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The crystal structure of 2-(4-((carbamimidoylthio)methyl)benzyl)isothiouronium hexafluorophosphate monohydrate, $C_{10}H_{17}F_6N_4OPS_2$

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Abstract

$C_{10}H_{17}F_6N_4OPS_2$, monoclinic, $P2_1/c$ (no. 14), $a = 13.0455(12)$ Å, $b = 12.6114(12)$ Å, $c = 10.7642(10)$ Å, $\beta = 99.546(8)^\circ$, $V = 1746.4(3)$ Å³, $Z = 4$, $R_{gt}(F) = 0.0425$, $wR_{ref}(F^2) = 0.1173$, $T = 150$ K.

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The asymmetric unit of the title structure is shown in the figure. Table 1 contains crystallographic data and Table 2 contains the list of the atoms including atomic coordinates and displacement parameters.

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Table 1: Data collection and handling.

Crystal:	Colorless prism
	Size $0.41 \times 0.37 \times 0.25$ mm
Wavelength:	Cu K α radiation (1.5418 Å)
μ :	4.29 mm ⁻¹
Diffractometer, scan mode:	Xcalibur, ω
θ_{max} , completeness:	77.8°, 99%
$N(hkl)_{measured}$, $N(hkl)_{unique}$, R_{int} :	15,711, 3652, 0.042
Criterion for I_{obs} , $N(hkl)_{gt}$:	$I_{obs} > 2 \sigma(I_{obs})$, 3093
$N(param)_{refined}$:	261
Programs:	CRYSAALIS ^{PRO} [1], SUPERFLIP [2], JANA2006 [3], DIAMOND [4]

Source of material

The solution of thiourea (0.63 g, 8.33 mmol) in ethanol (50 mL) was heated to reflux. To this solution 1,4-bis(bromomethyl)benzene (1.00 g, 3.78 mmol) was added. The heating continued for 50 min, then the mixture was allowed to cool to room temperature. The resulting crystals were filtered off, washed with hexane

Table 2: Fractional atomic coordinates and isotropic or equivalent isotropic displacement parameters (Å²).

Atom	x	y	z	U_{iso}^*/U_{eq}
S1	0.41813 (4)	0.12832 (4)	1.02025 (5)	0.02515 (15)
S2	0.12109 (4)	0.41067 (5)	0.43485 (5)	0.03245 (17)
O1w	0.3599 (2)	0.91493 (19)	0.2163 (3)	0.0612 (9)
N1	0.52470 (14)	0.05921 (15)	1.22986 (16)	0.0252 (5)
N2	0.61464 (15)	0.17645 (17)	1.12547 (18)	0.0308 (5)
N3	0.03372 (15)	0.46666 (18)	0.20929 (18)	0.0318 (5)
N4	−0.06054 (15)	0.34561 (19)	0.30126 (18)	0.0322 (5)
C1	0.34751 (16)	0.25763 (17)	0.82646 (18)	0.0241 (5)
C2	0.28882 (17)	0.34897 (18)	0.83177 (19)	0.0270 (6)
C3	0.20163 (17)	0.36718 (17)	0.7409 (2)	0.0272 (6)
C4	0.17224 (15)	0.29423 (17)	0.64494 (18)	0.0243 (5)
C5	0.22993 (18)	0.20180 (18)	0.64130 (19)	0.0280 (6)
C6	0.31726 (18)	0.18424 (18)	0.7315 (2)	0.0294 (6)
C7	0.44451 (18)	0.2392 (2)	0.9218 (2)	0.0338 (6)
C8	0.53010 (15)	0.12252 (15)	1.13325 (18)	0.0209 (5)
C9	0.07977 (17)	0.3147 (2)	0.5435 (2)	0.0328 (6)
C10	0.02186 (16)	0.40545 (18)	0.30522 (19)	0.0256 (6)
H1c2	0.308437	0.399485	0.898172	0.0324*
H1c3	0.161524	0.4306	0.744467	0.0327*
H1c5	0.209275	0.150221	0.576376	0.0335*
H1c6	0.357174	0.120661	0.728167	0.0353*
H1c7	0.459561	0.301362	0.973066	0.0406*
H2c7	0.501045	0.22124	0.878919	0.0406*
H1c9	0.024192	0.344322	0.580718	0.0393*
H2c9	0.059543	0.249931	0.499397	0.0393*
H1n1 ^a	0.5762 (17)	0.057 (3)	1.291 (2)	0.0303*
H2n1 ^b	0.471 (2)	0.020 (3)	1.231 (4)	0.0303*
H1n2 ^c	0.6680 (16)	0.170 (3)	1.184 (2)	0.0369*
H2n2 ^d	0.617 (3)	0.218 (2)	1.063 (2)	0.0369*
H1n3 ^a	−0.012 (2)	0.462 (3)	0.1418 (19)	0.0381*
H2n3 ^e	0.0919 (17)	0.499 (3)	0.212 (4)	0.0381*
H1n4	−0.1101 (18)	0.346 (3)	0.238 (2)	0.0386*
H2n4 ^f	−0.073 (3)	0.314 (3)	0.367 (2)	0.0386*
H1o1w	0.337 (4)	0.865 (3)	0.170 (4)	0.0734*
H2o1w	0.337 (4)	0.909 (4)	0.282 (2)	0.0734*
P1a ^g	0.77735 (9)	0.12491 (10)	0.46082 (11)	0.02217 (15)
F1a ^g	0.8655 (2)	0.0294 (2)	0.5059 (2)	0.0357 (5)
F2a ^g	0.6866 (2)	0.21992 (19)	0.4160 (2)	0.0285 (5)
F3a ^g	0.6816 (2)	0.0345 (3)	0.4402 (3)	0.0358 (6)
F4a ^g	0.7611 (2)	0.1415 (3)	0.61192 (17)	0.0281 (5)
F5a ^g	0.7919 (2)	0.1098 (3)	0.30920 (17)	0.0403 (7)
F6a ^g	0.8708 (2)	0.2162 (2)	0.4827 (3)	0.0410 (6)
P1b ^h	0.7778 (6)	0.1269 (7)	0.4604 (8)	0.02217 (15)
F1b ^h	0.8479 (12)	0.0218 (13)	0.5213 (15)	0.0357 (5)
F2b ^h	0.7052 (12)	0.2323 (13)	0.4001 (16)	0.0285 (5)
F3b ^h	0.6671 (12)	0.0628 (13)	0.4723 (16)	0.0358 (6)
F4b ^h	0.7817 (11)	0.1768 (15)	0.6066 (9)	0.0281 (5)
F5b ^h	0.7724 (11)	0.0789 (15)	0.3135 (9)	0.0403 (7)
F6b ^h	0.8866 (12)	0.1927 (13)	0.4498 (15)	0.0410 (7)

^aOccupancy: 0.90(6), ^bOccupancy: 0.73(6), ^cOccupancy: 0.96(6),^dOccupancy: 0.87(6), ^eOccupancy: 0.81(6), ^fOccupancy: 0.82(15),^gOccupancy: 0.883(10), ^hOccupancy: 0.117(10).

and dried under reduced pressure resulting in yield of 1.34 g (85%) of 2,2'-(1,4-phenylenebis(methylene))diisothiouonium bromide. The reaction product was dissolved in water and mixed with water solution containing an equimolar amount of silver hexafluorophosphate; the resulting AgBr was filtered off. The filtrate was allowed to slowly evaporate, forming crystals of the title compound.

Experimental details

H atoms bonded to C were placed in calculated positions. H bonded to N and O were refined with restrained bond lengths (N–H = 0.86 Å, O–H = 0.82 Å). $U_{iso}(H) = 1.2U_{eq}(C, N, O)$. The H bonded to N of S-alkylthiourea and isothiouonium groups are disordered with only H1n4 fully localized occupancies of remaining hydrogen atoms were refined with a sum constrained to 6 to keep the electroneutrality of crystal structure. The hexafluorophosphate anion was found to be disordered over two positions. Molecular refinement without any restraints was used to model the disorder (see Table 2).

Comment

Thiourea derivatives are used in anion complexation for their ability to form hydrogen bonds in a specific pre-arranged manner [5]. Recently their cyostatic potential was studied with promising results [6].

The crystal structure of the title compound is depicted in the figure. The asymmetric unit consists of one 2-(4-((carbamimidoylthio)methyl)benzyl)isothiouonium cation, one hexafluorophosphate anion and one molecule of water. Significant differences were observed between the C–S bond lengths with C(meth)–S bond at 1.821(3) and 1.825(3) Å and C(iso)–S bond at 1.7405(19) and 1.740(2) Å. This difference is caused by electron delocalization within the isothiouonium groups. However, the delocalization is not complete, since very small differences between C–N bond lengths remain with the C–N(*s-cis*) bonds at 1.310(3) and 1.308(3) Å and C–N(*s-trans*) at 1.322(3) and 1.319(3) Å.

The crystal structure packing is controlled by hydrogen bonds, with isothiouonium groups forming seven N–H...F hydrogen bonds and one N–H...O hydrogen bond. The molecule of crystal water forms two O–H...F hydrogen bonds, connecting two hexafluorophosphate anions.

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References

1. Rigaku O. D. CRYSTALIS^{PRO}; Rigaku Oxford Diffraction Ltd: Yarnton, Oxfordshire, England, 2020.
2. Palatinus L., Chapuis G. SUPERFLIP – a computer program for the solution of crystal structures by charge flipping in arbitrary dimensions. *J. Appl. Crystallogr.* 2007, 40, 786–790.
3. Petricek V., Dusek M., Palatinus L. Crystallographic computing system JANA2006: general features. *Z. Kristallogr. – Cryst. Mater.* 2014, 229, 345–352.
4. Brandenburg K. DIAMOND; Crystal Impact GbR: Bonn, Germany, 1999.
5. Leung A. N., Degenhardt D. A., Bühlmann P. Effect of spacer geometry on oxoanion binding by bis- and tetrakis-thiourea hosts. *Tetrahedron* 2008, 64, 2530–2536.
6. Desai D., Madhunapantula S. V., Gowdahalli K., Sharma A., Chandagaludoreswamy R., El-Bayoumy K., Robertson G. P., Amin S. Synthesis and characterization of a novel iNOS/Akt inhibitor Se, Se'-1,4-phenylenebis(1,2-ethanediy)bisoselenourea (PBISe)—against colon cancer. *Bioorg. Med. Chem. Lett.* 2010, 20, 2038–2043.