The Crystal Structure of (±)-Phenylalanine-(Pyridoxylidine 5-Phosphate)copper(II)

By G. A. BENTLEY, J. M. WATERS, and T. N. WATERS*

(*Chemistry Department, University of Auckland, Auckland, New Zealand*)

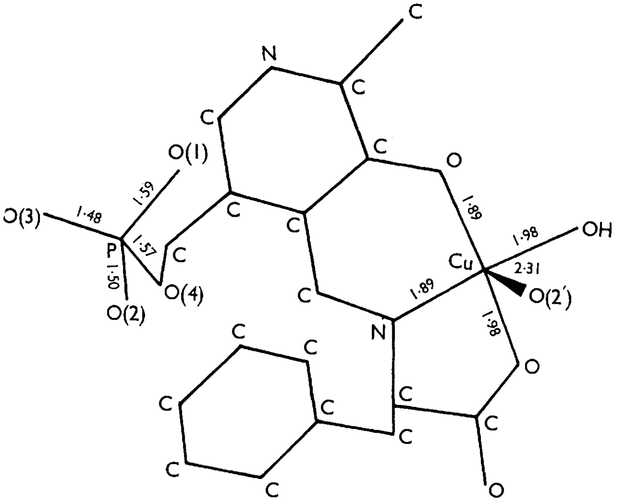
CO-ORDINATED SCHIFF BASES, as essential intermediate species during pyridoxal-catalysed reactions of amino-acids, are well established by studies in solution[1,2] and more recently in the solid state.[3,4] Generally these have involved pyridoxal itself, and not the common co-factor pyridoxal phosphate, it being presumably felt that the extra group, although activating, has no direct structural significance in the formation of the intermediate. In view, however, of the weak co-ordinating ability reported for the phosphate of ATP,[5] we have investigated the possibility of the group having a positive structure-determining role in pyridoxal systems and here report the crystal and molecular structure of the (±)-phenylalanine-(pyridoxylidene 5-phosphate)copper(II) complex.

Crystal data: $a = 8{\cdot}670 \pm 0{\cdot}010$, $b = 12{\cdot}925 \pm 0{\cdot}012$, $c = 12{\cdot}493 \pm 0{\cdot}012$ Å, $\alpha = 111{\cdot}7 \pm 0{\cdot}4$, $\beta = 109{\cdot}0 \pm 0{\cdot}4$, $\gamma = 65{\cdot}5 \pm 0{\cdot}2°$, $Z = 2$. Space group $P\bar{1}$. Intensity data were obtained with Cu-K_α radiation by conventional Weissenberg methods. Photographs were generally of poor quality, reflecting the difficulty in obtaining single crystals. Even the best of these were mis-shapen and tended to be multicrystalline, leading to split, badly shaped spots on regions of the films.

The positions of copper and phosphorus atoms were determined from a three-dimensional Patterson synthesis (the analysis of which was consistent with the centrosymmetric space group), and the light atoms, excluding hydrogens, from heavy-atom syntheses. Refinement of the structure by the block-diagonal least-squares procedure, produced an R-factor of 0·145 for the 1177 observed reflections. Individual isotropic temperature parameters were assumed for all light atoms with anisotropic values for copper and phosphorus.

The structural analysis reveals a five-co-ordinate copper atom with a square pyramidal environment, three of the in-plane donor atoms being the imine nitrogen and the phenolic and carboxy-oxygens of one pyridoxylidene group.

The fourth co-ordination position is occupied by a water molecule and the square pyramidal arrangement is completed by a phosphate oxygen from a neighbouring molecule. This fifth bond (2·31 Å) is longer than the other four, in agreement with previous observations. The amino-acid and co-factor are found to be approximately coplanar, revealing a plausible role for the metal ion in maintaining a conjugated system appropriate to the requirements of proposed reaction mechanisms. Of particular interest are the relative lengths of the four phosphorus–oxygen bonds and the positions of the two protons necessary for electrical neutrality. By analogy with the structure of other organic phosphates,[6] in which the exact phosphorus–oxygen bond lengths are found to reflect the positions of hydrogen atoms, we assume that O(1) is protonated. Of the remaining oxygens, O(2) is co-ordinated to copper, O(4) is linked to the methylene group, and O(3) lies only 2·61 Å from an adjacent pyridine nitrogen. This particular separation is associated with a molecular geometry appropriate for hydrogen bonding and such an interaction is assumed. However the short phosphorus–oxygen bond length suggests that the proton is not associated with O(2) but is to be found on the nitrogen atom, which must then be formulated as belonging to a pyridinium system. It is interesting that this further activation of the molecule has been suggested in other studies,[7] although it is not claimed here that its existence in the solid phase verifies formation of a pyridinium ion as a necessary pre-requisite for reaction.



(*Received, May* 31*st*, 1968; *Com.* 715.)

---

[1] P. Fasella, H. Lis, N. Siliprandi, and C. Baglioni, *Biochim. Biophys. Acta*, 1957, **23**, 417.
[2] G. D. Kalyankar and E. E. Snell, *Biochemistry*, 1962, **1**, 594.
[3] J. F. Cutfield, D. Hall, and T. N. Waters, *Chem. Comm.*, 1967, 785.
[4] E. Willstadter, T. A. Hamor, and J. L. Hoard, *J. Amer. Chem. Soc.*, 1963, **85**, 1205.
[5] P. W. Schneider and H. Brintzinger, *Helv. Chim. Acta*, 1964, **47**, 1717.
[6] C. T. Li and C. N. Caughlan, *Acta Cryst.*, 1965, **19**, 637.
[7] D. E. Metzler, M. Ikawa, and E. E. Snell, *J. Amer. Chem. Soc.*, 1965, **76**, 648.