LITERATURE CITED

1. É. B. Yagubskii, A. I. Kotov, G. P. Shibaeva, A. A. Ignat'ev, O. Ya. Neiland, and Ya. N. Kreitsberga, *Dokl. Akad. Nauk SSSR*, **289**; 676 (1986).
2. O. Ya. Neiland, Ya. Ya. Katsens, and Ya. N. Kreitsberga, *Zh. Org. Khim.*, **25**, 658 (1989).
3. K. Hartke, I. Quante, and I. Kampchen, *Ann.*, No. 10, 1482 (1980).
4. J. Gillman and K. Hartke, *Chem. Ber.*, **119**, 2819 (1988).
5. E. M. Engler, X. Y. Lee, R. R. Schumaker, S. S. Parkin, R. L. Green, and I. C. Scott, *Mol. Cryst. Liq. Cryst.*, **107**, 19 (1984).
6. Ya. N. Kreitsberga, K. A. Balodis, I. L. Kraupsha, and O. Ya. Neiland, *Zh. Org. Khim.*, **24**, 1243 (1988).

PYRROLES FROM KETOXIMES AND ACETYLENE.
46.* PYRROLES WITH STERICALLY HINDERED SUBSTITUENTS

I. A. Aliev, S. E. Korostova,
A. I. Mikhaleva, S. G. Shevchenko,
S. N. Zeinalova, L. N. Sobenina,
M. V. Sigalov, and B. R. Gasanov

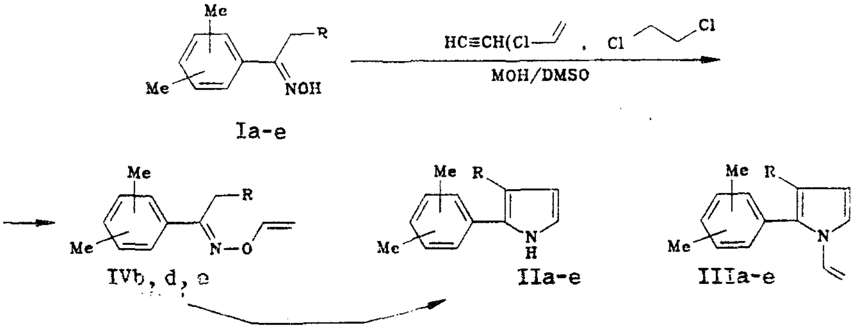
UDC 547.574.2+547.314.2+
536.423.4+547.741

The corresponding pyrroles and their N-vinyl derivatives were obtained by the catalyzed (by an MOH—DMSO superbase) reaction of acetylene and its crypto forms (vinyl chloride, 1,2-dichloroethane) with alkyl-2,4-, alkyl-2,5-, and alkyl-3,4-dimethylphenylketoximes. Reaction intermediates — O-vinylketoximes — were detected.

The condensation of ketoximes with acetylene in superbase media (the Trofimov reaction), which leads to pyrroles and N-vinylpyrroles, has been investigated quite extensively [2]. However, ketoximes with sterically bulky substituents that are capable of hindering the approach of the oximate anion to the acetylenic bond have not been involved in this reaction thus far.

The aim of the present research was to investigate the possibility of the use of such ketoximes, viz., alkyl 2,4-, 2,5-, and 3,4-dimethylphenyl ketone oximes Ia-e, in the reaction with acetylene and its crypto forms (vinyl chloride, 1,2-dichloroethane) under the influence of the MOH—DMSO catalytic pair (M = Li, K) and to synthesize the previously unknown sterically hindered pyrroles and N-vinylpyrroles, which are interesting models for the study of the dependence of the effects of conjugation on the degree of coplanarity of interacting π fragments.

Our research showed that, depending on the reaction conditions, ketoximes Ia-e can react with acetylene to give the corresponding pyrroles IIa-e or their N-vinyl derivatives IIIa-e (see Table 1).



I—IV a R=H, 2,4-Me$_2$; b R=H, 2,5-Me$_2$, c R=H, 3,4-Me$_2$, d R=Me, 2,5-Me$_2$; e R=Et, 2,5-Me$_2$; M=Li, K

---

*For Communication 45 See [1] .

Irkutsk Institute of Organic Chemistry, Siberian Branch, Academy of Sciences of the USSR, Irkutsk 664033.
Translated from Khimiya Geterotsiklicheskikh Soedinenii, No. 10, pp. 1320-1323, October, 1991. Original article submitted July 23, 1990.

TABLE 1. Effect of the Reaction Conditions on the Yields of Pyrroles IIa-e and N-Vinylpyrroles IIIa-e

Expt.	Location of the CH_3 group	R	T, °C	Time, h	$P_{C_2H_2}$, atm	M	Ketoxime: MOH, moles	Yield, %	
								pyrrole	N-vinylpyrrole
1	2,5	H	100	2	12	K	1:1	Trace	33
2	2,5	H	100	3	12	K	1:1	Trace	51
3	2,5	H	70	3	12	K	1:2	Trace	14
4	2,5	H	80	3	12	Li	1:1	25	Trace
5**	2,5	H	70	6	—	K	1:1	21	Trace
6	2,5	H	130	3,5	—	K	1:6	49	6
7	2,5	H	100	6	—	K	1:12	Not isolated	
8	2,4	H	130	3,5	—	K	1:6	49	6
9	3,4	H	130	3,5	—	K	1:6	48	7
10	2,5	Me	100	3	12	K	2,3:1	Traces	62
11***	2,5	Me	70	6	—	K	1:1	39	Traces
12***	2,5	Et	70	6	—	K	1:1	45	Traces
13	2,5	Et	115	3	—	K	1:1	Traces	52

---

*Vinyl chloride was used in experiments 6, 8, and 9, while 1,2-dichloroethane was used in experiment 7.

**The yield of the O-vinylketoxime was 10%.

***An O-vinylketoxime was present in the reaction mixture (according to the IR spectral data).

TABLE 2. Constants of Pyrroles IIa-e and N-Vinylpyrroles IIIa-e*

Compound	Empirical formula	T_{mp} °C [T_{bp} °C (hPa)]	d_4^{20}	n_D^{20}
IIa	$C_{12}H_{13}N$	65	—	—
IIb	$C_{12}H_{13}N$	47	—	—
IIc	$C_{12}H_{13}N$	71	—	—
IId	$C_{13}H_{15}N$	[104...106 (3,3)]	1,0196	1,5766
IIe	$C_{14}H_{17}N$	[114 (1,33...2,66)]	0,9988	1,5688
IIIa	$C_{14}H_{15}N$	[127...129 (1,33)]	1,0240	1,5898
IIIb	$C_{14}H_{15}N$	[104 (1,33...2,66)]	1,0026	1,5830
IIIc	$C_{14}H_{15}N$	[130...132 (1,33)]	1,0728	1,6018
IIId	$C_{15}H_{17}N$	[120...125 (5,32)]	0,9903	1,5745
IIIe	$C_{16}H_{19}N$	[112...113 (2)]	0,9802	1,5686

---

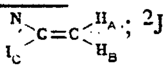
*The results of elementary analysis (C, H, N) were in agreement with the calculated values.

**The purity was 97.5% (according to GLC data).

TABLE 3. PMR Spectra of Pyrroles IIa-e and N-Vinylpyrroles IIIa-e

Compound	Chemical shifts, δ, ppm								
	NH	R or 3-H	4-H	5-H	A—H*	B—H*	C—H*	C_6H_3	Me_2
IIIc	8,11	6,30	6,30	6,79	—	—	—	7,14	2,39; 2,48
IIIb	8,07	6,34	6,34	6,82	—	—	—	7,21	2,43; 2,46
IIId	8,21	6,23	6,43	6,70	—	—	—	7,08; 7,19	2,22
IIIe	7,66	1,96	6,05	6,59	—	—	—	7,01	2,12; 2,25
	7,76	2,34 (CH_2);	6,14	6,67	—	—	—	7,02; 7,07	2,12; 2,27
IIa		1,09 (CH_3)							
IIb	—	5,98	5,98	6,17	4,94	4,40	6,63	7,00	2,06; 2,29
IIc	—	5,91	6,11	6,90	4,93	4,41	6,44	7,00	2,05; 2,27
IId	—	6,38	6,38	7,00	5,07	4,58	6,79	7,13	2,23
IIe	—	1,85	6,11	7,00	4,88	4,33	6,36	7,10	2,00; 2,28
	—	2,28 (CH_2);	6,20	7,00	4,92	4,35	6,36	7,00	1,58; 2,28
IIIa		1,04 (CH_3)							

---

* 
$\mathrm{N}(\mathrm{H_C})\mathrm{C{=}C}(\mathrm{H_A})\mathrm{H_B}$; $^2J_{AB} = 0.8$, $^3J_{BC} = 9.0$, $^3J_{AC} = 15.0$ Hz.

The reaction can be realized under both increased pressure and at atmospheric pressure. 1-(2,5-Dimethylphenyl)pyrrole (IIb) was obtained in 25% yield in the LiOH—DMSO system from ketoxime Ib and acetylene (initial pressure 12 atm) at 80°C. In this case, however, one observes its partial deoximation to give 2,5-dimethylacetophenone, which contaminates pyrrole IIb (experiment 4). This pyrrole was obtained in virtually the same yield at atmospheric pressure using the more effective KOH—DMSO system (experiment 5). In this variation the resulting intermediate — O-vinyl-2,5-dimethylacetophenone oxime (IVb) — does not undergo complete rearrangement to pyrrole IIb and can be isolated from the reaction mixture in 10% yield by chromatography. Its structure was confirmed by IR and PMR spectral data.

During prolonged storage O-vinylketoxime IVb, even at room temperature, undergoes partial conversion to pyrrole IIb, which was identified by TLC.

The pyrrolization of ketoxime Ib can also be realized by using 1,2-dichloroethane in place of acetylene in the same superbase medium at 100°C (experiment 7). However, a complex difficult-to-separate mixture of products (according to the IR spectroscopic and GLC data) containing, in addition to O-vinylketoxime IVb and pyrroles IIb and IIIb, ethylene glycol diether $[2,5\text{-}Me_2C_6H_3C{-}(Me){=}NOCH_2{-}]_2$, which is formed as a consequence of nucleophilic substitution of chlorine in 1,2-dichloroethane by the oximate anion [3], starting ketoxime Ib, and the product of its deoximation, viz., 2,5-dimethylacetophenone, is formed in this variation. The yield of pyrrole IIb is increased significantly (up to 24%) if vinyl chloride (130°C, experiment 6) ;is used in place of acetylene, but vinylpyrrole IIIb is formed in low yield (6%) in this case. Pyrroles IIa, c were similarly obtained in good yields from methyl-2,4- and methyl-3,4-dimethylphenylketoximes (Ia, c) (experiments 8 and 9, respectively).

N-Vinyl derivatives of 2-(2,5-dimethylphenyl)pyrroles are best obtained at an increased acetylene pressure in the KOH—DMSO system. Their yields depend on the temperature, the reaction time, and the KOH concentration (experiments 1-3). Increasing the amount of KOH in the reaction mixture and shortening the time during which ketoxime Ib is in contact with acetylene do not promote an increase in the yield (experiments 1 and 3). The best result (51%) is obtained by heating (at 100°C) ketoxime Ib and the equivalent amount of KOH (experiment 2). Vinylpyrroles IIId, e were similarly synthesized via the acetylene variation (experiments 10 and 13).

When one compares the results of experiments 5, 11, and 12, which were realized under identical conditions, one observes a tendency for an increase in the yields of the pyrroles in the order IIb (21%) < IId (39%) < IIe (45%), i.e., the reactivities of ketoximes Ib, Id, and Ie increase with an increase in their basicities (because of the electron-donor effect of the alkyl groups). This is in agreement with the idea that the first step in the reaction is nucleophilic addition of the oximate anion to the triple bond of acetylene.

The constants and PMR spectra of the synthesized pyrroles IIa-e and vinylpyrroles IIIa-e were determined (see Tables 2 and 3). With respect to the locations and forms of the characteristic frequencies their IR spectra are similar to the spectra of previously synthesized compounds of the pyrrole series [2].

EXPERIMENTAL

The IR spectra of liquid films (IIb, d, e, IIIb, d, e, and IVb, e) were recorded with a UR-20 spectrometer, while the IR spectra of suspensions in mineral oil (IIa-c and IIIa-c) were obtained with UR-430 and Shimadzu spectrometers. The PMR spectra of solutions in CCl_4 were obtained with a Tesla BSD-487C spectrometer (80 MHz) (IId, e and IIIb, d, e) or a Varian T-60 spectrometer (IIa-c and IIIa-c) with hexamethyldisiloxane (HMDS) as the internal standard.

2-(2,4-Dimethylphenyl)pyrrole (IIa) and N-Vinyl-2-(2,4-dimethylphenyl)pyrrole (IIIa). A mixture of 100 ml of DMSO, 18.8 g (0.3 mole) of KOH), and 8.15 g (0.05 mole) of methyl-2,4-dimethylphenylketoxime (Ia) was heated to 130°C with vigorous stirring, 15.7 g (0.25 mole) of vinyl chloride was fed into the resulting suspension at this temperature for 3 h, and the mixture was then heated with continuous stirring for another 30 min. It was then cooled to room temperature and diluted with water (1:4), and the aqueous mixture was extracted with benzene (5 × 50 ml). The benzene extract was washed three times with 25% KOH solution and dried with potassium carbonate. The benzene was removed, and the residue was fractionally distilled in vacuo to give a mixture of pyrrole IIa and vinylpyrrole IIIa. The bulk of pyrrole IIa was separated from the mixture by crystallization from isooctane, and the residue was separated by chromatography on a thin loose layer of Al_2O_3 [hexane—ether (2:1)]. This procedure gave 4.2 g (49%) of pyrrole IIa and 0.6 g (6%) of vinylpyrrole IIIa.

Pyrroles IIb, c and Vinylpyrroles IIIb, c. These compounds were obtained by the method presented above from ketoximes Ib, c.

2-(2,5-Dimethylphenyl)pyrrole (IIb). A mixture of 2.24 g (0.04 mole) of KOH and 70 ml of DMSO was heated until the KOH melted (120°C, 1 h), after which the temperature was decreased to 70°C, and the solution was saturated with acetylene in the course of 30 min, a solution of 6.7 g (0.04 mole) of ketoxime Ib in 30 ml of DMSO was added in the course of 45 min at the same temperature, and acetylene was bubbled into the mixture with vigorous stirring for another 6 h. The cooled mixture was then poured into 400 ml of water, the aqueous mixture was extracted with ether (5 × 100 ml), and the ether extracts were washed three times with water and dried with potassium carbonate. The ether was removed, and the residue was fractionated on Al_2O_3 [a thin loose layer, pentane—ether (5:1)] to give 1.5 g (21%) of pyrrole IIb and 0.8 g (10%l) of O-vinylketoxime IVb. IR spectrum (microlayer) of IVb: 1620 (C=C in $OCH{=}CH_2$); 1200, 1280 (as =C—O—); 3075 (as $=CH_2$); 3020, 3045, 3115 (CH in C_6H_3); 1640 (C=N); 2865, 2925, 2955 cm^{-1} (HC_{sp^3}). PMR spectrum (CCl_4): 4.50 (1H, dd, A—H, ^3J = 14.0 Hz), 4.00 (1H, dd, B—H, ^2J = 1.5, ^3J = 6.0 Hz), 6.70 (1H, q, C—H), 2.00 (3H, s, CH_3), 2.10 [6H, s, 2,5-$(CH_3)_2C_6H_3$], 6.8 ppm (3H, m, C_6H_3). Also isolated were 0.2 g of 2,5-dimethylacetophenone and ≈1 g of the starting ketoxime.

Pyrroles IId, e. These compounds were similarly obtained.

N-Vinyl-2-(2,5-dimethylphenyl)pyrrole (IIIb). A 5-g (51%) sample of vinylpyrrole IIIb was obtained from 8.1 g (0.05 mole) of ketoxime Ib and acetylene (at an initial pressure of 12 atm) by heating (100°C, 3 h) in the presence of 2.8 g (0.05 mole) of KOH and 80 ml of DMSO after the standard workup and fractional distillation in vacuo.

Vinylpyrrole IIId. This compound was similarly synthesized.

N-Vinyl-2-(2,5-dimethylphenyl)-3-ethylpyrrole (IIIe). The method described for obtaining pyrrole IIb was used to obtain 3.51 g (52%) of vinylpyrrole IIIe from 5.8 g (0.03 mole) of ketoxime Ie and acetylene (at atmospheric pressure) in the presence of 1.8 g (0.032 mole) of KOH and 65 ml of DMSO after 3 h at 115°C.

LITERATURE CITED

1. S. E. Korostova, S. G. Shevchenko, M. V. Sigalov, and N. I. Golovanova, *Khim. Geterotsikl. Soedin.*, No. 4, 460 (1991).
2. B. A. Trofimov and A. I. Mikhaleva, *N-Vinylpyrroles* [in Russian], Nauka, Novosibirsk (1984).
3. S. E. Korostova, A. I. Mikhaleva, L. N. Sobenina, S. G. Shevchenko, R. N. Nesterenko, V. B. Modonov, and R. I. Polovnikova, *Zh. Org. Khim.*, 24, 2538 (1988).