Synthesis of 2-*O*-β-D-xylopyranosyl-D-xylose

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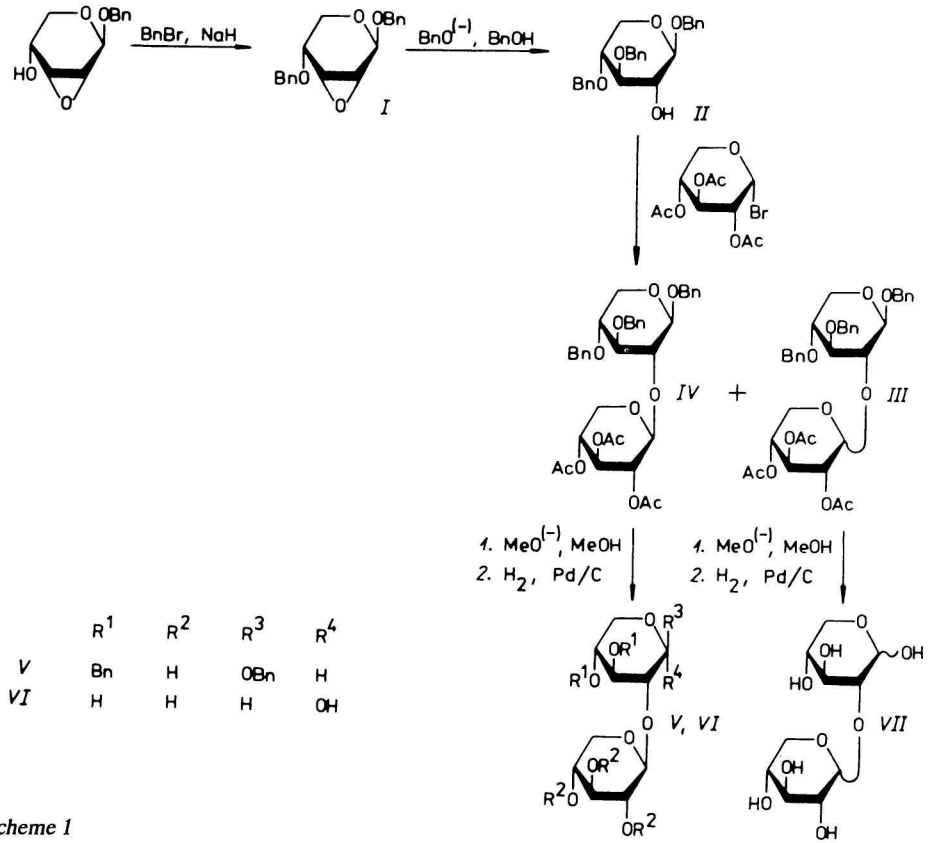
Benzylation of benzyl 2,3-anhydro-β-D-ribopyranoside with benzyl bromide and sodium hydride in 1,2-dimethoxyethane, followed by treatment of the formed, corresponding 4-*O*-benzyl derivative with benzyl alcoholate anion in benzyl alcohol, gave benzyl 3,4-di-*O*-benzyl-β-D-xylopyranoside. The foregoing compound was allowed to react with 2,3,4-tri-*O*-acetyl-α-D-xylopyranosyl bromide to give fully substituted (1→2)-linked xylobioses (combined yield 87%, α:β = 1:6.4) which, after removal of blocking groups, afforded 2-*O*-α- and -β-D-xylopyranosyl-D-xylose.

Бензилированием бензил-2,3-ангидро-β-D-рибопиранозида с бромистым бензилом и гидридом натрия в 1,2-диметоксиэтане было получено соответственное 4-*O*-бензил производное. Последнее после воздействия аниона бензилового спирта в бензиловом спирте превратилось в бензил-3,4-ди-*O*-бензил-β-D-ксилопиранозид. Его конденсацией с 2,3,4-три-*O*-ацетил-α-D-ксилопиранозилбромидом были получены полностью замещенные (1→2)-связанные ксилобиозы (общий выход продуктов конденсации 87%, α:β = 1:6,4), из которых после удаления блокирующих групп были получены 2-*O*-α- и -β-D-ксилопиранозил-D-ксилозы.

Xylan type polysaccharides branched at C-2 of some D-xylose units of the main chain are constituents of certain cell-wall polysaccharides [1, 2]. The title compound was isolated [2] from products of partial hydrolysis of seed mucilage of *Plantago major* L. var. *asiatica* DECAISNE, and it has been suggested [3] that 2-*O*-D-xylosyl-D-xyloses are formed by acid-catalyzed reversion of D-xylose. Chemical synthesis of 2-*O*-β-D-xylopyranosyl-D-xylose has not been described in the literature and its synthesis (Scheme 1) was undertaken as a part of a project aimed at systematic syntheses and studies of various properties of xylooligosaccharides.

The formation of (1→2)-interglycosidic linkage was achieved by condensation [4] of 2,3,4-tri-*O*-acetyl-α-D-xylopyranosyl bromide [5] with benzyl 3,4-di-*O*-benzyl-β-D-xylopyranoside (*II*). The intermediate *II* was obtained from



	R^1	R^2	R^3	R^4
V	Bn	H	OBn	H
VI	H	H	H	OH

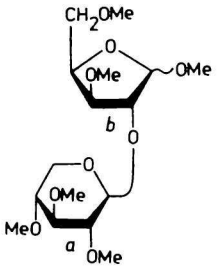
Scheme 1

the known [6] benzyl 2,3-anhydro-β-D-ribopyranoside by benzylation [7] under conditions which were found suitable in the synthesis of methyl 2,3-anhydro-4-*O*-benzyl-β-D-ribopyranoside, followed by opening of the anhydro ring in the formed benzyl 2,3-anhydro-4-*O*-benzyl-β-D-ribopyranoside (*I*) with benzyl alcoholate anion in benzyl alcohol. The exceptionally easily isolable, crystalline compound *I* (81.7%), when treated with the above-mentioned nucleophilic reagent, afforded *II* in a yield of 75.5%. Analogous reactions are known [8] to occur with high regioselectivity giving D-xylose derivatives in high yield.

When 2,3,4-tri-*O*-acetyl-α-D-xylopyranosyl bromide (100% molar excess over the amount of used *II*) was allowed to react with the nucleophile *II* the latter substance reacted completely (t.l.c.) and a portion of the β-linked disaccharide derivative *IV* could be directly isolated from the crude reaction product by crystallization. Chromatography of the material that remained in the mother liquor gave a further amount of *IV* (total yield 75.3%) and the α-linked isomer *III* (11.8%). The configuration of the interglycosidic linkage in *III* and *IV*, and

products of their further conversion, was assigned on the basis of their specific optical rotation.

The free disaccharides *VI* and *VII* were obtained from *IV* and *III*, respectively, by removal of blocking groups. The (1→2)-linkage in *VI* and *VII* follows from the mode of the synthesis and it was also confirmed by mass spectrometry of their fully methylated derivatives. Methylation [9] of *VI* as well as of *VII* gave two products one of which was identical, according to t.l.c. [10] and their mass spectra [11], with the known [10] methyl β-glycosides of (1→2)-α- and (1→2)-β-linked xylobioses. The mass spectra of the second product formed from *VI* and *VII* by methylation contained peaks of ions of the baE_1 Series (m/z 321) diagnostic [12] of the presence of some material containing furanoid cycle *b*



This showed that during methylation a portion of each of the disaccharides having the hemiacetal hydroxyl group unsubstituted had reacted in its furanoid form.

Experimental

Melting points were determined on a Kofler hot-stage. Optical rotations were measured with a Perkin—Elmer Model 141 automatic polarimeter. Mass spectra (70 eV) were recorded at an emission of 300 μA using a JMS 100-D spectrometer, applying direct sample-introduction technique. Thin-layer chromatography (t.l.c.) on Silica gel G and preparative chromatography on columns of dry-packed silica gel, equilibrated prior to packing with 40% of the mobile phase, was performed with *A*. benzene—acetone 10:1, *B*. benzene—acetone 15:1, *C*. carbon tetrachloride—acetone 10:1, *D*. carbon tetrachloride—ethyl acetate 8:1, *E*. chloroform—methanol 15:1, and *F*. chloroform—methanol 3:1. Detection was effected by spraying with 5% (v/v) sulfuric acid in ethanol and heating until permanent char spots were visible. The purity of the final products was checked also by chromatography on commercial thin layers of cellulose (Lucefol), with ethyl acetate—acetic acid—water 18:7:8 as the mobile phase, and detection with aniline hydrogen phthalate. Solutions were dried with anhydrous sodium sulfate and concentrated at 40°C/2 kPa.

Benzyl 2,3-anhydro-4-O-benzyl-β-D-ribopyranoside (I)

Sodium hydride (0.8 g; 33 mmol) followed by benzyl bromide (3 ml; 25 mmol) was added at 0°C and with stirring to a solution of benzyl 2,3-anhydro-β-D-ribopyranoside (5 g;

22 mmol) in 1,2-dimethoxyethane (50 ml). The mixture was stirred at room temperature and with the exclusion of atmospheric moisture and carbon dioxide for 1 h, and t.l.c. (solvent *A*) then showed that the conversion of the starting material (R_f 0.25) to a product (R_f 0.6) was complete. After cautious addition of water (50 ml), the organic solvent was removed at reduced pressure, and the mixture was diluted with another portion of water (50 ml). Crystalline product that separated on cooling (0°C) was filtered off, washed with water and recrystallized from ethanol to give *I* (5.7 g, 81.7%). A portion was recrystallized to afford the analytical sample melting at 89—89.5°C, $[\alpha]_D^{22} = +3.1°$ (*c* 1, chloroform).

For $C_{19}H_{20}O_4$ (312.35) calculated: 73.06% C, 6.45% H; found: 72.85% C, 6.54% H.

Benzyl 3,4-di-O-benzyl-β-D-xylopyranoside (II)

Sodium hydride (0.75 g; 33 mmol) was added portionwise and with stirring to benzyl alcohol (17 ml) and, when clear solution of sodium benzoxide in benzyl alcohol had formed, compound *I* (1 g; 3.2 mmol) was introduced. The mixture was stirred with the exclusion of atmospheric moisture and carbon dioxide at 100—105°C and occasionally checked [13] by t.l.c. (solvent *B*). When the reaction was complete (~3 h) the mixture was cooled (20°C), diluted with ethanol (35 ml), deionized with Dowex 50 W (H^+) resin and concentrated. Crystallization from isopropyl alcohol afforded *II* (1.1 g, R_f 0.4, *cf.* R_f 0.5 for the starting material), and further amount of the same material (0.1 g, total yield 75.5%) was obtained by chromatography of the material in the mother liquor. Recrystallization of a portion gave the analytical sample melting at 76—76.5°C and having $[\alpha]_D^{22} = -60.8°$ (*c* 1, chloroform).

For $C_{26}H_{28}O_5$ (420.50) calculated: 74.26% C, 6.71% H; found: 74.30% C, 6.82% H.

Benzyl 2-O-(2,3,4-tri-O-acetyl-α- (III) and -β-D-xylopyranosyl)-3,4-di-O-benzyl-β-D-xylopyranoside (IV)

2,3,4-Tri-*O*-acetyl-α-D-xylopyranosyl bromide (10.7 g; 31.6 mmol) was added to a stirred mixture of *II* (7 g; 16.6 mmol), mercuric cyanide (4 g; 15.8 mmol), and Drierite (42 g) in acetonitrile (100 ml), and the mixture was stirred with the exclusion of atmospheric moisture for 30 min. At this time t.l.c. (solvent *C*) showed absence of both starting materials and that one main product was formed (R_f 0.4). The reaction mixture was worked-up conventionally [4] and crystallization from ethanol gave *IV* (7.7 g), m.p. 126—127°C and $[\alpha]_D^{22} = -67.8°$ (*c* 1, after recrystallization from the same solvent).

For $C_{37}H_{42}O_{12}$ (678.71) calculated: 65.47% C, 6.24% H; found: 65.60% C, 6.35% H.

Thin-layer chromatography of the mother liquor (solvent *D*, double development) showed that in the region of the mobility of *IV* two spots (R_f 0.22 and 0.28) were present, the one with the slower mobility being indistinguishable from *IV*. Chromatography on a column of silica gel gave fractions enriched in the individual components and crystallization from ethanol gave a further amount of *IV* (0.8 g, total yield 75.3%) and *III* (1.4 g, 11.8%, total yield of isolated condensation products 87.1%), m.p. 92—93.5°C, $[\alpha]_D^{22} = +48.7°$ (*c* 1, chloroform).

Found: 65.66% C, 6.35% H.

Benzyl 3,4-di-O-benzyl-2-O-β-D-xylopyranosyl-β-D-xylopyranoside (V)

Methanolic 1 M sodium methoxide (2 ml) was added to a suspension of *IV* (1.9 g) in methanol (100 ml) and the mixture was stirred at room temperature and with the exclusion of atmospheric moisture and carbon dioxide until all starting material dissolved. Thin-layer chromatography then showed that the reaction was complete and conventional isolation gave *V* (1.5 g, ~100%, R_f 0.35, solvent *E*), m.p. 124—125.5°C (from ethanol), $[\alpha]_D^{22}$ = −46.2° (*c* 1, chloroform).

For $C_{31}H_{36}O_9$ (552.60) calculated: 67.37% C, 6.57% H; found: 67.60% C, 6.64% H.

2-O-β-D-Xylopyranosyl-D-xylopyranose (VI)

A solution of compound *V* (7.42 g) in ethanol—acetone (1:1, 200 ml) was hydrogenolyzed at room temperature over 5% palladium-on-charcoal catalyst (1.6 g) until t.l.c. (solvent *F*) showed complete conversion of the starting material to a product (R_f 0.25). Conventional isolation and crystallization from methanol gave the α form of the title disaccharide (3.5 g, 91.3%), m.p. 193—194.5°C (after recrystallization), $[\alpha]_D^{22}$ = +10.4° (extrapol.)→ +7.2° (1.5 min)→ −8.4° (240 min, const, *c* 1, water). Ref. [2], $[\alpha]_D$ = −28.9° for amorphous *VI*.

For $C_{10}H_{18}O_9$ (282.25) calculated: 42.55% C, 6.43% H; found: 42.72% C, 6.48% H.

2-O-α-D-Xylopyranosyl-D-xylopyranose (VII)

Compound *III* (0.2 g) was deacetylated as described for the preparation of *V*, and hydrogenated as described for the preparation of *VI*. Conventional isolation gave *VII* as a solid foam (49 mg, 73%), $[\alpha]_D^{22}$ = +105° (*c* 1.4, water).

Found: 42.37% C, 6.28% H.

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