The Brominolysis Reaction of Stannylene Derivatives: A Regiospecific Synthesis of Carbohydrate-derived Hydroxy-ketones

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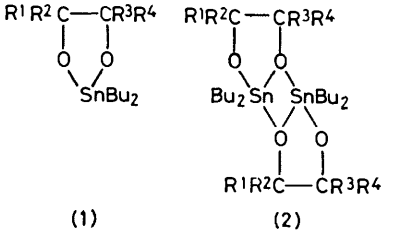
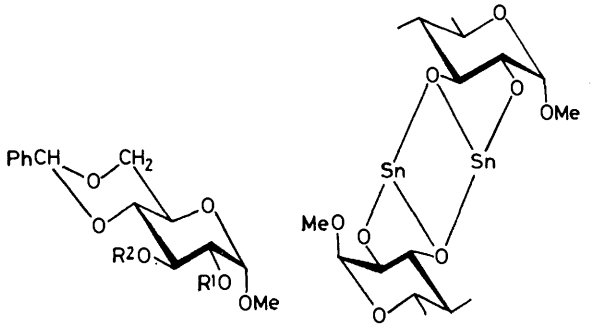
The oxidation of six partially protected derivatives of glucose and galactose with two free hydroxy-groups, by treatment with bromine of their *O*-dibutylstannylene derivatives, dissolved in benzene, in the presence of a hydrogen bromide or proton scavenger, was found to be regiospecific, giving in good yield only one of the two possible hydroxy-ketones. For instance, benzyl 4,6-*O*-benzylidene-β-D-*arabino*-hexopyranos-3-uloside (34) was prepared in 72% yield from benzyl 4,6-*O*-benzylidene-β-D-galactopyranoside. The benzoylation of these dibutylstannylenes in benzene solution without added base was often regiospecific. Possible correlations between the preferred sites of oxidation and benzoylation in these conditions are discussed.

THE reaction of 1,2-diols with dibutyltin bisethoxide [1,2] or oxide,[3] in benzene suspension with azeotropic removal of either alcohol or water, gives the so-called ' dibutylstannylenes '.[4] From their general properties, these have been considered [5-7] to exist in non-polar solvents as



(1) (2)

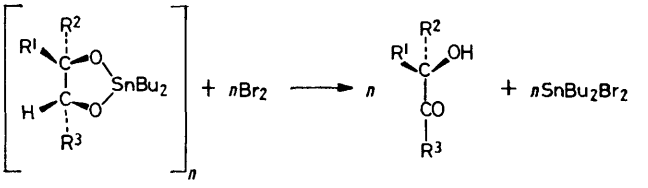
dimers (2) of the acetal-like compounds (1). A solid-state structure has been reported for only one compound of this family, the dibutylstannylene derivative of methyl 4,6-*O*-benzylidene-α-D-glucopyranoside, which was found to be the dimer (7) in this state.[8] In 1974 one of us



(7)

(3) $R^1 = R^2 = H$
(4) R^1 = PhCO, $R^2 = H$
(5) R^1 = Me, $R^2 = H$
(6) $R^1 = H$, R^2 = Me

reported that stannylenes in dichloromethane solution, are oxidized with bromine to the corresponding keto-alcohols. The reaction proceeds at room temperature, at the speed of a titration (Scheme 1).[9] Following our first report, this reaction was extended by other groups, to the tributyltin ethers of alcohols, the oxidant being bromine [10,11] or nitrosyl fluoroborate.[12] Already in 1971, one group had reported that the tributyltin ethers of some alcohols were oxidized to carbonyl derivatives by polyhalogenomethanes under u.v. irradiation.[13] However, stannylene oxidation seemed more interesting to us, as an exploration into glycol chemistry, a subject of current interest.[14-16] Sugar derivatives are good models to assess the scope of the method, in the presence of a variety of protecting groups, because of the ease of discrimination between possible isomeric oxidation products.



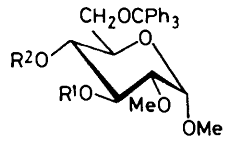
SCHEME 1

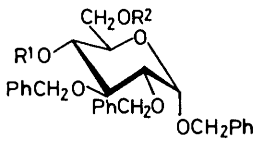
RESULTS AND DISCUSSION

The starting glycols for this study were the partially protected glucose and galactose derivatives (3), (8), (12), (18), (23), and (26). All were known except compound (8), the synthesis of which is described below. Although benzylic protons make the interpretation of ^{1}H n.m.r. spectra more difficult, derivatives with benzyl ether protecting groups were selected, when easily available, in the hope of preparing compounds useful for further syntheses. These glycols were converted into the corresponding stannylenes, (7), (9), (13), (19), (24), and (27) by reaction with an equimolar quantity of dibutyltin oxide in boiling benzene, with azeotropic removal of water, until the i.r. spectra of the solutions showed no absorptions around 3 500 cm^{-1}. The times needed for this were variable, from <1 h to *ca.* 12 h. Evaporation of benzene gave the crude stannylenes which were used as such, without further purification. The yields given are relative to the starting diols.

Model experiments with the stannylenes of acyclic diols show that, in many cases, their brominolyses do not follow the stoicheiometry indicated in Scheme 1. The reaction may become sluggish after addition of *ca.* two-thirds of the stoicheiometric amount of bromine. It seems probable that acidification of the reaction medium

causes Sn–O bond fission and formation of inactive material. Good yields were obtained in the brominolysis of the *trans*-cyclohexane-1,2-diol derivative in the





(8) $R^1 = R^2 = H$

(9) $R^1, R^2 = SnBu_2$

(10) $R^1 = Bz, R^2 = H$

(11) $R^1 = H, R^2 = PhCO$

(12) $R^1 = R^2 = H$

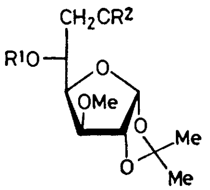
(13) $R^1, R^2 = SnBu_2$

(14) $R^1 = H, R^2 = PhCO$

(15) $R^1 = H, R^2 = Ac$

(16) $R^1 = H, R^2 = PhCH_2$

(17) $R^1 = R^2 = PhCH_2$



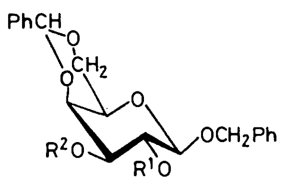
(18) $R^1 = R^2 = H$

(19) $R^1, R^2 = SnBu_2$

(20) $R^1 = H, R^2 = PhCO$

(21) $R^1 = PhCO, R^2 = H$

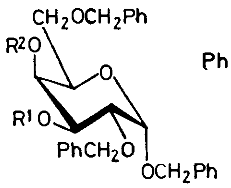
(22) $R^1 = R^2 = PhCO$



(23) $R^1 = R^2 = H$

(24) $R^1, R^2 = SnBu_2$

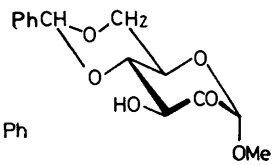
(25) $R^1 = H, R^2 = PhCO$



(26) $R^1 = R^2 = H$

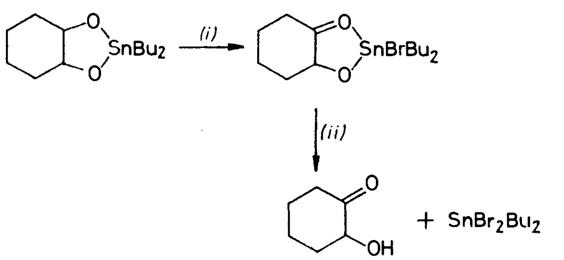
(27) $R^1, R^2 = SnBu_2$

(28) $R^1 = PhCO, R^2 = H$



(29)

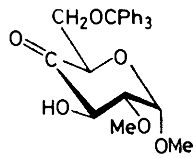
presence of 1.5 mol of pinacol dibutylstannylene, a non-oxidizable proton scavenger. Examination of the reaction medium by i.r. spectroscopy showed a carbonyl absorption at 1 685 cm^{-1}, which shifted to 1 720 cm^{-1} on acidification with hydrogen bromide. We consider that 2-hydroxycyclohexanone was originally present in the reaction medium as a chelated derivative (Scheme 2). Now, in the absence of a proton scavenger, the acid generated in the medium by the reaction may attack the



SCHEME 2

starting material as well as the chelated ketone. For this reason, brominolyses were carried out in the presence of 4 Å molecular sieves, a hydrogen bromide scavenger, or 1 equiv. tributyltin methoxide. Yields were slightly higher by the second method, but the introduction into the reaction medium of organotin compounds, which are difficult to remove, is always inconvenient.

In the presence of these additional reagents, oxidation of the dibutylstannylene derivatives of sugars, in benzene or dichloromethane solutions, occurs at the speed of titration on dropwise addition of a dichloromethane solution of bromine, as shown by the rapid discolouration. Chromatography then allowed the recovery, in good yield, of the hydroxy-ketones, the only other components of the system being the starting diol and organotin by-products. Thus the more stable hydroxy-ketones (31) (77—87%), (32) (48%), and (34) (46—72%) were readily prepared in a pure state. The structure of compound (31) was proved by reduction to a mixture of known *gluco*- and *galacto*-derivatives. The primary nature of the alcoholic function in compound (32) was proved by benzoylation. In the ^{1}H n.m.r. spectrum of the benzoate (33), the signal of the 6-H and 6′-H protons could be easily recognizable as a low-field quartet (relative to the parent hydroxy-ketone), with $|J_{6,6'}|$ 18 Hz. Finally, in the ^{1}H n.m.r. spectrum of the hydroxy-ketone obtained from (24) the proton *gem* to the hydroxy appeared strongly coupled (J 7.7 Hz) to a stable neighbour, which would not be possible if the carbonyl was located at C-2.



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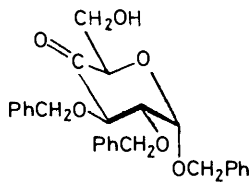
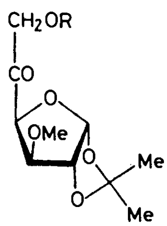
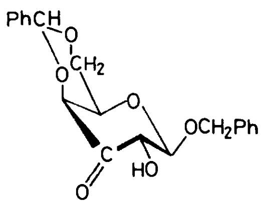


(31)



(32) R = H

(33) R = PhCO



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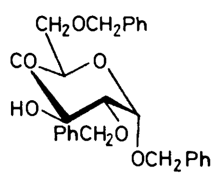

(35)

Oxidation by the same method of the related diols (8) and (26), with free hydroxy-functions at C-3 and C-4, gave the syrupy ketones (30) and (35) in 72 and 73% yield, respectively. They had to be examined immediately after their isolation, when they appeared homogeneous on t.l.c., since there was evidence of decomposition after 1 d at room temperature. Their formulation as α-D-*xylo*-hexopyranos-4-ulosides rests on the following evidence. Sodium borohydride reduction of (35) gave

a mixture of the starting diol (26) and benzyl 2,6-di-*O*-benzyl-α-D-glucopyranoside. This last glucoside was not characterized as such, but was benzylated to the known, crystalline derivative (17). From the hydroxy-ketone (35) could be prepared a crystalline semicarbazone with the expected composition.* The ^{1}H n.m.r. spectrum of this ketone is perfectly consistent with formula (35); the composition of a presumably altered sample was that of a monohydrate. For the related ketone (30), the proposed structure rests on the ^{1}H n.m.r. spectrum, in which the signals due to H-1, H-2, and H-3 could be unambiguously assigned.

Finally, the hydroxy-ketone from the stannylene (7) was stable only in a dilute chloroform solution (such as was obtained in the course of a chromatographic separation), in which it appeared homogeneous by t.l.c. and showed no tendency to decompose; but all attempts to concentrate or isolate it led to decomposition. The yield of the oxidation could be estimated as 60%, after transfer of the reaction mixture to methanol, by *in situ* reduction and isolation of compound (3). Structure (29) is given to this hydroxy-ketone, as it is distinct from the known [17] methyl 4,6-*O*-benzylidene-α-D-*ribo*-hexopyranos-3-uloside.

Related oxidation methods were tested with the diol (12). The 4,6-*O*-tributylstannyl ether [10] did not react with bromine. Treatment with bromine of an equimolecular mixture of the diol and hexabutylstannoxane [11] gave a 40% yield of compound (31); this method involves using twice as much organotin derivative as in the method using the stannylene, to give an inferior yield. The use of 5 mol of stannoxane per mol of diol only raised the yield to 43%, while with 0.5 mol of stannoxane the yield dropped to 20%.

At this point, it seemed interesting to see whether the same regiospecificity was operative in oxidation and electrophilic substitution on oxygen atoms. Thus, we examined the benzoylation of the stannylene derivatives in benzene, without added bases which might change the properties of the active species by co-ordinating with the tin atom. Molecular sieves were added as a hydrogen chloride scavenger. Benzoylation, in these unusual conditions, of 0.2 molar solutions of derivatives (7) and (24) was very fast, giving in each case, in <5 min at room temperature, a quantitative yield of only one isomer. The regiospecificity was the same as that of brominolysis, and also the same as that of conventional methods. Benzoylation of the *galacto*-3,4-*O*-dibutylstannylene derivative (27) only yielded the 3-benzoate (28) (74%), but at a greatly reduced rate, the reaction proceeding at least a thousand times more slowly than that of compounds (7) and (24). So the reactivities of the 3-*O* oxygen are very different in the two galactopyranose derivatives (24) and (27), although in both cases these atoms are part of a stannylene ring. The free diol (26) did not react at all under these conditions. In the same way, benzoylation of the derivative (9), which may be considered as a *gluco*-analogue of (27), needed 2 d for completion at room temperature, and gave the 3-benzoate (10) (59%) as the main product, with the 4-benzoate in smaller yield (22%). Regiospecific or regioselective benzoylation in the latter two instances are not due to the greater activation of the 3-*O* oxygen, but to the well known, but as yet unexplained, inertness of the 4-*O* oxygen in several gluco- and galacto-pyranose derivatives, which is apparently not overcome by substitution by tin. Finally, under the same conditions, the stannylene derivative (19) gave, in <5 min at room temperature, a mixture of the 6-benzoate (20) (38%) and the 5-benzoate (21) (7.5%) with some dibenzoate (22) (24%). As the 5-benzoate is the probable precursor of the dibenzoate, this indicates comparable reactivities towards benzoylation at positions 5 and 6. On the other hand, treatment of the stannylene derivative (19) with 2 equiv. benzoyl chloride in pyridine solution gives only the 6-benzoate after 30 min at room temperature. Again in the derivative of diol (18), as in the four preceding cases, we find that the oxygen linked to the carbon *not oxidized* is relatively deactivated when the stannylene derivative is reacted in benzene solution, in the absence of other co-ordinating molecules.

In the dimeric solid-state structure (7), which probably persists in weakly polar solvents,[18] the 3-*O* oxygen of one monomeric unit is co-ordinated to the tin atom of the other, and this may be the origin of a general deactivation towards electrophilic attack in the vicinity of this oxygen. If such dimers are the reactive species, the regiospecificity is readily explained by assuming co-ordination by the 2-*O* oxygen in the case of dimer (24), and by the 3-*O* oxygen in the cases of dimers (9) and (27); we would not expect the poorly nucleophilic 4-*O* oxygen of monomeric (9) and (27) to bind to a second tin atom. Finally, binding in the dimer of (19) should occur *via* the 6-*O* oxygen. Since we do not really know whether dimers are really involved in the rate-determining steps, we may make the more general assumption that regioselectivity in weakly polar solvents is controlled by the abilities of the stannylene oxygen atoms to co-ordinate with diorganotin compounds in the medium.

Benzoylation in benzene of the stannylene derivative (13) is rapid (5 min) and selective for the 6-position, but we cannot extend our comparisons to this six-membered ring stannylene, which is probably less strained than five-membered ones.

Dibutylstannylene derivatives of nucleosides [19] and sugars [20,21] have proved to be useful activated derivatives for the selective substitution of only one hydroxy-function; they have been used in good co-ordinating solvents, often in the presence of an excess of amine. Complexes of monomeric units with solvents, amine, or even reagent molecules may be present. The presence of unco-ordinated five-membered ring stannylene deriv-

* Isomerization in the derivatization medium before reaction with semicarbazide cannot be excluded, since the 90 MHz ^{1}H n.m.r. spectrum of the semicarbazone is not readily interpretable in the 2-H region.

atives is unlikely, because of the probable strain associated with the O–Sn–O angle [8] (*ca.* 80°), which is better accommodated in a trigonal bipyramid. In any case the regioselectivity of substitution will be altered. For example, treatment of the derivative (7) with methyl iodide in DMF at 45 °C gives a 2 : 1 mixture of the 2-*O*-methyl (5) and the 3-*O*-methyl ether (6). There is no apparent reaction in refluxing benzene. Benzylation of derivative (13) slowly gives the 6-*O*-benzyl ether (16) in hexamethylphosphoramide (HMPA) at room temperature, and a mixture of ethers (16) and (17) in DMF at 100 °C. Acetyl chloride in the system dioxan–triethylamine gives excellent yields of the 6-*O*-acetate (15).

EXPERIMENTAL

General Methods.—Hydrogen-1 n.m.r. spectra were recorded with tetramethylsilane as internal reference; unless otherwise stated, the frequency was 90 MHz and the solvent deuteriochloroform. Spots on t.l.c. were located by spraying the plates with sulphuric acid and then heating. This method does not allow detection of organotin by-products. Stannylene derivatives are decomposed on t.l.c. on silica gel plates and thus behave like tinless material.

General Procedure for Brominolyses.—A mixture of the diol (2 mmol) and dibutyltin oxide (545 mg; 2.2 mmol) in benzene was refluxed overnight with azeotropic removal of water by a Dean–Stark condenser. Evaporation of the solvent at 100 °C then gave the crude stannylene derivative, which was used without further purification. Brominolyses were carried out either on solutions of the stannylene derivatives in benzene (5 ml) in the presence of 4 Å molecular sieves (2 g) (method A), or on solutions in dichloromethane (8 ml), in the presence of tributyltin methoxide (320 mg; 1 mmol) (method B). In both cases, bromine (320 mg; 2 mmol) in dichloromethane (4 ml) was added dropwise at room temperature to the well stirred solution of the stannylene derivative as long as the discolouration was rapid (*ca.* 0.5 h). T.l.c. then indicated the presence of only two components in the reaction mixture, possibly as organotin derivatives; the hydroxy-ketone and the starting diol. After filtration (if necessary), the solution was evaporated to dryness and the hydroxy-ketone was isolated from the residue by column chromatography on a silica gel column (35 × 1.5 cm), with the eluant mixtures given below.

Benzyl 2,3-*di*-O-*benzyl*-α-D-xylo-*hexopyranos*-4-*uloside* (31). This was prepared from the diol (12) (eluant chloroform), yields 77% (A) and 87% (B), as a syrup; $\nu_{max.}$ (film) 1 740 (CO) and 3 500 cm^{-1} (OH); δ 3.65 (1 H, $J_{1,2}$ 3.8 Hz, 2-H), 3,76 (2 H, d, $J_{5,6}$ 4.5 Hz, 6-H and 6′-H), 4.09 (1 H, t, 5-H), 4.49 (1 H, d, $J_{2,3}$ 9 Hz, 3-H), and 4.95 (1 H, d, 1-H) (Found: C, 72.3; H, 6.3; O, 21.6. $C_{27}H_{28}O_6$ requires C, 72.3; H, 6.3; O, 21.4%). When either molecular sieves or tributyltin methoxide were omitted, the yield dropped to 57%.

Reduction of the ketone (31) (0.1 g) with $LiAlH_4$ (20 mg) in ether (10 ml) for 2 h at room temperature, followed by the usual work-up, gave a mixture of compounds which were separated by chromatography [ether–hexane (2 : 1)]. The less polar component (40 mg) was found to be identical (m.p. and t.l.c.) with the starting diol (12). The more polar component was benzyl 2,3-di-*O*-benzyl-α-D-galactopyranoside (35 mg), m.p. 115—116 °C (ethyl acetate, light petroleum) (lit.,[22] m.p. 116—118 °C).

1,2-O-*Isopropylidene*-3-O-*methyl*-α-D-xylo-*hexofuranos*-5-*ulose* (32). This was prepared from the diol (18) (eluant chloroform) in 48% yield (method A) as a syrup; $\nu_{max.}$ (film) 1 735 cm^{-1} (CO); δ 1.30 (3 H, s, CMe), 1.45 (3 H, s, CMe), 3.30 (3 H, s, OMe), 4.05 (1 H, d, $J_{3,4}$ 4 Hz, 3-H), 4.45 (2 H, m, 6-H and 6′-H), 4.57 (1 H, d, $J_{1,2}$ 3.5 Hz, 2-H), 4.75 (1 H, d, $J_{3,4}$ 4 Hz, 4-H), and 6.00 (1 H, d, 1-H) (Found: C, 51.7; H, 7.0. $C_{10}H_{16}O_6$ requires C, 51.7; H, 6.9%).

Benzoylation (pyridine) of the hydroxy-ketone (32) (175 mg) for 2 h at room temperature, followed by purification of the benzylated material by chromatography (chloroform) gave the benzoate (33) (170 mg), m.p. 120—121 °C (ethanol); δ 4.05 (1 H, d, $J_{3,4}$ 4 Hz, 3-H), 4.60 (1 H, d, $J_{1,2}$ 3.8 Hz, 2-H), 5.05 (1 H, d, $J_{6,6'}$ 18 Hz, 6-H), 5.35 (1 H, d, 6′-H), 4.78 (1 H, d, $J_{3,4}$ 4 Hz, 4-H), and 6.05 (1 H, d, 1-H) (Found: C, 60.4; H, 5.9; O, 33.2. $C_{17}H_{20}O_7$ requires C, 60.7; H, 6.00 O, 33.3%).

Benzyl 4,6-O-*benzylidene*-β-D-arabino-*hexopyranos*-3-*uloside* (34). This was prepared from the diol (23) [eluant chloroform–methanol (99 : 1)], yields 46% (method A) and 72% (method B), m.p. 156—158 °C (ethyl acetate, light petroleum); $\nu_{max.}$ (CH_2Cl_2) 1 740 (CO) and 3 490 cm^{-1} (OH); δ(240 MHz, [$^2H_6$]dimethyl sulphoxide, $SiMe_4$) 4.28 (1 H, dd, $J_{1,2}$ 7.7, $J_{2,OH}$ 5.5 Hz, 2-H), 4.58 (1 H, d, 1-H), 5.68 (1 H, s, PhC*H*), and 5.75 (1 H, d, OH) (Found: C, 67.3; H, 5.6; O, 26.8. $C_{20}H_{20}O_6$ requires C, 67.4; H, 5.7; O 27.0%).

Benzyl 2,6-*di*-O-*benzyl*-α-D-xylo-*hexopyranos*-4-*uloside* (35). This was prepared [23] from the diol (26) (eluant chloroform), yields 69% (method A) and 75% (method B) as a syrup; $\nu_{max.}$ (film) 1 760 (CO) and 3 500 (OH) cm^{-1}; δ 3.50 (1 H, q, $J_{1,2}$ 3.5, $J_{2,3}$ 10 Hz, 2-H), 3.55 (1 H, q, $J_{5,6'}$ 6, $J_{6,6'}$ 11 Hz, 6′-H), 3.78 (1 H, q, $J_{5,6}$ 4 Hz, 6-H), 4.27 (1 H, q, 5-H), and 4.90 (1 H, d, 1-H) (Found: C, 69.7; H, 6.2; O, 23.7. $C_{27}H_{28}O_6,H_2O$ requires C, 69.5; H, 6.5; O, 24.0%).

Semicarbazone. To a solution of the ketone (35) (0.6 g) in 95% alcohol (5 ml) were added sodium acetate (0.6 g) and semicarbazide hydrochloride (0.17 g) in water (1 ml). The mixture was set aside overnight at room temperature, then diluted with water, and the *semicarbazone* was extracted with chloroform, m.p. 149—151 °C (ethanol, water) (Found: C, 66.0; H, 6.0; O, 19.3; N, 8.1. $C_{28}H_{31}N_3O_5$ requires C, 66.5; H, 6.2; O, 19.0; N, 8.3%).

Reduction of the hydroxy-ketone (35) (65 mg) in methanol solution with sodium borohydride gave a mixture of two products which could be separated by chromatography [chloroform–methanol (98 : 2)]. The less polar component (18 mg) was identical with the starting diol (26). The more polar (34 mg) was shown to be benzyl 2,6-di-*O*-benzyl-α-D-glucopyranoside by benzylation: a mixture of this compound (91 mg), benzyl bromide (70 μl), and sodium hydride (20 mg) in tetrahydrofuran (5 ml) was refluxed for 4 h, then diluted with water and evaporated to dryness. The ether extract of the residue was crystallized from methanol to give benzyl 2,3,4,6-tri-*O*-benzyl-α-D-glucopyranoside, m.p. 93.5—94 °C, both alone or mixed m.p. with an authentic sample.[24]

Methyl 2-O-*methyl*-6-O-*triphenylmethyl*-α-D-xylo-*hexopyranos*-4-*ulose* (30). This was prepared from the diol (8) [eluant chloroform–acetone (9 : 1)], yield 72% (method A); δ 3.40 (1 H, dd, $J_{1,2}$ 4, $J_{2,3}$ 11 Hz, 2-H) 3.03 (3 H, s, OMe), 3.08 (3 H, s, OMe), 4.30 (1 H, dd, $J_{5,6}$ 4, $J_{5,6'}$ 7 Hz, 5-H), 4.50 (1 H, d, 3-H), and 5.05 (1 H, d, 1-H).

Sodium borohydride reduction of a sample of the ketone (30), pure on t.l.c., gave in 50% combined yield a mixture of protected hexopyranosides, half of which was the crystalline diol (8). Triphenylmethanol was formed under the weakly alkaline conditions of the reduction.

Estimation of the Yield in the Brominolysis of the Dibutylstannylene Derivative (7).—The reaction was carried out as in method A, except that dichloromethane was used as a solvent, to a total volume of 9 ml. Chromatography (dichloromethane) of an aliquot (3 ml) indicated that the weight of unreacted starting material (3) was 156 mg. The rest of the solution (6 ml) was diluted with methanol (15 ml), evaporated to a small volume, and treated with sodium borohydride. After the usual work-up, the weight of diol (3) in the reduced material was estimated, after chromatographic separation [dichloromethane–methanol (98 : 2)] as 334 mg. From these figures the amount of ketone (29) in the product of bromolysis was estimated as $334 \times 1.5 - 156 = 345$ mg (60.3%).

General Method for Benzoylation.—Molecular sieves (4 Å; 1 g) and benzoyl chloride (1.1 mmol) were added to a well stirred solution of the crude stannylene derivative prepared as above (1 mmol). After 5 min at room temperature, there was no longer evidence of the starting material (by t.l.c.) unless otherwise stated. The filtered solution was evaporated to dryness, and the benzoate separated from the residue by chromatography with the eluant indicated.

Methyl 2-O-*benzoyl*-4,6-O-*benzylidene*-α-D-*glucopyranoside* (4). This was prepared from the diol (3) (eluant chloroform) (yield 93%), m.p. 171—172 °C (isopropanol) (lit.,[21] m.p. 168—170 °C).

Benzyl 3-O-*benzoyl*-4,6-O-*benzylidene*-β-D-*galactopyranoside* (25). This was prepared from the diol (23) (eluant chloroform) (yield 95%), m.p. and mixed m.p. 180 °C (isopropanol) (lit.,[25] m.p. 179—180 °C).

Benzyl 3-O-*benzoyl*-2,6-*di*-O-*benzyl*-α-D-*galactopyranoside* (28). The benzoylation of (27) required 24 h at room temperature for completion. Chromatography (chloroform) gave the 3-O-*benzoyl derivative* (28) (74%) as a syrup; δ 4.20 (1 H, dd, $J_{1,2}$ 3.5, $J_{2,3}$ 10 Hz, 2-H), 5.00 (1 H, d, 1-H), and 5.50 (1 H, dd, $J_{3,4}$ 3 Hz, 3-H) (Found: C, 73.7; H, 6.2; O, 20.2. $C_{34}H_{34}O_7$ requires C, 73.6; H, 6.2; O, 20.2%).

Methyl 3- *and* 4-O-*benzoyl*-2-O-*methyl*-6-O-*triphenylmethyl*-α-D-*glucopyranoside* (10) *and* (11). These were prepared from the diol (8). The reaction needed 48 h for completion. Chromatographic separation [chloroform–acetone (97.5 : 2.5)] gave, as the less polar component, the 3-O-*benzoate* (10) (59%) as a syrup; δ 3.55 (1 H, dd, $J_{1,2}$ 4 $J_{2,3}$ 9 Hz, 2-H), 4.98 (1 H, d, 1-H), 5.50 (1 H, pseudo-triplet, $J_{3,4}$ 9 Hz, 3-H) (Found: C, 73.6; H, 6.2; O, 19.6. $C_{34}H_{34}O_7$ requires C, 73.6; H, 6.2; O, 20.2%). The more polar component was the 4-*O*-benzoate (11) (22%) also as a syrup; δ 3.25 (2 H, d, $J_{5,6} = J_{5,6'} = 4$ Hz, 6-H and 6′-H), 3.40 (1 H, dd, $J_{1,2}$ 4, $J_{2,3}$ 9 Hz, 2-H), 3.54 (3 H, s, OMe), 3.57 (3 H, s, OMe), 4.13 (1 H, pseudo-triplet, $J_{3,4}$ 9 Hz, 3-H), 5.03 (1 H, d, 1-H), and 5.23 (1 H, pseudo-triplet, 4-H).

5-O-*Benzoyl*-, 6-O-*benzoyl*-, *and* 5,6-*di*-O-*benzoyl*-1,2-O-*isopropylidene*-3-O-*methyl*-α-D-*glucofuranose* (21), (20), *and* (22). Chromatography (chloroform) of the products of benzoylation of the stannylene derivative (19) gave as the least polar component the di-*O*-benzoate (22) (yield 24%) as a syrup (Found: C, 64.95; H, 5.9; O, 28.85. $C_{24}H_{26}O_8$ requires C, 65.15; H, 5.9; O, 28.9%). The next compound eluted was the 6-*O*-benzoate (20) (38%) as a syrup, δ([$^2H_6$]dimethyl sulphoxide) 5.30 (1 H, d, $J_{5,OH}$ 5.3 Hz, 5-OH) (Found: C, 60.0; H, 6.7; O, 32.8. $C_{17}H_{22}O_7$ requires C, 60.3; H, 6.55; O, 33.1%). The most polar component was the 5-*O*-benzoate (21) (7.5%) as a syrup; δ 4.50 (2 H, 2-H and 3-H), 5.40 (1 H, m, 5-H), and 5.91 (1 H, d, $J_{1,2}$ 3 Hz, 1-H) (Found: C, 60.5; H, 6.5; O, 33.0. $C_{17}H_{22}O_7$ requires C, 60.3; H, 6.55; O, 33.1%).

Benzoylation of the stannylene derivative (19) (2.1 mmol) in pyridine (24 ml) with benzoyl chloride (0.5 ml; 4.2 mmol) for 30 min at room temperature only gave the 6-*O*-benzoate (20) (75%) and some starting material.

Benzyl 6-O-*benzoyl*-2,3-di-O-*benzyl*-α-D-*glucopyranoside* (14). This was prepared from the diol (12) [eluant ether–hexane (1 : 1)] (yield 90%), as a syrup; $\nu_{max.}$ (film) 1 730 (CO) and 3 525 cm^{-1} (OH); δ([$^2H_6$]dimethyl sulphoxide) 5.60 (1 H, d, $J_{4,OH}$ 6 Hz, 4-OH) (Found: C, 73.8; H, 6.1; O, 20.3. $C_{34}H_{34}O_7$ requires C, 73.6; H, 6.2; O, 20.2%).

Methyl 2-O-*Methyl*-6-O-*triphenylmethyl*-α-D-*glucopyranoside* (8).—A solution of the stannylene derivative of the diol (3) (3 mmol) and methyl iodide (1.3 ml) in DMF was heated for 20 h at 45 °C, and then evaporated to dryness. Chromatography [chloroform–acetone (95 : 5)] of the residue allowed the isolation of a mixture of the methyl ethers (5) and (6) (82%), which was dissolved in 50% acetic acid (20 ml), heated for 1 h at 70 °C, and then evaporated to dryness. The residue was dissolved in pyridine (15 ml), triphenylmethyl chloride (0.84 g) was added, and the solution was set aside overnight at 90 °C. Toluene was added, and after filtration, the solution was evaporated to dryness. Chromatography of the residue [chloroform–acetone (8 : 2)] gave first the 3-O-*methyl ether* (30%), m.p. 120—121 °C (ether, light petroleum) [lit.,[26] m.p. 115—118 °C (benzene)]. The next chromatographic fraction, was the 2-O-*methyl ether* (8) (57%), m.p. 166—167 °C (ether, light petroleum) (Found: C, 71.7; H, 6.6; O, 21.5. $C_{27}H_{30}O_6$ requires C, 72.0; H, 6.7; O, 21.3%).

Hydrolysis of the triphenylmethyl ether function in the above 3- and 2-*O*-methyl ethers with 80% acetic acid gave the known derivatives methyl 3-*O*-methyl-α-D-glucopyranoside, m.p. 79—80 °C (ethyl acetate) (lit.,[26] m.p. 80—81° C), and methyl 2-*O*-methyl-α-D-glucopyranoside, m.p. 148 °C (ethyl acetate) (lit.,[27] m.p. 147—148 °C), respectively.

Benzyl 2,3,6-*Tri*-O-*benzyl*-α-D-*glucopyranoside* (16).— A solution of the stannylene derivative of diol (12) (2 mmol), benzyl bromide (0.53 ml) in HMPA (5 ml), in the presence of 4 Å molecular sieves was set aside for 36 h at room temperature in the dark, then diluted with dichloromethane and filtered. The filtered solution was washed successively with 0.1M aqueous hydrochloric acid and water, and then evaporated to dryness. Chromatography of the residue [ether–hexane (1 : 2)] first gave compound (16) as a syrup (21%), identical with the derivative already described,[28] and then the starting material (12) (69%).

Benzylation with the same proportion of reagents in DMF for 3 h at 100 °C gave compound (16) (yield 30—36%), benzyl tetra-*O*-benzyl-α-D-glucopyranoside (17) (8%), and the starting material (12) (41%).

Benzyl 6-O-*Acetyl*-2,3-*di*-O-*benzyl*-α-D-*glucopyranoside* (15).—A solution of the derivative (13) (1 mmol), triethylamine (0.14 ml; 1 mmol), and acetyl chloride (70 μl) in dioxan (15 ml) was set aside for 15 min at room temperature and then evaporated to dryness. Chromatography of the residue [ether–hexane (1 : 1)] gave first the diacetate of the diol (12) as a syrup (32 mg; 6.3%); transparent in the i.r. near 3 400 cm^{-1}; δ 2.15 and 2.30 (2 × 3 H, 2 s, 2 COMe).

From the next fraction was obtained the monoacetate (15) as a syrup (0.46 g; 90%); δ 2.00 (3 H, s, COMe) and 5.45 (1 H, d, $J_{4,OH}$ 8 Hz, 4-OH) (Found: C, 70.5; H, 6.35; O, 22.8. $C_{29}H_{32}O_7$ requires C, 70.7; H, 6.55; O, 22.7%).

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