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5-Fluoro-3-(4-fluorophenylsulfinyl)-2-methyl-1-benzofuran

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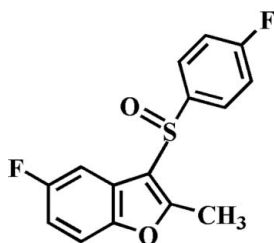
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Key indicators: single-crystal X-ray study; $T = 174$ K; mean $\sigma(\text{C}-\text{C}) = 0.002$ Å; R factor = 0.031; wR factor = 0.091; data-to-parameter ratio = 16.2.

In the title compound, $\text{C}_{15}\text{H}_{10}\text{F}_2\text{O}_2\text{S}$, the $\text{S}=\text{O}$ and the 4-fluorophenyl groups are located on opposite sides of the plane of benzofuran ring system, and the 4-fluorophenyl ring is nearly perpendicular to the benzofuran plane with a dihedral angle of $89.93(4)^\circ$. In the crystal structure, molecules are linked by weak intermolecular $\text{C}-\text{H}\cdots\text{O}$ hydrogen bonding and $\text{C}-\text{H}\cdots\pi$ interactions.

Related literature

For the pharmacological activity of benzofuran compounds, see: Aslam *et al.* (2006); Galal *et al.* (2009); Khan *et al.* (2005). For natural products with benzofuran rings, see: Akgul & Anil (2003); Soekamto *et al.* (2003). For the structures of related 3-(4-fluorophenylsulfinyl)-2-methyl-1-benzofuran derivatives, see: Choi *et al.* (2010a,b).



Experimental

Crystal data

 $\text{C}_{15}\text{H}_{10}\text{F}_2\text{O}_2\text{S}$
 $M_r = 292.29$ Orthorhombic, $Pbcn$
 $a = 14.9369(4)$ Å $b = 10.6284(3)$ Å
 $c = 16.1532(4)$ Å
 $V = 2564.41(12)$ Å³
 $Z = 8$ Mo $K\alpha$ radiation
 $\mu = 0.27$ mm⁻¹
 $T = 174$ K
 $0.40 \times 0.32 \times 0.28$ mm

Data collection

Bruker SMART APEXII CCD diffractometer
Absorption correction: multi-scan (SADABS; Bruker, 2009)
 $T_{\min} = 0.898$, $T_{\max} = 0.927$ 22576 measured reflections
2962 independent reflections
2578 reflections with $I > 2\sigma(I)$
 $R_{\text{int}} = 0.029$

Refinement

 $R[F^2 > 2\sigma(F^2)] = 0.031$
 $wR(F^2) = 0.091$
 $S = 1.08$
2962 reflections183 parameters
H-atom parameters constrained
 $\Delta\rho_{\max} = 0.29$ e Å⁻³
 $\Delta\rho_{\min} = -0.32$ e Å⁻³

Table 1

Hydrogen-bond geometry (Å, °).

 C_g is the centroid of the furan ring.

| $D-H\cdots A$ | $D-H$ | $H\cdots A$ | $D\cdots A$ | $D-H\cdots A$ |
|---|-------|-------------|-------------|---------------|
| $\text{C9}-\text{H9B}\cdots\text{O2}^i$ | 0.98 | 2.45 | 3.200 (2) | 133 |
| $\text{C14}-\text{H14}\cdots\text{O2}^{ii}$ | 0.95 | 2.55 | 3.270 (2) | 133 |
| $\text{C15}-\text{H15}\cdots\text{Cg}^{ii}$ | 0.95 | 2.98 | 3.828 (2) | 149 |

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

Data collection: APEX2 (Bruker, 2009); cell refinement: SAINT (Bruker, 2009); data reduction: SAINT; program(s) used to solve structure: SHELXS97 (Sheldrick, 2008); program(s) used to refine structure: SHELXL97 (Sheldrick, 2008); molecular graphics: ORTEP-3 (Farrugia, 1997) and DIAMOND (Brandenburg, 1998); software used to prepare material for publication: SHELXL97.

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Supplementary data and figures for this paper are available from the IUCr electronic archives (Reference: XU2777).

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supplementary materials

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5-Fluoro-3-(4-fluorophenylsulfinyl)-2-methyl-1-benzofuran

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Comment

The compounds containing benzofuran skeleton exhibit diverse pharmacological properties such as antifungal (Aslam *et al.*, 2006), antitumor and antiviral (Galal *et al.*, 2009), antimicrobial (Khan *et al.*, 2005) activities. These compounds widely occur in nature (Akgul & Anil, 2003; Soekamto *et al.*, 2003). As a part of our ongoing studies of the effect of side chain substituents on the solid state structures of 3-(4-fluorophenylsulfinyl)-2-methyl-1-benzofuran analogues (Choi *et al.*, 2010a,b), we report the crystal structure of the title compound (Fig. 1).

The benzofuran unit is essentially planar, with a mean deviation of 0.012 (1) Å from the least-squares plane defined by the nine constituent atoms. The 4-fluorophenyl ring is almost perpendicular to the plane of the benzofuran fragment [89.93 (4)°] and is tilted slightly towards it. The crystal packing (Fig. 2) is stabilized by weak intermolecular C–H⋯O hydrogen bonds; the first one between the methyl H atom and the oxygen of the S=O unit, with a C9–H9B⋯O2ⁱ, and the second one between the 4-fluorophenyl H atom and the oxygen of the S=O unit, with a C14–H14⋯O2ⁱⁱ, respectively (Table 1). The molecular packing (Fig. 2) is further stabilized by a C–H⋯π interaction between the 4-fluorophenyl H atom and the furan ring of an adjacent benzofuran system, with a C15–H15⋯Cgⁱⁱⁱ (Table 1; Cg is the centroid of the C1/C2/C7/O1/C8 furan ring).

Experimental

77% 3-Chloroperoxybenzoic acid (291 mg, 1.3 mmol) was added in small portions to a stirred solution of 5-fluoro-3-(4-fluorophenylsulfinyl)-2-methyl-1-benzofuran (350 mg, 1.2 mmol) in dichloromethane (30 ml) at 273 K. After being stirred at room temperature for 4 h, the mixture was washed with saturated sodium bicarbonate solution, the organic layer was separated, dried over magnesium sulfate, filtered and concentrated at reduced pressure. The residue was purified by column chromatography (hexane-ethyl acetate, 1:1 v/v) to afford the title compound as a colorless solid [yield 78%, m.p. 418–419 K; R_f = 0.49 (hexane-ethyl acetate, 1:1 v/v)]. Single crystals suitable for X-ray diffraction were prepared by slow evaporation of a solution of the title compound in benzene at room temperature.

Refinement

All H atoms were positioned geometrically and refined using a riding model, with C–H = 0.93 Å for aryl and 0.96 Å for methyl H atoms. $U_{\text{iso}}(\text{H}) = 1.2U_{\text{eq}}(\text{C})$ for aryl and $1.5U_{\text{eq}}(\text{C})$ for methyl H atoms.

Figures

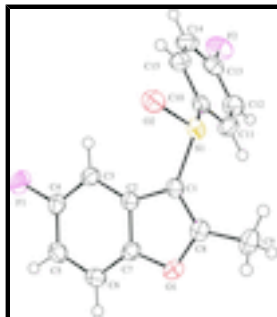


Fig. 1. The molecular structure of the title compound with the atom numbering scheme. Displacement ellipsoids are drawn at the 50% probability level. H atoms are presented as a small spheres of arbitrary radius.

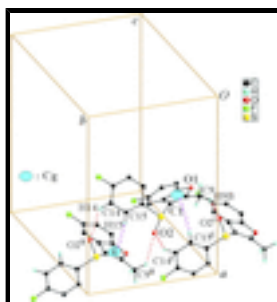


Fig. 2. C–H...O and C–H... π interactions (dotted lines) in the crystal structure of the title compound. Cg denotes the ring centroid. [Symmetry codes: (i) $-x + 3/2, y - 1/2, z$; (ii) $-x + 3/2, y + 1/2, z$.]

5-Fluoro-3-(4-fluorophenylsulfinyl)-2-methyl-1-benzofuran

Crystal data

$C_{15}H_{10}F_2O_2S$

$M_r = 292.29$

Orthorhombic, *Pbcn*

Hall symbol: $-P\ 2n\ 2ab$

$a = 14.9369\ (4)\ \text{\AA}$

$b = 10.6284\ (3)\ \text{\AA}$

$c = 16.1532\ (4)\ \text{\AA}$

$V = 2564.41\ (12)\ \text{\AA}^3$

$Z = 8$

$F(000) = 1200$

$D_x = 1.514\ \text{Mg m}^{-3}$

Mo $K\alpha$ radiation, $\lambda = 0.71073\ \text{\AA}$

Cell parameters from 9962 reflections

$\theta = 2.4\text{--}27.6^\circ$

$\mu = 0.27\ \text{mm}^{-1}$

$T = 174\ \text{K}$

Block, colourless

$0.40 \times 0.32 \times 0.28\ \text{mm}$

Data collection

Bruker SMART APEXII CCD diffractometer

Radiation source: rotating anode graphite multilayer

Detector resolution: $10.0\ \text{pixels mm}^{-1}$

ϕ and ω scans

Absorption correction: multi-scan (*SADABS*; Bruker, 2009)

$T_{\min} = 0.898, T_{\max} = 0.927$

22576 measured reflections

2962 independent reflections

2578 reflections with $I > 2\sigma(I)$

$R_{\text{int}} = 0.029$

$\theta_{\max} = 27.6^\circ, \theta_{\min} = 2.4^\circ$

$h = -19 \rightarrow 19$

$k = -13 \rightarrow 11$

$l = -18 \rightarrow 21$

Refinement

| | |
|--|--|
| Refinement on F^2 | Secondary atom site location: difference Fourier map |
| Least-squares matrix: full | Hydrogen site location: difference Fourier map |
| $R[F^2 > 2\sigma(F^2)] = 0.031$ | H-atom parameters constrained |
| $wR(F^2) = 0.091$ | $w = 1/[\sigma^2(F_o^2) + (0.0448P)^2 + 0.984P]$ |
| $S = 1.08$ | where $P = (F_o^2 + 2F_c^2)/3$ |
| 2962 reflections | $(\Delta/\sigma)_{\max} < 0.001$ |
| 183 parameters | $\Delta\rho_{\max} = 0.29 \text{ e } \text{\AA}^{-3}$ |
| 0 restraints | $\Delta\rho_{\min} = -0.32 \text{ e } \text{\AA}^{-3}$ |
| Primary atom site location: structure-invariant direct methods | Extinction correction: <i>SHELXL97</i> (Sheldrick, 2008), $F_c^* = kF_c[1 + 0.001x F_c^2 \lambda^3 / \sin(2\theta)]^{-1/4}$ |
| | Extinction coefficient: 0.0035 (5) |

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.

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 $F^2 > 2\sigma(F^2)$ 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 (\AA^2)

| | <i>x</i> | <i>y</i> | <i>z</i> | $U_{\text{iso}}^*/U_{\text{eq}}$ |
|----|--------------|--------------|--------------|----------------------------------|
| S1 | 0.66618 (2) | 0.39412 (3) | 0.07071 (2) | 0.02868 (12) |
| F1 | 0.74089 (8) | 0.39246 (10) | 0.42659 (5) | 0.0468 (3) |
| F2 | 0.43716 (7) | 0.81769 (9) | 0.16672 (7) | 0.0533 (3) |
| O1 | 0.59409 (7) | 0.09156 (9) | 0.19275 (6) | 0.0308 (2) |
| O2 | 0.76049 (7) | 0.43398 (11) | 0.08603 (7) | 0.0371 (3) |
| C1 | 0.63924 (9) | 0.27918 (12) | 0.14445 (8) | 0.0257 (3) |
| C2 | 0.65824 (8) | 0.27675 (12) | 0.23194 (8) | 0.0244 (3) |
| C3 | 0.69806 (9) | 0.35842 (13) | 0.28866 (9) | 0.0287 (3) |
| H3 | 0.7198 | 0.4390 | 0.2730 | 0.034* |
| C4 | 0.70389 (10) | 0.31507 (14) | 0.36869 (9) | 0.0317 (3) |
| C5 | 0.67501 (10) | 0.19769 (15) | 0.39509 (9) | 0.0334 (3) |
| H5 | 0.6817 | 0.1735 | 0.4514 | 0.040* |
| C6 | 0.63635 (10) | 0.11614 (13) | 0.33859 (9) | 0.0318 (3) |
| H6 | 0.6159 | 0.0350 | 0.3544 | 0.038* |
| C7 | 0.62909 (8) | 0.15881 (12) | 0.25823 (8) | 0.0265 (3) |
| C8 | 0.60257 (9) | 0.16619 (13) | 0.12435 (9) | 0.0287 (3) |
| C9 | 0.57225 (10) | 0.11157 (15) | 0.04501 (10) | 0.0379 (4) |

supplementary materials

| | | | | |
|-----|--------------|--------------|--------------|------------|
| H9A | 0.5068 | 0.1058 | 0.0448 | 0.057* |
| H9B | 0.5979 | 0.0273 | 0.0384 | 0.057* |
| H9C | 0.5919 | 0.1654 | -0.0008 | 0.057* |
| C10 | 0.59618 (9) | 0.51953 (13) | 0.10727 (8) | 0.0275 (3) |
| C11 | 0.50426 (10) | 0.50221 (15) | 0.11532 (10) | 0.0354 (3) |
| H11 | 0.4786 | 0.4215 | 0.1066 | 0.043* |
| C12 | 0.45059 (10) | 0.60330 (15) | 0.13609 (11) | 0.0401 (4) |
| H12 | 0.3877 | 0.5934 | 0.1423 | 0.048* |
| C13 | 0.49058 (11) | 0.71859 (14) | 0.14756 (10) | 0.0364 (3) |
| C14 | 0.58090 (11) | 0.73846 (14) | 0.13999 (10) | 0.0391 (4) |
| H14 | 0.6061 | 0.8195 | 0.1488 | 0.047* |
| C15 | 0.63445 (10) | 0.63648 (14) | 0.11909 (9) | 0.0342 (3) |
| H15 | 0.6972 | 0.6471 | 0.1129 | 0.041* |

Atomic displacement parameters (\AA^2)

| | U^{11} | U^{22} | U^{33} | U^{12} | U^{13} | U^{23} |
|-----|--------------|------------|--------------|--------------|---------------|--------------|
| S1 | 0.03005 (19) | 0.0329 (2) | 0.02308 (18) | 0.00313 (13) | -0.00015 (12) | 0.00211 (12) |
| F1 | 0.0588 (6) | 0.0527 (6) | 0.0289 (5) | -0.0174 (5) | -0.0098 (4) | -0.0059 (4) |
| F2 | 0.0614 (6) | 0.0369 (5) | 0.0617 (7) | 0.0204 (5) | 0.0077 (5) | 0.0049 (5) |
| O1 | 0.0328 (5) | 0.0259 (5) | 0.0338 (5) | -0.0047 (4) | -0.0004 (4) | -0.0046 (4) |
| O2 | 0.0271 (5) | 0.0422 (6) | 0.0421 (6) | 0.0011 (4) | 0.0044 (4) | 0.0098 (5) |
| C1 | 0.0250 (6) | 0.0265 (6) | 0.0257 (6) | 0.0018 (5) | -0.0009 (5) | -0.0013 (5) |
| C2 | 0.0227 (6) | 0.0250 (6) | 0.0256 (6) | 0.0021 (5) | 0.0002 (5) | -0.0009 (5) |
| C3 | 0.0305 (7) | 0.0261 (6) | 0.0294 (7) | -0.0034 (5) | -0.0007 (5) | -0.0014 (5) |
| C4 | 0.0312 (7) | 0.0363 (7) | 0.0275 (7) | -0.0027 (6) | -0.0048 (5) | -0.0038 (6) |
| C5 | 0.0342 (7) | 0.0388 (8) | 0.0273 (7) | 0.0008 (6) | -0.0016 (6) | 0.0063 (6) |
| C6 | 0.0331 (7) | 0.0272 (7) | 0.0352 (8) | -0.0009 (5) | 0.0024 (6) | 0.0053 (6) |
| C7 | 0.0248 (6) | 0.0244 (6) | 0.0302 (7) | 0.0002 (5) | -0.0003 (5) | -0.0031 (5) |
| C8 | 0.0256 (6) | 0.0302 (7) | 0.0302 (7) | 0.0024 (5) | -0.0005 (5) | -0.0039 (5) |
| C9 | 0.0349 (8) | 0.0414 (8) | 0.0373 (8) | -0.0003 (6) | -0.0064 (6) | -0.0134 (6) |
| C10 | 0.0292 (6) | 0.0289 (7) | 0.0244 (6) | 0.0016 (5) | -0.0027 (5) | 0.0035 (5) |
| C11 | 0.0285 (6) | 0.0306 (7) | 0.0471 (9) | -0.0018 (6) | -0.0034 (6) | 0.0011 (6) |
| C12 | 0.0295 (7) | 0.0414 (9) | 0.0493 (10) | 0.0042 (6) | -0.0001 (7) | 0.0055 (7) |
| C13 | 0.0435 (8) | 0.0303 (7) | 0.0352 (8) | 0.0101 (6) | 0.0008 (6) | 0.0064 (6) |
| C14 | 0.0477 (9) | 0.0267 (7) | 0.0429 (9) | -0.0032 (6) | 0.0018 (7) | 0.0028 (6) |
| C15 | 0.0318 (7) | 0.0334 (7) | 0.0374 (8) | -0.0051 (6) | 0.0005 (6) | 0.0041 (6) |

Geometric parameters (\AA , $^\circ$)

| | | | |
|--------|-----------|---------|-----------|
| S1—O2 | 1.492 (1) | C6—C7 | 1.379 (2) |
| S1—C1 | 1.753 (1) | C6—H6 | 0.9500 |
| S1—C10 | 1.794 (1) | C8—C9 | 1.478 (2) |
| F1—C4 | 1.363 (2) | C9—H9A | 0.9800 |
| F2—C13 | 1.357 (2) | C9—H9B | 0.9800 |
| O1—C8 | 1.366 (2) | C9—H9C | 0.9800 |
| O1—C7 | 1.379 (2) | C10—C15 | 1.381 (2) |
| C1—C8 | 1.359 (2) | C10—C11 | 1.391 (2) |
| C1—C2 | 1.442 (2) | C11—C12 | 1.382 (2) |

| | | | |
|--------------|--------------|-----------------|--------------|
| C2—C7 | 1.393 (2) | C11—H11 | 0.9500 |
| C2—C3 | 1.395 (2) | C12—C13 | 1.376 (2) |
| C3—C4 | 1.375 (2) | C12—H12 | 0.9500 |
| C3—H3 | 0.9500 | C13—C14 | 1.371 (2) |
| C4—C5 | 1.387 (2) | C14—C15 | 1.389 (2) |
| C5—C6 | 1.385 (2) | C14—H14 | 0.9500 |
| C5—H5 | 0.9500 | C15—H15 | 0.9500 |
| O2—S1—C1 | 107.57 (6) | C1—C8—C9 | 132.66 (14) |
| O2—S1—C10 | 106.55 (7) | O1—C8—C9 | 116.41 (13) |
| C1—S1—C10 | 99.22 (6) | C8—C9—H9A | 109.5 |
| C8—O1—C7 | 106.51 (10) | C8—C9—H9B | 109.5 |
| C8—C1—C2 | 107.32 (12) | H9A—C9—H9B | 109.5 |
| C8—C1—S1 | 123.09 (10) | C8—C9—H9C | 109.5 |
| C2—C1—S1 | 129.30 (10) | H9A—C9—H9C | 109.5 |
| C7—C2—C3 | 119.53 (12) | H9B—C9—H9C | 109.5 |
| C7—C2—C1 | 104.67 (11) | C15—C10—C11 | 120.97 (13) |
| C3—C2—C1 | 135.77 (13) | C15—C10—S1 | 118.22 (11) |
| C4—C3—C2 | 115.84 (13) | C11—C10—S1 | 120.50 (11) |
| C4—C3—H3 | 122.1 | C12—C11—C10 | 119.48 (14) |
| C2—C3—H3 | 122.1 | C12—C11—H11 | 120.3 |
| F1—C4—C3 | 117.95 (13) | C10—C11—H11 | 120.3 |
| F1—C4—C5 | 117.26 (13) | C13—C12—C11 | 118.25 (14) |
| C3—C4—C5 | 124.79 (13) | C13—C12—H12 | 120.9 |
| C6—C5—C4 | 119.34 (13) | C11—C12—H12 | 120.9 |
| C6—C5—H5 | 120.3 | F2—C13—C14 | 118.64 (14) |
| C4—C5—H5 | 120.3 | F2—C13—C12 | 117.82 (14) |
| C7—C6—C5 | 116.56 (13) | C14—C13—C12 | 123.53 (14) |
| C7—C6—H6 | 121.7 | C13—C14—C15 | 117.92 (14) |
| C5—C6—H6 | 121.7 | C13—C14—H14 | 121.0 |
| C6—C7—O1 | 125.52 (12) | C15—C14—H14 | 121.0 |
| C6—C7—C2 | 123.92 (13) | C10—C15—C14 | 119.84 (14) |
| O1—C7—C2 | 110.55 (12) | C10—C15—H15 | 120.1 |
| C1—C8—O1 | 110.93 (12) | C14—C15—H15 | 120.1 |
| O2—S1—C1—C8 | -129.33 (12) | C1—C2—C7—O1 | -0.14 (14) |
| C10—S1—C1—C8 | 119.93 (12) | C2—C1—C8—O1 | 1.61 (15) |
| O2—S1—C1—C2 | 43.56 (14) | S1—C1—C8—O1 | 175.85 (9) |
| C10—S1—C1—C2 | -67.18 (13) | C2—C1—C8—C9 | -177.80 (14) |
| C8—C1—C2—C7 | -0.87 (14) | S1—C1—C8—C9 | -3.6 (2) |
| S1—C1—C2—C7 | -174.64 (10) | C7—O1—C8—C1 | -1.69 (15) |
| C8—C1—C2—C3 | 176.94 (15) | C7—O1—C8—C9 | 177.83 (12) |
| S1—C1—C2—C3 | 3.2 (2) | O2—S1—C10—C15 | 17.87 (13) |
| C7—C2—C3—C4 | -1.17 (19) | C1—S1—C10—C15 | 129.42 (12) |
| C1—C2—C3—C4 | -178.74 (14) | O2—S1—C10—C11 | -168.52 (11) |
| C2—C3—C4—F1 | -178.89 (12) | C1—S1—C10—C11 | -56.97 (13) |
| C2—C3—C4—C5 | 1.3 (2) | C15—C10—C11—C12 | -0.5 (2) |
| F1—C4—C5—C6 | 179.52 (13) | S1—C10—C11—C12 | -173.95 (12) |
| C3—C4—C5—C6 | -0.7 (2) | C10—C11—C12—C13 | 0.4 (2) |
| C4—C5—C6—C7 | -0.1 (2) | C11—C12—C13—F2 | 179.03 (14) |

supplementary materials

| | | | |
|-------------|--------------|-----------------|--------------|
| C5—C6—C7—O1 | 178.89 (12) | C11—C12—C13—C14 | -0.4 (3) |
| C5—C6—C7—C2 | 0.2 (2) | F2—C13—C14—C15 | -179.02 (14) |
| C8—O1—C7—C6 | -177.78 (13) | C12—C13—C14—C15 | 0.4 (2) |
| C8—O1—C7—C2 | 1.10 (14) | C11—C10—C15—C14 | 0.5 (2) |
| C3—C2—C7—C6 | 0.5 (2) | S1—C10—C15—C14 | 174.11 (12) |
| C1—C2—C7—C6 | 178.75 (13) | C13—C14—C15—C10 | -0.5 (2) |
| C3—C2—C7—O1 | -178.39 (11) | | |

Hydrogen-bond geometry (Å, °)

Cg is the centroid of the furan ring.

| <i>D</i> —H \cdots <i>A</i> | <i>D</i> —H | H \cdots <i>A</i> | <i>D</i> \cdots <i>A</i> | <i>D</i> —H \cdots <i>A</i> |
|-----------------------------------|-------------|---------------------|----------------------------|-------------------------------|
| C9—H9B \cdots O2 ⁱ | 0.98 | 2.45 | 3.200 (2) | 133. |
| C14—H14 \cdots O2 ⁱⁱ | 0.95 | 2.55 | 3.270 (2) | 133. |
| C15—H15 \cdots Cg ⁱⁱ | 0.95 | 2.98 | 3.828 (2) | 149. |

Symmetry codes: (i) $-x+3/2, y-1/2, z$; (ii) $-x+3/2, y+1/2, z$.

Fig. 1

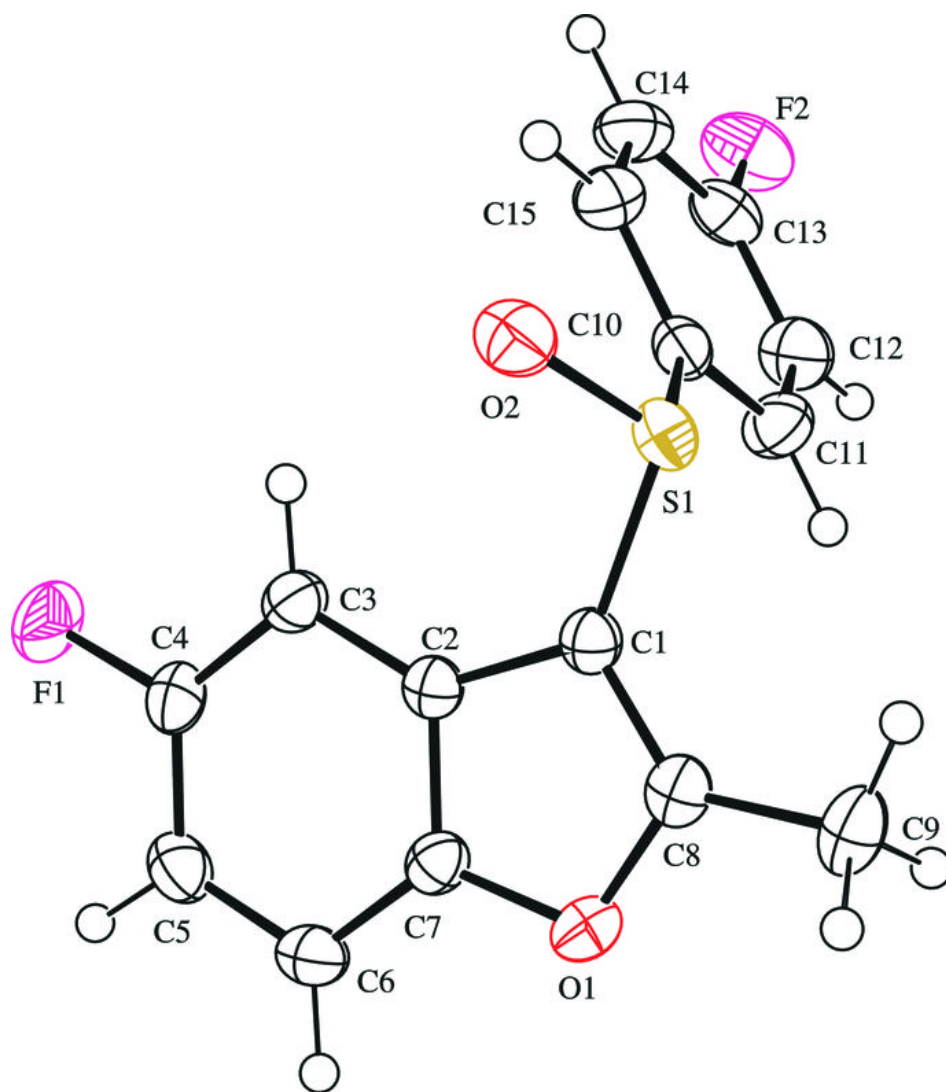


Fig. 2

