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GENERATION OF PHOSPHITE YLIDES FROM TRITHIOCARBONATES AND TRIMETHYL PHOSPHITE AND THEIR APPLICATION TO THE EXTENSION OF CARBON CHAINS

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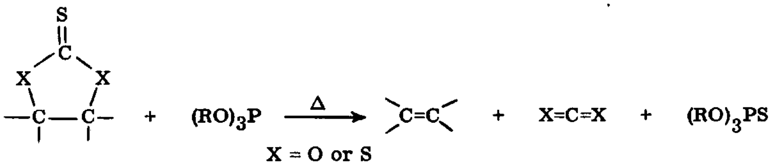
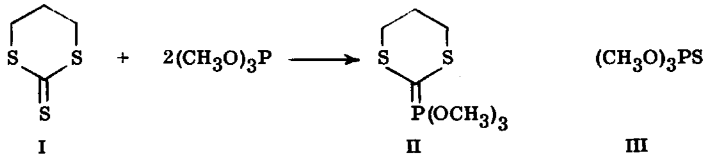
The reaction of cyclic 1,2-thionocarbonates or 1,2-trithiocarbonates with alkyl phosphites leads to olefins by cis-elimination (1,2) according to the overall equation:

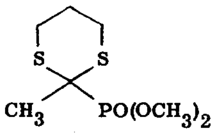


This note describes the somewhat different behavior of cyclic 1,3-trithiocarbonates which are transformed into phosphorus ylides by sulfur-phosphite exchange rather than cyclopropanes by 1,3-elimination. Evidence is also presented for the intermediacy of phosphite ylides in olefin formation from 1,2-trithiocarbonates.

The readily available 1,3-dithiacyclohexan-2-thione (I) (3) reacts quantitatively with excess trimethyl phosphite at 55° for 3 hr. under nitrogen to yield a 1:1 mixture of 1,3-dithiacyclohexylidinetrimethoxyphospnorane (II) and trimethyl thionophosphate (III) which are obtained together as a viscous liquid after lyophillization to remove excess trimethyl phosphite at 0.05 mm. The p.m.r. spectrum of the mixture dissolved in $CDCl_3$ shows the peaks expected for the thionophosphate III and, in addition, a doublet at 3.69 and 3.88 ppm. (downfield from tetramethylsilane) due to $P\text{-}OCH_3$ and a broad band peaking at 2.37 ppm. due to the methylene protons (ratio 1.5) of the ylide II. The ylide, which is air sensitive and also thermally



unstable, is not readily separated from III; however, its chemical properties are in full accord with expression II. Upon heating to 70-80° for 24 hr., it is converted into the phosphonate derivative IV, isolated by distillation at 90° (0.1 mm.) and recrystallization from ligroin, m.p. 51-53°, and characterized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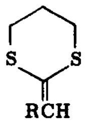
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analytically (4a) and spectroscopically [p.m.r. ($CDCl_3$), doublet 3.77 and 3.94 ppm. due to $P-(OCH_3)_2$, doublet at 1.35 and 1.59 ppm. due to $C-CH_3$, and multiplets in the region 1.7-2.7 ppm. due to four methylene protons and at 3.35-3.75 ppm. due to two methylene protons, probably one from each of the $-CH_2S-$ groupings; infrared absorption at 1250 cm.$^{-1}$ (P=O)].

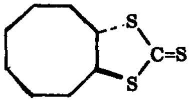
The ylide II reacts rapidly and exothermically with benzaldehyde to form the liquid ketene thioacetal V, R = C_6H_5, b.p. 142-145° (0.1 mm.) (90% yield), which was characterized analytically (4a) and by oxidation using m-chloroperbenzoic acid to the corresponding bis-sulfone (4), m.p. 198-199°. The ketene thioacetal V, R = C_6H_5, exhibits an absorption maximum in the ultraviolet at 306 mμ (hexane) and p.m.r. peaks (in $CDCl_3$) at 7-7.5 (multiplet, 5 H, phenyl), 6.77 (1 H, -CH=), 2.63-2.89 (4 H, $-CH_2S-$), and 1.68-2.11 ppm. (2 H, $-CH_2-$) as expected for this structure. The conversion of benzaldehyde to the ketene thioacetal V, R = C_6H_5, can also be effected by reaction of a mixture of the trithiocarbonate I, benzaldehyde and excess trimethyl phosphite at 55°, without prior formation of the intermediate ylide II.

The synthesis of ketene thioacetals from aldehydes and the ylide II appears to be quite general. For example, the reaction of pre-formed phosphite-free ylide II with p-nitrobenzaldehyde, cinnamaldehyde and isobutyraldehyde led in good yield to the corresponding Wittig-type products (4) V, R = $p-NO_2-C_6H_4$, m.p. 118-121°, V, R = $C_6H_5CH=CH$, m.p. 86-87°, and V, R = $(CH_3)_2CH$ (liquid), the structures of which were supported by p.m.r. data. It should be noted that certain aldehydes, e.g., p-nitrobenzaldehyde, are sufficiently reactive toward trimethyl phosphite to render the one-step reaction from aldehyde, trithiocarbonate I and trimethyl phosphite inoperable (5); in these cases pre-formed phosphite-free ylide II must be used.

The ylide II did not react measurably with a number of ketones under conditions (25°, 24 hr.) far in excess of those required for complete reaction with aldehydes. Indeed, even under the more drastic conditions which convert the ylide II to the phosphonate IV (60° up to 24 hr.), no Wittig-type products could be obtained from acetone, cyclohexanone, acetophenone, or benzophenone. Thus, a remarkable selectivity of the ylide II among carbonyl compounds is evident. Since ketene thioacetals upon hydrolysis yield carboxylic acids, it is apparent that the ylide II, which is now easily available in quantity, can be used as a reagent for the selective transformation of an aldehyde RCHO to the homologous acid RCH_2COOH. In addition it should be noted that the ketene thioacetals V are themselves useful synthetic intermediates (6,7). It has previously been reported that very stable phosphite ylides can be produced by the reaction of 2,2,4,4-tetra-trifluoromethyl-1,3-dithietane or thiofluoroenone with trimethyl phosphite (8); it is not clear at present if these stabilized ylides are suitable as Wittig reagents.

An ylide analogous to II has also been prepared from 5,5-dimethyl-1,3-dithiacyclohexan-2-thione and trimethyl phosphite; it too reacts smoothly with aldehydes to form ketene thioacetals.

The formation of phosphite ylides such as II from the reaction of six-membered 1,3-trithiocarbonates such as I and the fact that such ylides can be trapped by aldehydes encouraged us to investigate the possible intermediacy of phosphite ylides in the stereospecific synthesis of olefins from alkyl phosphites and 1,2-trithiocarbonates (2). Indeed, it was possible to show that the formation of *trans*-cycloöctene from *trans*-1,2-cycloöctene trithiocarbonate (VI) (2) and phosphite esters, which normally proceeds in high yield, was inhibited by the presence of excess benzaldehyde which caused instead the formation of a ketene thioacetal. Specifically, with excess trimethyl phosphite and excess benzaldehyde at 120° for 42 hr., the ketene thioacetal VII (4), m.p. 81-82°, was obtained from VI in 62% yield. A parallel result was obtained with *trans*-1,2-cyclohexene trithiocarbonate (9) in place of VI with benzaldehyde as the ylide trap; in this case the ketene thioacetal (4) had m.p. 99-101°; it is noteworthy that this trithiocarbonate upon heating alone with trimethyl phosphite affords the coupling product VIII(not cyclohexene) presumably by a Wittig reaction between an intermediate phosphite ylide and the trithiocarbonate.



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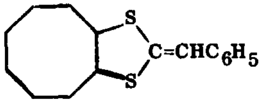

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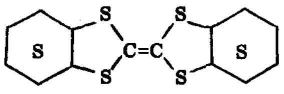

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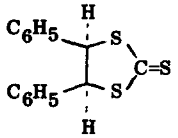

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In contrast, the reaction of the *cis*-trithiocarbonate IX with trimethyl phosphite in the presence of benzaldehyde yielded the elimination product, *cis*-stilbene, and not the phenylketene thioacetal.

It appears likely on the basis of the above results that phosphite ylides are formed as intermediates in the synthesis of olefins from trithiocarbonates and phosphites. In certain cases the ylides are easily diverted from olefin formation, while in others the ylide decomposes to olefin much more readily, rendering the efficient trapping of ylide more difficult.

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