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# Transition-metal complex-catalyzed reduction of amides with hydrosilanes: a facile transformation of amides to amines

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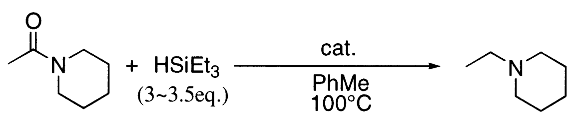
**Abstract**—The reaction of amides with hydrosilanes is catalyzed by a variety of transition-metal complexes in the presence or absence of halides and amines as co-catalysts to afford the corresponding amines in good yields. © 2001 Elsevier Science Ltd. All rights reserved.

The conversion of amides to the corresponding amines is one of the most important transformations in organic syntheses. Catalytic hydrogenation of amides usually required vigorous conditions (high pressures and elevated temperature),[1] therefore, the stoichiometric reduction using metal hydride complexes such as lithium aluminum hydride[2–4] or borane[5,6] has been used in organic syntheses. Recently, Rh complex-catalyzed reduction of tertiary amides to amines has been reported using $H_2SiPh_2$ or $H_3SiPh$,[7] where only one of H–Si bonds can be participated in the reaction, and no reaction can take place at room temperature with monohydrosilane, which is more stable and less expensive than polyhydrosilanes. Here, we wish to report the transition-metal-catalyzed transformation of primary, secondary and tertiary amides to the corresponding amines using monohydrosilanes as a reducing agent at elevated temperature.

**Table 1.** Reduction of *N*-acetylpiperidine using triethylsilane catalyzed by Group 7–10 transition-metal complexes




| Cat. 1 (1 mol%) | Cat. 2 (5 mol%) | Cat. 3 (5 mol%) | Time (h) | Yield (%) |
|---|---|---|---|---|
| $Mn_2(CO)_{10}$ | | $Et_2NH$ | 16 | 89.3 |
| $Re_2(CO)_{10}$ | | $Et_2NH$ | 16 | 95.6 |
| $Ru_3(CO)_{12}$ | | | 16 | 88.2 |
| $RuCl_2(CO)_2(PPh_3)_2$ | EtI | | 16 | 96.1 |
| | MeI | | 16 | 98.1 |
| | $I_2$ | | 16 | 94.1 |
| $RuH_2(CO)(PPh_3)_3$ | EtI | $Et_2NH$ | 40 | 94.4 |
| $Ru(acac)_3$ | EtI | $Et_2NH$ | 16 | 88.0 |
| $Os_3(CO)_{12}$ | | $Et_2NH$ | 16 | 99.8 |
| | | Pyridine | 16 | 99.3 |
| $RhH(PPh)_4$ | | $Et_2NH$ | 16 | 99.5 |
| $IrCl_3$ | | | 16 | 94.4 |
| $K_2IrCl_6$ | | $Et_2NH$ | 16 | 92.6 |
| $Pd(OH)_2/C$ | | $Et_2NH$ | 40 | 77.7 |
| $Pt_2Cl$ | | $Et_2NH$ | 16 | 78.5 |

*Keywords*: transition metals; catalysts; reduction; silicon and compounds; amides; amines.

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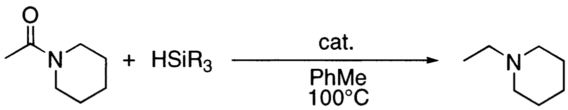
$$\text{Amide} + HSiR_3 \xrightarrow{\text{cat.}} \text{Amine}$$

Initially, we surveyed the active catalysts using *N*-acetylpiperidine as a substrate and triethylsilane as a monohydrosilane. Surprisingly, varieties of Group 7–10 transition metals (Mn, Re, Ru, Os, Rh, Ir, Pd and Pt) complexes have catalytic activities in the presence or absence of diethyl amine and/or ethyl iodide as co-catalysts to afford *N*-ethylpiperidine as a sole product (Table 1). Methyl iodide, or iodine can be used instead of ethyl iodide, however, bromides such as benzyl bromide were less effective. Pyridine shows the same effect as diethylamine, but triethylamine and *t*-butylamine showed nearly no effect.

Optimized conditions are as follows: A mixture of tertiary amide (1.0 mmol), $Et_3SiH$ (3–3.5 mmol), and transition metal complexes ([Metal]=0.01 mmol), amine (0.05 mmol), and halide (0.05 mmol) in toluene (1.0 ml) was heated at 100°C under Ar atmosphere. Product yields were measured by GLC analysis of the reaction mixture.

Not only triorganohydrosilanes such as triethylsilane, phenyldimethylsilane, *tert*-butyldimethylsilane and triisopropylsilane, but also chlorosilane or alkoxysilanes such as chlorodimethylsilane, ethoxydimethylsilane, diethoxymethylsilane and triethoxysilane, gave satisfac-

**Table 2.** Reduction of *N*-acetylpiperidine using hydrosilanes catalyzed by Ru or Os complexes




| $HSiR_3$ | Cat. 1 (1 mol%) | Cat. 2 (5 mol%) | Cat. 3 (5 mol%) | Time (h) | Yield (%) |
|---|---|---|---|---|---|
| $HSiEt_3$ | $Os_3(CO)_{12}$ | | $Et_2NH$ | 16 | 99.8 |
| $HSiMe_2Ph$ | $RuCl_2(CO)_2(PPh_3)_2$ | EtI | | 16 | 90.2 |
| $HSiMe_2{}^tBu$ | $RuCl_2(CO)_2(PPh_3)_2$ | EtI | | 16 | 70.4 |
| $HSi^iPr_3$ | $[RuCl_2(CO)_3]_2$ | EtI | $Et_2NH$ | 40 | 50.6 |
| $HSiMe_2Cl$ | $Os_3(CO)_{12}$ | | $Et_2NH$ | 16 | 80.1 |
| $HSiMe_2(OEt)$ | $RuCl_2(CO)_2(PPh_3)_2$ | EtI | | 16 | 93.1 |
| $HSiMe(OEt)_2$ | $RuCl_2(CO)_2(PPh_3)_2$ | EtI | | 16 | 90.8 |
| $HSi(OEt)_3$ | $[RuCl_2(CO)_3]_2$ | EtI | $Et_2NH$ | 16 | 86.1 |

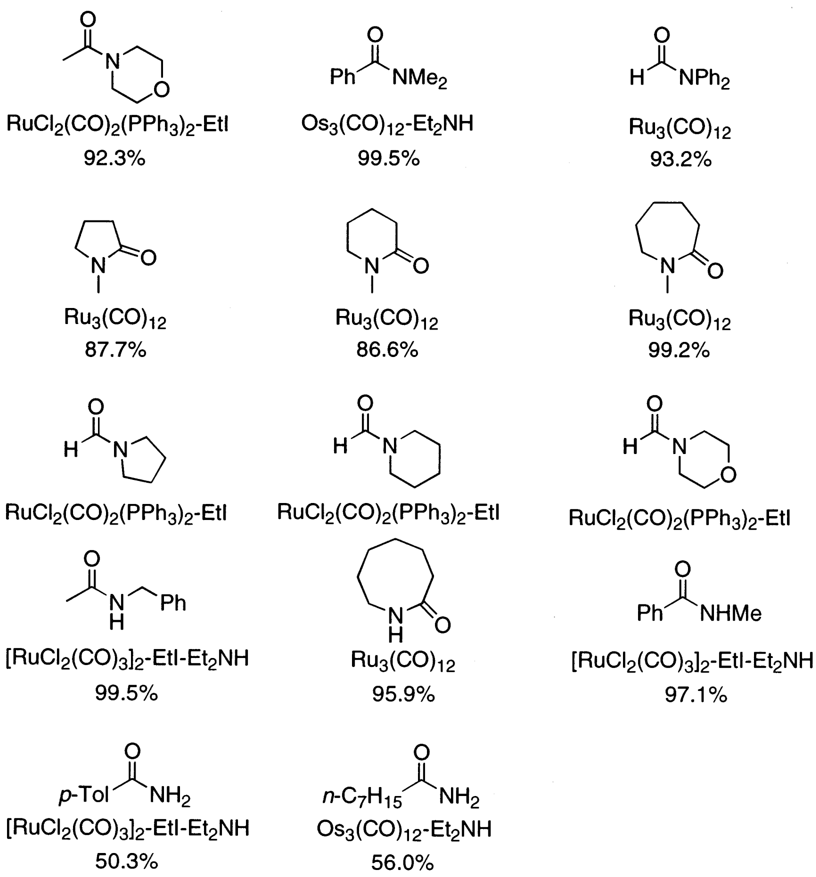



**Figure 1.** Reduction of cyclic and acyclic amides using triethylsilane.

tory yields of the products (Table 2). Lower yields in *tert*-butyldimethylsilane and triisopropylsilane may be attributed to the steric hindrance.

As shown in Fig. 1, a variety of cyclic and acyclic tertiary amides can be reduced to the corresponding amines under similar reaction conditions. Excess of triethylsilane should be required in the reaction with secondary amides (3–4 equiv.) and primary amides (4–5 equiv.), because dehydrogenative silylation of the N–H bond takes place faster than the reduction (within 30 min under the present reaction conditions). In the reaction with *N*-benzylacetamide, *N*-triethylsilyl-*N*-ethylbenzylamine was obtained in 80.3% yield with 18.7% of *N*-ethylbenzylamine before hydrolysis.

In summary, we have developed facile and efficient methods for the transformation of amides to amines by transition-metal complex-catalyzed reduction using monohydrosilanes. Our method has the following advantages. A variety of less expensive monohydrosilanes can be used as the reducing agent. Primary, secondary and tertiary amides can be converted into the corresponding amines. If desired, silyl-protected amines can be isolated before hydrolysis in the reaction with primary or secondary amides.

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