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Palladium-Catalyzed Aryl-Furanylation of Alkenes: Synthesis of Benzofuran-Containing 3,3-Disubstituted Oxindoles

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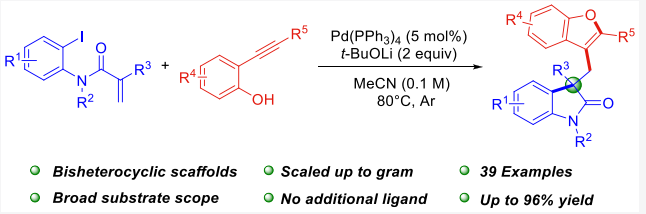
ABSTRACT: A novel palladium-catalyzed aryl-furanylation of alkenes is described. This protocol provided a straightforward route to the synthesis of various benzofuran-containing 3,3-disubstitutedoxindole derivatives bearing a quarternary carbon center. In the cascade process, one C(sp^2)−O bond, two C(sp^2)−C(sp^3) bonds, an oxindole, and a furan ring are formed in a single chemical operation.



INTRODUCTION

One of the approaches to discover or design modern drugs is to combine molecules with different biological activities.[1] Thus, the construction of diverse heterocycle compounds with biological activities in a single step is of great significance for organic synthesis. 3,3-Disubstituted oxindole scaffolds as important structural motifs broadly exist in many biologically active natural products and pharmaceutical molecules,[2,3] such as nelivaptan, amedalin, linopirdine, and isapheninum (Figure 1A−D, respectively).[4] Over the past decades, various synthetic methods to build 3,3-disubstituted oxindole scaffolds have been widely established.[5] Moreover, benzofuran ring systems are also valuable structures that have biological and pharmacological activities in numerous compounds (Figure 1E−H).[6] Therefore, the preparation of benzofuran derivatives has become a highly researched area in organic synthesis and has attracted much attention in recent years.[7] Consequently, the integration of a benzofuran moiety into oxindole derivatives may increase their biological activities or create new medicinal properties. However, as far as our knowledge is concerned, the method for the construction of these novel benzofuran-containing oxindoles is still scarce. Therefore, developing mild and rapid methods for the synthesis of bisheterocyclic compounds in a single synthetic sequence is highly desirable and urgent.

On the other hand, the palladium-catalyzed domino reaction has become a significant strategy in the synthetic community for the formation of carbon−carbon or carbon−heteroatom bonds. Among the various reactions involving palladium intermediates, the alkylpalladium species generated from the carbopalladation of a double bond has attracted considerable attention from synthetic chemists in recent years.[8−10] The generation of alkyl-Pd species in situ has generally proved more challenging due to their lower reactivity and stability characteristics compared to those of the arylpalladium, vinylpalladium, alkynylpalladium, and allylpalladium species.[11]

To our knowledge, the reported approaches that end in alkyl-Pd species include carbene,[12] terminal alkynes,[9b,13] unactivated C(sp^2)−H bond,[14] and sulfolene[15] (Scheme 1a). Moreover, the Lin group has recently reported a palladium-catalyzed cascade Heck cyclization to construct bisindoles, where the in situ-generated alkyl-Pd species was intercepted by the cyclization of *o*-ethynylanilines.[16] Inspired by these previous works and as a continuation of our interest in the area of transition-metal-catalyzed cascade reactions,[9b,17] herein we describe a palladium-catalyzed domino aryl furanylation of alkenes to construct diverse benzofuran-containing 3,3-disubstituted oxindole compounds, where one C(sp^2)−O bond, two C(sp^2)−C(sp^3) bonds, an oxindole, and a furan ring are formed in a single chemical operation (Scheme 1b). Significantly, this method offers facile access to a series of bisheterocyclic compounds from readily available *N*-phenylacrylamide and alkynylphenol derivatives without the assistance of an additional ligand.

RESULTS AND DISCUSSION

We began our study by investigating the cascade reaction with *N*-(2-iodophenyl)-*N*-methylmethacrylamide **1a** and 2-(phenylethynyl)phenol **2a** as the model substrates, and the results are summarized in Table 1. To our delight, the desired aryl-furanylation product **3aa** was obtained in a 15% yield by heating the mixture of **1a** and **2a** in MeCN with $Pd(OAc)_2$ (10 mol %), PPh_3 (20 mol %), and K_2CO_3 (2 equiv) at 80 °C (entry 1). Subsequently, different palladium catalysts were tested. $Pd(PPh_3)_4$ showed a great performance in comparison

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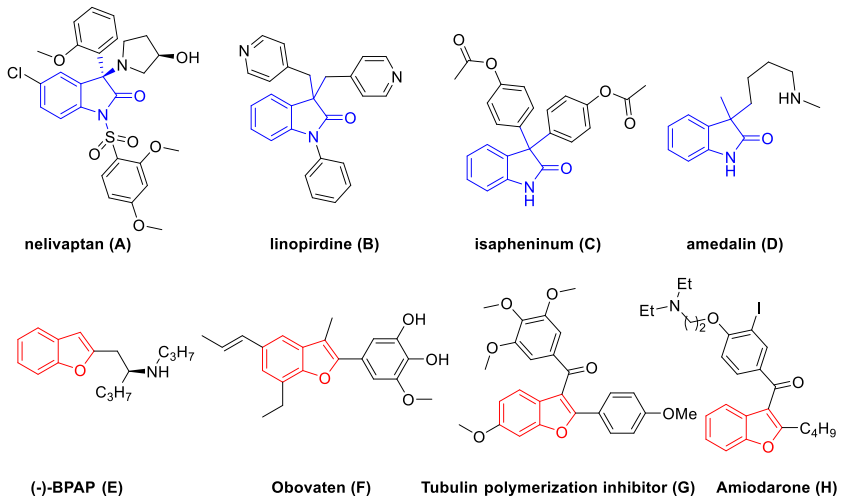
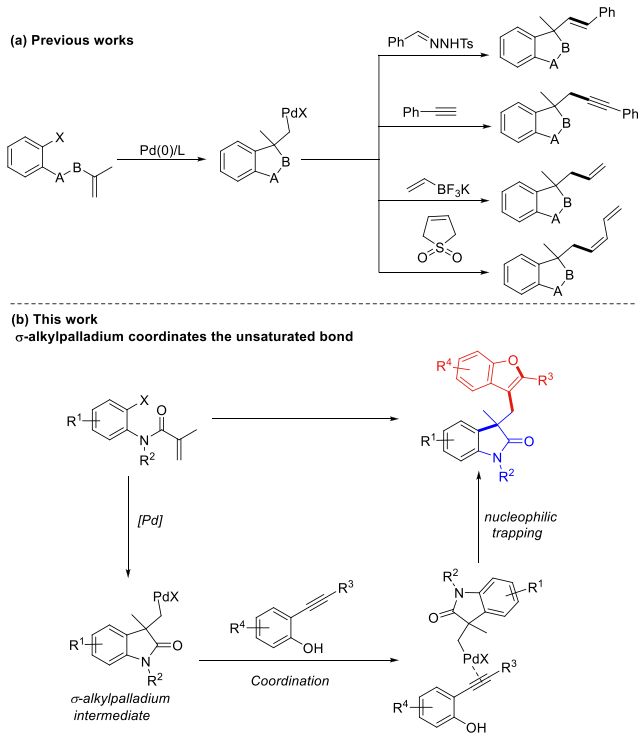


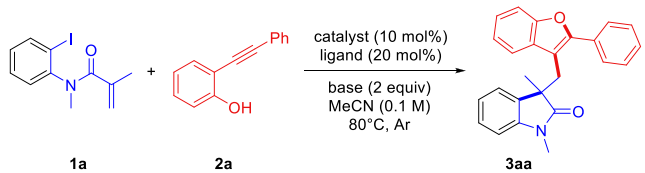
Figure 1. Representative bioactive benzofuran and 3,3-disubstituted oxindoles.

Scheme 1. Strategies for the Palladium-Catalyzed Aryl Functionalization of Alkenes



with those of $Pd(TFA)_2$, $Pd_2(dba)_3$, $PdCl_2(PPh_3)_2$, and $PdCl_2(dppf)$, affording the corresponding product **3aa** in an 80% yield (entries 2−6, respectively). Therefore, on using $Pd(PPh_3)_4$ as the catalyst, the cascade reaction conditions continued to be optimized. The specific identity of the base proved critical, and the exploration of different bases revealed that *t*-BuOLi provided the best yield of 96% (entries 7−13). In addition, decreasing the loading of the palladium catalyst to 5 mol % had almost no effect on the outcome of the product (entry 14, 94%), whereas a moderate yield was obtained when 3 mol % $Pd(PPh_3)_4$ was used (entry 15, 64%). Therefore, for economic reasons, the use of the 5 mol % catalyst is preferred. Further screening of the reaction temperature suggested that 80 °C was the best choice (entry 16).

Table 1. Optimization of the Cascade Reaction Conditions[a]



1a 2a 3aa

entry	catalyst	ligand	base	yield (%)[b]
1	$Pd(OAc)_2$	PPh_3	K_2CO_3	15
2	$Pd(PPh_3)_4$		K_2CO_3	80
3	$Pd(TFA)_2$	PPh_3	K_2CO_3	21
4	$Pd_2(dba)_3$	PPh_3	K_2CO_3	41
5	$PdCl_2(PPh_3)_2$	PPh_3	K_2CO_3	52
6	$PdCl_2(dppf)$	PPh_3	K_2CO_3	62
7	$Pd(PPh_3)_4$		Na_2CO_3	52
8	$Pd(PPh_3)_4$		$KOCH_3$	89
9	$Pd(PPh_3)_4$		Cs_2CO_3	55
10	$Pd(PPh_3)_4$		KOH	74
11	$Pd(PPh_3)_4$		$NaHCO_3$	54
12	$Pd(PPh_3)_4$		Li_2CO_3	50
13	$Pd(PPh_3)_4$		*t*-BuOLi	96
14	$Pd(PPh_3)_4$		*t*-BuOLi	94[c]
15	$Pd(PPh_3)_4$		*t*-BuOLi	64[d]
16	$Pd(PPh_3)_4$		*t*-BuOLi	83[c,e], 87[c,f]

[a]Reaction conditions are as follows unless otherwise noted: **1a** (0.1 mmol), **2a** (0.15 mmol), catalyst (10 mol %), ligand (20 mol %), MeCN (1.0 mL, 0.1 M), base (0.2 mmol), 80 °C, 10 h under an argon atmosphere. [b]Isolated yields. [c]$Pd(PPh_3)_4$ (5 mol %). [d]$Pd(PPh_3)_4$ (3 mol %). [e]70 °C. [f]90 °C.

Moreover, we also examined the effect of leaving groups of the acrylamide partner in this reaction (Scheme 2). It was found that both aryl iodide **1a** and aryl bromide **4** could provide the desired product **3aa** in excellent yields, while aryl chloride **5** was confirmed as an inactive substrate and the corresponding product **3aa** was not detected under the identical conditions. The aryl triflate **6** only gave the product **3aa** in a 25% yield. In addition, the reaction with *N*-methyl-*N*-phenylmethacrylamide **7** under identical conditions resulted in a complex mixture. These results indicated that neither aryl iodide nor bromide was superior to other aryl coupling partners in this cascade furanylation reaction.

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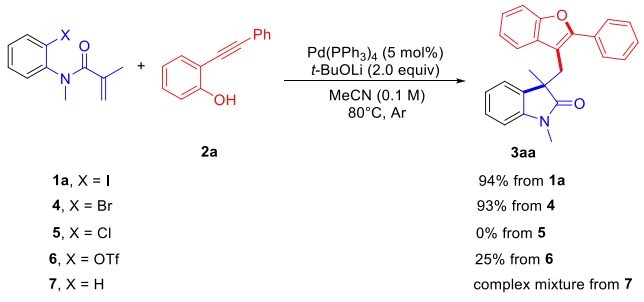
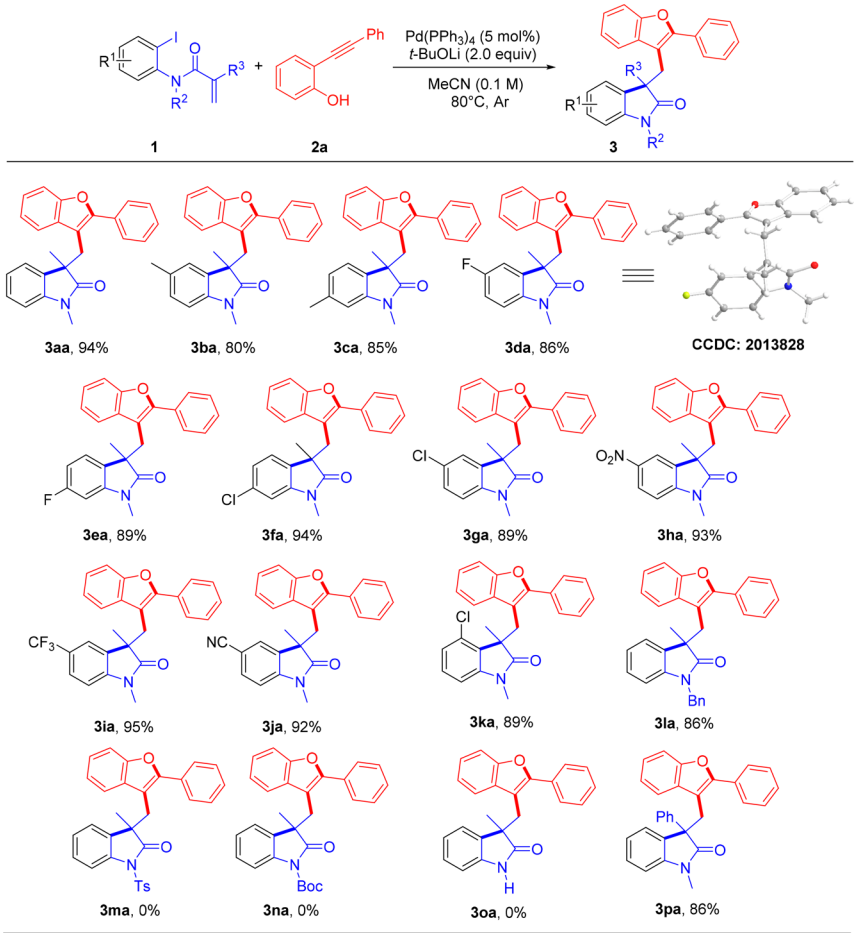
Scheme 2. Reactions of Aryl Halides 1a, 4, 5, Aryl Triflate 6, and *N*-Methyl-*N*-phenylmethacrylamide 7 with 2a



With the optimized reaction conditions in hand, we then investigated the substrate scope of the aryl iodides to evaluate the generality of this cascade reaction, and the results are depicted in Scheme 3. The methyl substituent on the aryl iodides at the *para*- or *meta*- osition could provide the products **3ba** and **3ca** in 80% and 85% yields, respectively. Fluoro and chloro groups at the different positions also performed well, and the corresponding products **3da**−**3ga** were isolated in 86−94% yields. The exact structure of **3da** was further unambiguously identified by single-crystal X-ray analysis.[18] When studying position substituent effects on the aniline part, the 5-position showed a better performance than the 4-position. For instance, the *N*-methylmethacrylamides with a 5-methyl, 5-fluoro, or 5-chloro substituent afforded the desired products **3ca**, **3ea**, and **3fa** in 85%, 89%, and 94% yields, respectively. However, the *N*-methylmethacrylamides with a 4-methyl, 4-fluoro, or 4-chloro substituent on the aromatic ring provided the corresponding products **3ba**, **3da**, and **3ga** in 80%, 86%, and 89% yields, respectively. Reactions of aryl iodides bearing a strong electron-withdrawing group proceeded smoothly, providing the corresponding products **3ha**−**3ja** in excellent yields. The chloro group at the 3-position also furnished this reaction well, offering the desired product **3ka** in a good yield. In addition, a benzyl-protected acrylamide also efficiently underwent the cascade reaction and delivered the desired product **3la** in an 86% yield. Unfortunately, none of the desired products **3ma** and **3na** were detected when *p*-toluenesulfonyl- and *t*-butyloxycarbonyl-protected acrylamides were used in this transformation. It should be noted that an acrylamide with a free N−H bond also failed in this reaction. Moreover, substrate **1p** with an aryl group at the α-position of the double bond proved to be a suitable reaction partner and offered **3pa** with a high yield.

Subsequently, we continued to examine the reaction scope with various *ortho*-alkynylphenols **2** using *N*-(2-iodophenyl)-*N*-methylmethacrylamide **1a**, and the results are shown in

Scheme 3. Substrate Scope of the Aryl Iodides[a,b]



[a]Reaction conditions are as follows: **1** (0.1 mmol), **2a** (0.15 mmol), $Pd(PPh_3)_4$ (5.0 mol %), *t*-BuOLi (0.2 mmol), MeCN (1.0 mL), under an argon atmosphere for 10 h, sealed tube. [b]Isolated yields.

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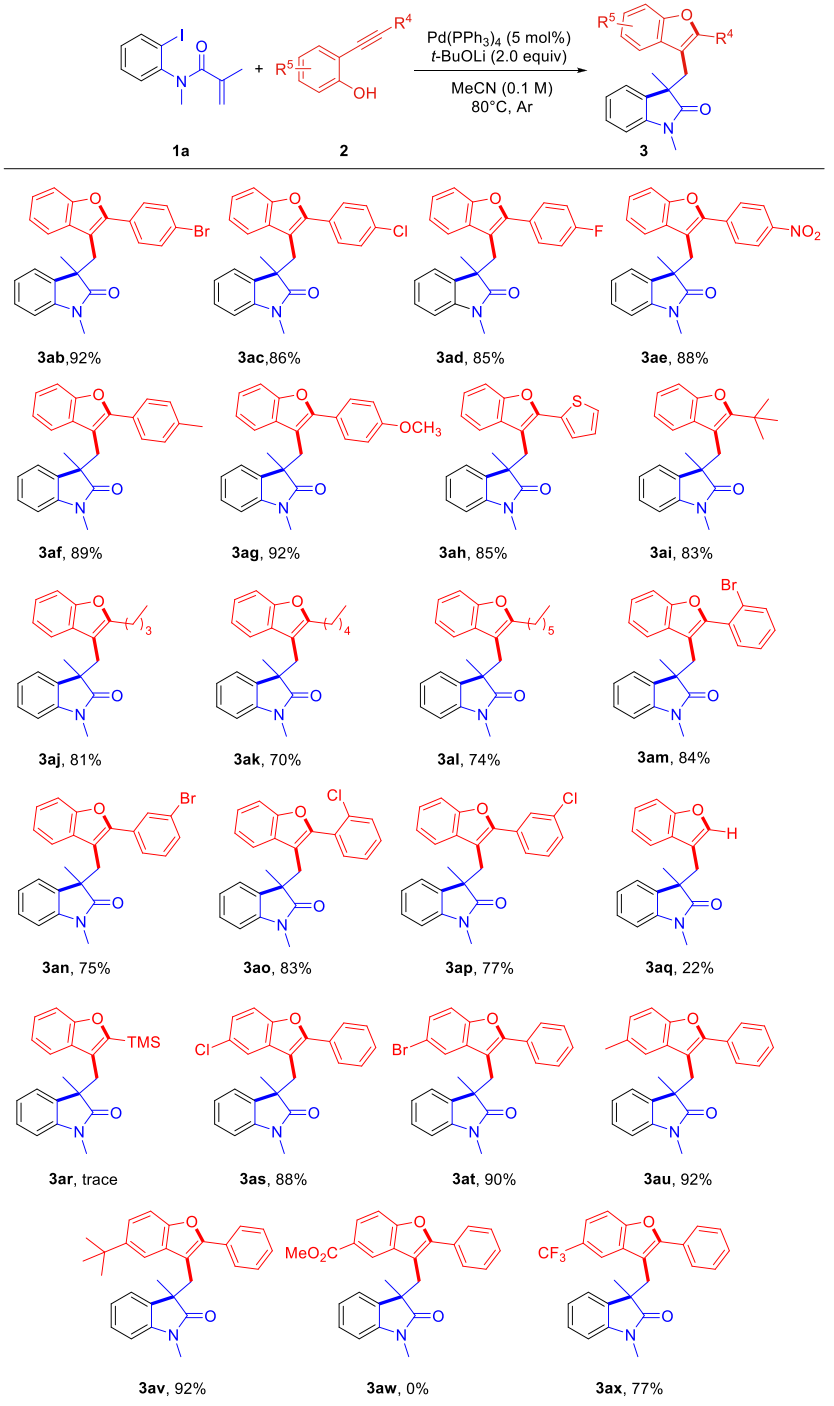
Scheme 4. Scope of *ortho*-Alkynylphenols[a,b]



[a]Reaction conditions are as follows: **1a** (0.1 mmol), **2** (0.15 mmol), $Pd(PPh_3)_4$ (5.0 mol %), *t*-BuOLi (0.2 mmol), MeCN (1.0 mL), under an argon atmosphere for 10 h, sealed tube. [b]Isolated yields.

Scheme 4. With respect to the benzene rings of alkyne moieties, both electron-withdrawing (**3ab**−**3ae**) and electron-donating (**3af**−**3ag**) substituents at the *para*-positions were also tolerated, giving the expected products in 85−92% yields. Notably, the substrates bearing a thiophene and a *tert*-butyl group were found to be a suitable reaction partners, affording the corresponding products **3ah** and **3ai** in 85% and 83% yields, respectively. The *n*-butyl-, *n*-pentyl-, and *n*-hexyl-substituted substrates were also adaptable and gave the spirocyclic products **3aj**−**3al** in good yields. In addition, substitution at the *meta*- or *ortho*-position was also tested, and the desired products **3am**−**3ap** were formed in 75−85% yields. To our delight, the desired product **3aq** could also be isolated in a 22% yield, although the terminal alkyne is a more challenging substrate due to its inherent stability and the lack of reactivity issues. However, compound **2r** with a silyl group failed to produce the desired product **3ar** under the optimal conditions, and a complex mixture was observed. Furthermore,

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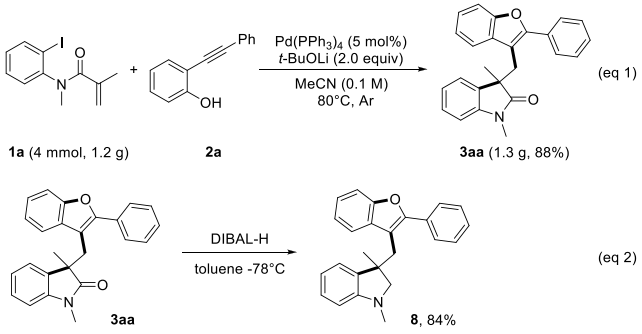
the electronic effects of R^5 were also investigated. The substrates with a chloro, bromo, methyl, or *tert*-butyl group at the 4-position could also proceed well, furnishing the target products **3as**−**3av**, respectively, with high yields. Unfortunately, none of the desired product **3aw** was obtained when the phenol bearing an ester group at the 4-position was used. The substrate possessing a trifluoromethyl group at the 4-position could perform this reaction smoothly, and the desired product **3ax** was isolated in a moderate yield.

Furthermore, to evaluate the productive practicability of this cascade reaction, the gram-scale preparation of **3aa** was performed under the standard conditions, which also showed a satisfactory result (Scheme 5, eq 1). In addition, we sought to

Scheme 5. Gram-Scale Experiment and Further Transformation

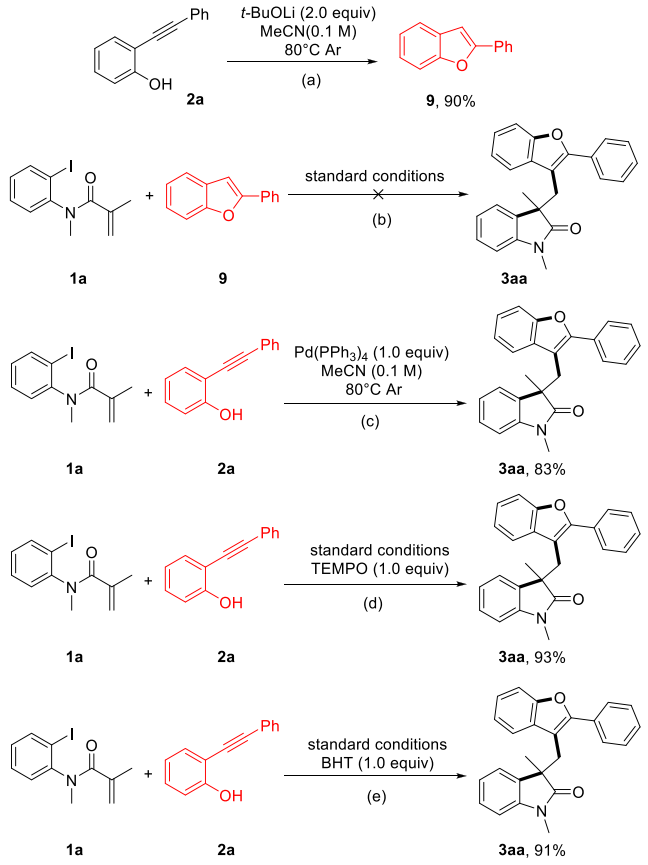


demonstrate the transformation of functional groups of the products. For example, the treatment of **3aa** under conditions with a DIBAL-H as the reducing reagent gave the indoline-containing benzofuran derivative **8** in an 84% yield (Scheme 5, eq 2).

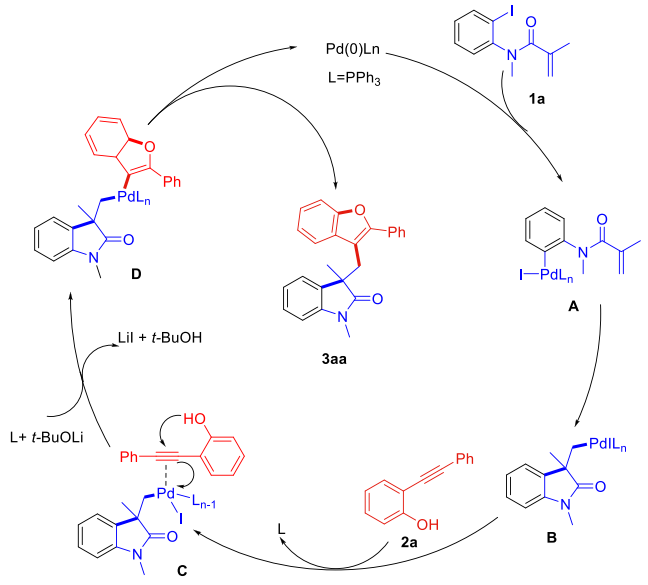
To gain some mechanistic insight into this reaction, several control experiments were carried out. Although the furan **9** could be generated by the cyclization of *o*-alkynylphenol **2a** in the presence of a base (Scheme 6a), we could not obtain any desired product **3aa** when **1a** and **9** were mixed under the standard reaction conditions, and all starting materials were recovered (Scheme 6b). Next, the reaction of **1a** and **2a** with 1.0 equiv of $Pd(PPh_3)_4$ in the absence of a base could generate product **3aa** in an 83% isolated yield (Scheme 6c). These results could eliminate the possibility in which the base-promoted deprotonation of **2a** and the cyclization occurr to generate furan **9** as an intermediate. Furthermore, when a radical inhibitor TEMPO or BHT was added, the reactions were still furnished smoothly and afforded the product **3aa** in high yields (Scheme 6d or e, respectively). These results indicated that a radical pathway might not be involved in this reaction.

On the basis of the above results, a mechanistic pathway for the formation of **3aa** is outlined in Scheme 7. The catalytic cycle is initiated by the oxidative addition of the carbon−halogen bond to Pd(0). Subsequently, the intermediate **A** preferentially undergoes an intramolecular Heck cyclization, generating a primary alkylpalladium species **B**.[19] Coordination of the alkylpalladium intermediate **B** to the triple bond of **2a** enables the intramolecular nucleophilic attack of the oxygen atom and generates the intermediate **C**.[20] Then, assisted by a base,[21] intermediate **C** could easily convert to the intermediate **D**. Finally, the reductive elimination of intermediate **D**

Scheme 6. Control Experiments on Mechanistic Aspect



Scheme 7. Proposed Mechanism



produces the product **3aa** and regenerates the active Pd(0) species.

CONCLUSIONS

In conclusion, we have successfully developed a novel and efficient palladium-catalyzed cascade aryl-furanylation of alkenes toward the synthesis of benzofuran-containing 3,3-disubstituted oxindole derivatives. This transformation in-

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volves the processes of intramolecular Heck cyclization, phenol-palladation, and furanylation in which one C(sp^2)−O bond, two C(sp^2)−C(sp^3) bonds, an oxindole, and a furan ring are formed sequentially in a single step. The good functional group tolerance, broad substrate scope, and moderate to high yields make the present protocol attractive for both academia and industry.

EXPERIMENTAL SECTION

General Information. All commercially available reagents were used directly without purification unless otherwise stated. All solvents were purified following standard procedures. For chromatography, 200−300 mesh silica gel (Qingdao, China) was employed. ^{1}H, ^{13}C, and ^{19}F NMR spectra were recorded at 500, 126, and 470 or 475 MHz, respectively. Chemical shifts are reported in parts per million (ppm) using tetramethylsilane as the internal standard in $CDCl_3$ as the solvent. IR spectra were recorded on a FT-IR instrument. High-resolution mass spectra were recorded with a ESI-Q-TOF mass spectrometer. Melting points were determined with a melting point apparatus and were uncorrected. The aryl halogens **1**,[7a] **4**,[10d] and **5**;[12a] aryl triflate **6**;[22] *N*-methyl-*N*-phenylmethacrylamide **7**;[16] and *ortho*-alkynylphenols **2**[20b] were prepared in the lab by the reported procedures.

General Procedure for the Synthesis of Products ***3***. To a solution of aryl halides **1** (0.1 mmol, 1.0 equiv), *o*-alkynylphenols **2** (0.15 mmol, 1.5 equiv), and *t*-BuOLi (16.0 mg, 0.2 mmol) in MeCN (1.0 mL) was added $Pd(PPh_3)_4$ (5.78 mg, 5.0 mol %) under an argon atmosphere in a sealed tube. The resulting mixture was stirred at 80 °C in an oil bath for 10 h. The solvent was removed in a vacuum, and the resulting residue was purified on a silica gel column to offer the products **3**.

Large-Scale Preparation of ***3aa***. Compound **1a** (4.0 mmol, 1,2 g), compound **2a** (6 mmol, 1.16 g), $Pd(PPh_3)_4$(0.2 mmol, 231 mg), and *t*-BuOLi (8 mmol, 640 mg) were added to a sealed tube. To the mixture was added MeCN (40.0 mL) via syringe. Under an argon atmosphere, the reaction mixture was stirred at 80 °C in an oil bath until completion (monitored by TLC). After cooling at room temperature, the mixture was concentrated under reduced pressure. The residue was purified by silica gel chromatography (petroleum ether/ethyl acetate = 10:1, v/v) to afford the product **3aa** (1.3 g, 88%).

*1,3-Dimethyl-3-((2-phenylbenzofuran-3-yl)methyl)indolin-2-one (**3aa**)*. Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1, v/v) afforded the title compound as a yellow solid (35 mg, 94% yield). mp: 104−105 °C. ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.54−7.49 (m, 3H), 7.43−7.35 (m, 4H), 7.27−7.23 (m, 1H), 7.20 (t, J = 7.0 Hz, 1H), 7.08−7.06 (m, 1H), 6.63−6.56 (m, 3H), 3.60 (d, J = 14.4 Hz, 1H), 3.45 (d, J = 14.4 Hz, 1H), 2.97 (s, 3H), 1.51 (s, 3H). ^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$): δ 180.4, 153.7, 153.3, 142.9, 132.7, 131.3, 123.0, 128.4, 128.3, 127.9, 127.6, 124.2, 123.7, 122.2, 122.1, 121.0, 111.4, 110.7, 107.5, 49.2, 32.7, 26.0, 23.0. IR (KBr): 3035, 3963, 2925, 2865, 1710, 1612, 1492, 1450, 1256, 1117, 1064, 886, 816, 748, 693, 666, 640 cm^{-1}. HRMS (ESI) m/z: calcd for $C_{25}H_{21}NO_2Na$ [M + Na]$^+$, 390.1464; found, 390.1467.

*1,3,5-Trimethyl-3-((2-phenylbenzofuran-3-yl)methyl)indolin-2-one (**3ba**)*. Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1, v/v) afforded the title compound as a yellow solid (31 mg, 80% yield). mp: 133−135 °C. ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.53 (dd, J = 8.8, 7.7 Hz, 3H), 7.43 (t, J = 7.4 Hz, 2H), 7.38 (dd, J = 7.4, 5.4 Hz, 2H), 7.26−7.22 (m, 1H), 7.19 (dd, J = 11.0, 3.9 Hz, 1H), 6.84 (d, J = 7.7 Hz, 1H), 6.46 (d, J = 7.8 Hz, 1H), 6.34 (s, 1H), 3.59 (d, J = 14.3 Hz, 1H), 3.44 (d, J = 14.3 Hz, 1H), 2.92 (s, 3H), 1.95 (s, 3H), 1.46 (s, 3H). ^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$): δ 180.4, 153.6, 153.2, 140.5, 132.6, 131.4, 131.4, 129.9, 128.4, 128.2, 127.8, 124.8, 124.8, 124.1, 122.1, 121.0, 111.4, 110.6, 107.1, 49.3, 32.7, 26.0, 22.9, 20.9. IR (KBr): 3062, 2971, 2925, 2868, 1711, 1617, 1505, 1452, 1273, 1259, 1135, 1060, 895, 834, 807, 753, 691, 640 cm^{-1}. HRMS (ESI) m/z: calcd for $C_{26}H_{24}NO_2$ [M + H]$^+$, 382.1801; found, 382.1790.

*1,3,6-Trimethyl-3-((2-phenylbenzofuran-3-yl)methyl)indolin-2-one (**3ca**)*. Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1, v/v) afforded the title compound as a brown solid (32 mg, 85% yield). mp: 201−204 °C. ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.52−7.47 (m, 3H), 7.43−7.38 (m, 3H), 7.36 (ddd, J = 7.3, 3.5, 1.5 Hz, 1H), 7.25 (ddd, J = 9.4, 6.8, 2.7 Hz, 1H), 7.21−7.16 (m, 1H), 6.44 (d, J = 7.2 Hz, 2H), 6.40 (d, J = 7.6 Hz, 1H), 3.56 (d, J = 14.3 Hz, 1H), 3.40 (d, J = 14.3 Hz, 1H), 2.95 (s, 3H), 2.27 (s, 3H), 1.47 (s, 3H). ^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$): δ 180.7, 153.6, 153.2, 143.0, 137.6, 131.3, 130.0, 129.7, 128.3, 128.3, 127.8, 124.1, 123.5, 122.5, 122.2, 121.0, 111.5, 110.6, 108.5, 48.9, 32.7, 25.7, 23.0, 21.7. IR (KBr): 3025, 2968, 2922, 2869, 1711, 1620, 1502, 1453, 1377, 1260, 1115, 1063, 810, 751, 722, 694, 642, 617 cm^{-1}. HRMS (ESI) m/z: calcd for $C_{26}H_{23}NO_2Na$ [M + Na]$^+$, 404.1621; found, 404.1613.

*5-Fluoro-1,3-dimethyl-3-((2-phenylbenzofuran-3-yl)methyl)-indolin-2-one (**3da**)*. Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1, v/v) afforded the title compound as a yellow solid (33 mg, 86% yield). mp: 141−143 °C. ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.58−7.53 (m, 1H), 7.49−7.47 (m, 2H), 7.45−7.41 (m, 2H), 7.41−7.37 (m, 2H), 7.25−7.21 (m, 2H), 6.76−6.70 (m, 1H), 6.46 (dd, J = 8.4, 4.1 Hz, 1H), 6.21 (dd, J = 8.1, 2.6 Hz, 1H), 3.60−3.54 (m, 1H), 3.49−3.44 (m, 1H), 2.90 (s, 3H), 1.46 (s, 3H). ^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$): δ 180.0, 158.7 (d, J_{C-F} = 240.4 Hz), 153.6, 153.5, 134.2 (d, J_{C-F} = 7.9 Hz), 113.7 (d, J_{C-F} = 23.5 Hz), 128.6, 128.5, 127.8, 124.2, 122.3, 120.8, 113.8, 113.6, 112.0 (d, J = 24.9 Hz), 110.9, 110.7, 107.7 (d, J_{C-F} = 8.2 Hz), 49.7, 32.6, 26.1, 22.8. ^{19}F NMR (470 MHz, $CDCl_3$): δ −120.8. IR (KBr): 3036, 2961, 2923, 2858, 1712, 1618, 1492, 1453, 1373, 1254, 1113, 1061, 837, 750, 720, 694, 643 cm^{-1}. HRMS (ESI) m/z: calcd for $C_{25}H_{21}FNO_2$ [M + H]$^+$, 386.1550; found, 386.1536.

*6-Fluoro-1,3-dimethyl-3-((2-phenylbenzofuran-3-yl)methyl)-indolin-2-one (**3ea**)*. Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1, v/v) afforded the title compound as a yellow oil (34 mg, 89% yield). ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.54−7.48 (m, 3H), 7.44−7.41 (m, 2H), 7.41−7.37 (m, 2H), 7.27−7.23 (m, 1H), 7.22−7.17 (m, 1H), 6.43 (dd, J = 8.2, 5.4 Hz, 1H), 6.32 (dd, J = 8.9, 2.3 Hz, 1H), 6.22 (ddd, J = 10.4, 8.2, 2.3 Hz, 1H), 3.57 (d, J = 14.4 Hz, 1H), 3.43 (d, J = 14.3 Hz, 1H), 2.90 (s, 3H), 1.47 (s, 3H). ^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$): δ 180.7, 162.7 (d, J_{C-F} = 244.2 Hz), 153.6, 153.3, 144.4 (d, J_{C-F} = 11.4 Hz), 131.2, 129.8, 128.4 (d, J_{C-F} = 2.2 Hz), 127.8, 124.6 (d, J_{C-F} = 9.8 Hz), 124.3, 122.3, 120.8, 111.1, 110.7, 107.9, 107.7, 96.3, 96.1, 48.8, 32.7, 26.1, 23.0. ^{19}F NMR (470 MHz, $CDCl_3$): δ −113.3. IR (KBr): 3018, 2972, 2927, 2869, 1711, 1615, 1512, 1455, 1385, 1258, 1138, 1025, 836, 755, 718, 689, 641 cm^{-1}. HRMS (ESI) m/z: calcd for $C_{25}H_{21}FNO_2$ [M + H]$^+$, 386.1550; found, 386.1562.

*6-Chloro-1,3-dimethyl-3-((2-phenylbenzofuran-3-yl)methyl)-indolin-2-one (**3fa**)*. Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1, v/v) afforded the title compound as a yellow oil (38 mg, 94% yield). ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.53 (d, J = 7.9 Hz, 1H), 7.48 (dd, J = 8.2, 1.4 Hz, 2H), 7.45−7.37 (m, 4H), 7.27−7.23 (m, 1H), 7.22−7.18 (m, 1H), 6.56 (d, J = 1.8 Hz, 1H), 6.48 (d, J = 1.8 Hz, 1H), 6.40 (d, J = 7.9 Hz, 1H), 3.57 (d, J = 14.4 Hz, 1H), 3.44 (d, J = 14.3 Hz, 1H), 2.88 (s, 3H), 1.46 (s, 3H). ^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$): δ 180.3, 153.6, 153.3, 144.1, 133.3, 131.2, 130.8, 129.7, 128.5, 128.4, 127.8, 124.4, 124.3, 122.3, 121.6, 120.8, 110.9, 110.7, 108.1, 48.9, 32.7, 26.0, 22.7. IR (KBr): 3006, 2962, 2921, 2862, 1717, 1608, 1492, 1453, 1373, 1257, 1112, 1071, 836, 752, 717, 693, 670, 640 cm^{-1}. HRMS (ESI) m/z: calcd for $C_{25}H_{21}ClNO_2$ [M + H]$^+$, 402.1255; found, 402.1279.

*5-Chloro-1,3-dimethyl-3-((2-phenylbenzofuran-3-yl)methyl)-indolin-2-one (**3ga**)*. Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1, v/v) afforded the title compound as a yellow solid (36 mg, 89% yield). mp: 190−192 °C. ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.56−7.53 (m, 1H), 7.49 (dd, J = 8.3, 1.4 Hz, 2H), 7.46 (t, J = 7.4 Hz, 2H), 7.42−7.37 (m, 2H), 7.25 (m, 1H), 7.21 (m, 1H), 7.01 (dd, J = 8.3, 2.0 Hz, 1H), 6.48−6.43 (m,

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2H), 3.57 (d, J = 14.4 Hz, 1H), 3.47 (d, J = 14.4 Hz, 1H), 2.89 (s, 3H), 1.45 (s, 3H). $^{13}C\{^1H\}$ NMR (126 MHz, $CDCl_3$): δ 179.9, 153.6, 141.5, 134.2, 131.0, 129.5, 128.7, 128.6, 127.9, 127.6, 127.4, 124.4, 124.2, 122.3, 120.8, 110.8, 110.7, 108.2, 49.6, 32.6, 26.1, 22.8. IR (KBr): 3044, 2969, 2920, 2869, 1712, 1609, 1516, 1453, 1274, 1221, 1140, 1071, 883, 806, 754, 719, 688, 635 cm^{-1}. HRMS (ESI) m/z: calcd for $C_{25}H_{20}ClNO_2Na$ $[M + Na]^+$, 424.1074; found, 424.1078.

*1,3-Dimethyl-5-nitro-3-((2-phenylbenzofuran-3-yl)methyl)-indolin-2-one (**3ha**).* Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 5:1, v/v) afforded the title compound as a yellow solid (38 mg, 93% yield). mp: 190−191 °C. ^1H NMR (500 MHz, $CDCl_3$): δ 7.95 (dd, J = 8.6, 2.2 Hz, 1H), 7.60 (dd, J = 7.0, 1.7 Hz, 1H), 7.38 (dd, J = 7.6, 4.9 Hz, 2H), 7.35 (d, J = 4.4 Hz, 4H), 7.32−7.30 (m, 1H), 7.27−7.20 (m, 2H), 6.54 (d, J = 8.6 Hz, 1H), 3.72−3.62 (m, 1H), 3.54 (d, J = 14.3 Hz, 1H), 2.82 (s, 3H), 1.54 (s, 3H). $^{13}C\{^1H\}$ NMR (126 MHz, $CDCl_3$): δ 180.3, 153.5, 153.3, 148.7, 142.7, 133.0, 130.7, 129.3, 128.9, 128.6, 127.4, 125.0, 124.5, 122.4, 120.5, 119.5, 110.8, 110.0, 106.7, 49.2, 33.0, 26.2, 22.0. IR (KBr): 3066, 2966, 2920, 2867, 1730, 1616, 1512, 1454, 1275, 1258, 1071, 1053, 871, 832, 754, 721, 691, 641 cm^{-1}. HRMS (ESI) m/z: calcd for $C_{25}H_{20}N_2O_4Na$ $[M + Na]^+$, 435.1315; found, 435.1306.

*1,3-Dimethyl-3-((2-phenylbenzofuran-3-yl)methyl)-5-(trifluoromethyl)indolin-2-one (**3ia**).* Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1, v/v) afforded the title compound as a yellow solid (37 mg, 95% yield). mp: 136−138 °C. ^1H NMR (500 MHz, $CDCl_3$): δ 7.52 (dd, J = 8.2, 1.4 Hz, 2H), 7.47 (dd, J = 7.8, 0.6 Hz, 1H), 7.44−7.38 (m, 3H), 7.38 (d, J = 2.7 Hz, 1H), 7.34 (dd, J = 8.1, 0.9 Hz, 1H), 7.26−7.22 (m, 1H), 7.20−7.16 (m, 1H), 6.82 (d, J = 0.8 Hz, 1H), 6.64 (d, J = 8.1 Hz, 1H), 3.64 (d, J = 14.5 Hz, 1H), 3.51 (d, J = 14.4 Hz, 1H), 2.96 (s, 3H), 1.49 (s, 3H). $^{13}C\{^1H\}$ NMR (126 MHz, $CDCl_3$): δ 180.4, 153.5 (d, J_{C-F} = 24.0 Hz), 145.9, 133.1, 130.8, 129.6, 128.7, 127.6, 125.7 (d, J_{C-F} = 3.8 Hz), 125.2, 124.3, 123.0, 122.3, 120.6, 110.8, 110.6, 107.3, 49.3, 32.7, 26.2, 22.8. ^{19}F NMR (470 MHz, $CDCl_3$): δ −61.3. IR (KBr): 3035, 2970, 2921, 2872, 1723, 1616, 1497, 1372, 1260,1116, 1056, 819, 753, 718, 692, 626 cm^{-1}. HRMS (ESI) m/z: calcd for $C_{26}H_{20}F_3NO_2Na$ $[M + Na]^+$, 458.1338; found, 458.1352.

*1,3-Dimethyl-2-oxo-3-((2-phenylbenzofuran-3-yl)methyl)-indoline-5-carbonitrile (**3ja**).* Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 5:1, v/v) afforded the title compound as a yellow solid (36 mg, 92% yield). mp: 201−203 °C. ^1H NMR (500 MHz, $CDCl_3$): δ 7.59−7.55 (m, 1H), 7.49−7.47 (m, 3H), 7.44−7.40 (m, 2H), 7.38 (dd, J = 7.3, 1.2 Hz, 1H), 7.33 (dd, J = 8.1, 1.6 Hz, 1H), 7.25−7.21 (m, 2H), 6.66 (d, J = 1.5 Hz, 1H), 6.55 (d, J = 8.1 Hz, 1H), 3.62 (d, J = 14.4 Hz, 1H), 3.51 (d, J = 14.4 Hz, 1H), 2.85 (s, 3H), 1.48 (s, 3H). $^{13}C\{^1H\}$ NMR (126 MHz, $CDCl_3$): δ 180.1, 153.6, 153.5, 146.8, 133.3, 133.0, 130.8, 129.2, 128.9, 127.7, 126.9, 124.5, 122.4, 120.6, 119.0, 110.8, 110.3, 107.6, 105.0, 49.1, 32.6, 26.1, 22.5. IR (KBr): 3046, 2972, 2927, 2867, 2219, 1721, 1616, 1496, 1454, 1258, 1142, 1058, 826, 753, 718, 689,637 cm^{-1}. HRMS (ESI) m/z: calcd for $C_{26}H_{20}N_2O_2Na$ $[M + Na]^+$, 415.1416; found, 415.1408.

*4-Chloro-1,3-dimethyl-3-((2-phenylbenzofuran-3-yl)methyl)-indolin-2-one (**3ka**).* Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1, v/v) afforded the title compound as a yellow solid (36 mg, 88% yield). mp: 112−113 °C. ^1H NMR (500 MHz, $CDCl_3$): δ 7.53−7.51 (m, 1H), 7.49−7.46 (m, 2H), 7.44−7.38 (m, 3H), 7.34 (d, J = 7.9 Hz, 1H), 7.23−7.18 (m, 1H), 7.17−7.14 (m, 1H), 6.98 (t, J = 8.0 Hz, 1H), 6.60 (dd, J = 8.2, 0.7 Hz, 1H), 6.39 (dd, J = 7.7, 0.5 Hz, 1H), 3.86 (d, J = 14.2 Hz, 1H), 3.53 (d, J = 14.2 Hz, 1H), 2.71 (s, 3H), 1.70 (d, J = 7.1 Hz, 3H). $^{13}C\{^1H\}$ NMR (126 MHz, $CDCl_3$): δ 179.3, 153.8, 153.6, 145.0, 131.2, 130.9, 129.4, 129.0, 129.0, 128.5, 128.4, 128.3, 124.0, 123.4, 122.0, 120.9, 110.6, 110.5, 105.8, 50.6, 31.2, 26.0, 20.3. IR (KBr): 3036, 2956, 2918, 2869, 1715, 1599, 1522, 1454, 1273, 1218, 1144, 1073, 885, 812, 754, 719, 686, 637 cm^{-1}. HRMS (ESI) m/z: calcd for $C_{25}H_{20}ClNO_2Na$ $[M + Na]^+$, 424.1074; found, 424.1080.

*1-Benzyl-3-methyl-3-((2-phenylbenzofuran-3-yl)methyl)indolin-2-one (**3la**).* Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1, v/v) afforded the title compound as a yellow solid (38 mg, 86% yield). mp: 123−124 °C. ^1H NMR (500 MHz, $CDCl_3$): δ 7.54−7.46 (m, 4H), 7.39−7.35 (m, 3H), 7.30−7.27 (m, 1H), 7.25−7.16 (m, 4H), 6.99−6.94 (m, 1H), 6.84 (d, J = 7.0 Hz, 2H), 6.68 (d, J = 7.2 Hz, 1H), 6.61 (t, J = 7.5 Hz, 1H), 6.46 (d, J = 7.8 Hz, 1H), 4.95 (d, J = 15.8 Hz, 1H), 4.54 (d, J = 15.8 Hz, 1H), 3.67 (d, J = 14.4 Hz, 1H), 3.57 (d, J = 14.3 Hz, 1H), 1.62 (s, 3H). $^{13}C\{^1H\}$ NMR (126 MHz, $CDCl_3$): δ 180.3, 153.8, 153.5, 142.2, 135.7, 132.7, 131.3, 130.0, 128.6, 128.4, 128.3, 127.9, 127.6, 127.2, 126.8, 124.3, 123.7, 122.4, 122.2, 121.1, 111.4, 110.7, 108.8, 49.3, 43.6, 32.5, 24.0. IR (KBr): 3059, 2959, 2923, 2854, 1708, 1609, 1490, 1443, 1260, 1115, 1065, 803, 751, 696 cm^{-1}. HRMS (ESI) m/z: calcd for $C_{31}H_{25}NO_2Na[M + Na]^+$, 466.1777; found, 466.1778.

*1-Methyl-3-phenyl-3-((2-phenylbenzofuran-3-yl)methyl)indolin-2-one (**3pa**).* Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1, v/v) afforded the title compound as a yellow solid (37 mg, 86% yield). mp: 133−134 °C. ^1H NMR (500 MHz, $CDCl_3$): δ 7.57 (d, J = 7.9 Hz, 2H), 7.43−7.35 (m, 10H), 7.25−7.21 (m, 1H), 7.15 (t, J = 7.5 Hz, 1H), 7.13−7.09 (m, 1H), 6.64 (t, J = 7.5 Hz, 1H), 6.58 (dd, J = 7.3, 5.0 Hz, 2H), 4.10 (d, J = 14.2 Hz, 1H), 4.05 (d, J = 14.1 Hz, 1H), 2.87 (s, 3H). $^{13}C\{^1H\}$ NMR (126 MHz, $CDCl_3$): δ 178.3, 153.9, 153.6, 143.6, 140.1, 131.2, 130.2, 129.3, 128.6, 128.5, 128.4, 128.3, 128.0, 127.5, 127.4, 126.0, 124.1, 122.2, 122.1, 121.2, 111.0, 110.6, 107.7, 56.9, 33.4, 26.2. IR (KBr): 3050, 2985, 2915, 2844, 1709, 1606, 1487, 1438, 1257, 1115, 1064, 800, 746, 691, cm^{-1}. HRMS (ESI) m/z: calcd for $C_{30}H_{23}NO_2Na[M + Na]^+$, 452.1621; found, 452.1649.

*3-((2-(4-Bromophenyl)benzofuran-3-yl)methyl)-1,3-dimethylindolin-2-one (**3ab**).* Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1, v/v) afforded the title compound as a brown solid (41 mg, 92% yield). mp: 158−160 °C. ^1H NMR (500 MHz, CDCl3): δ 7.51 (d, J = 8.5 Hz, 2H), 7.47 (d, J = 7.8 Hz, 1H), 7.39 (d, J = 8.1 Hz, 1H), 7.36 (d, J = 8.5 Hz, 2H), 7.27−7.23 (m, 1H), 7.18 (t, J = 7.6 Hz, 1H), 7.11−7.08 (m, 1H), 6.67−6.60 (m, 3H), 3.52 (d, J = 14.4 Hz, 1H), 3.39 (d, J = 14.4 Hz, 1H), 2.96 (s, 3H), 1.51 (s, 3H). $^{13}C\{^1H\}$ NMR (126 MHz, $CDCl_3$): δ 180.2, 153.6, 152.0, 143.0, 132.6, 131.6, 130.2, 129.8, 129.2, 127.8, 124.5, 123.7, 122.4, 122.4, 122.1, 121.0, 111.95, 110.71, 107.6, 49.1, 32.8, 26.0, 22.9. IR (KBr): 3056, 2971, 2920, 2869, 1709, 1610, 1462, 1273, 1265, 1139, 1070, 881, 825, 755, 717, 685, 636 cm^{-1}. HRMS (ESI) m/z: calcd for $C_{25}H_{21}BrNO_2$ $[M + H]^+$, 446.0750; found, 446.0744.

*3-((2-(4-Chlorophenyl)benzofuran-3-yl)methyl)-1,3-dimethylindolin-2-one (**3ac**).* Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1, v/v) afforded the title compound as a white solid (34 mg, 86% yield). mp: 190−192 °C. ^1H NMR (500 MHz, $CDCl_3$): δ 7.48−7.45 (m, 1H), 7.44−7.38 (m, 3H), 7.38−7.34 (m, 2H), 7.28−7.23 (m, 1H), 7.20−7.16 (m, 1H), 7.11−7.08 (m, 1H),, 6.67−6.60 (m, 3H), 3.52 (d, J = 14.4 Hz, 1H), 3.39 (d, J = 14.4 Hz, 1H), 2.96 (s, 3H), 1.51 (s, 3H). $^{13}C\{^1H\}$ NMR (126 MHz, $CDCl_3$) 180.2, 153.6, 152.0, 143.0, 134.2, 132.6, 129.8, 129.7, 129.0, 128.6, 127.8, 124.5, 123.7, 122.3, 122.0, 121.0, 111.9, 110.7, 107.6, 49.1, 32.8, 26.0, 22.9. IR (KBr): 3062, 2960, 2921, 2851, 1712, 1611, 1490, 1452, 1375, 1255, 1120, 1094, 833, 750, 715, 687, 638 cm^{-1}. HRMS (ESI) m/z: calcd for $C_{25}H_{21}ClNO_2$ $[M + H]^+$, 402.1255; found, 402.1264.

*3-((2-(4-Fluorophenyl)benzofuran-3-yl)methyl)-1,3-dimethylindolin-2-one (**3ad**).* Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1, v/v) afforded the title compound as a yellow solid (33 mg, 85% yield). mp: 142−144 °C. ^1H NMR (500 MHz, $CDCl_3$): δ 7.46 (ddd, J = 8.0, 5.5, 2.6 Hz, 3H), 7.39 (d, J = 8.1 Hz, 1H), 7.27−7.22 (m, 1H), 7.18 (dd, J = 11.1, 3.9 Hz, 1H), 7.12−7.06 (m, 3H), 6.65 (dd, J = 11.3, 4.0 Hz, 1H), 6.62−6.59 (m, 2H), 3.51 (d, J = 14.4 Hz, 1H), 3.39 (d, J = 14.4 Hz, 1H), 2.96 (s, 3H), 1.50 (s, 3H). $^{13}C\{^1H\}$ NMR (126 MHz, $CDCl_3$): δ 180.3, 162.6 (d, J_{C-F} = 248.8 Hz), 153.6, 152.3, 143.0, 132.7, 129.8, 129.7 (d, J_{C-F} = 8.2 Hz), 127.7, 127.5 (d, J_{C-F} = 3.3 Hz), 124.2, 123.6, 122.3, 122.0,

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120.9, 115.5 (d, J_{C-F} = 21.7 Hz), 111.2, 110.6, 107.5, 49.1, 32.8, 26.0, 22.9. ^{19}F NMR (470 MHz, $CDCl_3$): δ −112.5. IR (KBr): 3041, 2961, 2921, 2851, 1712, 1612, 1501, 1454, 1375, 1276, 1257, 1061, 838, 752, 719, 690, 629 cm^{-1}. HRMS (ESI) m/z: calcd for $C_{25}H_{21}FNO_2$ $[M + H]^+$, 386.1550; found, 386.1558.

*1,3-Dimethyl-3-((2-(4-nitrophenyl)benzofuran-3-yl)methyl)-indolin-2-one (**3ae**).* Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 5:1, v/v) afforded the title compound as a yellow solid (36 mg, 88% yield). mp: 193−195 °C. ^{1}H NMR (500 MHz, $CDCl_3$): δ 8.21 (d, J = 9.0 Hz, 2H), 7.68 (d, J = 9.0 Hz, 2H), 7.52−7.42 (m, 2H), 7.32 (ddd, J = 8.3, 7.2, 1.2 Hz, 1H), 7.21 (dd, J = 11.1, 4.0 Hz, 1H), 7.10 (td, J = 7.7, 1.2 Hz, 1H), 6.69−6.57 (m, 3H), 3.56 (d, J = 14.4 Hz, 1H), 3.44 (d, J = 14.4 Hz, 1H), 2.97 (s, 3H), 1.54 (s, 3H). ^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$): δ 179.9, 154.0, 150.3, 146.9, 143.0, 137.4, 132.3, 129.7, 128.1, 127.8, 125.6, 123.6, 122.8, 122.1, 121.4, 114.7, 111.0, 107.8, 49.0, 33.0, 26.1, 22.7. IR (KBr): 3051, 2963, 2918, 2887, 1711, 1607, 1515, 1469, 1453, 1377, 1342, 1257, 1106, 1058, 854,754, 631 cm^{-1}. HRMS (ESI) m/z: calcd for $C_{25}H_{21}N_2O_4$ $[M + H]^+$, 413.1495; found, 413.1492.

*1,3-Dimethyl-3-((2-(p-tolyl)benzofuran-3-yl)methyl)indolin-2-one (**3af**).* Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1, v/v) afforded the title compound as a brown oil (34 mg, 89% yield). ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.45 (d, J = 7.7 Hz, 1H), 7.40 (d, J = 8.1 Hz, 3H), 7.23−7.21 (m, 3H), 7.16 (dd, J = 11.0, 3.9 Hz, 1H), 7.10−7.07 (m, 1H), 6.65−6.57 (m, 3H), 3.57 (d, J = 14.4 Hz, 1H), 3.39 (d, J = 14.4 Hz, 1H), 2.99 (s, 3H), 2.43 (s, 3H), 1.49 (s, 3H). ^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$): δ 180.5, 153.6, 153.6, 142.9, 138.3, 132.8, 130.0, 129.1, 128.4, 127.8, 127.6, 123.9, 123.8, 122.1, 122.0, 120.8, 110.9, 110.6, 107.4, 49.2, 32.7, 26.0, 23.0, 21.4. IR (KBr): 3063, 2964, 2925, 2871, 1711, 1611, 1493, 1453, 1376, 1274, 1256, 1122, 1060, 819, 752, 717, 690, 636 cm^{-1}. HRMS (ESI) m/z: calcd for $C_{26}H_{24}NO_2$ $[M + H]^+$, 382.1801; found, 382.1786.

*3-((2-(4-Methoxyphenyl)benzofuran-3-yl)methyl)-1,3-dimethylindolin-2-one (**3ag**).* Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1, v/v) afforded the title compound as a brown oil (37 mg, 92% yield). ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.46−7.42 (m, 3H), 7.38 (d, J = 8.0 Hz, 1H), 7.24−7.19 (m, 1H), 7.16 (t, J = 7.5 Hz, 1H), 7.10−7.08 (m, 1H), 6.95−6.91 (m, 2H), 6.66 (t, J = 7.4 Hz, 1H), 6.63−6.59 (m, 2H), 3.89 (s, 3H), 3.54 (d, J = 14.4 Hz, 1H), 3.38 (d, J = 14.4 Hz, 1H), 2.99 (s, 3H), 1.49 (s, 3H). ^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$): δ 180.5, 159.7, 153.5, 153.4, 142.9, 132.8, 130.1, 129.3, 127.6, 123.8, 123.8, 123.8, 122.1, 122.0, 120.7, 113.9, 110.5, 110.3, 107.5, 55.4, 49.2, 32.7, 26.0, 23.0. IR (KBr): 3047, 2965, 2925, 2868, 1710, 1612, 1505, 1453, 1375, 1255, 1121, 1062, 833, 752, 718, 692, 632 cm^{-1}. HRMS (ESI) m/z: calcd for $C_{26}H_{24}NO_3$ $[M + H]^+$, 398.1750; found, 398.1736.

*1,3-Dimethyl-3-((2-(thiophen-2-yl)benzofuran-3-yl)methyl)-indolin-2-one (**3ah**).* Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1, v/v) afforded the title compound as a brown oil (32 mg, 85% yield). ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.43 (dd, J = 12.9, 7.9 Hz, 2H), 7.33 (dd, J = 5.0, 1.0 Hz, 1H), 7.28−7.23 (m, 2H), 7.21−7.16 (m, 1H), 7.14−7.11 (m, 1H), 7.05 (dd, J = 5.0, 3.7 Hz, 1H), 6.82 (d, J = 6.8 Hz, 1H), 6.76−6.66 (m, 2H), 3.57 (d, J = 14.5 Hz, 1H), 3.34 (d, J = 14.5 Hz, 1H), 3.10 (s, 3H), 1.58 (s, 3H). ^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$): δ 180.4, 153.6, 148.7, 143.0, 132.8, 132.8, 130.0, 127.9, 127.3, 126.1, 126.0, 124.4, 123.9, 122.5, 122.1, 120.8, 111.2, 110.7, 107.7, 49.1, 33.0, 26.2, 22.8. IR (KBr): 3003, 2970, 2926, 2867, 1709, 1610, 1492, 1452, 1257, 1115, 1061, 885, 854, 751, 716, 695, 639 cm^{-1}. HRMS (ESI) m/z: calcd for $C_{23}H_{19}NO_2SNa$ $[M + Na]^+$, 396.1028; found, 396.1053.

*3-((2-(Tert-butyl)benzofuran-3-yl)methyl)-1,3-dimethylindolin-2-one (**3ai**).* Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1, v/v) afforded the title compound as a brown solid (29 mg, 83% yield). mp: 119−120 °C. ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.37−7.32 (m, 2H), 7.24 (td, J = 7.7, 1.2 Hz, 1H), 7.21−7.17 (m, 1H), 7.14−7.07 (m, 1H), 6.96−6.93 (m, 1H), 6.84 (dd, J = 7.4, 0.8 Hz, 1H), 6.77 (d, J = 7.7 Hz, 1H), 3.35 (d, J = 14.7 Hz, 1H), 3.26 (d, J = 14.7 Hz, 1H), 3.17 (s, 3H), 1.58 (s, 3H), 1.22 (s, 9H). ^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$): δ 180.8, 161.8, 153.0, 143.1, 133.6, 130.7, 128.0, 124.6, 123.2, 122.1, 121.5, 120.6, 110.2, 108.4, 107.8, 48.9, 35.1, 32.0, 29.8, 26.2, 23.5. IR (KBr): 3046, 2970, 2925, 2883, 1714, 1613, 1511, 1491, 1456, 1377, 1260, 1126, 1058, 896, 754, 722, 690, 640 cm^{-1}. HRMS (ESI) m/z: calcd for $C_{23}H_{26}NO_2$ $[M + H]^+$, 348.1958; found, 348.1976.

*3-((2-Butylbenzofuran-3-yl)methyl)-1,3-dimethylindolin-2-one (**3aj**).* Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1, v/v) afforded the title compound as a yellow solid (28 mg, 81% yield). mp: 96−97 °C. ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.31 (dd, J = 10.9, 4.1 Hz, 2H), 7.21−7.18 (m, 1H), 7.16−7.11 (m, 1H), 7.11−7.08 (m, 2H), 7.00−6.96 (m, 1H), 6.67 (d, J = 7.7 Hz, 1H), 3.16−3.08 (m, 2H), 3.03 (s, 3H), 2.54−2.48 (m, 1H), 2.42−2.36 (m, 1H), 1.62−1.56 (m, 1H), 1.55 (s, 3H), 1.51−1.41 (m, 1H), 1.32 (dd, J = 14.9, 7.4 Hz, 2H), 0.92 (t, J = 7.3 Hz, 3H). ^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$): δ 180.5, 157.1, 153.6, 143.3, 133.3, 129.5, 127.9, 123.6, 122.8, 122.0, 121.8, 120.1, 110.2, 109.4, 107.8, 49.1, 33.0, 29.9, 26.4, 26.0, 22.6, 22.5, 13.9. IR (KBr): 3044, 2972, 2923, 2873, 1724, 1615, 1521, 1495, 1456, 1379, 1260, 1126, 1058, 896, 754, 724, 680, 638 cm^{-1}. HRMS (ESI) m/z: calcd for $C_{23}H_{26}NO_2$ $[M + H]^+$, 348.1958; found, 348.1965.

*1,3-Dimethyl-3-((2-pentylbenzofuran-3-yl)methyl)indolin-2-one (**3ak**).* Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1, v/v) afforded the title compound as a yellow solid (25 mg, 70% yield). mp: 103−104 °C. ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.33−7.29 (m, 2H), 7.21−7.18 (m, 1H), 7.16−7.12 (m, 1H), 7.11−7.07 (m, 2H), 7.00−6.96 m, 1H), 6.67 (d, J = 7.7 Hz, 1H), 3.15−3.08 (m, 2H), 3.03 (s, 3H), 2.53−2.47 (m, 1H), 2.41−2.35 (m, 1H), 1.55 (s, 3H), 1.52−1.46 (m, 1H), 1.35−1.25 (m, 5H), 0.91 (t, J = 7.1 Hz, 3H). ^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$): δ 180.5, 157.1, 153.6, 143.3, 133.3, 129.5, 127.9, 123.6, 122.8, 122.0, 121.8, 120.1, 110.2, 109.4, 107.8, 49.1, 33.0, 31.6, 27.5, 26.6, 26.1, 22.6, 22.5, 14.0. IR (KBr): 3035, 2967, 2927, 2885, 1720, 1615, 1513, 1500, 1458, 1379, 1260, 1126, 1058, 896, 756, 723, 692, 638 cm^{-1}. HRMS (ESI) m/z: calcd for $C_{24}H_{28}NO_2$ $[M + H]^+$, 362.2114; found, 362.2117.

*1,3-Dimethyl-3-((2-hexylbenzofuran-3-yl)methyl)indolin-2-one (**3al**).* Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1, v/v) afforded the title compound as a yellow solid (28 mg, 74% yield). mp: 101−102 °C. ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.33−7.29 (m, 2H), 7.21−7.18 (m, 1H), 7.16−7.12 (m, 1H), 7.11−7.08 (m, 2H), 7.00−6.96 (m, 1H), 6.67 (d, J = 7.7 Hz, 1H), 3.16−3.08 (m, 2H), 3.03 (s, 3H), 2.53−2.47 (m, 1H), 2.42−2.35 (m, 1H), 1.55 (s, 3H), 1.53−1.44 (m, 1H), 1.34−1.25 (m, 7H), 0.91 (t, J = 6.9 Hz, 3H). ^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$): δ 180.5, 157.2, 153.6, 143.3, 133.3, 129.5, 127.9, 123.6, 122.8, 122.0, 121.8, 120.1, 110.2, 109.3, 107.8, 49.1, 33.0, 31.6, 29.1, 27.8, 26.7, 26.0, 22.6, 14.1. IR (KBr): 3054, 2972, 2925, 2883, 1720, 1618, 1511, 1491, 1457, 1378, 1263, 1126, 1060, 896, 754, 725, 686, 652 cm^{-1}. HRMS (ESI) m/z: calcd for $C_{25}H_{30}NO_2$ $[M + H]^+$, 376.2271; found, 376.2268.

*3-((2-(2-Bromophenyl)benzofuran-3-yl)methyl)-1,3-dimethylindolin-2-one (**3am**).* Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1, v/v) afforded the title compound as a yellow solid (37 mg, 84% yield). mp: 100−102 °C. ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.68 (dd, J = 7.9, 0.8 Hz, 1H), 7.52 (d, J = 7.8 Hz, 1H), 7.41−7.34 (m, 2H), 7.33−7.30 (m, 1H), 7.27−7.23 (m, 1H), 7.22−7.15 (m, 2H), 7.15−7.10 (m, 1H), 6.73 (t, J = 7.5 Hz, 1H), 6.60 (dd, J = 18.0, 7.5 Hz, 2H), 3.33 (q, J = 14.3 Hz, 2H), 2.98 (s, 3H), 1.41 (s, 3H). ^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$): δ 180.2, 154.0, 152.3, 143.1, 133.2, 132.9, 132.7, 132.0, 130.6, 128.9, 127.7, 127.1, 124.3, 124.2, 123.3, 122.3, 122.3, 121.3, 113.4, 110.8, 107.7, 48.8, 32.9, 26.1, 23.5. IR (KBr): 3059, 2958, 2863, 2806, 1712, 1601, 1485, 1453, 1253, 1117, 1066, 962, 923, 801, 742, 694 cm^{-1}. HRMS (ESI) m/z: calcd for $C_{25}H_{20}BrNO_2Na$ $[M + Na]^+$, 470.0552; found, 470.0577.

*3-((2-(3-Bromophenyl)benzofuran-3-yl)methyl)-1,3-dimethylindolin-2-one (**3an**).* Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1, v/v) afforded the title

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compound as a white solid (34 mg, 75% yield). mp: 118−120 °C. ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.55 (d, J = 7.7 Hz, 1H), 7.48−7.42 (m, 3H), 7.41 (d, J = 8.1 Hz, 1H), 7.28−7.25 (m, 1H), 7.25−7.19 (m, 2H), 7.13−7.10 (m, 1H), 6.66−6.62 (m, 2H), 6.59 (dd, J = 7.6, 1.2 Hz, 1H), 3.51 (d, J = 14.4 Hz, 1H), 3.38 (d, J = 14.4 Hz, 1H), 2.96 (s, 3H), 1.53 (s, 3H). ^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$): δ 180.2, 153.7, 151.4, 143.0, 133.1, 132.3, 131.1, 130.5, 129.8, 129.7, 127.8, 126.1, 124.7, 123.6, 122.5, 122.5, 122.0, 121.1, 112.4, 110.8, 107.7, 49.0, 32.7, 26.0, 22.8. IR (KBr): 3062, 2961, 2866, 2803, 1712, 1607, 1482, 1447, 1250, 1111, 1066, 962, 920, 804, 745, 691 cm^{-1}. HRMS (ESI) m/z: calcd for $C_{25}H_{20}BrNO_2Na$ [M + Na]$^+$, 470.0552; found, 470.0562.

*3-((2-(2-Chlorophenyl)benzofuran-3-yl)methyl)-1,3-dimethylindolin-2-one (**3ao**).* Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1, v/v) afforded the title compound as a white solid (33 mg, 83% yield). mp: 124−125 °C. ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.56 (dd, J = 11.4, 7.8 Hz, 1H), 7.49 (dd, J = 8.0, 1.1 Hz, 1H), 7.43−7.37 (m, 2H), 7.32 (m, 1H), 7.28−7.23 (m, 1H), 7.21−7.17 (m, 2H), 7.11−7.10 (m, 1H), 6.71−6.68 (m, 1H), 6.60 (d, J = 7.7 Hz, 1H), 6.55 (d, J = 7.1 Hz, 1H), 3.38 (d, J = 14.3 Hz, 1H), 3.32 (d, J = 14.3 Hz, 1H), 2.95 (s, 3H), 1.41 (s, 3H). ^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$): δ 180.2, 154.1, 151.1, 143.0, 134.3, 132.7, 132.6, 131.5, 130.3, 130.0, 128.9, 127.7, 126.5, 124.3, 123.1, 122.3, 122.2, 121.2, 113.6, 110.8, 107.6, 48.8, 32.9, 26.0, 23.5. IR (KBr): 3053, 2967, 2922, 2854, 1712, 1610, 1491, 1451, 1250, 1118, 1099, 929, 821, 747, 714, 700, 654 cm^{-1}. HRMS (ESI) m/z: calcd for $C_{25}H_{20}ClNO_2Na$ [M + Na]$^+$, 424.1074; found, 424.1096.

*3-((2-(3-Chlorophenyl)benzofuran-3-yl)methyl)-1,3-dimethylindolin-2-one (**3ap**).* Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1, v/v) afforded the title compound as a yellow solid (31 mg, 77% yield). mp: 115−117 °C. ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.54 (dd, J = 7.8, 0.5 Hz, 1H), 7.44−7.38 (m, 2H), 7.35 (d, J = 1.0 Hz, 1H), 7.33−7.29 (m, 2H), 7.30−7.25 (m, 1H), 7.23−7.19 (m, 1H), 7.11−7.10 (m, 1H), 6.66−6.58 (m, 3H), 3.52 (d, J = 14.4 Hz, 1H), 3.40 (d, J = 14.4 Hz, 1H), 2.96 (s, 3H), 1.53 (s, 3H). ^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$): δ 180.2, 153.7, 151.6, 143.0, 134.4, 132.9, 132.4, 129.7, 129.6, 128.2, 127.8, 127.7, 125.7, 124.7, 123.61, 122.4, 122.0, 121.1, 112.4, 110.8, 107.6, 49.0, 32.8, 26.0, 22.8. IR (KBr): 3049, 2959, 2922, 2849, 1712, 1612, 1491, 1450, 1251, 1120, 1095, 927, 717, 701, 654 cm^{-1}. HRMS (ESI) m/z: calcd for $C_{25}H_{20}ClNO_2Na$ [M + Na]$^+$, 424.1074; found, 424.1095.

*3-(Benzofuran-3-ylmethyl)-1,3-dimethylindolin-2-one (**3aq**).* Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1, v/v) afforded the title compound as a white solid (7 mg, 22% yield). mp: 157−159 °C. ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.40 (d, J = 7.8 Hz, 1H), 7.34 (d, J = 8.1 Hz, 1H), 7.23−7.18 (m, 3H), 7.17−7.12 (m, 1H), 7.07−7.02 (m, 1H), 7.00 (s, 1H), 6.68 (d, J = 7.5 Hz, 1H), 3.27 (d, J = 14.4 Hz, 1H), 3.14 (d, J = 14.4 Hz, 1H), 3.01 (s, 3H), 1.55 (s, 3H). ^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$): δ 180.1, 154.7, 143.4, 142.93, 133.4, 128.0, 128.0, 123.9, 123.0, 122.3, 122.2, 120.1, 115.2, 111.0, 108.0, 49.0, 32.4, 26.0, 23.0. IR (KBr): 3045, 2971, 2927, 2867, 1708, 1611, 1511, 1453, 1373, 1273, 1256, 1135, 1069, 833, 753, 718, 686, 635 cm^{-1}. HRMS (ESI) m/z: calcd for $C_{19}H_{18}NO_2$ [M + H]$^+$, 292.1332; found, 292.1359.

*3-((5-Chloro-2-phenylbenzofuran-3-yl)methyl)-1,3-dimethylindolin-2-one (**3as**).* Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1, v/v) afforded the title compound as a yellow solid (35 mg, 88% yield). mp: 107−109 °C. ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.56−7.53 (m, 2H), 7.45−7.37 (m, 3H), 7.31 (d, J = 2.1 Hz, 1H), 7.29 (d, J = 3.0 Hz, 1H), 7.17 (dd, J = 8.6, 2.1 Hz, 1H), 7.12−7.11 (m, 1H), 6.69−6.66 (m, 1H), 6.64−6.60 (m, 2H), 3.51 (d, J = 14.5 Hz, 1H), 3.40 (d, J = 14.4 Hz, 1H), 2.98 (s, 3H), 1.49 (s, 3H). ^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$): δ 180.2, 154.8, 152.0, 143.0, 132.6, 131.2, 130.7, 128.7, 128.5, 128.0, 127.9, 127.8, 124.3, 123.6, 122.1, 120.6, 111.6, 111.2, 107.6, 49.0, 32.9, 26.0, 23.1. IR (KBr): 3059, 2955, 2925, 2851, 1715, 1611, 1492, 1448, 1260, 1121, 1079, 800, 751, 698 cm^{-1}. HRMS (ESI) m/z: calcd for $C_{25}H_{20}ClNO_2Na$ [M + Na]$^+$, 424.1074; found, 424.1072.

*3-((5-Bromo-2-phenylbenzofuran-3-yl)methyl)-1,3-dimethylindolin-2-one (**3at**).* Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1, v/v) afforded the title compound as a yellow solid (40 mg, 90% yield). mp: 110−112 °C. ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.57−7.53 (m, 2H), 7.46−7.38 (m, 4H), 7.30 (dd, J = 8.6, 2.0 Hz, 1H), 7.24 (d, J = 8.6 Hz, 1H), 7.12−7.11 (m, 1H), 6.71−6.68 (m, 1H), 6.65−6.60 (m, 2H), 3.50 (d, J = 14.5 Hz, 1H), 3.39 (d, J = 14.4 Hz, 1H), 2.99 (s, 3H), 1.48 (s, 3H). ^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$): δ 180.2, 154.6, 152.3, 143.0, 132.6, 131.7, 130.6, 128.8, 128.5, 128.0, 127.9, 127.0, 123.6, 123.6, 122.1, 115.30, 112.1, 111.0, 107.6, 49.0, 32.9, 26.1, 23.0. IR (KBr): 3056, 2955, 2922, 2854, 1706, 1613, 1491, 1453, 1256, 1116, 1066, 801, 748, 691 cm^{-1}. HRMS (ESI) m/z: calcd for $C_{25}H_{20}BrNO_2Na$ [M + Na]$^+$, 470.0552; found, 470.0572.

*1,3-Dimethyl-3-((5-methyl-2-phenylbenzofuran-3-yl)methyl)-indolin-2-one (**3au**).* Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1, v/v) afforded the title compound as a yellow solid (35 mg, 92% yield). mp: 112−114 °C. ^{1}H NMR (500 MHz, CDCl3): δ 7.52 (dd, J = 8.3, 1.3 Hz, 2H), 7.42−7.37 (m, 2H), 7.37−7.34 (m, 1H), 7.28 (d, J = 5.8 Hz, 1H), 7.17 (s, 1H), 7.09 (m, 1H), 7.05 (dd, J = 8.3, 1.3 Hz, 1H), 6.67−6.60 (m, 3H), 3.54 (d, J = 14.4 Hz, 1H), 3.38 (d, J = 14.4 Hz, 1H), 3.00 (s, 3H), 2.42 (s, 3H), 1.50 (s, 3H). ^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$): δ 180.5, 153.4, 152.1, 143.0, 132.9, 131.5, 131.4, 130.1, 128.4, 128.2, 127.7, 127.7, 125.4, 123.9, 122.0, 120.8, 111.2, 110.1, 107.5, 49.1, 32.8, 26.0, 22.9, 21.4. IR (KBr): 3053, 2957, 2916, 2848, 1716, 1606, 1493, 1462, 1257, 1118, 1065, 799, 752, 692 cm^{-1}. HRMS (ESI) m/z: calcd for $C_{26}H_{23}NO_2Na$ [M + Na]$^+$, 404.1621; found, 404.1621.

*3-((5-(tert-Butyl)-2-phenylbenzofuran-3-yl)methyl)-1,3-dimethylindolin-2-one (**3av**).* Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1, v/v) afforded the title compound as a yellow solid (39 mg, 92% yield). mp: 109−111 °C. ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.52 (d, J = 6.9 Hz, 3H), 7.41 (t, J = 7.4 Hz, 2H), 7.38−7.31 (m, 3H), 7.09−7.06 (m, 1H), 6.64−6.57 (m, 2H), 6.54 (d, J = 7.3 Hz, 1H), 3.64 (d, J = 14.4 Hz, 1H), 3.42 (d, J = 14.4 Hz, 1H), 2.99 (s, 3H), 1.49 (s, 3H), 1.41 (s, 9H). ^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$): δ 180.5, 153.5, 151.9, 145.2, 142.9, 132.7, 131.5, 129.6, 128.4, 128.2, 127.8, 127.6, 123.9, 122.1, 122.0, 117.3, 111.5, 109.9, 107.4, 49.2, 34.8, 32.6, 31.9, 26.0, 22.8. IR (KBr): 3027, 2958, 2920, 2854, 1706, 1610, 1494, 1447, 1259, 1117, 1069, 798, 751, 691 cm^{-1}. HRMS (ESI) m/z: calcd for $C_{29}H_{29}NO_2Na$ [M + Na]$^+$, 446.2090; found, 446.2090.

*1,3-Dimethyl-3-((2-phenyl-5-(trifluoromethyl)benzofuran-3-yl)-methyl)indolin-2-one (**3ax**).* Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1, v/v) afforded the title compound as a yellow solid (34 mg, 77% yield). mp: 121−122 °C. ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.60 (dd, J = 8.2, 1.3 Hz, 3H), 7.48−7.43 (m, 5H), 7.12−7.09 (m, 1H), 6.70−6.67 (m, 1H), 6.65−6.62 (m, 1H), 6.59 (d, J = 7.8 Hz, 1H), 3.57 (d, J = 14.5 Hz, 1H), 3.48 (d, J = 14.4 Hz, 1H), 2.93 (s, 3H), 1.49 (s, 3H). ^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$): δ 180.1, 155.2, 154.9, 143.0, 132.5, 130.5, 129.8, 129.0, 128.6, 128.1, 127.9, 124.9 (d, J_{C-F} = 32.0 Hz), 123.5, 122.2, 121.1 (d, J_{C-F} = 3.5 Hz), 118.8 (d, J_{C-F} = 4.0 Hz), 111.7, 111.0, 107.6, 49.0, 32.8, 25.9, 23.1. ^{19}F NMR (75 MHz, $CDCl_3$): δ −58.6. IR (KBr): 3033, 2975, 2922, 2871, 1725, 1617, 1497, 1375, 1266, 1120, 1056, 819, 753, 721, 694, 632 cm^{-1}. HRMS (ESI) m/z: calcd for $C_{26}H_{20}F_3NO_2Na$ [M + Na]$^+$, 458.1338; found, 458.1340.

*Synthesis of Compound **8**.* DIBAL-H (1.0 M in hexane, 4.8 mL, 4.8 mmol) was added dropwise to a solution of product **3aa** (220.2 mg, 0.6 mmol) in toluene (6.0 mL) at −78 °C. After stirring at −78 °C for 3 h, the mixture was quenched with 2.0 N NaOH (aq) and extracted with ethyl acetate. The combined organic extracts were dried over Na_2SO_4 and evaporated under reduced pressure. The residue was purified by flash chromatography on silica gel (petroleum ether/ethyl acetate = 10:1, v/v) to afford the corresponding product **8** as a white solid in an 84% yield (178.2 mg). mp: 120−121 °C. ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.80 (dd, J = 5.2, 3.3 Hz, 2H), 7.54 (d, J = 9.0 Hz, 2H), 7.47−7.41 (m, 2H), 7.39−7.35 (m, 1H), 7.35−7.31 (m, 1H), 7.26 (dd, J = 8.4, 7.4 Hz, 1H), 7.15−7.12 (m, 1H), 6.94 (dd, J = 7.2, 0.8 Hz, 1H), 6.66−6.63 (m, 1H), 6.55 (d, J = 7.8 Hz, 1H),

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3.34 (d, J = 8.8 Hz, 1H), 3.28 (d, J = 2.7 Hz, 2H), 2.76 (d, J = 8.8 Hz, 1H), 2.70 (s, 3H), 1.34 (s, 3H). $^{13}C\{^1H\}$ NMR (126 MHz, $CDCl_3$): δ 153.8, 152.5, 152.3, 137.6, 131.8, 131.7, 128.5, 128.1, 127.9, 127.3, 124.2, 122.5, 122.3, 120.6, 117.8, 113.3, 110.9, 107.3, 68.0, 46.2, 35.5, 33.4, 24.2. IR (KBr): 3053, 2957, 2928, 2862, 1675, 1603, 1489, 1453, 1255, 1109, 1059, 969, 919, 807, 745, 692 cm^{-1}. HRMS (ESI) m/z: calcd for $C_{25}H_{23}NONa$ $[M + Na]^+$, 376.1671; found, 376.1669.

■ ASSOCIATED CONTENT

Supporting Information

The Supporting Information is available free of charge at https://pubs.acs.org/doi/10.1021/acs.joc.1c00617.

X-ray analysis data of single-crystal **3da** and copies of ^1H, ^{19}F, and $^{13}C\{^1H\}$ NMR spectra for all new compounds (PDF)

Accession Codes

CCDC 2013828 contains the supplementary crystallographic data for this paper. These data can be obtained free of charge via www.ccdc.cam.ac.uk/data_request/cif, or by emailing data_request@ccdc.cam.ac.uk, or by contacting The Cambridge Crystallographic Data Centre, 12 Union Road, Cambridge CB2 1EZ, UK; fax: +44 1223 336033.

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Notes

The authors declare no competing financial interest.

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