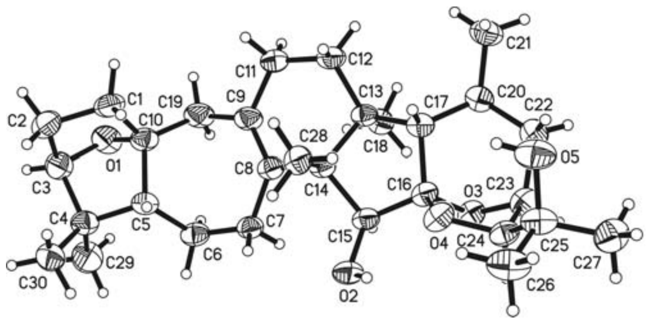
Z. Kristallogr. NCS **226** (2011) 169-170 / **DOI** 10.1524/ncrs.2011.0077

Crystal structure of 3,15*a*:8*a*,11-diepoxybenzo[4′,5′]cyclohept[1′,2′:4,5]-indeno[2,1*b*]oxepin-2-methanol-2,3,4,5,5*a*,5*b*,6,7,8,9,10,11,12,12*a*,13, 14,14*b*,15-octadecahydro-15-hydroxy-α,α,5,5*b*,12,12,14b-heptamethyl, $C_{30}H_{46}O_5$, *24-epi-acerinol*

Yan-Ru Liu[I], Chun-Tong Li[I], Qin Zhan[I], Lian-Na Sun[II] and Zhi-Jun Wu[*,I]

[I] Second Military Medical University, Department of Pharmacy, Changzheng Hospital, Shanghai 200003, P. R. China
[II] Second Military Medical University, College of Pharmacy, Shanghai 200433, P. R. China

Received November 17, 2010, in revised form January 19, 2011, accepted and available on-line April 9, 2011; CCDC no. 1267/3291



Abstract

$C_{30}H_{46}O_5$, monoclinic, $P2_1$ (no. 4), $a = 6.404(7)$ Å, $b = 14.76(2)$ Å, $c = 14.38(2)$ Å, $\beta = 93.72(1)°$, $V = 1356.8$ Å^3, $Z = 2$, $R_{gt}(F) = 0.056$, $wR_{\mathrm{ref}}(F^2) = 0.159$, $T = 293$ K.

Source of material

The dry rhizome (14 kg) of *Cimicifuga heracleifolia* were refluxed for 1 h with 70 % ethanol (140 L) three times. After removal of the ethanol under reduced pressure, the extract was suspended in water and then extracted with petroleum ether and ethyl acetate. The ethyl acetate soluble fraction (550 g) was subjected to silica gel column chromatography using gradient elution ($CHCl_3/CH_3OH$, 30:1 to 10:1, *v/v*). 24-epi-acerinol was obtained from the fraction eluted by $CHCl_3/CH_3OH$ (30:1, *v/v*). Single crystals suitable for X-ray diffraction analysis were obtained by slow evaporation from $CHCl_3/CH_3OH$ (1:1, *v/v*) after two weeks at room temperature.

Experimental details

All the H atoms were placed in calculated positions with d(O—H) = 0.82 Å, d(C—H) = 0.93 - 0.98 Å and $U_{\mathrm{iso}}(\mathrm{H}) = 1.5\,U_{\mathrm{eq}}(\mathrm{C,O})$ for methyl and hydroxyl groups and $1.2\,U_{\mathrm{eq}}(\mathrm{C})$ for the remaining H atoms. The Flack parameter is –1.7(14). For Mo K_α radiation the abnormal scattering is very small, so that the absolute structure could not be determined. The absolute configuration is known from [1] and confirmed by ^{1}H and ^{13}C 2D NMR.

Discussion

The rhizome of *Cimicifuga* species such as *Cimicifuga dahurica*, *Cimicifuga racemosa*, *Cimicifuga heracleifolia*, *Cimicifuga foetida*, *Cimicifuga simplex* have been widely used as antipyretic, analgetic, and anti-inflammatory drugs in oriental countries [2,3].

* Correspondence author (e-mail: wuzhijun999@sina.com)

Some cycloartanne-type triterpenoids have been isolated from *Cimicifuga heracleifolia* previously [1]. There extract was proved to have anti-inflammatory activity [4]. Our investigation of this plant for bioactive components resulted in the isolation of the title compound.

The crystal structure of the title compound is composed of discrete molecules. The molecule contains four five-membered rings, which exhibit envelope conformations, two six-membered rings, which adopt chair conformations, and a seven-membered ring, which exhibits chair-like conformation. The bond lengths and angles are within normal ranges. In the crystal structure, there are both intra- and intermolecular hydrogen bonds between the OH groups with $d(\mathrm{O2–H2\cdots O4}) = 2.628(5)$ Å, $\angle\mathrm{O2–H2\cdots O4} = 121.8°$ (intra-) and $d(\mathrm{O5–H5\cdots O3}) = 2.758(4)$ Å, $\angle\mathrm{O5–H5\cdots O3} = 165.7°$ (inter-). They interconnect the molecules to a chain parallel to [100].

Table 1. Data collection and handling.

Crystal:	colorless block, size 0.17 × 0.18 × 0.20 mm
Wavelength:	Mo K_α radiation (0.71073 Å)
μ:	0.79 cm^{-1}
Diffractometer, scan mode:	Bruker SMART CCD, φ/ω
$2\theta_{\max}$:	50.02°
$N(hkl)_{\mathrm{measured}}$, $N(hkl)_{\mathrm{unique}}$:	5657, 4442
Criterion for I_{obs}, $N(hkl)_{\mathrm{gt}}$:	$I_{\mathrm{obs}} > 2\,\sigma(I_{\mathrm{obs}})$, 3819
$N(param)_{\mathrm{refined}}$:	325
Programs:	SHELXS-97, SHELXL-97 [5]

Table 2. Atomic coordinates and displacement parameters (in Å^2).

Atom	Site	*x*	*y*	*z*	U_{iso}
H(2)	2*a*	0.7114	0.7660	0.5536	0.120
H(5)	2*a*	1.2628	0.5391	0.6455	0.126
H(1A)	2*a*	0.8681	1.1087	0.8475	0.095
H(1B)	2*a*	0.8018	1.1208	0.9507	0.095
H(2A)	2*a*	0.7705	1.2707	0.9273	0.107
H(2B)	2*a*	0.8327	1.2583	0.8232	0.107
H(3)	2*a*	0.4487	1.3018	0.8466	0.088
H(5A)	2*a*	0.6466	1.0930	0.7225	0.065
H(6A)	2*a*	0.2379	1.0357	0.7495	0.079
H(6B)	2*a*	0.2977	1.0613	0.6488	0.079
H(7A)	2*a*	0.5294	0.9478	0.6447	0.073
H(7B)	2*a*	0.3242	0.9059	0.6785	0.073
H(11A)	2*a*	0.6085	0.8636	0.9894	0.089
H(11B)	2*a*	0.8161	0.9117	0.9665	0.089
H(12A)	2*a*	0.7882	0.7413	0.9667	0.078
H(12B)	2*a*	0.9417	0.7908	0.9026	0.078

Table 2. Continued.

Atom	Site	x	y	z	U_{iso}
H(15)	2*a*	0.4358	0.7536	0.6722	0.067
H(17)	2*a*	0.9249	0.6692	0.7844	0.063
H(18A)	2*a*	0.4549	0.6891	0.9117	0.092
H(18B)	2*a*	0.3832	0.6853	0.8055	0.092
H(18C)	2*a*	0.3752	0.7772	0.8597	0.092
H(19A)	2*a*	0.3314	1.0054	0.8895	0.092
H(19B)	2*a*	0.5124	1.0155	0.9673	0.092
H(20)	2*a*	0.5904	0.5638	0.8408	0.071
H(21A)	2*a*	0.8519	0.5873	0.9567	0.128
H(21B)	2*a*	1.0194	0.5467	0.8936	0.128
H(21C)	2*a*	0.8445	0.4842	0.9303	0.128
H(22A)	2*a*	0.9049	0.4787	0.7450	0.079
H(22B)	2*a*	0.6879	0.4381	0.7676	0.079
H(23)	2*a*	0.5862	0.4702	0.6229	0.071
H(24)	2*a*	0.7396	0.5631	0.5236	0.068

Table 2. Continued.

Atom	Site	x	y	z	U_{iso}
H(26A)	2*a*	1.2650	0.5365	0.4832	0.130
H(26B)	2*a*	1.1646	0.6267	0.5165	0.130
H(26C)	2*a*	1.0479	0.5685	0.4383	0.130
H(27A)	2*a*	0.9357	0.3828	0.5910	0.127
H(27B)	2*a*	1.1108	0.3897	0.5200	0.127
H(27C)	2*a*	0.8790	0.4149	0.4885	0.127
H(28A)	2*a*	0.9700	0.8733	0.7828	0.094
H(28B)	2*a*	0.8952	0.8873	0.6779	0.094
H(28C)	2*a*	0.9816	0.7929	0.7121	0.094
H(29A)	2*a*	0.2076	1.2916	0.7111	0.151
H(29B)	2*a*	0.1468	1.1970	0.7508	0.151
H(29C)	2*a*	0.1989	1.2062	0.6462	0.151
H(30A)	2*a*	0.7441	1.2401	0.6811	0.132
H(30B)	2*a*	0.5738	1.3151	0.6610	0.132
H(30C)	2*a*	0.5637	1.2247	0.6037	0.132

Table 3. Atomic coordinates and displacement parameters (in Å^2).

Atom	Site	x	y	z	U_{11}	U_{22}	U_{33}	U_{12}	U_{13}	U_{23}
O(1)	2*a*	0.4181(4)	1.1711(2)	0.8881(2)	0.097(2)	0.084(2)	0.063(1)	0.021(2)	0.028(1)	−0.002(1)
O(2)	2*a*	0.6183(5)	0.7946(2)	0.5769(1)	0.116(2)	0.084(2)	0.040(1)	−0.009(2)	0.003(1)	0.005(1)
O(3)	2*a*	0.5363(3)	0.5981(2)	0.6613(1)	0.0374(9)	0.069(1)	0.065(1)	−0.012(1)	0.0057(8)	−0.0039(9)
O(4)	2*a*	0.8455(3)	0.6501(2)	0.6187(1)	0.057(1)	0.077(2)	0.056(1)	−0.022(1)	0.0180(9)	−0.0105(9)
O(5)	2*a*	1.1558(3)	0.5100(2)	0.6520(2)	0.047(1)	0.130(2)	0.074(1)	−0.018(1)	−0.008(1)	0.021(2)
C(1)	2*a*	0.7638(7)	1.1343(3)	0.8858(2)	0.089(3)	0.087(3)	0.059(2)	0.009(2)	−0.020(2)	−0.011(2)
C(2)	2*a*	0.7420(8)	1.2369(3)	0.8700(3)	0.101(3)	0.082(3)	0.080(2)	0.001(2)	−0.020(2)	−0.014(2)
C(3)	2*a*	0.5105(6)	1.2423(3)	0.8358(2)	0.084(2)	0.072(2)	0.066(2)	0.012(2)	0.010(2)	−0.006(2)
C(4)	2*a*	0.4644(6)	1.2083(2)	0.7359(2)	0.065(2)	0.073(2)	0.058(2)	0.011(2)	−0.000(1)	−0.001(1)
C(5)	2*a*	0.5131(4)	1.1057(2)	0.7496(2)	0.048(1)	0.069(2)	0.047(2)	0.006(1)	0.004(1)	0.002(1)
C(6)	2*a*	0.3530(5)	1.0391(3)	0.7089(2)	0.051(2)	0.088(2)	0.058(2)	−0.003(2)	−0.003(1)	0.000(2)
C(7)	2*a*	0.4408(5)	0.9453(2)	0.6969(2)	0.059(2)	0.070(2)	0.053(2)	−0.004(2)	−0.007(1)	0.001(1)
C(8)	2*a*	0.5649(5)	0.8996(2)	0.7764(2)	0.054(2)	0.071(2)	0.045(2)	−0.018(2)	0.005(1)	0.005(1)
C(9)	2*a*	0.5858(6)	0.9274(2)	0.8646(2)	0.073(2)	0.080(2)	0.043(2)	−0.007(2)	0.011(1)	0.007(1)
C(10)	2*a*	0.5482(5)	1.0987(3)	0.8571(2)	0.071(2)	0.075(2)	0.045(2)	0.011(2)	0.009(1)	−0.005(1)
C(11)	2*a*	0.7028(7)	0.8741(3)	0.9404(2)	0.102(3)	0.076(2)	0.045(2)	−0.004(2)	−0.005(2)	−0.000(1)
C(12)	2*a*	0.7956(6)	0.7829(2)	0.9148(2)	0.070(2)	0.079(2)	0.046(2)	−0.008(2)	−0.005(1)	0.005(1)
C(13)	2*a*	0.6773(4)	0.7431(2)	0.8288(2)	0.047(1)	0.067(2)	0.042(1)	−0.010(1)	0.004(1)	0.006(1)
C(14)	2*a*	0.6793(4)	0.8157(2)	0.7501(2)	0.049(2)	0.065(2)	0.042(1)	−0.012(1)	0.004(1)	0.004(1)
C(15)	2*a*	0.5868(5)	0.7595(2)	0.6663(2)	0.055(2)	0.070(2)	0.041(1)	−0.012(2)	0.003(1)	0.001(1)
C(16)	2*a*	0.6863(4)	0.6658(2)	0.6818(2)	0.043(1)	0.064(2)	0.049(1)	−0.019(1)	0.007(1)	−0.001(1)
C(17)	2*a*	0.7732(4)	0.6598(2)	0.7834(2)	0.039(1)	0.068(2)	0.051(1)	−0.012(1)	0.006(1)	0.007(1)
C(18)	2*a*	0.4512(5)	0.7216(2)	0.8538(2)	0.055(2)	0.071(2)	0.060(2)	−0.005(2)	0.018(1)	0.008(1)
C(19)	2*a*	0.4817(7)	1.0117(3)	0.9005(2)	0.093(3)	0.092(3)	0.045(2)	0.008(2)	0.017(2)	0.002(2)
C(20)	2*a*	0.7352(5)	0.5656(2)	0.8227(2)	0.051(2)	0.071(2)	0.057(2)	−0.004(2)	0.012(1)	0.009(1)
C(21)	2*a*	0.8756(7)	0.5440(3)	0.9087(3)	0.096(3)	0.094(3)	0.064(2)	0.010(2)	−0.008(2)	0.013(2)
C(22)	2*a*	0.7576(6)	0.4927(2)	0.7485(2)	0.060(2)	0.067(2)	0.071(2)	−0.009(2)	0.013(2)	0.007(2)
C(23)	2*a*	0.6671(4)	0.5202(2)	0.6520(2)	0.042(1)	0.067(2)	0.067(2)	−0.011(2)	0.004(1)	−0.009(1)
C(24)	2*a*	0.8170(4)	0.5589(2)	0.5846(2)	0.044(1)	0.074(2)	0.052(2)	−0.009(2)	−0.002(1)	−0.006(1)
C(25)	2*a*	1.0252(5)	0.5138(3)	0.5687(2)	0.046(2)	0.102(3)	0.053(2)	0.002(2)	0.005(1)	0.005(2)
C(26)	2*a*	1.1359(6)	0.5662(4)	0.4948(3)	0.058(2)	0.138(4)	0.064(2)	0.001(2)	0.015(2)	0.013(2)
C(27)	2*a*	0.9839(6)	0.4164(3)	0.5393(3)	0.069(2)	0.100(3)	0.084(2)	0.012(2)	0.006(2)	−0.013(2)
C(28)	2*a*	0.9027(5)	0.8451(2)	0.7287(2)	0.058(2)	0.069(2)	0.062(2)	−0.018(2)	0.010(1)	0.003(1)
C(29)	2*a*	0.2327(8)	1.2276(3)	0.7084(4)	0.087(3)	0.089(3)	0.121(3)	0.028(2)	−0.021(2)	0.002(3)
C(30)	2*a*	0.5990(8)	1.2510(3)	0.6637(3)	0.124(3)	0.078(2)	0.063(2)	−0.009(3)	0.010(2)	0.004(2)

Acknowledgment. This work was supported by the National Natural Science Foundation of China (grant no. 81073030).

References

1. Li, J. X.; Kadota, S.; Hattori, M.; Yoshimachi, S.; Shiro, M.; Oogami, N.; Mizuno, H.; Namba, T.: Constituents of *Cimicifugae Rhizoma*. I. Isolation and characterization of ten new cycloartenol triterpenes from *Cimicifuga heracleifolia* Komarov. Chem. Pharm. Bull. **41** (1993) 832-841.
2. New Medical College of Jiangsu: Shanghai Scientific and Technological Pulishing Co., Shanghai. Dictionary of Chinese Materia Medica **1** (1977) 451.
3. Lee, K. H.; Lee, W. J.; Yang, S. J.; Huh, J. W.; Choi, J.; Hong, H. N.; Hwang, O.; Cho, S. W.: Inhibitory effects of *Cimcifuga heracleifolia* extract on glutamate formation and glutamate dehydrogenase activity in cultured islets. Mol. Cells **17** (2004). 509-514.
4. Hirabayashi, T.; Ochiai, H.; Sakai, S.; Nakajima, K; Terasawa, K.: Inhibitory effect of ferulic acid and isoferulic acid on murine interleukin-8 pro duction in response to influenza virus infections *in vitro* and *vivo*. Planta Med. **61** (1995) 221-226.
5. Sheldrick, G. M.: A short history of SHELX. Acta Crystallogr. **A64** (2008) 112-122.