in hot water and chromatographed through a Dowex 1 (OH) column to afford yields of 18% **10a** and 18% **10b** and about 0.65% of a mixture of **Z** and its anomer. Crystallization of this mixture from methanol afforded a few crystals of **Z**, mp 265–270°.

A variety of other conditions were studied for this reaction, but were found unsatisfactory—reaction at reflux temperature of ammonia; use of diluents such as 1,2-dimethoxyethane or tetrahydrofuran to help dissolve the glassy **9** in the liquid ammonia; and use of alcohol to destroy the excess sodium. If the large amount of ammonium chloride is not removed before the products are placed on the column, the Dowex 1 (OH) is deactivated and separation of the anomers is poor.

Registry No.—**1**, 18039-25-3; **2**, 18039-26-4; **3**, 18039-21-9; **4** 18039-22-0; **7** 18039-23-1; **9a** 18039-24-2; **9b** 18031-17-9; **10a** 17434-52-5; **10b** 18031-19-1; **11a** 18031-20-4; **11b**, 18031-28-2; **12**, 18031-29-3; **Z**, 18031-42-0; **Y**, 18031-41-9.

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Improved Syntheses of 5-Thio-D-glucose[1]

U. G. NAYAK AND ROY L. WHISTLER

Department of Biochemistry, Purdue University, Lafayette, Indiana 47907

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Two convenient and improved routes for the synthesis of 5-thio-D-glucose are described starting with 5,6-anhydro-3-*O*-benzyl-1,2-*O*-isopropylidene-β-L-idofuranose (II). II reacts with thiourea in methanol to give 3-*O*-benzyl-5,6-dideoxy-5,6-epithio-1,2-*O*-isopropylidene-α-D-glucofuranose (III) which, on nucleophilic ring opening with potassium acetate in acetic acid–acetic anhydride, gives 6-*O*-acetyl-5-*S*-acetyl-3-*O*-benzyl-1,2-*O*-isopropylidene-5-thio-α-D-glucofuranose (IV). Reduction of IV with sodium in liquid ammonia, followed by hydrolysis in 0.5 *M* sulfuric acid, gives 5-thio-D-glucopyranose (VI) in 32% over-all yield from 1,2:5,6-di-*O*-isopropylidene-α-D-glucofuranose. On reaction with sodium in benzyl alcohol, followed by *p*-tolylsulfonylation, II gives 3,6-di-*O*-benzyl-1,2-*O*-isopropylidene-5-*O*-(*p*-tolylsulfonyl)-β-L-idofuranose (X). Nucleophilic displacement of the *p*-tolylsulfonyloxy group with thiolacetate anion in dry N,N-dimethylformamide (DMF) gives 5-*S*-acetyl-3,6-di-*O*-benzyl-1,2-*O*-isopropylidene-5-thio-α-D-glucofuranose (XI). Reduction of XI with sodium in liquid ammonia, followed by hydrolysis in 0.05 *M* sulfuric acid, gives VI.

In recent years this laboratory and others have been interested in the syntheses of 4-thio and 5-thio sugars which can be cyclized readily into furanose and pyranose sugars in which sulfur replaces the oxygen as the heteroatom. Thus 4-thio-D- and L-ribose,[2,3] 5-thio-L-arabinose,[4] 5-thio-D-ribose,[5] 5-thio-D-xylose,[6] 5-thio-D-glucose,[7] and a few others have been synthesized. The nucleosides synthesized from these thio sugars may possess unusual physiological properties. However, the syntheses of most of these thio sugars in quantity for biological examination requires the development of approaches which will lead to higher yields.

We wish to report the synthesis of 5-thio-D-glucose by two different routes using 5,6-anhydro-3-*O*-benzyl-1,2-*O*-isopropylidene-β-L-idofuranose (II) which has now been prepared in very high yields by modifications of the published procedure.[8]

An earlier synthesis of 5-thio-D-glucose[7] from this laboratory utilized 5,6-anhydro-1,2-*O*-isopropylidene-β-L-idofuranose which was prepared in 61% yield from 6-*O*-acetyl- (or benzoyl-) 1,2-*O*-isopropylidene-5-*O*-(*p*-tolylsulfonyl)-α-D-glucofuranose. However, the preparation of this latter 5-tosyl compound by a selective tosylation of 6-*O*-acetyl- (or benzoyl-) 1,2-*O*-isopropylidene-α-D-glucofuranose is in itself a poor preparation, giving a yield of 20% or less of the desired 5-tosyl compound, as the product is contaminated with the 3,5-ditosylate. Also, the free hydroxyl group on C-3 has made most of these compounds, both in the gluco- and idofuranose series, fairly water soluble, making their isolation difficult. If the hydroxyl group on C-3 is blocked with a group that is fairly stable to acid and alkali, such as a benzyl ether group, the water solubility of this class of compounds is lessened and problems of selective tosylation do not arise. Thus 6-*O*-benzoyl-3-*O*-benzyl-1,2-*O*-isopropylidene-5-*O*-(*p*-tolysulfonyl)-α-D-glucofuranose (I), prepared from 5,6-di-*O*-acetyl-3-*O*-benzyl-1,2-*O*-isopropylidene-α-D-glucofuranose in 92% yield, was selected as the starting material.

3-*O*-Benzyl-1,2:5,6-di-*O*-isopropylidene-α-D-glucofuranose, prepared in 90% yield by a slight modification of the literature procedure,[8] is selectively hydrolyzed to remove the 5,6-isopropylidene group and is acetylated in the usual manner. The resulting crystalline 5,6-di-*O*-acetyl-3-*O*-benzyl-1,2-*O*-isopropylidene-α-D-glucofuranose is isolated in an over-all yield of 77% starting from 1,2:5,6-di-*O*-isopropylidene-α-D-glucofuranose. The above 5,6-di-*O*-acetyl derivative is deacetylated using a catalytic amount of sodium methoxide in methanol and selectively benzoylated at −15° (rather than 0° as earlier recommended[8]). The 6-*O*-benzoyl-3-*O*-benzyl-1,2-*O*-isopropylidene-α-D-glucofuranose, isolated in almost quantitative yield, is tosylated in the manner described earlier.[8] The resulting 6-*O*-benzoyl-3-*O*-benzyl-1,2-*O*-isopropylidene-5-*O*-(*p*-tolylsulfonyl)-α-D-glucofuranose (I) is then isolated in 92% yield.

Compound I in dry chloroform is treated with methanolic sodium methoxide to obtain a 90% yield of 5,6-

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anhydro-3-*O*-benzyl-1,2-*O*-isopropylidene-β-L-idofuranose (II). Compound II is found to be a very useful precursor for the synthesis of 5-thio-D-glucose by the two different routes described in this paper.

In the first procedure, compound II in methanol is treated with thiourea to obtain crystalline 3-*O*-benzyl-5,6-dideoxy-5,6-epithio-1,2-*O*-isopropylidene-α-D-glucofuranose (III) in 79% yield from I. Formation of compound III by inversion of the anhydro ring as in II has been demonstrated by Hall, *et al.*[9] Nuceophlilic ring opening of compound III with potassium acetate in acetic acid and acetic anhydride[7] gives crystalline 6-*O*-acetyl-5-*S*-acetyl-3-*O*-benzyl-1,2-*O*-isopropylidene-5-thio-α-D-glucofuranose (IV) in 81% yield. The ir spectrum of compound IV exhibits characteristic absorption at 1730 (*O*-acetyl) and 1685 cm^{-1} (*S*-acetyl). Reduction of compound IV with sodium in liquid ammonia gives an almost quantitative yield of 5-deoxy-1,2-*O*-isopropylidene-5-thio-α-D-glucofuranose (V) which is directly hydrolyzed using 0.05 *M* sulfuric acid and cyclized to the stable 5-thio-D-glucose (VI). α-D-Glucothiopyranose is best isolated as its penta-*O*-acetyl derivative (VII) in 70% yield. Compound VII does not exhibit *S*-acetyl absorption in the ir spectrum. Compound V is characterized through its known 3,6-di-*O*-acetyl-5-*S*-acetyl-1,2-*O*-isopropylidene-5-thio-α-D-glucofuranose (VIII).

Another route to compounds V, VI, VII and VIII is by utilization of 3,6-di-*O*-benzyl-1,2-*O*-isopropylidene-5-*O*-(*p*-tolylsulfonyl)-β-L-idofuranose (*X*) which is prepared according to published directions[10] starting from compound II (Scheme I). The displacement of the tolylsulfonyloxy group in compound X with thiolacetate anion gives a 73% yield of 5-*S*-acetyl-3,6-di-*O*-benzyl-1,2-*O*-isopropylidene-5-thio-α-D-glucofuranose (XI). The infrared spectrum of compound XI shows a strong absorption at 1685 cm^{-1}, characteristic of an *S*-acetyl group. Reduction of compound XI with sodium in liquid ammonia gives an essentially quantitative yield of compound V which on acetylation gives the same acetyl derivative (VIII) prepared by the first procedure.

Experimental Section

Analytical Methods.—Purity of products was determined by thin layer chromatography (tlc) on silica gel G[11] coated glass plates 5 × 13 cm irrigated with A, benzene–ethyl acetate (4:1); B, chloroform–acetone (9:4); C, chloroform–methanol (4:1); D, benzene–ethyl acetate (6:1) and E, hexane–ethyl acetate (6:1). Solvent ratios are based on volumes. Components were located by spraying with 5% sulfuric acid in ethanol and heating until permanent char spots were visible. Melting points were determined on a Fisher-Johns apparatus and are corrected. Nuclear magnetic resonance spectra were obtained with a Varian Associates A-60 instrument. Infrared spectra were obtained with a Perkin-Elmer Model 337 spectrophotometer. Evaporations were done under reduced pressure with a bath temperature below 40°. Absorption chromatography was made on silica gel[12] and neutral alumina (Woelm). Comparison of materials with authentic compounds was made by mixture melting point determination, infrared and nmr spectra, and thin layer chromatography.

6-*O*-Benzoyl-3-*O*-benzyl-1,2-*O*-isopropylidene-5-*O*-(*p*-tolylsulfonyl)-α-D-glucofuranose (I).—Compound I was prepared in greatly improved yields following essentially the published procedure,[8] but with modifications in the following sequential manner using 1,2:5,6-di-*O*-isopropylidene-α-D-glucofuranose as the starting material.

3-*O*-Benzyl-1,2:5,6-di-*O*-isopropylidene-α-D-glucofuranose. A.—To a suspension of sodium sand, prepared from 25.3 g (1.1 g-atom) by dispersion in xylene in 300 ml of dry ether, was added a solution of 1,2:5,6-di-*O*-isopropylidene-α-D-glucofuranose (260 g, (1.0 mol) in 3 l. of dry ether under stirring and free of moisture. The reaction mixture was gently refluxed for 16 hr after which time it was carefully but quickly decanted to another flask to separate the solution from the unreacted sodium particles. To this alkoxide solution in ether was added α-bromotoluene (180 g, 1.05 mol) and, under stirring, the ether was gently distilled from the reaction. Benzylation was completed by heating the residue under stirring at 70° for 16 hr. Heating was then discontinued and the reaction mixture was stirred with 1.5 l. of petroleum ether (bp 60–80°) and filtered. The filtrate was then washed with three 500-ml portions of water. The combined water extracts, after extraction with chloroform, gave 18 g of unreacted 1,2:5,6-di-*O*-isopropylidene-α-D-glucofuranose. The petroleum ether extract was washed several times with water (usually five or six more washes) or until tlc in solvent A showed the complete absence of starting material. The solution was then dried over anhydrous sodium sulfate. After filtration, the filtrate was concentrated under reduced pressure to give 327 g of 3-*O*-benzyl-1,2:5,6-di-*O*-isopropylidene-α-D-glucofuranose as a thick yellow syrup and was chromatographically homogeneous (except for the excess α-bromotoluene).

3-*O*-Benzyl-1,2-*O*-isopropylidene-α-D-glucofuranose (B), and Its Diacetate (C).—Compound A (327 g) was selectively hydrolyzed using a mixture of acetic acid (966 ml) and water (544 ml) at 40° for 16 hr after which time the acetic acid was neutralized carefully with potassium carbonate under stirring, adding a little water occasionally to keep the reaction mixture mobile. The reaction mixture was then extracted with three 1-l. portions of chloroform. The combined chloroform extracts were washed with 10% sodium chloride solution and dried over anhydrous sodium sulfate. The dried chloroform solution was filtered and the filtrate concentrated under reduced pressure. The residual syrup (287 g) was acetylated using dry pyridine (200 ml) and acetic anhydride (240 ml) at 25° for 16 hr after which time the reaction mixture was poured into ice cold water under stirring whereupon the diacetate (C) crystallized. After stirring the mixture for an additional 2 hr, the crystals were removed by filtration and washed thrice with ice cold water. The crystals were taken in 1.5 l. of chloroform and the solution washed once with water. The chloroform solution, after drying over anhydrous sodium sulfate, was filtered and concentrated whereupon the residue solidified. The solid residue was recrystallized from ether, mp 119–120°, yield 306 g of C (78%, calculated on the basis of the 260 g of 1,2:5,6-di-*O*-isopropylidene-α-D-glucofuranose used).

6-*O*-Benzoyl-3-*O*-benzyl-1,2-*O*-isopropylidene α-D-glucofuranose (D).—To a suspension of the acetyl derivative (C, 295.5 g, 0.75 mol) in 1200 ml of anhydrous methanol was added a freshly prepared solution of 600 mg of sodium in 50 ml of anhydrous methanol and stirred for 16 hr during which time the diacetate crystals went into solution and deacetylation was complete as shown by tlc in solvent A. The reaction mixture was then concentrated under reduced pressure to a syrup which was dissolved in 1.5 l. of chloroform and washed twice with 10% aqueous sodium chloride solution to remove the alkalinity. The chloroform solution, after drying over anhydrous sodium sulfate, was filtered and concentrated under reduced pressure. The last traces of chloroform were removed on an oil bath at 120° and 0.1 mm pressure. The pale yellow syrupy residue (B) weighed 231.5 g.

Compound B (231.5 g) was dissolved in 2300 ml of dry pyridine and cooled to −15°. To this cooled, stirred solution was added a solution of benzoyl chloride (96 ml, 1.1 mol) in 96 ml of alcohol-free chloroform with the exclusion of moisture, the temperature was maintained at −15 ± 2°. The reaction mixture was stirred for an additional 4 hr below 0° and then for 16 hr at 25°, after which time the reaction was worked up in the same manner as described in the literature.[8]

To a solution of compound D (302 g) in 770 ml of dry pyridine was added a solution of 352 g of *p*-tolylsulfonyl chloride in 1320 ml of alcohol free chloroform and the mixture stirred for 36 hr at 40° after which time it was worked up in the same manner as

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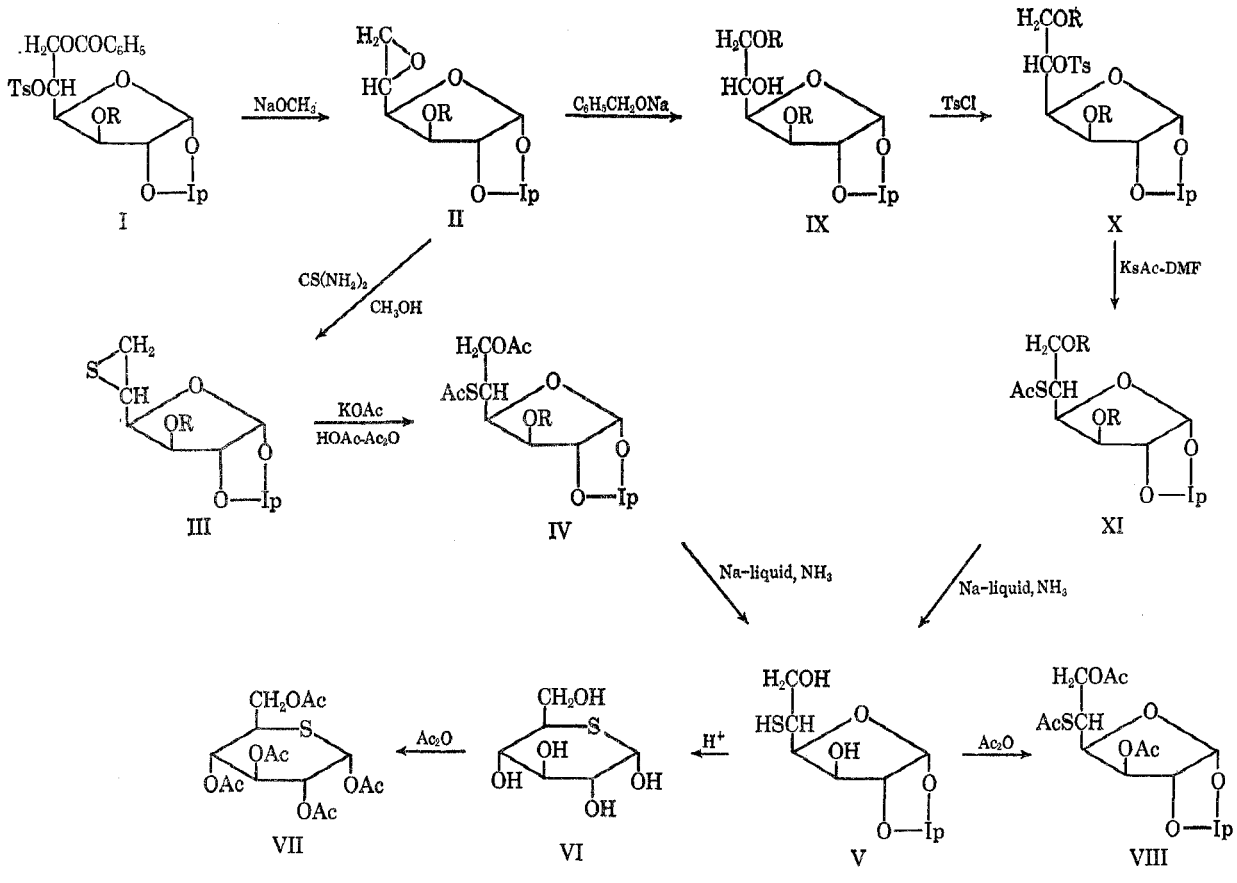
SCHEME I



Ip = $-C(CH_3)_2$; R = $-CH_2C_6H_5$

described in the literature.[8] The syrupy 6-*O*-benzoyl-3-*O*-benzyl-1,2-*O*-isopropylidene-5-*O*-(*p*-tolylsulfonyl)-α-D-glucofuranose (I) was crystallized from ether–hexane as small needles: mp 83–84°; $[\alpha]^{25}D$ −2.83 (*c* 3, chloroform) [lit.[8] mp 68–70°; $[\alpha]^{19}D$ −2.2° 0.8° (*c* 3.122, chloroform)]; yield of compound I was 92% of the theoretical, calculated from 5,6-di-*O*-acetyl derivative (C). *Anal.* Calcd for $C_{30}H_{32}O_9S$: C, 63.37; H, 5.66; S, 5.64. Found: C, 63.25; H, 5.73; S, 5.64.

5,6-Anhydro-3-*O*-benzyl-1,2-*O*-isopropylidene-β-L-idofuranose (II).—To a solution of compound I (284 g, 0.5 mol) in 2 l. of dry chloroform cooled to −15° was added, under stirring, an ice cold solution of freshly prepared sodium methoxide in methanol (31.35 g of sodium dissolved in 550 ml of methanol). The mixture was stirred for an additional 2 hr below 0° after which time it was left in the refrigerator at 0°. The reaction mixture was worked up as described in the literature[8] except that a 10% solution of sodium chloride was used for washing the chloroform extract to remove the alkalinity. The crude 5,6-anhydro compound (II) weighed 130 g after removal of chloroform and distillation of methyl benzoate under reduced pressure. Compound II was sufficiently pure for the next reaction.

3-*O*-Benzyl-5,6-dideoxy-5,6-epithio-1,2-*O*-isopropylidene-α-D-glucofuranose (III).—To a solution of compound II (crude syrup 130 g) in anhydrous methanol (4 l.) was added thiourea (48 g) and stirred at 25° with the exclusion of moisture until the reaction was complete as indicated by tlc in solvent A (usually 48–60 hr). The solution was poured into 4 l. of ice water in an evaporating dish and methanol was allowed to evaporate whereupon the epithio compound (III) crystallized.

The crystals were separated by filtration to yield 116 g of crystalline product which when recrystallized from absolute ethanol gave 103 g of the 5,6-epithio compound and 13 g of syrupy residue on concentration of the alcoholic filtrate: mp 68–69; $[\alpha]^{25}D$ −128.2° (*c* 1.02, chloroform).

The aqueous filtrate, after separation of the initial crystals, was extracted with two 750-ml portions of chloroform and the chloroform extract was washed twice with 10% sodium chloride solution. The washed chloroform solution, after drying over anhydrous sodium sulfate, was filtered and concentrated under reduced pressure to give another 20 g of crude epithio compound. This crude syrup (20 g) and the 13 g of syrup obtained above were combined and chromatographed over neutral alumina to give 25 g of a syrupy epithio compound contaminated with unreacted II and was recrystallized from absolute ethanol to give another 20 g of III, total yield 123 g (79%) calculated from compound I used). *Anal.* Calcd for $C_{16}H_{20}O_4S$: C, 62.31; H, 6.53; S, 10.39. Found: C, 62.48; H, 6.66; S, 10.53.

6-*O*-Acetyl-5-*S*-acetyl-3-*O*-benzyl-1,2-*O*-isopropylidene-5-thio-α-D-glucofuranose (IV).—A mixture of compound III (77 g, 0.25 mol), potassium acetate[13] (38.5 g, 0.40 mol), glacial acetic acid (87.5 ml) and acetic anhydride (440 ml) was refluxed for 16 hr after which time the reaction mixture was cooled and poured under stirring into 2500 ml of ice water. The mixture was stirred for about 3 hr during which time the acetic anhydride decomposed and the acetyl derivative (IV) started crystallizing out. These crystals were removed by filtration and the filtrate was extracted with two 750-ml portions of chloroform. The combined chloroform extracts were washed twice with water. The separated crystals of IV were dissolved in the chloroform solution and this solution was washed successively with water, dilute aqueous sodium bicarbonate until the washing was slightly alkaline and finally with water until the washing was neutral. This washed chloroform solution was dried over anhydrous sodium sulfate and a little decolorizing charcoal was added during this drying period. The mixture was filtered and the chloroform filtrate was concentrated under reduced pressure whereupon the residue crystallized. The solids were recrystallized from ether–petroleum ether (bp 60–80°) to give 83 g of compound IV: mp 110–111°; $[\alpha]^{25}D$ −48.8° (*c* 1, chloroform); yield 81%. The infrared spectrum in Nujol exhibited absorption peaks at 1730 (*O*-acetyl) and 1685 cm^{-1} (*S*-acetyl). *Anal.* Calcd for $C_{20}H_{26}O_7S$: C, 58.52; H, 6.38; S, 7.81; Found: C, 58.43; H, 6.45; S, 7.88.

5-Deoxy-1,2-*O*-isopropylidene-5-thio-α-D-glucofuranose (V)

(13) R. M. Rowell and R. L. Whistler, *J. Org. Chem.*, **31**, 1514 (1966).

and 3,6-Di-*O*-acetyl-5-*S*-acetyl-1,2-*O*-isopropylidene-5-thio-α-D-glucofuranose (VIII).—To a stirred solution of compound IV (41 g, 0.1 mol) in liquid ammonia (600 ml) was added 100 ml of dry 1,2-dimethoxyethane to assist the solubility of IV. Freshly cut sodium was added in small pieces (about 300 mg each) one at a time, until the blue color of the solution persisted for 15 min or more. The reaction mixture was then carefully decomposed with excess solid ammonium chloride and ammonia was allowed to evaporate overnight in a current of nitrogen. Chloroform (500 ml) was added and the solution warmed to 40° to drive off the last traces of ammonia with a current of nitrogen bubbling through the solution. The reaction mixture was filtered to separate the inorganic salts and the filtrate concentrated under reduced pressure to a reddish orange syrup which weighed 27 g. This crude syrup V was homogeneous by tlc in solvent B and was directly used for conversion to 5-thio-D-glucose (VI).

In a separate experiment, compound IV (4.1 g, 0.01 mol) was reduced as above to obtain syrupy V which was acetylated using pyridine and acetic anhydride and after the usual work-up gave an almost quantitative yield of 3,6-di-*O*-acetyl-5-*S*-acetyl-1,2-*O*-isopropylidene-5-thio-α-D-glucofuranose (VIII): mp 149°; $[\alpha]^{25}D$ +7.9° (*c* 1, chloroform) [lit.[13] mp 149°, $[\alpha]^{25}D$ +7.2° (*c* 1.8, chloroform)]. Compound VIII showed characteristic absorption at 1685 cm^{-1} in the infrared spectrum in Nujol. Both compounds and V and VIII gave an immediate color with sodium nitroprusside[14,15] and 2,3,5-triphenyl-2H-tetrazolium chloride.[16]

5-Thio-D-glucopyranose (VI) and 1,2,3,4,6-Penta-*O*-acetyl-α-D-glucothiopyranose (VII).—Compound V (27 g) was taken in 100 ml of 0.05 *M* sulfuric acid and stirred at 50° for 16 hr in a current of nitrogen. The hydrolysis and cyclization to thiopyranose (VI) was complete as indicated by the absence of starting material by tlc in solvent C. The acidic solution was then passed through a column of ir 45 (OH^-) and the column washed with deionized water until no more sugar was present in the washing. The aqueous solution collected from the column was concentrated under reduced pressure to give syrupy compound VI which was dried by coevaporation with absolute ethanol three times.

The residue (16 g) was taken in 150 ml of dry pyridine and 100 ml of acetic anhydride and stirred for 36 hr at 25°. The reaction mixture was poured into ice water with stirring for 2 hr after which time the mixture was extracted with chloroform. The chloroform extract was washed successively with cold 2 *N* hydrochloric acid with plenty of ice until slightly acidic, water, dilute aqueous sodium bicarbonate, and finally with water until neutral. The chloroform solution was dried over anhydrous sodium sulfate and a little decolorizing charcoal was added. The mixture was filtered and the filtrate was concentrated under reduced pressure to a viscous syrup which was dissolved in 100 ml of hot ethanol. On cooling in the refrigerator 1,2,3,4,6-penta-*O*-acetyl-α-D-glucothiopyranose (VII) crystallized out: yield 24 g; mp 103°; $[\alpha]^{25}D$ +212.5° (*c* 1, chloroform) [lit.[13] mp 103°, $[\alpha]^{20}D$ +213°, (*c* 1.35, chloroform)]. The residue after removal of ethanol, was chromatographed over neutral alumina giving another 4 g of compound VII, total yield 28 g (70% from compound IV).

3,6-Di-*O*-benzyl-1,2-*O*-isopropylidene-β-L-idofuranose (IX) and 3,6-Di-*O*-benzyl-1,2-*O*-isopropylidene-5-*O*-(*p*-tolylsulfonyl)-β-L-idofuranose (X).—Compound II (65 g of syrup) was allowed to react with benzyl alkoxide anion in benzyl alcohol at 40° and isolated in the manner described in the literature.[10] Compound IX, after two crystallizations from ether–hexane, had mp 75–76° $[\alpha]^{26}D$ −44.5° (*c* 2, chloroform). Compound X prepared from compound IX following the published directions was recrystallized from ether and had mp 89–90°, $[\alpha]^{25}D$ −15.8° (*c* 2, chloroform). Note: In an earlier publication[13] the melting points of these two compounds were erroneously reversed.

5-*S*-Acetyl-3,6-di-*O*-benzyl-1,2-*O*-isopropylidene-5-thio-α-D-glucofuranose (XI).—To a stirred solution of compound X (55.4 g, 0.1 mol) in dry DMF (500 ml), potassium thiolacetate (45.6 g, 0.4 mol) was added and heated for 16 hr at 115° in a current of nitrogen with the exclusion of moisture. The reaction mixture was then cooled in ice and poured under stirring into 3 l. of ice-cooled dry xylene. After stirring for 30 min the precipitated salts were removed by filtration, using a little xylene to wash the precipitate. The xylene filtrate was then concentrated under reduced pressure on a rotatory evaporator, care being taken to keep a nitrogen atmosphere as far as possible. After all the xylene and DMF were removed, the residue was shaken for a while with 700 ml of dry heptane, precipitating more of the residual salts which were removed by filtration. The heptane filtrate was then concentrated under reduced pressure to a deep red syrup (crude yield 46 g) which was taken in 90 ml of dry pyridine and 60 ml of acetic anhydride and stirred for 16 hr at 25°. The reaction mixture was then poured into ice cold water under stirring. After stirring for 1 hr the acetic acid was neutralized carefully with sodium bicarbonate and extracted with two 350-ml portions of ether. The ether extract was washed with water three times and dried over anhydrous sodium sulfate. After treatment with a little decolorizing charcoal, the ether solution was filtered. The filtrate was then concentrated to a deep yellow syrup (43 g) which was dissolved in 250 ml of ethanol. The ethanolic solution was left in the refrigerator for 24 hr at 0° where compound XI crystallized out as small needles. The crystals were removed by filtration, yield 25.2 g, mp 75–76°, $[\alpha]^{25}D$ −64.3° (c 1, chloroform). The filtrate, after concentration to a syrup, was fractionally chromatographed over silica gel using solvent E as eluent. The proper fractions containing the thioacetyl compound (XI) were collected and concentrated to give another 8 g of compound XI, total yield 33 g, 73.3%. The infrared spectrum of compound XI in Nujol showed the characteristic absorption at 1685 (*S*-acetyl) and 730 cm^{-1} (monosubstituted phenyl).

Anal. Calcd for $C_{25}H_{30}O_6S$: C, 65.48; H, 6.59; S, 6.99. Found: C, 65.48; H, 6.69; S, 7.05.

Compound XI on reduction with sodium in liquid ammonia in a manner similar to the reduction of compound IV gave the same compound V and was characterized through its acetyl derivative VIII, mp 149°. The ir and nmr spectra of compound VIII prepared by this method and the method described earlier were identical. The mixture melting point remained undepressed.

Registry No.—I, 18006-29-6; III, 18006-30-9; IV, 17968-65-9; VII, 10227-18-6; VIII, 10227-17-5; IX, 18006-23-0; X, 18006-24-1; XI, 17968-57-9; VI, 10,227-19-7; C, 18006-25-2.

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