Communications to the Editor

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COMPETITIVE REARRANGEMENT AND CYCLOREVERSION REACTIONS OF THE DIMETHOXY-SUBSTITUTED COOKSON'S CAGE DIKETONE EFFECTED WITH LEWIS ACID CATALYST

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The dimethoxy-substituted Cookson's cage diketone (1a) underwent competitive rearrangement and cycloreversion reactions under treatment with Lewis acid, where two types of electron push-pull interaction are operative.

KEYWORDS——Cookson's cage diketone; [1,2]rearrangement; [2+2]-cycloreversion; Lewis acid catalysis; (D_3)-trishomocubane

In accordance with the development of the applicability of photo-thermal olefin metathesis, there is an increasing interest in the reactivity of cage molecules in the field of physical and synthetic organic chemistry. Especially, the cycloreversion reaction of the Cookson's cage diketone derivative has been applied to the total synthesis of triquinanes, such as hirsutene and coriolin.[1) In this connection, we have recently reported the rapid [2σ+2σ]cycloreversion reaction of the dimethoxy- and monomethoxy-substituted Cookson's cage diketones (1a and 1b) to give the triquinane derivatives (2a and 2b) in terms of the through-bond interaction[2a) and the synergetic capto-dative diradical stabilization effect,[2b) and the electron push-pull effect[3) through the rigid cage skeleton, respectively (Chart 1).

Related to this mode of reaction, we report here competitive rearrangement and cycloreversion reactions of the dimethoxy-substituted derivative (1a) using Lewis acid catalyst.

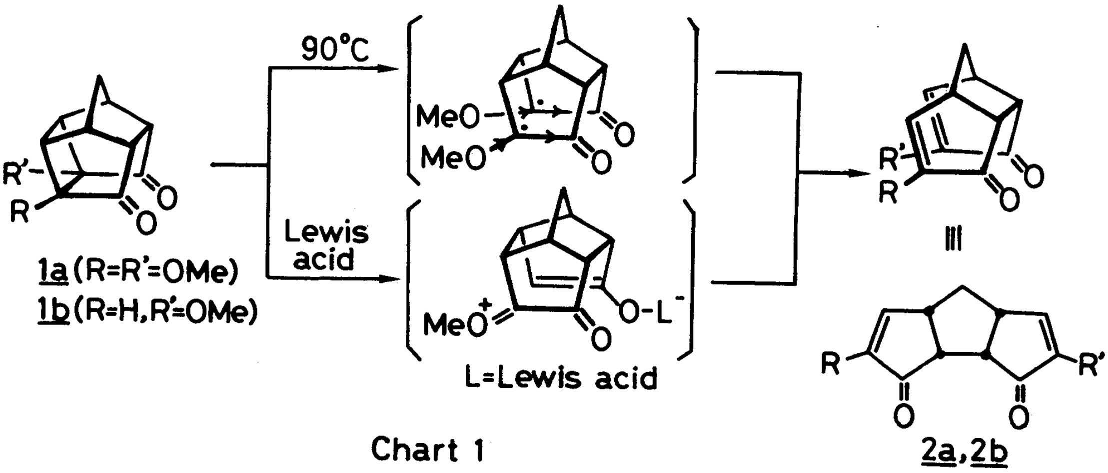

Chart 1

Treatment of 1a with a catalytic amount of $BF_3 \cdot Et_2O$ (0.1 eq) in dry benzene at 0°C caused a rapid reaction giving the [2σ+2σ]cycloreversion product 2a together with the rearrangement product 3 in 11 and 36% yields, respectively (Chart 2). When the reaction temperature was raised to the ambient (20-25°C), the rearrangement product 3 was obtained exclusively in 58% yield.

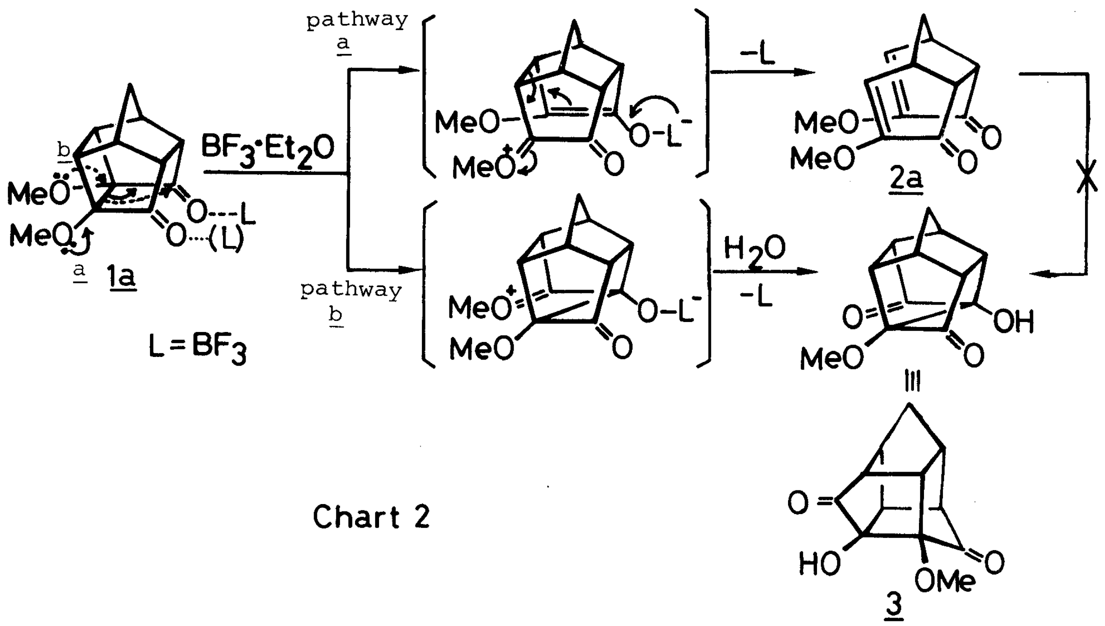

Chart 2

The structure of 2a was identified by the physical and spectral properties of an authentic sample obtained by the thermal reaction of 1a.[2b)] The structural determination of the major product 3 was accomplished by analyzing its characteristic spectral data as follows.[4)]

The IR absorptions at 3550, and 1790 cm^{-1} exhibit the presence of the corresponding hydroxyl and carbonyl groups. From the mass spectral data (m/z 220 (M^+)), it is confirmed that the extrusion of methanol from 1a has occurred. While, in the ^1H- and ^{13}C-NMR spectra, only one methoxy group is observed at δ3.51 and 53.6 ppm, respectively. The most definitive evidence is the absorptions of six methine and one methylene signals in the ^{13}C-NMR spectrum, whose chemical shifts are closely related to those of the basic skeleton of (D_3)-trishomocubane and related systems.[5)]

Since the (D_3)-trishomocubane skeleton is known to be the most stable among $C_{11}H_{14}$ isomers,[5a)] the product 3 was expected initially as the result of a thermodynamic rearrangement from the kinetic product 2a. However, the cycloreversion product 2a did not undergo the further rearrangement upon treatment with $BF_3 \cdot Et_2O$ at room temperature.

From these facts, we propose that the products 2a and 3 are formed from the same precursor (1a) *via* Lewis acid-catalyzed bond cleavage as depicted in Chart 2.[6)] As in the case of monomethoxy-substituted compound (1b), the cycloreversion pathway may result from the preferential electron donation from the methoxy group arranged in the anti-periplanar position of the carbonyl group which is coordinating to Lewis acid (pathway a, Chart 2). On the other hand, if the donation of an electron from the other methoxy group occurred, the competive [1,2]rearrangement giving the thermodynamically more stable trishomocubane derivative (3) should exist (pathway b, Chart 2). Thus, the observed difference in reactivity between 1a and 1b may be satisfactorily explained in terms of two types of electron "push-pull interaction" through the rigid cage skeletons.

In summary, these results clearly indicate the power of the cycloreversion of substituted Cookson's cage diketone under mild conditions to efficiently generate the complex triquinane systems. We are continuing our exploration of the scope of the cycloreversion which should find widespread use in organic synthesis.

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4) Physical and spectral data of 3: mp: 98-101°C; $\nu_{max}(CHCl_3)$: 3550 and 1790 cm^{-1}; ^{1}H-NMR ($CDCl_3$): δ1.88 (bs, 2H), 2.12-2.40 (m, 2H), 2.64-3.12 (m, 5H), 3.51 (s, 3H); ^{13}C-NMR ($CDCl_3$): 38.8 (d), 40.5 (t), 42.2 (d), 42.5 (d), 43.6 (d), 45.0 (d), 45.3 (d), 53.6 (q), 76.6 (s), 80.2 (s), 209.7 (s), 210.4 (s) ppm ; MS (m/z): 220 (M^+).

5) a) E. Ōsawa, K. Aigami, N. Takaishi, Y. Inamoto, Y. Fujikura, Z. Majerski, P. v. R. Schleyer, E. M. Engler and M. Farcausiu, J. Am. Chem. Soc., 99, 5361 (1977); b) G. J. Kent, S. A. Godleski, E. Ōsawa and P. v. R. Schleyer, J. Org. Chem., 42, 3852 (1977).

6) A further facile rearrenagement to the pentacycloundecane system through the intermediate carbocation formally related to the most stable pentacyclic (D_3)-trishomocubyl cation has been reported: see G. Mehta, A. V. Reddy, W. Tacreiter and T. S. Cameron, Chem. Commun., 1983, 441.

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