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PREPARATION OF 2-ARYL-SUBSTITUTED IMIDAZO[4,5-b]PYRIDINES AND IMIDAZO[4,5-c]PYRIDINES

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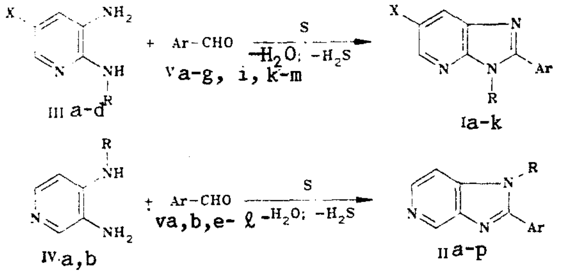
It is proposed that sulfur be used as the oxidizing agent in the synthesis of 2-arylimidazopyridines from o-diaminopyridines and aromatic (heteroaromatic) aldehydes. Benzyl alcohols and benzylpyridinium salts can be used in place of aldehydes. 2-Phenylimidazopyridines are also formed in the thermal oxidation with sulfur of o-diaminopyridines with a benzyl substituent attached to the ring or exocyclic nitrogen atoms.

It is known that o-diamines of the benzene series readily undergo cyclization to the corresponding benzimidazoles on heating with carboxylic acids or their anhydrides [1, 2]. However, imidazopyridines cannot be obtained by this method, since, with rare exceptions [3, 4], N-acylation products are formed from o-diaminopyridines [5-7]. The cyclization of o-diaminopyridines with aromatic acids proceeds only in strong dehydrating agents [polyphosphoric acid (PPA), $POCl_3$] [7, 8]. In this connection, the synthesis of imidazopyridines from o-diaminopyridines and aldehydes in the presence of oxidizing agents such as air oxygen, nitrobenzene [9], or a copper(II) salt [5, 10] is of particular interest.



I a–e, i–k X=H, f, g X=Cl, h X=Br; a–j R=H, k $R=CH_3$; a $Ar=C_6H_5$, b $Ar=4\text{-}ClC_6H_4$, c $Ar=4\text{-}FC_6H_4$, d $Ar=4\text{-}HOC_6H_4$, e $Ar=4\text{-}CH_3OC_6H_4$, f $Ar=4\text{-}(CH_3)_2NC_6H_4$, g $Ar=2\text{-}(HO)\text{-}3\text{-}(CH_3O)C_6H_3$, h $Ar=2{,}5\text{-}(CH_3O)_2C_6H_3$, i Ar=2-thienyl, Ar=3-pyridyl, k Ar=1-methyl-3-indolyl; II a, c–e, h, j, ℓ, n, p R=H; b, f, g, i, k, m, o $R=CH_3$; a, b $Ar=C_6H_5$, c $Ar=4\text{-}ClC_6H_4$, d $Ar=4\text{-}CH_3OC_6H_4$, e, f $Ar=4\text{-}(CH_3)_2NC_6H_4$, g $Ar=2\text{-}(HO)\text{-}3\text{-}(CH_3O)C_6H_3$, h $Ar=4\text{-}(HO)\text{-}3\text{-}(CH_3O)C_6H_3$, i $Ar=4\text{-}(HO)\text{-}3\text{-}(CH_3O)C_6H_3$, j, k $Ar=3{,}4\text{-}(CH_3O)_2C_6H_3$, ℓ, m $Ar=2{,}5\text{-}(CH_3O)_2C_6H_3$, n, o Ar=2-thienyl p Ar=3-pyridyl; III a, b X=H, c X=Cl, d X=Br; a, c, d R=H, b $R=CH_3$; IV a R=H; b $R=CH_3$; V a $Ar=C_6H_5$; b $Ar=4\text{-}ClC_6H_4$; c $Ar=4\text{-}FC_6H_4$; d $Ar=4\text{-}HOC_6H_4$; e $Ar=4\text{-}CH_3OC_6H_4$; f $Ar=4\text{-}(CH_3)_2NC_6H_4$; g $Ar=2\text{-}(HO)\text{-}3\text{-}(CH_3O)C_6H_3$; h $Ar=4\text{-}(HO)\text{-}3\text{-}(CH_3O)C_6H_3$; i $Ar=2{,}5\text{-}(CH_3O)_2C_6H_3$; j $Ar=3{,}4\text{-}(CH_3O)_2C_6H_3$; k Ar=2-thienyl, ℓ Ar=3-pyridyl; m Ar=1-methyl-3-indolyl.

We have found [11] that the simplest and most convenient modification of the last of the methods cited above for the synthesis of 2-arylimidazo[4,5-b]pyridines Ia, f and 2-aryl-

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TABLE 1. 2-Arylimidazo[4,5-b]pyridines Ia-e, i, j and 2-Arylimidazo[4,5-c]pyridines IIIa-d, p

Compound	Starting compounds		Reaction time, h		mp,* °C	mp, °C, lit. data	Yield, %	
	diamine	aldehyde	A	B			A	B
Ia	IIIa [13]	Va	1,5	2	290—291	291—293 [7] 294—295 [23]	92	93
Ib	IIIa	Vb	22	25	359—360	361 [7]	82	84
Ic	IIIa	Vc	12	15	289—290	219 [7]	77	75
Id	IIIa	Vd	16	20	329	340 [9]	84	85
Ie	IIIa	Ve	—	25	237—238	238 [9]	—	87
Ii	IIIa	Vk	22	25	275—276	273—274 [7]	76	75
Ij	IIIa	Vℓ	—	25	283—284	284 [20]	—	70
IIa	IVa	Va	4	5	227	224—225 [5]	91	90
IIb	IVb	Va	5	6	148—149	149 [10]	85	82
IIc	IVa	Vb	18	20	314	300 [19]	84	82
IId	IVa	Ve	5	6	243—244	243 [5]	80	82
IIp	IVa	Vℓ	12	15	245—246	247 [20]	80	77

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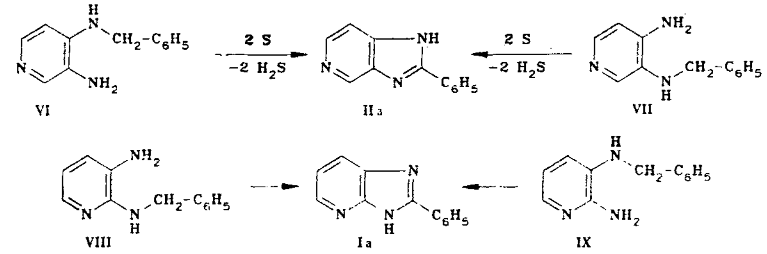
*The imidazopyridines were crystallized: IIa from 50% alcohol, Ib and IIc from DMF, Ia, c, e, j from methanol, Ii and IId from ethanol, IIb from water, Id from benzene—methanol, and IIp from MeCN—water.

imidazo[4,5-c]pyridines IIa, d, e involves the use of sulfur as the oxidizing agent for the intermediately formed (from o-diamines and aldehydes) dihydro derivatives of imidazopyridines [9]. To carry out the reaction, a mixture of equivalent amounts of the 2,3- or 3,4-diaminopyridine (IIIa-d, IVa, b), the aromatic or heteroaromatic aldehyde (Va-m), and sulfur is heated at high temperature (method A) or refluxed in a solvent (xylene, mesitylene) (method B) until hydrogen sulfide evolution ceases. Both known (Table 1) and previously undescribed (Table 2) I and II, including compounds that contain hydroxy, methoxy, and dimethylamino groups in the phenyl ring, were obtained in high yields by these methods.

Considering the oxidizing character of sulfur, we subjected benzyl alcohols, which may be precursors of aldehydes under these conditions, to the reaction with o-diamines. As a result, from diamine IVb, benzyl alcohol, and sulfur at 180-200°C we obtained 2-phenylimidazopyridine IIb; however, its yield did not exceed 20%. The cyclization of diamines IIIa and IVa with p-chlorophenylcarbinol proceeds considerably more readily. In this case the yields of 2-(p-chlorophenyl)imidazopyridines Ib and IIc reach 60%. The formation of Ia, c and IIa from diaminopyridines IIIa and IVa, sulfur, and 1-benzyl- or 1-(4-chlorobenzyl)pyridinium chloride, which have methylene groups that are quite active under the influence of an onium charge, proceeds very slowly and with low yields.

In contrast to benzylpyridinium chlorides, N,N-dimethylbenzylamine does not react with o-diaminopyridines in the presence of sulfur; however, this sort of reaction may occur intramolecularly if the N-benzyl group is a structural fragment of the diamine molecule. Heating both 3-amino-4-benzylaminopyridine (IV) and 4-amino-3-benzylaminopyridine (VII) with sulfur leads to the same 2-phenylimidazo[4,5-c]pyridine (IIa) in satisfactory yields. Similarly, 2-phenylimidazo[4,5-b]pyridine (Ia) was obtained from 3-amino-2-benzylamino- or 2-amino-3-benzylaminopyridine (VIII or IX) (Table 3).



The transformations described here made it possible to assume the possibility of realizing the oxidative cyclization or o-diamines also in those cases in which the benzyl substituent is bonded to the nitrogen atom of the pyridine ring rather than to an amino group. To verify this assumption, from diamines IIIa and IVa, benzyl chloride, and 4-chloro- and 3,4-dichlorobenzyl chlorides we prepared, in analogy with [12], pyridinium salts X and

TABLE 2. 2-Arylimidazo[4,5-b]pyridines If-h, k and 2-Arylimidazo[4,5-c]pyridines IIe-o

Compound	Starting compounds		Reaction time, h		mp,* °C	Found, %				Empirical formula	Calculated, %				Yield, %	
	diamine	aldehyde	A	B		C	H	Cl (Br)	N (S)		C	H	Cl (Br)	N (S)	A	B
If	IIIc [15]	Vf	1	2	306—307	61,9	4,9	13,2	20,8	$C_{14}H_{13}ClN_4$	61,6	4,8	13,0	20,5	86	85
Ig	IIIc	Vg	16	20	285—286	56,6	3,8	12,8	15,0	$C_{13}H_{10}ClN_3O_2$	56,6	3,7	12,8	15,2	92	94
Ih	IIId [16]	Vi	21	25	153—154	50,5	3,8	(23,7)	12,8	$C_{14}H_{12}BrN_3O_2$	50,3	3,6	(23,9)	12,6	89	87
Ik	IIIb [14]	Vm	6	9	160—161	72,9	5,3		21,2	$C_{16}H_{14}N_4$	73,2	5,4		21,4	87	89
IIe	IVa [17]	Vf	3	5	233—234	70,3	5,8		23,7	$C_{14}H_{14}N_4$	70,6	5,9		23,5	89	88
IIg	IVb [18]	Vg	8	10	198—199	66,0	4,9		16,3	$C_{14}H_{13}N_3O_2$	65,9	5,1		16,5	93	92
IIg HX					230—231	57,4	4,7	12,0	14,5	$C_{14}H_{13}N_3O_2 \cdot HCl$	57,6	4,8	12,2	14,4		
IIf	IVb	Vf	—	7	227—228	71,3	6,2		22,4	$C_{15}H_{16}N_4$	71,4	6,4		22,2	—	75
IIh HX	IVa	Vh	8	10	293—294	56,0	4,2	13,0	14,8	$C_{13}H_{11}N_3O_2 \cdot HCl$	56,2	4,4	12,8	15,1	85	88
IIi	IVb	Vh	—	8	217—218	65,7	5,0		16,2	$C_{14}H_{13}N_3O_2$	65,9	5,1		16,5	—	93
IIi HX					252—253	57,9	5,0	12,4	14,6	$C_{14}H_{13}N_3O_2 \cdot HCl$	57,6	4,8	12,2	14,4		
IIj HX	IVa	Vj	10	12	250—251	57,9	4,7	12,3	14,6	$C_{14}H_{13}N_3O_2 \cdot HCl$	57,6	4,8	12,2	14,4	88	90
IIk	IVb	Vj	12	15	125	67,1	5,4		15,8	$C_{15}H_{15}N_3O_2$	66,9	5,6		15,6	85	87
IIk HX					242—243	58,8	5,4	11,5	13,8	$C_{15}H_{15}N_3O_2 \cdot HCl$	58,9	5,3	11,6	13,7		
IIℓ	IVa	Vi	—	8	145—147	65,8	5,2		16,7	$C_{14}H_{13}N_3O_2$	65,9	5,1		16,5	—	75
IIℓ HX					230	57,4	4,6	12,5	14,2	$C_{14}H_{13}N_3O_2 \cdot HCl$	57,6	4,8	12,2	14,4		
IIm HX	IVb	Vi	10	12	253—254	59,0	5,4	11,4	14,0	$C_{15}H_{15}N_3O_2 \cdot HCl$	58,9	5,3	11,6	13,7	87	85
IIn	IVa	Vk	14	16	264—265	59,6	3,7		20,6 (15,9)	$C_{10}H_7N_3S$	59,7	3,5		20,9 (16,0)	83	78
IIo	IVb	Vk	10	12	130—131	61,4	4,3		19,4 (14,9)	$C_{11}H_9N_3S$	61,4	4,2		19,5 (14,9)	72	75

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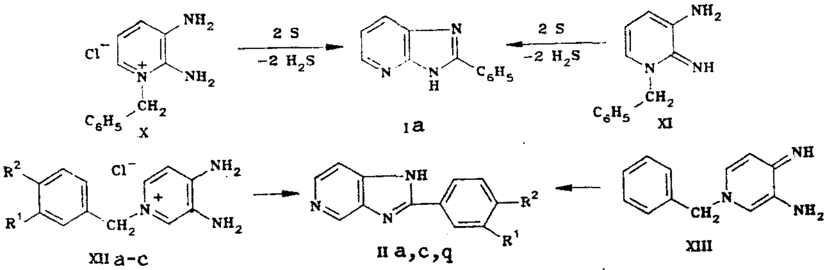
*The compounds were crystallized: If and IIf from methanol, Ik from benzene, Ig from propanol, IIg, k, ℓ from octane, IIo from decane, Ih, IIn, and the hydrochlorides (HX) of IIg-m from ethanol, IIi from dioxane, and IIe from ethanol—water.

XIIa-c. Imines XI and XIII were obtained by alkalization of aqueous solutions of salts X and XIIa.



IIa, XIIa $R^1=R^2=H$; IIc, XIIb $R^1=H$, $R^2=Cl$; IIq XIIc $R^1=R^2=Cl$

Oxidation and transfer of a benzyl group from the ring nitrogen atom to one of the exocyclic nitrogen atoms with subsequent cyclization to 2-phenylimidazopyridines (Ia and IIa, respectively) in 35-38% yields occur when 3-amino-1-benzyl-1,2-dihydro-2-pyridonimine (XI) or 3-amino-1-benzyl-1,4-dihydro-4-pyridonimine (XIII) is heated with sulfur (molar ratio 1:2) at 160°C for 12 h. Higher yields of imidazopyridines Ia and IIa, c, q (Table 3) are obtained as a result of oxidation of chlorides X and XIIa-c with sulfur; however, the reaction in these cases proceeds at 250-260°C.

EXPERIMENTAL

The PMR spectra of solutions of the compounds in CF_3COOH were recorded with a Tesla-467 spectrometer (60 MHz) with tetramethylsilane (TMS) as the internal standard. The identical character of samples of each of Ia, b, d, e, i, j and IIa-d, p obtained by different methods and with respect to the literature data was established from the absence of melting-point depressions for mixtures of the samples and from the coincidence of the IR spectra obtained from suspensions of the compounds in mineral oil with a UR-20 spectrometer.

The characteristics of Ia-e and IIa-d, p are presented in Table 1, and the characteristics of If-h, k and IIe-o are presented in Table 2.

2-Aryl(hetaryl)imidazopyridines Ia-k and IIa-p. A) A mixture of 0.1 mole of the o-diamine (IIIa-d or IVa, b), 0.105 mole of the aldehyde (Va-m), and 0.1 mole of sulfur was heated in a flask equipped with an air condenser at 165-175°C until hydrogen sulfide evolution ceased (test with lead paper). Compounds Ia, f and IIb were obtained at 150°C. The melt that formed after cooling was crystallized from a suitable solvent.

B) A mixture of the o-diaminopyridine, the aldehyde, and sulfur in the same ratio as in method A was refluxed in xylene (mixture of isomers) or mesitylene (in the synthesis of If and IId, f, h, n, o) until hydrogen sulfide evolution ceased (20 ml of the solvent was used per gram of sulfur). Part of the solvent (from 1/2 to 2/3 of the initial volume) was removed from the reaction mixture by distillation, the mixture was cooled, and the reaction product was removed by filtration and purified by recrystallization.

Compounds IIg-m were also converted to the hydrochlorides (HX). For this, a 1-g sample of the compound was dissolved by heating to 70°C in 15 ml of 18% hydrochloric acid. The solution was filtered and evaporated in an open dish on a water bath to 1/2-1/3 of the starting volume. After cooling, the precipitated hydrochloride was removed by filtration.

Reaction of o-Diamines IV with Benzyl Alcohols. A mixture of 10 mmole of the o-diamine (IVa, b), 10 mmole of the benzyl alcohol, and 20 mmole of sulfur was heated in a flask equipped with a reflux condenser in a stream of argon at 185-200°C until hydrogen sulfide evolution ceased. The contents of the flask were mixed with 5 ml of chloroform, and the precipitate was removed by filtration to obtain the 2-arylimidazopyridine.

2-Phenyl-1-methylimidazo[4,5-c]pyridine (IIb). The reaction time was 10 h. The yield of product with mp 148-149°C (from water) was 20%.

2-(4-Chlorophenyl)imidazo[4,5-b]pyridine (Ib). The reaction time was 2 h. The yield of product with mp 358-360°C (from DMF) was 61%.

2-(4-Chlorophenyl)imidazo[4,5-c]pyridine (IIc). The reaction time was 3 h. The yield of product with mp 313-315°C (from DMF) was 57%.

TABLE 3. Imidazopyridines Obtained by Oxidation of VI-XIII with Sulfur

Starting compound	Reaction conditions		Reaction product	mp, °C	Yield, %
	T, °C	time, h			
VI [21]	150—170	18	IIa	223—224	60
VII	150—170	18	IIa	222—223	41
VIII [13]	160—175	20	Ia	293—294	48
IX	160—175	20	Ia	293—294	31
X	190—200	12	Ia	293—294	67
XI	160—170	10	Ia	293—294	35
XIIa	250—260	6	IIa	223—224	56
XIIb	250—260	6	IIc	314	70
XIIc	250—260	20	IIq	259—260*	69
XIII	150—160	12	IIa	223—224	38

*Recrystallized from DMF. Found: C 54.9; H 2.9; Cl 26.4%. $C_{12}H_7Cl_2N_2$. Calculated: C 54.6; H 2.7; Cl 26.8%.

Reaction of Diaminopyridines IIIa and IVa with 1-Benzylpyridinium Chloride. A mixture of 0.55 g (5 mmole) of diamine IIIa or IVa, 1.05 g (5 mmole) of N-benzylpyridinium chloride, and 0.32 g (10 mmole) of sulfur was heated in a flask equipped with a reflux condenser at 160-170°C until hydrogen sulfide evolution ceased (∿30 h), after which the cooled mass was pulverized and mixed with 2 ml of water, and the mixture was neutralized with ammonium hydroxide. The precipitate was removed by filtration, washed with water, and recrystallized from 50% aqueous alcohol. The yield of 2-phenylimidazo[4,5-c]pyridine (IIa), with mp 223-224°C, was 0.4 g (40%). The yield of 2-phenylimidazo[4,5-b]pyridine (Ia), with mp 293-294°C, was 0.35 g (35%).

Similarly, heating 0.3 g (2.7 mmole) of 3,4-diaminopyridine (IVa), 0.7 g (2.7 mmole) of 1-(4-chlorobenzyl)pyridinium chloride, and 0.17 g (5.3 mmole) of sulfur for 25 h gave 0.22 g (35%) of 2-(4-chlorophenyl)imidazo[4,5-c]pyridine (IIc) with mp 314°C.

2-Nitro-3-benzylaminopyridine. A solution fo 2.95 g (19 mmole) of 3-methoxy-2-nitropyridine and 2.05 g (19 mmole) of benzylamine in 3 ml of chloroform was heated slowly in an open 20-ml flask to 110°C and maintained at this temperature for 2 h. It was then cooled, and the melt was triturated with 5 ml of ether. The precipitate was removed by filtration to give 3.92 g (90%) of yellow needles with mp 74-75°C (from benzene). Found: N 18.1%. $C_{12}H_{11}N_3O_2$. Calculated: N 18.3%.

2-Amino-3-benzylaminopyridine (IX). A 3-g (5.4 mmole) sample of iron and 0.6 ml of concentrated HCl were added in portions with stirring to a refluxing solution of 1.4 g (6.1 mmole) of 2-nitro-3-benzylaminopyridine in a mixture of 4 ml of water and 8 ml of alcohol, after which the mixture was refluxed for 3 h. The hot mixture was filtered, and the precipitate was washed on the filter with hot alcohol (4 ml) and water (4 ml). The filtrate was evaporated to 1/4 of its original volume, and the concentrate was made alkaline to pH 9 with 20% KOH solution. The resulting precipitate was removed by filtration and washed with a small amount of cold water. This procedure gave 0.92 g (75%) of snow-white crystals with mp 79-80°C (from benzene). Found: N 21.3%. $C_{12}H_{13}N_3$. Calculated: N 21.1%.

4-Nitro-3-benzylaminopyridine 1-Oxide. A mixture of 2.2 g (10 mmole) of 4-nitro-3-bromopyridine 1-oxide [22] and 1.93 g (17.8 mmole) of freshly distilled benzylamine in 20 ml of dioxane was heated in an open flask for 30 min at 50°C, after which 10 ml of dioxane was removed from the reaction mixture by distillation, and the residue was cooled. The precipitate was removed by filtration and washed with water (three 4-ml portions). This procedure gave 2.1 g (85%) of shiny yellow plates with mp 191°C (from alcohol). Found: C 59.0; H 4.4%. $C_{12}H_{11}N_3O_3$. Calculated: C 58.8; H 4.5%.

3-Benzylamino-4-aminopyridine (VII). This compound was obtained from 6.1 g (25 mmole) of 4-nitro-3-benzylaminopyridine 1-oxide and 14.8 g (264 mmole) of iron in a mixture of 80 ml of water, 80 ml of alcohol, and 4.4 ml of concentrated HCl by a procedure similar to that used to obtain diamine IX. The yield of prisms with mp 192-193°C (from DMF—dioxane) was 3.3 g (66%). Found: C 72.1; H 6.6; N 20.9%. $C_{12}H_{13}N_3$. Calculated: C 72.3; H 6.6; N 21.0%.

2,3-Diamino-1-benzylpyridinium Chloride (X). A mixture of 1.09 g (10 mmole) of 2,3-diaminopyridine (IIIa) and 1.43 g (11.3 mmole) of benzyl chloride in 5 ml of n-propyl alcohol was refluxed for 6 h, after which it was evaporated in the vacuum produced by a water aspirator on a boiling-water bath. The residue was recrystallized from nitromethane (5-6 ml) to give 0.78 g (33%) of the chloride with mp 157-158°C. Found: C 61.1; H 5.8; Cl 14.9%. $C_{12}H_{14}ClN_3$. Calculated: C 61.1; H 6.0; Cl 15.0%.

3,4-Diamino-1-benzylpyridinium Chloride (XIIa). This compound was obtained from 0.55 g (5 mmole) of 3,4-diaminopyridine (IVa) and 0.76 g (6 mmole) of benzyl chloride in 5 ml of methanol by a procedure similar to that used to obtain X. The yield of product with mp 257°C (from methanol) was 0.7 g (59%). PMR spectrum: 8.6 (1H, s, 2-H), 8.05 (1H, d, J = 6.0 Hz, 6-H), 7.34 (superimposition of the singlet of phenyl protons on the doublet of the 5-H proton of the pyridine ring), 5.35 ppm (2H, s, CH_2). Found: C 61.2; H 5.90; Cl 15.1; N 17.7%. $C_{12}H_{14}ClN_3$. Calculated: C 61.1; H 6.0; Cl 15.0; N 17.8%.

3,4-Diamino-1-(4-chlorobenzyl)pyridinium Chloride (XIIb). This compound was obtained from 0.77 g (7 mmole) of diamine IVa and 1.13 g (7 mmole) of 4-chlorobenzyl chloride in 15 ml of ethanol by a procedure similar to that used to obtain X. The yield of product with mp 225°C (from ethanol) was 1.3 g (69%). PMR spectrum: 8.27 (1H, s, 2-H), 7.67 (1H, d, J = 6 Hz, 6-H), 6.85 (superimposition of the singlet of phenyl protons on the doublet of the 5-H proton of the pyridine ring), 5.13 ppm (2H, s, CH_2). Found: C 53.5; H 4.7; Cl 26.0; N 15.5%. $C_{12}H_{13}Cl_2N_3$. Calculated: C 53.4; H 4.8; Cl 26.3; N 15.5%.

3,4-Diamino-1-(3,4-dichlorobenzyl)pyridinium Chloride (XIIc). This compound was obtained from 0.55 g (5 mmole) of diamine IVa and 0.98 g (5 mmole) of 3,4-dichlorobenzyl chloride in 8 ml of methanol by a procedure similar to that used to prepare X. The yield of product with mp 269-270°C (from methanol) was 1.02 g (67%). PMR spectrum: 8.71 (1H, s, 2-H), 8.08 (1H, d, J = 6.0 Hz, 6-H), 7.31 (superimposition of the singlet of phenyl protons on the doublet of the 5-H proton of the pyridine ring), 5.39 ppm (2H, s, CH_2). Found: C 47.2; H 4.1; Cl 34.6; N 14%. $C_{12}H_{12}Cl_3N_3$. Calculated: C 47.3; H 4.0; Cl 34.9; N 13.8%.

3-Amino-1-benzyl-1,2-dihydro-2-pyridonimine (XI). A 1.0-ml sample of 40% KOH solution was added at 18°C to a solution of 0.31 g (1.3 mmole) of chloride X in 2 ml of water, and the precipitate was removed by filtration, dried, and recrystallized from benzene to give 0.23 g (89%) of a product with mp 125-126°C. Found: N 21%. $C_{12}H_{13}N_3$. Calculated: N 21.1%.

3-Amino-1-benzyl-1,4-dihydro-4-pyridonimine (XIII). This compound was obtained from 0.47 g (2 mmole) of chloride XIIa by a procedure similar to that used to prepare XI. The yield of product with mp 83-84°C (from benzene) was 0.38 g (95%). Found: N 19.1%. $C_{12}H_{13}N_3 \cdot H_2O$. Calculated: N 19.3%.

Oxidation of VI-XIII with Sulfur (General Method, Table 3). A mixture of 5 mmole of the N-benzyldiaminopyridine (VI-XIII) and 0.32 g (0.01 mole) of sulfur was heated until hydrogen sulfide evolution ceased, after which the melt was pulverized and dissolved by heating in water (X and XIIa-c, 1 g of the melt in 12-15 ml) or in 18% hydrochloric acid (1 g of the melt in 5-8 ml). The solution was filtered, and the reaction product was precipitated from it with ammonium hydroxide. The products were purified by crystallization from the solvents indicated in Table 1.

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ELECTRON STRUCTURES OF AZOLOISOINDOLES WITH A NODAL NITROGEN ATOM.

1. DERIVATIVES OF ISOINDOLOBENZIMIDAZOLE AND IMIDAZO- AND PYRAZOLOISOINDOLES

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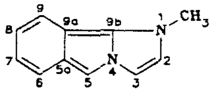
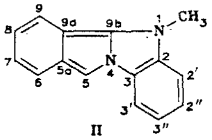
UDC 547.759.4:619.71

N-Methyl-substituted 1H-imidazo[2,1-a]isoindole, 5H-isoindolo[2,1-a]benzimidazole, and 3H-pyrazolo[5,1-a]isoindole were calculated by the PPP and CNDO/2 methods. On the basis of the canonical and localized MO it was concluded that the examined compounds can, to a first approximation, be regarded as 1,2-disubstituted isoindoles, i.e., 10π-electron systems. The calculated data are in good agreement with the experimental UV spectra and the chemical properties of the investigated compounds.

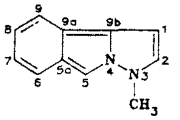
There is a vast group of compounds, viz., azoloisoindoles, among condensed heterocyclic systems with a nodal nitrogen atom. Compounds of this type have found application in practice as medicinal preparations and agents for the protection of plants and are currently under extremely intensive investigation [1]. Soviet chemists have also made a definite contribution to the study of this series of heterocyclic compounds [2-4]. However, all of the previous investigations have basically been experimental in character. We therefore attempted to study the electron structures of three typical representatives of this group, viz., 1H-imidazo[2,1-a]isoindole (I), 5H-isoindolo[2,1-a]benzimidazole (II),* and 3H-pyrazolo[5,1-a]isoindole, by quantum-chemical methods.



I



II



III

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*For the most concise exposition of the material, the numbering of the atoms does not always coincide with the generally accepted numbering.

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