Acta Crystallographica Section C
Crystal Structure Communications
ISSN 0108-2701

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

Silvia Cruz,[a] Jairo Quiroga,[b] José M. de la Torre,[c] Justo Cobo,[c] John N. Low[d] and Christopher Glidewell[e]*

[a]Departamento de Química, Universidad de Nariño, Ciudad Universitaria, Torobajo, AA 1175 Pasto, Colombia, [b]Grupo de Investigación de Compuestos Heterocíclicos, Departamento de Química, Universidad de Valle, AA 25360 Cali, Colombia, [c]Departamento de Química Inorgánica y Orgánica, Universidad de Jaén, 23071 Jaén, Spain, [d]Department of Chemistry, University of Aberdeen, Meston Walk, Old Aberdeen AB24 3UE, Scotland, and [e]School of Chemistry, University of St Andrews, Fife KY16 9ST, Scotland
Correspondence e-mail: cg@st-andrews.ac.uk

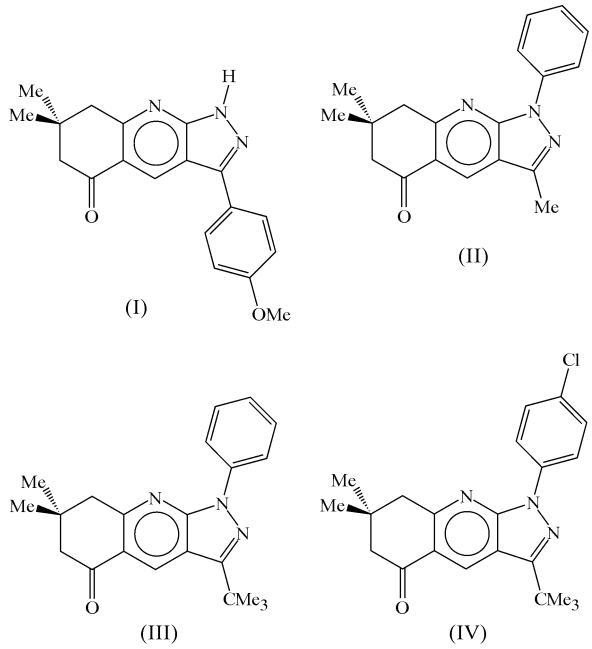
Received 30 June 2006
Accepted 3 July 2006
Online 29 July 2006

In the title compound, $C_{19}H_{19}N_3O_2$, the non-aromatic carbocylic 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; Smirnoff & 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 θ = 55.1 (4)° and φ = 167.4 (4)°, indicating a conformation close to an envelope form, for which the idealized parameters are θ = 54.7° and φ = (60*n*)°. 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

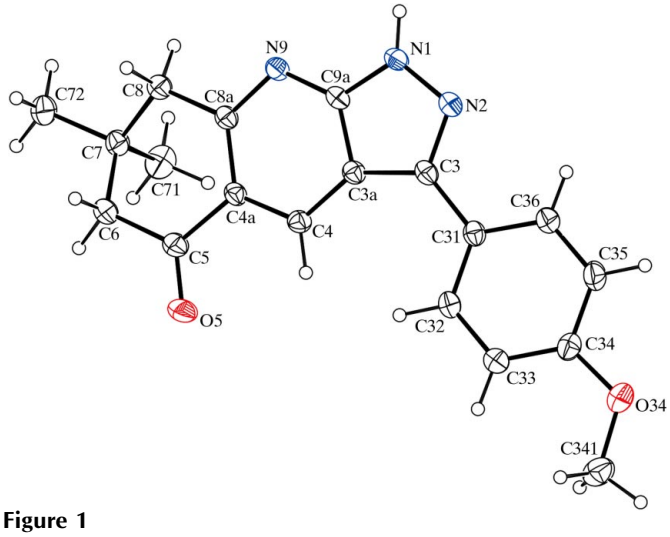


Figure 1
A molecule of compound (I), showing the atom-labelling scheme. Displacement ellipsoids are drawn at the 30% probability level and H atoms are shown as small spheres of arbitrary radii.

 DOI: 10.1107/S0108270106025522

$R_2^2(8)$ (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 H8*B*, 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 = 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 = 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 $P\overline{1}$ (Low *et al.*, 2003), each type of molecule forms a distinct chain built from a combination of C—H$\cdots$O and C—H$\cdots\pi$ hydrogen bonds. In compound (III), the molecules are linked by a single C—H$\cdots$N 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.

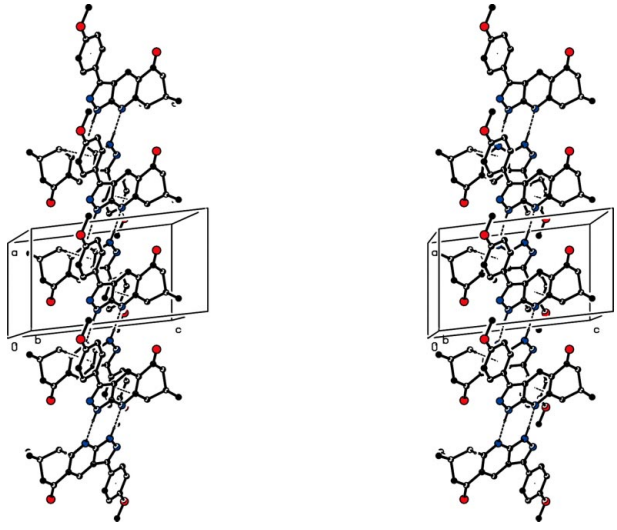


Figure 2
A stereoview of part of the crystal structure of compound (I), showing the formation of a hydrogen-bonded chain of centrosymmetric rings along [100]. For the sake of clarity, H atoms not involved in the motifs shown have been omitted.

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 [$(M-CH_3)^+$, 100], 222 (33), 134 (89), 77 (13), 39 (24).

Crystal data

$C_{19}H_{19}N_3O_2$
M_r = 321.37
Triclinic, $P\overline{1}$
a = 7.1510 (6) Å
b = 9.7680 (7) Å
c = 12.3780 (8) Å
α = 72.094 (5)°
β = 83.529 (4)°
γ = 85.055 (4)°
V = 816.28 (10) Å^3
Z = 2
D_x = 1.308 Mg m^{-3}
Mo $K\alpha$ radiation
μ = 0.09 mm^{-1}
T = 120 (2) K
Lath, colourless
0.20 × 0.10 × 0.03 mm

Data collection

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

Refinement

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

Cg 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—H8*B*$\cdots$*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 $P\overline{1}$ 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 (CH_3) or 0.99 Å (CH_2), an N—H distance of 0.88 Å, and $U_{iso}(H) = 1.2U_{eq}(C,N)$, or $1.5U_{eq}(C)$ 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).

The X-ray data were collected by the EPSRC National X-ray Crystallography Service, University of Southampton, England; the authors thank the staff for all their help and advice. JC and JMT thank the Consejería de Innovación, Ciencia y Empresa (Junta de Andalucía, Spain), and the Universidad de Jaén for financial support. JMT also thanks Universidad de Jaén for a scholarship grant. JQ and SC thank COLCIENCIAS, UNIVALLE (Universidad del Valle, Colombia) and UDENAR (Universidad de Nariño, Colombia) for financial support.

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.

References

Bernstein, J., Davis, R. E., Shimoni, L. & Chang, N.-L. (1995). *Angew. Chem. Int. Ed. Engl.* **34**, 1555–1573.
Burla, M. C., Caliandro, R., Camalli, M., Carrozzini, B., Cascarano, G. L., De Caro, L., Giacovazzo, C., Polidori, G. & Spagna, R. (2005). *J. Appl. Cryst.* **38**, 381–388.
Cremer, D. & Pople, J. A. (1975). *J. Am. Chem. Soc.* **97**, 1354–1358.
Crenshaw, R. R., Luke, G. M. & Smirnoff, P. (1976). *J. Med. Chem.* **19**, 262–275.
Ferguson, G. (1999). *PRPKAPPA*. University of Guelph, Canada.
Low, J. N., Cobo, J., Mera, J., Quiroga, J. & Glidewell, C. (2004). *Acta Cryst.* C**60**, o479–o482.
Low, J. N., Cobo, J., Mera, J., Quiroga, J. & Glidewell, C. (2005). *Acta Cryst.* E**61**, o49–o51.
Low, J. N., Mera, J., Quiroga, J. & Cobo, J. (2003). *Acta Cryst.* E**59**, o1804–o1806.
McArdle, P. (2003). *OSCAIL for Windows*. Version 10. Crystallography Centre, Chemistry Department, NUI Galway, Ireland.
Mera, J., Quiroga, J., Cobo, J., Low, J. N. & Glidewell, C. (2005). *Acta Cryst.* C**61**, o442–o444.
Nonius (1999). *COLLECT*. Nonius BV, Delft, The Netherlands.
Otwinowski, Z. & Minor, W. (1997). *Methods in Enzymology*, Vol. 276, *Macromolecular Crystallography*, Part A, edited by C. W. Carter Jr & R. M. Sweet, pp. 307–326. New York: Academic Press.
Quiroga, J., Hormaza, A., Insuasty, B., Ortiz, A. J., Sánchez, A. & Nogueras, M. (1998). *J. Heterocycl. Chem.* **35**, 231–233.
Quiroga, J., Insuasty, B., Hormaza, A., Saitz, C. & Jullian, C. (1998). *J. Heterocycl. Chem.* **35**, 575–578.
Sheldrick, G. M. (1997). *SHELXS97* and *SHELXL97*. University of Göttingen, Germany.
Sheldrick, G. M. (2003). *SADABS*. Version 2.10. University of Göttingen, Germany.
Smirnoff, P. & Crenshaw, R. R. (1977). *Antimicrob. Agents Chemother.* **11**, 571–573.
Spek, A. L. (2003). *J. Appl. Cryst.* **36**, 7–13.