181. É. A. Zvezdina, M. P. Zhdanova, V. A. Bren', and G. N. Dorofeenko, Khim. Geterotsikl. Soedin., No. 11, 1461 (1974).
182. H. Reimlinger, M. A. Peiren, and R. Merény, Chem. Ber., 105, 794 (1972).
183. H. Ogura, M. Kavana, and T. Itoh, Chem. Pharm. Bull. (Tokyo), 21, 2019 (1973); Curr. Abst. Chem., 51, Issue No. 521, 210589 (1974).
184. D. W. Dunwell and D. Evans, J. Chem. Soc., Perkin Trans. I, No. 15, 1588 (1973).
185. A. W. Show, US Patent No. 3468888 (1969); Chem. Abstr., 72, 3489 (1970).
186. A. W. Show, D. R. Jakas, B. P. Trotter, N. M. Hall, and J. R. E. Hoover, J. Heterocycl. Chem., 10, 71 (1973).
187. H. Alper and L. Pepper, Can. J. Chem., 53, 894 (1975).
188. L. Capuano and H. J. Schrepfer, Chem. Ber., 104, 3039 (1971).
189. M. Augustin and K. R. Kuppe, Tetrahedron, 30, 3533 (1974).
190. N. J. Leonard, D. Y. Curtin, and K. M. Beck, J. Am. Chem. Soc., 69, 2459 (1947).
191. S. N. Kolodyazhnaya and A. M. Simonov, Khim. Geterotsikl. Soedin., No. 4, 714 (1969).
192. A. M. Simonov, Yu. M. Yutilov, and V. A. Anisimova, Khim. Geterotsikl. Soedin., No. 6, 913 (1965).
193. V. G. Sayapin, Master's Dissertation, Rostov-on-Don (1969).
194. L. S. Éfros, B. A. Porai-Koshits, and S. G. Farbenshtein, Zh. Obshch. Khim., 23, 1691 (1953).

SYNTHESIS AND STEREOCHEMISTRY OF 2,2-DIMETHYL-5-ARYL-4-BENZOYL-1,3-DIOXOLANES

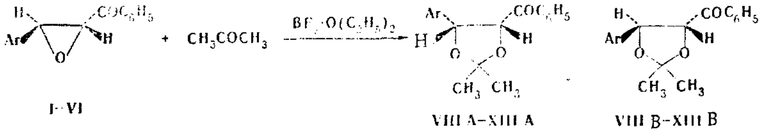
O. N. Bubel', I. G. Tishchenko,
G. Z. Stasevich, I. L. Romanko,
A. F. Abramov, and E. D. Skakovskii

UDC 547.729.7.07:541.634

The reaction of 3-aryl-2-benzoyloxiranes with acetone in the presence of catalytic amounts of boron trifluoride etherate leads to the formation of mixtures of cis and trans isomers (~30:70) of 2,2-dimethyl-5-aryl-4-benzoyl-1,3-dioxolanes, the structures and stereochemistry of which were established on the basis of data from their PMR spectra, measurement of the Overhauser nuclear effect, and some chemical transformations.

Acetyloxiranes of the aliphatic series react with ketones in the presence of boron trifluoride etherate with inversion of the configuration of the oxirane carbon atom that undergoes attack, and this leads to the formation of cis-1,3-dioxolanes [1, 2]. At the same time, the reaction of trans-2-acetyl-3-phenyloxirane with acetone in the presence of boron trifluoride etherate gives a mixture (35:65) of cis- and trans-2,2-dimethyl-5-phenyl-4-acetyl-1,3-dioxolanes [2], whereas trans- and cis-2-methyl-3-phenyloxiranes react with acetone in the presence of anhydrous copper sulfate to give a mixture (35:65) of the corresponding cis- and trans-dioxolanes; the latter do not undergo interconversion under the given conditions [3].

In the present research we studied the reaction of a number of trans-3-aryl-2-benzoyloxiranes (I-VI) with acetone in the presence of catalytic amounts of boron trifluoride etherate. In all cases we obtained mixtures of cis- and trans-5-aryl-4-benzoyl-1,3-dioxolanes (VIII-XIII) (Table 1), the ratios of which were



VIII Ar = C_6H_5; IX Ar = 4-$CH_3C_6H_4$, X Ar = 3-$CH_3C_6H_4$; XI Ar = 4-ClC_6H_4; XII Ar = 3-ClC_6H_4;
XIII Ar = 4-$CH_3OC_6H_4$

V. I. Lenin Belorussian State University, Minsk 220080. Translated from Khimiya Geterotsiklicheskikh Soedinenii, No. 7, pp. 888-891, July, 1979. Original article submitted October 30, 1978.

TABLE 1. 1,3-Dioxolanes VIII-XIII

Compound	Configuration	mp, °C	Found, %		Empirical formula	Calc., %		Overall yield, %	Percentage in the mixture, %
			C	H		C	H		
VIIIA	cis	117—118	76,4	6,4	$C_{18}H_{18}O_3$	76,6	6,4	77	43
VIIIB	trans	90—91	76,3	6,5	$C_{18}H_{18}O_3$	76,6	6,4		57
IXA	cis	148—149	77,1	6,7	$C_{19}H_{20}O_3$	77,0	6,8	87	32
IXB	trans	47—48	76,8	6,6	$C_{19}H_{20}O_3$	77,0	6,8		68
XA	cis	116—117	76,9	6,7	$C_{19}H_{20}O_3$	77,0	6,8	83	32
XB	trans	70—71	77,1	6,9	$C_{19}H_{20}O_3$	77,0	6,8		68
XIA	cis	147—148	68,3	5,3	$C_{18}H_{17}ClO_3$	68,2	5,4	82	33
XIB	trans	73—74	68,2	5,5	$C_{18}H_{17}ClO_3$	68,2	5,4		67
XIIA	cis	121—122	68,0	5,2	$C_{18}H_{17}ClO_3$	68,2	5,4	84	27
XIIB	trans	97—98	68,3	5,3	$C_{18}H_{17}ClO_3$	68,2	5,4		73
XIIIA*	cis	—	—	—	$C_{19}H_{20}O_4$	73,1	6,4	68	29
XIIIB	trans	47—48	73,0	6,3	$C_{19}H_{20}O_4$	73,1	6,4		71

---

* This compound was not isolated in the pure state.

TABLE 2. Data from the PMR Spectra of 1,3-Dioxolanes VIII-XIII

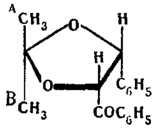
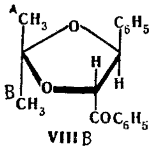
Compound	$\delta_{2\text{-}CH_3}$ s, ppm	$\Delta\nu$, Hz	$\delta_{4\text{-}H}$, d, ppm	$\delta_{5\text{-}H}$, d, ppm	$J_{4,5}$, Hz	$\delta_{R(Ar)}$, ppm	$\delta_{H(Ar)}$, m, ppm
VIIIA	1,51; 1,80	29	5,39	5,57	7,8		6,87—7,47
VIIIB	1,40; 1,61	21	4,71	5,54	7,2		7,12—7,50, 7,67—7,79
IXA	1,47; 1,74	27	5,35	5,53	7,8	2,12	6,65—7,45
IXB	1,44; 1,64	20	4,79	5,60	7.2	2,37	7,08—7,60, 7,96—8,12
XA	1,50; 1,80	30	5,30	5,55	7,8	2,14	6,60—7,44
XB	1,43; 1,65	22	4,80	5,61	7,2	2,38	7,00—7,62, 7,96—8,12
XIA	1,56; 1,83	27	5,48	5,78	7,8	—	6,95—7,57
XIB	1,39; 1,60	21	4,67	5,56	7,2	—	7,16—7,49, 7,85—8,04
XIIA	1,55; 1,84	29	5,46	5,78	7,8	—	6,90—7,50
XIIB	1,38; 1,60	22	4,68	5,56	7,2	—	7,12—7,48, 7,90—8,05
XIIIA	1,48; 1,76	28	5,34	5,53	7,8	3,60	6,80—7,72
XIIIB	1,40; 1,60	20	4,80	5,56	7,2	3,72	6,80—7,56, 7,96—8,08

established from the integral intensities of the PMR signals of the 2-CH_3 groups and the 4-H and 5-H protons. The reaction of cis-3-phenyl-2-benzoyloxirane (VII) with acetone in the presence of boron trifluoride etherate leads to the formation of a mixture (57:43) of isomers VIIIA and VIIIB. A comparative study of the reaction of oxiranes I and VII with acetone directly in the cell of the PMR spectrometer showed that cis-oxirane VII reacts considerably more slowly than trans-oxirane I, whereas diastereomers VIIIA and VIIIB are formed simultaneously in both cases. Considering the fact that acyloxiranes react, as a rule, in acid-catalyzed reactions with ring opening of the β-carbon atom side [4, 5], one may assume that the formation of a mixture of 1,3-dioxolanes is determined by the presence in the β position of an aryl substituent that promotes the formation of a carbonium ion.

The chemical structure of 1,3-dioxolanes VIII-XIII was confirmed by acid hydrolysis of isomers VIIIA and VIIIB. Acetone and benzaldehyde, the latter of which is evidently the product of dealdolization of the intermediate keto diol, were identified in the hydrolyzate in the form of the 2,4-dinitrophenylhydrazones. The PMR spectra of 1,3-dioxolanes VIII-XIII also confirm their chemical structure (Table 2).

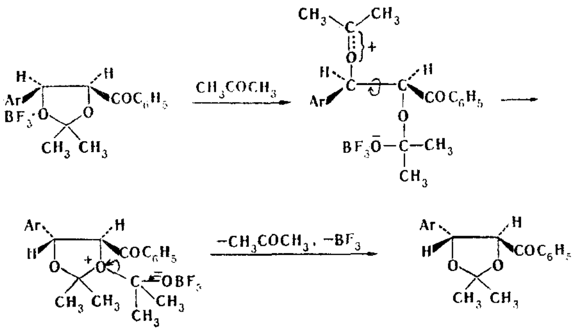
The establishment of the configurations of five-membered rings only from spin—spin coupling constants (SSCC) is unreliable [6, 7], and the stereochemistry of 1,3-dioxolanes VIII-XIII was therefore determined by a comparison of the characteristics of their PMR spectra with those of the spectra of the similarly constructed dioxolanes with known configurations. Thus the signals of the 4- and 5-H protons in the PMR spectrum of trans-2,2-dimethyl-4,5-diphenyl-1,3-dioxolane are shifted 0.78 ppm to stronger field as compared with the corresponding signals of the cis isomer; this is due to the shielding of these protons of the trans-1,3-dioxolane by phenyl groups [8]. A similar shift of 0.68 ppm of the signal of the 4-H proton in the PMR spectrum of 1,3-dioxolane VIIIB to stronger field with respect to the signal of the 4-H proton of 1,3-dioxolane VIIIA provides a basis for the assignment of trans and cis configurations, respectively, to these compounds. In addition, it is known [8] that the nonequivalence of the protons of the 2-CH_3 groups ($\Delta\nu$) in the cis isomers of unsymmetrical 1,3-dioxolanes is always greater than in the trans isomers. In our case $\Delta\nu$ is 29 Hz for cis-1,3-dioxolane VIIIA and 21 Hz for trans-dioxolane VIIIB; this consti-

TABLE 3. Results of Measurements of the Overhauser Nuclear Effect (ONE) in 1,3-dioxolanes

Compound	Irradiated CH_3 group	Observed proton	ONE, %
 VIII A	A	4-H	11,9
	A	5-H	5,7
	B	4-H	3,2
	B	5-H	0,0
 VIII B	A	4-H	10,1
	A	5-H	3,3
	B	4-H	0,0
	B	5-H	12,7

tutes an additional confirmation of their stereochemistry, which is also in agreement with the results of measurement of the Overhauser nuclear effect (Table 3). Since the 4-H and 5-H protons and the 2-CH_3 group (A) are on the same side of the 1,3-dioxolane ring in cis-dioxolane VIIIA, a large effect is observed when the 2-CH_3 (A) group is irradiated. In the case of trans-dioxolane VIIIB a large effect on the 4-H proton is observed when the 2-CH_3 (A) group is irradiated, and a large effect on the 5-H proton is observed when the 2-CH_3 (B) group is irradiated.

An analysis of the reaction mixtures of oxiranes I-VI with acetone by PMR spectroscopy showed that the ratio of the resulting cis- and trans-1,3-dioxolanes VIII-XIII depends on how long the latter remain in contact with the catalyst. It was established by special experiments with pure cis- and trans-dioxolanes that the thermodynamically less stable [9] cis-dioxolanes undergo slow isomerization to the trans isomers when acetone solutions of them containing catalytic amounts of boron trifluoride etherate are allowed to stand. When acetone is absent, this isomerization does not take place. Moreover, we observed similar isomerization of nonenolized (on the part of the 1,3-dioxolane ring) 2,2,4,5c-tetramethyl-4r-acetyl-1,3-dioxolane [10] and cis-4-phenyl-5-(p-nitrophenyl)-1,3-dioxolane (XIV) to the corresponding trans isomers. These facts, as well as a qualitative evaluation of the change in the rate of isomerization as a function of the nature of the substituent in the aryl group ($CH_3O \gg CH_3 > H > Cl$), make it possible to assume that the isomerization of cis-2,2-dimethyl-5-aryl-4-benzoyl-1,3-dioxolanes in acetone in the presence of boron trifluoride etherate proceeds as a consequence of nucleophilic attack by the acetone molecule on the benzyl center of the 1,3-dioxolane ring in accordance with the scheme



EXPERIMENTAL

The PMR spectra of 5-10% solutions of the compounds in CCl_4 were obtained with Varian HA-100 and JNM-100PS spectrometers with tetramethylsilane as the internal standard. The course of the reaction and the purity of the substances obtained were monitored by thin-layer chromatography (TLC) on a loose layer of activity II aluminum oxide [elution with ether – petroleum ether (1:3); the chromatograms were developed in iodine vapors].

trans-Acyloxiranes I-VI were obtained by oxidation of the corresponding chalcones with alkaline hydrogen peroxide, while cis-oxirane VII was obtained by a known method [11].

2,2-Dimethyl-5-aryl-4-benzoyl-1,3-dioxolanes (VIII-XIII). A cooled solution of 8 mmole of boron trifluoride etherate in 0.3 mole of acetone was added dropwise to a cooled (to 0°C) solution of 0.1 mole of oxirane-I-VI in 0.7 mole of acetone, and the mixture was allowed to stand for 1-2 h (for 100 h in the case of p- and m-chlorophenyloxiranes V and VI, and 4 mmole of the catalyst was added to the reaction mixture at intervals of 24-25 h). It was then neutralized with a solution of sodium hydroxide in methanol and diluted with a tenfold amount of water. The oil that was liberated crystallized after brief agitation, and the crystals were separated, washed with water, and dried. The composition of the mixture was analyzed by PMR spectroscopy. The cis isomers were isolated by repeated crystallization from hexane, while the trans isomers were isolated by column chromatography on activity II aluminum oxide [elution with ether – petroleum ether (1:2)].

Hydrolysis of 1,3-Dioxolanes VIIIA, B. Acetic acid was added to a mixture of 0.03 mole of dioxolane and 0.15 mole of water until the 1,3-dioxolane dissolved completely, and the solution was refluxed for 3-5 h. The acetone was distilled from the reaction mixture into a solution of 2,4-dinitrophenylhydrazine in 2 N hydrochloric acid, and the benzaldehyde was then steam distilled into another portion of a 2,4-dinitrophenylhydrazine solution. No melting-point depressions were observed for mixtures of the acetone and benzaldehyde 2,4-dinitrophenylhydrazones with authentic samples.

cis-2,2-Dimethyl-4-phenyl-5-(p-nitrophenyl)-1,3-dioxolane (XIV). A solution of 3 mmole of boron trifluoride etherate in 0.3 mole of acetone was added dropwise with vigorous stirring at 0°C to a solution of 0.05 mole of trans-2-phenyl-3-(p-nitrophenyl)oxirane in 4 mmole of acetone, and the mixture was allowed to stand at room temperature for 5 h. It was then neutralized with a solution of sodium hydroxide in methanol and diluted with water. The aqueous mixture was extracted with ether, the extract was dried with potassium carbonate, and the ether was removed. The residue (10.7 g), which, according to the PMR spectrum, contained 70% XIV and 30% of the corresponding trans isomer, was crystallized from isopropyl alcohol to give 6.1 g (41%) of dioxolane XIV with mp 105°C. PMR spectrum (in CS_2), δ: 1.58 (s, 2-CH_3), 1.79 (s, 2-CH_3), 5.46 (s, 4-H and 5-H), 6.80-7.00 (m, C_6H_5), 7.04 (d, J = 9 Hz, 2H), and 7.80 ppm (d, J = 9 Hz, 2H). Found: C 68.3; H 5.8%. $C_{17}H_{17}NO_4$. Calculated: C 68.2; H 5.7%.

Isomerization of 1,3-Dioxolanes VIII-XIV. A solution of 0.08 mmole of boron trifluoride etherate in 0.01 mole of acetone was added to a solution of 1 mmole of 1,3-dioxolane in 0.02 mole of acetone. After 24 h, the catalyst was neutralized by the addition of 0.1 mmole of pyridine (in control experiments with trans-1,3-dioxolanes, neutralization of the catalyst was carried out after 100-150 h), the acetone was removed at reduced pressure, and the residue was dissolved in CCl_4. The solution was filtered, and the filtrate was analyzed by PMR spectroscopy.

LITERATURE CITED

1. I. G. Tishchenko, O. N. Bubel', and G. Z. Stasevich, Khim. Geterotsikl. Soedin., No. 7, 885 (1974).
2. I. G. Tishchenko, O. N. Bubel', G. Z. Stasevich, and A. F. Abramov, Khim. Geterotsikl. Soedin., No. 7, 907 (1975).
3. R. P. Hanzlik and M. Leinwetter, J. Org. Chem., 43, 438 (1978).
4. I. G. Tishchenko, O. N. Bubel', and V. I. Kononovich, Vestn. Beloruss. Gos. Univ., Ser. II, 28 (1969).
5. L. Reichel and A. Neubauer, Ann., No. 8, 1538 (1975).
6. F. A. L. Anet and J. M. Muchowski, Chem. Ind., No. 2, 81 (1963).
7. L. H. Zalkow and M. Ghosal, Chem. Commun., No. 18, 922 (1967).
8. J. Chuche, G. Dana, and M.-R. Monot, Bull. Soc. Chim. Fr., No. 8, 3300 (1968).
9. J. Stoddart, Stereochemistry of Carbohydrates, Wiley (1971).
10. O. N. Bubel', I. G. Tishchenko, and G. Z. Stasevich, Vestn. Beloruss. Gos. Univ., Ser. 2, No. 1, 18 (1977).
11. H. H. Wasserman and N. E. Aubrey, J. Am. Chem. Soc., 77, 590 (1955).