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Crystal structure of ethyl-2-(3-benzoylthioureido)propanoate, $C_{13}H_{16}N_2O_3S$

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Abstract

$C_{13}H_{16}N_2O_3S$, triclinic, $P\bar{1}$ (no. 2), $a = 8.1998(4)$ Å, $b = 9.1320(4)$ Å, $c = 10.7062(6)$ Å, $\alpha = 106.183(5)^\circ$, $\beta = 111.506(5)^\circ$, $\gamma = 97.589(4)^\circ$, $V = 691.27(7)$ Å³, $Z = 2$, $R_{gt}(F) = 0.0346$, $wR_{ref}(F^2) = 0.0957$, $T = 293(2)$ K.

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The molecular structure is shown in the figure. Table 1 contains crystallographic data and Table 2 contains the list

Table 1: Data collection and handling.

Crystal:	Colourless plate
Size:	0.22 × 0.14 × 0.03 mm
Wavelength:	Cu K α radiation (1.54178 Å)
μ :	2.14 mm ⁻¹
Diffractometer, scan mode:	Oxford Diffraction Gemini, ω
θ_{max} , completeness:	71.3°, >99%
$N(hkl)_{measured}$, $N(hkl)_{unique}$, R_{int} :	13964, 2644, 0.026
Criterion for I_{obs} , $N(hkl)_{gt}$:	$I_{obs} > 2 \sigma(I_{obs})$, 2445
$N(param)_{refined}$:	182
Programs:	CrysAlis ^{PRO} [1], SHELX [2, 3], PLATON [4], Olex2 [5]

of the atoms including atomic coordinates and displacement parameters.

Source of material

Benzoyl chloride, ammonium thiocyanate, L-alanine, lanthanum(III) chloride and solvents were purchased and used without further purification.

The title compound (I) is an ester analogue of 2-(3-benzoylthioureido)propionic acid (II) [6]. In the first step, II was prepared as described by Ngah et al. [6]. Next, II was refluxed with $LaCl_3$ in ethanol for 17 h to yield the title compound. After cooling to room temperature, the solvent was reduced under atmospheric pressure. The crude product was extracted with water and dichloromethane to remove the catalyst ($LaCl_3$). The organic layer was dried over anhydrous $MgSO_4$, filtered and the solvent was removed *in vacuo*. It was recrystallised from an ethanol solution at room temperature to give colourless crystals suitable for single crystal X-ray diffraction. **Elem. Anal.:** Calc. for $C_{13}H_{16}N_2O_3S$: C = 55.70; H = 5.75; N = 9.99; S = 11.44%. Found: C = 55.54; H = 5.05; N = 9.52; S = 12.36%. **IR** (KBr, cm⁻¹): 3234 [$\nu(N-H)$], 1732 [$\nu(C=O_{carboxylate})$], 1672 [$\nu(C=O_{amide})$], 913 [$\nu(C=S)$]. **¹H NMR** ($CDCl_3$, 400 MHz) δ (ppm): 11.20 (s, 1H), 9.05 (s, 1H), 7.86 (d, $J = 7.3$ Hz, 2H), 7.63 (t, $J = 7.4$ Hz, 1H), 7.53 (t, $J = 7.3$ Hz, 2H), 5.00–5.06 (m, 1H), 4.27 (q, $J = 7.1$ Hz, 2H), 1.62 (d, $J = 7.1$ Hz, 3H), 1.32 (t, $J = 7.1$ Hz, 3H). **¹³C NMR** ($CDCl_3$, 400 MHz) δ (ppm): 179.6, 171.7, 166.8, 133.7, 131.8, 129.2, 127.6, 61.9, 54.2, 17.6, 14.2.

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

Atom	x	y	z	<i>U</i> _{iso} */ <i>U</i> _{eq}
S1	0.42897 (5)	0.74998 (4)	0.95514 (4)	0.02776 (13)
O1	0.58278 (15)	0.84892 (12)	0.61333 (11)	0.0312 (3)
O2	0.24347 (17)	0.45286 (13)	0.42096 (12)	0.0384 (3)
O3	0.09157 (14)	0.28051 (12)	0.48094 (11)	0.0313 (3)
N1	0.58871 (16)	0.90186 (14)	0.83662 (13)	0.0241 (3)
N2	0.43456 (17)	0.64057 (14)	0.69922 (13)	0.0259 (3)
C1	0.78337 (19)	1.08993 (16)	0.79635 (16)	0.0240 (3)
C2	0.9107 (2)	1.15302 (17)	0.93946 (17)	0.0274 (3)
H2	0.902510	1.104922	1.003690	0.033*
C3	1.0495 (2)	1.28723 (18)	0.98609 (19)	0.0341 (4)
H3	1.135636	1.328195	1.081110	0.041*
C4	1.0596 (2)	1.36000 (18)	0.8910 (2)	0.0369 (4)
H4	1.153061	1.449758	0.922111	0.044*
C5	0.9312 (2)	1.29990 (19)	0.7497 (2)	0.0371 (4)
H5	0.937126	1.350950	0.686857	0.045*
C6	0.7936 (2)	1.16379 (18)	0.70121 (17)	0.0301 (3)
H6	0.708961	1.122355	0.605722	0.036*
C7	0.64214 (19)	0.93740 (16)	0.73796 (16)	0.0240 (3)
C8	0.48330 (18)	0.75989 (16)	0.82029 (15)	0.0231 (3)
C9	0.3328 (2)	0.48246 (16)	0.67026 (16)	0.0267 (3)
H9	0.251469	0.491004	0.718485	0.032*
C10	0.21925 (19)	0.40686 (16)	0.50950 (16)	0.0268 (3)
C11	−0.0242 (2)	0.19127 (19)	0.32983 (17)	0.0341 (4)
H11A	0.048876	0.157055	0.279343	0.041*
H11B	−0.093019	0.256178	0.285852	0.041*
C12	−0.1500 (2)	0.0509 (2)	0.3227 (2)	0.0421 (4)
H12A	−0.229608	−0.010463	0.224172	0.063*
H12B	−0.220676	0.086364	0.373689	0.063*
H12C	−0.080314	−0.012834	0.365584	0.063*
C13	0.4585 (2)	0.38273 (18)	0.72445 (18)	0.0373 (4)
H13A	0.387471	0.278342	0.700561	0.056*
H13B	0.525739	0.430600	0.826769	0.056*
H13C	0.541315	0.376581	0.680090	0.056*
H1A	0.607 (2)	0.9762 (19)	0.9107 (17)	0.031 (5)*
H2A	0.463 (3)	0.657 (2)	0.6367 (19)	0.046 (6)*

Experimental details

All H atoms, except amine H atoms, were positioned geometrically and refined in a riding model approximation (C–H = 0.93–0.98 Å) with $U_{\text{iso}}(\text{H}) = 1.2\text{--}1.5U_{\text{eq}}(\text{C})$. The hydrogen atoms on N1 and N2, namely H1A and H2A, respectively, were located in a difference Fourier map and refined with a distance restraint of N–H = 0.86 ± 0.02 Å.

Comment

Benzoylthiourea derivatives represent a well-known category of organic compounds due to the diverse biological applications including insecticidal [7], antibacterial [8],

anticancer [9, 10] and antifungal [11]. In view of the interesting properties of this class of compounds, we synthesised a derivative linked with an amino acid congener. The adjunct amino acid derivative on the benzoylthiourea core is a significant chemical constituent found in biological systems. These class of compounds were reported to exhibit enhanced biological properties [12, 13]. Herein, the synthesis and crystal structure determination of the title compound (I) is described.

The compound adopts a *cis-trans* conformation with respect to the ethyl propanoate and benzoyl moieties, relative to the S atom across the C8–N2 and C8–N1 bonds, respectively. This conformation is commonly observed in other benzoylthiourea derivatives [14–16]. The C8–S1, N1–C8 and N2–C8 bond lengths of the thiourea core are almost equivalent to the corresponding bond lengths of related structures [17, 18]. The aforementioned benzoyl and ethyl propanoate fragments are inclined to the thiourea least-square plane (S1/N1/N2/C8) with dihedral angles of 33.61(5) and 45.70(5)°, respectively. Additionally, the benzoyl moiety and ethyl propanoate fragment subtend a dihedral angle of 12.11(6)°.

The crystal structure features an intramolecular N–H...O [N(2)–H(2A)...O(1): H(2A)...O(1) = 0.83(2) Å, N(2)...O(1) = 2.6696(18) Å at an angle of 135.2(17)°] hydrogen bond generating a *S*(6) ring according to graph-set notation [19]. This characteristic is also featured in the solid-state structure of archetypal benzoylthiourea compounds [11, 20, 21]. In the molecular packing, the only directional interaction observed is the N–H...S [N(1)–H(1A)...S(1): H(1A)...S(1) = 0.836(17) Å, N(1)...S(1) = 3.3923(14) Å at an angle of 152.7(15)°; symmetry operation of (i) 1 – *x*, 2 – *y*, 2 – *z*] contact, which leads to the formation of dimeric aggregates. The dimers form a stacking column along the *a*-axis which is stabilised by C–H... π interactions but no other significant directional interactions.

To probe the supramolecular aggregation further, Hirshfeld surface analysis in conjunction with two-dimensional fingerprint (FP) plots were obtained by utilizing Crystal Explorer 17 [22] with reference to previous methods [23, 24]. The FP plot delineated H...S/S...H contacts into distinct complementary long sharp spikes corresponding to the intermolecular N–H...S hydrogen bonds. H...S/S...H contacts contribute 11.9% of all contacts to the Hirshfeld surface. Noteworthy, the H...H contacts contribute 45.8% of all contacts to the surface. Other significant contributions to the surface are from H...C/C...H [18.1%] and H...O/O...H [18.0%] contacts.

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