Tetrahedron Letters Vol. 21, pp 2325 - 2328
© Pergamon Press Ltd. 1980. Printed in Great Britain

0040-4039/80/0608-2325$02.00/0

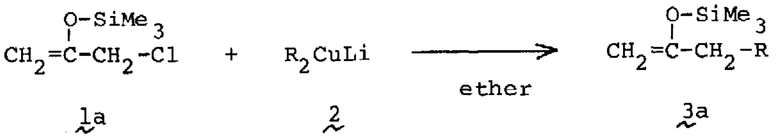
ALKYLATION AND ARYLATION OF 2-TRIMETHYLSILOXYALLYL HALIDES. A NEW REGIOSPECIFIC ROUTE TO SILYL ENOL ETHERS[1]

Hideki Sakurai,* Akihiko Shirahata, Yoshitaka Araki and Akira Hosomi
Department of Chemistry, Faculty of Science, Tohoku University, Sendai 980, Japan

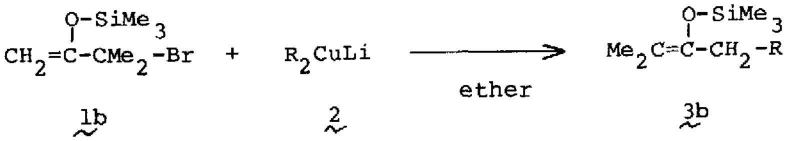
Summary: Alkylation and arylation of 2-trimethylsiloxyallyl halides with lithium dialkyl- and diarylcuprate, respectively, gave silyl enol ethers in a regiospecific manner.

Trimethylsilyl enol ethers have been recognized as extremely important intermediates in the organic synthesis for the regiospecific generation of enolates which may be used in the preparation of the regiospecifically α-substituted carbonyl derivatives.[2] Consequently, numerous reports on the preparation of silyl enol ethers have been published to date.[3] A standard method for the preparation of silyl enol ethers has been the silylation of carbonyl compounds with the combination of bases and chlorosilanes.[4] Many modifications[5] including our own very clean catalytic dehydrogenative silylation of ketones[6] have appeared recently, but the regiospecific preparation of silyl enol ethers from unsymmetric ketones remains unsolved except for few cases.[7]

In this paper we show a novel regiospecific route to trimethylsilyl enol ethers by the reaction of 2-trimethylsiloxyallyl halides (1) with lithium dialkyl- and diarylcuprates (2). The requisite 3-chloro-2-trimethylsiloxy-propene (1a) can be prepared by the rearrangement of (3-chloro-2-oxopropyl)trimethylsilane catalyzed by mercuric iodide.[8] Preparation of 3-bromo-3-methyl-2-trimethylsiloxy-1-butene (1b) has been described in a previous paper.[9] Results are listed in Table 1.[10]



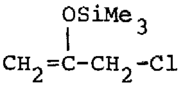
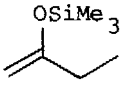
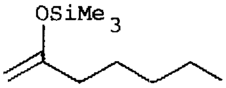
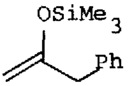
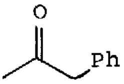
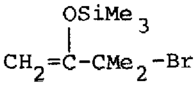
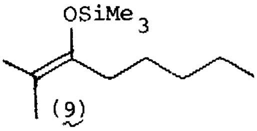
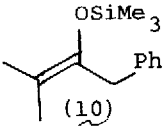
$$\underset{\mathbf{1a}}{CH_2=\overset{O-SiMe_3}{\overset{|}{C}}-CH_2-Cl} + \underset{\mathbf{2}}{R_2CuLi} \xrightarrow[\text{ether}]{} \underset{\mathbf{3a}}{CH_2=\overset{O-SiMe_3}{\overset{|}{C}}-CH_2-R} \qquad (1)$$



$$\underset{\mathbf{1b}}{CH_2=\overset{O-SiMe_3}{\overset{|}{C}}-CMe_2-Br} + \underset{\mathbf{2}}{R_2CuLi} \xrightarrow[\text{ether}]{} \underset{\mathbf{3b}}{Me_2C=\overset{O-SiMe_3}{\overset{|}{C}}-CH_2-R} \qquad (2)$$

R = alkyl or aryl

Table 1. Alkylation and Arylation of 2-Trimethylsiloxyallyl Halides (1) with Lithium Dialkyl- and Diarylcuprates (2)[a]

Entry	2-Trimethylsiloxy-allyl halide	Cuprate	Reaction conditions	Product	(% yield)[b]
1	 $CH_2{=}\overset{OSiMe_3}{C}{-}CH_2{-}Cl$ (1a)	Me_2CuLi (2a)	0°, 30min	 (4)	(80[c],96[d])
2	1a	$n\text{-}Bu_2CuLi$ (2b)	-40°, 30min	 (5)	(74)[d]
3	1a	2b	-40°, 30min	 (6)	(55)[e]
4	1a	Ph_2CuLi (2c)	0°, 5.5h	 (7)	(78)[f]
5	1a	2c	0°, 5h then rt, 4h	 (8)	(79)
6	 $CH_2{=}\overset{OSiMe_3}{C}{-}CMe_2{-}Br$ (1b)	2b	-78°, 1h	 (9)	(58)[d]
7	1b	2c	0°, 5h then rt, 2h	 (10)	(71)

---

[a] All reactions were carried out in ether. [b] The yield after isolation by TLC unless otherwise noted. [c] The product was isolated by GLC. [d] Determined by GLC. [e] The product was isolated by TLC-GLC combination. [f] The yield after isolation by distillation.

The reaction of trimethylsilyl enol ethers with an alkyllithium usually results in the formation of the corresponding lithium enolates,[4b] but the reaction of **1a** with several lithium dialkyl- and diarylcuprates proceeded very smoothly at the allylic position to give only one regioisomer of silyl enol ethers (**3a**) in good yield. It is noteworthy that a selective formation of pure silyl enol ethers having a terminal olefinic double bond, which are otherwise very difficult to obtain, was indeed realized starting from unsymmetric alkyl methyl ketones. Thus the importance of the synthesis of **4** by the present method (entry 1) lies in the fact that enolization of 2-butanone followed by silylation does not give pure **4** under either kinetically or thermodynamically controlled condition.[4a] Thus the kinetic enolate ($LiN(i\text{-}Pr)_2$, dimethoxyethane, Me_3SiCl, -78°) gave a mixture of **4** and its regioisomer in a ratio of 71:29, while under thermodynamic control (Et_3N, N,N-dimethylformamide, Me_3SiCl, reflux) the ratio was 12:88.[4a] Similar results have been obtained from 2-heptanone; eg. while in the present synthesis the exclusive formation of **5** was observed (entry 2), the ratio of **5** to its regioisomer was 84:16 from the kinetic enolate and 13:87 from the thermodynamic enolate.[4a] More remarkable is the reaction of **1a** with lithium diphenylcuprate (**2c**) which gave a silyl enol ether (**7**) exculsively in high yield (entry 4). To our knowledge, **7** has never been detected successfully under either kinetic or thermodynamic control, whereas its regioisomer was readily available.[4a]

Reactions of 3-bromo-3-methyl-2-trimethylsiloxy-1-butene (**1b**) with cuprates took place regioselectively at the less alkylated carbon atom to yield the corresponding silyl enol ethers (**3b**) via an allylic rearrangement (S_N2' reaction) similarly to reactions of allylic halides, tosylates and acetates with cuprates.[11] Thus the reaction of **1b** with **2b** and **2c** gave selectively tetra-substituted olefins **9** and **10**, respectively (entry 6 and 7).

As a general procedure, to a solution of a cuprate, prepared from an alkyl- or aryllithium (10.0 mmol) and cuprous iodide (5.0 mmol) in ether (10 ml) at 0°, a 2-trimethylsiloxyallyl halide (**1**) (2.0 mmol) in ether (5 ml) was added slowly from a dropping funnel. The solution was stirred magnetically for a period at a temperature indicated in the Table. A small portion (2∿3 ml) of saturated aqueous solution of NH_4Cl was added to the mixture to separate the organic layer which was taken out by a syringe. The residue was washed with ether (15 ml × 3) and the combined organic solution was passed through a short column (1 cm) packed with silica gel, dried over magnesium sulfate, and concentrated under reduced pressure. The residue was purified by distillation, preparative TLC or GLC.

The products from **1a** were readily converted to the corresponding acetonyl derivatives by TLC treatment.[12] Therefore **1a** can also be a novel and useful reagent for the direct acetonylation of alkyl and aryl groups (entry 3 and 5).

Related works are in progress.

Acknowledgment: We thank Toshiba Silicone Co., Ltd. for a gift of chlorosilanes. The work was supported in part by the Mitsubishi Foundation.

References and Notes

(1) Chemistry of Organosilicon Compounds, 137.

(2) For a review of organosilicon compounds in organic synthesis; see E. W. Colvin, Chem. Soc. Rev., 7, 15 (1978).

(3) For a review of silyl enol ethers, see J. K. Rasmussen, Synthesis, 91 (1977)

(4) a) H. O. House, L. J. Czuba, M. Gall, and H. D. Olmstead, J. Org. Chem., 34, 2324 (1969); b) G. Stork and P. F. Hudrlik, J. Am. Chem. Soc., 90, 4462 (1968).

(5) a) I. Fleming and I. Paterson, Synthesis, 736 (1979); b) R. D. Miller and D. R. McKean, ibid., 730 (1979), and references cited therein.

(6) H. Sakurai, K. Miyoshi, and Y. Nakadaira, Tetrahedron Lett., 2671 (1977).

(7) H. J. Reich, J. J. Rusek, and R. E. Olson, J. Am. Chem. Soc., 101, 2226 (1979).

(8) **1a**, bp 61-63° (35-37 mmHg); IR(neat) 2960, 2900, 1635, 1315, 1260, 1225, 1160, 1030, 915, 850 cm^{-1}; NMR(δ in CCl_4) 0.40(s, 9H), 3.92(s, 2H), 4.28 (bs, 1H), 4.50(bs, 1H), was obtained by the following reactions. Details will be published elsewhere.

$$Me_3SiCH_2Cl + Mg \longrightarrow Me_3SiCH_2MgCl$$

$$Me_3SiCH_2MgCl + (ClCH_2CO)_2O \longrightarrow Me_3SiCH_2COCH_2Cl$$

$$Me_3SiCH_2COCH_2Cl \xrightarrow{HgI_2} \underset{(\mathbf{1a})}{CH_2{=}C(OSiMe_3)CH_2Cl}$$

(9) H. Sakurai, A. Shirahata, and A. Hosomi, Angew. Chem. Int. Ed. Engl., 18, 163 (1979).

(10) Satisfactory NMR, IR, and low and high resolution mass spectra, and elemental analyses were obtained for all new compounds.

(11) a) R. J. Anderson, G. A. Henrick, J. B. Siddall, and R. Zurflüh, J. Am. Chem. Soc., 94, 5379 (1972); b) I. Kuwajima and Y. Doi, Tetrahedron Lett., 1163 (1972); c) E. J. Corey, H. Yamamoto, D. K. Herron, and K. Achiwa, J. Am. Chem. Soc., 92, 6635 (1970); d) For a review, see G. H. Posner, Org. Reactions, 22, 253 (1975).

(12) The products from **1b** were intact after hydrolysis and could be isolated by TLC. Hydrolysis of those was achieved with a catalytic amount of hydrochloric acid in methanol.

(Received in Japan 22 March 1980)