

1-Ethyl-3-(4-hydroxy-3-methoxyphenyl)-6-methoxy-2-methylindan-5-ol

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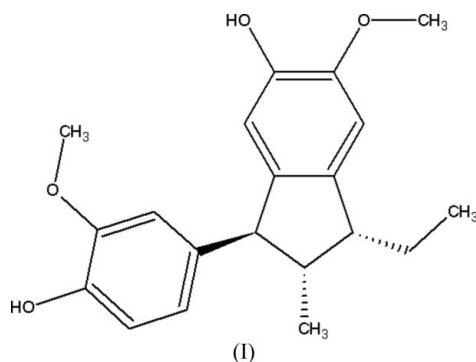
Key indicators

Single-crystal X-ray study
 $T = 298\text{ K}$
Mean $\sigma(\text{C}-\text{C}) = 0.003\text{ \AA}$
Disorder in main residue
 R factor = 0.057
 wR factor = 0.118
Data-to-parameter ratio = 17.1

Molecules in the title crystal structure, $\text{C}_{20}\text{H}_{24}\text{O}_4$, are linked into chains of $R_4^4(8)$ rings along [010] and these chains are linked into sheets *via* weak $\text{C}-\text{H}\cdots\pi(\text{arene})$ interactions. These sheets are, in turn, linked *via* weak $\text{C}-\text{H}\cdots\pi(\text{arene})$ and $\text{C}-\text{H}\cdots\text{O}$ interactions into a three-dimensional network. The ethyl substituent is disordered over two sites with refined occupancies of 0.700 (5) and 0.300 (5).

Comment

Products displaying anti-oxidant activity have acquired a great importance from the biological point of view, since they can show a series of activities ranging from the delay of cell deterioration to the inhibition of certain types of cancer (Liao *et al.*, 2003). We stress the importance of our method of synthesis (described in the experimental section) because we have obtained a unique condensation product, in contrast to reported syntheses (Angle & Arnaiz, 1992; Al-Farhan *et al.*, 1992; Alesso *et al.*, 2003) for which mixtures of diastereoisomers were obtained.



A view of the title compound, (I), is shown in Fig. 1. The ethyl group is disordered over two sites. Atoms C2–C6/C9–C11 are essentially coplanar (r.m.s. deviation = 0.002 for all atoms), while atom C7 deviates by 0.481 (2) Å from this plane. There are two intramolecular $\text{O}-\text{H}\cdots\text{O}$ hydrogen bonds (Table 2). The dihedral angle between the mean planes formed by the two benzene rings is 69.23 (11)°. In the crystal structure, four cooperative intermolecular strong $\text{O}-\text{H}\cdots\text{O}$ hydrogen bonds form chains of $R_4^4(8)$ rings (Bernstein *et al.*, 1995) along [010]. Both components (C13A/C13B) of the disordered ethyl group are involved in weak $\text{C}-\text{H}\cdots\pi(\text{arene})$ interactions (Malone *et al.*, 1997), which connect the chains into sheets parallel to (101) (see Table 2 and Fig. 2). A further $\text{C}-\text{H}\cdots\pi(\text{arene})$ interaction (Fig. 3) along with a weak $\text{C}-\text{H}\cdots\text{O}$ interaction link these sheets into a three-dimensional network.

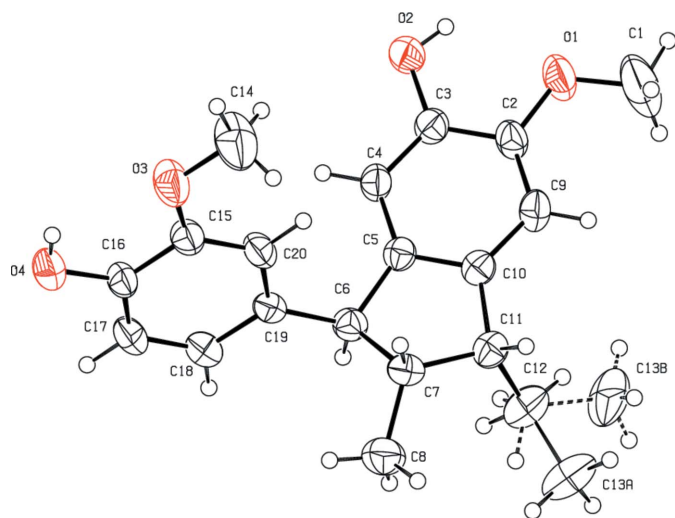


Figure 1
Molecular structure of (I), with displacement ellipsoids drawn at the 40% probability level and H atoms drawn as circles of arbitrary size. The minor component of disorder is shown by means of dashed bonds.

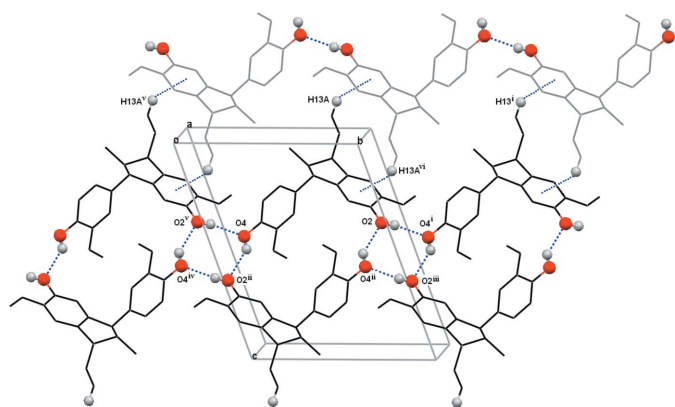


Figure 2
Part of the crystal structure, showing chains along [010] which are linked by two C—H... π (phenyl) interactions (dotted lines) forming sheets parallel to (101). The minor disorder component has been omitted and H atoms not involved in C—H... π or O—H...O (dashed lines) interactions have been omitted. [Symmetry codes: (i) $x, 1 + y, z$; (ii) $-x, 1 - y, 1 - z$; (iii) $-x, 2 - y, 1 - z$; (iv) $-x, -y, 1 - z$; (v) $x, -1 + y, z$; (vi) $1 - x, 2 - y, -z$.]

Experimental

To a solution of isoeugenol (200 mg, 1.22 mmol) in dichloromethane (5 ml) were added sodium nitrate (414.8 mg, 4.88 mmol), potassium acid sulfate (664 mg, 4.88 mmol) and wet silica (800 mg, 50%). The resulting dark-red solution was stirred at room temperature for 60 h. At the end of this period, the complete disappearance of the starting product was confirmed by means of thin-layer chromatography (AcOEt/ *n*-hexane 1:3). The reaction mixture was filtered to remove the remainders of silica gel; next it was dried with Na_2SO_4 (anhydrous) and the solvent was evaporated at low pressure to obtain a red oily product, which was purified by flash chromatography on silica gel with a mixture of *n*-hexane/AcOEt. The final product obtained was crystallized from a mixture of acetone/hexane (1:3), yielding colorless needle-shaped crystals of (I) suitable for X-ray analysis.

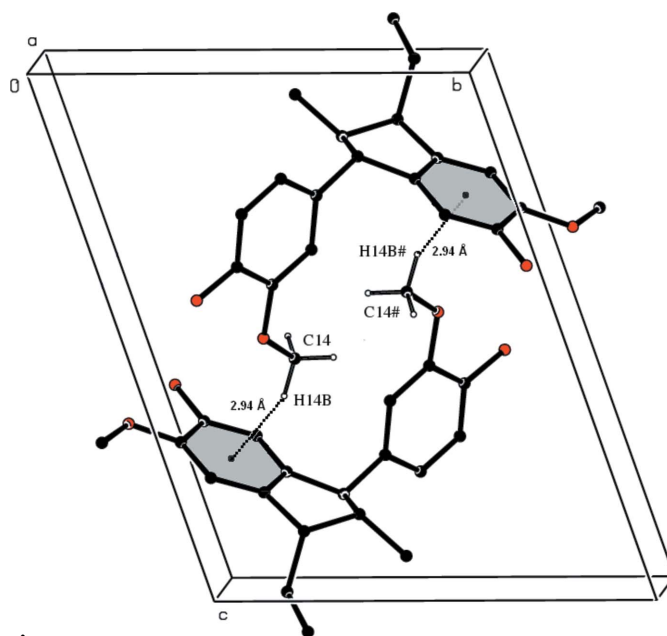


Figure 3
Detail of the two C—H... π (phenyl) interactions about the inversion center at $(\frac{1}{2}, \frac{1}{2}, \frac{1}{2})$. Each molecule is part of a different parallel sheet passing through the unit cell. The dotted lines represent the distances between atom H14B and the ring centroid. [Symmetry code: (#) $1 - x, 1 - y, 1 - z$.]

Crystal data

$\text{C}_{20}\text{H}_{24}\text{O}_4$
 $M_r = 328.39$
Triclinic, $P\bar{1}$
 $a = 6.5124 (10) \text{ \AA}$
 $b = 10.7915 (16) \text{ \AA}$
 $c = 14.147 (2) \text{ \AA}$
 $\alpha = 69.514 (2)^\circ$
 $\beta = 76.847 (3)^\circ$
 $\gamma = 79.238 (3)^\circ$

$V = 900.7 (2) \text{ \AA}^3$
 $Z = 2$
 $D_x = 1.211 \text{ Mg m}^{-3}$
Mo $K\alpha$ radiation
 $\mu = 0.08 \text{ mm}^{-1}$
 $T = 298 \text{ K}$
Block, colorless
 $0.39 \times 0.15 \times 0.10 \text{ mm}$

Data collection

Bruker SMART-NT CCD area-detector diffractometer
 φ and ω scans
Absorption correction: none
6723 measured reflections

3926 independent reflections
1834 reflections with $I > 2\sigma(I)$
 $R_{\text{int}} = 0.045$
 $\theta_{\text{max}} = 28.1^\circ$

Refinement

Refinement on F^2
 $R[F^2 > 2\sigma(F^2)] = 0.057$
 $wR(F^2) = 0.118$
 $S = 0.88$
3926 reflections
230 parameters

H-atom parameters constrained
 $w = 1/[\sigma^2(F_o^2) + (0.0333P)^2]$
where $P = (F_o^2 + 2F_c^2)/3$
 $(\Delta/\sigma)_{\text{max}} < 0.001$
 $\Delta\rho_{\text{max}} = 0.19 \text{ e \AA}^{-3}$
 $\Delta\rho_{\text{min}} = -0.16 \text{ e \AA}^{-3}$

Table 1
Selected geometric parameters (\AA , $^\circ$).

| | | | |
|---------------|-----------|------------------|-----------|
| O1—C1 | 1.399 (4) | O3—C14 | 1.415 (4) |
| O2—C3 | 1.376 (3) | O4—C16 | 1.371 (3) |
| O1—C2—C9 | 126.7 (2) | O3—C15—C16 | 113.9 (2) |
| O1—C2—C3 | 113.8 (2) | C11—C12—C13A | 117.3 (3) |
| O3—C15—C20 | 126.0 (2) | C11—C12—C13B | 113.5 (4) |
| C4—C5—C6—C19 | −37.0 (3) | C10—C11—C12—C13A | 157.0 (3) |
| C5—C6—C19—C20 | −45.6 (3) | | |

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

| $D-H\cdots A$ | $D-H$ | $H\cdots A$ | $D\cdots A$ | $D-H\cdots A$ |
|--------------------------------|-------|-------------|-------------|---------------|
| O2—H2···O1 | 0.82 | 2.19 | 2.645 (2) | 115 |
| O2—H2···O4 ⁱ | 0.82 | 2.11 | 2.849 (2) | 150 |
| O4—H4···O3 | 0.82 | 2.21 | 2.657 (2) | 114 |
| O4—H4···O2 ⁱⁱ | 0.82 | 2.13 | 2.825 (2) | 143 |
| C1—H1A···O2 ^{vii} | 0.96 | 2.56 | 3.499 (4) | 167 |
| C13A—H13A···Cg1 ^{vi} | 0.96 | 3.24 | 3.999 (5) | 137 |
| C13B—H13B···Cg1 ^{vi} | 0.96 | 2.95 | 3.663 (10) | 132 |
| C14—H14B···Cg1 ^{viii} | 0.96 | 2.95 | 3.697 (3) | 137 |

Symmetry codes: (i) $x, y + 1, z$; (ii) $-x, -y + 1, -z + 1$; (vi) $-x + 1, -y + 2, -z$; (vii) $x + 1, y, z$; (viii) $-x + 1, -y + 1, -z + 1$.

H atoms were placed in geometrically idealized positions and constrained to ride on their parents atoms, with $C-H = 0.93-0.98$ Å, $O-H = 0.82$ Å and $U_{iso}(H) = 1.2U_{eq}(C)$ or $U_{iso}(H) = 1.5U_{eq}(C_{methyl}, O)$. The methyl groups were allowed to rotate but not to tip. The ethyl group is disordered over two positions (C13A and C13B) with refined occupancy factors 0.700 (5) and 0.300 (5) while appropriate similarity restraints were applied to the displacement parameters of both components.

Data collection: *SMART-NT* (Bruker, 2001); cell refinement: *SAINT-NT* (Bruker, 2000); data reduction: *SAINT-NT*; program(s) used to solve structure: *SHELXS97* (Sheldrick, 1997); program(s) used to refine structure: *SHELXL97* (Sheldrick, 1997); molecular graphics: *XP* in *SHELXTL-PC* (Sheldrick, 1994); software used to prepare material for publication: *PLATON* (Spek, 2003) and *MERCURY* (Bruno *et al.*, 2002).

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