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REVERSIBLE CLEAVAGE OF 5-CHOLEST-3-ENOXYL RADICALS: ADDITION OF ALKYL RADICALS TO KETONES

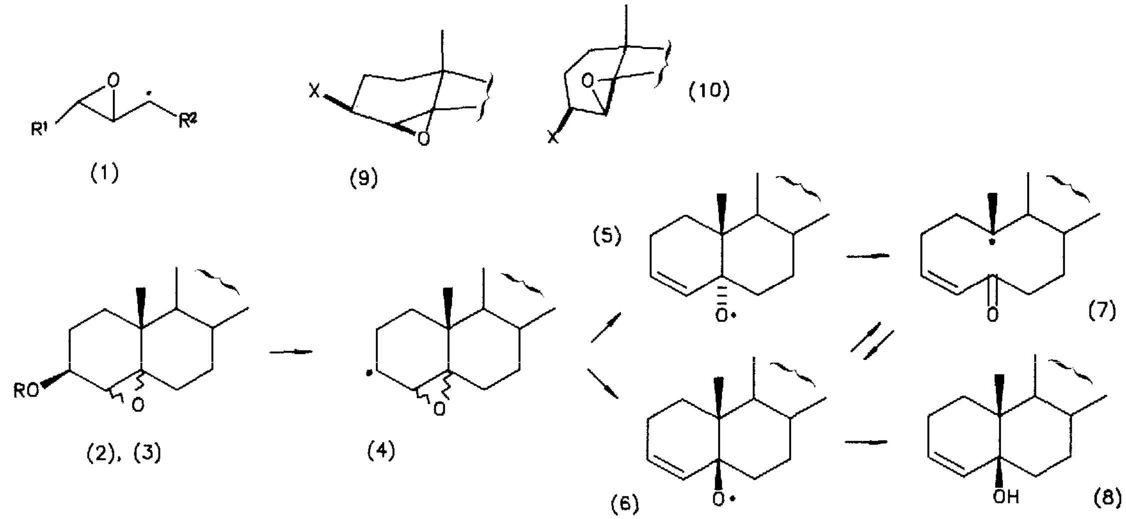
W. Russell Bowman*, Brian A. Marples*, and Naveed A. Zaidi
Department of Chemistry, University of Technology, Loughborough,
Leics. LE11 3TU

Summary: Oxiranylcarbinyl radicals (4) formed by photolysis of 3β-acetoxy-4ξ,5ξ-epoxycholestanes in HMPA/H_2O and by Bu_3SnH reduction of 4ξ,5ξ-epoxy-3β-[imidazol-1-yl(thiocarbonyl)oxy]-cholestanes gave the 5-cholest-3-enoxyl radicals which underwent reversible cleavage of the C5-C10 bond.

Evidence for the intermediacy of free radicals ($\cdot R^2$) in the photoreduction of alkyl acetates ($R^1CO_2R^2$) to alkanes in HMPA/H_2O is provided, in part, by the observation that 6β-acetoxy-3α,5α-cyclocholestane gave cholest-5-ene.[1] Oxiranes have been recently reported as probes for free radical intermediates[2] and it has generally been observed that C-C bond cleavage of the oxiranylcarbinyl radical (1) occurs when R^1 = aryl or vinyl but C-O bond cleavage is preferred when R^1 = alkyl. However, no significant stereoelectronic effects were reported. Our studies[3] on the photolysis of β,γ-epoxyketones suggested some stereoelectronic control may be operating in the cleavage of the oxirane and that the preferred cleavage of the weaker C-O bond probably requires that the semi-occupied p orbital of the radical should be coplanar with the C-O bond as for other β-scission radical processes.[4] There is evidence that changes in temperature may significantly influence the outcome of radical cleavage reactions[5] and the present investigation is an attempt to evaluate such influence in the cleavage of oxiranylcarbinyl radicals generated photochemically and thermally. Accordingly, the photolyses of the epoxy acetates (2a) and (2b) in HMPA/H_2O at 30°C have been compared with the thermal Bu_3SnH reductions of the epoxy O-thiocarbonylimidazolides (3a) and (3b)[6] in refluxing toluene solution.

Photolysis of the epoxy acetates (2a) and (2b) and Bu_3SnH reduction of the epoxy O-thiocarbonylimidazolides (3a) and (3b) afforded in each case 5-hydroxy-5β-cholest-3-ene (8)[6] as the major product after chromatography (yields 60-75%).

The formation of a single major product from each of the compounds (2a,b) and (3a,b) presumably involves the discrete radicals (4) which fragment according to the Scheme. The highly selective cyclisation of the radical (7) to afford the 5β-alkoxy radical (6) contrasts with observations made on the cleavage of 9-decalinoxyl radicals[5] in which *cis*- and *trans*-fused rings were obtained. Models suggest that for the radical (7), cyclisation to afford the 5β-alkoxy radical is highly favoured if the energetically more acceptable



Scheme: (2), R = Ac; (3), R = thiocarbonylimidazolide;
(2) and (3), a = 4α, 5α; b = 4β, 5β.

approach[7] involving the O-C---C• bond angle being close to 110° is important.

Although the C3-X bond in the radical precursors (9) and (10) is respectively 'antiperiplanar' with the C4-O and the C4-C5 bonds, the absence of major differences in the observed reactions suggests that the radicals (4) are formed initially and have sufficient life time to conformationally adjust to allow the C-O bond to achieve coplanarity with the semi-occupied p orbital of the C3 radical. The alternative explanation that neither the radicals (4) nor the precursors have any stereoelectronic requirement for cleavage seems less attractive.[3,4,6] The observed cyclisation of the radical (7) provides further evidence of the addition of alkyl radicals to carbonyl groups, a few examples of which have recently been reported[5,8] and appear to be of preparative value.[8]

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References

1. H. Deshayes, J.-P. Pète, and C. Portella, Tetrahedron Lett., 1976, 24, 2019.
2. J.A. Murphy, C.W. Patterson, and N.F. Wooster, Tetrahedron Lett., 1988, 29, 955.
3. R.W.G. Foster, S.H. Imman, B.A. Marples, and G.W.F. Stubbings, J. Chem. Soc., Perkin Trans., 1987, 2653.
4. A.L.J. Beckwith, C.J. Easton, and A.K. Serelis, J. Chem. Soc., Chem. Commun., 1980, 482.
5. A.L.J. Beckwith, R. Kazlauskas, and M.R. Syner-Lyons, J. Org. Chem., 1983, 48, 4718.
6. D.H.R. Barton, R.S. Hay Motherwell, and W.B. Motherwell, J. Chem. Soc., Perkin Trans.1, 1981, 2363.
7. A.L.J. Beckwith and C.H. Schliesser, Tetrahedron, 1985, 41, 3925.
8. J.E. Baldwin, R. M. Adlington, and J. Robertson, J. Chem. Soc. Chem., Commun., 1988, 1404; and references therein.

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