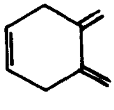
Tetrahedron Letters,Vol.28,No.47,pp 5913-5916,1987 0040-4039/87 $3.00 + .00
Printed in Great Britain Pergamon Journals Ltd.

THE SYNTHESIS OF NEW 3,4-DIMETHYLENETHIOLANE DERIVATIVES

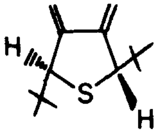
Samuel Braverman* and Meir Freund
Department of Chemistry, Bar-Ilan University
Ramat-Gan 52100, Israel

Summary: A convenient synthesis of the two new 3,4-dialkylidenethiolane derivatives 11 and 13, starting with the readily available condensed heterocycle 6 is described. Besides their synthetic utility as 1,3-dienes, these compounds are also of interest for the preparation of tetramethyleneethane diradical precursors.

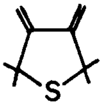
Since the preparation of the structurally unusual but relatively stable (double) exocyclic double bond isomer of *o*-xylene, 4,5-dimethylenecyclohexene (1), was first reported over three decades ago by Bailey and Rosenberg[1], a variety of other such isomers has been reported, including the corresponding five-membered oxygen[2], nitrogen[3] and sulfur[4] heterocycles (2). Of the last three compounds, 3,4-dimethylenethiolane (2, X=S) has received the most attention[5-9]. Its first synthesis by Gaoni was soon followed by the preparation of the two derivatives (3)[8] and (4)[9]. Besides their inherent structural interest, 3,4-dialkylidenethiolanes are also of synthetic interest as 1,3-dienes for various addition and cycloaddition reactions. They undergo oxidation to sulfones[4,8,9], which after Diels-Alder cycloaddition and subsequent stereospecific cheletropic[10] extrusion of sulfur dioxide[11,12], provide new conjugated dienes. An elegant application of this approach has been made by Beetz and Kellog[8] in the preparation of a tetramethyleneethane (TME) diradical (5) precursor. TME or 2,2'-bisallyl diradicals are the generally accepted intermediates in the well known and extensively studied dimerization of allenes to 1,2-dimethylenecyclobutanes[13], and in the thermally induced rearrangements of the latter[14]. In view of the interest in such systems, we now report the synthesis of the two new 3,4-dialkylidenethiolanes (11) and (13).


1

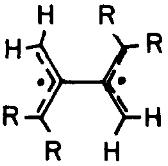

2 (X=O,NR,S)



3



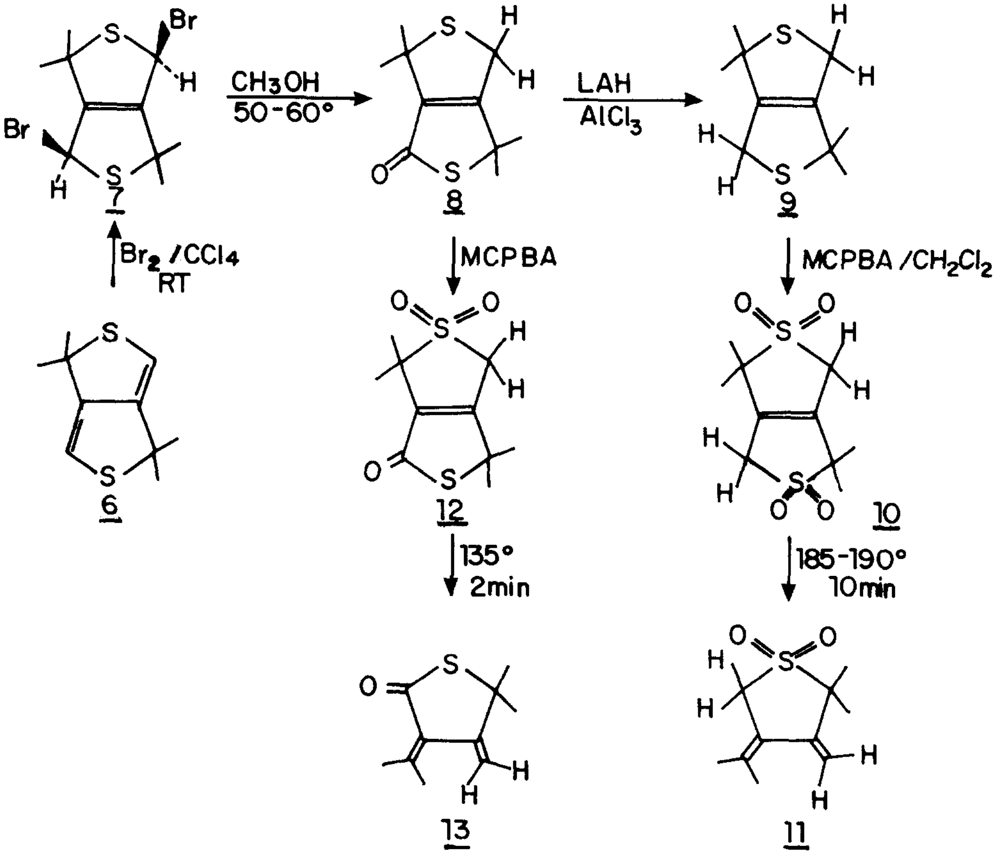
4



5

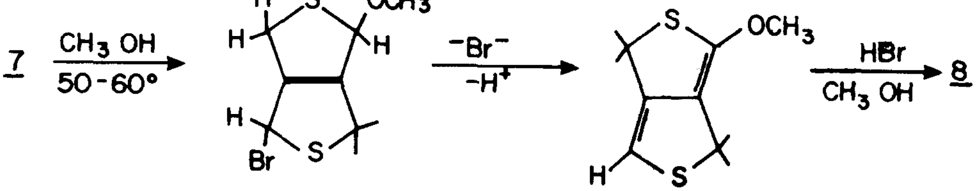
Previously, we have reported a facile synthesis of the novel 1,1,4,4-tetramethyl-1H,4H-thieno[3,4-c]thiophene (6) by the action of lithium methoxide on γ,γ-dimethylallenyl thiocyanate[15]. While investigating the chemistry of this condensed heterocycle, we have found that it provides a convenient entry to the synthesis of the two new 3,4-dialkylidenethiolanes (11) and (13)(Scheme 1).

Scheme 1



Addition of a carbon tetrachloride solution of bromine to compound (6) at room temperature gave the *cis*-dibromo-1,4 adduct (7)[16] exclusively and instantaneously (Scheme 1). This result is of interest because the addition of bromine to various cyclic and acyclic 1,3-dienes is frequently neither regio- nor stereospecific; however, high *cis*-stereoselectivity pertains for cases which also show a high ratio of 1,4- to 1,2-addition[17]. Methanolysis of (7) in the presence of triethylamine provided the corresponding dimethoxy derivative, a double monothioacetal, as a mixture of *cis* and *trans* isomers.[18] However, addition of methanol to a preheated sample of compound (7) in the absence of base gave the crystalline, stable, 1,1,4,4-tetramethyl-1H,4H-thieno[3,4-c]thiophene-6-dihydro-3-one (8)[16] rapidly in 70% yield. A tentative mechanism to explain the formation of thiolactone (8) is shown in Scheme 2. Both the methanolysis of (7) and subsequent work-up were performed under anhydrous conditions.

Scheme 2



While each of the generally recognized methods for converting lactones to cyclic ethers suffers from distinct structural limitations[19], apparently no general method for the conversion of thiolactones to cyclic sulfides has ever been published. Our initial attempts to employ Pettit's reagent derived from lithium aluminium hydride and boron trifluoride etherate, which is very effective with certain lactones[20], failed completely to reduce thiolactone (8). On the other hand, use of a similar procedure, a reagent derived from lithium aluminium hydride and aluminium chloride, originally employed for the reduction of α,β-unsaturated ketones[21] resulted in reduction of the thiolactone and formation of 1,1,4,4-tetramethyl-1H,4H-3,6-dihydrothieno[3,4-c]thiophene (9)[16] in 90% yield. Oxidation of this compound with MCPBA at room temperature afforded the corresponding bis sulfone (10)[16] directly. The latter, which dissolves poorly in chlorinated solvents was recrystallized from acetonitrile. Pyrolysis of (10) at 185-190^{0} for ten minutes affords 2,2-dimethyl-3-methylene-4-isopropylidenethiolane-1,1-dioxide (11)[16], the first 3,4-dimethylenethiolane derivative which bears alkyl substituents on the diene system in 68% yield. It is noteworthy that tetramethyleneethane diradical derivative (5, R=Me) is separated from (11) by a mere sulfur dioxide bridge. Compound (11) and its analogues may well serve as a convenient precursor for this elusive class of compounds[8,9].

Oxidation of thiolactone (8) in chloroform at 0^{0} using only two mole equivalents of MCPBA affords monosulfone (12)[16] exclusively in 80% yield. The latter is readily pyrolyzed by the gas chromatograph technique[11b], and affords 2,2-dimethyl-3-methylene-4-isopropylidenethiolane-5-one (13) in 74% yield, after two minutes at 135^{0}. We note that bicyclic compound (8) is composed of a thiolactone ring fused to a thiolane ring. The absence of any observable reaction in the thiolactone moiety upon treatment with MCPBA under these conditions is explained in terms of the low reaction temperature employed for the transformation of (8) to (12). In previously reported examples[22a,c] the conversion of α-ketosulfides to the corresponding sulfones required substantially higher temperatures. Considering that MCPBA oxidations of sulfides proceed via electrophilic mechanisms[23], it is not surprising then, that the more nucleophilic,nonconjugated sulfur in compound (8) is oxidized with greater facility.

REFERENCES AND NOTES

1. W.J. Bailey and J. Rosenberg, *J. Amer. Chem. Soc.*, 77, 73 (1955).
2. (a) W.J. Bailey and S.S. Miller, *J. Org. Chem.*, 28, 802 (1963); (b) Y. Gaoni, *Tetrahedron Letters*, 2361 (1973).
3. (a) H.W. Gschwend and H. Haider, *J. Org. Chem.*, 37, 59 (1972); (b) Ref. 2b.
4. (a) Ref. 2b; (b) S. Sadeh and Y. Gaoni, *Tetrahedron Letters*, 2365 (1973).
5. C.S. Marvel and E.E. Ryder, *J. Amer. Chem. Soc.*, 77, 66 (1955).
6. C.S. Marvel, R.M. Novak and E.J. Economy, *ibid.*, 78, 6171 (1956).
7. E.J. Fetter, *Dissertation Abstr.*, 22, 2985 (1962).

8. T. Beetz and R.M. Kellog, J. Amer. Chem. Soc., 95, 7925 (1973).
9. A.G. Talma, J.G.M. Goorhuis and R.M. Kellog, J. Org. Chem., 45, 2544 (1980).
10. (a) R.B. Woodward and R. Hoffmann, Angew. Chem. Int. Ed. Engl., 8, 781 (1969); (b) M.J.S. Dewar, ibid., 10 761 (1971).
11. (a) W.L. Mock, J. Amer. Chem. Soc., 88, 2857 (1966); (b) S.D. McGregor and P.M. Lemal, ibid., 88, 2858 (1966).
12. For a comprehensive and excellent review on the pyrolysis of sulfones see: F. Vögtle and L. Rossa, Angew. Chem. Int. Ed. Engl., 18, 515 (1979).
13. For reviews on this subject see: (a) J.D. Roberts and C.M. Sharts, Org. React., 12, 1 (1962); (b) J.E. Baldwin and R.H. Fleming, Fortsch. Chem. Forsch., 15, 281 (1970); (c) H. Hopf, in "The Chemistry of the Allenes" Vol 2, S.R. Landor Ed., Academic Press, London, 1982, p.525; (d) D.J. Pasto, Tetrahedron, 40, 2805 (1984).
14. e.g. (a) W. von E. Doering and W.R. Dolbier, Jr., J. Amer. Chem. Soc., 89, 4534 (1967); (b) J.J. Gajewski and C.N. Shih, ibid., 94, 1675 (1972); (c) W.R. Dolbier, Jr., and S-H. Dai, ibid., 92, 1774 (1970); (d) C.S. Chang and N.L. Bauld, ibid., 94, 7593, 7594 (1972); (e) B.G. Odell, R. Hoffmann and A. Imamura, J. Chem. Soc., (B), 1675 (1970).
15. S. Braverman, M. Freund and I. Goldberg, Tetrahedron Letters, 21, 3617 (1980).
16. All new compounds gave satisfactory elemental analysis and/or ir, nmr and mass spectral data in accord with the assigned structures: thiolactone 8 (mp, 147-148°), disulfide 9 (mp, 109-110°), disulfone 10 (mp, 205° (d)), monosulfone 12 (mp, 153-154°).
17. e.g. G.E. Heasley, V.L. Heasley, S.L. Manatt, H.A. Day, R.V. Hodges, P.A. Kroon, D.A. Redfield, T.L. Rold and D.E. Williamson, J. Org. Chem., 38, 4109 (1973).
18. R.G. Bordwell, G.D. Cooper and H. Morita, J. Amer. Chem. Soc., 79, 376 (1957).
19. S.W. Baldwin, R.J. Doll and S.A. Haut, J. Org. Chem., 39, 2470 (1974).
20. e.g. G.R. Pettit, U.R. Ghatak, B. Green, T.R. Kasturi, D.M. Piatak, J. Org. Chem., 26, 1685 (1961).
21. J. Broome, B.R. Brown, A. Roberts and A.M.S. White, J. Chem. Soc., 1406 (1960).
22. α-Oxosulfones have been rarely prepared, see: (a) H. Kohn, P. Charumilind and S.H. Simonsen, J. Amer. Chem. Soc., 101, 5431 (1979); (b) K. Schank and F. Werner, Tetrahedron Letters, 2567 (1977); (c) T. Olijnsma, J.B.F.N. Engberts and J. Strating, Rec. Trav. Chim., 89, 897 (1970); (d) A. Senning, O.N. Sorensen and C. Jacobsen, Angew. Chem., 80, 704 (1968).
23. S. Oae and T. Takata, Tetrahedron Letters, 21, 3213 (1980); For a review see D. Bernard L. Bateman and J.I. Cuneen, in Organic Sulfur Compounds, N. Kharasch, Ed., Pergamon Press, Oxford, 1961, Ch. 21.

(Received in UK 25 September 1987)