MASS SPECTROMETRIC STUDY OF N-OXIDES OF QUINOLYSIDINE ALKALOIDS OF THE MATRINE SERIES

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The elimination of an oxygen atom from the molecular ion is the most characteristic of the decomposition of N-oxides of heteroaromatic compounds under the action of electron impact [1]. Only in the presence of an ortho-alkyl substituent with respect to the N-oxide group does decomposition associated with the elimination of a OH radical play a significant, and sometimes the basic role [2, 3]. As for N-oxides of heterocyclic compounds of a nonaromatic nature, they have been little studied. We might mention, for example, the studies [4-8], in which the appearance of rather substantial M-17 together with M-16 has frequently been noted.

In a continuation of a study of the behavior of quinolysidine alkaloids under the action of electron impact [9, 10], we undertook a mass spectrometric study of N-oxides of alkaloids of the matrine series, that is, N-oxides of matrine (I), allomatrine (II), sophoridine (III), * isosophoridine (IV), sophocarpine (V), and isosophoramine (VI), of which compounds (I) and (V) are natural, isolated from <u>Sophora flavescens</u> and <u>Sophora pachycarpa</u>, respectively [12, 13], while the rest were produced [14] by the oxidation of allomatrine (IIa), sophoridine (IIIa),* isosophoridine (VIa), and isosophoramine (VIa) with a 3% aqueous solution of H_2O_2 . The position of the N-oxide group was demonstrated [14] on the basis of the absence of the band at 2700-2800 cm⁻¹, typical of trans-quinolysidine systems



in the IR spectra of (I)-(III), (V), and (VI) with trans-joining of the A/B rings.

The mass spectra of N-oxides (I)-(VI), as a rule, contain low-intensity peaks of the ions M^+ (Figs. 1 and 2). The peaks of the ions $[M-16]^+$ and $[M-17]^+$ are substantially more intense than the molecular peaks, and sometimes even the basic peaks in the spectrum. Although there is no doubt of the appearance of the ion $[M-16]^+$, as formed as a result of the elimination of an oxygen atom from the M^+ ion, the ion $[M-17]^+$ can be formed in three ways: a) by elimination of a H atom from the ion $[M-16]^+$; b) by elimination

*The stereochemistry of unoxidized sophoridine (IIIa) has not been definitively established; it is known only that it belongs to the trans-A/B series [11].

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TABLE 1

N Oxides	I[M-17]+/I[M-16]+	Un- oxidized alkaloids	I[M-1]+/I[M]+
(I) (II) (III) (IV) (V) (V1)	5,0 2,8 1,1 4,7 5,1 2,6	(Ia) (IIa) (IIa) (IVa) (Va) (Va) (VIa)	$0,7 \\ 2,0 \\ 1,1 \\ 1,2 \\ 1,1 \\ 1,5 \\ 0$

of an O atom from the ion $[M-1]^+$; and c) by a one-step elimination of the N-oxide oxygen with one of the hydrogen atoms in the form of the OH radical. A comparison of the ratios of the intensities of the peaks $I_{[M-17]}^+/I_{[M-16]}^+$ in the mass spectra of N-oxides with the ratios $I_{[M-1]}^+/I_{[M]}^+$ in the spectra of the corresponding unoxidized alkaloids [10] shows (Table 1) that only for (II) and (IIa), as well as (III) and (IIIa), are these ratios close, while in the remaining cases the ratios $I_{[M-17]}^+/I_{[M-16]}^+$ are several times as great as $I_{[M-1]}^+/I_{[M]}^+$.

On the basis of this comparison it can be assumed that in the case of (I) and (IV)-(VI), the first pathway of formation of the $[M-17]^+$ ion plays an inconsequential role. At the same time, the mass spectra of the N-oxides (I)-(IV), (V), and (VI) contain peaks of the metastable ions $m^* = 231$, 229.1, and 227.3, respectively, confirming the one-step nature of the transition $M^+ \rightarrow [M-17]^+$. Thus, in the case of the N-oxides considered, at least part of the $[M-17]^+$ ions are formed directly from the molecular ion as a result of a one-step process. On the basis of the comparison of the intensity ratios of the peaks cited above, it can be assumed that the fraction of this process in the case of N-oxides of allomatrine (II) and sophoridine (III) is negligible; however, their mass spectra differ rather greatly from the spectra of the corresponding alkaloids (IIa) and (IIIa) [10], although according to the ratio $I_{[M-17]}^{+}/I_{[M-16]}^{+}$, and, correspondingly $I_{[M-1]}^{+}/I_{[M]}^{+}$, the are close (see Table 1).

Since no metastable peaks, which would indicate the appearance of some ion (in addition to $[M-17]^+$) from the molecular ion, could be detected in the spectra of the N-oxides (I)-(VI), in the case of (II) and (III) the ions $[M-16]^+$ and $[M-17]^+$ in the structural respect or from the standpoint of localization of charge are not identical with the ions M^+ and $[M-1]^+$, respectively, in the spectra of (IIa) and (IIIa). The question of the origin of the H atom, eliminated together with the N-oxide oxygen, cannot be solved without the use of a deutero-label. However, the introduction of a deutero-label into the molecules of N-oxides considered is a complex and frequently insoluble problem.

On the basis of a comparison of the mass spectra of the N-oxides (I) and (IV) (see Figs. 1 and 2) and the corresponding unoxidized alkaloids (Ia) and (VIa) [10], it can be assumed that the hydrogen atoms eliminated in OH groups in the case of N-oxides leave different positions from the H atoms eliminated from the molecular ions of unoxidized alkaloids. This is supported, for example, by the rather intense peaks M-19 (evidently, M-17-2) observed in the spectra of (I)-(VI) (see Fig. 1), while in the spectra of the alkaloids (Ia)-(IVa) the peaks M-3 (=[M-1-2]) are negligible [10]. Although in the case of the alkaloids the ion [M-1]⁺ is most likely formed on account of removal of a H atom from the 6-position (since, as was shown with the aid of deutero-analogs [15], the ion [M-1]⁺ in the case of quinolysidine itself is formed primarily as a result of removal of an angular hydrogen atom), for N-oxides in the case of elimination of a OH radical, probably the basic role will be played by the presence of the sterically close N \rightarrow O and H atoms, as in the case of dehydration of carbocyclic alcohols under electron impact [16].

The mass spectra of stereoisomeric N-oxides (I)-(VI) (see Fig. 1) differ rather substantially; however, the absence of any information on the nature of the H atoms eliminated in OH groups (formation of the ion $[M-17]^+$) does not permit a correlation to be drawn between the nature of the mass spectrum and the stereochemistry, since most of the ions in the spectra of (I)-(IV) are genetically related to the ion $[M-17]^+$. Actually, such characteristic ions as those with m/e 150 (m* 91.2), 148 (m* 89), and 136 (m* 74.8) are formed from the ion $[M-17]^+$ (m/e 247) in the case of (I)-(IV). A comparison of the mass spectra of the N-oxides shows their qualitative closeness, although they differ quantitatively. They differ primarily in the ratios of the intensities of the peaks M-16, M-17, M-18, and M-19. There are also differences in the ratios of the peaks of the ions with m/e 148 and 150. It is interesting to note that although the ion with m/e 150, possessing structure A, is also observed in the mass spectra of stereoisomers of matrine (Ia)-(IVa) [10], the ion with m/e 148, the peak of which exceeds the peak of the ion





with m/e 150 in the spectra of (I)-(IV) (see Fig. 1), is negligible in the case of the alkaloids (Ia)-(IVa). It can be assumed that the ion with m/e 148 has the structure B



The peak of the ion m/e 177, which has the structure C [10], is common to the mass spectra of the N-oxides (I)-(IV) and the unoxidized alkaloids (Ia)-(IVa). However, together with it, the peak of an ion with m/e 176 appears in the spectra of the N-oxide; in the case of (I) it is practically unaccompanied by



Fig. 2. Mass spectra of N-oxides: a) sophocarpine; b) isosophoramine.

the peak of the ion with m/e 177. In the spectrum of the N-oxide of allomatrine (II), the peak of the ion with m/e 176 has low intensity. The observed differences in the intensities of the peaks of the ions with m/e 177 and 176 indicate their different origin. Actually, the presence of the peak of the metastable ion $m^* 125.8$ in the spectrum of (II) indicates the appearance of an ion with m/e 177 directly from the ion $[M-16]^+$ (m/e 248), while in the spectrum of the N-oxide of matrine (I) there is a peak $m^* 125.3$, indicating a one-step transition $[M-17]^+ \rightarrow m/e 176$. It can be assumed that the ion with m/e 176 has the structure D



In the case of N-oxides of sophocarpine (V) and isosophoramine (VI), the basic pathways of decomposition are also associated with the ion $[M-17]^+$. Thus, ions with m/e 216 (m* 190.4), 202 (m* 166.8), 150 (m* 92), and 136 (m* 75.5) are formed from this ion (m/e 245) in the decomposition of (V), while in the case of (VI) intense ions with m/e 215 (m* 190) and 148 (m* 90) are formed from the ion $[M-17]^+$ (m/e 243). Thus, from the aforementioned it follows that the decomposition of the N-oxides (I)-(VI) under the action of electron impact is analogous to the fragmentation of the unoxidized alkaloids (Ia)-(VIa). The only difference lies in the fact that in the case of N-oxides, together with the peaks characteristic of the alkaloids, peaks appear that are one or two atomic mass units smaller, the intensity of which depends on the relative intensity of the peaks M-16, M-17, and, possibly M-18 and M-19.

EXPERIMENTAL METHOD

The mass spectra were obtained with an MX-1309 instrument, equipped with an industrial system of direct introduction of the sample into the ion source, at a temperature of evaporation $60-70^{\circ}$ and energy of ionization 70 eV.

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CONCLUSIONS

1. The mass spectra of N-oxides of matrine, allomatrine, sophoridine, isosophoridine, sophocarpine, and isosophoramine were studied.

2. The ions $[M-17]^+$ are formed, at least partially, from molecular ions in one step by elimination of the OH radical.

3. With the aid of the peaks of the metastable ions and a comparison with the mass spectra of unoxidized alkaloids, the origin of individual ions in the spectra of the N-oxides studied was determined.

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