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Hydrosilylation

Asymmetric Cobalt-Catalyzed Regioselective Hydrosilylation/Cyclization of 1,6-Enynes

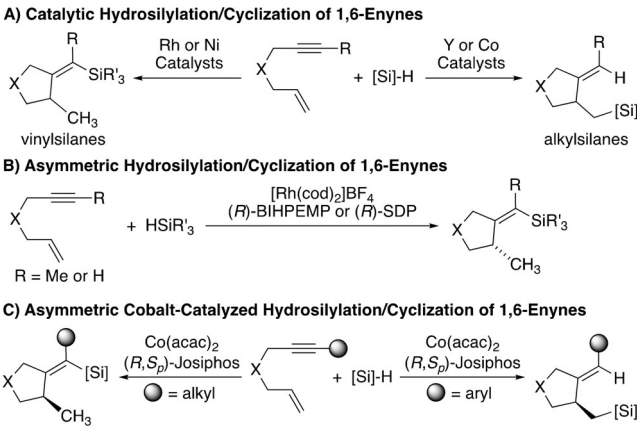
*Yang'en You and Shaozhong Ge**

Abstract: *We report an enantioselective cobalt-catalyzed hydrosilylation/cyclization reaction of 1,6-enynes with secondary and tertiary hydrosilanes employing a catalyst generated in situ from the combination of $Co(acac)_2$ and (R,S_p)-Josiphos. A wide range of oxygen-, nitrogen-, and carbon-tethered 1,6-enynes reacted with Ph_2SiH_2, $(EtO)_3SiH$, or $(RO)_2MeSiH$ to afford the corresponding chiral organosilane products in high yields and up to >99% ee. This cobalt-catalyzed hydrosilylation/cyclization also occurred with prochiral secondary hydrosilane $PhMeSiH_2$ to yield chiral alkylsilanes containing both carbon- and silicon-stereogenic centers with excellent enantioselectivity, albeit with modest diastereoselectivity. The chiral organosilane products from this cobalt-catalyzed asymmetric hydrosilylation/cyclization could be converted to a variety of chiral five-membered heterocyclic compounds by stereospecific conversion of their C–Si and Si–H bonds without loss of enantiopurity.*

Introduction

Enantioenriched organosilanes have recently gained increasing attention in organic synthesis, material sciences, and medicinal chemistry due to their versatile reactivity, high stability, and low-toxicity.[1] Catalytic asymmetric hydrosilylation of unsaturated hydrocarbons provides an atom-economic approach to synthesize chiral organosilane compounds.[2] Recent years have witnessed a tremendous progress in such enantioselective hydrosilylation reactions with first-row transition-metal catalysts.[3] However, the majority of these reactions have focused on asymmetric hydrosilylation of simple alkenes and alkylsilane products from these reactions are structurally rather limited. Therefore, it is still desirable to develop highly enantioselective protocols to synthesize structurally diverse chiral organosilanes from easily accessible starting materials, particularly with readily available base metal catalysts.

Metal-catalyzed enantioselective hydrosilylation/cyclization of 1,6-enynes can produce chiral silyl-functionalized carbo- or heterocyclic structural units that are widespread in a variety of bioactive natural products and synthetic compounds.[4] Various transition metal (such as Rh,[5] Ni,[6] Y,[7] and Co[8]) complexes can catalyze hydrosilylation/cyclization reactions of 1,6-enynes, and these reactions can afford either alkylsilane or vinylsilane products (Scheme 1 A). Chiral cationic rhodium catalysts have been identified for hydrosilylation/cyclization of 1,6-enynes, but these reactions can only afford enantioenriched vinylsilane products (Scheme 1 B).[9] Catalytic asymmetric hydrosilylation/cyclization reactions of 1,6-enynes that can lead to enantioenriched alkylsilane products still remain unknown. Furthermore, the control of the regioselectivity for hydrosilylation/cyclization reactions of 1,6-enynes is not well understood.



Scheme 1. Transition-metal-catalyzed hydrosilylation/cyclization of 1,6-enynes.

In recent years, cobalt catalysts have been extensively studied for selective hydrosilylation of a wide range of unsaturated hydrocarbons,[10] partially due to their high abundance, low-toxicity, and ready availability. Hydrosilylation/cyclization of 1,6-enynes has also been explored with cobalt catalysts, and these cobalt-catalyzed reactions form only racemic alkylsilane products.[8b] Considering complete lack of chiral catalysts for asymmetric hydrosilylation/cyclization of 1,6-enynes to synthesize enantioenriched cyclic alkylsilanes, we become particularly interested in identifying chiral cobalt catalysts for the synthesis of such chiral cyclic alkylsilane compounds during our continuous effort in developing cobalt-catalyzed hydrosilylation reactions of unsaturated hydrocarbons.[11] Herein, we report cobalt-catalyzed asymmetric hydrosilylation/cyclization of 1,6-enynes that yields chiral alkylsilane or vinylsilane products with excellent enantioselectivity. We also showed that chiral organosilane products from these reactions can be converted to a variety of chiral heterocyclic compounds via stereospecific transformations of either Si–H or C–Si bonds. Mechanistic studies reveal

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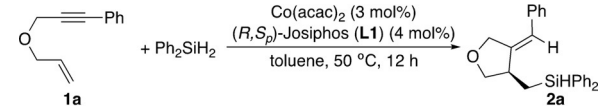
the chelation of 1,6-enynes to cobalt catalysts and the factors that control the regioselectivity of this cobalt-catalyzed hydrosilylation/cyclization of 1,6-enynes.

Results and Discussion

We began this study on cobalt-catalyzed asymmetric hydrosilylation/cyclization by identifying a selective chiral cobalt catalyst and reliable conditions for hydrosilylation of 1,6-enyne **1a** with Ph_2SiH_2 to yield chiral alkylsilane **2a** (Table 1). Upon examining a range of reaction parameters, we found that the reaction conducted with the combination of $Co(acac)_2$ and (R,S_p)-Josiphos (**L1**) in toluene at 50 °C afforded the desired product in 87 % isolated yield and 99 % *ee* (entry 1). The reactions conducted with other chiral phosphine ligands (**L2**–**L4**) either formed a complex mixture of hydrosilylation products (entries 2 and 3) or occurred to very low conversions of **1a** (entries 4 and 5). Furthermore, we identified another chiral ligand of Josiphos family (**L6**) for this reaction, and the reaction gave the desired product **2a** in 73 % yield with 99 % *ee* (entry 6). We also tested other solvents for this hydrosilylation reaction in the presence of $Co(acac)_2$ and **L1** (entries 7–10). The reaction conducted in THF proceeded well and product **2a** was obtained in 80 % yield with 99 % *ee* (entry 7). However, the reactions barely occurred when acetonitrile, hexane, or cyclohexane was used as solvents (entries 8–10). This reaction also occurred at room temperature, though the completion of the reaction could not be achieved, and **2a** was still obtained in a good yield and with excellent enantioselectivity (entry 11).

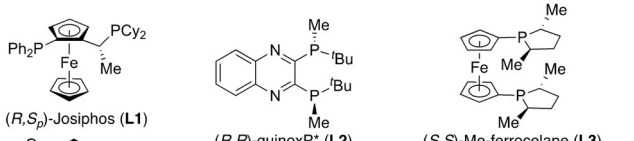
With a selective chiral catalyst and reliable conditions identified for this cobalt-catalyzed asymmetric hydrosilylation/cyclization (entry 1 in Table 1), we studied the scope of 1,6-enynes containing various linkers for this enantioselective reaction, and the results are listed in Table 2. In general,

Table 1: Evaluation of conditions for cobalt-catalyzed hydrosilylation/cyclization of enyne **1a**.[a]



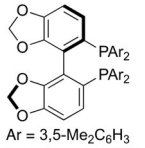
1a 2a

Entry	Variation from the standard conditions	Conversion of **1a** [%]	Yield of **2a** [%]	*ee* of **2a** [%]
1	none	> 99	87	99
2[b]	**L2** instead of **L1**	> 99	< 5	–
3[b]	**L3** instead of **L1**	77	< 5	–
4	**L4** instead of **L1**	< 5	< 5	–
5	**L5** instead of **L1**	< 5	< 5	–
6	**L6** instead of **L1**	> 99	73	99
7	THF instead of toluene	> 99	80	99
8	acetonitrile instead of toluene	< 5	< 5	–
9	hexane instead of toluene	< 5	< 5	–
10	cyclohexane instead of toluene	< 5	< 5	–
11	RT instead of 50 °C	94	73	99

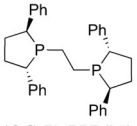

(R,S_p)-Josiphos (**L1**)

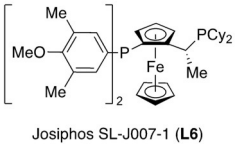
(R,R)-quinoxP* (**L2**)

(S,S)-Me-ferrocelane (**L3**)



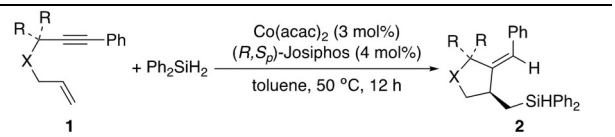
(R)-DM-segphos (**L4**)


(S,S)-Ph-BPE (**L5**)


Josiphos SL-J007-1 (**L6**)

[a] Conditions: $Co(acac)_2$ (3.0 μmol), chiral ligand (4.0 μmol), 1,6-enyne **1a** (0.100 mmol), Ph_2SiH_2 (0.130 mmol), toluene (0.5 mL), 50 °C, 12 h, isolated yields, conversion was determined by GC analysis on the crude reaction mixtures and *ee* was determined by chiral HPLC analysis with the isolated compound **2a**. [b] The reaction led to a complex mixture of multiple products.

Table 2: Scope of 1,6-enynes.[a]



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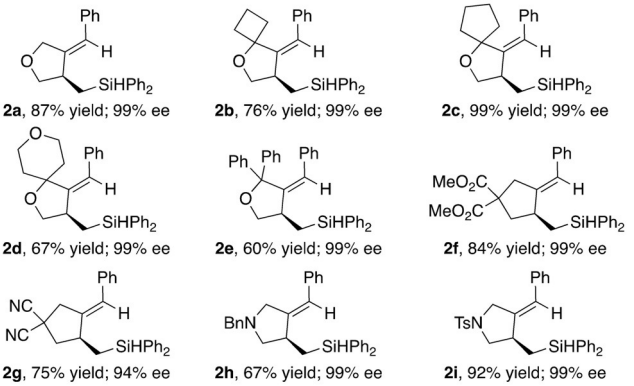
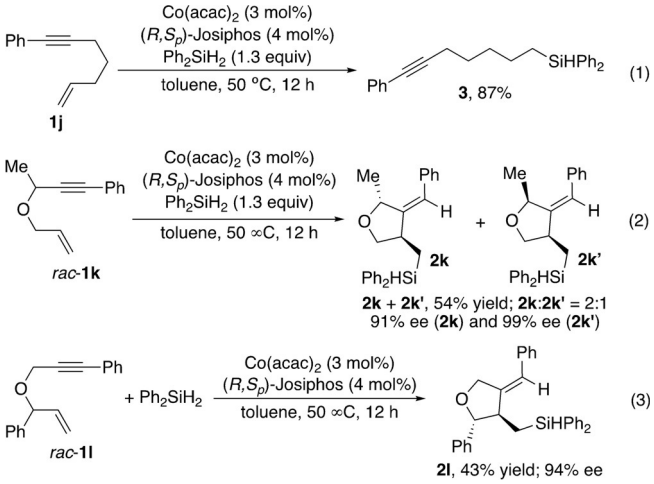


[a] Conditions: $Co(acac)_2$ (6.0 μmol), (R,S_p)-Josiphos (8.0 μmol), 1,6-enyne (0.200 mmol), Ph_2SiH_2 (0.260 mmol), toluene (0.5 mL), 50 °C, 12 h, isolated yields.

a variety of O- (**1a**–**1e**), C- (**1f** and **1g**), and N-tethered (**1h** and **1i**) 1,6-enynes reacted with Ph_2SiH_2 in the presence of 3 mol % of $Co(acac)_2$ and (R,S_p)-Josiphos, affording the corresponding enantioenriched β-stereogenic alkylsilanes (**2a**–**2i**) in good yields (60–99 %) with excellent enantioselectivity (94–99 % *ee*). The Thorpe–Ingold effect plays a key role in this cobalt-catalyzed cyclization of carbon-tethered 1,6-enynes. For example, $C(CO_2Me)_2$- and $C(CN)_2$-tethered 1,6-enynes (**1f** and **1g**) reacted smoothly to give the desired products (**2f** and **2g**) in good yields under identified conditions. However, the CH_2-tethered 1,6-enyne **1j** just underwent hydrosilylation of the terminal alkene unit without cyclization [Eq. (1)].

The data in Table 2 shows that the substituents at the propargylic position (**2a**–**2e**) do not have significant influence on the enantioselectivity of this cobalt-catalyzed asymmetric reaction. We then tested a racemic 1,6-enyne *rac*-**1k**, with a methyl group on the propargylic position, for this hydrosilylaiton/cyclization, and this reaction proceeded smoothly under standard conditions to form a pair of diastereomers **2k**

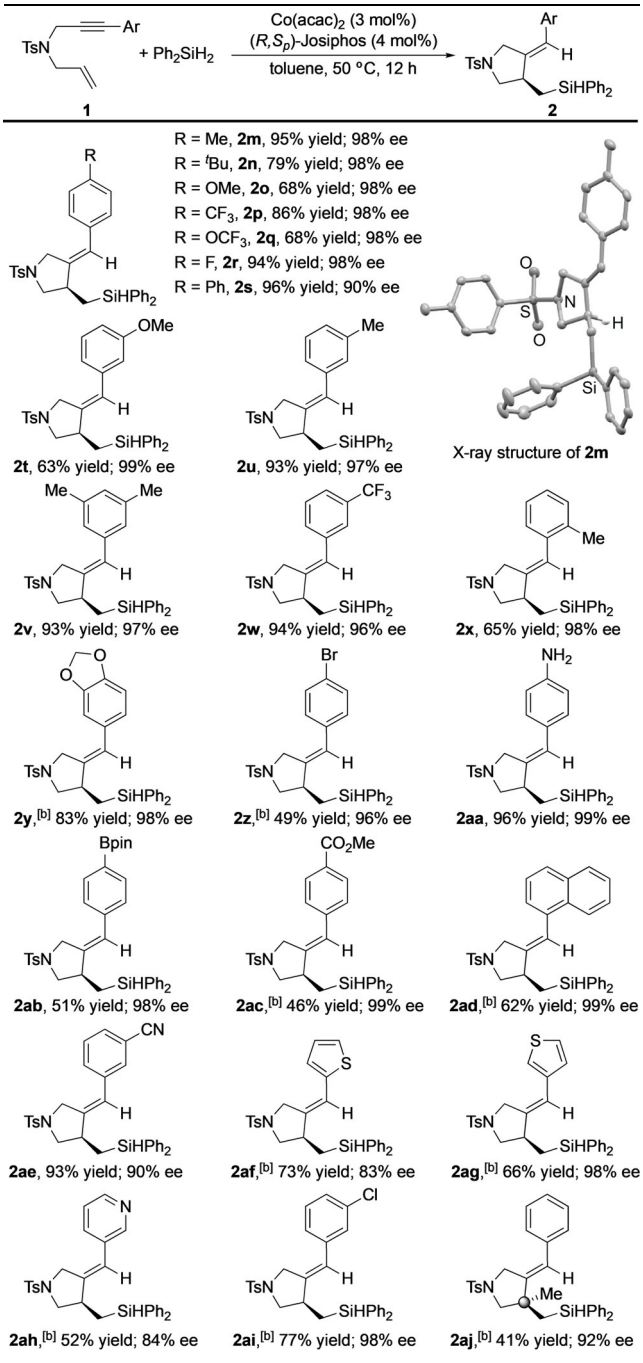


and **2k′** (**2k**:**2k′** = 2:1) in 54% isolated yield with high enantioselectivity for both diastereomers [Eq. (2)]. Interestingly, we found that racemic 1,6-enyne *rac*-**1l**, which contains a phenyl group at the allylic position, underwent stereospecific hydrosilylation/cyclization in the presence $Co(acac)_2$ and (R,S_p)-Josiphos. Under standard conditions, only (*S*)-enantiomer of 1,6-enyne *rac*-**1l** reacted to afford **2l** as a single diastereomer in 43% isolated yield with 94% *ee* [Eq. (3)].[12]

We subsequently explored the scope of N(Ts)-tethered 1,6-enynes, regarding the aryl-group on the alkynyl moiety, for this enantioselective hydrosilylation/cyclization reaction, and the results are summarized in Table 3. A range of N(Ts)-tethered 1,6-enynes (**1m**–**1aj**) containing various electronically varied aryl groups, such as aryl groups possessing an electron-donating group (i.e, -OMe, -Me, -^{t}Bu, or -NH_2) or an electron-withdrawing group (i.e., -CF_3, -CN, or -CO_2Me), reacted under the identified conditions (entry 1 in Table 1) to form the desired alkylsilane products (**2m**–**2aj**) in good isolated yields with high enantioselectivity (up to 99% *ee*). The absolute configuration of the stereogenic carbon and the stereochemistry of the alkene moiety in compound **2m** were assigned as (*R*) and (*Z*), respectively, by single-crystal X-ray diffraction analysis.[13]

Data in Table 3 indicate that the substitution pattern of the aryl groups on the alkynyl moieties has negligible influence on the enantioselectivity of these asymmetric reactions. For example, enynes containing *para*- (**1m**–**1r**), *meta*- (**1t**–**1w**), and *ortho*-substitutited aryl groups (**1x**) reacted to give the desired chiral alkylsilane products with excellent enantioselectivity. This cobalt-catalyzed asymmetric transformation tolerates a range of functionalities, such as trifluoromethoxy (**2q**), bromo (**2z**), unprotected aniline (**2aa**), boronic ester (**2ab**), carboxylic ester (**2ac**), cyano (**2ae**), and chloro (**2ai**) moieties. In addition, 1,6-enynes containing S- or N-heteroaryl groups also reacted smoothly to afford the desired products (**2af**–**2ah**) in good yields with high enantioselectivity (83–98% *ee*). Furthermore, this cobalt-catalyzed cyclization/hydrosilylation can also be used to construct quaternary stereogenic centers. For example, 1,6-enynes containing a *gem*-disubstituted alkene unit reacted

Table 3: Scope of N(Ts)-tethered 1,6-enynes.[a]

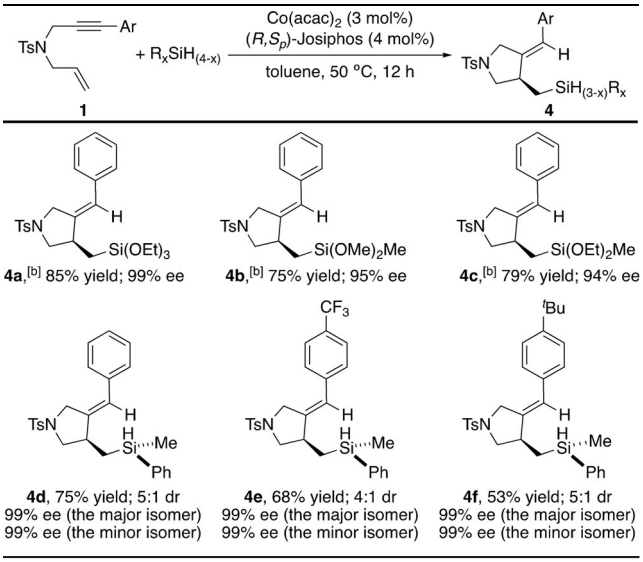


[a] Conditions: $Co(acac)_2$ (6.0 μmol), (R,S_p)-Josiphos (8.0 μmol), 1,6-enyne (0.200 mmol), Ph_2SiH_2 (0.260 mmol), toluene (0.5 mL), 50 °C, 12 h, isolated yields. [b] 48 h.

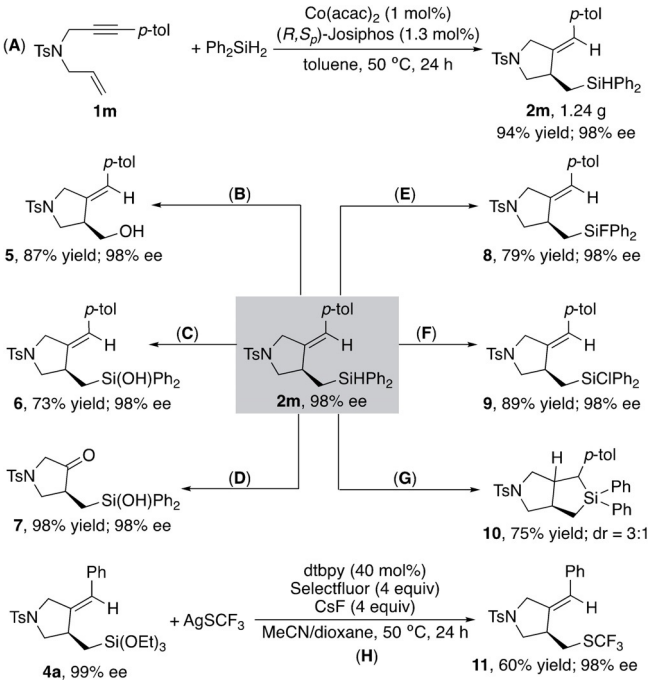
under identified conditions to give the desired product (**2aj**) with 92% *ee*, albeit in a lower yield (42%).

We then chose the hydrosilylation/cyclization reaction of N-tethered 1,6-enynes to study the scope of hydrosilanes and the results are listed in Table 4. Under standard conditions, the reaction of 1,6-enyne **1i** (Ar = Ph) with tertiary hydrosilanes, such as $(EtO)_3SiH$, $(MeO)_2MeSiH$, or $(EtO)_2MeSiH$, did not take place. However, with the addition of 10 mol% $NaBHEt_3$, these reactions proceeded smoothly at 50 °C to

Table 4: Scope of Hydrosilanes.[a]



[a] Conditions: $Co(acac)_2$ (6.0 μmol), (R,S_p)-Josiphos (8.0 μmol), 1,6-enyne (0.200 mmol), hydrosilane (0.260 mmol), toluene (0.5 mL), 50 °C, 12 h, isolated yields. [b] $NaBHEt_3$ (10 mol%), hydrosilane (0.400 mmol), 48 h.



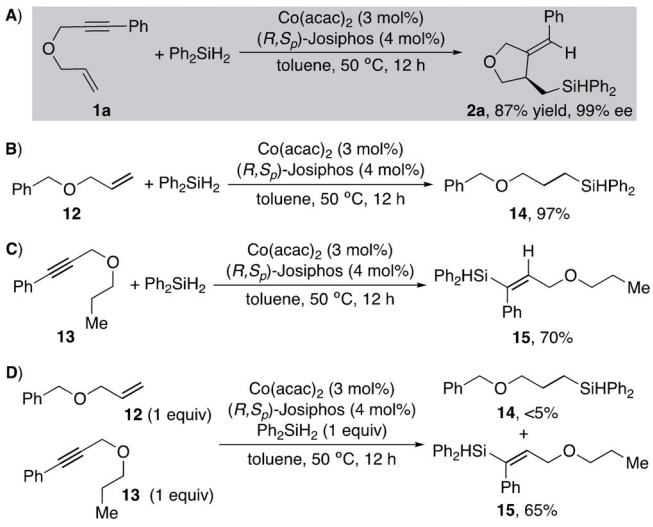
Scheme 2. Gram-scale hydrosilylation/cyclization reaction and derivatization of chiral alkylsilane products; Conditions: B) H_2O_2 (6 equiv), K_2CO_3 (2 equiv), MeOH/THF, RT, 12 h; C) KO^{t}Bu (5 mol%), DMSO/H_2O, RT, 12 h; D) O_3, CH_2Cl_2, −78 °C to RT, 1 h; E) CuI (3 mol%), $CuCl_2$ (2 equiv), KF (1.2 equiv), THF, RT, 12 h; F) CuI (3 mol%), $CuCl_2$ (2 equiv), Et_2O, RT, 12 h; G) $Rh(Oct)_2Cl_2$ (1 mol%), $CHCl_3$, 90 °C, 12 h.

afford the corresponding chiral alkylsilane products (**4a**–**4c**) in high isolated yields (75–86%) with excellent enantioselectivity (94–99% *ee*). Furthermore, we conducted the hydrosilylation/cyclization reaction of **1i** with $PhMeSiH_2$, a prochiral secondary silane, to test whether the formation of a stereogenic carbon center in the cyclization step could induce desymmetrization of this prochiral silane to form a stereogenic silicon center. As expected, 1,6-enyne **1i** reacted with $PhMeSiH_2$ to afford the desired product **4d** in 75% isolated yield with a diastereoselectivity of 5:1 and 99% *ee* for both diastereomers. We then tested two other N-tethered 1,6-enynes (**1n** and **1p**) for this enantioselective and diastereoselective transformation, and these two highly enantioselective reactions (99% *ee*) afforded the desired products (**4e** and **4f**) with dr of 5:1 and 4:1, respectively.

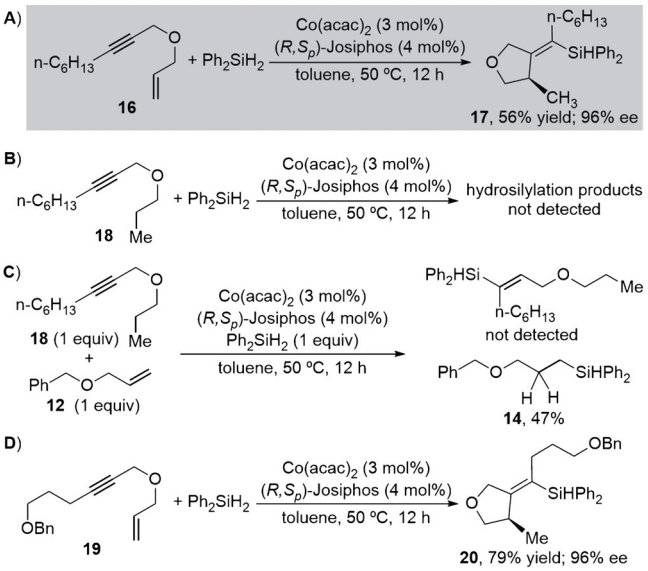
Scheme 2 summarizes the synthetic utility of this cobalt-catalyzed enantioselective protocol for the preparation of chiral alkylsilanes. We conducted a gram-scale reaction between 1,6-enyne **1m** and Ph_2SiH_2 with a reduced catalyst loading (1 mol%, compared with 3 mol% in Table 3). This reaction occurred smoothly to full conversion of **1m** in 24 h at 50 °C and afforded alkylsilane **2m** (1.24 g, 94% yield and 98% *ee*) without diminishing either the yield or the enantioselectivity (Scheme 2A).

The chiral alkylsilane products from these asymmetric hydrosilylation/cyclizaiton reactions could undergo a series of enantiospecific transformations without loss of enantiopurity. Alkylsilane **2m** underwent several selective oxidation reactions by employing appropriate oxidants (Scheme 2B–D). For example, it could be oxidized by H_2O_2 or DMSO to form chiral alcohol **5** or silanol **6**, respectively, in high isolated yields with 98% *ee* (Scheme 2B and C).[14] The C=C bond of compound **2m** could be oxidatively cleaved, with the concomitant oxidation of hydrosilane to silanol, to produce chiral pyrrolidin-3-one **7** in nearly quantitative yield with 98% *ee* (Scheme 2D).[15] Compound **2m** could react with KF or $CuCl_2$ in the presence of 3 mol% CuI to afford fluorosilane **8** and chlorosilane **9**, respectively, in high yields with 98% *ee* (Scheme 2E and F).[16] Furthermore, **2m** could also undergo rhodium-catalyzed intramolecular Si-H insertion into the C=C bond to form cyclic alkylsilane **10** in 75% yield with 3:1 dr (Scheme 2G).[17] We also showed that triethoxy-substituted alkylsilane **3a** could undergo silver-mediated trifluoromethylthiolation to afford thioether **11** in 60% yield with 98% *ee* (Scheme 2H).[18]

To gain some preliminary understanding of the regioselectivity of this cobalt-catalyzed hydrosilylation/cyclization of 1,6-enyne **1a** (Scheme 3A), we conducted hydrosilylation of terminal alkene **12** (Scheme 3B) and phenyl-substituted internal alkyne **13** (Scheme 3C) and compared the regioselectivity of these two reactions with that of hydrosilylation/cyclization of enyne **1a**. Terminal alkene **12** underwent *anti*-Markovnikov hydrosilylation with Ph_2SiH_2 under standard conditions and this reaction afforded alkylsilane product **14** in 97% yield (Scheme 3B), and this reaction showed the same regioselectivity with the hydrosilylation/cyclization of 1,6-enyne **1a** as the silyl group was added onto the terminal carbon of double bond for both reactions. Internal alkyne **13** also reacted with Ph_2SiH_2 in the presence of $Co(acac)_2$ and (R,Sp)-Josiphos, yielding vinylsilane **15** exclusively, as indicated by the GC-MS analysis of this reaction mixture (Scheme 3C). However, the regioselectivity for hydrosilylation of phenyl-substituted alkyne **13** is opposite to the regioselectivity for



Scheme 3. Control experiments of hydrosilylation of aryl-substituted 1,6-enynes.



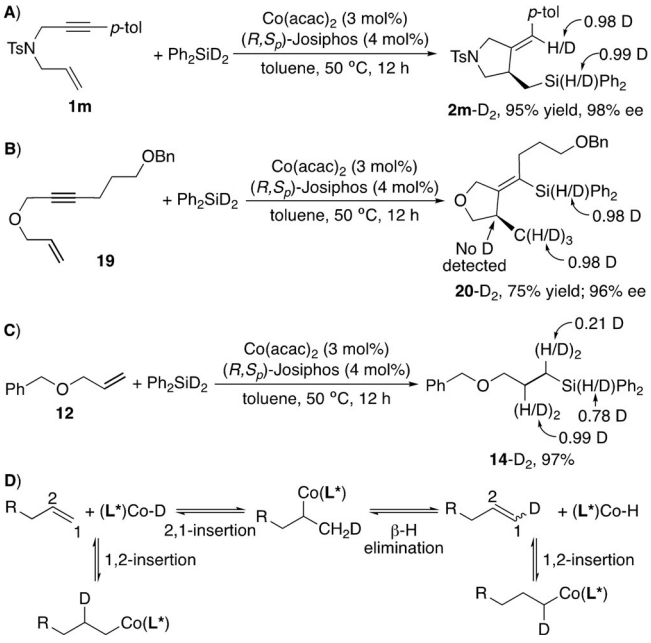
Scheme 4. Control experiments of hydrosilylation of alkyl-substituted 1,6-enynes.

hydrosilylation of internal alkyne in 1,6-enyne **1a**, as the hydrogen was added to different carbons of the triple bond in alkyne **13** and 1,6-enyne **1a**. This observed reversed regioselectivity between hydrosilylation reactions of internal alkyne **13** and 1,6-enyne **1a** suggests the chelation of 1,6-enyne to the cobalt catalyst.

Subsequently, we conducted a competition experiment between hydrosilylation reactions of terminal alkene **12** and internal alkyne **13** with a ratio of 1:1:1 for **12**:**13**:Ph_2SiH_2, and this reaction selectively provided vinylsilane **15** in 65% yield as a major product, together with only a trace amount (< 5%) of alkylsilane **14** as a minor product (Scheme 3D). The result of this competition experiment shows that phenyl-substituted internal alkyne **13** is more reactive toward cobalt-catalyzed hydrosilylation than terminal alkene **12**, suggesting that hydrosilylation/cyclization of 1,6-enyne **1a** may begin with hydrocobaltation of the internal alkyne unit of **1a**.

Interestingly, alkyl-substituted 1,6-enyne **16**, which contains a hexyl group on the alkyne moiety, also underwent this Co-catalyzed hydrosilylation/cyclization reaction under standard conditions, but this reaction afforded vinylsilane product **17** in 56% isolated yield with 96% *ee* (Scheme 4A). To understand the different regioselectivity of hydrosilylation/cyclization of alkyl-substituted 1,6-enyne **16**, we carried out the hydrosilylation reaction of an alkyl-substituted internal alkyne **18** and a competition experiment for hydrosilylation of this alkyl-substituted internal alkyne and terminal alkene **12**. Under standard conditions, internal alkyne **16** did not undergo this cobalt-catalyzed hydrosilylation reaction (Scheme 4B). The hydrosilylation reaction employing an equal molar amount of **12** and **18** only produced linear alkyl product **14** (Scheme 4C). This result indicates that terminal alkene **12** is more reactive toward cobalt-catalyzed hydrosilylation than internal alkyne **18**, suggesting that hydrosilylation/cyclization of 1,6-enyne **16** may begin with hydrocobaltation of the terminal alkene unit of **18**. Furthermore, the hydrocobaltation of alkene units in terminal alkene **12** and 1,6-enyne **16** showed different regioselectivity. The hydrogen atom of Ph_2SiH_2 was added to the internal carbon of the alkene unit of **12** (Scheme 4C), but the hydrogen atom of Ph_2SiH_2 was added to the terminal carbon of the alkene unit of **16** (Scheme 4A). Compared with hydrocobaltation of terminal alkene **12**, the presence of alkyne moiety in 1,6-enyne **16** changes the regioselectivity of hydrocobaltation of the alkene unit of **16**, suggesting the chelation of 1,6-enyne **16** to the cobalt catalyst.

We subsequently conducted some deuterium-labelling experiments for hydrosilylation of 1,6-enynes and terminal alkenes to get some mechanistic evidence for this cobalt-catalyzed transformation (Scheme 5). Aryl-substituted 1,6-enyne **1m** reacted with Ph_2SiD_2 under standard conditions to

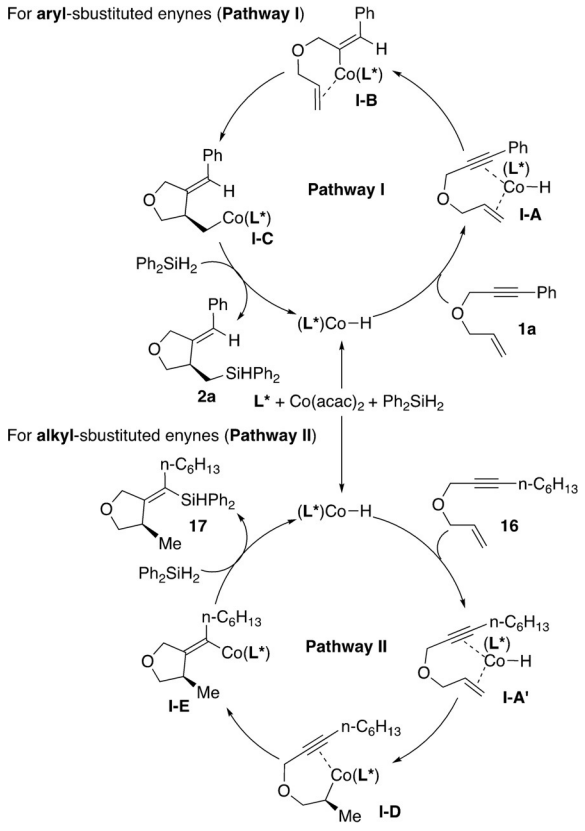


Scheme 5. Deuterium-labeling experiments.

form chiral alkylsilane **2m**-D_2 in 95% yield with 98% *ee* and one of the deuterium atoms in Ph_2SiD_2 was selectively incorporated onto the vinylic carbon of **2m**-D_2 (Scheme 5A). For hydrosilylation/cyclization of alkyl-substituted 1,6-enyne **19** with Ph_2SiD_2, the reaction afforded vinylsialne **20**-D_2 in 75% yield with 96% *ee* with one of the deuterium atoms in Ph_2SiD_2 selectively incorporated onto the terminal carbon in the alkene unit of enyne **19** (Scheme 5B). For comparison, we also carried out the hydrosilylation reaction of terminal alkene **12** with Ph_2SiD_2 and this reaction provided the desired product **14**-D_2 in high yield with deuterium-incorporation on both internal and terminal carbons of the double bond of alkene **12**. (Scheme 5C). This deuterium-incorporation can be explained by reversible 1,2-insertion, 2,1-insertion, and β-H elimination between alkene **12** and a cobalt hydride species (**L***)Co-H, as depicted in Scheme 5D.

Based on the results of the deuterium-labeling and control experiments and the precedent of cobalt-catalyzed hydrosilylation reactions,[19] we proposed a plausible catalytic pathway for this cobalt-catalyzed hydrosilylation/cyclization of 1,6-enynes (Scheme 6). The reaction of $Co(acac)_2$ with Ph_2SiH_2 in the presence of (*R*,*Sp*)-Josiphos (**L***) generates a cobalt hydride species (**L***)Co-H. For hydrosilylation/cyclization of aryl-substituted 1,6-enyne **1a** (Pathway I, Scheme 6), the chelation of 1,6-enyne **1a** to (**L***)Co-H forms the intermediate **A**. The coordinated alkyne unit then undergoes migratory insertion into Co–H bond to produce a vinylcobalt species **B**, followed by enantioselective intramolecular migratory insertion of the alkene unit into the Co–C bond of **B** to form an alkylcobalt intermediate **C**. Subsequent reaction of alkylcobalt species **C** with H_2SiPh_2 furnishes the chiral alkylsilane product **2a** and regenerates the catalytically active cobalt hydride species (**L***)Co-H.

For hydrosilylation/cyclization of alkyl-substituted 1,6-enyne **16** (Pathway II, Scheme 6), the chelation of **16** to (**L***)Co-H generate the intermediate **I-A′**, and subsequent enantioselective insertion of the coordinated alkene unit into the Co–H bond produces an alkylcobalt species **D**. The alkyne unit then undergoes intramolecular insertion to form a vinylcobalt intermediate **E**, which reacts with Ph_2SiH_2 to form vinylsilane product **17** and regenerate cobalt hydride species (**L***)Co-H. For the deuterium-labeling experiment of hydrosilylation of alkyl-substituted 1,6-enyne **19** (Scheme 5B), the lack of deuterium-incorporation onto the internal carbon of the double bond of **19** suggests that the C=C double bond in **19** tends to undergo 2,1-insertion into the Co–H bond due to the chelation of 1,6-enyne to the cobalt catalyst and that the rate of intramolecular insertion of the coordinated C≡C triple into the Co–C bond in intermediate **I-D** is faster than that of β-H elimination from intermediate **I-D** as depicted in Scheme 6.



Scheme 6. Proposed catalytic cycles for this Co-catalyzed hydrosilylation/cyclization of 1,6-enynes.

Conclusion

We have developed an enantioselective protocol for the synthesis of silyl-functionalized chiral cyclic compounds by cobalt-catalyzed hydrosilylation/cyclization of 1,6-enynes with hydrosilanes. A variety of carbon-, oxygen-, and nitrogen-tethered aryl-substituted 1,6-enynes react with secondary or tertiary hydrosilanes in the presence of a chiral cobalt catalyst generated in situ from $Co(acac)_2$ and (*R*,*Sp*)-Josiphos to afford the corresponding alkylsilane products in high isolated yields with excellent enantioselectivity. In addition, alkyl-substituted 1,6-enynes also react in the presence of the same chiral cobalt catalyst to yield vinylsilane products with high enantioselectivity. Mechanistic studies suggest that the chelation of 1,6-enyne to the cobalt catalyst and the relative reactivity of the alkyne and alkene moieties in 1,6-enynes towards hydrocobaltation controls the regioselectivity of this cobalt-catalyzed hydrosilylation/cyclization reaction.

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Conflict of interest

The authors declare no conflict of interest.

Keywords: 1,6-enyens · chiral alkylsilanes · cobalt · enantioselectivity · hydrosilylation/cyclization

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