

RING EXPANSION OF 7-HALO- AND 7,7-DIHALO-2-OXANORCARANES
IN QUINOLINE

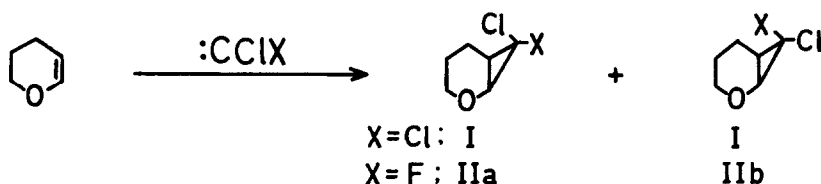
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Although it has been fully established that endo-7-halonorcaranes undergo ring expansion reactions much faster than the corresponding exo-isomers,^(1,2,3) some ambiguity still remains on the relative reactivities of endo- and exo-7-halo-2-oxanorcaranes in ring expansion.^(4,5) This communication will present some experimental facts concerning the pyrolytic ring expansion of 7,7-dichloro-, 7-chloro-7-fluoro-, 7-chloro-, and 7-fluoro-2-oxanorcaranes in quinoline, which strongly suggest the higher reactivity of the halogen at the endo-, as compared with the exo-, position.

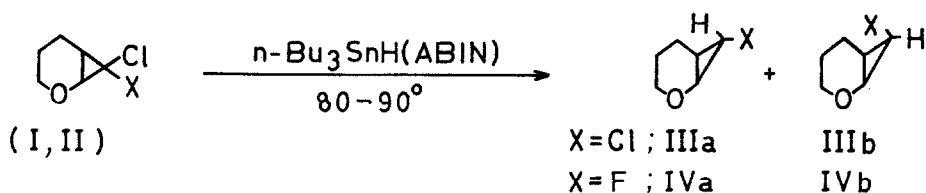
7,7-Dichloro-2-oxanorcarane (I) was prepared in a 70% yield by the reaction of 2,3-dihydro-4H-pyran with dichlorocarbene, generated from methyl trichloroacetate by the action of sodium hydride and methanol.⁽³⁾ A similar reaction with chlorofluorocarbene afforded 7-chloro-7-fluoro-2-oxanorcarane (II), in a 78% yield, as a mixture of the endo-chloro (IIa) and the exo-chloro (IIb) isomers (IIa/IIb = 1.5 to 1.6).



The assignment of the structures was made based on the fluorine nmr spectroscopy: it was assumed that between vicinal fluorine and proton in cyclopropanes the cis coupling is larger than the trans coupling.^(3,6) The parameters of the nmr spectra of IIa and IIb are shown in TABLE I.

When an equimolar mixture of I and tri-n-butyltin hydride containing a catalytic amount of azobisisobutyronitrile (ABIN) was heated at 80-90° for 3 hours, there was obtained a mixture of endo- (IIIb) and exo- (IIIa) 7-chloro-2-oxanorcarane (IIIa/IIIb

= 1.1 to 1.2) in a yield of 67%.



In contrast with the relatively easy conversion of I to III, II gave only a low yield (33%) of 7-fluoro-2-oxanorcarane (IV), composed of the two isomers IVa and IVb (IVa/IVb = 1.6 to 1.8), even after being heated at 80-90° for 100 hours with an excess of tri-*n*-butyltin hydride in the presence of ABIN. In these reductions,⁽⁷⁾ neither the formation of 2-oxanorcarane from I or II, nor of 7-chloro-2-oxanorcarane from II, was observed.

The configurations of III and IV were elucidated by their proton and fluorine nmr spectra. The chemical shifts and the coupling constants, obtained by the first-order analysis with the aid of spin-decoupling technique, are listed in TABLE I.

According to TABLE I, the trans coupling constant between H_X and F in IVb, as well as between H_X and H_M in IVa, have a value of nearly zero. This might be interpreted in terms of the substituent effect of the adjacent (electronegative) oxygen atom and by molecular geometry such as dihedral and/or bond angles.⁽⁶⁾

When heated in an excess of quinoline at 120° for 3 hours, I gave 2,3-dihydro-6-chloroöxepin in a 80% yield. A similar treatment of an isomeric mixture of II was found to convert IIa to 2,3-dihydro-6-fluoroöxepin (77%, based on IIa), but not to affect IIb. Analogously, under similar conditions, IIIb gave 2,3-dihydroöxepin in a 70% yield, while IIIa was recovered unchanged.

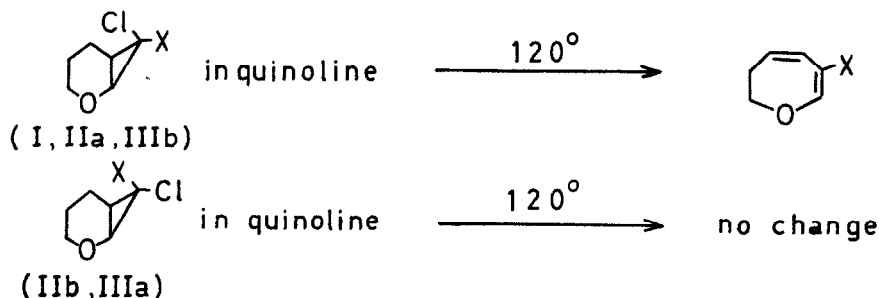
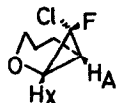
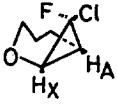
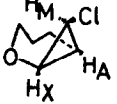
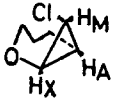
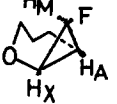
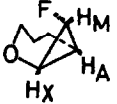


TABLE I
Parameters of the NMR Spectra of II, III, and IV

Compound	Chemical Shift, ppm			Coupling Constant, cps					
	H _M [*]	H _X [*]	F ^{**}	J _{H_MF}	J _{H_AF}	J _{H_XF}	J _{H_AH_M}	J _{H_AH_X}	J _{H_MH_X}
 (IIa)			58.2		22	12			
 (IIb)			90.0		6	2			
 (IIIa)	2.90	3.68					4.5	8.0	1.0
 (IIIb)	3.01	3.58					8.4	7.8	5.0
 (IVa)	4.40	3.78	135.1	61.5	26.6	12.0	3.0	9.0	0
 (IVb)	4.34	3.35	165.0	64.5	13.2	0	6.5	8.0	4.0

* downfield from TMS as internal reference (in CCl₄, 20%).

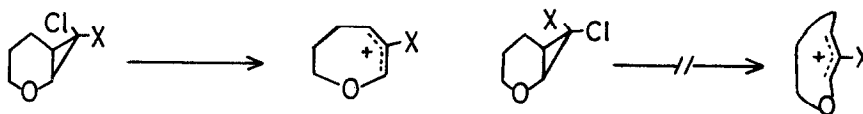
** upfield from trifluoroacetic acid as external reference (in CCl₄, 40%).

These results, which clearly indicate the more facile conversion of endo-chloro, compared with exo-chloro, isomers to 2,3-dihydrooxepin derivatives, do not agree with those reported by Schweizer and Parham,⁽⁴⁾ who prepared a mixture of IIIa and IIIb by the addition of chlorocarbene, generated by the method of Closs and Closs,⁽⁸⁾ to 2,3-dihydro-4H-pyran. They stated that IIIa decomposed more easily than IIIb, and attributed the difference in reactivity to an anchimeric assistance exerted by the trans-oxygen atom during the loss of the chlorine.

Their assignment of IIIa and IIIb, however, is tentative and lacks decisive evi-

dence: it was based only on the idea that the sterically less hindered isomer (IIIa) must be formed in greater predominance than the more hindered one (IIIb). In view of the findings by Closs, et al.,⁽⁹⁾ that chlorocarbene reacts with cyclohexene to yield more endo- than exo-7-chloronorcaradiene and with unsymmetrical olefins to yield more syn- than anti-isomers, it is not surprising that the more hindered isomer (IIIb) is formed in greater predominance when it reacts with 2,3-dihydro-4H-pyran.

The easier ring expansion of the isomers having an endo-chlorine may possibly be ascribed to the relief of the strain which comes from the non-bonded interaction between the chlorine and the axial proton at C₃ (or C₄), but a more reasonable explanation seems to lie in assuming the reaction to be a concerted disrotatory process, as was proposed by DePuy, et al.:^(1,5) ring expansion and ionization occur simultaneously, the groups trans to the leaving atom (chlorine) rotating outward, and those cis, inward. In this view, the difference in reactivity between endo- and exo-chloro isomers can be easily accounted for as being due to the difference in steric hindrance between the transition states shown below.



A mixture of IVa and IVb did not show any appreciable change when heated in quinoline at 120° for 10 hours, but prolonged heating at 140° for an additional 5 hours resulted in the decomposition of IVb to yield 2,3-dihydroöxepin, with recovery of IVa.

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