



Pd-catalyzed decarboxylative cross-coupling of perfluorobenzoic acids with simple arenes

Hai-Qing Luo^{a,*}, Wen Dong^a, Teck-Peng Loh^b

^a Department of Chemistry & Chemical Engineering, Gannan Normal University, Ganzhou, Jiangxi 341000, PR China

^b Division of Chemistry and Biological Chemistry, School of Physical and Mathematical Sciences, Nanyang Technological University, 637371 Singapore, Singapore

ARTICLE INFO

Article history:

Received 11 January 2013

Revised 10 March 2013

Accepted 19 March 2013

Available online 27 March 2013

Keywords:

Pd-catalyzed
Crosscoupling
Fluorobiphenyl
Simple arenes
Decarboxylative

ABSTRACT

Using a Pd/Ag bimetallic system, arylations of simple arenes with perfluorobenzoic acids have been achieved by decarboxylative C–H bond functionalization, providing the desired cross-coupling products in moderate to good yields. These straightforward protocols provide new and efficient methods for the synthesis of fluorobiphenyl scaffolds under simple and mild conditions.

© 2013 Elsevier Ltd. All rights reserved.

Transition-metal-catalyzed decarboxylative coupling is an important and very attractive research point of organic synthesis in recent years.¹ This method avoids the preparation and use of stoichiometric organometallic reagents such as boronic acids and releases gaseous carbon dioxide as the leaving group instead of often toxic or expensive metal salts. Representative examples include the decarboxylative coupling of benzoic acids with aryl halides or triflates with carefully optimized Pd/Cu catalytic systems,² the decarboxylative olefination, and biaryl coupling of aromatic carboxylic acids with Pd/Ag catalytic systems,³ and other recent developments of Pd-catalyzed decarboxylative coupling.⁴ However, the requirement of prefunctionalization of the coupling partners to activate the aromatic C–H bonds, for example, using aryl halides or aryl triflates as the synthetic substrates, limited the application of these kinds of decarboxylative aryl–aryl cross-couplings. To overcome this challenge, cross-coupling of unactivated arenes was developed via direct C–H activation. In that case, a directing group was usually necessary for the high chemo- and regioselectivity of the transformation.⁵ An alternative strategy to avoid installing a directing group for decarboxylative cross-coupling was the use of electron-rich heterocycles,⁶ or intramolecular direct arylation through Pd-catalyzed C–H activation.⁷

As part of our ongoing research on efficient palladium-catalyzed direct cross-coupling reaction,⁸ we aimed at the difficult but highly desirable coupling for the construction of complicated fluorinated

scaffolds,⁹ which have a potential value in the field of material science.¹⁰

Studies on the preparation of polyfluorobiaryls via direct cross-coupling are widely reported for its considerable advantages over traditional organometallic transformation process.^{11,12} Among these current progresses, it is of note that decarboxylative coupling of electron-deficient perfluorobenzoates represented one to polyfluorobiaryls.¹²

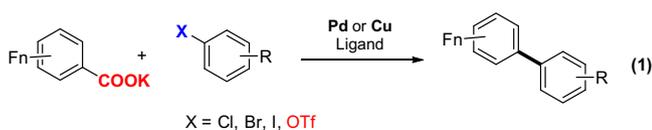
Nevertheless, to the best of our knowledge, the direct cross-coupling of perfluorobenzoic acids with simple arenes instead of aryl halides or triflates is unprecedented to date (Scheme 1, Eq. 1). Herein we describe the first example of direct Pd-catalyzed decarboxylative arylation of perfluorobenzoic acids with simple arenes via C–H bond functionalization (Scheme 1, Eq. 2). With a low loading of Pd catalyst (5 mol %) and ligand free, this direct arylation reaction provides a novel and efficient method for the synthesis of perfluorobiphenyls.

We began our investigation by choosing commercially available perfluorobenzoic acid (**1a**) and *p*-xylene (**2a**) as our initial model substrates. The effect of reaction parameters on the conversion was summarized in Table 1. It was found that the desired decarboxylative cross-coupling product **3a** was provided with a remarkable 88% isolated yield in the presence of the catalytic amount of Pd(OAc)₂ and stoichiometric Ag₂CO₃ at 130 °C in DMSO solution (Table 1, entry 5), whereas, small amounts of by-products **3aa** and **3ab** through homo-coupling and oxidation of arene were detected. Other commonly used palladium sources, such as Pd(TFA)₂, PdCl₂, Pd(CH₃CN)₂, and Pd(PhCN)Cl₂ were less effective

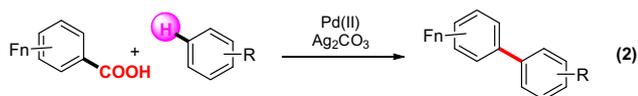
* Corresponding author. Tel.: +86 797 8393536; fax: +86 797 8393670.

E-mail address: luohaiq@sina.com (H.-Q. Luo).

Direct Arylation with Perfluoroarenes reported by Liu



Our work via C-H functionalization



Scheme 1. Decarboxylative arylation of perfluorobenzoic acids.

or completely ineffective (Table 1, entries 1–4). The yields collapsed significantly when the solvent was replaced by DMF, 1,4-dioxane, or NMP (Table 1, entries 6–8). DMSO proved to be the best choice, presumably because of its dual functions, not only as solvent but also as a ligand to activate the Pd catalyst and prevent the formation of palladium black.¹³ In addition, replacement of the oxidant Ag₂CO₃ with Cu(OAc)₂ or AgOAc led to lower reaction

Table 1
Direct arylation of pentafluorobenzoic acid **1a** with *p*-xylene **2a**^a

| Entry | Pd (mol %) | Oxidant | Solvent | Yield of 3a ^b (%) |
|-------|--|---|----------------------|-------------------------------------|
| 1 | Pd(TFA) ₂ (10) | Ag ₂ CO ₃ (2.0 equiv) | DMSO (0.1 mL) | 44 |
| 2 | PdCl ₂ (10) | Ag ₂ CO ₃ (2.0 equiv) | DMSO (0.1 mL) | 5 |
| 3 | Pd(CH ₃ CN) ₂ (10) | Ag ₂ CO ₃ (2.0 equiv) | DMSO (0.1 mL) | 53 |
| 4 | Pd(PhCN) ₂ (10) | Ag ₂ CO ₃ (2.0 equiv) | DMSO (0.1 mL) | 0 |
| 5 | Pd(OAc) ₂ (10) | Ag ₂ CO ₃ (2.0 equiv) | DMSO (0.1 mL) | 88 |
| 6 | Pd(OAc) ₂ (10) | Ag ₂ CO ₃ (2.0 equiv) | DMF (0.1 mL) | 32 |
| 7 | Pd(OAc) ₂ (10) | Ag ₂ CO ₃ (2.0 equiv) | 1,4-Dioxane (0.1 mL) | 36 |
| 8 | Pd(OAc) ₂ (10) | Ag ₂ CO ₃ (2.0 equiv) | NMP (0.1 mL) | 34 |
| 9 | Pd(OAc) ₂ (10) | Cu(OAc) ₂ (2.0 equiv) | DMSO (0.1 mL) | 19 |
| 10 | Pd(OAc) ₂ (10) | Ag ₂ CO ₃ (2.0 equiv) | DMSO (0.1 mL) | 41 |
| 11 | Pd(OAc) ₂ (7.5) | Ag ₂ CO ₃ (2.0 equiv) | DMSO (0.1 mL) | 87 |
| 12 | Pd(OAc)₂ (5) | Ag₂CO₃ (2.0 equiv) | DMSO (0.1 mL) | 89 |
| 13 | Pd(OAc) ₂ (2.5) | Ag ₂ CO ₃ (2.0 equiv) | DMSO (0.1 mL) | 54 |

^a Reactions were performed in a sealed tube under air with pentafluorobenzoic acid **1a** (0.3 mmol) and *p*-xylene **2a** (0.9 mL).

^b Isolated yield based on pentafluorobenzoic acid.

conversion (Table 1, entries 9 and 10). After further optimization on the catalyst loading of Pd(OAc)₂, the coupling product was obtained without any alteration in yield when the amount of Pd(OAc)₂ was reduced to 5 mol % (Table 1, entries 11–13).

Based on the optimized condition of direct decarboxylative arylation of pentafluorobenzoic acid with simple arenes, we proceeded to explore the scope of the decarboxylative arylation reaction of polyfluorobenzoic acid derivatives with various simple arenes. The results were presented in Table 2. It is intriguing to note that chloride substituent in the substrate was tolerant to the reaction system, despite lack of selectivity affording slightly reduced but acceptable yields of the desired product (Table 2, entry 3). Results of 1,2- and 1,3-disubstituted benzenes indicate that the steric effect dominates the reaction regioselectivity at the preferable less hindered C–H position (Table 2, entries 4 and 5). Less comparably active polyfluorobenzoic acid substrates, even bearing electron-donating group such as MeO – were also sustainable to the decarboxylative arylation reaction under the same condition (Table 2, entries 7–8).

Aromatic heterocycle was also subjected to the reaction (Scheme 2). We are happy to find that the desired cross-coupling

Table 2
Decarboxylative arylation of polyfluorobenzoic acid **3a** with various simple arenes **2**^a

| Entry | Polyfluorobenzoic acid | Arene | Product | Yield ^b (%) |
|-------|------------------------|-------|-----------|------------------------------------|
| 1 | | | 3a | 89 |
| 2 | | | 3b | 70 ^c o:m:p =1:2:2 |
| 3 | | | 3c | 65 o:m:p =1:2:2 |
| 4 | | | 3d | 79 2:1 = 6.3:1 |
| 5 | | | 3e | 80 1:2 = 2:2:1 |
| 6 | | | 3f | 82 |
| 7 | | | 3g | 65 |
| 8 | | | 3h | 73 |

^a Reactions were performed in a sealed tube under air with polyfluorobenzoic acid **1** (0.3 mmol) and simple arenes **2** (0.9 mL).

^b Isolated yield based on polyfluorobenzoic acids.

^c Yield determined as a mixture of isomers, and the ratio of isomers was calculated by GC–MS or/and ¹⁹F NMR.

Download English Version:

<https://daneshyari.com/en/article/5265713>

Download Persian Version:

<https://daneshyari.com/article/5265713>

[Daneshyari.com](https://daneshyari.com)