Conformations of Ten-membered Carbocyclic Rings in Zeylanine and Zeylanane as Determined by Application of Nuclear Overhauser Effects

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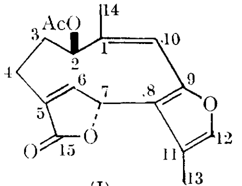
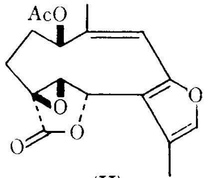
CONFORMATIONS of ten-membered carbocyclic rings in a number of sesquiterpenoids isolated from natural sources[1] are essential to an understanding of their chemical and biological properties in solution.[†] We report ^{1}H n.m.r. spectroscopic evidence for the conformations of the ten-membered rings in zeylanine (I) and zeylanane (II),[‡][2] as examples, selected from ten furanosesquiterpene lactones isolated and studied in this laboratory.[2,3] Examination of Dreiding models suggests two conformations for the ten-membered rings in (I) and (II); in the one H(6) and Me(1) are *syn* and in the other they are *anti*.



(I)



(II)

The so-called intramolecular nuclear Overhauser effect (NOE)[4] has proved to be a powerful tool for stereochemical and conformational studies and signal assignments in recent years.[5] The ^{1}H n.m.r. spectra of (I) and (II) show several NOE's as summarized in the Table.[§] To avoid ambiguities and to separate overlapping signals, the NOE's were measured in two solvents, $CDCl_3$ and C_6D_6. The assignment of the signals given in the Table is compatible with the NOE's observed.

A little increase in the integrated intensity of the H(6) signal caused by double irradiation (complete saturation) of the H(10) signal, or *vice-versa*, with scrupulous care[4] conclusively demonstrates that the ten-membered rings in (I) and (II) adopt the conformations in which H(6) and Me(1) are *syn*. The larger relative magnitude of this NOE in (II) than in (I) implies that H(6) and H(10) are situated in closer positions to each other in (II) than in (I). On the other hand, complete saturation of Me(1) in (II) causes no increase in the area of the H(6)-signal. The fact that the spacings of a clear quartet due to H(2α) in the 100 MHz spectrum of (II) in C_6D_6 are essentially equal to those observed in the 60 MHz spectrum[¶] implies that the $J_{2\alpha,3\alpha}$ and $J_{2\alpha,3\beta}$ values can be obtained from the spacings

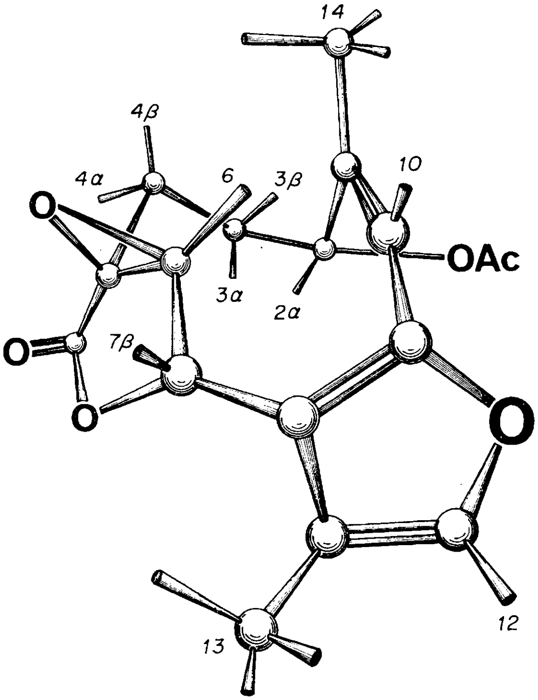


FIGURE. *The molecular conformation of* (II).

[†] Recently, the conformations of the ten- and eleven-membered carbocyclic rings of the silver nitrate adducts of germacratriene[9] and humulene[10] in crystals have been determined by *X*-ray analysis.

[‡] The elucidation of absolute configurations of these two compounds has been described in the preceding Communication.[2]

[§] The 100 MHz ^{1}H n.m.r. spectra were taken with a Varian HA-100 spectrometer using about 5% (w/v) degassed solutions in $CDCl_3$ and C_6D_6 in the frequency-swept and internal Me_4Si-locked mode. Calibration of the charts was carried out with direct readings of resonance frequencies, using a Hewlett–Packard HP-5212A electronic counter, accuracy ± 0·1 Hz. ^{1}H N.m.r. experiments were performed by using the spectrometer and two Hewlett–Packard HP-200ABR audio-oscillators.

[¶] The 60 MHz ^{1}H n.m.r. spectra were recorded on a Varian A-60A spectrometer.

The nuclear Overhauser effects (%) *and chemical shifts* (τ) *in* $CDCl_3$ *and* C_6D_6 (*in parentheses*)[a]

Observed signal	Increase in the integrated intensity of the signal observed during complete saturation of the signal irradiated in (I)							
	H(2α) τ 5·07X (4·75X)	H(6) 2·89m (3·67m)	H(7β) 4·27m (4·85m)	H(10) 3·77m (4·01m)	H(12) 2·79m (3·12m)	H(13) 7·88d (8·20d)	H(14) 8·11d (8·42d)	OAc 8·11s (8·59s)
H(2α)	—	2 (0)	0 (*c*)	0 (0)	*b*	*c* (*c*)	0 (0)	*b* (0)
H(6)	*b*	—	11 (14)	8 (*c*)	*b*	0 (0)	2 (6)	*b* (0)
H(7β)	*b*	18 (14)	—	−4 (3)	*b*	13 (8)	0 (0)	*b* (0)
H(10)	*b*	6 (*c*)	*c* −2	—	*b*	*b*	20 (17)	*b* (0)
H(12)	*b*	*c* (0)	0 (*b*)	0 (0)	—	19 (11)	0 (*b*)	*b* (0)
	in (II)							
	τ 4·65q (4·36X)	5·91br s (6·40br s)	4·68br s (5·09br s)	3·64m (3·97m)	2·72m (3·10)m	7·93d (8·30d)	8·09d (8·46d)	8·08s (8·58s)
H(2α)	—	0 (0)	*c* (0)	0 −3	*b*	*c* (*c*)	0 (0)	*b* −3
H(6)	*b*	—	15 (14)	10 (12)	*b*	*b* −3	0 (0)	*b* −4
H(7β)	*b*	14 (12)	—	−4 −2	*b*	17 (14)	0 (*c*)	*b* (0)
H(10)	*b*	8 (10)	*b* −4	—	*b*	*b* (*c*)	20 (19)	*b* (0)
H(12)	*b*	*b* −3	*b* −4	*b* −2	—	16 (15)	*b* (*c*)	*b* (0)

[a] Accuracies are about ±2% for NOE's and ±0·02 for chemical shifts. X: part of an complex ABC - - - X system.
[b] Not measured. [c] Undeterminable.

and are 5·0 and 12·0 Hz; these *J*-values show that H(2α) and H(3β) are close to *trans*-diaxial. These findings as well as the considerable NOE between H(7β) and Me(11) consequently determine the molecular conformation of (II) as illustrated in the Figure. The situation in (I) is similar to that in (II).

Of considerable interest is the fact that the signal due to H(2α) appears at a higher field in (I) than in (II) in $CDCl_3$ (see the Table); this can result from the difference in shielding effects of a double bond[6] and an epoxide group,[7] which should more or less shield H(2α), at the positions defined by the above conformations. The signals of Me(1) in (I) and (II) appear at considerably lower fields (Table), compared with those of Me(1) in other sesquiterpenes having a ten-membered carbocyclic system in which double bonds are located at C(1)–C(2) and C(5)–C(6).[8]

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