REACTION OF ACETYLOXIRANES WITH ACETONITRILE

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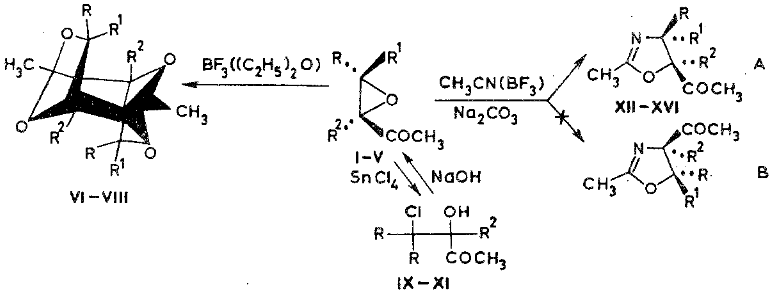
UDC 547.78

2-Acetyloxiranes react with acetonitrile in the presence of equimolar amounts of Lewis acids. It was established that the use of boron trifluoride etherate or sulfuric acid as the catalyst leads to 2,7- and 3,6-diepoxy-1,5-dioxocanes, the use of aluminum trichloride, as well as stannic chloride, leads to the corresponding chlorohydrins, while the use of gaseous boron trifluoride leads to 2-oxazolines in satisfactory yields. It is shown that the reaction is regio- and stereospecific and that the resulting substituted 2-methyl-5-acetyl-2-oxazolines have a cis configuration.

Alkene oxides react with nitriles under conditions of acid catalysis (H_2SO_4 and $SnCl_4$) to give small amounts of 2-oxazolines [1, 2]. This reaction has not been studied for acyl derivatives of oxiranes.

In the present research we investigated the reaction of 2-acetyloxiranes (I-V) with acetonitrile in the presence of acid catalysts.



I, XII $R=R^1=R^2=H$; II, XIII $R=CH_3$, $R^1=R^2=H$; III, VI, IX, XIV, $R=R^1=H$, $R^2=CH_3$; IV, VII, X, XV $R=R^1=CH_3$, $R^2=H$; V, VIII, XI, XVI $R=R^2=CH_3$, $R^1=H$

The use of H_2SO_4 or $Et_2O \cdot BF_3$ as the catalyst leads to the formation of readily sublimed products VI-VIII in up to 30% yields. Mass-spectrometric determination of the molecular masses showed that they are products of dimerization of oxiranes III-V.

Bands that are characteristic for the COCOC fragment at 1200, 1185, 1160, 1145, and 1120 cm^{-1}, for the vibrations of the 1,4-dioxane ring at 930 cm^{-1}, and for the stretching and deformation vibrations of methyl and methylene groups, respectively, at 2890-2990 and 1380-1460 cm^{-1} are observed in the IR spectra of these compounds. On the basis of these data and from a comparison of the physical constants with those obtained in [3], VI-VIII were identified as 2,7- and 3,6-diepoxy-1,5-dioxocanes. In addition, 2-oxazolines XII-XVI were isolated from the reaction mixtures in 2-8% yields.

According to the data in [4], dioxocane VI has a trans configuration with respect to the mutual orientation of the hydroxymethylene bridges between the C_2 and C_6 and C_4 and C_5 atoms. On the basis of a complete analogy in the IR spectra of dioxocanes VI and VII and VIII, a trans configuration can also be assumed for the latter. Molecules with a cis configuration have a different symmetry, which probably should lead to a substantial change in the IR spectra.

The use of $AlCl_3$ or $SnCl_4$ as the catalyst in the reactions under consideration leads to the formation of the corresponding chlorohydrins IX-XI in good yields (80-85%); it was established that in the case of oxirane V the resulting 4-chloro-3-hydroxy-3-methylpentan-2-

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0009-3122/82/1808-0773$07.50

TABLE 1. Yields and Physicochemical Properties of the Synthesized VI-XVI

Compound	bp, °C (mm)	n_D^{20}	d_4^{20}	Found, %			Experimental formula	Calculated, %			Yield, %
				C	H	N		C	H	N	
VI	155—156*	—	—	59,6	8,1	—	$C_{10}H_{16}O_4$	60,0	8,0	—	27
VII	149—151*	—	—	63,0	8,7	—	$C_{12}H_{20}O_4$	63,1	8,8	—	30
VIII	154—155*	—	—	62,9	8,9	—	$C_{12}H_{20}O_4$	63,1	8,8	—	28
IX	87—88 (10)	1,4518	1,1032	44,1	6,4	—	$C_5H_9CO_2$	44,0	6,6	—	72
X	91—92 (10)	1,4521	1,0848	47,3	7,2	—	$C_6H_{11}CO_2$	47,9	7,3	—	76
XI	90—91 (10)	1,4502	1,0787	48,1	7,2	—	$C_6H_{11}CO_2$	47,9	7,3	—	82
XII	81—82 (40)	1,4505	1,0249	56,9	6,9	10,9	$C_6H_9NO_2$	56,7	7,1	11,1	58
XIII	66—68 (10)	1,4476	1,0299	59,6	7,6	10,0	$C_7H_{11}NO_2$	59,6	7,8	9,9	68
XIV	66—67 (10)	1,4486	1,0162	57,9	7,9	10,1	$C_7H_{11}NO_2$	59,6	7,8	9,9	68
XV	68—69 (10)	1,4480	1,0338	61,9	8,3	9,0	$C_8H_{13}NO_2$	61,9	8,9	9,0	62
XVI	69—70 (10)	1,4476	1,0142	61,8	8,4	9,1	$C_8H_{13}NO_2$	61,9	8,9	9,0	58

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*These are the melting points, °C.

TABLE 2. PMR Spectra of VI-XVI

Compound	Chemical shifts, ppm (SSCC, Hz)				
	CH_3	R	R^1	R^2	$COCH_3$ (s)
VI	—	3,42 d (7)	4,27 d (7)	1,24 s	1,33
VII	—	1,7 s	2,1 s	4,1 s	1,7
VIII	—	1,43 d (6,8)	3,87 q (6,8)	1,09 s	1,30
IX	—	3,1—4 m	3,1—4 m	1,3 s	2,24
X	—	1,38 s	1,38 s	4,34 s	2,24
XI	—	1,34 d (8)	4,2 q (8)	1,30 s	2,23
XII	1,96 q (1,5)	4,38 m (14; 6,7; 1,5)	4,38 m (14; 6,7; 1,5)	3,62 q (6,7)	2,12
XIII	2,06 d (1,5)	1,14 d (7)	3,84 (7; 10; 1,5)	4,42 d (10)	2,16
XIV	1,93 q (1,5)	3,6 dq (14; 1,5)	3,6 dq (14; 1,5)	1,33 s	2,11
XV	1,99 s	1,05 s	1,36 s	4,33 s	2,16
XVI	2,04 d (1,5)	1,02 d (7,1)	3,84 dq (7,1; 1,5)	1,38 s	2,16

one has an erythro configuration. This is confirmed by the formation of the starting trans oxide V when XI is treated with NaOH solution [5]; in contrast to the data in [6], the formation of a cis-oxirane is not observed in this case.

The use of gaseous BF_3 as the catalyst gives 2-methyl-5-acetyl-2-oxazolines XII-XVI in all cases in up to 70% yields (Table 1).

An analysis of the reaction mixtures by means of gas-liquid chromatography (GLC) showed that oxazolines are formed along with a certain admixture of a product of transformation of the oxiranes, including 3-6% VI-VIII. In principle, in the reaction under consideration one may expect the formation of structural isomers A or B or a mixture of them, as well as mixtures or individual cis and trans isomers in the case of trans-oxiranes II and V.

The IR spectra of XII-XVI contain bands of C=N (1670-1685 cm^{-1}) and C=O (1718-1725 cm^{-1}) stretching vibrations and a band of a COC fragment (1200-1240 cm^{-1}); this, in conjunction with data from the PMR spectra (Table 2) and the results of elementary analysis (Table 1), makes it possible to assume that these compounds are 2-methyl-2-oxazolines.

In the PMR spectra of oxazolines XII-XIV and XVI the signals of the protons in the 4 position of the ring constitute an AB system with additional splitting (J = 1.5 Hz). The same splitting is observed for the signals of the protons of the methyl group in the 2 position, and this constitutes evidence for long-range spin-spin coupling of the indicated protons through the C=N bond. The latter is possible if the nitrogen atom is bonded with the methylene group. The absence of additional splitting of the signal of the methylidyne proton in XV constitutes evidence that the nitrogen atom is bonded to the tertiary ring atom. The presented character of the multiplicity of the signals of the protons attached to the C_4 atom shows that opening of oxiranes I-V with acetonitrile in the presence of the acid catalyst BF_3 takes place on the β-carbon atom side, and the resulting oxazolines have the 2-methyl-5-acetyl-2-oxazoline structure (A). For the compounds obtained from trans-3-methyl-2-acetyloxirane the constant of spin-spin coupling of the 4-H and 5-H protons is 10 Hz, which is characteristic for cis-substituted 2-oxazolines [7], and oxazoline XIII consequently has a cis configuration. In the case of the oxazoline obtained from trans-2,3-dimethyl-2-acetyloxirane the configuration was established on the basis of the Overhauser effect. A 26% increase in the intensity of the signal of the 4-H proton is observed when the 5-CH_3 group is irradiated, and this constitutes evidence for their cisoid orientation and, consequently, the cis configuration of oxazoline XVI. According to GLC, the formation of only cis-oxazolines is observed, and it may therefore be assumed that oxiranes I-V react with acetonitrile under acid-catalysis conditions with inversion of the configuration at the C_3 atom via the mechanism previously proposed for the reaction of carbonyl compounds with oxiranes [8].

EXPERIMENTAL

The IR spectra of 0.1 M solutions of the substances in CCl_4 were recorded with an IR-75 spectrometer. The PMR spectra of 10% solutions of the compounds in CCl_4 were obtained with a Varian-HA-100 spectrometer with hexamethyldisiloxane as the internal standard. An experiment on the Overhauser nuclear effect was carried out with a Tesla BS-467 spectrometer. The preparation of the samples and the measurements were carried out by known methods [9]. The mass spectra were recorded with a MAT-311 spectrometer at an ionization energy of 15 eV. The course of the reaction and the individuality of the compounds obtained were monitored by GLC with an LKhM-8-MD-1 chromatograph with a 2-m long column filled with Chezasorb AW-HMDS containing 5% XE-60 as the liquid phase with helium as the carrier gas. Starting oxiranes I-V were obtained by oxidation of the corresponding unsaturated ketones with alkaline hydrogen peroxide [10, 11].

2-Methyl-5-acetyl-2-oxazolines XIII-XVI. Boron trifluoride [2.25 liters (0.1 mole)] was passed with stirring through a solution of 5 g (0.12 mole) of acetonitrile in 100 ml of methylene chloride while maintaining the temperature of the reaction mixture at 0-5°C, after which 0.1 mole of oxirane I-V was added dropwise in the course of an hour. An 84-g (1 mole) sample of $NaHCO_3$ and 20 ml of water were then added, and the reaction product was extracted with three 100-ml portions of ether. The ether extracts were dried with anhydrous sodium sulfate, the solvent was removed by distillation, and the residual substance was distilled in vacuo with a 30-cm high Vigreux column.

The reactions in the presence of other catalysts (H_2SO_4, $EtO \cdot BF_3$, $AlCl_3$, and $SnCl_4$) were carried out similarly. Dioxocanes VI-VIII were crystallized from hexane—benzene (1:3).

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