A setup consisting of a ZMR-3 mirror monochromator, an FÉU-18 optical emission detector, and an M-95 microammeter was used to investigate the fluorescence spectra of toluene solutions ($c = 10^{-3}$ M) and powders. Photoluminescence was excited with an SVDSh-500 lamp, from the spectrum of which the exciting light with a wavelength of 313 nm was isolated with a DMR-4 quartz monochromator. The spectra obtained were corrected with allowance for the spectral sensitivity of the setup. The absolute fluorescence quantum yields were determined by the equal-absorption method [15].

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VINYLATION OF 3-PYRIDAZONES

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The vinylation of 3-pyridazones through a step involving the production of 2-hydroxy- and 2-chloroethyl-substituted compounds with subsequent dehydrochlorination, as well as vinylation by means of vinyl acetate, in all cases leads only to N-vinyl derivatives.

Depending on the direction of reactions of compounds with a pyridazine ring that display lactam–lactim tautomerism, one can obtain isomers that differ with respect to their properties. Their pesticidal [1] and pharmacological [2] activity provides a basis for the assumption that the unsaturated derivatives of such substances are promising products in the creation of preparations with prolonged action. They are also of interest for the chemistry of high-molecular-weight compounds [3]. The aim of the present research was therefore to study the direction of vinylation reactions of pyridazone and its derivatives.

The synthesis of unsaturated pyridazine derivatives by vinylation of pyridazines with acetylene under pressure has been reported [4]. Vinylation with vinyl acetate or vinyl alkyl ethers in the presence of divalent mercury salts is also possible. Vinyl derivatives

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Compound	mp or bp, °C (mm)	Found		Empirical formula	Calc.,		Yield, %
		N, %	M		N, %	M	
Ia	121—122 (1,0)	19,7	140,0	$C_6H_8N_2O_2$	20,0	140,2	70
Ib	114—115 (1,0)	17,6	159,3	$C_6H_7ClN_2O$	17,7	158,6	88
Ic	59—61 (0,7)	23,0	117,3	$C_6H_6N_2O$	23,0	122,1	70
IIa	105—106[a]	12,9	216,0	$C_{12}H_{12}N_2O_2$	13,0	216,3	75
IIb	66—67[b]	12,0	229,4	$C_{12}H_{11}ClN_2O$	11,9	234,7	90
IIc	75—76[b]	14,3	194,7	$C_{12}H_{10}N_2O$	14,1	198,2	85
IIIa	91—93[a]	13,0	218,0	$C_{12}H_{14}N_2O_2$	12,8	218,3	80
IIIb	55—56[c]	11,7	237,4	$C_{12}H_{13}ClN_2O$	11,8	236,7	75
IVa	154—156[d]	13,7	204,0	$C_{11}H_{12}N_2O_2$	13,7	204,3	70
IVb	110—111[e]	12,4	226,1	$C_{11}H_{11}ClN_2O$	12,6	222,7	78
IVc	141—142	15,2	190,1	$C_{11}H_{10}N_2O$	15,0	186,2	60

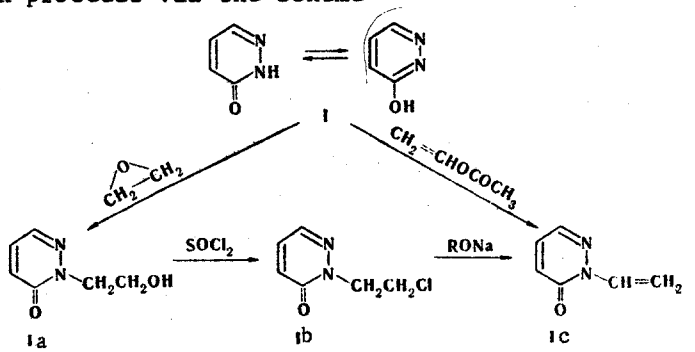
[a]From acetone. [b]From hexane. [c]This compound has bp 194-195°C (0.8 mm). [d]From DMF. [e]From methanol.

TABLE 2. Chemical Shifts of the Protons of the Substituent in the 2 Position of the Pyridazone Ring

Compound	δ, ppm		
Ia	3,53 (α-H);	3,87 (β-H)	
IIa	3,69 (α-H);	3,94 (β-H)	
IIIa	3,53 (α-H);	3,92 (β-H)	
IVa	3,67 (α-H);	4,00 (β-H)	
Ib	3,87 (α-H);	4,45 (β-H)	
IIb	3,70 (α-H);	4,44 (β-H)	
IIIb	3,54 (α-H);	3,94 (β-H)	
IVb	3,67 (α-H);	4,46 (β-H)	
Ic	4,84 (cis-β-H);	5,60 (trans-β-H);	7,53 (α-H)
IIc	4,89 (cis-β-H);	5,80 (trans-β-H);	8,27 (α-H)
IVc	4,89 (cis-β-H);	5,69 (trans-β-H);	8,21 (α-H)

can be obtained by incorporation of 2-hydroxyethyl groupings in the molecule with subsequent dehydration, as well as through 2-chloroethyl derivatives and dehydrochlorination. The latter methods are of decisive significance in the synthesis of substances that have biological activity, since the use of mercury salts is excluded in this case.

In connection with the fact that 3-pyridazone (I), 6-phenyl-3-pyridazone (II), 6-phenyl-4,5-dihydro-3-pyridazone (III), and 4-methyl-1-phthalazone (IV) may display lactam—lactim tautomerism with preponderance of the lactam form [5], the formation of N- or O-substituted isomers is possible in the case of vinylation if the reaction proceeds with transfer of the reaction center. We have shown that as in the case of alkenylation with vinyl acetate, in the synthesis of vinyl derivatives through intermediate 2-hydroxyethyl (Ia-IVa) and 2-chloroethyl (Ib-IVb) derivatives with subsequent dehydrochlorination of the latter the reaction proceeds via the scheme

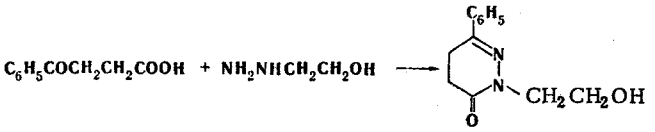


Spectroscopic studies, the results of alternative synthesis, gas—liquid chromatography (GLC), thin-layer chromatography (TLC), and the results of a study of the hydrogenation of some of the synthesized substances serve as a confirmation of this reaction pathway.

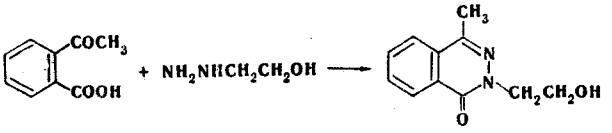
An intense absorption band at 1660-1700 cm^{-1} (ν_{CO}) is present in the IR spectra of all of the compounds obtained (Table 1) and in the IR spectra of starting I-IV. A distinctive feature of the spectra of Ia-IVa is the presence of broad bands at 3340-3370 cm^{-1} (ν_{OH}), while the intense band near 1060 cm^{-1} confirms the presence of a primary alcohol group [6]. The IR spectra of vinyl derivatives Ic, IIc, and IVc contain bands at ∿1640 cm^{-1} ($\nu_{C=C}$ of the vinyl grouping).

The PMR spectra (Table 2) of Ia-IVa differ from the spectra of starting I-IV with respect to the appearance of two triplets (3.90-4.00 and 3.50-3.70 ppm). Derivatives Ib-IVb also have spectra with two triplets at 3.50-3.90 and 4.00-4.50 ppm. However, the other spectral characteristics of the 2-chloroethyl derivatives do not differ from those of the starting substances. In the case of the vinyl compounds the signals of the protons of the unsaturated grouping form an ABX system (J_{trans} = 15.3 Hz, J_{cis} = 9.3 Hz, and $J_{gem} \approx 0$ Hz).

To confirm the structure of substances that correspond to N-substituted compounds we carried out the alternative synthesis of IIIa and IVa by condensation of 2-hydroxyethylhydrazine with β-benzoylpropionic and o-acetylbenzoic acids in an alkaline medium:



IIIa



IVa

The constants and spectral characteristics of the synthesized vinyl compounds and the compounds previously obtained [4] by the Favorskii–Shostakovskii method are identical.

The presence of only one isomer was established in the identification of the compounds obtained by means of GLC and TLC.

Thus, all of these data serve as a confirmation of the formation of only the N isomers in the investigated reactions.

The N isomers were isolated under the examined conditions for the synthesis of vinyl derivatives, as well as in the case of their preparation by direct condensation with acetylene [4]. It follows from this that under the investigated conditions, in the case of the action of weak electrophilic reagents on the lactam form of pyridazones the reaction takes place at the nitrogen atom without transfer of the reaction center [7].

In contrast to the vinyl-substituted Ic, IIc, and IVc, 2-vinyl-6-phenyl-4,5-dihydro-3-pyridazone could not be synthesized by any one of the methods examined above.

EXPERIMENTAL

The IR spectra of KBr pellets and films of the compounds were recorded with a UR-20 spectrometer. The PMR spectra of solutions of the compounds in CCl_4 (Ia, Ib-IIIb, Ic, IIc) and in $CDCl_3$ (IIa-IVa, IVb, IVc) were recorded with a Perkin-Elmer spectrometer (60 MHz) with hexamethyldisiloxane as the external standard. The molecular masses of Ia-IVa were determined with a Varian MAT-311 apparatus, while the molecular masses of the remaining compounds were determined by cryoscopy in dioxane. Chromatographic analysis was carried out with an LKhM-8MD apparatus with an ionization-flame detector; the carrier gas was helium, the column was 2-m long, and the adsorbent was Chromaton N with 10% apiezon. Chromatographic purification of the substances was carried out on LS 5/40μ silica gel with acetone as the eluent. The purity of the compounds was monitored by chromatography on Silufol UV-254 plates with elution by dioxane and diethyl ether.

3-Pyridazone (I), 6-phenyl-3-pyridazone, 6-phenyl-4,5-dihydro-3-pyridazone (III), and 4-methyl-1-phthalazone (IV) were obtained by the methods in [8-11], respectively.

2-(2-Hydroxyethyl)-3-pyridazone (Ia, Table 1). A solution of 6.6 g (0.15 mole) of ethylene oxide in 50 ml of DMF and 1 ml of a 10% solution of sodium methoxide in methanol were added to 9.6 g (0.1 mole) of 3-pyridazone (I), and the mixture was heated to 90°C and stirred for 4 h. The DMF was then removed by distillation, and the residue was subjected to vacuum fractionation to give 9.9 g (70%) of Ia.

2-Hydroxyethyl derivatives IIa, IIIa, and IVa were similarly synthesized.

2-(2-Hydroxyethyl)-6-phenyl-4,5-dihydro-3-pyridazone (IIIa). A mixture of 2.9 g (0.016 mole) of β-benzoylpropionic acid, 20 ml of 0.1 N KOH solution, and 2 g (0.03 mole) of 2-hydroxyethylhydrazine was heated on a water bath for 2 h, after which it was cooled, and the precipitated crystals were removed, dried, and recrystallized from acetone to give 1.7 g (50%) of product. The product melted without a temperature depression in a mixture with the preparation obtained by the method described above.

2-(2-Hydroxyethyl)-4-methyl-1-phthalazone (IVa). A 2.4 g (0.032 mole) of 2-hydroxyethylthydrazine was added to 3.3 g (0.02 mole) of o-acetylbenzoic acid in 30 ml of 0.1 N KOH solution, and the mixture was heated on a water bath for 2 h. It was then cooled, and the precipitated crystals were separated, dried, and recrystallized from DMF to give 2.7 g (66%) of product. A mixture of this product with a sample obtained as described above melted without a temperature depression.

2-(2-Chloroethyl)-3-pyridazone (Ib, Table 1). A 17.9-g (0.15 mole) sample of thionyl chloride was added with stirring to 14 g (0.1 mole) of Ia in 40 ml of chloroform, and the mixture was refluxed for 1 h. The solvent was removed, and the residue was distilled in vacuo to give 13.9 g (88%) of Ib.

The same method was used to synthesize 2-chloroethyl derivatives IIb-IVb (Table 1).

2-Vinyl-3-pyridazone (Ic, Table 1). A solution of sodium methoxide obtained from 1.5 g (0.065 mole) of sodium in 12 ml of methanol was added to 7.9 g (0.05 mole) of Ib in 30 ml of methanol, and the mixture was heated at 65°C for 3 h. The sodium chloride was removed by filtration, the solvent was removed by distillation, and the residue was subjected to vacuum fractionation in the presence of hydroquinone, as a result of which 4.4 g (70%) of Ic was obtained.

2-Vinyl-6-phenyl-3-pyridazone (IIc, Table 1). A) This compound was obtained by the method used to prepare Ic. After refluxing, the reaction mixture was neutralized with 20% hydrochloric acid, during which IIc precipitated.

B) An 18.6-g (0.22 mole) sample of vinyl acetate, 0.5 g of mercuric acetate, and 0.2 ml of concentrated sulfuric acid were added to 5.2 g (0.03 mole) of pyridazone II in 20 ml of chloroform, and the mixture was stirred at no higher than 60°C for 8 h. It was then diluted with 20 ml of chloroform and washed successively with water, sodium carbonate solution, and water until the wash waters were neutral. The chloroform solution was dried with magnesium sulfate, and the excess vinyl acetate and chloroform were removed by distillation. Recrystallization of the residue from hexane gave 3.5 g (60%) of IIc.

2-Vinyl-4-methyl-1-phthalazone (IVc, Table 1). This compound was obtained by a method similar to that used to prepare Ic.

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PYRIMIDINES.

71.* REARRANGEMENTS OF 2,2',4-TRIMETHOXY-6'-PHENYL-4',5-DIPYRIMIDINYL TO N-METHYL OXO DERIVATIVES

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A trimethoxy derivative with three nonequivalent methoxy groups was obtained from 2,2',4-trichloro-6'-phenyl-4',5-dipyrimidinyl. Rearrangement of 2,2',4-trimethoxy-6'-phenyl-4',5-dipyrimidinyl under Hilbert–Johnson conditions and thermal rearrangement with and without a catalyst make it possible to obtain 2',4-dimethoxy-1-methyl-2-oxo- and 2'-methoxy-1,3-dimethyl-2,4-dioxodipyrimidinyls and both tri-N-methyl isomers, viz., the 1,1',3- and 1,3,3'-trimethyl derivatives. The possibility of obtaining N-methyl derivatives of trioxodipyrimidinyl by methylation under various conditions was also examined.

We have previously reported the synthesis of 2,2',4-trichloro-6'-phenyl-4',5-dipyrimidinyl (I) and the sequence of nucleophilic substitution of the chlorine atoms in the compound by an amino group [1]. Continuing our study of the unsymmetrical 4',5-dipyrimidinyl system we carried out the replacement of the chlorine atoms by methoxy groups with the aim of subsequent rearrangements of the trimethoxy derivative to the isomeric N-methyl oxo derivatives of 4',5-dipyrimidinyl. It is known that the N-alkyl oxo derivatives of pyrimidine, both in the uracil series [2] and in the case of 4,6-diaryl-substituted pyrimidines [3] display physiological activity.

The chlorine atoms in dipyrimidinyl I were readily replaced by methoxy groups when it was refluxed with a solution of sodium methoxide in methanol. The resulting 2,2',4-trimethoxy-6'-phenyl-4',5-dipyrimidinyl (II) contains three nonequivalent methoxy groups.

The rearrangements of alkoxy derivatives of the pyrimidine series to N-methyl oxo derivatives have been described in the literature. Most study has been devoted to the rearrangements of the 2,4-dialkoxy derivatives by reaction with alkyl halides (under the conditions of the Hilbert–Johnson reaction) [2] and to thermal rearrangement in the presence of amines [4, 5] or without the use of catalysts [6] for monoalkoxypyrimidines. Known examples of rearrangements of methoxydipyrimidinyls have been described only for cases with 2,4-oriented alkoxy groups in pyrimidine fragments. 2,2',4,4'-Tetramethoxy-5,5'- [7] and 2,2',4,4'-tetramethoxy-4,5'-dipyrimidinyl [8] undergo rearrangement thermally, without the addition of a catalyst, togive products of complete rearrangement, whereas in the case of a symmetrical dipyrimidinyl [7] Chang and co-workers assume that an N,N'-dimethyl methoxy derivative is formed when it is heated under Hilbert–Johnson conditions, although the PMR spectra presented in [7] indicate, in our opinion, the formation of an N,N'N''-trimethyl monomethoxy derivative of 5,5'-dipyrimidinyl. It is known that N–CH_3 and OCH_3 groups in pyrimidines can be easily distinguished from their PMR spectra — the position of the signal of the methoxy group differs from the signal of the N-methyl grouping by ∿0.5 ppm [4, 9, 10].

*See [1] for communication 70.

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