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# SULPHUR SUBSTITUTION COMPOUNDS OF AMINOSUGARS—V[1]

## THE SYNTHESIS OF 2-AMINO-2,3-DIDEOXY-3-MERCAPTO-D-ALLOSE AND-D-GLUCOSE DERIVATIVES BY DISPLACEMENT REACTIONS

W. MEYER ZU RECKENDORF and W. A. BONNER
Department of Chemistry, Stanford University, Calif., U.S.A.

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**Abstract**—Thiolacetate, benzyl mercaptide and acetate ions in dimethylformamide caused displacements of the 3-O-mesyl group in I and analogous compounds affording derivatives of 2-amino-2-deoxy-D-allose and/or 2-amino-2-deoxy-D-glucose, the structures of which have been proved. 2-Amino-2,3-dideoxy-D-glucose has been prepared for the first time.

A VERY important reaction for the interconversion of carbohydrates is the nucleophilic displacement of sulphonate esters, a reaction which is greatly influenced by the stereochemistry of the sugar and by neighbouring substituents. In many cases secondary sulphonates are extremely unreactive in the absence of neighbouring group participation, and accordingly it seemed desirable to us to explore the reactions of such sulphonate esters more extensively.

We recently encountered the high reactivity of the 3-O-mesyl group in the 2-amino-2-deoxy-D-glucose derivative I, the replacement of this group being markedly facilitated by the neighbouring benzamido group at C2. Reaction of I with sodium methoxide caused ring closure to the corresponding oxazoline,[2] while reaction of the 3,4-unsubstituted analog of I yielded a derivative of the previously unknown 2-amino-3,6-anhydro-2-deoxy-D-glucose, formed by way of two consecutive Walden inversions at C3.[3] We have now explored the reactions of I with various other nucleophilic agents among which were the acetate, thiolacetate and benzylmercaptide anions.

On heating I with an excess of potassium thiolacetate[4] in dimethylformamide for two hours at 100° (Chart I), the precipitation of potassium mesylate was noted and a mixture of two compounds was obtained in high yield. After chromatographic separation, analyses and I.R. spectra indicated these compounds to be a methyl benzamido-4,6-O-benzylidene-dideoxy-thioacetyl-hexopyranoside (II) and its N-acetyl analog (III). The same N-acetyl compound III could be obtained in excellent yield and as the sole product from the N-acetyl mesylate XIV, synthesized in turn from the known[5] methyl 2-acetamido-4,6-O-benzylidene-2-deoxy-$\beta$-D-glucopyranoside.

The assignment of configurations to compounds II and III had to take into account the possibility that the displacement of the 3-O-mesyl group in I might have proceeded

[1] Part IV: W. Meyer zu Reckendorf and W. A. Bonner, *J. Org. Chem.* **26**, 5241 (1961).
[2] W. Meyer zu Reckendorf and W. A. Bonner, *Chem. Ber.* **95**, 1917 (1962).
[3] W. Meyer zu Reckendorf and W. A. Bonner, *Chem. Ber.* **95**, 996 (1962).
[4] When potassium thiolbenzoate instead of potassium thiolacetate was employed no crystalline material could be obtained.
[5] W. Roth and W. Pigman, *J. Amer. Chem. Soc.* **82**, 4608 (1960).

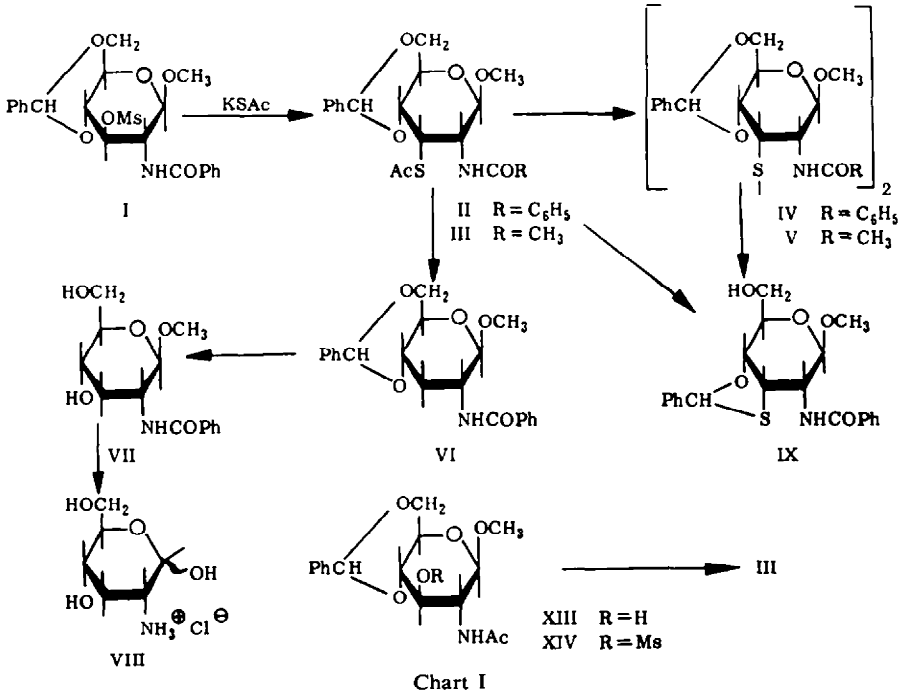



Chart I

in one of several ways, as discussed below. To decide between these we have devised independent syntheses of products II and III, as described in the following communication.[6] The products both proved to be 2-amino-2-deoxy-D-allose derivatives, namely, methyl 2-benzamido-4,6-O-benzylidene-2,3-dideoxy-3-thioacetyl-β-D-allopyranoside (II) and its 2-N-acetyl analog (III). Thus a displacement involving a Walden inversion of the 3-O-mesyl group of I occurred in the formation of II and, furthermore, exchange of the N-acyl substituent took place in the production of III.[6a]

Compounds II and III could easily be converted into the corresponding disulphides IV and V. On deblocking these, however, we encountered severe difficulties. V failed to yield a crystalline product on hydrolysis with 1 per cent hydrogen chloride in methanol. The N-benzoyl derivative IV under similar conditions gave a low yield of a product (IX) the I.R. spectrum of which showed only a single hydroxyl group as well as the presence of a benzylidene residue. The same product IX could be obtained in slightly higher yield from II directly. We assume this compound to possess the hemithioacetal structure IX on grounds of its analysis and the construction of its Dreiding model, which shows the possibility of the indicated ring closure involving a *cis* equatorial-axial arrangement of hydroxyl and thiol. Formation of IX from IV must involve reductive fission of the disulphide bond which we assume, in view of the low yield, might have been engendered by benzaldehyde. Desulphuration of II with Raney nickel afforded the 3-deoxy compound VI in good yield. Hydrogenolysis of the benzylidene residue seems to have been prevented by the precipitation of VI

[6] W. Meyer zu Reckendorf and W. A. Bonner, *Tetrahedron* **19**, 1069 (1963).

[6a] It was not possible to exchange the N-benzoyl group in the deoxy compound VI under the same reaction conditions. It therefore seems to be likely that the reaction intermediate in the conversion of I to II is also involved in the formation of III.

during the reaction. Acid hydrolysis of VI did not lead to a pure substance probably because of anomerization, but palladium-catalyzed hydrogenolysis gave a high yield of crystalline methyl 2-benzamido-2,3-dideoxy-β-D-glucopyranoside VII. Vigorous acidic hydrolysis of VII afforded the previously unknown 2-amino-2,3-dideoxy-D-glucose hydrochloride VIII as a white, very hygroscopic powder which was homogeneous in thin layer chromatography.

In further studying the displacement reactions of the 3-O-mesyl function, we have allowed I to react with sodium benzylmercaptide under similar conditions (Chart II).

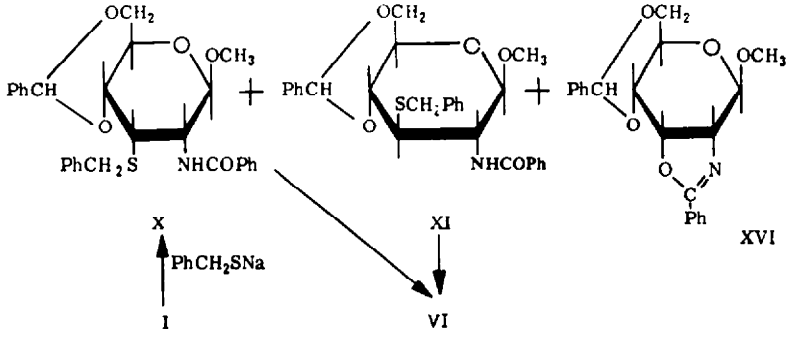



Chart II

The product was found by thin layer chromatography to be a mixture of three compounds. The fastest migrating component, subsequently purified by extraction with ether, was recognized as the oxazoline XVI described previously.[2] The remaining mixture was separated by recrystallization and chromatography into two isomeric compounds (X and XI), both of which contained S-benzyl functions and gave the same deoxy derivative VI on Raney nickel desulphuration. The latter observation demonstrates X and XI to be epimeric at C3. As reductive debenzylation with sodium in liquid ammonia gave no crystalline product[7]—due probably to concomitant debenzylidenation—we have tentatively assigned the configurations of X and XI on the basis of their optical rotations.[8] Derivatives of 2-amino-2-deoxy-β-D-allose generally show higher negative rotations than the corresponding 2-amino-2-deoxy-β-D-glucose compounds, as indicated in Table 1. We therefore have assumed X to be methyl 2-benzamido-4,6-O-benzylidene-3-benzyl-mercapto-2,3-dideoxy-β-D-alloside and XI to be the corresponding 2-amino-2-deoxy-D-glucose derivative.

The reactions of the mesylates I and XIV (Chart III) with potassium acetate are of particular interest since they afford known 3-O-acetyl compounds. When I was heated with anhydrous potassium acetate in dimethylformamide there resulted a 1 : 1 mixture of the oxazoline XVI and methyl 3-O-acetyl-2-benzamido-4,6-O-benzylidene-2-deoxy-β-D-allopyranoside (XII), as shown by thin layer chromatography and subsequent chromatographic isolation. The same reaction was carried out with the N-acetyl mesylate XIV. Thin layer chromatography of the complex mixture obtained revealed the presence of at least five components. The main one was shown by chromatographic comparison and I.R. spectra to be methyl 2-acetamido-3-O-acetyl-4,6-O-benzylidene-2-deoxy-β-D-allopyranoside (XV). Authentic XV was synthesized

[7] Further reactions were not carried out due to the difficult accessibility of X and XI.

[8] N.M.R. spectra, which might give an indication of the configurations at C3, could not be measured because of lack of solubility of X and XI in suitable solvents.

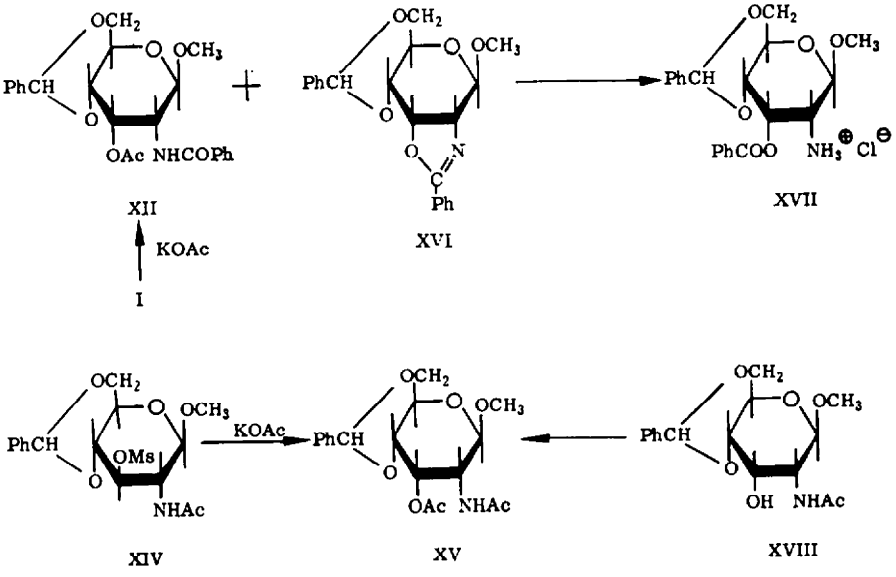



Chart III

from the known[2] XVII *via* the intermediate XVIII. The corresponding 2-amino-2-deoxy-D-glucose derivative was not present in the mixture, as revealed by thin layer chromatography.

In order to shed light on the mechanism involved in these displacement reactions we have employed compounds with N-blocking groups which might not be able to participate in the reaction. Mesylation of methyl 2-amino-4,6-O-benzylidene-2-

TABLE 1. OPTICAL ROTATIONS OF 2-AMINO-2-DEOXY-D-GLUCOSE AND 2-AMINO-2-DEOXY-D-ALLOSE DERIVATIVES

| Derivative | 2-Amino-2-deoxy-β-D-glucose | 2-Amino-2-deoxy-β-D-allose | Ref. |
|---|---|---|---|
| Hydrochloride | +25° → −73° | +1° → +16° | 9 |
| N-acetyl | −21·5° → +40° | −72° → −48° | 10 |
| Methyl N-benzoyl-4,6-O-benzylidene-hexoside | −41° | −56° | 2 |
| Methyl N-acetyl-4,6-O-benzylidene-hexoside | −64° | −96° | 5<br>this paper |
| Methyl N-acetyl-3-O-benzoyl-4,6-O-benzylidene-hexoside | −90° | −97° | 2 |
| Compound X | | −49° | |
| Compound XI | −2° | | |
| Compound XXI | −28° | | |
| Compound XXII | | −60° | |

deoxy-β-D-glucopyranoside XIX[11] yielded the N,O-dimesylate XX. Reaction of the latter with potassium thiolacetate in dimethylformamide gave a mixture of two

[9] R. Kuhn and J. C. Jochims, *Liebigs Ann.* **641**, 143 (1961).
[10] R. Kuhn and H. Fischer, *Liebigs Ann.* **617**, 88 (1958).
[11] W. Meyer zu Reckendorf and W. A. Bonner, *Chem. Ber.* **94**, 3293 (1961).

thioacetyl compounds, XXI and XXII, which was readily separable by recrystallization. Desulphuration of each with Raney nickel led to the formation of complex mixtures which, however, seemed to be quite similar in both cases as judged from thin layer chromatograms. We therefore assume XXI and XXII to be epimeric at C-3 and deduce their configurations from their optical rotations as shown in Table 1.

Another experiment was carried out employing a Schiff base for blocking the nitrogen atom at C-2. Reaction of XIX with 4-methoxy benzaldehyde afforded in good yield the corresponding Schiff base XXIII, which in turn was mesylated to XXIV. The latter, however, failed to react with potassium thiolacetate under the conditions previously employed. The above reactions are summarized in Chart IV.

## DISCUSSION

Displacement reactions of secondary sulphonates have been extensively investigated, and these groups have proved quite unreactive in cyclic sugar derivatives. Recently Baker[12] has found that sodium benzoate in boiling dimethylformamide is able to displace O-sulphonates of *axial* hydroxyl groups with Walden inversion, under reaction conditions, however, which were rather more drastic than those we have employed. Yields were considerably increased if the attack of the nucleophile was facilitated stereochemically, for instance by employing open-chain derivatives of carbohydrates.[13] This latter case has recently been investigated[14] and shown to proceed

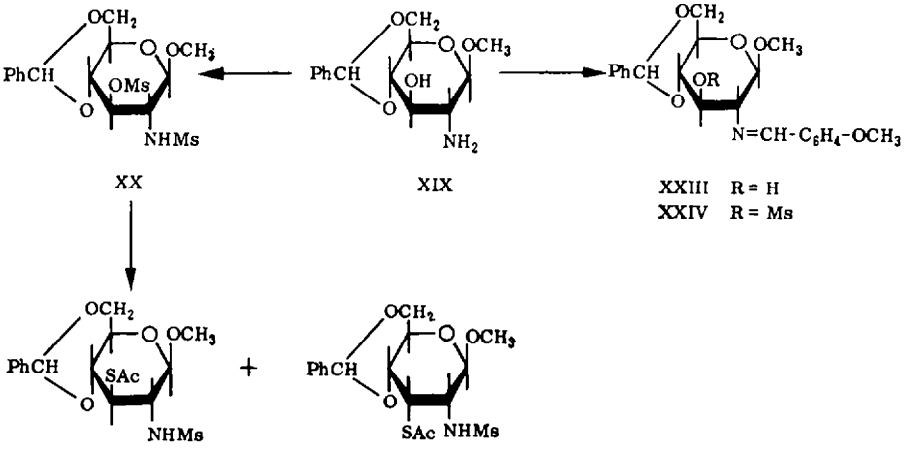



Chart IV

at least partly *via* direct displacement of the sulphonyloxy group by the attacking anion. The strong nucleophilicity of the azide ion probably accounts for several reactions recently discovered[14–16] to proceed *via* direct displacements. The reaction

[12] E. J. Reist, R. R. Spencer and B. R. Baker, *J. Org. Chem.* **24**, 1618 (1959); E. J. Reist, L. Goodman and B. R. Baker, *J. Amer. Chem. Soc.* **80**, 5775 (1958); W. W. Lee, A. Benitez, L. Goodman and B. R. Baker, *Ibid.* **82**, 2648 (1960).

[13] B. R. Baker, *Angew. Chem.* **74**, 786 (1962).

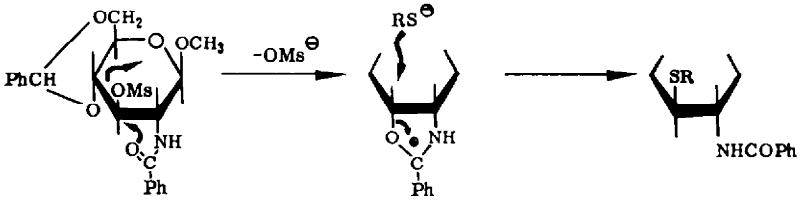
[14] B. R. Baker and A. H. Haines, *J. Org. Chem.* **28**, 438; 442 (1963).

[15] E. J. Reist, R. R. Spencer, B. R. Baker and L. Goodman, *Chem. & Ind.* 1794 (1962).

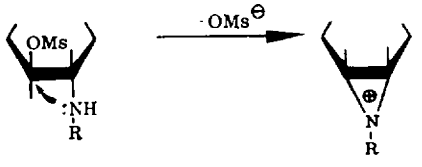
[16] R. D. Guthrie and D. Murphy, *Chem. & Ind.* 1473 (1962).

conditions, however, are again more drastic than those employed in our cases. Moreover Baker *et al.*[15] employed a derivative of 4-O-mesyl-D-galactose in which the sulphonyloxy group occupied an axial position, whereas Guthrie and Murphy[16] displaced a *p*-toluenesulphonyloxy group adjacent to a carbon atom bearing an azido function which might have been capable of anchimeric assistance.

These examples appear to us to render a direct displacement mechanism in our reactions rather improbable. We therefore turned our attention to the possibility of anchimeric assistance to the substitution reaction by the adjacent nitrogen and its blocking group at C-2. Neighbouring group participation of the benzamido, acetamido and perhaps also the sulphonamido groups *via* an intermediate analogous to the oxazolinium ion XXV shown below can easily be visualized. Coordination of the cationic intermediate XXV with anions, followed by subsequent collapse of the complex might give rise to products with a *cis* arrangement at C-2 and C-3, while rear-face attack at C-3 would lead to products having a *trans* arrangement at C-2 and C-3. We can offer no explanation at the present time, however, why the former path should be preferred in the majority of the cases which we have examined.




I XXV XXVI




XXVII Chart V XXVIII

An alternative mechanism permitting neighbouring group participation involves the formation of the aziridinium ion XXVIII as the cationic reaction intermediate. A recent observation by Christensen and Goodman[17] has disclosed that a ring closure reaction which should yield a thiazoline may actually give rise to the formation of an aziridine, and that in certain cases the latter reaction seems to be greatly preferred. Both mechanisms, involving either XXV or XXVIII as intermediates, might give rise to the readtion products which we have observed. Our further finding that the oxazoline XVI itself (or its hydrochloride) was completely unaffected by either potassium thiolacetate or thioacetic acid in dimethylformamide does not exclude the

[17] J. E. Christensen and L. Goodman, *J. Amer. Chem. Soc.* **82**, 4738 (1960).

formation of an oxazolinium ion as an intermediate, as the latter might not be formed from the oxazoline XVI itself in these reaction environments. The Schiff base XXIV, on the other hand, presumably cannot give rise to an oxazolinium ion, but would seem capable of forming an aziridinium ion intermediate. The failure of neighbouring group participation in this case, however, does not yet seem a compelling reason for giving preference to the oxazolinium mechanism. Further experiments employing similar reaction conditions have shown no reactivity of mesyloxy groups not adjacent to a carbon atom bearing a nitrogen function. These results are the subject of synthetic studies currently in progress and will be reported at a later date.

## EXPERIMENTAL

M.ps. have been determined in capillaries on a Thomas Hoover apparatus and are uncorrected. Thin layer chromatography has been carried out by the standard technique employing either Silica Gel G (E. Merck, Germany) or cellulose powder MN 300 G (Macherey & Nagel, Germany) as adsorbing materials, using the solvent systems indicated in each case. Spots were detected on silica gel with a spray containing 1% ceric sulphate in 10% sulphuric acid, and on cellulose with ninhydrin or anilin phthalate. Column chromatography was carried out on neutral alumina (E. Merck, Germany).

*Methyl 2-benzamido-4,6-O-benzylidene-2,3-dideoxy-3-thioacetyl-β-D-allopyranoside* (II) and the corresponding N-*acetyl derivative* (III)

The mesylate I (3 g) was heated with 4·5 g potassium thiolacetate in 45 ml dimethylformamide for 2 hr at 100°, and the mixture was poured into water and extracted with chloroform. The chloroform layer was washed with water, dried and evaporated *in vacuo*, whereupon addition of a small amount of water caused crystallization of the residue. The solid was dissolved in a 1:1 mixture of ethyl acetate and benzene and chromatographed on 200 g activity II aluminaw et with benzene. Elution with a 9:1 mixture of benzene and ethyl acetate gave 1·36 g (47%) compound II, which was recrystallized from a mixture of ethyl acetate and ligroin, m.p. 252–253°, $[\alpha]_D^{23}$ −32·8° (*c*, 1·03; chloroform) (Found: C, 61·9; H, 5·5; N, 3·4; S, 7·3. $C_{28}H_{25}NO_6S$ requires: C, 62·2; H, 5·7; N, 3·2; S, 7·2%). Elution of the column with a 1:1 mixture of benzene and ethyl acetate yielded 902 mg (36%) III which was recrystallized twice from 2-propanol, purifying it from a small amount of its disulphide formed on the column, m.p. 232–233°, $[\alpha]_D^{23}$ −120° (*c*, 1·3; chloroform) (Found: C, 56·7; H, 5·7; N, 3·6; S, 8·5. $C_{18}H_{23}NO_6S$ requires: C, 56·7; H, 6·1; N, 3·7; S, 8·4%).

*Methyl 2-benzamido-4,6-O-benzylidene-2,3-dideoxy-3-mercapto-β-D-allopyranoside disulphide* (IV)

Absolute methanol (50 ml) saturated with ammonia and containing 1 g II was stored at room temp overnight. The solvent was evaporated and the crystalline residue was recrystallized from ethanol, yielding 600 mg (67%) IV, m.p. 239–240°, $[\alpha]_D^{23}$ −14·9° (*c*, 1·2; dimethyl sulphoxide) (Found: C, 63·2; H, 5·6; N, 3·4; S, 8·1. $(C_{21}H_{22}NO_5S)_2$ requires: C, 63·1; H, 5·5; N, 3·5; S, 8·0%).

*Methyl 2-acetamido-4,6-O-benzylidene-2,3-dideoxy-3-mercapto-β-D-allopyranoside disulphide* (V)

Prepared from III analogously to IV, the crude product was recrystallized from an ethyl acetate–ligroin mixture in 90% yield. M.p. 244–245°, $[\alpha]_D^{23}$ −75° (*c*, 1·2; dimethyl sulphoxide) (Found: C, 56·7; H, 6·0; N, 4·1; S, 9·5. $(C_{16}H_{20}NO_5S)_2$ requires: C, 56·7; H, 6·0; N, 4·1; S, 9·5%).

*Methyl 2-benzamido-4,6-O-benzylidene-2,3-dideoxy-β-D-glucopyranoside* (VI)

Raney nickel catalyst (32 g, weighed as a slurry in ethanol) was heated with 4 g II in 160 ml refluxing absolute ethanol for 1 hr, the precipitated product was dissolved by addition of a large volume of solvent and the solution was filtered and evaporated. The residue was recrystallized from methanol to give 3·0 g (93%) VI, m.p. 247° (dec). $[\alpha]_D^{23}$ −48·1° (*c*, 0·9; dimethyl sulphoxide) (Found: C, 68·3; H, 6·3; N, 3·8. $C_{21}H_{23}NO_5$ requires: C, 68·3; H, 6·3; N, 3·8%). An identical product was obtained in 90% yield by similar desulphuration of X and XI.

*Methyl 2-benzamido-2,3-dideoxy-β-D-glucopyranoside* (VII)

A mixture of 800 mg VI and 1·0 g 10% palladium on carbon in 150 ml methanol was stirred in a hydrogen atmosphere for 3 hr, whereupon the solution was filtered through Celite and evaporated.

The residue was recrystallized from an ethanol–ether mixture to give 440 mg (72%) sturdy prisms, m.p. 189–190° (with evolution of gas), $[\alpha]_D^{23}$ −43° (*c*, 1·2; ethanol) (Found: C, 59·8; H, 6·7; N, 4·9. $C_{14}H_{19}NO_5$ requires: C, 59·8; H, 6·8; N, 5·0%).

*2-Amino-2,3-dideoxy-D-glucose hydrochloride* (VIII)

A 1:1 mixture of hydrochloric acid and water (10 ml) containing 100 mg VII was refluxed for 3 hr, evaporated and freed of HCl by codistillation with water. The dried sirupy residue was dissolved in absolute ethanol, decolourized with Norit and evaporated to a small volume, whereupon the product was precipitated by addition of absolute ether. There resulted 55 mg (78%) of an extremely hygroscopic white powder which proved to be homogeneous on thin layer chromatograms employing cellulose powder and the Fischer and Nebel solvent mixture.[18] Its $R_f$ compared to 2 amino-2-deoxy-D-glucose hydrochloride was 0·86. $[\alpha]_D^{23}$ +13° (without mutarotation; *c*, 0·7; water). Due to its hygroscopic nature the compound could not be successfully analyzed.

*Methyl 2-benzamido-3,4-S,O-benzylidene-2,3-dideoxy-3-mercapto-β-D-allopyranoside* (IX)

A solution of absolute methanol (200 ml) containing 0·5% hydrogen chloride and 2 g II was heated to boiling, then was stored at room temp for 6 hr. The solvent was evaporated, the residue was triturated with 2-propanol to induce crystallization and the product was recrystallized from a mixture of ethyl acetate and ligroin, yield 550 mg (31%), m.p. 194–197°, $[\alpha]_D^{23}$ −2·9° (*c*, 1·0; dimethyl sulphoxide) (Found: C, 63·1; H, 5·8; N, 3·4; S, 8·2. $C_{21}H_{23}NO_5S$ requires: C, 62·8; H, 5·8; N, 3·5; S, 8·0%).

*Methyl 2-benzamido-4,6-O-benzylidene-3-benzylmercapto-2,3-dideoxy-β-D-allopyranoside* (X) and the corresponding *glucopyranoside* (XI)

Mesylate I (8 g) was heated with 12 g of crude sodium benzylmercaptide in 160 ml dimethyl formamide for 2 hr at 100°. After addition of water the precipitate was filtered through glass wool and dried over $P_2O_5$. Thin layer chromatograms on silica gel, eluting with chloroform containing 1% methanol, revealed the presence of at least 3 components, one of which migrated with the solvent front. This could be separated from the crude product by extraction with ether (yield 1·8 g), and proved to be identical with the oxazoline XVI. The remaining mixture was recrystallized from methanol to give 910 mg XI. A second recrystallization gave a chromatographically homogeneous sample having m.p. 279–280° and $[\alpha]_D^{23}$ −1·9° (*c*, 1·0; dimethyl sulphoxide). (Found: C, 68·1; H, 5·9; N, 2·7; S, 6·7. $C_{28}H_{29}NO_5S$ requires: C, 68·4; H, 5·8; N, 2·8; S, 6·5%).

The residue from the mother liquors of XI (2.6 g) was dissolved in a 1:1 benzene–chloroform solvent and chromatographed on 220 g alumina (activity I). Elution with benzene containing 10% chloroform yielded 1·56 g pure X, followed by 935 mg of a mixture of X and XI. The pure substance was recrystallized once from ethanol, m.p. 196–197° (dec), $[\alpha]_D^{23}$ −48·6° (*c*, 1·0; dimethyl sulphoxide) (Found: C, 68·2; H, 5·9; N, 3·1; S, 6·7. $C_{28}H_{29}NO_5S$ requires: C, 68·4; H, 5·8; N, 2·8; S, 6·5%).

*Methyl 3-O-acetyl-2-benzamido-4,6-O-benzylidene-2-deoxy-β-D-allopyranoside* (XII)

Mesylate I (1 g) and 2 g potassium acetate (freshly fused) were stirred overnight in 20 ml dimethylformamide at 100°. Addition of water caused the separation of 750 mg crystalline material. Thin layer chromatography on silica gel (3:2 ethyl acetate–ligroin eluant) revealed the presence of 2 substances. These were separated chromatographically, using 70 g alumina (activity II) wet with benzene. Elution with a 9:1 benzene–ether solvent yielded 355 mg (45%) oxazoline XVI, identified by its I.R. spectrum, m.p. and mixed m.p. Final elution with ether gave 364 mg acetate XII (40%) which was recrystallized from an ethyl acetate–ligroin mixture, m.p. and mixed m.p. with authentic material[2] 220–221°, $[\alpha]_D^{23}$ −77.9° (*c*, 1·3; chloroform). The I.R. spectra of the product and an authentic sample of XII were identical.

*Methyl 2-acetamido-4,6-O-benzylidene-2-deoxy-3-O-methanesulphonyl-β-D-glucopyranoside* (XIV)

A solution of 7·5 g XIII[5] (purified by 4 recrystallizations) in anhydrous pyridine (100 ml) was cooled to −20° and treated under stirring with 7·5 ml methanesulphonyl chloride. After storage at

[18] F. G. Fischer and H. J. Nebel, *Z. physiol. Chem.* **302**, 10 (1955).

−5° overnight ice and water were added to the mixture, affording a crystalline product, 6·0 g (65%), m.p. 195–196° (after one recrystallization from 2- propanol), $[\alpha]_D^{23}$ −63° (*c*, 1·1; dimethyl sulphoxide) (Found: C, 50·7; H, 5·9; N, 3·5; S, 8·0. $C_{17}H_{23}NO_8S$ requires: C, 50·4; H, 5·8; N, 3·5; S, 8·0%).

*Methyl* 2-*acetamido*-4,6-O-*benzylidene*-2,3-*dideoxy*-3-*thioacetyl*-β-D-*allopyranoside* (III) from XIV

By the first procedure described above (for compound II) 1 g mesylate XIV gave a crude yield of 800 mg (84%) III which was shown to be homogeneous by thin layer chromatography on silica gel, using chloroform containing 2% methanol as eluant. After recrystallization from 2-propanol the product had m.p. 233–235° and a mixed m.p. with III obtained by acyl exchange 231–232°, $[\alpha]_D^{23}$ −118° (*c*, 1·0; chloroform). The I.R. spectra of the two samples were identical.

*Methyl* 2-*acetamido*-4,6-O-*benzylidene*-2-*deoxy*-β-D-*allopyranoside* (XVIII)

The hydrochloride of the oxazoline XVI[2] (2 g) was heated for 10 min in 60 ml refluxing ethanol and the solution was stripped of solvent. The residue was acetylated with a mixture of 6 ml pyridine and 4 ml acetic anhydride. After storage at room temp for 2 hr ice water was added and the crystalline product was collected, dried, and dissolved in 100 ml methanol saturated with ammonia. The mixture was stored at room temp overnight and the solvent was evaporated, yielding 1·4 g (87%) XVIII. This was recrystallized from ethanol, m.p. 285–286° (dec) $[\alpha]_D^{23}$ −96° (*c*, 1·0; chloroform) (Found: C, 59·5; H, 6·7; N, 4·5. $C_{16}H_{21}NO_6$ requires: C, 59·4; H, 6·6; N, 4·3%).

*Methyl* 2-*acetamido*-3-O-*acetyl*-4,6-O-*benzylidene*-2-*deoxy*-β-D-*allopyranoside* (XV)

(a) *By acetylation of* XVIII. Acetylation of XVIII with acetic anhydride in pyridine afforded a quantitative yield of XV, m.p. 214–215° (recrystallized from an ethanol–ether-ligroin mixture). $[\alpha]_D^{23}$ −118·5° (*c*, 1·1; chloroform) (Found: C, 58·9; H, 6·4; N, 3·9. $C_{18}H_{23}NO_7$ requires: C, 59·2; H, 6·3; N, 3·8%).

(b) *By a displacement reaction on* XIV. A mixture of 2 ml dimethylformamide, 100 mg mesylate XIV and 200 mg anhydrous potassium acetate was heated at 100° for 8 hr. On dilution with water 30 mg starting material precipitated; this was filtered and discarded. The filtrate was extracted with chloroform, the extract was evaporated and the residue was recrystallized from a solvent mixture of ethanol–ether–ligroin, yielding 32 mg product. Silica gel thin layer chromatograms of the latter (98:2 chloroform–methanol eluant) revealed the presence of several components, the principal one exhibiting the same $R_f$ value as pure XV. I.R. spectra also indicated that the mixture contained mainly XV. The corresponding 2-amino-2-deoxy-D-glucose derivative could not be detected in the crude product.

*Methyl* 2-*amino*-4,6-O-*benzylidene*-2-*deoxy*-N-3-O-*dimethanesulphonyl*-β-D-*glucopyranoside* (XX)

The amine XIX (3 g) was dissolved in 20 ml pyridine, the solution cooled to −80° and mesyl-chloride (3 ml) added. After storage at −5° overnight the product precipitated on addition of ice and water, m.p. 184–186° (dec), after 2 recrystallizations from ethanol, yield 2·7 g (58%). $[\alpha]_D^{27}$ −48·0° (*c*, 1·15; in dimethyl sulphoxide) (Found: C, 43·6; H, 5·3; N, 3·3; S, 14·4. $C_{16}H_{23}NO_9S_2$ requires C, 43·8; H, 5·3; N, 3·2; S, 14·6%).

*Methyl* 4,6-O-*benzylidene*-2,3-*dideoxy*-2-*methanesulphonamido*-3-*thioacetyl*-β-D-*glucopyranoside* (XXI) *and the corresponding allopyranoside* (XXII)

The dimesylate XX (2·6 g) was heated with potassium thiolacetate (4 g) in dimethylformamide (45 ml) for 1 hr at 100°. Water was added and the precipitated product recrystallized twice from ethanol, yield 1·4 g (56%) compound XXI, m.p. 203–204°, $[\alpha]_D^{29}$ −27·7° (*c*, 0·47; in dimethyl sulphoxide). (Found: C, 48·9; H, 5·6; N, 3·4; S, 15·3. $C_{17}H_{25}NO_7S_2$ requires: C, 49·0; H, 5·6; N, 3·4; S, 15·4%).

The dimethylformamide–water mixture obtained above was extracted with chloroform to give 250 mg (10%) compound XXII (after 2 recrystallizations from ethanol), m.p. 198–199°, $[\alpha]_D^{27}$ −60·4° (*c*, 0·48; in dimethyl sulphoxide). (Found: C, 49·0; H, 5·6; N, 3·4; S, 15·3%).

The purity of both compounds was checked by thin layer chromatography on silica gel using ethyl acetate–petroleum ether as the solvent system.

*Methyl* 2-*amino*-4,6-O-*benzylidene*-2-*deoxy*-N-4-*methoxy-benzylidene*-β-D-*glucopyranoside* (XXIII)

The amine XIX (0·5 g) was dissolved in chloroform (2 ml), 4-methoxy-benzaldehyde (0·3 g) added and the mixture stored for 4 hr at room temp. The addition of ether and pet ether caused the precipitation of a small amount of a brown tar which was discarded. On standing over night the product crystallized and was recrystallized from ethanol–ether–pet ether to give 0·5 g (71%) product, m.p. 193–194°, $[\alpha]_D^{25}$ −7·9° (*c*, 0·5; in chloroform) (Found: C, 66·1; H, 6·4; N, 3·6. $C_{22}H_{25}NO_6$ requires: C, 66·1; H, 6·3; N, 3·5%).

*Methyl* 2-*amino*-4,6-O-*benzylidene*-2-*deoxy*-3-O-*methanesulphonyl*-N-4-*methoxy-benzylidene*-β-D-*glucopyranoside* (XXIV)

Compound XXIII was mesylated as described above to give the product in 73% yield, m.p. 177–178° (from ethanol), $[\alpha]_D^{26}$ −4·7° (*c*, 1·1; in chloroform) (Found: C, 58·0; H, 5·8; N, 3·1; S, 6·7. $C_{23}H_{27}NO_8S$ requires: C, 57·9; H, 5·7; N, 2·9; S, 6·7%).

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