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THE EFFECT OF THE α-CYANO MOIETY ON NEIGHBORING GROUP PARTICIPATION BY THE CYCLOPROPYL GROUP

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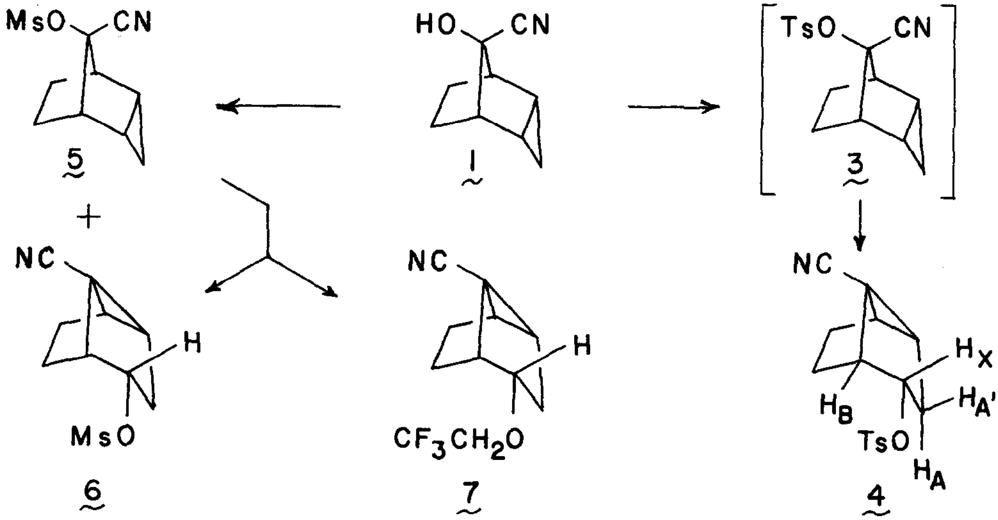
Summary: H/α-CN rate ratios have been derived for the solvolysis of sulfonate esters of *endo*-tricyclo[3.2.1.$0^{2,4}$]octan-*anti*-8-ol and tricyclo[2.2.1.$0^{2,6}$]heptan-3-ol. The role of the α-cyano moiety in the stabilization of highly delocalized cations has been evaluated.

Recently, we[1,2] and others[3,4] have studied both the experimental[1a-d,3] and theoretical[2,4] aspects of the interaction of the α-cyano group with carbonium ion centers. In simple systems, which lack a mechanism for extensive charge delocalization into an attached carbon skeleton, conjugative stabilization of the incipient cation by the cyano group almost balances the rate-retarding inductive effect of this function.[1a,c,d] In general, H/α-CN rate ratios of 10^3 were found for these systems, while for certain derivatives of the bicyclo-[2.2.1]heptyl system, where extensive charge delocalization occurs, H/α-CN rate ratios as large as 10^6 were observed.[1b] In view of these results, we have studied the effect of the cyano function on participation by neighboring cyclopropyl groups.

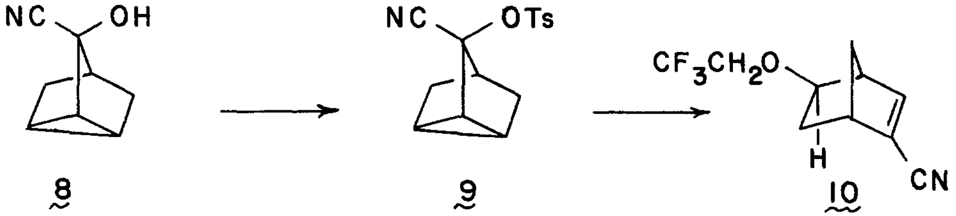
Treatment of *endo*-tricyclo[3.2.1.$0^{2,4}$]octan-8-one[5] with sodium bisulfite, followed by potassium cyanide gave an 88% yield of a 3:2 mixture of *syn*-8-cyano-*anti*-8-hydroxy-*endo*-tricyclo[3.2.1.$0^{2,4}$] octane(**1**) and *anti*-8-cyano-*syn*-8-hydroxy-*endo*-tricyclo[3.2.1.$0^{2,4}$] octane(**2**), respectively.[6] The structures of **1** and **2** were assigned on the basis of both spectroscopic and chemical evidence. Spectroscopically, **1** showed a single, sharp OH stretching vibration in the IR on high dilution in carbon tetrachloride at 3605 cm^{-1}, whereas **2** showed a non-hydrogen bonded absorption at 3600 cm^{-1} and an intramolecular-hydrogen bonded OH stretch at 3595 cm^{-1} due to bonding to the σ-electrons of the cyclopropyl ring.[7] More definitive evidence was provided through treatment of **1** and **2** with *p*-toluenesulfonyl chloride in pyridine at 0°C. Whereas **2** gave a *p*-toluenesulfonate derivative with retained structure, 1 gave only a *p*-toluenesulfonate with a rearranged carbon skeleton. It has been well established[8] that *endo*-tricyclo-$[3.2.1.0^{2,4}]$oct-*anti*-8-yl *p*-toluenesulfonate enjoys a 10^{14} rate acceleration due to neighboring group participation by the endo cyclopropyl ring, while the syn-isomer does not exhibit such an interaction. Thus, the chemical reactivity of the *p*-toluenesulfonate of 1 confirms the stereochemistry of the structural assignment. It is assumed that 1 initially gave 3, which, under the reaction conditions, ionized to a tight-ion pair and through internal return, gave 4. The ^{1}H NMR spectrum of 4 showed a six line pattern for H_X which is characteristic of the tricyclo$[3.3.0.0^{2,8}]$octan-*endo*-4-ol system[5,9] ($J_{AX} = J_{A'X} = 9.0$ Hz and $J_{BX} = 6.6$ Hz).



When 1 was treated with 1.0 equivalent of methanesulfonyl chloride and 1.5 equivalents of triethylamine in ether at -25°C, a 3:7 mixture of 5 and 6 was obtained. Solvolysis of 5[10] in anhydrous 2,2,2-trifluoroethanol buffered with 2,6-lutidine at *ca*. 25, 0, and -10°C gave $k_{25°C} = 2.72 \times 10^{-2}$ sec^{-1}, $\Delta H^{\ddagger} = 14.9 \pm 0.03$ kcal/mol, and $\Delta S^{\ddagger} = -15.8 \pm 0.9$ e.u. Product analysis showed that 5 gave a 94% yield of a 3:7 mixture of 6:7. Control experiments showed that 6 was stable to the reaction conditions.

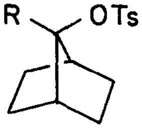
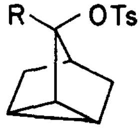
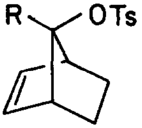
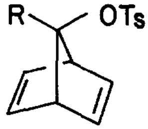
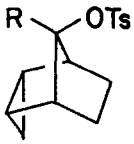
In a similar manner, tricyclo$[2.2.1.0^{2,6}]$heptan-3-one[11] was converted into the known[12] cyanohydrin, 8, using our method[13] in 95% overall yield. Upon treatment with *p*-toluenesulfonic anhydride, 8 gave 9 (84%). Solvolysis of 9 in

2,2,2-trifluoroethanol buffered with 2,6-lutidine at 95, 80, and 65°C gave $k_{25°C} = 3.41 \times 10^{-6}$ sec^{-1}, $\Delta H^{\ddagger} = 20.4 \pm 0.1$ kcal/mol, and $\Delta S^{\ddagger} = -14.9 \pm 0.3$ e.u. Product analysis indicated that **9** gave an 85% yield of **10**, which was consistent with the presence of neighboring group participation by the cyclopropyl moiety of **9**.



8 **9** **10**

In evaluating the effect of the α-cyano group on neighboring participation by the cyclopropyl sigma bonds, we examined the series outlined below.[14] For both **5** and **9**, it would appear that the cyano function enhanced cyclopropyl participation more than it enhanced double bond participation in the bicyclo[2.2.1]hept-2-en-7-yl and bicyclo[2.2.1]hepta-2,5-dien-7-yl systems.[1b] We believe that, in all of the examples shown, a balance between inductive destabilization and mesomeric stabilization of an incipient carbonium ion center by the α-cyano group is involved. The data indicates that this balance is a function of the degree of delocalization of charge in the transition state for ionization. When there is little delocalization, a large conjugative effect of the cyano group is in evidence.[1a] As delocalization of the developing positive charge increases, the mesomeric effect of the cyano group appears to decline more rapidly than the inductive effect (i.e., for the 7-cyanobicyclo[2.2.1]hepta-2,5-dien-7-yl system).[1b] In the case of the *endo*-tricyclo[3.2.1.0^{2,4}]oct-8-

k_{rel}					
R = H	1	$10^{8.5}$	10^{11}	10^{14}	10^{14}
R = CN	10^{-2}	10^{6}	10^{6}	10^{8}	10^{10}
H/CN ratio	10^{2}	$10^{2.5}$	10^{5}	10^{6}	10^{4}

yl system, it would appear that the charge is so effectively delocalized, that both the inductive and conjugative effects of the α-cyano group decrease significantly.

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