Acta Crystallographica Section E
Structure Reports Online
ISSN 1600-5368

5-Amino-4-(4-dimethylaminophenyl)-2-(4-methoxyphenyl)-7-(pyrrolidin-1-yl)-1,6-naphthyridine-8-carbonitrile

Sundari Bhaskaran,[a] M. Yogavel,[a] V. Rajakannan,[a] R. Krishna,[b] D. Velmurugan[a]* and V. Raghukumar[c]

[a]Department of Crystallography and Biophysics, University of Madras, Guindy Campus, Chennai 600 025, India, [b]Molecular Biophysics Unit, Indian Institute of Science, Bangalore 560 012, India, and [c]Department of Organic Chemistry, University of Madras, Guindy Campus, Chennai 600 025, India

Correspondence e-mail: d_velu@yahoo.com

Key indicators

Single-crystal X-ray study
T = 293 K
Mean σ(C–C) = 0.008 Å
R factor = 0.067
wR factor = 0.196
Data-to-parameter ratio = 15.0

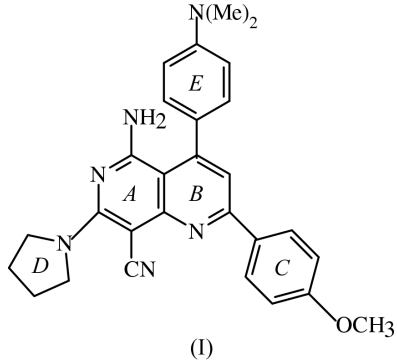
For details of how these key indicators were automatically derived from the article, see http://journals.iucr.org/e.

Received 2 January 2003
Accepted 14 January 2003
Online 24 January 2003

In the title compound, $C_{28}H_{28}N_6O$, the naphthyridine moiety is planar and the pyrrolidine ring adopts a half-chair conformation. The dimethylaminophenyl substituent is nearly orthogonal to the naphthyridine moiety, while the methoxyphenyl ring is twisted from it by 11.3 (2)°. The molecular structure is stabilized by an N—H···π interaction. In the solid state, the inversion-related molecules are linked to form N—H···N hydrogen-bonded dimers. The molecular packing is stabilized by weak C—H···π and π–π interactions.

Comment

Naphthyridine derivatives have a wide range of biological activities, such as anti-inflammatory, anticonvulsant (Balogh *et al.*, 1986), insecticidal (Takeuchi & Hamada, 1975), antitumour (El-Subbagh *et al.*, 1999), tuberculostatic (Ferrarini *et al.*, 1998), cardiotonic (Mohan & Mishra, 1997) and antibacterial (Datta *et al.*, 1995). They have been reported as potential drugs for the treatment of bladder function disorders (Natsugari *et al.*, 1999). The naphthyridine derivatives also act as dyes (Irikawa & Iijima, 1998). Since naphthyridine derivatives belong to the class of heterocyclic compounds, it is expected that they possess laser and non-linear optical properties (Lowe, 1984; Shanmugasundaram *et al.*, 1993; Murugan *et al.*, 1998). 1,6-Naphthyridine derivatives have been tested pharmacologically as antagonists at adrenoreceptors (Brown *et al.*, 1993) and are also used as novel potent adenosine 3′,5′-cyclic phosphate phosphodiesterase III inhibitors (Singh *et al.*, 1995). The structure analysis of the title compound, (I), was carried out as part of our studies on 1,6-naphthyridine derivatives (Sankaranarayanan *et al.*, 1999, 2001; Govindasamy *et al.*, 2000).



(I)

The five rings of the molecules are *A* (C5/N6/C7–C10), *B* (N1/C2–C4/C10/C9), *C* (C19–C24), *D* (N14/C15–C18) and *E* (C27–C32). The pyrrolidine ring adopts a half-chair conformation, confirmed by its ring-puckering parameters (Cremer & Pople, 1975); q_2 = 0.296 (6) Å and φ = 93.2 (9)°, and

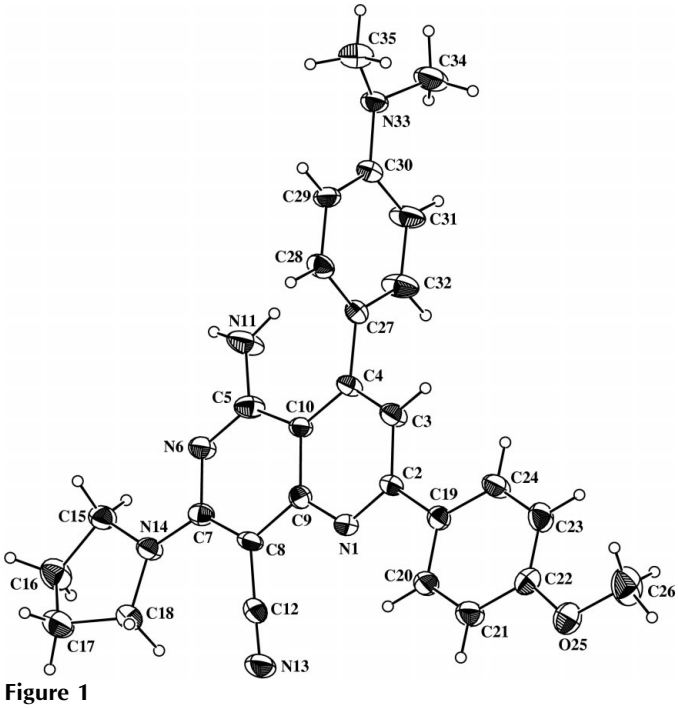


Figure 1
The molecular structure of (I), showing displacement ellipsoids at the 35% probability level.

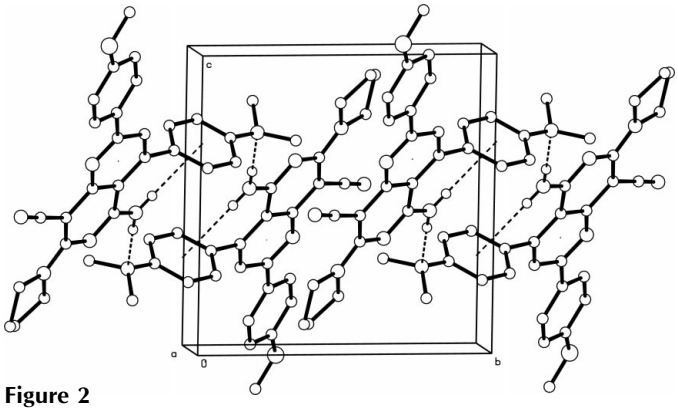


Figure 2
The molecular packing, viewed down the *a* axis.

asymmetry parameters ΔC_2(N14) = 0.009 (2) (Nardelli, 1983). The naphthyridine moiety is planar, the fused pyridine rings (rings *A* and *B*) forming a dihedral angle of 2.9 (1)°. The mean planes passing through phenyl rings *C* and *E* make dihedral angles of 12.7 (1) and 87.0 (2)°, respectively, with ring *B*. The mean plane through the pyrrolidine ring (*D*) makes a dihedral angle of 13.7 (4)° with the pyridine ring (*A*). The orientation of the substituents on the 1,6-naphthyridine ring may be determined from the torsion angels: N1—C2—C19—C20 [−12.5 (7)°], C3—C2—C19—C24 [−13.4 (8)°], C3—C4—C27—C28 [−91.5 (6)°], C10—C4—C27—C32 [−94.1 (7)°], N6—C7—N14—C15 [3.8 (7)°] and C8—C7—N14—C18 [8.5 (9)°]. The methoxy group is coplanar [C21—C22—O25—C26 = −179.6 (5)°] with the attached phenyl ring (*C*).

The bond distances and angles are comparable with related structures studied previously (Chinnakali *et al.*, 1998; Sankaranarayanan *et al.*, 1999, 2001; Govindasamy *et al.*, 2000; Thirumurugan *et al.*, 1999). The bond distance C5—N11 [1.346 (6) Å] is shorter than the typical C—N single-bond distance (1.47 Å), as in the other related structures, indicating conjugation of the amino group with the aromatic naphthyridine moiety. The sum of the bond angles around atom N14 is 359.8 (4)°, indicating sp^2 hybridization. The sum of the bond angles around atom N33 is 349.8 (4)°, indicating pyramidalization. The cyano bond distance C12—N13 [1.148 (6) Å] and the angle C8—C12—N13 [177.3 (6)°] are comparable with values in related structures. Due to steric interactions, the bond angles C4—C10—C5 [127.2 (4)°], C8—C7—N14 [125.4 (5)°] and C3—C2—C19 [122.4 (5)°] are widened from 120°, while angles N1—C9—C8 [116.8 (4)°], N14—C7—N6 [113.3 (5)°] and N1—C2—C19 [116.5 (4)°] are narrowed from 120°.

One of the amino H atoms, H11*B*, is involved in an intramolecular N—H···π interaction [N11—H11*B* = 0.86 Å, H11*B*···*Cg*(*E*) = 2.63 Å, N11···*Cg*(*E*) = 3.470 (3) Å and N11—H11*B*···*Cg*(*E*) = 166°, where *Cg*(*E*) is the centroid of ring *E*]. The other H atom, H11*A*, is involved in the formation of centrosymmetrically hydrogen-bonded (N11—H11*A*···N33) dimers in the solid state [N11—H11*A* = 0.86 Å, H11*A*···N33^{i} = 2.25 Å, N11···N33^{i} = 3.106 (6) Å and N11—H11*A*···N33^{i} = 173°; symmetry code: (i) $1-x, -y, 1-z$]. The *B* ring of the molecule at (*x*, *y*, *z*) and *E* ring of the molecule at ($-x$, $-y$, $1-z$) are arranged in a face-to-edge manner, with their centroids separated by 4.741 (3) Å. Apart from these interactions, the molecular packing is stabilized by weak C—H···π interactions [C28—H28 = 0.93 Å, H28···*Cg*(*A*) = 2.58 Å, C28···*Cg*(*A*) = 3.443 (6) Å and C28—H28···*Cg*(*A*) = 155°, where Cg(*A*) is the centroid of ring *A* at ($-x$, $-y$, $1-z$)].

Experimental

Refluxing a solution of 3-(4-dimethylaminophenyl)-1-(4-methoxyphenyl)-prop-2-en-1-one (0.5 g, 1.77 mmol), malononitrile (0.23 g, 3.48 mmol) and pyrrolidine (0.25 g, 3.52 mmol) in ethanol for 19 h gave the title compound. Single crystals were grown by slow evaporation of a solution in ethanol–ethyl acetate (1:1). The melting point of the title compound is 491–493 K.

Crystal data

$C_{28}H_{28}N_6O$
M_r = 464.56
Triclinic, $P\overline{1}$
a = 10.671 (2) Å
b = 10.974 (1) Å
c = 11.826 (2) Å
α = 82.82 (1)°
β = 64.04 (1)°
γ = 78.32 (1)°
V = 1218.3 (3) Å^3
Z = 2
D_x = 1.266 Mg m^{-3}
Cu $K\alpha$ radiation
Cell parameters from 25 reflections
θ = 10–35°
μ = 0.64 mm^{-1}
T = 293 (2) K
Parallelepiped, yellow
0.48 × 0.34 × 0.28 mm

Data collection

Enraf–Nonius CAD-4 diffractometer
$\omega/2\theta$ scans
Absorption correction: none
5192 measured reflections
4789 independent reflections
1438 reflections with $I > 2\sigma(I)$
R_{int} = 0.100
θ_{max} = 71.9°
$h = -12 \rightarrow 13$
$k = 0 \rightarrow 13$
$l = -14 \rightarrow 14$
3 standard reflections every 200 reflections
intensity decay: none

Refinement

Refinement on F^2	H-atom parameters constrained
$R[F^2 > 2\sigma(F^2)] = 0.067$	$w = 1/[\sigma^2(F_o^2) + (0.0694P)^2]$ where $P = (F_o^2 + 2F_c^2)/3$
$wR(F^2) = 0.196$	$(\Delta/\sigma)_{max} < 0.001$
$S = 0.90$	$\Delta\rho_{max} = 0.22$ e Å^{-3}
4789 reflections	$\Delta\rho_{min} = -0.26$ e Å^{-3}
319 parameters	

After location in a difference map, all H atoms were positioned geometrically and allowed to ride on their attached atoms using *SHELXL*97 (Sheldrick, 1997) defaults for bond lengths and displacement parameters. The high R_{int} value (0.1) and low ratio (0.3) of observed to unique reflections may be a result of the poor diffraction quality of the crystal.

Data collection: *CAD*-4 *Software* (Enraf–Nonius, 1989); cell refinement: *CAD*-4 *Software*; data reduction: *CAD*-4 *Software*; program(s) used to solve structure: *SHELXS*97 (Sheldrick, 1997); program(s) used to refine structure: *SHELXL*97 (Sheldrick, 1997); molecular graphics: *ZORTEP* (Zsolnai, 1997) and *PLATON* (Spek, 1990); software used to prepare material for publication: *SHELXL*97 and *PARST* (Nardelli, 1995).

Financial support from the Department of Science and Technology (DST), India, is gratefully acknowledged.

References

Balogh, M., Hermecz, I., Naray-Szabo, G., Siemen, K. & Meazaros, Z. (1986). *J. Chem. Soc. Perkin Trans.* 1, pp. 753–757.

Brown, C. M., MacKinnon, A. C., Redfem, W. S., Hicks, P. E., Kilpatrick, A. T., Small, C., Ramacharan, M., Clague, R. U., Clark, R. D. & MacFarlane, C. B. (1993). *Br. J. Pharmacol.* **108**, 516–525.

Chinnakali, K., Fun, H.-K., Razak. I. A., Murugan, P. & Ramakrishnan, V. T. (1998). *Acta Cryst.* C**54**, 781–783.

Cremer, D. & Pople, J. A. (1975). *J. Am. Chem. Soc.* **97**, 1354–1358.

Datta, M., Hannan, S. S. & Talukdar, A. N. (1995). *Acta Cryst.* C**51**, 978–980.

El-Subbagh, H. I., Abadi, A. H., Al-Khawad, I. E. & Al-Rashood, K. A. (1999). *Arch. Pharm. (Weinheim)*, **332**, 19–24.

Enraf–Nonius (1989). *CAD*-4 *Software*. Version 5.0. Enraf–Nonius, Delft, The Netherlands.

Ferrarini, P. L., Manera, C., Mori, C., Badawneh, M. & Soccomanni, G. (1998). *Farmaco*, **53**, 741–746.

Govindasamy, L., Velmurugan, D., Raghukumar, V., Suh, H.-I. & Ramakrishnan, V. T. (2000). *Acta Cryst.* C**56**, 80–81.

Irikawa, H. & Iijima, K. (1998). *Acta Cryst.* C**54**, 1318–1320.

Lowe, P. A. (1984). *Comprehensive Heterocyclic Chemistry*, Vol. II, pp. 581–620. New York: Pergamon Press.

Mohan, C. G. & Mishra, P. C. (1997). *Indian J. Biochem. Biophys.* **34**, 429–434.

Murugan, P., Shanmugasundaram, P., Ramakrishnan, V. T., Venkatachalapathy, B., Srividya, N., Ramamurthy, P., Gunasekaran, K. & Velmurugan, D. (1998). *J. Chem. Soc. Perkin Trans.* 2, pp. 999–1003.

Nardelli, M. (1983). *Acta Cryst.* C**39**, 1141–1142.

Nardelli, M. (1995). *J. Appl. Cryst.* **28**, 659.

Natsugari, H., Ikeura, Y., Kamo, I., Ishimaru, T., Ishichi, Y., Fujishiman, A., Tanaka, T., Kasahara, F., Kawada, M. & Doi, T. (1999). *J. Med. Chem.* **42**, 3982–3993.

Sankaranarayanan, R., Shanmuga Sundara Raj, S., Velmurugan, D., Fun, H.-K., Raghukumar, V. & Ramakrishnan, V. T. (1999). *Acta Cryst.* C**55**, 1670–1672.

Sankaranarayanan, R., Velmurugan, D., Shanmuga Sundara Raj, S. & Fun, H.-K. (2001). *Acta Cryst.* C**57**, 726–727.

Shanmugasundaram, P., Prabahar, K. J. & Ramakrishnan, V. T. (1993). *J. Heterocycl. Chem.* **30**, 1003–1007.

Sheldrick, G. M. (1997). *SHELXS*97 and *SHELXL*97. University of Göttingen, Germany.

Singh, B., Bacon, E. R., Lesher, G. Y., Robinson, S., Pennock, P. O., Bode, D. C., Pagani, E. D., Bentley, R. G. & Connell, M. J. (1995). *J. Med. Chem.* **38**, 2546–2550.

Spek, A. L. (1990). *Acta Cryst.* A**46**, C-34.

Takeuchi, I. & Hamada, Y. (1975). *Chem. Phar. Bull.* **24**, 1813–1821.

Thirumurugan, R., Shanmuga Sundara Raj, S., Shanmugam, G., Fun, H.-K., Raghukumar, V. & Ramakrishnan, V. T. (1999). *Acta Cryst.* C**55**, 1522–1524.

Zsolnai, L. (1997). *ZORTEP*. University of Heidelberg, Germany.