Oxidants in Palladium Catalyzed C-H Activation

Zhi Ren

2012/3/7

Importance

- 1. Martin’s Class
- 2. Related to our lab work

Outline

- 1. Iodine compound (I or III)

  Pd II→IV

- 2. Peroxides (Organic or Inorganic)

  Pd II→IV

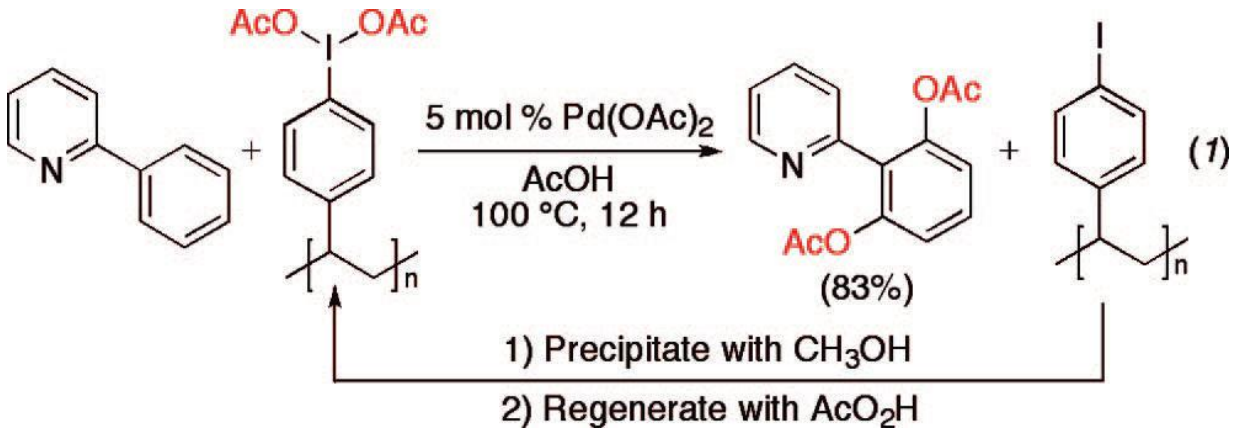
- 3. O_2 and other oxidants

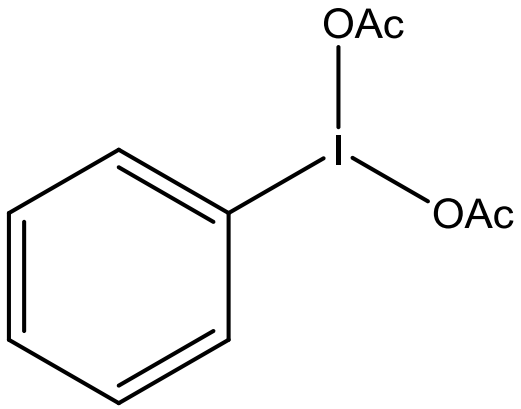
  Pd 0→II

Surely there are and will be more oxidants.

1. Iodine Compounds

- Iodine III Oxidants





Phenyliodine diacetate, PIDA

Chem. Rev. **2010**, *110*, 1147–1169

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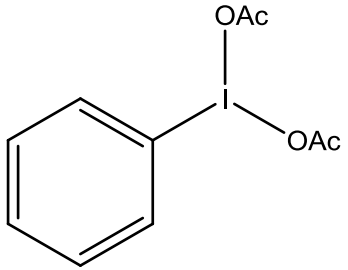
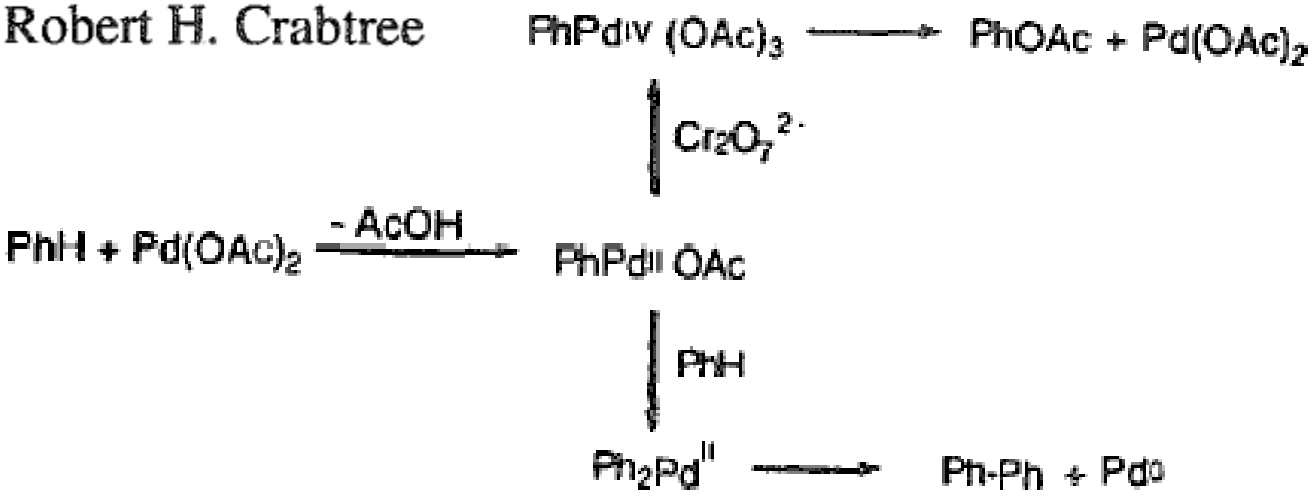


Phenyliodine diacetate, PIDA

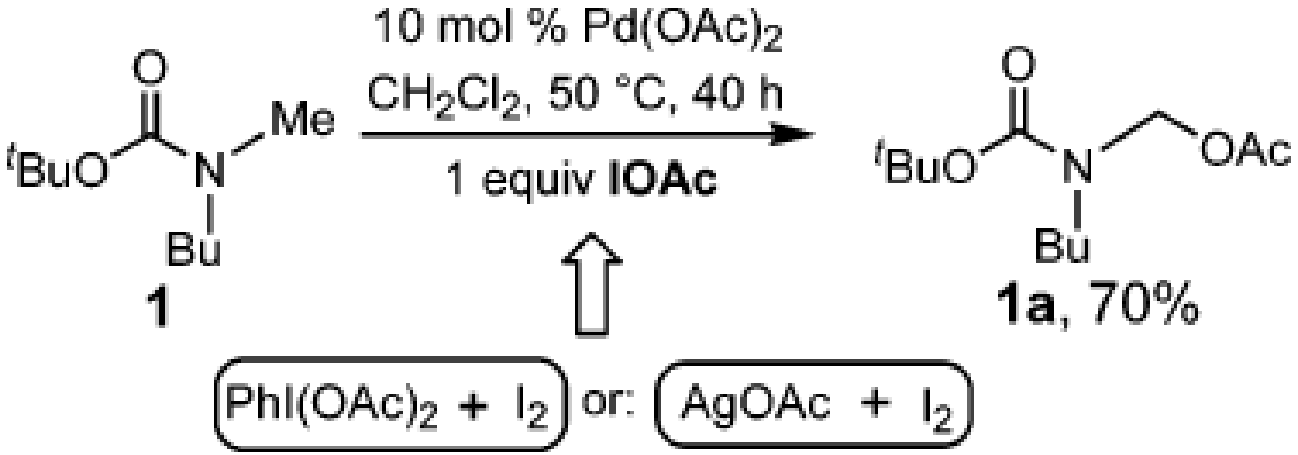
Robert H. Crabtree

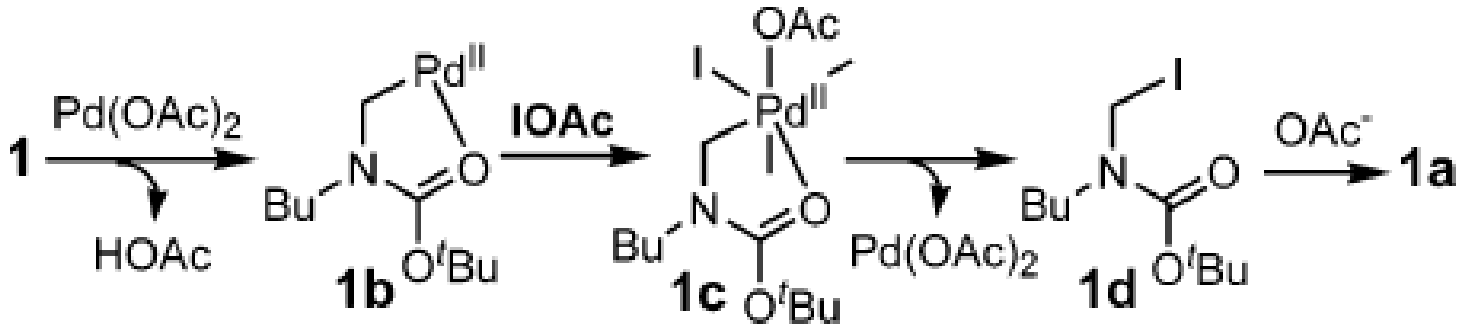


Journal of Molecular Catalysis A: Chemical 108 (1996) 35–40

1. Iodine Compounds

- Iodine I Oxidants **Jin-Quan Yu** Org. Lett., Vol. 8, No. 15, 2006, 3387-3390





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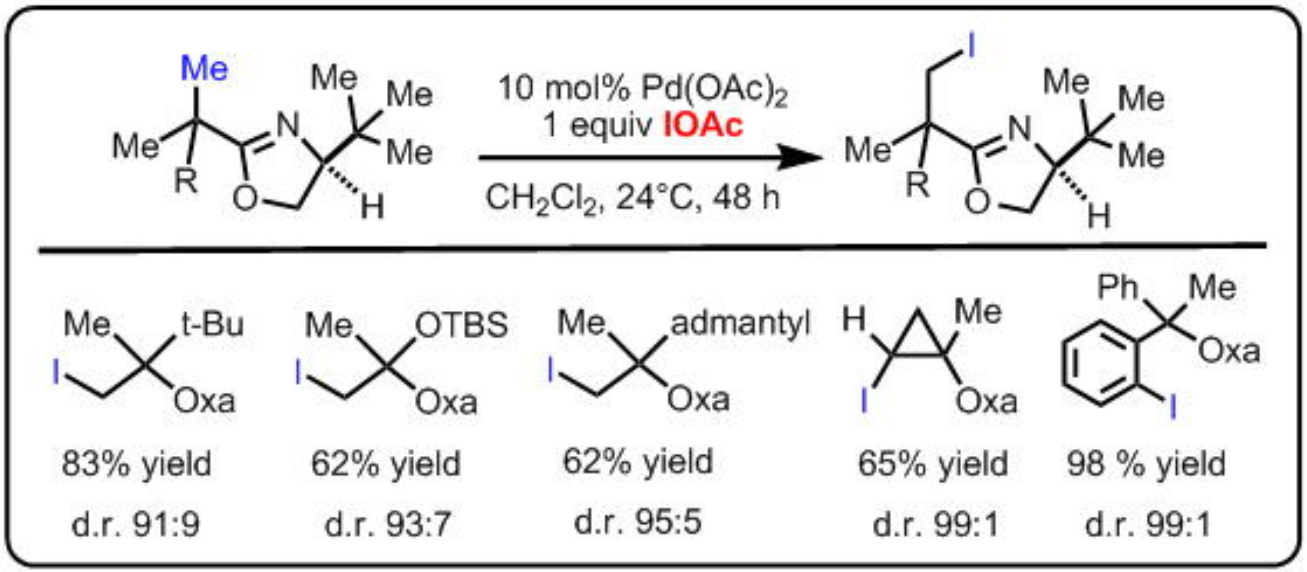

Jin-Quan Yu *Angew. Chem. Int. Ed.* **2005**, *44*, 2122

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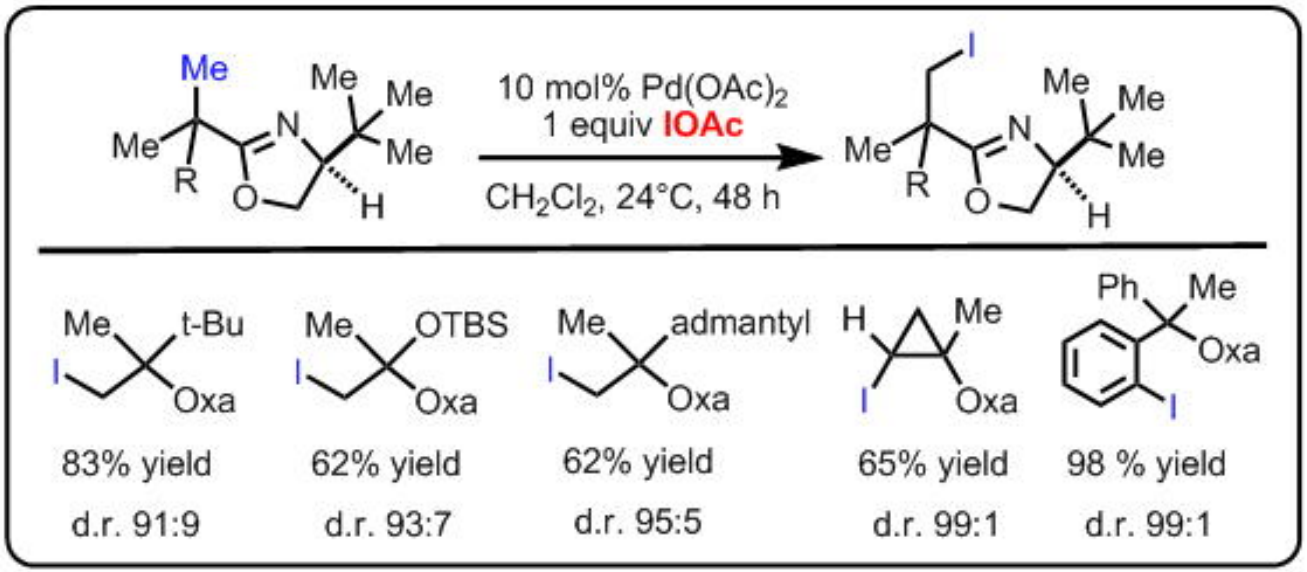

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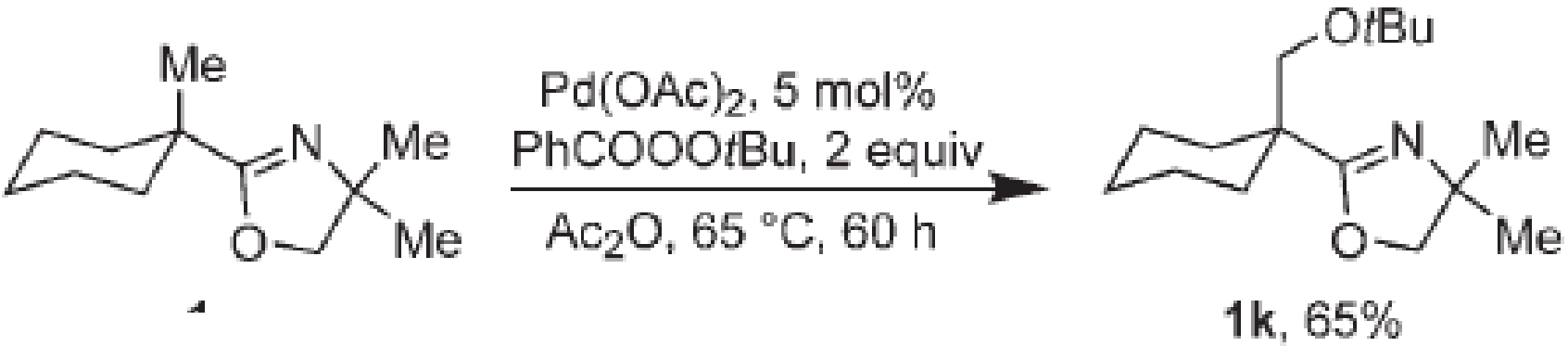
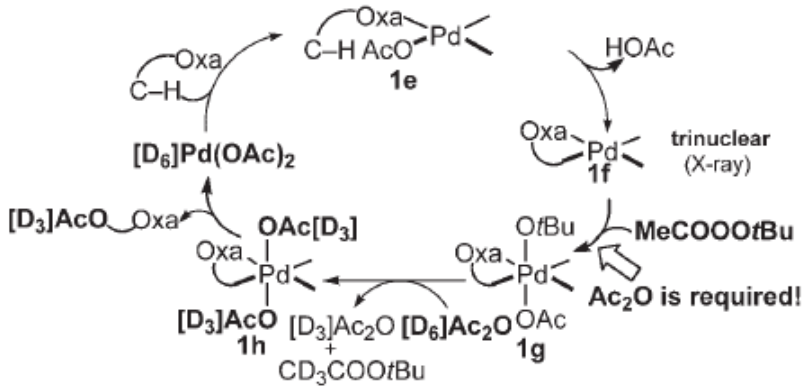
2. Peroxides

- Organic Peroxides





Yu, J. Q. *Angew. Chem., Int. Ed.* **2005, *44, 7420.***

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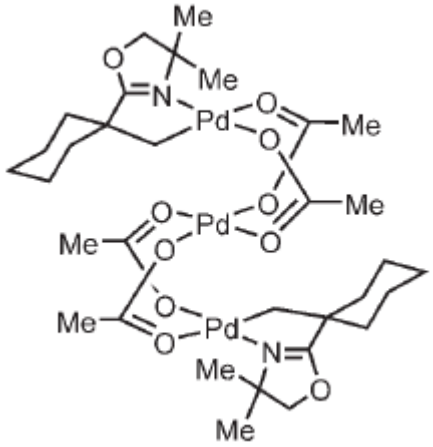
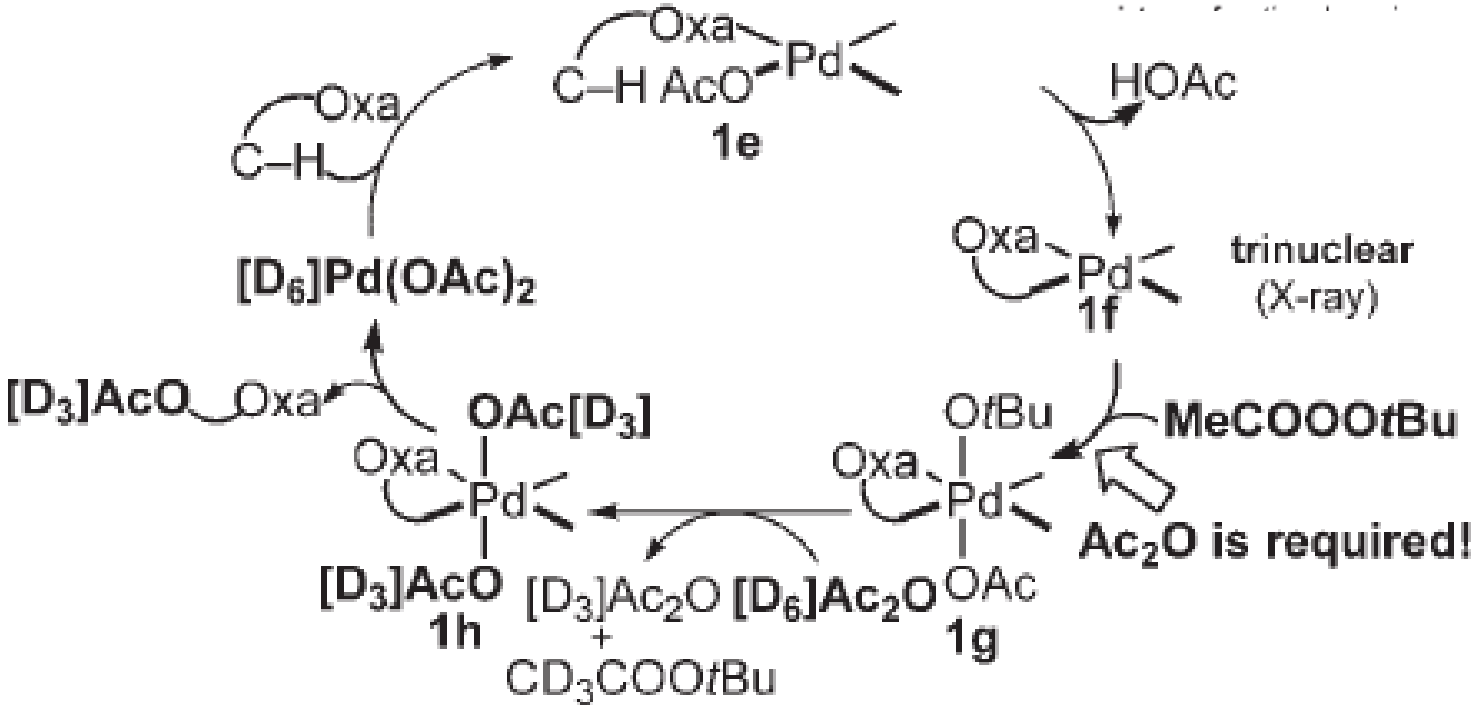




Yu, J. Q. *Angew. Chem., Int. Ed.* **2005, *44, 7420.***

2. Peroxides

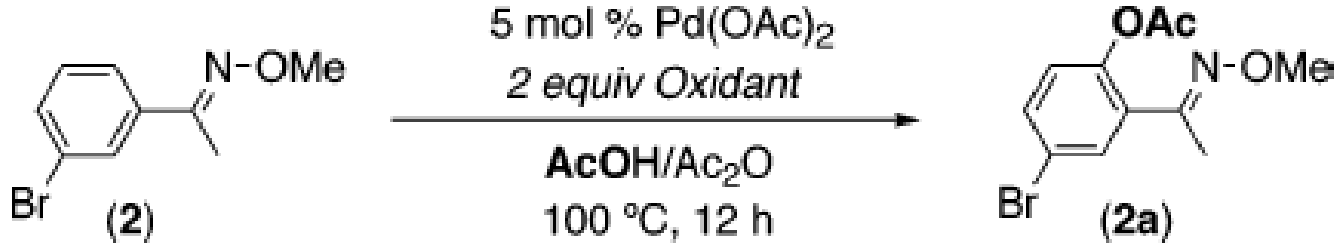
- Inorganic Peroxides

- Oxone
- $K_2S_2O_8$
- Oxone + $Mn(OAc)_2$

Chem. Rev. ***2010, 110, 1147–1169***

2. Peroxides

- Inorganic Peroxides



entry	oxidant	isolated yield (%) of **2a**[a]	entry	oxidant	isolated yield (%) of **2a**[a]
1	H_2O_2·urea	10	5	CH_3CO_3H	34
2	50% aq H_2O_2	11	6	Oxone	68
3	*m*-CPBA	14	7	$K_2S_2O_8$	76[b]
4	70% aq *t*-BuOOH	18	8	$PhI(OAc)_2$	81[b]

Sanford, M. S. *Org. Lett.* ***2006, 8, 1141***

2. Peroxides

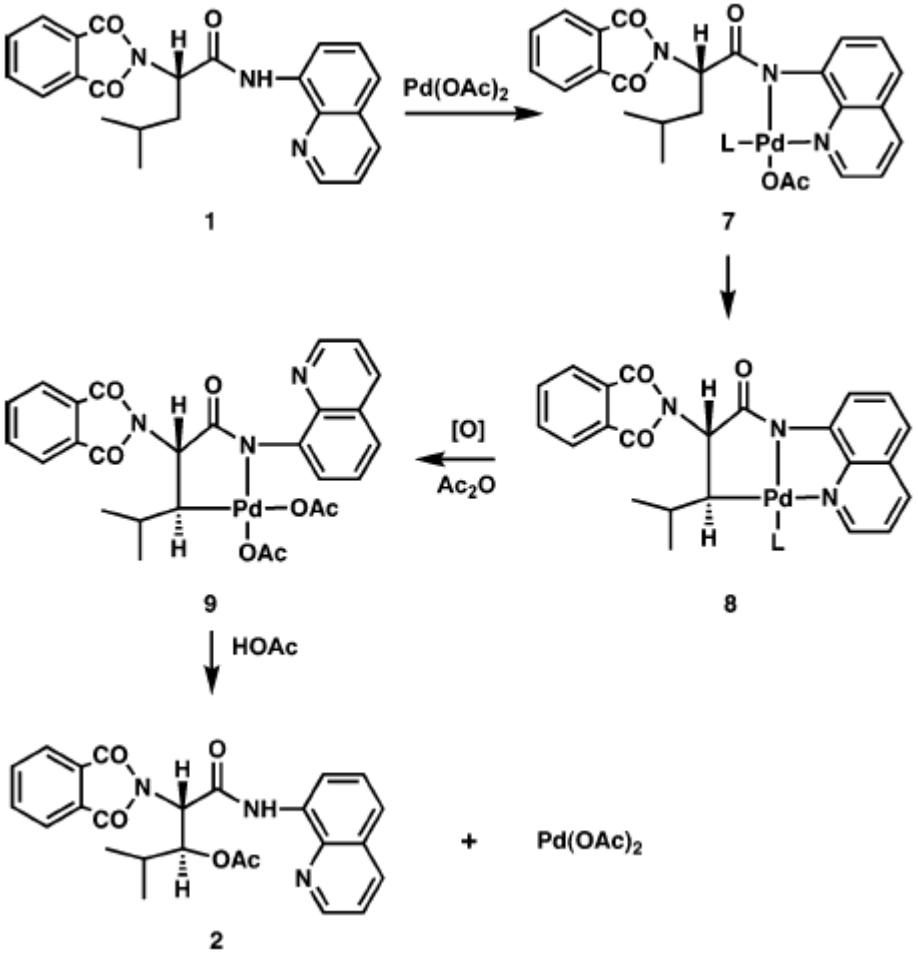
- Inorganic Peroxides
- Oxone + $Mn(OAc)_2$

Co, Cu, Ag acetate

Doesn't work

$Mn_3O(OAc)_7$

Mn (III)

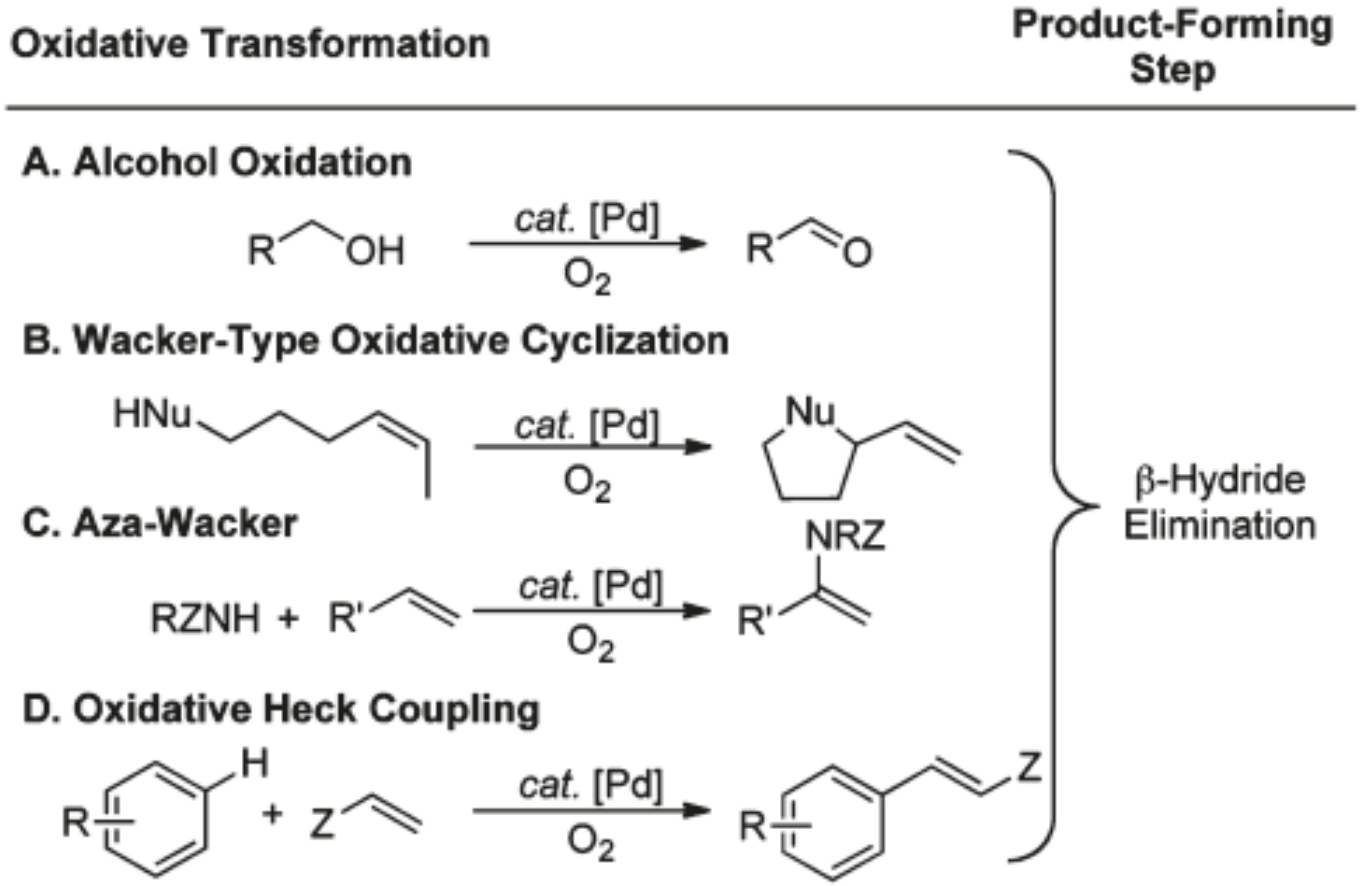


E. J. Corey **ORG. LET.** 2006, Vol. 8, No. 15, 3391-3394

3. O_2 and other oxidants

Campbell, A. N.; Stahl, S. S. *Acc. Chem. Res.* **2012**, **DOI:** 10.1021/ar2002045

- O_2



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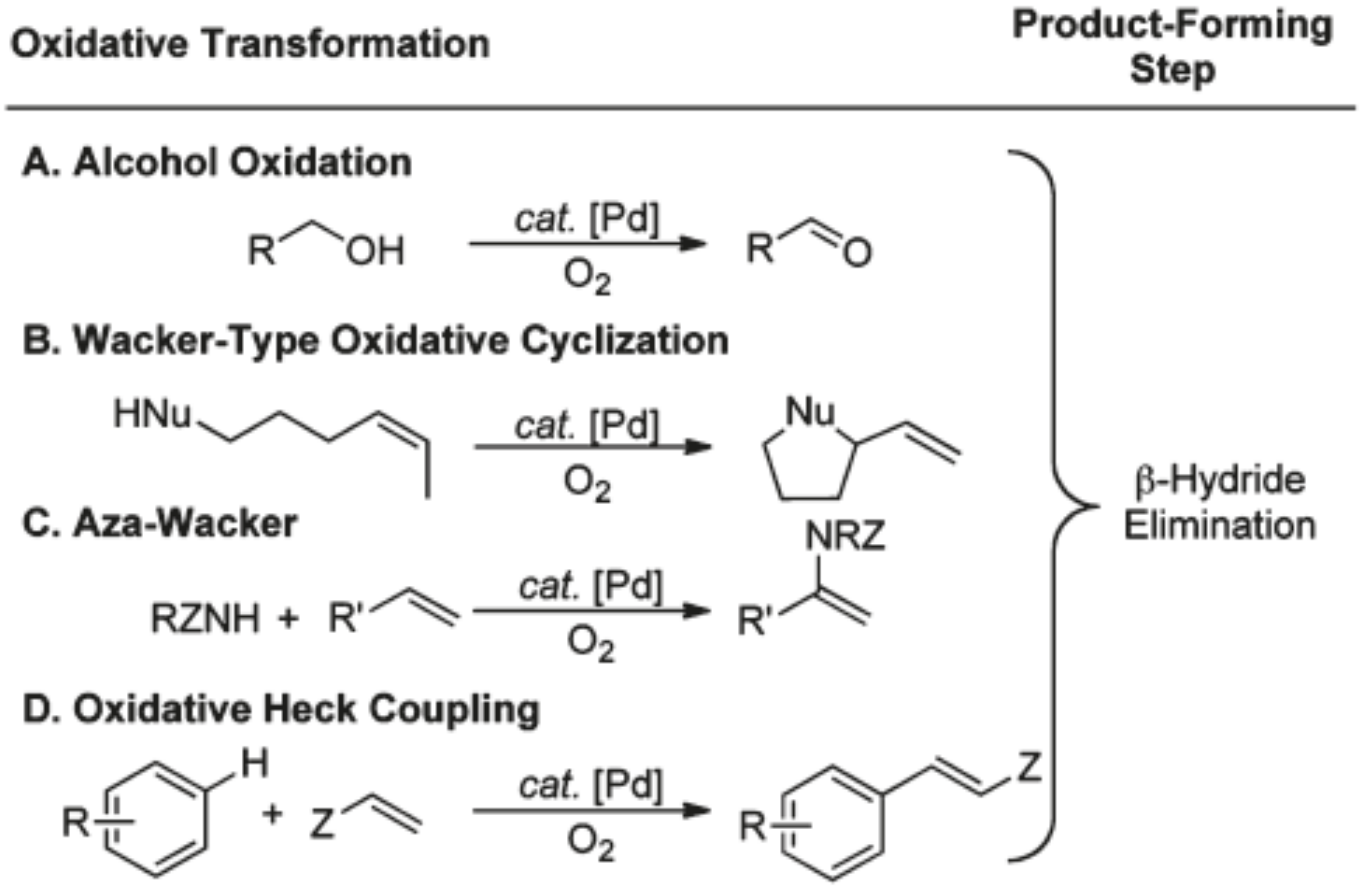

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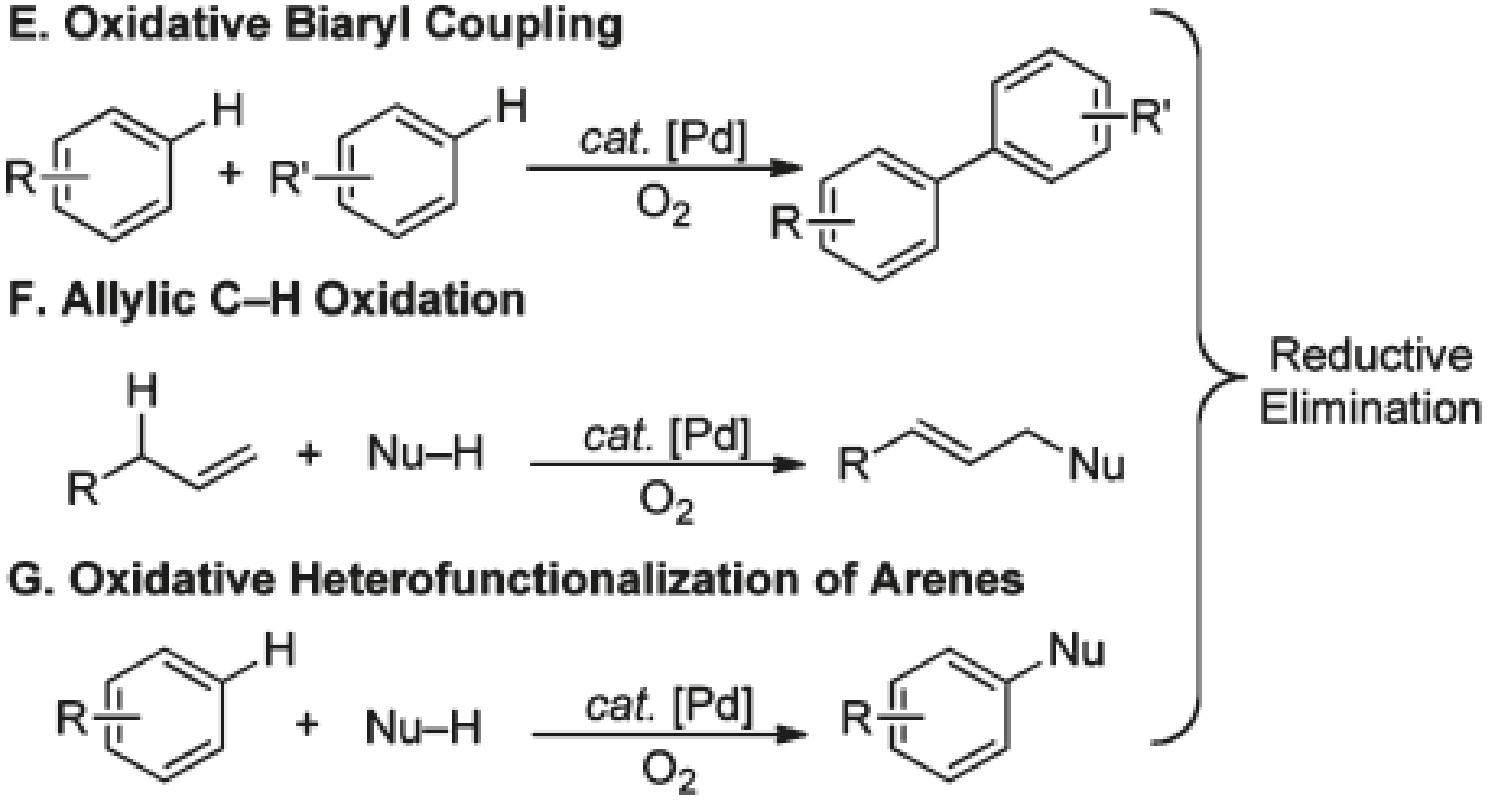

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- O_2
- The problem is with the reductive elimination reactions.
- The solution is ligand.

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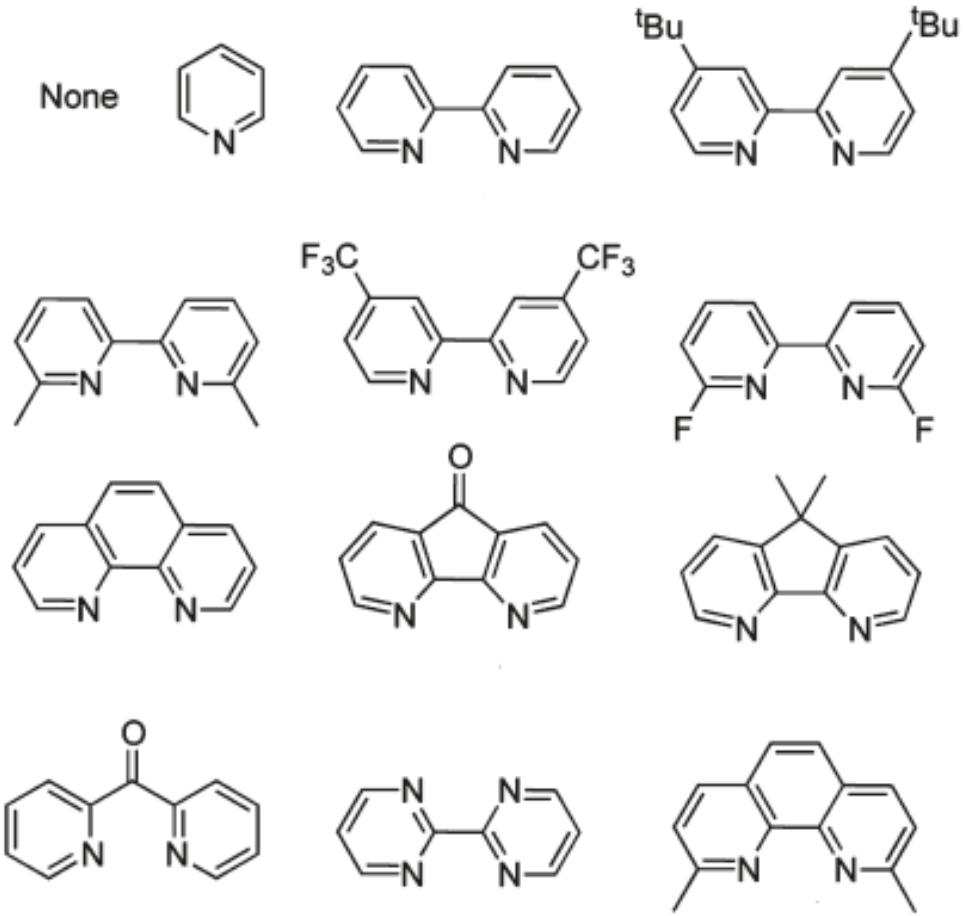
- O_2



Choose one for question 2 and explain why.
Hint: think about the formal charge changes in reductive elimination and beta-H elimination.

3. O_2 and other oxidants

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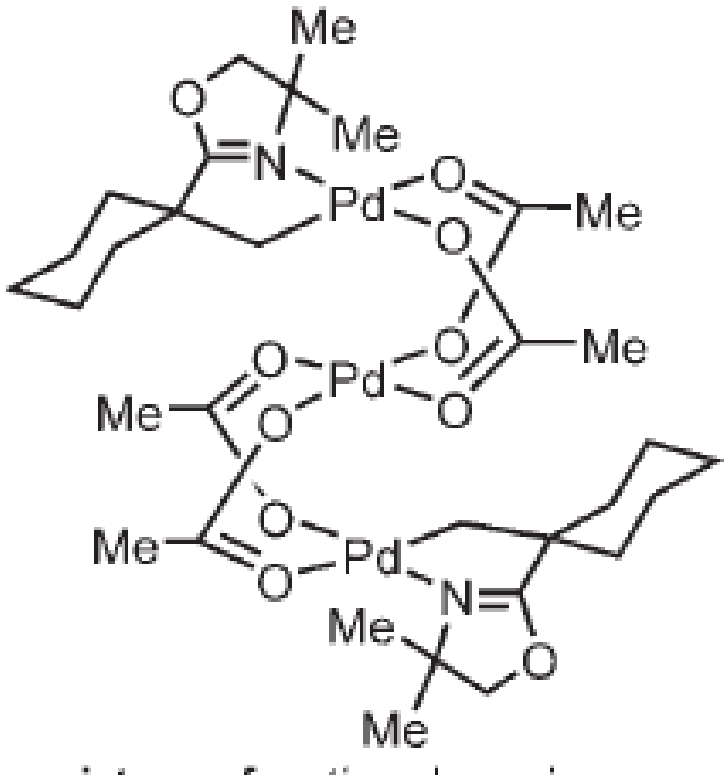
- Other oxidants
- BQ
- $Cu(OAc)_2$
- AgOAc



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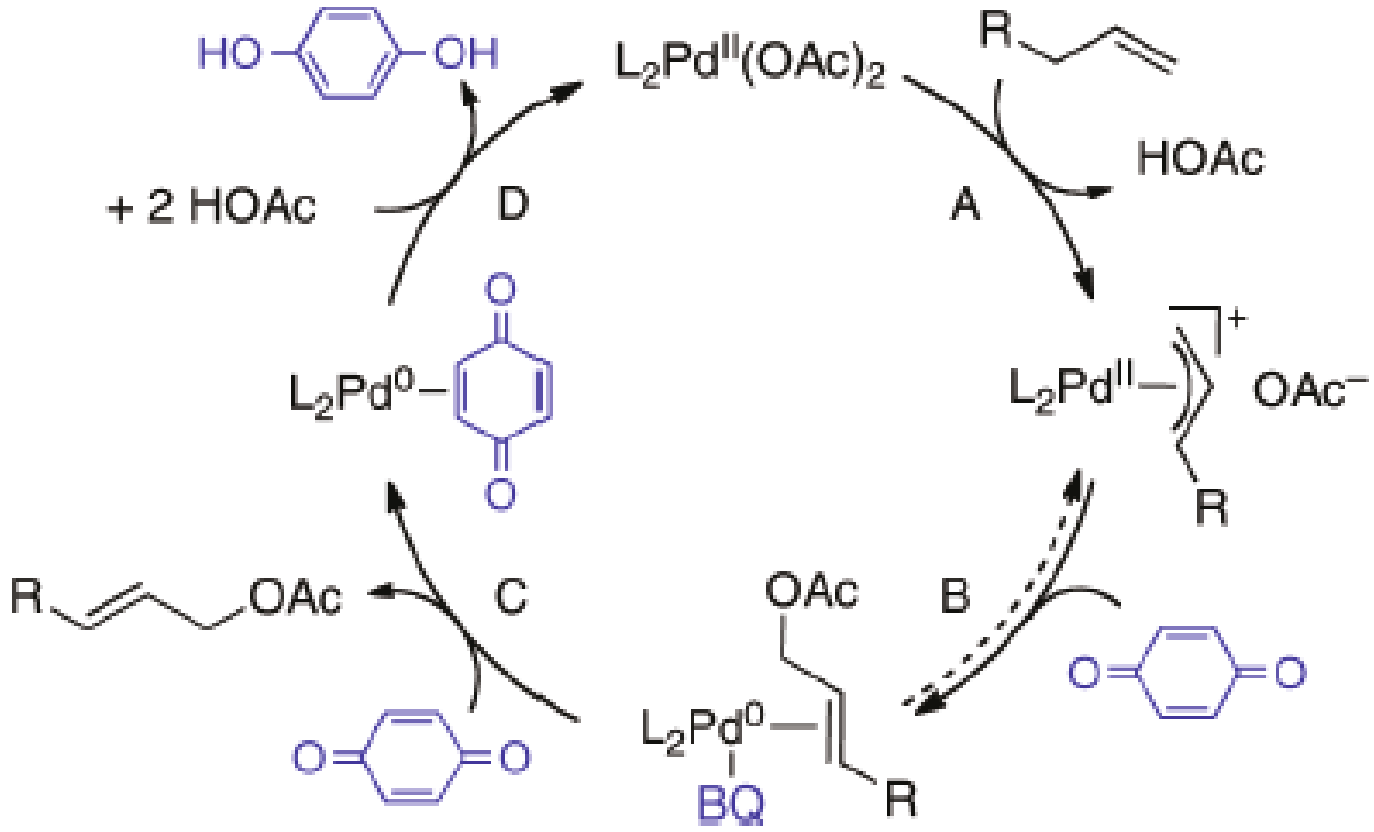

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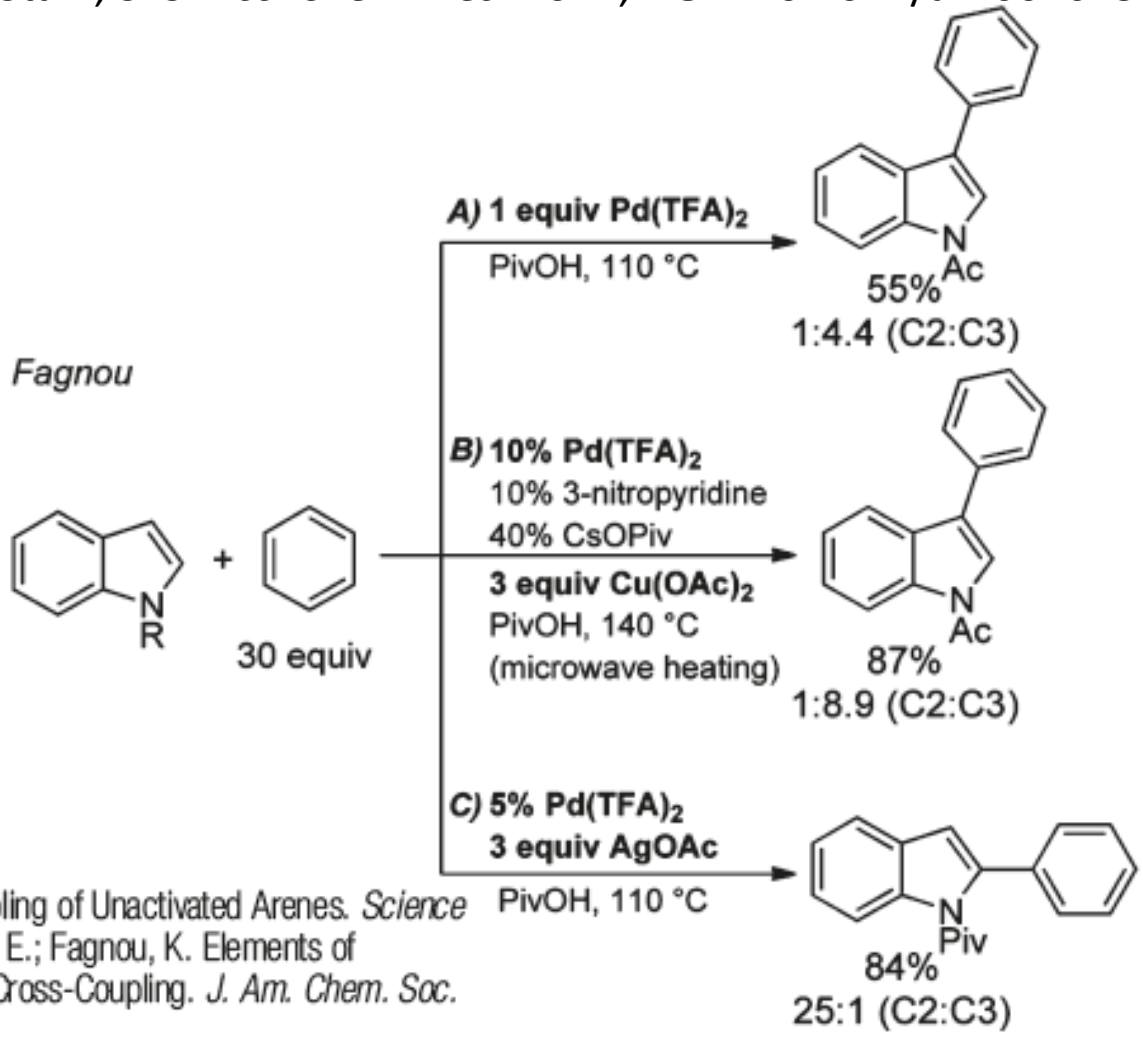
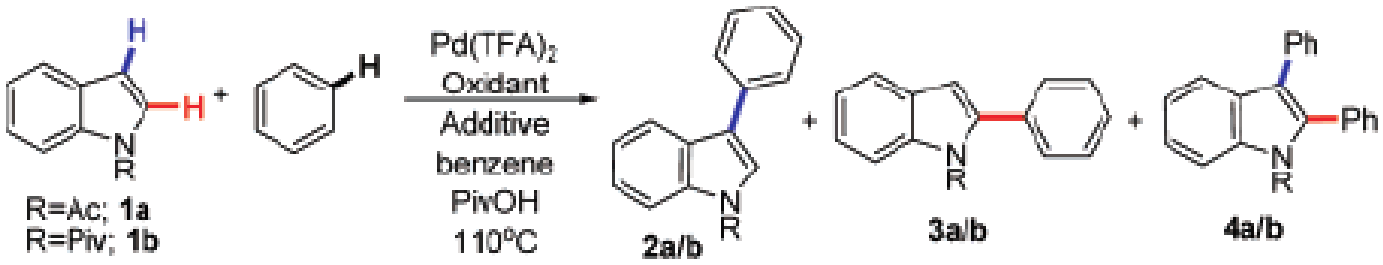


(a) Stuart, D. R.; Fagnou, K. The Catalytic Cross-Coupling of Unactivated Arenes. *Science* **2007**, *316*, 1172–1175. (b) Stuart, D. R.; Villemure, E.; Fagnou, K. Elements of Regiocontrol in Palladium-Catalyzed Oxidative Arene Cross-Coupling. *J. Am. Chem. Soc.* **2007**, *129*, 12072–12703.

O_2 and other oxidants

J. AM. CHEM. SOC. **2007**, *129*, 12072−12073



entry	mol % Pd[b]	oxidant (equiv)[b]	additive (mol %)[b]	indole	time (h)	% conv[c]	2:3:4[c]
1[d]	10	$Cu(OAc)_2$(3)	3-nitropyridine (10) CsOPiv (40)	**1a**	5	100	8.9:1:0.26
2	10	AgOAc (2.2)	3-nitropyridine (10) CsOPiv (40)	**1a**	24	32	1:4:0
3	10	AgOAc (2.2)	3-nitropyridine (10) CsOPiv (40)	**1b**	24	78	1:8.7:0.3
4	5	AgOAc (3)	none	**1b**	3	99	1:25:0.7
5	2	AgOAc (3)	none	**1b**	15	87	1:14:0.4
6	20	none	none	**1b**	3	18	1.1:1:0
7	50	none	none	**1b**	3	45	1.3:1:0
8	100	none	none	**1b**	3	61	3.7:1:0
9	300	none	none	**1b**	3	100	99:1:0
10	20	none	CsOAc (200)	**1b**	3	15	1:99:0

Summary

Oxidant	Advantage	Cycle
PIDA	O.A.	II-IV
IOAc	O.A. and R.E.	II-IV
$MeCO_2$-t-Bu	O.A.	II-IV
Oxone	Complete cycle Scale up	II-IV
$K_2S_2O_8$		II-IV
O2	β-elimination	0-II
BQ	R.E.	0-II

Thanks

- Question 2 should be via a reductive elimination process.
- Time to get some NMR tubes.