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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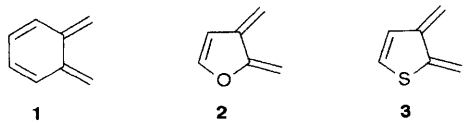
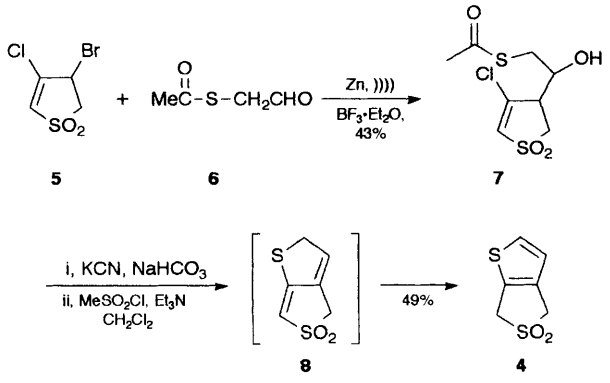
4,6-Dihydrothieno[3,4-*b*]thiophene 5,5-dioxide **4**, a stable precursor of 2,3-dihydro-2,3-dimethylenethiophene **3**, conveniently prepared from 4-bromo-3-chloro-2,3-dihydrothiophene *S,S*-dioxide, can easily be alkylated and loses SO_2 upon heating so that **4** serves as a useful synthetic equivalent of **3**.

The study of the preparation and reactivity of the heterocyclic analogues of *o*-quinodimethane **1** such as 2,3-dihydro-2,3-dimethylenefuran **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 SO_2 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

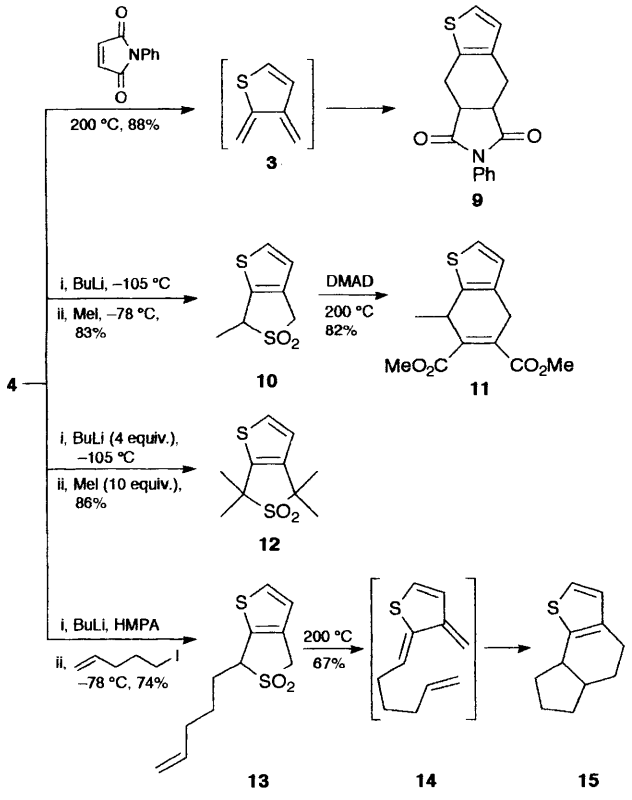


1 **2** **3**

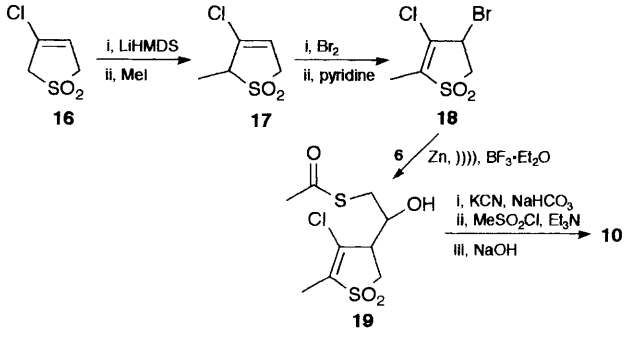


5 **6** **7** **8** **4**

Scheme 1



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 $BF_3{\cdot}Et_2O$ 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 Bu^nLi 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 SO_2 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**.

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