Cross Coupling of Aryl Triflates with Aryl Tosylates

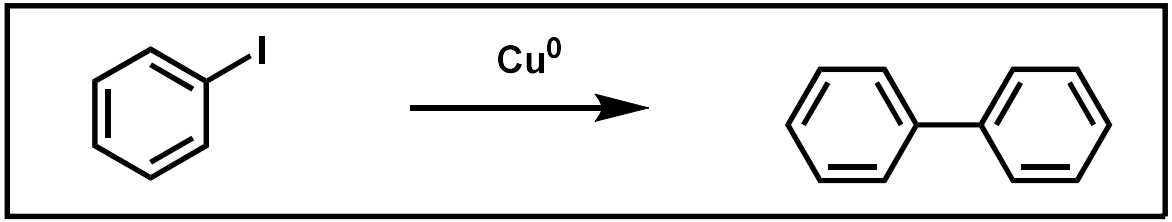
2021.5.15 Literature Seminar

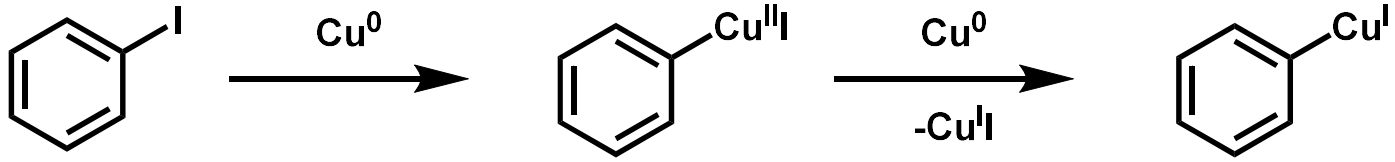
M1 Wataru Shigematsu

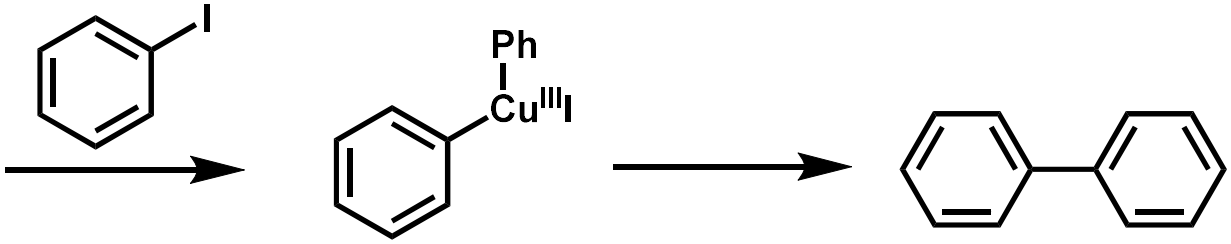
Contents

Contents

Ullmann Coupling







1) Ullmann, F.; Bielecki, J. *Chem. Ber.* **1901**, *34*, 2174.

Introduction of Prof. Weix

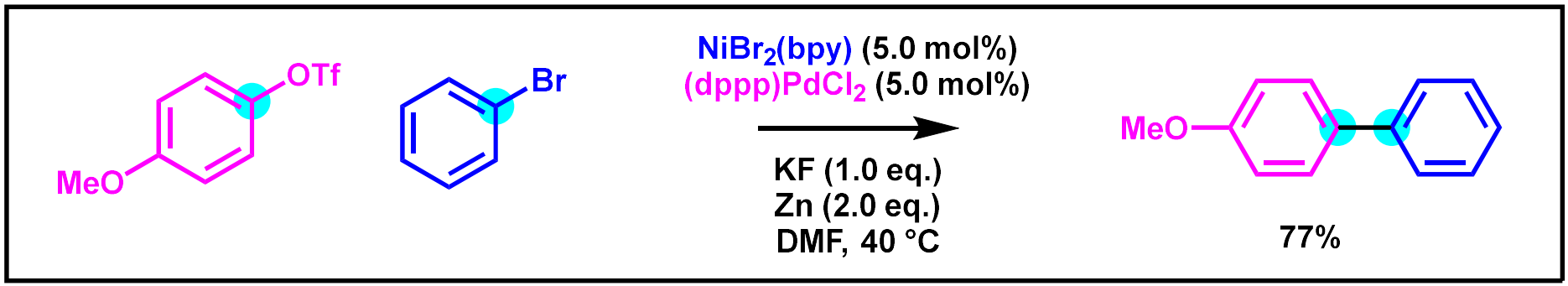
2000 B.S. @ Columbia University
(Prof. Thomas Katz)
2005 Ph.D @ University of California
(Prof. Jonathan Ellman)
2005 Postdoctoral Fellow @ Yale University
(Prof. John Hartwig)
2006 Postdoctoral Fellow @ University of Illinois
(Prof. John Hartwig)
2008 Professor @ University of Rochester
2015 Professor @ University of Wisconsin

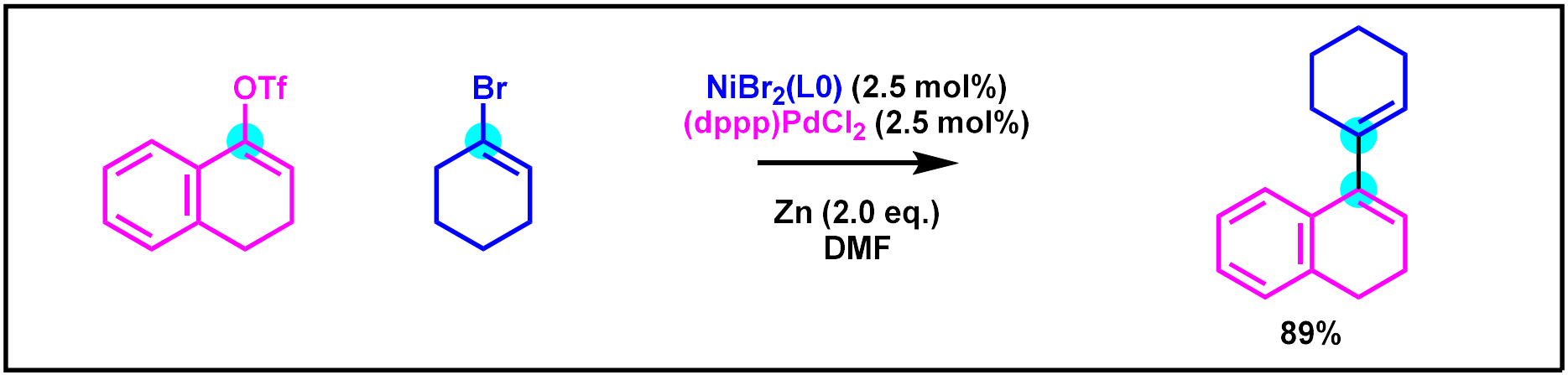
Research Topics

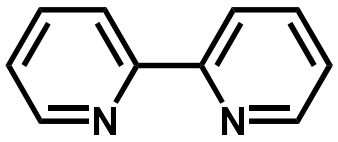
·Development of New Catalytic Method of Organic Chemistry

1) https://weixgroup.chem.wisc.edu/about-dan/
2) https://chem.wisc.edu/staff/weix-daniel/

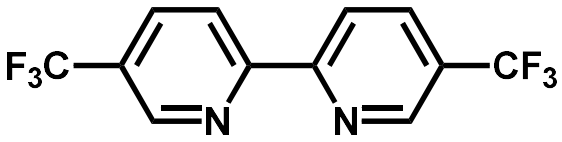
Coupling of C(sp2)-Bromide and C(sp2)-Triflate







bpy

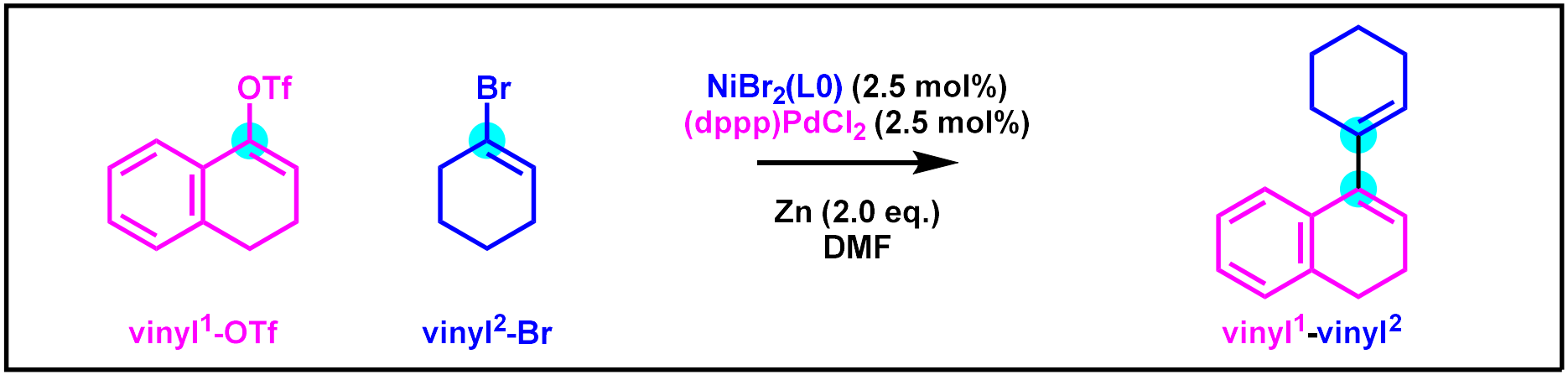


L0

dppp

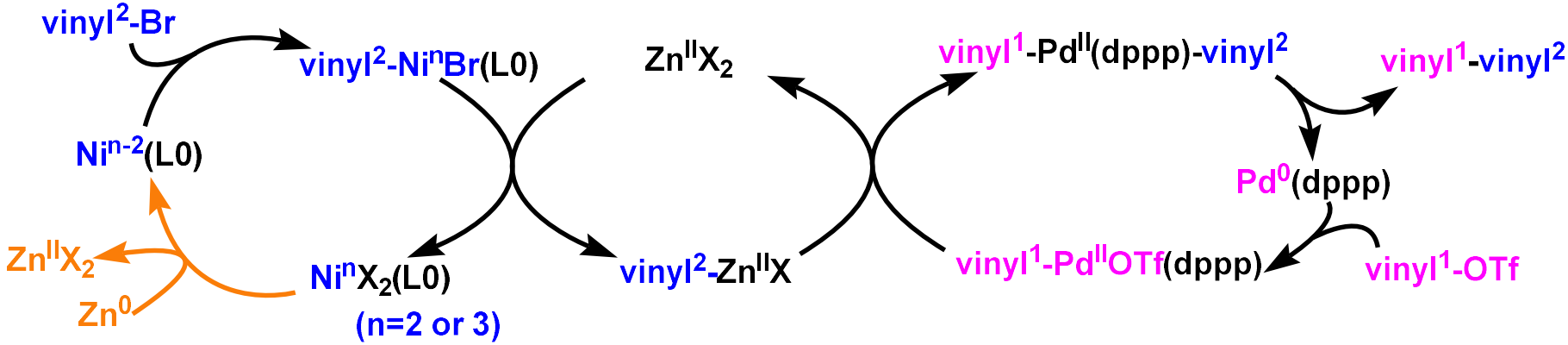
1) Ackerman, L. K. G.; Lovell, M. M.; Weix, D. J. *Nature* **2015**, *524*, 454.
2) Olivares, A. M.; Weix, D. J. *J. Am. Chem. Soc.* **2018**, *140*, 2446.

Proposed Reaction Mechanism



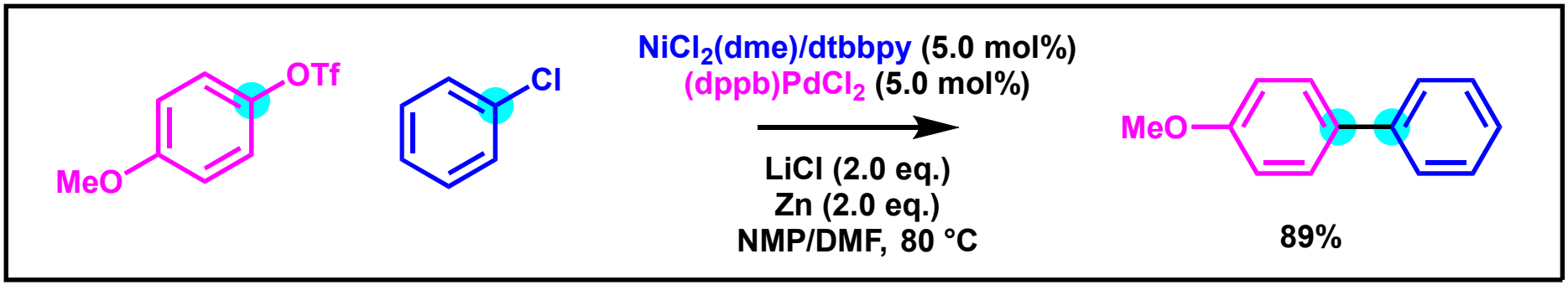
$Ni^{n-2}(L0)$: $vinyl^2$-Br > $vinyl^1$-OTf

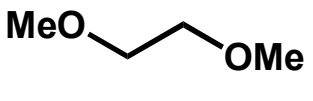
$Pd^0(dppp)$: $vinyl^1$-OTf > $vinyl^2$-Br



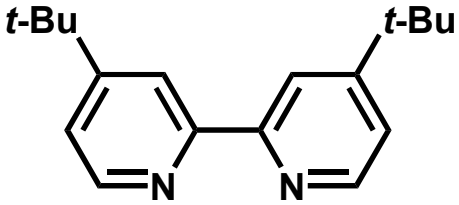
1) Olivares, A. M.; Weix, D. J. *J. Am. Chem. Soc.* **2018**, *140*, 2446.

Coupling of Aryl Chloride and Aryl Triflate





dme



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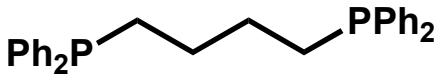

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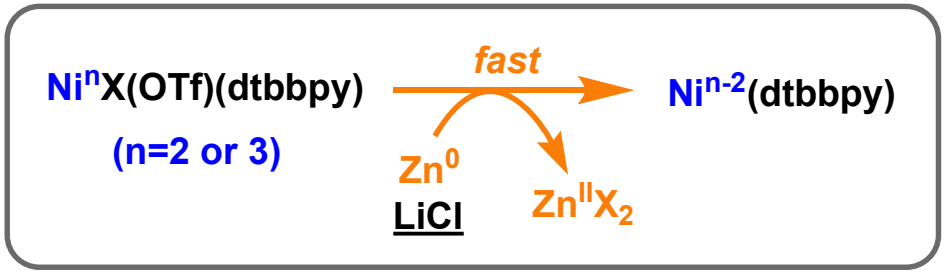
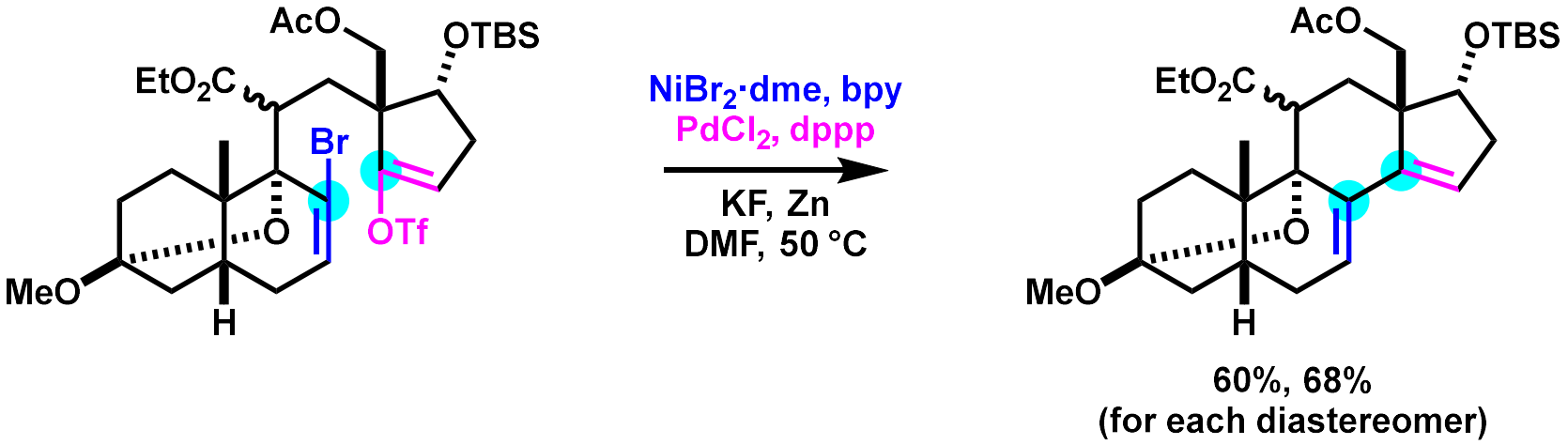
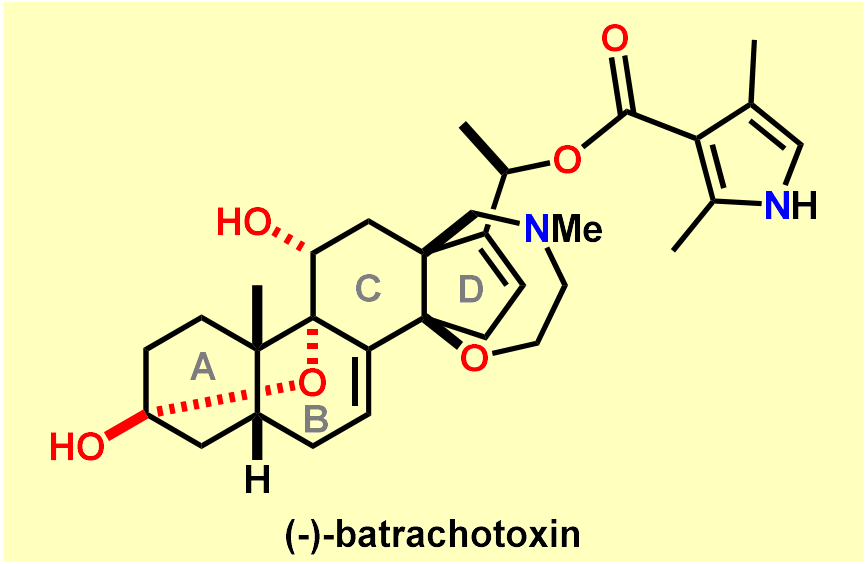


1) Huang, L. B.; Ackerman, L. K. G.; Kang, K.; Parsons, A. M.; Weix, D. J. *J. Am. Chem. Soc.* **2019**, *141*, 10978.

Application for Synthetic Study of Natural Product



60%, 68%
(for each diastereomer)

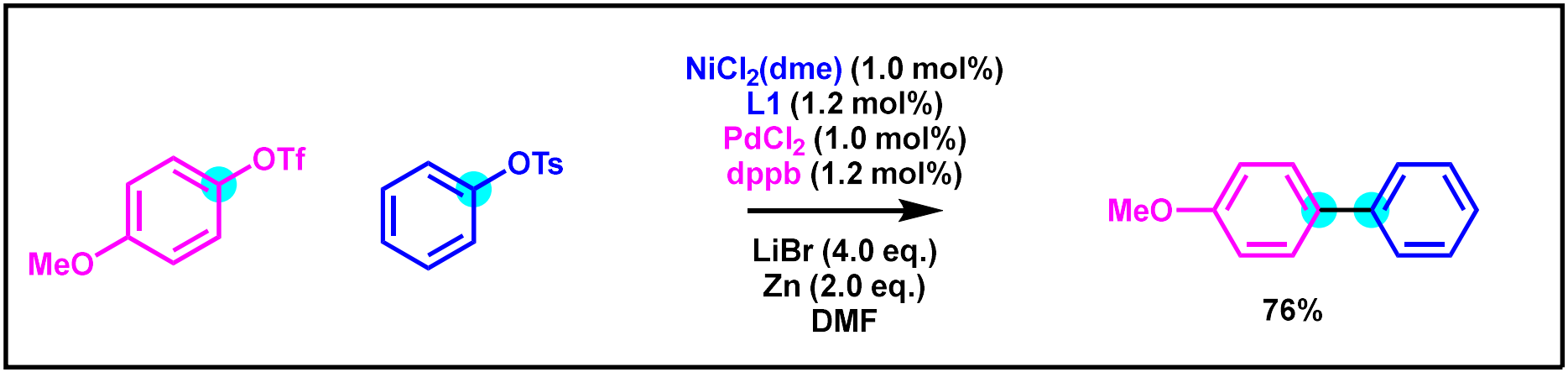


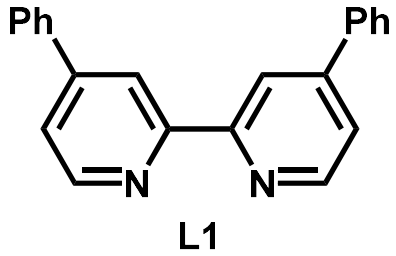
(-)-batrachotoxin

1) Sakata, K.; Wang, Y.; Urabe, D.; Inoue, M. *Org. Lett.* **2018**, *20*, 130.

Contents

Coupling of Aryl Tosylate and Aryl Triflate





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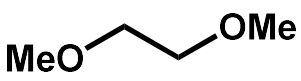

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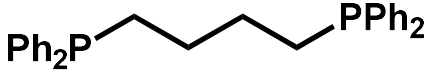


dppb

1) Kang, K.; Huang, L.; Weix, D. J. *J. Am. Chem. Soc.* **2020**, *142*, 10634.

Necessity of Reagents

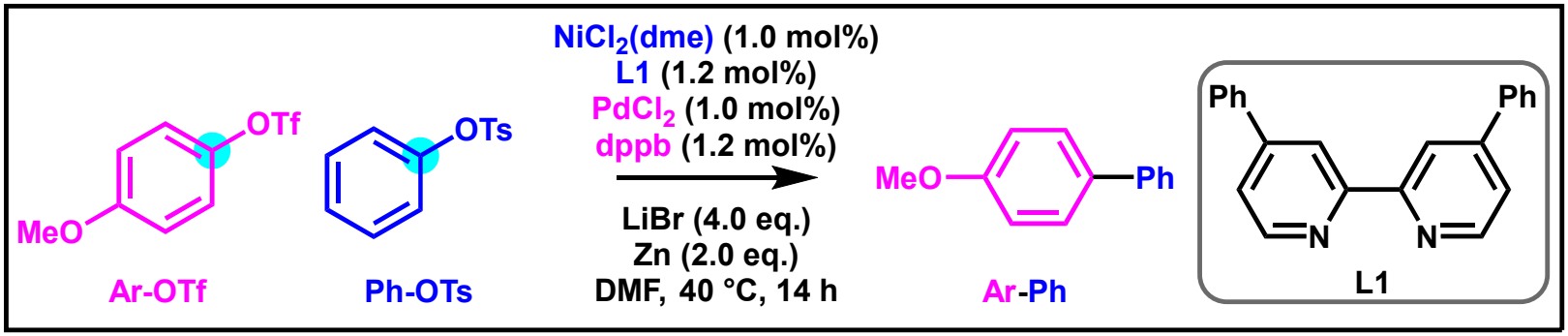
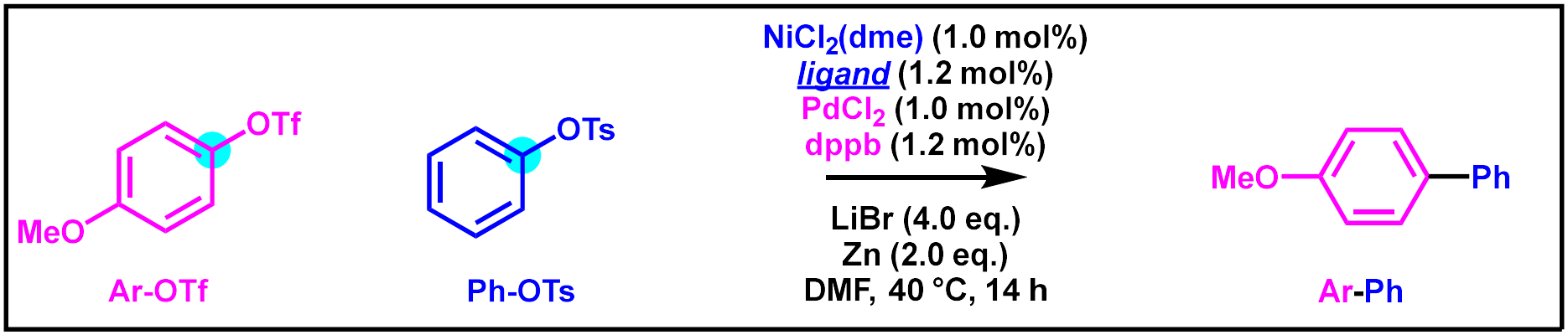


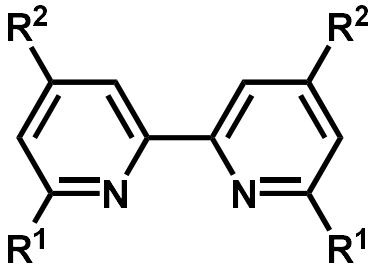
Table 1

entry	conditions	Ar-Ph	Ar-Ar	Ph-Ph	Ar-OTf	Ph-OTs
1	same as above	76%	12%	13%	0%	0%
2	w/o $PdCl_2$, dppb	58%	20%	18%	0%	0%
3	w/o $NiCl_2$(dme), L1	<5%	0%	0%	93%	95%
4	w/o L1	0%	0%	0%	98%	98%
5	w/o dppb	49%	13%	<5%	13%	30%
6	w/o Zn	0%	0%	0%	95%	95%
7	w/o LiBr	8%	3%	1%	82%	91%

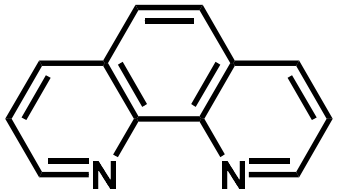
1) Kang, K.; Huang, L.; Weix, D. J. *J. Am. Chem. Soc.* **2020**, *142*, 10634.

Optimization: Ligand of Nikkel





R^1=H, R^2=Ph: 76%
R^1=H, R^2=*t*-Bu: 32%
R^1=H, R^2=CO_2Me: 12%
R^1=Me, R^2=H: 8%
R^1=H, R^2=H: 65%



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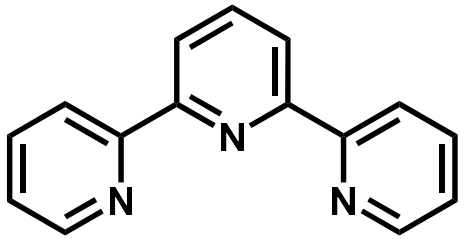
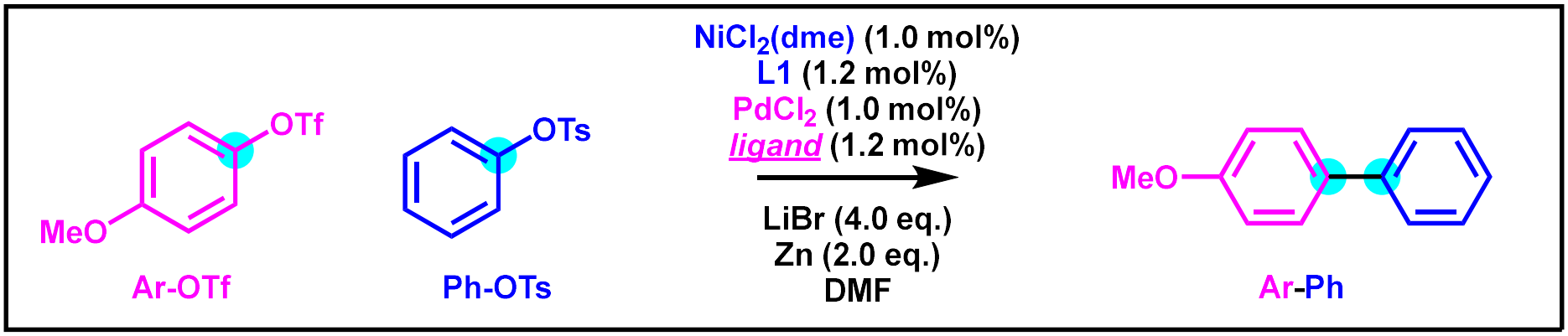
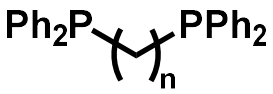


<5%

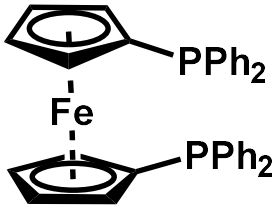
1) Kang, K.; Huang, L.; Weix, D. J. *J. Am. Chem. Soc.* **2020**, *142*, 10634.

Optimization: Ligand of Palladium

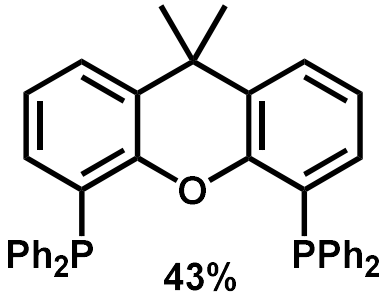




n=2: 61%
n=3: 41%
n=4: 76%



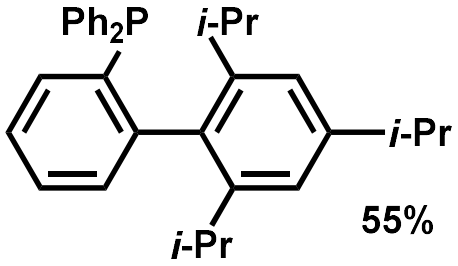
59%



43%

PCy_3: 29%

PPh_3: 43%



55%

1) Kang, K.; Huang, L.; Weix, D. J. *J. Am. Chem. Soc.* **2020**, *142*, 10634.

Optimization: Other Conditions

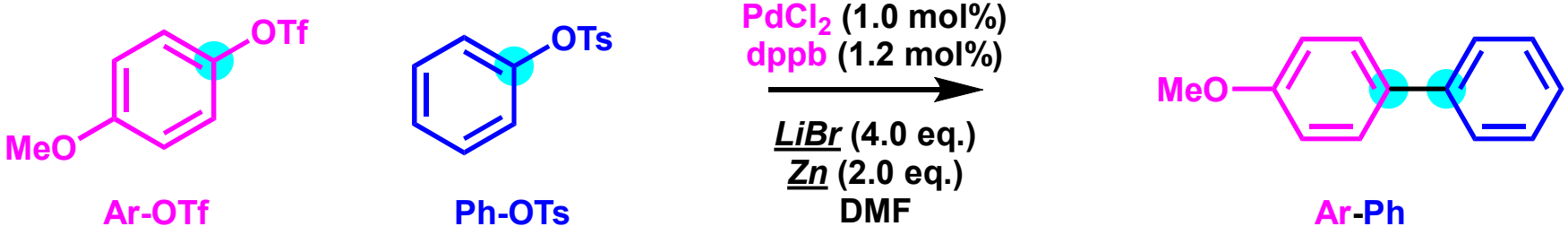
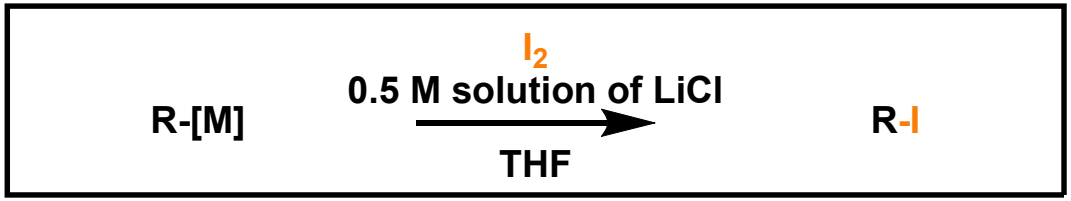


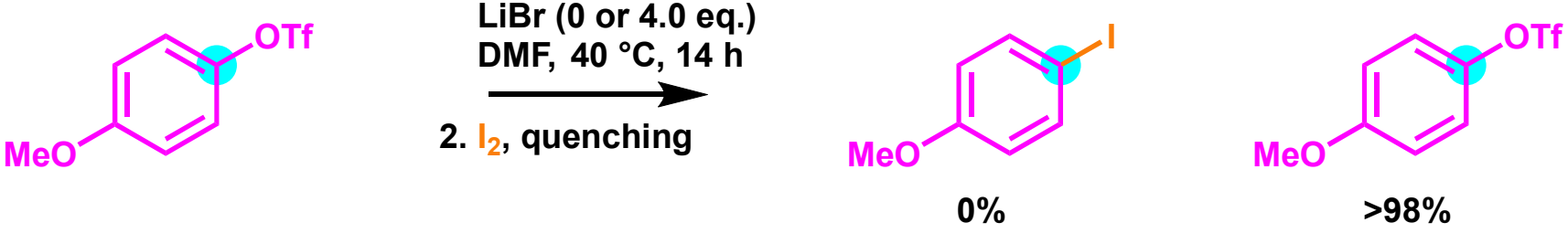
Table 2

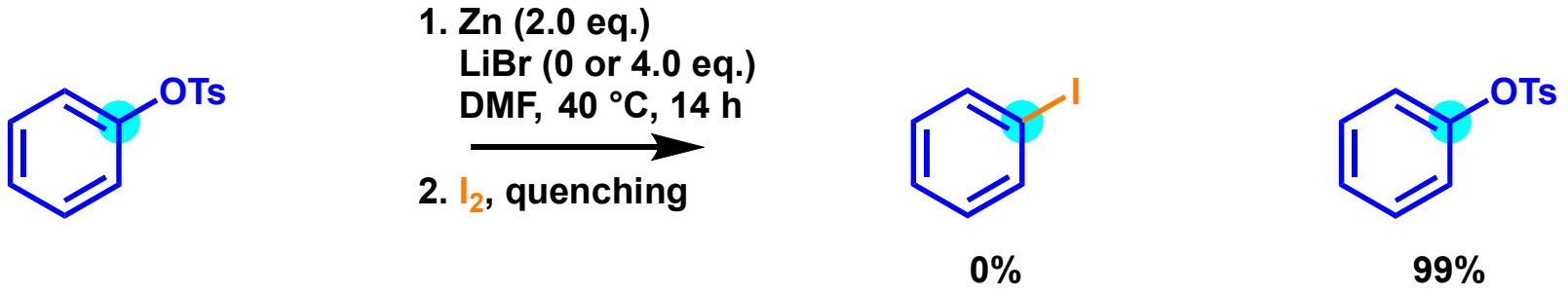
entry	conditions	Ar-Ph	Ar-OTf	Ph-OTs
1	same as above	76%	0%	0%
8	NaBr instead of LiBr	72%	0%	0%
9	KBr instead of LiBr	73%	0%	9%
10	*n*-Bu_4NBr instead of LiBr	54%	0%	9%
11	LiF instead of LiBr	5%	83%	92%
12	LiCl instead of LiBr	60%	0%	0%
13	$ZnBr_2$ instead of LiBr	0%	96%	98%
14	Mn instead of Zn	<5%	91%	95%

1) Kang, K.; Huang, L.; Weix, D. J. *J. Am. Chem. Soc.* **2020**, *142*, 10634.

Mechanistic Studies (1)

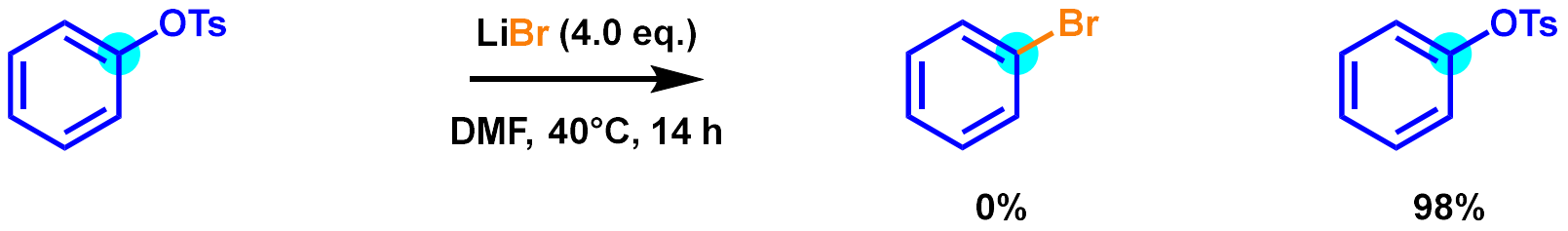






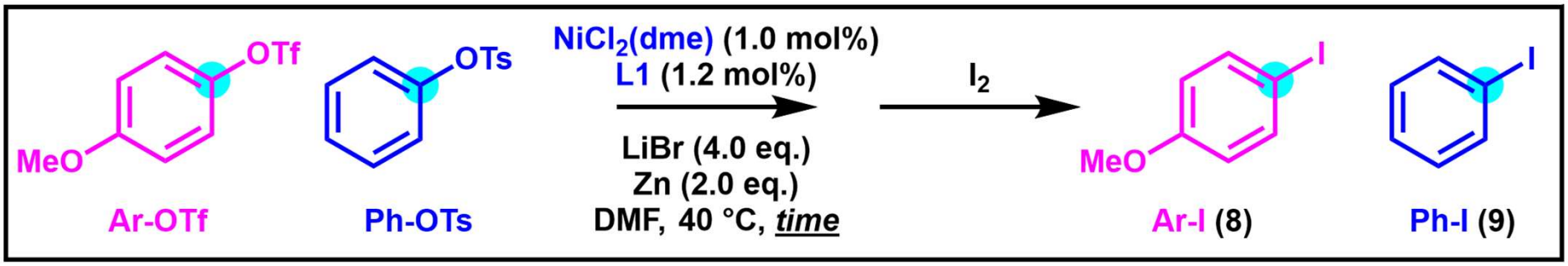
1) Kang, K.; Huang, L.; Weix, D. J. *J. Am. Chem. Soc.* **2020**, *142*, 10634.
2) Krasovskiy, A.; Knochel, P. *Synthesis*, **2006**, 890.

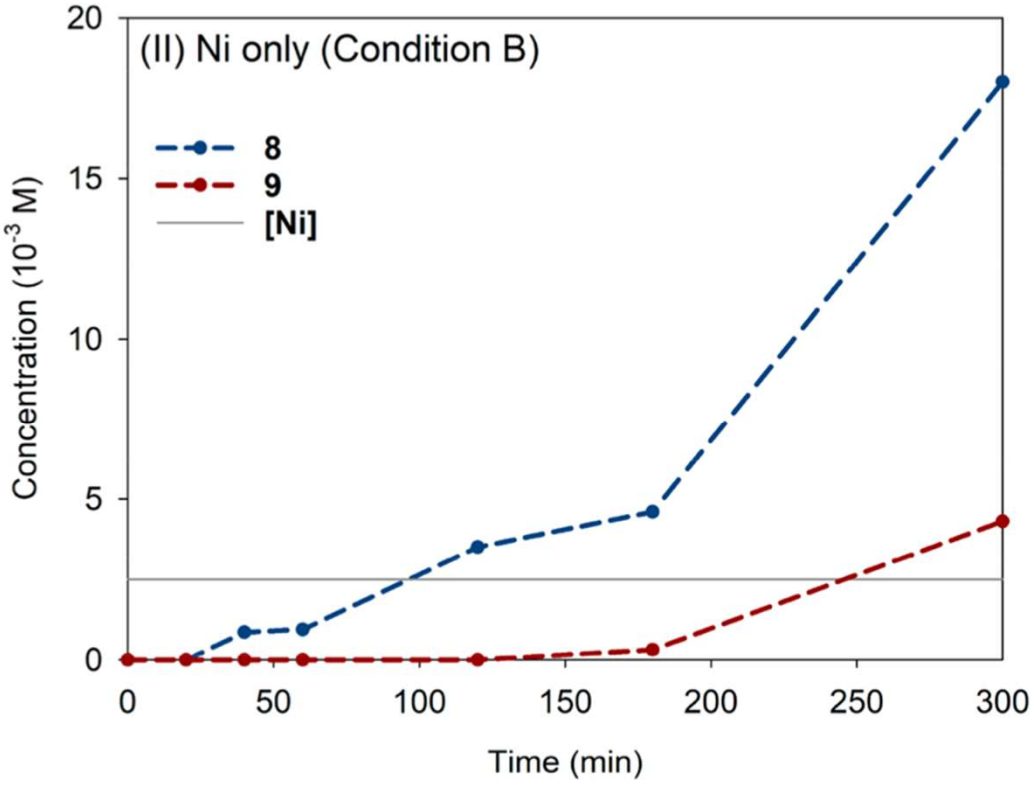
Mechanistic Studies (2)



1) Kang, K.; Huang, L.; Weix, D. J. *J. Am. Chem. Soc.* **2020**, *142*, 10634.

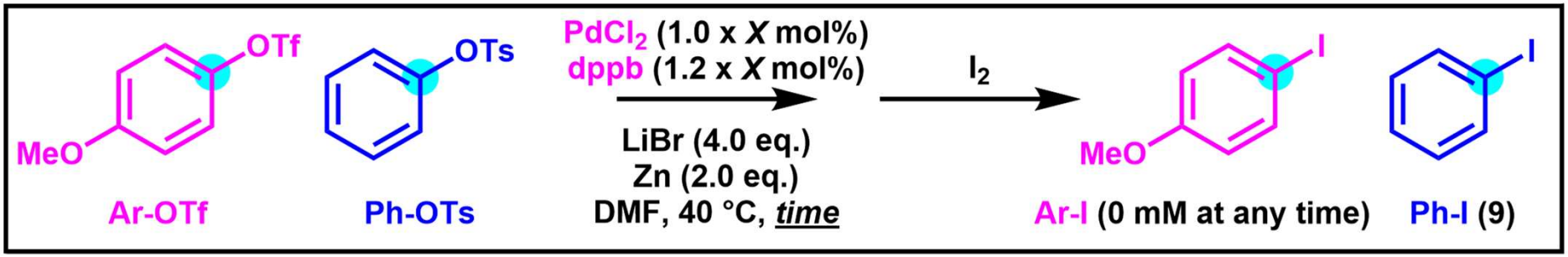
Mechanistic Studies (3)

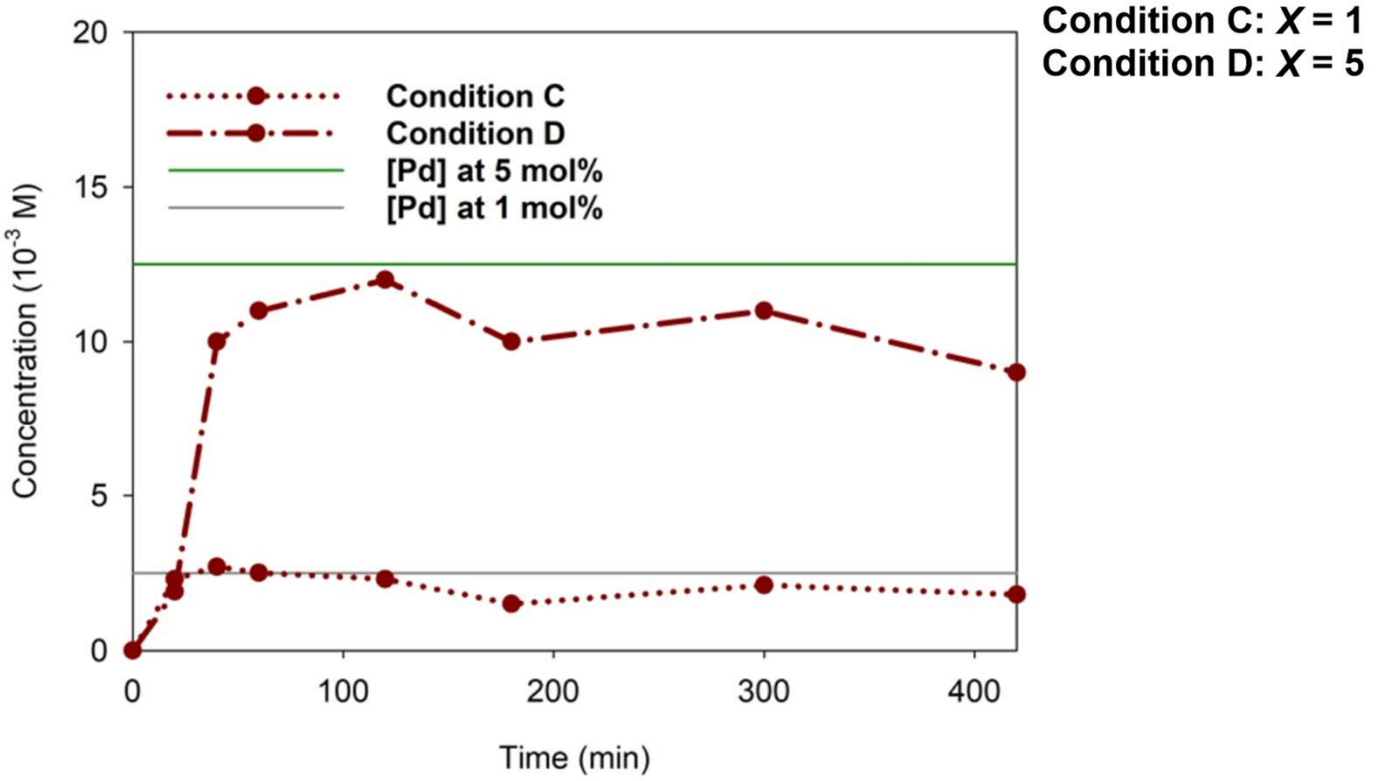




1) Kang, K.; Huang, L.; Weix, D. J. *J. Am. Chem. Soc.* **2020**, *142*, 10634.

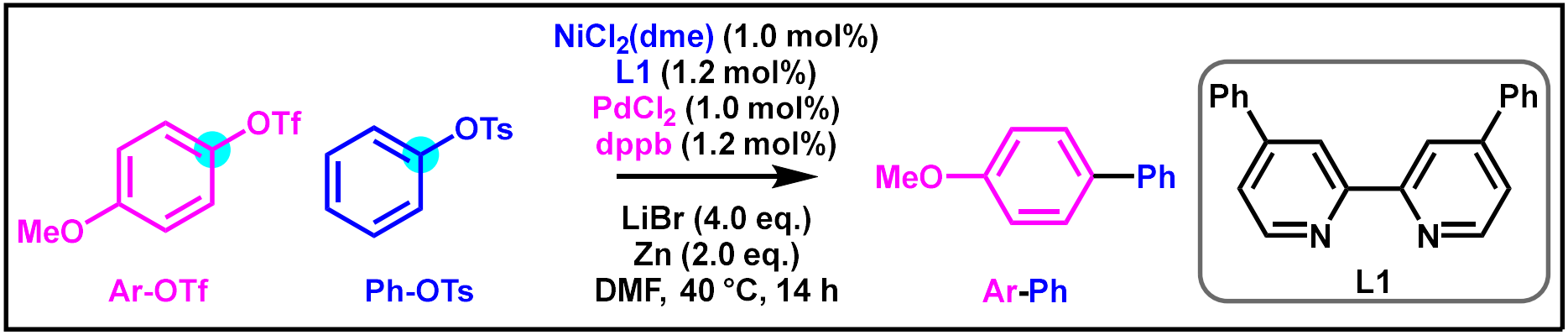
Mechanistic Studies (4)





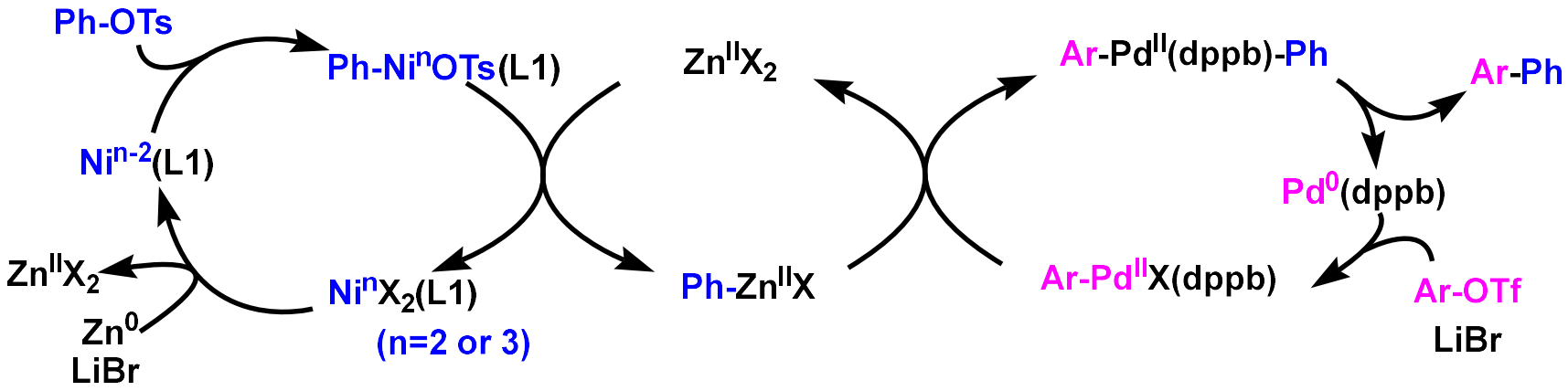
1) Kang, K.; Huang, L.; Weix, D. J. *J. Am. Chem. Soc.* **2020**, *142*, 10634.

Reaction Mechanism



Ni^{n-2}(L1) : Ph-OTs > Ar-OTf

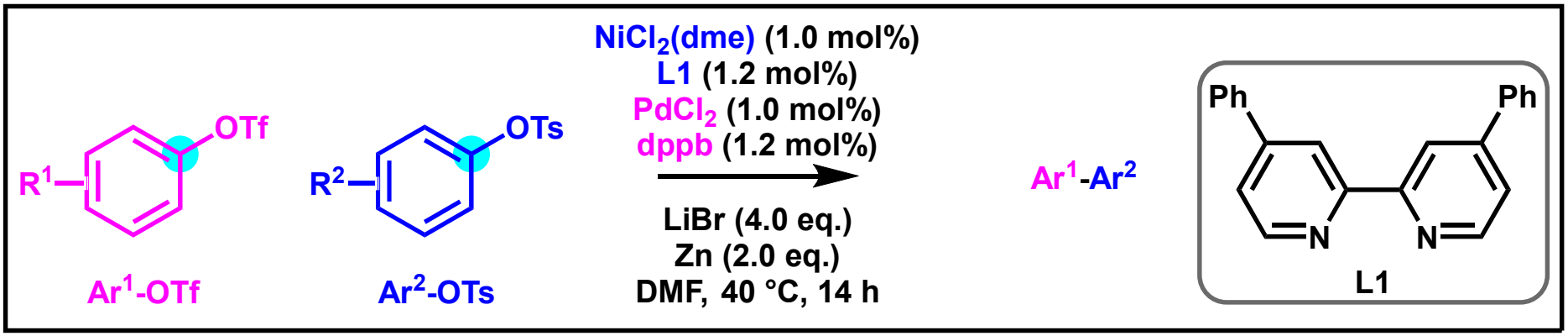
Pd^{0}(dppb) : Ar-OTf > Ph-OTs

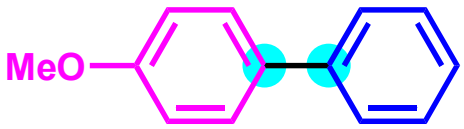


1) Kang, K.; Huang, L.; Weix, D. J. *J. Am. Chem. Soc.* **2020**, *142*, 10634.

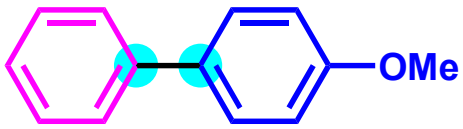
2) Huang, L. B.; Ackerman, L. K. G.; Kang, K.; Parsons, A. M.; Weix, D. J. *J. Am. Chem. Soc.* **2019**, *141*, 10978.

Substrate Scope





72%



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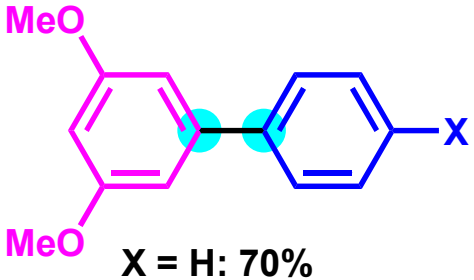
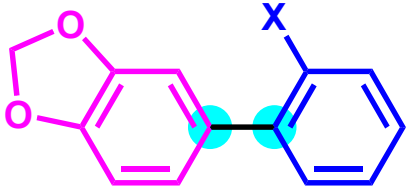
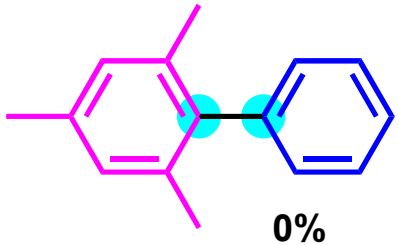


X = H: 70%
X = CF_3: 60%



X = CN: 72%
X = Me: 65%
X = *i*-Pr: 80%[2)3)]
X = *t*-Bu: 54%[2)]



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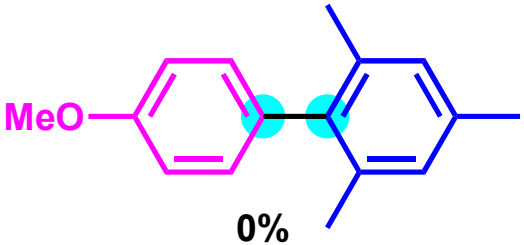
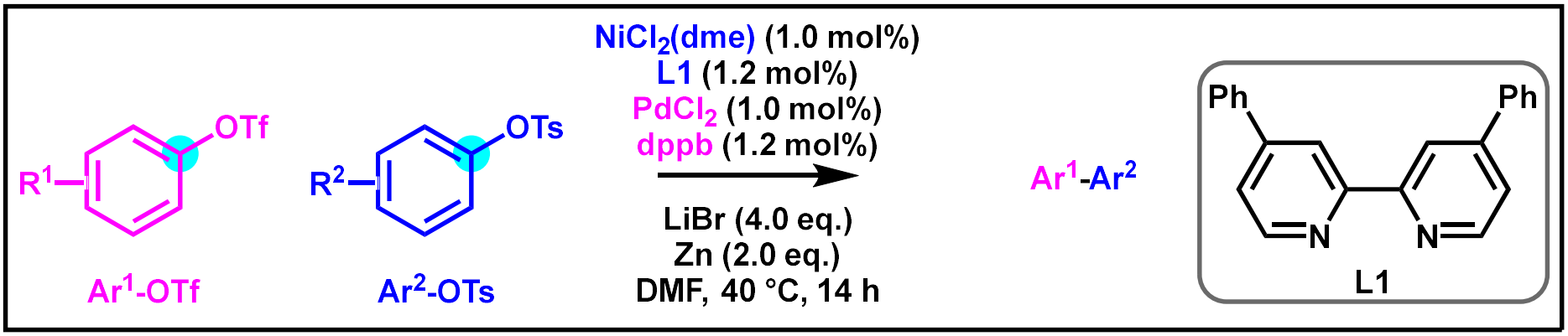
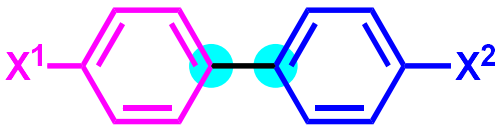


0%

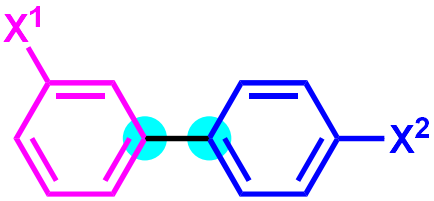
1) Kang, K.; Huang, L.; Weix, D. J. *J. Am. Chem. Soc.* **2020**, *142*, 10634.

Reactivity Preference of Each Catalyst (1)

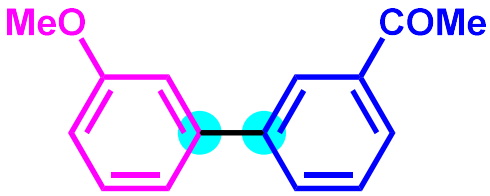




3a: X^1=OMe, X^2=H: 72%
3b: X^1=H, X^2=OMe: 62%
3k: X^1=OMe, X^2=Cl: 57%



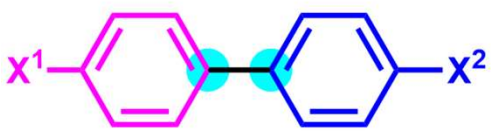
3i: X^1=NMe_2, X^2=OCF_3: 67%
3ah: X^1=F, X^2=H: 46%



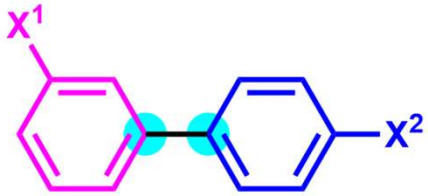
3e: 57%

1) Kang, K.; Huang, L.; Weix, D. J. *J. Am. Chem. Soc.* **2020**, *142*, 10634.

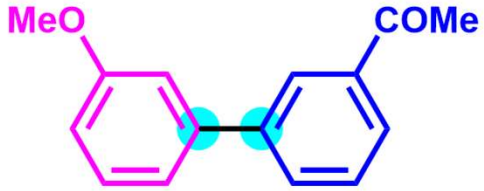
Reactivity Preference of Each Catalyst (2)
-Influence of Hammett Constants-



3a: X^1=OMe, X^2=H: 72%
3b: X^1=H, X^2=OMe: 62%
3k: X^1=OMe, X^2=Cl: 57%

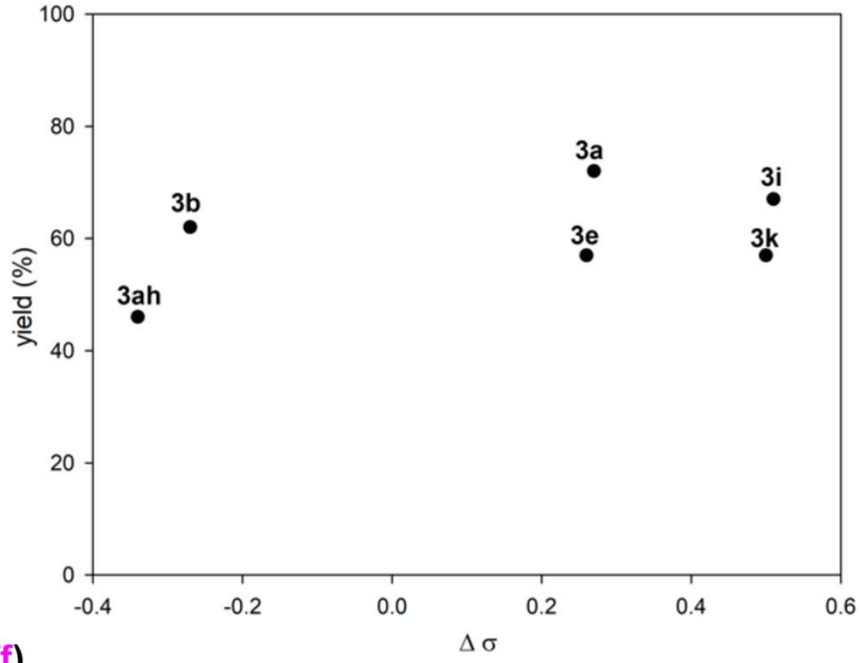


3i: X^1=NMe_2, X^2=OCF_3: 67%
3ah: X^1=F, X^2=H: 46%



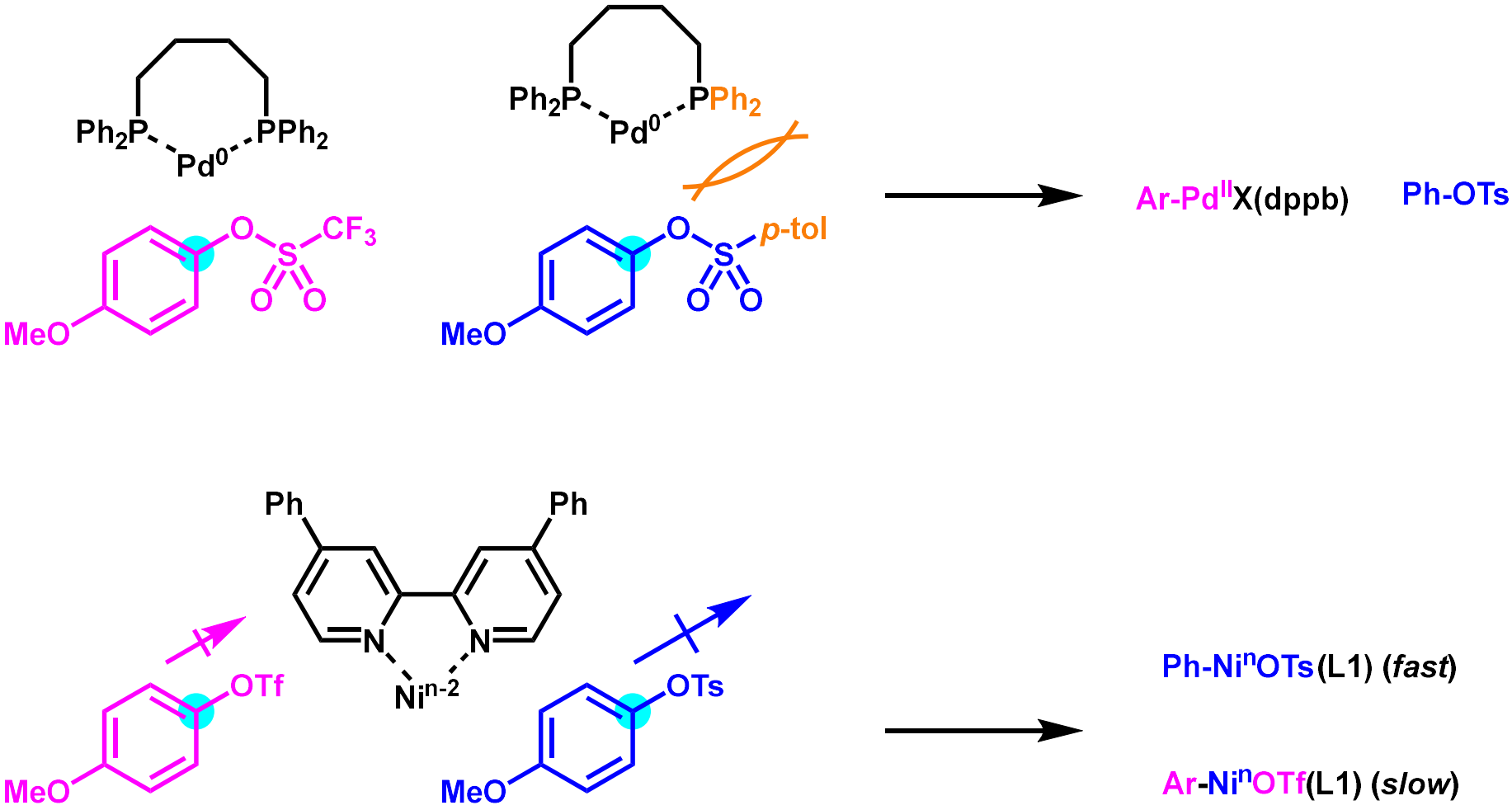
3e: 57%

$\Delta\sigma = \Delta\sigma(Ar^2\text{-OTs}) - \Delta\sigma(Ar^1\text{-OTf})$



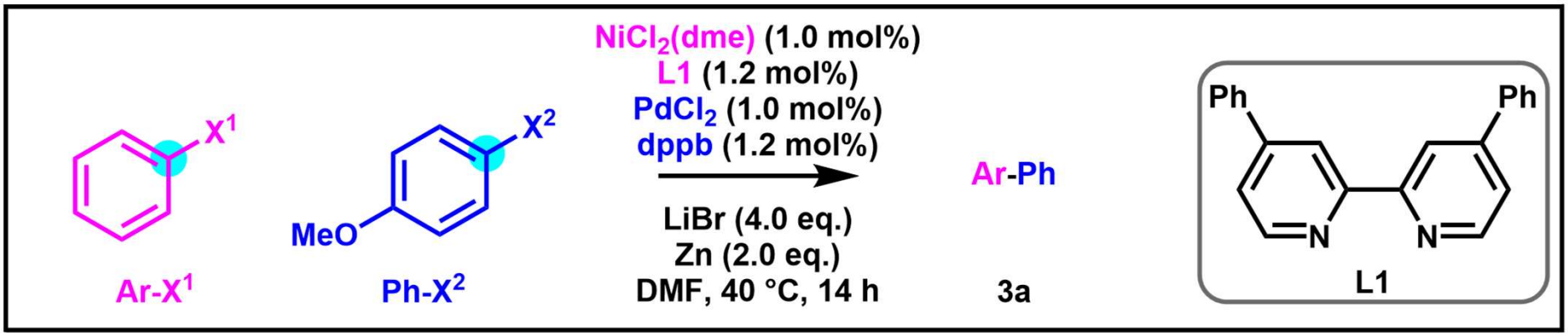
1) Kang, K.; Huang, L.; Weix, D. J. *J. Am. Chem. Soc.* **2020**, *142*, 10634.
2) Hansch, C.; Leo, A.; Taft, R. W. *Chem. Rev.* **1991**, *91*, 2, 165.

Reactivity Preference of Each Catalyst (3)
-My Proposal-



1) Kang, K.; Huang, L.; Weix, D. J. *J. Am. Chem. Soc.* **2020**, *142*, 10634.

Reactivity Preference of Each Catalyst (4)
-My Proposal-

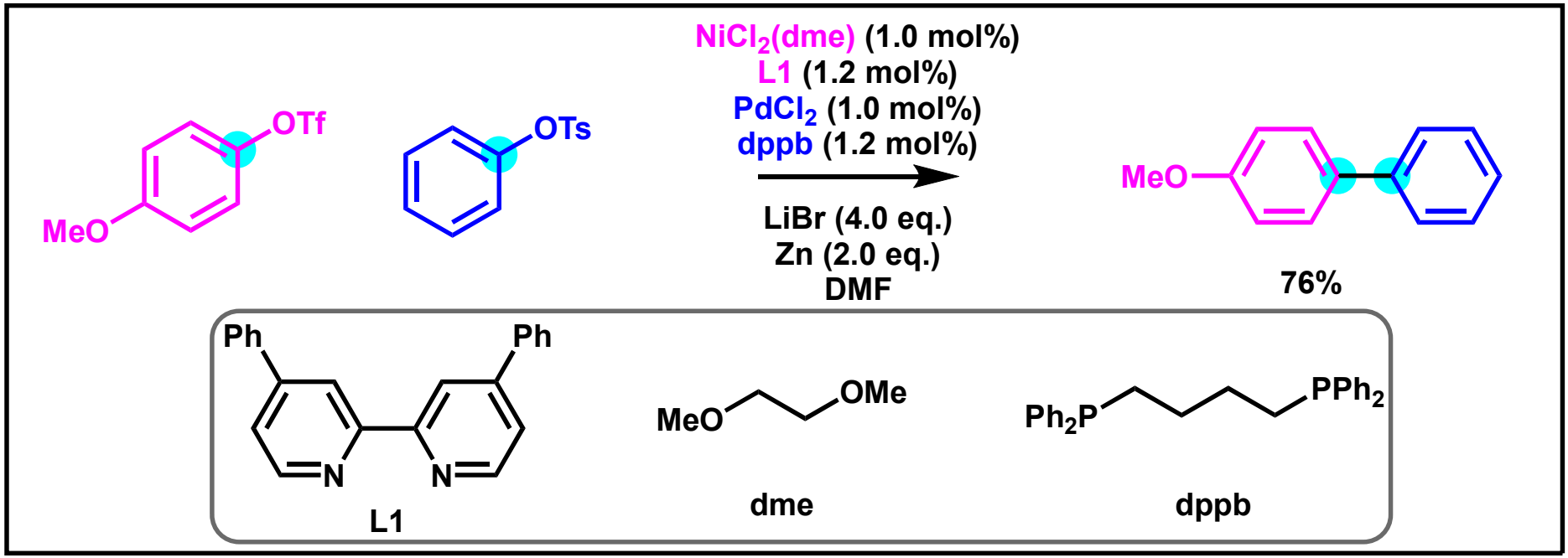


3a (%)	Ph-OTf	Ph-OTs	Ph-OMs	Ph-OPiv	Ph-ONf	Ph-OSO_2Im
Ar-OTf	55	76	19	0	0	47
Ar-OTs	66	36	3	0	0	11
Ar-OMs	13	0	0	0	0	0
Ar-OPiv	0	0	0	0	0	0
Ar-ONf	0	0	0	0	0	0
Ar-OSO_2Im	63	41	5	0	0	34

1) Kang, K.; Huang, L.; Weix, D. J. *J. Am. Chem. Soc.* **2020**, *142*, 10634.

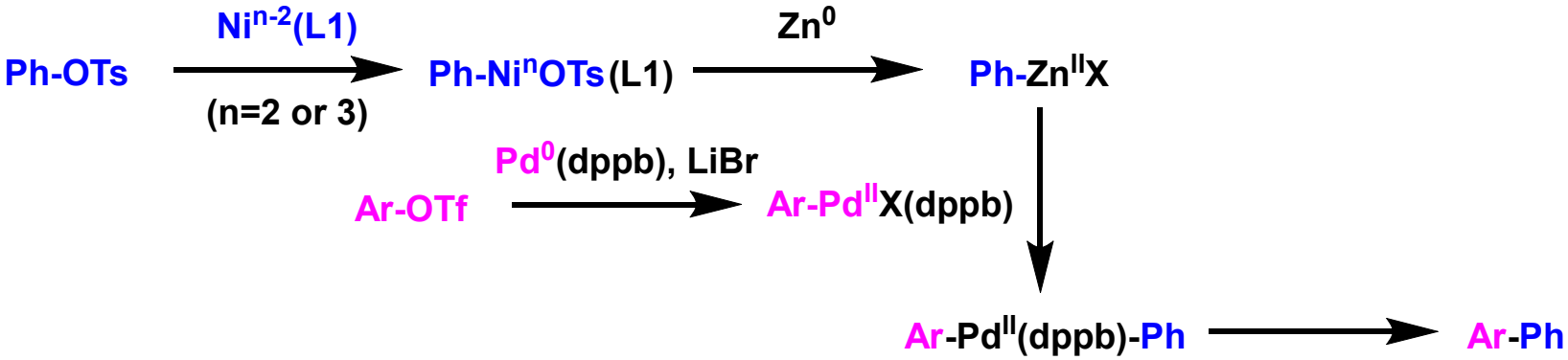
Contents

Summary



Ni^{n-2}(L1) : Ph-OTs > Ar-OTf

Pd^{0}(dppb) : Ar-OTf > Ph-OTs



1) Kang, K.; Huang, L.; Weix, D. J. *J. Am. Chem. Soc.* **2020**, *142*, 10634.