dine, tar filtered off and the filtrate evaporated in vacuo. Chromatography of the residue on silica gel (40 × 100 μ) with benzene:ethyl acetate (1:1) gave a fraction with R_f 0.6-0.8 on silufol and this was recrystallized from a mixture of benzene–ether or by vacuum distillation.

5-Methoxy-2-phenyl-3-methyl-1-propionylpyrazolidine (IIIh). Four drops of HCl were added to a solution of 5-hydroxy-2-phenyl-3-methyl-1-propionylpyrazolidine (Id, 0.3 g, 1.2 mmole) in a mixture of methanol (5 ml) and water (2 ml). After a day the solution was neutralized (Na_2CO_3), extracted with chloroform (3 × 5 ml) and separated chromatographically on silica gel (40 × 100 μ) in chloroform. Removal of solvent by distillation gave a viscous oil.

Acetic Acid β-phenyl-β-(3,3-dipropoxypropyl)hydrazide (IV). Ku-2 exchange resin (H^+ form, 0.1g) was added to a solution of 1-acetyl-2-phenyl-5-hydroxypyrazolidine (Ia, 1.03 g) in propanol (10 ml) was stirred at 20°C for 4 h. Filtration of tar, evaporation of alcohol, and chromatography of the mixture (silica gel, 40 × 100 μ, eluant benzene–ethyl acetate 1:1) gave two fractions with R_f 0.74 (IIIc) and 0.48 (IV) on silufol. Evaporation of solvent from the second fraction gave a white solid which was recrystallized from benzene–hexane (4:1) to give IV (0.15 g, 15%) with mp 64-65°C. IR Spectrum: 3210 (NH), 1690 cm^{-1} (CO). PMR spectrum ($CDCl_3$): 0.92 (6H, t, J = 7 Hz, $\underline{CH_3}CH_2CH_2O$), 1.60 (4H, m, $CH_3\underline{CH_2}CH_2O$), 1.98 (2H, m, $(C_3H_7)_2CH\underline{CH_2}$), 2.02 (3H, s, CH_3CO), 3.24 (6H, m, CH_2O, CH_2N), 4.58 (1H, m, OCH), 6.8-7.3 ppm (5H, m, $C_6\underline{H_5}$). Found, %: C 66.2, H 9.2. $C_{17}H_{28}N_2O_3$. Calculated, %: C 66.2, H 9.1.

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SYNTHESIS OF INDOLES FROM PYRIDINIUM SALTS

S. P. Gromov, M. M. Bkhaumik, and Yu. G. Bundel'

UDC 547.753'821.3:542.953.2:543.51

The detailed analysis of the products of the interaction of nitropyridinium salts with ketones and alkylamines resulted in new data testifying in favor of the previously proposed scheme for the formation of indoles from pyridinium salts.

The electron-deficient pyridine nucleus and, to a still greater degree, the 1-alkylpyridinium ring readily undergo ring opening by nucleophiles giving derivatives of glutaconic dialdehyde which may be utilized for the synthesis of carbo- and heterocycles; this occurs by way of an example in the enamine rearrangement [1]. The opening of the pyridine ring after addition of the nucleophile evidently proceeds by an electrocyclic mechanism [2]. There are also known examples where the derivatives of pyridine form bicyclic adducts with bidentate nucleophiles [3], or the products of their transformation [4]. With the exception of the Haner synthesis of azulenes, no conversions of pyridinium salts to new rings by the action of nucleophiles have been described [5, 6].

We established [7] that the condensation of the ketone (II) (or its enamine) with the pyridine nucleus occurs in regard to the action of substituted ketones and alkylamines on the 1-tropyridinium salts (Ia-f). This is evidently followed by the ring opening with the simulta

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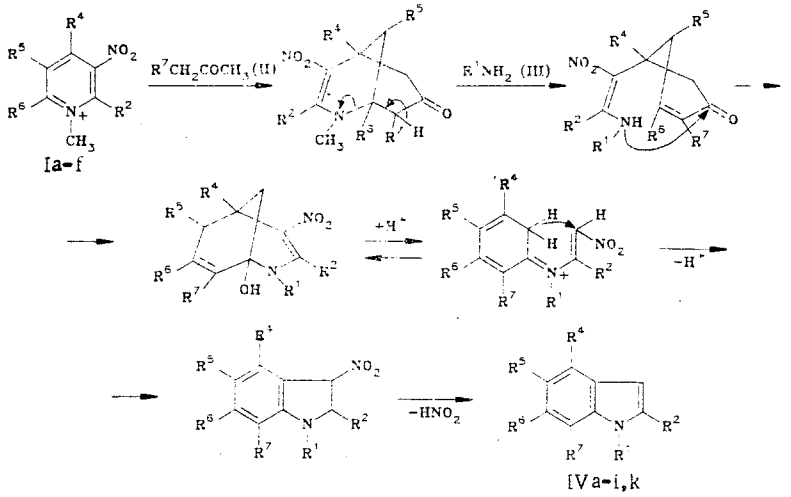
neous exchange of the N-alkyl group and the subsequent cyclization, and the formation of the indole derivatives (IVa-d) by the closing of the dihydropyrrole ring.



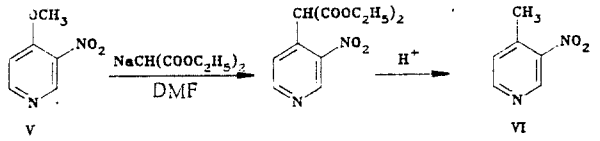
In the synthesis of indoles from pyridinium salts, the degree of the transamination depends on the character of the alkyl radical at the nitrogen atom of the amine, and the nucleophilicity of the latter [8]. The yields of the indoles decrease with the increase in the steric hindrance produced by the alkylamino group.

The optimal conditions in carrying out the reaction are room temperature and a prolonged reaction time (5-7 days); the solution of the alkylamine in the ketone was utilized as the reagent. If, for example, the reaction between 1,2,4,6-tetramethyl-3-nitropyridinium iodide (Ia) and acetone is performed in an aqueous solution of methylamine, the yield of 1,2,4,6-tetramethylindole (IVa) decreases to 3%. This is due to the competitive hydrolytic cleavage of the amino group, which evidently proceeds at the stage of the open form A.

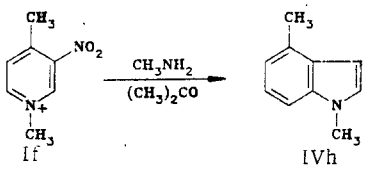
The introduction of methyl groups at the 2 and 6 positions of the pyridine ring lowers the electron deficiency of the ring and creates difficulties for the competitive opening of the pyridine ring by nucleophiles; this correspondingly increases the yield of the transformation products [7]. Thus, 1,2,4,6-tetramethylindole (IVa) is formed in 60% yield, which is maximal for the series of compounds studied, by the action of acetone and methylamine on 1,2,4,6-tetramethyl-3-nitropyridinium iodide (Ia). It is significant that 1,2,4-trimethyl-3-nitropyridinium iodide (Ib) is converted to 1,2,4-trimethylindole (IVd) with a better yield (34%) than in the case of its isomer 1,2,4-trimethyl-5-nitropyridinium iodide (Ic) (6%); therefore the transformation proceeds preferentially with the addition of acetone to the pyridine nucleus at the unblocked carbon atom of the methyl group in the para position to the nitro group. By analogy, 1,4,5-trimethyl-3-nitropyridinium iodide (Id) is converted to 1,4,5-trimethylindole (IVf) with a yield of only 28%, since the 2 and 6 positions are available for the competitive opening of the pyridine ring by nucleophiles. However, the presence of the methyl group at the 4 position is the most significant for the course of the reaction. Thus, 1,2,6-trimethylindole (IVg) is formed, albeit in the low yield of 3%, by the action of acetone and methylamine on 1,2,6-trimethyl-3-nitropyridinium iodide (Ie).

In the series of examples presented, we studied the conversions of the quaternary salts of nitropyridines with three and two methyl groups in the pyridine nucleus. The study of the conversion of nitropyridine derivatives with one methyl group in the pyridine ring is of principal importance. The compound required for this — 4-methyl-3-nitropyridine (VI) — was obtained from 4-nitropyridine-N-oxide in several stages [9, 10]. In the synthesis described for 4-methyl-3-nitropyridine (VI), a residue of malonic ester is introduced in DMF instead of the atom of chlorine in 4-chloro-3-nitropyridine, with the subsequent hydrolysis and decarboxylation [11]. The synthesis of 4-methyl-3-nitropyridine (VI) from 4-methoxy-3-nitropyridine (V) was also previously described. In this synthesis, the residue of malonic ester was introduced instead of the methoxyl group in the pyridine ring, with diethyl ether as the solvent, in 45% yield [10]. We proposed a new variant of the synthesis of 4-methyl-3-nitropyridine (VI) from 4-methoxy-3-nitropyridine (V), which was mainly based on the utilization of DMF as the solvent; this permitted a reduction in the number of the stages in comparison with the synthesis de-

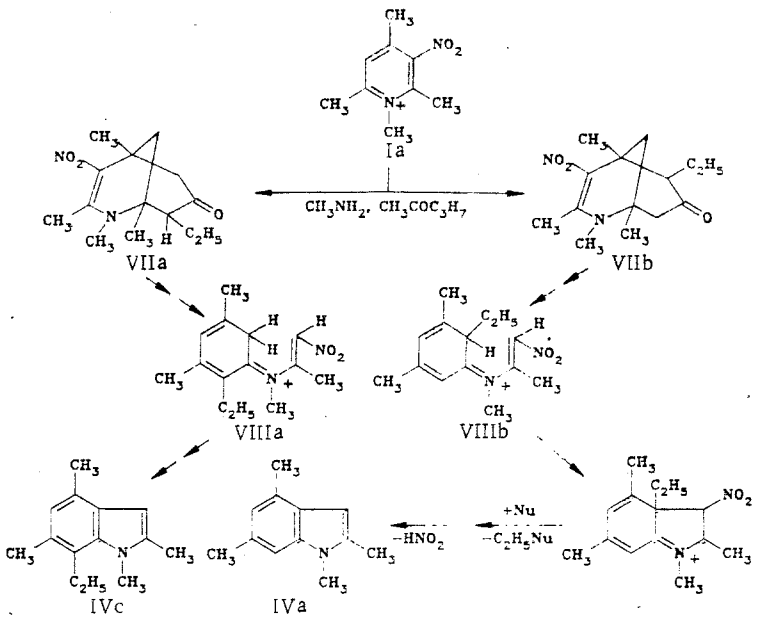
scribed in the work [11], and a significant increase in the yield of the final compound (VI) (91%).



It was found that 1,4-dimethylindole (IVh) is formed with a yield of 8% by the reaction of 1,4-dimethyl-3-nitropyridinium iodide (If) with methylamine in acetone. Therefore, the successive decrease in the number of the methyl groups in the pyridine nucleus of the nitropyridinium salts leads to a significant decrease in the yields of the methylindoles.



It could be expected that the complex route of the conversions leading to the indoles should be accompanied by the formation of byproducts, the detection of which permits certain conclusions on the character of the reaction as a whole. In fact, the complete analysis of the products of the reaction of 1,2,4,6-tetramethyl-3-nitropyridinium iodide (Ia) with methylamine in methyl propyl ketone succeeds in isolating 1,2,4,6-tetramethylindole (IVa) (yield 2.7%) and the compound (IXa) (see below; yield 22%) besides 1,2,4,6-tetramethyl-7-ethylindole (IVc).



The stepwise condensation of methyl propyl ketone (or its enamine) with the pyridine nucleus thereby evidently proceeds initially in two ways [cf. the structures (VIIa,b)]; the formation of the intermediates (VIIIa, b) further proceeds as a result of a chain of conversions. The closing of the dihydropyrrole ring leads to the subsequent cleavage of the ethyl group from the angular position in the structure (VIIIb), and the formation of the indoles (IVa, c). The aromatization of the cyclohexadiene ring in the structure (VIIIb) assists this process. An alternative method for the formation of the indoles (IVa, c) may also evidently be the mutual conversion of the isomers (VIIIa, b), proceeding by a prototropic transition. However, this route requires the additional cis,trans-isomerization for the nitrogen-carbon double bond [cf. the structures (VIIIa, b)], and seems less probable to us. The process, which is analogous to the dealkylation proposed in the scheme presented which affects the angular position of the dihydroindole ring, occurs in some cases in the Fischer synthesis of indoles [12].

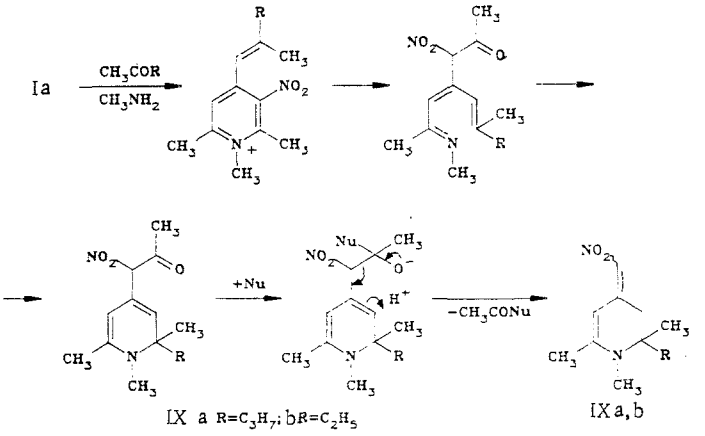
The indoles (IVa, c) obtained underwent a chromato-mass spectral investigation, and were separated chromatographically; their decomposition under electron impact was studied. The main routes of the decomposition of the indole (IVc) with the dissociative ionization are the formation of the $[M - H]^+$, $[M - CH_3]^+$, and $[M - C_2H_5]^+$ ions. The fragmentation of the indole (IVa) is characterized by the formation of the intense peaks of the $[M - H]^+$ and $[M - CH_3]^+$ ions. The mass spectral decomposition of the indole (IVa) is in complete agreement with the spectrum of this compound obtained by an independent route by the reaction of acetone and methylamine with 1,2,4,6-tetramethyl-3-nitropyridinium iodide (Ia).

The analysis of the PMR spectral data of the mixture of the indoles (IVa) and (IVc) and the GLC permitted the determination of the 1:3 ratio of the compounds (IVa) and (IVc) in the mixture. The position of the alkyl groups in the benzene nucleus of the indole (IVc) corresponds with their position in the tetramethylindole (IVa), for which the character of the substitution was determined using the ^{13}C NMR spectra including the partial uncoupling of the protons [8].

It is significant that the action of methyl ethyl ketone and methylamine on 1,2,4,6-tetramethyl-3-nitropyridinium iodide (Ia) results in the formation of 1,2,4,6-tetramethylindole (IVa) in trace amounts; it is only recorded mass spectrally.

Therefore, a new route for the reaction leading to indoles was found; the indoles are evidently formed as a result of the cleavage of the alkyl groups at the intermediate stages of the reaction. The degree of the realization of this process increases with the enlargement of the alkyl radical of the alkyl methyl ketone.

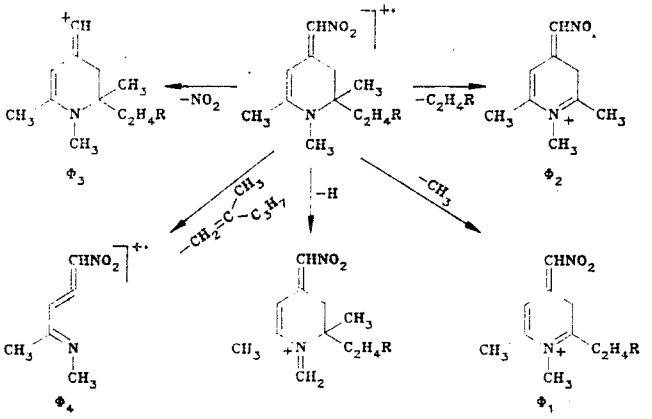
The analysis of the products of the reaction of the nitropyridinium salt (Ia) with methylamine in methyl propyl ketone resulted, as was already said, in the separation of the deeply colored compound (IXa) besides the indoles (IVa, c); the chromatographic mobility of (IXa) proved to be significantly lower than the mobilities of the investigated indoles (IVa, c). The formation of the compound (IXa) is not evidently an offshoot of the investigated process of the forming of the bicyclic indole. In this case, the condensation of methyl propyl ketone at the 4-methyl group of the pyridine ring probably proceeds prior to the ring opening and the subsequent cyclization, which is permitted by the orbital symmetry, with the formation of the dihydropyridine ring.



IX a R=C3H7; b R=C2H5 IXa,b

The process is completed by the cleavage of the acetyl group by a mechanism opposite to the C-acylation of nitro compounds [13]. By analogy, the action of methyl ethyl ketone and methylamine on 1,2,4,6-tetramethyl-3-nitropyridinium iodide (Ia) also leads to the formation of the deeply colored compound (IXb) (14% yield) and 1,2,4,6,7-pentamethylindole (IVb) (41% yield), i.e., the transformation proceeds preferably with the formation of the indole bicyclic system with the decrease in the length of hydrocarbon radical in the initial ketone.

The main routes of the decomposition in the dissociative ionization of the nitroenamines (IXa, b) are the formation of the $[M - H]^+$ ion as well as the Φ_1 and Φ_2 ions. The additional routes of decomposition of the molecular ions are characterized by the cleavage of the nitro group with the formation of the Φ_3 ion; the nitro-nitrite rearrangement of the M^+ ion proceeds to an insignificant extent.



A significant route of decomposition in the fragmentation of the compound (IXa) (besides those mentioned above), in order to establish the structure of (IXa), is the retrodiene decomposition with the formation of the Φ_4 ion.

With the object of clarifying the structure of the cyclic nitroenamines (IXa, b) in detail, we took their PMR spectra at the working frequency of 500 MHz. The interpretation of the spectra of (IXa) and (IXb) enabled it to be established that each of these compounds consists of a pair of the Z- and E-stereoisomers in the ratio of 6:1.

A significant factor to explain the position of some of the signals of the protons of the CH and CH_2 groups (see the experimental part) is the strong deshielding of the nitro group; this is at a lower field than could be expected as being due only to the electron-acceptor action of the nitro group in both the Z- and E-isomers of the compounds (IXa, b). The presence of four signals of the methyl groups, which are markedly different in the chemical shifts, in the spectrum of the compounds (IXa, b) indicates the absence of the geminal CH_3 groups; it simultaneously permits the assignment of the signals at the lowest field (at 3 ppm) to the NCH_3 groups and propyl groups correspondingly. The proposed spectral interpretation is also confirmed by the method of double resonance, which permitted the determination of the allylic interaction (J = 1 Hz) between the protons of the methylene and nitromethylidene groups.

The ^{13}C NMR spectra were obtained for the nitroenamines (IXa, b); these included the partial uncoupling of the protons. It was established that the compounds (IXa, b) each contain three quaternary carbon atoms having markedly different chemical shifts; this allowed the ready assignment of the signals. They each have two CH groups [$J_{C_{(3)}-H}$ = 176 Hz and J_{CNO_2-H} = 188 Hz for compound (IXa)].

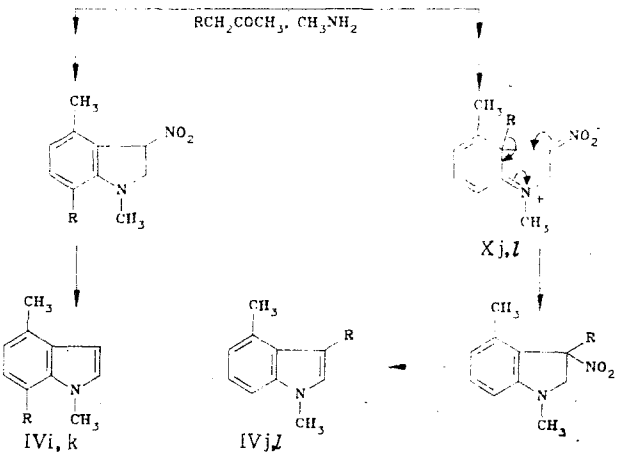
The UV spectra of the compounds (IXa, b) are characterized by a long-wave absorption maximum [λ_{max} 468 nm for (IXb)] and high extinction coefficients [log ε 4.46 for (IXb)]; this indicates a high degree of conjugation, which is guaranteed by the proposed structure of the cyclic nitroenamines (IXa, b).

The formation of a compound, for which an analogous structure was proposed, was previously established in the work [14] for the action of diethylketone and methylamine on 1,2,4,6-tetramethyl-3-nitropyridinium iodide (Ia).

In the scheme for the synthesis of indoles proposed by us, the principal feature is the possibility of the parallel formation of the structures (VIIIa, b); this leads to two indoles. For the alkyl group situated at the angular position of the dihydroindole bicyclic system, the migration of this group to one of the electron-rich positions of the intermediate can be proposed besides the elimination. In fact, the utilization of nitropyridinium salts with one methyl group in the pyridine nucleus permitted the realization of these reaction routes.

Thus, the 2:3 mixture of 1,4,7-trimethylindole (IVi) and 1,3,4-trimethylindole (IVj) is formed in the total yield of 22% by the action of methyl ethyl ketone and methylamine on 1,4-dimethyl-3-nitropyridinium iodide (If). By analogy, the 9:11 mixture (according to the NMR data) of 1,4-dimethyl-7-propylindole (IVk) and 1,4-dimethyl-3-propylindole (IVl) is obtained in the total yield of 2% by the action of butyl methyl ketone and methylamine on 1,4-dimethyl-3-nitropyridinium iodide (If).

If



IVi,j R=CH_3; k,l R=C_3H_7

The migration of the alkyl group from the angular position to the position 3, activated by the presence of a negative charge, evidently proceeds in the synthesized dihydroindole bicyclic ring of (Xj, l). The simultaneous aromatization of the cyclohexadiene ring of the structures (Xj, l) assists this migration. The absence of compounds of an indole nature with another type of substitution in the reaction products indicates the intramolecular character of the shift of the alkyl groups. The absence of the isomerization of the propyl group to the isopropyl group in both of the indoles (IVk, l) is also additional confirmation of this.

The structure of the indoles (IVi-l) was shown using the data of chromato-mass spectrometry and PMR (500 MHz). The interpretation of the spectrum of the mixture of the indoles (IVi, j) permitted the determination of the 2:3 ratio of the isomers (IVi) and IVj) in it. The aromatic part of the spectrum corresponds to the superposition of the two-proton system of the benzene ring in the indole (IVi) and the three-proton system of the benzene ring in the indole (IVj). The presence of the signal of the 2-H proton at lower field (6.79 ppm) is important for the localization of the methyl group at the 3 position in the indole (IVj). The analogous proton in the indole (IVi) gives a signal at 6.97 ppm. The signal of the 3-H proton in the indole (IVi) occurs at higher field (6.29 ppm). The proposed interpretation of the spectrum is confirmed by the method of double resonance; this permitted the determination of a small allylic interaction (J = 0.8 Hz) between the protons of the methyl group at the 3 position of the indole (IVj) and the 2-H proton. A proton is added at the 3 position of the indoles (IVi, j) in trifluoroacetic acid; this gives a characteristic doublet signal at 1.76 ppm for the methyl group in the indole (IVj), and a quadruplet at 4.54 ppm (J = 7.5 Hz) for the proton at the 3 position. The analysis of the spectrum of the indoles (IVk, l) gives analogous results. The isomers (IVk) and (IVl) are present in the mixture in approximately the same ratio as exists for the indoles (IVi, j). In contrast to the mixture of the indoles (IVi, j), the aromatic part of the spectrum of the indoles (IVk, l) is better resolved; this facilitates the interpretation of the spectrum. The presence of the absorption of the protons of the two propyl groups, corresponding to the isomeric indoles (IVk, l), is characteristic of the aliphatic part of the spectrum.

The indoles (IVi-l) were successfully separated chromatographically on chromato-mass spectral investigation; their decomposition under the action of electron impact was studied. The main routes of decomposition are the formation of the $[M-H]^+$, $[M-CH_3]^+$ and $[M-H]^+$, $[M-C_2H_5]^+$ ions correspondingly for the dissociative ionization of the indoles (IVj) and (IVl). In the case of the fragmentation of the indoles (IVi) and (IVk), the most characteristic routes of decomposition are the formation of the $[M-H]^+$ and $[M-CH_3]^+$ ions correspondingly.

The results presented are in accord with the analogous data previously obtained [15, 16] taking as an example the reaction of 1,2,4,5,6-pentamethyl-3-nitropyridinium iodide with methylamine and methyl alkyl ketones.

Therefore, we managed to find the reaction path, which was confirmed by studying the character of the migration of the alkyl radical at the 3 position of the indole, and to prove the proposed structures reliably at the same time.

The composition and structure of the remaining compounds obtained in the work were shown by spectral investigation methods in regard to the derivatives of the synthesized indoles. The position of the substituents in the benzene nucleus of the indoles (IVa, c, h) was specified using the ^{13}C NMR spectra, including the partial uncoupling from the protons according to the method previously proposed for 4-ethyl- and 4-propyl-1,2,6,7-tetramethylindoles [17].

The detailed analysis of the products of the reaction of nitropyridinium salts with ketones and alkylamines is carried out in the present work; it permitted the acquisition of new data testifying in favor of the previously proposed scheme for the formation of indoles from pyridinium salts [7].

EXPERIMENTAL

The PMR spectra were taken on a Bruker WM-500 spectrometer for the compounds (IXa, b) in $CDCl_3$ and (IVg, i-l) in acetone-D_6, and a Varian T-60 spectrometer for the alkylindoles (IVa, c, h) in $CDCl_3$, with reference to HMDS. The ^{13}C NMR spectra were taken on a Bruker WM-250 spectrometer in $CDCl_3$. The mass spectra were taken on a Finnigan-4021 instrument. The peaks of the molecular ions and the ions to 5% of the intensity were presented. The chromato-mass spectral analysis of the reaction products was accomplished on a Varian MAT Gnom 111 instrument with a column filled with SE-30 (5%). The UV spectra were taken on a Cary-219 instrument in ethanol. The course of the reaction was monitored using TLC (Silufol UV-254) in benzene.

(3-Nitro-4-pyridyl)malonic Ester. Sodium powder in toluene was obtained from 4.9 g (0.21 mole) of sodium. The toluene was decanted. To the sodium powder were added 516 ml of absolute ether and, with stirring, 33 ml (0.21 mole) of malonic ester dropwise. After solution of the sodium was effected, the ether was distilled. To the mixture were added 62 ml of DMF; it was heated in vacuo until the complete removal of the residues of ether was effected. A further 20 ml of DMF were added. Then, 24 g (0.16 mole) of 4-methoxy-3-nitropyridine (V) were gradually added at 20°C. The reaction mixture was heated for 1 h at 70°C prior to the distillation of the solvent in vacuo; the residue was dissolved in 60 ml of water, and was neutralized with 12-13 ml of acetic acid. The reaction product was extracted with ether; the extract was concentrated. The yield was 39 g (91%); the hydrochloride had the mp 123-124°C. According to the data of [11], it has the mp 125-126°C.

General Method for the Synthesis of Alkylindoles. The mixture of 10 mmole of the iodide (I) and 20 ml of a 10% solution of the alkylamine in the ketone was left at 20°C for 5-8 days. The reaction mixture was concentrated, and the residue was extracted with hexane. The indoles were separated on a column with silica gel L100/160 μm in the 1:4 system of benzene—hexane (see Table 1).

1,2,4,6-Tetramethylindole (IVa). This compound was obtained by analogy with the preceding description by the reaction of 5 mmole of the iodide (Ia) with 1 ml of acetone in 20 ml of a 25% aqueous solution of methylamine. The yield was 3%; the mp was 82-83°C [7].

General Method of the Isolation of the Nitroenamines (IXa, b). For the isolation of the compounds (IXa, b), the residue after the extraction of the indoles with hexane was separated on a column with silica gel L40/100 μm in ethyl acetate.

1,2,6-Trimethyl-4-nitromethylene-6-propyl-1,4,5,6-tetrahydropyridine (IXa). This compound was obtained as described above by the reaction of the iodide (Ia) with methylamine in methyl propyl ketone. The yield was 22%. The product had the mp 96-101°C. The UV spectrum, expressed as λ_{max} (log ε), was as follows: 266 nm (3.80) and 469 nm (4.49). The PMR spectrum ($CDCl_3$) for the Z-isomer was as follows: 0.87 (t, 3'-CH_3, J = 7.2 Hz), 1.19 (s, 6-CH_3), 1.21 (m, 2'-CH_2), 1.42 and 1.61 (m, 1'-CH_2), 2.05 (s, 2-CH_3), 2.23 and 2.36 (q, 5-H, J = 15.6 Hz), 2.91 (s, CH_3N), 6.45 (s, $CHNO_2$), and 6.66 ppm (s, 3-H). The corresponding spectrum of the E-isomer was as follows: 0.86 (t, 3'-CH_3, J = 7.2 Hz), 1.20 (m, 2'-CH_2), 1.21 (s, 6-CH_3), 1.43 and 1.60 (m, 1'-CH_2), 1.97 (s, 2-CH_3), 2.88 (s, CH_3N), 2.98 and 3.48 (m, 5-H, J_{gem} = 17.8, $J_{CH_2CHNO_2}$ = 1.2 Hz), 5.01 (s, 3-H), and 6.82 ppm (d, $CHNO_2$, J = 1.2 Hz). The ^{13}C NMR spectrum ($CDCl_3$) for the Z-isomer was as follows: 14.3 (3'-CH_3, J_{CH} = 125 Hz), 22.56 and 22.63 (2- and 6-CH_3, J_{CH} = 127 Hz), 29.56 (1'-CH_2, J_{CH} = 127 Hz), 31.69 (CH_3N, J_{CH} = 137 Hz), 37.89 (2'-CH_2, J_{CH} = 125 Hz), 39.22 [$C_{(5)}$, J_{CH} = 130 Hz], 59.73 $C_{(6)}$, 98.05 [$C_{(3)}$, J_{CH} = 176 Hz], 119.23 ($CHNO_2$, J_{CH} = 187 Hz), 144.77 [$C_{(4)}$], and 160.65 ppm [$C_{(2)}$]. The corresponding spectrum of the E-isomer was as follows: 17.38 (3'-CH_3), 22.20 and 23.06 (2- and 6-CH_3), 29.26 (1'-CH_2), 31.50 (CH_3N), 35.44 [$C_{(5)}$], 38.49 (2'-CH_2), 59.08 [$C_{(6)}$], 97.28 [$C_{(3)}$], and 122.13 ppm ($CHNO_2$). The mass spectrum (m/z) was as follows: 224 (26), 213 (73), 212 (16), 183 (15), 181 (31), 167

TABLE 1. Reaction of Nitropyridinium Salts with Ketones and Amines and the Properties of the Indoles Obtained

Pyridinium salt	Ketone	Indole	M+	mp, °C	PMR spectrum, δ, ppm	Yield, %
Ia	$(CH_3)_2CO$	IVa	173	82—83	6,83 and 6,97 (s, 5- and 7-H); 6,27 (s 3-H); 3,43 (s, CH_3N); 2,27—2,47 [3 s, 2,4,6-$(CH_3)_3$]	3
	$CH_3COC_3H_7$	IVc	201	64—66	6,62 (s, 5-H); 6,08 (s, 3-H); 3,57 (s CH_3N); 2,92 (m CH_2, Jvic = 7 Hz); 2,17—2,32 [3 s, 2,4,6-$(CH_3)_3$]; 1,13 (t, CH_3, Jvic = 7 Hz)	8
Ie		IVa	173	—	6,83 and 6,97 (s, 5- and 7-H); 6,27 (s, 3-H); 3,43 (s, CH_3N); 2,27—2,47 [3 s, 2,4,6-$(CH_3)_3$]	3
If	$(CH_3)_2CO$	IVg	159	50—51	7,21 (d, 4-H, J_{45}=7,9 Hz); 7,00 (s, 7-H); 6,73 (m, 5-H, J_{45}=7,9, J_{57}=1,5 Hz); 6,03 (s, 3-H); 3,55 (s, CH_3N); 2,34 (s, 6-CH_3); 2,29 (d, 2-CH_3), $J_{3\text{-}H,CH_3}$=0,9 Hz)	3
	$(CH_3)_2CO$	IVh	145	184*	6,84 and 7,08 (m 5-, 6-, and 7-H); 6,94 (d, 2-H, J_{23}=3 Hz); 6,42 (d, 3-H, J_{23}=3 Hz); 3,66 (s, CH_3N); 2,48 (s, 4-CH_3)	8
	$CH_3COC_2H_5$	IVi	159	—	6,97 (d, 2-H, J_{23}=3 Hz); 6,64 (m 5-H); 6,58 (d, 6-H, J_{56}=7,5 Hz); 6,29 (d, 3-H, J_{23}=3 Hz); 3,98 (s, CH_3N); 2,62 (s, 4-CH_3); 2,33 (s, 7-CH_3) [(in CF_3COOH) 9,15 (s, 2-H); 7,45 (d, 6-H, J_{56}=7,5 Hz); 7,41 (d, 5-H, J_{56}=7,5 Hz); 4,48 (s, CH_3N); 4,30 (s, 3-H); 2,80 (s, 7-CH_3); 2,47 (s 4-CH_3)]	9
		IVj	159	—	7,03 (s 5-H; J_{56}=8 Hz); 6,90 (m, 6-H); 6,79 (s 2-H); 6,6 (m 7-H); 3,61 (s CH_3N); 2,57 (s, 4-CH_3); 2,38 (s, 3-CH_3) [(in CF_3COOH) 9,12 (s, 2H); 7,65 (t, 6-H); 7,59 (m, 5- and 7-H); 4,54 (q, 3-H, Jvic = 7,5 Hz); 4,26 (s, CH_3N); 2,61 (s, 4-CH_3); 1,76 (d, 3-CH_3, Jvic = 7,5 Hz)]	13
If	$CH_3COC_4H_9$	IVk	187	—	7,00 (d, 2-H, J_{23}=3 Hz); 6,71 (d, 5-H, J_{56}=7 Hz); 6,63 (d, 6-H, J_{56}=7 Hz); 6,31 (d, 3-H, J_{23}=3 Hz); 3,95 (s, CH_3N); 2,93 (m 1'-CH_2); 2,70 (s 4-CH_3); 1,57—1,65 (m, 2'-CH_3); 0,93 (t, CH_3); 0,93 (t, CH_3, J = = 7 Hz)	1
		IVl	187	—	7,05 (d, 5-H, J_{56}=8 Hz); 6,92 (m, 6-H, J_{56}=8 Hz, J_{67}=7 Hz); 6,85 (s, 2-H); 6,65 (d, 7-H, J_{67}=7 Hz); 3,64 (s, CH_3N); 2,78 (m, 1'-CH_2); 2,56 (s, 4-CH_3); 1,57—1,65 (m, 2'-CH_2); 0,93 (t, CH_3, J=7 Hz)	1

*For the picrate. According to the data of [18], it has the mp 187°C.

(17), 166 (18), 165 (30), 164 (89), 163 (22), 155 (12), 140 (27), 57 (15), 56 (100), 55 (16), 51 (14), and 50 (31).

1,2,6-Trimethyl-4-nitromethylene-6-ethyl-1,4,5,6-tetrahydropyridine (IXb). This compound was obtained in the same way by the reaction of the iodide (Ia) with methylamine in methyl ethyl ketone. The yield was 14%; the product had the mp 102-107°C. The UV spectrum, expressed as λ_{max} (log ε), was as follows: 265 nm (3.76) and 468 nm (4.46). The IR spectrum (mineral oil) was as follows: 1343 cm^{-1} (νNO_2^s) and 1540 cm^{-1} (νNO_2^{as}). The PMR spectrum ($CDCl_3$) for the Z-isomer was as follows: 0.83 (t, 2'-CH_3, J_{vic} = 7.5 Hz), 1.19 (s, 6-CH_3), 1.51 and 1.71 (2 m, 1'-CH_2, J_{vic} = 7.5 Hz), 2.07 (s, 2-CH_3), 2.20 and 2.40 (q, 5-H, J = 15.8 Hz), 2.92 (s, CH_3N), 6.45 (s, $CHNO_2$), and 6.66 ppm (s, 3-H). The corresponding spectrum of the E-isomer was as follows: 0.85 (t, 2'-CH_3, J_{vic} = 7.5 Hz), 1.21 (s, 6-CH_3), 1.53 and 1.69 (2 m, 1'-CH_2, J_{vic} = 7.5 Hz), 1.99 (s, 2-CH_3), 2.89 (s, CH_3N), 3.00 and 3.46 (q, 5-H, J = 17.2 Hz), 5.01 (s, 3-H), and 6.81 ppm (s, $CHNO_2$). The ^{13}C NMR spectrum ($CDCl_3$) for the Z-isomer was as follows: 7.92 (2'-CH_3), 21.93 and 22.66 (2- and 6-CH_3), 28.03 (1'-CH_2), 31.56 (CH_3N), 38.39 [$C_{(5)}$], 59.89 [$C_{(6)}$], 98.12 [$C_{(3)}$], 119.25 ($CHNO_2$). 144.72 [$C_{(4)}$], and 160.67 ppm [$C_{(2)}$]. The corresponding spectrum of the E-isomer was as follows: 8.40 (2'-CH_3), 22.22 and 22.40 (2- and 6-CH_3), 28.58 (1'-CH_2), 31.37 (CH_3N), 34.64 [$C_{(5)}$], 59.23 [$C_{(6)}$], 97.31 [$C_{(3)}$], 122.15 ($CHNO_2$), 149.90 [$C_{(4)}$], and 158.21 [$C_{(2)}$]. The mass spectrum (m/z) was as follows: 210 (36), 209 (15), 181 (28), 180 (11), 178 (9), 165 (19), 164 (88), 163 (32), 135 (9), 121 (9), 112 (10), 110 (10), 57 (9), 56 (100), and 55 (13).

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SYNTHESIS OF 1,4,5,6-TETRAHYDROPYRIDINE DERIVATIVES STARTING FROM trans-3-CHLORO-1,3-ALKADIEN-5-ONES

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A method has been developed for the synthesis of 3-carbethoxy-2-methyl-6-(oxoalkylidene)-1,4,5,6-tetrahydropyridines by reaction of trans-3-chloro-1,3-alkadien-5-ones with ethyl aminocrotonate. It is shown that the corresponding vinylacetylanic ketones are intermediate products of the reactions.

β-Chlorovinyl ketones are reagents for C-, N-, O-, P-, and S-ketovinylation [2]. In particular, reaction of β-chlorovinyl ketones with ethyl aminocrotonate gives ethyl esters of 2-methyl-6-alkylnicotinic acid [3].

With a view to developing a method for the synthesis of nitrogen-containing heterocyclic compounds, it was of interest to react vinyl-substituted derivatives of β-chlorovinyl ketones — trans-3-chloro-1,3-alkadien-5-ones — in an analogous manner. The reactions were conducted without a solvent at 100°C with a molar ratio of dienone—ethyl aminocrotonate of 1:2.5. It turned out that the reaction products were not ethyl 4-vinyl-2-methyl-6-alkylnicotinates but 3-carbethoxy-2-methyl-6-(2-oxoalkylidene)-1,4,5,6-tetrahydropyridines.

β-Chlorovinyl ketones react with ethyl aminocrotonate through the chlorovinyl and carbonyl groups [3]. In the case of trans-3-chloro-1,3-alkadien-5-ones, as is evident from the structure of compounds I-V, the chlorovinyl and terminal vinyl groups participate in the reaction.

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