

# Furan derivatives. XXXVII.

## Preparation of sulfides and sulfones in the furan and arylfuran series

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The preparation of sulfides and sulfones in the furan and arylfuran series is described. The sulfones have been prepared by treatment of sodium arene-sulfonates with 5-nitro-2-furfuryl iodide.

In view of the biological importance of furan derivatives [1–7] and 4-nitrophenyl-2-furfuryl sulfones [8] attempts were made to synthesize some sulfides and sulfones in the arylfuran series. Few sulfur-containing furan derivatives have been known so far. The preparation of furfuryl aryl sulfides by the reaction of bromide magnesium furfuryl alcohol with formic or oxalic acid esters in the presence of halide magnesium thiophenolates [9] and the reaction of 2-furanethiol with nitro- or dinitrochlorobenzene [10] as well as the preparation of furfuryl sulfides from thiophenols and 5-bromo-2-furfural under alkaline conditions [11] have been described. Derivatives having the sulfo group attached to the furan cycle directly or through a methylene bridge were prepared by oxidation of the corresponding sulfides with hydrogen peroxide in glacial acetic acid [8, 11].

A new approach to the preparation of sulfones of furan derivatives comprising the reaction of the corresponding furan halides with sodium arenesulfonates is described. The sulfides described here were prepared by a modification of the known method [11]; substituted 5-phenyl-2-furfuryl bromides [13] were used as substrates.

### Experimental

Melting points were determined on a Kofler hot stage. Commercially unavailable starting materials were prepared as described in [14, 15]. Physical constants of the prepared compounds are listed in Table 1.

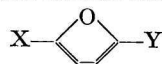
Infrared spectra were measured on a double-beam UR-10 (Zeiss, Jena) spectrophotometer in the range of 3600–600  $\text{cm}^{-1}$  in chloroform solutions (concentration 0.025 M; NaCl cells of 0.562 mm thickness). The instrument was calibrated with a standard polystyrene foil. The reading accuracy was  $\pm 1 \text{ cm}^{-1}$ . The characteristic absorption frequencies are summarized in Table 2.

#### *Substituted sulfides of the furyl and furfuryl series*

##### *Method A*

The corresponding thiophenol (0.0125 mole) was added to a water solution of sodium hydroxide (0.5 g; 0.0125 mole) followed by the addition of iodide (5-iodo-2-furaldehyde

Table 1  
Synthesized sulfides and sulfones



No.	X	Y	Formula	M	Calculated/found				Yield [%]	M.p. [°C]
					% C	% H	% N	% S		
I	-CHO	C <sub>6</sub> H <sub>5</sub> -S-	C <sub>11</sub> H <sub>6</sub> O <sub>2</sub> S	204.25	—	—	—	—	61.3	35— 37
II	-CHO	NO <sub>2</sub> -C <sub>6</sub> H <sub>4</sub> -S-	C <sub>11</sub> H <sub>7</sub> NO <sub>4</sub> S	249.25	53.00 53.10	2.83 2.80	5.62 5.56	12.86 12.80	53.4	95— 97
III	-NO <sub>2</sub>	C <sub>6</sub> H <sub>5</sub> -S-CH <sub>2</sub> -	C <sub>11</sub> H <sub>9</sub> NO <sub>3</sub> S	235.26	56.15 56.05	3.85 3.82	5.95 6.11	13.62 13.54	53.2	55— 58
IV	-NO <sub>2</sub>	4-CH <sub>3</sub> -C <sub>6</sub> H <sub>4</sub> -S-CH <sub>2</sub> -	C <sub>12</sub> H <sub>11</sub> NO <sub>3</sub> S	249.23	57.83 57.66	4.44 4.40	5.62 5.68	12.86 12.71	56.0	64— 66
V	-NO <sub>2</sub>	4-NO <sub>2</sub> -C <sub>6</sub> H <sub>4</sub> -S-CH <sub>2</sub> -	C <sub>11</sub> H <sub>5</sub> N <sub>2</sub> O <sub>5</sub> S	280.26	47.14 47.04	2.87 2.80	9.99 10.03	11.45 11.23	71.6 <sup>a</sup>	157—160
VI	-NO <sub>2</sub>	C <sub>6</sub> H <sub>5</sub> -SO <sub>2</sub> -CH <sub>2</sub> -	C <sub>11</sub> H <sub>5</sub> NO <sub>5</sub> S	267.26	49.43 49.33	3.39 3.25	5.25 5.34	12.00 11.99	70.3	190—191
VII	-NO <sub>2</sub>	4-CH <sub>3</sub> -C <sub>6</sub> H <sub>4</sub> -SO <sub>2</sub> -CH <sub>2</sub> -	C <sub>12</sub> H <sub>11</sub> NO <sub>5</sub> S	281.29	51.23 51.03	3.94 3.90	4.98 4.80	11.39 11.40	52.2	198—200
VIII	2-NO <sub>2</sub> -C <sub>6</sub> H <sub>4</sub>	4-NO <sub>2</sub> -C <sub>6</sub> H <sub>4</sub> -S-CH <sub>2</sub> -	C <sub>17</sub> H <sub>12</sub> N <sub>2</sub> O <sub>5</sub> S	356.36	57.29 57.30	3.39 3.40	7.86 8.09	8.96 8.82	66.3	173—175
IX	3-NO <sub>2</sub> -C <sub>6</sub> H <sub>4</sub>	4-NO <sub>2</sub> -C <sub>6</sub> H <sub>4</sub> -S-CH <sub>2</sub> -	C <sub>17</sub> H <sub>12</sub> N <sub>2</sub> O <sub>5</sub> S	356.36	57.29 57.32	3.39 3.36	7.86 7.65	8.96 8.87	64.6	185—187
X	4-NO <sub>2</sub> -C <sub>6</sub> H <sub>4</sub>	4-NO <sub>2</sub> -C <sub>6</sub> H <sub>4</sub> -S-CH <sub>2</sub>	C <sub>17</sub> H <sub>12</sub> N <sub>2</sub> O <sub>5</sub> S	356.36	57.29 57.36	3.39 3.32	7.86 8.05	8.96 9.26	62.0	178—180

a) When 5-nitro-2-furfuryl bromide and 5-nitro-2-furfuryl nitrate was used the yields were 67.8 and 51.1%, respectively.

Table 2

Infrared data of the synthesized sulfides and sulfones [cm<sup>-1</sup>]

No.	$\nu(\text{C-H})$	$\tilde{\nu}_{\text{sym}}(\text{C-O-C})$	$\tilde{\nu}_{\text{sym}}(\text{S=O})$	$\tilde{\nu}_{\text{asym}}(\text{S=O})$	$\tilde{\nu}_{\text{sym}}(\text{NO}_2)$	$\tilde{\nu}_{\text{asym}}(\text{NO}_2)$	$\tilde{\nu}_{\text{arom}}(\text{C=C})$
<i>I</i>	852 w	1032 s	—	—	—	—	1578 s; 1596 vw 1614 vw
<i>II</i>	862 s	1030 m	—	—	1356 vs	1542 s	1592 m; 1612 m
<i>III</i>	852 w	1031 m	—	—	1362 vs	1539 s	1596 s; 1610 w
<i>IV</i>	834 m	1027 s	—	—	1366 vs	1545 s	1600 m
<i>V</i>	855 m	1019 s	—	—	1355 vs	1543 s	1591 m; 1508 vs
<i>VI</i>	861 m	1019 s	1152 vs	1326 s	1354 vs	1527 s	1591 m; 1504 m
<i>VII</i>	856 w	1026 m	1162 vs	1331 s	1364 vs	1552 s	1606 s
<i>VIII</i>	864 s	1024 vw	—	—	1354 vs	1549 vs	1491 m; 1590 s
<i>IX</i>	863 vs	1019 m	—	—	—	—	1610 s
<i>X</i>	860 vs	1018 m	—	—	1353 vs	1542 vs	1486 m; 1588 s 1605 s
					1352 vs	1550 s	1488 m; 1588 s 1608 s

s — strong, w — weak, m — medium, vs — very strong, vw — very weak.

Compound *I* —  $\tilde{\nu}(\text{C=O})$  1695 vs; *II* —  $\tilde{\nu}(\text{C=O})$  1705 vs.

or 5-nitro-2-furfuryl iodide; 0.0125 mole) in ethanol (50 ml). The reaction mixture was stirred at 0°C and when the orange colour indicated that the reaction was complete the precipitated sodium iodide was filtered. The filtrate was diluted with water, extracted with ether and the ethereal solution dried (anhydrous sodium sulfate), concentrated, and the product 5-phenylthio-2-furaldehyde (*I*), 5-nitro-2-furfuryl phenyl sulfide (*III*) or 5-nitro-2-furfuryl *p*-tolyl sulfide (*IV*) was recrystallized from petroleum ether.

#### Method B

To a solution of halide 5-iodo-2-furaldehyde, 5-(*Z*-nitrophenyl)-2-furfuryl bromide (*Z* = 2, 3, or 4) or 5-nitro-2-furfuryl iodide (0.0125 mole) in ethanol (50 ml) sodium 4-nitrothiophenolate (2.3 g; 0.013 mole) mixed with water into a paste was added. The mixture was refluxed for 30–60 minutes, cooled and the separated sulfide 5-(4-nitrophenylthio)-2-furaldehyde (*II*), 5-nitro-2-furfuryl *p*-nitrophenyl sulfide (*V*) or 4-[5-(*Z*-nitrophenyl)-2-furfuryl] *p*-nitrophenyl sulfide (*VIII–X*) was filtered, dried, and crystallized from ethanol.

#### 5-Nitro-2-furfuryl phenyl and 4-tolyl sulfones (*VI*, *VII*)

To a hot solution of 5-nitro-2-furfuryl iodide (0.025 mole) in ethanol (about 20 ml) sodium benzenesulfinate or 4-methylbenzenesulfinate (0.025 mole) in ethanol (50–60 ml) was slowly added and the mixture was refluxed for 2 hours. The resulting suspension was filtered while hot and the filtrate was diluted with two volumes of water. After standing for several hours the separated crystals were filtered, washed with water, dried, and recrystallized from 80% acetic acid.

### Results and discussion

Sulfides of the furyl, furfuryl, and 5-aryl-2-furfuryl series were prepared by a modified Williamson method. The synthesis was carried out in two ways. According to method *A* it was conducted at temperatures ranging from 0°C to room temperature, the reaction mixture consisting of aryl thiol, and equimolar amount of sodium hydroxide, and the corresponding halide. In an almost identical manner *Carro et al.* [11] prepared compound *I*, the yield, however, is not given in the quoted work. Using the described method we obtained good yields of the wanted products.

In method *B* the starting material was sodium thiophenolate and the reaction was conducted at the boiling point of ethanol. As expected, in the preliminary experiments, where the effect of the starting 5-nitro-2-furfuryl bromide, iodide, or nitrate upon the yield of *V* was examined, the highest yield was obtained when iodide was used.

By the methods described 5-nitrosubstituted furan derivatives can be converted also to sulfides. No decomposition of the nitrofurans by the effect of the reaction medium was observed.

Using method *B* also sulfides of 5-(*Z*-nitrophenyl)-2-furfuryl bromides were prepared. The yields of yellow crystalline products were about 60% in average. The highest melting point of the 4-, 3-, and 2-nitrophenyl derivatives was observed in the case of the 3-nitro compound which is in analogy with the corresponding halide [12].

Sulfones *VI* and *VII* were prepared in good yields (50–70%) by direct reaction of furfuryl halides with sodium arenesulfates. 5-Iodo-2-furaldehyde did not react under the described conditions and the starting material was almost quantitatively recovered.

Interesting results were obtained in attempts to synthesize sulfones from 5-(*Z*-nitrophenyl)-2-furfuryl bromides. Low melting yellow crystalline substances isolated were identified as ethyl-5-(*Z*-nitrophenyl)-2-furfuryl ethers. These and other ethers of the arylfuran series will be described in a subsequent communication.

Infrared spectra of the synthesized substances show characteristic absorption bands of the deformation nonplanar  $\gamma(\text{C}-\text{H})$  vibrations of the furan cycle. The stretching vibrations of the C—S bonds of the sulfides ( $700-600\text{ cm}^{-1}$ ) were but slightly intense and thus difficult to identify. On the other hand, the absorption bands of the  $\text{SO}_2$  groups of the sulfones were well pronounced.

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