# Prof. Kenichiro Itami

N. Grabicki

- 1990 – 1994 Undergraduate, University of Kyoto (Prof. Hisanobu Ogoshi)
- 1994 – 1996 Master Course, University of Kyoto (Prof. Yoshihiko Ito)
- 1996 – 1998 Doctor Course, University of Kyoto (Prof. Yoshihiko Ito)
- 1997 – 1998 Visiting Scholar (Uppsala, Prof. Jan-E. Bäckvall)
- 1998 – 2005 Assistant Professor, Kyoto University (Prof. Jun-ichi Yoshida)
- 2005 – 2008 Associate Professor, Nagoya University (Prof. Ryoji Noyori Nobel prize 2001)
- 2008 – present Professor, Nagoya University

- Director of ITbM, Nagoya University (group size ca. 50 people, 3 Assistant Prof. and 2 Associate Prof.)

- Numerous Prizes – Research Director JST, ERATO, Itami Molecular Nanocarbon Project 2013 – 2018 (similar to ERC-grant)

- Member of several editorial and editorial advisory boards of Renown journals (e.g. ACIE, Chem, Acc. Chem. Res.)

- Over 320 peer-reviewed Publications

- H-index 77

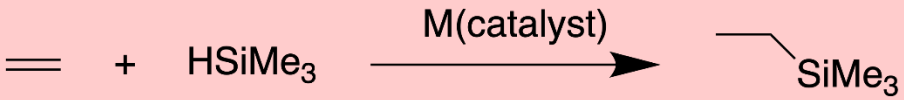
http://synth.chem.nagoya-u.ac.jp/wordpress/?lang=en

# Doctoral supervisor Yoshihiro Ito

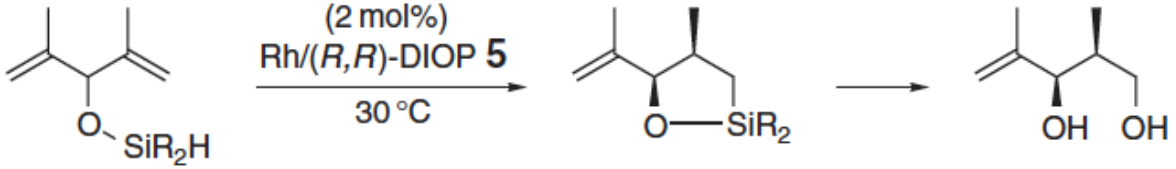
- Synthetic organic chemist
- Methodology
- Transition metal catalysis
- Synthetic methods of new silicon compounds

- Why silicon compounds? – Hydrosilylation and its variations are an important chemical transformation especially in asymmetric functionalization

**Metal catalyzed Hydrosilylation**



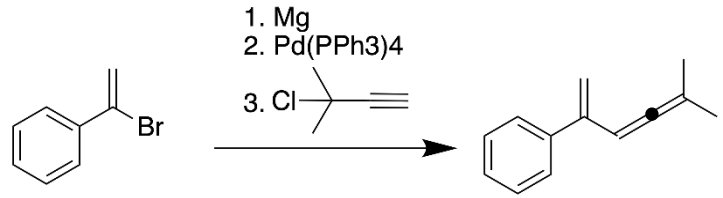

**Example: Asymmetric Intramolecular Hydrosilylation**



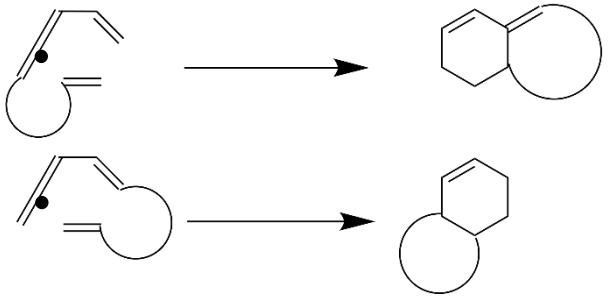

Tamao, K.; Tohma, T.; Inui, N.; Nakayama, O.; Ito, Y. *Tetrahedron Lett.* **1990**, *31*, 7333–7336

- Vinylallenes as versatile building blocks

**Synthesis**

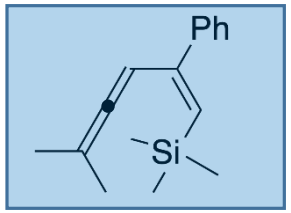



**Electrocyclic ring closure**



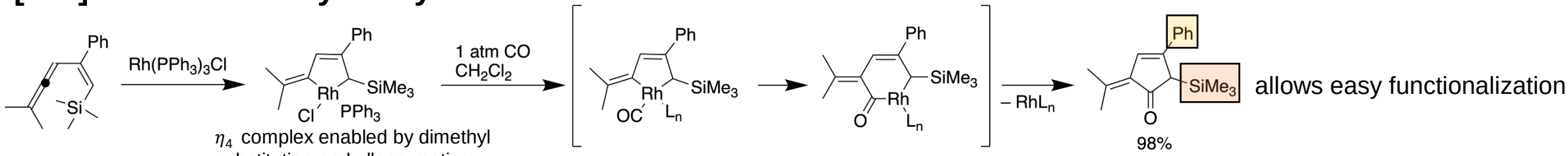
W. H. Okamura, M. L. Curtin; *Synlett* **1990**, *1*, 1–9

- Focused studies on silylated vinylallene




## [4+1] Rhodium-catalyzed cycloaddition

different substituents possible

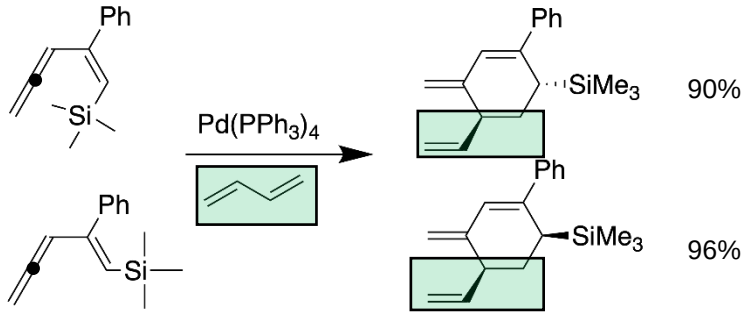



$\eta_4$ complex enabled by dimethyl substitution and allene motive

allows easy functionalization

M. Murakami, K. Itami, Y. Ito; *Angew. Chem. In. Ed*. **1995**, *34*, 2691–2694

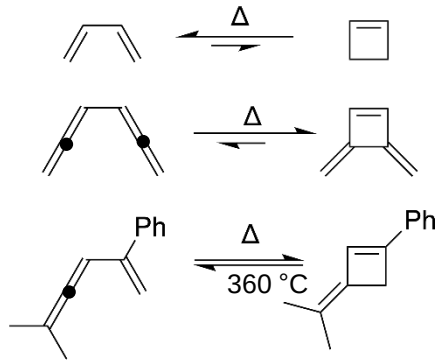
## [4+2] Palladium-catalyzed cycloaddition

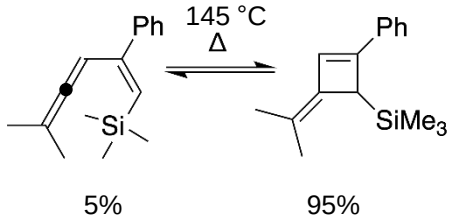



$\eta_4$ complex without dimethyl substitution

M. Murakami, K. Itami, Y. Ito; *J. Am. Chem. Soc.* **1997**, *119*, 7163–7164

## [2+2] Thermal electrcyclization



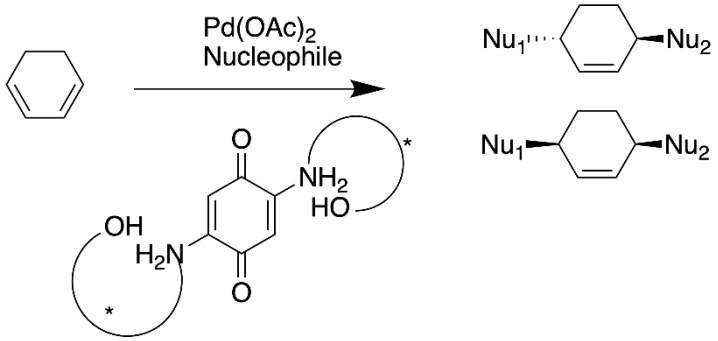



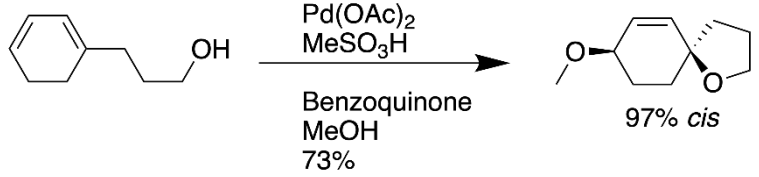

H. Amii, K, Itami, M,Murakami, Y. Ito; *Angew. Chem. Int. Ed.* **1995**, *34*, 1476–1477

# Prof. Kenichiro Itami

N. Gabicki

- Work in Sweden dedicated to asymmetric catalysis via transition metal catalyzed CH functionalization
- Using chiral benzoquinone ligands for 1,4-dialkoxylation of 1,3-dienes

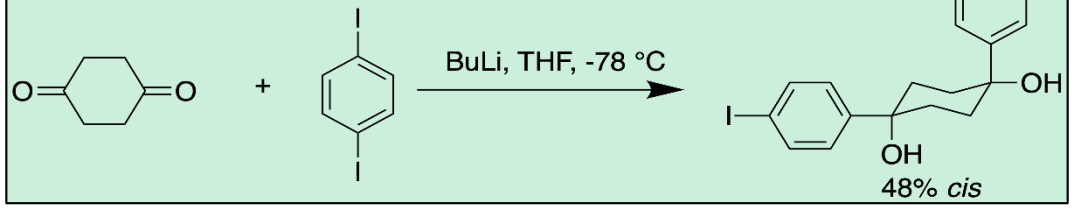


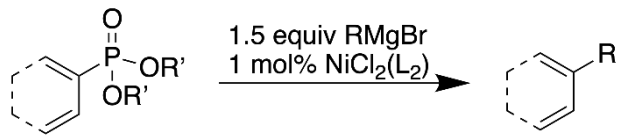

K. Itami, A. Palmgren, Jan-E. Bäckvall; *Tetra. Lett.*, **1998**, *39*, 1223 – 1226

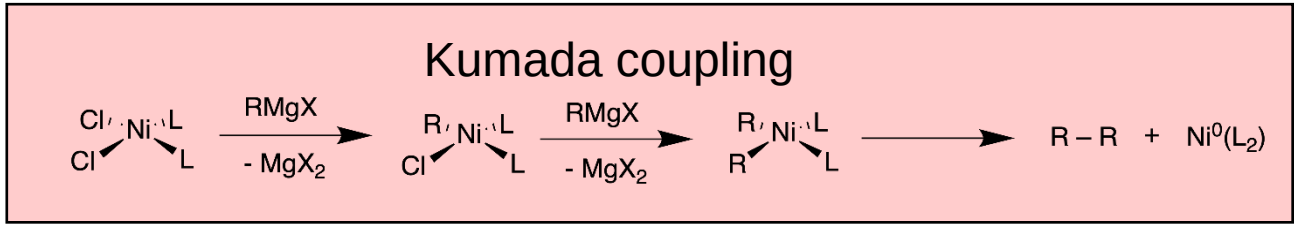
K. Itami, A. Palmgren, A. Thorarensen, Jan-E. Bäckvall; *J. Org. Chem.*, **1998**, *63*, 6466–6471

**Outlook: very important reaction at a later point in his career**




- Particitpating as well in other projects leading to the first publication dealing with Kumada type Nickel catalyzed cross coupling



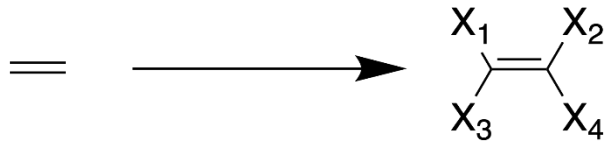



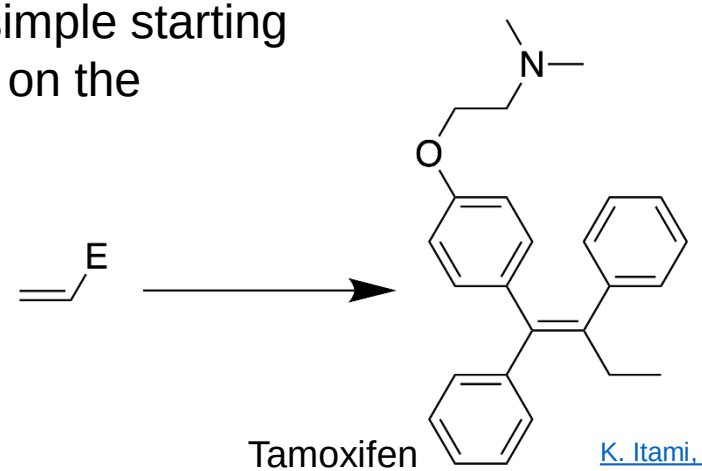

A. Sofia, E. Karlström, K. Itami, J.-E. Bäckvall; *J. Org. Chem.*, **1999,** *64,* 1745–1749

- Back again at his alma mater Kyoto University, Itami worked as assistant professor with Prof. Jun-ichi Yoshida
- Yoshida himself worked with people like B. M. Trost and M. Kumada before his independet career
- Itami‘s work was based on platform based synthesis of multiple substituted olefins

## Platform Synthesis

- How to realize these transformations based on a simple starting motive, while still covering a large chemical space on the product side?



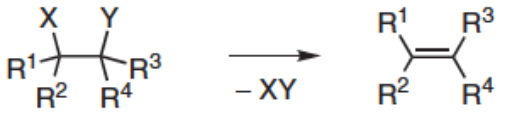

Large amount of derivatives for high throughput screenings

Tamoxifen
(used against breast cancer)

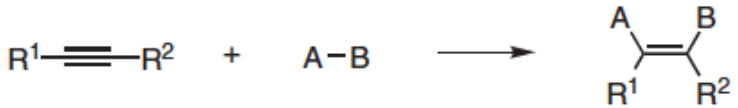
K. Itami, T. Kamei, J. Yoshida; *J. Am. Chem. Soc.* **2003**, *125*, 14670–14671

## Different possible strategies

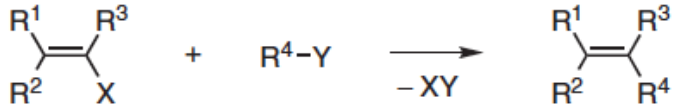
- Elimination

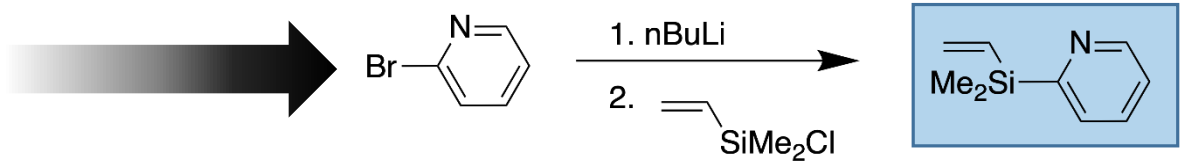



- Addition




- Substitution




- Removable hydrophilic group
- Removable directing group
- Phase tag

K. Itami, J. Yoshida; *Synlett;* **2006**, *2*, 157–180

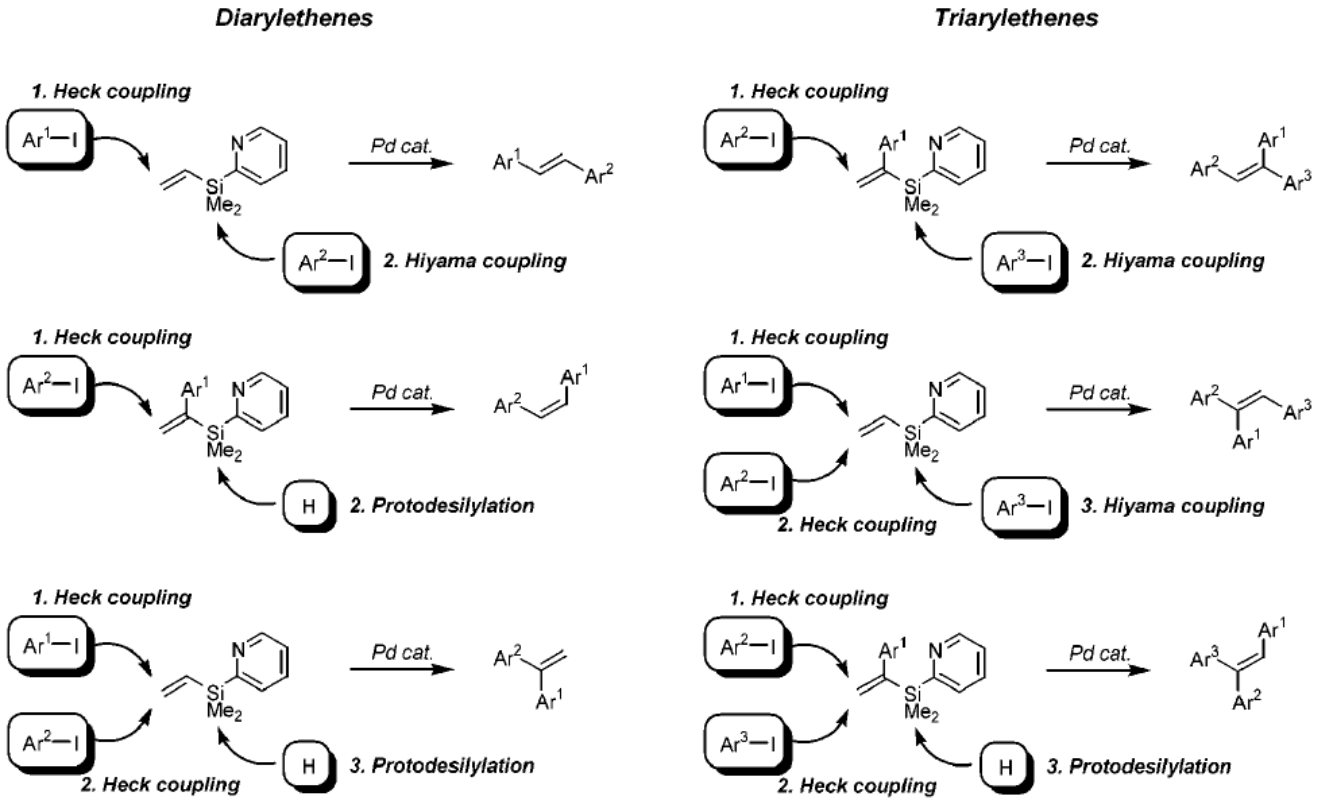
K. Itami, J. Yoshida; *Bull. Chem. Soc. Jpn.* **2006,** *79*, 811–824

K. Itami, K. Mitsudo, J. Yoshida; *Angew. Chem. Int. Ed.* **2002**, *41*, 3481–3485

# Prof. Kenichiro Itami

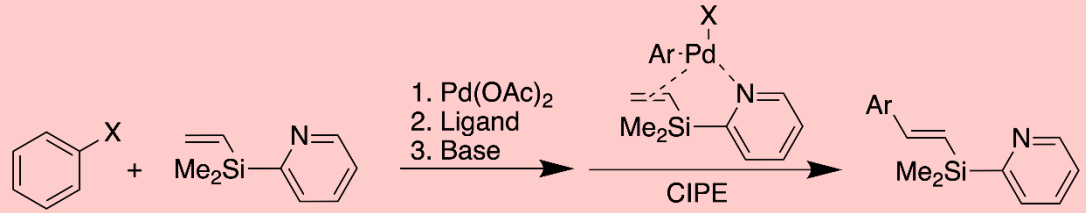
N. Grabicki

- Exploration of multiple transition metal catalyzed reactions
- Detailed mechanistic analysis on the ongoing transformations



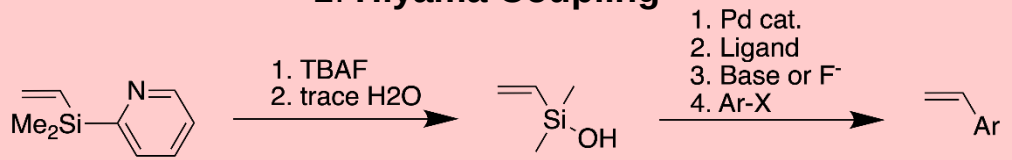

K. Itami, T. Nokami, Y. Ishhimura, K. Mitsudo, T. Kamei, J. Yoshida; *J. Am. Chem. Soc.*, **2001,** *123*, 11577 – 11586

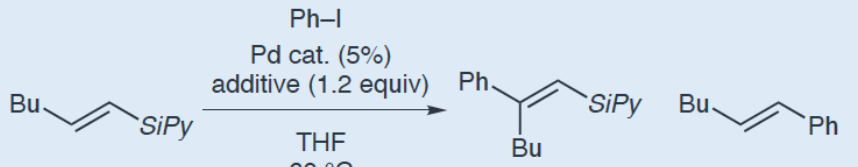
**Heck Coupling** already has a high *trans* selectivity




CIPE = complex-induced proximity effect

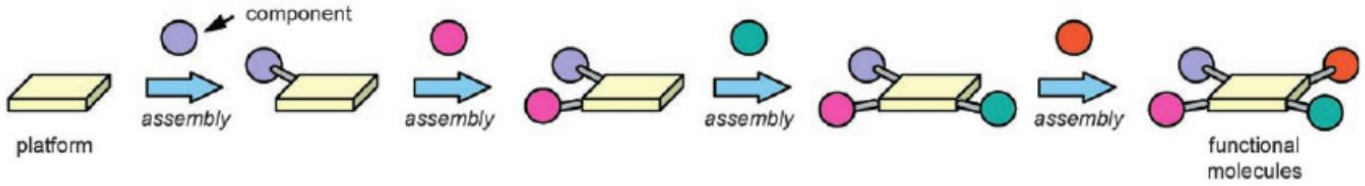
1. Cleavage of Si-Py bond *via* TBAF and trace amounts of water
2. **Hiyama Coupling**

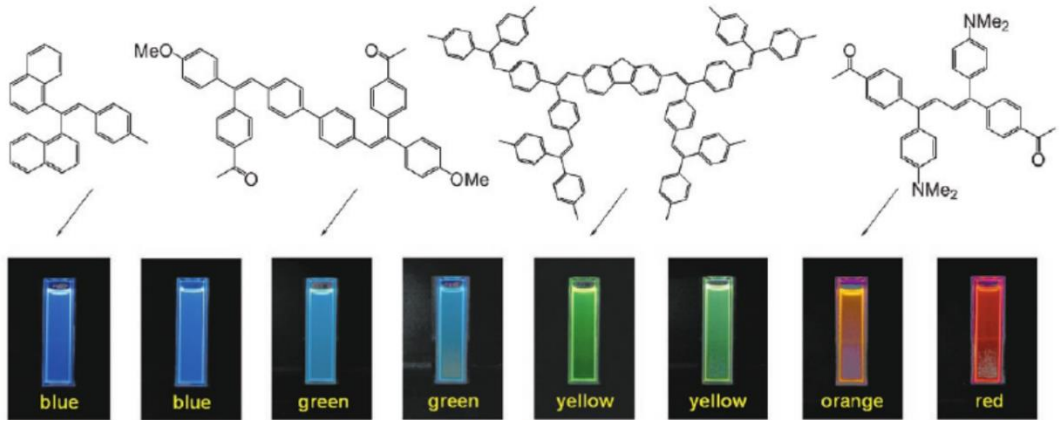



| Pd catalyst | Additive | Yield (%) | 34/35 |
|---|---|---|---|
| $Pd_2(dba)_3/P(2\text{-furyl})_3$ | $Et_3N$ | 94 | 100/0 |
| $Pd_2(dba)_3/P(2\text{-furyl})_3$ | **$Bu_4NF$** | 59 | **0/100** |
| $PdCl_2(PhCN)_2$ | **$Bu_4NF$** | 99 | **0/100** |

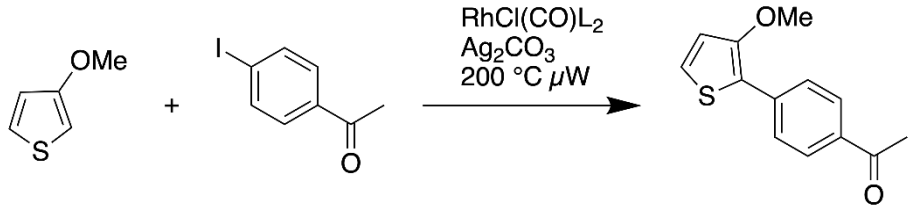
- Transition into his independent career



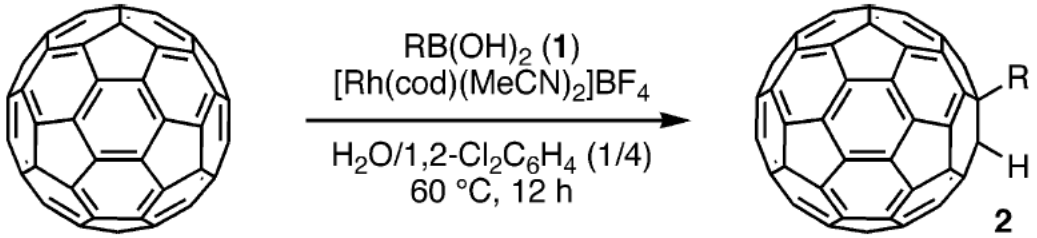

K. Itami, J. Yoshida; *Chem. Eur. J.* **2006**, *12*, 3966–3974

- First independent publications

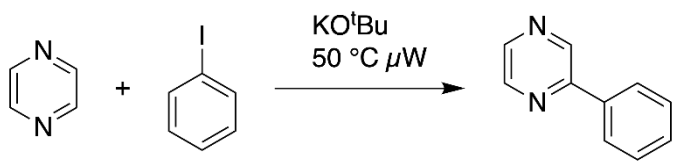



| ligand (L) | yield % | $\nu_{CO}$ in RhCl(CO)$L_2$ ($cm^{-1}$) |
|---|---|---|
| **$P[OCH(CF_3)_2]_3$** | **94** | **2070** |
| $P(C_6H_5)[OCH(CF_3)_2]_2$ | 31 | 2038 |
| $P(OC_6H_5)_3$ | 6 | 2018 |
| $P[OCH(CH_3)_2]_3$ | 9 | 2002 |
| $P(C_6H_5)_3$ | 0 | 1983 |

S. Yanagisawa, T. Sudo, R. Noyori, K. Itami; *J. Am. Chem. Soc.* **2006**, *128*, 11748–11749




M. Nambo, R. Noyori, K. Itami; *J. Am. Chem. Soc.*, **2007**, *129*, 8080–8081




- pyrazines
- pyridines
- pyrimidines

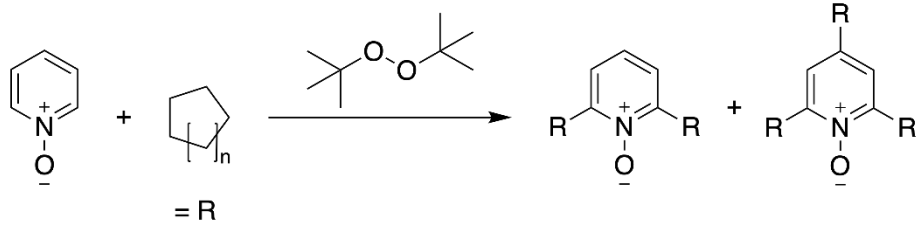
- benzene
- thiophene
- MeO-benzene

Yields: 33–98%

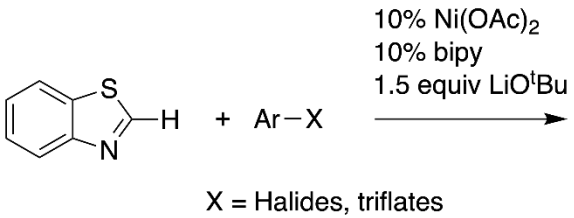
S. Yanagisawa, K. Ueda, T. Taniguchi, K. Itami; *Org. Lett.* **2008**, 20, 4673 – 4676

radical mechanism …

… always aiming to explore the full picture

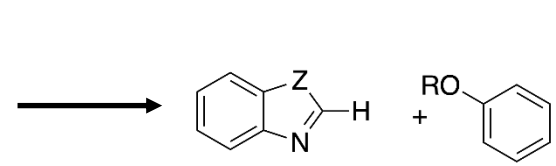


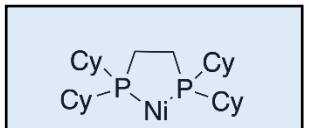

G. Deng, K. Ueda, S. Yanagisawa, K. Itami, C. Li; *Chem. Eur. J.* **2009**, *15*, 333–337

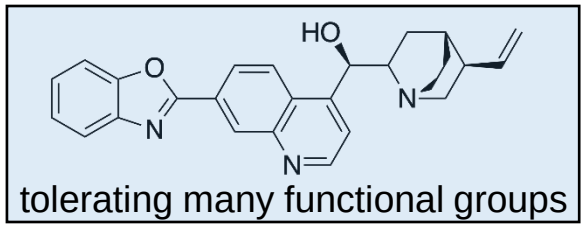



Several examples moderate to high yields.

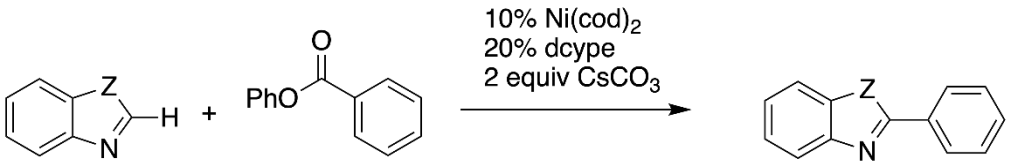
J. Canivet, J. Yamaguchi, I. Ban, K. Itami; *Org. Lett.* **2009**, *11*, 1733–1736



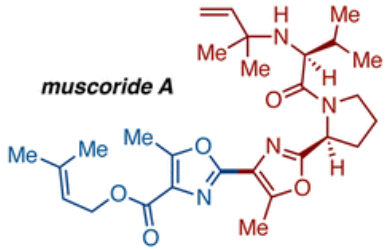




K. Muto, J. Yamaguchi, K. Itami; *J. Am. Chem. Soc.*, **2012**; *134*, 169–172



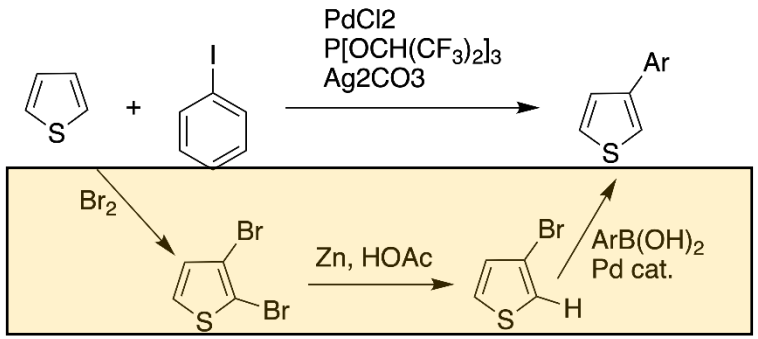

K. Amaike, K. Muto, J. Yamaguchi, K. Itami; *J. Am. Chem. Soc.* **2012,** *134*, 13573–13576

Application in natural product synthesis



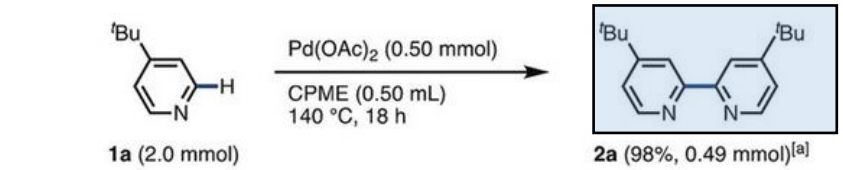

J. Yamaguchi, K. Muto, K. Itami; *Eur. J. Org. Chem.* **2013**, 19–30

- While Itami‘s focus on research topics has shifted, he still maintains a strong expertise on methodology for transition metall catalyzed reactions

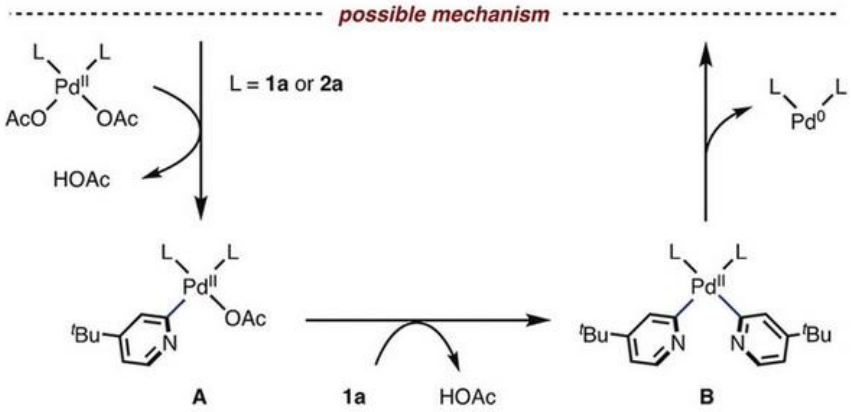



typical route
for β arylation

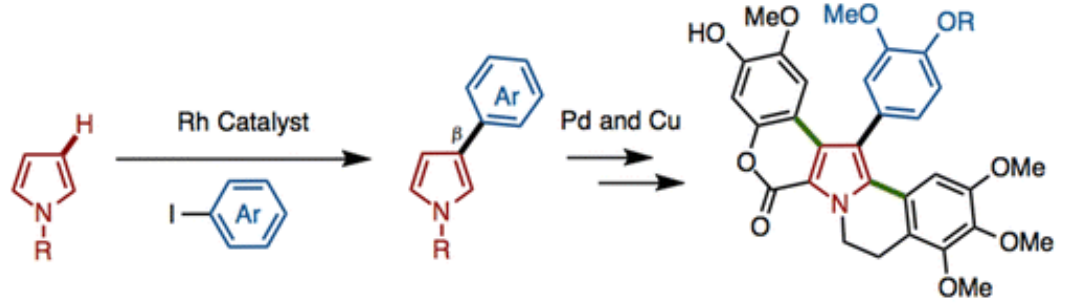
K. Ueda, S. Yanagisawa, J. Yamaguchi, K. Itami; *Angew. Chem. Int. Ed.* **2010**, *49*, 8946 – 8949



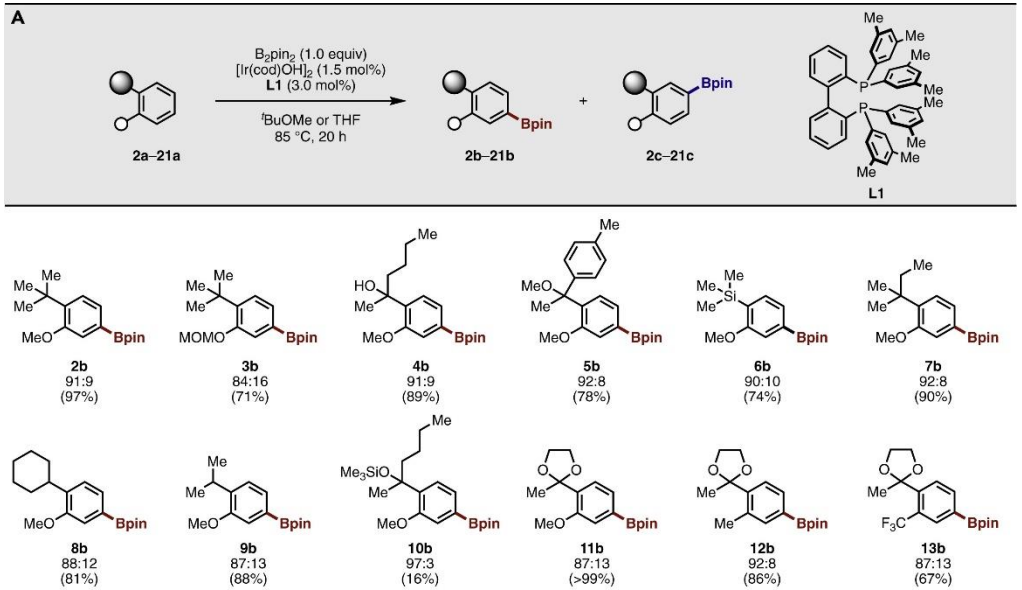

common ligand for Iridium and of course Ni-catalyzed reactions




S. Yamada, T. Kaneda, P. Steib, K. Murakami, K. Itami; *Angew. Chem. Int. Ed.* **2019**, *58*, 8341–8345




K. Ueda, K. Amaike, R. Maceiczyk, K. Itami, J. Yamaguchi, *J. Am. Chem. Soc.* **2014**, *136*, 13226–13232

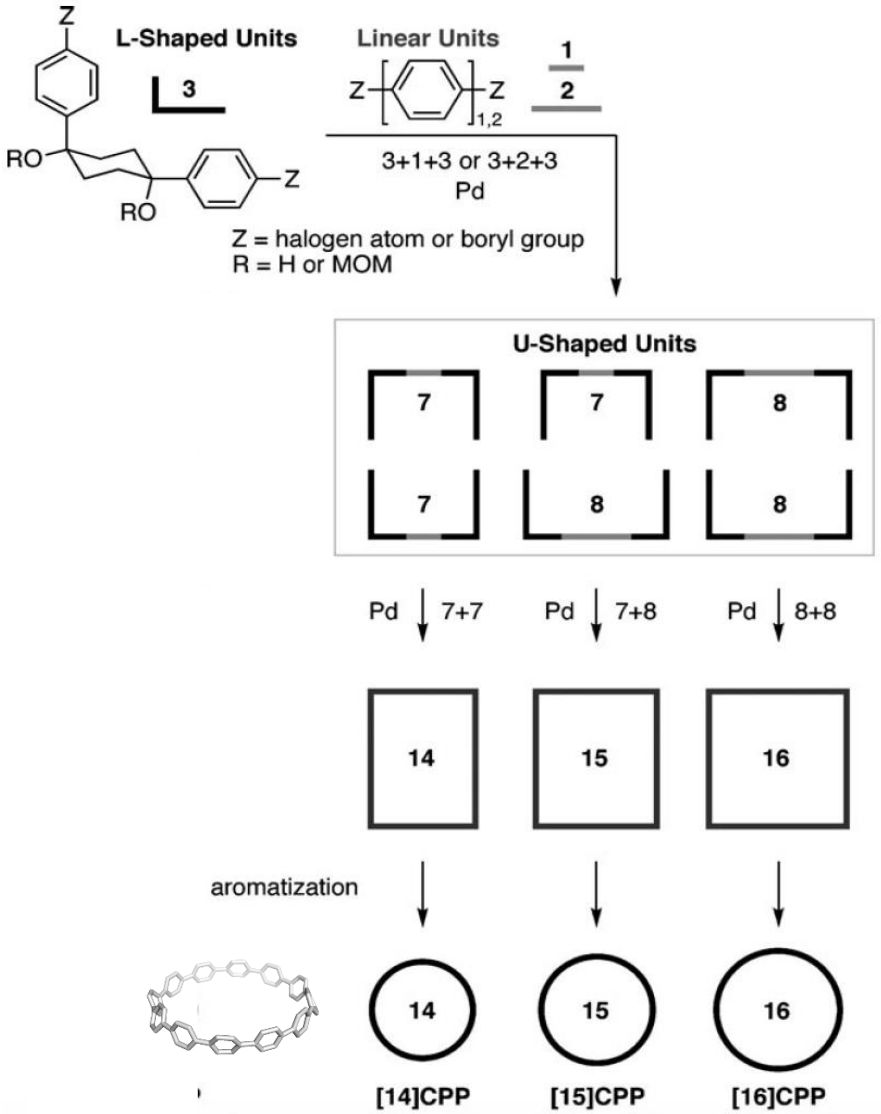



Y. Saito, K. Yamanoue, Y. Segawa, K. Itami; *Chem*, **2020**, *6*, 985–993
Y. Saito, Y. Segawa, K. Itami; *J. Am. Chem. Soc.* **2015**, *137*, 5193–5198

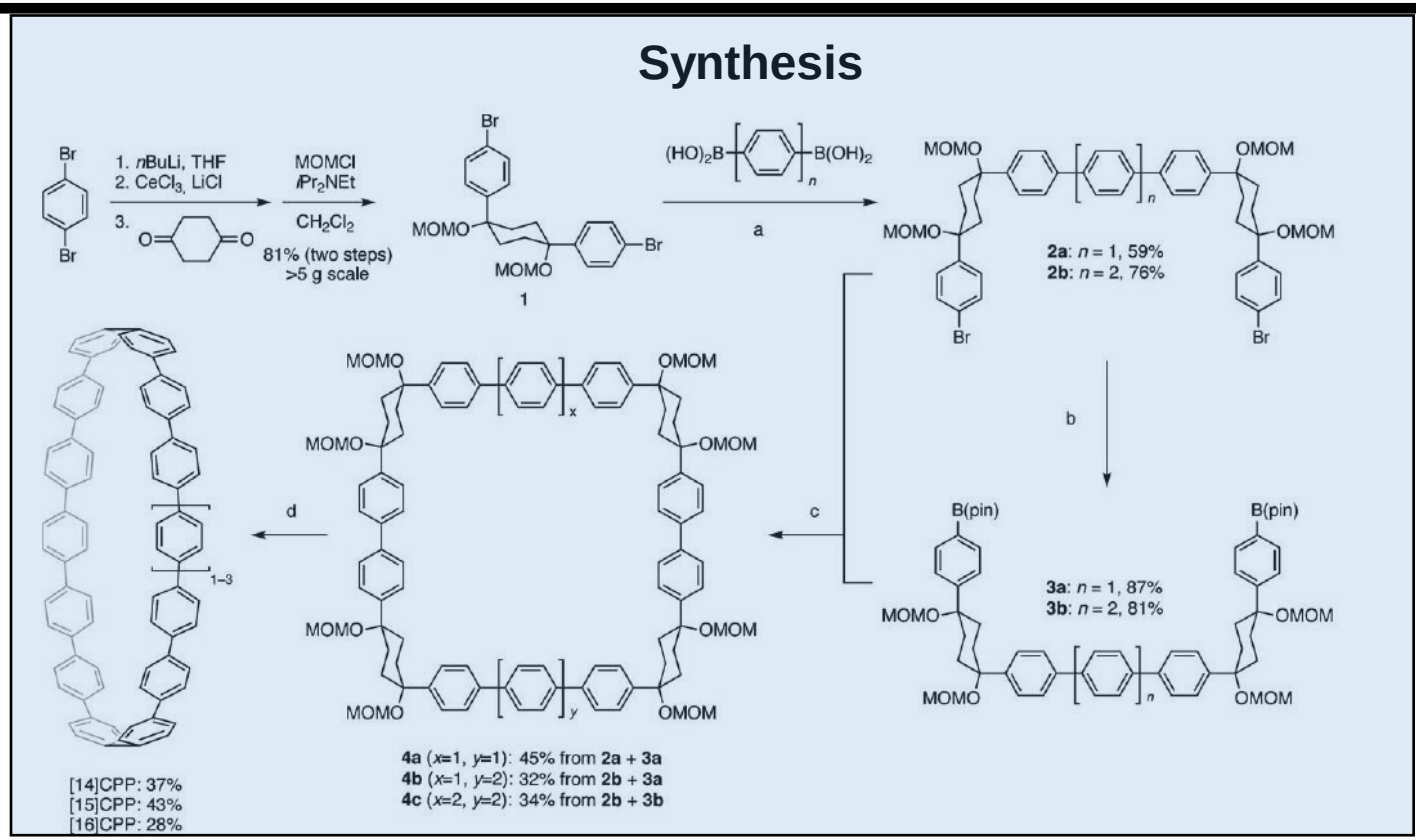
# Prof. Kenichiro Itami

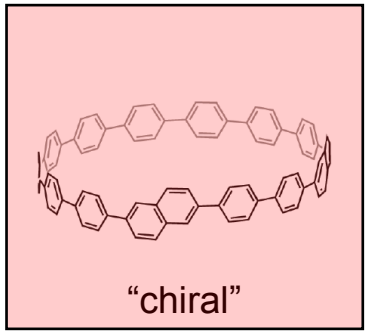
N. Gabicki

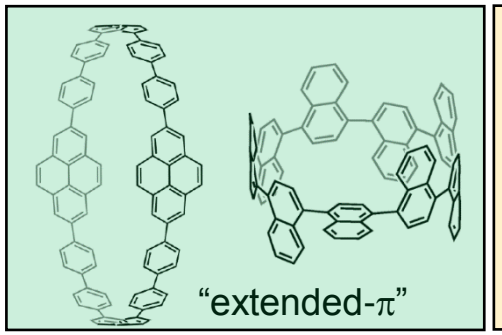
## General concept

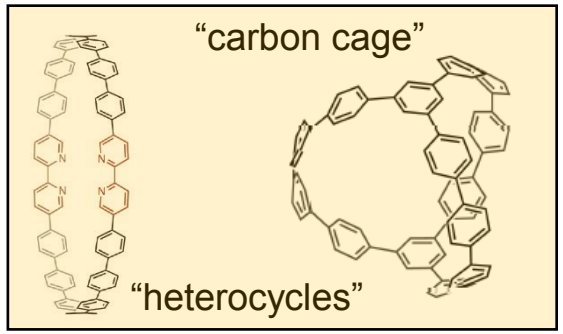



## Synthesis





H. Omachi, S. Matsuura, Y. Segawa, K. Itami; *Angew. Chem. Int. Ed*. **2010**, *49*, 10202–10205

H. Takaba, H. Omachi, Y. Yamamoto, J. Bouffard, K. Itami; *Angew. Chem. Int. Ed.*, **2009**, *121*, 6228–6232

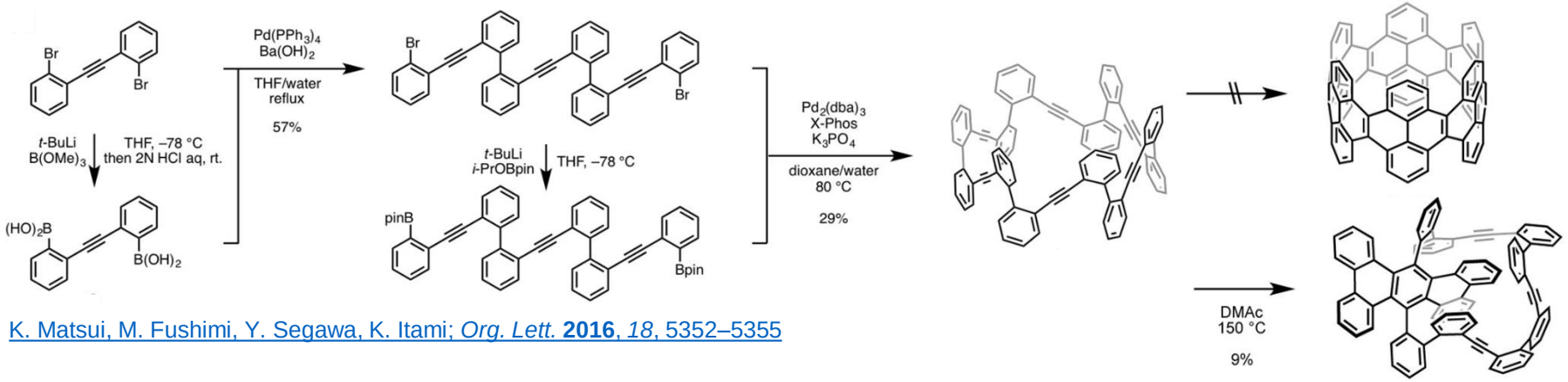
H. Omachi, Y. Segawa, K. Itami; *Org. Lett.* **2011**, *13*, 2480–2483

A.Yagi, G. Venkataramana,Y. Segawa,K. Itami; *Chem. Commun*., **2014**, *50*, 957–959

A. Yagi, Y. Segawa, K. Itami; *J. Am. Chem. Soc.* **2012**, *134*, 2962−2965

K. Matsui, Y. Segawa, K. Itami; *Org. Lett.* **2012**, *14*, 1888–1891

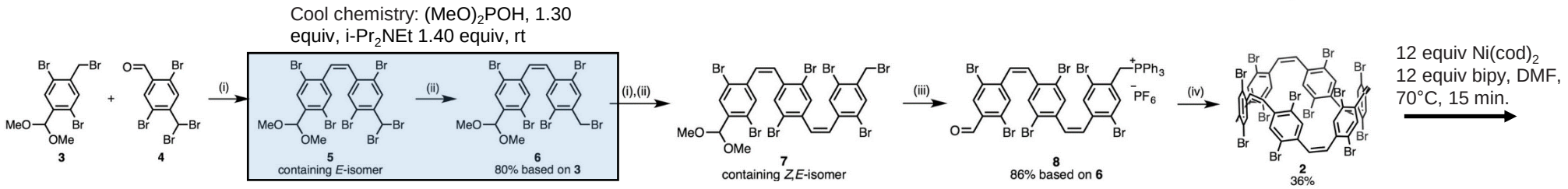
K. Matsui, Y. Segawa, K. Itami; *J. Am. Chem. Soc.* **2014**, *136*, 16452–16458

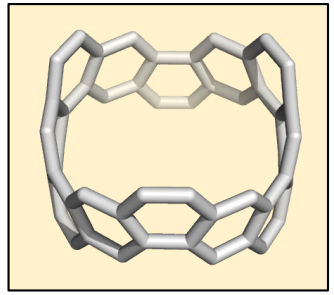



Calculations support 2 x [2+2] cycloaddition followed by bis-cyclobuten ring opening

K. Matsui, M. Fushimi, Y. Segawa, K. Itami; *Org. Lett.* **2016**, *18*, 5352–5355

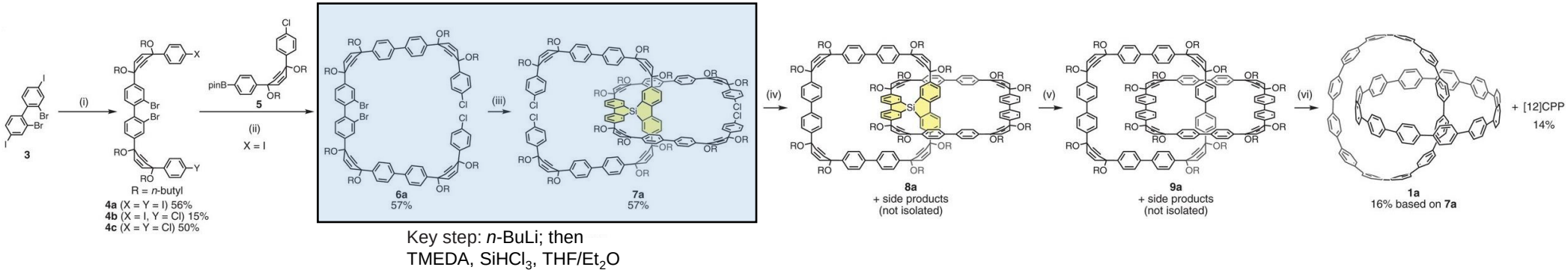
Cool chemistry: $(MeO)_2POH$, 1.30 equiv, i-$Pr_2NEt$ 1.40 equiv, rt



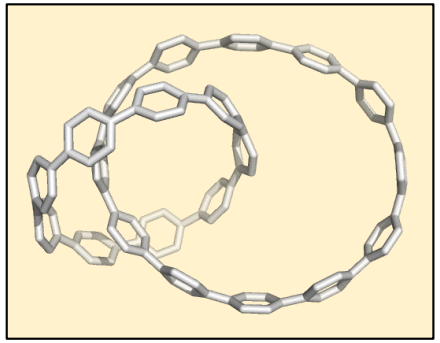



G. Povie, Y. Segawa, T. Nishihara, Y. Miyauchi, K. Itami; *Science*, **2017**, *356*, 172–175

X-Ray structures

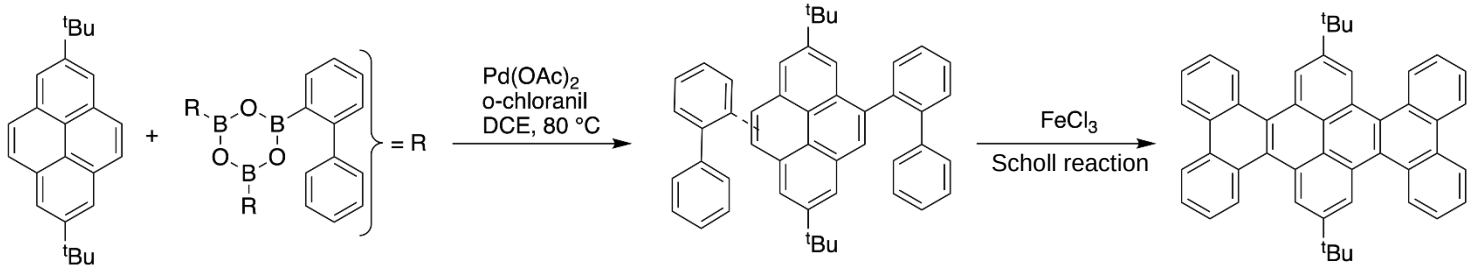



Key step: *n*-BuLi; then TMEDA, $SiHCl_3$, $THF/Et_2O$



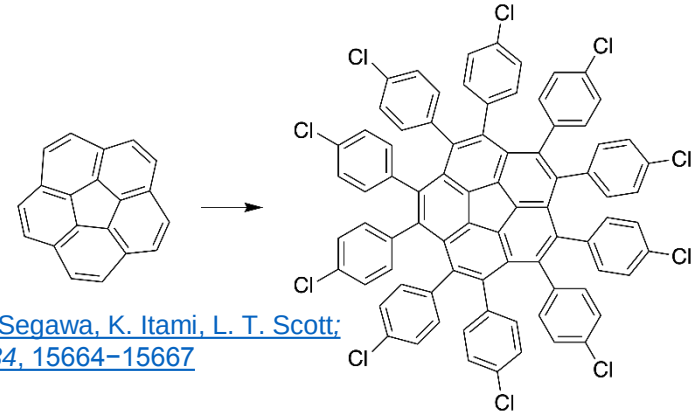
Y. Segawa, M. Kuwayama, Y. Hijikata, M. Fushimi, T. Nishihara, J. Pirillo, J. Shirasaki, N. Kubota, K. Itami; *Science*, **2019**, *365*, 272–276

- „**APEX**“ Methodology on polycyclic aromatic hydrocarbons (PAH‘s) developing methods for Annulative π-Extension (APEX)



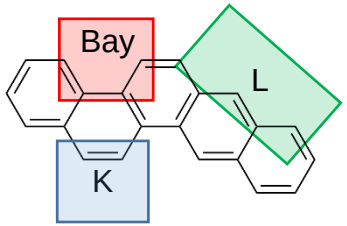

gram scale, up to 80%

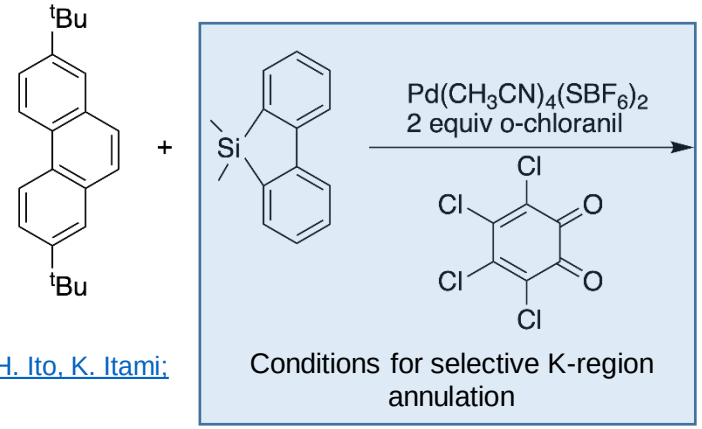
K. Mochida, K. Kawasumi, Y. Segawa, K. Itami; *J. Am. Chem. Soc.* **2011**, *133*, 10716–10719




Q. Zhang, K. Kawasumi, Y. Segawa, K. Itami, L. T. Scott; *J. Am. Chem. Soc.* **2012**, *134*, 15664−15667

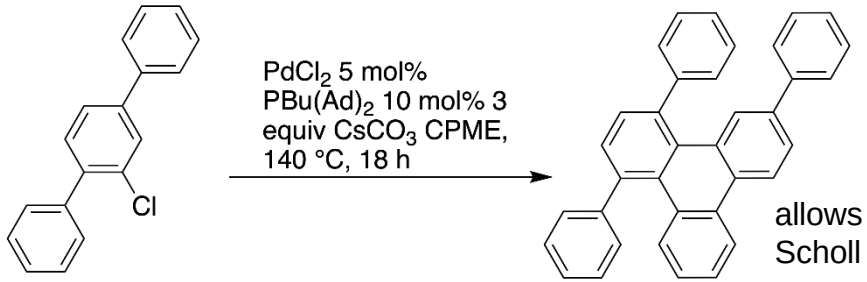
Bay = Diels–Alder selectivity




Conditions for selective K-region annulation

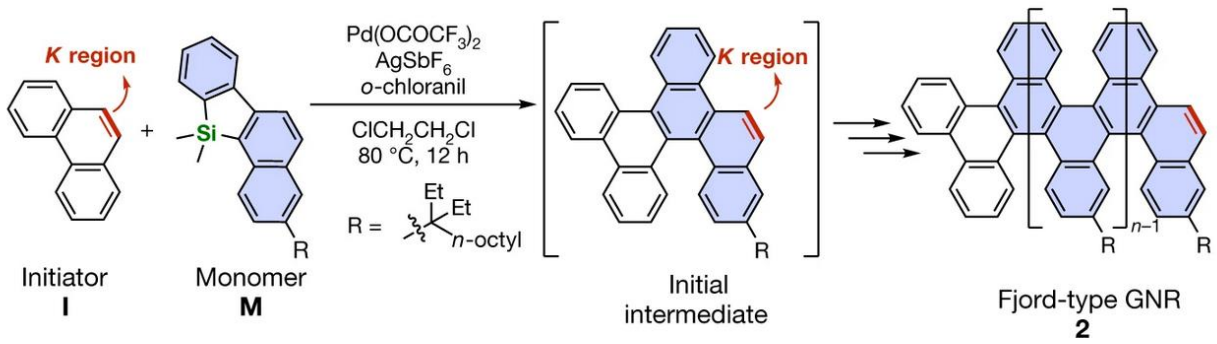
K. Ozaki, K. Kawasumi, M, Shibata, H. Ito, K. Itami; *Nat. Comm.* **2015**, *6*, 6251




allows subsequent Scholl reaction

Y. Koga, T. Kaneda, Y. Saito, K. Murakami, K. Itami; *Science*, **2018**, *359*, 435–439

“Living **APEX** polymerization”



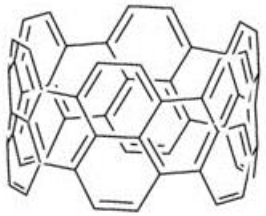

| M/I | $M_n$[a] (kDa) | $Đ$[a] | DP[a,b] | Length (nm)[c] | Yield of **2**[d] |
|---|---|---|---|---|---|
| 10 : 1 | 2.9 | 1.25 | 7 | 3 | 75% |
| 50 : 1 | 13 | 1.23 | 34 | 15 | 72% |
| 100 : 1 | 32 | 1.21 | 83 | 36 | 85% |
| 300 : 1 | 97 | 1.22 | 253 | 109 | 86% |
| 500 : 1 | 150 | 1.22 | 391 | 169 | 82% |

Y. Yano, N. Mitoma, K. Matsushima, F. Wang, K. Matsui, A. Takakura, Y. Miyauchi, H. Ito, K. Itami; *Nature*, **2019**, *571*, 387–392

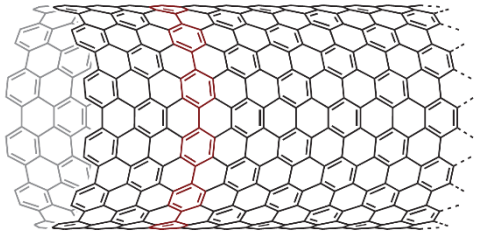
***What's next?***

- Bottom-up Synthesis of $C_{60}$ Fullerene?

- *Vögtle*-Belt structures *via* annulative dimerization of CPPs?



- Solution-phase synthesis of all carbon nanotubes?



http://synth.chem.nagoya-u.ac.jp/wordpress/?lang=en