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FERN CONSTITUENTS: THREE NEW SKELETAL TRITERPENOID HYDROCARBONS ISOLATED FROM *POLYPODIODES NIPONICA*

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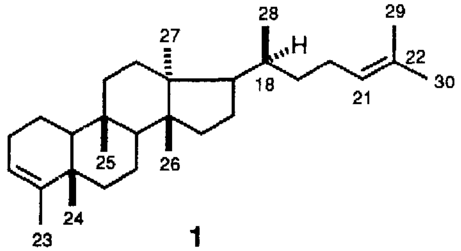
SUMMARY: Three new triterpenoid hydrocarbons, named aonena-3,21-diene (**1**), podioda-7,17,21-triene (**2**) and podioda-8,17,21-triene (**3**), were isolated from fresh rhizomes of *Polypodiodes niponica* and their structures were established by spectral and chemical studies. Compound **1** is the first example of a final migrated product of dammarane series. Compounds **2** and **3** constitute a new migrated malabaricane series.

We have reported the isolation and characterization of many kinds of pentacyclic triterpenoids including twenty seven hydrocarbons[1] from the air-dried rhizomes of *Polypodiodes niponica* (NAKAI) CHING[2,3] (*Polypodium niponicum* NAKAI, Aonekazura in Japanese) and *Polypodiodes formosana* (NAKAI) CHING[2,3] (*Polypodium formosanum* NAKAI, Taiwan-aone-kazura). From the fresh rhizomes of *P. niponica*, we isolated, as minor components, three novel triterpenoid hydrocarbons, named aonena-3,21-diene (**1**), podioda-7,17,21-triene (**2**) and podioda-8,17,21-triene (**3**), the first of which belongs to the migrated dammarane series and the rest belong to the migrated malabaricane group. They were obtained only from the fresh plant materials by careful separation procedure. This paper deals with the characterization of these compounds.

The fresh rhizomes (1.03 kg) collected in Shizuoka prefecture in May were extracted with n-hexane followed by Si gel chromatography to give 1.45 g of a hydrocarbon fraction. The fraction was chromatographed on $AgNO_3$-Si gel with a gradient of n-hexane to benzene to give pentacyclic triterpenoid hydrocarbons as the n-hexane eluate followed by more polar tetra- and tricyclic triterpenoid hydrocarbon fractions. The latter fractions were further chromatographed on $AgNO_3$-Si gel followed by HPLC [ODS, MeOH-$CHCl_3$ (7:3 or 8:2)] to give **1**, **2** and **3**.



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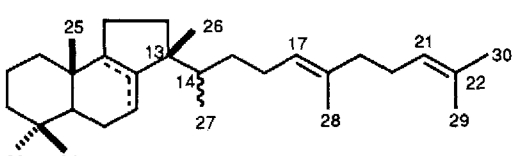


2 Δ^7
3 Δ^8

Compound **1**: 0.0003% (an estimated yield of the dried rhizomes), mp 89-91^{o}C, $[\alpha]_D^{23}$+8.9^o ($CHCl_3$, c=0.8), Rt_R 2.09,[4] M+ *m/z* 410.3915 ($C_{30}H_{50}$), IR ν_{max} cm^{-1}: 821, 798. The EI low mass spectrum of **1** showed some typical fragment peaks at m/z 297, 257, 218 and 191, which characterized a tetracyclic triterpenoid structure having a double bond at C-3 (Chart 1). These fragment peaks are the same as those observed in shiona-3,21-diene (**4**)[5] and friedel-3-ene (**5**).[1]

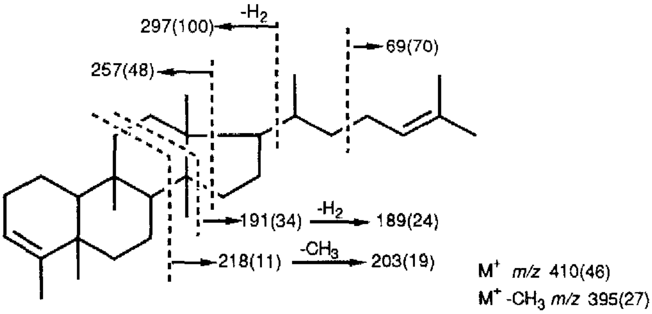


Chart 1. Mass Fragmentation Pattern of **1**. Relative intensities are shown in parentheses.

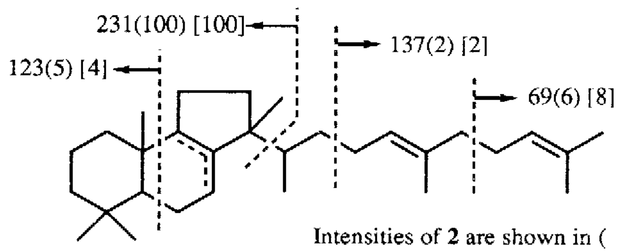
Table 1. ^{1}H-Chemical Shifts (δ) in $CDCl_3$ Solution on JEOL GX 270 at 270 MHz

	H-23	H-24	H-25	H-26	H-27	H-28	H-29	H-30	H-21	other olefinic protons*
1	1.580(*d*, 1.5)	0.989	0.847	0.817	0.779	0.904(*d*, 5.9)	1.603	1.683	5.098(*t*, 7.1)	[3] 5.163 (*m*)
4	1.566(*d*, 1.5)	0.987	0.884	0.884	1.076	0.906	1.590	1.676	5.110(*t*, 7.1)	[3] 5.154 (*m*)
6	0.845	0.882	0.745	0.978	0.818	0.850(*d*, 5.6)	1.603	1.684	5.100(*t*, 7.1)	[7] 5.239(*ddd*, 3.0,3.0,3.7)
7	0.845	0.884	0.745	0.968	0.821	0.885(*d*, 5.6)	1.598	1.676	5.100(*t*, 7.1)	[7] 5.237(*ddd*, 2.7,2.7,3.7)
8	0.875	0.830	0.948	0.875	0.764	0.860(*d*, 5.6)	1.610	1.688	5.095(*t*, 7.1)	
9	0.870	0.830	0.946	0.870	0.767	0.918(*d*, 5.6)	1.603	1.683	5.100(*t*, 7.1)	
10	0.860	0.801	0.846	0.846	1.071	0.920(*d*, 6.8)	1.587	1.683	5.127(*t*, 7.1)	
11	0.860	0.800	0.843	0.815	1.091	0.959(*d*, 6.8)	1.564	1.670	5.079(*t*, 7.1)	

Multiplicities and coupling constants are shown in parentheses. * Carbon numbers are given in square brackets.

The ^{1}H-NMR spectrum of **1** showed the signals of four singlet, one doublet and three olefinic methyl protons and two trisubstituted double bond protons. Two olefinic methyl proton signals at δ 1.603 and 1.683, and a trisubstituted double bond proton signal at δ 5.098 (*t*) indicate the presence of an isopropylidene group in the side chain like eupha-7,21-diene (**6**)[6] and tirucalla-7,21-diene (**7**)[5] (Table 1). The other olefinic proton signal at δ 5.163 (*m*), the olefinic methyl proton signal at δ 1.580 (*d*), and the methyl signal of H-24, indicate that this compound has a 3-ene structure like **4**. Thus **1** was considered to be a triterpenoid hydrocarbon of the migrated dammarane series. The absolute configuration at C-18 was determined by comparison with the chemical shifts of the methyl proton in each pair compound of the C-18 epimers, **6** and **7**, eupha-8,21-diene (**8**) and tirucalla-8,21-diene (**9**).[5] Between these pair of compounds, it is clear from Table 1 that the chemical shifts of the methyl proton of C-18 in the *S* configuration (**7** and **9**) appear at a lower field than that in the *R* (**6** and **8**). The acid induced migration reaction was investigated in order to confirm this structure. Treatment of **1** with 50% BF_3-etherate/ehter at 30°C for 4.5 hrs gave one of the C-18 epimers of dammara-13(17),21-diene (**11**) at 53% yield. Compound **11** was also obtained by the same method from **7**. The proton signal of C-28 methyl group attached to C-18 in **11** appeared at a lower field than that in (18*R*)-dammara-13(17),21-diene (**10**) obtained from *Polypodium someyae* YATABE.[6] Therefore **1** was elucidated to have the structure of migrated dammarane related to tirucallane group having a double bond at Δ^3. We named the corresponding saturated hydrocarbon as aonenane from Japanese plant name, and therefore **1** was called as aonena-3,21-diene according to the triterpenoid numbering system.[5,7]

The hydrocarbons **2**: 0.0002%, oil, $[\alpha]_D^{23}$ -11.5° ($CHCl_3$, c=0.2), R*t*$_R$ 1.00, M^+ *m/z* 410.3894 ($C_{30}H_{50}$) and **3**: 0.0002%, oil, $[\alpha]_D^{23}$+11.7° ($CHCl_3$, c=0.2), R*t*$_R$ 1.00, M^+ *m/z* 410.3945 ($C_{30}H_{50}$). Their EI low mass spectra showed a base peak at *m/z* 231, which was observed typically in 13αH-malabaricatriene (**12**) and 13βH-malabaricatriene (**13**) resulted in a loss of a side chain from a tricyclic ring system.[8] Although the other peaks were very weak in **2** and **3**, their fragment patterns were similar to those of malabaricatrienes. The ^{1}H-NMR spectra of **2** and **3** showed four singlet, one doublet and three olefinic methyl proton signals. Compound **2** also showed three olefinic proton signals, while **3** showed two olefinic proton signals. The splitting pattern of one of three olefinic proton signals in **2** appeared at δ 5.201(*ddd*) resembled those of 7-ene compounds such as **6** and **7**, and the chemical shift and splitting pattern of other two were the same as those of **3** and were similar to those of **12** and **13**.[8]



Intensities of **2** are shown in ( ), and **3** in [ ].

Chart 2. Mass Fragment Patterns of **2** and **3**.

Table 2. ^{1}H-Chemical Shifts (δ) in $CDCl_3$ Solution on JEOL GX 270 at 270 MHz

	H-23	H-24	H-25	H-26	H-27	H-28	H-29	H-30	H-17	H-21	H-7
2	0.865	0.889	0.709	0.923	0.813(*d*, 6.6)	1.605	1.605	1.684	5.126(*t*, 7.0)	5.103(*t*, 7.0)	5.201(*ddd*, 2.7,2.7,6.8)
3	0.886	0.849	0.947	0.956	0.722(*d*, 6.6)	1.605	1.605	1.684	5.126(*t*, 7.0)	5.103(*t*, 7.0)	
12	0.848	0.826	0.848	0.662	4.738, 4.888	1.598	1.598	1.680	5.100(*t*, 7.0)	5.100(*t*, 7.0)	
13	0.858	0.824	0.824	0.980	4.604, 4.876	1.598	1.598	1.686	5.100(*t*, 7.0)	5.100(*t*, 7.0)	

The above evidence indicated that **2** and **3** are the migrated malabaricane triterpenoid with a Δ^7 and Δ^8 double bond in the ring B, respectively. The structures of **2** and **3** were confirmed by the acid-induced reaction of authentic **12** and **13**. Treatment of **12** with 40 % BF_3-etherate/ether gave **2** (yield 14%) and **3** (25%), whereas that of **13** only induced 13βH-malabarica-14,17,21-triene.[8] Although the absolute configuration at C-14 of **2** and **3** was unknown, that at C-13 was established to be *R* (13β-Me), which was also reasonable from consideration of triterpenoid biogenesis. The corresponding saturated hydrocarbon for **2** and **3**, a migrated malabaricane group, was named as podiodane from the genus name, and thus **2** and **3** were called as podioda-7,17,21-triene and podioda-8,17,21-triene, respectively, according to the triterpenoid numbering system.

Aonena-3,21-diene (**1**) is the first example of a triterpenoid hydrocarbon of a final migrated product of the dammarane series, like filic-3-ene[9] of the hopane series and friedel-3-ene[1] of the oleanane series. Podioda-7,17,21-triene (**2**) and podioda-8,17,21-triene (**3**) are the first examples of migrated products of the malabaricane group. Further studies on triterpenoids of other Polypodiaceous ferns will lead to an isolation of related new triterpenoids.

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