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# HETEROCYCLIZATION OF 1-ACETOXY-4-HALO-SUBSTITUTED 2-BUTENES IN THE PRESENCE OF ALKALI

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The reaction of 1-acetoxy-4-halo-substituted 2-butenes with potassium hydroxide was studied. It was established that trans-1,4-haloacetates form α-oxides of 1,3-dienes, whereas the corresponding cis isomers form 2,5-dihydrofuran derivatives. It was observed that the acetyl group in these compounds facilitates, as compared with halovinylhydrins, the formation of the corresponding heterocycles under the conditions described.

In the series of methods that are widely used to obtain oxides of 1,3-dienes the most universal is cleavage of vicinal halohydrins and their esters by bases [1, 2]. Results, according to which oxiranes of this type can be obtained from halohydrins that contain a vinyl fragment [3] and their esters [4], has become a substantial supplement to this method. We observed the latter reaction [4] in the course of establishing the configuration of the double bond in 4-acetoxy-1-bromo-2-methyl-2-butene (Id), which was obtained in the reaction of 2-methyl-3,4-epoxy-1-butene with acetyl bromide [5]. One should have expected that the action of alkali on the cis isomer of bromoacetate Id, which has an orientation of the functional groups that is favorable for the reaction, would lead to 3-methyl-2,5-dihydrofuran, whereas the trans isomer would be converted to the corresponding bromohydrin. Carrying out the reaction in the presence of dry potassium hydroxide led to an unexpected result — the only reaction product was isoprene oxide (IIb), i.e., intramolecular γ-allylic substitution occurred under the conditions of the $S_N2$ reaction [6]. Both the cis and trans form of bromoacetate Id can participate in this transformation, in view of which it became necessary to study the behavior of the individual stereoisomers in this reaction, and the possibility of extending it to other molecules that have a similar carbon skeleton also arose.

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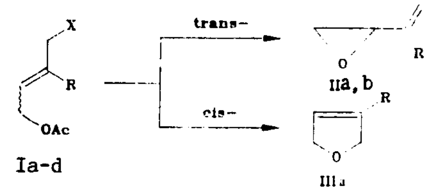
TABLE 1. Products of Transformations of Ia-d

| Compound | Isomer ratio in Ia-d, % |  | Product ratio, % |  | Overall yield, % | PMR spectrum, δ, ppm |
|---|---|---|---|---|---|---|
|  | trans | cis | IIa,b | IIIa |  |  |
| Ia | 8 | 92 | 7 (IIa) | 93 | 75 | IIa: 2.35...2.95 (3H, m, $-CH_2OCH$); 5.13...5.60 (3H, m, $-CH{=}CH_2$); IIIa: 4.66 (4H, br.s $-CH_2OCH_2-$); 5.93 (2H, br.s $-CH{=}CH-$) |
| Ib | 100 | — | 100 (IIb) | — | 70 | Completely identical to that described in [14] |
| Ic | 95 | 5 | 95 (IIa) | 5 | 70 | -- |
|  | 10 | 90 | 8 (IIa) | 92 | 72 | -- |
| Id | 100 | — | 100 (IIb) | — | 85 | -- |

With this end in mind, we synthesized some individual trans-1-acetoxy-4-halo-2-butenes or mixtures of the cis and trans isomers and investigated their behavior in the presence of potassium hydroxide. trans-Bromoacetate Id was obtained from isoprene dibromide, which has a trans configuration of the double bond [7]. It was shown that the compound synthesized by this method, like the sample of bromoacetate Id obtained from isoprene oxide, gives only oxirane IIb in 85% yield in the investigated reaction. Similarly, from butadiene dibromide we obtained 1-acetoxy-4-bromo-2-butene (Ic) [8], which has the isomeric composition cis: trans = 5:95 and, upon reaction with potassium hydroxide, forms not one but two compounds — 2,5-dihydrofuran (IIIa) [9] and butadiene oxide (IIa) [10] — also in a ratio of 5:95 (Table 1). The use of stereoisomeric mixtures of haloacetates Ia, c, obtained by cleavage of 2,5-dihydrofuran by, respectively, acetyl chloride or acetyl bromide [11], also lead to similar results (Table 1).

Then it was established that 1-acetoxy-4-halo-2-butene derivatives with a trans configuration of the double bond react with potassium hydroxide to give α-oxides of the corresponding 1,3-dienes, whereas the cis isomers give 2,5-dihydrofurans.



Ia-d

IIa, b

IIIa

I a R=H, X=Cl; b R=$CH_3$, X=Cl; c R=H, X=Br; d R=$CH_3$, X=Br; II, III a R=H;
b R=$CH_3$

Consequently, chloroacetate Ib [12], which was obtained by allylic isomerization of 4-acetoxy-2-methyl-3-chloro-1-butene and, upon reaction with potassium hydroxide, forms only isopropenyloxirane (IIb), like the bromides described in [3], has a trans configuration of the double bond.

On the basis of the stereochemistry of the heterocyclization of acetates of halovinylhydrins set forth above one should have expected that the corresponding alcohols would react with potassium hydroxide to give oxides more readily than acetates Ia-d. However, the formation of oxirans from vinylbromohydrins occurs only in the presence of sodium hydride and a crown ether [3]. Not even traces of 2-methyl-3,4-epoxy-1-butene (monitoring by GLC) can be obtained from 1-bromo-4-hydroxy-2-methyl-2-butene under the conditions that we used; a mixture of bromine-containing substances with unestablished structures is formed in this case. Experiments involving carrying out the dehydrobromination under superbase conditions were also unsuccessful.

A comparison of these results with data on the analogous reaction of acetates under relatively mild conditions shows that the acetoxy group facilitates γ-allylic substitution of the ester oxygen atom. In our opinion, a possible reason for this is the increase in the nucleophilicity of the oxygen atom of the ester group in the intermediate adduct formed by the addition of the base to the carbonyl group of bromoacetates I; this is similar in nature to the α-effect in so-called α-nucleophiles [13].

## EXPERIMENTAL

The PMR spectra of solutions in $CCl_4$ were recorded with a Perkin-Elmer R-12B spectrometer (60 MHz) with hexamethyldisiloxane as the internal standard. The isomer ratios in the mixtures were determined from the integral intensities of the methylene and methylidyne protons in the PMR spectra with the aid of GLC. Chromatography was carried out with an LKhM-8MD chromatograph with a catharometer with 2- and 3-m long columns packed with 5% SE-30 on Chromaton N-AW-HMDS; the carrier-gas (helium) flow rate was 40-60 ml/min, and the temperature was 60-180°C.

Reaction of Haloacetates Ia-d with Potassium Hydroxide. A 0.1-mole sample of acetate I was added dropwise with stirring at 60-80°C in the course of 20 min to 11.2g (0.2 mole) of potassium hydroxide, and the reaction products were removed by distillation as they formed. The isomer ratios in the products and the yields are presented in Table 1.

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