Carbohydrate Research, 71 (1979) 103–121

KINETIC ACETONATION OF D-GALACTOSE, D-ALLOSE, AND D-TALOSE WITH ALKYL ISOPROPENYL ETHERS AS A PREPARATIVE ROUTE TO THE 4,6-*O*-ISOPROPYLIDENEALDOHEXOPYRANOSES*

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(Received June 26th, 1978, accepted for publication, July 26th, 1978)

ABSTRACT

The action of 2 molar equiv of ethyl (or methyl) isopropenyl ether on D-galactose causes acetonation under conditions of kinetic control, to give 4,6-*O*-isopropylidene-α,β-D-galactopyranose (3), isolated crystalline in 67% yield after separation from a small proportion (14%) of the pyranoid 3,4-acetal and a trace (1–2%) of the furanoid 5,6-acetal Similar acetonation of D-allose led essentially exclusively (81%) to 4,6-*O*-isopropylidene-D-allopyranose, which crystallized mainly as the β anomer Analogous treatment of D-talose gives 4,6-*O*-isopropylidene-α-D-talopyranose in 93% yield The pyranoid ring-structures of the acetals were established by the sequence acetylation–deacetonation–acetylation to give the known aldopyranose pentaacetates, and studies by n m r spectroscopy and mass spectrometry established the positions of acetal substitution, compound 3 was also identified by comparison of its properties with data in the literature

INTRODUCTION

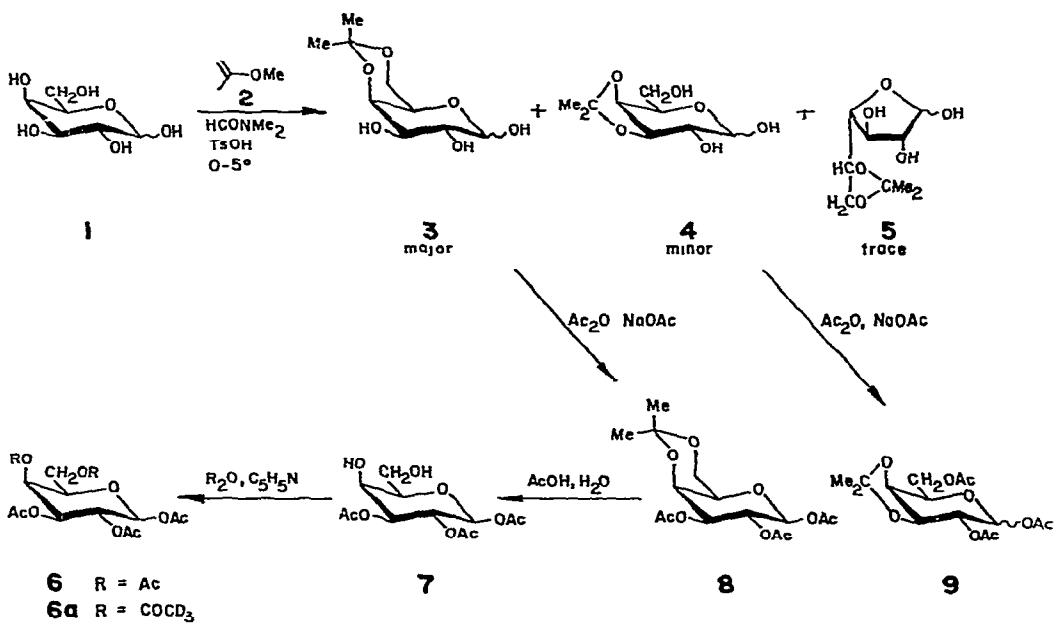
Previous papers in this series have established the use of alkyl isopropenyl ethers in *N*,*N*-dimethylformamide as a general reagent for acetonation of sugars under kinetic control, with favored initial attack at primary hydroxyl groups and subsequent ring-closure favoring formation of acetals of the 1,3-dioxane type without tautomeric modification of the ring-size of the starting sugar The reaction provides access to acetal-protected sugar derivatives whose substitution-mode differs from that obtainable by conventional acetonation under conditions of thermodynamic control In addition to studies on aldopentoses[2], the earlier reports have shown that D-glucose may be converted preparatively into 4,6-*O*-isopropylidene-D-glucopyra-

*For preliminary reports, see ref 1 Supported, in part, by Grant No GM-11976 (The Ohio State University Research Foundation Project 1820) from the National Institute of General Medical Sciences, National Institutes of Health, U S Public Health Service, and within the framework of RCP 529, CNRS, France

nose[3], and that D-mannose may likewise be converted in high yield into its pyranoid 4,6-isopropylidene acetal[4], or, by use of a larger excess of the reagent, into the pyranoid 2,3:4,6-diisopropylidene acetal Similar acetonation of α,α-trehalose may be controlled to afford the (monosubstituted) 4,6-isopropylidene acetal[5]. The generality of this reaction with the aldohexopyranoses is affirmed by the present investigation, which shows that preparative conversion into the pyranoid 4,6-isopropylidene acetals is readily achieved with D-galactose, D-allose, and D-talose Such derivatives, and derived transformation-products, have important potential for the synthesis of complex saccharides, both as glycosyl-group donors and as selectively protected acceptor-sugars

DISCUSSION

The general procedure used for acetonation was the same as that employed previously, namely, reaction of the crystalline aldose in *N*,*N*-dimethylformamide at 0–5° with 2 molar equiv of ethyl (or methyl) isopropenyl ether in the presence of a trace of *p*-toluenesulfonic acid, to the point (~4 h) where the starting aldose was no longer detectable It is important to keep the proportion of acid catalyst low, as otherwise, the yields of kinetic products are decreased and purification problems are encountered as a result of subsequent conversions that contaminate the kinetic products with those of thermodynamic control The present study was focused principally on preparative aspects, as conducted with the aldose on a 9-g (50 mmol) scale, but each reaction was also examined for the complete product-balance by



Scheme 1 D-Galactose series

analytical and preparative adsorption chromatography, and by g l c of per(trimethylsilyl)ated derivatives

Acetonation of D-galactose (**1**) with methyl isopropenyl ether (**2**) gave ~90% of water-soluble, monoacetal product, together with a small proportion of dichloromethane-soluble material, evidently a mixture of polyacetalated products (this was not examined in detail) The water-soluble fraction was readily resolved on a column of silica gel to afford crystalline 4,6-*O*-isopropylidene-α,β-D-galactopyranose (**3**) as the principal product (67%); a faster-migrating product obtained crystalline in 14% yield proved to be 3,4-*O*-isopropylidene-α,β-D-galactopyranose (**4**), and a very minor, third component, migrating faster than **4**, was isolated crystalline in 1–2% yield and shown to be 5,6-*O*-isopropylidene-D-galactofuranose (**5**) All three products could be identified by comparison of their melting points and specific rotations with those reported by Morgenlie[6], who had isolated the acetals in 22, 15, and 13% yields, respectively, from a complex product-mixture obtained by acetonation of **1** with hot acetone–*N*,*N*-dimethylformamide–copper(II) sulfate The structural attributions were further confirmed by mass- (see Experimental section) and n m r - (see Table I) spectral data

The n m r data showed that **5** in dimethyl sulfoxide-d_6 exists essentially as a single anomer (presumably β) whose H-1 signal falls to lower field (δ 5 25) than the H-1 signals of the pyranoid isomers. For compound **4**, the n.m r spectrum in dimethyl sulfoxide-d_6 readily established that the 6-hydroxyl group was unsubstituted (triplet signal for HO-6), and that it was a 13 7 mixture of pyranoid α and β anomers (from the intensities of the H-1 and HO-1 signals, the $J_{1\alpha,2}$ and $J_{1\beta,2}$ couplings of 3 4 and 8 Hz, respectively, and the H-1α and H-1β chemical-shifts of δ 5 00 and 4 37, respectively) The 3,4-acetal substitution in **4** was confirmed by the n m r spectrum of its triacetate **9**, obtained crystalline as a 9 11 α,β mixture, the H-1α and H-1β signals were observed, as anticipated, at low field (see Table I), and the H-2 signals (alone of the remaining protons) emerged at low field, as best observed with the spectrum of **9** in benzene-d_6, indicating that O-2, but not O-3, is acetylated in the triacetate **9**

The constitution of the principal product, the pyranoid 4,6-acetal **3**, could be gleaned from the n m r spectrum of **3** in dimethyl sulfoxide-d_6 (see Table I), the absence of triplet OH resonances indicated that O-6 was engaged in acetal substitution The signal-intensities for H-1α, H-1β, HO-1α, HO-1β, the chemical shifts of H-1α and H-1β (δ 5 14 and 4 52, respectively), and the $J_{1\alpha,2}$ and $J_{1\beta\ 2}$ values of 2 6 and 7 Hz, respectively, allow attribution of the pyranoid ring-form and an α,β anomeric ratio of 7 3, g l c data on per(trimethylsilyl)ated **3** (see Experimental section) were also in general accord with this anomeric ratio The observed upward mutarotation of **3** in water indicates a higher concentration of the α anomer at mutarotational equilibrium in water

Acetylation of **3** with hot acetic anhydride–sodium acetate, a system that would be expected to afford mainly the acetate of the HO-1 equatorial tautomer, gave 90% of a crystalline triacetate **8** whose n m r spectrum indicated that it was practically

TABLE I

N.M.R.-SPECTRAL DATA FOR D-GALACTOSE DERIVATIVES

Compound	*Solvent*	*Chemical shifts (δ), first-order couplings (Hz) in parentheses*									
		H-1 ($J_{1,2}$)	*H-2* ($J_{2,3}$)	*H-3* ($J_{3,4}$)	*H-4* ($J_{4,5}$)	*H-5* ($J_{5,6}$)	*H-6* ($J_{5,6'}$)	*H-6'* ($J_{6,6'}$)	CMe_2	*OAc*	*OH*
3	Me_2SO-d_6	5.14dd[a] (α) 4.52m[a] (β) (2.6α)(~7β)	←		3.2–4.3m[b]			→	1.33s 1.43s		6.61d[c] 6.27d[c]
4	Me_2SO-d_6	5.00dd[d] (α) 4.37dd[d] (β) (3.4α)(~8β)	←		3.2–4.2m			→	1.28s 1.42s		5.07d, 6.72d[e], 4.90d, 6.39d[e], 4.77t, 4.40t
5	Me_2SO-d_6	5.25d[f] (<0.5)	4.82d	4.47d	←	3.3–4.4m		→	1.29s 1.42s		6.60d[f]
6	$CDCl_3$	5.83d (7.2)	←		5.1–5.6m	→	←	4.23 →		2.03s[g], 2.08s(2), 2.14s, 2.20s	
7	Me_2SO-d_6	5.83d[h] (7.8)	5.37dd (9.8)	5.00dd (2.6)	←	3.4–4.2m[i]		→		2.02s, 2.03s 2.07s	5.22d[j]
8	$CDCl_3$	5.78d[k] (~8)	5.52dd (8.8)	4.98dd (3.6)	4.48m		4.28–3.60m		1.50s 1.42s	2.13s, 2.12s, 2.05s	
	$(CD_3)_2CO$	5.87d[k] (7.6)	5.46dd (9.5)	5.13dd (3.2)	4.57m (~3)	3.82m (2.4)	4.26dd (1.6)	3.80dd (12.8)	1.44s 1.40s	2.08s, 2.06s, 2.03s	
	C_6D_6	←	~6.0m →		~5.2m	←	4.4–3.2m	→	1.40s 1.12s	1.77s, 1.73s, 1.65s	

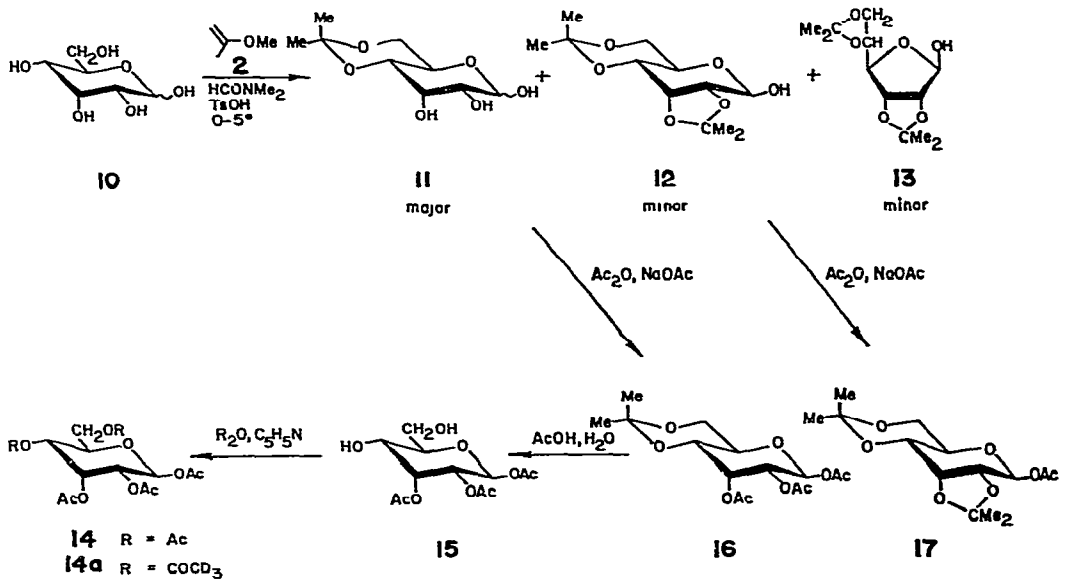
9	$CDCl_3$	6 50d(α) 5 80d(β)	5 1–5 7m	←——— 3 6-4 6m ———→	1 45s, 1 50s	2 04–2 17m
	$(CD_3)_2CO$	6 28d(α) 5 77d(β) (3 6α)(8.0β)	5 0–5 4m	←——— 4 0-4 7m ———→	1 37s, 1 50s, 1 53s	2 05–2 2m
	C_6D_6	6 84d(α) 5.98d(β)	5 57dd(α) 5 2–5 8m(β) (3 2α)	←——— 3 2-4 6m ———→	1 20s, 1 27s, 1 42s, 1 45s	1 75–1 87m

[a]After addition of D_2O (and lyophilization to remove HOD), two doublets were observed at δ 5 09 ($J_{1,2}$ 2 6 Hz, α anomer) and δ 4 35 ($J_{1,2} \sim 7$ Hz, β anomer) with concurrent disappearance of the OH signals [b]The intensity of this multiplet corresponded to 8 protons and, after addition of D_2O, to 6 protons [c]These two doublets at low field (integrated intensity one proton) corresponded to the anomers of compound **3** δ 6 61, $J_{1\beta,OH}$ 6 8 Hz (β anomer) and δ 6 27, $J_{1\alpha,OH}$ 4 4 Hz (α anomer) in the ratio 3 7 Besides these signals, another doublet (δ 4 76, $J \sim 5$ Hz) could be observed [d]After addition of D_2O (and lyophilization to remove HOD), two doublets were observed at δ 4 98 ($J_{1,2}$ 3 4 Hz, α anomer) and δ 4 33 ($J_{1,2} \sim 8$ Hz, β anomer) with concurrent disappearance of the OH signals [e]The signals at δ 6 72 ($J_{1\beta,OH}$ 6 6 Hz) and δ 6 39 ($J_{1\alpha,OH}$ 5 2 Hz) could be assigned to the β and the α anomers, respectively (ratio 7 13) Also observed were two doublets ($J_{2,OH}$ 5 6 and 4 8 Hz) and two triplets ($J_{6,OH}$ 5 2 Hz) [f]Became a singlet (δ 5 27) after addition of D_2O, with concurrent disappearance of the doublet at δ 6 60 ($J_{1,OH}$ 7 6 Hz) [g]Actually, these four peaks corresponded to 15 protons. Spectra of the deuterio derivative **6a** gave similar chemical shifts, and showed OAc signals only at δ 2 03, 2 08, and 2 14 [h]Another doublet was seen at δ 6 27 ($J_{1,2}$ 3,4 Hz), and it corresponded to the presence of ~15% of the α anomer [i]This multiplet actually corresponded to five protons, and thus included the signal of OH 6, which disappeared upon addition of D_2O [j]This signal ($J_{1,OH}$ 5 8 Hz) disappeared after addition of D_2O [k]This doublet actually appeared as a doublet of doublets ($J \sim 1$ 2Hz) as a consequence of "virtual coupling", as previously observed by Lemieux and Stevens[7] for β-D-galactopyranose pentaacetate A low-intensity doublet (δ 6 52, 6 43, and 6 84, respectively, in $CDCl_3$, $(CD_3)_2CO$, and C_6D_6, $J_{1,2}$ 3 2 Hz) was also observed at low field, it corresponded to the presence of ~10% of the α anomer in the sample analyzed

pure β anomer. The spectrum of **8** in acetone-d_6 was amenable to simple analysis, and the observed low-field position of the H-1, -2, and -3 signals provided clear evidence for the presence of acetoxyl groups at C-1, -2, and -3.

Further consolidation of the pyranoid 4,6-acetal attribution for **3** and its derived triacetate **8** was afforded by deacetonation of **8** with 1.3 acetic acid–water for 1 h at 50°, which afforded crystalline 1,2,3-tri-*O*-acetyl-β-D-galactopyranose (**7**) in 90% yield The n m r spectrum of **7** in dimethyl sulfoxide-d_6 showed the H-1, -2, and -3 signals at low field, as anticipated, and also indicated the presence of ~15% of the α anomer Acetylation of **7** with acetic anhydride–pyridine gave the known[8] β-D-galactopyranose pentaacetate (**6**) Repetition of this acetylation with acetic anhydride-d_6 gave the pentaacetate (**6a**) in which the 4- and 6-substituents were specifically replaced by deuterioacetyl groups Analysis of the acetate-signal region of the spectra of **6** and **6a** confirmed that the isotopic-group replacement was complete, and specific at two positions in the molecule Acetylated sugars specifically deuterioacetylated at known positions are needed for investigations[9] concerned with competitive reactions between hydroxyl groups in sugars

Acetonation of D-allose[10] (**10**) by 2 molar equiv of alkyl isopropenyl ether gave 81% of a water-soluble fraction and 19% of a dichloromethane-soluble fraction The water-soluble fraction was essentially a pure, single compound that could be crystallized from ethyl acetate with high recovery; it was identified by n m r spectroscopy (see Table II) and mass spectrometry (see Experimental section) as 4,6-*O*-isopropylidene-D-allopyranose (**11**) The crystalline product was almost exclusively the β anomer (the n m r spectrum showed the presence of ~10% of the α anomer), and the compound showed pronounced upward mutarotation in water. Its mass



Schem. 2 D-Allose series

TABLE II

N M R -SPECTRAL DATA FOR D-ALLOSE DERIVATIVES

Compound	*Solvent*	*Chemical shifts (δ), first-order couplings (Hz) in parentheses*									
		H-1 ($J_{1,2}$)	*H-2* ($J_{2,3}$)	*H-3* ($J_{3,4}$)	*H 4* ($J_{4,5}$)	*H-5* ($J_{5,6}$)	*H 6* ($J_{5,6'}$)	*H 6'* ($J_{6,6'}$)	*CMe_2*	*OAc*	*OH*
11	Me_2SO d_6	← 4 5-5 2m →			← 3 2-4 2m →				1 48s, 1 37s		6 63d[a]
	[b]	4 68d[c] (8 0)	← 3 2-4 2m →						1 44s, 1 33s		
12	$CDCl_3$	5 07t[d] (4,8)	4 17dd (5 8)	4 58dd (3 0)	← 3 7-4,1m →				1 43s, 1 50s, 1 53s, 1 60s		~4 0
	Me_2SO d_6	4 72t[d] (5 8)	4 41dd (5 4)	← 3 4-4 2m →					1 33s, 1 47s		6 97d (5 6)
13	Me_2SO-d_6	5 27d[e] (~0)	4 81d (6 0)	4 54d (~0)	← 3 7-4 3m →				1 28s, 1 35s, 1,38s		6,61d[f]
14	$CDCl_3$	6 08d	5 06dd	5 77t	5 10dd	← 4 0-4 4m →				2 03s(2), 2 09s, 2 13s, 2 19s[g]	
	$(CD_3)_2CO$	6 12d (8 4)	5 03dd (2 8)	5 84t (2 8)	5 10dd (9 8)	← 4 2-4 5m →				2 02s(2), 2 05s, 2 12s, 2 20s[g]	
	C_6D_6	6 49d	5 36dd	6 19t	5 28dd	← 4 0-4 4m →				1 69s(2), 1 72s, 1 75s, 1 82s[g]	

15	Me_2SO d_6	5 95d (8 6)	4 80dd (3 0)	5 54m	← 3 3–4 0m →		1 98s, 2 10s, 2 14s	4 7[a] 5 4[b]
16	$CDCl_3$	6 08d (8 4)	4 98dd (3 0)	5 71dd (2 0)	← 3 7–4 2m →	1 50s, 1 38s	2 03s, 2.12s, 2 17s	
	$(CD_3)_2CO$	5 99d	4 79dd	5 65dd	← 3 8–4 2m →	1 54s, 1 34s	1 98s, 2 09s, 2 16s	
	C_6D_6	6 38d	5 27dd	5 97dd	← 3 4–4 3m →	1 35s, 1 17s	1 81s, 1 78s, 1 75s	
17	$CDCl_3$	5 88d (4 4)	4 18d (6 2)	4 52dd (2 6)	← 3 5–4 1m →	1 59s, 1 51s, 1 48s, 1 40s	2 11s	
	$(CD_3)_2CO$	5 77d	4 21dd	4 51dd	← 3 6–4 2m →	1 50s, 1 35s	2 05s	
	C_6D_6	6 13d	← 3 5–4 4m →			1 46s, 1 43s	1 65s	

[a]Signal assigned to OH-1β ($J_{1\beta,OH}$ 6 5 Hz), a minor (~ 10%) doublet was also observed at δ 6 40 that may be assigned to OH-1α ($J_{1\alpha,OH}$ ~ 5 Hz), both signals disappeared after addition of D_2O [b]Spectra obtained after addition of D_2O and removal of HOD by lyophilization [c]A minor doublet was also observed (δ 4 91, $J_{1,2}$ 3 5 Hz), and this was attributed to the α anomer [d]Gave a doublet after addition of D_2O, with concurrent disappearance of the OH signal [e]Gave a singlet after addition of D_2O, with concurrent disappearance of the OH signal [f]$J_{1,OH}$ 4 0 Hz (this coupling was 6 4 Hz in CCl_4) [g]Spectra of the deuterio derivative **14a** gave similar chemical shifts, but showed OAc signals only at δ 2 03, 2 13, and 2 19 ($CDCl_3$), δ 2 02, 2.12, and 2 20 [$(CD_3)_2CO$], and δ 1 72, 1 75, and 1 82 (C_6D_6) [h]Broad signals that disappeared after addition of D_2O

spectrum was essentially identical to that of the stereoisomeric acetal **3** (of rigorously established constitution), the derived triacetate **16** likewise had a mass spectrum the same as that of the D-*galacto* isomer **8**

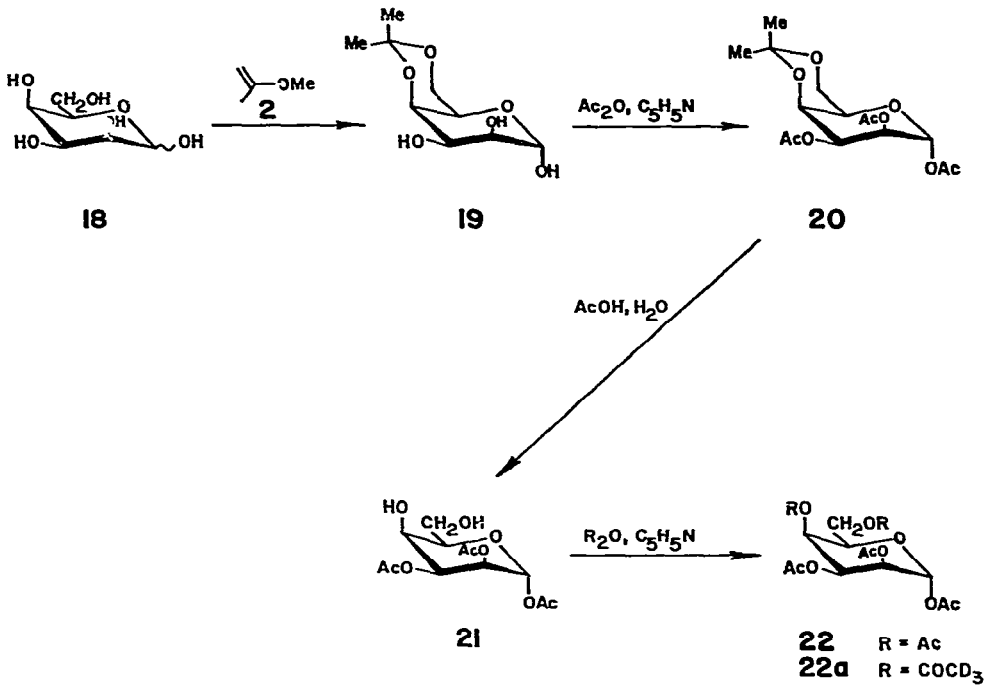
Acetylation of **11** was performed with acetic anhydride–sodium acetate, and gave the β anomer **16** exclusively Analysis of the n m r spectrum of **16** in various solvents showed the anticipated, low-field, wide doublet for H-1, together with signals for H-3 and H-2 at successively higher field, as expected for protons respectively equatorial and axial at carbon atoms bearing an acetoxyl group

Deacetonation of **16** with aqueous acetic acid gave a quantitative yield of syrupy 1,2,3-tri-*O*-acetyl-β-D-allopyranose (**15**), whose homogeneity was evident from t l c and from its n m r spectrum, its mass spectrum was essentially identical to that of the stereoisomer **7** Acetylation of **15** with acetic anhydride–pyridine gave the known[11], crystalline β-D-allopyranose pentaacetate (**14**), thus providing firm, independent proof for the pyranoid ring-structure of **11** As with the galactose analog, acetylation of **15** was also conducted with acetic anhydride-d_6, and the corresponding derivative (**14a**), having deuterioacetyl groups at O-4 and O-6, was obtained, it showed only acetyl-group peaks for AcO-1, AcO-2, and AcO-3 in the n m r spectrum

The minor, dichloromethane-soluble fraction from the acetonation of D-allose (**10**) was fractionated on silica gel, to give a small proportion (~2%) of a fast-migrating, crystalline product identified from its m p and specific rotation as the known[12] 2,3 5,6-di-*O*-isopropylidene-β-D-allofuranose (**13**), its n m r spectrum (see Table II) provided additional evidence for the structure assigned Further elution gave an isomeric diacetal that constituted ~9% of the product from **10**, it was isolated crystalline, and characterized as 2,3 4,6-di-*O*-isopropylidene-β-D-allopyranose (**12**) The n m r spectrum of **12** (see Table II) established that it was a diacetal, and the pyranoid 2,3 4,6-diisopropylidene acetal substitution-mode was established by the essential identity of the mass spectrum of **12** (see Experimental section) to that of 2,3 4,6-di-*O*-isopropylidene-α-D-mannopyranose, whose structure has been firmly established[4] The diacetal **12** is levorotatory (−24 6°) and shows no mutarotation, and its n m r spectrum showed only one H-1 and one HO-1 signal, these data indicate that **12** is the β anomer The $J_{1,2}$ value is relatively low (5 8 Hz in dimethyl sulfoxide-d_6, 4 8 Hz in chloroform-*d*) for H-1 and H-2, protons that are nominally diaxial, but it may be presumed that the 2,3-acetal ring causes considerable flattening of the pyranose ring in the region of C-1, C-2, and C-3, with consequent distortion of the H-1–H-2 dihedral angle

Acetylation of **12** gave the crystalline 1-acetate **17**, whose n m r spectrum (see Table II) closely resembled that of **12**, except for the anticipated, downfield shift of the H-1 signal and the appearance of an acetate-group signal, again, the product was exclusively the β anomer, was levorotatory (−30 5° in chloroform), and showed a $J_{1,2}$ value (4 4 Hz in chloroform-*d*) indicative of distortion of the pyranoid ring by the fused rings

It is probable that such monoacetals as **11** and its D-talose analog (described next), which have a *cis* arrangement of O-2 and O-3, resemble the similarly constituted



Scheme 3 D-Talose series

D-mannose analog[4] in being susceptible to ready conversion by an excess of acetonating reagent into the pyranoid 2,3 : 4,6-diisopropylidene acetals

Treatment of D-talose (**18**) under the standard conditions with a 2-molar excess of methyl isopropenyl ether (**2**) led essentially to a single compound, a solid product obtained in 93% yield from the aqueous extract, the dichloromethane extract afforded only ~1% of a product, presumed to be the pyranoid 2,3 4,6-diisopropylidene acetal The water-soluble, principal product was obtained crystalline from ethyl acetate, its mass spectrum (see Experimental section) was essentially identical to that of **3** and **11**, and the n m r spectrum of the compound in dimethyl sulfoxide-d_6 (see Table III) showed that it was a single anomer, presumably the α anomer, as was also indicated by the downward mutarotation observed These data were sufficient to allow formulation of the product as 4,6-*O*-isopropylidene-α-D-talopyranose (**19**).

Conventional, chemical proof of structure was achieved as for the D-galactose and D-allose analogs Acetylation of **19** with acetic anhydride–pyridine gave 90% of crystalline 1,2,3-tri-*O*-acetyl-4,6-*O*-isopropylidene-α-D-talopyranose (**20**), whose mass spectrum was essentially identical to those of the corresponding derivatives of D-galactose, D-allose, and D-mannose[4], and whose n m.r spectrum showed the anticipated, low-field signals for H-1, -2, and -3 (see Table III) The product was anomerically pure, and was assigned as the α anomer on the basis of its high dextrorotation (+132° in chloroform) and small $J_{1,2}$ value (1.6 Hz in chloroform-*d*) Upon deacetonation with aqueous acetic acid, compound **20** gave 1,2,3-tri-*O*-acetyl-α-D-

TABLE III

N M R -SPECTRAL DATA FOR D TALOSE DERIVATIVES

Compound	*Solvent*	*Chemical shifts (δ), first order couplings (Hz) in parentheses*									
		H-1 ($J_{1,2}$)	*H-2* ($J_{2,3}$)	*H-3* ($J_{3,4}$)	*H-4* ($J_{4,5}$)	*H-5* ($J_{5,6}$)	*H-6* ($J_{5,6'}$)	*H-6'* ($J_{6,6'}$)	CMe_2	*OAc*	*OH*
19	Me_2SO-d_6	5 12dd[a] (~1 5)	← 3 3–4 3m →						1 36s 1 43s		6 48d[b]
20	$CDCl_3$	6 37d (1 6)	5 20m (~3 5)	5 30dd (~3 5)	4 37m	← 3 7–4 4m →			1 53s, 1 47	2 13s, 2 17s, 2 18s	
	$(CD_3)_2CO$	6 20d (1 6)	5 10m (3 6)	5 30dd (3,2)	4 37dd (3 6)	← 3 6–4 2m →			1 41s, 1 43	2 02s, 2 09s, 2 13s	
	C_6D_6	6 60d	5 46m	5 37dd	3 97m	← 3 2–3 8m →			1 22s, 1 51s	1 65s, 1 80s, 1 83s	
21	Me_2SO-d_6	6 02s (<0 5)	← 5 03m →			← 3 3–3 8m →				2 03s, 2 10s, 2 13	4 47d 3 93t[c]
22	$CDCl_3$	6 27d (1 6)	← 5 1–5 5m →			← 4 05–4 60m →				2 02s, 2 06s 2 08s, 2 18s(2)[d]	
	$(CD_3)_2CO$	6 20d	← 5 1–5 5m →			← 4 1–4 7m →				1 97s, 2 01s, 2 16s(2), 2 19[d]	
	C_6D_6	6 45d	← 5 3–5 7m →			← 4 25–4 6m →				1 79s, 1 83s 1 86s, 1 90s, 1 96[d]	

[a]Became a doublet (δ 5 16) after addition of D_2O, with concurrent disappearance of the OH signals [b]Besides this doublet ($J_{1,OH}$ 4 0 Hz), another doublet could be observed (δ 4 72, *J* 7 0 Hz) that was attributed to either OH-2 or OH-3 [c]These signals may be assigned to OH-6 (t, *J* 4 5 Hz) and to OH-4 (d, *J* 6 6 Hz), respectively, they disappeared upon addition of D_2O [d]Spectra of the deuterio derivative **22a** gave similar chemical shifts, but showed OAc signals only at δ 2 02 and 2 18 (2) ($CDCl_3$), δ 1 97, 2 16, and 2 19 [$(CD_3)_2CO$], and 1 79, 1 90, and 1 96 (C_6D_6)

talopyranose (**21**), which was obtained crystalline in almost quantitative yield In addition to mass-spectral correlation of **21** with the corresponding derivatives (**7** and **15**) of D-galactose and D-allose, the appearance of a triplet HO-6 signal in the n m r spectrum of **21** in dimethyl sulfoxide-d_6 provided direct evidence for removal of an acetal substituent from O-6 Finally, acetylation of **21** with acetic anhydride–pyridine gave the known[13–15] α-D-talopyranose pentaacetate (**22**), the 4,6-bis(deuterioacetyl) analog **22a** was similarly prepared, to demonstrate that **21** retained acetyl groups exclusively at three positions and to supply reference data for specific attribution of acetyl-group signals for **22**

The foregoing results reinforce the generalities previously advanced for the kinetic acetonation of aldoses with alkyl isopropenyl ethers, namely, (*a*) the tautomeric form[16] of the starting aldose is conserved, (*b*) the anomeric position tends to remain free in the products of reaction, (*c*) 2 molar equiv of the reagent favors formation of a monoacetal, which is the pyranoid 4,6-isopropylidene acetal from aldohexose precursors and which may be obtained conveniently on a preparative basis, and (*d*) a greater excess of the reagent converts aldohexoses having the *cis* disposition of O-2 and O-3 into the pyranoid 2,3 4,6-diisopropylidene acetals[17]

This reaction thus offers potential for novel routes of glycoside synthesis through the free anomeric position, as well as the possibility for useful functional-group and stereochemical manipulation at the 2,3-positions

EXPERIMENTAL

General methods — These were as described in ref 4 N m r spectra were recorded with a Varian T-60 spectrometer G l c was performed with per(trimethylsilyl)ated samples in a glass column packed with 5% of OV-1 (Hewlett–Packard) and maintained at 170° Retention times (T_R) are given relative to the starting hexose and also (in parentheses) as absolute retention-times in sec Solvents used in column chromatography were carefully dried and distilled, especially methanol and ethanol

General procedure for acetonation — To a solution [the slightly turbid mixture for D-galactose (**1**) became clear after ~5 min of reaction] of 9 0 g (50 mmol) of the hexose (**1**, **10**, or **18**) in dry *N*,*N*-dimethylformamide (100 mL) containing 1 g of Sikkon (Fluka dehydrating agent) maintained at 0–5° (ice-bath) are added methyl isopropenyl ether (**2**, 7 2 g, 100 mmol; an equivalent amount of the ethyl analog may also be used) and *p*-toluenesulfonic acid (30–50 mg) The mixture is stirred magnetically at 0–5° until monitoring by t l c indicates that practically all of the starting material has disappeared (~4 h), whereupon anhydrous sodium carbonate (~5 g) is added, and the cold mixture is stirred vigorously for one h more A small aliquot is retained for g l c analysis The mixture is filtered, and the filtrate poured into ice–water (50 mL). The resultant solution is extracted with dichloromethane (3 × 30 mL), and the extracts are combined, extracted with water (3 × 30 mL), and dried (sodium sulfate) The aqueous phase is combined with the water extracts, and the entire solution is freeze-dried

Acetonation of D-*galactose* (**1**) — The dichloromethane extract contained several, fast-migrating byproducts that were not characterized The freeze-dried, aqueous extract gave 9 8 g of an amorphous solid, t l c of which showed a major component (R_F 0 30, 3 1 benzene–ethanol), a minor one (R_F 0 37), and traces of a third component (R_F 0 45) These products were separated by column chromatography (400 g of silica gel, 3 1 benzene–ethanol) to give, successively, **5** (0 10 g, yield 1–2%), **4** (1 5 g, yield 14%), and **3** (7 4 g, yield 67%) Directly upon evaporation of the eluates, these crystalline products were obtained pure

4,6-*O*-Isopropylidene-D-galactopyranose (**3**) thus obtained had m p 141–142°, $[\alpha]_D^{20}$ +92 (3 min) → +118° (48 h, *c* 0 1, water), (lit [6] m p 141–143°, $[\alpha]_D^{22}$ +153° in methanol), $\lambda_{max}^{CHCl_3}$ 2 95 broad (OH), 7 29 (CMe_2), and 8–10 μm (COCOC), for n m r data, see Table I, *m/e* 205 (21, M^+ — Me), 191 (2), 189 (2), 173 (1 5), 161 (0 8, M^+ — Me_2CO^+H), 149 (1 2), 145 (5, 205 — AcOH), 132 (1 5), 131 (14), 127 (4 5), 119 (1 5), 116 (1), 115 (1 5), 113 (1), 103 (5), 102 (3 5), 101 (5), 100 (1), 99 (9), 98 (1 5), 97 (1 5), 85 (8 5), 73 (28), 71 (6), 69 (7), 61 (11), 60 (13), 59 (100), 58 (6), 57 (10), and 43 (80), X-ray powder diffraction data 10 90 s, 6 34 vs, 5 40 s, 4 82 m, 4 38 s, 4 23 m, 3 81 s, 3 60 w, 3 41 w, 3 01 w, 2 83 s, and 2 71 m

Anal Calc for $C_9H_{16}O_6$ C, 49 09, H, 7 27, O, 43 64 Found C, 49 18, H, 7 31, O, 43 86

3,4-*O*-Isopropylidene-D-galactopyranose (**4**) had m p 99–103°, $[\alpha]_D^{20}$ +105 (3 min) → +44° (48 h, *c* 0 1, water) (lit [6] m p 100–102°, $[\alpha]_D^{22}$ +86° in methanol), $\lambda_{max}^{CHCl_3}$ 2 95 broad (OH), 7 30 (CMe_2), and 8–10 μm (COCOC), for n m r data, see Table I, *m/e* 205 (45, M^+ — Me), 189 (4 5), 187 (2, 205 — H_2O, m* 170 6), 171 (1 5), 161 (2, M^+ — Me_2CO^+H), 159 (9), 145 (4, 205 — AcOH), 144 (10), 131 (17), 129 (6), 127 (7), 116 (3 5), 115 (13), 113 (4 5), 103 (6), 102 (2), 101 (8), 100 (13), 99 (12), 98 (12), 97 (5 5), 96 (7), 86 (10), 85 (24), 81 (9 5), 73 (82), 71 (27), 69 (18), 59 (100), and 43 (79)

Anal Calc for $C_9H_{16}O_6$ C, 49 09, H, 7 27, O, 43 64 Found C, 49 06, H, 7 36, O, 43 60

5,6-*O*-Isopropylidene-D-galactofuranose (**5**) had m p 80–82°, $[\alpha]_D^{20}$ −20° (48 h, *c* 0 1, water) (lit [6] m p 83–84°, $[\alpha]_D^{22}$ −23° in methanol), $\lambda_{max}^{CHCl_3}$ 2 90 broad (OH), 7 27 (CMe_2), and 8–10 μm (COCOC), for n m r data, see Table I

G l c analysis of the acetonation products of D-*galactose* — Per(trimethylsilyl)ated derivatives of pure samples of compounds **3**, **4**, and **5**, as obtained by column chromatography, provided standards that allowed identification of the corresponding peaks detected in a per(trimethylsilyl)ated aliquot of the crude mixture from the acetonation of D-galactose Very minor, fast-moving peaks (at least six) were detected between T_R 0 3 (600) and 0 4 (750) Eluted then were **5**, 0 54 (1045), **3** (α anomer), 0 58 (1125), **4** (α anomer), 9 59 (1130), **4** (β anomer), 0 63 (1225), **3** (β anomer), 0 75 (1440), and a trace of **1** 1 00 (1930) The peak for the β anomer of **4** appeared as a shoulder on the peak of the α anomer of **3** The peaks for the α and β anomers of **3** (ratio 2 1) constituted the major part of the spectrum of the mixture The anomeric ratios as determined by g l c may not correspond exactly[16] to those

(more-reliable) ratios obtained by n m r spectroscopy of freshly prepared solutions of crystalline samples in dry dimethyl sulfoxide-d_6.

1,2,3-Tri-O-acetyl-4,6-O-isopropylidene-β-D-galactopyranose (**8**) — A stirred mixture of compound **3** (2 2 g, 10 mmol), acetic anhydride (6 1 g, 60 mmol), and sodium acetate (9 8 g, 120 mmol) was heated for 1 h at 100°. The mixture was cooled, and poured onto ice, and the product was extracted with dichloromethane The extract was dried (sodium sulfate), and evaporated to a syrup that was chromatographed on a small column of silica gel (30 g, eluant, ethyl acetate) to give a crystalline, low-melting compound (**8**, 3.1 g, 90%), m p 40° (modification), $[\alpha]_D^{22}$ +89° (*c* 0 1, chloroform), R_F 0 41 (1 1 ethyl acetate–petroleum ether), $\lambda_{max}^{CCl_4}$ 5.70 (C=O), 7.30 (CMe_2), and 8 5–10 μm (COCOC), no OH absorption, the n m r spectrum (see Table I) showed the presence of <10% of the α anomer, *m/e* 331 (30, M^+ — Me·), 287 (2 5, M^+ — AcO·), 246 (1 5), 245 (12, 287 — CH_2CO), 229 (2 5), 228 (1), 227 (1 5, 287 — AcOH), 226 (6, M^+ — 2AcOH), 217 (1 5), 203 (5 5, 245 — CH_2CO), 187 (5 5), 173 (2), 170 (2), 169 (22, 227 — Me_2CO), 158 (1 5), 157 (9, AcOCH=CH-C^+HOAc), 143 (17, 203 — AcOH), 127 (15, 169 — CH_2CO), 115 (25, 157 — CH_2CO), 109 (13, 169 — AcOH), 103 (4), 102 (2), 101 (8), 99 (3), 98 (3 5), 97 (5), 85 (6), 73 (9), 59 (14), and 43 (100)

Anal Calc for $C_{15}H_{22}O_9$ C, 52 02, H, 6 36, O, 41 62 Found C, 52 10, H, 6 39. O, 41 51

Deacetonation of **8** *to give* **7**, *and acetylation of* **7** *to give β-D-galactopyranose pentaacetate* (**6**) *and its 4,6-bis(trideuterioacetyl) analog* (**6a**) — A suspension of 0 5 g of **8** in 1 3 acetic acid–water (20 mL) was stirred for 1 h at 50°, cooled, and freeze-dried, and the amorphous solid was recrystallized from ethyl acetate, to give *1,2,3-tri-O-acetyl-β-D-galactopyranose* (**7**; 0 4 g, 90%), m p 76–78°, $[\alpha]_D^{22}$ +56° (*c* 0 1, chloroform), R_F 0 54 (ethyl acetate), $\lambda_{max}^{CCl_4}$ ~3 broad (OH) and 5 70 μm (C=O), the n m r spectrum (see Table I) showed the presence of ~15% of the α anomer, *m/e* 247 (2, M^+ — AcO), 245 (3, M^+ — H_2O — MeCO), 203 (3, 245 — CH_2CO), 200 (2 5), 187 (2 5), 186 (3), 173 (1 5), 169 (3), 158 (6 5, M^+ — AcOH — AcOCH=O), 157 (10, AcOCH=CH-CH^+OAc), 145 (5), 144 (3 5), 145 (6, 203 — AcOH), 140 (5 5), 131 (1 5), 127 (5), 126 (5), 116 (8 5, 158 — CH_2CO), 115 (27, 157 — CH_2CO), 114 (4), 109 (3 5), 103 (9 5), 102 (5), 101 (3 5), 99 (4 5), 98 (13), 97 (9 5), 87 (7 5), 73 (18), 60 (11), and 43 (100).

Anal Calc for $C_{12}H_{18}O_9$ C, 47 06, H, 5 88, O, 47 06 Found C, 47 12, H, 5 83, O, 47 32

A mixture of acetic anhydride (5 mL) and pyridine (5 mL) was slowly added at 0° to a stirred solution of **7** (0 2 g) in pyridine (5 mL) The solution was kept for 18 h at ~25°, and then poured onto ice The product was extracted with dichloromethane, and the extract was washed with saturated, aqueous sodium hydrogencarbonate (3 × 10 mL), dried (sodium sulfate), and evaporated, to give **6**, which was twice recrystallized from methanol–water, yield 0 2 g (~80%), m p 140–142°, $[\alpha]_D^{22}$ +28° (*c* 0 1, chloroform) (lit [8] m p 142°, $[\alpha]_D^{25}$ +25°) An additional 0 1 g of **7** was treated with acetic anhydride-d_6 by the procedure just described, to give the

4,6-bis(trideuterioacetyl) analog **6a**, for which all of the data were essentially identical to those recorded for **8**, but the n m r spectrum showed signals for only three of the five acetyl groups

1,2,6-Tri-O-acetyl-3,4-O-isopropylidene-α,β-D-galactopyranose (**9**) — Compound **4** (1 1 g, 5 mmol) was acetylated with acetic anhydride–sodium acetate exactly as described for compound **3** The syrupy acetate **9** thus obtained was chromatographed on a small column of silica gel (20 g, eluant, ethyl acetate), to give a syrup that was homogeneous by t l c (R_F 0 48, 1 1 petroleum ether–ethyl acetate) and that crystallized after a few weeks, m p. 40–45°, $\lambda_{max}^{CCl_4}$ 5 68 (C=O), 7 27 (CMe_2), and 8 5–10 μm (COCOC), no OH absorption, the n m r spectrum (see Table I) showed the product to be a 9 11 mixture of the α and β anomers

Anal Calc for $C_{15}H_{22}O_9$ C, 52 02, H, 6 36, O, 41 62 Found C, 52 08, H, 6 45, O, 41 70

Acetonation of D-*allose* (**10**) — The freeze-dried, aqueous phase gave an amorphous solid (8 9 g, 81%) that was practically pure **11** by t l c , it could be used directly for preparations requiring **11** The compound was obtained pure either by recrystallization (ethyl acetate, 7 9 g, 72%) or by column chromatography (150 g of silica gel, eluant, 4 1 ethyl acetate–methanol) 4,6-*O*-Isopropylidene-D-allopyranose (**11**) thus obtained had m p 136–137°, $[\alpha]_D^{20}$ −70 (3 min) → +18° (24 h, *c* 0 1, water), R_F 0 57 (4 1 ethyl acetate–methanol), $\lambda_{max}^{CHCl_3}$ 2 90 broad (OH), 7 30 (CMe_2), and 8 5–10 μm (COCOC), for n m r data, see Table II, *m/e* 205 (9, M^+ — Me), 187 (2, 205 — H_2O, m* 170 6), 161 (0 8, M^+ — Me_2C^+OH), 159 (1), 145 (4 5, 205 — AcOH), 131 (25), 127 (4), 119 (2), 116 (1), 115 (2), 114 (1), 113 (1 2), 103 (6), 102 (6), 101 (12), 85 (10), 73 (36), 59 (100), and 43 (65), X-ray powder diffraction data 8 62 w, 5 46 m, 4 92 vs, 4 52 s, 4 06 w, 3 45 m, 3 01 w, 2 73 s, 2 03 w, 1 94 w, 1 88 w, and 1 80 w

Anal Calc for $C_9H_{16}O_6$ C, 49 09, H, 7 27, O, 43 64 Found C, 49 01, H, 7 20, O, 43 39

The dichloromethane extract (1 1 g) showed, in t l c , a fast-migrating compound (R_F 0 85, 1 1 ethyl acetate–petroleum ether) present only as a trace, and a minor (R_F 0 73) and a major (R_F 0 48) compound The last two derivatives were isolated by column chromatography (30 g of silica gel, eluant, 1 1 ethyl acetate–petroleum ether) First eluted was 2,3 5,6-di-*O*-isopropylidene-D-allofuranose (**13**, 0 1 g), which was identified by comparison of its physical constants {m p 66–68°, $[\alpha]_D^{22}$ −1° (final, *c* 0 1, water), lit [12a] m p 65–67°, $[\alpha]_D^{23}$ −1° (water) and [12b] m p 66–67°, $[\alpha]_D^{20}$ −1 5° (water)} and its n m r spectrum (see Table II) with those reported in the literature[12] Next eluted was 2,3 4,6-di-*O*-isopropylidene-D-allopyranose (**12**, 0 75 g), m p 141–143°, $[\alpha]_D^{22}$ −24 6° (*c* 0 1, chloroform), $\lambda_{max}^{CHCl_3}$ 2 90 broad (OH), 7 30 and 7 25 (CMe_2), and 8 5–10 μm (COCOC), for n m r spectra, see Table II, *m/e* 260 (0 2, M^+), 245 (29, M^+ — Me), 217 (0 7, M^+ — MeCO), 202 (0 9, M^+ — Me_2CO), 187 (7, 245 — Me_2CO, m* 142 7), 185 (1, 245 — AcOH), 173 (2), 171 (1 5), 159 (19), 145 (1 5), 144 (1 8), 143 (2), 141 (2 5), 131 (15), 129 (5), 127 (11), 115 (7), 113 (4), 109 (4), 101 (30), 100 (14), 85 (18), 81 (7), 73 (16), 69 (11),

59 (95), and 43 (100); X-ray powder diffraction data: 10.45 s, 9.45 vs, 7.56 w, 6.14 m, 5.82 m, 5.42 vs, 5.16 m, 4.88 s, 4.43 m, 4.17 w, 3.98 vs, 3.73 w, 3.48 w, 3.15 w, and 2.66 w.

Anal. Calc. for $C_{12}H_{20}O_6$: C, 55.38; H, 7.69; O, 36.92. Found: C, 55.30; H, 7.76; O, 37.04.

It is probable that acetonation of D-allose with an excess of methyl isopropenyl ether would (as was demonstrated for D-mannose[4]) give a high yield of the diacetal **12**, which might prove a useful synthetic intermediate[17].

G.l.c. analysis of the acetonation products of D-*allose* (**10**). — Peaks corresponding to per(trimethylsilyl)ated derivatives of pure samples of compounds **11** and **12** were compared with the peaks detected in a per(trimethylsilyl)ated aliquot of the crude mixture of acetonation products of D-allose and with a per(trimethylsilyl)ated sample of authentic D-allose. Eluted after minor peaks at T_R 0.34 (620) and 0.43 (780, **12**) were **11** (α anomer) 0.59 (1080), **11** (β anomer) 0.68 (1235), and traces of **10** (α anomer) 0.92 (1680) and **10** (β anomer) 1.00 (1820). The peaks corresponding to the α and β anomers of **11** (ratio 1:3) constituted the greatest proportion of the mixture. Evidently, the crystallization of **11** causes almost complete conversion into the β anomer.

*1,2,3,-Tri-*O*-acetyl-4,6-*O*-isopropylidene-β-*D*-allopyranose* (**16**). — Compound **11** (1.1 g, 5 mmol) was acetylated with acetic anhydride–sodium acetate, exactly as described for compound **3**. The syrupy acetate **16** thus obtained was rapidly chromatographed (20 g of silica gel; eluant, ethyl acetate) to give crystalline **16**; yield 1.5 g (87%); m.p. 48° (modification), $[\alpha]_D^{22}$ −38° (*c* 0.1, chloroform); R_F 0.85 (1:1 ethyl acetate–petroleum ether); $\lambda_{max}^{CHCl_3}$ 5.70 (C=O), 7.29 (CMe_2), and 8.5–10 μm (COCOC), no OH absorption; for n.m.r. data, see Table II; *m/e* 331 (4, M^+ − Me·), 245 (9, M^+ − AcO· − CH_2CO), 227 (0, 4, M^+ − AcO· − AcOH), 226 (0.2, M^+ − 2AcOH), 203 (1.5, 245 − CH_2CO, m* 168.2), 187 (0.2), 186 (0.3), 173 (0.5), 169 (1.5, 227 − Me_2CO), 157 (2, AcO-CH=-C^+HOAc), 143 (6.5, 203 − AcOH, m* 100.7), 127 (1.5, 169 − CH_2CO, m* 95.4), 115 (7, 157 − CH_2CO, m* 84.2), 109 (2.5, 169 − AcOH, m* 70.3), 103 (1), 101 (2.5), 97 (0.8), 81 (1), 73 (2), 59 (4.5), and 43 (100).

Anal. Calc. for $C_{15}H_{22}O_9$: C, 52.02; H, 6.36; O, 41.62. Found: C, 52.09; H, 6.31; O, 41.57.

Deacetonation of **16** *to give* **15**, *and acetylation of* **15** *to give β-*D*-allopyranose pentaacetate* (**14**) *and its 4,6-bis(trideuterioacetyl) analog* (**14a**). — The method just described for the sequence **8**→**7**→**6** was followed. *1,2,3-Tri-*O*-acetyl-β-*D*-allopyranose* (**15**; yield 0.45 g, quantitative) thus obtained was a syrup, $[\alpha]_D^{22}$ −24° (*c* 0.15, chloroform); R_F 0.52 (ethyl acetate); $\lambda_{max}^{CHCl_3}$ ~3 broad (OH) and 5.7 μm (C=O); for n.m.r. data, see Table II; *m/e* 247 (0.5 M^+ − AcO·), 245 (0.8, M^+ − H_2O − MeCO·), 217 (0.6), 215 (2, M^+ − AcOH − ·CH_2O), 203 (1, 245 − CH_2CO), 173 (0.8), 158 (2.5, M^+ − AcOH − AcOCH=O), 157 (8, AcOCH=CH-C^+HOAc), 145 (1.5), 144 (1.5), 143 (3, 203 − AcOH), 127 (2), 126 (2.5), 116 (3, 158 − CH_2CO),

115 (24, 157 — CH_2CO), 103 (3 5), 102 (2), 101 (1 5), 98 (11), 97 (3), 85 (3 5), 73 (1 6), 61 (5), 60 (5), and 43 (100)

Anal Calc. for $C_{12}H_{18}O_9$ C, 47 06, H, 5 88, O, 47 06 Found C, 47 21, H, 5 92, O, 46 98

The β-D-allopyranose pentaacetate (**14**) finally obtained had physical constants {m p. 98 5–99 5°, $[\alpha]_D^{22}$ −15 2° (*c* 0 1, chloroform), lit [11] m p 96–98°, $[\alpha]_D^{20}$ −14 8° (chloroform)}, and n m r spectra (see Table II) in accord with those of authentic **14** The 4,6-bis(trideuterioacetyl) analog **14a** had characteristics essentially identical to those recorded for **14**, but the n m r spectrum showed signals for only three of the five acetyl groups

1-O-Acetyl-2,3 4,6-di-O-isopropylidene-β-D-allopyranose (**17**) — Compound **12** (0 52 g, 2 mmol) was acetylated with acetic anhydride–sodium acetate exactly as described for compound **3** The acetate **17** (0 54 g, 89%) had m p 78–79°, $[\alpha]_D^{22}$ −30 5° (*c* 0 1, chloroform), $\lambda_{max}^{CHCl_3}$ 5 7 (C=O), 7 3 (CMe_2), and 8 5–10 μm (COCOC), for n m r data, see Table II

Anal Calc for $C_{14}H_{22}O_7$ C, 55 63, H, 7 28, O, 37 09 Found C, 55 57, H, 7 21, O, 36 97

Acetonation of D-*talose* (**18**) — The dichloromethane extract contained very little material (<0 1 g), and this appeared to be composed of a single product (t l c), evidently a diisopropylidene derivative A high yield of 2,3 4,6-di-*O*-isopropylidene-D-talopyranose might be expected from the acetonation of D-talose with an excess of methyl isopropenyl ether[17]

The freeze-dried, aqueous phase gave an amorphous solid (10 2 g, 93%) that was practically pure by t l c , it crystallized from ethyl acetate 4,6-*O*-Isopropylidene-α-D-talopyranose (**19**) thus obtained had m p 52° (modification)–110°, $[\alpha]_D^{22}$ +62 (5 min) → +53° (24 h, *c* 0 1, water), R_F 0 60 (4 1 ethyl acetate–methanol), $\lambda_{max}^{CHCl_3}$ 2 9 broad (OH), 7 30 (CMe_2), and 8 5–10 μm (COCOC), for n m r data, see Table III, *m/e* 206 (60, M^+ — Me·), 187 (2, 205 — H_2O, m* 170 6), 161 (0 6, M^+ — Me_2C^+OH), 145 (3, 205 — AcOH), 131 (18), 127 (3), 119 (2), 116 (1 2), 115 (1 5), 113 (1.1), 103 (6), 102 (3). 101 (15), 99 (10), 98 (2), 85 (9), 73 (35), 60 (20), 59 (100) 58 (5), 57 (12), and 43 (62), X-ray powder diffraction data 12 27 m, 7 52 m, 6 68 vs, 6 17 w, 5 71 s, 5 33 s, 5 00 s, 4 46 vs, 4 21 s, 3 96 m, 3 66 m, 3 32 m, 3 19 w, 3 09 m, 3 03 m, 2 85 m, 2 77 m, 2 69 s, 2 00 m, and 1 82 m

Anal Calc for $C_9H_{16}O_6$ C, 49 09, H, 7 27, O, 43 64 Found C, 49 12, H, 7 30, O, 43 58

G l c analysis of the acetonation products of D-*talose* — A per(trimethylsilyl)-ated aliquot of the crude mixture from the acetonation of D-talose was compared with a per(trimethylsilyl)ated sample of authentic D-talose [T_R 1 00 (1850)] Essentially one peak, only, was observed, corresponding to **19**, at T_R 0 58 (1080), a very minor peak was present at T_R 0 41 (762)

1,2,3-Tri-O-acetyl-4,6-O-isopropylidene-α-D-talopyranose (**20**) — A solution of acetic anhydride (10 2 g, 60 mmol) in anhydrous pyridine (10 mL) was added as rapidly as possible at 0° to a stirred solution of compound **19** (2 2 g, 10 mmol) in

pyridine (10 mL) The mixture was stirred for 24 h at ~20°, and then poured onto ice The product was extracted (dichloromethane), and the extract was washed with saturated, aqueous sodium hydrogencarbonate (3 × 10 mL), dried (sodium sulfate), and evaporated, to give a crystalline compound that was recrystallized from methanol–water, and identified as **20** (3 1 g, 90%), m p 179–180°, $[\alpha]_D^{22}$ +132.4° (*c* 0.1, chloroform), $\lambda_{max}^{CHCl_3}$ 5 70 (C=O), 7 30 (CMe_2), and 8 5–10 μm (COCOC), no OH absorption; R_F 0 49 (1 1 ethyl acetate–petroleum ether), for n.m r. data, see Table III; *m/e* 331 (30, M^+ — Me), 287 (5, M^+ — AcO·), 245 (10, 287 — CH_2CO), 229 (3), 226 (5), 203 (3.5, 245 — CH_2CO), 187 (7), 169 (8, 227 — Me_2CO), 157 (4, AcOCH=CH-C^+HOAc), 143 (13, 203 — AcOH), 127 (16 5, 169 — CH_2CO), 115 (11 5, 157 — CH_2CO), 109 (4 5, 169 — AcOH), 101 (12), 85 (9), 81 (6), 73 (4), 69 (2 5), 59 (10), and 43 (100), X-ray powder diffraction data· 9 55 s, 8 03 s, 6 91 w, 5 84 m, 5 32 m, 5 00 m, 4 80 m, 4 34 m, 4 10 s, 3 87 m, and 3 41 w

Anal Calc for $C_{15}H_{22}O_9$. C, 52 02, H, 6 36, O, 41 62 Found C, 51 98, H, 6 32, O, 41 68

Deacetonation of **20** *to give* **21**, *and acetylation of* **21** *to give* α-D-*talopyranose pentaacetate* (**22**) *and its 4,6-bis(trideuterioacetyl) analog* (**22a**) — The method described earlier for the sequence **8**→**7**→**6** was followed *1,2,3-Tri*-O-*acetyl*-α-D-*talopyranose* (**21**, 0 43 g, 98%) thus obtained had m p 157–159°, $[\alpha]_D^{22}$ +82° (*c* 0.1, chloroform), R_F 0 30 (ethyl acetate), $\lambda_{max}^{CHCl_3}$ ~3 broad (OH) and 5 7 μm (C=O); for n m r data, see Table III, *m/e* 247 (4 5, M^+ — AcO), 246 (1 5, M^+ — AcOH), 245 (7 5, M^+ — H_2O — MeCO), 229 (1.3, M^+ — H_2O — AcO), 217 (0.8), 215 (0 7, 246 — CH_2OH), 203 (2, 243 — CH_2CO), 187 (3), 186 (4), 158 (4, 246 — AcOCH=O), 157 (17, AcOCH=CH-C^+OAc), 149 (2 5), 145 (5), 144 (5), 143 (9, 203 — AcOH), 128 (2 5), 127 (6 5), 126 (4), 115 (40, 157 — CH_2CO), 103 (6 5), 102 (2 5), 101 (1 5), 99 (3), 98 (13), 97 (6), 85 (6), 81 (3), 73 (20), 61 (3), 60 (16), 59 (8), and 43 (100)

Anal. Calc for $C_{12}H_{18}O_9$ C, 47 06, H, 5 88, O, 47 06 Found C, 47 19, H, 5 79, O, 47 21.

The α-D-talopyranose pentaacetate (**22**) finally obtained had physical constants {m p. 106–108°, $[\alpha]_D^{22}$ +52 5° (*c* 0 1, chloroform), lit [13] m p 106 5–107°, m p [14] 106–107°, $[\alpha]_D^{20}$ +68° (chloroform)[15]} and n m r data (see Table III) consistent with those of the authentic derivative The 4,6-bis(trideuterioacetyl) analog **22a** had characteristics essentially identical to those recorded for **22**, but the n m r spectrum showed signals for only three of the five acetyl groups

ACKNOWLEDGMENT

The authors thank C. R Weisenberger for recording the mass spectra

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