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Pd-PEPPSI: Pd-NHC Precatalyst for Suzuki–Miyaura Cross-Coupling Reactions of Amides

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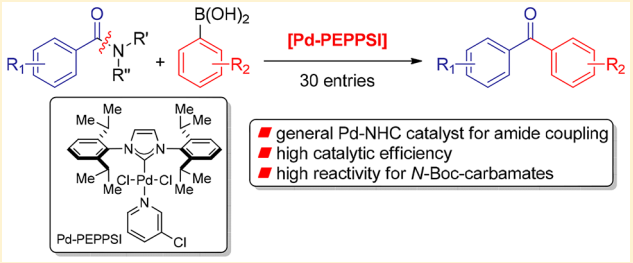
Supporting Information

ABSTRACT: Pd-PEPPSI-IPr serves as a highly reactive precatalyst in the direct Suzuki–Miyaura cross-coupling of amides. An array of amides can be cross-coupled with a range of arylboronic acids in very good yields using a single, operationally simple protocol. The studies described represent the first use of versatile PEPPSI type of Pd-NHC complexes as catalysts for the cross-coupling of amides by N–C bond activation. The method is user-friendly, since it employs a commercially available, air- and moisture-stable Pd-PEPPSI-IPr complex. Pd-PEPPSI-IPr provides a significant improvement over all current Pd/phosphane catalysts for amide N–C bond activation. Mechanistic studies provide insight into the reaction rates of Pd-NHC-catalyzed cross-coupling of different amides, with Pd-PEPPSI-IPr being particularly effective for the cross-coupling of *N*-Boc carbamates under the developed conditions.



1. INTRODUCTION

The careful tuning of electron-rich ligands has led to remarkable progress in transition-metal-catalyzed cross-coupling reactions.[1] In particular, nucleophilic *N*-heterocyclic carbenes (NHCs) have been identified as a class of highly useful ligands in promoting challenging cross-coupling reactions.[2] The strong σ-donation and variable steric bulk around the metal center facilitate oxidative addition and reductive elimination.[3] The high activity of well-defined, air- and moisture-stable Pd(II)-NHC precatalysts has led to their widespread application in catalysis.[1−3] Inspired by the remarkable properties of Pd-NHC catalysts, we recently reported that (NHC)Pd(R-allyl)Cl complexes are uniquely effective in promoting Suzuki–Miyaura cross-coupling reactions of amides by N–C bond activation.[4] In particular, we demonstrated that Nolan's (IPr)Pd(cinnamyl)Cl catalyst is extremely active for the cross-coupling of amides by N–C activation. Specifically, we demonstrated the cross-coupling of *N*-glutarimide amides, *N*-Boc/R, and *N*-Ts/R amides in high yields under one set of experimental conditions.[4]

As part of our program in amide bond cross-coupling,[4−7] herein we report that Pd-PEPPSI-IPr serves as a highly reactive precatalyst in the direct Suzuki-Miyaura cross-coupling of amides. The ease of preparation and modular nature of PEPPSI type catalysts provided clear motivation for investigating PEPPSI in the place of the cinnamoyl system.[3c] The following features of our findings are noteworthy:

(1) This study demonstrates the first use of versatile PEPPSI type Pd-NHC complexes as catalysts for the cross-coupling of amides by N–C bond activation.

(2) PEPPSI type Pd-NHC complexes represent a completely different class of Pd-NHC catalysts than (NHC)Pd(R-allyl)Cl complexes, which offers new opportunities for developing N–C bond activation reactions through ancillary ligand design.

(3) PEPPSI type complexes are often easier to prepare (single straightforward step) than (NHC)Pd(R-allyl)Cl, which is significant for future use in cross-coupling by amide N–C bond activation.

(4) PEPPSI type complexes are often cheaper to synthesize than (NHC)Pd(R-allyl)Cl, which is particularly important from the synthetic point of view.

(5) Activation to give active Pd(0) species proceeds through different pathways for PEPPSI type and (NHC)Pd(R-allyl)Cl complexes, which may lead to the design of practical Pd-NHC complexes for N–C bond activation.

(6) Most importantly, PEPPSI type complexes in the amide N–C bond activation demonstrate high reactivity for the most useful class of amides that can undergo the cross-coupling, namely N-R/Boc carbamates. These amides are easily prepared from secondary amides, while methods for Pd/PR_3-catalyzed cross-coupling of *N*-R/Boc carbamates have proven elusive so far.

2. RESULTS AND DISCUSSION

Over the past two years, there has been a significant effort to develop transition-metal-catalyzed cross-coupling of amides (Figure 1A).[5−7] Amides are widely prevalent in bioactive

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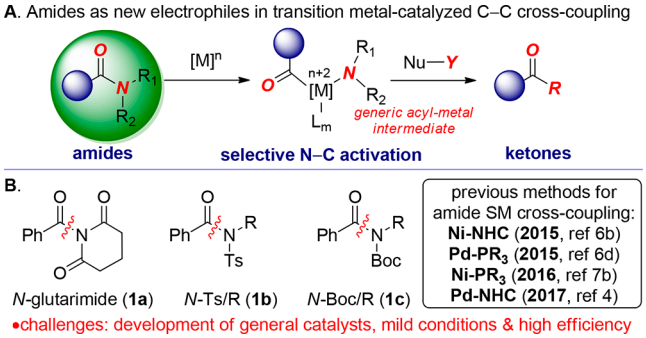


Figure 1. Amides as electrophiles in the Suzuki–Miyaura cross-coupling: attractive alternative to stoichiometric Weinreb synthesis.

molecules, including pharmaceuticals, peptides, and proteins.[8] Moreover, amides serve as valuable synthetic intermediates characterized by high bench stability resulting from amidic resonance ($n_N \rightarrow \pi^*_{C=O}$ barrier to rotation of ca. 15–20 mol/kcal).[5b] The controlled cleavage of C–N bonds by transition metal catalysis represents a new mode of amide bond disconnection, enabling (1) generic access to acyl-metal intermediates from bench stable amides that can be widely exploited in cross-coupling manifolds and (2) functional group tolerance and utility inaccessible by traditional nucleophilic addition via tetrahedral intermediates.

Since 2015, three major classes of amides have emerged as promising precursors for achieving highly selective amide acyl N–C bond cross-coupling reactions: (1) *N*-glutarimide amides, (2) *N*-acyl-*tert*-butyl-carbamates (Boc), (3) *N*-acyl-tosylamides (Ts) (Figure 1B).[5−7] Garg et al. reported a Ni/NHC catalyst system for the Suzuki–Miyaura cross-coupling of *N*-Boc amides.[6b] Zou et al. reported a Pd–PR_3 system for the cross-coupling of *N*-Ts amides.[5] We reported a Pd–PR_3 catalyst system for the cross-coupling of *N*-glutarimide amides.[5] To fully exploit the potential of cross-coupling of amide electrophiles, it is critical that new highly active catalysts are identified that (1) permit cross-coupling of amides with high efficiency; (2) operate under mild, operationally simple conditions; and (3) show high reactivity across different classes of amides.

Pd-PEPPSI (pyridine-enhanced precatalyst preparation stabilization and initiation) type Pd-NHC complexes have been extensively developed by Organ and co-workers for the cross-coupling of challenging, aryl- and alkyl-electrophiles.[9,10] PEPPSI complexes are among the most active catalysts for palladium-catalyzed cross-coupling reactions.[11] Our study represents the first use of versatile PEPPSI complexes as catalysts for cross-coupling of amides by N–C bond activation. Considering the versatility of PEPPSI catalysts,[9−11] we expect that this study will further the wide adoption of Pd-NHC complexes in amide bond cross-coupling by organic chemists. The properties of Pd-PEPPSI complexes render them attractive catalysts for amide bond N–C cross-coupling. The use of Pd-NHC precatalysts fine-tuned by the supporting ligand[2,3] offers exciting potential as highly efficient catalysts in amide N–C bond activation manifolds (Figure 2).[5−7]

Our optimizations were carried out using *N*-glutarimide (**1a**), *N*-acyl-Ts (**1b**), and *N*-acyl-Boc (**1c**) amides to evaluate the effect of electronic destabilization[12] on the reactivity. As noted above, the selected amides represent the only types of acyclic amides that engage in successful Suzuki cross-coupling by N–C bond cleavage thus far. A Pd-PEPPSI-IPr catalyst was selected for the initial study.[9,10] We were delighted to find that Pd-

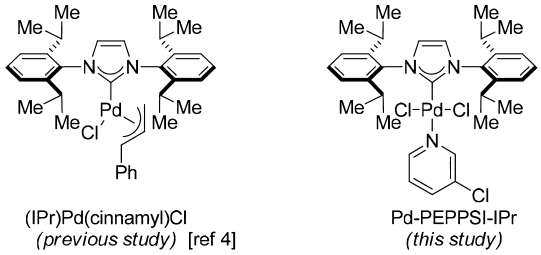
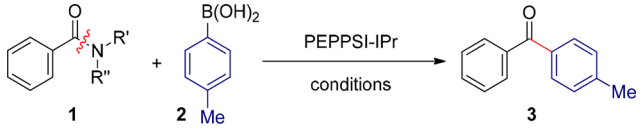


Figure 2. Highly active Pd(II)-NHC precatalysts in the Suzuki–Miyaura cross-coupling of amides.

PEPPSI-IPr promoted the desired cross-coupling with exceptional efficiency using all three amides at 60 °C (Table 1, entries 1–3). The low temperature for the Pd-catalyzed cross-coupling of *N*-acyl-Ts (**1b**) and *N*-acyl-Boc (**1c**) amides is particularly worth noting, since Pd–PR_3 catalyst systems either are completely ineffective (**1c**) or require temperatures of 110 °C (**1b**) for efficient coupling.[5] Since the cross-coupling of *N*-acyl-Ts amide (**1b**) proceeded with a slightly lower reaction rate (entry 2) than **1a** (entry 1) and **1c** (entry 3) (vide infra), **1b** was selected to further evaluate the effect of reaction conditions. As shown, the solvent and the base had a substantial effect on the reactivity (entries 4–11), with THF and K_2CO_3, KF, and K_3PO_4 being the most efficient. Importantly, 1 equiv of base suffices for the effective coupling (entries 12–15). Similarly, high reaction efficiency is observed using close to an equimolar ratio of the boronic acid coupling partner (entries 16–17). Finally, we were delighted to find that Pd-PEPPSI-IPr

Table 1. Optimization of the Reaction Conditions[a]



entry	amide	base	solvent	T (°C)	yield (%)[b]
1	**1a**	K_2CO_3	THF	60	>98
2	**1b**	K_2CO_3	THF	60	77
3	**1c**	K_2CO_3	THF	60	95
4	**1b**	K_2CO_3	THF	80	85
5	**1b**	K_2CO_3	dioxane	80	81
6	**1b**	K_2CO_3	toluene	80	76
7	**1b**	Cs_2CO_3	THF	80	50
8	**1b**	K_3PO_4	THF	80	68
9	**1b**	KF	THF	80	78
10	**1b**	KOH	THF	80	46
11	**1b**	NaO*t*-Bu	THF	80	<2
12[c]	**1b**	K_2CO_3	THF	80	85
13[d]	**1b**	K_2CO_3	THF	80	87
14[e]	**1b**	K_2CO_3	THF	80	84
15[f]	**1b**	K_2CO_3	THF	80	<2
16[g]	**1b**	K_2CO_3	THF	80	67
17[h]	**1b**	K_2CO_3	THF	80	86
18	**1a**	K_2CO_3	THF	40	75
19	**1b**	K_2CO_3	THF	40	30
20	**1c**	K_2CO_3	THF	40	71

[a] **1** (1.0 equiv), R-B(OH)$_2$ (2.0 equiv), [Pd] (3 mol %), K_2CO_3 (3.0 equiv), THF (0.25 M), T, 15 h. [b] GC/^{1}H NMR yields. [c] K_2CO_3 (5.0 equiv). [d] K_2CO_3 (2.0 equiv). [e] K_2CO_3 (1.0 equiv). [f] Without K_2CO_3. [g] R-B(OH)$_2$ (1.2 equiv). [h] R-B(OH)$_2$ (3.0 equiv). **1a** (*N*-glutarimide); **1b** (*N*-Ts/Ph); **1c** (*N*-Boc/Ph).

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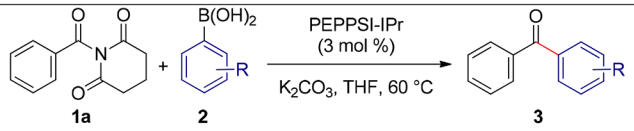
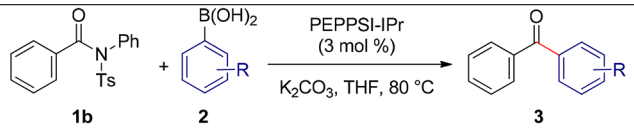
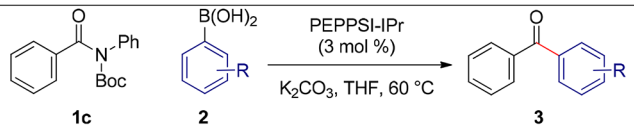
Table 2. Pd-PEPPSI-Catalyzed Suzuki−Miyaura Cross-Coupling of Amides: Scope of Boronic Acids[a,b]

entry	amide (Ar_1)	Ar_2-$B(OH)_2$	yield (%)
			
	1a	**2**	**3**
1	Ph	R = H	94
2	Ph	R = 2-CH_3	97
3	Ph	R = 4-CH_3	97
4	Ph	R = 4-OMe	98
5	Ph	R = 4-CO_2Me	90
entry	amide	Ar-$B(OH)_2$	yield (%)
			
	1b	**2**	**3**
6	Ph	R = H	92
7	Ph	R = 2-CH_3	83
8	Ph	R = 4-CH_3	83
9	Ph	R = 4-OMe	85[c]
10	Ph	R = 4-CO_2Me	63[c]
entry	amide	Ar-$B(OH)_2$	yield (%)
			
	1c	**2**	**3**
11	Ph	R = H	94
12	Ph	R = 2-CH_3	90
13	Ph	R = 4-CH_3	92
14	Ph	R = 4-OMe	98
15	Ph	R = 4-CO_2Me	90

[a] **1** (1.0 equiv), Ar−$B(OH)_2$ (2.0 equiv), [Pd] (3 mol %), K_2CO_3 (3.0 equiv), 60 °C, 15 h. Entries 6−10: 80 °C. [b] Isolated yields. [c] 110 °C.

promoted the coupling of all three amides at 40 °C (entries 18−20) in modest (**1b**) to high (**1a**, **1c**) yields, providing a solid entry point for future ligand design studies. The reaction is inefficient at ambient conditions. Polar solvents are not suitable for the coupling. The results obtained with Pd-PEPPSI-IPr are noteworthy from a practical point of view, since the catalyst is commercially available as well as air- and moisture-stable and a range of PEPPSI type Pd-NHC complexes by straightforward modification of the ligand structure are readily available.[9,10]

With the optimized conditions in hand, we systematically evaluated the scope of boronic acid (Table 2) and amide (Table 3) cross-coupling partners under the optimized conditions. As shown, the scope of the reaction is broad and

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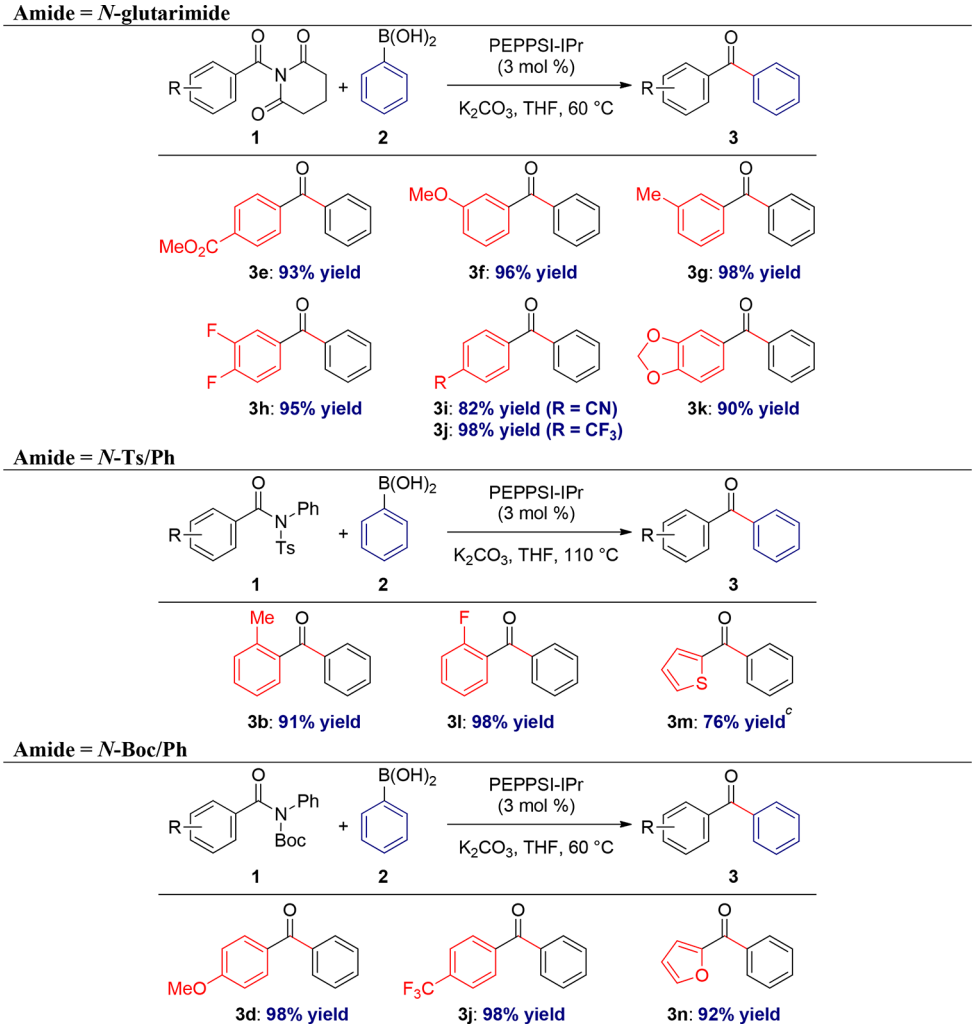
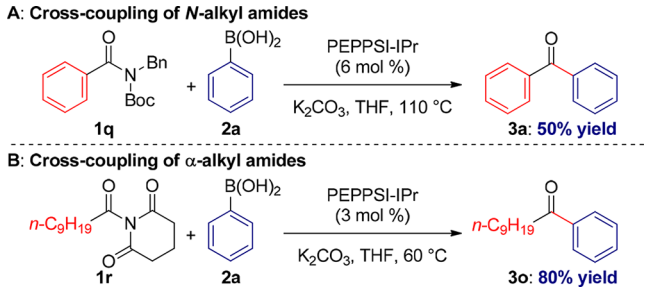
Table 3. Pd-PEPPSI-Catalyzed Suzuki–Miyaura Cross-Coupling of Amides: Scope of Amides[a,b]



[a]**1** (1.0 equiv), Ar–$B(OH)_2$ (2.0 equiv), [Pd] (3 mol %), K_2CO_3 (3.0 equiv), *T*, 15 h. [b]Isolated yields. [c][Pd] (6 mol %).

tolerates sterically hindered, electron-rich and electron-withdrawing substituents on the boronic acid component in all three types of amides examined (Table 2, entries 1–15). Cross-coupling with *N*-Ts-amides was routinely performed at 80 °C (entries 6–8) or 110 °C (entries 9–10), since this temperature results in slight improvement of the catalytic efficiency. The Pd-PEPPSI-IPr catalyst showed excellent reactivity across all three types of amides examined. A comparison with the (NHC)Pd-(R-allyl)Cl catalyst is included in the Supporting Information. The scope of the amide component is also broad (Table 3) and tolerates a range of electron-rich (**3f**, **3k**, **3d**), electron-withdrawing (**3e**, **3h**, **3i**, **3j**, **3l**, **3i**), sterically hindered (**3b**, **3l**), and heterocyclic (**3k**, **3m**, **3n**) amide substrates. Note that the catalyst tolerates strongly electron-donating five-membered heterocycles, such as thiophene (**3m**) and furan (**3n**), substituted at the conjugating 2-position. Importantly, several functional handles that are problematic in the classic Weinreb synthesis such as esters (**3e**) and nitriles (**3i**) are readily tolerated (Tables 2–3). Additionally, we were pleased to find that the challenging *N*-alkyl and *α*-alkyl amide substrates could be used to afford the desired cross-coupling products in modest to good yields (Scheme 1), further demonstrating generality of the PEPPSI Pd-NHC catalyst system. The cross-coupling of the challenging *α*-alkyl amide **1r** proceeds in an unoptimized 85% yield using (IPr)Pd(cinnamyl)Cl.[4]

Scheme 1. Cross-Coupling of Alkyl Amides



Kinetic studies were employed to investigate the effect of electronic destabilization of amides **1a–1c** under the Pd-PEPPSI-IPr conditions (Figure 3). Initial rates revealed the following order of reactivity: (**1a**) ($\nu_{initial}$ = 1.9 × 10^{-1} mM s^{-1}) > (**1c**) ($\nu_{initial}$ = 8.5 × 10^{-2} mM s^{-1}) > (**1b**) ($\nu_{initial}$ = 3.1 × 10^{-2} mM s^{-1}), which can be compared with (IPr)Pd(cinnamyl)Cl[13] under identical reaction conditions: (**1a**) ($\nu_{initial}$ = 4.0 × 10^{-1} mM s^{-1}) > (**1c**) ($\nu_{initial}$ = 7.5 × 10^{-2} mM s^{-1}) > (**1b**) ($\nu_{initial}$ = 4.0 × 10^{-2} mM s^{-1}).

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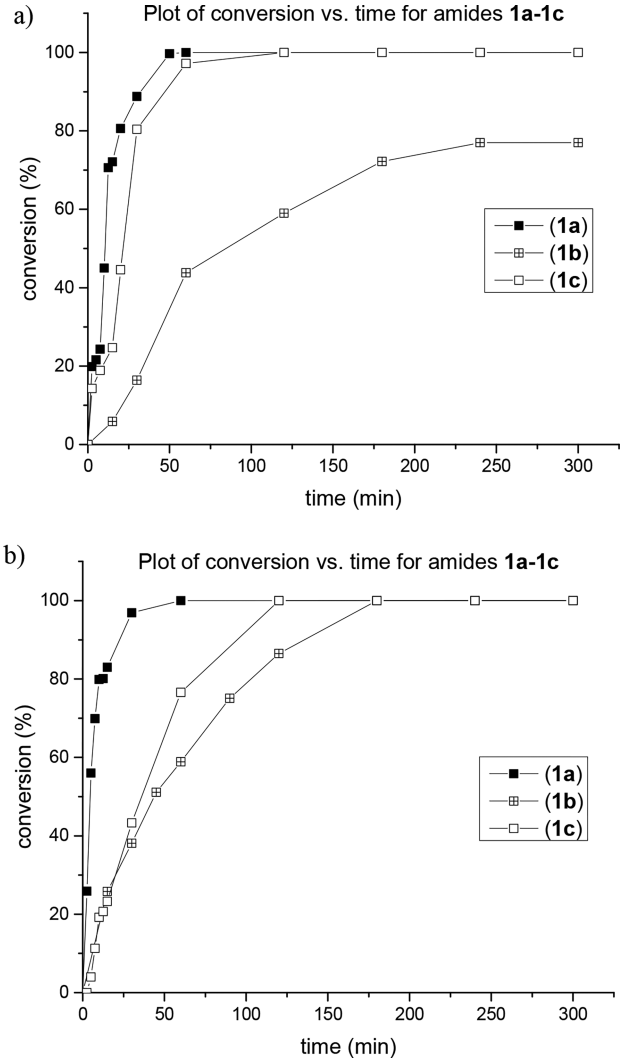

Figure 3. (a) Kinetic profile of amides **1a−1c** in the Suzuki−Miyaura cross-coupling with 4-tolylboronic acid catalyzed by PEPPSI-IPr (3 mol %) at 60 °C. (b) Kinetic profile using (IPr)Pd(cinnamyl)Cl (3 mol %) at 60 °C is shown for comparison.[4] Conditions: amide (1.0 equiv), [Pd] (3 mol %), 4-Tol-B(OH)$_2$ (2.0 equiv), K_2CO_3 (3.0 equiv), THF (0.25 M), 60 °C.

Additional Discussion. In general, we have observed the following reactivity trends of PEPPSI-IPr and (IPr)Pd(cinnamyl)Cl precatalysts in the Suzuki−Miyaura cross-coupling of amides:

1. Generally, faster reaction rates in the cross-coupling of *N*-Boc/Ar amides using PEPPSI-IPr.
2. Generally, faster reaction rates in the cross-coupling of *N*-glutarimide and *N*-Ts/Ar amides using (IPr)Pd(cinnamyl)Cl.
3. High preparative yields in the cross-coupling of *N*-glutarimide, *N*-Ts/Ar, and *N*-Boc/Ar amides using PEPPSI-IPr and (IPr)Pd(cinnamyl)Cl.
4. It should be noted that the cross-coupling of *N*-R/Boc carbamates proceeds in generally slightly higher yields with PEPPSI than with (NHC)Pd(R-allyl)Cl. While the cross-coupling of *N*-R/Ts sulfonamides proceeds in similar yields using PEPPSI-type NHC and (NHC)Pd(R-allyl)Cl, *N*-R/Boc amides are vastly preferred from the synthetic point of view due to ease of preparation from secondary amides.[5]

The results of kinetic studies further substantiate the amide bond N−C cross-coupling reactivity scale in which *N*-R/Boc amides (Er = 6−7 kcal/mol) should be more reactive than *N*-R/Ts amides (Er = 8−9 kcal/mol) on the basis of the difference of amidic resonance.[12] A plausible mechanism involves oxidative addition of a Pd(0)-NHC into the amide N−C bond, followed by transmetalation and reductive elimination.[2a,3c]

Turnover numbers (TON) of 760, 480, 690 were determined for the cross-coupling of amides **1a−1c** (Pd-PEPPSI-IPr, 0.10 mol %, 110 °C). This shows that PEPPSI type Pd-NHC complexes may be uniquely competent for cross-coupling of amides by N−C bond activation unattainable by Pd-PR$_3$ catalysts.

3. CONCLUSIONS

In conclusion, we have demonstrated the first direct Suzuki−Miyuara cross-coupling of amides catalyzed by the PEPPSI type of Pd-NHC catalysts. The versatile method shows broad scope with respect to both the boronic acid and amide components. The Pd-NHC catalyst described show a substantial improvement over Pd−PR$_3$ systems employed for the amide N−C bond activation. This type of Pd-NHC complexes has found widespread applications in organic synthesis due to high catalytic activity, ease of synthesis, and high air and moisture stability. From our results, it is clear that Pd-PEPPSI[9−11] and (NHC)Pd(R-allyl)Cl precatalysts[13] show high and complementary reactivity in catalytic activation of the amide N−C bond that is beyond the current scope of Pd−PR$_3$ systems. Rational optimization of the supporting NHC ligand has a considerable potential to improve the catalytic efficiency of the amide bond cross-coupling reactions by N−C activation.

4. EXPERIMENTAL SECTION

General Methods. All starting materials reported in the manuscript have been previously described in literature and prepared by the method reported previously.[4,6a,d] Amides were prepared by previously published procedures.[4,6a,d] All experiments were performed using standard Schlenk techniques under nitrogen or argon unless stated otherwise. All compounds reported in this manuscript have been previously reported or are commercially available. Spectroscopic data matched literature values. General methods have been published.[6d]

General Procedure for the Suzuki−Miyaura Cross-Coupling. An oven-dried vial equipped with a stir bar was charged with an amide substrate (neat, 1.0 equiv), potassium carbonate (typically, 3.0 equiv), boronic acid (typically, 2.0 equiv), PEPPSI-IPr ([1,3-bis(2,6-diisopropylphenyl)imidazol-2-ylidene](3-chloropyridyl)palladium(II) dichloride, typically, 3 mol %), placed under a positive pressure of argon, and subjected to three evacuation/backfilling cycles under high vacuum. THF (typically, 0.25 M) was added with vigorous stirring at room temperature, and the reaction mixture was placed in a preheated oil bath and stirred for the indicated time. After the indicated time, the reaction mixture was cooled down to room temperature, diluted with CH_2Cl_2 (10 mL), filtered, and concentrated. The sample was analyzed by ^{1}H NMR ($CDCl_3$, 500 MHz) and GC-MS to obtain conversion, selectivity, and yield using internal standard and comparison with authentic samples. Purification by chromatography on silica gel (EtOAc/hexanes, 1/20) afforded the title product.

Representative Cross-Coupling Procedure. 1.0 mmol Scale. An oven-dried vial equipped with a stir bar was charged with 1-benzoylpyrrolidine-2,6-dione (1.0 mmol, 217.2 mg, 1.0 equiv), potassium carbonate (3.0 mmol, 414.6 mg, 3.0 equiv), *p*-tolylboronic

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acid (2.0 mmol, 271.9 mg, 2.0 equiv), and PEPPSI-IPr (3 mol %, 20.4 mg), placed under a positive pressure of argon, and subjected to three evacuation/backfilling cycles under high vacuum. THF (0.25 M) was added with vigorous stirring at room temperature, and the reaction mixture was placed in a preheated oil bath at 60 °C and stirred for 15 h at 60 °C. After the indicated time, the reaction mixture was cooled down to room temperature, diluted with CH_2Cl_2 (20 mL), filtered, and concentrated. The sample was analyzed by ^1H NMR ($CDCl_3$, 500 MHz) and GC-MS to obtain conversion, selectivity, and yield using an internal standard and comparison with authentic samples. Purification by chromatography on silica gel (EtOAc/hexanes, 1/20) afforded the title product (190.4 mg). Yield 97%. White solid. Characterization data are included in the section below.

Cross-Coupling of Amides: Variation of Boronic Acid. Benzophenone (3a) (Table 2, Entry 1). According to the general procedure, the reaction of 1-benzoylpiperidine-2,6-dione (0.20 mmol), phenylboronic acid (2.0 equiv), K_2CO_3 (3.0 equiv), and PEPPSI-IPr (3 mol %) in THF (0.25 M) for 15 h at 60 °C afforded, after filtration and chromatography, the title compound in 94% yield (34.3 mg). White solid. ^1H NMR (500 MHz, $CDCl_3$) δ 7.81 (d, J = 7.4 Hz, 4H), 7.59 (t, J = 7.4 Hz, 2H), 7.49 (t, J = 7.7 Hz, 4H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 196. 8, 137.6, 132.4, 130.1, 128.3. Spectroscopic data matched literature values.[6d]

Phenyl(*o*-tolyl)methanone (3b) (Table 2, Entry 2). According to the general procedure, the reaction of 1-benzoylpiperidine-2,6-dione (0.20 mmol), *o*-tolyboronic acid (2.0 equiv), K_2CO_3 (3.0 equiv), and PEPPSI-IPr (3 mol %) in THF (0.25 M) for 15 h at 60 °C afforded after filtration and chromatography the title compound in 97% yield (38.1 mg). Oil. ^1H NMR (500 MHz, $CDCl_3$) δ 7.83 (d, J = 7.6 Hz, 2H), 7.61 (t, J = 7.3 Hz, 1H), 7.48 (t, J = 7.4 Hz, 2H), 7.42 (t, J = 7.4 Hz, 1H), 7.33 (t, J = 9.4 Hz, 2H), 7.28 (d, J = 5.9 Hz, 1H), 2.36 (s, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 198.7, 138.6, 137.8, 136.8, 133.2, 131.0, 130.3, 130.2, 128.5, 128.5, 125.2, 20.0. Spectroscopic data matched literature values.[6d]

Phenyl(*p*-tolyl)methanone (3c) (Table 2, Entry 3). According to the general procedure, the reaction of 1-benzoylpiperidine-2,6-dione (1.0 mmol), *p*-tolylboronic acid (2.0 equiv), K_2CO_3 (3.0 equiv), and PEPPSI-IPr (3 mol %) in THF (0.25 M) for 15 h at 60 °C afforded, after filtration and chromatography, the title compound in 97% yield (190.4 mg). White solid. ^1H NMR (500 MHz, $CDCl_3$) δ 7.78 (d, J = 7.5 Hz, 2H), 7.72 (d, J = 7.4 Hz, 2H), 7.57 (t, J = 7.3 Hz, 1H), 7.47 (t, J = 7.4 Hz, 2H), 7.28 (d, J = 7.6 Hz, 2H), 2.44 (s, 3H).^{13}C NMR (125 MHz, $CDCl_3$) δ 196.5, 143.3, 138.0, 134.9, 132.2, 130.3, 130.0, 129.0, 128.2, 21.7. Spectroscopic data matched literature values.[6d]

(4-Methoxyphenyl)(phenyl)methanone (3d) (Table 2, Entry 4). According to the general procedure, the reaction of 1-benzoylpiperidine-2,6-dione (0.20 mmol), (4-methoxyphenyl)boronic acid (2.0 equiv), K_2CO_3 (3.0 equiv), and PEPPSI-IPr (3 mol %) in THF (0.25 M) for 15 h at 60 °C afforded, after filtration and chromatography, the title compound in 98% yield (41.5 mg). White solid. ^1H NMR (500 MHz, $CDCl_3$) δ 7.83 (d, J = 8.4 Hz, 2H), 7.76 (d, J = 7.5 Hz, 2H), 7.56 (t, J = 7.3 Hz, 1H), 7.47 (t, J = 7.3 Hz, 2H), 6.97 (d, J = 8.4 Hz, 2H), 3.89 (s, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 195.6, 163.2, 138.3, 132.6, 131.9, 130.2, 129.8, 128.2, 113.6, 55.5. Spectroscopic data matched literature values.[6d]

Methyl 4-Benzoylbenzoate (3e) (Table 2, Entry 5). According to the general procedure, the reaction of 1-benzoylpiperidine-2,6-dione (0.20 mmol), (4-(methoxycarbonyl)phenyl)boronic acid (2.0 equiv), K_2CO_3 (3.0 equiv), and PEPPSI-IPr (3 mol %) in THF (0.25 M) for 15 h at 60 °C afforded, after filtration and chromatography, the title compound in 90% yield (43.3 mg). White solid. ^1H NMR (500 MHz, $CDCl_3$) δ 8.15 (d, J = 8.1 Hz, 2H), 7.84 (d, J = 8.1 Hz, 2H), 7.80 (d, J = 7.7 Hz, 2H), 7.62 (t, J = 7.3 Hz, 1H), 7.50 (t, J = 7.6 Hz, 2H), 3.97 (s, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 196.0, 166.3, 141.3, 137.0, 133.2, 133.0, 130.1, 129.8, 129.5, 128.5, 52.5. Spectroscopic data matched literature values.[6d]

Benzophenone (3a) (Table 2, Entry 6). According to the general procedure, the reaction of *N*-phenyl-*N*-tosylbenzamide (0.20 mmol), phenylboronic acid (2.0 equiv), K_2CO_3 (3.0 equiv), and PEPPSI-IPr (3 mol %) in THF (0.25 M) for 15 h at 80 °C afforded, after filtration and chromatography, the title compound in 92% yield (33.5 mg). White solid. ^1H NMR (500 MHz, $CDCl_3$) δ 7.81 (d, J = 7.4 Hz, 4H), 7.59 (t, J = 7.4 Hz, 2H), 7.49 (t, J = 7.7 Hz, 4H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 196.8, 137.6, 132.4, 130.1, 128.3. Spectroscopic data matched literature values.[6d]

Phenyl(*o*-tolyl)methanone (3b) (Table 2, Entry 7). According to the general procedure, the reaction of *N*-phenyl-*N*-tosylbenzamide (0.20 mmol), *o*-tolyboronic acid (2.0 equiv), K_2CO_3 (3.0 equiv), and PEPPSI-IPr (3 mol %) in THF (0.25 M) for 15 h at 80 °C afforded, after filtration and chromatography, the title compound in 83% yield (32.6 mg). Oil. ^1H NMR (500 MHz, $CDCl_3$) δ 7.83 (d, J = 7.6 Hz, 2H), 7.61 (t, J = 7.3 Hz, 1H), 7.48 (t, J = 7.4 Hz, 2H), 7.42 (t, J = 7.4 Hz, 1H), 7.33 (t, J = 9.4 Hz, 2H), 7.28 (d, J = 5.9 Hz, 1H), 2.36 (s, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 198.7, 138.6, 137.8, 136.8, 133.2, 131.0, 130.3, 130.2, 128.5, 128.5, 125.2, 20.0. Spectroscopic data matched literature values.[6d]

Phenyl(*p*-tolyl)methanone (3c) (Table 2, Entry 8). According to the general procedure, the reaction of *N*-phenyl-*N*-tosylbenzamide (0.20 mmol), *p*-tolylboronic acid (2.0 equiv), K_2CO_3 (3.0 equiv), and PEPPSI-IPr (3 mol %) in THF (0.25 M) for 15 h at 80 °C afforded, after filtration and chromatography, the title compound in 83% yield (32.6 mg).White solid. ^1H NMR (500 MHz, $CDCl_3$) δ 7.78 (d, J = 7.5 Hz, 2H), 7.72 (d, J = 7.4 Hz, 2H), 7.57 (t, J = 7.3 Hz, 1H), 7.47 (t, J = 7.4 Hz, 2H), 7.28 (d, J = 7.6 Hz, 2H), 2.44 (s, 3H).^{13}C NMR (125 MHz, $CDCl_3$) δ 196.5, 143.3, 138.0, 134.9, 132.2, 130.3, 130.0, 129.0, 128.2, 21.7. Spectroscopic data matched literature values.[6d]

(4-Methoxyphenyl)(phenyl)methanone (3d) (Table 2, Entry 9). According to the general procedure, the reaction of *N*-phenyl-*N*-tosylbenzamide (0.20 mmol), (4-methoxyphenyl)boronic acid (2.0 equiv), K_2CO_3 (3.0 equiv), and PEPPSI-IPr (3 mol %) in THF (0.25 M) for 15 h at 110 °C afforded, after filtration and chromatography, the title compound in 85% yield (36.1 mg). White solid. ^1H NMR (500 MHz, $CDCl_3$) δ 7.83 (d, J = 8.4 Hz, 2H), 7.76 (d, J = 7.5 Hz, 2H), 7.56 (t, J = 7.3 Hz, 1H), 7.47 (t, J = 7.3 Hz, 2H), 6.97 (d, J = 8.4 Hz, 2H), 3.89 (s, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 195.6, 163.2, 138.3, 132.6, 131.9, 130.2, 129.8, 128.2, 113.6, 55.5. Spectroscopic data matched literature values.[6d]

Methyl 4-benzoylbenzoate (3e) (Table 2, Entry 10). According to the general procedure, the reaction of *N*-phenyl-*N*-tosylbenzamide (0.20 mmol), (4-(methoxycarbonyl)phenyl)boronic acid (2.0 equiv), K_2CO_3 (3.0 equiv), and PEPPSI-IPr (3 mol %) in THF (0.25 M) for 15 h at 110 °C afforded, after filtration and chromatography, the title compound in 63% yield (30.3 mg). White solid. ^1H NMR (500 MHz, $CDCl_3$) δ 8.15 (d, J = 8.1 Hz, 2H), 7.84 (d, J = 8.1 Hz, 2H), 7.80 (d, J = 7.7 Hz, 2H), 7.62 (t, J = 7.3 Hz, 1H), 7.50 (t, J = 7.6 Hz, 2H), 3.97 (s, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 196.0, 166.3, 141.3, 137.0, 133.2, 133.0, 130.1, 129.8, 129.5, 128.5, 52.5. Spectroscopic data matched literature values.[6d]

Benzophenone (3a) (Table 2, Entry 11). According to the general procedure, the reaction of *tert*-butyl benzoyl(phenyl)carbamate (0.20 mmol), phenylboronic acid (2.0 equiv), K_2CO_3 (3.0 equiv), and PEPPSI-IPr (3 mol %) in THF (0.25 M) for 15 h at 60 °C afforded, after filtration and chromatography, the title compound in 94% yield (34.4 mg). White solid. ^1H NMR (500 MHz, $CDCl_3$) δ 7.81 (d, J = 7.4 Hz, 4H), 7.59 (t, J = 7.4 Hz, 2H), 7.49 (t, J = 7.7 Hz, 4H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 196.8, 137.6, 132.4, 130.1, 128.3. Spectroscopic data matched literature values.[6d]

Phenyl(*o*-tolyl)methanone (3b) (Table 2, Entry 12). According to the general procedure, the reaction of *tert*-butyl benzoyl(phenyl)-carbamate (0.20 mmol), *o*-tolyboronic acid (2.0 equiv), K_2CO_3 (3.0 equiv), and PEPPSI-IPr (3 mol %) in THF (0.25 M) for 15 h at 60 °C afforded, after filtration and chromatography, the title compound in 90% yield (35.3 mg). Oil. ^1H NMR (500 MHz, $CDCl_3$) δ 7.83 (d, J = 7.6 Hz, 2H), 7.61 (t, J = 7.3 Hz, 1H), 7.48 (t, J = 7.4 Hz, 2H), 7.42 (t, J = 7.4 Hz, 1H), 7.33 (t, J = 9.4 Hz, 2H), 7.28 (d, J = 5.9 Hz, 1H), 2.36 (s, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 198.7, 138.6, 137.8, 136.8, 133.2, 131.0, 130.3, 130.2, 128.5, 128.5, 125.2, 20.0. Spectroscopic data matched literature values.[6d]

Phenyl(*p*-tolyl)methanone (3c) (Table 2, Entry 13). According to the general procedure, the reaction of *tert*-butyl benzoyl(phenyl)-

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carbamate (0.20 mmol), *p*-tolylboronic acid (2.0 equiv), K_2CO_3 (3.0 equiv), and PEPPSI-IPr (3 mol %) in THF (0.25 M) for 15 h at 60 °C afforded, after filtration and chromatography, the title compound in 92% yield (36.2 mg). White solid. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.78 (d, J = 7.5 Hz, 2H), 7.72 (d, J = 7.4 Hz, 2H), 7.57 (t, J = 7.3 Hz, 1H), 7.47 (t, J = 7.4 Hz, 2H), 7.28 (d, J = 7.6 Hz, 2H), 2.44 (s, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 196.5, 143.3, 138.0, 134.9, 132.2, 130.3, 130.0, 129.0, 128.2, 21.7. Spectroscopic data matched literature values.[6d]

(4-Methoxyphenyl)(phenyl)methanone (3d) (Table 2, Entry 14). According to the general procedure, the reaction of *tert*-butyl benzoyl(phenyl)carbamate (0.20 mmol), (4-methoxyphenyl)boronic acid (2.0 equiv), K_2CO_3 (3.0 equiv), and PEPPSI-IPr (3 mol %) in THF (0.25 M) for 15 h at 60 °C afforded, after filtration and chromatography, the title compound in 98% yield (41.6 mg). White solid. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.83 (d, J = 8.4 Hz, 2H), 7.76 (d, J = 7.5 Hz, 2H), 7.56 (t, J = 7.3 Hz, 1H), 7.47 (t, J = 7.3 Hz, 2H), 6.97 (d, J = 8.4 Hz, 2H), 3.89 (s, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 195.6, 163.2, 138.3, 132.6, 131.9, 130.2, 129.8, 128.2, 113.6, 55.5. Spectroscopic data matched literature values.[6d]

Methyl 4-Benzoylbenzoate (3e) (Table 2, Entry 15). According to the general procedure, the reaction of *tert*-butyl benzoyl(phenyl)-carbamate (0.20 mmol), (4-(methoxycarbonyl)phenyl)boronic acid (2.0 equiv), K_2CO_3 (3.0 equiv), and PEPPSI-IPr (3 mol %) for 15 h at 60 °C afforded, after filtration and chromatography, the title compound in 90% yield (43.2 mg). White solid. ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.15 (d, J = 8.1 Hz, 2H), 7.84 (d, J = 8.1 Hz, 2H), 7.80 (d, J = 7.7 Hz, 2H), 7.62 (t, J = 7.3 Hz, 1H), 7.50 (t, J = 7.6 Hz, 2H), 3.97 (s, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 196.0, 166.3, 141.3, 137.0, 133.2, 133.0, 130.1, 129.8, 129.5, 128.5, 52.5. Spectroscopic data matched literature values.[6d]

Cross-Coupling of Amides: Variation of Amides. Methyl 4-Benzoylbenzoate (3e) (Table 3, Amide = *N*-Glutarimide). According to the general procedure, the reaction of 1-(4-(methoxy-carbonyl)benzoyl)piperidine-2,6-dione (0.20 mmol), phenylboronic acid (2.0 equiv), K_2CO_3 (3.0 equiv), and PEPPSI-IPr (3 mol %) in THF (0.25 M) for 15 h at 60 °C afforded, after filtration and chromatography, the title compound in 93% yield (44.7 mg). White solid. ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.15 (d, J = 8.1 Hz, 2H), 7.84 (d, J = 8.1 Hz, 2H), 7.80 (d, J = 7.7 Hz, 2H), 7.62 (t, J = 7.3 Hz, 1H), 7.50 (t, J = 7.6 Hz, 2H), 3.97 (s, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 196.0, 166.3, 141.3, 137.0, 133.2, 133.0, 130.1, 129.8, 129.5, 128.5, 52.5. Spectroscopic data matched literature values.[6d]

(3-Methoxyphenyl)(phenyl)methanone (3f) (Table 3, Amide = *N*-Glutarimide). According to the general procedure, the reaction of 1-(3-methoxybenzoyl)piperidine-2,6-dione (0.20 mmol), phenyl-boronic acid (2.0 equiv), K_2CO_3 (3.0 equiv), and PEPPSI-IPr (3 mol %) in THF (0.25 M) for 15 h at 60 °C afforded, after filtration and chromatography, the title compound in 96% yield (40.8 mg). White solid. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.81 (d, J = 7.7 Hz, 2H), 7.59 (t, J = 7.3 Hz, 1H), 7.48 (t, J = 7.5 Hz, 2H), 7.40−7.33 (m, 3H), 7.14 (d, J = 7.1 Hz, 1H), 3.86 (s, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 196.5, 159.6, 138.9, 137.7, 132.4, 130.1, 129.2, 128.3, 122.9, 118.9, 114.3, 55.5. Spectroscopic data matched literature values.[6d]

Phenyl(*m*-tolyl)methanone (3g) (Table 3, Amide = *N*-Glutarimide). According to the general procedure, the reaction of 1-(3-methylbenzoyl)piperidine-2,6-dione (0.20 mmol), phenylboronic acid (2.0 equiv), K_2CO_3 (3.0 equiv), and PEPPSI-IPr (3 mol %) in THF (0.25 M) for 15 h at 60 °C afforded, after filtration and chromatography, the title compound in 98% yield (38.3 mg). Oil. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.81−7.79 (m, 2H), 7.63 (s, 1H), 7.61−7.57 (m, 2H), 7.48 (t, J = 7.7 Hz, 2H), 7.41−7.57.34 (m, 2H), 2.43 (s, 3H).^{13}C NMR (125 MHz, $CDCl_3$) δ 197.0, 138.2, 137.8, 137.7, 133.2, 132.3, 130.5, 130.1, 128.3, 128.1, 127.4, 21.4. Spectroscopic data matched literature values.[6b]

(3,4-Difluorophenyl)(phenyl)methanone (3h) (Table 3, Amide = *N*-Glutarimide). According to the general procedure, the reaction of 1-(3,4-difluorobenzoyl)piperidine-2,6-dione (0.20 mmol), phenylboronic acid (2.0 equiv), K_2CO_3 (3.0 equiv), and PEPPSI-IPr (3 mol %) in THF (0.25 M) for 15 h at 60 °C afforded, after filtration and chromatography, the title compound in 95% yield (41.5 mg). White solid. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.76 (d, J = 7.6 Hz, 2H), 7.68 (t, J = 9.1 Hz, 1H), 7.63−7.58 (m, 2H), 7.50 (t, J = 7.6 Hz, 2H), 7.30−7.24 (m, 1H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 194.1, 153.3 (J = 256.3 Hz, J = 12.9 Hz), 150.2 (J = 251.1 Hz, J = 13.2 Hz), 136.9, 134.5 (J = 4.1 Hz), 132.8, 129.9, 128.5, 127.1 (J = 7.2 Hz, J = 3.7 Hz), 119.3 (J = 18.1 Hz, J = 1.3 Hz), 117.3 (J = 17.8 Hz). ^{19}F NMR (471 MHz, $CDCl_3$) δ −130.6, −136.2. Spectroscopic data matched literature values.[4]

4-Benzoylbenzonitrile (3i) (Table 3, Amide = *N*-Glutarimide). According to the general procedure, the reaction of 1-(4-cyano-benzoyl)piperidine-2,6-dione (0.20 mmol), phenylboronic acid (2.0 equiv), K_2CO_3 (3.0 equiv), and PEPPSI-IPr (3 mol %) in THF (0.25 M) for 15 h at 60 °C afforded, after filtration and chromatography, the title compound in 82% yield (34.0 mg). White solid. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.88 (d, J = 7.6 Hz, 2H), 7.82−7.74 (m, 4H), 7.64 (t, J = 7.2 Hz, 1H), 7.52 (t, J = 7.3 Hz, 2H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 195.1, 141.3, 136.4, 133.4, 132.2, 130.3, 130.1, 128.7, 118.0, 115.7. Spectroscopic data matched literature values.[6d]

Phenyl(4-(trifluoromethyl)phenyl)methanone (3j) (Table 3, Amide = *N*-Glutarimide). According to the general procedure, the reaction of 1-(4-(trifluoromethyl)benzoyl)piperidine-2,6-dione (0.20 mmol), phenylboronic acid (2.0 equiv), K_2CO_3 (3.0 equiv), and PEPPSI-IPr (3 mol %) in THF (0.25 M) for 15 h at 60 °C afforded, after filtration and chromatography, the title compound in 98% yield (49.2 mg). White solid. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.90 (d, J = 7.7 Hz, 2H), 7.81 (d, J = 7.3 Hz, 2H), 7.76 (d, J = 7.6 Hz, 2H), 7.63 (t, J = 7.3 Hz, 1H), 7.51 (t, J = 7.2 Hz, 2H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 195.6, 140.8, 136.8, 133.7 (J = 32.5 Hz), 133.1, 130.1 (J = 4.2 Hz), 128.6, 125.4 (J = 3.6 Hz), 123.7 (J = 258.1 Hz). ^{19}F NMR (471 MHz, $CDCl_3$) δ −63.0. Spectroscopic data matched literature values.[6d]

Benzo[*d*][1,3]dioxol-5-yl(phenyl)methanone (3k) (Table 3, Amide = *N*-Glutarimide). According to the general procedure, the reaction of 1-(benzo[*d*][1,3]dioxole-5-carbonyl)piperidine-2,6-dione (0.20 mmol), phenylboronic acid (2.0 equiv), K_2CO_3 (3.0 equiv), and PEPPSI-IPr (3 mol %) in THF (0.25 M) for 15 h at 60 °C afforded, after filtration and chromatography, the title compound in 90% yield (40.7 mg). White solid. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.74 (d, J = 7.4 Hz, 2H), 7.56 (t, J = 7.3 Hz, 1H), 7.47 (t, J = 7.3 Hz, 2H), 7.38 (d, J = 9.0 Hz, 2H), 6.86 (d, J = 7.8 Hz, 1H), 6.07 (s, 2H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 195.2, 151.5, 148.0, 138.1, 132.0, 131.9, 129.7, 128.2, 126.9, 109.9, 107.7, 101.9. Spectroscopic data matched literature values.[4]

Phenyl(*o*-tolyl)methanone (3b) (Table 3, Amide = *N*-Ts/Ph). According to the general procedure, the reaction of methyl 2-methyl-*N*-phenyl-*N*-tosylbenzamide (0.20 mmol), phenylboronic acid (2.0 equiv), K_2CO_3 (3.0 equiv), and PEPPSI-IPr (3 mol %) in THF (0.25 M) for 15 h at 110 °C afforded, after filtration and chromatography, the title compound in 91% yield (35.7 mg). Oil. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.83 (d, J = 7.6 Hz, 2H), 7.61 (t, J = 7.3 Hz, 1H), 7.48 (t, J = 7.4 Hz, 2H), 7.42 (t, J = 7.4 Hz, 1H), 7.33 (t, J = 9.4 Hz, 2H), 7.28 (d, J = 5.9 Hz, 1H), 2.36 (s, 3H).^{13}C NMR (125 MHz, $CDCl_3$) δ 198.7, 138.6, 137.8, 136.8, 133.2, 131.0, 130.3, 130.2, 128.5, 128.5, 125.2, 20.0. Spectroscopic data matched literature values.[6d]

(2-Fluorophenyl)(phenyl)methanone (3l) (Table 3, Amide = *N*-Ts/Ph). According to the general procedure, the reaction of 2-fluoro-*N*-phenyl-*N*-tosylbenzamide (0.20 mmol), phenylboronic acid (2.0 equiv), K_2CO_3 (3.0 equiv), and PEPPSI-IPr (3 mol %) in THF (0.25 M) for 15 h at 110 °C afforded, after filtration and chromatography, the title compound in 98% yield (39.2 mg). Oil. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.85 (d, J = 7.5 Hz, 2H), 7.61 (t, J = 7.3 Hz, 1H), 7.57−7.51 (m, 2H), 7.48 (t, J = 7.4 Hz, 2H), 7.28 (d, J = 7.4 Hz, 1H), 7.17 (t, J = 9.0 Hz, 1H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 193.5, 160.1 (J = 252.4 Hz), 137.4, 133.4, 133.1 (J = 8.3 Hz), 130.8 (J = 2.8 Hz), 129.8, 128.5, 127.1 (J = 14.7 Hz), 124.3 (J = 3.6 Hz), 116.3 (J = 21.8 Hz). ^{19}F NMR (471 MHz, $CDCl_3$) δ −111.0. Spectroscopic data matched literature values.[6d]

Phenyl(thiophen-2-yl)methanone (3m) (Table 3, Amide = *N*-Ts/Ph). According to the general procedure, the reaction of *N*-phenyl-

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N-tosylthiophene-2-carboxamide (0.20 mmol), phenylboronic acid (2.0 equiv), K_2CO_3 (3.0 equiv), and PEPPSI-IPr (6 mol %) for 15 h at 110 °C afforded, after filtration and chromatography, the title compound in 76% yield (28.6 mg). White solid. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.87 (d, J = 7.5 Hz, 2H), 7.73 (d, J = 4.7 Hz, 1H), 7.65 (d, J = 3.2 Hz, 1H), 7.59 (t, J = 7.3 Hz, 1H), 7.50 (t, J = 7.3 Hz, 2H), 7.17 (t, J = 3.8 Hz, 1H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 188.3, 143.7, 138.2, 134.9, 134.2, 132.3, 129.2, 128.4, 128.0. Spectroscopic data matched literature values.[4]

(4-Methoxyphenyl)(phenyl)methanone (3d) (Table 3, Amide = *N*-Boc/Ph). According to the general procedure, the reaction of *tert*-butyl 4-methoxybenzoyl (phenyl)carbamate (0.20 mmol), phenylboronic acid (2.0 equiv), K_2CO_3 (3.0 equiv), and PEPPSI-IPr (3 mol %) in THF (0.25 M) for 15 h at 60 °C afforded, after filtration and chromatography, the title compound in 98% yield (41.4 mg). White solid. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.83 (d, J = 8.4 Hz, 2H), 7.76 (d, J = 7.5 Hz, 2H), 7.56 (t, J = 7.3 Hz, 1H), 7.47 (t, J = 7.3 Hz, 2H), 6.97 (d, J = 8.4 Hz, 2H), 3.89 (s, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 195.6, 163.2, 138.3, 132.6, 131.9, 130.2, 129.8, 128.2, 113.6, 55.5. Spectroscopic data matched literature values.[6d]

Phenyl(4-(trifluoromethyl)phenyl)methanone (3i) (Table 3, Amide = *N*-Boc/Ph). According to the general procedure, the reaction of *tert*-butyl phenyl(4-(trifluoromethyl)benzoyl)carbamate (0.20 mmol), phenylboronic acid (2.0 equiv), K_2CO_3 (3.0 equiv), and PEPPSI-IPr (3 mol %) in THF (0.25 M) for 15 h at 60 °C afforded, after filtration and chromatography, the title compound in 98% yield (49.0 mg). White solid. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.90 (d, J = 7.7 Hz, 2H), 7.81 (d, J = 7.3 Hz, 2H), 7.76 (d, J = 7.6 Hz, 2H), 7.63 (t, J = 7.3 Hz, 1H), 7.51 (t, J = 7.2 Hz, 2H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 195.6, 140.8, 136.8, 133.7 (J = 32.5 Hz), 133.1, 130.1 (J = 4.2 Hz), 128.6, 125.4 (J = 3.6 Hz), 123.7 (J = 258.1 Hz). ^{19}F NMR (471 MHz, $CDCl_3$) δ −63.0. Spectroscopic data matched literature values.[6d]

Furan-2-yl(phenyl)methanone (3n) (Table 3, Amide = *N*-Boc/Ph). According to the general procedure, the reaction of *tert*-butyl (furan-2-carbonyl)(phenyl)carbamate (0.20 mmol), phenylboronic acid (2.0 equiv), K_2CO_3 (3.0 equiv), and PEPPSI-IPr (3 mol %) in THF (0.25 M) for 15 h at 60 °C afforded, after filtration and chromatography, the title compound in 92% yield (31.7 mg). Oil. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.97 (d, J = 7.6 Hz, 2H), 7.71 (s, 1H), 7.59 (t, J = 7.2 Hz, 1H), 7.50 (t, J = 7.3 Hz, 2H), 7.24 (s, 1H), 6.60 (s, 1H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 182.6, 152.3, 147.1, 137.3, 132.6, 129.3, 128.4, 120.6, 112.2. Spectroscopic data matched literature values.[4]

Benzophenone (1a) (Scheme 1A, Amide = *N*-Boc/alkyl). According to the general procedure, the reaction of *tert*-butyl benzoyl(benzyl)carbamate (0.20 mmol), phenylboronic acid (2.0 equiv), K_2CO_3 (3.0 equiv), and PEPPSI-IPr (6 mol %) in THF (0.25 M) for 15 h at 110 °C afforded, after filtration and chromatography, the title compound in 50% yield (18.3 mg). White solid. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.81 (d, J = 7.4 Hz, 4H), 7.59 (t, J = 7.4 Hz, 2H), 7.49 (t, J = 7.7 Hz, 4H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 196.8, 137.6, 132.4, 130.1, 128.3. Spectroscopic data matched literature values.[6d]

1-Phenyldecan-1-one (1o) (Scheme 1B, Amide = α-alkyl). According to the general procedure, the reaction of 1-decanoylpiperidine-2,6-dione (0.20 mmol), phenylboronic acid (2.0 equiv), K_2CO_3 (3.0 equiv), and PEPPSI-IPr(3 mol %) in THF (0.25 M) for 15 h at 60 °C afforded, after filtration and chromatography, the title compound in 80% yield (37.2 mg). White solid. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.96 (d, J = 7.4 Hz, 2H), 7.55 (t, J = 7.3 Hz, 1H), 7.46 (t, J = 7.3 Hz, 2H), 2.96 (t, J = 7.1 Hz, 2H), 1.76−1.71 (m, 2H), 1.38−1.27 (m, 12H), 0.88 (t, J = 6.0 Hz, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 200.7, 137.1, 132.9, 128.6, 128.1, 38.7, 31.9, 29.5, 29.5, 29.4, 29.3, 24.4, 22.7, 14.1. Spectroscopic data matched literature values.[6d]

Determination of Relative Rates. An oven-dried vial equipped with a stir bar was charged with an amide substrate (neat, 0.20 mmol, 1.0 equiv), potassium carbonate (3.0 equiv), boronic acid (2.0 equiv), and PEPPSI-IPr (3 mol %), placed under a positive pressure of argon, and subjected to three evacuation/backfilling cycles under high vacuum. THF (0.25 M) was added with vigorous stirring at room temperature, and the reaction mixture was placed in a preheated oil bath at 60 °C and stirred at 60 °C for the indicated time. After the indicated time, the reaction mixture was cooled down to room temperature, diluted with CH_2Cl_2 (10 mL), filtered, and concentrated. The sample was analyzed by ^{1}H NMR ($CDCl_3$, 500 MHz) and/or GC-MS to obtain conversion, selectivity, and yield using and internal standard and comparison with authentic samples.

■ ASSOCIATED CONTENT

Supporting Information

The Supporting Information is available free of charge on the ACS Publications website at DOI: 10.1021/acs.joc.7b00749.

^{1}H and ^{13}C NMR spectra (PDF)

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Notes

The authors declare no competing financial interest.

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