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# Copper-Catalyzed Three-Component Reaction for Regioselective Aryl- and Heteroarylselenation of Indoles using Selenium Powder

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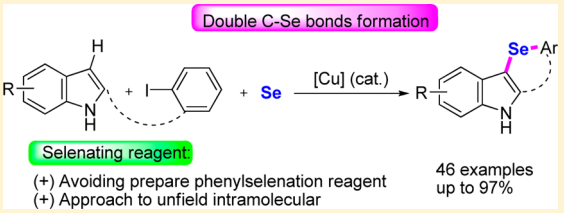
Supporting Information

**ABSTRACT:** A new and efficient copper-catalyzed $C_3$ aryl- and heteroarylselenation of indoles employing selenium powder has been developed. The advantages of this chemistry involve the use of cheap selenating reagents, tolerance of a variety of functional groups, and practicality. In addition, this protocol has been further elaborated in an intramolecular phenylselenation of a (hetero) aryl C−H bond to construct an important motif of benzoselenopheno[3,2-*b*]indole. A preliminary mechanism study suggests that the reaction starts with a Ullman-type selenation between aryl iodides and selenium, followed by an oxidative cross-coupling with indole. The utility of this method has been demonstrated in an efficient gram-scale synthesis and an application to the synthesis of tubulin polymerization inhibitor.




## INTRODUCTION

Selective C−Se bond formation is of great importance in modern organic synthesis, since selenium-containing architectures are prevalent in a diverse of drug candidates, biologically active compounds, and functional organic materials.[1] Considering the significance of organoselenium compounds, especially the 3-selenylindoles[2] display antitumor activity[3] and act as an inhibitor of tubulin polymerization.[4] Therefore, the development of a new synthetic route for the introduction of a stable, economical selenium reagent into organic skeletons would be of significant synthetic value.

In recent years, transition-metal-catalyzed cross-coupling reactions have become the most important methdology for the construction of C−Se bonds.[5] On the basis of the selenium source, there are two general methods for the construction of C−Se bonds to synthesize diaryl selenides. The first approach involves a transition-metal-catalyzed cross-coupling reaction between prefunctionalized aryl substrates and nucleophilic organoselenium reagents (selenol,[6] $ArSeSnR_3$,[7] diselenides[8]) under basic condtions. Whereas arylselenols have been used as the original material to prepare these phenylselenation reagents,[6] most arylselenols suffer from difficulties in handling because of their unpleasant odors and instability, which hamper their applications in the pharmaceutical industry. Recently, the direct transformation phenylselenation of inert C−H bonds with diaryl selenides has emerged as a complementary route.[9] However, most of these reactions are highly problematic due to the loss of 1 equiv of $PhSe^-$ as waste, requiring external copper or silver salts as oxidants. The second recent avenue is transition-metal-catalyzed C−Se bond formation using elemental selenium as the selenating reagent, which is mainly limited to affording symmetrical diaryl selenides.[10] The use of selenium powder, which is commercially available, stable, and easily handled, as a cross-coupling partner to construct C−Se bonds is a more straightforward and attractive alternative. However, reports on the activation of the selenium element are scarce.[11] This is presumably due to the affinity of selenium for transition metals, easily forming stable transition-metal selenium clusters,[12] which attenuates the activity of the catalysts. From these wonderful achievements, it is thereby envisioned that the strategy of a single Se atom bridging two cross-coupling partners of $C(sp^2)$−X and $C(sp^2)$−H under transition-metal catalysis might be more practical and economical. Such a method would receive considerable attention in the design of counterintuitive synthetic strategies that are unattainable by other means, such as intramolecular phenylselenation of (hetero)arene C−H bonds. Herein we report a new and efficient copper-catalyzed $C_3$ phenylselenation of indoles through double C−Se bond formation, using (hetero)aryl iodides, elemental selenium, and indoles as reactants.

To achieve the copper-catalyzed arylselenation of indole with selenium powder and aryl iodides, the following issues need to be considered. (i) Free (NH) indole has three accessible reaction positions;[13] in order to achieve high regioselectivity, the catalyst system for the C-arylselenation of indoles should avoid producing N-arylation of the indole under the reaction conditions.[14] (ii) The cleavage of the acidic N−H of indole usually requires basic conditions to enable the nucleophilicity of C3 posiiton; otherwise, if the cleavage of the C−H bond of indole is relatively slow, the symmetrical diaryl diselenides

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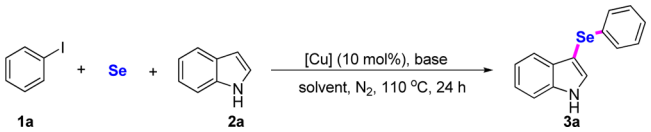
would form from the reaction aryl iodides with elemental selenium by copper catalysis. On the basis of these considerations, strategies to solve these problems involve the development of robust conditions that could match the rate of copper-catalyzed selenation of aryl iodides with elemental selenium and the rate of transmetalation of indole−-metal intermediate species,[15] to suppress undesired side reactions, including the homocoupling of PhSeCu species.

## RESULTS AND DISCUSSION

The project began with the study of the reaction between iodobenzene **1a** and indole **2a**. After initial optimizations, it was found that **2a** was transformed into the desired C3-arylsenelonation product **3a** in 35% isolated yield (Table 1, entry 1), along with a small amount of the diphenyl diselenide byproduct (entry 1). Among the several solvents examined, DMSO was the optimal solvent, affordeing the product in 60% isolated yield (entry 5), and the reaction became sluggish when solvents such as toluene, 1,4-dioxane, and $CH_3CN$ were used (entries 2−4). Among the various copper salts tested, the best result was obtained with CuO, providing the product in 92% yield (entry 9). Then we screened an array of bases; the use of $Na_2CO_3$ and NaOAc gave slightly lower yields (entries 10−13). An $N_2$ atmosphere is essential for this reaction, and when the reaction was conducted under $O_2$ or in air, the yield of the reaction decreased (entries 14 and 15). This is due to the fact that $O_2$ could intercept the catalytic intermediate in the process, and indole is not stable at high $O_2$ concentrations. A control experiment showed that the copper catalyst is essential for this transformation, since no coupling product was obtained in the absence of copper (entry 16). Of particular note, in all cases, the reaction shows excellent regioselectivity and no 2-arylselenolation of indoles or *N*-arylindole byproducts was observed from analysis of the crude reaction mixtures.

**Table 1. Reaction Optimization**[a]




| entry | [Cu] | base | solvent | yield (%)[b] |
|---|---|---|---|---|
| 1 | CuI | $Na_3PO_4{\cdot}12H_2O$ | DMF | 35 |
| 2 | CuI | $Na_3PO_4{\cdot}12H_2O$ | toluene | none |
| 3 | CuI | $Na_3PO_4{\cdot}12H_2O$ | 1,4-dioxane | none |
| 4 | CuI | $Na_3PO_4{\cdot}12H_2O$ | $CH_3CN$ | none |
| 5 | CuI | $Na_3PO_4{\cdot}12H_2O$ | DMSO | 60 |
| 6 | $CuBr_2$ | $Na_3PO_4{\cdot}12H_2O$ | DMSO | 56 |
| 7 | $CuCl_2$ | $Na_3PO_4{\cdot}12H_2O$ | DMSO | 59 |
| 8 | $Cu(OAc)_2$ | $Na_3PO_4{\cdot}12H_2O$ | DMSO | 64 |
| 9 | CuO | $Na_3PO_4{\cdot}12H_2O$ | DMSO | 92 |
| 10 | CuO | $Na_2CO_3$ | DMSO | 75 |
| 11 | CuO | $K_2CO_3$ | DMSO | 79 |
| 12 | CuO | NaOAc | DMSO | 42 |
| 13 | CuO | $K_3PO_4$ | DMSO | 50 |
| 14[c] | CuO | $Na_3PO_4{\cdot}12H_2O$ | DMSO | 31 |
| 15[d] | CuO | $Na_3PO_4{\cdot}12H_2O$ | DMSO | 54 |
| 16 | | $Na_3PO_4{\cdot}12H_2O$ | DMSO | 0 |

[a]Reaction conditions unless specified otherwise: 0.2 mmol of iodobenzene, 0.6 mmol of Se, 0.5 mmol of indole, 0.02 mmol of [Cu], 0.8 mmol of base, 2 mL of solvent, under $N_2$, 110 °C, 24 h. [b]Isolated yield. [c]Under $O_2$. [d]In air.

With the optimal conditions in hand, the scope of the substrates was explored. A wide range of aryl iodides were employed, and the reaction generally proceeded smoothly, affording the corresponding products in good to excellent yields (Scheme 1). When iodobenzenes bearing a variety of electron-donating groups were used, such as methyl (**3b**), methoxy (**3k**), and trifluoromethyl (**3e**), the reactions proceeded smoothly and good yields were obtained. The reaction of iodobenzenes bearing electron-withdrawing groups such as fluoro (**3g**), chloro (**3h**), bromo (**3i**), acetyl (**3j**), aldehyde (**3m**), and nitro (**3n**) gave the corresponding products in moderate to excellent yields. The compatibility of these functional groups in this reaction provided an opportunity for further elaboration to achieve more complex products. It was noteworthy that steric hindrance did not have a great effect on the reaction; for example, when a methyl substituent was located on the C-2, C-3, and C-4 positions of benzene iodide, similar yields of **3b,d,f** were observed. It was remarkable that heterocyclic iodides, such as pyridine, thiophene, and quinoline also provided the corresponding products **3o−q** in good yields.

Furthermore, a diverse array of substituted indoles were subjected to the optimal reaction conditions to explore the scope and generality of this reaction (Scheme 2). A variety of functional groups on the benzene ring of indoles were compatible, such as methyl (**4a,i,o**), fluoride (**4d,j**), chloride (**4k**), bromide (**4e,l**), methoxy (**4b,f,p**), and nitro (**4h**), which had little effect on the reactivity and the regioselectivity of reactions. When methyl and phenyl groups were introduced at the C2 position of the indole, the corresponding products were obtained (**4p−r**) in good yields. The free NH group of the indole was found to play a critical role; the more nucleophilic 1-methylindole (**3s**) and electron-poor N-Ac (**3m**) and N-Ts (**3n**) of indole did not undergo a copper-mediated arylselenation reaction. To investigate whether arylselenation occurred for other heterocyclic compounds such as functionalized pyrroles, benzofurans, thianaphthene, and benzimidazole under the current reaction conditions, however, only slight decomposition of the starting materials was found without formation of the expected products. On the basis of these experimental results, perhaps the relative stability of C3 nucleophilicity of indole was critical to the success of this reaction.

Next, the synthetic method was extended to intramolecular C−Se bond formation, providing a straightforward pathway to synthesize benzoselenopheno[3,2-*b*]indole. As shown in Scheme 3, the cyclization-starting substrates could be easily prepared by use of a Fischer indole synthesis approach. Overall, good to excellent yields of **6** were obtained, and various substituents on the indole ring showed on effect on the efficiency of the reactions. A variety of functional groups such as the electron-donating groups methyl (**6b,k**), methoxy (**6f**), and trifluoromethoxy (**6g**) and the electron-withdrawing groups fluoride (**6c**), chloride (**6d**), and bromide (**6e**) were compatible. Disubstitution on the benzene ring of benzoselenopheno[3,2-*b*]indole could also be obtained (**6h−j**). These results highlight the generality of the new method. The products of intramolecular reactions also could be potential compounds for electronic materials.[16]

The utility of this new method was further demonstrated by an efficient gram-scale synthesis and application to the synthesis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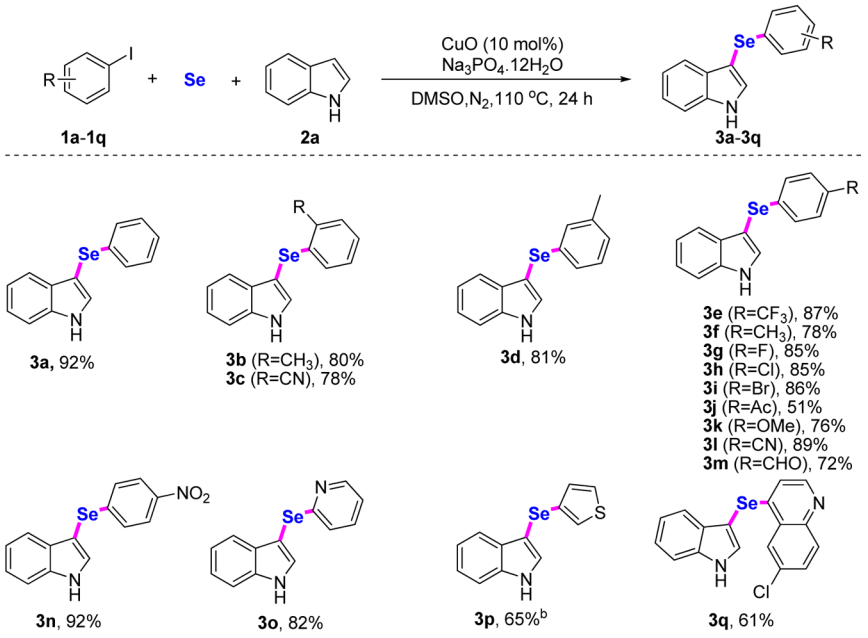
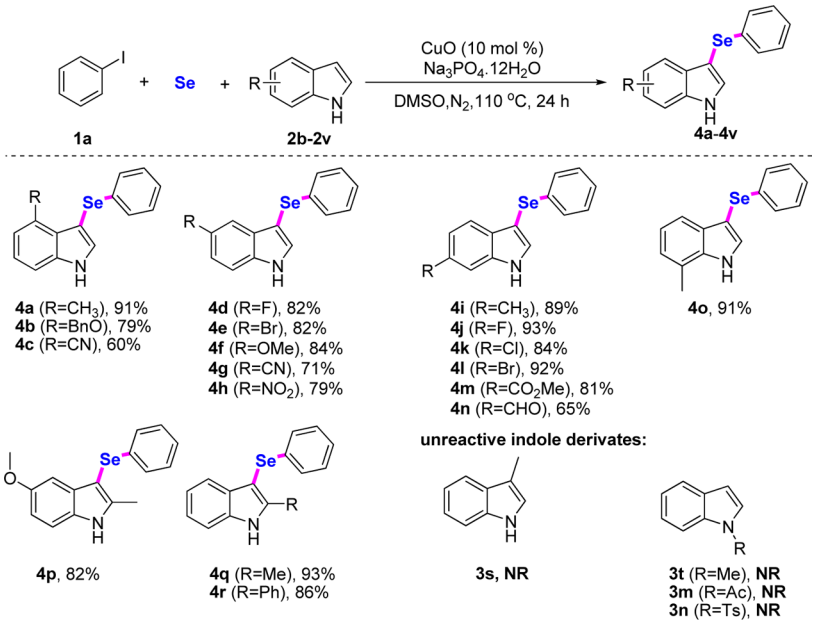
**Scheme 1. Aryl Iodide Scope**[a]




[a]Reaction conditions unless specified otherwise: aryl iodides (0.2 mmol), $Se_8$ (0.6 mmol), indole (0.5 mmol), CuO (0.02 mmol), $Na_3PO_4{\cdot}12H_2O$ (0.8 mmol), DMSO (2 mL), 110 °C, 24 h, $N_2$. Isolated yields are given. [b]CuO (20 mol %).

**Scheme 2. Indole Scope**




of an important inhibitor (Scheme 4). The copper-catalyzed double C−Se bond formation produced 2.14 g of the product **3a** in (79% yield) under standard reaction conditions. In addition, application of the new method in a two-step synthesis of (3-(3,4,5-trimethoxyphenylselenyl)methyl)indole[4] was achieved, a reported efficient inhibitor in tubulin polymerization and disruption of tubulin microtubule dynamics. Subsequent methylation with $CH_3I$ afforded the target product in 68% overall yield.

To understand the reaction mechanism, control experiments were conducted (Scheme 5). First, a stoichiometric reaction of PhSeCu with simple indole under an $N_2$ atmosphere did not promote the reaction, but the desired product **3a** was obtained in 92% isolated yield under an $O_2$ atmosphere. The lack of reactivity with PhSeCu under $N_2$ indicated that the C−Se bond formation of indole probably proceeded through an oxidative cross-coupling pathway. An interesting phenomenon was observed, however, when 3 equiv of selenium powder was added under an $N_2$ atmosphere; 3-phenylselenation of indole **3a** and the byproduct diphenyl selenide were obtained in a 1:1 ratio and the PhSeCu went to full conversion (Scheme 5, eq 2); these experiments could explain why the transformation needs an excess amount of elemental Se. Second, as shown in Scheme 5, eq 3, PhSeCu may be a chemically competent intermediate



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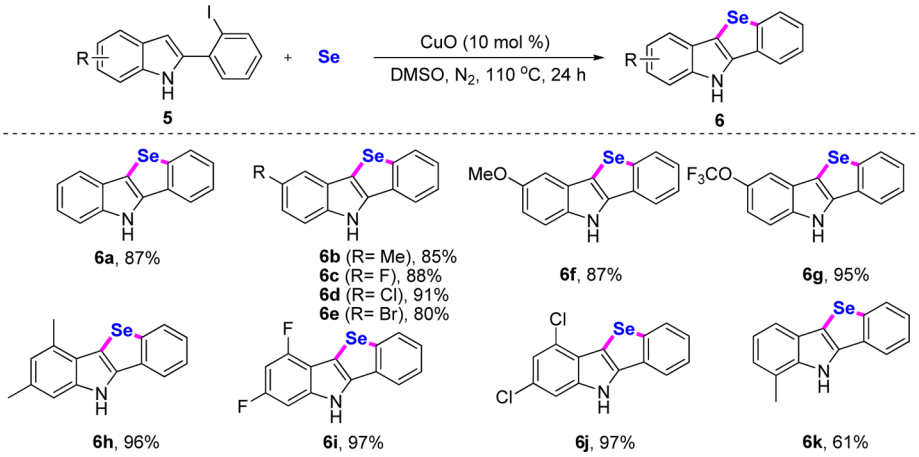
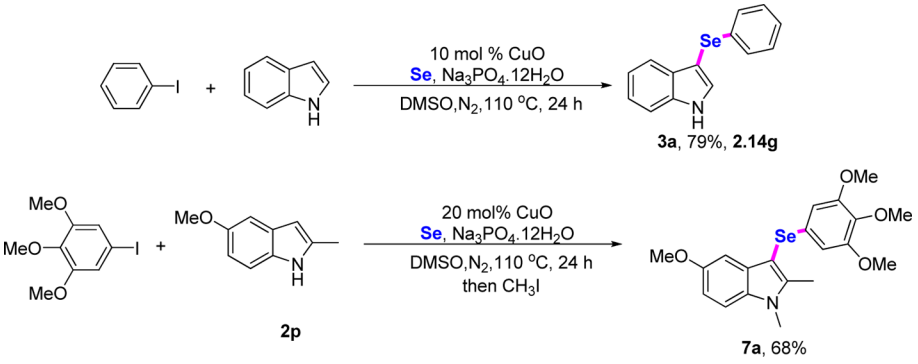
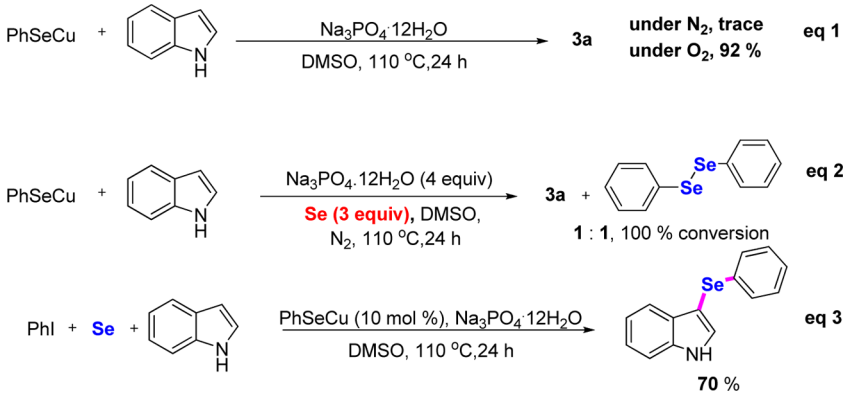
**Scheme 3. Intramolecular C−Se Bond Formation**




**Scheme 4. Gram-Scale Synthesis and Application**




**Scheme 5. Preliminary Mechanism Investigation**




produced in situ during the catalytic cycle. This could also rationalize why a small amount of diphenyl diselenides was detected in the reaction. Finally, when the radical inhibitor TEMPO was added under the reaction conditions, product **3a** was still obtained in 91% yield, which in turn suggested that a radical-involved mechanism could be ruled out.

On the basis of the above observations and related literature,[17] a plausible mechanism for the reaction is proposed (Scheme 6). It is well-known that selenium readily transforms to selenide anion and selenite in the presence of a base.[18] A proposed catalytic cycle could start with an oxidative addition of iodobenzene with CuX, followed by ligand exchange with $Se^{2-}$ to generate the intermediate III. Then, reductive elimination of III will generate the arylselenium anion IV), which reacts with CuX to form the PhSeCu species V. Then, base-assisted metalation of indole with PhSeCu led to VI through instantaneous oxidation of selenite, followed by immediate reductive elimination to provide the desired product and regeneration of the CuX catalyst. At this stage, the role of elemental selenium is vague, but it indeed participates in the oxidation step according to the above experimental results.

In summary, we have developed a new and efficient copper-catalyzed three-component reaction for the selective synthesis of unsymmetrical diphenyl selenides. Commercially available, stable, and easily handled elemental selenium was used as the selenating reagent. In addition, both intermolecular and intramolecular reactions were achieved to construct a linear or cyclic selenating system. Moreover, good to excellent yields



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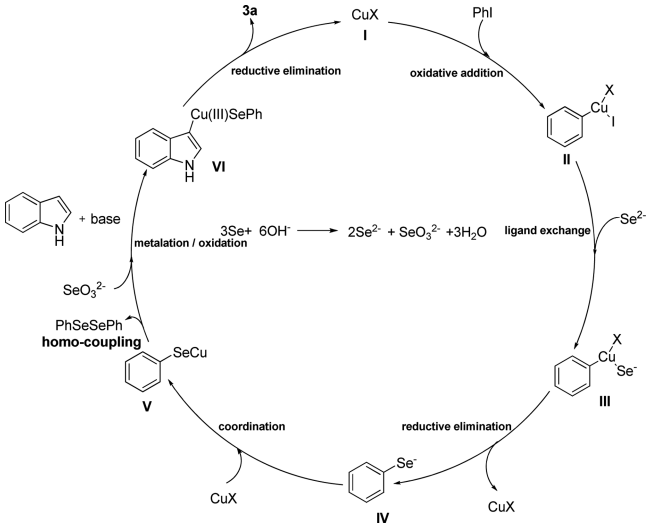
**Scheme 6. Proposed Catalytic Cycle**




were obtained and the reaction can tolerate a wide scope of functional groups. Furthermore, a early mechanism study suggests that copper-catalyzed direct double C−Se bond formation proceeds through the Ullman-type selenation of aryl iodides and selenium and subsequent oxidative cross-coupling with indole. Further studies on the reaction mechanism and the development of new strategies of selective selenation transformations are underway in our laboratory.

## EXPERIMENTAL SECTION

**General Remarks.** $^{1}$H NMR (500 MHz), $^{13}$C NMR (125 MHz), and $^{19}$F NMR (470 MHz) spectra were recorded in DMSO-$d_6$ solutions using a 500 MHz spectrometer. High-resolution mass spectra were recorded on an ESI-Q-TOF mass spectrometer. All reactions were conducted using standard Schlenk techniques. Column chromatography was performed using EM silica gel 60 (300−400 mesh). $^{1}$H NMR and $^{13}$C NMR spectra are provided as Supporting Information. 2-(2-Iodophenyl)-1*H*-indole,[19] 2-(2-iodophenyl)-5-methyl-1*H*-indole,[19] 5-fluoro-2-(2-iodophenyl)-1*H*-indole,[19] 5-chloro-2-(2-iodophenyl)-1*H*-indole,[19] 5-bromo-2-(2-iodophenyl)-1*H*-indole,[19] 2-(2-iodophenyl)-5-methoxy-1*H*-indole,[19] 2-(2-iodophenyl)-5-(trifluoromethoxy)-1*H*-indole,[19] 2-(2-iodophenyl)-4,6-dimethyl-1*H*-indole,[19] 4,6-difluoro-2-(2-iodophenyl)-1*H*-indole,[19] 4,6-dichloro-2-(2-iodophenyl)-1*H*-indole,[19] 2-(2-iodophenyl)-7-methyl-1*H*-indole,[19] and PhSeCu[20] were prepared according to the reported procedures. $^{1}$H and $^{13}$C spectra of known compounds were in accordance with those described in the literature.

**Procedure for Intermolecular Phenylselenation of Indole Reactions.** In a 10 mL Schlenk tube equipped with a stir bar were placed aryl iodide **1** (0.2 mmol), indole **2** (0.5 mmol), Se (47.4 mg, 0.6 mmol), CuO (10 mol %), and $Na_3PO_4{\cdot}12H_2O$ (0.8 mmol) in DMSO (2 mL). The tube was evacuated and refilled with $N_2$ three times. The reaction mixture was stirred at 110 °C for 24 h. After it was cooled, the reaction mixture was diluted with 10 mL of ethyl ether and filtered through a pad of silica gel, followed by washing the pad of silica gel with the same solvent (20 mL). The filtrate was washed with water (3 × 15 mL). The organic phase was dried over $Na_2SO_4$, filtered, and concentrated under reduced pressure. The residue was then purified by flash chromatography on silica gel to provide the corresponding product.

**Procedure for Intramolecular Phenylselenation of Indole Reactions.** In a 10 mL Schlenk tube equipped with a stir bar were placed substrate **5** (0.2 mmol), Se (47.4 mg, 0.6 mmol), CuO (10 mol %), and $Na_3PO_4{\cdot}12H_2O$ (0.8 mmol) in DMSO (2 mL). The tube was evacuated and refilled with $N_2$ three times. The reaction mixture was stirred at 110 °C for 24 h. After it was cooled, the reaction mixture was diluted with 10 mL of ethyl ether and filtered through a pad of silica gel, followed by washing the pad of silica gel with the same solvent (20 mL). The filtrate was washed with water (3 × 15 mL). The organic phase was dried over $Na_2SO_4$, filtered, and concentrated under reduced pressure. The residue was then purified by flash chromatography on silica gel to provide the corresponding product.

**Preliminary Mechanism Investigation.** In two 10 mL Schlenk tubes equipped with a stir bar were placed PhSeCu (0.2 mmol), indole (0.5 mmol), and $Na_3PO_4{\cdot}12H_2O$ (0.8 mmol) in DMSO (2 mL). The first tube was evacuated and refilled with $N_2$ three times. The other tube was fitted with a rubber septum and then evacuated and refilled with $O_2$ three times. These reaction mixtures were stirred at 110 °C for 24 h (see Scheme 5, eq 1). In a 10 mL Schlenk tube equipped with a stir bar were placed PhSeCu (0.2 mmol), Se (31.6 mg, 0.4 mmol), indole (0.5 mmol), and $Na_3PO_4{\cdot}12H_2O$ (0.8 mmol) in DMSO (2 mL). The tube was evacuated and refilled with $N_2$ three times. The reaction mixture was stirred at 110 °C for 24 h (see Scheme 5, eq 2). In a 10 mL Schlenk tube equipped with a stir bar were placed aryl iodide **1** (0.2 mmol), indole **2** (0.5 mmol), Se (47.4 mg, 0.6 mmol), PhSeCu (10 mol %), and $Na_3PO_4{\cdot}12H_2O$ (0.8 mmol) in DMSO (2 mL). The tube was evacuated and refilled with $N_2$ three times. The reaction mixture was stirred at 110 °C for 24 h (see Scheme 5, eq 3). After it was cooled, the reaction mixture was diluted with 10 mL of ethyl ether and filtered through a pad of silica gel, followed by washing the pad of silica gel with the same solvent (20 mL). The filtrate was washed with water (3 × 15 mL). The organic phase was dried over $Na_2SO_4$, filtered, and concentrated under reduced pressure. The residue was then purified by flash chromatography on silica gel to provide the corresponding product.

**Characterization Data of Compounds 3, 4, 6, and 7a.** *3-(Phenylseleno)-1H-indole (**3a**).* Following the general procedure, using 7/1 petroleum ether/EtOAc as the eluant afforded a white solid (50.2 mg, 92% yield). The $^{1}$H and $^{13}$C NMR spectra were in accordance with those described in the literature.[21]

*3-(o-Tolylseleno)-1H-indole (**3b**).* Following the general procedure, using 7/1 petroleum ether/EtOAc as the eluant afforded a white solid (45.6 mg, 80% yield). The $^{1}$H and $^{13}$C NMR spectra were in accordance with those described in the literature.[22]

*2-((1H-Indol-3-yl)seleno)benzonitrile (**3c**).* Following the general procedure with 0.04 mmol of CuO, using 7/1 petroleum ether/EtOAc as the eluant afforded a brown solid (46.6 mg, 78% yield), mp 103−105 °C. $^{1}$H NMR (500 MHz, DMSO-$d_6$): $\delta$ 11.85 (s, 1H), 7.84 (d, $J$ = 2.5 Hz, 1H), 7.80 (d, $J$ = 7.5 Hz, 1H), 7.53 (d, $J$ = 8.5 Hz, 1H), 7.41−7.36 (m, 2H), 7.29 (t, $J$ = 7.5 Hz, 1H), 7.21 (t, $J$ = 7.5 Hz, 1H), 7.10 (t, $J$ = 7.5 Hz, 1H), 6.90 (d, $J$ = 8.0 Hz, 1H). $^{13}$C NMR (125 MHz, DMSO-$d_6$): $\delta$ 139.1, 136.7, 133.6, 133.6, 133.5, 129.1, 128.7, 126.3, 122.2, 120.4, 118.6, 117.3, 112.3, 110.8, 93.0. HRMS (EI, 70 eV): calcd for $C_{15}H_{10}N_2Se$ [M$^+$] 298.0009, found 298.0013.

*3-(m-Tolylseleno)-1H-indole (**3d**).* Following the general procedure, using 7/1 petroleum ether/EtOAc as the eluant afforded a brown viscous oil (46.3 mg, 81% yield). $^{1}$H NMR (500 MHz, DMSO-$d_6$): $\delta$ 11.67 (s, 1H), 7.73 (d, $J$ = 2.5 Hz, 1H), 7.49 (d, $J$ = 8.0 Hz, 1H), 7.42 (d, $J$ = 8.0 Hz, 1H), 7.17 (t, $J$ = 7.5 Hz, 1H), 7.08−7.02 (m, 3H), 6.91 (d, $J$ = 7.5 Hz, 2H), 2.16 (s, 3H). $^{13}$C NMR (125 MHz, DMSO-$d_6$): $\delta$ 138.3, 136.6, 133.5, 132.7, 129.5, 128.9, 128.6, 126.4, 125.3, 121.9, 120.0, 119.0, 112.1, 95.1, 20.8. HRMS (EI, 70 eV): calcd for $C_{15}H_{13}NSe$ [M$^+$] 287.0213, found 287.0214.

*3-((4-(Trifluoromethyl)phenyl)seleno)-1H-indole (**3e**).* Following the general procedure, using 7/1 petroleum ether/EtOAc as the eluant afforded a yellowish solid (59.1 mg, 87% yield), mp 123−124 °C. $^{1}$H NMR (500 MHz, DMSO-$d_6$): $\delta$ 11.79 (s, 1H), 7.80 (s, 1H), 7.53−7.49 (m, 3H), 7.38 (d, $J$ = 7.5 Hz, 1H), 7.31 (d, $J$ = 7.5 Hz, 2H), 7.20 (t, $J$ = 7.0 Hz, 1H), 7.08 (t, $J$ = 7.0 Hz, 1H). $^{13}$C NMR (125 MHz, DMSO): $\delta$ 140.4, 136.7, 133.3, 129.2, 128.0, 126.0 (d, $J_F$ = 31.3 Hz), 125.6 (q, $J_F$ = 5.0 Hz), 124.3 (d, $J_F$ = 270.0 Hz), 122.2, 120.3, 118.8, 112.3, 93.7. $^{19}$F NMR (470 MHz, DMSO-$d_6$): $\delta$ −60.86 (s, 3F). HRMS (ESI): calcd for $C_{15}H_{10}F_3NSe$ [M + Na]$^+$ 363.9823, found 363.9827.

*3-(p-Tolylseleno)-1H-indole (**3f**).* Following the general procedure, using 7/1 petroleum ether/EtOAc as the eluant afforded a white solid



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(44.6 mg, 78% yield). The $^{1}H$ and $^{13}C$ NMR spectra were in accordance with those described in the literature.[21]

*3-((4-Fluorophenyl)seleno)-1H-indole* (**3g**). Following the general procedure with 0.04 mmol of CuO, using 7/1 petroleum ether/EtOAc as the eluant afforded a brown solid (49.3 mg, 85% yield), mp 135−136 °C. $^{1}H$ NMR (500 MHz, DMSO-$d_6$): $\delta$ 11.68 (s, 1H), 7.74 (s, 1H), 7.48 (d, $J$ = 8.0 Hz, 1H), 7.41 (d, $J$ = 8.0 Hz, 1H), 7.22−7.16 (m, 3H), 7.09−7.02 (m, 3H). $^{13}C$ NMR (125 MHz, DMSO-$d_6$): $\delta$ 160.8 (d, $J_F$ = 241.3 Hz), 136.6, 132.7, 130.3 (d, $J_F$ = 7.5 Hz), 129.30, 128.4 (d, $J_F$ = 3.8 Hz), 122.0, 120.1, 118.9, 116.1 (d, $J_F$ = 22.5 Hz), 112.1, 95.4. $^{19}F$ NMR (470 MHz, DMSO-$d_6$): $\delta$ −117.40 (s, 1F). HRMS (EI, 70 eV): calcd for $C_{14}H_{10}FNSe$ [$M^+$] 290.9962, found 290.9962.

*3-((4-Chlorophenyl)seleno)-1H-indole* (**3h**). Following the general procedure, using 7/1 petroleum ether/EtOAc as the eluant afforded a white solid (52.4 mg, 85% yield). The $^{1}H$ and $^{13}C$ NMR spectra were in accordance with those described in the literature.[21]

*3-((4-Bromophenyl)seleno)-1H-indole* (**3i**). Following the general procedure, using 7/1 petroleum ether/EtOAc as the eluant afforded a brown solid (60.6 mg, 86% yield), mp 131−135 °C. $^{1}H$ NMR (500 MHz, DMSO-$d_6$): $\delta$ 11.73 (s, 1H), 7.76 (s, 1H), 7.49 (d, $J$ = 8.0 Hz, 1H), 7.39−7.34 (m, 3H), 7.18 (t, $J$ = 7.5 Hz, 1H), 7.09−7.06 (m, 3H). $^{13}C$ NMR (125 MHz, DMSO-$d_6$): $\delta$ 136.6, 133.3, 132.9, 131.8, 130.0, 129.2, 122.1, 120.1, 118.8, 118.6, 112.2, 94.5. HRMS (EI, 70 eV): calcd for $C_{14}H_{10}BrNSe$ [$M^+$] 350.9162, found 350.9162.

*1-(4-((1H-Indol-3-yl)seleno)phenyl)ethan-1-one* (**3j**). Following the general procedure with 0.04 mmol of CuO, using 7/1 petroleum ether/EtOAc as the eluant afforded a yellow solid (32.1 mg, 51% yield), mp 139−141 °C. $^{1}H$ NMR (500 MHz, DMSO-$d_6$): $\delta$ 11.78 (s, 1H), 7.79 (d, $J$ = 2.5 Hz, 1H), 7.73 (d, $J$ = 8.5 Hz, 2H), 7.52 (d, $J$ = 8.0 Hz, 1H), 7.36 (d, $J$ = 8.0 Hz, 1H), 7.24−7.18 (m, 3H), 7.09−7.06 (m, 1H), 2.47 (s, 3H). $^{13}C$ NMR (125 MHz, DMSO-$d_6$): $\delta$ 197.0, 141.6, 136.7, 134.1, 133.1, 129.2, 128.7, 127.3, 122.1, 120.2, 118.8, 112.2, 93.8, 26.4. HRMS (EI, 70 eV): calcd for $C_{16}H_{13}NOSe$ [$M^+$] 315.0162, found 315.0168.

*3-((4-Methoxyphenyl)seleno)-1H-indole* (**3k**). Following the general procedure with 0.04 mmol of CuO, using 7/1 petroleum ether/EtOAc as the eluant afforded a white solid (45.9 mg, 76% yield), mp 113−115 °C. $^{1}H$ NMR (500 MHz, DMSO-$d_6$): $\delta$ 11.58 (s, 1H), 7.69 (s, 1H), 7.45 (t, $J$ = 8.0 Hz, 2H), 7.20−7.14 (m, 7.4 Hz, 3H), 7.06 (t, $J$ = 7.0 Hz, 1H), 6.78 (d, $J$ = 7.5 Hz, 2H), 3.66 (s, 3H). $^{13}C$ NMR (125 MHz, DMSO-$d_6$): $\delta$ 157.9, 136.5, 132.1, 130.7, 129.4, 123.0, 121.8, 119.8, 119.0, 114.8, 111.9, 96.5, 55.0. HRMS (EI, 70 eV): calcd for $C_{15}H_{13}NOSe$ [$M^+$] 303.0162, found 303.0159.

*4-((1H-Indol-3-yl)seleno)benzonitrile* (**3l**). Following the general procedure with 0.04 mmol of CuO, using 7/1 petroleum ether/EtOAc as the eluant afforded a brown liquid (52.9 mg, 89% yield). $^{1}H$ NMR (500 MHz, DMSO-$d_6$): $\delta$ 11.83 (s, 1H), 7.80 (s, 1H), 7.58 (d, $J$ = 7.5 Hz, 2H), 7.53 (d, $J$ = 8.0 Hz, 1H), 7.36 (d, $J$ = 8.0 Hz, 1H), 7.26 (d, $J$ = 8.0 Hz, 2H), 7.21 (t, $J$ = 7.5 Hz, 1H), 7.09 (t, $J$ = 7.5 Hz, 1H). $^{13}C$ NMR (125 MHz, DMSO-$d_6$): $\delta$ 142.5, 136.7, 133.4, 132.4, 129.1, 128.0, 122.3, 120.4, 118.9, 118.7, 112.3, 107.7, 93.3. HRMS (EI, 70 eV): calcd for $C_{15}H_{10}N_2Se$ [$M^+$] 298.0009, found 298.0008.

*4-((1H-Indol-3-yl)seleno)benzaldehyde* (**3m**). Following the general procedure, using 7/1 petroleum ether/EtOAc as the eluant afforded a yellow solid (43.1 mg, 72% yield), mp 143−145 °C. $^{1}H$ NMR (500 MHz, DMSO-$d_6$): $\delta$ 11.81 (s, 1H), 9.85 (s, 1H), 7.80 (d, $J$ = 2.5 Hz, 1H), 7.67 (d, $J$ = 8.0, 2H), 7.52 (d, $J$ = 8.0 Hz, 1H), 7.37 (d, $J$ = 8.0 Hz, 1H), 7.31 (d, $J$ = 8.0 Hz, 2H), 7.20 (t, $J$ = 7.5 Hz, 1H), 7.08 (t, $J$ = 7.5 Hz, 1H). $^{13}C$ NMR (125 MHz, DMSO-$d_6$): $\delta$ 192.1, 143.9, 136.7, 133.7, 133.3, 129.9, 129.2, 127.6, 122.2, 120.3, 118.8, 112.3, 93.5. HRMS (ESI): calcd for $C_{15}H_{11}NOSe$ [$M + H]^+$ 302.0079, found 302.0080.

*3-((4-Nitrophenyl)seleno)-1H-indole* (**3n**). Following the general procedure with 0.04 mmol of CuO, using 7/1 petroleum ether/EtOAc as the eluant afforded a yellow liquid (58.3 mg, 92% yield). $^{1}H$ NMR (500 MHz, DMSO-$d_6$): $\delta$ 11.86 (s, 1H), 8.00 (d, $J$ = 8.5 Hz, 2H), 7.82 (s, 1H), 7.54 (d, $J$ = 8.0 Hz, 1H), 7.37−7.33 (m, 3H), 7.21 (t, $J$ = 7.5 Hz, 1H), 7.09 (t, $J$ = 7.0 Hz, 1H). $^{13}C$ NMR (125 MHz, DMSO-$d_6$): $\delta$ 145.5, 145.3, 136.7, 133.4, 129.1, 127.8, 123.8, 122.3, 120.4, 118.7, 112.3, 93.2. HRMS (EI, 70 eV): calcd for $C_{14}H_{10}N_2O_2Se$ [$M^+$] 317.9907, found 317.9912.

*3-(Pyridin-2-ylseleno)-1H-indole* (**3o**). Following the general procedure, using 7/1 petroleum ether/EtOAc as the eluant afforded a white solid (44.8 mg, 82% yield), mp 103−104 °C. $^{1}H$ NMR (500 MHz, DMSO-$d_6$): $\delta$ 11.75 (s, 1H), 8.37 (s, 1H), 7.76 (s, 1H), 7.51 (d, $J$ = 8.0 Hz, 1H), 7.44−7.40 (m, 2H), 7.20 (t, $J$ = 7.0 Hz, 1H), 7.10−7.08 (m, 2H), 6.70 (d, $J$ = 7.5 Hz, 1H). $^{13}C$ NMR (125 MHz, DMSO-$d_6$): $\delta$ 159.2, 149.5, 136.9, 136.7, 133.1, 129.3, 122.1, 121.9, 120.2 (2C), 118.9, 112.2, 94.5. HRMS (ESI): calcd for $C_{13}H_{10}N_2Se$ [$M + H]^+$ 275.0082, found 275.0088.

*3-(Thiophen-3-ylseleno)-1H-indole* (**3p**). Following the general procedure, using 7/1 petroleum ether/EtOAc as the eluant afforded a yellow viscous oil (36.1 mg, 65% yield). $^{1}H$ NMR (500 MHz, DMSO-$d_6$): $\delta$ 11.58 (s, 1H), 7.70 (t, $J$ = 2.0 Hz, 1H), 7.53−7.42 (m, 3H), 7.23−7.12 (m, 2H), 7.08 (t, $J$ = 7.5 Hz, 1H), 6.91 (d, $J$ = 5.0 Hz, 1H). $^{13}C$ NMR (125 MHz, DMSO-$d_6$): $\delta$ 136.4, 131.8, 129.7, 129.3, 127.0, 126.1, 123.0, 121.9, 119.86, 119.0, 112.0, 96.2. HRMS (ESI): calcd for $C_{12}H_9NSSe$ [$M + H]^+$ 279.9694, found 279.9704.

*4-((1H-Indol-3-yl)seleno)-7-chloroquinoline* (**3q**). Following the general procedure, using 7/1 petroleum ether/EtOAc as the eluant afforded a yellow solid (43.6 mg, 61% yield), mp 176−177 °C. $^{1}H$ NMR (500 MHz, DMSO-$d_6$): $\delta$ 11.94 (s, 1H), 8.45 (d, $J$ = 4.0 Hz, 1H), 8.21 (d, $J$ = 8.5 Hz, 1H), 8.08 (s, 1H), 7.89 (s, 1H), 7.75 (d, $J$ = 8.5 Hz, 1H), 7.56 (d, $J$ = 8.0 Hz, 1H), 7.36 (d, $J$ = 8.0 Hz, 1H), 7.23 (t, $J$ = 7.5 Hz, 1H), 7.09 (t, $J$ = 7.5 Hz, 1H), 6.79 (d, $J$ = 4.0 Hz, 1H). $^{13}C$ NMR (125 MHz, DMSO-$d_6$): $\delta$ 150.7, 147.6, 146.6, 136.9, 134.4, 133.9, 129.1, 128.2, 127.5, 126.7, 125.7, 122.3, 120.5, 120.2, 118.7, 112.4, 91.3. HRMS (ESI): calcd for $C_{17}H_{11}ClN_2Se$ [$M + H]^+$ 358.9849, found 358.9864.

*4-Methyl-3-(phenylseleno)-1H-indole* (**4a**). Following the general procedure, using 7/1 petroleum ether/EtOAc as the eluant afforded a brown solid (52.2 mg, 91% yield), mp 141−142 °C. $^{1}H$ NMR (500 MHz, DMSO-$d_6$): $\delta$ 11.66 (s, 1H), 7.66 (d, $J$ = 2.5 Hz, 1H), 7.33 (d, $J$ = 8.0 Hz, 1H), 7.20−7.09 (m, 5H), 7.04 (t, $J$ = 7.5 Hz, 1H), 6.77 (d, $J$ = 7.0 Hz, 1H), 2.57 (s, 3H). $^{13}C$ NMR (125 MHz, DMSO-$d_6$): $\delta$ 137.1, 136.1, 133.8, 130.1, 129.1, 127.5, 126.7, 125.3, 122.0, 121.5, 110.2, 93.8, 18.4. HRMS (EI, 70 eV): calcd for $C_{15}H_{13}NSe$ [$M^+$] 287.0213, found 287.0215.

*4-(Benzyloxy)-3-(phenylseleno)-1H-indole* (**4b**). Following the general procedure, using 7/1 petroleum ether/EtOAc as the eluant afforded a dark purple liquid (59.8 mg, 79% yield). $^{1}H$ NMR (500 MHz, DMSO-$d_6$): $\delta$ 11.61 (s, 1H), 7.49 (d, $J$ = 2.5 Hz, 1H), 7.29−7.27 (m, 2H), 7.25−7.21 (m, 3H), 7.20−7.15 (m, 4H), 7.11−7.04 (m, 3H), 6.61 (d, $J$ = 7.5 Hz, 1H), 5.07 (s, 2H). $^{13}C$ NMR (125 MHz, DMSO-$d_6$): $\delta$ 152.6, 138.7, 137.3, 135.5, 131.8, 128.8, 128.2, 127.9, 127.1, 126.8, 125.2, 122.7, 118.6, 105.4, 101.7, 93.0, 68.8. HRMS (EI, 70 eV): calcd for $C_{21}H_{17}NOSe$ [$M^+$] 379.0475, found 379.0478.

*3-(Phenylseleno)-1H-indole-4-carbonitrile* (**4c**). Following the general procedure, using 7/1 petroleum ether/EtOAc as the eluant afforded a yellow solid (35.7 mg, 60% yield). The $^{1}H$ and $^{13}C$ NMR spectra were in accordance with those described in the literature.[22]

*5-Fluoro-3-(phenylseleno)-1H-indole* (**4d**). Following the general procedure, using 7/1 petroleum ether/EtOAc as the eluant afforded a brown solid (47.5 mg, 82% yield), mp 126−128 °C. $^{1}H$ NMR (500 MHz, DMSO-$d_6$): $\delta$ 11.81 (s, 1H), 7.82 (s, 1H), 7.52−7.48 (m, 1H), 7.19−7.00 (m, 7H). $^{13}C$ NMR (125 MHz, DMSO-$d_6$): $\delta$ 157.6 (d, $J_F$ = 231.3 Hz), 134.8, 133.3 (d, $J_F$ = 11.3 Hz), 130.2 (d, $J_F$ = 10.0 Hz), 129.1, 128.2, 125.7, 113.4 (d, $J_F$ = 8.8 Hz), 110.3 (d, $J_F$ = 26.3 Hz), 103.6 (d, $J_F$ = 23.8 Hz), 95.1. $^{19}F$ NMR (470 MHz, DMSO-$d_6$): $\delta$ −123.42 (s, 1F). HRMS (EI, 70 eV): calcd for $C_{14}H_{10}FNSe$ [$M^+$] 290.9962, found 290.9969.

*5-Bromo-3-(phenylseleno)-1H-indole* (**4e**). Following the general procedure, using 7/1 petroleum ether/EtOAc as the eluant afforded a brown solid (57.6 mg, 82% yield). The $^{1}H$ and $^{13}C$ NMR spectra were in accordance with those described in the literature.[21]

*5-Methoxy-3-(phenylseleno)-1H-indole* (**4f**). Following the general procedure, using 7/1 petroleum ether/EtOAc as the eluant afforded a brown viscous oil (50.7 mg, 84% yield). The $^{1}H$ and $^{13}C$ NMR spectra were in accordance with those described in the literature.[21]



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*3-(Phenylseleno)-1H-indole-5-carbonitrile (**4g**).* Following the general procedure, using 7/1 petroleum ether/EtOAc as the eluant afforded a brown solid (42.2 mg, 71% yield), mp 141−143 °C. $^1$H NMR (500 MHz, DMSO-$d_6$): $\delta$ 12.23 (s, 1H), 7.98 (s, 1H), 7.83 (s, 1H), 7.67 (d, $J$ = 8.5 Hz, 1H), 7.53 (d, $J$ = 8.5 Hz, 1H), 7.20−7.14 (m, 5H). $^{13}$C NMR (125 MHz, DMSO-$d_6$): $\delta$ 138.6, 135.5, 132.8, 129.4, 129.2, 128.5, 126.0, 124.8, 124.3, 120.2, 113.6, 102.3, 96.5. HRMS (EI, 70 eV): calcd for $C_{15}H_{10}N_2Se$ [M$^+$] 298.0009, found 298.0014.

*5-Nitro-3-(phenylseleno)-1H-indole (**4h**).* Following the general procedure with 0.04 mmol of Cu, using 7/1 petroleum ether/EtOAc as the eluant afforded a yellow solid (50.1 mg, 79% yield), mp 141−143 °C. $^1$H NMR (500 MHz, DMSO-$d_6$): $\delta$ 12.39 (s, 1H), 8.29 (s, 1H), 8.08 (d, $J$ = 11.5 Hz, 2H), 7.69 (d, $J$ = 8.5 Hz, 1H), 7.23−7.14 (m, 5H). $^{13}$C NMR (125 MHz, DMSO-$d_6$): $\delta$ 141.5, 139.9, 136.7, 132.6, 129.2, 129.1, 128.5, 126.0, 117.3, 115.6, 112.8, 98.1. HRMS (EI, 70 eV): calcd for $C_{14}H_{10}N_2O_2Se$ [M$^+$] 317.9907, found 317.9915.

*6-Methyl-3-(phenylseleno)-1H-indole (**4i**).* Following the general procedure, using 7/1 petroleum ether/EtOAc as the eluant afforded a yellow solid (51.0 mg, 89% yield), mp 140−143 °C. $^1$H NMR (500 MHz, DMSO-$d_6$): $\delta$ 11.52 (s, 1H), 7.63 (s, 1H), 7.27 (d, $J$ = 5.5 Hz, 2H), 7.17−7.09 (m, 5H), 6.89 (d, $J$ = 8.0 Hz, 1H), 2.40 (s, 3H). $^{13}$C NMR (125 MHz, DMSO-$d_6$): $\delta$ 137.0, 133.8, 132.0, 131.2, 129.0, 128.0, 127.4, 125.5, 121.8, 118.7, 111.8, 94.7, 21.2. HRMS (EI, 70 eV): calcd for $C_{15}H_{13}NSe$ [M$^+$] 287.0213, found 287.0216.

*6-Fluoro-3-(phenylseleno)-1H-indole (**4j**).* Following the general procedure, using 7/1 petroleum ether/EtOAc as the eluant afforded a brown solid (53.9 mg, 93% yield), mp 131−132 °C. $^1$H NMR (500 MHz, DMSO-$d_6$): $\delta$ 11.75 (s, 1H), 7.74 (s, 1H), 7.36 (dd, $J$ = 8.5, 5.0 Hz, 1H), 7.28 (d, $J$ = 9.5 Hz, 1H), 7.16−7.10 (m, 5H), 6.94−6.91 (m, 1H). $^{13}$C NMR (125 MHz, DMSO-$d_6$): $\delta$ 159.2, (d, $J_F$ = 233.8 Hz), 136.4 (d, $J_F$ = 13.8 Hz), 133.4 (d, $J_F$ = 12.5 Hz), 129.1, 128.2, 126.2, 125.7, 120.1 (d, $J_F$ = 10.0 Hz), 108.6 (d, $J_F$ = 25 Hz), 98.1 (d, $J_F$ = 26.3 Hz), 95.3. $^{19}$F NMR (470 MHz, DMSO-$d_6$): $\delta$ −121.07 (s, 1F). HRMS (EI, 70 eV): calcd for $C_{14}H_{10}FNSe$ [M$^+$] 290.9962, found 290.9969.

*6-Chloro-3-(phenylseleno)-1H-indole (**4k**).* Following the general procedure, using 7/1 petroleum ether/EtOAc as the eluant afforded a brown solid (51.6 mg, 84% yield), mp 127−130 °C. $^1$H NMR (500 MHz, DMSO-$d_6$): $\delta$ 11.82 (s, 1H), 7.79 (s, 1H), 7.55−7.54 (m, 1H), 7.40−7.38 (m, 1H), 7.18−7.07 (m, 6H). $^{13}$C NMR (125 MHz, DMSO-$d_6$): $\delta$ 136.9, 133.8, 133.2, 129.0, 128.3, 128.2, 126.7, 125.7, 120.3, 111.7, 95.5. HRMS (EI, 70 eV): calcd for $C_{14}H_{10}ClNSe$ [M$^+$] 306.9667, found 306.9672.

*6-Bromo-3-(phenylseleno)-1H-indole (**4l**).* Following the general procedure, using 7/1 petroleum ether/EtOAc as the eluant afforded a brown solid (64.6 mg, 92% yield), mp 126−127 °C. $^1$H NMR (500 MHz, DMSO-$d_6$): $\delta$ 11.80 (s, 1H), 7.77 (s, 1H), 7.68 (s, 1H), 7.34 (d, $J$ = 8.5 Hz, 1H), 7.21−7.10 (m, 6H). $^{13}$C NMR (125 MHz, DMSO-$d_6$): $\delta$ 137.5, 133.8, 133.3, 129.1, 128.6, 128.2, 125.7, 123.0, 120.8, 114.8, 114.7, 95.4. HRMS (EI, 70 eV): calcd for $C_{14}H_{10}BrNSe$ [M$^+$] 350.9162, found 350.9168.

*Methyl 3-(Phenylseleno)-1H-indole-6-carboxylate (**4m**).* Following the general procedure, using 7/1 petroleum ether/EtOAc as the eluant afforded a white solid (53.5 mg, 81% yield), mp 144−146 °C. $^1$H NMR (500 MHz, DMSO-$d_6$): $\delta$ 12.07 (s, 1H), 8.15 (s, 1H), 7.99 (d, $J$ = 2.0 Hz, 1H), 7.70 (d, $J$ = 8.0 Hz, 1H), 7.50 (d, $J$ = 8.5 Hz, 1H), 7.19−7.10 (m, 5H), 3.86 (s, 3H). $^{13}$C NMR (125 MHz, DMSO-$d_6$): $\delta$ 166.9, 136.4, 135.9, 133.2, 133.2, 129.1, 128.2, 125.7, 123.2, 120.6, 118.9, 114.0, 95.7, 51.7. HRMS (EI, 70 eV): calcd for $C_{16}H_{13}NO2Se$ [M$^+$] 331.0112, found 331.0115.

*3-(Phenylseleno)-1H-indole-6-carbaldehyde (**4n**).* Following the general procedure, using 7/1 petroleum ether/EtOAc as the eluant afforded a brown solid (39.1 mg, 65% yield), mp 144−147 °C. $^1$H NMR (500 MHz, DMSO-$d_6$): $\delta$ 12.24 (s, 1H), 10.03 (s, 1H), 8.06 (d, $J$ = 10.0 Hz, 2H), 7.61 (d, $J$ = 8.0 Hz, 1H), 7.56 (d, $J$ = 8.5 Hz, 1H), 7.18−7.10 (m, 5H). $^{13}$C NMR (125 MHz, DMSO-$d_6$): $\delta$ 192.6, 137.2, 136.1, 134.3, 133.0, 131.1, 129.1, 128.3, 125.8, 119.9, 119.5, 115.9, 96.2. HRMS (EI, 70 eV): calcd for $C_{15}H_{11}NOSe$ [M$^+$] 301.0006, found 301.0013.

*7-Methyl-3-(phenylseleno)-1H-indole (**4o**).* Following the general procedure, using 7/1 petroleum ether/EtOAc as the eluant afforded a brown liquid (52.1 mg, 91% yield). $^1$H NMR (500 MHz, DMSO-$d_6$): $\delta$ 11.71 (s, 1H), 7.75 (d, $J$ = 2.5 Hz, 1H), 7.30−7.28 (m, 1H), 7.19−7.13 (m, 4H), 7.08 (t, $J$ = 7.0 Hz, 1H), 6.99 (d, $J$ = 6.5 Hz, 2H), 2.54 (s, 3H). $^{13}$C NMR (125 MHz, DMSO-$d_6$): $\delta$ 136.1, 133.8, 132.3, 129.3, 128.9, 128.1, 125.4, 122.5, 121.3, 120.1, 116.6, 95.5, 16.6. HRMS (EI, 70 eV): calcd for $C_{15}H_{13}NSe$ [M$^+$] 287.0213, found 287.0208.

*5-Methoxy-2-methyl-3-(phenylseleno)-1H-indole (**4p**).* Following the general procedure, using 7/1 petroleum ether/EtOAc as the eluant afforded a yellow liquid (51.9 mg, 82% yield). $^1$H NMR (500 MHz, DMSO-$d_6$): $\delta$ 11.48 (s, 1H), 7.27 (d, $J$ = 9.0 Hz, 1H), 7.18−7.15 (m, 2H), 7.11−7.08 (m, 3H), 6.80 (d, $J$ = 2.5 Hz, 1H), 6.74 (dd, $J$ = 9.0, 2.5 Hz, 1H), 3.69 (s, 3H), 2.45 (s, 3H). $^{13}$C NMR (125 MHz, DMSO-$d_6$): $\delta$ 154.1, 142.2, 133.7, 131.4, 130.9, 129.1, 127.8, 125.4, 111.9, 110.8, 100.6, 93.3, 55.3, 12.7. HRMS (EI, 70 eV): calcd for $C_{16}H_{15}NOSe$ [M$^+$] 317.0319, found 317.0319.

*2-Methyl-3-(phenylseleno)-1H-indole (**4q**).* Following the general procedure, using 7/1 petroleum ether/EtOAc as the eluant afforded a white solid (53.1 mg, 93% yield). The $^1$H and $^{13}$C NMR spectra were in accordance with those described in the literature.[21]

*2-Phenyl-3-(phenylseleno)-1H-indole (**4r**).* Following the general procedure, using 7/1 petroleum ether/EtOAc as the eluant afforded a yellow viscous oil (59.9 mg, 86% yield). The $^1$H and $^{13}$C NMR spectra were in accordance with those described in the literature.[21]

*1-H-Benzo[4,5]selenopheno[3,2-b]indole (**6a**).* Following the general procedure, using 7/1 petroleum ether/EtOAc as the eluant afforded a brown solid (47.0 mg, 87% yield), mp 232−234 °C. $^1$H NMR (500 MHz, DMSO-$d_6$): $\delta$ 12.15 (s, 1H), 8.09 (t, $J$ = 7.5 Hz, 2H), 7.76 (d, $J$ = 8.0 Hz, 1H), 7.58 (d, $J$ = 8.0 Hz, 1H), 7.49 (t, $J$ = 7.5 Hz, 1H), 7.30 (t, $J$ = 7.5 Hz, 1H), 7.25 (t, $J$ = 7.0 Hz, 1H), 7.13 (t, $J$ = 7.5 Hz, 1H). $^{13}$C NMR (125 MHz, DMSO-$d_6$): $\delta$ 141.7, 139.8, 139.0, 129.2, 127.6, 124.9, 124.4, 124.3, 122.6, 121.4, 119.3, 119.3, 112.3, 110.9. HRMS (ESI): calcd for $C_{14}H_{10}NSe$ [M + H]$^+$ 271.9973, found 271.9980.

*3-Methyl-10H-benzo[4,5]selenopheno[3,2-b]indole (**6b**).* Following the general procedure, using 7/1 petroleum ether/EtOAc as the eluant afforded a dark brown solid (48.3 mg, 85% yield), mp 239−240 °C. $^1$H NMR (500 MHz, DMSO-$d_6$): $\delta$ 12.02 (s, 1H), 8.09−8.04 (m, 2H), 7.53 (s, 1H), 7.49−7.45 (m, 2H), 7.29 (t, $J$ = 7.5 Hz, 1H), 7.08 (d, $J$ = 8.0 Hz, 1H), 2.42 (s, 3H). $^{13}$C NMR (125 MHz, DMSO-$d_6$): $\delta$ 141.6, 139.1, 138.2, 129.3, 128.0, 127.6, 125.0, 124.5, 124.3, 124.2, 121.3, 118.9, 112.1, 110.4, 21.2. HRMS (ESI): calcd for $C_{15}H_{12}NSe$ [M + H]$^+$ 286.0129, found 286.0119.

*3-Fluoro-10H-benzo[4,5]selenopheno[3,2-b]indole (**6c**).* Following the general procedure, using 7/1 petroleum ether/EtOAc as the eluant afforded a light brown solid (50.7 mg, 88% yield), mp 238−240 °C. $^1$H NMR (500 MHz, DMSO-$d_6$): $\delta$ 12.26 (s, 1H), 8.11−8.07 (m, 2H), 7.65 (d, $J$ = 9.5 Hz, 1H), 7.56 (dd, $J$ = 8.5, 4.5 Hz, 1H), 7.49 (t, $J$ = 7.5 Hz, 1H), 7.32 (t, $J$ = 7.5 Hz, 1H), 7.09 (t, $J$ = 9.0 Hz, 1H). $^{13}$C NMR (125 MHz, DMSO): $\delta$ 156.8 (d, $J_F$ = 231.3 Hz), 142.1, 140.9, 136.5, 129.0, 127.7, 125.0, 124.8, 124.5 (d, $J_F$ = 11.3 Hz), 121.6, 113.2 (d, $J_F$ = 10.0 Hz), 110.7 (t, $J_F$ = 5.0 Hz), 110.5, 104.5 (d, $J_F$ = 25.0 Hz). $^{19}$F NMR (470 MHz, DMSO-$d_6$): $\delta$ −123.9 (s, 1F). HRMS (ESI): calcd for $C_{14}H_9FNSe$ [M + H]$^+$ 289.9879, found 289.9893.

*3-Chloro-10H-benzo[4,5]selenopheno[3,2-b]indole (**6d**).* Following the general procedure, using 7/1 petroleum ether/EtOAc as the eluant afforded a brown solid (55.4 mg, 91% yield), mp 263−265 °C. $^1$H NMR (500 MHz, DMSO-$d_6$): $\delta$ 12.38 (s, 1H), 8.11−8.09 (m, 2H), 7.94 (s, 1H), 7.59 (d, $J$ = 9.0 Hz, 1H), 7.49 (t, $J$ = 7.5 Hz, 1H), 7.32 (t, $J$ = 7.5 Hz, 1H), 7.24 (d, $J$ = 8.5 Hz, 1H). $^{13}$C NMR (125 MHz, DMSO-$d_6$): $\delta$ 142.3, 140.6, 138.3, 128.9, 127.7, 125.4, 125.1, 124.9, 123.7, 122.4, 121.7, 118.8, 113.7, 110.4. HRMS (ESI): calcd for $C_{14}H_9ClNSe$ [M + H]$^+$ 305.9583, found 305.9585.

*3-Bromo-10H-benzo[4,5]selenopheno[3,2-b]indole (**6e**).* Following the general procedure, using 7/1 petroleum ether/EtOAc as the eluant afforded a brown solid (55.9 mg, 80% yield), mp 263−264 °C. $^1$H NMR (500 MHz, DMSO-$d_6$): $\delta$ 12.37 (s, 1H), 8.07−8.12 (m, 3H), 7.54 (d, $J$ = 8.5 Hz, 1H), 7.49 (t, $J$ = 7.5 Hz, 1H), 7.36−7.31 (m, 2H).



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$^{13}$C NMR (125 MHz, DMSO-$d_6$): δ 142.3, 140.4, 138.5, 128.8, 127.7, 126.1, 125.0, 124.9, 124.9, 121.8, 121.6, 114.2, 111.5, 110.2. HRMS (ESI): calcd for $C_{14}H_9BrNSe$ $[M + H]^+$ 349.9078, found 349.9090.

*3-Methoxy-10H-benzo[4,5]selenopheno[3,2-b]indole* (**6f**). Following the general procedure, using 7/1 petroleum ether/EtOAc as the eluant afforded a brown solid (52.3 mg, 87% yield), mp 214−215 °C. $^1$H NMR (500 MHz, DMSO-$d_6$): δ 11.98 (s, 1H), 8.07 (d, $J$ = 8.0 Hz, 1H), 8.04 (d, $J$ = 8.0 Hz, 1H), 7.47 (t, $J$ = 7.5 Hz, 2H), 7.32 (s, 1H), 7.28 (t, $J$ = 7.5 Hz, 1H), 6.89−6.87 (m, 1H), 3.81 (s, 3H). $^{13}$C NMR (125 MHz, DMSO-$d_6$): δ 153.5, 141.6, 139.6, 134.8, 129.4, 127.6, 124.9, 124.6, 124.3, 121.3, 113.0, 112.8, 110.5, 101.2, 55.4. HRMS (ESI): calcd for $C_{15}H_{12}NOSe$ $[M + H]^+$ 302.0079, found 302.0079.

*3-(Trifluoromethoxy)-10H-benzo[4,5]selenopheno[3,2-b]indole* (**6g**). Following the general procedure, using 7/1 petroleum ether/EtOAc as the eluant afforded a light brown solid (67.3 mg, 95% yield), mp 222−223 °C. $^1$H NMR (500 MHz, DMSO-$d_6$): δ 12.45 (s, 1H), 8.11 (t, $J$ = 8.5 Hz, 2H), 7.93 (s, 1H), 7.66−7.63 (m, 1H), 7.50 (t, $J$ = 6.5 Hz, 1H), 7.34 (t, $J$ = 6.5 Hz, 1H), 7.22 (d, $J$ = 7.5 Hz, 1H). $^{13}$C NMR (125 MHz, DMSO-$d_6$): δ 142.4, 141.7, 141.1, 138.3, 128.9, 127.7, 125.1, 125.0, 124.5, 121.7, 120.5 (q, $J_F$ = 252.5 Hz), 116.1, 113.2, 112.1, 111.0. $^{19}$F NMR (470 MHz, DMSO-$d_6$): δ −56.9 (s, 3F). HRMS (ESI): calcd for $C_{15}H_9F_3NOSe$ $[M + H]^+$ 355.9796, found 355.9812.

*2,4-Dimethyl-10H-benzo[4,5]selenopheno[3,2-b]indole* (**6h**). Following the general procedure, using 7/1 petroleum ether/EtOAc as the eluant afforded a white solid (57.2 mg, 96% yield), mp 205−206 °C. $^1$H NMR (500 MHz, DMSO-$d_6$): δ 11.97 (s, 1H), 8.08 (dd, $J$ = 12.0, 8.0 Hz, 2H), 7.48 (t, $J$ = 7.5 Hz, 1H), 7.27 (t, $J$ = 7.5 Hz, 1H), 7.19 (s, 1H), 6.78 (s, 1H), 2.55 (s, 3H), 2.42 (s, 3H). $^{13}$C NMR (125 MHz, DMSO-$d_6$): δ 141.8, 140.1, 137.6, 132.3, 129.2, 127.9, 127.6, 125.0, 123.8, 122.3, 121.3, 121.2, 110.1, 109.9, 21.5, 18.8. HRMS (ESI): calcd for $C_{16}H_{14}NSe$ $[M + H]^+$ 300.0286, found 300.0276.

*2,4-Difluoro-10H-benzo[4,5]selenopheno[3,2-b]indole* (**6i**). Following the general procedure, using 7/1 petroleum ether/EtOAc as the eluant afforded a brown solid (59.4 mg, 97% yield), mp 197−199 °C. $^1$H NMR (500 MHz, DMSO-$d_6$): δ 12.65 (s, 1H), 8.13 (dd, $J$ = 16.0, 8.0 Hz, 2H), 7.52 (t, $J$ = 7.5 Hz, 1H), 7.36−7.30 (m, 2H), 7.02 (t, $J$ = 10.5 Hz, 1H). $^{13}$C NMR (125 MHz, DMSO-$d_6$): δ 158.8 (dd, $J_F$ = 11.3, 237.5 Hz), 154.2 (dd, $J_F$ = 16.3, 245.0 Hz), 141.9, 141.3 (dd, $J_F$ = 12.5, 15.0 Hz), 139.5 (d, $J_F$ = 2.5 Hz), 128.5, 127.8, 125.3, 124.8, 121.7, 110.3 (d, $J_F$ = 21.3 Hz), 106.7, 95.5 (dd, $J_F$ = 3.8, 26.3 Hz), 94.8 (dd, $J_F$ = 22.5, 28.8 Hz). $^{19}$F NMR (470 MHz, DMSO-$d_6$): δ −116.8 (s, 1F), 120.2 (s, 1F). HRMS (ESI): calcd for $C_{14}H_8F_2NSe$ $[M + H]^+$ 307.9785, found 307.9788.

*2,4-Dichloro-10H-benzo[4,5]selenopheno[3,2-b]indole* (**6j**). Following the general procedure, using 7/1 petroleum ether/EtOAc as the eluant afforded a yellowish solid (65.8 mg, 97% yield), mp 218−219 °C. $^1$H NMR (500 MHz, DMSO-$d_6$): δ 12.70 (s, 1H), 8.15 (t, $J$ = 6.5 Hz, 2H), 7.65 (s, 1H), 7.53 (t, $J$ = 7.0 Hz, 1H), 7.37 (t, $J$ = 7.0 Hz, 1H), 7.33 (s, 1H). $^{13}$C NMR (125 MHz, DMSO-$d_6$): δ 142.5, 140.4, 140.2, 128.3, 127.8, 127.0, 125.3, 125.2, 124.1, 122.0, 121.9, 118.7, 111.3, 109.2. HRMS (ESI): calcd for $C_{14}H_8Cl_2NSe$ $[M + H]^+$ 339.9194, found 339.9185.

*1-Methyl-10H-benzo[4,5]selenopheno[3,2-b]indole* (**6k**). Following the general procedure, using 7/1 petroleum ether/EtOAc as the eluant afforded a dark brown solid (34.7 mg, 61% yield). $^1$H NMR (500 MHz, DMSO-$d_6$): δ 11.91 (s, 1H), 8.22 (d, $J$ = 7.5 Hz, 1H), 8.08 (d, $J$ = 8.0 Hz, 1H), 7.58 (d, $J$ = 6.5 Hz, 1H), 7.49 (t, $J$ = 7.5 Hz, 1H), 7.29 (t, $J$ = 7.5 Hz, 1H), 7.04 (d, $J$ = 7.0 Hz, 2H), 2.59 (s, 3H). $^{13}$C NMR (125 MHz, DMSO-$d_6$): δ 141.6, 139.4, 138.9, 129.5, 127.6, 124.9, 124.3, 124.0, 123.2, 121. 7, 121.6, 119.5, 117.0, 111.5, 17.1. HRMS (ESI): calcd for $C_{15}H_{12}NSe$ $[M + H]^+$ 286.0129, found 286.0119.

*5-Methoxy-1,2-dimethyl-3-((3,4,5-trimethoxyphenyl)seleno)-1H-indole* (**7a**). Following the general procedure, using 7/1 petroleum ether/EtOAc as the eluant afforded a white solid (57.1 mg, 68% yield). The $^1$H and $^{13}$C NMR spectra were in accordance with those described in the literature.[4]

## ■ ASSOCIATED CONTENT

### Ⓢ Supporting Information

The Supporting Information is available free of charge on the ACS Publications website at DOI: 10.1021/acs.joc.6b00229.

$^1$H, $^{13}$C, and $^{19}$F NMR and HRMS spectral data of all compounds reported (PDF)

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### Notes

The authors declare no competing financial interest.

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