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AN EFFICIENT METHOD FOR THE PREPARATION OF 1,1-BIS(TRIMETHYLSILYL)ALKAN-1-OL

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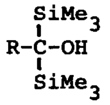
In the course of our studies on specific generation of carbanions, it became necessary to deduce a moderately strong base, since alkali metal amides are sometimes too strong and alkali metal alkoxides are too weak.

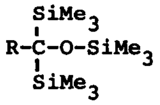
While various bases are employed for generation of various carbanions, there have been few bases available which have a character intermediate between those of alkoxides and amides with regard to basicity. Because of large positive inductive effect of trialkylsilyl groups[1], 1,1-bis(trimethylsilyl)-alkan-1-ol 1 is expected to possess a much larger pK_a value than the usual alcohol and to be one of the best candidates for our purpose.

In connection with the preparation of such kind of alcohols, Picard et al.[2] reported that treatment of methyl carboxylates with metallic lithium in the presence of trimethylchlorosilane led to the formation of 1,1-bis(trimethylsilyl)alkyl trimethylsilyl ether 2 , but the yields were usually low,[3] accompanied with the formation of several other products such as 1,2-bis(trimethylsiloxy)alkene 3[4] and ketal of trimethylacylsilane 4.

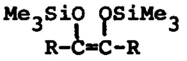
We wish to report herein an efficient method for the preparation of 2 which can easily be converted to the corresponding alcohol, 1,1-bis(trimethylsilyl)alkan-1-ol 1. The following procedure is representative. To the boiling


$\mathrm{R{-}\overset{SiMe_3}{\underset{SiMe_3}{C}}{-}OH}$

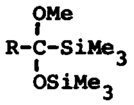
1


$\mathrm{R{-}\overset{SiMe_3}{\underset{SiMe_3}{C}}{-}O{-}SiMe_3}$

2


$\mathrm{R{-}\overset{Me_3SiO}{C}{=}\overset{OSiMe_3}{C}{-}R}$

3


$\mathrm{R{-}\overset{OMe}{\underset{OSiMe_3}{C}}{-}SiMe_3}$

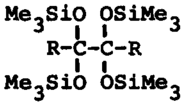
4

tetrahydrofuran (THF) solution (30 ml) of trimethylchlorosilane (20.5 g, 190 mmol) suspended with sodium dispersion[5] (6.50 g, 283 mmol) is added dropwise trimethylsilyl iso-valerate[6] (4.10 g, 23.6 mmol) in 20 ml of THF during 1 hr under argon atmosphere. After addition is complete, it is refluxed for an additional 30 min. Then, the deposited inorganic materials are filtered off and the solvent is removed in vacuo. Distillation of the residual oil affords 1,1-bis(trimethylsilyl)-3-methylbutyl trimethylsilyl ether (4.67 g, 65%), b.p. 120-128°/17mmHg. It is treated with 1.5 ml of 6N hydrochloric acid in 50 ml of dioxane at room temperature, and is neutralized with aq sodium bicarbonate solution. From the ether extracts, 1,1-bis(trimethylsilyl)-3-methylbutan-1-ol (3.32 g, 93%), b.p. 105-108°/20mmHg, is obtained after removal of the solvent, followed by distillation.

By a similar procedure, trimethylsilyl acetate, propionate, n-butyrate, and iso-butyrate could be reduced to the corresponding trimethylsilyl ether 2, which afforded, on hydrolysis, the desired 1,1-bis(trimethylsilyl)alkanol 1 in good yields as shown in the Table.

It should be noted that neither symmetrical bis(siloxy)alkene 3 nor acetal of acylsilane is formed in this reduction reaction, which makes it much easier to isolate the pure desired product.

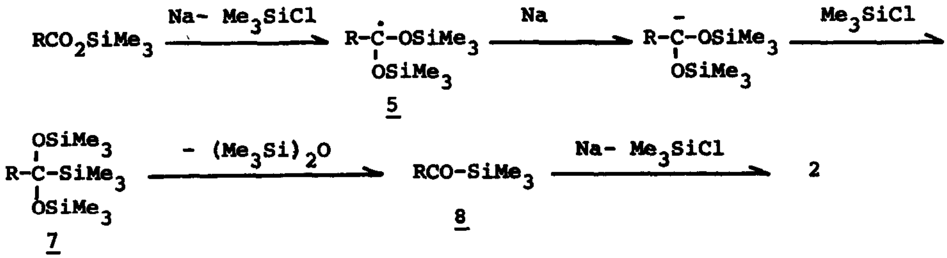
The result can be explained as follows. Because of large steric hindrance between two bulky trimethylsiloxy groups, the radical intermediate 5, initially formed through one-electron reduction followed by silylation, can not dimerize to the intermediate 6[7] which is finally converted to the bis(trimethylsiloxy)-alkene 3. Thus, further reduction followed by silylation takes place preferentially to give the trimethylacylsilane bis(trimethylsilyl)ketal 7. Elimination of hexamethyldisiloxane from the intermediate 7 is considered to be a favorable process due to the higher acidity of the silanol.[8] Acylsilane 8 thus formed is reduced further to afford the corresponding silyl ether of the desired alcohol.



$$\begin{array}{c} Me_3SiO\ \ OSiMe_3 \\ R-C-C-R \\ Me_3SiO\ \ OSiMe_3 \end{array}$$

3

6



$$RCO_2SiMe_3 \xrightarrow{Na-\ Me_3SiCl} \underset{\underset{5}{OSiMe_3}}{R-\overset{\bullet}{C}-OSiMe_3} \xrightarrow{Na} \underset{OSiMe_3}{R-\overset{-}{C}-OSiMe_3} \xrightarrow{Me_3SiCl}$$

$$\underset{\underset{7}{OSiMe_3}}{\overset{OSiMe_3}{R-C-SiMe_3}} \xrightarrow{-\ (Me_3Si)_2O} \underset{8}{RCO-SiMe_3} \xrightarrow{Na-\ Me_3SiCl} 2$$

Table. Preparation of 1 and 2.[a]

$$R\text{-}CO_2SiMe_3 \xrightarrow{Na\text{-}\ Me_3SiCl} \underset{OSiMe_3}{R\text{-}C(SiMe_3)_2} \longrightarrow \underset{OH}{R\text{-}C(SiMe_3)_2}$$

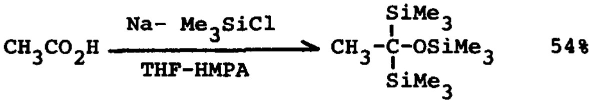
2 1

	2		1	
R	b.p.(°C/mmHg)	yield(%)[c]	b.p.(°C/mmHg)	yield (%)[e]
CH_3	104-115/24	55(88)[d]	126-128/32	87
C_2H_5	85-87/15	74	100-105/13	95
$n\text{-}C_3H_7$	110-115/17	69	93-95/10	93
$(CH_3)_2CH$[b]	110-113/12	72	93-95/20	81
$(CH_3)_2CHCH_2$	120-128/17	89	105-108/20	93

a) All of the reactions were performed under similar reaction conditions described in the text. All of the products gave satisfactory spectral (ir, nmr) and analytical data for the assigned structures. b) See reference 2.
c) Determined by glpc, using diphenylmethane as an internal standard.
d) The reaction was carried out in the presence of 8 eq of HMPA at room temperature. e) Isolated yields.

The yield of 2 seems to be increased when the reaction is carried out in the presence of hexamethylphosphoric triamide (HMPA) which is known to be effective for radical anion formation.[9]

It has been further found that 2 can be obtained when carboxylic acids are directly used in place of the trimethylsilyl esters. Thus, treatment of acetic acid with sodium dispersion (10 eq) in the presence of trimethylchlorosilane (10 eq) in THF-HMPA led to the formation of 2 ($R=CH_3$) in good yield. In the way of this reaction, the corresponding trimethylsilyl ester is considered to be formed in situ and to be reduced in a similar manner as described above.



$$CH_3CO_2H \xrightarrow[THF\text{-}HMPA]{Na\text{-}\ Me_3SiCl} CH_3\text{-}\overset{SiMe_3}{\underset{SiMe_3}{C}}\text{-}OSiMe_3 \qquad 54\%$$

We are currently investigating the basicities of these alkoxides and the reactions by the use of these bases.

References

1. See, for example; L. H. Sommer, J. R. Gold, G. M. Goldberg, and N. S. Marans, *J. Am. Chem. Soc.*, **71**, 1509 (1949); R. West, *J. Organometal. Chem.*, **3**, 314 (1965); H. Bock, H. Alt, and H. Seidl, *J. Am. Chem. Soc.*, **91**, 355 (1969).
2. J. P. Picard, A. Ekouya, J. Dunogues, N. Duffaut, and R. Calas, *J. Organometal. Chem.*, **93**, 51 (1975).
3. In the report of Picard et al.[2], only methyl pivalate afforded the reductive silylation product in good yield and they proposed it to be **2** (R= $(CH_3)_3C$) based on its ir and nmr spectra. But, from its mass spectral examination, we must conclude it not to be **2**. Examination by the use of CPK Model also supports our conclusion.
4. About the preparation of bis(trimethylsiloxy)alkene, see; K. Rühlmann, *Synthesis*, 236 (1971); J. Stratting, S. Reffers, and H. Wynberg, *ibid.*, 209, 211 (1971); J. M. Conia and J. M. Dennis, *Tetrahedron Lett.*, 2845 (1971); T. Wakamatsu, K. Akasaka, and Y. Ban, *ibid.*, 3879, 3883 (1974); J. Bloomfield and D. C. Owsley, *J. Org. Chem.*, **40**, 393 (1975).
5. A fine dispersion is essential for obtaining the ether **2** in good yield.
6. Trimethylsilyl esters were prepared by the reaction of carboxylic acids with trimethylchlorosilane in the presence of NaH in THF in 80-85% yields.
7. Examination by the use of CPK Model supports this assumption.
8. L. H. Sommer, E. W. Pietrusza, and F. C. Whitmore, *J. Am. Chem. Soc.*, **68**, 2282 (1946); R. West and R. H. Baney, *ibid.*, **81**, 6145 (1959).
9. M. Larcheveque and H. Normant, *Compt. Rend.(C)*, **268**, 640 (1968); H. Normant, *Angew. Chem.*, **79**, 1029 (1967).