THE FORMATION AND SUBSEQUENT CYCLISATION OF NOVEL HYDROPEROXIDES FROM A 1,4- AND A 1,5-DIENE Howard A.J. Carless\* and Richard J. Batten Department of Chemistry, Birkbeck College, Malet Street, London WClE 7HX

Summary: The preparation of the unsaturated hydroperoxides (3, 4, 5, 6 and 7) by the sensitized photo-oxidation of the 1,4-diene(1) and the 1,5-diene(2) is described, together with the attempted free-radical cyclisation of these.

Unsaturated hydroperoxides have been implicated as intermediates in the biosynthesis of prostaglandins<sup>1</sup> and during lipid oxidation in vegetable oils.<sup>2</sup> A common feature of these hydroperoxides is that they are derived from polyolefins containing a <u>cis,cis</u>-1,4-diene system. Although there has been much investigation of long chain poly-olefins,<sup>3</sup> short chain 1,4-dienes have received little attention. We chose to synthesise hydroperoxides by reaction of photochemically-generated singlet oxygen (<sup>1</sup>O<sub>2</sub>) with 2,6-dimethylhept-2,5-diene(<u>1</u>). The symmetry of <u>1</u> limits the number of possible monohydroperoxides to only two. Compound <u>1</u> was formed together with 2,6-dimethylhept-2,6-diene(<u>2</u>) by a modification of the published procedure:<sup>4</sup>



 $\underline{1}$  and  $\underline{2}$  were separated by column chromatography using silica impregnated with 10% silver nitrate.

Sensitized photo-oxidation of <u>1</u> (tetraphenylporphine,  $O_2$ ,  $CH_2Cl_2$ ,  $-50^{\circ}C$ , 2h) afforded the monohydroperoxides (3,21%) and (4, 13%) together with a more polar product (5,11%), which were isolated by flash chromatography.<sup>5</sup> Spectral characterisation of these compounds<sup>6</sup> supported the assignment of <u>5</u> as a dihydroperoxide derived by further reaction of <u>4</u> with singlet oxygen.

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Hydroperoxides derived from 1,5-dienes are of interest because of their role in the photodegradation of such polymers as poly(isoprene) or rubber.<sup>7</sup> A similarly sensitized photo-oxidation of the diene 2 (4h) yielded the mono-hydroperoxides (6,23%) and (7,25%).<sup>6</sup>



Further proof of structure was obtained by the reduction of each hydroperoxide with triphenylphosphine to give the corresponding known allylic alcohols:  $3 + 8;^8 + 2;^9 + 10;^{10} + 11;^{11}$  Reduction of the dihydroperoxide 5 gave the corresponding diallylic alcohol which decomposed upon silica column chromatography. A significant feature of these reactions is that the terminal methylene group of 2 appears to be much less reactive than the isopropylidene group towards singlet oxygen, an observation which has been predicted on theoretical grounds.<sup>12</sup>

We next investigated the cyclisation of these unsaturated hydroperoxides under the influence of free radicals, using di-tertiary-butyl peroxyoxalate (DBPO)<sup>13</sup> as a source of <u>t</u>-butoxy radicals. It has been shown that DBPO induces the abstraction of the hydroperoxide hydrogen leading to peroxy radicals, which further react with suitable double bonds present.<sup>14</sup>

Monohydroperoxide (<u>4</u>) when stirred for 19h at room temperature with 0.4 equivalents of DBPO in oxygenated benzene solution (0.02M) gave the cyclised product (<u>12</u>,20%), whose structure was assigned by spectral characterisation<sup>15</sup> and by reduction with triphenylphosphine to give the tertiary alcohol (<u>13</u>). The formation of a 3,5-disubstituted <u>cis</u>-1,2-dioxolane ring is in accord with the <u>cis</u>-selectivity observed in the cyclisation of hydroperoxides derived from methyl linoleate<sup>16</sup> and methyl linolenate.<sup>17</sup> The other hydroperoxides (<u>3,6 & 7</u>)

did not cyclise under the above reaction conditions.



This result is to be expected since <u>exo</u>-ring closure  $\underline{14} \rightarrow \underline{15}$  is kinetically favoured over the <u>endo</u>-process  $\underline{14} \rightarrow \underline{16}$  in intramolecular free-radical reactions.<sup>18</sup>



(n≤4)

With hydroperoxides (3, 6 and 7) formation of a dioxolane by <u>exo</u>-ring closure is prohibited.

We are currently investigating the free-radical cyclisation of other unsaturated hydroperoxides.

## References

- N.A. Porter, "Free Radicals in Biology", ed. W.A. Pryor, Academic Press, New York, 1980, 4, 261.
- A.H. Clements, R.H. Van den Engh, D.J. Frost, K. Hoogenhout and J.R. Nooi, J.Am.Oil Chem.Soc., 1973, <u>50</u>, 325.
- See, e.g., N.A. Porter, L.S. Lehman, B.A. Weber and K.J. Smith, J.Am.Chem. Soc., 1981, 103, 6447; E.N. Frankel, W.E. Neff and D. Weisleder, J. Chem. Soc., Chem. Commun., 1982, 599.
- 4. S.M. Baba, H.H. Mathur and S.C. Bhattacharyya, Tetrahedron, 1966, 22, 903.
- 5. W.C. Still, M. Kahn and A. Mitra, J.Org.Chem., 1978, 43, 2923.
- 6. <u>3</u>, R<sub>f</sub> 0.41(diethyl ether-hexane, 1:3); IR(film):3390, 1657cm<sup>-1</sup>; <sup>1</sup>H-NMR(200MHz,CDCl<sub>3</sub>)δ:1.41(6H,s, H-1,H-2'), 1.82(6H,s,H-6',H-7), 5.65(1H,d,J16Hz,H-3), 5.87(1H,d,J11Hz,H-5), 6.49(1H,dd,J11 and 16Hz,H-4), 7.47(1H,s,OOH): <sup>13</sup>C-NMR(15MHz,CDCl<sub>3</sub>):137.0(C-6), 133.5, 127.6(C-4), 124.6, 82.6(C-2), 26.1, 24.5, 24.5, 18.4 ppm.
  - 4, R<sub>f</sub> 0.49 (diethyl ether-hexane, 1:3); IR(film):3400, 1651cm<sup>-1</sup>; <sup>1</sup>H-NMR(200MHz,CDCl<sub>3</sub>)δ:1.67(3H,s,H-2'), 1.76(3H,s,H-7), 1.81(3H,s,H-6'), 2.19(2H,m,H-4), 4.35(1H,t,J8Hz,H-3), 5.05(3H,m,H-1,H-5), 8.02(1H,s,OOH); <sup>13</sup>C-NMR(15MHz,CDCl<sub>3</sub>):143.8(C-2), 134.3(C-6),119.4(C-5),114.3(C-1). 89.6(C-3), 30.0(C-4), 25.7 (C-6'), 17.9 (C-2'), 17.5(C-7) ppm.
  - 5, R<sub>f</sub> O.41(diethyl ether-hexane, 2:3): IR(film):3390, 1652cm<sup>-1</sup>; <sup>1</sup>H-NMR(200MHz,CDCl<sub>3</sub>)δ:1.36(6H,s,H-6',H-7), 1.76(3H,s,H-2'), 4.78(1H,d,J8Hz,H-3), 5.01,5.04(2H,m,H-1), 5.66(1H,dd,J8 and 16Hz,H-4),

5.89(lH,d,Jl6Hz,H-5), 7.96(lH,s,OOH), 8.44(lH,s,OOH); <sup>13</sup>C-NMR (15MHz,CDCl₃):142.6(C-2), 139.0(C-4), 127.1(C-5), 114.6(C-1), 89.2(C-3), 82.1(C-6), 24.3(C-6'), 24.0(C-7), 18.5(C-2') ppm.

- 6, R<sub>f</sub> 0.45 (diethyl ether-hexane, 1:3): IR(film):3403, 1651cm<sup>-1</sup>; <sup>1</sup>H-NMR (200MHz,CDCl<sub>3</sub>)δ:1.35(6H,s,H-1,H-2'), 1.73(3H,s,H-6'), 2.75(2H,d,J8Hz,H-5), 4.69(1H,d,J1Hz,H-7), 4.74(1H,d,J1Hz,H-7), 5.65(1H,d,J15Hz,H-3), 5.68 (1H,m,H-4), 7.39(1H,s,OOH); <sup>13</sup>C-NMR(15MHz,CDCl<sub>3</sub>):144.6(C-6), 135.4(C-3), 129.6(C-4), 111.2(C-7), 82.4(C-2), 40.9(C-5), 24.3, 24.3(C-1,C-2'), 22.4(C-6') ppm.
- 7, R<sub>f</sub> 0.54 (diethyl ether-hexane, 1:3); <sup>1</sup>H-NMR (200MHz,CDCl<sub>3</sub>)δ:1.70 (2H,m,H-4), 1.73 (3H,s,H-2'), 1.75 (3H,s,H-6'), 2.04 (2H,m,H-5), 4.33 (1H,t,J8Hz,H-3), 4.69 (1H,d,J1Hz,H-7), 4.73 (1H,d,J1Hz,H-7), 5.03 (2H,m,H-1), 7.82 (1H,s,OOH); <sup>13</sup>C-NMR (15MHz,CDCl<sub>3</sub>):145.2 (C-2), 143.8 (C-6), 114.7 (C-1), 110.5 (C-7), 89.3 (C-3), 33.7 (C-4), 28.7 (C-5), 22.4 (C-6'), 17.1 (C-2') ppm.
- J. Chaineaux and C. Tanielian, in "Singlet Oxygen: Reaction with Organic Compounds and Polymers", ed. B.Ranby and J.F. Rebek, Wiley-Interscience, 1978, p. 164.
- 8. E.A. Braude and J.A. Coles, J.Chem.Soc., 1952, 1425.
- 9. T. Shono, T. Yoshimura and R. Oda, J.Org.Chem., 1967, 32, 1088.
- 10. J. Colonge and A. Varagnat, Bull.Soc.Chim.Fr., 1964(3), 561.
- 11. W.S. Johnson, T.J. Brocksom, P. Loew, D.H. Rich, L. Werthemann, R.A. Arnold, T. Li and D.J. Faulkner, J.Am.Chem.Soc., 1970, 92, 4463.
- 12. L.A. Paquette, D.C. Liotta and A.D. Baker, Tetrahedron Lett., 1976, 2681.
- 13. P.D. Bartlett, E.P. Benzing and R.E. Pincock, J.Am.Chem.Soc., 1960, 82, 1762.
- 14. N.A. Porter, M.O. Funk, D. Gilmore, R. Isaac and J. Nixon, <u>J.Am.Chem.Soc</u>., 1976, 98, 6000.
- 15. <u>12</u>, R<sub>f</sub> 0.29 (diethyl ether-hexane, 1:3); IR(film):3415, 1653cm<sup>-1</sup>; <sup>1</sup>H-NMR (200MHz,CDCl<sub>3</sub>) $\delta$ :1.23, 1.36 (6H,s,H-1,H-2'), 1.81 (3H,s,H-6'), 2.50 (1H,ddd,J7,9 and 12Hz,H-4 $\alpha$ ), 2.74 (1H,ddd,J7,8 and 12Hz,H-4 $\beta$ ), 4.44 (1H,t,J8Hz,H-3),4.70 (1H,t,J8Hz,H-5), 4.98,5.09 (2H,m,H-7), 8.33 (1H,s, OOH); <sup>13</sup>C-NMR(15MHz,CDCl<sub>3</sub>): 140.6 (C-6), 114.4 (C-7), 85.4, 84.8 (C-3,C-5), 83.0 (C-2), 40.4 (C-4), 21.4,20.8 (C-1,C-2'), 18.0 (C-6') ppm.
  - 13, Rf 0.23(diethyl ether-hexane, 1:2); IR(film):3440, 1652cm<sup>-1</sup>; <sup>1</sup>H-NMR (200MHz,CDCl<sub>3</sub>)δ:1.18, 1.27(6H,s,H-1,H-2'), 1.78(3H,s,H-6'), 2.00 (1H,s,OH), 2.54(1H,ddd,J7,8 and 12Hz,H-4α), 2.66(1H,ddd,J7,8 and 12Hz, H-4β), 4.18(1H,t,J8Hz,H-3), 4.69(1H,t,J8Hz,H-5), 4.96,5.05(2H,m,H-7)ppm.
- 16. E.D. Mihelich, J.Am.Chem.Soc., 1980, 102, 7141.
- D.E. O'Connor, E.D. Mihelich and M.C. Coleman, <u>J.Am.Chem.Soc</u>., 1981, <u>103</u>, 223.
- 18. Some guidelines for radical reactions: A.L.J. Beckwith, C.J. Easton and A.K. Serelis, <u>J.Chem.Soc.</u>, Chem.Commun., 1980, 482.

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