

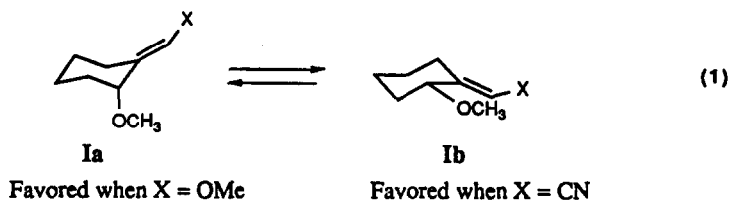
CONFORMATIONAL PREFERENCES OF C1-OXYGENATED ACYCLIC CHIRAL ALKENES: THE EFFECT OF VINYL AND ALLYL SUBSTITUENTS

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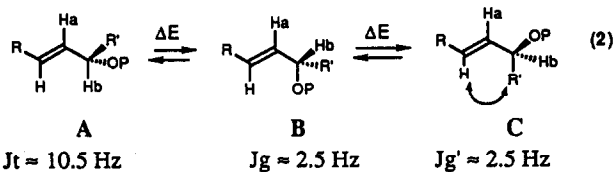
Summary: The conformational preferences of several chiral alkenes have been studied by the variable temperature NMR technique. Electron-withdrawing groups (EWG) enhance the C-O eclipsed form, and electron-releasing groups (ERG) favor the C-H eclipsed form in these C1-oxygenated chiral alkenes.

In 1987, Kahn and Hehre¹ stated in their theoretical study of the conformations of chiral alkenes: "---it is to be expected that EWG will favor conformations with the CO bond eclipsing π_{CC} , whereas ERG should enhance the ground-state preference for the CH eclipsing the double bond." Although this prediction is supported by earlier observations on the methylenecyclohexane system,² eq. 1, little direct experimental evidence has appeared with regard to acyclic chiral alkenes.³



In this letter, we wish to report the results from our study of several C1-oxygenated chiral alkenes utilizing the variable temperature NMR method. Our investigation provides strong support for the theoretical predictions made by Kahn and Hehre. The compounds under study were prepared by known procedures between an appropriate aldehyde with an organometallic reagent. The cyano-substituted alkenes were obtained following Nudelman's report.⁴

Our experiments involve the measurements of the proton coupling constants ($^3J_{ab}$, eq. 2)⁵ at various temperatures. The ¹H NMR spectra were recorded on a Bruker 300 MHz instrument typically with a window of 1800-2200 Hz centered around the vinyl H and methine H resonances. A total of 128,000 data points was collected, and the digital resolution of all such measurements was ± 0.017 Hz. The variable-



temperature data were reproducible to ± 0.02 Hz in duplicate runs. Deuterated solvents including toluene, acetone, and chloroform were used in these experiments. Different solvents did not significantly alter the magnitude of the coupling constants. Temperature, however, did cause considerable changes. The samples were degassed before each run, and the concentration was about 0.05 M. The key coupling constants (${}^3J_{ab}$) at various temperatures for the chiral alkenes under study are listed in Table I.

Table I Spin-Spin Coupling Constants (${}^3J_{ab}$, Hz) of Chiral Alkenes At Various Temperatures^a

Entry	R	P	R'	Temp. (K ^o)										
				193	240	253	273	295	315	335	345	355		
1	n-Pr	Me	n-Bu	8.32	-----	-----	8.20	8.04	7.90	7.80	7.69	-----		
2 ^b	n-Pr	Ac	Me	7.22	-----	-----	6.61	6.51	6.43	6.39	-----	-----		
3 ^c	n-Bu	Me	t-Bu	-----	8.96	8.85	8.75	8.61	8.41	-----	-----	-----		
4 ^c	n-Bu	H	Me	-----	6.94	6.74	6.63	6.46	6.18	-----	-----	-----		
5 ^c	n-Bu	H	Et	-----	7.61	7.37	7.27	7.07	6.80	-----	-----	-----		
6 ^c	n-Bu	H	i-Pr	-----	7.79	7.54	7.44	7.30	6.99	-----	-----	-----		
7 ^c	n-Bu	H	t-Bu	-----	7.69	7.44	7.34	7.27	7.15	-----	-----	-----		
8	CN	Ac	Me	3.98	4.39	-----	4.61	4.77	4.84	4.90	4.94	-----		
9	CN	H	Me	2.86	3.41	-----	3.62	3.85	3.90	3.98	4.05	-----		
10 ^c	CO ₂ Et	TBS	Et	-----	4.13	4.31	4.43	4.63	4.83	-----	-----	-----		
11, ^d	CO ₂ Et•LA	TBS	Et	-----	2.92	3.33	3.48	3.69	-----	4.06	-----	-----		
12	CO ₂ Et	H	i-Pr	-----	-----	-----	4.84	4.92	5.02	5.10	-----	5.18		

^a The NMR spectra were recorded in C₆D₅CD₃ unless specified otherwise. ^b The NMR spectrum was recorded in CD₃COCD₃. ^c The NMR spectrum was recorded in CDCl₃. ^d LA = SnCl₄

Interconversion between rotamers (eq. 2) is rapid even at 193 °K, so that only the weighted-average values of the coupling constants are observed.⁶ There is mounting evidence to suggest that form C is considerably higher in energy than either form A or B even when R' is a methyl group.^{1,7} Therefore, the population of conformer C is truly negligible when R' = *t*-Bu or *i*-Pr because of the steric repulsion between the R' and the vinyl H, eq. 2. Thus, the observed average coupling constants are mainly from the

$$J_{ab} = p_a J_t + p_b J_g \quad (3)$$

contributions of conformer A and B, eq. 3, where p_a and p_b are the fractional populations and J_t and J_g are the coupling constants characteristic of forms A and B respectively.

The relatively large coupling constants (6.4-9.0 Hz) observed for the first seven entries in Table I is consistent with the fact that the C-H eclipsed form (A) is predominant,⁸ assuming that the Karplus type of relationship is followed.⁵ Entries 8-12 have relatively small coupling constants (2.9-5.2 Hz), which is expected when conformer B predominates. However, one may argue that the electronegativity of the vinyl substituents may change the coupling constants in addition to the primary effect of the dihedral angle.^{5b} Since the chiral alkenes of entries 8-12 contain a vinyl electron withdrawing group, the coupling constants of the various conformations may have all been decreased. Therefore an overall smaller J_{ab} may be observed even when the CH eclipsed form actually dominates. This argument is, however, inconsistent with the trends revealed by the VT NMR data. The compounds in the first nine entries all containing a vinyl alkyl group, show increases in the observed couplings as the temperature decreases. This can be interpreted as a growth in the population of A as the temperature is lowered. In contrast, when the vinyl alkyl group is replaced by a cyano or an ethoxycarbonyl (entries 8-12, Table I), the trend is reversed. While the analysis based on population changes is consistent with the observed trend in $^3J_{ab}$, electronegativity argument is not. As can be seen from Table I, entries 8-12 exhibit decreasing coupling constants with decreasing temperature, indicating a growth in the population of B. These directions of changing $^3J_{ab}$ can be better expressed graphically. Entries 1-2 and 10-11 were plotted in Fig. 1 with the observed coupling constants on the Y-axis and the experimental temperatures as the X-axis. It is clear that the vinylic ERG and EWG groups cause two opposite trends in the conformational preferences of the C1-oxygenated chiral alkenes. Although this effect has been suggested previously,¹⁻³ we feel that this is, for the first time, shown without ambiguity.

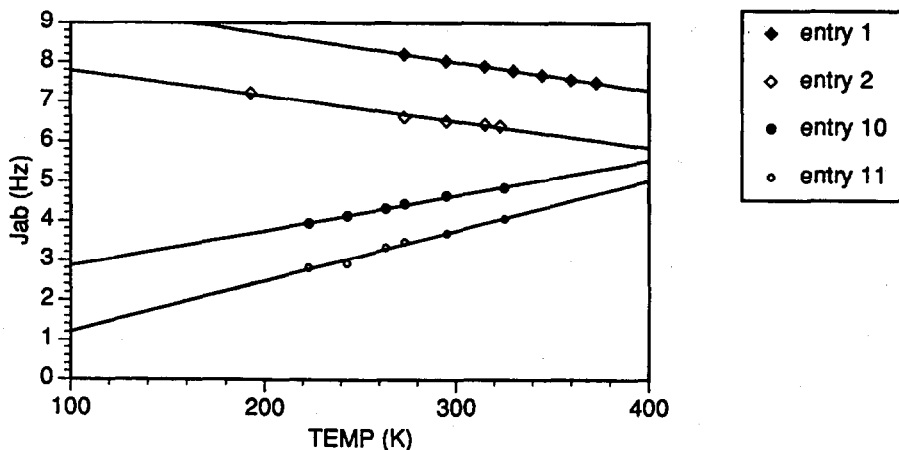


Figure 1. The population of the CH eclipsed form is increased upon lowering the temperature in cases where the chiral alkenes have a vinyl alkyl group (entries 1 and 2). This trend is reversed for the chiral alkenes with a vinyl EWG (entries 10 and 11).

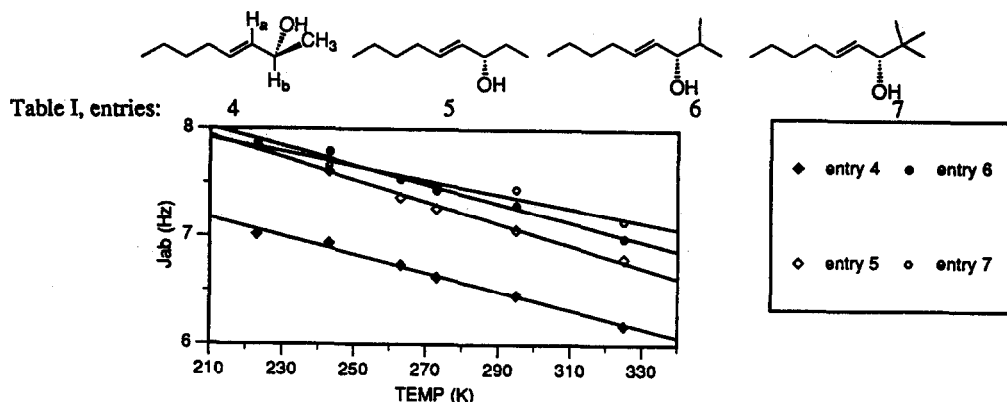


Figure 2. Observed coupling constants $^3J_{ab}$ increase as the steric size of the allylic substituent increases.

The substituent at the allylic position was changed from a methyl to a t-butyl group for entries 4-7 in Table I and plotted graphically in Figs. 2. One apparent trend is that the observed coupling constants increase with the size of the allylic substituent at a given temperature. The coupling constants of the methyl derivative are on an average 0.8 to 1.0 Hz smaller than those of the t-butyl derivative. In contrast to the gas phase results obtained in the microwave studies⁷ and the *ab initio* calculations,¹ our data from solution NMR appear to be most consistent with a three-rotamer (A, B, and C, eq. 2) equilibrium for the methyl derivative. When the population of C becomes significant, $^3J_{AB}$ is decreased due to the contribution of J_g' . It is apparent that when R = Me the steric interaction of the R group with the vinyl H in Ic is minimized. This results in a significant population of C, which in turn leads to a smaller $^3J_{AB}$. The results for alkenes with bulky allyl substituents are consistent with a two rotamer (A and B only) equilibrium. As the steric size of R increases, so will its interaction with the vinyl H in conformer C. Consequently, the population of C will diminish, yielding a larger $^3J_{ab}$. A full account of our results will appear in a different journal.

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