

Crystal and molecular structure of bis(niflumato)bis(3-pyridylmethanol)copper(II)

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Abstract—The crystal and molecular structure of the first copper(II) complex of $(2-\{[3-(trifluoromethyl) phenyl]amino\}$ -3-pyridinecarboxylate with 3-pyridylmethanol as neutral ligand was determined by X-ray analysis. () 1997 Elsevier Science Ltd. All rights reserved.

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(2 - {[3 - (Trifluoromethyl)phenyl]amino} - 3 - pyridinecarboxylic acid (niflumic acid) and other fenamates (flufenamic acid and mefenamic acid) are believed to act through the inhibition of prostaglandin biosynthesis, like other anti-inflammatory analgesics [1]. The interaction of the copper(II) atom, which plays a vital role in a number of quite different biological processes, with therapeutically administrated drugs is a subject of considerable interest.

X-ray crystallographic studies of the 1:1 complex between niflumic acid and ethanolamine showed deprotonation of one carboxylic oxygen atom [2]. The bond valences [3] of the niflumate anion calculated by the formula $s = (R_0/R)^N$ are shown in Fig. 1. *R* is the bond length, R_0 and *N* are fitted constants. Available atom valences of the terminal atoms were calculated as the difference between the theoretical atomic valence and the sum of bond valences around the atom. The greatest available valence of one oxygen atom indicates the preferred coordination of niflumate ligand to the metal cation through one carboxylic oxygen atom. On the basis of spectroscopic and magnetic properties of Cu(nif)₂(3-pyMe)₂ (nif = niflumate, 3-pyMe = 3-pyridylmethanol) the polymeric struc-



Fig. 1. Bond valences (in valence units, v.u.) of niflumic acid anion. Valences of C--C bonds are in the range 1.20-1.71 v.u. Available valences of the terminal atoms are enclosed in square brackets.

ture with a pseudo-octahedral environment about the Cu^{II} atom was proposed.

In order to understand better some aspects of metal ion-drug interactions, we have studied the structure of the title compound at room temperature.

EXPERIMENTAL

The copper(II) niflumate was prepared as described elsewhere [4]. The 3-pyridylmethanol adduct of cop-

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per(II) niflumate was prepared by adding the ligand 3-pyMe (2.73 g, 0.025 mol) to 100 cm³ of a methanol suspension of Cu(nif)₂ (3.43 g, 0.01 mol). After heating to boiling, a solution was obtained which was left to cool and stand at room temperature. The precipitated product was isolated, washed with cold methanol and then dried at room temperature. The crude product was recrystallized from hot methanol to yield green crystals. Found (Calc.) for Cu(nif)₂ (3-pyMe)₂: Cu, 7.5 (7.5); C, 53.5 (54.0); H, 3.9 (3.9); N, 5.5 (5.6)%.

Crystal data for Cu(nif)₂(3-pyMe)₂, C₃₈H₃₀F₆N₆O₆Cu

The density of the crystals measured by flotation in CCl_4 /benzene mixture is $D_m = 1.52 \text{ g cm}^{-3}$, calculated $D_{\rm x} = 1.53$ g cm⁻³. $M_{\rm r} = 844.23$, monoclinic, a =11.806(3), b = 22.856(6), c = 7.101(8) Å, $\beta =$ $106.7(3)^{\circ}$; V = 1835(2) Å³, space group $P2_1/n$, Z = 2, $F(000) = 862, \ \mu(\text{Mo-}K_{\alpha}) = 0.68 \text{ mm}^{-1}$. A crystal of dimensions ca $0.25 \times 0.20 \times 0.20$ mm³ was measured on a Syntex P2₁ diffractometer, with graphite-monochromated Mo- K_{α} radiation ($\lambda = 0.71069$ Å). The cell parameters were refined by least squares for 15 reflections in the range $11.0 \le 2\theta \le 32.1^{\circ}$. 3308 reflections in total were measured using the $\omega/2\theta$ scan technique, $2\theta_{\text{max}} = 110^{\circ}$, time per reflection *ca* 60 s, index range $0 \le h \le 15$, $0 \le k \le 25$, $-9 \le l \le 8$, two standard reflections with variation 2%, $R_{int} = 0.036$. Correction for empirical absorption was applied. The maximum and minimum transmission factor values were 1.0 and 0.825, respectively. 2219 unique reflections obeying the condition $F > 3\sigma(F)$ were estimated. All nonhydrogen atoms were localized by direct methods, using the SHELXS86 program [5]. The atomscattering factors and f° , f° values were obtained from International Tables for X-ray Crystallography [6]. The structure was refined by the least-squares method, using the SHELX76 program [7]. After the anisotropic refinement all hydrogen atoms were located from difference maps, but not refined. The final values were R = 0.048 and Rw = 0.048, $w = 0.3802/[\sigma(F_o) + 0.001(F_o)^2]$. Goodness-of-fit, S, was 0.06. The maximum and minimum heights in the final difference Fourier map were 0.5 and -0.3 e Å⁻³, respectively. All calculations were performed on a PC 386 computer.

RESULTS AND DISCUSSION

The molecular structure of $[Cu(nif)_2(3-pyMe)_2]$ is shown in Fig. 2. Selected bond lengths and bond angles are summarized in Table 1. *Trans* coordination of the Cu atom is formed by two carboxylic oxygen atoms from two niflumic ligands and two nitrogen atoms from two 3-pyridylmethanol ligands. This almost square-planar coordination of the Cu atom is supplemented by two methanolic oxygen atoms of the neighbouring structural units, forming a pseudooctahedral coordination connecting the units $[Cu(nif)_2(3-pyMe)_2]$ into infinite chains along the *Z*direction (Fig. 3). The chains are held mutually by the van de Waals forces.

Using the data in refs [8,9] for Cu—N(1) bond valence, according to Brown and Shannon [10] the predicted bond length Cu^{II}—O(3) is 2.61 Å, which is very close to the observed value (Table 1). The coordination of the Cu^{II} atom may therefore be described as pseudo-octahedral and the Cu···O(2) contact, being 3.231(3) Å, should be regarded as non-bonding. The dihedral angle between the rigid car-



Fig. 2. A perspective view of the molecular structure of Cu(nif)₂(3-pyMe)₂.

Cu—N(1)	2.038(3)	C(2) - C(3)	1.400(7)
Cu—O(1)	1.946(3)	C(2) - C(6)	1.526(7)
Cu—O(3)	2.573(3)	C(3) - C(4)	1.398(8)
N(1) - C(1)	1.359(6)	C(4) - C(5)	1.384(6)
N(1)-C(5)	1.361(6)	C(7) - C(8)	1.489(8)
N(2) - C(12)	1.361(7)	C(8) - C(9)	1.388(7)
N(2) - C(13)	1.389(6)	C(8)C(12)	1.423(6)
N(3) - C(11)	1.329(8)	C(9)—C(10)	1.426(8)
N(3) - C(12)	1.367(9)	C(10) - C(11)	1.420(6)
O(1)C(7)	1.252(5)	C(13)C(14)	1.423(8)
O(2)—C(7)	1.253(6)	C(13)C(18)	1.422(7)
O(3)C(6)	1.429(6)	C(14)C(15)	1.390(6)
F(1) - C(19)	1.285(6)	C(15)C(16)	1.391(8)
F(2)C(19)	1.272(5)	C(15)C(19)	1.480(8)
F(3) - C(19)	1.330(5)	C(16)C(17)	1.424(8)
C(1)—C(2)	1.392(6)	C(17)C(18)	1.386(6)
N(1)CuO(1)	89.9(1)	C(9) - C(8) - C(12)	118.7(5)
N(1)CuO(3)	96.4(1)	C(8) - C(9) - C(10)	120.0(4)
O(1)CuO(3)	85.1(1)	C(9) - C(10) - C(11)	115.2(5)
Cu—N(1)—C(5)	120.5(3)	N(3) - C(11) - C(10)	126.7(5)
Cu—N(1)—C(1)	120.2(3)	N(3) - C(12) - C(8)	122.8(5)
C(1) - N(1) - C(5)	119.4(4)	N(2) - C(12) - C(8)	119.2(5)
C(12)-N(2)-C(13)	130.5(4)	N(2) - C(12) - N(3)	118.0(5)
C(11) - N(3) - C(12)	116.4(6)	N(2) - C(13) - C(18)	115.6(4)
Cu—O(1)—C(7)	129.9(3)	N(2)-C(13)-C(14)	125.0(4)
C(6)—O(3)—Cu	127.6(2)	C(14)C(13)C(18)	119.4(4)
N(1) - C(1) - C(2)	122.1(4)	C(13)C(14)C(15)	117.7(5)
C(1) - C(2) - C(6)	122.0(4)	C(14)C(15)C(19)	117.5(4)
C(1) - C(2) - C(3)	118.7(4)	C(14)C(15)C(16)	123.5(5)
C(3) - C(2) - C(6)	119.2(4)	C(16)C(15)C(19)	119.0(4)
C(2) - C(3) - C(4)	118.6(4)	C(15)C(16)C(17)	119.0(5)
C(3) - C(4) - C(5)	120.2(5)	C(16)C(17)C(18)	118.9(5)
N(1) - C(5) - C(4)	121.0(5)	C(13)—C(18)—C(17)	121.6(5)
O(3) - C(6) - C(2)	110.4(4)	F(3) - C(19) - C(15)	113.3(4)
O(1)C(7)O(2)	123.6(5)	F(2) - C(19) - C(15)	113.8(4)
O(2) - C(7) - C(8)	119.9(4)	F(2)-C(19)-F(3)	103.3(4)
O(1) - C(7) - C(8)	116.4(4)	F(1)-C(19)-C(15)	115.2(4)
C(7)C(8)C(12)	124.3(5)	F(1)C(19)F(3)	100.4(4)
C(7)C(8)C(9)	117.0(4)	F(1)C(19)F(2)	109.5(4)

Table 1. Bond lengths (Å) and bond angles (°) with e.s.d.s in parentheses

boxylate group [the sum of the bond angles around the C(7) atom is $359.93(7)^{\circ}$] and the equatorial plane of the copper coordination sphere is $93.5(2)^{\circ}$. The intramolecular ligand hydrogen bond N(2)— H(15)…O(2) [the interatomic distances are N(2)…O(2) 2.657(5) and H(15)…O(2) 1.851(3) Å, and the bond angle N(2)—H(15)…O(2) is 135.4(3)°] encloses a pseudo-ring in the niflumic ligand (Fig. 2).

Both benzene and pyridine rings of the niflumic ligand deviate significantly from planarity (χ^2 values of 45.0 and 84.4, respectively). The dihedral angle created by the least-squares planes of both rings is 11.7(1)°. The torsion angle C(8)—C(12)—N(2)—C(13) (Table 2) does not differ from the corresponding angle for the niflumic acid anion (174.1°) [2]. The other two torsion angles defining the conformation of the niflumic ligand differ significantly from the values

for niflumic acid $(-177.2 \text{ and } -4.5^\circ)$. Such deformation is in agreement with the stabilization effect of the hydrogen bond N(2)—H(15) \cdots O(2) occurring in the niflumic acid anion, too. The pyridine ring of the 3-pyridylmethanol ligand is planar. Mean C—C and C—N bond lengths in the niflumic and 3-pyridylmethanol ligands exhibit no significant differences from mean bond lengths of the same type in the structures of morpholinoethyl niflumate [11] and bis (salicylato)-bis(3-pyridylmethanol)copper(II) [12]. The dihedral angle between the plane of pyridine ring and the equatorial plane of the copper atom coordination is 97.3(1)^o.

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Fig. 3. Structure of the chain in the crystal structure of Cu(nif)₂(3-pyMe)₂. Hydrogen atoms are omitted for clarity.

Table 2. Torsion angles (°)

O(2)—C(7)—C(8)—C(9)	-175.1(5)	C(8)—C(12)—N(2)—C(13)	174.3(5)
C(12)—N(2)—C(13)—C(14)	6.2(9)	C(1)—C(2)—C(6)—O(3)	-22.1(6)

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