# CYCLIZATION OF N-ALKYLAZINIUM CATIONS WITH BIFUNCTIONAL NUCLEOPHILES. 14.* REACTION OF QUINOXALINIUM SALTS WITH MONO- AND N,N'-DISUBSTITUTED AMIDINES

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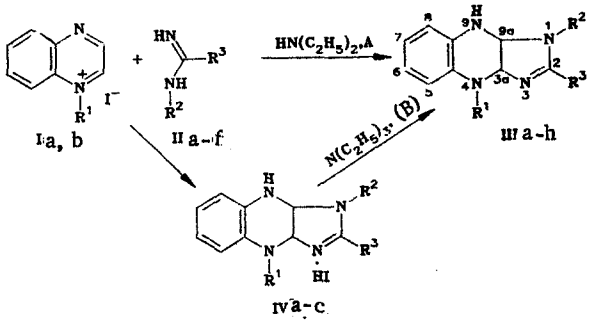
UDC 547.863'866.07:543.422

Monosubstituted benzamidines undergo cyclization with quinoxalinum salts to give 1,2-disubstituted 3a,4,9,9a-tetrahydroimidazo[4,5-b]quinoxalines. The participation in similar cyclizations of N,N'-disubstituted amidines with a CH-active group in the α position leads to 3a,4,9,9a-tetrahydropyrrolo[2,3-b]quinoxalines.

It is well known that α-substituted acetimido esters, upon reaction with quinoxalinium, cinnolinium, and quinazolinium cations, are capable of displaying the properties of 1,3-C,N-dinucleophiles, forming with them cyclization products or inducing their transformation [2]. In the present research we investigated the reaction of N-alkylquinoxalinium iodides with other imino acid derivatives, viz., mono- and N,N'-disubstituted amidines.

Taking into account the similarities in the reactivities of amidines and imidates [3], the reactions of N-alkylquinoxalinium salts with N -monosubstituted benzamidines IIa-e were carried out under the same conditions as those in the previously investigated cyclization with acetamide esters. As a result, we obtained 1,2-disubstituted 3a,4,9,9a-tetrahydroimidazo[4,5-b]quinoxalines IIIa-g (method A) in high yields.




Ia, IIIa, c, e-h, IVa–c $R^1=CH_3$; Ib, IIIb, d $R^1=C_6H_5$; IIa, IIIa, b, IVa $R^2$=p-Cl—$C_6H_4$; IIb, IIIc, d, IVb $R^2$=p-Br—$C_6H_4$; IIc, IIIe $R^2$=2-pyridyl; IId, IIIe-f $R^2$=2-pyrimidimyl; IIe, IIIg $R^2=COC_6H_5$; IIf, IIIh, IVc $R^2=C_6H_5$; IIa–e, IIIa–g, IVa, b $R^3=C_6H_5$; IIIh, IVc $R^3$=o-Cl—$C_6H_4$

In contrast to imidates, N-aryl-substituted benzamidines are strong bases ([3], p. 12) and are capable of reacting with the N-methylquinoxalinium cation Ia in the absence of diethylamine (method B). Thus tetrahydroimidazo[4,5-b]quinoxaline hydriodides IVa-c are formed in high yields in the reaction of equimolar amounts of salt Ia with amidines IIIa,b,f. Salts IV are brightly colored, yellow, crystalline substances that are stable at room temperature and unstable when they are heated; upon recrystallization from ethanol they undergo partial dissociation to give the starting substances. Under the influence of the more basic triethylamine hydriodides IV give bases III. By means of this method we obtained tetrahydroimidazo[4,5-b]quinoxalines IIIa,c, as well as IIIh; the latter, as a consequence of its high solubility in ethanol, could not be obtained by method A. The characteristics of III and IV are presented in Table 1.

*See [1] for Communication 13.

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 0009-3122/85/2103-0326 $09.50 

TABLE 1. Characteristics of III and IV

| Compound | mp, °C | Found, % | | | Empirical formula | Calc., % | | | Yield, % | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | C | H | N | | C | H | N | meth. A | meth. B |
| IIIa | 152—154 | 70,2 | 5,2 | 15,5 | $C_{22}H_{19}ClN_4$ | 70,5 | 5,1 | 15,0 | 78 | 81 |
| IIIb | 132—134 | 71,2 | 5,4 | 14,6 | $C_{23}H_{21}ClN_4$ | 71,0 | 5,4 | 14,4 | 69 | — |
| IIIc | 155—156 | 62,7 | 4,7 | 13,6 | $C_{23}H_{19}BrN_4$ | 63,0 | 4,6 | 13,4 | 86 | 95 |
| IIId | 131—132 | 63,9 | 4,9 | 13,0 | $C_{23}H_{21}BrN_4$ | 63,8 | 4,9 | 13,0 | 38 | — |
| IIIe | 156—157 | 73,9 | 5,3 | 20,8 | $C_{21}H_{91}N_5$ | 73,9 | 5,6 | 20,5 | 75 | — |
| IIIf | 154—156 | 70,0 | 5,4 | 24,2 | $C_{20}H_{18}N_6$ | 70,2 | 5,3 | 24,5 | 79 | — |
| IIIg | 133—135 | 75,0 | 5,8 | 15,5 | $C_{23}H_{20}N_4O$ | 75,0 | 5,5 | 15,2 | 54 | — |
| IIIh | 121—122 | 70,8 | 5,1 | 14,9 | $C_{22}H_{19}ClN_4$ | 70,5 | 5,1 | 15,0 | — | 89 |
| IVa | 137—138 | 52,9 | 4,0 | 11,0 | $C_{22}H_{20}ClN_4$ | 52,6 | 4,0 | 11,1 | 82 | |
| IVb | 138—139 | 48,7 | 3,9 | 10,0 | $C_{22}H_{20}BrN_4$ | 48,3 | 7,3 | 10,2 | 97 | |
| IVc | 136—137 | 52,8 | 4,3 | 11,2 | $C_{22}H_{20}ClN_4$ | 52,6 | 4,0 | 11,1 | 95 | |

TABLE 2. $^1$H NMR Spectra of Tetrahydroimidazo[4,5-b]quinoxalines III and IV

| Compound | Solvent | Chemical shifts, ppm | | | | | SSCC, Hz | |
|---|---|---|---|---|---|---|---|---|
| | | R$^1$ | 3a-H | 9a-H | $N_9$-H | aromatic protons | $^3J_{3a,9a}$ | $^3J_{9,9a}$ |
| IIIa | $CDCl_3$ | 3,23, s | 5,75,s | 5,75,s | 4,32 | 6,3—7,8, m | — | — |
| | $d_6$-DMSO | 3,00, s | 5,66,d | 5,54,dd | 6,32 | 6,5—7,5, m | 8,8 | 1,6 |
| IIIb | $CDCl_3$ | 1,40, t<br>3,63, q | 5,88,d | 5,70,dd | 4,28 | 6,25—7,0,m | 9,8 | 2,0 |
| IIIc | $CDCl_3$ | 3,22, s | 5,75,s | 5,75,s | 4,28 | 6,3—7,8, m | — | — |
| | $d_6$-DMSO | 3,02, s | 5,67,d | 5,53,dd | 6,34 | 6,5—7,6, m | 9,0 | 1,6 |
| IIId | $CDCl_3$ | 1,40, t<br>3,63, q | 5,87,d | 5,72,dd | 4,28 | 6,3—7,8, m | 9,8 | 2,0 |
| IIIe | $CDCl_3$ | 3,23, s | 5,77,d | 6,04,dd | 5,72 | 6,0—8,5, m | 8,9 | 1,5 |
| IIIf | $CDCl_3$ | 3,21, s | 5,72,d | 6,00,dd | 5,56 | 6,5—6,9, m<br>7,3, c. 8,3 d | 9,2 | 1,6 |
| IIIg | $CDCl_3$ | 3,23, s | 5,70,d | 6,14,dd | 5,30 | 6,5—7,8, m | 8,8 | 2,2 |
| IIIh | $CDCl_3$ | 3,19, s | 5,83,s | 5,83,s | 4,36 | 6,2—7,5, m | — | — |
| | $d_6$-DMSO | 2,97, s | 5,66,d | 5,72,dd | 6,16 | 6,4—7,5, m | 9,2 | 1,4 |
| IVa | $d_6$-DMSO | 3,02, s | 5,93,d | 6,12,dd | — | 6,5—7,9 | 9,6 | 3,0 |
| IVb | $d_6$-DMSO | 3,04, s | 5,92,d | 6,10,dd | — | 6,4—8,0 | 9,4 | 2,5 |
| IVc | $d_6$-DMSO | 3,02, s | 6,03,d | 6,32,dd | — | 6,5—7,8 | 9,6 | 2,5 |

In the $^1$H NMR spectra of IIIa-h the chemical shifts (CS) of the nodal 3a-H and 9a-H protons are located at 5.70-6.14 ppm; this is in good agreement with the positions of the signals of the corresponding protons in the spectra of the previously described hexahydroimidazo[4,5-b]quinoxaline-2-thiones [4]. The signal of the 3a-H proton shows up in the form of doublets, whereas the signal of the 9a-H protons appears in the form of a doublet of doublets due to additional spin—spin coupling with the proton of the NH group and is transformed to a doublet after exchange of NH by deuterium. In the $^1$H NMR spectra of IIIa,c in deuterochloroform the signals of the 3a-H and 9a-H protons merge into a common singlet at 5.75 ppm; however, in $d_6$-DMSO these signals are resolved to a doublet and a doublet of doublets, respectively. The vicinal $^3J_{3a,9a}$ constants, which amount to 8.8-9.8 Hz, constitute evidence for the cis orientation of the nodal hydrogen atoms; this is a characteristic feature of tetrahydroquinoxalines that are condensed with five-membered heterocycles [4].

The conclusion regarding the mutual orientation of the heterorings in tetrahydroimidazo[4,5-b]quinoxalines III was drawn proceeding from the effect of the $R^2$ substituent on the CS of the 3a-H and 9a-H protons and the proton of the NH group. Whereas the 3a-H proton, regardless of the character of the $R^2$ substituent, resonates at 5.70-5.88 ppm, the signals of the 9a-H and $N_9$—H protons on passing from aryl substituents (IIIa-d,h) to the more electron-acceptor pyridyl (IIIe), pyrimidinyl (IIIf), and benzoyl (IIIg) derivatives undergo a 0.3-ppm shift in the case of 9a-H and 1-1.5 ppm in the case of $N_9$—H to weak field (Table 2).

An examination of the $^{13}$C NMR spectra of IIIc,f and a comparison of them with the spectra of a number of model compounds (Fig. 1) lead to the same conclusions regarding the annelation of the imidazole ring and the region orientation to the heterocyclic fragments.

The signals of the methylidyne carbon atoms at 77.3 and 75.7 ppm in the $^{13}$C NMR spectra of IIIc and IIIf should be ascribed to the resonance of the 9a-C carbon atom bonded to the N-aryl fragment of the imidazole ring, considering the closeness of the chemical shifts (CS) of these compounds and the model compound hexahydroimidazo[4,5-b]quinoxaline-2-thione (75.9

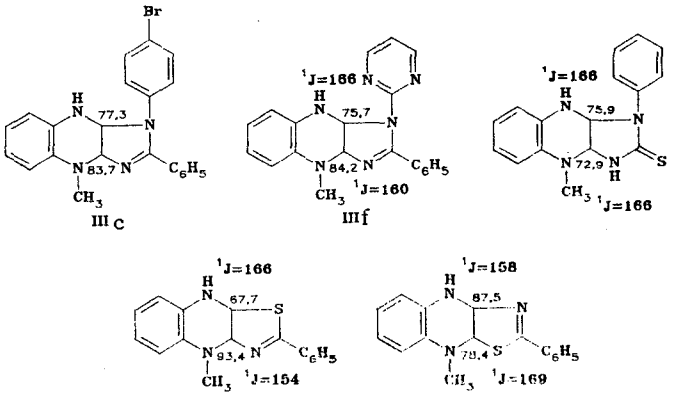



Fig. 1. Chemical shifts (ppm) and $^1J_{C-H}$ constants (Hz) in the $^{13}C$ NMR spectra of tetrahydroimidazo[4,5-b]quinoxalines IIIc,f and model compounds.

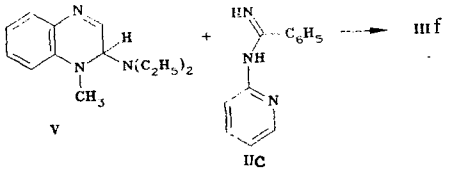
ppm [4]). The 3a-C carbon atoms attached to the C=N double bond of the imidazole ring of IIIc and IIIf resonate at weaker field, viz., 83.7 and 84.2 ppm, respectively.

For the accurate assignment of the signals of the nodal 3a-C and 9a-C carbon atoms in the $^{13}C$ NMR spectrum of IIIf we used the method of selective decoupling of the 3a-H and 9a-H protons. The signals of the 3a-H and 9a-H protons are easily distinguishable in the $^1H$ NMR spectrum, owing to the spin–spin coupling between the 9a-H and $N_9$–H protons (Table 2), which vanishes upon deuterium exchange of the NH group. Double-heteronuclear-resonance experiments confirmed that the 9a-H proton is bonded to the carbon atom that resonates at 75.7 ppm.

The direct $^1J_{(C-H)}$ constants are in complete agreement with the structure of IIIf (Fig. 1). On the basis of the data from the $^{13}C$ spectra of a number of tetrahydroquinoxalines that are annelated with various five-membered heterocycles, the signal at 75.7 ppm [$^1J_{(C-H)}$ = 166 Hz)] should be assigned to the carbon atom bonded to the $N_1$-pyrimidinyl residue and the signal at 84.2 ppm [$^1J_{(C-H)}$ = 160 Hz)] should be assigned to the 3a-C carbon atom attached to the C=N double bond. Thus the $^1J_{(C-H)}$ values for the carbon atoms of the pyrazine ring bonded to the N–R fragment amount to ∿164 Hz in hexahydropyrrolo[2,3-b]quinoxalin-2-ones, 168-169 Hz in hexahydrothiazolo[4,5-b]quinoxaline-2-thiones [5], and, finally, 164-166 Hz [4] in hexahydroimidazo[4,5-b]quinoxaline-2-thiones, which are most similar in a structural respect. In hydrogenated thiazolo[4,5-b]quinoxalines the $^1J_{(C-H)}$ values for the carbon atom bonded to the C=N double bond are considerably lower, viz., 154-158 Hz [6]. The fact that the signal of the more weak-field nodal carbon atom at 84.2 ppm, in addition to the direct constant with $^1J_{(C-H)}$ = 160 Hz, has a long-range constant of spin–spin coupling with the protons of the $N_4$-methyl group [$^3J_{(C-H)}$ ∿ 3 Hz] is a direct indication of the presence of an $H_3C-N-CH-N=C$ structural fragment in IIIf.

In a comparison of the $^1H$ NMR spectra of tetrahydroimidazo[4,5-b]quinoxalines IIIa,c,h and their hydroiodides IVa-c one's attention is drawn to the fact that the nodal 3a-H and 9a-H protons of salts IV not only show up at weaker field but also change positions: The weak-field signal of the 9a-H proton in the spectra of the bases resonates at weaker field in the spectra of the salts as compared with the 3a-H proton. Taking into account the differences in the conditions used to obtain bases III and salts IV, as well as the literature data on the cyclization of quinoxalinium salts with dithiocarbamates, in which the participation in the reaction of the σ adducts of the cation of Ia with diethylamine V led to inversion of the orientation of the thiazole ring [5], we found it necessary to establish the relative orientation of the heterorings in hydriodides IV. With this end in mind, we converted IVa,b to the bases under conditions that exclude the formation of regioisomeric products. The reaction was carried out in aprotic solvents [dimethyl sulfoxide (DMSO) and absolute ether], and the HI was tied up by means of triethylamine. In these experiments we obtained tetrahydroimidazo[4,5-b]quinoxalines IIIa,c, which were identical to genuine samples; this confirms regio orientation of the heterocyclic fragments in salts IV.

We also established that the participation in the cyclization with amidine IIc of not the N-methylquinoxalinium cation but rather its σ adduct (V) with diethylamine leads to product IIIf with the same orientation of the imidazole ring.

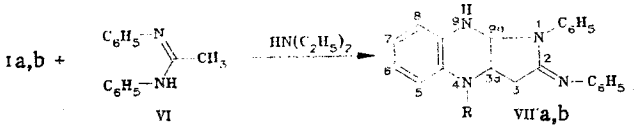


Thus signals of 4-methyl-2-phenyl-1-pyridyl-3a,4,9,9a-tetrahydroimidazo[4,5-b]quinoxaline (IIIf) appear immediately in the $^1$H NMR spectrum of the region mixture when equimolar amounts of 1-methyl-2-(N,N-diethyl)- 1,2-dihydroquinoxaline (V) and N-pyridylbenzamidine IIf are mixed in the cell of the NMR spectrometer. The same result was also obtained preparatively (see the experimental section).

Thus N-monosubstituted benzamidines in cyclizations with the quinoxalinium cation, both in the presence of diethylamine and without its participation, form tetrahydroimidazo[4, 5-b]quinoxaline derivatives with the same orientation.

The participation of the methyl group of N-monosubstituted acetamidines in triadic prototropism creates several possibilities for cyclizations, and complex mixtures of products that are difficult to separate are formed in their reaction with N-alkylquinoxalinium iodides. The cyclizations of salts Ia,b with symmetrically disubstituted N,N'-diphenylacetamidine VI, which leads to the formation of tetrahydro-3H-pyrrolo[2,3-b]quinoxalines VIIa,b, proceed in a more definite manner.

The structures of VII were established by means of the $^1$H NMR spectra. The nodal 3a-H and 9a-H protons are quite readily distinguishable, not only from their chemical shifts (CS) but also from the multiplicities of the signals. The signal of the 9a-H proton, which is situated between two nitrogen atoms (5.5 ppm for VIIa and 5.35 ppm for VIIb), shows up in the form of a doublet of doublets that is converted to a doublet after exchange of NH by deuterium. The 3a-H proton resonates at 4 ppm in the form of a multiplet in which spin–spin coupling both with the 9a-H proton and with two nonequivalent protons in the 3 position is observed. The vicinal $^3J_{3a,9a}$ constants, which amount to 6.6 Hz for VIIa and 6.2 Hz for VIIb, indicate the cis orientation of the nodal hydrogen atoms.



VII a R=$CH_3$, b R=$C_2H_5$

Thus the reactions examined in this paper show that amidines can serve as synthones for the direct annelation to quinoxalines of both the imidazole and the pyrrole rings.

## EXPERIMENTAL

The $^1$H NMR spectra of solutions of the compounds in $d_6$-DMSO deuterochloroform were recorded with a Perkin–Elmer R 12 B spectrometer (60 MHz) with hexamethyldisiloxane (HMDS) as the internal standard. The $^{13}$C NMR spectra of solutions in deuterochloroform and $d_6$-DMSO were recorded with a Varian FT-80A spectrometer; the chemical shifts (CS) were measured with respect to the signal of the solvent. The IR spectra of solutions in chloroform were recorded with a UR-20 spectrometer. The UV spectra of solutions in ethanol were obtained with a Specord UV-vis spectrophotometer.

The N-methyl- and N-ethylquinoxalinium iodides were obtained as described in [2]. Monosubstituted benzamidines IIa-e were synthesized from benzonitrile and the corresponding aryl- and hetarylamines [7]. 1-Methyl-2-(N,N-diethylamino)-1,2-dihydroquinoxaline (V) was obtained by the method described in [5].

4-Methyl-1-(4-chlorophenyl)-2-phenyl-cis-3a,4,9,9a-tetrahydroimidazo[4,5-b]quinoxaline Hydriodide (IVa). A solution of 2.5 g (10.9 mmoles) of N-(4-chlorophenyl)benzamidine in 5 ml of ethanol was added to a suspension of 3 g (10.9 mmoles) of N-methylquinoxalinium iodide in 5 ml of ethanol, and the precipitate that formed from the resulting solution was removed by filtration and washed on the filter with ethanol to give 4.5 g (82%) of yellow prisms with mp 137-138°C (dec., from ethanol). $^1$H NMR spectrum ($d_6$-DMSO): 3.02 (s, 3H, N–$CH_3$), 5.93 (d, 3a-H, $^3J_{3a,9a}$ = 9.6 Hz), 6.12 (dd, 9a-H, $^3H_{9,9a}$ = 3.0 Hz), and 6.5-7.9 ppm (m, 13H, aromatic). Found: C 52.9; H 4.0; N 11.0%. $C_{22}H_{20}ClIN_4$. Calculated: C 52.6; H 4.0; N 11.0%.

Compounds IVb,c. These compounds were similarly obtained (see Tables 1 and 2).

4-Methyl-1-(4-chlorophenyl)-2-phenyl-cis-3a,4,9,9a-tetrahydroimidazo[4,5-b]quinoxaline (IIIa). A) A 2.5-g (10.9 mmoles) sample of N-(4-chlorophenyl)benzimidine and 3 ml of diethylamine were added to a suspension of 3 g (10.9 mmoles) of N-methylquinoxalinium iodide in 3 ml of ethanol, as a result of which we observed the formation of a colorless solution, from which IIIa precipitated immediately. Workup gave 5.3 g (78%) of colorless prisms with mp 152-154°C (from ethanol). IR spectrum: 3390 $cm^{-1}$ (NH). UV spectrum, $\lambda_{max}$ (log ε): 221 (4.47), 246 (4.12), and 286 nm (3.81). $^1H$ NMR spectrum ($d_6$-DMSO): 3.0 (s, 3H, N–$CH_3$), 5.54 (dd, 9a-H, $^3J_{9,9a}$ = 1.6 Hz), 5.66 (d, 3a-H, $^3J_{3a,9a}$ = 8.8 Hz), 6.32 (broad s, $N_9$–H), and 6.4-7.5 ppm (m, 13 H, aromatic). Found: C 70.2; H 5.2; N 15.5%. $C_{22}H_{19}ClN_4$. Calculated: C 70.5; H 5.1; N 15.0%.

Compounds IIIb-g. These compounds were also obtained by method A (see Tables 1 and 2).

B) A 4.45-g (8.9 mmoles) sample of salt IVa was dissolved in 5 ml of dimethyl sulfoxide (DMSO) containing 1.25 ml (8.9 mmoles) of triethylamine. The colorless solution was then added in small portions with stirring to 150 ml of water, and the resulting precipitate was removed by filtration and air dried to give 3.3 g (98%) of product. The melting points and IR and $^1H$ NMR spectra of the compounds obtained by methods A and B were in complete agreement.

Method B was also used for the synthesis of IIIc,h (Tables 1 and 2).

Reaction of 1-Methyl-2-(N,N-diethylamino)-1,2-dihydroquinoxaline (V) with N-(2-pyridyl)-benzamidine (IIc). A 0.72-g (3.68 mmoles) sample of amidine IIc was added to a solution of 0.8 g (3.68 mmoles) of dihydroquinoxaline V in 50 ml of absolute ether, after which the resulting colorless solution was evaporated *in vacuo*, and the resinous residue was treated with ethanol. The precipitate was removed by filtration and recrystallized from ethanol to give 0.58 g (47%) of product. The melting points and $^1H$ NMR spectra of the samples of 4-methyl-2-phenyl-1-(2-pyridyl)-cis-3a,4,9,9a-tetrahydroimidazo[4,5-b]quinoxaline (IIIe) obtained from N-methylquinoxalinium iodide by method A and from σ adduct V were in complete agreement.

4-Methyl-1-phenyl-2-phenylimino-cis-3a,4,9,9a-tetrahydro-3H-pyrrole[2,3-b]quinoxaline (VIIa). A solution of 0.75 g (3.6 mmole) of N,N'-diphenylacetamidine and 1 ml of diethylamine in 2 ml of ethanol was added to a stirred suspension of 1 g (3.6 mmoles) of N-methylquinoxalinium iodide in 3 ml of ethanol. After 5 min, we observed the formation of a copious precipitate, workup of which gave 1 g (79%) of colorless prisms with mp 150-152°C (from ethanol). IR spectrum: 3430 $cm^{-1}$ (NH). UV spectrum, $\lambda_{max}$ (log ε): 220 (4.60), 256 (4.21), and 302 nm (3.83). $^1H$ NMR spectrum ($CDCl_3$): 2.25-3.0 (m, 2H, 3-H protons), 2.80 (s, 3H, N–$CH_3$), 3.85-4.30 (m, 3a-H), 4.40 (broad s, NH), 5.50 (dd, 9a-H, $^3J_{3a,9a}$ = 6.7 Hz), and 6.40-7.90 ppm (m, 14H, aromatic). Found: C 77.6; H 6.2; N 15.6%. $C_{23}H_{22}N_4$. Calculated: C 77.9; H 6.3; N 15.8%.

4-Ethyl-1-phenyl-2-phenylimino-cis-3a,4,9,9a-tetrahydro-3H-pyrrole[2,3-b]quinoxaline (VIIb). This compound was similarly obtained in 81% yield in the form of colorless prisms with mp 153-155°C (from ethanol). IR spectrum: 3425 $cm^{-1}$ (NH). UV spectrum, $\lambda_{max}$ (log ε): 220 (4.60), 257 (4.23), and 303 nm (3.83). $^1H$ NMR spectrum ($CDCl_3$): 1.15 (t, 3H, $CH_3$), 2.27-3.0 (m, 2H, 3-H protons), 3.0-3.50 (m, 2H, $CH_2$), 3.90-4.40 (m, 3a-H), 4.35 (broad s, NH), 5.35 (dd, 9a-H, $^3J_{3a,9a}$ = 6.2 Hz), and 6.40-7.90 ppm (m, 14H, aromatic). Found: C 78.3; H 6.4; N 15.2%. $C_{24}H_{24}N_4$. Calculated: C 78.2; H 6.6; N 15.2%.

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# CYCLIZATION OF N-ALKYLAZINIUM CATIONS WITH BIFUNCTIONAL NUCLEOPHILES. 15.* ISOMERIZATION OF THIAZOLO[4,5-b]QUINOXALINES IN THE PRESENCE OF ACIDS

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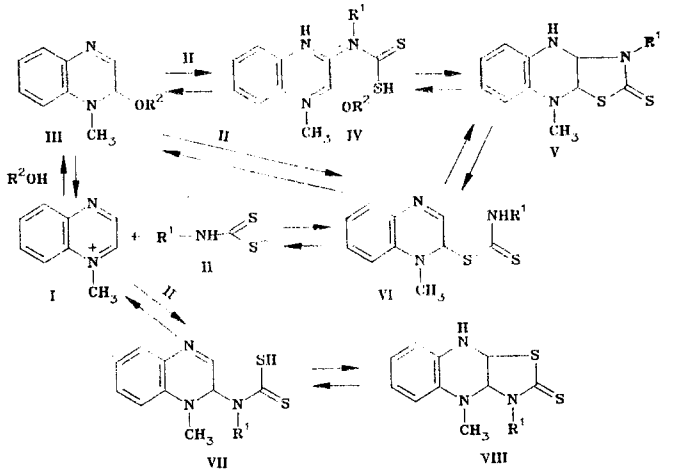
UDC 547.863'789.6:542.952.1

4-Alkyl-2-phenyl-3a,4,9,9a-tetrahydrothiazolo[4,5-b]quinoxalines undergo isomerization in chloroform in the presence of acids to the regioisomeric (with respect to them) 9-alkyl-substituted derivatives. Under the same conditions 2,4-dimethyl-3a,4-9,9a-tetrahydrothiazolo [4,5-b]quinoxaline undergoes isomerization to 4-methyl-1H-2,3,3a,4,9,9a-hexahydropyrrolo[2,3-b]quinoxaline-2-thione. It was demonstrated by means of deuterium labels that in both cases the isomerization proceeds through a step involving dissociation to a quinoxalinium cation and the corresponding thioamide.

Thanks to previous studies [2-13] that have been recently published, the cyclization of 2,3,5,6-tetrachloropyrazines and 2,3-dichloroquinoxalines with dinucleophiles can today be regarded as one of the general and quite attractive (because of its simplicity and accessibility) methods for the synthesis of 1,4-diazaaromatic systems that are condensed with imidazole [10, 11], thiazole [12], furan [13], pyran [13], thiazine [2], and other heterocycles.

The cyclization of quaternary N-alkylpyrazinium and quinoxalinium salts with dinucleophiles also leads to annelation of the pyrazine ring by various carbo- and heterocycles [14]; however, the products (formed as a result of diaddition) of cyclization with the tetrahydropyrazine ring differ substantially in their properties from their aromatic analogs. This is primarily manifested in the ability of hydrogenated polycyclic compounds to undergo dissociation in the presence of acids to give the starting substances; we have already noted that for derivatives of furo- [15] and pyrrolo[2,3-b]quinoxalines [16]. Another distinctive feature of the reactions of N-alkyl-1,4-diazinium salts with unsymmetrical dinucleophiles is the possibility of the formation of regioisomeric cycloadducts. Thus, depending on the condi-



*See [1] for Communication 14.

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0009-3122/85/2103-0331$09.50  