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A three-dimensional hydrogen-bonded framework in 2-amino-6-(*N*-methylanilino)pyrimidin-4(3*H*)-one and a ribbon of fused hydrogen-bonded rings in 2-amino-6-(*N*-methylanilino)-5-nitropyrimidin-4(3*H*)-one

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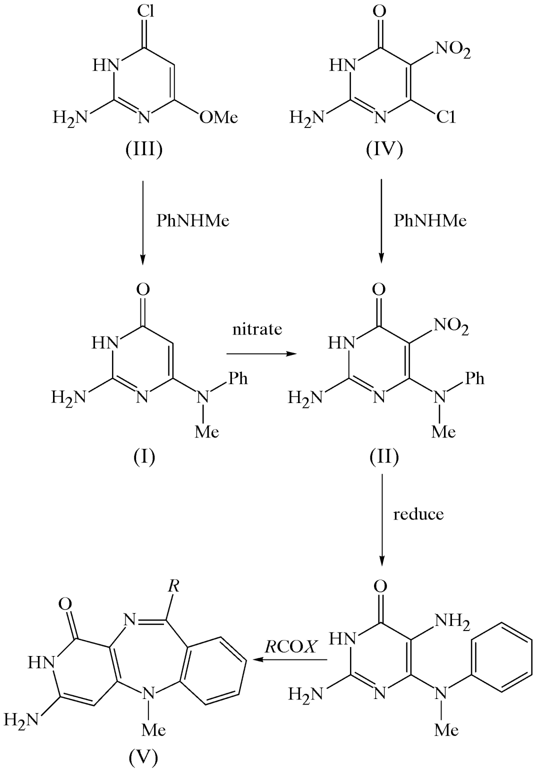
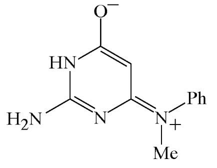
The molecular dimensions of both 2-amino-6-(*N*-methylanilino)pyrimidin-4(3*H*)-one, $C_{11}H_{12}N_4O$, (I), and 2-amino-6-(*N*-methylanilino)-5-nitropyrimidin-4(3*H*)-one, $C_{11}H_{11}N_5O_3$, (II), are consistent with considerable polarization of the molecular–electronic structures. The molecules of (I) are linked into a three-dimensional framework by a combination of one N—H···N hydrogen bond, two independent N—H···O hydrogen bonds and one C—H···π(arene) hydrogen bond. The molecules of (II) are linked into ribbons containing three types of edge-fused ring by the combination of two independent three-centre N—H···$(O)_2$ hydrogen bonds.

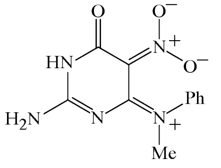
Comment

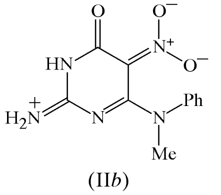
As part of a wide-ranging investigation of biologically active heterocyclic compounds, we have initiated a study of pyrimido[4,5-*b*][1,4]benzodiazepine derivatives that are analogous to the well known benzodiazepine derivatives and which show related pharmacological properties, such as anti-anxiety or antidepressive activity (Dlugosz & Machon, 1990), as well as being candidates as effective anti-HIV-1 inhibitors (Di Braccio *et al.*, 2001). We report here the molecular and supramolecular structures of two compounds, 2-amino-6-(*N*-methylanilino)pyrimidin-4(3*H*)-one, (I), and 2-amino-6-(*N*-methylanilino)-5-nitropyrimidin-4(3*H*)-one, (II), which were prepared, from the commercially available pyrimidines, (III) and (IV), respectively, for use as intermediates for the syntheses of pyrimido[4,5-*b*][1,4]benzodiazepines, (V).

In compounds (I) and (II) (Figs. 1 and 2), the coordination at N6 is planar and the methyl atom C67 and the *ipso* atom of the phenyl ring, atom C61, are very close to the plane of the pyrimidine ring, as indicated by the relevant torsion angles (Table 3). On the other hand, the planes of the phenyl group in each compound are well removed from the pyrimidine planes with dihedral angles between these two planes of 70.1 (2)° in (I) and 58.9 (2)° in (II). In (II), the dihedral angle between the CNO_2 unit and the pyrimidine ring is 47.4 (2)°.




(I*a*)


(II*a*)


(II*b*)

The molecules in each compound exhibit some unusual bond distances, which are indicative of polarized molecular–electronic structures. In compound (I), the C4—C5 and C5—C6 distances are identical within experimental uncertainty, although in the conventional representation these bonds are, respectively, single and double bonds. In addition, the C—O bond is long for its type (Allen *et al.*, 1987), while the C6—N6 bond is short. These data together indicate that the polarized form (I*a*) may be a significant contributor to the overall

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molecular–electronic structure of this compound, in addition to the unpolarized form (I).

Despite the large dihedral angle between the pyrimidine and nitro-group planes in (II), the C5—N5 bond is rather short for its type (mean value 1.486 Å; Allen *et al.*, 1987); the C4—O4 bond is significantly shorter in (II) than in (I); and the N1—C2 and C2—N2 distances are effectively identical in (II). These observations indicate that the polarized forms (II*a*) and (II*b*) both contribute to the overall molecular–electronic structure of this compound, in addition to the unpolarized form (II).

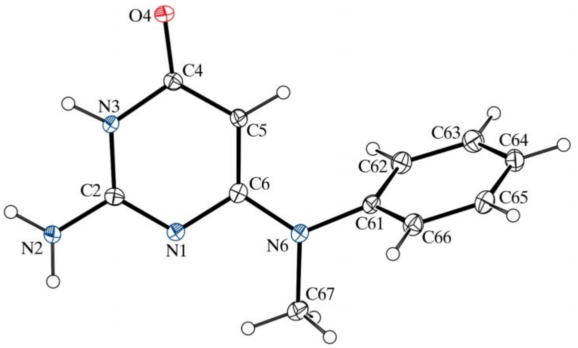

Figure 1
The molecular structure of (I), showing the atom-labelling scheme. Displacement ellipsoids are drawn at the 30% probability level.

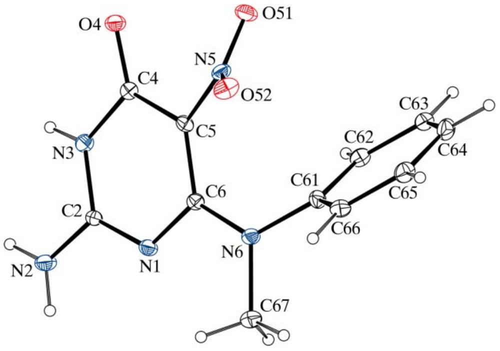

Figure 2
The molecular structure of (II), showing the atom-labelling scheme. Displacement ellipsoids are drawn at the 30% probability level.

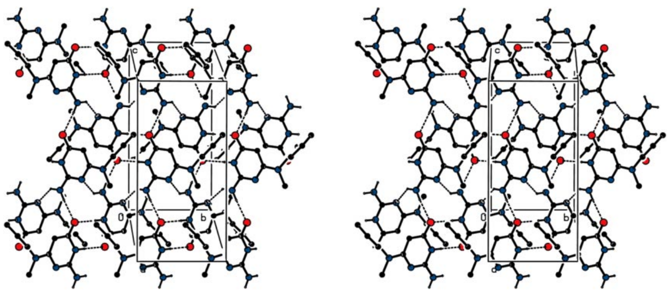

Figure 3
A stereoview of part of the crystal structure of (I), showing the formation of a hydrogen-bonded sheet parallel to (100). For clarity, H atoms bonded to C atoms have been omitted.

The molecules of (I) are linked into sheets by three hydrogen bonds, one of N—H$\cdots$N type and two of N—H$\cdots$O type (Table 1). It is convenient to consider a centrosymmetric dimer unit, formed by paired N—H$\cdots$O hydrogen bonds, as the basic building block forming the sheet. Ring atom N3 in the molecule at (x, y, z) acts as a donor, in an almost linear hydrogen bond, to atom O4 in the molecule at ($1 - x$, $-y$, $1 - z$), so generating by inversion an $R_2^2(8)$ motif (Bernstein *et al.*, 1995), centred at ($\frac{1}{2}$, 0, $\frac{1}{2}$). This dimer is linked directly, by the other two hydrogen bonds, to the four dimers centred at ($\frac{1}{2}$, $\frac{1}{2}$, 0), ($\frac{1}{2}$, $-\frac{1}{2}$, 0), ($\frac{1}{2}$, $\frac{1}{2}$, 1) and ($\frac{1}{2}$, $-\frac{1}{2}$, 1), and propagation by the space group of these hydrogen bonds then generates a rather complex sheet parallel to (100) (Fig. 3). Each such sheet is weakly linked to the two adjacent sheets by a single C—H$\cdots\pi$(arene) hydrogen bond (Table 1), so forming a continuous hydrogen-bonded framework structure in three dimensions.

The supramolecular aggregation of (II) is only one-dimensional; despite the presence of the two nitro-group O atoms as additional sites that are potential hydrogen-bond acceptors, one of the N—H bonds of the exocyclic amino group in (II) plays no part in the hydrogen bonding, and the supramolecular aggregation depends entirely on two independent three-centre N—H$\cdots$(O)$_2$ hydrogen-bond systems, both of them effectively planar (Table 2).

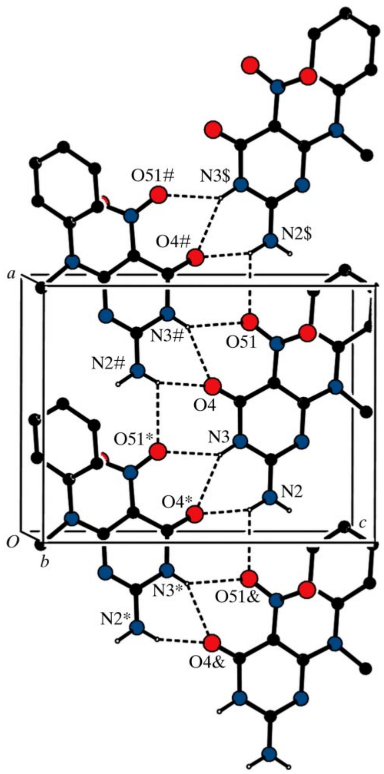

Figure 4
Part of the crystal structure of (II), showing the formation of a hydrogen-bonded ribbon of edge-fused rings parallel to [100]. For clarity, H atoms bonded to C atoms have been omitted. Atoms marked with an asterisk (*), a hash (#), a dollar sign ($) or an ampersand (&) are at the symmetry positions ($-\frac{1}{2} + x, \frac{3}{2} - y, 1 - z$), ($\frac{1}{2} + x, \frac{3}{2} - y, 1 - z$), ($1 + x, y, z$) and ($-1 + x, y, z$), respectively.

Amino atom N2 in the molecule at (x, y, z) acts as a hydrogen-bond donor, *via* H2*B*, to atoms O4 and O51 in the molecules at ($-\frac{1}{2} + x$, $\frac{3}{2} - y$, $1 - z$) and ($-1 + x$, y, z), respectively. In the second three-centre system, ring atom N3 acts as a hydrogen-bond donor to atoms O4 and O51, both in the molecule at ($-\frac{1}{2} + x, \frac{3}{2} - y, 1 - z$). Hence, two of the N—H bonds act as double donors of hydrogen bonds, while the third N—H bond does not participate in the hydrogen bonding, and two of the O atoms act as double acceptors of hydrogen bonds, while the third O atom does not participate in the hydrogen bonding. The combination of all these hydrogen bonds produces a ribbon of edge-fused rings running parallel to the [100] direction and generated by the 2_1 screw axis along (x, $\frac{3}{4}$, $\frac{1}{2}$) (Fig. 4). The ribbon contains an $R^1_2(6)$ ring where the sole acceptor is an O4 atom, an $R^2_1(6)$ ring where both hydrogen bonds involve an H3 atom and an $R^2_2(6)$ ring containing both O4 and O51 atoms as the acceptors. A second ribbon, running antiparallel to the reference ribbon, is generated by the 2_1 screw axis along (x, $\frac{1}{4}$, $\frac{1}{2}$), but there are no direction-specific interactions between adjacent chains.

Experimental

For the synthesis of (I), a mixture of 2-amino-4-chloro-6-methoxypyrimidine (1.82 mmol) and *N*-methylaniline (2.80 mmol) was heated to fusion between 563 and 573 K for 4 min. The reaction mixture was cooled to ambient temperature and the resulting solid mass was broken up; it was washed thrice with ether, and then successively with a saturated aqueous solution of potassium carbonate, with water and finally again with ether. The mixture was then dried in an oven giving (I) as a pale-beige solid (yield 97%, m.p. 552–554 K). For the synthesis of (II), a mixture of 2-amino-6-chloro-5-nitropyrimidin-4(3*H*)-one (2.78 mmol), *N*-methylaniline (3.13 mmol) and triethylamine (1 ml) in methanol (20 ml) was stirred magnetically at ambient temperature for 2 h. The resulting yellow solid was collected by filtration, washed with methanol and then dried in an oven to yield (II) (yield 83%, m.p. 585–588 K). Yellow crystals of (I) and (II) suitable for single-crystal X-ray diffraction were obtained from solutions in dimethyl sulfoxide.

Compound (I)

Crystal data

$C_{11}H_{12}N_4O$
M_r = 216.25
Monoclinic, $P2_1/c$
a = 10.6860 (12) Å
b = 7.1647 (14) Å
c = 14.4911 (12) Å
β = 110.024 (9)°
V = 1042.4 (3) Å^3
Z = 4
Mo $K\alpha$ radiation
μ = 0.09 mm^{-1}
T = 120 (2) K
0.52 × 0.25 × 0.16 mm

Data collection

Bruker–Nonius KappaCCD diffractometer
Absorption correction: multi-scan (*SADABS*; Sheldrick, 2003)
$T_{\min}$ = 0.962, $T_{\max}$ = 0.985
23278 measured reflections
2396 independent reflections
1568 reflections with $I > 2\sigma(I)$
$R_{\rm int}$ = 0.057

Refinement

$R[F^2 > 2\sigma(F^2)]$ = 0.050
$wR(F^2)$ = 0.137
S = 1.07
2396 reflections
146 parameters
H-atom parameters constrained
$\Delta\rho_{\max}$ = 0.35 e Å^{-3}
$\Delta\rho_{\min}$ = −0.26 e Å^{-3}

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

Cg is the centroid of the C61–C66 ring.

D—H···A	D—H	H···A	D···A	D—H···A
N2—H2A···O4$^{\rm i}$	0.88	2.07	2.940 (2)	168
N2—H2B···N1$^{\rm ii}$	0.88	2.30	2.998 (2)	136
N3—H3···O4$^{\rm iii}$	0.88	1.94	2.818 (2)	173
C64—H64···$Cg^{\rm iv}$	0.95	2.82	3.695 (2)	154

Symmetry codes: (i) $x, -y + \frac{1}{2}, z - \frac{1}{2}$; (ii) $-x + 1, y - \frac{1}{2}, -z + \frac{1}{2}$; (iii) $-x + 1, -y, -z + 1$; (iv) $-x + 2, y + \frac{1}{2}, -z + \frac{3}{2}$.

Compound (II)

Crystal data

$C_{11}H_{11}N_5O_3$
M_r = 261.25
Orthorhombic, $P2_12_12_1$
a = 8.955 (3) Å
b = 11.2165 (15) Å
c = 11.5670 (15) Å
V = 1161.8 (4) Å^3
Z = 4
Mo $K\alpha$ radiation
μ = 0.11 mm^{-1}
T = 120 (2) K
0.32 × 0.26 × 0.09 mm

Data collection

Bruker–Nonius KappaCCD diffractometer
Absorption correction: multi-scan (*SADABS*; Sheldrick, 2003)
$T_{\min}$ = 0.923, $T_{\max}$ = 0.991
15997 measured reflections
1447 independent reflections
879 reflections with $I > 2\sigma(I)$
$R_{\rm int}$ = 0.102

Refinement

$R[F^2 > 2\sigma(F^2)]$ = 0.054
$wR(F^2)$ = 0.138
S = 1.05
1447 reflections
173 parameters
H-atom parameters constrained
$\Delta\rho_{\max}$ = 0.28 e Å^{-3}
$\Delta\rho_{\min}$ = −0.32 e Å^{-3}
Friedel pairs merged

Table 2
Hydrogen-bond geometry (Å, °) for (II).

D—H···A	D—H	H···A	D···A	D—H···A
N2—H2B···O4$^{\rm i}$	0.88	1.97	2.783 (4)	153
N2—H2B···O51$^{\rm ii}$	0.88	2.40	2.936 (5)	119
N3—H3···O4$^{\rm i}$	0.88	2.25	3.000 (5)	143
N3—H3···O51$^{\rm i}$	0.88	2.33	3.093 (4)	145

Symmetry codes: (i) $x - \frac{1}{2}, -y + \frac{3}{2}, -z + 1$; (ii) $x - 1, y, z$.

Table 3
Selected geometric parameters (Å, °).

Parameter	(I)	(II)
N1—C2	1.321 (3)	1.318 (5)
C2—N3	1.355 (2)	1.357 (5)
N3—C4	1.396 (2)	1.400 (5)
C4—C5	1.394 (3)	1.421 (5)
C5—C6	1.396 (3)	1.403 (5)
C6—N1	1.363 (2)	1.356 (5)
C2—N2	1.342 (3)	1.322 (5)
C4—O4	1.268 (2)	1.235 (5)
C5—N5	–	1.430 (5)
N5—O51	–	1.231 (4)
N5—O52	–	1.243 (4)
C6—N6	1.365 (2)	1.352 (5)
C4—C5—N5—O51	–	−49.4 (5)
N1—C6—N6—C61	−176.53 (17)	161.7 (4)
N1—C6—N6—C67	6.6 (3)	−6.1 (5)
C6—N6—C61—C62	−73.7 (3)	−51.5 (5)

The space groups $P2_1/c$, for (I), and $P2_12_12_1$, for (II), were both uniquely assigned from the systematic absences. All H atoms were located in difference maps and then treated as riding atoms, with C—H distances of 0.95 (aromatic or heteroaromatic) or 0.98 Å (methyl), and N—H distances of 0.88 Å, and with $U_{iso}(H) = kU_{eq}$(carrier), where $k = 1.5$ for the methyl groups and $k = 1.2$ for all other H atoms.

For both compounds, data collection: *COLLECT* (Hooft, 1999); cell refinement: *DIRAX/LSQ* (Duisenberg *et al.*, 2000); data reduction: *EVALCCD* (Duisenberg *et al.*, 2003); program(s) used to solve structure: *SIR2004* (Burla *et al.*, 2005); program(s) used to refine structure: *OSCAIL* (McArdle, 2003) and *SHELXL97* (Sheldrick, 1997); molecular graphics: *PLATON* (Spek, 2003); software used to prepare material for publication: *SHELXL97* and *PRPKAPPA* (Ferguson, 1999).

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Supplementary data for this paper are available from the IUCr electronic archives (Reference: SK3172). Services for accessing these data are described at the back of the journal.

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