Phosphine ligands stabilized Cu(I) catalysts for carbene insertion into the N−H bond

Kankanala Ramakrishna, Chinnappan Sivasankar[*]

Catalysis and Energy Laboratory, Department of Chemistry, Pondicherry University, Puducherry 605014, India

A B S T R A C T

Phosphine ligands have been successfully used along with Cu(I) for several catalytic reactions, nevertheless these ligands were less explored relatively for carbene involved reactions owing to the formation of carbene-phosphine ylides. In this report we successfully used three different phosphine stabilized Cu(I) complexes (**1**−**3**) as catalysts for chemoselective carbene insertion into the N−H bond of different aromatic amines over the formation of olefin (carbene dimerized product). In order to understand the substrate scope, different α-diazo esters have been reacted with large number of amines and all the reactions produced reasonably good yields under normal experimental conditions (38 examples). All the carbene inserted products have been isolated by column chromatography and fully characterized using standard spectroscopic techniques without any ambiguities. Several control reactions have been conducted in order to understand the importance of the type of phosphine ligands used in the catalysts **1**−**3** and found that without these catalysts we observed less selectivity (more of olefin as the product over N−H inserted product) and low yield. From this present study, it can be noted that the rigid framework phosphine ligands would be the better choice for carbene chemistry. The results obtained from the current studies would inspire chemists to develop more novel Cu(I)-phosphine catalysts for carbene related reactions including asymmetric versions in the near future.

© 2016 Elsevier B.V. All rights reserved.

1. Introduction

The C−N bond has the significant place in both synthetic and nature made molecules. There are many methods known in the literature to form C−N bonds [1–3], however the most studied methods are simple nucleophilic substitution and coupling reactions. Apart from these widespread methods, carbene insertion into the N−H bond catalyzed by metals or metal salts is also found to be a useful method [4–6]. Nevertheless from the commercial point of view, catalytic methods are more economic than the simple stoichiometric nucleophilic substitution methods.

Carbene insertion into the N−H bond is one of the fast growing research areas in the last decade. Thus far only Cu [7–22], Rh [23–27] and Fe [28–36] based catalysts have been widely used with nitrogen and carbene type ligands respectively.

Apart from these metal based catalysts, Ru [33,37–40], Pd [41], Ir [42], Au [43,44], Re [45] and Ag [10] have also been developed for carbene insertion into the N−H bond. Thus far mostly N, O and C

based ligands have been used to stabilize the desired oxidation states of the above mentioned transition metal ions (Scheme 1). However, phosphine based ligands have been neglected for carbene chemistry mainly owing to the formation of carbene-phosphine ylides when the phosphine ligands are not tightly linked with the metal ions [11,41]. Therefore only few Cu(I) phosphine complexes are known for this carbene chemistry (Scheme 2).

On the other hand phosphine ligands based catalysts have been used successfully for the C−C coupling reactions, C−H activation and many other organic reactions [46–50]. Nevertheless if the phosphine ligands exist only in the complex form during the course of the reaction, one can avoid the formation of carbene-phosphine ylides. Prudently by choosing the right substituents and scaffold, one can develop catalysts with phosphine ligands for carbene chemistry. In this regard, continuation of our research upon carbene insertion reaction [21], we herein report three phosphine based copper catalysts (Scheme 3) for carbene insertion reactions and demonstrate the substrate scope (38 examples). These results perhaps useful to develop large number of phosphine stabilized cooper catalysts for similar chemistry including for asymmetric version in the near future.
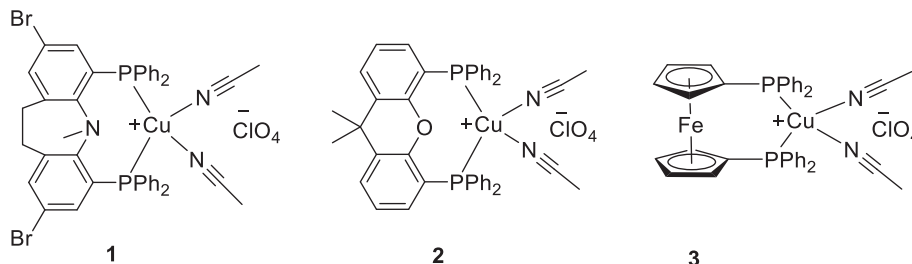
* Corresponding author.
  E-mail address: siva.che@pondiuni.edu.in (C. Sivasankar).
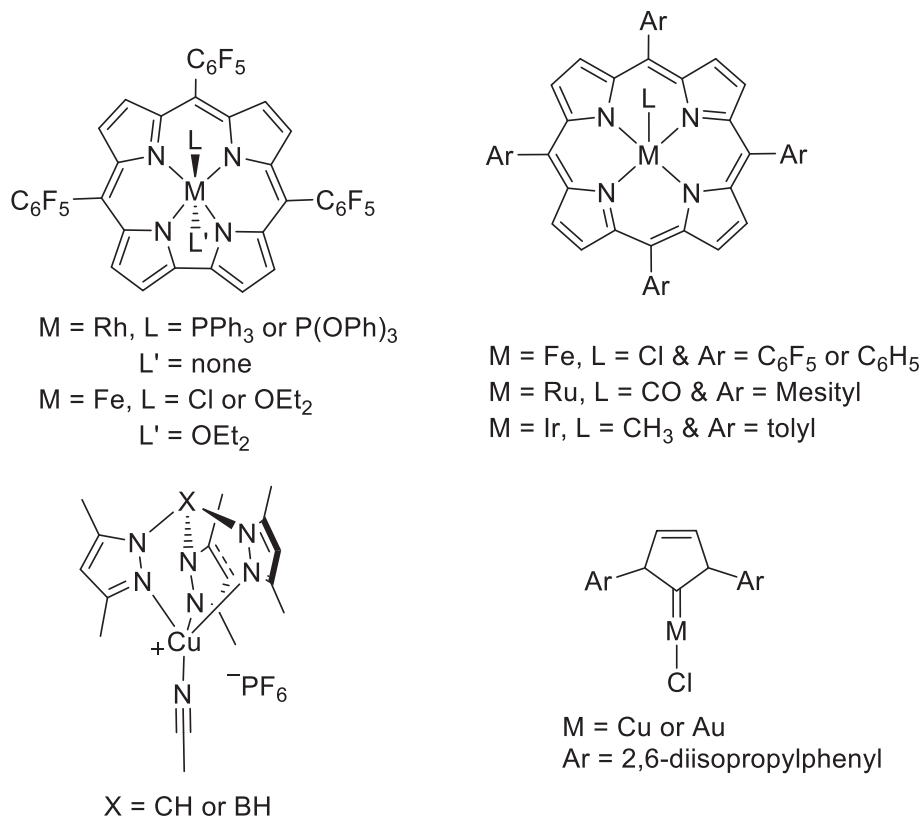
Scheme 1. Some known catalysts for carbene insertion into the N–H bond.
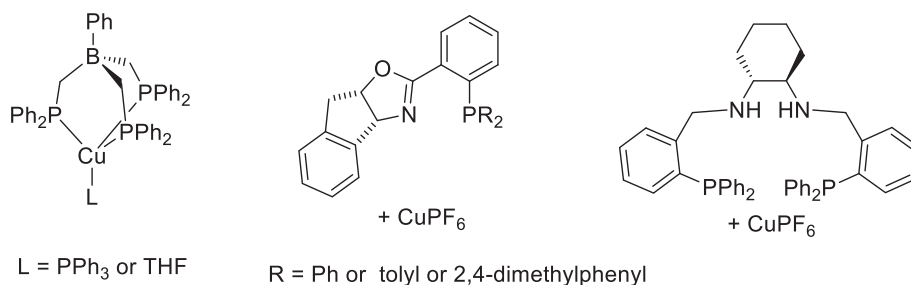
Scheme 2. Widely used phosphine ligands stabilized Cu(I) catalysts for carbene insertion reaction.

Scheme 3. Cu(I) catalysts used in the present study.

2. Results and discussion

We started our investigation with simple aniline and α-phenyl diazoacetate using 2 mol % of catalyst **1** in DCM (Scheme 4). The reaction was completed within 4 h and furnished an excellent yield 97%. This result prompted us to optimize the reaction conditions.

For optimizing the reaction conditions, we screened commonly used organic solvents and catalyst load as well. First of all we screened the catalyst load, we observed the best yield with 2 mol % of catalyst. In case of solvents, we observed excellent yields with DCM solvent. In case of coordinating solvent THF (Table 1, entry 2), the reaction was found to be slow and given 76% yield in 10 h. In