

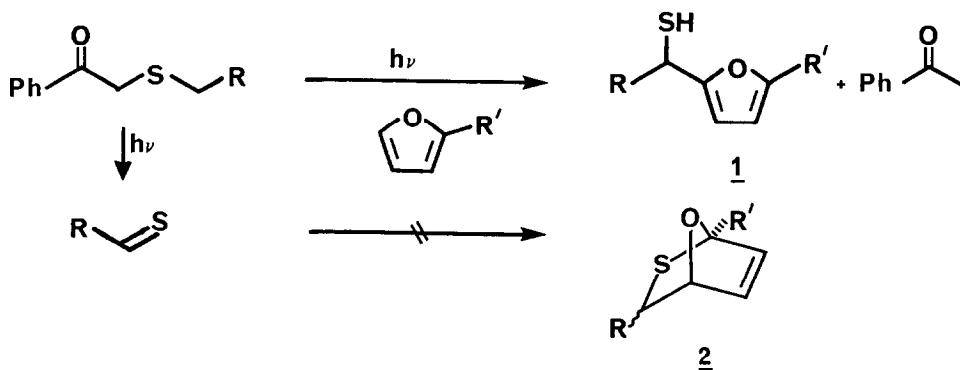
## FUNCTIONALIZATION OF FURANS VIA PHENACYL SULFIDES

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Summary: A mild, efficient, photochemical method for the functionalization of furans via phenacyl sulfides is described.

Furans have received significant attention in recent years, as versatile and functional starting units in the implementation of synthetic strategies<sup>2</sup> and as constituent functional components in a variety of structurally interesting and biologically important natural products.<sup>3</sup> The growing interest in furans has prompted the development of new methods to prepare functionalized furans.<sup>4</sup> In this communication we report a new, mild method for the synthesis of a variety of functionalized furans via photochemical addition of phenacyl sulfides.

During the course of studies on the cycloaddition of thioaldehydes to furans, we discovered that photolysis of phenacyl sulfides in the presence of furans provided good to excellent yields of  $\alpha$ -mercapto alkylated furans (**1**), instead of the bicyclic adducts (**2**), which would have resulted from 4+2 cycloaddition of thioaldehydes to the furans. Although the photolysis of phenacyl sulfides is known to induce Norrish II cleavage of the  $\alpha$ -carbon sulfur bond,<sup>5</sup> producing reactive and dienophilic<sup>5g</sup> thio-



carbonyl compounds, furan cycloaddition adducts have not been isolated from most of these reactions.<sup>6</sup>

This photochemical reaction appears to be quite general (Table 1), and proceeds well with a variety of functionalized phenacyl sulfides and with most furans. Only furans which contain substituents in both the 2 and 5 positions fail to form the  $\alpha$ -mercapto alkylated furans.

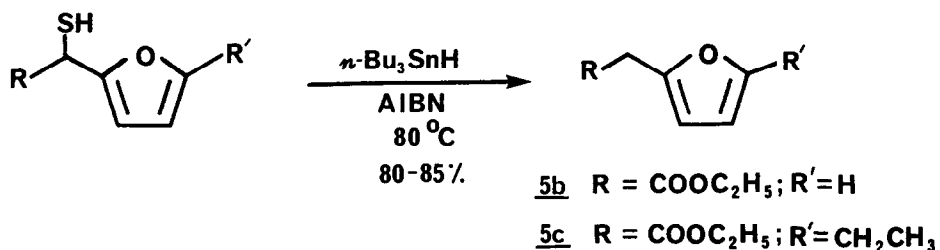
Treatment of the  $\alpha$ -mercapto alkylated furans with  $\text{Bu}_3\text{SnH}$  and AIBN in benzene at  $80^\circ$  brought about desulfurization, providing good yields of the alkylated furans.<sup>8</sup> This two step method allows access to furans such as **5b** and **5c**, which might be difficult to prepare by alkylation of the 2-furyl anion, or by electrophilic substitution.

In a typical experiment, 1.0 mmol of the phenacyl sulfide and 2.0

Table 1

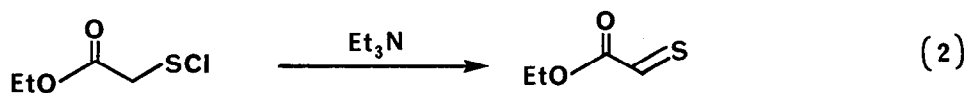
			(Yield, %) <sup>a,b</sup>
R = -CO <sub>2</sub> Et	R' = -H	<b>3a</b>	87
"	-CH <sub>3</sub>	<b>3b</b>	89
"	-C <sub>2</sub> H <sub>5</sub>	<b>3c</b>	84
"	-SiMe <sub>3</sub>	<b>3d</b>	69
"	-OMe	<b>3e</b>	89
"	-CH <sub>2</sub> OH	<b>3f</b>	81
"	-3,4 di- CH <sub>2</sub> OH	<b>3g</b>	75
-H	-H	<b>4</b>	44
-CH <sub>3</sub>	"	<b>5</b>	51
- <i>n</i> -Pr	"	<b>6</b>	65
-CN	"	<b>7</b>	64
-CF <sub>3</sub>	"	<b>8</b>	47
-COC <sub>6</sub> H <sub>5</sub>	"	<b>9</b>	66

<sup>a</sup>yields refer to isolated, chromatographically pure materials. <sup>b</sup>All products gave satisfactory IR, <sup>1</sup>H and <sup>13</sup>C NMR, and mass spectral data.<sup>7</sup>



mmol of the furan are dissolved in dichloromethane and irradiated (275 watt sunlamp, pyrex) for 2-3 hours. When the phenacyl sulfide has been consumed, the solvent is removed and the reaction mixture purified by flash chromatography. This reaction can be conducted on a relatively large scale (0.1 mole), though irradiation times must be extended for these reactions.

We have conducted preliminary mechanistic studies in order to determine the pathway by which the  $\alpha$ -mercapto alkylated furans are produced. Several thioaldehydes have been generated by the non-photochemical routes shown in Equations 1<sup>9</sup> and 2<sup>10</sup>, but these thioaldehydes did not react with furans, either under thermal conditions or under conditions identical to the photochemical irradiation described above. Only polymeric material and smaller amounts of thioaldehyde trimer formed in these reactions, with complete recovery of the furan starting material. Thus, it appears that thioaldehydes are not involved in the formation of the  $\alpha$ -mercapto alkylated furans. Further efforts to elucidate the mechanism of this reaction are underway in our laboratories.



**Acknowledgement.** We thank the Petroleum Research Fund and the Research Corporation for financial support of this work, and the N.I.H. NMR Research Resource (RR-01317) in this department for high field NMR spectra.

#### References and Notes

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6. We have isolated small amounts of Diels-Alder adducts in the reaction of methyl phenacyl sulfide with 2-methylthiofuran, and 2,5-bis-methylthiofuran. Middleton (J. Org. Chem. **1965**, 30, 1390-4.) reported the Diels-Alder adduct of hexafluorothioacetone and furan, and noted its thermal instability at room temperature.
7. Spectral data for representative compounds are as follows: **3a**: IR (KBr): 3000  $\text{cm}^{-1}$ , 2550  $\text{cm}^{-1}$ , 1700  $\text{cm}^{-1}$ ;  $^1\text{H}$  NMR (250 MHz,  $\text{CDCl}_3$ , ppm): 7.39 (s, 1H), 6.38 (bs, 1H), 6.35 (bs, 1H), 4.68 (d, 1H,  $J = 9$  Hz), 4.25 (q, 2H,  $J = 7$  Hz), 2.68 (d, 1H,  $J = 9$  Hz, -SH), 1.29 (t, 3H,  $J = 7$  Hz);  $^{13}\text{C}$  NMR (63 MHz,  $\text{CDCl}_3$ , ppm): 167.8 (s, 1C), 146.7 (s, 1C), 143.1 (d, 1C), 110.9 (d, 1C), 110.7 (d, 1C), 62.1 (t, 1C), 51.2 (d, 1C), 14.0 (q, 1C); MS, m/e (rel. intensity):  $\text{M}^+$ , 186 (23), 153 (17), 113 (100). **6**: IR (KBr): 2900  $\text{cm}^{-1}$ , 2500  $\text{cm}^{-1}$ ;  $^1\text{H}$  NMR (250 MHz,  $\text{CDCl}_3$ , ppm): 7.33 (bs, 1H), 6.28 (bs, 1H), 6.13 (bs, 1H), 4.03 (dt, 1H,  $J = 7.0$  Hz, 7.2 Hz), 2.00 (d, 1H,  $J = 6.6$  Hz), 1.40 (m, 2H), 0.92 (t, 3H, 7.4 Hz);  $^{13}\text{C}$  NMR (63 MHz,  $\text{CDCl}_3$ , ppm): 156.9 (s, 1C), 141.7 (d, 1C), 110.5 (d, 1C), 105.3 (d, 1C), 39.5 (d, 1C), 36.9 (t, 1C), 13.9 (q, 1C); MS, m/e (relative intensity):  $\text{M}^+$ , 156 (4), 123 (36), 81 (100).
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(Received in USA 1 October 1984)