Literature Report II

Catalytic Regio- and Enantioselective Boracarboxylation of Arylalkenes with CO_2 and Diboron

Reporter: Kai Xue
Checker: Jian Chen
Date: 2024-03-18

Zhang, S.; Li, L.; Li, D.; Zhou, Y.-Y.; Tang, Y.* *J. Am. Chem. Soc.* **2024**, *146*, 2888

CV of Prof. Tang Yong

Background:

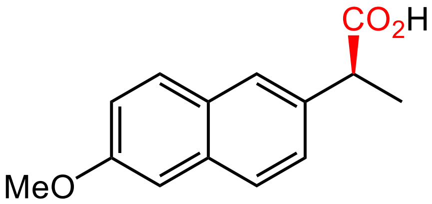
- **1982-1986** B.S., Sichuan Normal University
- **1990-1993** M.S., SIOC (Prof. Huang Yao-Tseng)
- **1993-1996** Ph.D., SIOC (Prof. Dai Li-Xin)
- **1996-1996** Associate Professor, SIOC
- **1996-1997** Postdoc., Colorado State University
- **1997-1999** Postdoc., Georgetown University
- **1999-now** Professor, SIOC

Research:

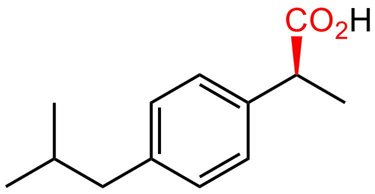
- **Asymmetric Catalysis**
- **Design, Synthesis and Application of Olefin Polymerization Catalysts**
- **Total Synthesis of Natural Products**

Contents

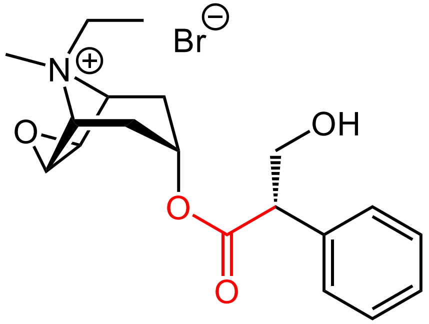
Introduction



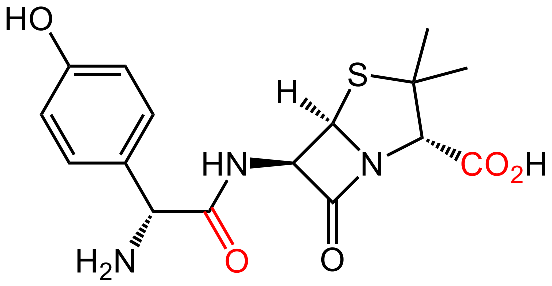
Naproxen
NSAID



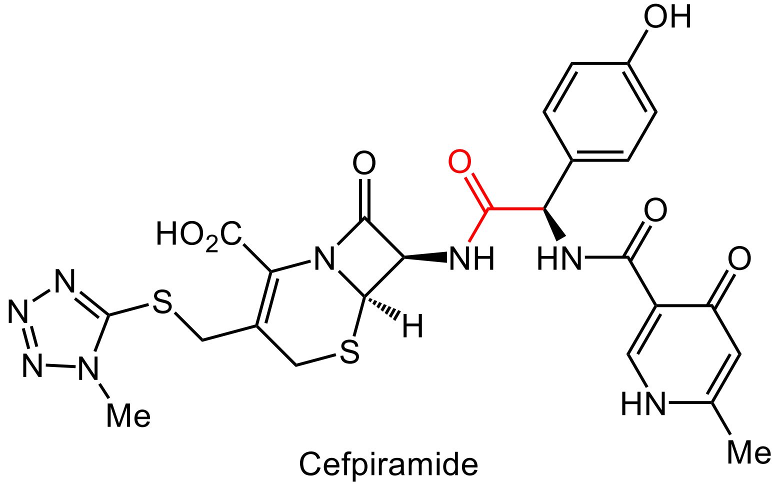
Ibuprofen
NSAID



Oxivent
Anticholinergic



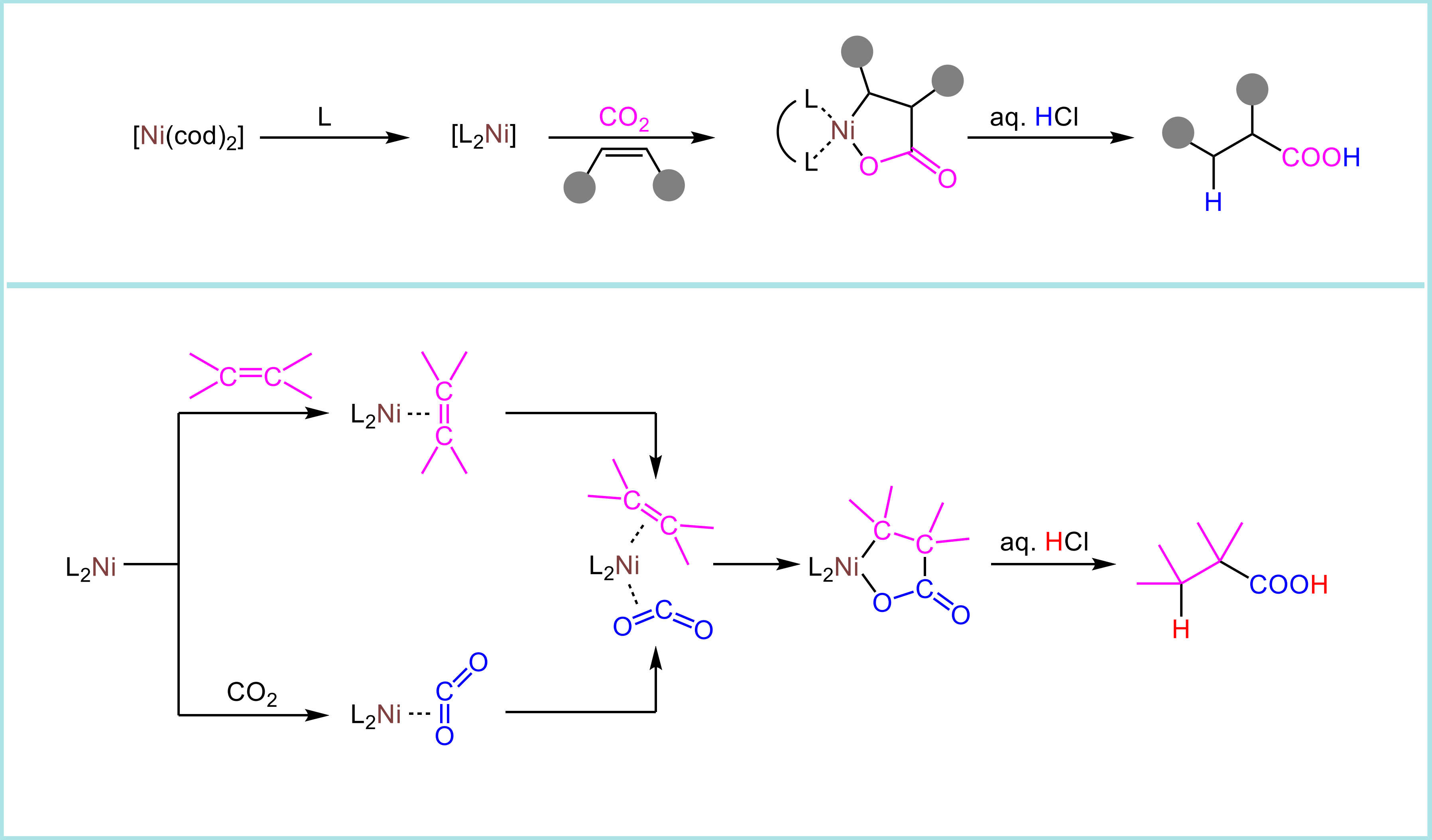
Amoxicillin
Antibiotic



Cefpiramide
Antibiotic

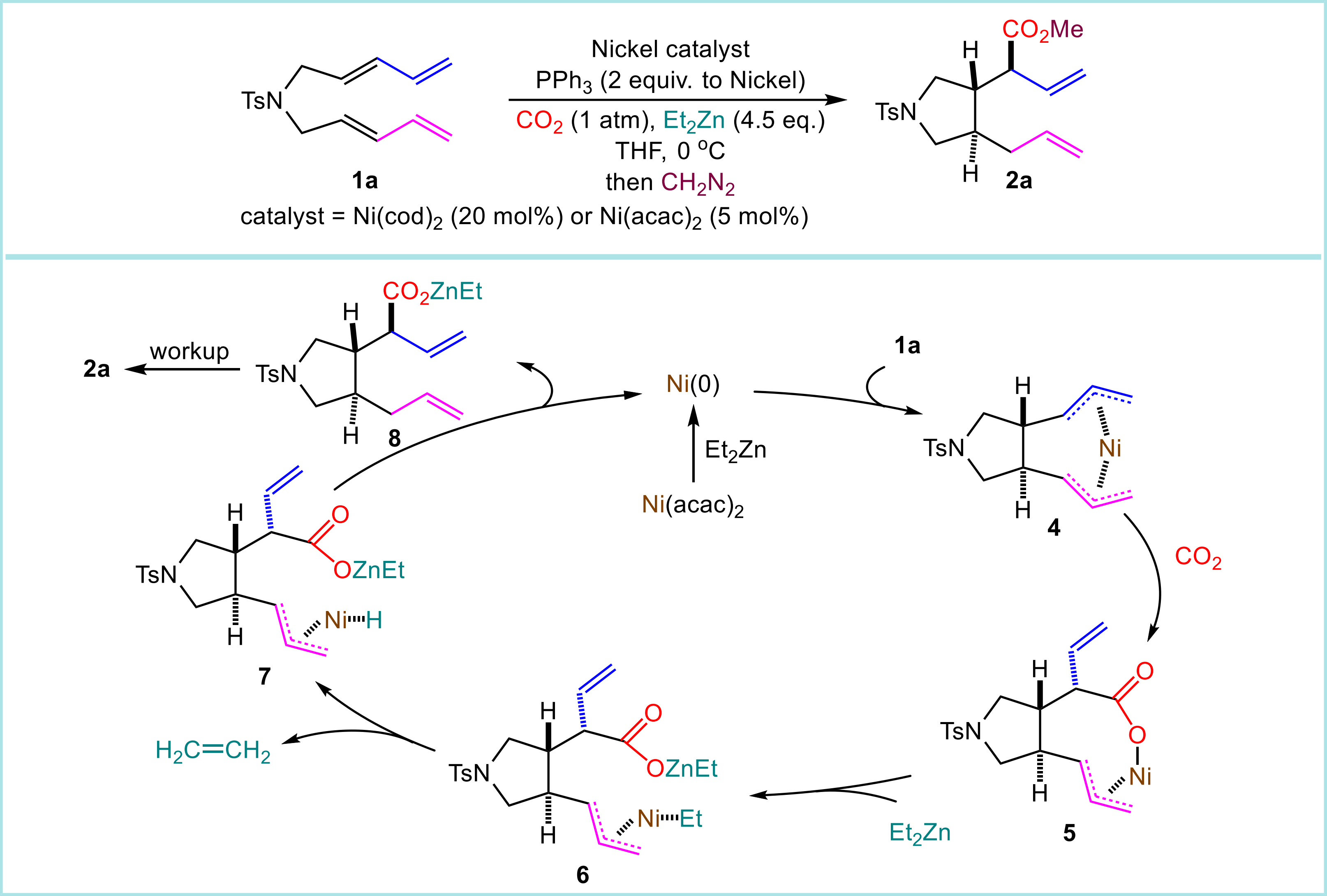
Zhang, S.; Li, L.; Li, D.; Zhou, Y.-Y.; Tang, Y.* *J. Am. Chem. Soc.* **2024**, *146*, 2888

Introduction



Hoberg, H.; Schaefer, S.; Burkhart, G.; Romao, M.* J. *J. Organomet. Chem.* **1984**, *266*, 203

Introduction



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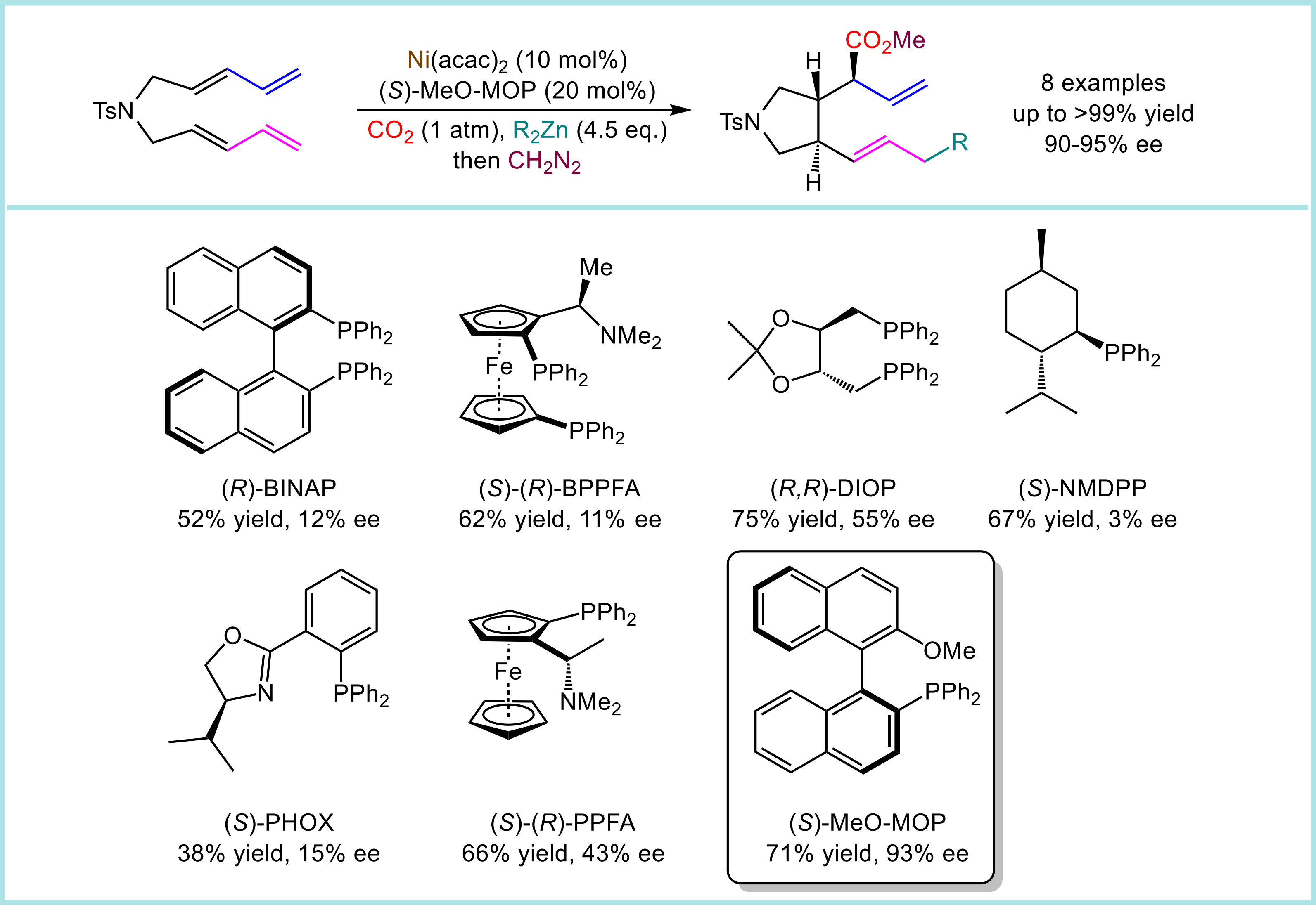
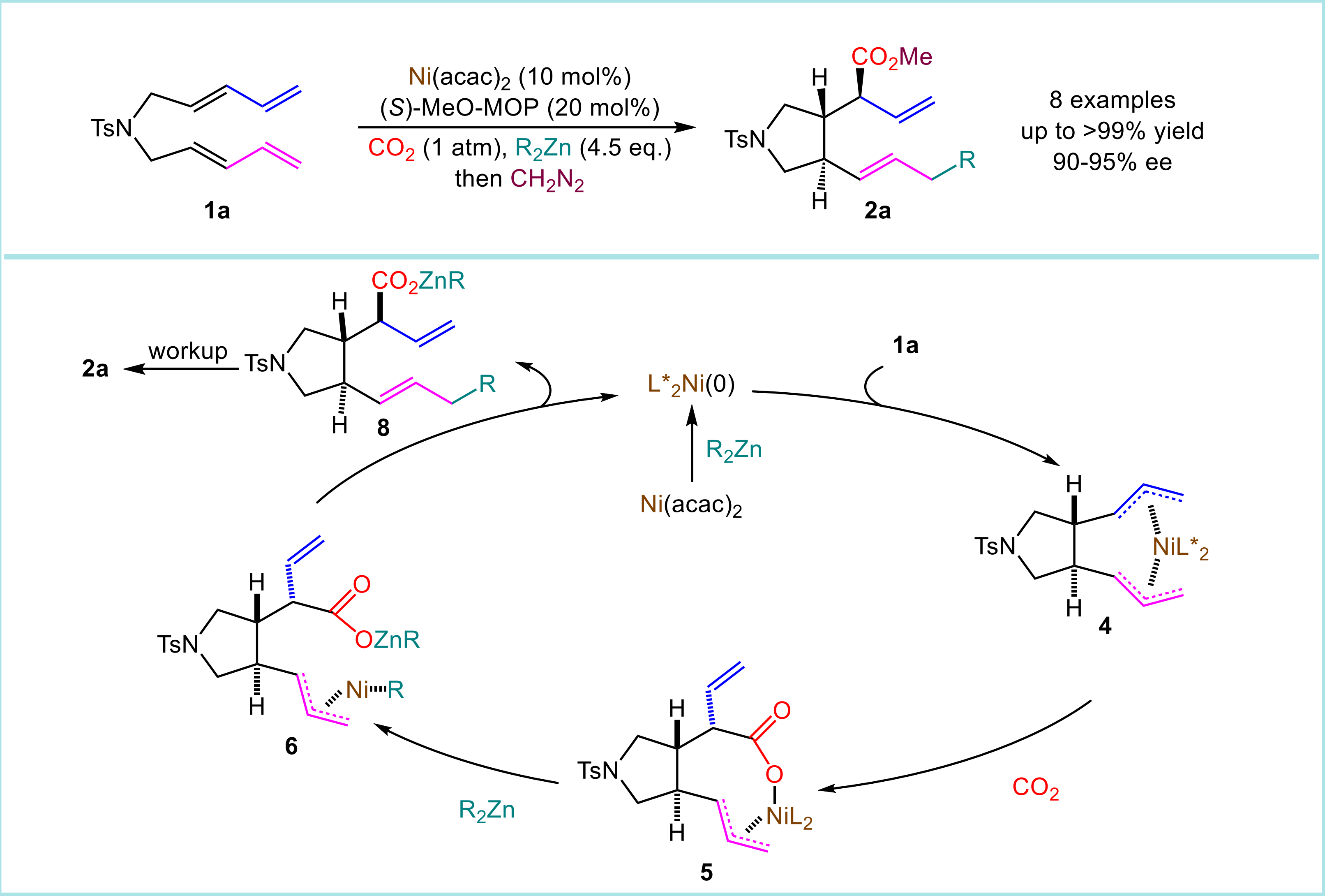
Introduction



Takimoto, M.; Nakamura, Y.; Mori, M.* *J. Am. Chem. Soc.* **2004**, *126*, 5956

Introduction



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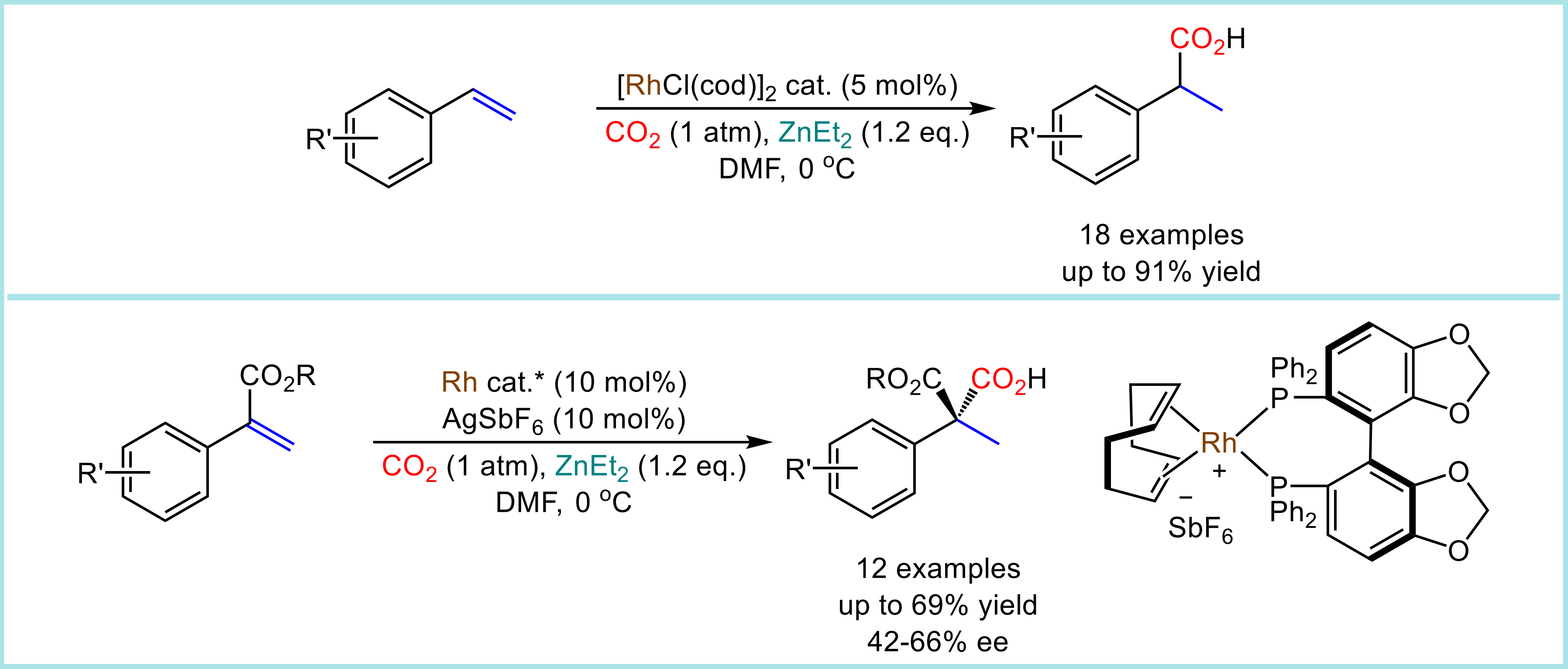

Kawashima, S.; Aikawa, K.; Mikami, K.* *Eur. J. Org. Chem.* **2016**, *19*, 3166

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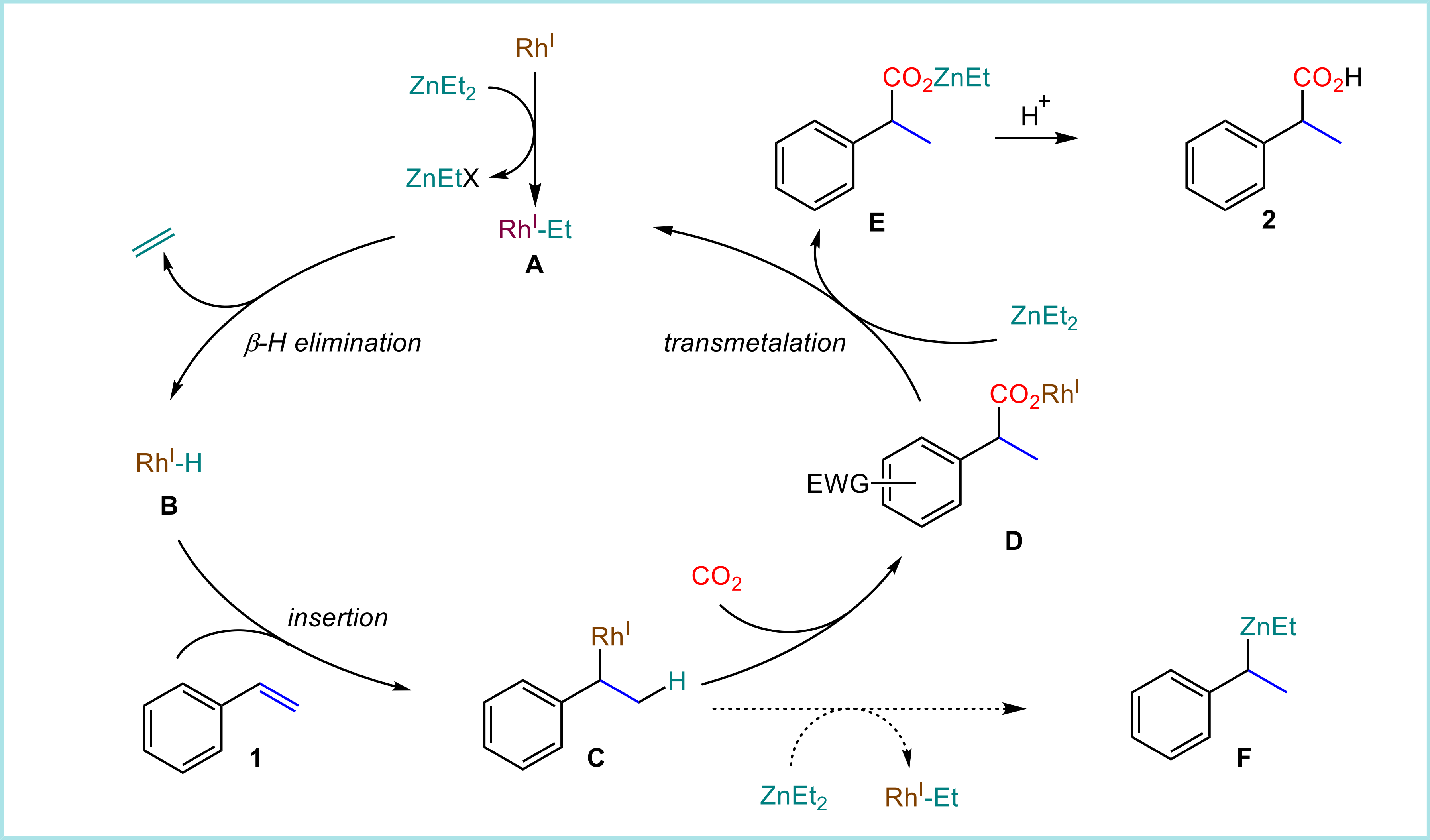

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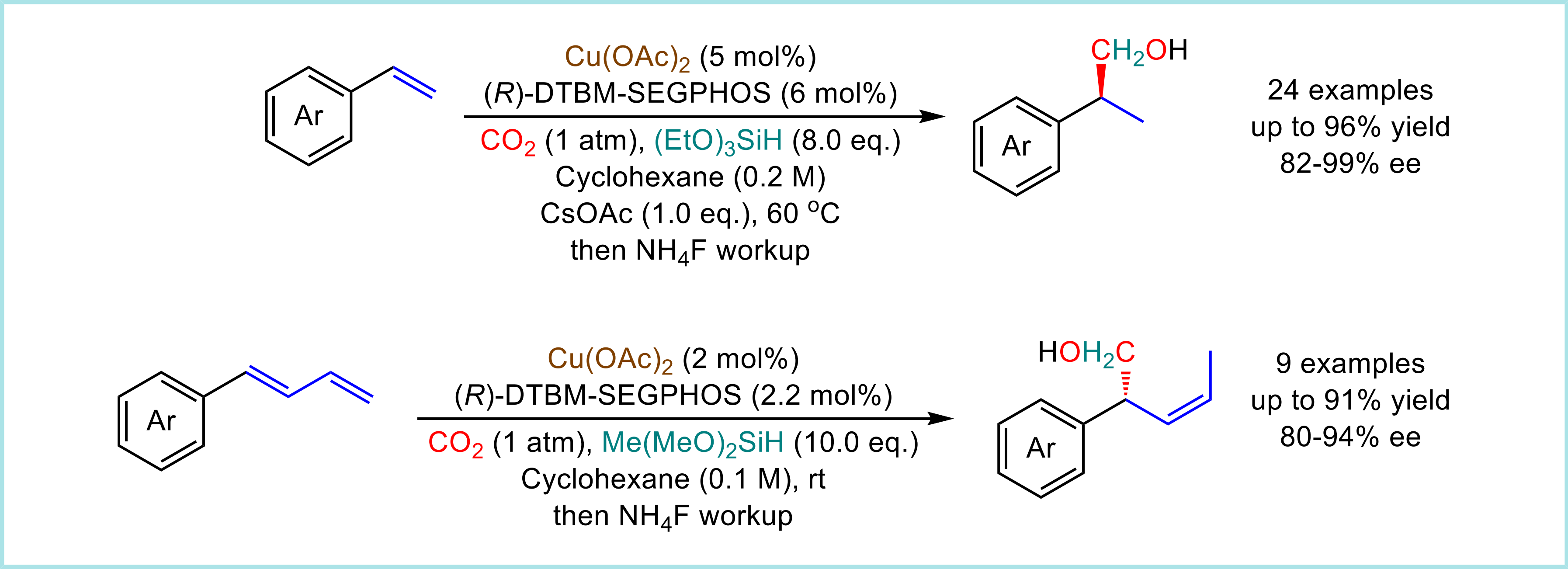
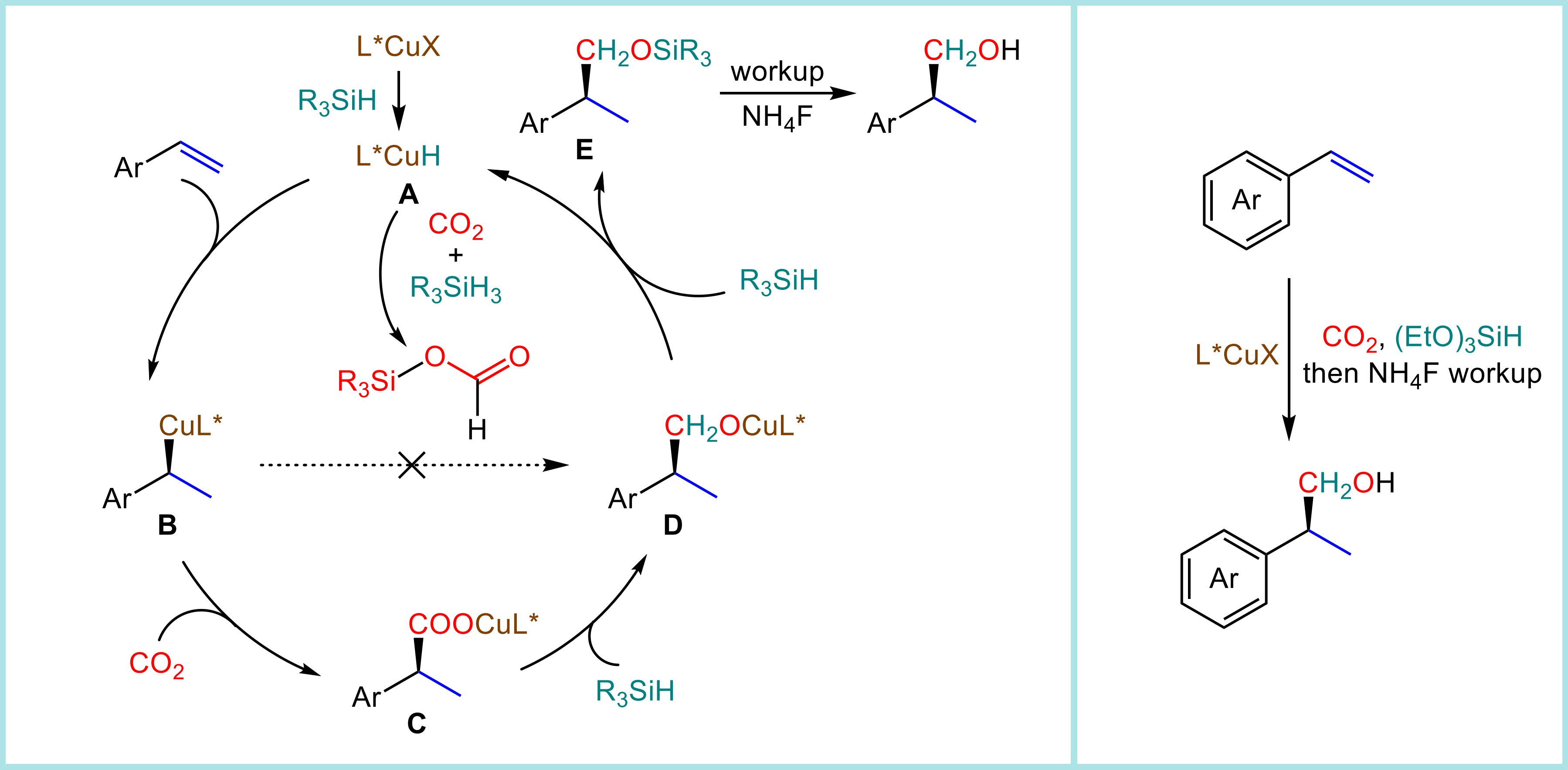


Gui, Y.-Y.; Hu, N.; Chen, X.-W.; Yu, D.-G.* *J. Am. Chem. Soc.* **2017**, *139*, 17011

Introduction



Gui, Y.-Y.; Hu, N.; Chen, X.-W.; Yu, D.-G.* *J. Am. Chem. Soc.* **2017**, *139*, 17011

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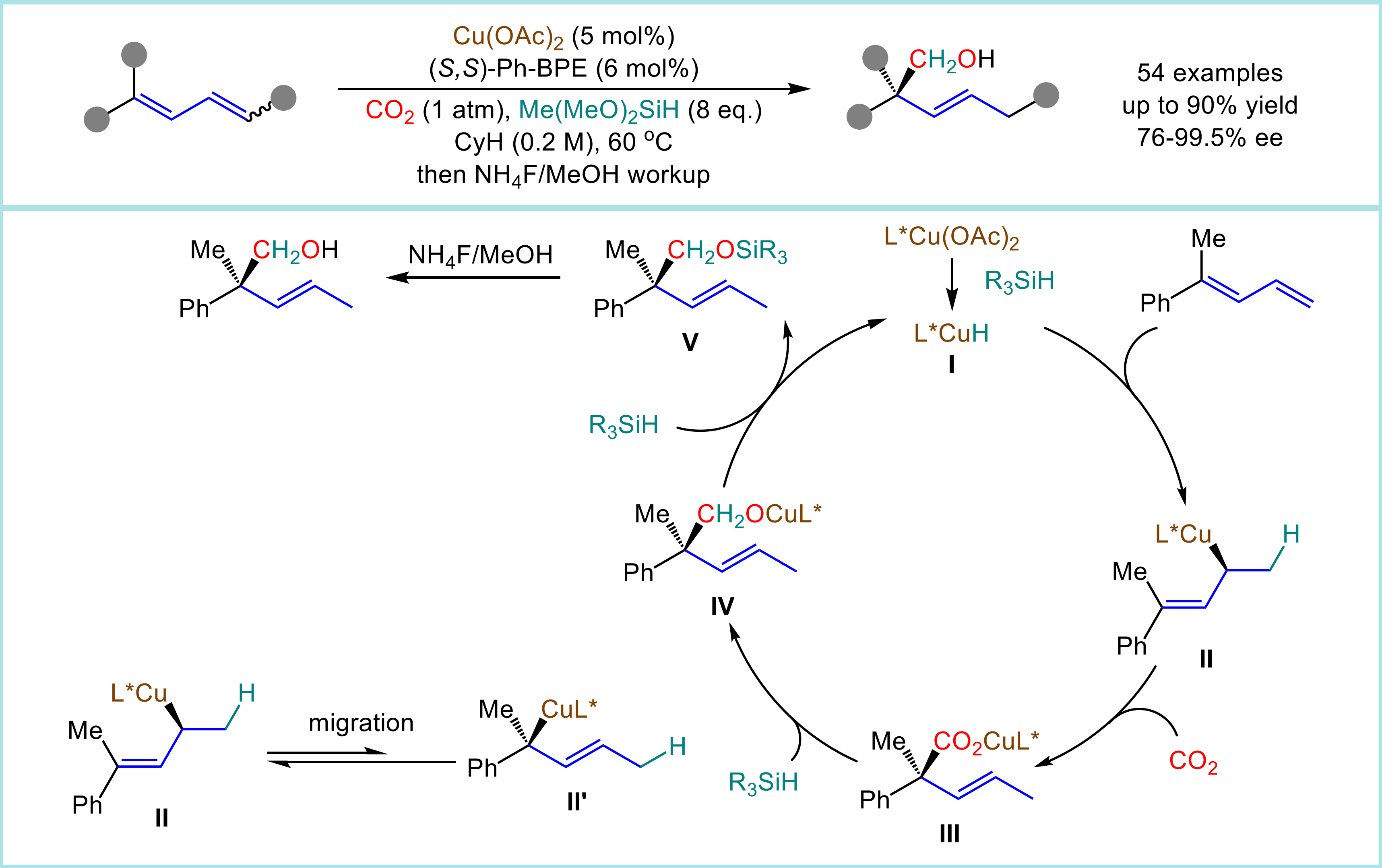
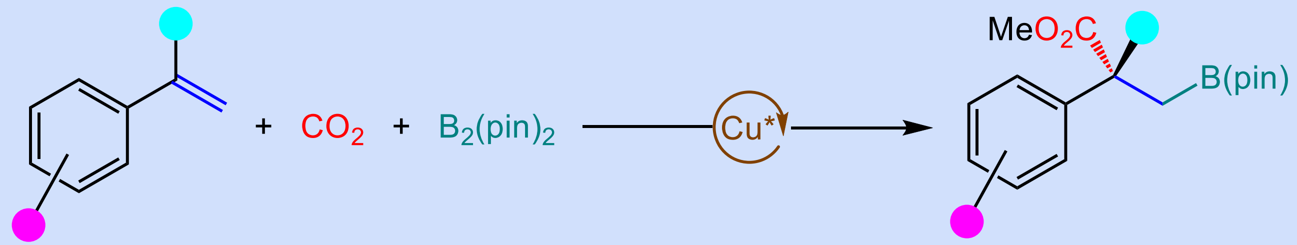
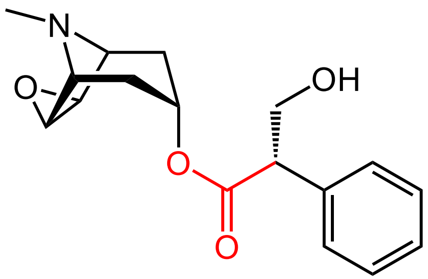


Chen, X.-W.; Zhu, L.; Gui, Y.-Y.; Yu, D.-G.* *J. Am. Chem. Soc.* **2019**, *141*, 18825

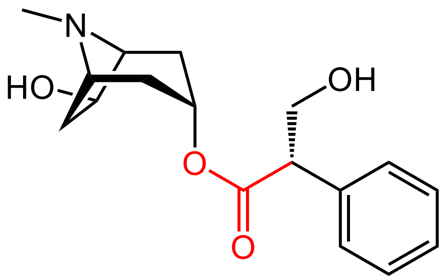
Project Synopsis

Cu-catalyzed Asymmetric Boracarboxylation of Olefins with CO_2

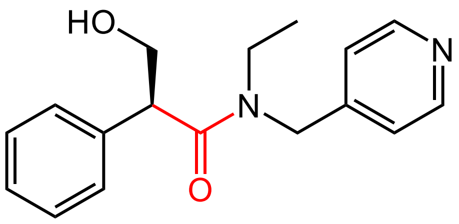




(*S*)-Scopolamine

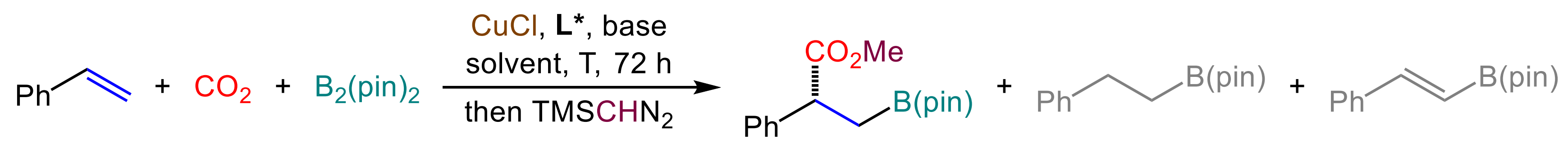


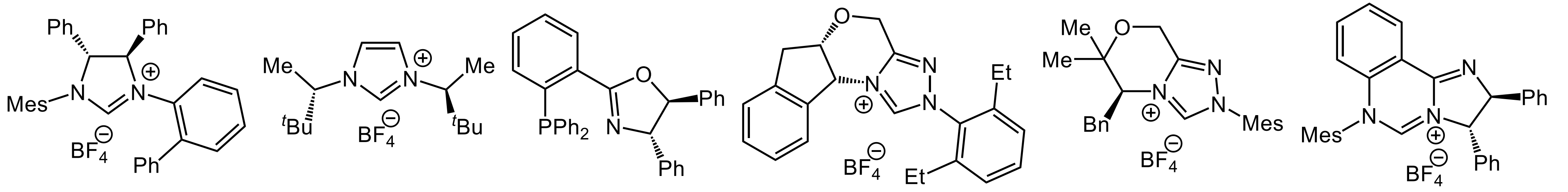
(*S*)-Anisodamine



(*S*)-Tropicamide

Optimization of the Reaction Conditions

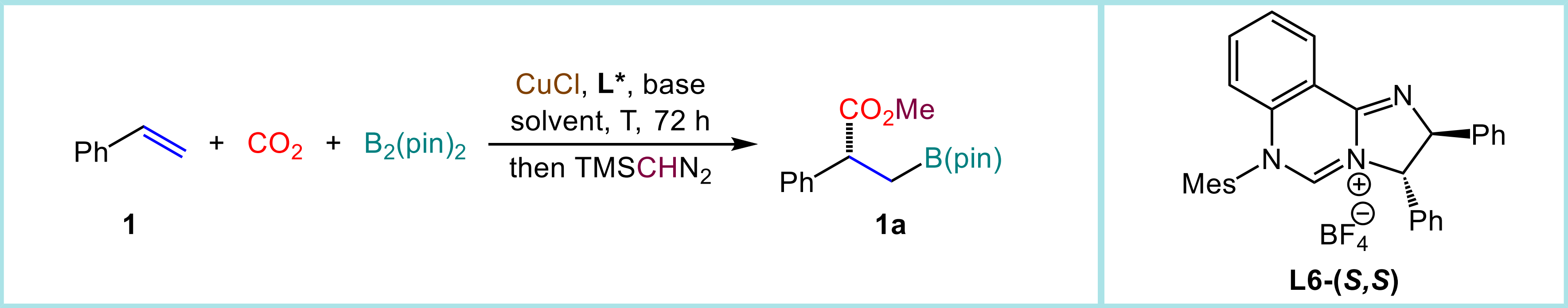




Entry[a]	L	Base	Solvent	Yield (%)[b] (**1a**/**1b**/**1c**)	Ee (%) (**1a**)[c]
1	**L1**	NaO^{t}Bu	THF	96/0/0	18
2	**L2**	NaO^{t}Bu	THF	99/0/0	13
3	**L3**	NaO^{t}Bu	THF	23/45/0	-40
4	**L4**	NaO^{t}Bu	THF	43/5/0	35
5	**L5**	NaO^{t}Bu	THF	93/7/0	-40
6	**L6-(*S*,*S*)**	NaO^{t}Bu	THF	93/<5/0	79

[a]**1** (0.25 mmol), $B_2(pin)_2$ (0.375 mmol), base (0.50 mmol), CuCl (10 mol%), ligand (11 mol%), solvent (4 mL), 1 atm of CO_2, ambient temperature, 72 h. [b]Yields of **1a**, **1b**, and **1c** determined by 1H NMR. [c]ee of **1a** determined by HPLC. [d]Reaction temperature = −10 °C; reaction time = 96 h.

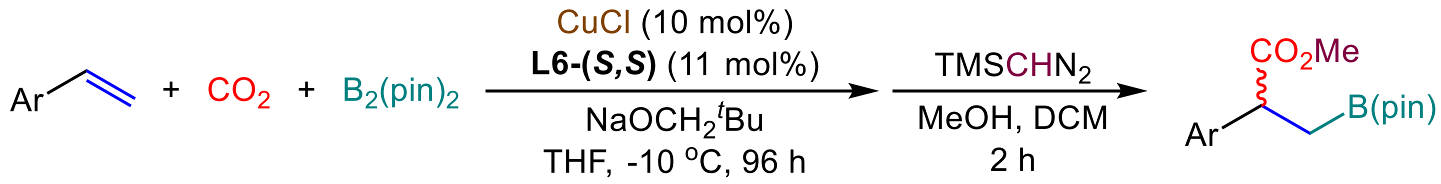
Optimization of the Reaction Conditions

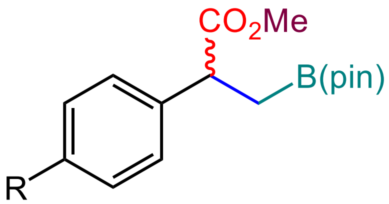


Entry[a]	L	Base	Solvent	Yield (%)[b] (**1a/1b/1c**)	Ee (%) (**1a**)[c]
7	**L6-(*S*,*S*)**	NaO^{t}Bu	Et_2O	18/14/<5	85
8	**L6-(*S*,*S*)**	NaO^{t}Bu	$^iPr_2O$	24/14/0	84
9	**L6-(*S*,*S*)**	LiO^{t}Bu	THF	<5/0/0	/
10	**L6-(*S*,*S*)**	KO^{t}Bu	THF	53/<5/0	39
11	**L6-(*S*,*S*)**	NaO^{t}Am	THF	88/<5/0	79
12	**L6-(*S*,*S*)**	NaOEt	THF	43/56/0	85
13	**L6-(*S*,*S*)**	$NaOCH_2{}^tBu$	THF	75(74)/25/0	90
14[d]	**L6-(*S*,*S*)**	$NaOCH_2{}^tBu$	THF	70(70)/30/0	92
15[d]	**L6-(*S*,*S*)**	$NaOCH_2{}^tBu$	THF	72(70)/28/0	-91

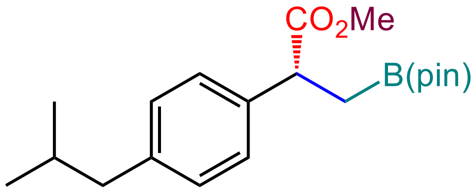
[a]**1** (0.25 mmol), $B_2(pin)_2$ (0.375 mmol), base (0.50 mmol), CuCl (10 mol%), ligand (11 mol%), solvent (4 mL), 1 atm of CO_2, ambient temperature, 72 h. [b]Yields of **1a**, **1b**, and **1c** determined by 1H NMR. [c]ee of **1a** determined by HPLC. [d]Reaction temperature = −10 ^oC; reaction time = 96 h.

Cu-Catalyzed Boracarboxylation of Styrenes

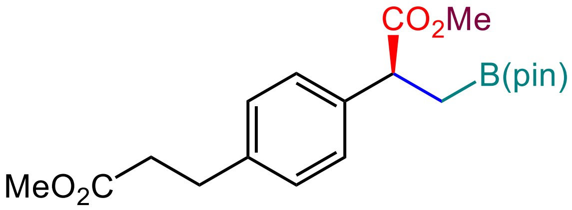




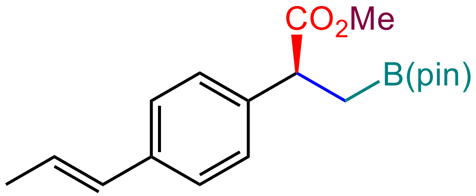
1a, R = H, 70%, 92% ee
2a, R = Me, 87%, -92% ee
3a, R = ^{t}Bu, 71%, 93% ee
4a, R = OMe, 86%, 95% ee
5a, R = OPh, 52%, -92% ee
6a, R = F, 63%, 92% ee
7a, R = OAc, 53%, 90% ee
8a, R = SMe, 63%, -88% ee



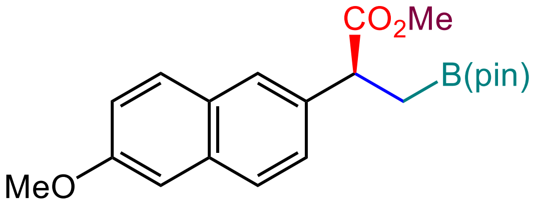
9a, 65%, 94% ee



10a, 72%, -93% ee

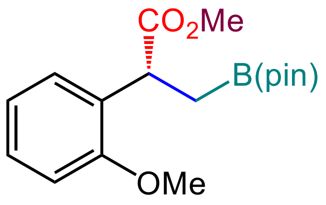


11a, 65% (*E/Z* = 77:23)
-83% ee (*E*); -84% ee (*Z*)

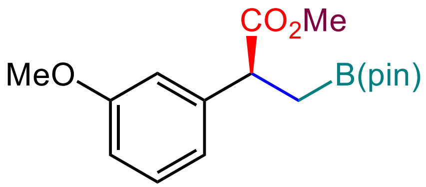


12a, 62%, -78% ee

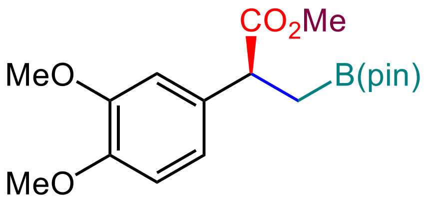
Cu-Catalyzed Boracarboxylation of Styrenes



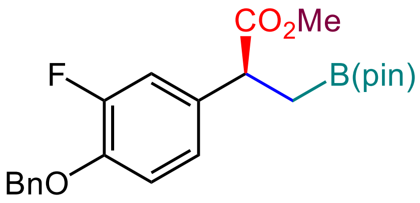
13a, 32%, 91% ee



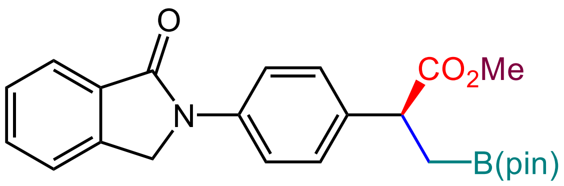
14a, 55%, -88% ee



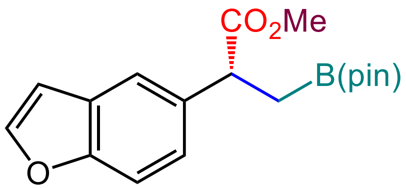
15a, 73%, -91% ee



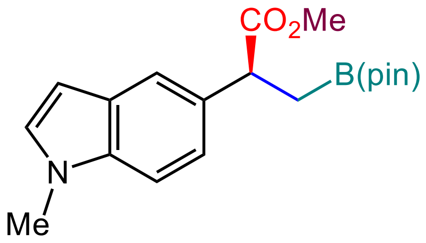
16a, 45%, -90% ee



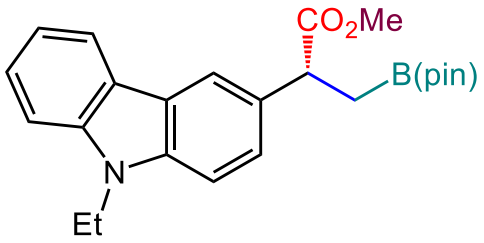
17a, 41%, -85% ee



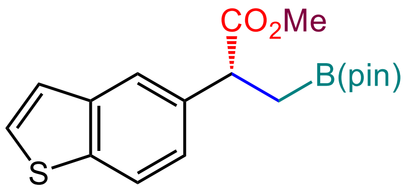
18a, 68%, 92% ee



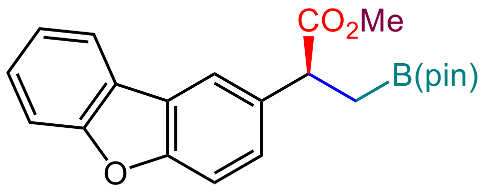
19a, 43%, -94% ee



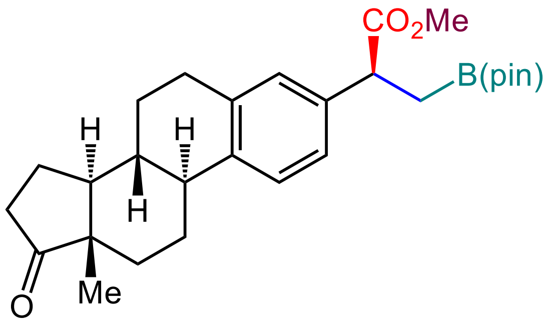
20a, 56%, 95% ee



21a, 61%, 85% ee

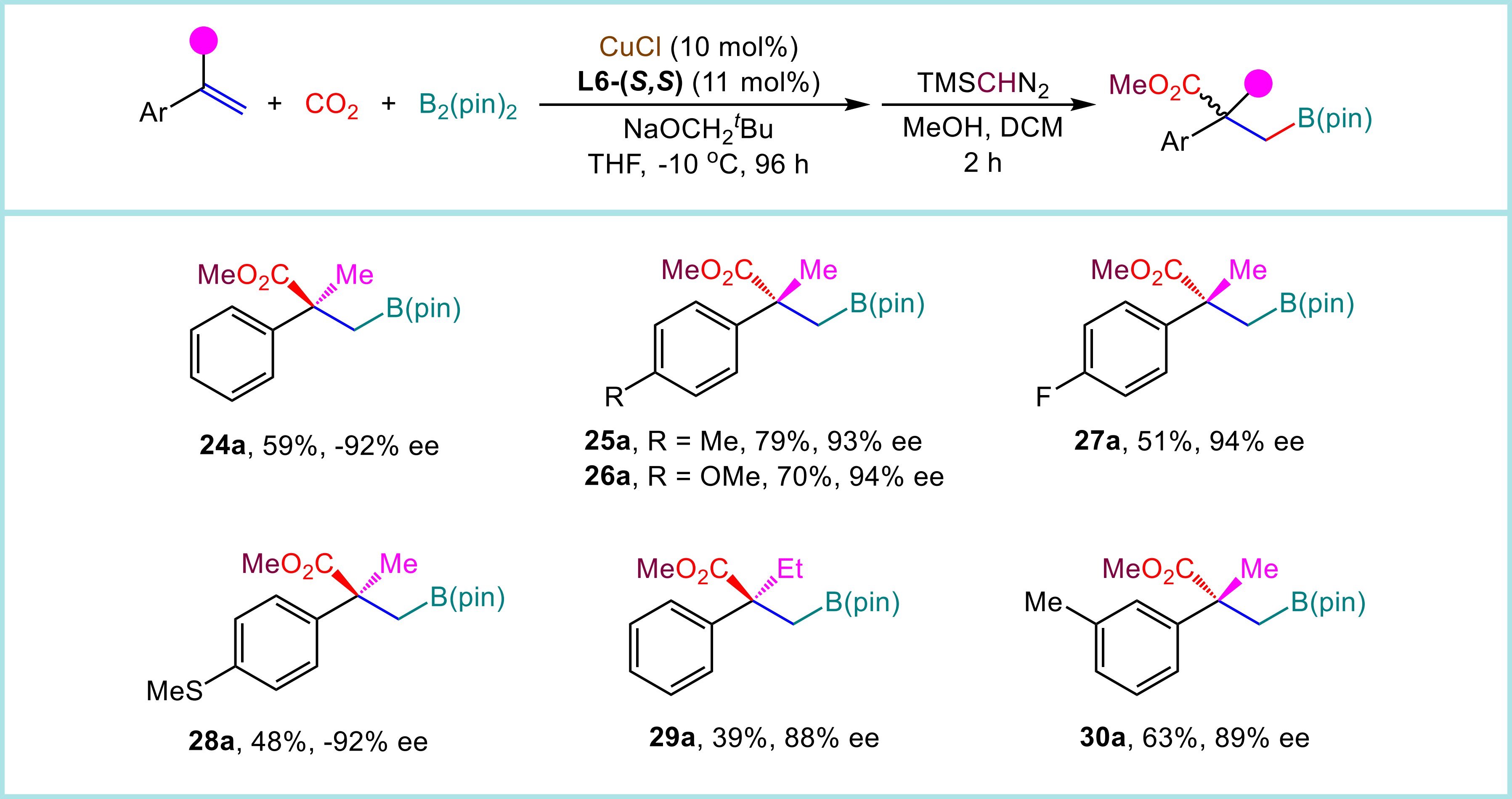


22a, 70%, -85% ee

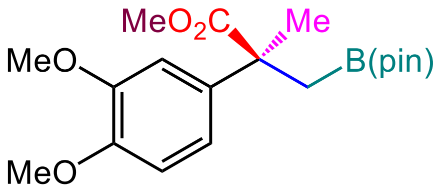


23a, 60%, -92% ee

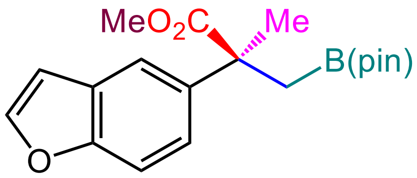
Scope of α-Substituted Styrenes



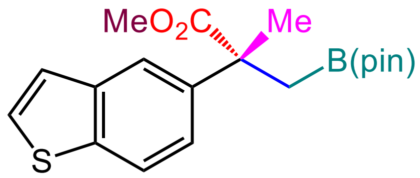
Scope of α-Substituted Styrenes



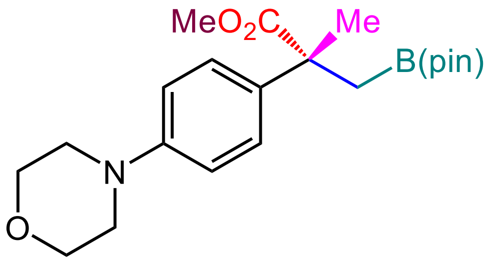
31a, 56%, -96% ee



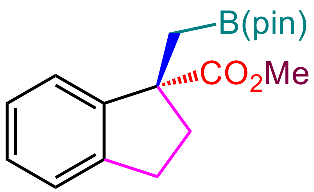
32a, 72%, -94% ee



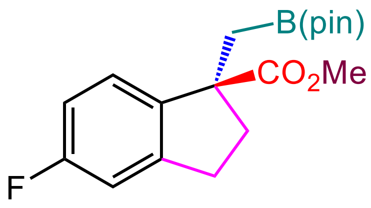
33a, 42%, 91% ee



34a, 35%, 95% ee

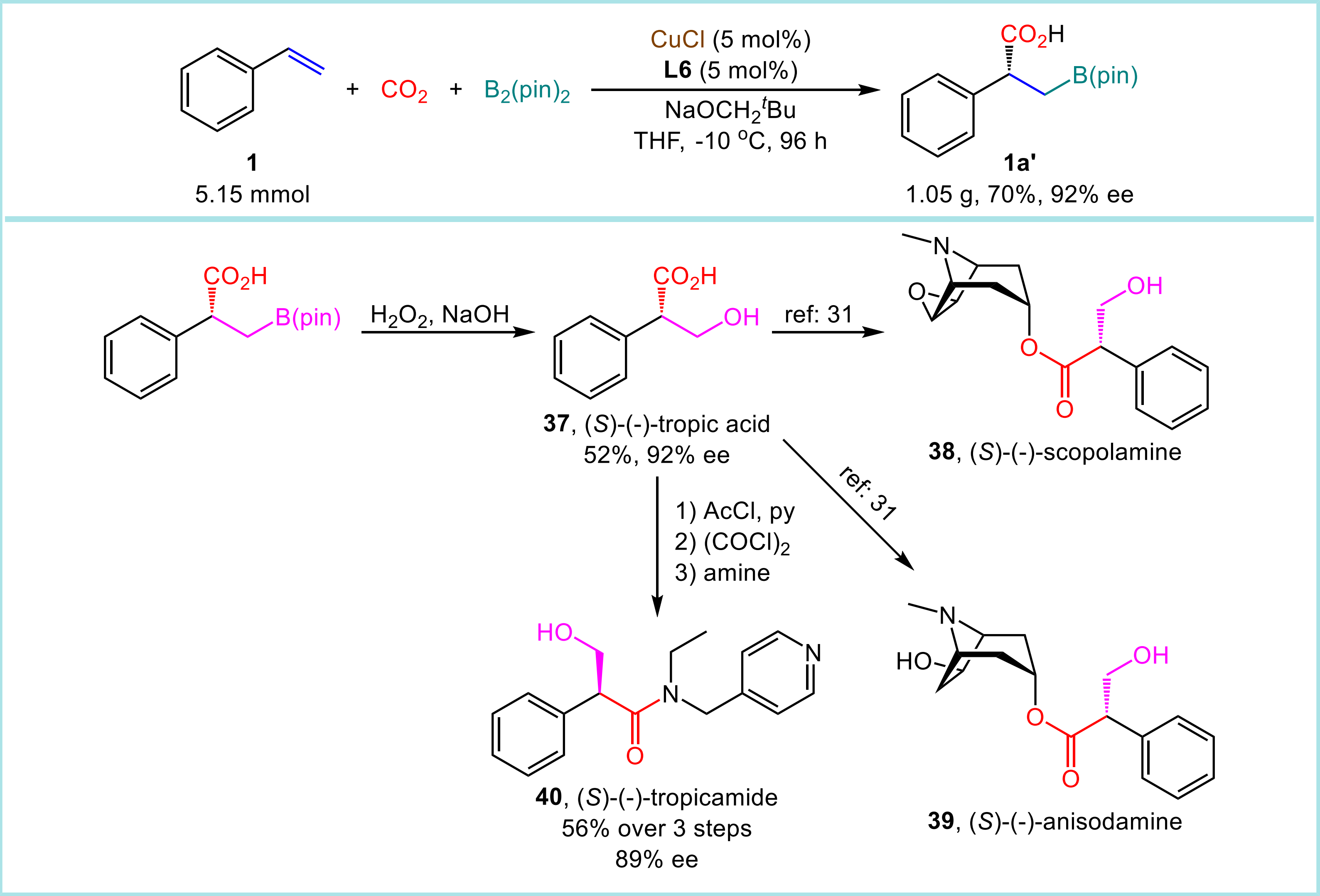


35a, 42%, -97% ee



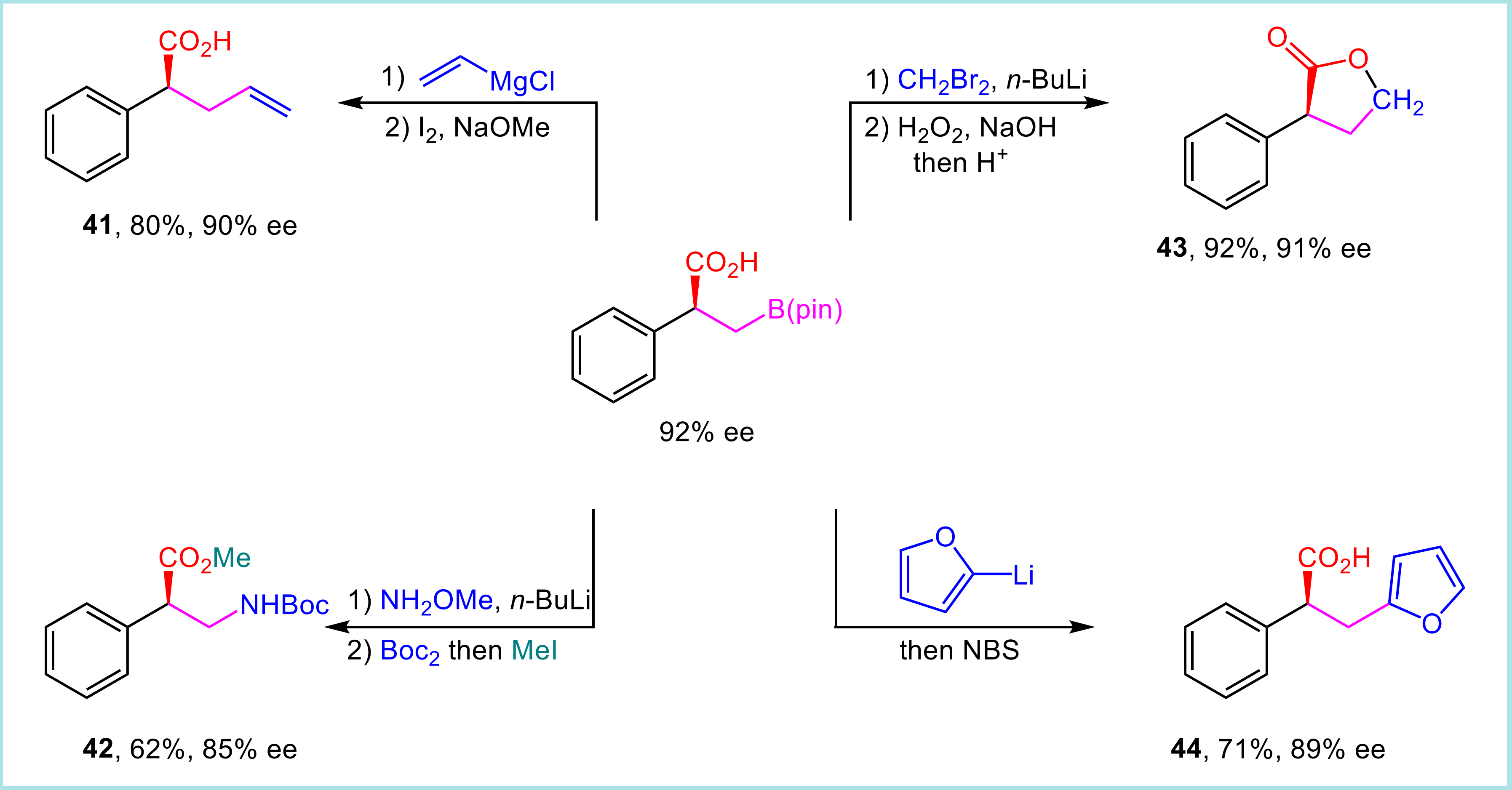
36a, 52%, 97% ee

Gram Scale & Transformations of Products

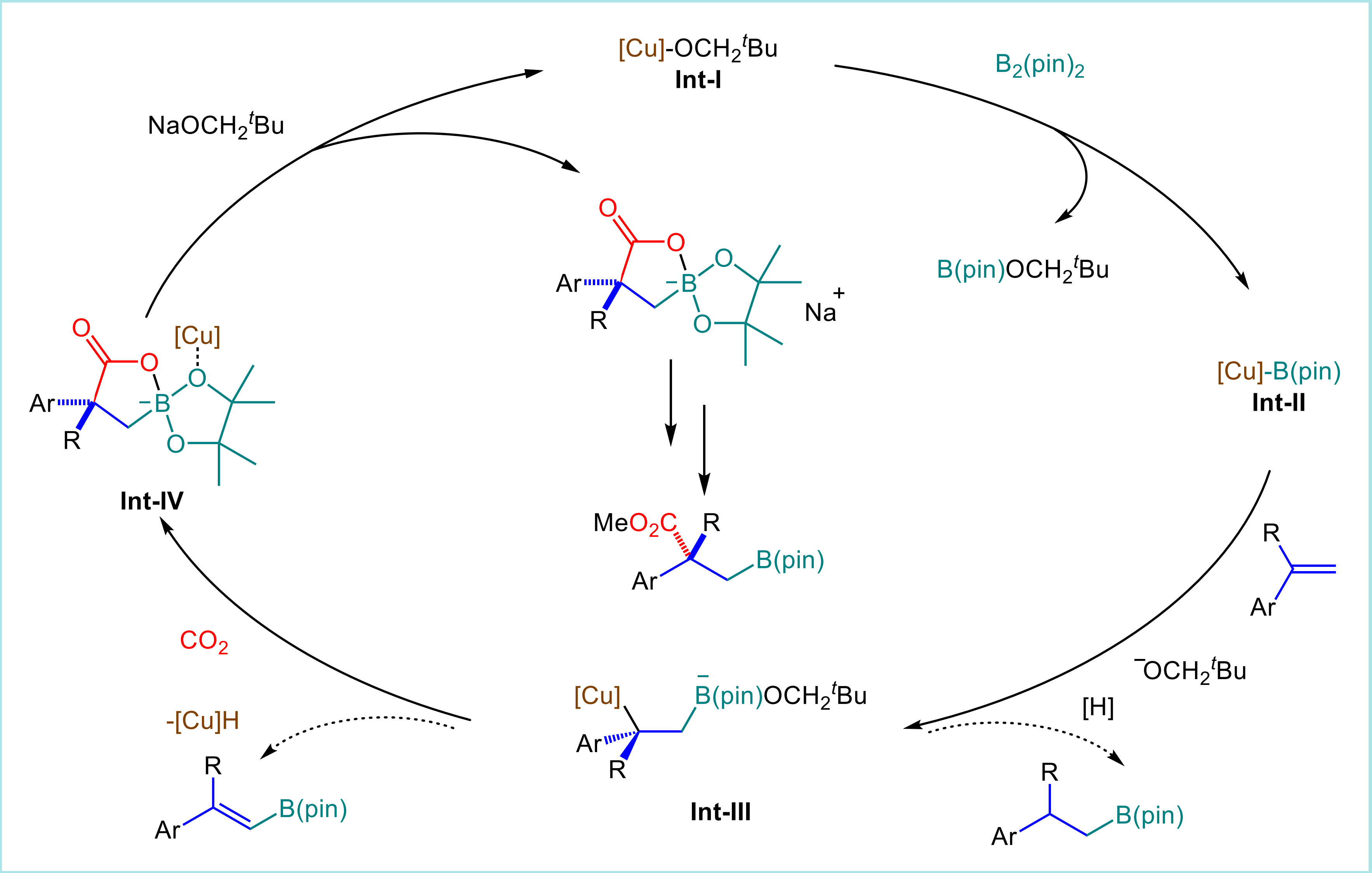


Ushimaru, R.; Ruszczycky, M. W.; Liu, H.-W.* *J. Am. Chem. Soc.* **2018**, *140*, 7433

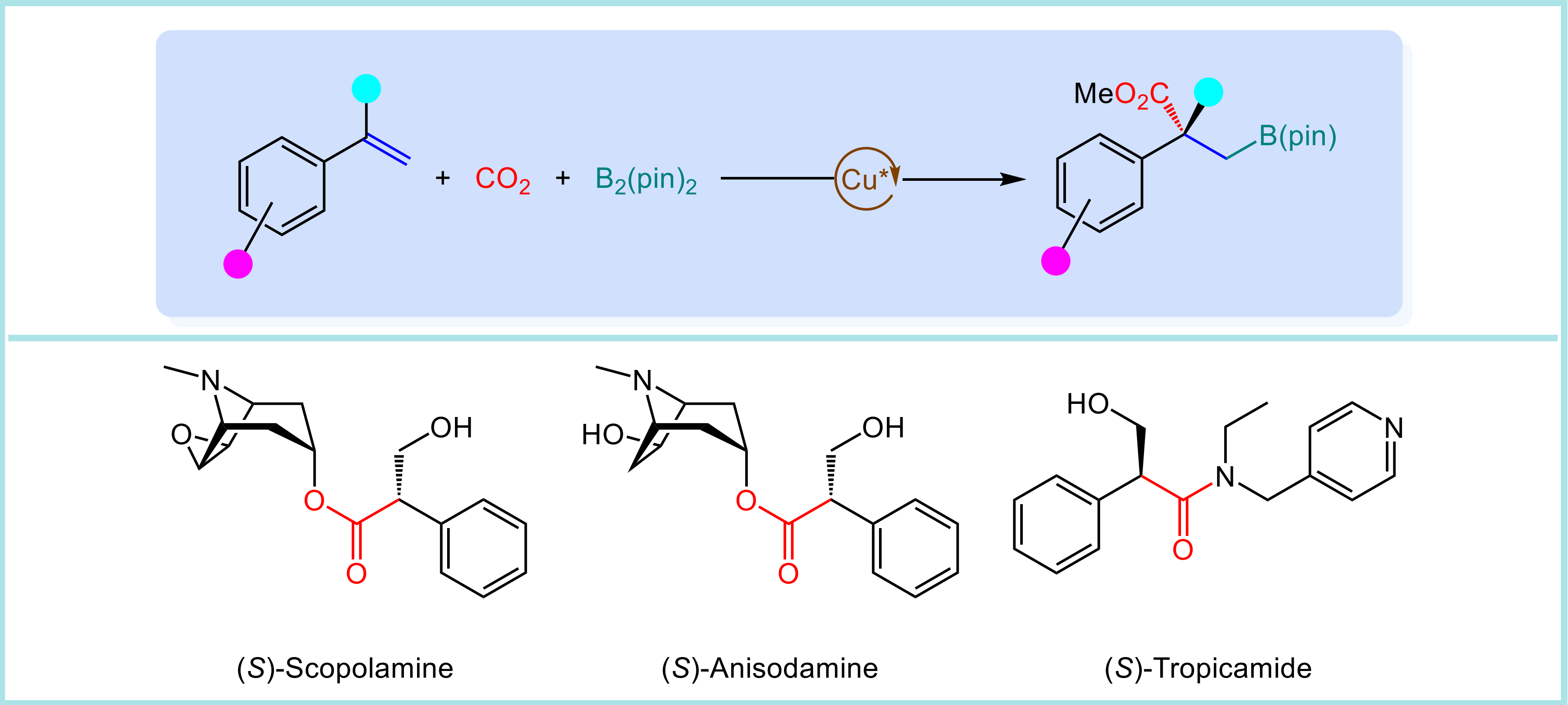
Gram Scale & Transformations of Products



Proposed Mechanism



Summary



- Enantioselective boracarboxylation of arylalkenes with diboron and CO_2
- Mild reaction conditions, high catalytic efficacy, and excellent enantioselectivity
- Synthesis of bioactive compounds

Strategy for Writing The First Paragraph

α立体中心手性羧酸的重要性

- ✓ Chiral carboxylic acids and derivatives bearing an α-stereogenic center are one of the most prevalent functional motifs among natural products and pharmaceuticals and have therefore attracted the synthetic community for decades to develop highly efficient and direct synthetic methods.

过去α-羧酸的合成方法

- ✓ In recent years, chemists have devoted extensive efforts to the transition-metalcatalyzed carboxylation of suitable nucleophiles with CO_2 for the synthesis of high-value-added carboxylic acids via C−C bond construction.

引出本文工作

- ✓ Among these, boracarboxylation of olefins with CO_2 provides the most profound versatility because of the many established transformations of the boron moiety.

Strategy for Writing The Last Paragraph

总结工作

强调亮点

- ✓ In summary, the first enantioselective boracarboxylation protocol of arylalkenes with diboron and 1 atm of CO_2 was developed. Featuring mild reaction conditions, high catalytic efficacy, and excellent enantioselectivity, this strategy provides access to a myriad of β-boron-functioned chiral α-carboxylic acids.
- ✓ In addition to a broad range of functional group tolerance, the reaction can also be applied to styrenes with αsubstitution to deliver enantioenriched carboxylic acids with αchiral all-carbon quaternary centers that were previously inaccessible. The synthetic utility was further showcased by gram-scale reactions, product conversion, and the synthesis of bioactive compounds.

Representative Examples

- … for the synthesis of high-value-added carboxylic acids (high-value-added, 高附加值的: 指产品或服务在生产过程中获得的价值显著增加)
- … has remained a formidable challenge (formidable, 艰难的)
- … which furnished valuable enantioenriched alcohols with broad functional group tolerance (furnish, 提供).

Acknowledgement

Thanks for your attention