followed by heating on a water bath for 45 min. Enough 6 *N* sulfuric acid was added to neutralize the base used and the 4-methoxy-2-pyrrolecarboxylic acid that formed was filtered from the solution. The crude acid was dissolved in chloroform, the insoluble material was separated, and the acid remaining in solution was crystallized from chloroform and ether. The resulting grey colored crystalline acid, 1.07 g., melted with decomposition at 164–167°. Recrystallization raised this to 175.0–175.5° (lit.,[27] m.p. 179–180°).

Anal. Calcd. for $C_6H_7O_3N$: C, 51.06; H, 5.00; N, 9.93; neut. equiv., 141. Found: C, 51.27; H, 4.85; N, 9.77; neut. equiv., 145.

2-Methoxycarbonyl-4-methoxypyrrole.—A mixture of 14.2 g. of the methoxypyrrole diester fraction, prepared as described above, 87 ml. of methanol and 3.3 g. of potassium hydroxide in 28 ml. of water was boiled for 10 min. To the mixture was added *ca.* 7% more 6 *N* sulfuric acid than equivalent to the potassium hydroxide used, the resulting mixture was diluted with water and extracted with ether. The ether solution was washed with sodium bicarbonate solution, dried with sodium sulfate, and the solvent evaporated. The dark colored oil was taken up in carbon tetrachloride and after two crystallizations 1.9 g. of purple-tinged crystals of 2-methoxycarbonyl-4-methoxypyrrole, m.p. 75–79°, remained. After decoloration of a portion with charcoal in ethyl alcohol and all in ether, which proved more effective, recrystallization from ether–petroleum ether mixture and finally benzene, beautiful white blades of the ester, m.p. 86.2 86.8° (lit.,[27] m.p. 85–86°), resulted.

Anal. Calcd. for $C_7H_9O_3N$: C, 54.25; H, 5.85; N, 9.02. Found: C, 54.33; H, 6.01; N, 9.10.

2-Formyl-3-methoxy-5-methoxycarbonylpyrrole.—A 0.75-g. sample of the crude ester derived from the hydrolysis of the methoxydialkoxycarbonylpyrrole fraction, b.p. 144–156°/3.5 mm., in a manner like that described as leading to 2-methoxycarbonyl-4-methoxypyrrole was formylated employing a procedure like that for the syntheses of 2-formyl-4-amyl-5-methylpyrrole. The crude aldehyde was crystallized from ethyl alcohol whereupon 0.52 g. (59%) of cream colored crystals, m.p. 164–165°, were obtained. A recrystallized sample melted at 166.5–168.2°.

Anal. Calcd. for $C_8H_9O_4N$: C, 52.46; H, 4.95. Found: C, 52.71; H, 5.16.

The 2,4-dinitrophenylhydrazone[28] of the aldehyde is a red, crystalline solid, which after crystallizing from ethyl alcohol was found to melt at 270° dec.

2,2′-(3-Methoxy-4′-amyl-5′-methyl-5-methoxycarbonyl)-dipyrrylmethene Hydrobromide.—To a solution of 0.36 g. of 2-formyl-3-methoxy-5-methoxycarbonylpyrrole and 0.28 g. of 2-methyl-3-amylpyrrole in 3 ml. of 95% ethyl alcohol, 1 ml. of 47.5% hydrobromic acid was added dropwise with cooling. Red crystals of the methene hydrobromide precipitated upon standing. These weighed 0.51 g. (69%) after separation, washing with water and air drying for a short time. Recrystallization from a mixture of chloroform and petroleum ether gave microscopic red crystals that exhibit a green reflex at 137.2–138.5° and melt dec.

Anal. Calcd. for $C_{18}H_{25}O_3N_2Br$: C, 54.41; H, 6.34; N, 7.05; Br, 20.11. Found: C, 55.19; H, 6.55; N, 6.70; Br, 20.47.

2,2′-(4,4′-Diamyl-5,5′-dimethyl)dipyrrylmethene Hydrobromide.—This compound was synthesized from 0.45 g. of 2-formyl-4-amyl-5-methylpyrrole and 0.53 g. of 2-methyl-3-amylpyrrole as in the preceding case. Red needles of the methene hydrobromide, 0.6 g. (61%), m.p. 126–128° dec., were obtained from alcohol. Two recrystallizations from benzene raised the melting point to 137.0–138.0° dec.

Anal. Calcd. for $C_{21}H_{33}N_2Br$: C, 63.61; H, 9.17; N, 7.07; Br, 20.15. Found: C, 63.64; H, 8.44; N, 7.33; Br, 20.30.

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Isopropyl Tetra-*O*-acetyl-α-D-glucopyranoside; A Synthesis of Kojibiose

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The chemical synthesis of α-D-glucopyranosides has proved very difficult. The β-D-anomers are readily synthesized by the use of the Koenigs–Knorr reaction[3] in which a tetra-*O*-acyl-α-D-glucopyranosyl halide reacts with a hydroxylic compound. Application of the Koenigs–Knorr reaction to the synthesis of α-D-glucopyranosides has been of limited success. Wolfrom, Pittet, and Gillam[4] introduced the use of stable, crystalline 3,4,6-tri-*O*-acetyl-2-*O*-nitro-β-D-glucopyranosyl chloride in a modified Koenigs–Knorr reaction leading to the successful synthesis of β-isomaltose octaacetate when 1,2,3,4-tetra-*O*-acetyl-β-D-glucopyranose[5] was used as the alcohol component. Methyl tetra-*O*-acetyl-α-D-glucopyranoside was obtained in 86% yield when methanol was used as both the solvent and the reactant.[4] The 2-nitrate group does not participate in the displacement at C-1 and the condensation reaction proceeds with Walden inversion at C-1 to yield the desired α-D linkage.

It was of interest to investigate the reaction of this glucosyl chloride with secondary alcohols. Isopropyl alcohol was chosen for this purpose since it is the simplest secondary alcohol available. Isopropyl alcohol and 3,4,6-tri-*O*-acetyl-2-*O*-nitro-β-D-glucopyranosyl chloride were condensed in the presence of silver carbonate, silver perchlorate, and anhydrous calcium sulfate, the alcohol serving as both solvent and reactant. The nitrate group was removed by catalytic reduction, the sirup acetylated, and subjected to silicate chromatography whereby there was obtained a 4.7% yield of crystalline isopropyl tetra-*O*-acetyl-β-D-glucopyranoside[6] and a 35% yield of the crystalline α-D anomer.[7] This constitutes the first direct chemical synthesis of isopropyl tetra-*O*-acetyl-α-D-glucopyranoside which had been prepared[7] previously by anomerization with boron trifluoride, of a chloroform solution of isopropyl tetra-*O*-acetyl-β-D-glucopyranoside.

When the condensation reaction was carried out in an ether solvent with the isopropyl alcohol present in a fourfold excess, the yields of both the α- and β-D-glucoside tetraacetate were reduced to 15.3% and 3.18%, respectively. The addition of iodine[8] to the reaction mixture produced no noticeable effect on the yields of products.

Attempts to extend this condensation reaction to the preparation of a disaccharide involving reaction with a

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secondary alcohol group resulted in a very low yield of the desired α-D-linked disaccharide. Condensation of 3,4,6-tri-*O*-acetyl-2-*O*-nitro-β-D-glucopyranosyl chloride with 1,3,4,6-tetra-*O*-acetyl-β-D-glucopyranose[9] under the conditions employed in the synthesis of β-isomaltose octaacetate[4] gave only 1.5% yield of crystalline 2-*O*-(α-D-glucopyranosyl)-β-D-glucopyranose (β-kojibiose) octaacetate with no 2-*O*-(β-D-glucopyranosyl)-D-glucopyranose (β-sophorose) octaacetate being detected. This low yield is undoubtedly due to steric reaction hindrance at the secondary hydroxyl position of the substituted hexose. The isolation of this small yield of product illustrates the power of the separation methods employed. Other methods for the chemical synthesis of kojibiose, isolated in low yield (3.2–2.8%) as the octaacetate, have been reported.[10,11] The relationship between crystalline α-kojibiose and its β-acetate is well established.[12]

Experimental

Materials.—The "active" silver carbonate was prepared by the method developed in this laboratory by Klemm and described by Wolfrom and co-workers.[4]

The silver perchlorate catalyst was prepared according to the general method described by Bredereck and co-workers.[13] A suspension of 5.5 g. (0.02 mole) of silver carbonate in 50 ml. of water stirred in the dark at 100° and 3.90 g. (0.0388 mole) of 60% perchloric acid was added dropwise. The mixture was then heated for 8 hr. at 95–103° and filtered hot through a sintered-glass filter funnel. The solution was evaporated to dryness in a porcelain dish on a steam bath, with occasional filtration, and the crystalline solid dried in a vacuum oven for 3.5 days at 100–110°; yield 6.5 g. The silver perchlorate was stored in the dark over solid potassium hydroxide. For best results, the silver perchlorate catalyst must be completely water-soluble. CAUTION! While this laboratory has never experienced any difficulties with silver perchlorate, it has been reported to detonate occasionally. Bredereck and co-workers observe no precautions regarding its use.

Isopropyl Tetra-*O*-acetyl-α-D-glucopyranoside.—An amount of 3.0 g. of 3,4,6-tri-*O*-acetyl-2-*O*-nitro-β-D-glucopyranosyl chloride[4] was treated as described by Wolfrom and co-workers[4] for the synthesis of methyl 2,3,4,6-tetra-*O*-acetyl-α-D-glucopyranoside except that about double the amount of "active" silver carbonate was used and stirring was maintained at room temperature for 77 hr. The nitrate group was removed by hydrogenation and the product was acetylated as described[4] previously. The resultant sirupy acetate was dissolved in 25 ml. of benzene. This solution was chromatographed, in equal amounts, on two 210 × 53 mm. (diam.) columns of Magnesol–Celite[14] (5:1 by wt.). Development with 500 ml. of benzene–2-methyl-2-propanol (100:1 by vol.), extrusion, and streaking with alkaline permanganate solution resulted in the appearance of two zones 50–90 and 130–180 mm. from the column top. The combined and sectioned zones were twice extracted with acetone, the combined extracts filtered, the solvent removed under reduced pressure, and the resulting sirups dissolved in ethanol. The ethanol solutions were decolorized with carbon, filtered, the solvent removed under reduced pressure, and the resulting sirups dissolved in hot absolute ethanol. The slower moving zone furnished crystalline isopropyl tetra-*O*-acetyl-β-D-glucopyranoside; yield 160 mg. (4.65%), m.p. 137–138°, $[\alpha]^{24}D$ −23° (*c* 2.0, chloroform) [reported[15]: m.p. 136–137°, $[\alpha]^{20}D$ −24.4° (*c* 2.0, chloroform)], X-ray powder diffraction pattern[16]: 11.19 s (3), 9.31 s (2), 7.63 vw, 6.11 w, 5.64 vw, 4.96 vs (1), 4.53 m, 4.13 m, 3.80 m, 3.49 vw, 3.14 w, 2.95 w, 2.77 w, 2.10 vw.

The faster moving zone furnished 1.67 g. of a sirup which produced crystalline isopropyl tetra-*O*-acetyl-α-D-glucopyranoside following nucleation[17]; yield 1.21 g. (35.1%), m.p. 85–88°, $[\alpha]^{24}D$ +143° (*c* 2.0, chloroform) [reported[7]: m.p. 85.5–86.5°, $[\alpha]^{20}D$ +143° (*c* 2.0, chloroform)], X-ray powder diffraction pattern[16]: 10.65 vw, 8.59 s (2), 7.69 s (3), 6.33 w, 5.72 vs (1), 4.98 m, 4.33 w, 3.99 w, 3.77 w, 3.53 m, 3.03 vw, 2.87 vw.

The condensation reaction was repeated with 0.5 g. (2 mmoles) of iodine in the original mixture. Processing in the manner described above yielded 157 mg. (5.90%), m.p. 135–137°, of crystalline isopropyl tetra-*O*-acetyl-β-D-glucopyranoside and 1.17 g. (34.1%), m.p. 84–87°, of crystalline isopropyl tetra-*O*-acetyl-α-D-glucopyranoside.

The condensation was carried out in 100 ml. of dry ether using 2.10 g. (35 mmoles) of isopropyl alcohol and processed as described above to yield 109 mg. (3.18%), m.p. 136–137.5°, of the isopropyl tetra-*O*-acetyl-β-D-glucopyranoside and 525 mg. (15.3%), m.p. 84–87°, of the isopropyl tetra-*O*-acetyl-α-D-glucopyranoside.

β-Kojibiose Octaacetate.—An amount of 2.6 g. (7.5 mmoles) of 1,3,4,6-tetra-*O*-acetyl-β-D-glucopyranose[9] was treated as described[4] for the synthesis of β-isomaltose octaacetate except that the reaction mixture was stirred at room temperature for 7.5 days and treatment with carbon was omitted. The reaction solution was then processed, hydrogenated, acetylated,[4] and chromatographed as described above (1500 ml. of developer). Extrusion and streaking with alkaline permanganate solution resulted in the appearance of one zone 65–90 mm. from the column top. The zone was sectioned, combined, and processed as previously described to yield 25 mg. (1.5%) of β-kojibiose octaacetate, m.p. 123–125°, no depression upon admixture with known β-kojibiose octaacetate, X-ray powder diffraction pattern identical to that of known β-kojibiose octaacetate. Processing the column effluent yielded 1.86 g. of β-D-glucopyranose pentaacetate, m.p. 127–129°.

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(17) Kindly furnished by Dr. B. Lindberg.

Sulfamylguanidines

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Reactions of sulfamide or mono-substituted sulfamides (*i.e.*, sulfamylamines) with primary or secondary amines to displace ammonia are well known.[1–3]

$$RNHSO_2NH_2 + R'NH_2 \longrightarrow RNHSO_2NHR' + NH_3$$

However, when we attempted to treat substituted guanidines with N,N-disubstituted sulfamylamines, such as N-sulfamylpiperidine, 3-methyl-N-sulfamylpiperidine, or N-sufamyldimethylamine in dimethyl sulfoxide, no ammonia could be detected. Instead, further examination showed the products to be sulfamylguanidines (I). This unexpected reaction provides a facile method for preparing the heretofore unknown sulfamylguanidines and appears to be of general application when guanidine, mono-substituted or N,N-disubstituted guanidines are reacted with N,N-

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