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RADICAL-INDUCED CLEAVAGE OF KETOEPOXIDES

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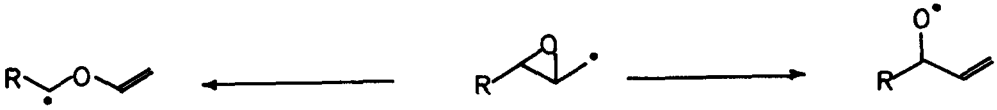
Summary Radical-induced cleavage of ketoepoxides leads to products of a novel fragmentation featuring epoxide C-O bond cleavage.

Recent work by us[1,2] and earlier work by Stogryn and Gianni[3] has probed the circumstances under which radical-induced fragmentation of epoxides leads to carbon-carbon as opposed to carbon-oxygen cleavage. The examples investigated showed that when a radical (1) is formed adjacent to an epoxide, the epoxide will undergo predominant or exclusive C-C bond cleavage when it is appropriately substituted either by an aryl group or a vinyl group. This contrasts with alkyl substituted epoxides where C-O bond cleavage is exclusively seen.[3,4] We were curious to know whether a carbonyl group could also assist C-C bond cleavage. Below we outline the results of our investigations.

The test molecules (2), (5) and (6) were synthesised by Darzens reactions of the appropriate haloketone (phenacyl bromide or α-bromopinacolone) with either crotonaldehyde or acrolein. Treatment of epoxide (2) with n-butanethiyl radicals, prepared in situ by reaction of azobisisobutyronitrile with n-butanethiol gave benzaldehyde (3), and the α,β-unsaturated aldehyde (4) (28%, all percentages refer to isolated yields following chromatography). Similar addition to the epoxides (5) and (6) led to isolation of the unsaturated aldehydes (4) (29%) and (7) (19%) respectively. In both these cases only a single aldehyde product was observed.

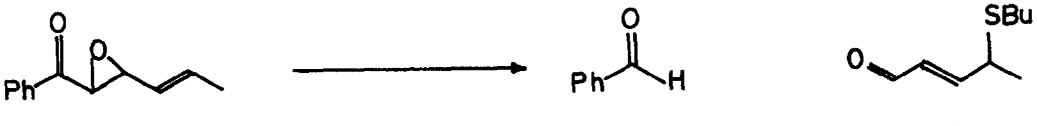
The formation of these products is rationalised in the Scheme. Thiyl radical addition to the generalised epoxide (8) is followed by epoxide C-O bond cleavage to yield the oxyradical (9). Similar acyloin radicals prepared by other routes have previously been shown to undergo fragmentation adjacent to the carbonyl group.[5] In our cases this would yield the observed α,β-unsaturated aldehyde (10) and an acyl radical (11). Where this is a benzoyl radical, hydrogen atom abstraction from the surrounding medium yields benzaldehyde, but for the pivalyl radical (R=^{t}Bu), rapid decarbonylation



R = Aryl or Vinyl

(1)

R = Alkyl



(2)

(3)

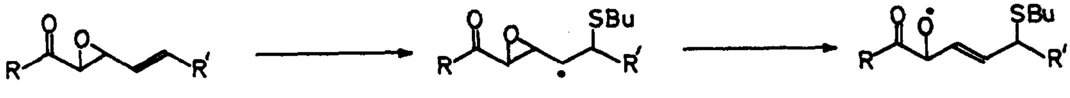
(4)

(5) R′ = Me

(6) R′ = H

(4) R′=Me

(7) R′= H



(8)

(9)

(12)

(11)

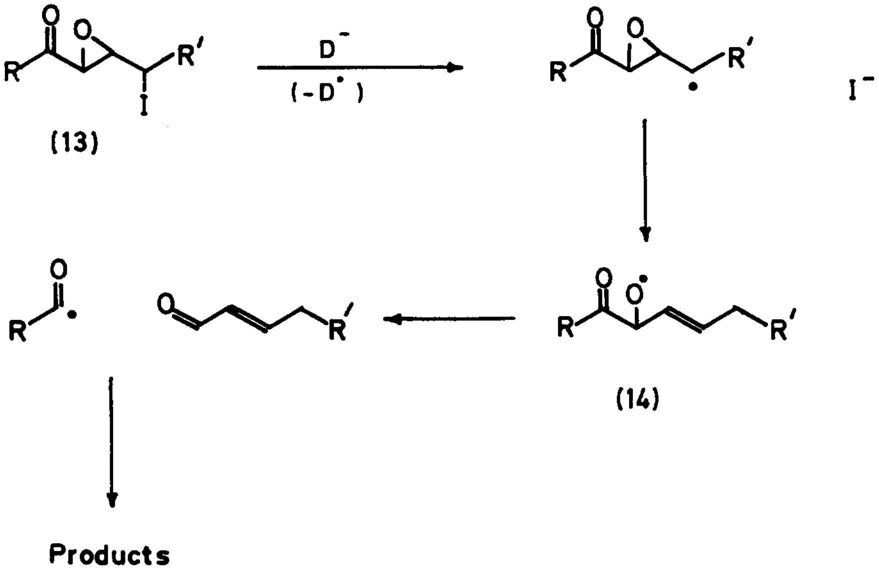
(10)

ensues to give a t-butyl radical which forms volatile products.

The above results are surprising since the presence of a vinyl group in place of our carbonyl leads to regiospecific cleavage of the carbon-carbon bond of the epoxide.

We have looked for evidence of vinyl ethers (12) resulting from a similar process in crude n.m.r.s from the above reactions, but have found none. However because the yields of isolated aldehydes are not quantitative, we cannot rule out the formation of (12) and its subsequent decomposition during the reaction. (We have also estimated the yields of the aldehydes described above before purification from the crude n.m.r. spectra. These yields are not significantly greater than the isolated yields. Accordingly the isolated yields do not reflect significant loss during chromatography).

The fragmentations described above may have special applications, in the trapping and detection of radical intermediates in displacement reactions. There is much current interest[6] in the mechanism of displacement of halides by particular nucleophiles, where studies have indicated that single-electron transfer may be the initial step. With the halo epoxide (13) electron transfer from the donor D^- would yield the radical (14). Isolation of products resulting from fragmentation of (14) as shown would then provide evidence of radical species.



References

1. M. Cook, O. Hares, A. Johns, J.A. Murphy and C.W. Patterson, J.Chem.Soc., Chem.Commun., 1986, 1419.
2. A. Johns, J.A. Murphy, C.W. Patterson and N.F. Wooster, J.Chem.Soc., Chem. Commun., 1987, 1238.
3. E.L. Stogryn and M.H. Gianni, Tet.Letters, 1970, 3025.
4. D.H.R. Barton, R.S. Hay Motherwell and W.B. Motherwell, J.Chem.Soc., Perkin Trans.I 1981, 2363; A.G. Davies and B. Muggleton, J.Chem.Soc., Perkin Trans.II, 1979, 589; A.G. Davies and M.-W. Tse, J.Organomet.Chem., 1978, 155, 25.
5. A.L. Nussbaum, E.P. Yuan, C.H. Robinson, A. Mitchell, E.P. Oliveto, J.M. Beaton and D.H.R. Barton, J.Org.Chem., 1962, 27, 20.
6. M.S. Alnajjar, G.F. Smith and H.G. Kuivila; J.Org.Chem., 1984, 49, 1271; E.C. Ashby and R.De Priest, J.Amer.Chem.Soc., 1982, 104, 6144; M. Newcomb and M.G. Smith J.Organomet.Chem., 1982, 228, 61; K.-W. Lee and J. San Filippo Jr. Organometallics 1983, 2, 906; J.F. Garst and J.B. Hines, Jr., J.Amer.Chem.Soc., 1984, 106, 6443; Y. Darensbourg and M. Newcomb J.Amer. Chem.Soc., 1987, 109, 3313; E.C. Ashby and D. Coleman J.Org.Chem., 1987, 52, 4554.

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