Inorganica Chimica Acta, 26 (1978) L1–L2

Stereoselective Effects in the Coordination of Amino Acids. Crystal Structure of the Copper(II) Complex with the Schiff Base between (1*R*)-3-hydroxymethylenecamphor and (*S*)-phenylalanine

L. CASELLA, M. GULLOTTI and A. PASINI*

Istituto di Chimica Generale ed Inorganica, Via Venezian 21, 20133 Milano, Italy

G. CIANI, M. MANASSERO* and A. SIRONI

Centro di Studio per la Sintesi e la Struttura dei Composti dei Metalli di Transizione nei Bassi Stati di Ossidazione del C.N.R., Via Venezian 21, 20133 Milano, Italy

Received October 13, 1977

The existence of stereoselective effects in the coordination of amino acids to metal ions has been discussed by a number of authors and is still a matter of controversy, in view of its relevance to some bioinorganic mechanisms [1]. In a previous paper [2] some of us have reported some interesting stereoselective effects which are displayed by copper complexes of general formula [Cu{(+)-hmcaa}], where (+)-hmcaaH_2 stands for the diastereoisomeric Schiff base formed by the condensation of (+)-(1*R*)-3-hydroxymethylenecamphor (hmcH) and (*R*)- or (*S*)-amino acids (aaH). In fact the circular dichroism spectra, in the 800–300 nm range, of the diastereoisomers [Cu{(+)-hmc(*S*)-aa}] and [Cu{(+)-hmc-(*R*)-aa}] are nearly enantiomeric, suggesting that the overall chirality is dictated by the amino acid, while the contribution of the β-ketoaldehyde to the optical activity of the complex is almost irrelevant [2]. To understand this behaviour we have determined the structure of N-(*S*)-phenylalaninato[(+)-hydroxymethylidenecamphorato] copper(II).

The compound was prepared adding copper acetate to a refluxing ethanol solution of (+)-hydroxymethylenecamphor and (*S*)-phenylalanine and crystallized from ethanol [3].

Crystal Data. Green orthorombic prisms, space group $P2_12_12_1$ (No. 19), $a = 19.903(5)$, $b = 13.835(3)$, $c = 6.968(1)$ Å, $U = 1918.7$ Å^3, $d_c = 1.35$ gcm^{-3} for $Z = 4$, $\mu_1 = 12.0$ cm^{-1} for Mo-K_α.

1993 intensities, corresponding to the $+h$ $+k$ $+l$ octant in the 2θ range 6–50°, were collected on the BASIC diffractometer [4] using graphite-monochromatized Mo-K_α radiation and the ω-scan technique. The structure solution, performed by Patterson and Fourier methods, is based upon 1207 independent absorption corrected reflections having $\sigma(I)/I \leqslant .30$. In the block-matrix least squares refinement the copper atom was assigned an anisotropic thermal factor and its contribution to anomalous dispersion was taken into account. All the hydrogen atoms were located in the last Fourier maps and their contribution was kept constant in the subsequent structure factor calculations. Current conventional agreement indices are $R = 0.050$ and $R_w = 0.061$ for the other.

The structure is shown in Fig. 1. The amino acid and the (+)-hydroxymethylenecamphor residues are condensed through the formyl group in agreement with former suggestions [5]. The Schiff base behaves as a tridentate ligand (through N, O(1) and O(3)) towards the same copper atom, the carboxylate group being also bound (through O(2)) to a different metal atom, giving rise to an infinite, monodimensional, right handed helix which develops around the cell screw axes parallel to *c* (see Fig. 2). The three dimensional crystal structure consist of the pakcing of these polymeric units by means of usual Van der Waals contacts.

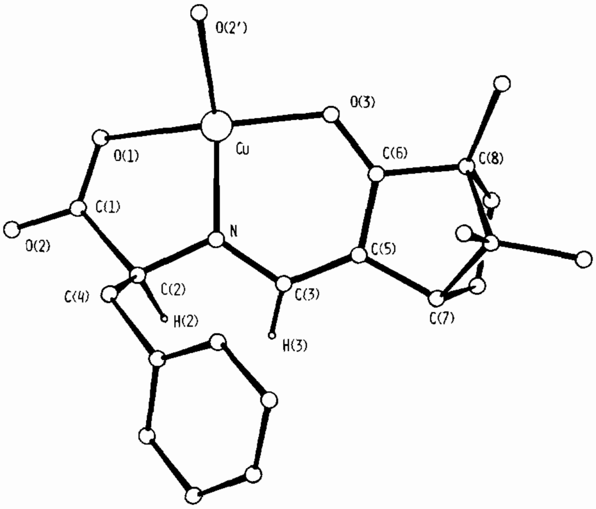

Fig. 1. Projection of the molecular structure on the plane of the six membered chelate ring. Bond parameters are: Cu–N 1.916(7), Cu–O(3) 1.906(6), Cu–O(2′) 1.978(6), Cu–O(1) 1.983(6), O(1)–C(1) 1.26(1), C(1)–O(2) 1.24(1), C(1)–C(2) 1.54(1), C(2)–N 1.46(1), N–C(3) 1.31(1), C(3)–C(5) 1.37(1), C(5)–C(6) 1.38(1), C(6)–O(3) 1.28(1), C(5)–C(7) 1.52(1), C(6)–C(8) 1.51(1) Å. O(1)–Cu–N 83.5(2), N–Cu–O(3) 96.7(3), O(3)–Cu–O(2′) 91.8(3), O(2′)–Cu–O(1) 92.8(2)°.

The copper atom is four coordinate, *quasi*-planar, with a slight tetrahedral distorsion (O(1)–Cu–O(3) = 162.7(3); N–Cu–O(2′) = 162.6(3)°). A fifth long contact (Cu. . .O(1′) = 2.592(6)Å) is in an unfavourable direction for a coordinative bond to take place (C(1′)–O(1′)–Cu = 76.6°; O(2′)–Cu–O(1′) = 55.3°). To our knowledge this is the first tetracoordinate copper(II) complex with tridentate Schiff bases of amino acids [6, 7].

---

*Authors to whom correspondence should be addressed.

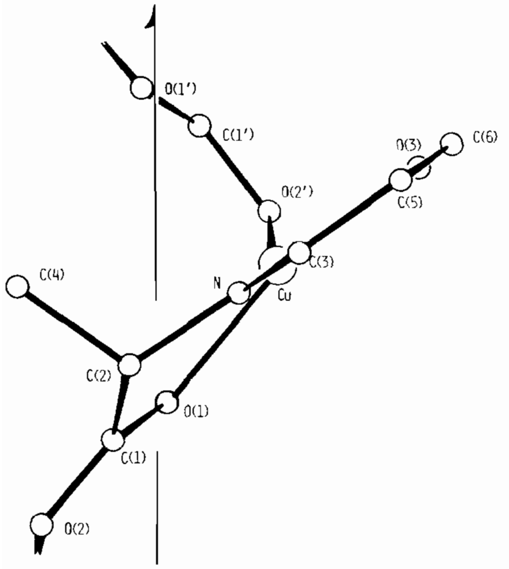

Fig. 2. Projection of the inner coordination environment on the crystallographic plane *ac*. The copper atom lies 0.59 Å above the screw axis.

Of the two fused chelate rings, the six membered one is planar; the planarity extends not only to C(7) and C(8) of the camphor moiety, but also, in the five membered chelate ring, to the asymmetric carbon atom of the amino acid C(2) which is the only chiral centre of the whole coordination set. The largest deviation from the best plane is shown by O(3) (0.17(6)Å). The bond distances in the six membered chelate ring are in agreement with extended π delocalization involving also the ligand to copper bonds (Cu–O(3) = 1.906(6), Cu–N = 1.916(7)Å, *vs.* Cu–O(1) = 1.983(6) and Cu–O(2′) = 1.978(6)Å), as has been found in related amino acid Schiff base complexes of copper(II) [6, 7].

The amino acid moiety is in a puckered λ conformation with the benzyl group axial ($\omega = -17°$) [8]. Interestingly this situation is common to other tetracoordinate metal complexes of Schiff bases of both amino acids and C-substituted 1,2-diamines forming five membered chelate rings [9], presumably because of some repulsive interaction between the azomethine hydrogen atom $\dot{H}(3)$ and the benzyl group in the equatorial position†.

In conclusion the coordination set is partly planar and partly chiral, the chirality being dictated solely by the α-carbon atom of the amino acid (Fig. 2). Therefore it can be reasonably assumed that the derivatives of (*R*)- and (*S*)-phenylalanine have a mirror image relationship of the copper environment. This accounts for the observed *quasi* enantiomeric circular dichroism spectra in the studied range [2], since only minor (vicinal) contributions from the camphor chiral centres can be expected, and were indeed found in [Cu{(+)-hmcgly}] [2], (glyH = glycine).

Unfortunately the derivative of (*R*)-phenylalanine could not be obtained in a crystalline form. Interestingly when the complex was prepared from racemic phenylalanine, almost optically pure [Cu{(+)-hmc(*S*)-phe}] (pheH = phenylalanine) precipitated from the reaction mixture in a high yield††. This diastereoisomeric behaviour should arise only from a favourable packing in the solid state of [Cu{(+)-hmc(*S*)-phe}], probably due to the relative positions of the various groups in the right handed helix, rather than to diastereoisomeric interactions of the two chiral fused ligands in the coordination sphere.

Acknowledgements

This work has been supported by the Italian C.N.R.

References

1 See for instance V. A. Davankov, A. A. Kurganov, and S. V. Rogozhin, *Russian Chem. Rev.*, *43*, 764 (1974), and S. T. Chow and C. A. McAuliffe, *Progr. Inorg. Chem.*, *19*, 51 (1975).

2 L. Casella, M. Gullotti, A. Pasini, and M. Visca, *Inorg. Chim. Acta*, *19*, L9 (1976); L. Casella, M. Gullotti, A. Pasini, and A. Rockenbauer, paper in preparation.

3 *Anal.* Calcd. for $CuC_{20}H_{23}NO_3$:C 61.8, H 5.9, N 3.6; found C 61.5, H 6.1, N 3.6%.

4 BASIC stands for "Basic Siemens Controlled" diffractometer. It has been assembled by Prof. P. L. Bellon with a Siemens-Hoppe four circle goniometer and a 8K Hewlett & Packard computer, partly programmed in the BASIC language.

5 M. Gullotti, A. Pasini, P. Fantucci, R. Ugo, and R. D. Gillard, *Gazz. Chim. Ital.*, *102*, 855 (1972), and references therein.

6 T. Ueki, T. Ashida, Y. Sasada, and M. Kakudo, *Acta Crystallogr. Sect. B*, *25*, 328 (1969).

7 J. F. Cutfield, D. Hall, and T. N. Waters, *Chem. Commun.*, 785 (1967); G. A. Bentley, J. M. Waters, and T. N. Waters, *Chem. Commun.*, 988 (1968).

8 C. J. Hawkins, "Absolute Configuration of Metal Complexes", Wiley–Interscience, New York, N.Y., (1971), p. 97; J. R. Gollogly, C. J. Hawkins, and C. L. Wong, *Inorg. Nucl. Chem. Lett.*, *6*, 215 (1970).

9 A. Pasini, M. Gullotti, and R. Ugo, *J. Chem. Soc. Dalton*, 346 (1977), and references therein.

---

† As a matter of fact an approximated estimate of the C(4). . .H(3) contact, in the hypothetical equatorial conformation, gave a value of 2.4 Å *vs.* the observed 3.0 Å of the axial case.

†† 80% yield; optical purity 90%, by comparison of the circular dichroism spectrum, in chloroform solution, of the precipitate with that of an authentic sample; the remaining solution showed the chiroptical features of [Cu{(+)-hmc(*R*)-phe}].