The Remarkable Solvent Effect on $Zn(OAc)_2$-Catalyzed Hydrosilylation of Ketones

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The combination of $Zn(OAc)_2$ and *N*,*N*-dimethylformamide was found to effectively hydrosilylate various ketones at room temperature. Furthermore, our protocol allows the chemoselective reduction of a formyl group in the presence of a ketone group.

Key words hydrosilylation; zinc; silane; chemoselective reduction

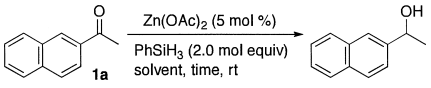
Reduction of C=O bonds to alcohols, is an important reaction in organic synthesis.[1] Among the available reduction methods, hydrosilylation is very useful because of its less severe reaction, as compared with other reduction methods such as the one that uses $LiAlH_4$. As part of a program for development of synthetic reactions using catalysts, composed of elements with a high Clarke number,[2—4] we planned to investigate the catalytic hydrosilylation of ketones using $Zn(OAc)_2$.

During this search, the research group led by Nishiyama had independently reported the hydrosilylation of ketones in tetrahydrofuran (THF) at 65 °C using $Zn(OAc)_2$ and $(EtO)_2MeSiH$.[5] Therefore, we decided to further develop effective hydrosilylation. We intensively examined the hydrosilylation of 2-acetonaphtone (**1a**) with $PhSiH_3$ in various solvents (Table 1): the use of Ph_3SiH, Ph_2SiH_2, $(EtO)_3SiH$, and Et_3SiH as silane reagents gave less satisfactory results. Remarkably, only *N*,*N*-dimethylformamide (DMF) allowed effective hydrosilylation at room temperature.

Under the optimized conditions, the reaction proved to be a general reaction and could be applied to a broad range of ketones (Table 2). Specifically, the reaction proceeded smoothly under mild conditions with a synthetically acceptable catalyst loading (5 mol%). Various benzylic ketones **1b**—**i**, aliphatic ketones **1j**—**l** and α,β-unsaturated ketones **1m** were employable, affording the corresponding reduction products in good yields. Fortunately, our method was found to allow the chemoselective reduction of an aldehyde in the presence of a ketone group or a ketone in the presence of cyano and ester groups as shown in Fig. 1.

In summary, the combination of $Zn(OAc)_2$ and DMF was

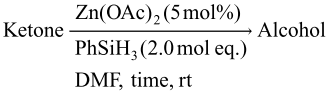
Table 1. Solvent Effect in $Zn(OAc)_2$-Catalyzed Hydrosilylation

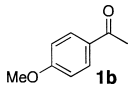
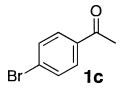
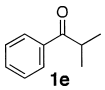
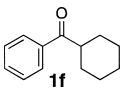
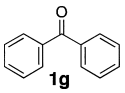
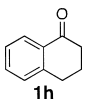
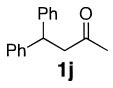
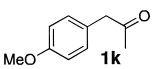
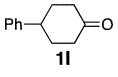


Entry	Solvent	Time (h)	Yield (%)
1	DMF	2	quant
2	MeCN	4	trace[a]
3	MeOH	4	trace[a]
4	EtOAc	4	trace[a]
5	THF	4	trace[a]
6	dioxane	4	trace[a]
7	toluene	4	trace[a]

a) TLC revealed the major component to be the starting ketone.

Table 2. Substrate Generality



Entry	Substrate	Time (h)	Yield (%)
1		24	quant
2		24	quant
3		9	95
4		6	81
5		6	91
6		24	96
7		5	quant
8		3	97
9		4	quant
10		24	87
11		2	quant[a]
12		6	quant[b]

a) Only anti-product was obtained. *b*) Reduced in only the 1,2-mode.

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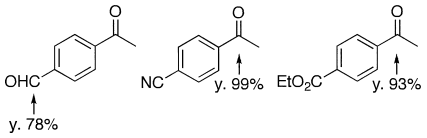

Fig. 1. Chemoselective Hydrosilylation

found to effectively hydrosilylate various ketones at room temperature. Recently, chemoselective hydrosilylation of an amide in the presence of a ketone group with $Zn(OAc)_2$ and $(EtO)_3SiH$ in THF, was reported by Beller's group.[6] Interestingly, Beller's results are different from our results, which hydrosilylate ketones in amide solvent, DMF.

Experimental

General IR spectra were measured on a SHIMADZU FTIR-8100 diffraction grating IR spectrophotometer. ^{1}H- and ^{13}C-NMR spectra were measured on a JEOL JNM-EX-270 NMR spectrometer, operating at 270 MHz for ^{1}H-NMR and at 68 MHz for ^{13}C-NMR. ^{1}H- and ^{13}C-NMR spectra were reported in d units, parts per million (ppm) downfield from tetramethylsilane (δ=0). Electron ionization (EI)- and FAB-MS spectra were measured on a JEOL JMS-SX-102A instrument.

Representative Procedure for the Hydrosilylation of 1-(Naphthalen-2-yl)ethanone (1a) (entry 1, Table 1) To a stirred solution of $Zn(OAc)_2$ (4.7 mg, 0.0250 mmol) in DMF (1.00 ml) were added 2-acetonaphthone (86.0 mg, 0.500 mmol) and $PhSiH_3$ (127 μl, 1.00 mmol). The reaction mixture was stirred for 2 h at room temperature. To this mixture, 1 M NaOH was added at 0 °C and then extracted with EtOAc. Organic extracts were washed with brine, dried (Na_2SO_4), and concentrated. Purification by silica gel column (hexane : EtOAc=4 : 1) afforded 1-(naphthalen-2-yl)ethanol (86.1 mg, quant) as a white solid. Physical data were comparable with those of a commercially available sample.

The physical data of the products as described below were comparable with those reported: 1-*o*-tolylethanol (entry 3),[7] 2-methyl-1-phenylpropan-1-ol[8] (entry 4), cyclohexyl(phenyl)methanol[9] (entry 5), 4,4-diphenylbutan-2-ol[10] (entry 9), 1-(4-methoxyphenyl)propan-2-ol[11] (entry 10), (*E*)-4-phenylbut-3-en-2-ol[7] (entry 12), 1-(4-(hydroxymethyl)phenyl)ethanone[12] (Fig. 1), ethyl 4-(1-hydroxyethyl)benzoate (Fig. 1).[13] The physical data of the all other products were comparable with those of a commercially available sample.

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