(2R,4S,5S)-5-Methoxy-4-methyl-3-oxohept-6-en-2-yl benzoate

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The title compound, C₁₆H₂₀O₄, was synthesized in the course of the total synthesis of fusaequisin A in order to verify and confirm the configurations of the stereogenic centers and to exclude the possibility of epimerization during the methylation process. The crystal structure of the title compound at 100 K has orthorhombic (P₂₁₂₁₂₁) symmetry. The absolute configuration was determined by anomalous dispersion and agrees with the configuration of the allylic alcohol used in the synthesis.

Structure description

The title compound, C₁₆H₂₀O₄ (Fig. 1), was obtained during the synthesis of the Western fragment of fusaequisin A. Background to fusaequisin A is given by Shiono et al. (2013). The asymmetric synthesis of the Western fragment is based on Paterson’s anti aldol chemistry (Paterson et al., 1994; Paterson, 1998). In the course of the total synthesis of curvicollide C (Che et al., 2004) the precursor of the title compound (I) was prepared (von Kiedrowski et al., 2017) and provided potential for further investigations regarding the total synthesis of fusaequisin A. The methylation process is shown in Fig. 2.

The title compound crystallizes in the orthorhombic space group P₂₁₂₁₂₁ with four molecules in the unit cell with H1A and H3A almost in plane (H1A—C1—C3—H3A pseudo torsion angle = −1°) and H2A and H3A in an antiperiplanar arrangement (H2A—C2—C3—H3A = 179°), which minimizes 1,3-allylic strain. Furthermore, the C8 methyl group and the O1 atom of the ether group are also in an antiperiplanar arrangement with a C8—C4—C3—O1 torsion angle of 177.32 (10)°. The ester moiety shows the most stable and expected s-cis-conformation. In the crystal, a weak C—H···O interaction arising from the aromatic C—H grouping para to the side chain links the molecules into C(10) chains propagating in the [010] direction (Table 1).
Methylation of naphthalene (proton sponge 3 Å molecular sieves, C;C14=C14, 2013); m.p. = 80–83°C, [α]D20 = −8.3° (c = 0.5 g ml⁻¹ in CHCl₃); ¹H NMR (500 MHz, CDCl₃) δ 1,06 (d, J = 7.1 Hz, 3H, 3-CH₃), 1.55 (d, J = 7.0 Hz, 3H, 1-CH₃), 2.93 (dq, J = 9.7, 7.1 Hz, 1H, 3-CH₃), 3.15 (s, 3H, 4-OCH₃), 3.70 (dd, J = 10.1, 9.3 Hz, 1H, 4-CH₃), 5.24–5.35 (m, 2H, 6-CH₂), 5.41 (q, J = 7.0 Hz, 1H, 1-CH), 5.56 (ddd, J = 17.1, 10.1, 8.5 Hz, 1H, 5-CH), 7.43–7.48 (m, 2H, aryl-CH), 7.55–7.60 (m, 1H, aryl-CH), 8.05–8.12 (m, 2H, aryl-CH); ¹³C NMR (126 MHz, CDCl₃) δ 14.1 (3-CH₃), 15.3 (1-CH₃), 47.0 (3-CH₃), 52.4 (3-CH₂), 65.6 (2-CH₃), 127.4 (CH=), 128.0 (CH), 128.2 (CH), 128.4 (CH), 130.5 (CH), 131.4 (CH), 135.1 (C), 142.8 (C), 146.7 (C), 151.8 (C), 161.2 (C=O).
CH), 56.6 (4-CH3), 75.5 (1-CH), 85.4 (4-CH), 120.2 (6-CH2), 128.5 (aryl-CH), 129.8 (aryl-CH), 129.9 (aryl-CH), 133.3 (aryl-CH), 136.0 (5-CH), 166.0 (aryl-C), 210.1 (2-C); IR ν = 3075 (w), 2985 (w), 2935 (w), 2825 (w), 1720 (s), 1065 (w), 1450 (m), 1420 (w), 1375 (m), 1315 (m), 1265 (s), 1205 (w), 1175 (w), 1115 (s), 1090 (s), 1070 (m), 1025 (m), 1010 (m), 965 (m), 935 (m), 715 (s), 685 (w) cm⁻¹; HRMS (ESI): m/z [M + H]^+ calculated for C16H21O4: 277.1434; found: 277.1342.

Refinement
Crystal data, data collection and structure refinement details are summarized in Table 2.

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References
Bruker (2016). APEX3, SAINT and SADABS (version 2016/2). Bruker AXS Inc., Madison, Wisconsin, USA.
Che, Y., Gloer, J. B. & Wicklow, D. T. (2004). Org. Lett. 6, 1249–1252.
Dolomanov, O. V., Bourhis, L. J., Gildea, R. J., Howard, J. A. K. & Puschmann, H. (2009). J. Appl. Cryst. 42, 339–341.
Kiedrowski, V. von, Quentin, F. & Hiersemann, M. (2017). Org. Lett. 19, 4391–4394.
Parsons, S., Flack, H. D. & Wagner, T. (2013). Acta Cryst. B69, 249–259.
Paterson, I. (1998). Synthesis, pp. 639–652.
Paterson, I., Wallace, D. J. & Velázquez, S. M. (1994). Tetrahedron Lett. 35, 9083–9086.
Sheldrick, G. M. (2008). Acta Cryst. A64, 112–122.
Sheldrick, G. M. (2015a). Acta Cryst. A71, 3–8.
Sheldrick, G. M. (2015b). Acta Cryst. C71, 3–8.
Shiono, Y., Shibuya, F., Murayama, T., Koseki, T., Poumale, H. M. P. & Ngadjui, B. T. (2013). Z. Naturforsch. Teil B, 68, 289–292.
full crystallographic data

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Crystal data
C16H20O4  
Mr = 276.32
Orthorhombic, P2₁2₁2₁
a = 8.1297 (4) Å  
b = 11.8232 (6) Å  
c = 15.7213 (9) Å
V = 1511.12 (14) Å³
Z = 4
F(000) = 592

Dx = 1.215 Mg m⁻³
Melting point = 353–356 K
Cu Kα radiation, λ = 1.54178 Å
Cell parameters from 9807 reflections
θ = 6.1–74.6°  
µ = 0.71 mm⁻¹
T = 100 K
Block, colourless
0.12 × 0.10 × 0.06 mm

Data collection
Bruker APEXII CCD
diffractometer
φ and ω scans
Absorption correction: multi-scan
(SADABS;Bruker, 2016)
Tmin = 0.700, Tmax = 0.754
28627 measured reflections
3078 independent reflections
3054 reflections with I > 2σ(I)
Rint = 0.027
θmax = 74.5°, θmin = 4.7°
h = −10→10
k = −14→14
l = −18→19

Refinement
Refinement on F²
Least-squares matrix: full
R[F² > 2σ(F²)] = 0.023
wR(F²) = 0.060
S = 1.07
3078 reflections
184 parameters
0 restraints
Primary atom site location: dual
Hydrogen site location: inferred from neighbouring sites
H-atom parameters constrained
w = 1/[σ²(Fo²) + (0.0308P)² + 0.2127P]
where P = (Fo² + 2Fc²)/3
(Δ/σ)max < 0.001
Δρmax = 0.18 e Å⁻³
Δρmin = −0.12 e Å⁻³
Absolute structure: Flack x determined using
1293 quotients [(I⁺)-(I⁻)]/[(I⁺)+(I⁻)] (Parsons et al., 2013)
Absolute structure parameter: 0.03 (2)

Special details
Geometry. All esds (except the esd in the dihedral angle between two l.s. planes) are estimated using the full covariance matrix. The cell esds are taken into account individually in the estimation of esds in distances, angles and torsion angles; correlations between esds in cell parameters are only used when they are defined by crystal symmetry. An approximate (isotropic) treatment of cell esds is used for estimating esds involving l.s. planes.
### Fractional atomic coordinates and isotropic or equivalent isotropic displacement parameters (Å²)

| Atom | x       | y       | z       | \(U_{eq}^{\text{iso}}/U_{eq}^{\text{iso}}\) |
|------|---------|---------|---------|------------------------------------------|
| C1   | 0.09507 (18) | 0.29265 (12) | 0.39623 (10) | 0.0306 (3) |
| H1A  | 0.080921 | 0.309404 | 0.337584 | 0.037* |
| H1B  | 0.010147 | 0.255322 | 0.426807 | 0.037* |
| O1   | 0.52090 (11) | 0.31350 (8) | 0.40027 (6) | 0.0257 (2) |
| C2   | 0.23199 (17) | 0.32109 (12) | 0.43502 (9) | 0.0260 (3) |
| H2A  | 0.241816 | 0.302998 | 0.493680 | 0.031* |
| O2   | 0.57315 (12) | 0.55222 (8) | 0.31396 (6) | 0.0257 (2) |
| C3   | 0.37402 (15) | 0.38013 (10) | 0.39331 (8) | 0.0210 (3) |
| O3   | 0.79670 (11) | 0.67523 (7) | 0.40634 (6) | 0.02254 (19) |
| C4   | 0.41493 (15) | 0.49330 (10) | 0.43492 (8) | 0.0200 (2) |
| H4A  | 0.442788 | 0.480340 | 0.496105 | 0.024* |
| H7A  | 0.58296 (11) | 0.79534 (7) | 0.39300 (6) | 0.0255 (2) |
| H7B  | 0.508591 | 0.247754 | 0.284770 | 0.052* |
| C8   | 0.27180 (16) | 0.57771 (12) | 0.42921 (10) | 0.0279 (3) |
| C9   | 0.80093 (17) | 0.50522 (12) | 0.48637 (10) | 0.0298 (3) |
| H9A  | 0.733683 | 0.448423 | 0.515567 | 0.045* |
| H9B  | 0.878182 | 0.539103 | 0.526875 | 0.045* |
| H9C  | 0.862385 | 0.469110 | 0.440132 | 0.045* |
| C10  | 0.72720 (16) | 0.77408 (10) | 0.38331 (7) | 0.0204 (3) |
| C11  | 0.85150 (16) | 0.85390 (10) | 0.34781 (8) | 0.0206 (3) |
| C12  | 0.79937 (18) | 0.96224 (11) | 0.32518 (8) | 0.0237 (3) |
| H12A | 0.686828 | 0.982661 | 0.330513 | 0.028* |
| C13  | 0.91308 (19) | 1.04000 (11) | 0.29482 (9) | 0.0286 (3) |
| H13A | 0.878073 | 1.114116 | 0.280093 | 0.034* |
| C14  | 1.07716 (19) | 1.01054 (12) | 0.28578 (9) | 0.0303 (3) |
| H14A | 1.153904 | 1.064064 | 0.264420 | 0.036* |
| C15  | 1.12937 (17) | 0.90223 (13) | 0.30810 (9) | 0.0294 (3) |
| H15A | 1.241701 | 0.881748 | 0.301761 | 0.035* |
| C16  | 1.01703 (17) | 0.82427 (11) | 0.33962 (8) | 0.0243 (3) |
| H16A | 1.052798 | 0.750788 | 0.355613 | 0.029* |

### Atomic displacement parameters (Å²)

|        | \(U_11\) | \(U_22\) | \(U_33\) | \(U_{12}\) | \(U_{13}\) | \(U_{23}\) |
|--------|---------|---------|---------|---------|---------|---------|
| C1     | 0.0290 (7) | 0.0303 (7) | 0.0325 (7) | −0.0065 (6) | 0.0030 (6) | 0.0020 (6) |
### Geometric parameters (Å, °)

|         |         |         |         |         |         |         |         |         |         |
|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| C1—C2  | 1.313 (2) | C7—H7B  | 0.9800  |         |         |         |         |         |         |
| C1—H1A | 0.9500  | C7—H7C  | 0.9800  |         |         |         |         |         |         |
| C1—H1B | 0.9500  | C8—H8A  | 0.9800  |         |         |         |         |         |         |
| O1—C7  | 1.4220 (17) | C8—H8B | 0.9800  |         |         |         |         |         |         |
| O1—C3  | 1.4347 (15) | C8—H8C | 0.9800  |         |         |         |         |         |         |
| C2—C3  | 1.5001 (18) | C9—H9A | 0.9800  |         |         |         |         |         |         |
| C2—H2A | 0.9500  | C9—H9B  | 0.9800  |         |         |         |         |         |         |
| O2—C5  | 1.2087 (16) | C9—H9C | 0.9800  |         |         |         |         |         |         |
| C3—C4  | 1.5261 (17) | C10—C11 | 1.4911 (18) |         |         |         |         |         |         |
| C3—H3A | 1.0000  | C11—C12 | 1.3953 (18) |         |         |         |         |         |         |
| O3—C10 | 1.3477 (15) | C11—C16 | 1.3965 (19) |         |         |         |         |         |         |
| O3—C6  | 1.4438 (15) | C12—C13 | 1.3883 (19) |         |         |         |         |         |         |
| C4—C5  | 1.5215 (17) | C12—H12A | 0.9500  |         |         |         |         |         |         |
| C4—C8  | 1.5357 (17) | C13—C14 | 1.386 (2)  |         |         |         |         |         |         |
| C4—H4A | 1.0000  | C13—H13A | 0.9500  |         |         |         |         |         |         |
| O4—C10 | 1.2089 (16) | C14—C15 | 1.394 (2)  |         |         |         |         |         |         |
| C5—C6  | 1.5199 (17) | C14—H14A | 0.9500  |         |         |         |         |         |         |
| C6—C9  | 1.5188 (18) | C15—C16 | 1.389 (2)  |         |         |         |         |         |         |
| C6—H6A | 1.0000  | C15—H15A | 0.9500  |         |         |         |         |         |         |
| C7—H7A | 0.9800  | C16—H16A | 0.9500  |         |         |         |         |         |         |

**data reports**

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data-3
C1—C2—H2A 117.7 H8A—C8—H8C 109.5
C3—C2—H2A 117.7 H8B—C8—H8C 109.5
O1—C3—C2 110.60 (10) C6—C9—H9A 109.5
O1—C3—C4 105.50 (10) C6—C9—H9B 109.5
C2—C3—C4 112.85 (10) H9A—C9—H9B 109.5
O1—C3—H3A 109.3 C6—C9—H9C 109.5
C2—C3—H3A 109.3 H9A—C9—H9C 109.5
C4—C3—H3A 109.3 H9B—C9—H9C 109.5
C10—O3—C6 115.73 (10) O4—C10—O3 123.58 (12)
C5—C4—C3 109.85 (10) O4—C10—C11 124.96 (12)
C5—C4—C8 107.29 (10) O3—C10—C11 111.42 (11)
C3—C4—C8 112.31 (10) C12—C11—C16 119.97 (12)
C5—C4—H4A 109.1 C6—C9—H9A 109.5
C3—C4—H4A 109.1 C6—C9—H9B 109.5
O2—C5—C6 122.72 (12) C4—C5—C6—C9 79.43 (13)
O2—C5—C4 122.56 (12) C6—O3—C10—O4 −102.56 (14)
C6—C5—C4 114.69 (10) C6—O3—C10—C11 173.50 (10)
O3—C6—C9 106.34 (10) O4—C10—C11—C12 1.17 (19)
O3—C6—C5 111.60 (10) O3—C10—C11—C12 −176.74 (11)
C9—C6—C5 111.27 (11) O4—C10—C11—C16 178.96 (13)
O3—C6—H6A 109.2 O4—C10—C11—C16 −1.06 (16)
C9—C6—H6A 109.2 C11—C12—C13—C14 −0.6 (2)
C5—C6—H6A 109.2 C12—C13—C14—C15 0.8 (2)
O1—C7—H7A 109.5 C13—C14—C15—C16 0.9 (2)
O1—C7—H7B 109.5 C15—C16—C11—C10 −0.70 (19)
H7A—C7—H7B 109.5 C15—C16—C11—C10 −178.45 (12)
O1—C7—H7C 109.5 C15—C16—H16A 120.0
H7A—C7—H7C 109.5 C15—C16—H16A 120.0
C7—O1—C3—C2 75.42 (14) O2—C5—C6—C9 178.96 (13)
C7—O1—C3—C4 −162.25 (11) O2—C5—C6—C9 −102.56 (14)
C1—C2—C3—O1 −121.33 (15) C4—C5—C6—C9 79.43 (13)
C1—C2—C3—C4 120.75 (15) C6—O3—C10—O4 −4.44 (17)
O1—C3—C4—C5 58.00 (12) C6—O3—C10—C11 173.50 (10)
O1—C3—C4—C5 178.86 (10) O4—C10—C11—C12 1.17 (19)
O1—C3—C4—C8 177.32 (10) O3—C10—C11—C12 −176.74 (11)
O2—C5—C6—C9 −61.81 (14) O4—C10—C11—C16 178.96 (13)
C3—C4—C5—O2 46.33 (16) O3—C10—C11—C16 1.06 (16)
C8—C4—C5—O2 −76.02 (15) C16—C11—C12—C13 −0.16 (19)
C3—C4—C5—C6 −135.66 (10) C10—C11—C12—C13 177.67 (11)
C8—C4—C5—C6 101.99 (12) C11—C12—C13—C14 0.8 (2)
C10—O3—C6—C9 −167.80 (11) C12—C13—C14—C15 −0.6 (2)
C10—O3—C6—C5 70.68 (13) C13—C14—C15—C16 −0.2 (2)
O2—C5—C6—O3 16.05 (17) C14—C15—C16—C11 0.9 (2)
O2—C5—C6—O3 −161.96 (10) C12—C11—C16—C15 −0.70 (19)
O2—C5—C6—O3 16.05 (17) C10—C11—C16—C15 −178.45 (12)
**Hydrogen-bond geometry (Å, ″)**

|       | D—H | H···A | D···A  | D—H···A |
|-------|-----|------|--------|---------|
| C14—H14···O2\(^i\) | 0.95 | 2.54 | 3.2838 (18) | 135 |

Symmetry code: (i) −x+2, y+1/2, −z+1/2.