REACTION OF DIBENZOYLFUROXANE WITH PRIMARY ALIPHATIC AMINES AND METHYLHYDRAZINE

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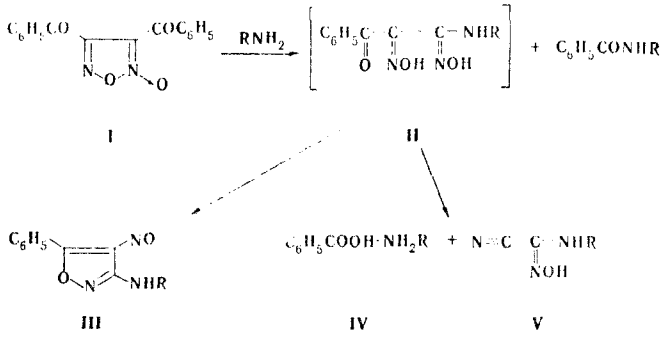
Mixtures of products of the reaction of dibenzoylfuroxane with isopropylamine, tert-butylamine, and methylhydrazine were separated by high-pressure liquid chromatography. According to the proposed reaction scheme, benzamidoglyoxime is formed in the first step, after which it undergoes cyclization to give an N-substituted 3-amino-4-nitroso-5-phenylisoxazole or decomposes via the mechanism of a Beckmann rearrangement of the second type.

The reaction of diacylfuroxanes with ammonia, aniline, and phenylhydrazine does not lead to the formation of the corresponding imines or hydrazones but is accompanied by opening of the furoxane ring and subsequent cyclization to give various heterocyclic compounds [1]. It has been recently shown that the structures of many previously described products of the reaction with aniline and phenylhydrazine were not correctly established [2]. At the same time, no study at all has been devoted to the reaction of diacylfuroxanes with aliphatic amines and hydrazines.

We have established that the reactions of 3,4-dibenzoylfuroxane (I) with amines proceed exothermically at room temperature and lead to the formation of complex mixtures of products. Separation of the reaction mixtures was possible only by means of preparative high-pressure liquid chromatography. The corresponding benzamide was detected in the reaction mixture in all cases. As in the case of aniline [2], the reaction of furoxane I with aliphatic amines evidently proceeds through the formation of intermediate benzamidoglyoxime II. However, we were unable to isolate dioxime II from the reaction mixture. A dioxime having an amphi configuration, which is known to be unstable [3], is probably formed as a result of this reaction. In the separation of the mixture obtained by reaction of furoxane I with isopropylamine, we isolated a bright-green substance with empirical formula $C_{12}H_{13}N_3O_2$. A band at 3420 cm^{-1}, which is characteristic for a secondary amino group, is observed in the IR spectrum of this compound, and bands at 1620-1800 cm^{-1}, which could have been assigned to vibrations of the C=O group, are absent. An absorption maximum at 760 nm, which is responsible for the green color and attests to the presence of a nitroso group, is observed in its electronic spectrum. These data made it possible to identify the compound as 3-isopropylamino-4-nitroso-5-phenylisoxazole (IIIa). Isoxazole IIIb was similarly obtained in the reaction of furoxane I with tert-butylamine. However, in this case, in addition to isoxazole IIIb and benzoic acid tert-butylamide, two compounds with empirical formulas $C_{11}H_{17}NO_2$ (IV) and



III a R = *i*-C_3H_7; III b, IV, V R = *t*-C_4H_9

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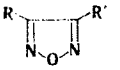
TABLE 1. ^{13}C NMR Spectra (δ, ppm) of Disubstituted Furazans



R	R′	$C_{(3)}$	$C_{(4)}$
NH_2	NH_2	150,9	150,9
CH_3	CH_3	152,2[4]	152,2[4]
NH_2	PhCO	157,6	144,0

$C_6H_{11}N_3O$ (V) were isolated from the reaction mixture. The first compound (IV) was identified as a salt of benzoic acid and tert-butylamine. The IR spectrum of C contains a band at 2248 cm^{-1} (C≡N), a broad band at 3100-3450 cm^{-1}, and bands at 1635 and 980 cm^{-1}, which we assigned to the oxime group. Four signals – 30.4 (quartet in the case of monoresonance, CH_3), 51.8 (C-N), 112.2 (C≡N), and 132.0 ppm (C=NOH) – are observed in the ^{13}C NMR spectrum of V. An analysis of the spectra enabled us to identify V as N-tert-butylcyanoformamidoxime. It is apparent that IV and V are formed in the decomposition of amidoxime II via the mechanism of a Beckmann rearrangement of the second type.

In the reaction of furoxane I with methylhydrazine we obtained a compound with empirical formula $C_{10}H_{10}N_4O_2$, for which we assumed the 3-methylhydrazino-4-benzoylfurazan structure (VI). The IR spectrum of VI contains bands at 3428 and 3334 (NH_2) and 1632 cm^{-1} (C=O). To confirm this structure we made a comparison of the spectral characteristics of VI with the characteristics of model compound 3-amino-4-benzoylfurazan (VII), obtained by reaction of furoxane I with ammonia. The IR spectrum of furazan VII contains bands at 3454, 3336, 3245, 3190 (NH_2), and 1665 cm^{-1} (C=O). The signals of the carbon atoms of the carbonyl group are observed at 184.7 and 186.1 ppm, respectively, in the ^{13}C NMR spectra of VI and VII. However, a comparison of the chemical shifts of the carbon atoms of the heteroring (Table 1) in VI at 113.7 and 150.4 ppm with the shifts of the carbon atoms of the furazan ring in VII and in some other furazans shows that whereas the signal at 150.4 ppm can be assigned to the carbon atom of the furazan ring that is linked with the hydrazino group, the signal at 113.7 ppm is found in a region that is not characteristic for the carbon atoms of the furazan ring. Thus the structure of VI cannot be considered to be definitely established.

When the reaction of furoxane I with amines was carried out in ethanol, ethyl benzoate was isolated in all cases, in addition to the products enumerated above. In the chromatographic separation of the mixtures the ester was eluted before all of the remaining compounds. When the reaction is carried out in alcohol, furoxane I, which is unstable with respect to the action of nucleophilic reagents, is attacked by a molecule of ethanol. This is confirmed by the fact that ethyl benzoate was obtained when an alcohol solution of furoxane I was refluxed.

EXPERIMENTAL

The electronic spectra of ethanol solutions of the compounds were recorded with a Specord UV-vis spectrophotometer. The IR spectra of Nujol suspensions of the compounds were recorded with a UR-20 spectrometer. The PMR spectra of d_6-DMSO solutions of the compounds were recorded with a Perkin–Elmer R12B spectrometer (60 MHz) with tetramethylsilane as the internal standard. The ^{13}C NMR spectra of DMSO solutions of the compounds were recorded in the Institute of Cybernetics of the Academy of Sciences of the Estonian SSR with a universal spectrometer at 15.09 MHz by the Fourier transformation method.

The mixtures were separated with an RVK-1 high-pressure liquid chromatograph with a UV detector (at 254 nm). The adsorbent was Woelm activity II adsorption silica gel (60-80 μ). The column was 1.0-m long and had an inner diameter of 15 mm. The mobile phase was pentane–ether (4:1), and the flow rate was 0.6-0.9 liter/h.

The characteristics of the compounds obtained are presented in Table 2.

Reaction of Furoxane I with Isopropylamine. A solution of 2.95 g (0.05 mole) of isopropylamine in 10 ml of alcohol was added dropwise to a solution of 5.92 g (0.02 mole) of

TABLE 2. Characteristics of III-VI

Compound	mp, °C	Found, %			Empirical formula	Calc., %		
		C	H	N		C	H	N
IIIa	*	62,0	5,8	18,0	$C_{12}H_{13}N_3O_2$	62,3	5,6	18,2
IIIб	*	63,5	6,1	17,4	$C_{13}H_{15}N_3O_2$	63,7	6,1	17,1
IV	>300	68,1	8,8	7,1	$C_{11}H_{17}NO_2$	67,7	8,7	7,2
V	60—61	51,2	7,6	30,1	$C_6H_{11}N_3O$	51.1	7,8	29,8
VI	186—187	54,8	4,5	25,4	$C_{10}H_{10}N_4O_2$	55,0	4,6	25,7

furoxane I in 100 ml of alcohol, and the mixture was stirred at room temperature for 2 h. The alcohol was then removed, and the resulting dark-red oil was subjected to chromatographic separation to give ethyl benzoate, isoxazole IIIa, and benzoic acid isopropylamide, which was identified by comparison with an authentic sample of the amide. IR spectrum of isoxazole IIIa: 3420 (N-H), 1598, 1556 (N=O), 1429, 1301, 1238, 1191, 1186, 1147, 1102, 1078, 911, 802, 783, 735, 688 cm^{-1}. UV spectrum: λ_{max} 760 nm (log ε 1.66) (N=O).

Reaction of Furoxane I with tert-Butylamine. A solution of 4.38 g (0.06 mole) of tert-butylamine in 15 ml of alcohol was added dropwise to a solution of 5.92 g (0.02 mole) of furoxane I in 100 ml of ethanol, and the mixture was stirred at room temperature for 2 h. The precipitated salt (IV) was removed by filtration, and the alcohol was removed from the filtrate by evaporation to give a dark-red oil. During chromatographic separation of the oil, the reaction products were eluted in the following order: ethyl benzoate, isoxazole IIIb, nitrile V, and benzoic acid tert-butylamide. The amide and salt IV were identified by comparison of their characteristics with the characteristics of the products of alternative synthesis. IR spectrum of isoxazole IIIb: 3399 (N-H), 1600, 1553 (N=O), 1428, 1323, 1302, 1240, 1194, 1175, 1100, 1080, 1004, 918, 881, 806, 784, 736, 685 cm^{-1}. UV spectrum: λ_{max} 760 nm (log ε 1.65) (N=O). IR spectrum of nitrile V: 3100-3450 (N-H, O-H), 2248 (C≡N), 1636 (C=N), 1505, 1415, 1238, 1214, 1018, 980 (C=NOH), 842, 716 cm^{-1}.

Reaction of Furoxane I with Methylhydrazine. A 2.30-g (0.05 mole) sample of methylhydrazine was added to a solution of 5.92 g (0.02 mole) of furoxane I in 100 ml of alcohol. The reaction proceeded exothermically and was accompanied by warming up of the reaction mixture to 50-60°C. The mixture was cooled, and the resulting precipitate was removed by filtration to give 0.75 g (17%) of VI, which was recrystallized from ethanol. IR spectrum: 3438 and 3334 (NH_2), 1632 (C=O), 1515, 1464, 1356, 1339, 1284, 1213, 1148, 1118, 974, 910, 796, 756, 740, 712, 670 cm^{-1}. PMR spectrum, δ: 3.76 (3H, s, CH_3) and 8.0-8.7 ppm (5H, m, C_6H_5). UV spectrum, λ_{max}, nm (log ε): 204 (3.26), 255 (2.87), 290 (2.95), 358 (2.54). ^{13}C NMR spectrum: 127.7, 128.6, 132.3, 136.4 (C_6H_5), 113.7, 150.4, 184.7 (C=O), 34.3 ppm (CH_3). Chromatographic separation of the filtrate gave only ethyl benzoate and benzoic acid methylhydrazide.

3-Amino-4-benzoylfurazan (VII). Furazan VII was obtained by the method in [3] and had mp 135-136°C. IR spectrum: 3454, 3334, 3245, 3190 (NH_2), 1665 (C=O), 1638, 1603, 1575, 1505, 1455, 1347, 1179, 1015, 930, 912, 866, 760, 745, 698, 689 cm^{-1}. ^{13}C NMR spectrum: 129.6, 130.7, 135.4, 136.2 (C_6H_5), 144.0 ($C_{(4)}$), 157.6 ($C_{(3)}$), 186.1 ppm (C=O).

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