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RHODIUM-CATALYZED N-ALKYLATION OF AMINES BY A CARBON MONOXIDE-WATER SYSTEM

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Metal hydride species are well known to be key intermediates in such catalytic reactions as hydrogenation and hydrocarbonylation. Recent papers have demonstrated that rhodium and ruthenium complexes are homogeneously active for the water gas shift reaction.[1)] These reactions were postulated to include a nucleophilic attack of water on a metal-coordinated carbonyl.[1,2)] Hydrogen production appears to come from a metal hydride intermediate.

$$L_nM\text{-}CO \;+\; H_2O \longrightarrow L_nMCOOH \longrightarrow L_nMH \;+\; CO_2$$

Rhodium complexes combined with carbon monoxide-water are effective for reduction of nitrobenzenes and α,β-unsaturated carbonyl compounds.[3)] Our previous communication has indicated that a rhodium-carbon monoxide-water system can be employed for the α-alkylation of ketones.[4)] We herein wish to report the rhodium-catalyzed N-alkylation of amines by carbon monoxide-water.

Typically, a mixture of rhodium chloride($RhCl_3 \cdot 3H_2O$)(10 mg), primary or secondary amine(40 mmol), aldehyde(45-85 mmol) and moist ethanol(20 ml) was stirred at 180°C under pressures of carbon monoxide(initial pressure, 70 atm) for 4 hr in a 100 ml stainless autoclave. Products were analyzed by IR, PMR, GLPC and elemental analysis.

Some representative results are listed in Table. Amines combined with formaldehyde or benzaldehyde gave N-methyl- or N-benzylamines, respectively. Morpholine was converted into the corresponding tert-amines in excellent yields by this procedure. With N-methylation of morpholine, such rhodium complexes as $RhCl_3$ and $[Rh(COD)Cl]_2$ were more reactive than $RhCl(PPh_3)_3$ and $RhCl(CO)(PPh_3)_2$.

Table. Rhodium-Catalyzed N-Alkylation of Amines by Carbon monoxide-Water

	Amine	Aldehyde	Catalyst*	Product	Yield %
1	Morpholine	aq.Formaldehyde	a	N-Methylmorpholine	90
2	Morpholine	aq.Formaldehyde	b	N-Methylmorpholine	92
3	Morpholine	aq.Formaldehyde	c	N-Methylmorpholine	30
4	Morpholine	aq.Formaldehyde	d	N-Methylmorpholine	22
5	Morpholine	Benzaldehyde	b	N-Benzylmorpholine	56
6	Cyclohexylamine	aq.Formaldehyde	a	N-Methylcyclohexylamine N,N-Dimethyl-	10 6
7	Cyclohexylamine	Benzaldehyde	b	N-Benzylcyclohexylamine	55
8	Aniline	aq.Formaldehyde	a	N-Methylaniline N,N-Dimethyl-	4 2
9	Aniline	Benzaldehyde	a	N-Benzylaniline	33
10	N-Benzylideneaniline		a	N-Benzylaniline	63

* a, $RhCl_3 \cdot 3H_2O$; b, $[Rh(COD)Cl]_2$; c, $RhCl(PPh_3)_3$; d, $RhCl(CO)(PPh_3)_2$.

N-Benzylideneaniline and aniline combined with benzaldehyde gave N-benzylaniline. These reactions appear to involve the reduction of C=N bonds of Schiff base and immonium ion.[5)]

$$>NH + OHCR \longrightarrow >N^{+}=CHR \longrightarrow >N\text{-}CH_2R$$

$$-NH_2 + OHCR \longrightarrow -N=CHR \longrightarrow -NHCH_2R$$

In case of aniline-formaldehyde, some side reaction predominated to give resinous material. N-Methylated anilines were obtained in 6 %. Cyclohexylamine gave N-benzylcyclohexylamine in good yield. The results obtained here illustrate the general synthetic utility of our procedure.

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