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Synthesis of Triarylmethanes by Palladium-Catalyzed C−H/C−O Coupling of Oxazoles and Diarylmethanol Derivatives

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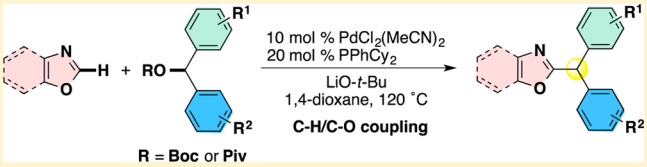
Supporting Information

ABSTRACT: A $PdCl_2(MeCN)_2$/$PPhCy_2$ catalyst couples oxazoles with diarylmethyl carbonates or pivalates to form the corresponding triarylmethanes in good yields. The catalysis involves successive secondary benzylic sp^3 C−O and heteroaromatic sp^2 C−H cleavages and provides an effective access to heteroarene-containing triarylmethanes from nonhalogenated and nonmetalated starting materials, which is complementary to precedented cross-coupling technologies with organic halides and organometallic reagents.



INTRODUCTION

Triarylmethanes are prevalent substructures in biologically active compounds[1] and natural products.[2] Additionally, they also constitute an important class of compounds in material science, exemplified by their frequently occurring in dyes,[3] fluorescent probes,[4] and photochromic agents.[5] A classical access to the above target structure is the Lewis-acid-promoted Friedel−Crafts-type alkylation of arenes with diarylmethyl electrophiles.[6] This reaction is well-established and practical, but the arene substrate scope is strictly limited to the electron-rich aromatics. Moreover, the regioselectivity is largely dependent on innate electronic and steric natures of the arene employed.

To address the above problems, the transition-metal-catalyzed cross-coupling approaches have been recently developed (Scheme 1). Kuwano reported the palladium-catalyzed Suzuki−Miyaura cross-coupling of diarylmethyl carbonates with arylboronic acids (route a).[7] Jarvo[8] and Watson[9] independently developed relevant nickel catalysis, in which the asymmetric synthesis becomes possible by the stereospecific C−C bond formation with optically active diarylmethanol derivatives. More recently, Crudden introduced diarylmethyl sulfones as coupling partners in this type of the reaction.[10] The same group also succeeded in the enantiospecific reverse cross-coupling with chiral diarylmethylboronates.[11] On the other hand, metal-mediated C−H functionalization strategies[12] also have received significant attention in this research field because they can obviate some preactivation steps, such as halogenation and stoichiometric metalation, of starting substrates. Yorimitsu and Oshima reported the palladium-catalyzed arylation of aryl(azaaryl)methanes with aryl halides, in conjunction with $CsOH{\cdot}OH_2$ as base, providing the corresponding triarylmethanes directly (route b).[13] Walsh and co-workers successfully expanded the substrate scope into more general diarylmethanes by the combination of stronger metal amide bases and a $Cr(CO)_3$[14a] stoichiometric activator or a uniquely deprotonatable ligand, NiXantphos.[14b,c] While relatively restricted in scope, the dehydrogenative C−H/C−H coupling of simple diarylmethanes and electron-rich anisoles is also achieved by the iron/DDQ catalyst system (route c).[15] In this context, we focused on the less explored fourth route with nonfunctionalized arenes and diarylmethanol electrophiles via aromatic sp^2 C−H and benzylic sp^3 C−O cleavages (route d). Herein, we report a $PdCl_2(MeCN)_2$/$PPhCy_2$-catalyzed C−H/C−O coupling of oxazoles and diarylmethyl carbonates or pivalates. This catalysis allows the rapid and concise construction of oxazole-incorporated triarylmethanes, which are somewhat difficult to prepare by other means (Scheme 2).[16]

RESULTS AND DISCUSSION

Previously, we reported a $Pd_2(dba)_3$/dppp/NaOAc/DMSO system for the successful direct benzylation of oxazoles with primary benzyl methyl carbonates (Scheme 3a).[17] Unfortunately, this first generation catalyst was not capable of coupling of benzoxazole (**1a**) with secondary diarylmethyl carbonates. Attempts to apply methyl diphenylmethyl carbonate gave no desired triarylmethane, and the corresponding homocoupling product, 1,1,2,2-tetraphenylethane, was formed exclusively (Scheme 3b).[18] Even with conceivably more reactive naphthyl-substituted Boc carbonate **2a**[19] and higher catalyst loading, only 11% yield of **3aa** was observed by ^1H NMR analysis (Scheme 3c).

Inspired by recent advances in the nickel-catalyzed cross-coupling reaction with C−O electrophiles,[8,9,20] we then turned our attention into Ni(0) catalysts (Scheme 4). However, we could not obtain an acceptable yield of **3aa** as far as we tested, although the reaction proceeded to some extent in the presence of several $Ni(cod)_2$/bulky monodentate phosphine catalysts and a LiO-*t*-Bu base in heating diglyme (see the Supporting Information for more details). Thus, on the basis of positive effects of LiO-*t*-Bu and ethereal solvents in Scheme 4, we re-investigated Pd-based catalyst systems (Table 1). To our delight, **1a** coupled with **2a** smoothly under $PdCl_2(MeCN)_2$/Cy-JohnPhos

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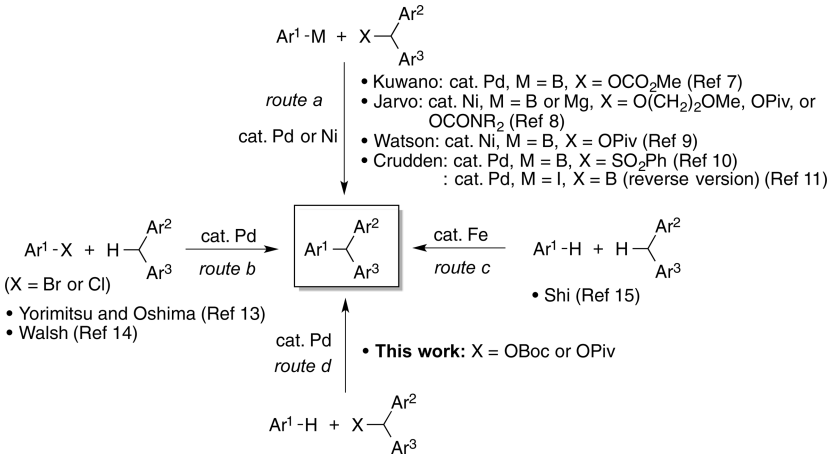
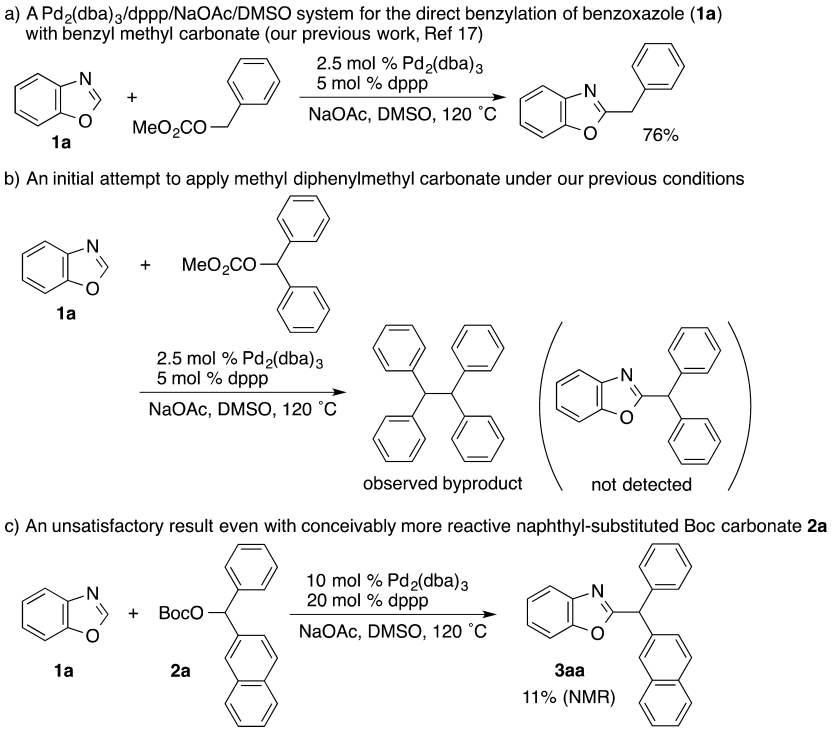
Scheme 1. Cross-Coupling Approaches to Triarylmethanes



Scheme 2. Palladium-Catalyzed C−H/C−O Coupling of Oxazoles and Diarylmethanol Derivatives

catalysis to form **3aa** in 69% NMR yield (entry 1). The choice of Pd precursors was critical: $Pd(OAc)_2$ and $Pd(acac)_2$ proved to be comparable, whereas $PdCl_2(PhCN)_2$, $PdCl_2$, $[PdCl(\pi\text{-allyl})]_2$, $Pd(OCOCF_3)_2$, and $Pd_2(dba)_3$ were less effective (entries 2−8). Subsequent screening of solvents (entries 9−11) identified 1,4-dioxane to be optimal, giving **3aa** in 79% NMR yield (entry 9). On the other hand, the yield largely dropped when we employed other bases including K_3PO_4, NaO-*t*-Bu, KO-*t*-Bu, and $Mg(O\text{-}t\text{-}Bu)_2$ (entries 12−15). The ancillary ligands also gave major impacts on the reaction efficiency. While other Buchwald biarylphosphines did not increase the yield (entries 16−20), simpler monodentate phosphines such as PPh_3, PCy_3, PPh_2Cy, and $PPhCy_2$ showed similar or better performance (entries 21−24). In particular, $PPhCy_2$ resulted in the highest yield and good reproducibility (entry 24). Some bidentate phosphines also promoted the reaction, albeit with lower yields (entries 25−28). Finally, an increase in the amount of 1,4-dioxane to 3.0 mL suppressed a major side reaction, hydrolysis of **2a**, to further improve the yield to 90% (entry 29). Even with the lower catalyst loading (5 mol % $PdCl_2(MeCN)_2$ and 10 mol % $PPhCy_2$), a satisfactory yield was obtained (entry 30). The control experiments in the absence of Pd, ligand, or both revealed no formation of **3aa**, confirming Pd catalysis in the present process (data not shown).

Scheme 3. Our Early Attempts to Apply Primary and Secondary Benzyl Carbonates in $Pd_2(dba)_3$/dppp/NaOAc/DMSO System



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Scheme 4. Representative Results of Optimization Studies for Nickel-Catalyzed C−H/C−O Coupling of Benzoxazole (1a) and Naphthyl-Substituted Boc Carbonate 2a

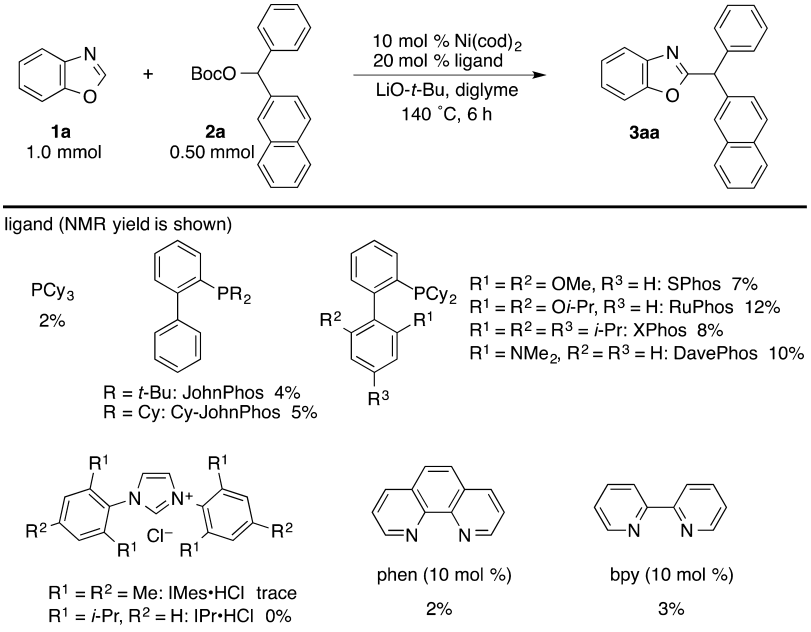
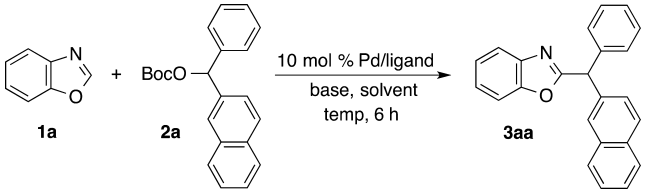
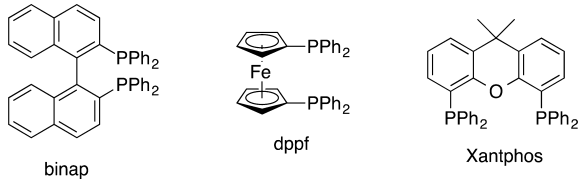


Table 1. Optimization Studies for Palladium-Catalyzed C−H/C−O Coupling of Benzoxazole (1a) and Naphthyl-Substituted Boc Carbonate 2a[a]



entry	Pd/ligand	base	solvent	temp (°C)	yield (%)[b]
1	$PdCl_2(MeCN)_2$/Cy-JohnPhos	LiO-*t*-Bu	diglyme	120	69 (60)
2	$PdCl_2(PhCN)_2$/Cy-JohnPhos	LiO-*t*-Bu	diglyme	120	28
3	$PdCl_2$/Cy-JohnPhos	LiO-*t*-Bu	diglyme	120	18
4	$[PdCl(\pi\text{-allyl})]_2$/Cy-JohnPhos	LiO-*t*-Bu	diglyme	120	18
5	$Pd(OAc)_2$/Cy-JohnPhos	LiO-*t*-Bu	diglyme	120	61
6	$Pd(OCOCF_3)_2$/Cy-JohnPhos	LiO-*t*-Bu	diglyme	120	18
7	$Pd(acac)_2$/Cy-JohnPhos	LiO-*t*-Bu	diglyme	120	64
8	$Pd_2(dba)_3$/Cy-JohnPhos	LiO-*t*-Bu	diglyme	120	40
9	$PdCl_2(MeCN)_2$/Cy-JohnPhos	LiO-*t*-Bu	1,4-dioxane	120	79 (64)
10	$PdCl_2(MeCN)_2$/Cy-JohnPhos	LiO-*t*-Bu	DME	80	trace
11	$PdCl_2(MeCN)_2$/Cy-JohnPhos	LiO-*t*-Bu	CPME	100	19
12	$PdCl_2(MeCN)_2$/Cy-JohnPhos	K_3PO_4	1,4-dioxane	120	0
13	$PdCl_2(MeCN)_2$/Cy-JohnPhos	NaO-*t*-Bu	1,4-dioxane	120	9
14	$PdCl_2(MeCN)_2$/Cy-JohnPhos	KO-*t*-Bu	1,4-dioxane	120	10
15	$PdCl_2(MeCN)_2$/Cy-JohnPhos	$Mg(O\text{-}t\text{-}Bu)_2$	DMF	120	10
16	$PdCl_2(MeCN)_2$/JohnPhos	LiO-*t*-Bu	1,4-dioxane	120	2
17	$PdCl_2(MeCN)_2$/SPhos	LiO-*t*-Bu	1,4-dioxane	120	53
18	$PdCl_2(MeCN)_2$/RuPhos	LiO-*t*-Bu	1,4-dioxane	120	60
19	$PdCl_2(MeCN)_2$/XPhos	LiO-*t*-Bu	1,4-dioxane	120	7
20	$PdCl_2(MeCN)_2$/DavePhos	LiO-*t*-Bu	1,4-dioxane	120	36
21	$PdCl_2(MeCN)_2/PPh_3$	LiO-*t*-Bu	1,4-dioxane	120	83
22	$PdCl_2(MeCN)_2/PCy_3$	LiO-*t*-Bu	1,4-dioxane	120	77
23	$PdCl_2(MeCN)_2/PPh_2Cy$	LiO-*t*-Bu	1,4-dioxane	120	74−87[c]
24	$PdCl_2(MeCN)_2/PPhCy_2$	LiO-*t*-Bu	1,4-dioxane	120	86 (76)
25	$PdCl_2(MeCN)_2$/dppe	LiO-*t*-Bu	1,4-dioxane	120	67
26	$PdCl_2(MeCN)_2$/binap	LiO-*t*-Bu	1,4-dioxane	120	63
27	$PdCl_2(MeCN)_2$/dppf	LiO-*t*-Bu	1,4-dioxane	120	53
28	$PdCl_2(MeCN)_2$/Xantphos	LiO-*t*-Bu	1,4-dioxane	120	13
29[d]	$PdCl_2(MeCN)_2/PPhCy_2$	LiO-*t*-Bu	1,4-dioxane	120	92 (90)
30[d,e]	$PdCl_2(MeCN)_2/PPhCy_2$	LiO-*t*-Bu	1,4-dioxane	120	90 (88)

[a]Reaction conditions: **1a** (0.50 mmol), **2a** (0.25 mmol), Pd (0.025 mmol), ligand (0.050 mmol for monodentate ligands, 0.025 mmol for bidentate ligands), base (0.50 mmol), solvent (1.5 mL), N_2. [b]NMR yield. Yield is given in parentheses. [c]Somewhat poor reproducibility. We have no explanation for the reason at present. [d]In 3.0 mL of 1,4-dioxane. [e]With 5 mol % of $PdCl_2(MeCN)_2$ and 10 mol % of $PPhCy_2$.



With the optimized conditions in hand (Table 1, entry 29), we performed the C−H/C−O coupling of benzoxazole (**1a**) with a variety of diarylmethanol derivatives **2** (Table 2). As the leaving group, pivalate (**2a′**) and methyl carbonate (**2a″**) were also accommodated in the synthesis of **3aa** (entries 2 and 3). In the case of electron-rich substrates, the pivalate group worked better (entries 4−7), probably due to its higher stability under reaction conditions. The opposite trend was observed when the electron-withdrawing substituent was introduced (entries 8−10). The catalysis was compatible with electron-rich heteroaromatics

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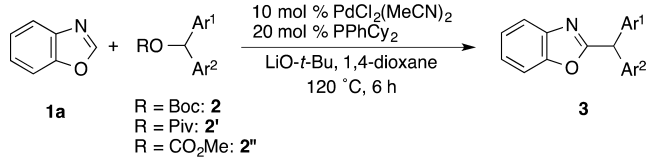
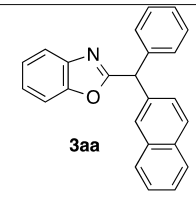
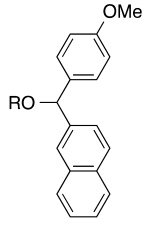
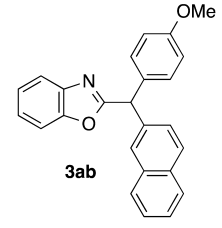
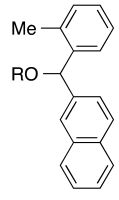
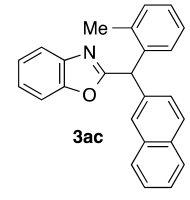
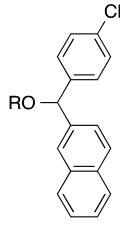
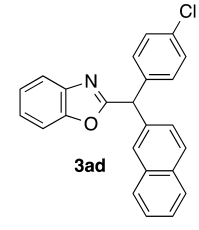
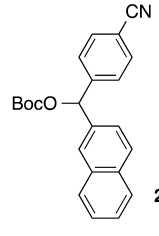
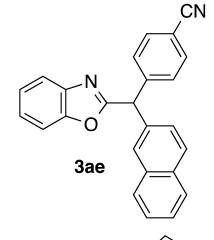
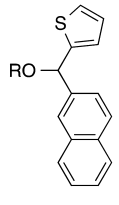
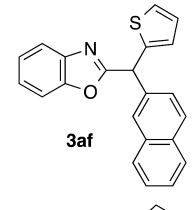
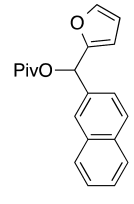
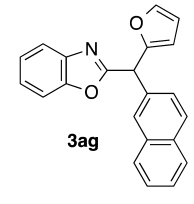
Table 2. Palladium-Catalyzed C−H/C−O Coupling of Benzoxazole (1a) with Various Diarylmethanol Derivatives (2)[a]

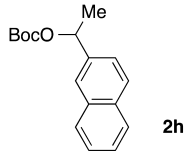
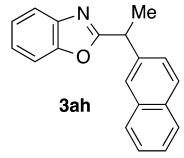
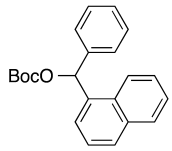
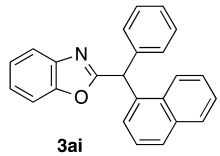
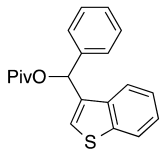
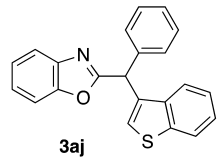
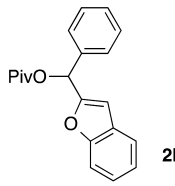
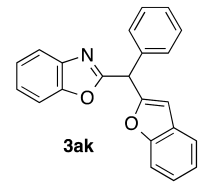
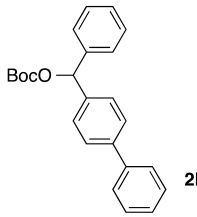
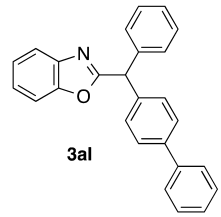
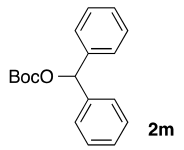
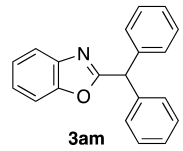
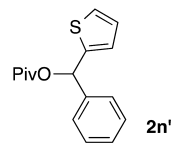
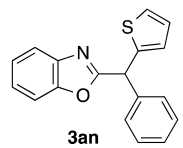


1a R = Boc: **2** R = Piv: **2'** R = CO_2Me: **2"** **3**

entry	diarylmethanol derivative **2**	triarylmethane **3**	yield (%)[b]
1	R = Boc: **2a**	 **3aa**	92 (90)
2	R = Piv: **2a'**		85
3[c]	R = CO_2Me: **2a''**		73
4	 R = Boc: **2b**	 **3ab**	(31)
5	R = Piv: **2b'**		(83)
6	 R = Boc: **2c**	 **3ac**	(47)
7	R = Piv: **2c'**		(58)
8	 R = Boc: **2d**	 **3ad**	(47)
9	R = Piv: **2d'**		41
10	 **2e**	 **3ae**	(53)
11	 R = Boc: **2f**	 **3af**	0
12	R = Piv: **2f'**		(62)
13	 **2g'**	 **3ag**	(40)

dx.doi.org/10.1021/jo5010636 | J. Org. Chem. XXXX, XXX, XXX−XXX

Table 2. continued

entry	diarylmethanol derivative **2**	triarylmethane **3**	yield (%)[b]
14	 **2h**	 **3ah**	(77)
15	 **2i**	 **3ai**	(82)
16	 **2j'**	 **3aj**	(76)
17	 **2k'**	 **3ak**	(39)
18[d]	 **2l**	 **3al**	(42)
19[d]	 **2m**	 **3am**	(31)
20[d,e]			7
21[d,f]			10
22[d]	 **2n'**	 **3an**	(35)

[a]Reaction conditions: **1a** (0.50 mmol), **2a** (0.25 mmol), $PdCl_2(MeCN)_2$ (0.025 mmol), $PPhCy_2$ (0.050 mmol), LiO-*t*-Bu (0.50 mmol), 1,4-dioxane (3.0 mL), N_2. [b]NMR yield. Yield is given in parentheses. [c]In 1.5 mL of 1,4-dioxane. [d]In 0.50 mL of 1,4-dioxane. [e]With Cy-JohnPhos instead of $PPhCy_2$. [f]With PPh_3 instead of $PPhCy_2$.

such as thiophene and furan in the Ar^1 ring (entries 11−13). Notably, the more remarkable positive effect of Piv was observed in the reaction of the thiophene-containing substrate (entry 11 vs 12). The product was not a target triarylmethane, but methyl-substituted diarylmethane **3ah** was also accessible (entry 14), despite the possibility of β-hydrogen elimination from an alkyl Pd intermediate (vide infra).[21] We next tested fused aromatics other than the 2-naphthyl group (Ar^2). The diarylmethanol derivatives that bear 1-naphthyl, 3-benzothienyl, and 2-benzofuryl substituents reacted with **1a** to afford **3ai**−**ak** with synthetically valuable levels (entries 15−17). The biphenyl-type system **2l** also underwent the direct coupling, and the corresponding **3al** was produced in an acceptable yield (entry 18). On the other hand, expectedly, the simpler diphenylmethyl Boc carbonate **2m** and phenyl(2-thienyl)methyl pivalate **2n′** afforded moderate yields of **3am** and **3an** (entries 19 and 22).[19] Even with Cy-JohnPhos or PPh_3 instead of $PPhCy_2$, the yield of **3am** was not improved (entries 20 and 21).[22]

In addition to the simple benzoxazole (**1a**), monocyclic 5-substituted oxazoles could be employed for the catalytic C−H/C−O coupling. In these cases, slight modifications were essential for obtaining the successful conversion: (1) the use of

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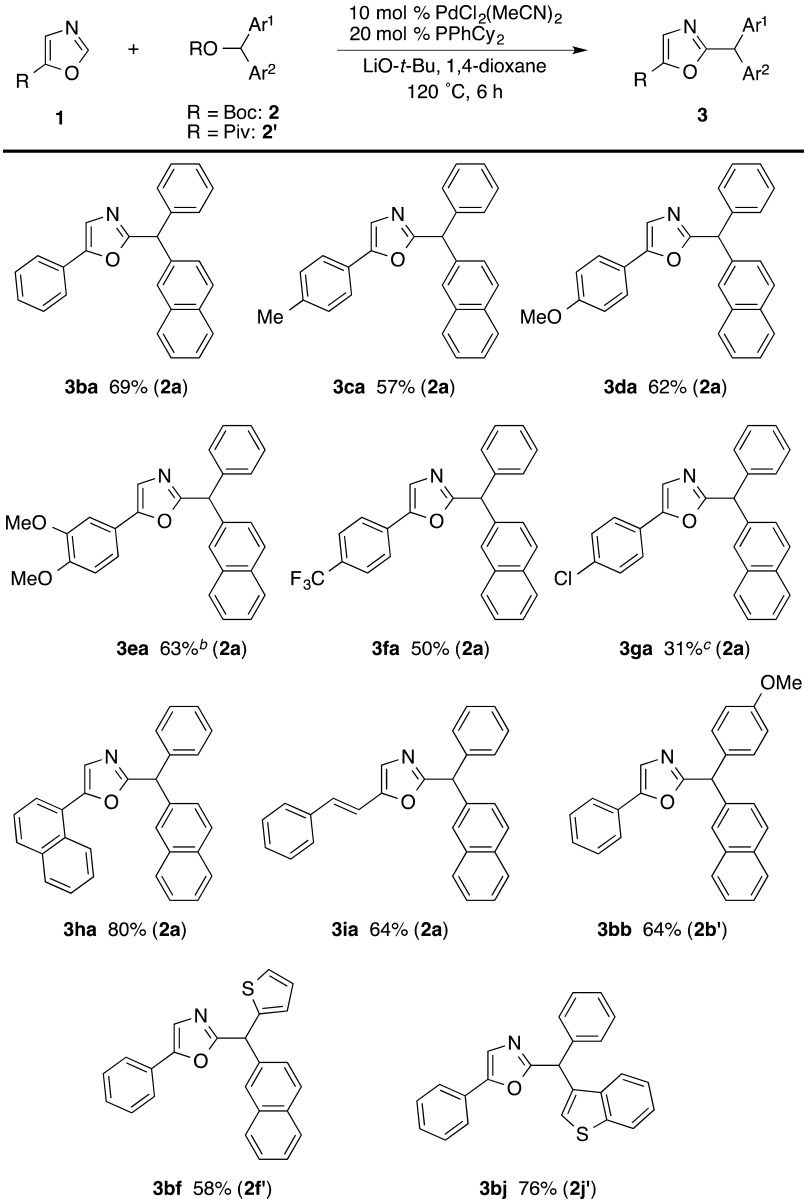
Scheme 5. Palladium-Catalyzed C−H/C−O Coupling of Various 5-Substituted Oxazoles[a]



[a]Reaction conditions: **1** (0.25 mmol), **2** (0.50 mmol), $PdCl_2(MeCN)_2$ (0.025 mmol), $PPhCy_2$ (0.050 mmol), LiO-*t*-Bu (1.0 mmol), 1,4-dioxane (3.0 mL), N_2. The coupling partner is given in parentheses. [b]With 1.5 mmol of LiO-*t*-Bu. [c]With PPh_3 instead of $PPhCy_2$.

oxazoles as a limiting agent; (2) higher loading of LiO-*t*-Bu. Representative results are illustrated in Scheme 5. Both electron-donating methyl and methoxy and electron-withdrawing trifluoromethyl groups on the phenyl ring of the parent 5-phenyloxazole were well tolerated for the coupling with **2a** (**3ba**−**fa**). Only in the reaction of chloro-substituted oxazole, the replacement of $PPhCy_2$ with PPh_3 was necessary, due to the competitive protodechlorination under the standard conditions (**3ga**). Bulky naphthyl and conjugated styryl moieties did not interfere with this catalysis to furnish **3ha** and **3ia** in 80 and 64% yields, respectively. The 5-phenyloxazole also effectively coupled with the methoxyphenyl-, thienyl-, and benzothienyl-substituted pivalates **2b**′, **2f**′, and **2j**′, leading to **3bb**, **3bf**, and **3bj** in good yields. The current major limitation is inaccessibility to other heteroarenes including thiazoles and imidazoles. While the exact reason is not clear at this stage, the acidity of C−H may play a pivotal role in the C−H cleavage step.[23]

On the basis of literature information and our findings, we are tempted to assume the reaction mechanism of **1a** with **2a** as follows (Scheme 6). Initial off-cycle reduction of Pd(II) by the action of the $PPhCy_2$, LiO-*t*-Bu,[24] or LiO-*t*-Bu/**1a**[25] and coordination of $PPhCy_2$ forms the starting Pd(0) species **4**. Subsequent oxidative addition of **2a** (**4** → **5**) is followed by decarboxylation to generate the alkyl(*tert*-butoxy)palladium intermediate **6**. With the pivalate **2a**′ in place of the Boc carbonate **2a**, the decarboxylation step is skipped and the oxidative addition of **2a**′ directly affords the alkyl(pivaloyloxy) palladium **6**′ corresponding to **6**. Base-assisted C−H palladation of **1a**[26] with **6** occurs to form the alkyl(heteroaryl) palladium **7**. Final productive reductive elimination provides the desired triarylmethane **3aa** along with the regeneration of the starting Pd(0) complex **4** to close the catalytic cycle. Given the better reactivity of higher fused aromatic systems observed in Table 2 (for example, entry 1 vs 19 and entry 12 vs 22), the

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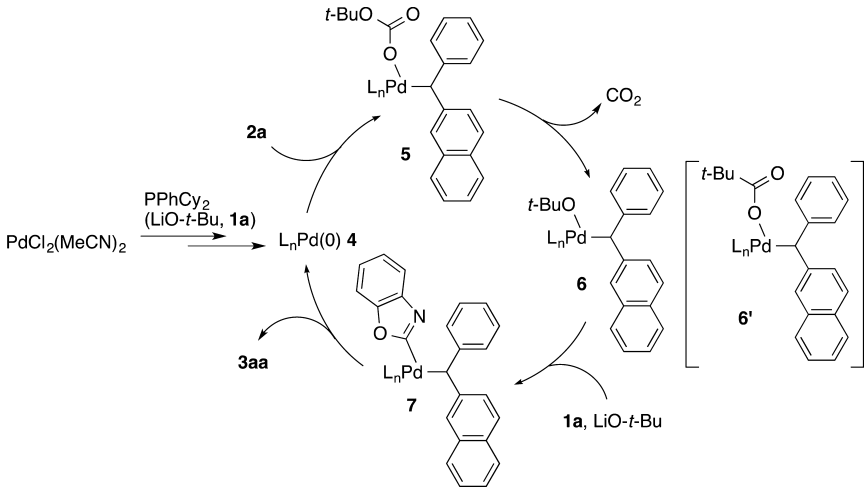
Scheme 6. Plausible Mechanism



participation of π-benzyl intermediate is likely.[19] The overall stereochemistry (retention or inversion of configuration of starting diarylmethanols) remains elusive at present. The facile racemization of the triarylmethane product associated with higher acidity of the benzylic C−H increased difficulties to study the mechanistic details.[27] Further efforts on modification of the catalyst system were essential.

■ CONCLUSION

We have developed a second generation palladium-based catalyst system, $PdCl_2(MeCN)_2$/$PPhCy_2$/LiO-*t*-Bu/1,4-dioxane for the C−H/C−O coupling of oxazoles and diarylmethanol derivatives. The present catalysis allows the relatively challenging secondary benzyl carbonates and pivalates to be adopted in the direct coupling with oxazoles and provides a concise access to heteroarene-containing triarylmethanes, which are interesting scaffolds in medicinal and material chemistry. Further development of more mild and reactive catalysts and clarification of the stereochemistry are currently underway in our laboratory.

■ EXPERIMENTAL SECTION

Instrumentation and Chemicals. ^1H and ^{13}C NMR spectra were recorded at 400 and 100 MHz, respectively, for $CDCl_3$ solutions. HRMS data were obtained by APCI using a TOF. GC analysis was carried out using a silicon OV-17 column (i.d. 2.6 mm × 1.5 m) or a CBP-1 capillary column (i.d. 0.5 mm × 25 m). TLC analyses were performed on commercial glass plates bearing a 0.25 mm layer of Merck silica gel $60F_{254}$. Silica gel was used for column chromatography. Gel permeation chromatography (GPC) was performed with a $CHCl_3$ eluent (3.5 mL/min, UV detector). Unless otherwise noted, materials obtained from commercial suppliers were used without further purification. Anhydrous THF was purchased and used out of the bottle without further purification, and 1,4-dioxane was dried on a Glass Contour Solvent dispending system (Nikko Hansen & Co., Ltd.) prior to use. 5-Substituted oxazoles **1** were prepared by the van Leusen reaction with TosMIC and the corresponding aldehydes.[28] Diarylmethyl Boc carbonates **2** and pivalates **2′** were synthesized from the corresponding secondary carbinols and Boc_2O or PivCl, respectively.[8,9] Unless otherwise noted, all reactions were carried out under N_2 conditions.

Typical Procedure for Preparation of *tert*-Butyl Diarylmethyl Carbonates 2. The synthesis of **2a** is representative: Mg turnings (875 mg, 36 mmol) were placed in a 100 mL three neck flask, which was filled with nitrogen. A solution of 1,2-dibromoethane (0.2 mL, 2.3 mmol) in THF (3 mL) was added to the flask, and the suspension was stirred for a few minutes to activate Mg. A solution of bromobenzene (3.15 mL, 30 mmol) in THF (27 mL) was then added slowly to the flask via an addition funnel. After the addition completion, the resulting suspension was stirred for additional 30 min at room temperature. A solution of 2-naphthaldehyde (3.12 g, 20 mmol) in THF (10 mL) was added dropwise, and the suspension was stirred for 24 h. The resulting mixture was quenched with aq. NH_4Cl and then extracted three times with ethyl acetate. The combined organic layer was dried over sodium sulfate. Concentration in vacuo and subsequent purification by column chromatography on silica gel with hexane/ethyl acetate (5/1 v/v) as an eluent gave (2-naphthyl)(phenyl)methanol (3.95 g, 17 mmol) in 85% yield.

To a solution of the above (2-naphthyl)(phenyl)methanol (3.95 g, 17 mmol) in THF (30 mL), *n*-BuLi (1.6 M hexane solution, 10.6 mL, 17 mmol) was added dropwise at −78 °C, and the solution was stirred at −78 °C. After 30 min, Boc_2O (3.9 mL, 17 mmol) was added dropwise at 0 °C, and the suspension was stirred for 2 h at room temperature. The resulting mixture was quenched with water and then extracted three times with ethyl acetate. The combined organic layer was dried over sodium sulfate. Concentration in vacuo and subsequent purification by column chromatography on silica gel with hexane/ethyl acetate (20/1 v/v) as an eluent gave *tert*-butyl (2-naphthyl)(phenyl)-methyl carbonate (**2a**; 5.11 g, 15.3 mmol) in 90% yield.

Typical Procedure for Preparation of Diarylmethyl Pivalates 2′. The synthesis of **2a′** is representative: to a solution of (2-naphthyl)-(phenyl)methanol (3.95 g, 17 mmol), which is synthesized by the same procedure as for the preparation of the carbonate **2a**, in THF (30 mL), *n*-BuLi (1.6 M hexane solution, 10.6 mL, 17 mmol) was added dropwise at −78 °C, and the solution was stirred at −78 °C. After 30 min, pivaloyl chloride (2.0 mL, 17 mmol) was added dropwise at 0 °C, and the mixture was stirred for 2 h at room temperature. The resulting mixture was quenched with water and then extracted three times with ethyl acetate. The combined organic layer was dried over sodium sulfate. Concentration in vacuo and subsequent purification by column chromatography on silica gel with hexane/ethyl acetate (20/1 v/v) as an eluent gave (2-naphthyl)(phenyl)methyl pivalate (**2a′**; 4.65 g, 14.6 mmol) in 86% yield.

Typical Procedure for Pd-Catalyzed Direct C−H/C−O Coupling of Oxazoles and Diarylmethanol Derivatives. The synthesis of **3aa** is representative (Table 2, entry 1): $PdCl_2(MeCN)_2$ (6.5 mg, 0.025 mmol), PCy_2Ph (13.7 mg, 0.050 mmol), and LiO-*t*-Bu (40.0 mg, 0.50 mmol) were placed in a 20 mL two neck flask equipped with a reflux condenser, which was filled with nitrogen. 1,4-Dioxane (2.0 mL) was added to the flask, and suspension was stirred for 2 min at room temperature. A solution of benzoxazole (**1a**; 59.5 mg, 0.50 mmol) and *tert*-butyl (2-naphthyl)(phenyl)methyl carbonate (**2a**; 83.5 mg, 0.25 mmol) in 1,4-dioxane (1.0 mL) was then added to the flask, and the suspension was stirred for 6 h at 120 °C. The resulting mixture was quenched with water and then extracted three times with

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ethyl acetate. The combined organic layer was dried over sodium sulfate. Concentration in vacuo and subsequent purification by column chromatography on silica gel with hexane/ethyl acetate (20/1 v/v) as an eluent gave 2-[naphthalen-2-yl(phenyl)methyl]benzo[*d*]oxazole (**3aa**; 75.5 mg, 0.23 mmol) in 90% yield.

2-[Naphthalen-2-yl(phenyl)methyl]benzo[d]oxazole (***3aa***). Purified by column chromatography on silica gel with ethyl acetate/hexane (1/20 v/v) as an eluent; 76 mg (90%): mp 114−115 °C (from ethyl acetate/hexane); ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.93 (s, 1H), 7.27−7.40 (m, 7H), 7.43−7.51 (m, 4H), 7.74−7.79 (m, 3H), 7.80−7.83 (m, 2H); $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 51.7, 110.7, 120.3, 124.3, 124.9, 126.1, 126.3, 126.9, 127.52, 127.53, 127.6, 128.0, 128.5, 128.8, 128.9, 132.6, 133.4, 136.7, 139.1, 141.3, 151.0, 166.7; HRMS (APCI) m/z ($[M + H]^+$) calcd for $C_{24}H_{18}NO$ 336.1387, found 336.1383.

2-[(4-Methoxyphenyl)(naphthalen-2-yl)methyl]benzo[d]oxazole (***3ab***). Purified by column chromatography on silica gel with ethyl acetate/hexane (1/5 v/v) as an eluent; 76 mg (83%): mp 113−114 °C (from ethyl acetate/hexane); ^{1}H NMR (400 MHz, $CDCl_3$) δ 3.79 (s, 3H), 5.89 (s, 1H), 6.89 (dd, J = 8.8, 2.1 Hz, 2H), 7.29−7.34 (m, 4H), 7.43−7.52 (m, 4H), 7.72−7.83 (m, 5H); $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 50.9, 55.3, 110.7, 114.2, 120.2, 124.3, 124.9, 126.1, 126.3, 126.8, 127.3, 127.6, 128.0, 128.5, 130.0, 131.2, 132.6, 133.4, 137.0, 141.3, 151.0, 158.9, 167.0; HRMS (APCI) m/z ($[M + H]^+$) calcd for $C_{25}H_{20}NO_2$ 366.1494, found 366.1489.

2-[Naphthalen-2-yl(2-methylphenyl)methyl]benzo[d]oxazole (***3ac***). Purified by column chromatography on silica gel with ethyl acetate/hexane (1/5 v/v) as an eluent; 50 mg (58%): mp 125−126 °C (from ethyl acetate/hexane); ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.34 (s, 3H), 6.10 (s, 1H), 7.16−7.24 (m, 4H), 7.29−7.34 (m, 2H), 7.40−7.49 (m, 4H), 7.64 (s, 1H), 7.73−7.79 (m, 2H), 7.80−7.83 (m, 2H); $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 19.8, 48.4, 110.7, 120.3, 124.3, 124.9, 126.1, 126.2, 126.4, 127.1, 127.7 (three signals were overlapped.), 128.0, 128.5, 128.8, 130.9, 132.6, 133.4, 136.1, 136.5, 137.4, 141.4, 151.0, 166.9; HRMS (APCI) m/z ($[M + H]^+$) calcd for $C_{25}H_{20}NO$ 350.1539, found 350.1539.

2-[(4-Chlorophenyl)(naphthalen-2-yl)methyl]benzo[d]oxazole (***3ad***). Purified by column chromatography on silica gel with ethyl acetate/hexane (1/20 v/v) as an eluent followed by GPC with chloroform; 43 mg (47%), oil: ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.89 (s, 1H), 7.30−7.33 (m, 6H), 7.43−7.50 (m, 4H), 7.72−7.82 (m, 5H); $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 51.2, 110.7, 120.3, 124.5, 125.1, 126.3, 126.4, 126.6, 127.5, 127.7, 128.0, 128.7, 129.0, 130.3, 132.7, 133.4, 133.5, 136.2, 137.6, 141.2, 151.0, 166.2; HRMS (APCI) m/z ($[M + H]^+$) calcd for $C_{24}H_{17}ClNO$ 370.0993, found 370.0993.

4-[Benzo[d]oxazol-2-yl(naphthalen-2-yl)methyl]benzonitrile (***3ae***). Purified by column chromatography on silica gel with ethyl acetate/hexane (1/5 v/v) as an eluent; 48 mg (53%): mp 53−54 °C (from ethyl acetate/hexane); ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.96 (s, 1H), 7.33−7.37 (m, 2H), 7.43 (dd, J = 8.6, 1.8 Hz, 1H), 7.47−7.52 (m, 5H), 7.65 (d, J = 8.4 Hz, 2H), 7.73 (s, 1H), 7.75−7.86 (m, 4H); $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 51.5, 110.8, 111.6, 118.6, 120.4, 124.6, 125.4, 126.4, 125.55, 126.63, 127.68, 127.71, 128.0, 129.0, 129.8, 132.6, 132.8, 133.3, 135.3, 141.1, 144.4, 150.9, 165.3; HRMS (APCI) m/z ($[M + H]^+$) calcd for $C_{25}H_{17}N_2O$ 361.1335, found 361.1335.

2-[Naphthalen-2-yl(thiophen-2-yl)methyl]benzo[d]oxazole (***3af***). Purified by column chromatography on silica gel with ethyl acetate/hexane (1/20 v/v) as an eluent; 53 mg (62%): mp 102−103 °C (from ethyl acetate/hexane); ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.12 (s, 1H), 6.99 (dd, J = 5.1, 3.6 Hz, 1H), 7.04−7.05 (m, 1H), 7.29 (dd, J = 5.1, 1.1 Hz, 1H), 7.31−7.35 (m, 2H), 7.45−7.51 (m, 3H), 7.58 (dd, J = 8.5, 1.1 Hz, 1H), 7.75−7.86 (m, 5H); $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 47.1, 110.8, 120.4, 124.4, 125.1, 125.7, 126.28, 126.31, 126.4, 126.9, 127.0, 127.3, 127.7, 128.1, 128.7, 132.8, 133.4, 136.4, 141.2, 141.7, 151.0, 165.8; HRMS (APCI) m/z ($[M + H]^+$) calcd for $C_{22}H_{16}NOS$ 342.0958, found 342.0947.

2-[Furan-2-yl(naphthalen-2-yl)methyl]benzo[d]oxazole (***3ag***). Purified by column chromatography on silica gel with ethyl acetate/hexane (1/20 v/v) as an eluent; 33 mg (40%), oil: ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.94 (s, 1H), 6.30−6.31 (m, 1H), 6.38 (dd, J = 2.9, 2.6 Hz, 1H), 7.30 (dd, J = 4.3, 3.3 Hz, 1H), 7.33 (dd, J = 4.4, 3.0 Hz, 1H), 7.44 (dd, J = 1.8, 0.76 Hz, 1H), 7.45−7.52 (m, 3H), 7.57 (dd, J = 8.5, 1.1 Hz, 1H), 7.73−7.77 (m, 1H), 7.79−7.85 (m, 4H) ; $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 46.0, 108.9, 110.6, 110.7, 120.4, 124.4, 125.1, 126.3 (overlapped), 126.4, 127.6, 127.7, 128.1, 128.7, 132.9, 133.4, 134.2, 141.2, 142.7, 151.0, 151.6, 164.7; HRMS (APCI) m/z ($[M + H]^+$) calcd for $C_{22}H_{16}NO_2$ 326.1176, found 326.1176.

2-[1-(Naphthalen-2-yl)ethyl]benzo[d]oxazole (***3ah***). Purified by column chromatography on silica gel with ethyl acetate/hexane (1/20 v/v) as an eluent; 53 mg (77%): mp 115−116 °C (from ethyl acetate/hexane); ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.92 (d, J = 7.2 Hz, 3H), 4.58 (q, J = 7.2 Hz, 1H), 7.27 (ddd, J = 7.4, 4.7, 1.6 Hz, 1H), 7.30 (ddd, J = 7.4, 4.7, 1.6 Hz, 1H), 7.42−7.50 (m, 4H), 7.72−7.75 (m, 1H), 7.79−7.82 (m, 4H); $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 19.8, 40.3, 110.5, 119.9, 124.2, 124.7, 125.6, 125.9, 126.1, 126.3, 127.7, 127.9, 128.6, 132.6, 133.5, 138.6, 141.2, 150.9, 168.8; HRMS (APCI) m/z ($[M + H]^+$) calcd for $C_{19}H_{16}NO$ 274.1236, found 274.1226.

2-[Naphthalen-1-yl(phenyl)methyl]benzo[d]oxazole (***3ai***). Purified by column chromatography on silica gel with ethyl acetate/hexane (1/20 v/v) as an eluent; 68 mg (82%): mp 155−156 °C (from ethyl acetate/hexane); ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.54 (s, 1H), 7.27−7.38 (m, 8H), 7.39−7.48 (m, 4H), 7.71−7.74 (m, 1H), 7.82 (d, J = 8.4 Hz, 1H), 7.86−7.89 (m, 1H), 8.03−8.06 (m, 1H); $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 48.0, 110.7, 120.3, 123.3, 124.3, 124.9, 125.4, 125.8, 126.7, 126.9, 127.5, 128.4, 128.8, 128.98, 129.02, 131.5, 134.0, 135.0, 138.8, 141.4, 151.0, 167.0; HRMS (APCI) m/z ($[M + H]^+$) calcd for $C_{24}H_{18}NO$ 336.1383, found 336.1383.

2-[Benzo[b]thiophen-3-yl(phenyl)methyl]benzo[d]oxazole(***3aj***). Purified by column chromatography on silica gel with ethyl acetate/hexane (1/20 v/v) as an eluent; 65 mg (76%): mp 154−155 °C (from ethyl acetate/hexane); ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.07 (s, 1H), 7.27−7.36 (m, 8H), 7.43−7.45 (m, 2H), 7.45−7.50 (m, 1H), 7.62 (d, J = 7.7 Hz, 1H), 7.71−7.74 (m, 1H), 7.85 (dd, J = 7.2, 1.2 Hz, 1H); $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 46.0, 110.7, 120.3, 121.9, 123.0, 124.3, 124.4, 124.6, 125.0, 125.4, 127.8, 128.7, 128.9, 133.3, 137.8, 137.9, 140.5, 141.3, 150.9, 165.9; HRMS (APCI) m/z ($[M + H]^+$) calcd for $C_{22}H_{16}NOS$ 342.0947, found 342.0953.

2-[Benzofuran-2-yl(phenyl)methyl]benzo[d]oxazole (***3ak***). Purified by column chromatography on silica gel with ethyl acetate/hexane (1/20 v/v) as an eluent; 32 mg (39%), oil: ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.89 (s, 1H), 6.66 (s, 1H), 7.18−7.27 (m, 2H), 7.31−7.44 (m, 6H), 7.49−7.53 (m, 4H), 7.73−7.77 (m, 1H); $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 46.3, 105.8, 110.8, 111.3, 120.4, 121.1, 122.9, 123.3, 124.3, 124.5, 125.2, 128.2, 128.7, 129.0, 136.2, 141.2, 151.0, 154.7, 155.2, 164.1; HRMS (APCI) m/z ($[M + H]^+$) calcd for $C_{22}H_{16}NO_2$ 326.1176, found 326.1176.

2-([1,1′-Biphenyl]-4-yl(phenyl)methyl)benzo[d]oxazole (***3al***). Purified by column chromatography on silica gel with ethyl acetate/hexane (1/20 v/v) as an eluent; 37 mg (42%): mp 126−127 °C (from ethyl acetate/hexane); ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.81 (s, 1H), 7.29−7.44 (m, 12H), 7.48−7.50 (m, 1H), 7.56−7.58 (m, 4H), 7.72−7.77 (m, 1H); $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 51.3, 110.7, 120.3, 124.3, 124.9, 127.1, 127.4, 127.5 (overlapped), 128.77, 128.82, 128.83, 129.2, 138.3, 139.2, 140.4, 140.6, 141.3, 151.0, 166.7; HRMS (APCI) m/z ($[M + H]^+$) calcd for $C_{26}H_{20}NO$ 362.1539, found 362.1539.

2-[(Diphenyl)methyl]benzo[d]oxazole (***3am***). Purified by column chromatography on silica gel with ethyl acetate/hexane (1/20 v/v) as an eluent; 22 mg (31%): mp 62−63 °C (from ethyl acetate/hexane); ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.77 (s, 1H), 7.27−7.35 (m, 12H), 7.46−7.50 (m, 1H), 7.71−7.76 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 51.6, 110.7, 120.2, 124.3, 124.9, 127.4, 128.76, 128.81, 139.2, 141.3, 151.0, 166.7; HRMS (APCI) m/z ($[M + H]^+$) calcd for $C_{20}H_{16}NO$ 286.1226, found 286.1232.

2-(Phenyl(thiophen-2-yl)methyl)benzo[d]oxazole (***3an***). Purified by column chromatography on silica gel with ethyl acetate/hexane (1/20 v/v) as an eluent followed by GPC with chloroform; 26 mg (35%), oil: ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.96 (s, 1H), 6.97−7.02 (m, 2H), 7.25−7.38 (m, 6H), 7.43−7.45 (m, 2H), 7.48−7.52 (m, 1H), 7.71−7.77 (m, 1H); $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 46.9, 110.7, 120.3, 124.4, 125.1, 125.5, 126.82, 126.84, 127.9, 128.4, 128.9, 139.0,

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141.1, 141.8, 151.0, 165.9; HRMS (APCI) m/z ([M + H]$^+$) calcd for $C_{18}H_{14}NOS$ 292.0791, found 292.0788.

*2-[Naphthalen-2-yl(phenyl)methyl]-5-phenyloxazole (**3ba**).* Purified by column chromatography on silica gel with ethyl acetate/hexane (1/5 v/v) as an eluent followed by GPC with chloroform; 62 mg (69%): mp 150−151 °C (from $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.84 (s, 1H), 7.28−7.32 (m, 2H), 7.35−7.41 (m, 7H), 7.44−7.48 (m, 3H), 7.59−7.61 (m, 2H), 7.72 (s, 1H), 7.77−7.83 (m, 3H); ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$) δ 51.3, 122.2, 124.2, 126.1, 126.2, 126.9, 127.3 (overlapped), 127.6, 128.0 (overlapped), 128.4, 128.5, 128.7, 128.8, 128.9, 132.6, 133.4, 137.4, 139.8, 151.6, 164.1; HRMS (APCI) m/z ([M + H]$^+$) calcd for $C_{26}H_{20}NO$ 362.1548, found 362.1539.

*5-(4-Methylphenyl)-2-[naphthalen-2-yl(phenyl)methyl]oxazole (**3ca**).* Purified by column chromatography on silica gel with ethyl acetate/hexane (1/5 v/v) as an eluent followed by GPC with chloroform; 53 mg (57%): mp 149−150 °C (from $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.34 (s, 3H), 5.83 (s, 1H), 7.18 (d, J = 7.9, 2H), 7.26−7.29 (m, 2H), 7.34−7.35 (m, 4H), 7.43−7.49 (m, 5H), 7.71 (s, 1H), 7.76−7.81 (m, 3H); ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$) δ 21.4, 51.3, 121.6, 124.2, 125.3, 126.0, 126.2, 126.9, 127.3, 127.3, 127.6, 128.0, 128.4, 128.7, 128.8, 129.5, 132.6, 133.4, 137.5, 138.4, 139.9, 151.8, 163.7; HRMS (APCI) m/z ([M + H]$^+$) calcd for $C_{27}H_{22}NO$ 376.1699, found 376.1696.

*5-(4-Methoxyphenyl)-2-[naphthalen-2-yl(phenyl)methyl]oxazole (**3da**).* Purified by column chromatography on silica gel with ethyl acetate/hexane (1/5 v/v) as an eluent followed by GPC with chloroform; 61 mg (62%): mp 183−184 °C (from $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 3.81 (s, 3H), 5.82 (s, 1H), 6.91 (dd, J = 8.7, 1.4 Hz, 2H), 7.21 (s, 1H), 7.26−7.29 (m, 1H), 7.34−7.35 (m, 4H), 7.43−7.47 (m, 3H), 7.52 (d, J = 8.7 Hz, 2H), 7.71 (s, 1H), 7.76−7.82 (m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 51.2, 55.4, 114.3, 120.7, 120.9, 125.7, 126.0, 126.2, 126.9, 127.28, 127.31, 127.6, 128.0, 128.4, 128.7, 128.8, 132.5, 133.4, 137.5, 139.9, 151.6, 159.7, 163.4; HRMS (APCI) m/z ([M + H]$^+$) calcd for $C_{27}H_{22}NO_2$ 392.1644, found 392.1645.

*5-(3,4-Dimethoxyphenyl)-2-[naphthalen-2-yl(phenyl)methyl]-4,5-dihydrooxazole (**3ea**).* Purified by column chromatography on silica gel with ethyl acetate/hexane (1/5 v/v) as an eluent followed by GPC with chloroform; 66 mg (63%): mp 147−148 °C (from $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 3.89 (s, 3H), 3.91 (s, 3H), 5.83 (s, 1H), 6.87 (d, J = 7.2 Hz, 1H), 7.07 (d, J = 2.0 Hz, 1H), 7.18 (dd, J = 8.3, 2.0 Hz, 1H), 7.23 (s, 1H), 7.27- 7.33 (m, 1H), 7.34−7.36 (m, 4H), 7.43−7.47 (m, 3H), 7.72 (s, 1H), 7.76−7.82 (m, 3H); ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$) δ 51.2, 55.99, 56.03, 107.5, 111.4, 117.2, 121.1 (overlapped), 126.0, 126.2, 126.9, 127.3 (overlapped), 127.6, 128.0, 128.4, 128.7, 128.8, 132.5, 133.4, 137.5, 139.9, 149.26, 149.34, 151.6, 163.5; HRMS (APCI) m/z ([M + H]$^+$) calcd for $C_{28}H_{24}NO_3$ 422.1750, found 422.1751.

*2-[Naphthalen-2-yl(phenyl)methyl]-5-[4-(trifluoromethyl)-phenyl]oxazole (**3fa**).* Purified by column chromatography on silica gel with ethyl acetate/hexane (1/5 v/v) as an eluent followed by GPC with chloroform; 54 mg (50%), oil: ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.85 (s, 1H), 7.27−7.33 (m, 1H), 7.33−7.38 (m, 4H), 7.45 (ddd, J = 3.6, 3.2, 1.6 Hz, 2H), 7.47 (dd, J = 3.6, 3.0 Hz, 2H), 7.63 (d, J = 8.4 Hz, 2H), 7.70 (d, J = 8.2 Hz, 2H), 7.72 (s, 1H), 7.76−7.83 (m, 3H); ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$) δ 51.3, 123.9 (q, J = 270 Hz), 124.1, 124.3, 125.3 (q, J = 3.8 Hz), 126.2, 126.3, 126.7, 127.4, 127.5, 127.7, 128.0, 128.6, 128.77, 128.81, 130. 0 (q, J = 32 Hz), 131.2, 132.6, 133.4, 137.1, 139.5, 150.3, 165.0; HRMS (APCI) m/z ([M + H]$^+$) calcd for $C_{27}H_{19}F_3NO$ 430.1412, found 430.1413.

*5-(4-Chlorophenyl)-2-[naphthalen-2-yl(phenyl)methyl]oxazole (**3ga**).* Purified by column chromatography on silica gel with ethyl acetate/hexane (1/5 v/v) as an eluent followed by GPC with chloroform; 31 mg (31%), oil: ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.83 (s, 1H), 7.27−7.32 (m, 1H), 7.33−7.36 (m, 7H), 7.44−7.47 (m, 3H), 7.50−7.54 (m, 2H), 7.71 (s, 1H), 7.77−7.83 (m, 3H); ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$) δ 51.3, 121.6, 124.2, 125.3, 126.0, 126.2, 126.9, 127.31, 127.33, 127.6, 128.0, 128.4, 128.7, 128.8, 129.5, 132.6, 133.4, 137.5, 138.4, 139.9, 151.8, 163.9; HRMS (APCI) m/z ([M + H]$^+$) calcd for $C_{26}H_{19}ClNO$ 396.1149, found 396.1150.

*5-(Naphthalen-1-yl)-2-[naphthalen-2-yl(phenyl)methyl]oxazole (**3ha**).* Purified by column chromatography on silica gel with ethyl acetate/hexane (1/5 v/v) as an eluent followed by GPC with chloroform; 82 mg (80%): mp 52−53 °C (from $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.92 (s, 1H), 7.28−7.35 (m, 1H), 7.35−7.53 (m, 11H), 7.69 (d, J = 7.2 Hz, 1H), 7.79−7.88 (m, 6H), 8.18 (d, J = 0.76 Hz, 1H); ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$) δ 51.4, 125.0, 125.28, 125.34, 125.6, 126.1, 126.2, 126.3, 126.4, 126.9, 127.0, 127.39, 127.43, 127.7, 128.0, 128.5, 128.7, 128.8, 128.9, 129.6, 130.1, 132.6, 133.4, 133.9, 137.4, 139.9, 150.9, 164.4; HRMS (APCI) m/z ([M + H]$^+$) calcd for $C_{30}H_{22}NO$ 412.1702, found 412.1696.

*(E)-2-[Naphthalen-2-yl(phenyl)methyl]-5-styryloxazole (**3ia**).* Purified by column chromatography on silica gel with ethyl acetate/hexane (1/5 v/v) as an eluent followed by GPC with chloroform; 62 mg (64%): mp 146−147 °C (from $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.81 (s, 1H), 6.86 (d, J = 16.2 Hz, 1H), 6.99 (d, J = 16.2 Hz, 1H), 7.06 (s, 1H), 7.24−7.36 (m, 8H), 7.42−7.46 (m, 5H), 7.71 (s, 1H), 7.77−7.83 (m, 3H); ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$) δ 51.3, 113.1, 125.1, 126.1, 126.3, 126.5, 126.9, 127.35, 127.36, 127.7, 128.0, 128.2, 128.5, 128.76, 128.78, 128.81, 129.5, 132.6, 133.4, 136.3, 137.3, 139.7, 150.7, 164.1; HRMS (APCI) m/z ([M + H]$^+$) calcd for $C_{28}H_{22}NO$, 388.1706, found 388.1706.

*2-[(4-Methoxyphenyl)(naphthalen-2-yl)methyl]-5-phenyloxazole (**3bb**).* Purified by column chromatography on silica gel with ethyl acetate/hexane (1/5 v/v) as an eluent; 63 mg (64%), oil: ^{1}H NMR (400 MHz, $CDCl_3$) δ 3.79 (s, 3H), 5.79 (s, 1H), 6.88 (d, J = 11.7 Hz, 2H), 7.26−7.31 (m, 3H), 7.34 (s, 1H), 7.36−7.40 (m, 2H), 7.43−7.47 (m, 3H), 7.57−7.61 (m, 2H), 7.69 (s, 1H), 7.76−7.82 (m, 3H); ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$) δ 50.5, 55.3, 114.1, 122.2, 124.2, 126.0, 126.2, 126.8, 127.1, 127.6, 128.0 (overlapped), 128.3, 128.4, 128.9, 129.9, 131.9, 132.5, 133.4, 137.7, 151.5, 158.8, 164.4; HRMS (APCI) m/z ([M + H]$^+$) calcd for $C_{27}H_{22}NO_2$ 392.1645, found 392.1645.

*2-[Naphthalen-2-yl(thiophen-2-yl)methyl]-5-phenyloxazole (**3bf**).* Purified by column chromatography on silica gel with ethyl acetate/hexane (1/20 v/v) as an eluent followed by GPC with chloroform; 53 mg (58%): mp 122−123 °C (from $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.03 (s, 1H), 6.97−7.01 (m, 2H), 7.26−7.41 (m, 5H), 7.45−7.49 (m, 2H), 7.54−7.62 (m, 3H), 7.80−7.85 (m, 4H); ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$) δ 46.7, 122.2, 124.2, 125.5, 126.2, 126.26, 126.31, 126.6, 126.8, 127.0, 127.7, 127.9, 128.1, 128.5, 128.6, 128.9, 132.8, 133.4, 137.0, 142.5, 151.7, 163.2; HRMS (APCI) m/z ([M + H]$^+$) calcd for $C_{24}H_{18}NOS$ 368.1104, found 368.1104.

*2-(Benzo[b]thiophen-3-yl(phenyl)methyl)-5-phenyloxazole (**3bj**).* Purified by column chromatography on silica gel with ethyl acetate/hexane (1/20 v/v) as an eluent; 70 mg (76%): mp 137−138 °C (from ethyl acetate/hexane); ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.97 (s, 1H), 7.26−7.42 (m, 12H), 7.56−7.64 (m, 3H), 7.71−7.74 (m, 1H); ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$) δ 45.6, 122.0, 122.3, 122.9, 124.2, 124.3, 124.5, 125.1, 127.6, 127.9, 128.4, 128.5, 128.86, 128.88, 134.1, 137.9, 138.4, 140.6, 151.6, 163.4; HRMS (APCI) m/z ([M + H]$^+$) calcd for $C_{24}H_{18}NOS$ 368.1104, found 368.1104.

■ ASSOCIATED CONTENT

Supporting Information

More detailed results of nickel-catalyzed reactions and ^{1}H and ^{13}C{^{1}H} NMR spectra for products. This material is available free of charge via the Internet at http://pubs.acs.org.

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Notes

The authors declare no competing financial interest.

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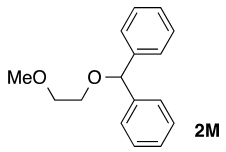
(21) With 2-vinylnaphthalene instead of **2g**, no product **3ag** was detected under otherwise identical or LiO-*t*-Bu-free modified conditions. Thus, the C−H insertion pathway of **1a** could be excluded under the present catalysis. For the C−H insertion reactions of **1a** by Rh(I) and Ni(0) catalysts, see: (a) Tan, K. L.; Bergman, R. G.; Ellman, J. A. *J. Am. Chem. Soc.* **2002**, *124*, 13964. (b) Nakao, Y.; Kanyiva, K. S.; Oda, S.; Hiyama, T. *J. Am. Chem. Soc.* **2006**, *128*, 8146. (c) Nakao, Y.; Kashihara, N.; Kanyiva, K. S.; Hiyama, T. *Angew. Chem., Int. Ed.* **2010**, *49*, 4451.

(22) Prompted by the work of Jarvo (refs 8a and 20e), we prepared the diphenylmethanol derivative **2M** that bears the chelating leaving group and tested it in place of **2m**. However, **3am** was not obtained at all under identical conditions, and **2M** was recovered intact.



2M

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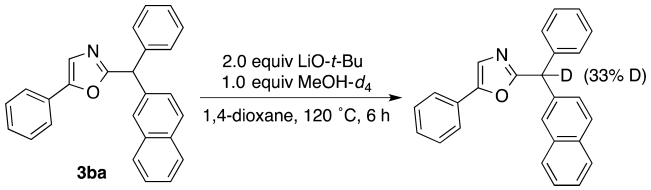
(27) Actually, the product **3ba** underwent the facile deuterium incorporation by LiO-*t*-Bu and MeOH-d_4 in refluxing 1,4-dioxane (see the following scheme). Development of much milder conditions and detailed stereochemical studies under modified catalysis are ongoing and will be reported in due course.



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