

## 1,3-Cycloaddition of Benzyne to Thiophens

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*Summary* Benzyne, generated from diphenyliodonium-2-carboxylate, reacts with various thiophens by addition to the sulphur and  $\beta$ -carbon to give, after loss of an acetylene moiety, benzo[*b*]thiophens in low but reproducible yields.

DURING a study<sup>1</sup> of the solution-phase reactions of various thiophens (**1**) with benzyne generated from diphenyliodonium-2-carboxylate,<sup>2</sup> the formation of benzo[*b*]thiophens in low but reproducible yields was repeatedly observed (Table). A similar observation was reported some years

ago from the gas-phase reaction of thiophen and benzyne generated from phthalic anhydride, and was rationalized by a mechanism which predicted that both  $\beta$ -carbons of the thiophen were lost and both  $\alpha$ -carbons were retained in the product (**2**).<sup>3</sup> Aside from the improbability of portions of this mechanism as revealed by more recent studies,<sup>4</sup> the substitution patterns of the benzo[*b*]thiophens (**2**) in the Table clearly contradict this prediction. Instead, it appears that adjacent  $\alpha$ - and  $\beta$ -carbons of the thiophens (**1**) are either retained as C-2 and C-3 of the product (**2**), respectively, or they are lost entirely.

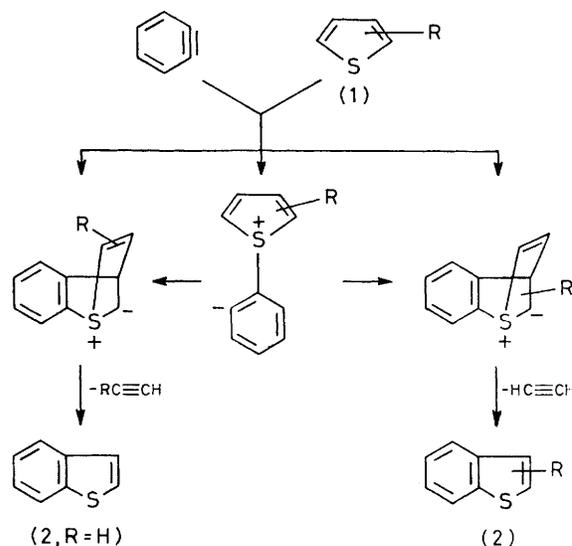
TABLE. Yields<sup>a</sup> of benzo[*b*]thiophens (2).<sup>b</sup>

| Thiophen (1)<br>R              | Benzo[ <i>b</i> ]thiophen (2)<br>R | % Yield              |
|--------------------------------|------------------------------------|----------------------|
| <b>a</b> ; H                   | H                                  | 0.5                  |
| <b>b</b> ; 2-Br                | H                                  | 1.5                  |
| <b>c</b> ; 3,4-Br <sub>2</sub> | 3-Br                               | 3.8                  |
| <b>d</b> ; 2-Me                | 2-Me                               | ca. 0.5 <sup>c</sup> |
|                                | H                                  | 0.5                  |
| <b>e</b> ; 3-Me                | H                                  | 0.5                  |
| <b>f</b> ; 2,5-Me <sub>2</sub> | 2-Me                               | 3.0                  |
| <b>g</b> ; 2-OMe               | H                                  | 1.0                  |

<sup>a</sup> Identification based on g.c.-m.s. comparison with authentic materials. Yields are g.c.-determined. <sup>b</sup> Conditions and major products are given in ref. 2. <sup>c</sup> Incomplete resolution from other components of the reaction mixture.

Although details such as the sequence and timing of the steps cannot be specified as yet, the mechanism must involve a 1,3-cycloaddition of benzyne to the sulphur and  $\beta$ -carbon of the thiophen ring and expulsion of an acetylene moiety composed of the  $\alpha$ - and  $\beta$ -carbons of the unattacked side of the thiophen ring. With monosubstituted thiophens, the unsubstituted side is preferentially attacked for (**1b**, **e**, and **g**) but for 2-methylthiophen (**1d**) either side may react. An illustrative mechanism incorporating these features is shown in the Scheme.†

Benzyne is known to participate in 1,3-cycloaddition reactions,<sup>5</sup> including several with mesoionic five-membered heterocycles.<sup>6</sup> Two recent examples closely related to the mechanism in the Scheme involve the stepwise attack of benzyne on the sulphur atoms of dithiin dioxides<sup>7</sup> or 2,1,3-benzothiadiazoles,<sup>8</sup> followed by attack at a  $\beta$ -carbon and elimination of an acetylene or a nitrile, respectively. All these examples, however, involve species relatively more



SCHEME.

dipolar or less aromatic than thiophen. Although 1,3-cycloaddition to a thiophen ring had previously been considered to explain certain photochemical reactions, this hypothesis was eliminated<sup>9</sup> thereby leaving the present reaction as the first apparent example of this phenomenon.

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† Added in proof. A similar mechanism has been recently proposed to explain the reactions of cyclic thioenol ethers with di methyl acetylenedicarboxylate (K. Gollnick and S. Fries, *Angew. Chem., Int. Ed. Engl.*, 1980, **19**, 832).

<sup>1</sup> D. Del Mazza, Dissertation, Texas Christian University, 1980.

<sup>2</sup> D. Del Mazza and M. G. Reinecke, *Heterocycles*, 1980, **14**, 647.

<sup>3</sup> E. K. Fields and S. Meyerson, *Chem. Commun.*, 1966, 708.

<sup>4</sup> D. N. Reinhoudt and C. G. Kouwenhoven, *Tetrahedron*, 1974, **30**, 2431.

<sup>5</sup> R. W. Hoffman, 'Dehydrobenzene and Cycloalkynes,' Academic Press, New York, 1967, p. 206.

<sup>6</sup> H. Kato, S. Nakazawa, T. Kiyosawa, and K. Hirakawa, *J. Chem. Soc., Perkin Trans. 1*, 1976, 672.

<sup>7</sup> K. Kobayashi and K. Mutai, *Tetrahedron Lett.*, 1978, 905.

<sup>8</sup> C. D. Campbell, C. W. Rees, M. R. Bryce, M. D. Cooke, P. Hanson, and J. M. Vernon, *J. Chem. Soc., Perkin Trans. 1*, 1978, 1006.

<sup>9</sup> A. H. A. Tinnemans and D. C. Neckers, *J. Org. Chem.*, 1978, **43**, 2493.