research communications

Crystal structure of 1-[3,5-bis(trifluoromethyl)-phenyl]-2-bromoethan-1-one

Sandeep Chandrashekharappa,[a] Keshab M. Bairagi,[b] Mahendra K. Mohan,[a] Viresh Mohanlall,[c] Kabange Kasumbwe,[c] Katharigatta N. Venugopala[c]* and Susanta K. Nayak[b]*

[a]Institute for Stem Cell Biology and Regenerative Medicine (inStem), GKVK Campus, Bellary Road, Bangalore 560 065, Karnataka, India, [b]Department of Chemistry, Visvesvaraya National Institute of Technology, Nagpur 440010, Maharashtra, India, and [c]Department of Biotechnology and Food Technology, Faculty of Applied Science, Durban University of Technology, Durban 4001, South Africa. *Correspondence e-mail: katharigattav@dut.ac.za, sknayak@chm.vnit.ac.in

The title compound, $C_{10}H_5BrF_6O$, synthesized *via* continuous stirring of 3,5-bis(trifluoromethyl) acetophenone with bromine in an acidic medium and concentrated under reduced pressure, crystallizes with four molecules in the unit cell ($Z = 4$) and one formula unit in the asymmetric unit. In the crystal, molecules are linked in a head-to-tail fashion into dimers along the *b*-axis direction through weak C—H···Br and C—O···Csp^2 interactions. C—H···O, C—F···π and F···F interactions are also observed.
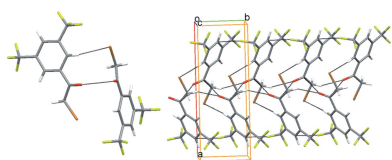
1. Chemical context

Substituted phenacyl bromides can be achieved by α-bromination of substituted ketones employing suitable bromination reagents such as molecular bromine (Curran & Chang, 1989), copper bromide (King & Ostrum, 1964), *N*-bromosuccinimide (Tanemura *et al.*, 2004), 3-methylimidazolium tribromide (Chiappe *et al.*, 2004) and hydrogen bromide (Podgoršek *et al.*, 2009). In our previous communications, we tried to develop intermediates (Chopra *et al.*, 2007) for the construction of biologically active heterocyclic compounds (Kasumbwe *et al.*, 2017). In this context, the title compound serves as a synthetic precursor and finds application in the construction of pharmacologically active heterocyclic compounds (Venugopala *et al.*, 2018, 2007).

2. Structural commentary

A displacement ellipsoid plot of the title compound with the atom labelling is shown in Fig. 1. The compound crystallizes in the monoclinic space group $P2_1/c$ with one molecule in the asymmetric unit and four molecules in the unit cell ($Z = 4$). The torsion angle between the alkyl bromide unit and the
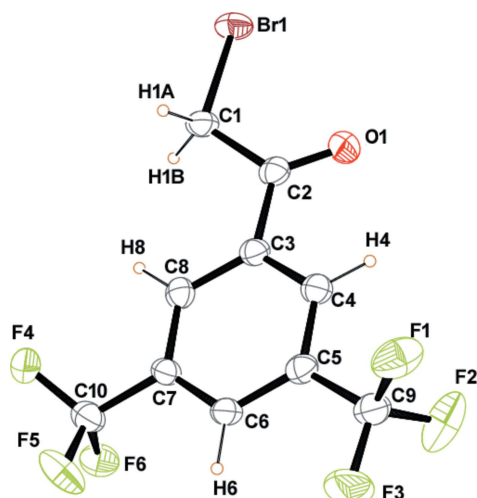
Figure 1
The asymmetric unit of the title compound, with 50% probability ellipsoids.

Table 1
Hydrogen-bond geometry (Å, °).

D—H⋯A	D—H	H⋯A	D⋯A	D—H⋯A
C1—H1A⋯O1[i]	0.99	2.57	3.501 (5)	157
C1—Br1⋯H4[ii]	1.92 (1)	2.94 (11)	3.882	169
C2—O1⋯C2[iii]	1.20 (1)	3.05 (1)	4.126	149 (1)
C9—F2⋯π[iv]	1.32 (1)	3.89	4.848	130

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

phenyl ring (C3—C2—C1—Br1) is −179.6 (3)° whereas that between the alkyl bromide and carbonyl parts (O1—C2—C1—Br1) is 0.3 (5)°, which shows a preference for a *syn* orientation of the alkyl bromide unit with respect to the carbonyl group.

3. Supramolecular features

In the crystal, the molecules are arranged in a head-to-tail fashion, forming dimers sustained by C—Br⋯H and >C=O⋯π(>C=O) (O⋯π = 3.252 Å) interactions. The dimers are linked along the *c*-axis direction by C—H⋯O and C—F⋯π interactions (Table 1, Fig. 2). The assembly of dimers is further extended along the *a*-axis direction by F1⋯F4($x, \frac{3}{2} - y, \frac{1}{2} + z$) [2.868 (4) Å] interactions, resulting in a bilayer which further packs in parallel fashion along the a-axis direction (Fig. 3).

4. Database survey

There are more than 1000 crystal structure of phenyl ethanone derivatives in the Cambridge Structural Database (CSD) (Conquest Version 1.17; Groom *et al.*, 2016) but none of them gave a hit for 1-[3,5-bis(trifluoromethyl)phenyl]-2-bromo-
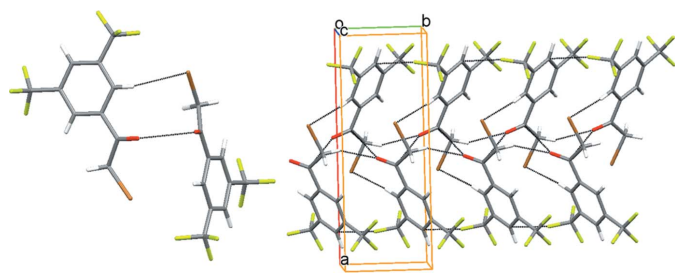
ethanone. However, the crystal structures of related derivatives have been reported. These include phenyl 2-bromoethanone (URELEJ; Betz *et al.*, 2011) and a phenyl 2-bromoethanone complex (VIVFIP; Laube *et al.*, 1991). The first compound, $Z = 4$, features two prominent hydrogen bonds involving the oxygen atom while in the second, also $Z = 4$, the oxygen atom forms a complex with antimony pentachloride.

5. Synthesis and crystallization

A stirred solution of 3,5-bis(trifluoromethyl) acetophenone (0.5 g, 1.95 mmol) in acetic acid (5 mL) was added dropwise to bromine (0.312 g, 1.95 mmol) in acetic acid. The reaction medium was stirred at room temperature for 5 h. To the resulting mixture, water (5 mL) was added and the mixture was concentrated under reduced pressure. The residue

Figure 2
Dimer assembled through C—H⋯Br and >C=O⋯π(>C=O) interactions (left) and dimers extending along the *b*-axis direction *via* C—H⋯O and C—F⋯π interactions (Table 1).
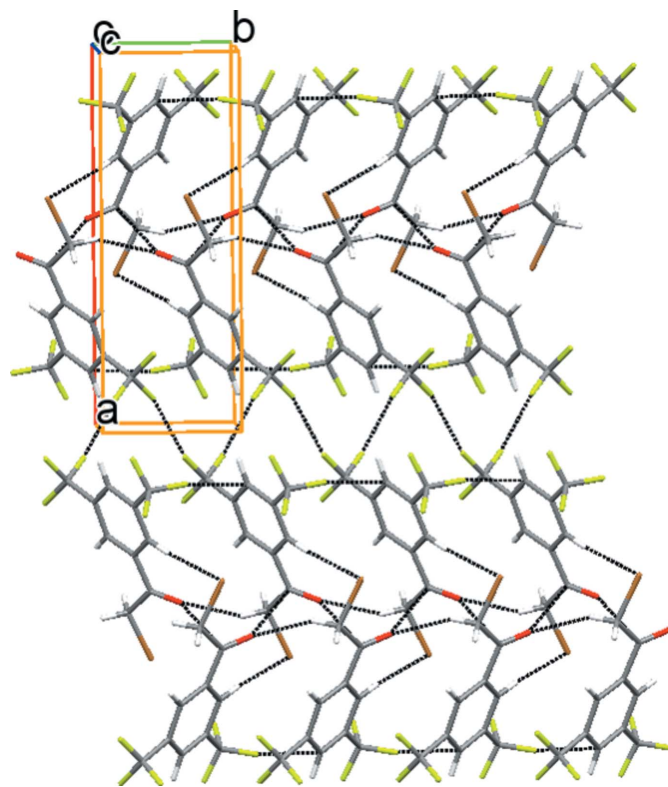

Figure 3
F⋯F interactions resulting in a bilayer that packs in a parallel fashion along the *a*-axis direction.

obtained was diluted with ethylacetate (10 mL), the organic layer washed with water (10 mL) and a sodium bicarbonate solution (5 mL), and filtered through dried sodium sulfate and evaporated to obtain 1-(3,5-bis(trifluoromethyl)phenyl)-2-bromoethanone as a light-yellow solid in 62% yield. m.p: 317–318 K. ^{1}H NMR: (CDCl$_3$, 600 MHz): 8.44 (2H, s), 8.13 (1H, s), 4.48 (2H, s); ^{13}C NMR: (CDCl$_3$, 150 MHz): 188.81, 135.31, 133.06, 132.83, 132.60, 128.99, 127.08, 127.06, 125.42, 123.61, 121.80, 120.00, 29.46.

6. Refinement

Crystal data, data collection and structure refinement details are summarized in Table 2. Hydrogen atoms were placed in idealized positions (C—H = 0.95–0.99 Å) and refined using a riding model with U_{iso}(H) = 1.2–1.5U_{eq}(C).

References

Betz, R., McCleland, C. & Marchand, H. (2011). *Acta Cryst.* E**67**, o1207.
Bruker (2012). *APEX2*, *SAINT* and *SADABS*, Bruker AXS Inc., Madison, Wisconsin, USA.
Chiappe, C., Leandri, E. & Pieraccini, D. (2004). *Chem. Commun.* pp. 2536–2537.
Chopra, D., Venugopala, K. N. & Rao, G. K. (2007). *Acta Cryst.* E**63**, o4872.
Curran, D. P. & Chang, C. T. (1989). *J. Org. Chem.* **54**, 3140–3157.
Groom, C. R., Bruno, I. J., Lightfoot, M. P. & Ward, S. C. (2016). *Acta Cryst.* B**72**, 171–179.
Kasumbwe, K., Venugopala, K. N., Mohanlall, V. & Odhav, B. (2017). *Anticancer Agents Med. Chem.* **17**, 276–285.
King, L. C. & Ostrum, G. K. (1964). *J. Org. Chem.* **29**, 3459–3461.
Laube, T., Weidenhaupt, A. & Hunziker, R. (1991). *J. Am. Chem. Soc.* **113**, 2561–2567.
Macrae, C. F., Bruno, I. J., Chisholm, J. A., Edgington, P. R., McCabe, P., Pidcock, E., Rodriguez-Monge, L., Taylor, R., van de Streek, J. & Wood, P. A. (2008). *J. Appl. Cryst.* **41**, 466–470.
Nardelli, M. (1995). *J. Appl. Cryst.* **28**, 659.
Podgoršek, A., Jurisch, M., Stavber, S., Zupan, M., Iskra, J. & Gladysz, J. A. (2009). *J. Org. Chem.* **74**, 3133–3140.
Sheldrick, G. M. (2008). *Acta Cryst.* A**64**, 112–122.
Sheldrick, G. M. (2015). *Acta Cryst.* C**71**, 3–8.
Spek, A. L. (2009). *Acta Cryst.* D**65**, 148–155.
Tanemura, K., Suzuki, T., Nishida, Y., Satsumabayashi, K. & Horaguchi, T. (2004). *Chem. Commun.* pp. 470–471.
Venugopala, K. N. (2018). *Asian J. Chem.* **30**, 684–688.
Venugopala, K. N., Rao, G. K., Pal, P. N. S. & Ganesh, G. L. (2007). *Orient. J. Chem.* **23**, 1093–1096.

Table 2
Experimental details.

Crystal data	
Chemical formula	$C_{10}H_5BrF_6O$
M_r	335.04
Crystal system, space group	Monoclinic, $P2_1/c$
Temperature (K)	153
a, b, c (Å)	14.156 (5), 5.0111 (16), 15.535 (5)
β (°)	104.316 (5)
V (Å^3)	1067.7 (6)
Z	4
Radiation type	Mo $K\alpha$
μ (mm^{-1})	3.92
Crystal size (mm)	0.23 × 0.09 × 0.06
Data collection	
Diffractometer	Bruker Kappa APEXII DUO
Absorption correction	Multi-scan (*SADABS*; Bruker, 2012)
T_{min}, T_{max}	0.442, 0.759
No. of measured, independent and observed [$I > 2\sigma(I)$] reflections	11628, 2405, 1741
R_{int}	0.060
$(\sin \theta/\lambda)_{max}$ (Å^{-1})	0.646
Refinement	
$R[F^2 > 2\sigma(F^2)]$, $wR(F^2)$, S	0.041, 0.103, 1.03
No. of reflections	2405
No. of parameters	163
H-atom treatment	H-atom parameters constrained
$\Delta\rho_{max}$, $\Delta\rho_{min}$ (e Å^{-3})	0.78, −1.12

Computer programs: *APEX2* and *SAINT* (Bruker, 2012), *SHELXS* (Sheldrick, 2008), *SHELXL2014* (Sheldrick, 2015), *Mercury* (Macrae *et al.*, 2008), *PLATON* (Spek, 2009) and *PARST* (Nardelli, 1995).

Crystal structure of 1-[3,5-bis(trifluoromethyl)phenyl]-2-bromoethan-1-one

Sandeep Chandrashekharappa, Keshab M. Bairagi, Mahendra K. Mohan, Viresh Mohanlall, Kabange Kasumbwe, Katharigatta N. Venugopala and Susanta K. Nayak

Computing details

Data collection: *APEX2* (Bruker, 2012); cell refinement: *SAINT* (Bruker, 2012); data reduction: *SAINT* (Bruker, 2012); program(s) used to solve structure: *SHELXS* (Sheldrick, 2008); program(s) used to refine structure: *SHELXL2014* (Sheldrick, 2015); molecular graphics: *Mercury* (Macrae *et al.*, 2008); software used to prepare material for publication: *PLATON* (Spek, 2009) and *PARST* (Nardelli, 1995).

1-[3,5-Bis(trifluoromethyl)phenyl]-2-bromoethan-1-one

Crystal data

$C_{10}H_5BrF_6O$	$F(000) = 648$
$M_r = 335.04$	$D_x = 2.084$ Mg m^{-3}
Monoclinic, $P2_1/c$	Mo $K\alpha$ radiation, $\lambda = 0.71073$ Å
Hall symbol: -P 2ybc	Cell parameters from 2405 reflections
$a = 14.156$ (5) Å	$\theta = 2.7–27.4°$
$b = 5.0111$ (16) Å	$\mu = 3.92$ mm^{-1}
$c = 15.535$ (5) Å	$T = 153$ K
$\beta = 104.316$ (5)°	Needle, colorless
$V = 1067.7$ (6) Å^3	$0.23 \times 0.09 \times 0.06$ mm
$Z = 4$	

Data collection

Bruker Kappa APEXII DUO diffractometer	11628 measured reflections
	2405 independent reflections
Radiation source: fine-focus sealed tube	1741 reflections with $I > 2\sigma(I)$
Graphite monochromator	$R_{int} = 0.060$
ω scans	$\theta_{max} = 27.4°$, $\theta_{min} = 2.7°$
Absorption correction: multi-scan (SADABS; Bruker, 2012)	$h = -18 \rightarrow 18$
	$k = -6 \rightarrow 6$
$T_{min} = 0.442$, $T_{max} = 0.759$	$l = -20 \rightarrow 20$

Refinement

Refinement on F^2	Secondary atom site location: difference Fourier map
Least-squares matrix: full	
$R[F^2 > 2\sigma(F^2)] = 0.041$	Hydrogen site location: inferred from neighbouring sites
$wR(F^2) = 0.103$	
$S = 1.03$	H-atom parameters constrained
2405 reflections	$w = 1/[\sigma^2(F_o^2) + (0.0541P)^2 + 0.3605P]$ where $P = (F_o^2 + 2F_c^2)/3$
163 parameters	
0 restraints	$(\Delta/\sigma)_{max} < 0.001$
Primary atom site location: structure-invariant direct methods	$\Delta\rho_{max} = 0.78$ e Å^{-3}
	$\Delta\rho_{min} = -1.12$ e Å^{-3}

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)

	x	*y*	*z*	U_{iso}*/U_{eq}
Br1	0.60416 (2)	0.14882 (9)	0.09433 (3)	0.03259 (16)
F1	0.21893 (17)	0.1990 (6)	0.38145 (15)	0.0468 (7)
F2	0.1420 (2)	−0.0983 (6)	0.29661 (17)	0.0597 (8)
F3	0.07527 (19)	0.2781 (7)	0.3050 (2)	0.0655 (9)
F4	0.19332 (17)	0.8957 (5)	0.00403 (18)	0.0480 (7)
F5	0.07651 (19)	0.8912 (5)	0.06942 (16)	0.0484 (7)
F6	0.07736 (15)	0.6137 (5)	−0.03417 (14)	0.0362 (6)
O1	0.45527 (18)	−0.0571 (6)	0.18612 (18)	0.0329 (6)
C1	0.4825 (2)	0.3126 (8)	0.0979 (3)	0.0278 (9)
H1A	0.4955	0.4921	0.1249	0.033*
H1B	0.4423	0.3352	0.0365	0.033*
C2	0.4258 (3)	0.1506 (8)	0.1506 (2)	0.0258 (8)
C3	0.3301 (2)	0.2646 (8)	0.1557 (2)	0.0237 (8)
C4	0.2889 (3)	0.1673 (8)	0.2217 (2)	0.0264 (8)
H4	0.3218	0.0353	0.2620	0.032*
C5	0.1991 (2)	0.2642 (8)	0.2285 (2)	0.0255 (8)
C6	0.1483 (2)	0.4474 (8)	0.1686 (2)	0.0259 (8)
H6	0.0857	0.5070	0.1722	0.031*
C7	0.1901 (2)	0.5434 (8)	0.1028 (2)	0.0239 (8)
C8	0.2806 (3)	0.4557 (8)	0.0968 (2)	0.0255 (8)
H8	0.3091	0.5261	0.0524	0.031*
C9	0.1583 (3)	0.1609 (9)	0.3022 (3)	0.0313 (9)
C10	0.1348 (3)	0.7374 (9)	0.0362 (3)	0.0308 (9)

Atomic displacement parameters (Å²)

	U^{11}	U^{22}	U^{33}	U^{12}	U^{13}	U^{23}
Br1	0.0200 (2)	0.0386 (3)	0.0398 (3)	0.00282 (17)	0.00868 (15)	−0.0043 (2)
F1	0.0405 (14)	0.072 (2)	0.0306 (13)	−0.0144 (13)	0.0130 (11)	−0.0053 (12)
F2	0.093 (2)	0.044 (2)	0.0531 (17)	−0.0302 (15)	0.0394 (16)	−0.0108 (13)
F3	0.0370 (14)	0.094 (2)	0.077 (2)	0.0245 (15)	0.0356 (14)	0.0359 (17)
F4	0.0332 (13)	0.0366 (17)	0.0686 (18)	−0.0044 (11)	0.0020 (12)	0.0237 (13)
F5	0.0500 (14)	0.0464 (18)	0.0440 (14)	0.0282 (13)	0.0024 (11)	−0.0025 (12)
F6	0.0292 (11)	0.0432 (17)	0.0324 (12)	−0.0001 (10)	0.0005 (9)	−0.0029 (10)
O1	0.0285 (14)	0.0294 (18)	0.0420 (16)	0.0055 (12)	0.0109 (12)	0.0065 (13)
C1	0.0188 (16)	0.029 (3)	0.036 (2)	0.0010 (15)	0.0074 (15)	−0.0008 (17)
C2	0.0235 (17)	0.023 (2)	0.030 (2)	−0.0036 (16)	0.0046 (14)	−0.0040 (17)
C3	0.0203 (17)	0.023 (2)	0.028 (2)	−0.0016 (15)	0.0056 (15)	−0.0021 (16)
C4	0.0237 (17)	0.022 (2)	0.032 (2)	−0.0005 (15)	0.0052 (15)	−0.0020 (16)

C5	0.0230 (18)	0.025 (2)	0.028 (2)	−0.0036 (15)	0.0061 (15)	−0.0023 (16)
C6	0.0189 (16)	0.025 (2)	0.034 (2)	0.0007 (15)	0.0056 (15)	−0.0002 (17)
C7	0.0190 (16)	0.021 (2)	0.029 (2)	0.0009 (14)	0.0017 (14)	−0.0010 (16)
C8	0.0274 (18)	0.021 (2)	0.028 (2)	−0.0007 (15)	0.0071 (15)	−0.0012 (16)
C9	0.0253 (18)	0.032 (3)	0.037 (2)	−0.0022 (17)	0.0085 (16)	−0.0016 (18)
C10	0.0263 (19)	0.029 (2)	0.034 (2)	0.0032 (17)	0.0013 (16)	−0.0008 (18)

Geometric parameters (Å, º)

Br1—C1	1.921 (4)	C3—C4	1.388 (5)
F1—C9	1.329 (4)	C3—C8	1.389 (5)
F2—C9	1.319 (5)	C4—C5	1.388 (5)
F3—C9	1.325 (4)	C4—H4	0.9500
F4—C10	1.330 (5)	C5—C6	1.377 (5)
F5—C10	1.324 (5)	C5—C9	1.497 (5)
F6—C10	1.343 (4)	C6—C7	1.388 (5)
O1—C2	1.203 (5)	C6—H6	0.9500
C1—C2	1.516 (5)	C7—C8	1.378 (5)
C1—H1A	0.9900	C7—C10	1.492 (5)
C1—H1B	0.9900	C8—H8	0.9500
C2—C3	1.490 (5)		
C2—C1—Br1	112.7 (3)	C7—C6—H6	120.6
C2—C1—H1A	109.1	C8—C7—C6	120.8 (3)
Br1—C1—H1A	109.1	C8—C7—C10	119.9 (3)
C2—C1—H1B	109.1	C6—C7—C10	119.3 (3)
Br1—C1—H1B	109.1	C7—C8—C3	120.1 (3)
H1A—C1—H1B	107.8	C7—C8—H8	119.9
O1—C2—C3	121.6 (3)	C3—C8—H8	119.9
O1—C2—C1	122.7 (3)	F2—C9—F3	107.2 (3)
C3—C2—C1	115.7 (3)	F2—C9—F1	105.4 (3)
C4—C3—C8	119.5 (3)	F3—C9—F1	106.3 (3)
C4—C3—C2	117.3 (3)	F2—C9—C5	112.7 (3)
C8—C3—C2	123.1 (3)	F3—C9—C5	112.7 (3)
C5—C4—C3	119.5 (4)	F1—C9—C5	112.1 (3)
C5—C4—H4	120.2	F5—C10—F4	107.8 (4)
C3—C4—H4	120.2	F5—C10—F6	106.0 (3)
C6—C5—C4	121.2 (3)	F4—C10—F6	106.1 (3)
C6—C5—C9	120.8 (3)	F5—C10—C7	112.4 (3)
C4—C5—C9	118.0 (4)	F4—C10—C7	112.4 (3)
C5—C6—C7	118.8 (3)	F6—C10—C7	111.8 (3)
C5—C6—H6	120.6		
Br1—C1—C2—O1	0.3 (5)	C10—C7—C8—C3	−176.6 (4)
Br1—C1—C2—C3	−179.6 (3)	C4—C3—C8—C7	−1.4 (6)
O1—C2—C3—C4	17.6 (5)	C2—C3—C8—C7	176.9 (3)
C1—C2—C3—C4	−162.5 (3)	C6—C5—C9—F2	117.1 (4)
O1—C2—C3—C8	−160.8 (4)	C4—C5—C9—F2	−62.1 (5)

C1—C2—C3—C8	19.1 (5)	C6—C5—C9—F3	−4.4 (6)
C8—C3—C4—C5	−0.6 (6)	C4—C5—C9—F3	176.5 (4)
C2—C3—C4—C5	−179.0 (3)	C6—C5—C9—F1	−124.2 (4)
C3—C4—C5—C6	2.7 (6)	C4—C5—C9—F1	56.6 (5)
C3—C4—C5—C9	−178.1 (3)	C8—C7—C10—F5	−151.0 (4)
C4—C5—C6—C7	−2.7 (6)	C6—C7—C10—F5	30.9 (5)
C9—C5—C6—C7	178.2 (3)	C8—C7—C10—F4	−29.3 (5)
C5—C6—C7—C8	0.5 (6)	C6—C7—C10—F4	152.6 (4)
C5—C6—C7—C10	178.7 (4)	C8—C7—C10—F6	89.9 (4)
C6—C7—C8—C3	1.5 (6)	C6—C7—C10—F6	−88.2 (4)

Hydrogen-bond geometry (Å, º)

D—H$\cdots A$	D—H	H$\cdots A$	$D\cdots A$	D—H$\cdots A$
C1—H1$A\cdots$O1[i]	0.99	2.57	3.501 (5)	157
C1—Br1$\cdots$H4[ii]	1.92 (1)	2.94 (11)	3.882	169
C2—O1$\cdots$C2[iii]	1.20 (1)	3.05 (1)	4.126	149 (1)
C9—F2$\cdots\pi$[iv]	1.32 (1)	3.89	4.848	130

Symmetry codes: (i) x, y+1, z; (ii) −x+1, y+1/2, −z+1/2; (iii) −x+1, y−1/2, −z+1/2; (iv) x, y−1, z.