

(-)-THERMAROL, A NEW ENT-PIMARANE-CLASS DITERPENE DIOL
FROM *JUNGERMANNIA THERMARUM* (LIVERWORT)

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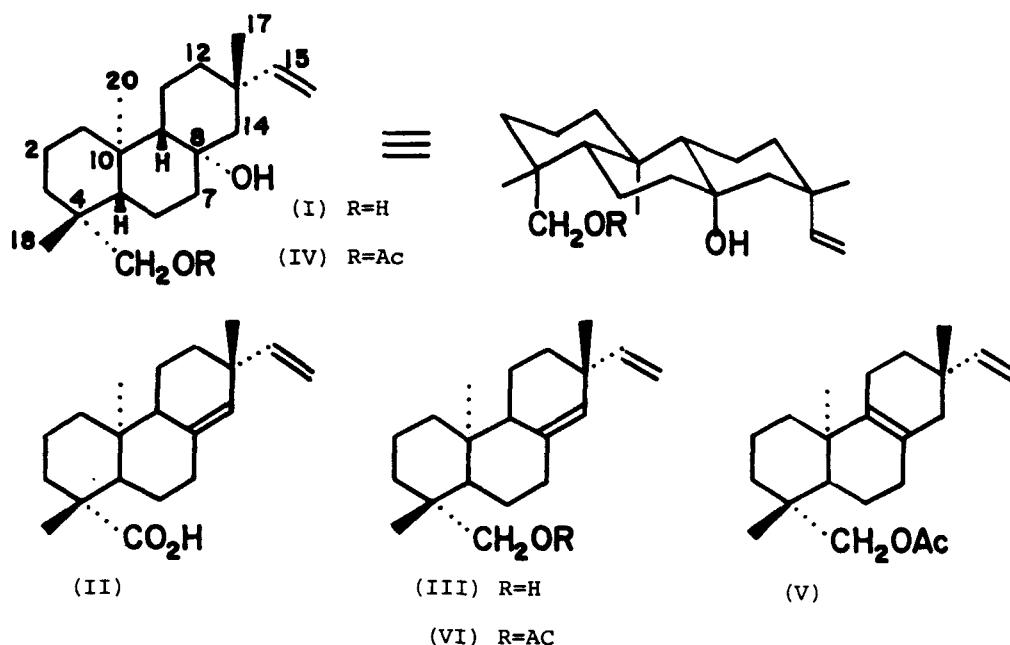
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In the liverworts (*Hepaticae*) forming a unique group of the plant kingdom, the haploidal plant bodies (gametophytes) which grow from the spores contain some oil bodies characteristic of the species in the cells. In our course of the investigation on terpenoids in essential oils of the liverworts, several antipodes for sesquiterpenoids obtained from the higher plants had been isolated,¹⁾ and now three *ent*-pimarane-type diterpenoids including a new one were isolated from a leafy liverwort, *Jungermannia thermanum* Steph. We are interested in such occurrence of enantiomeric terpenoids in the liverworts in view of a relation between the terpenoid biogenesis and the plant chemotaxonomy. The present communication deals with the isolation and structural determination of the new *ent*-pimarene diol (I) named (-)-thermarol.

The diol (I), $C_{20}H_{34}O_2$ (M^+ 306.2569); mp 146-147°; $[\alpha]_D -17.1^\circ$ (c 0.70, $CHCl_3$), was isolated in elution chromatography of a methanol extract of the liverwort together with a diterpene acid, $C_{20}H_{30}O_2$ (M^+ 302); mp 163-164°; $[\alpha]_D -108^\circ$, and a diterpene alcohol, $C_{20}H_{32}O$ (M^+ 288); mp 109-110°; $[\alpha]_D -95.3^\circ$. The latter two were confirmed to be *ent*-pimara-8(14),15-dien-19-oic acid (II) and *ent*-pimara-8(14),15-dien-19-ol (III) based on the chemical treatments and the coincidence of spectra with the authentic ones,²⁾ whose ^{13}C nmr spectra were reasonably assigned as shown in Table 1.

The ir and 1H nmr spectra of the diol exhibited the presence of both primary and tertiary hydroxyl groups (ν 3625, 3555, 3430 cm^{-1} ; δ 3.38, 3.81, each 1H, d, $J=11.0$) in addition to one vinyl group (ν 3075, 1633, 978, 909 cm^{-1} ; δ 4.90-6.35, 3H, ABC type) and three tertiary methyls (ν 1385, 1373 cm^{-1} ; 0.89, 6H, s; 0.97, 3H, s) which were common to the others. In the treatment

with $(\text{CH}_3\text{CO})_2\text{O}$ in pyridine, the diol(I) was converted to acetoxy-alcohol(IV), $\text{C}_{22}\text{H}_{36}\text{O}_3$ (M^+ 348); mp 62-63°; $[\alpha]_D -14.6^\circ$; ν 3580, 1740 cm^{-1} , which was then dehydrated with SOCl_2 in pyridine to give a tricyclic diene(V), $\text{C}_{22}\text{H}_{34}\text{O}_2$ (M^+ 330); $[\alpha]_D -50.7^\circ$, containing a newly formed-tetrasubstituted double bond along with one vinyl (ν 3070, 1639, 981, 915 cm^{-1} ; δ 4.68-6.04, 3H, ABC type), three tertiary methyls (ν 1378, 1370 cm^{-1} ; δ 0.92, 0.97, 0.98, each 3H, s) and one primary acetoxy group (ν 1740 cm^{-1} ; δ 1.98, 3H, s; 3.79, 4.27, each 1H, d, $J=11.0$). The tricyclic diene thus obtained was confirmed in ir, ^1H nmr and mass spectroscopies to be identical with *ent*-pimara-8,15-dien-19-yl acetate(V), $\text{C}_{22}\text{H}_{34}\text{O}_2$ (M^+ 330); $[\alpha]_D -43.7^\circ$, which was prepared by subjecting the pimariadienyl acetate(VI), $\text{C}_{22}\text{H}_{34}\text{O}_2$ (M^+ 330); $[\alpha]_D -66.0^\circ$, to isomerization under refluxing with HCO_2H . Accordingly, it is certain that the diol(I) is a hydroxyl derivative of *ent*-pimar-15-en-19-ol which carries an additional tertiary hydroxyl group on $\text{C}(8)$ or $\text{C}(9)$.



In Table 1, ^{13}C nmr spectra of the three diterpenoids were assigned by referring to those of pimarane-type diterpenoids.^{3,4,5)} In the nmr spectrum of the diol(I), two triplets (δ 42.3, 53.4) and one doublet (δ 57.2) assigned to $\text{C}(7)$, $\text{C}(14)$ and $\text{C}(9)$ exhibited lower shifts compared with those of the corresponding carbon atoms in other compounds.^{3,4)} This fact is reasonably explained by the deshielding effect of the tertiary hydroxyl group.⁶⁾

Table 1. ^{13}C Chemical Shifts of the *ent*-Pimarane Diterpenoids, I, II and III. ^{a)}

Carbon No.	Diol I	Acid II	Alcohol III
1	39.5, t	39.3, t	39.2, t
2	18.1, t	19.3, t ^{b)}	18.6, t
3	35.6, t ^{b)}	38.0, t	35.4, t ^{b)}
4	38.7, s	44.1, s	38.2, s ^{c)}
5	56.5, d	56.2, d	55.7, d
6	18.1, t	24.2, t	22.4, t
7	42.3, t	35.8, t	37.7, t ^{b)}
8	72.5, s	137.9, s	138.0, s
9	57.2, d	50.6, d	51.4, d
10	36.4, s	39.3, s	35.7, s
11	17.4, t	19.6, t ^{b)}	19.2, t
12	36.1, t ^{b)}	36.5, t	36.1, t ^{b)}
13	37.1, s	38.5, s	38.5, s ^{c)}
14	53.4, t	128.0, d	128.1, d
15	147.5, d	147.2, d	147.3, d
16	111.9, t	112.9, t	112.7, t
17	32.3, q	29.4, q ^{c)}	29.4, q
18	27.0, q	29.2, q ^{c)}	27.0, q
19	65.1, t	184.5, s	65.2, t
20	16.1, q	13.9, q	15.8, q

a) The ^{13}C nmr spectra were taken in CDCl_3 solutions on JEOL JNM-PFT-100 spectrometer (25.15 MHz) at the condition of pulse repetition 3 sec, accumulation 1800 times and spectral width 6.25 KHz, and the chemical shifts are expressed as δ ppm from an internal reference of TMS; s, singlet; d, doublet; t, triplet; q, quartet in the off-resonance spectra.

b, c) The values in any vertical column may be interchanged.

Furthermore, the pyridine-induced solvent shifts of ^1H nmr signals were examined on the diol(I), ⁷⁾ and the results were compared with that of the *ent*-pimaradienol(III). As seen in Table 2, the diol exhibited considerable solvent shifts on the 20- CH_3 (Δ 0.30), 18- CH_3 (Δ 0.29), hydroxymethyl (Δ 0.30) and vinyl methine (Δ 0.47), while alcohol III with no tertiary hydroxyl group exhibited considerable solvent shifts on the 18- CH_3 (Δ 0.23) and 19- CH_2OH (Δ 0.22) merely. This fact reveals that the diol(I) carries the tertiary hydroxyl group on C(8) of the *ent*-pimar-15-en-19-ol skeleton in α -configuration, that is, the tricyclic nucleus of this compound is in *trans-anti-trans* configuration, and the hydroxyl group carries a doubly 1,3-diaxial relationship to 20- CH_3 and 16- $\text{CH}=\text{CH}_2$.

Table 2. Pyridine-induced Solvent Shifts of the Proton Signals Characteristic of Two *ent*-Pimarane Diterpenoids, I and III.

	Diol I			Alcohol III		
	in CDCl ₃ ^{a)}	in C ₅ D ₅ N	Difference	in CDCl ₃	in C ₅ D ₅ N	Difference
20-CH ₃	0.97	1.27	0.30	0.70	0.78	0.08
18-CH ₃	0.91	1.20	0.29	0.99	1.22	0.23
17-CH ₃	0.91	0.98	0.07	0.99	1.03	0.04
19-CH ₂ OH	3.61	3.91	0.30	3.61	3.83	0.22
16-CH=CH ₂	6.01	6.48	0.47	5.73	5.82	0.09

a) The assignment referred to sandaraco-pimar-15-en-8 β ,19-diol.⁸⁾

Thus, the structure and absolute configuration of the diol can be represented by *ent*-pimar-15-en-8 β ,19-diol(I). The occurrence of (-)-thermarol(I) is very interesting as a positive proof for the biogenetic assumption that such tetracyclic diterpenoids as *ent*-stachane-, *ent*-trachylabane- and *ent*-kaurane-type ones are synthesized *via* the *ent*-pimarane-type carbonium ion.⁹⁾

References

- 1) S Hayashi and A. Matsuo, *Kagakunoryoiki* (Japanese), 29, 46 (1975).
- 2) S. Shibata, S. Mihashi and O. Tanaka, *Tetrahedron Lett.*, 5241 (1967).
- 3) E. Wenkert and B.L. Buckwalter, *J. Amer. Chem. Soc.*, 94, 4367 (1972).
- 4) J. Polonsky, Z. Baskevitch, N.C.- Bellavita, P. Ceccherelli, B.L. Buckwalter and E. Wenkert, *J. Amer. Chem. Soc.*, 94, 4369 (1972).
- 5) R.C. Cambie, I.R. Burfitt, T.E. Goodwin and E. Wenkert, *J. Org. Chem.*, 40, 3789 (1975).
- 6) S.H. Grover and J.B. Stothers, *Can. J. Chem.*, 52, 870 (1974).
- 7) P.V. Demarco, E. Farkas, D. Doddrell, B.L. Mylari and E. Wenkert, *J. Amer. Chem. Soc.*, 90, 5480 (1968).
- 8) F. Bohlmann, G. Weickgenannt and C. Zdero, *Chem. Ber.*, 106, 826 (1973).
- 9) I. Shechter and C.A. West, *J. Biol. Chem.*, 244, 3200 (1969).