

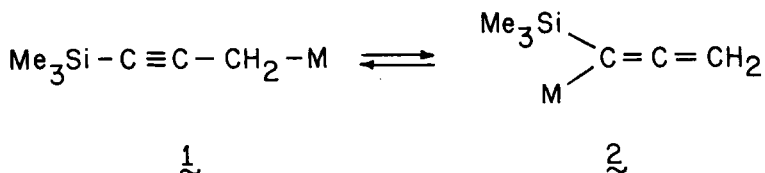
SILANES IN ORGANIC SYNTHESIS. 11. REGIOCONTROLLED SYNTHESIS OF
 α -HYDROXYMETHYLATED (TRIMETHYLSILYL)ALLENES¹

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Summary: The organometallic produced by reaction of trimethylsilylpropargyl bromide with aluminum amalgam in anhydrous tetrahydrofuran condenses readily with aldehydes and ketones to give allenic alcohols resulting from coupling α to the trimethylsilyl substituent.

Considerable attention has been given in recent years to the control of propargylic-allenic equilibria for practical synthetic purposes.³ In the specific case of the silyl derivatives 1 and 2 (M = metal), conditions have been elucidated which lead to carbon-carbon bond formation



via 1. In this regard, the lithium reagent (M = Li) is particularly effective in adding to alkyl and allyl halides,⁴ as well as to epoxides,⁵ with regiocontrolled formation of propargylic products. The derived cuprate (1, M = Cu) is recognized to enter into conjugate addition⁶ or vinyl halide displacement⁷ with similar results in most cases.⁸ The Grignard reagent (1, M = MgX) also reacts in the propargylic form, but adds to aldehydes and ketones only in low yield.⁹ Our own recent experiences with Rieke magnesium¹⁰ have provided somewhat improved (ca 25%), although still unattractive efficiency. We wish to report here that functionalized (trimethylsilyl)allenes are formed efficiently and with high positional selectivity by reaction of the aluminum derivative with carbonyl compounds in tetrahydrofuran solution. Although structurally simpler allenylsilanes can be prepared by various methods,¹¹ the present methodology holds promise as a general route to a wide range of α -substituted derivatives.

The dramatically divergent behavior of the zinc¹² and aluminum reagents becomes clearly apparent upon inspection of Table I. The superior efficiency of the Reformatsky species (relative to its Grignard counterpart) in delivering propargyl alcohols in acceptable yields appears to stem principally from a noticeable dropoff in the amounts of coupling by-products. Indeed, the zinc derivative is recommended for use when propargylic products are desired. In contrast, the complex organoaluminum species generally favors allene formation to an overwhelming extent.

Table I. Comparison of Zinc and Aluminum Mediated Condensations of Trimethylsilylpropargyl Bromide with Carbonyl Compounds.^a

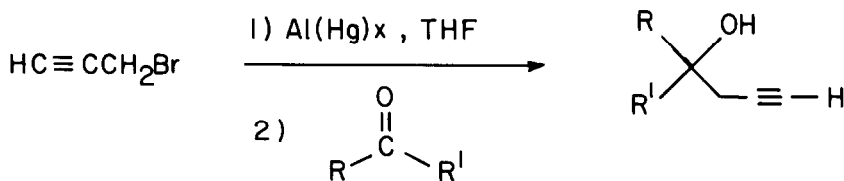
Electrophile	$\text{Me}_3\text{Si-C}\equiv\text{C-CH}_2\text{ZnBr}$	(% Yield)	$\text{Me}_3\text{Si-C}\equiv\text{C-CH}_2\text{Al}_{2/3}\text{Br}$	(% Yield)
		(61)		(69)
		(76)		(81) ^c
		(75)		(70)
		(71) ^b		(80) ^d
		(66)		(68) ^d

^aAll reactions were conducted in dry, freshly distilled tetrahydrofuran as solvent. While the Reformatsky reagent was prepared by stirring the bromide with activated (HgCl_2) granular zinc at 0-25°C for 5-8 hr, formation of the aluminum reagent required the reflux temperature for 3-5 hr. Exposure to the carbonyl reagent was limited to 1 hr at 0°C, at which point saturated ammonium chloride solution was introduced. Yields are given for chromatographically purified products whose IR, ^1H NMR, and mass (accurate) spectra proved fully consistent with the assigned structures. ^bThe product in this example consisted of a 9:1 mixture (separable) of the propargyl and allenyl alcohols. ^cApproximately 10% of the product in this case proved to be the propargyl isomer (separated by VPC). ^dThe yields given here include the variable amounts of structurally related ketones which result from oxidation (see text).

Table II. Solvent Effects on the Regioselectivity of Protonolysis of the Aluminum Reagent.

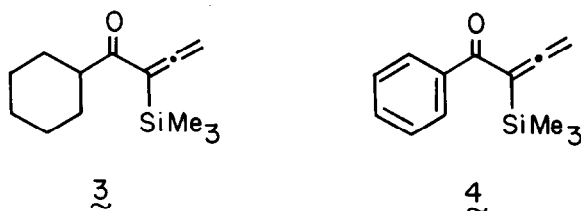
Solvent	Me ₃ Si-C≡C-CH ₃ (%)	Me ₃ Si- $\begin{matrix} \diagdown \\ \text{C}=\text{C}=\text{CH}_2 \\ \diagup \\ \text{H} \end{matrix}$ (%)
(C ₂ H ₅) ₂ O, Δ	72	28
THF, Δ	18	82
Diglyme, 80°C	14	86

While the structural character of this reagent is unclear at present, its striking α -selective reactivity causes us to suspect a fundamental distinction between it on the one hand, and the Grignard and Reformatsky species on the other. If relative steric hindrance at the reactive site does play a significant role in formation of the acetylenic product when M in 1 and 2 is Zn or Mg, the organoaluminum species is much less sensitive to this factor. In this connection, however, the contributing electronic influence of the trimethylsilyl substituent must not be ignored, as evidenced by the reported behavior of the aluminum reagent derived from the unsubstituted propargyl bromide:¹³



The regiochemical selectivity of the aluminum reagent has also been found to be highly dependent upon its solvation environment. The impact of solvent changes on product composition was conveniently evaluated by simple protonolysis experiments. As seen in Table II, diglyme and tetrahydrofuran, solvents with enhanced donor properties relative to ether, contribute strikingly to heightened reactivity of the allenyl-generating form of the complex.¹⁴

Unlike the secondary homopropargyl alcohols, the secondary allenyl carbinols were found to be contaminated with low levels of the corresponding ketones (5% of 3; 15% of 4). Since



the purified carbinols were not particularly sensitive to air oxidation, 3 and 4 would appear to arise from Oppenauer oxidation by unreacted aldehyde of the aluminum alkoxide intermediates initially formed. Alternatively, these structurally interesting ketones can be efficiently produced by nickel peroxide oxidation of the allenyl carbinols.¹⁵

Synthetic applications of the α -hydroxymethylated (trimethylsilyl)allenes will be reported elsewhere.

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