and liquid junction potentials were neglected throughout, and hence the experimental values are nonthermodynamic dissociation constants.[21]

(21) Tables listing the potentiometric titration results and the calculated pK values over the titration range are given in ref. 4b.

Acknowledgment.—We are indebted to the Mellon Institute for the use of laboratory facilities and to Dr. Myra Gordon for the determination of p.m.r. spectra. A sample of acid **14** was provided through the generosity of Professor Dietmar Seyferth.

Synthetic Nucleosides. LXV.[1a] Studies on the Synthesis of *cis*-2,3-Diamino Sugars. V.[1b] Neighboring Group Reactions with Derivatives of Methyl 2-Amino-4,6-*O*-benzylidene-2-deoxy-α-D-altropyranoside[1c]

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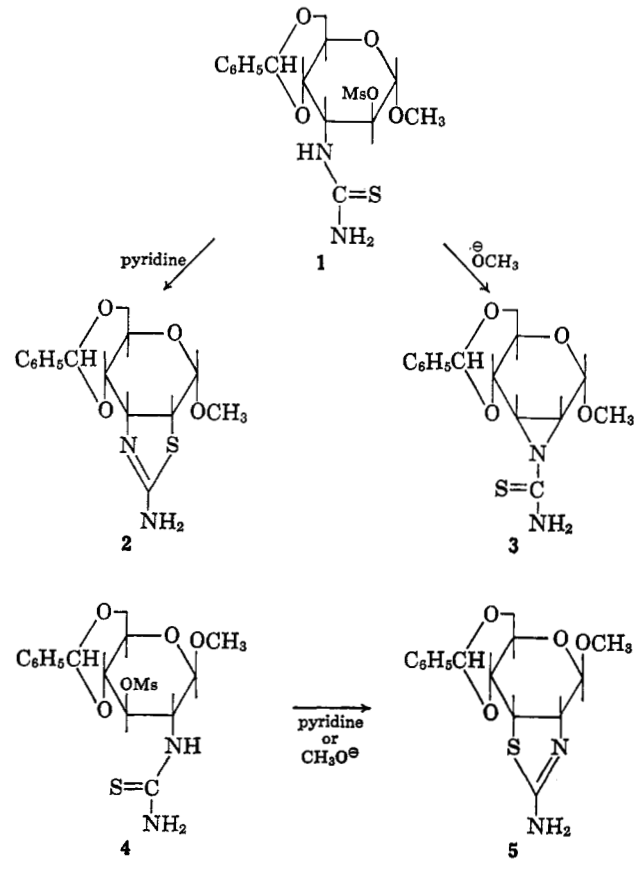
Treatment of methyl 4,6-*O*-benzylidene-*N*-cyano-2-deoxy-2-(*p*-tolylsulfonamido)-3-*O*-(*p*-tolylsulfonyl)-α-D-altropyranoside (**10a**) with hydrogen sulfide gave the *N*-detosylated thioureido derivative, methyl 4,6-*O*-benzylidene-2-deoxy-3-*O*-(*p*-tolylsulfonyl)-2-thioureido-α-D-altropyranoside (**16**). Cyclization of **16** in pyridine or ethanolic solution gave 2-amino-4′,6′-*O*-benzylidene-1′-*O*-methyl-α-D-mannopyrano[2′,3′:4,5]-2-thiazoline (**17**). In contrast, anionic cyclization of the ureido derivative, methyl 4,6-*O*-benzylidene-2-deoxy-3-*O*-(*p*-tolylsulfonyl)-2-ureido-α-D-altropyranoside (**25**), gave the aziridine, methyl 4,6-*O*-benzylidene-*N*-carbamoyl-2,3-dideoxy-2,3-imino-α-D-mannopyranoside (**26**). These results further confirm the generality that formation of aziridines readily occurs when the requisite substituents are *trans*-diaxial to each other. Addition of benzylamine to **10a** gave, after cyclization and hydrolysis, a derivative of 2,3-diamino-2,3-dideoxy-D-mannose.

Recent studies[1b,2-4] directed to the synthesis of *cis*-2,3-diamino sugars showed that a secondary sulfonate ester group could be displaced by a trifunctional neighboring group[5] to give three- or five-membered rings depending upon the conditions of the reactions. Thus, in pyridine solution the sulfonate ester in methyl 4,6-*O*-benzylidene-3-deoxy-2-*O*-methanesulfonyl-3-thioureido-α-D-altropyranoside (**1**) was displaced by the thioureido sulfur atom to give 2-amino-4′,6′-*O*-benzylidene-1′-*O*-methyl-α-D-allopyrano[3′,2′:4,5]-2-thiazoline (**2**) (Scheme I).[3] However, under conditions sufficiently basic to form an anion (methanolic sodium methoxide), the sulfonate ion was displaced by the secondary nitrogen atom to give the aziridine derivative, methyl 4,6-*O*-benzylidene-2,3-dideoxy-2,3-imino-*N*-thiocarbamoyl-α-D-allopyranoside (**3**).[3]

Ring closure of **1** to form the aziridine **3** can be attributed to the *trans*-diaxial disposition of the attacking and departing groups. The anion of the secondary nitrogen atom is thus ideally positioned to effect an intramolecular nucleophilic displacement of the mesylate; the anion of the primary nitrogen or of the sulfur are not so advantageously placed and furthermore would suffer hindrance by the axial C-1 methoxyl.[7] Under conditions insufficiently basic to form an anion, displacement by the most nucleophilic function, in this case the thione group, is the expected course of reaction.

SCHEME I[1e]



In methyl 4,6-*O*-benzylidene-2-deoxy-3-*O*-methanesulfonyl-2-thioureido-β-D-glucopyranoside (**4**) ring closure occurs in pyridine or sodium methoxide solution to give only the thiazoline **5**.[3] The lack of aziridine formation from **4** undoubtedly results from the *trans*-

(1) (a) For the previous paper in this series, see B. R. Baker and D. H. Buss, *J. Org. Chem.*, **30**, 2308 (1965). (b) For the previous paper in this series, see B. R. Baker and T. Neilson, *ibid.*, **29**, 1063 (1964). (c) This work was supported in part by Grant CY-5845 of the National Cancer Institute, U. S. Public Health Service. (d) National Science Foundation Postdoctoral Fellow, 1963–1964. (e) Abbreviations used: Ac = acetyl; Bz = benzoyl; Ms = mesyl = methanesulfonyl; and Ts = tosyl = *p*-tolylsulfonyl.

(2) B. R. Baker and T. Neilson, *J. Org. Chem.*, **29**, 1047 (1964).

(3) B. R. Baker and T. Neilson, *ibid.*, **29**, 1051 (1964).

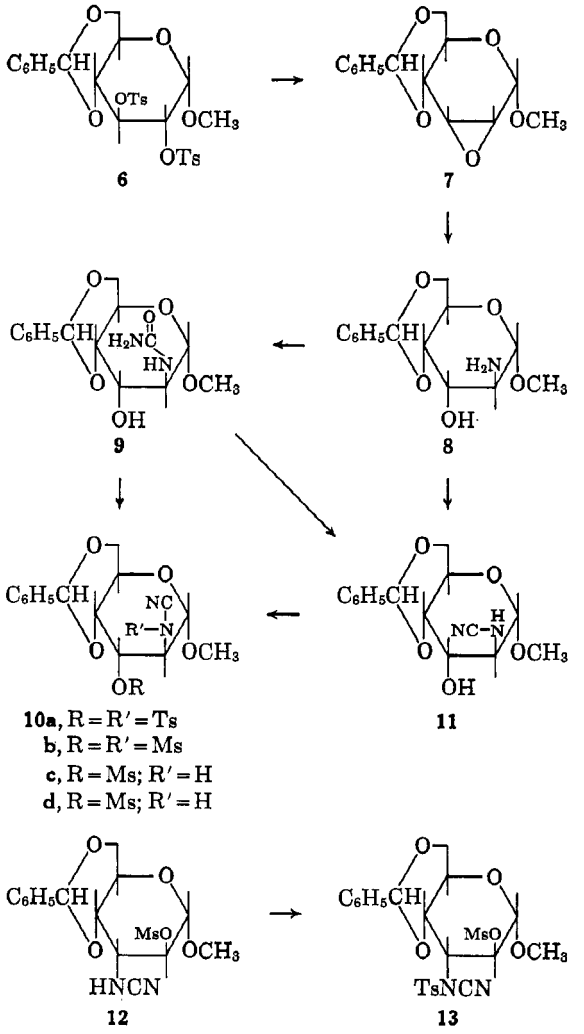
(4) B. R. Baker and T. Neilson, *ibid.*, **29**, 1057 (1964).

(5) Such groups may alternatively be termed tridentate neighboring groups to follow the terminology of Scott and Flynn.[6]

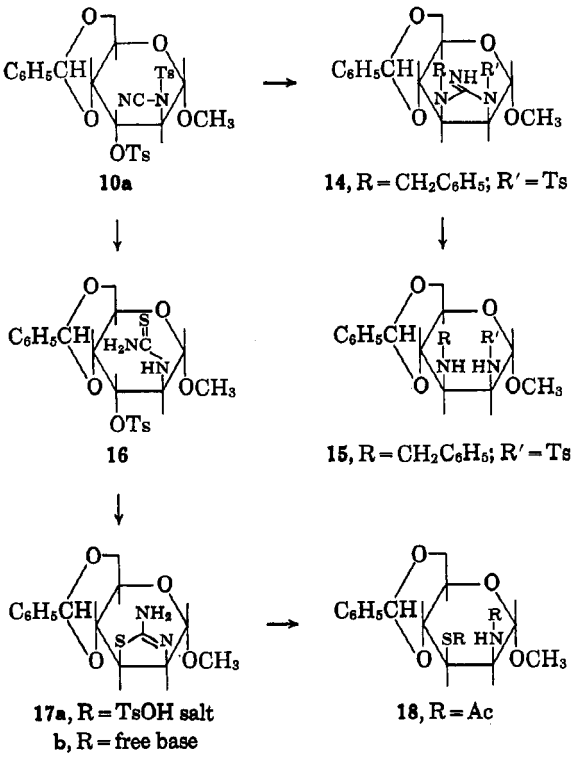
(6) F. L. Scott and E. Flynn, *Tetrahedron Letters*, 1675 (1964).

(7) D. H. Buss, L. Hough, and A. C. Richardson, *J. Chem. Soc.*, 5295 (1963).

SCHEME II



SCHEME III



diequatorial conformation of the requisite substituents in **4**.

To examine the generality of these findings, it was considered desirable to study another system also containing *trans*-diaxial substituents at C-2 and C-3. For this purpose, derivatives of methyl 2-amino-4,6-*O*-benzylidene-2-deoxy-α-D-altropyranoside (**8**) have been synthesized and their mode of ring closure in pyridine and methanolic sodium methoxide has been studied. The results obtained form the subject of this paper.

Reaction of methyl 2-amino-4,6-*O*-benzylidene-2-deoxy-α-D-altropyranoside[8,9a] (**8**) with cyanic acid in aqueous ethanol[3] gave methyl 4,6-*O*-benzylidene-2-deoxy-2-ureido-α-D-altropyranoside (**9**) in 84% yield (Scheme II). Attempted conversion of **9** to the cyanamido mesylate (**10c**) by the action on **9** of mesyl chloride (4.3 molar equiv.) in pyridine[3] gave a mixture of products estimated by elemental analysis to consist of 83% **10c** and only 17% of **10b**; neither could be crystallized. A similar distribution of products was obtained when the reaction was carried out using only 2.2 equiv. of mesyl chloride. The action of 1.3 molar equiv. of mesyl chloride on **9** gave a mixture of products; infrared analysis showed dehydration to be incomplete and that both *N*- and 3-*O*-mesylation had occurred, thus demonstrating that *N*-mesylation of the cyanamido group, *O*-mesylation of the alcohol, and dehydration of the urea group (*via* its *O*-mesyl derivative) were competitive in rate.

This lack of selectivity was further demonstrated by mesylation of the preformed cyanamide **11**; both *N*- and 3-*O*-mesylation were obtained with 2.2 equiv. of mesyl chloride. Since little selectivity in acylation was observed, the synthesis of methyl 4,6-*O*-benzylidene-N-cyano-2-deoxy-2-methanesulfonamido-3-*O*-methanesulfonyl-α-D-altropyranoside (**10b**) was attempted using 9 molar equiv. of mesyl chloride. Elemental analysis indicated the resulting product to be about 90% pure, but again no crystalline compound could be obtained.

Since the reaction of mesyl chloride on **9** failed to furnish the desired **10c** and since the dimesyl derivative, **10b**, could not be crystallized, the action of tosyl chloride on **9** was studied in the hope of achieving more selective acylation.[10] Reaction of **9** with 4.5 molar equiv. of tosyl chloride at 50°[11,12] furnished highly crystalline methyl 4,6-*O*-benzylidene-*N*-cyano-2-deoxy-2-(*p*-tolylsulfonamido)-3-*O*-(*p*-tolylsulfonyl)-α-D-altropyranoside (**10a**) in 69% yield. Two molar equivalents of tosyl chloride at 25° furnished a mixture of **10a** and methyl 4,6-*O*-benzylidene-2-cyanamido-2-deoxy-α-D-altropyranoside (**11**); at 5° a quantitative yield of **11** was obtained. Reaction of **8** with cyanogen bromide afforded an alternative synthesis of **11**. Thus, even though tosyl chloride did not react so

(8) G. J. Robertson, W. H. Myers, and W. E. Tetlow, *Nature*, **142**, 1076 (1938); W. H. Meyers and G. J. Robertson, *J. Am. Chem. Soc.*, **65**, 8 (1943).

(9) (a) S. N. Danilov and I. S. Lishanskii, *Zh. Obsch. Khim.*, **25**, 2106 (1955); *Chem. Abstr.*, **50**, 8462*f* (1956). These authors report a 94% yield of **7** when the ring closure was run only 20 hr. at room temperature. (b) Prepared by the method of D. A. Rosenfeld, N. K. Richtmeyer, and C. S. Hudson, *J. Am. Chem. Soc.*, **70**, 2201 (1948).

(10) (a) B. Helferich and A. Gnüchtel, *Ber.*, **71**, 712 (1938); (b) R. S. Tipson, *Advan. Carbohydrate Chem.*, **8**, 107 (1953).

(11) *Cf.* M. Gyr and T. Reichstein, *Helv. Chim. Acta*, **28**, 226 (1945).

(12) *Cf.* K. Hess and H. Stenzel, *Ber.*, **68**, 981 (1935).

rapidly as did mesyl chloride, it could dehydrate the urea selectively to the cyanamide **11**, but further tosylation at *O*-3 or at the NH of the cyanamide occurred at competitive rates.

The facility of this *N*-sulfonylation in the 2-amino-D-altrose series (**10**) is particularly striking because it was not observed in the previous studies of derivatives of the 3-amino-D-altrose (**1**) and 2-amino-D-glucose[3] or in the 3-amino-D-glucose series.[13] However, *N*-mesylation does occur readily in the treatment of methyl 3-deoxy-3-ureido-β-D-arabinofuranoside with mesyl chloride.[14] The relative ease with which **9** undergoes *N*-tosylation is evident from the observation that methyl 4,6-*O*-benzylidene-3-cyanamido-3-deoxy-2-*O*-methanesulfonyl-α-D-altropyranoside (**12**) was only partially converted to its *N*-tosyl derivative (**13**)[15] under conditions which completely converted **11** to **10a**.

Reaction of **10a** with benzylamine (8 molar equiv.) in refluxing ethanol[1b] gave, presumably, an intermediate guanidine derivative which cyclized under the reaction conditions to give impure 1-benzyl-2-imino-3-(*p*-tolylsulfonyl)-4′,6′-*O*-benzylidene-1′-*O*-methylmannopyrano[2′,3′:4,5]imidazolidine (**14**) (Scheme III). Vigorous alkaline hydrolysis of **14** gave methyl 3-benzylamino-4,6-*O*-benzylidene-2-(*p*-tolylsulfonamido)-α-D-mannopyranoside (**15**) in 36% over-all yield from **10a**. No effort was made to remove the blocking groups of this *cis*-2,3-diamino sugar.

Hydrogen sulfide reacted with **10a** at room temperature in pyridine solution more slowly than it did with the monosubstituted cyanamides, methyl 4,6-*O*-benzylidene-3-cyanamido-3-deoxy-2-*O*-methanesulfonyl-α-D-altropyranoside[3] and the isomeric methyl 4,6-benzylidene-3-cyanamido-3-deoxy-2-*O*-methanesulfonyl-α-D-glucopyranoside.[13] In this behavior **10a** resembled the *N*-benzylcyanamide, methyl *N*-benzyl-4,6-*O*-benzylidene-3-cyanamido-2-*O*-methanesulfonyl-α-D-altropyranoside, which only slowly added hydroxide ion or hydrogen sulfide.[4] This reaction of **10a** with hydrogen sulfide, however, did not afford the expected *N*-tosyl-*N*-thiocarbamoyl derivative, but rather products resulting from *N*-detosylation were obtained.[17]

When the reaction mixture was processed through sodium bicarbonate solution methyl 4,6-*O*-benzylidene-2-deoxy-2-thioureido-3-*O*-(*p*-tolylsulfonyl)-α-D-altropyranoside (**16**) was isolated in only 33% yield; the remaining product was identified as 2-amino-4′,6′-*O*-benzylidene-1′-*O*-methyl-α-D-mannopyrano[2′,3′:4,5]-2-thiazoline (**17b**). Since no tolylsulfonate salt (**17a**) was isolated, it is evident that the formation of **17b** occurred in the pyridine–hydrogen sulfide solution.[20] The sulfonate salt **17b** was obtained in 62% yield when the pyridine solution was concentrated directly to a solid residue which was then recrystallized from hot ethyl acetate. Alternatively, the thiazoline salt **17b** was readily obtained in high yield by simply heating **16** in ethanolic solution, the resulting thiazoline evidently acting as its own acid acceptor.

The structure of **17a** was established by effecting alkaline hydrolysis of the thiazole ring followed by acylation to furnish methyl 2-acetamido-*S*-acetyl-4,6-*O*-benzylidene-2,3-dideoxy-3-mercapto-α-D-mannopyranoside (**18**). This result demonstrates that ring closure of **16** in weakly basic solution occurred by the expected sulfur attack to afford the thiazoline **17**. Thus, the 2-thioureido-3-*O*-(*p*-tolylsulfonyl)-D-*altro* system (**16**) and the corresponding 2-*O*-methanesulfonyl-3-thioureido-D-*altro* system (**1**)[3] with *trans*-diaxial neighboring groups both undergo ring closure in weakly basic solution by sulfur attack to afford thiazolines.

Since **10c** or **10d** could not be obtained pure and since the preparation of **16** was tedious and capricious, it was not easily possible to examine the reaction of **16** under strongly basic conditions. Consequently, attention was turned to the preparation of the ureido tosylate **25** using a series of reactions employed previously (Scheme IV).[4] Reaction of **8** with 1-naphthaldehyde gave crystalline methyl 2-amino-4,6-*O*-benzylidene-2-deoxy-*N*-(1-naphthylidene)-α-D-altropyranoside (**19a**) in 90% yield. The action of tosyl chloride at 50° effected conversion of **19a** to crystalline methyl 2-amino-4,6-*O*-benzylidene-2-deoxy-*N*-(1-naphthylidene)-3-*O*-(*p*-tolylsulfonyl)-α-D-altropyranoside (**20a**) in 70% yield. No crystalline compounds were obtained when **8** was treated with benzaldehyde, 4-nitrobenzaldehyde, and 4-methoxybenzaldehyde (**19b–d**) nor when the resulting anils (**19b, c**) were mesylated (**21**). However, tosylation of sirupy **19b** afforded crystalline methyl

(13) B. R. Baker and T. L. Hullar, *J. Org. Chem.*, **30**, 4045 (1965).

(14) B. R. Baker and T. L. Hullar, *ibid.*, **30**, 4053 (1965).

(15) It is known that reaction of phenylcyanamide with 2 equiv. of benzenesulfonyl chloride in pyridine gives benzenesulfonylphenylcyanamide in 60% yield.[16] Consequently, the selective *N*-sulfonylation of sugar cyanamides most likely depends upon steric factors. Inspection of molecular models suggests that *N*-acylation occurs in those compounds where the nitrogen atom is exposed rather openly to the solvent medium and where the NH of the cyanamido group is not crowded by adjacent groups. Thus, in the 2-amino-D-*altro* derivative **11**, the NH of the cyanamido group is openly exposed to the medium. The only deterrents to approach of the sulfonylating agent are the slight steric interference of the axial C-4 hydrogen and an electrical repulsion by the ring oxygen.

In **12**, the N-cyano group, because of its size, most likely extends away from the ring into the solvent. This results in the *N* hydrogen and the unshared pair of electrons being crowded next to the C-1 and C-4 oxygens. These two oxygens will tend to prevent *N*-mesylation since they could exert a repulsive force on the bulky and electronegative mesyl chloride. *O*-Mesylation of **12** can readily occur since as for the cyanamido group in **11** only minor repulsions are encountered by the sulfonylating agent. Similar arguments explain the resistance to *N*-mesylation of the diequatorial compounds, methyl 4,6-*O*-benzylidene-3-cyanamido-3-deoxy-2-*O*-methanesulfonate-α-D-glucopyranoside[13] and the analogous 2-amino isomer.[3]

(16) F. Kurzer, *J. Chem. Soc.*, 1034 (1949).

(17) The nature of the detosylation reaction is not clear. Two processes may be suggested. The susceptibility of sulfonamides to reductive cleavage[18] and the isolation of molecular sulfur from the reaction mixture strongly suggest that detosylation occurred by a reductive process. Such a cleavage would be expected to occur at the tosylcyanamide level (**10a**) since the addition of hydrogen sulfide to *N,N*-disubstituted cyanamides of sugars is known to be a slow process[4] and the N-cyano group may be expected to labilize the *N–S* bond.

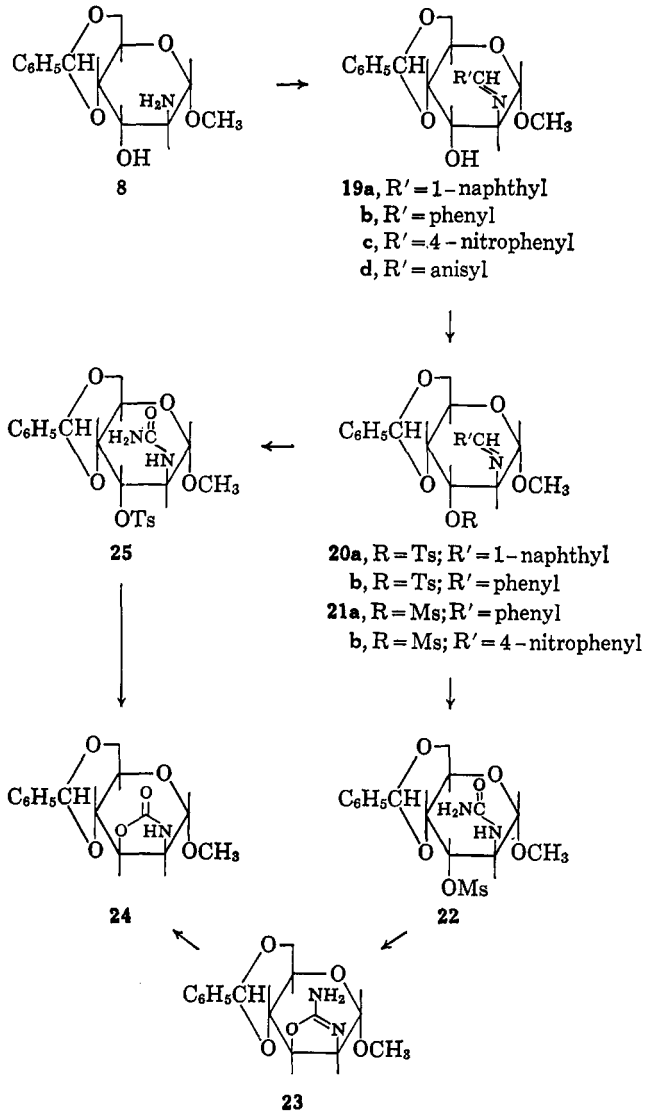
Solvolysis of the sulfonamide by the pyridine is rendered unlikely since alkaline cleavage of sulfonamides bearing electron-withdrawing substituents normally requires the employment of strong bases[19] or amines at high temperatures.[19] These facts are in agreement with the observation that **10a** undergoes reactions with benzylamine in refluxing ethanol to give an imidazolidine derivative (**14**) which contains the *N*-tosyl group (**10a** → **15**). Therefore, solvolytic cleavage of the sulfonamide **10a** under anhydrous conditions by the weakly basic amine, pyridine, at room temperature seems highly improbable.

(18) See S. Searles and S. Nukina, *Chem. Rev.*, **59**, 1077 (1959), for a general review of the cleavage of sulfonamides.

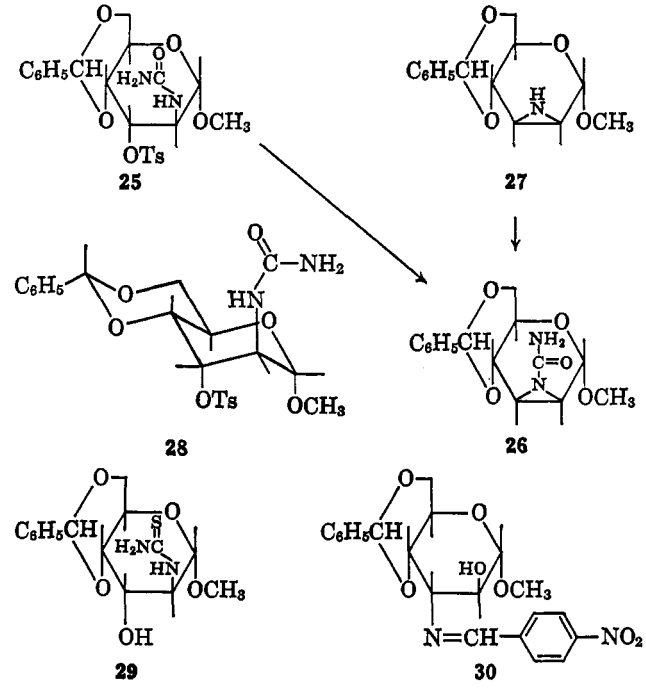
(19) Y. Takata, *J. Pharm. Soc. Japan*, **71**, 1474 (1951); *Chem. Abstr.* **46**, 8036*f* (1952); see ref. 18 for additional references.

(20) This facile ring closure of a 2-thioureido-D-altrose derivative is noteworthy because in the 3-amino-D-altrose series[3] the uncyclized thioureido derivative **1** was isolated directly from the reaction mixture in 73% yield by spin evaporation of the pyridine and hydrogen sulfide. The lack of ring closure of **1** is probably due to the repulsive effect of the axial C-1 methoxyl of **1** preventing the ready attack by sulfur. No such hindrance to *S* attack exists for the 2-aminothioureido derivative **16**. Furthermore, the extensive 1,3-interactions in **16** caused by the axial tosylate ester and C-1 methoxyl groups would be relieved by formation of the thiazoline **17b**.

SCHEME IV



SCHEME V



2-amino-*N*-benzylidene-4,6-*O*-benzylidene-2-deoxy-3-*O*-(*p*-tolylsulfonyl)-α-D-altropyranoside (**20b**).

In the earlier study[4] treatment of methyl 3-amino-*N*-benzylidene-4,6-*O*-benzylidene-3-deoxy-2-*O*-metnanesulfonyl-α-D-altropyranoside with cyanic acid gave the corresponding urea smoothly in 78% yield. This reaction of anils with cyanic acid proceeded less satisfactorily in the present study. Thus, treatment of **20a** with aqueous cyanic acid afforded only partial reaction of the anil, indicated by strong C=N absorption still remaining at 6.05 μ in the infrared. Repetition of the cyanation allowed isolation of crystalline **25** in only 19% yield; additional **25** remained in the mother liquors, but its isolation was difficult. Complete reaction of **20b** with cyanic acid under the same conditions also required repetition of the cyanation procedure. In this case, however, a higher yield (50–60%) of **25** was obtained. A by-product in this latter reaction appeared, by infrared analysis, to be the oxazolinone **24**. Treatment of **21a** and **21b** with cyanic acid in aqueous ethanol failed to give a crystalline mesylate (**22**). On the basis of the infrared spectra of the products, the ureido mesylate **22**, which was probably formed, appeared to have undergone rapid ring closure to the 2-aminooxazoline **23** which itself was partially hydrolyzed to the 2-oxazolinone **24**.[4,21]

Treatment of **25** with refluxing methanolic sodium methoxide for 2 hr. gave methyl 4,6-*O*-benzylidene-2,3-dideoxy-2,3-imino-*N*-carbamoyl-α-D-mannopyranoside (**26**) in quantitative yield (Scheme V). Reaction of the imine **27**[7,14,22] with aqueous cyanic acid also furnished **26**.

The results obtained in this study on the ring-closure reactions of monosubstituted[23] trifunctional neighboring groups on the 2-amino group of 2-amino-D-altrose demonstrate that the direction of ring closure is dependent on the reaction medium employed. That is, ring closure in pyridine results in formation of a five-membered ring; thus, the thiourea **16** undergoes ring closure by *S*-attack to furnish the thiazoline **17**. In a strongly basic medium in which anion formation can occur,[25] such as methanolic sodium methoxide, ring closure results in a three-membered ring; thus, the urea **25** reacts with sodium methoxide to give the *N*-carbamoylaziridine **26**. Since the most stable conformation of the urea **25** maintains the tosylate ester and the ureido groups in a *trans*-diaxial disposition (**28**), the ready formation of the aziridine (**26**) supports the view, expressed at the outset, that aziridine formation will most easily occur when the anion of the secondary nitrogen atom is *trans*-diaxial to the adjacent sulfonate ester.[26]

(21) In retrospect it might be that selective hydrolysis of **20a** or **20b** to give the amine hydrochloride which could then be treated with potassium cyanate[14] offers a more attractive synthesis of **25**.

(22) R. D. Guthrie and D. Murphy, *J. Chem. Soc.*, 5288 (1963).

(23) The restriction to monosubstituted neighboring groups is important since the disubstituted neighboring group, *N*-alkyl-*N*′-phenylureas, undergo ring closure in alkali to give imidazolidinones.[14,24]

(24) F. L. Scott, R. E. Glick, and S. Winstein, *Experientia*, **13**, 183 (1957).

(25) T. Taguchi and M. Kojima, *J. Am. Chem. Soc.*, **81**, 4316 (1961).

(26) For additiona lexamples of this phenomenon, see ref. 7, 14, and 22.

Experimental Section[27]

Methyl 2-Amino-4,6-*O*-benzylidene-2-deoxy-α-D-altropyranoside (8).—Treatment of crude methyl 4,6-*O*-benzylidene-2,3-di-*O*-(*p*-tolylsulfonyl)-α-D-glucopyranoside (6)[9b] with sodium methoxide (6 molar equiv.) in a solution of 1,2-dichloroethane and methanol at room temperature for 41 hr. gave pure methyl 2,3-anhydro-4,6-*O*-benzylidene-α-D-allopyranoside (7) in 65% yield.[9a] Since the mother liquor showed sulfonate absorption (7.3 and 8.5 μ) in the infrared, the sirupy material from the mother liquors was re-treated as above with the proportionate amount of sodium methoxide to furnish additional 7 in 23% yield (88% total yield from methyl 4,6-*O*-benzylidene-α-D-glucopyranoside).

When ring closure was carried out with sodium methoxide (6 equiv.) in refluxing methanol for 4 hr., 7 was isolated in only 63% yield. The remaining material was presumably a mixture of *O*-methyl ethers since methyl 4,6-*O*-benzylidene 3-*O*-methyl-α-D-glucopyranoside,[28] m.p. 142–144° (lit.[28] m.p. 147°), was isolated in low yield. This 3-*O*-methyl ether was converted to its crystalline 2-*O*-acetyl derivative, m.p. 116–118° (lit.[28] m.p. 121°), to ensure its identity.

A suspension of 7 (5.06 g.) in methanol (40 ml.) containing ammonia (3.5–4.8 g.) was heated in a stainless steel bomb at 125–140° for 24 hr.[29] The resulting solution was concentrated to a solid residue which was recrystallized from a mixture of ethanol (100 ml.) and petroleum ether (75 ml.) to give 8 (3.66 g., 68%): m.p. 167–168°, $[\alpha]^{20}D$ +114° (0.26%, chloroform); lit.[3] m.p. 168°, $[\alpha]^{18}D$ +104.7° (1.35%, chloroform). T.l.c. showed the product to be free of the 3-amino-*gluco* isomer (R_f 0.09, R_f 0.26 for 8). A second crop (0.712 g., 13%, 81% total yield) was obtained from the mother liquors; a trace of the *gluco* isomer in the product was indicated by t.l.c.

In a second preparation, isolation of pure 8 in 79% yield followed by analysis of the mother liquor by t.l.c. indicated the ratio of *altro*–*gluco* isomers resulting from ammonolysis to be about 87:13. T.l.c. of a deliberately overloaded plate indicated that a small proportion of 7 may have been present.

Methyl 4,6-*O*-Benzylidene-2-deoxy-2-ureido-α-D-altropyranoside (9).—To a solution of 8 (10.0 g., 35.6 mmoles) in ethanol (300 ml.) at room temperature was added a solution of potassium cyanate (4.32 g., 53.4 mmoles) and glacial acetic acid (2.74 ml., 48.0 mmoles) in water (175 ml.). The clear solution was kept at room temperature for 4 hr., refluxed 50 min.,[30] and then spin evaporated until the product began to separate. The mixture was cooled at 5° overnight and then filtered to give crude 9 (9.62 g., 84%). The mother liquors were concentrated to a solid residue which was recrystallized from 95% ethanol to give a second crop of crude 9 (1.54 g., 13%). Recrystallization of the combined crops from 95% ethanol gave pure 9 as fine needles (10.42 g., 90%): m.p. 237–239°; λ_{max} 2.90, 3.09 (OH, NH), 6.19 (amide I), 6.50 (amide II), 13.08, and 14.36 μ (phenyl).

Anal. Calcd. for $C_{15}H_{20}N_2O_6$ (324.2): C, 55.53; H, 6.22; N, 8.64. Found: C, 55.65; H, 6.39; N, 8.70.

Methyl 4,6-*O*-Benzylidene-*N*-cyano-2-deoxy-2-(*p*-tolylsulfonamido)-3-*O*-(*p*-tolylsulfonyl)-α-D-altropyranoside (10a). A.—To a suspension of 9 (0.192 g., 0.6 mmole) in pyridine (6 ml.) at room temperature was added tosyl chloride (0.513 g., 2.70 mmoles). The solid dissolved within 5 min. and the resulting yellow solution, protected from moisture, was kept at 50° for 52 hr.[11] The amber solution was poured onto crushed ice (20 g.), and the mixture was extracted with three 10-ml. portions of chloroform. The combined chloroform solutions were washed with three 10-ml. portions of water, dried, and concentrated to an orange sirup (0.335 g.). The sirup was decolorized in ethyl acetate to give a light yellow glass (0.304 g., 85%) shown to be essentially homogeneous by t.l.c. A solution of the glass in ethanol–ethyl acetate–petroleum ether gave crystalline 10a (0.255 g., 69%), m.p. 184–188°. The analytical sample of 10a was obtained by recrystallization from ethyl acetate–petroleum ether: m.p. 192–193°; λ_{max} 4.46 (C≡N), 6.28 (aromatic C=C), 7.31, 8.51, 8.57 (sulfonate, sulfonamide), 13.21, and 14.35 μ (phenyl), no absorption at 2.8–3.0 μ (NH or OH).

Anal. Calcd. for $C_{29}H_{30}N_2O_9S_2$ (614.7): C, 56.67; H, 4.92; N, 4.56; S, 10.43. Found: C, 57.28; H, 4.89; N, 4.54; S, 10.43.

B.—The following results were obtained when the reaction was carried out in pyridine using 3 molar equiv. of tosyl chloride. Reaction at 5° for 11 hr. followed by heating at 50° for 71 hr. gave crude 10a in 58% yield. Retreatment of the mother liquors in pyridine with tosyl chloride allowed isolation of an additional 22% yield of 10a. Similar yields (56%) could be obtained when the time of heating at 50° was decreased to 46 hr. or when the entire reaction was carried out at room temperature for 114 hr.[12] However, if the reaction was run only at 50° (*i.e.*, without low temperatures at the initial stage), the yields decreased to approximately 45%.

C.—A solution of 11 (0.038 g., 0.124 mmole) and tosyl chloride (0.052 g., 0.264 mmole) in pyridine (0.62 ml.) was kept at 50° for 63 hr. The solution was poured onto ice (10 g.), and the mixture was extracted with three 7-ml. portions of chloroform. The combined chloroform solutions were washed with three 7-ml. portions of water, dried, and concentrated; the resulting sirup was decolorized in ethanol to give a colorless glass (0.073 g., 96%). From a solution of the glass in ethyl acetate–petroleum ether, 10a (0.053 g., 70%) crystallized, m.p. 185–188°, with an infrared spectrum identical with that for 10a prepared in A.

Methyl 4,6-*O*-Benzylidene-2-cyanamido-2-deoxy-α-D-altropyranoside (11). A.—To a stirred, ice-cooled suspension of 9 (0.100 g., 0.31 mmole) in pyridine (3 ml.) was added dropwise a solution of tosyl chloride (0.123 g., 0.65 mmole) in pyridine (1 ml.). After stirring for 15 min. the clear solution was kept at 5° for 42 hr., protected from moisture, then poured onto ice (20 g.). The aqueous mixture was extracted with three 10-ml. portions of chloroform, and the combined chloroform solutions were washed twice with 10-ml. portions of water, dried, and concentrated to a solid residue (0.111 g.) Recrystallization from ethyl acetate–petroleum ether gave short needles (0.092 g., 97%) m.p. 153–154°. Recrystallization from chloroform–petroleum ether gave the analytical sample: m.p. 156–160°; λ_{max} 2.80, 2.95, 3.05 (OH), 4.44 (C≡N), 13.10, and 14.36 μ (phenyl); no sulfonate absorption near 7.3 or 8.5 μ was observed.

Anal. Calcd. for $C_{15}H_{18}N_2O_5$ (306.3): C, 58.82; H, 5.92; N, 9.14. Found: C, 58.51; H, 6.25; N, 8.76.

If the dehydration was attempted with 1.1 molar equiv. of tosyl chloride at 5° for 50 hr. or at 25° for 6 hr., some starting material remained unchanged. If the reaction was run at 25° using 2.0 molar equiv. of tosyl chloride, 10a and 11 were formed in an approximate ratio of 1:3 respectively, as shown by t.l.c.

B.—A solution of 8 (0.100 g., 0.36 mmole) in methanol (2 ml.) containing cyanogen bromide (0.052 g., 0.49 mmole) was heated on the steam bath for 2 hr.,[1b] kept at room temperature for 18 hr., and then poured into water (10 ml.). The aqueous solution was processed as in A to give a sirup (0.097 g.) from which crystalline 11 (0.059 g., 55%), m.p. 154–158°, was obtained.

Methyl 4,6-*O*-Benzylidene-*N*-cyano-3-deoxy-2-*O*-methanesulfonyl-3-(*p*-tolylsulfonamido)-α-D-altropyranoside (13).—A solution of methyl 4,6-*O*-benzylidene-3-cyanamido-2-*O*-methanesulfonyl-α-D-altropyranoside (12, 3.84 g., 10.0 mmoles) and tosyl chloride (7.60 g., 40.0 mmoles) in pyridine (25 ml.) was kept at 50° for 95 hr. Excess tosyl chloride was decomposed by addition of water (0.5 ml.) and the amber solution was poured onto ice (75 g.). The aqueous solution was extracted four times with 20-ml. portions of chloroform, and the combined chloroform solutions were washed with three 20-ml. portions of water, dried, decolorized, and concentrated to a solid residue (5.215 g., 97%). Since the product was quite insoluble in ethyl acetate, the residue was triturated with refluxing ethyl acetate (15 ml.) to remove the

(27) Melting points were taken with a Fisher-Johns melting block and those below 230° are corrected. Infrared spectra were determined in KBr disks, unless otherwise indicated, with a Perkin-Elmer Model 137B spectrophotometer. Optical rotations were determined in *N*,*N*-dimethylformamide, unless otherwise stated, in a 1-dm. microtube, and concentrations are indicated in grams per 100 ml. as per cent. Petroleum ether used throughout was a fraction of b.p. 30–60°. Thin layer chromatography (t.l.c.) was done with silica gel G using chloroform–acetone (4:1 by volume) as the solvent system; the compounds were detected by exposing the plates to iodine vapor, and the relative proportions of the components were estimated visually. Chloroform extracts were dried over anhydrous magnesium sulfate. All solutions were concentrated by spin evaporation at 60–70° at reduced pressure (aspirator) unless otherwise indicated. Whenever pyridine was employed in a reaction, the residual pyridine in the chloroform extract was always removed by repeated spin evaporation of toluene until the odor of pyridine was absent.

(28) E. J. Bourne, M. Stacey, C. E. M. Tatlow, and J. C. Tatlow, *J. Chem. Soc.*, 826 (1951).

(29) In the conversion of 9 to 10a, 7 was isolated in 12% yield. Thus, it is believed that the conditions of ammonolysis employed here were insufficient to convert 7 completely to 8.

(30) In smaller runs the solution was kept only 30 min. at room temperature and refluxed an additional 30 min.

yellow color and leave **13** as a nearly white crystalline mass (3.710 g., 69%). Recrystallization was achieved by dissolving the crude **13** in the minimum volume of refluxing ethyl acetate (150 ml.) and then concentrating the solution at 70° to a 50-ml. volume. Crystallization occurred spontaneously from the hot solution. After standing overnight at room temperature, the mixture was diluted with petroleum ether and kept at 5°. If the petroleum ether were added before crystallization from ethyl acetate was complete, the crystals were slightly yellow due to precipitation of impurities in the mother liquors. Analysis by t.l.c. showed the product to be pure (R_f 0.93) and the mother liquor to contain three components of R_f 0.93, 0.85, and 0.075, present in the approximate proportions of 1:1:5, respectively.

The analytical sample had m.p. 225–228°; λ_{max} 4.44 (C≡C), 6.26 (C=C), 7.23, 8.50 (sulfonate), 7.46, 8.53 (sulfonamide), 13.66, and 14.21 μ (phenyl); the absorption of 3.00 μ (NH) had disappeared.

Anal. Calcd. for $C_{28}H_{26}N_2O_9S_2$ (538.6): C, 51.29; H, 4.86, N, 5.20; S, 11.91. Found: C, 51.21; H, 4.92; N, 5.04; S; 11.76.

Treatment of **12** (0.384 g., 1.0 mmole) with tosyl chloride (0.285 g., 2.0 mmoles) in pyridine (5 ml.) at 50° for 48 hr. gave a partially tosylated product as shown by t.l.c. and by infrared absorption at 3.0 μ (NH). Retreatment in the same manner resulted in a product containing **13** and only a trace of **12**.

1-Benzyl-2-imino-3-(*p*-tolylsulfonyl)-4′,6′-*O*-benzylidene-1′-*O*-methyl-α-D-mannopyrano[2′,3′:5,4]imidazolidine (14).—A solution (stirred) of **10a** (1.233 g., 2.0 mmoles) in ethanol (25 ml.) containing benzylamine (1.75 ml., 16.0 mmoles) was refluxed, a clear solution being obtained after 10 min. After 16 hr. at reflux, the clear yellow solution was cooled and poured into water (10 ml.). The aqueous solution was extracted with three 10-ml. portions of chloroform, and the combined chloroform solutions were washed twice with 10-ml. portions of water, dried, and concentrated to give a yellow sirup (2.146 g.) which did not crystallize. By decolorization in ethanol, the analytical sample was obtained as a pale yellow sirup and was dried at 78° *in vacuo* for 21.5 hr.: $\lambda_{max}^{chloroform}$ 3.02 (NH), 6.10 (C=N), 7.55, 8.60 (sulfonamide), and 14.30 μ (phenyl).

Anal. Calcd. for $C_{29}H_{31}N_3O_6S$ (549.6): C, 63.37; H, 5.68; N, 7.64; S, 5.83. Found: C, 63.64; H, 5.90; N, 7.69; S, 6.01.

Methyl 3-Benzylamino-4,5-*O*-benzylidene-2,3-dideoxy-2-(*p*-tolylsulfonamido)-α-D-mannopyranoside (15).—A solution of sirup **14** (1.958 g.) in ethanol (7 ml.) was combined with water (7 ml.) and potassium hydroxide (7 g.) in a stainless steel bomb and heated at 148–152° for 92 hr. The cooled solution, which had a sharp, acrid smell, was neutralized with glacial acetic acid and then extracted with three 10-ml. portions of chloroform. The combined chloroform solutions were extracted with three 10-ml. portions of water, dried, and concentrated to an amber sirup. The sirup was decolorized in ethanolic solution, and, after concentration, was triturated with ethanol to give **15** (0.374 g., 36% yield from **10a**), m.p. 108–110°. The analytical sample was recrystallized from ethyl acetate–petroleum ether and from chloroform–petroleum ether to give dense, white plates: m.p. 114–115°; λ_{max} 3.01 (NH), 6.24 (C=C), 7.54, 8.58 (sulfonamide), 13.42, and 14.20 μ (phenyl).

Anal. Calcd. for $C_{28}H_{32}N_2O_6S$ (524.6): C, 64.10; H, 6.15; N, 5.34; S, 6.11. Found: C, 64.10; H, 5.94; N, 5.10; S, 6.24.

Methyl 4,6-*O*-Benzylidene-2-deoxy-2-thioureido-3-*O*-(*p*-tolylsulfonyl)-α-D-altropyranoside (16).—Into an ice-cooled solution of **10a** (1.00 g., 1.62 mmoles) in pyridine (25 ml.) was bubbled hydrogen sulfide gas (about 1.4 g., 41 mmoles, absorbed). The yellow solution was kept at room temperature in a stoppered flask for 49 hr. and then poured into saturated aqueous sodium bicarbonate (20 ml.). The aqueous solution was extracted with three 15-ml. portions of chloroform, and the combined chloroform solutions were washed with three 15-ml. portions of water, dried, and concentrated to a solid yellow residue (0.864 g.). The solids were triturated with four 2-ml. portions of toluene at room temperature and were each time collected by centrifugation. The remaining solids were finally washed with petroleum ether and air dried to give **16** (0.264 g., 33%), m.p. 203–205°. Recrystallization from *N,N*-dimethylformamide–ethyl acetate–petroleum ether gave the analytical sample: m.p. 205–208°; λ_{max} 2.84, 2.94 (NH), 6.16, 6.64 (NH), 7.42, 8.50, 8.55 (sulfonate), 7.53 (C=S), 13.24, and 14.38 μ (phenyl).

Anal. Calcd. for $C_{22}H_{26}N_2O_7S_2$ (494.6): C, 53.43; H, 5.30; N, 5.66; S, 12.96. Found: C, 53.29; H, 5.25; N, 5.62; S, 12.99.

The toluene-soluble material (0.600 g.) gave an infrared spectrum similar to that of the thiazoline **17b**.

2-Amino-4′,6′-*O*-benzylidene-1′-*O*-methyl-α-D-mannopyrano-[2′,3′:4,5]-2-thiazoline *p*-Tolylsulfonate (17a). A.—Into an ice-cooled solution of **10a** (1.875 g., 3.05 mmoles) in pyridine (18 ml.) was bubbled hydrogen sulfide (about 0.9 g. absorbed). The yellow solution was kept at room temperature for 20 hr. and then concentrated at room temperature to give a crystalline residue (2.195 g.) which still showed weak C≡N absorption at 4.48 μ. Therefore, the material was re-treated as above with hydrogen sulfide, kept at room temperature for 42 hr., and concentrated at room temperature to give a yellow sirup (2.587 g.). The sirup was dissolved in refluxing ethyl acetate; the salt **17a** slowly crystallized at room temperature (0.615 g., 41%), m.p. 223–225°. An additional crop of **17a** (0.320 g., 21%), m.p. 218–220°, was obtained from the mother liquors. Recrystallization from ethanol–petroleum ether gave the analytical sample of **17a** as glistening plates: m.p. 221–224°; λ_{max} 3.1–3.8 (broad), 5.93 (C=N), 6.16 (NH), 8.31 (ionic sulfonate), 13.40, and 14.34 μ (phenyl), no absorption near 7.3 μ (covalent sulfonate).

Anal. Calcd. for $C_{22}H_{26}N_2O_7S_2$ (494.6): C, 53.43; H, 5.30; N, 5.66; S, 12.96. Found: C, 53.26; H, 5.19; N, 5.76; S, 13.14.

B.—A suspension of **16** (0.120 g.) in ethanol was refluxed for 0.5 hr., and the resulting solution was then evaporated to dryness. Trituration with ethanol–petroleum ether gave **17a**, m.p. 222–225°, in 92% yield.

Neutralization of an aqueous solution of **17a** with dilute ammonium hydroxide followed by extraction into chloroform gave the free base **17b** as an analytically pure glass: $[\alpha]_D$ −106.7° (0.78%); λ_{max} 2.90, 2.96 (NH), 6.11 (C=N), 6.25 (NH), 13.30, and 14.35 μ (phenyl), no absorption at 7.3 and 8.5 μ due to sulfonamide or sulfonate.

Anal. Calcd. for $C_{15}H_{18}N_2O_4S$ (322.4): C, 55.88; H, 5.63; N, 8.69; S, 9.94. Found: C, 56.14; H, 5.74; N, 8.59; S, 10.08.

In all of these reactions, small amounts of sulfur, m.p. 113–116°, were isolated.

Methyl 2-Acetamido-*S*-acetyl-4,6-*O*-benzylidene-2,3-dideoxy-3-mercapto-α-D-mannopyranoside (18).—A stirred suspension of **17a** (0.145 g.) in 20% sodium hydroxide (5 ml.) was refluxed 18 hr. After neutralization to pH 8–9 with aqueous acetic acid (5 ml.), acetic anhydride (0.3 ml.) was added to the stirred solution. The pH was readjusted to 9 with aqueous sodium hydroxide, more acetic anhydride was added (0.2 ml.), and the mixture was stirred at room temperature for 14 hr. The mixture was extracted with three 10-ml. portions of chloroform, and the combined chloroform solutions were washed with three 10-ml. portions of water, dried, and concentrated to a sirup (0.120 g.). The sirup was decolorized in ethyl acetate to give a white glass (0.100 g.) which was further purified by preparative t.l.c. to give pure **18** as a glass (0.089 g., 79%): $[\alpha]_D$ −33.0° (2.6%); λ_{max} 3.00 (NH), 5.90, 6.02 (C=O), 6.50 (NH), 7.30 (CH_3), 13.2, and 14.3 μ (phenyl).

Anal. Calcd. for $C_{18}H_{23}NO_6S$ (381.4): C, 56.68; H, 6.08; N, 3.67; S, 8.40. Found: C, 56.33; H, 6.00; N, 3.59; S, 8.62.

Methyl 2-Amino-4,6-*O*-benzylidene-2-deoxy-*N*-(1-naphthylidene)-α-D-altropyranoside (19a).—A solution of **8** (1.00 g., 3.56 mmoles) in ethanol (20 ml.) containing 1-naphthaldehyde (0.68 ml., 5.0 mmoles) was refluxed for 1 hr., kept at room temperature for 14 hr., and then concentrated to a solid residue. Crystallization from ethyl acetate–petroleum ether gave **19a** as white needles (1.337 g., 90%). The analytical sample was obtained by recrystallization from the same solvents: m.p. 133–136°; λ_{max} 2.80 (OH), 6.12 (C=N), 6.30 (aromatic C=C), 12.40, 12.90, 14.12 (naphthyl), 13.34, and 14.32 μ (phenyl).

Anal. Calcd. for $C_{25}H_{25}NO_5$ (419.5): C, 71.58; H, 6.01; N, 3.34. Found: C, 70.68; H, 5.74; N, 3.21.

Similar reaction of **8** with anisaldehyde furnished a semicrystalline gum which gave the infrared spectrum expected for the *N*-anisylidene derivative.

Methyl 2-Amino-4,6-*O*-benzylidene-2-deoxy-*N*-(1-naphthylidene)-3-*O*-(*p*-tolylsulfonyl)-α-D-altropyranoside (20a).—To a solution of **19a** (0.787 g., 1.87 mmoles) in pyridine (4 ml.) at room temperature was added tosyl chloride (1.41 g., 7.42 mmoles). The solution was kept at 50° for 60 hr., and was then poured dropwise into a stirred mixture of aqueous sodium bicarbonate

and ice (60 ml.). The mixture was extracted with three 10-ml. portions of chloroform, and the combined chloroform solutions were washed with aqueous sodium bicarbonate (10 ml.) followed by water (three 10-ml. portions), dried, and concentrated to give a crystalline solid (1.161 g.). Recrystallization from ethanol–ethyl acetate afforded white needles of **20a** (0.752 g., 70%), m.p. 180–181°. An additional crop of less pure **20a** (0.212 g., 20%), m.p. 158–175°, was obtained from the mother liquors. Recrystallization from ethanol–ethyl acetate–petroleum ether gave the analytical sample as needles: m.p. 178–181°; λ_{max} 6.11 (C=N), 7.39, and 8.51 μ (sulfonate).

Anal. Calcd. for $C_{32}H_{31}NO_7S$ (573.7): C, 67.00; H, 5.45; N, 2.44; S, 5.59. Found: C, 66.86; H, 5.60; N, 2.47; S, 5.62.

Methyl 2-Amino-*N*-benzylidene-4,6-*O*-benzylidene-2-deoxy-3-*O*-(*p*-tolylsulfonyl)-α-D-altropyranoside (20b).—A solution of **8** (1.124 g., 4.0 mmoles) and benzaldehyde (0.560 ml., 5.6 mmoles) in ethanol (20 ml.) was refluxed for 2 hr. and then kept 36 hr. at room temperature. After the solution was concentrated to dryness and dried *in vacuo* to remove excess benzaldehyde, **19b** was obtained as a glass (1.48 g., quantitative) which was suitable for subsequent transformations: λ_{max} 2.88 (OH), 6.11 (C=N), 6.35 (C=C), 13.32, and 14.46 μ (phenyl).

A solution of crude **19b** (1.48 g., 4 mmoles) in pyridine (20 ml.) containing tosyl chloride (3.04 g., 16 mmoles) was kept at 50–55° for 33 hr. *p*-Aminobenzoic acid (1.80 g., 1.1 mmoles) was added; the solution was kept at room temperature for 0.5 hr. and then poured onto crushed ice (50 g.) and saturated potassium carbonate (20 ml.). The mixture was extracted with chloroform (three 10-ml. portions) and the combined chloroform solutions were washed with saturated potassium carbonate (10 ml.) followed by water (three 10-ml. portions), dried, and concentrated to a sirup which was decolorized to furnish crude **20b** (1.94 g., 92%). Recrystallization from ethanol gave **20b** (1.30 g., 62%), m.p. 129–132°, which was recrystallized from ethanol–petroleum ether to afford the analytical sample: m.p. 132–134°; λ_{max} 6.06 (C=N), 6.22, 6.30 (C=C), 7.3–7.4, 8.48 (sulfonate), 13.10, 13.22, 14.12, and 14.38 μ (phenyl).

Anal. Calcd. for $C_{28}N_{29}NO_7S$ (523.6): C, 64.23; H, 5.58; N, 2.68; S, 6.12. Found: C, 64.22; H, 5.86; N, 2.59; S, 5.92.

Methyl 2-Amino-*N*-benzylidene-4,6-*O*-benzylidene-2-deoxy-3-*O*-methanesulfonyl-α-D-altropyranoside (21a).—To an ice-cooled, stirred solution of **19b** (0.528 g., 1.43 mmoles) in pyridine (6 ml.) was added mesyl chloride (0.22 ml., 2.9 mmoles) dropwise. The solution was stirred an additional 15 min., kept at 5° for 16 hr., then poured onto ice (20 g.). The mixture was extracted with three 10-ml. portions of chloroform, and the combined chloroform solutions were washed twice with 10-ml. portions of water, dried, and concentrated to give a glass (0.573 g., 89%): λ_{max} 6.10 (C=N), 6.32 (C=C), 7.40, 8.50 (sulfonate), 13.3 and 14.4 μ (phenyl). T.l.c. gave one spot of R_f about 0.50.

Anal. Calcd. for $C_{22}H_{25}NO_7S$ (447.5): C, 59.05; H, 5.63; N, 3.13; S, 7.16. Found: C, 59.42; H, 5.95; N, 3.11; S, 7.08.

Methyl 4,6-*O*-Benzylidene-2-deoxy-3-*O*-(*p*-tolylsulfonyl)-2-ureido-α-D-altropyranoside (25). A.—A solution of **20a** (1.000 g., 1.74 mmoles) in 1,2-dimethoxyethane (30 ml.) and water (5 ml.) containing potassium cyanate (0.68 g., 8.4 mmoles) and acetic acid (0.48 ml., 8.4 mmoles) was refluxed for 15 min. and then kept at room temperature for 11 hr. The solution was concentrated to 5 ml. and then extracted with chloroform (three 10-ml. portions). The combined chloroform solutions were washed with water (two 10-ml. portions), dried, and concentrated to a glass (1.05 g.). The glass showed appreciable absorption at 6.10 μ (C=N) showing the presence of unchanged **20a**. Retreatment of the glass with potassium cyanate (8.4 mmoles) and acetic acid (16.7 mmoles) during a 1-hr. reflux period gave, after processing as above, a pale yellow sirup (0.977 g.) which showed only slight absorption at 6.10 μ (C=N). Trituration of the sirup with ethyl acetate–petroleum ether gave crude **25** (0.161 g., 19%). The further purification was achieved by precipitating **25** from chloroform solution upon addition of petroleum ether (0.141 g.), m.p. 180–182°. The analytical sample was recrystallized from methanol–ethanol–ethyl acetate–petroleum ether: m.p. 185–187°; λ_{max} 2.83, 2.92, 3.02 (NH), 6.00 (C=O), 6.42 (NH), 7.31, 8.40, 8.50 (sulfonate), 13.30, and 14.4 μ (phenyl).

Anal. Calcd. for $C_{22}H_{26}N_2O_8S$ (478.5): C, 55.22; H, 5.48; N, 5.85; S, 6.70. Found: C, 55.07; H, 5.30; N, 5.79; S, 6.57.

The mother liquor appeared (by infrared analysis) to contain additional **25**, unreacted **20a**, and the *O*-3,*N*-ditosyl derivative of **8**, the latter being due to its presence as an impurity in the starting material used.

B.—A suspension of **20b** (1.30 g., 2.48 mmoles) in 50% aqueous ethanol (26 ml.) containing potassium cyanate (0.402 g., 5.0 mmoles) and acetic acid (0.29 ml., 5.1 mmoles) was stirred 15 min. at 90° followed by 10 hr. at room temperature. The mixture was stored 7 hr. at 5° and filtered, and the residue was washed with 30% ethanol to give a white solid (0.832 g., 70%). Trituration of the solid with ethyl acetate (2 ml.) followed by decantation and washing with petroleum ether gave crude **25** (0.390 g., 33%). Since the mother liquors showed evidence [λ_{max} 6.10 μ (C=N)] of containing unchanged **20b**, the combined mother liquors were re-treated as above to give a solid (0.640 g.) from which crude **25** (0.340 g., 29%) was isolated.

That some ring closure to **23** or **24** had occurred was indicated by the unchanged infrared spectrum of the products in the final mother liquors when they were heated in pyridine for 2 hr. at 95°, conditions which will cause ring closure.[4]

Methyl 4,6-*O*-Benzylidene-*N*-carbamoyl-2,3-dideoxy-2,3-imino-α-D-mannopyranoside (26). A.—A solution of methyl 4,6-*O*-benzylidene-2,3-dideoxy-2,3-imino-α-D-mannopyranoside (**27**)[7,22] (0.060 g.) in 50% aqueous ethanol (2 ml.) containing potassium cyanate (0.037 g., 0.47 mmole) and acetic acid (0.024 ml., 0.42 mmole) was heated on the steam bath for 10 min. Crystallization commenced on cooling the solution and was completed at 5°. Filtration of the mixture followed by washing of the crystals in cold water gave **26** (0.058 g., 83%). Recrystallization from ethanol–petroleum ether gave **26** as needles, m.p. 195–197°. The analytical sample was recrystallized from ethyl acetate–petroleum ether and had m.p. 203–205°; λ_{max} 2.83, 2.91, 3.06 (NH), 5.93 (C=O), 13.28, and 14.39 μ (phenyl), no absorption at 6.5 μ (NH).

Anal. Calcd. for $C_{15}H_{18}N_2O_5$ (306.3): C, 58.82; H, 5.92; N, 9.14. Found: C, 59.01; H, 5.96; N, 8.82.

B.—A suspension of **25** (0.054 g., 0.11 mmole) in methanol (2.0 ml.) containing sodium methoxide (0.22 mmole) was refluxed 2 hr. The solution was neutralized with carbon dioxide, then concentrated. The white, solid residue was suspended in water, and the aqueous mixture was extracted with three 10-ml. portions of chloroform. The combined chloroform solutions were washed with water (two 10-ml. portions), dried, and concentrated to a white solid (0.036 g., 100%). Recrystallization of the solid from ethanol–petroleum ether gave **26**, m.p. and m.m.p. (with authentic **26**) 195–197°; the infrared spectrum and behavior on t.l.c. were identical with those of authentic **26**.

Methyl 4,6-*O*-Benzylidene-2-deoxy-2-thioureido-α-D-altropyranoside (29).—Into an ice-cooled solution of **11** (0.100 g.) in pyridine (2 ml.) was bubbled hydrogen sulfide for 30 min. to give an amber solution. The solution was kept at room temperature for 1 week and was then poured into water. The aqueous solution was extracted with three 10-ml. portions of chloroform, and the combined chloroform solutions were washed with two 10-ml. portions of water, dried, and concentrated to give a yellow solid. The crystals were virtually insoluble in refluxing chloroform but dissolved in hot ethyl acetate. Decolorization in hot ethyl acetate followed by recrystallization in ethyl acetate–petroleum ether gave pure **29** (0.060 g., 55%): m.p. 212–214°; λ_{max} 2.85, 2.94, 3.08 (OH, NH), 6.13, 6.50 (amide II), 13.10, and 14.30 μ (phenyl).

Anal. Calcd. for $C_{15}H_{20}N_2O_5S$ (340.4): C, 52.93; H, 5.92; N, 8.23; S, 9.42. Found: C, 52.87; H, 6.06; N, 8.24; S, 9.41.

Methyl 3-Amino-4,6-*O*-benzylidene-3-deoxy-*N*-(4-nitrobenzylidene)-α-D-altropyranoside (30).—A solution of methyl 3-deoxy-3-amino-4,6-*O*-benzylidene-α-D-altropyranoside[2] (0.400 g., 1.42 mmoles) and 4-nitrobenzaldehyde (0.283 g., 1.88 mmoles) in ethanol (5 ml.) was refluxed for 2 hr. and then kept at 5° for 2 days. The crystals were filtered and dried (0.561 g., 95%), m.p. 208–211°. Recrystallization of **30** from ethanol–ethyl acetate–petroleum ether gave the analytical sample: m.p. 209–212°; λ_{max} 2.91 (OH), 6.12 (C=N), 6.29 (C=C), 6.62, 7.52 (nitro), 13.35, and 14.28 μ (phenyl).

Anal. Calcd. for $C_{21}H_{22}N_2O_7$ (414.4): C, 60.86; H, 5.35; N, 6.76. Found: C, 60.43; H, 5.19; N, 6.61.