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Recyclable Heterogeneous Palladium-Catalyzed Carbonylative Cyclization of 2-Iodoanilines with Aryl Iodides Leading to 2-Arylbenzoxazinones

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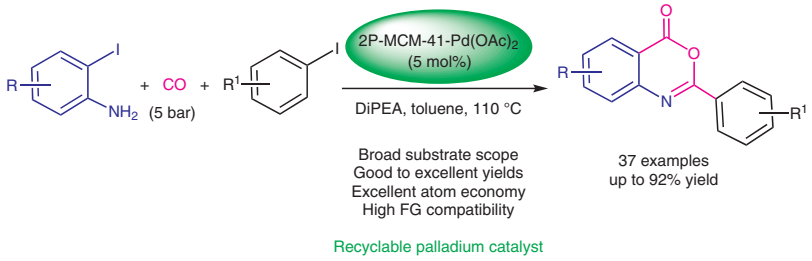

Received: 01.09.2019
Accepted after revision: 22.10.2019
Published online: 13.11.2019
DOI: 10.1055/s-0039-1690265; Art ID: ss-2019-h0498-op

Abstract A highly efficient and practical heterogeneous palladium-catalyzed carbonylative coupling of 2-iodoanilines with aryl iodides has been developed. The reaction occurs smoothly in toluene at 110 °C with *N*,*N*-diisopropylethylamine as base under carbon monoxide (5 bar) and offers a general and powerful tool for the construction of various valuable 2-arylbenzoxazinones with excellent atom-economy, high functional group tolerance, good to high yields, and easy recyclability of the palladium catalyst. The reaction is the first example of heterogeneous palladium-catalyzed carbonylative coupling for the preparation of diverse 2-arylbenzoxazinones from commercially easily available 2-iodoanilines and aryl iodides.

Key words palladium, benzoxazinone, carbonylative coupling, 2-iodoaniline, heterogeneous catalysis

Benzoxazinones make up a class of important fused N-heterocycles that are present in numerous biological compounds and pharmaceutical drugs[1] and exhibit a variety of biological activities such as antibacterial, antifungal, HSV-1 protease inhibition, serine protease inhibition, and other activities.[2] They are also versatile and valuable synthetic intermediates in organic synthesis and medicinal chemistry.[1a,3] For instance, 2-aryl-substituted 4*H*-benzoxazin-4-ones have been employed as key building blocks in the synthesis of bioactive quinazolin-4(3*H*)-one derivatives.[4] As a result, various methods have been developed for the construction of these compounds over the past decades.[5] The most common approaches for the synthesis of benzoxazinones are the cyclization of anthranilic acid, *N*-acylanthranilic acid, and isotoic anhydride.[6] Recently, transition-metal-mediated reactions have been developed for the construction of benzoxazinones; these include copper-catalyzed cyclization of *N*-acyl-2-iodobenzamides,[7] oxidative cyclization of *N*-TFA-protected 2-alkynylanilines,[8] reaction of 2-iodobenzoic acids with arylmethanamines,[9] oxidation of 2-arylindoles,[10] and aza-Wittig reaction of 2-azidophenyl anhydrides[11] and palladium-catalyzed carbon–carbon triple-bond cleavage of 2-azidoalkynylbenzenes,[12] as well as $CoCl_2$- or Ag_2O-mediated intramolecular oxidative cyclization.[13] In addition, transition-metal-free syntheses of benzoxazinones have also been reported via oxidation of 2-arylindoles with oxone and oxidative cyclization of 2-aminobenzoic acids with aryl aldehydes or 2-aminobenzyl alcohols with aldehydes.[14] However, in terms of the availability and scope of substrates, yields, and required reaction conditions, most of these methods suffer from one or more drawbacks.

Palladium-catalyzed carbonylative reactions of commercially readily available aryl halides with inexpensive carbon monoxide have become a general and practical route for the synthesis of benzoic acid derivatives.[15] The combination of such carbonylation reactions with subsequent intramolecular cyclization processes would allow for a highly efficient construction of various heterocycles.[16] Palladium-catalyzed carbonylative cyclization reactions have been developed into a highly efficient and powerful tool for the synthesis of benzoxazinones.[17] Cacchi et al. described a general approach for the synthesis of benzoxazinones via the carbonylative coupling of 2-iodoanilines with unsaturated halides or triflates.[17a] Similar carbonylative coupling reactions of 2-iodoanilines with acid chlorides were reported by the Alper group[17b] and the Petricci group.[17c] Wu and Beller have developed palladium-catalyzed carbonylative cyclization reactions of 2-bromoanilines with aryl bromides,[17d] acid anhydrides,[17e] or isocyanates.[17f] Palladium-catalyzed carbonylative C–H activation of benzanilides or aryl urea derivatives for the synthesis of benzoxazinones was independently reported by the Yu group[17g] and the Lloyd-Jones and Booker-Milburn group.[17h] In addition, Pd-catalyzed carbonylative cyclization of

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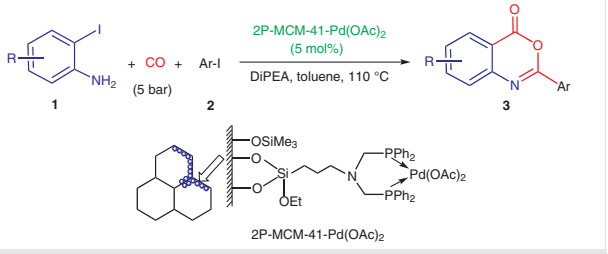
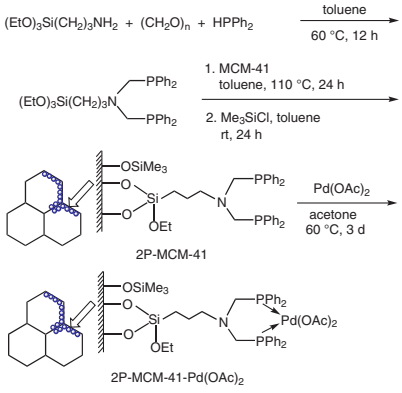
N-acyl-2-haloanilines in the presence of CO surrogates such as paraformaldehyde, phenyl formate, and oxalyl chloride has also been developed for the construction of benzoxazinones.[18]

Although these palladium-catalyzed carbonylative cyclizations are highly efficient for the synthesis of benzoxazinones,[17,18] application of these homogeneous palladium complexes in large-scale synthesis or industry remains a challenge, because expensive palladium catalysts are difficult to recover from reaction mixtures and cannot be recycled. Moreover, homogeneous palladium catalysis might lead to unacceptable palladium contamination of the desired product owing to coordination of benzoxazinone molecules to palladium and palladium leaching, thereby restricting its application to the construction of some drug molecules containing benzoxazinones, which have to be free metal residues. Catalyst recycling represents one of the most important features in green organic synthesis. In recent years, some heterogeneous palladium-catalyzed carbonylation reactions have been reported with silica-supported palladium complexes or Pd/C as catalysts.[19] To overcome these drawbacks, our ongoing interest in developing green and sustainable catalytic systems for organic transformations[20] has led us to investigate a highly efficient heterogeneous palladium-catalyzed double carbonylation procedure, which allows for a general construction of 2-arylbenzoxazinones starting from commercially easily available 2-iodoanilines and aryl iodides (Scheme 1). To the best of our knowledge, this method is the first example of a heterogeneous Pd-catalyzed carbonylative cyclization reaction for the synthesis of benzoxazinone derivatives.



Scheme 1 Heterogeneous palladium-catalyzed carbonylative coupling of 2-iodoanilines with aryl iodides

Mesoporous MCM-41 has emerged as an ideal support for immobilization of homogeneous catalysts, because of its unique properties such as extremely high surface area, homogeneity of the pores, big pore volume, and high thermal stability in comparison with other solid supports.[21] In addition, nano-sized catalysts can serve as efficient bridges and fill the gap between homogeneous and heterogeneous catalysts.[22] The bidentate phosphino-modified MCM-41-anchored palladium complex [2P-MCM-41-Pd(OAc)$_2$] was readily prepared according to our previously reported procedure, as illustrated in Scheme 2.[20h] Firstly, the triethoxysilyl-containing bidentate phosphine ligand was obtained in high yield by the reaction of $(EtO)_3Si(CH_2)_3NH_2$ with paraformaldehyde and $HPPh_2$.[23] Condensation of mesoporous MCM-41 with $(EtO)_3Si(CH_2)_3N(CH_2PPh_2)_2$ at 110 °C in toluene, followed by treatment with Me_3SiCl at room temperature gave an MCM-41-anchored bidentate phosphine ligand (2P-MCM-41). Subsequent reaction of 2P-MCM-41 with $Pd(OAc)_2$ in acetone at 60 °C for 3 days afforded the bidentate phosphino-modified MCM-41-anchored palladium complex [2P-MCM-41-Pd(OAc)$_2$] as a light yellow powder, with a palladium content of 0.37 mmol/g based on ICP-AES analysis. The TEM images of fresh 2P-MCM-41-Pd(OAc)$_2$ complex (a) and the recovered palladium catalyst (b) after recycling 8 times are shown in Figure 1. The highly ordered structures with a hexagonal ordered porous parallel channels can be clearly observed from this figure. In addition, from Figure 1b, one can easily observe the palladium nanoparticles as black dots either inside the pore of the mesoporous MCM-41 or impregnated on the external surface of the support, indicating that the oxidation state of palladium in the used catalyst is Pd(0).



Scheme 2 Preparation of the 2P-MCM-41-Pd(OAc)$_2$ complex

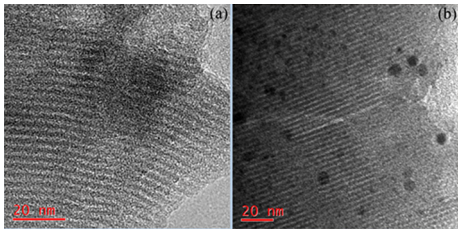
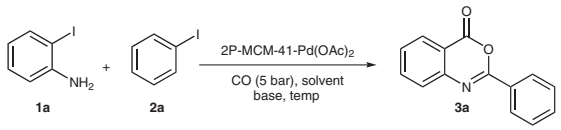


Figure 1 TEM images of fresh 2P-MCM-41-Pd(OAc)$_2$ complex (a) and the recovered palladium catalyst (b) after recycling 8 times

The 2P-MCM-41-Pd(OAc)$_2$ complex was then employed as the catalyst for the carbonylative coupling of 2-iodoanilines with aryl iodides. Initial experiments, with 2-iodoaniline (**1a**) and iodobenzene (**2a**) under carbon monoxide (5 bar), were performed to optimize the reaction conditions (solvent, base, catalyst loading, reaction temperature), and the results are listed in Table 1. At first, the solvent effect on

the model reaction was examined in the presence of 2P-MCM-41-Pd(OAc)$_2$ (5 mol%) with K_2CO_3 as base at 110 °C, and a significant solvent effect was observed (entries 1–7). When NMP and toluene were used as solvents, the desired **3a** was isolated in good yields, with toluene giving the best result (entry 5), while other solvents such as DMF, DMA, DMSO, MeCN, and dioxane were substantially less effective and considerable amounts of non-cyclized intermediate [*N*-benzoyl-2-iodoaniline] were detected as a byproduct. Our next studies focused on the effect of base on the model reaction with toluene as solvent (entries 8–11). Replacement of K_2CO_3 with organic bases such as NEt_3, DBU, DiPEA, and TMEDA provided the target product **3a** in 80–88% yield, with DiPEA found to be the most efficient (entry 10). Reducing reaction temperature to 100 °C resulted in a decreased yield and a significant amount of non-cyclized intermediate was observed (entry 12), while raising reaction temperature to 120 °C did not increase the yield of **3a** (entry 13). Lower catalyst loading (2.5 mol%) also led to a significant decrease in the yield, and a mixture of starting materials, non-cyclized intermediate, and **3a** was obtained (entry 14); however, increasing the loading of the catalyst to 10 mol% did not enhance the yield significantly (entry 15). When Pd(OAc)$_2$ (5 mol%) and PPh_3 (10 mol%) were used as the catalyst system, the desired product **3a** was isolated in only 80% yield (entry 16), indicating that the catalytic efficiency of 2P-MCM-41-Pd(OAc)$_2$ was higher than that of the homogeneous Pd(OAc)$_2$/2PPh_3 system. Thus, the optimized reaction conditions for this carbonylative coupling are the use of 2P-MCM-41-Pd(OAc)$_2$ (5 mol%), DiPEA (4 equiv) as base, in toluene as solvent, at 110 °C, and under CO (5 bar) for 24 hours (entry 10).

Table 1 Optimization of the Reaction Conditions[a]



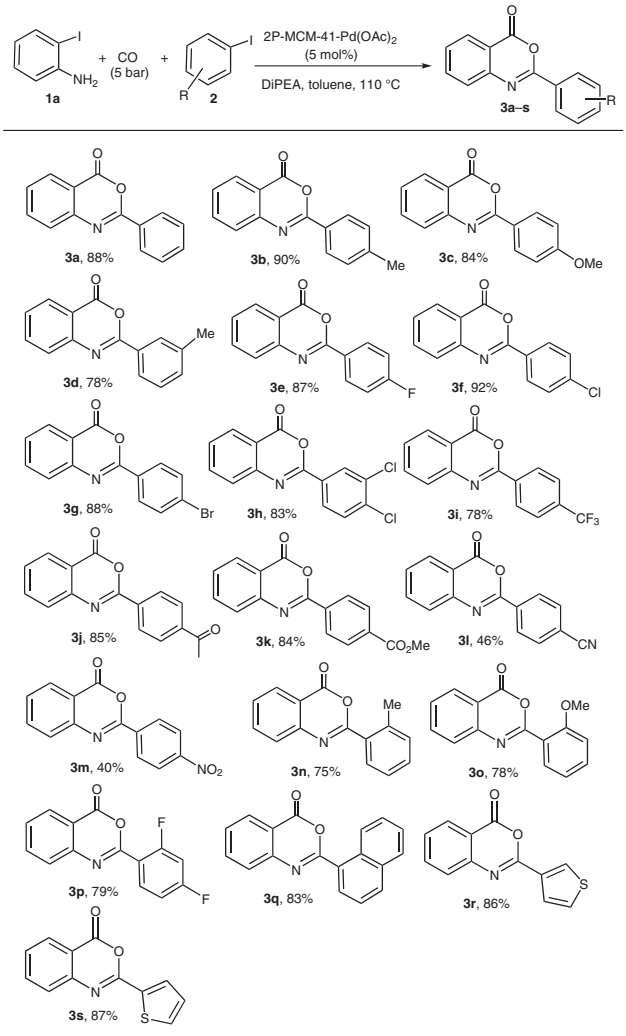
Entry	Solvent	Base	Temp (°C)	Pd loading (mol%)	Yield (%)[b]
1	NMP	K_2CO_3	110	5	70
2	DMF	K_2CO_3	110	5	61
3	DMA	K_2CO_3	110	5	52
4	DMSO	K_2CO_3	110	5	58
5	toluene	K_2CO_3	110	5	77
6	MeCN	K_2CO_3	110	5	46
7	dioxane	K_2CO_3	110	5	39
8	toluene	NEt_3	110	5	80
9	toluene	DBU	110	5	82
10	toluene	DiPEA	110	5	88
11	toluene	TMEDA	110	5	83
12	toluene	DiPEA	100	5	69
13	toluene	DiPEA	120	5	87
14	toluene	DiPEA	110	2.5	53
15	toluene	DiPEA	110	10	89
16[c]	toluene	DiPEA	110	5	80

[a] Reaction conditions: **1a** (1.2 mmol), **2a** (1.0 mmol), base (4.0 mmol), solvent (2 mL), CO (5 bar), 24 h.
[b] Isolated yield.
[c] Pd(OAc)$_2$ (5 mol%) and PPh_3 (10 mol%) were used.

With this promising result in hand, we started to examine the substrate scope of this heterogeneous palladium-catalyzed carbonylative coupling reaction under the optimal reaction conditions. Firstly, the substrate scope of aryl iodides was investigated by evaluating a variety of aryl iodides **2**; the results are summarized in Table 2. Iodobenzenes **2b–d** bearing various *para* or *meta* electron-donating substituents undergo the carbonylative cyclization with 2-iodoaniline **1a** smoothly to give the corresponding products **3b–d** in good to excellent yields. Electron-deficient aryl iodides **2e–k** showed similar reactivity with iodobenzene **2a** and afforded the desired 2-arylbenzoxazinones **3e–k** in 78–92% yield. Notably, 4-bromoiodobenzene (**2g**) underwent the carbonylative coupling selectively to give the corresponding 2-(4-bromophenyl)-4*H*-benzo[*d*][1,3]oxazin-4-one (**3g**) in 88% yield. However, aryl iodides bearing a strong electron-withdrawing group such as 4-cyanoiodobenzene (**2l**) and 4-nitroiodobenzene (**2m**) afforded the corresponding 2-arylbenzoxazinones **3l** and **3m** in lower yields, due to the formation of byproducts. Sterically hindered *ortho*-substituted iodobenzenes **2n–p** were also compatible with the standard conditions and produced the desired products **3n–p** in good yields. Additionally, bulky 1-iodonaphthalene (**2q**) proved to be also a good substrate and provided the target product **3q** in 83% yield. In addition to substituted iodobenzenes, heteroaryl iodides such as 3-iodothiophene (**2r**) and 2-iodothiophene (**2s**) reacted well in this transformation and furnished the expected 2-heteroarylbenzoxazinones **3r** and **3s** in high yields. A wide range of electron-donating or electron-withdrawing functional groups such as methyl, methoxy, fluoro, chloro, bromo, ketone, ester, cyano, and trifluoromethyl, as well as bulky 1-naphthyl or heteroaryl groups were tolerated well.

Encouraged by the above results, we then examined the substrate scope of 2-iodoanilines **1** under the optimized reaction conditions; the results are listed in Table 3. To our delight, we found this transformation to be quite general for a wide range of substituted 2-iodoanilines. For example, 2-iodo-4-methylaniline (**1b**) underwent the carbonylative coupling reaction smoothly with a variety of electron-neutral, electron-rich, or electron-poor aryl iodides to afford the corresponding 2-arylbenzoxazinones **3t–w** in 82–87% yield. The reactions of 2-iodo-4-methylaniline (**1b**) with bulky 1-iodonaphthalene (**2q**) or 3-iodothiophene (**2r**) also worked well, thus providing the desired products **3x** and **3y**

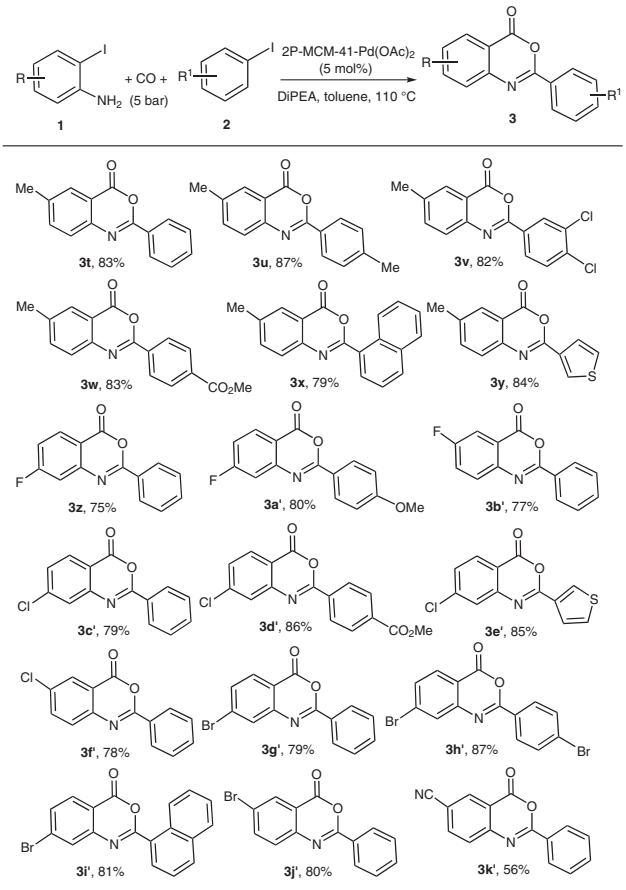
Table 2 Heterogeneous Palladium-Catalyzed Carbonylative Coupling of 2-Iodoaniline with Various Aryl Iodides[a]



[a] Reaction conditions: **1a** (1.2 mmol), **2** (1.0 mmol), DiPEA (4.0 mmol), 2P-MCM-41-Pd(OAc)$_2$ (5 mol%), CO (5 bar), toluene (2 mL), 110 °C, 24 h; isolated yields are given.

in 79 and 84% yield, respectively. Furthermore, 5- or 4-fluoro or chloro-substituted 2-iodoanilines **1c–f** displayed good reactivity and gave 7- or 6-fluoro or chloro-substituted 2-arylbenzoxazinones **3z–f′** in 75–86% yield. It is noteworthy that 5- or 4-bromo-2-iodoanilines **1g** and **1h** underwent this transformation chemoselectively with various aryl iodides, providing the corresponding 7- or 6-bromo-substituted 2-arylbenzoxazinones **3g′-j′** in high yields. However, 4-cyano-2-iodoaniline (**1i**) with a strong electron-withdrawing substituent led to the target product **3k′** in only 56% yield due to the low reactivity difference between 4-cyano-2-iodoaniline (**1i**) and iodobenzene (**2a**), which reduces the chemoselectivity of the initial oxidative addition of aryl iodide to Pd(0). In addition, we also performed carbonylative coupling reaction of 2-bromoanilines with aryl bromides, but, unfortunately, no desired products were detected even at higher reaction temperatures and under higher pressures of CO. This is because the oxidative addition reaction of an aryl bromide to the heterogeneous phosphine–palladium(0) complex is too slow under the optimized conditions, and, thus, 2-arylbenzoxazinones **3g** and **3g′–j′** were obtained in high yields through the chemoselective carbonylative couplings of 4-bromoiodobenzene (**2g**) with 2-iodoaniline (**1a**) and 5- or 4-bromo-substituted 2-iodoanilines **1g** or **1h** with aryl iodides, respectively. The present method is applicable to a wide range of aryl iodides and various 2-iodoanilines and provides a novel, highly efficient, and practical procedure for the construction of 2-arylbenzoxazinones from easily available starting materials.

Table 3 Heterogeneous Palladium-Catalyzed Carbonylative Coupling of Various Substituted 2-Iodoanilines with Aryl Iodides[a]



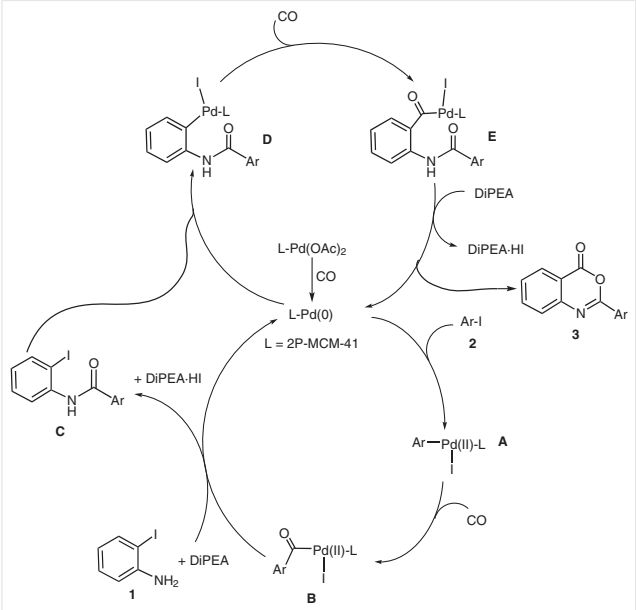
[a] Reaction conditions: **1** (1.2 mmol), **2** (1.0 mmol), DiPEA (4.0 mmol), 2P-MCM-41-Pd(OAc)$_2$ (5 mol%), toluene (2 mL) at 110 °C under 5 bar of CO for 24 h; isolated yields are given.

To confirm that the observed catalysis results from the palladium sites on the channel inner walls of the MCM-41 support and not from soluble Pd species leached from 2P-

MCM-41-Pd(OAc)$_2$, the heterogeneity of the 2P-MCM-41-Pd(OAc)$_2$ complex was investigated by the hot filtration test.[24] We focused on the carbonylative coupling reaction of 2-iodoaniline (**1a**) and iodobenzene (**2a**). After the reaction was carried out for 10 hours, we removed the catalyst from the reaction mixture by filtration at 110 °C and the catalyst-free solution was allowed to react further under identical conditions for 14 hours. It was found that no increase in conversion of iodobenzene **2a** was observed in the solution, indicating that the observed reaction should be attributed only to heterogeneous Pd species. In addition, no palladium species could be detected in the clear solution based on ICP-AES analysis. These results confirm the fact that the 2P-MCM-41-Pd(OAc)$_2$ catalyst is stable under the optimized reaction conditions and supports the heterogeneous nature of the reaction.

A plausible mechanism for this heterogeneous palladium-catalyzed carbonylative synthesis of 2-arylbenzoxazinone is shown in Scheme 3. Firstly, the 2P-MCM-41-Pd(OAc)$_2$ complex can be easily reduced to 2P-MCM-41-Pd(0) in the presence of carbon monoxide. Oxidative addition of aryl iodide **2** to 2P-MCM-41-Pd(0) produces an MCM-41-bound arylpalladium(II) complex intermediate **A**, which is followed by migratory insertion of carbon monoxide, giving an MCM-41-bound acylpalladium(II) complex intermediate **B**. Then intermediate **B** reacts immediately with the amino group of 2-iodoaniline **1** in the presence of DiPEA to give *N*-(2-iodophenyl)arylcarboxamide **C** and regenerate 2P-MCM-41-Pd(0). After this initial amidation of aryl iodide **2**, another oxidative addition of intermediate **C** to 2P-MCM-41-Pd(0) takes place to form intermediate **D**, which then undergoes CO insertion to furnish intermediate **E**. Subsequent intramolecular cyclization of intermediate **E** in the presence of DiPEA affords the desired 2-arylbenzoxazinone **3** and regenerates 2P-MCM-41-Pd(0) again to complete the catalytic cycle. It is noteworthy that the initial oxidative addition to 2P-MCM-41-Pd(0) is highly chemoselective for aryl iodide **2** because of the reactivity difference to the electron-rich 2-iodoaniline **1**.

For the practical application of the heterogeneous 2P-MCM-41-Pd(OAc)$_2$ catalyst, its ease of separation and recyclability are important factors to be examined. This immobilized palladium catalyst can be readily separated and recovered via a simple filtration process. We next studied the recycling of 2P-MCM-41-Pd(OAc)$_2$ in the carbonylative cyclization reaction of 4-chloroiodobenzene (**2f**) with 2-iodoaniline (**1a**). Upon completion of the reaction, the reaction mixture was diluted with ethyl acetate, and the catalyst was separated by simple filtration and washed with distilled water and acetone. After being dried under vacuum at 80 °C for 2 hours, the recovered palladium catalyst was directly employed in the next cycle using the same substrates under identical conditions. As presented in Figure 2, the 2P-MCM-41-Pd(OAc)$_2$ complex can be recycled at least eight times



Scheme 3 Proposed catalytic cycle

without any significant loss of activity. Additionally, the palladium leaching in this supported catalyst was also checked, and the Pd content of the recovered 2P-MCM-41-Pd(OAc)$_2$ catalyst after eight consecutive cycles was determined to be 0.36 mmol/g based on ICP-AES analysis, indicating negligible palladium leaching.

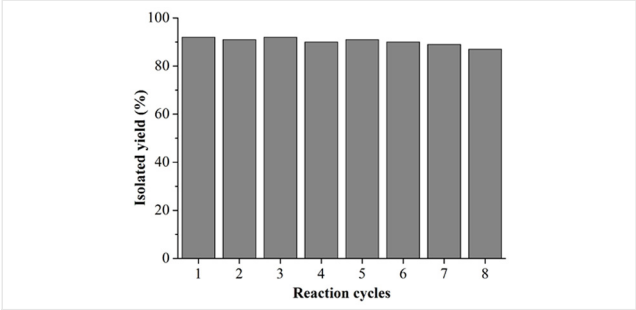


Figure 2 Recycling of the 2P-MCM-41-Pd(OAc)$_2$ complex

In conclusion, we have developed a novel and practical domino synthesis of 2-arylbenzoxazinones from commercially available 2-iodoanilines and aryl iodides through a heterogeneous palladium-catalyzed double carbonylation procedure. In contrast to traditional methods for the synthesis of 2-arylbenzoxazinones, this heterogeneous double carbonylation strategy has many attractive features, including: (a) the scope of both aryl iodide and 2-iodoaniline substrates is broad, and a wide range of aryl iodides and various 2-iodoanilines can be used; (b) the reaction provides a wide variety of 2-arylbenzoxazinones in mostly good to excellent yields; (c) the reaction is highly atom-economic and is tolerant of a wide range of functional groups; and (d) this

immobilized palladium catalyst can be obtained via a simple preparative procedure from commercially available reagents, recovered by filtration of the reaction mixture, and reused at least seven times without any apparent loss of catalytic efficiency.

All starting chemicals were purchased from different commercial sources and used without further purification. Toluene was distilled from sodium ketyl and stored under argon. $(EtO)_3Si(CH_2)_3N(CH_2PPh_2)_2$ was prepared by the reaction of paraformaldehyde and $HPPh_2$ with $(EtO)_3Si(CH_2)_3NH_2$ according to a literature procedure.[23] Mesoporous MCM-41 material was prepared by our previous method.[20] Products were isolated by column chromatography on silica gel (100–200 mesh) with a mixture of EtOAc and light petroleum ether as eluent. The products were confirmed by the comparison of their spectra and physical data with authentic samples. ^1H and ^{13}C NMR spectra were recorded at 400 or 100 MHz with $CDCl_3$ as the solvent and TMS as an internal standard. Chemical shifts are reported in δ (ppm) relative to TMS. HRMS spectra were recorded using a Q-Tof spectrometer with micromass MS software using electrospray ionization (ESI). Melting points are uncorrected. The content of palladium was measured based on ICP-AES analysis.

2P-MCM-41-Pd(OAc)$_2$ Complex[20h]

A mixture of $(EtO)_3Si(CH_2)_3N(CH_2PPh_2)_2$ (0.927 g, 1.5 mmol) and MCM-41 (2.0 g) in anhyd toluene (120 mL) was stirred at 110 °C for 24 h under argon. The solid product was filtered, washed with $CHCl_3$ (20 mL), and dried under vacuum at 130 °C for 8 h. The resulting white powdery solid was then treated with Me_3SiCl (3.0 g) in anhyd toluene (100 mL) at room temperature under stirring for 12 h. The product was filtered, washed with acetone (2 × 30 mL), and dried under vacuum at 110 °C for 4 h to provide bidentate phosphino-modified material 2P-MCM-41 (2.518 g) with a phosphorus content of 0.81 mmol g^{-1}.

A mixture of 2P-MCM-41 (1.00 g) and $Pd(OAc)_2$ (86 mg, 0.38 mmol) in anhyd acetone (30 mL) was stirred under reflux for 3 d under argon. The resulting product was filtered, washed with distilled water and acetone, and dried at 70 °C under vacuum for 8 h to afford 2P-MCM-41-Pd(OAc)$_2$ (1.032 g) as a light yellow powder. The content of palladium was determined to be 0.37 mmol/g based on ICP analysis.

Heterogeneous Palladium-Catalyzed Carbonylative Synthesis of 2-Arylbenzoxazinones 3; General Procedure

To a 12 mL vial equipped with a magnetic stirring bar were added 2P-MCM-41-Pd(OAc)$_2$ (5 mol%), 2-iodoaniline **1** (1.2 mmol) and aryl iodide **2** (1.0 mmol) (if solid). The vial was purged with argon and then aryl iodide **2** (1.0 mmol) (if liquid), DiPEA (4.0 mmol), and toluene (2 mL) were injected by syringe. The vial was placed in an alloy plate and the plate was then transferred into a 300 mL autoclave under argon. After the autoclave had been flushed with CO (3×), the CO pressure was adjusted to 5 bar and the reaction was carried out for 24 h at 110 °C. Upon completion of the reaction, the autoclave was cooled to ambient temperature and the pressure was released cautiously. EtOAc (10 mL) was then added and the resulting mixture was filtered. The Pd catalyst was recovered, by washing with distilled water (2 × 5 mL) and acetone (2 × 5 mL), followed by drying under vacuum at 80 °C for 2 h, and reused in the next cycle. The filtrate was washed with water (2 × 10 mL) and dried over anhydrous $MgSO_4$ and concentrated under reduced pressure. The residue was purified by column chromatography (silica gel, light PE–EtOAc, 10:1) to afford the desired product **3**.

2-Phenyl-4*H*-benzo[*d*][1,3]oxazin-4-one (3a)[25]

Yield: 196.4 mg (88%); white solid; mp 124–126 °C.

^1H NMR (400 MHz, $CDCl_3$): δ = 8.31–8.28 (m, 2 H), 8.23 (dd, *J* = 7.8, 1.0 Hz, 1 H), 7.84–7.79 (m, 1 H), 7.70–7.66 (m, 1 H), 7.58–7.48 (m, 4 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 159.5, 157.1, 147.0, 136.5, 132.6, 130.3, 128.7, 128.6, 128.3, 128.2, 127.2, 117.1.

2-(*p*-Tolyl)-4*H*-benzo[*d*][1,3]oxazin-4-one (3b)[25]

Yield: 213.5 mg (90%); white solid; mp 137–139 °C.

^1H NMR (400 MHz, $CDCl_3$): δ = 8.23 (dd, *J* = 7.8, 1.0 Hz, 1 H), 8.20 (d, *J* = 8.4 Hz, 2 H), 7.84–7.79 (m, 1 H), 7.68 (d, *J* = 8.0 Hz, 1 H), 7.52–7.47 (m, 1 H), 7.32 (d, *J* = 8.0 Hz, 2 H), 2.44 (s, 3 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 159.7, 157.4, 147.2, 143.4, 136.5, 129.5, 128.6, 128.3, 128.0, 127.5, 127.1, 117.0, 21.7.

2-(4-Methoxyphenyl)-4*H*-benzo[*d*][1,3]oxazin-4-one (3c)[17d]

Yield: 212.7 mg (84%); white solid; mp 151–152 °C.

^1H NMR (400 MHz, $CDCl_3$): δ = 8.25–8.22 (m, 2 H), 8.19 (dd, *J* = 8.0, 1.2 Hz, 1 H), 7.78–7.75 (m, 1 H), 7.62 (d, *J* = 8.0 Hz, 1 H), 7.48–7.43 (m, 1 H), 6.98 (d, *J* = 8.8 Hz, 2 H), 3.88 (s, 3 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 163.3, 159.7, 157.1, 147.4, 136.4, 130.3, 128.5, 127.7, 126.9, 122.6, 116.7, 114.1, 55.5.

2-(*m*-Tolyl)-4*H*-benzo[*d*][1,3]oxazin-4-one (3d)[17d]

Yield: 185.1 mg (78%); white solid; mp 118–120 °C.

^1H NMR (400 MHz, $CDCl_3$): δ = 8.22 (d, *J* = 8.0 Hz, 1 H), 8.12–8.07 (m, 2 H), 7.83–7.78 (m, 1 H), 7.67 (d, *J* = 8.0 Hz, 1 H), 7.49 (t, *J* = 7.4 Hz, 1 H), 7.41–7.35 (m, 2 H), 2.44 (s, 3 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 159.6, 157.3, 147.1, 138.6, 136.5, 133.5, 130.2, 128.8, 128.6, 128.5, 128.1, 127.2, 125.6, 117.0, 21.3.

2-(4-Fluorophenyl)-4*H*-benzo[*d*][1,3]oxazin-4-one (3e)[25]

Yield: 209.8 mg (87%); white solid; mp 177–178 °C.

^1H NMR (400 MHz, $CDCl_3$): δ = 8.36–8.30 (m, 2 H), 8.24 (dd, *J* = 8.0, 1.2 Hz, 1 H), 7.83 (t, *J* = 7.4 Hz, 1 H), 7.67 (d, *J* = 8.4 Hz, 1 H), 7.52 (t, *J* = 7.4 Hz, 1 H), 7.19 (t, *J* = 8.6 Hz, 2 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 165.6 (d, *J* = 252.8 Hz), 159.4, 156.3, 146.9, 136.6, 130.7 (d, *J* = 9.0 Hz), 128.7, 128.3, 127.2, 126.5 (d, *J* = 2.8 Hz), 116.9, 116.0 (d, *J* = 22.0 Hz).

2-(4-Chlorophenyl)-4*H*-benzo[*d*][1,3]oxazin-4-one (3f)[25]

Yield: 237.1 mg (92%); white solid; mp 190 °C.

^1H NMR (400 MHz, $CDCl_3$): δ = 8.24–8.20 (m, 3 H), 7.83–7.79 (m, 1 H), 7.66 (d, *J* = 8.0 Hz, 1 H), 7.54–7.45 (m, 3 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 159.2, 156.2, 146.8, 139.1, 136.6, 129.6, 129.1, 128.7, 128.6, 128.4, 127.2, 117.0.

2-(4-Bromophenyl)-4*H*-benzo[*d*][1,3]oxazin-4-one (3g)[25]

Yield: 265.8 mg (88%); white solid; mp 119–120 °C.

^1H NMR (400 MHz, $CDCl_3$): δ = 8.24 (d, *J* = 7.6 Hz, 1 H), 8.17 (d, *J* = 8.4 Hz, 2 H), 7.84–7.81 (m, 1 H), 7.70–7.63 (m, 3 H), 7.53 (t, *J* = 7.4 Hz, 1 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 159.2, 156.4, 146.8, 136.7, 132.1, 129.7, 129.2, 128.7, 128.5, 127.7, 127.3, 117.0.

2-(3,4-Dichlorophenyl)-4*H*-benzo[*d*][1,3]oxazin-4-one (3h)[26]

Yield: 242.4 mg (83%); white solid; mp 171–172 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.40 (d, *J* = 2.0 Hz, 1 H), 8.24 (d, *J* = 7.6 Hz, 1 H), 8.13 (dd, *J* = 8.4, 2.0 Hz, 1 H), 7.88–7.83 (m, 1 H), 7.69 (d, *J* = 8.0 Hz, 1 H), 7.60–7.53 (m, 2 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 159.0, 155.1, 146.5, 137.2, 136.8, 133.4, 130.9, 130.2, 130.1, 128.8, 128.7, 127.4, 127.2, 117.0.

2-[4-(Trifluoromethyl)phenyl]-4*H*-benzo[*d*][1,3]-oxazin-4-one (3i)[17d]

Yield: 227.1 mg (78%); white solid; mp 80–82 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.38 (d, *J* = 8.4 Hz, 2 H), 8.21 (d, *J* = 8.0 Hz, 1 H), 7.85–7.80 (m, 1 H), 7.73 (d, *J* = 8.4 Hz, 2 H), 7.67 (d, *J* = 8.0 Hz, 1 H), 7.53 (t, *J* = 7.6 Hz, 1 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 158.9, 155.6, 146.4, 136.7, 133.9 (q, *J* = 32.6 Hz), 133.5, 128.9, 128.7, 128.6, 127.4, 125.7 (q, *J* = 3.7 Hz), 123.7 (q, *J* = 271.0 Hz), 117.1.

2-(4-Acetylphenyl)-4*H*-benzo[*d*][1,3]oxazin-4-one (3j)

Yield: 225.5 mg (85%); white solid; mp 181–183 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.41–8.38 (m, 2 H), 8.25 (d, *J* = 8.0 Hz, 1 H), 8.07 (d, *J* = 8.4 Hz, 2 H), 7.88–7.83 (m, 1 H), 7.72 (d, *J* = 8.0 Hz, 1 H), 7.58–7.54 (m, 1 H), 2.67 (s, 3 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 197.4, 159.1, 156.1, 146.6, 139.9, 136.7, 134.2, 128.8, 128.7, 128.6, 128.5, 127.5, 117.1, 26.8.

HRMS (ESI): *m*/*z* $[M]^+$ calcd for $C_{16}H_{11}NO_3$: 265.0739; found: 265.0737.

Methyl 4-(4-Oxo-4*H*-benzo[*d*][1,3]oxazin-2-yl)benzoate (3k)

Yield: 236.3 mg (84%); white solid; mp 166–167 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.38 (d, *J* = 8.4 Hz, 2 H), 8.26 (dd, *J* = 7.8, 1.0 Hz, 1 H), 8.17 (d, *J* = 8.4 Hz, 2 H), 7.87–7.83 (m, 1 H), 7.72 (d, *J* = 8.0 Hz, 1 H), 7.59–7.54 (m, 1 H), 3.97 (s, 3 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 166.3, 159.2, 156.2, 146.7, 136.7, 134.2, 133.6, 129.9, 128.8, 128.7, 128.3, 127.5, 117.2, 52.4.

HRMS (ESI): *m*/*z* $[M]^+$ calcd for $C_{16}H_{11}NO_4$: 281.0688; found: 281.0693.

4-(4-Oxo-4*H*-benzo[*d*][1,3]oxazin-2-yl)benzonitrile (3l)

Yield: 114.2 mg (46%); white solid; mp 227–228 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.43 (d, *J* = 8.4 Hz, 2 H), 8.27 (d, *J* = 8.0 Hz, 1 H), 7.88 (t, *J* = 7.6 Hz, 1 H), 7.82 (d, *J* = 8.4 Hz, 2 H), 7.74 (d, *J* = 8.0 Hz, 1 H), 7.59 (t, *J* = 7.4 Hz, 1 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 158.8, 155.3, 146.4, 136.9, 134.3, 132.5, 129.2, 128.8, 128.7, 127.6, 117.9, 117.2, 115.7.

HRMS (ESI): *m*/*z* $[M]^+$ calcd for $C_{15}H_8N_2O_2$: 248.0586; found: 248.0579.

2-(4-Nitrophenyl)-4*H*-benzo[*d*][1,3]oxazin-4-one (3m)[14c]

Yield: 107.3 mg (40%); yellow solid; mp 204–205 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.52–8.49 (m, 2 H), 8.37 (d, *J* = 8.8 Hz, 2 H), 8.28 (dd, *J* = 7.8, 1.0 Hz, 1 H), 7.92–7.87 (m, 1 H), 7.76 (d, *J* = 8.0 Hz, 1 H), 7.63–7.58 (m, 1 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 158.7, 155.0, 146.3, 138.9, 136.9, 135.9, 129.3, 129.2, 128.9, 127.7, 123.9, 117.2.

2-(*o*-Tolyl)-4*H*-benzo[*d*][1,3]oxazin-4-one (3n)[17d]

Yield: 177.9 mg (75%); white solid; mp 119–120 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.25 (d, *J* = 8.0 Hz, 1 H), 8.03 (d, *J* = 7.6 Hz, 1 H), 7.85–7.80 (m, 1 H), 7.68 (d, *J* = 8.0 Hz, 1 H), 7.53 (t, *J* = 7.6 Hz, 1 H), 7.44–7.40 (m, 1 H), 7.35–7.30 (m, 2 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 159.7, 158.3, 146.9, 139.2, 136.5, 131.9, 131.6, 130.2, 129.9, 128.5, 128.4, 127.3, 126.1, 116.8, 22.1.

2-(2-Methoxyphenyl)-4*H*-benzo[*d*][1,3]oxazin-4-one (3o)[25]

Yield: 197.6 mg (78%); white solid; mp 150–152 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.25 (dd, *J* = 8.0, 1.2 Hz, 1 H), 7.88–7.80 (m, 2 H), 7.70 (d, *J* = 8.0 Hz, 1 H), 7.55–7.48 (m, 2 H), 7.09–7.02 (m, 2 H), 3.93 (s, 3 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 159.8, 158.7, 157.8, 147.1, 136.4, 133.2, 131.3, 128.4, 128.3, 127.3, 120.6, 117.0, 112.2, 56.1.

2-(2,4-Difluorophenyl)-4*H*-benzo[*d*][1,3]oxazin-4-one (3p)

Yield: 204.8 mg (79%); brown solid; mp 135–137 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.25 (dd, *J* = 8.0, 1.2 Hz, 1 H), 8.20–8.15 (m, 1 H), 7.87–7.82 (m, 1 H), 7.70 (d, *J* = 8.0 Hz, 1 H), 7.56 (t, *J* = 7.6 Hz, 1 H), 7.06–6.94 (m, 2 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 165.5 (d, *J* = 254.9 Hz), 165.3 (d, *J* = 255.2 Hz), 159.0, 154.1 (d, *J* = 6.4 Hz), 146.6, 136.7, 132.7 (dd, *J* = 10.3, 2.0 Hz), 128.8, 128.6, 127.4, 117.0, 112.0 (dd, *J* = 21.6, 3.7 Hz), 105.7, 105.6 (t, *J* = 25.4 Hz).

HRMS (ESI): *m*/*z* $[M]^+$ calcd for $C_{14}H_7F_2NO_2$: 259.0445; found: 259.0448.

2-(1-Naphthyl)-4*H*-benzo[*d*][1,3]oxazin-4-one (3q)[27]

Yield: 226.8 mg (83%); white solid; mp 138 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 9.14 (d, *J* = 8.8 Hz, 1 H), 8.30 (dd, *J* = 7.4, 1.0 Hz, 1 H), 8.27 (dd, *J* = 8.0, 1.2 Hz, 1 H), 8.02 (d, *J* = 8.0 Hz, 1 H), 7.90 (d, *J* = 8.0 Hz, 1 H), 7.84–7.81 (m, 1 H), 7.77 (d, *J* = 8.0 Hz, 1 H), 7.67–7.62 (m, 1 H), 7.59–7.51 (m, 3 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 159.7, 157.7, 146.8, 136.6, 134.1, 133.2, 130.8, 130.1, 128.9, 128.6, 128.5, 127.9, 127.4, 127.0, 126.4, 125.8, 124.8, 117.0.

2-(3-Thienyl)-4*H*-benzo[*d*][1,3]oxazin-4-one (3r)

Yield: 197.2 mg (86%); white solid; mp 102–104 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.28 (d, *J* = 2.4 Hz, 1 H), 8.21 (d, *J* = 7.6 Hz, 1 H), 7.83–7.77 (m, 2 H), 7.63 (d, *J* = 8.0 Hz, 1 H), 7.49 (t, *J* = 7.6 Hz, 1 H), 7.40 (dd, *J* = 5.0, 3.8 Hz, 1 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 159.5, 153.9, 147.1, 136.6, 133.4, 130.7, 128.6, 128.1, 127.0, 126.8, 116.9.

HRMS (ESI): *m*/*z* $[M]^+$ calcd for $C_{12}H_7NO_2S$: 229.0197; found: 229.0196.

2-(2-Thienyl)-4*H*-benzo[*d*][1,3]oxazin-4-one (3s)[27]

Yield: 199.5 mg (87%); white solid; mp 133–135 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.22 (dd, *J* = 7.8, 1.0 Hz, 1 H), 7.97 (dd, *J* = 3.8, 1.0 Hz, 1 H), 7.81 (t, *J* = 7.4 Hz, 1 H), 7.65–7.60 (m, 2 H), 7.49 (t, *J* = 7.4 Hz, 1 H), 7.18 (dd, *J* = 5.0, 3.8 Hz, 1 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 159.1, 153.8, 147.1, 136.6, 134.3, 132.4, 131.8, 128.8, 128.3, 128.0, 126.9, 116.8.

6-Methyl-2-phenyl-4*H*-benzo[*d*][1,3]oxazin-4-one (3t)[28]

Yield: 196.9 mg (83%); white solid; mp 114–115 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.29 (d, *J* = 7.6 Hz, 2 H), 8.03 (s, 1 H), 7.64–7.48 (m, 5 H), 2.48 (s, 3 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 159.8, 156.4, 144.9, 138.7, 137.8, 132.4, 130.4, 128.7, 128.2, 127.0, 116.7, 21.3.

6-Methyl-2-(*p*-tolyl)-4*H*-benzo[*d*][1,3]oxazin-4-one (3u)

Yield: 218.6 mg (87%); white solid; mp 165–167 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.15 (d, *J* = 7.2 Hz, 2 H), 7.99 (s, 1 H), 7.59 (d, *J* = 8.4 Hz, 1 H), 7.53 (d, *J* = 8.4 Hz, 1 H), 7.28 (d, *J* = 8.0 Hz, 2 H), 2.46 (s, 3 H), 2.41 (s, 3 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 159.8, 156.6, 145.0, 143.1, 138.4, 137.7, 129.5, 128.2, 128.1, 127.6, 126.9, 116.6, 21.7, 21.3.

HRMS (ESI): *m*/*z* $[M]^+$ calcd for $C_{16}H_{13}NO_2$: 251.0946; found: 251.0938.

2-(3,4-Dichlorophenyl)-6-methyl-4*H*-benzo[*d*][1,3]oxazin-4-one (3v)

Yield: 251.1 mg (82%); white solid; mp 161–163 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.37 (d, *J* = 2.0 Hz, 1 H), 8.10 (dd, *J* = 8.4, 2.0 Hz, 1 H), 8.02 (s, 1 H), 7.65 (dd, *J* = 8.4, 1.2 Hz, 1 H), 7.59–7.55 (m, 2 H), 2.50 (s, 3 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 159.2, 154.4, 144.3, 139.4, 138.0, 136.9, 133.4, 130.8, 130.3, 129.9, 128.4, 127.2, 127.1, 116.7, 21.4.

HRMS (ESI): *m*/*z* $[M + H]^+$ calcd for $C_{15}H_{10}Cl_2NO_2$: 306.0089; found: 306.0096.

Methyl 4-(6-Methyl-4-oxo-4*H*-benzo[*d*][1,3]oxazin-2-yl)benzoate (3w)

Yield: 245.1 mg (83%); yellow solid; mp 175–176 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.35 (d, *J* = 8.8 Hz, 2 H), 8.15 (d, *J* = 8.4 Hz, 2 H), 8.04 (s, 1 H), 7.65 (dd, *J* = 8.0, 1.6 Hz, 1 H), 7.60 (d, *J* = 8.0 Hz, 1 H), 3.96 (s, 3 H), 2.50 (s, 3 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 166.3, 159.4, 155.4, 144.5, 139.4, 137.9, 134.3, 133.3, 129.8, 128.3, 128.1, 127.3, 116.8, 52.4, 21.4.

HRMS (ESI): *m*/*z* $[M]^+$ calcd for $C_{17}H_{13}NO_4$: 295.0845; found: 295.0847.

6-Methyl-2-(1-naphthyl)-4*H*-benzo[*d*][1,3]oxazin-4-one (3x)

Yield: 226.9 mg (79%); yellow solid; mp 112–114 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 9.14 (d, *J* = 8.8 Hz, 1 H), 8.29 (d, *J* = 6.8 Hz, 1 H), 8.07 (s, 1 H), 8.02 (d, *J* = 8.0 Hz, 1 H), 7.91 (d, *J* = 8.0 Hz, 1 H), 7.67–7.57 (m, 3 H), 7.56–7.51 (m, 2 H), 2.50 (s, 3 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 159.9, 156.9, 144.7, 139.1, 137.8, 134.1, 133.0, 130.8, 129.9, 128.8, 128.1, 127.8, 127.2, 127.1, 126.4, 125.9, 124.8, 116.7, 21.4.

HRMS (ESI): *m*/*z* $[M + H]^+$ calcd for $C_{19}H_{14}NO_2$: 288.1025; found: 288.1014.

6-Methyl-2-(3-thienyl)-4*H*-benzo[*d*][1,3]oxazin-4-one (3y)

Yield: 204.4 mg (84%); white solid; mp 132–134 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.25–8.22 (m, 1 H), 7.99 (s, 1 H), 7.76 (d, *J* = 4.8 Hz, 1 H), 7.59 (dd, *J* = 8.2, 1.4 Hz, 1 H), 7.52 (d, *J* = 8.4 Hz, 1 H), 7.39 (dd, *J* = 5.0, 3.0 Hz, 1 H), 2.46 (s, 3 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 159.6, 153.3, 144.9, 138.5, 137.8, 133.5, 130.2, 128.2, 127.0, 126.8, 126.7, 116.6, 21.3.

HRMS (ESI): *m*/*z* $[M]^+$ calcd for $C_{13}H_9NO_2S$: 243.0354; found: 243.0363.

7-Fluoro-2-phenyl-4*H*-benzo[*d*][1,3]oxazin-4-one (3z)

Yield: 180.9 mg (75%); white solid; mp 132–134 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.31–8.26 (m, 2 H), 8.24 (dd, *J* = 8.8, 6.0 Hz, 1 H), 7.58 (t, *J* = 7.4 Hz, 1 H), 7.50 (t, *J* = 7.4 Hz, 2 H), 7.33 (dd, *J* = 9.2, 2.4 Hz, 1 H), 7.23–7.18 (m, 1 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 167.8 (d, *J* = 256.4 Hz), 158.6, 158.4, 149.5 (d, *J* = 13.3 Hz), 133.0, 131.3 (d, *J* = 10.8 Hz), 129.9, 128.8, 128.5, 116.6 (d, *J* = 23.2 Hz), 113.6, 113.3 (d, *J* = 22.4 Hz).

HRMS (ESI): *m*/*z* $[M]^+$ calcd for $C_{14}H_8FNO_2$: 241.0539; found: 241.0533.

7-Fluoro-2-(4-methoxyphenyl)-4*H*-benzo[*d*][1,3]oxazin-4-one (3a′)

Yield: 216.9 mg (80%); white solid; mp 174–175 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.27–8.20 (m, 3 H), 7.30 (dd, *J* = 9.2, 2.4 Hz, 1 H), 7.24–7.17 (m, 1 H), 7.01 (d, *J* = 8.8 Hz, 2 H), 3.90 (s, 3 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 167.8 (d, *J* = 255.4 Hz), 163.6, 158.8, 158.4, 149.9, 131.3 (d, *J* = 11.1 Hz), 130.5, 122.1, 116.1 (d, *J* = 23.6 Hz), 114.2, 113.3, 112.9 (d, *J* = 22.4 Hz), 55.5.

HRMS (ESI): *m*/*z* $[M + H]^+$ calcd for $C_{15}H_{11}FNO_3$: 272.0723; found: 272.0726.

6-Fluoro-2-phenyl-4*H*-benzo[*d*][1,3]oxazin-4-one (3b′)

Yield: 185.7 mg (77%); white solid; mp 137–139 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.20 (d, *J* = 7.6 Hz, 2 H), 7.79 (dd, *J* = 8.0, 2.8 Hz, 1 H), 7.62 (dd, *J* = 8.8, 4.8 Hz, 1 H), 7.51–7.39 (m, 4 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 161.4 (d, *J* = 249.2 Hz), 158.8, 156.5, 143.6, 132.7, 130.0, 129.6 (d, *J* = 8.1 Hz), 128.8, 128.2, 124.7 (d, *J* = 23.5 Hz), 118.3 (d, *J* = 8.6 Hz), 113.9 (d, *J* = 24.1 Hz).

HRMS (ESI): *m*/*z* $[M + H]^+$ calcd for $C_{14}H_9FNO_2$: 242.0617; found: 242.0612.

7-Chloro-2-phenyl-4*H*-benzo[*d*][1,3]oxazin-4-one (3c′)

Yield: 203.6 mg (79%); white solid; mp 190–192 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.28 (d, *J* = 7.6 Hz, 2 H), 8.15 (d, *J* = 8.4 Hz, 1 H), 7.68 (d, *J* = 1.6 Hz, 1 H), 7.59 (t, *J* = 7.4 Hz, 1 H), 7.51 (t, *J* = 7.6 Hz, 2 H), 7.46 (dd, *J* = 8.4, 2.0 Hz, 1 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 158.8, 158.3, 148.1, 143.0, 133.0, 129.9, 129.8, 128.8, 128.7, 128.5, 127.0, 115.4.

HRMS (ESI): *m*/*z* $[M]^+$ calcd for $C_{14}H_8ClNO_2$: 257.0244; found: 257.0251.

Methyl 4-(7-Chloro-4-oxo-4*H*-benzo[*d*][1,3]oxazin-2-yl)benzoate (3d′)

Yield: 271.5 mg (86%); white solid; mp 173–174 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.36 (d, *J* = 8.8 Hz, 2 H), 8.19–8.16 (m, 3 H), 7.72 (d, *J* = 1.6 Hz, 1 H), 7.51 (dd, *J* = 8.4, 2.0 Hz, 1 H), 3.97 (s, 3 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 166.2, 158.4, 157.4, 147.7, 143.2, 133.9, 133.7, 130.0, 129.9, 129.3, 128.4, 127.3, 115.5, 52.5.

HRMS (ESI): *m*/*z* [M + H]$^+$ calcd for $C_{16}H_{11}ClNO_4$: 316.0377; found: 316.0388.

7-Chloro-2-(3-thienyl)-4*H*-benzo[*d*][1,3]oxazin-4-one (3e')

Yield: 224.1 mg (85%); light green solid; mp 137–139 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.30–8.28 (m, 1 H), 8.14 (d, *J* = 8.4 Hz, 1 H), 7.77 (d, *J* = 5.2 Hz, 1 H), 7.64 (d, *J* = 2.0 Hz, 1 H), 7.44 (dd, *J* = 8.4, 2.0 Hz, 1 H), 7.43–7.40 (m, 1 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 158.7, 155.0, 148.3, 143.0, 133.0, 131.4, 129.9, 128.6, 127.1, 126.9, 126.8, 115.3.

HRMS (ESI): *m*/*z* [M]$^+$ calcd for $C_{12}H_6ClNO_2S$: 262.9808; found: 262.9811.

6-Chloro-2-phenyl-4*H*-benzo[*d*][1,3]oxazin-4-one (3f')

Yield: 200.8 mg (78%); white solid; mp 195–197 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.29 (d, *J* = 7.2 Hz, 2 H), 8.20 (d, *J* = 2.4 Hz, 1 H), 7.76 (dd, *J* = 8.8, 2.4 Hz, 1 H), 7.64 (d, *J* = 8.4 Hz, 1 H), 7.61 (t, *J* = 7.2 Hz, 1 H), 7.52 (t, *J* = 7.4 Hz, 2 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 158.5, 157.4, 145.5, 136.9, 133.9, 132.9, 129.9, 128.8, 128.7, 128.4, 128.0, 118.1.

HRMS (ESI): *m*/*z* [M + H]$^+$ calcd for $C_{14}H_9ClNO_2$: 258.0322; found: 258.0329.

7-Bromo-2-phenyl-4*H*-benzo[*d*][1,3]oxazin-4-one (3g')[14c]

Yield: 238.6 mg (79%); yellow solid; mp 172–174 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.29 (d, *J* = 7.6 Hz, 2 H), 8.07 (d, *J* = 8.4 Hz, 1 H), 7.87 (d, *J* = 1.2 Hz, 1 H), 7.62 (dd, *J* = 8.4, 1.6 Hz, 1 H), 7.58 (t, *J* = 7.2 Hz, 1 H), 7.51 (t, *J* = 7.6 Hz, 2 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 158.9, 158.3, 148.0, 133.0, 131.6, 131.5, 130.2, 129.9, 129.8, 128.8, 128.5, 115.8.

7-Bromo-2-(4-bromophenyl)-4*H*-benzo[*d*][1,3]oxazin-4-one (3h')

Yield: 331.4 mg (87%); white solid; mp 169–170 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.14 (d, *J* = 8.8 Hz, 2 H), 8.07 (d, *J* = 8.4 Hz, 1 H), 7.86 (d, *J* = 1.6 Hz, 1 H), 7.67–7.62 (m, 3 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 158.6, 157.5, 147.8, 132.2, 131.9, 131.7, 130.2, 129.9, 129.8, 128.8, 128.2, 115.7.

HRMS (ESI): *m*/*z* [M + H]$^+$ calcd for $C_{14}H_8Br_2NO_2$: 379.8922; found: 379.8927.

7-Bromo-2-(1-naphthyl)-4*H*-benzo[*d*][1,3]oxazin-4-one (3i')

Yield: 285.2 mg (81%); white solid; mp 168–170 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 9.16 (d, *J* = 8.4 Hz, 1 H), 8.35–8.32 (m, 1 H), 8.12 (d, *J* = 8.4 Hz, 1 H), 8.06 (d, *J* = 8.4 Hz, 1 H), 7.97 (d, *J* = 1.6 Hz, 1 H), 7.93 (d, *J* = 8.0 Hz, 1 H), 7.69–7.64 (m, 2 H), 7.61–7.56 (m, 2 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 159.1, 158.7, 147.8, 134.1, 133.7, 132.0, 131.6, 130.8, 130.4, 130.3, 129.8, 128.9, 128.1, 126.5, 126.4, 125.8, 124.8, 115.8.

HRMS (ESI): *m*/*z* [M + H]$^+$ calcd for $C_{18}H_{11}BrNO_2$: 351.9973; found: 351.9964.

6-Bromo-2-phenyl-4*H*-benzo[*d*][1,3]oxazin-4-one (3j')[14c]

Yield: 241.6 mg (80%); white solid; mp 179–181 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.36 (d, *J* = 2.0 Hz, 1 H), 8.29 (d, *J* = 7.6 Hz, 2 H), 7.91 (dd, *J* = 8.8, 2.0 Hz, 1 H), 7.61–7.55 (m, 2 H), 7.52 (t, *J* = 7.6 Hz, 2 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 158.3, 157.5, 145.9, 139.7, 132.9, 131.1, 129.9, 128.9, 128.8, 128.4, 121.5, 118.4.

4-Oxo-2-phenyl-4*H*-benzo[*d*][1,3]oxazine-6-carbonitrile (3k')

Yield: 138.9 mg (56%); yellow solid; mp 127–129 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.53 (d, *J* = 2.0 Hz, 1 H), 8.33 (d, *J* = 7.6 Hz, 2 H), 8.03 (dd, *J* = 8.4, 2.0 Hz, 1 H), 7.79 (d, *J* = 8.4 Hz, 1 H), 7.65 (t, *J* = 7.4 Hz, 1 H), 7.55 (t, *J* = 7.6 Hz, 2 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 159.7, 157.6, 149.9, 138.7, 133.7, 133.4, 129.4, 129.0, 128.9, 128.5, 117.8, 117.3, 111.8.

HRMS (ESI): *m*/*z* [M]$^+$ calcd for $C_{15}H_8N_2O_2$: 248.0586; found: 248.0591.

Funding Information

We thank the National Natural Science Foundation of China (No. 21462021), the Natural Science Foundation of Jiangxi Province of China (No. 20161BAB203086), and Key Laboratory of Functional Small Organic Molecule, Ministry of Education (No. KLFS-KF-201704) for financial support.

Supporting Information

Supporting information for this article is available online at https://doi.org/10.1055/s-0039-1690265.

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