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Acetolysis of a 2,4-*O*-benzylidene-L-*ribo*-hex-5-enitol derivative †

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Abstract

Acetolysis of (*Z*)-1,3-di-*O*-acetyl-2,4-*O*-benzylidene-5,6-dideoxy-6-*C*-(2,4-dichlorophenyl)-L-*ribo*-hex-5-enitol afforded, besides 2-*C*-[(*S*)-acetoxy(2,4-dichlorophenyl)methyl]-3,4,6-tri-*O*-acetyl-2-deoxy-β-D-*allo*- and -*gluco*-hexopyranosylbenzene, (*E*)-1,2,3,4-tetra-*O*-acetyl-5,6-dideoxy-6-*C*-(2,4-dichlorophenyl)-D-*lyxo*- and -L-*ribo*-hex-5-enitol as main products. The rate of this reaction as well as the ratio of the products depends on the chirality of C-3. This was confirmed by acetolysis of the corresponding L-*erythro*-pent-4-enitol derivative.

1. Introduction

We have described [1,2] the rearrangement of 2,4-*O*-benzylidene-D-*xylo*-hex-5-enitols into *C*-glycosylbenzene derivatives on acetolysis and investigated the influence of different substituents on this reaction. In order to study the role of the configuration at C-3 and the presence or absence of a terminal acetoxymethyl group on this rearrangement, the corresponding *ribo*-hex-5-enitol and *erythro*-pent-4-enitol derivatives have been synthesised and submitted to acetolysis.

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† Rearrangement of Unsaturated 2,4-*O*-Benzylidenehexitol Derivatives into *C*-Glycosylbenzene Derivatives, Part III. For Part II, see ref 1.

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2. Results and discussion

It was expected that acetolysis of the *ribo*-hex-5-enitol derivative **2**, which differs from the corresponding D-*xylo* isomer only in the configuration at C-3 (possessing an equatorial instead of an axial acetoxyl group at this position), would form on acetolysis the key intermediate **5** (Scheme 1) according to the mechanism suggested previously [1,2]. Attack of acetic anhydride on C-4 of the allylic intermediate **5** should then give the D-*lyxo* and L-*ribo* isomers (**8** and **10**), whereas an attack at C-6 should lead via the cation **7** and the cyclic intermediate **6** to the D-*allo*- (**12**) and D-*gluco*-hexosylbenzene (**13**).

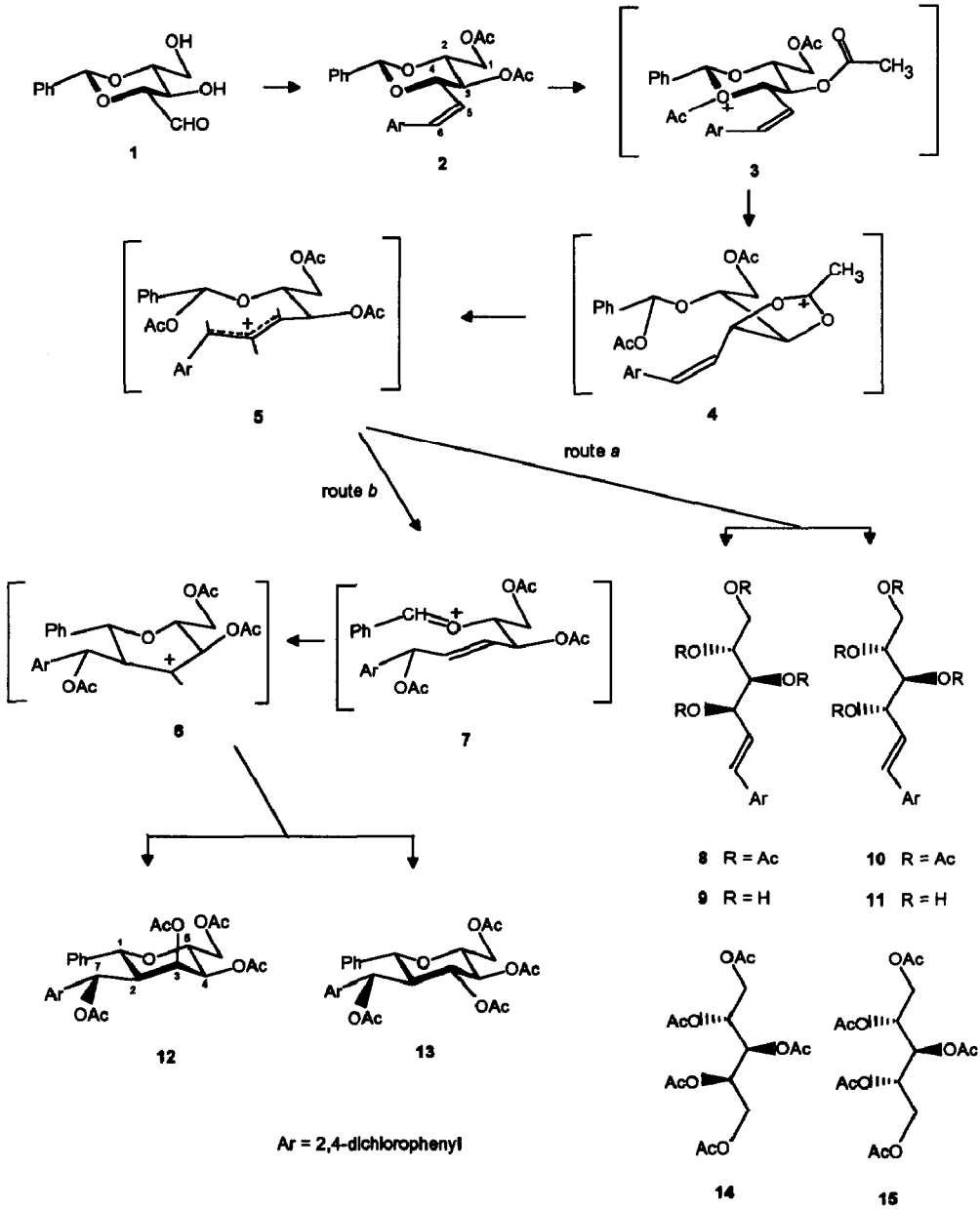
For the synthesis of the model compound **2**, 2,4-*O*-benzylidene-D-ribose [3] (**1**) was used as starting material, which was coupled in tetrahydrofuran–*N*,*N*-dimethylformamide with the ylid prepared from [(2,4-dichlorophenyl)methyl]triphenylphosphonium chloride and potassium *tert*-butoxide to yield, after acetylation, a mixture from which the *Z* isomer **2** was isolated in 33% yield.

Acetolysis of **2**, using sulfuric acid in acetic anhydride, proceeded much faster then in the case of the *xylo* derivatives [1,2]; according to TLC, the starting material was consumed after 1.5 h, whereas 20 h were required for the *xylo* isomers. As the main component (70%), a syrup was separated, which, according to NMR, proved to be a 1:1 mixture of the two acyclic tetraacetates **8** and **10**. The expected *C*-glycosyl compounds were formed as byproducts (7.5%) and could be isolated only as a mixture containing, according to NMR, the D-*allo* and D-*gluco* isomers (**12** and **13**) in a ratio of 9:1.

The acyclic derivatives **8** and **10** could be separated after deacetylation, and the structure of the tetraols **9** and **11** so formed was established by ozonolysis followed by reduction with sodium borohydride and subsequent acetylation, to afford the expected penta-*O*-acetyl-D-arabinitol (**14**) and penta-*O*-acetylribitol (**15**), respectively. The *C*-glycosyl compounds **12** and **13** could not be separated, but a comparison of their NMR spectra with those of the corresponding L-*galacto* and L-*gulo* derivatives [1,2] made the assignment of the newly formed chiral centres possible.

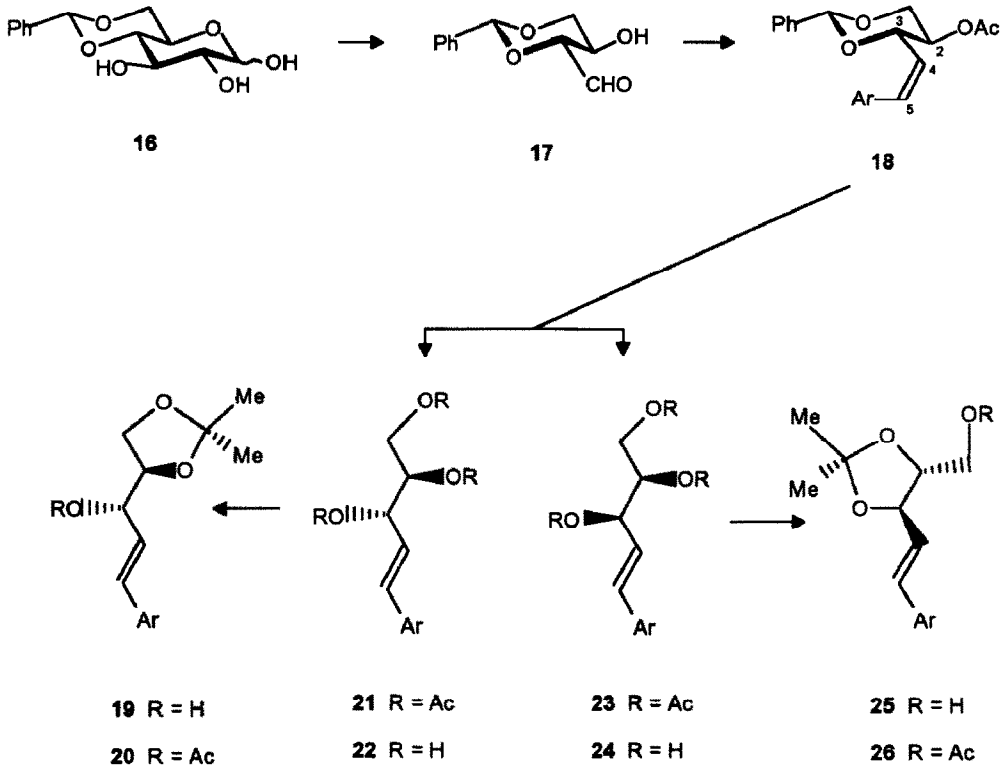
The increase in the rate of the acetolysis reaction and the unexpectedly high yield of the acyclic isomers **8** and **10** are probably a consequence of the stereoelectronic effect of the equatorially oriented 3-OAc group, which is able to offer neighbouring group assistance in the opening of the acetal ring in **3**, leading via the dioxolanium intermediate **4** to the allylic cation **5**. Clearly, such assistance is not possible in the *xylo* analogue, where the 3-OAc group is axial. On the other hand, for the rearrangement process leading to the *C*-glycosyl compounds **12** and **13**, a benzylic cation (**7**) is required as an intermediate, the formation of which from **5** should not depend on the configuration of C-3. As a consequence, route *a* is preferred over route *b*, resulting in the observed shift in the yields of the products.

For checking the influence of the terminal acetoxymethyl group at C-2 of **2** on the acetolysis reaction, the synthesis of the corresponding 1,3-*O*-benzylidene-L-erythritol derivative **18** was examined (Scheme 2), in which this substituent is replaced by a hydrogen. For the synthesis of **18**, 4,6-*O*-benzylidene-D-glucose (**16**)



Scheme 1.

was required, which had been prepared in 1931 by Zervas [4], using zinc chloride and benzaldehyde as reagents. Despite the fact that this method was published later [5] without much alteration, it afforded only traces of **16** in our hands; mainly other isomers and di-*O*-benzylidene derivatives were formed. Relatively satisfac-



Scheme 2.

tory yields (39%) of **16** could be obtained only after reducing drastically the proportions of benzaldehyde and zinc chloride.

Crude 2,4-*O*-benzylidene-D-erythrose (**17**), obtained from **16** via periodate oxidation [6,7], was coupled with the ylid as described for **2**, to yield the *Z* isomer **18** in fairly high yield (61%). Acetolysis of **18**, using sulfuric acid in acetic anhydride, was a similarly fast process to that of **2**, and according to TLC only one component was formed, which, after separation (68%), proved (NMR) to be a 1:1 mixture of the two acyclic triacetates **21** and **23**. Neither they, nor their *O*-deacetylated derivatives **22** and **24**, could be separated by column chromatography. The mixture of the latter compounds was therefore treated with acetone in the presence of sulfuric acid. The two derivatives formed (**19** and **25**) differed significantly in their R_f values, enabling their separation by column chromatography. According to ^{13}C NMR, both isomers contained a dioxolane ring [8] (δ OCO: 109.6 and 110.0 ppm). In the ^1H NMR spectrum of **25** (recorded in C_6D_6), broadening of the H-1a,1b signals at 3.56 and 3.39 ppm was observed due to the coupling with the primary

hydroxyl group. This broadening could be eliminated upon irradiation of the broad OH signal at 1.32 ppm. Furthermore, the rather similar shifts of the isopropylidene-Me groups (26.9 and 26.6 ppm) were in full agreement with the "symmetric" structure of **25**, containing a trans-substituted dioxolane ring, whereas in isomer **19** the corresponding shifts were 26.4 and 25.0 ppm. The trans relation of H-2 and H-3 in **25** was proved by an NOE experiment performed in C_6D_6, in which irradiation of the CMe_2 groups at 1.39 and 1.43 ppm resulted in intensity enhancements of H-3 (4.48 ppm) and H-2 (3.68 ppm), respectively. The spectra of the acetylated derivatives **20** and **26** afforded further proof of the proposed structures, since a downfield shift of 1.04 ppm for H-3 in **20** was observed, compared to **19**. On the other hand, the signals of H-1a and H-1b are deshielded by 0.4 ppm in **26** compared to **25**.

It is not surprising that the introduction of the isopropylidene group under thermodynamically controlled conditions leads to two different regioisomers in the case of the L-*erythro* (**22**) and the D-*threo* (**24**) isomers, since non-terminal dioxolane rings are more stable then terminal ones [9–11]. As a consequence, the terminal dioxolane rings formed first in the kinetic phase of the reaction tend to migrate to the non-terminal positions if no other unfavourable factors are present. For the *threo* isomer **24**, the kinetically formed 1,2-dioxolane derivative rearranges immediately to the more stable, sterically favoured, 2,3-trans isomer **25**. In the case of the L-*erythro* isomer, however, the terminal dioxolane ring (**19**) is preferred since, on migration to C-2,3, a *cis*-substituted dioxolane system would be formed, which is sterically crowded and therefore unfavoured.

The high speed of the acetolysis reaction must have the same reason as discussed for **2**, and the absence of any *C*-glycosyl compounds might be due to the absence of the terminal acetoxymethyl group. As a consequence, the benzylidene group in **18** is attached to a primary and a secondary OH group. Accordingly, the cation formed via route *b* (see **7**) would be attached to a terminal methylene group, making its acetolytic splitting a much faster process then its rearrangement to the cyclic cation (see **6**).

3. Experimental

General methods.—Organic solutions were dried with Na_2SO_4 and concentrated under diminished pressure. Reactions were carried out at room temperature (20°C) and optical rotations were determined at 20°C on 1% solutions in $CHCl_3$ unless stated otherwise. TLC was performed on Kieselgel G with *A*, EtOAc; EtOAc–hexane mixtures (*B*, 1:2; *C*, 1:3; *D*, 1:5); and *E*, EtOAc–EtOH (4:1); with detection using 1:1 0.1 M $KMNO_4$–M H_2SO_4 at 200°C. For column chromatography, Kieselgel 60 was used. NMR spectra were recorded with a Bruker 250 spectrometer at 250 (^1H) and 62.9 MHz (^{13}C) on solutions in $CDCl_3$ (internal Me_4Si) unless stated otherwise. Signal multiplicities of the ^{13}C NMR spectra were obtained from DEPT experiments. H-3′,5′,6′ refer to the protons of the 2,4-dichlorophenyl group.

(Z)-1,3-Di-O-acetyl-2,4-O-benzylidene-5,6-dideoxy-6-C-(2,4-dichlorophenyl)-L-ribo-*hex-5-enitol* (**2**).—To a stirred slurry of [(2,4-dichlorophenyl)methyl]triphenylphosphonium chloride (13 g) in dry THF (100 mL) and DMF (20 mL) was added potassium *tert*-butoxide (3.2 g). The orange solution was stirred for 1 h at room temperature, then a solution of crude *aldehydo*-sugar **1** [3] [4 g, obtained from its dipropyl dithioacetal[12] (7.4 g)] in DMF (10 mL) was added, and, after 1 h, the mixture was diluted with water and extracted with EtOAc. The combined extracts were washed with brine and dried, and the solvent was evaporated. The residue was dissolved in pyridine (30 mL) and Ac_2O (20 mL) was added. After 20 h, the mixture was processed in the usual way. Column chromatography (solvent *C*) then gave **2** (3.1 g, 33.3%); mp 113–115°C (from hexane); $[\alpha]_D$ −132°; R_f 0.55; NMR data: ^{1}H, δ 7.53 (m, 2 H, Ph) 7.45 (d, 1 H, H-3′), 7.43–7.37 (m, 4 H, Ph and H-6′), 7.29 (dd, 1 H, H-5′), 6.81 (d, 1 H, H-6), 5.90 (dd, 1 H, H-5), 5.61 (s, 1 H, OCHO), 5.07, 4.45 (2 t, each 1 H, H-3,4), 4.30 (dd, 1 H, H-1a), 4.26 (dd, 1 H, H-1b), 3.95 (ddd, 1 H, H-2), 2.09 and 2.04 (2 s, each 3 H, 2 AcO); $J_{1a,1b}$ 11, $J_{1a,2}$ 5.1, $J_{1b,2}$ 2.5, $J_{2,3} = J_{3,4} = J_{4,5} = 9.5$, $J_{5,6}$ 11.5, $J_{3',5'}$ 2.0, $J_{5',6'}$ 8.3 Hz; ^{13}C, δ 170.8, 169.5 (2 CH_3COO), 136.9, 134.6, 134.5, 133.2, 132.6, 131.1, 129.6, 129.4, 129.2, 128.5, 127.1, 126.4 (aromatic and C-5,6), 100.8 (OCO), 77.0, 75.6, 66.0 (C-2,3,4), 62.8 (C-6), 20.9 and 20.8 (CH_3COO). Anal. Calcd for $C_{23}H_{22}Cl_2O_6$: C, 59.36; H, 4.76; Cl, 15.23. Found: C, 59.32; H, 4.81; Cl, 15.19.

Acetolysis of **2**.—Sulfuric acid (6.5 mL) was added to a solution of **2** (6.5 g) in Ac_2O (65 mL) at 0°C. The solution was kept at room temperature for 1.5 h, then poured onto ice, and, after 20 min, extracted with $CHCl_3$, to give, after the usual processing, a syrup that was submitted to column chromatography (solvent *B*).

The fractions having R_f 0.60 gave, on concentration, a syrup (4.6 g, 70.3%) which, according to NMR, was a 1:1 mixture of (*E*)-1,2,3,4-tetra-*O*-acetyl-5,6-dideoxy-6-*C*-(2,4-dichlorophenyl)-D-*lyxo*-(**8**) and -L-*ribo*-hex-5-enitol (**10**). These isocould be separated only after *O*-deacetylation (see below).

The fractions having R_f 0.15 gave, on concentration, a syrup (0.5 g, 7.5%) which, according to NMR, was a 9:1 mixture of 2-*C*-[(*S*)-acetoxy(2,4-dichlorophenyl)methyl]-3,4,6-tri-*O*-acetyl-2-deoxy-β-D-*allo*- (**12**) and -*gluco*-hexopyranosylbenzene(**13**). NMR data of **12**: ^{1}H, δ 7.20 (m, 5 H, aromatic), 7.05 (d, 1 H, H-3′), 7.00 (dd, 1 H, H-5′), 6.90 (d, 1 H, H-6′), 5.75 (d, 1 H, H-7), 5.67 (t, 1 H, H-3), 4.98 (dd, 1 H, H-4), 4.82 (d, 1 H, H-1), 4.25–4.1 (m, 3 H, H-5, 6a, 6b), 2.77 (ddd, 1 H, H-2), 2.25, 2.05, 2.02, and 2.00 (4 s, each 3 H, 4 AcO); $J_{1,2}$ 10.2, $J_{2,3}$ 2.2, $J_{2,7}$ 7.1, $J_{3,4}$ 2.8, $J_{4,5}$ 9.8, $J_{3',5'}$ 2.0, $J_{5',6'}$ 8.4 Hz; ^{13}C, δ 170.8, 170.0, 169.7, 168.9 (4 CH_3COO), 137.2, 134.4, 134.0, 133.1, 129.5, 129.4, 128.7, 128.3, 127.6, 127.1 (aromatic), 77.7 (C-1), 72.1, 69.6, 68.3, 66.6 (C-3,4,5,7), 63.1 (C-6), 47.4 (C-2), 21.0, 20.8, 20.7, and 20.6 (4 CH_3COO). Characteristic ^{1}H NMR data of the minor component **13**: δ 5.52 (d, 1 H, H-7) and 2.98 (td, 1 H, H-2); $J_{1,2} = J_{2,3} = 10.5$, $J_{2,7}$ 2.0 Hz. Anal. Calcd for $C_{27}H_{28}Cl_2O_9$: C, 57.15; H, 4.97; Cl, 12.50. Found: C, 57.03; H, 5.12; Cl, 12.41.

O-*Deacetylation of* **8** *and* **10**.—To a solution of the above mixture of the isomers **8** + **10** (4.5 g) in MeOH (25 mL) was added methanolic M NaOMe (0.1 mL). The solid material which started to separate after 1 h was filtered off after 2

h and washed with MeOH to give (*E*)-5,6-dideoxy-6-*C*-(2,4-dichlorophenyl)-D-*lyxo*-hex-5-enitol (**9**; 0.82 g, 30%); mp 136–138°C (from hexane); $[\alpha]_D$ +2° (pyridine); R_f 0.65 (solvent *E*). NMR data (Me_2SO-d_6 + D_2O): ^1H, δ 7.71 (d, 1 H, H-6'), 7.59 (d, 1 H, H-3'), 7.40 (dd, 1 H, H-5'), 6.86 (dd, 1 H, H-6), 6.51 (dd, 1 H, H-5), 4.42 (ddd, 1 H, H-4), 3.63 (dd, 1 H, H-1a), 3.57 (m, 1 H, H-2), 3.47 (dd, −1 H, H-1b), and 3.43 (dd, 1 H, H-3); $J_{1a,1b}$ 10.6, $J_{1a,2}$ 3.8, $J_{1b,2}$ 5.5, $J_{2,3}$ 7.3, $J_{3,4}$ 3.2, $J_{4,5}$ 5.1, $J_{4,6}$ 1.7, $J_{5,6}$ 15.9, $J_{3',5'}$ 2.2, $J_{5',6'}$ 8.5 Hz; ^{13}C, δ 137.3, 134.2, 132.7, 132.4, 129.2, 128.5, 128.0, 123.4 (aromatic and C-5), 74.1, 71.7, 71.1 (C-2,3,4), and 63.6 (C-1).

The solid residue obtained on evaporation of the filtrate was purified by column chromatography (solvent *A*), to give (*E*)-5,6-dideoxy-6-*C*-(2,4-dichlorophenyl)-L-*ribo*-hex-5-enitol (**11**; 1.1 g, 38%); as a solid foam; $[\alpha]_D$ − 17.5° (pyridine); R_f 0.70 (solvent *E*). Anal. Calcd for $C_{12}H_{14}Cl_2O_4$: C, 49.16; H, 4.81; Cl, 24.19. Found for **9**: C, 49.15; H, 4.85; Cl, 24.11. Found for **11**: C, 49.32; H, 4.98; Cl, 24.31.

Acetylation of **9** *and* **11**.—A solution of **9** (0.7 g) in pyridine (10 mL) and Ac_2O (5 mL) was kept overnight at room temperature and then concentrated. The residue was coevaporated with toluene, the solid residue dissolved in Et_2O, and the solution filtered with carbon and diluted with hexane to give **8** (0.91 g, 83%); mp 106–108°C; $[\alpha]_D$ − 7°; R_f 0.60 (solvent *C*); NMR data: ^1H, δ 7.44 (d, 1 H, H-6'), 7.37 (d, 1 H, H-3'), 7.22 (dd, 1 H, H-5'), 6.95 (d, 1 H, H-6), 6.12 (dd, 1 H, H-5), 5.66 (ddd, 1 H, H-4), 5.43 (dd, 1 H, H-3), 5.26 (ddd, 1 H, H-2), 4.37 (dd, 1 H, H-1a), 4.18 (dd, 1 H, H-1b), 2.19, 2.12, 2.07, and 2.06 (3 s, each 3 H, 3 AcO); $J_{1a,1b}$ 12.5, $J_{1a,2}$ 3.1, $J_{1b,2}$ 5.7, $J_{2,3}$ 7.2, $J_{3,4}$ 4.7, $J_{4,5}$ 7.4, $J_{5,6}$ 15.9, $J_{4,6}$ 1.0, $J_{3',5'}$ 1.9, $J_{5',6'}$ 8.4 Hz; ^{13}C, δ 169.6, 169.5, 169.5, 169.4 (4 CH_3COO), 134.2, 133.7, 132.4, 129.8, 129.3, 127.7, 127.3, 125.5 (aromatic and C-5,6), 72.3, 70.8, 69.2 (C-2,3,4), 61.6 (C-1), 20.8, 20.6, 20.6, and 20.5 (4 CH_3COO).

Likewise, **11** (1 g) afforded a syrup to give, after purification by column chromatography (solvent *D*), **10** as a solid foam (0.75 g, 48%); $[\alpha]_D$ +27°; R_f 0.65 (solvent *C*); NMR data: ^1H δ 7.37 (d, 1 H, H-3'), 7.36 (d, 1 H, H-6'), 7.20 (dd, 1 H, H-5'), 6.91 (dd, 1 H, H-6), 6.02 (dd, 1 H, H-5), 5.73 (ddd, 1 H, H-4), 5.42 (dd, 1 H, H-3), 5.25 (ddd, 1 H, H-2), 4.29 (dd, 1 H, H-1a), 4.20 (dd, 1 H, H-1b), 2.15, 2.09, 2.08, 2.07 (4 s, each 3 H, 4 AcO); $J_{1a,1b}$ 12.5, $J_{1a,2}$ 2.7, $J_{1b,2}$ 5.0, $J_{2,3}$ 8.1, $J_{3,4}$ 3.4, $J_{4,5}$ 5.7, $J_{4,6}$ 1.5, $J_{5,6}$ 15.8, $J_{3',5'}$ 1.9, $J_{5',6'}$ 8.4 Hz; ^{13}C, δ 170.5, 169.8, 169.7, 169.7 (4 CH_3COO), 134.3, 133.8, 132.8, 129.5, 128.6, 127.9, 127.4, 126.6 (aromatic and C-5,6), 70.9, 70.3, 68.5 (C-2,3,4), 61.9 (C-1), 20.8, 20.8, 20.7, and 20.7 (4 CH_3COO) Anal. Calcd for $C_{20}H_{22}Cl_2O_8$: C, 52.07; H, 4.80; Cl, 15.37. Found for **8**: C, 52.03; H, 4.87; Cl, 15.40. Found for **10**: C, 52.21; H, 4.92; Cl, 15.55.

Structure elucidation of **8** *and* **10**.—A stream of O_3/O_2 was passed into a cooled (−70°C) solution of **8** (0.5 g) in CH_2Cl_2 (25 mL) until the colour turned blue (30 min). The solution was purged with N_2 to remove the excess of O_3 and then concentrated. The residue was dissolved in MeOH (20 mL), and $NaBH_4$ (0.5 g) was added in small portions at 0°C. After stirring at room temperature for 1 h, the pH was adjusted to 2 with methanolic 2 M HCl, then the mixture was concentrated. Methanol (3 × 20 mL) was evaporated from the residue which was then treated with Ac_2O (3 mL) in pyridine- (5 mL). After 20 h at room temperature, the solvent was evaporated and the residue coevaporated with toluene.

Purification of the residue by column chromatography (solvent *C*) afforded penta-*O*-acetyl-D-arabinitol (**14**; 0.25 g, 63.7%); mp 70–72°C; $[\alpha]_D$ +34°; R_f 0.3; lit. [13] mp 74°C; $[\alpha]\Delta$ +37°.

Similar treatment of **10** (0.3 g) yielded penta-*O*-acetylribitol (**15**; 0.18 g, 75%); mp 49–50°C; lit. [14] mp 51°C. The NMR data of both **14** and **15** were in full agreement with those published [15,16].

4,6-O-Benzylidene-D-glucose (**16**).—The procedure [5] was modified as follows. A slurry of freshly fused $ZnCl_2$ (18 g) in benzaldehyde (60 mL) was stirred at room temperature for 30 min, then D-glucose (18 g) was added and stirring was continued at 40°C for 4 h. Thereafter the mixture was cooled with ice–water. Hexane (40 mL) and water (30 mL) were added and the precipitate formed was filtered to give, after recrystallisation from dioxane–$CHCl_3$, **16** (11.6 g, 39%); mp 164–169°C; which according to ^1H NMR was a ~1:1 mixture of the α and β anomers. Characteristic NMR data ($Me_2SO + D_2O$): ^1H, δ 5.5 (OCHO), 5.1 (d, *J* 2.7 Hz, H-1α), and 4.55 (d, *J* 8.5 Hz, H-1β); ^{13}C δ 100.8, 100.7 (OCO), 97.3 [C-1(β)], and 92.7 [C-1(α)].

*(Z)-2-O-Acetyl-1,3-O-benzylidene-4,5-dideoxy-5-C-(2,4-dichlorophenyl)-*L*-erythro-pent-4-enitol* (**18**).—To a stirred slurry of [(2,4-dichlorophenyl)methyl]triphenylphosphonium chloride (14.3 g) in dry THF (100 mL) and DMF (20 mL) was added potassium *tert*-butoxide (3.5 g). The solution was stirred for-1 h at room temperature, then a solution of crude 2,4-*O*-benzylidene-D-erythrose [**17** [6,7]; obtained from **16** (7.2 g)] in DMF (20 mL) was added. The mixture was processed as described for **2**, to give, after column chromatography (solvent *D*), **18** (6.4 g, 61.8%); mp 145–147°C (from EtOAc–hexane); $[\alpha]_D$ −210°; R_f 0.55; NMR data: ^1H, δ 7.6–7.25 (m, 8 H, aromatic), 6.80 (d, 1 H, H-5), 5.87 (dd, 1 H, H-4), 5.49 (s, 1 H, OCHO), 4.99 (td, 1 H, H-2), 4.43 (t, 1 H, H-3), 4.36 (dd, 1 H, H-1*eq*), 3.61 (t, 1 H, H-1*ax*), and 2.01 (s, 3 H, AcO); $J_{1ax,1eq}$ 10.7, $J_{1ax,2}$ 10.3, $J_{1eq,2}$ 5.3, $J_{2,3}$ 9.8, $J_{3,4}$ 9.3, $J_{4,5}$ 11.5 Hz; ^{13}C, δ 169.6 (CH_3COO), 137.0, 134.5, 134.2, 133.2, 132.2, 131.0, 129.4, 129.2, 128.3, 126.9, 126.1 (aromatic and C-4,5), 101.0 (OCO), 75.7, 68.0, 66.2 (C-1,2,3), and 20.8 (CH_3COO). Anal. Calcd for $C_{20}H_{18}Cl_2O_4$: C, 61.08; H, 4.61; Cl, 18.03. Found: C, 61.02; H, 4.75; Cl, 18.12.

Acetolysis of **18**.—A solution of **18** (8 g) in Ac_2O (80 mL) and H_2SO_4 (8 mL) was treated as described for **2**, to give, after column chromatography (solvent *D*), a syrup (5.37 g, 68%) which, according to NMR, was a 1:1 mixture of (*E*)-1,2,3-tri-*O*-acetyl-4,5-dideoxy-5-*C*-(2,4-dichlorophenyl)-L-*erythro*- (**21**) and -D-*threo*-pent-4-enitol (**23**); R_f 0.40; NMR data: ^1H δ 7.45–7.15 (m, 3 H, aromatic), 6.99 (m, 1 H, H-5), 6.15–6.0 (m, 1 H, H-4), 5.75–5.25 (m, 2 H, H-2,3), 4.45–4.0 (m, 2 H, H-1a,b), 2.14, 2.13, 2.12, 2.09, 2.07, and 2.06 (6 s, 2 × 3 AcO); ^{13}C, δ 72.2, 71.8, 71.3, 71.0 (4 d, C-2,3), 62.0 and 61.7 (2 t, C-1). Anal. Calcd for $C_{17}H_{18}Cl_2O_6$: C, 52.45; H, 4.66; Cl, 18.21. Found: C, 52.27; H, 4.52; Cl, 18.35.

*(E)-4,5-Dideoxy-5-C-(2,4-dichlorophenyl)-1,2-O-isopropylidene-*L*-erythro-* (**19**) *and (E)-4,5-dideoxy-5-C-(2,4-dichlorophenyl)-2,3-O-isopropylidene-*D*-threo-pent-4-enitol* (**25**).—A solution of the foregoing mixture of isomers **21** and **23** (1.9 g) in $CHCl_3$ (10 mL) and MeOH (5 mL) was treated with M methanolic NaOMe (0.1 mL). After 2 h at room temperature, when according to TLC the *O*-deacetylation

was complete (R_f 0.40, solvent *A*), the solution was neutralised with solid CO_2, to give on concentration a syrup (1.3 g, ~ 100%) containing **22** and **24**. This syrup was dissolved in acetone (15 mL), and H_2SO_4 (0.2 mL) was added at 0°C. The mixture was kept at room temperature for 3 h and then neutralised with solid $NaHCO_3$. The residue obtained on concentration was separated by column chromatography (solvent *B*).

The fractions having R_f 0.50 gave, on concentration, **19** (370 mg, 48%) as a syrup; $[\alpha]_D$ +4°; NMR data: ^1H, δ 7.2–7.05 (m, 3 H, aromatic), 7.01 (d, 1 H, H-5), 6.18 (dd, 1 H, H-4), 4.44 (t, 1 H, H-3), 4.19 (m, 1 H, H-2), 3.98 (m, 2 H, H-1a,1b), 1.49, and 1.37 (2 s, each 3 H, $C(CH_3)_2$; $J_{2,3}$ 5.0, $J_{3,4}$ 5.2, $J_{4,5}$ 16.0 Hz; ^{13}C, δ 133.8, 133.6, 133.5 (3 s, C-1′, 2′, 4′), 130.6, 129.4, 127.6, 127.2, 127.0 (5 d, C-4,5,3′,5′,6′), 109.6 (s, OCO), 78.6 (d, C-2), 71.6 (d, C-3), 65.0 (t, C-1), 26.4 and 25.0 (each q, $C(CH_3)_2$).

The fractions having R_f 0.45 gave, on concentration, **25** (350 mg, 45%) as a syrup; $[\alpha]_D$ +3°; NMR data: ^1H, δ 7.46 (d, 1 H, H-6′), 7.36 (d, 1 H, H-3′), 7.18 (dd, 1 H, H-5′), −7.01 (d, 1 H, H-5), 6.14 (dd, 1 H, H-4), 4.52 (m, 1 H, H-3), 3.95–3.85 (m, 2 H, H-1a,2), 3.67 (m, 1 H, H-1b), and 1.49 (s, 6 H, $C(CH_3)_2$); $J_{3,4}$ 6.8, $J_{4,5}$ 15.9, $J_{3',5'}$ 2.0, $J_{5',6'}$ 8.4 Hz; ^{13}C δ 134.0, 133.7, 132.8 (3 s, C-1′,2′,4′), 129.4, 129.0, 127.7, 127.6, 127.2 (5 d, C-4,5,3′,5′,6′), 109.6 (s, OCO), 81.1 (d, C-2), 77.8 (d, C-3), 60.7 (t, C-1), 27.0 and 26.9 (2 q, $C(CH_3)_2$). Anal. Calcd for $C_{14}H_{16}Cl_2O_3$: C, 55.45; H, 5.32; Cl, 23.15. Found for **19**: C, 55.27; H, 5.40; Cl, 23.32. Found for **25**: C, 55.38; H, 5.25; Cl, 23.10.

*(E)-3-O-Acetyl-4,5-dideoxy-5-C-(2,4-dichlorophenyl)-1,2-O-isopropylidene-*L-erythro*-pent-4-enitol* (**20**).—A solution of **19** (200 mg) in pyridine (5 mL) and Ac_2O (2 mL) was processed in the usual way to give, after column chromatography (solvent *B*), **20** as a syrup (170 mg, 74.6%); R_f 0.65; $[\alpha]_D$ +20°; NMR data: ^1H, δ 7.42 (dd, 1 H, H-5′), 7.33 (d, 1 H, H-3′), 7.16 (d, 1 H, H-6′), 6.94 (d, 1 H, H-5), 6.16 (dd, 1 H, H-4), 5.48 (t, 1 H, H-3), 4.28 (q, 1 H, H-2), 4.07 (dd, 1 H, H-1a), 3.84 (dd, 1 H, H-1b), 2.12 (s, 3 H, AcO), 1.42 and 1.35 (2 s, each 3 H, $C(CH_3)_2$); $J_{1a,1b}$ 8.5, $J_{1a,2} = J_{1b,2} = J_{2,3} = J_{3,4} = 6.0$, $J_{4,5}$ 16.1, $J_{3',5'}$ 1.8, $J_{5',6'}$ 8.4 Hz; ^{13}C, δ 169.7 (s, CH_3COO), 134.0, 133.7, 132.7 (3 s, C-1′,2′,4′) 129.3, 129.0, 127.6, 127.1, 126.7 (5 d, C-4,5,3′,5′,6′), 110.0 (s, OCO), 76.6 (d, C-2), 73.7 (d, C-3), 65.8 (t, C-1), 26.3, 25.1 (2 q, $C(CH_3)_2$), and 21.0 (q, CH_3COO). Anal. Calcd for $C_{16}H_{18}Cl_2O_4$: C, 55.66; H, 5.25; Cl, 20.54. Found: C, 55.52; H, 5.16, Cl, 20.36.

*(E)-1-O-Acetyl-4,5-dideoxy-5-C-(2,4-dichlorophenyl)-2,3-O-isopropylidene-*D-threo*-pent-4-enitol* (**26**).—A solution of **25** (200 mg) was acetylated as described for **20**, to give **26** as a syrup (180 mg, 79%); R_f 0.70 (solvent *B*); $[\alpha]_D$ +18°; NMR data: ^1H, δ 7.40 (d, 1 H, H-6′), 7.30 (d, 1 H, H-3′), 7.14 (dd, 1 H, H-5′), 6.94 (d, 1 H, H-5), 6.07 (dd, 1 H, H-4), 4.34 (dd, 1 H, H-3), 4.29 (dd, 1 H, H-1a), 4.07 dd, 1 H, H-1b), 3.95 (ddd, 1 H, H-2), 2.02 (s, 3 H, AcO), 1.42 and 1.40 (2 s, each 3 H, $C(CH_3)_2$); $J_{1a,1b}$ 11.9, $J_{1a,2}$ 3.6, $J_{1b,2}$ 5.7, $J_{2,3}$ 8.3, $J_{3,4}$ 7.4, $J_{4,5}$ 15.8, $J_{3',5'}$ 2.1, $J_{5',6'}$ 8.4 Hz; ^{13}C, δ 170.6 (s, CH_3COO), 134.2, 133.7, 132.7 (3 s, C-1′, 2′, 4′), 129.5, 129.3, 128.9, 127.8, 127.2 (5 d, C-4, 5, 3′, 5′, 6′), 110.1 (s, OCO), 78.9, 78.5 (2 d, C-2, 3), 63.3 (t, C-1), 27.0, 26.8 (2 q, $C(CH_3)_2$), and 20.7 (q, CH_3COO). Anal. Calcd for $C_{16}H_{18}Cl_2O_4$: C, 55.66; H, 5.25; Cl, 20.54. Found: C, 55.49; H, 5.32; Cl, 20.41.

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