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THE ACID CATALYZED RING OPENING OF 1-OXASPIRO[2.6]NONANE. A 1,5 HYDROGEN SHIFT.

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The acid catalyzed ring opening of 1-oxaspiro[2.6]nonane (I) has been previously reported. Corey and Chaykovsky (1) studied the opening of the epoxide ring using $BF_3 \cdot Et_2O$ at 0°C and obtained only cycloheptanecarboxaldehyde. Traynham and Pascual (2), using HBr at room temperature, obtained 1-hydroxymethyl-1-bromocycloheptane and cycloheptanecarboxaldehyde. We now wish to report the results of our study on the reaction of 1-oxaspiro[2.6]-nonane (I) with 45% sulfuric acid at 150°.

The reaction was carried out in such a way as to isolate only steam-distillable products. 1-Oxaspiro[2.6]nonane (I) was added in 0.20 ml portions to 45% aqueous sulfuric acid at 150°. A fast stream of nitrogen was bubbled through the reaction mixture in order to steam-distill volatile products as they formed. The acid concentration was kept constant by the dropwise addition of water. Gas chromatographic analysis of the crude product (80% yield) indicated the formation of four major products and a number of minor products. The products were separated and collected by preparative gas chromatography (20% Dow Corning Silicone Oil 550). Spectroscopic analyses, followed by comparison of the dinitrophenylhydrazones with the corresponding derivatives of authentic samples, indicated three of the major products[3] to be α-methylcyclohexanecarboxaldehyde (II) (12%), α-methylcycloheptanone (III) (15%) and cycloheptanecarboxaldehyde (IV) (50%).

Combustion analysis and molecular weight determination of the fourth major product (13%) indicated the molecular formula to be $C_8H_{14}O$. The infrared spectrum showed no absorption in the 1800-1650 cm^{-1} and 3600-3100 cm^{-1} regions, indicating the absence of carbonyl and alcohol, respectively. The presence of a strong band at 1040 cm^{-1} was consistent with the remaining possibility, an ether. The nmr spectrum showed a broad doublet centered at δ 4.25 (1H, $J \approx 6$ c./s., H-C-O), a broad multiplet centered at δ 1.60 (10H, CH_2) and a

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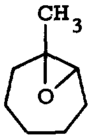
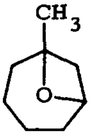
[3] Per cent of the total crude yield is indicated in parenthesis.

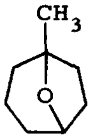
sharp singlet at δ 1.20 (3H, CH_3-C-O). Three possible structures are suggested by this information, 1-methyl-8-oxabicyclo[5.1.0]octane (V), 1-methyl-7-oxabicyclo[4.1.1]-octane (VI) and 1-methyl-8-oxabicyclo[3.2.1]octane (VII).



V



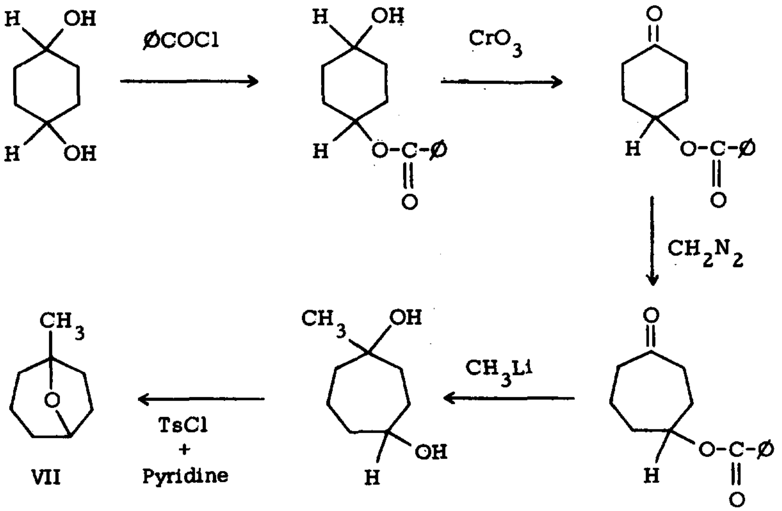
VI



VII

The structure of this product was shown to be 1-methyl-8-oxabicyclo[3.2.1]octane (VII) by synthesis and comparison of spectral properties. The synthesis of VII is outlined in Scheme I.

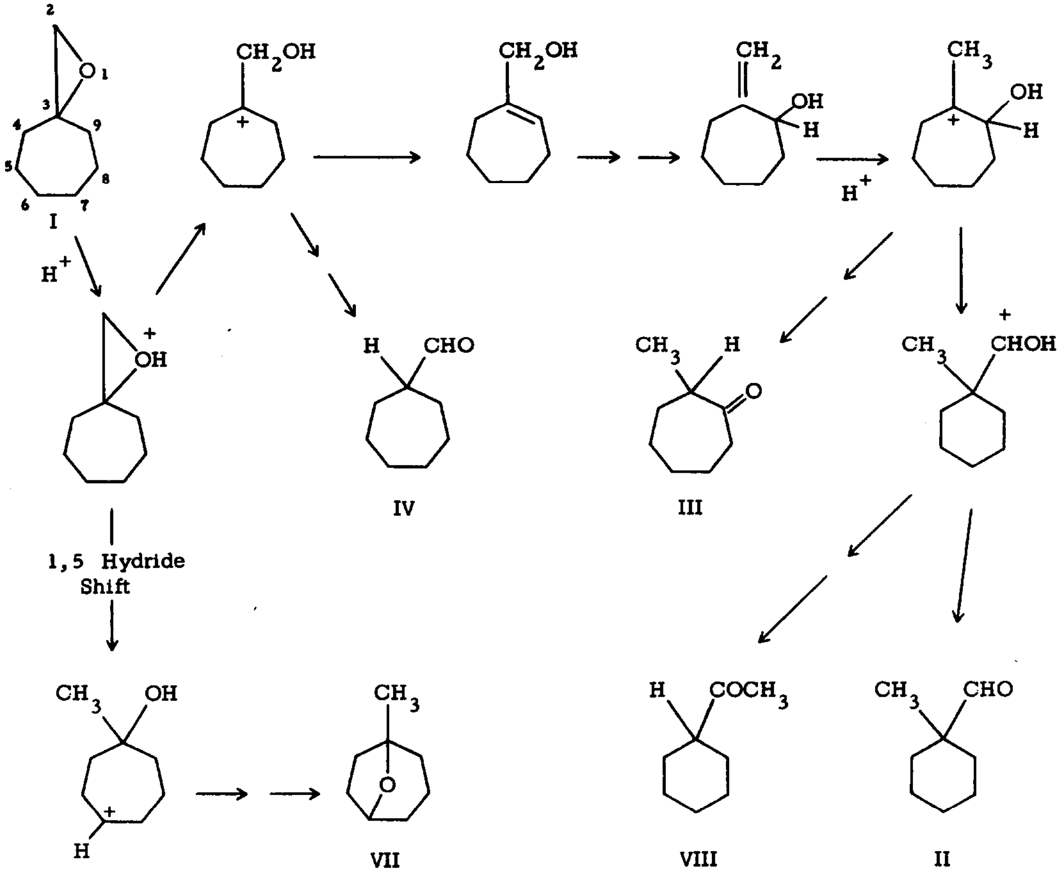
SCHEME I



Two of the minor components (6% of the total product) were identified by retention times, nmr and mass spectral analyses as methyl cyclohexyl ketone (VIII) and cycloheptanone (IX).

A mechanism to explain the formation of the observed products is offered in Scheme II.[4]

SCHEME II[5,6]



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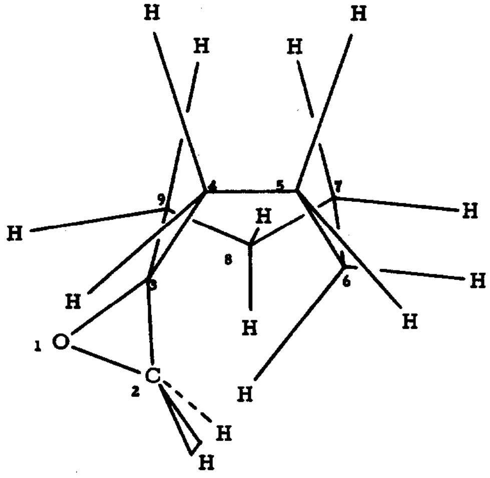
[4] A referee has suggested that 1-(hydroxymethyl)-1-cycloheptanol is the intermediate in this reaction. Under our reaction conditions, this diol does indeed lead to the same products as from I, but in quite different proportions.

[5] Two arrows leading to a product indicate a multistep process.

[6] Evidence cited later in this paper and preliminary labeling results from our laboratories indicate that many of the suggested steps are reversible.

Of particular interest is the step involving a 1,5 hydride shift. An examination of a Dreiding model of I indicates that one of the hydrogen atoms at C-6 is situated near, and directly behind, the C_2-O bond.[7] This is illustrated in Figure 1 for the chair conformer of I. Thus, the postulated 1,5 hydride shift requires little molecular reorganization and should be stereochemically favorable. Interactions in a cycloheptylcarbinyl framework are not without precedent. It has been reported that cyclohept-4-enylmethyl p-bromobenzene sulfonate solvolyzes sixty two times faster than the corresponding saturated compound in acetic acid and yields 93% endo-2-acetoxybicyclo[3.2.1]octane (3).

FIGURE I



I

The relative harshness of the reaction conditions, and the fact that only steam-volatile material was removed from the reaction vessel, explains the more extensive rearrangement observed in this work, compared to the previously reported ring openings of 1-oxaspiro[2.6]-nonane (1, 2). Under our reaction conditions we find that cycloheptanecarboxaldehyde (IV) partially rearranges to II, III, VII and VIII. In agreement with the proposed mechanism, α -methylcyclohexanecarboxaldehyde (II) similarly yields III and VIII.

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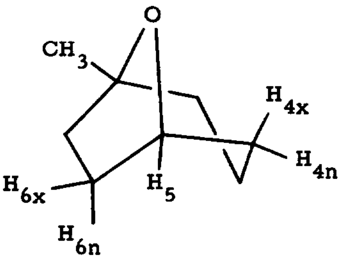
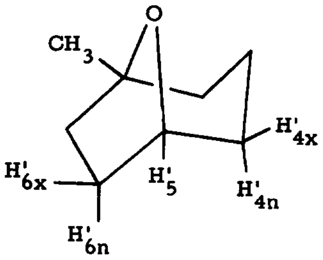
[7] This appears to be true for the three commonly considered conformations of a seven membered ring, the twist-chair, chair and boat conformations.

Cycloheptanone probably arises from cycloheptanecarboxaldehyde (IV). This reaction has been previously reported (4).

The nmr spectrum of VII warrants further comment. The appearance of the bridgehead hydrogen as a broad doublet with a major coupling constant of 6 c./s. allows a choice between the chair (X) and boat (XI) conformers for the six-membered ring. Table I lists the predicted coupling constants, determined by using Dreiding models to estimate the dihedral angles and the 1963 Karplus equation (5) to estimate coupling constants.[8] The appearance of H_5 as a broad doublet is inconsistent with the boat conformer (XI) for which two relatively large coupling constants are predicted. This would lead to a broad triplet. The observed coupling is consistent with the chair conformer (X).



X



XI

TABLE I

Predicted Coupling Constants for the Bridgehead Hydrogen Atom of 1-Methyl-8-oxabicyclo[3.2.1]octane.

Chair Conformer (X)		Boat Conformer (XI)	
Angle	J	Angle	J
H_5H_{4x}	1.3	$H'_5H'_{4x}$	7.4
H_5H_{4n}	2.2	$H'_5H'_{4n}$	0.2
H_5H_{6x}	6.5	$H'_5H'_{6x}$	6.4
H_5H_{6n}	−0.2	$H'_5H'_{6n}$	−0.2

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[8] For a discussion of the possible errors involved in such an analysis, see reference (5).

We are presently investigating the generality of such cycloheptylcarbinyl shifts as reported above[9] and are continuing our detailed studies of the mechanisms of these reactions.

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References

(1) E. J. Corey and M. Chaykovsky, J. Am. Chem. Soc., **87**, 1353 (1965).

(2) J. G. Traynham and O. S. Pascual, Tetrahedron, **7**, 165 (1959).

(3) G. Le Ny, Compt. Rend., **251**, 1526 (1960); H. Felkin, G. Le Ny, C. Lion, W. D. K. Macrosson, J. Martin and W. Parker, Tetrahedron Letters, 157 (1966).

(4) J. G. Traynham and M. T. Yang, J. Am. Chem. Soc., **87**, 2394 (1965).

(5) M. Karplus, J. Am. Chem. Soc., **85**, 2870 (1963).

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[9] Preliminary results by Mr. A. J. Kascheres and Mr. S. H. Stoldt indicate similar shifts in the pinacol rearrangement of 1-(hydroxymethyl)-1-cycloheptanol and in the Friedel Crafts reaction of 1-bromo-1-(bromomethyl)cycloheptane with benzene.