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SHORT COMMUNICATIONS

Synthesis of Functionally Substituted Furan and Resorcinol Derivatives from Dimethyl 3-Oxopentanedioate

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Abstract—The alkylation of dimethyl 3-oxopentanedioate with 1,2-dibromoethane and 1,2,3-tribromopropane afforded C,C- (cyclopropane derivative) and C,O-dialkylation products. The initial trioxo compound underwent partial self-condensation to produce resorcinol derivative.

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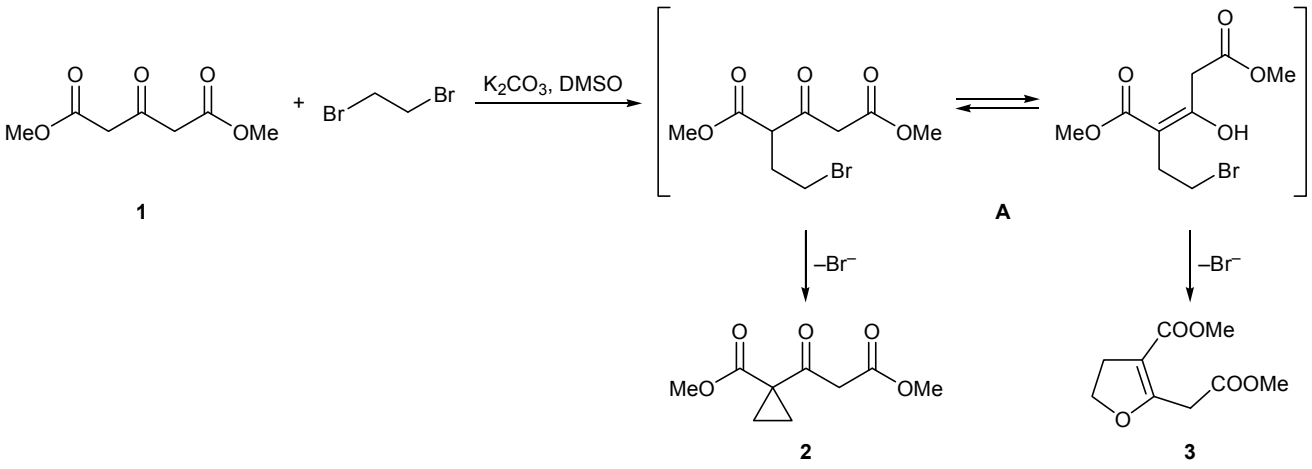
A convenient procedure for the synthesis of functionally substituted furans is based on the alkylation of β-dicarbonyl compounds with 1,2,3-trihaloalkanes [1]. Reactions of polycarbonyl compounds with di- and trihaloalkanes allow alternative pathways which may be varied by changing the conditions and reactant nature.

Herein, we describe a one-step synthesis of functionally substituted furan and resorcinol derivatives by alkylation of dimethyl 3-oxopentanedioate (**1**) with di- and trihaloalkanes.

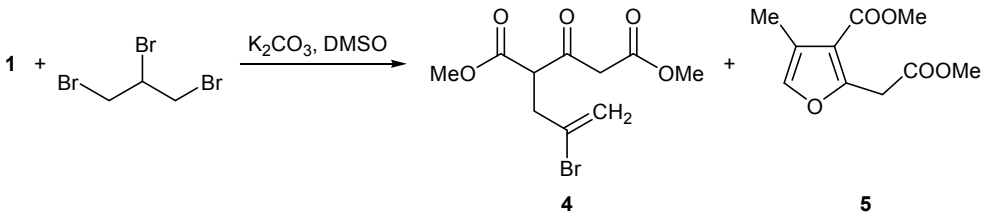
Tricarbonyl compound **1** reacted with 1,2-dibromoethane in DMSO in the presence of potassium carbonate at 50–60°C to give a mixture of methyl 1-(3-methoxy-3-oxopropanoyl)cyclopropane-1-carboxyate (**2**, C,C-dialkylation product) and methyl 2-(2-methoxy-2-oxoethyl)-4,5-dihydrofuran-3-carboxylate (**3**, C,O-dialkylation product) (Scheme 1). Presumably, the primary C-alkylation product (**A**) undergoes further intramolecular C- or O-alkylation, yielding diester **2** or **3**. The product structure was confirmed by ^{1}H NMR spectra. The ^{1}H NMR spectrum of **2** displayed four singlets due to protons of the methoxy and methylene groups, while the spectrum of **3** showed three singlets and two multiplets. Analogous reaction was described in [2, 3]; it was carried out in the presence and in the absence of acetals and ortho esters, and only C,C-dialkylation product was isolated.

The reaction of **1** with 1,2,3-tribromopropane afforded dimethyl 2-(2-bromoprop-2-en-1-yl)-3-oxopen-

Scheme 1.



Scheme 2.



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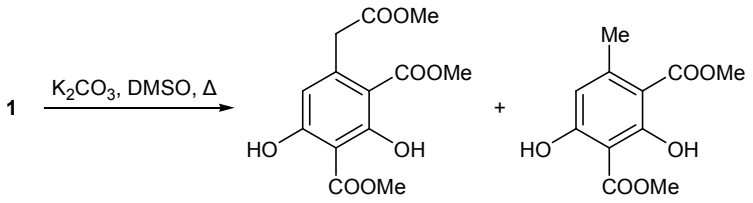
Scheme 3.



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tanedioate (**4**) and methyl 4-methyl-2-(2-methoxy-2-oxoethyl)furan-3-carboxylate (**5**) (Scheme 2). Furan **5** is likely to be formed according to the mechanism proposed previously [1], which implies rearrangement of primary alkylation product **4**, intramolecular O-alkylation, and prototropic isomerization. Compound **4** was converted completely to substituted furan **5** in the presence of K_2CO_3 in DMSO at 60°C (4 h), which confirmed the proposed mechanism.

In these experiments, acidification of the aqueous phase with aqueous HCl led to separation of amorphous crystals which were identified as a mixture of two resorcinol derivatives. By recrystallization we isolated dimethyl 2,4-dihydroxy-6-(2-methoxy-2-oxoethyl)- and 2,4-dihydroxy-6-methylbenzene-1,3-dicarboxylates **6** and **7** (Scheme 3). Presumably, diester **6** is formed via intermolecular Claisen condensation of compound **1** with subsequent intramolecular alkylation, dehydration, and prototropic isomerization. Partial hydrolysis and decarboxylation of **6** during the reaction yields compound **7**.

The low yields of the alkylation products of **1** with mono- and polyhaloalkanes suggest a concurrent process involving only compound **1** and no alkylating agent. By special experiment we showed that compound **1** in the absence of alkylating agent undergoes self-condensation to give substituted resorcinol potassium salt; acidification of the latter with aqueous HCl yields compounds **6** and **7**. The formation of triester **6** from compound **1** in the presence of sodium metal was reported in [2].

Alkylation of dimethyl 3-oxopentanedioate (1) (*general procedure*). 1,2-Dibromoethane or 1,2,3-tribromopropane, 0.05 mol, was added with stirring to a mixture of 0.05 mol of diester **1** and 0.05 mol of calcined potassium carbonate in 100 mL of DMSO. The mixture was stirred for 3 h at 20°C and for 5 h at 70°C, cooled, and treated with water and diethyl ether (3×100 mL). The combined extracts were dried over anhydrous $MgSO_4$, the solvent was distilled off, and the residue was distilled under reduced pressure.

Methyl 1-(3-methoxy-3-oxopropanoyl)cyclopropane-1-carboxylate (2). Yield 2.6 g (15%), bp 95°C (3 mm). ^{1}H NMR spectrum, δ, ppm: 1.48 s (4H, CH_2CH_2), 3.60 s (3H, CH_3O), 3.65 s (3H, CH_3O), 3.68 s (2H, CH_2CO). Found, %: C 56.34; H 5.42. $C_9H_{12}O_5$. Calculated, %: C 56.19; H 5.71.

Methyl 2-(2-methoxy-2-oxoethyl)-4,5-dihydrofuran-3-carboxylate (3). Yield 2.2 g (12%), bp 115°C (3 mm). ^{1}H NMR spectrum, δ, ppm: 2.7 m (2H, CH_2C=), 3.50 s (3H, CH_3O), 3.65 s (3H, CH_3O), 3.68 s (2H, CH_2CO), 4.40 m (2H, CH_2CO). Found, %: C 55.81; H 5.43. $C_9H_{12}O_5$. Calculated, %: C 56.19; H 5.71.

Dimethyl 2-(2-bromoprop-2-en-1-yl)-3-oxopentanedioate (4). Yield 2.7 g (14%), bp 85°C (3 mm). Found, %: C 40.44; H 4.63; Br 27.56. $C_{10}H_{13}BrO_5$. Calculated, %: C 40.95; H 4.43; Br 27.30.

Methyl 2-(2-methoxy-2-oxoethyl)-4-methylfuran-3-carboxylate (5). Yield 6.1 g (31%), bp 120°C (3 mm). ^{1}H NMR spectrum, δ, ppm: 2.10 s (3H, CH_3), 3.60 s (3H, CH_3O), 3.75 s (3H, CH_3O), 3.90 s (2H, CH_2CO), 7.10 s (1H, CH=). ^{13}C NMR spectrum, δ_C, ppm: 9.78 (CH_3), 34.05 (CH_2CO), 51.13 (CH_3O), 52.21 (CH_3O), 121.22 (C^4), 139.11 (C^3), 154.90 (C^5), 165.00 (C=O), 169.20 (C=O). Found, %: C 56.39; H 5.26. $C_{10}H_{12}O_5$. Calculated, %: C 56.60; H 5.66.

Dimethyl 2,4-dihydroxy-6-(2-methoxy-2-oxoethyl)benzene-1,3-dicarboxylate (6) and dimethyl 2,4-dihydroxy-6-methylbenzene-1,3-dicarboxylate (7). A mixture of 10 g (0.05 mol) of compound **1** and 15 g of potassium carbonate in 50 mL of DMSO was stirred for 5 h at 60–70°C. The mixture was cooled, treated with water, and acidified with aqueous HCl. The precipitate (a mixture of **6** and **7**) was recrystallized from ethanol to isolate 4.2 g (52%) of compound **6**, mp 139–140°C. ^{1}H NMR spectrum, δ, ppm: 3.60 s (3H, CH_3O), 3.80 s (3H, CH_3O), 3.85 s (2H, CH_2CO), 3.90 s (3H, CH_3O), 6.50 s (1H, H_{arom}), 11.4 s (1H, OH), 12.3 s (1H, OH). ^{13}C NMR spectrum, δ_C, ppm: 42 (CH_2); 51, 52, 53 (CH_3O); 112 (C_{arom}); 163, 170, 171 (C=O). Found, %: C 52.34; H 4.69. $C_{13}H_{14}O_8$. Calculated, %: C 52.21; H 4.87.

Compound **7** was isolated from the mother liquor. Yield 1.8 g (15%), mp 105°C. ^{1}H NMR spectrum, δ, ppm: 2.35 s (3H, CH_3), 3.80 s (3H, CH_3O), 4.00 s (3H, CH_3O), 6.35 s (1H, H_{arom}), 10.9 s (1H, OH), 11.8 s (1H, OH). ^{13}C NMR spectrum, δ_C, ppm: 21 (CH_2), 51.2 and 51.6 (CH_3O), 110.7 (C_{arom}), 169 and 172 (C=O). Found, %: C 55.00; H 5.00. $C_{11}H_{12}O_6$. Calculated, %: C 54.87; H 5.11.

The ^{1}H and ^{13}C NMR spectra were recorded from solutions in $CDCl_3$ on a Bruker A-300 spectrometer at 300 and 75 MHz, respectively; the chemical shifts were measured relative to tetramethylsilane.

REFERENCES

1. Akhmedov, Sh.T., Sadykhov, N.S., Ismailov, V.M., Akhundova, M.A., Sadovaya, N.K., Karimov, F.N., and Zefirov, N.S., *Chem. Heterocycl. Compd*., 1986, vol. 22, no. 12, p. 1291.
2. Covarrubias-Zúñiga, A., San Germán-Sanchez, L., and Avila-Zárraga, J.G., *Synth. Commun*., 2003, vol. 33, no. 18, p. 3165.
3. Rahn, T, Bendrath, F., Hein, M, Baumann, W., Jiao, H., Börner, A., Villinger, A., and Langer, P., *Org. Biomol. Chem*., 2011, vol. 9, no. 14, p. 5172.
4. Stone, M.J., Maplestone, R.A., Rahman, S.K., and Williams, D.H., *Tetrahedron Lett*., 1991, vol. 32, no. 23, p. 2663.