mixture was filtered and evaporated, and the residue was treated with water to precipitate 3.5 g (49%) of white crystals with mp < 182°C (dec., from ethanol). Found: C 47.8; H 5.6; N 3.9%. $C_{29}H_{40}N_2O_{19}$. Calculated: C 48.3; H 5.6; N 3.9%.

Bis(1-β-D-mannopyranosyl)carbamide (IV). A) A 3-g (13 mmole) sample of mannosylurea Id obtained by the method in [2] and containing admixed urea was refluxed in ethanol for 3 h to give 4 g (77%) of white crystals of IV with mp < 223°C (dec.).

B) Dry ammonia was passed for 1 h through a solution of 3 g (4.5 mmole) of Va in ethanol to give white crystals that did not give the characteristic reaction for ureido derivatives with Erlich's reagent. Workup gave 1.5 g (87%) of a product with mp < 222°C (dec.). Found: C 40.2; H 6.5; N 6.7%. $C_{13}H_{24}N_2O_{11}$. Calculated: C 40.6; H 6.3; N 7.3%.

The identical character of the compounds obtained by methods A and B was established on the basis of the similarity in their NMR spectra.

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N-GLYCOSIDES.

4.* SYNTHESIS OF 3-GLYCOSYL-4-HYDROXYHEXAHYDROPYRIMIDINE-2-THIONES ON THE BASIS OF GLYCOSYL ISOTHIOCYANATES

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The reaction of peracetylgluco(galacto)pyranosyl isothiocyanates with β-aminopropionaldehyde diethylacetal gave the corresponding glycosylthioureas, which, after removal of the protective groups, are converted spontaneously to 3-gluco(galacto)pyranosyl-4-hydroxyhexahydropyrimidine-2-thiones.

We have previously described [2, 3] the synthesis of N_1-[2,3,4,6-tetra-O-acetyl-β-D-gluco(galacto)pyranosyl]-N_3-(4-methyl-2-oxo-4-pentyl)thioureas, which were obtained by the reaction of the corresponding glycosyl isothiocyanates with 4-amino-4-methyl-2-pentanone, and their deacetylation products. A characteristic peculiarity of the aglycone in the synthesized N-glycosides is its primary acyclic structure both in the crystalline state and in solutions, whereas the N-alkyl analogs, which do not contain a sugar residue, have the cyclic 4-hydroxy-3-alkyl-4,6,6-trimethylhexahydropyrimidine-2-thione structure [4]. An examination of Dreiding models of glycosyloxoalkylthioureas shows that cyclization of the aglycone hinders steric interaction of the CH_3CO group with the substituents attached to the $C_{(2')}$ atom or with the electron pairs of the $O_{(1')}$ atom.

*See [1] for communication 3.

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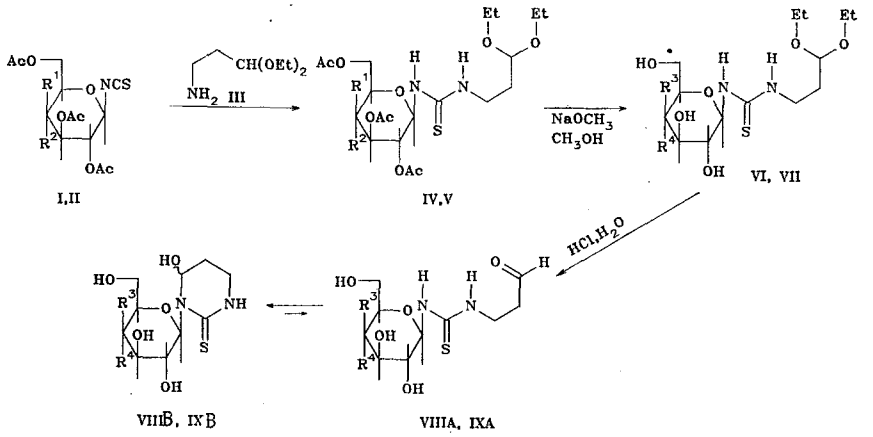
TABLE 1. Characteristics of IV-IX

Compound	mp, °C	$[\alpha]_D^{20}$ (c; solvent)	IR spectrum,[b] cm^{-1}	UV spectrum,[c] λ_{max}, nm (log ε)	Found, % C	H	N	S	Empirical formula	Calc., % C	H	N	S	Yield, %
IV	45—46,5	+6,3° (1,1; $CHCl_3$)	3380, 1752, 1550	249 (4,08)	49,6	6,8	5,4	6,0	$C_{22}H_{36}N_2O_{11}S$	49,2	6,8	5,2	6,0	67,2
V	41—43	+20,5° (1,3; $CHCl_3$)	3370, 1750, 1550	249 (4,09)	48,4	6,4	—	—	$C_{22}H_{36}N_2O_{11}S \cdot 0,5H_2O$	48,4	6,8	—	—	80,0
VI	69—70	−25,0° (0,8; H_2O)	3400, 1560	247 (4,08)	—	—	7,7	8,7	$C_{14}H_{28}N_2O_7S$	—	—	7,6	8,7	74,3
VII	52—53	0,0[a] (0,15; DMSO	3350, 1560	247 (4,08)	—	—	7,7	8,6	$C_{14}H_{28}N_2O_7S$	—	—	7,6	8,7	71,0
VIII	159—160 (dec.)	+26,3° (1,0; H_2O)	3260, 1560	252 (4,07)	40,8	6,6	—	—	$C_{10}H_{18}N_2O_6S$	40,8	6,2	—	—	84,8
IX	135—136 (dec.)	+65,2° (0,15; DMSO	3310, 1550	252 (4,01)	—	—	8,6	10,2	$C_{10}H_{18}N_2O_6S \cdot H_2O$	—	—	9,0	10,3	73,0

[a]For VII, $[\alpha]_{366}^{20}$ +143.5 (c 0.15; DMSO). [b]In mineral oil. [c]In methanol.

To create favorable electronic and steric factors that promote cyclization of the aglycone to give 3-glycosyl-4-hydroxyhexahydropyrimidine-2-thiones we attempted to synthesize N_1-glycosyl-N_3-oxoalkylthioureas, in the molecules of which there is a hydrogen atom rather than a methyl group attached to the carbonyl carbon atom.



I, IV R^1=H, R^2=OAc; II, V R^1=OAc, R^2=H; VI, VIII R^3=H, R^4=OH; VII, IX R^3=OH; R^4=H

We obtained the corresponding N_1-[2,3,4,6-tetra-O-acetyl-β-D-gluco(galacto)pyranosyl]-N_3-(3,3-diethoxypropyl)thioureas (IV, V) in 70-80% yields by the reaction of 2,3,4,6-tetra-O-acetyl-β-D-gluco(galacto)pyranosyl isothiocyanates (I, II) [5, 6] with β-aminopropionaldehyde diethylacetal (III) in benzene at 20°C. Deblocking of glycosylthioureas IV and V via the Zemplén reaction leads to N_1-[β-D-gluco(galacto)pyranosyl]-N_3-(3,3-diethoxypropyl)-thioureas (VI, VII). The acetal protective group was removed by the action of 1 N hydrochloric acid solution; The corresponding N-glycosides, which were identified as 3-[β-D-gluco-(galacto)pyranosyl]-4-hydroxyhexahydropyrimidine-2-thiones (VIII, IX) from a combination of UV, IR, and PMR spectral data, were obtained in 75-85% yields in this case. The properties and yields of the synthesized compounds are presented in Table 1.

The presence of a thiourea fragment in IV-IX is responsible for the presence in their UV spectra of an intense absorption band at 250 nm, which corresponds to a $\pi \rightarrow \pi^*$ transition of the thioureido chromophore [7]. In addition, a strong thioamide II band, which is characteristic for substituted thioureas [8], is observed in the IR spectra of the synthesized compounds at 1550 cm^{-1}. The IR spectra of acetylated N-glycosides IV and V in the crystalline state also contain two broad overlapped bands of stretching vibrations of N—H groups at 3370 cm^{-1} (at 3400 cm^{-1} in the case of solutions in chloroform).

TABLE 2. Parameters of the PMR Spectra of N-Glycosides IV-IX

Compound	Chemical shifts, δ, ppm (SSCC, Hz)							Solvent
	signals of the protons of the sugar residue)				signals of the aglycone protons			
	1′-H ($J_{1',2'}$)	2′-, 3′-, 4′-H	5′-, 6′-, 6″-H	$CH_3C=O$	CH_2CO	CH_2N	CHCO	
IV	6,31d (8,3)	4,74—5,79m	3,77—4,41 m	2,02 2,00 1,98 1,97	1,73—2,0 m	3,32—3,77 m	4,51t	$CDCl_3$
V	6,41d (6,7)	5,09—5,46m	4,0—4,17 m	2,12 2,05 2,03 1,97	1,76—2,29 m	3,32—3,84 m	4,56t	$CDCl_3$
VI	5,19d (8,0)	3,38—3,95 m		—	1,89 q	3,38—3,95 m	4,59t	CD_3OD
VII	5,14d (7,8)	3,40—3,93 m		—	1,91 q	3,40—3,93 m	4,59t	CD_3OD
VIII	6,17d (8,5), 6,14d (7,5)	3,04—3,68 m		—	1,50—2,00 m	3,04—3,68 m	5,09 (s br) 5,15 (s br)	d_6-DMSO + D_2O
IX	6,14d (9,5), 6,12d (8,5)	3,10—3,70 m		—	1,50—2,00 m	3,10—3,70 m	5,17 (s br) 5,11 (s br)	d_6-DMSO + D_2O

The IR spectra of VIII and IX in the crystalline state do not contain absorption bands of stretching vibrations of an aldehyde group that is characteristic for the acylic tautomeric form of the aglycone. This fact constitutes evidence for cyclization of the aglycone in the N_1-glycosyl-N_3-(3-oxopropyl)thioureas (VIIIA, IXA) that are formed in hydrolysis to give 3-glycosyl-4-hydroxyhexahydropyrimidine-2-thiones (VIIIB, IXB).

The cyclic structures of the aglycones of N-glycosides VIII and IX are confirmed by the parameters of their PMR spectra (Table 2). The PMR spectra of solutions of VIII and IX in d_6-DMSO at 8-9 ppm contain signals of only one N—H group. In addition, the spectra do not contain signals of an aldehyde proton of acyclic tautomeric form A of the aglycone. The presence of a heterocyclic aglycone in VIII and IX is also characterized by signals of 4-H (5.1-5.2 ppm) and 5-H (at 1.3-2.1 ppm) protons of 4-hydroxyhexahydropyrimidine-2-thiones.

On the basis of the SSCC values ($J_{1',2'}$ = 7-10 Hz) in the PMR spectra of N-glycosides IV-IX we concluded that the protons attached to the $C_{(1')}$ and $C_{(2')}$ atoms are trans-diaxially oriented and that there are consequently β-glycoside bonds in their molecules.

Since a new asymmetric $C_{(4)}$ atom is formed in the preparation of 3-glycosyl-4-hydroxyhexahydropyrimidine-2-thiones VIII and IX, these compounds may exist in two diastereomeric forms. The presence in solutions of VIII and IX in d_6-DMSO, CD_3OD, and D_2O of two diastereomers in approximately equal amounts was proved by the presence in their PMR spectra of different signals of 1′-H, 4-H, and N—H protons corresponding to two stereoisomers.

The signal of the 4-H proton of each diastereomer is a broad singlet; this constitutes evidence for small constants of spin—spin coupling of the 4-H proton with the 5-H protons and, consequently, for an axial orientation of the 4-OH group in the diastereomers of VIII and IX.

It should be noted that the anomeric protons in glycosylpyrimidines VIII and IX are deshielded significantly ($\delta_{1'\text{-H}}$ = 6.1-6.2 ppm) as compared with the anomeric protons of glycosylthioureas VI and VII ($\delta_{1'\text{-H}}$ = 5.1-5.2 ppm) and the previously described [3] N_1-[β-D-gluco(galacto)pyranosyl]-N_3-(4-methyl-2-oxo-4-pentyl)thioureas ($\delta_{1'\text{-H}}$ = 5.0-5.2 ppm). This fact can evidently be explained by different values of the angle of mutual rotation of the aglycone and sugar residue [9].

EXPERIMENTAL

The specific rotations were determined with a Perkin-Elmer 241 MC polarimeter. The IR spectra of mineral oil suspensions of the compounds were recorded with a UR-10 spectrometer. The UV spectra of solutions of the compounds in methanol ($6 \cdot 10^{-5}$ mole/liter) were obtained with a Specord UV-vis spectrophotometer. The PMR spectra were recorded with Brucker WM-250

(250 MHz) and Brucker HX-90E (90 MHz) spectrometers with tetramethylsilane as the internal standard. Thin-layer chromatography (TLC) was carried out on Silufol UV-254 plates in the following systems: A) chloroform–ethanol (14:1) and B) chloroform–ethanol (2:3). Column chromatography was carried out on L40/100 μ silica gel (Czechoslovakian SSR) in the following systems: C) benzene–ethyl acetate (2:1), D) chloroform–ethanol (4:1), and E) chloroform–methanol (6:1). Because of their hygroscopicity, the N-glycosides were stored in a desiccator over P_2O_5.

N_1-(2,3,4,6-Tetra-O-acetyl-β-D-glucopyranosyl)-N_3-(3,3-diethoxypropyl)thiourea (IV). A 5-ml sample of a solution of 0.49 g (3.33 mmole) of β-aminopropionaldehyde diethylacetal (III) [10] in benzene was added with stirring to a cooled (to 10°C) solution of 1.3 g (3.34 mmole) of glucosyl isothiocyanate I in 10 ml of dry benzene, and the solution was allowed to stand at 20°C for 1 h. It was then chromatographed with a column in system C to give 1.2 g of IV with R_f 0.39 (A).

Compound V, with R_f 0.33 (A), was similarly obtained.

N_1-(β-D-Glycopyranosyl)-N_3-(3,3-diethoxypropyl)thiourea (VI). A mixture obtained by the reaction of a solution of 6.40 (16.44 mmole) of I and 2.50 g (16.98 mmole) of III in 30 ml of benzene was evaporated to dryness, and the residue was dissolved in 30 ml of anhydrous methanol and evaporated again. The residue was dissolved in 55 ml of anhydrous methanol, 5 ml of a 0.2 N solution of sodium methoxide in methanol was added, and the mixture was maintained at 20°C for 1 h (with monitoring by TLC, system B). The solvent was removed, and the residue was recrystallized from acetone and reprecipitated from solution in methanol by means of ether to give 4.5 g of VI with R_f 0.50 (B).

Compound VII was similarly obtained and purified with a column in system D to give a product with R_f 0.40 (B).

3-(β-D-Glucopyranosyl)-4-hydroxyhexahydropyrimidine-2-thione (VIII). A 1-ml sample of a 1 N solution of hydrochloric acid was added to a solution of 2.3 g (7.81 mmole) of VII in 13 ml of water, and the mixture was maintained at 20°C for 3 h (with monitoring by TLC, system B). It was then neutralized to pH 7 with sodium bicarbonate, the solvent was removed *in vacuo*, and the residue was treated three times with dry acetone to give 1.56 g of VIII, which was purified by chromatography with a column in system E to give a product with R_f 0.28 (B).

Compound IX, with R_f 0.26 (B), was similarly obtained.

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