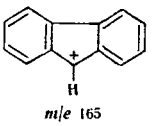

m/e 165

$[C_{13}H_7]^+$

m/e 163

Thus the mass-spectrometric behavior of 5-phenyl-1,4-benzodiazepine-2-thiones differs substantially from the fragmentation of the corresponding benzodiazepinones. This difference is due to the fact that, in contrast to benzodiazepinones, tautomerization to enethione and eniminethione tautomeric forms is characteristic for the molecular ions of the thiones.

EXPERIMENTAL

The mass spectra were obtained with an MKh-1303 spectrometer with a system for direct introduction of the samples at an ionizing voltage of 50 V, an emission current of 1.5 μA, and temperatures ranging from 140 to 170°. Compound II was obtained by repeated refluxing of I in deuteromethanol and subsequent evaporation of the solvent. The mass spectrum showed that II contains 34% of the deuterated derivative.

LITERATURE CITED

1. P. A. Sharbatyan, P. B. Terent'ev (Terentyev), A. W. Bogat-skii (Bogatsky), S. A. Andronati, and A. N. Kost, Org. Mass Spectrom., (1976, in press).
2. W. Sadee, J. Med. Chem., 13, 475 (1970).
3. G. A. Archer and L. H. Sternbach, J. Org. Chem., 29, 231 (1964).
4. A. V. Bogat-skii, S. A. Andronati, V. P. Gul'tyai, Yu. I. Vikhlyaev, A. F. Galatin, Z. I. Zhilina, and T. A. Klygul', Zh. Obshch. Khim., 41, 1358 (1971).
5. M. Z. Pahl, Naturforsch, 9b, 418 (1954).
6. S. C. Bell and S. J. Childress, J. Org. Chem., 27, 1691 (1967).
7. S. C. Bell, R. J. McCaully, and S. J. Childress, J. Med. Chem., 2, 172 (1968).
8. R. I. Fryer, D. Winter, and L. H. Sternbach, J. Heterocycl. Chem., 4, 355 (1967).
9. A. V. Bogat-skii and S. A. Andronati, Usp. Khim., 39, 2217 (1970).

STRUCTURE AND PROPERTIES OF 1- AND 3-HYDROXYTRIAZOLO[4,5-b]PYRIDINES

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It is shown that 1-hydroxytriazolo[4,5-b]pyridine exists in alcohol solution primarily in the N-oxide form, whereas 3-hydroxytriazolo[4,5-b]pyridine exists in the hydroxy form. 4-Methyltriazolo[4,5-b]pyridine 1-oxide is formed in the methylation of 1-hydroxytriazolo[4,5-b]pyridine, whereas 3-methoxytriazolo[4,5-b]pyridine is formed in the methylation of 3-hydroxytriazolo[4,5-b]pyridine.

It has previously been reported [1] that two isomeric compounds corresponding to two tautomeric forms – the N-oxide (Ia) and the N-hydroxy form (Ib) – are formed in the methylation of 1-hydroxybenzotriazole. The Ia⇌Ib tautomerism was studied by comparison of the UV spectra of the starting compound and its methylation

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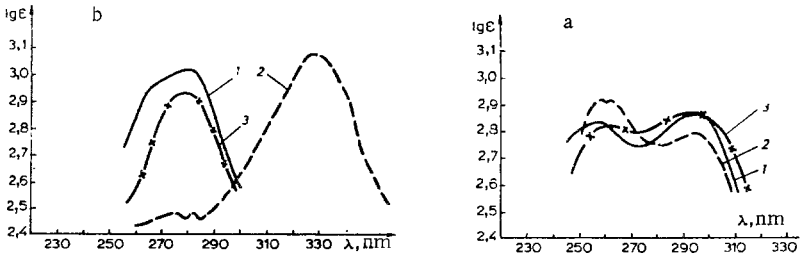


Fig. 1. UV spectra in alcohol: a) 1) 3-methoxytriazolo[4,5-b]-pyridine IVa (R = CH_3); 2) 1-methoxybenzotriazole IIa; 3) 3-hydroxytriazolo[4,5-b]pyridine IVa (R = H); b) 1) 4-methyltriazolo[4,5-b]pyridine 1-oxide IIIc (R = CH_3); 2) 1-methylbenzotriazole 3-oxide IVb; 3) triazolo[4,5-b]pyridine 1-oxide IIIc (R = H).

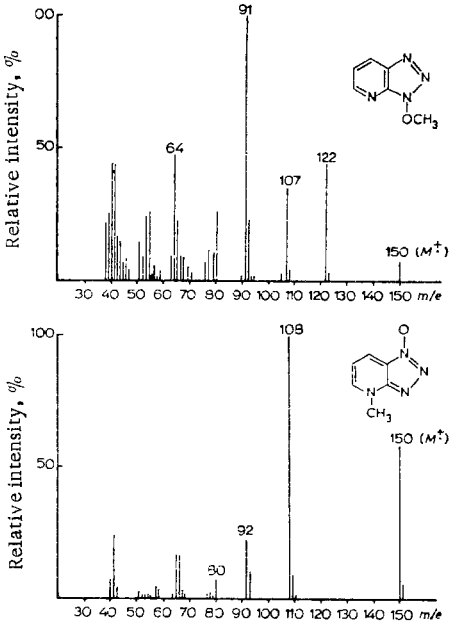
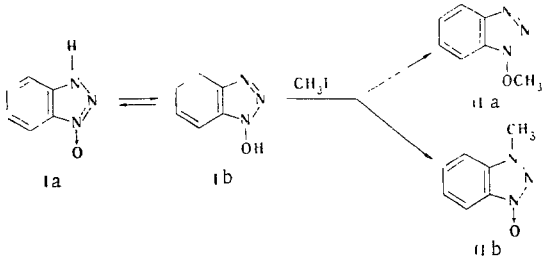
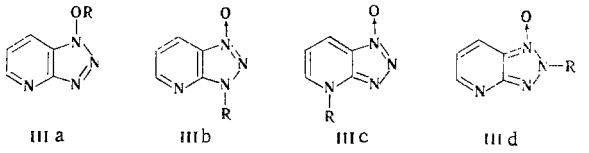


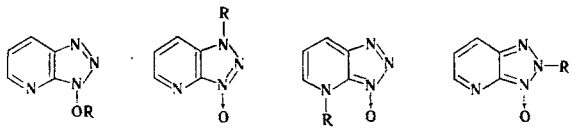
Fig. 2. Mass spectra: a) 3-methoxytriazolo[4,5-b]pyridine; b) 4-methyltriazolo[4,5-b]pyridine.

products (IIa and IIb). It seemed of interest to us to study the tautomerism of 1- and 3-hydroxytriazolo[4,5-b]-pyridines III and IV.



Tautomeric forms b, c, and d are possible for 1-hydroxytriazolo[4,5-b]pyridine (IIIa, R = H) and 3-hydroxytriazolo[4,5-b]pyridine (IVa, R = H):



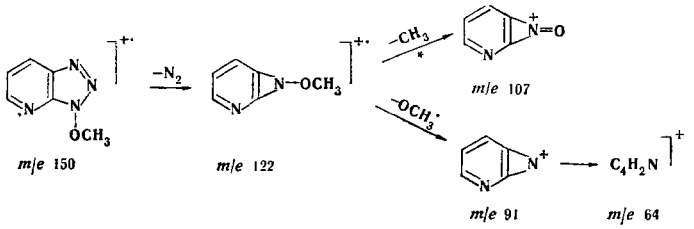


IV a IV b IV c IV d

R=H, CH_3

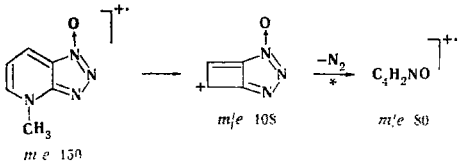
It was found that only one product is formed on the methylation of hydroxythiazoles III and IV under conditions similar to those used for benzotriazole. The structures of the methyl derivatives and starting III and IV could be ascertained by comparison of the UV spectra of these substances with the spectra of the corresponding benzo derivatives IIa and IIb and also by mass-spectral studies of both the methylation products and the starting 1- and 3-hydroxytriazolo[4,5-b]pyridines.

The character of the curves and the position of the absorption maxima in the UV spectra of the product of methylation of 3-hydroxytriazolo[4,5-b]pyridine coincide with the character and position of the absorption maxima in the spectra of O-methyl derivative IIa (Fig. 1). This makes it possible to assign to it the 3-methoxytriazolo[4,5-b]pyridine (IVa, R = CH_3) structure. The data from the mass-spectroscopic fragmentation of IVa (R = CH_3) (Fig. 2), the fragmentation of which can be represented by the following scheme, are also in agreement with this conclusion:



m/e 150 m/e 122 m/e 107 m/e 91 m/e 64

The UV spectrum of the product of methylation of 1-hydroxytriazolo[4,5-b]pyridine (IIIa, R = H) does not coincide with respect to the form of the curve and the position of the maxima with the spectra of the O- and N-methyl derivatives (IIa and IIb) of benzotriazole (Fig. 1b). In other words, it does not correspond to IIIa or IIIb (R = CH_3). We obtained the greatest amount of information regarding structure of this compound during a study of its mass spectrum, in which ions with masses of 150, 108, and 80 are observed (Fig. 2b). The formation of an ion with mass 108 corresponds to detachment of 42 mass units from the molecular ion and can be represented by the scheme



m/e 150 m/e 108 m/e 80

The fragmentation of the ion with mass 108 with ejection of a nitrogen molecule is confirmed by the presence in the spectrum of a metastable ion with m/e 59.5.

From these data it can be concluded that the methylation product has the IIIc (R = CH_3) structure, in which the methyl group is attached to the nitrogen atom of the pyridine portion of the molecule. If, however, it is assumed that the methyl group is in the triazole ring, it becomes impossible to explain detachment of a fragment with a mass of 42 units and subsequent splitting out of a nitrogen molecule.

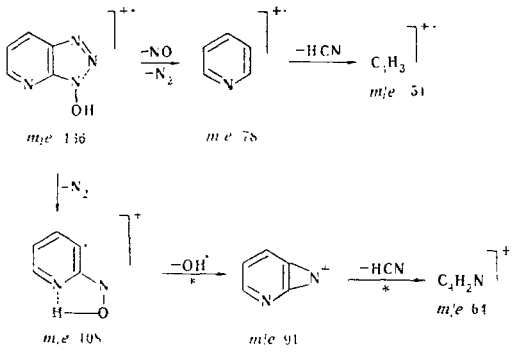
A judgment regarding the structures of the starting nonmethylated III and IV can be formed by comparing the UV spectra of these compounds with the spectra of the methylated products. It was found that in alcohol solutions the spectra of these and other compounds coincide both with respect to the position of the maxima and the overall form of the curve (Fig. 1). On the basis of this it can be concluded that III (R = H) exists in alcohol solution primarily in the form of N-oxide IIIc and that IV exists primarily in hydroxy form IVa (R = H).

We obtained interesting information regarding the properties of III and IV during a study of the electronic spectra of aqueous solutions of these compounds at various pH values. A maximum at 330 nm that is absent in the spectra of alcohol solutions is observed in the spectra of these compounds. When the pH of the solutions is increased, the intensity of this maximum increases, and the curves obtained at various pH values pass through an isopiestic point at 300 nm. From this it can be concluded that the appearance of a maximum at 330 nm is due

to the presence of the ionized form, and this indicates the acid character of 1- and 3-hydroxytriazolo[4,5-b]-pyridines. Their ionization constants are, respectively, 3.02 and 3.28, whereas the pK_a value of 1-hydroxybenzotriazole is 4.60.

The IR spectra of crystalline samples of III and IV (R = H) contain continuous absorption at 2200-2700 cm^{-1}, the intensity of which decreases after deuteration. This depressed absorption makes it possible to assume the presence in the crystalline state of III and IV (R = H) of a considerable contribution of a polar salt structure.

The mass-spectroscopic study of III and IV (R = H) indicates the existence of these compounds in the form of two possible tautomeric forms under the conditions of recording of the mass spectra. The principal peaks in the spectrum of IV (R = H) can be explained by a scheme corresponding to fragmentation of the hydroxy form:



In addition, an ion peak with a mass of 120 ($[M - O]^{+\cdot}$) is observed in the mass spectra of III and IV, and this constitutes evidence for the presence of the N-oxide form. The relative intensities of the peaks with m/e 108, 91, and 64 in the spectrum of III is considerably less than in the spectrum of IV. The concentration of the hydroxy form in III is probably appreciably lower than in the case of IV.

The mass spectrum of 1-hydroxybenzotriazole contains peaks with m/e 135, 107, 90, and 77, which correspond to similar fragmentation of the hydroxy form, and an ion peak with m/e 119, which indicates detachment of oxygen from the tautomeric form of the N-oxide.

EXPERIMENTAL

The electronic spectra were recorded with a Specord UV-vis spectrophotometer. The mass spectra were obtained with an MKh-1303 spectrometer equipped with a system for introduction of the samples directly into the ion source near the ionizing chamber at an ionizing voltage of 30-40 V and an ionization chamber temperature of 125°. The IR spectra were recorded with a UR-20 spectrometer.

1-Hydroxybenzotriazole and its methyl derivatives were obtained by the method in [2], and their physical characteristics were in complete agreement with the previously described compounds.

Triazolo[4,5-b]pyridine 1-Oxide IIIc (R = H). This compound was obtained by refluxing 2-hydrazino-3-nitropyridine [3] in 50% alcoholic hydrazine hydrate for 1 h, after which the alcohol was removed, and the residue was acidified to pH 3-4. The resulting precipitate was removed by filtration to give a product with mp 220-222° (from water) in 90% yield. Found: C 44.1; H 3.1; N 41.2%. $C_5H_4N_4O$. Calculated: C 44.2; H 2.9; N 41.2%.

3-Hydroxytriazolo[4,5-b]pyridine IVa (R = H). This compound, with 215-217° (from water), was similarly obtained in 70% yield from 2-hydrazino-3-nitropyridine [4]. Found: C 44.4; H 3.3; N 41.0%. $C_5H_4N_4O$. Calculated: C 44.2; H 2.9; N 41.2%.

4-Methyltriazolo[4,5-b]pyridine 1-Oxide IIIc ($R = CH_3$). This compound was obtained from IIIc (R = H) by the method used to methylate 1-hydroxybenzothiazole [2]. The reaction mixture was made alkaline to pH 8-9 and extracted with chloroform. The solvent was then evaporated to give IIIc, with mp 136-138° (from water), in 80% yield. Found: C 48.1; H 4.1; N 37.1%. $C_6H_6N_4O$. Calculated: C 48.0; H 4.0; N 37.3%.

3-Methoxytriazolo[4,5-b]pyridine IVa ($R = CH_3$). This compound, with mp 92-93° (from aqueous alcohol), was obtained in 80% yield from IVa (R = H) by the method used to prepare Ic. Found: C 48.0; H 4.3; N 37.5%. $C_6H_6N_4O$. Calculated: C 48.0; N 4.0; H 37.3%.

LITERATURE CITED

1. A. K. Macbeth and I. R. Price, J. Chem. Soc., 111 (1936).
2. O. L. Brady and C. V. Reynolds, J. Chem. Soc., 196 (1928).
3. A. Lewis and R. G. Schepherd, J. Heterocycl. Chem., 8, 41 (1971).
4. G. A. Mokrushina, Yu. A. Azev, and I. Ya. Postovskii, Khim. Geterotsikl. Soedin., No. 7, 1004 (1975).