

SYNLETT Spotlight

This feature focuses on a reagent chosen by a postgraduate, highlighting the uses and preparation of the reagent in current research

Applications of Allenylsilanes in Organic Synthesis

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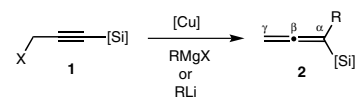


Introduction

Allenylsilanes **2** are versatile reagents widely used in organic synthesis.¹ Generally, allenylsilanes react as propargyl anion equivalents in Lewis acid mediated² or thermal³ nucleophilic addition to electrophiles such as carbonyls, imines, Selectfluor, and *N*-bromosuccinimide, etc.^{1,4,5} The regioselective addition of allenylsilanes provides a β -vinyl cation, which is stabilized by a C–Si bond, which is called β effect. The C–Si bond in allenylsilanes is oriented cis-planar to the *p*-orbital of the carbocation and provides direct stabilization.⁵ Allenylsilanes undergo [3+2] annulations with α,β -unsaturated carbonyls, carbonyl compounds, imines, and nitrosyl cations to form cyclo-

pentenones, dihydrofurans, dihydropyrroles, and isoxazoles, respectively.^{1,4,5}

The efficient methods for the synthesis of allenylsilanes **2** are copper-mediated 1,3-substitution reactions of carbon nucleophiles to propargylic substrates **1** having a leaving group at the propargylic position.^{6,7}

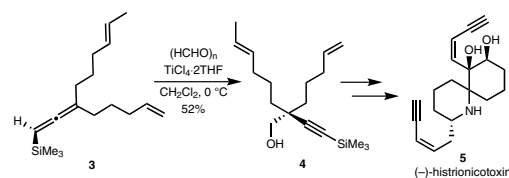


[Si] = SiMe₃, TBDMS, TBDPS, etc.
X = OMs, OAc, etc. R = alkyl, aryl

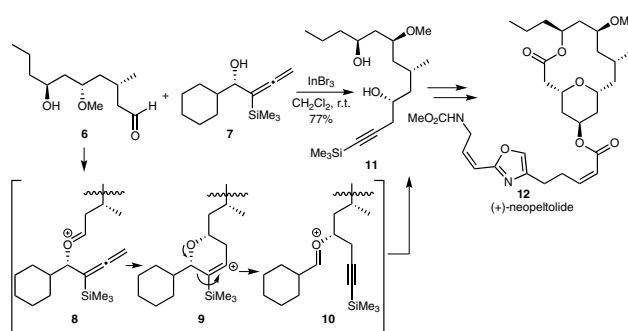
Scheme 1 Synthesis of allenylsilanes

Abstracts

(A) *Reactions with Aldehydes:* Allenylsilanes react with aldehydes and ketones in the presence of titanium tetrachloride to provide homopropargylic alcohols in a regioselective manner. The reaction of chiral allenylsilanes with chiral aldehydes leads to the formation of mainly *syn* homopropargylic alcohols.³ The reaction of chiral 3,3-disubstituted allenylsilane **3** with paraformaldehyde in the presence of TiCl₄·2THF generates chiral homopropargylic alcohol **4**, which is the key intermediate in the total synthesis of (–)-histrionicotxin **5**.⁸



(B) *Reactions with Aldehydes:* The reaction of chiral 2-silyl-substituted α -allenyl alcohol **7** with aldehyde **6** in the presence of InBr₃ give rise to chiral homopropargylic alcohol **11**. The reaction proceeds via formation of oxocarbenium ion **8**, which undergoes a [3,3]-sigmatropic rearrangement to form the alcohol **11**. The alcohol **11** is the key intermediate in the total synthesis of the natural product (+)-neopeltolide **12**.⁹



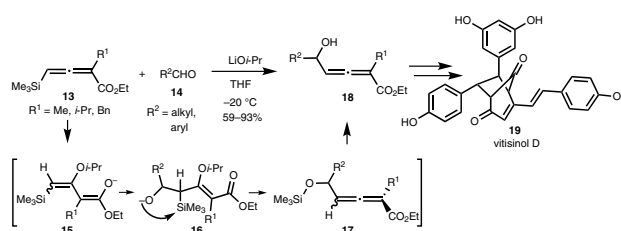
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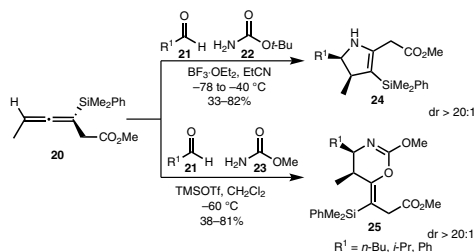
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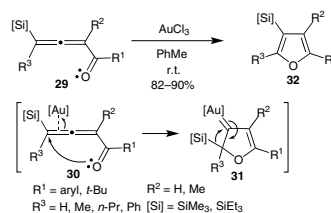
(C) *Reactions with Aldehydes*: The addition of γ -trimethylsilyl alene esters **13** to aldehydes **14** in the presence of *i*-PrOLi leads to the formation of regioselective γ -carbinols **18**. The addition of anionic catalyst *i*-PrOLi leads to the intermediate **15**, which possess enolate-like reactivity. The nucleophilic addition of intermediate **15** to aldehyde **14** generates intermediate **16**. Then, the silyl group undergoes a 1,3-shift and the nucleophile eliminates to form the intermediate **17**. This reaction is the key step in the total synthesis of the [3.2.1] bicyclic natural product vitisinol D.¹⁰



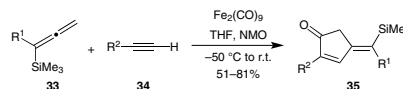
(D) *Reactions with Imines*: The enantioenriched allenylsilane **20** reacts with the in situ generated iminium ion generated from *t*-butyl carbamate **22** and aldehydes **21** in the presence of $\text{BF}_3 \cdot \text{OEt}_2$ to form substituted 4,5-dihydropyrroles **24**. Similarly, the reaction of allenylsilane **20** with an iminium ion, generated in situ from methyl carbamate **23** and aldehydes **21** in the presence of TMSOTf, forms substituted 4,5-dihydrooxazines **25**.¹¹



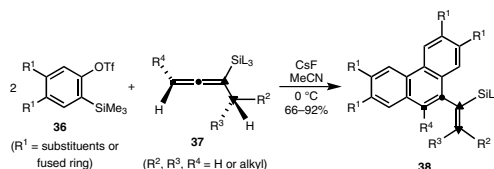
(E) *Gold-Catalyzed Cycloisomerization*: In the presence of AuCl_3 the γ -silyl-substituted allenyl ketones **29** undergoes cycloisomerization to 3-silyl furans **32**. The cyclization of the allenyl ketone **29** give rise to the intermediate gold-carbene **31**, and upon the 1,2-Si shift, the 3-silyl furan **32** is produced.¹²



(F) *The Pauson–Khand Reaction of 1,1-Disubstituted Allenylsilanes*: The Pauson–Khand reaction of 1,1-disubstituted allenylsilanes with terminal alkynes leads to 4-alkylidene-2-cyclopenten-1-ones in good yields. The reaction proceeds through a [2+2+1] pathway. A three-membered iron metacycle is generated by reaction of allenylsilane **33** with diiron nonacarbonyl. The iron metacycle undergoes complexation with alkyne **34**, and finally, a reductive elimination takes place to provide the 4-alkylidene-2-cyclopenten-1-one **35**.¹³



(G) *[2+2+2] Cycloaddition with Benzenes*: Benzenes possess a strained triple bond and are highly electrophilic. Allenylsilanes **37** react with two equivalents of benzenes **36** to generate (α -phenanthrenyl)vinylsilanes **38** in excellent yields. The reaction proceeds through a [2+2+2] pathway.¹⁴



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