methanol (2 ml.) was refluxed for 1 min. and left 1 day at room temperature. Addition of ether to the solution gave crystalline methyl 3 - amino - 3 - deoxy - α - D - mannopyranoside hydrochloride (IX); yield, 0.16 g. (82%); physical constants identical to those of an authentic sample; X-ray powder diffraction data[20]: 10.98 m (3), 7.53 s (1), 6.03 vw, 5.45 vw, 5.23 vw, 4.46 s (2), 4.07 m, 3.79 m, 3.45 s (2,2), 3.14 w, 2.83 vw, 2.73 vw.

Examinations of the reaction mixture by paper chromatography revealed a major zone, R_m 1.66, corresponding to IX, with weak zones at R_m 1.0 and 2.7.

Conversion of 2-Amino-2-deoxy-1-thio-D-glucose Derivatives into Glycosyl Halide Derivatives. A Tetra-*O*-acetylglycosylsulfenyl Bromide[1]

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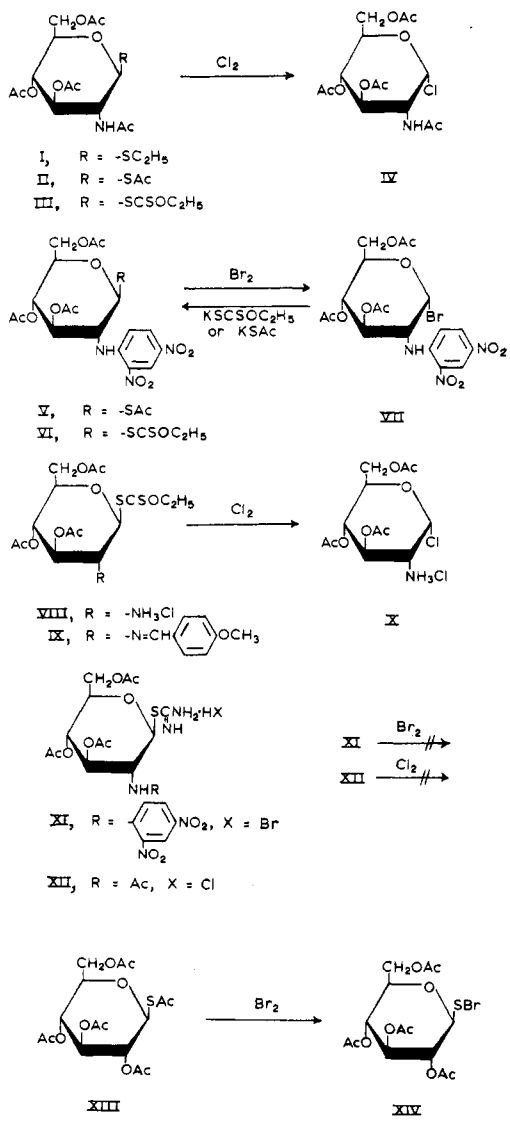
The *N*- and *S*-substituted derivatives I, II, III, V, VI, and VIII of 3,4,6-tri-*O*-acetyl-2-amino-2-deoxy-1-thio-D-glucose react with chlorine or bromine to give the corresponding *N*-substituted 3,4,6-tri-*O*-acetyl-2-amino-2-deoxy-α-D-glucopyranosyl chlorides (IV, X) or bromides (VII). 3,4,6-Tri-*O*-acetyl-2-amino-2-deoxy-α-D-glucopyranosyl chloride hydrochloride (X) is also formed on chlorination of 3,4,6-tri-*O*-acetyl-2-anisylidene-amino-2-deoxy-β-D-glucopyranosyl ethylxanthate (IX). Bromination of 2,3,4,6-tetra-*O*-acetyl-1-*S*-acetyl-1-thio-β-D-glucopyranose (XIII) in carbon tetrachloride solution gives crystalline 2,3,4,6-tetra-*O*-acetyl-β-D-glucopyranosylsulfenyl bromide (XIV), a novel derivative in the carbohydrate field with potential value as a synthetic intermediate. The *N*-substituted 2-(3,4,6-tri-*O*-acetyl-2-amino-2-deoxy-β-D-glucopyranosyl)-2-thiopseudourea salt derivatives XI and XII were found to be unreactive under the halogenation conditions. The mechanism of these reactions is discussed from a common standpoint.

The conversion of acetylated phenyl 1-thioglycosides to poly-*O*-acetylglycosyl bromides by bromine treatment in an inert solvent was first described by Bonner,[2] and extended by Weygand and associates,[3] and others,[4] with the ethyl analogs. Chlorination to the corresponding glycosyl chlorides was described by Wolfrom and Groebke,[5] and the reaction was extended in this laboratory[6] to the synthesis of amino sugar glycosyl halides in the 3-amino-3-deoxy-D-mannose series.[6] The present work describes the conversion of a range of *N*- and *S*-substituted derivatives of 3,4,6-tri-*O*-acetyl-2-amino-2-deoxy-1-thio-β-D-glucose into *N*-substituted 3,4,6-tri-*O*-acetyl-2-amino-2-deoxy-α-D-glucopyranosyl bromides or chlorides, and the behavior of related derivatives which do not react to give products of this type.

Most of the compounds utilized were prepared by the procedures described by Horton and Wolfrom.[7] 3,4,6-Tri - *O* - acetyl - 2 - deoxy - 2 - (2,4 - dinitroanilino)-β-D-glucopyranosyl ethylxanthate (VI) was prepared by treatment of 3,4,6-tri-*O*-acetyl-2-deoxy-2-(2,4-dinitroanilino)-α-D-glucopyranosyl bromide (VII) with potassium ethylxanthate in acetone–ethanol solution, followed by chromatography of the product on silica gel.

Ethyl 2-acetamido-3,4,6-tri-*O*-acetyl-2-deoxy-1-thio-β-D-glucopyranoside[8] (I), 2-acetamido-3,4,6-tri-*O*-acetyl 1-*S*-acetyl-2-deoxy-1-thio-β-D-glucopyranose[7] (II), and



2-acetamido-3,4,6-tri-*O*-acetyl-2-deoxy-β-D-glucopyranosyl ethylxanthate[7] (III), all reacted rapidly in

(1) This work was supported in part by Grant No. Cy-3232 (C5) (The Ohio State University Research Fund Project 759E) from the Department of Health, Education, and Welfare, U. S. Public Health Service, National Institutes of Health, Bethesda, Md., and in part by Contract No. DA-49-193-MD-2143 (The Ohio State University Research Fund Project 1187) from the Walter Reed Army Institute of Research, Washington, D. C. The opinions expressed in this article are those of the authors, and not necessarily those of either sponsoring agency. Preliminary report: Abstracts of Papers, 145th National Meeting of the American Chemical Society, New York, N. Y., September, 1963, p. 8D.

(2) W. A. Bonner, *J. Am. Chem. Soc.*, **70**, 3491 (1948).

(3) F. Weygand, H. Ziemann, and H. J. Bestmann, *Ber.*, **91**, 2534 (1958); F. Weygand and H. Ziemann, *Ann.*, **657**, 179 (1962).

(4) H. Zinner, A. Koine, and H. Nimz, *Ber.*, **93**, 2705 (1960).

(5) M. L. Wolfrom and W. Groebke, *J. Org. Chem.*, **28**, 2986 (1963).

(6) M. L. Wolfrom, H. G. Garg, and D. Horton, *ibid.*, **28**, 2989 (1963).

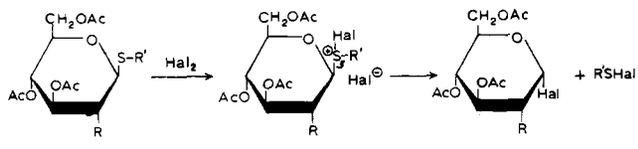
(7) D. Horton and M. L. Wolfrom, *ibid.*, **27**, 1794 (196.

(8) L. Hough and M. I. Taha, *J. Chem. Soc.*, 2042 (1952)6).

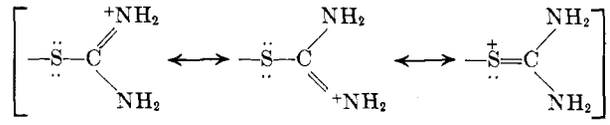
methylene chloride solution with chlorine at room temperature, to give crystalline 2-acetamido-3,4,6-tri-*O*-acetyl-2-deoxy-α-D-glucopyranosyl chloride[7,9] (IV) in high yield. Treatment of 3,4,6-tri-*O*-acetyl-1-*S*-acetyl-2-deoxy-2-(2,4-dinitroanilino)-1-thio-β-D-glucopyranose[7] (V), or 3, 4, 6-tri-O-acetyl-2-deoxy-2-(2,4-dinitroanilino)-β-D-glucopyranosyl ethylxanthate (VI), in methylene chloride solution, with bromine at room temperature gave in each case a high yield of crystalline 3,4,6-tri-*O*-acetyl-2-deoxy-2-(2,4-dinitroanilino)-α-D-glucopyranosyl bromide[7,10] (VII). Similarly, treatment of 3,4,6-tri-*O*-acetyl-2-amino-2-deoxy-β-D-glucopyranosyl ethylxanthate hydrochloride[7] (VIII) in methylene chloride with chlorine gave a high yield of a crystalline product showing the correct analysis for the anticipated 3,4,6-tri-*O*-acetyl-2-amino-2-deoxy-α-D-glucopyranosyl chloride hydrochloride (X). The latter compound has not to our knowledge been reported previously; it is the chlorine analog of 3,4,6-tri-*O*-acetyl-2-amino-2-deoxy-α-D-glucopyranosyl bromide hydrobromide, a compound first described by Irvine and co-workers[11] and widely used in synthetic work.[12] The infrared spectra of X and Irvine's compound[11] were closely similar. The same product X was produced, in practically quantitative yield, when an ethereal solution of 3,4,6-tri-*O*-acetyl-2-anisylideneamino-2-deoxy-β-D-glucopyranosyl ethylxanthate[13] (IX) was treated with chlorine at room temperature, indicating a rapid cleavage of the Schiff base substituent under these conditions. Generation of hydrogen chloride by hydrolysis of the sulfenyl chloride derivative formed from the C-1 substituent was not considered probable. Rapid chlorination of the (activated) aromatic nucleus, with cleavage of the (labilized) Schiff base by the hydrogen chloride thus formed, would logically explain the observed reaction.

The reaction at C-1 in each of the foregoing examples would appear to follow the mechanism proposed by Bonner[2] (Scheme A) for the bromination of phenyl tetra-*O*-acetyl-1-thio-β-D-glucopyranoside; *S*-halogenation by a halonium ion is followed by C-1 to *S*-heterolysis to yield a glycosyl carbonium ion, which is attacked, possibly synchronously, by halide ion, to give the α-D halide. The rapidity of the reaction suggests that initial formation of a β-D halide, and subsequent anomerization, is not involved.

SCHEME A



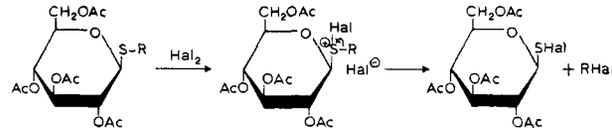
Attempted halogenation of the thiopseudourea derivatives 2-[3,4,6-tri-*O*-acetyl-2-deoxy-2-(2,4-dinitroanilino)-β-D-glucopyranosyl]-2-thiopseudourea hydrobromide[7] (XI) (with bromine), and 2-(2-acetamido-3,4,6-tri-*O*-acetyl-2-deoxy-β-D-glucopyranosyl)-2-thiopseudourea hydrochloride[7] (XII) (with chlorine) under considerably more vigorous conditions than those used in the foregoing conversions, gave no detectable reaction, and in each case the starting material was recovered in high yield. It would appear probable that the inductive effect of the positively charged amidinium group and the contribution of resonance structures of the type



would so lower the electron density on the sulfur atom as to prevent electrophilic halogenation on the sulfur atom, the postulated first stage in the replacement reaction.

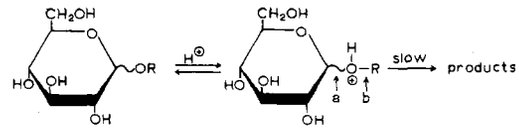
The reaction of 2,3,4,6-tetra-*O*-acetyl-1-*S*-acetyl-1-thio-β-D-glucopyranose[7,14] (XIII) follows a different course from the foregoing examples, and treatment of a carbon tetrachloride solution of XIII with bromine for five minutes at room temperature gives a high yield of a crystalline, strongly levorotatory product showing the correct analysis for tetra-*O*-acetyl-β-D-glucopyranosylsulfenyl bromide (XIV). Formation of this product can be rationalized on the basis of an alternative cleavage pathway (Scheme B) of the initial halogenated

SCHEME B



derivative with, in this case, heterolysis of the sulfur to acetyl bond to give XIV and acetylium ion, which combines with the halide ion. It would appear that the course of the reaction will depend on the readiness with which the glycosyl carbonium ion (Scheme A) or the R^+ carbonium ion (Scheme B) are formed; clearly, in the case of ethyl 1-thioglycoside derivatives, Scheme A would be favored owing to the relative difficulty with which the $C_2H_5^+$ carbonium ion is formed, while in the case of XIII the more stable acetylium ion can form, to favor reaction by Scheme B. Further experiments will be necessary to provide proof of this hypothesis, but a relevant parallel case may be cited in the hydrolysis of alkyl and aryl D-glucopyranosides, which is believed to occur[15] (Scheme C) by initial reversible protonation to

SCHEME C



(9) B. R. Baker, J. P. Joseph, R. E. Schaub, and J. H. Williams, *J. Org. Chem.*, **19**, 1786 (1954); D. H. Leaback and P. G. Walker, *J. Chem. Soc.*, 4754 (1957); F. Micheel, F.-P. van de Kamp, and H. Petersen, *Ber.*, **90**, 521 (1957).

(10) P. F. Lloyd and M. Stacey, *Tetrahedron*, **9**, 116 (1960).

(11) J. C. Irvine, D. McNicoll, and A. Hynd, *J. Chem. Soc.*, **99**, 250 (1911); see also M. L. Wolfrom and T. M. Shen Han, *J. Org. Chem.*, **26**, 2145 (1961).

(12) D. Horton, "The Amino Sugars," R. W. Jeanloz and E. A. Balasz, Ed., Vol. 1, Academic Press, Inc., New York, N. Y., 1963, in press.

(13) W. Meyer zu Reckendorf and W. A. Bonner, *Ber.*, **94**, 2431 (1961).

(14) The authors wish to acknowledge an earlier synthesis of XIII by a route similar to that described in ref. 7 but not cited therein: J. F. Danielli, M. Danielli, J. B. Fraser, P. D. Mitchell, L. N. Owen, and G. Shaw, *Biochem. J.*, **41**, 325 (1947).

(15) C. Armour, C. A. Bunton, S. Patai, L. H. Selman, and C. A. Vernon, *J. Chem. Soc.*, 412 (1961).

the conjugate acid, which then undergoes rate-determining heterolysis, normally at point *a* with primary alkyl, or aryl groups, to give a glycopyranosyl carbonium ion intermediate. In the case of *t*-butyl β-D-glucopyranoside, however, the evidence[15] indicates cleavage at *b*, the *t*-butyl carbonium ion being generated more readily than the glycopyranosyl carbonium ion.

The sulfenyl bromide derivative XIV showed no change in rotation in chloroform or ether solution over an observation period of four hours. The relative stability of alkanesulfenyl halide in nonpolar solvents such as carbon tetrachloride has been noted.[16] Crystalline XIV could be stored in a desiccator at 25° for several days before it decomposed to an oil. By analogy with the general reactivity of alkyl and aryl sulfenyl halides,[17] carbohydrate sulfenyl halides should find wide application in syntheses, providing an electrophilic sulfur atom as an attacking group, in contrast to the nucleophilic character of known thio sugar derivatives.[18] The observed stability of XIV would indicate a reactivity intermediate between that of the very labile alkanesulfenyl halides and the more stable aryl analogs; it can be expected to undergo ionic addition to unsaturated functions, and to replace active hydrogen atoms as in ketones, diethyl malonate, ethyl acetoacetate, and phenols. With amines it should form sulfenamides; it should give disulfides with thiols, and sulfides with Grignard reagents or aromatic hydrocarbons (Friedel–Crafts conditions).

Experimental[19]

2-Acetamido-3,4,6-tri-*O*-acetyl-2-deoxy-α-D-glucopyranosyl Chloride (IV). A. From Ethyl 2-Acetamido-3,4,6-tri-*O*-acetyl-2-deoxy-1-thio-β-D-glucopyranoside (I).—Chlorine was passed for 5 min. through a chilled solution of I[8] (100 mg.) in methylene chloride (10 ml.). Concentration of the solution after a 10-min. reaction time gave crystalline IV, yield, 90 mg. (96%); m.p. 130–132°; X-ray powder diffraction data identical with those of an authentic specimen.[7]

B. From 2-Acetamido-3,4,6-tri-*O*-acetyl-1-*S*-acetyl-2-deoxy-1-thio-β-D-glucose (II).—Treatment of II[7] (0.50 g.) in methylene chloride (20 ml.), with chlorine, and processing as for A gave IV; yield, 0.38 g. (84%), with physical constants identical with those of authentic material.

C. From 2-Acetamido-3,4,6-tri-*O*-acetyl-2-deoxy-β-D-glucopyranosyl Ethylxanthate (III).—Treatment of III[7] (0.50 g.) in methylene chloride (20 ml.) with chlorine, and processing as for A gave IV [yield (after two recrystallizations), 0.35 g. (73%)] with physical constants identical with those of authentic material.

3,4,6-Tri-*O*-acetyl-2-deoxy-2-(2,4-dinitroanilino)-β-D-glucopyranosyl Ethylxanthate (VI).—A solution of 3,4,6-tri-*O*-acetyl-2-deoxy-2-(2,4-dinitroanilino)-α-D-glucopyranosyl bromide (VII)[7,10] (0.62 g.) in acetone (10 ml.) was mixed with a solution of potassium ethylxanthate (0.35 g.) in ethanol (10 ml.). After 1 hr. the product was poured into water (250 ml.), and after 24 hr. the yellow gum was washed by decantation, dried, dissolved in benzene (15 ml.), and placed at the top of a 17 × 150 mm. column of silica gel.[20] The colored zone was developed off the column with ether to give the product VI as a yellow glass; yield, nearly quantitative; $[\alpha]^{26}D$ +65 ± 0.6° (*c* 0.9, chloroform); λ_{max}^{KBr} 3.03 (NH), 5.73 (OAc), 6.17, 6.28, 6.56 (aryl C=C), 7.33 (C=S?), 7.48 (NO_2), 13.43, 13.84 μ (substituted benzene). Traces of colored side-products remained at the top of the column.

Anal. Calcd. for $C_{21}H_{25}N_3O_{12}S_2$: C, 43.82; H, 4.36; N, 7.30; S, 11.13. Found: C, 43.79; H, 4.57; N, 7.35; S, 11.53.

3,4,6-Tri-*O*-acetyl-2-deoxy-2-(2,4-dinitroanilino)-α-D-glucopyranosyl Bromide (VII). A. From 3,4,6-Tri-*O*-acetyl-1-*S*-acetyl-2-deoxy-2-(2,4-dinitroanilino)-1-thio-β-D-glucopyranose (V).—A solution of V[7] (100 mg.) in methylene chloride (5 ml.) at room temperature was treated dropwise with a slight excess of bromine in methylene chloride, and after 10 min. at room temperature the solution was concentrated and triturated with ether to give a crystalline product, which was filtered and washed well with ether; yield, 75 mg. (75%); m.p. 150–152° dec., undepressed on admixture with authentic VII[7]; infrared spectrum identical with that of authentic VII.

B. From 3,4,6-Tri-*O*-acetyl-2-deoxy-2-(2,4-dinitroanilino)-β-D-glucopyranosyl Ethylxanthate (VI).—Under conditions similar to those used in A above, VI (100 mg.) gave 80 mg. (86%) of VII, m.p. 150–152°, with an infrared spectrum indistinguishable from that of authentic material.

3,4,6-Tri-*O*-acetyl-2-amino-2-deoxy-α-D-glucopyranosyl Chloride Hydrochloride (X). A. From 3,4,6-Tri-*O*-acetyl-2-anisylideneamino-2-deoxy-β-D-glucopyranosyl Ethylxanthate (IX).—Chlorine was passed for 5 min. through a solution of IX[21] (1.0 g.) in anhydrous ether (30 ml.). A gummy product separated, and after 10 min. the ether was decanted and the residue triturated with anhydrous ether, whereupon it solidified, to give X in practically quantitative yield. Recrystallization from methylene chloride–ether was effected with little loss to give pure X; m.p. 155–157° dec., raised to 161–163° on further recrystallization; $[\alpha]^{20}D$ +146 ± 1° (*c* 0.5, chloroform); λ_{max}^{KBr} 2.90 (NH_3^+), 5.75 (OAc), 6.25 (NH_3^+), 13.55 μ (C–Cl); X-ray powder diffraction data[19]: 13.39 vw, 11.19 w, 10.28 s (1), 7.76 s (2), 5.47 m, 5.04 m, 4.77 m, 4.55 w, 4.33 m (3), 4.13 m (3,3), 3.93 vw, 3.87 vw.

Anal. Calcd. for $C_{12}H_{19}Cl_2NO_7$: C, 40.00; H, 5.27; Cl, 19.72; N, 3.88. Found: C, 40.26; H, 5.14; Cl, 19.50; N, 3.96.

B. From 3,4,6-Tri-*O*-acetyl-2-amino-2-deoxy-β-D-glucopyranosyl Ethylxanthate Hydrochloride (VIII).—Chlorine was passed for 5 min. through a suspension of VIII[7] (50 mg.) in methylene chloride (10 ml.) at 0°. The suspended material dissolved during this time, and concentration of the solution after an additional 10 min. at room temperature gave crystalline X; yield, 25 mg. (60%); m.p. 155–157° dec.; infrared spectrum identical with that of material isolated by procedure A above.

Attempted Reaction of 2-(Glycosyl)-2-thiopseudourea Derivatives with Chlorine and Bromine. A. Reaction of 2-[3,4,6-Tri-*O*-acetyl-2-deoxy-2-(2,4-dinitroanilino)-β-D-glucopyranosyl)-2-thiopseudourea Hydrobromide (XI) with Bromine.—A suspension of XI[7] (100 mg.) in methylene chloride was treated with a slight excess of bromine in methylene chloride at room temperature. After 1 hr. the undissolved solid was filtered and washed with methylene chloride, to give a quantitative return of material indistinguishable from the starting material by mixture melting point and infrared spectrum.

B. Reaction of 2-(2-Acetamido-3,4,6-tri-*O*-acetyl-2-deoxy-β-D-glucopyranosyl)-2-thiopseudourea Hydrochloride (XII) with Chlorine.—Chlorine was passed for 10 min. through a suspension of XII[7] (500 mg.) in methylene chloride at 0°. After 1 hr. at room temperature the suspension was filtered to give a quantitative return of starting material.

2,3,4,6-Tetra-*O*-acetyl-β-D-glucopyranosylsulfenyl Bromide (XIV).—A slight excess of bromine in carbon tetrachloride was added to a solution of 2,3,4,6-tetra-*O*-acetyl-1-*S*-acetyl-1-thio-β-D-glucopyranose (XIII)[7,14] (0.30 g.) in carbon tetrachloride (10 ml.). After 5 min. at room temperature the pale yellow solution was evaporated, reevaporated twice from small quantities of anhydrous ether to give a fully crystalline product; yield, 0.25 g. (75%); m.p. 102–104° (browning); $[\alpha]^{21}D$ −59 ± 1° (*c* 0.64, chloroform), $[\alpha]^{22}D$ −58 ± 1.5° (*c* 0.36, ether), both unchanged

(16) C. G. Moore and M. Porter, *J. Chem. Soc.*, 2890 (1958).

(17) I. B. Douglass, in "Organic Sulfur Compounds," Vol. 1, N. Kharasch, Ed., Pergamon Press, London, 1961, p. 350.

(18) D. Horton and D. H. Hutson, *Advan. Carbohydrate Chem.*, **18**, 123 (1963).

(19) Melting points were taken with a Hershberg apparatus. Infrared spectra were measured with a Perkin-Elmer "Infracord" infrared spectrophotometer. Microanalytical determinations were made by W. N. Rond. X-Ray powder diffraction data give interplanar spacings, Å., for CuKα radiation. Relative intensity, estimated visually: s, strong; m, medium; w, weak; v, very. First few lines are numbered (1 strongest); double numbers indicate approximately equal intensities.

(20) Silica Gel Davison, Grade 950, 60–200 mesh, a product of the Davison Division of the W. R. Grace Chemical Co., Baltimore, Md.

(21) Prepared by Dr. D. H. Hutson of this laboratory by the method of Meyer zu Reckendorf and Bonner.[18]

after 4 hr.; λ_{max}^{KBr} 5.90 μ (OAc); $\lambda_{max}^{C_2H_5OH}$ 210 (1215), 256 mμ (ϵ 731); X-ray powder diffraction data[19]: 12.81 w, 11.19 s (2), 9.83 s (2,2), 8.93 s (2,2), 6.61 vw, 6.24 vw, 5.19 m (3), 4.85 s (1), 4.48 m, 4.11 s (1,1), 3.71 w, 3.56 w.

Anal. Calcd. for $C_{14}H_{19}BrO_9S$: C, 37.92; H, 4.28; Br, 18.05; S, 7.22. Found: C, 38.18; H, 4.74; Br, 18.00; S, 7.48.

The product could be stored unchanged in a desiccator for 2 days at 25°, but it changed to an oil during the third or fourth day.

Preparation of Some *trans*-Aminomercaptofuranose Sugars[1]

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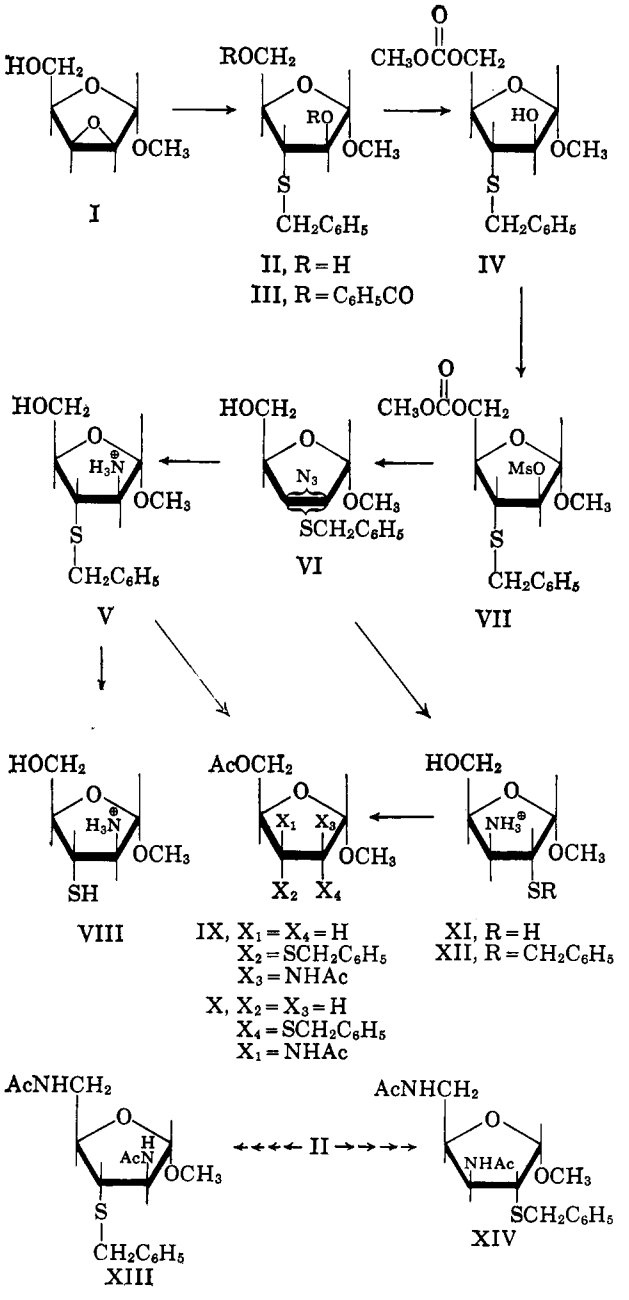
Received June 5, 1963

Two *trans*-aminomercapto glycosides, methyl 2-amino-2-deoxy-3-thio-α-D-arabinofuranoside hydrochloride (VIII) and methyl 3-amino-3-deoxy-2-thio-α-D-xylofuranoside hydrochloride (XI), have been prepared using the benzylthio neighboring group approach. Assignments of structure of the intermediates to the final products were made on the basis of n.m.r. interpretation. An estimate is made of the relative amount of ring-opening at the two carbons of an episulfonium ion intermediate.

Use of the benzylthio moiety as a neighboring group permitted the synthesis of two *trans*-aminomercaptopyranose glycosides.[2] The extension of these techniques to some furanosides has now led to the preparation of methyl 2-amino-2-deoxy-3-thio-α-D-arabinofuranoside hydrochloride (VIII) and the isomeric *trans*-aminomercaptan, methyl 3-amino-3-deoxy-2-thio-α-D-xylofuranoside hydrochloride (XI).

Both glycosides VIII and XI were derived from methyl 2,3-anhydro-α-D-lyxofuranoside (I).[3] Treatment of I with sodium benzyl mercaptide gave an excellent yield of a sirup that could be converted, in good yield, to a crystalline dibenzoate. Ring opening of 2,3-anhydrofuranosides has been generally observed to occur predominantly at C-3[4] and, on this basis, the diol II that formed the dibenzoate III was the expected major product. The structure assignment for III was verified by the nuclear magnetic resonance spectrum which showed the C-1 proton as a sharp singlet not visibly coupled to the *trans*-proton at C-2; the 2-benzylthio isomer of III would be expected to show its C-1 proton as a doublet with $J \cong 5$ c.p.s. according to its n.m.r. spectrum.[5b] The situation with the α-anhydrolyxoside (I) contrasts with that in the reaction of methyl 2,3-anhydro-β-D-lyxofuranoside and sodium benzyl mercaptide where the predominant product results from attack at C-2 of the epoxide.[5a] It seems probable that steric factors decide the position of attack in these two anomers; the bulky mercaptide ion's access to C-2 is seriously hindered by the C-1 methoxyl group in I but not in the β-anomer of I.

It was necessary to block the C-5 hydroxyl of II and this was done conveniently by reaction of II with slightly more than one equivalent of methyl chloroformate to give IV, which contained some II as shown by subsequent reactions. Use of the trityl blocking group for the C-5 hydroxyl gave poorer results. Treat-



(1) This work was carried out under the joint auspices of the Office of the Surgeon General, Medical Research and Development Command, under Contract No. DA 49-193-MD-2068 and of the Cancer Chemotherapy National Service Center, National Cancer Institute, National Institutes of Health, Public Health Service under Contract No. SA-43-ph-1892. The opinions expressed in this article are those of the authors and not necessarily those of either sponsoring agency.

(2) (a) J. E. Christensen and L. Goodman, *J. Am. Chem. Soc.*, **83**, 3827 (1961); (b) L. Goodman and J. E. Christensen, *J. Org. Chem.*, **28**, 158 (1963).

(3) B. R. Baker, R. E. Schaub, and J. H. Williams, *J. Am. Chem. Soc.*, **77**, 7 (1955).

(4) For leading references, see C. D. Anderson, L. Goodman, and B. R. Baker, *ibid.*, **80**, 5247 (1958).

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