

3-(4-Methoxyphenyl)-7,7-dimethyl-1,6,7,8-tetrahydropyrazolo[3,4-*b*]-quinolin-5-one: a chain of centrosymmetric rings built from N—H···N and C—H··· π (arene) hydrogen bonds

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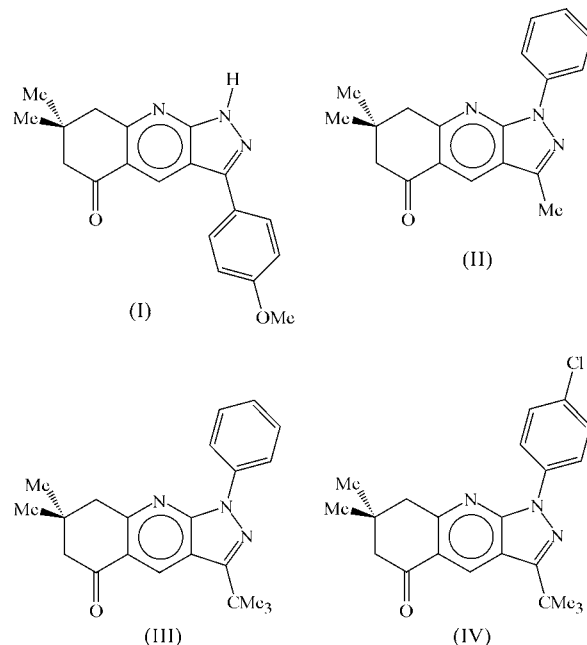
In the title compound, C₁₉H₁₉N₃O₂, the non-aromatic carbocyclic ring adopts an envelope conformation. The molecules are linked by a combination of N—H···N and C—H··· π (arene) hydrogen bonds into a chain of centrosymmetric rings.

Comment

Pyrazolo[3,4-*b*]quinolines are of interest because of their pharmacological applications, *e.g.* as antiviral agents (Crenshaw *et al.*, 1976; Smirnov & Crenshaw, 1977). We have recently reported several efficient methods for the synthesis of compounds of this type, using the reactions between 5-aminopyrazoles, 5,5-dimethylcyclohexane-1,3-dione (dimedone) and substituted benzaldehydes, both in solution and under solvent-free conditions, using microwave irradiation (Quiroga, Hormaza *et al.*, 1998; Quiroga, Insuasty *et al.*, 1998). We report here the molecular and supramolecular structures of the title compound, (I) (Fig. 1), synthesized using microwave irradiation in the absence of solvent. The structures of several analogous compounds have been reported recently, including those of (II), in both triclinic (Low *et al.*, 2003) and monoclinic polymorphs (Mera *et al.*, 2005), (III) (Low *et al.*, 2004) and (IV) (Low *et al.*, 2005), but in none of compounds (II)–(IV) is there an N—H bond at pyrazole atom N1, as found in compound (I). Hence, the supramolecular aggregation in (I) is necessarily different from those found in (II)–(IV).

The bond lengths in (I) (Table 1) show clear evidence for electronic delocalization in the pyridine ring with significant bond fixation in the pyrazole ring. Methoxy atom C341 is

almost coplanar with the adjacent aryl ring, while the exocyclic bond angles at C34 show the usual difference of *ca* 10°. The



dihedral angle between the aryl and pyrazole rings is 13.4 (2)°. Within the non-aromatic carbocyclic ring, the ring-puckering parameters (Cremer & Pople, 1975) corresponding to the atom sequence C4a—C5—C6—C7—C8—C8a are $\theta = 55.1$ (4)° and $\varphi = 167.4$ (4)°, indicating a conformation close to an envelope form, for which the idealized parameters are $\theta = 54.7^\circ$ and $\varphi = (60n)^\circ$. The ring is folded across the C6···C8 vector.

The molecules of (I) are linked into a chain of rings by a combination of N—H···N and C—H··· π (arene) hydrogen bonds (Table 2). Pyrazole atom N1 in the molecule at (*x*, *y*, *z*) acts as hydrogen-bond donor to pyridine atom N9 in the molecule at (2 − *x*, 1 − *y*, 1 − *z*), so generating by inversion an

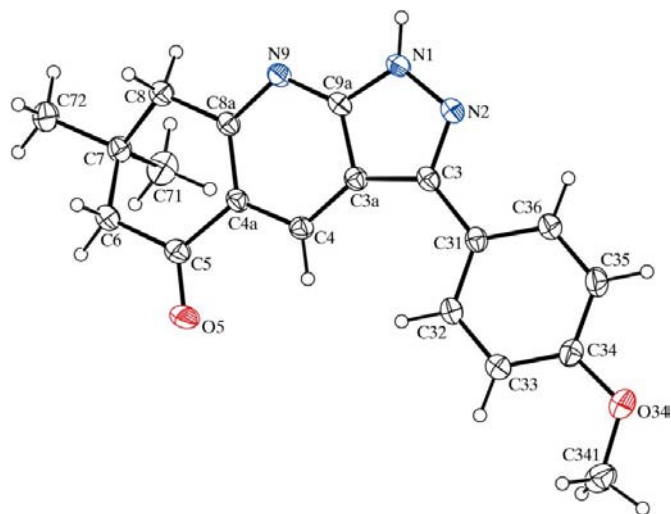


Figure 1

A molecule of compound (I), showing the atom-labelling scheme. Displacement ellipsoids are drawn at the 30% probability level and H atoms are shown as small spheres of arbitrary radii.

$R_2^2(8)$ (Bernstein *et al.*, 1995) ring centred at $(1, \frac{1}{2}, \frac{1}{2})$. In addition, atom C8 in the molecule at (x, y, z) acts as hydrogen-bond donor, *via* axial atom H8B, to the aryl ring C31–C36 in the molecule at $(1-x, 1-y, 1-z)$, so forming a second cyclic motif, this time centred at $(\frac{1}{2}, \frac{1}{2}, \frac{1}{2})$. Propagation by inversion of these two hydrogen bonds then generates a chain of rings running parallel to the $[100]$ direction, with $R_2^2(8)$ rings centred at $(n, \frac{1}{2}, \frac{1}{2})$ ($n = \text{zero or integer}$) and rings generated by the C–H $\cdots\pi$ (arene) hydrogen bond centred at $(n + \frac{1}{2}, \frac{1}{2}, \frac{1}{2})$ ($n = \text{zero or integer}$) (Fig. 2). The formation of this chain is reinforced by a π – π stacking interaction involving the pyridine rings of the molecules at (x, y, z) and $(1-x, 1-y, 1-z)$. These rings are strictly parallel, with an interplanar spacing of 3.310 (2) Å. The ring-centroid separation is 3.709 (2) Å, corresponding to a ring offset of 1.674 (2) Å. There are no direction-specific interactions between adjacent chains.

We briefly compare here the supramolecular aggregation in compound (I) with that found in each of compounds (II)–(IV). In the monoclinic polymorph of compound (II), which crystallizes with $Z' = 1$ in the space group $P2_1/n$ (Mera *et al.*, 2005), two distinct C–H $\cdots\pi$ hydrogen bonds link the molecules into chains of rings, which are further linked into sheets by π – π stacking interactions. By contrast, in the triclinic polymorph of (II), which crystallizes with $Z' = 2$ in the space group $P\bar{1}$ (Low *et al.*, 2003), each type of molecule forms a distinct chain built from a combination of C–H $\cdots\pi$ and C–H $\cdots\pi$ hydrogen bonds. In compound (III), the molecules are linked by a single C–H $\cdots\pi$ hydrogen bond to form simple $C(6)$ chains (Low *et al.*, 2004), while in compound (IV) the molecules are linked into isolated centrosymmetric dimers by two distinct C–H $\cdots\pi$ hydrogen bonds (Low *et al.*, 2005). Thus, no two members of this series show the same pattern of supramolecular aggregation, confirming that such aggregation is very sensitive to the details of the substituents on the heterocyclic ring system.

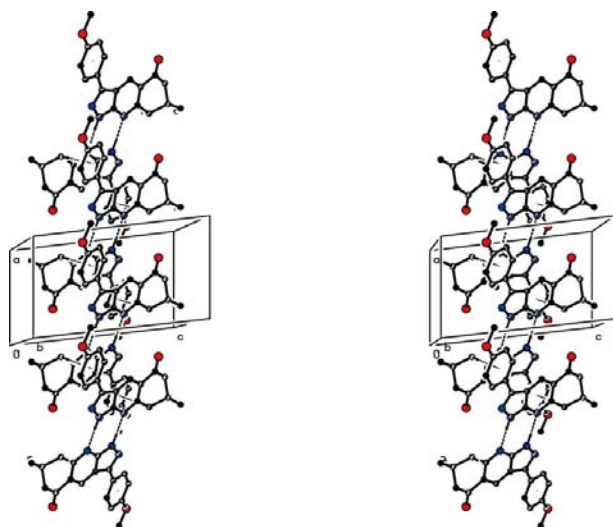


Figure 2
A stereoview of part of the crystal structure of compound (I), showing the formation of a hydrogen-bonded chain of centrosymmetric rings along $[100]$. For the sake of clarity, H atoms not involved in the motifs shown have been omitted.

Experimental

Equimolar quantities (1 mmol of each component) of 5-amino-3-(4-methoxyphenyl)pyrazole, 5,5-dimethylcyclohexane-1,3-dione and formaldehyde (as a 37% aqueous solution) were placed in an open Pyrex glass vessel and irradiated in a domestic microwave oven for 6 min at 600 W. The product mixture was extracted with ethanol and after removal of the solvent, the resulting product, (I), was recrystallized from ethanol to give crystals suitable for single-crystal X-ray diffraction (m.p. 566–567 K, yield 65%). MS (70 eV) m/z (%): 321 (M^+ , 66), 306 [$(M - \text{CH}_3)^+$, 100], 222 (33), 134 (89), 77 (13), 39 (24).

Crystal data

$C_{19}H_{19}N_3O_2$	$V = 816.28 (10) \text{ \AA}^3$
$M_r = 321.37$	$Z = 2$
Triclinic, $P\bar{1}$	$D_x = 1.308 \text{ Mg m}^{-3}$
$a = 7.1510 (6) \text{ \AA}$	Mo $K\alpha$ radiation
$b = 9.7680 (7) \text{ \AA}$	$\mu = 0.09 \text{ mm}^{-1}$
$c = 12.3780 (8) \text{ \AA}$	$T = 120 (2) \text{ K}$
$\alpha = 72.094 (5)^\circ$	Lath, colourless
$\beta = 83.529 (4)^\circ$	$0.20 \times 0.10 \times 0.03 \text{ mm}$
$\gamma = 85.055 (4)^\circ$	

Data collection

Bruker–Nonius KappaCCD area-detector diffractometer	17481 measured reflections
φ and ω scans	3721 independent reflections
Absorption correction: multi-scan (SADABS; Sheldrick, 2003)	2099 reflections with $I > 2\sigma(I)$
$T_{\min} = 0.977, T_{\max} = 0.997$	$R_{\text{int}} = 0.108$
	$\theta_{\max} = 27.5^\circ$

Refinement

Refinement on F^2	$w = 1/[\sigma^2(F_o^2) + (0.0572P)^2 + 0.2906P]$
$R[F^2 > 2\sigma(F^2)] = 0.074$	where $P = (F_o^2 + 2F_c^2)/3$
$wR(F^2) = 0.160$	$(\Delta/\sigma)_{\max} < 0.001$
$S = 1.03$	$\Delta\rho_{\max} = 0.26 \text{ e \AA}^{-3}$
3721 reflections	$\Delta\rho_{\min} = -0.18 \text{ e \AA}^{-3}$
218 parameters	Extinction correction: SHELXL97 (Sheldrick, 1997)
H-atom parameters constrained	Extinction coefficient: 0.036 (6)

Table 1

Selected geometric parameters (Å, °).

N1–N2	1.366 (3)	C4a–C8a	1.425 (3)
N2–C3	1.331 (3)	C8a–N9	1.342 (3)
C3–C3a	1.436 (3)	N9–C9a	1.343 (3)
C3a–C4	1.394 (3)	C9a–N1	1.352 (3)
C4–C4a	1.384 (3)	C3a–C9a	1.412 (3)
O34–C34–C33	125.0 (2)	C34–O34–C341	118.3 (2)
O34–C34–C35	115.6 (2)		
N2–C3–C31–C32	166.7 (2)	C33–C34–O34–C341	3.5 (4)

Table 2

Hydrogen-bond geometry (Å, °).

C_g is the centroid of the C31–C36 ring.

$D-H\cdots A$	$D-H$	$H\cdots A$	$D\cdots A$	$D-H\cdots A$
N1–H1 \cdots N9 ⁱ	0.88	2.01	2.884 (3)	173
C8–H8B \cdots Cg ⁱⁱ	0.99	2.80	3.772 (3)	167

Symmetry codes: (i) $-x + 2, -y + 1, -z + 1$; (ii) $-x + 1, -y + 1, -z + 1$.

Crystals of compound (I) are triclinic; the space group $P\bar{1}$ was chosen and confirmed by the successful structure analysis. All H atoms were located in difference maps and then treated as riding atoms, with C–H distances of 0.95 (aromatic), 0.98 (CH₃) or 0.99 Å (CH₂), an N–H distance of 0.88 Å, and $U_{\text{iso}}(\text{H}) = 1.2U_{\text{eq}}(\text{C,N})$, or $1.5U_{\text{eq}}(\text{C})$ for the methyl groups.

Data collection: *COLLECT* (Nonius, 1999); cell refinement: *DENZO* (Otwinowski & Minor, 1997) and *COLLECT*; data reduction: *DENZO* and *COLLECT*; 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: SK3039). Services for accessing these data are described at the back of the journal.

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