# 2-SUBSTITUTED 3-METHYLFURANS

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In the acylation of 3-methylfuran, acetyl and formyl groups enter predominantly into position 2 with the formation of 2-acetyl-3-methylfuran and 2-formyl-3-methylfuran; the latter readily reacts with methyl ketones and methoxycarbonylmethylenetriphenylphosphoranes with the formation of the corresponding α,β-unsaturated compounds.

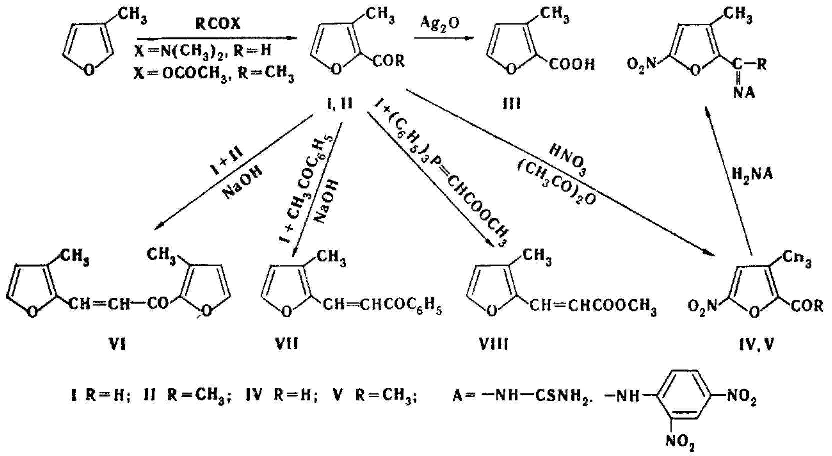
The possibility of the formylation of 3-methylfuran with the aid of HCN has been shown previously [1]; this gave 2-formyl-3-methylfuran with a yield of 56%. However, the properties of this compound were studied to only a small extent, although it is of interest for the synthesis of some natural analogs of 3-methylfurans.

We have investigated the behavior of 3-methylfuran in acetylation with acetic anhydride in the presence of anhydrone [2, 3] and in formylation with dimethylformamide (DMFA) in the presence of $POCl_3$ [4].

It has been found that a methyl group in the β position of the furan ring orients the acyl groups predominantly into the adjacent α position with the formation of 2-formyl-3-methyl- and 2-acetyl-3-methylfurans (I and II) with yields of 84.5 and 50%, respectively. Their structure was shown by the preparation of derivatives (Table 1), by analysis by IR, UV, and PMR spectroscopy, and by the oxidation of (I) to the known 3-methylfuran-2-carboxylic acid (III).

2-Substituted 3-methylfurans, like other furan derivatives, having a free α position, are smoothly nitrated with the formation of the corresponding 2-acyl-3-methyl-5-nitrofurans (IV and V); the thiosemicarbazone and 2,4-dinitrophenylhydrazone of (V) have been obtained.

2-Formyl-3-methylfuran condenses with methyl ketones with the formation of α,β-unsaturated ketones (VI, VII) and it reacts with methoxycarbonylmethylenetriphenylphosphorane with the formation of methyl β-(3-methyl-2-furyl)acrylate (VIII).



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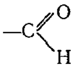
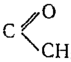
Rostov State University, Rostov-on-Don. Translated from Khimiya Geterotsiklicheskikh Soedinenii, No. 8, pp. 1011-1013, August, 1973. Original article submitted July 18, 1972.

TABLE 1. 2-Substituted 3-Methylfurans

| Compound | R | mp, °C | Empirical formula | Found, % |  |  | Calc., % |  |  | Yield, % |
|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  |  | C | H | N | C | H | N |  |
| I |  | 65—66* (23) | $C_5H_6O_2$ | 65,4 | 5,8 | — | 65,4 | 5,5 | — | 85 |
|  | CH=NOH | 111—112 | $C_6H_7NO_2$ | 57,5 | 5,7 | 11,1 | 57,6 | 5,6 | 11,1 | 50 |
|  | CH=N—NHCONH$_2$ | 198 | $C_7H_9N_3O_2$ | 50,2 | 5,4 | 24,8 | 50,2 | 5,9 | 25,1 | 90 |
|  | CH=N—NHCSNH$_2$† | 163—164 | $C_7H_9N_3OS$ | 50,2 | 5,0 | 23,2 | 50,3 | 5,0 | 22,9 | 72 |
|  | CH=N—N=CH—R′ | 118—119 | $C_{12}H_{12}N_2O_2$ | 66,6 | 5,6 | 12,6 | 66,7 | 5,6 | 13,0 | 60 |
| II |  | 88* (10) | $C_7H_8O_2$ | 67,5 | 6,5 | — | 67,6 | 6,5 | — | 50 |
|  | CH=N—NHCONH$_2$ | 178—179 | $C_8H_{11}N_3O_2$ | 53,4 | 6,5 | 23,2 | 53,0 | 6,1 | 23,2 | 79 |
|  | CH=N—NHCSNH$_2$ | 160 | $C_8H_{11}N_3OS$ | 48,8 | 5,5 | 21,0 | 48,7 | 5,6 | 21,3 | 70 |
| VI | CH=CHCO—R′‡ | 72—73 | $C_{13}H_{12}O_3$ | 71,8 | 5,7 | — | 72,2 | 5,6 | — | 75 |
| VII | CH=CHCOC$_6$H$_5$ | 77—78 | $C_{14}H_{12}O_2$ | 79,8 | 5,8 | — | 79,2 | 5,7 | — | 76 |
|  |  $CH{=}CH{-}\underset{\displaystyle C_6H_5}{\underset{\vert}{C}}{=}N{-}NHC_6H_3(NO_2)_2$ | 182—183 | $C_{20}H_{16}N_4O_5$ | 60,9 | 4,2 | 14,8 | 61,2 | 4,1 | 14,3 | 90 |
| VIII | CH=CHCOOCH$_3$ | 108—109 | $C_9H_{10}O_3$ | 48,1 | 6,9 | — | 48,1 | 7,4 | — | 65 |

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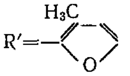
*bp, °C (pressure, mm).

† Found: S 17.32%. Calculated: S 17.49%.

‡ R′= 

## EXPERIMENTAL

2-Formyl-3-methylfuran (I). With stirring, 25 g (0.15 mole) of phosphorus oxychloride was added dropwise over 25 min at a temperature not exceeding 5°C to 11 g (0.15 mole) of dimethylformamide cooled to 0°C. Then the mixture was stirred at 5°C for 30 min, and 8.2 g (0.1 mole) of 3-methylfuran was added over 20 min in such a way that the temperature did not rise above 5°C. After the end of the addition, the mixture was stirred at −3°C for 30 min and at 10°C for 30 min. The solution was poured onto ice, neutralized with 30-35 g of sodium carbonate, and left overnight, after which it was extracted with ether. The ethereal solution was dried with anhydrous sodium sulfate, the solvent was distilled off with the use of a Vigreux fractionating column, and the residue was distilled in vacuum; bp 65-66°C (23 mm), yield 9.3 g. $\lambda_{max}$ 265 nm (log ε 4.08); $\nu_{C=O}$ 1690 cm$^{-1}$. PMR spectrum,* protons: CHO group 9.43; $C_4$ 6.06; $C_5$ 6.95; $CH_3$ group 2.35 ppm. The constants of the aldehyde and its derivatives are given in the table.

2-Acetyl-3-methylfuran (II). A mixture of 8.2 g (0.1 mole) of 3-methylfuran, 0.223 g of anhydrone, and 11.7 ml of acetic anhydride was heated in the water bath at 45°C for 45 min. The reaction mixture gradually darkened, and then the bath was removed and the mixture was heated over a burner flame for 5 min. The color changed from brown to dark green and then to dark violet. The reaction product was poured into cold water, the mixture was stirred, and the organic layer was separated off. The aqueous layer was neutralized with sodium carbonate and extracted with benzene. The benzene extracts and the organic layer were combined, washed with 5% sodium carbonate solution and with water, and dried over anhydrous sodium sulfate. The benzene was evaporated off, and the residue was distilled in vacuum at 88°C (10 mm). The yield of 2-acetyl-3-methylfuran was 6.2 g. $\lambda_{max}$ 284 nm (log ε 4.16); $\nu_{C=O}$ 1680 cm$^{-1}$. PMR spectrum, protons: $C_4$ 6.03; $C_5$ 6.83; $CH_3$ group 2.33 ppm. The constants of (II) and its derivatives, obtained by the usual methods, are given in the table.

3-Methylfuran-2-carboxylic acid (III) was obtained by a handbook method [5]. A mixture of 1.1 g of 2-formyl-3-methylfuran (I) was stirred with an aqueous suspension of AgOH (obtained from 1.7 g of $AgNO_3$ in 10 ml of water and 0.44 g of NaOH in 4 ml of water)for 10 min. The solid matter was separated off and washed with hot water, the filtrate and the wash-waters were acidified with dilute (1 : 1) hydrochloric acid, and the acid (III) was extracted with ether. Evaporation of the ether yielded 0.95 g of 3-methylfuran-2-carboxylic acid with mp 133-134°C (according to the literature [1], mp 133-134°C).

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*The PMR spectra were taken on an RYa-2305 spectrometer at a working frequency of 60 MHz.

2-Formyl-3-methyl-5-nitrofuran (IV). At a temperature of from −9 to −10°C, 3.7 g of $HNO_3$ (d 1.5) was added dropwise to 8.4 g of acetic anhydride. Then a solution of 1.1 g of 2-formyl-3-methylfuran in 2.5 g of acetic acid was added slowly at a temperature of from −10 to −15°C and the mixture was stirred at −15°C for 2 h. After this, it was poured onto crushed ice and was neutralized partially with 10% NaOH solution and completely with sodium carbonate. The yellow oil that separated out was extracted with ether and treated with 2 g of pyridine. After 15 min, the ether was distilled off under vacuum (water pump). The residue was poured onto ice and extracted with ether. The ethereal solution was washed with 10% HCl solution; after evaporation of the ether, the residue formed a viscous oil. Compound (IV) was identified in the form of its thiosemicarbazone, mp 166°C (from methanol). Found, %: N 24.7; S 13.9. $C_7H_8N_4O_3S$. Calculated, %: N 24.6; S 14.1.

2-Acetyl-3-methyl-5-nitrofuran (V). This was obtained from (II) by the same method as (IV). Yellow oil. Identified in the form of derivatives.

Thiosemicarbazone: mp 154-155°C (from ethanol). Found, %: N 26.3; S 14.9. $C_8H_{10}N_4OS$. Calculated, %: N 26.6; S 15.3.

2,4-Dinitrophenylhydrazone. Red crystals with mp 141-142°C. Found, %: N 19.8. $C_{13}H_{10}N_5O_7$. Calculated, %: N 20.1.

2-(3-Methyl-2-furfurylideneacetyl)-3-methylfuran (VI). To a solution of 0.22 g (2 mmoles) of 2-formyl-3-methylfuran (I) in the minimum amount of ethanol was added 0.29 g (2 mmoles) of 2-acetyl-3-methylfuran (II) followed, with stirring and cooling with ice water, by 0.4 ml of 20% caustic soda in drops. The oil that separated out was extracted with ether and the residue from the evaporation of the ether (yellow needles) was recrystallized from methanol. Yield 0.3 g. The constants of compound (VI) and its derivatives are given in Table 1.

3-Methylfurfurylideneacetophenone (VII). This was obtained in a similar manner to (VI) from 0.22 g (2 mmoles) of (I), 0.24 g (2 mmoles) of acetophenone, 3 ml of ethanol, and 0.4 ml of 20% caustic soda solution. Yield 0.3 g. Yellow crystals. Characterized by the 2.4-dinitrophenylhydrazone (Table 1).

Methyl β-(3-Methyl-2-furyl)acrylate (VIII). A solution of 0.55 g (5 mmoles) of 2-formyl-3-methylfuran and 1.67 g of methoxycarbonylmethylenetriphenylphosphorane in 7.5 ml of benzene was heated in the water bath under reflux for 10 h. Then the reaction mixture was separated on a chromatographic column of alumina (with benzene as the eluent). The product was recrystallized from aqueous ethanol. Yield 0.54 g (Table 1). Yellow crystals.

## LITERATURE CITED

1. T. Reichstein, H. Zschokke. and A. Goerg, Helv. Chim. Acta, 14, 1277 (1931).
2. Z. N. Nazarova, Yu. A. Babaev, and L. G. Umanskaya, Khim. Geterotsikl. Soedin., 17 (1969).
3. Ya. L. Gol'dfarb, M. A. Marakatkina, and L. I. Belen'kii, Khim. Geterotsikl. Soedin., 132 (1970).
4. A. L. Mndzhoyan, Synthesis of Heterocyclic Compounds, No. 3 [in Russian], Izd-vo Akad. Nauk ArmSSR, Erevan (1958), p. 13.
5. Organic Synthesis, Vol. 4 [Russian translation], IL, Moscow (1953), p. 119.