Olefin Stereochemistry: Analysis of Methylene Steroids and Related Compounds by the Octant Rule

By M. FETIZON* and I. HANNA

(*Laboratoire de Stereochimie, Universite de Paris-Sud*, 91 *Orsay, France*)

and A. I. SCOTT,* A. D. WRIXON, and T. K. DEVON

(*Sterling Chemistry Laboratory, Yale University, New Haven, Connecticut* 06520)

Summary Detailed analysis of a number of exocyclic olefins has shown that the sign of $\pi \rightarrow \pi^*$ absorption can be related to absolute configuration by use of the Octant rule.

IN previous papers from these laboratories[1-3] it was shown that although a considerable number of chiral olefins could be assigned absolute configuration on the basis of a set of signs determined by an Octant rule[1,2] the signs of the Cotton effects of a number of methylene steriods[3] appeared at variance with those predicted for the lowest energy optically active $\pi \rightarrow \pi^*$ absorption. However, as noted earlier[2] the majority of olefins display two Cotton effects of opposite sign in the $\pi \rightarrow \pi^*$ region. As suggested[2] for the case of the Δ^6 steroids, careful examination of the c.d. curves for the apparently exceptional methylene compounds reveals that the lowest energy band (assigned the $\pi_x \rightarrow \pi_x^*$ transition) is almost obscured by the higher energy transition of opposite sign. Thus in most cases examined so far,

the anomalous olefins display a shoulder near the position expected for lowest energy transition and in fact the principal c.d. maximum frequently occurs at a wavelength (λ_1, Table) considerably lower than that found for 'normal' olefins.[1,2]

A representative set of *exo*-methylene compounds with the wavelengths of the shoulder (λ_2) and the lowest wavelength c.d. maximum is given in the Table. A typical curve for an *exo*-methylene compound is characterised by an intense Cotton effect of sign opposite to that required by the Octant rule but at abnormally *low* wavelength with a shoulder corresponding to a transition of the sign predicted for the lowest energy transition using the Octant rule.
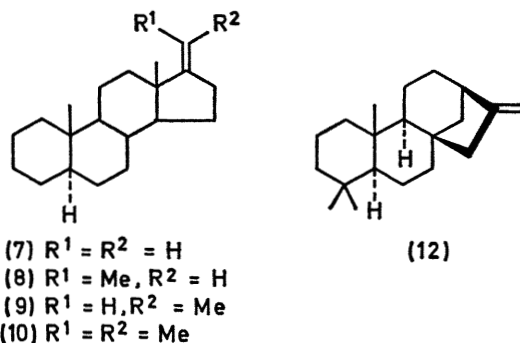
TABLE

	Compound			λ_1/nm	Sign	λ_2†/nm	Sign	Predicted signs‡ λ_1	λ_2
(1)	2-Methylene-5α-androstane	..	..	197	+	200†	−	+	−
(2)	3-Methylene-5α-androstane ..	..	..	193	+	197†	−	+	−
(3)	3-Isopropylidene-5α-cholestane	..	..	209	+	?		+	−
(4)	3-Methylene-5β-androstane	..	..	193	−	199†	+	−	+
(5)	4-Methylene-5α-cholestane ..	..	..	200	−	?	+	−	+
(6)	6-Methylene-5α-androstane ..	..	..	?	−	197	+	−	+
(7)	17-Methylene-5α-androstane	..	..	193	+	200†	−	+	−
(8)	17-*cis*-Ethylidene-5α-androstane	..	..	?		197	−	+	−
(9)	17-*trans*-Ethylidene-5α-androstane	..	..	193	+	214	−	+	−
(10)	17-Isopropylidene-5α-androstane ..	..	..	?	+	193(!)	−	+	−
(11)	(−)-Kaurene ..	..	..	..	< 185	−	205	+	−	+
(12)	Phyllocladene	..	..	..	< 188	+	203	−	+	−
(13)	13(15)-Abieten-18-oic acid ..	..	..	208	+	?		+	−
(14)	(+)-Sabinene	..	..	..	< 185	+	207	−	?	
(15)	(−)-β-Pinene	..	..	..	< 185	−	198	+	?	

† λ_2 is taken as the position of the shoulder (shown by †) in curves of type III (Figure 2) or as the maximum where this appears. The shoulder is given the sign opposite to λ_1 for the reasons discussed in the text. ‡ Using the Octant rule.

Computerised curve analysis of the c.d. spectra of a number of *exo*-methylene steroids has been unsuccessful since in most cases the shoulder is too weak to be resolved. However, we have been successful in carrying out an analysis of 5α-cholest-6-ene which possesses a more readily discernible shoulder. This is given in Figure 1 along with the curves of its pseudo-enantiomer, 5α-cholest-3-ene. The presence

of the two c.d. bands of opposite sign with 5α-cholest-3-ene is consistent with our proposed analysis. For the *exo*-methylene cases we thus feel confident in assigning to the shoulder (at λ_2) a sign opposite to that of the background on which it occurs (Table).

(7) $R^1 = R^2 = H$
(8) $R^1 = Me, R^2 = H$
(9) $R^1 = H, R^2 = Me$
(10) $R^1 = R^2 = Me$

(12)

An interesting illustration of this effect where both shoulder and full sign inversions are evident is provided by 17-methylene-5α-androstane and its relatives [(7—10); Table]. The methylene compound (7) shows a strong positive c.d. maximum at 193 nm ($\theta = 16{,}100$) with a shoulder at 200 nm. The *cis*-ethylidene compound (8) has $[\theta] - 12{,}600$ (197 nm). The *trans*-2 compound (9) displays both transitions with $[\theta]$ 15,300 (193 nm) and $[\theta]$ −570 (214 nm). The isopropylidene compound (10) exhibits a broad c.d. with a (negative) maximum at 193 nm. Thus all four members (7)–(10) of the series contain either the
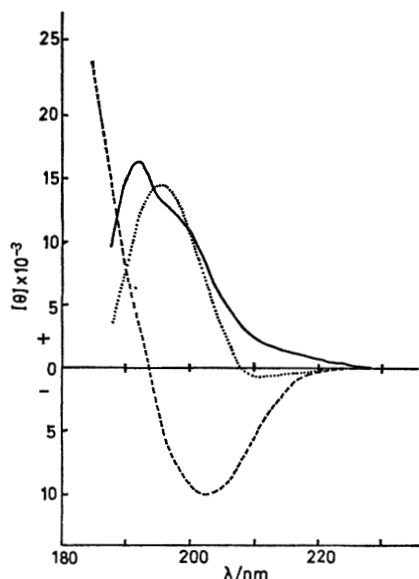
diminished with respect to the other in this series. Although it is not yet possible to predict the relative intensities of the two $\pi \to \pi^*$ c.d. bands of a chiral olefin the following considerations apply to over 100 olefins so far studied. (1) The Octant rule predicts the correct sign
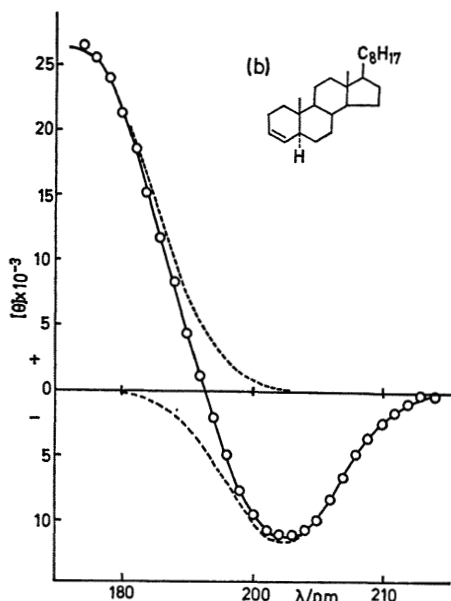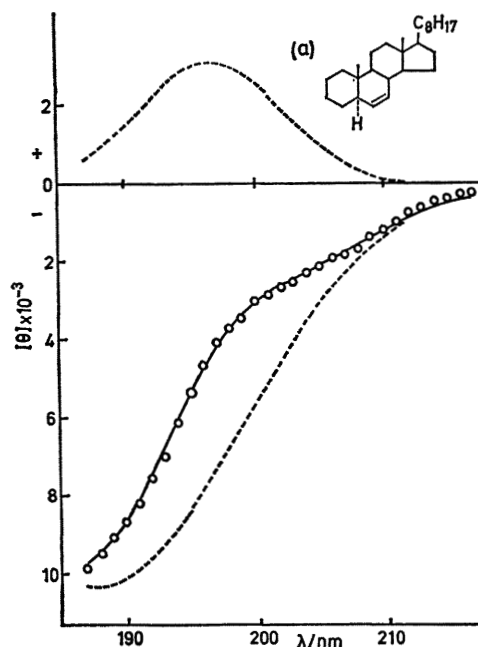

FIGURE 2. *The c.d. spectra of phyllocladene* (12) ------ (*type* I), 17-trans-*ethylidene-5α-androstane* (9) ...... (*type* II), *and* 17-*methylene-5α-androstane* (7) ———(*type* III) *in cyclohexane.*

FIGURE 1. *Curve analysis of* (a) *5α-cholest-6-ene and* (b) *5α-cholest-3-ene showing theoretical resultant* (———) *of the sum of two assumed Gaussians* (------) *giving the best fit for the observed experimental values marked* ○.

(predicted) negative band or evidence for its intervention at the expected position ($\pi_x \to \pi_x^*$) in accord with the predictions of the Octant rule. It appears that these olefins, like all others studied so far, contain both $\pi_x \to \pi_x^*$ and $\pi_x \to \pi_y^*$ transitions of opposite sign but (for reasons unknown at present) the lower energy band is considerably

unambiguously for the higher wavelength c.d. where the two transitions are clearly separated (type I, Figure 2). (2) Where apparent exceptions have arisen the presence of two Cotton effects can be inferred from the band shape or the appearance of only one transition (types II, III,

Figure 2). (3) Curve analysis suggests that the appearance of a low-wavelength absorption with a high-wavelength shoulder (type III; Figure 2) is best resolved into two transitions of unequal intensities of opposite sign (see Figure 1).

[1] A. I. Scott and A. D. Wrixon, *Chem. Comm.,* 1969, 1182.
[2] A. I. Scott and A. D. Wrixon, *Tetrahedron,* 1970, 26, 3695.
[3] M. Fetizon and I. Hanna, *Chem. Comm.,* 1970, 462.