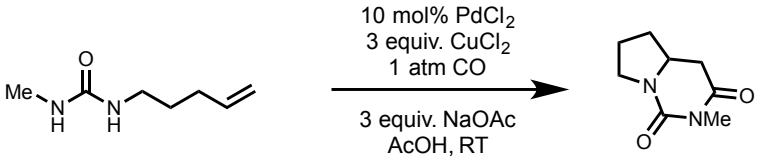
Organometallic Chemistry 2019 Problem Set 2
Due: June 5, 2019 at 10:00 AM PST

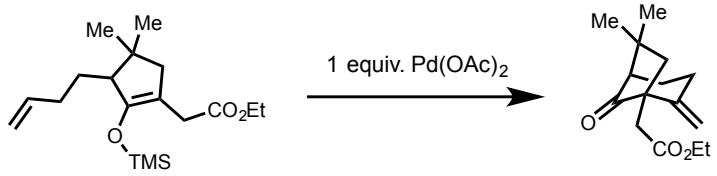
***Directions*:** Please provide all answers on separate sheets of paper. Label all sheets with your name in the top right corner. Please staple the sheets in the top left corner. Do not write on the back of pages. You may work with other students in the class only.

1. Nucleopalladation (20 points).

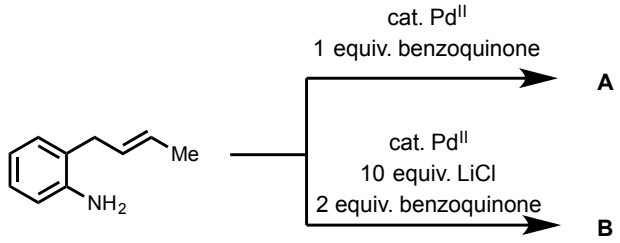
A. Provide a reasonable mechanism for the following transformation **(5 points)**.



B. Provide a reasonable mechanism for the following transformation **(5 points)**.

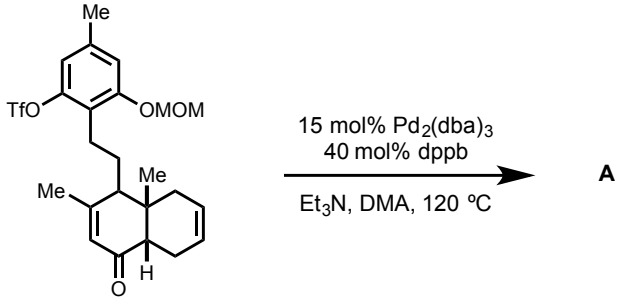


C. In the following reaction, excess chloride in solution was shown to impact the regioselectivity. Predict the products and provide rationale for the outcome based on the reaction conditions **(10 points)**.



2. Heck-type couplings (20 points).

A. Construct a reasonable catalytic cycle for the following process and provide the product (**10 points**).

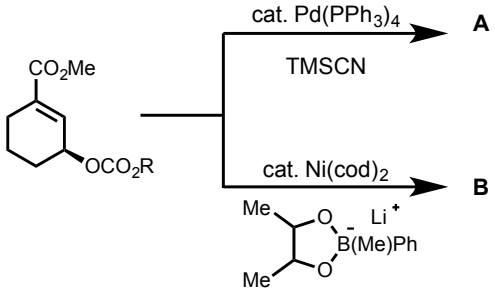


B. Despite the enormous utility of the Mizoroki-Heck coupling, alkyl variants of this reaction are challenging to develop. Give **two reasons** as to why alkyl Heck reactions may be difficult to develop and provide **two strategies** toward overcoming these challenges (**5 points each, 10 points total**).

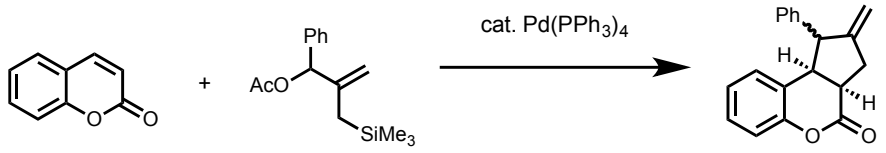
Organometallic Chemistry 2019 Problem Set 2
Due: June 5, 2019 at 10:00 AM PST

3. Allylic substitution (20 points).

A. Predict the products **A** and **B** in the following palladium- and nickel-catalyzed allylic substitution reactions and provide a reasonable mechanism for their stereochemical outcome and formation **(5 points each, 10 points total)**.

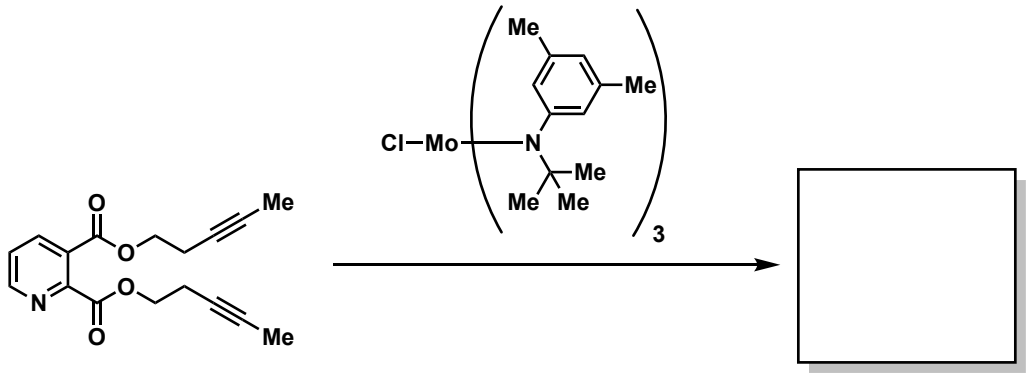


B. Provide a reasonable mechanism for the following transformation **(10 points)**.

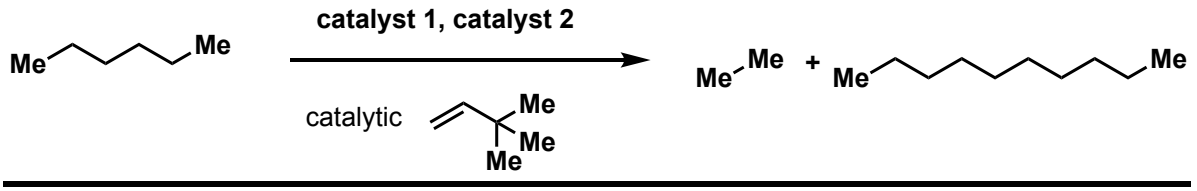


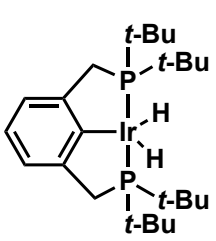
4. Olefin metathesis (20 points).

A. Predict the product for the following transformation AND propose a catalytic cycle to explain your reasoning:

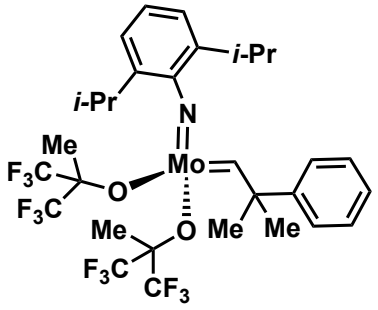


B. Provide a mechanism for the following reaction:





catalyst 1

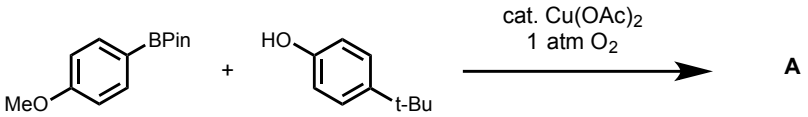


catalyst 2

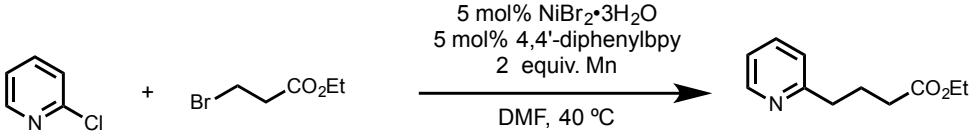
5. Cross-coupling (40 points).

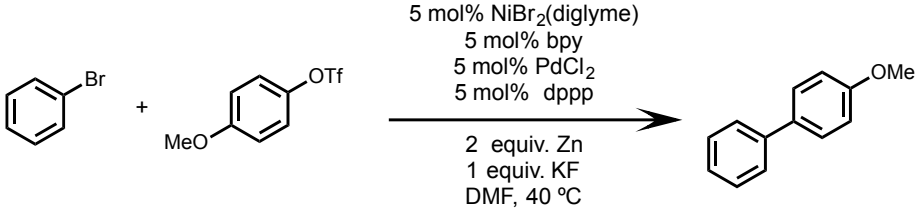
A. Design a C(sp^3)–C(sp^3) cross-coupling reaction based on your understanding of transition-metal-catalyzed cross-coupling and provide rationale for your decision for each of the following: *(1) transition metal catalyst, (2) transmetalating agent, (3) ligand scaffold* **(3 points each, 9 points total)**. Draw a catalytic cycle for your proposed reaction and *identify off-cycle pathways that prevent productive catalysis* **(6 points)**.

B. As mentioned in class, one example of an oxidative cross-coupling reaction is the Chan-Lam reaction. For the reaction below, *propose a reasonable catalytic cycle and provide the product* **(10 points)**.



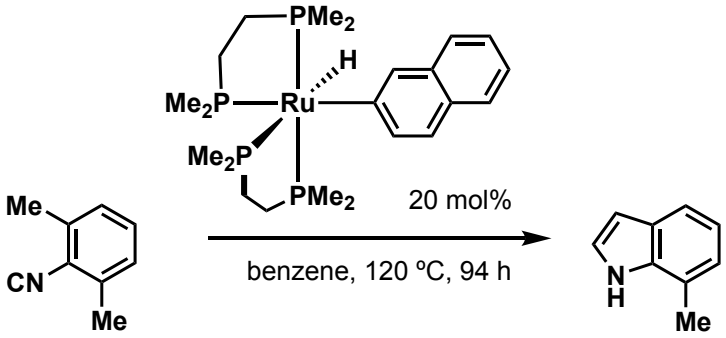
C. Though reductive cross-couplings are still a topic of mechanistic debate, various groups have made groundbreaking progress in achieving selective cross-electrophile coupling. Consider the reactions below and *propose a reasonable catalytic cycle for each* **(5 points each, 10 points total)**. For one reaction of your choosing, rationalize the observed selectivity for cross-electrophile coupling over homo-coupling **(5 points**).



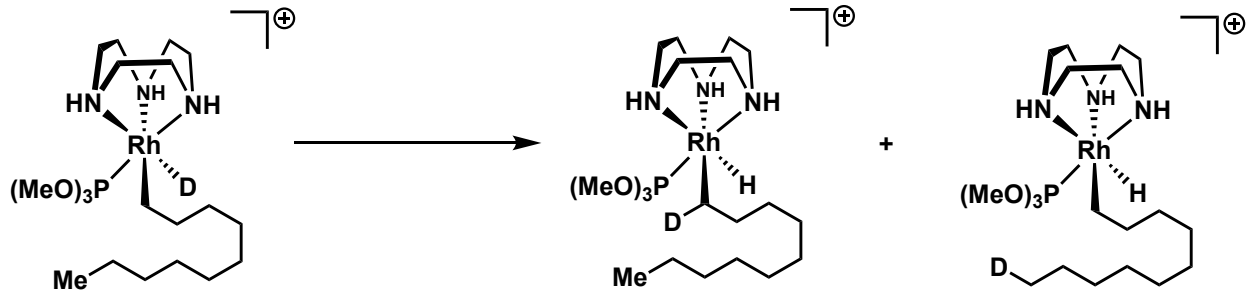


6. C–H Activation (40 points).

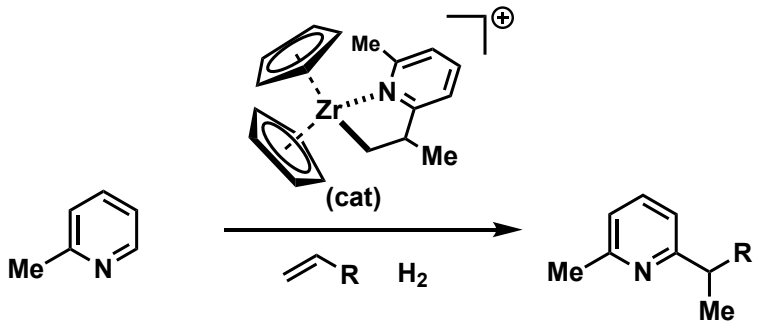
A. Propose a catalytic cycle for the following transformation that affords indoles in good yields. Identify the type of C–H activation that is happening (*e.g.* Oxidative addition, electrophilic C–H activation, CMD-type, or sigma-bond metathesis; **10 points**):



B. For the following reaction neither free hexane nor free hexane is incorporated into the product. Note that NO deuterium scrambling was observed! Please provide a mechanism (**10 points**).



C. α-picoline undergoes the following transformation. (i) Provide a mechanism for this transformation. (ii) Show the key transition state for C–H activation. (iii) Propose a structure of an off cycle species to explain catalyst deactivation. (iv) If pyridine is used instead of picoline no reaction proceeds, explain why. (v) How would you modify the catalyst to make a more reactive zirconium catalyst? (**2 points for i-iv; 10 points total**)



D. Predict the product for the four-step transformation of fenchol. Show the two catalytic cycles for steps 1 and 2.