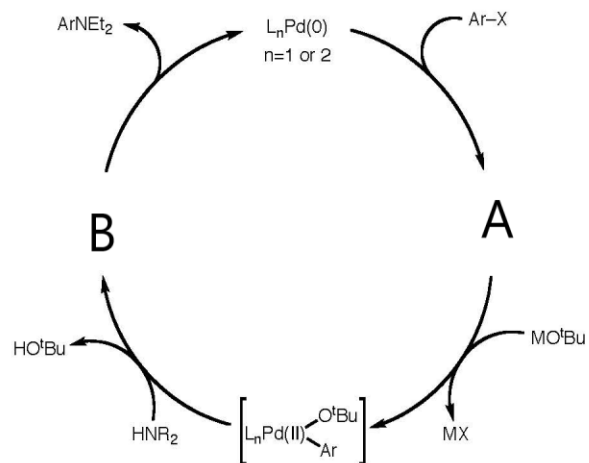
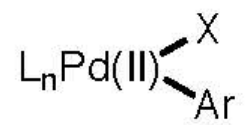


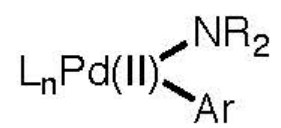
Pd-catalyzed C-N cross-coupling is similar to C-C cross coupling. Below is a catalytic cycle for Pd-catalyzed C-N coupling. Please draw the structures of intermediates A and B. And label their oxidation states



A
:



B
:



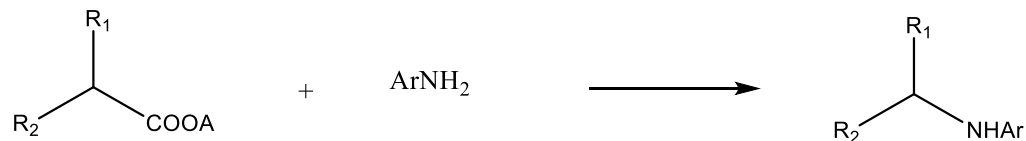
Answer:

1. They are formed by replacement of $P(o\text{-tol})_3$ ligands of the Pd catalysts by the amine nucleophile, which is in excess.
2. Yes, a bidentate ligand will inhibit the replacement. As a result, the catalyst is more stable and expect to have higher turnovers.

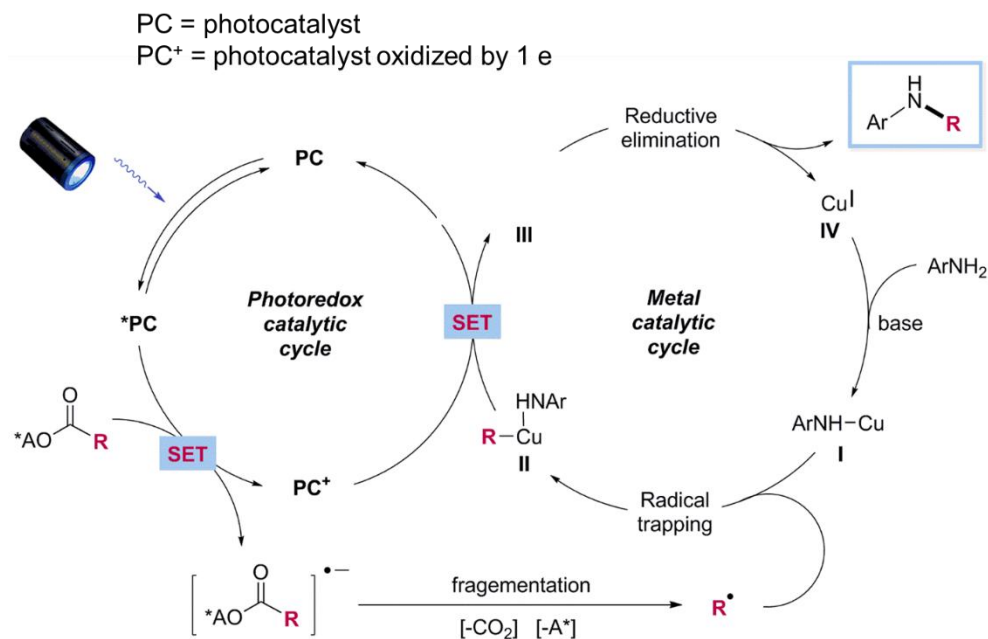
For Pd-catalyzed C-N coupling, the C-N reductive elimination is known to correlate with the electron density on the N nucleophiles. The more nucleophilic N is, the faster the reaction is. Based on this information, predict the order of the reaction rate for reductive elimination with (alkyl)NH⁻, (aryl)NH⁻, and (aryl)₂N⁻.

Answers: (alkyl)NH⁻ > (aryl)NH⁻ > (aryl)₂N⁻

Cross coupling of alkyl electrophiles with nitrogen nucleophile is difficult. The group of Hu at EPFL developed a strategy to combine photocatalysis and Cu-catalyzed cross-coupling to achieve C(sp³)-N coupling.



They proposed the following catalytic cycle



- (i) Give the oxidation state of Cu in intermediates I, II, and III

- (ii) Draw a formula of intermediate III

- (iii) Explain why reductive elimination occurs on III, but not II.

(i) Give the oxidation state of Cu in intermediates I, II, and III.

Cu(I); Cu(II); Cu(III)

(ii) Draw a formula of intermediate III.

R-Cu(III)-NHAr

(iii) Explain why reductive elimination occurs on III, but not II.

C(sp³)-N reductive elimination is difficult. By oxidizing the complex, the metal is in a higher oxidative state, which facilitates reductive elimination.