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ONE-FLASK SYNTHESIS OF TRIACETALATED ALDOHEXOSES WITH 2,2-DIALKOXYPROPANE AND *p*-TOLUENESULFONIC ACID*

MAKOTO KISO, AKIHIRO KONDO, YUMI KONDO, AND AKIRA HASEGAWA
Department of Agricultural Chemistry, Gifu University, Gifu 501-11 (Japan)
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ABSTRACT

2-Deoxy-D-*arabino*-hexose and some *N*-protected 2-amino-2-deoxy-D-glucose derivatives were each treated with 2,2-dimethoxy- or 2,2-dibenzyloxy-propane in 1,4-dioxane in the presence of *p*-toluenesulfonic acid at 60–70°. The major products were acyclic, dimethyl and dibenzyl acetals of 2-deoxy-3,4:5,6-di-*O*-isopropylidene-*aldehydo*-D-*arabino*-hexose or of *N*-protected 2-amino-2-deoxy-3,4:5,6-di-*O*-isopropylidene-*aldehydo*-D-glucose. Some of the dibenzyl acetals were converted into the corresponding 3,4:5,6-di-*O*-isopropylidene-*aldehydo*-D-hexoses in good yield.

INTRODUCTION

In a previous paper[1a], we described a simple procedure for preparing 1,1-dialkyl acetal derivatives of 2-acetamido- or 2-(benzyloxycarbonylamino)-2-deoxy-3,4:5,6-di-*O*-isopropylidene-*aldehydo*-D-glucose (**8, 10, 14,** and **16**) which were not readily obtained when *N,N*-dimethylformamide was employed[1c] as the solvent in the acetal-exchange reaction with 2,2-dialkoxypropane and *p*-toluenesulfonic acid. Hough *et al.*[2] and, later, Ueno *et al.*[3] prepared some new tetra-acetals of lactose, maltose, and some other glucobioses by conducting the acetalation with 2,2-dimethoxypropane in the absence of *N,N*-dimethylformamide, or in 1,4-dioxane. Recently, this acetalation procedure has also been applied to a synthesis of benzylidene acetals[4]. We now describe further investigations of the one-flask, triacetalation of some aldohexoses with the 2,2-dialkoxypropane reagent, and also point out the potential utility of the products as synthetic precursors.

RESULTS AND DISCUSSION

2-Deoxy-D-*arabino*-hexose (**1**; 1 g) was treated with a large excess of 2,2-dimethoxypropane or 2,2-dibenzyloxypropane in dry 1,4-dioxane in the presence of

*The Behavior of Some Aldoses with Acetal-Exchange Reagents, Part XI. The title of this series has been modified, and a preceding paper (ref. 1a) is now numbered Part X. For Part IX and the previous title, see ref. 1b.

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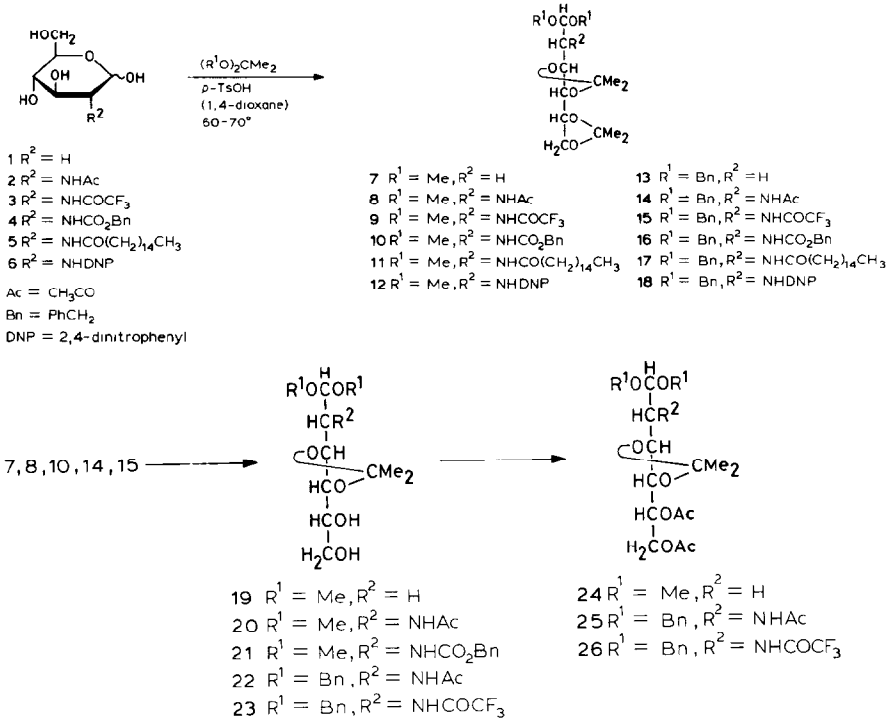
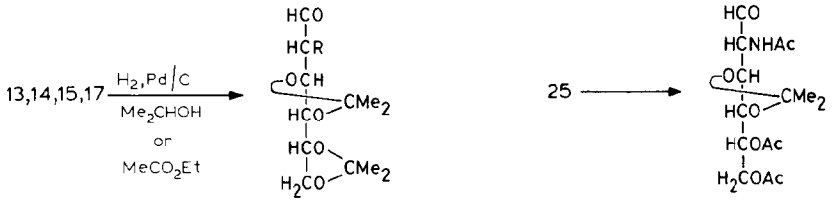


p-toluenesulfonic acid monohydrate (150 mg) for 1.5–2 h at 60–70° according to the procedure employed[1a] for the preparation of **8, 10, 14,** or **16**. The major product was, as expected, 2-deoxy-3,4:5,6-di-*O*-isopropylidene-*aldehydo*-D-*arabino*-hexose dimethyl acetal (**7**; 62%) or the dibenzyl acetal derivative (**13**; 61%), respectively. Treatment of 2-deoxy-2-(trifluoroacetamido)-D-glucose[5] (**3**) with 2,2-dimethoxypropane in 1,4-dioxane, as just described, gave crystalline 2-deoxy-3,4:5,6-di-*O*-isopropylidene-2-(trifluoroacetamido)-*aldehydo*-D-glucose dimethyl acetal (**9**) in 68% yield. When treated with 2,2-dibenzyloxypropane, compound **3** gave the corresponding dibenzyl acetal **15** in 60% yield after chromatography on a column of silica gel. Starting from the *N*-hexadecanoyl (**5**) or the *N*-(2,4-dinitrophenyl) (**6**) derivative of 2-amino-2-deoxy-D-glucose, the corresponding dialkyl acetals **11** (72%), **12** (95%), **17** (53%), and **18** (72%) were obtained as the major products.

Similar treatment of D-glucose with 2,2-dialkoxypropane reagents afforded a mixture of 2,3:5,6- and 3,4:5,6-di-*O*-isopropylidene-*aldehydo*-D-glucose dialkyl (dimethyl and dibenzyl) acetals in good yield[6], in contrast to the results with 2-acetamido-2-deoxy-D-galactose, 2-acetamido-2-deoxy-D-mannose, D-galactose, D-mannose, D-arabinose, and D-ribose, from which such acyclic, 1,1-dialkyl acetal derivatives could scarcely be obtained[7]. Thus, the results show that, in this one-flask acetalation method, 2-deoxy-D-*arabino*-hexose or aldohexoses of the *gluco* type, as far as examined, give mainly the acyclic, 1,1-dialkyl acetal derivatives. In



27 R = H
28 R = NHAc
29 R = $NHCOCF_3$
30 R = $NHCO(CH_2)_{14}CH_3$

31

the same way, the acetalation of some aldohexoses with 1,1-dialkoxycyclohexane, instead of 2,2-dialkoxypropane, has also been examined[8].

Selective removal of the 5,6-*O*-isopropylidene group in **7, 14,** or **15** was accomplished by heating at 40–45° with 80% aqueous acetic acid by the procedure employed[1a] for **8** and **10**. The yield was almost quantitative, except for **19**, in which part of the dimethyl acetal on C-1 was simultaneously cleaved. Compound **19, 22,** or **23** was then acetylated, to give **24, 25,** or **26**, respectively, and these were subjected to instrumental analysis. All of the spectral features were consistent with the respective structures assigned.

Hydrogenolysis of the dibenzyl acetals **13, 14, 15,** and **17** in the presence of 10% palladium–carbon catalyst in 2-propanol or ethyl acetate gave the corresponding, acyclic aldehydes **27, 28, 29,** and **30** in almost quantitative yield. Compound **25** was also converted into **31** by the same procedure. Aldehyde **28** had been prepared[9] by the demercaptalation of 2-acetamido-2-deoxy-3,4:5,6-di-*O*-isopropylidene-*aldehydo*-D-glucose diethyl dithioacetal, but the method entailed use of thiols having unpleasant effluvia and of a large amount of cadmium or mercuric reagent[10], or both. The present procedure thus provides a new route to acyclic sugar aldehydes that might be potentially useful as synthetic precursors in the extension reactions of carbon chains.

EXPERIMENTAL

General methods. — Melting points were determined with a Yanagimoto micro melting-point apparatus and are uncorrected. Evaporations were conducted *in vacuo*. Preparative chromatography was performed on silica gel (Wako Co.; 200 mesh) with the solvent systems specified. For hydrogenolysis, 10% palladium–carbon catalyst was pre-activated in ethanol, filtered, washed, and suspended in the solvents specified. Specific rotations were determined with a Union MP-201 polarimeter, and i.r. spectra were recorded with a Jasco IRA-1 spectrophotometer. ^{1}H-N.m.r. spectra were recorded at 60 and 90 MHz with Hitachi R-24 and R-22 spectrometers, for solutions in chloroform-*d*, unless otherwise noted, and the n.m.r. data were confirmed by use of decoupling techniques.

2-Deoxy-3,4:5,6-di-O-*isopropylidene*-aldehydo-D-arabino-*hexose dimethyl acetal* (**7**). — A suspension of 2-deoxy-D-*arabino*-hexose (**1**; 1 g) in dry 1,4-dioxane (10 mL) was stirred at 65–70°, while 2,2-dimethoxypropane (4 mL) and *p*-toluenesulfonic acid monohydrate (150 mg) were added; stirring was continued for 1.5–2 h at 65–70°. The mixture was treated as described[1a] for the preparation of **8**, to give a crude syrup that was chromatographed on a column of silica gel with 200:1 chloroform–methanol.

Compound **7** (1.1 g; 62%) was a syrup, $[\alpha]_D$ +26.1° (*c* 0.66, methanol); ν_{max}^{film} 870, 850, and 825 cm^{-1} (Me_2C); n.m.r. data: δ 1.30 and 1.36 (2 s, 6 H, Me_2C), 1.39 (s, 6 H, Me_2C), 1.77 (m, 1 H, J_{gem} 14, $J_{1,2}$ 3.8, $J_{2,3}$ 9 Hz, H-2), 2.17 (m, 1 H, $J_{1,2'}$ 8, $J_{2',3}$ 3.2 Hz, H-2'), 3.36 (s, 6 H, 2 MeO), and 4.63 (dd, 1 H, H-1).

Anal. Calc. for $C_{14}H_{26}O_6$: C, 57.91; H, 9.03. Found: C, 57.73; H, 8.98.

2-Deoxy-3,4:5,6-di-O-*isopropylidene-2-(trifluoroacetamido)*-aldehydo-D-*glucose dimethyl acetal* (**9**). — A stirred suspension of 2-deoxy-2-(trifluoroacetamido)-D-glucose[5] (**3**; 0.1 g) in dry 1,4-dioxane (2 mL) was heated to ~70°, and then 2,2-dimethoxypropane (1 mL) and *p*-toluenesulfonic acid monohydrate (16 mg) were added; stirring was continued for 2 h at ~70°. The mixture was cooled, the acid neutralized by addition of sodium hydrogencarbonate, the suspension filtered, and the solid washed with methanol. The filtrate and washings were combined, and evaporated to a residue that was chromatographed on a column of silica gel with 500:1 chloroform–methanol to give crystalline **9** (0.1 g; 68%); m.p. 44–45°, $[\alpha]_D$ +5° (*c* 1, chloroform); ν_{max}^{film} 3400 and 3300 (NH), 1730 and 1540 (amide), and 870 and 840 cm^{-1} (Me_2C); n.m.r. data: δ 1.33, 1.39 and 1.42 (3 s, 12 H, 2 Me_2C), 3.36 and 3.39 (2 s, 6 H, 2 MeO), and 6.82 (broad d, 1 H, NH).

Anal. Calc. for $C_{16}H_{26}F_3NO_7$: C, 47.88; H, 6.53; N, 3.49. Found: C, 47.69; H, 6.38; N, 3.43.

2-Deoxy-2-(hexadecanoylamino)-3,4:5,6-di-O-*isopropylidene*-aldehydo-D-*glucose dimethyl acetal* (**11**). — 2-Deoxy-2-(hexadecanoylamino)-D-glucose (**5**; 0.5 g) was suspended in dry 1,4-dioxane (5 mL), and stirred with 2,2-dimethoxypropane (2 mL) and *p*-toluenesulfonic acid monohydrate (80 mg) under the condition described for **7**. The mixture was cooled, and treated with IRA-410 (OH^-) ion-exchange resin to remove the acid; the resin was filtered off, and washed with methanol. The filtrate and washings were combined, and evaporated to a syrup which was chromatographed on a column of silica gel with 300:1 chloroform–methanol, to afford an amorphous mass of **11** (0.47 g; 72%); $[\alpha]_D$ +3° (*c* 2, chloroform); ν_{max}^{film} 3280 (NH), 1660 and 1520 (amide), and 880 and 840 cm^{-1} (Me_2C); n.m.r. data: δ 0.7–1.7 (m, 41 H, alkyl chain and Me_2C), 2.1–2.5 (m, 2 H, $COCH_2$-), 3.31 and 3.36 (2 s, 6 H, 2 MeO), and 5.78 (d, 1 H, NH).

Anal. Calc. for $C_{30}H_{57}NO_7$: C, 66.26; H, 10.57; N, 2.58. Found: C, 66.37; H, 10.54; N, 2.46.

2-Deoxy-2-(2,4-dinitrophenyl)amino-3,4:5,6-di-O-*isopropylidene*-aldehydo-D-*glucose dimethyl acetal* (**12**). — A suspension of 2-deoxy-2-(2,4-dinitrophenyl)amino-D-glucose (**6**; 0.5 g) in dry 1,4-dioxane (5 mL) was heated at 65–70°,

and stirred while 2,2-dimethoxypropane (2.5 mL) and *p*-toluenesulfonic acid monohydrate (80 mg) were added. The mixture was stirred for 2 h at 65–70°, cooled, and freed of the acid by addition of Amberlite IRA-410 (OH^-) ion-exchange resin. The suspension was filtered, and the filtrate evaporated, to give a crude mass which crystallized from ether. The crystals (0.48 g) were collected by filtration, and the filtrate was evaporated to a residue that was chromatographed on a column of silica gel with 500:1 chloroform–methanol, to give an additional 0.17 g of crystals. The total yield of crystalline **12** was 0.65 g (95%); m.p. 181°, $[\alpha]_D$ +80.6° (*c* 1, chloroform); ν_{max}^{Nujol} 3300 (NH), 1620, 1590 and 1520 (NO_2), 840 (Me_2C), and 740 and 720 cm^{-1} (Ph); n.m.r. data: δ 1.22, 1.30, 1.40, and 1.50 (4 s, 12 H, 2 Me_2C), 3.3 and 3.47 (2 s, 6 H, 2 MeO), and 7.05, 8.04, and 8.9 (m, 4 H, C_6H_4).

Anal. Calc. for $C_{20}H_{29}N_3O_{10}$: C, 50.95; H, 6.20; N, 8.91. Found: C, 51.13; H, 6.38; N, 9.02.

*2-Deoxy-3,4:5,6-di-*O*-isopropylidene-*aldehydo-D-arabino-*hexose dibenzyl acetal* (**13**). — A stirred suspension of 2-deoxy-D-*arabino*-hexose (**1**; 1.0 g) in dry 1,4-dioxane (5 mL) was heated to 60–65°, and then 2,2-dibenzyloxypropane[10] (5 mL) was added. The mixture was stirred for 2 h at 60–65°, cooled, and freed of the acid by addition of powdered sodium hydrogencarbonate; the suspension was filtered, and the solid washed with methanol. The filtrate and washings were combined, and evaporated to a syrup that was chromatographed on a column of silica gel with chloroform, to give **13** (1.65 g; 61%) as a syrup; $[\alpha]_D$ +19.2° (*c* 0.6, chloroform); ν_{max}^{film} 3120–3000, 1980–1680, 740 and 695 (Ph), and 880 and 845 cm^{-1} (Me_2C); n.m.r. data: δ 1.30 and 1.32 (2 s, 6 H, Me_2C), 1.37 (s, 6 H, Me_2C), 1.94 (m, 1 H, J_{gem} 14, $J_{1,2}$ 4, $J_{2,3}$ 9 Hz, H-2), 2.33 (m, 1 H, $J_{1,2'}$ 8, $J_{2',3}$ 3 Hz, H-2'), 4.46–4.79 (m, 4 H, 2 PhCH_2), and 7.2–7.4 (m, 10 H, 2 Ph).

Anal. Calc. for $C_{26}H_{34}O_6$: C, 70.56; H, 7.74. Found: C, 70.43; H, 7.66.

*2-Deoxy-3,4:5,6-di-*O*-isopropylidene-2-(trifluoroacetamido)-*aldehydo-D-*glucose dibenzyl acetal* (**15**). — A suspension of **3** (10 g) in 2,2-dibenzyloxypropane (60 mL) was stirred at 65°, while *p*-toluenesulfonic acid monohydrate (0.4 g) was added. The mixture was stirred for 1.5 h at 65°, and processed as just described for **13**. The crude syrup was acetylated with acetic anhydride (40 mL) and pyridine (80 mL), to permit eventual removal of the benzyl alcohol formed in the initial reaction. The product was chromatographed on a column of silica gel with (*a*) chloroform and (*b*) 300:1 chloroform–methanol. Eluant *b* gave **15** (12 g; 60%) as a syrup; $[\alpha]_D$ +2.6° (*c* 1, chloroform); ν_{max}^{film} 3430 and 3120 (NH), 3120–3000, 1980–1680, 740 and 705 (Ph), 1740 and 1540 (amide), and 880, 855, and 820 cm^{-1} (Me_2C); n.m.r. data: δ 1.32 and 1.41 (2 s, 12 H, 2 Me_2C), 6.79 (d, 1 H, NH), and 7.26 and 7.30 (2 s, 10 H, 2 Ph).

Anal. Calc. for $C_{28}H_{34}F_3NO_7$: C, 60.75; H, 6.19; N, 2.53. Found: C, 60.58; H, 6.34; N, 2.33.

*2-Deoxy-2-(hexadecanoylamino)-3,4:5,6-di-*O*-isopropylidene-*aldehydo-D-*glucose dibenzyl acetal* (**17**). — A solution of **5** (0.2 g) in dry 1,4-dioxane (2 mL)

was stirred at 65° while *p*-toluenesulfonic acid monohydrate (60 mg) and 2,2-dibenzyloxypropane (1 mL) were added; stirring was continued for 2 h at 65°, and the mixture was processed as described before. The main product (**17**), purified by preparative t.l.c. (Merck, $60F_{254}$) with 20:1 chloroform–methanol, was a syrup (0.18 g; 53%); $[\alpha]_D$ −1.3° (*c* 1, chloroform); ν_{max}^{film} 3300 (NH), 3060–3000, 2000–1600, 730 and 690 (Ph), 1670 and 1500 (amide), and 840 and 800 cm^{-1} (Me_2C); n.m.r. data: δ 0.7–1.8 (m, 41 H, $C_{14}H_{29}$ and Me_2C), 2.1 (m, 2 H, $C(O)CH_2$), 5.79 (broad d, 1 H, NH), and 7.15 (s, 10 H, 2 Ph).

Anal. Calc. for $C_{42}H_{65}NO_7$: C, 72.48; H, 9.41; N, 2.01. Found: C, 72.69; H, 9.48; N, 1.84.

*2-Deoxy-2-(2,4-dinitrophenyl)amino-3,4:5,6-di-*O*-isopropylidene-*aldehydo-D-*glucose dibenzyl acetal* (**18**). — A solution of **6** (0.2 g) in dry 1,4-dioxane (2 mL) was heated at 65°, and stirred while *p*-toluenesulfonic acid monohydrate (30 mg) and 2,2-dibenzyloxypropane (1.5 mL) were added. The mixture was stirred for 2 h at 65°, and processed. The product was purified by preparative t.l.c. as described for **17**, to give **18** (0.26 g; 72%) as a syrup; $[\alpha]_D$ +81.4° 8*c* 1, chloroform); ν_{max}^{film} 3300 (NH), 3080–3000, 740, and 690 (Ph), 1620, 1590 and 1520 (NO_2), and 840 (Me_2C); n.m.r. data: δ 1.19, 1.29, 1.37 and 1.48 (4 s, 12 H, 2 Me_2C), 7.03, 7.91, and 8.90 (m, 3 H, dinitrophenyl), and 7.22 and 7.24 (2 s, 10 H, 2 CH_2Ph).

Anal. Calc. for $C_{32}H_{37}N_3O_{10}$: C, 61.63; H, 5.98; N, 6.74. Found: C, 61.49; H, 5.77; N, 6.71.

*2-Deoxy-3,4-*O*-isopropylidene-*aldehydo-D-arabino-*hexose dimethyl acetal* (**19**). — A solution of **7** (108 mg) in methanol (4 mL) containing a catalytic amount of *p*-toluenesulfonic acid monohydrate was stirred for 5 h at room temperature, and then treated with Amberlite IRA-410 (OH^-) resin to remove the acid. The suspension was filtered, and the filtrate evaporated, to give a syrup that was chromatographed on a column of silica gel with (*a*) 200:1 and (*b*) 100:1 chloroform–methanol. Eluant *a* gave **7** (24 mg, 22.2%), and eluant *b*, compound **19** (36 mg, 39%) as a syrup; $[\alpha]_D$ +29.5° (*c* 0.36, chloroform); ν_{max}^{film} 3400 (OH), and 875 and 830 cm^{-1} (Me_2C).

*2-Deoxy-3,4-*O*-isopropylidene-2-(trifluoroacetamido)-*D*-glucose dibenzyl acetal* (**23**). — A solution of **15** (545 mg) in 80% aqueous acetic acid (20 mL) was heated for 4 h at 40°. It was then evaporated at 40° to a syrup which was chromatographed on a column of silica gel with (*a*) 300:1, (*b*) 150:1, and (*c*) 100:1 chloroform–methanol Eluant *c* gave a syrup of **23** (495 mg; 98%); $[\alpha]_D$ +14.7° (*c* 0.57, chloroform); ν_{max}^{film} 3460 (OH), 3410 (NH), 3100–3000, 740 and 700 (Ph), 1720 and 1540 (amide), and 880 and 820 cm^{-1} (Me_2C).

*5,6-Di-*O*-acetyl-2-deoxy-3,4-*O*-isopropylidene-*aldehydo-D-arabino-*hexose dimethyl acetal* (**24**). — Compound **19** (200 mg) was acetylated with acetic anhydride (1 mL) and pyridine (2 mL). The product (**24**), purified by chromatography on a column of silica gel, was a syrup; $[\alpha]_D$ +44.7° (*c* 1, chloroform); ν_{max}^{film} 1750 (ester), and 865 and 820 cm^{-1} (Me_2C); n.m.r. data: δ 1.39 (s, 6 H, Me_2C), 1.8–2.0 (m, 2 H, H-2,2′), 2.06 and 2.08 (2 s, 6 H, 2 AcO), 3.33 and 3.36 (2 s, 6 H, 2 MeO),

3.83 (dd, 1 H, $J_{3,4}$ 7.5, $J_{4,5}$ 6.5 Hz, H-4), 4.02 (m, $J_{2,3}$ 7.5, $J_{2',3}$ 4.5 Hz, H-3), 4.12 (dd, 1 H, J_{gem} 12, $J_{5,6}$ 6 Hz, H-6), 4.5 (dd, 1 H, $J_{5,6'}$ 3 Hz, H-6'), 4.56 (dd, 1 H, $J_{1,2}$ 6.2, $J_{1,2'}$ 5 Hz, H-1), and 5.13 (m, 1 H, H-5).

*2-Acetamido-5,6-di-*O*-acetyl-2-deoxy-3,4-*O*-isopropylidene*-aldehydo-D-*glucose dibenzyl acetal* (**25**). — A solution of **14** (1 g) in 70% aqueous acetic acid (20 mL) was heated for 2 h at 45°, and processed as described for **23**. The product (**22**) was acetylated, and compound **25** (1.1 g; 93%) crystallized from ether–hexane, m.p. 120°, $[\alpha]_D$ +40° (*c* 1.5, chloroform); ν_{max}^{Nujol} 3240 (NH), 1740 (ester), 1640 and 1540 (amide), 870 and 850 (Me_2C), and 740 and 690 cm^{-1} (Ph); n.m.r. data: δ 1.33 and 1.36 (2 s, 6 H, Me_2C), 1.91, 1.95, and 1.98 (3 s, 9 H, 2 AcO and AcN), 5.20 (m, 1 H, H-5), 6.13 (d, 1 H, NH), and 7.27 and 7.29 (2 s, 10 H, 2 Ph).

*5,6-Di-*O*-acetyl-2-deoxy-3,4-*O*-isopropylidene-2-(trifluoroacetamido)*-aldehydo-D-*glucose dibenzyl acetal* (**26**). — Compound **23** (308 mg) was acetylated with acetic anhydride and pyridine, to give **26** as a syrup; $[\alpha]_D$ +33.6° (*c* 0.72, chloroform); ν_{max}^{film} 3410 and 3310 (NH), 3100–3000, 740 and 705 (Ph), 1750 and 1540 (ester and amide), and 880 and 825 cm^{-1} (Me_2C); n.m.r. data: δ 1.35 (s, 6 H, Me_2C), 1.99 and 2.01 (2 s, 6 H, 2 AcO), 3.8 (t, 1 H, $J_{3,4} = J_{4,5} = 7.5$ Hz, H-4), 4.05 (dd, 1 H, J_{gem} 12, $J_{5,6}$ 5.5 Hz, H-6), 4.25–4.85 (m, 8 H, H-1,2,3,6' and 2 PhCH_2), 5.15 (m, $J_{5,6'}$ 5.8 Hz, H-5), 6.65 (d, 1 H, $J_{2,NH}$ 10 Hz, NH), and 7.2–7.4 (m, 10 H, 2 Ph).

*2-Deoxy-3,4:5,6-di-*O*-isopropylidene*-aldehydo-D-arabino-*hexose* (**27**). — To a solution of **13** (750 mg) in 2-propanol (25 mL) was added 10% palladium–carbon catalyst (400 mg), and hydrogen was bubbled through for 2 h while the solution was stirred at room temperature. The catalyst was filtered off, and washed with 2-propanol. The filtrate and washings were combined, and evaporated to a residue that was chromatographed on a column of silica gel with 150:1 chloroform–methanol, to afford **27** (340 mg; 82%) as a syrup; $[\alpha]_D$ +14.6° (*c* 0.7, chloroform); ν_{max}^{film} 2740 and 1730 (CHO), and 875 and 850 cm^{-1} (Me_2C); n.m.r. data: δ 1.32 (s, 3 H, 0.5 Me_2C), 1.37 (s, 9 H, 1.5 Me_2C), 2.64 (m, 1 H, J_{gem} 16.3, $J_{1,2}$ 2.5, $J_{2,3}$ 7.8 Hz, H-2), 2.88 (m, 1 H, $J_{1,2'}$ 2, $J_{2',3}$ 4 Hz, H-2'), 3.55 (m, 1 H, H-5), 4.38 (m, 1 H, $J_{3,4}$ 7.8 Hz, H-3), and 9.72 (t, 1 H, H-1).

Anal. Calc. for $C_{12}H_{20}O_5$: C, 59.00; H, 8.25. Found: C, 59.24; H, 8.09.

*2-Acetamido-2-deoxy-3,4:5,6-di-*O*-isopropylidene*-aldehydo-D-*glucose* (**28**). — To a solution of **14** (1 g) in ethyl acetate (40 mL) was added 10% palladium–carbon catalyst (500 mg), and hydrogen was bubbled through for 2 h at 45°. The product, purified by chromatography on a column of silica gel with 30:1 chloroform–acetone, gave **28** (590 mg; 98%) as a syrup; $[\alpha]_D$ +6.8° (*c* 2.8, chloroform) {lit.[9] $[\alpha]_{578}^{20}$ +2.07° (*c* 8.25, methanol)}; ν_{max}^{film} 3280 (NH), 2700 and 1730 (CHO), 1650 and 1510 (amide), and 870 and 840 cm^{-1} (Me_2C); n.m.r. data: δ 1.34, 1.37 and 1.45 (3 s, 12 H, 2 Me_2C), 2.10 (s, 3 H, AcN), 3.7 (m, 1 H, H-5), 3.8–4.4 (m, 3 H, H-4,6,6'), 4.50 (dd, 1 H, $J_{2,3}$ 2.2, $J_{3,4}$ 8 Hz, H-3), 4.99 (dd, 1 H, $J_{1,2}$ ~0, $J_{2,NH}$ 9.4 Hz, H-2), 6.35 (d, 1 H, NH), and 9.62 (s, 1 H, CHO).

Anal. Calc. for $C_{14}H_{23}NO_6$: C, 55.80; H, 7.69; N, 4.65. Found: C, 56.02; H, 7.84; N, 4.38.

2-Deoxy-3,4:5,6-di-O-isopropylidene-2-(trifluoroacetamido)-aldehydo-D-*glucose* (**29**). — Compound **15** (522 mg) was hydrogenolyzed in 2-propanol (25 mL) as described for **27**. The product (**29**; 290 mg, 86%), purified by column chromatography, was a syrup; $[\alpha]_D$ −2° (*c* 0.56, chloroform); ν_{max}^{film} 3400 and 3300 (NH), 1730 (CHO), 1710 and 1540 (amide), and 840 cm^{-1} (Me_2C); n.m.r. data: δ 1.25, 1.36, 1.38, and 1.43 (4 s, 12 H, 2 Me_2C), 4.40 (dd, 1 H, $J_{2,3}$ 2.3, $J_{3,4}$ 8 Hz, H-3), 5.50 (dd, 1 H, $J_{1,2}$ ~0, $J_{2,NH}$ 8.6 Hz, H-2), 7.4 (very broad d, 1 H, NH), and 9.65 (s, 1 H, CHO).

Anal. Calc. for $C_{14}H_{20}F_3NO_6$: C, 47.32; H, 5.67; N, 3.94. Found: C, 47.57; H, 5.41; N, 4.19.

2-Deoxy-2-(hexadecanoylamino)-3,4:5,6-di-O-isopropylidene-aldehydo-D-*glucose* (**30**). — Hydrogenolysis of **17** was conducted in 2-propanol as just described, to give **30** in quantitative yield as a syrup; $[\alpha]_D$ +2.2° (*c* 1.4, chloroform); ν_{max}^{film} 3280 (NH), 1740 (CHO), 1650 and 1520 (amide), and 850 cm^{-1} (Me_2C); n.m.r. data: δ 0.7–1.8 (m, 41 H, alkyl and Me_2C), 2.25 (m, 2 H, $COCH_2$-), 4.5 (dd, 1 H, H-3), 5.0 (dd, 1 H, H-2), and 9.55 (s, 1 H, CHO).

Anal. Calc. for $C_{28}H_{51}NO_6$: C, 67.57; H, 10.33; N, 2.81. Found: C, 67.36; H, 10.18; N, 2.75.

2-Acetamido-5,6-di-O-acetyl-2-deoxy-3,4-O-isopropylidene-aldehydo-D-*glucose* (**31**). — Hydrogenolysis of **25** (700 mg) in ethyl acetate (30 mL) was performed as described for **28**, and the product was purified by chromatography on a column of silica gel with 50:1 chloroform–acetone, to afford **31** (430 mg; 97%) as a syrup; $[\alpha]_D$ +9.8° (*c* 1.9, chloroform); ν_{max}^{film} 3320 (NH), 2720 and 1730 (CHO), 1650 and 1530 (amide), and 850 cm^{-1} (Me_2C); n.m.r. data: δ 1.4 (s, 6 H, Me_2C), 2.07, 2.13, and 2.15 (3 s, 9 H, 2 AcO and AcN), 4.60 (dd, 1 H, $J_{2,3}$ 2.2, $J_{3,4}$ 6 Hz, H-3), 4.81 (dd, 1 H, $J_{1,2}$ ~0, $J_{2,NH}$ 8.4 Hz, H-2), 6.5 (d, 1 H, NH), and 9.60 (s, 1 H, CHO).

Anal. Calc. for $C_{15}H_{23}NO_8$: C, 52.17; H, 6.71; N, 4.06. Found: C, 52.39; H, 6.64; N, 3.87.

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