

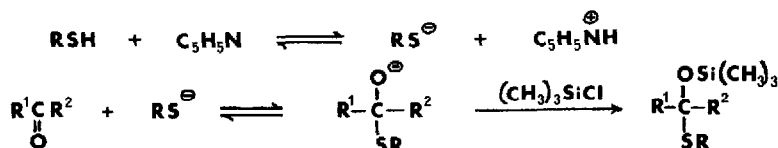
O-TRIMETHYLSILYL HEMITHIOACETALS AND KETALS.
REACTION WITH ORGANOLITHIUMS.

T.H. Chan* and B.S. Ong,
Department of Chemistry,
McGill University, Montreal, Canada

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O-Trimethylsilyl hemithioacetals have been obtained from the Pummerer rearrangement of α -trimethylsilyl sulfoxides¹⁻³. However, preparation of the hemithioacetal directly from the carbonyl compound was reported only for isolated cases^{1,4}. As part of our program in the study of organosilicon and organosulfur chemistry, we have investigated the synthesis of O-trimethylsilyl hemithioacetals and ketals, their properties and, in particular, their reaction with organolithiums.

We found that O-trimethylsilyl hemiacetals and ketals can be conveniently prepared from the corresponding carbonyl compounds in high yields by a simple procedure. To a well-stirred mixture of 50 mmole of carbonyl compound, 70 mmole of trimethylchlorosilane and 30 ml dried pyridine was added dropwise a solution of 50 mmole thiol in 10 ml of dried pyridine over a period of 15-30 minutes at 25°C. After stirring for 3 hrs, the mixture was filtered. The filtrate was distilled to give the product. The base, pyridine, was essential to the preparation. In the absence of pyridine, only thioacetals or ketals were obtained⁴. Thus, the reaction is considered to proceed according to scheme 1.

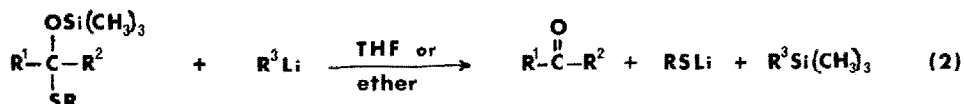


Scheme 1.

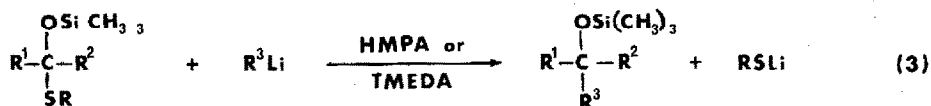
The O-trimethylsilyl hemithioacetals and ketals (Table I) are thermally stable to distillation. They resisted hydrolysis in 5% aqueous sodium hydroxide or carbonate. They remained intact in aqueous methanol, pyridine, hexamethylphosphoramide, and most common organic solvents. They were, however,

readily hydrolysed by dilute aqueous hydrochloric acid.

The reactions of the O-trimethylsilyl hemithioacetals and ketals with organolithiums were extensively investigated and the results were found to be rather unexpected. When the hemithioacetals or ketals were treated with alkyl lithium in ether or tetrahydrofuran, reaction occurred predominantly by cleavage of the silicon-oxygen bond, giving the alkyltrimethylsilane, the carbonyl compound, and the mercaptide as the main products (Table II). Similar substitution at silicon occurred when lithium diisopropylamide was used as the reagent in tetrahydrofuran (Equation 2).



However, if the reaction of the O-trimethylsilylhemithioacetals or ketals with alkyl lithiums were carried out in hexamethylphosphoramide as the solvent, there was a dramatic change in the course of reaction, leading to substitution at carbon (Equation 3). The products were the trimethylsilyl ether of the corresponding alcohol plus the mercaptide ion (Table II).



We attributed the difference in reactivity of the alkyl lithium to the solvating ability of HMPA to give a solvent separated ion pair⁵. Even with alkyl lithium in tetrahydrofuran, if tetramethylethylenediamine (TMEDA) or diazabicyclo-[2.2.2]octane (DABCO) were added, similar substitution reactions at carbon took place. Both TMEDA and DABCO are known to enhance carbanion reactivity by complexation with the lithium ion⁶.

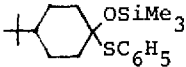
There remains the question of why the carbon-sulfur bond in O-trimethylsilyl hemithioacetals (or ketals) is susceptible to substitution. Neither acetals (or ketals) nor dithioacetals, or for that matter, other hemithioacetals, are cleaved by alkyl lithium. It appears that the presence of the silyl group has considerable influence on the lability of the carbon-sulfur bond as a manifestation of the β -effect⁷. The lability of the carbon-sulfur bond is also evident in the mass spectra of all O-trimethylsilyl hemithioacetals and ketals. $[\text{M-RS}]^+$ is always the base ion, indicating that the predominant fragmentation of the molecule under electron impact is the cleavage of the carbon-sulfur bond.

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References and footnote

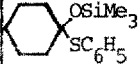
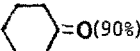
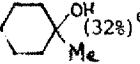
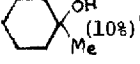
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Table I. Physical data of O-trimethylsilyl hemithioacetals and ketals.^a

$\begin{array}{c} \text{OSiMe}_3 \\ \\ \text{R}^1-\text{C}-\text{R}^2 \\ \\ \text{SR} \end{array}$	Yield (%)	b.p. °C/mmHg	pmr (ppm)		
			R ¹	R ²	R
$\begin{array}{l} \text{R}^1=\text{C}_6\text{H}_5, \text{R}^2=\text{H} \\ \text{R}=\text{CH}_2\text{CH}_3 \end{array}$	83	77.8/0.2	7.1-7.6 (m)	5.95 (s)	2.1-2.7 (m) 1.1 (t, J=7Hz)
$\begin{array}{l} \text{R}^1=\text{R}=\text{C}_6\text{H}_5, \text{R}^2=\text{H} \end{array}$	90	98-100/0.03	7.1-7.7 (m)	6.25 (s)	
$\begin{array}{l} \text{R}^1=\text{CH}_3, \text{R}^2=\text{H} \\ \text{R}_1=\text{C}_6\text{H}_5 \end{array}$	91	96-7/2.8	1.6 (d, J=6Hz)	5.3 (q, J=6Hz)	7.2-7.7 (m)
$\begin{array}{l} \text{R}^1=\text{R}^2=\text{CH}_3 \\ \text{R}=\text{C}_6\text{H}_5 \end{array}$	78	94-5/1.4	1.55 (s)		7.1-7.7 (m)
$\begin{array}{l} \text{R}^1=\text{R}^2=-\text{(CH}_2\text{)}_5- \\ \text{R}=\text{C}_6\text{H}_5 \end{array}$	75	111-13/0.2		1.0-2.0 (m)	7.0-7.7 (m)
	α^b 31	44-6/0.15	0.8-2.3 (m), 0.85 (s)		7.0-7.5 (m)
(2 isomers)	β^b 23	110-13/0.25	0.8-2.0 (m), 0.85 (s)		7.0-7.7 (m)

(a) Prepared according to procedure described in the text. (b) Separated by distillation.

Table II Reaction of O-trimethylsilyl hemithioacetals and ketals with organolithiums^a

	MeLi, ether or THF, -78°, 1 hr	BuLi, ether or THF, -78°, 1 hr	t-BuLi, THF, -78° 10 min.	(i-Pr) ₂ NLi THF, 25°, 12 hrs	MeLi, HMPA, 0° 1 hr	BuLi-HMPA 0° 1 hr	MeLi-TMEDA 0° 1 hr
$\begin{array}{c} \text{OSiMe}_3 \\ \\ \text{C}_6\text{H}_5-\text{C}-\text{H} \\ \\ \text{SCH}_2\text{CH}_3 \end{array}$	C ₆ H ₅ CHO (80%) C ₆ H ₅ CH ₂ SCH ₂ CH ₃ ^b (90)	C ₆ H ₅ CHO (80%) C ₆ H ₅ CH ₂ SCH ₂ CH ₃ ^b (90)	t-BuSiMe ₃ (40%) C ₆ H ₅ CHO (83%) C ₆ H ₅ CH ₂ SCH ₂ CH ₃ ^b (87)	50% reaction ^c C ₆ H ₅ CHO C ₆ H ₅ CH ₂ SCH ₂ CH ₃	$\begin{array}{c} \text{OSiMe}_3 \\ \\ \text{C}_6\text{H}_5-\text{CH} \\ \\ \text{Me} \end{array}$ (75%)	$\begin{array}{c} \text{OSiMe}_3 \\ \\ \text{C}_6\text{H}_5-\text{CH} \\ \\ \text{Bu} \end{array}$ (78%)	$\begin{array}{c} \text{OH} \\ \\ \text{C}_6\text{H}_5-\text{CH} \\ \\ \text{CH}_3 \end{array}$ (50%) ^e
$\begin{array}{c} \text{OSiMe}_3 \\ \\ \text{C}_6\text{H}_5-\text{CH} \\ \\ \text{SC}_6\text{H}_5 \end{array}$		C ₆ H ₅ CHO (85%) C ₆ H ₅ SCH ₃ ^b (92%)		50% reaction ^c	$\begin{array}{c} \text{OSiMe}_3 \\ \\ \text{C}_6\text{H}_5-\text{CH} \\ \\ \text{Me} \end{array}$ (86%)	$\begin{array}{c} \text{OSiMe}_3 \\ \\ \text{C}_6\text{H}_5-\text{CH} \\ \\ \text{Bu} \end{array}$ (83%)	
$\begin{array}{c} \text{OSiMe}_3 \\ \\ \text{CH}_3-\text{CH} \\ \\ \text{SC}_6\text{H}_5 \end{array}$		C ₆ H ₅ SCH ₃ ^b (93%)	C ₆ H ₅ SCH ₃ ^b (85%)		$\begin{array}{c} \text{OH} \\ \\ \text{CH}_3-\text{CH} \\ \\ \text{Bu} \end{array}$ (46%) ^d		
$\begin{array}{c} \text{OSiMe}_3 \\ \\ \text{CH}_3-\text{C}-\text{CH}_3 \\ \\ \text{SC}_6\text{H}_5 \end{array}$					$\begin{array}{c} \text{OH} \\ \\ \text{CH}_3-\text{C}-\text{CH}_3 \\ \\ \text{Bu} \end{array}$ (38%) ^d		
	 (90%) C ₆ H ₅ SH (88%)				 (32%) ^e		 (10%) ^e

(a) Products obtained are given with yields in parenthesis. (b) Obtained by quenching the reaction mixture with either MeI or C₆H₅CH₂Br. (c) 50% starting material recovered. (d) Obtained after hydrolysis of the product. (e) Isolated by TLC, the trimethylsilyl group was hydrolyzed during separation.