Selective Synthesis of (*Z*)-Alk-2-enenitriles from Aldehydes

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A highly stereoselective synthesis of (*Z*)-alk-2-enenitriles from aldehydes is accomplished by reaction with tris(trimethylsilyl)ketenimine, followed by alkali treatment.

The synthesis of alk-2-enenitriles from aldehydes has been realised *via* several routes: Doebner modification of the Knoevenagel reaction,[1] Wittig reaction,[2] Wittig–Horner reaction,[3] Peterson reaction,[4] and direct condensation with acetonitrile.[5] In these reactions, *Z*-isomers are usually produced in lower yield than *E*-isomers, and isolation of the former requires inefficient and laborious fractional distillation or crystallization. We report here a highly stereoselective

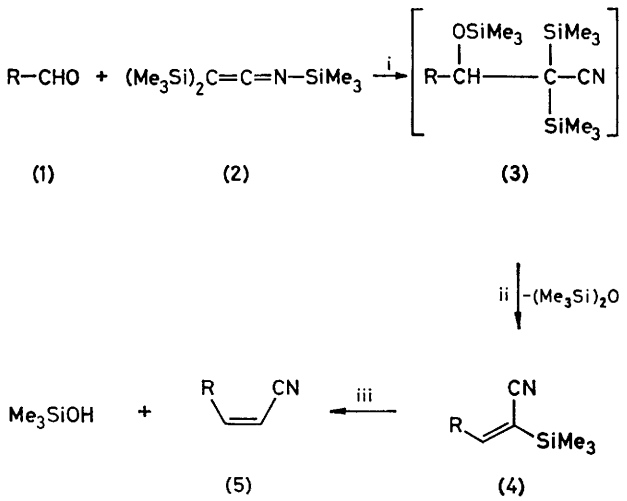
Table 1. Yields of (*E*)-2-trimethylsilylalk-2-enenitriles (**4**) and (*Z*)-alk-2-enenitriles (**5**).[a]

R	% Yield[b] (1) → (4)	% Yield[b] (4) → (5)	% Isomeric purity of (5)[c]
a; n-C_3H_7	78	65	100
b; n-C_5H_{11}	74	85	100
c; Cyclohexyl	67	85	100
d; Et(Bu^n)CH	74	91	100
e; $PhCH_2CH_2$	78	95	100
f; Ph	89	97	96
g; *p*-$MeOC_6H_4$	88	92	96

[a] Satisfactory spectral and analytical data were obtained for all products. [b] All yields refer to isolated materials. [c] Determined on a Silicone DC-550 column.

synthesis of (*Z*)-alk-2-enenitriles from aliphatic and aromatic aldehydes (Table 1).†

Tris(trimethylsilyl)ketenimine (**2**),[6] which was easily prepared by silylation of trimethylsilylacetonitrile,[7] reacted with aldehydes (**1**) to give a 1:1 adduct (**3**) in the presence of BF_3–Et_2O at room temperature in benzene (Scheme 1). Upon heating, (**3**) was converted quantitatively into (*E*)-2-trimethylsilylalk-2-enenitriles (**4**) with the elimination of hexamethyldisiloxane. Compounds (**4**) were distillable oils and stable in neutral and acidic medium at room temperature, but were quickly desilylated in an alkaline medium giving pure (*Z*)-alk-2-enenitriles (**5**). The stereoselectivity of this reaction was high, indeed, the *E* isomers were not detected by either g.l.c. or ^1H n.m.r. spectra of the products, except for the cinnamonitrile (**5f**) and an analogue (**5g**).



Scheme 1. i, BF_3–Et_2O, C_6H_6; ii, heat, C_6H_6; NaOH–MeOH, Et_2O, 0 °C.

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† A typical experimental procedure is as follows. A solution of (**2**) (7.00 mmol) in benzene (5 ml) was added dropwise to an ice-cooled solution of (**1d**) (5.83 mmol) and BF_3–Et_2O (2.91 mmol) in benzene (7 ml). Stirring was continued at 25 °C for 2 h, and then under reflux for 1 h. The mixture was diluted with benzene (20 ml), washed with water (10 ml × 3), dried ($CaCl_2$), and concentrated. Kugelrohr distillation of the residue gave crude (**4d**) (b.p. 130 °C at 35 mmHg). This product contained a small amount of bis(trimethylsilyl)acetonitrile which was removed by means of 10% NaOH (10 ml). 961 mg (74%) of pure (**4d**) resulted, b.p. 115—117 °C at 10 mmHg; i.r. (film) 1595 (C=C) and 2190 cm^{-1}(CN); n.m.r. ($CDCl_3$) δ 0.23 (3H, s, $SiMe_3$) and 6.22 (1H, d, *J* 10.0 Hz, -CH=). To a solution of (**4d**) (3.98 mmol) at 0 °C in ether (40 ml) was added 1M-NaOH in MeOH (4 mmol). The mixture was stirred for 1 h, washed with ice–water (20 ml × 3), dried ($CaCl_2$), and concentrated. Distillation gave 545 mg (91%) of (**5d**), b.p. 128—129 °C at 60 mmHg; i.r. (film) 1622 (C=C) and 2215 cm^{-1} (CN); n.m.r. ($CDCl_3$ δ 5.39 (1H, d, *J* 11.0 Hz, =CH–CN) and 6.27 (1H, d,d, *J* 11.0 and 11.0 Hz, R–CH=).