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THE COBALT CATALYZED REDUCTIONS USING CARBON MONOXIDE AND WATER. THE N-ALKYLATION OF MORPHOLINE BY CARBONYL COMPOUNDS

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The cobalt carbonyl complex modified by α,ω-bis(diphenylphosphino)-alkane (PCnP, n=2 or 3) was an effective catalyst for the N-alkylation of morpholine by carbonyl compounds, in which carbon monoxide and water were used in place of hydrogen. N-Methyl, N-isopropyl, and N-benzyl-morpholines were obtained in excellent yields.

Recently, homogeneous catalysis of water gas shift reaction by transition metal complexes has been of interest to many workers.[1-3] This reaction is considered to involve a metal hydride as a key intermediate for the generation of hydrogen. Several workers have paid attention to the use of metal hydrides produced from carbon monoxide and water for organic synthesis.[3,4] We previously proposed in our patent[2] that the cobalt carbonyl complex modified by 1,2-bis(diphenylphosphino)ethane (PC2P) in the presence of tertiary amine was an excellent catalyst for water gas shift reaction. In this paper, we wish to describe the effectiveness of this system for the N-alkylation of morpholine by carbonyl compounds.

Typically, a mixture of dicobalt octacarbonyl (0.25 mmol), PC2P (0.25-1.0 mmol), morpholine (50 mmol), aldehyde (60 mmol), water (1 ml), and ethanol (30 ml) was stirred at 120°C under 100 kg/cm^2 of carbon monoxide for 2-20 hr in a 100 ml stainless steel autoclave. Products were analyzed by H^1 and C^{13} NMR and GLPC.

Table 1 shows some results. Morpholine was alkylated by formaldehyde, acetone, and benzaldehyde to give N-methyl, N-isopropyl, and N-benzylmorpholines, respectively, in excellent yields using the PC2P-modified cobalt carbonyl complex. No hydrogen formation was observed during the reaction, while hydrogen was produced after the completion of the alkylation. The ratio of PC2P and dicobalt octacarbonyl has a

Table 1. N-Alkylation of Morpholine Catalyzed by PC2P-modified Cobalt Carbonyl Complex

Carbonyl Compound	Time(hr)	P/Co[a)]	Product	Yield(%)[b)]
Paraformaldehyde	2	4	N-Methylmorpholine	34.6
Paraformaldehyde	2	2	N-Methylmorpholine	98.4
Paraformaldehyde	2	1	N-Methylmorpholine	95.7
Paraformaldehyde	2	0	N-Methylmorpholine	3.9
Acetone	20	2	N-Isopropylmorpholine	51.3
Benzaldehyde	20	2	N-Benzylmorpholine	97.0
p-Tolualdehyde	20	2	N-p-Methylbenzylmorpholine	99.2
p-Anisaldehyde	20	2	N-p-Methoxybenzylmorpholine	80.8
p-Chlorobenzaldehyde	20	2	N-p-Chlorobenzylmorpholine	87.4

a) Atomic ratio. b) Based on morpholine introduced.

Table 2. Effect of Phosphine[a)]

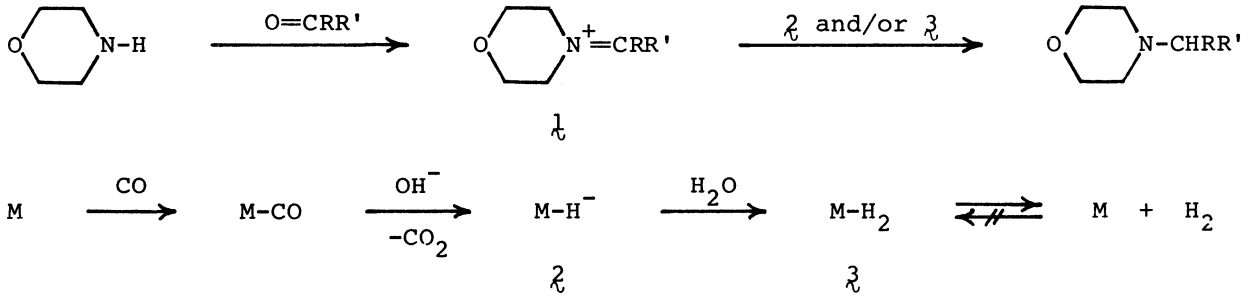
Phosphine	Yield (%) N-Methyl-morpholine	N-Benzyl-morpholine
None	3.9	-
PC1P	3.4	-
PC2P	98.4	97.0
PC3P	90.7	45.2
PC4P	3.0	-
Ph_3P	0.1	-

a) P/Co=2.

remarkable effect on the yield of N-alkylmorpholine. The reaction was very slow in the absence of PC2P, and excess phosphine also retarded the reaction.

As shown in Table 2, the catalytic activity was affected by the chain length of α,ω-bis(diphenylphosphino)alkane (PCnP, n=1-4): the complexes of PC2P and PC3P have high activities for the N-alkylation, while those of PC1P and PC4P were less active. Triphenylphosphine was not effective, either.

The alkylation of morpholine will involve the formation of immonium ion 1 from morpholine and carbonyl compound, followed by the reduction with metal hydrides 2



and/or 3 produced from carbon monoxide and water. To test plausibility of this hypothesis, the benzylation by CO and D_2O in EtOD was studied using the PC2P modified complex (P/Co=2) in the presence of H_2 (20 kg/cm^2). H^1 and C^{13} NMR analyses showed that N-benzylmorpholine, thus produced, contained a deuterium atom. However, no deuterium atom was found in the benzylation by CO and H_2O in the presence of D_2. These results suggest that the formation of metal hydride from carbon monoxide and water is faster than the oxidative addition of molecular hydrogen to the metal: the metal hydride reduces the substrate as soon as it is produced, and that molecular hydrogen, once dissociated from the complex, can not participate in the reduction.

The natures of active species and further applications are under investigations.

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