

## Laboratory of Molecular Design Chemistry

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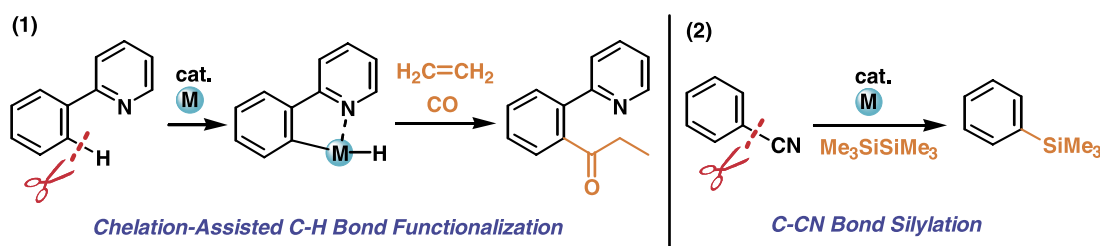


## Invention of New Catalytic Transformations for the Next Generation

The pressing demand to produce the myriad of substances required by society in an environmentally benign fashion poses great challenges for researchers in the chemical sciences. A major goal must be to maximize the efficiency of the synthetic processes that convert fossil fuel-derived raw materials into the target molecules, while minimizing waste. Undoubtedly, this goal cannot be achieved with minor improvements in the existing synthetic processes. The establishment of synthetic methodologies based on fundamentally new concepts is required. In this context, our research group has been developing the following catalytic reactions.

### Catalytic Cleavage and Functionalization of Unreactive Bonds

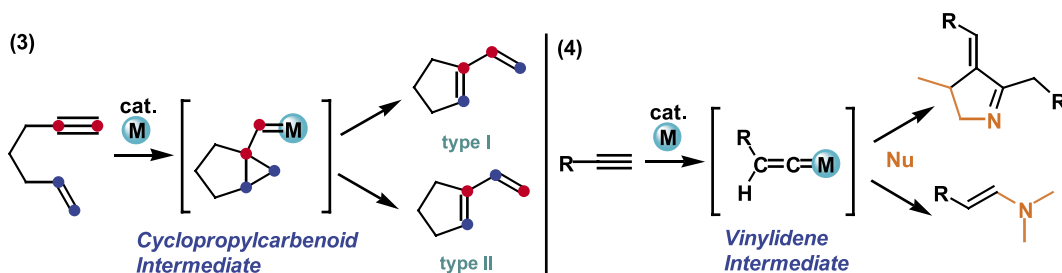
Basically, current synthetic methods rely on the use of reactive functional groups, such as halides or unsaturated bonds, which are susceptible to substitution or addition reactions. The development of methodologies that can cleave and functionalize unreactive chemical bonds should provide new strategies for organic synthesis with enormously increased efficiency. For example, the direct transformation of unreactive carbon-hydrogen bonds, ubiquitously present in organic compounds, removes the need for the pre-preparation of functionalized intermediates, thus allowing us to reach the target molecules in fewer steps. We have established that transition metal catalyzed cleavage reactions of unreactive bonds can be facilitated by the presence of a neighboring coordinating group (Eq. 1). This chelation-assisted strategy is applicable to the catalytic functionalization of a variety of unreactive bonds, including carbon-hydrogen, carbon-carbon, carbon-oxygen, and carbon-fluorine bonds. In addition, we have recently shown that the carbon-cyano bond can be cleaved and silylated catalytically in the absence of chelation assistance (Eq. 2).



### Catalytic Transformations via New Organometallic Intermediates

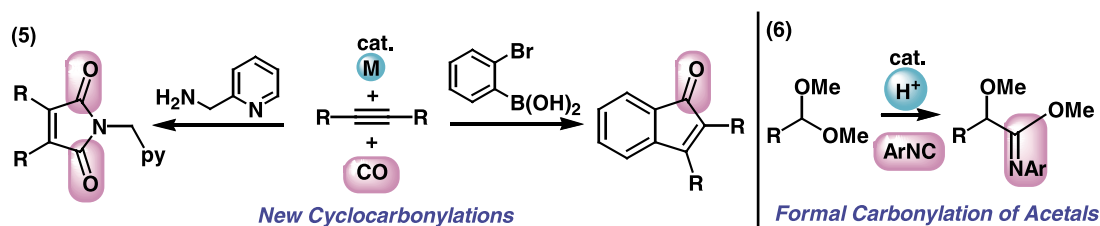
The utilization of unique organometallic species as intermediates in a catalytic cycle often leads to highly unusual transformations. The catalytic skeletal reorganization of enynes represents such a case, in which electrophilic metal halides activate the alkyne moiety to form a cyclopropylcarbenoid intermediate,

followed by the ring opening of the cyclopropane to afford vinylcyclopentenes (Eq. 3). Notably, the alignment of the carbon atoms derived from alkyne and alkene moieties can be precisely controlled by the nature of the catalyst and the substituents on the starting enynes. Another example is the utilization of a vinylidene intermediate, which is generated by the reaction of terminal alkynes with metal complexes. We have discovered the novel reactivity of this intermediate on the pathway towards nitrogen nucleophiles, furnishing a variety of valuable nitrogen-based compounds (Eq. 4).



### Catalytic Reactions Using Carbon Monoxide and Isocyanides

Catalytic carbonylation reactions represent a powerful and valuable way to prepare synthetically versatile carbonyl compounds. However, the type of reaction and applicable substrates are still limited. We have developed new cyclocarbonylations, leading to maleimides and indenones (Eq. 5). Moreover, the unprecedented carbonylation of acetals has been formally realized by using isocyanides as a carbon monoxide equivalent (Eq. 6).



### References (main papers in 2006-2007)

- (1) Skeletal Reorganization of Enynes Catalyzed by  $\text{InCl}_3$ , Y. Miyanohana and N. Chatani, *Org. Lett.*, **8**(10), 2155-2158 (2006).
- (2) Rh(I)-Catalyzed Silylation of Aryl and Alkenyl Cyanides Involving the Cleavage of C-C and Si-Si Bonds, M. Tobisu, Y. Kita, and N. Chatani, *J. Am. Chem. Soc.*, **128**(25), 8152-8153 (2006).
- (3) Rhodium-Catalyzed Reaction of Terminal Alkynes with Allylamine Leading to (*E*)-3-Alkylidene *N*-Heterocycles, Y. Fukumoto, F. Kinashi, T. Kawahara, and N. Chatani, *Org. Lett.*, **8**(20), 4641-4643 (2006).
- (4) Rh(I)-Catalyzed Carbonylative Cyclization Reactions of Alkynes with 2-Bromophenylboronic Acids Leading to Indenones, Y. Harada, J. Nakanishi, H. Fujihara, M. Tobisu, Y. Fukumoto, and N. Chatani, *J. Am. Chem. Soc.*, **129**(17), 5766-5771 (2007).
- (5) Ru/C-Catalyzed Carbonylation at *ortho* C-H Bonds in 2-Phenylpyridines, S. Imoto, T. Uemura, F. Kakiuchi, and N. Chatani, *Synlett*, (1), 170-172 (2007).
- (6) A Chelation-Assisted Transformation: Synthesis of Maleimides by the Rh-Catalyzed Carbonylation of Alkynes with Pyridin-2-yl-methylamine, S. Inoue, Y. Fukumoto, and N. Chatani, *J. Org. Chem.*, **72**(17), 6588-6590 (2007).
- (7) Brønsted Acid Catalyzed Formal Insertion of Isocyanides into a C-O Bond of Acetals, M. Tobisu, A. Kitajima, S. Yoshioka, I. Hyodo, M. Oshita, and N. Chatani, *J. Am. Chem. Soc.*, **129**(37), 11431-11437 (2007).
- (8) Anti-Markovnikov Addition of Both Primary and Secondary Amines to Terminal Alkynes Catalyzed by  $\text{TpRh}(\text{C}_2\text{H}_4)_2/\text{PPh}_3$  System, Y. Fukumoto, H. Asai, M. Shimizu, and N. Chatani, *J. Am. Chem. Soc.*, in press.

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