Facile Synthesis of 4,6-Dihydrothieno[3,4-*b*]thiophene 5,5-Dioxide. A Synthetic Equivalent of 2,3-Dihydro-2,3-dimethylenethiophene

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4,6-Dihydrothieno[3,4-*b*]thiophene 5,5-dioxide 4, a stable precursor of 2,3-dihydro-2,3-dimethylenethiophene 3, conveniently prepared from 4-bromo-3-chloro-2,3-dihydrothiophene S,S-dioxide, can easily be alkylated and loses SO₂ upon heating so that 4 serves as a useful synthetic equivalent of 3.

The study of the preparation and reactivity of the heterocyclic analogues of *o*-quinodimethane 1 such as 2,3-dihydro-2,3dimethylenefuran 2^1 and 2,3-dihydro-2,3-dimethylenethiophene 3^2 has attracted wide attention. There have been several reports on the preparation of 3 in solution and by flash thermolysis.² However, owing to their instability, compounds of type 3 are normally generated *in situ* and can be trapped in the form of cycloadducts. Therefore, the synthetic utility of this class of compound has been rather limited.

The use of 2,5-dihydrothiophene S, S-dioxides (3-sulpholenes) as stable precursors for unstable 1,3-dienes has several advantages.³ The thermal removal of SO₂ to regenerate the dienes can easily be achieved, normally around 130 °C.⁴ The electron-withdrawing sulphonyl group provides



entries to a variety of substituted derivatives which are stable precursors for the corresponding substituted dienes. This approach should be especially useful in the area of *o*-quinodimethane chemistry where the introduction of substitution is





Scheme 2



Scheme 3 LiHMDS = lithium hexamethyldisilazide

otherwise difficult. We now report a very efficient synthesis of compound 4, a precursor of 3, and some of its applications in organic synthesis.

Compound 4 can be synthesized in essentially three steps from compound 5^5 (Scheme 1). The ultrasound-promoted zincation of 5 with the aldehyde 6 (prepared from allyl bromide by treatment with potassium thioacetate followed by ozonolysis) in the presence of BF₃·Et₂O gave the corresponding secondary alcohol 7.⁶ Base-induced hydrolysis of the thioester followed by cyclization and subsequent elimination gave 4. Presumably the primary product from the cyclization– elimination sequence, 8, was spontaneously isomerized to the thermodynamically more stable form 4 under the reaction conditions.

Compound 4 (m.p. 146–147 °C)⁷ is stable at room temperature under moderately basic (2 mol dm⁻³ NaOH) or acidic (2% HCl) conditions but loses sulphur dioxide readily upon heating. Thermolysis of 4 at 200 °C in a sealed tube in the presence of *N*-phenylmaleimide gave the cycloadduct 9^{2c} (Scheme 2). The isolation of the reactive intermediate 3 was not necessary. This reaction illustrates that 4 is a convenient and stable precursor of 3.

Similar to other 2,5-dihydrothiophene S,S-dioxides,³ compound 4 can be easily deprotonated and substituted with high regioselectivity. Treatment of 4 with BunLi in tetrahydrofuran (THF) followed by MeI produced 10 (83%). Similarly, compound 13 could be obtained by deprotonation-substitution with pent-4-enyl iodide. Multi-substitution with four methyl groups leading to 12 was easily achieved in one step. The monodeprotonation-alkylation reactions take place exclusively at the α -position to the sulphur atom of the thiophene dioxide. It is known that deprotonation of the 2-methyl group occurs more readily than that of the 3-methyl group of 2,3,4,5-tetramethylthiophene.8 By analogy, it was expected that the deprotonation of 4 would take place preferentially at the position as indicated. However, for unambiguous identification, compound 10 was independently synthesized from 18 via the zincation-cyclization-elimination sequence (Scheme 3).

The substituted products 10 and 13 are also precursors of the corresponding heterocyclic *o*-quinodimethanes. For example, thermolysis of 10 with dimethyl acetylenedicarboxylate (DMAD) at 200 °C directly produced 11 in 82% yield, whereas heating 13 at 200 °C resulted in SO₂ extrusion followed by the intramolecular Diels-Alder reaction of the intermediate 14 to afford 15 (67%) as a 3:1 mixture of stereoisomers. This provides a very facile synthesis of polycyclic fused-thiophene compounds. The sequential substitution and thermolysis make 4 a synthetic equivalent of the anion of 2,3-dihydro-2,3-dimethylenethiophene 3.

We thank the National Science Council for financial support and Dr R. C. Storr for providing the ¹H NMR spectral data of **4** for comparison.

Received, 10th June 1991; Com. 1/02782D

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