The PMR spectra of the N-oxides and the quaternary salts were obtained from solutions in D_2O with a JEOL-PS-100 spectrometer at room temperature. The chemical shift of D_2O was 4.70 ppm.

LITERATURE CITED

1. V. J. Baker, I. D. Blackburn, and A. R. Katritzky, J. Chem. Soc., Perkin II, No. 10, 1563 (1974).
2. M. J. Cook, A. R. Katritzky, and M. Manas, J. Chem. Soc., B, No. 7, 1330 (1971).
3. Y. Shvo and E. D. Kaufman, Tetrahedron, 28, 573 (1972).
4. D. R. Brown, R. Lygo, J. McKenna, J. M. McKenna, and B. G. Butley, J. Chem. Soc., B, No. 6, 1184 (1967).
5. S. Abidi, G. Fodor, C. S. Huber, J. Miura, and N. Nakanishi, Tetrahedron Lett., No. 4, 355 (1972).
6. A. A. Akhrem, L. I. Ukhova, and N. F. Marchenko, Khim. Geterotsikl. Soedin., No. 3, 394 (1974).
7. A. A. Akhrem, L. I. Ukhova, N. F. Marchenko, and N. F. Uskova, Izv. Akad. Nauk SSSR, Ser. Khim., No. 12, 2776 (1968).
8. A. A. Akhrem, L. I. Ukhova, N. F. Marchenko, and V. M. Gorul'ko, Khim. Geterotsikl. Soedin., No. 10, 1378 (1976).
9. Y. Kawazoe, M. Tsuda, and M. Ohnishi, Chem. Pharm. Bull. (Tokyo), 15, 51 (1967).
10. J. K. Becconsall, R. A. Y. Jones, and J. McKenna, J. Chem. Soc., No. 7, 1726 (1965).
11. J. C. N. Ma and E. W. Waruholf, Can. J. Chem., 43, 1849 (1965).
12. A. A. Akhrem, V. M. Gorul'ko, L. I. Ukhova, N. F. Marchenko, and A. P. Marochkin, Khim. Geterotsikl. Soedin., No. 10, 1372 (1976).

RESEARCH IN THE IMIDAZOLE SERIES

XCII.* REDUCTION OF SOME PYRROLO[1,2-a]IMIDAZOLE AND PYRROLO[1,2-a]BENZIMIDAZOLE DERIVATIVES

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UDC 547.76.785:542.942

The reduction of pyrrolo[1,2-a]imidazole-2-one and pyrrolo[1,2-a]benzimidazole derivatives, which leads to the formation of 2,3-dihydropyrrolo[1,2-a]imidazole derivatives and derivatives of the previously unknown 1,2,3,3a-tetrahydropyrrolo[1,2-a]benzimidazole, was studied. A method was developed for the preparation of 5- and 7-amino derivatives of pyrrolo[1,2-a]-imidazole by reduction of the corresponding nitroso- and arylazo-substituted pyrrolo[1,2-a]-imidazoles.

Little study [2] has been devoted to the reduction of derivatives of polynuclear systems with a bridged nitrogen atom that include a pyrroloimidazole fragment. In developing research [3, 4] on the transformations of compounds of the pyrrolo[1,2-a]imidazole and pyrrolo[1,2-a]benzimidazole series we studied the reduction of some derivatives of these systems.

A method for the preparation of 2,3-dihydropyrrolo[1,2-a]imidazole derivatives from 1,2-dialkylimidazolines and α-halo ketones was proposed in [5]. In order to develop other methods for the synthesis of these compounds we carried out the reduction of pyrrolo[1,2-a]imidazol-2-ones (I, II) with lithium aluminum hydride

*See [1] for communication XCI.

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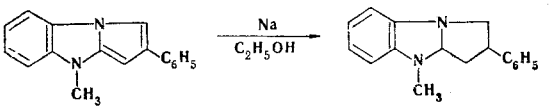
in ether. It was established that only the carbonyl group is reduced under these conditions without involvement of the pyrrole ring.

I, II III, IV

I, III R = C_6H_5; II, IV R = H

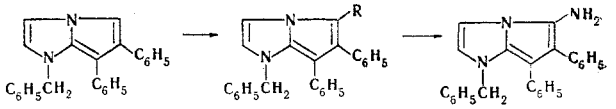
The action of sodium in alcohol on 2-phenyl-4-methylpyrrolo[1,2-a]benzimidazole (V) leads to reduction of the pyrrole ring and formation of 1,2,3,3a-tetrahydro-2-phenyl-4-methylpyrrolo[1,2-a]benzimidazole (VI).



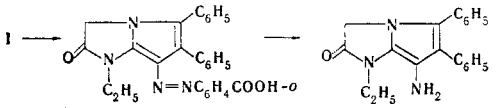
V VI

The structures of the synthesized dihydropyrroloimidazoles (III, IV) and tetrahydropyrrolobenzimidazole (VI) were confirmed by data from the PMR spectra, in which the distinct signals of protons of both methylene and methylidyne groups are observed.

In order to synthesize amines of the pyrroloimidazole series we also studied the reduction of 5-nitroso, 5-arylazo, and 7-arylazo derivatives of this heterocycle (X-XII) [4]. Reducing agents that reduce the functional groups without involvement of the pyrrole ring were also used in this reaction.



IX X, XI XIII



XII XIV

X R = NO; XI R = N=NC$_6$H$_4$COOH-*o*

Compounds X-XII are easily reduced by zinc in glacial acetic acid or by sodium hydrosulfite in aqueous alcoholic alkali to the corresponding 5- or 7-amino derivatives XIII and XIV. The latter, in contrast to the 1-amino derivatives of pyrrolobenzimidazole [2], are stable in the base form.

EXPERIMENTAL

The IR spectra of mineral oil suspensions of the compounds were recorded with a UR-10 spectrometer. The PMR spectra of $CDCl_3$ and CCl_4 solutions of the compounds were recorded with a JNM-4H-100 spectrometer with tetramethylsilane as the internal standard.

1-Ethyl-5,6-diphenylpyrrolo[1,2-a]imidazol-2-one (I) was prepared by the method in [6].

1-Ethyl-6-phenylpyrrolo[1,2-a]imidazol-2-one (II). This compound, with mp 109-110° (from methanol), was obtained in 19% yield by the method used to prepare I. Found: C 74.0; H 6.4; N 12.1%. $C_{14}H_{14}N_2O$. Calculated: C 74.3; H 6.2; N 12.3%.

1-Ethyl-2,3-dihydro-5,6-diphenylpyrrolo[1,2-a]imidazole (III). A solution of 3 g (0.01 mole) of I in 230 ml of ether was added with stirring to a solution of 4.5 g (0.12 mole) of lithium aluminum hydride in 520 ml of absolute ether, and the mixture was refluxed for 2 h, after which it was allowed to stand at 18-20° for 24 h. It was then treated with 18 ml of water, and 270 ml of 10% H_2SO_4 was added until the precipitated lithium and aluminum hydroxide dissolved completely. The ether layer was separated, washed with saturated NaCl solution, and dried with $MgSO_4$. The ether was removed by distillation to give 2.6 g (91%) of a product with mp 116-118° (from ethanol). PMR spectrum ($CDCl_3$), ppm: 1.21, 3.05 (CH_2CH_3); 3.49 (3-CH_2); 3.99 (2-CH_2); 5.33 (7-H); 6.9-7.3 (C_6H_5). Found: C 83.4; H 7.1; N 9.8%. $C_{20}H_{20}N_2$. Calculated: C 83.3; H 7.0; N 9.7%.

1-Ethyl-2,3-dihydro-6-phenylpyrrolo[1,2-a]imidazole (IV). This compound was prepared by the method used to synthesize pyrroloimidazole III. It was isolated in the form of the picrate, with mp 119-201° (from nitromethane), in 20% yield. Found: C 54.5; H 4.3; N 15.6%. $C_{14}H_{16}N_2 \cdot C_6H_3N_3O_7$. Calculated: C 54.4; H 4.3; N 15.9%.

1,2,3,3a-Tetrahydro-2-phenyl-4-methylpyrrolo[1,2-a]benzimidazole (VI). Lumps of sodium [10 g (0.4 g-atom)] were added in the course of 5 min to a refluxing solution of 2.5 g (0.01 mole) of 2-phenyl-4-methylpyrrolo[1,2-a]benzimidazole (V) [7] in 100 ml of absolute ethanol, after which the mixture was refluxed for 30 min. It was then cooled and treated with 100 ml of water, and the precipitate was removed by filtration and washed with water and alcohol to give 0.9 g (36%) of a product with mp 104-106° (from ethyl acetate). PMR spectrum (CCl_4), ppm: 3.32 (1-H and 2-H); 2.20 (3-H); 4.92 (3a-H); 2.69 (n-CH_3). Found: C 81.7; H 7.0; N 11.2%. $C_{17}H_{18}N_2$. Calculated: C 81.6; H 7.2; N 11.2%.

1,2-Dibenzylimidazole (VII). This compound, with mp 190-192° (3 mm) and mp 75-77°, was obtained in 52% yield by benzylation of 2-benzimidazole under the conditions of the synthesis of 1-benzyl-2-methylimidazole [8]. Found: C 82.4; H 6.4; N 11.1%. $C_{17}H_{16}N_2$. Calculated: C 82.2; H 6.5; N 11.3%.

1,2-Dibenzyl-3-phenacylimidazolium Bromide (VIII). This compound, with mp 256-258° (from absolute ethanol), was obtained in 70% yield from VII and phenacyl bromide by the method in [6]. Found: C 67.3; H 5.3; Br 16.8; N 6.0%. $C_{25}H_{23}BrN_2O$. Calculated: C 67.1; H 5.2; Br 16.9; N 6.2%.

1-Benzyl-6,7-diphenylpyrrolo[1,2-a]imidazole (IX). This compound, with mp 120-122° (from ethanol), was obtained in 59% yield by refluxing bromide VIII in an alcohol solution of sodium ethoxide by the method in [9]. Found: C 85.9; H 6.0; N 8.0%. $C_{25}H_{20}N_2$. Calculated: C 86.2; H 5.8; N 8.0%.

1-Benzyl-5-nitroso-6,7-diphenylpyrrolo[1,2-a]imidazole (X). A solution of 0.35 g (5 mmole) of sodium nitrite in 1 ml of water was added with stirring at 18-20° to a solution of 1.74 g (5 mmole) of IX in 25 ml of glacial acetic acid, and the mixture was stirred at the same temperature for 15 min. It was then diluted with 35 ml of water, and the aqueous mixture was cooled and made alkaline to pH 8 with aqueous NaOH solution. The precipitate was removed by filtration to give 0.75 g (40%) of green plates with mp 193-195° (from ethanol). Found: N 11.5%. $C_{25}H_{19}N_3O$. Calculated: N 11.1%.

1-Benzyl-5-(o-carboxyphenylazo(-6,7-diphenylpyrrolo[1,2-a]imidazole (XI). A solution of 1.75 g (4 mmole) of IX in 200 ml of acetic acid was added to a solution of diazonium chloride prepared by diazotization of 1 g (6.9 mmole) of anthranilic acid with $NaNO_2$ in 20 ml of acidified alcohol. The mixture was allowed to stand at 18-20° for 24 h, after which it was poured into water, and the aqueous solution was neutralized to pH 6-7 with ammonium hydroxide. The resulting precipitate was removed by filtration to give 1.38 g (55%) of red needles with mp 242-243° (dec., from ethanol). Found: C 75.4; H 5.4; N 10.9%. $C_{32}H_{24}N_4O_2 \cdot H_2O$. Calculated: C 74.7; H 5.1; N 10.9%.

1-Ethyl-5,6-diphenyl-7-(o-carboxylphenylazo)pyrrolo[1,2-a]imidazol-2-one (XII). This compound, with mp 233-235° (from 80% ethanol), was obtained in 98% yield as orange needles from pyrroloimidazolone I by the method used to prepare XI. Found: C 69.2; H 4.9; N 12.1%. $C_{27}H_{22}N_4O_3 \cdot H_2O$. Calculated: C 69.2; H 5.1; N 12.0%.

1-Benzyl-5-amino-6,7-diphenylpyrrolo[1,2-a]imidazole (XIII). A) Zinc dust (2 g) was added with stirring to a solution of 1 g (2.8 mmole) of X in 35 ml of glacial acetic acid, and the mixture was allowed to stand at 30° for 2 h. It was then filtered, and 100 ml of water was added to the filtrate. The aqueous solution was neutralized to pH 8-9 with ammonium hydroxide and extracted with ether. The ether extract was washed with water, dried with $MgSO_4$, and treated with an ether solution of hydrogen chloride. Workup gave 0.5 g (63%) of XIII hydrochloride with mp 211-213° (from methanol). Found: C 75.1; H 5.4; N 10.5%. $C_{25}H_{21}N_3 \cdot HCl$. Calculated: C 75.1; H 5.5; N 10.5%.

B) Zinc dust (2.5 g) was added to a solution of 0.97 g (2 mmole) of XI in 100 ml of glacial acetic acid, and the mixture was stirred at room temperature for 20 min. It was then worked up by method A to give 0.75 g (81%) of XIII hydrochloride with mp 211-213°. No melting-point depression was observed for a mixture of this product with a sample obtained by method A.

1-Ethyl-5,6-diphenyl-7-aminopyrrolo[1,2-a]imidazol-2-one (XIV). A) Zinc dust (1.65 g) was added to a solution of 1 g (2 mmole) of XII in 30 ml of glacial acetic acid, and the mixture was heated at 100° until it became completely colorless. It was then poured into water, and the resulting suspension was neutralized to pH 8-9 with ammonium hydroxide and extracted with ether. The solvent was removed by distillation to give

0.6 g (37%) of a product with mp 177-179° (from 80% ethanol). IR spectrum: 3400 and 3280 (NH_2), 1680 (CO) cm^{-1}. Found: C 71.1; H 6.1; N 12.0%. $C_{20}H_{19}N_3O \cdot H_2O$. Calculated: C 71.6; H 6.0; N 12.5%.

B) A total of 200 ml of 2 N NaOH and 5 g (0.3 mole) of sodium hydrosulfite were added to a solution of 2.3 g (5 mmole) of XII in 200 ml of 80% ethanol, and the mixture was gradually heated to 80° and allowed to stand at this temperature until it became completely colorless (1 h). It was then filtered, and the filtrate was cooled and extracted with ether. The ether extract was evaporated to give 0.3 g (19%) of a product with mp 177-179°. The product was identical to the product obtained by method A.

LITERATURE CITED

1. A. A. Druzhinina and P. M. Kochergin, Khim. Geterotsikl. Soedin., No. 12, 1658 (1976).
2. F. S. Babichev, G. P. Kutrov, and M. Yu. Kornilov, Ukr. Khim. Zh., 36, No. 9, 909 (1970).
3. P. M. Kochergin, Yu. N. Sheinker, A. A. Druzhinina, R. M. Palei, and L. M. Alekseeva, Khim. Geterotsikl. Soedin., No. 6, 826 (1971).
4. A. A. Druzhinina, P. M. Kochergin, and L. M. Alekseeva, Khim. Geterotsikl. Soedin., No. 3, 405 (1972).
5. A. A. Druzhinina and P. M. Kochergin, USSR Author's Certificate No. 196,867; Byul. Izobr., No. 12, 40 (1967).
6. A. A. Druzhinina and P. M. Kochergin, Khim. Geterotsikl. Soedin., No. 3, 532 (1967).
7. R. M. Palei and P. M. Kochergin, Khim. Geterotsikl. Soedin., No. 3, 536 (1967).
8. A. A. Druzhinina and P. M. Kochergin, Khim. Geterotsikl. Soedin., No. 3, 527 (1967).
9. A. A. Druzhinina, P. M. Kochergin, and N. P. Bychkova, Khim. Geterotsikl. Soedin., No. 5, 856 (1969).

REACTIONS WITH ELECTRON TRANSFER TO N-ACYLHETEROAROMATIC CATIONS

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The behavior of some benzoquinolines and imidazoles in reactions with acylating agents in the presence of zinc dust was investigated. The possibility of free-radical hetarylation under these conditions of organic compounds by the intermediately formed N-acylheteroaromatic radicals was established. The structure of 2,2'-diacetyl-1,1',2,2'-tetrahydro-1,1'-diisoquinolyl was determined by means of x-ray diffraction analysis.

The electrophilicity of N-heteroaromatic cations increases as the electron-acceptor properties of the substituents attached to the heteroatom increases [1] and becomes particularly high in the case of N-acylheteroaromatic cations. The high electrophilicity of the latter is manifested not only by the fact that they can readily add to reaction centers with increased electron density (the so-called hetarylation reaction [2]): reactions involving one-electron transfer to the heteroring, which leads to the formation of N-acylheteroaromatic radicals, are also facilitated in this series. The anions themselves of the corresponding salts [2] and various metals can act as electron donors for cations of this sort, and, in contrast to N-alkylpyridinium salts, which are reduced only by sodium amalgam under severe conditions, the reduction of N-acyl salts proceeds at room temperature under the influence of zinc and even less active metals [3]. The resulting N-acylpyridine radicals are extremely stable in some cases and may exist in the crystalline state for a rather long time, but they most often immediately recombine to give 1,1'-diacyl-1,1',4,4'-tetrahydro-4,4'-dipyridyls. This reaction has been extended to N-acylpyridinium and benzopyridinium salts [4, 5]. However, N-acyl salts of acridine were re-

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