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1,6:3,4-Dianhydro-β-D-galactopyranose as Intermediate for the Synthesis of 3,4-Disubstituted D-Glucose Derivatives

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Abstract

1,6:3,4-Dianhydro-β-D-galactopyranose **(6)** was synthesized in five steps with an overall yield of 19.3% starting from D-glucose. This intermediate was used for the synthesis of 4-*O*-substituted and 3,4-di-*O*-substituted D-glucose derivatives which are of interest as potential pharmaceuticals or building blocks for syntheses of oligosaccharides.

Keywords: 1,6:3,4-dianhydro-β-D-galactopyranose, stereoselective oxirane ring formation and opening, alkylation, THP ether

Introduction

1,6:3,4-Dianhydro-β-D-galactopyranose **(6)** [1,2] is an important intermediate that has been used for syntheses of 4-deoxy [3], 4-amino-4-deoxy [4,5], 4-deoxy-4-fluoro [6,7], 4-deoxy-4-thio [8], 4-*O*-alkyl [2] and 4-C-alkyl-D-glucose [9] derivatives. **6** has been so far prepared by partial 4-*O*-tosylation of levoglucosan (1,6-anhydro-β-D-glucopyranose) **(21)** followed by displacement of the tosyl group with formation of 3,4-anhydro ring under alkaline conditions [10] or by reductive or photochemical cleavage of the corresponding 2-*O*-tosyl derivative **8,** a compound obtained in two steps from **21** [2,7,9,11]. Since we were interested in evaluation of several substituted glucose derivatives as potential pharmaceuticals we have developed new synthesis of product **6** and have used this intermediate in routine synthesis of a series of 4-*O*-substituted or 3,4-di-*O*-substituted D-glucose derivatives.

Chemistry

Levoglucosan, 1,6-anhydro-β-D-glucopyranose **(21)**, is usually prepared by thermal vacuum degradation of starch or polysaccharides [12-16]. With its rigid structure, axial orientation of hydroxy groups and sterically hindered hydroxy group in position C-3, **21** has been frequently used for synthesis of 2,4-di-*O*-substituted and 2,3,4-tri-*O*-substituted D-glucose derivatives [10]. In addition, chemical syntheses of substituted derivatives of **21** have been described, i.e., by treatment of 6-*O*-benzyl-1,2-*O*-orthoacetate-D-glucose derivatives under conditions of Koenigs-Knorr synthesis [17] or by alkali catalyzed treatment of phenyl-glucosides or glucose derivatives carrying *O*-tosyl or other leaving group on C-6 [3,7,10,18,19]. Based on the last mentioned synthetic method we have tried to prepare **6** in a new way starting directly from D-glucose **(1)**. In a modified procedure of Wolfrom, **1** was treated with iso-

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propenyl-methyl ether to afford 4,6-*O*-isopropylidene derivative **2** [20]. This product was acetylated with acetic anhydride in presence of dry sodium acetate to obtain 1,2,3-tri-*O*-acetyl-β-D-glucopyranose derivative **3**. The isopropylidene group of **3** was removed by mild acidic hydrolysis and **4** was mesylated to obtain crystalline **5**. This new dimesylate was treated with dry potassium carbonate in methanol. During this reaction, after cleavage of the acetyl groups, the β-hydroxy group on C-1 and the hydroxy group on C-3 were expected to displace the 6-*O*-mesyl and 4-*O*-mesyl groups, respectively [7], under direct formation of 1,6:3,4-dianhydro-β-D-galactopyranose **6**. This reaction succeeded and gave after vacuum destillation and crystallization pure **6** in an overall 19.3% yield starting from **1**. All intermediates with exception of **4** are crystalline and require no chromatography. No migration of the 3,4-anhydro ring to 1,6:2,3-dianhydro-β-D-talopyranose was observed under the reaction conditions [1].

The 3,4-anhydro ring of **6** can be stereoselectively opened by acid or base catalyzed solvolysis or alcoholysis to give gluco-derivatives with trans diaxial oriented hydroxy functions [21]. The free hydroxy group of **6** had to be protected by an alkali stable protecting group to allow further alkylation. In analogy to previously published method a diastereoisomeric mixture of the dihydropyranyl ether **7** was prepared [2]. **7** could be crystallized and showed two signals of the same intensity for H-1 in proton NMR. Subsequently, **7** was treated with sodium hydroxide, solutions of sodium in benzyl alcohol or n-propanol to give 1,6-anhydro-2-*O*-tetrahydropyranyl-β-D-glucopyranose **(9)** and the corresponding 4-*O*-benzyl and 4-*O*-propyl ethers **10** and **11**. Interestingly, the diastereoisomers **10** and **11** could be separated by preparative chromatography. The more hydrophilic diastereoisomers **10b** and **11b** could be crystallized and showed more negative value of optical rotation. Determination of absolute configuration of these THP ethers is in progress. Cleavage of the THP group of **10** gave 1,6-anhydro-4-*O*-benzyl-β-D-glucopyranose **(12)** prepared previously on a different way [19]. The products **9** or **10** were alkylated with benzyl chloride or propyl bromide in DMSO in the presence of powdered KOH or benzoylated under standard conditions to give **13, 14** and **15**. Cleavage of the THP ether of these products afforded the 3,4-di-*O*-substituted levoglucosan derivatives **16-18. 16** was identical with product obtained on an alternative way [17] and was further converted to 2-*O*-methyl-derivative **19** and to crystalline 2-*O*-benzoyl derivative **20**.

In conclusion, new method for synthesis of 1,6:3,4-dianhydro-β-D-galactopyranose **(6)** has been developed. The product **6** has been further used for synthesis of less known 4-*O*-substituted and 3,4-di-*O*-substituted D-glucose derivatives.

Experimental Part

Melting points were determined in open capillary tubes and are uncorrected. TLC of each compound was performed on Merck F 254 silica gel plates, and column chromatography on Merck silica gel 60 (230-400 mesh). Gas chromatography was performed with a Carlo Erba GC 6000, Vega Series 2. Elemental analyses were within ±4% of the theoretical values, except where indicated. The structure of all compounds were confirmed by their IR spectra (Perkin-Elmer 1310 or 298 spectrophotometers), ^{1}H-NMR spectra (Varian HA-100D or Bruker WM-250) and fast atom bombardment mass spectra FAB-MS (VG-Manchester). Abbreviations used: Bzl = benzyl, Bz = benzoyl, Ms = methanesulfonyl, THP = tetrahydropyranyl, Ts = *p*-toluenesulfonyl.

4,6-O-Isopropylidene-D-glucose (2)

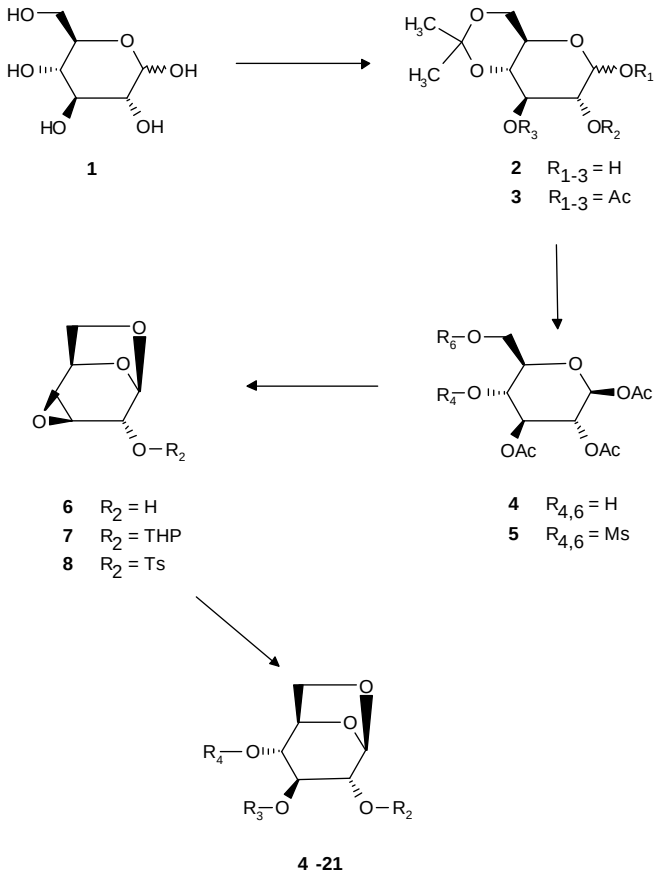
Stirred suspension of 450.0 g (2.5 mol) of D-glucose **(1)** in 2.25 l of dry DMF was cooled to 0 – 5 °C. 1.25 ml of methanesulfonic acid was added followed by dropwise addition of 470.0 ml (5.0 mol) of isopropenyl-methylether (Fluka AG) at such a rate to keep the temperature of the reaction mixture below 5 °C (4 h). The resulting clear solution was treated with 5.0 ml of NEt_3 and evaporated in vacuum. The residue was crystallized from 650 ml of isopropanol to afford 231.2 g (42.0 %) of white crystals of **2**, mp. 169 – 170 °C, $[\alpha]_D^{20} = -6° \pm 1°$ (water, c = 1.631). Anal. for $C_9H_{16}O_6$ (m.w. 220.22) calc. C 49.09 %, H 7.33 %; found C 49.3%, H 7.3 %.

4,6-O-Isopropylidene-1,2,3-tri-O-acetyl-β-D-glucopyranose (3)

Suspension of 30 g of dry sodium acetate in 1000 ml (10 mol) of Ac_2O and 20 ml water was stirred under nitrogen and warmed to 100 °C. Then, without external heating, 220 g (1 mol) of **2** was added in portions at such a rate to keep the temperature at 100 – 105 °C. After complete addition the clear reaction mixture was stirred for additional 0.5 h at 100 °C, cooled to 45 – 50 °C and used directly in the next step. An aliquot of the reaction mixture was withdrawn and put on excess crushed ice. The separated product was collected, washed with water, dried and recrystallized from ethyl acetate/hexane to obtain **3** in 85% yield, mp. 170-173 °C, $[\alpha]_D^{20} = -32° \pm 1°$ ($CHCl_3$, c = 1.218). ^{1}H-NMR ($CDCl_3$) δ 5.72 (d, 1H); 5.16 (t, 1H); 5.03 (t, 1H); 3.34 – 4.06 (m, 4H); 2.09 (s, 3H); 2.03 (s, 3H); 2.0 (s, 3H); 1.5 (s, 3H); 1.42 (s, 3H). Anal. for $C_{15}H_{22}O_9$ (346.34) calc. C 52.02 %, H 6.41 %; found C 52.25 %, H 6.58 %.

1,2,3-Tri-O-acetyl-β-D-glucopyranose (4)

The reaction mixture of **3** described above was treated dropwise with 610 ml of water, stirred for 4 h at 50 – 60 °C



Scheme 1

	R_2	R_3	R_4
9	THP	H	H
10	THP	H	Bzl
11	THP	H	*n*-C_3H_7
12	H	H	Bzl
13	THP	Bzl	Bzl
14	THP	*n*-C_3H_7	Bzl
15	THP	Bz	Bzl
16	H	Bzl	Bzl
17	H	*n*-C_3H_7	Bzl
18	H	Bz	Bzl
19	CH_3	Bzl	Bzl
20	Bz	Bzl	Bzl
21	H	H	H

and evaporated. The residue was taken up in 2 l of dichloromethane, was washed with saturated $NaHCO_3$ solution and with brine, and dried over $MgSO_4$. The filtrate was evaporated to give 256 g (83.6%) of **4** as clear oil. The product was used without further purification.

4,6-Di-O-methanesulfonyl-1,2,3-tri-O-acetyl-β-D-glucopyranose (5)

Solution of 306.0 g (1.0 mol) of **4** in 800 ml of dry pyridine was cooled in ice bath and treated dropwise during 3 h with 178 ml of mesylchloride. After standard workup and crystallization from EtOH 376.8 g (81.5 %) of **5** was obtained as white crystals, mp. 176-179 °C, $[\alpha]_D^{20}$ = –8° ± 1° ($CHCl_3$, c = 1.074), ^{1}H-NMR ($CDCl_3$) δ 5.82 (d, 1H); 5.42 (t, 1H); 5.05 (t, 1H); 4.8 (t, 1H); 4.26 – 4.58 (m, 2H); 4.09 (m, 1H); 3.12 (s, 3H); 3.08 (s, 3H); 2.14 (s, 3H); 2.09 (s, 3H); 2.03 (s, 3H). Anal. for $C_{14}H_{22}O_{13}S_2$ (462.45) calc. C 36.36 %, H 4.80 %, S 13.7 %; found C 36.8, H 4.8 %, S 13.8 %.

*1,6:3,4-Dianhydro-β-D-galactopyranose (**6**).*

Suspension of 543.0 g (1.17 mol) of **5** in 5 l of methanol was treated with 330.0 g of dry K_2CO_3 and stirred at RT for 3 h. The reaction mixture was filtered, and the filtrate was neutralized with about 100 ml of acetic acid and evaporated. The residue was dissolved in 500 ml of dest. water and extracted continuously during 14 h with dichloromethane. The organic extract was dried over $MgSO_4$ and evaporated to afford 113.3 g (66.5%) of **6** as brown oil, which was crystallized from ethyl acetate/hexane; mp. 64 – 67 °C, bp. 130 °C/0.1 torr, $[\alpha]_D^{20}$ = –77° ± 1° (water, c = 1.040). ^{1}H-NMR ($CDCl_3$) δ 5.23 (s, 1H); 4.81 (t, 1H); 4.02 (d, 1H); 3.77 (d, 1H); 3.42 – 3.68 (m, 2H); 3.12 (m, 1H); 2.87 (d, 1H). Anal. for $C_6H_8O_4$ (144.13) calc. C 50.00 %, H 5.60; found C 50.12 %, H 5.45 %.

*1,6:3,4-Dianhydro-2-O-tetrahydropyranyl-β-D-galactopyranose (**7**)*

Solution of 31.4 g (0.218 mol) of **6** in 300 ml of dichloromethane was treated with 30 ml of dihydropyrane and with a solution of 100 mg of dry *p*-TsOH in 30 ml of dichloromethane during 10 min. Then, 1 ml of NEt_3 was added and the mixture was evaporated. The residue was dissolved in ether and washed with diluted $NaHCO_3$ and with water, dried over $MgSO_4$ to afford 41.0 g (82.5 %) of a diastereoisomeric mixture of **7;** mp. 84 – 106 °C, $[\alpha]_D^{20}$ = –37° ± 1° ($CHCl_3$, c = 1.029). ^{1}H-NMR ($CDCl_3$) δ 5.38 and 5.18 (2 s, 1H); 4.78 (m, 2H); 3.0 – 4.03 (m, 7H); 1.38 – 2.0 (m, 6H). Anal. for $C_{11}H_{16}O_5$ (228.25) calc. C 57.89 %, H 7.07 %; found C 58.2 %, H 6.9 %.

*1,6-Anhydro-2-O-tetrahydropyranyl-β-D-glucopyranose (**9**)*

Solution of 50.0 g (0.219 mol) of **7** in 400 ml of dioxan and 400 ml of 5% KOH solution was refluxed for 48 h and cooled. The reaction mixture was diluted with 750 ml of

ether and the water layer was separated, washed once more with ether, treated with 19.5 g of NH_4Cl and evaporated. The residue was extracted with dichloromethane to give 45.1 g (83.6 %) as white crystals of a diastereoisomeric mixture of **9**, mp. 111 – 113 °C, $[\alpha]_D^{20} = -120° \pm 1°$ ($CHCl_3$, c = 0.909). Anal. for $C_{11}H_{18}O_6$ (246.26) calc. C 53.65 %, H 7.37 %; found C 53.8 %, H 7.5 %.

*1,6-Anhydro-4-O-benzyl-2-O-tetrahydropyranyl-β-D-glucopyranose (**10**)*

10 g (0.04 mol) of **9** was added to a solution of 1.5 g of sodium in 100 ml of benzyl alcohol and the mixture was kept for 23 h at 100 °C. After cooling 500 ml of ether was added and the solution was washed with water until neutral, was dried over $MgSO_4$ and evaporated in vacuum. The residue was purified by column chromatography on 500 g of silica gel with dichloromethane/ethyl acetate to obtain

a) 4.1 g (27.8 %) of a more lipophilic diastereoisomer of **10a** as yellow oil, Rf-value 0.22, $[\alpha]_D^{20} = +24° \pm 1°$ ($CHCl_3$, c = 0.627). ^{1}H-NMR (CCl_4) δ 7.26 (m, 5H); 5.15 (s, 1H); 4.69 (q, 2H); 4.63 (m, 1H); 4.39 (t, 1H); 3.4 – 4.1 (m, 6H); 3.16 (m, 2H); 1.3 – 2.02 (m, 6H). Anal for $C_{18}H_{24}O_6$ (336.39) calc. C 64.27 %, H 7.19 %; found C 64.10 %, H 7.44 %.

b) 3.2 g (21.7 %) of the second diastereoisomer of **10b**, which was crystallized from ethyl acetate/hexane; mp. 118-119 °C, Rf-value 0.14, $[\alpha]_D^{20} = -90° \pm 1°$ ($CHCl_3$, c = 0.951). ^{1}H-NMR (CCl_4) δ 7.28 (m, 5H); 5.28 (s, 1H); 4.78 (m, 2H); 4.63 (s, 2H); 4.46 (d, 1H); 3.18 - 4.02 (m, 7H); 1.3 – 1.98 (m, 6H). Anal for $C_{18}H_{24}O_6$ (336.39) calc. C 64.27 %, H 7.19 %; found C 64.09 %, H 7.28 %.

*1,6-Anhydro-4-O-n-propyl-2-O-tetrahydropyranyl-β-D-glucopyranose (**11**)*

Similarly as described for **10** a mixture of diastereoisomers of **11** was prepared and separated by column chromatography on silica gel with dichloromethane/ethyl acetate 85/15 to give **11a** as oil in 27.0 % yield, Rf-value 0.21, $[\alpha]_D^{20} = -47° \pm 1°$ ($CHCl_3$, c = 1.002). Anal for $C_{14}H_{24}O_6$ (288.34) calc. C 58.32 %, H 8.39 %; found C 57.99 %, H 8.55 % and **11b** in 11.36 % yield, mp. 53-54 °C, Rf-value 0.12, $[a]_D^{20} = -114° \pm 1°$ ($CHCl_3$, c = 1.998). Anal for $C_{14}H_{24}O_6$ (288.34) calc. C 58.32 %, H 8.39 %; found C 58.33 %, H 8.59 %.

*1,6-Anhydro-4-O-benzyl-2-O-tetrahydropyranyl-β-D-glucopyranose (**10**) and 1,6-anhydro-3,4-di-O-benzyl-2-O-tetrahydropyranyl-β-D-glucopyranose (**13**).*

Solution of 31.6 g (0.128 mol) of **9** in 150 ml of dry DMSO was stirred under nitrogen. 25.0 g of powdered KOH was added followed by dropwise addition of 33 ml of benzylchlorid at 55 – 60 °C during 6 h. The reaction mixture was stirred for additional 2 h at 60 °C, cooled and poured on 500 ml of ice water. The separated product was extracted with ether and the ether solution was washed with water, dried over $MgSO_4$, filtered over 200 g of basic aluminum oxide and evaporated to yield 51.0 g (93 %) of a diastereomeric mixture of **13** as yellowish oil, Rf-value 0.49 with dichloromethane / ethyl acetate 85/15. The product was used without further purification.

Shortening of reaction time or addition of less than two equivalents of benzyl chloride favored the production of **10a** which was eluted from aluminum oxide with ethyl acetate and was obtained as yellowish oil, Rf-value 0.22 with dichloromethane/ethyl acetate 85/15, $[\alpha]_D^{20} = +20° \pm 1°$ ($CHCl_3$, c = 1.121). Anal for $C_{18}H_{24}O_6$ (336.39) calc. C 64.27 %, H 7.19 %; found C 65.05 %, H 7.27 %.

*1,6-Anhydro-4-O-benzyl-3-O-n-propyl-2-O-tetrahydropyranyl-β-D-glucopyranose (**14**)*

Solution of 17.0 g (0.05 mol) of **10** in 50 ml of DMSO was treated with 4.6 g of powdered KOH, while stirring under in N_2 atmosphere, and the mixture was warmed to 50 °C. A solution of 5.0 ml of propyl bromide in 10 ml of DMSO was added dropwise on the course of 4 h. After further 10 h, 3.2 g of KOH and 2.5 ml of propyl bromide were once more added and the mixture was stirred at 50 °C for 16 h. Then, the reaction was poured on ice water and extracted with ether. After standard work-up 17.0 g (86 %) of **14** was obtained as yellow oil, Rf-value 0.40 with dichloromethane / ethyl acetate 85/15.

*1,6-Anhydro-3-O-benzoyl-4-O-benzyl-2-O-tetrahydropyranyl-β-D-glucopyranose (**15**)*

Solution of 43.5 g (0.13 mol) of **10a** in 250 ml of dry pyridine was treated dropwise with 18 ml of benzoyl chloride while stirring under nitrogen for 18 h. After addition of 10 ml of ice water the reaction mixture was evaporated and the residue was taken up in ether. Standard work up afforded 63.8 g (110 %) of **15** which could not be crystallized and was used without further purification, Rf-value 0.54 (dichloromethane/ethyl acetate 85/15).

*1,6-Anhydro-3,4-di-O-benzyl-β-D-glucopyranose (**16**)*

a) Solution of 51.0 g of **13** in 400 ml of acetone and 20 ml of 1N HCl was stirred at 50 °C for 20 min. The reaction mixture was cooled, neutralized with 1N NaOH and evaporated. The residue was extracted with ether and the solution was washed with water and dried over $MgSO_4$. The crude product was purified over the benzoyl derivative **20** as described below.

b) Solution of 20.5 g (0.05 mol) of **20** in 300 ml MeOH and 50 ml 1N NaOH was stirred at 25 °C for 18 h and evaporated. The residue was extracted with ether and washed with water until neutral. The organic solution was dried over $MgSO_4$, filtered and evaporated to give 15.5 g (90.5 %) of **16** as yellowish oil, $[\alpha]_D^{20} = -37° \pm 1°$ ($CHCl_3$,

c = 0.895). ^{1}H-NMR (CCl_4) δ 7.26 (s, 10H), 5.29 (s, 1H); 4.54 (q, 2H); 4.48 (s, 2H); 4.4 (m, 1H); 4.02 (q, 1H); 3.22 - 3.7 (m, 4H); 1.38 (d, 1H). Anal. for $C_{20}H_{22}O_5$ (342.40) calc. C 70.13 %, H 6.48 %; found C 70.18 %, H 6.58 %.

*1,6-Anhydro-4-O-benzyl-3-O-n-propyl-β-D-glucopyranose (**17**)*

Solution of 17.0 g (0.04 mol) of **14** in 100 ml of EtOH and 10 ml of 1N HCl was stirred at 50 °C for 1 h. The reaction mixture was neutralized, evaporated and the residue was purified by column chromatography (500 g of silica gel) with dichloromethane/ethyl acetate 85/15 as mobile phase to obtain 10.8 g (91.8 %) of **17** as yellow oil, Rf-value 0.25, $[\alpha]_D^{20}$ = –40° ± 1° ($CHCl_3$, c = 1.178). ^{1}H-NMR (CCl_4) δ 7.3 (s, 5H); 5.24 (s, 1H); 4.61 (s, 2H); 4.44 (m, 1H); 4.0 (m, 1H); 3.1 – 3.7 (m, 6H); 2.3 (bs, 1H); 1.54 (m, 2H); 0.92 (t, 3H). Anal for $C_{16}H_{22}O_5$ (294.35) calc. C 65.29 %, H 7.53 %, found C 65.39 %, H 7.66 %.

*1,6-Anhydro-3-O-benzoyl-4-O-benzyl-β-D-glucopyranose (**18**)*

Solution of 63.8 g (0.13 mol) of crude **15** in 500 ml of EtOH and 50 ml of 1N HCl was stirred during 30 min. at 50 °C. After cooling, the mixture was neutralized with 40 ml 1N NaOH and solid $NaHCO_3$ and evaporated. The residue was partitioned between ether and water and the organic phase was dried over $MgSO_4$ and evaporated to afford, after crystallization from ether/petrolether 28.1 g (60.7 %) of **18**, mp. 90 – 92 °C, $[\alpha]_D^{20}$ = –15° ± 1° ($CHCl_3$, c = 2.598). ^{1}H-NMR (CCl_4) δ 8.04 (m, 2H); 7.3 (m, 8H); 5.39 (s, 1H); 5.14 (s, 1H); 4.8 (q, 2H); 4.43 (m, 1H); 3.9 (d, 1H); 3.2 – 3.79 (m, 3H); 2.74 (d, 1H). Anal. for $C_{20}H_{20}O_6$ (356.38) calc. C 67.4 %, H 5.6 %; found C 67.68 %, H 5.77%.

*1,6-Anhydro-3,4-di-O-benzyl-2-O-methyl-β-D-glucopyranose (**19**)*

19 was obtain by methylation of **16** with dimethyl sulfate under phase transfer catalysis as a clear oil in 68.5 % yield. $[\alpha]_D^{20}$ = –15° ± 1° ($CHCl_3$, c = 0.890). ^{1}H-NMR ($CDCl_3$) δ 7.36 (s, 10H); 5.51 (s, 1H); 4.63 (s, 2H); 4.59 (s, 2H); 3.56 – 4.01 (m, 4H); 3.41 (2s, 4H); 3.2 (bs, 1H). $C_{21}H_{24}O_5$ (356.42) calc. C 70.77 %, H 6.79 %, found C 71.0 %, H 6.8 %.

*1,6-Anhydro-2-O-benzoyl-3,4-di-O-benzyl-β-D-glucopyranose (**20**)*

Solution of 47.7 g (0.14 mol) of **16** in 250 ml of dry pyridine was treated dropwise with 18.5 ml of benzoyl chloride and stirred at room temperature during 16 h. Then 10 ml of ice water was added and after further 30' the reaction mixture was evaporated. The residue was extracted with ether and washed with water, could 2N HCl, diluted $NaHCO_3$ solution and water. The organic phase was then dried over $MgSO_4$ and evaporated to yield, after crystallization from EtOH, 57.3 g (91.7 %) of **20**, mp. 78 – 89 °C, $[\alpha]_D^{20}$ = +9° ± 1° ($CHCl_3$, c = 1.048). ^{1}H-NMR (CCl_4) δ 8.02 (m, 2H); 7.08 – 7.45 (m, 13H); 5.41 (s, 1H); 4.87 (s, 1H); 4.49 – 4.87 (bq, 2H); 4.55 (m, 1H); 4.39 (s, 2H); 3.99 (bd, 1H); 3.5 – 3.72 (m, 2H); 3.3 (bs, 1H). Anal. for $C_{27}H_{26}O_6$ (446.50) calc. C 72.63 %, H 5.87 %; found C 72.48 %, H 5.81 %.

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References

1. Cerny, M.; Buben, I.; Pacak, J. *Collection Czechoslov. Chem. Commun.* **1963**, *28*, 1569
2. Höök, J. E.; Lindberg, B. *Acta Chem. Scand.* **1966**, *20*, 2363-2369.
3. Cerny, M.; Pacak, J. *Collection Czechoslov. Chem. Commun.* **1962**, *27*, 94-104.
4. Jeanloz, R. W.; Rapin, A. M. C. *J. Org. Chem.* **1963**, *28*, 2978-2983.
5. Cerny, M.; Cerny, I.; Pacak, J. *Collection Czechoslov. Chem. Commun.* **1976**, *41*, 2942-2951.
6. Pacak, J.; Drasar, P.; Nerudova, J.; Cerny, M. *Collection Czechoslov. Chem. Commun.* **1972**, *37*, 4120-4125.
7. Akagi, M.; Tejima, S.; Haga, M. *Chem. Pharm. Bull.* **1962**, *10*, 905-909.
8. Vegh, L.; Hardegger, E. *Helv. Chim. Acta* **1973**, *56*, 2020-2025.
9. Magdzinski, L.; Fraser-Reid, B. *Can. J. Chem.* **1988**, *66*, 2819-2825.
10. Jeanloz, R. W.; Rapin, A. M. C.; Hakomori, S. I. *J. Org. Chem.* **1961**, *26*, 3939-3946.
11. Cerny, M.; Stanek, J.; Pacak, J. *Collection Czechoslov. Chem. Commun.* **1969**, *34*, 849-856.
12. Cerny, M.; Stanek, J. *J.In Anonymous* **1977**, 24-177.
13. Miura, M.; Tanaka, R. *Mokuzai Gakkaishi* **1996**, *42*, 318-321.
14. Miura, M.; Tanaka, S.; Ando, K. *Kagaku Kogaku Ronbunshu* **1995**, *21*, 843-846.
15. Longley, C. J.; Howard, J.; Fung, D. P. C.**1996**, *2*, 1441-1451.abstract.
16. Manley-Harris, M.; Richards, G. N. *Carbohydr. Res.* **1994**, *254*, 195-202.
17. Malysheva, N. N.; Torgov, V. I.; Klimov, E. M.; Kochetkov, N. K. *Izv. Akad. Nauk SSSR, Ser. Khim.* **1974**, 2153-2155.
18. Boons, G.-J.; Isles, S.; Setala, P. *Synlett* **1995**, 755-756.

19. Seib, P. A. *Carbohyd. Res.* **1968**, *8*, 101-109.
20. Wolfrom, M. L.; Diwadkar, A. B.; Altmanand, B.; Gelas, J.; Horton, D. *Carbohyd. Res.* **1974**, *35*, 87-96.
21. Stanek, J.; Cerny, M. *Synthesis* **1972**, 698-699.