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 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 regiospecific 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-coplanar 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 cyclopentenones, dihydrafurans, dihydropyrroles, and isoxazoles, respectively.1,4,5

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

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 (−)-histrionicotoxin 5.8

(B) Reactions with Aldehydes: The reaction of chiral 2-silyl-substituted α-allenic 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
Reactions with Aldehydes: The addition of γ-trimethylsilyl aldehyde esters to aldehydes in the presence of iPrOLi leads to the formation of regiospecific γ-carbinols. The addition of anionic catalyst iPrOLi leads to the intermediate, which possesses enolate-like reactivity. The nucleophilic addition of intermediate to aldehyde generates intermediate. Then, the silyl group undergoes a 1,3-shift and the nucleophile eliminates to form the intermediate. This reaction is the key step in the total synthesis of the bicyclic natural product vitisinol D.

Reactions with Imines: The enantioenriched allenylsilane reacts with the in situ generated iminium ion generated from i-butyl carbamate and aldehydes in the presence of BF₃·OEt₂ to form substituted 4,5-dihydrooxazines. Similarly, the reaction of allenylsilane with an iminium ion, generated in situ from methyl carbamate and aldehydes in the presence of TMSOTf, forms substituted 4,5-dihydrooxazines.

Gold-Catalyzed Cycloisomerization: In the presence of AuCl₃, the silyl-substituted allenyl ketones undergo cycloisomerization to 3-silyl furans. The cyclization of the allenyl ketone gives rise to the intermediate gold-carbene, and upon the 1,2-Si shift, the 3-silyl furan is produced.

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 with diiron nonacarbonyl. The iron metacycle undergoes complexation with alkynyl, and finally, a reductive elimination takes place to provide the 4-alkylidene-2-cyclopenten-1-one.

Cycloaddition with Benzynes: Benzynes possess a strained triple bond and are highly electrophilic. Allenylsilanes react with two equivalents of benzynes to generate a phenanthro[3,4-c][1,2,3]triazole.

References: