

Furan derivatives. LXXXV.
**Relative reactivity of furan and thiophene upon arylation
with diazoaminobenzene and isopentyl nitrite**

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A new method for arylation of thiophene by a radical generated during an aprotic diazotization of derivatives of diazoaminobenzene with isopentyl nitrite is described. This method served for preparation of substituted 2-(X-phenyl)thiophene derivatives, where X = H, 4-Br, 4-Cl, 3-Cl, 4-CH₃, 4-OCH₃, 4-NO₂, 4-COOCH₃. Arylation of benzene led to biphenyl. The relative reactivity of furan and thiophene has been established by arylation of a great excess of an equimolar mixture of furan and thiophene.

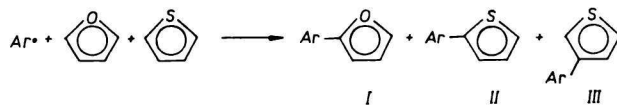
В работе описан новый метод арилирования тиофена радикалом, образующимся апротонным диазотированием производных диазоаминобензола с изопентилнитритом. При помощи указанного метода были приготовлены замещенные производные 2-(X-фенил)тиофена, где X = H, 4-Br, 4-Cl, 3-Cl, 4-CH₃, 4-OCH₃, 4-NO₂ и 4-COOCH₃. Арилированием бензола был приготовлен дифенил. Далее, была определена относительная реакционная способность фурана и тиофена при помощи арилирования большого избытка эквимолярной смеси фурана и тиофена.

We ascertained that derivatives of diazoaminobenzene are unstable in an aromatic solvent in the presence of isopentyl nitrite [1]. The aprotic diazotization of substituted derivatives of diazoaminobenzene with isopentyl nitrite furnished at 30°C phenyl radical used for arylation of furan. This finding was applied for arylation of thiophene and benzene and we compared the reactivity of the furan and thiophene rings.

Substituted 2-(X-phenyl)thiophene derivatives (X = H, 4-Br, 4-Cl, 3-Cl, 4-CH₃, 4-NO₂, 4-COOCH₃) were synthesized by reacting the substituted diazoaminobenzene derivatives with isopentyl nitrite in thiophene at 30°C. The identity of all prepared derivatives was verified gas chromatographically by comparison of the respective retention time with that of a reference substance. Yields of the reaction

(calculated on 2 moles of 2-phenylthiophene derivative formed from 1 mole of diazoaminobenzene derivative) varied from 32 to 59%. The arylation of benzene under the same conditions afforded biphenyl in a 45.4% yield.

Comparison of the relative reactivity of furan and thiophene with phenyl radical was investigated by arylation of an equimolar mixture of furan and thiophene according to Scheme 1 by the method of competition reactions under conditions minimalizing errors [2]. Phenyl radical was generated from diazoaminobenzene and isopentyl nitrite.



Scheme 1

The amounts of arylated derivatives were determined by an analysis of the reaction mixture by g.l.c. on the basis of a calibration dependence. We found that the furan ring is by 4.27 times more reactive towards the phenyl radical than the thiophene one. This result is in accordance with data $F_{\text{T}}^{\text{u}}K = 4.4$ [3] characterizing the reactivity of the phenyl radical, obtained by an aprotic diazotization of aniline with isopentyl nitrite, with a mixture of furan and thiophene.

Experimental

The synthesized compounds were analyzed with a gas chromatograph Hewlett—Packard 7620A with a flame-ionization detector, in a metal column 183×0.2 cm packed with Diatiport (80—100 mesh); stationary phase 10% silicone rubber UCW-98, temperature of the column 160°C , that of injector and detector 220°C , the flow rate of nitrogen carrier gas was 30 ml/min. Quantitative and qualitative results of the analysis were obtained by an H-P 337 08 integrator. Furan, thiophene, and benzene commercially available were distilled before each reaction. Substituted 2-(X-phenyl)thiophene derivatives (standards) were prepared according to [4—8].

Reaction of diazoaminobenzene with isopentyl nitrite and thiophene

The mixture of diazoaminobenzene (1.97 g; 0.01 mole), isopentyl nitrite (2 ml; 0.017 mole), and thiophene (50 ml) was kept at 30°C for 24 hrs. The solution was concentrated and the solid residue chromatographed on a SiO_2 column with light petroleum (b.p. $40\text{--}60^\circ\text{C}$). 2-Phenylthiophene of m.p. $35\text{--}37^\circ\text{C}$ ([9] $34\text{--}35^\circ\text{C}$, [4] $42\text{--}43^\circ\text{C}$), $t_{\text{R}} = 12.16$ min, a mixture containing 2- and 3-phenylthiophene, and 3-phenylthiophene of m.p. $91\text{--}93^\circ\text{C}$ ([5] $91\text{--}92^\circ\text{C}$) and $t_{\text{R}} = 12.88$ min were gradually eluted. Yield 35.8 and $<2\%$, respectively. 2-Phenylthiophene was found to be identical with the reference substance prepared from aniline, isopentyl nitrite, and thiophene. This method was also applied for preparation of further derivatives which were obtained by distillation with steam. They are as follows:

2-(4-Brömphényl)thiophene (IV) from 4,4'-dibromodiazaminobenzene, $t_{\text{R}} = 19.14$ min, m.p. and mixed m.p. $101\text{--}102^\circ\text{C}$ ([4] 100°C), yield 59%.

2-(4-Chlorophenyl)thiophene (V) from 4,4'-dichlorodiazaminobenzene, $t_R = 13.32$ min, m.p. and mixed m.p. 83—84°C ([4] 83°C), yield 43.1%.

2-(3-Chlorophenyl)thiophene (VI) from 3,3'-dichlorodiazaminobenzene, $t_R = 13.69$ min, b.p. 134—136°C/0.6 kPa ([8] 154—156°C/2 kPa), yield 32.2%.

2-(4-Tolyl)thiophene (VII) from 4,4'-dimethyldiazaminobenzene, $t_R = 11.11$ min, m.p. and mixed m.p. 64°C ([7] 63—64°C), yield 48.8%.

2-(4-Methoxyphenyl)thiophene (VIII)[†] from 4,4'-dimethoxydiazaminobenzene, $t_R = 16.86$ min, m.p. and mixed m.p. 112—114°C ([5] 111—113°C), yield 38.1%.

2-(4-Nitrophenyl)thiophene (IX) from 4,4'-dinitrodiazaminobenzene, $t_R = 36.20$ min, m.p. and mixed m.p. 138—139°C ([6] 137—138°C), yield 46.5%.

2-(4-Methoxycarbonylphenyl)thiophene (X) from 4,4'-dimethoxycarbonyldiazaminobenzene, $t_R = 40.20$ min, m.p. and mixed m.p. 141—142°C ([5] 140—142°C), yield 48.1%.

Establishment of the mutual reactivity of furan and thiophene

A mixture consisting of diazoaminobenzene (1.97 g; 0.01 mole), isopentyl nitrite (2 ml; 0.017 mole), furan (34 g; 0.5 mole), and thiophene (42 g; 0.5 mole) heated at 30°C for 24 hrs was analyzed by gas chromatography on the basis of calibration curve constructed from single derivatives: 2-phenylfuran I ($t_R = 3.21$ min), 2-phenylthiophene II ($t_R = 12.16$ min), 3-phenylthiophene III ($t_R = 12.88$ min).

The value $F_{T,K}^u = 4.27$ was calculated from the relationship

$$F_{T,K}^u = \frac{\text{mole [I]}}{\text{mole [II]} + \text{mole [III]}}$$

as an average value of 4 measurements.

Reaction of diazoaminobenzene with isopentyl nitrite and benzene

Diazoaminobenzene (1.97 g; 0.01 mole), isopentyl nitrite (2 ml; 0.017 mole), and benzene (50 ml) were mixed together and allowed to stand at 30°C for 24 hrs. The volatile portion was distilled off and the solid residue was steam distilled. The yield of biphenyl (XI) was 1.4 g (45.4%), $t_R = 5.68$ min, m.p. and mixed m.p. 70—71°C ([4] 69—71°C).

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