Tetrahedron Letters, Vol.32, No.31, pp 3867-3870, 1991
Printed in Great Britain

0040-4039/91 $3 00 + 0
Pergamon Press plc

A NOVEL SYNTHESIS OF THIOPHENES FROM ALLENIC SULFONES INVOLVING α,β-UNSATURATED SULFINES AS INTERMEDIATES

S. Braverman#, P.F.T.M. van Asten, J.B. van der Linden and B. Zwanenburg*

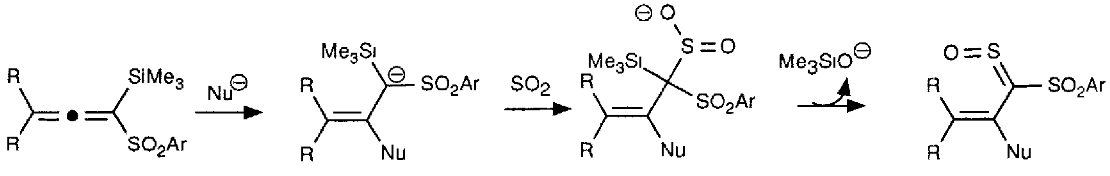
Department of Organic Chemistry, NSR Center for Molecular Structure, Design and Synthesis, University of Nijmegen, Toernooiveld, 6525 ED Nijmegen, The Netherlands

Abstract: *A new method for the synthesis of α,β-unsaturated sulfines by a Peterson alkylidenation of sulfur dioxide is described. The required α-silyl carbanions are generated by heteroconjugate addition of alkyllithium to α-trimethylsilylated allenic sulfones. The conjugated vinylsulfines thus prepared undergo a rapid and unprecedented cycloaromatization to thiophene derivatives. A mechanism for this remarkable conversion is presented.*

During the past three decades a large variety of substituted sulfines has been reported[1]. Thus far, conjugated vinylsulfines received scarce attention in the literature. They have been prepared by oxidation of the corresponding α,β-unsaturated thiones[2], by rearrangement of vinylsulfinyl carbenes[3], by oxidation of 2,5-dimethylthiophene with singlet oxygen[4] and as intermediates in a thermal fragmentation of their formal dimers[5]. All these routes have a very limited scope.

Oxidation of thiocarbonyl compounds is the most general route to sulfines[1], although there are some limitations regarding the availability of suitable starting materials. An alternative and also general approach to the synthesis of sulfines involves the Peterson alkylidenation of sulfur dioxide. The α-silyl carbanions required for this method of preparation can be obtained either by deprotonation of appropriate silyl compounds[6] or by heteroconjugate addition[7] of alkyllithium to vinylsilanes[8].

Scheme 1



A **B** **C**

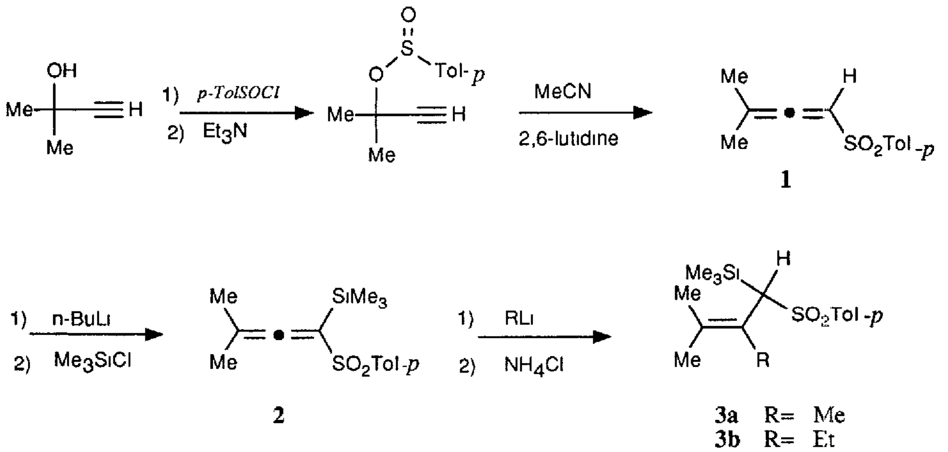
In this paper we report our efforts to prepare α,β-unsaturated sulfines by a modified Peterson reaction. The design for the synthesis of conjugated vinylsulfines C involves heteroconjugate addition of a suitable

---

On leave from the Department of Chemistry, Bar-Ilan University, Ramat-Gan, Israel.

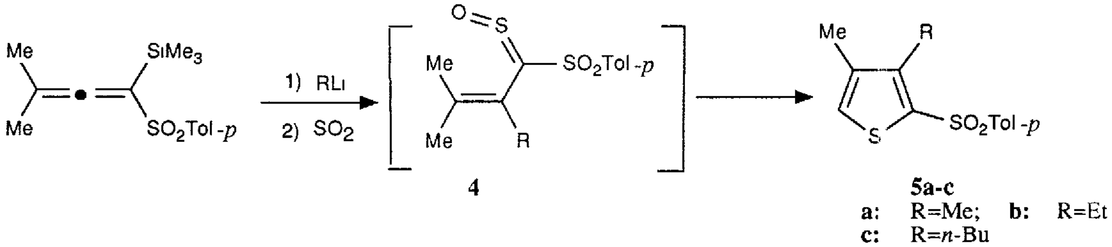
nucleophile to α-silylated allenic sulfones **A**, as depicted in Scheme 1. An attractive feature of the proposed scheme is that allenic sulfones are readily available starting materials[9] and that the heteroconjugate addition of various nucleophiles to these unsaturated sulfones has already been demonstrated[10].

Scheme 2



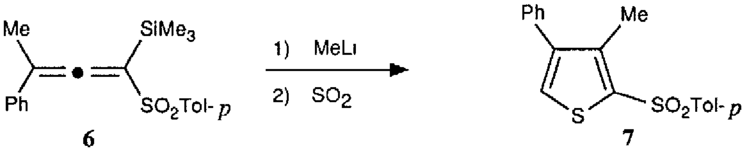
γ,γ-Dimethylallenyl *p*-tolyl sulfone **1** was selected as the first substrate and was prepared by the [2,3]-sigmatropic rearrangement of α,α-dimethylpropargyl *p*-toluenesulfinate, as described previously[11] (Scheme 2). Treatment of a solution of the sulfone **1** in THF with 1.1 equivalent of n-butyllithium at -78°C for 3 hrs, followed by addition of 1.2 equivalent of chlorotrimethylsilane at the same temperature, resulted in the formation of the corresponding trimethylsilane derivative[12] **2**, in practically quantitative yield. It should be noted that control of temperature is very important; if the reaction is carried out at 0°C dimerization to a conjugated vinylallene derivative is observed[10d] and hardly any trimethylsilylation occurs. Interestingly, α-silylated allenic sulfones of type **2** are virtually unknown in the literature[10e]. α-Silylallyl sulfone **2** undergoes smooth heteroconjugate addition on treatment with methyllithium. After quenching with aqueous ammonium chloride, α-silylallyl sulfone **3a** was obtained in quantitative yield. Similarly, treatment of **2** with n-butyllithium gave product **3b** in 80% yield. This result implies that anions of type **B** shown in Scheme 1, indeed are formed by the planned heteroconjugate addition to substrate **A**.

Scheme 3



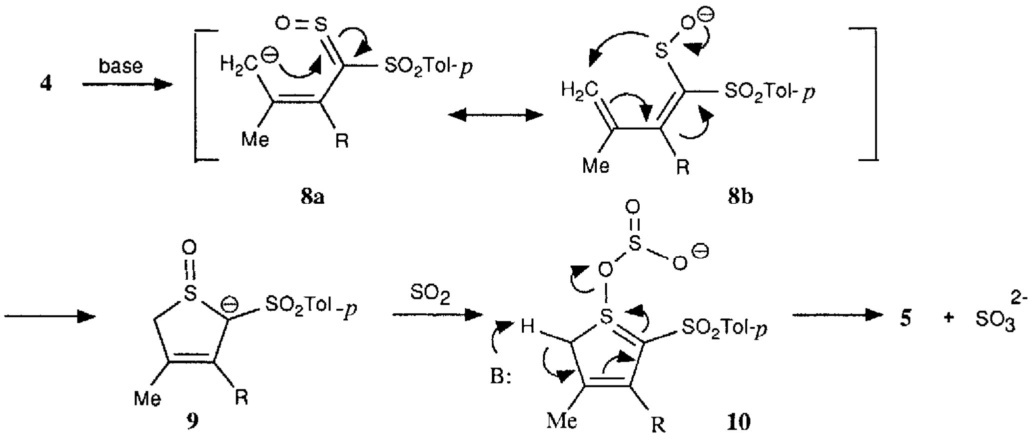
A remarkable result was obtained when the preparation of an α,β-unsaturated sulfine was attempted as proposed in Scheme 1. Treatment of α-silylallenyl sulfone **2** with methyllithium in THF at -78°C for 3 hrs, and adding the solution of the allyl α-silyl carbanion thus formed to an excess of sulfur dioxide in THF at -78°C in 3 hrs, followed by stirring of the reaction mixture for 15 hrs at -70°C, did not produce the expected sulfine **4**, but instead, 3,4-dimethyl-2-*p*-tolylsulfonylthiophene[12] (**5a**, m.p 125°C) was isolated in a yield of 75% (Scheme 3). It is interesting to note that addition of 2,3-dimethylbutadiene, a standard sulfine trap, to the reaction mixture had no effect on the formation of thiophene **5a** or its yield. This indicates that the rearrangement of the expected sulfine **4** to the observed thiophene derivative **5a** is even faster than its Diels-Alder addition to the diene. Reaction of **2** with ethyl and n-butyllithium followed by treatment with sulfur dioxide, similarly resulted in the thiophenes **5b** and **5c**, respectively[12] (**5b**, m.p. 96°C, yield 55%; **5c**, m.p.98°C, yield 35%). An attempt to accomplish an analogous reaction with *tert*-butyllithium failed, probably due to steric reasons.

Scheme 4



Starting from α-silylallenyl sulfone **6**, which can be readily prepared from the ethynyl carbinol derived from acetophenone (cf Scheme 2), thiophene derivative **7** was prepared in 40 % yield (m.p. 142°C) as shown in Scheme 4. The new synthesis of substituted thiophenes described above, produces 2-sulfonyl substituted thiophenes which are scarcely encountered in the literature, moreover, thiophenes are formed with substituents at the 3- and 4-positions.

Scheme 5



The novel cycloaromatization reaction can mechanistically be rationalized by assuming that initially an α,β-unsaturated sulfine **4** is being formed as expected according to Scheme 1. Subsequent proton abstraction, with trimethylsilanolate acting as the base, from the γ-carbon atom of **4** leads to allylic anion **8a**, alternatively described as mesomeric form **8b**. Intramolecular addition, which is conceivable from either mesomeric form of anion **8** (see Scheme 5), leads to product **9**. Aromatization and concomitant deoxygenation can be envisaged by invoking a reaction with sulfur dioxide as pictured in structure **10**. This elimination of HSO_3^- is reminiscent of a novel Pummerer-type rearrangement, induced by sulfur dioxide under basic conditions. Current investigations are directed towards the elucidation of the mechanism, as well as to explore the scope and limitations of this new thiophene synthesis.

Acknowledgement: This investigation was supported by the Netherlands Foundation of Chemical Research with financial aid from the Netherlands Organization for Scientific Research (NWO). One of us (S.B.) expresses his appreciation for the award of an NWO-visiting professorship.

References and Notes:

1. a: Zwanenburg, B. *Recl. Trav. Chim. Pays-Bas*, **1982**, *101*, 1; b: Zwanenburg, B. and Lenz, B.G." Houben-Weyl, *Methoden der Organischen Chemie", Band E 11/2, Organische Schwefelverbindungen*, Georg Thieme Verlag, Stuttgart, **1985**, p.911; c: Zwanenburg, B.in "*Rev. Heteratom. Chem*" (Oae, S. Ed), **1988**, *1*, 218; d. Zwanenburg, B *Phosphorus, Sulfur and Silicon*, **1989**, *43*, 1; e: Block, E. in "*Organic Sulfur Chemistry*", Freidlina, R.Kh. and Skorova, A.E Eds, Pergamon Press, Oxford, **1981**, p.15
2. a. Unpublished results from the autors laboratory (cf ref 1a); b: Saito, T.; Shibahara, N.; Motoki. S. *Tetrahedron Lett.*, **1983**, *24*, 4435; c· Barton, D H.R ; Choi, L.S.L.; Hesse, R.H.; Pechet, M.M.; Wilshire, C. *J.Chem. Commun.* **1975**, 557; d: Bognar, R.; Balint, J.; Rakosi, M. *Liebigs Ann. Chem* , **1977**, 1529.
3. Franck-Neumann, M ; Lohmann, J.J. *Tetrahedron Lett* , **1977**, 2391.
4. a· Skold, C.N.; Schlessinger, R.H. *Tetrahedron Lett.*, **1970** ,791; b: van Tilborg, W.J.M. *Recl. Trav. Chim. Pays-Bas*, **1976** , *95*, 140.
5. a· Karakasa, T.; Motoki, S. *Tetrahedron Lett.*, **1979**, 3961; b: Karakasa, T.; Ohmura, H.; Motoki, S. *Chem. Lett* , **1980**, 825.
6. a: van der Leij, M.; Porskamp, P.A.T W ; Lammerink, B.H.M.; Zwanenburg, B. *Tetrahedron Lett* , **1978**, 811.; b: van der Leij, M.; Porskamp, P.A T W.; Lammerink, B.H.M.; Zwanenburg, B. *Recl Trav. Chim Pays-Bas*, **1983**, *102*, 400 ; c Porskamp, P.A.T.W.; Lammerink, B.H.M.; Zwanenburg, B *J Org.Chem.*, **1984**, *49*, 263.
7. M. Isobe in: *Perspectives in the Organic Chemistry of Sulfur*, Eds., Zwanenburg, B.; Klunder, A.J.H., Elsevier, Amsterdam, 1987 The term "heteroconjugate addition" has been adopted from; Isobe, M ; Kitamura, M.; Goto, T. *Tetrahedron Lett.*, **1979**, *22*, 3465; b: Isobe, M.; Kitamura, M.; Goto, T. *Chem. Lett.*, **1980**, 3331
8. a van der Leij, M.; Zwanenburg, B *Tetrahedron Lett.*, 1978, 3383; b: Porskamp, P.A T.W.; van de Wijdeven, A.M., Zwanenburg, B. *Recl. Trav. Chim Pays-Bas*, **1983**, *102*, 506.
9. Braverman, S. in: *The Chemistry of Sulfones and Sulfoxides,* Patai, S.; Rappoport, Z ; Stirling, C.J.M. Eds., Wiley, Chichester, **1988**, Ch. 13.
10. a: Stirling, C.J.M. *J Chem Soc* , **1964**, 5856, 5863.; b: McMullen, C.H.; Stirling, C.J.M. *J. Chem. Soc , B*, **1966**, 1217, 1221.; c: Denmark, S.E.; Harmata, M.A *J Org Chem.*,**1987**,*52*, 4031; d: Braverman, S.; Freund, M.; Reisman, D.; Goldberg, I. *Tetrahedron Lett.*, **1986**, *27*, 1297; e: Ohmori, M.; Takano, Y.; Yamada, S.; Takayama, H *Tetrahedron Lett* , **1986**, *27*, 71.
11. Braverman, S.; Mechoulam, H *Tetrahedron*, **1974**, *30*, 3883
12. All new compounds gave satisfactory elemental analyses and IR, NMR and mass spectral data in accord with the assigned structures.

(Received in UK 30 April 1991)