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SOLVOLYTIC REARRANGEMENTS OF BICYCLO[2.1.1]HEX-2-YL MESYLATES

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Summary
Solvolysis of 2-carbomethoxybicyclo[2.1.1]hex-2-yl mesylate in formic acid is significantly more rapid than expected and occurs with C1-C5 alkyl migration to give a primary product in which the leaving group is retained.

One of the areas of current interest in solvolytic processes is that concerned with production of carbocations attached to electron-withdrawing substituents, the "electron-deficient" cations[1]. Examination of substituents such as the ester[2], cyano[3], and keto[1] groups, which are potentially capable of mesomeric stabilisation of the intermediate cation, has shown that π-conjugation, as exemplified by the carbonyl function (Fig.1), can dominate the destabilising inductive influence of the substituent.

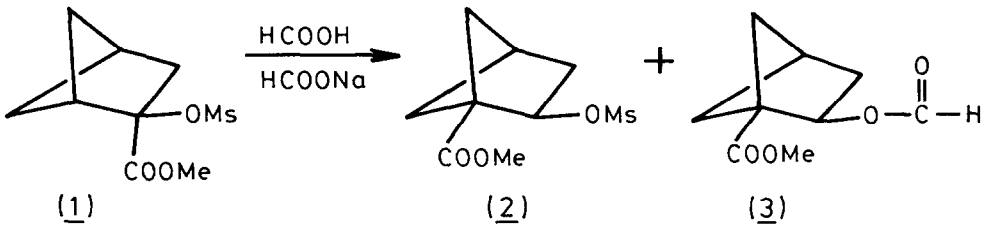
We wish to report our observations on the solvolytic behaviour of 2-carbomethoxybicyclo[2.1.1]hex-2-yl mesylate (1) which appears to involve, to some extent at least, resonance-stabilisation of this kind. We undertook the solvolysis of the

Fig. 1

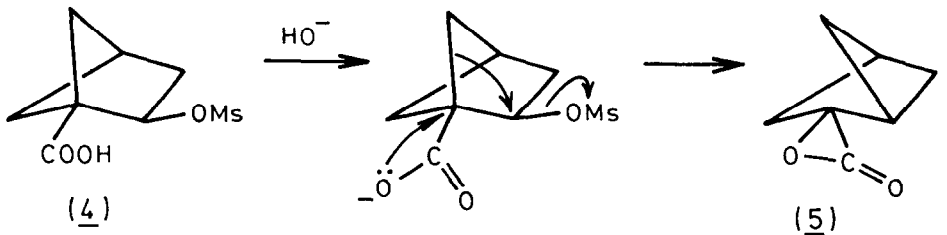
mesylate (1) in anticipation that it would rearrange to the formate (3) and thus constitute a convenient entry into the bicyclo[2.1.1]hexyl system with a versatile functional group at the bridgehead[4].

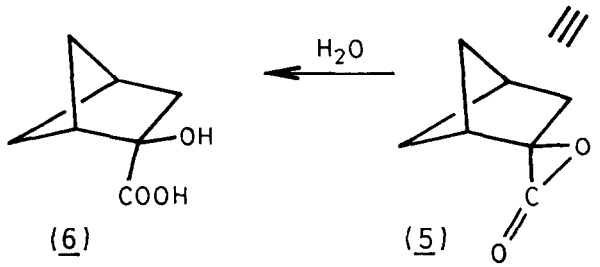
Solvolysis of (1) in buffered formic acid was, indeed, characterised by 1,2-migration of neighbouring carbon; to our surprise, however, the primary product of solvolysis consisted predominantly of the ester (2) corresponding to retention of the mesylate group. Such solvolyses in which internal return is accompanied by rearrangement are uncommon.[5] Furthermore, despite the presence of the strongly electron-withdrawing α-substituent, the mesylate ester (1) (k_1 =3.98 x 10^{-3} sec^{-1} at 75°C) is considerably more reactive than the ß-carbomethoxy mesylate (2) (k_1 = 1.23 10^{-5} sec^{-1}). Indeed, the ester (1) is almost as reactive as the parent compound, bicyclo[2.1.1]hex-2-yl mesylate (k_1 = 1.45 x 10^{-2} sec^{-1} at 75°C) although this comparison is somewhat tenuous in view of the amount of internal return anticipated during formolysis of the latter.

Several interesting conclusions can be drawn from these results. On the one hand, the kinetic data demonstrate that the minor component (3) must arise essentially from capture of the rearranged cation by solvent as it is formed from (1), and is not produced to any appreciable extent from formolysis of (2). In fact, the ratio of (2):(3) was shown by n.m.r. analysis to be constant throughout the reaction. At the same time we recognise that one or more of a number of factors may be responsible for the relatively high reactivity displayed by the mesylate (1). Firstly, some rate enhancement may be attributable to the relief of eclipsing strain between the mesylate and carbomethoxy groups and the hydrogen atoms on C3 upon loss of the leaving group. Alternatively, anchimeric assistance may be provided by migration of the C1-C5 bond during ionisation. Thirdly, the increased rate may be a reflection of an energetically favourable mesomeric interaction between the carbonyl group and the incipient cationic centre in the transition state (Fig.1). It is highly unlikely that the steric factor alone is responsible for the high reactivity of (1). While the relative importance of σ-participation versus π-stabilisation is difficult to assess at this stage, it seems reasonable to suggest that the reactive nature of



(2) : (3)
= 95 : 5





the mesylate (1) is attributable in part to resonance-stabilisation of the kind depicted (Fig.1).

As a further illustration of the unpredictable nature of rearrangements we have observed that the reverse of the 2.2 → 1.2 rearrangement process observed during solvolysis of ester (1) occurs under appropriate conditions. Thus, treatment of the acid mesylate (4)[6] with aqueous potassium hydroxide yields the α-hydroxyacid (6) in good yield (74%). This reversal may simply reflect the relative stabilities of the pairs (1 and 2) and (4 and 6) as a result of the differing influence of the -COOR and

$-COO^-$ groups on an adjacent carbocationic centre. Alternatively, rearrangement (4)→(6) may involve the intermediacy of the α-lactone (5).

Acknowledgement: We thank the Australian Research Grants Committee for financial support.

References and Footnotes

1. See X. Creary, Acc.Chem.Res., 1985, 18, 3 for leading references.

2. X. Creary and C.C. Geiger, J.Am.Chem.Soc., 1982, 104, 4151.

3. P.G. Gassman and T.T. Tidwell, Acc.Chem.Res., 1983, 16, 279 and references cited therein.

4. The ester mesylate (1) is prepared via a four-step sequence from the readily available bicyclo[2.1.1]hexanone by sequential treatment with aqueous $NaHSO_3$ - KCN; conc. HCℓ, Δ; methanol-H^+; methanesulfonyl chloride-triethylamine.

5. See e.g. (a) X. Creary, P.A. Inocencio, T.L. Underiner, and R. Kostromin, J.Org.Chem., 1985, 50, 1932 for a recent example involving the norbornyl system; and (b) J. Meinwald and P.G. Gassman, J.Am.Chem.Soc., 1963, 85, 57 in which rearrangement of 5,5-dimethylbicyclo[2.1.1]hex-2-yl tosylate to the 3,3-dimethyl isomer is reported.

6. Obtained from the corresponding ester (2) by hydrolysis with KOH in aqueous dioxan under mild conditions.

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