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Studies on the Fischer's Glucal-hydrobromid-diacetat and Glucal-hydrobromid-triacetat[1]

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Reaction of hydrogen bromide in glacial acetic acid upon 3,4,6-tri-O-acetyl-D-glucal and successive treatment of the reaction product with aqueous acetone under the presence of silver carbonate afforded crystals (V), mp 99°, $[\alpha]_D^{20}$ +40.5°→+34.5°, in 70% yield.

The product was also obtainable from 2,3-dideoxy-1,4,6-tri-O-acetyl-D-*erythro*-hex-2-enose or 2-deoxy-1,3,4,6-tetra-O-acetyl-α-D-*arabino*-hexopyranose in 70 or 50% yield. The structure of V was assigned to 3-bromo-4,6-di-O-acetyl-2,3-dideoxy-α-*arabino*-hexopyranose.

Acetylation of V with acetic anhydride in pyridine gave crystals (VI), mp 82°, $[\alpha]_D^{20}$ +58°, in 85% yield. The structure of VI was assigned to 3-bromo-2,3-dideoxy-1,4,6-tri-O-acetyl-α-D-*arabino*-hexopyranose. The physical constants of V and VI were in agreement with that of the Fischer's Glucal-hydrobromid-diacetat and triacetat (E. Fischer, M. Bergmann, and H. Schotte, *Ber.*, **53**, 509 (1920)), which might presumably be the same compounds.

Our recent publication[3] has reported that when 6-O-tosyl-3,4-di-O-acetyl-D-glucal is treated with hydrogen bromide the addition proceeds to afford two different products according to the solvents used. Namely, in benzene the addition results in giving sirupy 2-deoxy-6-O-tosyl-3,4-di-O-acetyl-α-D-*arabino*-hexopyranosyl bromide, while, in glacial acetic acid, crystalline 4-O-acetyl-3-bromo-6-O-tosyl-2,3-dideoxy-α-D-*arabino*-hexopyranosyl bromide (XVI) in 75% yield. It is noteworthy to describe that, in the latter case, elimination of the acetyl at C_3 and successive stereospecific addition of bromine occur to afford hexopyranosyl bromide having 2,3-dideoxy-D-*arabino* configuration, simultaneously with the addition of hydrogen bromide to the double bond at C_1 and C_2. As the extension of this attractive reaction, the authors now extended the reaction to 3,4,6-tri-O-acetyl-D-glucal (I). The present report describes the full details of the work.

Treatment of I with a saturated solution of hydrogen bromide in glacial acetic acid for three hours at room temperature afforded sirupy bromide (IV) after removal of the solvent by a standard procedure.

Without interval of time, IV in aqueous acetone was stirred under the presence of silver carbonate. Crystals (V), mp 99°, $[\alpha]_D^{20}$ +40.5°→+34.5°, were separated in 70% yield from the reaction mixture. The product was Beilstein's bromine test positive, and also obtainable with the similar procedure from 2,3-dideoxy-1,4,6-tri-O-acetyl-D-*erythro*-hex-2-enose (1,4,6-tri-O-acetyl-D-pseudoglucal) (II) or 2-deoxy-1,3,4,6-tetra-O-acetyl-α-D-*arabino*-hexopyranose (III) in 70 or 50% yield, respectively.

Acetylation of V with acetic anhydride in pyridine gave triacetate (VI), mp 82°, $[\alpha]_D^{20}$ +58°, in 85% yield. The nuclear magnetic resonance spectroscopy (NMR) of VI revealed a triplet (1H) at τ 3.90 with $J_{1,2}$=2.5 cps which was assigned to the anomeric proton. A multiplet (2H) at τ 7.45 was assigned to the methylene at C_2. Two singlets at τ 7.86 (6H) and 7.90 (3H) showed the presence of three acetyls.

1) Preliminary communication of this paper: *Chem. Pharm. Bull.* (Tokyo), **15**, 1069 (1967).
2) Location: *Kita 12-jo, Nishi 5-chome, Sapporo.*
3) T. Maki and S. Tejima, *Chem. Pharm. Bull.* (Tokyo), **15**, 1367 (1967).

On the one hand, another triacetate (VII), mp 85.5—86°, $[\alpha]_D^{20}$ +12.5°, was prepared in 48% yield when a solution of IV in acetonitril was treated with silver acetate. The NMR of VII revealed a quartet (1H) at τ 4.28 (anomeric proton), a multiplet (2H) at τ 7.50 (methylene at C_2) and two singlets at τ 7.80 (6H) and 7.84 (3H). As the product has the same elemental composition with VI, VII must be the β-anomer of VI.

Methyl glycosidation of V with methanolic hydrogen chloride afforded both anomeric glycosides (VIII:α, IX:β): the individual crystals were separated by silica gel chromatography. Both of them involved bromine, and did not consume sodium metaperiodate which suggested the pyranoside structure.

The experimental data mentioned above suggest that V is a 2-deoxysugar derivative having one bromine, two acetyls and an anomeric hydroxyl. The values of the mutarotation in V strongly suggest the α-anomer.

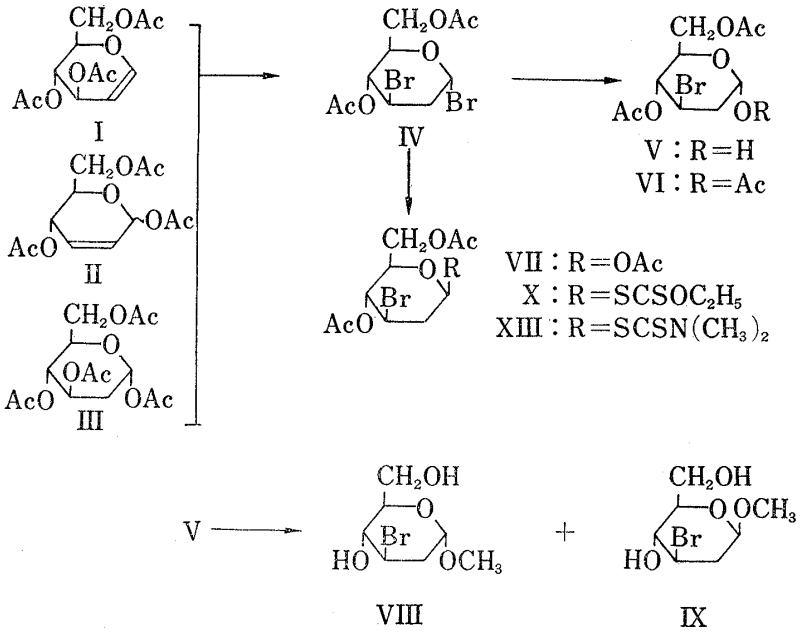

Chart 1

To determine the position of bromine in the molecule, the authors, in the next step, carried out the following experiments.

Reaction of potassium ethylxanthate upon IV, which is the precursor of V, in acetone afforded crystals (X) in 77% yield. The product involved bromine and showed ultraviolet (UV) absorption at 274 mμ (ε=10400) which is characteristic of sugar xanthates. Reductive desulfurization of X with Raney nickel gave a colorless oil in 63% yield. The oil was indistinguishable with authentic 4,6-di-O-acetyl-1,5-anhydro-2,3-dideoxy-D-*erythro*-hexitol (XI)[4] by infrared (IR) spectrum in nujol. Crystalline 1,5-anhydro-4,6-O-benzylidene-2,3-dideoxy-D-*erythro*-hexitol, mp 136—137°, was prepared from XI. Ferrier, *et al.*[5] report mp 135°, Bergmann and Breuers[6] give mp 137° for the benzylidene derivative.

Thus, it may be reasonable to consider that, in the course of the desulfurization, the bromine in the molecule removed reductively to afford 2,3-dideoxy derivative. Consequently, the position of the bromine was assigned to C_3.

Deacetylation of X with methanolic hydrogen chloride gave crystalline sugar xanthate (XII). As an another sulfur containing derivative, acetylated glycosyl N,N-dimethyl dithio-

4) T. Maki, H. Nakamura, S. Tejima, and M. Akagi, *Chem. Pharm. Bull.* (Tokyo), **13**, 764 (1965).
5) R.J. Ferrier, W.G. Overend, and A.E. Ryan, *J. Chem. Soc.*, **1962**, 3667.
6) M. Bergmann and W. Breuers, *Ann.*, **470**, 51 (1929).
7) M. Akagi, S. Tejima, M. Haga, Y. Hirokawa, M. Yamada, M. Ishiguro, and D. Mizuno, *Yakugaku Zasshi*, **87**, 287 (1967).

carbamate (XIII) was synthesized starting with IV and sodium N,N-dimethyldithiocarbamate. Deacetylation of XIII with methanolic ammonia afforded glycosyl dithiocarbamate (XIV). Both of XII and XIV involve deoxy and bromine in the molecule and these may be interesting as potential antitumor compounds.[7]

Finally, the configuration of bromine in XII was determined by introduction of XII to authentic compound with the experiments mentioned below.

Tosylation of XII with one molar equivalent of tosylchloride in pyridine, followed by acetylation, afforded crystals (XV) in 53% yield. The product was indistinguishable with authentic 4-O-acetyl-3-bromo-6-O-tosyl-2,3-dideoxy-β-D-*arabino*-hexopyranosyl ethylxanthate[3] by IR, mixed melting point and thin-layer chromatography (TLC).

In addition, both anomeric triacetates (VI and VII) were prepared starting with 4-O-acetyl-3-bromo-6-O-tosyl-2,3-dideoxy-α-D-*arabino*-hexopyranosyl bromide (XVI).[3] Namely, crystals (XVII), mp 128—131°, $[\alpha]_D^{20}$ +46°, were obtained in theoretical yield after stirred a mixture of XVI and silver carbonate in aqueous acetone. The elemental analysis of XVII was quite in agreement with $C_{15}H_{19}O_7SBr$, thus XVII was assigned to 4-O-acetyl-3-bromo-6-O-tosyl-2,3-dideoxy-D-*arabino*-hexopyranoses. As the product scarcely showed mutarotation we could not detect the anomeric configuration at C_1.

Acetylation of XVII gave two anomeric 3-bromo-6-O-tosyl-1,4-di-O-acetyl-2,3-dideoxy-D-*arabino*-hexopyranoses. The α-anomer (XVIII), mp 104—105°, $[\alpha]_D^{20}$ +60°, revealed the anomeric proton as a triplet at τ 3.93, while β-anomer (XIX), mp 103—105°, $[\alpha]_D^{20}$ +16.5°, as a quartet at τ 4.38. Reflux of XVIII with potassium acetate in acetic anhydride for one hour gave crystals in 52% yield. The product was indistinguishable with authentic 3-bromo-2,3-dideoxy-1,4,6-tri-O-acetyl-α-D-*arabino*-hexopyranose (VI).

In conclusion, when addition of hydrogen bromide is carried out upon 3,4,6-tri-O-acetyl-D-glucal in glacial acetic acid, elimination of acetyl at C_3 and stereospecific addition of bromine proceed to give 3-bromo-4,6-di-O-acetyl-2,3-dideoxy-α-D-*arabino*-hexopyranosyl bromide (IV). The result is similar to that in 6-O-tosyl-3,4-di-O-acetyl-D-glucal, which had been reported by us.[3] Thus the structure of V, which is prepared by treatment of IV with aqueous acetone under the presence of silver carbonate, is assigned to 3-bromo-4,6-di-O-acetyl-2,3-dideoxy-α-D-*arabino*-hexopyranose. Accordingly, the structures of derivatives prepared from IV and V are assigned to that as shown in Charts 1 and 2.

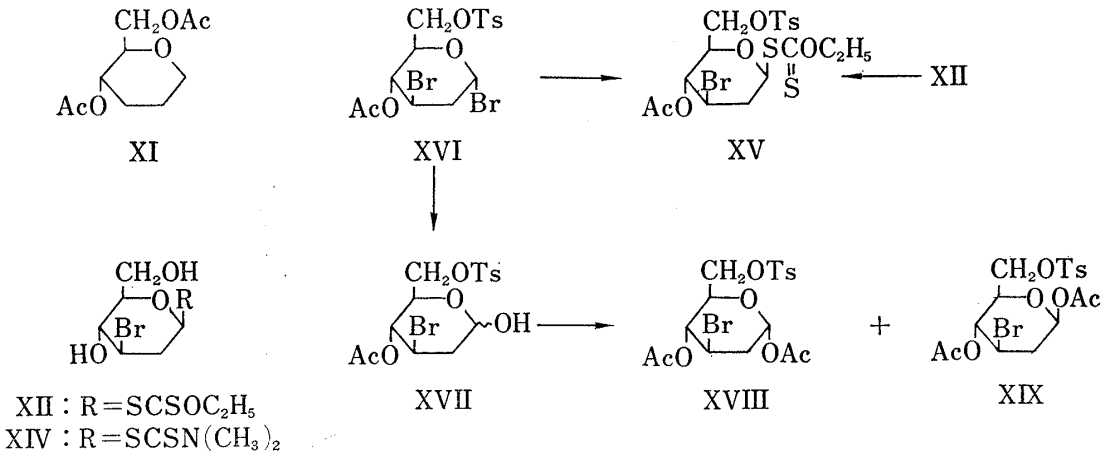

Chart 2

Several papers on addition of hydrogen bromide upon 3,4,6-tri-O-acetyl-D-glucal (I) have been referred in the literature.[4,8] As the reaction always proceeds to give 2-deoxy-

8) *a*) J. Davoll and B. Lythgoe, *J. Chem. Soc.*, **1949**, 2526; *b*) J.J. Fox, L.F. Cavalieri, and N. Chang, *J. Am. Chem. Soc.*, **75**, 4315 (1953); *c*) J.J.K. Novák and F. Sǒrm, *Collection Czechoslov. Chem. Communs.*, **27**, 902 (1962); *d*) W.A. Bonner, *J. Org. Chem.*, **26**, 908 (1961).

3,4,6-tri-O-acetyl-α-D-*arabino*–hexopyranosyl bromide, which presents a facile synthetic route for 2-deoxy-D-*arabino*–hexopyranose derivatives.

On the contrary, only a few papers have been reported on addition of hydrogen bromide upon I in acetic acid. In the year of 1920, Fischer, *et al.*[9] recorded that I and hydrogen bromide in acetic acid gave a crystalline Glucal-hydrobromid-diacetat, $C_{10}H_{15}O_6Br$, mp 99—100°, $[\alpha]_D^{17}$ +39.9° (3 min)→ +34.1° (90 hr), which on acetylation yielded a Glucal–hydrobromid-triacetat, $C_{12}H_{17}O_7Br$, mp 82—85°, $[\alpha]_D^{19}$ +54.4°. Repetition of the work by Davoll and Lythgoe[8a] yielded a sirup which decomposed in a way suggesting the presence of 1-bromo-1,2-dideoxy-D-*arabino*–hexopyranose derivative. Since then, numerous effort to elucidate the Fischer's compounds has been envisaged up to this time. However, the structure and configuration of these compounds have not yet been clarified.[10]

The authors now emphasize that 3-bromo-4,6-di-O-acetyl-2,3-dideoxy-α-D-*arabino*–hexopyranose (V) has similar physical constants with that of the Fischer's Glucal–hydrobromid-diacetat. Furthermore, 3-bromo-2,3-dideoxy-1,4,6-tri-O-acetyl-α-D-*arabino*–hexopyranose (VI), prepared by acetylation of V, also reveals similar constants with that of the Glucal-hydrobromid–triacetat.

According to the Fischer's original paper, when the addition of hydrogen bromide completed, the reaction mixture was diluted with ether and then poured into ice water. The ether layer was washed throughly with water, then treated with silver acetate to remove hydrogen bromide from the solution, and finally dried over sodium sulfate. Consequently, it may be not so unreasonable to speculate that in the course of the reaction the orginally formed bromide might be hydrolyzed to hydroxyl to afford V.

Presumably compounds V and VI might be the same with the Fischer's Glucal–hydrobromid–diacetat and triacetat, respectively.

Experimental

Unless stated otherwise, solvents were evaporated *in vacuo* at a bath temperature of 40° in a rotatory evaporator. TLC was performed by ascending method with silica gel G (E. Merck, Darmstadt, Germany) as the absorbent using benzene–ether (4:1, v/v) as the solvent. Identification was effected with UV lamp or dil. H_2SO_4. The NMR spectra were measured by H-6013 (Hitachi Ltd., Tokyo) in $CDCl_3$ at 60 Mc with tetramethylsilane as an internal standard. Chemical shifts were given in τ values and coupling constants (J) cps.

3-Bromo-4,6-di-O-acetyl-2,3-dideoxy-α-D-*arabino*-hexopyranose (V)——a) From 3,4,6-Tri-O-acetyl-D-glucal (I): To a glacial AcOH (25 ml), previously saturated with dry HBr at 0°, was added I (5 g). The mixture was left to stand at room temperature, during which gradually turned to dark brown. After 3 hr the mixture was diluted with addition of ice H_2O (100 ml) and extracted with $CHCl_3$ (2×50 ml). The organic layer was washed with aq. $NaHCO_3$ and H_2O, dried over Na_2SO_4. After filtration, the solvent was removed to give a sirupy bromide (IV), $[\alpha]_D^{20}$ +116° (c=1.06, $CHCl_3$). Without interval of time, freshly prepared Ag_2CO_3 (5 g) and 30% aq. acetone (v/v, 80 ml) were added and the mixture was stirred for 1 hr at room temperature. Insoluble material was removed through Celite and the filtrate was evaporated to give an oil, which was extracted with $CHCl_3$ (70 ml). The $CHCl_3$–layer was washed with ice H_2O, dried over $CaCl_2$, filtered, and evaporated to give an oil. Crystallization was induced after left the oil in a desiccator. Recrystallization from benzene–petr. ether gave pure material (4 g, 70%), mp 99°, $[\alpha]_D^{20}$ +40.5° (10 min)→ +34.5° (17 hr) (c=1, EtOH). *Anal.* Calcd. for $C_{10}H_{15}O_6Br$: C, 38.60; H, 4.85; Br, 25.69. Found: C, 38.63; H, 4.82; Br, 25.86.

b) From 2,3-Dideoxy-1,4,6-tri-O-acetyl-D-*erythro*-hex-2-enose (1,4,6-tri-O-acetyl-D-pseudoglucal) (II)—— The starting material (II) was prepared by the method of Bergmann.[11] A mixture of II (1 g) in glacial AcOH (6 ml) containing HBr saturated at 0°, was left to stand for 3 hr at room temperature, then treated as described in a). The resultant crystals (0.8 g, 70%), mp 98—99°, were indistinguishable with V by IR and did not show mixed mp depression.

9) E. Fischer, M. Bergmann, and H. Schotte, *Ber.*, **53**, 509 (1920).
10) B. Helferich, "Advances in Carbohydrate Chemistry," Vol. 7, 1952, p. 218; W.G. Overend and M. Stacey, *ibid.*, Vol. 8, 1953, p. 72; R.J. Ferrier, *ibid.*, Vol. 20, 1965, p. 83.
11) M. Bergmann, *Ann.*, **434**, 99 (1923).

c) From 2-Deoxy-1,3,4,6-tetra-O-acetyl-α-D-*arabino*-hexopyranose (III)——The starting material (III) was prepared by the method of Bonner.[8d] A mixture of III (1 g) in glacial AcOH–HBr (7 ml) was treated as described in a) to give crystals (0.5 g, 50%), mp 99°, which were indistinguishable with V by IR and TLC.

3-Bromo-2,3-dideoxy-1,4,6-tri-O-acetyl-α-D-*arabino*-hexopyranose (VI)——To a chilled mixture of Ac_2O (12 ml) and pyridine (15 ml) was gradually added V (2 g) under stirring at 0°. After standing in a refrigerator overnight, the mixture was poured into ice H_2O (500 ml). Resultant crystals were collected by filtration and the filtrate was extracted with $CHCl_3$ (2×40 ml). The organic layer was washed with cold 10% H_2SO_4, aq.$NaHCO_3$ and H_2O, dried over Na_2SO_4. The solvent was removed from the filtrate to afford a sirup which crystallize by trituration with aq.EtOH. Recrystallization from aq.EtOH gave pure material (1.94 g, 85%), mp 82°, $[\alpha]_D^{20}$ +58° (c=1, $CHCl_3$), NMR τ: 3.90 (1H, triplet, anomeric proton, $J_{1,2}$ =2.5 cps), 7.45 (2H, multiplet, CH_2 at C_2), 7.86 (6H, singlet, $2CH_3CO$), 7.90 (3H, singlet, CH_3CO). *Anal.* Calcd. for $C_{12}H_{17}O_7Br$: C, 40.81; H, 4.85; Br, 22.63. Found: C, 41.08; H, 4.96; Br, 22.72.

3-Bromo-2,3-dideoxy-1,4,6-tri-O-acetyl-β-D-*arabino*-hexopyranose (VII)——Sirupy bromide (IV) was prepared starting with I (5 g) by the method described in the preceding part of the preparation of Va. To a solution of IV in acetonitril (70 ml) was added silver acetate (6 g) and the mixture was stirred for 1 hr at room temperature. Insoluble material was removed by filtration and the filtrate was evaporated to dryness. The residue was dissolved in $CHCl_3$ (50 ml) and filtered through Celite. The solvent was removed from the filtrate to afford a sirup which crystallized from EtOH–petr. ether by keeping the solution in a refrigerator for 2 days. The crystals were collected by filtration and recrystallized from EtOH–petr. ether to give pure material (3 g, 48%), mp 85.5—86°, $[\alpha]_D^{20}$ +12.5° (c=1, $CHCl_3$), NMR τ: 4.28 (1H, quartet, anomeric proton), 7.50 (2H, multiplet, CH_2 at C_2), 7.80 (6H, singlet, $2CH_3CO$), 7.84 (3H, singlet, CH_3CO). *Anal.* Calcd. for $C_{12}H_{17}O_7Br$: C, 40.81; H, 4.85. Found: C, 40.82; H, 4.91.

Anomeric Methyl 3-Bromo-2,3-dideoxy-D-*arabino*-hexopyranoses (α: VIII, β: IX)——A solution of V (5 g) in dry MeOH (50 ml) containing 1% HCl was stirred for 8 hr at room temperature, then neutralized with Ag_2CO_3. Insoluble material was removed by filtration and the solvent was removed from the filtrate to give crystals. Recrystallization from benzene gave product (3.8 g, 97%), mp 95—97°, $[\alpha]_D^{21}$ +72° (c=1, MeOH) which contained two components by TLC: Benzene–ethyl acetate (1:1, v/v) was used as the solvent. The product (3 g) was dissolved in benzene–ethyl acetate (2:1, v/v) and chromatographed on silica gel (80 g) with the same solvent. From the forthcoming effluent, α-anomer (VIII) crystallized after evaporation of the solvent. Recrystallization from ethyl acetate–petr. ether gave pure material (1.45 g, 48%), mp 108—109°, $[\alpha]_D^{22}$ +100° (c=0.5, MeOH). The product did not consume $NaIO_4$. *Anal.* Calcd. for $C_7H_{13}O_4Br$: C, 34.87; H, 5.43. Found: C, 35.10; H, 5.26.

From the successive effluent of the same solvent, β-anomer (IX) crystallized after evaporation of the solvent. Recrystallization from ethyl acetate gave pure material (0.65 g, 22%), mp 100—101°, $[\alpha]_D^{22}$ −31° (c=0.5, MeOH). The product did not consume $NaIO_4$. *Anal.* Calcd. for $C_7H_{13}O_4Br$: C, 34.87; H, 5.43. Found: C, 35.01; H, 5.45.

3-Bromo-4,6-di-O-acetyl-2,3-dideoxy-β-D-*arabino*-hexopyranosyl Ethylxanthate (X)——A mixture of IV, prepared starting with I (5 g), and potassium ethylxanthate (4 g) in acetone (60 ml) was stirred for 1 hr at room temperature, then poured into ice H_2O (700 ml). The resultant crystals were collected by filtration and recrystallized from EtOH to give pure material (5.6 g, 77%), mp 94°, $[\alpha]_D^{20}$ −23.5° (c=1, $CHCl_3$), UV λ_{max}^{EtOH} mμ (ε): 274 (10400). *Anal.* Calcd. for $C_{13}H_{19}O_6S_2Br$: C, 37.66; H, 4.62; S, 15.74; Br, 19.27. Found: C, 37.57; H, 4.75; S, 15.50; Br, 19.09.

4,6-Di-O-acetyl-1,5-anhydro-2,3-dideoxy-D-*erythro*-hexitol (XI)——A mixture of X (1.5 g) and freshly prepared Raney Ni, activated from alloy (30 g), in EtOH (60 ml) was refluxed for 6 hr, then filtered through Celite. The solvent was removed from the filtrate to give a sirup which was dissolved in ether (30 ml). The ether solution was washed with cold H_2O, dried over $CaCl_2$, and filtered. Evaporation of the solvent afforded a colorless oil (0.5 g, 63%), $[\alpha]_D^{20}$ +35° (c=1, EtOH), indistinguishable with authentic 4,6-di-O-acetyl-1,5-anhydro-2,3-dideoxy-D-*erythro*-hexitol[4] by IR. Gray and Barker[12] give $[\alpha]_D$ +34° (MeOH) for 4,6-di-O-acetyl-1,5-anhydro-2,3-dideoxy-D-*erythro*-hexitol. 1,5-Anhydro-4,6-O-benzylidene-2,3-dideoxy-D-*erythro*-hexitol was prepared by the method of Ferrier, *et al.*[5] The product melted at 136—137°. Ferrier, *et al.* report mp 135° or Bergmann and Breuers[6] give mp 137° for 1,5-anhydro-4,6-O-benzylidene-2,3-dideoxy-D-*erythro*-hexitol.

3-Bromo-2,3-dideoxy-β-D-*arabino*-hexopyranosyl Ethylxanthate (XII)——To a chilled suspension of X (3.5 g) in MeOH (18 ml) was added MeOH (15 ml), containing HCl previously saturated at 0°, and the mixture was kept in a refrigerator overnight. The solvent was removed to give crystals which were recrystallized from ethyl acetate to give pure material (2.5 g, 89%), mp 129—130°, $[\alpha]_D^{22}$ −10° (c=1, MeOH). *Anal.* Calcd. for $C_9H_{15}O_4S_2Br$: C, 32.63; H, 4.56; S, 19.36; Br, 24.12. Found: C, 32.77; H, 4.74; S, 19.43; Br, 23.89.

12) G.R. Gray and R. Barker, *J. Org. Chem.*, 32, 2764 (1967).

Acetylation of XII (0.5 g) in pyridine (2 ml) with Ac_2O (1.5 ml) overnight, then poured the mixture into ice H_2O (150 ml) to give crystals which were collected by filtration. Recrystallization from EtOH gave pure material (0.6 g, 95%), mp 94°, did not show mixed mp depression with X.

3-Bromo-4,6-di-O-acetyl-2,3-dideoxy-β-D-*arabino*-hexopyranosyl N,N-Dimethyldithiocarbamate (XIII)—A mixture of IV, prepared starting with I (5 g), and sodium N,N-dimethyldithiocarbamate (3.5 g) in acetone (60 ml) was treated with the same procedure for the preparation of X. Recrystallization from EtOH gave pure material (5 g, 66%), mp 134—135°, $[\alpha]_D^{20}$ +8° (c=0.5, $CHCl_3$). IR ν_{max}^{Nujol} cm^{-1}: 1490 (dithiocarbamate). UV λ_{max}^{EtOH} mμ (ε): 278 (8600). *Anal.* Calcd. for $C_{13}H_{20}O_5NS_2Br$: C, 37.68; H, 4.87. Found: C, 37.38; H, 4.98.

3-Bromo-2,3-dideoxy-β-D-*arabino*-hexopyranosyl N,N-Dimethyldithiocarbamate (XIV)——A suspension of XIII (2 g) in MeOH (50 ml), saturated with dry NH_3 at 0°, was stirred for 6 hr at room temperature, during which XIII gradually dissolved in solution. After being left to stand overnight, the solvent was removed to give crystals. Recrystallization from ethyl acetate gave pure material (1.5 g, 94%), mp 164° (decomp.), $[\alpha]_D^{20}$ +29.5° (c=1, MeOH). *Anal.* Calcd. for $C_9H_{16}O_3NS_2Br$: C, 32.73; H, 4.88; N, 4.24. Found: C, 32.88; H, 4.98; N, 4.16.

4-O-Acetyl-3-bromo-6-O-tosyl-2,3-dideoxy-β-D-*arabino*-hexopyranosyl Ethylxanthate (XV)——To a solution of XII (2 g) in dry pyridine (20 ml) was added dropwise at 0°, under stirring, a solution of TsCl (1.3 g) in dry pyridine (7 ml). After the mixture was left to stand for 2 days at room temperature, Ac_2O (20 ml) was added. The mixture was left for further 24 hr, then poured into ice H_2O (500 ml). Resultant crystals were collected by filtration and recrystallized first from EtOH ,then from ether–petr. ether to give pure material (1.7 g, 53%), mp 126—128°, indistinguishable with authentic 4-O-acetyl-3-bromo-6-O-tosyl-2,3-dideoxy-β-D-*arabino*-hexopyranosyl ethylxanthate[3] by IR and TLC.

4-O-Acetyl-3-bromo-6-O-tosyl-2,3-dideoxy-D-*arabino*-hexopyranoses (XVII)——A mixture of 4-O-acetyl-3-bromo-6-O-tosyl-2,3-dideoxy-α-D-*arabino*-hexopyranosyl bromide (XVI)[3] (2 g) and Ag_2CO_3 (2.5 g) in 30% aq. acetone (v/v, 20 ml) was stirred for 1 hr at room temperature, then filtered through Celite. The residue was washed with the same solvent. The combined filtrate and washings were evaporated to afford crystals. Recrystallization from EtOH gave pure material (1.7 g, 96%), mp 128—131°, $[\alpha]_D^{20}$ +46° (c=1, acetone). A solution of XVII in dioxane—H_2O (9: 1, v/v) scarcely showed mutarotation: $[\alpha]_D^{26}$ +45° (20 min), +47° (24 hr) and +48° (48 hr). *Anal.* Calcd. for $C_{15}H_{19}O_7SBr$: C, 42.50; H, 4.52; S, 7.58; Br, 18.88. Found: C, 42.46; H, 4.49; S, 7.66; Br, 18.64.

3-Bromo-6-O-tosyl-1,4-di-O-acetyl-2,3-dideoxy-α-D-*arabino*-hexopyranose (XVIII)——To a chilled mixture of pyridine (10 ml) and Ac_2O (8 ml) was gradually added XVII (1 g) at 0°. After being left to stand in a refrigerator overnight, the mixture was poured into ice H_2O (300 ml). The resultant crystals were collected by filtration and twice recrystallizations from EtOH and, finally, from ether–petr. ether gave pure material (0.62 g, 56%), mp 104—105°, $[\alpha]_D^{20}$ +60° (c=0.5, $CHCl_3$), NMR τ: 3.93 (1H, triplet, anomeric proton, $J_{1,2}$=2.5 cps). *Anal.* Calcd. for $C_{17}H_{21}O_8SBr$: C, 43.88; H, 4.55. Found: C, 43.96; H, 4.59.

A mixture of XVIII (0.5 g) and AcOK (0.5 g) in Ac_2O (10 ml) was refluxed for 1 hr, then poured into ice H_2O (200 ml). After left to stand for 5 hr at room temperature, the solution was extracted with $CHCl_3$ (3×20 ml). The organic layer was washed with aq. $NaHCO_3$ and H_2O, dried over Na_2SO_4, and filtered. The solvent was removed to give a sirup which was dissolved in aq.EtOH and left in a refrigerator to crystallize. Collected crystals were recrystallized from aq.EtOH to give pure material (0.2 g, 52%), mp 82°. The product was indistinguishable with 3-bromo-2,3-dideoxy-1,4,6-tri-O-acetyl-α-D-*arabino*-hexopyranose (VI).

3-Bromo-6-O-tosyl-1,4-di-O-acetyl-2,3-dideoxy-β-D-*arabino*-hexopyranose (XIX)——To a solution of XVII (2 g) in dry pyridine (10 ml) was added Ac_2O (8 ml) and the mixture was left overnight at room temperature. Then the mixture was treated as described in the preparation of XVIII to afford crystals. Recrystallization from EtOH gave pure material (0.78 g, 36%), mp 103—105°, $[\alpha]_D^{20}$ +16.5° (c=1, $CHCl_3$), NMR τ: 4.38 (1H, quartet, anomeric proton). *Anal.* Calcd. for $C_{17}H_{21}O_8SBr$: C, 43.88; H, 4.55; S, 6.89; Br, 17.19. Found: C, 43.66; H, 4.55; S, 7.07; Br, 17.17.

From the mother liquid of the recrystallization, another crystals (0.73 g, 33%) were obtained after concentration of the solvent. The product was indistinguishable with XVIII by IR and did not show mixed mp depression.

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