FORMATION OF THE BENZO[f]PYRAZOLO[3,4-c][1,2,5]-TRIAZEPINE SYSTEM IN THE TEMPLATE REACTION OF o-AMINO-o'-HALOPHENYLAZOPYRAZOLES

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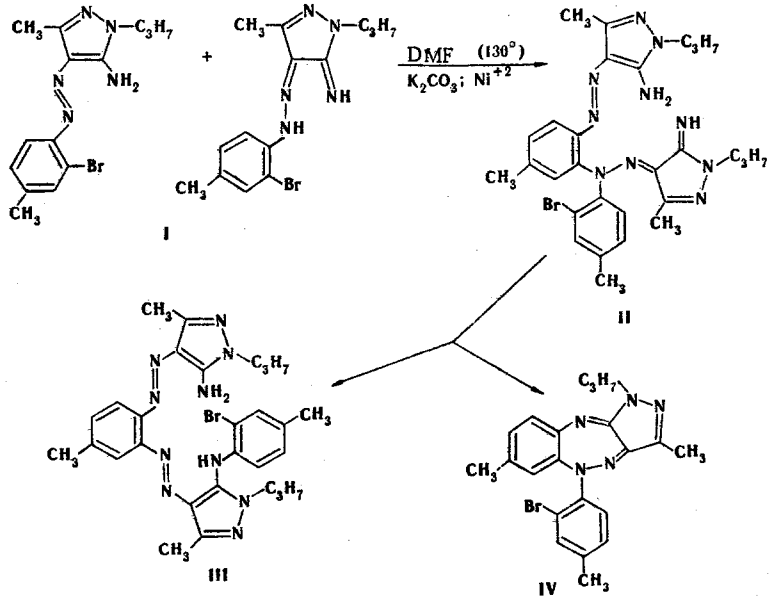
The substance isolated from the template cyclization of 4-(2-bromo-4-methyl-1-phenylazo)-5-amino-3-methyl-1-propylpyrazole was identified by spectroscopic methods as 5-(2-bromo-4-methylphenyl)-3,7-dimethyl-1-propyl-1,5-dihydrobenzo[f]-pyrazolo[3,4-c][1,2,5]triazepine.

[1,2,5,8,9,12]Hexaazacyclotetradecene derivatives were formed, as a rule, in reactions involving template cyclization of o-amino-o'-halo azo compounds and o,o'-dihalo azo compounds in a polar aprotic solvent [dimethylformamide (DMF)] in the presence of Cu(II), Ni(II), and Pd(II) salts and potassium carbonate [1-7]. [1,2,5,6,9,12]Hexaazacyclotetradecenate was obtained along with [1,2,5,8,9,12]hexaazacyclotetradecenate in the template self-cyclization of 4-(2-bromo-4-methyl-1-phenylazo)-5-amino-3-methyl-1-propylpyrazole (I) [8], and a mechanism for the formation of a macrocyclic complex with an ortho orientation of the azo groups that assumes the formation of intermediate azohydrazone II and o-bisazo compound III was proposed.



Macrocyclic complexes — [1,10,11,20-tetrahydro-1,11-dipropyl-3,8,13,18-tetramethyldibenzo[c,j]dipyrazole[3,4-f:3',4'-m][1,2,5,8,9,12]hexaazacyclotetradecenato(2-)-$N^{4(5)}$,N^{10},-$N^{14(15)}$, N^{20}]nickel and [1,14,15,20-tetrahydro-1,14-dipropyl-3,7,12,17-tetramethyldibenzo-[c,j]dipyrazolo[4,3-g;3',4'-m][1,2,5,6,9,12]hexaazacyclotetradecenato(2-)-N^{5},N^{10},N^{15},N^{20}]-nickel, as well as 5-(2-bromo-4-methylphenyl)-3,7-dimethyl-1-propyl-1,5-dihydrobenzo[f]-pyrazolo[3,4-c][1,2,5]triazepine (IV) — are formed, other things being equal, when the template cyclization is carried out in a more concentrated (by a factor of 2.5) DMF solution as compared with that in [8].

The IR spectrum of IV does not contain characteristic bands in the region of the stretching vibrations of the NH bonds. The signals observed in the PMR spectrum constitute

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TABLE 1. PMR Spectra of I and IV (δ, ppm; J, Hz)

Group of protons	Compound				
	I ($CDCl_3$; 0.5 M; 30°)	IV (CCl_4; 0.2 M; 22°)			
		benzene ring attached to the N_5 atom	Δδ*	condensed benzene ring	Δδ*
Propyl CH_3	0,86 t · J=7,0	0,95 t; J=7,2	+0,09		
Propyl CH_2	1,78 m	1,68 m	−0,10		
Propyl CH_2−N	3,70 t; J=7,0	3,43 t; J=6,5	−0,27		
Phenyl CH_3	2,28 s	2,35 s	−0,09	1,94 s	−0,34
Pyrazole CH_3	2,44 s	1,86 s	−0,58		
3-H	7,41 s	7,35 d; J=1,4	−0,06	5,40 d; J=1,5	−2,01
5-H	7,07 d; J=8,1	7,09 dd; J=8,0; 1,4	−0,02	6,57 dd; J=8,0; 1,5	−0,50
6-H	7,63 d; J=8,1	7,39 d; J=8,0	−0,24	6,38 d; J=8,0	−1,25

*This is the difference in the chemical shifts in the spectra of I and IV.

evidence for the presence of aliphatic groups and two benzene rings in the molecule. The signals of the CH_3CH_2, propyl, and CH_3 groups and 3-H and 5-H of the phenyl ring attached to the N_5 atom of the triazepine undergo virtually no shift (the chemical shift does not exceed 0.1 ppm) on passing from azo compound I to IV. The signals of the CH_3 and pyrazole CH_2−N groups and of 6-H of the phenyl ring attached to the N_5 atom are shifted on the average 0.24-0.34 ppm to strong field; this is evidently explained by the closeness of these groups of protons to the triazepine ring. The signals of the phenyl ring condensed with the triazepine ring and of 6-, 8-, and 9-H, as well as the 7-CH_3 signal, are shifted to strong field on passing from I to IV (Table 1); in the case of 2-methyl-6-phenyl-8-chloro-4H-imidazo[1,2-a][1,4]benzodiazepine [9] the signals of the protons of the two phenyl rings are found at 7.15-7.85 ppm (eight protons). The significant shift to strong field of the 6-H, 8-H, and 9-H signals in the spectrum of IV is evidently due to the magnetic anisotropy of the N-phenyl ring, and it may therefore be assumed that the phenyl ring deviates from the plane of the triazepine ring. Molecular-ion peaks with m/e 423-425, which have the maximum intensities, are observed in the mass spectrum of IV, and their configurations (of approximately identical intensities) constitute evidence for the presence of a bromine atom in the investigated compound. The $[M - C_3H_6]^+$ ion peaks with m/e 381-383 indicate detachment of a propyl substituent with the simultaneous migration of one of the hydrogen atoms of the propyl group to the nitrogen atom. In addition, the peak of a bromotropylium cation with m/e 169-171 (3.3% of the maximum) is recorded in the mass spectrum.

The probability of cleavage of the Ar−N bond in noncyclic systems such as arylazopyrazoles is high, and the intensity of the peak of the resulting fragment ion in the mass spectrum is comparable to the intensity of the molecular-ion peak. This process is not observed in the case of IV. Here, a bromine atom is eliminated in the first stages of the fragmentation, and the pyrazole ring is destroyed, as a result of which ions with masses 272, 248, and 235 are formed. Similar processes are characteristic for benzodiazepine, triazinodiazepine, and pyrazolodiazepine systems [11-13].

The production and identification of triazepine IV are in agreement with our previously [8] proposed scheme for the transformations of a macrocyclic metal chelate with ortho-oriented azo groups.

EXPERIMENTAL

The IR spectra of solutions of the compounds in CCl_4 were recorded with a UR-20 spectrometer. The UV spectra were obtained with a Unicam-100A spectrophotometer. The PMR spectra were obtained with a Varian XL-100-12 spectrometer (100 MHz) with tetramethylsilane as the internal standard. The mass spectra were obtained with an MS-702 mass spectrometer with direct introduction of the samples into the ionization region at an ionizing voltage of 70 V; the temperature of the block for vaporization of the sample was 160-170°C. Thin-layer chromatography (TLC) was carried out on Silufol UV-254 plates in an acetone−petroleum ether system (1:5).

4-(2-Bromo-4-methyl-1-phenylazo)-5-amino-3-methyl-1-propylpyrazole (I). This compound was obtained by the method in [8] and had mp 135°C (mp 135-136°C [8]).

5-(2-Bromo-4-methylphenyl)-3,7-dimethyl-1-propyl-1,5-dihydrobenzo[f]pyrazolo[3,4-c]-[1,2,5]triazepine (IV). A mixture of 6.72 g (0.02 mole) of I, 20 g of potassium carbonate, 2.91 g (0.01 mole) of nickel(II) nitrate hexahydrate, and 300 ml of DMF was heated at 150°C for 6 h until the starting I disappeared (as monitored by TLC), after which the mixture was cooled and poured into 300 ml of water. The resulting precipitate was removed by filtration, washed with water, dried, and purified with a column filled with neutral activity II Al_2O_3 (elution with benzene). The first fraction was collected and the purification was repeated three times; recrystallization from benzene gave 0.51 g (12%) of IV with mp 158-160°C as a dark-green crystalline substance that was quite soluble in trichloromethane, tetrachloromethane, acetone, DMF, and DMSO but insoluble in water. UV spectrum (in methanol), λ_{max} (log ε): 345 (3.47) and 400 (3.75); in $CHCl_3$: 405 (3.66) and 580 nm (2.81). Mass spectrum, m/e (relative intensities of the ion peaks in percent): 425-423 (100), 383-381 (12.5), 302 (15.8), 272 (17.2), 248 (44.2), 235 (41.6), 220 (11.9), 208 (11.8), 194 (8.3). Found: C 59.5; H 5.2; Br 18.7; N 16.4%. $C_{21}H_{22}BrN_3$. Calculated: C 59.4; H 5.2; Br 18.8; N 16.5%; M 424.3.

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