Tetrahedron Letters No.5, pp. 519-523, 1968. Pergamon Press. Printed in Great Britain.

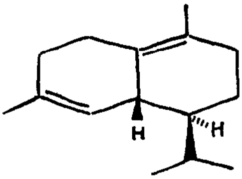
TERPENOID CHEMISTRY XIV.
THE SIGNIFICANCE OF THE TERM "δ-CADINENE"

D.W. Connell, R.P. Hildebrand(1) and M.D. Sutherland
Department of Chemistry, University of Queensland, Brisbane,
Australia.

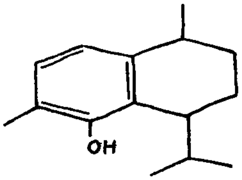
(Received in UK 3 October 1967)

Our unpublished studies on δ-cadinene make it regretably necessary to critically review certain aspects of two recent papers(2,3) on " δ-cadinene" in order to forestall gross confusion arising in the literature.

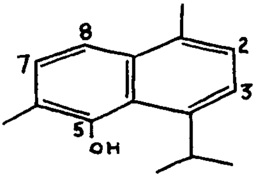
Firstly, the evidence provided for the structure [(±)-I] for the hydrocarbon dysoxylonene [(±)- δ-cadinene] from *Dysoxylon frazeranum* by Hildebrand and Sutherland(4) is misrepresented(3) as "mainly on the basis of a formation of phenol XIV". In fact, structure [(±)-I] was assigned to dysoxylonene principally because 5-hydroxycadalene(II) was isolated in 6% yield from the dehydrogenation of the crystalline (±)-diepoxide(III) obtained in 41% yield from a dysoxylonene concentrate and because isophthalic acid resulted from a sequence of reactions on the ozonolysis product(IV) of dihydrodysoxylonene.



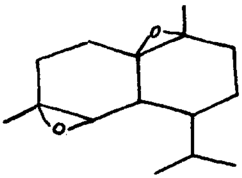
I



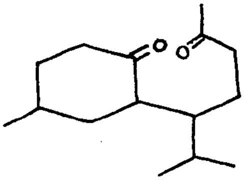
"phenol XIV"



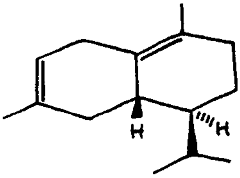
II



III



IV



V

Further evidence for structure (III) for the diepoxide (and thus for (±)I for dysoxylonene) has been obtained by gas chromatography of the dehydrogenation products(4,5,6) (see Table I). 5-Hydroxycadalene was recognised but 7- (and 2-) hydroxycadalene could not be detected (flame ionization detector) thus excluding the alternative structure (V) implied by Vlahov, Holub and Herout(3) (c.f. the production of 2- and 7-hydroxycadalenes from β-cadinene diepoxide(5)).

TABLE I

Characteristics of Dehydrogenation Products

Dehydrogenation Product	Relative Gas Chromatographic Retentions		U.V. Spectral Data
	SF96/160°	XF1150/150°	
Cadalene	1.0	1.0	Ref. 4
5-hydroxycadalene	0.91	0.89	" 4
2-hydroxycadalene	3.36	3.58	" 6
7-hydroxycadalene	3.85	3.89	" 6

Procedure - The mono- or di-epoxide (10 mg. is sufficient) and 10% palladized charcoal (approx. equal amount) are heated at 265° for 1 hr. under a nitrogen stream. The reaction vessel is broken into a flask containing water and the reaction products are steam distilled for 1 hr. under an oil trap containing isooctane (10 ml.). U.V. spectral measurements are made on suitably diluted solutions of the isooctane layer and gas chromatography measurements are carried out on the evaporated solution. The solubility of 2-hydroxy- and 7-hydroxycadalene in alkaline solution can also be used as a means of distinction from cadalene and 5-hydroxycadalene.

Herout and Santavy(7) in 1954 described the preparation in 43% yield* of δ-cadinene diepoxide, m.p. 83.5 - 84.5, $[\alpha]_D$ + 13° ± 2° from a citronella oil fraction which also yielded in excess of 80% of (-)-cadinene dihydrochloride. Ylang ylang(7) and sweet flag(7,8) oils were also cited as sources of the same

---

* Presumably "mg" in Table 2 of ref. 7 should read "g".

hydrocarbon. Structure (I) which had been suggested by Pliva, Herout, Schneider and Sorm(9) for the hydrocarbon from citronella and sweet flag oils on the basis of its infrared spectrum, was regarded by Herout and Santavy(7) as best explaining the resistance of the diepoxide to reaction with methyl magnesium iodide, etc.

In this laboratory, the fractions of b.p. 133-134°/10 mm of the essential oils of cubebs and of the wood of Juniperus oxycedrus were treated with perphthalic acid to yield about 10% of crystalline diepoxide, m.p. 83.5-84.5° of $[\alpha]_D$ + 18° after alumina chromatography. These products showed no depression of melting point on mixing with authentic δ-cadinene diepoxide kindly supplied by Dr. V. Herout. Cade oil yielded a fraction,b.p. 133-134/10 mm, $[\alpha]_D$ + 5° (containing a substantial proportion of mixed tetralins ($[\alpha]_D$ - 41°) with the cadalene skeleton) which yielded 15% of crude diepoxide, m.p. 79-81°, $[\alpha]_D$ + 13° and 45% of (-)-cadinene dihydrochloride. Repeated recrystallization of the diepoxide from light petroleum yielded the pure diepoxide, m.p. 84.5-85.5°, $[\alpha]_D$ + 23° (C = 6.7% in $CHCl_3$). The cade oil diepoxide also showed no depression of melting point with Dr. Herout's sample. The p.m.r. spectra of this diepoxide in $CDCl_3$ and in benzene were identical with those of the inactive diepoxide from dysoxylonene, showing two unsplit methyls at 1.22 and 1.27 ppm (in $CDCl_3$) and a one proton singlet (line width = 2 c/s at ½ height) at 2.52 ppm in agreement with the proposed structure (III). Similarly the infrared spectra showed complete correspondence(4). It may be concluded that δ-cadinene diepoxide prepared from citronella oil is identical with the diepoxide which we have prepared from cubebs oil and from the wood oil of J. oxycedrus and that the same diepoxide may be prepared in racemic form from the wood oil of D. frazeranum.

Dehydrogenation of the optically active diepoxide yields the same aromatic and other products (identified by gas chromatography and ultraviolet spectra) as does the optically inactive diepoxide and yields no 7- (or 2-) hydroxycadalene. It follows that the δ-cadinene from citronella oil has the structure (I) suggested for it by Herout and Santavy(7) in 1954 as do also dysoxylonene and the hydrocarbons from J. oxycedrus and cubebs oil.

However the recent paper(3) by Vlahov, Holub and Herout proves structure V for "δ-cadinene". The new "δ-cadinene" was isolated from Bulgarian *Mentha piperita* oil and was recognised as δ-cadinene only by a comparison of physical constants (n,d,[α]) and infrared spectrum. It was *not* characterised by the preparation of the crystalline diepoxide of δ-cadinene which Herout and Santavy(7) stated in 1964 was "well suited for the characterisation of δ-cadinene". Although the evidence presented by Vlahov *et al* supports the proposed structure V, it fails to demonstrate that the new "δ-cadinene" is identical with the δ-cadinene from citronella oil described(7) in 1954 which yields the crystalline diepoxide described above. Vlahov *et al* make no reference to any attempts to prepare the characteristic diepoxide of δ-cadinene. It is clear that two structurally different hydrocarbons have been confused because of the similarity of their physical constants and infrared spectra*.

If a trivial name is to be associated with the new "δ-cadinene" of Vlahov *et al*(7), it should not be δ-cadinene since this has long been associated with structure I and with the hydrocarbon of that structure which has been isolated from citronella oil(7) and *D. frazeranum* wood oil and has now been shown to be present in oil of cubebs and *J. oxycedrus* wood oil. We suggest the name ω-cadinene for V as the last of the cadinenes to be specifically named (apart from two of the four γ-cadinenes(13) all of which are characterised by one exocyclic methylene group+).

The utility of the epoxide dehydrogenation procedure is now extended by combining gas chromatographic analysis with the originally described ultraviolet spectral identification(4) of the phenolic products and merits application in the muurolene, amorphene, bulgarene, isozingiberene, and other

---

* It may be doubted whether the identity of two liquids can be demonstrated by physical constants and infrared spectra if both are not perfectly pure. For this reason and contrary to the common tendency(2,10,11,12), we attach particular importance to the use whenever possible of crystalline derivatives for the characterisation of sesquiterpene hydrocarbons.

\+ The designations γ- and γ_1-cadinene are already established in the literature(13). To avoid possible confusion in the future, we suggest that the two remaining *structures* be designated γβ- and $\gamma_1\delta$-cadinenes according to similarity in position of (i) the exocyclic double bond to that of γ or γ_1-cadinene and (ii) the endocyclic to that of β- or δ-cadinene.

hydro-aromatic systems. Thus the absence of 2- and 7-hydroxycadalenes from the dehydrogenation products of crude epoxidised cade oil fraction of b.p. 133-134°/ 10 mm demonstrates the absence of α,β and ω-cadinenes, muurolenes etc. in this fraction of cade oil. The behaviour of the γ-cadinenes in the epoxide dehydrogenation procedure has not been examined for lack of samples but the results of Newman *et al*(15,16) on the dehydrogenation of hydroxymethyltetralins may be relevant.

We wish to thank Destilaciones Bordas Chinchurretta S.A. of Seville for generous gifts of cade oil and steam distilled *J. oxycedrus* wood oil.

REFERENCES

(1) Present address: Central Research Laboratories, Carlton and United Breweries, Melbourne, Australia.

(2) R. Vlahov, M. Holub, I. Ognajanov and V. Herout, *Coll.Trav.Chim.Tchecosl.* **32**, 808 (1967).

(3) R. Vlahov, M. Holub and V. Herout, *Coll.Trav.Chim.Tchecosl.* **32**, 822 (1967).

(4) R.P. Hildebrand and M.D. Sutherland, *Aust.J.Chem.* **12**, 678 (1959).

(5) M.J. Gallagher, R.P. Hildebrand and M.D. Sutherland, *Tetrahedron Letters*, 3715 (1964).

(6)M.J. Gallagher and M.D. Sutherland, *Aust.J.Chem.*, **18**, 1111 (1965).

(7) V. Herout and F. Santavy, *Coll.Trav.Chim.Tchecosl.* **19**, 118 (1954).

(8) F. Sorm, M. Holub, V. Sykora, J. Mleziva, M. Streibl, J. Pliva, B. Schneider and V. Herout, *Coll.Trav.Chim.Tchecosl.* **18**, 512 (1953).

(9) J. Pliva, V. Herout, B. Schneider and F. Sorm, *Coll.Trav.Chim.Tchecosl.* **18**, 500 (1953).

(10) V. Benesova, V. Herout and F. Sorm, *Coll.Trav.Chim.Tchecosl.* **26**, 1832 (1961).

(11) M.C. Nigam, I.C. Nigam, L. Levi and K.L. Handa, *Can.J.Chem.* **42**, 2610 (1964).

(12) G. Chiurdoglu and P. Tullen, *Bull.Soc.Chim.Belg.* **66**, 169 (1957).

(13) V. Herout, T. Kolos and J. Pliva, *Coll.Trav.Chim.Tchecosl.* **18**, 886 (1953).

(14) V. Herout and V. Sykora, *Tetrahedron*, **4**, 246, 1958.

(15) M.S. Newman and T.J. O'Leary, *J.Amer.Chem.Soc.* **68**, 258 (1946).

(16) M.S. Newman and H.V. Zahm, *J.Amer.Chem.Soc.* **65**, 1097 (1943).