Literature Report

Cu-Catalyzed Enantioselective Ring Opening of Cyclic Diaryliodoniums

Reporter: Hong-Qiang Shen

Checker: Fan-Jie Meng

Date: 2018/08/27

Li, B.; Chao, Z.; Li, C.; Gu, Z.
J. Am. Chem. Soc. **2018**, *140*, 9400.

Contents

CV of Zhenghua Gu

Education:

1998-2002 B. D., Nanjing University

2002-2007 Ph. D., Shanghai Institute of Organic Chemistry

2007-2008 Postdoctoral Fellow, UC, Berkeley

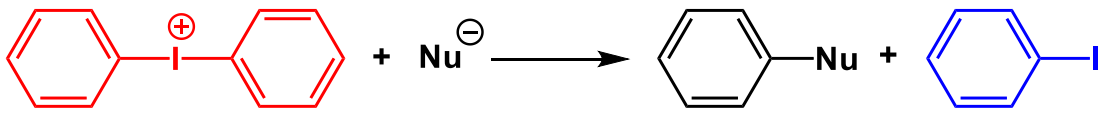
2008-2011 Postdoctoral Fellow, UC, Santa Barbara

2011-至今 Professor, USTC

Research:

- The total synthesis of natural products；
- Development of simple, novel methods and strategies that enable C-C, C-heteroatom bond formations.

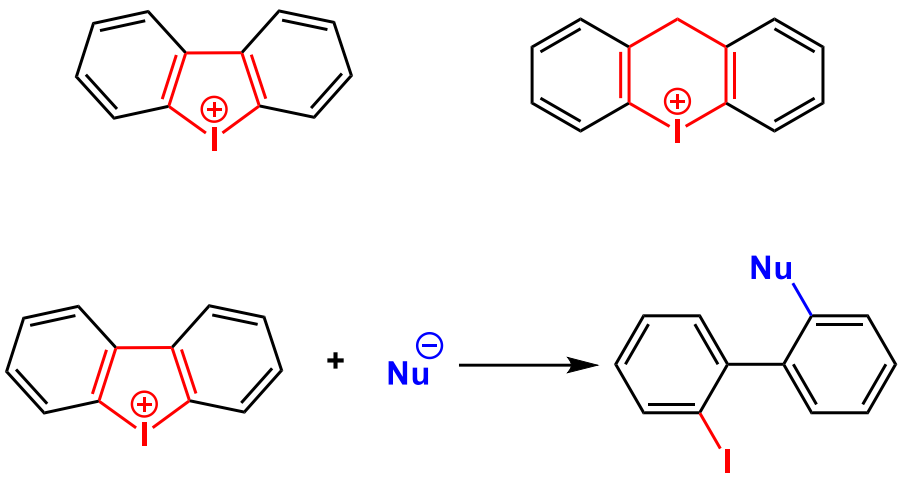
Diaryliodoniums



- Non-explosive
- Non-toxic
- Stable

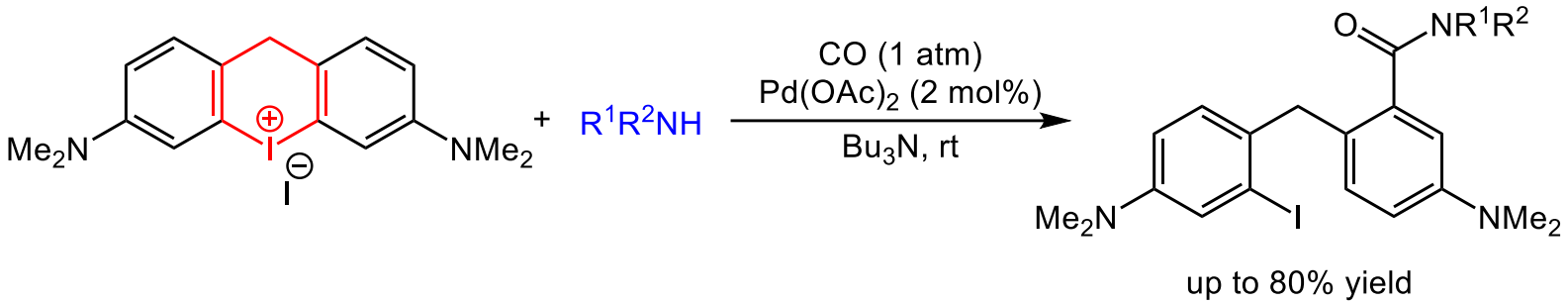
Grushin, V. V. *Chem. Soc. Rev.* **2000**, *29*, 315.

Diaryliodoniums



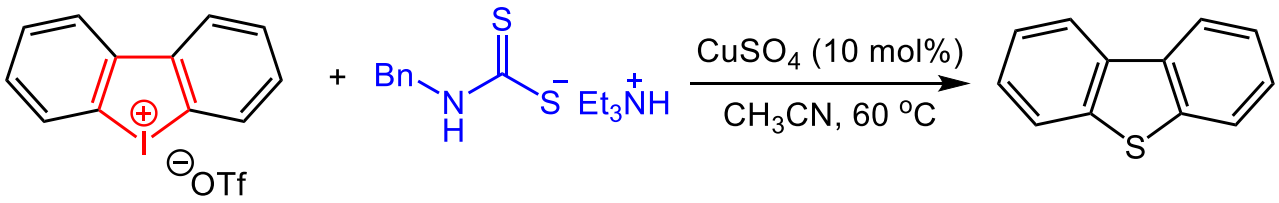
Grushin, V. V. *Chem. Soc. Rev.* **2000**, *29*, 315.

Introduction



up to 80% yield

Ma, Y.-X. *et al. Molecules* **2005**, *10*, 238.



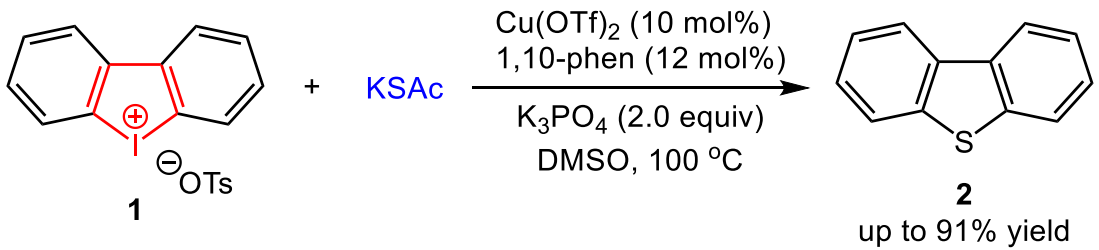
1

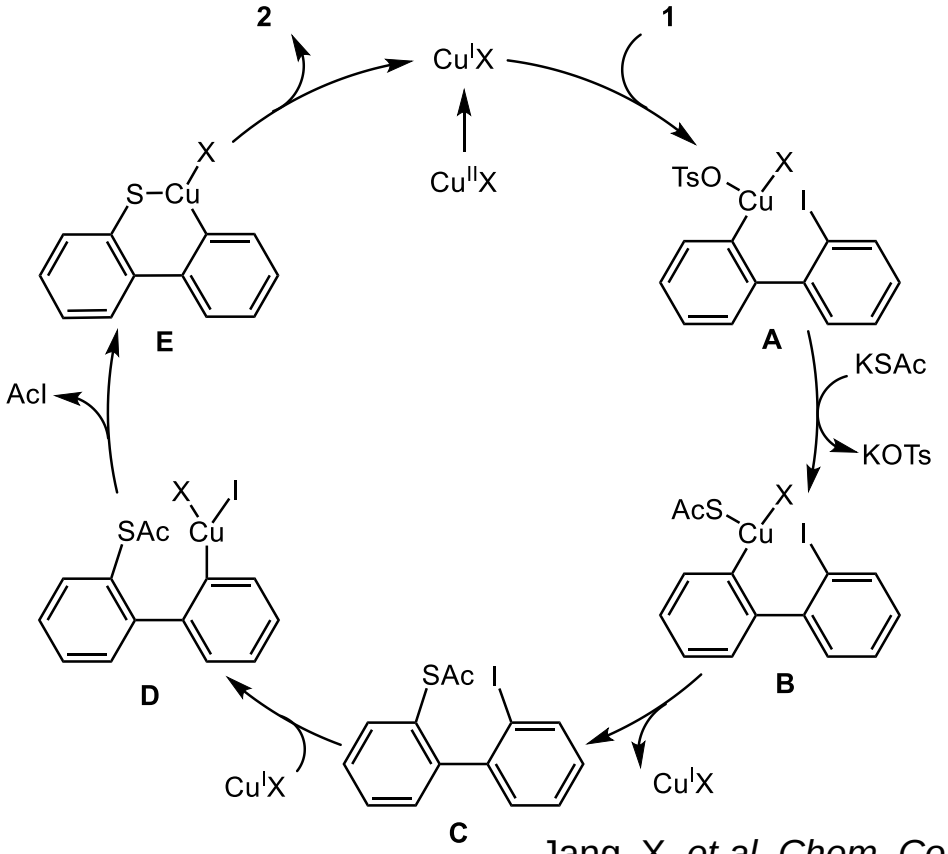
2

up to 93% yield

Wen, S. *et al. Adv. Synth. Catal.* **2016**, *358*, 2733.

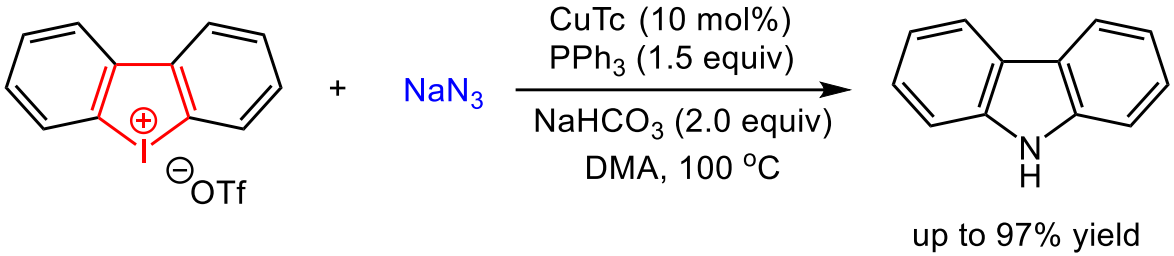
Introduction

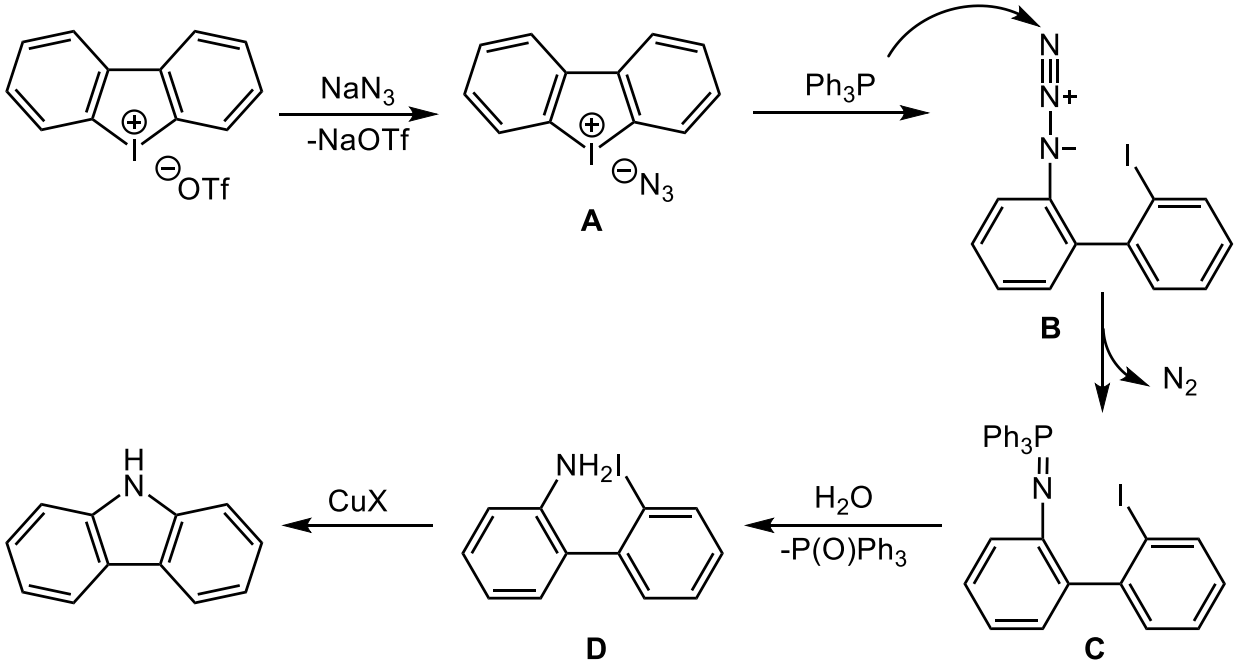




Jang, X. *et al. Chem. Commun.* **2017**, *53*, 2918.

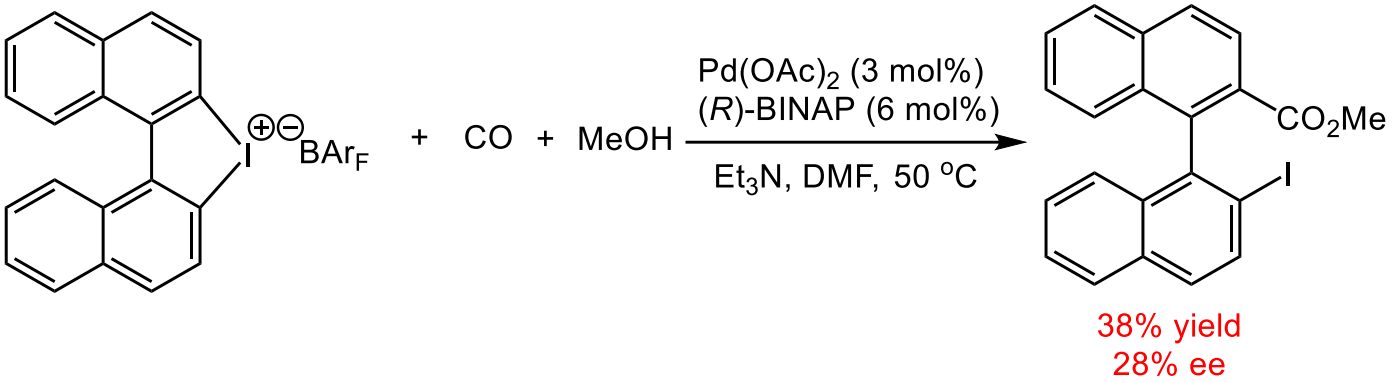
Introduction





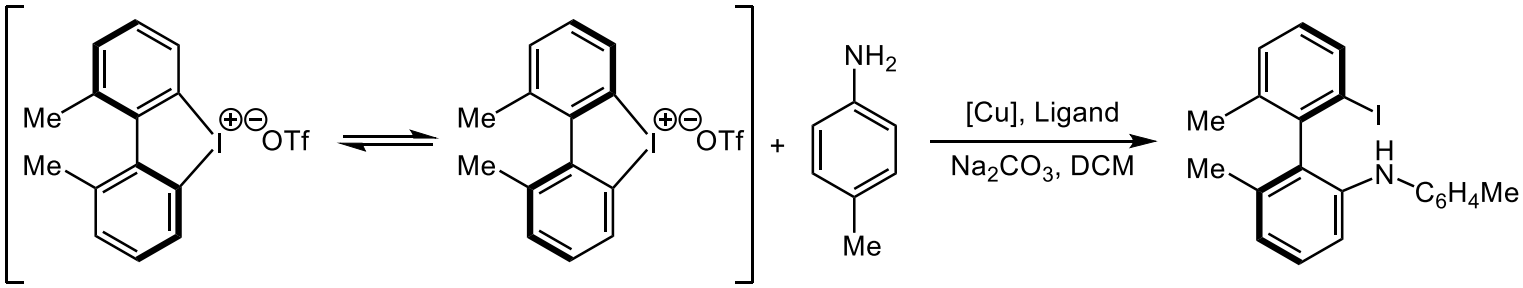
Takemoto, Y. *et al. Org. Lett.* **2018**, *20*, 216.

Introduction



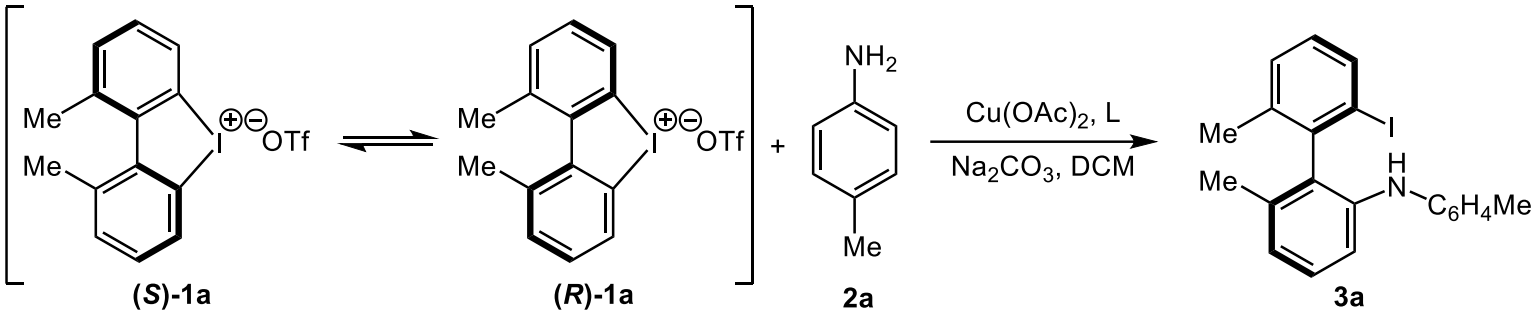
Hayashi, T. *et al. Adv. Synth. Catal.* **2004**, *346,* 1728.

Ring-Opening of Cyclic Diaryliodoniums



Gu, Z.; Fu, Y. *et al*. *Chem*. **2018**, *4*, 599.

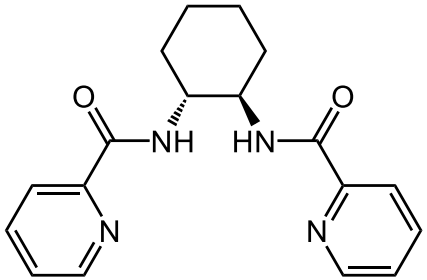
Optimization of the Reaction Parameters



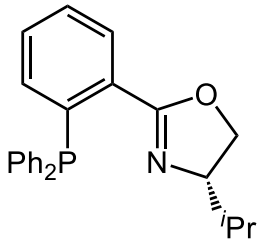
Entry[a]	L	Yield (%)[b]	Ee (%)[c]
1	L1	99	0
2	L2	99	0
3	L3	99	0
4	L4	99	54
5	L5	99	60

[a] Reaction conditions: **1a** (0.10 mmol), **2a** (0.12 mmol), $Cu(OAc)_2$ (20 mol%), L (40 mol%), Na_2CO_3 (0.3 mmol), DCM (2.0 mL), 40 °C. [b] Isolated yield. [c] Determined by chiral HPLC.

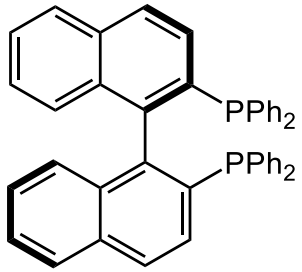
Ring-Opening of Cyclic Diaryliodoniums



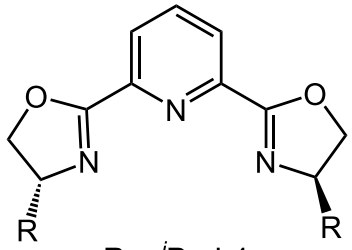
L1



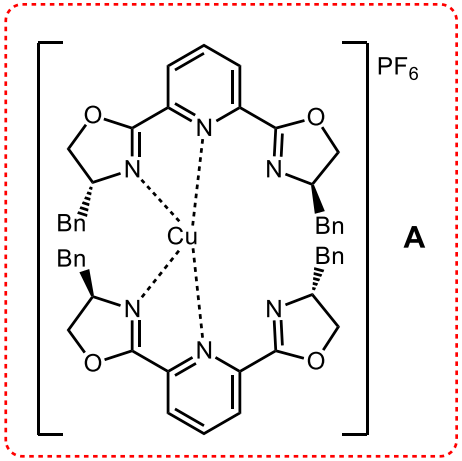
L2



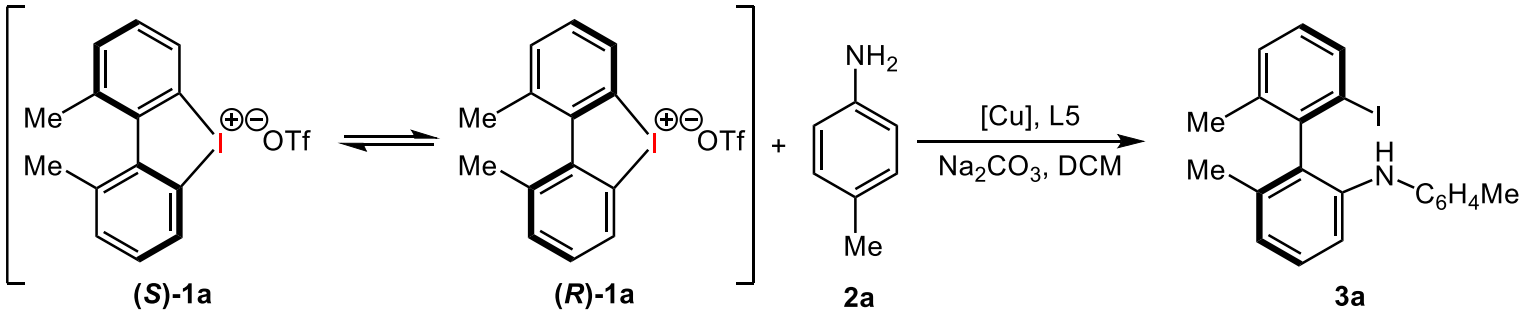
L3



R = ^{i}Pr, L4
R = Ph, L5
R = Bn, L6



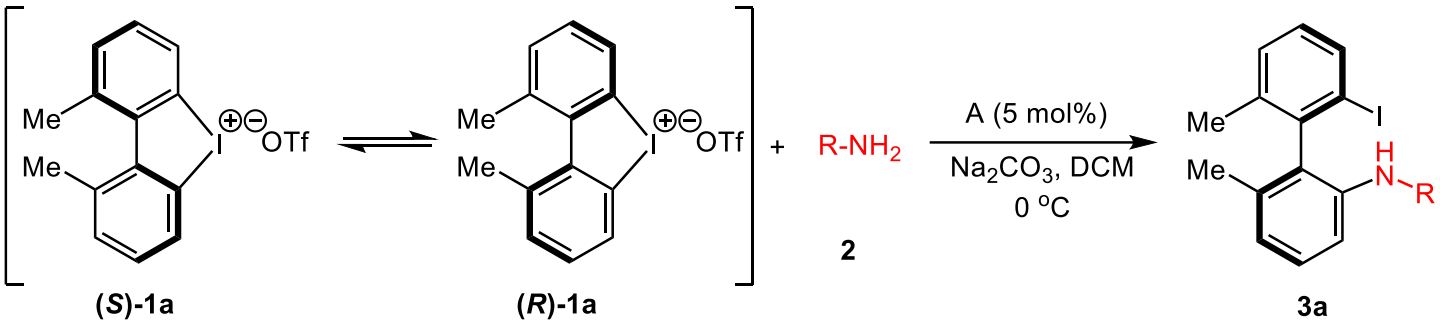
Optimization of the Reaction Parameters

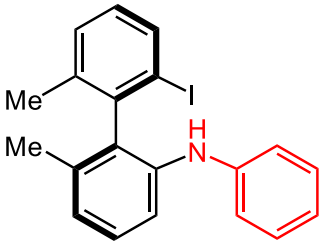


Entry[a]	[Cu]	T (°C)	L	Yield (%)[b]	Ee (%)[c]
1	$Cu(OAc)_2$	40	L5	99	60
2	CuOTf•1/2Benzene	40	L5	99	85
3	$Cu(OTf)_2$	40	L5	99	85
4[d]	$Cu(OTf)_2$	40	L5	99	26
5	$Cu(OTf)_2$	0	L6	99	99
6	**A**	0	--	99	98

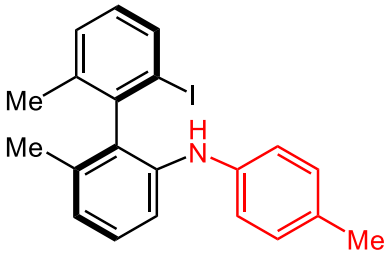
[a] Reaction conditions: **1a** (0.10 mmol), **2a** (0.12 mmol), $Cu(OAc)_2$ (20 mol%), L (40 mol%), Na_2CO_3 (0.3 mmol), DCM (2.0 mL), 40 °C. [b] Isolated yield. [c] Determined by chiral HPLC. [d] The 20 mol% ligand was used.

Substrate Scope

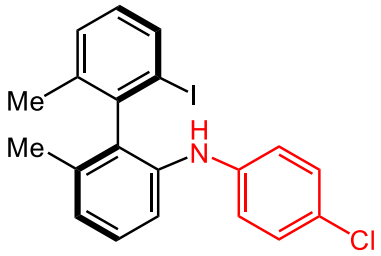




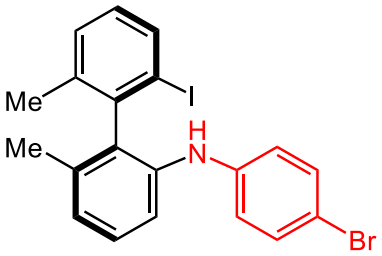
3a: 99% yield, > 99% ee



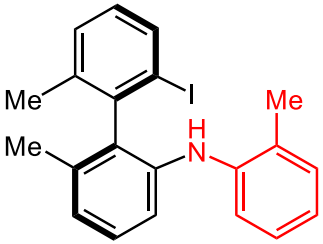
3b: 99% yield, 98% ee



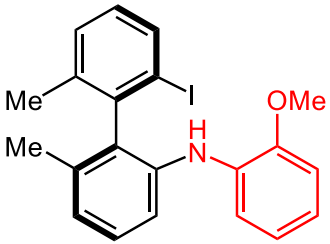
3c: 72% yield, 99% ee



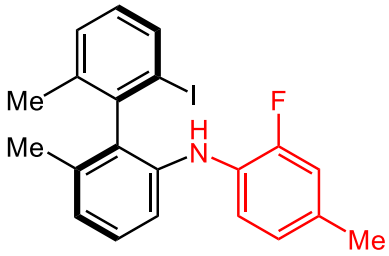
3d: 69% yield, 99% ee



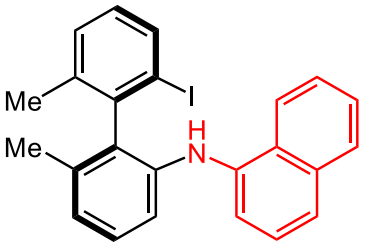
3e: 90% yield, 96% ee



3f: 98% yield, 99% ee

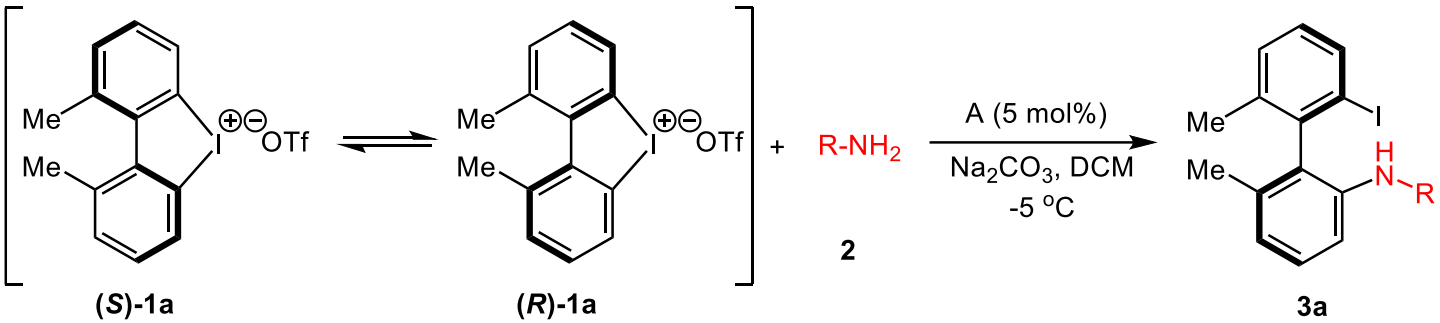


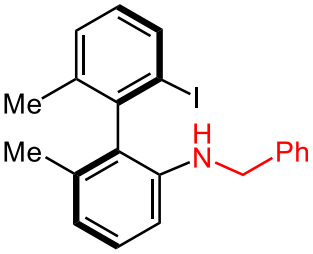
3g: 79% yield, > 99% ee



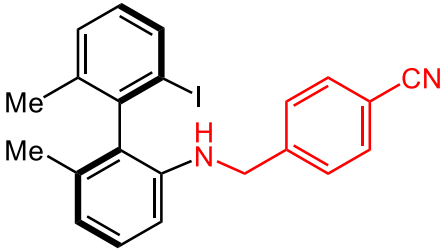
3h: 70% yield, > 99% ee

Substrate Scope

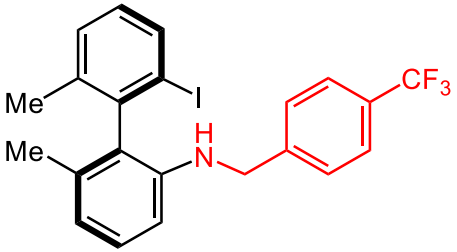




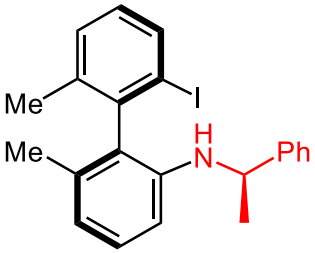
3i: 99% yield, 95% ee



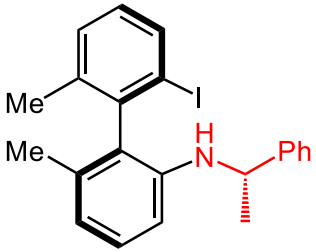
3j: 63% yield, 90% ee



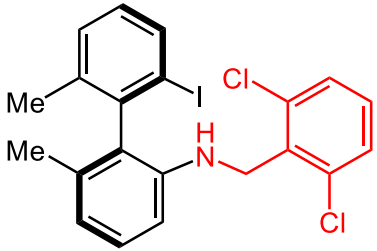
3k: 99% yield, 95% ee



3l: 86% yield, d.r. 20:1

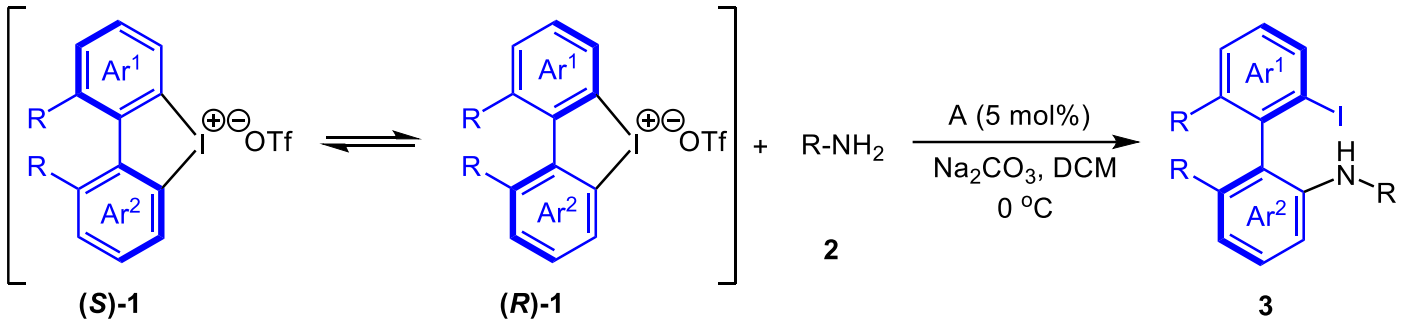


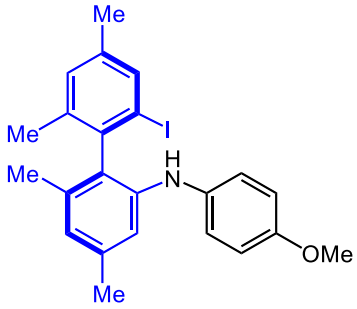
3m: 93% yield, d.r. 1:13



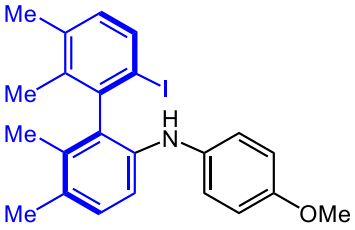
3n: 99% yield, 97% ee

Substrate Scope

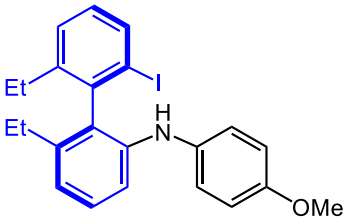




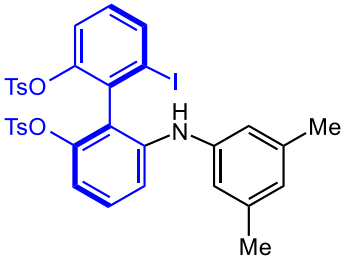
3o: 98% yield, 97% ee



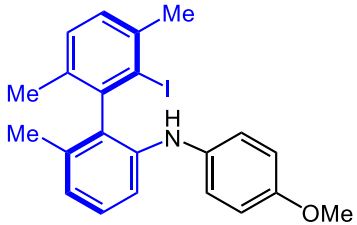
3p: 97% yield, 95% ee



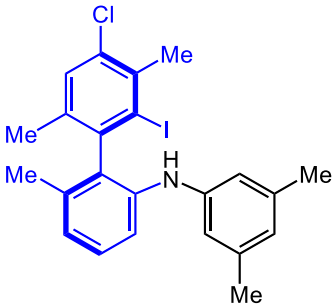
3q: 98% yield, 94% ee



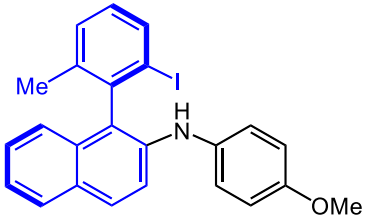
3r: 60% yield, > 99% ee



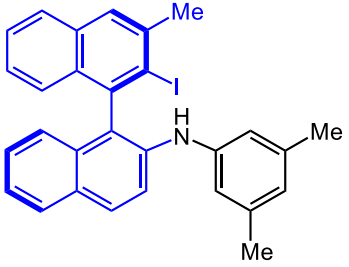
3s: 99% yield, 95% ee



3t: 88% yield, 99% ee

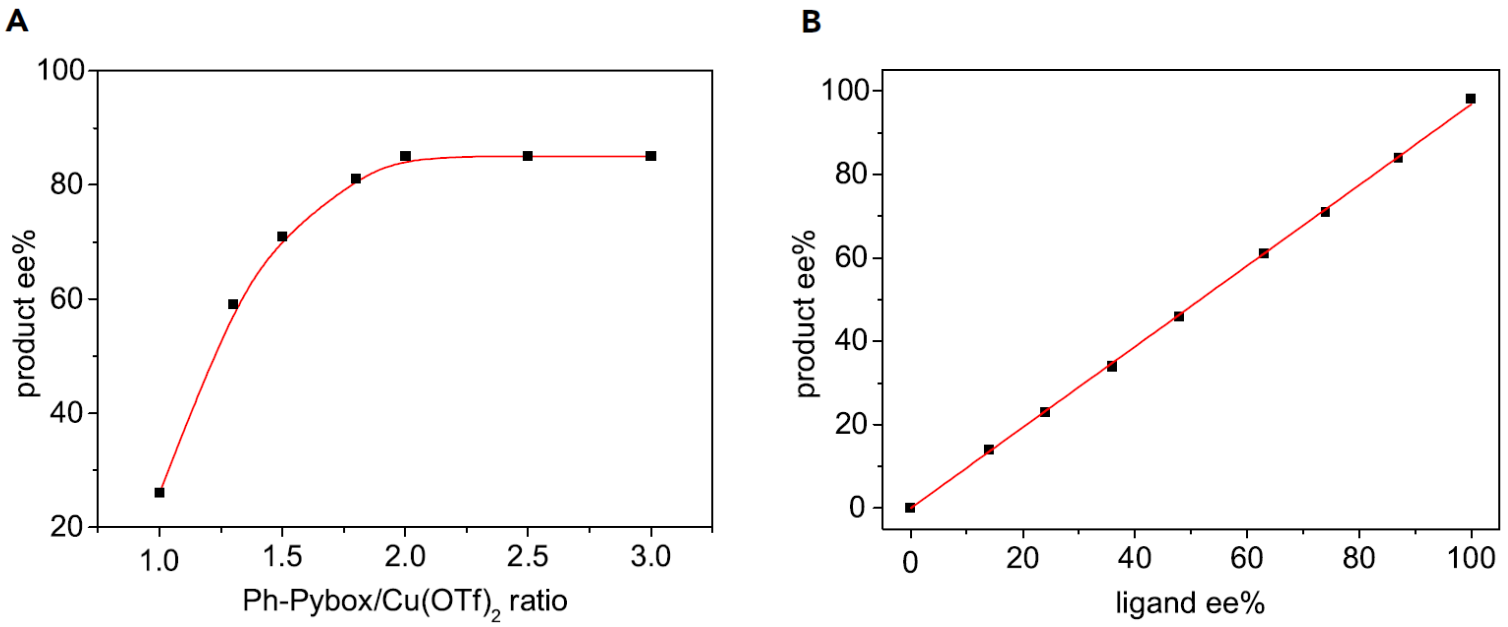


3u: 97% yield, 93% ee



3v: 72% yield, > 99% ee

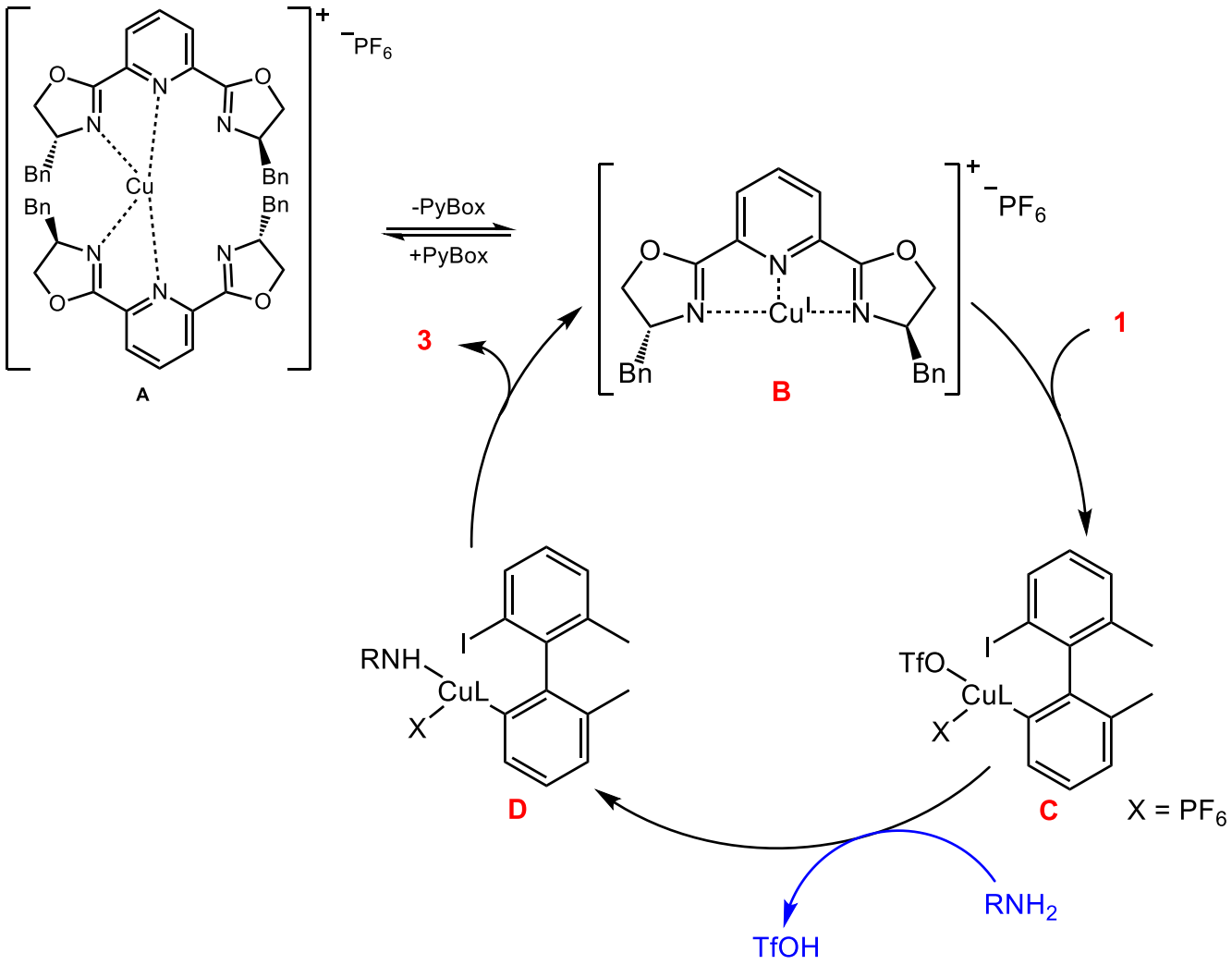
Control Experiments



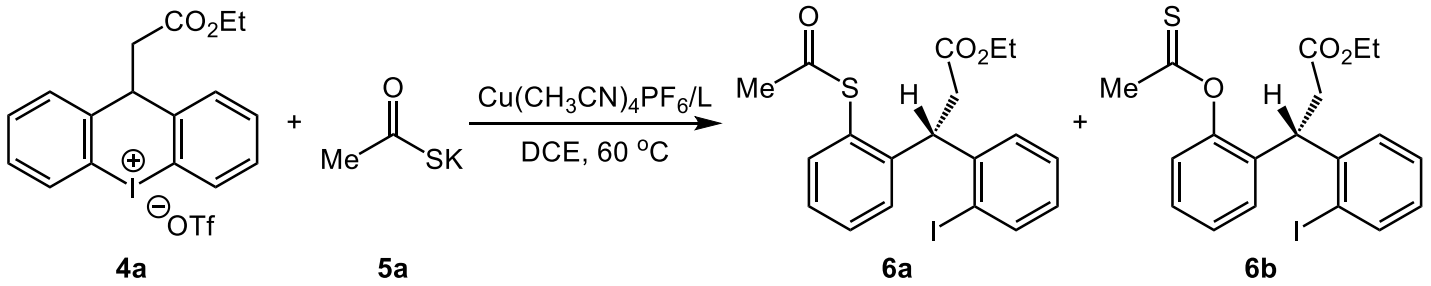
A. Enantiomeric excess of 3a versus the ratio of Ph-PyBox/$Cu(OTf)_2$.

B. Correlation between the enantiomeric excesses of 3a and the ee values of Bn-PyBox.

Proposed Mechanism

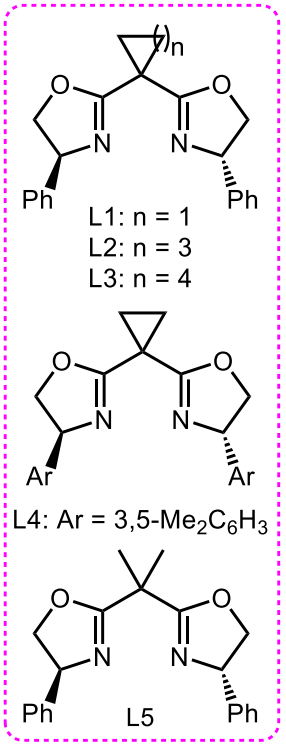


Optimization of the Reaction Parameters



Entry[a]	L	Yield (%)[b]	Ee (%)[c]	**6a**:**6b**
1	L1	88	86	11:1
2	L2	45	51	10:1
3	L3	47	3	15:1
4	L4	81	93	14:1
5	L5	61	28	17:1

[a] Reaction conditions: **4a** (0.10 mmol), **5a** (0.10 mmol), $Cu(CH_3CN)_4PF_6$ (5 mol%), L (5 mol%), DCE (2.0 mL), 60 °C. [b] Isolated yield. [c] Determined by chiral HPLC.



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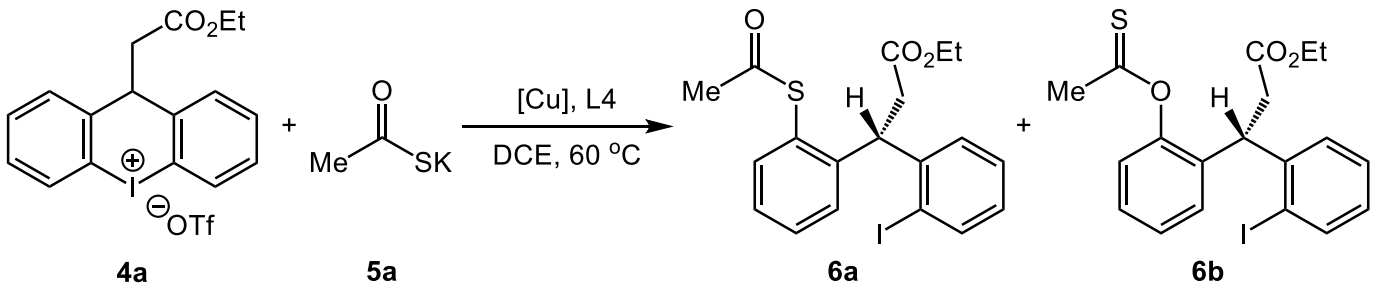
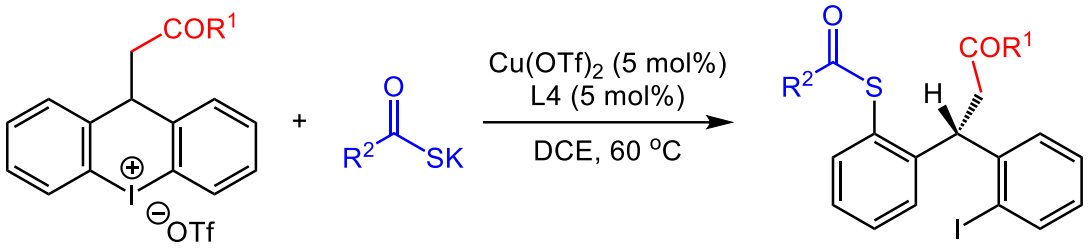
Optimization of the Reaction Parameters

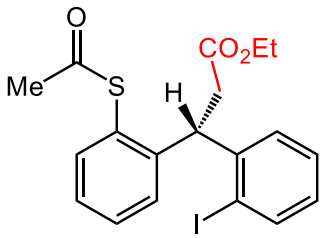


Entry[a]	[Cu]	Yield (%)[b]	Ee (%)[c]	**6a**:**6b**
1	$Cu(CH_3CN)_4PF_6$	81	93	14:1
2	CuTc	85	94	10:1
3	CuI	85	93	13:1
4	$Cu(OAc)_2$	79	93	7:1
5	$Cu(OTf)_2$	83	94	14:1
6[d]	$Cu(OTf)_2$	89	93	11:1
7[d,e]	$Cu(OTf)_2$	93	93	11:1

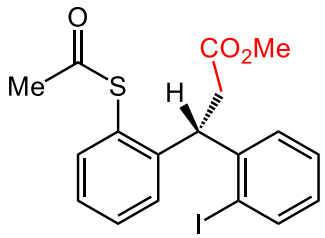
[a] Reaction conditions: **4a** (0.10 mmol), **5a** (0.10 mmol), [Cu] (5 mol%), L4 (5 mol%), DCE (2.0 mL), 60 °C. [b] Isolated yield. [c] Determined by chiral HPLC. [d] **5a** (0.12 mmol). [e] The scale of reaction was 0.20 mmol.

Substrate Scope

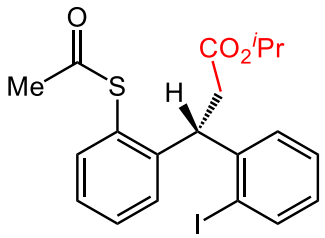




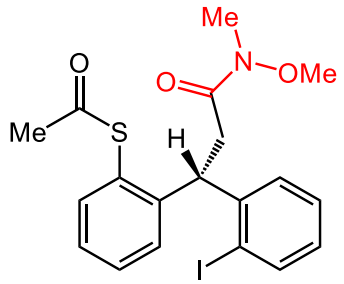
6a: 93% yield, 93% ee, rr 11:1



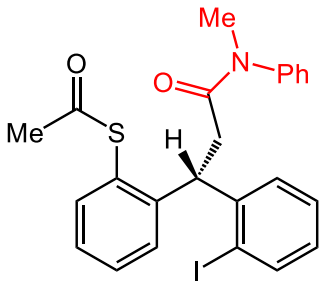
6b: 94% yield, 93% ee, rr 14:1



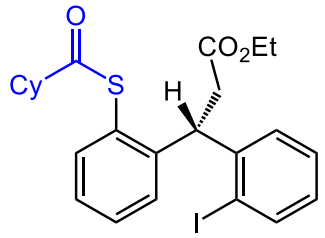
6c: 78% yield, 91% ee, rr 10:1



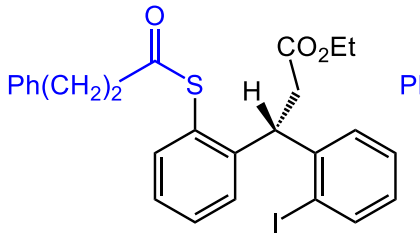
6d: 99% yield, 97% ee, rr > 20:1



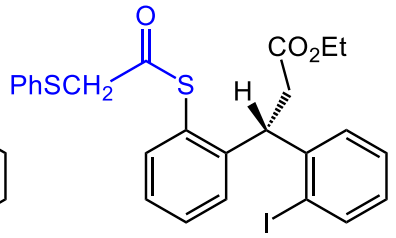
6e: 99% yield, 97% ee, rr > 20:1



6f: 97% yield, 97% ee, rr > 20:1

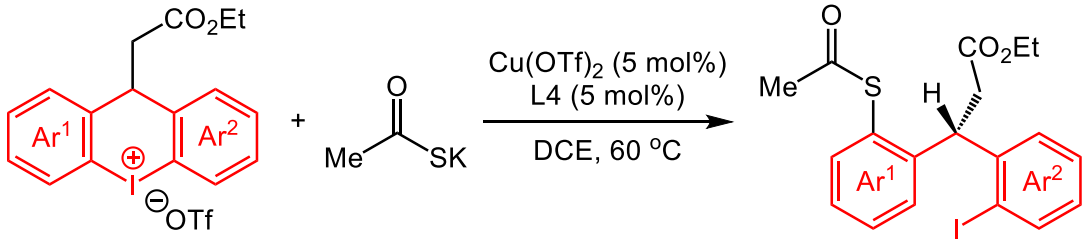


6g: 78% yield, 95% ee, rr > 20:1

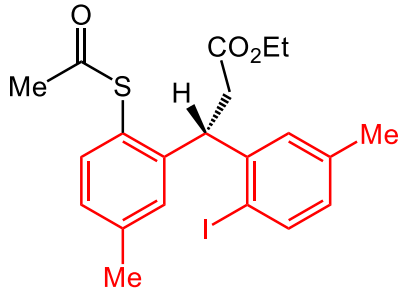


6h: 75% yield, 97% ee, rr > 20:1

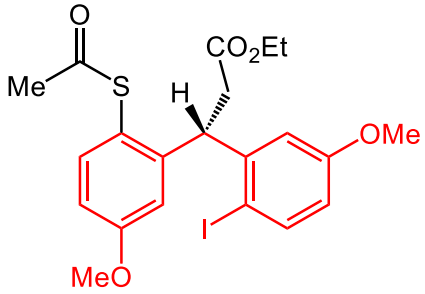
Substrate Scope



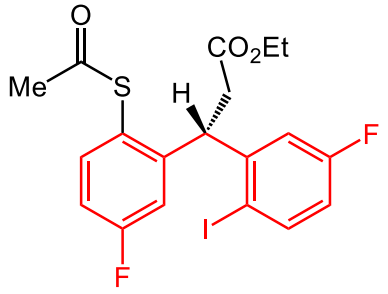
4 **5a** **6**



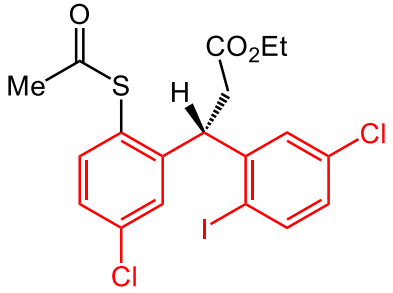
6i: 99% yield, 93% ee, rr > 20:1



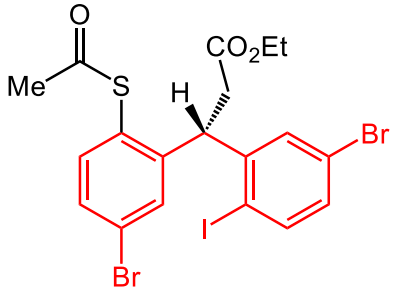
6j: 93% yield, 94% ee, rr > 20:1



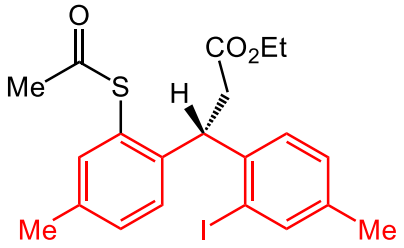
6c: 98% yield, 91% ee, rr 15:1



6e: 91% yield, 93% ee, rr 10:1

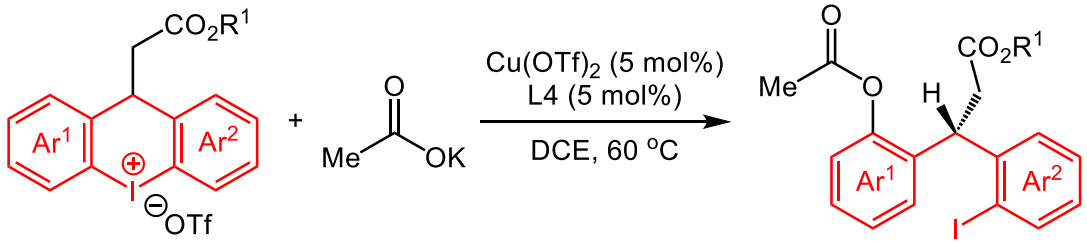


6f: 93% yield, 90% ee, rr 10:1

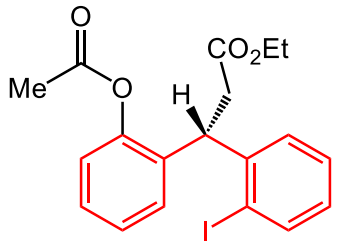


6g: 99% yield, 96% ee, rr 8:1

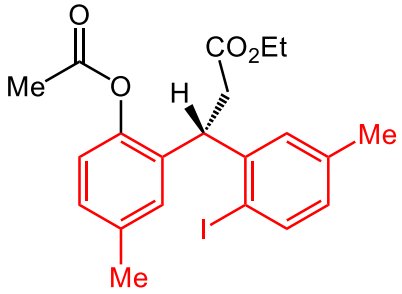
Substrate Scope



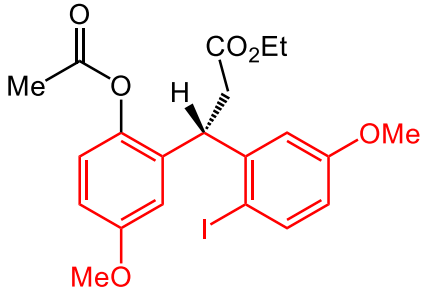
4 **7a** **8**



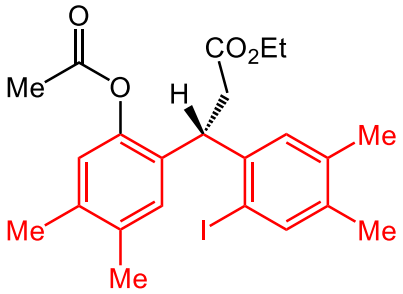
8a: 99% yield, 97% ee



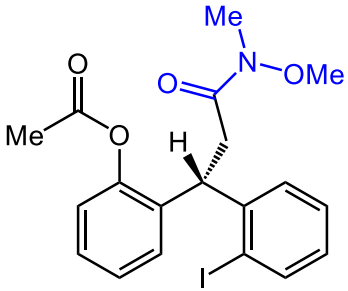
8b: 71% yield, 93% ee



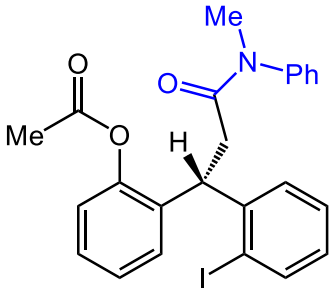
8c: 81% yield, 94% ee



8d: 86% yield, 97% ee

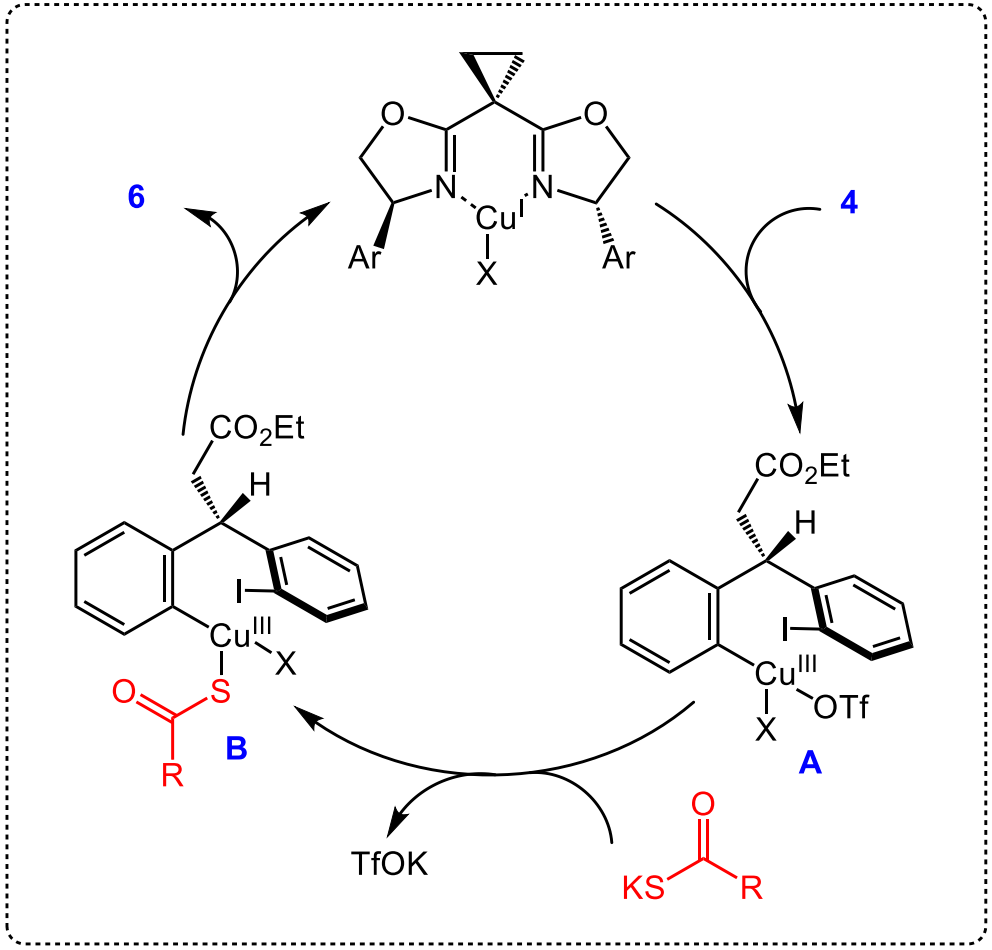


8e: 82% yield, 98% ee

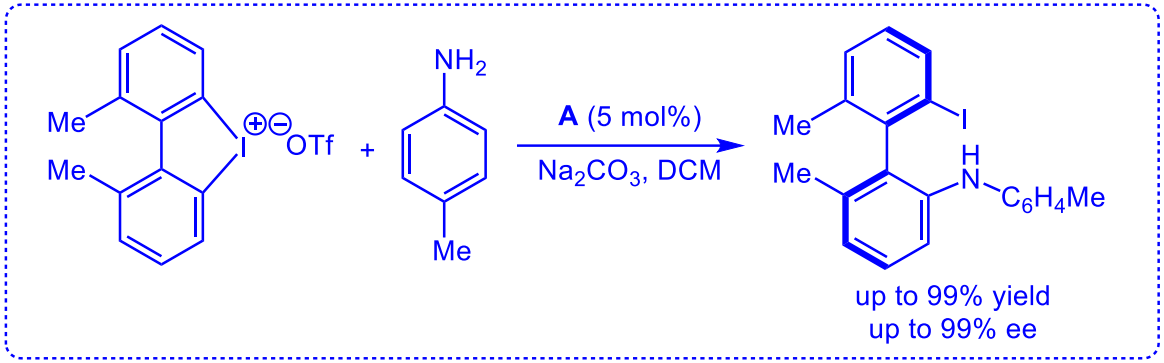


8f: 90% yield, 97% ee

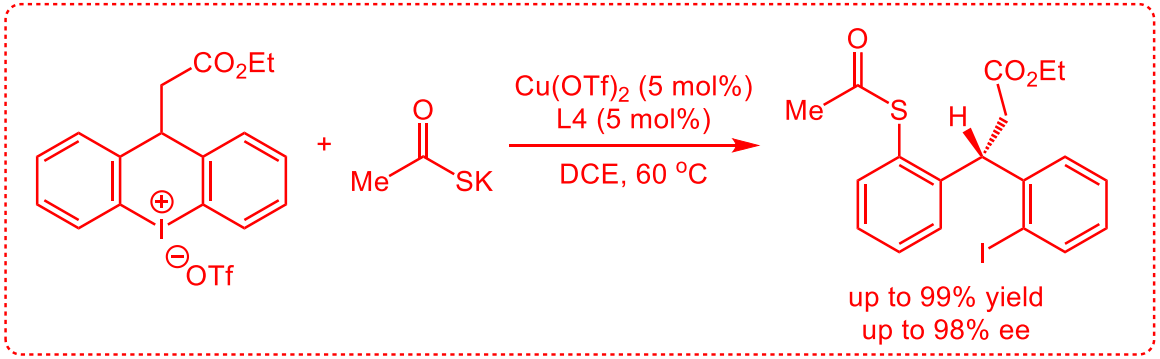
Proposed Mechanism



Summary



Gu, Z.; Fu, Y. *et al*. *Chem*. **2018**, *4*, 599.



Gu, Z. *et al*. *J. Am. Chem. Soc.* **2018**, *140*, 9400.

The First Paragraph

Diaryliodonium salts, also known as diaryl-λ^3-iodanes, represent an important class of compounds that are widely used in organic synthesis and molecule assembly chemistry. The highly electron-deficient nature of diaryliodonium salts, in combination with the excellent leaving propensity of Ar−I, renders these compounds powerful arylation reagents in synthetic organic chemistry. Generally, diaryliodonium salts demonstrate higher reactivity profiles than the corresponding aryl iodides in transition-metal-catalyzed arylation reactions.

The First Paragraph

Many elegant transformations of diaryliodonium salts have been developed, including some elegant enantioselective arylations reported by Gaunt and others. However, these reactions typically involve acyclic diaryliodonium salts as arylation reagents, which would produce 1 equiv of aryl iodide as the byproduct, reducing their atom economy. Examples where the aryl iodide "byproduct" could be used in situ as the second arylation reagents are very limited. However, this drawback has been avoided with the use of cyclic diaryliodoniums, which have been successfully applied in the synthesis of a series of functionalized biaryls.

The Last Paragraph

In conclusion, we have disclosed an asymmetric ring-opening reaction of diaryliodoniums to access molecules with center chirality. Optically active functionalized diarylmethane derivatives that bear (thio)phenol and versatile $C(sp^2)-I$ functionalities have been synthesized in high yields and enantioselectivity. On the basis of X-ray diffraction analysis, it was found that the cyclic diaryliodonium salt showed “Λ”-shape structure in the solid state. A model for the stereochemical outcome has been proposed.