Scripps Research

Organometallic Chemistry 2019 Exam 2
June 12th, 2019; 10:00 AM PST

Directions: This is a closed notes exam. Answer the following questions to the best of your ability. There are **8 questions** and the exam is **130 points total.** There is one bonus question worth 10 points. You have **2 hours and 45 minutes** to complete this exam. All answers must be written on the pages provided.

NAME:____

1____________________________/20

2____________________________/15

3____________________________/10

4____________________________/15

5____________________________/20

6____________________________/20

7____________________________/15

8____________________________/15

9 (BONUS)____________________________/10

TOTAL:________________/130 (+10 bonus)

1. **Wacker Oxidation (20 points).**

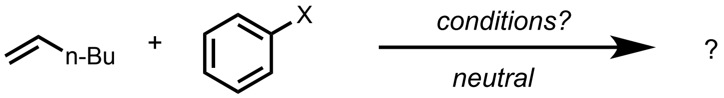
A) Provide the starting materials, standard conditions, and major product of the Wacker Process and draw a complete catalytic cycle based on your understanding of the established mechanism (10 points).

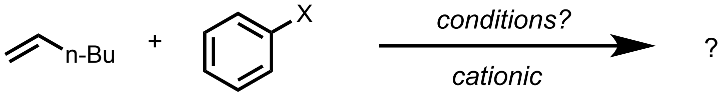
B) Design a detailed mechanistic experiment that supports the mechanism described in Part A (5 points).

C) Propose a strategy to render the reaction “aldehyde-selective” (5 points).

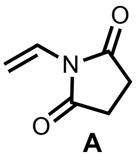
2. Mizoroki–Heck Coupling (15 points).

A) As mentioned in class, palladium-catalyzed Heck-type reactions can be classified into “neutral” or “cationic” mechanisms depending on the reaction conditions. Give the corresponding set of conditions for both neutral and cationic in the context of the reaction below and provide the major product (5 points). Provide rationale for the selectivity in each case (5 points).

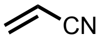




B) From the list of substrates below, determine which alkene would react with the same selectivity irrespective of the neutral or cationic pathway and explain why (5 points).



A

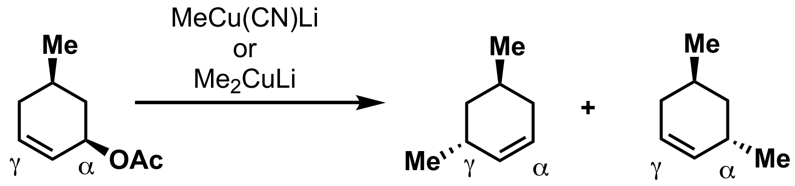


B

C

3. Allylic Substitution (10 points).

Cu-catalyzed allylic substitutions allow for the use of different nucleophiles compared to allylic substitutions catalyzed by other transition metals. For the following Cu-mediated reaction, please provide a mechanism (5 points) and explain the difference in products based off of the organometallic Cu reagent used (5 points). *You must explain the origin of anti stereoselectivity for full credit.*

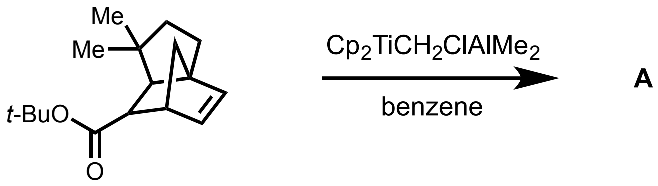


$MeCu(CN)Li$:	**96**	**:**	**4**
Me_2CuLi:	**50**	**:**	**50**

4. Olefin Metathesis (15 points).

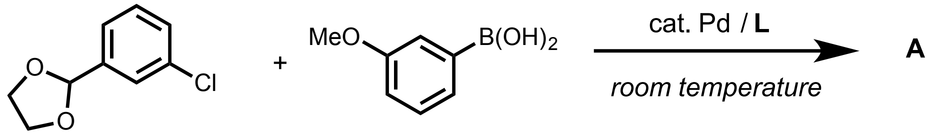
A) Provide an example of a monomer and catalyst combination that would be expected to undergo efficient ring-opening metathesis polymerization including initiation and propagation steps (5 points).

B) Propose a reasonable mechanism for the following transformation and draw the structure of the organometallic reagent complex (10 points, +1 point bonus for name of reagent). Explain why this reaction is not catalytic and what the fate of the organometallic reagent is (5 points).

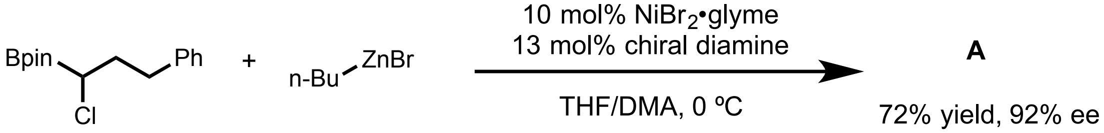


5. Catalytic Cross-Coupling.

A) For difficult C–C and C–X bond formation, Buchwald ligands have emerged as a powerful toolkit for palladium-catalyzed cross-coupling. Provide a general structure of canonical Buchwald ligands and indicate their coordination mode to a palladium catalyst throughout a catalytic cycle for the reaction below (10 points).

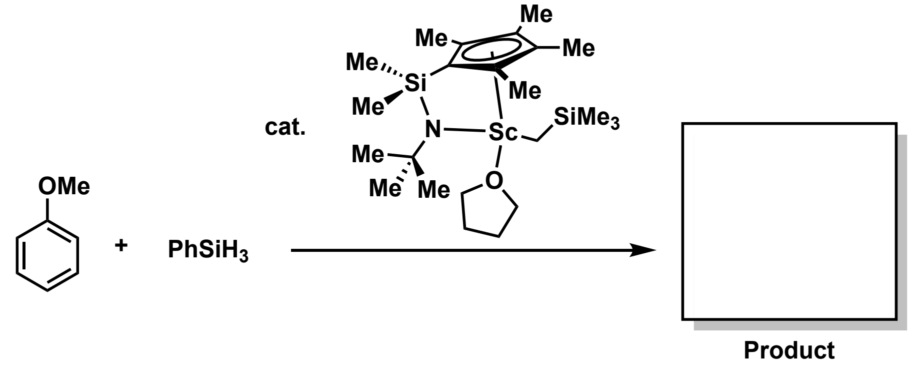


B) For the following asymmetric reaction, predict the product and draw a reasonable catalytic cycle *including catalyst activation* (8 points). Give an example of a potential off-cycle product based on your knowledge of cross-coupling (2 points).

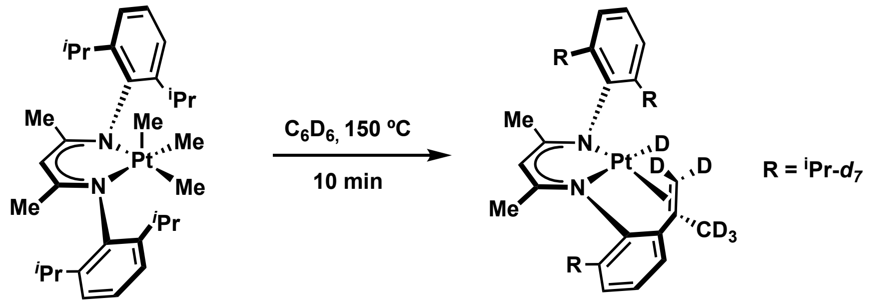


6. C–H Activation (20 points).

A. For the following reaction predict the product (5 points) and provide a catalytic cycle (5 points). Hint: the Scandium species is a pre-catalyst.

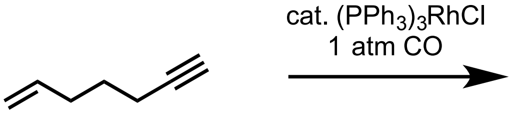


6. B. For the following transformation, please provide a mechanism (10 points). You need not explain the transformation of the other three isopropyl groups.

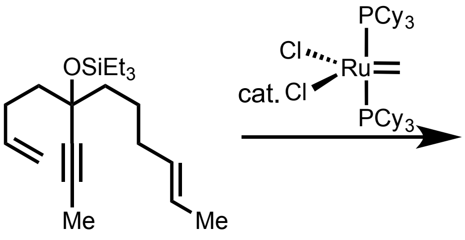


7. Predict the major products (or condition) in each of the following reactions (3 points each, 15 points total).

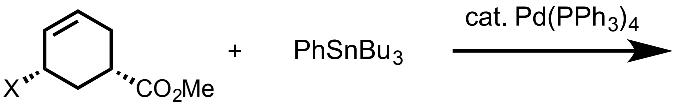
A)



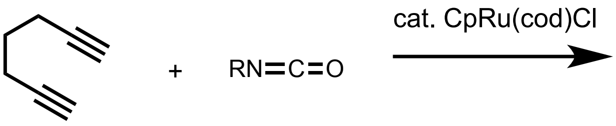
B)



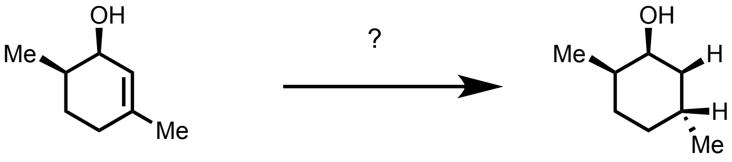
C)



D)

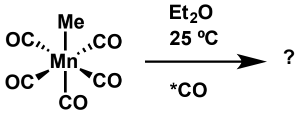


E)



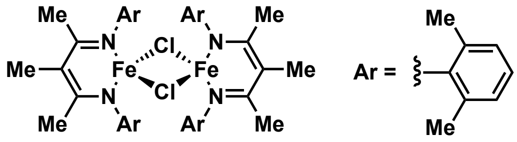
8. Previous topics (15 points; 3 points each).

A. Predict the product of the following reaction. Indicate relative stereochemistry. Provide the mechanism.



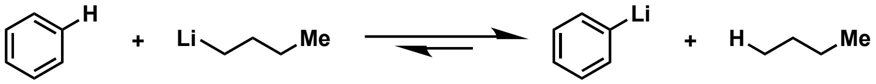
B. The Pt(IV) complex $(Ph_3P)_2PtPh_2I_2$ only undergoes reductive elimination in methanol, but not cyclohexane. (i) Why? (ii) And what product forms?

C. Provide the (i) oxidation state, (ii) *d*-electron count, (iii) total electron count of the following complex

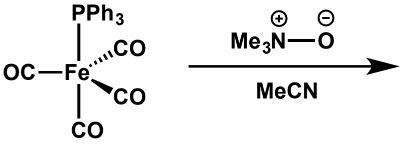


Oxidation state	*d*-electron count	Total electron count

D. The following reaction between *n*-Butyl lithium in benzene is immeasurably slow; however, rapid Li/H exchange occurs upon addition of tetramethylethylenediamine (TMEDA). Explain why.



E. Indicate the product of the following reaction:



9. **(BONUS).** Very recently (Nature 2019, in press), an algal nonheme dioxygenase called CMD1 was found to catalyze the addition of glyceryl motif to 5-methylcytosine (5-mC). Unlike typical Fe/αKGs, CMD1 does not require αKG in the reaction and instead utilizes ascorbic acid as co-substrate. The 3-carbon unit of the addition product was found to be derived from ascorbic acid. Propose a mechanism for this transformation.