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Michael Additions to 3(2H)-Thiophenone 1,1-dioxide.

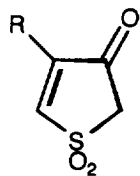
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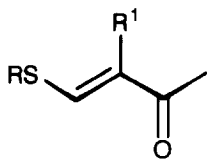
Abstract: The addition of thiols and amines to 3(2H)thiophenone 1,1-dioxide takes place with extrusion of sulfur dioxide, furnishing in high yields the corresponding vinyl sulfides and enamines. Addition of dithiols afforded the corresponding thioacetals. The rates of the the Michael addition and the extrusion reaction are strongly influenced by the solvent employed. In ethanol, sulfur dioxide extrusion took place even at room temperature.

The thermally induced, orbital symmetry controlled extrusion of sulfur dioxide from 2,5-dihydrothiophene 1,1-dioxide derivatives is a synthetically valuable method for the preparation of 1,3-butadienes.^{1,2} We have studied Michael additions of thiols and amines to the 3(2H)-thiophenone 1,1-dioxides **1** and the subsequent sulfur dioxide extrusion which in some cases took place even at room temperature.

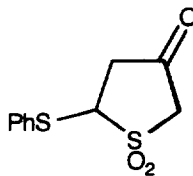
The ketone **1a** was available from 2,5-dihydrothiophene 1,1-dioxide through three consecutive steps in 40% overall yield,^{3,4} and the homologue **1b** was prepared in a similar yield from 3,4-dimethyl-2,5-dihydrothiophene 1,1-dioxide.⁵ Reaction of **1a** with benzenethiol in THF under reflux, in the presence of pyridine, proceeded with extrusion of sulfur dioxide and formation of a 7 : 2 mixture of (E)- and (Z)-4-phenylsulfinyl-3-buten-2-one (**2a**)⁶ in 80% isolated yield. Quenching the reaction after 30 min. gave 5-phenylsulfinyl-2,5-dihydro-3-thiophenone 1,1-dioxide (**3**), in almost quantitative yield. The rate of this Michael addition was strongly influenced by the base and solvent employed. While no reaction of **1a** took place after 20 hours in refluxing THF without added base, an ethanol solution in the presence of triethylamine was completely converted to a mixture of **2a** and **3** after 10 min. at room temperature; apparently these conditions strongly enhanced the rate of sulfur dioxide extrusion as well.⁷ Heating an ethanol solution of **3** under reflux for 40 min. in the presence of triethylamine gave E-**2a** as sole product in practically quantitative yield; a separate experiment showed no equilibration of an isomer mixture of **2a** under the reaction conditions, indicating that the extrusion reaction takes place preferentially by an outward rotation of the phenylsulfinyl group. Further addition of benzenethiol to **2a** occurs as well; depending on the reaction conditions, a small amount⁸ of the acetal **4** was occasionally present in the product.



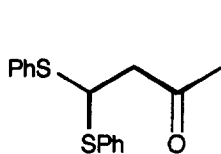
1 a R = H
b R = Me



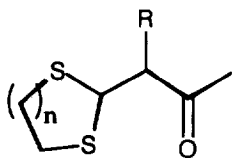
2 a R = Ph; R¹ = H
b R = Ph; R¹ = Me
c R = Bu; R¹ = H
d R = (CH₂)₂CO₂Me; R¹ = H



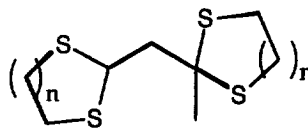
3



4



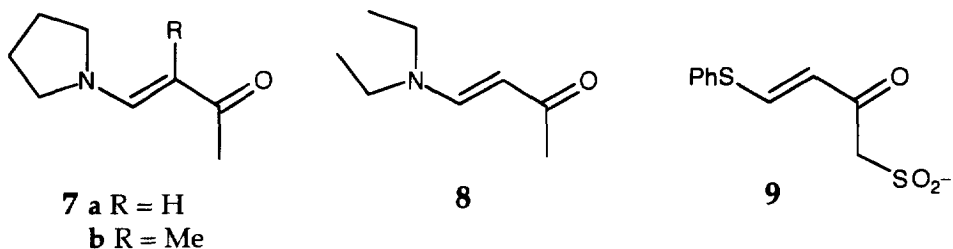
5 a R = H; n = 1
b R = H; n = 2
c R = Me; n = 2



6 a n = 1
b n = 2

Similarly, reactions of an ethanol solution of **1 a** with 1-butanethiol and methyl 3-mercaptopropionate in the presence of pyridine furnished the ketones **2 c**⁹ and **2 d** in 88 and 92% yields, respectively, as almost pure *E*-isomers.¹⁰ Furthermore, the addition of one equivalent of 1,2-ethanedithiol and 1,3-propanedithiol to **1 a** under the same conditions provided the thioacetals **5 a**¹¹ and **5 b**¹¹ in 93 and 88% yields, respectively; however, using two equivalents of the dithiols and *p*-toluenesulphonic acid as catalyst the bis-thioacetals **6 a**¹¹ and **6 b**¹¹ were formed in 93 and 91% yields. The methyl-substituted derivative **1 b** was much less reactive; with benzenethiol (*E*)-3-methyl-4-phenylsulfinyl-3-buten-2-one (**2 b**)¹² was obtained in 99% yield after 2.5 hours of reflux in ethanol-triethylamine, and with 1,3-propanedithiol the thioacetal **5 c** was obtained in 85% yield after 56 hours of reflux in ethanol-pyridine. On the other hand, a reaction of **1 b** and 1,3-propanedithiol in toluene-pyridine was incomplete even after several days under reflux.

The addition of pyrrolidine to a THF solution of **1 a** at room temperature afforded as sole product the *E*-isomer of the enaminone **7 a**¹³ in 92% yield, and a similar yield of **8** was obtained using diethylamine. The reactions of the amines were also slower in the case of **1 b**; pyrrolidine furnished the enaminone **7 b**¹³ as the *E*-isomer in 73% yield after 24 hours of reflux in toluene.



It is known that five-membered cyclic sulfones react with base by cleavage of the carbon-sulfur bond forming sulfinate anions which may lose sulfur dioxide.¹⁴ Such a two-step mechanism may account for our products and the effects of both solvent and base as well; however, using the sulfolene 3 as a model compound, we were unable to trap an intermediate sulfinate anion 9 by methyl iodide.¹⁵ Hence, for our reactions we favour a concerted ring opening and sulfur dioxide extrusion from an enolate intermediate, the rate of which must be strongly influenced by substituent effects; while the sulfur dioxide extrusion from 3 was finished in less than one hour, the reaction of 3-tetrahydrothiophenone 1,1-dioxide under the same conditions, yielding 4-phenylsulfanylbutan-2-one,¹⁶ was incomplete after 91 hours of reflux.

The thioacetals 5 a and b may prove synthetically interesting, particularly since they are easily obtained in high yields by transacetalization of commercially available 4,4-dimethoxybutan-2-one with 1,2-ethanedithiol and 1,3-propanedithiol, respectively.¹¹ The synthetic use of these compounds is being explored.

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References and Notes:

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7. A solvent effect has been reported previously;¹ the sulfur dioxide extrusion from 2-vinyl-substituted tetrahydrothiophene 1,1-dioxides took place in ethanol at 60 °C.¹⁷ Relatively little is known about the effect of substituents on this reaction; the 2-methyl derivative extrudes sulfur dioxide 5 x faster than the parent 3-sulfolene.¹
8. The compound was generally formed in barely detectable amounts, except in the product from the reaction of 1a with benzenethiol in ethanol-pyridine, which furnished 13% of the acetal; it was identified from the ¹H NMR spectrum of the crude product, particularly by the triplet at δ 4.92, due to the acetal proton.
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