

METHYLENE INSERTION IN VINYL CUPRATES BEARING AN ALLYLIC SILYL GROUP

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Abstract. The silylcupration of allene has emerged as a useful tool for the synthesis of functionalized allylsilanes which have been used in the synthesis of different-sized carbocycles. We now described the preparation of allylsilane-allylcuprate intermediates by homologation reaction with iodomethylzinc iodide and their reaction with different electrophiles.

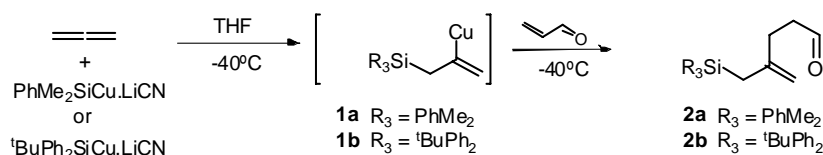
Introduction

The use of organosilicon compounds as useful reagents in the construction of natural products has become a powerful tool in organic synthesis.¹

For the last decade we have been involved in the study of the metallo-cupration reactions of allenes and acetylenes and their synthetic applications.^{2,3} These reactions involve the addition of copper to one end of a multiple bond and a metal (Si or Sn) to the other, allowing the formation of intermediates of type **1** (Scheme 1).

The intermediate cuprate **1** can be captured by a great variety of electrophiles.⁴ In particular, the use of α,β -unsaturated oxocompounds affords oxoallylsilanes of type **2** (Scheme 1) which are useful building blocks for cyclopentane annulations.

Scheme 1



On the other hand, it is known that zinc carbenoids are excellent carbene precursors and as such have found several synthetic applications.⁵ Using Knochel methodology for the transformation of organocopper reagents into methylene homologated organocuprates, we decide to study the synthesis of γ -oxoallylsilanes,^{4a} which would be interesting intermediates for the synthesis of methylenecyclohexanols.

Results and discussion

Thus, the reaction of phenyldimethylsilylcopper or tert-butyldiphenylsilylcopper with allene gas at -40°C affords an allylsilane-vinylcuprate intermediate **1a-b** which was treated with an excess of iodomethylzinc iodide (3 equiv.) leading to the homologated allylsilane-allylcuprate **3a** and **3b**. A further reaction with different electrophiles such as iodine, allylic bromide, acetyl chloride, ketones, α,β -unsaturated ketones and α,β -unsaturated acid chlorides gives compounds **4-13**.

Table 1. Reaction of homology of allylsilane-vinylcuprates **1a** and **1b**.

$\text{CH}_2=\text{CH}-\text{CH}_2-\text{Si}(\text{R}_3)_2 + \text{PhMe}_2\text{SiCu.LiCN}$
 or
 $\text{CH}_2=\text{CH}-\text{CH}_2-\text{Si}(\text{R}_3)_2 + \text{tBuPh}_2\text{SiCu.LiCN} \xrightarrow[\text{-40}^\circ\text{C}]{\text{THF}} \left[\text{R}_3\text{Si}-\text{CH}_2-\text{CH}=\text{CH}-\text{Cu} \right] \xrightarrow[\text{-40}^\circ\text{C}]{\text{ICH}_2\text{ZnI}} \left[\text{PhMe}_2\text{Si}-\text{CH}_2-\text{CH}=\text{CH}-\text{IZnCu} \right] \xrightarrow{\text{E}^+}$

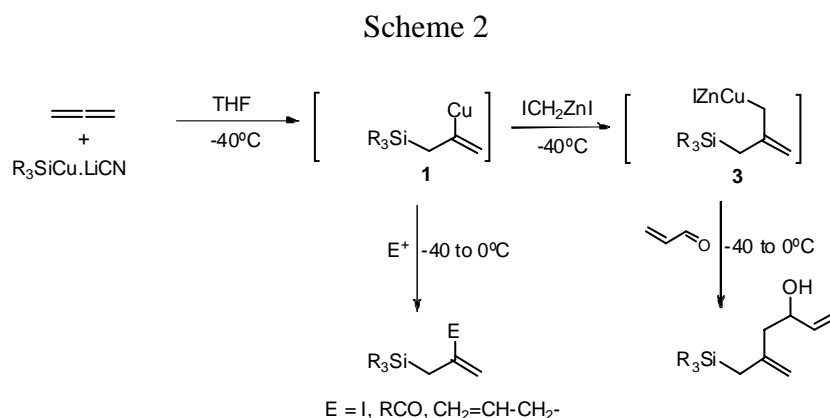
1a $\text{R}_3 = \text{PhMe}_2$ **3a** $\text{R}_3 = \text{PhMe}_2$
1b $\text{R}_3 = \text{tBuPh}_2$ **3b** $\text{R}_3 = \text{tBuPh}_2$

Entry	Electrophile	Cuprate	Product	Yield (%)
1		1a	4	85
2	I ₂	1a	5	85
3	AcCl	1a	6	70
4		1a	7	27
5		1a	8	20
6		1b	9	65
7		1b	10	75
8		1b	11	61
9		1b	12	9
10		1b	13	10

From the results observed in Table 1 it could be deduce that the homology **1** into **3** only works when the electrophile used to capture the intermediate cuprate is a ketone (saturated or α,β -unsaturated). This evidence may indicate that the homology process is much slower than the reaction of cuprate **1** with electrophiles different than ketones.

It has to be noted that the homology reaction of the *tert*-butyldiphenylsilylcuprate **1b** works well whereas the reaction for the phenyldimethylsilyl derivative **1a** leads to poor yields of the corresponding alcohols **7-8**. It is uncertain whether the homology

of cuprate **1a** occurs in little extent or the reactivity of allylcuprate derivative **3a** towards ketones is low.



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General experimental procedures

Homologation of cuprates **1a and **1b** and reaction with electrophiles.** A solution of (iodomethyl)zinc iodide (9 mmol) freshly prepared in THF (5 ml) was added at -40 °C to a solution of intermediate **1a** or **1b** (3 mmol) which was prepared using the general procedure. The reaction mixture was stirred at this temperature for 30 min, then 3.6 mmol of the corresponding electrophile in THF (3 ml) were added dropwise and the resulting solution was kept at -40 °C for 2 h. After allowing the mixture to warm up to 0 °C, it was quenched with saturated ammonium chloride solution and extracted twice with Et₂O. The organic layer was dried, rotoevaporated and chromatographed (EtOAc:hexanes) to give compounds **4-13**^{4c} (Table 1).

1-[2-Dimethyl(phenyl)silylmethylprop-2-en-1-yl]cyclopentan-1-ol (7**).** Oil, 27%; IR (neat): 3580, 3500, 1620; ¹H NMR: 7.54-7.34 (m, 5H), 4.71 (s, 2H), 2.14 (s, 2H), 1.89 (s, 2H), 1.84-1.47 (m, 8H), 1.76 (br s, 1H), 0.33 (s, 6H); ¹³C NMR: 144.3, 138.8, 133.6, 129.0, 127.7, 111.9, 80.8, 48.6, 39.9, 27.7, 23.4, 23.1; MS(EI) m/z: 274 (M⁺, 0.2%), 259, 219, 135 (100).

1-[2-Dimethyl(phenyl)silylmethylprop-2-en-1-yl]cyclohex-2-en-1-ol (8**).** Oil, 20%; IR (neat): 3450, 1630; ¹H NMR: 7.57-7.32 (m, 5H), 5.75 (dt, *J* = 10.1 and 3.4 Hz, 1H), 5.56 (d, *J* = 10.1 Hz, 1H), 4.72 (m, 2H), 2.42-1.40 (m, 6H), 2.13 (s, 2H), 1.92 (s, 2H), 1.63 (br s, 1H), 0.32 (s, 6H); ¹³C NMR: 143.5, 138.8, 134.3, 133.6, 129.0, 128.2, 127.7, 112.5, 77.2, 49.8, 35.9, 28.0, 25.1, 19.2, 22.9; MS(EI) m/z: 286 (M⁺, 0.3%), 268, 209, 190, 135 (100).

(*E*)-1-Phenyl-3-methyl-5-tert-butyl(diphenyl)silylmethylhexa-1,5-dien-3-ol (9**).** Oil, 65%; IR (neat): 3550, 1632, 1599; ¹H NMR: 7.68-7.28 (m, 15H), 6.51 (d, *J* = 16.2 Hz, 1H), 6.14 (d, *J* = 16.2 Hz, 1H), 4.87 (d, *J* = 1.6 Hz, 1H), 4.72 (d, *J* = 1.6 Hz, 1H), 2.35 (d, *J* = 13.9 Hz, 1H), 2.28 (d, *J* = 13.9 Hz, 1H), 2.04 (br s, 1H), 1.99 (s, 2H), 1.23 (s,

3H), 1.05 (s, 9H); ¹³C NMR: 143.4, 137.0, 136.9, 136.3, 136.1, 135.9, 134.7, 134.5, 129.2, 128.5, 127.5, 127.4, 127.2, 126.4, 126.2, 115.2, 71.9, 50.6, 28.6, 27.7, 22.2, 18.5; MS(CI) m/z: 441 (M⁺+1, 1%), 440 (M⁺, 2%), 423, 345, 383, 239 (100). Anal. Calcd for C₃₀H₃₆SiO: C, 81.76; H, 8.23. Found: C, 81.50; H, 8.11.

1-[2-tert-Butyl(diphenyl)silylmethylprop-2-en-1-yl]cyclopentan-1-ol (10). Oil, 75%; IR (neat): 3555, 1624; ¹H NMR: 7.69-7.34 (m, 10H), 4.82 (d, *J* = 0.8 Hz, 1H), 4.68 (d, *J* = 0.8 Hz, 1H), 2.35 (s, 2H), 1.91 (s, 2H), 1.80-1.35 (m, 8H), 1.63 (br s, 1H), 1.10 (s, 9H); ¹³C NMR: 144.2, 136.3, 134.6, 129.1, 127.4, 113.8, 80.8, 48.5, 39.8, 27.8, 23.4, 22.0, 18.5; MS(CI) m/z: 379 (M⁺+1, 2%), 378 (M⁺, 1%), 361, 321, 239, 123 (100). Anal. Calcd for C₂₅H₃₄SiO: C, 79.31; H, 9.05. Found: C, 79.52; H, 9.16.

1-[2-tert-Butyl(diphenyl)silylmethylprop-2-en-1-yl]cyclohex-2-en-1-ol (11). Oil, 61%; IR (neat): 3650, 3400, 1635; ¹H NMR: 7.70-7.32 (m, 10H), 5.71 (dt, *J* = 10.2 and 3.6 Hz, 1H), 5.46 (d, *J* = 10.2 Hz, 1H), 4.81 (d, *J* = 1.8 Hz, 1H), 4.64 (d, *J* = 1.8 Hz, 1H), 2.40 (d, *J* = 13.8 Hz, 1H), 2.33 (d, *J* = 13.8 Hz, 1H), 1.98-1.47 (m, 6H), 1.92 (d, *J* = 13.6 Hz, 1H), 1.83 (d, *J* = 13.6 Hz, 1H), 1.72 (br s, 1H), 1.08 (s, 9H); ¹³C NMR: 143.4, 136.4, 134.6, 132.8, 129.1, 127.5, 128.9, 114.7, 69.5, 49.6, 35.9, 27.8, 25.1, 22.4, 19.2, 18.6; MS(CI) m/z: 391 (M⁺+1, 9%), 390 (M⁺, 2%), 373, 333, 295 (100), 239. Anal. Calcd for C₂₆H₃₄SiO: C, 79.94; H, 8.77. Found: C, 80.34; H, 9.08.

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