REACTION OF ETHOXYVINYL DERIVATIVES OF PYRYLIUM AND PYRIDINIUM SALTS WITH PRIMARY AND SECONDARY AMINES

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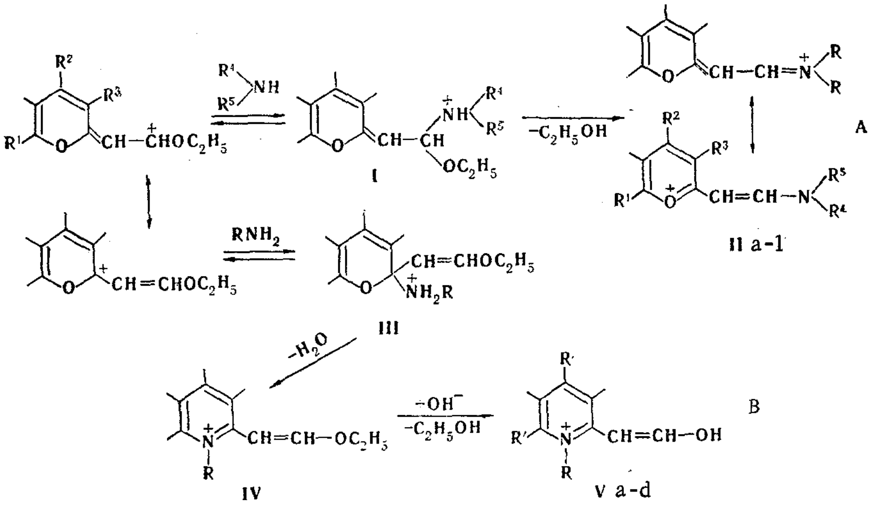
The reaction of β-ethoxyvinylpyrylium salts with primary aromatic amines gives β-R-aminovinylpyrylium salts, the alkaline hydrolysis of which gives azomethines and, subsequently, pyranylideneacetaldehydes; reaction with methylamine gives N-methylpyridinium salts, which, under the influence of alkali, give pyridinylideneacetaldehydes, while reaction with secondary amines gives β-R,R'-dialkylaminovinylpyrylium salts or acetalacylals; reaction with acetate gives hydroxyvinylpyridines.

We recently reported the synthesis of a number of β-ethoxyvinylpyrylium salts [1]. The present paper is devoted to a study of the behavior of these compounds with respect to various amines (primary aromatic and aliphatic amines, secondary amines, ammonia, acid amides, carbamide, guanidine, and some polyfunctional amines). The reactions of some β-ethoxyvinylpyrylium salts with aromatic amines were previously studied by Wizinger and co-workers [2, 3].

We have shown that in reactions with amines β-ethoxyvinylpyrylium salts display dual reactivity, and the direction of the reaction depends on the basicity of the amine.



V a-d R = CH_3

Thus primary aromatic amines react via scheme A, while more basic amines (methylamine and ammonia) react via scheme B. Despite their high basicities, secondary aliphatic amines also react via scheme A, inasmuch as stabilization of intermediate I (and of

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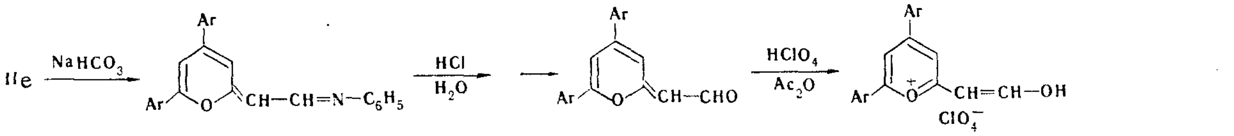
the analogous III) to give a nitrogen heterocycle of the IV type is impossible in this case.

A bis derivative similar in structure to compounds of the II type is obtained in the case of O-phenylenediamine. Data on the yields and properties of the β-R-aminovinylpyrylium salts are presented in Table 1.

A bathochromic shift as compared with the starting β-alkoxyvinylpyrylium salts (10-40 nm) as a consequence of an increase in the conjugation chain and the appearance of auxochromes is observed in the UV spectra of II. The results of elementary analysis and the IR and UV spectra do not provide an argument that is complete enough to reject the structure of N-arylpyridinium salts, which could form during the reaction of β-ethoxyvinylpyrylium salts with aromatic amines. In order to obtain definitive proof that the reaction in this case proceeded via path A rather than path B, we performed a number of transformations in the case of 2,4-dianisyl-6-β-phenylaminovinylpyrylium perchlorate (IIe). Thus, when IIe is treated with sodium bicarbonate, perchloric acid is split out to give azomethine VI, the hydrolysis of which produces the aldehyde (VII) that we described in [1], which reacts with perchloric acid to give the previously described [1] β-hydroxyvinylpyrylium perchlorate.

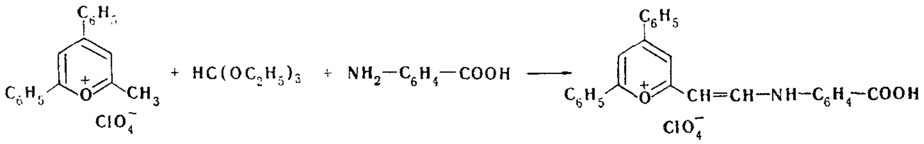
2,4-Diphenylpyranylideneacetaldehyde (VIIb, Ar = Ph) was also obtained by direct alkaline hydrolysis of IIa, which completely confirms the impossibility of reaction via path B.



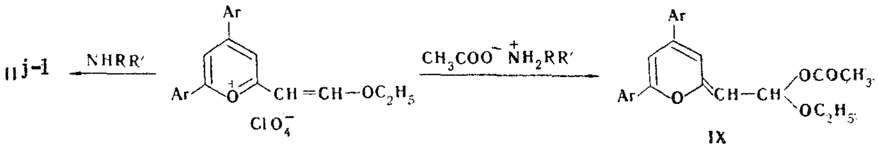
VII VIII VII a Ar=p-$CH_3OC_6H_4$

Delocalization of the positive charge in β-R-aminovinylpyrylium salts IIa-l makes replacement of the heterocyclic oxygen atom by nitrogen on reaction with methylamine, ammonium acetate, and aromatic amines impossible, and in the latter case the reaction cannot be carried out even under severe conditions by heating salts IIa-l with aniline at 170°C.

The formation of β-aminovinylpyrylium salts IIa-i may also occur in one step when equimolecular amounts of a mixture of the methylpyrylium salts, ethyl orthoformate, and an aromatic amine are heated in acetic acid. We demonstrated this reaction thoroughly in the case of the condensation of 2,4-diphenyl-6-methylpyrylium perchlorate, ethyl orthoformate, and p-aminobenzoic acid:



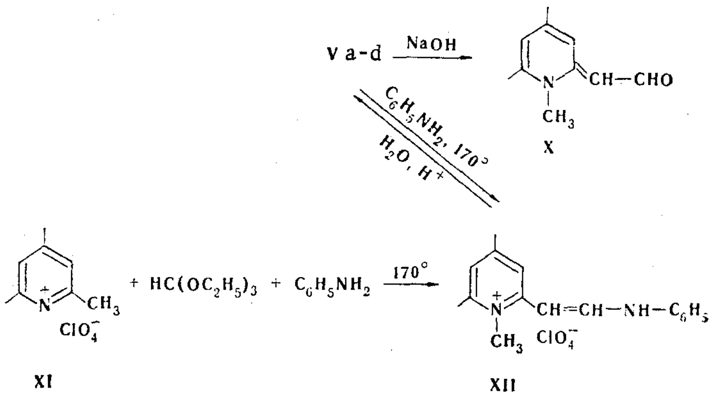
When the reaction of β-ethoxyvinylpyrylium salts with secondary amines (diethylamine, piperidine, morpholine) is carried out in acetic acid, mixed acetalacylals IX are formed, while 6-β-R,R'-dialkylaminovinylpyrylium salts IIj-l are obtained in nitromethane.



IX

The IR spectrum of acetalacylal IX contains an intense band at 1725 cm^{-1} (C=O) and a band at 1240-1250 cm^{-1}, which is related to the stretching vibrations of the C—O ether group.

The oxygen atom of the pyrylium ring is replaced by an N-methyl group in the reaction of β-ethoxyvinylpyrylium salts with methylamine, and the β-ethoxyvinyl group is similtaneously hydrolyzed to a β-hydroxyvinyl group.

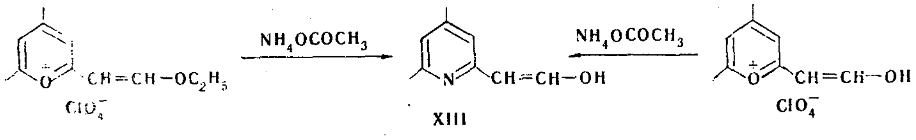


Compounds Va-d are also formed in the reaction of methylamine with salts VIII. In order to prove the structure, β-hydroxyvinylpyrydinium salts Va-d were obtained by an alternative route (by the method in [4]) from the corresponding 2-methylpyridinium salts, ethyl orthoformate, and aniline with subsequent acid hydrolysis of vinylpyridinium salts XII. Salts XII are reformed when Va-d are heated with aniline. Treatment of Va-d with 5% alkali leads to splitting out of perchloric acid and the formation of the corresponding pyridinylideneacetaldehyde (X).

A hypsochromic shift of 80-100 nm as compared with β-ethoxyvinylpyrylium salts is observed in the UV spectra of Va-d.

It was shown that the conversion of XI to XII occurs through the intermediate formation of β-hydroxyvinylpyridinium salt V, inasmuch as the second possible reaction through the formimido ester does not occur under these conditions. The formation of XII from V does not occur under mild conditions but requires heating in acetic acid; this indicates less localization of the positive charge on the β-carbon atom in salts Va-d than in β-ethoxyvinylpyrylium salts, which react very readily with aromatic amines.

β-Hydroxyvinylpyridines (XIII), which were also obtained by alternative synthesis from β-hydroxyvinylpyrylium salts, are obtained when β-ethoxyvinylpyrylium salts are refluxed with ammonium acetate in acetic acid.



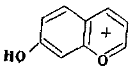
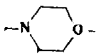
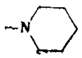
β-Hydroxyvinylpyrylium salts do not react with acid amides because of the very weak basicity of the latter, nor do they react with urea and guanidine.

EXPERIMENTAL

The IR spectra of mineral-oil suspensions of the compounds were recorded with a UR-20 spectrometer. The UV spectra of acetic acid solutions of the compounds were recorded with a Specord UV-vis spectrophotometer.

2,4-Diphenyl-6-β-phenylaminovinylpyrylium Perchlorate (IIa). A 0.12-ml (1 mmole) sample of aniline in a small amount of acetic acid was added to a hot solution of 0.4 g (1 mmole) of 2,4-diphenyl-6-β-ethoxyvinylpyrylium perchlorate in anhydrous acetic

TABLE 1. 6-β-R_3,R_4-Aminovinylpyrylium Salts

Compound	R^1	R^2	R^3	R^4	R^5	mp, °C	Empirical Formula	Found, %				Calc., %				IR spectrum, cm^{-1}	UV spectrum, λ_{max}, nm	Yield, %
								C	H	Cl	N	C	H	Cl	N			
IIa	C_6H_5	C_6H_5	H	C_6H_5	H	247	$C_{25}H_{20}ClNO_5$	66,5	5,0	7,6	3,1	66,7	4,5	7,9	3,1	3250, 1640, 1610, 1100	440	89
IIb	C_6H_5	C_6H_5	H	C_6H_4COOH	H	230	$C_{26}H_{20}ClNO_7$	63,1	4,7	7,9	2,7	63,1	4,1	7,3	2,8	3200, 1630, 1590, 1100	472	80
IIc	C_6H_5	C_6H_5	H	$C_6H_4OCH_3$	H	221	$C_{26}H_{22}ClNO_6$	64,7	4,6	7,8	2,8	65,0	4,6	7,7	2,9	3300, 1640, 1600, 1095	480	83
IId	C_6H_5	C_6H_5	H	$C_6H_4OC_2H_5$	H	228	$C_{27}H_{24}ClNO_6$	65,8	4,7	7,7	2,9	65,6	4,8	7,2	2,8	3250, 1630, 1590, 1100	485	86
IIe	$C_6H_4OCH_3$	$C_6H_4OCH_3$	H	C_6H_5	H	192	$C_{27}H_{24}ClNO_7$	63,5	4,8	7,0	2,7	63,5	4,7	6,9	2,7	3300, 1640, 1595, 1100	470	90
IIf	$C_6H_4OCH_3$	$C_6H_4OCH_3$	H	$C_6H_4OCH_3$	H	256	$C_{28}H_{26}ClNO_8$	62,3	4,5	6,6	2,7	62,2	4,8	6,7	2,6	3350, 1630, 1600, 1100	475	100
IIg	$C_6H_4OCH_3$	$C_6H_4OCH_3$	H	C_6H_4COOH	H	265	$C_{28}H_{24}ClNO_9$	61,0	4,6	6,3	2,4	60,7	4,3	6,0	2,5	3350, 1640, 1590, 1100	478	84
IIh	C_6H_5	H	$COOC_2H_5$	$C_6H_4O_2N$	H	251	$C_{26}H_{21}ClN_2O_9$	57,6	4,0	6,9	4,9	57,7	3,9	6,7	5,2	3300, 1725, 1640, 1590, 1100	710	100
IIi		H	$COOC_2H_5$	$C_6H_4O_2N$	H	265	$C_{20}H_{17}ClN_2O_{10}$	50,3	3,8	8,0	5,7	49,9	3,5	7,5	5,8	3550, 3350, 1720, 1630, 1100	712	92
IIj	C_6H_5	C_6H_5	H	C_2H_5	C_2H_5	221	$C_{23}H_{24}ClNO_5$	64,6	5,7	8,7	3,5	64,2	5,6	8,3	3,3	1630, 1590, 1100	450	70
IIk	C_6H_5	C_6H_5	H			267	$C_{23}H_{22}ClNO_6$	62,3	5,0	7,6	3,3	62,3	5,0	7,9	3,2	1650, 1625, 1590, 1100	448	91
IIl	C_6H_5	C_6H_5	H			259	$C_{24}H_{24}ClNO_5$	65,4	5,2	8,0	3,1	65,2	5,4	8,0	3,2	1650, 1630, 1590, 1095	442	95

acid. After 30 min, the precipitated salt (IIa) was removed by filtration. The other aminovinylpyrylium salts were similarly obtained (see Table 1).

Bis-1,2-(2,4-diphenyl-6-β-vinylaminopyrylium)benzene Diperchlorate. A solution of 0.1 g (1 mmole) of o-phenylenediamine in acetic acid was added to a hot solution of 0.4 g (1 nmole) of 2,4-diphenyl-6-β-ethoxyvinylpyrylium perchlorate. After 1 h, a dark-red substance was removed by filtration. The yield of product with mp 265° was 0.45 g (56.2%). IR spectrum: 3320, 1630, 1590, and 1100 cm^{-1}. UV spectrum: 712 nm (in acetic acid). Found: C 64.6; H 4.2; Cl 8.4; N 3.4%. $C_{44}H_{34}Cl_2N_2O_{10}$. Calculated: C 64.3; H 4.1; Cl 8.6; N 3.4%.

2,4-Diphenyl-6-β-diethylaminovinylpyrylium perchlorate (IIj). A 0.1-ml (1 mmole) sample of diethylamine was added to a solution of 0.4 g (1 mmole) of 2,4-diphenyl-6-β-ethoxyvinylpyrylium perchlorate in 3 ml of nitromethane, and salt IIj was removed by filtration after 1-1.5 h, washed with ether, dried, and recrystallized from acetic acid. The other dialkylaminovinylpyrylium salts were similarly obtained (see Table 1).

2,4-Diphenyl-6-β-hydroxyvinyl-N-methylpyridinium Perchlorate (Va). A suspension of alcohol with two to three drops of 25% aqueous methylamine was added to 0.4 g (1 mmole) of 2,4-diphenyl-6-β-ethoxyvinylpyrylium perchlorate, after which another 0.45 ml of methylamine was added, and the mixture was heated until the salt had dissolved completely. The mixture was then cooled to give a light-yellow precipitate, which was recrystallized from the minimum amount of acetic acid containing two to three drops of 30% perchloric acid. The other N-methylpyrydinium salts were similarly obtained (see Table 2).

2,4-Di(p-methoxyphenyl)-6-β-pyranylideneacetalaniline (VI). A suspension of 0.5 g (1 mmole) of IIe in chloroform was shaken with a solution of sodium bicarbonate, and the mixture was allowed to stand for 24 h. The chloroform extract was washed with water and dried with sodium sulfate. The solvent was then removed by distillation, and the residue was recrystallized from petroleum ether to give 0.36 g (95%) of a product with mp 165°. IR spectrum: 1655, 1610, 1590, and 1245 cm^{-} . Found: C 79.6; H 5.9; N 3.3%. $C_{27}H_{23}NO_3$. Calculated: C 79.2; H 5.6; N 3.4%.

2,4-Di(p-methoxyphenyl)-6-β-pyranylideneacetaldehyde (VIIa). A 0.38-g (1 mmole) sam-

TABLE 2. N-Methyl-6-β-hydroxyvinylpyridinium Salts

Compound	R^1	mp, °C	Empirical Formula	Found, %				Calc., %				IR spectrum, cm^{-1}	UV spectrum, λ_{max}, nm	Yield %
				C	H	Cl	N	C	H	Cl	N			
Va	C_6H_5	144	$C_{20}H_{18}ClNO_5$	61,5	4,5	9,1	3,5	61,8	4,6	9,1	3,6	3500, 1610, 1590, 1100	343	93
Vb	$CH_3OC_6H_4$	176	$C_{22}H_{22}ClNO_7$	58,5	4,8	8,0	3,3	58,9	4,9	8,0	3,1	3550, 1615, 1595, 1100	345	96
Vc	$C_2H_5OC_6H_4$	185	$C_{24}H_{26}ClNO_7$	60,6	5,6	7,6	3,2	60,5	5,5	7,6	2,9	3500, 1610, 1595, 1090	344	80
Vd	$CH_3C_6H_4$	184	$C_{22}H_{22}ClNO_5$	63,8	5,4	8,6	3,2	63,4	5,3	8,6	3,4	3500, 1610, 1590, 1100	310	84

ple of VI was refluxed for 20 min in 10% hydrochloric acid. The mixture was then extracted with ether, and the ether extract was washed with sodium bicarbonate solution and water. The ether was removed by distillation to give 0.3 g (91%) of a colorless substance with mp 133° (mp 132-133° [1]).

2,4-Diphenyl-6-β-pyranilideneacetaldehyde (VIIb). A 5% aqueous alkali solution was added to 0.45 g (1 mmole) of salt IIa in alcohol. After 2-3 days, the material was removed by filtration and recrystallized from petroleum ether to give 0.19 g (70%) of a product with mp 125° (mp 125-126° [5]).

2,4-Diphenyl-6-β-(p-carboxyphenyl)Aminovinylpyrylium Perchlorate (IIb). A 0.3-g (1 mmole) sample of 2,4-diphenyl-6-methylpyrylium perchlorate was dissolved in anhydrous acetic acid, and 0.18 ml (1 mmole) of ethyl orthoformate was added to the hot solution. A solution of 0.14 g (1 mmole) of p-aminobenzoic acid in acetic acid was added all at once to the resulting green solution. After 30 min, IIb was removed by filtration.

2,4-Diphenylpyranylideneacetaldehyde 6-β-Acetalacylal (IX). A solution of 0.1 ml (1 mmole) of diethylamine in acetic acid was added to a solution of 0.4 g (1 mmole) of 2,4-diphenyl-6-β-ethoxyvinylpyrylium perchlorate. The mixture was diluted with ether, and the diethylamine perchlorate was removed by filtration. The ether extract was washed with dilute sodium bicarbonate solution and water and dried with sodium sulfate. The ether was removed by distillation to give 0.32 g (89%) of IX as a yellow oil. IR spectrum: 1725, 1660, 1590, and 1245 cm^{-1}. Found: C 76.6; H 6.1%. $C_{23}H_{24}O_4$. Calculated: C 76.2; H 6.1%.

2,4-Dianisyl-6-β-phenylamino-N-methylpyridinium Perchlorate (XII). A 0.4-g (1 mmole) sample of Vb was refluxed in excess aniline at 170° for 30 min. When the mixture was cooled, a yellow substance crystallized out of the mixture. Workup gave 0.4 g (77%) of a product with mp 135-137°. IR spectrum: 3300, 1620, 1590, and 1245 cm^{-1}. Found: C 64.6; H 5.0; Cl 6.4; N 5.1%. $C_{28}H_{26}N_2ClO_6$. Calculated C 64.4; H 5.0; Cl 6.8; N 5.4%.

2,4-Di(p-methoxyphenyl)-6-β-pyridinylideneacetaldehyde (X). A suspension in ether of 0.4 g (1 mmole) of hydroxyvinylpyrylium salt Vb was shaken with 5% aqueous alkali. The ether layer was separated, washed with water, and dried with sodium sulfate. The ether was removed, and the residue was recrystallized from petroleum ether to give 0.32 g (91%) of a product with mp 166°. IR spectrum: 1680, 1610, 1590, and 1245 cm^{-1}. Found: C 76.5; H 6.2; N 4.0%. $C_{22}H_{21}NO_3$. Calculated: C 76.1; H 6.1; N 4.0%.

2,4-Di(p-methoxyphenyl)-6-β-hydroxyvinylpyridine (XIII). A 0.4-g (1 mmole) sample of 2,4-di(p-methoxyphenyl)-6-β-ethoxyvinylpyrylium perchlorate was refluxed with a fivefold excess of ammonium acetate in acetic acid for 1-1.5 h, after which the mixture was poured into water, and the colorless precipitate was removed by filtration, vacuum-dried, and recrystallized from the minimum amount of alcohol to give 0.2 g (56%) of a product with mp 121°. IR spectrum: 3360, 1610, 1595, and 1250 cm^{-1}. Found: C 75.7; H 5.9; N 4.4%. $C_{21}H_{19}NO_3$. Calculated: C 75.7; H 5.7; N 4.2%.

2,4-Di(p-methylphenyl)-6-β-hydroxyvinylpyridine was similarly obtained.

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