

Lithium Diisobutylpiperidinoaluminumate (LDBPA) as a Mild and Efficient Reducing Agent for the Conversion of Ester to Aldehyde

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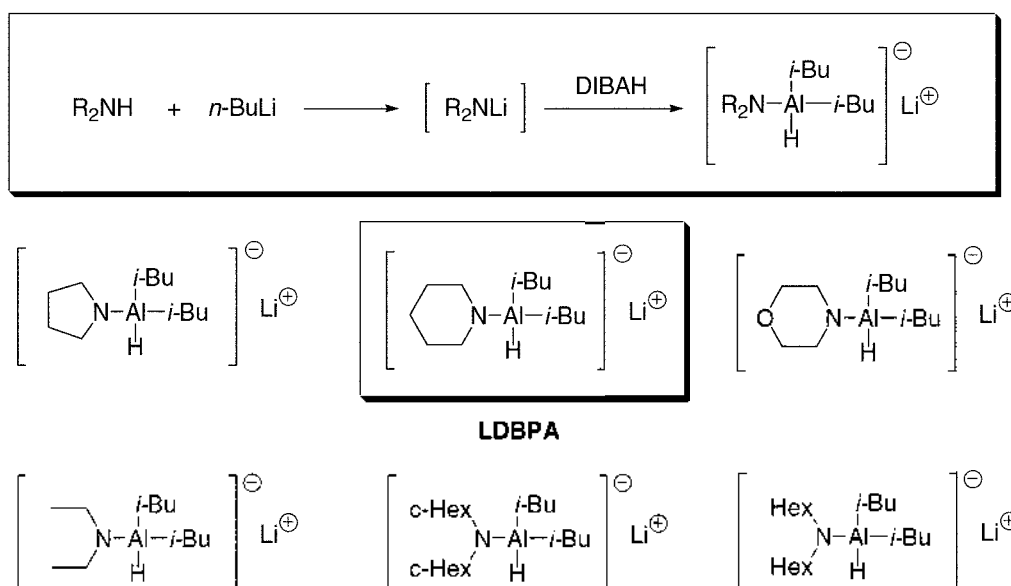
Key Words : Lithium diisobutylpiperidinoaluminumate (LDBPA), Diisobutylaluminum hydride, Aldehyde, Partial reduction, Piperidine

Partial reduction of ester to aldehyde is very efficient and reliable procedure in organic synthesis, and a number of reducing agents for this have been reported.¹⁻⁵ Among them, diisobutylaluminum hydride (DIBAH) which is commercially available is used as one of the most popular reducing agent. However, to achieve the partial reduction successfully, this reagent requires very low temperature ($-78\text{ }^{\circ}\text{C}$). Recently, we^{5a,b} reported the synthesis of aldehyde from ester with sodium diethylpiperidinoaluminumate (SDPA) at $0\text{ }^{\circ}\text{C}$. However, sodium diethylaluminum hydride which is the precursor for synthesis of SDPA is not commercially available. In the course of our program for developing new selective reducing agent, we found that lithium diisobutyl-dialkylaminoaluminumates prepared from DIBAH smoothly reduced esters to aldehydes at $0\text{ }^{\circ}\text{C}$, although it has been reported that the reduction of esters to aldehydes using aluminum hydride derivatives having *n*-butyl⁶ or alkoxy⁷ groups obtained from DIBAH has been not successful. We hereby report such conversion using these new mild and efficient reducing agents.

Scheme 1 outlines the preparation of lithium diisobutyl-

dialkylaminoaluminumates from DIBAH. Thus, when an equimolar amount of lithium dialkylamides with DIBAH was reacted in THF at $0\text{ }^{\circ}\text{C}$ or room temperature, these reagents were obtained quantitatively. Next, we examined partial reduction of esters to aldehydes using these hydride reagents in THF at $0\text{ }^{\circ}\text{C}$. Of these hydrides examined, we found that lithium diisobutylpiperidinoaluminumate (LDBPA)⁸ provided the best results. So we have applied this LDBPA for the synthesis of aldehydes from the various esters at $0\text{ }^{\circ}\text{C}$. The results for representative esters are summarized in Table 1.

As shown in Table 1, ethyl benzoate was smoothly reduced to produce benzaldehyde in 83% yield (entry 1).⁹ Under identical conditions, the reduction with DIBAH itself provided only benzyl alcohol (entry 2). Similarly, reduction of isopropyl benzoate afforded benzaldehyde in 81% yield (entry 3). The case of *t*-butyl benzoate under the same condition proceeded somewhat slowly (entries 4-6). It is attributable to the bulky size of *t*-butyl group. Also, reduction of other aromatic esters, such as phenyl benzoate, methyl 3,4-dimethoxybenzoate and methyl 3-chlorobenzoate,



Scheme 1. Preparation of lithium diisobutyl-dialkylaminoaluminumates.

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

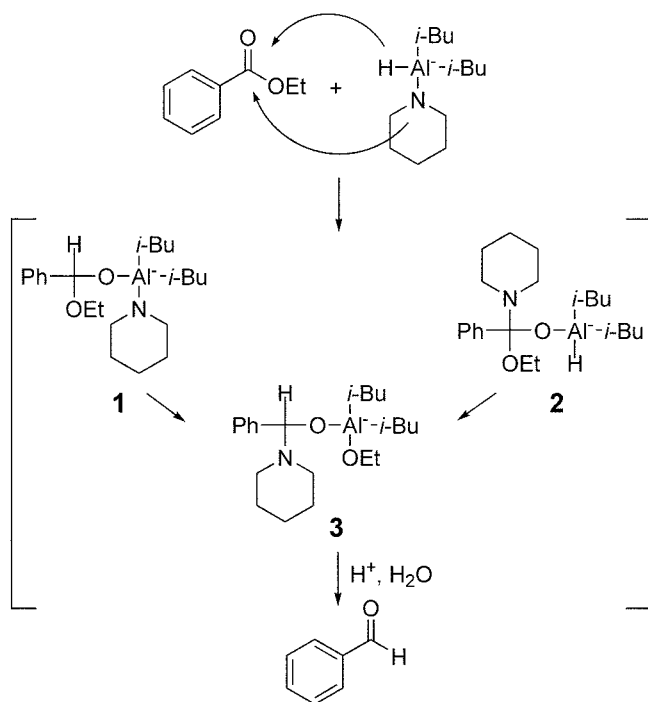
entry	compound	product	reaction condition		yield (%) ^a
			H ⁺ /ester	time (h)	
1	ethyl benzoate	benzaldehyde	1.5	1	83
2			(1.5)	(1)	(0) ^b
3	isopropyl benzoate	benzaldehyde	1.5	1	81
4	t-butyl benzoate	benzaldehyde	1.5	1	57
5			2.0	1	69
6			2.5	1	71
7	phenyl benzoate	benzaldehyde	1.5	1	67
8	methyl 3,4-dimethoxybenzoate	3,4-dimethoxybenzaldehyde	1.5	1	67
9	methyl-3-chlorobenzoate	3-chlorobenzaldehyde	1.5	1	83
10	ethyl caproate	caproaldehyde	2.0	1	66
11	isopropyl caproate	caproaldehyde	2.0	1	77
12	ethyl undecanoate	undecanal	2.0	1	54
13	ethyl cinnamate	cinnamyl aldehyde	2.0	1	47

^aYields were determined by GC. ^bYields obtained by DIBAH alone are shown in parenthesis.

gave the corresponding aldehydes in moderate yields (entries 7-9). Reduction of aliphatic esters, namely ethyl caproate, isopropyl caproate and ethyl undecanoate, and an α,β -unsaturated ester, ethyl cinnamate, provided product aldehyde with lower yields than aromatic analogues (entries 10-13).

Although the mechanism of this reduction is not clear, we propose it as follow. Reaction of equimolar esters and LDBPA rapidly forms two unstable intermediates **1** and **2** by the attack of hydride or piperidyl group on sp^2 carbon of ester, and these are quickly transformed into a more stable intermediate, α -piperidyl alkoxoaluminate **3**, by the rearrangement involving migration of piperidyl group or hydride (Scheme 2).

In summary, we have prepared a series of lithium

**Scheme 2**

diisobutyl dialkylaminoaluminates by reacting DIBAH with lithium dialkylamides. Among them, LDBPA was most effective for partial reduction of esters to aldehydes in moderate to good yields at 0 °C. This reagent proved to be one of effective partial reducing agents for preparation of esters to aldehydes. Therefore, LDBPA is believed to be an alternative reagent for the synthesis of aldehydes from esters instead of DIBAH.

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References and Notes

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- The following procedure for the preparation of LDBPA is illustrative. To a solution of piperidine (0.99 mL, 10 mmol) in THF (2.76 mL) was added *n*-butyllithium (6.25 mL, 1.6 M in hexane, 10 mmol) at 0 °C. After being stirred for 1 h at room temperature, to this added dropwise DIBAH (10 mL, 1.0 M in hexane, 10 mmol) at 0 °C and the mixture was stirred for 1 h at room temperature. The result was clear colorless solution.
- The following procedure for the reduction of ethyl benzoate with LDBPA is representative. To a solution of ethyl benzoate (0.07 mL, 0.5 mmol) in THF (5 mL) containing naphthalene as an internal standard was added LDBPA (1.5 mL, 0.5 M in THF-hexane) at 0 °C. After 3h, 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 an 83% yield of benzaldehyde.