Anal. Calcd. for $C_{21}H_{29}NO_3$: C, 73.43; H, 8.51; N, 4.08. Found: C, 73.35; H, 8.83; N, 3.53.

An *acetate* (**15b**), not further characterized, had λ^{CHBr_3} 5.65, 5.86, 6.03, and 6.19 μ.

16α-Hydroxy-5-pregnene-3,20-dione Acetate Bisethylene Ketal (**19**, *R* = *Ac*). 16α-Acetoxy-4-pregnene-3,20-dione[28,31] (**18**, R = Ac, 500 mg.) was dissolved in 45 ml. of benzene. Ethylene glycol (10 ml.) and *p*-toluenesulfonic acid monohydrate (30 mg.) were added, and the two-phase system was refluxed for 4 hr., water being continuously removed by means of a Dean–Stark trap. At the end of the reaction period, the mixture was cooled and neutralized with a saturated sodium bicarbonate solution and partitioned between water and methylene chloride. The organic layer was dried and concentrated. Crystallization from acetone–petroleum ether (b.p. 60–90°) gave 547 mg. of the bisketal acetate **19** (R = Ac),[27] m.p. 234–237°.

16α-Hydroxy-5-pregnen-3,20-dione Bisethylene Ketal (**19**, *R* = *H*). The foregoing acetate (**19**, R = Ac, 490 mg.) was refluxed under nitrogen for 2 hr. in 40 ml. of a solution consisting of 5 g. of potassium hydroxide dissolved in 5 ml. of water made up to 100 ml. with methanol. After cooling, the pH of the solution was adjusted to 8 with acetic acid, the solution was concentrated to incipient crystallization under vacuum, and water was added. The resulting crystals were filtered and recrystallized from acetone–petroleum ether to give 246 mg. of **19** (R = H),[28] m.p. 197–202°.

Deketalization of 16-Oximino-5-pregnene-3,20-dione Bisethylene Ketal. 16-Oximino-5-pregnene-3,20-dione bisethylene ketal[27] (**16**, R = NOH, 85.5 mg.) was dissolved in 1 ml. of 90% acetic acid and heated to 100° for 12 min. The solution was cooled and carefully neutralized with sodium bicarbonate solution and extracted with methylene chloride, and the extract was washed with water, dried, and concentrated. The resulting mixture of substances was chromatographed on 1.5 g. of Florisil, using 10-ml. eluates. After removing an oil with benzene, the desired 16-oximino-4-pregnene-3,20-dione (**15**) was eluted with 30% ether–benzene. A crude yield of 9.5 mg. gave 5.9 mg. after recrystallization from methylene chloride–isopropyl ether, identical with the photolysis transformation product **15**a (*vide supra*) by melting and mixture melting points, R_f, and infrared spectrum.

The Methanolysis of Some D-Arabinofuranosyl Halides Having a Nonparticipating Group at Carbon 2

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Contribution from the National Institute of Arthritis and Metabolic Diseases, National Institutes of Health, Public Health Service, U. S. Department of Health, Education, and Welfare, Bethesda, Maryland 20014. *Received January 21, 1964*

The rates of methanolysis of three 2-O-nitro-3,5-di-O-p-nitrobenzoyl-D-arabinofuranosyl halides have been measured and the proportions of anomeric products formed have been analyzed by gas–liquid chromatography; the evidence adduced indicates that an SN1 mechanism operates in these solvolyses, and that the stability of the intermediate ion pair has a strong influence on the configuration of the products. The possible role of participation by acyl groups at C-3 and C-5 in the nucleophilic displacement of the halogen in pentofuranosyl halides is discussed. The solvolysis of pentofuranosyl halides lacking a participating group at C-2 favors the 1,2-cis product in the cases examined; it is possible that this may be generally true irrespective of the configuration of the halide.

Owing to the central role which they play in a large variety of syntheses, the fully acylated glycosyl halides have been the subject of many investigations.[2] In recent years, particular attention has been given to the mechanism of the solvolysis of these halides,[3–7] and it appears established that an SN1 type reaction is normally involved but that, with certain nucleophiles and with solvents of low polarity, some SN2 character is manifest. Those halides bearing an acyloxy group at C-2 *cis* to the halogen at C-1 normally react with inversion while the corresponding *trans* halides react with predominant retention of configuration, the acyl group at C-2 participating in the nucleophilic displacement. Thus, from a practical synthetic point of view, aldose derivatives having a substituent at C-1 *trans* to that at C-2 are readily accessible whether the parent halide is *cis* or *trans*. On the other hand, the synthesis of the anomeric *cis* derivatives, many of which are of biochemical interest, often presents a difficult problem. One approach to the synthesis of such substances is through the use of glycosyl halides which are fully masked by nonparticipating groups or masked by such only at C-2, the remainder being masked by acyl groups. We have recently listed a number of halides of this latter type which have been reported in the literature.[8]

(1) Visiting Scientist in the Visiting Program of the National Institutes of Health, 1962–1965.

(2) L. J. Haynes and F. H. Newth, *Advan. Carbohydrate Chem.*, **10**, 207 (1955).

(3) F. H. Newth and G. O. Phillips, *J. Chem. Soc.*, 2896, 2900, 2904 (1953).

(4) R. U. Lemieux and G. Huber, *Can. J. Chem.*, **33**, 128 (1955).

(5) G. L. Mattok and G. O. Phillips, *J. Chem. Soc.*, 1836 (1956); G. L. Mattok and G. O. Phillips, *ibid.*, 268 (1957).

(6) R. U. Lemieux and A. R. Morgan, *J. Am. Chem. Soc.*, **85**, 1889 (1963).

(7) B. Capon, P. M. Collins, A. A. Levy, and W. G. Overend, *J. Chem. Soc.*, 3242 (1964).

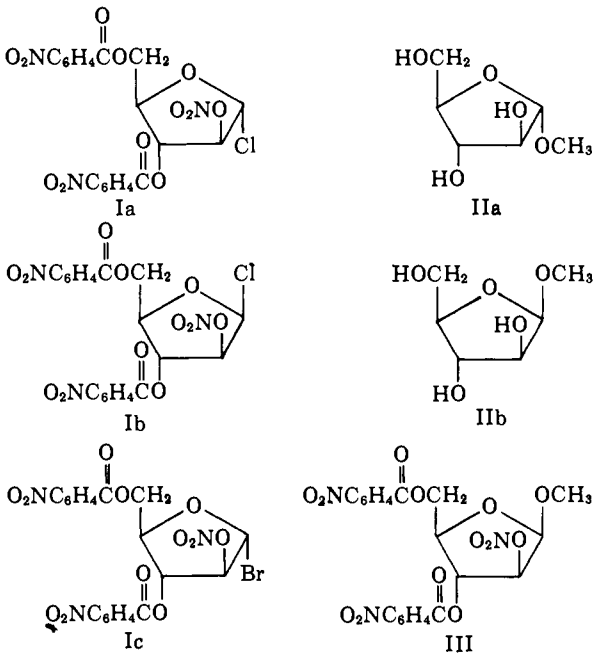
Table I. Solvolysis of Halides with Nonparticipating Groups at C-2

Run	Substrate	Concn., m*M*	Solvent	Methanol, % (v./v.)	IIa/IIb, %	k_0[a]	Bu_4NBr, *M*	$[\alpha]^{20}D$, deg. Initial	$[\alpha]^{20}D$, deg. Final[b]
1	Ia	16.4	CH_2Cl_2	16.7	3/97	4.9×10^{-5}	0	+69.6	−81.9
2	Ia	16.9	CH_2Cl_2	25	3/97[c]	8.7×10^{-5}	0	+69.4	−78.4
3	Ib	16.4	CH_2Cl_2	25	39/61	*d*	0	−91	−4.2
4	Ic	15.1	CH_2Cl_2	16.7	4/96	3.5×10^{-3}	0.135	+94.8	−50.6
5	Ic	15.1	CH_3CN	16.7	5/95	6.2×10^{-3}	0	+112	−56.6
6	Ic	15.1	CH_2Cl_2	16.7	4/96	3.7×10^{-3}	0	+108.4	−79.3
7	Ic	15.4	CH_3CN	16.7	7/93	5.1×10^{-3}	0.06	+101	−46.4
8	Ic	15.3	CH_2Cl_2	35	...	9.0×10^{-3}	0	+106	−77.2

[a] Min.$^{-1}$, natural logs. [b] Calculated on the assumption that conversion to the substituted methyl arabinofuranosides was quantitative. [c] Calculated from optical rotations. [d] Complex reaction; see Figure 2.

Effective use for synthetic purposes of glycosyl halides with nonparticipating groups (as well as of the halides of 2-deoxyaldoses) requires some knowledge of the mechanism whereby the halogen in these substances undergoes nucleophilic displacement. To our knowledge, the only relevant study is that of Rhind-Tutt and Vernon[9] who examined some reactions of 2,3,4,6-tetra-*O*-methyl-D-glucopyranosyl and -D-mannopyranosyl chlorides, both amorphous substances which appear to be predominantly the α-anomers. It was found that the simple methanolysis of these compounds proceeds by an SN1 mechanism, inversion of configuration at C-1 being essentially complete. With less polar media and stronger nucleophiles, the displacement was found to acquire more SN2 character, the nature of the product depending on steric factors.

All of the foregoing refers, of course, to the pyranosyl halides. Owing to general problems associated with the synthesis of nucleosides, particularly those in which the aglycon is *cis* to the hydroxyl at C-2, our main interest has been directed toward the furanosyl halides. Here, also, *cis* derivatives are not normally obtained when fully acylated glycofuranosyl halides are used and, as one solution, one may turn to halides bearing nonparticipating groups. We have recently shown,[10] for instance, that the amorphous 2,3,5-tri-*O*-benzyl-D-arabinofuranosyl chloride (which is predominantly the α-anomer[11]) which may be prepared by treatment of 2,3,5-tri-*O*-benzyl-1-*O*-*p*-nitrobenzoyl-D-arabinofuranose with hydrogen chloride gives, on methanolysis, almost exclusively methyl 2,3,5-tri-*O*-benzyl-β-D-arabinofuranoside. Likewise, on condensation with *N*-benzoyladenine, this halide yielded, after removal of the masking groups, 9-β-D-arabinofuranosyladenine (spongoadenosine) along with a very small amount of the corresponding α-nucleoside. While of synthetic significance, these isolated facts throw no light on the mechanism whereby glycofuranosyl halides of this class react. For such studies, one should, ideally, have in hand at least an anomeric pair of halides of the desired type. Since no fully etherified glycosyl halide has, apparently, ever been obtained in crystalline (and, therefore, anomerically pure) form, we turned our attention to the synthesis of glycofuranosyl halides in which C-2 is masked with the nonparticipating[12] *O*-nitro group, and have recently described[8] the preparation of three crystalline furanosyl halides of the desired type: the two anomeric 2-*O*-nitro-3,5-di-*O*-*p*-nitrobenzoyl-D-arabinofuranosyl chlorides (Ia and Ib) and 2-*O*-nitro-3,5-di-*O*-*p*-nitrobenzoyl-α-D-arabinofuranosyl bromide (Ic). The present paper describes some studies of the methanolysis of these halides.



Each of the three halides was dissolved in an appropriate solvent (dichloromethane or acetonitrile), the solution was diluted with an excess of methanol, and the ensuing reaction followed polarimetrically at 20°. When the reaction had ceased, the *p*-nitrobenzoyl groups were removed with alkali and the *O*-nitro group was removed by catalytic hydrogenation. The relative proportions of the two anomeric methyl D-arabinofuranosides (IIa and IIb) in the resulting mixture were then determined by gas–liquid chromatography after conversion to the trimethylsilyl ethers[13] which were completely resolved on Gaschrom-SE 52. Data from a series of such solvolyses are presented in Table I, the initial pseudo-first-order rate constants (k_0) being calculated from polarimetric data. The major initial product of the solvolyses, methyl 2-*O*-nitro-3,5-di-*O*-*p*-nitrobenzoyl-β-D-arabinofuranoside (III), was isolated in crystalline form and characterized; that its rotation remained unchanged under the conditions of the sol-

(8) C. P. J. Glaudemans and H. G. Fletcher, Jr., *J. Org. Chem.*, **29**, 3286 (1964).
(9) A. J. Rhind-Tutt and C. A. Vernon, *J. Chem. Soc.*, 4637 (1960).
(10) C. P. J. Glaudemans and H. G. Fletcher, Jr., *J. Org. Chem.*, **28**, 3004 (1963).
(11) C. P. J. Glaudemans and H. G. Fletcher, Jr., unpublished results.
(12) L. Fishbein, *J. Am. Chem. Soc.*, **79**, 2959 (1957).
(13) C. C. Sweeley, R. Bentley, M. Makita, and W. W. Wells, *ibid.*, **85**, 2497 (1963).

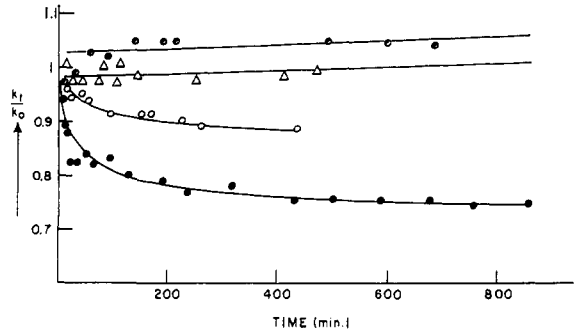


Figure 1. Variation of k_t/k_0 with time for the methanolysis of Ic: ●, in CH_2Cl_2; ○, in CH_3CN; △, in CH_3CN containing $(n\text{-}C_4H_9)_4N^+Br^-$; ◐, in CH_2Cl_2 containing $(n\text{-}C_4H_9)_4N^+Br^-$.

volyses indicates that secondary anomerization does not take place.

Methanolysis of the α-halides Ia and Ic (runs 1 and 6) gave, predominantly, the inverted product, methyl 2-*O*-nitro-3,5-di-*O*-*p*-nitrobenzoyl-β-D-arabinofuranoside (III). With increased methanol concentration (runs 2 and 8), a disproportionate increase in the rate of solvolysis resulted; use of a more polar medium, acetonitrile (run 5), also increased the rate. Furthermore, as shown in Figure 1, the calculated pseudo-first-order rate constants decreased with time save when bromide ion was deliberately added in the form of tetrabutylammonium bromide.

The solvolysis of a halide by an SN1 mechanism may be written as

$$RX \underset{k_2}{\overset{k_1}{\rightleftharpoons}} R^+ + X^- \xrightarrow[CH_3OH]{k_3} ROCH_3$$

and, in the presence of an excess of methanol, the rate can be represented by

$$\frac{d[RX]}{dt} = \frac{k_1[RX]}{1 + \frac{k_2}{k_3}[X^-]}$$

(steady-state approximation) and since a first-order rate is $d[RX]/dt = k[RX]$, we may expect that the observed rate constant, k, under these conditions will be equal to

$$\frac{k_1}{1 + \frac{k_2}{k_3}[X^-]}$$

From this it may be seen that the increasing concentration of the halide ion will progressively slow the rate of the solvolysis. This effect will, of course, be masked by the initial addition of a large excess of halide ion. It is evident, therefore, that the experimental findings are compatible with an SN1 mechanism. The slight decrease in the observed rate caused by the addition of bromide ion (compare runs 1 and 4) indicates at least some external ion return.

The solvolysis of Ic (15 mmoles/l.) in 1,2-dichloroethane[14] containing 16.7% (v./v.) methanol was measured at 20.2, 29.8, and 39.0° giving pseudo-first-order rate constants of 3.3×10^{-3}, 9.2×10^{-3}, and 2.2×10^{-2}, ln, $min.^{-1}$, respectively. These data lead to an average entropy of activation, ΔS^*, −23 cal.

(14) Owing to its low boiling point, dichloromethane was replaced by 1,2-dichloroethane in this particular series of measurements.

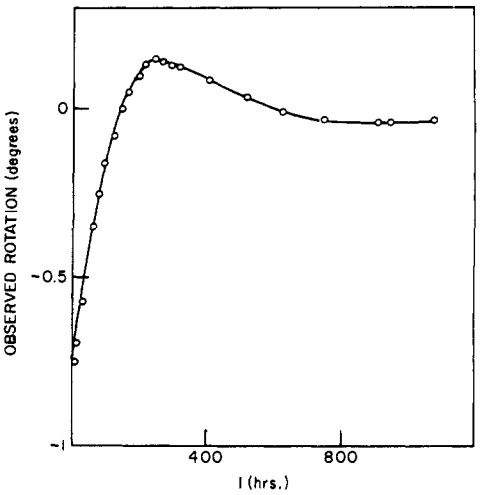
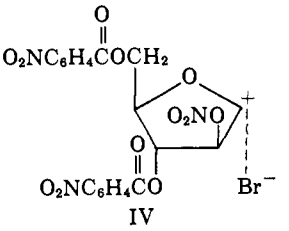


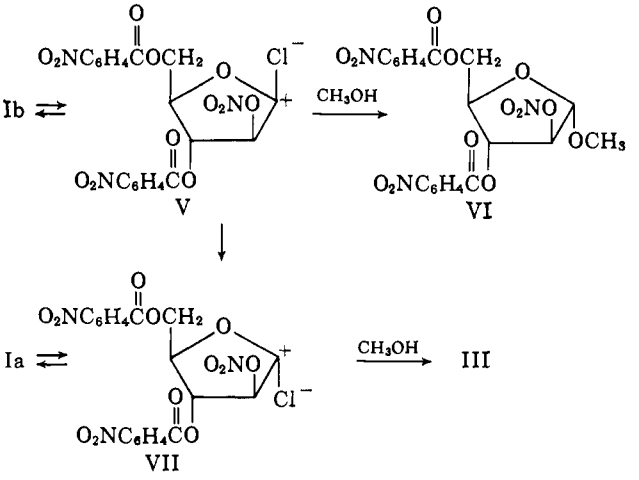
Figure 2. Mutarotation of Ib on methanolysis.

deg.$^{-1}$ mole^{-1}, confirming the intermediacy of an ionic species and (by its magnitude) suggesting that the charge separation is substantial in the transition state (IV), which may be regarded as an ion pair.



IV

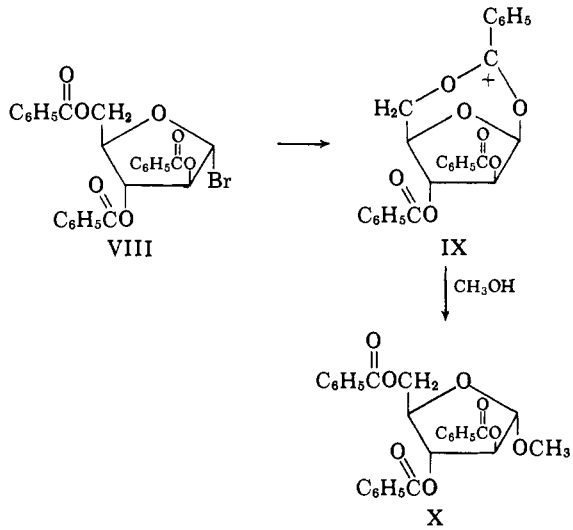
We turn now to a consideration of the solvolysis of the β-halide Ib. Here (run 3), in contrast to the solvolysis of Ia and Ic, a complex mutarotation (Figure 2) was encountered and the product contained a substantial proportion of methyl 2-*O*-nitro-3,5-di-*O*-*p*-nitrobenzoyl-α-D-arabinofuranoside. It is known that the β-halide Ib is less stable than its α-anomer Ia,[15] possibly because of electrostatic compression between the chlorine atom and the nitro group *cis* to it. If we postulate the ion pair V, it is readily seen that two



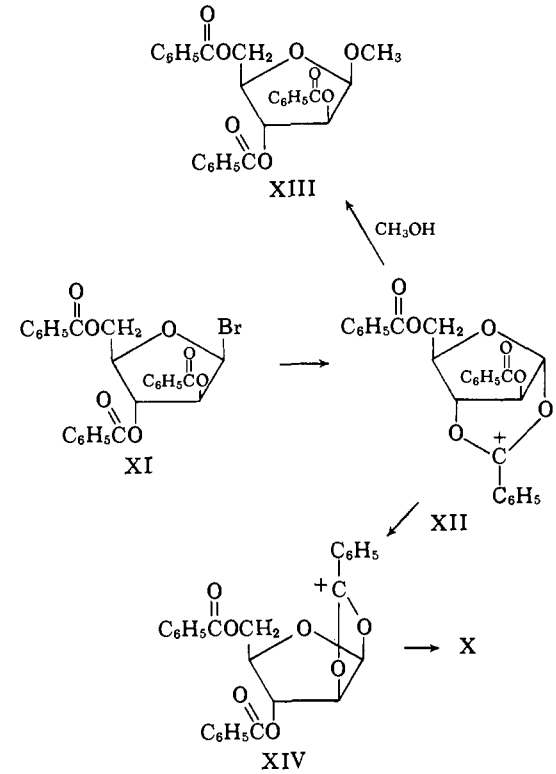
(15) Thus, under anomerizing conditions (as in its preparation or in the presence of active silver chloride[6]), the α-anomer predominates at equilibrium. The same holds true for all tri-*O*-acylarabinofuranosyl halides which have been investigated[17]: A. K. Bhattacharya, R. K. Ness, and H. G. Fletcher, Jr., *J. Org. Chem.*, **28**, 428 (1963).

competing reactions should take place. First, V may go directly to the α-glycoside VI. Second, V may invert to the more stable ion pair VII; the latter may go reversibly to Ia or irreversibly with inversion to the glycoside III. The nature of the rotation curve (Figure 2) suggests that the conversion of the levorotatory Ib to the dextrorotatory Ia and VI (ascending portion of the curve) is followed by the conversion of Ia (or VII) to the more levorotatory III.

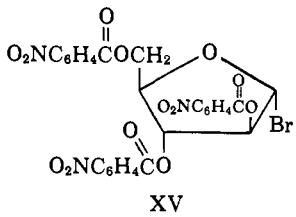
As indicated earlier, the steric features of the reactions of fully acylated *trans* glycosyl halides appear to be dominated by anchimeric assistance and participation of the acyloxy group at C-2. While such an effect was deliberately excluded here, one must consider the possibility of the participation of the *p*-nitrobenzoyl groups at C-3 and C-5 in these solvolyses.[16] Ness and Fletcher[17] showed that both anomeric forms of 2,3,5-tri-*O*-benzoyl-D-arabinofuranosyl bromide (VIII and XI) react with methanol in dioxane solution to give rotations very nearly those of methyl 2,3,5-tri-*O*-benzoyl-α-D-arabinofuranoside (X), and this substance was isolated in both cases in high yield. Participation



of the benzoyl group at C-5 in the methanolysis of VIII *via* IX would yield the α-glycoside X, but X would also have resulted had participation been restricted to the benzoyl group at C-2, the latter mechanism no doubt predominating. Thus, this experiment failed to eliminate the possibility of participation by the acyl group at C-5. However, the fact that Ia and Ic give very small yields of IIa indicates that, in our cases at least, participation by the *p*-nitrobenzoyl group at C-5 is negligible. That 2,3,5-tri-*O*-benzoyl-β-D-arabinofuranosyl bromide (XI) gives only X suggests that participation by the C-3 benzoyl group is not involved to a significant extent since at least some of the intermediate XII would be expected to yield the *cis* glycoside XIII, although, possibly, a part of it could have rearranged to the ion XIV which would then give the *trans* glycoside X.

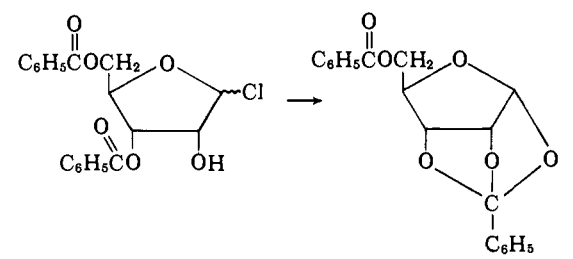


In this connection, we have deemed it of interest to compare the effectiveness of the participation of the *p*-nitrobenzoyl group with the benzoyl group in these solvolyses. 2,3,5-Tri-*O*-benzoyl-α-D-arabinofuranosyl bromide (VIII) and 2,3,5-tri-*O*-*p*-nitrobenzoyl-α-D-arabinofuranosyl bromide (XV)[8] were allowed to react with methanol in dichloromethane and the proportions



of anomeric products determined as described earlier. Both X and methyl 2,3,5-tri-*O*-*p*-nitrobenzoyl-α-D-arabinofuranoside[8] were shown to be stable under the conditions of the solvolysis. As shown in Table II the benzoylated halide (VIII) gives predominantly the α-glycoside IIa (after deacylation) while the *p*-nitrobenzoylated halide (XV) affords a mixture containing a substantial proportion of the β-glycoside (after deacylation). The comparative inefficiency of the *p*-nitrobenzoyl group in controlling the steric course of this solvolysis may be ascribed to the greater electron-attracting ability of the *p*-nitrophenyl group and tends to support our assumption that the *p*-nitrobenzoyl group on C-3 is not likely to participate significantly in the solvolyses of Ia, Ic, or Ib.

(16) R. K. Ness and H. G. Fletcher, Jr., *J. Org. Chem.*, 22, 1465 (1957), found that 3,5-di-*O*-benzoyl-D-ribosyl chloride is converted to 5-*O*-benzoyl-1,2,3-benzylidyne-α-D-ribose when treated in benzene solution with mercuric acetate. It is likely that the first stage of this transformation represents an example of participation by an acyl group at C-3.



(17) R. K. Ness and H. G. Fletcher, Jr., *J. Am. Chem. Soc.*, 80, 2007 (1958).

Table II. Solvolysis of Halides with Participating Groups

Substrate	Concn., m*M*	Solvent	Methanol, % (v./v.)	IIa/IIb, %
XV	33.6	CH_2Cl_2	16.7	75/25[a]
VIII	33.6	CH_2Cl_2	16.7	96/4

[a] The same proportions were formed when 33.3% methanol in dichloromethane was used and when 16.7% methanol in dioxane was used.

In conclusion we wish to note that, since even Ib gave a substantial yield of β-glycoside, it appears possible that *cis* products may generally be favored in the solvolysis of pentofuranosyl halides lacking a participating group at C-2, regardless of the configuration at C-1 in such halides,[18] as it appears that a *trans* ion pair is more stable than its *cis* counterpart in halides of this type.

Experimental[19]

Substrates. Compounds Ia, Ib, Ic, and XV were prepared as described by Glaudemans and Fletcher[8]; the preparation of VIII has been described by Ness and Fletcher.[17]

Methyl L-*Arabinofuranosides.* The methyl L-arabinofuranosides were utilized as chromatographic standards as they were more readily accessible than the D-enantiomorphs at the time the research was undertaken. The α-L-anomer was prepared by debenzoylation of its crystalline tribenzoate[17,20]; a mixture containing the β-L-anomer was prepared as follows. 2,3,5-Tri-*O*-benzyl-L-arabinofuranose[21] (10 g.) was dissolved in 300 ml. of methanol and 3 ml. of concentrated sulfuric acid was slowly added to the vigorously stirred solution. The reaction mixture was kept at room temperature and samples were withdrawn periodically for thin layer chromatography which was conducted on Silica Gel G (E. Merck AG, Darmstadt, Germany) using ethyl acetate–cyclohexane (1:2). Components were visualized by spraying the chromatograms with 5% sulfuric acid and heating briefly on a hot plate. After 24 hr., starting material was no longer detectable and the two methyl 2,3,5-tri-*O*-benzyl-L-arabinofuranosides appeared to be present in approximately equal quantities. A solution of sodium hydroxide (10 g.) in water (50 ml.) was added to the reaction mixture which was then stirred vigorously. The excess of base was neutralized with carbon dioxide and the methanol was removed *in vacuo*. The mixture of glycosides was extracted with dichloromethane, the extract then being washed with water, dried, and concentrated *in vacuo* to a sirup (9.54 g., 92%). Palladium chloride (300 mg.) was suspended in methanol and reduced by shaking with hydrogen, and the palladium black was washed by decantation with methanol. A solution of 1 g. of the mixture of methyl 2,3,5-tri-*O*-benzyl-L-arabinofuranosides in methanol was added to the palladium black and the suspension was shaken with hydrogen until absorption of the gas ceased. The catalyst was removed by filtration and the solution was concentrated *in vacuo* to yield a sirupy mixture of the anomeric methyl L-arabinofuranosides. Thin layer chromatography on Silica Gel G, using 1-butanol, showed but two components, the methyl β-L-arabinofuranoside migrating slightly more slowly than its α-anomer.

Gas–Liquid Chromatography of the Anomeric Methyl Arabinofuranosides. The relative proportions of the two anomeric methyl arabinofuranosides in mixtures were determined through gas–liquid chromatography of their trimethylsilyl ethers.[13] The glycosidic mixture (*ca.* 10 mg.) was treated with 1.5 ml. of a mixture of pyridine (1 part), hexamethyldisilazane (0.2 part), and chlorotrimethylsilane (0.1 part). The mixture was kept at room temperature for several hours and an aliquot (3–5 μl.) injected onto a column (0.25 in. × 6 ft.) of SE 52 (3%) on Gaschrom A[22] at 50°. The temperature of the column was increased at 5.6°/min. until it reached 135°, where it was held. A flame ionization detector was used. The peaks obtained with an authentic mixture of methyl arabinofuranosides were identified by the addition of authentic methyl α-L-arabinofuranoside in a parallel run; likewise all mixtures from solvolyses were first run as such and again after the addition of a mixture of the two anomeric glycosides. The relative proportions in the mixtures were ascertained by estimating the area under each peak, the response of the detector being assumed to be the same for each anomer.

*Methyl 2-O-Nitro-3,5-di-O-p-nitrobenzoyl-β-*D-*arabinofuranoside* (*III*). 2-*O*-Nitro-3,5-di-*O*-*p*-nitrobenzoyl-α-D-arabinofuranosyl bromide[8] (Ic, 400 mg.) was dissolved in 40 ml. of dichloromethane and the solution was diluted with 10 ml. of methanol. After being kept at room temperature for 24 hr., the solution was concentrated to a dry residue which was dissolved in dichloromethane. The solution was washed with aqueous sodium bicarbonate, dried with sodium sulfate, and concentrated to afford a residue which was dissolved in 25 ml. of boiling ethanol. The crystals (332 mg., 91%), obtained on cooling the solution, were recrystallized from hot ethanol to give 289 mg. of product which was chromatographically homogeneous (Silica Gel G, CH_2Cl_2). At this stage the substance rotated $[\alpha]^{20}D$ −85.4° in dichloromethane–methanol (4:1, *c* 1.8) and had a double melting point (129–130° and 141–142° cor.). After another recrystallization from ethanol, the material showed m.p. 129° and 141–142° cor., $[\alpha]^{20}D$ −85.1° (CH_2Cl_2–CH_3OH, 4:1, *c* 1.25) and $[\alpha]^{20}D$ −84.1° (CH_2Cl_2–CH_3OH, 3:1, $c \sim 1.0$).

Anal. Calcd. for $C_{20}H_{17}N_3O_{13}$ (507.38): C, 47.34; H, 3.38; N, 8.28. Found: C, 47.46; H, 3.54; N, 8.13.

A solution (5 ml.) of III (42.8 mg.), made up with dichloromethane which was 0.019 *N* in hydrogen bromide, was diluted with anhydrous methanol to a volume of 6 ml.; the observed rotation remained constant (followed over the course of 80 days) and corresponded to $[\alpha]^{20}D$ −85.5°.

(18) P. A. J. Gorin, *Can. J. Chem.*, **40**, 275 (1962), for instance, found that methanolysis of 3,5-di-*O*-benzoyl-2-*O*-nitro-L-arabinofuranosyl bromide and of the corresponding D-ribofuranosyl bromide (both amorphous substances) gave *cis* glycosides.

(19) Reagent dichloromethane was dried over Drierite. 1,2-Dichloroethane was dried with magnesium sulfate, fractionally distilled, and stored over Drierite. Reagent acetonitrile was dried over molecular sieve, type A-4. Methanol was refluxed with magnesium methoxide and then distilled from this substance.

(20) R. S. Wright and H. G. Khorana, *J. Am. Chem. Soc.*, **80**, 1994 (1958).

(21) S. Tejima and H. G. Fletcher, Jr., *J. Org. Chem.*, **28**, 2999 (1963).

(22) Applied Science Laboratories, Inc., State College, Pa.

Solvolyses of Ia, Ib, and Ic. All measurements were at 20°. In a typical experiment, 2-*O*-nitro-3,5-di-*O*-*p*-nitrobenzoyl-α-D-arabinofuranosyl bromide (Ic, 50.5 mg.) was dissolved in anhydrous dichloromethane to a volume of 5 ml. The solution was diluted to 6 ml. with anhydrous methanol and mixed thoroughly.

The optical rotation of the reaction mixture was observed in a 2-dm. silica polarimeter tube with Teflon stoppers, α_0 being determined by extrapolation on a semilogarithmic plot. Pseudo-first-order rate constants were calculated using the expression $k = 1/t \ln (\alpha_0 - \alpha_\infty)/(\alpha_t - \alpha_\infty)$ and the initial value of k (k_0) was determined by extrapolation.

When mutarotation had ceased, the reaction mixture was washed with aqueous sodium bicarbonate solution, dried with sodium sulfate, and concentrated. The residue, dissolved in 5 ml. of benzene, was treated with 3 ml. of 0.3 *N* sodium methoxide in methanol and the resulting solution was kept at room temperature for 7 days. Solvent was removed and the residue, dissolved in water, was filtered and deionized with Amberlite MB-1. Reconcentration yielded a sirup which was reductively denitrated in aqueous methanolic solution using palladium black and hydrogen at atmospheric pressure. The catalyst was removed by filtration and the solution was concentrated to a sirup which was dried *in vacuo* at room temperature for 24 hr. This product was converted to its trimethylsilyl derivative and analyzed by gas–liquid chromatography as described above.[23]

Where solvolyses were carried out in the presence of tetrabutylammonium bromide, the halide Ic was dissolved in dichloromethane or dry acetonitrile to make a volume of 5 ml. The solution was then made up to 6 ml. with anhydrous methanol 0.36 *M* (or 0.81 *M*) in tetramethylammonium bromide, and the solvolysis was studied as described above.

Since the methanolysis of Ib is slow in dichloromethane containing 16.7% methanol and since a higher rate should favor the detection of a maximum in the curve of rotation *vs.* time (Figure 2), the reaction was carried out using a methanol concentration of 25%.

Solvolysis of VIII and XV. 2,3,5-Tri-*O*-benzoyl-α-D-arabinofuranosyl bromide (VIII, 105.8 mg., $[\alpha]^{20}D$ +83° in CH_2Cl_2) was dissolved in anhydrous dichloromethane to a volume of 5 ml., anhydrous methanol (1 ml.) was added, and the rotation of the resulting solution was observed in a 1-dm. tube, $\alpha^{20}D$ +1.054° (2 min.) → −0.280° (17 min., constant). The product was then deacylated with sodium methoxide, converted to the trimethylsilyl derivative, and subjected to gas–liquid chromatography as described earlier. The proportions of IIa and IIb were thus found to be 96 and 4%, respectively.

Methyl α-D-arabinofuranoside tribenzoate[17] (100 mg.) was dissolved in 4.75 ml. of 5:1 dichloromethane–methanol which was 0.03 *N* in hydrogen bromide. In a 1-dm. tube the solution showed $\alpha^{20}D$ −0.276°, no change being observed over the course of 2 hr.

2,3,5-Tri-*O*-*p*-nitrobenzoyl-α-D-arabinofuranosyl bromide (XV, 133 mg.) was dissolved in dichloromethane to a volume of 5 ml. and 1.00 ml. methanol was added. When mutarotation was complete (*ca.* 7 hr.), the proportions of anomeric products were analyzed as described earlier, with the results shown in Table II.

Methyl α-D-arabinofuranoside tri-*p*-nitrobenzoate (100 mg.) was dissolved in 5 ml. of 20:1 dichloromethane–methanol which was 0.03 *N* in hydrogen bromide. In a 1-dm. tube the rotation of the solution ($\alpha^{20}D$ −0.680°) was constant over the course of 19 hr.

Acknowledgment. We are indebted to the Section on Analytical Services and Instrumentation of this laboratory for elemental analyses.

(23) The proportions of anomeric products formed in run 2 were, however, calculated from optical rotatory data and gas–liquid analysis data obtained in run 3.