

Conjugate Addition of Hydrogen Azide to the α,β -Unsaturated Carbonyl Compounds: New Azidoaluminum Reaction with Diethylaluminum Azide

Bong Young Chung*, Young Sook Park, In Sik Cho, and Bong Chul Hyun

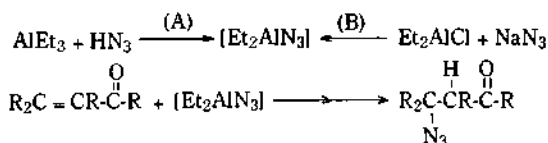
Department of Chemistry, Korea University, Seoul 136-701. Received April 18, 1988

Diethylaluminum cyanide which was prepared from triethylaluminum and hydrogen cyanide has been successfully employed for the conjugate addition of hydrogen cyanide to the α,β -unsaturated ketones¹ and esters². The structurally related diethylalkynylalanes have also been developed to transfer alkynyl unites to the β -carbon of the α,β -unsaturated carbonyl compounds³ and to open the epoxide rings⁴.

In view of the easy migratory aptitude of the *sp*-hybridized carbons of the above aluminum reagents, we have prepared a new aluminum reagent, *diethylaluminum azide* and investigated its reaction with simple α,β -unsaturated carbonyl compounds. So far, conjugate addition of hydrogen azide to the α,β -unsaturated carbonyl compounds has mainly been studied in acidic media (i.e., aqueous AcOH, CHCl_3 , $\text{AcOH-CCl}_3\text{COOH}$)⁵, but only with poor results.

Diethylaluminum azide may be prepared either from triethylaluminum and hydrogen azide or from diethylaluminum chloride and sodium azide. Thus, reaction of 15% triethylaluminum in hexane with equimolar amounts of hydrogen azide in chloroform⁶ at room temperature for 1 hr (*Method A*) followed by solvent removal left oily residue⁷. The ir spectrum of this residue in chloroform showed a strong absorption band at $\nu = 2140 \text{ cm}^{-1}$, which indicates the presence of the azido group. Reaction of 20% diethylaluminum chloride in hexane with 1.2 equivalents of sodium azide in dichloromethane at room temperature for 2 hr, subsequent transfer of the supernatant liquid with hypodermic syringe (*Method B*), and solvent removal also left oily residue. Its ir spectrum indicated the presence of the azido group.

The above results have clearly demonstrated the formation of diethylaluminum azide by either *Method A* or *Method B*, and thus, we have investigated the conjugate addition of hydrogen azide to the α,β -unsaturated carbonyl compounds with diethylaluminum azide.



Reaction of the α,β -unsaturated carbonyl compounds with 1.5-2.0 equivalents of diethylaluminum azide in dichloromethane (*Method A*) or in hexane-dichloromethane (1:2) (*Method B*) at room temperature for 5 hr and subsequent basic (aqueous NaHCO_3) work-up produced β -azidocarbonyl compounds in moderate yields (see Table 1). In general, flexible cisoid enones gave better results compared to the transoid enones; which can be best understood through the precedent reaction mechanism involving six-membered cyclic transition state^{3,8}. The moderate results from the cisoid enones may be ascribed to the partial decomposition of the intermediary diethylaluminum azide by moisture and to the

Table 1. Hydroazidation of α,β -Unsaturated Carbonyl Compounds with Diethylaluminum Azide

	Yields*(%)
$\text{R}^1 = \text{CH}_3, \text{R}^2 = \text{R}^3 = \text{R}^4 = \text{H}$	82 (65)
$\text{R}^1 = \text{R}^3 = \text{R}^4 = \text{CH}_3, \text{R}^2 = \text{H}$	78 (66)
$\text{R}^1\text{-R}^2 = \text{CH}_2\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}_2, \text{R}^3 = \text{R}^4 = \text{CH}_3$	92 (40)
$\text{R}^1\text{-R}^4 = \text{CH}_2\text{CH}_2, \text{R}^2 = \text{R}^3 = \text{H}$	32 (24)
$\text{R}^1\text{-R}^4 = \text{CH}_2\text{CH}_2\text{CH}_2, \text{R}^2 = \text{R}^3 = \text{H}$	23 (20)
$\text{R}^1\text{-R}^4 = \text{CH}_2\text{C}(\text{CH}_3)_2\text{CH}_2, \text{R}^2 = \text{H}, \text{R}^3 = \text{CH}_3$	22 (23)
$\text{R}^1 = \text{OCH}_2\text{CH}_3, \text{R}^2 = \text{R}^3 = \text{R}^4 = \text{H}$	65 (63)
$\text{R}^1\text{-R}^4 = \text{OCH}_2\text{CH}_2, \text{R}^2 = \text{R}^3 = \text{H}$	40 (23)

*Isolated yields after column chromatography by *Method A*. Yields in parenthesis are from *Method B*.

migration of ethyl group rather than azido group. When benzoyl chloride was treated with diethylaluminum azide in dichloromethane at room temperature for 2 hr, benzoyl azide was obtained in 45% yield along with ethyl phenyl ketone in 50% yield. Reaction of benzoyl chloride with triethylaluminum or diethylaluminum chloride also produced ethyl phenyl ketone in ~65% yield.

The typical experimental procedures for the conjugate addition of hydrogen azide to the α,β -unsaturated carbonyl compounds with diethylaluminum azide are exemplified as follows⁹:

Method A. To 4.0 ml of 1.0 M solution of hydrogen azide in chloroform (4.0 mmol) cooled to -78°C , was added 3.6 ml of 15% triethylaluminum in hexane (4.0 mmol), and the solution was stirred for 1 hr at the same temperature. Solvent was removed in vacuo and the oily residue was dissolved in 10 ml of dichloromethane. 0.22 ml of mesityl oxide (2.0 mmol) was added and the solution was stirred at room temperature for 5 hr. The solution was treated with 8% aqueous sodium bicarbonate and washed twice with brine water. Usual work-up and column chromatography on silica gel afforded 4-azido-4-methylpentan-2-one¹⁰ in 88% yield (0.31 g).

Method B. To the suspension of 0.38 g (6.0 mmol) of sodium azide in 8.0 ml of dry dichloromethane, was added dropwise 4.3 ml of 20% diethylaluminum chloride in hexane (5.0 mmol). The mixture was stirred for 2 hr at room temperature and stood to let the solid settle down. The supernatant liquid was transferred to the other flask with hypodermic syringe and mesityl oxide (0.28 ml, 2.5 mmol) was added. The clear solution was stirred for 6 hr at room temperature. Base treatment, usual work-up and column chromatography

just as *Method A* afforded the same product in 63% yield.

Acknowledgement. The financial support of this work by the Korea Science and Engineering Foundation is gratefully acknowledged.

References

1. W. Nagata, M. Yoshioka and T. Terasawa, *J. Am. Chem. Soc.*, **94**, 4672 (1972) and references cited therein.
2. J. N. Marx and G. Minaskanian, *Tetrahedron Lett.*, 4175 (1979).
3. J. Hooz and R. B. Layton, *J. Am. Chem. Soc.*, **93**, 7320 (1981).
4. R. S. Matthews and D. J. Eickhoff, *J. Org. Chem.*, **50**, 3923 (1985).
5. S. Patai, Ed., "The Chemistry of the Azido Group", Interscience Publishers, London, 1971, pp. 57-190.
6. R. Adams, Ed., "Organic Reactions", Vol. 3, John Wiley and Sons, Ltd., New York, 1956, pp. 327.
7. This residue may contain diethylaluminum azide, ethylaluminum diazide and aluminum triazide along with triethylaluminum. We did not attempt to separate pure diethylaluminum azide.
8. (a) R. E. Lutz and W. Reveley, *J. Am. Chem. Soc.*, **63**, 3180 (1941); (b) P. Jacob and H. C. Brown, *J. Am. Chem. Soc.*, **98**, 7832 (1976).
9. The reaction was carried out under dry nitrogen atmosphere
10. The spectral data of this compound: ir (neat); $\nu = 2140$ (azido), 1740 cm^{-1} (carbonyl). $^1\text{H-nmr}$ (CDCl_3); $\delta = 2.65$ (s, 2H, $-\text{CH}_2-$), 2.25 (s, 3H, $\text{CH}_3\text{CO-}$), 1.40 ppm (s, 6H, two CH_3).