

## CHLOROALKYL 1,2-DIOXOLANES FROM UNSATURATED HYDROPEROXIDES AND t-BUTYL HYPOCHLORITE.

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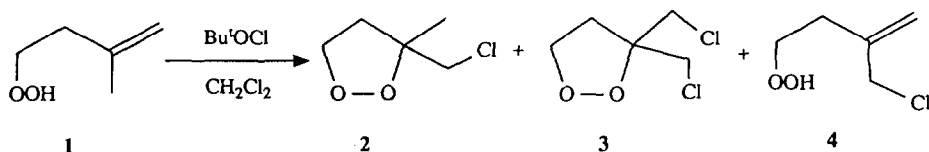
**Summary:** Five monocyclic and one bicyclic 3-(1-chloroalkyl)-1,2-dioxolanes have been prepared by reaction of alk-3-en-1-yl hydroperoxides with t-butyl hypochlorite in  $\text{CH}_2\text{Cl}_2$  in the presence of pyridine or silica; cyclooct-4-en-1-yl hydroperoxide with  $\text{t-BuOCl/SiO}_2$  regiospecifically affords 4-chlorocyclooctanone as major product.

Cycloperoxyhalogenation has proved an effective route not only to monocyclic 1,2-dioxolanes,<sup>1,2</sup> but also to 2-halogeno-8,9-dioxabicyclo[5.2.1]decanes.<sup>3</sup> Appropriate alk-3-en-1-yl hydroperoxides react with *N*-iodosuccinimide or *N*-bromosuccinimide by the favoured 5-*exo*-cyclization mode to give the corresponding iodoalkyl or bromoalkyl 1,2-dioxolanes<sup>1-3</sup>. However, an attempt to extend these reactions to *N*-chlorosuccinimide was unsuccessful, no chloroalkyl 1,2-dioxolane being obtained from 3-methylbut-3-en-1-yl hydroperoxide<sup>1</sup>. To the best of our knowledge, chloroalkyl 1,2-dioxolanes remain unknown and there are no published examples of cycloperoxychlorination.<sup>4</sup> t-Butyl hypochlorite has been used as a source of chlorine in the peroxychlorination of alkenes to afford  $\beta$ -chloroalkyl hydroperoxides and peroxides.<sup>5</sup>



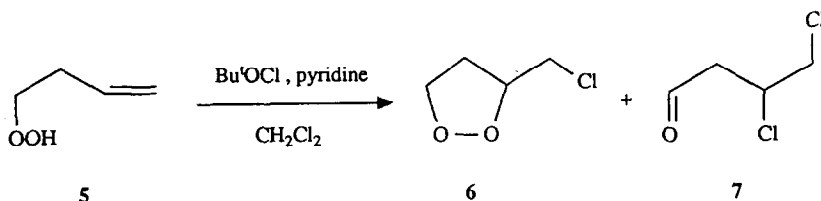
We now report an intramolecular variant of this reaction whereby alk-3-en-1-yl hydroperoxides afford chloroalkyl 1,2-dioxolanes. In addition to the synthetic value of these reactions, they are interesting from a mechanistic point of view since, *a priori*, both free radical chain and polar mechanisms can reasonably be proposed.

Initial experiments were carried out with 3-methylbut-3-en-1-yl hydroperoxide (1). By mixing the reagents in  $\text{CH}_2\text{Cl}_2$  at 0-5 °C and allowing the mixture to warm to room temperature over a period of 1-3 h, three major products were obtained which were identified as the expected 3-chloromethyl-3-methyl-1,2-dioxolane (2), together with 3,3-di(chloromethyl)-1,2-dioxolane (3) and 3-chloromethylbut-3-en-1-yl hydroperoxide (4). It appears that, under these conditions, regioselective<sup>6</sup> chlorination of the hydroperoxide competes with the desired cycloperoxychlorination and gives hydroperoxide (4) which is clearly the precursor of the dichlorinated 1,2-dioxolane (3).

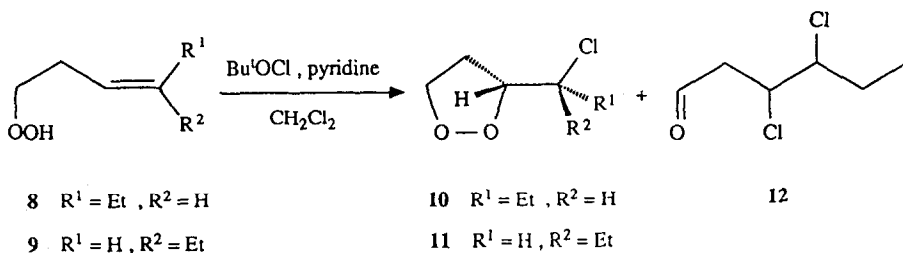


Attempts were made to optimise the yield of (2) by varying the molar ratio of the reactants, the concentrations and the solvent, and by investigating the effect of certain additives. The best result was achieved by using 1.4  $\text{Bu}^t\text{OCl}$  + 0.7 pyridine with 0.05 M (1) in  $\text{CH}_2\text{Cl}_2$ . This afforded a crude mixture of (2) plus (3) corresponding to yields of 53% of (2) and 13% of (3). The 1,2-dioxolanes (2)' and (3)' were separated by HPLC.

Under similar conditions, but-3-en-1-yl hydroperoxide (5) afforded the expected 3-chloromethyl-1,2-dioxolane (6) together with one major by-product which was identified as 3,4-dichlorobutanal (7); (6)' was isolated by silica chromatography in a yield of 17%.

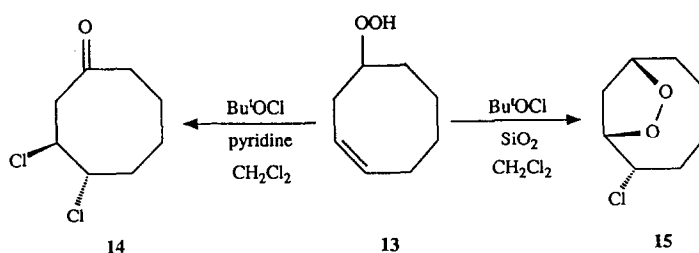


Reactions with *cis* and *trans* hex-3-en-1-yl hydroperoxide provided information about the stereoselectivity of cycloperoxychlorination. The *cis* isomer (8) gave *threo* and *erythro* 3-(1-chloropropyl)-1,2-dioxolane (10 & 11) in the ratio 70 : 30 together with a single diastereoisomer of 3,4-dichlorohexanal (12); the *trans* isomer (9) gave (10) and (11) in the ratio 25 : 75, together again with (12).

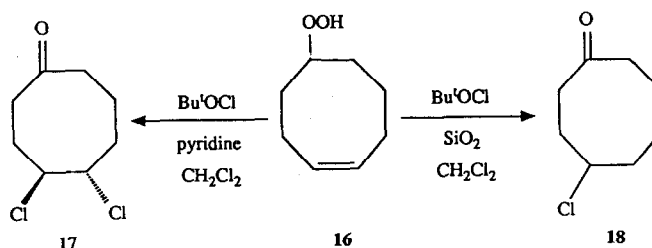


Stereospecific cyclization ( $8 \rightarrow 10$  and  $9 \rightarrow 11$ )<sup>8</sup> was achieved by using silica<sup>9</sup> rather than pyridine as the additive. Under these conditions, formation of (12) was suppressed, but a new by-product, thought to be a 5-substituted-3-(1-chloropropyl)-1,2-dioxolane, was obtained. From these reactions, (10)<sup>7</sup> and (11)<sup>7</sup> were isolated by silica chromatography in yields of 18% and 8% respectively.

In the presence of pyridine, cyclooct-3-en-1-yl hydroperoxide (13) failed to give a peroxide, the major product being *trans* 3,4-dichlorocyclooctanone (14). However, in the presence of silica, the desired 2-chloro-8,9-dioxabicyclo[5.2.1]decane (15)<sup>7</sup> was the major product and was isolated by silica chromatography in a yield of 20%.



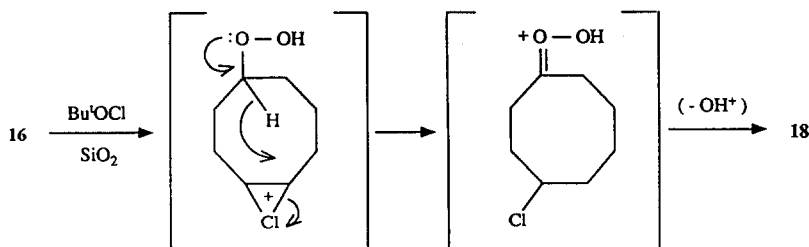
By way of contrast, cyclooct-4-en-1-yl hydroperoxide (16) afforded chlorinated cyclooctanones as major products under both sets of conditions.



The stereoselectivity observed with the hex-3-en-1-yl hydroperoxides (8 & 9) suggests that the cycloperoxychlorinations proceed predominantly (pyridine added) or wholly ( $\text{SiO}_2$  added) by a polar mechanism. The likely role of the silica is to enhance the electrophilicity of the *t*-butyl hypochlorite. The chlorination of (1) to afford (4), which was not suppressed when silica was present, could also proceed by a polar mechanism, which might explain the observed regioselectivity. The origin of the dichlorocarbonyl products (7, 12, 14 & 17) remains obscure at present. Chlorine is obviously implicated and probably arises by reaction of  $\text{Bu}^t\text{OCl}$  with  $\text{HCl}$ . The carbonyl groups are unlikely to arise by base-induced dehydration of the hydroperoxides under the conditions used, and in agreement with this there was no reaction between (8) and pyridine. Alcohols have been oxidised by  $\text{Bu}^t\text{OCl}$ -pyridine by a mechanism involving abstraction of  $\text{CH}(\text{OH})$  as hydride.<sup>10</sup> A similar process with hydroperoxides could account for both  $\text{HCl}$  and

carbonyl formation, but if this occurs the fate of the resultant electrophilic OH group is presently unknown.

Cyclooct-4-en-1-yl hydroperoxide (16) was included in this study because of its tendency to react with electrophiles to form *gem*-dialkylperoxonium ions and thence bicyclic ethers.<sup>11</sup> The formation of (18) was therefore unexpected, but may be accounted for by the following mechanism which incorporates the well-established<sup>12</sup> process of transannular 1,5-hydride transfer.



Again, we cannot, as yet, comment on the fate of the electrophilic OH group.

#### Acknowledgement

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#### References and Notes

1. A.J. Bloodworth and R.J. Curtis, *J. Chem. Soc., Chem. Commun.*, 1989, 173.
2. A.J. Bloodworth, R.J. Curtis, and N. Mistry, *J. Chem. Soc., Chem. Commun.*, 1989, 954.
3. A.J. Bloodworth and M.D. Spencer, *Tetrahedron Letters*, in the press.
4. A cycloperoxychlorination has been achieved using an allylic hydroperoxide and  $\text{BuOCl}$  (J.L. Courtneidge, personal communication; we thank Dr Courtneidge for disclosing his results to us ahead of publication).
5. K. Weissmerel and M. Lederer, *Chem. Ber.*, 1963, 96, 77.
6. Unidentified minor components were also present in the mixture, but there was no evidence for products of chlorination at other sites (*eg.* at C-2) of (1).
7. All new peroxides had satisfactory elemental analyses and/or MS accurate masses, and  $^1\text{H}$  and  $^{13}\text{C}$  nmr spectra consistent with the proposed structures.
8. Other isomer not detected in  $^{13}\text{C}$  nmr spectrum of crude product.
9. W. Sato, N. Ikeda, and H. Yamamoto, *Chem. Letters*, 1982, 141.
10. J.N. Milovanović, M. Vasojević, and S. Gojković, *J. Chem. Soc., Perkin Trans. 2*, 1988, 533.
11. S.P. Best, A.J. Bloodworth, and M.D. Spencer, *J. Chem. Soc., Chem. Commun.*, 1990, 416; A.J. Bloodworth, T. Melvin, and J.C. Mitchell, *J. Org. Chem.*, 1988, 53, 1078.
12. P.W. Henniger, L.J. Dukker, and E. Havinga, *Recl. Trav. Chim. Pays-Bas*, 1966, 85, 1177; G. Haufe, M. Mühlstädt, and J. Graefe, *Monatsh. Chem.*, 1977, 108, 803; G. Nagendrappa, *Tetrahedron*, 1982, 38, 2429.

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