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## Kynurenic Acid Monohydrate

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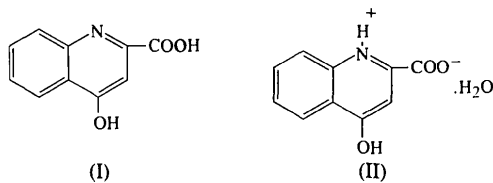
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### Abstract

In the structure of the title compound, 4-hydroxy-2-quinolinecarboxylic acid monohydrate,  $C_{10}H_7NO_3 \cdot H_2O$ , the carboxyl group is ionized and the ring N atom is protonated giving it a positive charge. The molecule is almost planar. The crystal structure is stabilized both by intermolecular  $O-H \cdots O$  and  $N-H \cdots O$  hydrogen bonds involving the solvated water molecule and by ring stacking.

### Comment

Kynurenic acid (4-hydroxy-2-quinolinecarboxylic acid), (I), a well known tryptophan metabolite, is a deaminated product of kynurenine catalyzed by kynurenine aminotransferase (Martin, Mayes & Rodwell, 1983). Kynurenic acid has been reported to have neuroactivity to inhibit excitatory amino acid receptor-mediated neurodegeneration (Jauch, Sethy, Weick, Chase & Schwarcz, 1993; Stone, 1993) and may play a role in the control of blood pressure and the pathogenesis of hypertension in rats (Kapoor, Kapoor & Chalmers, 1994). In order to elucidate the structure–function relationship of this tryptophan metabolite, accurate structural and conformational information is indispensable. Accordingly, we have undertaken the structure analysis of the title compound, (II), the results of which are presented here.



The molecular structure of (II) is shown in Fig. 1 and the unit-cell packing is shown in Fig. 2. The molecule occurs in the solid state as a zwitterion solvated by a water molecule. The carboxyl group is ionized and the N atom of the quinoline ring is protonated. The quinoline ring, including the hydroxy O(4) atom, is planar, with a maximum deviation of a ring atom from the least-squares plane of 0.04 (1) Å for C(3) and a mean deviation of 0.02 Å. The plane of the carboxylate group in position 2 is nearly coplanar with that of the quinoline ring [O(1)—C(11)—C(2)—N(1)

—6(2) Å]. This planarity has also been observed for the crystal structures of other tryptophan metabolites, for example, picolinic acid (2-pyridinecarboxylic acid; Takusagawa & Shimada, 1973) and quinolinic acid (2,3-pyridinedicarboxylic acid; Takusagawa, Hirotsu & Shimada, 1973; Kvik, Koetzle, Thomas & Takusagawa, 1974; Takusagawa & Koetzle, 1978), where the carboxyl groups and the pyridine ring are nearly coplanar. Furthermore, the ring N atoms adjacent to the carboxyl

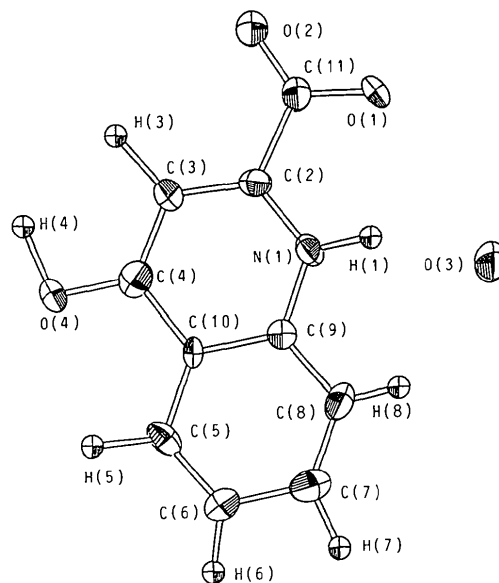


Fig. 1. An ORTEP (Johnson, 1976) drawing of the title compound with the atomic numbering scheme. Ellipsoids for non-H atoms correspond to 50% probability.

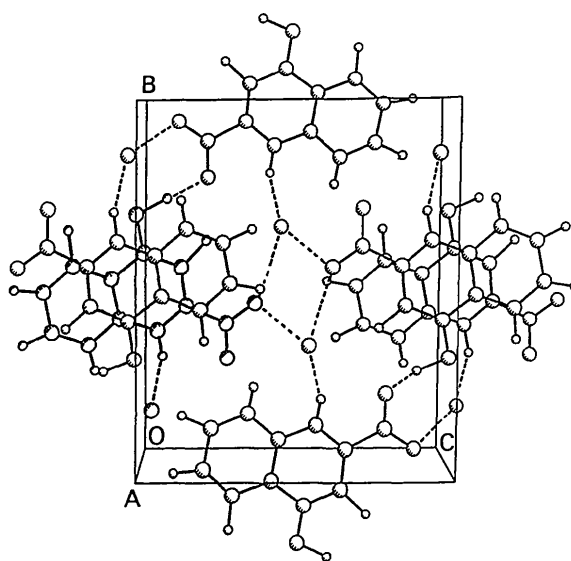


Fig. 2. A packing diagram of the title compound viewed along the *a* axis of the unit cell. Intermolecular hydrogen bonds are represented by dashed lines.

groups in position 2 of these compounds are protonated, as is the case in kynurenic acid. In the crystal structure of (II), the molecules are connected by hydrogen bonds through the water molecule; O(4)—H(4)···O(1<sup>i</sup>) 2.47 (1), N(1)—H(1)···O(3) 2.92 (1), O(3)···O(2<sup>ii</sup>) 2.80 (1) and O(3)···O(2<sup>iii</sup>) 2.94 (1) Å [symmetry codes: (i)  $\frac{1}{2} - x, \frac{1}{2} + y, \frac{3}{2} - z$ ; (ii)  $\frac{1}{2} - x, -\frac{1}{2} + y, \frac{3}{2} - z$ ; (iii)  $\frac{1}{2} + x, \frac{1}{2} - y, \frac{1}{2} + z$ ]. The crystal structure is also stabilized by stacking of the quinoline rings as seen from the interatomic distances between the N(1) atom and the O(4), C(4) and C(10) atoms of an adjacent molecule; N(1)···O(4<sup>iv</sup>) 3.53 (1), N(1)···C(4<sup>iv</sup>) 3.46 (2) and N(1)···C(10<sup>iv</sup>) 3.48 (1) Å [symmetry code: (iv)  $1 - x, 1 - y, 2 - z$ ].

## Experimental

It is difficult to obtain good quality crystals of kynurenic acid. A small plate-shaped colorless crystal was obtained by slow evaporation of an approximate 95% ethanol solution of kynurenic acid, (I), at room temperature by adjusting the pH of the crystallizing solution to pH 8 by dilution with NH<sub>4</sub>OH.

### Crystal data

C<sub>10</sub>H<sub>7</sub>NO<sub>3</sub>·H<sub>2</sub>O

*M<sub>r</sub>* = 207.19

Monoclinic

*P*2<sub>1</sub>/*n*

*a* = 6.713 (3) Å

*b* = 12.602 (4) Å

*c* = 10.869 (6) Å

$\beta$  = 94.10 (5)°

*V* = 917.1 (7) Å<sup>3</sup>

*Z* = 4

*D<sub>x</sub>* = 1.500 Mg m<sup>-3</sup>

*D<sub>m</sub>* not measured

Mo *K*α radiation

$\lambda$  = 0.71069 Å

Cell parameters from 11 reflections

$\theta$  = 4.45–12.25°

$\mu$  = 0.110 mm<sup>-1</sup>

*T* = 296 K

Plate

0.10 × 0.10 × 0.03 mm

Colorless

### Data collection

Rigaku AFC-5R diffractometer

$\omega$ -2 $\theta$  scans

Absorption correction:

none

2385 measured reflections

2207 independent reflections

670 observed reflections

[*I* > 1.5 $\sigma$ (*I*)]

*R<sub>int</sub>* = 0.134

$\theta_{\max}$  = 27.50°

*h* = 0 → 8

*k* = 0 → 15

*l* = -14 → 13

3 standard reflections

monitored every 150

reflections

frequency: 90 min

intensity decay: 0.40%

### Refinement

Refinement on *F*<sup>2</sup>

*R* = 0.096

*wR* = 0.079

*S* = 1.620

670 reflections

131 parameters

H-atom parameters refined

isotropically

*w* = 4*F<sub>o</sub>*<sup>2</sup>/ $\sigma$ <sup>2</sup>(*F<sub>o</sub>*<sup>2</sup>)

( $\Delta$ / $\sigma$ )<sub>max</sub> = 0.009

$\Delta\rho_{\max}$  = 0.43 e Å<sup>-3</sup>

$\Delta\rho_{\min}$  = -0.47 e Å<sup>-3</sup>

Extinction correction: none

Atomic scattering factors

from *International Tables*

for X-ray Crystallography

(1974, Vol. IV)

Table 1. Fractional atomic coordinates and equivalent isotropic displacement parameters (Å<sup>2</sup>)

$$B_{eq} = (8\pi^2/3)\sum_i \sum_j U_{ij} a_i^* a_j^* \mathbf{a}_i \cdot \mathbf{a}_j$$

	<i>x</i>	<i>y</i>	<i>z</i>	<i>B<sub>eq</sub></i>
O(1)	0.276 (1)	0.2862 (6)	0.7122 (7)	4.3 (5)
O(2)	0.212 (1)	0.4389 (6)	0.6159 (7)	3.9 (4)
O(3)	0.374 (1)	0.1475 (6)	0.9601 (6)	4.1 (4)
O(4)	0.226 (1)	0.6905 (6)	0.9869 (7)	3.1 (4)
N(1)	0.269 (1)	0.3718 (8)	0.9324 (8)	2.2 (4)
C(2)	0.249 (2)	0.4379 (8)	0.836 (1)	1.9 (5)
C(3)	0.227 (2)	0.5456 (8)	0.848 (1)	2.5 (6)
C(4)	0.236 (2)	0.5879 (9)	0.966 (1)	2.3 (5)
C(5)	0.267 (2)	0.5570 (8)	1.196 (1)	2.5 (6)
C(6)	0.285 (2)	0.485 (1)	1.290 (1)	3.2 (6)
C(7)	0.293 (2)	0.378 (1)	1.266 (1)	3.9 (7)
C(8)	0.290 (2)	0.339 (1)	1.149 (1)	2.7 (6)
C(9)†	0.271 (2)	0.4083 (8)	1.051 (1)	1.6 (2)
C(10)	0.257 (2)	0.5184 (8)	1.072 (1)	1.8 (5)
C(11)	0.243 (2)	0.3849 (8)	0.710 (1)	2.6 (5)

† Refined isotropically.

Table 2. Selected geometric parameters (Å, °)

O(1)—C(11)	1.26 (1)	C(4)—C(10)	1.45 (1)
O(2)—C(11)	1.24 (1)	C(5)—C(6)	1.36 (1)
O(4)—C(4)	1.32 (1)	C(5)—C(10)	1.42 (1)
N(1)—C(2)	1.34 (1)	C(6)—C(7)	1.39 (2)
N(1)—C(9)	1.37 (1)	C(7)—C(8)	1.36 (2)
C(2)—C(3)	1.37 (1)	C(8)—C(9)	1.38 (1)
C(2)—C(11)	1.52 (1)	C(9)—C(10)	1.41 (1)
C(3)—C(4)	1.39 (1)		
C(2)—N(1)—C(9)	122 (1)	C(7)—C(8)—C(9)	119 (1)
N(1)—C(2)—C(3)	123 (1)	N(1)—C(9)—C(8)	121 (1)
N(1)—C(2)—C(11)	115.2 (9)	N(1)—C(9)—C(10)	119 (1)
C(3)—C(2)—C(11)	122 (1)	C(8)—C(9)—C(10)	120 (1)
C(2)—C(3)—C(4)	118 (1)	C(4)—C(10)—C(5)	123 (1)
O(4)—C(4)—C(3)	122 (1)	C(4)—C(10)—C(9)	118 (1)
O(4)—C(4)—C(10)	117 (1)	C(5)—C(10)—C(9)	120 (1)
C(3)—C(4)—C(10)	120 (1)	O(1)—C(11)—O(2)	125 (1)
C(6)—C(5)—C(10)	119 (1)	O(1)—C(11)—C(2)	115 (1)
C(5)—C(6)—C(7)	121 (1)	O(2)—C(11)—C(2)	119.7 (9)
C(6)—C(7)—C(8)	122 (1)		

Most of the H atoms were located from difference Fourier maps, but the positions of the H atoms of the water O(3) atom were not located. The *R*, *wR* and *R<sub>int</sub>* values are very high due to the small size of the crystal and, as a result, the small number of observed reflections.

Data collection: *MSCIAFC Diffractometer Control Software* (Molecular Structure Corporation, 1988). Cell refinement: *MSCIAFC Diffractometer Control Software*. Data reduction: *TEXSAN* (Molecular Structure Corporation, 1985). Program(s) used to solve structure: *SHELX86* (Sheldrick, 1985) and *DIRDIF* (Beurskens, 1984). Program(s) used to refine structure: *TEXSAN*. Molecular graphics: *ORTEPII* (Johnson, 1976).

Lists of structure factors, anisotropic displacement parameters, H-atom coordinates, complete geometry, least-squares-planes data and torsion angles have been deposited with the IUCr (Reference: KH1080). Copies may be obtained through The Managing Editor, International Union of Crystallography, 5 Abbey Square, Chester CH1 2HU, England.

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## A *cis*-Fused Decalone and a Bicyclo[4.3.1]-decanone Ring System

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### Abstract

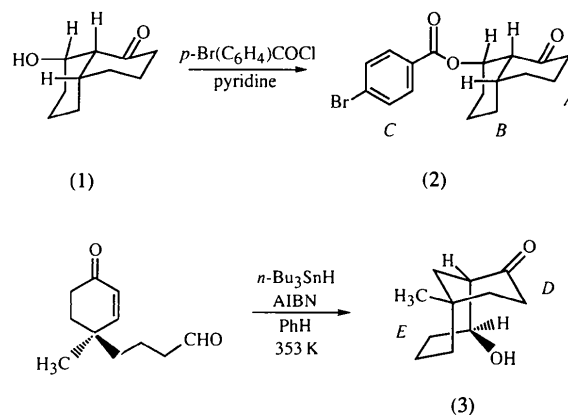
The crystal structures of (4 $\alpha$ ,8 $\alpha$ ,8 $\alpha$ )-(±)-1-oxoperhydro-8-naphthyl *p*-bromobenzoate, C<sub>17</sub>H<sub>19</sub>BrO<sub>3</sub>, (2), and (±)-*endo*-5-hydroxy-1-methylbicyclo[4.3.1]decan-7-one, C<sub>11</sub>H<sub>18</sub>O<sub>2</sub>, (3), were determined in order to ascertain their relative configurations. Compound (2) has two *cis*-fused six-membered rings which both adopt chair conformations. Compound (3) has a bridged bicyclic ring system consisting of a six- and a seven-membered ring which both adopt chair conformations. Molecules of (3) are linked about inversion centers into dimers by O—H...O hydrogen bonds [O...O 2.844 (3) Å] involving the hydroxy and carbonyl groups.

### Comment

Many of the sophisticated organic molecules found in nature, such as carbohydrates, steroids and some terpenes, possess the common feature of cyclic components

(Thebtaranonth & Thebtaranonth, 1994). Cyclization reactions, especially those promoted by free radicals, are therefore particularly valuable in the synthesis and modification of these complex molecules (Giese, 1986). The application of free radicals to synthesis, in general, permits neutral reaction conditions and alleviates the need for protecting groups (Curran, 1988).

As part of a plan to develop and exploit free-radical reactions, unsaturated ketones were subjected to treatment with tri-*n*-butyltin hydride, which led to the formation of *O*-stannyl ketyls. The title molecules, (2) and (3), were prepared by a new *O*-stannyl ketyl reaction which promoted an aldol-like cyclization (Enholtm, Xie & Abboud, 1995). This contrasts with most aldol reactions which require strong bases or dissolving metal conditions. Three new stereocenters were formed in compound (2) and two in compound (3) in the free-radical annulation reaction. Since it was not clear what relative stereochemistry would prevail in compounds (2) and (3), we undertook X-ray studies to ascertain these details. The results of these studies are described herein.



Displacement ellipsoid drawings of compounds (2) and (3) with the atom-labeling schemes are shown in Figs. 1 and 2, respectively. All bond lengths and angles of both molecules are normal. Compound (2) has two six-membered rings (A and B), which are fused together along the C5—C10 bond, and a phenyl ring (C). Ring A exhibits a <sup>1</sup>C<sub>4</sub> conformation (Boeyens, 1978), with atoms C1 and C4 at distances of 0.60 (1) and −0.66 (1) Å, respectively, from the plane composed of atoms C2, C3, C5 and C10. Ring B exhibits a <sup>6</sup>C<sub>9</sub> inverted chair conformation, with atoms C6 and C9 at distances of 0.66 (1) and −0.61 (1) Å, respectively, from the plane containing atoms C5, C7, C8 and C10. The planes of rings A and B form an angle of 126.4 (2)° with one another. The plane of the carboxy group (C11, O11a and O11b) is slightly skewed from the plane of the bromophenyl ring, with a dihedral angle of 12.1 (2)°. Phenyl ring C is planar, with the largest deviation from the least-squares plane being 0.002 (4) Å and the average bond length 1.382 (6) Å.