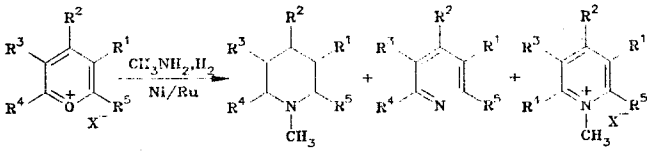
HYDROAMINATION OF PYRYLIUM SALTS

A. P. Kriven'ko, O. V. Fedotova,
P. V. Reshetov, and V. G. Kharchenko

UDC 547.822.3'821.3'812:542.941.4'7'
958.3:543.422

Some pyrylium salts and condensed systems derived therefrom have been hydromethylaminated to saturated azaheterocycles and N-methylpyridinium salts. Attempts to hydroarylaminate pyrilium salts resulted in the formation of the corresponding hydrocarbons.

Pyrylium salts are well known to undergo recyclization with nitrogenous reagents to form heteroaromatic compounds and pyridinium salts [1, 2]. The possibility of converting pyrylium salts into saturated piperidine bases and their condensed analogs has not hitherto been examined. We have studied for the first time the phase-transfer catalyzed reductive amination of pyrylium salts and their condensed derivatives, namely, 2,4,6-triphenylpyrylium (I), 2,4-diphenyl,5,6,7,8-tetrahydrochromylium (II), and sym-octahydroxanthylium (III) tetrafluoroborates, and 2-phenyl-4-(3,4-dimethoxyphenyl)-7,8-benzo-5,6-dihydrochromylium trifluoroacetate (IV). The reaction was carried out in an autoclave at 100°C under hydrogen pressure in the presence of nickel promoted by ruthenium. The aminating agents used were methylamine and aniline (molar ratio of pyrylium salt to amine, 1:2).



I–IV V–VIII IX–XI XII–XIV

I, V, IX, XII $R^1=R^3=H$; $R^2=R^4=R^5=C_6H_5$; II, VI, X, XIII $R^1=H$, $R^2=R^5=C_6H_5$, $R^3+R^4=(-CH_2-)_4$; III, VII, XI, XIV $R^1+R^5=R^3+R^4=(-CH_2-)_4$; $R^2=H$; IV, VIII $R^1=H$, $R^2=C_6H_3(OCH_3)_2$-3,4, $R^3+R^4=2,3$-(3,4-dihydronaphtho), $R^5=C_6H_5$; I–III $X^-=BF_4$; IV $X^-=CF_3COO$

Under these conditions, the pyrylium salts were found to be converted completely into nitrogenous heterocycles (Table 1).

Thus, hydromethylation of (I), (III), and (IV) afforded saturated piperidine bases (triphenylpiperidine (V), trans-anti-cis-N-methylperhydroacridine (VII) [3], and benzooctahydroquinoline (VIII) in yields of 40, 73, and 97%, respectively. In addition, low yields of the substituted pyridines (IX-XI) and N-methylpyridinium salts (XII-XIV), isolated preparatively or identified by chromatography, were obtained. A feature of the hydromethylamination of tetrahydrochromylium tetrafluoroborate (II) is the preferential formation (60%) of the N-methylpyridinium salt (XIII), the yield of the piperidine being 22%.

Thus, we have found a reaction, new to the pyrylium salt series, for their conversion into piperidine bases.

It is assumed that the reductive amination of pyrylium salts proceeds via nucleophilic attack by the amine at the α-position of the pyrylium cation, with ring-opening of the latter to the unsaturated aminoketone, which then undergoes ring closure to the N-methylated dihydropyridinol, which is subsequently hydrogenated to the saturated base or converted into a stable pyridine structure. It is also possible that the reaction occurs via the formation of pyrans, followed by the above sequence of reactions.

The structures of the reaction products were confirmed by direct synthesis of pyridines (X; and (XI) by boiling 1,5-diketones with hydroxylamine hydrochloride in isopropyl alcohol, and of the saturated bases (V-VIII) by the hydromethylamination of the 1,5-dioxo-compounds

N. G. Chernyshevskii Saratov State University, Saratov 410601. Translated from Khimiya Geterotsoklicheskikh Soedinenii, No. 12, pp. 1652-1655, December, 1984. Original article submitted November 22, 1983.

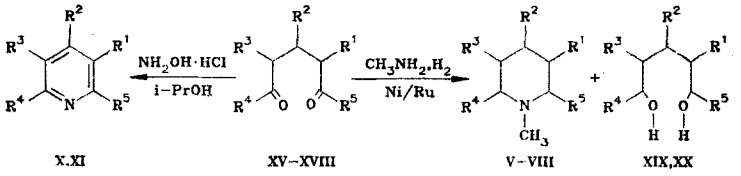
0009-3122/84/2012-1361$08.50

TABLE 1. Hydromethylamination of Pyrylium Salts (I-IV) and 1,5-Diketones (XV-XVIII) ($1.013 \cdot 10^4$ hPa, 100°C, Ni/Ru catalyst)

Compound	Reaction products	Yield, %
I	V, IX, XII	40, 4, 28
II	VI, X*, XIII	22, —, 60
III	VII, XI*, XIV	73, —, 26
IV	VIII	97
XV	V, XIX	17, 82
XVI	VI	62
XVII†	VII	98
XVIII	VIII, XX	84, 7

*The products were identified by TLC and GLC by comparison with samples obtained by direct synthesis.
†Experiment carried out with 10% Ru/C.

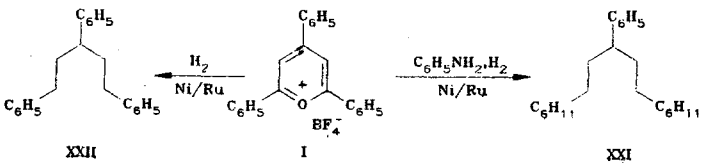
(XV-XVIII).



XV—XVIII R^1—R^5 have the values given above.

A comparison of the hydromethylamination of the pyrylium salts (I-IV) and of the 1,5-diketones (XV-XVIII) showed the former to be definitely preferable (Table 1) in the case of substrates (I) and (IV), since the hydroamination of the dicarbonyl compounds (XV) and (XVIII) was complicated by competitive hydrogenation of the carbonyl functions to give the diols (XIX) and (XX). In the case of 1,3,5-triphenylpentane-1,5-dione (XV), as a result of electronic and steric factors nucleophilic attack is hindered, and hydrogenation becomes the principal reaction pathway, the yield of diol being 82%. Fixation of the planar structure in the diketone (XVIII) has a favorable effect on the yield of the desired product, the benzooctahydroquinoline (VIII) (84%).

It was expedient to hydroarylaminate pyrylium salts, since saturated azaheterocycles have been obtained from 1,5-diketones in the case of methylenebiscyclohexanone only [5]. We assumed that in consequence of their high electrophilicity, the use of pyrylium salts would enable N-phenylated piperidines to be obtained, these being inaccessible from 1,5-dioxo-compounds. However, when it was attempted to hydroaminate triphenylpyrylium fluoroborate (I) in the presence of a weak base (aniline), a hydrocarbon was obtained, namely, 1,5-dicyclohexyl-3-phenylpentane (XXI). This behavior made it necessary to examine the hydrogenation of (I). It was found that at 50°C, in the presence of nickel promoted by ruthenium, (I) underwent hydrogenation with opening of the heterocycle to give as the principal product of hydrocarbon 1,3,5-triphenylpentane (XXII).



The latter reaction is novel for pyrylium salts. It is noteworthy that under similar conditions the corresponding 1,5-diketones afford the diols.

TABLE 2. Properties of Compounds Obtained

Compound	Mp or bp, °C (mm)	Found, %			Empirical formula	Calculated, %		
		C	H	N		C	H	N
IV	102—102,5	71,0	4,8	—	$C_{29}H_{23}F_3O_5$	71,0	4,8	—
V	68—70	88,1	8,1	4,6	$C_{24}H_{25}N$	88,2	7,7	4,3
VI	116—118	87,1	9,1	5,5	$C_{22}H_{27}N$	86,6	8,9	4,5
VIII	140—141	81,6	7,6	3,1	$C_{28}H_{31}NO_2$	81,3	7,6	3,4
IX	135—136	88,8	5,9	4,8	$C_{23}H_{17}N$	89,8	5,5	4,6
XIII	133—135	—	—	3,6	$C_{22}H_{22}BF_4N$	—	—	3,6
XIV	49—50	—	—	5,0	$C_{14}H_{20}BF_4N$	—	—	4,8
XIX	34	83,4	7,6	—	$C_{23}H_{24}O_2$	83,1	7,2	—
XX	174—175	77,0	7,3	—	$C_{27}H_{30}O_4$	77,5	7,2	—
XXI	180—185 (2)	91,5	9,5	—	$C_{23}H_{36}$	91,3	8,7	—
XXII	205—210 (3)	88,4	12,0	—	$C_{23}H_{24}$	88,5	11,5	—

The spectra of the newly synthesized compounds confirmed the proposed structures. The IR spectra of the piperidine bases (V-VIII), which contain the N—CH_3 group, showed absorption for stretching vibrations of this group at 2760-2820 cm^{-1}. The pyridine compounds (IX-XI) were characterized by the pyridine ring vibrations at 1590 and 3020-3070 cm^{-1}, and salts (XII-XIV) gave bands at 1590 cm^{-1} and absorption for the BF_4^- anion at 1060 and CF_3COO^- at 1130-1205 and 1690-1758 cm^{-1}, respectively. The PMR spectra of the tetrafluoroborates (XII-XIV) showed low-field signals for the aromatic protons at 7.5 ppm, N—CH_3 protons at 3.90-4.12 ppm, and the alicyclic protons at 1.96-3.88 ppm.

EXPERIMENTAL

TLC analyses were carried out on an LKhM-8MD apparatus with a flame ionization detector and a stainless steel column (0.6 × 100), sorbent Inzensk brick, grade TND-TS-M, modified with 2% KOH and soaked in 15% Apiezon L. The temperature in the experiments was 217°C, carrier gas (helium) flow rate 1.2 liter/h. TLC analyses were carried out on Silufol UV-254 plates, eluent hexane—ether—chloroform (4:1:1). IR spectra were obtained on a UR-20 spectrometer in Vaseline oil and hexachlorobutadiene, and PMR spectra on a Varian T-80 in deuteroacetone solution, internal standard HMDS.

The pyrylium salts (I-III) were synthesized as described in [4]. 2-Phenyl-4-(3,4-dimethoxyphenyl)-7,8-benzo-5,6-dihydrochromylium trifluoroacetate was obtained as described in [6]; purification was effected by reprecipitation from chloroform with ether.

Hydromethylamination of Pyrylium Salts (I-IV). In an autoclave of 150 ml capacity were placed 0.1 mole of the pyrylium salt, 80 ml of methanol containing 0.02 mole of methylamine, and 1 g of catalyst (ruthenium-promoted nickel). The initial hydrogen pressure was $1.013 \cdot 10^4$ hPa, and the temperature 100°C. After 7-10 h, the catalyst was filtered off, and the methanol evaporated under a hood. In the case of (I), the residue separated into two layers, which were separated in a separatory funnel. The more viscous portion crystallized on standing (salt XII). The other portion was treated with hexane to give colorless crystals of pyridine (IX). The filtrate containing the saturated base (V) was purified by chromatography on a column of alumina (activity grade 3) (1 × 37). Evaporation of the hydrogenation products of salts (II-IV) gave solids consisting of base (VIII) and a mixture of crystals of (VI, XIII) and (VII, XIV), respectively. The latter were separated with ether, and the readily soluble compounds (VI), (VII) and salts (XIII), (XIV) separated from the ether as colorless crystals. Compounds (X) and (XI) were identified by TLC and GLC by comparison with samples obtained by direct synthesis as described in [7].

Attempts to hydroarylaminate (I) gave the hydrocarbon (XXI) by evaporation of the hydrogenation products followed by extraction of the residue with ether and hexane followed by vacuum distillation. The reaction mixture obtained by hydrogenation of (I) and 50°C was worked up similarly to give (XXII).

Hydromethylamination of 1,5-Diketones (XV-XVIII) was carried out as described in [5], using ruthenium-promoted nickel as catalyst. Evaporation of the hydrogenation products gave a mixture of the saturated heterocycles (V-VIII) and diols (XIX) and (XX). Diols (XIX) and (XX) were isolated as colorless crystals by treatment of the mixtures with hexane and ether, respectively.

LITERATURE CITED

1. G. N. Dorofeenko, A. N. Tkachenko, and V. V. Mezheritskii, Khim. Geterotsikl. Soedin., No. 4, 465 (1975).
2. G. N. Dorofeenko and V. G. Korobkova, Khim. Geterotsikl. Soedin., No. 3, 342 (1974).
3. N. Barbulesku and J. Potmischil, Tetrahedron Lett., 27, 2309 (1969).
4. J. A. Van Allan and J. A. Reynold, J. Org. Chem., 33, 1102 (1968).
5. V. G. Kharchenko, A. P. Krivenko, O. V. Fedotova, and T. G. Nikolaeva, Khim. Geterotsikl. Soedin., No. 7, 944 (1982).
6. L. K. Kulikova, V. G. Kharchenko, O. V. Fedotova, and G. K. Kravtsova, Khim.-Farm. Zh., 16, 545 (1982).
7. G. V. Pavel', M. N. Tilichenko, and A. D. Chumak, Dep. in VINITI, No. 4253. Dep.; Ref. Zh. Khim., 15Zh245 (1977).

TAUTOMERISM OF 6- AND 2-(ARYLAZO)-3-HYDROXYPYRIDINES IN APROTIC POLAR SOLVENTS

K. M. Dyumaev, L. A. Osmolovskaya, and B. A. Korolev

UDC 547.556.3:547.823:541.62

On the basis of calculations of the basicities of possible protonation sites, electronic spectra, and potentiometric titration, it has been shown that 6- and 2-(arylazo)-3-hydroxypyridines exist in nitromethane and acetonitrile in the hydroxyazo-form, and are protonated at the pyridine nitrogen atom.

A number of dyes have recently been developed both for natural and synthetic fibers, derived from 3-hydroxypyridine [1, 2]. Dyeing of synthetic fibers presupposes working in nonaqueous solvents, and it is therefore of great importance to examine the tautomerism of arylazo-3-hydroxypyridines in such media. The scattered reports in the literature on this topic, especially for aprotic solvents, are contradictory. For instance, in acetonitrile and dimethylformamide azo-3-hydroxypyridines exist as tautomeric mixtures of the azo- and hydrazono-forms [3, 4], whereas in nitromethane (which is similar to acetonitrile in its properties), they exist in the hydroxyazo-form [5]. To resolve this contradiction, we have carried out further studies with 6- and 2-(arylazo)-3-hydroxypyridines in aprotic polar solvents (nitromethane and acetonitrile), by examination of the acid–base properties and UV spectra of the compounds.

The 6- and 2-(arylazo)-3-hydroxypyridines (Tables 1 and 2) were obtained by azo-coupling. Earlier workers [6] have shown that reaction of 3-hydroxypyridine with p-nitrophenyldiazonium chloride gives a mixture of the 6- and 2-isomers, coupling in the 4-position not occurring [7]. It is known that the chromatographic mobility of 2-(p-nitrophenylazo)-3-hydroxypyridine is much higher than that of the 6-substituted compound, and by analogy with [6] we have tentatively regarded the compounds with low R_f values as the 6-azo-compounds (IIa-f) (Table 1), and those with high R_f values as the 2-derivatives (IXa-f). The assignment of compounds with high R_f values to the 2-azo series is supported by the presence in their IR spectra of a broad absorption band in the region of stretching of the hydroxyl group involved in intramolecular hydrogen bonding (2700-3200 cm^{-1}), and by identification of the reduction product of one of them (IXb) as 2-amino-3-hydroxypyridine.

To confirm the structure of the second series of isomers (IIa-f), diazotized 2,4,6-trimethyl-3,5-dinitroaniline was coupled with 3-hydroxypyridine to give the isomer with a low R_f value (IIg), the structure of which was proved by PMR. Actually, the spectrum of the 2-substituted compound should contain signals of different multiplicity, and the 4-substituted compound, from

Research Institute for Organic Intermediates and Dyes, Moscow 103787. Translated from Khimiya Geterotsiklicheskikh Soedinenii, No. 12, pp. 1656-1661, December, 1984. Original article submitted January 3, 1983; revision submitted April 29, 1984.

 0009-3122/84/2012-1364$08.50