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6-Methyl-1,4-bis[(pyridin-2-yl)methyl]quinoxaline-2,3(1*H*,4*H*)-dione

Ayman Zouitini,[a]* Youssef Kandri Rodi,[a] Fouad Ouazzani Chahdi,[a] Jerry P. Jasinski,[b] Manpreet Kaur[b] and El Mokhtar Essassi[c]

[a]Laboratoire de Chimie Organique Appliquée, Faculté des Sciences et Techniques, Université Sidi Mohammed Ben Abdellah, Fès, Morocco, [b]Department of Chemistry, Keene State College, 229 Main Street, Keene, NH 03435-2001, USA, and [c]Laboratoire de Chimie Organique Hétérocyclique, Pôle de Compétences, Pharmacochimie, Mohammed V University in Rabat, BP 1014, Avenue Ibn Batouta, Rabat, Morocco. *Correspondence e-mail: ayman.zouitini@gmail.com

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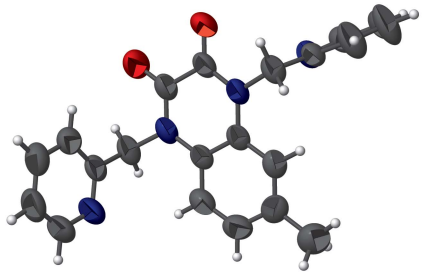
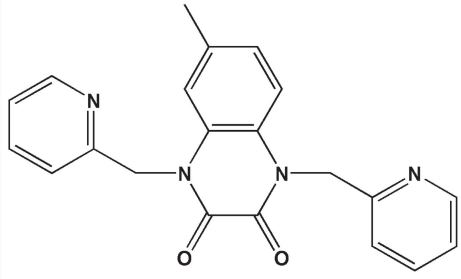
The title compound, $C_{21}H_{18}N_4O_2$, crystallizes with one independent molecule in the asymmetric unit. The 6-methylquinoxaline-2,3(1*H*,4*H*)-dione unit is essentially planar. The dihedral angles between the mean plane of the 6-methylquinoxaline-2,3(1*H*,4*H*)-dione ring and its pendant pyridin-2-yl rings are 85.1 (3) and 73.8 (4)°. The pyridin-2-yl rings are inclined pointing away from the 6-methylquinoxaline-2,3(1*H*,4*H*)-dione ring system. In the crystal, molecules are linked by weak C—H···O interactions, forming a three-dimensional network structure.

3D view



Chemical scheme



Structure description

Quinoxalines and their derivatives are a varied class of nitrogen-containing heterocyclic compounds, which display various pharmacological and biological activities, such as anticancer (Carta *et al.*, 2006), antimalarial (Guillon *et al.*, 2004), antiviral (Fonseca *et al.*, 2004), antibacterial (El-Sabbagh *et al.*, 2009), antimicrobial (Singh *et al.*, 2010), anti-inflammatory (Wagle *et al.*, 2008) and antiprotozoal (Hui *et al.*, 2006). In this work, we report the synthesis of a new quinoxaline derivative by the reaction of 2-picolyl chloride with 6-methyl-1,4-dihydroquinoxaline-2,3-dione in dimethylformamide in the presence of potassium carbonate and a catalytic quantity of tetra-*n*-butylammonium bromide.

The title compound (Fig. 1) crystallizes with one independent molecule in the asymmetric unit. The 6-methylquinoxaline-2,3(1*H*,4*H*)-dione unit is essentially planar, the maximum r.m.s. deviation from the mean plane through the atoms N1/N2/C1–C8 is 0.047 (9) Å for N2. The dihedral angles between this plane and its pendant pyridin-2-yl

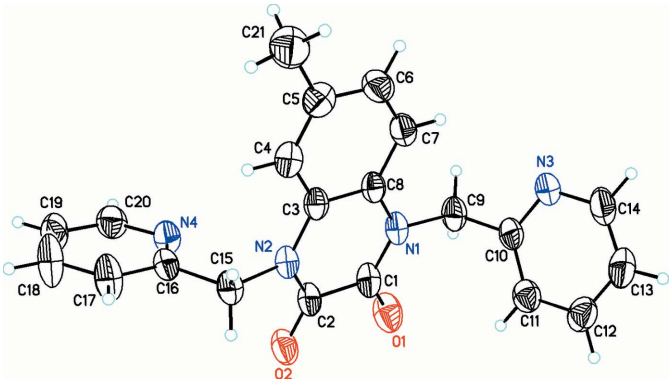


Figure 1
The molecular structure of the title compound, shown with 30% probability displacement ellipsoids.

rings N4/C16–C20 and N3/C10–C13 are 85.1 (3) and 73.8 (4)°, respectively. The two pyridin-2-yl rings are inclined by a dihedral angle of 75.2 (5)°, pointing away from the 6-methyl-quinoxaline-2,3(1*H*,4*H*)-dione ring system.

In the crystal, the molecules are linked by weak C—H···O intermolecular interactions involving O2 as the common acceptor (Table 1), and form a three-dimensional network structure (Fig. 2).

Synthesis and crystallization

To a solution of 6-methyl-1,4-dihydroquinoxaline-2,3-dione (0.3 g, 1.73 mmol) in DMF (20 ml), were added potassium carbonate (0.47 g, 3.61 mmol) and tetra-*n*-butyl ammonium (BTBA; 0.1 mmol). After 10 min of stirring, 0.55 ml (5.25 mmol) of 2-picolyl chloride were added, then the mixture was allowed to stir at room temperature for 24 h. After filtration of the salts, the DMF was evaporated under reduced pressure and the residue obtained was dissolved in dichloromethane. The organic phase was then dried over Na_2SO_4 and then concentrated. The mixture obtained was chromatographed on a silica gel column [eluent: hexane/ethylacetate (2/1)]. The compound formed white columnar crystals in 30% yield and was recrystallized from an ethanol–water (1/1) solvent mixture.

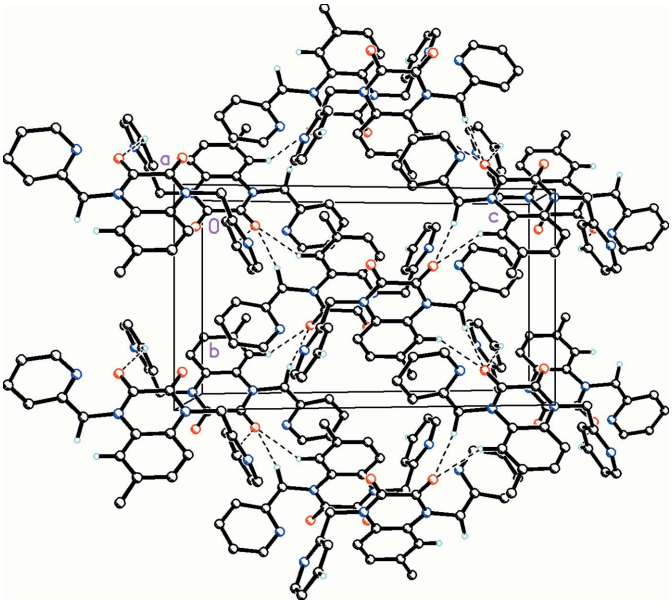


Figure 2
Packing diagram of the title compound viewed along the *a* axis. Dashed lines indicate weak C—H···O interactions linking the molecules into a three-dimensional-network structure. H atoms not involved in these weak intermolecular interactions are omitted for clarity.

Table 1
Hydrogen-bond geometry (Å, °).

D—H···*A*	*D*—H	H···*A*	*D*···*A*	*D*—H···*A*
C4—H4···O2^{i}	0.93	2.52	3.270 (3)	138
C12—H12···O2^{ii}	0.93	2.48	3.227 (4)	137
C15—H15*A*···O2^{i}	0.97	2.37	3.297 (4)	160

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

Table 2
Experimental details.

Crystal data	
Chemical formula	$C_{21}H_{18}N_4O_2$
M_r	358.39
Crystal system, space group	Monoclinic, $P2_1/n$
Temperature (K)	293
a, *b*, *c* (Å)	12.465 (1), 9.1221 (6), 16.1585 (12)
β (°)	102.761 (8)
V (Å^3)	1792.0 (2)
Z	4
Radiation type	Cu $K\alpha$
μ (mm^{-1})	0.71
Crystal size (mm)	0.24 × 0.12 × 0.08
Data collection	
Diffractometer	Rigaku Oxford Diffraction
Absorption correction	Multi-scan (*CrysAlis PRO*; Rigaku Oxford Diffraction, 2015)
T_{min}, T_{max}	0.812, 1.000
No. of measured, independent and observed [$I > 2\sigma(I)$] reflections	6708, 3385, 2343
R_{int}	0.024
(sin $\theta/\lambda)_{max}$ (Å^{-1})	0.613
Refinement	
$R[F^2 > 2\sigma(F^2)]$, $wR(F^2)$, *S*	0.068, 0.222, 1.04
No. of reflections	3385
No. of parameters	245
H-atom treatment	H-atom parameters constrained
$\Delta\rho_{max}$, $\Delta\rho_{min}$ (e Å^{-3})	0.55, −0.27

Computer programs: *CrysAlis PRO* (Rigaku Oxford Diffraction, 2015), *SHELXT* (Sheldrick, 2015*a*), *SHELXL2014* (Sheldrick, 2015*b*) and *OLEX2* (Dolomanov *et al.*, 2009).

Refinement

Crystal data, data collection and structure refinement details are summarized in Table 2.

Acknowledgements

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full crystallographic data

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Crystal data

$C_{21}H_{18}N_4O_2$
M_r = 358.39
Monoclinic, $P2_1/n$
a = 12.465 (1) Å
b = 9.1221 (6) Å
c = 16.1585 (12) Å
β = 102.761 (8)°
V = 1792.0 (2) Å^3
Z = 4
$F(000)$ = 752
D_x = 1.328 Mg m^{-3}
Cu $K\alpha$ radiation, λ = 1.54184 Å
Cell parameters from 1702 reflections
θ = 5.1–71.0°
μ = 0.71 mm^{-1}
T = 293 K
Irregular, colourless
0.24 × 0.12 × 0.08 mm

Data collection

Rigaku Oxford Diffraction diffractometer
Radiation source: fine-focus sealed X-ray tube, Enhance (Cu) X-ray Source
Graphite monochromator
Detector resolution: 16.0416 pixels mm^{-1}
ω scans
Absorption correction: multi-scan (CrysAlis PRO; Rigaku Oxford Diffraction, 2015)
T_{min} = 0.812, T_{max} = 1.000
6708 measured reflections
3385 independent reflections
2343 reflections with $I > 2\sigma(I)$
R_{int} = 0.024
θ_{max} = 70.9°, θ_{min} = 4.1°
h = −13→15
k = −10→11
l = −14→19

Refinement

Refinement on F^2
Least-squares matrix: full
$R[F^2 > 2\sigma(F^2)]$ = 0.068
$wR(F^2)$ = 0.222
S = 1.04
3385 reflections
245 parameters
0 restraints
Primary atom site location: dual
Hydrogen site location: inferred from neighbouring sites
H-atom parameters constrained
$w = 1/[\sigma^2(F_o^2) + (0.1138P)^2 + 0.4268P]$ where $P = (F_o^2 + 2F_c^2)/3$
$(\Delta/\sigma)_{max} < 0.001$
$\Delta\rho_{max}$ = 0.55 e Å^{-3}
$\Delta\rho_{min}$ = −0.27 e Å^{-3}

Special details

Geometry. All esds (except the esd in the dihedral angle between two l.s. planes) are estimated using the full covariance matrix. The cell esds are taken into account individually in the estimation of esds in distances, angles and torsion angles; correlations between esds in cell parameters are only used when they are defined by crystal symmetry. An approximate (isotropic) treatment of cell esds is used for estimating esds involving l.s. planes.

Fractional atomic coordinates and isotropic or equivalent isotropic displacement parameters (Å²)

	x	*y*	*z*	U_{iso}*/U_{eq}
O1	0.8255 (2)	0.3490 (3)	0.50506 (15)	0.0993 (8)
O2	0.8436 (2)	0.3550 (2)	0.67356 (13)	0.0869 (7)
N1	0.69219 (19)	0.5224 (2)	0.48599 (12)	0.0622 (6)
N2	0.71149 (19)	0.5301 (2)	0.66018 (12)	0.0587 (5)
N3	0.7006 (2)	0.7502 (4)	0.32323 (19)	0.0977 (10)
N4	0.6070 (2)	0.3429 (3)	0.75468 (15)	0.0735 (7)
C1	0.7651 (3)	0.4307 (3)	0.53355 (17)	0.0684 (7)
C2	0.7758 (2)	0.4345 (3)	0.62905 (16)	0.0651 (7)
C3	0.6315 (2)	0.6168 (3)	0.60794 (15)	0.0571 (6)
C4	0.5606 (2)	0.7055 (3)	0.64092 (18)	0.0655 (7)
H4	0.5651	0.7053	0.6992	0.079*
C5	0.4840 (3)	0.7934 (3)	0.5902 (2)	0.0754 (8)
C6	0.4768 (3)	0.7916 (4)	0.5030 (2)	0.0806 (9)
H6	0.4254	0.8509	0.4678	0.097*
C7	0.5444 (3)	0.7038 (3)	0.46837 (19)	0.0714 (7)
H7	0.5381	0.7036	0.4099	0.086*
C8	0.6224 (2)	0.6148 (3)	0.51950 (15)	0.0569 (6)
C9	0.6875 (3)	0.5222 (4)	0.39327 (16)	0.0733 (8)
H9A	0.6116	0.5334	0.3628	0.088*
H9B	0.7140	0.4288	0.3773	0.088*
C10	0.7552 (2)	0.6432 (3)	0.36818 (15)	0.0646 (7)
C11	0.8688 (3)	0.6415 (4)	0.39011 (18)	0.0744 (8)
H11	0.9055	0.5634	0.4210	0.089*
C12	0.9270 (3)	0.7554 (4)	0.3662 (2)	0.0839 (9)
H12	1.0035	0.7561	0.3807	0.101*
C13	0.8704 (4)	0.8672 (4)	0.3209 (2)	0.0929 (11)
H13	0.9072	0.9468	0.3042	0.111*
C14	0.7602 (4)	0.8601 (5)	0.3008 (3)	0.1098 (14)
H14	0.7223	0.9366	0.2692	0.132*
C15	0.7345 (3)	0.5450 (3)	0.75291 (15)	0.0682 (7)
H15A	0.7237	0.6467	0.7667	0.082*
H15B	0.8113	0.5215	0.7754	0.082*
C16	0.6652 (2)	0.4500 (3)	0.79695 (15)	0.0610 (6)
C17	0.6703 (4)	0.4774 (4)	0.8817 (2)	0.0992 (12)
H17	0.7120	0.5549	0.9092	0.119*
C18	0.6127 (5)	0.3880 (5)	0.9246 (2)	0.1218 (17)
H18	0.6146	0.4042	0.9817	0.146*
C19	0.5526 (4)	0.2752 (4)	0.8825 (2)	0.0964 (11)
H19	0.5137	0.2124	0.9105	0.116*
C20	0.5507 (3)	0.2562 (4)	0.7984 (2)	0.0829 (9)
H20	0.5087	0.1801	0.7697	0.100*
C21	0.4082 (4)	0.8904 (5)	0.6247 (3)	0.1095 (13)
H21A	0.3348	0.8517	0.6096	0.164*
H21B	0.4093	0.9871	0.6015	0.164*
H21C	0.4316	0.8949	0.6854	0.164*

Atomic displacement parameters (Å²)

	U^{11}	U^{22}	U^{33}	U^{12}	U^{13}	U^{23}
O1	0.148 (2)	0.0856 (16)	0.0754 (14)	0.0314 (15)	0.0491 (15)	0.0046 (12)
O2	0.1128 (17)	0.0827 (14)	0.0710 (12)	0.0252 (13)	0.0325 (12)	0.0268 (11)
N1	0.0869 (15)	0.0562 (12)	0.0472 (10)	−0.0095 (11)	0.0224 (10)	0.0025 (9)
N2	0.0799 (14)	0.0523 (11)	0.0475 (10)	−0.0044 (10)	0.0217 (10)	0.0033 (9)
N3	0.0859 (17)	0.126 (3)	0.0859 (18)	0.0139 (17)	0.0299 (14)	0.0515 (19)
N4	0.0863 (16)	0.0746 (15)	0.0609 (13)	−0.0066 (13)	0.0190 (11)	0.0073 (11)
C1	0.100 (2)	0.0546 (14)	0.0576 (15)	0.0019 (14)	0.0328 (14)	0.0030 (12)
C2	0.0897 (19)	0.0544 (14)	0.0564 (14)	−0.0003 (13)	0.0271 (13)	0.0106 (12)
C3	0.0750 (15)	0.0437 (12)	0.0555 (13)	−0.0110 (11)	0.0206 (11)	0.0023 (10)
C4	0.0854 (18)	0.0519 (13)	0.0642 (14)	−0.0088 (13)	0.0278 (13)	−0.0060 (11)
C5	0.0818 (19)	0.0556 (15)	0.094 (2)	−0.0023 (14)	0.0310 (16)	−0.0004 (14)
C6	0.083 (2)	0.0715 (18)	0.085 (2)	0.0046 (15)	0.0127 (16)	0.0179 (16)
C7	0.0818 (18)	0.0708 (17)	0.0616 (15)	−0.0064 (14)	0.0158 (13)	0.0120 (13)
C8	0.0720 (15)	0.0480 (12)	0.0527 (12)	−0.0090 (11)	0.0181 (11)	0.0047 (10)
C9	0.098 (2)	0.0771 (18)	0.0480 (13)	−0.0137 (16)	0.0227 (13)	−0.0046 (12)
C10	0.0836 (18)	0.0712 (16)	0.0422 (11)	0.0015 (14)	0.0211 (11)	0.0014 (11)
C11	0.089 (2)	0.0762 (18)	0.0627 (15)	0.0094 (15)	0.0267 (14)	0.0027 (14)
C12	0.084 (2)	0.103 (3)	0.0718 (18)	−0.0079 (19)	0.0329 (15)	−0.0017 (18)
C13	0.112 (3)	0.096 (2)	0.084 (2)	−0.007 (2)	0.050 (2)	0.0154 (19)
C14	0.117 (3)	0.115 (3)	0.110 (3)	0.026 (2)	0.053 (2)	0.062 (3)
C15	0.0877 (19)	0.0697 (17)	0.0488 (13)	−0.0069 (14)	0.0187 (12)	0.0000 (12)
C16	0.0809 (17)	0.0537 (13)	0.0502 (12)	0.0060 (12)	0.0183 (12)	0.0062 (10)
C17	0.159 (4)	0.086 (2)	0.0586 (16)	−0.022 (2)	0.038 (2)	−0.0048 (16)
C18	0.203 (5)	0.110 (3)	0.067 (2)	−0.026 (3)	0.063 (3)	0.006 (2)
C19	0.121 (3)	0.091 (2)	0.088 (2)	0.004 (2)	0.045 (2)	0.034 (2)
C20	0.088 (2)	0.0734 (19)	0.087 (2)	−0.0045 (16)	0.0181 (16)	0.0169 (16)
C21	0.131 (3)	0.087 (2)	0.118 (3)	0.021 (2)	0.042 (3)	0.009 (2)

Geometric parameters (Å, º)

O1—C1	1.219 (3)	C9—H9B	0.9700
O2—C2	1.220 (3)	C9—C10	1.499 (4)
N1—C1	1.345 (4)	C10—C11	1.381 (4)
N1—C8	1.404 (3)	C11—H11	0.9300
N1—C9	1.486 (3)	C11—C12	1.371 (4)
N2—C2	1.355 (3)	C12—H12	0.9300
N2—C3	1.400 (3)	C12—C13	1.359 (5)
N2—C15	1.468 (3)	C13—H13	0.9300
N3—C10	1.314 (4)	C13—C14	1.342 (6)
N3—C14	1.343 (5)	C14—H14	0.9300
N4—C16	1.315 (4)	C15—H15A	0.9700
N4—C20	1.354 (4)	C15—H15B	0.9700
C1—C2	1.520 (3)	C15—C16	1.509 (4)
C3—C4	1.389 (4)	C16—C17	1.380 (4)
C3—C8	1.408 (3)	C17—H17	0.9300

C4—H4	0.9300	C17—C18	1.371 (5)
C4—C5	1.371 (4)	C18—H18	0.9300
C5—C6	1.392 (5)	C18—C19	1.363 (6)
C5—C21	1.490 (5)	C19—H19	0.9300
C6—H6	0.9300	C19—C20	1.365 (5)
C6—C7	1.369 (5)	C20—H20	0.9300
C7—H7	0.9300	C21—H21A	0.9600
C7—C8	1.389 (4)	C21—H21B	0.9600
C9—H9A	0.9700	C21—H21C	0.9600

C1—N1—C8	123.5 (2)	C11—C10—C9	121.9 (3)
C1—N1—C9	116.5 (2)	C10—C11—H11	120.1
C8—N1—C9	120.0 (2)	C12—C11—C10	119.7 (3)
C2—N2—C3	122.7 (2)	C12—C11—H11	120.1
C2—N2—C15	116.1 (2)	C11—C12—H12	120.8
C3—N2—C15	121.1 (2)	C13—C12—C11	118.4 (3)
C10—N3—C14	117.0 (3)	C13—C12—H12	120.8
C16—N4—C20	116.9 (3)	C12—C13—H13	120.8
O1—C1—N1	124.1 (2)	C14—C13—C12	118.4 (3)
O1—C1—C2	118.3 (3)	C14—C13—H13	120.8
N1—C1—C2	117.6 (2)	N3—C14—H14	117.7
O2—C2—N2	123.6 (2)	C13—C14—N3	124.6 (3)
O2—C2—C1	118.6 (3)	C13—C14—H14	117.7
N2—C2—C1	117.7 (2)	N2—C15—H15A	108.5
N2—C3—C8	119.5 (2)	N2—C15—H15B	108.5
C4—C3—N2	121.8 (2)	N2—C15—C16	115.1 (2)
C4—C3—C8	118.7 (2)	H15A—C15—H15B	107.5
C3—C4—H4	119.0	C16—C15—H15A	108.5
C5—C4—C3	122.0 (3)	C16—C15—H15B	108.5
C5—C4—H4	119.0	N4—C16—C15	119.3 (2)
C4—C5—C6	118.6 (3)	N4—C16—C17	123.3 (3)
C4—C5—C21	122.6 (3)	C17—C16—C15	117.3 (3)
C6—C5—C21	118.8 (3)	C16—C17—H17	120.7
C5—C6—H6	119.6	C18—C17—C16	118.6 (4)
C7—C6—C5	120.9 (3)	C18—C17—H17	120.7
C7—C6—H6	119.6	C17—C18—H18	120.4
C6—C7—H7	119.6	C19—C18—C17	119.2 (3)
C6—C7—C8	120.8 (3)	C19—C18—H18	120.4
C8—C7—H7	119.6	C18—C19—H19	120.7
N1—C8—C3	118.7 (2)	C18—C19—C20	118.6 (3)
C7—C8—N1	122.2 (2)	C20—C19—H19	120.7
C7—C8—C3	119.0 (3)	N4—C20—C19	123.3 (3)
N1—C9—H9A	109.2	N4—C20—H20	118.4
N1—C9—H9B	109.2	C19—C20—H20	118.4
N1—C9—C10	111.9 (2)	C5—C21—H21A	109.5
H9A—C9—H9B	107.9	C5—C21—H21B	109.5
C10—C9—H9A	109.2	C5—C21—H21C	109.5
C10—C9—H9B	109.2	H21A—C21—H21B	109.5

N3—C10—C9	116.3 (3)	H21A—C21—H21C	109.5
N3—C10—C11	121.8 (3)	H21B—C21—H21C	109.5

Hydrogen-bond geometry (Å, º)

D—H···*A*	*D*—H	H···*A*	*D*···*A*	*D*—H···*A*
C4—H4···O2^{i}	0.93	2.52	3.270 (3)	138
C12—H12···O2^{ii}	0.93	2.48	3.227 (4)	137
C15—H15*A*···O2^{i}	0.97	2.37	3.297 (4)	160

Symmetry codes: (i) −*x*+3/2, *y*+1/2, −*z*+3/2; (ii) −*x*+2, −*y*+1, −*z*+1.