INVESTIGATION OF STEREOISOMERS OF 4-ALKENYL-trans-DECAHYDROQUINOL-4-OLS IN MIXTURES BY THE METHOD OF REACTION CHROMATO-MASS SPECTROMETRY*

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The mass spectra of the appropriate 4-ethyl derivatives, which provide the determination of the configuration of the 4 position in the initial alcohols, are registered in the chromato-mass spectrometric investigation of mixtures of the stereoisomeric 4-vinyl-trans-decahydroquinol-4-ols using a microreactor for hydrogenation; the microreactor is placed before or after the chromatographic column.

The principle possibility for the application of electron-impact mass spectrometry (EI) in the determination of the configuration of the 2 and 4 positions in substituted 4-alkyl-trans-decahydroquinol-4-ols was previously [2] shown on a large number of examples. In this case, the utilization of the high stereospecificity of reactions of the cleavage of the alkyl substituents from the indicated positions was proposed for the stereochemical assignments. At the same time, it was established that it does not seem possible to determine the configuration of the 4 position in 4-alkenyl-trans-decahydroquinol-4-ols by the direct mass-spectrometric investigation due to the disadvantageous breaking of the $C-C_{vinyl}$ bond by the EI; this problem can be solved by the preliminary hydrogenation of the samples to their saturated analogues. It is al interest to accomplish the hydrogenation reaction directly in the inlet system of the instrument during the process of CMS. It was shown in the work [3] that the method of CMS can be successfully utilized for the analysis of mixtures of the stereoisomers of 4-alkyl-trans-decahydroquinol-4-ols in spite of the fairly drastic conditions of the experiment. In the present work, the possible utilization of pre- and post-column hydrogenation directly in the instrument was studied to determine the configuration of the 4-alkenyl-trans-decahydroquinol-4-ols contained in the mixtures. Mixtures of the stereoisomers of the 4-vinyl-trans-decahydroquinol-4-ols (I), (II) and (III), (IV), of known stereochemistry [2], were taken for the investigation; they were obtained from the corresponding trans-decahydroquinol-4-ones by the Norman reaction.

The work was carried out on an LKB-2091 instrument (energy of the ionizing electrons 70 eV, emission current 50 μA, temperature of the ionization chamber and the molecular separator 250°C). In the chromatographic part, we utilized a quartz capillary column 25 m × 0.26 mm with the stationary liquid phase of Carbowax 20 M (the gas carrier and gas reagent was hydrogen; the division of flow was 1:30; the temperature of the inlet block was 300°C; the temperature was programmed from 40 to 200°C at a rate of 8°C/min).

We utilized 1.5% Pd/porous glass (diameter of the granules ~0.3 mm) as the catalyst for the hydrogenation. It was placed in the microreactor, previously described [4], between the glass plugs. Special experiments using the hydrogenation microreactor between the inlet block and the chromatography column with the individual compounds (I)-(V) showed that the core of the catalyst of the diameter 2 mm and the height 20 mm guaranteed the quantitative hydrogenation of up to 0.1 μg of the individual vinyl alcohol to the 4-ethyl analog at a temperature of 150-200°C. The isomerization, hydrogenolysis, or dehydration of the compounds investigated was not thereby noted.

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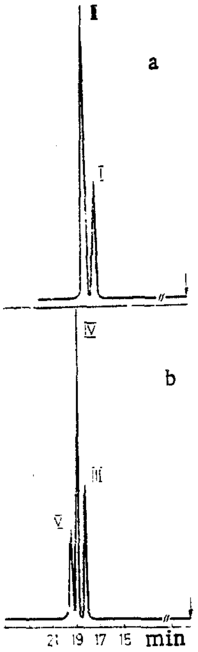
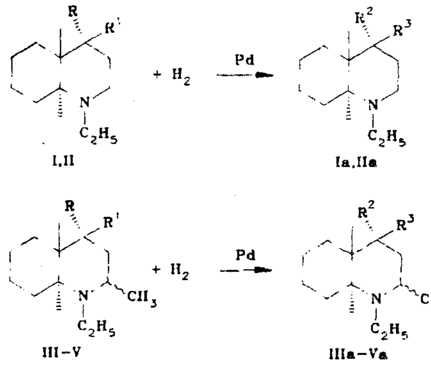


Fig. 1. Chromatograms of the mixtures of the stereoisomers of 1-ethyl-4-vinyldecahydroquinol-4-ols (a) and 1-ethyl-2-methyl-4-vinyldecahydroquinol-4-ols (b) registered using the hydrogenation microreactor (170°C), placed between the column and the mass spectrometer.

In the investigations on the development of the method of reaction CMS [5], we paid special attention to the utilization of microreaction systems situated between the chromatography column and the mass spectrometer. The advantage of such a disposition of the microreactor is the fact that each component eluted from the column undergoes chemical reaction in the given case, whereby the registered chromatogram corresponds to that of the initial mixture; the mass spectra correspond to the conversion products. We also utilized such a disposition of the hydrogenation microreactor in the present investigation.

Two artificial mixtures were prepared with the following ratios of the components: (I):(II) ≈ 1:1.5 and (III):(IV):(V) ≈ 1.5:4:1. The fact that the ionization profiles of the stereoisomers are close, and that the ratio of the areas of the chromatographic bands is equal to the mass and molar ratio of the stereoisomers, was utilized for the assignment of the chromatographic bands to a specific compound. The chromatograms of both the mixtures of the stereoisomers are presented in Fig. 1; they represent the recording of the change of the full ion current in the process of the entry of the substances into the ionization chamber of the mass spectrometer, and are registered on passing the components through the bypass or the hydrogenation microreactor. It was established that the presence of the hydrogenation microreactor with the amount of the catalyst indicated above has practically no influence on the times of outflow of the components, and does not impair the chromatrographic separation which is obtained using the capillary column. At the same time, the registered mass spectra correspond completely with the spectra of the 4-ethyl analogs (Ia)-(Va); this indicates the quantitative hydrogenation of the vinyl alcohols (I)-(V) with the retention of configuration.



I R=OH, R^1=CH=CH_2; II R=CH=CH_2, R^1=OH; Ia R^2=OH, R^3=C_2H_5; IIa R^2=C_2H_5, R^3=OH; III 2a-CH_3; R=OH, R^1=CH=CH_2; IV 2e-CH_3; R=OH, R^1=CH=CH_2; V 2e-CH_3; R=CH=CH_2, R^1=OH; IIIa 2a-CH_3; R^2=OH, R^3=C_2H_5; IVa 2e-CH_3; R^2=OH, R^3=C_2H_5; Va 2e-CH_3; R^2=C_2H_5, R^3=OH

TABLE 1. Ratio of the Intensities of the Peaks of the Characteristic Ions

Compound	$I_{[M-CH_3]^+}/I_{[M]^{+\cdot}}$		$I_{[M-C_2H_5]^+}/I_{[M]^{+\cdot}}$	
	MS	RCMS	MS	RCMS
Ia	—	—	5,00	5,10
IIa	—	—	6,30	6,30
IIIa	6,15	6,00	5,30	5,15
IVa	3,96	3,85	3,64	3,75
Va	3,24	3,10	8,46	9,00

As was noted above, the determination of the configuration of the 2 and 4 positions in the 2-methyl-4-ethyldecahydroquinol-4-ols was based on the high stereospecificity of the cleavage reactions of the alkyl substituents from these positions. In this case, the ratios of the intensities of the peaks of the $[M - CH_3]^+$ (elimination of the 2-CH_3 group) and the $[M - C_2H_5]^+$ (elimination of the 4-ethyl, but not the N-ethyl group [6]) ions to the intensity of the peak of the molecular ion were utilized; these ratios were always higher for the compounds with axial alkyl groups by comparison with their equatorial analogues. The values of the ratios of the intensities of the peaks of the ions, namely $I_{[M - CH_3]^+}/I_{[M]^+}$ and $I_{[M - C_2H_5]^+}/I_{[M]^+}$, are presented in Table 1; they were obtained by using the direct introduction of the individual substances (Ia)-(Va) into the ion source on the one hand (MS), and by using the gas-chromatographic introduction of the mixture of alcohols (I)-(V) with the passage of the components of the mixture through the hydrogenation microreactor (RCMS), under the conditions described, on the other hand. As can be seen from Table 1, these values, which were obtained under different experimental conditions, are fairly close; the character of their change in the transition from one stereoisomer to the other is preserved. The fact that the ratios of the intensities of the peaks of the ions, namely $I_{[M - C_2H_5]^+}/I_{[M]^+}$, are significantly higher in the mass spectra of the compounds (IIa) and (Va) than in the spectra of the stereoisomers (Ia) and (IVa) correspondingly shows that the first have the axial, and the second have the equatorial, ethyl groups. This result, in its turn, permits the assignment of the axial orientation of the 4-vinyl group in the compounds (II) and (V), and the equatorial orientation in the compounds (I) and (IV).

Therefore, the utilization of hydrogenation in the admission system of the chromato-mass spectrometer facilitates the mass-spectrometric differentiation of the stereoisomers with unsaturated substituents in the decahydroquinoline series. The proposed method does not require the additional outlay of work and time on the isolation, separation, and hydrogenation of the stereoisomers.

LITERATURE CITED

1. A. I. Mikaya, T. P. Popova, V. G. Zaikin, V. E. Shiryaeva, L. S. Glebov, G. A. Kliger, A. V. Antonova, and N. S. Prostakov, J. High Res. Chromatogr. Chromatogr. Commun., in press.
2. V. G. Zaikin and N. S. Vul'fson, Khim. Geterotsikl. Soedin., No. 11, 1443 (1978).
3. V. G . Zaikin, V. I. Smetanin, N. S. Vul'fson, A. A. Skhrem, and L. I. Ukhova, Khim. Geterotsikl. Soedin., No. 11, 1537 (1976).
4. V. I. Smetanin, A. I. Mikaya, and V. G. Zaikin, Zavod. Lab., 49, No. 10, 24 (1983).
5. A. I. Mikaya, V. I. Smetanin, and V. G. Zaikin, Izv. Akad. Nauk SSSR, Ser. Khim., No. 10, 2270 (1982).
6. N. S. Vul'fson, V. G. Zaikin, A. A. Bakaev, A. A. Akhrem, and L. I. Ukhova, Khim. Geterotsikl. Soedin., No. 7, 962 (1975).