Table 1. *Fractional atomic coordinates and isotropic or equivalent isotropic displacement parameters* (Å^2)

U_{iso} for C atoms; $U_{eq} = (1/3)\Sigma_i\Sigma_j U_{ij}a_i^* a_j^* \mathbf{a}_i.\mathbf{a}_j$ for O and N.

	x	y	z	U_{iso}/U_{eq}
O(1)	0.1333 (2)	0.6175 (3)	−0.4465 (13)	0.059 (3)
O(2)	0.0963 (2)	1.0774 (3)	−0.0783 (13)	0.058 (3)
O(3)	0.3630 (2)	0.7528 (3)	0.2234 (13)	0.054 (3)
N(1)	0.2920 (2)	0.8976 (3)	0.0772 (13)	0.032 (3)
N(2)	0.1632 (3)	1.0167 (4)	−0.0211 (15)	0.041 (3)
C(1)	0.1524 (3)	0.9219 (4)	−0.1408 (15)	0.030 (1)
C(2)	0.0788 (3)	0.8823 (4)	−0.3181 (18)	0.041 (2)
C(3)	0.0734 (3)	0.7819 (4)	−0.4186 (17)	0.040 (2)
C(4)	0.1406 (4)	0.7099 (5)	−0.3545 (18)	0.040 (2)
C(5)	0.2142 (3)	0.7503 (5)	−0.1840 (16)	0.037 (2)
C(6)	0.2212 (3)	0.8508 (4)	−0.0862 (16)	0.030 (1)
C(7)	0.3572 (3)	0.8484 (4)	0.2245 (17)	0.032 (1)
C(8)	0.4216 (3)	0.9176 (5)	0.3818 (17)	0.044 (2)

Table 2. *Selected geometric parameters* ($\text{Å}, °$)

O(1)—C(4)	1.234 (7)	O(2)—N(2)	1.361 (6)
O(3)—C(7)	1.222 (7)	N(1)—C(6)	1.424 (7)
N(1)—C(7)	1.341 (7)	N(2)—C(1)	1.301 (7)
C(1)—C(2)	1.446 (8)	C(1)—C(6)	1.462 (7)
C(2)—C(3)	1.339 (8)	C(3)—C(4)	1.453 (8)
C(4)—C(5)	1.440 (8)	C(5)—C(6)	1.339 (8)
C(7)—C(8)	1.482 (8)		
C(7)—N(1)—C(6)	127.4 (5)	C(1)—N(2)—O(2)	112.5 (4)
C(2)—C(1)—N(2)	125.4 (5)	C(6)—C(1)—N(2)	116.1 (5)
C(6)—C(1)—C(2)	118.5 (5)	C(3)—C(2)—C(1)	120.3 (5)
C(4)—C(3)—C(2)	121.4 (5)	C(3)—C(4)—O(1)	119.8 (5)
C(5)—C(4)—O(1)	122.3 (5)	C(5)—C(4)—C(3)	118.0 (5)
C(6)—C(5)—C(4)	121.5 (5)	C(1)—C(6)—N(1)	114.6 (5)
C(5)—C(6)—N(1)	125.1 (5)	C(5)—C(6)—C(1)	120.2 (5)
N(1)—C(7)—O(3)	121.8 (5)	C(8)—C(7)—O(3)	122.8 (5)
C(8)—C(7)—N(1)	115.5 (5)		

The methods of data collection and data processing were similar to those described previously (Adams *et al.*, 1980). The structure was solved by direct methods using *SHELXS*86 (Sheldrick, 1985) and difference Fourier maps. The positions of the H atoms were found from difference Fourier maps using $\sin\theta < 0.35$. The displacement parameters of the atoms were fixed at $0.07\,\text{Å}^2$ and their parameters were used in the calculation of standard factors but were not refined. During the final stages of structure solution, anisotropic displacement parameters were assigned to the three O and the two N atoms of the molecule. Full-matrix refinement was carried out on the parameters of all non-H atoms, with weights assigned to individual reflections. The structure was refined using *SHELX*76 (Sheldrick, 1976). Molecular graphics were prepared using *ORTEP*II (Johnson, 1976).

References

Adams, K. R., Andergg, G., Lindoy, L. F., Lip, H. C., McPartlin, M., Rea, J. H., Smith, R. J. & Tasker, P. A. (1980). *Inorg. Chem.* **19**, 2956–2964.

Allen, F. H., Brammer, L., Kennard, O., Orpen, A. G., Taylor, R. & Watson, D. G. (1987). *J. Chem. Soc. Perkin Trans.* 2, pp. S1–S19.

Barjesteh, H., Charalambous, J. & Pathirana, N. D. (1993). *Polyhedron*, **12**, 883–889.

Bartindale, G. W. R., Crowder, M. M. & Morley, K. A. (1959). *Acta Cryst.* **12**, 111–115.

Boeyens, J. C. A. (1976). *J. Cryst. Mol. Struct.* **6**, 217–222.

Burawoy, A., Cais, M., Chamberlain, J. T., Liversedge, F. & Thompson, A. R. (1955). *J. Chem. Soc.* pp. 3727–3733.

Charalambous, J., Christidis, P. C., Dodd, A., McPartlin, M., Pathirana, N. D. & Talee, N. (1991). *Acta Cryst.* C47, 2640–2641.

Fischer, A., Golding, R. M. & Tennant, W. C. (1965). *J. Chem. Soc.* pp. 6032–6035.

Fischmann, E. & Romers, C. (1960). *Acta Cryst.* **13**, 809–813.

Fischmann, E., Romers, C. & Shoemaker, C. B. (1957). *Recl. Trav. Chim. Pays-Bas*, **76**, 490–494.

French, H. S. & Perkins, D. J. (1937). *J. Chem. Soc.* **59**, 1182–1186.

Hadzi, D. (1956). *J. Chem. Soc.* pp. 2725–2731.

Hayashi, Y., Shinra, K. & Shono, T. (1971). *Bull. Chem. Soc. Jpn*, **44**, 3179–3181.

Johnson, C. K. (1976). *ORTEP*II. Report ORNL-5138. Oak Ridge National Laboratory, Tennessee, USA.

Korvenranta, J., Näsäkkälä, M. & Saarinen, H. (1977a). *Finn. Chem. Lett.* pp. 47–56.

Korvenranta, J., Näsäkkälä, M. & Saarinen, H. (1977b). *Acta Chem. Scand. Ser. A*, **31**, 213–218.

Sheldrick, G. M. (1976). *SHELX*76. *Program for Crystal Structure Determination*. Univ. of Cambridge, England.

Sheldrick, G. M. (1985). *SHELXS*86. *Program for the Solution of Crystal Structures*. Univ. of Cambridge, England.

Two Related Potent Antiviral Compounds: 3-Bromo-N-butyl-4-butylamino-1,8-naphthalenedicarboximide (1) and 4-Amino-3-bromo-N-butyl-1,8-naphthalenedicarboximide (2)

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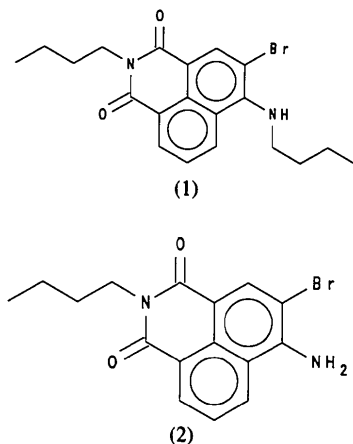*Department of Chemistry, South Dakota State University, Brookings, SD 57007, USA*

Abstract

The crystal structures of two brominated derivatives of 4-amino-N-butyl-1,8-naphthalenedicarboximide [alternative systematic names: 8-bromo-2-butyl-7-butylamino-1*H*-benzo[*de*]isoquinoline-1,3(2*H*)-dione, $C_{20}H_{23}BrN_2O_2$, and 7-amino-8-bromo-2-butyl-1*H*-benzo[*de*]isoquinoline-1,3(2*H*)-dione, $C_{16}H_{15}BrN_2O_2$] are reported. The N-butyl groups, which are common to both compounds, are perpendicular to the plane of the naphthalenedicarboximide ring system. The butylamino

group at position 4 in (1) is in the plane of the naphthalenedicarboximide ring, with the butyl group oriented towards the *peri* position of the naphthalenedicarboximide ring. This arrangement results in an opening of the (ring C)—N—(butyl C) angle.

Comment

During the course of a project where dyes are used to mediate the inactivation of cells and enveloped viruses by visible light, we discovered that the lipophilic 3-bromo-4-alkylamino-*N*-alkyl-1,8-naphthalenedicarboximides are potent photochemical inactivators of enveloped viruses, including HIV-1, the enveloped retrovirus which is the causative agent for AIDS (Chanh *et al.*, 1993; Lewis, Utecht, Judy, Matthews & Chanh, 1993; Lewis, Utecht, Judy & Matthews, 1993). In order to elucidate the mechanism of antiviral activity of these compounds, accurate structural and conformational information is indispensable. Accordingly, we have undertaken the single-crystal X-ray structure analysis of a simple prototypical antiviral dye, 3-bromo-*N*-butyl-4-butylamino-1,8-naphthalenedicarboximide (1), and the cytotoxic dealkylated product formed from it by oxidation with bromine. 3-Bromo-*N*-butyl-4-butylamino-1,8-naphthalenedicarboximide was prepared from 4-chloro-1,8-naphthalenedicarboxylic anhydride as described previously (Chang *et al.*, 1993). The dealkylation product, 4-amino-3-bromo-*N*-butyl-1,8-naphthalenedicarboximide, (2), was obtained by oxidative dealkylation of the antiviral dye with bromine for extended periods of time.

this, the butyl group of the butylamino substituent of (1) is coplanar with the ring. The conformation about the N—(ring C) bond of molecule (1) results in the butyl group of the substituent being oriented towards the *peri* H atom of the naphthalenedicarboximide ring system rather than towards the Br atom. This sterically crowded environment results in distortions of the geometry from ideality, with C(4)—N(2)—C(17) = 133.8 (3), N(2)—C(4)—C(3) = 117.7 (3) and N(2)—C(4)—C(10) = 125.9 (3)°. The substantial expansion of the angles C(4)—N(2)—C(17) and C(10)—C(4)—N(2) compared with their idealized values of 120° results in relief of the van der Waals repulsion between the H atoms at C(17) and C(5), as does the compression of the N(2)—C(4)—C(3) angle. The net result of these distortions from idealized geometry is to move the *N*-butyl chain to a direction approximately parallel to the line joining C(9) and C(4).

In the crystal structure of molecule (2) there is a short intermolecular non-bonded distance of 2.10 (1) Å between the carbonyl O atom [O(2)] of one molecule and the HN group [H(2A)] of the second, which is strongly suggestive of a hydrogen bond between O(2) and H(2A) in the crystal (*cf.* Table 2 and Fig. 3). The amino N atom of these compounds is a vinylogous amide, and the O···H distance is very close to the optimum value for a hydrogen bond between the carbonyl O atom and amide H atom of proteins (Creighton, 1984). In (1), the H atom corresponding to H(2A) in (2) is replaced by the butyl group, so the same intermolecular hydrogen bonding cannot occur.

(1)

(2)

The structures of the molecules exhibit, as expected, a planar naphthalenedicarboximide ring system and planar geometry about the N atom at the 4 position of the ring. All butyl side chains are in the fully extended zigzag conformation and all four C atoms of all four butyl groups are coplanar. The butyl group bonded to the imide ring is oriented in a plane approximately perpendicular to the plane of the ring. In contrast to
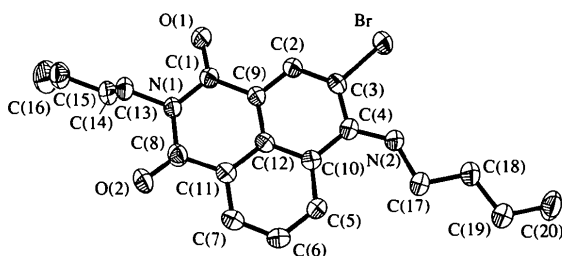

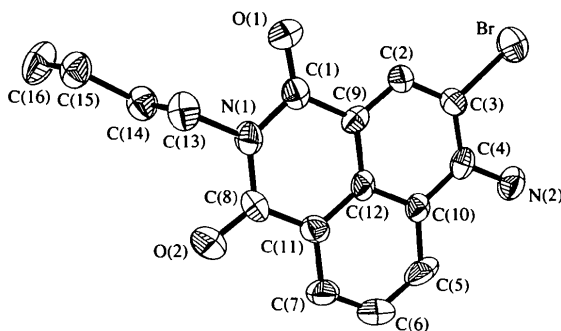Fig. 1. Molecule (1) showing 50% probability ellipsoids.

Fig. 2. Molecule (2) showing 50% probability ellipsoids.

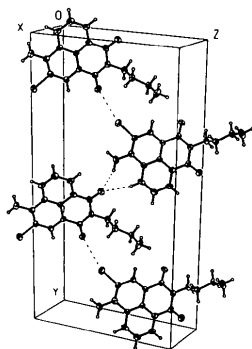Fig. 3. Packing of (2) showing 30% probability ellipsoids.

Experimental

Compound (1)

Crystal data

$C_{20}H_{23}BrN_2O_2$
$M_r = 403.31$
Triclinic
$P\bar{1}$
$a = 8.374\,(2)$ Å
$b = 9.935\,(2)$ Å
$c = 11.139\,(2)$ Å
$\alpha = 87.84\,(2)°$
$\beta = 88.13\,(2)°$
$\gamma = 80.61\,(2)°$
$V = 913.3\,(4)$ Å^3
$Z = 2$
$D_x = 1.467$ Mg m^{-3}

Mo $K\alpha$ radiation
$\lambda = 0.71073$ Å
Cell parameters from 25 reflections
$\theta = 5.1–13.1°$
$\mu = 2.266$ mm^{-1}
$T = 290\,(2)$ K
Prism
$0.375 \times 0.23 \times 0.11$ mm
Yellow
Crystal source: recrystallized from EtOAc

Data collection

Siemens $P3$ diffractometer
$\omega/2\theta$ scans
Absorption correction:
ψ scan
$T_{min} = 0.428$, $T_{max} = 0.775$
6359 measured reflections
3228 independent reflections
2343 observed reflections
$[I > 2\sigma(I)]$

$R_{int} = 0.0318$
$\theta_{max} = 25.04°$
$h = -9 \rightarrow 9$
$k = -11 \rightarrow 11$
$l = -13 \rightarrow 13$
3 standard reflections
monitored every 50 reflections
intensity decay: 1.2%

Refinement

Refinement on F^2
$R(F) = 0.0379$
$wR(F^2) = 0.0913$
$S = 1.050$
3227 reflections
226 parameters
H-atoms riding (C—H 0.96 Å)
$w = 1/[\sigma^2(F_o^2) + (0.0559P)^2]$
where $P = (F_o^2 + 2F_c^2)/3$

$(\Delta/\sigma)_{max} = -0.001$
$\Delta\rho_{max} = 0.316$ e Å^{-3}
$\Delta\rho_{min} = -0.249$ e Å^{-3}
Extinction correction: none
Atomic scattering factors from *International Tables for Crystallography* (1992, Vol. C, Tables 4.2.6.8 and 6.1.1.4)

Table 1. *Fractional atomic coordinates and equivalent isotropic displacement parameters* (Å^2) *for* (1)

$$U_{eq} = (1/3)\Sigma_i\Sigma_j U_{ij}a_i^* a_j^* \mathbf{a}_i.\mathbf{a}_j.$$

	x	y	z	U_{eq}
Br	-0.0491 (1)	0.3733 (1)	-0.1918 (1)	0.057 (1)
O(1)	-0.1362 (3)	-0.0200 (2)	0.1375 (2)	0.051 (1)
O(2)	-0.4283 (3)	0.1663 (3)	0.4562 (2)	0.057 (1)
N(1)	-0.2895 (3)	0.0715 (3)	0.2938 (2)	0.036 (1)
N(2)	-0.2522 (4)	0.5999 (3)	-0.0580 (3)	0.059 (1)
C(1)	-0.2098 (4)	0.0831 (3)	0.1837 (3)	0.036 (1)
C(2)	-0.1447 (4)	0.2347 (3)	0.0163 (3)	0.037 (1)
C(3)	-0.1589 (4)	0.3622 (3)	-0.0409 (3)	0.039 (1)
C(4)	-0.2475 (4)	0.4821 (3)	0.0076 (3)	0.042 (1)
C(5)	-0.4193 (5)	0.5764 (4)	0.1855 (3)	0.056 (1)
C(6)	-0.4905 (5)	0.5572 (4)	0.2960 (3)	0.059 (1)
C(7)	-0.4765 (5)	0.4284 (3)	0.3505 (3)	0.047 (1)
C(8)	-0.3720 (4)	0.1828 (3)	0.3564 (3)	0.040 (1)
C(9)	-0.2200 (4)	0.2193 (3)	0.1265 (3)	0.033 (1)
C(10)	-0.3264 (4)	0.4666 (3)	0.1235 (3)	0.037 (1)
C(11)	-0.3864 (4)	0.3182 (3)	0.2949 (3)	0.037 (1)
C(12)	-0.3108 (4)	0.3349 (3)	0.1815 (3)	0.033 (1)
C(13)	-0.2864 (4)	-0.0663 (3)	0.3500 (3)	0.041 (1)
C(14)	-0.1411 (4)	-0.1118 (3)	0.4272 (3)	0.042 (1)
C(15)	-0.1434 (5)	-0.2515 (4)	0.4858 (3)	0.052 (1)
C(16)	0.0063 (6)	-0.3033 (5)	0.5580 (4)	0.081 (1)
C(17)	-0.3206 (5)	0.7415 (3)	-0.0366 (3)	0.047 (1)
C(18)	-0.2772 (5)	0.8277 (3)	-0.1447 (3)	0.047 (1)
C(19)	-0.3453 (5)	0.9769 (3)	-0.1367 (3)	0.049 (1)
C(20)	-0.2912 (6)	1.0612 (4)	-0.2408 (4)	0.067 (1)

Table 2. *Selected geometric parameters* (Å, °) *for* (1)

Br—C(3)	1.898 (3)	C(5)—C(10)	1.420 (5)
O(1)—C(1)	1.228 (4)	C(6)—C(7)	1.385 (5)
O(2)—C(8)	1.209 (4)	C(7)—C(11)	1.380 (5)
N(1)—C(1)	1.387 (4)	C(8)—C(11)	1.475 (5)
N(1)—C(8)	1.401 (4)	C(9)—C(12)	1.418 (4)
N(1)—C(13)	1.481 (4)	C(10)—C(12)	1.426 (4)
N(2)—C(4)	1.351 (4)	C(11)—C(12)	1.411 (4)
N(2)—C(17)	1.455 (4)	C(13)—C(14)	1.511 (5)
C(1)—C(9)	1.464 (4)	C(14)—C(15)	1.515 (5)
C(2)—C(9)	1.377 (4)	C(15)—C(16)	1.518 (6)
C(2)—C(3)	1.385 (4)	C(17)—C(18)	1.521 (5)
C(3)—C(4)	1.413 (4)	C(18)—C(19)	1.503 (5)
C(4)—C(10)	1.446 (4)	C(19)—C(20)	1.506 (5)
C(5)—C(6)	1.370 (5)		
C(1)—N(1)—C(8)	124.0 (3)	N(1)—C(8)—C(11)	117.0 (3)
C(1)—N(1)—C(13)	118.5 (3)	C(2)—C(9)—C(12)	119.5 (3)
C(8)—N(1)—C(13)	117.5 (3)	C(2)—C(9)—C(1)	119.6 (3)
C(4)—N(2)—C(17)	133.8 (3)	C(12)—C(9)—C(1)	120.8 (3)
O(1)—C(1)—N(1)	119.3 (3)	C(5)—C(10)—C(12)	116.9 (3)
O(1)—C(1)—C(9)	122.8 (3)	C(5)—C(10)—C(4)	123.8 (3)
N(1)—C(1)—C(9)	117.9 (3)	C(12)—C(10)—C(4)	119.4 (3)
C(9)—C(2)—C(3)	120.1 (3)	C(7)—C(11)—C(12)	120.5 (3)
C(2)—C(3)—C(4)	123.8 (3)	C(7)—C(11)—C(8)	118.5 (3)
C(2)—C(3)—Br	117.0 (2)	C(12)—C(11)—C(8)	121.0 (3)
C(4)—C(3)—Br	119.2 (2)	C(11)—C(12)—C(9)	119.1 (3)
N(2)—C(4)—C(3)	117.7 (3)	C(11)—C(12)—C(10)	120.1 (3)
N(2)—C(4)—C(10)	125.9 (3)	C(9)—C(12)—C(10)	120.9 (3)
C(3)—C(4)—C(10)	116.3 (3)	N(1)—C(13)—C(14)	113.3 (3)
C(6)—C(5)—C(10)	121.8 (3)	C(13)—C(14)—C(15)	112.1 (3)
C(5)—C(6)—C(7)	120.8 (3)	C(14)—C(15)—C(16)	113.2 (3)
C(11)—C(7)—C(6)	119.9 (3)	N(2)—C(17)—C(18)	108.0 (3)
O(2)—C(8)—N(1)	120.5 (3)	C(19)—C(18)—C(17)	113.8 (3)
O(2)—C(8)—C(11)	122.5 (3)	C(18)—C(19)—C(20)	112.7 (3)

C(4)—C(10)—C(12)—C(9)	-0.4 (5)
C(4)—C(10)—C(12)—C(11)	179.7 (3)
C(5)—C(10)—C(12)—C(9)	-179.9 (3)
C(6)—C(7)—C(11)—C(12)	-1.4 (5)
C(1)—N(1)—C(13)—C(14)	87.6 (3)
C(8)—N(1)—C(13)—C(14)	-91.7 (3)
N(1)—C(13)—C(14)—C(15)	178.6 (3)
C(13)—C(14)—C(15)—C(16)	176.6 (3)
C(3)—C(4)—N(2)—C(17)	-175.9 (3)
C(10)—C(4)—N(2)—C(17)	4.6 (6)

C(4)—N(2)—C(17)—C(18)	177.2 (4)		
N(2)—C(17)—C(18)—C(19)	178.0 (3)		
C(17)—C(18)—C(19)—C(20)	176.1 (3)		

C(14)	−0.472 (2)	0.3522 (4)	1.0008 (7)	0.044 (2)
C(15)	−0.635 (3)	0.3257 (4)	1.0840 (8)	0.050 (3)
C(16)	−0.449 (3)	0.3118 (5)	1.1800 (9)	0.078 (4)

Compound (2)

Crystal data

$C_{16}H_{15}BrN_2O_2$
$M_r = 347.21$
Monoclinic
Cc
$a = 4.514$ (2) Å
$b = 24.87$ (1) Å
$c = 13.054$ (4) Å
$\beta = 97.41$ (3)°
$V = 1453$ (1) Å³
$Z = 4$
$D_x = 1.587$ Mg m⁻³

Mo $K\alpha$ radiation
$\lambda = 0.71073$ Å
Cell parameters from 25 reflections
$\theta = 5.1–11.9°$
$\mu = 2.834$ mm⁻¹
$T = 288$ (2) K
Thin parallelepiped
$0.31 \times 0.25 \times 0.063$ mm
Yellow
Crystal source: recrystallized from mesitylene

Data collection

Siemens $P3$ diffractometer
$\omega/2\theta$ scans
Absorption correction:
ψ scan
$T_{min} = 0.405$, $T_{max} = 0.836$
2859 measured reflections
1465 independent reflections
952 observed reflections
$[I \geq 2\sigma(I)]$

$R_{int} = 0.0767$
$\theta_{max} = 25.02°$
$h = 0 \rightarrow 5$
$k = -29 \rightarrow 29$
$l = -15 \rightarrow 15$
3 standard reflections
monitored every 50 reflections
intensity decay: 6%

Refinement

Refinement on F^2
$R(F) = 0.0480$
$wR(F^2) = 0.0951$
$S = 0.972$
1464 reflections
190 parameters
H-atoms riding (C—H 0.96 Å)
$w = 1/[\sigma^2(F_o^2) + (0.0558P)^2]$
where $P = (F_o^2 + 2F_c^2)/3$

$(\Delta/\sigma)_{max} = -0.013$
$\Delta\rho_{max} = 0.354$ e Å⁻³
$\Delta\rho_{min} = -0.509$ e Å⁻³
Extinction correction: none
Atomic scattering factors from *International Tables for Crystallography* (1992, Vol. C, Tables 4.2.6.8 and 6.1.1.4)

Table 3. *Fractional atomic coordinates and equivalent isotropic displacement parameters* (Å²) *for* (2)

$$U_{eq} = (1/3)\Sigma_i\Sigma_j U_{ij}a_i^* a_j^* \mathbf{a}_i.\mathbf{a}_j.$$

	x	y	z	U_{eq}
Br	0.1300 (2)	0.3015 (1)	0.4292 (1)	0.071 (1)
O(1)	−0.4663 (18)	0.3012 (3)	0.7628 (5)	0.063 (2)
O(2)	−0.5110 (16)	0.4703 (3)	0.8895 (5)	0.063 (2)
N(1)	−0.4982 (17)	0.3861 (3)	0.8229 (6)	0.045 (2)
N(2)	0.2749 (18)	0.4225 (3)	0.4463 (6)	0.058 (2)
C(1)	−0.409 (2)	0.3486 (4)	0.7537 (7)	0.040 (2)
C(2)	−0.139 (2)	0.3342 (3)	0.6036 (7)	0.044 (2)
C(3)	0.021 (2)	0.3528 (4)	0.5269 (7)	0.045 (2)
C(4)	0.108 (2)	0.4053 (4)	0.5199 (7)	0.040 (2)
C(5)	0.087 (2)	0.4984 (4)	0.5949 (8)	0.055 (3)
C(6)	0.003 (2)	0.5324 (4)	0.6684 (9)	0.058 (3)
C(7)	−0.164 (2)	0.5139 (4)	0.7432 (8)	0.052 (3)
C(8)	−0.428 (2)	0.4408 (4)	0.8233 (6)	0.045 (2)
C(9)	−0.234 (2)	0.3690 (3)	0.6732 (6)	0.035 (2)
C(10)	0.015 (2)	0.4433 (3)	0.5934 (6)	0.037 (2)
C(11)	−0.245 (2)	0.4605 (4)	0.7448 (7)	0.040 (2)
C(12)	−0.157 (2)	0.4244 (3)	0.6706 (7)	0.036 (2)
C(13)	−0.670 (2)	0.3654 (4)	0.9041 (7)	0.045 (2)

Table 4. *Selected geometric parameters* (Å, °) *for* (2)

Br—C(3)	1.912 (9)	C(5)—C(6)	1.370 (14)
O(1)—C(1)	1.218 (10)	C(5)—C(10)	1.406 (13)
O(2)—C(8)	1.228 (10)	C(6)—C(7)	1.387 (13)
N(1)—C(1)	1.393 (11)	C(7)—C(11)	1.377 (13)
N(1)—C(8)	1.398 (11)	C(8)—C(11)	1.479 (12)
N(1)—C(13)	1.484 (11)	C(9)—C(12)	1.421 (12)
N(2)—C(4)	1.365 (11)	C(10)—C(12)	1.429 (11)
C(1)—C(9)	1.484 (12)	C(11)—C(12)	1.417 (12)
C(2)—C(9)	1.364 (12)	C(13)—C(14)	1.486 (13)
C(2)—C(3)	1.387 (13)	C(14)—C(15)	1.536 (12)
C(3)—C(4)	1.369 (12)	C(15)—C(16)	1.46 (2)
C(4)—C(10)	1.446 (12)		
C(1)—N(1)—C(8)	124.7 (7)	O(2)—C(8)—C(11)	122.5 (9)
C(1)—N(1)—C(13)	117.0 (10)	N(1)—C(8)—C(11)	117.8 (7)
C(8)—N(1)—C(13)	118.3 (7)	C(2)—C(9)—C(12)	120.0 (8)
O(1)—C(1)—N(1)	120.1 (8)	C(2)—C(9)—C(1)	119.8 (8)
O(1)—C(1)—C(9)	122.7 (8)	C(12)—C(9)—C(1)	120.1 (8)
N(1)—C(1)—C(9)	117.2 (8)	C(5)—C(10)—C(12)	117.1 (8)
C(9)—C(2)—C(3)	120.5 (8)	C(5)—C(10)—C(4)	124.1 (8)
C(4)—C(3)—C(2)	123.0 (8)	C(12)—C(10)—C(4)	118.8 (7)
C(4)—C(3)—Br	119.5 (7)	C(7)—C(11)—C(12)	120.1 (9)
C(2)—C(3)—Br	117.5 (7)	C(7)—C(11)—C(8)	120.2 (9)
N(2)—C(4)—C(3)	122.3 (8)	C(12)—C(11)—C(8)	119.7 (8)
N(2)—C(4)—C(10)	119.6 (8)	C(11)—C(12)—C(9)	120.5 (8)
C(3)—C(4)—C(10)	118.1 (8)	C(11)—C(12)—C(10)	120.0 (8)
C(6)—C(5)—C(10)	121.9 (9)	C(9)—C(12)—C(10)	119.5 (8)
C(5)—C(6)—C(7)	120.8 (9)	N(1)—C(13)—C(14)	111.8 (7)
C(11)—C(7)—C(6)	120.1 (10)	C(13)—C(14)—C(15)	113.9 (8)
O(2)—C(8)—N(1)	119.7 (8)	C(16)—C(15)—C(14)	115.6 (10)

C(4)—C(10)—C(12)—C(9)	−0.3 (12)
C(4)—C(10)—C(12)—C(11)	178.9 (8)
C(5)—C(10)—C(12)—C(9)	−179.6 (8)
C(5)—C(10)—C(12)—C(11)	−0.4 (13)
C(1)—N(1)—C(13)—C(14)	92.9 (10)
C(8)—N(1)—C(13)—C(14)	−84.7 (10)
N(1)—C(13)—C(14)—C(15)	−174.7 (8)
C(13)—C(14)—C(15)—C(16)	179.6 (9)

Table 5. *Hydrogen-bonding geometry* (Å, °) *for* (2)

O(2)···H(5A^i)	2.57 (1)	N(2)···H(7A^{ii})	2.99 (1)
O(2)···H(2A^i)	2.10 (1)		
C(8)—O(2)···H(5A^i)	151.8 (7)	N(2)···H(7A^{ii})—C(7^{ii})	113.0 (10)
C(8)—O(2)···H(2A^i)	154.1 (7)	O(2)···H(2A^i)—N(2^i)	160.6 (9)
O(2)···H(5A^i)—C(5^i)	167.7 (11)	C(4)—N(2)···H(7A^{ii})	97.6 (6)

C(11)—C(8)—O(2)···H(2A^i)	39.6 (21)
C(8)—O(2)···H(2A^i)—N(2^i)	−15.0 (35)

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

Computations were performed using *SHELXL93* (Sheldrick, 1993) and *SHELXTL/PC* (Sheldrick, 1990).

References

Chang, S.-C., Archer, B. J., Utecht, R. E., Lewis, D. E., Judy, M. M. & Matthews, J. L. (1993). *Biomed. Chem. Lett.* **3**, 555–556.

Chanh, T. C., Lewis, D. E., Allan, J. S., Sogandares-Bernal, E., Judy, M. M., Utecht, R. E. & Matthews, J. L. (1993). *Aids Res. Human Retrovir.* **9**, 891–896.

Creighton, T. E. (1984). *Proteins*, p. 137. New York: W. H. Freeman.

Lewis, D. E., Utecht, R. E., Judy, M. M. & Matthews, J. L. (1993). US Patent No. 5 235 045.

Lewis, D. E., Utecht, R. E., Judy, M. M., Matthews, J. L. & Chanh, T. C. (1993). *Spectrum*, **6**, 8–14.

Sheldrick, G. M. (1990). *SHELXTL/PC User's Manual.* Siemens Analytical Instruments Inc., Madison, Wisconsin, USA.

Sheldrick, G. M. (1993). *SHELXL93. Program for the Refinement of Crystal Structures.* Univ. of Göttingen, Germany.

A New Polymorph of 7-Hydroxy-2',3',4'-trimethoxyflavone

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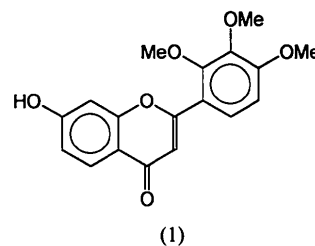*Medical Foundation of Buffalo, 73 High Street,*
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Abstract

The crystal structure of the monoclinic form of 7-hydroxy-2-(2,3,4-trimethoxyphenyl)-4H-1-benzopyran-4-one, $C_{18}H_{16}O_6$, contains two molecules in the asymmetric unit which differ from each other in both the torsion angle between the γ-benzopyrone portion and the trimethoxylated phenyl ring, and the orientation of the out-of-plane methoxy groups. The torsion angle values are different from those of the previous form [Llorca, Molins, Miravitlles, Cody, Wallet & Gaydou (1993). *J. Crystallogr. Spectrosc. Res.* **23**, 481–484] and are indicative of a large degree of 'floppiness' in the trimethoxylated phenyl ring.

Comment

The title flavone is an inhibitor of uric acid production by xanthine oxidase (Cotelle, Bernier, Hénichart, Catteau, Gaydou & Wallet, 1992). It also has weak antimutagenic activity against B[a]P in the *Salmonella tymphimurium* test (Laget, De Méo, Wallet, Gaydou, Guiraud & Duménil, 1993). Since flavones are good candidates for anticarcinogenic drugs, it has been tested at the National Cancer Institute (Bethesda, MD) against sixty human cell lines derived from seven cancer types. It did not, however, show any interesting antitumor activity (Wallet, 1992).

Crystal structures of flavones or flavonols with two or more independent molecules in the asymmetric unit are known (Jarchow & Schmalle, 1981; Cody, Luft, Koehrle, Hesch & Irmscher, 1988; Abboud, Simonsen, Mabry & Fang, 1989; Tinant, Declercq, Wallet, Gaydou & Baldy, 1991; Kawai, Yoshimura, Shimaoka, Nakamura & Yano, 1991) and one example of polymorphism has been described (Castleden, Hall, Nimgirawath, Thadaniti & White, 1985). The title flavone, (1), provides another example of polymorphism and, moreover, contains two independent molecules in the asymmetric unit.

(1)

Views of the molecules showing the atom labelling are presented in Fig. 1. Fig. 2 is a stereoscopic view of the unit cell. The previous polymorph was reported to be orthorhombic with space group *Pbna* (Llorca, Molins, Miravitlles, Cody, Wallet & Gaydou, 1993). The geometry of the molecules in the two polymorphs is identical within experimental error for both bond lengths and angles. The most striking difference between the two molecules in the polymorph described here is seen in the torsion angle O(1)—C(2)—C(1')—(6') between the γ-benzopyrone portion and the trimethoxylated phenyl ring; this angle is −4.6 (3)° in molecule I, which is almost planar, and −40.8 (3)° in molecule II, which is more twisted. As expected, the methoxy substituents at atoms C(2') and C(3') have an out-of-plane conformation and the C(4') methoxy group lies close to the plane of the phenyl ring. However, in molecule I the methoxy groups at atoms C(2') and
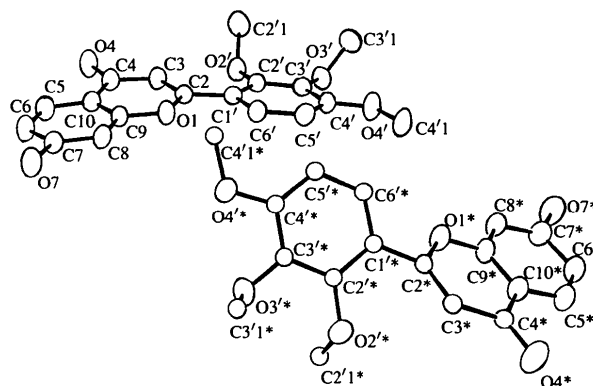

Fig. 1. Numbering of atoms and conformations of molecules (I) and (II).