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# STRUCTURE AND CONFORMATION OF HETEROCYCLES. *VII*[1]

## 2,5,7,10,11,14 - HEXAOXA[4.4.4]PROPELLANE.

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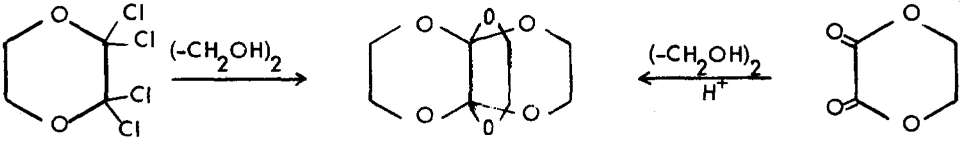
Our interest in 1,4,5,8 - tetraoxadecalins[1], has recently been extended to the related tetraoxapropellanes[2], i.e. tetraoxadecalins with the angular positions bridged by aliphatic or aromatic moieties. We wish now to report on the novel 2,5,7,10,11,14-hexaoxa[4.4.4]propellane (triethylene orthoöxalate)..

Two approaches to the synthesis of *I* have been considered and both were rewarding. The acid catalyzed condensation of ethylene glycol with ethylene oxalate[3] and the reaction of ethylene glycol with 2,2,3,3- tetrachloro - 1,4 - dioxane[4] provided *I*, m.p. 258 (from methanol); NMR ($CDCl_3$) $\tau$ 3.98 (singlet!); Mass spectrum: m/e (rel. abund.) 204 (<u>22</u>), 177 (31), 144 (17), 117 (20), 116 (10), 91 (10), 89 (77), 45 (100)[5].



*I*

Orthoöxalic esters are poorly documented and the known synthetic procedures are rather lengthy. The present cyclic orthoöxalate is relatively easily accessible apparently because of its enhanced stability. No isomeric product has been detected. The propellanic structure is proven beyond doubt by the sharp singlet for all twelve hydrogens. Furthermore, the fragmentation under electron impact closely resembles those of the reported tetraoxapropellanes[2].

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[‡] Taken from the Ph.D. Thesis of Y.A., Tel-Aviv, 1972.

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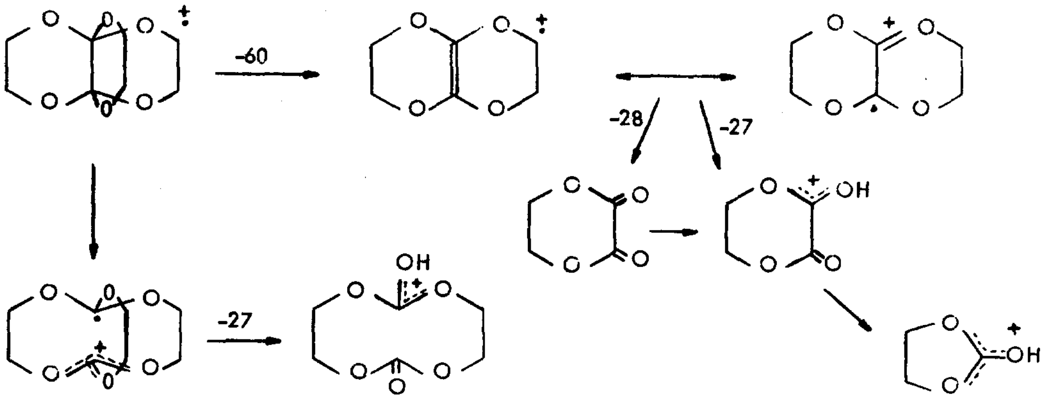
Scheme



The static and dynamic conformational analysis of the hexaoxapropellane *I* is of interest, particularly in the light of the recent results on 1,4-dioxane[7] and 1,4,5,8 - tetraoxadecalin[1] as well as on the carbocyclic [4.4.4] propellane[8]. Thus, *I* is a disymmetric molecule (point group $D_3$) with two interconverting enantiomeric conformers (Fig.1; a chair-chair-chair conformation assumed). To investigate the dynamic behavior of *I*, a variable temperature NMR study of a 10% solution in $CHFCl_2$ - Pyridine was undertaken (Fig.2)[5b]. On lowering the temperature the singlet broadens and eventually yields a typical AA'BB' spectrum but lacking fine-structure, which does not change on further lowering down to -104°C even at 100 MHz. Coalescence occurs at -24°C.

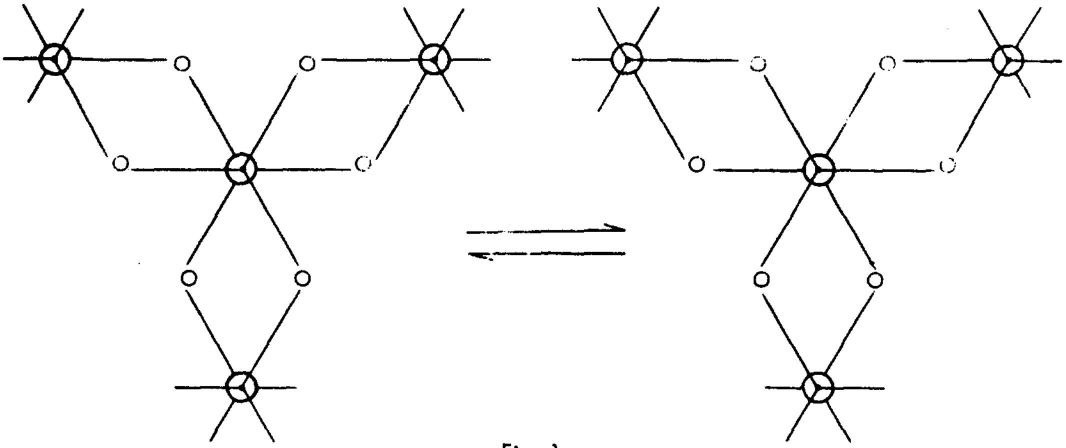


Fig. 1

The lack of resolution precludes exact analysis of the AA'BB' spectrum; the next best approximation is to assume an $A_2B_2$ system of intermediate coupling which lends itself to approximate analysis[9], to yield $\delta_{AB} \cong 30$ Hz, $J_{AB} \cong 10$ Hz[5b]. Using the same approximate expression for the lifetime at coalescence as for a nonexchanging AB system[10-13], i.e. $\tau_c = \sqrt{2}/\pi\ (\delta_{AB}^2 + 6\ J_{AB}^2)^{\frac{1}{2}}$, and applying the absolute reaction rate theory (Eyring equation) one calculates the rate constant for inversion $k = 39\ \mathrm{sec}^{-1}$ and hence $\Delta G^{\ddagger}_{249}$ 12,6 kcal/mole.

This result, even after allowing for the relatively large uncertainty (less than 1 kcal/mole) introduced by the above inevitable approximations, permits an illuminating comparison between 1,4-dioxane derivatives and their carbocyclic analogues. The ratios of free energies of activation for inversion of the corresponding pairs are: cyclohexane[14]/1,4-dioxane[7] = 10.3/9.7 = 1.06; 9,10-bis(bromomethyl)decalin[15]/ 9,10-bis(bromomethyl)-1,4,5,8-tetraoxadecalin[1,16] = 14.7/11.7 = 1.25; 3,3-difluoro-[4.4.4]-propellane[8,17]/ 2,5,7,10,11,14-hexaoxa[4.4.4]propellane =16.7/12.6= 1.3. Thus, an increase in relative mobilities is recorded in the order mono-,bi-and tricyclic, 1,4-dioxane derivatives. Two, probably interconnected rationales are possible : relative destabilization of the ground state in the latter two systems due to the anomeric effect and their possible occurrence in solution with the twist-boat conformations[1] appreciably populated.

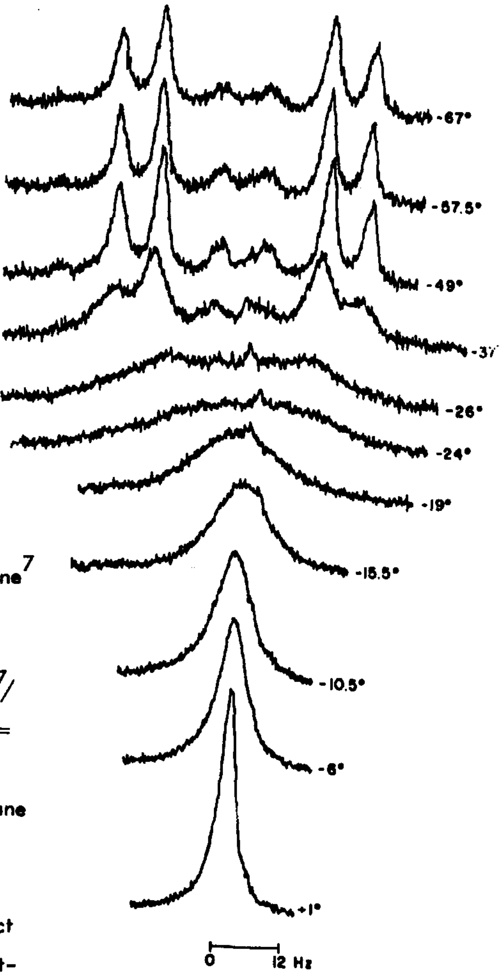


Fig. 2

Further experiments designed to test the above hypotheses as well as computer simulation of the NMR spectra are presently being performed.

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5a. Analysis. Found: C, 47.13; H, 6.01; Calculated for $C_8H_{12}O_6$: C, 47.06; H, 5.92%.

b. NMR spectra were measured on a Jeolco-60 MHz instrument.

c. Mass spectra were taken with a Perkin Elmer - Hitachi RMU-6 mass spectrometer courtesy of the Department of Chemistry, Bar-Ilan University, Ramat-Gan, Israel.

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12. Use of an alternative approximation $\tau_c = \sqrt{2}/\pi\,\delta_{AB}$[11,13], which is valid for the case of two non-interacting, equally populated sites, yields close, if not similar, results.

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14. The values of $\Delta G^{\ddagger}$ for chair-to-chair inversion of cyclohexane were averaged from VI of ref. 11, p. 158 and converted to 176°K for the comparison[7].

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16. The $\Delta G^{\ddagger}$ value for this compound[1] was converted to 300°K for the comparison[14].

17. The $\Delta G^{\ddagger}$ value for this compound[8] was converted to 250°K for the comparison.