Aust. J. Chem., 1996, **49**, 293–298

Regioselective Deacetylation of Fully Acetylated Mono- and Di-saccharides with Hydrazine Hydrate*

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Selective deacetylation reactions of the peracetylated reducing disaccharides (1), (5), (9), (15), β-D-glucopyranose (17) and 2-acetamido-2-deoxy-β-D-glucopyranose (19), with 1·2 equiv. of hydrazine hydrate in acetonitrile, gave predominantly the corresponding heptaacetates (2), (6), (10), (16), the tetraacetate (18) and the triacetate (20), with the free hydroxy group at C1. Reaction of (1) with 1·2 equiv. of hydrazine hydrate in *N,N*-dimethylformamide also afforded the heptaacetate (2), but in lower yield. When reactions of (1), (5) and (9) were performed with 2·5 equiv. of hydrazine hydrate, deacetylation also occurred at other positions to afford the corresponding hexaacetates (3), (7), (11) and (12), with hydroxy groups at C1,2 or C1,3, and the pentaacetates (4), (8) and (13), with hydroxy groups at C1,2,3. Maltose octaacetate (9), in addition, yielded the tetraacetate (14) in which the free hydroxy groups were located at C1,2,2′,3. Compound (15) on treatment with 2·5 equiv. of hydrazine hydrate afforded an intractable mixture. The reaction of methyl 2,3,4,6-tetra-*O*-acetyl-α-D-glucopyranoside (21) with 2·5 equiv. of hydrazine hydrate gave the 3,4,6-triacetate (22), a mixture of the 2,6- and the 3,6-diacetates (23) and (24), respectively, the 4,6-diacetate (25), and the 6-acetate (26).

Introduction

The oligosaccharide residues of glycoproteins and glycolipids are components of biological membranes and are known to be involved in biological processes such as cell–cell interaction and cell–virus recognition. This has stimulated interest in the synthesis of oligosaccharides[1] and in devising suitable strategies for the protection and deprotection of hydroxy groups in carbohydrates.

Selective removal of the C1 acetate group from β-D-glycopyranose pentaacetate by way of glycosyl halides with use of silver carbonate in aqueous acetone has been described.[2] However, the instability of many of the glycosyl halides and the expense of using silver compounds make this process unattractive. Several peracetyl monosaccharides and maltose octaacetate have been regioselectively deacetylated at the anomeric position by using bis(tributyltin) oxide in aprotic solvents with good to excellent yields.[3] Reactions of the β-anomers have been shown to occur more efficiently and with higher regioselectivity. A combination of potassium cyanide and potassium hydroxide has been used to selectively deacetylate at the C1 position in peracetylated aldopyranoses.[3] The use of expensive and toxic organotin reagents and highly toxic potassium cyanide make these routes less desirable. Piperidine[4] and hydrazine acetate[5] have also been employed to selectively deacetylate peracetyl sugars at the anomeric centre. However, piperidine on prolonged treatment leads to the corresponding 1-piperidyl 2-hydroxy derivatives,[4] and hydrazine acetate is considerably more expensive than hydrazine hydrate. Selective deacylation of fully acylated glycosides and 1,2-*O*-isopropylidenealdofuranose derivatives with hydrazine hydrate in combination with pyridine/acetic acid or pyridine alone has been reported[6] mainly to afford products having one free hydroxy group at C2 or C6 for peracylated glycosides and 1,2-*O*-isopropylidenealdofuranoses, respectively.

In a preliminary communication[7] we have described the use of hydrazine hydrate as a simple and relatively inexpensive reagent for selective deacetylation of peracetylated reducing disaccharides. The study

* This paper is dedicated to Professor Stephen J. Angyal on the occasion of his 80th birthday.

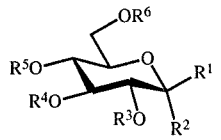
Manuscript received 24 April 1995

0004-9425/96/030293$05.00

has now been extended and also includes the selective deacetylation of peracetylated β-D-glucopyranose, 2-acetamido-2-deoxy-β-D-glucopyranose and methyl α-D-glucopyranoside.

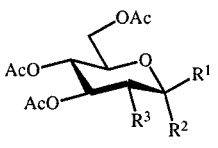
Results and Discussion

Treatment of octaacetates of β-cellobiose (1), β-lactose (5), β-maltose (9), and β-melibiose (15) with 1·2 mol. equiv. of aqueous hydrazine hydrate (24% hydrazine content) in acetonitrile at 5°C for 16 h caused selective removal of the acetate group from the anomeric (C 1) position to afford the corresponding heptaacetates (2), (6), (10), and (16) in greater than 80% yield. The selective deacylation reaction of (1) was also achieved in *N,N*-dimethylformamide; however, the yield of the heptaaacetate (2) was lower and workup conditions were harsher. Treatment of peracetylated β-D-glucopyranose (17) and 2-acetamido-2-deoxy-β-D-glucopyranose (19) with hydrazine hydrate in acetonitrile afforded predominantly (18) and (20), respectively, with free hydroxyls at C 1. The structures of the partially acetylated derivatives were confirmed by ^{1}H n.m.r. experiments. The shift of the resonances



	R1	R2	R3	R4	R5	R6
(1)	OAc	H	Ac	Ac	β-D-Glc*p*2,3,4,6Ac$_4$	Ac
(2)	H,OH		Ac	Ac	β-D-Glc*p*2,3,4,6Ac$_4$	Ac
(3)	H,OH		H	Ac	β-D-Glc*p*2,3,4,6Ac$_4$	Ac
(4)	H,OH		H	H	β-D-Glc*p*2,3,4,6Ac$_4$	Ac
(5)	OAc	H	Ac	Ac	β-D-Gal*p*2,3,4,6Ac$_4$	Ac
(6)	H,OH		Ac	Ac	β-D-Gal*p*2,3,4,6Ac$_4$	Ac
(7)	H,OH		H	Ac	β-D-Gal*p*2,3,4,6Ac$_4$	Ac
(8)	H,OH		H	H	β-D-Gal*p*2,3,4,6Ac$_4$	Ac
(9)	OAc	H	Ac	Ac	α-D-Glc*p*2,3,4,6Ac$_4$	Ac
(10)	H,OH		Ac	Ac	α-D-Glc*p*2,3,4,6Ac$_4$	Ac
(11)	H,OH		H	Ac	α-D-Glc*p*2,3,4,6Ac$_4$	Ac
(12)	H,OH		Ac	H	α-D-Glc*p*2,3,4,6Ac$_4$	Ac
(13)	H,OH		H	H	α-D-Glc*p*2,3,4,6Ac$_4$	Ac
(14)	H,OH		H	H	α-D-Glc*p*3,4,6Ac$_3$	Ac
(15)	H,OAc		Ac	Ac	Ac	α-D-Gal*p*2,3,4,6Ac$_4$
(16)	H,OH		Ac	Ac	Ac	α-D-Gal*p*2,3,4,6Ac$_4$

α-D-Glc*p*2,3,4,6Ac$_4$ = 2,3,4,6-tetra-*O*-acetyl-α-D-glucopyranosyl
α-D-Glc*p*3,4,6Ac$_3$ = 3,4,6-tri-*O*-acetyl-α-D-glucopyranosyl
β-D-Glc*p*2,3,4,6Ac$_4$ = 2,3,4,6-tetra-*O*-acetyl-β-D-glucopyranosyl
α-D-Gal*p*2,3,4,6Ac$_4$ = 2,3,4,6-tetra-*O*-acetyl-α-D-galactopyranosyl
β-D-Gal*p*2,3,4,6Ac$_4$ = 2,3,4,6-tetra-*O*-acetyl-β-D-galactopyranosyl



	R1	R2	R3
(17)	OAc	H	OAc
(18)	H,OH		OAc
(19)	H	OAc	NHAc
(20)	H,OH		NHAc

due to H 1α and H 1β signals to higher field would be expected if the anomeric position carried a free hydroxy group instead of an acetoxy group. This was supported by the ^{1}H n.m.r. data of (2), (6), (10), and (16) (see Tables 1–4). The structures of the 1-hydroxy compounds (18) and (20) were similarly in agreement with their ^{1}H n.m.r. spectra (see Table 5).

When the peracetylated sugars were treated with 2·5 mol. equiv. of aqueous hydrazine hydrate (24% hydrazine content), at 5°C for 16 h, deacetylation also occurred at other positions. For example, the reaction of β-cellobiose octaacetate (1) afforded a mixture containing three main deesterified products which were isolated by silica gel column chromatography and characterized by ^{1}H n.m.r. spectroscopy as the 1-hydroxy heptaacetate (2) (30%), the 1,2-dihydroxy hexaacetate (3) (22%) and the 1,2,3-trihydroxy pentaacetate (4) (11%). A comparison of H 1β (δ 4·68) and H 2β (δ 3·43) resonances of the β-anomeric form of (3) with the corresponding resonaces at δ 5·68 (H 1β) and δ 5·03 (H 2β) of β-cellobiose octaacetate (1) confirmed that the two hydroxy groups in (3) were located at C 1,2 positions. Similarly, the resonances for H 1β, H 2β and H 3β in (4) shifted upfield to δ 4·64, 3·39 and 3·64, respectively, as compared to the corresponding proton resonances in (1), which were observed at δ 5·68, 5·03, and 5·23, thus confirming that the three hydroxy groups in (4) were located at C 1,2,3 positions (see Table 1).

The deacetylation pattern of β-lactose octaacetate (5) when treated with 2·5 mol. equiv. of hydrazine hydrate was found to be similar to that of β-cellobiose octaacetate (1). The 1-hydroxy heptaacetate (6) (33%), the 1,2-dihydroxy hexaacetate (7) (20%) and the 1,2,3-trihydroxy pentaacetate (8) (8%) were isolated by silica gel column chromatography and their structures ascertained by ^{1}H n.m.r. (see Table 2). The similarity in the deacetylation behaviour between (1) and (5) is probably due to the fact that in both the disaccharides the interglycosidic linkages are β-1→4.

Treatment of β-maltose octaacetate (9) with 2·5 mol. equiv. of hydrazine hydrate at 5°C for 16 h afforded a mixture which gave, after extensive chromatography on a column of silica gel, the 1-hydroxy heptaacetate (10) (28%), the 1,2-dihydroxy hexaacetate (11) (25%), the 1,3-dihydroxy hexaacetate (12) (10%), the 1,2,3-trihydroxy pentaacetate (13) (5%) and the 1,2,2′,3-tetrahydroxy tetraacetate (14) (3%). The structures of these compounds were in agreement with their ^{1}H n.m.r. data (see Table 3). The formation of the 1,2-dihydroxy hexaacetate (11) and the 1,3-dihydroxy hexaacetate (12) indicates that, unlike (1) and (5), the deacetylation in (9) is probably non-sequential. The somewhat similar reactivity of the C 2,3 acetoxy groups in (9) or (10) towards the deacetylation reaction could be due to the influence of the α-1→4 interglycosidic linkage.

Table 1. ^{1}H n.m.r. data of acetylated cellobiose derivatives

Key to symbols: A, reducing end; B, non-reducing end; a, coupling constant could not be determined; b, resonances could not be resolved

Disaccharide	Anomer	Residue	Chemical shift (δ)										Coupling constants J/Hz						
			H1	H2	H3	H4	H5	H6a	H6b	OH1	OH2	OH3	$J_{1,2}$	$J_{2,3}$	$J_{3,4}$	$J_{4,5}$	$J_{5,6a}$	$J_{5,6b}$	$J_{6a,6b}$
(1)	β[8]	B	4·54	4·92	5·15	5·06	3·70	4·37	4·05										
		A	5·68	5·03	5·23	3·84	3·78	4·49	4·13										
(2)	α	B	4·53	4·93	5·15	5·07	3·67	4·38	4·06				7·7	8·2	a	9·5	4·3	a	a
		A	5·38	4·84	5·51	3·75	3·75	4·53	4·18	3·22			3·6	10·2	9·8	9·4	2·4	4·4	a
	β	B	4·53	4·92	5·15	5·07	3·67	4·38	4·06				7·7	8·2	a	9·5	4·3	a	a
		A	4·73	4·81	5·23	3·78	3·67	4·51	4·11	b			8·1	9·6	9·6	9·7	a	a	a
(3)	α	B	4·49	4·94	5·18	5·07	3·68	4·42	4·08				7·8	9·3	9·3	a	a	a	a
		A	5·28	3·60	5·38	3·62	3·62	4·45	4·07	4·52	3·25		3·6	9·6	9·6	a	a	a	a
	β	B	4·49	4·94	5·18	5·07	3·68	4·42	4·08				7·8	9·3	9·3	a	a	a	a
		A	4·68	3·43	5·09	3·64	3·64	4·45	4·07	b	b		a	a	a	a	a	a	a
(4)	α	B	4·63	5·02	5·22	5·07	3·84	4·31	4·16				8·0	9·9	9·5	9·8	a	a	a
		A	5·25	3·58	3·88	3·44	3·44	4·11	3·88	4·48	3·31	b	a	a	a	a	a	a	a
	β	B	4·63	5·01	5·22	5·07	3·84	4·31	4·16				8·0	9·9	9·5	9·8	a	a	a
		A	4·64	3·39	3·64	3·49	3·63	4·34	4·02	b	3·81	b	6·4	9·7	8·3	a	a	a	a

Table 2. ^{1}H n.m.r. data of acetylated lactose derivatives

Key to symbols: A, reducing end; B, non-reducing end; a, resonances could not be resolved; b, coupling constant could not be determined

Disaccharide	Anomer	Residue	Chemical shift (δ)										Coupling constants J/Hz						
			H1	H2	H3	H4	H5	H6a	H6b	OH1	OH2	OH3	$J_{1,2}$	$J_{2,3}$	$J_{3,4}$	$J_{4,5}$	$J_{5,6a}$	$J_{5,6b}$	$J_{6a,6b}$
(5)	β	B	4·47	5·12	4·95	5·35	3·92	a	a				7·7	10·4	3·4	1·0	b	b	b
		A	5·68	5·05	5·26	3·82	3·86	4·06	3·84				8·2	9·4	8·3	b	b	b	b
(6)	α	B	4·51	5·12	4·96	5·36	3·89	4·16	4·08				7·7	10·4	3·4	0·9	6·4	6·8	b
		A	5·37	4·82	5·53	3·77	3·77	4·50	4·19	3·50			3·6	10·0	9·3	9·5	b	b	b
	β	B	4·49	5·11	4·96	5·36	3·89	4·16	4·08				7·8	10·4	3·4	0·9	6·4	b	b
		A	4·74	4·81	5·24	3·80	3·66	4·50	4·12	a			8·2	9·8	9·3	b	b	b	b
(7)	α	B	4·44	5·10	4·99	5·37	3·89	4·27	4·04				7·7	10·5	3·4	1·1	6·2	7·4	11·2
		A	5·30	3·56	5·45	3·66	3·66	4·45	4·13	4·12	3·18		3·9	9·5	9·5	9·5	b	b	b
	β	B	4·45	5·11	4·97	5·37	3·89	4·27	4·04				7·7	10·5	3·4	1·1	6·2	7·4	11·2
		A	4·69	3·43	5·13	3·75	3·67	4·45	4·13	a	a		7·7	9·6	8·7	9·9	b	b	b
(8)	α	B	4·57	5·23	5·03	5·41	4·06	4·32	4·05				7·9	10·2	3·4	<1	b	b	b
		A	5·27	3·57	3·91	3·45	3·45	4·13	3·91	4·35	3·20	4·25	b	b	8·5	9·6	b	b	b
	β	B	4·60	5·22	5·03	5·41	4·06	4·32	4·05				7·9	10·2	3·4	<1	b	b	b
		A	4·67	3·39	3·68	3·49	3·64	4·34	4·04	a	a	a	7·3	9·0	b	b	b	b	b

Table 3. ^{1}H n.m.r. data of acetylated maltose derivatives

Key to symbols: A, reducing end; B, non-reducing end; a, coupling constant could not be determined; b, resonances could not be resolved

Disaccharide	Anomer	Residue	Chemical shift (δ)										Coupling constants J/Hz						
			H1	H2	H3	H4	H5	H6a	H6b	OH1	OH2	OH3	$J_{1,2}$	$J_{2,3}$	$J_{3,4}$	$J_{4,5}$	$J_{5,6a}$	$J_{5,6b}$	$J_{6a,6b}$
(9)	β[8]	B	5·40	4·86	5·36	5·05	3·95	4·24	4·04										
		A	5·75	4·97	5·30	4·02	3·87	4·45	4·23										
(10)	α	B	5·45	4·87	5·38	5·07	3·99	4·26	4·06				4·0	10·5	9·5	10·0	a	a	a
		A	5·37	4·79	5·59	3·99	3·99	4·50	4·24	3·28			3·6	10·2	9·1	a	a	a	a
	β	B	5·41	4·86	5·36	5·06	3·99	4·26	4·06				4·0	10·2	9·5	10·1	a	a	a
		A	4·79	4·74	5·31	4·01	3·75	4·50	4·24	b			7·9	9·0	a	a	a	a	a
(11)	α	B	5·50	4·88	5·38	5·09	3·98	4·25	4·07				4·0	10·5	9·6	10·0	2·3	2·7	12·5
		A	5·26	3·51	5·41	3·92	4·21	4·47	4·25	4·31	2·62		3·9	10·2	9·8	9·5	2·6	3·7	12·2
(12)	α	B	5·43	4·98	5·45	5·08	4·14	4·26	4·08				4·1	10·4	10·6	9·8	a	a	a
		A	5·39	4·70	4·19	3·65	3·65	4·50	4·14	3·63	3·00		3·6	10·2	a	9·6	a	a	a
	β	B	5·39	4·98	5·43	5·08	4·14	4·25	4·08				4·1	10·4	10·6	9·8	a	a	a
		A	4·66	4·68	3·82	3·68	3·65	4·51	4·19	4·03		3·2	a	a	a	a	a	a	a
(13)	α	B	5·49	4·93	5·44	5·08	4·11	4·25	3·98				3·8	10·4	9·5	10·6	a	a	a
		A	5·25	3·51	3·96	3·57	4·09	4·47	4·20	4·54	3·29	b	3·7	9·4	9·6	a	a	a	a
	β	B	5·52	4·92	5·43	5·08	4·11	4·25	3·98				3·8	10·5	9·7	10·6	a	a	a
		A	4·59	3·32	3·69	3·60	3·64	4·48	4·18	b	b	b	7·8	a	a	a	a	a	a
(14)	α	B	5·24	3·79	5·24	4·99	4·13	4·28	4·08		b		3·5	9·9	a	9·7	a	a	a
		A	5·21	3·53	4·02	3·58	4·11	4·52	4·16	b	b	b	a	a	a	a	a	a	a
	β	B	5·24	3·79	5·24	4·99	4·13	4·28	4·08		b		3·5	9·9	a	9·7	a	a	a
		A	4·59	3·32	3·74	3·73	4·16	4·52	4·16	b	b	b	a	a	a	a	a	a	a

Table 4. ^{1}H n.m.r. data of acetylated melibiose derivatives

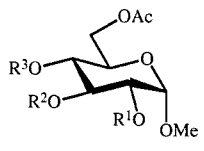
Key to symbols: A, reducing end; B, non-reducing end; a, coupling constant could not be determined; b, signals (δ 4·30–4·22) not resolved; c, signals (δ 3·80–3·60) not resolved; d, not resolved

Disaccharide	Anomer	Residue	Chemical shift (δ) H1	H2	H3	H4	H5	H6a	H6b	OH1	Coupling constants J/Hz $J_{1,2}$	$J_{2,3}$	$J_{3,4}$	$J_{4,5}$	$J_{5,6a}$	$J_{5,6b}$	$J_{6a,6b}$
(15)	α	B	5·16	5·09	5·34	5·46	4·19	4·21	4·07		3·6	10·8	3·4	1·1	a	a	a
		A	6·29	5·04	5·48	5·15	4·07	3·73	3·59		3·7	10·3	9·9	10·2	4·6	2·7	11·6
(16)	α	B	5·17	5·08	5·34	5·43	b	b	b		3·5	10·6	3·3	1·3	a	a	a
		A	5·44	4·84	5·55	4·95	4·25	c	c	4·11	3·6	10·5	9·5	a	a	a	a
	β	B	5·19	5·09	5·35	5·43	b	b	b		3·7	10·6	3·2	a	a	a	a
		A	4·74	4·86	5·24	4·98	3·73	c	c	d	7·8	a	a	a	a	a	a

Table 5. ^{1}H n.m.r. data of acetylated monosaccaharides

Key to symbols: a, resonance (δ 4·06–4·34) not resolved; b, coupling constant could not be determined; c, resonance (δ 4·08–4·30) not resolved; d, resonance (δ 4·25–4·50) not resolved

Monosaccharide	Anomer	Chemical shift (δ) H1	H2	H3	H4	H5	H6a	H6b	OCH_3	NH	OH	Coupling constants J/Hz $J_{1,2}$	$J_{2,3}$	$J_{3,4}$	$J_{4,5}$	$J_{5,6a}$	$J_{5,6b}$	$J_{6a,6b}$
(17)	β	5·72	5·14	5·26	5·13	3·84	4·30	4·11.				8·2	9·2	9·3	10·1	4·6	2·2	12·6
(18)	α	5·45	4·89	5·54	5·08	4·27	a	a				3·6	10·2	9·6	9·9	b	b	b
	β	4·75	4·91	5·25	5·08	3·77	a	a				8·0	9·2	9·4	9·9	2·5	4·7	b
(19)	α	6·13	4·45	5·19	5·19	3·96	4·21	4·03		6·02		3·6	10·5	b	b	4·0	2·4	12·4
(20)	α	5·26	4·29	5·31	5·14	4·22	c	c		6·10	4·60	3·3	10·5	9·5	9·4	b	b	b
(21)	α	4·96	4·90	5·48	5·07	3·99	4·27	4·11	3·42			3·7	10·2	9·3	10·1	4·6	2·4	12·2
(22)	α	4·83	3·69	5·23	5·01	3·95	4·28	4·08	3·49			3·8	9·7	9·6	10·0	4·7	2·4	12·3
(23)	α	4·79	3·52	5·08	3·50	3·78	d	d	3·38			3·7	9·4	9·4	b	b	b	b
(24)	α	4·88	4·72	3·92	3·47	3·78	d	d	3·45			3·7	10·0	9·3	b	b	b	b
(25)	α	4·79	3·63	3·85	4·87	3·90	4·24	4·06	3·43			3·7	9·5	9·4	9·9	5·2	2·3	12·2
(26)	α	4·81	3·58	3·79	3·46	3·86	4·42	4·30	3·43			3·8	9·6	8·6	10·0	5·0	2·5	12·3



	R^1	R^2	R^3
(21)	Ac	Ac	Ac
(22)	H	Ac	Ac
(23)	Ac	H	H
(24)	H	Ac	H
(25)	H	H	Ac
(26)	H	H	H

The effect of the interglycosidic linkage on the deacetylation reaction was further supported by the results of the deacetylation of β-melibiose octaacetate (α-1→6) (15). Compound (15), unlike (1), (5) and (9), on deacetylation with 2·5 equiv. of hydrazine hydrate gave a complex and intractable mixture of products. Similar results were obtained when β-D-glucopyranose pentaacetate (17) was treated with 2·5 mol. equiv. of hydrazine hydrate. Chemical shifts for the acetyl methyl proton resonances of the disaccharide derivatives are shown in Table 6.

Treatment of methyl α-D-glucopyranoside tetraacetate (21) with 2·5 mol. equiv. of hydrazine hydrate in acetonitrile at ambient temperature for 48 h gave, after column chromatography, (21), the 2-hydroxy triacetate (22), a mixture of 3,4-dihydroxy and 2,4-dihydroxy diacetates (23) and (24), respectively, the 2,3-dihydroxy diacetate (25), and the 2,3,4-trihydroxy monoacetate (26), in yields of 17, 6, 4, 4 and 45%, respectively. The structures of (22)–(26) were confirmed by ^{1}H n.m.r. on the basis of the upfield shift of the adjacent proton, in comparison with the corresponding proton in the fully acetylated compound (21) (see Table 5). The formation of the 6-acetate (26) as the predominant product and the presence of compounds (23)–(25) could be due to acetyl migration (C 2 → 3 → 4 → 6) in the reaction.

Table 6. ^{1}H n.m.r. data of the acetyl methyl protons of acetylated disaccharides

Disaccharide	Chemical shift (δ)
(1)	2·12, 2·09, 2·03, 2·02, 2·01, 1·98
(2)	2·17, 2·14, 2·09, 2·08, 2·03, 2·01, 1·98
(3)	2·13, 2·10, 2·09, 2·06, 2·02, 2·00, 1·99
(4)	2·18, 2·13, 2·12, 2·11, 2·06, 2·04, 2·01
(5)	2·18, 2·16, 2·13, 2·06, 2·00, 1·97
(6)	2·19, 2·16, 2·13, 2·08, 2·07, 2·06, 2·05, 1·97
(7)	2·18, 2·17, 2·16, 2·13, 2·12, 2·07, 2·06, 2·05, 1·98, 1·97
(8)	2·18, 2·12, 2·10, 2·08, 1·99
(9)	2·13, 2·10, 2·09, 2·05, 2·02, 2·01, 2·00
(10)	2·18, 2·15, 2·11, 2·07, 2·06, 2·03, 2·02, 2·01
(11)	2·18, 2·15, 2·10, 2·09, 2·07, 2·06, 2·03, 2·01, 1·97
(12)	2·18, 2·17, 2·16, 2·11, 2·10, 2·08, 2·07, 2·03, 2·01
(13)	2·18, 2·15, 2·12, 2·10, 2·09, 2·04, 2·03, 2·01
(14)	2·11, 2·09, 2·08, 2·03
(15)	2·20, 2·14, 2·13, 2·12, 2·06, 2·05, 2·04, 2·02, 1·99
(16)	2·15, 2·11, 2·10, 2·07, 2·06, 2·05, 2·02, 1·99

The order of reactivity of acetoxy groups in peracetylated disaccharides (1), (5) and (9) towards deesterification with hydrazine hydrate is: 1-OH > 2-OH > 3-OH. In the case of (9) the 2′-acetoxyl is the next most reactive group. On the basis of these results, it is concluded that the initial deacetylation reaction at the reducing end (C 1) is followed by the attack of the nucleophilic reagent, preferentially, at the lower face of the molecule, and that the reaction is dependent on the conformation around the glycosidic linkage.

Experimental

General Methods

All evaporations were carried out under reduced pressure. Melting points were measured on a Büchi 510 hot-stage apparatus and are uncorrected. Optical rotations were measured on a Perkin–Elmer 141 polarimeter in 1-dm tubes. Column chro-

matography on silica gel was carried out at room temperature with Kieselgel (Fluka). T.l.c. was performed on aluminium plates precoated with silica gel 60 F_{254} (Merck 1.05554) with detection by viewing in u.v. light at 254 nm and by charring with sulfuric acid.

^{1}H n.m.r. spectra were recorded at 297 K and at 200·13 and 300·13 MHz, respectively, by using Bruker AC 200 and AM 300 WB spectrometers. Spectra were recorded in $CDCl_3$ with chemical shifts referenced to tetramethylsilane as internal standard (δ 0·00). For the assignment of the signals in ^{1}H n.m.r. spectra, two-dimensional homonuclear correlated spectroscopy COSY-45, one-dimensional TOCSY experiments and homodecoupling were used. In the one-dimensional TOCSY experiments, performed on the AM 300 WB spectrometer, a selective excitation of a half-Gaussian pulse of 150 ms was used followed by an MLEV-17 spin lock[9] (mixing time 20–150 ms) with the transmitter low power mode. On the AC 200 spectrometer a selective spin echo excitation[10] with DANTE pulse train[11] was used.

Mono- and di-saccharide β-peracetylated derivatives were prepared by reaction of the parent sugar with acetic anhydride and sodium acetate.[12]

General Procedure for the Selective Deacetylation of Fully Acetylated Mono- and Di-saccharides

A solution of the peracetylated sugar (2 or 5 g) in acetonitrile (50 ml) was treated with an aqueous solution of hydrazine monohydrate (24% hydrazine monohydrate content; 1·2 or 2·5 mol. equiv.) at the stated temperature and time. The reaction mixture was then treated with excess Amberlite IR 120 (H^+) ion exchange resin to remove hydrazine derivatives, filtered, washed, concentrated and crystallized or the product purified by silica gel column chromatography.

2,3,6,2′,3′,4′,6′-Hepta-O-acetylcellobiose (2)

A solution of (1) (5 g, 7·37 mmol) in acetonitrile was treated with hydrazine monohydrate (1·85 ml, 8·84 mmol) at 5°C for 16 h as described in the general procedure above to give after workup and crystallization from ether 2,3,6,2′,3′,4′,6′-hepta-*O*-acetylcellobiose (2) (4·2 g, 90%); m.p. 206–209°C; $[\alpha]_D$ +27·1° (*c*, 1·1 in $CHCl_3$) {lit.[4] m.p. 209°C; $[\alpha]_D$ +33·4°(*c*, 2·22 in pyridine, 24 h)}; ^{1}H n.m.r. data, see Table 1.

Reaction of β-Cellobiose Octaacetate (1) with 2·5 mol. equiv. of Hydrazine Hydrate

The deacetylation reaction of (1) (5 g, 7·37 mmol) with hydrazine hydrate (3·85 ml, 18·4 mmol) at 5°C for 16 h, as described in the general procedure, gave, after workup and elution through a column of silica gel with acetone/light petroleum (2:1 v/v), the following products.

2,3,6,2′,3′,4′,6′-Hepta-*O*-acetylcellobiose (2) (1·41 g, 30%); the product had physical constants identical to those reported above.

3,6,2′,3′,4′,6′-Hexa-O-acetylcellobiose (3) (0·95 g, 22%); m.p. 196–198°C; $[\alpha]_D$ +45·2° (*c*, 1·1 in $CHCl_3$) (Found: C, 48·3; H, 5·9. $C_{24}H_{34}O_{17}$ requires C, 48·5; H, 5·8%).

6,2′,3′,4′,6′-Penta-O-acetylcellobiose (4) (0·45 g, 11%); $[\alpha]_D$ +29·8° (*c*, 0·28 in $CHCl_3$) (Found: C, 47·7; H, 5·9. $C_{22}H_{32}O_{16}$ requires C, 47·8; H, 5·8%).

^{1}H n.m.r. data of compounds (2)–(4), see Table 1.

2,3,6,2′,3′,4′,6′-Hepta-O-acetyllactose (6)

A solution of (5) (5 g, 7·37 mmol) in acetonitrile (50 ml) was treated with hydrazine monohydrate (1·85 ml, 8·84 mmol) at 5°C for 16 h to give, after workup and crystallization from acetone/diethyl ether, the title compound (6) (4·4 g, 88%); m.p. 86–87°C (lit.[4] 90°C); $[\alpha]_D$ +32·6° (*c*, 1·1 in $CHCl_3$); ^{1}H n.m.r. data, see Table 2.

Reaction of β-Lactose Octaacetate (5) with 2·5 mol. equiv. of Hydrazine Monohydrate

The deacetylation of (5) (5 g, 7·37 mmol) with hydrazine monohydrate (3·85 ml, 18·4 mmol) in acetonitrile at 5°C for 16 h gave, after workup and elution on a column of silica gel with acetone/light petroleum mixture (2:1 v/v), the following products.

2,3,6,2′,3′,4′,6′-Hepta-*O*-acetyllactose (6) (1·55 g, 33%); the product had physical constants identical to those reported above.

3,6,2′,3′,4′,6′-Hexa-O-acetyllactose (7) (1·0 g, 20%); $[\alpha]_D$ +41·4° (*c*, 1·1 in $CHCl_3$) (Found: C, 48·9; H, 5·9. $C_{24}H_{34}O_{17}$ requires C, 48·5; H, 5·8%).

6,2′,3′,4′,6′-Penta-O-acetyllactose (8) (0·4 g, 8%); $[\alpha]_D$ +54·6° (*c*, 1·13 in $CHCl_3$) (Found: C, 47·4; H, 6·0. $C_{22}H_{34}O_{16}$ requires C, 47·8; H, 5·8%).

^{1}H n.m.r. data of compounds (6)–(8), see Table 2.

2,3,6,2′,3′,4′,6′-Hepta-O-acetylmaltose (10)

A solution of (9) (2 g, 2·95 mmol) in acetonitrile (25 ml) was treated with hydrazine monohydrate (0·74 ml, 3·54 mmol) at 5°C for 16 h as described in the general procedure to give, after workup and crystallization from acetone/diethyl ether, 2,3,6,2′,3′,4′,6′-hepta-*O*-acetylmaltose (10) (1·71 g, 86%); m.p. 188–190°C; $[\alpha]_D$ +81·9° (*c*, 1·1 in $CHCl_3$) {lit.[4] m.p. 188°C; $[\alpha]_D$ +84 → 114° (*c*, 0·928 in pyridine, 24 h)}; ^{1}H n.m.r. data, see Table 3.

Reaction of β-Maltose Octaacetate with 2·5 mol. equiv. of Hydrazine Monohydrate

Deacetylation of (9) (5 g, 7·37 mmol) with hydrazine monohydrate (3·34 ml, 18·4 mmol) in acetonitrile (75 ml) at 5°C for 16 h gave, after workup and extensive chromatography on a column of silica gel with light petroleum/acetone mixtures, the following products.

2,3,6,2′,3′,4′,6′-Hepta-*O*-acetylmaltose (10) (1·33 g, 28·3%); the product had physical constants identical to those reported above.

3,6,2′,3′,4′,6′-Hexa-O-acetylmaltose (11) (1·11 g, 25·4%); m.p. 151°C; $[\alpha]_D$ +94·9° (*c*, 1·1 in $CHCl_3$) (Found: C, 48·3; H, 6·0. $C_{29}H_{34}O_{17}$ requires C, 48·5; H, 5·8%).

2,6,2′,3′,4′,6′-Hexa-O-acetylmaltose (12) (0·44 g, 10·0%); $[\alpha]_D$ +98·0° (*c*, 0·69 in $CHCl_3$) (Found: C, 48·2; H, 6·0. $C_{29}H_{34}O_{17}$ requires C, 48·5; H, 5·8%).

6,2′,3′,4′,6′-Penta-O-acetylmaltose (13) (0·21 g, 5·1%); $[\alpha]_D$ +116·1° (*c*, 0·95 in $CHCl_3$) (Found: C, 47·4; H, 6·0. $C_{22}H_{32}O_{16}$ requires C, 47·8; H, 5·8%).

6,3′,4′,6′-Tetra-O-acetylmaltose (14) (0·12 g, 3·1%); $[\alpha]_D$ +129·5° (*c*, 0·7 in $CHCl_3$) (Found: C, 47·4; H, 6·1. $C_{20}H_{30}O_{15}$ requires C, 47·1; H, 5·8%).

^{1}H n.m.r. data of compounds (10)–(14), see Table 3.

2,3,4,2′,3′,4′,6′-Hepta-O-acetylmelibiose (16)

A solution of (15) (2 g, 2·95 mmol) in acetonitrile (25 ml) was treated with hydrazine monohydrate (0·74 ml, 3·54 mmol) at 5°C for 16 h as described in the general procedure to give, after workup and crystallization from acetone/diethyl ether, 2,3,4,2′,3′,4′,6′-hepta-*O*-acetylmelibiose (16) (1·64 g, 82%); m.p. 196–197°C; $[\alpha]_D$ +92·2° (*c*, 1·02 in $CHCl_3$) {lit.[4] m.p. 199–200°C; $[\alpha]_D$ +151 → 163° (*c*, 2·38 in pyridine, 24 h)}; for ^{1}H n.m.r. data, see Table 4.

2,3,4,6-Tetra-O-acetyl-D-glucopyranose (18)

A solution of (17) (2 g, 5·12 mmol) in acetonitrile (25 ml) was treated with hydrazine monohydrate (1·28 ml, 6·14 mmol) at 5°C for 16 h as described in the general procedure to give, after workup and elution on a column of silica gel with light petroleum/acetone (3:2 v/v), 2,3,4,6-tetra-*O*-acetyl-D-glucopyranose (18) as a syrup (1·35 g, 75·6%); $[\alpha]_D$ +75·3° (*c*,

1·1 in $CHCl_3$) [lit.[5] +74°(*c*, 1·95 in $CHCl_3$)]. ^1H n.m.r. data for (17) and (18), see Table 5.

*2-Acetamido-3,4,6-tri-*O*-acetyl-2-deoxy-α-*D*-glucopyranose (20)*

A solution of (19) (2 g, 5·14 mmol) in acetonitrile (25 ml) was treated with hydrazine monohydrate (1·29 ml, 6·17 mmol) at 5°C for 16 h as described in the general procedure to give, after workup and elution on a column of silica gel with light petroleum/acetone, the triacetate (20) as a syrup (1·32 g, 74·0%); $[\alpha]_D$ +51·3° (*c*, 1·1 in $CHCl_3$) [lit.[13] +49·4° (*c*, 2·1 in $CHCl_3$)]; ^1H n.m.r. data for compounds (19) and (20), see Table 5.

*Reaction of Methyl 2,3,4,6-Tetra-*O*-Acetyl-α-*D*-glucopyranoside (21) with 2·5 mol. equiv. of Hydrazine Monohydrate*

A solution of (21) (5·0 g, 13·8 mmol) in acetonitrile (50 ml) was treated with hydrazine monohydrate (7·2 ml, 34·5 mmol) for 48 h at ambient temperature to afford, after chromatography on a column of silica gel with light petroleum/acetone (3:2 v/v), the following products.

Methyl 2,3,4,6-tetra-*O*-acetyl-α-D-glucopyranoside (21) (0·85 g, 17%).

*Methyl 3,4,6-tri-*O*-acetyl-α-*D*-glucopyranoside* (22) (0·26 g, 6%); $[\alpha]_D$ +117·5° (*c*, 1·5 in $CHCl_3$) (Found: C, 48·7; H, 6·3. $C_{13}H_{20}O_9$ requires C, 48·8; H, 6·3%).

A mixture of methyl 2,6- and 3,6-di-*O*-acetyl-α-D-glucopyranoside (23) and (24) (0·15 g, 4%).

*Methyl 4,6-di-*O*-acetyl-α-*D*-glucopyranoside* (25) (0·15 g, 4%); $[\alpha]_D$ +123·3° (*c*, 1·28 in $CHCl_3$) (Found: C, 47·7; H, 6·6. $C_{11}H_{18}O_8$ requires C, 47·5; H, 6·5%).

*Methyl 6-*O*-acetyl-α-*D*-glucopyranoside* (26) (1·47 g, 45%); $[\alpha]_D$ +97·3° (*c*, 1·38 in $CHCl_3$) (Found: C, 45·7; H, 7·1. $C_9H_{16}O_7$ requires C, 45·8; H, 6·8%).

^1H n.m.r. data of compounds (22)–(25), see Table 5.

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