

Selective Reduction of Aromatic Nitriles to Aldehydes by Lithium Diisobutylpiperidinoaluminumate (LDBPA)

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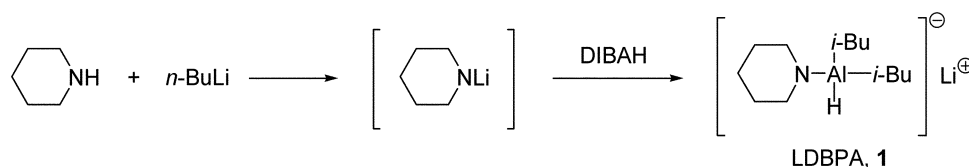
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Partial reduction of nitriles into aldehyde is one of the most important and highly desirable means in organic synthesis, and a large number of reducing agents for this have been reported.¹ Among them, a commercially available diisobutylaluminum hydride (DIBAH)¹ⁱ is commonly used for the preparation of aldehydes from both aromatic and aliphatic nitriles, although the reagent provides moderate yields (48-90%). It has been also reported that other several reducing agents such as potassium 9-*sec*-amyl-9-borata-cyclo[3.3.1]nonane (K-9-*sec*-Am-9-BBNH),^{1f} lithium tris-(dihexylamino)aluminum hydride (LTDHA)^{1g} and lithium *N,N'*-dimethylethylenediaminoaluminum hydride (LDME-DAH)^{1k} reduce chemoselectively nitriles to aldehydes. We have recently reported that diisobutylpiperidinoaluminumate (LDBPA, **1**)² can effectively reduce esters to aldehydes in moderate to good yields at 0 °C.

As a part of our research program directed toward the discovery of new reducing agents through the simple modification of commercial DIBAH (Scheme 1), we applied this reagent for the partial reduction of nitriles to aldehydes.

We first examined partial reduction of benzonitrile and capronitrile with **1** in THF at 0 °C. The reduction of benzonitrile provided benzaldehyde in quantitative yield in 1 h. Using the same methodology, the partial reduction of other aromatic and aliphatic nitriles to the corresponding aldehydes was carried out. As shown in Table 1, aromatic benzonitriles, such as 1-cyanonaphthalene, chlorobenzonitriles, toluonitriles and methoxybenzonitriles were smoothly reduced to the corresponding aldehydes in quantitative yields (entries 1-11). Among them, the reduction of toluonitriles and methoxybenzonitriles required longer reaction time than other nitriles (entries 7-11). This may be



Scheme 1. Preparation of LDBPA.

Table 1. Yields of aldehydes in the reduction of representative nitriles with LDBPA at 0 °C

entry	nitrile	product	reaction condition		yield (%) ^a
			H ⁻ /ester	time (h)	
1	benzonitrile	benzaldehyde	1.2	1	99
2	1-cyanonaphthalene	1-cyanonaphthylaldehyde	1.2	2	98
3	2-chlorobenzonitrile	2-chlorobenzaldehyde	1.2	1	97
4	3-chlorobenzonitrile	3-chlorobenzaldehyde	1.2	1	98
5	4-chlorobenzonitrile	4-chlorobenzaldehyde	1.2	1	97
6	2,6-dichlorobenzonitrile	2,6-dichlorobenzaldehyde	1.2	1	98
7	2-tolunitrile	2-tolualdehyde	1.2	12	98
8	3-tolunitrile	3-tolualdehyde	1.2	12	97
9	4-tolunitrile	4-tolualdehyde	1.2	12	98
10	2-methoxybenzonitrile	2-methoxybenzaldehyde	3.0	24	99
11	4-methoxybenzonitrile	4-methoxybenzaldehyde	3.0	24	99
12	capronitrile	caproaldehyde	1.2	1	no reaction
13	undecyl cyanide	undecylenic aldehyde	1.2	1	no reaction

^aYields were determined by GC.

Table 2. Selective reduction of benzonitrile in the presence of capronitrile with LDBPA at 0 °C^{a,b}

compound	product	yield (%) ^c
benzonitrile and capronitrile	benzaldehyde	99
	benzonitrile	0
	caproaldehyde	0
	capronitrile	99

^aThe reduction of a 1 : 1 mixture of benzonitrile and capronitrile using 1.2 equiv of **1** was carried out. ^bReacted for 1 h. ^cYields were determined by GC.

attributed to the electron donating effect of methyl or methoxy group. In contrast, aliphatic nitriles, such as capronitrile and undecyl cyanide were not reduced entirely (entries 12-13). The results indicate that the reagent **1** can selectively reduce aromatic nitriles in the presence of aliphatic nitriles. Indeed, when **1** was reacted with a 1 : 1 mixture of benzonitrile and capronitrile at 0 °C, the reaction afforded only benzaldehyde with essentially no reduction of the capronitrile (Table 2).

In summary, we have established a convenient method for the conversion of aromatic nitriles to the corresponding aldehydes in high yields using **1** as a selective reducing agent. It was found that the reagent did not reduce aliphatic nitriles to allow a chemoselective conversion of aromatic nitriles in the presence of aliphatic nitriles.

Experimental Section

General. All glassware used was dried thoroughly in an oven, assembled hot, and cooled under a stream of dry nitrogen prior to use. All reaction and manipulation of air and moisture sensitive materials were carried out using standard techniques for handling air sensitive materials. All chemicals were commercial products of the highest pure which were purified further by standard methods before use. THF was dried over sodium-benzophenone and distilled. Diisobutylaluminum hydride (DIBAH) and *n*-butyllithium were purchased from Aldrich Chemical Company. GC analyses were performed on a Donam DS 6200 FID chromatograph, using a HP-1 (Crosslinked methyl siloxane) capillary column (30 m). All GC yields were determined with use of a suitable internal standard and authentic mixture. LDBPA, **1** was prepared from DIBAH according to the reported procedure.²

Reduction of nitriles with LDBPA to aldehydes. Reduc-

tion of benzonitrile is representative. To a solution of benzonitrile (0.051 mL, 0.5 mmol) in THF (5 mL) containing naphthalene as an internal standard was added LDBPA (1.2 mL, 0.5 M in THF-hexane) at 0 °C. After 3 h, the reaction mixture was hydrolyzed with 5 mL of 1 N HCl (aq) and the product was extracted with 10 mL of diethyl ether. The ether layer was dried over anhydrous potassium carbonate. GC analysis showed 99% yield of benzaldehyde.

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