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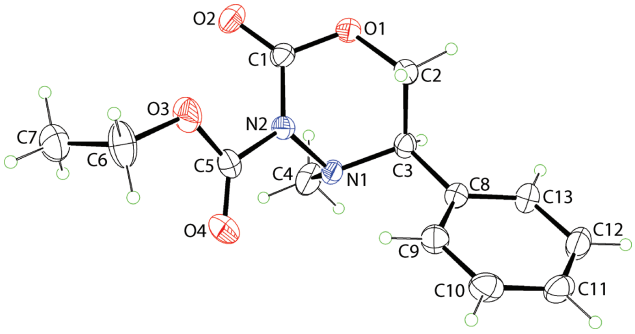
Crystal structure of ethyl 4-methyl-2-oxo-5-phenyl-1,3,4-oxadiazinane-3-carboxylate, $C_{13}H_{16}N_2O_4$



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Abstract

$C_{13}H_{16}N_2O_4$, orthorhombic, $P2_12_12_1$ (no. 19), $a = 6.7876(2)$ Å, $b = 8.8984(2)$ Å, $c = 22.3399(6)$ Å, $V = 1349.30(6)$ Å^3, $Z = 4$, $R_{gt}(F) = 0.0384$, $wR_{ref}(F^2) = 0.0947$, $T = 293(2)$ K.

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

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Table 1: Data collection and handling.

Crystal:	Colourless irregular prism
Size:	0.25 × 0.22 × 0.19 mm
Wavelength:	Mo $K\alpha$ radiation (0.71073 Å)
μ:	0.10 mm^{-1}
Diffractometer, scan mode:	KappaCCD,
θ_{max}, completeness:	27.5°, 99%
$N(hkl)_{measured}$, $N(hkl)_{unique}$, R_{int}:	7907, 2859, 0.036
Criterion for I_{obs}, $N(hkl)_{gt}$:	$I_{obs} > 2\ \sigma(I_{obs})$, 2591
$N(param)_{refined}$:	174
Programs:	COLLECT [1], DENZO/SCALEPACK [2], SIR2014 [3], SHELX [4], WinGX/ORTEP [5]

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

Atom	x	y	z	U_{iso}*/U_{eq}
O1	0.2121(2)	−0.21849(18)	0.54715(6)	0.0556(4)
O2	−0.0033(2)	−0.3109(2)	0.61126(8)	0.0658(5)
O3	−0.0178(3)	−0.0858(2)	0.69632(8)	0.0713(5)
O4	0.2812(3)	−0.0568(2)	0.73833(7)	0.0721(5)
N1	0.4574(2)	−0.16094(18)	0.63936(7)	0.0419(4)
N2	0.2488(2)	−0.15464(19)	0.64480(7)	0.0429(4)
C1	0.1373(3)	−0.2332(3)	0.60243(9)	0.0457(5)
C2	0.3457(3)	−0.0930(3)	0.53941(10)	0.0532(5)
H2A	0.278486	0.000034	0.549223	0.064*
H2B	0.387762	−0.087546	0.497973	0.064*
C3	0.5224(3)	−0.1118(2)	0.57931(9)	0.0421(4)
H3	0.605280	−0.191288	0.562334	0.051*
C4	0.5267(4)	−0.3114(3)	0.65494(12)	0.0655(7)
H4A	0.484998	−0.335772	0.694843	0.098*
H4B	0.667895	−0.314187	0.652862	0.098*
H4C	0.472633	−0.383132	0.627357	0.098*
C5	0.1766(3)	−0.0954(2)	0.69848(9)	0.0479(5)
C6	−0.1167(5)	−0.0279(4)	0.74953(13)	0.0842(9)
H6A	−0.026266	0.035429	0.771729	0.101*
H6B	−0.227989	0.033387	0.737446	0.101*
C7	−0.1852(5)	−0.1481(4)	0.78787(13)	0.0824(9)
H7A	−0.273814	−0.211539	0.765898	0.124*
H7B	−0.252629	−0.106171	0.821768	0.124*
H7C	−0.074707	−0.206185	0.801396	0.124*

Table 2 (continued)

Atom	x	y	z	U_{iso}*/U_{eq}
C8	0.6421(3)	0.0319(2)	0.58057(9)	0.0414(4)
C9	0.6038(4)	0.1439(2)	0.62178(10)	0.0536(5)
H9	0.505563	0.130085	0.650261	0.064*
C10	0.7106(4)	0.2765(3)	0.62104(12)	0.0659(7)
H10	0.684085	0.351146	0.649033	0.079*
C11	0.8555(4)	0.2977(3)	0.57900(12)	0.0666(7)
H11	0.927531	0.386637	0.578758	0.080*
C12	0.8945(4)	0.1882(3)	0.53726(13)	0.0653(7)
H12	0.991934	0.203206	0.508599	0.078*
C13	0.7879(3)	0.0552(2)	0.53812(11)	0.0521(5)
H13	0.814443	−0.019043	0.509947	0.063*

Source of material

The title compound (I) was prepared by the carboxylation reaction of (5*R*)-4-methyl-5-phenyl-1,3,4-oxadiazinan-2-one (II) which was prepared as described in [6]. A solution of BuLi (2.00 M in hexane, 1.45 mL, 2.86 mmol) was added drop-wise to a solution of (II) (500 mg, 2.60 mmol) in dry THF (10 mL) at 195 K. The reaction was stirred for an additional 15 min. An ethyl chloroformate (272 µL, 2.86 mmol) solution in THF (1 mL) was added slowly to the reaction mixture. After 15 min, the light-yellow solution was warmed to RT for a further 30 min. The reaction was quenched with saturated aqueous ammonium chloride solution (5 mL). The mixture was then concentrated under reduced pressure, taken up in water (5 mL) and extracted with CH_2Cl_2 (3 × 15 mL) then dried ($MgSO_4$). Evaporation of the solvent *in vacuo* gave the crude product which was purified by flash column chromatography on silica gel with 40% EtOAc in hexane to give the pure product as a white solid (446 mg, 65%). Colourless crystals of (I) were obtained by vapour diffusion from hexane/acetone at 298 K. **M. pt.**: 394–396 K. **$[\alpha]_D^{25}$**: + 28.7° (c. 1.07, $CHCl_3$). **Anal. calcd.** for $C_{13}H_{16}N_2O_4$: C, 59.08, H, 6.10, N, 10.60%. Found: C, 58.94, H, 6.01, N, 10.65%. **^{1}H NMR** (500 MHz, $CDCl_3$/TMS): δ (p.p.m.): 7.41–7.32 (m, 5H), 4.72 (dd, ^2J = 11.4 Hz, ^3J = 5.8 Hz, 1H), 4.45 (dd, ^2J = 11.4 Hz, ^3J = 9.2 Hz, 2H), 4.38–4.28 (m, 2H), 2.82 (s, 3H), 1.33 (t, ^3J = 7.1 Hz, 3H). **^{13}C NMR** (125 MHz, $CDCl_3$/TMS): δ (p.p.m.): 152.17, 149.74, 135.96, 128.95, 128.51, 126.90, 68.49, 63.63, 63.58, 43.93, 14.24.

Experimental details

The C-bound H atoms were geometrically placed (C—H = 0.93–0.98 Å) and refined as riding with U_{iso}(H) = 1.2–1.5U_{eq}(C). The absolute structure was not determined in the X-ray experiment but, the assignment of stereochemistry at the C3 centre, i.e. R, is based on the chirality of the synthetic precursor employed in the synthesis.

Comment

1,3,4-Oxadiazin-2-one molecules related to the title compound, (I), first attracted interest as stimulants for the central nervous system [7]. Subsequently, there has been interest in employing these molecules as chiral auxiliaries in organic synthesis [8, 9]. Over and above these considerations, these molecules exhibit interesting conformational flexibility [10]. In continuation of previous structural studies on related 1,3,4-oxadiazin-2-ones [11, 12], herein, the crystal and molecular structures of (I) are described.

The molecular structure of (I) is shown in the figure (25% displacement ellipsoids) and is constructed about a 1,3,4-oxadiazin-2-one core. To a first approximation, the six-membered ring has a boat conformation with the N2 and C2 atoms lying out of and to the same side of the plane through the four remaining atoms. In this description, the N1-methyl group occupies an axial position, the N2-bound ethyloxycarbonyl is bisectional as is the C3-phenyl group and, finally, the C2-carbonyl group occupies an equatorial position. Globally, the carbonyl groups are directed to opposite sides of the molecule, and the N-bound methyl group is orientated to the opposite side of the ring to the ethyloxycarbonyl and phenyl substituents. The sum of the angles subtended at the N1 atom amounts to 334° indicating a pyramidal geometry but, that about N2 is planar, with the sum of angles being 359°.

There are crystal structures for two literature precedents for (I) that differ only in the nature of the C(=O)R group [11, 12]. The structures confirm the conformational variability in the six-membered ring [10], so the derivative with R = CH_2OPh [11] has a distorted twisted-boat conformation and that with R = CH_2Cl has a distorted half-chair conformation [12].

In the molecular packing, methyl-C—H···O(carboxylate-carbonyl) [C4—H4b···O2^i: H4b···O2^i = 2.42 Å, C4···O2^i = 3.336(3) Å with angle at H4b = 160° for symmetry operation (i) 1 + *x*, *y*, *z*] interactions link molecules into linear, supramolecular chains along the *a*-axis. Chains are connected into double-chains via phenyl-C—H···π(phenyl) [C12—H12···Cg(C8–C13)^{ii}: H12···Cg(C8–C13)^{ii} = 2.88 Å with angle at H12 = 164° for (ii) 1/2 + *x*, 1/2 − *y*, 1 − *z*] interactions. The double-chains assemble in the crystal without directional interactions between them. Accordingly, in order to probe further the molecular packing, the Hirshfeld surfaces and of the full and delineated two-dimensional fingerprint plots were calculated using Crystal Explorer 17 [13] and literature methods [14].

Consistent with the above description, H···H contacts contribute 54.1% to the overall surface. The fingerprint plot delineated into H···O/O···H contacts exhibits the characteristic spikes due to the C—H···O contact and overall

contributes 29.2% of all contacts. The next most significant contributions are from H···C/C···H contacts [13.0%] followed by O···C/C···O contacts [2.4%].

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