

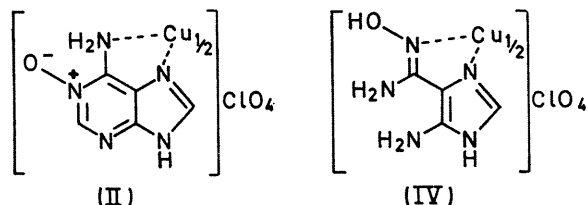
Crystal Structure of Bis-(4-aminoimidazole-5-carboxamide oxime)copper(II) Perchlorate. A Degradation Product of Adenine *N*¹-Oxide

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Summary The X-ray structure analysis of what was believed to be a copper(II) complex of adenine *N*¹-oxide showed that it was a complex of its degradation product, 4-aminoimidazole-5-carboxamide oxime.

STRUCTURAL studies of the interaction of metal ions with the nucleic acid constituents and their derivatives is of considerable current interest.¹ Solution studies of metal-ion interactions with adenine *N*¹-oxide (I) have been reported^{2,3} but no crystal structures have been hitherto investigated. Weiss and Venner² concluded that the most probable binding sites to copper were N(7) and the amino-nitrogen N(6) for (II). In order to establish the co-ordination scheme in these compounds we have undertaken an X-ray study of a series of copper complexes involving the anions Cl⁻, SO₄²⁻, and ClO₄⁻. We report here the crystal structure of the copper(II) perchlorate complex.



Crystals of "bis-(6-aminopurine *N*¹-oxide)copper(II) perchlorate" were dark brown. *Crystal data*: monoclinic, $P2_1/c$, $a = 9.988$, $b = 10.883$, $c = 16.648$ Å, $\beta = 90.24^\circ$. $V = 903.72$ Å³, $M = 543.78$, $D_o = 1.965$ g cm⁻³, $D_c = 2.002$ g cm⁻³. The molecular weight indicated the presence at

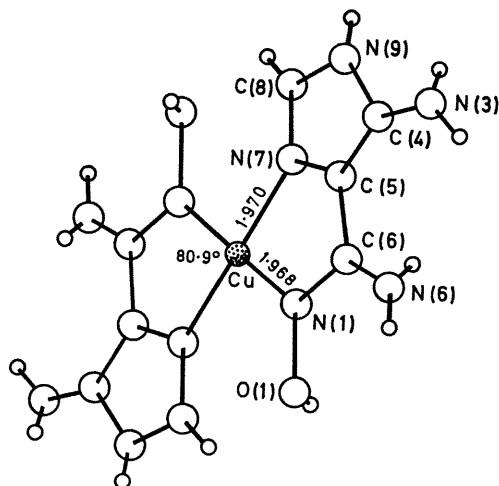
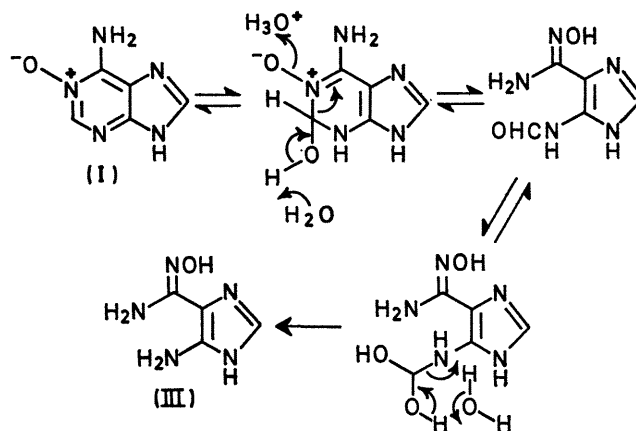


FIGURE. The structure of the bis-(4-aminoimidazole-5-carboxamide oxime)copper(II) ion.

most of only two copper atoms in the unit cell. Therefore, copper had to be at a special position. This was confirmed by a sharpened, origin-removed Patterson synthesis, which

additionally provided the position of the chlorine in the perchlorate. The structure was determined by the heavy-atom technique and refined to an R value of 0.053 by full-matrix least-squares. All calculations used 1136 independent reflections recorded on an automated diffractometer.

The structure of the complex is shown in the Figure. Surprisingly, adenine *N*¹-oxide had undergone acid-promoted degradation to 4-aminoimidazole-5-carboxamide oxime with the expulsion of C(2) as formic acid, followed by rotation about the C(5)-C(6) bond (of the *N*-oxide) and co-ordination of the sites N(1) and N(7) to copper to afford bis-(4-aminoimidazole-5-carboxamide oxime)copper(II) perchlorate. The amino-nitrogen N(3) is not at bonding distance to adjacent copper atoms, while the amino-nitrogen N(6) of adjacent chelates lies in the octahedral positions 3.136 Å on either side of copper. This at most represents only weak interaction with copper. The usual strong Cu-N distances (average 1.969 Å) were found between N(7) and N(1) of ligands related by a centre of inversion, forming distorted square-planar co-ordination around the copper.



SCHEME

Apparently the conditions employed by Weiss and Venner² in the preparation of the complex had caused rearrangement of (I) to (III), and this rearrangement has also been reported by Stevens and Brown.⁴ Thus treatment of compound (I) with 3*N*-HCl at reflux for 10 min gave the oxime quantitatively. A possible mechanism is given in the Scheme. Stevens and Brown⁴ inferred the presence of a hydroxylamino-function in the oxime from colour tests with copper(II) sulphate and iron(III) chloride. Our finding, by X-ray determination, that the chelate with copper involved both oxime and imidazole fragments, raised the question of possible metal participation in the rearrangement, which might be manifest as a lessening of the reversibility of the ring-opening step in the rearrangement, *e.g.*, by chelation of the nascent oxime (see Scheme),

thereby accelerating the rate of formation of the final product.

The rearrangement of compound (I) to (III) in 1N-HCl¹ at steam-bath temperature was complete in *ca.* 25 min. The addition of up to a 20-fold molar excess of CuCl₂ had no noticeable effect on the rate of conversion. Moreover, the rearranged oxime, formed in acid solution in the absence of copper salt, could be rapidly converted into the copper chelate by the addition of a molar amount of CuCl₂. The same compound could be obtained by the addition of the appropriate amount of CuCl₂ to authentic 4-aminoimidazole-5-carboxamide oxime dihydrochloride. The products obtained by these methods were identical (u.v. spectra and physical properties.)

The apparently correct elemental analysis obtained for the chelate postulated by Weiss and Venner² may equally

as well describe the elemental composition corresponding to the dihydrate of the rearranged chelate.

The formation of copper chelates with numerous other purines, as described by Weiss and Venner,² is probably due to the initial rearrangement of these compounds to substituted 4-aminoimidazole-5-carboxamides, as described by Brown.^{4,5} In addition, adenine N¹-oxide itself forms a copper chelate at neutral pH as reported by Perrin.³ The structures of these two classes of metal chelates are currently under investigation in our laboratory.

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