of water, and the mixture was allowed to stand overnight. The precipitated phenylhydrazone was separated to give 1.4 g (72%) of a product with mp 203-205°C and R_f 0.605. IR spectrum: 3027-3419 (NH) and 1682 cm^{-1} (C=O). Found: C 74.8; H 5.1; N 15.8%. $C_{22}H_{18}N_4O$. Calculated: C 74.6; H 5.1; N 15.8%.

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SYNTHESIS AND SOME CHEMICAL TRANSFORMATIONS OF 4'-ARYL-4-HYDROXY-4-METHYL-4,5,4',5'-TETRAHYDRO- AND 4,5-DIHYDRO-3,3'-DIPYRAZOLYLS

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The reaction of 3-epoxypropionyl-2-pyrazolines and 3(5)-epoxypropionylpyrazoles with hydrazine hydrate leads to 4,5,4',5'-tetrahydro- and -4,5-dihydro-3,3'-dipyrazolyls, on the basis of which 4',5'-dihydro-3,3'-dipyrazolyls and 3,3'-dipyrazolyls were subsequently obtained.

Depending on the structure of the substrate, the reaction of α,β-epoxy ketones with hydrazine hydrate may lead to hydroxypyrazolines, pyrazoles, or allyl alcohols [1, 2]. The application of this reaction in series of previously synthesized epoxypropionylpyrazolines and epoxypropionylpyrazoles [3] opens up a route to dipyrazolinyls, pyrazolinylpyrazoles, and dipyrazolyls.

In fact, when epoxypropionylpyrazolines Ia-c are refluxed with hydrazine hydrate in methanol, they are converted to 4'-aryl-4-hydroxy-4-methyl-4,5,4',5'-tetrahydro-3,3'-dipyrazolyls (II-IV), the structure of which was confirmed by chemical transformations and spectral methods. Thus the IR spectra of dipyrazolinyls II-IV (KBr) do not contain the absorption of a carbonyl group that is characteristic for the starting ketones, and the presence of hydroxy absorption at 3310 cm^{-1} indicates opening of the epoxide ring. Starting vibrations of the NH bonds of pyrazoline rings are observed at 3250 and 3340 cm^{-1}. The position of the band of stretching vibrations of an OH group at 3510 cm^{-1} (CCl_4, 10^{-3} mole/liter) indicates intramolecular bonding of the hydroxy group; this is possible in the case of an s-trans orientation of the pyrazoline rings. A characteristic feature of the PMR spectra of II-IV is the presence in them of an ABC spin system of the protons of a pyrazoline ring and an AB spin system of the protons of a hydroxypyrazoline ring (Table 1). The signals of the vicinal transoid protons (H_A and H_C) of the aryl-substituted pyrazoline ring are two quartets with J_{AC} = 4.0 Hz; the spin–spin coupling constants (SSCC) of the geminal pro-

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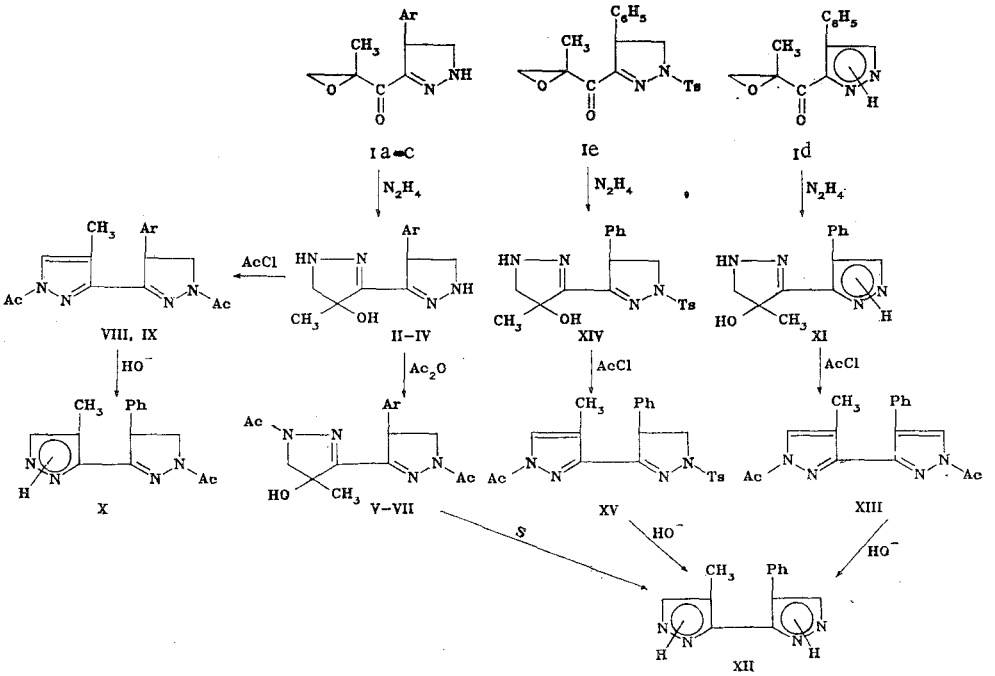
TABLE 1. Data from the PMR Spectra of 3,3'-Dipyrazolyls

Compound	δ_{CH_3}	δ_{ABC}			δ_{CH_2} or δ_{C_4-H}	Other protons
		H_4—C	H_5—A	H_5—B		
II[a]	1,80	4,50	3,66	3,32	3,50, 3,30	3,34 (s H)
III[a]	1,77	4,42	3,55	3,24	3,50, 3,24	3,18 (s H)
IV[a]	1,84	4,43	3,60	3,24	3,55, 3,33	3,28 (s H)
V	1,84	4,60	4,28	4,00	4,10, 3,68	1,90 (s 3H); 2,25 (s 3H); 4,66 (s H); 7,15 (s 5H)
VI[b]	1,86	4,62	4,23	3,95	4,10, 3,68	1,95 (s 3H); 2,23 (s 3H); 4,56 (s H); 6,98 (m 4H)
VII[b]	1,85	4,60	4,22	3,95	4,12, 3,68	1,92 (s 3H); 2,22 (s 3H); 4,56 (s H); 7,08 (m 4H)
VIII[b]	2,14	4,78	4,26	4,05	7,80	2,30 (s 3H); 2,34 (s 3H); 7,20 (s 5H)
X[b]	2,40	5,08	4,45	4,35	7,88	2,50 (s 3H); 7,60 (m 6H)
XI[c]	1,50		7,40		4,05, 3,42	3,26 (s, H); 7,25 (m, 7H)
XII[c]	1,66		7,46		7,88	7,20 (m 7H)
XIV[c]	1,50	4,56	3,88	3,58	3,58, 3,22	2,38 (s 3H); 3,20 (s H); 7,12 (m 6H); 7,33 (d), 7,73 (d, 4H, J = 10,0 Hz)
XV[c]	2,18	4,67	3,83	3,67	7,90	2,25 (s 3H); 2,32 (s 3H); 7,06 (s 5H); 7,40 (d), 7,78 (d 4H, J=10,0 Hz)

[a]In solution in pyridine. [b]In solution in d_6-acetone.
[c]In solution in d_5-pyridine.

tons J_{AB} = 9.6 Hz, and the SSCC of the cisoic vicinal protons J_{BC} = 11.0 Hz. The absorption of the H_B proton shows up in the form of three lines as a consequence of overlapping of the two doublets with J_{AB} = 9.6 Hz and J_{BC} = 11.0 Hz. The J_{AB} = 10.0 Hz SSCC of the geminal protons of the hydroxypyrazoline ring constitutes convincing evidence for participation of the epoxy ring in cyclization.

The acetylation of II-IV with acetic anhydride in chloroform in the presence of triethylamine leads to 1,1'-diacetamides V-VII; in agreement with the spectral data, the hydroxy group is not involved in the reaction. Thus bands of stretching vibrations of a hydroxy group at 3590 cm^{-1} are present in the IR spectra of diacetamides V-VII (CCl_4, 10^{-3} mole/liter). At the same time, in addition to N-acylation, dehydration to give 1,1'-diacetyl-4'-aryl-4-methyl-4',5'-dihydro-3,3'-dipyrazolyls (VIII, IX) occurs in the reaction of acetyl chloride with dipyrazolinyls II and IV. It is interesting to note that the stretching vibrations of the acetamide C=O groups are located at 1680 and 1750 cm^{-1}. The shift of the absorption band of the acetamide group of the pyrazole ring to 1750 cm^{-1} is due



Ia II, V, VIII, X—XV Ar=C_6H_5; Ib, III, VI Ar=4-FC_6H_4; Ic, IV, VII, IX Ar=4-ClC_6H_4

TABLE 2. Physicochemical Characteristics of II-XV

Compound	mp, °C	Found, %			Empirical formula	Calculated, %			Yield, %
		C	H	N		C	H	N	
II	169—170	63,8	6,5	22,9	$C_{13}H_{16}N_4O$	63,9	6,6	22,9	70
III	149—150	59,6	5,7	21,3	$C_{13}H_{15}FN_4O$	59,5	5,8	21,4	70
IV	156—157	55,9	5,5	20,0	$C_{13}H_{15}ClN_4O$	56,0	5,4	20,1	69
V	175—176	62,0	6,1	17,0	$C_{17}H_{20}N_4O_3$	62,2	6,2	17,1	74
VI	181—182	59,0	5,4	16,1	$C_{17}H_{19}FN_4O_3$	58,9	5,5	16,2	68
VII	207—208	56,3	5,2	15,3	$C_{17}H_{19}ClN_4O_3$	56,3	5,3	15,4	60
VIII	169—170	65,6	5,9	17,9	$C_{17}H_{18}N_4O_2$	65,8	5,9	18,1	64
IX	171—172	59,1	4,9	16,2	$C_{17}H_{17}ClN_4O_2$	59,2	5,00	16,3	70
X	178—179	67,1	6,0	20,9	$C_{15}H_{16}N_4O$	67,1	6,0	20,9	87
XI	143—144	64,6	5,8	23,1	$C_{13}H_{14}N_4O$	64,4	5,8	23,1	54
XII	111—113	69,5	5,3	25,0	$C_{13}H_{12}N_4$	69,6	5,4	25,0	91
XIII	166—167	66,4	5,1	18,0	$C_{17}H_{16}N_4O_2$	66,2	5,2	18,2	70
XIV	163—165	60,2	5,4	14,0	$C_{20}H_{22}N_4O_3$	60,3	5,6	14,1	83
XV	145—146	62,6	5,2	13,3	$C_{22}H_{22}N_4O_3$	62,5	5,3	13,3	78

to delocalization of the unshared electron pair of the nitrogen atom in the pyrazole ring, which decreases the particpation of the acetyl group in normal amide resonance, and the frequency of the stretching vibrations of the C=O group is increased.

Alkaline hydrolysis of diacetamide VIII removes the acetyl group from the nitrogen atom of the pyrazole ring to give 1'-acetyl-4-methyl-4'-phenyl-4',5'-dihydro-3,3'-dipyrazolyl (X), in the IR spectrum of which the high-frequency band of the C=O group vanishes, and the band of the stretching vibrations of the acetamide group at 1600 cm^{-1} is retained.

The reaction of epoxypropionylpyrazole Id with hydrazine hydrate also takes place with opening of the epoxy ring to give 4-hydroxy-4-methyl-4'-phenyl-4,5-dihydro-3,3'-dipyrazolyl (XI). The PMR spectrum of XI contains the characteristic AB spin system of the signals of the protons of the pyrazoline ring with J = 10.0 Hz; the absorption of the 5-H proton of the pyrazole ring, the NH proton, and the protons of the benzene ring shows up in the form of a multiplet at 6.85-7.50 ppm.

The synthesis of 4-methyl-4'-phenyl-3,3'-dipyrazolyl (XII) was realized by three methods. Thus treatment of 4,5-dihydro-3,3'-dipyrazolyl XI with acetyl chloride gives 3,3'-dipyrazolyl XIII, the alkaline hydrolysis of which leads to dipyrazolyl XII in 34% yield based on epoxypropionylpyrazole Id.

Dipyrazolyl XII was also obtained by using N-tosylpyrazoline Ie as the starting compound. Reaction of the latter with hydrazine hydrate in methanol gives dipyrazolinyl XIV, which is transformed to pyrazolinylpyrazole XV by the action of acetyl chloride. Dipyrazolyl XII was isolated in 46% yield (based on tosylpyrazoline Ie) after alkaline hydrolysis of XV.

Dipyrazolyl XII is also formed in 54% yield (based on epoxypropionylpyrazoline Ia) by oxidation of diacetylpyrazoline V with sulfur at 180-210°C.

Thus the reaction of 3-epoxypropionyl-2-pyrazolines and 3(5)-epoxypropionylpyrazoles with hydrazine hydrate is a convenient method for the synthesis of diverse compounds of the 3,3'-dipyrazolyl series.

EXPERIMENTAL

The IR spectra of 10^{-2} and 10^{-3} mole/liter solutions in CCl_4 (layer thicknesses 0.01 and 1.00 cm) and KBr pellets were recorded with a Specord 75IR spectrometer. The PMR spectra of solutions in pyridine, d_5-pyridine, and d_6-acetone were measured with a Varian HA-100D-15 spectrometer with hexamethyldisiloxane as the internal standard. The synthesis of Ia-e was described in [3].

4'-Aryl-4-hydroxy-4-methyl-4,5,4',5'-tetrahydro-3,3'-dipyrazolyls (II-IV). A 0.02-mole sample of pyrazoline Ia-c was mixed with 6.2 ml of a 24% aqueous solution of hydrazine hydrate (0.03 mole) in 40 ml of methanol, and the mixture was refluxed for 30 min. It was then cooled, and the precipitate was removed by filtration, washed with cold methanol, air dried, and crystallized from toluene to give the corresponding tetrahydrodipyrazolyl II-IV.

1,1'-Diacetyl-4'-aryl-4-hydroxy-4-methyl-4,5,4',5'-tetrahydro-3,3'-dipyrazolyls (V-VII). A 0.1-mole sample of acetic anhydride and 10 ml of triethylamine were added to a solution of

0.02 mole of II-IV in 20 ml of chloroform, and the reaction mixture was maintained at 20°C for 15 h. The chloroform was evaporated, 50 ml of water was added to the residue, and the precipitate was removed by filtration, air dried, and crystallized from isopropyl alcohol—hexane (2:1).

1,1'-Diacetyl-4'-aryl-4-methyl-4',5'-dihydro-3,3'-dipyrazolyls (VII, IX). A solution of 0.02 mole of II or IV and 0.3 mole of acetyl chloride in 20 ml of chloroform was maintained at 20°C for 15 h, after which the solvent was evaporated, and a solution of sodium bicarbonate was added to the residue. Dihydrodipyrazolyls VIII and IX were removed by filtration, air dried, and crystallized from toluene.

1-Acetyl-4-methyl-4'-phenyl-4,5-dihydro-3,3'-dipyrazolyl (X). A 1-ml sample of a 40% solution of potassium hydroxide was added in portions to a refluxing solution of 2.0 g (6.4 mmole) of acetamide VIII in 100 ml of methanol, after which the mixture was refluxed for 3 h. It was then cooled, and the methanol was evaporated. Water was added to the dry residue, and dipyrazolyl X was removed by filtration and crystallized from toluene.

4-Hydroxy-4-methyl-4'-phenyl-4,5-dihydro-3,3'-dipyrazolyl (XI). A 3.4-g (0.015 mole) sample of pyrazole Id was mixed with 4 ml (0.024 mole) of a 30% solution of hydrazine hydrate in 50 ml of methanol, and the mixture was refluxed for 30 min. The solvent was evaporated, and the residue was diluted with water and extracted with benzene. The benzene was evaporated, and XI was crystallized from acetone—ether (1:5).

1,1'-Diacetyl-4-methyl-4'-phenyl-3,3'-dipyrazolyl (XIII). A solution of 2.4 g (0.01 mole) of XI in a mixture of 5 ml of acetyl chloride and 10 ml of chloroform was maintained at room temperature for 12 h, after which the precipitate was removed by filtration, washed with water, and recrystallized from methanol.

4-Hydroxy-4-methyl-4'-phenyl-1'-tosyl-4,5,4',5'-tetrahydro-3,3'-dipyrazolyl (XIV). A 7.7-g (0.02 mole) sample of N-tosylpyrazoline Ie was dissolved in 100 ml of methanol—THF (2:1), 10 ml of a 25% aqueous solution of hydrazine hydrate was added, and the mixture was refluxed for 30 min. Part of the solvent was evaporated, and the residual solution was cooled to give XIV, which was crystallized from isopropyl alcohol.

1-Acetyl-4-methyl-1'-tosyl-4'-phenyl-4',5'-dihydro-3,3'-dipyrazolyl (XV). A 0.016-mole sample of N-tosylpyrazoline XIV was mixed with 20 ml of chloroform and 4 ml of acetyl chloride, and the mixture was allowed to stand for 12 h. The solvent was then evaporated, and the residue was diluted with sodium bicarbonate solution and extracted with ether. The ether extracts were dried with magnesium sulfate, and part of the ether was evaporated to give 3,3-dipyrazolyl XV, which was crystallized from ethanol.

4-Methyl-4'-phenyl-3,3'-dipyrazolyl (XII). A) A 2.2-g (0.007 mole) sample of dipyrazolyl XIII was dissolved in 75 ml of ethanol, and 1 ml of a 40% aqueous solution of potassium hydroxide was added. After 2 days, the alcohol was evaporated, and the solid residue was treated with 200 ml of water. The aqueous mixture was filtered, and the solid was washed with water, air dried, and crystallized from toluene to give dipyrazolyl XII in 91% yield.

B) A 1.7-ml sample of a 40% aqueous solution of potassium hydroxide was added to 5.3 g (0.012 mole) of dipyrazolyl XV in 100 ml of methanol, and the mixture was refluxed for 1 h. The methanol was evaporated, and XII was isolated in 76% yield by method A.

C) A 1.5-g sample of sulfur was added to 4.9 g (0.015 mole) of pyrazoline V heated to 140°C, and the mixture was heated at 180-210°C until hydrogen sulfide evolution ceased. The mixture was cooled, and the reaction product was extracted with methanol. Part of the methanol was evaporated, and the residue was filtered through a layer of silica gel by elution with ether. Compound XII crystallized in the cold and was recrystallized from toluene to give the product in 73% yield.

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