Acta Crystallographica Section E
Structure Reports Online
ISSN 1600-5368

4,6,7-Trimethoxyfuro[2,3-*b*]quinoline–water (2/3)

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Key indicators

Single-crystal X-ray study
T = 298 K
Mean σ(C–C) = 0.004 Å
R factor = 0.041
wR factor = 0.102
Data-to-parameter ratio = 7.2

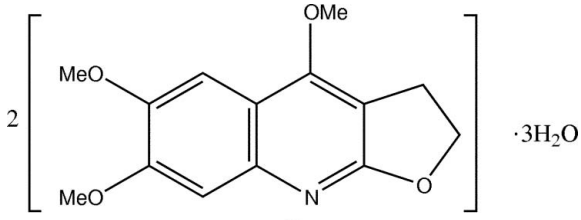
For details of how these key indicators were automatically derived from the article, see http://journals.iucr.org/e.

Received 27 April 2005
Accepted 15 June 2005
Online 24 June 2005

The title compound, $2C_{14}H_{13}NO_4\cdot 3H_2O$, was isolated from the plant *Acronychia pendunculata*. The asymmetric unit consists of two quinoline molecules and three water molecules of crystallization. Intra- and intermolecular hydrogen bonds are highly effective in forming infinite chains parallel to the *b* axis, thereby stabilizing the crystal structure.

Comment

Furoquinoline alkaloids isolated from several plant species have been extensively studied for their biological applications such as psychotropic (Nesterova *et al.*, 1995), anti-allergic (Yamada *et al.*, 1992) and anti-inflammatory (Faber *et al.*, 1984). The isomeric 4,5,6-, 4,5,7-, 4,6,7- and 4,7,8-trimethoxy-substituted furo[2,3-*b*]quinolines have been isolated mainly from *Rutacaeae* (Robertson, 1963; Khalid & Waterman, 1981; Pusset *et al.*, 1991), and other plants such as *Haplophyllum buxbaumii* (Ulubelen, 1985) and *Melicope semecarpifolia* (Tsai *et al.*, 1995). Recent studies have shown that 4,7,8-trimethoxyfuro[2,3-*b*]quinoline (skimmianine) is an inhibitor against the Leishmania APRT enzyme (Napolitano *et al.*, 2003).



(I)

The title compound, (I), is a 4,6,7-trimethoxyfuro[2,3-*b*]-quinoline isomer isolated from the plant *Acronychia pendunculata* (Fig. 1). The asymmetric unit consists of two

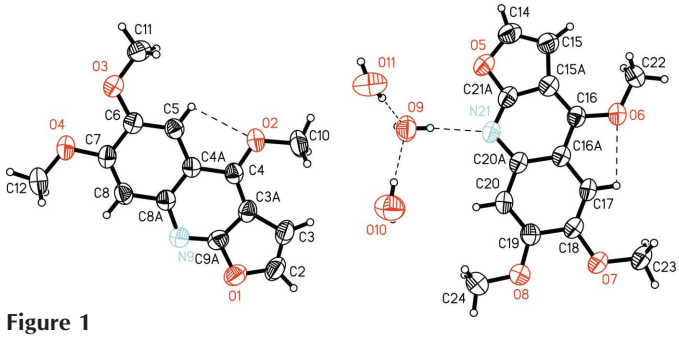


Figure 1
A drawing of the asymmetric unit of (I), showing the atom-numbering scheme. Displacement ellipsoids are drawn at the 50% probability level and dashed lines indicate hydrogen bonds.

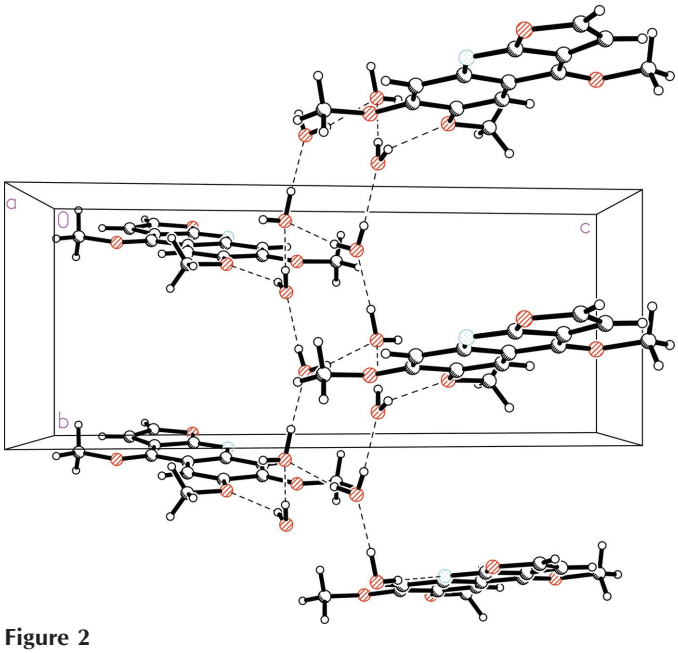


Figure 2
The packing of (I). Dashed lines indicate hydrogen bonds.

organic molecules and three water molecules of crystallization. Both organic molecules are approximately planar, with a maximum deviation of 0.117 (3) Å for atom C12. The second molecule is more nearly planar, with a maximum deviation of 0.050 (3) Å for atom C23. For the discrete 4,7,8-trimethoxyfuro[2,3-*b*]quinoline (skimmianine) isomer, the C12 atom deviates by 1.028 (2) Å from the mean plane (Cox *et al.*, 1989; Napolitano *et al.*, 2003), as was also observed in the four-ring system of flindersiamine, isolated from *Raulinoa echinata* Cowan (Rutaceae) (Biavatti *et al.*, 2002).

The bond lengths and angles in (I) are in normal ranges (Allen *et al.*,1987) and comparable with those in skimmianine. Intramolecular C—H···O, O—H···N, O—H···O and intermolecular O—H···O hydrogen bonds (Table 1) are highly effective in forming infinite chains parallel to the *b* axis (Fig. 2), thereby stabilizing the crystal structure.

Experimental

The leaves of *Acronychia pendunculata* were collected from the Endau-Rompin Forest Reserve, Pahang, Malaysia, and a sample was deposited at the Herbarium of the School of Bioscience, Universiti Pertanian Malaysia. The leaves (1 kg) were air dried, ground and successively extracted with a soxhlet apparatus into petroleum ether, ethyl acetate and ethanol. The ethanol extract was subjected to vacuum liquid chromatography over silica gel 6OH using a hexane/EtOAc mixture (3:7) as eluent, and yielded seven fractions (UG1–UG7). Fraction UG5 was rechromatographed over silica 6OH eluted with hexane/EtOAc (3:7), followed by a purification step over a chromatotron using a mixture of hexane/$CHCl_3$ (4:6), and afforded 4,6,7-trimethoxyfuroquinoline (0.13 g, 0.01%). Pale-yellow crystals were obtained by recrystallization from chloroform [m.p. 441.5–443.4 K; literature value: 441–442 K (Pusset *et al.*, 1991)]. ^{1}H NMR($CDCl_3$, 400 MHz): δ 7.46 (H, *s*, H-5), 7.32 (H, *s*, H-8), 7.56 (1H, *d*, J = 2.6, H-9), 7.03 (1H, *d*, J = 2.6, H-10), 4.42 (3H, *s*, OMe-4), 4.01 (3H, *s*, OMe-6), 4.03 (3H, *s*, OMe-7); ^{13}C{^{1}H}: δ 163.3 (C2), 102.4 (C3), 155.7 (C4), 113.1 (C4a), 100.4 (C5), 147.9 (C6), 152.7 (C7), 106.9 (C8), 142.7 (C8a), 142.6 (C9a), 104.7 (C10), 59.03 (OMe-4), 56.2 (OMe-6), 56.1 (OMe-7). MS *m*/*z* (%int): 249 $[M]^+$ (100), 244 (58), 216 (17), 201 (21), 173 (13).

Crystal data

$2C_{14}H_{13}NO_4\cdot3H_2O$
M_r = 572.56
Monoclinic, $P2_1$
a = 11.155 (2) Å
b = 7.0897 (16) Å
c = 17.488 (4) Å
β = 99.313 (3)°
V = 1364.9 (5) Å^3
Z = 2
D_x = 1.393 Mg m^{-3}
Mo $K\alpha$ radiation
Cell parameters from 827 reflections
θ = 1.8–26.0°
μ = 0.11 mm^{-1}
T = 298 (2) K
Block, pale yellow
0.48 × 0.24 × 0.16 mm

Data collection

Bruker SMART APEX CCD area-detector diffractometer
ω scans
Absorption correction: multi-scan (*SADABS*; Sheldrick, 1996)
T_{min} = 0.949, T_{max} = 0.982
7393 measured reflections
2897 independent reflections
2607 reflections with $I > 2\sigma(I)$
R_{int} = 0.018
θ_{max} = 26.0°
$h = -13 \rightarrow 13$
$k = -8 \rightarrow 8$
$l = -21 \rightarrow 19$

Refinement

Refinement on F^2
$R[F^2 > 2\sigma(F^2)]$ = 0.041
$wR(F^2)$ = 0.102
S = 1.16
2897 reflections
400 parameters
H atoms treated by a mixture of independent and constrained refinement
$w = 1/[\sigma^2(F_o^2) + (0.0543P)^2 + 0.0928P]$ where $P = (F_o^2 + 2F_c^2)/3$
$(\Delta/\sigma)_{max} < 0.001$
$\Delta\rho_{max}$ = 0.15 e Å^{-3}
$\Delta\rho_{min}$ = −0.13 e Å^{-3}

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

D—H···A	D—H	H···A	D···A	D—H···A
C5—H5···O2^{i}	0.93	2.40	2.719 (3)	100
C17—H17···O6^{i}	0.93	2.39	2.706 (3)	100
O9—H9*A*···O10^{ii}	0.94 (5)	1.82 (5)	2.756 (5)	176 (3)
O9—H9*B*···N21^{i}	0.80 (3)	2.05 (3)	2.853 (3)	174 (4)
O10—H10*D*···O11^{ii}	0.81 (5)	1.98 (5)	2.778 (5)	173 (5)
O10—H10*E*···O9^{i}	0.85 (5)	1.97 (5)	2.803 (4)	169 (6)
O11—H11*D*···O9^{i}	0.88 (5)	1.91 (5)	2.786 (5)	176 (3)
O11—H11*E*···O7^{iii}	0.85 (5)	2.12 (5)	2.861 (4)	146 (5)

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

H atoms were located in a difference synthesis. Water H atoms are refined freely [O—H = 0.80 (4)–0.93 (5) Å and U_{iso}(H) = 0.074 (14)–0.110 (17) Å^2]. The remaining H atoms were refined using a riding model, with fixed C—H distances of 0.93 (CH) [U_{iso}(H) = 1.2U_{eq}(C)] and 0.96 Å (CH_3) [U_{iso}(H) = 1.5U_{eq}(C)]. In the absence of significant anomalous scattering effects, Friedel pairs were merged. The short contact between C22 and O1 may be due to librational effects or intra- and intermolecular interactions resulting from the hydrogen bonds.

Data collection: *SMART* (Siemens, 1996); cell refinement: *SAINT* (Siemens, 1996); data reduction: *SAINT*; program(s) used to solve structure: *SHELXTL* (Sheldrick, 1997); program(s) used to refine structure: *SHELXTL*; molecular graphics: *SHELXTL*; software used to prepare material for publication: *SHELXTL*, *PARST* (Nardelli, 1995) and *PLATON* (Spek, 2003).

The authors thank the Malaysian Government and Universiti Kebangsaan Malaysia for the research grant IRPA No. 09–02-02–0163.

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