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Isomeric pyrazolo[3,4-*d*]pyrimidine-based molecules: disappearance of dimerization due to interchanged substitutions[1]

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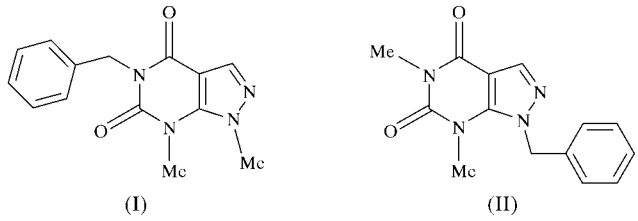
In 5-benzyl-1,7-dimethyl-4,5,6,7-tetrahydro-1*H*-pyrazolo[3,4-*d*]-pyrimidine-4,6-dione, $C_{14}H_{14}N_4O_2$, which crystallizes in space group $P\overline{1}$, weak intermolecular C—H···O hydrogen bonds generate dimers. The isomeric compound 1-benzyl-5,7-dimethyl-4,5,6,7-tetrahydro-1*H*-pyrazolo[3,4-*d*]pyrimidine-4,6-dione, $C_{14}H_{14}N_4O_2$, crystallizes in space group $P2_1/n$, and shows no such dimerization. Instead, it exhibits C—H···π interactions with the phenyl ring. In both structures, the molecules are linked by aromatic π–π-stacking interactions.

Comment

Xanthine (3,7-dihydro-1*H*-purine-2,6-dione) compounds are well known for their intermolecular stacking (Falk *et al.*, 1998) and C—H···O interactions (Desiraju & Steiner, 1999). Last year, we reported the crystal structure of 1,3-bis(8-chlorotheophyllin-7-yl)propane, containing the xanthine skeleton, which also shows intermolecular stacking (Maulik *et al.*, 2001). In this communication, we report the X-ray structures of two isomeric compounds, namely 5-benzyl-1,7-dimethyl-4,5,6,7-tetrahydro-1*H*-pyrazolo[3,4-*d*]pyrimidine-4,6-dione, (I), and 1-benzyl-5,7-dimethyl-4,5,6,7-tetrahydro-1*H*-pyrazolo[3,4-*d*]-pyrimidine-4,6-dione, (II). The syntheses of these two compounds have been reported previously (Avasthi *et al.*, 1998) and they are derived from the pyrazolo[3,4-*d*]-pyrimidine ring system; however, structurally they are closer to the xanthine system, which is well known for its C—H···O interactions (Desiraju & Steiner, 1999). In xanthine compounds, however, two N atoms flank the CH group, while in compounds (I) and (II), there is only one adjacent N atom.



The conformations of (I) and (II), together with the atom-numbering schemes, are shown in Figs. 1 and 4, respectively. The molecules are isomeric and differ from one another by the interchange of methyl and benzyl groups at positions N1 and N5. The pendent benzyl substituents are out of the planes of the pyrazolo[3,4-*d*]pyrimidine ring systems [twist angle: 83.19 (4)° in (I) and 80.4 (1)° in (II)]. The crystal packing of (I) reveals the presence of weak intermolecular C—H···O bonding (Table 1). Interestingly, this hydrogen bonding (C3—H3···O15) leads to the dimerization of the molecules (Fig. 2).

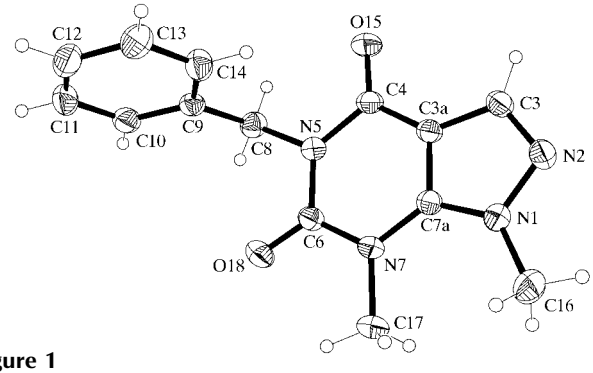


Figure 1
Displacement ellipsoid plot (30% probability) showing the molecular structure of (I) with the atom-labelling scheme.

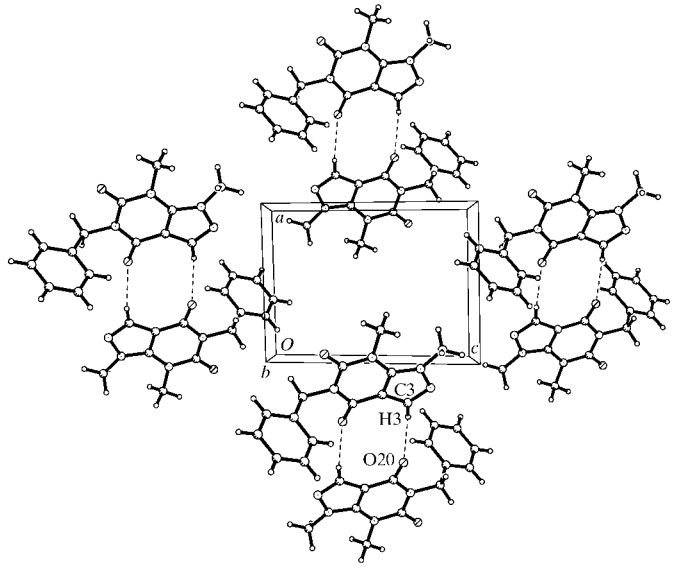


Figure 2
Crystal-packing diagram showing the dimerization of the molecules of (I) through C—H···O hydrogen bonding (dashed lines).

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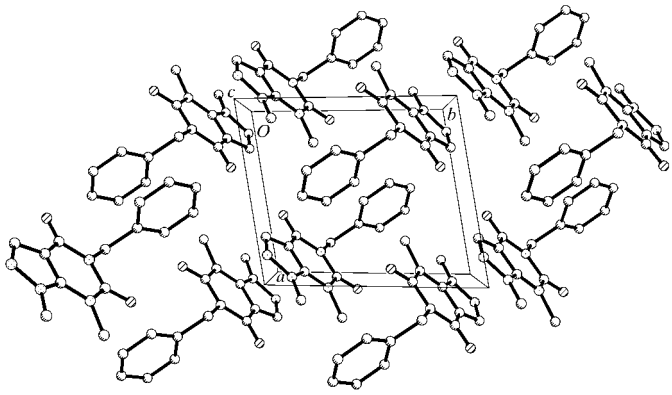

Figure 3
Crystal-packing diagram of (I) showing the intermolecular π–π stacking among the phenyl rings and pyrazolo[3,4-*d*]pyrimidine rings in pairs.

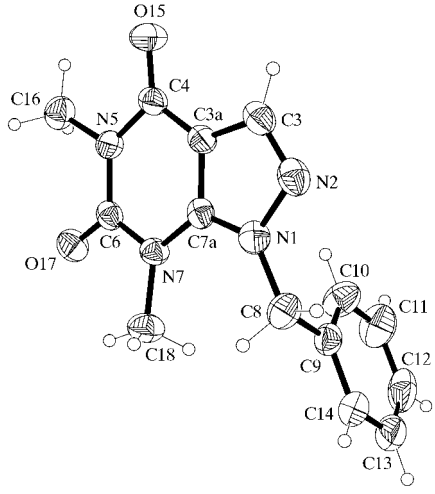

Figure 4
Displacement-ellipsoid plot (30% probability) showing the molecular structure of (II) with the atom-labelling scheme.

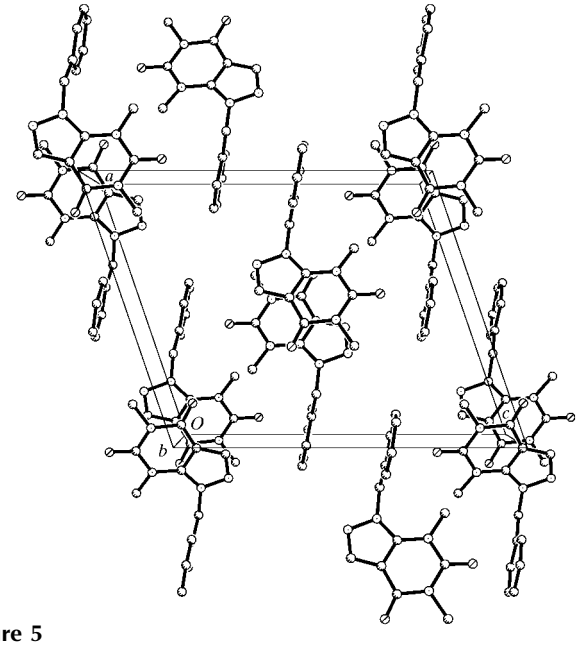

Figure 5
Crystal-packing diagram of (II) showing the intermolecular π–π stacking between pyrazolo[3,4-*d*]pyrimidine rings.

The crystal packing (Fig. 3) shows further independent intermolecular stacking between the phenyl rings and the pyrazolo[3,4-*d*]pyrimidine systems due to π–π interactions. Pairs of phenyl rings (symmetry code: $1-x, 1-y, 2-z$) overlap with an interplanar separation of 3.511 (2) Å and a centroid–centroid separation of 3.374 (2) Å in a 'parallel-displaced' orientation. The face-to-face overlapping of the pyrazolo[3,4-*d*]pyrimidine ring systems (symmetry code: $-x, 2-y, 1-z$) displays an interplanar separation of 3.276 (2) Å and a centroid–centroid separation of 3.374 (2) Å. Both modes of stacking interactions are common in xanthine compounds (Falk *et al.*, 1998). The crystal packing of (II), on the other hand, shows no such dimerization. Intermolecular stacking, however, is still present (Fig. 5) among pairs of pyrazolo[3,4-*d*]pyrimidine ring systems [symmetry code: $-x, 2-y, -z$; interplanar spacing: 3.303 (3) Å; centroid separation: 3.365 (2) Å], in similar orientations to those found in (I). Thus, the crystal structures of (I) and (II) are stabilized mainly by C—H···O and π–π interactions, and van der Waals forces.

Experimental

Compounds (I) and (II) were synthesized according to Avasthi *et al.* (1998). Diffraction quality crystals were obtained by slow evaporation of ethyl acetate/hexane solutions at room temperature.

Compound (I)

Crystal data

$C_{14}H_{14}N_4O_2$
$M_r = 270.29$
Triclinic, $P\overline{1}$
$a = 7.476$ (1) Å
$b = 8.923$ (1) Å
$c = 10.155$ (1) Å
$\alpha = 76.68$ (1)°
$\beta = 89.08$ (1)°
$\gamma = 80.66$ (1)°
$V = 650.3$ (1) Å^3
$Z = 2$
$D_x = 1.380$ Mg m^{-3}
Mo $K\alpha$ radiation
Cell parameters from 59 reflections
$\theta = 5.0$–$14.9°$
$\mu = 0.10$ mm^{-1}
$T = 293$ (2) K
Block, colourless
0.45 × 0.30 × 0.20 mm

Data collection

Bruker *P*4 diffractometer
θ–2θ scans
3155 measured reflections
2539 independent reflections
2128 reflections with $I > 2\sigma(I)$
$R_{int} = 0.015$
$\theta_{max} = 26.0°$
$h = -1 \rightarrow 9$
$k = -10 \rightarrow 10$
$l = -12 \rightarrow 12$
3 standard reflections
every 97 reflections
frequency: 60 min
intensity decay: none

Refinement

Refinement on F^2
$R[F^2 > 2\sigma(F^2)] = 0.046$
$wR(F^2) = 0.134$
$S = 1.05$
2539 reflections
183 parameters
H-atom parameters constrained
$w = 1/[\sigma^2(F_o^2) + (0.0745P)^2 + 0.1361P]$ where $P = (F_o^2 + 2F_c^2)/3$
$(\Delta/\sigma)_{max} < 0.001$
$\Delta\rho_{max} = 0.16$ e Å^{-3}
$\Delta\rho_{min} = -0.30$ e Å^{-3}

Table 1
Hydrogen-bonding geometry (Å, °) for (I).

D—H···A	D—H	H···A	D···A	D—H···A
C3—H3···O15^{i}	0.93	2.42	3.317 (2)	161

Symmetry code: (i) $1-x, 2-y, 1-z$.

Compound (II)

Crystal data

$C_{14}H_{14}N_4O_2$
$M_r = 270.29$
Monoclinic, $P2_1/n$
$a = 12.468$ (1) Å
$b = 7.449$ (1) Å
$c = 15.076$ (2) Å
$\beta = 108.94$ (1)°
$V = 1324.4$ (3) Å^3
$Z = 4$
$D_x = 1.356$ Mg m^{-3}
Mo $K\alpha$ radiation
Cell parameters from 43 reflections
$\theta = 5.1$–12.5°
$\mu = 0.10$ mm^{-1}
$T = 293$ (2) K
Block, colourless
0.38 × 0.28 × 0.20 mm

Data collection

Bruker $P4$ diffractometer
θ–2θ scans
3782 measured reflections
2885 independent reflections
1504 reflections with $I > 2\sigma(I)$
$R_{int} = 0.089$
$\theta_{max} = 27.0°$
$h = -1 \rightarrow 15$
$k = -1 \rightarrow 9$
$l = -19 \rightarrow 18$
3 standard reflections
frequency: 60 min
intensity decay: none

Refinement

Refinement on F^2
$R[F^2 > 2\sigma(F^2)] = 0.059$
$wR(F^2) = 0.159$
$S = 1.01$
2885 reflections
183 parameters
H-atom parameters constrained
$w = 1/[\sigma^2(F_o^2) + (0.0653P)^2 + 0.0892P]$ where $P = (F_o^2 + 2F_c^2)/3$
$(\Delta/\sigma)_{max} < 0.001$
$\Delta\rho_{max} = 0.17$ e Å^{-3}
$\Delta\rho_{min} = -0.22$ e Å^{-3}

For both compounds, data collection: *XSCANS* (Siemens, 1996); cell refinement: *XSCANS*; data reduction: *XSCANS*; program(s) used to solve structure: *SHELXTL-NT* (Bruker, 1997); program(s) used to refine structure: *SHELXTL-NT*; molecular graphics: *SHELXTL-NT*; software used to prepare material for publication: *SHELXTL-NT*.

Supplementary data for this paper are available from the IUCr electronic archives (Reference: GD1201). Services for accessing these data are described at the back of the journal.

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