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ACID CATALYZED ISOMERIZATION OF BICYCLIC ALKENES: A FACILE BETWEENANENE SYNTHESIS

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Isomerization of *cis*-bicyclo[10.8.0]eicos-1(12)-ene (1a) and *cis*-bicyclo[10.10.0]docos-1(12)-ene (1b) to [10.8]- and [10.10]betweenanene (2a and 2b) has been effected by sulfuric acid. In both cases, the betweenanene isomers were found to predominate at equilibrium (70/30 2a/1a and 95/5 2b/1b).

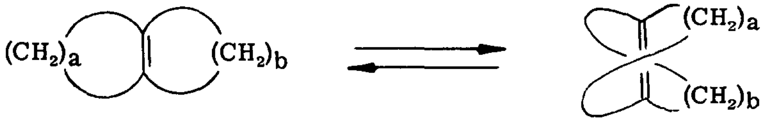
The quest for strained, twisted, bent, battered, crowded and often bizarre organic molecules has yielded valuable insight to structure-reactivity parameters while providing new challenges to synthesis methodology. Another structurally interesting and as yet less explored class of molecular curiosities are functionalized compounds whose structure endows them with an unusually low degree of chemical reactivity. The betweenanenes (2) are the most recent additions to this latter category.

[a.b]Betweenanenes are a homologous series of olefins whose double bond is sandwiched between bridging (a and b) carbon chains of a *trans*-bicycloalkene.[1] These carbon bridges effectively shield the double bond and thus render it inaccessible to external electrophilic reagents. For example, [10.10]betweenanene (2b), the prototype member of the family, shows no inclination (quantitative recovery after three weeks) toward epoxidation with *m*-chloroperoxybenzoic acid under conditions where the *cis* isomer 1b is completely converted (three minute reaction time) to epoxide 3b (Z=O). Likewise [10.8]betweenanene (2a), obtained via sensitized photoisomerization of olefin 1a (2a/1a=0.4), did not react with dichlorocarbene and failed to undergo catalytic hydrogenation.[2] The *cis* isomer 1a, on the other hand, readily gave the dichlorocyclopropane 3a ($Z=CCl_2$) and was hydrogenated to the dihydro derivative.[2]

We now wish to report that sulfuric acid effects equilibration of olefins 1 and 2 to a mixture which greatly favors the betweenanene isomer 2. This unexpected finding markedly simplifies the synthetic problems heretofore associated with larger ring [a.b]betweenanenes (a, b>8) and makes it apparent that while betweenanenes 2a and 2b are relatively unreactive olefins, they are not fully immune to attack by small electrophiles.

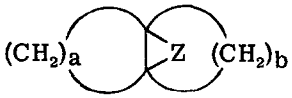
Our initial experiments were conducted on the *cis* [10.8] alkene 1a.[2,3] Treatment of 1a with sulfuric acid-acetic acid in benzene for 16 hours resulted in a 70/30 mixture of [10.8]betweenanene (2a) and unchanged 1a. Similar treatment of [10.8]betweenanene (2a) afforded the identical 70/30 mixture in 75% distilled yield. This mixture could be readily separated and analyzed by selective conversion of the *cis* olefin 1a to epoxide 3a (Z=O) with *m*-chloroperoxybenzoic acid. As expected, the *trans* isomer **2a** was not epoxidized by the peroxy acid.

The *cis* [10.10] bicycloalkene **1b** was prepared by the abbreviated sequence outlined in Chart I. Addition of 4-pentenyllithium to 1,2-cyclododecanedione afforded the *cis* diol **5** in 80% yield.



1

2



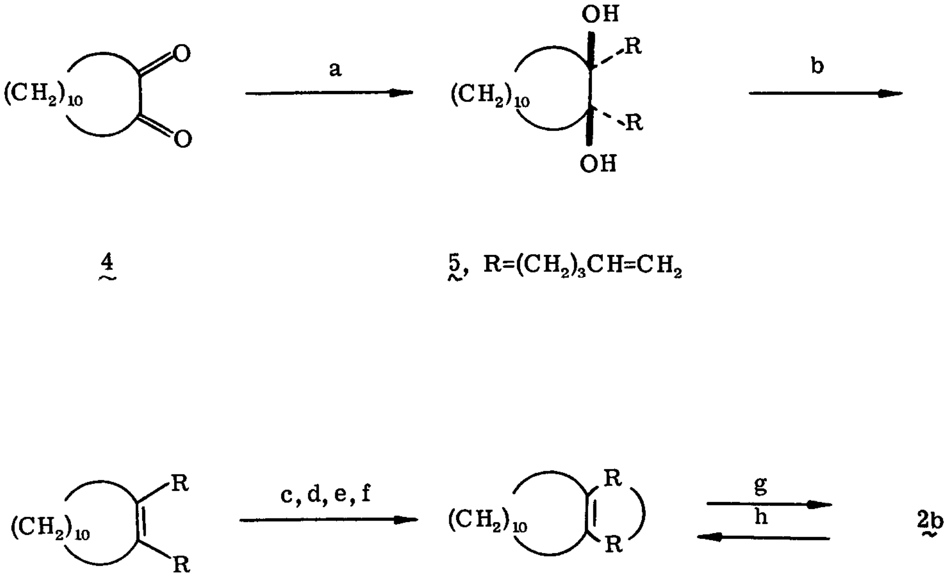
3

a series; a=8, b=10
b series; a=b=10

Conversion to the *cis* cyclododecene **6** was effected with potassium hexachlorotungstate, according to Sharpless and Flood, in 50% yield.[4] Selective hydroboration with disiamylborane [5] followed by oxidation first with alkaline hydrogen peroxide and then with chromium trioxide-pyridine in methylene chloride gave the dialdehyde **8** (85% yield) which was cyclized to the crystalline diene **9** (40% yield) using McMurry's titanium trichloride/zinc-copper couple method.[6] Hydrogenation over platinum-on-carbon afforded the *cis* [10.10] alkene **1b**, mp 136-137° C. Treatment with sulfuric acid-acetic acid in benzene effected conversion of this olefin to [10.10]betweenanene of 95% purity in high yield. Sensitized photoisomerization of olefin **1b** gave rise to a 50/50 mixture of *cis* and *trans* isomers **1b** and **2b**. This mixture was likewise converted to virtually pure [10.10] betweenanene (**2b**) on acid treatment.

Evidently, the betweenanene arrangement (**2**) is thermodynamically favored in the bicyclo [10.8] and [10.10] systems **2a** and **2b**. The isomerization most likely proceeds via a carbocation intermediate and may involve double bond migration although we could detect no vinylic

Chart I



4

5, $R=(CH_2)_3CH=CH_2$

6, $R=(CH_2)_3CH=CH_2$
7, $R=(CH_2)_4CH_2OH$
8, $R=(CH_2)_4CHO$

9, $R\text{-}R=(CH_2)_4CH=CH(CH_2)_4$
1b, $R\text{-}R=(CH_2)_{10}$

(a) $CH_2=CH(CH_2)_3Li$, ether, -78°
(b) CH_3Li; K_2WCl_6
(c) $(SiAm)_2BH$; H_2O_2, NaOH
(d) $CrO_3\cdot C_5H_5N$, CH_2Cl_2
(e) $TiCl_3$, Zn(Cu)
(f) $H_2/Pt\text{-}C$
(g) H_2SO_4, HOAc, C_6H_6
(h) $h\nu$, xylene, C_6H_{14}

hydrogens in the nmr spectra of the equilibrated olefins. Based on molecular models and our findings regarding the unreactivity of **2a** and **2b** with peroxy acid, face protonation of the buried double bond seems unlikely but not impossible.[7] We intend to examine this point in future studies.

Acknowledgement

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References and Notes

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