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TRANSANNULAR CYCLIZATION OF CYCLODECYN-6-OLS

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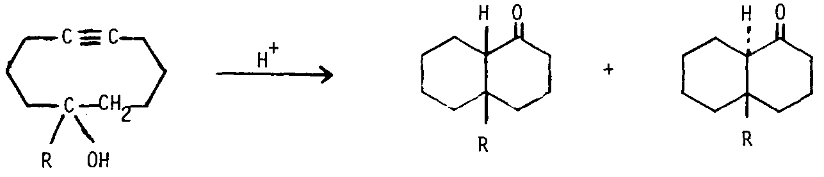
In the past there has been a great deal of interest in the transannular reactions of carbonium ions in medium-sized rings.[1] Cope[1] and Goering[2] have found that solvolysis of cis- or trans-cyclodec-5-en-1-yl tosylate gave products containing the bicyclo[4.4.0]decane skeleton only, indicating that these transannular reactions occur via six-membered ring transition states. We were interested in extending this to a study of the effect of a triple bond in the cyclodecane ring since the solvolysis of 6-octyn-2-yl tosylate in trifluoroacetic acid yields products arising mainly by cyclization through a five-membered ring transition state.[3] Recently the solvolysis of cyclodec-5-yn-1-yl tosylate has been found to give predominantly cis- and trans-decalone-1 and small amounts of bicyclo[5.3.0]decanone-2.[4] We wish to report our results on this cyclization which has given different results from the solvolysis[4] and some rather unusual products.

Cyclodecyn-6-ol (1)[6b] is readily available from the LiAlH$_4$ reduction of cyclodecyn-6-one.[5] Treatment of 1 with refluxing methanolic HCl gave a mixture of cis- and trans-decalone-1 (2a and 2b)[6b] in 75% isolated yield. No trace of bicyclo[5.3.0]decanone-2 could be found by vpc under conditions in which 0.5% of this later compound would have been detected. We investigated the effect of proton and Lewis acids, and solvent polarity on this cyclization and in all cases 2a and 2b were formed in good yield and no trace of the isomeric bicyclo[5.3.0]decanone-2 could be detected.

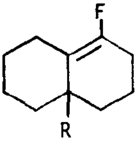


1, R = H
6, R = Me

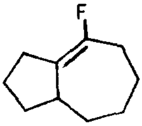
2a, R = H
7a, R = Me

2b, R = H
7b, R = Me

Treatment of 1 with $BF_3 \cdot Et_2O$ in methylene chloride gave a single very volatile product[6b] isolated in 65-70% yield. No other product could be detected by the vpc. The molecular formula of this product was established as $C_{10}H_{15}F$ by high resolution mass spectroscopy and the ir spectrum of this compound has a strong band at 1705 cm^{-1} (C=C-F).[7] The proton nmr of the product shows a broad absorption δ 1-3 and no vinyl proton. The flourine nmr has a sharp singlet at 111 ppm upfield from internal $CFCl_3$; this also indicates the homogeneity of our product. But the spectroscopic evidence did not allow us to distinguish between structure 3 or 4 for the fluoroalkene. Ozonolysis, oxidative work-up of the ozonide, and esterification of the resulting acid gave methyl 2-oxocyclohexylbutyrate (5).[6b] The ir spectrum of the acid (1705 and 1725 cm^{-1}) and the ester 5 (1705 and 1735 cm^{-1}) were consistent only with a six-membered ring keto compound, thus eliminating structure 4 for the fluoroalkene. The ester 5 was converted to its DNP derivative[6a,b] (mp 109-111°) and compared to the DNP of a sample of 5 prepared by the alkylation of the enamine of cyclohexanone with methyl γ-iodobutyrate (mp 110-113°, lit. mp 112°[8], mmp 108-111°).



3, R = H
9, R = Me



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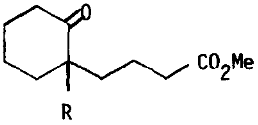
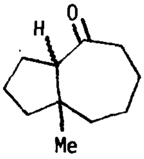


5, R = H
10, R = Me



8a, cis
8b, trans

Addition of methyllithium to cyclodecyn-6-one gave 6-methylcyclodecyn-6-ol (6)[6b] in excellent yield. Treatment of alcohol 6 in refluxing methonolic HCl gave a mixture of cis- and trans-5-methyldecalone-2 (7a and 7b) plus cis- and trans-7-methyl-bicyclo[5.3.0]-decanone-2 (8a and 8b). The yield of isolated ketones was 70% and the ratios of cis-trans isomers of 7 and 8 are probably equilibrium values since they did not change on prolonged acid treatment. Unfortunately vpc did not allow a clean separation of all four products; however, by using vpc and nmr (vide infra) we were able to measure the amount of each isomer present.

An authentic mixture of 7a and 7b[9] was prepared by the conjugate addition of lithium dimethylcopper to $\Delta^{1,6}$-octalone-2. The cis-trans mixture was separated by vpc. Compound 7a[6b] has a nmr singlet at δ 1.02 and 7b[6b] has a nmr singlet at δ 0.77. We have measured the equilibrium ratio of 7a and 7b (1:1.42) by vpc and nmr, and we have confirmed the earlier indirect measurement of this equilibrium.[10] An authentic mixture of 8a and 8b was prepared by the conjugate addition of lithium dimethylcopper to $\Delta^{1,7}$-bicyclo[5.3.0]decanone-2. Again the cis-trans mixture was separated by vpc. Compound 8a[6a,b] has a nmr singlet at δ 1.18 and compound 8b[6a,b] has a nmr singlet at δ 0.72 due to the angular methyl group. Using nmr and vpc the ratio of 7a:7b:8a:8b from the acid treatment of 6 was 1.0: 1.4: 0.1: 0.25. This is the only example in which we have found any transannular products resulting from a five-membered ring transition state.

Treatment of 6 with $BF_3{\cdot}Et_2O$ in methylene chloride gave the fluoroalkene 9[6b], isolated in 87% yield. No other product could be detected by tlc, vpc, proton nmr - singlet at δ 1.05 due to angular methyl group - or fluorine nmr - singlet at 110 ppm upfield from $CFCl_3$. The structure 9 was confirmed by ozonolysis, oxidative work-up of the ozonide, and esterification to yield methyl 1-methyl-2-oxocyclohexylbutyrate (10)[6b] which was converted to its DNP[6a,b] (mp 99-100°). No trace of the isomeric cyclopentanone could be detected in the acid or ester from the ozonolysis sequence.

All the transannular cyclizations,[11] except one, proceed stereospecifically through six-membered ring transition states. We feel that these reactions are concerted and that they are controlled by torsional effects[12] in the cyclodecane ring. In the case of alcohol 6 and the solvolysis of the tosylate of 1[4] the transition state may have substantial carbonium ion character and lead to the observed bicyclo[5.3.0]decanes since the intermediary vinyl cation may be more stable in a seven-membered ring.[13]

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(b) J. Schreiber, et al., Helv. Chim. Acta, 50, 2101 (1967).

(6) (a) Analytical and (b) spectroscopic data for this compound were in accord with the assigned structure.

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(9) We are grateful to Professor E. Piers and Miss W.M. Phillips for these compounds.

(10) F. Sondheimer and D. Rosenthal, *J. Amer. Chem. Soc.*, **80**, 3995 (1958).

(11) Acid treatment of cyclodecyn-6-one yields $\Delta^{1,6}$-octalone-2 exclusively and Li-NH$_3$ reduction of cyclodecyn-6-one yields $\Delta^{1,2}$-octalol-6 only; B. Rao and L. Weiler, unpublished results.

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