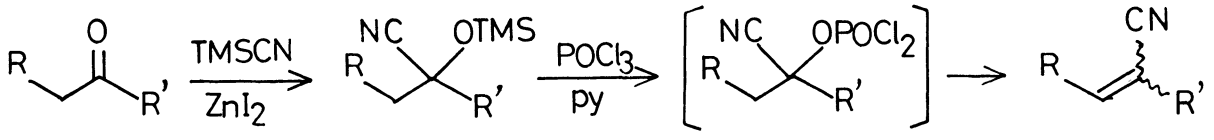
CHEMISTRY LETTERS, pp. 1427-1430, 1979.

ONE-POT TRANSFORMATION OF KETONES TO α,β-UNSATURATED NITRILES VIA TRIMETHYLSILOXY NITRILES

Masaji ODA, Akira YAMAMURO, and Takashi WATABE
Department of Chemistry, Faculty of Science, Tohoku University
Aramaki-aza-Aoba, Sendai 980

Treatment of ketones with trimethylsilyl cyanide in benzene in the presence of a Lewis acid (ZnI_2) as a catalyst and subsequent heating after addition of pyridine and phosphoryl chloride have given α,β-unsaturated nitriles in good yields, providing a general one-pot preparation of α,β-unsaturated nitriles from ketones.

Dehydration of cyanohydrins has been a practical way for the transformation of ketones to α,β-unsaturated nitriles.[1] The transformation, however, suffers some disadvantages which limit the scope of application: (i) the conversion requires a two-step procedure using hazardous hydrogen cyanide in the first step and, (ii) because of equilibrating nature of cyanohydrin formation, conjugated or hindered ketones such as α-tetralone or camphor do not give the corresponding cyanohydrins under usual conditions.[2] Recently, it has been found that trimethylsilyl cyanide (TMSCN) readily adds to ketones 1, even though they are conjugated or hindered ones,[3] and resulting trimethylsiloxy nitriles 2 can be hydrolyzed to cyanohydrins.[4] We found that treatment of trimethylsiloxy nitriles 2 with pyridine and phosphoryl chloride directly gave α,β-unsaturated nitriles 4. The finding provides a general one-pot transformation of ketones 1 to α,β-unsaturated nitriles 4 in virtue of the ready formation of trimethylsiloxy nitriles 2.



1 2 3 4

General procedure of the transformation is as follows: a mixture of a ketone (5 mmol), TMSCN (6-6.5 mmol), and zinc iodide (ca 40 mg) in benzene (2 ml) was stirred at room temperature until the completion of the addition reaction (a few hours to one day; TLC analysis). Pyridine (8 ml) and $POCl_3$ (15 mmol) were added, and the whole mixture was heated to reflux for 5 to 10 h. The cooled dark solution was poured into ice-hydrochloric acid, and extracted with ether. The extract was washed with water and then brine, and dried. The solvent was removed and the product was purified by distillation or column chromatography on silica gel.

The results of some typical experiments are summarized in Table I. When isolated trimethylsiloxy nitriles 2 were used, the yields of α,β-unsaturated nitriles became somewhat better. A great advantage of the present reaction, in addition to the simplicity of the procedure, is that even α-tetralone can be converted, in good yield, into 1-cyano-3,4-dihydronaphthalene (entry f) which was not accessible by the previous method.

When the reaction was applied to bicyclo[4.2.0]oct-7-ene-2,5-dione 5[6], 1,4-dicyanocyclooctatetraene 8 was obtained via the valence isomer 7 in a moderate yield [8: pale yellow needles; mp 128-129°C; δ ($CDCl_3$) 5.9-6.6 br.; λ (EtOH) 217 (log ε 4.43), 307 nm (2.86)]. Similar reaction of bicyclo[4.2.0]octane-2,5-dione 9[6] gave 2,5-dicyanobicyclo[4.2.0]octa-1,5-diene 11 [mp 147-148°C; δ ($CDCl_3$) 2.55 (4H, s), 3.08 (4H, s); λ (EtOH) 302 (log ε 4.12), 314.5 (4.21), 330 nm (4.05)]. In these transformations, the better yields were resulted from the isolated bis-adducts 6 and 10[7] rather than from the one-pot procedure.

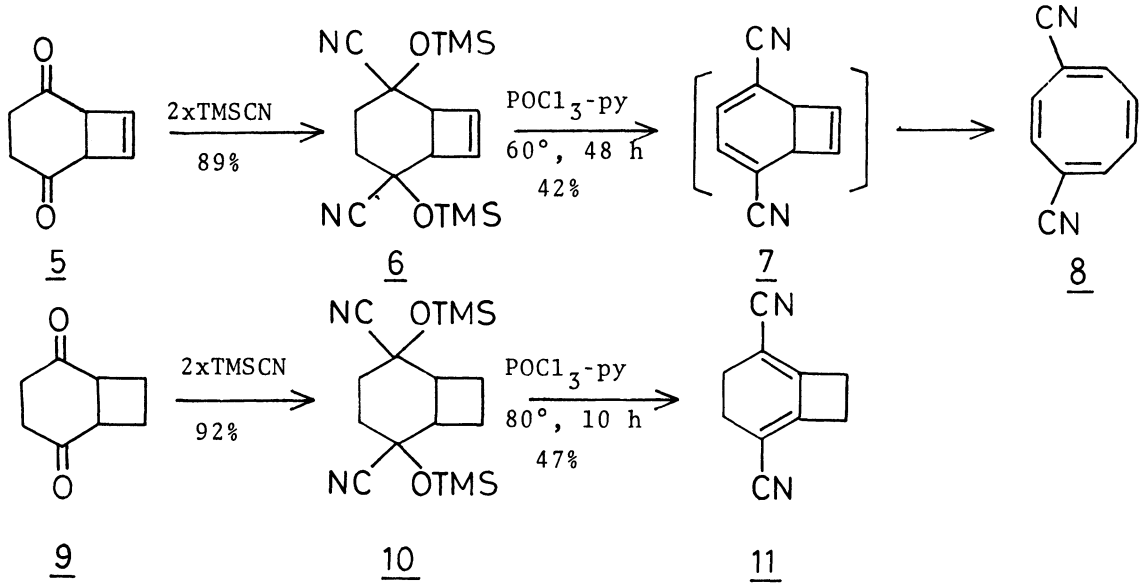
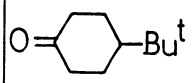
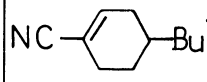
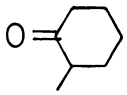
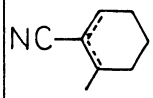
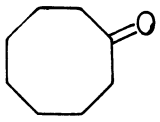
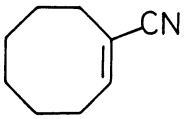
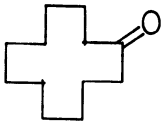
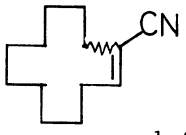
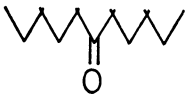
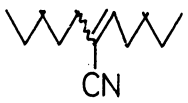
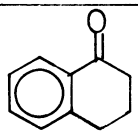
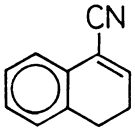
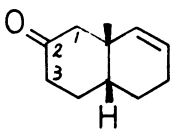
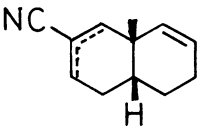


Table I. α,β-Unsaturated Nitriles from Ketones by One-Pot Procedure[a)]

Entry	Ketones	α,β-Unsaturated Nitriles	Yield (%)	Mp or bp/torr (°C)	Lit. mp or bp/torr, or ^{1}H-NMR data, δ ppm[b)]
a			82	45-46	45-46[c)]
b		 (6-Me/2-Me=3/1)[d)]	71	82-83/8	Mix.: 1.20(ca 2.3H,d), 1.4-2.7(ca 6.7H,m), 6.50 (0.75H,m)
c			93	91-92/0.3	100-101/10[e)]
d		 (Z/E=73/27)[d,f)]	85	95-97/0.3	112-118/0.7[g)]
e		 (Z/E=23/77)[d,f)]	87	78-79/1.0	Z: 0.7-1.8(16H,m), 2.17 (4H,m), 6.25(1H,t) E: 0.7-2.0(16H,m), 2.25 (4H,m), 6.05(1H,t)
f			89	88-89/0.3	2.2-3.1(4H,m), 6.80 (1H,t,4.2 Hz), 7.0-7.6 (4H,m)
g	 [h)]	 (Δ^1/Δ^2=56/44)[d)]	79	———	Mix.: 0.68(1.2H,s), 0.83 (1.8H,s), 1.0-2.1 (7H,m), 5.15(2H,m), 5.96(0.44H, br., $W_{1/2}$ =10 Hz, 6.21(0.56H, t,1.8 Hz)

a) Correct mass spectra and/or elemental analyses were obtained for all the new compounds. b) In CCl_4. c) R. A. Abramovitch and D. L. Struble, Tetrahedron Lett., 1966, 289. d) The ratios were determined by GLC (10% SE-30) and/or ^{1}H-NMR spectra. e) J. Sicher, F. Sipos, and J. Jones, Collect. Czech. Chem. Commun., 26, 262 (1961). f) The Z-E assignments were based on their Eu(fod)$_3$ shifted ^{1}H-NMR spectra.[5)] g) von W. Kirchhof, W. Stumpf, and W. Franke, Justus Liebigs Ann. Chem., 681, 32 (1965). h) I. Nagakura, S. Maeda, M. Ueno, M. Funamizu, and Y. Kitahara, Chem. Lett., 1975, 1143.

An intermediate responsible for an elimination of the trimethylsiloxyl group in 2 is probably a phosphoryl ester 3. It is, however, uncertain whether 3 is formed directly by the reaction of the trimethylsiloxy nitrile 2 and phosphoryl chloride or in a two-step process via a cyanohydrin generated in situ by the reaction of 2 and pyridinium hydrochloride.

REFERENCES AND NOTES

1) See the references for Table I and also, L. F. Fieser and M. Fieser, "Reagents for Organic Synthesis," Vol. 1, pp 876-881, John-Wiley and Sons, INC., New York, 1967.

2) D. T. Mowry, Chem. Rev., 42, 189 (1948).

3) a) D. A. Evans, L. K. Truesdale, and G. L. Carroll, J. Chem. Soc. Chem. Commun., 1972, 55; b) D. A. Evans, J. M. Hoffman, and L. K. Truesdale, J. Am. Chem. Soc., 95, 8522 (1973); c) D. A. Evans and L. K. Truesdale, Tetrahedron Lett., 1973, 4929; d) D. A. Evans, G. L. Carroll, and L. K. Truesdale, J. Org. Chem., 39, 914 (1974).

4) P. G. Gassman and J. J. Talley, Tetrahedron Lett., 1978, 3773.

5) J. A. Young and J. G. Grasselli, Anal. Chem., 45, 1410 (1973).

6) M. Oda, H. Oikawa, Y. Kanao, and A. Yamamuro, Tetrahedron Lett., 1978, 4905.

7) Two stereoisomeric bisadducts, cis and trans, were formed, where the cis adduct was overwhelmingly predominant.

6 (cis): mp 118-119°C; δ (CCl_4) 0.27 (18H, s), 2.10 (4H, s), 3.58 (2H, s), 6.07 (2H, s).

6 (trans): liquid; δ (CCl_4) 0.25 (9H, s), 0.30 (9H, s), 3.30 (1H, d, J=4 Hz), 3.45 (1H, d, 4 Hz), 6.27 (2H, m).

10 (cis): mp 82-84°C; δ (CCl_4) 0.24 (18H, s), 2.0 (8H, m), 2.87 (2H, m).

(Received September 8, 1979)