

Novel Regioselectivity in Radical Addition to a Diene

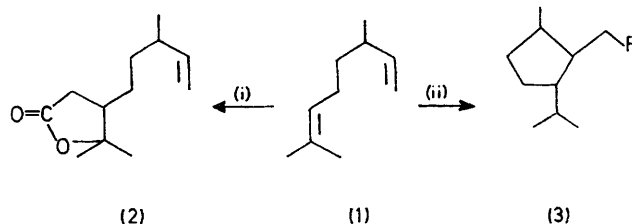
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Summary With 3,7-dimethylocta-1,6-diene, carbon radicals $\cdot\text{CH}_2\text{CO}_2\text{H}$, $\cdot\text{CH}(\text{COMe})_2$, and $\cdot\text{CH}(\text{COMe})\text{CO}_2\text{Et}$ add at the 6,7-alkene bond, whilst $\cdot\text{CH}_2\text{COR}$ ($\text{R} = \text{Me}$, Ph), $\cdot\text{CH}(\text{CO}_2\text{Me})_2$, oxocyclopentyl, and oxocyclohexyl react at the 1,2-alkene; it is suggested that this behaviour is indicative of reversible addition at the 6,7 positions by the second group of radicals.

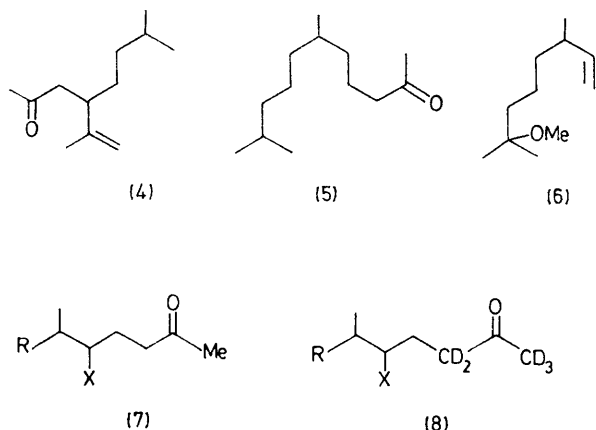
We have found that addition to 3,7-dimethylocta-1,6-diene (1) of carbon radicals generated *in situ* by manganese(III) acetate oxidation,¹ shows discrimination between pathways (i) and (ii) depending on the nature of the radical. Radicals $\cdot\text{CH}_2\text{CO}_2\text{H}$, $\cdot\text{CH}(\text{COMe})\text{CO}_2\text{Et}$, and $\cdot\text{CH}(\text{COMe})_2$ lead to products of the type exemplified by (2). Radicals $\text{R} = \cdot\text{CH}_2\text{COMe}$, $\cdot\text{CH}(\text{CO}_2\text{Me})_2$, $\cdot\text{CH}_2\text{COPh}$, oxocyclopentyl, and oxocyclohexyl, on the other hand, yield products of type (3). Radicals $\cdot\text{CH}_2\text{CO}_2\text{H}$ and $\cdot\text{CH}(\text{COMe})_2$ gave also some product of type (3), but $\cdot\text{CH}(\text{CO}_2\text{Me})_2$ and the ketone radicals gave no evidence of addition at the 6,7-alkene centre.

Also, as judged by loss of the brown Mn^{III} colour, reactions following pathway (i) are rapid, whilst reactions *via* (ii) are slower by a factor of *ca.* 100. Conditions have not been optimised, but yields, 25–53% based on diene, varied with the addend.



In competition for $\cdot\text{CH}_2\text{COMe}$, generated with $\frac{1}{3}$ equiv. of manganese(III) acetate, the diene (1), and the isomeric octenes, 2,6-dimethyloct-2-ene and 3,7-dimethyloct-1-ene, gave (3; $\text{R} = \text{CH}_2\text{COMe}$), (4), and (5) in a ratio 74:21:5

(g.l.c. analysis). Thus the alkene bond located at 6,7 is intrinsically more reactive than the 1,2 alkene.



In competition for (6), acetone and [$^2\text{H}_6$]-acetone with manganese(III) acetate gave (7; X = H), (7; X = D), (8; X = H), and (8; X = D) in a ratio 8:1.5:1.5:1 (mass spectral analysis). Hence for acetone addition, radical formation *via* breaking the CH bond is, as expected, rate limiting.

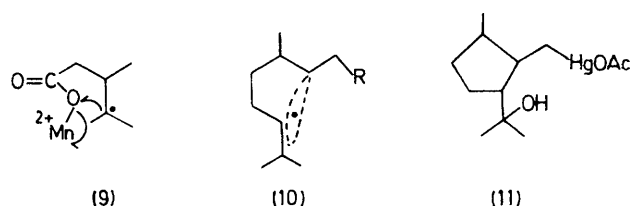
The paradox is that radicals from malonic ester and the ketones apparently fail to show the expected addition at the 6,7-bond. However, in the examples of addition by pathway (i) reaction is completed by irreversible ring closure between the tertiary radical centre and a hydroxy group in the addend unit, *i.e.* leading to (2), or, from ethyl acetoacetate or pentane-2,4-dione to a dihydrofuran. Oxidative ring closure should be assisted by the ligand properties of these addends in co-ordinating Mn-ion, *e.g.* as in (9).

We infer that $\cdot\text{CH}(\text{CO}_2\text{Me})_2$ or the ketone radicals do initially react at the 6,7-alkene bond, but, lacking the facility for rapid ring closure to the new radical centre, do so

reversibly, *i.e.* with radical transfer to the 1,2-alkene bond followed by ring closure to the cyclopentane (3). Precedents² do not support reaction *via* a three-centre radical such as (10). There is, however, some evidence for reversible addition to an alkene bond,³ and the present examples appear significantly to extend the phenomenon into the important area of synthesis.

Products both of type (2) and of type (3) derive ultimately from an intermediate tertiary radical, but reaction pathway (ii) offers the advantage of bonding of the addend to a primary carbon centre with the disadvantage of a larger negative entropy change. Thus the free energy of activation for routes (i) and (ii) may not be very different.

All products were characterised by mass spectral, n.m.r., and correct C and H analyses. Products (3) could also be independently synthesised utilising the previously observed⁴ reaction of (1) with mercury(II) acetate in aqueous tetrahydrofuran. The derived HgOAc adduct (11) could be



transformed: $-\text{CH}_2\text{HgOAc} \rightarrow -\text{CH}_2\text{HgBr} \rightarrow -\text{CH}_2\text{I}$, and the propan-2-ol substituent dehydrated: $-\text{C}(\text{OH})\text{Me}_2 \rightarrow -\text{C}(\text{Me})=\text{CH}_2$. Condensation with the sodio-derivative of ethyl oxocyclopentanecarboxylate, hydrolysis, and decarboxylation, or with the sodio derivative of dimethyl malonate, gave products which could be hydrogenated to give [3; R = $\text{CH}(\text{CO}_2\text{Me})_2$ or 2-oxocyclopentyl]. The observed identities (mass and n.m.r. spectra and g.l.c.) of these products with those derived by Mn^{III} induced addition to (1) also establish the stereochemistry as *r*-1-Pr¹,*t*-2- CH_2R ,*c*-3-Me, *cf.* ref. 4.

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² B. B. Jarvis and J. B. Yount, *Chem. Comm.*, 1969, 1405; B. B. Jarvis, J. B. Yount and T-H Yang, *J. Org. Chem.*, 1972, **37**, 797.

³ M. Julia, M. Maumy and L. Liou, *Bull. Soc. chim. France*, 1967, 2641; J. C. Chottard and M. Julia, *Tetrahedron Letters*, 1971, 2561.

⁴ F. J. McQuillin and D. G. Parker, *J.C.S. Perkin I*, 1974, 809.