- 174. Don. M. Lynch and R. G. Stein, US Patent No. 3869274; Chem. Abstr., 84, 164770 (1976).
- 175. J. L. Buchanan, A. R. Edgar, R. J. Hutchison, A. Stobie, and R. H. Wightman, J. Chem. Soc., Perkin Trans 1, No. 11, 2567 (1980).
- 176. I. A. Korbukh, S. V. Kitaev, and M. N. Preobrazhenskaya, Zh. Org. Khim., 12, 682 (1976).
- 177. I. A. Korbukh, N. G. Yakunina, and M. N. Preobrazhenskaya, Zh. Org. Khim., <u>11</u>, 463 (1977).
- 178. I. A. Korbukh, L. M. Abramova, and M. N. Preobrazhenskaya, Zh. Org. Khim., <u>13</u>, 731 (1977).
- 179. I. A. Korbukh, O. V. Budanova, N. G. Yakunina, V. I. Seraya, and M. N. Preobrazhenskaya, Zh. Org. Khim., <u>12</u>, 1560 (1976).
- 180. I. A. Korbukh, L. M. Abramova, V. I. Stepanenko, and M. N. Preobrazhenskaya, Zh. Org. Khim., <u>14</u>, 2169 (1978).
- 181. I. A. Korbukh, O. V. Budanova, and M. N. Preobrazhenskaya, Nucleic Acid Chem., No. 1, 469 (1978).
- 182. G. Rainer, R. Reidel, K. Klemm, and M. Eltze, Ger. Offen. 3029281; Chem. Abstr., <u>95</u>, 43186 (1981).
- 183. P. G. Braraldi, C. B. Vicentini, D. Simoni, and M. Guarneri, Farmaco Ed. Sci., <u>38</u>, 369 (1983).
- 184. M. Braraldi, R. Manservigi, E. Cassai, D. Simoni, P. Vittorio, S. Manfredini, and M. Guarneri, J. Med. Chem., <u>27</u>, 986 (1984).
- 185. H. A. Dewald, J. C. Nordin, Y. J. L'Italien, and F. R. Pareell, J. Med. Chem., <u>16</u>, 1346 (1973).
- 186. Coispeau and E. E. Gerard, Ger. Offen. 2435921; Chem. Abstr., 83, 12184 (1975).
- 187. L. I. Baryshnenkova, V. P. Perevalov, M. A. Andreeva, and B. I. Stepanov, in: Summaries of Papers Presented at the 4th All-Union Conference on Organic Luminophores and Their Application in the National Economy [in Russian], Kharkov (1984), p. 16.

2-DIAZOMETHYL-4-FURANONES. SYNTHESIS AND PROPERTIES

- L. A. Tolochko, A. M. Sipyagin,
- V. G. Kartsev, Z. G. Aliev,

370

L. O. Atovmyan, and A. T. Lebedev

UDC 547.722.3'442.4'235.42.07: 548.737:543.422

1,5-Bisdiazo-3-alkylpentane-2,4-diones were synthesized by the reaction of alkylmalonic acid chlorides with diazomethane; the products readily undergo intramolecular cyclization at the oxygen atom and one of the diazoacetyl groups under the influence of acidic agents with the formation of 2-diazomethyl-3-alkyl-4-furanones. It is shown that diazomethyl-4-furanones, which are vinylogs of α -diazo ketones, undergo reactions that are characteristic for aliphatic diazo compounds. The structure of the product of 1,3-dipolar cycloaddition of dimethyl acetylenedicarboxylate to a diazomethyl-4-furanone was investigated by means of x-ray diffraction analysis.

 α -Diazo ketones are widely used in the synthesis of various classes of organic compounds [1]. Acid-catalyzed intramolecular cyclizations leading to the formation of carbocyclic and heterocyclic compounds are among the pathways for the realization of their synthetic possibilities [2]. From this point of view bisdiazo ketones, among which important biologically active compounds have been detected [3-5], are little-studied and extremely interesting compounds.

It is known that bisdiazo ketones are formed in the reaction of dicarboxylic acid chlorides with diazomethane. Their transformations at both diazocarbonyl groups under the influence of acids, which proceed with the liberation of a molecule of nitrogen and the formation of derivatives of α -methyl ketones, have been described [6]. Reactions with retention of diazo groups are virtually unknown in the literature.

Branch of the Institute of Chemical Physics, Academy of Sciences of the USSR, Chernogolovka 142432. Translated from Khimiya Geterotsiklicheskikh Soedinenii, No. 4, pp. 454-459, April, 1988. Original article submitted October 3, 1986.

Com- pound		Ph J	AR spectrum, δ, ppm (No. of protons, Hz)			
	n	cocH ₂ CI (s, 2H)	$-(CH_2)_n -, CH_3 - C-CH_3$	CH№ (s, 1H)	IR spectrum, v_i cm ⁻¹	
IIa IIb	2 3	4,20 4,11	2.67 br.s (2H); 2.85 t (2H, $J=7.5$) 1.94 m (2H, $J=7.5$); 2.38 br.s (2H);	5,35 5,32	3075, 2080, 1710, 1610 3080, 2090, 1710, 1610	
IIc	4	4,08	$(2,09 \text{ f} (2\Pi, J=7,5))$ (1,65 m (4H); 2,35 br.s (2H); 2,63 f	5,27	3080, 2090, 1710, 1610	
IIu	5	4,06	$I_{J,36} = 1,30$ $I_{J,36} = 1,20$ $I_{J,36} = 1,20$ $I_{J,37} = $	5,21	3080, 2090, 1710, 1610	
IIe	6	4,07	J = 7,5 1.3 m (4H); 1.64 m (4H); 2.33 t (2H, J = 7,5); 2.60 + (2H, $J = 7,5$)	5,27	3090, 2100, 1710, 1615	
IIf	7	4,06	(1.36 br s (6H); 1.64 m(4H); 2.32 br	5,20	3080, 2090, 1710, 1610	
VIII		4,41	2,47 s' (6H)	5,51	3100, 2100, 1715, 1610	

TABLE 1. Spectral Characteristics of Chloroacetyldiazoacetylalkanes II and VIII

The aim of the present research was to investigate the acidic transformations of bisdiazo ketones IV with retention of one of the diazo groups and to study the possibility of the synthesis from them of 2-diazomethyl-4-furanones VI.

We have shown that diazo ketones I under the influence of hydrogen chloride undergo stepwise conversion initially to monochloroketones II (see Table 1) and then to dichloro ketones III [6].

 $\begin{array}{c} N_2 CHCO(CH_2)_n COCHN_2 & \frac{HCl}{-N_2} & CICH_2 CO(CH_2)_n COCHN_2 & \frac{HCl}{-N_2} & CICH_2 CO(CH_2)_n COCH_2 Cl}{IIIa-f} \\ n=2-7 & IIIa-f & IIIa-f \\ \end{array}$

Compounds II are formed as side products also in the reaction of diazomethane with the dichlorides of the corresponding carboxylic acids.

The reaction proceeds differently in the case of bisdiazo ketones IV — derivatives of substituted malonic acid. Under the influence of hydrogen chloride, acetic acid, and even silica gel they undergo intramolecular cyclization at the oxygen atom of one of the diazo-carbonyl groups with the formation of 2-diazomethyl-3-alkyl-5H-furan-4-ones VI [7], which are members of the previously unknown class of cyclic vinylogs of diazo ketones:



Splitting out of a molecule of nitrogen and a labile proton of the 1,3-dicarbonyl fragment evidently may occur both synchronously and with the formation of cyclic onium intermediate V. Replacement of the labile hydrogen atom in the 3 position of the VIa molecule by a methyl group makes intramolecular cyclization impossible. In this case only compounds with linear structures VIII and IX, which are similar to II and III, are formed.

$$\begin{array}{cccc} CH_{3} & CH_{3} & CH_{3} & CH_{3} \\ N_{2}CHCO - C - COCHN_{2} & \frac{HC1}{-N_{2}} & CICH_{2}CO - C - COCHN_{2} & \frac{HC1}{-N_{2}} & CICH_{2}CO - C - COCH_{2}CI \\ CH_{3} & CH_{3} & CH_{3} & CH_{3} \\ \hline VII & VIII & IX \end{array}$$

Let us note that diazomethylfuranones VI are also present in the reaction mixtures in the reaction of chlorides of monosubstituted malonic acids with diazomethane. This transfor-

Com- pound	PMR spectrum, δ, pp J, Hz)	IR spectrum,				
	R		CH CHN ₂ (s , 2H)		ν, cm ⁻¹	(log ε)
IVa	1,37 d (3H, $J=7$)	_	3,37 q (1H,	5,49	3070, 2090, 1600	277,5 (4,21)
IVb	0,968 t $(3H, J=7);$ 1.88 m $(2H, J=7)$	-	3,15 t (1H, J=7)	5,51	3070, 2080, 1610	277,5 (4,26)
IVc	3.21 d (2H, J=7.35); 7.18-7.36 m (5H)	-	3,58 t (1H, 1=7.35)	5,51	3070, 2090, 1615	278,0 (4,32)
VII	1,41 s (6H)			5,55	3090, 2080, 1600	277,0 (4,36)

TABLE 2. Spectral Characteristics of Bisdiazoacetylalkanes

TABLE 3. Spectral Characteristics of Diazomethylfuranones VI

Com- pound	PMR spectrum, δ	, ppm (J, 1	IR spectrum,	IR spectrum	
	R	CH ₂ (\$, 2H)	CHN ₂ (\$, 1H)	ν, cm ⁻¹	$(\log \varepsilon)$
VIa VIb VIc	1,62 s (3H) 1,02 t (3H; $J=7,2$); 2,04 q (2H; $J=7,2$) 3,50 s (2H); 7,17—7,33 m (5H)	4,51 4,49 4,61	5,08 5,10 4,90	3040, 2080, 1650, 1560 3040, 2085, 1655, 1580 3040, 2085, 1650, 1570	325,5 (4,45) 325,5 (4,40) 325,5 (4,33)

mation is evidently due to intramolecular cyclization of the intermediately formed diazonium ion [8].

In addition to signals of the protons of substituent R, signals of protons of diazoacetyl groups at 5.49-5.55 ppm and of the CH-R fragment at 3.15-3.58 ppm are observed in the PMR spectra of bisdiazo ketones IV. However, a singlet of the protons of a methylene group at 4.49-4.61 ppm and a singlet of the proton of a diazomethyl group at 4.90-5.10 ppm appear in the case of diazomethylfuranones VI.

Absorption bands of diazoacetyl [3090 (CH), 2100 (N N)] and carbonyl [1600 cm⁻¹ (C=0)] groups are observed in the IR spectra of bisdiazo ketones IV. Absorption bands of 3090 and 2080 cm⁻¹ (N \equiv N), which characterize the diazomethyl fragment, are retained bands at 1640-1650 cm⁻¹, which correspond to the conjugated -C=C-C=O system in the furan ring, also appear (see Tables 2 and 3).

An absorption maximum at 325 nm instead of at 277 nm, as in the case of starting bisdiazo ketones IV, appears in the UV spectra of cyclic substances VI. The absorption maximum at 325 nm is probably due to the presence of a unified N₂CH=C-C=O π system.

Diazomethylfuranones VI undergo the reactions that are characteristic for diazomethanes with acidic agents: with CH1 they form chloromethylfuranones X, while with dimethyl acetylene-dicarboxylate and N-phenylmaleinimide they form adducts — pyrazole derivatives XI and pyrazoline derivatives XII.



VI, XI, XII a $R=CH_3$, b $R=C_2H_5$, c $R=CH_2C_6H_5$

In the PMR spectra of XI and XII (see Tables 4 and 5) the furanone fragment is characterized by the presence of a singlet (XI) or two doublets of an AB system (XII) of the methylene protons at 4.50-4.70 ppm.

Com- pound	PMR spectrun					
	R	H ₃ COOC- (s, 3H)	—СН _? — (s, 2 Н)	NH	IR spectrum, ν , cm ⁻¹	
XIa XIb	1,04 s (3H) 1,10 t (3H, $J=7,0$);	3,94; 3,96 3,93; 3,97	4,68 4,67	12,76 br.s (1H)	1715, 1665, 1610, 1560 1730, 1660, 1610, 1560	
Xlc	3,94 s (8H); 7,10-7,	34 m (5H)	4,66	, 	1720, 1645, 1590, 1560	

TABLE 4. Spectral Characteristics of Adducts XI

TABLE 5. Spectral Characteristics of Adducts XII

Com- pound		IR spectrum				
	R	CH ₂ (d , 1H)	н' (d . 1н)	H" (q 1H)	Ph (1771)	ν , cm ⁻¹
XII a XIIЪ XIIС	2,0 s (3H) 1,07 t (3H; J = 7,2); 2,50 m (2H) 2,86 c (2H)	$\begin{array}{l} 4,56 (J=18,75);\\ 4,65 (J=18,75)\\ 4,55 (J=18,0);\\ 4,63 (J=18,0)\\ 4,61 (J=18,4) \end{array}$	4,83 (J = 10,5) 4,82 (J = 10,5) 4,74	5,08 $(J = 2,7)$ and 10,5) 5,08 $(J = 2,5)$ and 10,5) c os $(L = 0,5)$	7,25—7,53 (5H) 7,22—7,53 (5H)	3200, 1700, 1650, 1580 3200, 1690, 1645, 1570
AILC	3,00 \$ (2H)	$\begin{array}{c} 4,01 (J=18,4) \\ 4,69 (J=18,4) \end{array}$	(J=11,5)	and $11,5$ ($J=2,5$	7,17—7,50 (10H)*	3170, 1705, 1650, 1580

*Taking into account the phenyl protons of substituent R.

Intense peaks of molecular ions are observed in the mass spectra of adducts XI and XII. The maximum ion peak in the spectra of XI is formed due to the elimination of a molecule of CH₃OH from the molecular ion; subsequent loss of CO leads to the [M - 32 - 28] ion, the principal fragmentation pathway of which is the elimination of H, CHO, and CH₂O fragments (Table 6). In the case of XII initial fragmentation of the molecular ion proceeds with splitting out of CO and PhNCO molecules and the formation of the [M - 28 - 119] ion; subsequent fragmentation occurs through the loss of CO and CH₂O molecules (Table 6).

The literature does not contain information regarding the structure and conformation of diazomethylfuranones VI. Attempts to obtain single crystals of VI were unsuccessful. We were able to establish the structure of the furanone fragment of these molecules in the case of adduct XIb. Monoclinic crystals are obtained in the crystallization of XIb, $C_{13}N_{14}N_2O_6$, from ether. The unit cell parameters are as follows: a = 10.715(5), b = 9.479(5), c = 14.673(6) Å, $\gamma = 70.7(1)^\circ$, Z = 4, and space group P_2/a .

The structure of the XIb molecule is depicted in Fig. 1. The furanone fragment of the molecule is planar and forms an angle of 15° with the plane of the pyrazole ring. The plane of the carbomethoxy group in the 5 position of the pyrazole ring forms an angle of 12° with the latter. The dihedral angle between the planes of the carbomethoxy group in the 4 position and the pyrazole ring is 87°.

An intermolecular contact (2.79 \AA) between the $O(_2)$ atom of the furanone fragment and the $N_{(*)}$ atom of the pyrazole ring of an adjacent molecule is observed in the crystal structure; this constitutes evidence for the presence of a rather strong hydrogen bond.

EXPERIMENTAL

The IR spectra of mineral oil suspensions of the compounds were recorded with a Specord IR-75. The PMR spectra were obtained with a Bruker WH-360 spectrometer with tetramethylsilane as the internal standard. The UV spectra were obtained with a Beckmann DU-7 spectrophotometer. The reactions were monitored on Silufol UV-254 plates in benzene-ethyl acetate systems. Silica gel L40/100 µm was used for column chromatography. The mass spectra were obtained with an MKh-1320 spectrometer with direct introduction of the substances into the ion source; the ionizing-electron energy was 50 eV, and the temperature of the samples was 150°C. Experimental data from x-ray diffraction analysis in terms of 1520 independent non-

TABLE 6. Mass Spectra of XI and XII

Com- pound	m/z values ($I_{re1}, \%$)
XIa	280 M+ (50), 248 (100), 220 (31), 219 (38), 191 (76), 190 (57), 166 (64),
XIP	162 (69), 161 (64), 106 (57), 134 (38), 91 (36), 83 (31) 294 M ⁺ (20), 262 (100), 234 (24), 230 (54), 219 (23), 204 (34), 202 (42),
VIA	189 (20), 176 (36), 162 (18), 147 (14)
AIC	237 (36), 236 (52), 224 (14), 222 (13), 299 (28)
XIIa	311 M^+ (52), 283 (97), 164 (75), 136 (98), 119 (26), 106 (100)
XIIb	325 M^+ (84), 297 (97), 178 (74), 163 (74), 150 (90), 135 (77), 121 (42),
	120 (39), 119 (74), 107 (71), 91 (100), 77 (93)
XIIc	387 M^{+} (62), 359 (68), 240 (21), 212 (29), 211 (88), 188 (59), 172 (35),
	171 (38), 154 (35), 145 (38), 144 (41), 115 (41), 95 (59), 91 (100), 69 (62)

 c_{00} ^{2,79} N(8)

Fig. 1. Data from x-ray diffraction analysis of adduct XIb.

zero reflections were obtained with a DAR-UM automatic diffractometer in monochromatized CuK_{α} emission. The maximum (sin θ)/ λ value was 0.61. Absorption was not taken into account. The structure was determined by the direct method and was refined within the anisotropic total-matrix approximation up to R = 0.077. The hydrogen atoms could not be revealed. The coefficients of the isotropic thermal vibrations of the C(z₆) and C(21) atoms were anomalously high. The coordinates of the atoms are presented in Table 7. The calculations were accomplished by means of the Rentgen-75 complex of programs [9].

<u>Chloroacetyldiazoacetylalkanes IIa, b.</u> A) A solution of hydrogen chloride in chloroform was added dropwise with stirring to a solution of 0.03 mole of Ia, b in chloroform up to the point of maximum accumulation of the substance in the reaction mixture (according to TLC data), after which the solvent was evaporated in vacuo, and the residue was dissolved in benzene-ethyl acetate. Compounds IIa, b were isolated chromatographically with a column packed with silica gel. Compound IIa was obtained in 63% yield and had mp 60-61°C. Compound IIb was obtained in 54% yield and had mp 53-54°C.

Chloroacetyldiazoacetylalkanes IIc-f and VIII. B) These compounds were isolated chromatographically from the filtrates of the reaction mixtures formed in the preparation of the corresponding bisdiazo ketones Ic-f and VII. The compounds were obtained in 5-10% yields. Compound IIc had mp 51-52°C, IId had mp 51-52°C, IIe had mp 54-56°C, IIf had mp 62-63°C, and VIII was an oil.

<u>Bisdiazoacetylalkanes IV and VII.</u> A solution of 0.05 mole of the dichloride of the corresponding carboxylyic acid in dry ether was added with vigorous stirring dropwise to 250 ml of an ether solution of diazomethane (from 25 g of nitrosomethylurea) at -20° C. At the end of the addition the mixture was stirred for another 15 min, and the tem-

TABLE 7. Coordinates of Atoms ('10")*

A tom	u _j	x	. <i>y</i>	z	Atom	uj	x	y	z
$\begin{array}{c} O_{(1)} \\ O_{(2)} \\ O_{(3)} \\ O_{(4)} \\ O_{(5)} \\ O_{(6)} \\ N_{(7)} \\ N_{(8)} \\ C_{(9)} \\ C_{(10)} \\ C_{(11)} \end{array}$	3,72 4,48 5,62 5,92 4,83 6,40 3,98 4,15 3,84 3,41 4,12	2555 (6) 1327 (6) 4787 (7) 5423 (8) 3409 (6) 5247 (7) 3667 (7) 36689 (7) 1985 (9) 1745 (8) 2155 (10)	6263 (6) 3280 (7) 9148 (8) 9351 (8) 9116 (7) 7130 (8) 6171 (8) 7011 (7) 5450 (10) 4248 (9) 4502 (10)	$\begin{array}{c} 268(4)\\ 4(4)\\ 3605(5)\\ 2180(5)\\ 442(4)\\ 321(5)\\ 2684(5)\\ 3101(5)\\ 353(6)\\ 251(5)\\ 1146(6)\\ \end{array}$	$\begin{array}{c} C_{(12)} \\ C_{(13)} \\ C_{(14)} \\ C_{(15)} \\ C_{(16)} \\ C_{(17)} \\ C_{(18)} \\ C_{(19)} \\ C_{(20)} \\ C_{(21)} \end{array}$	3,53 3,51 4,05 3,71 8,55 5,16 4,14 7,66 5,60 13,41	2619(8) 3173(8) 4183(8) 3905(8) 2440(14) 4886(8) 4270(8) 5363(14) 3575(11) 1290(16)	$\begin{array}{c} 5648(8)\\ 6378(9)\\ 7751(9)\\ 7364(9)\\ 3340(20)\\ 8845(10)\\ 7836(9)\\ 10347(15)\\ 9588(12)\\ 3590(15)\\ \end{array}$	1101 (6) 1795 (6) 2496 (6) 1630 (6) 1910 (10) 2733 (7) 704 (6) 3851 (9) 484 (7) 249 (14)

*The anisotropic temperature factors can be obtained from the authors.

perature was raised to 10°C. The precipitated bisdiazo ketone was removed by filtration and washed on the filter with dry ether. In the case of IVb and VII the excess diazomethane was removed from the reaction mixture with nitrogen, the solvent was evaporated in vacuo, and the residue was chromatographed with a column packed with silica gel. Compound IVa was obtained in 57% yield and had mp 61.5°C, IVb was obtained in 45% yield and had mp 44-45°C, IVc was obtained in 64% yield and had mp 63-64°C, and VII was obtained in 56% yield.

<u>2-Diazomethyl-3-alkyl-5H-furan-4-ones VIa, b.</u> A) A solution of 0.015 mole of bisdiazo ketone IIa, b in benzene-ethyl acetate was chromatographed with a column packed with silica gel. After isolation of the necessary fraction, the solvent was removed in vacuo. The compounds were obtained in 5-10% yields. Compound VIa had mp 90-91°C (with decomposition), and VIb had mp 70-71°C (with decomposition).

<u>2-Diazomethyl-3-alkyl-5H-furan-4-ones VIa-c.</u> B) A solution of hydrogen chloride in chloroform was added dropwise with stirring to a solution of 0.025 mole of bisdiazo ketone IVa-c in chloroform up to the point of maximum accumulation of the cyclic compound in the reaction mixture (according to TLC data). Compounds VIa-c were isolated by method A. Compound VIa was obtained in 33% yield and had mp 90-01°C (with decomposition), IVb was obtained in 13% yield and had mp 70-71°C (with decomposition), and VIc was obtained in 18% yield and had mp 86-88°C (with decomposition).

<u>2-Chloromethyl-3-benzyl-5H-furan-4-one (X)</u>. This compound was obtained by a method similar to the preparation of chloroacetyldiazoacetylalkanes IIa, b by method A. The yield was 37%.

<u>Reaction of 2-Diazomethyl-3-alkyl-5H-furan-4-ones VIa-c with Dimethyl Acetylenedicarboxylate (XIa-c) and N-Phenylmaleinimide (XIIa-c).</u> A solution of 0.5 mmole of diazomethylfuranone VI in 10 ml of dry ether was added to an equimolar amount of dimethyl acetylenedicarboxylate or N-phenylmaleinimide, and the mixture was maintained at 20°C for 1-20 days. The resulting precipitate was removed by filtration and washed on the filter with dry ether. Compound XIa was obtained in 59% yield and had mp 173-174°C, XIb was obtained in 78% yield and had 188-189°C (with decomposition), XIc was obtained in 36% yield and had mp 138-139°C, XIIa was obtained in 71% yield and had mp 152-153°C, XXIb was obtained in 47% yield and had mp 194-196°C (with decomposition), and XIIc was obtained in 66% yield and had mp 213-214°C (with decomposition).

LITERATURE CITED

- 1. B. Huisgen, M. Regits, G. Heck, and H. Schwall, in: Methoden der organischen Chemie (Houben-Weyl), Vol. X/4, Georg Thieme Verlag, Stuttgart (1968), p. 482.
- S. D. Burke and P. A. Grieco, in: Organic Reactions, Vol. 26, Wiley, New York (1979), p. 361.
- N. M. Émanuél', L. L. Gumanov, N. P. Konovalova, R. F. D'yachkovskaya, G. N. Bogdanov, L. S. Vasil'eva, L. A. Plugina, and Zh. I. Orlova, Dokl. Akad. Nauk SSSR, <u>183</u>, 724 (1968).
- 4. R. Leary, D. Larsen, H. Watanabe, and E. Shaw, Biochemistry, 16, 5857 (1977).
- 5. T. V. Sal'nikova and N. N. Zoz, in: Supermutagens [in Russian], Nauka, Moscow (1966), p. 121.

- 6. E. Fahr, Annalen, 638, 1 (1960).
- 7. L. A. Tolochko, A. M. Sipyagin, and V. G. Kartsev, Khim. Geterotsikl. Soedin., No. 2, 276 (1986).
- 8. E. Piers, M. B. Geraghty, R. D. Smillie, and M. Soucy, Can. J. Chem., 53, 2849 (1975).
- 9. V. I. Andrianov, Z. M. Safina, and B. L. Tarnopol'skii, Rentgen-75 Programs [in Russian], Chernogolovka (1975).

INTRAMOLECULAR CYCLIZATION OF 2-HYDROXYCINNAMALDEHYDES

UDC 547.576'814.1.07

Yu. M. Chunaev, N. M. Przhiyalgovskaya, and L. N. Kurkovskaya

The effect of substituents on the intramolecular cyclization of 2-hydroxycinnamaldehydes was studied. It was established that aldehydes that contain bulky groups in the side chain and in the 3 position of the benzene ring are readily converted to intramolecular hemiacetals or bimolecular acetals either spontaneously at the moment of isolation or in solutions in DMF or DMSO, as well as on heating. An increase in the lability of the phenolic proton favors the cyclization.

It has been reported that 2-hydroxycinnamaldehydes Ia-c are not capable of intramolecular cyclization and the formation of 2H-chromene form II [1-4]. At the same time, this form of isomerism is known for 2-hydroxybenzocinnamaldehydes [3-6]. In order to study the effect of structural factors on the relative stabilities of linear (I) and ring (II) isomers we obtained 2-hydroxycinnamaldehydes containing various substituents in the side chain and in the benzene ring. Their synthesis was accomplished by condensation of salicylaldehydes with aldehydes of the aliphatic series in an alkaline medium.



I-IVa,b,d,g,h X=H, c,e,i,j,m X=Br, f, 1 X=NO₂, k X=OCH₃; n X=CH₃; a,k, 1 Y=H, b,c,f,h,j,n Y=NO₂, d,e,g,i,m Y=Br; a-f R=H,g,h, k-n R=C₂H₅, i,j R=CH₃

It was established that the majority of 2-hydroxycinnamaldehydes Id-l have a linear structure. α -Ethyl-3,5-dibromo-2-hydroxycinnamaldehyde (IIm) was isolated in cyclic form. Acetal IIIn was formed in the synthesis of α -ethyl-3-methyl-5-nitro-2-hydroxycinnamaldehyde (In), evidently as a consequence of intermolecular dehydration of intermediate hemiacetal IIn. A comparison of aldehydes Im, n, which exist in the form of 2H-chromenes, with Ie, g, h, which have linear structures, makes it possible to conclude that the introduction of bulky substituents into the side chain and the 3 position of the benzene ring promotes cyclization. Similar facts are known in the literature. Thus, according to the data in [7], the stability of ring isomers increases in the presence of alkyl substituents attached to the sp³-carbon atoms in the chain between the interreacting groups. Alkyl groups or halogen atoms in the ortho position relative to the reaction group (hydroxy) exert "steric pressure" on it and thereby also promote cyclization.

Compounds Ii-Z, like aldehydes Im, n, contain bulky substituents stimultaneously in both the side chain and the 3 position of the benzene ring. However, despite this, they exist primarily in the open form. The greater stability of the linear isomer of α -methyl-3,5-dibromo-2-hydroxycinnamaldehyde (Ii) as compared with α -ethyl-substituted aldehyde Im can be explained by the decrease in the volume of the substituent in the side chain. An im-

D. I. Mendeleev Moscow Institute of Chemical Technology, Moscow 125047. Translated from Khimiya Geterotsiklicheskikh Soedinenii, No. 4, pp. 460-465, April, 1988. Original article submitted December 1, 1986.

376