8. A. N. Frumkin and L. N. Nekrasov, Dokl. Akad. Nauk SSSR, 126, 115 (1959).
9. W. J. Albery and S. Bruckenstein, Trans. Faraday Soc., 62, 1946 (1966).
10. L. Eberson and K. Nyberg. J. Am. Chem. Soc., 88, 1686 (1966).
11. I. M. Sosonkin and A. N. Domarev, Élektrokhimiya, 8, 1168 (1972).
12. H. Volz and W. Lotsch, Tetrahedron Lett., 2275 (1969).
13. I. M. Sosonkin, A. N. Domarev, É. G. Kaminskaya, A. I. Tolstikov, F. F. Lakomov, and A. Ya. Kaminskii, Zh. Prikl. Khim., 44, 950 (1971).
14. I. M. Sosonkin, V. A. Subbotin, and N. V. Fedyainov, Zh. Org. Khim., 15, 344 (1979).

SYNTHESIS AND THREE-DIMENSIONAL STRUCTURE OF 5,5-DISUBSTITUTED 2-ALKOXY-1,3-DIOXANES

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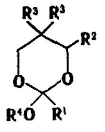
UDC 541.63:547.841.07:543.422.25

It was established by PMR spectroscopy that a chair conformation with an axial orientation of the alkoxy substituent is the primary conformation for 5,5-disubstituted (and unsubstituted) 2-alkoxy-1,3-dioxanes. As compared with alkyl-1,3-dioxanes, 2-alkoxy-1,3-dioxanes are characterized by reversal of the chemical shifts of the axial and equatorial protons attached to C_4 and C_6.

Little study has been devoted to the stereochemical peculiarities of 2-alkoxy-1,3-dioxanes. Only several studies [1-4] in which the conformational equilibria of a number of 4-, 4,6-, and 4,4,6-methyl-substituted 2-methoxy-1,3-dioxanes are known.

We have synthesized a number of 2-alkoxy-1,3-dioxanes with the general structure I-IX:



I-IX

I $R^1=R^2=H$, $R^3=CH_3$, $R^4=C_2H_5$; II $R^1=R^2=H$, $R^3=CH_3$, $R^4=n\text{-}C_3H_7$; III $R^1=R^2=H$, $R^3=CH_3$, $R^4=i\text{-}C_3H_7$; IV $R^1=R^2=H$, $R^3=CH_3$, $R^4=n\text{-}C_4H_9$; V $R^1=R^2=H$, $R^3=CH_2Cl$, $R^4=C_2H_5$; VI $R^1=R^2=R^3=H$, $R^4=C_2H_5$; VII $R^1=R^2=R^3=H$, $R^4=i\text{-}C_3H_7$; VIII $R^1=R^4=CH_3$, $R^2=R^3=H$; IX $R^1=R^2=CH_3$, $R^3=H$, $R^4=C_2H_5$

The configurations and primary conformations of dioxanes I-IX were determined by an analysis of the character of the multiplet splitting and the chemical shifts of the resonance lines of the protons in the PMR spectra of 10% solutions of these compounds in carbon tetrachloride, deuteroacetone, and deuterochloroform.

It is generally accepted that a chair conformation with an axial orientation of the alkoxy group is the preferred conformation in 2-alkoxy-1,3-dioxanes [1-6].

In the PMR spectra of I-V (Table 1), as a consequence of a shift of the conformational equilibrium to favor a certain primary conformation, the protons of the methylene groups in the equivalent 4 and 6 positions give a typical AB quartet with a geminal constant of −11.0 Hz. The magnitude of the $^2J_{ae}$ constant and the rather great magnetic nonequivalence of the axial and equatorial protons of these groups ($\Delta\delta$ = 0.4-0.5 ppm) constitute evidence for a chairlike conformation of the ring [7-10].

In contrast to alkyl-1,3-dioxanes [8], the axial protons attached to C_4 and C_6 resonate at weaker field (δ 3.65 ppm for I-IV and 3.95 ppm for V) than the equatorial protons (δ 3.16-3.20 ppm and 3.57 ppm, respectively). The reversal of the constants of shielding of the H_a

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Ufa Petroleum Institute, Ufa 450062. Translated from Khimiya Geterotsiklicheskikh Soedinenii, No. 9, pp. 1182-1185, September, 1981. Original article submitted October 8, 1980; revision submitted February 18, 1981.

0009-3122/81/1709-0876$07.50

TABLE 1. Chemical Shifts and Spin—Spin Coupling Constants in the PMR Spectra of 2-Alkoxy-1,3-dioxanes

Compound	δ, ppm						J, Hz					
	2-H	6-H_e	6-H_a	R_e^3	R_a^3	R^4	6a6e	6a5a	6a5e	6e5a	6e5e	5a5e
I[a]	5,17	3,21	3,63	0,84	0,92	1,10, 3,52	−11,0	—	—	—	—	—
II[a]	5,10	3,17	3,64	0,82	0,97	0,90, 1,54, 3,40	−10,8	—	—	—	—	—
III[a]	5,17	3,16	3,65	0,82	0,96	1,12, 3,89	−11,0	—	—	—	—	—
IV[a]	5,13	3,20	3,63	0,81	0,94	0,84, 1,40, 3,42	−10,8	—	—	—	—	—
V[a]	5,20	3,57	3,95	3,50	3,73	1,16, 3,55	−11,0	—	—	—	—	—
VI[b]	5,10	3,57	4,03	1,47	1,76	1,15, 3,50	−11,2	8,4	4,0	5,2	4,2	−13,3
VII[b]	5,16	3,58	4,03	1,47	1,75	1,11, 3,74	−11,4	8,4	4,0	5,2	4,2	−13,0
VIII[c]		3,44	3,94	1,23	1,92	3,15	−11,4	11,4	3,0	5,2	1,6	−13,8
IX[d]		3,53	3,93	—	—	1,12	−11,4	10,8	3,8	4,8	2,0	−12,0[e]

[a] ${}^4J_{4e6e}$ = 1.3 Hz. [b] ${}^5J_{2e5e}$ = 1.0 Hz. [c] $\delta_{2\text{-Me}}$ 1.23 ppm. [d] $\delta_{2\text{-Me}}$ 1.25 ppm. [e] In solution in d_6-acetone.

TABLE 2. 2-Alkoxy-1,3-dioxanes

Compound	bp, °C (mm)	d_4^{20}	n_D^{20}	MR_D		Found, %		Empirical formula	Calc., %	
				found	calc.	C	H		C	H
I	36 (1)	0,9861	1,4241	41,41	41,84	59,8	10,1	$C_8H_{16}O_3$	60,0	10,1
II	68—69 (7)	0,9562	1,4279	46,80	46,51	61,9	10,5	$C_9H_{18}O_3$	62,0	10,4
III	35—37 (1)	0,9509	1,4250	46,79	46,52	61,9	10,5	$C_9H_{18}O_3$	62,0	10,4
IV	63—64 (2)	0,9446	1,4302	51,43	51,14	63,7	10,8	$C_{10}H_{20}O_3$	63,8	10,7
V	89—91 (2)	1,2737	1,4759	50,70	50,76	41,9	6,2	$C_8H_{14}Cl_2O_3$	41,9	6,2
VI	65 (15)	1,0449	1,4255	32,34	32,57	54,5	9,2	$C_6H_{12}O_3$	54,5	9,2
VII	57 (12)	1,0189	1,4270	36,79	37,26	57,4	9,7	$C_7H_{14}O_3$	57,5	9,6
VIII	53—55 (12)	1,0387	1,4215	32,26	32,55	54,4	9,2	$C_6H_{12}O_3$	54,5	9,2
IX	76—77 (20)	0,9780	1,4200	41,40	41,84	59,8	10,1	$C_8H_{16}O_3$	60,0	10,1

and H_e protons can be judged from the additional splitting of the lines of the high-field part of the AB quartet with spin—spin coupling constant (SSCC) ${}^4J_{4e6e}$ = 1.3 Hz. The magnitude of the splitting is characteristic for long-range spin—spin coupling (LRSSC) of protons through four σ bonds in a planar zigzag (W) form [11].

The LRSSC between the axial 4— and 6-H protons and the protons of the axial 5-CH_3 group (δ 0.92-0.97) also indicates reversal of the H_a and H_e shielding constants. This fact was detected by means of a homonuclear ${}^1H-\{CH_3\}$INDOR experiment. Long-range spin—spin coupling is also manifested in the different half width of the bands of the protons of the groups of the substituents attached to C_5 in axial and equatorial orientations [$\Delta\nu^1/_2(a) - \Delta\nu^1/_2(e) \sim 0.6$ Hz].

The reversal of the chemical shifts of the H_a and H_e protons attached to C_4 and C_6 can be explained qualitatively by the magnetic anisotropy effect of the unshared pair of the oxygen atom of the axially oriented alkoxy group if one assumes a primary exo conformation for RO. The reasons for the preferableness of an axial orientation of the electron-withdrawing group in the α position relative to the ring heteroatom — the "anomeric effect" — has been discussed in detail in the literature [5, 6]. Correspondingly, the 2-H proton is equatorially oriented (δ 5.10-5.25 ppm).

It should be noted that the protons of the axial substituent attached to C_5 resonate at weaker field than the protons of the equatorial substituent (Table 1). This reversal of the chemical shifts is characteristic for 1,3-heterocycles in the chair conformation and is primarily due to the anisotropy of the diamagnetic susceptibility of the unshared electron pairs of the oxygen atoms [12-14].

The spectra of the methylene protons in the 4 and 6 positions of VI-VIII are more complex as compared with the corresponding spectra of dioxanes I-V due to vicinal spin—spin couplings with the 5-H protons. As in the case of I-V, reversal of the chemical shifts of the H_a and H_e protons attached to C_4 and C_6 is observed for dioxanes VI-VIII; this is characteristic for compounds in a chair conformation with an axially oriented alkoxy substituent attached to C_2. In addition, the correctness of the choice of the conformation for dioxanes

VI and VII is confirmed by the observed LRSSC between the equatorial 5- and 2-H protons, which is manifested as relative broadening of the signal of the 2-H proton and additional splitting of the 5-H_e signal with $^5J_{HH}$ = 1.0 Hz. As regards VIII, it is known that an equatorial orientation of the 2-CH_3 group is energically more favorable than an axial orientation (ΔG° = 3.55 kcal/mole [8]), whereas an axial orientation of the methoxy group is more favorable than the equatorial orientation (ΔG° = 0.50 kcal/mole [4]). Thus the 2-methyl(e)-2-methoxy(a) conformer is ∿4 kcal/mole more stable than the 2-methyl(a)-2-methoxy(e) conformer. Consequently, it may be assumed that VIII exists virtually completely in the form of the energically more stable conformer.

The SSCC for methoxydioxane VIII (Table 1) are typical for the protons of the 1,3-dioxane ring in a conformation that is close to the "ideal" chair conformation [7-9]. The SSCC for VI and VII differ considerably from the canonical values. Thus $^3J_{4a5a}$ = $^3J_{6a5a}$ decreases to 8.4 Hz, while $^3J_{4e5e}$ = $^3J_{6e5e}$ increases to 4.2 Hz. We were unable to record alternative conformations at −80 to +20°C, since the changes in the SSCC virtually do not exceed the experimental error. It may be assumed that the changes in the SSCC arise as a result of a decrease in the H_a—C_4—C_5—H_e and H_e—C_4—C_5—H_e dihedral angles, which corresponds to flattening of the carbon part of the ring.

To estimate the distortion of the conformation we used the approximate R-factor method [9, 15]. In the case of VI and VII, R = 1.35, i.e., torsion angle $\psi \approx 50°$. In 1,3-dioxane $\psi = 54°$ [9]. The observed flattening of the carbon part of the ring of VI and VII may be due to free rotation of the alkoxy substituent about the exocyclic C—O bond.

Judging from the published data [1, 8], isomerism due to the different orientations of 4-CH_3 is possible for 2,4-dimethyl-2-ethoxy-1,3-dioxane. However, the spectrum of IX (Table 1) is the spectrum of an individual isomer in the preferred chair conformation with an axial orientation of OCH_3. The orientation of 4-CH_3 can be determined from the SSCC of the 4-H proton. The $^3J_{4H_5a}$ value of 10.8 Hz corresponds to θ ∿ 180° on the Karplus curve[[9] and indicates an axial—axial orientation of the C_4—H and C_5—H bonds. The $^3J_{4H_5e}$ constant of 3.8 Hz gives a θ value close to 55° and corresponds to an equatorial—axial interaction of the corresponding protons. In addition, this θ value constitutes evidence for a trans orientation of the 5-H_e and oxygen atoms of the heteroring. These results confirm the choice of the orientation of the substituents and the conformation of the ring. Thus the 4-CH_3 group is oriented equatorially, and IX is the 4_e-CH_3—2_a-OC_2H_5 or trans isomer.

EXPERIMENTAL

The PMR spectra of solutions of the investigated compounds were recorded with a Tesla BS-497 spectrometer (100 MHz) at room temperature with hexamethyldisiloxane as the internal standard. To ascertain the structures of the overlapped signals of the protons we used spin decoupling, INDOR, and recording of the spectra of solutions in deuteroacetone and deuterochloroform.

2-Ethoxy-1,3-dioxanes I, V, and VI. These compounds were synthesized by transesterification of triethyl orthoformate with diols by the method in [16].

2-Alkoxy-1,3-dioxanes II-IV and VII. These compounds were obtained by heating mixtures of equimolar amounts of 2-ethoxy-1,3-dioxane and the corresponding alcohol in the presence of p-toluenesulfonic acid (0.5%) at 100-110°C for 2-3 h with simultaneous removal of the liberated ethanol by distillation. At the end of the reaction the mixture was neutralized with dry sodium carbonate and filtered, and the reaction products were isolated in 70-80% yields by vacuum distillation.

2-Alkoxy-2-methyl-1,3-dioxanes VIII and IX. These compounds were synthesized by stirring mixtures of the alkyl acetimidate hydrochloride (0.2 mole) [17] and the diol (0.2 mole) in 100 ml of pentane at room temperature until the phases were mixed completely and ammonium chloride was liberated. The precipitate was then removed by filtration, and the pentane was removed by distillation. Vacuum distillation of the residue gave alkoxydioxanes VIII and IX in 55-60% yields.

The physicochemical constants of I-IX are presented in Table 2.

The authors thank T. A. Rudkevich for his participation in the experimental part of this research.

LITERATURE CITED

1. E. L. Eliel and C. A. Giza, J. Org. Chem., 33, 3754 (1968).
2. E. L. Eliel and F. W. Nader, J. Am. Chem. Soc., 92, 584 (1970).
3. E. L. Eliel and F. W. Nader, J. Am. Chem. Soc., 92, 3045 (1970).
4. F. W. Nader and E. L. Eliel, J. Am. Chem. Soc., 92, 3050 (1970).
5. N. S. Zefirov and N. M. Shekhtman, Usp. Khim., 40, 593 (1971).
6. S. L. Zhdanov, in: Modern Problems of Organic Chemistry [in Russian], Vol. 5, Izd. Leningradsk. Gos. Univ., Leningrad (1976), p. 2.
7. N. S. Zefirov and I. V. Kazimirchik, Usp. Khim., 43, 252 (1974).
8. M. Anteunis, D. Tavernier, and F. Borremans, Heterocycles, 4, 293 (1976).
9. Yu. Yu. Samitov, Khim. Geterotsikl. Soedin., No. 12, 1587 (1978).
10. A. I. Gren', S. G. Soboleva, and G. R. Tantsyura, in: Problems in Stereochemistry [in Russian], Vysshaya Shkola, Kiev (1971), p. 52.
11. G. Stoddart, The Stereochemistry of Carbohydrates [Russian translation], Mir, Moscow (1975), p. 183.
12. G. Kh. Kamai, N. A. Chadaeva, I. I. Saidashev, and N. K. Tazeeva, in: Problems in Stereochemistry [in Russian], Vol. 1, Izd. Kievsk. Univ., Kiev (1971), p. 127.
13. B. A. Arbuzov and Yu. Yu. Samitov, Tetrahedron Lett., No. 8, 433 (1963).
14. Yu. Yu. Samitov, Dokl. Akad. Nauk SSSR, 164, 347 (1965).
15. J. B. Lambert, J. Am. Chem. Soc., 89, 1836 (1967).
16. O. B. Chalova, E. A. Kantor, R. A. Karakhanov, and D. L. Rakhmankulov, Public Scientific-Research Institute of Theoretical and Experimental Chemistry, Cherkassy, No. 192khp-D-80 (February 14, 1980); Ref. Zh. Khim., 22Zh165 (1980).
17. S. M. McElvain and Y. W. Nelson, J. Am. Chem. Soc., 64, 1825 (1942).

REACTION OF 5-CHLOROANTHRA[1,9-cd]-6-ISOXAZOLONE WITH PYRIDINE BASES

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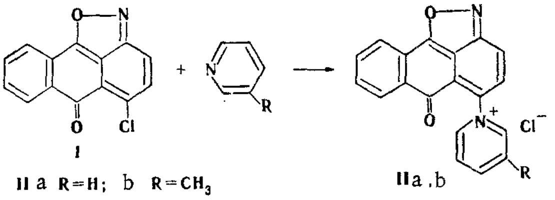
UDC 547.786.37'828

In the reaction of 5-chloroanthra[1,9-cd]-6-isoxazolone with pyridine bases the chlorine atom is substituted to give the corresponding pyridinium salts. The pyridine ring of the synthesized anthra[1,9-cd]isoxazol-6-one-5-pyridinium chloride was cleaved by the Zincke method. The reduction of the cleavage product, viz., N-(anthra[1',9'-cd]isoxazol-6-on-5-yl)-5-amino-2,4-pentadienal, under various conditions was investigated.

In [1, 2] it was shown that 5-haloanthra[1,9-cd]-6-isoxazolones are readily aminated by alkyl- and arylamines. It seemed of interest to study the behavior of isoxazolone I with respect to pyridine bases. We found that pyridine and β-picoline are quaternized by isoxazole I under mild conditions; pyridinium chlorides IIa,b were isolated in high yields.



I

II a R=H; b R=CH$_3$

IIa,b

This confirms the higher lability of the chlorine atom in I as compared with 1-chloroanthraquinone, which reacts with pyridine only under severe conditions [3].

Krasnoyarsk State Pedagogical Institute, Krasnoyarsk 660049. Translated from Khimiya Geterotsiklicheskikh Soedinenii, No. 9, pp. 1186-1188, September, 1981. Original article submitted January 9, 1981.