Literature Report (7)

Cu^{I}-catalyzed enantioselective protoboration for the construction of α-chiral C-B bond

Reporter: Yue Ji
Checker: Guang-Shou Feng
Date: 2015/09/28

Ito, H. et al.
Angew. Chem. Int. Ed. **2015**, *54*, 8809.

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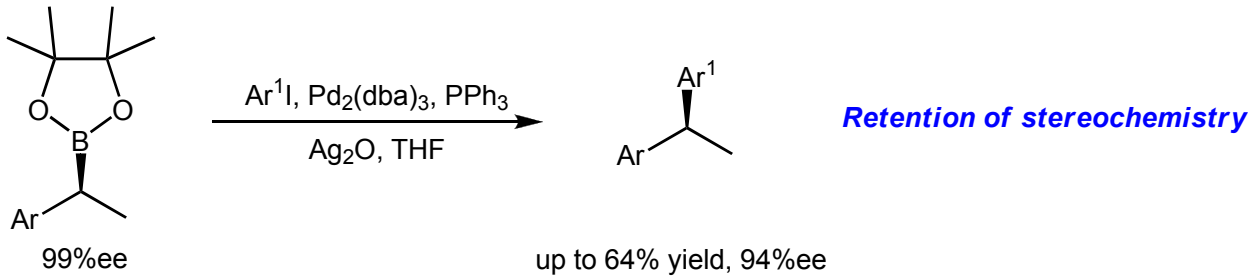
Introduction

Direct stereospecific transformation of stereogenic C-B bonds

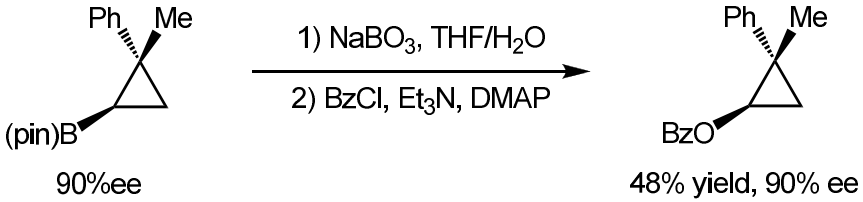
Direct stereospecific transformation of stereogenic C-B bonds to C-C bonds



Crudden, C. M. et al. *J. Am. Chem. Soc*. **2009**, *131,* 5024;
Suginome, M. et al. *J. Am. Chem. Soc*. **2010**, *132,* 13191.

Introduction

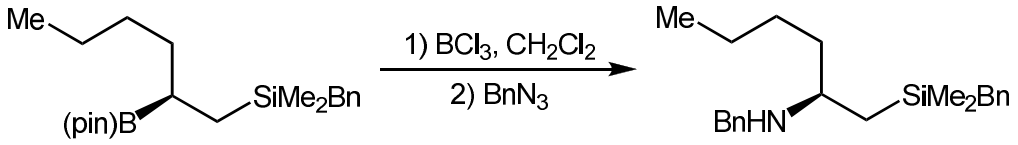
Direct stereospecific transformation of stereogenic C-B bonds to C-O bonds



90%ee

48% yield, 90% ee

Direct stereospecific transformation of stereogenic C-B bonds to C-N bonds

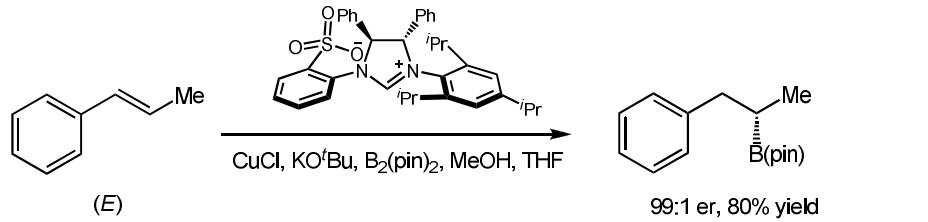


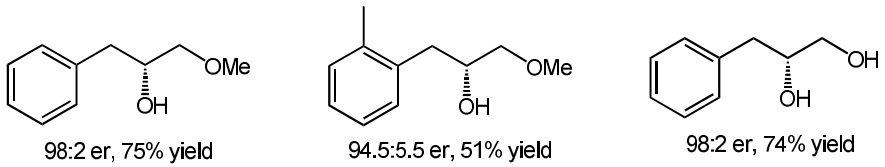
94%ee

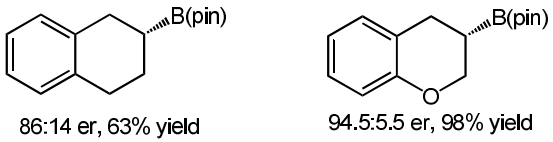
80% yield, 93%ee

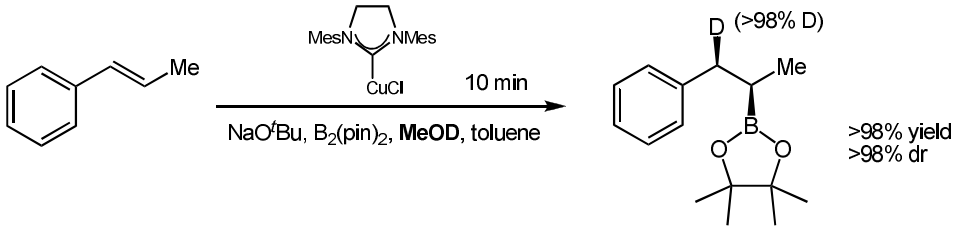
Tortosa, M. et al. *J. Am. Chem. Soc*. **2014**, *136*, 15833.
Ito, H. et al. *Adv. Synth. Catal.* **2013**, *355*, 3527

Cu^{I}-catalyzed enantioselective protoboration of alkenes



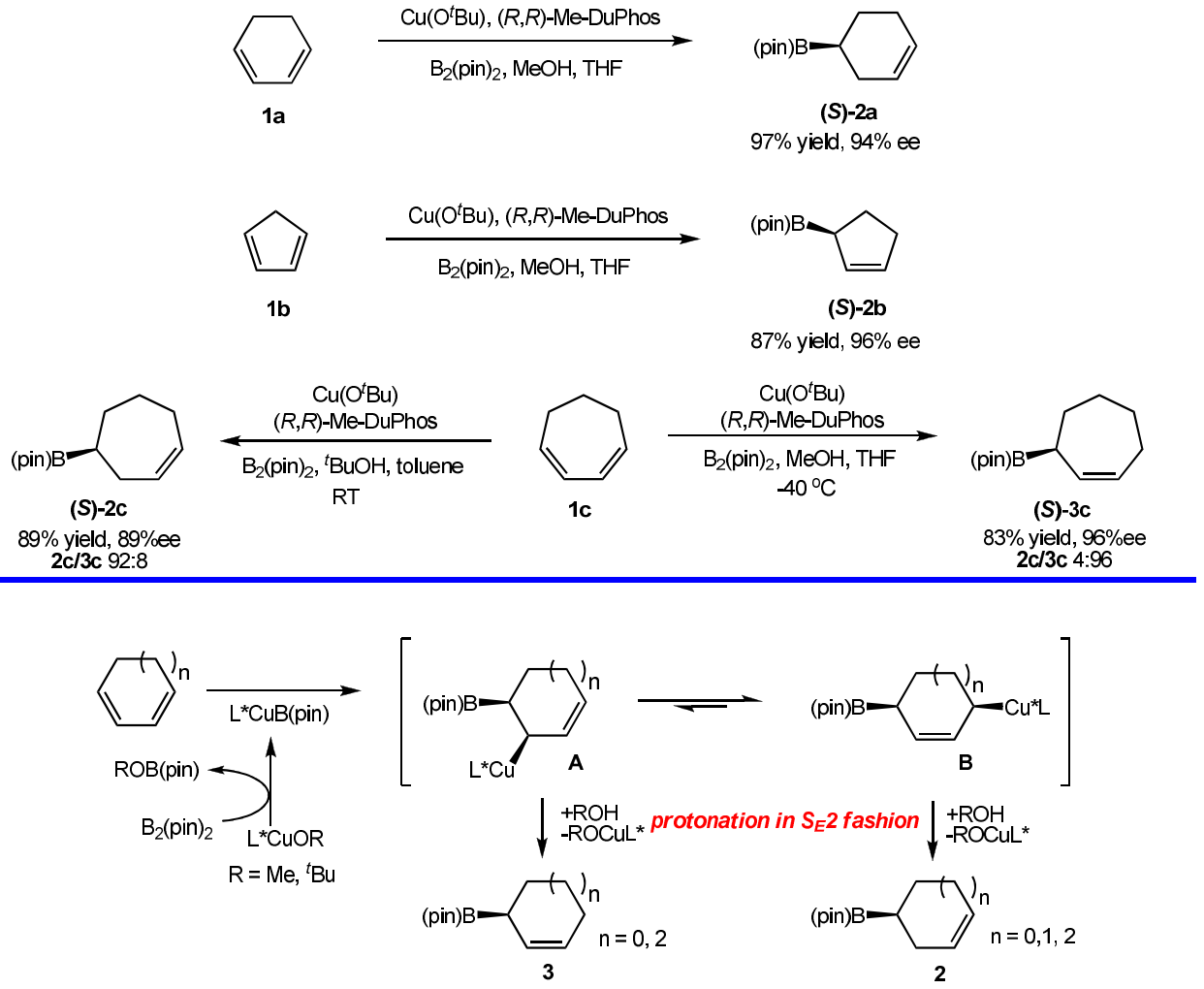






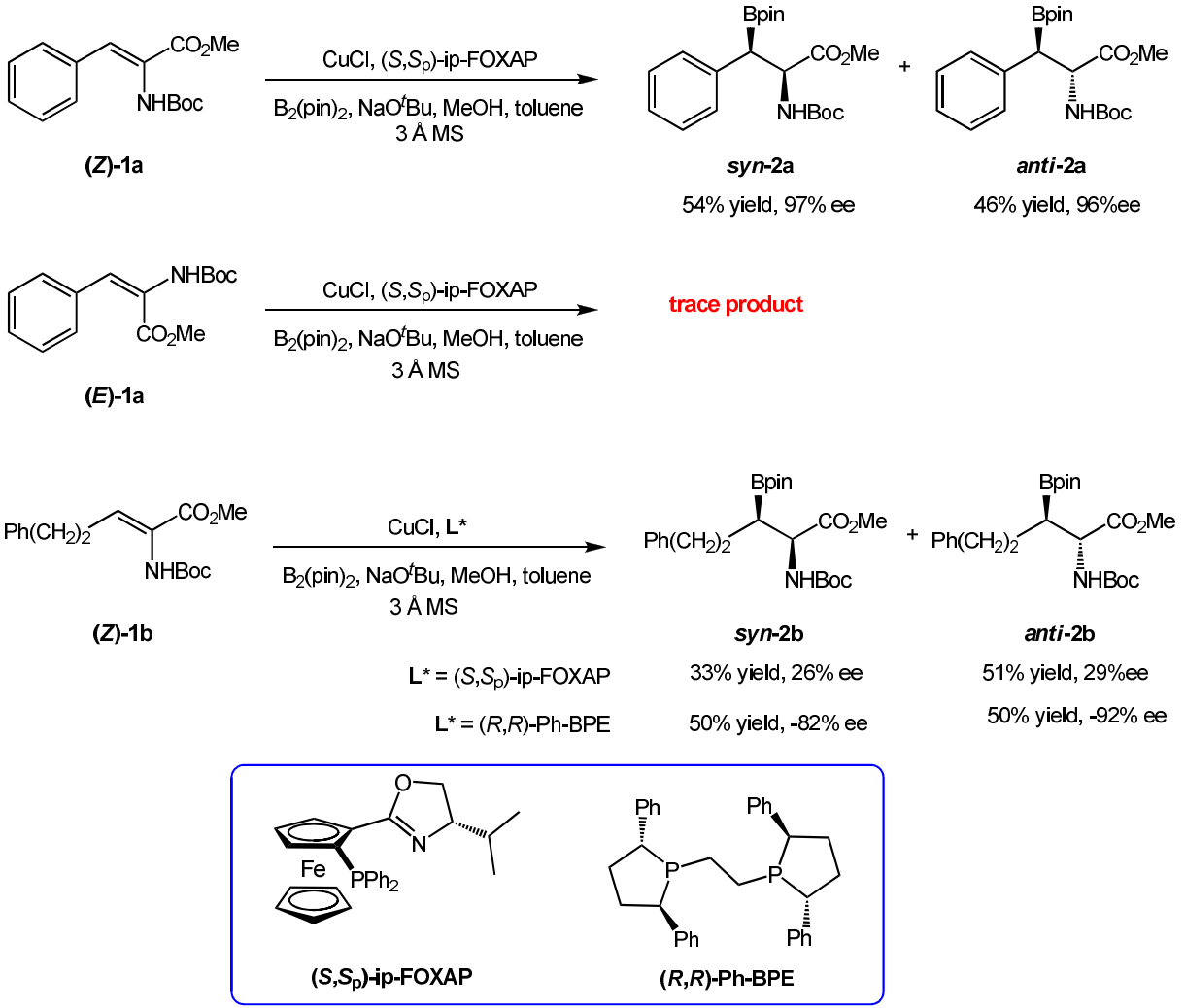
Hoveyda, A. H. et al. *J. Am. Chem. Soc.* **2009**, *131,* 3160.

Cu^{I}-catalyzed enantioselective protoboration of alkenes



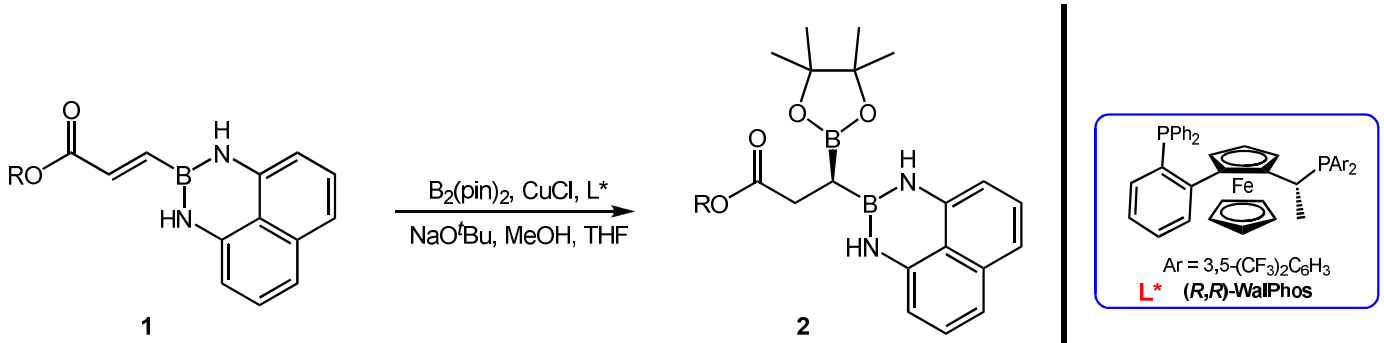
Ito, H. et al. *J. Am. Chem. Soc.* **2010**, *132,* 1226.

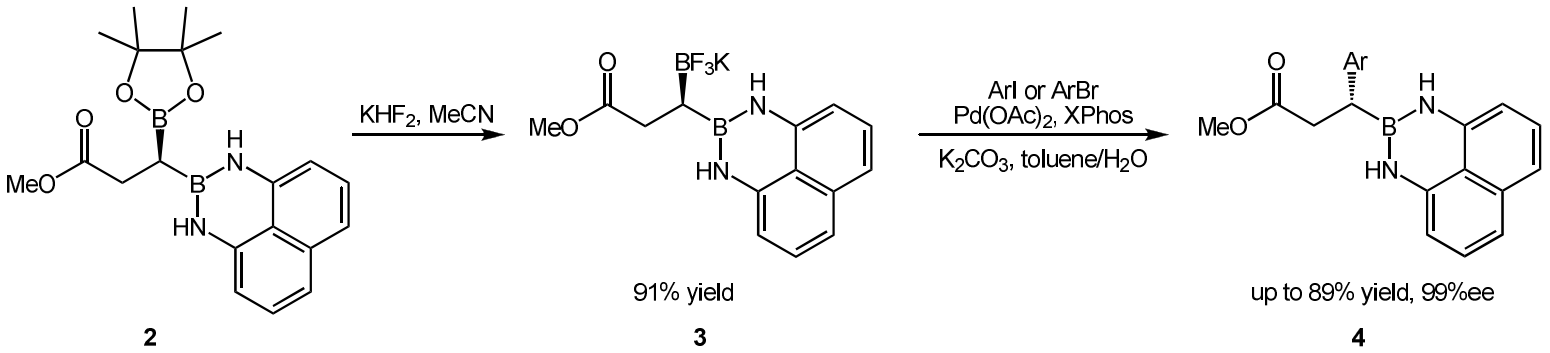
Cu^{I}-catalyzed enantioselective protoboration of alkenes



Lin, G.-Q. et al. *Org. Lett*. **2014**, *16*, 1426.

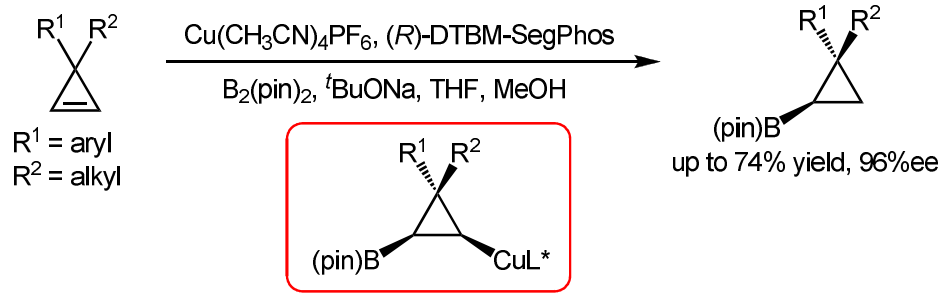
Cu^{I}-catalyzed enantioselective protoboration of alkenes

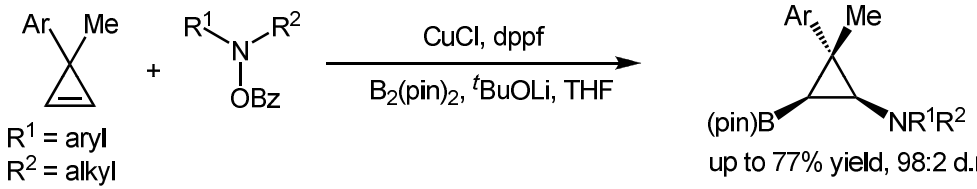


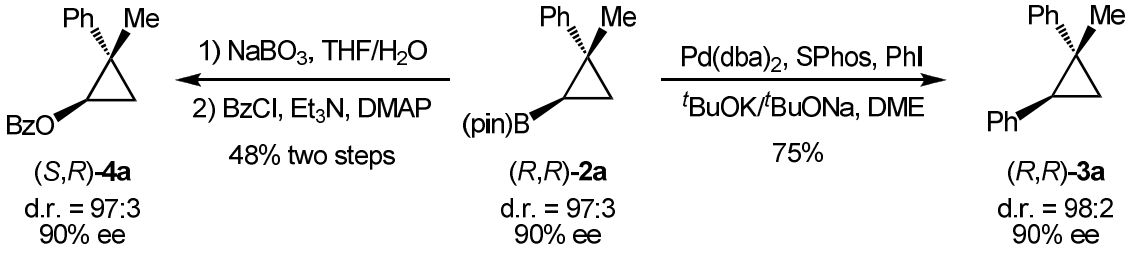


Hall, D. G. et al. *Nat. Chem.* **2011**, *3*, 894.

Cu^{I}-catalyzed enantioselective protoboration of alkenes



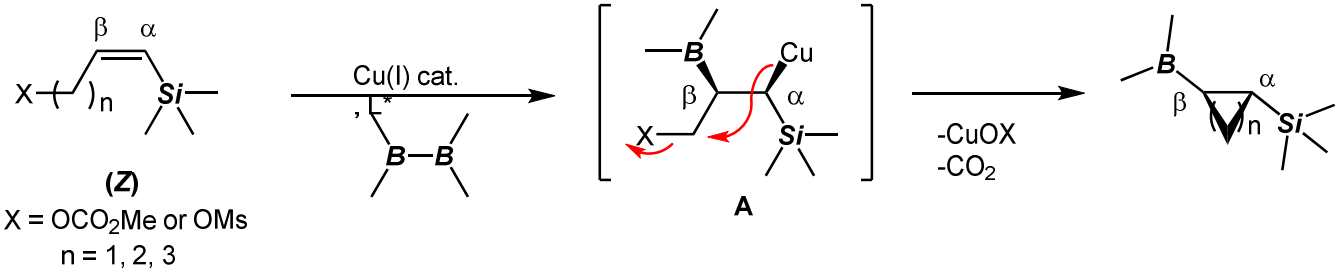




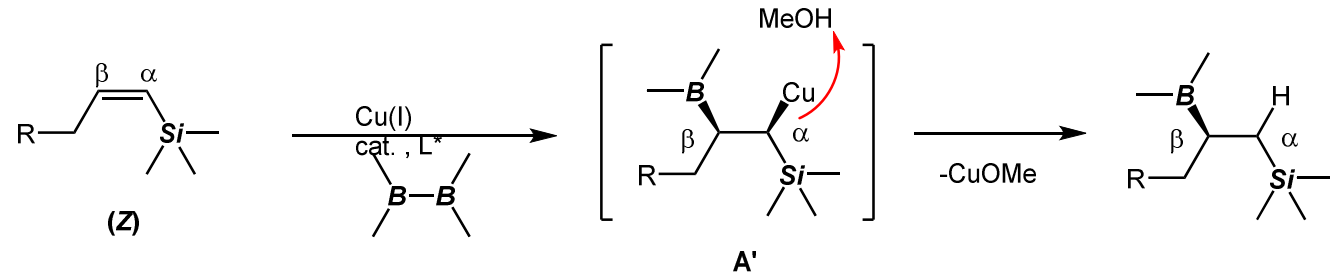
Tortosa, M. et al. *J. Am. Chem. Soc.* **2014**, *136*, 15833.

Cu^{I}-catalyzed enantioselective protoboration of alkenes

annular vicinal borosilane synthesis

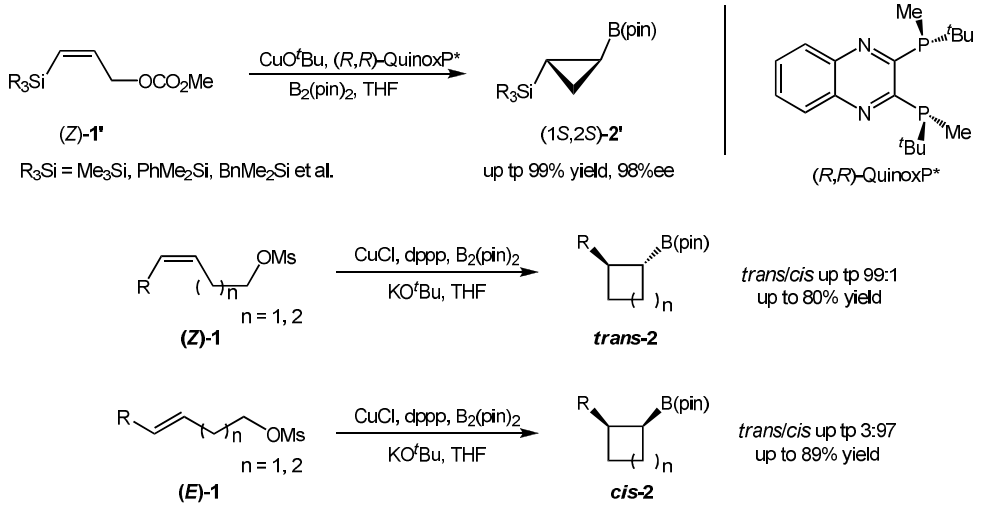


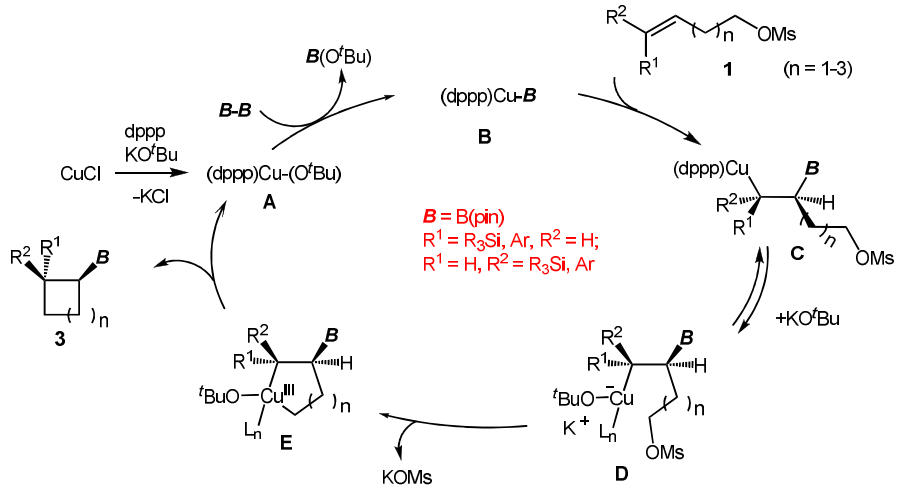
enantioenriched linear vicinal borosilane synthesis



Ito, H. et al. *Adv. Synth. Catal.* **2013**, *355*, 3527.

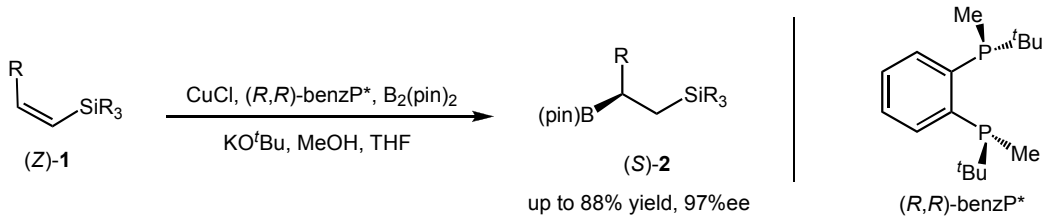
Cu^{I}-catalyzed enantioselective protoboration of alkenes

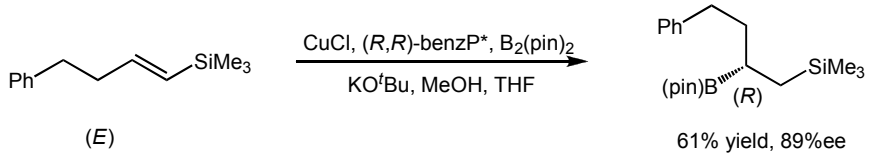


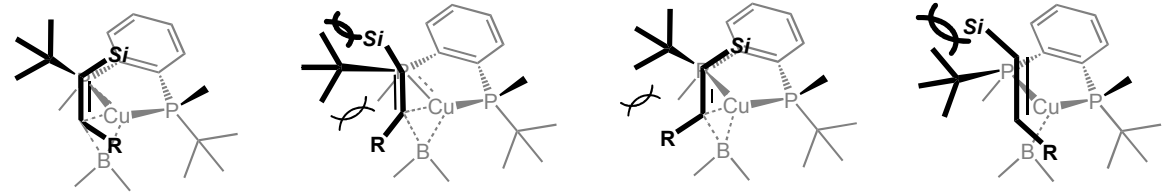


Ito, H. et al. *Angew. Chem. Int. Ed*. **2008**, *47*, 7424; *J. Am. Chem. Soc*. **2010**, *132,* 5990.

Cu^{I}-catalyzed enantioselective protoboration of alkenes



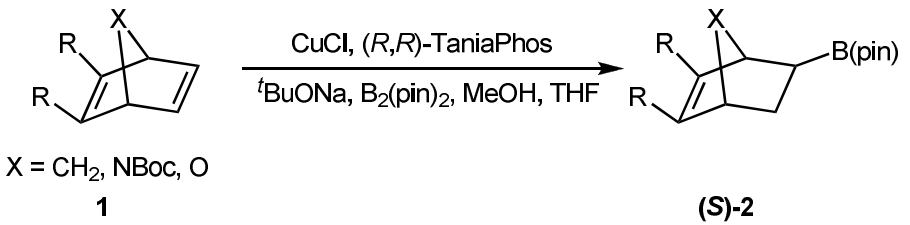




Transition state models explaining the higher enantioselectivity for (Z)-configuration

Ito, H. et al. *Adv. Synth. Catal.* **2013**, *355*, 3527.

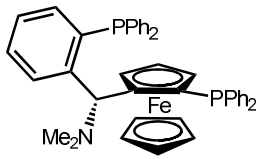
Cu^{I}-catalyzed enantioselective protoboration of alkenes

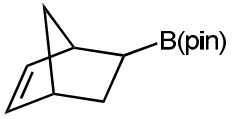


X = CH_2, NBoc, O

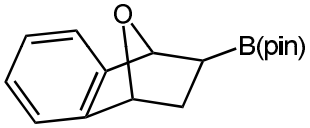
1

(*S*)-2

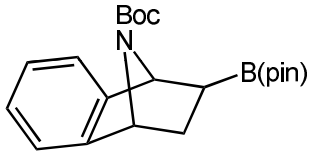




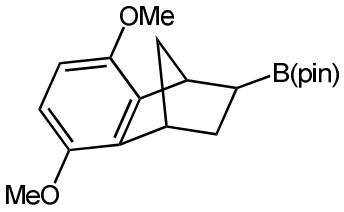
74% yield, >99%ee



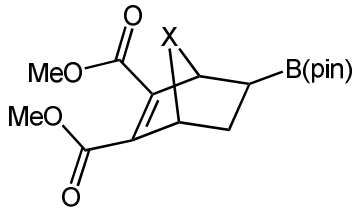
79% yield, 94%ee



90% yield, >99%ee



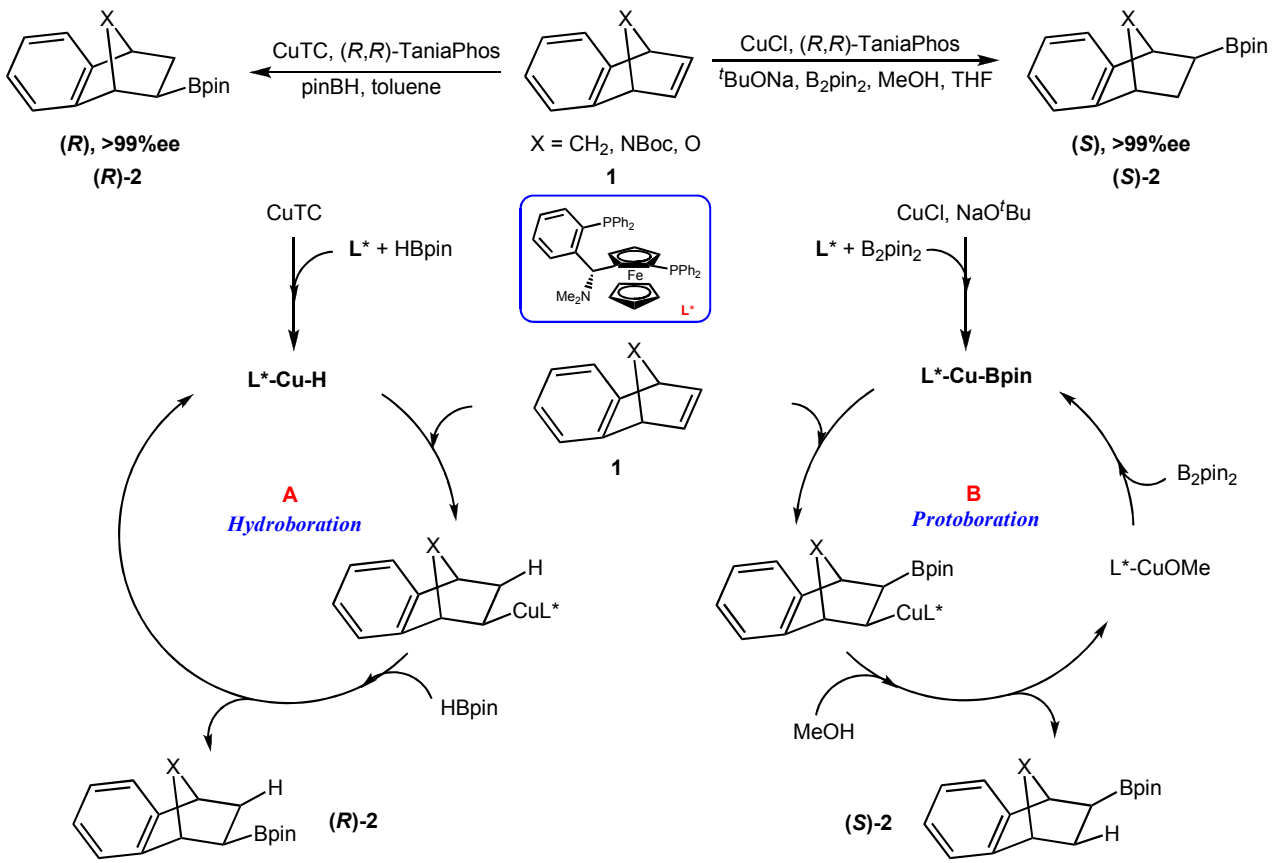
82% yield, >99%ee



42% yield, >99%ee

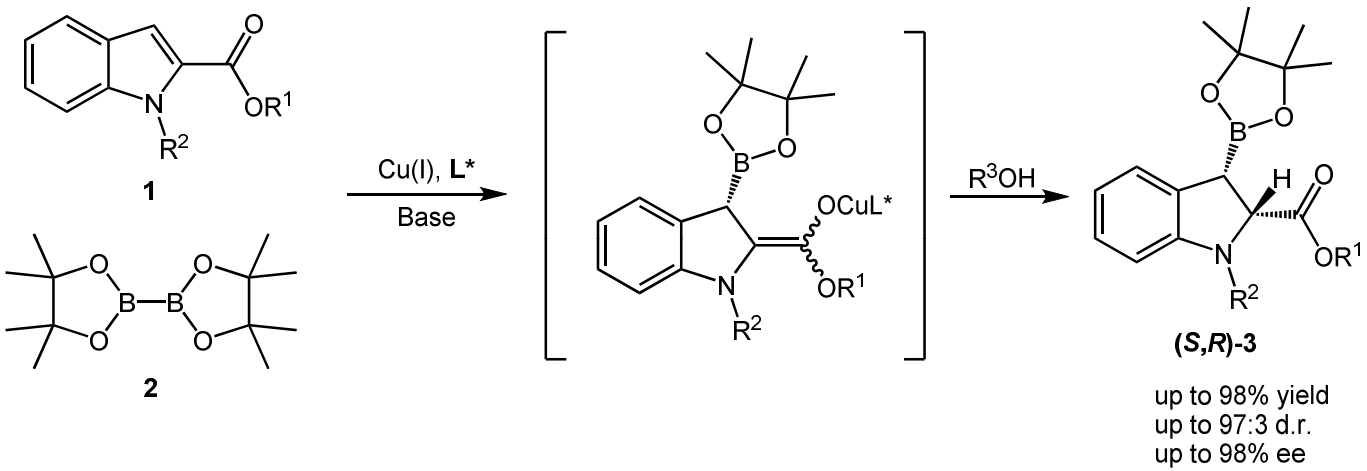
Yun, J. et al. *Org. Lett*. **2015**, *17*, 764.

Cu^{I}-catalyzed enantioselective protoboration of alkenes



Yun, J. et al. *Org. Lett*. **2015**, *17*, 764.

Cu^{I}-catalyzed enantioselective protoboration of indoles



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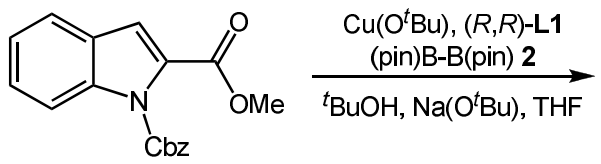
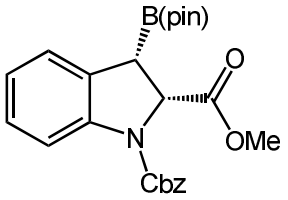
Cu^{I}-catalyzed enantioselective protoboration of indoles

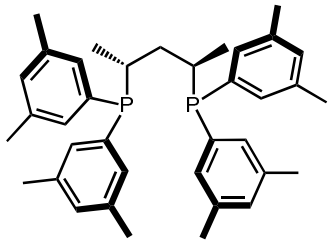


1a

Cu(O^{t}Bu), (*R*,*R*)-**L1**
(pin)B-B(pin) **2**
^{t}BuOH, Na(O^{t}Bu), THF

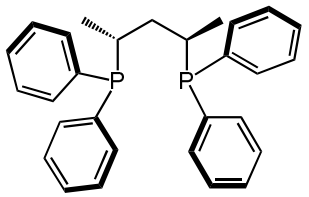


(*S*,*R*)-3a

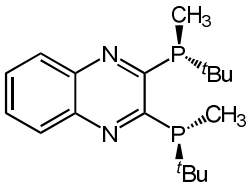


L1

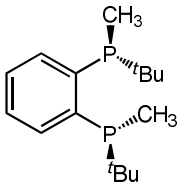
entry	conditions	yield (%)	d.r.	ee (%)
1	standard conditions	98	97:3	93
2	no Cu(O^{t}Bu)	<5	--	--
3	no (*R*,*R*)-**L1**	<5	--	--
4	no Na(O^{t}Bu)	74	89:11	93
5	no ^{t}BuOH	33	76:24	74
6	**L2** instead of **L1**	98	89:11	74
7	**L3** instead of **L1**	93	90:10	27
8	**L4** instead of **L1**	77	91:9	61
9	**L5** instead of **L1**	71	97:3	37
10	**L6** instead of **L1**	<5	--	--
11	MeOH instead of ^{t}BuOH	94	75:25	94



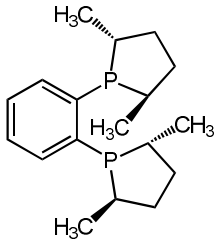
L2



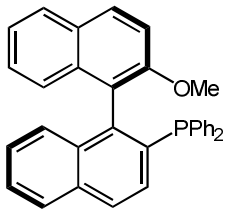
L3



L4

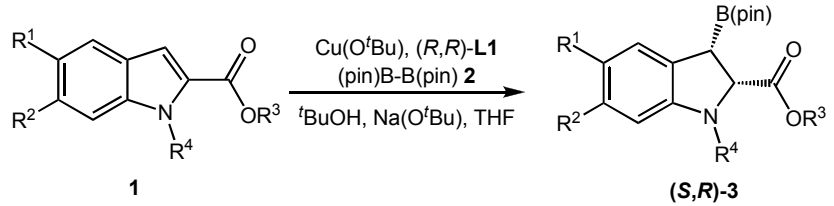


L5

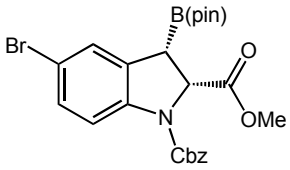


L6

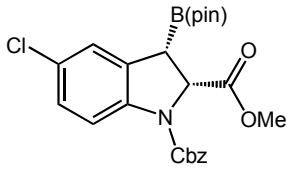
Cu^{I}-catalyzed enantioselective protoboration of indoles



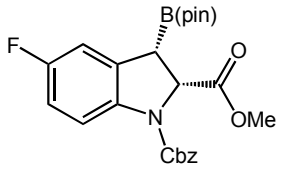
1 **(*S*,*R*)-3**



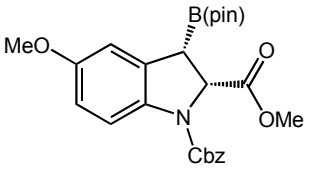
74% (96%)
d.r. 97:3, 92%ee



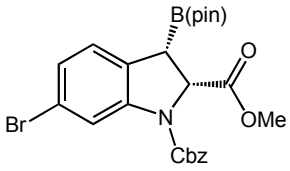
64% (93%)
d.r. 97:3, 95%ee



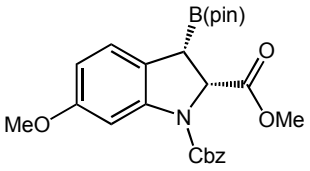
74% (93%)
d.r. 97:3, 95%ee



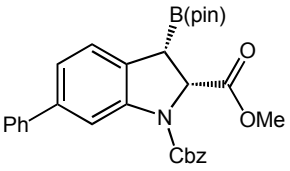
74% (99%)
d.r. 97:3, 97%ee



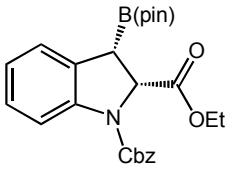
62% (99%)
d.r. 97:3, 86%ee



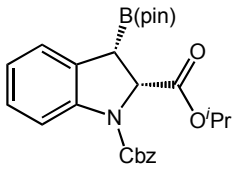
76% (88%)
d.r. 94:6, 93%ee



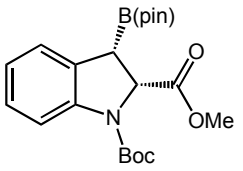
71% (82%)
d.r. 83:17, 89%ee



52% (55%)
d.r. 86:14, 95%ee

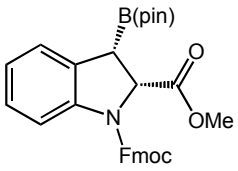


(*R*,*R*)-**L2**
67% (88%)
d.r. 95:5, 90%ee

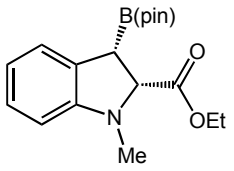


(*R*,*R*)-**L1**
13% (22%)
d.r. 94:6, 98%ee

(*R*,*R*)-**L2**
95% (98%)
d.r. 93:7, 86%ee

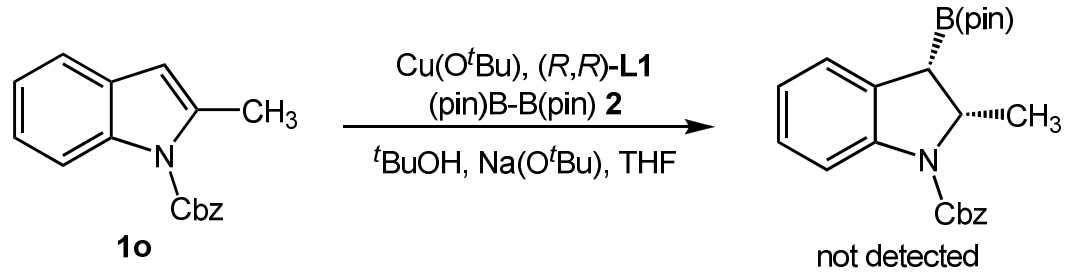


complex mixture

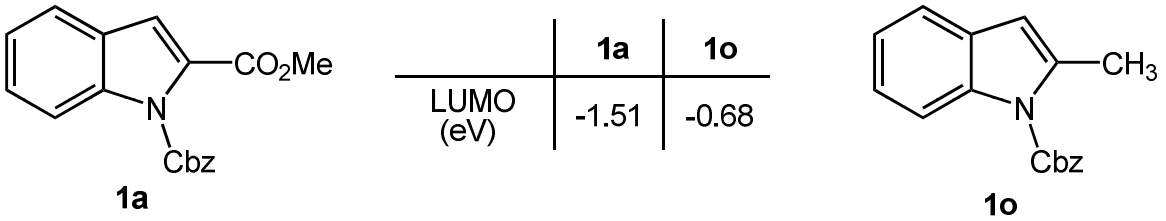


no product

Cu^{I}-catalyzed enantioselective protoboration of indoles



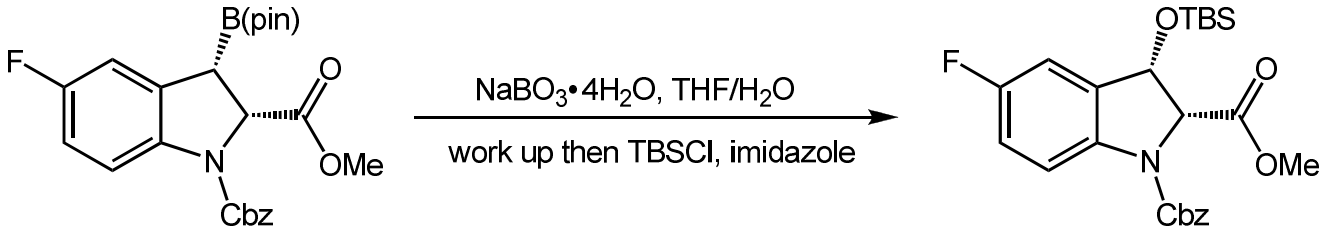
1o not detected



	1a	1o
LUMO (eV)	-1.51	-0.68

1a **1o**

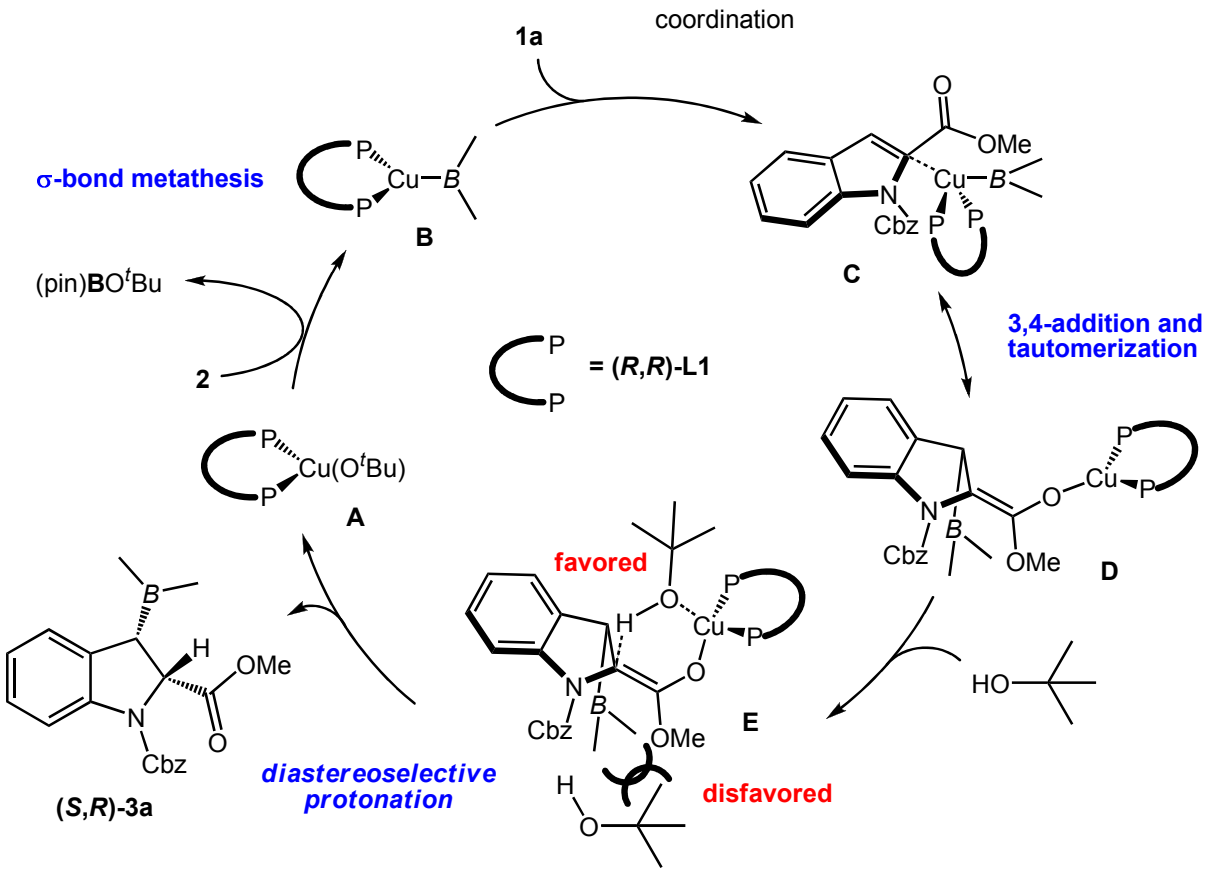
Strereospecific oxidation of chiral 3-borylindoline



d.r. 97:3, 95%ee

64%, d.r. >99:1, 94%ee

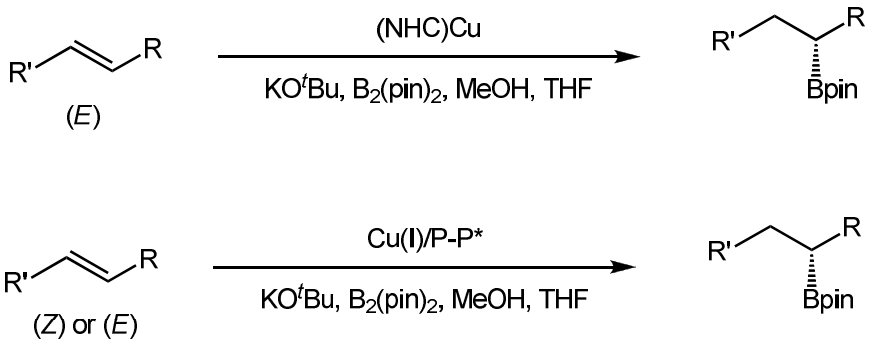
Cu^{I}-catalyzed enantioselective protoboration of indoles



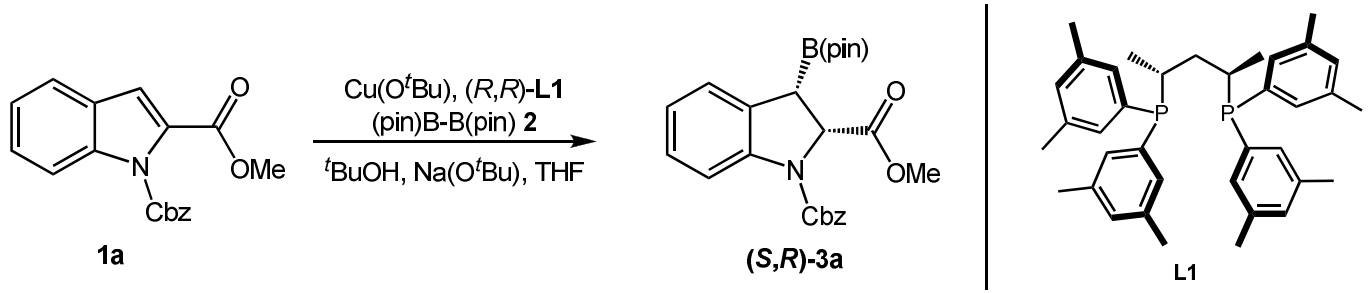
Ito, H. *et al*. *Angew. Chem. Int. Ed.* **2015**, *54*, 8809.

Summary

Cu^{I}-catalyzed enantioselective protoboration of alkenes



Cu^{I}-catalyzed enantioselective protoboration of indoles



Aromatic compounds are ubiquitous in nature and readily available as synthetic materials. Enantioselective dearomatization reactions of heteroaromatic compounds are very powerful transformations because they provide direct access to a wide variety of chiral saturated heterocycles, which are important components of pharmaceutical drugs and bioactive molecules. The development of new methods for the formation of consecutive stereogenic centers through the stereoselective dearomatization of multisubstituted aromatic compounds would also have important practical implications for the synthesis of natural products.

In summary, we have developed the enantioselective C-B bond-forming dearomatization of heteroaromatic compounds using a chiral bisphosphine-copper (I) complex as catalyst and a diboron reagent. This reaction involved the enantioselective dearomative addition of borylcopper (I) to methyl indole-2-carboxylate with concomitant formation of a stereogenic C-B bond, followed by the diastereoselective protonation of the copper (I) enolate intermediate to deliver the enantioenriched chiral indoline bearing consecutive stereogenic centers with excellent regio-, diastereo-, and enantioselectivities. We envisage that the results of this study will provide further opportunities for the development of novel stereoselective dearomative borylation reactions involving a wide variety of aromatic compounds, such as pyrroles, furans, and polyaromatic hydrocarbons. Advances in this area would therefore allow the efficient synthesis of complex saturated heterocyclic compounds with potentially interesting biological activities.