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(2*E*,6*E*)-2,6-Bis[(5-methylthiophen-2-yl)-methylene]cyclohexanone

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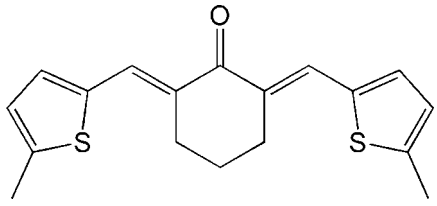
Key indicators: single-crystal X-ray study; T = 293 K; mean σ(C–C) = 0.004 Å; R factor = 0.056; wR factor = 0.144; data-to-parameter ratio = 17.8.

In the title molecule, $C_{18}H_{18}OS_2$, the geometric parameters are normal and the two S atoms are both in an anti arrangement with respect to the carbonyl O atom. The dihedral angle between the thiophene rings is 5.16 (9)°.

Related literature

For related structures, see: Butcher, Jasinski, Narayana *et al.* (2007); Butcher, Jasinski, Sarojini *et al.* (2007). For background information, see: Liang *et al.* (2007); Jagetia & Aggarwal (2007); Kuttan *et al.* (2007); Deng *et al.* (2007); Ryu *et al.* (2006); Weber *et al.* (2005).



Experimental

Crystal data

$C_{18}H_{18}OS_2$
M_r = 314.44
Monoclinic, $P2_1/n$
a = 15.0631 (19) Å
b = 5.9790 (8) Å
c = 17.689 (2) Å
β = 99.204 (2)°
V = 1572.6 (4) Å^3
Z = 4
Mo $K\alpha$ radiation
μ = 0.33 mm^{-1}
T = 293 (2) K
0.50 × 0.33 × 0.15 mm

Data collection

Bruker SMART CCD area-detector diffractometer
Absorption correction: multi-scan (*SADABS*; Sheldrick, 1996)
T_{min} = 0.693, T_{max} = 1.000
(expected range = 0.659–0.951)
8803 measured reflections
3419 independent reflections
2425 reflections with $I > 2\sigma(I)$
R_{int} = 0.118

Refinement

$R[F^2 > 2\sigma(F^2)]$ = 0.056
$wR(F^2)$ = 0.144
S = 0.96
3419 reflections
192 parameters
H-atom parameters constrained
$\Delta\rho_{max}$ = 0.48 e Å^{-3}
$\Delta\rho_{min}$ = −0.30 e Å^{-3}

Data collection: *SMART* (Siemens, 1996); cell refinement: *SAINT* (Siemens, 1994); data reduction: *SAINT*; program(s) used to solve structure: *SHELXS97* (Sheldrick, 1997); program(s) used to refine structure: *SHELXL97* (Sheldrick, 1997); molecular graphics: *SHELXTL* (Sheldrick, 1999); software used to prepare material for publication: *SHELXTL*.

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Supplementary data and figures for this paper are available from the IUCr electronic archives (Reference: LH2505).

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supplementary materials

Acta Cryst. (2007). E**63**, o4118 [**doi:10.1107/S160053680704531X**]

(2*E*,6*E*)-2,6-Bis[(5-methylthiophen-2-yl)methylene]cyclohexanone

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Comment

Curcumin, a natural and multifunctional extract from ginger genus plants, is an excellent lead compound for new antiinflammatory and antitumor drug design. It has been reported to possess a variety of bioactivities such as antitumor, antioxidation, antiinflammation, and antivirus as a inhibitor of HIV integrase (Jagetia & Aggarwal, 2007; Kuttan *et al.*, 2007). Many studies on the structural design and modification of curcumin have been carried out (Weber *et al.*, 2005; Ryu *et al.*, 2006). Our group has designed and synthesized a series of curcumin analogues without the central beta-ketone moiety, which is considered to be cleaved by the noncytochrome P450 pathway in the liver and plays an important role in the poor pharmacokinetics and bioavalability of curcumin (Deng *et al.*, 2007). Some crystal structures of monocarbonyl analogues of curcumin have reported *e.g.* (2E,5E)-2,5-bis(2-bromobenzylidene)cyclopentanone (Liang *et al.*, 2007), 2,5-bis(3,4-dimethoxybenzylidene)cyclopentanone (Butcher, Jasinski, Narayana *et al.*, 2007), and 1,5-Bis(4-fluorophenyl)penta-1,4-dien-3-one (Butcher, Jasinski, Sarojini *et al.*, 2007). In this paper, we present the crystal structure of the title heterocyclic analogue of curcumin, (2E,6E)-2,6-bis((5-methylthiophen-2-yl)methylene) cyclohexanone. The geometrical parameters of the title molecule (Fig. 1) are normal, the two sulfur atoms are in an anti arrangment with respect the carbonyl O atom and the dihedral angle between the five-membered thiophene ring planes is 5.16 (9)°.

Experimental

To a solution of 15 mmol 5-methylthiophene-2-carbaldehyde in MeOH (10 ml) was added 7.5 mmol cyclopentanone. The solution was stirred at room temperature for 15 min, followed by added dropwise 2.0 mol/*L* NaOCH3 (3.75 ml, 7.5 mmol). The mixture was stirred at R·T. for 2 h and monitored with TLC. When the reaction was complete, the residue was poured into saturated NH_4Cl solution and filtered. The precipitate was washed and purified by chromatography over silica gel using CH_2Cl_2 / CH_3OH as the eluent to afford the pure product (yield: 71.8%). Single crystals were grown in a CH_2Cl_2—CH_3CH_2OH mixture (4:1 *v*/*v*) by slow evaporation (mp 438–440 K). 1*H*-NMR ($CDCl_3$): 1.93 (2*H*, m, CH2), 2.54 (6*H*, s, CH3), 2.88 (4*H*, t, J=4.8 Hz, CH2—CH2), 6.80 (2*H*, d, J = 3.6 Hz, Ar—H3), 7.18 (2*H*, d, J = 3.6 Hz, Ar—H4), 7.89 (2*H*, s, CH=C). ESI-MS m/*z*: 315.37 (*M*+1)+, calcd for $C_{18}H_{18}O_S2$: 314.46.

Refinement

The H atoms were positioned geometrically (C—H = 0.93–0.97 Å) with U_{iso}(H) = 1.2U_{eq}(C) or 1.5U_{eq}(C) for methyl H atoms.

Figures

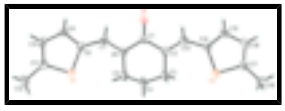


Fig. 1. The molecular structure of with atom numbering, shoiwng xx% displacement ellipsoids for the non-hydrogen atoms.

(2E,6E)-2,6-Bis[(5-methylthiophen-2-yl)methylene]cyclohexanone

Crystal data

$C_{18}H_{18}OS_2$	F_{000} = 664
M_r = 314.44	D_x = 1.328 Mg m^{-3}
Monoclinic, $P2_1/n$	Melting point: 438-440K K
Hall symbol: -P 2yn	Mo $K\alpha$ radiation λ = 0.71073 Å
a = 15.0631 (19) Å	Cell parameters from 2150 reflections
b = 5.9790 (8) Å	θ = 4.7–52.9º
c = 17.689 (2) Å	μ = 0.33 mm^{-1}
β = 99.204 (2)º	T = 293 (2) K
V = 1572.6 (4) Å^3	Prismatic, yellow
Z = 4	0.50 × 0.33 × 0.15 mm

Data collection

Bruker SMART CCD area-detector diffractometer	3419 independent reflections
Radiation source: fine-focus sealed tube	2425 reflections with $I > 2\sigma(I)$
Monochromator: graphite	R_{int} = 0.118
T = 293(2) K	θ_{max} = 27.0º
φ and ω scans	θ_{min} = 1.9º
Absorption correction: multi-scan (SADABS; Sheldrick, 1996)	h = −19→13
T_{min} = 0.693, T_{max} = 1.000	k = −7→7
8803 measured reflections	l = −22→22

Refinement

Refinement on F^2	Secondary atom site location: difference Fourier map
Least-squares matrix: full	Hydrogen site location: inferred from neighbouring sites
$R[F^2 > 2\sigma(F^2)]$ = 0.056	H-atom parameters constrained
$wR(F^2)$ = 0.144	$w = 1/[\sigma^2(F_o^2) + (0.0606P)^2]$ where $P = (F_o^2 + 2F_c^2)/3$
S = 0.96	$(\Delta/\sigma)_{max}$ = 0.001
3419 reflections	$\Delta\rho_{max}$ = 0.48 e Å^{-3}
192 parameters	$\Delta\rho_{min}$ = −0.30 e Å^{-3}
Primary atom site location: structure-invariant direct methods	Extinction correction: none

Special details

Geometry. All e.s.d.'s (except the e.s.d. in the dihedral angle between two l.s. planes) are estimated using the full covariance matrix. The cell e.s.d.'s are taken into account individually in the estimation of e.s.d.'s in distances, angles and torsion angles; correlations between e.s.d.'s in cell parameters are only used when they are defined by crystal symmetry. An approximate (isotropic) treatment of cell e.s.d.'s is used for estimating e.s.d.'s involving l.s. planes.

Refinement. Refinement of F^2 against ALL reflections. The weighted *R*-factor *wR* and goodness of fit S are based on F^2, conventional *R*-factors *R* are based on F, with F set to zero for negative F^2. The threshold expression of $F^2 > 2\text{sigma}(F^2)$ is used only for calculating *R*-factors(gt) *etc*. and is not relevant to the choice of reflections for refinement. *R*-factors based on F^2 are statistically about twice as large as those based on F, and R– factors based on ALL data will be even larger.

Fractional atomic coordinates and isotropic or equivalent isotropic displacement parameters ($Å^2$)

	x	*y*	*z*	U_{iso}*/U_{eq}
S1	0.66053 (5)	0.60400 (10)	1.02262 (4)	0.0457 (2)
S2	0.42563 (4)	0.72792 (11)	0.53701 (4)	0.0500 (2)
O1	0.46099 (14)	0.1525 (3)	0.78293 (11)	0.0650 (6)
C1	0.49669 (17)	0.3352 (4)	0.78007 (14)	0.0441 (6)
C2	0.48304 (16)	0.4675 (4)	0.70766 (13)	0.0428 (6)
C3	0.53608 (18)	0.6800 (5)	0.70181 (15)	0.0529 (7)
H3A	0.4977	0.8077	0.7067	0.063*
H3B	0.5541	0.6869	0.6516	0.063*
C4	0.61929 (19)	0.6951 (5)	0.76260 (15)	0.0599 (8)
H4A	0.6625	0.5827	0.7528	0.072*
H4B	0.6469	0.8409	0.7603	0.072*
C5	0.59505 (19)	0.6594 (5)	0.84138 (14)	0.0540 (7)
H5A	0.6488	0.6735	0.8794	0.065*
H5B	0.5530	0.7743	0.8514	0.065*
C6	0.55374 (16)	0.4335 (4)	0.84869 (13)	0.0416 (6)
C7	0.56103 (16)	0.3136 (4)	0.91373 (14)	0.0417 (6)
H7	0.5328	0.1750	0.9078	0.050*
C8	0.60433 (16)	0.3593 (4)	0.99076 (14)	0.0405 (6)
C9	0.60517 (18)	0.2174 (4)	1.05115 (15)	0.0485 (6)
H9	0.5785	0.0767	1.0465	0.058*
C10	0.64957 (18)	0.3018 (5)	1.12083 (15)	0.0523 (7)
H10	0.6549	0.2228	1.1666	0.063*
C11	0.68413 (17)	0.5092 (5)	1.11535 (14)	0.0475 (6)
C12	0.7374 (2)	0.6518 (5)	1.17666 (16)	0.0664 (8)
H12A	0.7129	0.6373	1.2233	0.100*
H12B	0.7343	0.8054	1.1606	0.100*
H12C	0.7990	0.6038	1.1852	0.100*
C13	0.42223 (17)	0.3906 (4)	0.64973 (14)	0.0449 (6)
H13	0.3942	0.2582	0.6604	0.054*
C14	0.39269 (16)	0.4772 (4)	0.57379 (13)	0.0431 (6)
C15	0.33238 (17)	0.3723 (4)	0.51864 (15)	0.0491 (6)
H15	0.3056	0.2361	0.5266	0.059*
C16	0.31508 (17)	0.4888 (5)	0.44959 (15)	0.0515 (6)

H16	0.2764	0.4359	0.4071	0.062*
C17	0.35950 (16)	0.6853 (4)	0.44977 (14)	0.0457 (6)
C18	0.3575 (2)	0.8562 (5)	0.38763 (16)	0.0616 (8)
H18A	0.3248	0.7977	0.3407	0.092*
H18B	0.4179	0.8909	0.3807	0.092*
H18C	0.3285	0.9894	0.4016	0.092*

Atomic displacement parameters (Å^2)

	U^{11}	U^{22}	U^{33}	U^{12}	U^{13}	U^{23}
S1	0.0494 (4)	0.0454 (4)	0.0407 (4)	−0.0035 (3)	0.0025 (3)	0.0017 (3)
S2	0.0466 (4)	0.0566 (4)	0.0437 (4)	−0.0097 (3)	−0.0021 (3)	0.0006 (3)
O1	0.0870 (16)	0.0497 (11)	0.0512 (12)	−0.0167 (10)	−0.0104 (10)	0.0022 (9)
C1	0.0469 (15)	0.0414 (14)	0.0422 (14)	−0.0026 (11)	0.0012 (11)	−0.0019 (10)
C2	0.0405 (14)	0.0490 (14)	0.0383 (13)	−0.0016 (11)	0.0043 (10)	−0.0025 (11)
C3	0.0497 (16)	0.0669 (17)	0.0391 (14)	−0.0130 (13)	−0.0023 (11)	0.0048 (12)
C4	0.0556 (18)	0.0796 (19)	0.0416 (16)	−0.0251 (15)	−0.0016 (12)	0.0056 (13)
C5	0.0581 (18)	0.0630 (17)	0.0378 (14)	−0.0171 (13)	−0.0015 (12)	0.0037 (12)
C6	0.0391 (14)	0.0456 (14)	0.0396 (13)	−0.0003 (11)	0.0044 (10)	−0.0006 (10)
C7	0.0390 (14)	0.0408 (13)	0.0446 (14)	−0.0001 (10)	0.0047 (11)	0.0004 (10)
C8	0.0342 (13)	0.0420 (14)	0.0445 (14)	0.0010 (10)	0.0034 (10)	0.0030 (10)
C9	0.0440 (15)	0.0463 (15)	0.0533 (16)	−0.0019 (11)	0.0020 (12)	0.0093 (11)
C10	0.0539 (17)	0.0612 (17)	0.0401 (15)	0.0029 (13)	0.0018 (12)	0.0123 (12)
C11	0.0440 (15)	0.0577 (16)	0.0393 (14)	0.0059 (12)	0.0015 (11)	0.0004 (11)
C12	0.071 (2)	0.080 (2)	0.0450 (17)	−0.0059 (17)	−0.0024 (14)	−0.0083 (14)
C13	0.0434 (14)	0.0484 (15)	0.0425 (14)	−0.0041 (11)	0.0052 (11)	−0.0023 (11)
C14	0.0372 (13)	0.0494 (14)	0.0424 (14)	−0.0036 (11)	0.0050 (10)	−0.0046 (11)
C15	0.0403 (15)	0.0564 (16)	0.0490 (15)	−0.0085 (12)	0.0028 (11)	−0.0031 (12)
C16	0.0414 (15)	0.0676 (17)	0.0421 (15)	−0.0013 (13)	−0.0038 (11)	−0.0093 (12)
C17	0.0363 (14)	0.0595 (16)	0.0398 (14)	−0.0005 (12)	0.0018 (10)	−0.0023 (11)
C18	0.0581 (19)	0.073 (2)	0.0516 (17)	0.0001 (15)	0.0025 (14)	0.0088 (14)

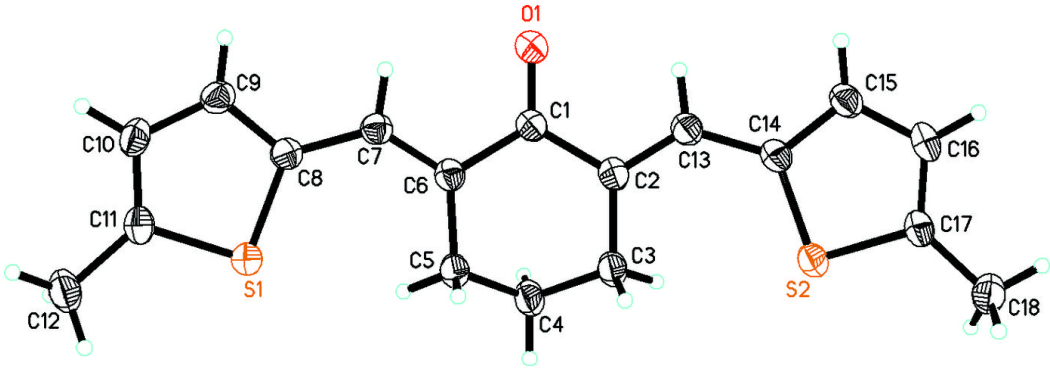
Geometric parameters (Å, °)

S1—C11	1.718 (2)	C8—C9	1.363 (3)
S1—C8	1.738 (2)	C9—C10	1.399 (4)
S2—C17	1.717 (2)	C9—H9	0.9300
S2—C14	1.738 (2)	C10—C11	1.355 (4)
O1—C1	1.222 (3)	C10—H10	0.9300
C1—C6	1.491 (3)	C11—C12	1.506 (4)
C1—C2	1.491 (3)	C12—H12A	0.9600
C2—C13	1.342 (3)	C12—H12B	0.9600
C2—C3	1.513 (3)	C12—H12C	0.9600
C3—C4	1.518 (3)	C13—C14	1.442 (3)
C3—H3A	0.9700	C13—H13	0.9300
C3—H3B	0.9700	C14—C15	1.374 (3)
C4—C5	1.511 (4)	C15—C16	1.394 (4)
C4—H4A	0.9700	C15—H15	0.9300
C4—H4B	0.9700	C16—C17	1.352 (4)

C5—C6	1.501 (3)	C16—H16	0.9300
C5—H5A	0.9700	C17—C18	1.497 (4)
C5—H5B	0.9700	C18—H18A	0.9600
C6—C7	1.345 (3)	C18—H18B	0.9600
C7—C8	1.440 (3)	C18—H18C	0.9600
C7—H7	0.9300		
C11—S1—C8	92.72 (12)	C8—C9—H9	122.9
C17—S2—C14	92.81 (12)	C10—C9—H9	122.9
O1—C1—C6	121.2 (2)	C11—C10—C9	113.7 (2)
O1—C1—C2	120.6 (2)	C11—C10—H10	123.1
C6—C1—C2	118.2 (2)	C9—C10—H10	123.1
C13—C2—C1	117.2 (2)	C10—C11—C12	129.3 (2)
C13—C2—C3	122.6 (2)	C10—C11—S1	110.32 (19)
C1—C2—C3	120.2 (2)	C12—C11—S1	120.4 (2)
C2—C3—C4	112.7 (2)	C11—C12—H12A	109.5
C2—C3—H3A	109.0	C11—C12—H12B	109.5
C4—C3—H3A	109.0	H12A—C12—H12B	109.5
C2—C3—H3B	109.0	C11—C12—H12C	109.5
C4—C3—H3B	109.0	H12A—C12—H12C	109.5
H3A—C3—H3B	107.8	H12B—C12—H12C	109.5
C5—C4—C3	110.5 (2)	C2—C13—C14	131.3 (2)
C5—C4—H4A	109.5	C2—C13—H13	114.4
C3—C4—H4A	109.5	C14—C13—H13	114.4
C5—C4—H4B	109.5	C15—C14—C13	124.6 (2)
C3—C4—H4B	109.5	C15—C14—S2	108.91 (19)
H4A—C4—H4B	108.1	C13—C14—S2	126.47 (18)
C6—C5—C4	111.8 (2)	C14—C15—C16	113.8 (2)
C6—C5—H5A	109.3	C14—C15—H15	123.1
C4—C5—H5A	109.3	C16—C15—H15	123.1
C6—C5—H5B	109.3	C17—C16—C15	114.1 (2)
C4—C5—H5B	109.3	C17—C16—H16	122.9
H5A—C5—H5B	107.9	C15—C16—H16	122.9
C7—C6—C1	116.3 (2)	C16—C17—C18	129.7 (2)
C7—C6—C5	125.1 (2)	C16—C17—S2	110.30 (19)
C1—C6—C5	118.5 (2)	C18—C17—S2	120.0 (2)
C6—C7—C8	132.2 (2)	C17—C18—H18A	109.5
C6—C7—H7	113.9	C17—C18—H18B	109.5
C8—C7—H7	113.9	H18A—C18—H18B	109.5
C9—C8—C7	124.7 (2)	C17—C18—H18C	109.5
C9—C8—S1	109.08 (19)	H18A—C18—H18C	109.5
C7—C8—S1	126.15 (18)	H18B—C18—H18C	109.5
C8—C9—C10	114.2 (2)		
O1—C1—C2—C13	7.8 (4)	C7—C8—C9—C10	−178.3 (2)
C6—C1—C2—C13	−171.3 (2)	S1—C8—C9—C10	−0.1 (3)
O1—C1—C2—C3	−172.7 (3)	C8—C9—C10—C11	−0.4 (3)
C6—C1—C2—C3	8.2 (3)	C9—C10—C11—C12	−178.7 (3)
C13—C2—C3—C4	−161.9 (3)	C9—C10—C11—S1	0.6 (3)
C1—C2—C3—C4	18.6 (4)	C8—S1—C11—C10	−0.6 (2)

C2—C3—C4—C5	−52.5 (3)	C8—S1—C11—C12	178.8 (2)
C3—C4—C5—C6	60.4 (3)	C1—C2—C13—C14	179.4 (2)
O1—C1—C6—C7	−2.1 (4)	C3—C2—C13—C14	−0.1 (4)
C2—C1—C6—C7	177.1 (2)	C2—C13—C14—C15	176.4 (3)
O1—C1—C6—C5	−179.6 (3)	C2—C13—C14—S2	−4.2 (4)
C2—C1—C6—C5	−0.4 (3)	C17—S2—C14—C15	−0.5 (2)
C4—C5—C6—C7	149.1 (3)	C17—S2—C14—C13	−180.0 (2)
C4—C5—C6—C1	−33.6 (3)	C13—C14—C15—C16	−179.6 (2)
C1—C6—C7—C8	−175.5 (2)	S2—C14—C15—C16	0.9 (3)
C5—C6—C7—C8	1.8 (4)	C14—C15—C16—C17	−1.1 (3)
C6—C7—C8—C9	179.8 (2)	C15—C16—C17—C18	−179.2 (3)
C6—C7—C8—S1	1.9 (4)	C15—C16—C17—S2	0.7 (3)
C11—S1—C8—C9	0.4 (2)	C14—S2—C17—C16	−0.1 (2)
C11—S1—C8—C7	178.6 (2)	C14—S2—C17—C18	179.8 (2)

Fig. 1


O1
C1
C2
C3
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C7
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C10
C11
C12
S1
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C14
C15
C16
C17
C18
S2