$\alpha$ -Cyano- $\beta$ -aminocrotonic Acid N-Benzylamide (XIII). A mixture of 1.15 g (4.7 mmole) of amide XII and 20 ml of an alcohol solution of ammonia ( $\sim$ 14%) was heated in a bomb at 80°C for 6 h, after which it was evaporated to give 0.93 g of amide XIII.

 $\frac{1-\text{Benzyl}-4-(\beta-N,N-\text{dimethylamino})\,\text{vinyl}-5-\text{cyano}-1,6-\text{dihydro}-6-\text{pyrimidinone}~(XIV).}{\text{of 1 g (4.7 mmole) of amide XIII, 2.8 g (18.8 mmole) of acetal IV, and 20 ml of absolute ethanol was refluxed for 4 h, after which it was evaporated, and the residue was triturated with a small amount of alcohol to give 1.09 g of pyrimidinone XIV. IR spectrum: 2210 (C=N) 1600, 1620 cm<sup>-1</sup> (C=O, C=N), UV spectrum (in alcohol), <math>\lambda_{\text{max}}$  (log  $\varepsilon$ ): 214 (4.20), 287 (4.37), and 376 nm (4.31).

 $\alpha$ -Chano- $\beta$ -hydroxycrotonic Acid N-Benzylæmide (XV). A) A 0.2-g (0.71 mmole) sample of pyrimidinone XIV was refluxed from 3 h in 20 ml of 1 N NaOH, after which the solution was cooled and neutralized to pH 4-5 with concentrated HCl. The precipitate was removed by filtration to give 0.07 g of amide XV. IR spectrum: 2220 (C=N), 3340 (OH), and 1600 cm<sup>-1</sup> (C=O).

B) A mixture of 0.5 g (2 mmole) of amide XII and 20 ml of 1 N NaOH was refluxed for 1 h, after which it was cooled and neutralized to pH 4-5 with concentrated HCl to give 0.23 g of a product with a melting point and IR spectrum identical to those for amide XV.

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SYNTHESIS OF HETEROCYCLES ON THE BASIS OF 1,5-DIKETONE HYDRAZONES. 2.\* OXIDATIVE CYCLIZATION OF  $\delta$ -BICYCLANONE BIS(PHENYLHYDRAZONES) AS A METHOD FOR THE SYNTHESIS OF SUBSTITUTED 2-PHENYL-4R- $\Delta^{1}(B^{2})$ -OCTAHYDROCINNOLINE-3-SPIROCYCLOHEXANES

Τ.	V.	Moskovkina	and M.	Ν.	Tilichenko	UDC	55	547.288.3'642'759.32'852.7:
							5	542.943'953:543.422

Little study has been devoted to the reaction of 1,5-diketone hydrazones. We have previously shown that the phenylhydrazones of semicyclic and alicyclic 1,5-diketones undergo Fischer cyclization to give, respectively, pyridocarbazoles [1] and indoloacridines [2].

\*See [1] for Communication 1.

Far Eastern State University, Vladivostok 690600. Translated from Khimiya Geterotsiklicheskikh Soedinenii, No. 6, pp. 821-825, June, 1983. Original article submitted October 12, 1982. In a continuation of our study of the chemistry of 1,5-diketone hydrazones we observed the ability of alicyclic 1.5-diketone bis(phenylhydrazones) IIa-c to undergo oxidative cyclization to 2-phenyl-4R- $\Delta^1$ (<sup>9a</sup>)-octahydrocinnoline-3-spirocyclohexane derivatives IV. This cyclization takes place under the influence of oxidizing agents, viz., oxygen or ferric chloride. Intermediates IIIa-c, which contain an azo olefin fragment and are formed under the influence of oxidizing agents on phenylhydrazones IIa-c, undergo intramolecular cyclization as a result of 1,4-addition of the N-H group of the hydrazone fragment to the azo olefin system:



Similar reactions, viz., the oxidation of phenylhydrazones of ketones, including cyclohexanone, to azo olefins under the influence of various oxidizing agents [3-6], as well as the ability of azo olefins to add H-active reagents in the 1 and 4 positions, are known [7, 8]. However, in our case these reagents proceed intramolecularly and give new heterocyclic systems IVa-c.

The structures of cyclization products IVa-c were confirmed by spectral data and chemical transformations. Thus, in the mass spectra of IVa-c the molecular-ion peaks are two units smaller than the values calculated for starting hydrazones IIa-c. This decrease in the molecular masses for the products makes it possible to propose that the conversion of II to IV proceeds through dehydrogenation in one of the hydrazone fragments.



**a** R = H; **b**  $R = CH_3$ ; **c**  $R = C_6H_5$ 

The presence of a singlet signal in the <sup>13</sup>C NMR spectra of IVa-c at 60-62 ppm in experiments with incomplete suppression of the coupling with the protons confirms cyclization to form a quaternary carbon atom bonded to the nitrogen atom. This signal is absent in the spectra of starting hydrazones IIa-c. The structural fragment that contains a quaternary carbon atom adjacent to the nitrogen atom could have been formed due to the addition of a hydrazone residue to the 1,4 position of the azo olefin. The chemical shifts and the multiplicities of the signals of the other carbon atoms in the spectra of IVa-c (Table 1) correspond to the proposed formulas.

TABLE 1. ~~C NMR Spectra of IVa-c an	.d V1	Ľ
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Carbon	Observed signals, ppm (simplicity)													
atoms		IV/b					IVC VI							
$\begin{array}{c} C_{(3)} \\ C_{(4)} \\ C_{(4a)} \\ C_{(5)} \\ C_{(6)} \\ C_{(7)} \\ C_{(8)} \\ C_{(8a)} \\ C_{(2a)} \\ C_{(2a)} \\ C_{(2a)} \\ C_{(3)} \\ C_{(4)} \\ C_{(5)} \\ C_{(5)} \\ C_{(6)} \\ Signals of \\ the aromatic \\ carbon atoms \end{array}$	$\begin{array}{c} 60.9 \text{ (s)} \\ 25.3 \text{ (t)}^{\text{b}} \\ 38.7 \text{ (d.)} \\ 33.8 \text{ (t)} \\ 26.3 \text{ (t)} \\ 32.1 \text{ (t)} \\ 37.2 \text{ (t)} \\ 147.0 \text{ (s)} \\ 145.9 \text{ (s)} \\ 21.6 \text{ (t)} \\ 24.3 \text{ (t)} \\ 32.5 \text{ (t)} \\ 112.8 \text{ (d. 2-C)} \\ 123.2 \text{ (d. 1-C)} \\ 129.7 \text{ (d. 2-C)} \\ 142.2 \text{ (s. 1-C)} \\ 142.2 \text{ (s. 1-C)} \\ \end{array}$	; 119,3 ; 126,7 ; 129,1 ; 144,5	(d., (d., (d., (s.,	1-C); 2-C); 2-C); 1-C)	$\begin{array}{c} 61,3 \ ( \ \mathbf{s} ) \\ 45,1 \ ( \ \mathbf{d} ) \\ 40,7 \ ( \ \mathbf{d} ) \\ 27,2 \ ( \ \mathbf{t} ) \\ 26,3 \ ( \ \mathbf{t} ) \\ 32,0 \ ( \ \mathbf{t} ) \\ 36,3 \ ( \ \mathbf{t} ) \\ 150,7 \ ( \ \mathbf{s} ) \\ 149,8 \ ( \ \mathbf{s} ) \\ 22,3 \ ( \ \mathbf{t} ) \\ 35,1 \ ( \ \mathbf{t} ) \\ 147,5 \ ( \ \mathbf{s} , \\ 129,2 \ ( \ \mathbf{d} , \\ 125,6 \ ( \ \mathbf{d} , \\ 119,6 \ ( \ \mathbf{d} , \\ \end{array} \right)$	1-C); 2-C); 1-C); 1-C);	145,8 129,0 128,2 113,1	(s. (d. (d,	1-C); 2-C); 2-C); 2-C)		$ \begin{array}{c} 67,6 \ (s) \\ 34,0 \ (t) \\ 31,1 \ (d) \\ 32,9 \ (t) \\ 26,4 \ (t) \\ 26,4 \ (t) \\ 26,4 \ (t) \\ 37,9 \ (t) \\ 146,3 \ (s) \\ 208,3 \ (s) \\ 37,9 \ (t) \\ 25,3 \ (t) \\ 21,4 \ (t) \\ 38,3 \ (t) \\ 149,9 \ (s \\ 1-C) \\ 127,9 \ (d, \\ 2-C) \\ 126,7 \ (d, \\ 2-C) \\ 123,9 \$			
$CH_3$					15.2 (q,	-C)								

<sup>a</sup>The signals were assigned after experiments under off-resonance conditions and by comparison with model derivatives of cyclohexanone [9] and  $\Delta^1({}^8a)$ -octahydroquinoline [10] and with the aid of the computational methods in [11]. <sup>b</sup>The assignment of these signals is ambiguous.

The presence of a hydrazone fragment in the cyclization products was confirmed by conversion of IVa to tetrahydrocarbazole derivatives Va and ketone VIa under the influence of the dilute hydrochloric acid. After changing the acidic treatment conditions, we obtain tetrahydrocarbazole-1-spiro-3'-(2'-phenyl- $\Delta^{1'}$ (<sup>8'a</sup>)-octahydrocinnolines) (Va-c) in higher yields by the reaction of spiro compounds IVa-c with boron trifluoride etherate in acetic acid.

Characteristic (for the indole ring) absorption bands at 1500, 1600, and  $3360-3460 \text{ cm}^{-1}$  (NH) and absorption bands of the C=N bond in the cinnoline ring at 1620-1630 cm<sup>-1</sup> are observed in the IR spectra of Va-c. Molecular-ion peaks are observed in the mass spectra of Va-c at m/z 369 (Va), 383 (Vb), and 445 (Vc), in agreement with the calculated values for the proposed formulas.

The structure of ketone VI was confirmed by the IR, <sup>13</sup>C NMR, and mass spectra. The <sup>13</sup>C NMR spectrum of this derivative contains a characteristic signal for the carbon atom of the carbonyl group of six-membered ketones at 208.3 ppm (s). A signal of a spiro atom is observed at 67.6 ppm (s). The positions and multiplicities of the signals of the other carbon atoms are presented in Table 1.

Thus the oxidation of alicyclic 1,5-diketone bis(phenylhydrazones) is accompanied by cyclization, which opens up a route to the synthesis of previously unknown spiro derivatives of  $\Delta^{1}(^{8}a)$ -octahydrocinnoline.

## EXPERIMENTAL

Diketones Ia-c were obtained by the methods in [12-14]. The course of the reactions and the individualities of the substances obtained were realized by thin-layer chromatography (TLC) [Silufol UV-254, ether-hexane (3:5); the spots were detected by means of **iodine** vapors]. The IR spectra of solutions of the compounds in carbon tetrachloride were obtained with a Specord IR-75 spectrometer. The NMR spectra of solutions in CDCl<sub>3</sub> were recorded with a Brucker HX-90E spectrometer (90 MHz) with tetramethylsilane as the internal standard. The mass spectra were determined with an LKB-9000S spectrometer with direct introduction of the substances into the ionization chamber at an ionization energy of 70 eV.

<u>Diketone Bis(phenylhydrazones) IIa-c.</u> A 0.04-mole sample of the corresponding diketone Ia-c\* in 100 ml of ethanol was added in the course of 1 h with stirring in a stream of argon

\*In the case of Ic we used an equilibrium mixture of the diketone and hydroxydecahydroxanthene obtained by thermal decyclization of 8-phenyltricyclo[7.3.3.0<sup>2,7</sup>[tridecan-2-ol-13-one as described in [14].

TABLE 2.  $\delta$ -Bicyclanone Bis(phenylhydrazones) (IIa-c) and 2-Phenyl-4-R- $\Delta^{1}(^{8}a)$ -octahydrocin-noline-3-spiro-1'-cyclohexan-2'-one Phenylhydrazones (IIIa-c)

Com'- pound	R	mp, °C	R <sub>f</sub>	IR spect	rum (in n cm <sup>-1</sup>	mineral oil),			Found C, % H, % N, % M			Empirical formula	Calc.				Yield, %
II a II b II c III a	H CH₃ C₅H₅ H	126—128a 164—165a 144—146b 167—168c	0,53 0,74 0,73 0,28	1600 (C=NN 1600 (C=NN 1602 (C=NN 1600 (C=NN	$HC_{6}H_{5}), HC_{6}H_{5}), HC_{6}H_{6}), $	3332, 3 3214, 3 3310, 3 3351 (	8266 (NH) 8318 (NH) 8245 (NH) (NH)	77,4 77,4 80,3 77,9	8,2 8,8 7,8 8,0	14,5 14,3 12,3 14,8	386	$\begin{array}{c} C_{25}H_{31}N_4\\ C_{26}H_{34}N_4\\ C_{31}H_{36}N_4\\ C_{25}H_{30}N_4 \end{array}$	77,3 77,6 80,2 77,7	8,2 8,6 7,7 7,8	14,4 13,9 12,1 14,5	388 402 464 386	80 25 37 53 (A) 25 (B)
IIIb	CH₃	163—165 <b>c</b>	0,30	1600 (C=N) 3226 (NH)	NHC6H5),	1640	(C=N)	77,8	7,9	14,3	400	$C_{26}H_{32}N_4$	78,0	8,0	14,0	400	36 (C) 58
IIIc	C <sub>6</sub> H₅	122—124 <b>c</b>	0,32	1600 (C=N 3380 (NH)	NHC <sub>6</sub> H₅),	1666	(C=N),	80,8	7,5	12,3	462	$C_{31}H_{34}N_4$	80,5	7,3	12,1	462	60

<sup>a</sup>From ethanol. <sup>b</sup>With decomposition (from ethyl acetate).

to a solution of 0.08 mole of freshly distilled (in an argon atmosphere) phenylhydrazine in 50 ml of ethanol. The resulting precipitate of the corresponding bis(phenylhydrazone) IIa-c was removed by filtration after 10 h and was washed with ethanol (two 30-ml portions) or ether (two 30-ml portions) in the case of IIa,b-i. Data on the substances obtained by this procedure are presented in Table 2.

2-Phenyl-4R- $\Delta^{1}$  (sa)-octahydrocinnoline-3-spiro-1'-cyclohexan-2'-one Phenylhydrazones (IVa-c). A) A 0.02-mole sample of the corresponding bis (phenylhydrazone) IIa-c was dissolved or suspended in 100 ml of dry benzene, and a stream of oxygen was passed through the solution or suspension until the starting substance vanished in the reaction medium according to TLC data. The benzene was then removed from the reaction mixture by distillation, 30 ml of ethanol was added to the residue, and the mixture was allowed to stand for crystallization. The resulting precipitate was removed by filtration and washed with ethanol to give the desired IVa-c (Table 2).

B) A 7.76-g sample of diketone bis(phenylhydrazone) Ia was dissolved in 50 ml of ethanol, a solution of 5.4 g (0.02 mole) of ferric chloride hexahydrate in 20 ml of 50% ethanol was added, and the mixture was allowed to stand at room temperature for 2 h. The resulting precipitate was removed by filtration and washed with ethanol (three 10-ml portions). Water (40 ml) was added to the precipitate, and the resulting suspension was refluxed for 2 h. The undissolved material was removed by filtration and washed with water (two 5-ml portions) and ethanol (two 5-ml portions) to give 1.9 g (25%) of IIIa.

C) A 4-ml (0.04 mole) sample of phenylhydrazine was added in an argon atmosphere to a solution of 4.16 g (0.02 mole) of diketone Ia in 20 ml of ethanol, and the mixture was allowed to stand at room temperature for 40 min. A solution of 5.4 g (0.02 mole) of ferric chloride hexahydrate in 20 ml of ethanol was added to the reaction mixture. Darkening and heating up of the solution to  $48^{\circ}$ C were observed. After 3 h, the precipitate was removed by filtration, washed with water and ethanol, and worked up as described in method B to give 2.8 g (36%) of IIIa.

<u>1,2,3,4-Tetrahydrocarbazole-l-spiro-3'(2'-phenyl- $\Delta^{1'}(^{a'a})$ -octahydrocinnoline) (Va).</u> A 3.9-g (0.01 mole) sample of hydrazone IIIa was mixed with 15 ml of glacial acetic acid, 3 ml of boron trifluoride etherate was added, and the mixture was allowed to stand at room temperature for 24 h. The precipitate was removed by filtration, washed with acetic acid (two 10-ml portions) and water, transferred to a separatory funnel, and shaken with ether and a saturated solution of sodium carbonate. The ether layer was separated, washed with water until the wash water was neutral, dried with MgSO<sub>4</sub>, and evaporated to give 3 g (80%) of Va with mp 199-200°C (from ethanol). IR spectrum (CHCl<sub>3</sub>): 1500, 1600 (aromatic ring vibrations); 1624 (C=N); 3465 cm<sup>-1</sup> (NH). Found: C 81.6; H 7.3; N 11.2%, M 369; C<sub>25</sub>H<sub>27</sub>N<sub>3</sub>. Calculated: C 81.3; H 7.3; N 11.3%; M 369.

 $\frac{1.2,3,4-\text{Tetrahydrocarbazole-1-spiro-3'-(2'-phenyl-4'-methyl-\Delta^{1'(s'a)}-octohydrocinnoline)}{(Vb)}$ . Compound Vb was obtained from 4 g (0.01 mole) of hydrazone IVb by the method described for Va. However, for the isolation of Vb the reaction mixture was neutralized at the end of the reaction with sodium bicarbonate and extracted with ether. The extract was dried with MgSO<sub>4</sub>, the ether was removed by distillation, and 6 ml of ethanol was added. The precipitate was removed by fil-tration to give 2.4 g (62%) of the desired product with mp 187-188°C (from ethanol). IR spec-

trum (CHCl<sub>3</sub>): 1500, 1600 (aromatic ring vibrations); 1620 (C=N); 3366 cm<sup>-1</sup> (NH). Found: C 81.3; H 7.8; N 11.1%; M 383. Calculated: C 81.5; H 7.6; N 11.0%; M 383.

1,2,3,4-Tetrahydrocarbazole-l-spiro-3'-(2',4'-diphenyl- $\Delta^{1'(8'a)}$ -octahydrocinnoline) (Vc). Acetic acid (3 ml) and 0.5 ml of boron trifluoride etherate were added to 1.8 g (0.005 mole) of IVc, and the mixture was allowed to stand at room temperature for 6 h. The resulting precipitate was removed by filtration, washed with acetic acid and water, and dried to give 0.6 g (40%) of Vc. The product was recrystallized twice from ethyl acetate and from ethanol to give golden needles with mp 190-192°C. IR spectrum (CHCl<sub>3</sub>): 1500, 1600, 1620 (C=N); 3370 cm<sup>-1</sup> (NH). Found: C 83.0; H 8.1; N 9.4%; M 445. C<sub>31</sub>H<sub>31</sub>N<sub>3</sub>. Calculated: C 83.6; H 8.6; N 9.4%; М 445.

2-Phenyl-Δ<sup>1</sup>(<sup>8</sup>a)-octahydrocinnoline-3-spiro-l'-cyclohexan-2'-one (VI). A 3.9-g (0.01 mole) sample of IVa was added with stirring to 20 ml of 3 N hydrochloric acid, during which the added substance dissolved, and a new precipitate formed. The mixture was allowed to stand at room temperature for 2 h, and the resulting precipitate was removed by filtration, washed with 3 N hydrochloric acid (two 10-ml portions), and dried to give 1.55 g of a precipitate, which was identified as a mixture of phenylhydrazone hydrochloride and IVa. To isolate IVa, the mixture was treated with water and extracted with ether (two 10-ml portions). The extract was dried with calcined  $K_2CO_3$  and concentrated in vacuo to give 1 g (23%) of IVa.

The filtrate remaining after separation of the mixture of IVa and phenylhydrazine hydrochloride was made alkaline with Na<sub>2</sub>CO<sub>3</sub>. The resulting precipitate was extracted with ether (three 30-ml portions), the extract was dried with MgSO4, and the ether was removed by distillation. Ethanol (10 ml) was added to the oily residue (2.2 g), and the mixture was allowed to stand for crystallization. The crystals were removed by filtration and washed with ethanol (two 5-ml portions) to give 1.5 g (51%) of V with mp 118-119°C (from alcohol). IR spectrum (CHCl<sub>3</sub>): 1710 (C=O) and 1630 cm<sup>-1</sup> (C=N). Found: C 77.3; H 8.5; N 9.7%; M 296. C19H24N2O. Calculated: C 77.0; H 8.1; N 9.5%; M 296.

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