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Nucleophilic opening of the 3,5-anhydro ring in 1,2-*O*-cyclohexylidene- -D-xylofuranose

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The reactivity of the oxetane ring in 3,5-anhydro-1,2-*O*-cyclohexylidene- -D-xylofuranose (**1**) was exemplified by its regiospecific nucleophilic opening. The action of concentrated hydrobromic or hydroiodic acid on **1** resulted in the exclusive formation of the 5-deoxy-5-halo derivatives, while the action of acetyl chloride or acetyl bromide yielded the corresponding 3-*O*-acetyl-5-deoxy-5-halo derivatives in 70 – 90 % yield. Under strongly acidic reaction conditions, the protection of the cyclohexylidene acetal function remained intact.

Keywords: oxetane, sulfonyl esters, nucleophilic ring opening, D-xylofuranose derivatives.

INTRODUCTION

Four-membered rings containig oxygen are not so frequently encountered among carbohydrate derivatives. When its formation, owing to a favourable orientation of the reacting groups, is possible, the oxetane ring is usually formed under mild reaction conditions and in good yield. Several sugars containing the oxetane ring are known, most are 3,5-anhydroaldofuranose derivatives.

Oxetanes and epoxides undergo similar reactions, since they have quite similar strain energies[1] (114.2 kJ/mol for ethylene oxide and 106.7 kJ/mol for trimethylene oxide). Consequently, oxetane derivatives represent promising starting compounds for the synthesis of different 1,3-disubstituted products, usually in one-step reactions, by opening the oxetane ring under various conditions.

In this paper, the high yield synthesis of 3,5-anhydro-1,2-*O*-cyclohexylidene- -D-xylofuranose[2] (**1**), as a model compound for studying the reactivity of the oxetane ring, starting from different 5-sulfonyl, 3,5-disulfonyl, or 3-*O*-acetyl-5-*O*-sulfonyl esters of 1,2-*O*-cyclohexylidene- -D-xylofuranose under simple reaction condi-

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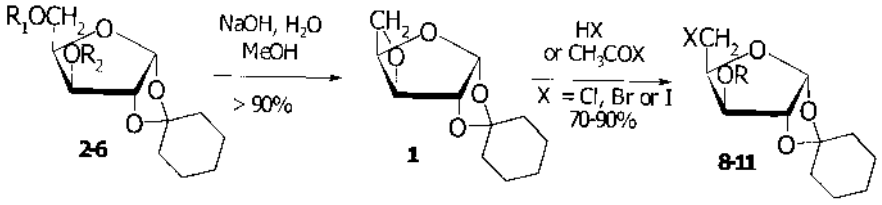
tions is reported (Scheme 1). The anhydroderivative **1** proved its versatility in the simple, high yield and straightforward synthesis of terminal 5-deoxy-5-halo, or 3-*O*-acetyl-5-deoxy-5-halo derivatives of xylofuranose, by nucleophilic opening of the oxetane ring with hydrohalogen acids or acetyl halogenides.

RESULTS AND DISCUSSION

All known examples of the preparation of 3,5-anhydro ring in 1,2-*O*-alkyli - dene- -D-xylofuranose included a terminal (C5) hydroxyl group of xylofuranose ring, always in the form of the sulfonyl ester, except in an interesting example of the reductive displacement of C-5 phthalimide.[3] On the other hand, the C-3 function of the furanose ring could be either a free hydroxyl group, or its sulfonyl ester. The reaction conditions for the formation of the oxetane ring always involved the action of sodium alkoxide in alcohol, or potassium hydroxide in dry alcohol.[2,4,5]

We have found that anhydrous conditions are not necessary for the formation of the anhydro ring in **1**, and that they do not even augment the yield of products. Namely, the action of aqueous sodium hydroxide in methanol on the 5-*O*-benzenesulfonyl **2**, 5-*O*-toluenesulfonyl[6] **3**, 3,5-di-*O*-benzenesulfonyl **4**, 3,5-di-*O*-toluenesulfonyl[7] **5**, and 3-*O*-acetyl-5-*O*-benzenesulfonyl **6** esters of 1,2-cyclohexylidene- -D-xylofuranose resulted in oxetane ring formation, whereupon the corresponding 3,5-anydride was formed in high yield (over 90 %, Scheme 1). The starting sulfonyl esters **2-5** are easily obtainable by standard sulfonylation procedures (sulphonyl chloride/pyridine) from monocyclohexylidene- -D-xylofuranose.[7] Compound **6** was prepared by acetylation of **2** with acetyl chloride. Monitoring of the reaction of esters **2-6** with aqueous sodium hydroxide in methanol by TLC revealed the formation of no other compound but **1**, and full disappearance of the starting compounds **2-6**.

The formation of the oxetane ring in **1** in over 90 % yield, starting from mono sulfonyl esters **2** and **3** presents classical examples of intramolecular nucleophilic substitution. The role of the added alkali is just to deprotonate the C-3 hydroxyl function (Fig. 1a). Intramolecular substitution must be a very fast process, since no traces of



	R_1	R_2
2	$PhSO_2$-	H
3	Ts-	H
4	$PhSO_2$-	$PhSO_2$-
5	Ts-	Ts-
6	$PhSO_2$-	CH_3CO

	X	R
8	Br	H
9	I	H
10	Cl	CH_3CO
11	Br	CH_3CO

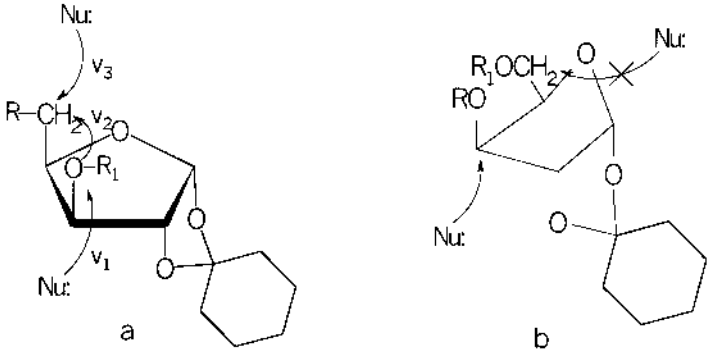
Scheme 1. Formation and opening of the oxetane ring.

monocyclohexylidene-D-xylofuranose were found in the reaction mixture (TLC), as a consequence of collateral C-5 sulfonyl ester hydrolysis.

The formation of oxetane **1**, starting from the disulfonyl esters **4** and **5**, and the 3-*O*-acetyl-5-*O*-benzenesulfonyl ester (**6**), proceeds under the same reaction conditions and with equally high yields. Again, careful monitoring of the course of the reaction of the ditosylate **5** by TLC revealed neither the formation of 1,2-*O*-cyclohexylidene-3-*O*-tosyl- -D-xylofuranose (**7**), nor monocyclohexylidene- -D-xylofuranose.

The formation of the 3,5-anhydro ring in **1**, starting from the 3-*O*-tosyl ester of monocyclohexylidene- -D-xylofuranose[8] **7**, could not be expected under the applied conditions. If it would appear as an intermediate in the reaction of ditosylate **5**, the most probable reaction is further hydrolysis of the 3-*O*-tosyl ester function. Indeed, in a separate experiment, it was shown that 1,2-*O*-cyclohexylidene-3-*O*-tosyl- -D-xylofuranose (**7**), under the same reaction contidions (aqueous sodium hydroxide in methanol), really gave monocyclohexylidene- -D-xylofuranose in quantitative yield.

The formation of **1** from diesters **4-6** is worthy of further comment. Intramolecular C3 C5 substitution is a general reaction mechanism in the formation of the oxetane ring in diesters **4-6**. It appears that in 3,5-diesters the C-3 position of the xylofuranose ring is much more susceptible to ester hydrolysis than the C-5 position; the C3 ester group must be hydrolyzed before the C5 ester function, to produce the 3,5-anydro ring. Our experimental results point to the following reaction rates relations: $_1 >> _3$ and $_2 >> _1$, $_3$, where $_1$ is the reaction rate of the hydrolysis of the C-3 ester function, $_2$ is the rate of intramolecular C3 C5 substitution and $_3$ is the reaction rate of the hydrolysis of the C-5 sulfonyl ester function (Fig. 1a). The lower susceptibility of the C-5 position in xylofuranose ring to hydrolysis, compared to postition C-3, could be attributed to the partial shielding of the C-5 position by the furanose ring oxygen (Fig. 1b).



	R	R1
2 and 3	sulfonyl	H
4 and 5	sulfonyl	sulfonyl
6	sulfonyl	acetyl

Fig. 1. Mechanism of formation of the 3,5-anhydro ring.

The opening of anhydro rings in carbohydrate chemistry provide many synthetic possiblities. Particularly, the oxetane ring in 3,5-anhydro-1,2-*O*-isopropylidene- -D-xylofuranose has been regio-selectively opened under basic conditions, at the less hindered C-5 position, producing 5-thio derivatives of xylofuranose,[9] while under strong Lewis-acid conditions, on the contraty, non-carbohydrate oxetanes could be efficiently opened at the more substituted carbon.[10]

Bearing this in mind, we looked for a possibility of the regio-selective opening of the 3,5-anhydro ring by hidrohalogen acids and acetyl halogenides, hoping to obtain the terminal 5-deoxy-5-halo and 3-*O*-acetyl-5-deoxy-5-halo derivatives of xylofuranose in accordance with the general behaviour of oxetane ring. However, it was shown previously that for many 1,2-*O*-isopropylidene protected aldofuranose derivatives the isopropylidene protecting group is hydrolized by aqueous acids faster than the oxetane ring.[11] As the cyclohexylidene moiety requires more rigorous hydrolytic conditions than the isopropylidene group, it was hoped that its use for the protection of the C1 and C2 hydroxyl functions and the use of concentrated hydrohalogen acids at room temperatures could give positive results.

Indeed, the action of conc. hydrohalogen acids (HBr and HI) on **1** at room temperature gave the expected 5-bromo-5-deoxy[12] **8** and 5-deoxy-5-iodo **9** derivatives in good yields, while action of acetyl chloride or acetyl bromide provided the expected 3-*O*-acetyl-5-chloro-5-deoxy[13] **10**, and the corresponding 3-*O*-acetyl-5-bromo-5-deoxy derivative[12] **11**, in 70 – 90 % yields.

The ^{1}H and ^{13}C spectral data of the synthesized compounds were in full agreement with the expected structures (Table I and Table II).

TABLE I. ^{1}H-NMR Spectral data for **1** – **11** (in $CDCl_3$)

Compound	Signals (in ppm, *J* in Hz)
1	1.3–1/71, *m*, 10 H, cyclohexylidene protons; 4.15, *dd*, 1 H, H-5a, $J_{5a,5b}$=7.65, $J_{3,5a}$ = 0.5, $J_{4,5a}$ = 2.4; 4.59–4.7, *m*, 2H, H-2 and H-5b, $J_{1,2}$ = 3.6, $J_{4,5b}$ = 4.1; 5.01, *m*, 1H, H-4, $J_{3,4}$ = 4,0; 5.1, *d*, 1H, H-3; 6.18, *d*, 1H, H-1.
2	1.31–1.74, *m*, 10H, cyclohexylidene protons; 2.36, *d*, 1H, OH, $J_{3.OH}$ = 5.0; 4.17, *m*, 1H, H-4, $J_{3.4}$ = 2.5; $J_{4.5b}$ = 6.8; 4.23–4.40, *m*, 3H, H-3 and 5-CH_2; 4.50, *d*, 1H, H-2, $J_{1.2}$ = 3.6; 5.89, *d*, 1H, H-1; 7.53–7.98, *m*, 5H, aromatic.
4	1.29–1.68, *m,* 10H cyclohexylidene protons; 4.02, *dd*, 1H, H-5a, $J_{5a,5b}$ = 10.5, $J_{4,5a}$ = 6.2; 4.09, *dd*, 1H, H5b, $J_{4,5b}$ = 6.2; 4.36, *dt*, 1H, H-4, $J_{3,4}$ = 2.9; 4.66, *d*, 1H, H-2, $J_{1,2}$ = 3.6; 4.84, *d*, 1H, H-3; 5.87, *d*, 1H, H-1; 7.51–7.96, *m*, 10H, aromatic
6	1.37–1.65, *m*, 10H from cyclohexylidene; 2.02, *s,* 3H, CH3; 4.22, *m*, 2H, 5-CH_2; 4.44. *dt*, 1H, H-4, $J_{4.5}$ = 6.1, $J_{3.4}$ = 3.1; 4.48, *d,* 1H, H-2, $J_{1.2}$ = 3.7; 5.21, *d*, 1H, H–3, $J_{3.4}$ = 3.1; 5.86, *d*, 1H, H–1; 7.54–7.94, *m*, 5H aromatic.
7	1.28–1.80, *m*, 10H, from cyclohexylidene; 2.01, *t*, 1H, OH, $J_{H\text{-}5.OH}$ = 6.5; 2.48, *s*, 3H, CH_3; 3.65, *m*, 1H, H-5a, $J_{5a.5b}$ = 11.9, $J_{5a.4}$ = 6.4 Hz; 4.32, *td*, 1H, H-4, $J_{3.4}$ = 2.8; 4.59, *d*, 1H, H-3; 5.91, *d*, 1H, H-1.
8	1.3–1.76, *m*, 10H from cyclohexylidene; 2.27, *d*, 1H, OH, $J_{3.OH}$ = 4.9; 3.50 and 3.51, 2*xd*, 2H, H-5, $J_{4,5a}$ = 8.4, $J_{4,5b}$ = 6.3; 4.35, *d*, 1H, H-3, $J_{3,4}$ = 2.6; 4.46, *m*, 1H, H-4; 4.53, *d*, 1H, H-2, $J_{1,2}$ = 3.6; 5.95, *d*, 1H, H-1.
9	1.33–1.77, *m*, 10H, from cyclohexylidene; 2.05, *bs*, 1H, OH; 3.24, *d*, 1H, H-5a, $J_{5a\text{-}5b}$ = 9.5; 3.32, *dd*, 1H, H-5b, $J_{4.5b}$ = 5.3; 4.3–4.5, *m*, 2H, H-3 and H-4, $J_{3.4}$ = 2.7; 4.56, *d*, 1H, H-2, $J_{1.2}$ = 3.6; 5.99, *d*, 1H, H-1.

TABLE I. Cont.

Compound	Signals (in ppm, *J* in Hz)
10	1.29–1.75, *m*, 10H, from cyclohexylidene; 2.08, *s*, 3H, CH_3; 3.51–3.67, *m*, 2H, 5-CH_2, $J_{5a.5b}$ = 11.1, $J_{5b.4}$ = 6.9, $J_{5a.4}$ = 7.8; 4.44, *m*, 1H, H-4, $J_{3.4}$ = 2.7; 4.48, *d*, 1H, H-2, $J_{1.2}$ = 3.6; 5.26, *d*, 1H, H-3; 5.89, *d*, 1H, H-1.
11	1.31–1.77, *m*, 10H, from cyclohexilidene; 2.11, *s*, 3H, CH_3; 3.35–3.31, *m*, 2H, H-5, $J_{5a.4}$ = 6.2. $J_{5b.4}$ = 8.5. $J_{5a.5b}$ = 10; 4.48–4.59, *m*, 2H, H-4 and H-2, $J_{1.2}$ = 3.6, $J_{3.4}$ = 3; 5.31. *d*. 1H. H-3. 5.92. *d*. 1H. H-1.

TABLE II. ^{13}C-NMR Spectral data for **1**–**11** (in ppm)

No.	C1	C2	C3	C4	C5	3' 4' 5'	2' 6'	Cq	Aromatic	C=O	Me
1	107.51	83.89	87.26	77.89	78.01	23.32 23.51 24.47	36.24 37.13	114.04			
2	104.53	84.59	74.37	77.51	66.53	23.52 23.83 24.79	35.65 36.42	112.84	127.95 129.36 134.09		
4	104.26	82.36	81.36	75.99	65.99	23.26 23.60 24.53	35.5 36.1	113.15	127.77 127.79 129.22 129.53 135.13 Cq 135.21 Cq		
6	104.3	82.6	75.6	75.9	66.1	23.3 23.7 24.6	35.6 36.2	113.1	135.5 133.9 129.9 (2C) 127.8 (2C)	169.4	20.5
7	104.06	82.73	81.62	79.18	59.42	23.28 23.61 24.58	35.58 36.05	113.0	127.75 130.01 132.3Cq 145.58 Cq		21.56
8	104.87	84.49	74.47	80.08	26.77	23.51 23.83 24.78	35.65 36.41	112.80			
9	105.15	84.60	75.01	80.71	–1.15	23.56 23.88 24.84	35.71 36.46	112.77			
10	104.51	78.70	82.62	75.54	39.29	23.36 23.68 24.66	35.57 36.25	113.03		169.42	20.54
11	104.59	78.58	82.64	75.74	26.14	23.35 23.67 24.65	35.55 36.24	112.97		169.36	20.52

All the experimental results concerning the opening of the oxetane ring in **1** can be interpreted as S_N2 type ring opening of an activated anhydro ring; activation being the protonation of the oxygen function by hydrohalogen acids, which are, obviously, present in sufficient quantities for catalytic action in the reactions with acetyl halogenides, too. The experimental results obtained point to a significant reactivity of the 3,5-anhydro ring in 3,5-anhydro-1,2-*O*-cyclohexylidene- -D-xylofuranose and its synthetic value for the preparation of 5-deoxy-5-halogeno sugar derivatives.

EXPERIMENTAL

General methods

Melting points were determined on a Buchi SMP50 apparatus and are not corrected. The IR spectra were recorded on a Perkin-Elmer model 577 spectrometer. The NMR spectra were taken on a Bruker AC250E apparatus in $CDCl_3$, using Me_4Si as an internal standard. Chemical shifts ( ) are expressed in ppm (*s*, *d*, *t* and *m* denote singlet, doublet, triplet and multiplet, respectively). Mass spectra were redorded with a Finingen MAT 311A spectrometer; the first number when referring to the spectra denotes the m/z value, while the numbers in parenthesis correspond to the abundance of the mass peaks. Optical rotations were neasured on an automatic polarimeter Polamet A (Karl Zeiss, Jena). TLC was performed on Silica gel DC Alufolien (Merck 1.05553.), with benzene-ethyl acatate 4:1 as the mobile phase. Visualization of the spots was achieved by spraying with 50 % sulphuric acid and subsequent heating to 150 ºC. All organic extracts were dried with anhydrous Na_2SO_4. Organic solutions were concentrated using a rotary evaporator, under reduced pressure and a bath temperature below 40 ºC.

5-O-*Benzenesulfonyl-1,2*-O-*cyclohexylidene*-α-*D-xylofuranose (**2**)*

1,2-*O*-Cyclohexylidene- -D-xylofuranose[7] (10.0 g, 43.48 mmol) was dissolved in a mixture of pyridine (80 mL) and chloroform (30 mL). Benzenesulfonyl chloride (11.0 g, 62.32 mmol) was added under stirring. The reaction mixture was left for 48 h at room temperature. The reaction mixture was then poured onto crushed ice (100 g), acidified with 6 M HCl (to pH 2) and extracted with $CHCl_3$ (3 100 mL). The combined extracts were washed with water, dried and evaporated to leave syrup, which spontaneously crystallized. Recrystallization from methylene chloride–*n*-hexane gave **2** (14.0 g, 87 %): mp 98 ºC;$[\ _D]^{20}$ –7.20 (*c* 0.84, $CHCl_3$). Mass spectrum: 372 (M^+ +2, 10), 370 (M^+, 90), 326 (7), 186 (12), 150 (59), 84 (100). Anal. Calcd for $C_{17}H_{22}O_7S$: C, 55.13; H, 5.95; S, 8.65. Found: C, 55.26; H, 6.24; S, 8.67.

3,5-Di-O-*Benzenesulfonyl-1,2*-O-*cyclohexylidene*-α-*D-xylofuranose (**4**)*

1,2-*O*-Cyclohexylidene- -D-xylofuranose (9.0 g, 39.13 mmol) was dissolved in pyridine (100 mL) and benzenesulfonyl chloride (19.0 g, 107.6 mmol) was added under stirring at 5 ºC over 4 h. The reaction mixture was left at room temperature overnight and then poured onto crushed ice (200 g), acidified with 6 M HCl (to pH 2) and extracted with chloroform (3 100 mL). The combined extracts were washed with water (100 mL), dried and evaporated.

The remaining oily residue was crystallized from MeOH to give **4** (17.5 g, 87.7 %): mp 97 ºC; $[\ _D]^{20}$ –26.6 (*c* 0.74, $CHCl_3$). Mass spectrum: 510 (M^+, 59), 467 (35), 240 (7), 151 (100). Anal. Calcd for $C_{23}H_{26}O_9S_2$: C, 54.12; H, 5.10; S, 12.55. Found: C, 54,39; H, 5.32; S, 12.34.

3-O-*Acetyl-5*-O-*benzeneslufonyl*-α-*D-xylofuranose (**6**)*

Monosulfonyl ester **2** (1.0 g, 2.7 mmol) was dissolved in acetyl chloride (10 mL) and kept under reflux for 45 min. The acetyl chloride was then evaporated under vacuo and the remaining oil dissolved in CH_2Cl_2 (50 mL), washed with 2 % $NaHCO_3$ (20 mL). The organic layer was dried and evaporated. The remaining oil on crystallization from 90 % EtOH gave **6** (0.865 g, 77.7 %): mp 93 ºC; $[\ _D]^{20}$ –11.4 (*c* 0.72, $CHCl_3$); IR n 1760 (acetate carbonyl); Mass spectrum: 412 (M^+, 59), 383 (14), 369 (74), 138 (74), 97 (100); Anal. Calcd for $C_{19}H_{24}O_8S$: C, 55.32; H, 5.86; S, 7.77. Found: C, 55.33; H, 5.55; S, 7.60.

Preparation of 3,5-anhydro-1,2-O-*cyclohexylidene*-α-*D-hylofuranose*[2] *(**1**)*

From the 5-O-*benzenesulfonyl ester **2***. Sodium hydroxide (2.0 g, 50 mmol) was dissolved in a mixture of water (25 mL) and MeOH (75 mL), then the 5-*O*-benzenesulfonyl ester **2** (6.0 g, 16.2 mmol) was added. The reaction mixture was kept under reflux until TLC revealed the full disappearance of **2** and the formation of a new product (about 30 min). The reaction mixture was concentrated approximately to one third of its inital volume, then water (100 mL) was added and the resulting mixture extracted with chloroform (3 50 mL). The combined extracts were washed with water, dried and evaporated to leave **1** as an oil (3.20 g, 93.2 %): $[\ _D]^{20}$ +17.4 (*c* 0.66, $CHCl_3$), lit.[2] +17.2; Mass spectrum: 212 (M^+, 5), 211 (37), 183 (17), 169 (96), 98 (18), 55 (100).

From the 5-O-*tosyl ester.* In an analogous experiment to that described, the 5-*O*-tosyl ester[6] **3** (5.0 g, 13 mmol) when reacted with sodium hydroxide (2.0 g, 50 mmol), in a mixture of methanol (75 mL) and water (25 mL) gave **1** (2.53 g, 92 %) with analytical data (TLC, [$_D$] and IR spectral data) corresponding to that given above.

From the di-O-*benzenesulfonyl ester.* Sodium hydroxide (4.0 g, 100 mmol) was dissolved in a mixture of water (50 mL) and MeOH (150 mL) and the di-*O*-benzenesulfonyl ester **4** (6.0 g, 11.76 mmol) was added. The reaction mixture was stirred under reflux for one hour and then concentrated to approximately one third of its initial volume. Workup of the reaction mixture, as above, gave **1** (2.24 g, 90 %), with analytical data as previously described.

From the di-O-*tosyl ester.* Sodium hydroxide (4.0 g, 100 mmol) was dissolved in a mixture of water (50 mL) and MeOH (150 mL), and the ditosyl ester[7] **5** (6 g, 11.15 mmol) added. The reaction mixture was stirred under reflux for one hour. Further workup of the reaction mixture, as described, gave **1** (2.15 g, 91,2 %).

From the 3-O-*acetyl-5*-O-*benzenesulfonyl-* -D-*xylofuranose (**6**)*. To the 3-*O*-acetyl-5-*O*-benzenesulfonyl- -D-xylofuranose **6** (618 mg, 1.5 mmol), in mixture of MeOH (20 mL) and water (5 mL), sodium hydroxide (200 mg, 5.0 mmol) was added, and the reaction mixture was kept under reflux temperature for 20 min. The reaction mixture was concentrated to one third of its initial volume and diluted with water (50 mL). Extraction with chloroform (3 50 mL), drying of the combined extracts and evaporation of the solvent gave **1** (280 mg, 88 %), with correct analytical data.

Hydrolysis of 3-O-*tosyl ester (**7**).*

To the 3-*O*-tosyl ester[8] **7** (750 mg, 1.95 mmol), in mixture of MeOH (20 mL) and water (5 mL) sodium hydroxide (250 mg, 6.25 mmol) was added and kept under reflux for one hour. Water (50 mL) added and the resulting mixture was extracted with chloroform (5 20 mL). The combined extracts were dried and evaporated. The remaining solid was crystallized from benzen–*n*-hexane to give crystalline monocyclohexylidene- -D-xylofuranose (420 mg, 94.5 %): mp 82 – 83 ºC, lit.[7] 83 – 84 ºC.

5-Bromo-5-deoxy-1,2-O-*cyclohexylidene*-α-*D-xylofuranose*[12] ***(8)***

To a solution of oxetane **1** (800 mg, 3.8 mmol) in dioxane (500 mg), concentrated hydrobromic acid (700 mg, 47 %) was added under stirring and cooling to maintain room temperature. The reactiom mixture was left at room temperature for 24 h with occasional mixing and then poured into 2 % $NaHCO_3$ (60 mL) and left at 5 ºC for 24 h. The formed solid was separated, air dried and crystallized from methylene chloride, to give **8** (870 mg, 78 %): mp 105 ºC, lit.[12] 96 ºC; [$_D$]^{20} – 8.4 (*c* 0.6, $CHCl_3$); Mass spectrum: 294 (M^+, 76), 292 (90), 250 (82), 248 (82), 99 (100).

5-Deoxy-5-iodo-1,2-O-*cyclohexylidene*-α-*D-xylofuranose (**9**)*

Concentrated hydroiodic acid (57 %) (900 mg) was added to a solution of oxetane **1** (800 mg, 3.8 mmol) in dioxane (500 mg), with stirring and cooling to room temperature. The reaction mixture was left for 24 h at room temperature, with occasional mixing and then poured into 2 % $NaHCO_3$ (60 mL) and left at 5 ºC for 24 h. The white solid which formed was separated, air dried and crystallized from petroleum ether (40 – 70 ºC) to give **9** (1.1 g, 85 %): mp 71 – 72 ºC; [$_D$]^{20} – 16.4 (*c* 0.72, $CHCl_3$); Mass spectrum: 340 (M^+, 22), 296 (22), 105 (16), 99 (20), 18 (100); Anal. Calc for $C_{11}H_{17}O_4I$: C, 38.83, H, 5.00 Found: C, 39.10; H, 4.95

3-O-*Acetyl-5-chloro-5-deoxy-1,2*-O-*cyclohexylidene*-α-*D-xylofuranose*[13] ***(10)***

Acetyl chloride (800 mg, 10.2 mmol) was added to the oxetane **1** (1.2 g, 5.66 mmol) in one portion, with stirring for 10 min, and left at 50 ºC for 24 h. Ether (100 mL) was added to the reaction mixture, and the solution washed with 2 % $NaHCO_3$ (3 25 mL), dried and evaporated to leave an oil. Crystallization from *n*-hexane gave **10** (1.23 g, 76 %): mp 33 – 34 ºC; [$_D$]^{20} – 18.4 (*c* 0.65, $CHCl_3$); Mass spectrum: 292 (M^+, 10), 290 (M^+, 27), 249 (20), 247 (57), 133 (22), 99 (33), 18 (100).

3-O-*Acetyl-5-bromo-5-deoxy-1,2*-O-*cyclohexylidene*-α-D-*xylofuranose (**11**)*

Acetyl bromide (300 mg, 2.46 mmol) was added to the oxetane **1** (460 mg, 2.16 mmol) in one portion, with stirring and cooling to room temperature for 10 min, and left overnight. Ether (25 mL) was added to the reaction mixture and the solution washed with 2 % $NaHCO_3$ (2 10 mL), dried and evaporated to leave an oil. Crystallization from *n*-hexane gave **11** (534 mg, 88 %): mp 77 ºC, lit.[12] 74 ºC; [$_D$]^{20} – 32.9 (*c* 0.76, $CHCl_3$); Mass spectrum: 336 (M^+, 69), 334 (M^+, 69), 297 (77), 291 (78), 221 (23), 219 (24), 55 (100).

И З В О Д

НУКЛЕОФИЛНО ОТВАРАЊЕ 3,5-АНХИДРО ПРСТЕНА КОД 1,2-*O*-ЦИКЛОХЕКСИЛИДЕН- -D-КСИЛОФУРАНОЗЕ

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Испитивана је реактивност и стереохемијски ток реакције 3,5-анхидро прстена код 3,5-анхидро-1,2-*O*-циклохексилиден- -D-ксилофуранозе (**1**) у условима нуклеофилног отварања оксетанског прстена коцентрованим воденим растворима халогеноводоничних киселина (HBr или HI), односно ацетилхалогенидима (ацетилхлорид или ацетилбромид). Реакцијом **1** са киселинама настају искључиво одговарајући 5-деокси-5-халогено деривати, док у реакцији са ацетихалогенидима настају одговарајући 3-*O*-ацетил-5-деокси-5-халогено деривати 1,2-*O*-циклохексилиден- -D-ксилофуранозе у преносима 70–90 %. Без обзира на јако киселе реакционе услове, заштитна ацетална група остаје неизмењена.

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