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Syntheses of 1,ω-Bis(5-ethyl-8-hydroxy-7-quinolyl)alkanes and Their Copper(II) Complexes

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It is of interest to synthesize compounds in which two molecules of 8-quinolinol are connected by a polymethylene bridge in their 7-positions, and also to examine their complexes as formed with metal ions, because the structure of the complex is expected to be one of three types: mono-, di-, or poly-nuclear metal complexes—that is, A, B, and C in Fig. 1, depending on the chain length of the polymethylene bridge.

The synthetic routes are shown in Scheme 1. The III_n compounds (n=6, 8, and 10) were synthesized by the Friedel-Crafts acylation of 5-ethyl-8-quinolinol[3] with polymethylenedicarbonyl chlorides of different chain lengths. In order to cause the acylation exclusively at the 7-position, the 5-position of 8-quinolinol was blocked by an ethyl group. The IV_n compounds were obtained by the Huang-Minlon modification of the Wolff-Kischner reduction of the corresponding III_n compounds. The copper(II) complexes were obtained by the addition of an ethanolic solution of copper(II) acetate monohydrate to a solution of the corresponding IV_n compounds in ethanol (n=6 and 10) or dioxane (n=8).

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[3] K. W. Rosenmund and G. Kerst, *Arch. Pharm.*, **279**, 154 (1941).

Table 1.

Comp[a)]	Cryst. form[b)]	Cryst. Solv.[b)]	Mp (°C)	Analyses, % Found C	H	N	Cu	Calcd C	H	N	Cu	Yield %
III_6	py. n	CH_2Cl_2	219.0—219.5	73.62	6.37	5.94		73.66	6.18	6.14		69
III_8	w. n	THF	184.6—185.2	74.26	6.63	5.61		74.35	6.66	5.78		69.4
III_{10}	py. c	C_2H_5OH	136.0—136.5	75.14	7.21	5.35		74.97	7.08	5.46		70
IV_6	w. n	C_6H_6	174.0—174.6	77.82	7.09	6.81		77.97	7.05	7.00		69
IV_8	w. c	$CHCl_3$	158.0—158.4	79.18	8.02	5.92		78.91	7.95	6.14		35.4
IV_{10}	w. c	C_2H_5OH	103.8—104.5	79.52	8.23	5.51		79.30	8.32	5.78		66
IV_6-Cu[c)]	rb. l			68.09	6.47	5.26	12.38	68.61	6.17	5.26	12.96	63
IV_8-Cu	or. p			69.69	6.67	5.16	12.04	69.54	6.61	5.40	12.26	43.2
IV_{10}-Cu	or. p			69.96	7.00	5.06	12.09	69.85	6.96	5.09	11.54	60.3

a) Percentages were calculated according to the formula. III_6: $C_{28}H_{28}N_2O_4$, III_8: $C_{30}H_{32}N_2O_4$, III_{10}: $C_{32}H_{36}N_2O_4$, IV_{16}: $C_{28}H_{32}N_2O_2$, IV_8: $C_{30}H_{36}N_2O_2$, IV_{10}: $C_{32}H_{40}N_2O_2$,, IV_6-Cu: $C_{28}H_{30}N_2O_2Cu$, IV_8-Cu: $C_{30}H_{34}N_2O_2Cu$, IV_{10}-Cu: $C_{32}H_{38}N_2O_2Cu$.

b) c; crystals. l,; leaflets. n; needles. or: ;orange. p; powder. py; pale yellow. rb; reddish brown. THF; tetrahydrofuran. w; white.

c) Anal; mol wt, 985 in $CHCl_3$. Calcd for $C_{56}H_{60}N_4O_4Cu_2$ as B in Fig. 1; mol wt, 980.18.

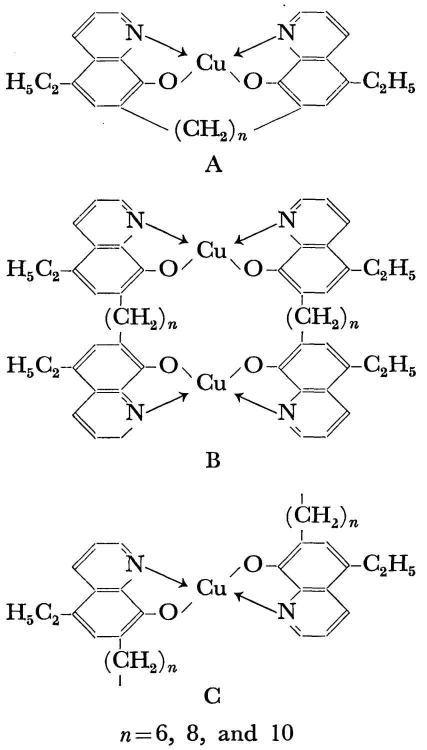
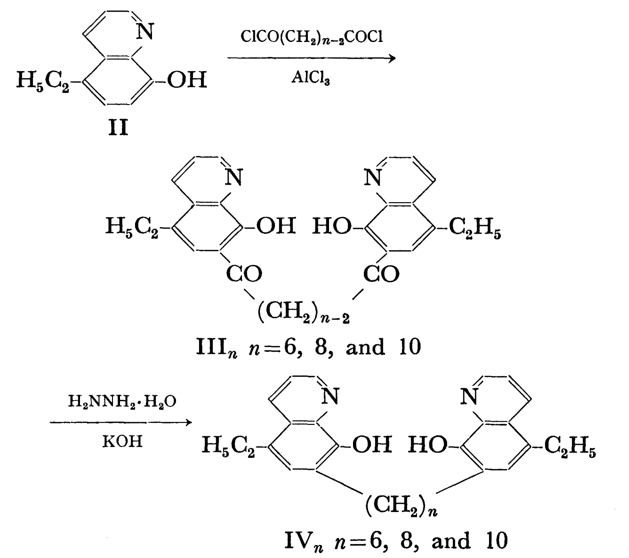


Fig. 1



Scheme 1.

The physical properties and analytical data are shown in Table 1. The results of the molecular-weight determination indicate that the benzene-soluble copper(II) complex of the IV_6 compound is dimeric. For the copper(II) complexes of the IV_8 and IV_{10} compounds, the molecular weight could not be determined owing to the extremely low solubility in the solvents suitable for molecular weight determination. Bis(5-ethyl-8-quinolinolato)copper(II) is considered to have a *trans*-planar configuration, as does the well-known bis(8-quinolinolato)copper(II),[4)] and to have an absorption maximum at 693 mμ in chloroform, as is shown in Table 2. The copper(II) complexes of the IV_8 and IV_{10} compounds also showed an absorption maximum at a similar position. Therefore, these complexes are inferred to have probably a polymeric, *trans*-planar structure either C in Fig. 1 or a similar structure. In the case of the copper(II) complex of the IV_6 compound, however, the absorption maximum is slightly different from those of the complexes of 5-ethyl-8-quinolinol as well as those of the IV_8 and IV_{10} compounds. From

Table 2. Absorption maxima of copper(II) complexes of II, IV_6, IV_8, and IV_{10} in chloroform

	λ_{max}	ε_{max}
II-Cu	693	52
IV_6-Cu	715	46
IV_8-Cu	690	a)
IV_{10}-Cu	690	a)

a) Accurate measurements of extinction coefficients could not be obtained in chloroform, owing to extremely low solubility of the compounds in this solvents.

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4) R. C. Hoy and R. H. Morris, *Acta Crystallogr.*, **22**, 476 (1967).

the fact that the absorption maximum differed from those of the *trans*-structure and the fact that the molecular weight coincided with that of the dimer, as has been described above, the benzene-soluble copper(II) complex of the IV_6 compound may be concluded probably to have such a dinuclear *cis*- or near-*cis*-structure as B in Fig. 1.

Experimental

The melting points are uncorrected. The infrared spectra were obtained on a Hitachi EPI-S2 spectrophotometer in a KBr disk. The electronic spectra were measured in chloroform on a Hitachi EPI-3T spectrophotometer. The molecular weight was determined on a Hitachi Perkin-Elmer molecular-weight-determination apparatus, using benzene as the solvent.

1,6-Bis(5-ethyl-8-hydroxy-7-quinolyl)hexane-1,6-dione. III_6. To a stirred solution of 5-ethyl-8-quinolinol[3] (5 g) in tetrachloroethane (140 m*l*), adipyl chloride (2 g) was added. The then separated yellow precipitate was dissolved during the portion-by-portion addition of anhydrous aluminum chloride (15.5 g). The resulting yellow solution was kept at about 70°C for 15 hr to separate a green precipitate. After being cooled, the mixture was poured onto ice to precipitate hydrochloride of the III_6 compound, which was collected, washed with benzene, and boiled with water to change it into the corresponding free base. The base was then crystallized to give pale yellow needles by extraction with methylene chloride using a Soxhlet extractor. $\nu_{C=O}$, 1628 cm^{-1}.

1,8-Bis(5-ethyl-8-hydroxy-7-quinolyl)octane-1,8-dione. III_8. A mixture of 15 g of 5-ethyl-8-quinolinol, 9 g of suberyl chloride, 33 g of anhydrous aluminum chloride, and 150 m*l* of tetrachloroethane was heated at 65—68°C for 15 hr. The reaction mixture was poured onto crushed ice. The tetrachloroethane was removed by steam distillation. A precipitate of III_8 hydrochloride was filtered and suspended in water. The free base, III_8, was obtained by the neutralization of III_8 hydrochloride with sodium hydroxide. $\nu_{C=O}$, 1658 cm^{-1}.

1,10-Bis(5-ethyl-8-hydroxy-7-quinolyl)decane-1,10-dione. III_{10}. A mixture of 10 g of 5-ethyl-8-quinolinol, 6.8 g of sebacyl chloride, 31.5 g of anhydrous aluminum chloride, and 120 m*l* of tetrachloroethane was heated at 65—70°C for 20 hr. After the subsequent removal of the tetrachloroethane by steam distillation, a separated precipitate of the III_{10} hydrochloride was filtered and then suspended in water. The free base, III_{10}, was obtained by the neutralization of the III_{10} hydrochloride with sodium hydroxide. $\nu_{C=O}$, 1662 cm^{-1}.

1,6-Bis(5-ethyl-8-hydroxy-7-quinolyl)hexane. IV_6. A mixture of the III_6 compound (2 g), hydrazine hydrate (20 m*l*), and potassium hydroxide (15 g) in triethylene glycol (75 m*l*) was heated at 200—220°C for 1 hr until gas evolution ceased. The resulting red solution was poured into water and neutralized with hydrochloric acid to give a yellow precipitate, which was then collected and dried. The crude product was dissolved in benzene and chromatographed on silica gel to afford colorless needles.

1,8-Bis(5-ethyl-8-hydroxy-7-quinolyl)octane. IV_8. A mixture of 1 g of the III_8 diketone, 15 m*l* of hydrazine hydrate, 10 g of potassium hydroxide, and 60 m*l* of diethylene glycol was heated at 200—230°C for 1.5 hr. After being cooled, the reaction mixture was poured into water and then neutralized with hydrochloric acid to give a precipitate. The precipitate was collected by filtration and dried. The crude product was dissolved in chloroform and chromatographed on silica gel to afford colorless crystals.

1,10-Bis(5-ethyl-8-hydroxy-7-quinolyl)decane. IV_{10}. A mixture of 1 g of the III_{10} diketone, 13 m*l* of hydrazine hydrate, 10 g of potassium hydroxide, and 80 m*l* of triethylene glycol was heated at 220°C for 1.5 hr. The crude product was dissolved in benzene and chromatographed on silica gel to afford colorless needles.

Copper(II) Complex of the Compound IV_6. $B(n=6)$. A solution of copper(II) acetate monohydrate (100.8 mg) in ethanol (100 m*l*) was vigorously stirred, drop by drop over a 20 min period, into a warm solution of the IV_6 compound (214 mg) in ethanol (150 m*l*) to give reddish-brown leaflets. About 1 mg of the complex is soluble in 1 m*l* of benzene.

Copper(II) Complex of the Compound IV_8. $B(n=8)$. A solution of 20.1 mg of copper(II) acetate monohydrate in 15 m*l* of ethanol was added to a solution of 45.8 mg of IV_8 in 30 m*l* of dioxane. The solution turned dark yellow, and after it had stand overnight the orange precipitate was separated. It was insoluble in benzene and chloroform.

Copper(II) Complex of the Compound IV_{10}. $B(n=10)$. A solution of 100.7 mg of copper(II) acetate monohydrate in 100 m*l* of ethanol was added, drop by drop to a solution of 21.7 mg of VI_{10} in 150 m*l* of ethanol. The mixture turned yellow and the orange precipitate was separated. It was very slightly soluble in chloroform and soluble in pyridine, but the pyridine solution gave no precipitate when concentrated and cooled.