Tetrahedron Letters No.26, pp. 2277-2280, 1970. Pergamon Press. Printed in Great Britain.

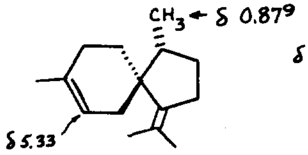
THE ALASKENES - PRECURSORS OF TRICYCLIC SESQUITERPENES

Niels H. Andersen, Daniel D. Syrdal*

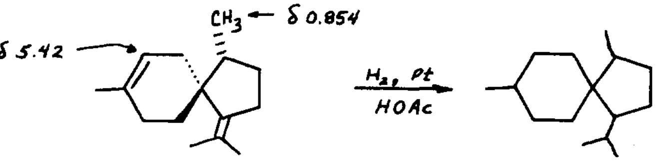
Department of Chemistry, University of Washington, Seattle, Washington 98105

(Received in USA 29 December 1969; received in UK for publication 7 May 1970)

We recently reported[1] that the sesquiterpene fraction of the leaf oil of Chamaecyparis nootkatensis consists largely of levorotatory α-, β-, and γ-curcumene with lesser amounts of (-)-α-copaene, (+)-α-ylangene, (+)-cadinenes, diastereomeric calamenenes, (+)-longifolene, (+)-β-bisabolene, β-farnesene, (+)-trans-nerolidol, and two new bicyclic sesquiterpenes designated α- and β-alaskene. In this communication we present the data - spectroscopic, a correlation with the acorones, and the results of acid-catalyzed cyclizations - which allows us to assign structures I and II to α- and β-alaskene respectively (relative stereochemistry only), and discuss the biogenetic significance of these spiro-sesquiterpenes. The absolute stereochemistry is assigned on the basis of a presumed genesis from the (-)-curcumenes occurring in the oil and is in accord with the established stereochemistry of the cedrenes, which are elaborated by many species of the closely allied genus Juniperus.

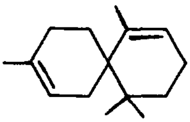


I

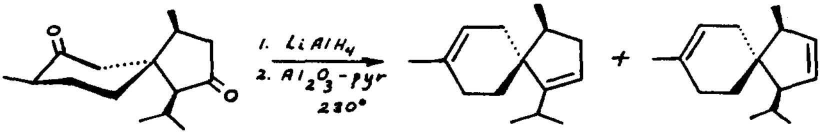


II

III



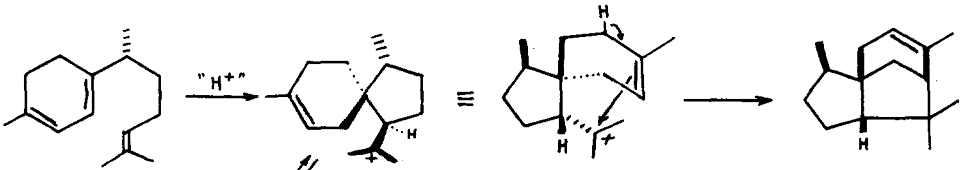
IV



V

VI

VII



(-)-γ-curcumene

I

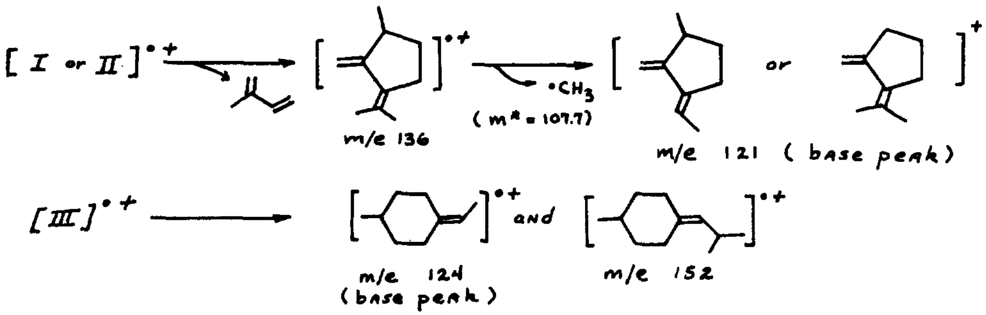
VIII

α-cedrene

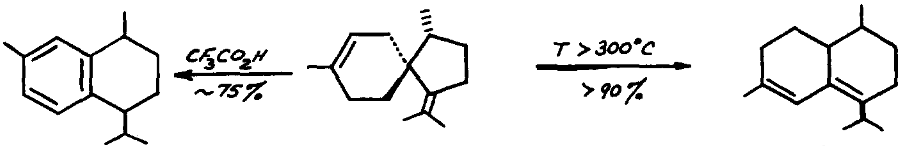
---

* National Science Foundation Predoctoral Fellow. 1968-1969.

The combination of NMR, IR, and mass spectroscopy together with hydrogenation data[1] allowed us to assign bicyclic structures with one trisubstituted double bond and an isopropylidene group to both alaskenes. Hydrogenation of α- or β-alaskene afforded the same mixture of four (glc resolvable) diastereomeric hydrocarbons (III). Mixture III did not contain any of the saturated cadalane diastereomers,[1] but did display a thick film IR spectrum nearly identical to that of "acorane" from the Clemmenson reduction of acorone.[2] This identification of skeleton was confirmed by direct comparison (IR, glc, ms) with authentic "acorane." Neoacorone (V) was converted to acoradiene (VI) and an isomer (VII). The hydrogenation product of acoradiene (consisting of the four diastereomers obtained from the alaskenes in nearly the same proportions[3]) showed an IR spectrum superimposable to that of III. Due to the unique fragmentations of spiranes,[4] the mass spectra (given below) of the alaskenes and the saturation product (III) offered additional confirmation of the skeleton. The same fragments have been reported for α-chamigrene (IV) and its hydrogenation product.[5] Acoradiene (VI) exhibited a mass spectrum very similar to that of the alaskenes and, as expected, its hydrogenation product and III were indistinguishable by mass spectroscopy.



A final proof of the spirane nature of the alaskenes is seen in the rearrangements of β-alaskene with heat (→X) and acid (→IX) - both possible ortho-fused systems can be obtained. The structures of IX and X are based on compatible NMR, UV, IR, and mass spectra and on dehydrogenation to the corresponding naphthalenes. Discussion of the stereochemical and mechanistic details of these reactions will appear in the full paper.



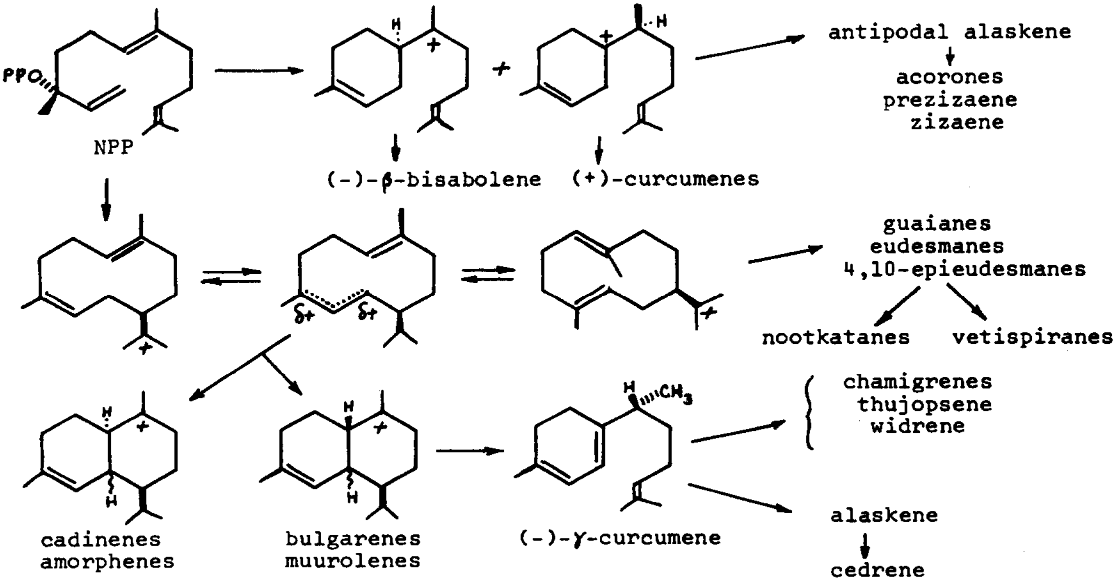
IX II X

The relative stereochemistry of the alaskenes was initially assigned on the basis of the chemical shifts shown - the doublet-CH_3 of structure II is assumed to be upfield due to its placement above the cyclohexene double bond in the most stable twist chair and half chair cyclohexene conformations. The recent biogenetically-patterned total synthesis of α-cedrene, based on the cyclization of an alcohol related to ion VIII,[6] suggested a method for confirming the relative stereochemistry - only diastereomer I should afford α-cedrene (via ion VIII) under acidic conditions.

We studied the isomerization of the alaskenes and acoradiene in formic and trifluoroacetic acid (TFA) using glc,[7] the pertinent results follow. In mixed n-decane-TFA both alaskenes and acoradiene afforded tetralin IX in 60% or greater yields. In formic acid, acoradiene is relatively inert but affords a tricyclic formate and a number of isomeric olefins; β-alaskene affords the same isomeric olefins; but α-alaskene affords α-cedrene[8] in 70% yield.

We consider the facile conversion of α-alaskene to α-cedrene as a final proof of relative stereochemistry and further wished to use a preparative version of this reaction for the confirmation of absolute stereochemistry by ORD comparison of α-cedrene so produced with authentic material. In an attempt to accomplish this, a new batch of Alaska Cedar boughs was collected[9] and processed. The resulting leaf oil contained the usual components but the amount of α-alaskene was less than in the previous sample and not sufficient for our purposes. The rearrangement of β-alaskene (to X) was discovered in the course of this work when final purification by preparative glc was attempted using higher detector temperatures.

Ions related to the alaskenes appear well set up for cyclizations to a number of tricyclic sesquiterpene types. The biogenetic scheme which we have adopted is given below. The scheme envisions only two cyclizations of, as an



example, nerolidyl pyrophosphate (NPP) and these two suffice to explain all but those sesquiterpenes presently derived from cycloundecyl intermediates. Two features deserve note: 1) that one cyclization to a set of cyclodecadienyl cations accounts for all of the common sesquiterpenes previously considered to be derived from *trans*, *trans*- and *cis*, *trans*-farnesyl derivatives by separate routes - in this way the observed correlation in absolute configuration of sesquiterpenes of "different" classes[10] is given a rational chemical basis and 2) that direct cyclization of NPP produces (-)-β-bisabolene,[11] the (+)-curcumenes and their further transformation products such as acorone, prezizaene,[12] and zizaene,[12] whereas the (-)-curcumenes are viewed as fragmentation products from the muurolene group[13] and further cyclization of (-)-curcumenes produces the alaskenes, cedrenes, chamigrenes, thujopsene, etc. Attempts at the chemical simulation of these biogenetic steps and radiolabel feeding experiments designed to confirm them are in progress.

Acknowledgements - We are deeply indebted to the Research Corporation for their support of this research through a Frederick Gardner Cottrell Grant and to Professor V. Herout (Czechoslovak Academy of Sciences) for generous samples of acorone, isoacorone, and "neoacorone."

REFERENCES

1. N. H. Andersen and D. D. Syrdal, *Phytochem.*, in press.
2. J. Pliva, M. Horak, V. Herout, F. Šorm, *Die Terpene*, *Teil I*, *Sesquiterpenes*, S182, Akademie Verlag, Berlin (1960).
3. Isomer VII afforded two saturated products. Identifications were made by glc on four stationary phases using authentic samples. Retention data was compared in the form of self-consistent Kovat's indices: N. H. Andersen and M. S. Falcone, *J. Chromatog.*, **44**, 52 (1969).
4. The mass spectral fragmentation of spirane sesquiterpenes and tricyclic sesquiterpenes will be the subject of a future communication.
5. Y. Ohta and Y. Hirose, *Tetrahedron Letters*, 2483 (1968).
6. T. G. Crandall and R. G. Lawton, *J. Am. Chem. Soc.*, **91**, 2127 (1969). The biogenetic model was suggested by Ruzicka nearly twenty years ago [*Experientia*, **9**, 357 (1953)].
7. Ca. 1% solutions in n-decane were stirred with the acids. Stirring was stopped intermittently to allow for glc analysis of the upper layer.
8. α-Cedrene was identified by glc[3] using three columns.
9. Collected at 4500' in the North Cascades inland from Bellingham, Washington, in October, 1969. Later collections were prevented by snow.
10. N. H. Andersen, *Phytochem.*, **9**, 145 (1970).
11. Note that Ch. nootkatensis produces the very rare (+)-β-bisabolene even though it contains normal nerolidol. This suggests a relationship to the (-)-curcumenes also found in the oil. We will comment at length on the (+)-nerolidol → (-)-β-bisabolene step and literature precedents for it, in the full paper.
12. See the following communication.
13. Only the muurolene group exists in conformations having the stereoelectronically favored antiparallel relationship between the fragmenting bond and the hydrogen at the fusion.[1]