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[2+2]CYCLOADDITION OF SUBSTITUTED THIOPHENES TO ACETYLENES

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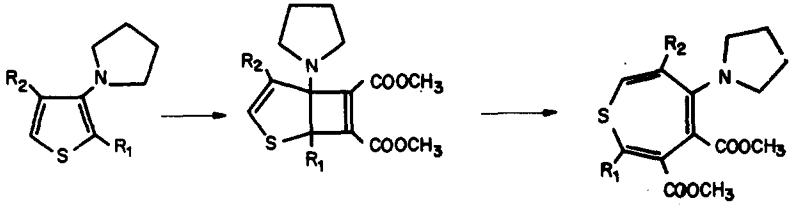
Recently both groups of authors reported independently the first synthesis of a monocyclic thiepine[1,2]. Two modes of preparation were recorded. One comprised the cycloaddition of 3-methyl-4-pyrrolidinothiophene to dimethyl acetylenedicarboxylate at -30 °. Subsequent isomerization, at this temperature, of the initially formed 5-pyrrolidino-2-thiabicyclo[3.2.0]hepta-3,6-diene (I) yielded a monocyclic thiepine (II)[1] (Scheme 1). The structure of this thiepine was confirmed by PMR and IR spectroscopy. At -30 ° the sulphur was slowly extruded from the thiepine to give the corresponding benzene derivative.



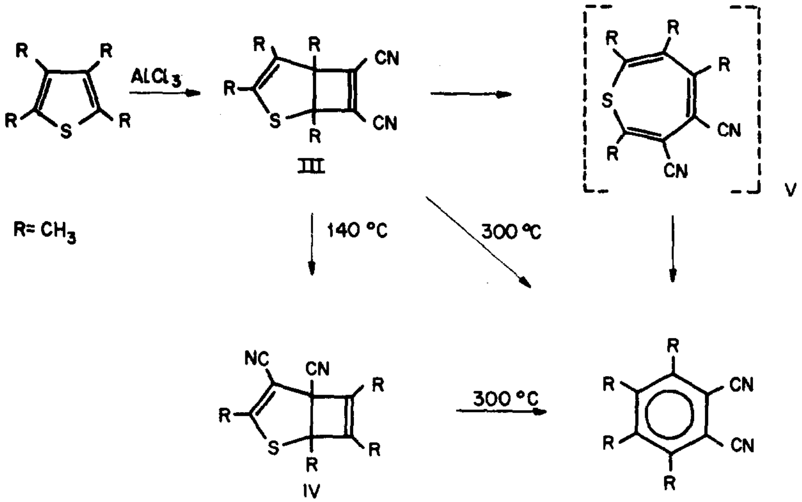
I

II

$R_1, R_2 = H, CH_3$

SCHEME 1

The other synthesis was described as a facile reaction at room temperature between tetramethylthiophene and dicyanoacetylene in the presence of $AlCl_3$[2]. On the basis of spectroscopical data (IR, UV, PMR and MS) of the reaction product as well as of its sulphone, a thiepine structure (V) was assigned. The product, m.p. 93-94 °, could be pyrolysed at 300 ° to tetramethylphthalonitrile; heating at 140 °yielded an isomer, m.p. 97.5-99 °, to which structure IV was assigned (Scheme 2).

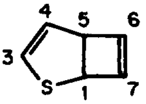


SCHEME 2

The difference in thermal stability between II and V was striking and difficult to interpret[3]. The theoretically predicted instability of thiepines[4] cast some doubt on the structural assignment of the reaction product of tetramethylthiophene and dicyanoacetylene. In addition, the medium strong absorption at 1610 cm^{-1} in the IR spectrum of this product could equally well be assigned to a bicyclobutene structure[6] as to a thiepine.

In order to arrive at an unambiguous assignment ^{13}C NMR spectra were recorded for the product of this reaction and its isomer (IV). They showed that the two compounds had the same structural skeleton: 4 sp^2 C atoms, 2 nitrile C atoms, 2 bridgehead C atoms and 4 methyl C atoms (the latter showed up as quartets on partial decoupling, Table I[8]). These data leave no doubt that the reaction product of tetramethylthiophene and dicyanoacetylene is not a thiepine (V), as proposed earlier[2], but a 2-thiabicyclo[3.2.0]heptadiene (III) formed by a [2+2]cycloaddition.

Table I ^{13}C NMR chemical shifts of 2-thiabicyclo[3.2.0]hepta-3,6-dienes[a]

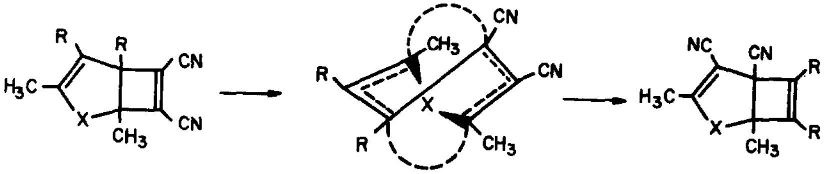


No. of compound	$\delta_{C_{3,4,6,7}}$ [b]	δ_{CN}	$\delta_{C_{1,5}}$	δ_{CH_3} [c]
III	131.3 128.7 126.8 124.4	110.7 110.1	72.8 63.7	19.4 15.2 14.9 12.7
IV	162.3 145.9 140.0 114.9	113.7 100.5	66.4 62.0	22.2 18.2 10.8 9.2

a. In CCl_4 solution with CS_2 as internal standard.
b. Chemical shifts are given in ppm relative to TMS = 0.
c. Quartets on partial C-H decoupling.

The difference in thermal stability between the 2-thiabicyclo[3.2.0]hepta-3,6-dienes I and III can be explained as follows. The cyclobutene ring in III is thermally stable because the symmetry-allowed conrotatory ring opening would give rise to a <u>cis</u>, <u>trans</u>, <u>cis</u>-thiacycloheptatriene. In I the opening of the cyclobutene ring is accelerated by the presence of the donating bridgehead pyrrolidino substituent and proceeds via a two-step process (compare ref. 9).

The isomerization of III into IV and of VI into VII are the first examples of a [3,3] antara,antara Cope rearrangement of 2-<u>hetero</u>bicyclo[3.2.0]hepta-3,6-dienes.



III ; X = S, R = CH_3
IIIa ; X = S, R = CH_2D
VI ; X = SO_2, R = CH_3

IV ; X = S , R = CH_3
IVa ; X = S , R = CH_2D
VII ; X = SO_2, R = CH_3

Mukai et al.[10] and Baldwin et al.[11] recently reported a similar rearrangement in the carbocyclic series (X = CO and $C(CH_3)_2$). Other postulated pathways, a twofold antara,supra [1,3] sigmatropic reaction and the symmetry-allowed conrotatory opening of the cyclobutene ring, are unlikely[10,11]. The first would give rise to a thianorcaradiene as an intermediate - a structure which will eliminate sulphur rapidly - and the second to a highly strained <u>cis</u>, <u>trans</u>,-<u>cis</u>-thiacycloheptatriene system. Desulphurization of III and IV at 300 ° may well proceed via thiepine V (compare ref. 10).

Acknowledgement

We thank Dr. A.D.M. Clague and Mr. L.L. Blaauw of the Koninklijke/Shell-Laboratorium for recording and interpreting the ^{13}C NMR spectra.

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2. H. Wynberg and R. Helder, <u>Tetrahedron Letters</u>, <u>1972</u>, 3647.
3. The observed high thermal stability of an annulated thiepine reported by Hoffman and Schlessinger[5] is misleading because in this compound the two bulky groups at C_2 and C_7 render desulphurization difficult.
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