USE OF (2-PYRIDYL)-2,3,4,6-TETRA-O-BENZYL-β-D-GLUCOPYRANOSIDE IN THE SYNTHESIS OF 1,2-CIS-BOUND DISACCHARIDES

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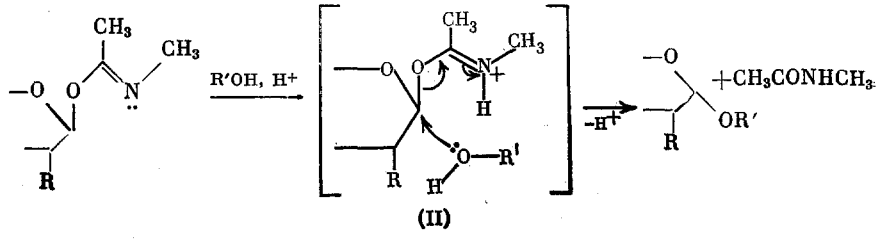
One of the promising approaches to the synthesis of 1,2-cisglycosides is the use [1, 2] of 1,2-trans-glycosylimidates* of type (I) as glycosylating agents. The reaction of these compounds with alcohols in the presence of TsOH, possibly proceeding via the formation of an immonium ion (II) [2], led to 1,2-cis-glycosides (III) with a high degree of stereoselectivity and in high yields

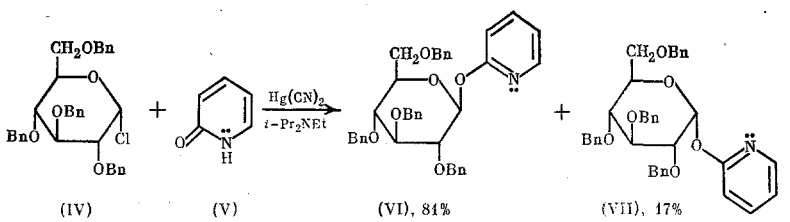


(II)

(I) R = OCH_2Ph, N_3, H. (III)

It was interesting to study the glycosylating properties of (2-pyridyl)-2,3,4,6-tetra-O-benzyl-β-D-glucopyranoside (VI). From an electronic point of view, its aglycone is related to the N-methylacetimidoyl residue in (I). It can be assumed that the presence of an aromatic system will increase the stability of the glycoside bond in (VI), compared with the case of imidates of type (I).

The synthesis of the 2,3,4,6-tetra-O-acetyl analog of derivative (VI) by condensing acetobromoglucose with silver 2-pyridinolate is known [7], but the authors did not consider it as a possible glycosylating agent. In the present work, we have described the preparation of (VI) and its use as a glycosylating agent in the disaccharide synthesis under electrophilic catalysis conditions



(IV) (V) (VI), 81% (VII), 17%

β-Pyridylglycoside (VI) was obtained in an 81% yield by the reaction between glycosyl chloride (IV) and 2-pyridone (V) in CH_2Cl in the presence of $Hg(CN)_2$ and diisopropylethylamine. Together with (VI), its α-isomer (VII) was also isolated from the reaction mixture in a 17% yield. When i-Py_2NEt was replaced by 2,4,6-collidine, the glycosylation of (V) proceeded more slowly, and the yields of (VI) and (VII) were 73 and 19%, respectively. The presence of $Hg(CN)_2$ in the mixture is necessary, since in the presence of i-Pr_2NEt_2 only, ~90% of glycosyl chloride (IV) is recovered from the reaction. If the reaction is carried out in $Hg(CN)_2$ only, (VI) and (VII) are slowly formed in approximately equal amounts. It is possible that the role of the base consists in the ionization of the 2-pyridone molecule to a pyridinolate anion, which reacts fairly rapidly and preferentially with glycosyl chloride (IV) in the presence of $Hg(CN)_2$ (or with the corresponding "intimate" ionic pair), with

*A similar principle for activating the glycoside center was used in [3-6].

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TABLE 1. ^1H and ^{13}C NMR Spectra (δ, ppm) and First-Order J (Hz) of Compounds (IV)-(VII) and (XVIII)

atom	^{13}C NMR (IV)	^{13}C NMR (VII)	^{13}C NMR (VI)	^1H NMR (VII)	^1H NMR (VI)	^1H NMR (V)*	^1H NMR (XVIII)*
Pyridine fragment							
NH						12.0 s	13.1 br.s
2		162.6	169.1				
3		111.8	111.3	6.83 ddd, $J_{3,4}=8.0$ $J_{3,5}=0.9$	6.81 ddd, $J_{3,4}=8.0$ $J_{3,5}=0.9$	6.44 d.d $J_{3,5}=1.2$	7.43 d, $J_{3,4}=8.8$
4		139.0	138.8	7.59 ddd, $J_{4,5}=6.9$ $J_{4,6}=1.8$	7.60 ddd, $J_{4,5}=6.9$ $J_{4,6}=1.8$	7.50, ddd, $J_{3,4}=J_{4,5}=6.3$	8.35 ddd $J_{4,5}=6.5$
5		118.0	118.1	6.93 ddd, $J_{5,6}=4.8$	6.94 ddd, $J_{5,6}=4.8$	6.26 ddd, $J_{5,6}=6.3$	7.34 dd, $J_{5,6}=6.5$
6		147.1	147.0	8.20 ddd, $J_{3,6}=0.6$	8.19 ddd, $J_{3,6}=0.6$	7.47 dd, $J_{5,6}=2.2$	8.30 dd, $J_{6,4}=1.7$
Glucopyranose fragment							
1	93.6	91.4	96.3	6.70 d, $J_{1,2}=3.3$	6.08 d, $J_{1,2}=7.8$		
($^1J_{C,H}$)	(179.4)	(173.9)	(164.6)				
2	80.1	79.7	81.7	3.80 dd, $J_{2,3}=9.0$			
3	81.5	82.1	84.8	4.23 dd, $J_{3,4}=9.0$	3.65–3.84 m		
4	76.7	77.6	77.7	3.81 dd, $J_{4,5}=9.8$			
5	73.6	72.1	75.4	3.97 ddd, $J_{5,6'}=1.8$, $J_{5,6''}=3.0$			
6	68.1	68.6	68.7	3.69 dd, 3.75 dd $J_{6',6''}=10.5$			
$-\underline{CH_2}Ph$ **							
2	73.0	72.9	75.4	5.05 d, 4.52 d, $J=10.5$	4.96 d, 4.78 d, $J=11.0$		
3	75.8	75.6	74.7	4.89 d (×2), $J=10.7$	4.91 d, 4.83 d $J=10.5$		
4	75.2	75.1	74.6	4.77 d, 4.72 d, $J=11.0$	4.85 d, 4.56 d, $J=10.6$		
6	73.6	73.4	73.2	4.57 d, 4.40 d $J=11.7$	4.60 d, 4.47 d, $J=11.9$		

*The spectra were run in $(CD_3)_2CO$.
†A specific assignment is correct only for signals of benzyloxy groups at C^2 and C^6 in the ^{13}C NMR spectra.

inversion of the configuration at C^1. The reaction between unionized (V) with (IV) in the presence of $Hg(CN)_2$ proceeds fairly slowly, so that a glycosyl cation has time to form. This reacts with (V) and converts into a mixture of β- and α-pyridylglycosides (VI) and (VII). It should be noted that when chloride (IV) is boiled with silver pyridinolate [7] and $Hg(CN)_2$ in MeCN, a mixture of (VI) and (VII) is also formed.

The pyridylglycosides obtained are more stable to the action of acidic reagents than are imidates of type (I), so that they could be isolated by chromatography on SiO_2. The presence in (VI) and (VII) of O-glycoside bond was confirmed by the absence of a band in the 1670-1650 cm^{-1} region of their IR spectra (amide I), characteristic of absorption of a carbonyl group in 2-pyridone, and also in its N-alkyl and N-glycosyl derivatives [7-9]. According to the data in [7], this absorption band was also absent in 2-O-glycosyloxypyridines. The configuration of the glycoside bonds in (VI) and (VII) was deduced from the chemical shifts (CS) and the SSCC values of the anomeric protons [for (VI) $J_{1,2}$ = 7.8, for (VII) 3.3 Hz] and anomeric carbon atoms [for (VI) $^1J_{C,H}$ = 164.6, for (VII) 173.9 Hz] of these compounds.* The glycosylating properties of β-pyridylglycoside (VI) were studied on the example of reactions with methyl-2,3-di-O-benzyl-α-L-rhamnopyranoside (VIII) [10], and also with trimethylsilyl (TMS) ethers (IX), (XII) and (XV) (see Scheme 1). The latter were obtained by treating the corresponding monohydroxyl derivatives with Me_3SiCl in the presence of Et_3N and a catalytic amount of imidazole. TMS derivatives were chosen as the glycosylating components because they have stronger nucleophilic properties than the initial alcohols. It was also interesting to compare the influence of the position of the Me_3SiO sub-

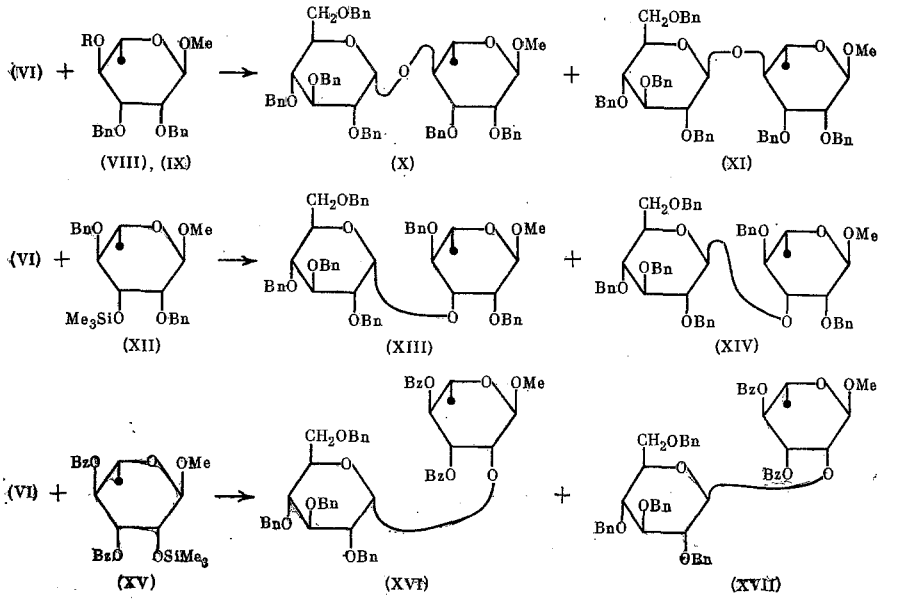
*A complete interpretation of the ^1H and ^{13}C NMR spectra is given in Table 1.

TABLE 2. Yields and Ratio of 1,2-Cis and 1,2-Trans-Bound Disaccharides Formed by Using (2-Pyridyl)-2,3,4,6-tetra-O-benzyl-β-D-glucopyranoside (VI) as Glycosylating Agent

Reagents	Promoter, equ.	Disaccharides formed	Yield, %		1,2-cis / 1,2-trans
			1,2-cis	1,2-trans	
(VI)+(VIII)	$TrClO_4$, 1*	(X)+(XI)	24	21	1,14
As above	$BF_3 \cdot Et_2O$, 3	As above	35	14	2,50
(VI)+(IX)	CF_3SO_3Me, 1,1	»	40	28	1,43
As above	$Et_3O^+BF_4^-$, 1	»	39	18	2,16
(VI)+(XII)	CF_3SO_3Me, 1,1	(XIII)+(XIV)	44	22	2,00
As above	$Et_3O^+BF_4^-$, 1,3	As above	39	11	3,55
(VI)+(XV)	CF_3SO_3Me, 1,1	(XVI)+(XVII)	32	25	1,28
As above	$Et_3O^+BF_4^-$, 1,3	As above	38	19	2,00
(VII)+(IX)	$Et_3O^+BF_4^-$, 1,3	(X)+(XI)	25	28	0,89

*The synthesis was carried out at 50°C; for all the remaining compounds at 20°C.

Scheme 1



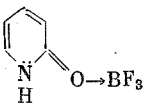
R = H (VIII), $SiMe_3$ (IX).

stituent [axial in (XV) and equatorial in (IX) and (XII)], and also the nature of the protecting groups [acyl in (XV) and aralkyl in (IX) and (XII)] on the course of the glycosylation reaction.

Derivatives (VIII), (IX) and (XV) were glycosylated in CH_2Cl_2* in the presence of different electrophilic promoting reagents (≥1 equivalent) at 20°C. In all the cases studied, mixtures of 1,2-cis- and 1,2-trans-bound disaccharides (X) + (XI), (XIII) + (XIV) and (XVI) + (XVII) were formed in which the 1,2-cis isomer predominated. Table 2 shows that its fraction changed noticeably depending on the nature of the electrophilic reagent. The overall yield of the disaccharides in glycosylating of TMS ethers was somewhat higher than it was when alcohol (VIII) was used in the condensation. The most successful promoters were $BF_3 \cdot Et_2O$ and $TrClO_4$ in the reaction of (VI) and (VIII), and $MeSO_3CF_3$ and $Et_3O^+BF_4^-$ in the glycosylation of silyl ethers (IX), (XII) and (XV). The use of other electrophilic agents, for example CF_3SO_3H (in the reaction of (VI) + (VIII)) or $CF_3SO_3SiMe_3$ (in the reaction of (VI) + (IX)) led to more complex reaction mixtures and lower yields of isomeric disaccharides. A similar result was obtained when catalytic amounts of promoting agent (0.2 equiv. CF_3SO_3Me, $TrClO_4$ or $Et_3O^+ \cdot BF_4^-$) were used in the reaction of (VI) + (IX).

*The use of ether or benzene does not lead to appreciable changes in the composition of the reaction products.

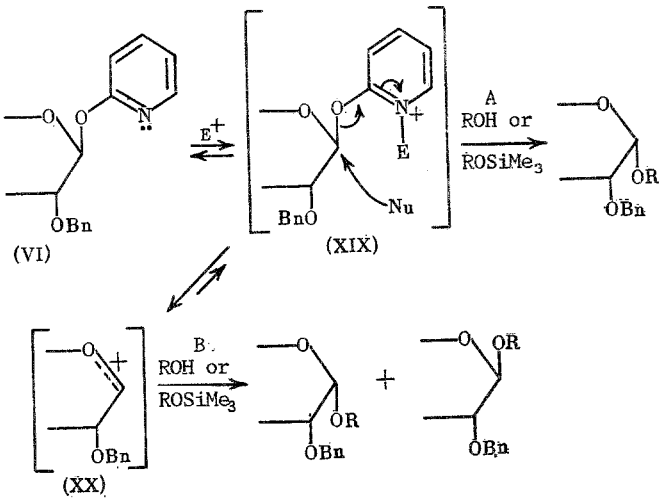
It should be noted that when the reaction of (VI) and (VIII) was promoted by the action of $BF_3 \cdot Et_2O$, a crystalline complex of pyridone-BF_3 was isolated. According to analytical and spectral characteristics (compare with [11] and with the spectrum of (V) in Table 1), a structure of amide complex (XVIII) was ascribed to this compound, which was also obtained by an alternative synthesis



(XVIII)

The absence of stereoselectivity observed in the glycosylation of alcohol (VIII) and TMS ethers (IX), (XII) and (XV) under electrophilic catalysis conditions can be explained by the occurrence of an S_N1-like reaction with preliminary formation of a glycosyl cation (XX) (Scheme 2, B)

Scheme 2



It is possible that replacement of the glycosylating agent (VI) by its α-anomer (VII) should not appreciably influence the stereodirectivity of the glycoside synthesis. However, in the condensation of (IX) with α-pyridylglycoside (VII) in the presence of $Et_3O^+ \cdot BF_4^-$, the ratio of the 1,2-cis and 1,2-trans-glycosylation products noticeably differed from the results of the reaction of (VI) + (IX): the 1,2-trans-bound disaccharide (XI) somewhat predominated in the mixture (see Table 2). On the other hand, in the glycosylation of (VIII), (IX), (XII) and (XV) by β-pyridylglycoside (VI), the ratio of the isomeric glycosides markedly depended on the nature of the electrophilic promoter used in the reaction. The fraction of the predominating 1,2-cis-isomer was higher when the anion of this reagent was less nucleophilic. $BF_4^- < CF_3SO_3^- < ClO_4^-$ [12]. If we consider the possible participation of these weak nucleophiles [13] and the formation of glycosyl cation (XX) by splitting the intermediate (IX), and also the result of the condensation of (IX) with α-pyridylglycoside (VII), we can assume that path B is not the only one for the glycosylation of ROH and $ROSiMe_3$ by derivative (VI). In particular, probably also variant A occurs, consisting in direct inversion of the configuration in the glycoside center by a nucleophilic attack on the intermediate ion (XIX).

The structure of the disaccharide derivatives (X), (XI), (XIII), (XIV), (XVI) and (XVII) synthesized was confirmed by the data of ^1H and ^{13}C NMR spectra (Tables 3 and 4), and elemental analysis. The ^{13}C NMR spectra of these compounds, as well as the spectra of (IV), (VI) and (VII) (see Table 1) were completely interpreted using the literature data on the CS of methyl-2,3,4,6-tetra-O-benzyl-α-D-glucopyranoside [14], O-glycosylated 3,4-di-O-benzoyl-, 2,4-di-O-benzyl- and 2,3-di-O-benzyl-α-methyl-L-rhamnopyranosides [15, 10], as well as of O-substituted derivatives of O-hydroxypyridines [16]. The configuration of the glycoside bonds was deduced from the CS and SSCC values of anomeric protons and signals of C^1, C^3, and C^5 signals of glucose residues.

TABLE 3. ^{1}H Spectra and First-Order J (Hz) of Disaccharide Derivatives (X), (XI), (XIII), (XIV), (XVI), and (XVII)

Atom	(X)	(XI)	(XIII)	(XIV)	(XVI)	(XVII)
H^1	4.68 d, $J_{1,2}\simeq 2.0$	4.67 d $J_{1,2}=1.6$	4.62 d $J_{1,2}=2.0$	4.59 d $J_{1,2}=1.5$	4.77 d $J_{1,2}=1.5$	5.04 d $J_{1,2}=1.5$
H^2	~3.84 m	3.72 dd $J_{2,3}=3.1$	3.86 dd $J_{2,3}=2.0$	3.89 dd $J_{2,3}=3.1$	4.27 dd, $J_{2,3}=2.0$	4.32 dd $J_{2,3}=2.5$
H^3	3.82 dd, $J_{2,3}=2.9$	3.78 dd $J_{3,4}=8.9$	4.10 dd $J_{3,4}=9.0$	4.19 dd $J_{3,4}=8.8$	} ~5.64 m	} ~5.70 m
H^4	3.97 dd, $J_{3,4}=J_{4,5}=8.9$	3.92 dd $J_{4,5}=8.9$	} ~3.67 m	3.47 dd, $J_{4,5}=7.5$		
H^5	~3.84 m	3.67 d.q		~3.66 m	~4.08 m	4.11 d.q $J_{4,5}=9.0$
H^6 (×3)	1.37 d $J_{5,6}=5.5$	1.42 d $J_{5,6}=6.0$	1.35 d $J_{5,6}=5.3$	1.33 d $J_{5,6}=5.6$	1.36 d $J_{5,6}=6.0$	1.36 d $J_{5,6}=6.0$
H$^{1'}$	5.11 d $J_{1,2}=3.2$	4.91 d $J_{1,2}=7.5$	5.17 d $J_{1,2}=3.4$	4.80 d $J_{1,2}=8.0$	4.90 d, $J_{1,2}=3.1$	4.47 d $J_{1,2}=7.0$
H$^{2'}$	3.58 dd $J_{2,3}=9.4$	3.41 dd $J_{2,3}=8.8$	3.65 dd $J_{2,3}=9.2$	3.46 dd, $J_{2,3}=9.2$	3.57 dd $J_{2,3}=9.1$	} ~3.58 m
H$^{3'}$	3.84 dd	3.67 dd $J_{3,4}=8.8$	4.13 dd $J_{3,4}=9.2$	} ~3.66 m	4.08 dd $J_{3,4}=9.1$	
H$^{4'}$	3.68 dd $J_{3,4}=9.8$	3.60 dd $J_{4,5}=8.8$	3.73 dd $J_{4,5}=10.0$		3.63 dd $J_{4,5}=10$	3.58 dd, $J_{3,4}=7.0$
H$^{5'}$	4.15 d $J_{4,5}=9.8$	~3.40	4.05 dd $J_{5,6'}=1.8$		3.88 ddd, $J_{5,6'}=1.8$	3.66 ddd, $J_{4,5}=10.6$
H$^{6'}$	3.22 s	} ~3.70–3.80	3.44 dd, $J_{6',6''}=10.7$	3.75 dd, $J_{5,6'}=1.6$, $J_{6',6''}=11.1$	2.98 dd, $J_{6',6''}=10.6$	3.68 dd, $J_{5,6'}=2.0$, $J_{6',6''}=10.6$
H$^{6''}$	3.22 s		3.55 dd $J_{5,6''}=2.9$	3.61 dd, $J_{5,6''}=2.6$	3.15 dd $J_{5,6''}=2.5$	3.40 dd, $J_{5,6''}=3.0$
OCH_2Ph	4.96 d 4.85 d $J=10.3$	5.00 d 4.78 d $J=11.3$	4.96 d 4.83 d $J=10.8$	5.08 d 4.84 d $J=11.3$	5.01 d 4.88 d $J=10.7$	5.32 d 4.91 d $J=11.5$
	4.78 d 4.72 d $J=11.1$	4.92 d 4.80 d $J=10.8$	4.91 d 4.45 d $J=10.2$	4.95 d 4.82 d $J=11.0$	4.76 d 4.65 d $J=11.3$	4.92 d 4.74 d $J=10.7$
	4.78 d 4.40 d $J=10.5$	4.81 d 4.63 d $J=10.5$	4.83 d 4.59 d $J=11.8$	4.91 d 4.77 d $J=12.0$	4.76 d 4.35 d $J=10.7$	4.80 d 4.53 d $J=10.5$
	4.73 d 4.67 d $J=11.8$	4.70 d 4.56 d $J=11.8$	4.83 d 4.58 d $J=10.5$	4.85 d 4.58 d $J=10.3$	4.38 d 4.12 d $J=12.0$	4.55 s (2H)
	4.53 d 4.44 d $J=10.5$	4.65 s (2H)	4.73 s (2H)	4.83 d 4.41 d $J=10.6$		
	4.52 d 4.22 d $J=11.6$	4.48 d 4.35, $J=10.5$	4.56 d 4.30 d $J=11.9$	4.56 d 4.52 d $J=12.0$		

TABLE 4. ^{13}C NMR Spectra of Disaccharide Derivatives (X), (XI), (XIII), (XIV), (XVI), and (XVII)

Atom	(X)	(XI)	(XIII)	(XIV)	(XVI)	(XVII)
		Rhamnopyranose fragment				
C¹	99,1 ($^1J_{C,H}$=165 Hz)	99,3 ($^1J_{C,H}$=170.5 Hz)	99,4	99,9	98,3	101,0
C²	74,8	74,8	75,6	78,4	75,6	77,0
C³	78,5	76,9	76,3	78,9	71,5	71,8
C⁴	78,9	80,6	80,0	81,5	72,2	72,3
C⁵	68,2	67,6	68,4	67,9	67,0	66,7
C⁶	18,4	18,2	18,2	18,1	17,8	17,7
OCH_3	54,5	54,8	54,8	54,6	55,1	55,1
2-OCH_2Ph	72,8	72,8	73,5	73,6		
3-OCH_2Ph	71,8	72,2				
4-OCH_2Ph			75,6	75,3		
OCOPh					165,8 (×2)	165,7; 166,1
		Glucopyranose fragment				
C¹	97,9 ($^1J_{C,H}$=165 Hz)	103,0 ($^1J_{C,H}$=161 Hz)	95,2	103,8	96,6	105,2
C²	80,5	83,0	80,3	83,0	80,4	82,1
C³	82,2	84,9	82,4	84,9	81,8	84,7
C⁴	78,1	78,2	78,2	78,1	77,6	78,0
C⁵	70,6	74,8	70,6	74,8	71,0	75,0
C⁶	68,4	69,1	68,4	69,1	68,2	69,4
2-OCH_2Ph	73,4	75,5	73,4	75,8	73,0	75,5
3-OCH_2Ph	75,4*	74,8	75,6*	75,1	74,8*	74,8
4-OCH_2Ph	74,8*	74,8	75,0*	75,1	74,3*	74,8
6-OCH_2Ph	74,0	73,7	73,5	73,8	73,5	73,6

*The assignment may be inverse.

EXPERIMENTAL

The melting points were determined on Koffler block. The optical rotation was measured on on a "Perkin-Elmer 141" polarimeter at 20 ± 2°C in $CHCl_3$. The IR spectra were obtained of UR-20 and "Specord 75-IR" spectrophotometers. The ^1H and ^{13}C NMR spectra were run of "Bruker WP-250" spectrometer with a working frequency of 62.89 MHz with respect to carbon in $CDCl_3$ (if not otherwise specified) with reference of Me_4Si on the δ scale.

The data on the NMR spectra are given in Tables 1, 3, and 4. The solutions were evaporated in vacuo at ≤ 40°C. The analytical TLC was carried out on plates with a stationary layer of SiO_2 Kieselgel 60 (Merck) in ethyl acetate (EA) with n-hexane (3:7), developed by 25% H_2SO_4 with heating. The column chromatography (CC) was carried out on SiO_2, TLC on Kieselgel 60H (Merck, particle size 15 μm) in a 20% (for (VI) and (VII)) and 15% solution of EA in n-hexane under pressure of ∿2 atm [17]. Absolute CH_2Cl_2 was distilled directly before the reaction over CaH_2.

2,3,4,6-Tetra-O-benzyl-α-D-glucopyranosyl Chloride (IV) was obtained from 2,3,4,6-tetra-O-benzyl-α-D-glucopyranose by the method in [18] in a close to quantitative yield, in the form of a syrup, $[\alpha]_D$ +112° (C2, benzene) (cf. [1]).

(2-Pyridyl)-2,3,4,6-tetra-O-benzyl-β-D-glucopyranoside (VI). A 0.35 ml portion (2 mmoles) of i-Pr_2NEt was added to a solution of 190 mg (2 mmoles) of 2-pyridone in 4 ml of CH_2Cl_2, and after 3 h, 1 mmole of (IV) in 6 ml of CH_2Cl_2 and 253 mg (1 mmole) of $Hg(CN)_2$ were added. The mixture was stirred for 20 h at 20°C, diluted with $CHCl_3$ (100 ml), washed with 1 N KBr, water, dried, and evaporated. The residue was separated by the CC method; the first to elute was (2-pyridyl)-2,3,4,6-tetra-O-benzyl-α-D-glucopyranoside (VII) (105 mg, 17% syrup), $[\alpha]_D$ +82° (C 1). Found: C 75.84; H 6.69; N 2.19%. $C_{39}H_{39}NO_6$. Calculated: C 75.83; H 6.36; N 2.27%. The yield of (VI) was 500 mg (81%), mp 54-55°C (ether–hexane, −10°C), $[\alpha]_D$ +14°. Found: C 75.56; H 6.48; N 2.23%.

Methyl-2,3-di-O-benzyl-4-O-trimethylsilyl-(IX), methyl-2,4-di-O-benzyl-3-O-trimethylsilyl-(XII) and methyl-3,4-di-O-benzoyl-2-O-trimethylsilyl-α-L-rhamnopyranoside (XV). A 0.25 ml portion (2 mmoles) of Me_3SiCl was added with stirring to a solution of 1 mmole of the monohydroxyl derivative (VIII) [10], methyl-2,4-di-O-benzyl- [10] or methyl-3,4-di-O-benzoyl-α-L-rhamnopyranoside [15], 0.31 ml (2.2 mmoles) of Et_3N and 14 mg (0.2 mmole) of

TABLE 5. Optical Rotation, Spectral and Analytical Characteristics of Compounds (IX), (XII) and (XV)

Compound	$[\alpha]_D^\circ$	Found/Calculated, %			Empirical formula	^{1}H NMR spectra, J, Hz							
		C	H	Si		H^1	H^2	H^3	H^4	H^5	H$^{6,6',6''}$	$-CH_2Ph$	Me_3Si
(IX)	−38 (*C*5)	67,17 / 66.94	8.02 / 7.96	6,88 / 6.52	$C_{24}H_{34}O_5Si$	4.63 d $J_{1,2}$=1.8	3.74 dd $J_{2,3}$=3.1	3.62 dd $J_{3,4}$=8,9	3.79 dd $J_{4,5}$=8 9	3.60 d.q $J_{5,6}$=6.0	1,29 d	4.57 s 4.64 d 4.72 d J=12,2	0.13 s
(XII)	−42 (*C*1)	66.79 / 66.94	7,75 / 7 96	6,48 / 6,52	$C_{24}H_{34}O_5Si$	4.59 d $J_{1,2}$=1.6	3,54 dd $J_{2,3}$=3.0	4,02 dd $J_{3,4}$=8,8	3,50 dd $J_{4,5}$=8.8	3.63 d.q $J_{5,6}$=6.0	1.29 d	4.61 d 4,90 d J=11.0 4.72 d 4.82 d J=12,5	0.13 s
(XV)	+46 (*C*1)	62,88 / 62.86	6.66 / 6.59	6,08 / 6.13	$C_{24}H_{30}O_7Si$	4.61 d $J_{1,2}$=1.8	4.32 dd $J_{2,3}$=2.8	5.52 dd $J_{3,4}$=9,5	5,62 dd $J_{4,5}$=9.5	4.06 d.q $J_{5,6}$=6,1	1.33 d		0 07 s

imidazole in 10 ml of absolute CH_2Cl_2. The mixture was held for 1 h at 20°C, diluted by $CHCl_3$ (70 ml), washed with ice water (4× 50 ml), dried and evaporated. Chromatographically homogeneous (IX), (XII), and (XV) were obtained in the form of syrups in close to quantitative yields. The optical rotation, spectral and analytical characteristics of compounds obtained are given in Table 5.

General Procedure for Glycosylation by β-Pyridylglycoside (VI). A 125 mg portion (0.203 mmole) of (VI) and 0.256 mmole of derivative (92 mg) (VIII), or 110 mg of (IX), or (XII), or 117 mg of (XV) to be glycosylated were evaporated by themselves or together with absolute CH_2Cl_2 (3 × 7 ml).* A 0.20-0.22 mmole portion of the promoting reagent (in the case of $BF_3 \cdot Et_2O$, 0.64 mmole) was added under argon to the solution of the residue in 5 ml of CH_2Cl_2. The mixture was held for 18-24 h in darkness at 20°C,† neutralized‡ by 0.1 ml of Et_3N, diluted with chloroform, washed with water, dried and evaporated. From the residue, α- and β-bound protected disaccharides (X) and (XI), (XIII) and (XIV), (XVI) and (XVII) were isolated by the CC method.

Methyl-2,3-di-O-benzyl-4-O-(2,3,4,6-tetra-O-benzyl-α-D-glucopyranosyl)-α-L-rhamnopyranoside (X) and Methyl-2,3-di-O-benzyl-4-O-(2,3,4,6-Tetra-O-benzyl-β-D-glucopyranosyl)-α-L-rhamnopyranoside (XI). In the reaction of (VI) and (IX) in the presence of 0.025 ml (0.22 mmole) of CF_3SO_3Me, derivatives (X) and (XI) were obtained in yields of 72 mg (40%) and 50 mg (28%), respectively. In CC, the first to elute was (XI) (syrup), $[\alpha]_D$ −6.5° (Cl). Found: C 75.16; H 6.76%. $C_{55}H_{60}O_{10}$. Calculated: C 74.98; H 6.86%. For (X) (syrup), $[\alpha]_D$ +34° (Cl). Found: C 74.97; H 6.92%. Derivatives (X) and (XI) were also obtained by reacting (VI) and (IX) in the presence of $Et_3O^+BF_4^-$ and by reacting (VI) and (VIII) in the presence of $BF_3 \cdot Et_2O$ or $TrClO_4$.* The yields are given in Table 2.

Methyl-2,4-di-O-benzyl-3-O-(2,3,4,6-tetra-O-benzyl-α-D-glucopyranosyl)-α-L-rhamnopyranoside (XIII) and Methyl-2,4-di-O-benzyl-3-O-(2,3,4,6-tetra-O-benzyl-β-D-glucopyransoyl)-α-L-rhamnopyranoside (XIV). a) The condensation of (VI) and (XII) in the presence of 0.025 ml of CF_3SO_3Me was carried out according to the general glycosylation procedure. After 18 h, 62 mg (0.1 mmole) of (VI) and 0.011 ml (0.1 mmole) of CF_3SO_3Me were added to the solution. The mixture was held for another 24 h at 20°C, and then was treated by standard procedure. In the CC, the first to elute was (XIV) (50 mg, 22%, syrup), $[\alpha]_D$ −0.5° (C 1). Found: C 75.12; H 7.19%. $C_{55}H_{60}O_{10}$. Calculated: C 74.98; H 6.86%. The yield of (XIII) was 100 mg (44% syrup), $[\alpha]_D$ +39° (C 1.8). Found: C 74.73; H 6.81%.

b) When the reaction of (VI) and (XII) was carried in the presence of 40 mg of $Et_3O^+BF_4^-$ (see general procedure), 43 mg (0.1 mmole) of (XII) and 10 mg (0.05 mmole) of $Et_3O^+BF_4^-$ were added to the solution after 18 h. After another 24 h, the mixture was treated by standard procedure to give (XIII) and (XIV) in yields of 70 mg (39%) and 20 mg (11%), respectively.

Methyl-3,4-di-O-benzoyl-2-O-(2,3,4,6-tetra-O-benzyl-α-D-glucopyranosyl)-α-L-rhamnopyranoside (XVI) and Methyl-3,4-di-O-benzoyl-2-O-(2,3,4,6-tetra-O-benzyl-β-D-glucopyranosyl)-α-L-rhamnopyranoside (XVII). a) The condensation of (VI) and (XV) in the presence of 0.025 ml of CF_3SO_3Me was carried out in a similar way as in procedure a) for the glycosylation of (XII) (see synthesis of (XIII) and (XIV)). In the CC, the first to elute was compound (XVII) (58 mg, 25%, syrup), $[\alpha]_D$ +48.4° (C 1). Found: C 72.48; H 6.29%. $C_{55}H_{56}O_{12}$. Calculated: C 72.67; H 6.21%. The yield of (XVI) was 74 mg (32%), $[\alpha]_D$ +102.8° (C 1). Found: C 73.00; H 6.47%.

b) When the glycosylation of (XV) was carried out by derivative (VI) in the presence of 40 mg of $Et_3O^+BF_4^-$, 10 mg of this reagent were added to the solution after 20 h. After standard treatment (another 24 h), the yields of (XVI) and (XVII) were 70 mg (38%) and 35 mg (19%), respectively.

*In the glycosylation of (VIII) in the presence of $TrClO_4$, all the operations were carried in a vacuum apparatus, in accordance with a procedure described in [19]. After mixing the reagents in CH_2Cl_2, the mixture was heated in CH_2Cl_2 for 3 h at 50°C.
†In the glycosylation of TMS ethers (XII) and (XV), the addition of the reagents was repeated (see synthesis of (XIII) and (XIV), (XVI and (XVII)).
‡In the glycosylation of (VIII) in the presence of $BF_3 \cdot Et_2O$, the crystalline precipitate of (XVIII) (20 mg) was filtered before neutralization.

Glycosylation of (IX) by α-pyridylglycoside (VII) was carried out according to method b) for glycosylation of (XV) (see synthesis of (XVI) and (XVII)). The yields of the isolated derivatives (X) and (XI) are given in Table 2.

The Boron Trifluoride–2-Pyridone Complex (XVIII). A 0.123 ml portion (1 mmole) of $BF_3 \cdot Et_2O$ was added to a solution of 95 mg (1 mmole) of (V) in 5 ml of CH_2Cl_2. The white crystalline precipitate was filtered after 16 h, washed with benzene, and dried in vacuo. The yield of (XVIII) was 140 mg (86%), mp 149-150°C (dec. from 142°C); IR spectrum (ν, cm^{-1}, in mineral oil): 3300, 3220 (NH); 1550 (CO); 1153, 1115, 1098 (BF_3, assym.), 930 (BF_3, symm.). ^1H NMR spectrum, see Table 1. Found: C 36.99; H 2.83; F 34.52; N 8.55%. $C_5H_5BF_3NO$. Calculated: C 36.86; H 3.09; F 34.99; N 8.60%.

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CONCLUSIONS

1. A synthesis of (2-pyridyl)-2,3,4,6-tetra-O-benzyl-β-D-glucopyranoside has been carried out by glycosylation of 2-pyridone by 2,3,4,6-tetra-O-benzyl-α-D-glucopyranosyl chloride.

2. The β-pyridylglycoside obtained glycosylated monohydroxyl and O-trimethylsilyl derivatives of sugars in the presence of electrophilic reagents with the formation of mixtures 1,2-cis- and 1,2-trans-bound disaccharides with the 1,2-cis-isomer predominating.

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