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The crystal structure of (5*R*,8*R*,9*R*,10*R*,12*R*,13*R*,14*R*)-12-hydroxy-4,4,8,10,14-pentamethyl-17-((*R*)-2,6,6-trimethyltetrahydro-2*H*-pyran-2-yl)tetradecahydro-3*H*-cyclopenta[*a*]phenanthrene-3,6(2*H*)-dione, C₃₀H₄₈O₄

Abstract

C₃₀H₄₈O₄, orthorhombic, *P*₂₁₂₁₂₁ (no. 19), *a* = 12.34133(14) Å, *b* = 16.50759(15) Å, *c* = 26.8804(2) Å, *V* = 5476.23(9) Å³, *Z* = 8, *R*_{gt}(*F*) = 0.0422, *wR*_{ref}(*F*²) = 0.0990, *T* = 293 K.

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The molecular structure of one of the two crystallographically independent molecules is shown in the figure. Table 1 contains crystallographic data and Table 2 contains the list of the atoms including atomic coordinates and displacement parameters.

Table 1: Data collection and handling.

Crystal:	Colourless block
Size:	0.29 × 0.22 × 0.21 mm
Wavelength:	CuKα radiation (1.54184 Å)
μ:	0.58 mm ^{−1}
Diffractometer, scan mode:	Xcalibur, ω
θ _{max} , completeness:	76.8°, 98%
<i>N</i> (<i>hkl</i>) _{measured} , <i>N</i> (<i>hkl</i>) _{unique} , <i>R</i> _{int} :	74600, 9829, 0.072
Criterion for <i>I</i> _{obs} , <i>N</i> (<i>hkl</i>) _{gt} :	<i>I</i> _{obs} > 2 σ(<i>I</i> _{obs}), 8694
<i>N</i> (<i>param</i>) _{refined} :	632
Programs:	CrysAlis ^{PRO} [1], Olex2 [2], SHELX [3, 4]

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Source of material

The title compound is synthesized by a two-step oxidation reaction. A solution of panaxatriol in dichloromethane and pyridinium chlorochromate was stirred for 1 h at room temperature. The solvent was removed under reduced pressure to give a white solid. The white solid was dissolved in ethyl acetate and washed with sodium bicarbonate, dried (magnesium sulfate) and concentrated under reduced pressure to give the crude product. The crude products were purified using silica-gel column chromatography and eluted with [petroleum ether-EtOAc (3:1)] to give the intermediate product, named 3-oxo-panaxatriol.

Table 2: Fractional atomic coordinates and isotropic or equivalent isotropic displacement parameters (Å²).

Atom	x	y	z	U_{iso}^*/U_{eq}
O1	0.3302 (2)	1.02650 (15)	0.43762 (12)	0.1049 (9)
O1'	0.1266 (3)	0.39182 (18)	0.30088 (14)	0.1228 (11)
O2	0.65269 (18)	0.88460 (14)	0.53499 (9)	0.0816 (6)
O2'	0.3898 (2)	0.54084 (14)	0.17499 (9)	0.0928 (8)
O3	0.43530 (17)	0.51269 (10)	0.40903 (6)	0.0563 (4)
H3	0.421917	0.467049	0.419386	0.084*
O3'	0.1825 (3)	0.91186 (12)	0.30352 (7)	0.0893 (8)
H3'	0.177526	0.956950	0.290925	0.134*
O4	0.39547 (14)	0.38013 (10)	0.46654 (6)	0.0519 (4)
O4'	0.19221 (14)	1.04627 (10)	0.24772 (6)	0.0503 (4)
C1	0.3999 (2)	0.82718 (14)	0.40615 (9)	0.0503 (5)
H1A	0.405282	0.793860	0.376527	0.060*
H1B	0.332225	0.813829	0.422530	0.060*
C1'	0.1830 (3)	0.59978 (17)	0.31881 (10)	0.0629 (7)
H1'A	0.109169	0.609243	0.307903	0.076*
H1'B	0.197354	0.636159	0.346376	0.076*
C2	0.3965 (3)	0.91632 (16)	0.39042 (11)	0.0620 (7)
H2A	0.459012	0.928033	0.369735	0.074*
H2B	0.331997	0.925749	0.370653	0.074*
C2'	0.1923 (3)	0.51210 (18)	0.33744 (12)	0.0708 (8)
H2'A	0.261286	0.505437	0.354269	0.085*
H2'B	0.135385	0.502059	0.361541	0.085*
C3	0.3962 (3)	0.97255 (16)	0.43410 (12)	0.0667 (7)
C3'	0.1841 (3)	0.45068 (18)	0.29660 (14)	0.0724 (8)
C4	0.4851 (2)	0.96030 (15)	0.47302 (10)	0.0589 (6)
C4'	0.2546 (3)	0.46310 (17)	0.25115 (12)	0.0686 (8)
C5	0.4913 (2)	0.86803 (14)	0.48504 (9)	0.0475 (5)
H5	0.422019	0.856844	0.501490	0.057*
C5'	0.2453 (2)	0.55376 (15)	0.23535 (10)	0.0536 (6)
H5'	0.169737	0.559684	0.224691	0.064*
C6	0.5748 (2)	0.84375 (16)	0.52364 (9)	0.0552 (6)
C6'	0.3109 (3)	0.57737 (16)	0.18976 (10)	0.0617 (7)
C7	0.5539 (2)	0.76300 (16)	0.54770 (9)	0.0573 (6)
H7A	0.486678	0.765603	0.566340	0.069*
H7B	0.611904	0.751059	0.570920	0.069*
C7'	0.2719 (3)	0.65401 (16)	0.16520 (9)	0.0611 (7)
H7'A	0.198075	0.646489	0.153690	0.073*
H7'B	0.316896	0.665704	0.136509	0.073*
C8	0.54632 (19)	0.69408 (15)	0.50880 (9)	0.0452 (5)
C8'	0.27605 (19)	0.72631 (14)	0.20178 (8)	0.0444 (5)
C9	0.47108 (17)	0.72025 (13)	0.46491 (8)	0.0397 (5)
H9	0.399036	0.725446	0.479906	0.048*
C9'	0.22158 (19)	0.70233 (14)	0.25186 (8)	0.0438 (5)
H9'	0.145328	0.693119	0.243413	0.053*
C10	0.49418 (19)	0.80549 (14)	0.44125 (8)	0.0433 (5)
C10'	0.26017 (19)	0.62068 (14)	0.27602 (8)	0.0457 (5)
C11	0.4595 (2)	0.65116 (13)	0.42710 (8)	0.0465 (5)
H11A	0.407026	0.667285	0.402125	0.056*
H11B	0.528509	0.643834	0.410435	0.056*
C11'	0.2200 (3)	0.77476 (15)	0.28747 (8)	0.0562 (7)
H11C	0.293947	0.787055	0.297103	0.067*
H11D	0.180978	0.759315	0.317325	0.067*
C12	0.4244 (2)	0.56996 (13)	0.44885 (8)	0.0434 (5)
H12	0.348053	0.573236	0.458694	0.052*
C12'	0.1682 (3)	0.85179 (15)	0.26627 (8)	0.0548 (6)

Table 2: (continued)

Atom	x	y	z	U_{iso}^*/U_{eq}
H12'	0.090471	0.842401	0.261385	0.066*
C13	0.49241 (18)	0.54739 (13)	0.49407 (8)	0.0407 (5)
H13	0.566942	0.539735	0.482394	0.049*
C13'	0.2197 (2)	0.87299 (14)	0.21640 (8)	0.0445 (5)
H13'	0.296999	0.882233	0.222498	0.053*
C14	0.49477 (19)	0.61650 (14)	0.53284 (8)	0.0444 (5)
C14'	0.21075 (19)	0.80011 (14)	0.18040 (8)	0.0429 (5)
C15	0.5596 (3)	0.57703 (17)	0.57547 (9)	0.0611 (7)
H15A	0.636903	0.582817	0.569940	0.073*
H15B	0.541269	0.601597	0.607154	0.073*
C15'	0.2533 (2)	0.83763 (16)	0.13214 (9)	0.0537 (6)
H15C	0.331500	0.843331	0.133066	0.064*
H15D	0.233423	0.804932	0.103579	0.064*
C16	0.5265 (3)	0.48747 (17)	0.57455 (10)	0.0632 (7)
H16A	0.481120	0.475034	0.603023	0.076*
H16B	0.590230	0.453192	0.575810	0.076*
C16'	0.1979 (3)	0.92034 (16)	0.13033 (9)	0.0588 (7)
H16C	0.129958	0.916782	0.112357	0.071*
H16D	0.244057	0.959544	0.113769	0.071*
C17	0.4628 (2)	0.47237 (14)	0.52536 (8)	0.0455 (5)
H17	0.385514	0.476363	0.533289	0.055*
C17'	0.1774 (2)	0.94612 (14)	0.18549 (8)	0.0462 (5)
H17'	0.098838	0.949261	0.190366	0.055*
C18	0.6634 (2)	0.67674 (18)	0.49078 (11)	0.0605 (7)
H18A	0.699675	0.643010	0.514619	0.091*
H18B	0.701971	0.726918	0.487326	0.091*
H18C	0.660940	0.649565	0.459222	0.091*
C18'	0.3972 (2)	0.74808 (18)	0.20803 (11)	0.0610 (7)
H18D	0.406967	0.777880	0.238367	0.092*
H18E	0.420295	0.780600	0.180393	0.092*
H18F	0.439389	0.699283	0.209214	0.092*
C19	0.6000 (2)	0.80868 (17)	0.41101 (10)	0.0571 (6)
H19A	0.660125	0.816492	0.433142	0.086*
H19B	0.596688	0.852819	0.387806	0.086*
H19C	0.609107	0.758719	0.393219	0.086*
C19'	0.3770 (2)	0.62394 (17)	0.29592 (10)	0.0570 (6)
H19D	0.426671	0.612160	0.269404	0.086*
H19E	0.385604	0.584643	0.321941	0.086*
H19F	0.391591	0.677064	0.308814	0.086*
C20	0.4820 (2)	0.38762 (15)	0.50315 (9)	0.0481 (5)
C20'	0.2250 (2)	1.03104 (15)	0.19665 (9)	0.0491 (5)
C21	0.5936 (2)	0.38068 (17)	0.47882 (11)	0.0621 (7)
H21A	0.608890	0.324821	0.471790	0.093*
H21B	0.647665	0.401740	0.500997	0.093*
H21C	0.594286	0.411121	0.448390	0.093*
C21'	0.3479 (2)	1.0319 (2)	0.19179 (13)	0.0713 (8)
H21D	0.372727	1.086821	0.188955	0.107*
H21E	0.368851	1.002104	0.162660	0.107*
H21F	0.379672	1.007304	0.220680	0.107*
C22	0.4677 (3)	0.32329 (16)	0.54363 (10)	0.0647 (7)
H22A	0.532119	0.322058	0.564263	0.078*
H22B	0.406991	0.338324	0.564640	0.078*
C22'	0.1713 (3)	1.09334 (16)	0.16253 (10)	0.0630 (7)
H22C	0.204837	1.090291	0.129941	0.076*
H22D	0.095444	1.079312	0.158688	0.076*
C23	0.4479 (3)	0.23944 (17)	0.52269 (12)	0.0721 (8)

Table 2: (continued)

Atom	x	y	z	U_{iso}^*/U_{eq}
H23A	0.510255	0.222102	0.503504	0.087*
H23B	0.437103	0.201198	0.549634	0.087*
C23'	0.1792 (3)	1.18039 (17)	0.18142 (12)	0.0754 (9)
H23C	0.254209	1.198013	0.180891	0.091*
H23D	0.137749	1.215996	0.159950	0.091*
C24	0.3484 (3)	0.24136 (18)	0.48978 (13)	0.0740 (9)
H24A	0.285709	0.254924	0.509862	0.089*
H24B	0.336771	0.187849	0.475869	0.089*
C24'	0.1355 (3)	1.18482 (17)	0.23410 (12)	0.0707 (8)
H24C	0.143247	1.239771	0.246389	0.085*
H24D	0.058907	1.171737	0.233799	0.085*
C25	0.3585 (2)	0.30250 (16)	0.44747 (11)	0.0610 (7)
C25'	0.1938 (2)	1.12733 (16)	0.26902 (11)	0.0605 (7)
C26	0.4335 (3)	0.2721 (2)	0.40691 (12)	0.0824 (10)
H26A	0.443313	0.313816	0.382424	0.124*
H26B	0.402292	0.225154	0.391474	0.124*
H26C	0.502338	0.258173	0.421143	0.124*
C26'	0.3084 (3)	1.1559 (2)	0.28090 (16)	0.0931 (11)
H26D	0.346364	1.114115	0.298562	0.140*
H26E	0.305038	1.203819	0.301117	0.140*
H26F	0.345962	1.167910	0.250501	0.140*
C27	0.2492 (3)	0.3218 (2)	0.42546 (17)	0.0920 (11)
H27A	0.205548	0.349041	0.449823	0.138*
H27B	0.214083	0.272430	0.415582	0.138*
H27C	0.258293	0.356128	0.396947	0.138*
C27'	0.1313 (3)	1.1170 (2)	0.31708 (12)	0.0820 (10)
H27D	0.062288	1.092597	0.310140	0.123*
H27E	0.120333	1.169013	0.332250	0.123*
H27F	0.171514	1.082859	0.339307	0.123*
C28	0.4540 (4)	1.00473 (19)	0.52117 (13)	0.0846 (10)
H28A	0.389637	0.980858	0.534849	0.127*
H28B	0.440851	1.060844	0.513979	0.127*
H28C	0.512097	1.000263	0.544755	0.127*
C28'	0.2131 (5)	0.4117 (2)	0.20771 (16)	0.1091 (15)
H28D	0.138301	0.424124	0.201606	0.164*
H28E	0.220143	0.355300	0.215850	0.164*
H28F	0.254889	0.423393	0.178459	0.164*
C29	0.5901 (3)	0.99849 (19)	0.45195 (13)	0.0779 (9)
H29A	0.647688	0.992186	0.475627	0.117*
H29B	0.578291	1.055072	0.445716	0.117*
H29C	0.609320	0.971894	0.421446	0.117*
C29'	0.3689 (3)	0.4333 (2)	0.26608 (16)	0.0877 (10)
H29D	0.418316	0.442473	0.239079	0.132*
H29E	0.366205	0.376465	0.273512	0.132*
H29F	0.393082	0.462501	0.294898	0.132*
C30	0.3799 (2)	0.63294 (16)	0.55356 (9)	0.0543 (6)
H30A	0.381934	0.679338	0.575065	0.081*
H30B	0.355542	0.586579	0.571984	0.081*
H30C	0.331065	0.643093	0.526482	0.081*
C30'	0.0905 (2)	0.77821 (16)	0.17043 (9)	0.0536 (6)
H30D	0.086392	0.740062	0.143535	0.080*
H30E	0.051121	0.826339	0.161748	0.080*
H30F	0.059482	0.754672	0.199821	0.080*

The title compound is synthesized by reacting 3-oxo-panaxatriol with DDQ in 1,4-dioxane under reflux for 30 min. The mixture was concentrated *in vacuo*. The residue was dissolved with ethyl acetate and washed with water and brine. The organic phase was dried over anhydrous sodium sulfate and concentrated under reduced pressure to give the white powder. The crude product was separated by silica-gel column chromatography [petroleum ether–EtOAc (4:1)] to give a white solid. Suitable crystals of the title compound were obtained by recrystallization in ethyl acetate solution.

Experimental details

All H atoms were included in calculated positions and refined as riding atoms, with C–H = 0.93–0.98 Å, with $U_{iso}(H) = 1.5U_{eq}(C)$ for methyl H atoms and $1.2U_{eq}(C)$ for all other H atoms. The absolute configuration was derived from the synthesis and the configuration of the educts.

Comment

Ginseng is a kind of traditional Chinese medicinal plant, which has been widely used for the treatment of heart failure and various tissue damages under cellular and environmental stress [5, 6]. Modern medical science has verified that ginseng is effective in improving blood circulation and brain function, enhancing immune function, preventing diabetes, as well as having anti-cancer and antibacterial properties [7–10]. In addition, ginsenoside isomers have stereoselective effect on P2Y12 receptor [11]. Ginsenosides are the major active constituents of ginseng responsible for the most of pharmacological actions of ginseng. Ginsenosides are often classified into several groups: protopanaxadiol (PPD) type, protopanaxatriol (PPT) type, oleanolic acid type, and ocotillol type [9] sharing a tetrahydrofuran ring and a dammarane skeleton [12]. Because of wide biological properties of these ginsenosides and their derivatives synthesis and biological activity of them and their derivatives have attracted much attention. The title compound is a derivative of PPT type.

Single-crystal structure analysis reveals that there are two molecules in the asymmetric unit of the title crystal structure. The structure of the title compound and panaxatriol are equivalent except for the substituents at C(3) and C(6). Two carbon-oxygen double bonds exist in the

compound which was synthesized by two-step oxidation reaction. Both the first ring and the second ring contain a carbon-oxygen double bond. The C–O bond distance (C3–O1) is 1.211(4) Å, The C–O bond distance (C6'–O2') is 1.212(4) Å. The C–O bond distance (C12–O3) is 1.435(3) Å. The distance of C–O bond (C25'–O4') in tetrahydropyran ring is 1.455(3) Å and the distance of C–O bond (C20'–O4') is 1.453(3) Å. The C25–O4–C20, O2–C6–C7, O3–C12–C13 and O1–C3–C4 torsion angles are 122.91(19), 121.4(3), 112.48(18) and 121.8(3)°, respectively. The structure of the molecule is similar to the stereo configuration of the compound reported in the references [13–15]. The bond lengths and angles are all in the expected ranges.

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