Crystal structure of 2-[(4-bromobenzyl)thio]-5-(5-bromothiophen-2-yl)-1,3,4-oxadiazole, $C_{13}H_8Br_2N_2OS_2$

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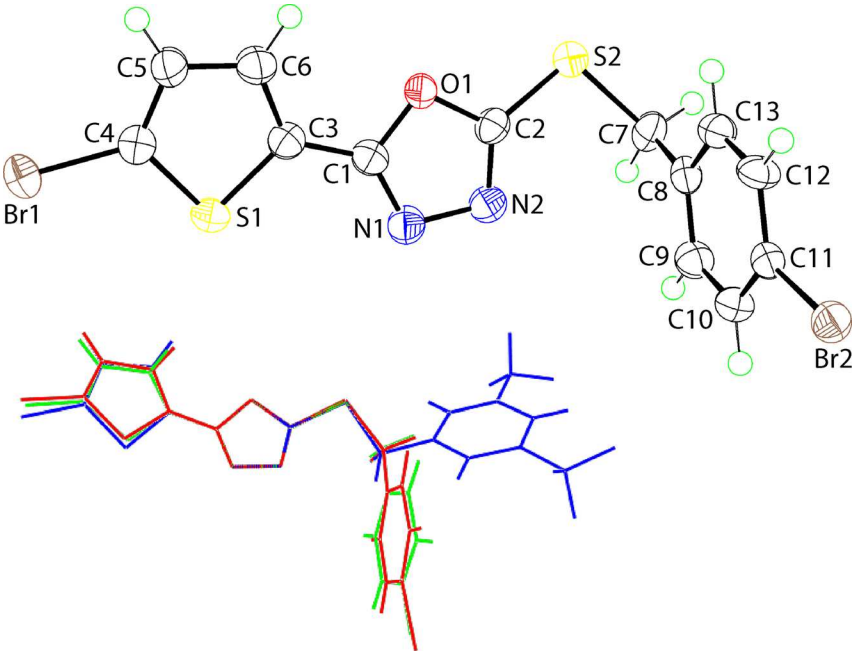

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Abstract

$C_{13}H_8Br_2N_2OS_2$, monoclinic, *Pc* (no. 7), a = 13.4050(4) Å, b = 4.7716(1) Å, c = 11.7303(4) Å, β = 105.885(3)°, V = 721.66(4) Å^3, Z = 2, $R_{gt}(F)$ = 0.0294, $wR_{ref}(F^2)$ = 0.0808, T = 160 K.

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Table 1: Data collection and handling.

Crystal:	Colourless plate
Size:	0.28 × 0.13 × 0.02 mm
Wavelength:	CuKα radiation (1.54184 Å)
μ:	9.80 mm^{-1}
Diffractometer, scan mode:	SuperNova,
θ_{max}, completeness:	74.4°, >99 %
$N(hkl)_{measured}$, $N(hkl)_{unique}$, R_{int}:	13,407, 2803, 0.031
Criterion for I_{obs}, $N(hkl)_{gt}$:	$I_{obs} > 2\sigma(I_{obs})$, 2778
$N(param)_{refined}$:	181
Programs:	CrysAlis^{Pro} [1], Shelx [2, 3], WinGX/Ortep [4]

Table 1 contains crystallographic data and Table 2 contains the list of the atoms including atomic coordinates and displacement parameters.

1 Source of material

A mixture of 5-(5-bromothiophen-2-yl)-1,3,4-oxadiazole-2-thiol (1.32 g, 5.0 mmol), 4-bromobenzyl bromide (1.25 g, 5.0 mmol) and anhydrous potassium carbonate (0.69 g, 5.0 mmol),

Table 2: Fractional atomic coordinates and isotropic or equivalent isotropic displacement parameters (Å^2).

Atom	*x*	*y*	*z*	U_{iso}*/U_{eq}
Br1	0.92814 (4)	−0.19744 (10)	0.89748 (4)	0.02809 (18)
Br2	0.07189 (3)	0.31074 (10)	0.10251 (4)	0.02696 (18)
S1	0.73153 (11)	0.1726 (3)	0.79808 (14)	0.0260 (3)
S2	0.52009 (10)	1.1099 (3)	0.40031 (12)	0.0251 (3)
O1	0.6360 (3)	0.7405 (8)	0.5411 (4)	0.0224 (7)
N1	0.5406 (3)	0.5644 (10)	0.6516 (4)	0.0269 (9)
N2	0.4800 (4)	0.7651 (11)	0.5729 (5)	0.0272 (9)
C1	0.6294 (4)	0.5567 (11)	0.6288 (5)	0.0226 (10)
C2	0.5401 (4)	0.8612 (12)	0.5114 (5)	0.0228 (9)
C3	0.7198 (4)	0.3877 (12)	0.6770 (5)	0.0233 (10)
C4	0.8511 (4)	0.0619 (10)	0.7885 (5)	0.0238 (10)
C5	0.8805 (5)	0.1814 (11)	0.6980 (6)	0.0282 (12)
H5	0.944134	0.142967	0.680130	0.034*
C6	0.8050 (5)	0.3693 (13)	0.6338 (6)	0.0279 (11)
H6	0.812297	0.473041	0.567425	0.033*
C7	0.3835 (4)	1.1834 (10)	0.3835 (6)	0.0264 (13)
H7A	0.372858	1.207674	0.463122	0.032*
H7B	0.365391	1.362691	0.340305	0.032*
C8	0.3109 (4)	0.9592 (10)	0.3185 (5)	0.0223 (10)
C9	0.2336 (5)	0.8537 (12)	0.3648 (5)	0.0258 (11)
H9	0.229283	0.915919	0.440269	0.031*
C10	0.1622 (5)	0.6576 (12)	0.3020 (5)	0.0263 (11)
H10	0.109364	0.586118	0.333922	0.032*
C11	0.1697 (4)	0.5697 (10)	0.1926 (5)	0.0223 (10)
C12	0.2475 (5)	0.6668 (12)	0.1455 (6)	0.0264 (12)
H12	0.252799	0.599779	0.071139	0.032*
C13	0.3175 (4)	0.8635 (13)	0.2086 (5)	0.0261 (10)
H13	0.370449	0.933436	0.176504	0.031*

in N,N-dimethylformamide (5.0 mL), was stirred at room temperature for 12 h. Water (10 mL) was then gradually added, and the mixture was stirred for further 10 min and allowed to stand for 1 h. The precipitated crude product was filtered, washed with cold water, dried and crystallised from ethanol/chloroform (2:1, v/v) to yield 1.99 g (92 %) of the title compound (I) as colourless, transparent plates. **M.pt**: 399–401 K. **^{1}H NMR (DMSO-d$_6$, 700.17 MHz)**: δ 4.54 (s, 2H, CH_2), 7.44–7.45 (m, 3H, 2 Ar–H & 1 Thiophene–H), 7.54 (d, 2H, Ar–H, J = 8.0 Hz), 7.63 (d, 1H, Thiophene–H, J = 3.0 Hz). **^{13}C NMR (DMSO-d$_6$, 176.06 MHz)**: δ 35.56 (CH_2), 117.85, 125.79, 131.59, 132.68 (Thiophene–C), 121.46, 131.78, 131.93, 136.69 (Ar–C), 160.89, 163.34 (Oxadiazole–C). **ESI–MS, m/z (Rel. Int.)**: 430.6 [M + H, 44 %]$^+$, 432.6 [M$^+$ + 2 + H, 100]$^+$, 434.6 [M$^+$ + 4 + H, 26 %]$^+$.

2 Experimental details

The C-bound H atoms were geometrically placed (C–H = 0.95–0.99 Å) and refined as riding with U_{iso}(H) = 1.2 U_{eq}(C). Owing to poor agreement, three reflections, i.e. (12 1 6), (11 1 7) and (11 0 8), were omitted from the final cycles of refinement. The absolute structure was determined based on differences in Friedel pairs included in the data set.

3 Comment

The 1,3,4–oxadiazole nucleus is a biologically-important heterocycle that has numerous and diverse biological activities [5, 6]. Thus, the chemotherapeutic activities of 1,3,4-oxadiazole derivatives are well-established as anti-cancer [7], anti-microbial [8] and anti-viral [9] agents. In addition, the thiophene nucleus represents a crucial motif in several anti-cancer agents [10]. With the above in mind, in the present study, the synthesis and single crystal X-ray characteristics of the title 1,3,4-oxadiazole-thiophene hybrid derivative (I, systematic name: 2-{ [(4-bromophenyl)methyl]sulfanyl}-5-(5-bromothiophen-2-yl)-1,3,4-oxadiazole) are reported.

The molecular structure of (I) comprises a central 1,3,4-oxadiazole ring C1-connected to a 2-thienyl ring and C2-connected to a thioether–S atom, as shown in the upper image of the figure (70 % probability ellipsoids). Within the oxadiazole ring, the C–O bonds are experimentally equivalent to each other [C1–O1 = 1.373(7) Å and C2–O1 = 1.364(6) Å] as are the formally C = N double bonds [C1 = N1 = 1.291 (7) Å and C2 = N2 = 1.304(8) Å]; the N1–N2 bond length = 1.421(7) Å. A twist is noted between the oxadiazole and 2-thienyl rings with a dihedral angle of 8.8 (4)°. A near to perpendicular relationship is noted between the oxadiazole and phenyl rings as they form a dihedral angle of 81.53 (17)°; the dihedral angle between the outer rings is 81.99 (16)°. The L-shaped molecule arises from the *syn-clinal* conformation of the C2–S2–C7–C8 torsion angle, i.e. −75.5 (5)°.

There are two closely related derivatives in the literature which differ only in their substitution patterns in the phenyl ring, namely, the 4–F [11] and 3,5–CF_3 [12] derivatives, hereafter (II) and (III), respectively. With the exception of the substituted phenyl rings, the conformations are closely related as evident from the overlay diagram shown in the image; (II) green image and (III) blue image. The obvious difference between the molecular conformations relate to the relative disposition of the phenyl rings. While the dihedral angles between the oxadiazole and phenyl rings are similar for both molecules, i.e. for (II) and (III) the dihedral angles are 76.4 (2)° and 81.4 (2)°, respectively, and resemble that in (I), the C2–S2–C7–C8 torsion angles are − 74.8(7) and 174.9 (5)°, respectively, consistent with-syn-clinal and +anti-periplanar conformations, respectively.

The molecular packing features a number of directional interactions between molecules. The presence of phenyl–C–H···N(oxadiazole) contacts [C13–H13···N2^i: H13···N2^i = 2.58 Å,

C13···N2^{i} = 3.510(8) Å with angle at H13 = 165° for symmetry operation (i): $x, 2-y, -1/2+z$] is noted within supramolecular layers in the *bc*-plane. The layers are consolidated by methylene–C–H···π(phenyl) [C7–H7b···Cg(C8–C13)^{ii}: H7b···Cg(C8–C13)^{ii} = 2.55 Å with angle at H7b = 153° for (ii): $x, 1+y, z$] and side-on C–Br···π(thienyl and phenyl) [C4–Br1···Cg(S1,C3–C6)^{iii}: Br1···Cg(S1,C3–C6)^{iii} = 3.575(2) Å with angle at Br1 = 90.64(16)° and C11–Br2···Cg(C8–C13)^{iii}: Br2···Cg(C8–C13)^{iii} = 3.599(2) Å with angle at Br2 = 87.31(16)° for (iii) $x, -1+y, z$] interactions. The primary interactions between layers along the *a*-axis are Br···Br contacts [Br1···Br2^{iv} = 3.5310(7) Å and Br1···Br2^{v} = 3.5834(7) Å for (iv): $1+x, -1+y, 1+z$ and (v): $1+x, y, 1+z$] which associate in a zigzag pattern along the *b*-axis. The C–Br···Br angles associated with the shorter of the contacts are phenyl–C11^{iv}–Br2^{iv}···Br1 = 96.41(16)° and thienyl–C4–Br1···Br2^{iv} = 179.62(16)°, and for the longer contact: thienyl–C4–Br1···Br2^{v} = 96.07(16)° and C11^{v}–Br2^{v}···Br1 = 167.59(16)°.

In order to understand in more detail the role of the directional interactions involving the bromide atoms upon the molecular packing in (I), the Hirshfeld surfaces and two-dimensional fingerprint plots were calculated using CrystalExplorer [13] and published methods [14]. Calculated Hirshfeld surface contacts involving H amount to 65.4 % of all contacts, indicating significant contributions from other surface contacts. Among the contacts involving H, the most significant contribution of 20.5 % arises from Br···H/H···Br contacts followed by H···H contacts of 17.6 %. Other contacts involving H are: C···H/H···C [12.0 %], N···H/H···N [10.8 %] and S···H/H···S [4.5 %]. Of the other Hirshfeld surface contacts, Br···C/C···Br contacts [7.0 %] are the most dominant followed by S···O/O···S [5.0 %] and Br···Br [4.3 %]. Notable contributions to the surface contacts are also made by S···N/S···N [4.3 %], S···C/C···S [3.9 %], C···C [3.3 %] and O···C/C···O [2.7 %] contacts but at separations beyond the respective sums of the van der Waals radii.

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