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

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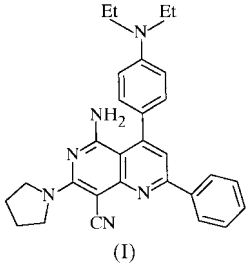
In the title compound, $C_{29}H_{30}N_6$, the naphthyridine ring is almost planar with a dihedral angle of 5.4 (1)° between the pyridyl rings. The dihedral angles between the naphthyridine system and the diethylaminophenyl, phenyl and pyrrolidine rings are 53.1 (1), 19.8 (1) and 20.9 (1)°, respectively. The pyrrolidine ring adopts a half-chair conformation. The molecule is stabilized by weak C—H···N interactions.

Comment

Naphthyridine derivatives have extensive pharmacological properties. These derivatives have anti-inflammatory (Di Braccio *et al.*, 1997), antibacterial (against gram-positive organisms) (Hong *et al.*, 1997), antitumour (Chen *et al.*, 1997), cardiotonic (Mohan & Mishra, 1997), and anticonvulsant and insecticidal (Damon & Nadelson, 1981) properties. In addition, 1,6-naphthyridine derivatives are also used as novel potent adenosine 3′,5′-cyclic phosphate phosphodiesterase III



(I)

inhibitors (Singh *et al.*, 1995). 1,6-Naphthyridine systems are known (Reed *et al.*, 1988; Vinick, 1989) but few structural data have been reported (Balogh *et al.*, 1986). The structure analysis of the title compound, (I), was carried out in order to determine the stereochemical and conformational changes induced by the substituents on the 1,6-naphthyridine ring system.

The molecule of (I) (Fig. 1) consists of a 1,6-naphthyridine ring system substituted with five different chemical substituents, namely a phenyl ring, a diethylaminophenyl ring, a pyrrolidine ring, a cyano group and an amino group. The C25≡N4 bond length [1.145 (3) Å] and the C5—C25—N4 bond angle [177.5 (3)°] are comparable with previously reported values of 1.136 (9) Å and 177.2 (8)°, respectively, in a 1,6-naphthyridine derivative (Gomez de Anderez *et al.*, 1992). The bond distances C1—C9 [1.491 (3) Å] and C3—C15 [1.489 (3) Å] are slightly longer than normal $Csp^2—Csp^2$ values. This is due to the π-electron repulsion of the bulky substituted phenyl rings at C1 and C3. The C—N and C—C distances in the structure agree well with literature values (Allen *et al.*, 1987). The bond angles C1—C8—C7 [127.1 (2)°] and N5—C6—C5 [125.1 (2)°] are larger than the normal value of 120°. This is due to the steric interactions imposed by the substituents.

The naphthyridine ring system is almost planar and there is a dihedral angle of 5.4 (1)° between the pyridyl rings. The two phenyl rings substituted at C1 and C3 of the naphthyridine ring system are inclined at angles of 53.1 (1) and 19.8 (1)°, respectively. The dihedral angle between the pyrrolidine and naphthyridine rings is 20.9 (1)°. The pyrrolidine ring adopts a half-chair conformation which was confirmed using the ring-puckering parameters (Cremer & Pople, 1975) q_2 = 0.342 (4) Å and φ_2 = 91.6 (6)°, and the asymmetry parameter ΔC_2(N5) = 0.006 (1) (Nardelli, 1983). The amino N3 atom deviates by 0.244 (3) Å from the mean plane of the 1,6-naphthyridine ring. The orientation of the substituents on the 1,6-naphthyridine ring may be described by using the following torsion angles at C1, C3 and C6: C2—C1—C9—C14 = −124.2 (3), C8—C1—C9—C10 = 51.7 (3), C2—C3—C15—C20 = −166.5 (3), N1—C3—C15—C16 −158.8 (3),

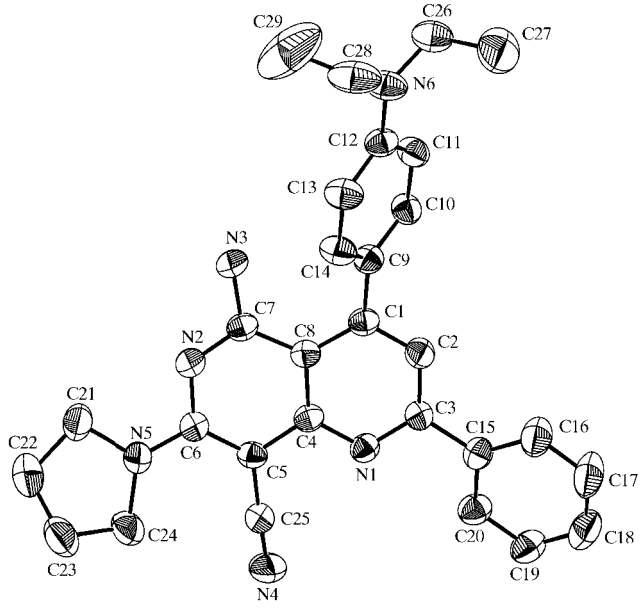


Figure 1
The molecular structure of (I) showing 50% probability displacement ellipsoids and the atom-numbering scheme.

N2—C6—N5—C24 13.4 (4) and C5—C6—N5—C21 = −176.4 (2)°.

The structure is stabilized by weak intermolecular C—H···N interactions [C28—H28*B* 0.97, H28*B*···N1^{i} 2.58, C28···N1^{i} 3.478 (4) Å and C28—H28*B*···N1^{i} 154°; symmetry code: (i) $-x, 2-y, 2-z$] in addition to van der Waals forces.

Experimental

The title compound was synthesized from a solution of 4-*N*,*N*-diethylaminobenzylacetophenone (2.4 mmol), malononitrile (4.8 mmol) and a few drops of pyrrolidine (4.8 mmol) in ethanol refluxed for 25 h. The reaction mixture was concentrated under reduced pressure and purified by column chromatography over silica gel (m.p. 493–495 K) (Murugan *et al.*, 2000). Single crystals were grown by slow evaporation of a methanol solution of the compound.

Crystal data

$C_{29}H_{30}N_6$
M_r = 462.59
Triclinic, $P\overline{1}$
a = 11.117 (3) Å
b = 11.1824 (11) Å
c = 11.3444 (10) Å
α = 70.906 (8)°
β = 83.953 (12)°
γ = 67.355 (12)°
V = 1229.6 (3) Å^3
Z = 2
D_x = 1.249 Mg m^{-3}
Mo $K\alpha$ radiation
Cell parameters from 24 reflections
θ = 3–25°
μ = 0.076 mm^{-1}
T = 290 (2) K
Parallelepiped, yellow
0.63 × 0.36 × 0.30 mm

Data collection

Enraf–Nonius CAD-4 diffractometer
$\omega/2\theta$ scans
Absorption correction: empirical *via* ψ scan (North *et al.*, 1968)
T_{min} = 0.954, T_{max} = 0.978
4564 measured reflections
4323 independent reflections
2715 reflections with $I > 2\sigma(I)$
R_{int} = 0.039
θ_{max} = 24.97°
$h = -13 \rightarrow 13$
$k = -12 \rightarrow 13$
$l = 0 \rightarrow 13$
3 standard reflections
every 200 reflections
frequency: 60 min
intensity decay: <3%

Refinement

Refinement on F^2
$R[F^2 > 2\sigma(F^2)]$ = 0.060
$wR(F^2)$ = 0.180
S = 1.022
4323 reflections
316 parameters
H-atom parameters constrained
$w = 1/[\sigma^2(F_o^2) + (0.1P)^2]$ where $P = (F_o^2 + 2F_c^2)/3$
$(\Delta/\sigma)_{max} < 0.001$
$\Delta\rho_{max}$ = 0.35 e Å^{-3}
$\Delta\rho_{min}$ = −0.20 e Å^{-3}

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, 1990); program(s) used to refine structure: *SHELXL*97 (Sheldrick, 1997); molecular graphics: *ZORTEP* (Zsolnai, 1997); software used to prepare material for publication: *PARST* (Nardelli, 1995).

Table 1
Selected geometric parameters (Å, °).

N1—C3	1.334 (3)	N5—C6	1.356 (3)
N1—C4	1.357 (3)	N5—C24	1.458 (3)
N2—C7	1.324 (3)	N5—C21	1.472 (3)
N2—C6	1.354 (3)	N6—C12	1.370 (3)
N3—C7	1.344 (3)	N6—C26	1.441 (4)
N4—C25	1.145 (3)		
C6—N5—C24	125.9 (2)	N1—C4—C8	122.9 (2)
C6—N5—C21	122.1 (2)	C6—C5—C25	124.9 (2)
C24—N5—C21	111.4 (2)	C4—C5—C25	116.7 (2)
C26—N6—C28	116.6 (2)	N2—C6—N5	113.8 (2)
C2—C1—C8	117.5 (2)	N5—C6—C5	125.1 (2)
C2—C1—C9	117.9 (2)	C1—C8—C7	127.1 (2)
C8—C1—C9	124.5 (2)	C14—C9—C10	116.8 (2)
N1—C3—C15	114.7 (2)	N5—C24—C23	103.7 (2)
C2—C3—C15	123.2 (2)	N4—C25—C5	177.5 (3)
N1—C4—C5	116.8 (2)		

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Supplementary data for this paper are available from the IUCr electronic archives (Reference: FG1556). Services for accessing these data are described at the back of the journal.

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