A Journal of the Gesellschaft Deutscher Chemiker

Angewandte International Edition GDCh Chemie

www.angewandte.org

Accepted Article

Title: Enantioselective Silylation of Aliphatic C–H Bonds for the Synthesis of Silicon-Stereogenic Dihydrobenzosiloles

Authors: Chuan He, Bo Yang, Wu Yang, Yonghong Guo, and Lijun You

To be cited as: *Angew. Chem. Int. Ed.* 10.1002/anie.202009912

Link to VoR: https://doi.org/10.1002/anie.202009912

WILEY-VCH

10.1002/anie.202009912

RESEARCH ARTICLE

WILEY-VCH

Enantioselective Silylation of Aliphatic C–H Bonds for the Synthesis of Silicon-Stereogenic Dihydrobenzosiloles

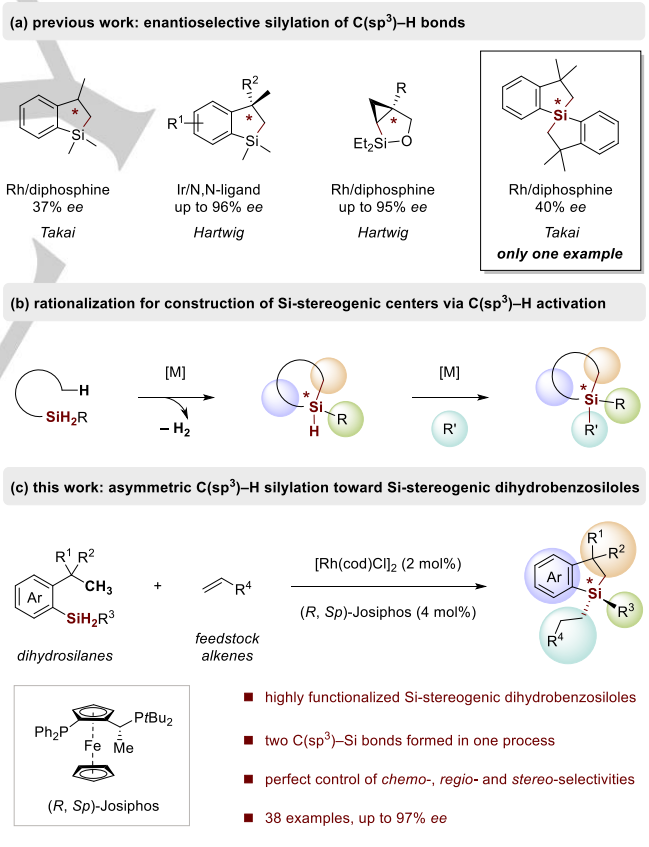
Bo Yang, Wu Yang, Yonghong Guo, Lijun You, and Chuan He*

Abstract: A rhodium(I)-catalyzed enantioselective silylation of aliphatic C–H bonds for the synthesis of silicon-stereogenic dihydrobenzosiloles is demonstrated. This reaction involves a highly enantioselective intramolecular C(sp^3)−H silylation of dihydrosilanes, followed by a stereospecific intermolecular alkene hydrosilylation leading to the asymmetrically tetrasubstituted silanes. A wide range of dihydrosilanes and alkenes displaying various functional groups are compatible with this process, giving access to a variety of highly functionalized silicon-stereogenic dihydrobenzosiloles in good to excellent yields and enantioselectivities.

Introduction

The development of new catalytic transformations based on enantioselective functionalization of unactivated C−H bonds is of great significance, given the ubiquitous nature of C−H bonds and paramount importance of chirality in organic molecules.[1] Over the past decade, despite remarkable progress has been achieved by chiral transition metal catalysis in this emerging area, the enantioselective functionalization of unactivated C(sp^3)−H bonds is still in its infancy.[1f] Among various C−H functionalization approaches, the silylation of aliphatic C−H bonds has emerged as a powerful tool for converting C(sp^3)−H bonds into C(sp^3)−Si bonds,[2] which is particularly valuable, because organosilicon compounds have wide applications in materials science, agroscience, and medicinal chemistry.[3] The process is usually initiated by oxidative addition of the Si−H bond to the metal center, which delivers the metal atom to the proximal C−H bond site, allowing the selective C−H bond activation.[2a,4] The Hartwig group have made leading efforts in this field,[2a,2d,5] and successfully developed two enantioselective processes for the silylation of unactivated C(sp^3)−H bonds, enabling the construction of chiral carbon-stereogenic centers (Scheme 1a).[6] However, to the best of our knowledge, there is only one example reported by Takai and co-workers, that achieved an asymmetric C(sp^3)−H silylation toward silicon-stereogenic center, producing a specific spirosilabiindane compound in moderate yield with 40% enantiomeric excess (*ee*) (Scheme 1a).[7] As a result, the design and development of more general and effective strategies for the enantioselective silylation of aliphatic C–H bonds toward novel silicon-stereogenic silanes remain underdeveloped.

Despite many organosilicon compounds have been synthesized, which display valuable properties that have led to their broad applications in synthetic chemistry, materials science and pharmaceuticals,[3] the creation of silicon-stereogenic centers in enantioenriched forms has been less explored. Historically, the exploitation of chirality at silicon in asymmetric catalysis is one of the most intriguing and challenging tasks.[8] Traditionally, reagent- or substrate-controlled transformations were reported for the preparation of silicon-stereogenic silanes in enantioenriched form but, without exception, the enantioselectivities were usually not easy to control.[8b,8d] In the past decade, research endeavors have been dedicated to the design and development of chiral transition-metal catalysts, that have delivered a number of desymmetrization approaches converting prochiral dihydrosilanes or tetraorganosilanes into enantioenriched silicon-stereogenic silanes.[8g,9] The increasing demand for novel silicon-stereogenic silanes has continued to drive the development of practical asymmetric catalytic methods with high enantioselectivity for the synthesis of these compounds.



Scheme 1. Enantioselective silylation of aliphatic C–H bonds.

As part of an overarching goal to develop new modes for catalytic enantioselective C–H bond functionalization, as well as construction of silicon-stereogenic center, we questioned whether we could developed a strategy for the direct enantioselective silylation of less reactive aliphatic C−H bonds, giving access to a new type of silicon-stereogenic silanes. We

[*] Dr. B. Yang, Dr. W. Yang, Y. Guo, L. You, Prof. Dr. C. He
Shenzhen Grubbs Institute and Department of Chemistry
Guangdong Provincial Key Laboratory of Catalysis
Southern University of Science and Technology
Shenzhen 518055, Guangdong, China
E-mail: hec@sustech.edu.cn

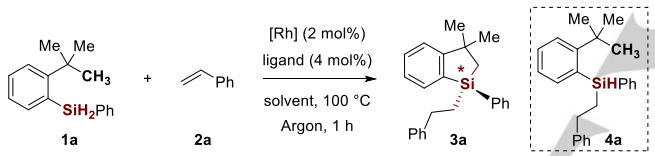
Supporting information for this article is given via a link at the end of the document.

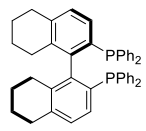
10.1002/anie.202009912

rationalized that, reaction of an appropriate chiral transition metal catalyst with a suitable dihydrosilane substrate would initiate an enantioselective intramolecular C(sp^3)−H silylation to furnish the corresponding desymmetric monohydrosilane. To avoid the feasible decomposition or racemization of the newly formed monohydrosilane in the presence of highly active transition metals,[9a] appropriate reaction partners could be employed in the system to trap the monohydrosilane instantly, and delivered the asymmetrically tetrasubstituted silicon-stereogenic silanes (Scheme 1b). Key to the success of this strategy is the precise control of the reaction sequence in the one-pot process, which could be rather challenging, given that dihydrosilane is usually more reactive than monohydrosilane under the transition-metal-catalyzed conditions. Previously, the majority of the intramolecular silylation with tethered silanes is using monohydrosilane (-SiH) rather than dihydrosilane (-SiH_2).[2] Herein, we report the development of a cascade enantioselective silylation of aliphatic C−H bond/stereospecific alkene hydrosilylation, which successfully enables the efficient construction of a wide range of enantioenriched silicon-stereogenic dihydrobenzosiloles in decent yields and enantioselectivites (Scheme 1c).

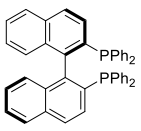
Results and Discussion

Table 1. Condition optimization.[a]

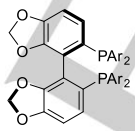




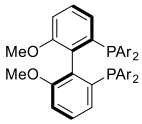
L1, (*R*)-H_8-BINAP



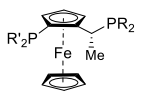
L2, (*R*)-BINAP



L3, Ar = Ph
L4, Ar = 3,5-*di*-Me-4-OMePh



L5, Ar = 3,5-*di*-Me-Ph



Josiphos

L6, R = Cy, R' = Ph
L7, R = *t*Bu, R' = Ph
L8, R = *t*Bu, R' = *p*-CF_3Ph
L9, R = *t*Bu, R' = 3,5-*di*-Me-4-OMePh
L10, R = *o*-MePh, R' = *t*Bu
L11, R = 3,5-*di*-MePh, R' = Ph

Entry	[Rh]	Ligand	Solvent	Yield [%]	*ee* [%]
1	$[Rh(cod)Cl]_2$	**L1**	toluene	67	25
2	$[Rh(cod)Cl]_2$	**L2**	toluene	61	25
3	$[Rh(cod)Cl]_2$	**L3**	toluene	66	33
4	$[Rh(cod)Cl]_2$	**L4**	toluene	69	3
5	$[Rh(cod)Cl]_2$	**L5**	toluene	72	30
6	$[Rh(cod)Cl]_2$	**L6**	toluene	54	35
7	$[Rh(cod)Cl]_2$	**L7**	toluene	77	85
8	$[Rh(cod)Cl]_2$	**L8**	toluene	78	84
9	$[Rh(cod)Cl]_2$	**L9**	toluene	76	83
10	$[Rh(cod)Cl]_2$	**L10**	toluene	17	18
11	$[Rh(cod)Cl]_2$	**L11**	toluene	71	1
12	$[Rh(cod)Cl]_2$	**L7**	dioxane	71	83
13	$[Rh(cod)Cl]_2$	**L7**	DCE	78 (75)	92
14	$[Rh(cod)Cl]_2$	**L7**	*n*-hexane	75	79
15	$[Rh(cod)OH]_2$	**L7**	DCE	67	86
16	$[Rh(nbd)Cl]_2$	**L7**	DCE	72	89

[a] Conditions: **1a** (0.1 mmol), **2a** (0.22 mmol), $[Rh(cod)Cl]_2$ (2 mol%), ligand (4 mol%), in 1.0 mL solvent under Argon atmosphere at 100 ˚C for 1 h. The yield is determined by ^1H NMR using $CHCl_2CHCl_2$ as internal standard; yield in brackets is isolated yield. The *ee* values were determined by chiral HPLC.

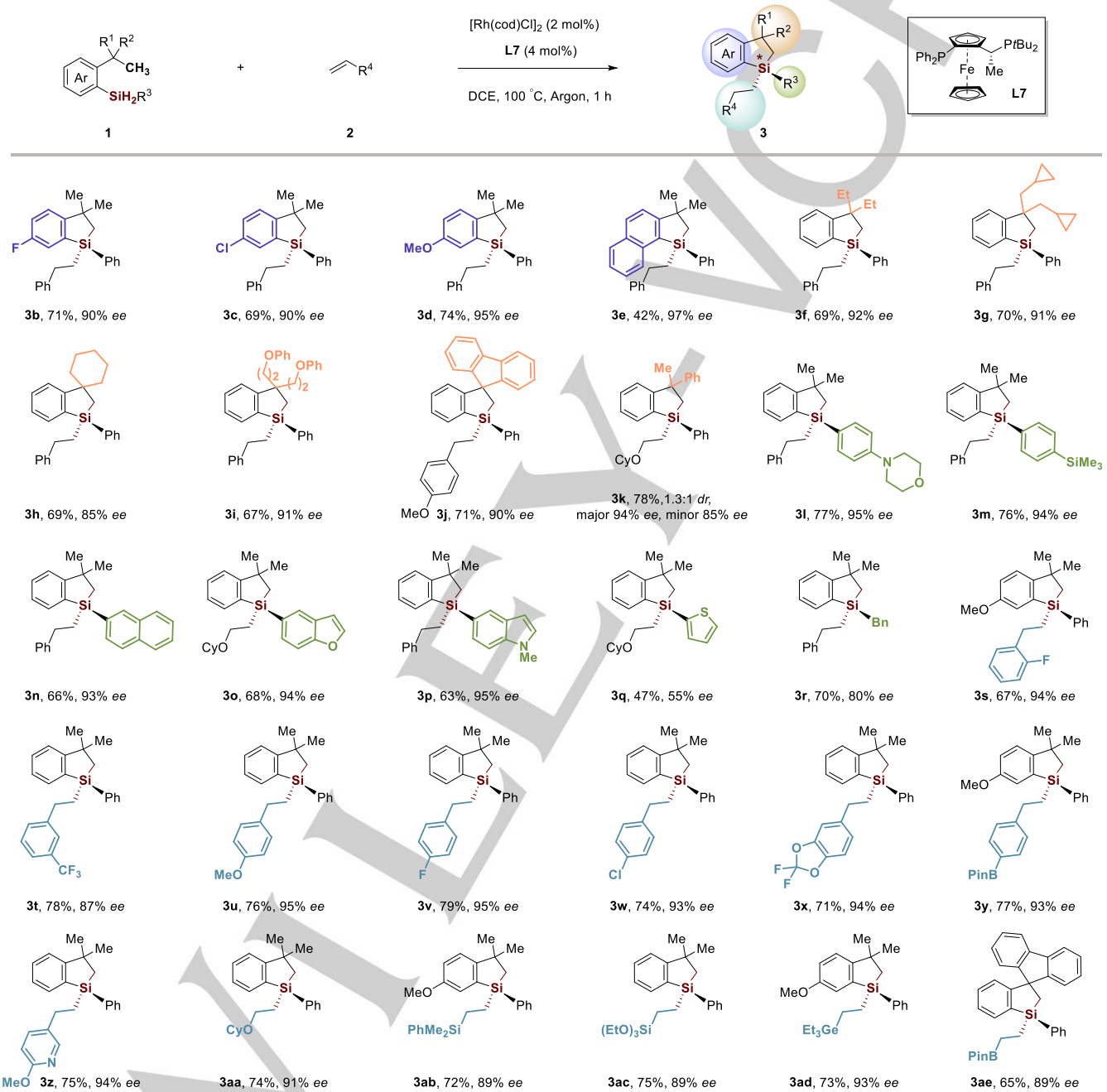
We commenced our studies of the enantioselective silylation of unactivated C(sp^3)−H bond using dihydrosilane **1a**, which could presumably undergo C(sp^3)−H bond activation via a six-membered metallocycle intermediate, in the presence of styrene **2a** as the reaction partner with $[Rh(cod)Cl]_2$ as the catalyst and diphosphines as the chiral ligands in toluene at 100 ˚C. The reactions occurred in 1 hour under these conditions when BINAP (**L1** and **L2**), Segphos (**L3** and **L4**) and MeOBIPHEP (**L5**) derivatives were employed as the chiral ligands, producing the cyclized dihydrobenzosilole **3a** as major product in 61%-72% yield and 3%-33% *ee* (Table 1, entries 1-5), along with the minor direct hydrosilylation side-product **4a**. These results suggest that this enantioselective aliphatic C–H silylation/alkene insertion process is feasible for the construction of tetrasubstituted silicon-stereogenic silanes, albeit in low *ee*. In the absence of alkene, only trace corresponding C–H silylation product could be observed under the Rh-catalyzed conditions; most of the starting material dihydrosilane **1a** was decomposed in the reaction**.** Further examination of the chiral diphosphine ligands showed that Josiphos type ligands improved both the yield and *ee* significantly, especially **L7**-**L9**, affording **3a** in 76%-78% yield and 83%-85% *ee* (Table 1, entries 6-11). Investigation of other common solvents disclosed that the use of DCE (1,2-dichloroethane) increased the *ee* of **3a** to 92% in the presence of **L7**, while dioxane and *n*-hexane gave similar *ee* as toluene (Table 1, entries 12-14). Other Rh(I) catalysts such as $[Rh(cod)OH]_2$ and $[Rh(nbd)Cl]_2$ had a small effect on the reaction (entries 15-16).

Having identified the optimized conditions for the enantioselective aliphatic C–H silylation/alkene insertion process, we next assessed the scope of this transformation to establish the synthetic methodology for the construction of tetrasubstituted silicon-stereogenic dihydrobenzosiloles (Table 2). First, the aromatic rings (purple) of dihydrosilane substrates bearing different functional groups, including electron-withdrawing fluro (**3b**), chloro (**3c**) groups and electron-donating methoxy group (**3d**), as well as naphthyl (**3e**) groups, all reacted smoothly with styrene to afford the desired asymmetrically tetrasubstituted dihydrobenzosilole products in moderate to good yields (42–74%) with good to excellent enantioselectivities (90–97% *ee*). Second, the quaternary carbon center part (orange) of dihydrosilane was investigated under the standard conditions. Replacement two of the methyl groups into various alkyl chains containing ethyl (**3f**), cyclopropyl (**3g**), cyclohexyl (**3h**), and protected hydroxyl (**3i**) groups, as well as aromatic 9-fluorene (**3j**) group also produced the corresponding dihydrobenzosiloles in good yields without the loss of enantioselectivities. In addition, changing only one of the methyl group into phenyl group, diastereoisomers were obtained in a ratio of 1.3:1 under good enantiocontrol (**3k**). Next, the third substituents (green) on the dihydrosilane substrates were tested. We found that a variety of functionalized aromatic rings containing amino (**3l**), trimethylsilyl

10.1002/anie.202009912

(**3m**), naphthyl (**3n**) groups, heterocycles including benzofuran (**3o**), indole (**3p**), thiophene (**3q**), as well as benzyl group (**3r**) were well tolerated in the reactions. Finally, for the scope of alkenes (blue), we found that a wide range of styrene derivatives displaying various functional substituents, such as 2-fluro (**3s**), 3-trifluoromethyl (**3t**), 4-methoxy (**3u**), 4-fluro (**3v**), 4-chloro (**3w**), protected hydroxyl (**3x**), 4-Bpin (**3y**), and pyridine groups (**3z**) were all competent substrates, providing the desired highly functionalized dihydrobenzosiloles in good yields with excellent enantioselectivities. Other type of alkenes, including vinyl ether (**3aa**), vinylsilane (**3ab** and **3ac**), vinylgermane (**3ad**), and vinylborane ester (**3ae**) also worked well in the transformation, providing readily manipulable functional groups suitable for downstream modification of varying substitution patterns.

Table 2. Substrate scope.[a]

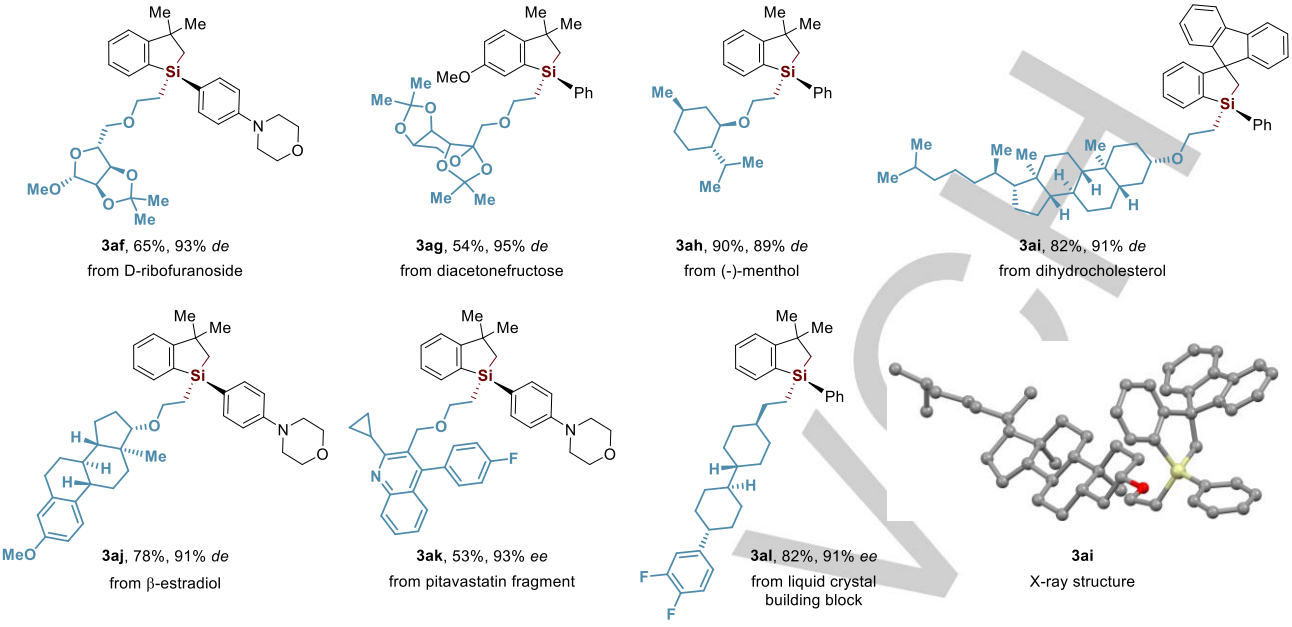


[a] Conditions: **1** (0.1 mmol), **2** (0.22 mmol), $[Rh(cod)Cl]_2$ (2 mol%), ligand (4 mol%), in 1.0 mL DCE under Argon atmosphere at 100 °C for 1 h. Isolated yields. The *ee* values were determined by chiral HPLC.

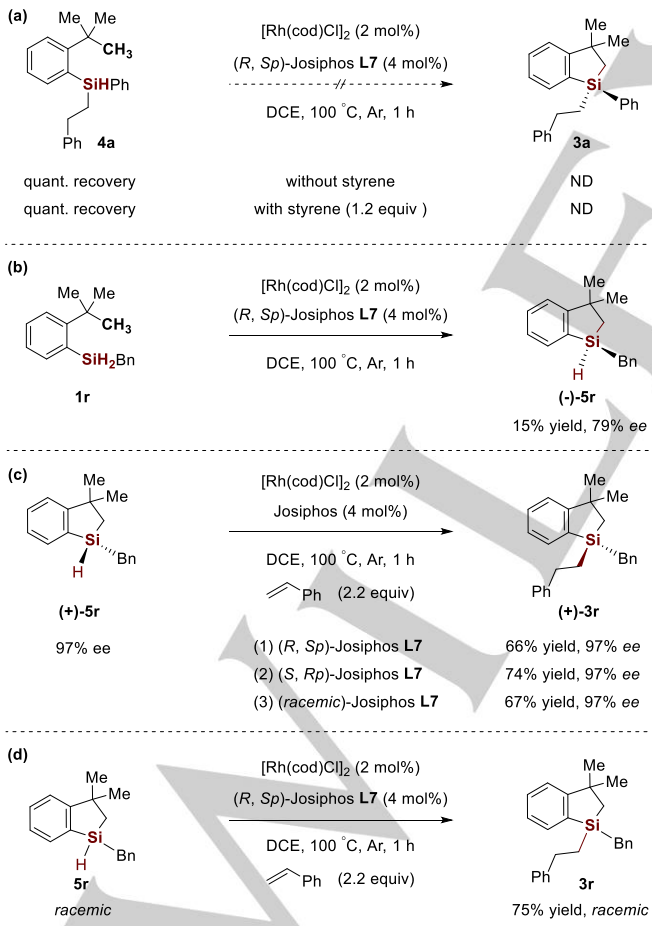
To further demonstrate the diversity and utility of this enantioselective aliphatic C–H silylation/alkene insertion process, we further examined the reaction employing the core structures of several bioactive molecules, pharmaceuticals and material building blocks (Table 3). We were delighted to find that the corresponding silicon-stereogenic dihydrobenzosilole products containing D-ribofuranoside (**3af**), diacetonefructose (**3ag**), (-)-menthol (**3ah**), dehydrocholesterol (**3ai**), β-estradiol (**3aj**), pitavastatin fragment (**3ak**) or liquid crystal building block (**3al**) derivatives, could be obtained in good yields with excellent stereoselectivities, irrespective of existing diverse functional groups and complex molecular structures.

10.1002/anie.202009912

Table 3. Scope with core structures of bioactive molecules, pharmaceuticals and material building blocks.[a]



[a] See Supporting Information for details. Isolated yields. The *ee* values were determined by chiral HPLC. *de* = diastereomic excess. X-ray crystallographic analysis of **3ai** allowed to determine the absolute configuration; and configurations of the products **3** were assigned by analogy.



Scheme 2. Control experiments.

Finally, given that this transformation displayed a remarkable selectivity, we're interested to elucidate the reaction pathway and identify the reaction intermediate. Usually, direct hydrosilylation of alkene with dihydrosilane is feasible under metal-catalyzed conditions;[9e,9m,9n] and we did observe minor hydrosilylation product **4a** in the reaction. One may argue that the direct hydrosilylation of alkene with dihydrosilane could be the first step, and the generated monohydrosilane **4a** could reasonably undergo C−H activation/silylation affording the final product **3a**. In light of this, several control experiments were investigated (Scheme 2). First, monohydrosilane **4a** was prepared and subjected to the standard reaction conditions either with or without styrene (Scheme 2a). In both cases, no C−H silylation product **3a** could be obtained. The quantitively recovery of starting material **4a** suggesting that **4a** is not the intermediate in the reaction. Next, under the optimized conditions only without the alkene partner, the intramolecular C−H silylation/cyclization product **(-)-5r** was obtained in 15% yield from dihydrosilane **1r** (Scheme 2b).[9m] Despite low yield, the comparable 79% *ee* of **(-)-5r** with **(-)-3r** (Table 2, 80% *ee*) indicates that the stereo-determining step is the C–H activation/silylation process. To further confirm **5r** is the key intermediate in this cascade process, treatment of enantioenriched **(+)-5r** (97% *ee*, chiral resolution via prepared HPLC, see Supporting Information section 5.2) with styrene under the Rh-catalyzed conditions furnished the identical tetrasubstituted dihydrobenzosilole product **(+)-3r** with the same absolute configuration, regardless the use of (*R*, *Sp*)-Josiphos **L7** or (*S*, *Rp*)-Josiphos **L7** or (*racemic*)-Josiphos **L7** (Scheme 2c). Moreover, when a racemic **5r** was subjected to the reaction conditions using (*R*, *Sp*)-Josiphos **L7**, a racemic product **3r** was obtained (Scheme 2d). These results further suggest that the intramolecular C−H silylation/cyclization product is the key intermediate in the reaction, and the chirality of the silicon-stereogenic center is induced in the first C–H activation/silylation step which leads to the formation of the final product. It is worth mentioning that, for most cases, the key C−H silylation/cyclization monohydrosilane intermediates are not

stable in the reaction systems, the one-pot trap of them with alkenes in a stereospecific fashion stabilized the silicon-stereogenic center, providing an elegant strategy for the construction of various asymmetrically tetrasubstituted dihydrobenzosiloles.[10] This process also suggests that the intramolecular C(sp^3)−H silylation is more favoured than the intermolecular alkene hydrosilylation. In addition, we believe that the alkene could also play a role as the hydrogen acceptor in the first dehydrogenative cyclization. For example, we could isolate the hydrogenated product 1-ethyl-4-methoxybenzene in 81% yield when 1-methoxy-4-vinylbenzene was used in the reaction (Table 2, **3u**). Further detailed mechanistic studies are in progress, which will be disclosed in due course.

Conclusion

In summary, we develop an enantioselective aliphatic C–H silylation/alkene hydrosilylation methodology for the efficient synthesis of silicon-stereogenic dihydrobenzosiloles. This process involves a highly selective asymmetric C(sp^3)–H silylation of dihydrosilanes, followed by a stereospecific alkene hydrosilylation. A wide range of dihydrosilanes and alkenes displaying various functional groups are compatible with this process, giving access to a variety of highly functionalized silicon-stereogenic dihydrobenzosiloles in good to excellent yields and enantioselectivities. We believe that the operational simplicity and efficacy of this enantioselective C(sp^3)–H silylation and broad scope of the asymmetrically tetrasubstituted silanes displaying functional diversity will find widespread use among synthetic chemistry, medicinal chemistry, and materials science.

Experimental Section

Inside an argon-filled glovebox, an oven-dried 5 mL microwave reaction tube was charged with $[Rh(cod)Cl]_2$ (1 mg, 0.002 mmol), (*R*, *Sp*)-Josiphos (2.2 mg, 0.004 mmol) and anhydrous DCE (1 mL). After being stirred at room temperature for 5-10 min, dihydrosilane (0.10 mmol) and alkene (0.22 mmol) were added. The tube was capped and taken outside of the glovebox. The resulting mixture was placed into a pre-heated (100 ^oC) aluminium block and stirred for 1 hour. Then the reaction mixture was diluted with dichloromethane (2 mL) and filtered through a plug of silica gel, which was rinsed with petroleum/ ether acetate. The filtrate was concentrated and then purified by preparative TCL to afford target product. The enantiomeric excess was determined by chiral HPLC analysis. Corresponding racemic samples were obtained as references by carrying out the reactions at the identical conditions with (±)-BINAP or (±)-Josiphos.

Acknowledgements

We are grateful for financial support from the National Natural Science Foundation of China (21901104), the Thousand Talents Program for Young Scholars, the start-up fund from Southern University of Science and Technology, the Shenzhen Nobel Prize Scientists Laboratory Project (C17783101), and Guangdong Provincial Key Laboratory of Catalysis (No. 2020B121201002). We also thank Dr. Xiao-Yong Chang for assistance in solving the X-ray structures.

Keywords: asymmetric catalysis • silicon-stereogenic silanes • chiral dihydrobenzosiloles • enantioselective C(sp^3)–H silylation • stereospecific hydrosilylation

[1] a) H. M. L. Davies, R. E. J. Beckwith, *Chem. Rev.* **2003**, *103*, 2861-2903; b) R. Giri, B.-F. Shi, K. M. Engle, N. Maugel, J.-Q. Yu, *Chem. Soc. Rev.* **2009**, *38*, 3242-3272; c) L. Yang, H. Huang, *Catal. Sci. Technol.* **2012**, *2*, 1099-1112; d) C. Zheng, S.-L. You, *RSC Adv.* **2014**, *4*, 6173-6214; e) C. G. Newton, S.-G. Wang, C. C. Oliveira, N. Cramer, *Chem. Rev.* **2017**, *117*, 8908-8976; f) T. G. Saint-Denis, R.-Y. Zhu, G. Chen, Q.-F. Wu, J.-Q. Yu, *Science* **2018**, *359*, 759; g) J. Loup, U. Dhawa, F. Pesciaioli, J. Wencel-Delord, L. Ackermann, *Angew. Chem., Int. Ed.* **2019**, *58*, 12803-12818.

[2] a) C. Cheng, J. F. Hartwig, *Chem. Rev.* **2015**, *115*, 8946-8975; b) Z. Xu, W.-S. Huang, J. Zhang, L.-W. Xu, *Synthesis* **2015**, *47*, 3645-3668; c) M. Parasram, V. Gevorgyan, *Acc. Chem. Res.* **2017**, *50*, 2038-2053; d) J. F. Hartwig, E. A. Romero, *Tetrahedron* **2019**, *75*, 4059-4070; e) Y. Fukumoto, N. Chatani, Transition-Metal-Catalyzed C−H Bond Silylation, In *Organosilicon Chemistry: Novel Approaches and Reactions*; T. Hiyama, M. Oestreich, Eds., Wiley: Weinheim, Germany, **2019**, 171-211; f) S. C. Richter, M. Oestreich, *Trends in Chemistry* **2020**, *2*, 13-27.

[3] a) S. Yamaguchi, K. Tamao, *J. Chem. Soc., Dalton Trans.* **1998**, 3693-3702; b) W. Bains, R. Tacke, *Curr. Opin. Drug Discovery Dev.* **2003**, *6*, 526-543; c) S. Yamaguchi, K. Tamao, *Chem. Lett.* **2005**, *34*, 2-7; d) J. Chen, Y. Cao, *Macromol. Rapid Commun.* **2007**, *28*, 1714-1742; e) M. Shimizu, T. Hiyama, *Synlett* **2012**, *23*, 973-989; f) A. K. Franz, S. O. Wilson, *J. Med. Chem.* **2013**, *56*, 388-405; g) S. Fujii, Y. Hashimoto, *Future Med. Chem.* **2017**, *9*, 485-505; h) R. Ramesh, D. S. Reddy, *J. Med. Chem.* **2018**, *61*, 3779-3798.

[4] T. Lee, J. F. Hartwig, *J. Am. Chem. Soc.* **2017**, *139*, 4879-4886.

[5] a) E. M. Simmons, J. F. Hartwig, *J. Am. Chem. Soc.* **2010**, *132*, 17092-17095; b) B. Li, M. Driess, J. F. Hartwig, *J. Am. Chem. Soc.* **2014**, *136*, 6586-6589; c) Q. Li, M. Driess, J. F. Hartwig, *Angew. Chem., Int. Ed.* **2014**, *53*, 8471-8474; d) T. Lee, T. W. Wilson, R. Berg, P. Ryberg, J. F. Hartwig, *J. Am. Chem. Soc.* **2015**, *137*, 6742-6745; e) C. Karmel, B. Li, J. F. Hartwig, *J. Am. Chem. Soc.* **2018**, *140*, 1460-1470; f) B. Su, T. Lee, J. F. Hartwig, *J. Am. Chem. Soc.* **2018**, *140*, 18032-18038.

[6] a) T. Lee, J. F. Hartwig, *Angew. Chem., Int. Ed.* **2016**, *55*, 8723-8727; b) B. Su, J. F. Hartwig, *J. Am. Chem. Soc.* **2017**, *139*, 12137-12140.

[7] M. Murai, H. Takeshima, H. Morita, Y. Kuninobu, K. Takai, *J. Org. Chem.* **2015**, *80*, 5407-5414.

[8] a) K. Igawa, K. Tomooka, Chiral Silicon Molecules, In *Organosilicon Chemistry: Novel Approaches and Reactions*; T. Hiyama, M. Oestreich, Eds., Wiley: Weinheim, Germany, **2019**, 495-532; b) M. Oestreich, *Synlett* **2007**, 1629-1643; c) A. Weickgenannt, M. Mewald, M. Oestreich, *Org. Biomol. Chem.* **2010**, *8*, 1497-1504; d) L.-W. Xu, L. Li, G.-Q. Lai, J.-X. Jiang, *Chem. Soc. Rev.* **2011**, *40*, 1777-1790; e) A. Weickgenannt, M. Oestreich, *Asymmetric Synth. II* **2013**, 35-42; f) J. O. Bauer, C. Strohmann, *Eur. J. Inorg. Chem.* **2016**, *2016*, 2868-2881; g) R. Shintani, *Synlett* **2018**, *29*, 388-396.

[9] For review, see: a) L.-W. Xu, *Angew. Chem., Int. Ed.* **2012**, *51*, 12932-12934. For desymmetrization of dihydrosilanes, see: b) R. J. P. Corriu, J. J. E. Moreau, *Tetrahedron Lett.* **1973**, 4469-4472; c) T. Hayashi, K. Yamamoto, M. Kumada, *Tetrahedron Lett.* **1974**, 331-334; d) T. Ohta, M. Ito, A. Tsuneto, H. Takaya, *J. Chem. Soc., Chem. Commun.* **1994**, 2525-2526; e) K. Tamao, K. Nakamura, H. Ishii, S. Yamaguchi, M. Shiro, *J. Am. Chem. Soc.* **1996**, *118*, 12469-12470; f) Y. Yasutomi, H. Suematsu, T. Katsuki, *J. Am. Chem. Soc.* **2010**, *132*, 4510-4511; g) K. Igawa, D. Yoshihiro, N. Ichikawa, N. Kokan, K. Tomooka, *Angew. Chem., Int. Ed.* **2012**, *51*, 12745-12748; h) Y. Kurihara, M. Nishikawa, Y. Yamanoi, H. Nishihara, *Chem. Commun.* **2012**, *48*, 11564-11566; i) Y. Kuninobu, K. Yamauchi, N. Tamura, T. Seiki, K. Takai, *Angew. Chem., Int. Ed.* **2013**, *52*, 1520-1522; j) Y. Naganawa, T. Namba, M. Kawagishi, H. Nishiyama, *Chem. - Eur. J.* **2015**, *21*, 9319-9322; k) L. Chen, J.-B. Huang, Z. Xu, Z.-J. Zheng, K.-F. Yang, Y.-M. Cui, J. Cao, L.-W. Xu, *RSC Adv.* **2016**, *6*, 67113-67117; l) H. Wen, X. Wan, Z. Huang, *Angew. Chem., Int. Ed.* **2018**, *57*, 6319-6323; m) G. Zhan, H.-L. Teng, Y. Luo, S.-J. Lou, M. Nishiura, Z. Hou, *Angew. Chem., Int. Ed.* **2018**, *57*, 12342-12346; n) X. Chang, P.-L. Ma, H.-C. Chen, C.-Y. Li, P. Wang, *Angew. Chem., Int. Ed.* **2020**, *59*, 8937-8940; (o) J. R. Jagannathan, J.

C. Fettinger, J. T. Shaw, A. K. Franz, *J. Am. Chem. Soc.* **2020**, *142*, 11674-11679. For desymmetrization of tetraorganosilanes, see: p) R. Shintani, K. Moriya, T. Hayashi, *J. Am. Chem. Soc.* **2011**, *133*, 16440-16443; q) R. Shintani, E. E. Maciver, F. Tamakuni, T. Hayashi, *J. Am. Chem. Soc.* **2012**, *134*, 16955-16958; r) R. Shintani, H. Otomo, K. Ota, T. Hayashi, *J. Am. Chem. Soc.* **2012**, *134*, 7305-7308; s) R. Kumar, Y. Hoshimoto, H. Yabuki, M. Ohashi, S. Ogoshi, *J. Am. Chem. Soc.* **2015**, *137*, 11838-11845; t) R. Shintani, C. Takagi, T. Ito, M. Naito, K. Nozaki, *Angew. Chem., Int. Ed.* **2015**, *54*, 1616-1620; u) Y. Sato, C. Takagi, R. Shintani, K. Nozaki, *Angew. Chem., Int. Ed.* **2017**, *56*, 9211-9216; v) Q.-W. Zhang, K. An, L.-C. Liu, Q. Zhang, H. Guo, W. He, *Angew. Chem., Int. Ed.* **2017**, *56*, 1125-1129; w) H. Chen, Y. Chen, X. Tang, S. Liu, R. Wang, T. Hu, L. Gao, Z. Song, *Angew. Chem., Int. Ed.* **2019**, *58*, 4695-4699; x) Y. Lin, W.-Y. Ma, Z. Xu, Z.-J. Zheng, J. Cao, K.-F. Yang, Y.-M. Cui, L.-W. Xu, *Chem. - Asian J.* **2019**, *14*, 2082-2085; y) G. Zhang, Y. Li, Y. Wang, Q. Zhang, T. Xiong, Q. Zhang, *Angew. Chem., Int. Ed.* **2020**, *59*, 11927-11931.

[10] a) L. H. Sommer, K. W. Michael, H. Fujimoto, *J. Am. Chem. Soc.* **1967**, *89*, 1519-1521; b) M. Oestreich, S. Rendler, *Angew. Chem., Int. Ed.* **2005**, *44*, 1661-1664; c) S. Rendler, M. Oestreich, C. P. Butts, G. C. Lloyd-Jones, *J. Am. Chem. Soc.* **2007**, *129*, 502-503.

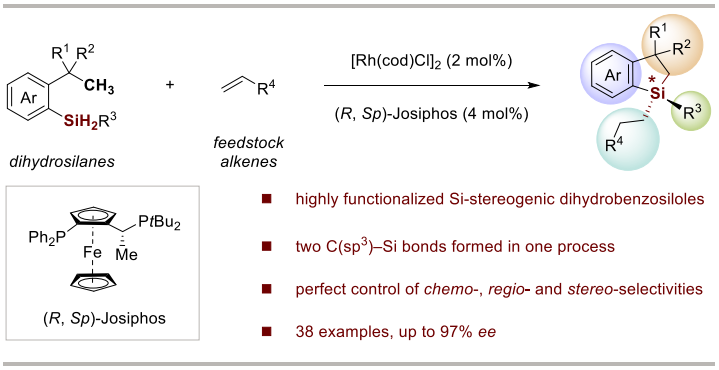
10.1002/anie.202009912

WILEY-VCH

Entry for the Table of Contents (Please choose one layout)

Layout 2:

RESEARCH ARTICLE



*B. Yang, W. Yang, Y. Guo, L. You, C. He**

Page No. – Page No.

Enantioselective Silylation of Aliphatic C–H Bonds for the Synthesis of Silicon-Stereogenic Dihydrobenzosiloles

A rhodium(I)-catalyzed enantioselective silylation of aliphatic C–H bonds for the synthesis of silicon-stereogenic dihydrobenzosiloles is demonstrated. This reaction involves a highly enantioselective C–H silylation of dihydrosilanes, followed by a stereospecific alkene hydrosilylation. A wide range of dihydrosilanes and alkenes displaying various functional groups are compatible with this process, giving access to a variety of highly functionalized silicon-stereogenic dihydrobenzosiloles in good to excellent yields and enantioselectivities.