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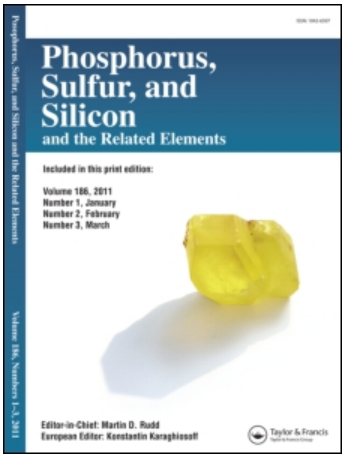

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INVESTIGATION IN THE CHROMONE SERIES. PART XXI. 4,4-DICHLORO-4H-1-BENZOPYRAN-2-CARBONYL CHLORIDE IN REACTION WITH PHOSPHITES

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INVESTIGATION IN THE CHROMONE SERIES. PART XXI.† 4,4-DICHLORO-4H-1-BENZOPYRAN-2-CARBONYL CHLORIDE IN REACTION WITH PHOSPHITES

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4,4-Dichloro-4H-1-benzopyran-2-carbonyl chloride in the reaction with tertiary phosphites forms two stereoisomeric products (E) and (Z). The mechanism of their formation and the structure has been suggested.

Key words: 4-Chloro-(E) and (Z) 2(dialkylphosphato, dialkylphosphono)methylene-2H-1-benzopyran; reaction mechanism; structure.

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In our previous paper[1] we described the reaction of chromone-2-carbonyl chloride with some trialkyl phosphites and trialkylsilyldialkylphosphites and as a result of these reactions two stereoisomeric products (E) and (Z) 2(dialkylphosphato, dialkylphosphono)methylene-4[(4-oxo-4H-1-benzopyran-2-yl)carbonyloxy]2H-1-benzopyran are formed, with a general formula as shown in Figure 1.

At the first step of the reaction a reactive α-ketophosphonate is formed whose oxygen of the carbonyl group reacts with phosphite. In the formed carbanion the negative charge is transferred to the carbonyl group in 4 position of γ-pyron through the system of conjugated double bonds. The formed stereoisomeric betaines undergo secondary reactions with acid chloride with subsequent formation of the compounds of the foregoing formula (Figure 1).

The aim of this study was to investigate the behaviour of 4,4-dichloro-4H-1-benzopyran-2-carbonyl chloride 1, which does not contain a carbonyl group in position 4 and hence it cannot yield an oxoanionic structure in a reaction with tertiary phosphites.

Simple aliphatic[2] and aromatic[3] acid chlorides react with trialkyl phosphites to the expected dialkyl α-ketophosphonate esters (Michaelis-Arbuzov reaction). In case of some aromatic acid chlorides secondary reactions with the formation of phosphonophosphate compound[4] were observed. α, β unsaturated acid chlorides undergo the Perkow reaction with the formation of vinyl derivatives.[5] The suggested

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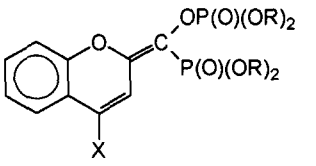

(E) and (Z) stereoisomers

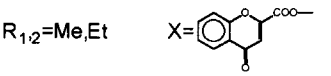

FIGURE 1

mechanism of their formation is based on the attack of the phosphite molecule on the oxygen of the carbonyl group of α-ketophosphonate which is possible by reversal of the polarization of this group by the presence of electron "withdrawing" substituents.

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RESULTS AND DISCUSSION

The reactions of 4,4-dichloro-4H-1-benzopyran-2-carbonyl chloride[6] 1 were carried out with trimethyl phosphite 2a, triethyl phosphite 2b, trimethylsilyldimethyl phosphite 2c and trimethylsilyldiethyl phosphite 2d. Instead of the expected dialkyl α-ketophosphonate 3 we observed the formation of two products 5(a-b) and 6(a-b). The formed compounds 6(a-b) are unstable and at room temperature (about 7 hours for 6a and 10 hours for 6b) they isomerize to 5a and 5b, respectively (see experimental part). Because of their instability they were not isolated in a pure form and they were characterized by the means of ^{31}P NMR and TLC. On the basis of the analysis of ^{31}P NMR spectra carried out during the reaction, only the formation of 5(a-b) and 6(a-b) was observed, which was independent of temperature and the order of reagent addition. The measured chemical shifts δ ^{31}P NMR and coupling constants J_{PP} of 5(a-b) and 6(a-b) are similar to those observed for (E) and (Z) stereoisomers which had been obtained before.[1] Analogously the formation of 6(a-b) was kinetically favoured in relation to 5(a-b) at a ratio ranging from 2:1 at the temperature of $-40°C$ to 4:1 at the temperature of $+40°C$. Compounds 5(a-b) are brightly yellow, crystalline solids easily soluble in organic solvents and in water. The compound 5a was investigated by X-ray analysis and was identified as 4-chloro-(E)2(dimethylphosphato, dimethylphosphono)methylene-2H-1-benzopyran.[7]

On the basis of spectroscopic ^{31}P NMR data (identical coupling constants J_{PP} for 5a and 6a as well as for 5b and 6b) and on the basis of elemental analysis for 5a it was found that compound 5 can be regarded as the thermodynamically more stable (E) stereoisomer of 4-chloro-2(dialkylphosphato, diakylphosphono)methylene-2H-1-benzopyran. This constitutes a parallel to the stereoisomers that we had described previously.[1]

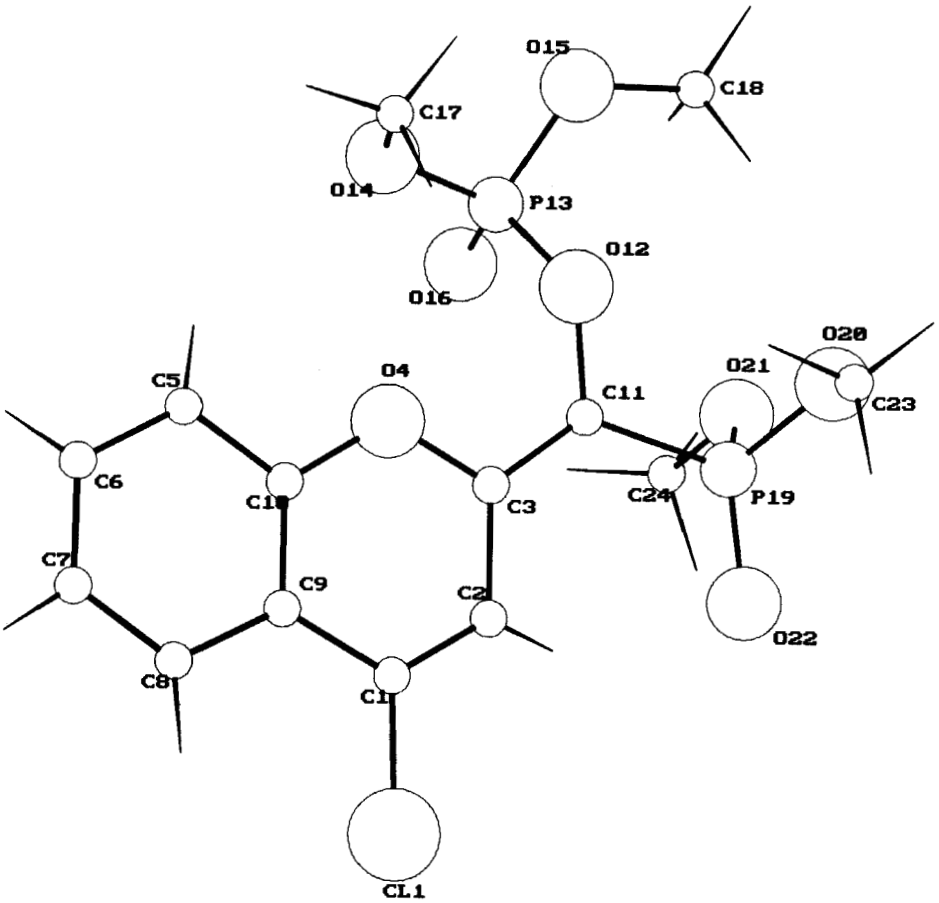

FIGURE 2 Structure of 4 chloro-2(dimethylphosphato, dimethylphosphono)methylene-2H-1-benzopyran.

Suggested course of the reaction of compound 1 with 2(a-d) is presented in Scheme I.

4,4-dichloro-4H-1-benzopyran-2-carbonyl chloride 1, which can be found in two tautomeric forms 1A and 1B[8], reacts with 2(a-d) yielding reactive α-ketophosphonates 3A and 3B. The second phosphite molecule may attack either the carbon atom or the oxygen atom of the carbonyl group of compound 3. The attack of the oxygen atom is more probable because of reversal of the polarization of the carbonyl group caused by the presence of the electronegative chlorine atom in the β position of 3B form (like for α-chloro-acid chlorides[9]) or by the presence of double bond[5] in the β, γ position for the 3A form.

Unstable structures 4A and 4B are stabilized by the elimination of Cl^- anion and by dealkylation of OP^+ $(OR')(OR)_2$ with subsequent formation of the stereoisomeric compounds 5(a-b) and 6(a-b). The confirmation of the assumed course of the reaction comes from the reaction of compound 1 with trimethylsilyldialkyl phosphites 2(c-d). In case of the attack of compound 2(c-d) on the carbon atom

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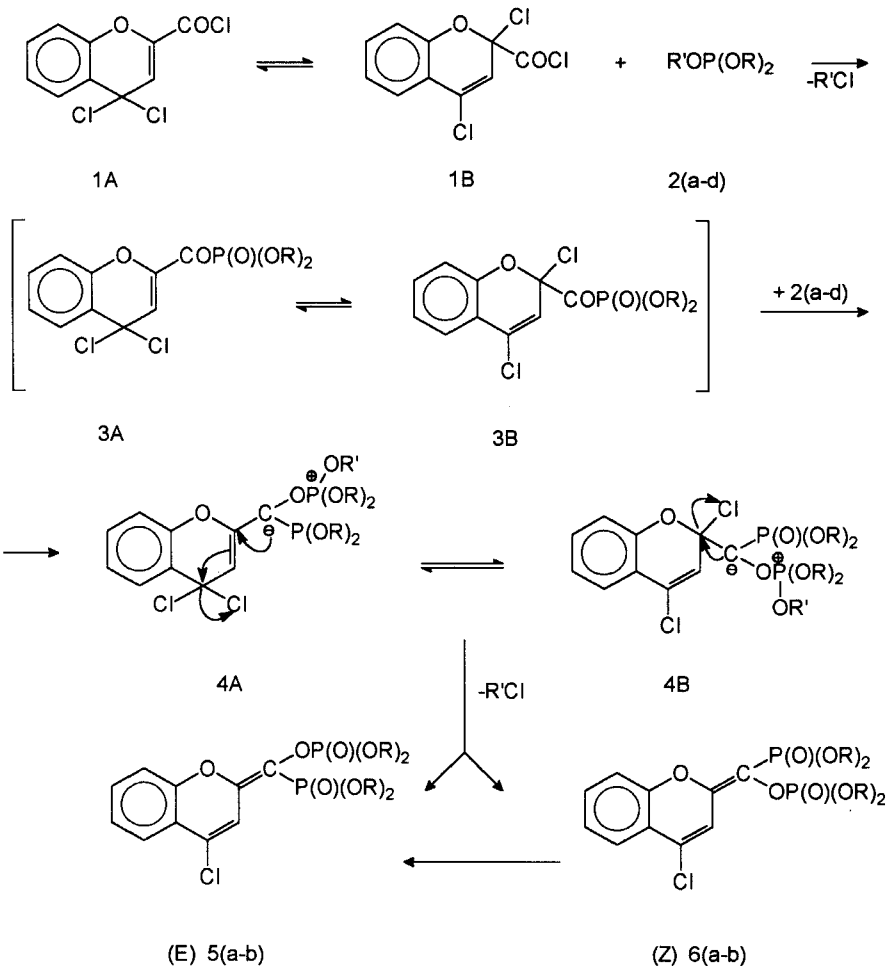

a: R'=R=Me; b: R'=R=Et; c: R'=Me_3Si, R=Me; d: R'=Me_3Si, R=Et

SCHEME I

of the carbonyl group of compounds 3A and 3B, α-trimethylsilyloxydiphosphonic compound should be formed; however such a change was not observed. The influence of benzoic acid on the course of the reaction of compound 1 with 2a was not confirmed as well. Elimination of Cl^- anion with simultaneous formation of the double bond (Perkow reaction) is quicker than protonation of the carbonanionic structures 4A and 4B. This kind of protonation had been observed before.[1,4]

Compounds 5(a-b) react with water and methanol with subsequent formation of compound 8(a-b)[1] (Scheme II). A catalytic influence of proton ions on the course of this reaction was observed (reduction of reaction time from more than ten hours to slightly more than ten minutes). At the first step the protonation of acyclic carbon of compounds 5 takes place. As a result of nucleophilic attack of XOH on

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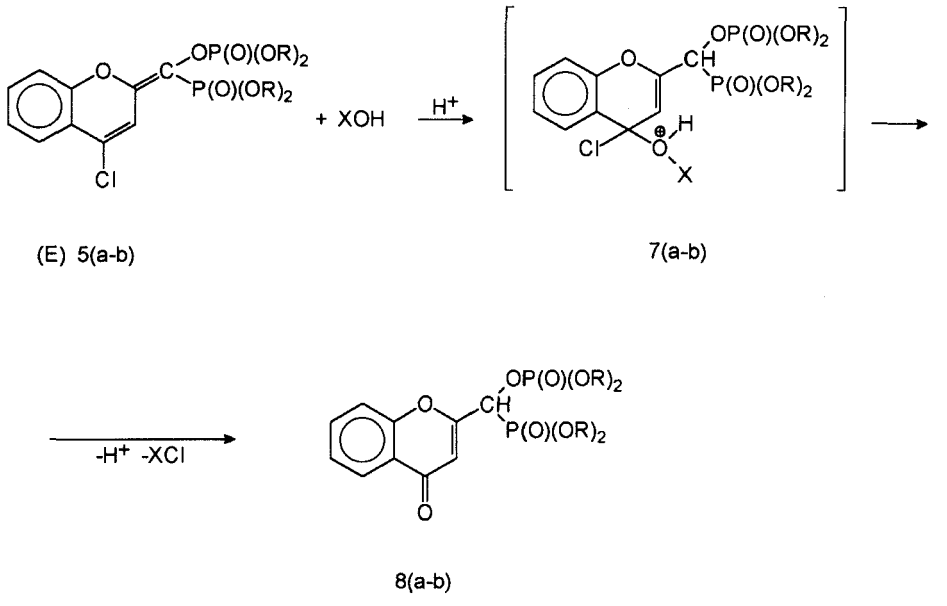

$X_{1,2}$ = H,Me a: R=Me; b: R=Et

SCHEME II

the carbon atom C_4 an unstable compound 7 is subsequently formed. Compound 7 yields compounds 8 by the elimination of XCl molecule. The observed transformation is analogous to the exchange of the halogen atom in 4-chlorocoumarin in the reaction with nucleophiles, while the tetrahedral carbon atom C_4^{10} is also involved in this reaction.

EXPERIMENTAL

Melting points are uncorrected. IR spectra were taken on a Pye-Unicam 200G, in KBr (tablets) or in $CHCl_3$, ν, cm^{-1}. ^1H NMR spectra were recorded on Varian EM-360 (60 MHz) in $CDCl_3$, δ, ppm; ^{31}P NMR spectra on a Brucker AC 200 (81, 01 MHz) spectrometer in $C_6D_5CD_3$, δ, ppm; ^{13}C NMR were made using Tesla BS 567A (25, 31 MHz) spectrometer in $CDCl_3$, δ, ppm. Mass spectrum were measured on LKB-2091 (70eV). All solvents were dried according to standard methods, trialkyl phosphites were purified by fractional distillation. Silyl phosphites commercial (Fluka AG). All reaction were carried out under dry argon atmosphere. Compounds were purified by column chromatography using silica gel with ethyl acetate: acetone 1:1 as the eluant; TLC-silica gel plate with ethyl acetate: acetone 1:1.

4-Chloro-(E) and (Z) 2(dimethylphosphato, dimethylphosphono)methylene-2H-1-benzopyran (5a) and (6a). Reaction 1 with 2a or 2c: To 2.62g (0.01 mol) of compound 1 in 10 ml of benzene at room temperature was added 0.02 mol of compound 2a or 2c dropwise. The mixture was stirred for 30 min. TLC showed 5a, R_f = 0.47 and 6a, R_f = 0.24. Benzene was distilled off under reduced pressure and the residue cooled. Obtained 5a in reaction with 2a, 3.73 g (91%), mp. 114–116°C (diethyl ether); in reaction with 2c, 3.40 g (83%), mp. 114–116°C (diethyl ether), light yellow prisms. (Found C, 40.80; H, 4.14; Cl, 8.40; P, 14.85%. Calc. for $C_{14}H_{17}ClO_8P_2$, C, 40.96; H, 4.15; Cl, 8.54; P, 15.12%). ^1H NMR, δ: 3.82 (d, 6H, $2CH_3$); 3.92 (d, 6H, $2CH_3$); 6.86–7.69 (m, $4H_{arom}$); 7.75 (s, 1H, C_3H). ^{13}C NMR: C_2(dd, 154.1, $^2J_{PCC}$ = 48.83 Hz, $^3J_{POCC}$ = 7.51 Hz); C_2, (dd, 115.8, $^1J_{PC}$ = 242.26 Hz, $^2J_{POC}$ = 11.27 Hz); C_3 (C_5) (115.4); C_4 (134.3); C_{4a} (119.2); C_5 (C_3) (115.9); C_6 (C_7) (124.2); C_7 (C_6) (124.8); C_8 (131.7); C_{8a} (152.4); CH_3—O—P (d, 54.8, $^2J_{POC}$ = 7.51 Hz); CH_3—O—P (d, 52.9, $^2J_{POC}$ = 5.63 Hz).

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IR: 1625, 1600, 1575, 1440, 1350, 1290 (P=O), 1255 (P=O), 1050 (P—O—C), 1025 (P—O—C). MS, m/z, (%): 412 (15), 411 (7), 410 (43, M^+), 301 (11), 207 (21), 192 (18), 187 (12), 178 (26), 166 (29), 165 (11), 164 (88), 129 (62), 109 (47), 101 (24), 93 (100), 79 (16), 63 (14), 52 (11), 50 (41), 38 (10), 36 (34), 35 (23), 15 (38).

Conversion of 6a into 5a. 0.001 mol of compound 1 in 1 ml of $C_6D_5CD_3$ and 0.002 mol of 2a in 1 ml of $C_6D_5CD_3$ was kept in a NMR tube at −40°C. ^{31}P NMR showed 5a: +12.89(d), − 2.67(d), $^3J_{PP}$ = 6.84 ± 0.97 Hz and 6a: +11.86(d), −0.29(d), $^3J_{PP}$ = 4.88 ± 0.97 Hz. Ratio 6a to 5a was ca 2:1 respectively. After 7 hrs at room temperature ^{31}P NMR showed only 5a.

Reaction of compound 1 with 2a in the presence of benzoic acid. To 2.62 g (0.01 mol) of compound 1 in 10 ml of benzene were added 1.22 g (0.01 mol) of benzoic acid and added dropwise 0.02 mol of 2a at room temperature. The mixture was stirred for 30 min. TLC showed 5a and a small amount of 6a. Benzene was distilled off under reduced pressure. The oily residue was separated by column chromatography. Obtained: 5a, 2.5 g (61%), mp. 114–116°C (diethyl ether) and 0.89 g (73%) of benzoic acid.

4-Chloro-(E) and (Z) 2(diethylphosphato, diethylphosphono)methylene-2H-1-benzopyran (5b) and (6b). To 2.62 g (0.01 mol) of 1 in 10 ml of benzene was added dropwise 0.02 mol of 2b or 2d at room temperature. The mixture was stirred for 1 hr. TLC show 5b, R_f = 0.58 and 6b, R_f = 0.39. Benzene was distilled off under reduced pressure. The oily yellow residue, after washing with several ml of petroleum ether, solidified on cooling (24 hrs). Obtained 5b in reaction with 2b, 3.54 g (76%), mp. 42–45°C (petroleum ether) and in reaction with 2d, 3.02 g (65%), mp. 44–47°C (petroleum ether), light yellow prisms. (Found C, 46.50; H, 5.50; Cl, 7.16; P, 13.05%. Calc. for $C_{18}H_{25}ClO_8P_2$—C, 46.35; H, 5.36; Cl, 7.51; P, 13.30%). ^1H NMR: 1.40 (3t, 12H, $4CH_3$); 4.25 (m, 8H, $4CH_2$); 6.95–7.75 (m, $4H_{arom}$); 7.88 (s, 1H, C_3H). IR: 1625, 1600, 1575, 1355, 1290 (P=O), 1280 (P=O), 1070 (P—O—C).

Conversion of 6b to 5b. The reaction was carried out as described for compound 6a. ^{31}P NMR showed 5b: +11.16(d), −4.28(d), $^3J_{PP}$ = 7.79 ± 0.59 Hz and 6b: +10.23(d), −2.19(d), $^3J_{PP}$ = 4.89 ± 0.59 Hz).

2(dialkylphosphato, dialkylphosphono)methyl-4H-1-benzopyran-4-one 8(a,b). a. *Reaction of 5a or 5b with water:* 0.005 mol of compound 5a or 5b was dissolved in 20 ml of water with 2–3 drops of concentrated HCl. The mixture was refluxed for 5 min. the solution gradually loses colour. Water was distilled off under reduced pressure. The oily residue was purified by column chromatography. Obtained 8a,[1] 1.35 g (69%), mp. 106–108°C (THF) or 8b,[1] 1.16 g (52%), mp. 61–64°C (diethyl ether).

b. *Reaction of 5a or 5b with methanol:* 0.005 mol of compound 5a or 5b was dissolved in 20 ml of anhydrous methanol saturated with ca 50 ml of gaseous HCl. The solution was refluxed for 1 hr (TLC control). Methanol was distilled off under reduced pressure. The oily residue solidified on cooling. Obtained 8a, 1.74 g (79%), mp. 106–108°C (THF) or 8b, 1.59 g (71%), mp. 62–65°C (diethyl ether).

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REFERENCES

1. K. Kostka and R. Modranka, *Phosphorus, Sulfur and Silicon*, **70,** 29 (1992).
2. K. D. Berlin, D. M. Hellwege and M. Nagabhushanam, *J. Org. Chem.*, **30,** 1265 (1965). R. S. Marmor and D. Seyferth, *ibid.*, **36**, 128 (1971).
3. K. D. Berlin and M. A. Taylor, *J. Am. Chem. Soc.*, **86,** 3862 (1964).
4. D. V. Griffiths, H. A. R. Jamali and J. C. Tebby, *Phosphorus and Sulfur*, **11,** 95 (1981). D. V. Griffiths, H. A. R. Jamali and J. C. Tebby, *ibid*, **25,** 173 (1985).
5. T. Winkler and W. L. Bencze, *Helv. Chim. Acta*, **63,** 402 (1980).
6. V. A. Zagorevskii and D. A. Zykov, *Zh. Obshch. Khim.*, **30,** 3100 (1960).
7. T. A. Olszak, A. Stępień, M. Renz, M. J. Grabowski, K. Kostka and R. Modranka, *Acta Cryst.* in press.
8. V. A. Zagorevskii and D. A. Zykov, *Zh. Obshch. Khim.*, **30,** 1378 (1960). V. A. Zagorevskii, *ibid.*, **32,** 3770 (1962). V. A. Zagorevskii, I. D. Tsvetkova and E. K. Orlova, *ibid.*, **34,** 1911 (1964).
9. F. W. Lichtenthaler, *Chem. Rev.*, **61,** 607 (1961).
10. V. A. Zagorevskii, V. L. Savel'ev and L. M. Meshcheryakova, *Khim. Geteroc. Soed.*, **8,** 1019 (1970). V. A. Zagorevskii, V. L. Savel'ev and N. V. Dubykina, *Zh. Org. Khim.*, **4,** 2041 (1968).