

BULLETIN

OF THE

KOREAN CHEMICAL SOCIETY

ISSN 0253-2964
Volume 24, Number 1

BKCSDE 24(1)
January 20, 2003

Communications

Transformation of Carboxylic Esters to Aldehydes with Lithium *N,N'*-Dimethylethylenediaminoaluminum Hydride

Jin Soon Cha,^{*} Seung Ho Jang, Jung Hag Park, Seog K. Kim, Chong-Soon Lee,[†] and Yong Rok Lee[‡]

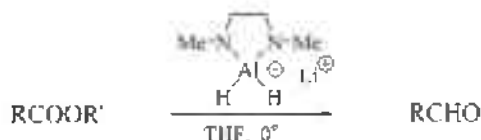
Department of Chemistry, Institute of Natural Sciences, [†]Department of Biochemistry, and [‡]School of Chemical Engineering and Technology, Yeungnam University, Gyongsan 712-749, Korea

Received August 8, 2002

Key Words : Aldehyde synthesis, Ester reduction, Lithium *N,N'*-dimethylethylenediaminoaluminum hydride

Reductions of carboxylic esters to aldehydes are fundamental transformation in synthetic organic chemistry. Therefore, a number of useful reducing agents for such transformation have been reported, *e.g.*, lithium tri-*tert*-butoxyaluminum hydride,¹ diisobutylaluminum hydride,² sodium diisobutylaluminum hydride,³ tris(4-methyl-1-piperazinyl)aluminum hydride,⁴ sodium diethylpiperidinylaluminum hydride,⁵ and sodium and lithium tris(diethylamino)aluminum hydrides.^{6,7} In addition to those, the reduction-oxidation procedure appeared promising for transformation of carboxylic esters to aldehydes.^{8,9}

Very recently, we have synthesized a new class of reducing agents, cyclic diamino-derivatives of lithium aluminum hydride, and applied them for selective reduction of organic functionalities. In the course of this study, we found that lithium *N,N'*-dimethylethylenediaminoaluminum hydride (LDMEDAH),¹⁰ one of these diamino-derivatives, effects the transformation of esters to aldehydes in good yields at 0 °C.



We first examined the reactions of ethyl caproate and ethyl benzoate as representatives of aliphatic and aromatic esters under the various reaction conditions: *i.e.*, change in the ratio of reagent to compound and the reaction temperature. The reactions of ethyl caproate and ethyl benzoate with a half equivalent of the reagent (*i.e.*, one equivalent of hydride)

generated only about 50% yield of the corresponding aldehydes along with the corresponding alcohols and the unreacted starting esters. The reaction temperature at 0 or -20 °C did not show any difference in the yield. However, when we examined the reaction with one equivalent of the reagent (*i.e.*, two equivalents of hydride) and found that the yields of aldehydes increased up to 77-92% along with the corresponding alcohols. These reaction also showed no reaction temperature dependence. Accordingly, we performed all the following reactions of representative esters with one equivalent of the reagent at 0 °C.¹¹

As shown in Table 1, the reagent, LDMEDAH, reduces aliphatic carboxylic esters to aldehydes in yields of 75-82%. There does not seem to exist any significant steric factor in influencing the yields: regardless of the structure of alkyl and alkoxy portion of aliphatic esters, the yields appeared rather constant. The reduction of aromatic esters by this reagent provides the corresponding aldehydes in 80-95% yields. The yields of aromatic aldehydes are somewhat higher than those obtained from the reaction of aliphatic esters. The unsubstituted benzoate with a variety of alkoxy portions are reduced to benzaldehyde in yields of 80-90%, showing no significant difference in the yields. Methyl-substituted benzoates such as 3- and 4-methyl benzoates afford the corresponding aldehydes in 91-92% yields. Finally, chloro, nitro and methoxy groups on the benzene ring are readily accommodated and gave aldehydes in better than 90% yield; however the yield in the reduction of amino-substituted benzoate such as ethyl 4-aminobenzoate is somewhat low to give 68%.

In summary, we have developed a newly-devised cyclic

Table 1. Yields of Aldehydes in the Reduction of Representative Carboxylic Esters with Lithium *N,N'*-Dimethylethylenediaminoaluminum Hydride(LDMEDAH) in Tetrahydrofuran

Ester	Ratio of LDMED A/Ester	Temp. (°C)	Reaction time (h)	Yield (%) ^a		
				Aldehyde	Alcohol	Ester ^b
Ethyl caproate	0.5	0	0.5	48	28	23
			1.0	49	26	24
		-20	0.5	49	24	26
	1	0	0.5	78	21	0
			1.0	78	21	0
		-20	0.5	77	21	2
Isopropenyl acetate	1	0	0.5	77	22	0
			1.0	74	24	0
Phenyl acetate	1	0	0.5	81	19	0
			1.0	82	18	0
Ethyl butyrate	1	0	0.5	75	24	0
			1.0	73	27	0
Ethyl isobutyrate	1	0	0.5	73	25	0
			1.0	74	25	0
Ethyl isovalerate	1	0	0.5	74	26	0
			1.0	74	25	0
Ethyl caprylate	1	0	0.5	72	26	2
			1.0	75	24	1
Ethyl benzoate	0.5	0	0.5	43	20	37
			1.0	48	24	26
			3.0	47	23	28
	1	-20	0.5	55	19	26
			1.0	57	19	24
		0	0.5	92	6	0
1.5	0	1.0	92	6	0	
		-20	0.5	90	3	0
Methyl benzoate	1	0	1.0	92	4	0
			0.5	88	11	0
Butyl benzoate	1	0	0.5	85	14	0
			1.0	84	14	0
Phenyl benzoate	1	0	0.5	80	19	0
			1.0	80	19	0
Ethyl 3-methylbenzoate	1	0	1.0	89	10	0
			1.0	90	10	0
Ethyl 4-methylbenzoate	1	0	1.0	91	7	0
			1.0	92	7	0
Methyl 3-chlorobenzoate	1	0	1.0	92	7	0
			1.0	94	4	0
Methyl 4-chlorobenzoate	1	0	1.0	93	4	0
			1.0	92	7	0
Ethyl 4-chlorobenzoate	1	0	1.0	92	7	0
			1.0	92	7	0
Ethyl 4-aminobenzoate	1	0	1.0	68	30	0
			1.0	91	6	0
Ethyl 4-methoxybenzoate	1	0	1.0	91	6	0

^aAnalyzed by GC with an internal standard. ^bThe unreacted starting ester.

diamino-derivative of lithium aluminum hydride and found that the reagent reduces both aliphatic and aromatic carboxylic esters to the corresponding aldehydes in good yields. A further study in development of alkoxy-derivatives of LDMEDAH is currently underway.

Acknowledgment. This work was supported by Research Grant of Advanced Research Center in Yeungnam University (105096). One of authors (J. S. Cha) thanks Prof. K. H. Ahn (Postech) for his kind suggestion for the reagent. The Al-NMR spectra were recorded on a Bruker AMX 300 spectrometer at the Yeungnam University Instrumental Analysis Center.

References and Notes

- Weissman, P. M.; Brown, H. C. *J. Org. Chem.* **1966**, *31*, 282.
- Zakharkin, L. I.; Khorlina, I. M. *Tetrahedron Lett.* **1962**, 619.
- Zakharkin, L. I.; Khorlina, I. M. *Izv. Akad. Nauk. SSSR. Ser. Khim.* **1964**, 465.
- Muraki, M.; Mukaiyama, T. *Chemistry Lett.* **1975**, 215.
- (a) Yoon, N. M.; Shon, Y. S.; Ahn, J. H. *Bull. Korean Chem. Soc.* **1992**, *13*, 199. (b) Yoon, N. M.; Ahn, J. H.; An, D. K. *Ibid.* **1992**, *13*, 339. (c) Yoon, N. M.; Ahn, J. H.; Ahn, D. K.; Shon, Y. S. *J. Org. Chem.* **1993**, *58*, 1941.
- Cha, J. S.; Kim, J. M.; Jeoung, M. K.; Kwon, O. O.; Kim, E. J. *Org. Prep. Proced. Int.* **1995**, *27*, 95.
- Cha, J. S.; Min, S. J.; Lee, J. C.; Lee, H. S.; Lee, S. E. *Org. Prep. Proced. Int.* **1992**, *24*, 359.
- Cha, J. S.; Kim, J. M.; Chun, J. H.; Kwon, O. O.; Lee, J. C. *Bull. Korean Chem. Soc.* **1998**, *19*, 1301.
- Cha, J. S.; Chun, J. H.; Kim, J. M.; Lee, D. Y.; Cho, S. D. *Bull. Korean Chem. Soc.* **1999**, *20*, 1373.
- The procedure for the preparation of lithium *N,N'*-dimethylethylenediaminoaluminum hydride (LDMEDAH) in THF is following. To an oven-dried, 200-mL flask fitted with a side-arm and a stopcock leading to a mercury bubbler was added 50 mL of 2 M solution of LAH in THF and the solution was cooled to -78 °C using dry ice-acetone bath. To this solution was added 101 mL of a precooled 1 M solution of *N,N'*-dimethylethylenediamine in THF dropwise. After the hydrogen evolution, the resulting LDMEDAH solution was diluted with THF to be 0.5 M, and the ²⁷Al NMR spectrum of the solution showed a triplet (*J*_{Al-H} = 170 Hz) centered at δ 78 ppm relative to [Al(H₂O)₆]³⁺.
- The following procedure for the reduction of ethyl benzoate with 1 equiv of LDMEDAH at 0 °C is representative. An oven-dried 50-mL flask, fitted with a side-arm and a bent adapter connected to a mercury bubbler, was flushed with dry nitrogen and charged with 8.0 mL of the reagent solution (4.0 mmol) and *n*-dodecane as an internal standard. The solution was cooled to 0 °C in an ice-water bath and 4.0 mL of a precooled 1 M solution of ethyl benzoate (4.0 mmol) in THF was added with stirring. At the appropriate time interval of 0.5 and 1.0 h, an aliquot was withdrawn and quenched with 3 N HCl. The organic layer was dried over anhydrous MgSO₄ and subjected to GC analysis to indicate the presence of benzaldehyde in yields of 92%, respectively (Table 1).