The Synthesis of *cis,cis*-1,3,5-Triaminocyclohexane-*NN'N''*-triacetic Acid and Its Cobalt(III) Complex

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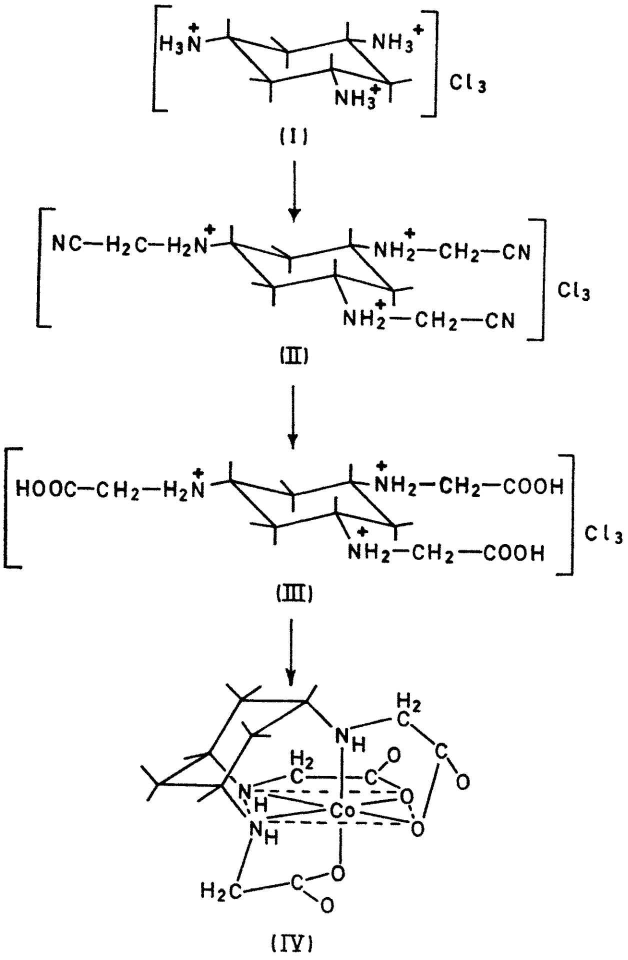
Summary The synthesis of a new stereospecific amino-acid *cis,cis*-1,3,5-triaminocyclohexane-*NN'N''*-triacetic acid and its cobalt(III) complex are reported.

cis,cis-1,3,5-TRIAMINOCYCLOHEXANE (*cis,cis*-tach) has recently been synthesized in good isomeric purity.[1,2] The restrictive tridentate stereochemistry of *cis,cis*-tach in metal complexes was previously demonstrated by i.r.[3] and electronic[1b] spectral studies. Equilibrium studies[4] confirmed the uniquely tridentate property of the ligand when no evidence of protonated metal–ligand species was found. The synthesis of a stereoselective amino-acid derivative of *cis,cis*-tach, *cis,cis*-1,3,5-triaminocyclohexane-*NN'N''*-triacetic acid (*cis,cis*-tachta) is now reported.

A reaction mixture consisting of *cis,cis*-tach,$3HCl,H_2O$ (I) and sodium cyanide in 37% formalin was diluted with methanol and saturated with HCl gas. Crystals of *cis,cis*-1,3,5-triaminocyclohexane-*NN'N''*-triacetonitrile trihydrochloride monohydrate (II) immediately precipitated. Hydrolysis of the nitrile in constant-boiling HCl gave *cis,cis*-tachta,3HCl,$2H_2O$ (III), m.p. 186° (dec).



The i.r. spectrum of *cis,cis*-tachta, 3HCl,$2H_2O$ shows a band at 1740 cm^{-1} (sharp doublet) which is assigned to un-ionized carboxylate.[5] The high-field portion of the n.m.r. spectrum is consistent with those of other *cis,cis*-1,3,5-substituted cyclohexane derivatives[6,7] and exhibits a splitting pattern nearly identical with that of *cis,cis*-tach,3HCl,H_2O.[1a] The spectra of *cis,cis*-tachta,3HCl,$2H_2O$ and *cis,cis*-tach, 3HCl,H_2O are compared in the Table.

TABLE

Assignment	*cis,cis*-tach,3HCl,H_2O[a]	*cis,cis*-tachta,3HCl,$2H_2O$
Axial methylene H ..	δ 1·99 (q)	δ 2·33 (q)
Equitorial methylene H ..	δ 2·82 (d)	δ 3·24 (d)
Methine H	δ 3·86 (t)	δ 4·11(t)
Methylene (glycyl)H	—	δ 4·63(s)

Solvent D_2O, external capillary (Si_4Me)

[a] The chemical shifts reported for *cis,cis*-tach,3HCl,H_2O are *ca.* 0·23 δ upfield from those reported by Wentworth and Felton.[1a] The first-order coupling constants which they report, however, are in agreement with those obtained in this study.

The cobalt(III) complex of *cis,cis*-tachta (IV) was prepared from the amino-acid hydrochloride and sodium tris(carbinato)cobaltate(III). The electronic spectrum of the red Co(tachta),1·$5H_2O$ exhibits two symmetrical absorption maxima at 368 (ε 148) and 512 nm (ε 193) and is quite similar to that of the β (facial-*N*) isomer of tris(glycinato)cobalt(III).[8] The i.r. spectrum of Co(tachta),1·$5H_2O$ shows a single absorption at 1639 cm^{-1}, nearly the same frequency reported for the antisymmetric carboxylate stretching in β-tris(glycinato)cobalt(III).[9] It appears that all six donor groups of the ligand are co-ordinated to the central cobalt(III) ion.

The results of Gillum, Wentworth, and Childers[10] indicate an octahedral rather than trigonal-prismatic co-ordination in the present case. Further, we feel that the ligand here has sufficiently different π-electronic structure and is not so sterically constraining as in the case of certain Schiff base derivatives of *cis,cis*-tach[11] and similar ligands[12] where trigonal-prismatic co-ordination can be imposed. An octahedral coordination implies the existence of two optical isomers. These would have opposite chirality along the C_3 axis.

(*Received, November 5th,* 1970; *Com.* 1935.)

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[1] (a) R. A. D. Wentworth and J. J. Felten, *J. Amer. Chem. Soc.*, 1968, **90**, 621; (b) R. A. D. Wentworth, *Inorg. Chem.*, 1968, **7**, 1030.
[2] H. Stetter, D. Theisen, and G. J. Steffens, *Chem. Ber.*, 1970, **103**, 200.
[3] F. L. Urbach, J. E. Sarneski, L. J. Turner, and D. H. Busch, *Inorg. Chem.*, 1968, **7**, 2169.
[4] R. F. Childers, R. A. D. Wentworth, and L. J. Zompa, *Inorg. Chem.*, in the press.
[5] K. Nakamoto, "Infrared Spectra of Inorganic and Co-ordination Compounds," Wiley, New York, 1963, p. 206.
[6] A. Segre, *Tetrahedron Letters*, **1964**, 1001.
[7] A. Segre and J. I. Musher, *J. Amer. Chem. Soc.*, 1967, **89**, 706.
[8] F. Basolo, C. Ballhausen, and J. Bjerrum, *Acta Chem. Scand.*, 1955, **9**, 810.
[9] K. Nakamoto, Y. Morimoto, and A. E. Martell, *J. Amer. Chem. Soc.*, 1961, **83**, 4528.
[10] W. O. Gillum, R. A. D. Wentworth, and R. F. Childers, *Inorg. Chem.*, 1970, **9**, 1825.
[11] W. O. Gillum, J. C. Hoffman, W. E. Streib, and R. A. D. Wentworth, *Chem. Comm.*, 1969, 843.
[12] E. B. Fleischer, A. E. Gebala, and P. A. Tasker, *J. Amer. Chem. Soc.*, 1970, **92**, 6365.