Acta Crystallographica Section C
Crystal Structure
Communications
ISSN 0108-2701

2,2′-Methylenebis(3-hydroxy-5,5-dimethylcyclohex-2-en-1-one)

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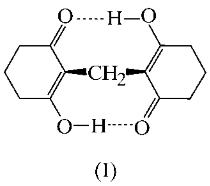
Received 13 October 2003
Accepted 17 October 2003
Online 8 November 2003

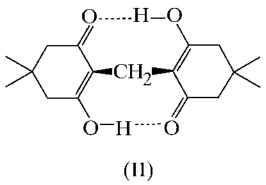
The title compound, $C_{17}H_{24}O_4$, crystallizes with two independent molecules, both lying across twofold rotation axes in space group *Pccn*, in a unit cell whose dimensions closely mimic those of a tetragonal cell. Each molecule contains paired O—H···O hydrogen bonds [H···O = 1.81 and 1.83 Å, O···O = 2.640 (2) and 2.642 (2) Å, and O—H···O = 168 and 162°].

Comment

The structure of 2,2′-methylenebis(3-hydroxy-2-cyclohexen-1-one), (I), has recently been the subject of a brief report (SethuSankar *et al.*, 2000), although the molecular constitution is incorrectly depicted in that report. This compound crystallizes in space group *Pbca*, with $Z' = 1$, and the molecular structure is characterized by two rather short intramolecular hydrogen bonds.



(I)



(II)

We report here the structure of a tetramethyl analogue of (I), namely 2,2′-methylenebis(3-hydroxy-5,5-dimethylcyclohex-2-en-1-one), (II), originally obtained in low yield as an unexpected by-product of a three-component reaction between 4-amino-2-methoxypyrimidin-6(1*H*)-one, formaldehyde and 5,5-dimethylcyclohexane-1,3-dione (dimedone), which had been intended to produce a tricyclic octahydropyrimido[3,4-*b*]quinoline system. Compound (II) was subsequently obtained in *ca* 70% yield by reaction of dimedone with aqueous formaldehyde in a reaction analogous to that used for the synthesis of compound (I) (SethuSankar *et al.*, 2000). Compound (II) crystallizes in the orthorhombic space group *Pccn*; there are two independent molecules in the cell, each lying across a twofold rotation axis, so that $Z' = 2 \times 0.5 = 1$. In the selected asymmetric unit, molecule 1, containing atom C1 (Fig. 1*a*), lies across the axis along $(\frac{3}{4}, \frac{1}{4}, z)$, while molecule 2, containing atom C2 (Fig. 1*b*), lies across the axis $(\frac{1}{4}, \frac{1}{4}, z)$. The metric unit cell very closely mimics a tetragonal cell, with the *a* and *b* repeat vectors differing by only *ca* 0.002 Å. However, the refined structure is clearly orthorhombic, although subject to twinning across the $(1\bar{1}0)$ plane; a search for possible additional symmetry revealed none, and the arrangement of the molecules in the unit cell (Fig. 2) clearly rules out the possibility of any kind of fourfold axis.

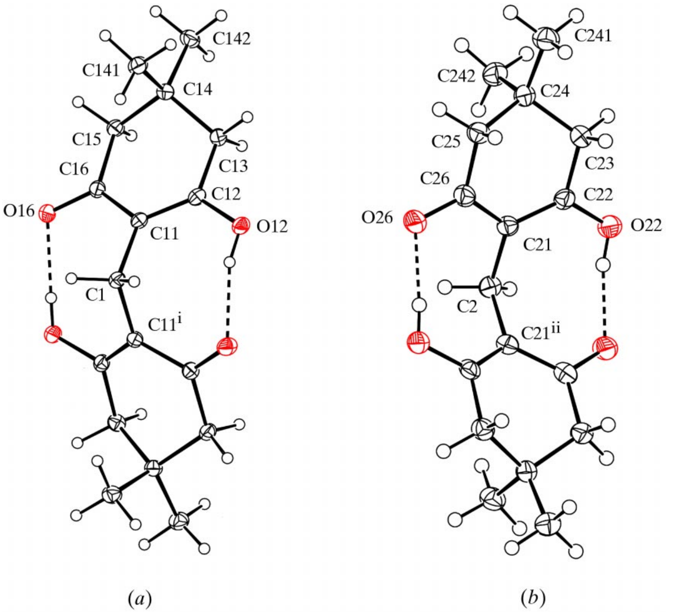


Figure 1
The two independent molecules of compound (II), showing the atom-labelling scheme for (*a*) molecule 1 and (*b*) molecule 2. Displacement ellipsoids are drawn at the 30% probability level. The symmetry codes are as in Table 1.

The two independent molecules are both chiral, with C_2 molecular symmetry, but the space group ensures that for each there are equal numbers of the two enantiomorphs present in the crystal. The two molecules in the selected asymmetric unit are in fact of opposite hand, as shown qualitatively by their overall configurations (Fig. 1) and quantitatively both by the key torsion angles (Table 1) and, better, by the ring-puckering parameters. For the independent rings C11–C16 and C21–C26, the overall puckering amplitudes Q (Cremer & Pople, 1975) are identical within experimental uncertainty, *viz.* 0.457 (3) and 0.459 (3) Å, respectively, but for the atom sequences Cn1 to Cn6 (n = 1 or 2), the θ values are 59.0 (3) and 119.8 (3)°, respectively, and the supplementary nature of these values defines different absolute configurations for the two molecules (Boeyens, 1978). The φ values, based on the same atom

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DOI: 10.1107/S0108270103023606

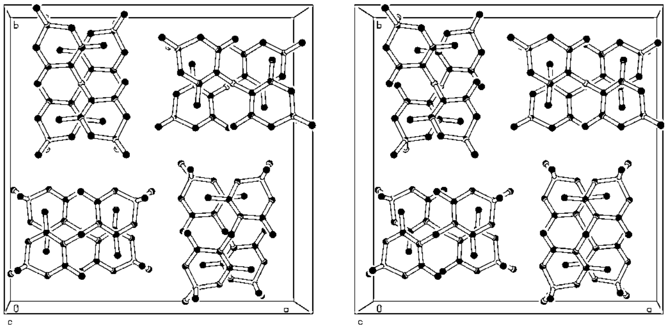

Figure 2
Stereoview of part of the crystal structure of (II), showing how the packing of the molecules precludes tetragonal symmetry. For the sake of clarity, the H atoms have been omitted.

sequences for the rings C11–C16 and C21–C26, are 178.5 (4) and 0.9 (6)°, respectively, and the ring-puckering parameters taken together indicate a sofa or envelope conformation as the best single qualitative descriptor, with the local pseudo-mirror planes in each ring passing through atoms C*n*1 and C*n*4.

Within the molecules, the C—C and C—O distances in the O*n*2—C*n*2—C*n*1—C*n*6—O*n*6 (*n* = 1 or 2) fragments are clearly indicative of alternating single and double bonds, and are consistent with the location of the associated H atoms from difference maps. The remaining bond distances and angles show no unusual values. In each molecule, there are two fairly short O—H···O hydrogen bonds (Table 2) which probably play a role in controlling the overall molecular conformation, in particular, in constraining the molecules to have overall twofold rotational symmetry.

There are, however, no direction-specific interactions between the molecules of (II). In particular, there are no C—H···O hydrogen bonds; the shortest intermolecular H···O contact distance is not significantly less than the the sum of the van der Waals radii. In compound (I), a number of intermolecular C—H···O contacts were reported as hydrogen bonds (SethuSankar *et al.*, 2000), but in every case the H···O distance exceeds 2.55 Å (the overall range reported was 2.56–2.71 Å), so that it is doubtful if these contacts are structurally significant.

Experimental

For the preparation of compound (II), a large excess (26.5 mmol) of formaldehyde (35% aqueous solution) was added to a solution of 2-methoxy-4-aminopyrimidin-6(1*H*)-one (2.12 mmol) and dimedone (1.92 mmol) in ethanol (30 ml). The mixture was then heated under reflux for 2 h and the resulting white solid was filtered off and washed firstly with cold ethyl acetate and then with ethanol. The product was purified by crystallization firstly from ethanol–water (9:1, *v*/*v*) and then from *N*,*N*-dimethylformamide, giving, in very low yield, crystals of the title compound, (II), suitable for single-crystal X-ray diffraction analysis (m.p. 463 K). Analysis found: C 69.5, H 8.5%; $C_{17}H_{24}O_4$ requires: C 69.8, H, 8.3%. The same product was obtained in *ca* 70% yield in the absence of the pyrimidinone as follows: to a solution of dimedone (2 mmol) in ethanol (10 ml) was added formaldehyde (35% aqueous solution, 1 mmol). The mixture was stirred at room temperature for 2 h and then left to evaporate at atmospheric pressure, producing (II).

Crystal data

$C_{17}H_{24}O_4$
$M_r = 292.36$
Orthorhombic, *Pccn*
$a = 18.8968$ (4) Å
$b = 18.8989$ (4) Å
$c = 8.7038$ (2) Å
$V = 3108.38$ (12) Å^3
$Z = 8$
$D_x = 1.249$ Mg m^{-3}

Mo *K*α radiation
Cell parameters from 3552 reflections
$\theta = 3.1$–27.5°
$\mu = 0.09$ mm^{-1}
$T = 120$ (2) K
Block, colourless
0.22 × 0.20 × 0.10 mm

Data collection

Nonius KappaCCD diffractometer
φ scans, and ω scans with κ offsets
Absorption correction: multi-scan (*DENZO–SMN*; Otwinowski & Minor, 1997)
$T_{\min} = 0.973$, $T_{\max} = 0.991$
22 526 measured reflections

3552 independent reflections
2991 reflections with $I > 2\sigma(I)$
$R_{\rm int} = 0.080$
$\theta_{\max} = 27.5°$
$h = -24 \rightarrow 20$
$k = -24 \rightarrow 24$
$l = -9 \rightarrow 11$

Refinement

Refinement on F^2
$R[F^2 > 2\sigma(F^2)] = 0.047$
$wR(F^2) = 0.116$
$S = 1.03$
3553 reflections
199 parameters
H-atom parameters constrained
$w = 1/[\sigma^2(F_o^2) + (0.0453P)^2 + 1.0196P]$
where $P = (F_o^2 + 2F_c^2)/3$

$(\Delta/\sigma)_{\max} < 0.001$
$\Delta\rho_{\max} = 0.20$ e Å^{-3}
$\Delta\rho_{\min} = -0.22$ e Å^{-3}
Extinction correction: *SHELXL*
Extinction coefficient: 0.0104 (13)

Table 1
Selected geometric parameters (Å, °).

O12—C12	1.335 (3)	O22—C22	1.324 (3)
C12—C11	1.360 (3)	C22—C21	1.375 (3)
C11—C16	1.441 (3)	C21—C26	1.428 (3)
C16—O16	1.251 (3)	C26—O26	1.263 (3)
C1—C11—C12—O12	4.8 (3)	C2—C21—C22—O22	−6.2 (3)
C1—C11—C16—O16	−7.9 (3)	C2—C21—C26—O26	7.4 (3)
C11^{i}—C1—C11—C12	−83.8 (2)	C21^{ii}—C2—C21—C22	87.2 (2)
C11^{i}—C1—C11—C16	94.2 (2)	C21^{ii}—C2—C21—C26	−91.4 (2)

Symmetry codes: (i) $\frac{3}{2} - x, \frac{1}{2} - y, z$; (ii) $\frac{1}{2} - x, \frac{1}{2} - y, z$.

Table 2
Hydrogen-bonding geometry (Å, °).

D—H···*A*	*D*—H	H···*A*	*D*···*A*	*D*—H···*A*
O12—H12···O16^{i}	0.84	1.83	2.642 (2)	162
O22—H22···O26^{ii}	0.84	1.81	2.640 (2)	168

Symmetry codes: (i) $\frac{3}{2} - x, \frac{1}{2} - y, z$; (ii) $\frac{1}{2} - x, \frac{1}{2} - y, z$.

Space group *Pccn* was uniquely assigned from the systematic absences. All H atoms were located in difference maps and then treated as riding atoms, with C—H = 0.98 (CH_3) or 0.99 Å (CH_2), and O—H = 0.84 Å. A TWIN refinement using the matrix (010/100/00$\overline{1}$) gave twin fractions 0.468 and 0.532. Examination of the refined structure using the ADDSYM option in *PLATON* (Spek, 2003) revealed no possible additional symmetry.

Data collection: *KappaCCD Server Software* (Nonius, 1997); cell refinement: *DENZO–SMN* (Otwinowski & Minor, 1997); data reduction: *DENZO–SMN*; program(s) used to solve structure: *SHELXS*97 (Sheldrick, 1997); program(s) used to refine structure: *SHELXL*97 (Sheldrick, 1997); molecular graphics: *PLATON* (Spek, 2003); software used to prepare material for publication: *SHELXL*97 and *PRPKAPPA* (Ferguson, 1999).

X-ray data were collected at the EPSRC X-ray Crystallographic Service, University of Southampton, England; the authors thank the staff for all their help and advice. JNL thanks NCR Self-Service, Dundee, for grants which have provided computing facilities for this work. JC thanks the Ministerio de Educación, Cultura y Deportes (Programa de Cooperación con Iberoamérica, AECI) of Spain. SC and JQ thank COLCIENCIAS and the Univesidad de Valle for financial support for this work.

Supplementary data for this paper are available from the IUCr electronic archives (Reference: NA1621). Services for accessing these data are described at the back of the journal.

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