Decarboxylation of *endo*- and *exo*-6-Isobutyl-1,4-dimethyl-2,7-dioxabicyclo[2.2.1]-heptane-6-carboxylic Acids

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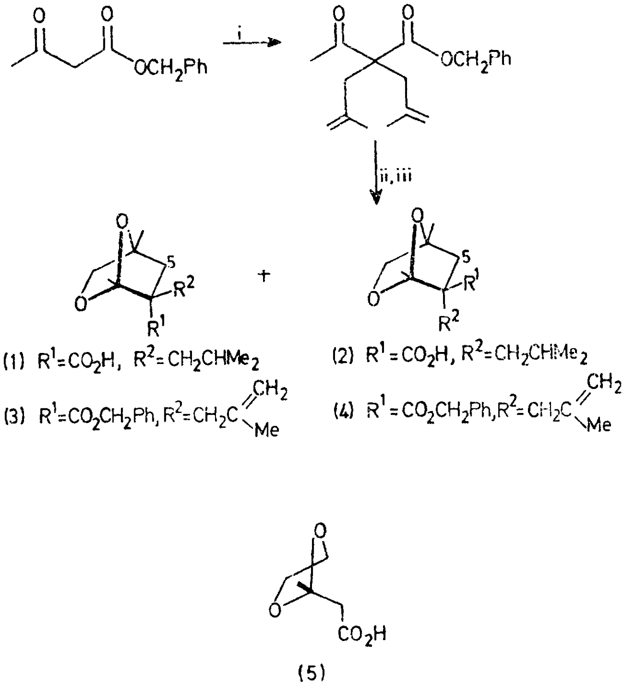
Summary Decarboxylation of the title *endo*-acid (**1**) in chlorobenzene follows first-order kinetics with $k = 3{\cdot}7 \times 10^{-4}\,s^{-1}$ at 69 °C and is significantly faster than decarboxylation of the corresponding *exo*-acid (**2**) with $k = 7{\cdot}8 \times 10^{-5}\,s^{-1}$ at 121 °C; both (**1**) and (**2**) decarboxylate faster than a model compound, 2-methyl-1,3-dioxolan-2-acetic acid (**5**).

We have synthesised the epimeric bicyclic acetal acids (**1**) and (**2**) by the route shown in Scheme 1 and have studied their rates of decarboxylation on heating. The reaction of $\gamma\delta$-unsaturated ketones with peracids forming bicyclic acetals is well documented.[1] Kieselgel chromatography followed by crystallisation separated the two benzyl esters (**3**) and (**4**) and hydrogenolysis yielded the corresponding crystalline acids (**1**) and (**2**) with concomitant saturation of the 2-methylpropenyl side-chain.

Identification of (**1**) and (**2**) follows from the chemical shifts (chlorobenzene) of the 5-*endo* and W-coupled 5-*exo*-protons.[2] In the *endo*-acid, the 5-*endo*-proton (δ 2·6 d, J 12 Hz) is deshielded relative to the 5-*exo*-proton (δ 1·9 dd, J 12 and 3 Hz), whereas in the *exo*-acid the reverse situation obtains (δ 1·3, d, J 12 Hz, and 2·5, dd, J 12 and 3 Hz, respectively).

The rate of thermal decarboxylation of the acids (**1**) and (**2**) in chlorobenzene solution was followed by g.l.c. (Pye 104 3% A.P.L. 150 °C, chloronaphthalene as internal standard) determination of the concentration of unchanged acids, after conversion into their methyl esters with diazomethane. Good first-order plots were obtained for decarboxylation of both (**1**) ($k = 3{\cdot}7 \times 10^{-4}\,s^{-1}$; 69 °C) and (**2**) ($k = 7{\cdot}8 \times 10^{-5}\,s^{-1}$; 121 °C). For comparison, the rate of decarboxylation of the acid (**5**) was measured (by n.m.r. spectroscopy) in bromobenzene ($k = 3{\cdot}9 \times 10^{-5}\,s^{-1}$; 138 °C).

Decarboxylation of the *endo*-acid (**1**) is considerably faster than that of the *exo*-acid (**2**) and both decarboxylate faster than the model acid (**5**). Examination of the products of decarboxylation of the *endo*-acid by n.m.r.



(1) $R^1 = CO_2H$, $R^2 = CH_2CHMe_2$

(2) $R^1 = CO_2H$, $R^2 = CH_2CHMe_2$

(3) $R^1 = CO_2CH_2Ph$, $R^2 = CH_2C(=CH_2)Me$

(4) $R^1 = CO_2CH_2Ph$, $R^2 = CH_2C(=CH_2)Me$

(5)

Scheme 1. Reagents: i, NaH–$CH_2{:}C(Me)CH_2Cl$; ii, *m*-chloroperbenzoic acid; iii, H_2–Pd.

spectroscopy shows that an epimeric mixture of bicyclic acetals (**8**) and (**9**) is formed together with a small amount of the dihydrofuran (**7**). Following the decomposition of the *exo*-acid by n.m.r. spectroscopy reveals the growth and decay of a product which we believe to be the dihydropyran (**11**): in particular, the allylic methyl group at δ 1·7 is similar in chemical shift and multiplicity to that in the dihydrofuran (δ 1·6, t, *J* 2 Hz). Eventually, decomposition of the *exo*-acid yields a similar mixture of bicyclic acetals and dihydrofuran (**7**) to that obtained from the *endo*-acid.

Since the decarboxylation of both acids (**1**) and (**2**) is faster than the model acid (**5**), it appears that, at least in the case of (**1**), relief of ring strain is important in the rate-determining step. An economical explanation for the faster rate of decarboxylation of (**1**) over (**2**) is that decarboxylation takes place from the zwitterions (**6**) and (**10**) (Scheme 2).[3] The less favourable geometry for proton transfer and expected lower basicity of the 7-oxygen would result in a lower concentration of the zwitterion (**10**) relative to (**6**). It is likely, also, that stabilisation of an incipient carbonium ion at position 1 would be greater by the 7-oxygen in (**6**) than by the 2-oxygen in (**10**). However, the exact timing of bond breaking and making in these decarboxylative eliminations remains to be determined.†

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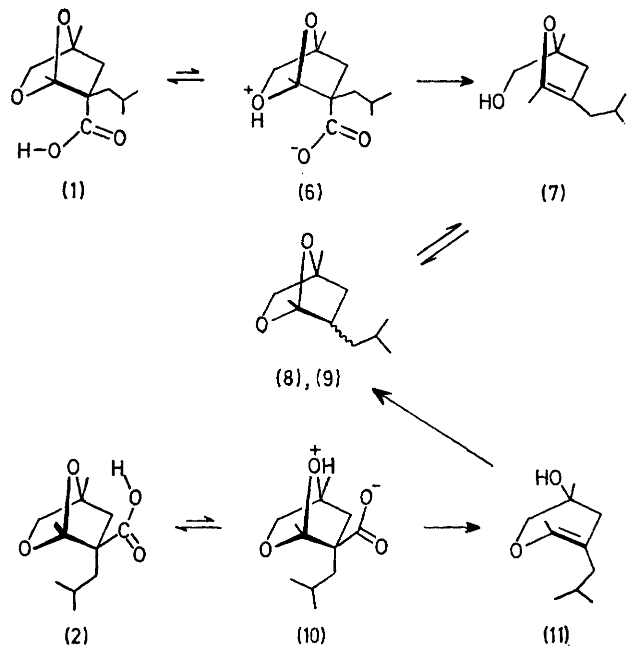

Scheme 2

(*Received*, 21*st October* 1976; *Com.* 1191.)

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† A concerted loss of carbon dioxide (by-passing the zwitterion intermediates; see ref. 4) for both (**1**) and (**2**) we consider unlikely.

[1] Y. Gaoni, *J. Chem. Soc.* (*C*), 1968, 2925.
[2] Y. Gaoni, *J. Chem. Soc.* (*B*), 1968, 382.
[3] B. R. Brown, *Quart. Rev.*, 1951, **5**, 131.
[4] D. B. Bigley and R. W. May, *J. Chem. Soc.* (*B*), 1969, 994.