

SHORT COMMUNICATIONS

*The Reductive Aminations of α -Keto Acids
with Cobalt Complex Ions in
Homogeneous Solution*

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It has been known¹⁾ that the reductive amination of α -keto acid with aqueous ammonia can be carried out with an active metal such as platinum, palladium and Raney-nickel. However, the same reaction using metal complex ion under homogeneous conditions is still unknown. It has been shown recently²⁾ that

various unsaturated compounds using cyano cobalt complex which prepared from cobaltous chloride and five moles of potassium cyanide were hydrogenated in aqueous solution.

In this communication, we wish to report that reductive amination of α -keto acids with aqueous ammonia can be made either with cyano cobalt complex as a catalyst or chloropentamminecobalt(III) chloride as a reagent of the reductive amination in alkaline solution.

Most of the experiments using cyano cobalt complex were carried out at 30~70°C under a hydrogen pressure of 50 kg./cm² using 6% aqueous ammonia. The results of the reductive amination of α -keto acids are summarized in Table I.

When the reaction was carried out at room temperature under an atmospheric pressure,

TABLE I

Compound	Run	Keto acid/ CoCl ₂ ·6H ₂ O	Temp. °C	Time hr.	Corre- sponding amino acid, %	Co Deposited
$\text{C}_6\text{H}_5\text{CH}_2\text{C}(=\text{O})\text{COOH}$	1	1	30	8	— ^{a)}	None
	2	3	40	8	85.6	None
	3	1	70	5	95.0	None
	4	10	70	5	76.5	None
	5	1	70	5	36.3 ^{b)}	None
$\text{CH}_3\text{C}(=\text{O})\text{COOH}$	6	1	40	8	73.2	None
$\text{HOOC}(\text{CH}_2)_2\text{C}(=\text{O})\text{COOH}$	7	1	40	8	36.4	None

a) The reaction was carried out at a hydrogen pressure of one atmosphere.

b) Potassium cyanide was not added in the reaction system.

TABLE II

Compound	Run	nKCN	Keto acid/ Complex	Corresponding amino acid, %	Co Deposited
$\text{C}_6\text{H}_5\text{CH}_2\text{C}(=\text{O})\text{COOH}$	1	5	1	29.6	Small
	2	5	5	53.0	None
	3	5	2	96.4	None
	4	5	1	94.0	None
$\text{CH}_3\text{C}(=\text{O})\text{COOH}$	5	5	2	85.0	None

1) F. Knoop and H. Oesterlin, *Z. Physiol. Chem.*, **148**, 294 (1925); **170**, 185 (1927).

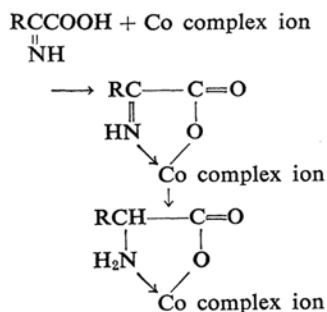
2) M. Iguchi, M. Takahashi et al., Presented in part at the 9-11th Annual Meetings of the Chemical Society of Japan, Tokyo and Kyoto, April, 1956-1958; B. Devries, *Koninkl. Ned. Akad. Wetenschap, Proc.*, **B63**, 443 (1960); N. Kelso King

and M. E. Winfield, *J. Am. Chem. Soc.*, **83**, 3366 (1961); J. Kwiatek, I. L. Mador and J. K. Seyler, *J. Am. Chem. Soc.*, **84**, 304 (1962); M. Murakami and J. W. Kang, Presented in part at the 15th Annual Meeting of the Chemical Society of Japan, Kyoto, April, 1962.

phenylalanine was not detected among the products even by the paper chromatographic analysis of the products.

At run 5, the reductive amination of phenylpyruvic acid was carried out with cobaltous chloride under the similar conditions. Comparison of runs 3 and 5 indicated that the yield of phenylalanine increases appreciably by the addition of potassium cyanide to the reaction mixture.

The above results also indicated that cyano cobalt complex acts as a catalyst for the reductive amination of α -keto acids with aqueous ammonia. The mechanism of this reaction seems to be as follows: the unstable intermediate, α -imino acid, coordinates with cobalt complex ion and then the complex is reduced.



When α -keto acids were treated with chloropentamminecobalt(III) chloride³⁾ alone or together with potassium cyanide at 70°C under hydrogen pressure of 50 kg./cm² for five hours in alkaline solution, α -amino acids were obtained. The results of the reductive aminations with $[\text{Co}(\text{NH}_3)_5\text{Cl}]\text{Cl}_2$ are summarized in Table II.

While the reductive amination of phenylpyruvic acid with $[\text{Co}(\text{NH}_3)_5\text{Cl}]\text{Cl}_2$ gave phenylalanine in 29.6% yield, the yield was greatly increased by the addition of five moles of potassium cyanide. The yield of the amino acid decreased with the decrease of the molar ratio of $[\text{Co}(\text{NH}_3)_5\text{Cl}]\text{Cl}_2$ to α -keto acid.

The mechanism of this reaction seems to be similar to that of the reductive amination of α -keto acid with aqueous ammonia using cyano cobalt complex. A more detailed description of this work will be published shortly

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3) T. Inoue, "Mukikagaku Seizo Jikken", Shokabo Ltd., Tokyo (1949), p. 358.