

## References and Notes

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- We are going to study the reaction of this enolate of amide in near future.

## The Pfeiffer Effect of $[\text{Co}^{\text{II}}(\text{acac})_2(\text{diamine})]$ with Cinchona Alkaloid in Some Organic Solvents

Chang Eon Oh\* and Yang Kim

Department of Chemistry, Yeungnam University, Gyongsan 632. Received June 1, 1988

The Pfeiffer effect was examined on the systems of racemic  $[\text{Co}^{\text{II}}(\text{acac})_2(\text{diamine})]$  with *d*-cinchonine and *l*-cinchonidine as chiral environment substances in methanol, ethanol, chloroform and methanol-chloroform mixture solvents. It was found that the  $\Delta$ -enantiomer is enriched for the  $[\text{Co}^{\text{II}}(\text{acac})_2(\text{diamine})]$ -*d*-cinchonine system, but the *A*-enantiomer is enriched for the  $[\text{Co}^{\text{II}}(\text{acac})_2(\text{diamine})]$ -*l*-cinchonidine system. The complexes having no N-H protons such as  $[\text{Co}^{\text{II}}(\text{acac})_2(\text{bpy})]$  and  $[\text{Co}^{\text{II}}(\text{acac})_2(\text{phen})]$  were Pfeiffer-inactive in alcoholic solvents, where bpy = 2,2'-bipyridine and phen = 1,10-phenanthroline. This was interpreted to mean that the hydrogen bonding between N-H proton of diamine ligand and C-9 hydroxyl group of alkaloid plays an important role in the chiral discrimination. And the rate of antiracemization ( $k_{\text{ant}}$ ) by the Pfeiffer effect was also measured for the  $[\text{Co}^{\text{II}}(\text{acac})_2(\text{diamine})]$ -*d*-cinchonine system in alcoholic solvents. It was found that the rate of appearance of the Pfeiffer effect was enhanced as the concentration of added chloroform is increased.

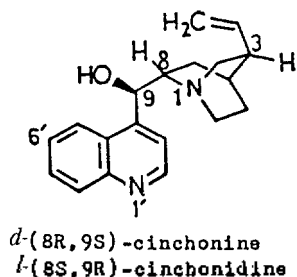
### Introduction

When a racemic mixture of an optically labile dissymmetric complex is mixed in solution containing a certain optically active compound (called an environment substance), an anomalous change in optical activity is developed. This phenomenon is known as the Pfeiffer effect<sup>1,2</sup>, and partial resolution<sup>3,5</sup> of several metal complexes was accomplished by using the Pfeiffer effect. Either the optically active metal complex or chiral organic compound as the environment substance is used in the Pfeiffer effect. A number of the Pfeiffer effect have been reported<sup>6,9</sup> and it has been known that an enantiomerization<sup>10-12</sup> of the complex takes place in favor of either *A*- or  $\Delta$ -enantiomer, depending on the spacial demand of the environment substance. This enantiomerization ("equilibrium shift") is known as a prototype of so-called first order asymmetric transformation. Several investigators have studied the Pfeiffer effect of ionic complexes, and notable works have been accomplished by Miyoshi *et al.*<sup>3,5</sup> and Kirschner *et al.*<sup>2,6,7</sup>, who investigated a through study of the Co(II), Ni(II) and Zn(II) complexes. Nearly all of their works have been concerned with the charged complexes in aqueous solutions. And in most of the Pfeiffer-active systems which have been reported as yet, racemic metal complexes are all ionic and environment substances are electrolytes or nonelectrolytes. However, little is known yet on the Pfeiffer-active system in which racemic complex and environment substance are all neutral molecules. Furthermore, a paucity<sup>13</sup> of the Pfeiffer effect for neutral complexes was only concern-

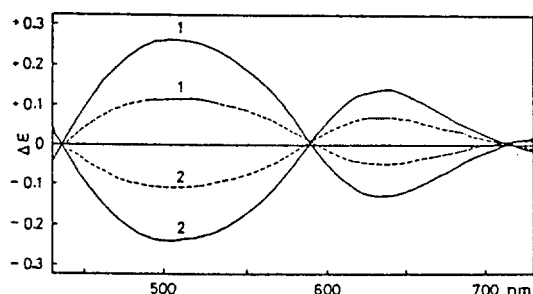
ed with the tris-chelate complexes  $[\text{M}(\text{AA})_3]$ , where AA is dithiophosphate, dithiocarbamate, dithioxanthate, or acetylacetonate, and M is Co(III) or Cr(III). And the Pfeiffer system for the neutral complexes with mixed ligand has not been reported as yet. In this study, in order to investigate the Pfeiffer effect of the neutral complexes with mixed ligand which is expected neither the electrostatic association nor electrostatic repulsion between complex and environment substance, and to elucidate the solvent effect of their Pfeiffer systems, we report the Pfeiffer effect of  $[\text{Co}^{\text{II}}(\text{acac})_2(\text{diamine})]$  complexes with cinchona alkaloid as an environment substance in some organic solvents.

### Experimental

**Preparation of Metal Complexes.** The racemic complexes used in this study are follows:  $[\text{Co}^{\text{II}}(\text{acac})_2(\text{tn})]$ ,  $[\text{Co}^{\text{II}}(\text{acac})_2(\text{N-metn})]$ ,  $[\text{Co}^{\text{II}}(\text{acac})_2(\text{N-meenn})]$ ,  $[\text{Co}^{\text{II}}(\text{acac})_2(\text{N,N'-dmen})]$ ,  $[\text{Co}^{\text{II}}(\text{acac})_2(\text{N,N,N',N'-tmenn})]$ ,  $[\text{Co}^{\text{II}}(\text{acac})_2(\text{amp})]$ ,  $[\text{Co}^{\text{II}}(\text{acac})_2(\text{bpy})]$ ,  $[\text{Co}^{\text{II}}(\text{acac})_2(\text{phen})]$ , where acac = acetylacetonate anion, tn = trimethylenediamine, N-metn = N-methyltrimethylenediamine, N-meenn = N-methylethylenediamine, N,N'-dmen = N,N'-dimethylethylenediamine, N,N,N',N'-tetramethylethylenediamine, and amp = 2-aminomethylpyridine, respectively. These complexes were prepared in a similar way to that for  $[\text{Co}^{\text{II}}(\text{acac})_2(\text{phen})]$ <sup>14</sup>. To a hot benzene solution(50ml) of anhydrous bis(acetylacetonato)cobalt(II) (0.01 mole) was added dropwise diamine ligand(0.05 mole) in benzene(10ml). The solution was stirred



**Figure 1.** The structures of cinchona alkaloids used as an environment substance.



**Figure 2.** The PCD spectra for  $[\text{Co}^{\text{II}}(\text{acac})_2(\text{phen})]$ - $l$ -cinchonidine (---, 1),  $[\text{Co}^{\text{II}}(\text{acac})_2(\text{phen})]$ - $d$ -cinchonine (...., 2),  $[\text{Co}^{\text{II}}(\text{acac})_2(\text{N},\text{N}'\text{-dmen})]$ - $l$ -cinchonidine (—, 1), and  $[\text{Co}^{\text{II}}(\text{acac})_2(\text{N},\text{N}'\text{-dmen})]$ - $d$ -cinchonine (—, 2) systems.

at 50 °C and concentrated to 10 ml. The slurry was cooled in ice. The precipitated crystals were filtered off and washed with four 5 ml portions of cold benzene, and dried in a vacuum oven to constant weight.

All the chemicals were used as purchased without further purification.

**Detection of the Pfeiffer Effect.** Sample solutions were prepared by dissolving racemic complex and alkaloid ( $d$ -cinchonine or  $l$ -cinchonidine) with various solvents. These solutions were stored in the water bath at 25 °C and kept standing in the dark. The rate of appearance of the Pfeiffer effect (antiracemization rate) in  $[\text{Co}^{\text{II}}(\text{acac})_2(\text{diamine})]$ - $d$ -cinchonine system was followed by measuring the CD intensity at the first  $d-d$  transition region as a function of time (hour) elapsed after racemic complex ( $3.75 \times 10^{-4}$  mole) was dissolved with  $d$ -cinchonine ( $3.75 \times 10^{-4}$  mole) in each solvent (50 ml). The wavelength adopted here for the antiracemization was 635 nm, since their wavelength at maximum peak are very similar on all complexes.

CD spectra were measured by a JASCO Model J500C automatic spectropolarimeter at 25 °C.

## Results and Discussion

Figure 1 shows the structure of the cinchona alkaloid used as an environment substance in this study.

The configurations of around C-8 and C-9 atoms of cinchonine and cinchonidine, respectively, have been reported by Lyle and Keeper<sup>15</sup>.

Figure 2 is the representative Pfeiffer circular dichroism (PCD) spectra of  $[\text{Co}^{\text{II}}(\text{acac})_2(\text{N},\text{N}'\text{-dmen})]$  and  $[\text{Co}^{\text{II}}(\text{acac})_2(\text{phen})]$  complexes enriched by the Pfeiffer effect when  $d$ -cinchonine and  $l$ -cinchonidine are employed as environment substances in chloroform. It can be seen that the PCD spectra of the  $[\text{Co}^{\text{II}}(\text{acac})_2(\text{diamine})]$  complexes in the presence of  $d$ -cinchonine and  $l$ -cinchonidine are enantiomeric, respec-

**Table 1.** PCD Intensity ( $\Delta\epsilon$ ) and Absolute Configuration Obtained for the  $[\text{Co}^{\text{II}}(\text{acac})_2(\text{diamine})]$ - $d$ -cinchonine System in Chloroform

diamine	$\Delta\epsilon$	$\lambda_{\text{max}}(\text{nm})$	absolute configuration
tn	+0.11	637	$\Delta$
	-0.21	505	
N-metn	+0.16	631	$\Delta$
	-0.31	500	
N-meen	+0.11	637	$\Delta$
	-0.20	505	
N,N'-dmen	+0.13	635	$\Delta$
	-0.24	505	
N,N,N',N'-tmen	+0.24	635	$\Delta$
	-0.45	503	
amp	+0.14	635	$\Delta$
	-0.26	505	
bpy	+0.28	631	$\Delta$
	-0.51	505	
phen	+0.061	635	$\Delta$
	-0.11	510	

tively. And when the same alkaloid is employed as an environment substance, it can be seen that the PCD spectra are similar to each other in patterns although their magnitudes are different.

It is shown that  $[\text{Co}^{\text{II}}(\text{acac})_2(\text{diamine})]$ -alkaloid system gives two Cotton effects of opposite sign in  $d-d$  transition region;

- 1)  $[\text{Co}^{\text{II}}(\text{acac})_2(\text{diamine})]$ - $d$ -cinchonine system: (+) and (-) listing from the longer wavelength and a negative major CD component,
- 2)  $[\text{Co}^{\text{II}}(\text{acac})_2(\text{diamine})]$ - $l$ -cinchonidine system: (-) and (+) listing from the longer wavelength and a positive major CD component.

Boucher<sup>16</sup> and Nakano *et al.*<sup>17</sup> have assigned the  $A$ -configuration to the  $[\text{Co}^{\text{II}}(\text{acac})_2(\text{diamine})]^+$ , where diamine is ethylenediamine or trimethylenediamine, on the basis of the positive sign of the dominant CD band ( $A_2 + B_2$ ) in the first absorption region. Accordingly, the absolute configuration of  $[\text{Co}^{\text{II}}(\text{acac})_2(\text{diamine})]$  complexes which is induced by  $d$ -cinchonine in chloroform can be assigned to  $\Delta$ -configuration. And  $[\text{Co}^{\text{II}}(\text{acac})_2(\text{diamine})]$ - $l$ -cinchonidine system can be assigned to  $A$ -configuration.

When the cinchona alkaloid cations are used as the environment substances, Miyoshi *et al.*<sup>18</sup> have proposed that cinchoninium ion interacts with  $[\text{Cr}(\text{ox})_3]^{3-}$  (ox = oxalate dianion) and  $[\text{M}(\text{phen})_3]^{2+}$  ( $M = \text{Zn}(\text{II})$  or  $\text{Ni}(\text{II})$ ) so that the stereochemical demand due to the asymmetry around its C-8 and/or C-9 atom(s) is exerted upon them, the chiral discrimination being thereby effected. And they have suggested that the direction of the equilibrium shift for  $[\text{Co}(\text{phen})_3]^{2+}$  is determined by the configuration around the C-9 atom of these environment substances and that the hydroxyl group on the C-9 atom is essential to the chiral discrimination between  $A$ - and  $\Delta$ - $[\text{Co}(\text{phen})_3]^{2+}$ . And it has been found that the hydroxyl group on the asymmetric carbon atom of the chiral environment substance plays an essential role in the chiral discrimination in  $[\text{Co}(\text{phen})_3]^{2+}$ - $(R,R)$ -tartaric acid system<sup>19</sup>. Therefore, it can be seen that the hydroxyl group on the C-9 atom of alkaloid (Figure 1) is essential to the chiral

**Table 2. PCD Intensity ( $\Delta\epsilon$ ) Obtained for the  $[\text{Co}^{\text{II}}(\text{acac})_2(\text{diamine})]$ —*d*-cinchonine System at Equilibrium**

diamine	in methanol		in ethanol	
	$\Delta\epsilon$	$\lambda_{\text{max}}$	$\Delta\epsilon$	$\lambda_{\text{max}}$
tn	+0.30	645	+0.68	650
	-0.29	555	-0.40	550
N-metn	+0.56	647	+0.65	650
	-0.63	553	-1.05	558
N-meen	+0.21	650	+0.36	652
	-0.39	555	-0.59	540
N,N'-dmen	+0.13	650	+0.21	655
	-0.41	550	-0.69	555
N,N,N',N'-tmen	(+0.026)	650	(+0.036)	650
	(-0.012)	550	(-0.032)	550
amp	+0.14	645	+0.23	650
	-0.33	545	-0.69	545
bpy	inactive		inactive	
phen	inactive		inactive	

discrimination and that the direction of the equilibrium shift (enantiomerization) for  $[\text{Co}^{\text{II}}(\text{acac})_2(\text{diamine})]$  complex depend on the stereochemical demand of asymmetry around the C-9 atom of alkaloid.

In order to see the solvent effect of the discriminating interaction between the diamine ligand of the complex and environment substance, the Pfeiffer effect of  $[\text{Co}^{\text{II}}(\text{acac})_2(\text{diamine})]$  has been investigated in some organic solvents. Table 1 and 2 show the PCD intensity ( $\Delta\epsilon$ ) obtained for the  $(\text{Co}^{\text{II}}(\text{acac})_2(\text{diamine}))$ —*d*-cinchonine system at equilibrium. The complexes having the N-H protons are Pfeiffer-active in all solvents used in this study. On the other hand, the complexes having no N-H protons such as  $[\text{Co}^{\text{II}}(\text{acac})_2(\text{bpy})]$  and  $[\text{Co}^{\text{II}}(\text{acac})_2(\text{phen})]$  are Pfeiffer-active in chloroform, but they are Pfeiffer-inactive in alcoholic solvents. And  $[\text{Co}^{\text{II}}(\text{acac})_2(\text{N,N,N',N'-tmen})]$  complex having no N-H protons can be also regarded as Pfeiffer-inactive, since the PCD of this complex is developed after the elapse of long periods up to 5 days and the intensity of the PCD is very weak (Table 2). Therefore, in alcoholic solvents, it seems that the sites of the chiral discrimination between complex and environment substance are the N-H proton of diamine ligand and C-9 hydroxyl group of alkaloid. That is, it can be supposed that the source for the Pfeiffer effect of the present system is attributed to the hydrogen bonding between N-H proton and C-9 hydroxyl group.

In chloroform solution, all systems of the present study are Pfeiffer-active. Since chloroform is almost nonpolar (its dielectric constant  $\epsilon = 4.70^{20}$ ), the interaction between neutral complexes used in this study and chloroform molecules is expected to be weak. Thus it is supposed that the complex and the environment substance are contact intimately, thereby all systems are Pfeiffer-active.

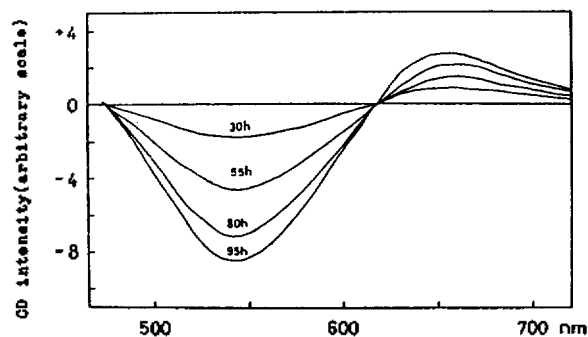
From Table 2, it can be seen that the PCD in ethanol is more induced than that in methanol. It has been reported<sup>21</sup> that the Pfeiffer rotation ( $\alpha_p$ ) in  $[\text{Zn}(\text{phen})_3]^{2+}$ —cinchona alkaloid systems (in aqueous solution) decreases with molar alcohol concentration, and that the Pfeiffer rotation decreases with the increased length of the carbon chain of the added molecules. These phenomena were supposed that a certain fraction of added alcohols penetrates into the aggregates composed of the complex and the chiral environ-

ment compound, thereby diminishing the Pfeiffer effect, *i.e.*, added alcohols are distributed between water and the aggregates. However, our results (Table 2) can not be explained by above proposal, since the PCD in ethanol was more enhanced than that in methanol in spite of the longer carbon chain of ethanol. It can therefore be presumed that the hydrogen bonding between complex and environment substance in ethanol with a lower dielectric constant ( $\epsilon = 24.3$ )<sup>20</sup> is more favorable than that in methanol with higher dielectric constant ( $\epsilon = 32.6$ )<sup>20</sup>.

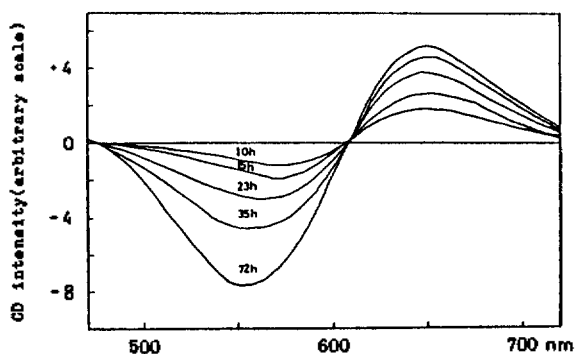
In case of chloroform solutions, though the C-H proton of chloroform become capable of hydrogen bonding as a result of the electron-withdrawing nature of the chlorides of chloroform, it is expected that the hydrogen bonding between the C-H proton and acetylacetonate oxygen is very weak in the complexes having no N-H protons, and that the interaction between complex and alkaloid is predominant. Therefore, the Pfeiffer effect for the complexes having no N-H protons can be explicable by the proposal of Miyoshi *et al.*<sup>22</sup> which is applied in the case of  $[\text{Cr}(\text{ox})_2(\text{phen})]^-$ —cinchona alkaloid cation systems. That is, C-9 hydroxyl group of alkaloid can be located between the two coordinating oxygen atoms of acetylacetonate ligand, so that it is hydrogen bonded to both of the two acetylacetonate oxygen, the chiral discrimination being thereby effected.

In the case of chloroform-methanol mixture solvents, the complexes having N-H protons are all Pfeiffer-active, while the complexes having no N-H protons are Pfeiffer-inactive up to 50% (v/v) of methanol except for  $[\text{Co}^{\text{II}}(\text{acac})_2(\text{N,N,N',N'-tmen})]$ . From IR studies, Davis *et al.*<sup>23</sup> have reported that methanol binds the acetylacetonate oxygen by hydrogen bonding. In our present systems, the OH group of methanol can also form hydrogen bonding with N-H proton of diamine in  $[\text{Co}^{\text{II}}(\text{acac})_2(\text{diamine})]$  complex. From our results, in mixture of chloroform-methanol solvents, we can deduce that a preferential alignment of the methanol molecules due to the hydrogen bonding in outer sphere of the complex. And it may be interpreted that the interaction between N-H proton of diamine and hydroxyl group of cinchonine is stronger than that between N-H proton and methanol, since the complexes having N-H protons are Pfeiffer-active in alcoholic solvents. On the other hand, it is interpreted that the interaction between acetylacetonate oxygen and hydroxyl group of cinchonine is weaker than that between acetylacetonate oxygen and methanol, since the complexes that is capable of the chiral discrimination through the hydrogen bonding between acetylacetonate oxygen and hydroxyl group of alkaloid are Pfeiffer-inactive in alcoholic solvents. And in chloroform-methanol mixture solvents, it seems that the methanol molecules surrounding the N-H protons of complex are partially removed when the hydrogen bonding is formed between N-H protons and C-9 hydroxyl group. On the other hand, it is difficult to say that the methanol molecules being hydrogen bonded with acetylacetonate oxygen are substituted by hydroxyl group of cinchonine, since the complexes having N-H protons are Pfeiffer-active, and these having no N-H protons are Pfeiffer-inactive as mentioned above.

Figure 3 and 4 show the representative PCD spectra induced for the systems of racemic  $[\text{Co}^{\text{II}}(\text{acac})_2(\text{amp})]$  and  $[\text{Co}^{\text{II}}(\text{acac})_2(\text{N,N'-dmen})]$  with *d*-cinchonine as an environment substance in methanol, respectively, where the numbers attached to each spectrum represent the hours elapsed after the complex is mixed with *d*-cinchonine in methanol. It



**Figure 3.** The time-dependent CD spectra induced in the  $[\text{Co}^{\text{II}}(\text{acac})_2(\text{amp})]$  ( $7.5 \times 10^{-3}\text{M}$ )-*d*-cinchonine ( $7.5 \times 10^{-3}\text{M}$ ) system in methanol.



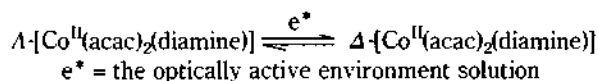
**Figure 4.** The time-dependent CD Spectra induced in the  $[\text{Co}^{\text{II}}(\text{acac})_2(\text{N,N}'\text{-dmen})]$  ( $7.5 \times 10^{-3}\text{M}$ )-*d*-cinchonine ( $7.5 \times 10^{-3}\text{M}$ ) system in methanol.

can be known that the varying shapes of PCD spectra of those complexes in the presence of *d*-cinchonine are similar to each other in patterns although their varying magnitudes are different. When *d*-cinchonine is added as an environment substance, the PCD developed is time-dependent and the patterns of the PCD spectra of other complexes used in this study are also induced in an analogous type.

$[\text{Co}^{\text{II}}(\text{acac})_2(\text{diamine})]$ -*d*-cinchonine system gives two Cotton effect listing (+) and (-) from the longer wavelength and a negative major CD component in methanol (Figure 3 and 4). Therefore, the absolute configuration of  $[\text{Co}^{\text{II}}(\text{acac})_2(\text{diamine})]$  which is induced by *d*-cinchonine in alcoholic solvents can be assigned to  $\Delta$ -configuration.

In order to estimate the solvent dependence of the Pfeiffer effect for the  $[\text{Co}^{\text{II}}(\text{acac})_2(\text{diamine})]$  complexes and analyze it quantitatively, we have investigated the rate of appearance of the Pfeiffer effect ("antiracemization rate") for some complexes with *d*-cinchonine as an environment substance in alcoholic solvents.

When the following equilibrium exists,



the antiracemization rate constant  $k_{\text{anti}}$  is expressed as

$$\ln[(\text{CD}_\infty - \text{CD}_0) / (\text{CD}_\infty - \text{CD}_t)] = t \cdot k_{\text{anti}}$$

where  $\text{CD}_0$ ,  $\text{CD}_t$  and  $\text{CD}_\infty$  refer to the CD intensity at  $t = 0$ ,  $t = t$ , and equilibrium, respectively, after racemic complex is mixed with environment substance.

In Table 3 are listed the antiracemization rate constants calculated from above equation. In chloroform solution, the

**Table 3.** Antiracemization Rate Constants  $k_{\text{anti}}$  for  $[\text{Co}^{\text{II}}(\text{acac})_2(\text{diamine})]$ -*d*-Cinchonine Systems at 25°C

diamine	$k_{\text{anti}} (\times 10^2)$			
	in ethanol	in methanol	in 10% chloroform <sup>a</sup>	in 50% chloroform <sup>b</sup>
tn	2.63	5.39	5.95	5.98
N-metn	4.80	5.02	5.19	6.11
N-meen	1.51	5.90	6.50	7.32
N,N'-dmen	1.55	4.16	—	—
amp	0.78	1.43	—	—

<sup>a</sup>10% chloroform-90% methanol (v/v %). <sup>b</sup>50% chloroform-50% methanol (v/v %).

antiracemization rate for all  $[\text{Co}^{\text{II}}(\text{acac})_2(\text{diamine})]$ -*d*-cinchonine systems was very fast. Thus we did not attempt to measure the antiracemization rate in chloroform and only the intensity of PCD was measured, since the equilibrium shift by the Pfeiffer effect was attained within about 30 seconds. The fast antiracemization rate in chloroform is ascribed to the relatively weak interaction between complex and solvent molecules.

And the antiracemization rate in methanol is faster than that in ethanol (Table 3) even though the solvation of the complex and alkaloid by methanol is more favorable than that by ethanol. These show the opposite phenomena differing from the intensity of the PCD at equilibrium. This anomalous result may be influenced by other factors such as steric hindrance or micelle formation<sup>24,25</sup> or hydrophobic bonding<sup>26</sup> by the difference of carbon chain in alcohols. However, since  $k_{\text{anti}}$  in the present systems have no relation to the kinds of diamine ligands, *i.e.*, the numbers of N-H protons bear no relation to  $k_{\text{anti}}$ , further interpretation of  $k_{\text{anti}}$  in alcoholic solvents is out of our present knowledge as yet.

In methanol-chloroform mixture solvents,  $k_{\text{anti}}$  is enhanced as the concentration of chloroform is increased, though the values of  $k_{\text{anti}}$  for trimethylenediamine-complex are similar to each other in 10% and 50%(v/v) chloroform solution. It can be deduced that the interaction between N-H protons of diamine ligand and C-9 hydroxyl group of *d*-cinchonine may be facilitated as the concentration of solvating alcohol is decreased. Therefore, it seems that  $k_{\text{anti}}$  may be influenced by the interaction between complex and solvent molecules, and that the hydrogen bonding between N-H protons and alcohol molecules may affects the rate of antiracemization.

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## Synthetic Studies on Fused Nitrogen-heterocycles from *N*-Amino-*N,N'*-dihydrodiazinediones (I). Condensation of *N*-Amino-*N,N'*-dihydrodiazinediones with 1,3-Dicarbonyl Compounds

Sung Chul Shin<sup>†</sup> and Youn Young Lee<sup>\*</sup>

Department of Chemistry, Seoul National University, Seoul 151-742. Received June 14, 1988

The condensation of 1-amino-1,2-dihydro-3,6-pyridazinedione (**1**) and 2-amino-2,3-dihydro-1,4-phthalazinedione (**2**) with 1,3-diketones or 1,3-dialdehydes in polyphosphoric acid gave 6,9-dihydro-6,9-dioxopyridazino[1,2-*a*][1,2,3]triazines (**3–6**) and 6,11-dihydro-6,11-dioxo[1,2,3]triazino[1,2-*b*]phthalazines (**7–10**), respectively. The condensation of **2** with 2,4-pentanedione in acetic acid gave *N*-alkylidene intermediate (**11**), which was cyclized to **9** by treatment with polyphosphoric acid.

### Introduction

Of the three possible triazine systems the 1,2,3-triazines are by far the least studied class. Recently, interest in the 1,2,3-triazines has increased as a result of the wide range of biological activity associated with many derivatives of 1,2,3-benzotriazin-4(2*H*)-one<sup>1</sup>. There have been known a variety of fused 1,2,3-triazines. However, only a limited number of fused 1,2,3-triazines in which two nitrogen atoms are common to two adjacent ring have been reported<sup>2</sup>.

We prepared 1-amino-1,2-dihydro-3,6-pyridazinedione (**1**) and 2-amino-2,3-dihydro-1,4-phthalazinedione (**2**) from 1,2-dihydro-3,6-pyridazinedione and 2,3-dihydro-1,4-phthalazinedione, respectively, by *N*-amination with hydroxylamine-*O*-sulfonic acid<sup>3</sup>. It was hoped that **1** and **2** as a 1,3-dinitrogenocyclophile would condense with 1,3-dicarbonyl or  $\alpha,\beta$ -unsaturated carbonyl compounds to afford N-N fused 1,2,3-triazines.

We have recently reported<sup>4</sup> that the condensation of **1** and **2** with 2,4-pentanedione, 4-methyl-3-penten-2-one or

diethyl 2-butynoate yields the novel heterocyclic ring systems, pyridazino[1,2-*a*][1,2,3]triazines and 1,2,3-triazino[1,2-*b*]phthalazines, respectively. We describe here the full details of the condensation of **1** and **2** with various 1,3-dicarbonyl compounds to synthesize these heterocycles.

### Results and Discussion

The syntheses of fused nitrogen-heterocycles from condensation of 1,3-dinitrogenocyclophiles with 1,3-dicarbonyl compounds can be achieved with acidic cyclizing agents, such as sulfuric acid, polyphosphoric acid (PPA), acetic acid etc. Recently it was reported<sup>5</sup> that phosphoryl chloride containing a small amount of PPA was a good cyclizing agent in these condensations.

We have found that PPA was a good cyclizing agent for the condensation of *N*-amino-*N,N'*-dihydrodiazinediones with 1,3-dicarbonyl compounds. Thus 1-amino-1,2-dihydro-3,6-pyridazinedione (**1**) and 2-amino-2,3-dihydro-1,4-phthalazinedione (**2**) was mixed well with PPA preheated to 60–90°C and reacted with 1,3-propanedial, 3-oxobutanal, 2,4-pentanedione or 1,3-diphenyl-1,3-propanedione for 40–60 min

<sup>†</sup>Present address: The Korea Ginseng and Tobacco Research Institute, Daejeon 302-345, Korea.