Unprecedented Solvolytic Diversion of Carbonyl Oxide Intermediates derived from the Ozonolysis of 1-Methyl-2,3-diphenylindene. Isolation and Characterisation of a Novel Solvent-participated Product

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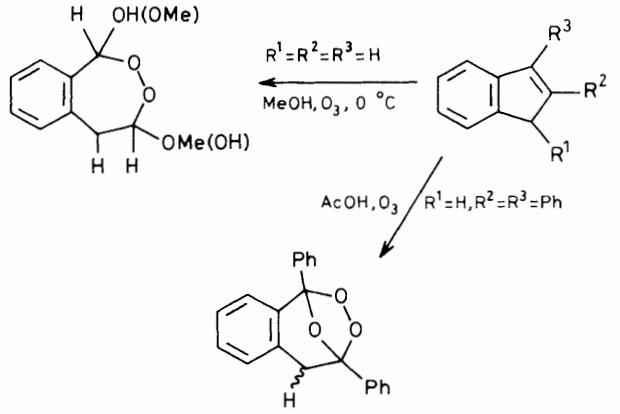
Ozonolysis of 1-methyl-2,3-diphenylindene (**1**) in methylene chloride–methanol at −70 °C affords a novel alkoxyhydroperoxide product (**3**), incorporating methanol, whose crystal structure has been established by *X*-ray analysis.

The reaction of ozone with cyclic olefins can give rise to a variety of products depending on the ring substituents and the reaction conditions.[1] In non-participating solvents, ozonation of indenes normally produces the corresponding bicyclic ozonides.[2] Alternatively, in protic solvents, the formation of ozonides may be retarded and cyclic hemiperacetals,[3] which have incorporated one molecule of solvent may be observed instead (Scheme 1).

We have recently shown that the ozonation of 1-methyl-2,3-diphenylindene (**1**) proceeds, not unexpectedly, in a similar fashion to that of 2,3-diphenylindene[4] (Scheme 1). Even in a mixed solvent system (CCl_4–MeOH, 1 : 1), the major ozonolysis products were the corresponding isomeric ozonides (**2**) (71%) together with a solvent-derived product (7%).† This product was obtained as the major isolable component (46%) when (**1**) was ozonised in CH_2Cl_2–MeOH (3 : 2) at −70 °C;‡

† Satisfactory microanalytical data have been obtained. Crystalline solid, m.p. 155—157 °C (from ethyl acetate–hexane); ^{1}H n.m.r. ($CDCl_3$, Me_4Si) δ 1.03 (3H, s, MeO), 3.34 (1H, q, *J* 7 Hz, –C*H*Me), 3.46 (3H, s, MeO), 7.0—7.9 (14H, m, aromatic), and 8.75 (1H, s, exchanges with D_2O, –OOH).

‡ The *exo*/*endo* ozonides (**2**) (27%) and dicarbonyl compounds derived from oxidative cleavage of the olefinic bond were also obtained; the latter were not quantified.



Scheme 1

although the analytical and spectral data indicated that it had been formed from (**1**) by incorporation of one equivalent of methanol, in addition to ozone, the data were incompatible with either the cyclic or open-chain hemiperacetals. An *X*-ray crystal structure determination was therefore undertaken.§

The crystal structure reveals that the solvent-derived product is an isochroman derivative (**3**) with relative stereochemistry as depicted in Figure 1. Compound (**3**) represents the first alkoxyhydroperoxide of this type isolated from an ozonolysis reaction.¶ A plausible mechanism for the conversion [(**1**) → (**2**) + (**3**)] based on the scission pathways (a and b) of the primary ozonide (**4**) is illustrated in Scheme 2.

In polar solvents, zwitterionic intermediates such as (**5**) derive some stabilisation from solvation. The absence of more conventional solvent-derived products, *e.g.* hemiperacetals, indicates that partial capture of the carbonyl oxide moiety by the adjacent carbonyl group oxygen (O-1) in (**5**), to produce cyclised forms (**6**) and (**7**), is faster than nucleophilic attack by methanol at C-1. Examination of molecular models, together with the crystal structure of (**3**), suggests that (**6**) might preferentially adopt a half-chair conformation, puckered at C-1, with the *cis* methyl and phenyl groups axial and equatorial respectively, and the peroxy moiety axial. Both the peroxy group and methanol may subsequently compete for capture of the incipient carbenium ion at C-9. At lower

§ *Crystal data*: compound (**3**), $C_{23}H_{22}O_4$, M = 362.4, triclinic, space group $P\bar{1}$, a = 9.047(2), b = 9.167(1), c = 12.016(2) Å, α = 72.91(1), β = 89.01(2), γ = 82.62(2)°, U = 944.5 Å^3, D_c = 1.275, D_m = 1.281 g cm^{-3}, Z = 2, μ(Mo-K_α) = 0.50 cm^{-1}. The intensity data were collected on an Enraf-Nonius CAD-4 diffractometer using graphite-monochromated Mo-K_α radiation and the ω–2θ scanning technique, corrected for Lorentz and polarisation effects, and crystal decay, but not for absorption. Of the 3547 intensities measured, 1653 had $|F| > 2\sigma(|F|)$. The structure was solved by direct methods using MULTAN 80[5] and refined by full-matrix least squares[6] (all non-hydrogen atoms were anistropic). The phenyl groups were treated as hexagonal rigid bodies. Hydrogen atoms were all found from difference-Fourier maps and included in calculated positions with fixed temperature factors in the final stages of refinement. At convergence, the final conventional *R*-factor was 0.062. The bond distances and angles were all within the expected ranges. The atomic co-ordinates for this work are available on request from the Director of the Cambridge Crystallographic Data Centre, University Chemical Laboratory, Lensfield Road, Cambridge CB2 1EW. Any request should be accompanied by the full literature citation for this communication.

¶ A methoxyhydroperoxide has recently been isolated from the photo-oxygenation of 5-methylfurfural at −60 °C in methanol. Since, however, this product results from nucleophilic attack of methanol on the strained bicyclic adduct, the hydroperoxy and methoxy groups are *trans* with respect to each other (ref. 7).

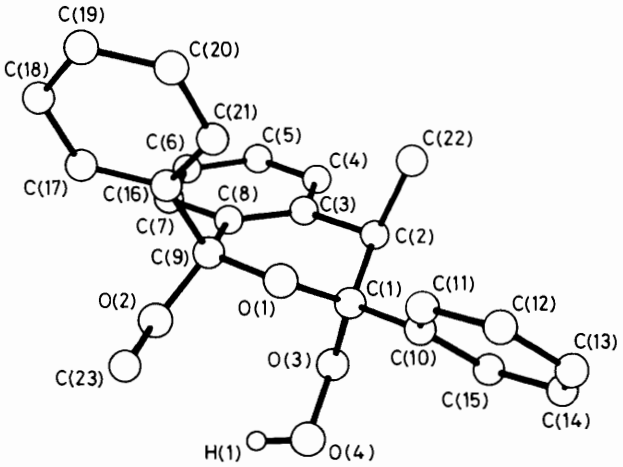
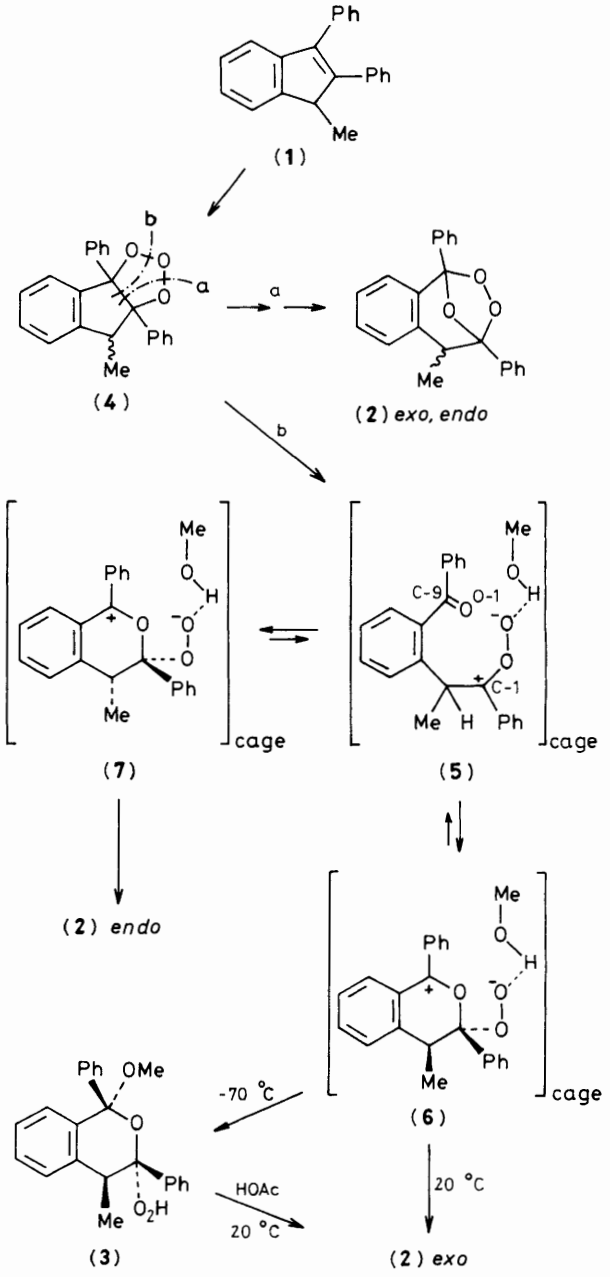


Figure 1. The *X*-ray crystal structure of (**3**).



Scheme 2

temperatures, when the solvent cage is likely to be more structured and hence tighter, cyclisation of the solvated species (**6**) would be severely hindered, thereby rendering solvent capture as the favoured process. To account for the observed stereochemistry of (**3**) requires that the nucleophilic attack by methanol occurs exclusively from the sterically least hindered face, possibly with assistance from the neighbouring peroxy group.

Since solvent effects are likely to be less important at room temperature, intramolecular cyclisation of (**6**) to give the *exo*-ozonide (**2**) should predominate. This is confirmed to some extent since treatment of (**3**) with acetic acid for 10 min at 20 °C, or catalytic quantities of trifluoroacetic acid under similar conditions, affords exclusively the *exo*-isomer of (**2**).

No solvent-participated products derived from intermediate (**7**) have been observed. Molecular models do, however, suggest that in order to minimise steric repulsion between the adjacent di-equatorial methyl and phenyl substituents, (**7**) adopts a half-chair conformation which is puckered at O-1. Consequently, (**7**) is more likely than (**6**) to undergo intramolecular cyclisation to the corresponding *endo*-ozonide (**2**).

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