Synthesis of 3,4,6-Tri-*O*-acetyl-2-oximino-α-D-hexopyranosides[1]

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Received August 9, 1967

The reaction of the dimeric nitrosyl chloride adducts of tri-*O*-acetyl-D-glucal and tri-*O*-acetyl-D-galactal with alcohols and phenols in dimethylformamide at room temperature provides the corresponding tri-*O*-acetyl-2-oximino-α-D-hexopyranosides in good to excellent yields. The condensation can also be carried out in tetrahydrofuran in the presence of pyridine or simply in refluxing methylene chloride for the simple alkyl alcohols. The stereospecificity of the reaction is extreme; only products of one configuration for both glycosidic linkage and the oximino group were detected. This result is rationalized on the basis of a *cis*-configuration for a tri-*O*-acetyl-2-nitroso-D-glycal intermediate in the H1 half-chair conformation. The introduction of methyl groups on the carbon of the methoxy group of methyl α-D-glucopyranosides causes a progressive deshielding of the anomeric proton. The data indicate that isopropyl α-D-glycopyranosides avoid the orientation for the aglycon which has the anomeric hydrogen projecting between the two methyl groups of the aglycon. Methyl tri-*O*-acetyl-6-*O*-(tri-*O*-acetyl-2-oximino-α-D-*arabino*-hexopyranosyl)-β-D-glucopyranoside was prepared in 70% yield to illustrate the use of the method for the preparation of an α-linked disaccharide.

Canadian Journal of Chemistry, 46, 405 (1968)

The presence of the α-linkage between a variety of 2-amino-2-deoxysugar residues and the aglycon in several antibiotics has rendered important the development of reliable methods for the synthesis of 2-amino-2-deoxy-α-glycopyranosides. Although the 2-amino group in most of these antibiotics (1), e.g. streptomycin, kanamycin B, neomycins, and paromomycins, is in equatorial orientation, in at least one case, e.g. kasugamycin (2), the group is oriented axially. The purpose of this communication is to report a general synthesis of 2-oximino-α-glucopyranosides which can serve, through reduction, as precursors of the corresponding 2-amino-2-deoxy-α-glucopyranosides (3). Also, through hydrolysis followed by reduction the oximes can serve as precursors of α-D-glucopyranosides (4). The preparations of the α-oximinoglycosides are highly stereospecific and the yields are good even with highly hindered alcohols. Preliminary reports of this work were published (5, 6).

As previously shown (5), reaction of tri-*O*-acetyl-D-glucal with nitrosyl chloride yields tri-*O*-acetyl-2-deoxy-2-nitroso-α-D-glucopyranosyl chloride (**1**) as a dimer in over 90% yield. Compound **1** is extremely prone to dehydrochlorination. This is demonstrated by the fact that addition of triethylamine to the compound dissolved in tetrahydrofuran at −15° results in the immediate precipitation of triethylamine hydrochloride and the formation of an intensely blue solution. The product isolated was an amorphous colorless substance which was not characterized. The colored intermediate in this reaction is considered to be 2-nitroso-D-glucal triacetate (**2**). The postulation of this compound as an intermediate in the reaction provides a basis for the rationalization of the retention of configuration obtained in the overall reaction. Indeed, recently, Collin and Pritzkow (7, 8) have shown several dimeric nitroso–chloro adducts of olefins to undergo nucleophilic substitution by way of highly reactive conjugated nitroso-olefins to give α-substituted oximes. It was expected then, that the intermediate **2** would be strongly electrophilic especially in view of its enolic ether structure and readily undergo reaction with a wide variety of nucleophiles. This has proven to be the case.

Initially, it was thought necessary to perform the condensation of the nitrosyl chloride adduct (**1**) with an alcohol in the presence of a base to carry out the dehydrochlorination reaction and release the acetylated 2-nitroso-D-glucal (**2**). Indeed, using 4 moles of alcohol per mole of the dimer (**1**) and 4 mole equivalents of pyridine

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[1]Presented in part by T. L. Nagabhushan in partial fulfillment of the requirements for the Ph.D. degree, 1966. Presented in part at the 150th Meeting of the American Chemical Society, Atlantic City, N.J., September 13–17, 1965. Abstract of Papers, p. 21D.

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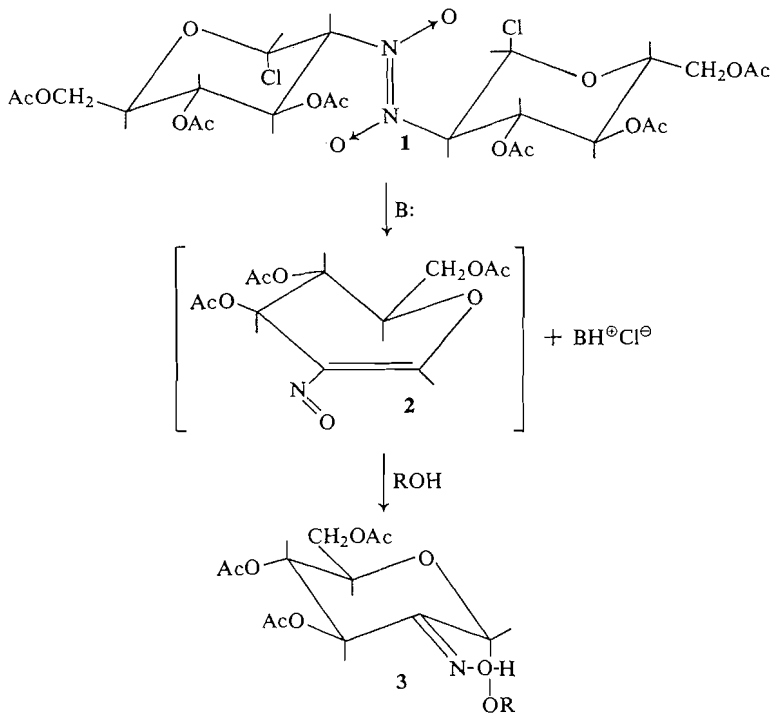


in tetrahydrofuran, excellent yields (over 80%) of the oximino-α-D-hexopyranoside (**3**) were obtained (see Table I). In the absence of the alcohol, acetylated pyridinium oximinoglycoside was the product of the reaction. The compound was highly unstable and could not be purified. It was subsequently found that the nitrosyl chloride adduct (**1**) underwent dehydrochlorination with sufficient ease that a base, such as pyridine, was not required in the reaction medium. Thus, for example, the variety of alkyl tri-*O*-acetyl-2-oximino-α-D-*arabino*-hexopyranosides (see Table I) were prepared in excellent yield simply by refluxing for a few hours a solution of the nitrosyl chloride adduct (**1**) in methylene chloride containing about 1.2 mole equivalents of the alkyl alcohol. The products of these reactions were the same as those obtained in the presence of the pyridine. It was found that the glycosidation reaction proceeded well at room temperature using dimethylformamide as solvent. This fact renders this reaction useful for the α-glycosidation of virtually any alcohol. To illustrate this fact, the preparation of methyl tri-*O*-acetyl-6-*O*-(3,4,6-tri-*O*-acetyl-2-oximino-α-D-*arabino*-hexopyranosyl)-β-D-glucopyranoside in 70% yield is reported herein. This and other similar condensations did not proceed in acceptable yields by simply refluxing a solution of the reactants in methylene chloride. The

TABLE I

3,4,6-Tri-*O*-acetyl-2-oximinohexopyranosides

Aglycon	Method*	Yield, %	Melting point, °C	$[\alpha]_D^{25}$ (chloroform)
α-D-*Arabino*				
Methyl	A	81†	145–146	+48°
	B	88		
Ethyl	B	75†	154–157	+72
n-Propyl	B	75†	61.5–62	+74
n-Butyl	B	80‡	—	+61
Isobutyl	B	83‡	—	+63
Isopropyl	A	85†	94–96	+79
	B	89†	94–96	+79
	C	80†	94–96	+79
t-Butyl	B	80‡	—	+77
Phenyl	C	67†	165–167	+94
α-Naphthyl	C	42†	155–158	+131
Acetyl	—	31†	138–139	+44
α-D-*Lyxo*				
n-Propyl	A	—‡	—	+51
Isopropyl	A	—‡	—	+66

*See Experimental section.
†After purification by recrystallization.
‡Crude syrupy product.

TABLE II

Nuclear magnetic resonance parameters for alkyl, aryl, and acetyl 3,4,6-tri-*O*-acetyl-2-oximino-α-D-*arabino*-hexopyranosides[1]

Aglycon	Chemical shifts, τ values			
	H-1	H-3	H-4	OH
Deuteriochloroform as solvent				
Methyl	4.08	4.18	4.79	—
Ethyl	3.95	4.14	4.78	—
n-Propyl	3.97	4.15	4.81	—
n-Butyl	3.99	4.16	4.82	—
Isobutyl	4.01	4.17	4.81	—
Isopropyl	3.86	4.13	4.81	—
Isopropyl, *O*-acetyl	3.93	4.08	4.71	—
trans-4-*t*-Butylcyclohexyl	3.83	4.13	4.82	—
t-Butyl	3.65	4.11	4.83	—
Phenyl	3.50	4.06	4.87	—
α-Naphthyl	3.32	4.04	4.81	—
Acetyl	2.71	4.18	4.75	—
Perdeuteriodimethyl sulfoxide as solvent				
Methyl	4.18	4.43	4.96	−1.75
Ethyl	4.12	4.45	5.02	—
n-Propyl	4.13	4.46	5.02	—
n-Butyl	4.10	4.45	4.98	−1.68
Isobutyl	4.12	4.44	4.98	−1.68
Isopropyl	4.01	4.47	5.02	—
trans-4-*t*-Butylcyclohexyl	4.00	4.50	5.04	—
t-Butyl	3.78	4.43	5.01	−1.52

[1]The spacings arising from $J_{3,4}$ and $J_{4,5}$ were 9.5 c.p.s. in deuteriochloroform and 10.0 c.p.s. in perdeuteriodimethyl sulfoxide.

phenyl and α-naphthyl oximinoglycosides were obtained readily using dimethylformamide as solvent. Inspection of the nuclear magnetic resonance (n.m.r.) and optical rotational data in Tables I and II indicates that the reaction products are configurationally and conformationally related. The values of the coupling constants $J_{3,4}$ and $J_{4,5}$, reported in Table II require the compounds to exist in solution in the C1 conformation. That these compounds were in fact oximes was established by the presence of a signal at τ 0.28–0.75 in deuteriochloroform which was attributable to oximino-hydroxyl and which disappeared on exchange with deuterium oxide. Further evidence for the oximino group in the title compounds was provided by the infrared absorption for the hydroxyl group at 3450 cm^{-1} and the preparation of isopropyl tetra-*O*-acetyl-2-oximino-α-D-*arabino*-hexopyranoside with n.m.r. parameters similar to the parent triacetate. The α-configurations for the *O*-acetyl-oximinoglucosides were in several cases established by reduction to known 2-amino-2-deoxy-α-D-glucopyranosides (3). In the cases of the isopropyl and phenyl oximinoglucosides, each compound was converted to the known α-D-glucopyranoside tetraacetate by hydrolysis of the oxime followed by borohydride reduction and reacetylation (4).

Reaction of the nitrosyl chloride adduct **1** with sodium acetate in acetic acid gave crystalline 1,3,4,6-tetra-*O*-acetyl-2-oximino-α-D-*arabino*-hexopyranose. The α-configuration was established by reduction with zinc–copper couple in glacial acetic acid followed by *N*-acetylation to the known 2-acetamido-tetra-*O*-acetyl-2-deoxy-α-D-glucopyranose (5).

Table I reports the syrupy products obtained on reaction of dimeric tri-*O*-acetyl-2-deoxy-2-nitroso-α-D-galactopyranosyl chloride with *n*-propyl and isopropyl alcohol. The n.m.r. spectra of these products left no doubt as to their virtual purity and structure. The α-D-anomeric configurations are assigned on the basis of the rotational and n.m.r. data.

The yields given in Table I relate in most cases to the amount of material obtained in pure form after crystallization of the crude product. In these instances, the n.m.r. spectrum of the purified substance was virtually identical to that of the initially isolated syrupy product. It was evident, therefore, that the reactions proceeded in near quantitative yield and that the reaction was of extreme stereospecificity. Collins (9) has shown that the oximation of ketoglycosides normally provides mixtures of the expected *syn* and *anti* forms. Efforts are at present underway to determine the configuration of β-chloroethyl tri-*O*-acetyl-2-oximino-α-D-*arabino*-hexopyranoside by *x*-ray crystallography.

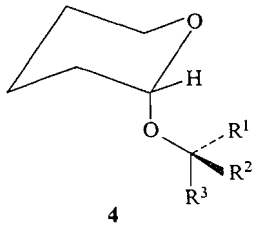
Nuclear magnetic resonance parameters for a number of oximinoglycosides using both deuteriochloroform and perdeuterated dimethylsulfoxide as solvents are presented in Table II. The data indicate that all the oximes have the same configuration since the range in chemical shifts for the anomeric protons is less than would be expected if these occurred as *syn* and *anti* forms (9). In this regard, it is to be noted that the trend observed for the chemical shift of the anomeric proton on changing the aglycon from methyl to ethyl to isopropyl to *t*-butyl is the same as that for the corresponding alkyl α-D-glucopyranosides listed in Table III and consequently is not related to the presence of the oximino group. Also, the chemical shift for H-1

TABLE III

Nuclear magnetic resonance parameters for the anomeric proton of alkyl α-D-glucopyranosides in deuterium oxide

Aglycon	Chemical shifts, τ values	Spacing, c.p.s.
Methyl	5.13	3.0
Ethyl	5.08	3.0
Isopropyl	4.95	3.0
t-Butyl	4.78	3.5

of *t*-butyl 2-deoxy-α-D-glucopyranoside is 0.46 τ-values to lower field than that of H-1 for the corresponding methyl glycoside (10). The magnitudes of the shifts for H-1 as methyl groups are introduced into the aglycon of the methyl oximinoglycoside suggest that the aglycons are oriented as shown in **4** with the anomeric hydrogen (H-1) projecting between the R^1 and R^2 substituents. On this basis, the chemical shift difference of H-1 for the methyl and *t*-butyl glycosides using deuteriochloroform as solvent indicates a deshielding effect amounting to 0.22 τ-values per methyl group. It would follow, for the isopropyl group, that the conformation where both R^1 and R^2 are methyl groups is of very low abundance. Indeed, a consideration of molecular models indicates a strong interaction between R^1 and R^2 and the anomeric proton which is to be expected in view of the relatively short C—O bonds. The chemical shift of H-1 for the isopropyl glycoside would then require an about equal abundance of the two conformations with a methyl group at the position of R^3. These considerations are of obvious interest relative to the orientation of the aglycons in α-glucopyranosides.



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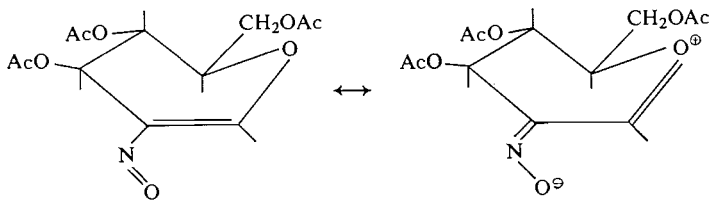
The precise mechanism of the nucleophilic attack of the alcohol at the anomeric center of the tri-*O*-acetyl-2-nitroso-D-glucal (**2**) was not determined. Nevertheless, the high degree of stereospecificity of the glycosidation reaction can readily be appreciated since carbon-2 must retain a trigonal configuration throughout the course of the reaction and the compound must be expected to undergo reaction in the H1 half-chair conformation shown. This latter expectation follows from the fact that the triacetates of 2-acetoxy and 2-chloro-D-glucal exist in H1 conformations (11) and the non-bonded interaction between the 3-acetoxy group and the 2-substituent in these compounds [$A^{(1,3)}$ effect (12, 13)] can be expected to be at least as great as that between the nitroso group and the 3-acetoxy group in **2** if, indeed, the nitrosoolefinic system is in the *cis*-configuration as shown. *p*-Iodonitrosobenzene exists as a planar molecule in the monomeric form presumably because of conjugation (14). Therefore, the nitroso group of a 2-nitrosoglycal must be conjugated with vinylic ether system as indicated by the extreme canonical partial structures **5** and **6**. A powerful $A^{(1,3)}$ interaction between the nitroso group and the 3-acetoxy group would be expected should the nitrosoglucal possess a *trans* arrangement of the nitrosoolefinic system (as in **7**) since in the structurally closely related tri-*O*-acetyl-2-nitro-D-glucal (**9**) this interaction is sufficiently strong to require the 1H half-chair conformation (**10**) for this compound (11). Because of this conformation, this nitroglucal undergoes nucleophilic attack at the anomeric center primarily by way of axial approach from the β-side of the pyranoid ring (15). Therefore, if the nitrosoglucal possessed the *trans* configuration, it would, in all likelihood, exist in the 1H conformation (**8**) and also provide β-glucoside on nucleophilic attack. However, the reaction is, in fact, highly preferential for the formation of α-glucoside. The inference then is clear that the nitrosoglucal exists in the *cis* configuration and in the H1 conformation as shown in **2** and **5**. The preference of the compound for axial nucleophilic attack at the anomeric center is then readily appreciated on both steric and electronic grounds regardless of whether or not nucleophilic attack precedes or follows protonation of the nitroso group or, indeed, whether or not these are synchronous (bi- or trimolecular) or not. By making an axial attack, the alcohol both provides maximum orbital overlap in the transition state and avoids a strong destabilizing nonbonded interaction with the developing oximino group. In all likelihood, therefore, the oximes prepared in this research have the configuration wherein the hydroxyl group points in the direction of the anomeric center as shown in **3**. Fur-



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thermore, this isomer must be considerably more stable than the other possible geometrical isomer which was never detected in the reaction products. In this regard, prolonged heating in methanol did not give rise to a second oxime as detectable by n.m.r. spectroscopy.

Experimental

Unless otherwise stated, optical rotations were measured in 1 dm tubes using a Perkin–Elmer 141 automatic polarimeter. The nuclear magnetic resonance (n.m.r.) spectra were determined using Varian A60 and HA100 spectrometers, and the solvents are mentioned where pertinent. Melting points were determined on a microstage and are uncorrected.

Dimeric 3,4,6-tri-*O*-acetyl-2-deoxy-2-nitroso-α-D-glucopyranosyl chloride (**1**), m.p. 129–130° (decomp.), $[\alpha]_D^{23}$ +149° (*c*, 2.2 in chloroform) and dimeric 3,4,6-tri-*O*-acetyl-2-deoxy-2-nitroso-α-D-galactopyranosyl chloride, m.p. 128–131°, $[\alpha]_D^{23}$ +128° (*c*, 2.2 in chloroform) were prepared as described previously (5).

Methyl 3,4,6-Tri-O-acetyl-2-oximino-α-D-arabino-hexopyranoside (Method A)

Dry pyridine (0.316 g, 4 mmoles) was added with stirring to a solution of dimeric 3,4,6-tri-*O*-acetyl-2-deoxy-2-nitroso-α-D-glucopyranosyl chloride (0.675 g, 1 mmole) in anhydrous tetrahydrofuran (15 ml) containing anhydrous methanol (0.128 g, 4 mmoles). The resultant mixture was heated under reflux for 1.5 h with the exclusion of moisture and then taken to dryness *in vacuo*. The resultant syrup was taken up in chloroform (200 ml) and washed with water. The chloroform solution was dried over anhydrous sodium sulfate and the solvent was removed *in vacuo* to yield a syrup. Crystallization from ether–hexane gave material (0.54 g) with m.p. 145–146°, $[\alpha]_D^{24}$ +48° (*c*, 1.24 in chloroform) in 81% yield.

Anal. Calcd. for $C_{13}H_{19}O_9N$: C, 46.85; H, 5.75; N, 4.20. Found: C, 46.82; H, 5.46; N, 3.84.

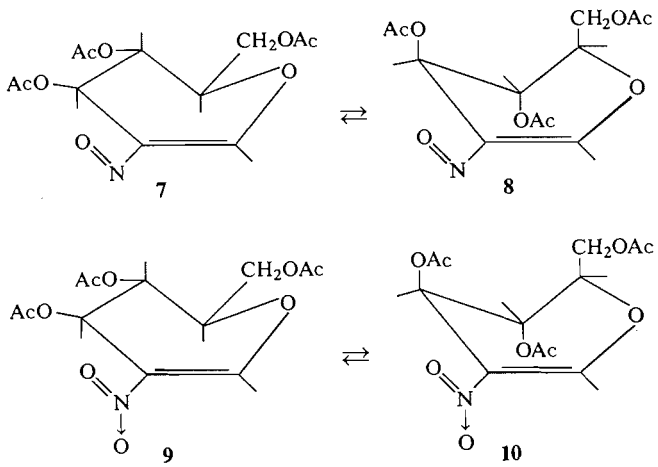
The n.m.r. spectrum of the crude syrup was essentially the same as that for the crystalline product (see Table II).

N-(3,4,6-Tri-O-acetyl-2-oximino-D-arabino- hexopyranosyl) pyridinium Chloride

To a solution of dimeric 3,4,6-tri-*O*-acetyl-2-deoxy-2-nitroso-α-D-glucopyranosyl chloride (**1**, 0.675 g) in dry tetrahydrofuran (3 ml) was added dry benzene until it appeared that further addition of benzene to the solution would cause turbidity. Anhydrous pyridine (0.16 g) was then introduced into the mixture with swirling of the flask and then the mixture was set aside at room temperature. Soon the solution turned turbid and the mixture was shaken for 5 h. The precipitated white crystalline mass was filtered, washed with benzene, and dried in a high vacuum. The yield of the compound, m.p. 82–84°, $[\alpha]_D^{23}$ +54° (*c*, 0.5 in water) was 0.7 g (84%). The n.m.r. spectrum was in general agreement with the assigned structure. Attempts to purify the substance by recrystallization led to extensive decomposition.

Isopropyl 3,4,6-Tri-O-acetyl-2-oximino-α-D-arabino-hexopyranoside (Method B)

Tri-*O*-acetyl-2-deoxy-2-nitroso-α-D-glucopyranosyl



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chloride dimer (**1**) (3.37 g, 5 mmoles) was added to a solution of dry isopropyl alcohol (0.72 g, 12 mmoles) in anhydrous methylene chloride (5 ml) contained in a 10 ml flask. The resultant solution was heated under very gentle reflux for 3–4 h with the exclusion of moisture, cooled, and after dilution with methylene chloride (100 ml), was passed through a small pad of neutral alumina (2 g). The pale-green solution was taken to dryness *in vacuo* to yield a syrup in near quantitative yield. Crystallization from dry isopropyl alcohol (20 ml) afforded the purified material (yields varying from 80 to 89% in a large number of experiments) with m.p. 85–87°. This could be raised to 94–96° on successive recrystallizations from the same solvent; $[\alpha]_D^{25}$ +79° (*c*, 3 in chloroform).

Anal. Calcd. for $C_{15}H_{23}O_9N$: C, 49.86; H, 6.42; N, 3.88. Found: C, 50.63; H, 6.91; N, 3.87.

The n.m.r. spectrum (see Table II) of the compound was in accord with the assigned structure.

This material could also be prepared in comparable yield using the conditions described for the preparation of the corresponding methyl oximino glycoside (Method A). Reaction of 1.35 g of **1** with 0.3 g of isopropyl alcohol in 4 ml of dimethylformamide (Method C) for 76 h at room temperature followed by isolation of the product in the usual manner (see below), gave, after recrystallization, 1.15 g (80% yield) of this compound.

Isopropyl Tetra-O-acetyl-2-oximino-α-D-arabino-hexopyranoside

Isopropyl 3,4,6-tri-*O*-acetyl-2-oximino-α-D-*arabino*-hexopyranoside (1.0 g) was dissolved in dry acetic anhydride (10 ml) containing fused sodium acetate (1 g) and heated at 50° for 20 h. Workup in the usual manner yielded a syrup in near quantitative yield which crystallized *in vacuo*. Recrystallization from ethanol–water yielded the fully acetylated oximinoglycoside as plates, m.p. 83.5–84.5°, $[\alpha]_D^{25}$ +76° (*c*, 3.2 in chloroform). The n.m.r. spectrum of the compound in deuteriochloroform showed the presence of four acetyl groups per isopropyl moiety and the pertinent data are given in Table II.

Anal. Calcd. for $C_{17}H_{25}O_{10}N$: C, 50.61; H, 6.25; N, 3.47. Found: C, 50.98; H, 6.33; N, 3.44.

n-Propyl 3,4,6-Tri-O-acetyl-2-oximino-α-D-arabino-hexopyranoside

Method B was employed. The pale-green syrup which was obtained in near quantitative yield gave an n.m.r. spectrum identical with that of the material after crystallization from *n*-propanol – *n*-hexane in 75% yield with m.p. 61.5–62°, $[\alpha]_D^{25}$ +74° (*c*, 0.8 in chloroform).

Anal. Calcd. for $C_{15}H_{23}O_9N$: C, 49.86; H, 6.42; N, 3.88. Found: C, 49.81; H, 6.36; N, 3.85.

Ethyl 3,4,6-Tri-O-acetyl-2-oximino-α-D-arabino-hexopyranoside

This compound was obtained as a pale-green syrup in near quantitative yield using Method B. Crystallization from methylene chloride – petroleum ether gave small needles in 75% yield, m.p. 154–157°, $[\alpha]_D$ +72° (*c*, 0.8 in chloroform). Nuclear magnetic resonance data are given in Table II.

Anal. Calcd. for $C_{14}H_{21}O_9N$: C, 48.41; H, 6.09; N, 4.03. Found: C, 48.61; H, 6.11; N, 4.15.

4-t-Butylcyclohexyl 3,4,6-Tri-O-acetyl-2-oximino-α-D-arabino-hexopyranoside

This compound was prepared as described previously (Method B) using commercial *trans*-4-*t*-butylcyclohexanol except that a reaction time of 18 h was necessary. The resultant pale-green syrup was taken up in carbon tetrachloride (25 ml) and *n*-hexane was added to turbidity. After standing at 0° for 12 h the precipitated material was filtered to yield an amorphous solid in 38% yield, $[\alpha]_D^{25}$ +74° (*c*, 0.59 in chloroform). Attempts at crystallization were unsuccessful. Nuclear magnetic resonance data are given in Table II.

Anal. Calcd. for $C_{22}H_{35}O_9N$: C, 57.75; H, 7.71; N, 3.06; Found: C, 57.82; H, 7.43; N, 3.22.

n-Butyl, Isobutyl and t-Butyl 3,4,6-Tri-O-acetyl-2-oximino-α-D-arabino-hexopyranosides

These compounds were obtained using Method B as syrups which could not be induced to crystallize. The physical constants are reported in Tables I and II. The n.m.r. spectra required in each case a high degree of purity.

Phenyl 3,4,6-Tri-O-acetyl-2-oximino-α-D-arabino-hexopyranoside (Method C)

Dimeric 3,4,6-tri-*O*-acetyl-2-deoxy-2-nitroso-α-D-glucopyranosyl chloride (3.375 g, 5 mmoles) and phenol (1.50 g, 15 mmoles) were dissolved in dry dimethylformamide (10 ml) and kept for 66 h at room temperature. The resultant light-brown solution was diluted with methylene chloride (100 ml) and washed with 0.01 *N* sodium hydroxide (5 × 25 ml). The organic layer was dried and yielded a yellow syrup which crystallized on standing. Recrystallization from aqueous ethanol gave 2.65 g (67% yield), m.p. 165–167°, $[\alpha]_D^{25}$ +94° (*c*, 2.0 in chloroform).

Anal. Calcd. for $C_{18}H_{21}O_9N$: C, 54.68; H, 5.35; N, 3.54. Found: C, 54.57; H, 5.20; N, 3.57.

Nuclear magnetic resonance data are presented in Table II.

A somewhat lower yield (51%) was obtained when the reaction was carried out at 35° for 18 h.

α-Naphthyl 3,4,6-Tri-O-acetyl-2-oximino-α-D-arabino-hexopyranoside

Dimeric 3,4,6-tri-*O*-acetyl-2-deoxy-2-nitroso-α-D-glucopyranosyl chloride (2.03 g, 3 mmole) and α-napthol (1.3 g, 9 mmoles) were dissolved in dry dimethylformamide (10 ml) and the procedure described for the preparation of the corresponding phenyl oximinoglycoside was followed. The crude brown syrup was then taken up in aqueous ethanol and afforded shiny plates; 1.2 g (42% yield), m.p. 155–158°, $[\alpha]_D^{25}$ +131° (*c*, 2 in chloroform).

Anal. Calcd. for $C_{24}H_{23}O_9N$: C, 61.40; H, 4.94; N, 2.98. Found: C, 60.35; H, 5.08; N, 2.72.

Nuclear magnetic resonance data are presented in Table II.

Methyl 2,3,4-Tri-O-acetyl-6-O-(3,4,6-tri-O-acetyl-2-oximino-α-D-arabino-hexopyranosyl)-β-D-glucoside (Method C)

Methyl 2,3,4-tri-*O*-acetyl-β-D-glucopyranoside was prepared by standard procedures and had physical constants identical to those reported in the literature (16).

The compound (2.56 g, 8 mmoles), m.p. 134–137°, $[\alpha]_D^{25}$ −10.9° (*c*, 1.12 in $CHCl_3$), and dimeric 3,4,6-tri-*O*-acetyl-2-deoxy-2-nitroso-α-D-glucopyranosyl chloride (2.70 g, 4 mmoles) were placed in a 25 ml flask and dry dimethylformamide (8 ml) was added. The flask was flushed with a stream of dry nitrogen, stoppered with a serum cap, and kept at 40° for 24 h. The resultant light-brown solution was diluted with methylene chloride (120 ml) and repeatedly washed with water (6 × 25 ml) until the aqueous layer was near colorless. The organic layer was dried over anhydrous sodium sulfate and then taken to dryness *in vacuo* at 40° to yield a yellow foam (5.12 g), $[\alpha]_D^{25}$ +23° (*c*, 0.77 in chloroform). The n.m.r. spectrum of the crude product in deuteriochloroform was similar to those of the acetylated alkyl oximinoglycosides in that a sharp singlet attributable to H-1, was present at τ 3.99. The expected H-3′ doublet was noted at τ 4.23 with a spacing of 9.5 c.p.s. The signal due to the oximino proton (τ ~ 1) disappeared on exchange with deuterium oxide. The H-4′, triplet could not be seen due to overlapping of the other signals. A comparison of the integrated H-1′, H-3′ signals and the acetoxy and methoxy signals showed that the α-oximino disaccharide had formed to an extent of 70% in the condensation reaction.

The same yield of crude product could also be obtained if the reaction was carried out in dry dimethylformamide at room temperature for 96 h. However, no isolable product was obtained when the reaction was carried out for 24 h in methylene chloride as previously described for the alkyl glycoside derivatives (Method B).

1,3,4,6-Tetra-O-acetyl-2-oximino-α-D-arabino-hexopyranose

A solution of the dimeric nitrosyl chloride adduct (**1**) (6.75 g, 10 mmoles) in glacial acetic acid (55 ml) was stirred with anhydrous sodium acetate (1.64 g, 20 mmoles) at 60° for 30 min under anhydrous conditions. The solvent was removed *in vacuo* at 35° and the residual syrup was taken up in chloroform (100 ml). The chloroform solution was washed successively with water (30 ml), saturated sodium bicarbonate solution (30 ml), and water (30 ml). The organic phase was dried over anhydrous sodium sulfate and the solvent removed *in vacuo*. The residual foamy white solid was dried and crystallized from ether – *n*-hexane. The yield was 2.2 g (31%), m.p. 138–139°, $[\alpha]_D^{24}$ +44.39° (*c*, 1.2 in chloroform).

Anal. Calcd. for $C_{14}H_{19}O_{10}N$: C, 46.54; H, 5.30; N, 3.88. Found: C, 46.60; H, 5.04; N, 3.64.

In the absence of sodium acetate and at room temperature the reaction was much slower.

n-Propyl and Isopropyl 3,4,6-Tri-O-acetyl-2-oximino-α-D-lyxo-hexopyranosides

These compounds were prepared from dimeric tri-*O*-acetyl-deoxy-2-nitroso-α-D-galactopyranosyl chloride using Method A. The syrupy crude products were obtained in near quantitative yields. Although some purification was effected by passing a solution in benzene through a small column of silica gel and elution with benzene, the compounds failed to crystallize. Nevertheless, the n.m.r. spectra were in agreement with the assigned structures. The chemical shifts for H-1, H-3, and H-4 were τ 3.90, 4.10, and 4.48, respectively, for the *n*-propyl compound and τ 3.76, 4.08, and 4.50, respectively, for the isopropyl compound. In both cases, spacings of 3.5 and <1 c.p.s. were present arising from the $J_{3,4}$ and $J_{4,5}$ interactions, respectively. The optical rotations are reported in Table I.

Acknowledgments

The authors are grateful for grants to R.U.L. from the National Research Council of Canada (T-172) and the Corn Industries Research Foundation in aid of this research. The microanalyses and n.m.r. spectra were determined in this department.

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