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THE MICHAEL REACTION OF A METHYL 2-*C*-NITRO-α-D-HEX-2-ENOPYRANOSIDE: PREPARATION AND STRUCTURAL DETERMINATION OF THE ADDUCTS HAVING THE D-*altro*-, D-*gluco*, AND D-*manno* CONFIGURATIONS*

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ABSTRACT

The reactions of methyl 4,6-*O*-benzylidene-2,3-dideoxy-2-*C*-nitro-α-D-*erythro*-hex-2-enopyranoside (**1**) with 2,4-pentanedione and diethyl malonate afforded adducts having the D-*altro*, D-*gluco*, and D-*manno* configurations. Besides the adducts having the D-*gluco* and D-*altro* configurations, a 1,5-anhydro-2-*C*-nitrohex-1-enitol derivative was isolated in the reaction of **1** with dimethyl malonate. The product ratio was found to depend on the solvent. The nucleophilic addition and subsequent protonation appear to be respectively controlled kinetically and thermodynamically.

INTRODUCTION

As part of our studies on the stereochemistry of nucleophilic addition reactions to nitro sugars[1], we have examined the reaction of methyl 4,6-*O*-benzylidene-2,3-dideoxy-2-*C*-nitro-α-D-*erythro*-hex-2-enopyranoside (**1**) with active methylene compounds, and have isolated adducts having the D-*altro*, D-*gluco*, and D-*manno* configurations, and also 1,5-anhydro-4,6-*O*-benzylidene-2,3-dideoxy-3-*C*-bis[(methoxycarbonyl)methyl]-2-*C*-nitro-D-*ribo*-hex-1-enitol: we now report the preparation, structural determination, epimerization, and conformational analysis of these products.

RESULTS AND DISCUSSION

When the nitro alkene **1** was treated with 2,4-pentanedione in the presence of M sodium hydroxide in dimethyl sulfoxide, the reaction was complete within 3 min (as judged by t.l.c.) and gave only the D-*gluco* isomer **2**. The yield of **2** was, however, low under such conditions*. When 0.1M sodium hydroxide was employed (instead of

*Stereochemistry of Nucleophilic Addition Reactions: Part XI. For Part X, see ref. 1.
*When the D-*gluco* isomer **2** was treated under the same conditions, only a small proportion of **2** was extracted with chloroform.

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TABLE I

REACTIONS OF **1** WITH 2,4-PENTANEDIONE IN VARIOUS SOLVENTS[a]

Solvent	*Reaction temperature (degrees)*	*Product ratios*[b]		
		gluco (2)	manno (5)	altro (8)
Me_2SO	r.t.	8	2	—
Me_2CO	0	7	1	2
MeCN	0	8	1	1
Oxolane	0	6	t	4
Oxolane[c]	0	7	3	—
1,4-Dioxane	r.t.	2.5	—	6
CH_2Cl_2[d]	0	1	1	—
Benzene[d]	r.t.	1	1	—

[a]A solution of **1** (30 mg, 0.1 mmol) in the solvent indicated (2 mL) was stirred with 2,4-pentanedione (20 mg, 0.2 mmol) in the presence of 0.1M sodium deuteride (0.2 mL) for 1 h. [b]The product ratios were calculated on the basis of integration of the methoxyl and benzylidene methine proton signals in the n.m.r. spectra; t = trace; — = product not detected. [c]Instead of 0.1M sodium deuteride, tributylphosphine (0.8 mg) was used as the base. [d]Tributylhexadecylphosphonium bromide (2 mg) was added as the phase-transfer catalyst.

TABLE II

REACTIONS OF **1** WITH ACTIVE METHYLENE COMPOUNDS[a]

Nucleophile	*Solvent (mL)*	*Reaction time*	*Molarity of NaOH*	*Yield (%)*[b]	*Product ratios*[c]		
					gluco	manno	altro
$CH_2(COMe)_2$	Me_2SO (1.5)	3 min	0.1	69	3.5	1	—
$CH_2(COMe)_2$	1,4-Dioxane (3)	30 min	0.1	73	—	—	1
$CH_2(COMe)_2$	Benzene (2)[d]	1 h	0.1	94	1	1.2	—
$CH_2(CO_2Me)_2$	Me_2SO (3)	10 min	0.1	80	3.5	1	—
$CH_2(CO_2Me)_2$	Me_2SO (3)	15 min	1	54	1	—	—
$CH_2(CO_2Me)_2$	1,4-Dioxane (3)	20 h	0.1	77	—	—	1
$CH_2(CO_2Me)_2$	1,4-Dioxane (3)	15 min	1	56	—	—	1[e]
$CH_2(CO_2Me)_2$	Benzene (3)[d]	20 h	1	73	1	1	—
$CH_2(CO_2Et)_2$	Me_2SO (1.5)	10 min	0.1	89	3.1	1	—
$CH_2(CO_2Et)_2$	Me_2SO (1.5)	15 min	1	41	1	—	—
$CH_2(CO_2Et)_2$	1,4-Dioxane (3)	20 h	0.1	76	—	—	1
$CH_2(CO_2Et)_2$	1,4-Dioxane (3)	15 min	1	32	—	—	1
$CH_2(CO_2Et)_2$	Benzene (3)[d]	4 h	1	80	2	1	—

[a]A solution of **1** (30 mg, 0.1 mmol) in the solvent indicated was stirred at ~15° with the active methylene compound in the presence of sodium hydroxide (M or 0.1M, 0.2 mL); 2,4-pentanedione (0.2 mmol), and dimethyl and diethyl malonate (0.15 mmol) were used. [b]Crude, isolated yield. [c]Determined by n.m.r. spectroscopy on the basis of integration of the methoxyl and benzylidene methine proton; —, product not detected. [d]Tributylhexadecylphosphonium bromide was added. [e]The products were **9** and **11** in the ratio of 1:5.

TABLE III

CHEMICAL SHIFTS[a] (δ) AND FIRST-ORDER COUPLING-CONSTANTS (Hz) AT 100 MHz IN CHLOROFORM-*d*

Compound	*H-1*	*H-2*	*H-3*	*H-4*	*PhCH*	*OMe*	$J_{1,2}$	$J_{2,3}$	$J_{3,4}$	$J_{4,5}$	$J_{5,6}$[b]
2[b]	4.94	5.17	3.48	4.18	5.18	3.00	4.0	11.0	11.0	9.5	3.5
5	5.16	5.08	3.45		5.50	3.46	2.0	4.3	10.5		10.5
8	5.28	4.54	3.75		5.49	3.45	1.1	1.1	4.0		11.0
3	5.24	5.06	3.75		5.51	3.75	4.0	10.0	10.0		3.6
9	5.29	4.87	3.63		5.46	3.72	1.1	1.1	4.0		
11[c]	7.71	—	4.56	3.00	5.04	—	—	—	6.0	9.7	8.4
4	5.24	5.06	3.55		5.54	3.42	4.0	10.0	10.0		3.4
7	5.19	5.32	3.39		5.51	3.50	2.0	4.3	9.7		9.7
10	5.34	4.98	3.80		5.50	3.46	1.1	1.1	4.0		

[a]Me_4Si as the internal standard. [b]Methine proton of the substituent at C-3. [c]Recorded in benzene-d_6.

TABLE IV

EPIMERIZATION OF THE ADDUCTS[a]

Starting material	*Solvent (mL)*	*Reaction time*	*0.1M NaOH (mL)*	*Product ratios*[b] gluco	manno	altro
2	1,4-Dioxane (2)	30 min	0.15	1	—	—
2	1,4-Dioxane (2)	20 h	0.15	1	1.4	—
2	Benzene (1.5)[c]	1 h	0.15	5.2	1	—
5	Me_2SO (1.1)	3 min	0.15	1.2	1	—
5	1,4-Dioxane (1.3)	30 min	0.1	1	5.6	—
5	Benzene (1.5)[c]	1 h	0.15	3.3	1	—
8	Me_2SO (1.1)	3 min	0.15	—	—	1
8[d]	Benzene (0.9)[c]	1 h	0.1	—	—	1
3	1,4-Dioxane (2)	20 h	0.14	2.1	1	—
9	Me_2SO (1)	10 min	0.14	—	—	1
4	1,4-Dioxane (2)	20 h	0.14	2	1	—
10	Me_2SO (1)	10 min	0.14	—	—	1

[a]A solution of the adduct (30 mg) in the solvent indicated was stirred at ~ 15° in the presence of the corresponding, active methylene compound and 0.1M sodium hydroxide. Crude yields ≥ 75%. [b]Determined by n.m.r. spectroscopy; —, product not detected. [c]Tributylhexadecylphosphonium bromide was added. [d]Twenty mg of the starting material was used.

M sodium hydroxide), a mixture consisting of **2** and the D-*manno* isomer **5** in the ratio of 7:2 was obtained in 69% yield. In a heterogeneous system consisting of benzene–0.1M sodium hydroxide in the presence of tributylhexadecylphosphonium bromide as the phase-transfer catalyst, the ratio of **2** to **5** became 5:6 (94% yield).

As the direction of approach of the nucleophile is strongly affected by the solvent in the Michael reaction of the corresponding 3-nitro alkene[1], the reaction

was now performed in various solvents. As shown in Table I, the *altro* isomer **8** became the major product in 1,4-dioxane (in the case of 3-nitro alkenes, 1,4-dioxane shows similar behavior[1]), and, under appropriate conditions, compound **8** was obtained in 73% yield. Similar solvent-effects were found in the reactions of **1** with dimethyl and diethyl malonate (see Table II). In dimethyl sulfoxide, the D-*gluco* isomers (**3** and **4**) were formed as the major product, and the D-*manno* isomers (**6** and **7**) as the minor product, but their ratios were lower in the heterogeneous system. On the other hand, the *altro* isomers (**9** and **10**) were selectively obtained in 1,4-dioxane.

Except for the D-*manno* isomer **6**, these products were isolated by fractional recrystallization. Although several attempts to isolate pure compound **6** failed, the D-*manno* configuration was deduced for **6** by comparison of its n.m.r. spectrum with those of the D-*manno* isomers **5** and **7**. The D-*gluco* and D-*manno* configurations in the $^4C_1$ conformation was determined by means of coupling constants (see Table III). The conformation of both the D-*allo* and the D-*altro* isomers would be flattened by the 1,3-diaxial interaction between the methoxyl group and the substituent on C-3. As a result, the dihedral angles between H-1 and H-2 and between H-2 and H-3 both approach 90° for the D-*altro* isomer, and 30° for the D-*allo* isomer. Therefore, the coupling constants, $J_{1,2} = J_{2,3} = 1.1$ Hz, strongly suggested that compounds **8**, **9**, and **10** have the D-*altro* configuration[2].

In order to elucidate whether or not the reaction was kinetically controlled, the isolated products (**2**–**5**, and **8**–**10**) were treated under conditions corresponding to those under which they formed. As shown in Table IV, (*i*) treatment of the D-*altro* isomers (**8**–**10**) in dimethyl sulfoxide, or in a heterogeneous system (for **8**), resulted in the recovery of the starting material, (*ii*) epimerization of the D-*gluco* isomer to the D-*manno* isomer occurred, and *vice versa* for **5** (the other D-*manno* isomers not being investigated), but epimerization of them to the D-*altro* isomer was not observed, even in 1,4-dioxane, wherein the D-*altro* isomer was selectively formed from **1**. From these results, it is apparent that, on addition of a nucleophile, the reaction proceeds under kinetic control, and that the direction of the approaching nucleophile is strongly affected by the reaction conditions; in dimethyl sulfoxide, or in heterogeneous systems, equatorial attack occurs exclusively, whereas, in 1,4-dioxane, axial attack takes place.

In contrast to the 3-nitro sugars*, the nitro group often has an axial orientation in the present compounds. The product ratios of the D-*gluco* to the D-*manno* isomer, and their epimerization data, indicated that the differences in their thermodynamic stabilities are not large. It would be expected that protonation to the intermediary nitronate **12**, derived by axial attack of a nucleophile on **1**, should occur mainly from the axial direction, to give the D-*allo* isomer **13** under kinetic control, because of the steric hindrance due to both the axially oriented methoxyl group and the 2,4-pentanedione moiety; however, the D-*allo* isomer **13** was never detected in this study. Further-

*To our knowledge, the nitro group in 3-nitro sugars is almost always equatorially oriented; for an exception, see ref. 1.

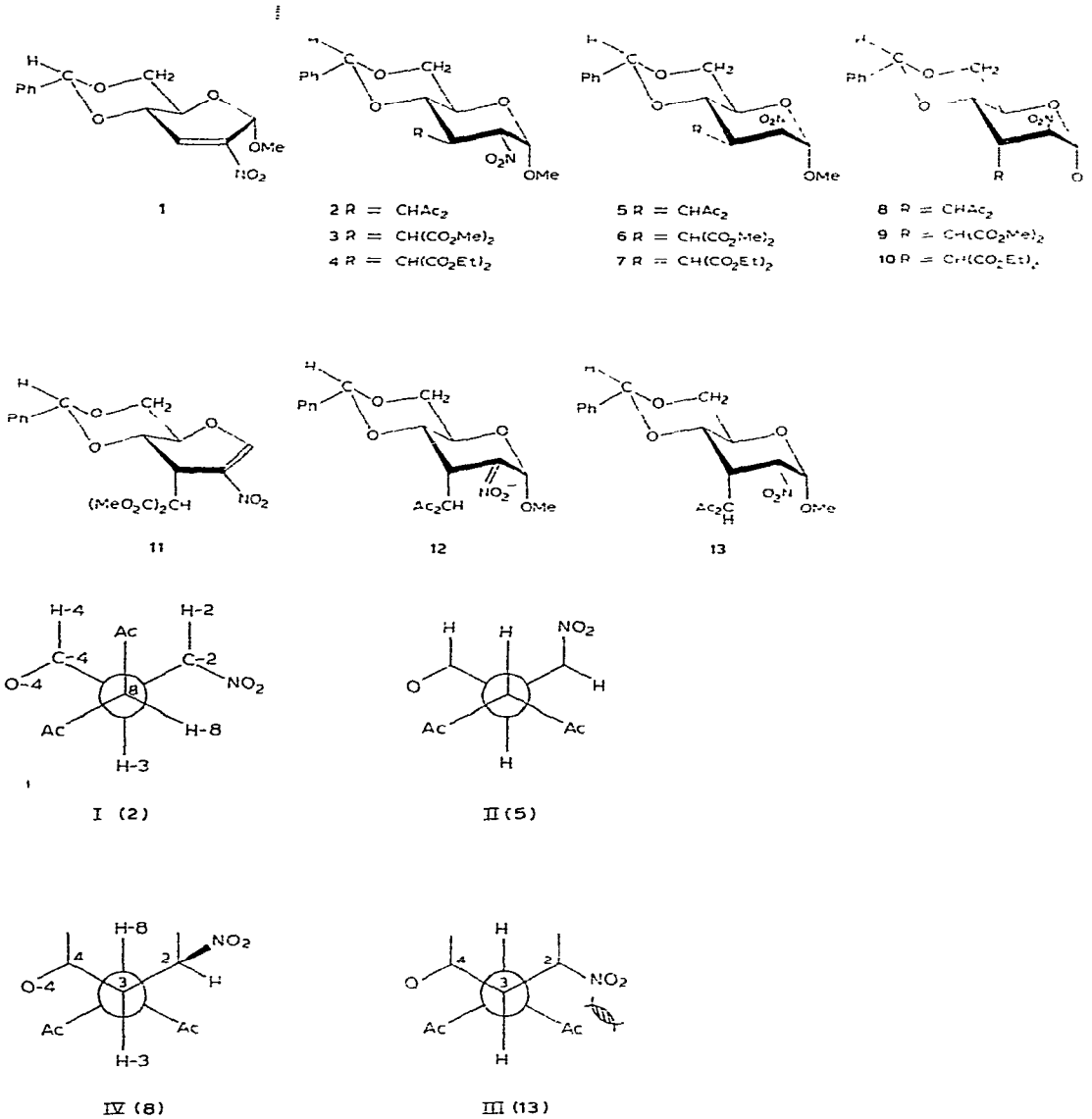


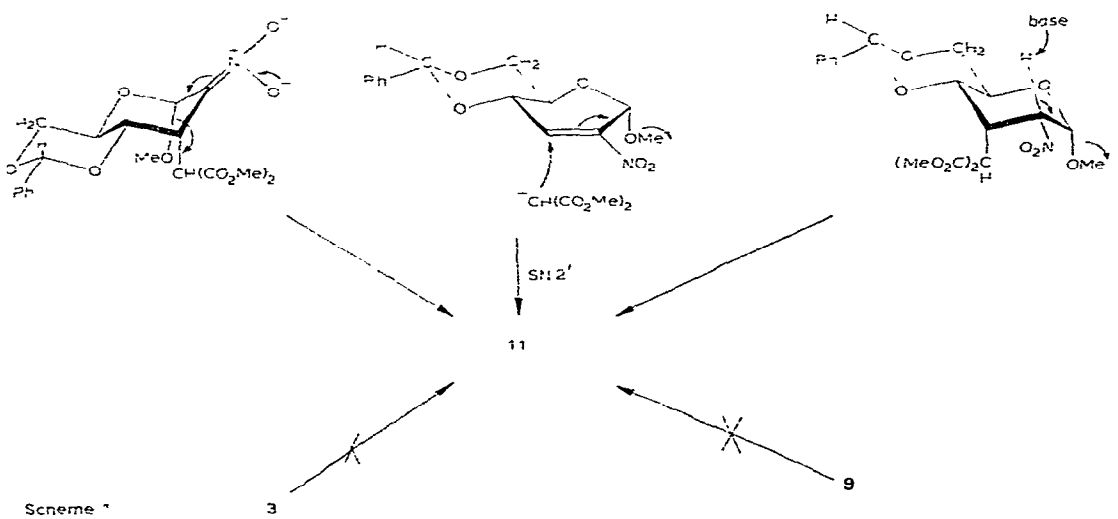
Fig. 1. "Newman" projections of the most stable conformation, showing C-8 to C-3 for the D-*gluco* (**2**) and D-*manno* isomer (**5**), and C-3 to C-8 for the D-*altro* (**8**) and D-*allo* isomer **13**.

more, when the D-*altro* isomer **8** was treated with 0.1M sodium deuteride in chloroform-*d* in the presence of tributylhexadecylphosphonium bromide, deuteration slowly occurred at C-2, to afford the 2-deuterated derivative of **8**, but there was no evidence for formation of its 2-epimer. These results indicate that the protonation is thermodynamically controlled, and that the D-*altro* isomer is much more stable than the D-*allo* isomer.

The following conformational analysis led to the same conclusion. Assuming

that the 1,3-diaxial repulsion between the nitro and acetyl groups has the most destabilizing effect, the most stable conformation of **2** is I, and II for **5** (see Fig. 1); these are supported by the values of the coupling constants, ($J_{2,8}$ 3.5 Hz for **2** and $J_{2,8}$ 10.5 Hz for **5**). The stability of these rotamers (I and II) seems to be nearly equal, because 1,3-diaxial interaction between the acetyl group and H-4 for I is replaced by that between the nitro group and H-4 for II. It is reasonable that the sterically favored rotamer of the diacetylmethyl group in the D-*altro* and D-*allo* isomers would be that in which the α-proton of the 2,4-pentanedione residue (H-8) is oriented towards the sterically crowded ring, and the acetyl group points away from the ring. The coupling constant ($J_{2,8}$ 11 Hz) for the D-*altro* isomer supports assignment of this conformation. In this conformation, the D-*allo* isomer (III), having a considerable, nonbonded repulsion between the nitro and acetyl groups, must be less stable than the D-*altro* isomer (IV), having no such repulsion. Similar arguments may be applied in regard to the reactions of dimethyl and diethyl malonate.

As concerns the reversibility of the substituent on C-3, it is noteworthy that the reaction of **1** with dimethyl malonate in 1,4-dioxane in the presence of M sodium hydroxide for 15 min at 20° afforded the 2-nitrohex-1-enitol **11** in 56% yield (besides a small proportion of the D-*altro* isomer **9**. The structure of **11** was deduced by elemental analysis, and i.r. [1755, 1730 (CO), 1630 (C=C), and 1500 cm^{-1} (C=C-NO_2)] and n.m.r. data (alkenic proton at δ 7.71, $J_{3,4}$ 6.0 Hz). The configuration of C-3 was confirmed chemically; treatment of **11** with refluxing methanol for 3 h afforded **9** in high yield. Neither the D-*altro* nor the D-*gluco* isomer was the intermediate for the enitol **11**, because a similar reaction of the former (or the latter) resulted in degradation (or formation) of almost equal amounts of the D-*gluco* (**3**) and the *manno* isomer **6**, respectively. Compound **11**, therefore, would form the nitronate, *via* the D-*allo* isomer, or an S_N2' mechanism (see Scheme 1), or both. In any case, formation of **11** strongly suggested that the elimination of the anomeric methoxyl group is more facile



Scheme 1

than that of the substituent on C-3, and this conclusion also supports the concept that the nucleophilic-addition step is kinetically controlled.

EXPERIMENTAL

General methods. — All melting points were determined with a Yanagimoto micro melting-point apparatus and are uncorrected. Optical rotations were measured with a JASCO DIP-4 polarimeter. Solutions were evaporated under diminished pressure. Column chromatography was conducted on silica gel (C-300, Wakogel, Japan). T.l.c. was performed with Merck (Darmstadt) silica gel GF 254. The catalyst used refers to tributylhexadecylphosphonium bromide. I.r. spectra were recorded for potassium bromide discs, and n.m.r. spectra were recorded, for solutions in chloroform-*d*, with tetramethylsilane as the internal standard, with a JNM-PS-100 (JEOL) spectrometer.

Methyl 4,6-O-benzylidene-2,3-dideoxy-3-C-(diacetylmethyl)-2-C-nitro-α-D-glucopyranoside (**2**). — A mixture of[3] **1** (117 mg, 0.4 mmol), 2,4-pentanedione (67 mg, 0.67 mmol), acetonitrile (8 mL), and 0.1M sodium hydroxide (0.8 mL) was stirred for 1 h at 0°. After neutralization of the base with Dry Ice, the mixture was extracted with chloroform. The extracts were washed with water, dried (magnesium sulfate), and evaporated to a solid, which consisted of **2**, **5**, and **8** in the ratios of ~8 : 1 : 1, as judged from n.m.r. spectroscopy. Recrystallization from ethanol afforded 104 mg (66%) of **2**; m.p. 141–142.5°, $[\alpha]_D^{20}$ +61° (*c* 0.5, chloroform): ν_{max} 1720 (CO) and 1540 cm^{-1} (NO_2).

Anal. Calc. for $C_{19}H_{23}NO_8$: C, 58.01; H, 5.89; N, 3.56. Found: C, 58.09; H, 5.92; N, 3.48.

Methyl 4,6-O-benzylidene-2,3-dideoxy-3-C-(diacetylmethyl)-2-C-nitro-α-D-mannopyranoside (**5**). — To a solution of **1** (150 mg, 0.5 mmol) and 2,4-pentanedione (157 mg, 1.57 mmol) in benzene (20 mL) in the presence of the catalyst (25 mg) was added 0.1M sodium hydroxide (2 mL), and the mixture was stirred for 2 h at room temperature. The base was neutralized with 0.1M hydrochloric acid, the organic layer was separated, and the aqueous layer was extracted with benzene. The benzene layers were combined, washed with water, dried (magnesium sulfate), and evaporated. Recrystallization from benzene–hexane afforded two kinds of crystals; the first crop was 100 mg (50%) of **2**, and the second, 64 mg (32%) of **5**; m.p. 137–138.5°, $[\alpha]_D^{20}$ +145° (*c* 0.5, chloroform); ν_{max} 1735, 1700 (CO), and 1555 cm^{-1} (NO_2).

Anal. Calc. for $C_{19}H_{23}NO_8$: C, 58.01; H, 5.89; N, 3.56. Found: C, 58.05; H, 5.83; N, 3.52.

Methyl 4,6-O-benzylidene-2,3-dideoxy-3-C-(diacetylmethyl)-2-C-nitro-α-D-altropyranoside (**8**). — To a solution of **1** (30 mg, 0.1 mmol) and 2,4-pentanedione (20 mg, 0.2 mmol) in 1,4-dioxane (3 mL) was added 0.1M sodium hydroxide (0.2 mL), with stirring at room temperature. After being stirred for 30 min, the mixture was made neutral with 0.1M hydrochloric acid, and extracted with diethyl ether. The extracts were washed with water, dried (magnesium sulfate), and evaporated to a solid (29.4

mg, 73%) that was pure by n.m.r. spectroscopy. An analytical sample of **8** was prepared by recrystallization from ethanol; m.p. 142–144°, $[\alpha]_D^{20}$ −66° (*c* 1, chloroform); ν_{max} 1736, 1708 (CO), and 1544 cm^{-1} (NO_2).

Anal. Calc. for $C_{19}H_{23}NO_8$: C, 58.01; H, 5.89; N, 3.56. Found: C, 58.08; H, 5.90; N, 3.46.

Methyl 4,6-O-benzylidene-2,3-dideoxy-3-C-bis[(methoxycarbonyl)methyl]-2-C-nitro-α-D-glucopyranoside (**3**). — (*a*) To a solution of **1** (200 mg, 0.68 mmol) and dimethyl malonate (132 mg, 1.02 mmol) in dimethyl sulfoxide (10 mL) was added triethylamine (100 mg, 1.02 mmol) at room temperature, and the mixture was stirred for 15 min. Processing as for the preparation of **8** afforded a solid (193.8 mg, 67%) that was pure by n.m.r. spectroscopy. Recrystallization from 2-propanol gave 156.2 mg (54%) of **3**: m.p. 146–147°, $[\alpha]_D^{20}$ +59° (*c* 0.5, chloroform); ν_{max} 1765, 1743 (CO) and 1555 cm^{-1} (NO_2).

Anal. Calc. for $C_{19}H_{23}NO_{10}$: C, 53.64; H, 5.45; N, 3.29. Found: C, 53.57; H, 5.33; N, 3.21.

(*b*) To a solution of **1** (100 mg, 0.34 mmol) and dimethyl malonate (65.9 mg, 0.51 mmol) in dimethyl sulfoxide (10 mL) was added 0.1M sodium hydroxide (0.6 mL) at room temperature. After stirring for 10 min, processing as described for **8** gave a syrup (115.4 mg, 80%) whose n.m.r. spectrum showed the presence of **3** and **6** in the ratio of 7:2.

(*c*) A mixture of **1** (500 mg, 1.7 mmol), dimethyl malonate (329.5 mg, 2.55 mmol), the catalyst (37.5 mg), benzene (50 mL), and M sodium hydroxide (3.3 mL) was stirred for 20 h at room temperature. Processing as for the preparation of **5** afforded 518.2 mg of a syrup (73%) consisting of **3** and **6** in the ratio of 1:1, as judged from n.m.r. spectroscopy. Crystallization from ethanol afforded **3** (212.9 mg, 30%) as the first crop. Fractional recrystallization or chromatographic separation failed to achieve isolation of pure **6**.

Methyl 4,6-O-benzylidene-2,3-dideoxy-3-C-bis[(methoxycarbonyl)methyl]-2-C-nitro-α-D-altropyranoside (**9**). — (*a*) *From the nitro alkene* **1**. To a solution of **1** (30 mg, 0.1 mmol) and dimethyl malonate (19.8 mg, 0.15 mmol) in 1,4-dioxane (3 mL) was added 0.1M sodium hydroxide (0.2 mL) at room temperature. After stirring for 20 h, processing as described for the preparation of **8** afforded a solid (33.5 mg, 77%) that was pure as judged by n.m.r. spectroscopy. Recrystallization from ethanol gave 30.1 mg (69%) of **9**; m.p. 176–178°, $[\alpha]_D^{20}$ +19° (*c* 0.4, chloroform); ν_{max} 1757, 1730 (CO), and 1550 cm^{-1} (NO_2).

Anal. Calc. for $C_{19}H_{23}NO_{10}$: C, 53.64; H, 5.45; N, 3.29. Found: C, 53.85; H, 5.48; N, 3.32.

(*b*) *From the l-enitol* **11**. A solution of **11** (9.5 mg, 24 μmol) in methanol (1.3 mL) was boiled under reflux for 3 h, and then evaporated, to give a solid (9.3 mg, 91%), the n.m.r. spectrum of which was identical with that of an authentic sample of **9**.

1,5-Anhydro-4,6-O-benzylidene-2,3-dideoxy-3-C-bis[(methoxycarbonyl)methyl]-2-C-nitro-D-ribo-hex-1-enitol (**11**). — To a solution of **1** (200 mg, 0.68 mmol) and dimethyl malonate (132 mg, 1.02 mmol) in 1,4-dioxane (20 mL) was added M sodium

hydroxide (1.3 mL), with stirring, at 22°. The mixture was stirred for 15 min, made neutral with 0.1M hydrochloric acid, and then extracted with dichloromethane. The extracts were washed with water, dried (magnesium sulfate), and evaporated to a syrup (202.3 mg, 75%) whose n.m.r. spectrum showed that it was composed of **11** and **9** in the ratio of 5:1. Crystallization from ethanol gave 151.1 mg (56%) of **11** as the first crop; m.p. 172–174°, $[\alpha]_D^{20}$ +104° (*c* 1, chloroform); ν_{max} 1755, 1730 (CO), 1630 (C=C), and 1500 cm^{-1} (C=C-NO_2).

Anal. Calc. for $C_{18}H_{19}NO_9$: C, 54.96; H, 4.86; N, 3.56. Found: C, 54.56; H, 4.89; N, 3.35.

When the same reaction was conducted at 15°, the altropyranoside **9** became the major product, and the 1-enitol **11** was scarcely detectable by n.m.r. spectroscopy.

*Methyl 4,6-O-benzylidene-2,3-dideoxy-3-C-bis[(ethoxycarbonyl)methyl]-2-C-nitro-α-*D*-glucopyranoside* (**4**). — To a solution of **1** (200 mg, 0.68 mmol) and diethyl malonate (160 mg, 1.01 mmol) in dimethyl sulfoxide (10 mL) was added triethylamine (133 mg, 1.01 mmol), and the mixture was stirred for 15 min at room temperature. Processing as described for the preparation of **8** gave a syrup (194.4 mg, 63%) that was pure **4** by n.m.r. spectroscopy. Crystallization from 2-propanol gave 126.5 mg (41%) of **4**; m.p. 82–83°, $[\alpha]_D^{20}$ +100° (*c* 0.5, chloroform); ν_{max} 1750, 1730 (CO), and 1560 cm^{-1} (NO_2).

Anal. Calc. for $C_{21}H_{27}NO_{10}$: C, 55.62; H, 6.00; N, 3.09. Found: C, 55.67; H, 5.98; N, 2.99.

*Methyl 4,6-O-benzylidene-2,3-dideoxy-3-C-bis[(ethoxycarbonyl)methyl]-2-C-nitro-α-*D*-mannopyranoside* (**7**). — (*a*) A mixture of **1** (500 mg, 1.70 mmol), diethyl malonate (400 mg, 2.55 mmol), the catalyst (37.5 mg), benzene (50 mL), and 0.1M sodium hydroxide (3.3 mL) was stirred for 4 h at room temperature. Processing as for the preparation of **5** afforded a mixture (618.6 mg, 80%) of **4** and **7** in the ratio of 2:1, as judged from n.m.r. spectroscopy. Recrystallization from ethanol gave **4** as the first crop. Repeated, fractional recrystallization from ethanol yielded pure **7** (16.5 mg, 2.1%); m.p. 104–105°, $[\alpha]_D^{20}$ −1.1° (*c* 1, chloroform); ν_{max} 1728, 1740 (CO), and 1560 cm^{-1} (NO_2).

Anal. Calc. for $C_{21}H_{27}NO_{10}$: C, 55.62; H, 6.00; N, 3.09. Found: C, 55.58; H, 5.90; N, 3.09.

(*b*) To a solution of **1** (30 mg, 0.1 mmol) and diethyl malonate (24 mg, 0.15 mmol) in dimethyl sulfoxide (1.5 mL) was added 0.1M sodium hydroxide (0.2 mL). After stirring for 10 min at room temperature, processing as for the preparation of **8** afforded a syrup (41.4 mg, 89%) whose n.m.r. spectrum showed the presence of **4** and **7** in the ratio of 3.1:1.

*Methyl 4,6-O-benzylidene-2,3-dideoxy-3-C-bis[(ethoxycarbonyl)methyl]-2-C-nitro-α-*D*-altropyranoside* (**10**). — (*a*) To a solution of **1** (200 mg, 0.68 mmol) and diethyl malonate (160 mg, 1.01 mmol) in 1,4-dioxane (20 mL) was added M sodium hydroxide (1.3 mL) at room temperature. After stirring for 15 min at room temperature, processing as described for the preparation of **11** afforded a syrup (217.2 mg,

70%). Recrystallization from ethanol afforded 99.3 mg (32%) of **10**; m.p. 124–125°, $[\alpha]_D^{20}$ +38° (*c* 0.5, chloroform); ν_{max} 1757, 1722 (CO), and 1557 cm^{-1} (NO_2).

Anal. Calc. for $C_{21}H_{27}NO_{10}$: C, 55.62; H, 6.00; N, 3.09. Found: C, 55.60; H, 5.99; N, 3.02.

(*b*) To a solution of **1** (30 mg, 0.1 mmol) and diethyl malonate (24 mg, 0.15 mmol) in 1,4-dioxane (3 mL) was added 0.1M sodium hydroxide (0.2 mL) at room temperature. The mixture was stirred for 20 h at room temperature, and then processed as for the synthesis of **8** affording 35.2 mg (76%) of a syrup that was pure **10** as judged from n.m.r. spectroscopy.

REFERENCES

1 T. SAKAKIBARA, A. SETA, Y. TACHIMORI, AND R. SUDOH, *Bull. Chem. Soc. Jpn.*, 53 (1980) 2322–2326.
2 See, for example, L. M. JACKMAN AND S. STERNHELL, *Application of Nuclear Magnetic Resonance Spectroscopy in Organic Chemistry*, 2nd edn., Pergamon Press, Oxford, 1969, Chapter 4–2.
3 Y. TACHIMORI, T. SAKAKIBARA, AND R. SUDOH, *Carbohydr. Res.*, 82 (1980) 51–58.