# Oxetane Synthesis: Methyl Vinyl Sulphides as New Traps of Excited Benzophenone in a Stereoselective and Regiospecific Paterno–Büchi Reaction

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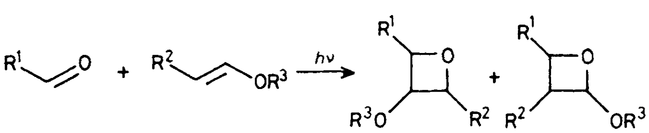
The almost exclusive products in the photochemical addition of benzophenone to methyl vinyl sulphides are the 3-methylthio-oxetanes, formed with selectivity for the *trans*-4-alkyl-3-methylthio configuration, as shown by an *X*-ray crystal structure determination and difference nuclear Overhauser effect studies.

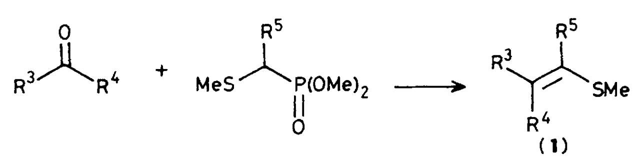
The photochemical [2 + 2]cycloaddition of aldehydes and ketones to simple enol ethers has been known for a long time and results in the production of 2- and 3-alkoxyoxetanes with a slight preference (1 : 1.4 to 1 : 2.5) for the latter (Scheme 1).[1] The corresponding vinyl sulphides have not been reported as general alkene components of the Paterno–Büchi reaction.[2] This communication indicates that the use of the sulphur counterparts instead of enol ethers has considerable advantages in terms of reaction rates and selectivities at least in their reaction with benzophenone.

The vinyl sulphides (**1a**—**f**)† were prepared by the Wadsworth–Emmons condensation according to the literature (Scheme 2).[3] In general those products predominated which had the SMe group and the larger alkyl group ($R^3$) in a *trans*-relationship. In the Paterno–Büchi reaction solutions of benzophenone and the vinyl sulphide in dry benzene (both 0.05—0.15 M) at approximately 10 °C were initially degassed by




**Scheme 1**

† Satisfactory spectral data and elemental analyses or high resolution mass spectra were obtained for new compounds.



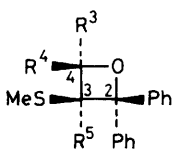

**a**; $R^3 = Pr^n$, $R^4 = R^5 = H$
**b**; $R^3 = Pr^i$, $R^4 = R^5 = H$
**c**; $R^3 = Bu^t$, $R^4 = R^5 = H$
**d**; $R^3 = PhCHMe$, $R^4 = R^5 = H$
**e**; $R^3, R^4 = -[CH_2]_5-$, $R^5 = H$
**f**; $R^3 = Pr^i$, $R^4 = H$, $R^5 = Me$

**Scheme 2.** *Conditions:* NaH, $C_6H_6$, room temp.

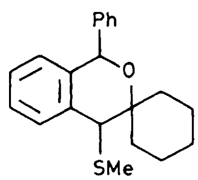
**Table 1.** Photochemical synthesis of the oxetanes (**2**) from the vinyl sulphides (**1**) and benzophenone.

| | Vinyl sulphide (**1**) | | | | Equivalent irradiation | Oxetane (**2**) | | Ratio |
|---|---|---|---|---|---|---|---|---|
| | Ratio *trans* : *cis* | $R^3$ | $R^4$ | $R^5$ | Time[a]/h; Conc./M | M.p., *t*/°C | Yield (%)[b] | *trans* : *cis* |
| (**1a**) | 6 : 1 | $Pr^n$ | H | H | 6.5; 0.05 | 29—31 | 59 | ≥97 : 3 |
| (**1b**) | 6 : 1 | $Pr^i$ | H | H | 6.5; 0.15 | 54—58 | 79 | 9 : 1 |
| (**1c**) | ≥97 : 3 | $Bu^t$ | H | H | 10; 0.05 | 59—63 | 52 | ≥97 : 3 |
| (**1d**) | 7 : 1 | PhCHMe | H | H | 20; 0.10 | 60—68[c] | 36 | ≥97 : 3 |
| (**1e**) | — | $-[CH_2]_5-$ | | H | 10.5; 0.05 | —[d] | 12[e] | — |
| (**1f**) | 4 : 1 | $Pr^i$ | H | Me | 2; 0.05 | 59—60 | 60 | 3 : 2 |

[a] Time of irradiation equivalent to that required for a 0.05 M solution. [b] Isolated products; yields are not optimised. [c] Isolated as a 1 : 1 mixture of diastereoisomers. [d] Gum. [e] + Pyran (**3**) (15%).




(**2**)




(**3**)

an upward flow of dry nitrogen through a glass frit for 30 min and then irradiated through Pyrex (>300 nm) using a Hanovia 125 W medium pressure lamp under continued agitation with dry nitrogen, to give the 3-methylthio-oxetanes (**2**).† The results are summarised in Table 1.

The reaction was regiospecific, with the 3-methylthio-oxetanes (**2**) forming the only regioisomers isolated or detected in the crude reaction mixtures. A high selectivity for the *trans*-4-alkyl-3-methylthio-oxetanes was observed as shown by *X*-ray crystallography for (**2b**)[4]‡ and by difference nuclear Overhauser effect (d.n.O.e.) studies for (**2a,c,d**). Thus the latter studies clearly showed the close spatial proximity of the SMe group and the proton on C-4. This method serves as an admirable alternative to approaches based on $^1H-^{13}C$ coupling constants[5] for the determination of the stereochemistry of oxetanes. For the formation of oxetane (**2f**), the stereoselectivity was less marked but the major isomer still contained the SMe and vicinal alkyl groups in a *trans*-relationship, again by d.n.O.e. studies. The non-stereospecific nature of the reaction was shown by the isolation of the product (**2f**) in the same ratio of stereoisomers irrespective of the isomer ratio of the starting vinyl sulphide (**1f**) (4 : 1 or 1.8 : 1 *trans* : *cis*).

The influence of increased substitution in the vinyl sulphide on the outcome of the reaction was interesting. For the 2,2-dialkyl congener (**1e**), a comparable quantity (15%) of the isomeric pyran (**3**) was produced in addition to oxetane (**2e**), and this possibly represents the steric limit to the synthetic potential of the method for oxetane formation. In contrast, the 1,2-dialkyl compound (**1f**) gave the oxetane cleanly and at a substantially faster rate than any other vinyl sulphide. In all cases reaction times were reduced in comparison to those for enol ethers (typically 48 h for 0.1 M solutions under 450 W irradiation[1]).

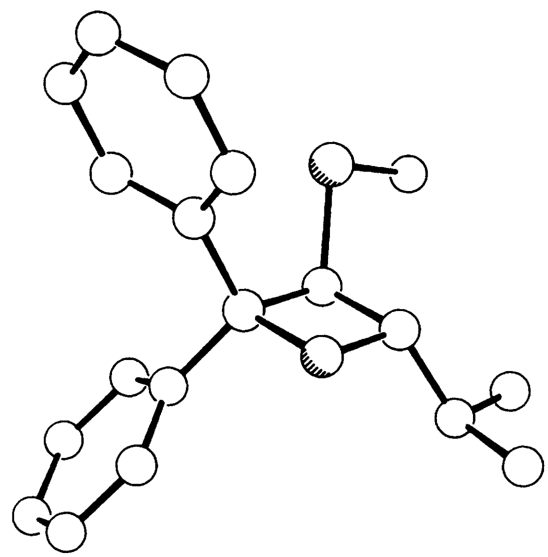


**Figure 1.** *X*-Ray structure of the methylthio-oxetane (**2b**).

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‡ *Crystal data:* $C_{19}H_{22}OS$, $M = 298.4$, monoclinic, $a = 8.497(2)$, $b = 19.151(4)$, $c = 10.769(3)$ Å, $\beta = 103.17(2)°$, $U = 1706$ Å$^3$, space group $P2_1/a$, $Z = 4$, $D_c = 1.16$ g cm$^{-3}$, $\mu(\text{Cu-}K_\alpha) = 16$ cm$^{-1}$. Data were measured on a Nicolet R3m diffractometer with Cu-$K_\alpha$ radiation (graphite monochromator) using ω-scans. The structure was solved by direct methods and refined anisotropically to give $R = 0.044$, $R_w = 0.051$ for 1981 independent observed reflections $[|F_o| \geq 3\sigma(|F_o|), \theta \leq 58°]$. Atomic co-ordinates, bond lengths and angles, and thermal parameters have been deposited at the Cambridge Crystallographic Data Centre. See Notice to Authors, Issue No. 1.

## References


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