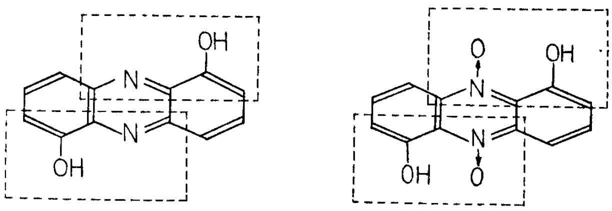
UDC 547.864.6—156 : 541.486 : 541.651

113. Yoshinori Kidani: Studies on Metal Chelate Compounds of Phenazine Derivatives. II.* Spectrophotometric Studies on Copper Chelate Compounds of 1,6-Dihydroxyphenazine and its Di-N-oxide, Iodinin.

(*International Christian University***)

In the preceding report, it has been shown that 1-hydroxyphenazine and its di-N-oxide, which have one oxine-like functional group, a hydroxyl group *peri* to the ring-nitrogen, respectively form five- and six-membered chelate ring.

In this paper, copper chelates of 1,6-dihydroxyphenazine and its di-N-oxide are described. They possess two oxine-like functional groups and spectrophotometry was carried out under conditions similar to that described in Part I.



Experimental

Apparatus and materials, as well as the procedures, were described in the preceding report.*

Preparation of 1,6-dihydroxyphenazine and its di-N-oxide in EtOH—A $1\times10^{-4}M$ solution was prepared by dissolving 2.12 mg. of 1,6-dihydroxyphenazine or 2.44 mg. of iodinin in 100 cc. of dehyd. EtOH.

Results

I. 1,6-Dihydroxyphenazine-Copper Chelate Compound

1) Absorption Spectra—Absorption curves in a 1×10^{-4} M solution measured at a different pH of 4.5, 8.0, and 9.5 are shown in Fig. 1. The curves of reagent in both acidic and neutral media are nearly the same. In alkaline solution, however, the curve is different from the former two. The first absorption region which is typical in chelate chemistry appears at 700 mμ in acidic and alkaline solutions and at 710 mμ in neutral solution.

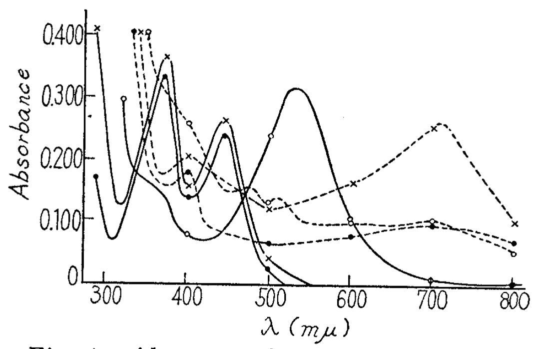


Fig. 1. Absorption Spectra of 1,6-Dihydroxyphenazine-Copper Chelate
(The solution contains $1\times10^{-4}M$ 1,6-dihydroxyphenazine)

	Reag.	Complex
pH 4.5	—•—	--•--
pH 8.0	—×—	--×--
pH 9.5	—∘—	--∘--

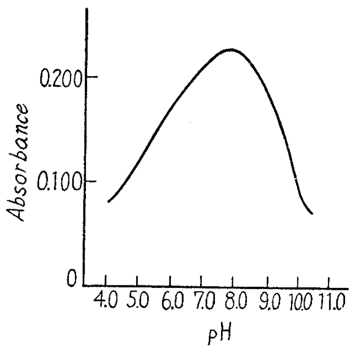


Fig. 2. Effect of pH Change on 1,6-Dihydroxyphenazine-Copper Chelate
(Measured at 650 mμ. The solution contains $1\times10^{-4}M$ 1,6-dihydroxyphenazine)

* Part I: This Bulletin, **6**, 556(1958).

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2) Effect of pH Change—The absorption of the copper chelate solution containing 1×10^{-4} *M* of 1, 6-dihydroxyphenazine in various pH is shown in Fig. 2, measured at 650 mμ. The solution of the chelate shows the maximum absorption at a pH of about 8.0 and decreases markedly in intensity if the pH is increased or decreased.

3) Composition of Chelate in Solution—As to the composition of this chelate compound, the molar ratio of 1, 6-dihydroxyphenazine to copper is reported to be 1:1 in normal complex, from elemental analysis.[1] The chelate compound was obtained in an amorphous form and not in a crystalline form, as revealed by X-Ray and electromicroscopic observations. From this fact, Kanda, *et al.*[2] proposed the possibility of an ultra-polynuclear complex.

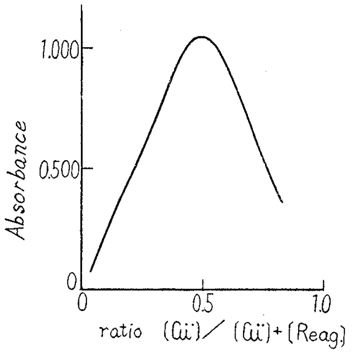

Fig. 3. Absorption Curve of 1, 6-Dihydroxyphenazine-Copper Chelate (Job Method) (Measured at 650mμ and at pH 8.0. Total concentration is 2×10^{-4}*M*)

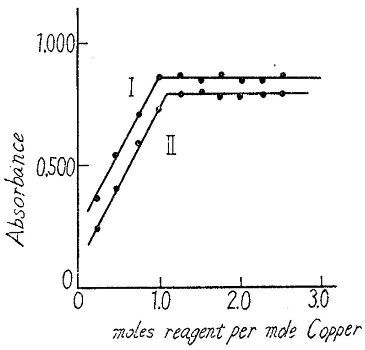

Fig. 4. Absorption Curves of 1,6-Dihydroxyphenazine-Copper Chelate (Molar Ratio Method) (Measured at 710 mμ (I), and at 650 mμ (II), at pH 8.0. The concentration of copper is 1×10^{-4}*M*)

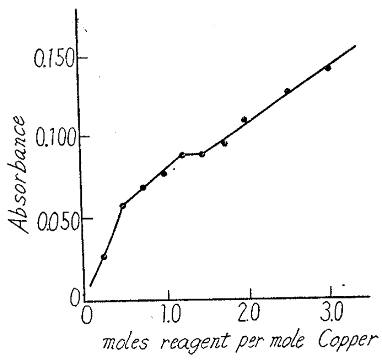

Fig. 5. Absorption Curve of 1,6-Dihydroxyphenazine-Copper Chelate (Molar Ratio Method) (Measured at 440 mμ and at pH 6.5. The concentration of copper is 1×10^{-4}*M*)

The composition of the chelate in solution was measured by the following two methods:

(i) Job's Continuous Variation Method: As is shown in Fig. 3, the composition of the chelate in solution was determined as 1:1 (Reag.:Cu) at 650 mμ, at pH 8.0.

(ii) Molar Ratio Method: Under similar conditions, at pH 8.0, and at both 650 mμ and 710 mμ, the composition of this chelate compound measured was found to be 1:1 (Fig. 4). When the measurement was carried out in an acidic EtOH solution, at pH 6.5, two sharp breaks were observed at a wave length of 440 mμ, as shown in Fig. 5. This fact seems to suggest the formation of a cation complex 2:1 (Cu:Reag.), besides the normal complex, which was also observed in the case of 1-hydroxyphenazine in acidic medium.

II. 1, 6-Dihydroxyphenazine Di-N-oxide-Copper Chelate Compound (Iodinin)

1) Absorption Spectra—Absorption of reagent and respective chelate in three kinds of medium, i.e. acidic (pH 4.5), neutral (pH 8.0), and alkaline (pH 9.5), are shown in Fig. 6. Absorption maximum of the chelate appeared at 670 mμ in acidic and at 700 mμ in neutral solution.

2) Effect of pH Change—The solution of the chelate shows maximum absorption at pH 8.0~9.0 and decreases markedly in intensity if the pH is increased or decreased, as shown by the curves in Fig. 7, measured at both 760 and 620 mμ.

3) Composition of the Chelate in Solution—(i) Job's Continuous Variation Method: At the wave length of 760 mμ, the 1:1 molar ratio of normal complex was observed at pH 9.0, and the 1:2 molar ratio of cation complex, at pH 5.0 (Fig. 8).

1) I. Murase: Research Rept., Dept. Chem., Kyushu Univ., **1**, 225 (1953).
2) S. Kanda, K. Nakatsu, Y. Saito: Paper presented at the Symposium on Complex Chemistry, October, 1956.

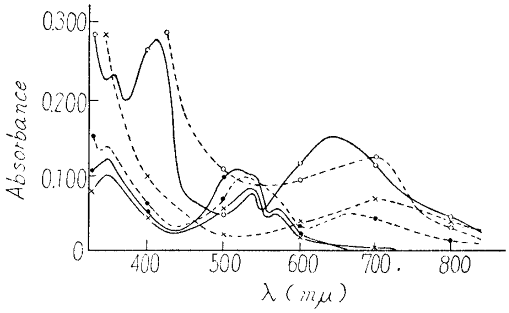

Fig. 6. Absorption Spectra of 1,6-Dihydroxyphenazine Di-N-oxide-Copper Chelate

(The solution contains $1\times10^{-4}M$ of 1,6-dihydroxyphenazine di-N-oxide)

	Reag.	Complex
pH 4.5	—•—	--•--
pH 8.0	—×—	--×--
pH 9.5	—∘—	--∘--

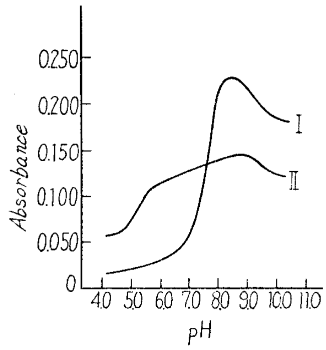

Fig. 7. Effect of pH Change on 1,6-Dihydroxyphenazine Di-N-oxide-Copper Chelate

(Measured at 760 mμ (I) and 620 mμ (II). The solution contains 5×10^{-4} M of 1,6-dihydroxyphenazine di-N-oxide)

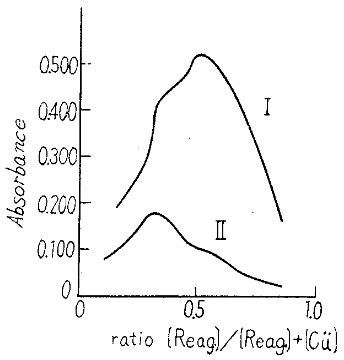

Fig. 8. Job Method
Absorption Curves of 1,6-Dihydroxyphenazine Di-N-oxide-Copper Chelate

(Measured at 760 mμ, at a pH of 9.0 (I), and at 620 mμ, at a pH of 5.0 (II). Total concentration is $5\times10^{-5}M$.)

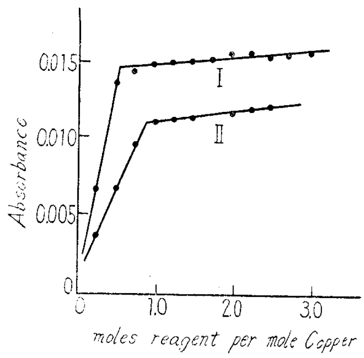

Fig. 9. Molar Ratio Method
Absorption Curves of 1,6-Dihydroxyphenazine Di-N-oxide-Copper Chelate

(Measured at 760 mμ, at a pH of 9.0 (I), and at 620 mμ, at a pH of 6.0 (II). The concentration of copper is $5\times10^{-5}M$.)

(ii) Molar Ratio Method: Under the same conditions, similar results as shown in Fig. were obtained.

4) **Degree of Dissociation (α) and Dissociation Constants (K) of the Chelate Compounds**—From the experimental data obtained, according to the above (1) and (3), measured by the molar ratio method, the calculated results are tabulated below.

Compound	α	Reag. : Cu	−log K	pH
1,6-Dihydroxyphenazine	0.18	1 : 1	5.41	8.0
1,6-Dihydroxyphenazine	0.06	1 : 1	7.12	9.0
di-N-oxide	0.13	1 : 2	3.57	5.0

5) **Structure of the Chelate**—As 1,6-dihydroxyphenazine contains two oxine-like functional groups, it probably forms a five-membered chelate ring in neutral solution. Iodinin-copper chelate, same as 1-hydroxyphenazine di-N-oxide, would form a six-membered chelate ring. In neutral medium, it forms a normal complex of 1 : 1, while the molar ratio was measured as 1 : 2 (Reag. : Cu) in an acidic medium. The normal complex exists as an ultrapolynuclear chelates which may be represented as in Chart 1.

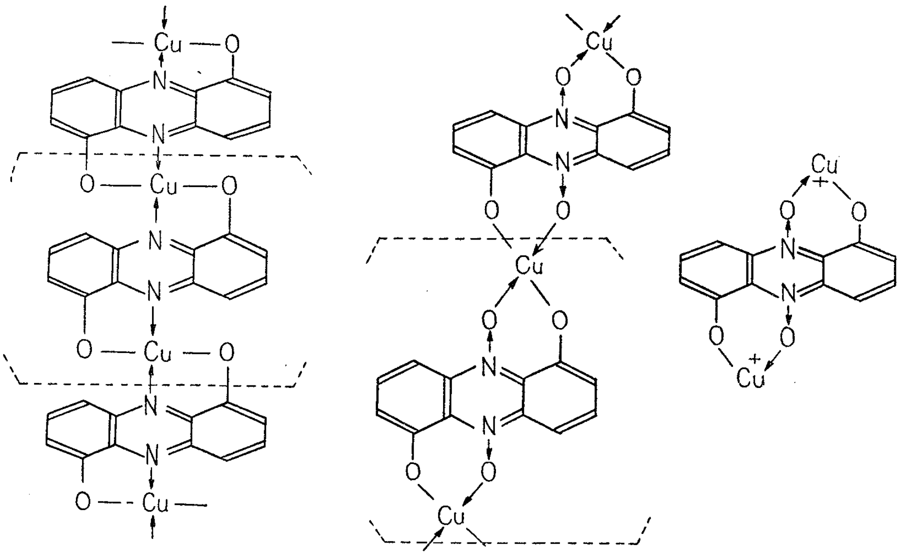

Chart. 1.

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Summary

Copper chelates of 1, 6-dihydroxyphenazine and its di-N-oxide, which possess two functional groups, were examined by spectrophotometric method concerning their properties and compositions in solution, as well as their dissociation constants. 1, 6-Dihydroxyphenazine forms a five-membered chelate ring, indicating the molar ratio of 1:1, a normal complex. The N-oxide derivative also form a chelate with molar ratio of 1:1, forming a six-membered chelate ring.

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114. **Hirotaka Otomasu and Shoichi Nakajima**: On the Nitration of Quinoxalines.

(*Hoshi College of Pharmacy**)

Some reports on substitution reaction of quinoxalines with nucleophilic reagents have appeared but not those dealing with electrophilic reagents. In a series of earlier papers,[1] one of the authors (H. O.) established the nitro substitution reaction of phenazine and its derivatives. In this connection, nitration reaction of quinoxaline compounds, structurally related to phenazines, was examined in order to find the reaction mechanism of electrophilic reagents, and some experimental results obtained are reported in this paper.

Generally speaking, the present series of experiments on quinoxaline derivatives has proved that the derivatives are quite stable to nitration and only a few of them could be nitrated.

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1) H. Otomasu: This Bulletin, **2**, 283(1954); **4**, 117(1956); **6**, 77(1958).