SYNTHESIS AND PROPERTIES OF BENZYL-SUBSTITUTED THIIRANES

M. A. Allakhverdiev, A. Z. Khalilova,
V. M. Farzaliev, and Yu. M. Sultanov

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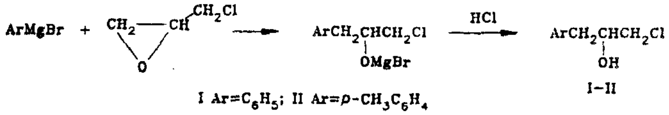
The reaction of phenyl- and p-tolylmagnesium bromides, as well as di, tri, and tetramethylbenzene, with epichlorohydrin was used to synthesize the corresponding chlorohydrins, which were then converted to various benzyl-substituted oxiranes and thiiranes.

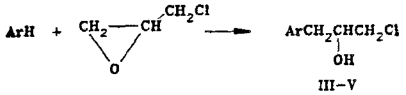
Information regarding the synthesis, structures, and reactivities of various thiiranes has been presented in a monograph [1]; however, virtually no data on the synthesis of benzyl-substituted thiiranes are available. Only a study in which 1,2-epithio-3-phenylpropane was obtained in 23% yield by the reaction of 1-phenyl-3-propene with sulfur dichloride and the subsequent action of sodium sulfide has been published [2].

Continuing our research on the synthesis of thiiranes and their various amino derivatives [3-9], in the present paper we describe the synthesis and properties of benzylthiirane and its mono-, di-, tri-, and tetramethyl-substituted derivatives. 1-Chloro-3-phenyl(p-tolyl)-2-propanols (I, II), which were synthesized on the basis of the reaction of phenyl- and p-tolylmagnesium bromides with epichlorohydrin, were used as the starting compounds:



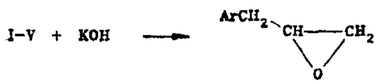
The physicochemical characteristics of chlorohydrins I and II were identical to the data for the chlorohydrins obtained by the reaction of phenyl- and p-tolyllithium and epichlorohydrin [10].

Chlorohydrins III-V were synthesized in the alkylation of p-xylene, mesitylene, and durene with epichlorohydrin in the presence of aluminum chloride:



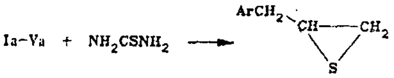
III Ar=2,5-$(CH_3)_2C_6H_4$; IV Ar=2,4,6-$(OH_3)_3C_6H_3$; V Ar=2,3,5,6-$(CH_3)_4C_6H_2$

Chlorohydrins III and IV were obtained by the method in [11] with an ArH–epichlorohydrin–$AlCl_3$ ratio of 24:1:1. For the first time we investigated the reaction of durene with epichlorohydrin and established that chlorohydrin V is formed in 70% yield at a reagent ratio of 5:1:1. The corresponding oxiranes Ia-Va were synthesized as a result of treatment of the chlorohydrins with finely ground KOH in dry ether:



Ia-Va

Benzyl-substituted thiiranes Ib-Vb were isolated in the thioepoxidation of oxiranes Ia-Va with thiourea:



Ib-Vb

Institute of the Chemistry of Additives, Academy of Sciences of the Azerbaidzhan SSR, Baku 370603. Translated from Khimiya Geterotsiklicheskikh Soedinenii, No. 5, pp. 598-602, May, 1988. Original article submitted November 4, 1986; revision submitted March 4, 1987.

TABLE 1. Spectral Characteristics of the Synthesized Compounds

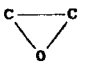
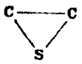
Compound	PMR spectrum (CCl_4), δ, ppm					IR spectrum, cm^{-1}				
	CH_3, s	$ArCH_2$, d	CH_2X, d	CH, m	Ar, s	OH	CH_2Cl			position
I	—	2.70	3.25	3.75	6.90	3400, 3585	750	—	—	690, 750, 1800, 1860, 1940
II	2.15	2.65	3.30	3.65	6.70	3390, 3580	770	—	—	840, 1790, 1960
III	2.23	2.60	3.30	3.70	6.75	3380, 3590	745	—	—	805, 875, 1790, 1910
IV	2.25	2.75	3.35	3.65	6.67	3400, 3585	755	—	—	850, 1810, 1930
V	2.15	2.80	3.35	3.55	6.50	3380, 3590	750	—	—	845, 1905
Ia	—	2.70	2.42 and 2.70	2.90	6.80	—	—	1245, 1020, 860	—	700, 740, 1815, 1880, 1960
IIa	2.20	2.65	2.35 and 2.70	2.80	6.60	—	—	1250, 1010, 830	—	805, 1785, 1900
IIIa	2.15	2.70	2.35 and 2.65	2.80	6.70	—	—	1250, 1030, 850	—	880, 1710, 1950
IVa	2.20	2.60	2.30 and 2.60	2.85	6.65	—	—	1240, 1020, 850	—	820, 850, 1925, 1810
Va	2.15	2.80	2.45 and 2.70	2.90	6.50	—	—	1265, 1020, 850	—	840, 1900
Ib	—	2.75	2.10 and 2.35	2.75	6.80	—	—	—	650	690, 750, 1930
IIb	2.20	2.70	2.08 and 2.25	2.70	6.60	—	—	—	635	825, 1700, 1900
IIIb	2.10	2.65	2.05 and 2.28	2.75	6.65	—	—	—	630	800, 880, 1885
IVb	2.20	2.70	2.10 and 2.35	2.70	6.70	—	—	—	635	820, 845, 1715, 1910
Vb	2.18	2.65	2.07 and 2.37	2.67	6.60	—	—	—	620	860, 1910

TABLE 2. Physicochemical Characteristics of the Synthesized Thiiranes

Compound	bp, °C, (mm)	n_D^{20}	d_4^{20}	MR_D		Found, %			Empirical formula	Calculated, %			R_f	Yield, %
				found	calc.	C	H	S		C	H	S		
Ib*	80 (1.1)	1.5748	1,0673	46.18	46,67	71,8	6,9	21,6	$C_9H_{10}S$	71.9	6.7	21,3	0,71	73
IIb	98 (1.3)	1,5642	1,0408	51,28	51,39	73,4	7,2	19,3	$C_{10}H_{12}S$	73.1	7.4	19,5	0,73	83
IIIb	114 (1.3)	1.5645	1,0448	55,70	55,31	73,4	8,6	17,7	$C_{11}H_{14}S$	73.7	8.4	17.9	0.75	75
IVb	96 (0.7)	1.5610	1,0403	59,69	59,92	75,1	8,2	16.9	$C_{12}H_{16}S$	74.9	8.4	16,7	0,80	66
Vb	138 (2.0)	1.5520	0.9069	64,75	64,53	75.5	8,9	15,3	$C_{13}H_{18}S$	75.7	8.8	15,5	0,88	61

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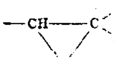
*The constants presented in the table correspond to the data in [2].

It should be noted that we were unable to obtain the corresponding thiiranes IIIb-Vb by treatment of oxiranes IIIa-Va with thiourea in the presence of sulfuric acid: a polymeric product was always ultimately isolated. In this connection the thioepoxidation of these oxiranes was carried out in ethanol in the absence of a catalyst. This method made it possible to synthesize benzyl-substituted thiiranes IIIb-Vb in 61-83% yields.

The compositions and structures of all of the synthesized compounds were proved by IR and PMR spectroscopy, and the purity was verified by the results of elemental analysis and TLC. The IR and PMR spectral data for the compounds obtained are presented in Table 1.

It is apparent from Table 1 that broad intense bands at 3380-3400 and 3550-3560 cm^{-1}, which correspond to associated and free hydroxy groups [12], appear in the IR spectra of chlorohydrins I-V. The intense band at 750-760 cm^{-1} shows the stretching vibrations of the CH_2Cl bond. In addition to this, the IR spectra of I-V contain weak absorption bands at 1680-2000 cm^{-1}, which characterize the types of substitution in the aromatic ring [13]. In contrast to the IR spectra of the chlorohydrins, intense bands at 830-860, 1010-1030, and 1240-1250 cm^{-1}, which correspond to asymmetrical, symmetrical, and pulsation vibrations of the oxirane ring, appear in the IR spectra of oxiranes Ia-Va, while absorption bands corresponding to hydroxy and CH_2Cl groups are absent. Stretching vibrations that are characteristic for the thiirane ring are observed at 620-650 cm^{-1}.

Signals at 2.10-2.25 ppm in the form of singlets, which are related to methyl groups bonded to an aromatic ring, are present in the PMR spectra of all of the synthesized compounds at strong field, while signals at 2.60-2.85 ppm (doublets) correspond to the protons of methylene groups bonded to a benzene ring. Signals of the protons of the methyl groups in chlorohydrins I-V are observed in the form of a doublet at 3.25-3.40 ppm, and signals of methylidyne groups are observed in the form of multiplets at 3.55-3.75 ppm. It should be noted that signals of the protons of the methylidyne groups in the oxirane and thiirane rings of Ia-Va and Ib-Vb are shifted to stronger field as compared with the signals of the methylidyne groups of the chlorohydrins and appear at 2.70-2.90 ppm. The signals of the proton of the OH group are superimposed on the signals of the CH_2Ar group; this was determined by recording the spectra in the presence of D_2O. In the PMR spectra of oxiranes Ia-Va the signals of the protons of the CH_2 group of the oxirane ring  appear in the form of two doublets at 2.30-2.45 and 2.60-2.70 ppm; this corresponds to trans and cis orientations of the hydrogen atoms. Similarly, the signals of the protons of the CH_2 group bonded with the thiirane ring are shifted to stronger field and are observed in the form of doublets at 2.05-2.10 and 2.25-2.37 ppm. This phenomenon is evidently due to the fact that sulfur is less electronegative than oxygen [14].

EXPERIMENTAL

The IR spectra of liquid films of the compounds at 400-4000 cm^{-1} (KBr, NaCl, and LiF prisms) were recorded with a Shimadzu IR-430 spectrometer. The PMR spectra of solutions of the compounds in CCl_4 were obtained with a Varian T-60 spectrometer with tetramethylsilane (TMS) as the internal standard. The course of the reactions and the purity of the compounds obtained were monitored by TLC on activity II aluminum oxide in a hexane–ethanol system (5:1).

The starting chlorohydrins I-IV and the corresponding oxiranes Ia-IVa were obtained by the methods in [10, 11].

1-Chloro-3-(2,4,5,6-tetramethylphenyl)-2-propanol (V). A 67 g (0.5 mole) sample of durene was dissolved in 100 ml of hexane, and the solution was mixed with 13.4 g (0.1 mole) of aluminum chloride. A 9.3 g (0.1 mole) sample of epichlorohydrin was added dropwise with vigorous stirring to the cooled (to 10°C) suspension, after which the temperature was raised to 20°C, and the mixture was stirred for another 6 h. The reaction product was acidified with hydrochloric acid and decomposed with water, and the organic layer was separated, washed several times with water until the wash water was neutral, and dried with anhydrous $MgSO_4$. The solvent and unchanged components were removed by distillation, and the reaction product was subjected to vacuum distillation to give 16 g (70%) of a product with R_f 0.46, bp 144-146°C (2 mm), and mp 55-56°C. Found: C 68.5; H 8.9; Cl 15.4%. $C_{13}H_{19}ClO$. Calculated: C 68.9; H 8.5; Cl 15.6%.

1,2-Epoxy-3-(2,4,5,6-tetramethylphenyl)propane (Va). A mixture of 22.6 g (0.1 mole) of the chlorohydrin and 50 ml of hexane was placed in a three-necked flask, 8 g (0.2 mole) of a 20% solution of sodium hydroxide was added dropwise with vigorous stirring, and the mixture was heated to 60°C for 2 h. It was then cooled, washed several times with water until the wash water was neutral, and dried over anhydrous $MgSO_4$. The solvent was removed by distillation, and the reaction product was subjected to vacuum distillation to give 16 g (82%) of a product with R_f 0.93, bp 120°C (3 mm), and mp 35°C. Found: C 82.3; H 9.4%. $C_{13}H_{18}O$. Calculated: C 82.0; H 9.2%.

1,2-Epithio-3-phenylpropane (Ib). A 7.6 g (0.1 mole) sample of thiourea and 3 ml of sulfuric acid (0.1 mole of H_2SO_4 + 35 ml of H_2O) were added to a three-necked flask, and the reaction mixture was cooled to 5°C with vigorous stirring. Stirring was continued, and 13.4 g (0.1 mole) of 1,2-epoxy-3-phenylpropane was added dropwise in the course of 1 h. After all of the oxirane had been added, the temperature of the reaction mixture was raised to 20°C, and stirring was continued for another 2 h. The reaction product was neutralized with sodium carbonate solution (5.3 g of Na_2CO_3 + 22.5 ml of H_2O) and extracted with CCl_4. The extract was washed with water and dried over anhydrous Na_2SO_4. The solvent was removed by distillation, and the product was subjected to vacuum distillation to give 11 g of product. According to the data in [2], this compound had bp 60°C (0.1 mm) and n_D^{20} 1.5780. Compound IIb was similarly synthesized.

1,2-Epithio-3-(2,4,5,6-tetramethylphenyl)propane (Vb). A 7.6 g (0.1 mole) sample of thiourea was added to a solution of 19.0 g (0.1 mole) of oxirane Va in 50 ml of ethanol, and the mixture was stirred for 2 h at 60°C. The reaction product was washed with 100 ml of water and extracted with carbon tetrachloride, and the extract was dried with anhydrous magnesium sulfate. The solvent was removed by distillation, and the reaction product was subjected to vacuum distillation to give 12 g of product. Compounds IIIb and IVb were similarly synthesized (Table 2).

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