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

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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 ketones[1] and esters[2]. The structurally related diethylalkynylalanes have also been developed to transfer alkynyl unites to the β-carbon of the α,β-unsaturated carbonyl compounds[3] and to open the epcxide rings[4].

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, $CHCl_3$-AcOH-CCl_3COOH)[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 chloroform[6] at room temperature for 1 hr (*Method A*) followed by solvent removal left oily residue[7]. The ir spectrum of this residue in chloroform showed a strong absorption band at $\nu = 2140\ cm^{-1}$, 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.

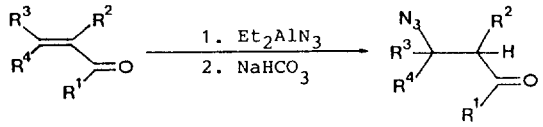
The above results have clearly demonstrated the formation of diethylaluminum azide by either *Method A* or *Method B*, and thus, we have investigated the conjugate addition of hydrogen azide to the α,β-unsaturated carbonyl compounds with diethylaluminum azide.

$$AlEt_3 + HN_3 \xrightarrow{(A)} [Et_2AlN_3] \xleftarrow{(B)} Et_2AlCl + NaN_3$$

$$R_2C{=}CR\text{-}\overset{\overset{O}{\|}}{C}\text{-}R + [Et_2AlN_3] \longrightarrow R_2C(N_3)\text{-}CR\text{-}\overset{\overset{H\ \ O}{|\ \ \|}}{C}\text{-}R$$

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 precedented 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 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.

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



	Yields*(%)
$R^1 = CH_3$, $R^2 = R^3 = R^4 = H$	82 (65)
$R^1 = R^3 = R^4 = CH_3$, $R^2 = H$	78 (66)
R^1-$R^2 = CH_2CH(CH_3)CH_2CH_2$, $R^3 = R^4 = CH_3$	92 (40)
R^1-$R^4 = CH_2CH_2$, $R^2 = R^3 = H$	32 (24)
R^1-$R^4 = CH_2CH_2CH_2$, $R^2 = R^3 = H$	23 (20)
R^1-$R^4 = CH_2C(CH_3)_2CH_2$, $R^2 = H$, $R^3 = CH_3$	22 (23)
$R^1 = OCH_2CH_3$, $R^2 = R^3 = R^4 = H$	65 (63)
R^1-$R^4 = OCH_2CH_2$, $R^2 = R^3 = H$	40 (23)

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

The typical experimental procedures for the conjugate addition of hydrogen azide to the α,β-unsaturated carbonyl compounds with diethylaluminum azide are examplified as follows[9]:

Method A. To 4.0 m*l* of 1.0 M solution of hydrogen azide in chloroform (4.0 mmol) cooled to -78°C, was added 3.6 m*l* 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 m*l* of dichloromethane. 0.22 m*l* 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-one[10] in 88% yield (0.31 g).

Method B. To the suspension of 0.38 g (6.0 mmol) of sodium azide in 8.0 m*l* of dry dichloromethane, was added dropwise 4.3 m*l* 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 trnsferred to the other flask with hypodermic syringe and mesityl oxide (0.28 m*l*, 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.

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References

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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}H-nmr ($CDCl_3$); $\delta = 2.65$ (s, 2H, $-CH_2-$), 2.25 (s, 3H, CH_3CO-), 1.40 ppm (s, 6H, two CH_3-).