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V. G. GLUKHOVTSEV, S. V. ZAKHAROVA,

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Abstract

Full Text

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V. G. GLUKHOVTSEV, S. V. ZAKHAROVA,
Corresponding Member of the Academy of Sciences of the USSR A. D. PETROV

SYNTHESIS OF DIALDEHYDES OF THE FURAN SERIES

Furan alcohols, acids, esters, and difuran ketones react in an acidic medium with α,β-unsaturated aldehydes and ketones according to the Michael reaction type ([1–3]).

It seemed of interest to study furan aldehydes in this reaction with the aim of obtaining little-studied furan dialdehydes. The known methods for the synthesis of furan dialdehydes do not make it possible to obtain dialdehydes of different structures ([4–7]).

It was found that furan aldehydes in which the carbonyl group is conjugated with the furan nucleus do not react in an acidic medium with α,β-unsaturated aldehydes. At the same time, furan aldehydes with a carbonyl group not conjugated with the furan nucleus enter into this reaction, forming symmetrical or unsymmetrical dialdehydes:

$$(\text{furan})-(\text{CH}_2)_n\text{CH}{=}O + \text{RCH}{=}\text{CHCH}{=}O \xrightarrow[\text{or } \text{H}_2\text{SO}_4]{\text{CH}_3\text{COOH}} O{=}\text{HCCH}_2\text{CH(R)}-(\text{furan})-(\text{CH}_2)_n\text{CH}{=}O.$$

$$(\text{furan})\text{CH}_2\text{CH(R}')\text{CH}{=}O + \text{RCH}{=}\text{CHCH}{=}O \xrightarrow[\text{or } \text{H}_2\text{SO}_4]{\text{CH}_3\text{COOH}} O{=}\text{HCCH}_2\text{CH(R)}-(\text{furan})\text{CH}_2\text{CH(R}')\text{CH}{=}O$$

$$\text{R} = \text{H},\ \text{CH}_3; \quad \text{R}' = \text{CH}_3,\ \text{C}_2\text{H}_5; \quad n = 2, 4.$$

Furylacetic aldehyde ($n = 1$) polymerizes readily in the presence of acids, alkalis, atmospheric oxygen, and also when the temperature is raised ([8]).

The furan-series dioxo derivatives synthesized by us, according to data from the Ordzhonikidze All-Union Scientific Research Chemical-Pharmaceutical Institute, possess biological activity against the influenza virus APR-8. From 2,5-bis-(3′-oxopropyl)-furan and isonicotinic acid hydrazide, diisoniazone 2,5-(3′-oxopropyl)-furan was obtained, which, according to available data ([9]), may possess antitubercular activity. It is interesting that when aldehyde and ketone groups are present in the molecule of a furan compound, the aldehyde group reacts first with isonicotinic acid hydrazide.

Experimental Part

The starting 2-(3′-oxopropen-1′-yl)-furan, 2-(2′-methyl-3′-oxopropen-1′-yl)-furan, and 2-(5′-oxopentaliene-1′,3′-yl)-furan were obtained by the described method ([10]). In the synthesis of 2-(2′-ethyl-3′-oxopropen-1′-yl)-furan with b.p. 94° (2 mm); n_D^{20} 1.5948; d_4^{20} 1.0621 (literature data ([11]), n_D^{16} 1.595; d_4^{16} 1.065), a product was also obtained (ratio 6.5 : 1) with b.p. 64° (2 mm); n_D^{20} 1.5638; d_4^{20} 1.0797, apparently 2-(2′-formylbuten-2′-yl)-furan (literature data ([12]), n_D^{20} 1.5668; d_4^{20} 1.061).

Upon hydrogenation of the above-mentioned aldehydes in ethanol over Raney nickel at 20° and a hydrogen pressure of 100 atmospheres, the following furan aldehydes were obtained:

2-(3′-oxopropyl)-furan, b.p. 81° (16 mm); n_D^{20} 1.4760; d_4^{20} 1.0681 (literature data ([6]), b.p. 81° (17 mm); n_D^{19} 1.4772, d_4^{19} 1.0574).

2-(2′-Methyl-3′-oxopropyl)furan, b.p. 81° (15 mm); n_D^{20} 1.4711; d_4^{20} 1.0364; MR_D found 37.26, calculated 37.66.

Found, %: C 69.48, 69.56; H 7.25, 7.31
$C_8H_{10}O_2$. Calculated, %: C 69.54; H 7.29

2-(5′-Oxopentyl)furan, b.p. 51° (2 mm); n_D^{20} 1.4720; d_D^{20} 1.0186; MR_D found 41.83; calculated 42.28.

Found, %: C 70.95, 70.43; H 8.28, 8.23
$C_9H_{12}O_2$. Calculated, %: C 71.02; H 7.94

2-(2′-Ethyl-3′-oxopropyl)furan, b.p. 96° (18 mm); n_D^{20} 1.4839; d_4^{20} 1.0323; MR_D found 42.17; calculated 42.28.

Found, %: C 71.00, 71.09; H 7.93, 8.05
$C_9H_{12}O_2$. Calculated, %: C 71.02; H 7.94

2,5-Bis-(3′-oxopropyl)furan. To a mixture of 30 g of 2-(3′-oxopropyl)furan, 3 g of acetic acid, 16 ml of water, and 0.2 g of hydroquinone, 14 g of acrolein was added over 5 minutes. After stirring for 1.5 hours at 55°, the reaction mixture was diluted with water and extracted with ether. The ethereal extracts were neutralized with sodium bicarbonate and the ether was distilled off. There were obtained 9 g of 2-(3′-oxopropyl)furan and 15 g (34.5%) of 2,5-bis-(3′-oxopropyl)furan with b.p. 107° (2 mm); m.p. 41-42°. Literature data ([16]): b.p. 150-153° (10 mm); m.p. 41-42°.

Diisoniazone of 2,5-bis-(3′-oxopropyl)furan*, m.p. 184°.

Found, %: C 63.15, 63.25; H 5.17, 5.29
$C_{22}H_{22}N_6O_3$. Calculated, %: C 63.14; H 5.30

Diisoniazone of 2-(3′-oxopropyl)-5-(3′-oxobutyl)furan*, m.p. 193°.

Found, %: C 63.79, 63.61; H 5.69, 5.32
$C_{23}H_{24}N_6O_3$. Calculated, %: C 68.87; H 5.59

Isoniazone of 2(3′-oxypropyl)-5-(3′-oxobutyl)furan*

$$\underset{\text{pyridyl}}{N-C_5H_4}-C(=O)NH-N=CHCH_2CH_2-\underset{O}{C_4H_2O}-CH_2CH_2C(=O)CH_3$$

m.p. 110°.

Found, %: C 65.27, 65.21; H 6.10, 6.12
$C_{17}H_{19}N_3O_3$. Calculated, %: C 65.15; H 6.11

2-(3′-Oxopropyl)-5-(1′-methyl-3′-oxopropyl)furan

$$OHCCH_2CH_2-C_4H_2O-CH(CH_3)CH_2CHO$$

From 31 g of 2-(3′-oxopropyl)furan and 1.8 g of crotonaldehyde, in the presence of 0.25 ml of sulfuric acid, 18 ml of water, and 0.2 g of hydroquinone, there were obtained, as described above, 3.5 g of crotonaldehyde, 8.5 g of 2-(3′-oxopropyl)furan, and 22.8 g (47%) of 2-(3′-oxopropyl)-5-(1′-methyl-3′-oxopropyl)furan with b.p. 112° (2 mm); n_D^{20} 1.4912; d_4^{20} 1.0871; MR_D found 51.76; calculated 51.73.

Found, %: C 68.09, 68.14; H 7.30, 7.21
$C_{11}H_{14}O_3$. Calculated, %: C 68.02; H 7.26

2-(3′-Oxopropyl)-5-(2′-methyl-3′-oxopropyl)furan

$$OHCCH_2CH_2-C_4H_2O-CH_2CH(CH_3)CHO$$

From 19 g of 2-(2′-methyl-3′-oxopropyl)furan and 8 g of acrolein, in the presence of 3 g of acetic acid, 15 ml of water, and 0.2 g of hydroquinone, there were obtained, as described above, 4 g of 2-(2′-methyl-3′-oxopropyl)furan and 9 g (33.7%) of 2-(3′-oxo-

* Obtained by L. N. Pavlov (Akrikhin plant).

propyl)-5-(2-methyl-3′-oxopropyl)furan with b.p. 117° (3 mm), n_D^{20} 1.4900; d_4^{20} 1.0863; MR_D found 51.59, calculated 51.73.

Found, %: C 67.56; 67.65; H 7.30; 7.28
$C_{11}H_{14}O_3$. Calculated, %: C 68.02; H 7.27

2-(1′-methyl-3′-oxopropyl)-5-(2′-methyl-3′-oxopropyl)furan

$$HCOCH_2CH(CH_3) - C_4H_2O - CH_2CH(CH_3)CHO$$

From 28 g of 2-(2′-methyl-3′-oxopropyl)furan, 15.0 g of crotonaldehyde in the presence of 0.2 ml of sulfuric acid, 17 ml of water, and 0.2 g of hydroquinone, there were obtained, as described above, 11 g of 2-(2′-methyl-3′-oxopropyl)furan and 16.5 g (38%) of 2-(1′-methyl-3′-oxopropyl)-5-(2′-methyl-3′-oxopropyl)furan with b.p. 106° (2 mm); n_D^{20} 1.4850; d_4^{20} 1.0577; MR_D found 56.42, calculated 56.54.

Found, %: C 69.54; 69.53; H 7.96; 7.91
$C_{12}H_{16}O_3$. Calculated, %: C 69.20; H 7.74

Raman spectrum* ($\Delta\nu$, cm^{-1}): 920 (1); 967 (3); 1018 (4); 1044 (1); 1080 (1); 1105 (0sh); 1170 (0sh); 1218 (0sh); 1245 (0sh); 1276 (1sh); 1315 (3sh); 1340 (4sh); 1378 (3sh); 1395 (4sh); 1427 (2); 1454 (5sh); 1473 (5sh); 1563 (10); 1608 (5); 1628 (3); 1718 (4); 2877 (5sh); 2502 (4sh); 2935 (5sh); 2977 (5).

2-(3′-oxopropyl)-5-(2′-ethyl-3′-oxopropyl)furan

$$HCOCH_2CH_2 - C_4H_2O - CH_2CH(C_2H_5)CHO$$

From 22 g of 2-(2′-ethyl-3′-oxopropyl)furan and 9 g of acrolein in the presence of 3 g of acetic acid, 18 ml of water, and 0.2 g of hydroquinone, there were obtained, as described above, 12 g of 2-(2′-ethyl-3′-oxopropyl)furan and 14.5 g (47%) of 2-(3′-oxopropyl)-5-(2′-ethyl-3′-oxopropyl)furan with b.p. 120° (2.5 mm); n_D^{20} 1.4908; d_4^{20} 1.0726; MR_D found 56.21, calculated 56.15.

Found, %: C 69.12; 69.14; H 7.89; 7.83
$C_{12}H_{16}O_3$. Calculated, %: C 69.20; H 7.74

2-(1′-methyl-3′-oxopropyl)-5-(2′-ethyl-3′-oxopropyl)furan

$$HCOCH_2CH(CH_3) - C_4H_2O - CH_2CH(C_2H_5)CHO$$

From 31 g of 2-(2′-ethyl-3′-oxopropyl)furan and 15 g of crotonaldehyde in the presence of 0.2 ml of sulfuric acid, 20 ml of water, and 0.2 g of hydroquinone, there were obtained, as described above, 9 g of 2-(2′-ethyl-3′-oxopropyl)furan and 19 g (41%) of 2-(1′-methyl-3′-oxopropyl)-5-(2′-ethyl-3′-oxopropyl)furan with b.p. 116° (2.5 mm); n_D^{20} 1.4941; d_4^{20} 1.0704; MR_D found 60.46, calculated 60.76.

Found, %: C 68.40; 68.61; H 8.28; 8.11
$C_{12}H_{16}O_3$. Calculated, %: C 69.20; H 7.74

* The Raman spectrum was recorded by G. K. Gaivoronskaya, to whom the authors express their gratitude.

2-(3′-Oxopropyl)-5-(5′-oxopentyl)furan

$$HC(=O)CH_2CH_2{}_{[-0.6em]\text{furan}}\quad CH_2CH_2CH_2CH_2CH(=O)$$

From 13.5 g of 2-(5′-oxopentyl)furan, 6 g of acrolein, 2 g of acetic acid, 13 ml of water, and 0.2 g of hydroquinone, as described above, there were obtained 3 g of 2-(5′-oxopentyl)furan and 7 g (38%) of 2-(3′-oxopropyl)-5-(5-oxopentyl)furan with b.p. 108° (2 mm); n_D^{20} 1.4920; d_4^{20} 1.0768; MR_D found 56.11, calculated 56.14.

Found, %: C 69.50; 69.64; H 7.99; 7.88
$C_{12}H_{16}O_3$. Calculated, %: C 69.20; H 7.74

N. D. Zelinsky Institute of Organic Chemistry
Academy of Sciences of the USSR

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Note: Figure translations are in progress. See original paper for figures.