PYRAZINES AND THEIR N-OXIDES

III.* SYNTHESIS AND PROPERTIES OF N-OXIDES OF 2- AND 2,3-SUBSTITUTED PYRAZINES

A. S. Elina, I. S. Musatova, and G. P. Syrova

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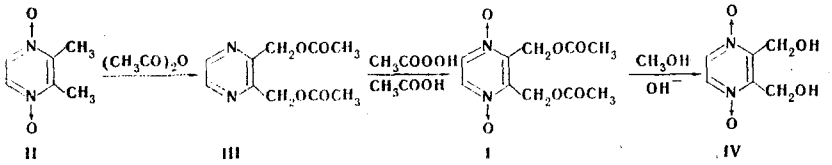
The N-oxides of 2- and 2,3-substituted pyrazines were synthesized. It was found that the synthesized 2-formylpyrazine N,N'-dioxide, in which the aldehyde group is in the hydrated form, undergoes redox transformations leading to deoxidation of one of the ring nitrogens and oxidation of the dihydroxymethyl group to a carboxyl group under the influence of alkaline reagents.

In developing our research to find biologically active substances among N-oxides of aromatic nitrogen-containing heterocycles, we contemplated the synthesis of N-oxides of several 2- and 2,3-substituted pyrazines. Thus we undertook the synthesis of the N,N'-dioxides of 2,3-di(acetoxymethyl)- and 2,3-di(hydroxymethyl)pyrazines. These compounds are analogs of the corresponding quinoxaline derivatives, which display high antibacterial activity with a broad spectrum of action [1,2].

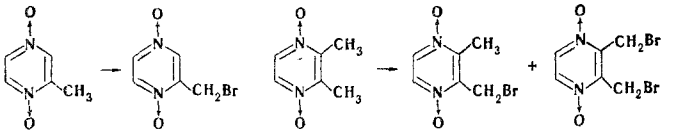
The synthesis of 2,3-di(acetoxymethyl)pyrazine 1,4-dioxide (I) was accomplished from 2,3-dimethylpyrazine N,N'-dioxide (II). Like the analogous quinoxaline derivative [3], II on heating with acetic anhydride underwent deoxidation of the ring nitrogen atoms accompanied by acetoxylation of both methyl groups to give 2,3-di(acetoxymethyl)pyrazine (III), which was then oxidized with peracetic acid solution to I.



II III I IV

The acetyl groups were removed by transesterification of I with lower alcohols in the presence of catalytic amounts of alkali.

In order to find routes to the synthesis of the starting materials for the preparation of the N,N'-dioxides of mercaptomethyl, aminomethyl, and other pyrazine derivatives, we investigated the bromination of the N,N'-dioxides of 2-methyl- and 2,3-dimethylpyrazines. We demonstrated the fundamental possibility of bromination of the methyl groups of these compounds, but the yields of bromination products were low, and the products could be separated only by column chromatography: 2-bromomethylpyrazine N,N'-dioxide (VI)



V VI II VII VIII

*See [10] for communication II.

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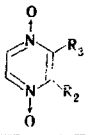
TABLE 1. PMR Spectra of N,N'-Dioxides of 2-Methylpyrazine (V) and N,N'-Dioxides of Bromo Derivatives of 2-Methyl- and 2,3-Dimethylpyrazines (VI-VIII)*

V $R_2=CH_3$, $R_3=H$;
VI $R_2=CH_2Br$, $R_3=H$;



VII $R_2=CH_2Br$, $R_3=CH_3$;
VIII $R_2=R_3=CH_2Br$

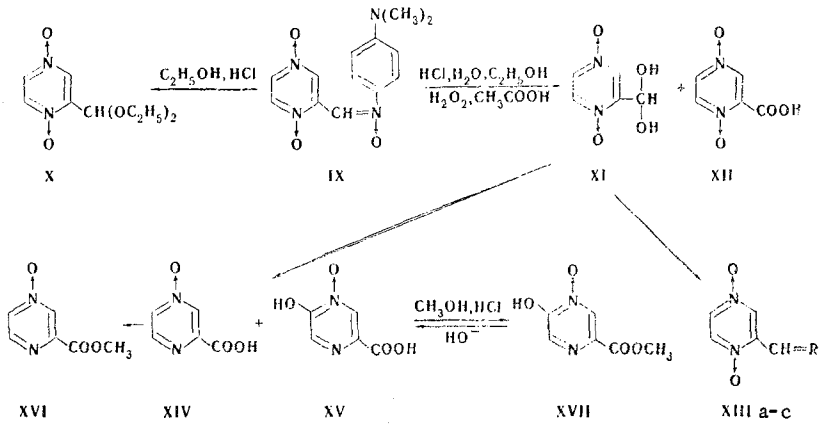
Comp.	R_2, ppm	R_3, ppm	H_5, ppm	H_6, ppm	J_{35}, Hz	J_{56}, Hz	J_{63}, Hz
V	2,40; s†	8,46; q	8,25; q	8,38; d	2,2	5,6	0,8
VI	4,66; s	8,75,;q	8,42; q	8,50; d	2,5	5,5	0,5
VII‡	4,82; s	2,62; s	8,43	8,43	—	—	—
VIII**	4,81; s	4,81; s	8,41	8,41	—	—	—

*All of the spectra were recorded in D_2O with an internal standard (dioxane) (the spectrum of VIII was recorded in dimethyl sulfoxide).
† Abbreviations: s is singlet, q is quartet, and d is doublet.
‡ Because of the nonequivalence of the H_5 and H_6 protons, their signals appear as an intense line with two low-intensity satellites at a distance of 6 Hz.
**The H_5 and H_6 protons of VIII are equivalent and appear with the same δ value.

was obtained in 28-29% of the theoretical yield from 2-methylpyrazine N,N'-dioxide (V), while 2-bromomethyl-3-methylpyrazine N,N'-dioxide (VII) (30.5%) and 2,3-di(bromomethyl)pyrazine N,N'-dioxide (VIII) (29.6%) were isolated from II in the same reaction. The PMR spectra of V-VIII are presented in Table 1.

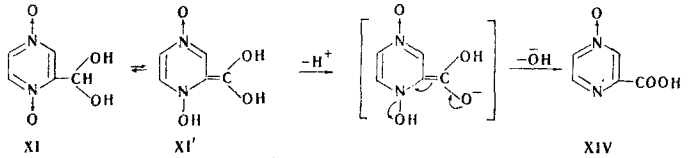
In connection with the high in vitro antitubercular activity of N,N'-dioxides of unsubstituted and N-substituted amides of quinoxaline-2-carboxylic acid [4], it seemed of interest to synthesize the corresponding derivatives in the pyrazine series and study their biological activity. Possible routes to the synthesis of the N-oxides of 2-formylpyrazine or pyrazine-2-carboxylic acids starting from the N,N'-dioxide of 2-methylpyrazine (V) or the nitrone (IX) were investigated. The methyl group in V displayed considerably greater resistance to oxidation by selenium dioxide than in the corresponding quinoxaline derivative [5], and this method did not enable us to obtain pyrazine N,N'-dioxides with an aldehyde or carboxyl group as substituents. Decomposition of nitrone IX in anhydrous alcohol saturated with HCl gave 2-formylpyrazine diethylacetal N,N'-dioxide (X); the formation of a complex mixture of substances was observed on attempts to hydrolyze X. It was found that the hydrolysis of nitrone IX in dilute acid was accompanied by considerable resinification of the reaction mass. It was found to be more convenient to carry out the hydrolysis in aqueous alcohol containing HCl with subsequent oxidation of the resulting product with hydrogen peroxide. Quinoxaline-2-carboxylic acid N,N'-dioxide was formed when a similar reaction was carried out with the corresponding nitrone of the quinoxaline series; pyrazine-2-carboxylic acid 1,4-dioxide (XII) was obtained only in low yield (12.6%) from nitrone IX. The major reaction product was XI, which changed appreciably on heating in solvents and could therefore not be purified for analysis. Since the compound obtained reacted readily with dinitrophenylhydrazine, semicarbazide, or hydroxylamine and was characterized by the corresponding derivatives (XIIIa, XIIIb, and XIIIc), we were able to assign the 2-formylpyrazine 1,4-dioxide structure to it. However, the aldehyde existed in hydrated form XI, which was confirmed by its IR spectrum, in which the absorption band of an aldehyde carbonyl group was absent, and strong splitting of the band of the stretching vibrations of an associated hydroxyl group at 3120-3180 cm^{-1} was displayed. (See scheme on following page.)

Further investigations revealed a number of peculiarities in the chemical properties of XI associated with its structure. It was found that XI forms pyrazine-2-carboxylic acid 4-oxide (XIV) admixed with 5-hydroxypyrazine-2-carboxylic acid 4-oxide (XV) in aqueous NaOH or $NaHCO_3$ solutions. A mixture of the same substances containing more of hydroxy acid XV was obtained in an attempt to oxidize XI with hydrogen peroxide in alkaline media. The structure of XV was proved by chemical transformations and the IR and PMR spectra. The presence of a hydroxyl group was confirmed by the acidic properties of the ester (XVII) and by the IR spectrum of this compound, in which strong bands of amide (1690 cm^{-1}) and ester (1738 cm^{-1}) carbonyl groups were displayed. Two singlets of protons of the pyrazine ring at 8.01 and 8.56 ppm

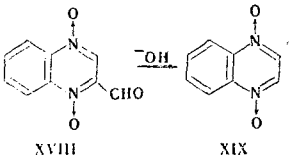


XIII a R = $NNHC_6H_3(NO_2)_2$, b R = $NNHCONH_2$, c R = NOH

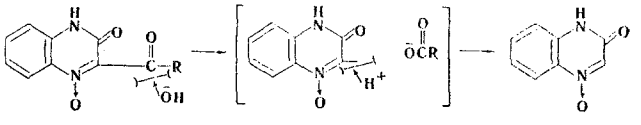
(CD_3OD) were observed in the PMR spectrum of XVII, which was evidence in favor of location of the hydroxy group in the 5 position. Thus 2-formylpyrazine N,N'-dioxide (XI) in the hydrated form underwent a redox reaction in the presence of alkaline reagents. It may be assumed that these reactions, like the related transformations of the N-oxides of hydroxymethyl derivatives of quinoxaline that we described in [6], are associated with the possibility of the existence of tautomerism of the XI ⇌ XI' type and with a shift in the tautomeric equilibrium under the reaction conditions to favor the XI' form. The splitting out of a proton in XI', which is accompanied by redistribution of the electron density, should have led to conversion of the dihydroxymethyl group to a carboxyl group with simultaneous elimination of a hydroxyl ion.



Within the framework of the assumption stated above, it seemed interesting that 2-formylquinoxaline N,N'-dioxide (XVIII), which does not develop a hydrated form, reacted differently in alkaline media: under these conditions, it was converted in high yield to the N,N'-dioxide of unsubstituted quinoxaline (XIX).



Others have previously described a similar transformation of the N-oxides of carbonyl derivatives of quinoxaline of the XX type and have stated the assumption that such reactions occur because of nucleophilic attack of the carbonyl group carbon by hydroxide ions [7, 8].



EXPERIMENTAL

2,3-Dimethylpyrazine 1,4-Dioxide (II). A 0.37-g sample of anhydrous sodium acetate, 0.01 g of $Na_4P_2O_7$, and 0.69 g (6.4 mmole) of 2,3-dimethylpyrazine were added to 29 ml of a 6.8% solution of peracetic acid (27 mmole of CH_3COOOH, and the mixture was heated at 40° for 1 h, at 65° for 5.5 h, and vacuum-evaporated at 40° to one fourth of its original volume. The residue was cooled and neutralized with 40% NaOH solution and extracted with $CHCl_3$. The extract was dried with anhydrous Na_2SO_4, the solvent was removed in vacuo, and the residue was treated with ether, after which 0.83 g (93%) of II with mp 212-214° (from anhydrous alcohol) was removed by filtration. Found: C 51.53; H 5.7; N 19.97%. $C_6H_8N_2O_2$. Calculated: C 51.42; H 5.76; N 20.01%.

2,3-Di(acetoxymethyl)pyrazine (III). A solution of 2.6 g (18 mmole) of II in 13.5 ml of glacial acetic acid was added with stirring in the course of 20 min to 9.6 ml of acetic anhydride previously heated to 110°. The reaction mixture was refluxed and vacuum-evaporated, and the residue was distilled to give 2.4 g (58%) of III with bp 143-145° (3 mm) and mp 72-74° (from anhydrous alcohol). Found: C 53.45; H 5.17; N 12.48%. $C_{10}H_{12}N_2O_4$. Calculated: C 53.56; H 5.40; N 12.50%. IR spectrum: $\nu_{C=O}$ 1741 cm^{-1}.

2,3-Di(acetoxymethyl)pyrazine 1,4-Dioxide (I). A 0.25-g sample of anhydrous sodium acetate, 0.01 g of $Na_4P_2O_7$, and 1.25 g (5.6 mmole) of III were added successively to 16.5 ml of a 10.3% solution of peracetic acid (23 mmole of CH_3COOOH), and the reaction solution was heated at 62-65° for 10.5 h. It was then evaporated to one fourth of its original volume, neutralized with aqueous $NaHCO_3$ solution, and extracted with $CHCl_3$. The extracts were dried, the solvent was removed in vacuo, and the dry residue was treated several times with petroleum ether (with heating) and crystallized from anhydrous alcohol to give 0.46 g (32.4%) of I with mp 160-162°. Found: C 47.14; H 4.62; N 10.93%. $C_{10}H_{12}N_2O_6$. Calculated: C 46.89; H 4.72; N 10.96%. IR spectrum: $\nu_{C=O}$ 1720-1730 cm^{-1}.

2,3-Di(hydroxymethyl)pyrazine 1,4-Dioxide (IV). A total of 0.63 ml of an 8% methanol solution of NaOH (1.2 mmole of NaOH) was added to a suspension of 1.04 g (4 mmole) of I in 9 ml of methanol. The reaction mixture was stirred at 22-25° for 2 h and cooled to give 0.34 g (48.7%) of IV with mp 123-124° (from methanol). Found: C 42.16; H 4.82; N 16.56%. $C_6H_8N_2O_4$. Calculated: C 41.87; H 4.68; N 16.29%. The IR spectrum contains a broad absorption band at 3200-3300 cm^{-1}, which can be assigned to the stretching vibrations of an associated hydroxyl group.

Bromination of 2-Methylpyrazine 1,4-Dioxide (V). An 8.1-ml (0.16 mole) sample of bromine was added with stirring to 91.2 ml of dry dioxane, and 10 g (0.08 mole) of V and 0.15 g of benzoyl peroxide were added to the resulting suspension of dioxane dibromide in dioxane. The mixture was stirred at 80-85° for 9.5 h, the dioxane was removed by vacuum distillation, and the residue was treated with $NaHCO_3$ solution to pH 7 and extracted with $CHCl_3$. The mixture of substances obtained after removal of the chloroform was suspended in methanol–chloroform and introduced into a column filled with 450 g of silica gel. Chloroform eluted an oily substance that did not contain nitrogen (1.28 g) and had bp 82-85° (16 mm). Ethyl acetate eluted 4.6 g (28.3%) of 2-bromomethylpyrazine 1,4-dioxide (VI) with mp 165.5-166° (dec., from aqueous methanol). Found: C 28.93; H 2.70; N 13.97%. $C_5H_5BrN_2O_2$. Calculated: C 29.27; H 2.46; N 13.67%. Successive elution with ethyl acetate–methanol and methanol gave a mixture of substances (4.2 g) in which starting V and bromo derivative VI were detected by chromatography.

Bromination of 2,3-Dimethylpyrazine 1,4-Dioxide (II). A 2.93-ml (0.06 mole) sample of bromine and 2 g (0.0145 mole) of II were added successively to 29.8 ml of dry dioxane, and the bromination was carried out as in the bromination of V. The mixture of substances obtained after removal of the chloroform was suspended in chloroform–methanol and applied to a column filled with 200 g of silica gel. Petroleum ether eluted 8.9 g of an oily substance that did not contain nitrogen and had bp 52° (4 mm). The fractions eluted by chloroform yielded 1.26 g (29.6%) of 2,3-di(bromomethyl)pyrazine 1,4-dioxide (VIII) with mp 170-171° (from aqueous alcohol). Found: C 24.56; H 2.00; Br 53.18; N 9.46%. $C_6H_6N_2O_2Br_2$. Calculated: C 24.17; H 2.03; Br 53.62; N 9.40%. Chloroform–ethyl acetate (9:1) eluted 0.95 g (30.5%) of 2-bromomethyl-3-methylpyrazine 1,4-dioxide (VII) with mp 140-141° (from methanol). Found: C 33.2; H 3.30; Br 36.25; N 12.71%. $C_6H_7BrN_2O_2$. Calculated: C 32.90; H 3.22; Br 36.48; N 12.79%. Successive elution with ethyl acetate–methanol and methanol gave a mixture of substances consisting of starting II, mono- and dibromo derivatives VII and VIII, and side products. When II was brominated under the same conditions with a smaller amount of bromine (about 1.5 mole of Br_2 per mole of II), the yield of dibromo derivative VIII was 15.3% of the theoretical, while that of the monobromo derivative (VII) was 28.2%.

2-Formylpyrazine Hydrate 1,4-Dioxide (XI) and Pyrazine-2-carboxylic Acid 1,4-Dioxide (XII) from N-(p-Dimethylaminophenyl)-α-(1,4-dioxido-2-pyrazyl)nitrone (IX). A 5-g (18 mmole) sample of nitrone IX was placed in a mixture of 25 ml of 13.5% alcoholic HCl, 13 ml of ethanol, and 12 ml of water, and the mixture was allowed to stand at 20-25° for 20 h. It was then heated at 45-50° for 30 min and cooled. The precipitate, which according to the results of elementary analysis corresponds to p-hydroxylaminodimethylaniline, was removed by filtration to give 1.6 g (47%) of a product with mp 177-178° (dec., rapid melting) and 268-270° (slow melting). Found: N 14.80; Cl 18.78%. $C_8H_2N_2O \cdot HCl$. Calculated: N 14.87; Cl 18.81%. The reaction solution remaining after the removal of the precipitate was vacuum-evaporated. A total of 15 ml of 30% hydrogen peroxide was added gradually to the cooled (to 0 to −2°) dark resinous residue, and the mixture was allowed to stand for 2.5 h after the temperature had risen to 20-22°. The resulting light precipitate was removed by filtration and treated rapidly with cooling with 8% $NaHCO_3$ solution. The insoluble

portion was separated and washed successively with water, acetone, and ether to give 1.45 g (50.4%) of XI with mp 110-112° (violent decomposition accompanied by sparking). The IR spectrum displayed strong splitting of the band of associated hydroxyl groups at 3150 cm^{-1}. Bands of stretching vibrations of the C=O group were absent at 1650-1750 cm^{-1}.

2-Formylpyrazine Semicarbazone 1,4-Dioxide (XIIIb). This compound had mp 272-273° (dec., from 50% acetic acid). Found: C 35.97; H 3.64; N 35.49%. $C_6H_7N_5O_3$. Calculated: C 36.55; H 3.58; N 35.51%.

2-Formylpyrazine Oxime 1,4-Dioxide (XIIIc). This compound had mp 208-209° (dec., from aqueous alcohol). Found: C 38.66; H 3.60; N 27.07%. $C_5H_5N_3O_3$. Calculated: C 38.73; H 3.25; N 27.00%. PMR spectrum (in DMSO): q, 3H, δ = 8.41 ppm; q, 5H, δ = 8.26 ppm; q 6H, δ = 8.36 ppm (J_{56} ~ 6.0 Hz, J_{35} ~ 2.5 Hz, J_{36} ~ 1 Hz); oxime proton, δ = 8.23 ppm.

2-Formylpyrazine Dinitrophenylhydrazone 1,4-Dioxide (XIIIa). This compound had mp 280-281° (dec.). (The compound was not analyzed because it is practically insoluble in the usual organic solvents).

2-Formylpyrazine Diethylacetal 1,4-Dioxide (X). A 1.84-g (67 mmole) sample of nitrone IX in 18 ml of 13.5% HCl solution (67 mmole of HCl) in anhydrous alcohol was allowed to stand at 20-25° for 40 h. The precipitate was then removed by filtration, ether was added to the filtrate, and the mixture was filtered again and vacuum-evaporated. A solution of $NaHCO_3$ was added to the oily residue to pH 7, and the mixture was extracted with $CHCl_3$. The chloroform was removed to give 1.1 g (77%) of X with mp 94-94.5° (from ether–methanol). Found: C 50.62; H 6.39; N 13.08%. $C_9H_{14}N_2O_4$. Calculated: C 50.47; H 6.59; N 13.08%. PMR spectrum (in $CDCl_3$): CH_3 protons t, δ = 1.26 ppm; q, CH_2, δ = 3.78 ppm; s, CH, δ = 5.82 ppm; q, 3H, δ = 8.36 ppm; q, 5H, δ = 7.96 ppm; q, 6H, δ = 2.05 ppm (J_{56} ~ 5.5 Hz, J_{35} ~ 2.5 Hz, J_{36} ~ 1.4 Hz). The bicarbonate solution after separation of XI was acidified with 2.5 N hydrochloric acid to pH 2 to give 0.35 g (12.6%) of pyrazine-2-carboxylic acid N,N'-dioxide (XII) with mp 268° (dec., rapid melting). Found: C 38.07; H 2.75; N 17.77%. $C_5H_4N_2O_2$. Calculated: C 38.50; H 2.57; N 17.97%. IR spectrum: $\nu_{OH(ass)}$ 3085 cm^{-1}, $\nu_{C=O}$ 1720 cm^{-1}. PMR spectrum (in D_2O): q, 3H, δ = 8.46 ppm; q, 5H, δ = 8.27 ppm; and q, 6H, δ = 8.31 ppm (J_{56} ~ 6 Hz, J_{35} ~ 2 Hz, J_{36} ~ 0.8 Hz).

Redox Reactions of 2-Formylpyrazine Hydrate 1,4-Dioxide (XI). A. A 7-ml sample of a $NaHCO_3$ solution was added gradually to 1 g (6.3 mmole) of XI in the course of 4 h until the addition of a fresh portion of $NaHCO_3$ did not raise the temperature, and CO_2 evolution was no longer observed. The reaction temperature was no higher than 37°. The reaction mixture was vacuum-evaporated to dryness at 30-35°, 2.5 N hydrochloric acid solution was added to pH 1, and the mixture was cooled. The precipitate was removed by filtration and dried. The dry precipitate was placed in 30 ml of anhydrous methanol, HCl was bubbled through the solution (for 2 h), and the mixture was allowed to stand at 20-25° for 18 h. The reaction mixture was filtered, and the filtrate was evaporated to dryness. A $NaHCO_3$ solution was added to the residue to pH 7, and the mixture was extracted with chloroform to give 0.48 g (49.1%) of 2-carbomethoxypyrazine 4-oxide (XVI) with mp 172-173°. The compound was identical to the compound synthesized in [9] (mixed-melting point and R_f*). The bicarbonate solution remaining after separation of ester XVI was acidified to pH 1-2 and extracted with $CHCl_3$. Removal of the solvent gave 0.21 g (19.6%) of 2-carbomethoxy-5-hydroxypyrazine 4-oxide (XVII) with mp 173.5-174° (from methanol) and R_f 0.16. The product gave a wine-red color reaction with $FeCl_3$ and liberated CO_2 from $NaHCO_3$ solution. Found: C 42.30; H 3.41; N 16.5%. $C_6H_6N_2O_4$. Calculated: C 42.36; H 3.56; N 16.47%. IR spectrum: 3070 cm^{-1} (w), 2650 cm^{-1} (br), 1737 cm^{-1} (ester $\nu_{C=O}$), 1690 cm^{-1} (amide $\nu_{C=O}$). PMR spectrum (in $CDCl_3$): two singlets in the region of pyrazine ring protons (3H, 6H), δ = 8.26 and 8.55 ppm; signal of protons of a CH_3 group at δ = 3.92 ppm. In CD_3OD, δ = 8.06 and 8.60 ppm (for 3H and 6H).

B. A 0.5-g (3 mmole) sample of XI was treated with 1.7 ml of 2.5 N NaOH via the method described in experiment A. Anhydrous ethanol (6 ml) was then added, the precipitate was separated and dissolved in a small amount of water, and the pH of the solution was brought to 1-2. The mixture of acids XIV and XV (0.15 g) was esterified by the method described in experiment A to give 0.13 g of 2-carbomethoxypyrazine 4-oxide (XVI). 2-Carbomethoxy-5-hydroxypyrazine 4-oxide (XVII) was formed in low yield and was detected in the mixture of esters only by chromatography.

C. A 37-ml sample of 30% H_2O_2 was added to 3 g (19 mmole) of XI, and 11 ml of 2.5 N NaOH was added with stirring in the course of 2-3 h at no higher than 30°. The mixture was held at 20-25° for 20 min and filtered. Methanol was added to the filtered solution until it no longer became turbid, and the mixture

*The chromatography was performed on paper with n-butyl alcohol–5% acetic acid.

was cooled. The precipitate was separated and treated with 2.5 N hydrochloric acid to pH 1 to give 0.77 g of a mixture of acids XIV and XV. The aqueous methanol solution remaining after separation of the bulk of the precipitate was vacuum-evaporated at 25-30°. The residue was dissolved in water, the solution was acidified to pH 1, and the pyrazine-2-carboxylic acid N-oxide (XIV) [0.8 g (30%)] was removed by filtration. This compound was identical with respect to melting point and R_f value to pyrazine-2-carboxylic acid 4-oxide synthesized by a known method [9].

After esterification, the mixture of acids (0.77 g) yielded 0.4 g (12.4%) of 2-carbomethoxy-5-hydroxypyrazine 4-oxide, which was identical to XVII described in experiment A. Compound XVI was detected only by chromatography.

5-Hydroxypyrazine-2-carboxylic Acid 4-Oxide (XV). This compound was prepared by saponification of the methyl ester of this acid (XVII) (1.18 g) in 4.4 ml of 2.5 N NaOH at 20-25° for 20 min. The yield of XV with mp 234-235° (dec., from water) was 0.58 g (53.7%); it gave a wine-red color reaction with $FeCl_3$. Found: C 38.42; H 2.77; N 17.50%. $C_5H_4N_2O_4$. Calculated: C 38.53; H 2.58; N 17.05%. IR spectrum: 3160 cm^{-1} (br), 2400-2650 cm^{-1} (br), 1715 cm^{-1} (carboxyl $\nu_{C=O}$), 1670 cm^{-1} (amide $\nu_{C=O}$). PMR spectrum in CD_3OD: two singlets in the region of pyrazine ring protons (3H, 6H), δ = 8.12 and 8.63 ppm.

LITERATURE CITED

1. E. N. Padeiskaya, G. N. Pershin, and K. A. Belozerova, Farmakol. i Toksikol., 702 (1966).
2. E. N. Padeiskaya (Padeiskaja), G. N. Pershin, T. A. Guskova, and T. P. Radkevich (Radkevitch), Abstracts of Papers Presented at the 6th International Congress of Chemotherapy, Aug. 10-15, Tokyo (1969), ctr. A1-26.
3. A. S. Elina, Zh. Obshch. Khim., 31, 1018 (1961).
4. A. S. Elina, T. N. Zykova, O. Yu. Magidson, G. N. Pershin, L. G. Tsyrul'nikova, and V. I. Fatneva, USSR Author's Certificate No. 235,767 (1967); Byull. Izobr., No. 2, 204 (1970).
5. A. S. Elina and O. Yu. Magidson, Zh. Obshch. Khim., 25, 161 (1955).
6. A. S. Elina, L. G. Tsyrul'nikova, and G. P. Syrova, Khim. Geterotsikl. Soedin., 149 (1969).
7. C. Tennant, J. Chem. Soc., 2428 (1963).
8. Y. Ahmad and M. S. Habib, Ziauddin, Tetrahedron, 20, 1107 (1964).
9. H. Foks and J. Sawlewicz, Acta Polon. Pharmac., 21, 429 (1966); Ref. Zh. Khim., 4Zh338 (1966).
10. A. S. Elina, I. S. Musatova, and G. P. Syrova, Khim. Geterotsikl. Soedin., 725 (1968).