

Trimethylcyanosilane as a Convenient Reagent for the Preparation of Trimethylsilyl Enol Ethers of 1,3-Diketones

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Abstract: Trimethylsilyl enol ethers of 1,3-diketones are generated “in situ” or obtained in high isolated yield by the reaction of 1,3-diketones with trimethylcyanosilane in various solvents such as cyclohexane, hexane, benzene, methylene chloride, chloroform, carbon tetrachloride, and acetonitrile.

Keywords: Trimethylcyanosilane, Silylation, 1,3-Diketones, Trimethylsilyl enol ethers.

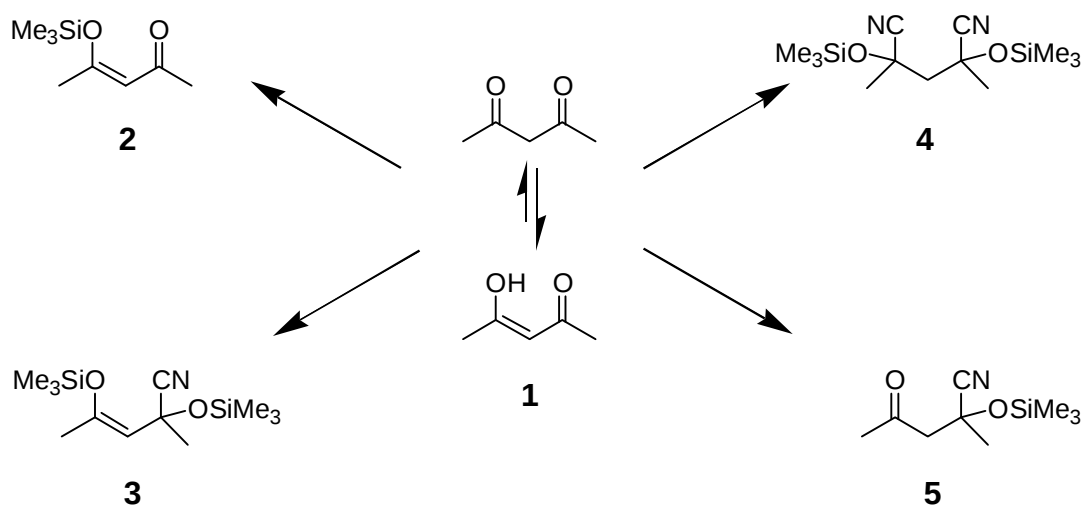
Introduction

Silyl enol ethers of 1,3-diketones are effective silylating agents and useful precursors for the preparation of *Diels-Alder* dienes, 1,3-bis(silyloxy)buta-1,3-dienes. They have found extensive application in organic synthesis. The preparation of the silyl enol ethers of 1,3-diketones resulted in only fair yields by using reagents such as trimethylchlorosilane/strong bases [1], bis(trimethylsilyl)formamide [2], bis(trimethylsilyl)acetamide [3], triethylsilyl-thiobenzene [4], trimethylsilyl trifluoromethanesulfonate [5], and ethyl trimethylsilylacetate/tetra-*n*-butylammonium fluoride [6], employed previously for the silylation of carbonyl compounds. A few methods for the preparation of trimethylsilyl enol ethers of 1,3-diketones have been developed by using hexamethyldisilazane [7], hexamethyldisilazane/imidazole [8], 2-oxo-3-trimethylsilyltetrahydro-1,3-oxazole [9], and (trimethylsilyl)-diethylamine /methyl iodide [10].

Trimethylcyanosilane (Me_3SiCN) has been used widely in organic synthesis [11, 12]. It has been used to protect a variety of alcohols, phenols, carboxylic acids, amines and thiols [13]. Previously we have shown that α -cyano enols were conveniently converted to trimethylsilyl enol ethers by using Me_3SiCN [14]. We now wish to report a method for the silylation of 1,3-diketones to their trimethylsilyl enol ethers by using Me_3SiCN .

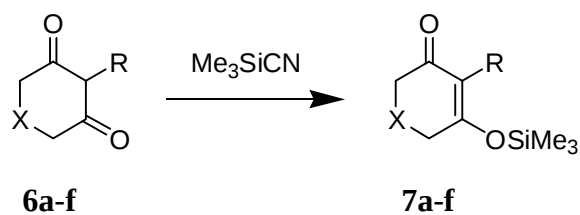
Results and Discussion

The reaction of Me_3SiCN with 1,3-diketones is complicated as shown in Scheme 1. The products formed depend upon the experimental conditions: temperature, time, the stoichiometric amount of Me_3SiCN added, and the catalyst used [11]. The reaction of pentan-1,3-dione (**1**) with excess Me_3SiCN formed trimethylsilyl enol ether **2** at room temperature or the adduct **3** at elevated temperatures (90°C) [11, 15]. Alternatively, the reaction yielded compounds **4** or/and **5** under different conditions, [15-17].

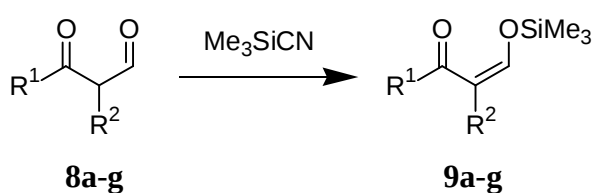


Scheme 1.

We observed that the silylation proceeded very smoothly at ambient temperature when Me_3SiCN was added to the 1,3-diketones **6a-f** or **8a-g** in CDCl_3 solution. The reactions were completed in 10 min (monitored by ^1H NMR) and produced the corresponding trimethylsilyl enol ethers **7a-f** or **9a-g** in quantitative yield (Scheme 2). The reactions of Me_3SiCN with 1,3-diketones can be carried out in various solvents. For example, the reaction of Me_3SiCN with cyclohexane-1,3-dione **6b** proceeded very smoothly in cyclohexane, hexane, benzene, carbon tetrachloride, chloroform, methylene chloride, and acetonitrile, and afforded **7b** in quantitative yield.



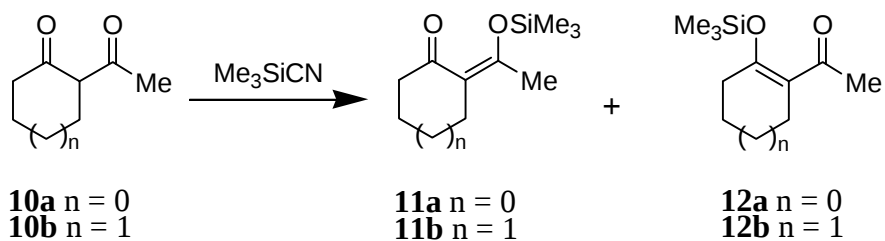
	X	R		X	R
a	-	H	d	-	Me
b	CH ₂	H	e	CH ₂	Me
c	CMe ₂	H	f	CMe ₂	Me



	R ¹	R ²		R ¹	R ²
a	Me	H	e	Ph	Me
b	Ph	H	f	Ph	Ph
c	Me	Me	g	-(CH ₂) ₄ -	
d	Et	Me			

Scheme 2.

The reaction of Me₃SiCN with 2-acetylcyclopentanone **10a** gave a ca. 1:1 ratio mixture of the two trimethylsilyl enol ethers **11a** and **12a** in quantitative yield (Scheme 3). Interestingly, the reaction of Me₃SiCN toward 2-acetylcyclohexanone **10b** was slow and produced only trimethylsilyl enol ether **12b** in 50% yield after 24 h.



Scheme 3.

Conclusion

In summary, we have shown that Me_3SiCN is an efficient silylation reagent for silylating 1,3-diketones, especially for the cyclic 1,3-diketones and 2-(hydroxymethylene)ketones. The method provides a convenient way to trimethylsilyl enol ethers of 1,3-diketones under neutral conditions.

Experimental

The general procedure for the preparation of trimethylsilyl enol ethers of 1,3-diketones is as follows: Me_3SiCN (0.205 g, 2.05 mmol) was added to 1,3-diketone (2 mmol) in dry CDCl_3 (3 ml) or other suitable solvent under a nitrogen atmosphere. The progress of the reaction was directly monitored by ^1H -NMR. The reaction is generally completed at room temperature in 5–10 min. After the completion of the reaction, a stream of nitrogen was allowed to pass through the mixture for 5 min. The resulting solution contains the trimethylsilyl enol ether. The solvent was evaporated under reduced pressure. The residue is the desired compound.

3-(Trimethylsilyloxy)cyclopent-2-en-1-one (**7a**): ^1H NMR(CDCl_3): 5.30 (t, $J = 1.0$, H-2), 2.57 (m, 2H, H-4), 2.42 (m, 2H, H-5), 0.33 (s, 9H, OSiMe_3).

3-(Trimethylsilyloxy)cyclohex-2-en-1-one (**7b**): ^1H NMR(CDCl_3): 5.37 (t, $J = 0.7$, H-2), 2.36 (td, $J = 6.2, 0.7$, 2H, H-4), 2.32 (t, $J = 6.7$, 2H, H-6), 1.97 (m, 2H, H-5), 0.30 (s, 9H, OSiMe_3).

5,5-Dimethyl-3-(trimethylsilyloxy)cyclohex-2-en-1-one (**7c**): ^1H NMR(CDCl_3): 5.35 (t, $J = 0.6$, H-2), 2.24 (d, $J = 0.6$, 2H, H-4), 2.17 (s, 2H, H-6), 1.07 (s, 6H, 2 Me), 0.30 (s, 9H, OSiMe_3).

2-Methyl-3-(trimethylsilyloxy)cyclopent-2-en-1-one (**7d**): ^1H NMR(CDCl_3): 2.51 (m, 2H, H-4), 2.43 (m, 2H, H-5), 1.58 (t, $J = 1.8$, Me), 0.33 (s, 9H, OSiMe_3).

2-Methyl-3-(trimethylsilyloxy)cyclohex-2-en-1-one (**7e**): ^1H NMR(CDCl_3): 2.40 (tq, $J = 6.4, 1.6$, 2H, H-4), 2.35 (t, $J = 6.7$, 2H, H-6), 1.94 (m, 2H, H-5), 1.66 (t, $J = 1.6$, Me), 0.28 (s, 9H, OSiMe_3).

5,5-Dimethyl-2-methyl-3-(trimethylsilyloxy)cyclohex-2-en-1-one (**7f**): ^1H NMR(CDCl_3): 2.26 (q, $J = 1.5$, 2H, H-4), 2.23 (s, 2H, H-6), 1.67 (t, $J = 1.5$, 3H, Me), 1.07 (s, 6H, 2 Me), 0.28 (s, 9H, OSiMe_3).

4-(Trimethylsilyloxy)but-3-en-2-one (**9a**): ^1H NMR(CDCl_3): 7.51 (d, $J = 12.2$, 1H, H-4), 5.73 (d, $J = 12.2$, 1H, H-3), 2.17 (s, 3H, Me), 0.29 (s, 9H, OSiMe_3).

1-Phenyl-3-(trimethylsilyloxy)prop-2-en-1-one (**9b**): ^1H NMR(CDCl_3): 7.87–7.91 (m, 2H, Ph), 7.75 (d, $J = 11.6$, 1H, H-3), 7.50–7.55 (m, 1H, Ph), 7.42–7.47 (m, 2H, Ph), 6.53 (d, $J = 11.6$, 1H, H-2), 0.32 (s, 9H, OSiMe_3).

3-Methyl-4-(trimethylsilyloxy)but-3-en-2-one (**9c**): ^1H NMR(CDCl_3): 7.46 (q, $J = 1.2$, 1H, H-4), 2.17 (s, 3H, MeCO), 1.70 (d, $J = 1.2$, Me-3), 0.30 (s, 9H, OSiMe_3).

2-Methyl-1-(trimethylsilyloxy)pent-1-en-3-one (**9d**): ^1H NMR(CDCl_3): 7.48 (q, $J = 1.3$, 1H, H-4), 2.55 (q, $J = 7.4$, 2H, H-4), 1.72 (d, $J = 1.3$, Me-2), 1.10 (t, $J = 7.4$, 3H, H-5), 0.29 (s, 9H, OSiMe_3).

2-Methyl-1-phenyl-3-(trimethylsilyloxy)prop-2-en-1-one (**9e**): ^1H NMR(CDCl_3): 7.53 (m, 2H, Ph), 7.48 (m, 1H, Ph), 7.41 (m, 2H, Ph), 7.15 (q, $J = 1.3$, 1H, H-3), 1.88 (d, $J = 1.3$, 3H, Me-2), 0.22 (s, 9H,

OSiMe₃).

1,2-Diphenyl-3-(trimethylsilyloxy)prop-2-en-1-one (**9f**). ¹H NMR(CDCl₃): 7.63-7.67 (m, 2H), 7.21-7.49 (m, 9H), 0.24 (s, 9H, OSiMe₃).

2-(Trimethylsilyloxymethylene)cyclohexan-1-one (**9g**). ¹H NMR(CDCl₃): 7.46 (t, J = 2.0, 1H, =CH), 2.44 (td, J = 6.7, 2.0, 2H, H-3), 2.34 (t, J = 6.7, 2H, H-6), 1.77-1.90 (m, 2H, H-5), 1.64-1.76 (m, 2H, H-4), 0.26 (s, 9H, OSiMe₃).

2-(1-Trimethylsilyloxyethylene)cyclopentan-1-one (**11a**). ¹H NMR(CDCl₃): 2.59 (tq, J = 7.3, 1.8, 2H, H-3), 2.48-2.52 (m, 2H, H-5), 2.32 (t, J = 1.8, 3H, Me), 1.76-1.87 (m, 2H, H-4), 0.26 (s, 9H, OSiMe₃).

2-(1-Oxoethyl)-1-(Trimethylsilyloxy)cyclopent-1-ene (**12a**). ¹H NMR(CDCl₃): 2.47-2.52 (m, 4H, H-3 and H-5), 2.34 (s, 3H, MeCO), 1.76-1.87 (m, 2H, H-4), 0.32 (s, 9H, OSiMe₃).

2-(1-Oxoethyl)-1-(Trimethylsilyloxy)cyclohex-1-ene (**12b**). ¹H NMR(CDCl₃): 2.37 (s, 3H, MeCO), 2.30-2.36 (m, 2H), 2.20-2.28 (m, 2H), 1.64-1.71 (m, 2H), 1.51-1.58 (m, 2H), 0.29 (s, 9H, OSiMe₃).

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