82. J. Verbeek and L. Brandsma, J. Org. Chem., 49, 3857 (1984).
83. Y. Yamamoto, Y. Azuma, and H. Mitoh, Synthesis, No. 7, 564 (1986).
84. D. L. Comis and J. D. Brown, Tetrahedron Lett., No. 20, 2219 (1986).
85. H. Hara and H. C. van der Plas, J. Heterocycl. Chem., 19, 1285 (1982).
86. H. C. van der Plas and D. J. Buurman, Tetrahedron Lett., No. 34, 3763 (1984).
87. A. F. Pozharskii, V. V. Kuz'menko, I. S. Kashparov, V. I. Sokolov, and M. M. Medvedeva, Khim. Geterotsikl. Soedin., No. 3, 356 (1976).
88. H. C. van der Plas, V. N. Charushin, and B. van der Veldhuizen, J. Org. Chem., 48, 1354 (1983).
89. M. A. Yurovskaya, V. A. Chertkov, A. Z. Aganas'ev, F. V. Ienkina, and Yu. G. Bundel', Khim. Geterotsikl. Soedin., No. 4, 509 (1985).
90. K. A. Watanabe, T.-L. Su, K. W. Pankiewicz, and K. Harada, Heterocycles, 21, 289 (1984).
91. H. C. van der Plas, Tetrahedron, 41, 237 (1985).
92. A. A. Konstantinchenko and A. F. Pozharskii, USSR Inventor's Certificate No. 899,533; Byull. Izobret., No. 3 (1982).
93. A. A. Konstantinchenko, A. F. Pozharskii, and V. N. Stepanova, USSR Inventor's Certificate No. 1,318,587; Byull. Izobret., No. 23 (1987).
94. D. L. Boger, Tetrahedron, 39, 2869 (1983).
95. D. L. Boger, Chem. Rev., 86, 781 (1986).
96. M. Dewar, Molecular Orbital Theory [Russian translation], Mir, Moscow (1972), p. 500.
97. H.-J. Altenbach, H. Stegelmeier, M. Wilhelm, B. Voss, and E. Vogel, Angew. Chem., 91, 1028 (1979).
98. E. G. Popova and L. A. Chetkina, Zh. Strukt. Khim., 29, 664 (1979).
99. M. A. Paradisi, G. P. Zecchini, and I. Torrini, Tetrahedron Lett., No. 41, 5029 (1986).
100. K. G. Devine and C. B. Reese, Tetrahedron Lett., No. 45, 5529 (1986).

SYNTHESIS OF BENZO[c]-2-FURANONE DERIVATIVES FROM FUNCTIONALLY-SUBSTITUTED 2-BUTEN-2-OLIDES

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The reaction of substituted 2-acetyl-2-buten-4-olides with diethyl oxalate gives 3-hydroxy-5-ethoxycarbonyl-7,7-dialkylbenzo[c]-2-furanones. These products were also converted to their 5-carboxy derivatives and some salts.

In previous work [1], we showed that the condensation of 2-acetyl-2-buten-4-olides Ia-Ic with diethyl oxalate leads to the corresponding 2-(1-ethoxycarbonyl-1,3-diketopropyl)-3,4,4-trialkyl-2-buten-4-olides.

We have found that carrying out this condensation at 90-95°C in the presence of dry sodium methylate leads to a new heteroaromatic system, namely, 3-hydroxy-5-ethoxycarbonyl-7,7-dialkylbenzo[c]-2-furanones IIa-IIc, probably through the following transformations.

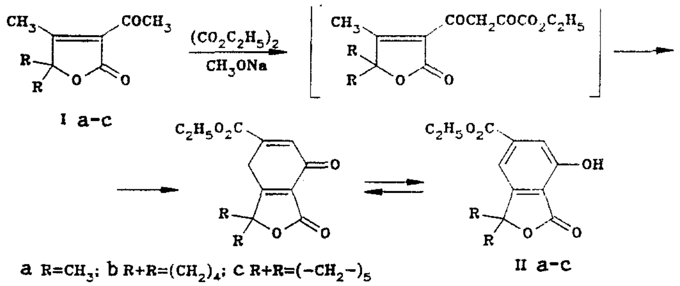

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TABLE 1. Characteristics of Synthesized Compounds

Compound	Chemical formula	mp, °C (from CCl_4)	R_f (acetone–benzene, 1:3)	IR spectrum, ν, cm^{-1}	PMR spectrum, δ, ppm (in DMSO-D_6)	Mass spectrum,* m/z (I_{rel}, %)	Yield, %
IIa	$C_{13}H_{14}O_5$	159...160	0,58	1610 (C=C arom.) 1620 (C=C), 1690 (C=O ketone) 1710 (C=O ester), 1740 (C=O lact.) 3410 (OH)	1,50 t (3H, J=7 Hz, CH_3CH_2); 1,45 s (6H, $(CH_3)_2$); 4,20 q (2H. J=7 Hz, CH_3CH_2); 7,55 s (1H), 7,65 s (1H)	250 (25), 235 (44), 221 (50), 161 (44), 160 (40), 159 (100), 119 (56), 103 (51), 91 (48), 77 (52), 43 (85)	83
IIb	$C_{15}H_{16}O_5$	141...142	0,72	1610 (C=C arom.) 1630 (C=C), 1695 (C=O ketone) 1715 (C=O ester), 1745 (C=O lact.) 3390 (OH)	1,20 t (3H, J=7,5 Hz, CH_3CH_2); 1,60...2,05 m (8H, $(CH_2)_4$); 4,30 q (2H, J=7,5 Hz, CH_3CH_2); 7,45 s (1H), 7,55 s (1H)	276 (100), 261 (46), 258 (90), 247 (11), 244 (38), 185 (8), 149 (16), 96 (15), 84 (20), 83 (18), 70 (15)	41
IIc	$C_{16}H_{18}O_5$	166...167	0,68	1610 (C=C arom.) 1620 (C=C), 1700 (C=O ketone) 1720 (C=O ester), 1755 (C=O lact.), 3380 (OH)	1,35 t (3H, J=7 Hz, CH_3CH_2); 1,59...2,00 m (10H, $(CH_2)_5$); 4,35 q (2H, J=7 Hz, CH_3CH_2); 7,40 s (1H), 7,50 s (1H)	290 (100), 276 (29), 272 (67), 259 (23), 247 (61), 245 (31), 234 (23), 226 (15), 219 (17), 199 (25), 189 (17)	65

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*Values are given for M^+ and the ten strongest peaks.

IR, PMR, and UV spectroscopy indicates the presence of a tautomeric quinoid form in addition to the phenolic form in IIa-IIc. Thus, the IR spectra have a band at 1700-1690 cm^{-1}, which may be assigned to the quinoid carbonyl group. The PMR signals are solvent-dependent. Thus, the signals obtained in DMSO indicate the presence of only the phenolic form, while the signal at 3.65-3.80 ppm, assigned to the protons of the quinoid ring methylene group and the multiplet at 7.45-7.60 ppm assigned to the aromatic protons found in deuteropyridine and CH_3OD indicate the existence of both forms. Unequivocal evidence for the simultaneous existence of both tautomeric forms under certain conditions is found in the UV spectra of tabulated compounds (see the work of Bol'shakova et al. [2, p. 56]). For this purpose, the UV spectra for IIa taken in a neutral medium (ethanol), acid medium, and alkaline medium. Benzofuranone IIa in ethanol absorbs at λ_{max} 218, 234, 255, 325, and 370 nm, while in acid medium it absorbs at λ_{max} 234, 260, and 370 nm (quinoid form), and in alkaline medium it absorbs at λ_{max} 218, 254, and 323 nm (phenolic form). Comparison of these data shows that IIa exists in two forms in neutral media. In addition to spectral studies, the existence of the phenolic form was demonstrated by a color reaction with ferric chloride (see the work of Shriner et al. [3, p. 403]).

The hydrolysis of the ethoxyl group in II was carried out in a 1:3 mixture of hydrochloric and acetic acids to give 3-hydroxy-5-carboxy-7,7-dimethylbenzo[c]-2-furanone (III). The reaction of III with piperidine and ethylenimine give salts IV and IV. These products were obtained in order to study their biological activity.

EXPERIMENTAL

The IR spectra were taken in a Vaseline mull on a UR-20 spectrometer. The PMR spectra were taken on a Varian T-60 spectrometer at 60 MHz with HMDS as the internal standard and deuterated DMSO, pyridine, and methanol as the solvents. The mass spectra were taken on an MKh-1303 mass spectrometer with direct sample inlet into the ion source. The ionization voltage was 30 eV. The purity of all the compounds synthesized was monitored by thin-layer chromatography on Silufol UV-254 plates with 1:3 benzene—acetone as the eluent. The plates were developed with iodine vapor or in UV light.

3-Hydroxy-5-ethoxy-7,7-dialkylbenzo[c]-2-furanones (IIa)-(IIc). A sample of 4 g (74 mmoles) dry sodium methylate was added in small portions with vigorous stirring to a mixture of 36 mmoles 2-acetyl-3-methyl-4,4-dialkyl-2-buten-4-olides (Ia)-(Ic) and 14.6 g (100 mmoles) diethyl oxalate. Considerable heat evolution and darkening of the reaction mixture were noted. The mixture was heated at 90-95°C for 7-10 h and then 300 ml 3% acetic acid was added. The precipitate formed was filtered off and washed with water, acidified with acetic acid, and recrystallized from carbon tetrachloride to give IIa-IIc (see Table 1).

3-Hydroxy-5-carboxy-7,7-dimethylbenzo[c]-2-furanone (III), $C_{11}H_{10}O_5$. A mixture of 3 g (12 mmoles) furanone IIa, 20 ml acetic acid, and 10 ml concentrated hydrochloric acid was heated on a water bath at 80-90°C for 4-5 h. The crystals formed were filtered off to give 2.5 g (95%) III, mp 190°C (decomp.). IR spectrum: 1700 (C=O acid), 1750 (C=O lact.), 2600-2800 (wave crest), 3400 cm^{-1} (OH).

Salts IV and V. A sample of 4 mmoles heterocyclic amine was added to 1 g (4 mmoles) III dissolved in 30 ml absolute ethanol and left overnight. The solvent was distilled off on the following day and the crystalline residue was washed with acetone to give salts IV and V. Salt IV ($C_{16}H_{21}NO_5$) was obtained in 81% yield, mp 204°C (from CCl_4). IR spectrum: 1740 (C=O lact.), 2600-2800, 3120 (NH), 3400 cm^{-1} (OH). Salt V ($C_{13}H_{15}NO_5$) was obtained in 85% yield, mp 185°C (from CCl_4). IR spectrum: 1750 (C=O lact.), 2400-2800, 3150 (NH), 3240 cm^{-1} (OH).

LITERATURE CITED

1. A. A. Avetisyan, A. N. Dzhandzhapanyan, and M. T. Dangyan, Khim. Geterotsikl. Soedin., No. 12, 1611 (1978).
2. G. F. Bol'shakova, V. S. Vatago, and F. B. Agrest, Ultraviolet Spectra of Heteroorganic Compounds [in Russian], Khimiya, Leningrad (1969).
3. R. Shriner, R. Fuson, D. Curtin, and T. Morril, The Identification of Organic Compounds [Russian translation], Mir, Moscow (1983).