalytic hydrogenation of 2,4-di-*O*-benzoyl-*L-erythro-*hex-2-enono-1,5-lactone* (**2**) *over platinum oxide.* — Compound **2** (50 mg) was dissolved in 20 mL of ether and hydrogenated overnight in the presence of platinum oxide. The catalyst was filtered off and the mixture evaporated to a syrup. T.l.c. showed no original product, but the low R_F value of the main spots indicated considerable opening of the lactones to the corresponding acids.

The syrup was dissolved in ether (5 mL) and 30 mg of lithium aluminum hydride was added. The mixture was stirred for 20 h at room temperature. The

excess of reductant was decomposed by careful addition of water, the mixture was filtered, and the gelatinous precipitate of aluminum oxide was repeatedly washed with methanol. The alcoholic solution was decationized with Dowex-50 (H^+ form) and evaporated to a syrup, which was acetylated. G.l.c. of the alditol acetates showed two peaks having the same retention-times as before, in a molar relation of 63:37.

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REFERENCES

1 R. M. de Lederkremer and M. I. Litter, *Carbohydr. Res.*, 20 (1971) 442–444.
2 M. I. Litter and R. M. de Lederkremer, *Carbohydr. Res.*, 26 (1973) 431–434.
3 M. I. Litter and R. M. de Lederkremer, *An. Asoc. Quim. Argent.*, 62 (1974) 147–150.
4 R. M. de Lederkremer, M. I. Litter, and L. F. Sala, *Carbohydr. Res.*, 36 (1974) 185–187.
5 R. M. de Lederkremer and L. F. Sala, *Carbohydr. Res.*, 40 (1975) 385–386.
6 C. Fouquey, J. Polonsky, and E. Lederer, *Bull. Soc. Chim. Biol.*, 39 (1957) 101–132.
7 C. Fouquey, J. Polonsky, and E. Lederer, *Bull. Soc. Chim. Biol.*, 40 (1958) 315–325.
8 C. Fouquey, J. Polonsky, and E. Lederer, *Bull. Soc. Chim. Biol.*, 44 (1962) 69–81.
9 D. A. L. Davies, *Nature*, 191 (1961) 43–44.
10 O. Westphal and O. Lüderitz, *Angew. Chem.*, 72 (1960) 881–891.
11 E. H. Williams, W. A. Szarek, and J. K. N. Jones, *Can. J. Chem.*, 49 (1971) 796–799.
12 G. Ekborg and S. Svensson, *Acta Chem. Scand.*, 27 (1973) 1437–1439.
13 K. Eklind, P. J. Garegg, and B. Gotthammar, *Acta Chem. Scand., Ser. B*, 29 (1975) 633–634.
14 C. Monneret, J.-C. Florent, N. Gladieux, and Q. Khuong-Huu, *Carbohydr. Res.*, 50 (1976) 35–44.
15 C. S. Hudson and H. S. Isbell, *J. Am. Chem. Soc.*, 51 (1929) 2225–2229.
16 E. W. Garbisch, Jr., *J. Am. Chem. Soc.*, 86 (1964) 5561–5564.
17 R. J. Ferrier and G. M. Sankey, *J. Chem. Soc. (C)*, (1966) 2345–2349.
18 D. M. Mackie and A. S. Perlin, *Carbohydr. Res.*, 24 (1972) 67–85.
19 R. C. Sheppard and S. Turner, *Chem. Commun.*, (1968) 77–78.
20 C. S. Hudson, *J. Am. Chem. Soc.*, 39 (1917) 462–470.
21 P. Kohn, R. H. Samaritano, and L. M. Lerner, *J. Am. Chem. Soc.*, 87 (1965) 5475–5480.
22 P. Kohn, L. M. Lerner, A. Chan, Jr., S. D. Ginocchio, and C. A. Zitrin, *Carbohydr. Res.*, 7 (1968) 21–26.
23 R. K. Ness, H. G. Fletcher, Jr., and C. S. Hudson, *J. Am. Chem. Soc.*, 73 (1951) 296–300.
24 M. Haga, M. Chonan, and S. Tejima, *Carbohydr. Res.*, 16 (1971) 486–491.
25 L. Hough, R. Khan, and B. A. Otter, *Adv. Chem. Ser.*, 74 (1968) 120–140.
26 C. Fouquey, J. Polonsky, and E. Lederer, *Bull. Soc. Chim. Fr.*, (1959) 803–810.
27 W. E. Trevelyan, D. P. Procter, and J. S. Harrison, *Nature*, 166 (1950) 444–445.
28 L. Hough, J. K. N. Jones, and W. H. Wadman, *J. Chem. Soc.*, (1950) 1702–1706.
29 M. Abdel-Akher and F. Smith, *J. Am. Chem. Soc.*, 73 (1951) 5859–5860.