742. *The Preparation of Copper*(II) *Complexes from Optically Active α-Hydroxy-amidines*

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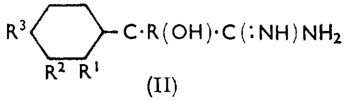
The preparation of a series of copper(II) complexes derived from optically active α-hydroxy-amidines related to lactamidine and mandelamidine is described along with details of their ultraviolet absorption spectra.

Basing their work on an earlier observation by Neilson,[1] Jameson and Gould [2] prepared and studied a series of transition-metal complexes of the (±)-α-hydroxy-amidines (Ia—c) related to mandelamidine.

$Ph{\cdot}CR(OH)C(:NH)NH_2$ (Ia; R = H: b; R = Me: c; R = Et)

In the case of the copper(II) complexes, chemical analysis pointed to a structure (amidine)$_2$Cu,2H$_2$O, copper having replaced the hydrogen of the hydroxyl group. However, the chelate of compound (Ia) and to a lesser extent that of compound (Ib) lost water of crystallisation on keeping or warming. The molecular structure of the copper(II) complex of compound (Ic) was later confirmed by Iball and Morgan [3] using *X*-ray analysis, as was that derived from *o*-chloromandelamidine (II; $R = R^2 = R^3 = H$, $R^1 = Cl$). The copper complexes of these substances are of interest because of their analogous nature to the complexes of the α-amino-acids, the O and NH functions having been interchanged in the parent ligands. As the copper complexes of optically active α-amino-acids [4] and also the copper salts of α-hydroxy-acids [5] have been used to correlate configurations of their parent ligands by means of optical rotatory dispersion (o.r.d.) measurements in the visible region, it was thought that similar work on the complexes of optically active α-hydroxy-amidines would repay investigation. This Paper describes the preparation of complexes derived from optically active substituted mandelamidines (II) and lactamidines (III) and (IV); the o.r.d. results are reported separately.[6]



(II)

$Me{\cdot}CH(OH)C(:NH)NH_2$ (III)

$Ph{\cdot}CH_2{\cdot}CMe(OH){\cdot}C(:NH)NH_2$ (IV)

All the complexes were obtained as violet-blue solids with the exception of that from (+)-lactamidinium chloride (III). This complex was not obtained solid but appeared to be stable in ethanol containing a trace of sodium hydroxide solution. This behaviour

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[1] R. O. Gould, R. F. Jameson, and D. G. Neilson, *Proc. Chem. Soc.*, 1960, 314.
[2] R. O. Gould and R. F. Jameson, *J.*, 1963, 15.
[3] J. Iball and C. Morgan, *Nature*, 1964, **202**, 689.
[4] P. Pfeiffer and W. Christeleit, *Z. physiol. Chem.*, (*a*) 1937, **245**, 197; (*b*) 1937, **247**, 262.
[5] P. Karrer and J. Heyer, *Helv. Chim. Acta*, 1937, **20**, 407.
[6] T. R. Emerson, D. F. Ewing, W. Klyne, D. G. Neilson, D. A. V. Peters, L. H. Roach, and R. J. Swan, following Paper.

is somewhat similar to that of the copper(II) complex of lactic acid which dissociated in dilute solution.[4b] Analysis of the solid complexes pointed in general to a formula $(\text{amidine})_2\text{Cu},2\text{H}_2\text{O}$ in good agreement with Jameson and Gould's [2] findings, but the copper complex from (—)-mandelamidinium chloride appeared to lose water readily and analysis pointed to a formula between $(\text{amidine})_2\text{Cu}$ and $(\text{amidine})_2\text{Cu},2\text{H}_2\text{O}$.

The spectra of the copper(II) complexes in methanol showed in each case a single broad absorption band with asymmetric contour in the visible region, with $\lambda_{\text{max.}}$ lying between 575 and 595 mμ and with ε 30—50. O.r.d. measurements have since shown this band to be an optically active one associated with a Cotton effect, the sign of which is diagnostic of the configuration of the parent ligand.[6] The more intense band at 260—270 mμ is complex in nature. When a phenyl group or more especially in alkoxy-phenyl group is present, strong absorption due to the parent ligand in this region occurs,[6] but in addition the presence of extrema in the 250—270 mμ region of the o.r.d. curves for the copper(II) complexes of mandelamidines, which do not appear to be present in the o.r.d. curves of the parent halogen-substituted mandelamidinium chlorides, or are of the opposite sign to those observed in this region with alkoxy-substituted mandelamidinium chlorides,[6] points to the fact that this band involves not only the aromatic absorption but also charge transfer involving the copper atom.

EXPERIMENTAL

All specific rotations of the copper complexes were measured at 5461 Å in a 1-dm. tube using concentrations of *ca.* 0·1 g./100 ml. of methanol within the temperature range 18—20°. The specific rotations of the amidinium chlorides were measured in water at the same wavelength.

Copper(II) *Complexes.—Method A.* (—)-Mandelamidinium chloride (0·5 g.), [α] −80·4° (lit.,[7] [α] −90°) in water (30 ml.) was added to copper sulphate pentahydrate (0·5 g.) in water (40 ml.), and dilute sodium hydroxide solution (4N) added slowly until the solution became dark blue. The solution was then filtered to remove insoluble hydroxides and set aside to crystallise in an ice-chest. Blue-violet crystals of the *complex*, m. p. 189—190° (decomp.), [α] −350°, which readily lost water on standing, were deposited in low yield [Found: C, 51·3; H, 5·4. $(\text{C}_8\text{H}_9\text{N}_2\text{O})_2\text{Cu},2\text{H}_2\text{O}$ requires C, 48·3; H, 5·5 and $(\text{C}_8\text{H}_9\text{N}_2\text{O})_2\text{Cu}$ requires C, 53·0; H, 5·0%].

Similarly, the *complex* from (—)-atrolactamidinium chloride, [α] −45·6° (lit.,[8] [α] −55·6°) had m. p. 194—196° (decomp.), [α] −73·9° [Found: C, 50·1; H, 5·9; N, 13·1. $(\text{C}_9\text{H}_{11}\text{N}_2\text{O})_2\text{Cu},2\text{H}_2\text{O}$ requires C, 50·7; H, 6·1; N, 13·1%], and the *complex* from (—)-α-hydroxy-α-phenylbutyramidinium chloride, [α] −43·5° (lit.,[9] [α] −49·0°), had m. p. 184—185° (decomp.), [α] −219·7° [Found: C, 52·2; H, 6·2; N, 12·4. $(\text{C}_{10}\text{H}_{13}\text{N}_2\text{O})_2\text{Cu},2\text{H}_2\text{O}$ requires C, 52·9; H, 6·6; N, 12·4%].

Method B. A solution of (±)-2-chloromandelamidinium chloride (V) (1 g.) in ethanol (40 ml.) was treated with a solution of copper sulphate pentahydrate (0·6 g.) in water (30 ml.) and dilute sodium hydroxide solution (4N) added. Solid which deposited after 24 hr. at 0° was dissolved in ethanol. This solution was then filtered and an equal volume of water added. Solid which deposited after 24 hr. at 0° was treated twice more in the same way yielding finally the (±)-*complex*, m. p. 169—170° (decomp.) [Found: C, 41·3; H, 4·4. $(\text{C}_8\text{H}_8\text{ClN}_2\text{O})_2\text{Cu},2\text{H}_2\text{O}$ requires C, 41·2; H, 4·3%]. Similarly, the *complex* from (—)-(V), [α] −54·1° (lit.,[10] [α] −54·1°), had m. p. 151—152° (decomp.), [α] ~0·0° (Found: C, 41·3; H, 4·3%); the *complex* from (+)-2-bromomandelamidinium chloride, [α] +41·6° (lit.,[10] [α] +41·6°), had m. p. 159—160° (decomp.) [Found: C, 34·5; H, 3·8. $(\text{C}_8\text{H}_8\text{BrN}_2\text{O})_2\text{Cu},2\text{H}_2\text{O}$ requires C, 34·5; H, 3·6%], and the *complex* from (—)-2-ethoxymandelamidinium chloride, [α] −103·3° (lit.,[11] [α] −107·5°), had m. p. 168—169° (decomp.) [Found: C, 48·6; H, 5·8. $(\text{C}_{10}\text{H}_{13}\text{N}_2\text{O}_2)_2\text{Cu},2\text{H}_2\text{O}$ requires C, 49·3; H, 6·2%].

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[7] P. Bellingham, D. A. V. Peters, and D. G. Neilson, *J.*, 1964, 2118.

[8] R. Roger and D. G. Neilson, *J.*, 1959, 688.

[9] R. Roger and D. G. Neilson, *J.*, 1961, 3181.

[10] D. G. Neilson and L. H. Roach, *J.*, 1965, 1658.

[11] D. G. Neilson and D. A. V. Peters, *J.*, 1963, 4455.

Method C. (+)-2·4-Dichloromandelamidinium chloride (0·2 g.), [α] +37·4° (lit.,[10] [α] +50·0°) in ethanol (15 ml.) was added to cupric sulphate pentahydrate (0·13 g.) dissolved in water (20 ml.) and sodium hydroxide solution (4N) added until the solution became dark blue. Any initial precipitate was filtered off and the resultant solution evaporated to dryness *in vacuo* at 5°. The blue solid was washed with water and acetone and then dissolved in ethanol, filtered, and again evaporated to dryness. This process was repeated and finally the solid was dissolved in ethanol (10 ml.), and water (10 ml.) added. After 48 hr. at 0° a *complex*, m. p. 168—169° (decomp.), was obtained [Found: C, 35·9; H, 3·5. $(C_8H_7Cl_2N_2O)_2Cu,2H_2O$ requires C, 35·8; H, 3·4%].

Similarly, the *complex* from (−)-3-ethoxymandelamidinium chloride, [α] −80·5° (lit.,[11] [α] −84·3°), had m. p. 158—159° (decomp.) [Found: C, 48·6; H, 6·7. $(C_{10}H_{13}N_2O_2)_2Cu,2H_2O$ requires C, 49·4; H, 6·2%]; the *complex* from (+)-4-methoxymandelamidinium chloride, [α] +87·8° (lit.,[11] [α] +87·8°), had m. p. 160—161° (decomp.) [Found: C, 47·5; H, 6·0. $(C_9H_{11}N_2O_2)_2Cu,2H_2O$ requires C, 47·2; H, 5·7%]; and the *complex* from (−)-α-benzyl-lactamidinium chloride, [α] −50·5° (lit.,[12] [α] −50·9°), had m. p. 190—191° (decomp.) [Found: C, 53·1; H, 6·7. $(C_{10}H_{13}N_2O)_2Cu,2H_2O$ requires C, 52·9; H, 6·7%]. Complexes from (+)-4-ethoxymandelamidinium chloride, [α] +59·2° (lit.,[11] [α] +59·2°), and from (−)-2-methoxymandelamidinium chloride, [α] −104·0° (lit.,[11] [α] −106·5°), had m. p.s 184—185 and 153—154° (decomp.), respectively, but the smallness of the samples preclined analysis or purification.

Copper(II) *Complex from* (+)-*Lactamidinium Chloride* (III).—(+)-(III), [α] +15·4° (lit.,[13] [α] +16·8°) (0·2 g.), and cupric sulphate pentahydrate (0·2 g.) in ethanol–water were basified with sodium hydroxide solution. No solid resulted, but the complex appeared to be reasonably stable in ethanol containing alkali, as the blue colour of the complex persisted.

Ultraviolet Spectra of the Copper(II) *Complexes.*—These spectra were measured in methanol solution on an Optica CF4R spectrophotometer.

Ultraviolet spectra of copper(II) complexes

Amidine (II)							
R	R^1	R^2	R^3	$\lambda_{max.}$ (mμ)	log ε	$\lambda_{max.}$ (mμ)	log ε
H	H	H	H	260·5	3·61	575—585	1·50
Me	H	H	H	251·5	3·70	575—585	1·47
H	Cl	H	H	266·0	3·77	580—590	1·62
H	Br	H	H	266·0	3·79	570—590	1·58
H	Cl	H	Cl	263·0	3·85	585—595	1·61
H	EtO	H	H	270·0	3·81	580—590	1·61
H	H	EtO	H	277·0	3·91	580—590	1·61
H	H	H	EtO	270·0	3·72	585—595	1·69
		(IV)		260·0	3·49	580—590	1·62

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[12] D. F. Ewing and D. G. Neilson, *J.*, 1965, 770.

[13] D. G. Neilson and D. A. V. Peters, *J.*, 1962, 1309.