

# The 5th China-Japan Young Chemists Forum

## Molecular Activation Directed toward Straightforward Organic Synthesis

The Chemical Society of Japan  
The 95th Annual Meeting

**Date** March 27th, 2015

**Venue** Funabashi Campus, Nihon University,  
Chiba, Japan



**The Chinese Chemical Society**



**The Chemical Society of Japan**



# Welcome Address

Welcome to the 5th China-Japan Young Chemists Forum, held at the same venue as the 95th CSJ Annual Meeting, Funabashi Campus, College of Science and Technology, Nihon University, Chiba, Japan on March 27th, 2015, under the co-sponsorship of the Chinese Chemical Society (CCS) and the Chemical Society of Japan (CSJ).



The CSJ has a history of 137 years, with a current membership of about 30,000, and is one of the most influential learned societies in Japan, covering most areas of pure and applied chemistry both in academia and industry.

Our prime mission is to contribute to social development through advancing science, developing technology, promoting industry, diffusion of knowledge relating to chemistry, and developing human resources. To pursue this mission, the CSJ holds various conferences, such as "the CSJ Annual Meeting" with 8,500 participants every spring, and "CSJ Chemistry Festa" every autumn.

This series of bilateral meetings originates from the first one in 2010 held in Xiamen University, followed by the second in 2012 at Sichuan University and the third in 2013 at Ritsumeikan University during the 93rd CSJ Annual Meeting. The fourth Forum was held in 2014 at Peking University during the 29th CCS Annual Meeting

*"A Molecular Activation Directed toward Straightforward Organic Synthesis"*, the topic of the 2015 China-Japan Forum is a highly advanced interdisciplinary field that covers from organotransition metal chemistry to organic synthesis, featuring novel metal complexes that enable activation of unreactive C-H and C-C bonds, catalytic CO<sub>2</sub> fixation, novel radical reactions, catalytic C-H and C-O functionalizations and their applications to total synthesis of natural products. Ten distinguished scientists in the area of advanced measurements are invited to present their research results and to exchange information and ideas.

I would like to thank co-Chairs Prof. NAKAO, Yoshiaki, Kyoto University and Prof. SHI, Zhang-Jie, Peking University, for their great efforts to make this forum possible. It is my hope that this joint event will contribute to the rapid development of this field toward useful applications and I also have great expectations that all of the attendants will strengthen their friendships and find new colleagues throughout the forum and the CSJ Annual Meeting for further collaboration.

A handwritten signature in black ink, appearing to read 'N. Kawashima'.

Mr. Nobuyuki Kawashima  
Executive Director / Secretary General  
The Chemical Society of Japan  
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**The 5th China-Japan Young Chemists Forum**  
**—Molecular Activation Directed toward Straightforward Organic Synthesis—**  
The Chemical Society of Japan    The 95th Annual Meeting

- Date    March 27th (Fri), 2015 10:00-17:10
- Venue   Room 1424 (S6) 2nd Floor 14th Bldg.,
- Funabashi Campus, Nihon University, Chiba, Japan
- Hosted by The Chemical Society of Japan (CSJ)
- Co-hosted by The Chinese Chemical Society (CCS)

■10:00	Opening Remarks	<b>Zhang-Jie SHI</b> Peking University	... 1
■10:10	One or Two Electron Redox, Radical Oxidative Coupling and Mechanism Revealed by Operando XAS, Raman, EPR, and IR	<b>Aiwen LEI</b> Wuhan University	... 2
■10:40	C-H and C-C Bond Cleavage by Using Group 9 Metal Complexes Possessing a Boron-Based Pincer Ligand	<b>Makoto YAMASHITA</b> Chuo University	... 4
■11:10	C-N Bonds Construction Based on Nitrogen-Centered Radicals	<b>Qian ZHANG</b> Northeast Normal University	... 6
■11:40	Carboxylation of Unsaturated Hydrocarbons with CO <sub>2</sub> Catalyzed by Palladium Complexes Bearing a Group 14 Element-based Pincer Type Ligand	<b>Jun TAKAYA</b> Tokyo Institute of Technology	... 8
■12:10	Highly Efficient Methodologies via Aerobic Oxygenation	<b>Ning JIAO, et al.</b> Peking University	... 10
■12:40	<b>Lunch Break</b>		
■14:30	Directed C-H Bond Activation Using Iron Catalysis	<b>Laurean ILIES, et al.</b> The University of Tokyo	... 12
■15:00	Phosphine-Participated C-H Transformation	<b>Shang-Dong YANG</b> Lanzhou University	... 14
■15:30	A C-H Arylation/Ring Transformation Approach: Synthesis of Polyarylated Arenes and Natural Products	<b>Junichiro YAMAGUCHI</b> Nagoya University	... 16
■16:00	Act like Molecule Transformers — Rapid Creation of Molecular Complexity through Strategic Bond Disconnections	<b>Guangxin LIANG</b> Nankai University	... 18
■16:30	Cross-Coupling Reactions via the Activation of Inert Carbon-Oxygen Bonds	<b>Mamoru TOBISU</b> Osaka University	... 20
■17:00	Closing Remarks	<b>Yoshiaki NAKAO</b> Kyoto University	... 22

# Zhang-Jie SHI

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Peking University Beijing 100871 China  
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## ➤ Educational Background

1992-1996 East China Normal University, B.Sc.  
1996-2001 Shanghai Institute of Organic Chemistry, CAS,  
(Supervised by Professor Shengming Ma), Ph.D

## ➤ Academic Career

2001-2002 Harvard University (Mentor: Professor Gregory L. Verdine), Fellow  
2002-2004 The University of Chicago (Mentor: Professor Chuan He), Associate  
2004-2008 Peking University, Associate Professor  
2008-present Peking University, Professor  
2012-present Peking University, Changjiang Professor

## ➤ Research Interests

Zhangjie Shi and his team are aiming at developing efficient and economic synthetic methodologies as well as understanding the intrinsic properties of the inert bonds to meet the requirement of green and sustainable development. His current work is focused on direct transformations of “inert” chemical bonds, including C-O, C-H and C-Cs.

## ➤ Awards

Chief Scientist for “973” Project from MOST (2014), National Excellent Contributor in Science and Technology (2014), HLHL Innovative Award of Science and Technology (2014), Mr. and Mrs. Sun Chan Memorial Award (2014), Highly Cited Researcher (2014), Mao Yisheng Young Investigator Award of Science of Technology of Beijing City (2013), The Second Rank Award of National Natural Sciences (2013), OMCOS Award (2013), Wuxi Apptec Excellence Chemistry Award for Life Sciences (2012), Lilly Excellence Chemistry Award (2012), ACP Lectureship Award (2012, Japan and Singapore), Tetrahedron Young Investigator Award (2011), CCS-RSC Excellent Young Chemist Award (2011), SFB Guest Professorship (University of Munster, Germany, 2010), Adjunct Professor (Beijing University of Science and Technology, 2010), Scopus Young Star of Sciences (2010), Distinguished Young Investigator Foundation (NSFC, 2009), New Star on Creative Research of Beijing City (2009), P&G Excellent Teaching Award (2008) CAPA Distinguished Professor Award (2008), The First Rank Fok Ying Tung Education Foundation Award (2008), CCS-John Wiley Excellent Chemistry Award (2008), The Second Rank Award of National Natural Sciences (2007), Distinguished Young Chemist Award of Chinese Chemical Society (2007), Synlett/Synthesis Journal Award (2006), The First Rank Award of Science and Technology of Shanghai City (2005)

## ➤ Recent Publications

118 (cited by others: more than 7500, H index: 46)

## ➤ Edited

Homogeneous Catalysis in C-X Activation (Editor, 2014), C-H Activation (Co-Editor), and other 6 chapters in different books.

# Aiwen LEI

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## ➤ Educational Background

1995 B.Sc., Huaibei Normal University  
2000 Ph.D., Shanghai Institute of Organic Chemistry (supervisor: Prof. Xiyan Lu)

## ➤ Professional Career

2000-2003 Postdoctoral Fellow, Pennsylvania State University  
2003-2005 Research Associate, Stanford University  
2005- now Professor, Wuhan University

## ➤ Research Interests

1) Developing highly selective and efficient transition-metal-catalyzed C-C, and C-heteroatom bond formation in syntheses, e.g. oxidative coupling reactions, C-H bond functionalization  
2) Mechanistic studies including kinetic and active intermediate studies

## ➤ Awards

2008 Chinese Chemistry Society—John Wiley Young Chemist Award  
2009 CAPA Distinguished Faculty Award  
2010 National Science Fund for Distinguished Young Scholars, China  
2011 Eli Lilly Scientific Excellence Award in Chemistry  
2012 First-Class Natural Science Award of Hubei Province  
2013 Asian Rising Stars (15th ACC Meeting)  
2014 Chinese Chemistry Society—Royal Society of Chemistry Young Chemist Award

## ➤ Recent Publications

1. "From Anilines to Isatins: Palladium-Catalyzed Oxidative C–H Double Carbonylation ", Wu Li, Zhengli Duan, Xueye Zhang, Heng Zhang, Mengfan Wang, Ru Jiang, Hongyao Zeng, Chao Liu and Aiwen Lei. *Angew. Chem. Int. Ed.* **2015**, DOI: 10.1002/anie.201410321.
2. "Chloroacetate-Promoted Selective Oxidation of Heterobenzylic Methylenes under Copper Catalysis ", Jianming Liu, Xin Zhang, Hong Yi, Chao Liu, Ren Liu, Heng Zhang, Kelei Zhuo, and Aiwen Lei. *Angew. Chem. Int. Ed.* **2015**, DOI: 10.1002/anie.201409580.
3. "Direct Observation of Reduction of Cu(II) to Cu(I) by Terminal Alkynes", Guanghui Zhang, Hong Yi, Guoting Zhang, Yi Deng, Ruopeng Bai, Heng Zhang, Jeffrey T. Miller, A. Jeremy Kropf, Emilio E. Bunel, and Aiwen Lei. *J. Am. Chem. Soc.* **2014**, 136, 924.
4. "Visible Light Mediated Decarboxylation / Oxidative Amidation of  $\alpha$ -Keto Acids with Amines under Mild Conditions Using O<sub>2</sub>", Jie Liu, Qiang Liu, Hong Yi, Chu Qin, Ruopeng Bai, Xiaotian Qi, Yu Lan, and Aiwen Lei. *Angew Chem Int Ed* **2014**, 53, 502.



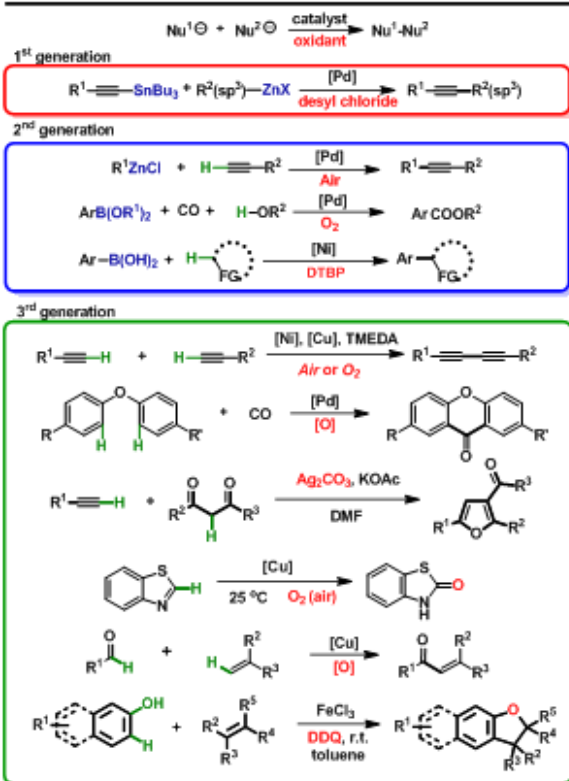
# One or Two Electron Redox, Radical Oxidative Coupling and Mechanism Revealed by Operando XAS, Raman, EPR, and IR

Aiwen LEI

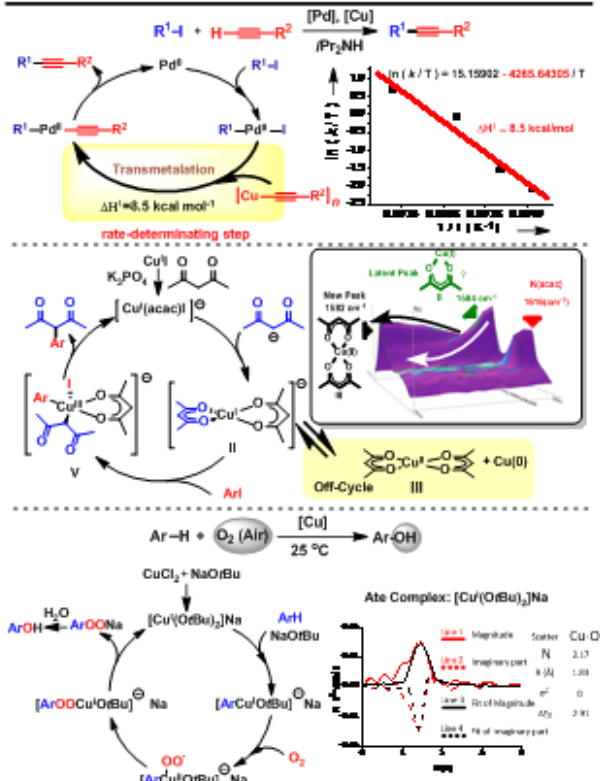
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Our research focuses on the oxidative coupling to develop a novel and efficient bond-formation method between two nucleophiles. We have successfully developed three generations of oxidative coupling. In addition, in-depth understanding toward the reactions is the other focus. Recently, a new series of oxidative coupling reactions have been developed. New insights into the reaction mechanism have also been revealed by operando X-ray absorption, Raman, electron paramagnetic resonance, and nuclear

## Oxidative Coupling



## Mechanistic & Kinetic Investigation



magnetic resonance spectroscopy.

## References

- (a) Liu, C.; Zhang, H.; Shi, W.; Lei, A. W., *Chem. Rev.* **2011**, *111* (3), 1780-1824; (b) Liu, Q.; Zhang, H.; Lei, A. W., *Angew. Chem. Int. Ed.* **2011**, *50* (46), 10788-10799; (c) He, C.; Ke, J.; Xu, H.; Lei, A. W., *Angew. Chem. Int. Ed.* **2013**, *52* (5), 1527-1530; (d) He, C.; Zhang, G. H.; Ke, J.; Zhang, H.; Miller, J. T.; Kropf, A. J.; Lei, A. W., *J. Am. Chem. Soc.* **2013**, *135* (1), 488-493.



## Makoto YAMASHITA

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URL: <http://www.chem.chuo-u.ac.jp/~element/index-e.html>



### ➤ Educational Background

- 1997 B.Sc., Hiroshima University (supervisor: Prof. Kin-ya Akiba)
- 1999 M.Sc., Graduate School of Science, Hiroshima University (supervisor: Prof. Kin-ya Akiba)
- 2002 Doctor of Science, Graduate School of Science, Hiroshima University (supervisors: Profs. Kin-ya Akiba, Yohsuke Yamamoto)

### ➤ Professional Career

- 2001 JSPS research fellow (DC2,PD)
- 2002 postdoctoral fellow, Yale University (Prof. John F. Hartwig)
- 2003 postdoctoral fellow, The University of Tokyo (Prof. Takayuki Kawashima)
- 2004 Research Associate, The University of Tokyo (w. Prof. Kyoko Nozaki)
- 2007 Assistant Professor, The University of Tokyo
- 2008 Senior Lecturer, The University of Tokyo
- 2011 Associate professor (Principal Investigator), Chuo University

### ➤ Research Interests

- 1) Organometallic chemistry for homogeneous catalyst
- 2) Main group chemistry for new species, structure, and properties
- 3) Chemistry of coal tars for organic devices in future

### ➤ Awards

- 2005 Inoue Research Award for Young Scientist
- 2009 Chemical Society of Japan Award for Young Chemists
- 2009 The Young Scientists' Prize from the Minister of Education, Culture, Sports, Science and Technology
- 2010 Banyu Chemist Award
- 2015 Thieme Chemistry Journal Award

### ➤ Recent Publications

1. "Synthesis, Structure, and Bonding Properties of Ruthenium Complexes Possessing a Boron-Based PBP Pincer Ligand and Their Application for Catalytic Hydrogenation" Miyada, T.; Huang Kwan, E.; Yamashita, M., *Organometallics* **2014**, 33, 6760.
2. "Assessing the Brønsted Basicity of Diaminoboryl Anions: Reactivity toward Methylated Benzenes and Dihydrogen" Dettenrieder, N.; Aramaki, Y.; Wolf, B. M.; Maichle-Mössmer, C.; Zhao, X.; Yamashita, M.; Nozaki, K.; Anwender, R., *Angew. Chem. Int. Ed.* **2014**, 53, 6259.
3. "Facile scission of isonitrile carbon–nitrogen triple bond using a diborane(4) reagent" Asakawa, H.; Lee, K.-H.; Lin, Z.; Yamashita, M., *Nat. Commun.* **2014**, 5, 4245.



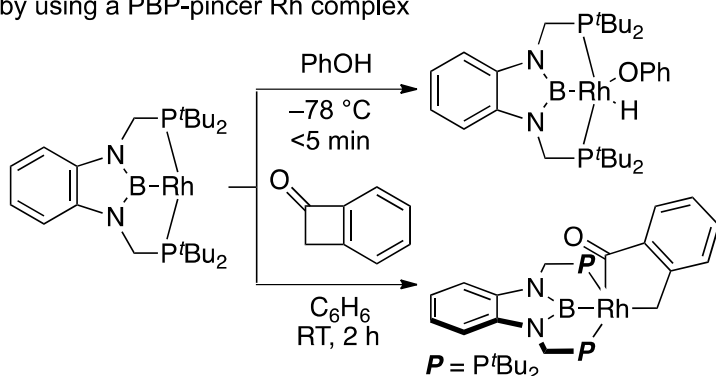
# C-H and C-C Bond Cleavage by Using Group 9 Metal Complexes Possessing a Boron-Based Pincer Ligand

Makoto YAMASHITA

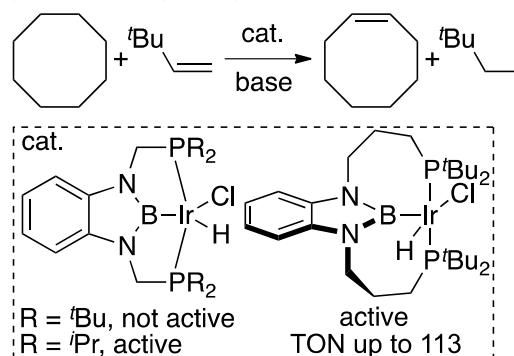
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"Pincer ligand" is a class of tridentate ligand coordinating to metal atoms in a meridional fashion. Recently, activation reactions of inert bonds and small molecules using pincer complexes have been widely explored. On the other hand, transition metal boryl complexes have been interested in their catalytic performance and very strong donor ability of boryl ligand.<sup>1</sup> However, it is difficult to utilize the boryl complex for catalytic reaction other than borylation due to the high reactivity of anionic boryl ligand. Recently, we reported synthesis of a novel boron-containing tridentate PBP-pincer ligand precursor and its complexation with transition metals.<sup>2</sup> Herein, we report reactivity PBP-pincer Rh complexes toward O-H bond of phenol and aliphatic alcohols and C-C bond of benzocyclobutenone (Scheme 1).<sup>3</sup> The similar PBP-pincer Ir complexes possessing a structurally modified pincer ligand were also found to catalyze the transfer dehydrogenation of cyclooctane in the presence of hydrogen acceptor (Scheme 2).<sup>4</sup> Catalytic activity of these complexes were altered by the structure of the ligand. In the presentation, details about chemistry of newly obtained PBP-pincer complexes will be reported.

Scheme 1. O-H and C-C bond cleavage by using a PBP-pincer Rh complex



Scheme 2. Catalytic dehydrogenation of cyclooctane by using PBP-Ir complexes



## References

1. Irvine, G. J.; Lesley, M. J. G.; Marder, T. B.; Norman, N. C.; Rice, C. R.; Robins, E. G.; Roper, W. R.; Whittell, G. R.; Wright, L. J., *Chem. Rev.* **1998**, 98, 2685-2722.
2. (a) Segawa, Y.; Yamashita, M.; Nozaki, K., *J. Am. Chem. Soc.* **2009**, 131, 9201. (b) Segawa, Y.; Yamashita, M.; Nozaki, K., *Organometallics* **2009**, 28, 6234. (c) Miyada, T.; Yamashita, M., *Organometallics* **2013**, 32, 5281-5284. (d) Ogawa, H.; Yamashita, M., *Dalton Trans.* **2013**, 42, 625-629. (e) Miyada, T.; Huang Kwan, E.; Yamashita, M., *Organometallics* **2014**, 33, 6760-6770. (f) Ogawa, H.; Yamashita, M., *Chem. Lett.* **2014**, 43, 664-666.
3. (a) Hasegawa, M.; Segawa, Y.; Yamashita, M.; Nozaki, K., *Angew. Chem. Int. Ed.* **2012**, 51, 6956. (b) Y. Masuda, M. Hasegawa, M. Yamashita, K. Nozaki, N. Ishida, M. Murakami, *J. Am. Chem. Soc.* **2013**, 135, 7142.
4. Kawai, J. Y.; Tanoue, K.; Yamashita, M. unpublished results.



## Qian ZHANG

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### ➤ Educational Background

1993 B.Sc., Northeast Normal University,

1996 M.Sc., Northeast Normal University, (supervisor: Prof. Qun Liu)

2003 Changchun Institute of Applied Chemistry, CAS (supervisor: Prof. Lixiang Wang)

### ➤ Professional Career

2004 The University of Sydney, Australia, 2004 (Visiting Scholar)

2004 Assistant professor, Northeast Normal University

2008 Professor, Northeast Normal University

### ➤ Research Interests

1) the area for the construction of C–N bonds

2) the development of new radical amination reagents

### ➤ Awards

2014 Thieme Chemistry Journals Award

### ➤ Recent Publications

1. Palladium-Catalyzed C–H Aminations of Anilides with *N*-Fluorobenzenesulfonimide, K. Sun, Y. Li, T. Xiong, J. Zhang, Q. Zhang,\* *J. Am. Chem. Soc.*, **2011**, *133*, 1694-1697.
2. Copper-Catalyzed Dehydrogenative Cross-Coupling Reactions of *N*-*p*-Tolylamides through Successive C–H Activation: Synthesis of 4*H*-3,1-Benzoxazines, T. Xiong, Y. Li, X. Bi,\* Y. Lv, Q. Zhang,\* *Angew. Chem., Int. Ed.*, **2011**, *50*, 7140-7143.
3. Highly Regioselective Copper-Catalyzed Benzylic C–H Amination by *N*-Fluorobenzenesulfonimide, Z. Ni, Q. Zhang,\* T. Xiong, Y. Zheng, Y. Li, H. Zhang, J. Zhang,\* and Q. Liu,\* *Angew. Chem., Int. Ed.*, **2012**, *51*, 1244-1247.
4. Copper-Catalyzed Intermolecular Aminocyanation and Diamination of Alkenes, H. Zhang, W. Pu, T. Xiong,\* Y. Li,\* X. Zhou, K. Sun, Q. Liu, and Q. Zhang,\* *Angew. Chem., Int. Ed.*, **2013**, *52*, 2529-2533.
5. Regioselective Radical Aminofluorination of Styrenes, H. Zhang, Y. Song, J. Zhao, J. Zhang,\* and Q. Zhang,\* *Angew. Chem., Int. Ed.*, **2014**, *53*, 11079-11083.

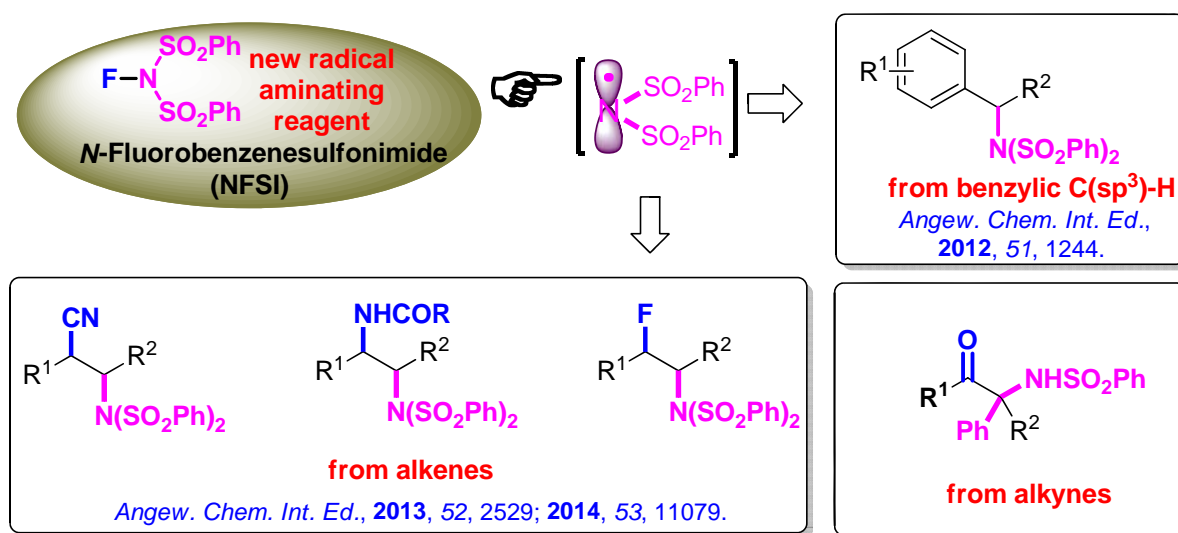
# C-N Bonds Construction Based on Nitrogen-Centered Radicals

Qian ZHANG

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P. R. China

The construction of C–N bond is of great importance because of the interesting and diverse biological activities of nitrogen-containing compounds. Nitrogen-centered radicals, highly reactive and short-lived species, have been efficiently employed in amination reaction. However, compared with the well established nucleophilic and electrophilic amination reaction, the construction of C–N bonds based on nitrogen-centered radicals have not received sufficient attention, which can be partly attributed to harsh conditions for the generation of nitrogen-centered radicals and their leading propensity for hydrogen abstraction or engaging in other degradation pathway.

Recently, radical fluorine atom transfer reaction of *N*-Fluorobenzenesulfonimide (NFSI) was realized, which suggested that NFSI might become a radical amination reagent. Through the well combination of copper catalysts and NFSI, acted as copper stabilized nitrogen-centered radical, for the first time, we realized benzylic C(sp<sup>3</sup>)–H direct amination reactions, highly regio-selective aminative difunctionalization reactions of alkenes and aminative multiple-functionalization of alkynes (Figure 1).



**Figure 1.** Amination Reactions with *N*-Fluorobenzenesulfonimide as Nitrogen-centered Radical.



## Jun TAKAYA

Associate Professor

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### ➤ Educational Background

1999 B.Sc., Gakushuin University (supervisor: Prof. Takahiko Akiyama)

2001 M.Sc., Graduate School of Science, Gakushuin University (supervisor: Prof. Takahiko Akiyama)

2004 Doctor of Science, Graduate School of Science and Engineering, Tokyo Institute of Technology (supervisor: Prof. Nobuharu Iwasawa)

### ➤ Professional Career

2004 JSPS postdoctoral fellow, Yale University

2005 Assistant professor, Tokyo Institute of Technology

2014 Associate professor, Tokyo Institute of Technology

### ➤ Research Interests

- 1) Design, synthesis, and utilization of functional transition metal complexes
- 2) Development of new synthetic reactions

### ➤ Awards

2013 Incentive Award in Synthetic Organic Chemistry, Japan

2014 Banyu Chemist Award

2014 Thieme Chemistry Journal Award 2015

2014 Lectureship Award MBLA 2014

### ➤ Recent Publications

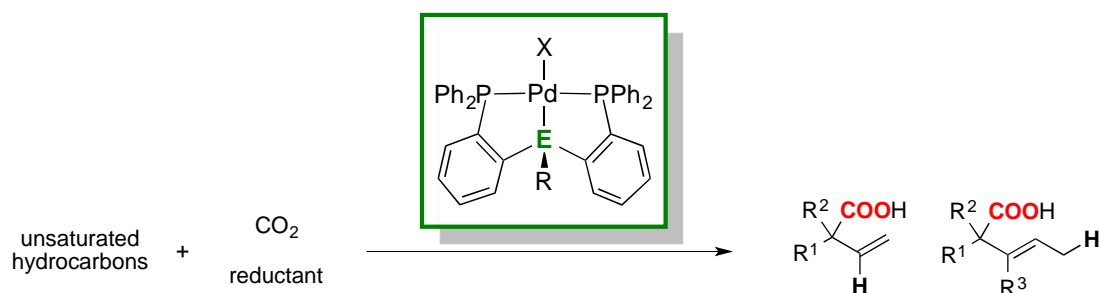
1. "Direct Carboxylation of Simple Arenes with CO<sub>2</sub> through a Rhodium-Catalyzed C–H Bond Activation" T. Suga, H. Mizuno, J. Takaya, N. Iwasawa, *Chem. Commun.*, **2014**, 50, 14360.
2. "Silyl Ligand-Mediated Reversible  $\beta$ -Hydrogen Elimination and Hydrometallation at Palladium" J. Takaya, N. Iwasawa, *Chem. Eur. J.*, **2014**, 20, 11812.
3. "Mechanistic Studies on the Stereoisomerization between Two Stereoisomeric, Isolable Five-Coordinate Borylpalladium(II) Complexes Bearing a Phenylene-Bridged PSiP-Pincer Type Ligand" J. Takaya, N. Kirai, N. Iwasawa, *Organometallics*, **2014**, 33, 1499.
4. "PSiP-Pincer Type Palladium-Catalyzed Dehydrogenative Borylation of Alkenes and 1,3-Dienes" N. Kirai, S. Iguchi, T. Ito, J. Takaya, N. Iwasawa, *Bull. Chem. Soc. Jpn.*, **2013**, 86, 784.
5. "Palladium(II)-Catalyzed Direct Carboxylation of Alkenyl C–H Bonds with CO<sub>2</sub>" K. Sasano, J. Takaya, N. Iwasawa, *J. Am. Chem. Soc.*, **2013**, 135, 10954.
6. "Two Reversible sigma-Bond Metathesis Pathways for Boron-Palladium Bond Formation: Selective Synthesis of Isomeric Five-Coordinate Borylpalladium Complexes" N. Kirai, J. Takaya, N. Iwasawa, *J. Am. Chem. Soc.*, **2013**, 135, 2493.

# Carboxylation of Unsaturated Hydrocarbons with CO<sub>2</sub> Catalyzed by Palladium Complexes Bearing a Group 14 Element-based Pincer Type Ligand

Jun TAKAYA

*Department of Chemistry, Tokyo Institute of Technology, O-okayama, Meguro-ku, Tokyo, 152-8551, Japan*

We have been developing new synthetic reactions utilizing palladium complexes bearing a PSiP–pincer type ligand as a catalyst. Salient features of the PSiP–palladium complex are as follows; 1) Strong trans influence of the silicon atom enhances reactivity of its trans substituent. 2) The strained square planar structure of the PSiP-linkage facilitates structural change to trigonal bipyramidal geometry, allowing unique fluxional behaviors of the silicon atom via an  $\eta^2$ –(Si–H)Pd(0) intermediate. Consequently, we have developed hydrocarboxylation reaction of unsaturated hydrocarbons with CO<sub>2</sub> and selective dehydrogenative borylation of alkenes and dienes with diboron by utilizing characteristics of the PSiP–palladium complexes. Furthermore, new reaction mechanisms for bond activation and formation with  $\eta^2$ –(Si–H)Pd(0) intermediate through fluxional behavior of the silicon ligand were revealed, demonstrating promising utility of the PSiP–pincer ligand in organometallic and synthetic chemistry. In this presentation, we describe recent progress in the PEP–palladium-catalyzed CO<sub>2</sub>-fixation reaction (E=group 14 element) and some new mechanistic insights into  $\eta^2$ –(Si–H)Pd(0)-mediated molecular transformations.



**Figure 1.** New CO<sub>2</sub>-fixation reactions catalyzed by PEP-palladium complexes (E=Si, Ge).



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## ➤ Educational Background

- 1999 B.Sc., Shandong University, 1995-1999
- 2004 Ph.D., Shanghai Institute of Organic Chemistry, Chinese Academy of Sciences (with Prof. Shengming Ma), 1999-2004
- 2006 Postdoctoral, Max Planck Institute für Kohlenforschung (MPI), Germany, Alexander von Humboldt Fellowship (with Prof. Manfred T. Reetz), 2004-2006

## ➤ Professional Career

- 2007 Associate professor, Peking University
- 2010 Professor, Peking University

## ➤ Research Interests

Jiao's research interests are focused on: 1) To develop green and efficient synthetic methodologies through Single Electron Transfer (SET) process; 2) Aerobic oxidation, Oxygenation and Nitrogenation reactions; 3) The activation of inert chemical bonds catalyzed by the first-row transition metal catalysts.

## ➤ Awards

- 2013 National Science Fund for Distinguished Young Scholars
- 2013 The Chinese Homogenous Catalysis Young Chemist Award
- 2013 Thieme Journal Award
- 2012 National Youth Top-notch Talents
- 2010 Young Chemist Award of the Chinese Chemical Society
- 2010 CAPA Distinguished Faculty Award
- 2008 New Century Excellent Talents in University Award from Chinese Ministry of Education

## ➤ Recent Publications

1. Yu-Feng Liang and **Ning Jiao\***, Transition-Metal Free Highly Efficient C-H Hydroxylation of Carbonyls with Molecular Oxygen Under Mild Conditions, *Angew. Chem. Int. Ed.* **2014**, 53, 548.
2. Teng Wang and Ning Jiao\*, TEMPO-catalyzed Aerobic Oxygenation and Nitrogenation of Olefins via C=C Double Bond Cleavage, *J. Am. Chem. Soc.* **2013**, 135, 11692.
3. Shengtao Ding, and Ning Jiao\*, The Direct Transformation of DMF (N,N-Dimethylformamide) to -CN: Pd-catalyzed Cyanation of Heteroarenes via C-H Functionalization. *J. Am. Chem. Soc.* **2011**, 133 (32), 12374-12377.
4. Chun Zhang, and Ning Jiao\*, Dioxygen Activation at Ambient Conditions: Cu-catalyzed Oxidative Amidation-Diketonization of Terminal Alkynes. *J. Am. Chem. Soc.* **2010**, 132, 28-29.
5. Teng Wang, and **Ning Jiao\***, Direct Approaches to Nitriles via Highly Efficient Nitrogenation Strategy through C-H or C-C Bond Cleavage, *Acc. Chem. Res.* **2014**, 47, 1137.

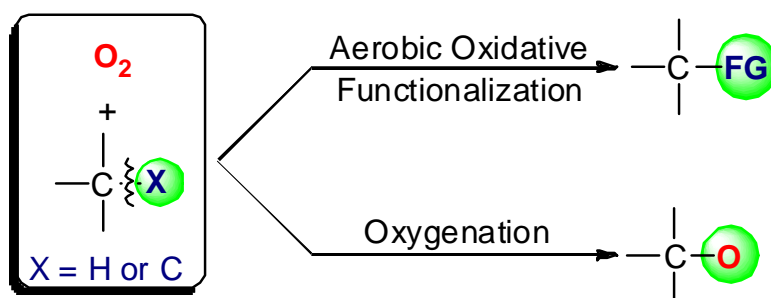


# Highly Efficient Methodologies via Aerobic Oxygenation

Ning JIAO,\* Chun ZHANG, Yijin SU, Riyuan LIN, Teng WANG, Yuepeng YAN,  
Xiang SUN, Yufeng LIANG, and Zejun XU

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On the behalf of green and sustainable chemistry, molecular oxygen has been considered as an ideal oxidant and offers attractive academic and industrial prospects.<sup>1</sup> Recently, we developed some direct dehydrogenative transformations using O<sub>2</sub> as the oxidant including the Direct-Dehydrogenative Anulation (DDA) reactions for the synthesis of heterocyclics. Using inexpensive iron, copper or organocatalyst as the catalysts, some approaches to the amides, ketones, diynes, ynamides and azo compounds could be highly efficiently synthesized using O<sub>2</sub> as oxidant and reactant. In this seminar, I would like to introduce some cases on the aerobic oxygenations via dioxygen activation through radical pathway.



Keywords: Aerobic Oxidation, Oxygenation, Molecular Oxygen

## References:

- (a) Punniyamurthy, T.; Velusamy, S.; Iqbal, J. *Chem. Rev.* **2005**, *105*, 2329. (b) Stahl, S. S. *Angew. Chem., Int. Ed.* **2004**, *43*, 3400. (c) Gligorich, K. M.; Sigman, M. S. *Angew. Chem. Int. Ed.* **2006**, *45*, 6612. (d) Wu, W.; Jiang, H. *Acc. Chem. Res.*, **2012**, *45*, 1736. (e) Shi, Z.; Zhang, C.; Tang, C.; Jiao, N. *Chem. Soc. Rev.* **2012**, *41*, 3381. (f) Zhang, C.; Tang, C.; Jiao, N. *Chem. Soc. Rev.* **2012**, *41*, 3464.

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### ➤ Educational Background

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- 2006 M.Sc., Graduate School of Science, The University of Tokyo (supervisor: Prof. Eiichi Nakamura)
- 2009 Doctor of Science, Graduate School of Science, The University of Tokyo (supervisor: Prof. Eiichi Nakamura)

### ➤ Professional Career

- 2009 The University of Tokyo (PD)
- 2009 Assistant professor, The University of Tokyo
- 2014 Associate professor, The University of Tokyo

### ➤ Research Interests

- 1) Synthetic organic chemistry
- 2) Organometallic chemistry

### ➤ Awards

- 2015 Thieme Chemistry Journal Award
- 2014 Banyu Chemist Award
- 2013 Diploma of Excellency from the Ministry of Education of Romania
- 2012 Chemistry Innovation GCOE Lectureship
- 2009 Incentive Award of the Graduate School of Science, The University of Tokyo

### ➤ Recent Publications

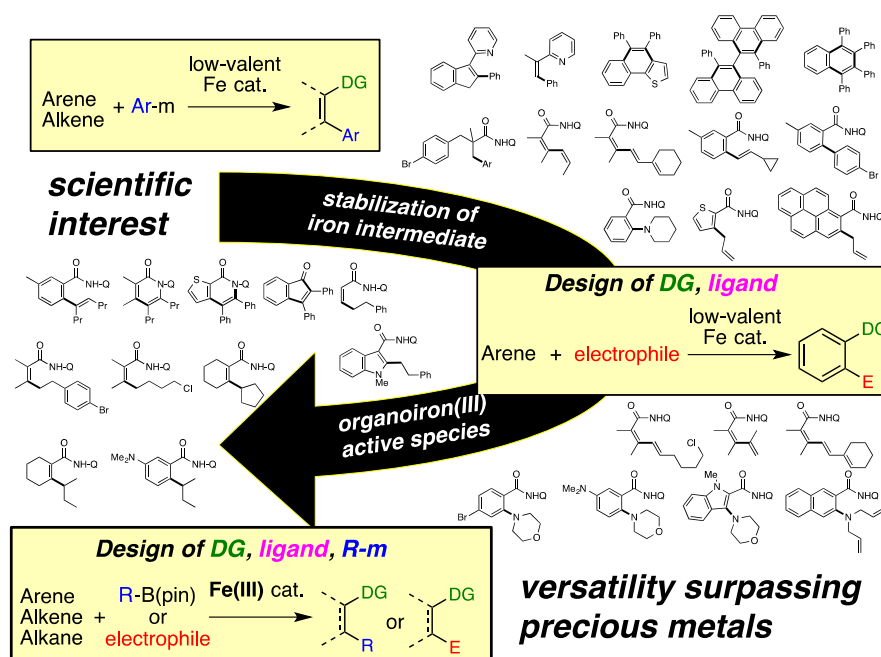
1. "Iron-catalyzed C(sp<sup>2</sup>)-H Bond Functionalization with Organoboron Compounds", R. Shang, L. Ilies, S. Asako, and E. Nakamura, *J. Am. Chem. Soc.* **2014**, *136*, 14349.
2. "Iron-Catalyzed Directed Alkylation of Aromatic and Olefinic Carboxamides with Primary and Secondary Alkyl Tosylates, Mesylates, and Halides", L. Ilies, T. Matsubara, S. Ichikawa, S. Asako, and E. Nakamura, *J. Am. Chem. Soc.* **2014**, *136*, 13126.
3. "Synthesis of Anthranilic Acid Derivatives through Iron-Catalyzed Ortho Amination of Aromatic Carboxamides with N-Chloroamines", T. Matsubara, S. Asako, L. Ilies, and E. Nakamura, *J. Am. Chem. Soc.* **2014**, *136*, 646.
4. "Iron-Catalyzed Ortho Allylation of Aromatic Carboxamides with Allyl Ethers", S. Asako, L. Ilies, and E. Nakamura, *J. Am. Chem. Soc.* **2013**, *135*, 17755.
5. "β-Arylation of Carboxamides via Iron-Catalyzed C(sp<sup>3</sup>)-H Bond Activation", R. Shang, L. Ilies, A. Matsumoto, and E. Nakamura, *J. Am. Chem. Soc.* **2013**, *135*, 6030.

# Directed C-H Bond Activation Using Iron Catalysis

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Iron-catalyzed C-H bond activation is of interest because iron is abundant, inexpensive, and non-toxic, and direct functionalization of simple substrates streamlines the synthetic strategy. However, the reactivity of catalytic organoiron species is difficult to control,<sup>1</sup> hampering the development of efficient and selective reactions. This presentation will describe our journey from a scientifically interesting, but synthetically insignificant oxidative C-H bond functionalization catalyzed by low-valent iron species,<sup>2</sup> to the development of the reaction of C-H bonds with electrophiles enabled by a bidentate directing group and a diphosphine ligand bearing a  $\pi$ -conjugated backbone,<sup>3</sup> and finally the design of an organoiron(III) catalyst that could achieve versatility comparable with and even surpassing precious metal catalysis.<sup>4</sup>



**Figure 1.** From low-valent iron to organoiron(III) species for directed C-H bond activation.

## References

- 1) Ilies, L.; Nakamura, E. in *The Chemistry of Organoiron Compounds*; Eds. Marek, I.; Rappoport, Z.; John Wiley & Sons, Ltd.: Chichester, UK, 2014.
- 2) Selected examples: (a) Matsumoto, A.; Ilies, L.; Nakamura, E. *J. Am. Chem. Soc.* **2011**, *133*, 6557. (b) Ilies, L.; Asako, S.; Nakamura, E. *J. Am. Chem. Soc.* **2011**, *133*, 7672. (c) Shang, R.; Ilies, L.; Matsumoto, A.; Nakamura, E. *J. Am. Chem. Soc.* **2013**, *135*, 6030.
- 3) (a) Asako, S.; Ilies, L.; Nakamura, E. *J. Am. Chem. Soc.* **2013**, *135*, 17755. (b) Matsubara, T.; Asako, S.; Ilies, L.; Nakamura, E. *J. Am. Chem. Soc.* **2014**, *136*, 646.
- 4) (a) Shang, R.; Ilies, L.; Asako, S.; Nakamura, E. *J. Am. Chem. Soc.* **2014**, *136*, 14349. (b) Ilies, L.; Matsubara, T.; Asako, S.; Ichikawa, S.; Nakamura, E. *J. Am. Chem. Soc.* **2014**, *136*, 13126.



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2006-2007 Postdoctoral research at Peking University (Supervisor: Zhangjie Shi), China  
2007-2009 Postdoctoral research at The University of Chicago (Supervisor: Chuan He), USA

### ➤ Professional Career

2009 Professor, Lanzhou University

### ➤ Research Interests

- 1) The Development of New and Efficient Methodologies for C-P Bond Formation
- 2) Asymmetric C-H Functionalization

### ➤ Awards

2011 "New Century Excellent Talents in University Award" from Chinese Ministry of Education  
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### ➤ Recent Publications

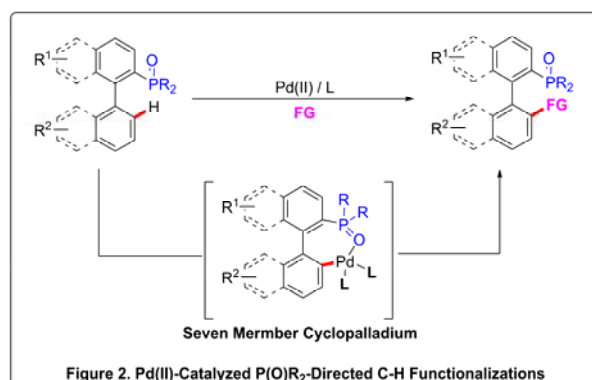
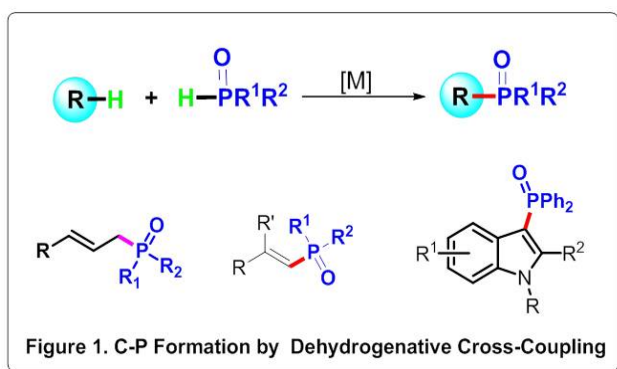
1. Enantioselective Synthesis of Arylglycine Derivatives by Direct C-H Oxidative Cross-coupling, Wei, X.-H.; Wang, G.-W. And Yang, S.-D.\*, *Chem. Commun.*, **2015**, 51, 832—835.
2. Regio- and Stereoselective Allylic C-H Arylation with Electron-Deficient Arenes by 1,1'-Bi-2-naphthol-Palladium Cooperation, Wang, G.-W.; Zhou, A.-X.; Li, S.-X. And Yang, S.-D.\*, *Org. Lett.* **2014**, 16, 3118-3121.
3. Palladium-catalyzed P(O)R<sub>2</sub> directed C-H arylation to synthesize electron-rich polyaromatic monophosphorus ligands, Hu, R.-B.; Zhang, H.; Zhang, X.-Y. And Yang, S.-D.\*, *Chem. Commun.* **2014**, 50, 2193-2195.
4. A unique Copper-catalyzed Cross-coupling Reaction by Hydrogen (H<sub>2</sub>) Removal for the Stereoselective Synthesis of 3-phosphoindoles, Zhou, A.-X.; Mao, L.-L.; Wang, G.-W.; And Yang, S.-D.\*, *Chem. Commun.* **2014**, 50, 8529-8532.
5. Direct Annulations toward Phosphorylated Oxindoles: Silver-Catalyzed Carbon-Phosphorus Functionalization of Alkenes, Li, Y.-M.; Sun, M.; Wang, H.-L.; Tian, Q.-P. And Yang, S.-D.\*, *Angew. Chem. Int. Ed.*, **2013**, 52, 3972–3976.
6. Pd(II)-Catalyzed Ph<sub>2</sub>(O)P-Directed C-H Olefination toward Phosphine-alkene Ligands, Wang, H.-L.; Hu, R.-B.; Zhang, H.; Zhou, A.-X. And Yang, S.-D.\*, *Org. Lett.* **2013**, 15, 5302-5305.
7. Nickel-Catalyzed C-P Cross-Coupling via C-CN Bond Cleavage, Sun, M.; Zhang, H.-Y.; Han, Q.; Yang, K. And Yang, S.-D.\*, *Chem. Eur. J.* **2011**, 17, 9566–3976.
8. Copper-Catalyzed C-P Coupling via Decarboxylation, Hu, J.; Zhao, N.; Yang, B.; Wang, G.; Guo, L.-N.; Liang, Y.-M. And Yang, S.-D.\*, *Chem. Eur. J.* **2011**, 17, 5516–5521.

# Phosphine-Participated C-H Transformation

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Aromatic organophosphorus compounds play very important roles and are ubiquitous. They can be found in a wide range of nucleotides, pharmaceuticals, and phosphine-containing ligands. Therefore, the development of a more concise and efficient method for the C-P bond formation is highly desirable and presents a considerable challenge to research. Recently, transition-metal-catalyzed direct C-H activation and functionalization have become powerful tools in organic synthesis by virtue of the step economy, lower-cost, and decreased waste production. With recent efforts, our group explored and developed some new methodologies of C-P bond construction by transition metal-catalyzed dehydrogenative cross-coupling reactions (**Figure 1**). Moreover, by using the diphenylphosphine oxide (P(O)Ph<sub>2</sub>) as directing group, our group also developed a series of the Pd(II)-catalyzed P(O)Ph<sub>2</sub>-directed C-H functionalizations to synthesis different phosphine ligands (**Figure 2**).



## References:

1. Hu, R.-B.; Zhang, H.; Zhang, X.-Y. And Yang, S.-D.\*, *Chem. Commun.* **2014**, 50, 2193-2195.
2. Zhou, A.-X.; Mao, L.-L.; Wang, G.-W.; And Yang, S.-D.\*, *Chem. Commun.* **2014**, 50, 8529-8532.
3. Li, Y.-M.; Sun, M.; Wang, H.-L.; Tian, Q.-P. And Yang, S.-D.\*, *Angew. Chem. Int. Ed.*, **2013**, 52, 3972-3976.
4. Wang, H.-L.; Hu, R.-B.; Zhang, H.; Zhou, A.-X. And Yang, S.-D.\*, *Org. Lett.* **2013**, 15, 5302-5305.



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2006 Exchange Student, The Scripps Research Institute, USA (Prof. K. C. Nicolaou)

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## ➤ Professional Career

2007 Postdoctoral Researcher, The Scripps Research Institute, USA (with Professor. Phil S. Baran)

2008 Assistant Professor, Graduate School of Science, Nagoya University, Japan (with Professor Kenichiro Itami)

2012 Associate Professor, Graduate School of Science, Nagoya University, Japan

## ➤ Research Interests

- 1) Organic synthesis
- 2) Synthesis of natural products

## ➤ Awards

2009 Teijin Pharma Award in Synthetic Organic Chemistry, Japan

2011 Young Scientist's Research Award in Natural Product Chemistry, Japan

2012 The Chemical Society of Japan Lecture Award for Young Chemists

2013 Japan Union of Chemical Science and Technology Chemistry Communication Award

2013 The Chemical Society of Japan Award for Distinguished Young Chemists

2014 Banyu Chemist Award

2014 Thieme Chemistry Journal Award

2014 Asian Core Lectureship Award, China and Thailand

## ➤ Recent Publications

1. "Synthesis and characterization of hexaarylbenzenes with five or six different substituents enabled by programmed synthesis ", Suzuki, S.; Segawa, Y.; Itami, K. Yamaguchi, J. *Nature Chem.* **2015**, 7, 277.
2. "Concise Syntheses of Dictyodendrins A and F by a Sequential C–H Functionalization Strategy ", Yamaguchi, A.; Chepiga, K.; Yamaguchi, J.; Itami, K.; Davies, H. *J. Am. Chem. Soc.* **2015**, 137, 644.
3. "Stereodivergent Synthesis of Arylcyclopropylamines by Sequential C–H Borylation and Suzuki–Miyaura Coupling" Miyamura, S.; Araki, M.; Suzuki, T.; Yamaguchi, J.; Itami, K. *Angew. Chem., Int. Ed.* **2015**, 54, 846.
4. "β-Selective C–H Arylation of Pyrroles Leading to Concise Syntheses of Lamellarins C and I" Ueda, K.; Amaike, K.; Maceiczky, R. M.; Itami, K.; Yamaguchi, J. *J. Am. Chem. Soc.* **2014**, 136, 13226.



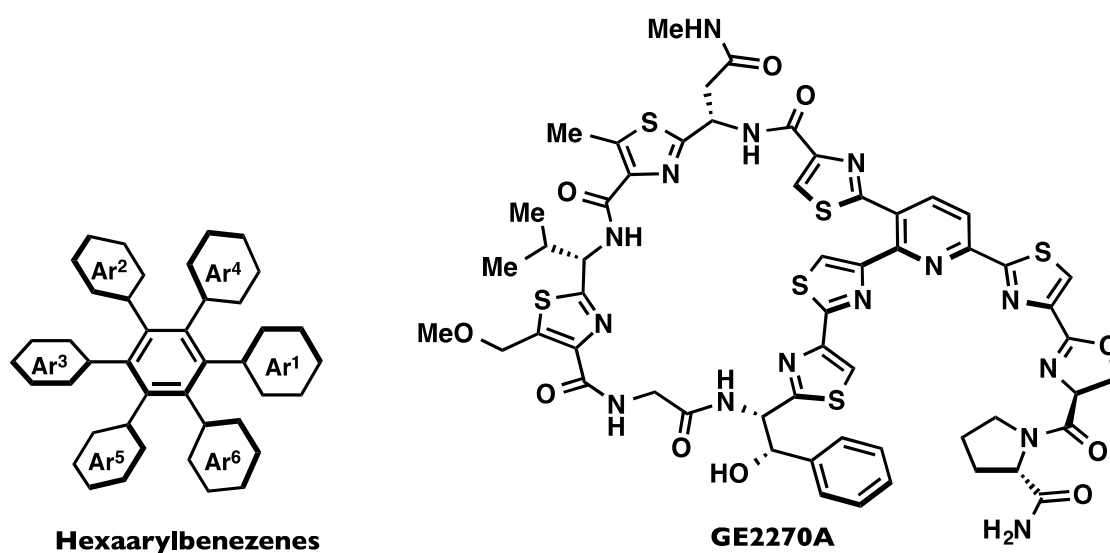
# A C-H Arylation/Ring Transformation Approach: Synthesis of Polyarylated Arenes and Natural Products

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Polyarylated arenes are privileged structures with many interesting functions and fascinating optoelectronic or biological properties, and therefore, the construction of these scaffolds has been a topic of great importance in chemistry. Recently, the C–H arylation method of arenes has garnered much attention from the synthetic chemistry community as a next-generation coupling method to construct such motifs. The development of C–H arylation of five-membered heteroarenes with controlled regioselectivity has been well established. However, the C–H arylation of six-membered aromatics such as benzenes and pyridines has considerable room for further investigations in terms of overcoming challenges in reactivity and regioselectivity. To address these issues and to synthesize polyarylated arenes, the regioselective C–H arylation of five-membered heteroarenes, followed by a ring transformation approach, has been developed.

To this end, the synthesis and characterization of hexaarylbenzenes with five or six different aryl groups was achieved by first a C–H arylation of thiophenes, followed by thiophene oxidation, then a [4+2] cycloaddition of the resulting tetraarylthiophene *S*-oxide. Furthermore, a formal synthesis of GE2270A, a thiopeptide antibiotic, has been accomplished by using this approach (Figure 1).

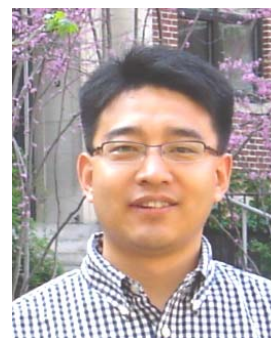


**Figure 1.** Synthetic Targets with Multiply Arylated Six-membered Arenes as the Core Structure.



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## ➤ Professional Career

2007 Senior Research Scientist, Global Pharmaceutical R&D Division, Abbott Laboratories  
 2009 Professor, Nankai University

## ➤ Research Interests

- 1) Total synthesis of structurally intriguing natural products of biological and medicinal interests.
- 2) Large scale synthesis and process development of important active pharmaceutical ingredients.

## ➤ Awards

2004 Roche Graduate Fellowship, USA  
 2005 Bristol-Myers Squibb Graduate Fellowship, USA  
 2006 Thieme SYNStar Award, USA  
 2008 Excellent Performance Award, Abbott Laboratories, USA  
 2008 Robert G. Stern Award, Abbott Laboratories, USA  
 2012 ACP Lectureship Awards, Singapore  
 2013 Young Investigator of the New Century, Ministry of Education, China

## ➤ Recent Publications

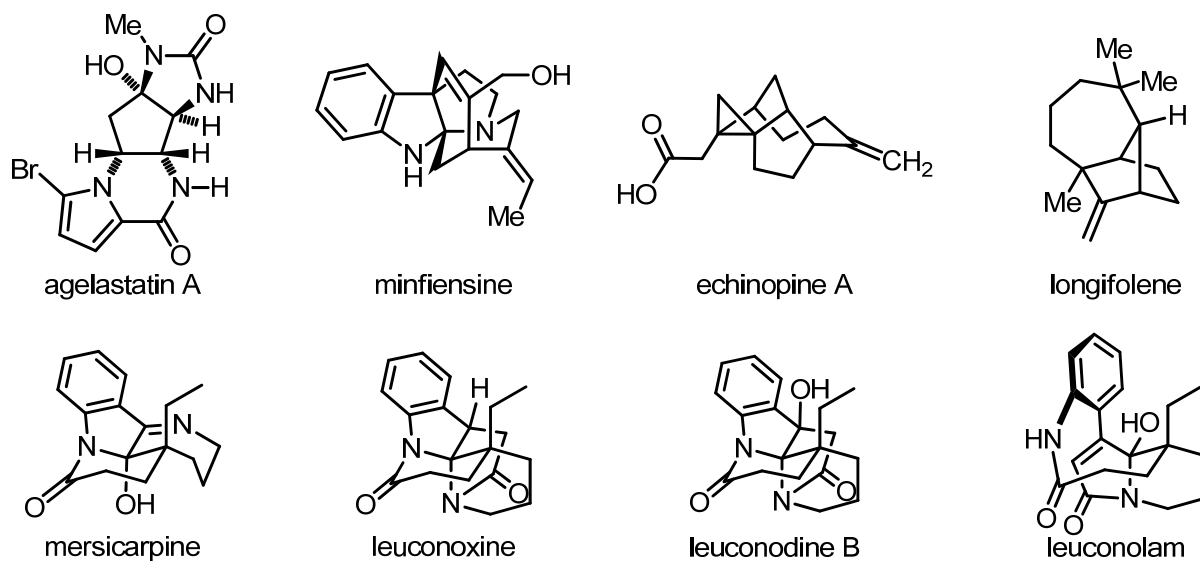
1. "Total Synthesis of (–)-Isatisine A", Zhang, X.; Mu, T.; Zhan, F.; Ma, L.; Liang, G.\* *Angew. Chem. Int. Ed.* **2011**, *50*, 6164.
2. "Rapid Construction of the ABC Ring System in the Daphniphyllum Alkaloid Daphniyunnine C", Yao, Y.; Liang, G.\* *Org. Lett.* **2012**, *14*, 5499.
3. "Formation of Enehydrazine Intermediates through Coupling of Phenylhydrazines with Vinyl Halides: Entry into the Fischer Indole Synthesis", Zhan, F.; Liang, G.\* *Angew. Chem. Int. Ed.* **2013**, *52*, 1266.
4. "Total Syntheses of Echinopines", Xu, W.; Wu, S.; Zhou, L.; Liang, G.\* *Org. Lett.* **2013**, *15*, 1978.
5. "Total Synthesis of Mersicarpine through a Cationic Cyclization Approach", Lv, Z.; Li, Z.; Liang, G.\* *Org. Lett.* **2014**, *16*, 1653.
6. "Total Syntheses of (±)-Omphadiol and (±)-Pyxidatol C through a Cis-Fused 5,7-Carbocyclic Common Intermediate", Zhou, L.; Yao, Y.; Xu, W.; Liang, G.\* *J. Org. Chem.* **2014**, *79*, 5345.
7. "Selective Syntheses of Leuconolam, Leuconoxine, and Mersicarpine Alkaloids from a Common Intermediate through Regiocontrolled Cyclizations by Staudinger Reactions", Li, Z.; Geng, Q.; Lv, Z.; Pritchett, B. P.; Baba, K.; Numajiri, Y.; Stoltz, B. M.\*; Liang, G.\* *Org. Chem. Front.* **2014**, In Print

# Act like Molecule Transformers — Rapid Creation of Molecular Complexity through Strategic Bond Disconnections

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Creation of new substances is the central value of chemistry. To understand the new substances and to further use it as a probe to explore the world require synthetic science, the major platform for chemists to perform such creation, to be able to synthesize in an efficient way. Creation of molecular complexities rapidly from relative simple ones is one of the solutions for efficient synthesis. We believe strategic bond disconnections play a vital role in synthetic design so that to develop efficient synthesis. Synthetic examples will be discussed to demonstrate how we rapidly created molecular complexity based on this guideline.



**Figure:** Targets Synthesized through Rapid Creation of Molecular Complexities.



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## ➤ Educational Background

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- 1998 M.Sc., Graduate School of Engineering, Osaka University (supervisor: Prof. Shinji Murai)
- 2001 Doctor of Engineering, Graduate School of Engineering, Osaka University (supervisor: Prof. Shinji Murai)

## ➤ Professional Career

- 2001 Takeda Pharmaceutical Company
- 2005 Assistant professor, Osaka University
- 2011 Associate professor, Osaka University

## ➤ Research Interests

- 1) Synthetic Organic Chemistry
- 2) Organometallic Chemistry

## ➤ Awards

- 2009 The Chemical Society of Japan Award For Young Chemists
- 2012 The Young Scientists' Prize from the Ministry of Education, Culture, Sports, Science and Technology, Japan
- 2012 Merck-Banyu Lectureship Award

## ➤ Recent Publications

1. "Rhodium-Catalyzed Borylation of Aryl 2-Pyridyl Ethers through Cleavage of the Carbon-Oxygen Bond: Borylative Removal of the Directing Group", H. Kinuta, M. Tobisu,\* and N. Chatani\* *J. Am. Chem. Soc.* *in press*
2. "Nickel-Catalyzed Alkynylation of Anisoles via C-O Bond Cleavage", M. Tobisu,\* T. Takahira, A. Ohtsuki, and N. Chatani\* *Org. Lett.* *in press*
3. "Rhodium-Catalyzed Borylation of Aryl and Alkenyl Pivalates through Cleavage of Carbon-Oxygen Bonds", H. Kinuta, J. Hasegawa, M. Tobisu,\* and N. Chatani\* *Chem. Lett.* *in press*
4. "Palladium-Catalyzed Synthesis of Six-Membered Benzofused Phosphacycles via Carbon-Phosphorus Bond Cleavage", K. Baba, M. Tobisu,\* and N. Chatani\* *Org. Lett.* **2015**, 17, 70.
5. "1,3-Dicyclohexylimidazol-2-ylidene as a Superior Ligand for the Nickel-Catalyzed Cross-Couplings of Aryl and Benzyl Methyl Ethers with Organoboron Reagents", M. Tobisu,\* A. Yasutome, H. Kinuta, K. Nakamura, and N. Chatani\*, *Org. Lett.* **2014**, 16, 5572.
6. "Nickel-Catalyzed Reductive and Borylative Cleavage of Aromatic Carbon-Nitrogen Bonds in N-Aryl Amides and Carbamates", M. Tobisu,\* K. Nakamura, and N. Chatani\* *J. Am. Chem. Soc.* **2014**, 136, 5587.

# Cross-Coupling Reactions via the Activation of Inert Carbon-Oxygen Bonds

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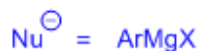
Arene synthesis has been revolutionized by the invention of catalytic cross-coupling reactions, wherein aryl halides are coupled with organometallic and organic nucleophiles. Although the replacement of aryl halides with phenol derivatives as substrates would lead to more economical and ecological methods, success has been primarily limited to the use of activated phenol derivatives such as triflates. Aryl ethers arguably represents one of the most ideal substrates in terms of their availability, cost, safety and atom efficiency. However, among the various phenol derivatives, the robust nature of C(aryl)-O bonds in aryl ethers makes it extremely difficult to use in catalytic reactions.

Since the seminal work by Wenkert in 1979 on the nickel-catalyzed cross-coupling of aryl ethers with Grignard reagents, progress in this field has been relatively slow. One reason for this is that the accumulated knowledge regarding palladium-catalyzed cross-couplings was not readily translated to nickel catalysis, in particular, in cases of aryl ether substrates. In this symposium, we report on advances that have been made in the cross-coupling of aryl ethers over the last decade, with particular emphasis on contributions from our laboratory.



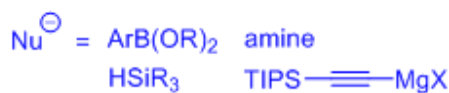
## State-of-the-art

**1979: Wenkert**

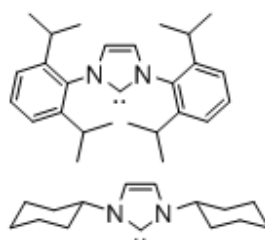


Ligand = PPh<sub>3</sub>

**2015: Our works**



Ligand = PCy<sub>3</sub>



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## ➤ Professional Career

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- 2011 JST-PRESTO Researcher
- 2012 Associate professor, Kyoto University
- 2014 Professor, Kyoto University
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## ➤ Research Interests

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## ➤ Awards

- 2009 Mitsui Chemicals Catalysis Science Award of Encouragement
- 2009 The Society of Silicon Chemistry Award of Encouragement
- 2010 Thieme Journal Award
- 2010 Merck–Banyu Lectureship Award
- 2011 The Chemical Society of Japan Award for Young Chemists
- 2011 The Young Scientist's Prize from the Ministry of Education, Culture, Sports, Science and Technology
- 2015 Tetrahedron Young Investigator Award

## ➤ Recent Publications

1. "Intramolecular Oxycyanation of Alkenes by Cooperative Pd/BPh<sub>3</sub> Catalysis", D. C. Koester, M. Kobayashi, D. B. Werz, and Y. Nakao. *J. Am. Chem. Soc.* **2012**, 134, 6544.
2. "Intramolecular Aminocyanation of Alkenes by Cooperative Palladium/Boron Catalysis", Y. Miyazaki, N. Ohta, K. Semba, and Y. Nakao. *J. Am. Chem. Soc.* **2014**, 136, 3732.
3. "Arylboration of Alkenes by Cooperative Palladium/Copper Catalysis", K. Semba and Y. Nakao. *J. Am. Chem. Soc.* **2014**, 136, 3732.

