

Base metal catalysis for cross coupling and addition reactions

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Base metal catalysis, where the catalysts contain only elements abundant in the Earth's crust, offers potential advantages in cost, availability, scalability, and sometimes compatibility with health and the environment. Our lab is developing base metal catalyzed cross coupling reactions and functionalization of alkenes and alkynes.

We developed a well-defined Ni catalyst, Nickamine, that catalyzes the alkyl-alkyl, alkyl-aryl, and alkyl-alkynyl Kumada coupling of activated alkyl halides, as well as direct alkylation of alkynes and heterocycles (Figure 1).¹ The mechanism of these reactions was thoroughly studied using radical probes, kinetics and DFT computations.² We also studied the mechanism of analogous Fe-catalyzed alkyl-aryl Kumada coupling using defined Fe pincer complexes.³ A common bimetallic oxidative addition reaction pathway involving alkyl radical intermediates was found for these coupling reactions.

We discovered that Fe catalysts could be used to promote the 1,2-addition of perfluoroalkyl iodides to alkynes and alkenes.⁴ The resulting perfluoroalkylated alkyl and alkenyl iodides could be further functionalized by cross coupling reactions. Further investigation showed that copper catalysis can be used to promote the 1,2-addition of alpha-carbonyl iodides to alkynes,⁵ resulting beta,gamma-unsaturated ketones which are an important class of organic molecules. We also reported a novel Fe-catalyzed reductive coupling of terminal alkynes with alkyl halides to give cis-olefins.⁶

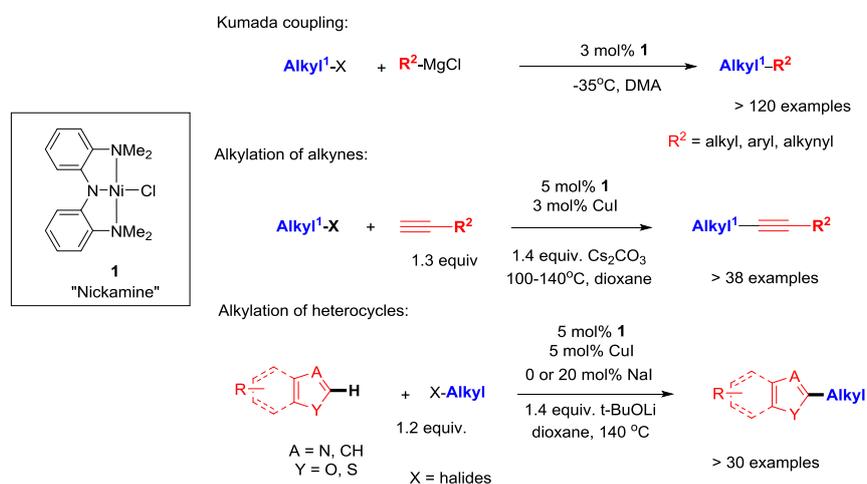


Figure 1. Cross coupling-type reactions catalyzed by Nickamine.

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² J. Breitenfeld, J. Ruiz, M.D. Wodrich, X.L. Hu *J. Am. Chem. Soc.* **2013**, *135*, 12004-12012; J. Breitenfeld, M.D. Wodrich, X.L. Hu *Organometallics* **2014**, *33*, 5708-5715.

³ G. Bauer, M.D. Wodrich, R. Scopelliti, X.L. Hu *Organometallics* **2015**, *34*, 289-298.

⁴ T. Xu, C.W. Cheung, X.L. Hu *Angew. Chem. Int. Ed.* **2014**, *53*, 4910-4914.

⁵ T. Xu, X.L. Hu *Angew. Chem. Int. Ed.* **2015**, *54*, 1307-1311

⁶ C. W. Cheung, F. Zhurkin, X.L. Hu *J. Am. Chem. Soc.* **2015**, *137*, 4932-4935.