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The Crystal Structure of Hop-17(21)-en-3 β -yl acetate of *Pluchea pteropoda* Hemsl. from Vietnam

C₃₂H₅₂O₂ (293K): monoclinic space group C2, a= 13.227(7), b= 6.600(1), c= 32.514(2) Å, β =96.18(5)°, V= 2821.9(16) Å³, D_x= 1.103 g.cm⁻³, Z= 4, F(000)= 1040, λ (CuK α)=1.5418 Å, μ = 0.499 mm⁻¹. The title compound isolated from the roots of a Vietnamese plant and being known for its activity against fever was identified by this X-ray analysis to be a pentacyclic triterpene of hopanoide type with a C17=C21 endocyclic double bond in the five membered ring. The presence of several axially substituted methyl groups on both the α and β side causes the so called "mid-molecule strain" having already been reported in the literature for other hopane type ring systems.

Keywords: crystal structure, vietnamese plant

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Introduction

In traditional East Asiatic medicine pharmaceutically active compounds from domestic plants play an important role. In several cases the chemical identity of the extracted compounds was not known, being now a challenging task for modern analytical methods. The title compound was isolated from the roots of the Vietnamese plant *Pluchea pteropoda* Hemsl. This species growing in wild in coastal regions belongs to family Asteraceae, which has about 80 species, 35 of them occurring in tropical regions. In Asia, about 10 species have been identified, including 3 (or 4) in Vietnam, such as *Pluchea indica* (L.) Less, *Pluchea pteropoda* Hemsl. and *Pluchea eupatoroides* (WILLIS, 1975; Ho, 1993). They have been used in Vietnamese folk medicine since long time (Loi, 1995) for their activity against fever. Until now, only the chemical composition of the *Pluchea indica* (L.) Less has been studied. The following class was found: lignan (9 compounds), sesquiterpenes (7 constituents), phenylpropanoid (4 components), benzenoid (3 compounds), monoterpenes (3 constituents), triterpenes (2 compounds), 5-compounds (2 constituents), steroid (1 compound) and alken (1 constituent). Recently the volatile composition of the essential oil of *Pluchea indica* (L.) Less. has been reported. More than twenty components were found (NAM, NINH, LEOD, DUNG, 1999; DUNG, VAN HAC, CHUNG, LECLERCQ, 1999).

Since the chemical identity of the title compound was originally not known, its structure was elucidated, by X-ray analysis.

Experimental

Roots of *Pluchea pteropoda* Hemsl were collected in wild from Cho Con area, Hai Hau District, Nam Ha Province, Vietnam. A voucher specimen has been deposited in the

herbarium of the Institute of Ecology and Biological Resources, N CST, Hanoi, Vietnam, and this institute has confirmed the identity of this plant. Raw material was dried at 110°C for 10 min and then at 60°C until dryness and pulverized. Root-powder of *P. pteropoda* Hemsl. was extracted with n-hexane by percolation. The n-hexane extract was evaporated to dryness under reduced pressure. The mixture was chromatographed on a silica-gel column, elution was started with a mixture of n-hexane: ethyl acetate with increasing polarity (from 0% to 100% ethyl acetate). From 1.40 g dried extracted powder, 0.20 g pure compound [needle crystals; melting point 258-260°C; IR (gem-1)(KBr) 2850-2945 (CH₃) 1739 (CO), 1380, 1252 (acetate) EIMS: M⁺=468] were collected after re-column chromatography.

A crystal with dimensions 1.0 x 0.08 x 0.04 mm was used for all X-ray investigations, which were carried out on a STOE four circle diffractometer using Ni-filtered CuK α radiation. Only very thin needle shaped crystals were available diffracting poorly in the high order region, so that only moderately resolved intensity data could be obtained. Crystal data and details of the intensity data collection are summarized in Table 1. The unit cell constants were determined by least-squares refinement of 143 reflections in a range 30° < 2 θ < 70°. The repeated measurement of three standard reflections (frequency: 90 minutes) revealed no significant decay (maximum intensity variation 3 %) during the data collection. The intensity data were corrected for Lorentz and polarization factors, but not for absorption. The atomic scattering factors were taken from International Tables for X-ray crystallography, Vol. C.

Formula	C ₃₂ H ₃₂ O ₂
M _r	468.74
a (Å)	13.227(7)
b (Å)	6.600(1)
c (Å)	32.514(2)
α (°)	96.18(5)
V (Å ³)	2821.9(16)
Z	4
Space group	C2
D _x (Mg.m ⁻³)	1.103
F(000)	1040
Radiation [λ (Å)]	CuK α (1.5418)
μ (mm ⁻¹)	0.499
Crystal size (mm)	1.0 x 0.08 x 0.04
Diffractometer	STOE 4-circle
No. of reflections measured	2843
No. of independent reflections	2716
h _{min} h _{max}	0,15
k _{min} k _{max}	-7,0
l _{min} l _{max}	-38,38
θ _{max} (°)	66.8
R _{int}	0.04
Refinement	F ²
No. of parameters refined	317
No. of reflections	1225 [F _o > 2 σ (F _o)]
wR(F ²) (overall)	0.2156
wR(F ²) (obs)	0.2037

R (overall)	0.1576
R (obs)	0.0697
Mean shift/esd	0.06
Electron density ($e \text{ \AA}^{-3}$) maximum	0.31
Electron density ($e \text{ \AA}^{-3}$) minimum	-0.27

Table 1: Crystal data, details of data collections and structure determination

*Additional material to this paper can be ordered referring to the CCDC no. 135169, the names of the authors and the journal citation from the Cambridge Crystallographic Data Centre, 12 Union Road, Cambridge CB2 1EZ, UK.

The phase problem was solved by routine application of direct methods (program SHELXS, SHELDRIK, 1986), least-squares refinements with anisotropic displacement parameters for C and O and isotropic displacement parameters for H calculated from stereochemical considerations and refined in the "riding model" option, were executed using SHELXL97 (SHELDRIK, 1997). Details of the refinement are included in Table 1, final atomic parameters are in Table 2, geometric parameters are in Table 3.

	x	y	z	U_{eq}
C1	7244(5)	-3045(11)	3389(2)	45(2)
C2	7385(5)	-3448(12)	3852(2)	55(2)
C3	8371(5)	-4582(11)	3971(2)	44(2)
O3	8511(4)	-4923(8)	4416(2)	58(1)
C31	8097(7)	-6581(14)	4580(2)	60(2)
O31	7593(5)	-7760(9)	4363(2)	88(2)
C32	8345(7)	-6716(15)	5025(2)	84(3)
C4	9325(5)	-3539(11)	3851(2)	46(2)
C41	9625(6)	-1676(13)	4134(2)	65(2)
C42	10202(6)	-5105(13)	3915(2)	64(2)
C5	9136(4)	-3019(10)	3384(2)	38(2)
C6	10042(5)	-2056(12)	3199(2)	53(2)
C7	9926(5)	-2179(11)	2731(2)	49(2)
C8	8939(5)	-1187(9)	2522(2)	41(2)
C81	9103(6)	1160(10)	2568(2)	55(2)
C9	8016(5)	-1874(10)	2749(2)	41(2)
C10	8135(5)	-1843(9)	3232(2)	40(2)
C101	8104(6)	315(10)	3404(2)	57(2)
C11	7023(5)	-953(13)	2546(2)	52(2)
C12	6824(5)	-1368(12)	2085(2)	50(2)
C13	7728(5)	-745(10)	1853(2)	45(2)
C14	8744(5)	-1751(9)	2041(2)	39(2)
C141	8682(6)	-4113(10)	1991(2)	56(2)
C15	9603(5)	-1050(12)	1797(2)	49(2)
C16	9417(5)	-1311(12)	1330(2)	52(2)
C17	8444(5)	-354(11)	1170(2)	46(2)
C18	7504(5)	-813(11)	1378(2)	44(2)

C181	7023(7)	-2824(12)	1204(3)	71(3)
C19	6776(6)	938(12)	1216(2)	58(2)
C20	7120(6)	1497(13)	794(2)	63(2)
C21	8232(5)	903(12)	837(2)	49(2)
C211	8935(6)	1567(12)	540(2)	58(2)
C212	8581(7)	940(20)	100(3)	104(4)
C213	9111(8)	3901(14)	555(3)	94(3)

$$U_{\text{eq}} = \left(\frac{1}{3} \right) \sum_i \sum_j U_{ij} a_i^* a_j^* a_i a_j$$

Table 2: Fractional atomic coordinates and equivalent isotropic displacement parameters (\AA^2)

C1-C2	1.522(10)	C2-C1-C10	113.5(6)
C1-C10	1.551(8)	C3-C2-C1	110.5(6)
C2-C3	1.518(9)	O3-C3-C2	110.1(5)
C3-O3	1.456(8)	O3-C3-C4	107.8(6)
C3-C4	1.525(9)	C2-C3-C4	115.0(6)
O(3-C31	1.357(10)	C31-O3-C3	120.0(6)
C31-O31	1.202(10)	O31-C31-O3	121.0(7)
C31-C32	1.454(10)	O31-C31-C32	126.5(8)
C4-C5	1.551(9)	O3-C31-C32	112.5(8)
C4-C42	1.551(10)	C3-C4-C5	107.5(5)
C4-C41	1.561(10)	C3-C4-C42	107.0(6)
C5-C6	1.535(9)	C5-C4-C42	108.6(6)
C5-C10	1.568(8)	C3-C4-C41	111.7(6)
C6-C7	1.517(9)	C5-C4-C41	114.0(6)
C7-C8	1.550(9)	C42-C4-C4	107.8(6)
C8-C9	1.561(9)	C6-C5-C4	115.1(6)
C8-C81	1.570(9)	C6-C5-C10	109.9(6)
C8-C14	1.599(9)	C4-C5-C10	117.4(5)
C9-C11	1.531(8)	C7-C6-C5	111.8(6)
C9-C10	1.560(9)	C6-C7-C8	114.0(6)
C10-C101	1.533(9)	C7-C8-C9	109.5(5)
C11-C12	1.520(9)	C7-C8-C81	105.9(6)
C12-C13	1.536(9)	C9-C8-C81	110.4(6)
C13-C18	1.541(9)	C7-C8-C14	111.7(5)
C13-C14	1.564(9)	C9-C8-C14	110.1(5)
C14-C15	1.526(8)	C81-C8-C14	109.3(5)
C14-C141	1.568(9)	C11-C9-C10	114.7(5)
C15-C16	1.523(9)	C11-C9-C8	111.0(5)
C16-C17	1.477(9)	C10-C9-C8	118.3(6)
C17-C21	1.367(9)	C101-C10-C1	107.7(5)
C17-C18	1.510(9)	C101-C10-C9	112.1(6)
C18-C181	1.552(10)	C1-C10-C9	109.0(5)
C18-C19	1.558(10)	C101-C10-C5	113.6(6)
C19-C20	1.538(9)	C1-C10-C5	106.8(5)
C20-C21	1.514(9)	C9-C10-C5	107.5(5)

C21-C211	1.477(10)	C12-C11-C9	113.8(6)
C211-C212	1.516(11)	C11-C12-C13	112.0(6)
C211-C213	1.557(12)	C12-C13-C18	114.1(6)
		C12-C13-C14	112.1(6)
		C18-C13-C14	116.4(6)
		C15-C14-C13	108.9(5)
		C15-C14-C141	106.3(6)
		C13-C14-C141	110.4(6)
		C15-C14-C8	112.7(5)
		C13-C14-C8	109.0(5)
		C141-C14-C8	109.5(5)
		C16-C15-C14	115.8(6)
		C17-C16-C15	110.1(6)
		C21-C17-C16	129.4(7)
		C21-C17-C18	111.6(6)
		C16-C17-C18	119.0(6)
		C17-C18-C13	111.4(6)
		C17-C18-C181	109.5(6)
		C13-C18-C181	114.6(6)
		C17-C18-C19	102.1(6)
		C13-C18-C19	111.2(6)
		C181-C18-C19	107.3(6)
		C20-C19-C18	104.3(6)
		C21-C20-C19	103.5(6)
		C17-C21-C211	127.4(7)
		C17-C21-C20	110.2(6)
		C211-C21-C20	122.4(7)
		C21-C211-C212	112.6(7)
		C21-C211-C213	112.1(7)
		C212-C211-C213	109.2(8)

Table 3: Bond lengths (Å) and angles (°)

Ring	Size	Q, q _z [Å]	Φ, φ _z [°]	θ [°]	Type ¹
A	6	0.55(2)	25.(13)	3.(2)	C
B	6	0.56(2)	12.(18)	11.(2)	C
C	6	0.58(2)	214.(8)	175(2)	C
D	6	0.48(2)	296.(35)	172.(2)	C
E	5	0.29(2)	69.(4)	--	E ²

¹ Type: C= chair, E= envelope² C19 out of plane atom (19 envelope)

Table 4: Cremer Pople puckering parameters of the Rings A to E.

Results and Discussion

The molecular structure of the title compound is shown in Fig. 1 along with the atomic numbering scheme.

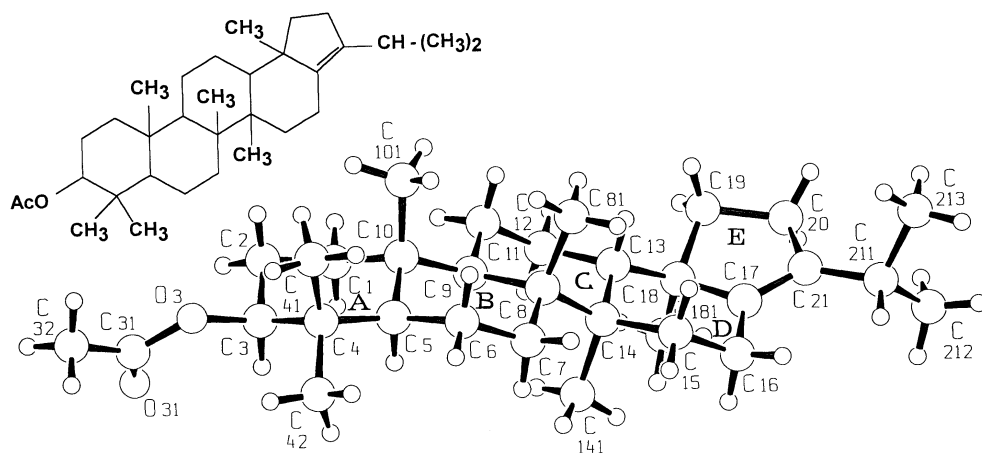


Fig. 1: Molecular structure and atom numbering scheme of the title compound, SCHAKAL drawing (KELLER, 1988)

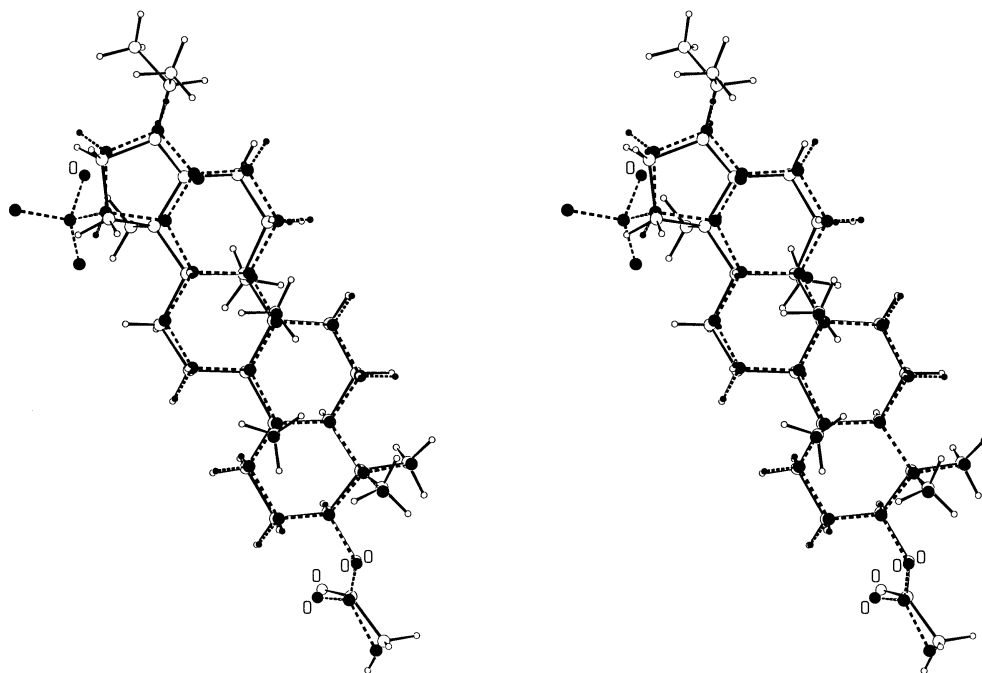


Fig. 2: Graphical superposition of the title molecule (solid lines) and 3 β -acetoxy-20-hydroxylupane (filled dashed lines), stereo drawing generated with SCHAKAL

The molecule was identified as a pentacyclic triterpene (rings A-E) of a hopanoide type, however, an endocyclic double bond in the five-membered ring at C17=C21 was confirmed by the short bond length of 1.367(9) Å. The molecule consists of the four trans-fused six-membered rings A,B,C,D and the five-membered ring E cis-fused at C17-C18. All six-membered rings are in the normal chair form (see Cremer-Pople ring puckering parameters

in Table 4), (CREMER & POPLE, 1975; LUGER & BÜLOW, 1983). Ring E is in a 19- β -envelope form. A geminal dimethyl groups is at C4, further methyl groups are in β -positions at C8 and C10 and in α -positions at C14 and C18. The acetoxy group is 3 β . This substitution pattern causes close 1,3-diaxial contacts for the 4 β , 10 β and 8 β methyl groups on one side and the 14 α and 18 α methyl groups on the other side of the molecule. This steric situation causes a "mid-molecule strain" observed already by Smith for other hopane ring systems (SMITH, 1979) being obviously the reason for the unusual long bond C8-C14 (1.599(9) Å) and for some bond angles significantly larger than the usual tetrahedral angle, see Table 3, for example C4-C5-C10= 117.4(5) or C10-C9-C8= 118.3(6)°.

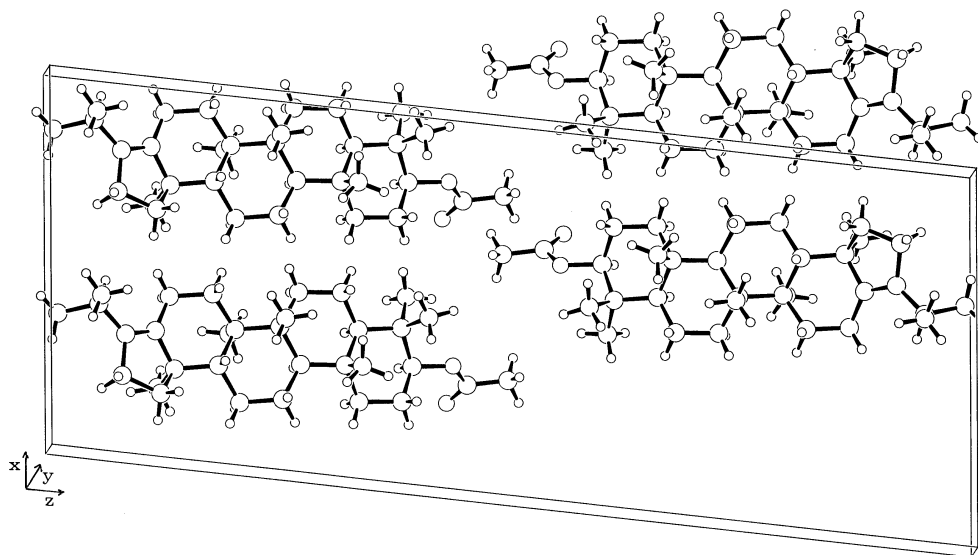


Fig. 3: Illustration of the crystal packing.

It is interesting to note that the overall molecular geometry is almost identical to that of 3 β -acetoxy-20-hydroxylupane (WATSON et al., 1972), even for the orientation of the 3 β acetoxy group, although the lupane derivative lacks the C17=C21 double bond (see superposition of both molecules in Fig. 2).

In the crystal lattice (Fig. 3) the molecules are arranged with their long molecular axes almost parallel to the crystallographic c-axis in a head-to-head packing with the acetoxy head groups of adjacent layers approaching at $z = 1/2$. The shortest intermolecular contact is C101-H10C...O31' with H...O= 2.65 Å and C...C= 3.498 Å where O31' belongs to a molecule neighbored by a pure translation in y-direction. Further intermolecular contacts of interest are not seen.

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