The absolute configuration of (−)-(3*R* : 4*R*)-3,4-dimethyladipic acid (Ⅵ) and of (−)-(3*R* : 4*R*)-3,4-dimethylcyclopentanone (Ⅲb) had confirmed by correlating to naturally occurring (−)-(*S*)-2-methyl-1-butanol (Ⅶ).2) Consequently, the absolute configuration of 2α,3α-dideoxylyoniresinol dimethyl ether (Ⅱ) and of lyoniresinol (Ia) was determined as (2*R* : 3*S* : 4*S*)-(Ⅱ) and (2*R* : 3*R* : 4*S*)-(Ia), respectively.

For the further comparison, the antipodes of Ⅲa and Ⅵ were synthesized. By optical resolution from free 3,4-dimethyladipic acid which was synthesized by modified method of known procedure,4) there was obtained (+)-3,4-dimethyladipic acid (Ⅴ), m.p. 99.3~100° (*Anal.* Calcd. for $C_8H_{14}O_4$: C, 55.16; H, 8.10. Found : C, 55.15; H, 8.25), $[\alpha]_{546}^{15.8}$ +4.27° ($CHCl_3$, c=6.43), $[\alpha]_{546}^{17.8}$ +2.98° (H_2O, c=6.165). (+)-3,4-Dimethylcyclopentanone semicarbazone (Ⅳa), m.p. 205.5~207.5° (*Anal.* Calcd. for $C_8H_{15}ON_3$: C, 56.78; H, 8.94; N, 24.83. Found : C, 57.19; H, 8.78; N, 24.94), $[\alpha]_{546}^{22.6}$ +81° ($CHCl_3$, c=0.33) was prepared from (+)-3,4-dimethylcyclopentanone (Ⅳb), b.p. 155~157° (bath temperature), $[\alpha]_{546}^{23.5}$ +149° ($CHCl_3$, c=0.24) which was derived from Ⅴ by pyrolysis.2~4)

The mass spectra of three semicarbazones, (−)-specimen from lyoniresinol, Dr. B. Carnmalm's authentic sample and synthesized (+)-compound, were completely identical each other.

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Structure of Cyperolone

A sesquiterpenic keto-alcohol, $C_{15}H_{24}O_2$, m.p. 41~42° (monohydrate), $[\alpha]_D$ +31.4°,[*1] of a novel skeleton has been isolated from the tuber of nutgrass (*Cyperus rotundus* LINNÉ) of Japanese origin and named cyperolone. The present paper reports evidence leading to stereoformula I for this substance.

The infrared and nuclear magnetic resonance (NMR) spectra of cyperolone show the presence of a secondary hydroxyl (3436 cm^{-1} 5.70 τ), an acetyl (1695 cm^{-1}, 7.93 τ), an isopropenyl (3086, 1642, 885 cm^{-1}, 8.25, 5.32 τ), and a tertiary methyl group (9.06 τ).

Cyperolone was hydrogenated to give the saturated dihydro-derivative (Ⅱ), $C_{15}H_{26}O_2$, $[\alpha]_D$ +24.7°, whose NMR spectrum indicates the disappearance of the isopropenyl and the formation of an isopropyl group (9.06 τ) during hydrogenation.

Oxidation of cyperolone (I) and dihydrocyperolone (Ⅱ) with chromic acid gave the

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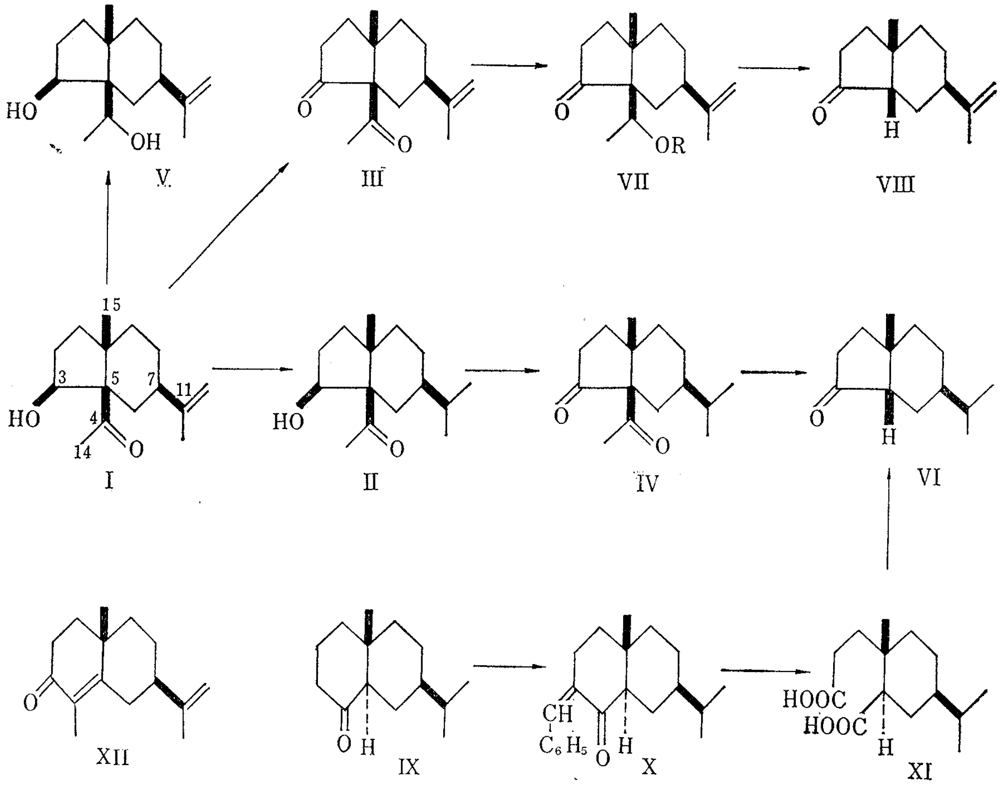
[*1] Analytical values are in agreement with the molecular formulae shown. $[\alpha]_D$s were measured in $CHCl_3$ solution, ORD curves in CH_3OH solution, and IR spectra in liquid film unless otherwise indicated. NMR spectra were determined at 60 Mc. in CCl_4 solution *vs.* internal $(CH_3)_4Si$.

dione (III), $C_{15}H_{22}O_2$, $[\alpha]_D$ +38.7°, and the dione (IV), $C_{15}H_{24}O_2$, $[\alpha]_D$ +48.5°, respectively, whose infrared absorption at 1742 or 1748 (cyclopentanone) and 1692 or 1695 cm^{-1} (acetyl) indicates the hydroxyl group of cyperolone to be situated on a five-membered ring. Reduction of cyperolone with lithium aluminum hydride yielded the diol (V), $C_{15}H_{26}O_2$, m.p. 112~112.5°, $[\alpha]_D$ +72.4°, which exhibits an NMR signal due to the hydrogen on carbon attached to the newly formed hydroxyl group as a quadruplet (J=7 c.p.s.) showing that the carbon atom bearing the acetyl group in cyperolone is quarternary. Alkali treatment of the dione (IV) afforded, with the loss of the acetyl group, a monoketone, $C_{13}H_{22}O$, ORD : a +90, with infrared absorption at 1742 cm^{-1} (cyclopentanone). Therefore, the diones (III and IV) must have the partial structure $-CO-C\lessdot CO-CH_3$.



From these results and biogenesis that the sesquiterpenoid may be derived from an epoxide of the alcohol corresponding to α-cyperone (XII) present in the same oil,[1] it is assumed that cyperolone has the structure I (without stereochemistry).

14-Noreudesmanone (IX)[2] was converted into the benzylidene derivative (X), $C_{21}H_{28}O$, m.p. 88~88.5°, which was further transformed to the dicarboxylic acid (XI) by ozonolysis followed by hydrogen peroxide oxidation. Ketonization of the di-acid (XI) gave the ketone (VI), $C_{13}H_{22}O$, which was identical with the monoketone, the alkaline cleaved product of the dione (IV). As the ketone (VI) was obtained from the kotone (IX) of the naturally occurring eudesmane series, the structure and absolute stereochemistry of cyperolone were therefore elucidated, except for the configuration at C-3 and C-5. Application of the benzoate rule[3] to cyperolone ($\Delta[M]_D$ +169°) indicates that the C-3 hydroxyl group is β-situated. Partial reduction of the dione (III) with lithium aluminum hydride gave the unstable ketol (VII; R=H), IR bands (CCl_4) at 3428 (hydroxyl), 1726 (cyclopentanone), 1406 cm^{-1} (methylene α to carbonyl), NMR : doublet at 8.75 τ and

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1) H. Hikino, K. Aota, T. Takemoto : This Bulletin, **14**, 890 (1966).
2) H. Hikino, Y. Hikino, Y. Takeshita, K. Meguro, T. Takemoto : *Ibid.*, **13**, 1408 (1965).
3) J. H. Brewster : Tetrahedron, **13**, 106 (1961).

quadruplet at $6.21\,\tau$ ($J=6$ c.p.s., $\mathrm{C\underline{H}_3\text{-}C\underline{H}(OH)\text{-}C}\leqslant$), which was subject to conversion into the ketone (Ⅷ), $C_{13}H_{20}O$, m.p. 40.5°, IR band (KBr) at 1730 cm^{-1} (cyclopentanone), ORD: *a* +153. Acetylation of the kotol (Ⅶ; R=H) furnished the stable acetate (Ⅶ; $R=COCH_3$) whose optical rotatory dispersion curve shows a positive Cotton effect (*a* +48); the C-5 substituent being consequently β-oriented.[4] The *cis* relationship of the C-3 and C-5 substituents was further confirmed by the presence of an intramolecularly-hydrogen-bonded hydroxyl band at 3535 cm^{-1} in the infrared (CCl_4) of the diol (Ⅴ).

Whereupon the absolute stereochemistry of cyperolone is represented by formula I.*2

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*2 The authors propose the name cyperane, with the numbering shown, for the skeleton of cyperolone.

[4] cf. W. Klyne: Tetrahedron, **13**, 29 (1961).

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Synthesis of Cyperolone

The sesquiterpenic keto-alcohol cyperolone, $C_{15}H_{24}O_2$, was recently isolated from the rhizome of nutgrass (*Cyperus rotundus* LINNÉ) by the authors who proposed the stereostructure I based on the chemical and physico-chemical evidence obtained.[1] A synthesis of cyperolone by a method which confirms both structure and absolute stereochemistry is now presented.

Biogenetic considerations suggest that the carbon skeleton of cyperolone is derived from an intermediate having the structure A, by some version of the "pinacol-pinacolone" rearrangement as shown in Chart 1. This rearrangement must be useful in the synthetic work, which has been performed as follows.

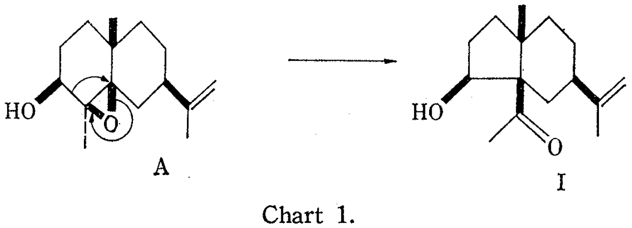

Chart 1.

(+)-α-Cyperone (Ⅱ) was reduced with lithium aluminum hydride to give eudesma-4,11-dien-3β-ol (Ⅲ) (quantitative yield), $[\alpha]_D$ +10.9°, IR band (liquid) at 3390 cm^{-1} (hydroxyl).*1 The orientation of the hydroxyl group is shown by the nuclear magnetic resonance (NMR) signal of the C-3 hydrogen at $6.13\,\tau$ as a broad peak (band width at half height: 15 c.p.s.). Epoxidation of the alcohol (Ⅲ) with 1 mole of perbenzoic acid produced a single mono-epoxide, 4β,5β-oxido-eudesm-11-en-3β-ol (Ⅳ) (59% yield), NMR peaks at 8.62 (singlet, $\mathrm{C\underline{H}_3\text{-}}\underset{\mathrm{O}}{\underset{\vee}{\mathrm{C\text{-}C}}}\langle$), 8.29, $5.36\,\tau$ (triplet

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*1 Specific rotations were measured in $CHCl_3$ solution. NMR spectra were determined at 60 Mc. in CCl_4 solution against internal $(CH_3)_4Si$.

[1] H. Hikino, K. Aota, Y. Maebayashi, T. Takemoto: This Bulletin, **14**, 1439 (1966), and the experimental details to be published.