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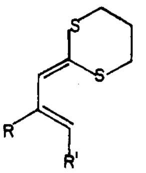
Conjugate and Diels-Alder Reactions of an Activated Allylidenedithiane

Summary: Peterson olefination of 2-methoxyacrolein and 2-lithio-2-trimethylsilyl-1,3-dithiane gives 2-(2-methoxy)-allylidene-1,3-dithiane; this compound reacts in a Michael sense with some electron-deficient unsaturated systems and in a Diels-Alder process with others.

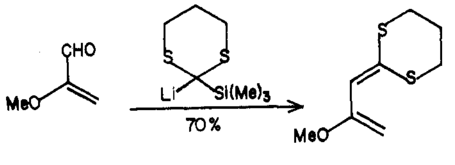
Sir: We have been studying the preparation and utilization of extensively functionalized dienes which might impart to their cycloaddition products relatively complex oxygenation and unsaturation patterns. This facet of the Diels-Alder reaction appears not to have received the degree of study commensurate with its potentialities in organic synthesis.[1-3]

Carey and Court[4] reported the preparation of alkylated allylidenedithianes and their study as potential enophiles. For instance, compound **1a** reacts with tetracyanoethylene and with maleic anhydride to give Diels-Alder adducts. However, it does not appear to react with weaker dienophiles.



1a R = R' = Me
1b R = R' = H

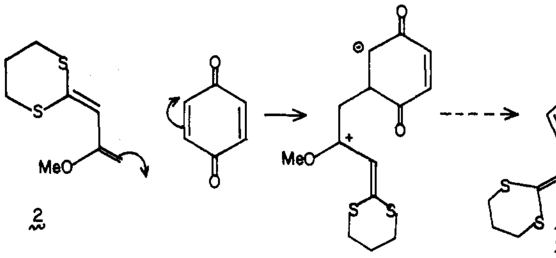
We reasoned that greater reactivity might be achieved if the terminal carbon of the allylidene group were unsubstituted, and if an additional electron-donating group were introduced at the 3 position of the diene. The synergism of such a group with the electron-donating capabilities of the sulfur atoms might be particularly helpful in promoting cycloadditions with electron-deficient dienophiles. Our precise objective thus became compound **2**.



2

In practice, Peterson olefination[5] of 2-methoxyacrolein[6] with 2-lithio-2-trimethylsilyl-1,3-dithiane[7] gave a 70% yield (distilled) of virtually[8] pure **2**: $\delta_{\text{ppm}}^{\text{CDCl}_3}$ 1.8–2.4 (m, 2), 2.8–3.1 (m, 4), 3.58 (s, 3), 4.13 (d, J = 2 Hz, 1), 4.18 (d, J = 2 Hz, 1), 6.18 (s, 1).[9] In the light of the reports of Seebach[10] that the parent compound **1b** was unstable, it was useful to discover that compound **2** can be prepared on a reasonably large scale and can be distilled [bp 92–94 °C (0.07 mm)] without serious decomposition.

Compound **2** reacts with 1,4-benzoquinone at room temperature. After 3 hr, a 62% yield of a crystalline product, mp 92–95 °C, was isolated. Its formula, $C_{13}H_{12}O_2S_2$, shows it to be a 1:1 adduct minus CH_3OH. Its infrared spectrum ($\lambda_{\max}^{\text{CHCl}_3}$ 2.85 µm) suggests the presence of a hydroxyl group but lacks absorptions which are characteristic of a carbonyl group. Acetylation with pyridine and acetic anhydride gives a monoacetate, mp 95–96 °C, $\lambda_{\max}^{\text{CHCl}_3}$ 5.70 µm. The NMR spectrum of this compound measured at 250 MHz [$\lambda_{\text{ppm}}^{\text{CDCl}_3}$ 2.05–2.20 (m, 2), 2.23 (s, 3), 2.85–3.05 (m, 4), 6.69 (s, 1), 6.83 (s, 1), 6.91 (d, d, J_1 = 8.0 Hz, J_2 = 2.5 Hz, 1), 7.20 (d, J = 2.5 Hz, 1), 7.35 (d, J = 8 Hz, 1)] defines its structure to be **4**.[9]



2

3 R = H
4 R = Ac

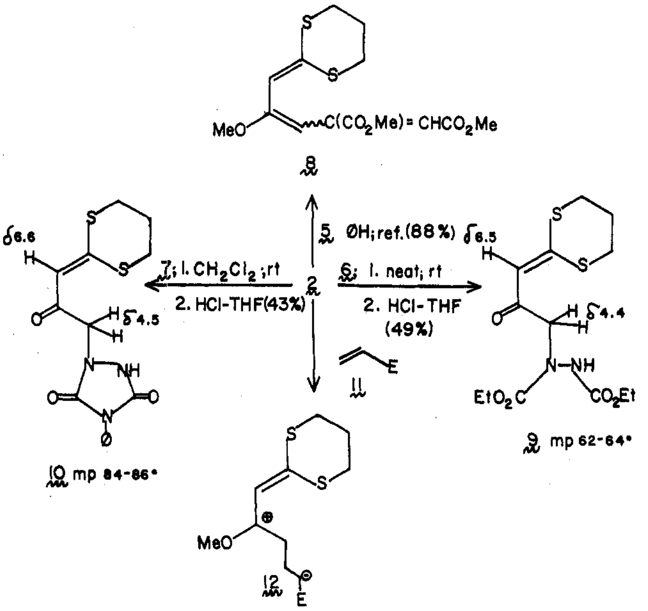
The formation of benzofuran **3** corresponds to Michael addition of diene **2** to the quinone followed by cyclization (with elimination of methanol) and tautomerization in unspecified order. Such a sequence finds analogy in the reaction of ketene acetals with quinones.[11]

The tendency of compound **2** to participate in Michael-type processes was also exhibited in its reactions with dimethyl acetylenedicarboxylate (**5**), diethyl azodicarboxylate (**6**), and 4-phenyl-2,4-triazoline-3,5-dione (**7**)[12] to give **8**,[9] **9**,[9] and **10**,[9] in the yields shown in Scheme I. In the latter two cases, homogeneous products were obtained as the ketones after hydrolysis of the intermediate enol ethers with dilute acid. Though full accounting of the reaction course was not achieved owing to the formation of complex products,[13] we found no evidence for the formation of any [4 + 2] cycloaddition adducts from these reactions.

These results may be understood in terms of the strongly nucleophilic character of diene **2** which is attacked by highly reactive unsaturated electrophiles (cf. **11**) in orientational arrangements which are not suitable for concerted cycloaddition. Dipolar structures of the type **12** which are produced find other pathways for charge dissipation which are of lower energy than cyclization.

On the basis of the arguments cited above, it seemed possible that *less reactive electrophiles might be more prone to give Diels-Alder products.* It was hoped that cycloaddition, which presumably requires more exacting orientational ar-

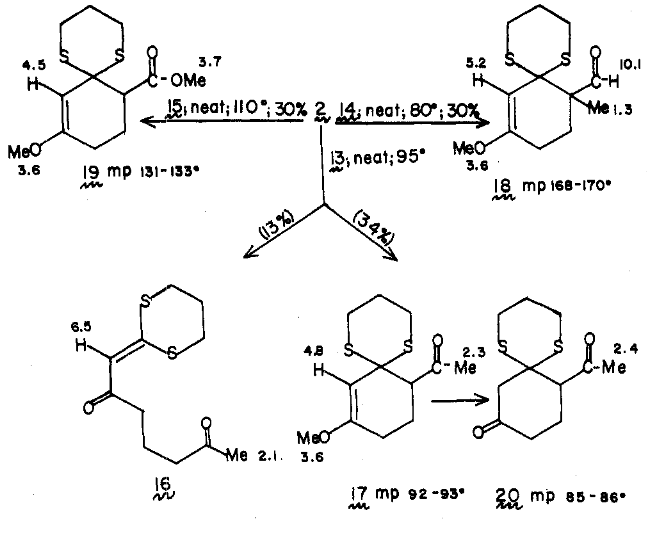
Scheme I



rangements in the alignment of the diene and the dienophile,[14] could be possible if the "electrophile" is of insufficient energy to react via a conjugate addition (one-bond) pathway. The latter process, while less entropically demanding, does, of course, require the sustenance of charged (or radical) intermediates.

While the reasoning advanced above must be regarded as conjectural, in practice *compound 2 does participate in Diels–Alder reactions with methyl vinyl ketone (13), methacrolein (14), and methyl acrylate (15)*. In the case of the reaction of **2** + **13**, a 13% yield of Michael-type product **16** was obtained along with the cycloaddition compound, **17**. In the reactions of **14** and **15** no Michael products were detected, though the complexity of the reaction mixtures[13] rules out a definite statement in this regard. The structures of compounds **16–19**[9] are rigorously proven by their infrared, NMR, and mass spectra. Pertinent reaction conditions and yields, as well as diagnostically valuable NMR chemical shifts (as $\delta_{\rm ppm}^{\rm CDCl_3}$ from tetramethylsilane) are given in Scheme II. Though of limited scope, diene **3** may be regarded as a synthetic equivalent of $^{+}C(O)CH_2C(O)C^{-}H_2$.[15] It will be noted that, in products **17**, **18**, and **19**, three carbonyl systems are produced in varying, but differentiated, states of exposure. While the synthetic value of such systems remains to be demonstrated, we note already that compound **17** reacts with aqueous HCl in THF, to give the specifically monoprotected 1,3,5 triketone **20** in 87% yield.

Scheme II



Studies involving the utilization of such systems as well as the exploration of new highly functionalized dienes are in progress and will be described in due course.

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Supplemental Material Available. Experimental procedures for these reactions (4 pages). Ordering information is given on any current masthead.

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α-Arylation of α,β-Unsaturated Ketones. Utilization of the α-Epoxytosylhydrazone Functional Group as a Δ^2-Enonium Synthon

Summary: The sequential reaction of α-epoxytosylhydrazones (easily available in two steps from α,β-unsaturated ketones) with *n*-butyllithium (1.0 equiv) followed by phenylcopper (1.2 equiv) yields α-aryl-β-hydroxytosylhydrazones which may be dehydrated and hydrolyzed to produce α-aryl α,β-unsaturated ketones.

Sir: In connection with a synthetic project, we required methodology for the α-arylation of α,β-unsaturated ketones (1 → 2).[1,2]