

## FURAN DERIVATIVES. XLV.\*

 $\alpha,\beta$ -UNSATURATED SULPHONES OF THE 5-NITROFURAN SERIES

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1-(5-Nitro-2-furyl)-1-phenylsulphonyl-2-(X-phenyl)ethylenes where X = H, 4-OCH<sub>3</sub>, 4-N(CH<sub>3</sub>)<sub>2</sub>, 4-NHCOCH<sub>3</sub>, 3,4-OCH<sub>2</sub>O, 4-Cl, 3-Cl, 3,4-Cl<sub>2</sub>, 4-I, 4-NO<sub>2</sub>, 4-CN, have been prepared by condensation of 5-nitrofurfuryl phenyl sulphone (I) with substituted benzaldehydes. Condensation of nicotinaldehyde with I afforded 1-(5-nitro-2-furyl)-1-phenylsulphonyl-2-(3-pyridyl)ethylene XIV and reaction of 4-nitrobenzyl phenyl sulphone (II) with 5-nitro-2-furaldehyde led to 1-(4-nitrophenyl)-1-phenylsulphonyl-2-(5-nitro-2-furyl)ethylene (XV). Structure of the products has been determined by IR and UV spectroscopy.

Besides usual methods,  $\alpha,\beta$ -unsaturated sulphones were synthesized in several cases by condensation of aldehydes with derivatives of the type R-SO<sub>2</sub>-CH<sub>2</sub>-X, where R is an alkyl or aryl, and X is an electron-accepting group, e.g. COOH (ref.<sup>1-6</sup>), COOR (ref.<sup>2</sup>), CN (ref.<sup>7</sup>), NO<sub>2</sub> (ref.<sup>8</sup>). This reaction affords unsaturated sulphones which are formally 1,1,2-trisubstituted ethylenes; only when X = COOH, the product decarboxylates under formation of 1,2-disubstituted ethylene derivatives. To these derivatives belong also  $\alpha,\beta$ -unsaturated sulphones of the 5-nitrofurane series prepared by oxidation of the corresponding sulphides with hydrogen peroxide<sup>9</sup>.

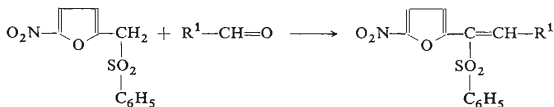
It was of interest to us whether an attachment of a nitrofurane or a nitrophenyl group to a methylene group, which is simultaneously bonded to a phenylsulphonyl moiety, will sufficiently "acidify" the methylene hydrogens for a condensation reaction with aldehydes. The possibility of realization of condensation reactions of such sulphones containing two aromatic nuclei bears new possibilities in the synthesis of unsaturated sulphones of the 5-nitrofurane series which are interesting for their biological activity. Also interesting was the stereochemistry of the arising system, as well as the question whether a mutual interaction exists between the NO<sub>2</sub> or SO<sub>2</sub> group and the double bond, and to what extent it is affected by the nature of the substituent bonded to the aromatic nucleus.

In some cases, the yields of sulphones are low; however, the effort to rise them by using a prolonged reaction time, or changing reaction conditions, was unsuccessful. Physical constants and elemental analyses of the new compounds are listed in Table I and their IR and UV spectral data in Table II.

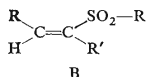
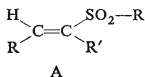
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In connection with synthesis<sup>10</sup> and study of the properties of 5-nitrofurfuryl phenyl sulphones we have found that *I* on treatment with usual alkaline reagents (*e.g.* alkoxides in alcohols) affords a relatively stable carbanion, which can be isolated as the sodium salt. This carbanion undergoes a condensation reaction with aromatic and heterocyclic aldehydes to give 1,1,2-trisubstituted ethylenes. Of various condensation media (ethyl acetate–piperidine–ammonium acetate; methanol–sodium methoxide; pyridin–piperidine; acetic acid–ammonium acetate; benzene–piperidine acetate *etc.*) the medium of choice is the mixture acetic acid–ammonium acetate–piperidine and in some cases acetic anhydride. Even 4-nitrobenzyl phenyl sulphone (*II*), which is reported<sup>11</sup> to be alkali-insoluble, reacted with 5-nitro-2-furaldehyde by refluxing in acetic anhydride; the yield of the condensation product *XV* being however, low (19%).

Concerning the configuration, ethylene derivatives formed by the reaction, can exist as two geometric isomers; *A* and *B* for compounds *III–XIV*, and *C* and *D* for *XV*. As seen on molecular models, the isomer *A* can exist in conformers *A'* or *A''*. An analogous situation is in the isomer *B*. These systems are non-planar, having all the three nuclei rotated from the plane of the double bond; this is the result of the interactions between hydrogens  $H_a$  and  $H_b$  and also of the interference of  $H_c$  with the furan oxygen. The furan nucleus may be oriented either with oxygen pointing below (*A'*) or above the plane (*A''*). Molecular models show that the most fixed nucleus is the furan ring. The compound *XV*, which is isomeric with *XIII*, can exist also in two geometric isomers, *C* and *D*. The isomer *C* can exist in conformer *C'* or *C''*; the same situation is in the case of the isomer *D*. In both conformers of *C* the *p*-nitrophenyl, 5-nitrofuryl and phenylsulphonyl groups are rotated from the plane of the double bond, again as the result of steric interactions of certain hydrogens and of the bulky  $SO_2$  group. The furan ring may again be oriented with the oxygen below (*C'*) or above (*C''*) the plane the form *C'* being energetically favoured because here the ring oxygen is farther from the sulphone group than in *C''*. (For the same reason *A'* is preferred to *A''*.) In contrast to *A*, in *C* the most fixed nucleus is the *p*-nitrophenyl group.



*I*;  $\text{R}^1$  = an aromatic or heterocyclic moiety



$\text{R} = \text{C}_6\text{H}_5$ ;  $\text{R}' = 5\text{-O}_2\text{N}-\text{C}_4\text{H}_2\text{O}$

As indicated by the relatively sharp melting points of compounds *III*–*XIV* (Table I), the synthesis affords only energetically most favourable isomers, except for *XV* which melts in a wide range of temperature (150–180°C) and which is obviously a mixture of compounds. Since this

TABLE I

Physical Properties and Analyses of 1-(5-Nitro-2-furyl)-1-phenylsulphonyl-2-(X-phenyl)ethylenes

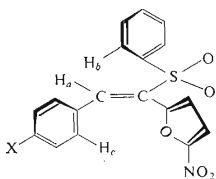
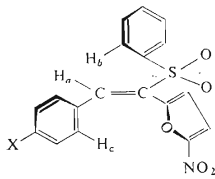
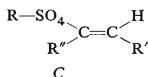
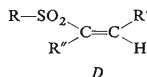
No X	M.p., °C (yield, %) <sup>a</sup>	Formula (m. w.)	Calculated/Found			
			% C	% H	% N	% S
1-(5-nitro-2-furyl)-1-phenylsulfonyl-2-(X-phenyl)ethylene						
<i>III</i>	136–138	C <sub>18</sub> H <sub>13</sub> NO <sub>5</sub> S	60.84	3.66	3.94	9.02
H	(64)	(255.4)	60.77	3.59	4.09	9.04
<i>IV</i>	171–172	C <sub>19</sub> H <sub>15</sub> NO <sub>6</sub> S	59.22	3.89	3.63	8.31
4-OCH <sub>3</sub>	(52)	(385.4)	58.98	3.68	3.75	8.31
<i>V</i>	165–166	C <sub>19</sub> H <sub>13</sub> NO <sub>7</sub> S	57.14	3.28	3.50	8.02
3,4-OCH <sub>2</sub> O	(69)	(399.4)	57.40	3.39	3.67	8.36
<i>VI</i>	202–203	C <sub>20</sub> H <sub>18</sub> N <sub>2</sub> O <sub>5</sub> S	60.30	4.54	7.03	8.06
4-N(CH <sub>3</sub> ) <sub>2</sub>	(22)	(398.4)	60.39	4.48	6.90	7.98
<i>VII</i>	228–229	C <sub>20</sub> H <sub>16</sub> N <sub>2</sub> O <sub>6</sub> S	58.25	3.88	6.77	7.76
4-NHCOCH <sub>3</sub>	(52.6)	(412.4)	58.36	3.83	6.66	7.52
<i>VIII</i>	132–134	C <sub>18</sub> H <sub>12</sub> ClNO <sub>5</sub> S	55.52	3.08	3.59	8.22
4-Cl	(72)	(389.8)	55.93	2.98	3.73	8.17
<i>IX</i>	117–120	C <sub>18</sub> H <sub>12</sub> ClNO <sub>5</sub> S	55.52	3.08	3.59	8.22
3-Cl	(38)	(389.8)	55.28	3.11	3.74	8.13
<i>X</i>	176–178	C <sub>18</sub> H <sub>11</sub> Cl <sub>2</sub> NO <sub>5</sub> S	50.99	2.61	3.30	7.56
3,4-Cl <sub>2</sub>	(33.5)	(424.0)	51.13	2.48	3.39	7.62
<i>XI</i>	154–157	C <sub>18</sub> H <sub>12</sub> INO <sub>5</sub> S	44.92	2.51	2.92	6.66
4-I	(55.5)	(481.3)	45.10	2.65	3.26	6.70
<i>XII</i>	154–156	C <sub>19</sub> H <sub>12</sub> N <sub>2</sub> O <sub>5</sub> S	60.00	3.15	7.36	8.42
4-CN	(55)	(380.4)	60.32	3.25	7.40	8.58
<i>XIII</i>	157–158	C <sub>18</sub> H <sub>12</sub> N <sub>2</sub> O <sub>7</sub> S	54.00	3.00	7.00	8.00
4-NO <sub>2</sub>	(72.5)	(400.4)	54.09	3.07	6.97	7.93
<i>XIV</i> <sup>b</sup>	147–149	C <sub>17</sub> H <sub>12</sub> N <sub>2</sub> O <sub>5</sub> S	57.30	3.36	7.86	8.98
	(36)	(356.3)	57.26	3.40	8.12	8.92
<i>XV</i> <sup>c</sup>	150–180	C <sub>18</sub> H <sub>12</sub> N <sub>2</sub> O <sub>7</sub> S	54.00	3.00	7.00	8.00
	(19)	(400.4)	54.17	3.10	7.17	8.32

<sup>a</sup> Based on the reacted sulphone; <sup>b</sup> 1-(5-nitro-2-furyl)-1-phenylsulphonyl-2-(3-pyridyl)ethylene;

<sup>c</sup> 1-(4-nitrophenyl)-1-phenylsulphonyl-2-(5-nitro-2-furyl)ethylene.

mixture was separated by Ag-thin layer chromatography, which is known to separate geometrical isomers<sup>12,13</sup>, we may anticipate that *XV* represents a mixture of such isomers.

In order to prove the structure of the synthesized compounds we measured their IR and UV spectra. For comparison, we prepared also the already known<sup>14</sup> compound *XVI* which can exist in a coplanar arrangement. The IR-spectra exhibit, besides the bands of functional groups, absorption bands at 900, 972–978, 1088 to 1092, 1500–1515, 1592–1605 and other bands characteristic for the furan nucleus<sup>15</sup>, together with bands, characteristic for SO<sub>2</sub> and NO<sub>2</sub> groups<sup>16</sup>. In the whole series of compounds the band corresponding to  $\nu(\text{NO}_2)_s$  is splitted into two bands, one strong and one of medium intensity (Table II). The influence of substituents on the position of the absorption bands corresponding to the SO<sub>2</sub> and NO<sub>2</sub> vibrations is not clear. The nonplanarity of our 1,1,2-trisubstituted ethylenes is best shown by comparison of their UV-spectra (Table II) with the spectrum of the “parent” saturated sulphone *I* and of the standard *XVI*, in which the coplanar arrangement is possible. The UV-spectra of all compounds exhibit three bands; the first, at 208–217 nm, is relatively intensive, the second at 213–249 nm appears as a shoulder and the third, which is the most intense, is in the range of 286–304 nm. All these bands

*A'**A''**C**D*

$\text{R} = \text{C}_6\text{H}_5$ ;  $\text{R}' = 5\text{-NO}_2\text{C}_4\text{H}_2\text{O}$ ;  $\text{R}'' = 4\text{-NO}_2\text{-C}_6\text{H}_4$

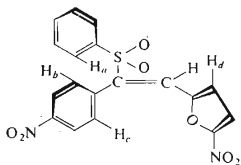
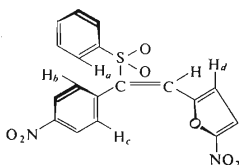
*C'**C''*

TABLE II  
Infrared and Ultraviolet Spectral Data of 1-(5-Nitro-2-furyl)-1-phenylsulphonyl-2-(X-phenyl)ethylenes

No	X	$\lambda_{\max}$ (log $\epsilon$ )	$\nu(\text{C—O—C})$	$\nu(\text{SO}_2)_s$	$\nu(\text{SO}_2)_{as}$	$\nu(\text{NO}_2)_s$	$\nu(\text{NO}_2)_{as}$	$\nu(\text{C}=\text{C})_{\text{aliph}}$
III	H	209 (4.59), 217 (4.57) sh, 289 (4.65)	1 028	1 155	1 323	1 350 1 380	1 535	1 630
IV	4-OCH <sub>3</sub>	209 (4.59), 213 (4.53), 311 (4.67)	1 038	1 155	1 325	1 352 1 381	1 540	1 630
V	3,4-OCH <sub>2</sub> O	211 (4.59), 233 (4.42) sh, 302 (4.43)	1 028	1 155	1 324	1 352 1 380	1 540	1 620
VI	4-N(CH <sub>3</sub> ) <sub>2</sub>	208 (4.35), 249 (4.10) sh, 303 (4.17) 376 (4.33)	1 028	1 152	1 325	1 352 1 378	1 530	—
VIII	4-Cl	209 (4.51), 219 (4.49), 296 (4.55)	1 025	1 156	1 327	1 352 1 380	1 540	1 632
IX	3-Cl	211 (4.69), 231 (4.54) i, 286 (4.53), 323 (4.14) sh	1 030	1 160	1 330	1 357 1 388	1 545	1 642
XI	4-I	210 (4.55), 217 (4.51) sh, 304 (4.71)	1 026 1 012	1 158	1 328	1 352 1 380	1 540	1 630
XII	4-CN	209 (4.51), 217 (4.48) sh, 289 (4.47)	1 028	1 160	1 336	1 360 1 390	1 550	1 640
XIII	4-NO <sub>2</sub>	217 (4.58), —	298 (4.62)	1 158	1 329	1 357 1 388	1 550	1 650
XV <sup>a</sup>	—	208 (4.53), 219 (4.46) i, 248 (4.42) sh, 270 (4.46), 347 (4.43)						
XVI <sup>b</sup>	—	210 (4.47), 239 (4.24), 244 (4.23), 279 (4.41), 395 (4.69)						
I <sup>c</sup>	—	211 (4.45) sh, 219 (4.38), 267 (3.80), 275 (3.88), 318 (4.35)						

<sup>a</sup> 1-(4-Nitrophenyl)-1-phenylsulphonyl-2-(5-nitro-2-furyl)ethylene; <sup>b</sup> 1-(5-nitro-2-furyl)-2-phenylethylene; <sup>c</sup> 5-nitrofurfuryl phenyl sulphone.

may be ascribed to electronic transitions in the furan<sup>17</sup> or benzene<sup>18</sup> nucleus. Compound *VI* with  $N(CH_3)_2$  group exhibits a band at 376 nm (strong bathochromic shift) which corresponds to an excited state of the phenyl moiety, indicating thus that an interaction of the nitrofuran nucleus with the remaining part of the molecule is possible. The reference derivative *XVI* exhibits four absorption bands of which the band at 395 nm obviously corresponds to electron oscillation along the whole conjugated system of the molecule (K-band). The absence of the K-band in the spectra of the studied compounds shows that the angle of the plane of the para-substituted phenyl moiety with the plane of the 5-nitro-2-furyl substituent is near 90° and therefore there is no interaction between these two aromatic nuclei. As a result, the nature of substituent can influence neither the valence vibrations in the IR-spectrum nor the  $\pi \rightarrow \pi^*$  or  $n \rightarrow \pi^*$  transitions in the UV-spectra of these compounds<sup>19</sup>. On the other hand, molecular models show that in the isomer *XV* the 5-nitrofuran moiety can occupy a position in which the angle between the double bond and the nuclei is relatively small allowing thus certain interaction between them. This is in accord with the occurrence of the absorption band at 347 nm.

## EXPERIMENTAL

### Preparation of Compounds

The starting saturated sulphones *I* and *II* were prepared by the reaction of 5-nitrofurfuryl nitrate<sup>10</sup> and 4-nitrobenzyl chloride<sup>11</sup>, respectively, with sodium benzenesulphinate. 1-(5-Nitro-2-furyl)-2-phenylethylene (*XVI*) was synthesized by Wittig reaction according to ref.<sup>14</sup>.

**Procedure A** (derivatives *III*–*XIV*): Piperidine (0.5 ml) and ammonium acetate (3.0 g; 0.04 mol) was added to a mixture of *I* (5.4 g; 0.02 mol) and of the corresponding aldehyde (0.02 mol) in acetic acid (50 ml), the mixture was refluxed for 5 hours, poured on ice (150 g) and the precipitate was filtered and dried. The crude product was extracted with chloroform, the extract boiled with charcoal, filtered and concentrated to a small volume. The addition of ether or light petroleum precipitated the product, which was contaminated with a small amount of *I*. The product was purified by chromatography on an alumina column (16 cm,  $\varnothing$  2 cm; Brockmann II), usually using n-hexane-ethyl acetate (2 : 3) as eluent.

**Procedure B** (derivative *XV*): A mixture of *II* (2.77 g; 0.01 mol), 5-nitro-2-furaldehyde (2.8 g; 0.02 mol) and acetic anhydride (25 ml) was refluxed for 4 hours, cooled in salt-ice mixture, and the precipitate (non-reacted *II*) was filtered off. The filtrate was treated with hydrochloric acid (20 ml; 1 : 1), the mixture was stirred for 1 hour and then poured on crushed ice (100 g). The precipitate is filtered, washed with ether and purified chromatographically as described in the procedure *A*.

### Spectral Measurements

The infrared spectra were taken in chloroform in  $10^{-2}$ M solutions and in NaCl cells of 1.02 mm thickness on a Zeiss (Jena) UR-20 spectrometer, calibrated with polystyrene. The electronic absorption spectra were measured on a registration spectrophotometer Specord UV VIS Zeiss, in  $2.5-5 \cdot 10^{-5}$ M ethanolic solutions, using 10 mm cells. The accuracy was  $\pm 1$  nm.

## REFERENCES

1. Tröger I., Hille W.: J. Prakt. Chem. [2] 71, 201 (1905).
2. Chodroff S., Whitmore W. F.: J. Am. Chem. Soc. 72, 1073 (1950).
3. Balasubramanian M., Baliah V.: J. Chem. Soc. 1954, 1844.
4. Balasubramanian M., Baliah V., Rangarajan T.: J. Chem. Soc. 1955, 3296.
5. Baliah V., Seshapathirao M.: J. Org. Chem. 24, 867 (1959).
6. Baliah V., Rangarajan T.: J. Chem. Soc. 1954, 3068.
7. Tröger I., Prochnow A.: J. Prakt. Chem. [2] 78, (1908).
8. Gairaud C. B., Lappin G. R.: J. Org. Chem. 18, 1 (1953).
9. Enomoto Sakae, Harada Kinji: Japan. Pat. 7132, 174 (1969); Chem. Abstr. 75, 140669 (1971).
10. Jurášek A., Kováč J., Krutošiková A., Hrdina M.: This Journal 37, 3144 (1972).
11. Tröger I., Bolte F.: J. Prakt. Chem. [2] 101, 139 (1921).
12. Barret C. B., Dalas M. S. I., Padlav F. B.: Chem. Ind. (London) 16, 1050 (1962).
13. Bergelson L. D., Djalovskaja V. E., Voronkova V. V.: Chromatografija 15, 191 (1964).
14. Yoshima Shigetaka, Tamaka Akira, Yamamoto Katsumi: Yakugaku Zasshi 88, 65 (1968)] Chem. Abstr. 69, 27134 (1968).
15. Katritzky A. R., Lagowski J. M.: J. Chem. Soc. 1959, 657.
16. Nakanishi K.: *Infrared Absorption Spectroscopy*, Russian translation, p. 64. Mir, Moscow 1965.
17. Raffauf R. F.: J. Am. Chem. Soc. 72, 753 (1950).
18. Brand J. C. D., Eglinton G.: *Applications of Spectroscopy to Organic Chemistry*, Russian translation, p. 212. Mir, Moscow 1967.
19. Higasi K., Baba H., Rembaum A.: *Quantum Organic Chemistry*, Russian translation, p. 214. Mir, Moscow 1967.

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