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POLYFURYL(ARYL)ALKANES AND THEIR DERIVATIVES
16.* CONVENIENT PATH TO BENZOFURAN KETONES

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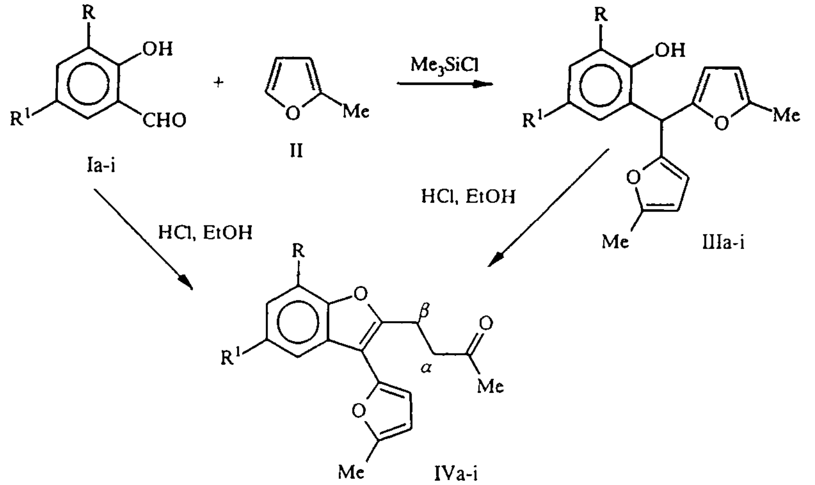
2-(3-Oxobutyl)-3-(5-methyl-2-furyl)benzofurans were synthesized by the recyclization of 2-hydroxyarylbis(5-methyl-2-furyl)methanes in methanol saturated with hydrogen chloride. They can also be obtained by the reaction of salicylaldehydes and sylvane in an ethanol solution of hydrogen chloride.

Earlier [2] we reported that the condensation of salicylaldehydes (I) and sylvane (II) in benzene in the presence of catalytic amounts of perchloric acid does not stop at the formation of the expected 2-hydroxyaryldifurylmethanes (III) but is accompanied by side reactions, leading to the ketones (IV) and other derivatives of benzofuran. As a result, the isolation of the final products is complicated, which inevitably leads to losses and accordingly to reduced yields.

In view of the broad synthetic possibilities of the obtained products (III) and (IV) and also the practical value of the benzofuran derivatives [3-5], we set out to develop preparative syntheses for the above-mentioned compounds. We have already described the conditions for the selective synthesis of compounds (III) [6]. In the present paper, we present the results of the search for the optimum conditions for the synthesis of the ketones (IV).



I, III, IV a-g R = H, a R^1 = H, b R^1 = Me, c R^1 = OMe,
d R^1 = Cl, e R^1 = Br, f R^1 = I, g R^1 = NO_2, h R = R^1 = Br, i R = R^1 = I

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*For Communication 15, see [1].

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TABLE 1. Physicochemical Characteristics of the Synthesized Compounds

Compound	Empirical formula	Found, %/Calculated, % C	H	Hal	mp, °C	Yield, %†
IIIa	$C_{17}H_{16}O_3$	75.93 76,10	6.21 6,01		64...65	90
IIIb	$C_{18}H_{18}O_3$	76.72 76,57	6.57 6,43		Oil	91
IIIc	$C_{18}H_{18}O_4$	72.61 72,47	5.89 6,08		Oil	88
IIId	$C_{17}H_{15}ClO_3$	67.36 67,44	5.14 4,99	11.79 11,71	88...89	78
IIIe	$C_{17}H_{15}BrO_3$	58.62 58,80	4.56 4,36	22.83 23,02	96...97	82
IIIf	$C_{17}H_{15}IO_3$	52.07 51,80	3.61 3,84	31.87 32,19	109...110	76
IIIg	$C_{17}H_{15}NO_5$	64.99 65,17	4.97 4,83	4.32 4,47	142...143	65
IIIh	$C_{17}H_{14}Br_2O_3$	48.03 47,92	3.25 3,31	37.78 37,50	94...95	51
IIIi	$C_{17}H_{14}I_2O_3$	39.05 39,26	2.52 2,71	48.98 48,80	Oil	81
IVa	$C_{17}H_{16}O_3$	76.31 76,10	6.17 6,01		54...55	71(64)
IVb	$C_{18}H_{18}O_3$	76.80 76,57	6.39 6,43		74...75	79(61)
IVc	$C_{18}H_{18}O_4$	72.29 72,47	6.22 6,08		35...36	80(57)
IVd	$C_{17}H_{15}ClO_3$	67.71 67,44	4.78 4,99	11.68 11,71	73...74	81(60)
IVe	$C_{17}H_{15}BrO_3$	58.96 58,80	4.11 4,36	23.14 23,02	81...82	78(54)
IVf	$C_{17}H_{15}IO_3$	51.96 51,80	4.02 3,84	31.95 32,19	87...88	80(58)
IVg	$C_{17}H_{15}NO_5$	65.09 65,17	4.65 4,83	4.61 4,47	121...122	85(63)
IVh	$C_{17}H_{14}Br_2O_3$	47.77 47,92	3.59 3,31	37.74 37,50	104...105	86(34)
IVi	$C_{17}H_{14}I_2O_3$	39.37 39,26	2.78 2,71	48.64 48,80	133...134	75(35)

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*Compounds (IIIa, d-h) were recrystallized from a mixture of hexane and benzene, (IVa, c-g, i) from hexane, (IVb) from ethanol, and (IVh) from a mixture of hexane and methyl ethyl ketone.

†For compounds (IVa-i), the yields by method A (B).

TABLE 2. PMR Spectra of Compounds (IIIa-i) (deuterochloroform), δ, ppm

Compound	Phenyl or substituted phenyl				5-Methyl-2-furyl			CH (1H), s	Other signals and SSCC, Hz
	3-H (1H)	4-H (1H)	6-H (1H)	OH (1H), bs	3-H (2H)	4-H (2H)	Me (6H), s		
III a	6,40...7,53 m*			5,03	5,70 s		2,13	5,40	2,15 (3H, s, Me)
III b	6,50...6,95 m			5,35	5,83 s		2,15	5,45	3,75(3H, s, OMe)
III c	6,48 s			5,12	5,75 s		2,17	5,38	
III d	6,62...7,05 m			5,32	5,85 s		2,19	5,44	
III e	7,12 d	7,16 dd	6,61 d	5,37	5,78...5,92 m		2,18	5,44	J_{34Ar} = 8,5; J_{46Ar} = 2,2
III f	7,32 d	7,36 dd	6,51 d	5,41	5,80...5,91 m		2,19	5,41	J_{34Ar} = 8,6; J_{46Ar} = 2,1
III g	6,84 d	8,03 dd	7,96 d	6,36	5,95 d	5,86 d	2,20	5,53	J_{34Ar} = 9,3; J_{46Ar} = 2,7; J_{34Fur} = 3,2
III h		7,43 d	7,05 d	5,52	5,78 s		2,20	5,62	J_{46Ar} = 2,2
III i		7,77 d	7,25 d	5,51	5,85 s		2,17	5,59	J_{46Ar} = 2,1

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*Multiplet of four protons, including 5-H.

TABLE 3. PMR Spectra of Compounds (IVa-i) (deuterochloroform), δ, ppm

Compound	Benzofuran			5-Methyl-2-furyl*			α-CH$_2$, m (2H)	β-CH$_2$, m (2H)	Me, s	Other signals and SSCC, Hz
	4-H† (1H)	6-H (1H)	7-H (1H)	3-H, d (1H)	4-H, d (1H)	Me, s (3H)				
IVa	7,57 m	6,92...7,27 m		6,27	5,90	2,30	3,00...3,32	2,60...2,92	2,03	
IVb	7,48 d	6,99 dd	7,20 d	6,39	6,00	2,31	3,12...3,30	2,71...2,99	2,12	2,39 (3H, s, Me); J_{46Ar} = 1,2; J_{67Ar} = 8,0
IVc	7,18 d	6,80 dd	7,23 d	6,37	6,05	2,32	3,12...3,36	2,72...2,95	2,13	3,80 (3H, s, OMe); J_{46Ar} = 3,2; J_{67Ar} = 8,8
IVd	7,70 m	7,06...7,32 m		6,38	6,04	2,33	3,11...3,35	2,73...2,97	2,14	
IVe	7,81 m	7,09...7,36 m		6,37	6,03	2,31	3,09...3,36	2,70...2,95	2,12	
IVf	8,03 d	7,47 dd	7,11 d	6,38	6,04	2,33	3,14...3,36	2,78...2,99	2,13	J_{46Ar} = 1,7; J_{67Ar} = 8,6
IVg	8,64 d	8,14 dd	7,40 d	6,49	6,08	2,35	3,15...3,43	2,72...3,00	2,15	J_{46Ar} = 2,4; J_{67Ar} = 9,0
IVh	7,79 d	7,49 d		6,39	6,05	2,33	3,14...3,38	2,78...3,02	2,17	J_{46Ar} = 1,7
IVi	7,99 d	7,84 d		6,39	6,05	2,33	3,17...3,42	2,74...2,99	2,17	J_{46Ar} = 1,6

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*J_{34Fur} = 3.2 Hz.

†For compounds (IIa, d, e), the centers of the multiplets are indicated.

One of the known methods for opening the furan ring is treatment of the furan derivative with a hot solution of hydrogen chloride in ethanol [7]. We established that 2-hydroxyaryldifurylmethanes (IIIa-i) are converted under analogous conditions into the respective ketones (IVa-i) with yields of 70-90%.

The presence of the carbonyl group in these products is confirmed by a strong band in the region of 1700-1715 cm^{-1} in their IR spectra.

Since hydrogen chloride can be used as a catalyst for the condensation of carbonyl compounds and furan derivatives [8], an attempt was made to synthesize compounds (VIa-i) directly from the aldehydes (Ia-i) and sylvane (II). In fact, the reaction of compounds (Ia-i) and (II) in an ethanol solution of hydrogen chloride leads to the ketones (IVa-i) through the intermediate formation of 2-hydroxyaryldifurylmethanes (III) (monitored by TLC). In this case, the yields of the products (IV) are somewhat lower and amount to 35-65%. However, the advantage of this method is the possibility of obtaining the ketones (IV) in a single stage, bypassing the isolation of compounds (III).

The characteristics of the obtained compounds are given in Table 1. The data from the PMR spectra are given in Tables 2 and 3.

EXPERIMENTAL

The PMR spectra were recorded on a Tesla BS-467 instrument at 60 MHz with HMDS as internal standard. The IR spectra were recorded on a Specord M-80 spectrometer. The reactions and the individuality of the final products were monitored by TLC on Silufol UV-254 plates; the eluant was chosen individually in each case.

2-Hydroxyarylbis(5-methyl-2-furyl)methanes (IIIa-i). The compounds were synthesized by the method described in [6] with Me_3SiCl as catalyst.

General Procedure for the Production of 2-(3-Oxobutyl)-3-(5-methyl-2-furyl)benzofurans (IV). A. To a solution of 0.01 mole of compound (III) in 5 ml of methanol we added 10 ml of methanol saturated with hydrogen chloride. The mixture was boiled for 1 min, and the crystals that separated on cooling were filtered off and recrystallized from ethanol. When crystals did not separate, 50 ml of water was added to the reaction mixture, and the thick oil that separated was washed with water and dissolved in boiling hexane. The solution was filtered through a small layer of aluminum oxide, and the crystals that separated from the filtrate were filtered off.

B. To a warm solution of 0.1 mole of the aldehyde (I) and 0.25 mole of sylvane (II) in 30-50 ml of ethanol we added 10 ml of ethanol saturated with hydrogen chloride. After some time, an exothermic reaction began and the mixture boiled. At the end of boiling, a further 40 ml of ethanol saturated with hydrogen chloride was added. The mixture was boiled for 1 min and was then treated as in method A.

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