organic compounds

Methyl 4-[(1-acetyl-3-*tert*-butyl-1*H*-pyrazol-5-yl)amino]-3-nitrobenzoate

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In the molecule of the title compound, $C_{17}H_{20}N_4O_5$, there are two intramolecular N—H···O hydrogen bonds having amidic and nitro-group O atoms as the acceptors and together forming a three-centre N—H···(O)$_2$ system. These interactions appear to play an important role in controlling the relative orientation of the pyrazole and aryl rings. The bond distances provide evidence for some polarization of the electronic structure. Molecules are linked into simple chains by a single C—H···O hydrogen bond.

Comment

We report here the structure of the title compound, (I) (Fig. 1), which we compare with the structures of some aryl analogues (Quiroga *et al.*, 2008, 2010) containing unsubstituted amino groups, compounds (II)–(IV) (see Scheme). Compound (I) was prepared as an intermediate within a current programme for the synthesis of novel benzimidazole derivatives of antitumoral interest (Abonía *et al.*, 2010).

The intramolecular dimensions in compound (I) show some interesting features, involving both the molecular conformation and the intramolecular distances and angles. Firstly, the dihedral angle between the two rings is only 22.3 (2)° despite the rather short nonbonded distance of 1.97 Å between the two H atoms on atoms C4 and C56. Associated with this short distance is a large C—N—C angle (Table 1) at amino atom N51 which links the two rings, whose magnitude is reminiscent of the large C—C—C angle at the bridging methine atom in each of a series of seven (*Z*)-5-arylmethylene-2-thioxothiazolidin-4-ones, (V) (Delgado *et al.*, 2005, 2006), where it was concluded that the short intramolecular C—H···S contact between the two independent rings was strongly repulsive. A similarly wide angle at the bridging methine C atom was also observed in the dimethylamino derivative, (VI), obtained by aminolysis of the corresponding derivative of type (V) (Low *et al.*, 2007). In addition, the two exocyclic bond angles at atom

C5 differ by more than 15° (Table 1) in a sense consistent with the occurrence of a strong repulsive interaction between the H atoms on C4 and C56; on the other hand, the two exocyclic
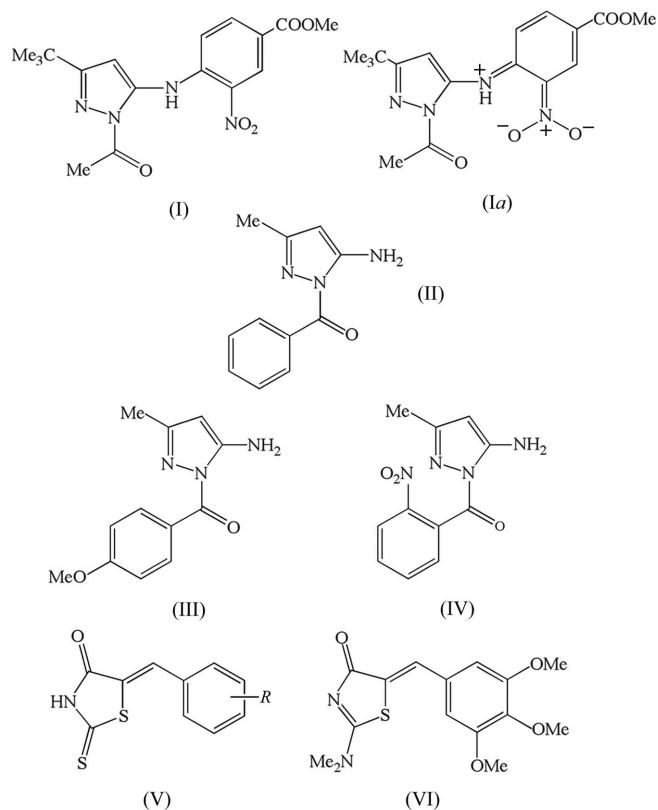
angles at atom C51 are the same within experimental uncertainty, although the C51—N51 distance is longer than expected (*cf.* the discussion of the intramolecular distances, below).
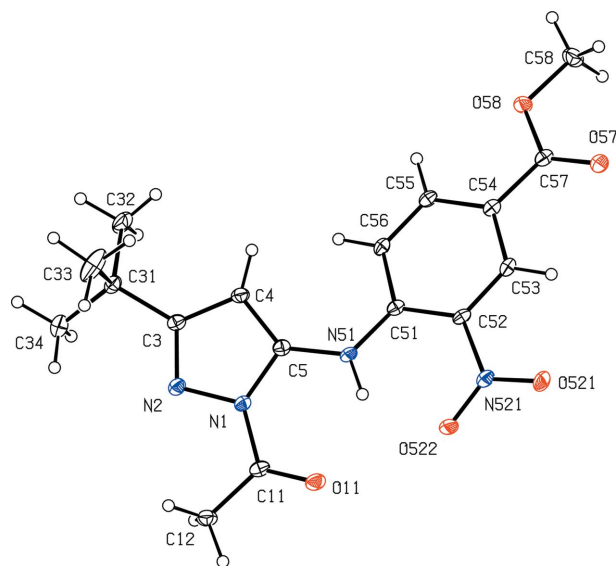

Figure 1
The molecular structure of compound (I), showing the atom-labelling scheme. Displacement ellipsoids are drawn at the 30% probability level.
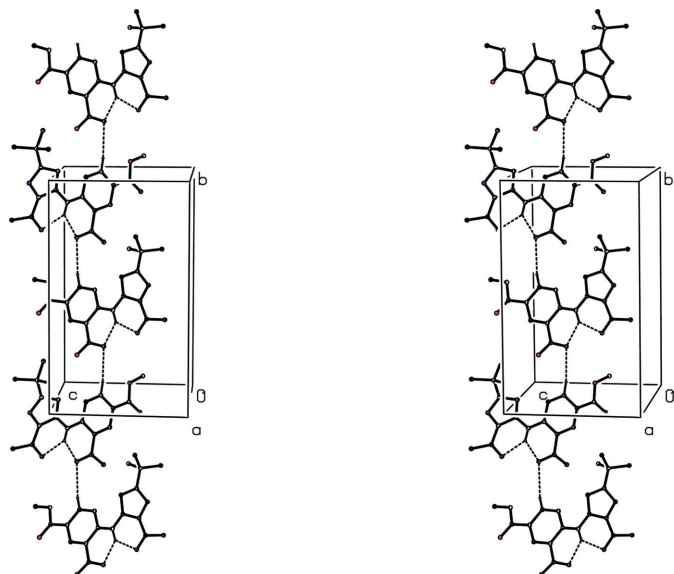
Figure 2
A stereoview of part of the crystal structure of compound (I), showing the formation of edge-fused $S(6)$ rings and a $C(7)$ hydrogen-bonded chain parallel to [010]. For the sake of clarity, H atoms not involved in the motif shown have been omitted.

The question thus arises why the dihedral angle between the rings is not larger, since rotation about the C—N bonds, particularly about the C5—N51 bond, seems at first sight to provide a means of avoiding the short intramolecular H···H contact which involves a lower energy cost than the substantial distortion of the bond angles at C5 and N51. A possible answer lies in the observation that atom N51 acts as the hydrogen-bond donor to atoms O11 and O522 in a planar three-centre N—H···(O)$_2$ system. While both the acetyl and the nitro substituents are slightly twisted out of the plane of their adjacent rings, with dihedral angles of 10.8 (2) and 8.1 (2)°, respectively, it is notable that in each case the sense of the rotation about the exocyclic bonds, N1—C11 and C52—N521, respectively, is such as to bring atoms O11 and O522 closer to atom H51 than they would be if the acetyl and nitro substituents were coplanar with their adjacent rings. Accordingly, it can be concluded that the N—H···O interactions are strongly attractive, and probably charge-assisted (Gilli *et al.*, 1994) (*cf.* the discussion of the intramolecular distances below) and that they are probably one of the key factors controlling the molecular conformation, in particular the relative orientations of the two rings.

Secondly, there is evidence for some quinonoid-type bond fixation within the aryl ring. Thus, the C53—C54 and C55—C56 distances (Table 1) are the shortest within this ring, while C51—C52 is the longest. In addition, the C52—N521 distance is short for its type [mean value (Allen *et al.*, 1987) = 1.468 Å, lower quartile value = 1.460 Å], while the two associated N—O distances are both slightly long for their type. However, the N51—C51 distance does not differ significantly from the mean value for bonds of this type, possibly for reasons connected with the steric demands in the vicinity of atom N51, as discussed above. Overall, however, the bond distances provide

some support for a contribution to the electronic structure from the polarized form, (I*a*) (see Scheme). However, there is no evidence for any participation by the ester function.

As noted above, the N—H bond participates in a three-centre intramolecular hydrogen bond (Table 2), giving rise to two edge-fused $S(6)$ (Bernstein *et al.*, 1995) motifs, but it plays no role in the intermolecular hydrogen bonding. This is determined solely by a C—H···O hydrogen bond in which, despite the presence of two independent carbonyl groups in the molecule, one in an amide group and the other in an ester group, the hydrogen-bond acceptor is one of the nitro-group O atoms, O522, which is also a participant in the intramolecular three-centre system. By contrast, where amidic carbonyl groups and nitro groups are present in the same molecules, the amidic O atoms usually appear to act as the better hydrogen-bond acceptors (Garden *et al.*, 2005; Wardell *et al.*, 2005, 2006). The acceptor behaviour in compound (I) is thus consistent with the development of significant negative charge on the O atoms of the nitro group as a consequence of the electronic polarization discussed above. The effect of the C—H···O hydrogen bond is to link molecules related by the 2_1 screw axis along $(\frac{1}{2}, y, \frac{3}{4})$ into a $C(7)$ (Bernstein *et al.*, 1995) chain running parallel to the [010] direction (Fig. 2).

It is of interest briefly to compare the supramolecular aggregation in compound (I), where there is an excess of conventional hydrogen-bond acceptors over donors, with that in the closely related series of compounds (II)–(IV) (see Scheme). In compound (II) (Quiroga *et al.*, 2010), there is an excess of conventional hydrogen-bond donors over acceptors; compound (III) (Quiroga *et al.*, 2008) contains equal numbers of conventional hydrogen-bond donors and acceptors; and in compound (IV) (Quiroga *et al.*, 2008) the conventional hydrogen-bond acceptors are in excess over the donors, as in compound (I). In each of the structures of compounds (II)–(IV), there is an intramolecular N—H···O hydrogen bond. The molecules of compound (II) are linked into sheets by a combination of N—H···N, C—H···O and C—H···π(arene) hydrogen bonds, so that the single O atom present acts as a double acceptor of hydrogen bonds, while the aryl ring and the two-connected N atom of the pyrazole ring both also act as acceptors. In the 4-methoxy derivative, compound (III), the molecules are linked into a chain of rings by a combination of N—H···N and N—H···π(arene) hydrogen bonds, while in the 2-nitro derivative, compound (IV), a combination of one N—H···N hydrogen bond and three C—H···O hydrogen bonds, all of which utilize nitro O atoms as the acceptors, links the molecules into a three-dimensional framework structure. Thus, in each of the crystal structures of compounds (I)–(IV), a different range of hydrogen bonds is utilized in the aggregation and the resulting hydrogen-bonded structures are all different: a simple chain in (I), a chain of rings in (III), a sheet in (II) and a three-dimensional framework structure in (IV).

Experimental

A mixture of methyl 4-(3-*tert*-butyl-1*H*-pyrazol-5-ylamino)-3-nitro-benzoate (1.0 mmol) and acetic anhydride (0.5 ml) was heated at

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323 K for 5 min. When the starting ester had been completely acetylated, as indicated by thin-layer chromatography, the reaction mixture was cooled to ambient temperature and the excess of solvent was removed under reduced pressure. The resulting solid was washed twice with ethanol (0.5 ml) to give the title compound, (I), as an orange solid (yield 96%, m.p. 429 K). MS (70 eV) m/z (%): 360 (34) $[M^+]$, 318 (100) $[(M - 43)^+]$, 303 (21), 272 (27), 216 (29). Crystals suitable for single-crystal X-ray diffraction were grown by slow evaporation, at ambient temperature and in air, from a solution in ethanol.

Crystal data

$C_{17}H_{20}N_4O_5$	$V = 1723.4$ (3) Å^3
$M_r = 360.37$	$Z = 4$
Monoclinic, $P2_1/c$	Mo $K\alpha$ radiation
$a = 11.9079$ (15) Å	$\mu = 0.10$ mm^{-1}
$b = 15.6452$ (13) Å	$T = 120$ K
$c = 9.255$ (1) Å	$0.44 \times 0.28 \times 0.10$ mm
$\beta = 91.727$ (11)°	

Data collection

Bruker–Nonius KappaCCD diffractometer	19894 measured reflections
Absorption correction: multi-scan (*SADABS*; Sheldrick, 2003)	3200 independent reflections
	2743 reflections with $I > 2\sigma(I)$
$T_{min} = 0.965$, $T_{max} = 0.990$	$R_{int} = 0.051$

Refinement

$R[F^2 > 2\sigma(F^2)] = 0.049$	240 parameters
$wR(F^2) = 0.112$	H-atom parameters constrained
$S = 1.11$	$\Delta\rho_{max} = 0.25$ e Å^{-3}
3200 reflections	$\Delta\rho_{min} = -0.24$ e Å^{-3}

Table 1
Selected geometric parameters (Å, °).

C51—C52	1.413 (3)	N51—C51	1.363 (3)
C52—C53	1.375 (3)	C52—N521	1.446 (2)
C53—C54	1.372 (3)	N521—O521	1.224 (2)
C54—C55	1.392 (3)	N521—O522	1.227 (2)
C56—C51	1.404 (3)	C54—C57	1.470 (3)
C55—C56	1.357 (3)	C57—O57	1.200 (2)
C4—C5—N51	134.62 (18)	C5—N51—C51	127.15 (16)
N1—C5—N51	118.89 (16)		
N2—N1—C11—O11	−169.03 (17)	C51—C52—N521—O521	−174.16 (17)
N2—N1—C11—C12	11.7 (3)	C51—C52—N521—O522	6.3 (3)
N1—C5—N51—C51	166.06 (18)	C53—C54—C57—O57	−3.9 (3)
C5—N51—C51—C52	169.05 (18)	C53—C54—C57—O58	175.12 (17)

All H atoms were located in difference maps and then treated as riding atoms. The H atom bonded to atom N51 was permitted to ride at the position deduced from the difference map, with $U_{iso}(H) = 1.2U_{eq}(N)$, giving an N—H distance of 0.88 Å. The H atoms bonded to C atoms were treated as riding atoms in geometrically idealized positions, with C—H distances of 0.95 (aromatic and pyrazole) or 0.98 Å (methyl) and with $U_{iso}(H) = kU_{eq}(C)$, where $k = 1.5$ for the methyl groups, which were permitted to rotate but not to tilt, and 1.2 for all other H atoms bonded to C atoms.

Data collection: *COLLECT* (Hooft, 1999); cell refinement: *DIRAX/LSQ* (Duisenberg *et al.*, 2000); data reduction: *EVALCCD*

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

D—H···A	D—H	H···A	D···A	D—H···A
N51—H51···O11	0.88	2.02	2.694 (2)	132
N51—H51···O522	0.88	1.94	2.614 (2)	132
C55—H55···O522^i	0.95	2.55	3.452 (2)	158

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

(Duisenberg *et al.*, 2003); program(s) used to solve structure: *SIR2004* (Burla *et al.*, 2005); program(s) used to refine structure: *SHELXL97* (Sheldrick, 2008); molecular graphics: *PLATON* (Spek, 2009); software used to prepare material for publication: *SHELXL97* and *PLATON*.

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