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FERN CONSTITUENTS: HYDROXYADIANTONE AND KETOHAKONANOL ISOLATED FROM ADIANTUM MONOCHLAMYS

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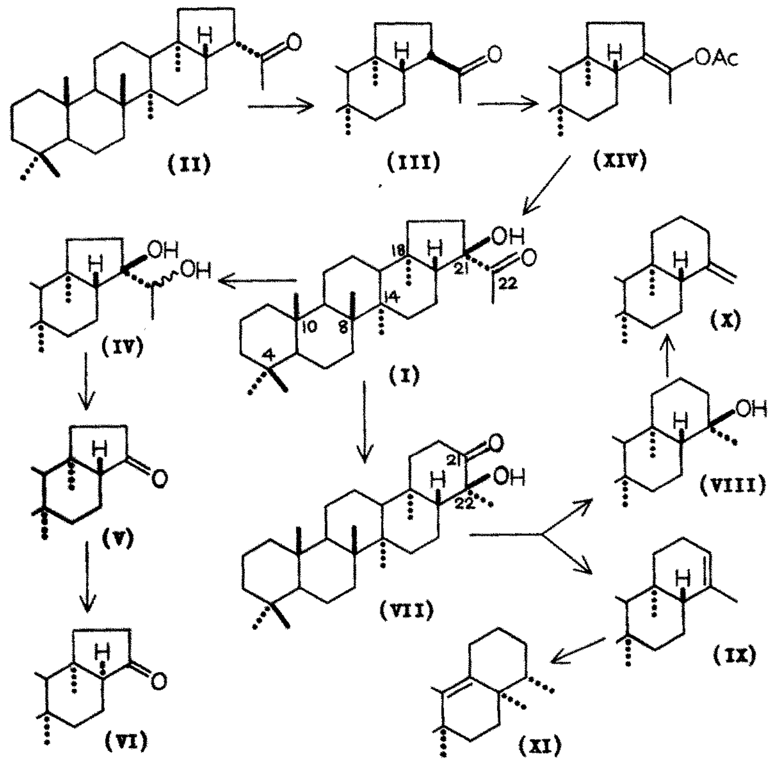
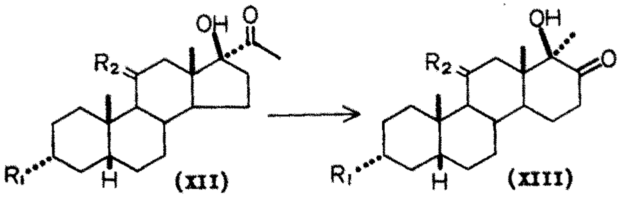
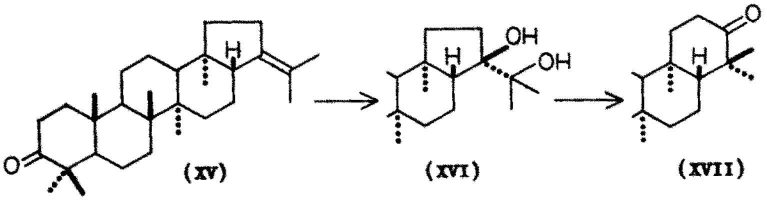
From the leaves of a japanese fern, Adiantum monochlamys EATON (Pteridaceae, "Hakone-shida"), several triterpenoid hydrocarbons were isolated and their chemistry was reported.[1)] Further studies on the triterpenoids of the same plant have now afforded two new compounds, hydroxyadiantone and ketohakonanol, and also adiantone.[2)] These three compounds are characteristic of the feature that they are ketones of 29 carbon atoms.

Hydroxyadiantone (I) was obtained from the methanol extract of the dried material. M.p. 270-275°, $[\alpha]_D$ +50° (c=0.5, pyridine). $C_{29}H_{48}O_2$ for the compound was confirmed by a mass analysis, m/e 428 (11), which also suggested the presence of $-COCH_3$ as well as -OH in the molecule, m/e 410(2), 385(4) and 367(3), and the saturated pentacyclic skelton giving a very strong base peak at m/e 191. The IR spectrum of I was closely related to that of adiantone (II) except for the presence of additional hydroxyl bands, ν_{-OH} 3430, 1082 cm^{-1} $\nu_{C=O}$ 1695 cm^{-1}; on the other hand, the spectrum differed considerably


(II)
(III)
(XIV)
OAc
(I)
OH
18
21
22
10
8
14
4
(IV)
OH
OH
(V)
(VI)
(VII)
21
22
OH
(VIII)
OH
(X)
(IX)
(XI)
H


OH
R2
R1
H
(XII)
(XIII)


(XV)
(XVI)
OH
OH
(XVII)
H

from that of isoadiantone (III). $LiAlH_4$ reduction of hydroxyadiantone afforded a mixture of two isomeric diols (IV), in which the presence of a 1,2-glycol system and the structure of ring A, B, C, D and E were established by formation of the ketone (V) by lead tetraacetate oxidation. The less stable ketone (V), m.p. 184-186°, thus obtained was confirmed to be identical with a sample derived from hopene-a;[3] it was isomerized to the more stable ketone (VI), m.p. 244-246°, by alkaline treatment.

When hydroxyadiantone was chromatographed over alumina, it was changed into an isomeric keto-alcohol, $C_{29}H_{48}O_2$, m.p. 295-297°, $[\alpha]_D$ +8° (c=1, $CHCl_3$), which was identical with ketohakonanol (VII), isolated directly from the plant extract. The presence of a six-membered ketone and a tertiary hydroxyl groups was demonstrated by its IR spectrum, $\nu_{C=O}$ 1713 cm^{-1} and ν_{-OH} 3470, 1070 cm^{-1}, and by its NMR spectrum (Table I). In the latter, the structure of ring A, B and C must be the same with that of hopane because the chemical shifts of the four methyl groups at C(4α), (4β), (10) and (8) gave essentially the same with those of hopane and derivatives.[4] The methyl signal at τ8.74 can be assigned to that at C(22) carrying a tertiary hydroxyl group; the remaining methyl signal at τ8.93 to that at C(18), which is subject to the deshielding effect of the C(21)-carbonyl.

Wolff-Kishner reduction of ketohakonanol (VII) afforded three products, i.e. hakonanol (VIII), $C_{29}H_{50}O$, m.p. 283-285°, $[\alpha]_D$ +20° (c=1, $CHCl_3$), ν_{-OH} 3450, 1065 cm^{-1}, 21-hakonene (IX), $C_{29}H_{48}$, m.p. 215-218°, $[\alpha]_D$ +55° (c=1, $CHCl_3$), and another hydrocarbon. The chemical shifts of the methyl groups attached to C(4α), (4β), (10), (8), (14) and (18) in VIII were similar to those of hopane (Table I). The remaining τ8.90 methyl signal should be attached to C(22) carrying a hydroxyl group. Formation of the hydrocarbon, 21(29)-hakonene (X), m.p. 210; 218-220°, $\nu_{C=CH_2}$ 3020, 1644, 882 cm^{-1}, by dehydration of VIII with acetic anhydride, suggested the hydroxyl group of hakonanol to be equatorial (β) and the methyl group axial (α) at C(22). The *NMR spectrum of IX supported its structure having a vinyl proton* (τ4.79m) and a vinyl methyl (τ8.42); the methyl groups at C(18) and (14) are subject to a week anisotropic effect of the double bond. Acid treatment of the hydrocarbon (IX), in which the double bond is suggested to be in ring E by its mass spectrum, m/e M^+ 396(33), 231 (42), 191(100) and 175(79), afforded two isomeric hydrocarbons as detected by VPC. One of them has a tetra-substituted double bond at the 13(18) position (XI), since its mass spectrum, m/e M^+ 396(23), 205(34), 204(87), 192(48), 191(100), 189(24) and 175(33), was very similar to that of olean-13(18)-ene$^{5)}$ and of neohop-13(18)-ene (hopene-II).

The acyloin rearrangement of hydroxyadiantone (I) to ketohakonanol (VII) induced by alumina is similar to the rearrangements of 17β-hydroxy-17-isopregnan-20-ones (XII) to 17aβ-ketols (XIII).$^{6)}$ Hence ketohakonanol has the stereochemistry as shown in formula VII, and hydroxyadiantone must be formulated as in formula I.

The structure of hydroxyadiantone was again confirmed by partial synthesis of the compound from isoadiantone (III). Treatment of III with acetic anhydride in the presence of p-toluenesulfonic acid gave the enol acetate (XIV), $C_{31}H_{50}O_2$, m.p. 151.5-156.5°, $\nu_{C=O}$ 1748 cm^{-1}, NMR (τ): 7.86 ($OCOCH_3$), 8.16 ($C=\underset{|}{C}-CH_3$), which upon OsO_4 oxidation afforded a compound of m.p. 268-272°. This was confirmed to be identical with natural hydroxyadiantone (I). Since the hydroxylation would occur from the less hindered β side of XIV, the hydroxyl group in hydroxyadiantone should have the β configuration at C(21) as shown in formula I. A model compound, hopenone-a$^{7)}$(hop-21-en-3-one, XV)

Table I Chemical shifts of the methyl groups
(Varian A-60, CCl_4 or $CDCl_3$ solution)

compound	methyl groups attached to C( )				
	4α,4β,10	8	14	18	22
hopane	9.16,9.19,9.20	9.05	9.05	9.29	9.11d,9.24d(J=6.5 cps)
21αH-hopane	9.16,9.19,9.22	9.04	9.07	9.37	9.12d,9.22d(J=6.5 cps)
(II)	9.16,9.18,9.20	9.02	9.06	9.41	7.90
(III)	9.16,9.19,9.21	9.04	9.04	9.30	7.87
(VII)	9.15,9.19,9.19	9.05	8.97	8.93	8.74
(VIII)	9.16,9.19,9.22	9.04	9.04	9.22	8.90
(IX)	9.16,9.19,9.19	8.97	9.05	9.30	8.42

was also treated with OsO_4 to give 3-keto-hopane-21β,22-diol (XVI), m.p. 264-268°, which on treatment with mesyl chloride-pyridine gave gammacerane-3,21-dione (XVII), a pinacol rearrangement product, and hopa-15,17(21)-dien-3-one, $C_{30}H_{46}O$, m.p. 160-163°, the former being identified by direct comparison with a sample derived from α-onocerin. 8)9)

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All m.p.s are measured by Kopfler block and uncorrected.

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NMR data for hopane in this paper is different from our observation, but quite similar to that of 21αH-hopane (Table I).

Since the stereochemistry of hydrocarbons derived from 22-hydroxy-hopanes has been finally clarified (Y. Tsuda, K. Isobe, S. Fukushima, H. Ageta: Tetrahedron Letters, in press), it is obvious that hopane and derivatives (22-deoxy compounds) used by French authors have $21\alpha H$-configuration.

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