Catalytic Synthesis of *endo*-Brevicomin and Related Di- and Tri-oxabicyclo[x.2.1] Systems

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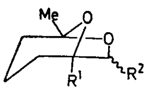
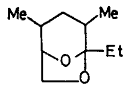
Summary Palladium(II)-catalysed intramolecular cyclisation of terminal olefins containing a suitably located vicinal diol group gives the corresponding cyclic acetal.

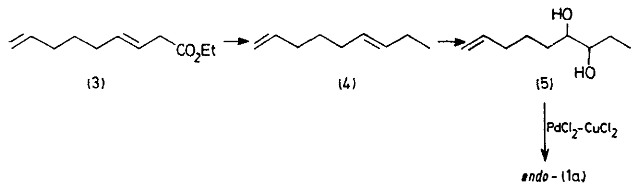
DIOXABICYCLO[3.2.1]ALKANES have attracted interest because of the structures of various bark beetle pheromones such as brevicomin (**1a**)[1], frontalin (**1b**),[2] and the Dutch elm beetle pheromone (**2**)[3] and several syntheses of these pheromones have been reported.[4] We have devised a short stereospecific synthesis of *endo*-brevicomin from butadiene which appears to have general applicability. Palladium catalysed dimerisation of butadiene with concomitant carbonylation in ethanol gave the nonadienoate (**3**)[5] which was converted by a standard reduction–tosylation–reduction sequence into the *trans*-nonadiene (**4**; 64%).



(1) a; R¹ = H, R² = Et
b; R¹ = Me, R² = H

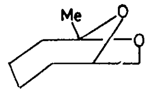


(2)

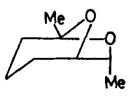


(3) (4) (5)

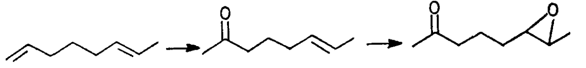
Epoxidation (76%) followed by hydrolysis (74%) gave the diol (**5**) which was cyclised directly to *endo*-brevicomin (45%)[6] using palladium chloride as catalyst[7] in anhydrous dimethoxyethane with copper(II) chloride as reoxidant for the palladium. Octa-1,7-diene and octa-1,6-diene were similarly converted into the dioxabicyclo[4.2.1]nonane (**6**) and the dioxabicyclo[3.2.1]octane (**7**) respectively, by mono-epoxidation, ring opening to the olefinic diol, and palladium(II)-catalysed cyclisation. Yields for the final cyclisation step were moderate [(**6**), 30%; (**7**) 49%]. The spectroscopic properties of *endo*-brevicomin (*endo*-**1a**) and (**7**) were in accord with published data. The mass spectra of (*endo*-**1a**) and (**7**) contained *M* – EtCO, *M* – EtCHO and *M* – MeCO, *M* – MeCHO ions respectively. In contrast the mass spectrum of (**6**) did not contain the corresponding *M* – CHO, *M* – CH_2O ions but did exhibit an *M* – 42 ion. The synthesis may be varied by palladium-catalysed conversion of the dienes into the keto-olefins followed by epoxidation and thermal (acid-catalysed) rearrangement[8] to the dioxabicyclic system (*e.g.* **8** → **9** → **10** → **7**).



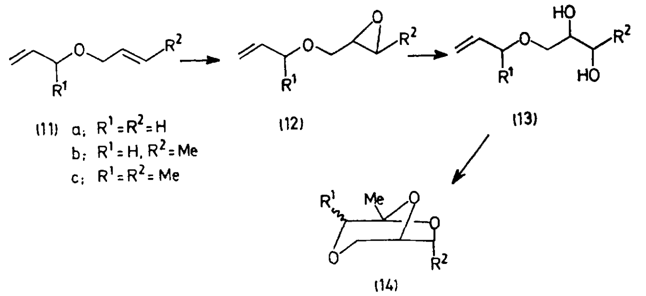
(6)



(7)



(8) (9) (10)



(11) a; R¹ = R² = H
b; R¹ = H, R² = Me
c; R¹ = R² = Me

(12) (13) (14)

The reaction has been extended to the trioxabicyclo-[3.2.1]-series using diallyl ethers as precursors. The ethers (**11a**—**c**) were converted into the corresponding mono-epoxides (**12a**—**c**) [*e.g.* (**12b**) τ ($CDCl_3$) 3·70—4·0 (1H, $CH_2{=}CH$–), 4·53—5·0 (2H, $CH_2{=}CH$–), 5·98, 6·45 (2 × 2H, m, CH_2-O), 7·15 (2H, m, epoxide H), and 8·70 (3H, d, Me)]. The epoxides were hydrolysed (H_2SO_4 in tetrahydrofuran) to the diols (**13a**—**c**) which were cyclised, without purification, to (**14a**—**c**; *ca.* 20%) using $PdCl_2$–$CuCl_2$ [*e.g.* (**14b**) τ ($CDCl_3$) 5·40—6·40 (4H, m), 4·53 (2H, s), 8·53 (3H, d), and 8·65 (3H, s)]. The mass spectrum of (**14b**) indicates fragmentation of the largest bridge is preferred, *i.e.* $M - 30$ (20% abundance).

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[1] R. M. Silverstein, R. G. Brownlee, T. E. Bellas, D. L. Wood, and L. E. Browne, *Science*, 1968, **159**, 889.

[2] G. W. Kinzer, A. F. Fentiman, T. F. Page, R. L. Foltz, J.P. Vite, and G. B. Pitman, *Nature*, 1969, **221**, 477.

[3] *Chem. and Eng. News*, 1974, No. 7, 4.

[4] B. P. Mundy, K. B. Lipkowitz, and G. W. Dirks, *Synthetic Comm.*, 1975, **5**, 7; and references therein.

[5] J. Tsuji, Y. Mori, and M. Hara, *Tetrahedron*, 1972, **28**, 3721.

[6] T. E. Bellas, R. G. Brownlee, and R. M. Silverstein, *Tetrahedron*, 1969, **25**, 5149.

[7] W. G. Lloyd and B. J. Luberoff, *J. Org. Chem.*, 1969, **34**, 3949.

[8] Y. Gaoni, *J. Chem. Soc.* (*C*), 1968, 2925; H. H. Wasserman and E. H. Barber, *J. Amer. Chem. Soc.*, 1969, **91**, 3674.