Tetrahedron Letters No.40, pp. 3619-3624, 1965. Pergamon Press Ltd.
Printed in Great Britain.

A NEW SESQUITERPENE HYDROCARBON FROM *LAURENCIA GLANDULIFERA*[1]

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(Received 21 August 1965)

In the preceding paper[2] we reported on the structure of laurencin, a compound containing bromine obtained from *Laurencia glandulifera* Kützing. While Obata and Fukushi[3] pointed out the presence of a sesquiterpene hydrocarbon in the same algae, a new hydrocarbon, $C_{15}H_{20}$, was isolated on our further examination and designated laurene. In this paper, the hydrocarbon will be shown to have structure I on the basis of arguments mentioned in the following.

Laurene (I) was obtained in ca. 0.11% yield by chromatography of a neutral fraction obtained by steam distillation of methanol extracts of the seaweed.[4] The hydrocarbon, b.p. 131~133°/21 mm, $[\alpha]_D^{23}$ +48.7° (EtOH), λ_{max}^{EtOH} 253 (280), 259 (280), 265 (280) and 274 mμ (ε 240), ν_{max}^{film} 1653, 1512, 1017, 875, 812 and 725 cm^{-1}, was analyzed for $C_{15}H_{20}$.[5] The n.m.r. spectrum (60 Mc., in CCl_4) showed peaks at 3.01 (4H, s),[6] 5.19 (2H, q, J = 1 c.p.s.), 7.69 (3H, s), 8.71 (3H, s) and 9.32τ (3H, d, J = 7 c.p.s.). All these spectral data indicated the presence of a tolyl (probably *p*-substituted), a terminal methylene, a secondary methyl and a tertiary methyl group. In view of the number of sites of unsaturation of laurene, another carbon ring must be present in the molecule.

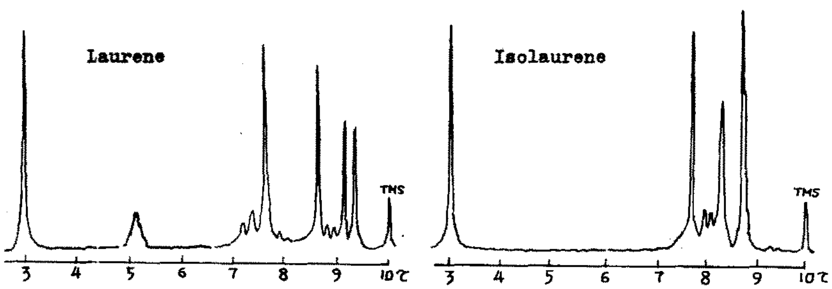
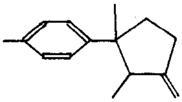


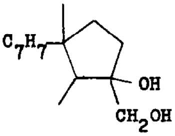
Fig. 1. n.m.r. Spectra of laurene and isolaurene (60 Mc., in CCl_4)

Oxidation of I with osmium tetroxide in ether-pyridine afforded a glycol (II), $C_{15}H_{22}O_2$, $[\alpha]_D^{23}$ +40°, $\nu_{max}^{CHCl_3}$ 3520, 3380, 1508, 1012, 975 and 812 cm^{-1}, n.m.r. 3.05 (4H, s), 5.95 (2H, m), 7.73 (3H, s), 8.54 (3H, s) and 9.38τ (3H, d, J = 7 c.p.s.). When treated with periodic acid, II was converted to a ketone (III), $C_{14}H_{18}O$, $[\alpha]_D^{23}$ +70°, which was found to have a five-membered ring carbonyl group (ν_{max} 1737 cm^{-1}) and probably a methylene group adjacent to the carbonyl group (ν_{max} 1410 cm^{-1}). The n.m.r. spectrum of III showed peaks at 2.70~2.99 (4H, m; aromatic protons), 7.66 (3H, s; aromatic methyl), 8.84 (3H, s; tertiary methyl) and 9.04τ (3H, d; secondary methyl). This ketone showed a positive Cotton effect and gave a crystalline semicarbazone, m.p. 227~229°.

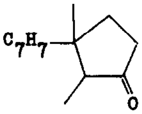
Treatment of I with silicic acid in petroleum ether yielded an isomeric hydrocarbon, isolaurene (IV), $C_{15}H_{20}$, b.p. 140~142°/21 mm, $[\alpha]_D^{23}$ +108.7°, ν_{max}^{film} 1510, 1015, 819 and 720 cm^{-1}. While the n.m.r. spectrum of IV exhibited absorptions at 3.04 (4H, s), 7.76 (3H, s) and 8.67τ (3H, s) which were comparable to those due to aromatic protons (3.01τ), an aromatic methyl group (7.69τ) and a tertiary methyl group (8.71τ) of I respectively, the signals due to the methylene (5.19τ)



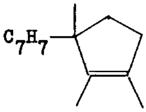
I



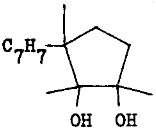
II



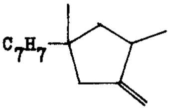
III



IV



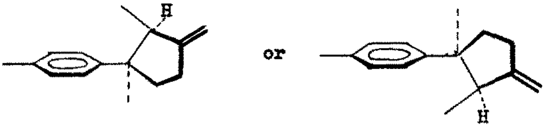
V



VI

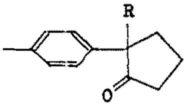
and the secondary methyl groups (9.32τ) of I were replaced by those at 8.30 (3H, s) and 8.63τ (3H, s)[7], which were attributable to methyl groups attached to olefinic carbon. Hence, the isomerization involves migration of the exo-cyclic double bond to an endo-cyclic one to which two methyl groups are attached and, therefore, the terminal methylene and the secondary methyl groups must be located on vicinal carbons in I, as far as no skeletal change occurs during the isomerization. This was supported by the formation of a ditertiary glycol (V), m.p. 114~116°, $\nu_{max}^{CHCl_3}$ 3320, 1512, 1069, 1017 and 810 cm^{-1}, on treatment of IV with osmium tetroxide; that is, the n.m.r. spectrum of V exhibited two sharp signals at 8.82 and 8.90τ due to the methyl groups on vicinal carbons bearing hydroxyl group instead of those at 8.30 and 8.63τ in IV.

All these results indicate that I is the most preferable structure for laurene,[8] since the possibility of formula VI is ruled out by the presence of optical activity in isolaurene. It is evident on the basis of the high τ-value of the secondary methyl signal in the n.m.r. spectrum of laurene or the glycol II that the secondary methyl group is <u>cis</u> oriented to the tolyl group.[9]

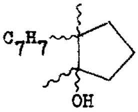


I

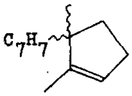
The structure I for laurene has now been confirmed by the synthesis of the ketone III. 2-(*p*-Tolyl)-cyclopentanone[10] (VII) was methylated with methyl iodide and sodium amide to yield 2-methyl-2-(*p*-tolyl)-cyclopentanone (VIII), b.p. 124~126°/5.5 mm, ν_{max}^{film} 1737, 1408 and 810 cm^{-1}, n.m.r. 2.90 (4H, s), 7.72 (3H, s) and 8.72 τ (3H, s). The treatment of VIII with methyl lithium in ether afforded stereoisomers of 1,2-dimethyl-2-(*p*-tolyl)-cyclopentanol (IX). On acid dehydration, both the *cis*- and the *trans*-isomer[11] gave the same 2,3-dimethyl-3-(*p*-tolyl)-cyclopentene (X), $\nu_{max}^{CHCl_3}$ 1505, 1072, 1020 and 820 cm^{-1}, n.m.r. 2.93 (4H, s), 4.57 (1H, m), 7.70 (3H, s), 8.55 (3H, d, J = 2 c.p.s.) and 8.58 τ (3H, s). On hydroboration, the cyclopentene X gave mainly *trans*-2,3-dimethyl-3-(*p*-tolyl)-cyclopentanol (XI),[12] $\nu_{max}^{CHCl_3}$ 3630, 3460 and 1042 cm^{-1}, n.m.r. 3.00 (4H, s), 7.72 (3H, s), 8.60 (3H, s) and 9.38 τ (3H, d, J = 7 c.p.s.).



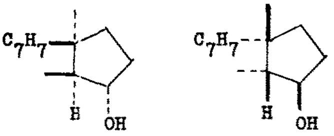
VII R = H
VIII R = CH_3



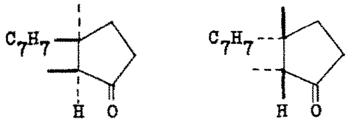
IX



X



XI



XII

This alcohol was oxidized with chromic oxide-pyridine to yield *trans*-2,3-dimethyl-3-(*p*-tolyl)-cyclopentanone (XII), $\nu_{max}^{CHCl_3}$ 1737, 1515 and 1410 cm^{-1}, n.m.r. 2.70~2.99 (4H, m), 7.66 (3H, s), 8.84 (3H, s) and 9.04 τ (3H, d, J = 7 c.p.s.), the semicarbazone, m.p. 214~215°. The infrared and n.m.r. spectra and Rf-values on the thin layer chromatograms of the *dl*-ketone XII and its semicarbazone thus obtained were completely identical with those of the ketone III and its semicarbazone obtained from laurene.

Acknowledgments — The authors wish to thank to Dr. Iemasa Yamada of Department of Botany, this Faculty, for collection of the seaweed and to Mr. Shigezo Shimokawa for measurments of the n.m.r. spectra.

REFERENCES

(1) Part III of "Constituents from Marine Plants"; Part II, reference 2.

(2) T. Irie, M. Suzuki and T. Masamune, *Tetrahedron Letters*, 1091 (1965).

(3) Y. Obata and S. Fukushi, *J. Agricult. Chem. Soc. Japan*, **27**, 331 (1953).

(4) The seaweed was collected in August at Oshoro Bay, Hokkaido.

(5) Satisfactory analyses were obtained for the new compounds listed in this report.

(6) s: singlet, d: doublet, q: quartet, and m: multiplet.

(7) The absorption at 8.63 τ appears in the extraordinarily high field as that due to methyl group attached to olefinic carbon, and this abnormality would be caused by magnetic anisotropy of benzene ring, cf. reference 9.

(8) Laurene might be probably a precursor of aplysin, a sesquiterpene containing bromine isolated from *Sea rat* (*Aplysia kurodai* Baba) by S. Yamamura and Y. Hirata (*Tetrahedron*, **19**, 1485 (1963)), since *Sea rat* feeds on Laurencia. (Professor Jun Tokida, the Faculty of Fisheries, this University, private communication).

(9) Cf. G. L. Chetty and S. Dev, Tetrahedron Letters, 73 (1964) and J. A. Steele, L. A. Cohen and E. Mosettig, J. Amer. Chem. Soc., **85**, 1134 (1963).

(10) K. Mislow and C. H. Hammermesh, ibid., **77**, 1590 (1955).

(11) The terms "cis" and "trans" refer to the relative configuration of methyl groups in vicinal carbons C_1 and C_2. One isomer in the spectrum of which a peak due to the methyl group on C_1 appeared at 8.85τ was assigned cis-compound, and another which showed the corresponding peak at 9.13τ was assigned trans-compound.

(12) Hydroboration involves cis addition from the less hindered side of the double bond, H. C. Brown and G. Zweifel, ibid., **81**, 247 (1959); **83**, 2544 (1961); **86**, 393 (1964).