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Synthesis of Fused 1-Aminoindole Polycycles by a Sequence of Palladium-Catalyzed N−H and C(sp^2)−H Arylations

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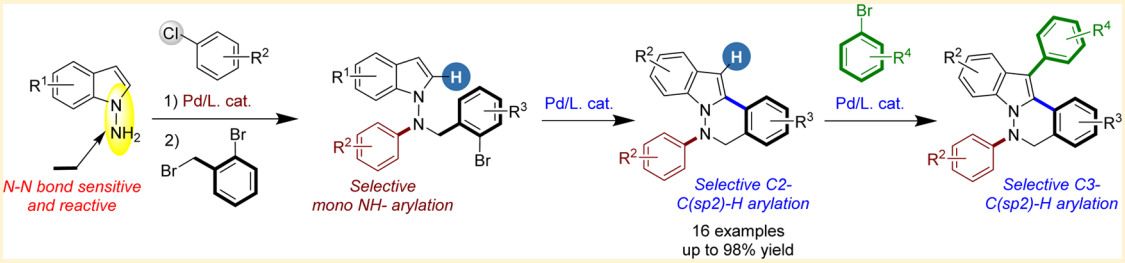
Supporting Information



ABSTRACT: An efficient Pd-catalyzed selective intramolecular arylation of functionalized *N*,*N*′-substituted 1-aminoindoles has been reported. In all cases, the reactions take place rapidly in DMA and efficiently proceed in the presence of a $Pd(OAc)_2$/Dpephos catalytic system, furnishing the fused indolo[2,1-*a*]phthalazines in high yields. Additionally, the one-pot double C−H arylation at positions C-2 and C-3 of *N*,*N*′-substituted 1-aminoindoles is effective and leads to unknown complex scaffolds of biological interest.

1. INTRODUCTION

The transition metal-catalyzed functionalization of C−H bonds has attracted considerable attention as a useful alternative to traditional methods used for carbon−carbon bond formation.[1] This approach avoids the need for stoichiometric amounts of the organometallic reagent, some of which are toxic or must be prepared through multistep procedures. In particular, the intramolecular version of this approach was used as a powerful tool for the synthesis of fused heterocycles such as fused indole frameworks, which are present in a plethora of biologically active compounds and are probably the most important nitrogen-containing heterocyclic compounds of all structural classes in drug discovery.[2] Although direct C−H arylation of indoles at positions C-2[3] and C-3[4] has been extensively studied, to the best of our knowledge, there is no previously reported study involving 1-aminoindoles in a direct C−H arylation approach to fused 1-aminoindole heterocycle synthesis.[5]

As part of our effort to develop efficient methods for the functionalization of heterocycles via transition metal catalysis for generating an original collection of nitrogen-containing molecules,[6] we envisioned that *N*-aryl-*N*′-benzyl-1-aminoindoles of type **2** could be utilized as partners in an intramolecular direct C-2 arylation approach to fused indolo[2,1-*a*]phthalazine synthesis (Scheme 1). This modular strategy is conceptually attractive in terms of diversifying the 1-aminoindole frameworks with the aim of identifying new scaffolds of biological interest. However, a number of potential limitations exist. The first is the metal-mediated N−N bond cleavage[7] of the *N*-aryl-*N*′-benzyl-1-aminoindoles that results in the formation of undesired indole byproducts. Second, and most importantly, the limitation arises when more than one activated hydrogen is available (Scheme 1), which can lead to a mixture of byproducts. Therefore, the development of a selective and general method for the direct arylation of *N*-aryl-*N*′-benzyl-1-aminoindoles is strongly desirable and presents an interesting challenge. Herein, we report our success in the development of such a protocol.

2. RESULTS AND DISCUSSION

To achieve our goal, we initially prepared selectively a series of *N*-monoarylated 1-aminoindoles **1a**−**k** in good to excellent yield (57−98%) by coupling of various substituted 1-aminoindoles with aryl chlorides using our previously reported protocol [Pd_2dba_3 (2.5 mol %), Xphos (5 mol %), *t*-BuOK (1.5 equiv), LiCl (2 equiv), and toluene at 130 °C][8] (Table 1). Following the selective preparation of *N*-aryl-1-aminoindoles **1a**−**k**, we expected that the remaining N−H bond can undergo further N-benzylation with various 1-bromo-2-(bromomethyl)-benzenes to lead to disubstituted 1-aminoindoles **2a**−**p**. To this end, various reaction conditions (base, solvent, and temperature) were screened, and the best conditions were found to require *N*-arylated 1-aminoindoles **1a**−**k** (1 equiv), substituted benzyl bromide derivatives (1.2 equiv), and KOH (2 equiv) in DMSO as the solvent at room temperature for 1−2 h. In line with these data, compounds **2a**−**p** bearing various electron-withdrawing or -donating groups on the indole, the aryl as well

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Scheme 1. Potential Reactive Sites in Direct Arylation of *N*-Aryl-*N*′-benzyl-1-aminoindoles 2

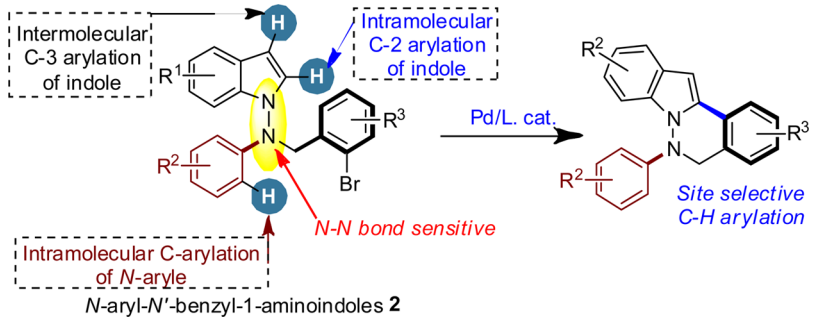
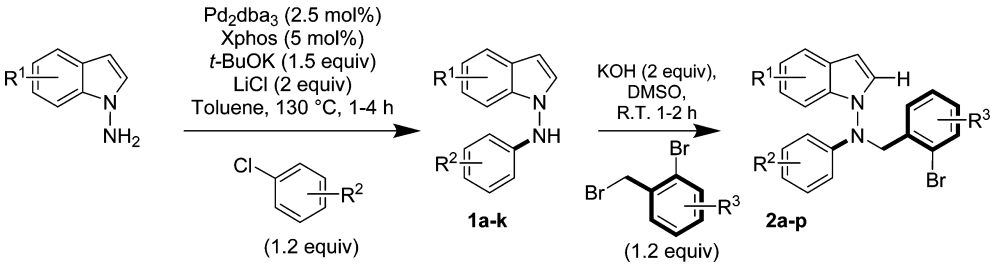
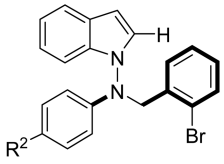
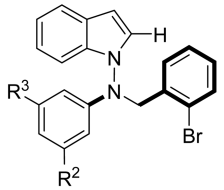


Table 1. Synthesis of *N*,*N*′-Substituted 1-Aminoindoles 2a–p

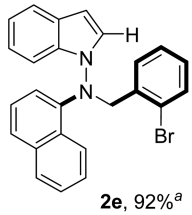




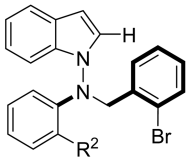
2a, R^2 = OMe, 94%[a]
2b, R^2 = Cl, 91%[a]



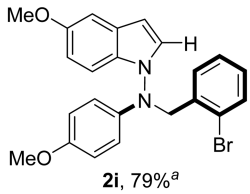
2c, R^2 = Me, R^3 = H, 92%[a]
2d, R^2 = R^3 = OMe, 94%[a]



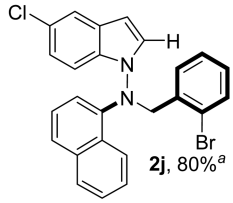
2e, 92%[a]



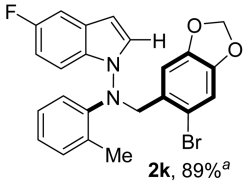
2f, R^2 = OMe, 98%[a]
2g, R^2 = Me, 99%[a]
2h, R^2 = Cl, 90%[a]



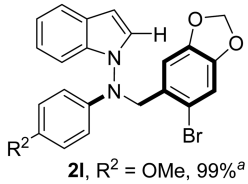
2i, 79%[a]



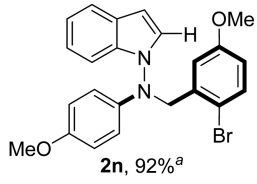
2j, 80%[a]



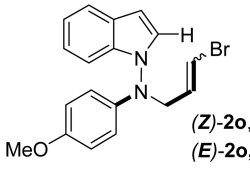
2k, 89%[a]



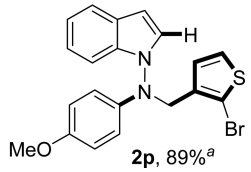
2l, R^2 = OMe, 99%[a]
2m, R^2 = Cl, 91%[a]



2n, 92%[a]



***(Z)*-2o**, 56%[a] (*Z*-isomer)
***(E)*-2o**, 27%[a] (*E*-isomer)



2p, 89%[a]

[a]Yield of isolated products **2a–p** related to the N-benzylation reaction step.

as the benzyl moieties were isolated in excellent yields [89–99% (Table 1)].

Next, we continued our study by exploring the second key step concerning the intramolecular C(sp^2)–H arylation. To determinate the feasibility of the C-2 direct arylation of intermediates **2a–p**, we examined at first the arylation of **2a** as a model under various palladium sources, ligands, bases, and solvents. Representative results from this study are summarized in Table 2. The reaction of **2a** was first investigated under initially reported conditions[5,9] [$Pd(OAc)_2$, PPh_3, K_2CO_3, TBAB

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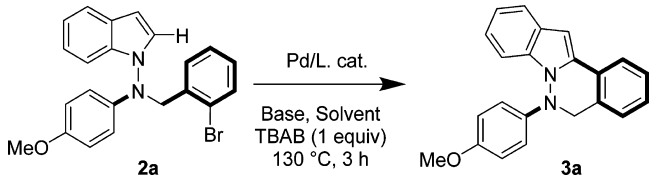
Table 2. Optimization of the Pd-Catalyzed Intramolecular C-2 Arylation of 2a[a]



entry	Pd	ligand	base	solvent	conversion (%)[b]	yield (%)[c]
1	$Pd(OAc)_2$	PPh_3	K_2CO_3	DMF	100	30
2	$Pd(OAc)_2$	PPh_3	Cs_2CO_3	DMF	100	65
3	$Pd(OAc)_2$	PPh_3	*t*-BuOLi	DMF	0	–
4	$Pd(OAc)_2$	PPh_3	*t*-BuOK	DMF	0	–
5	$Pd(OAc)_2$	PPh_3	Cs_2CO_3	DMA	100	65
6	$Pd(OAc)_2$	PPh_3	Cs_2CO_3	PhMe	40	–
7	$Pd(OAc)_2$	PPh_3	Cs_2CO_3	CPME	36	–
8	$Pd(OAc)_2$	PPh_3	Cs_2CO_3	dioxane	44	–
9	$Pd(OH)_2$	PPh_3	Cs_2CO_3	DMA	10	–
10	$Pd(acac)_2$	PPh_3	Cs_2CO_3	DMA	100	64
11	$PdCl(C_3H_5(dppb))$	PPh_3	Cs_2CO_3	DMA	63	–
12	$Pd(OAc)_2$	P(*o*-tolyl)$_3$	Cs_2CO_3	DMA	100	68
13	$Pd(OAc)_2$	P(*c*-hexyl)$_3$	Cs_2CO_3	DMA	100	67
14	$Pd(OAc)_2$	Xantphos	Cs_2CO_3	DMA	100	66
15	$Pd(OAc)_2$	Xphos	Cs_2CO_3	DMA	100	68
16	$Pd(OAc)_2$	Davephos	Cs_2CO_3	DMA	100	62
17	**$Pd(OAc)_2$**	**Dpephos**	**Cs_2CO_3**	**DMA**	**100**	**80**[d,e]
18	$Pd(OAc)_2$	dppb	Cs_2CO_3	DMA	100	26

[a] **1a** (1 equiv), Pd (10 mol %), L (20 mol %), base (2 equiv), TBAB (1 equiv), and solvent (0.04 M) for 3 h at 130 °C. [b] The ratio was determined by ^{1}H NMR in the crude reaction mixture based on the chemical shift of the proton signal (parts per million) at position 3 of the indole nucleus (**2a**, δ 6.47; **3a**, δ 6.93). [c] Yield of isolated product **3a**. [d] An identical yield of **3a** was obtained when the reaction was performed with 5 mol % $Pd(OAc)_2$ and 10 mol % Dpephos. [e] No reaction occurred in the absence of $Pd(OAc)_2$ or Dpephos.

(tetrabutylamonium bromide), and DMF at 130 °C]. However, this transformation was inefficient and resulted in the formation of the expected product **3a** in only 30% yield (entry 1). A brief survey of other bases was undertaken and revealed that Cs_2CO_3 is the most effective with a significant improvement in the performance of the arylation reaction (65% yield, entry 2). However, using *tert*-butoxide bases such as *t*-BuOLi and *t*-BuOK failed (entries 4 and 5, respectively). The screening reaction was continued with respect to the solvent. The use of highly polar solvents (DMF and DMA, entries 2 and 5, respectively) was found to be the best choice because reactions with etheral solvents (dioxane and CPME) or a nonpolar solvent (toluene) were much slower (entries 6–8). DMA was chosen to evaluate the effect of other parameters of the reaction, including catalysts, ligands, and temperatures. The catalytic activity of $Pd(acac)_2$ proved to be similar to that of $Pd(OAc)_2$, leading to **3a** in a similar yield (64%, entry 10). The use of other palladium sources, however, did not promote the C–H arylation reaction or induce a decrease in conversion rate (entries 9–11). With $Pd(OAc)_2$ as the catalyst, the screening reactions with respect to the ligand (entries 12–18) revealed that the bidentate phosphine Dpephos is superior to all other choices, providing **3a** in an 80% yield (entry 17). In summary, the best conditions were found to include $Pd(OAc)_2$ (5 mol %), Dpephos (10 mol %), TBAB (1 equiv), and Cs_2CO_3 (2 equiv) in DMA at 130 °C for 3 h.

Motivated by these results, we next explored the scope of the coupling reaction with previously synthesized *N*,*N*′-substituted 1-aminoindoles **2a**–**p**. Gratifyingly, tetracycles **3** bearing a wide variety of functional groups could be synthesized in good to excellent yields without any side product (Table 3). Electron-donating and electron-withdrawing functions on the indole, on the aryl, and on the benzyl moieties of **2a**–**p** were well tolerated. It was found that the chloro-substituted compounds **3b**, **3h**, and **3k** survived under the reaction conditions, and the presence of a C–Cl bond provided a handle for further diversifications of transition metal catalysis. It is noteworthy that the alkenylation reaction of less rigid derivative (*Z*)-**2o** bearing a (*Z*)-vinyl bromide succeeded and leads to the formation of the tricyclic **3o** in 68% yield; however, all attempts to react its *E*-isomer (*E*)-**2o** under our optimized conditions have failed.

Interestingly, the polycyclic heteroaromatic compound **3p** bearing the indole and thiophene rings, which is obtained in good yield, can be used as a platform in further selective C–H functionalization processes at position C-3[4] of the indole or positions C-3 and C-4 of thiophene rings.[10]

Although the exact mechanism of the reaction is still not clear, it is believed that an oxidative addition of *N*-benzyl aminoindole **2a** to a zero-valent Pd species is envisioned to take place as an initial step leading to the arylpalladium complex **I** (Scheme 2). Next, in the presence of Cs_2CO_3, complex **I** evolves through the C–H functionalization at the C-2 position of the indole to provide the intermediate palladocycle **II**. This later undergoes a reductive elimination to afford the desired fused tetracycle **3a** and the Pd(0) species that move back to the catalytic system for the next cycle. Various scenarios may occur at this C–H functionalization step, including (i) a Heck-type pathway[5,11] involving a carbopalladation followed by an atypical anti-β-hydride elimination,[12] (ii) a direct C-2 palladation via a nonelectrophilic pathway,[13] and (iii) an electrophilic sub-

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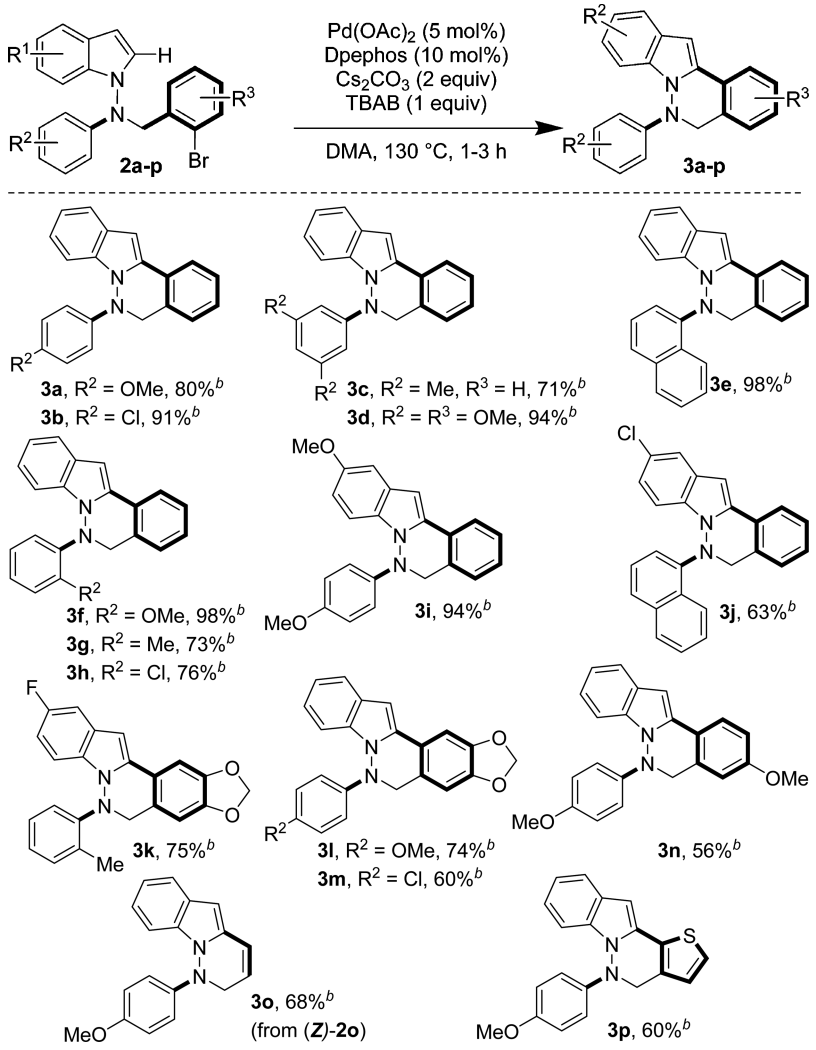
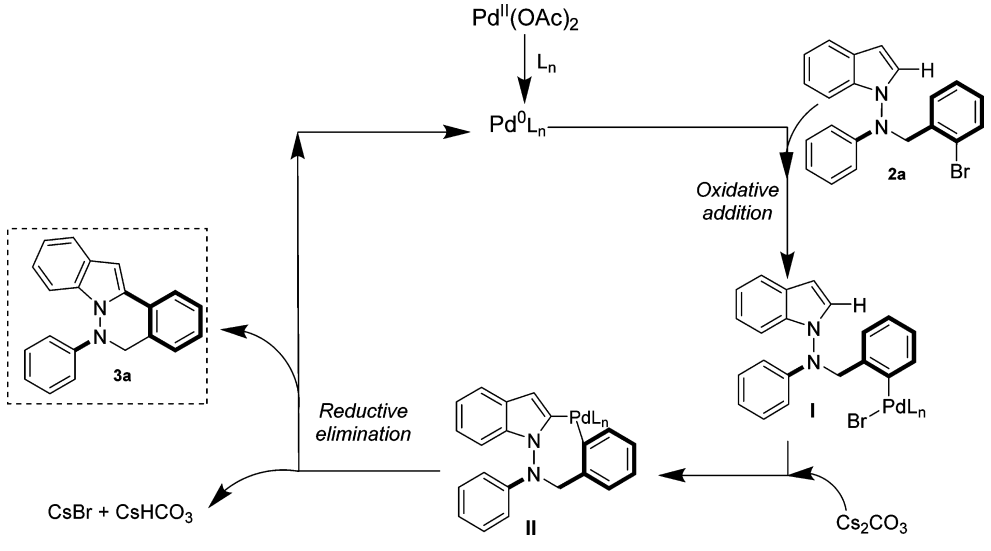
Table 3. Pd-Catalyzed Intramolecular C-2 Arylation of 2a−p[a]



[a]Reactions of **2** (0.122 mmol, 1 equiv) were performed in a sealed tube at 130 °C in DMA (0.04 M) by using $Pd(OAc)_2$ (5 mol %), Dpephos (10 mol %), TBAB (1 equiv), and Cs_2CO_3 (2 equiv). [b]Yield of the isolated product. [c]A 75% yield of **3a** were obtained when the reaction was performed on a larger scale (using 0.5 mmol of starting material **2a**).

Scheme 2. Proposed Mechanism for the Pd-Catalyzed Intramolecular C-2 Arylation of 2a



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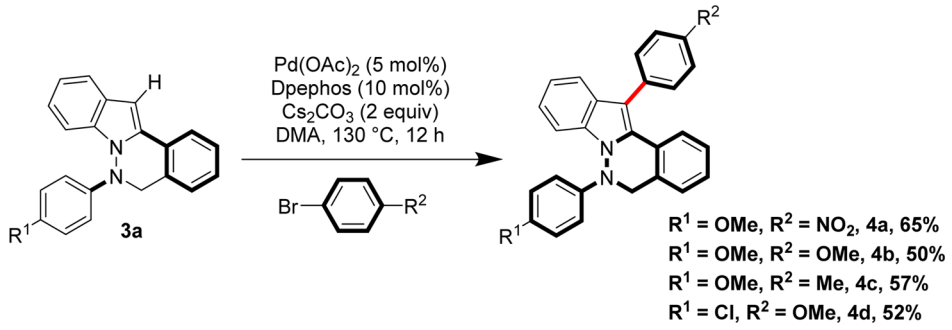
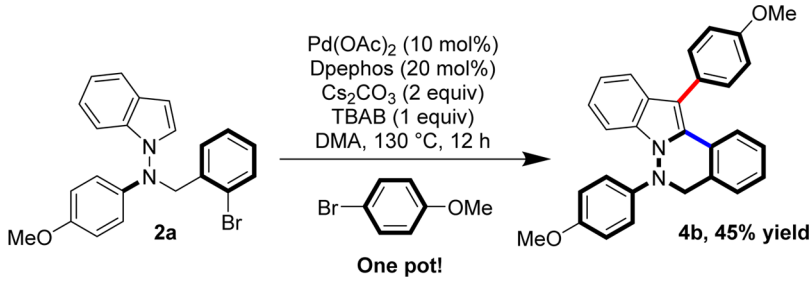
Scheme 3. Pd-Catalyzed C-3 Arylation of 3a with Arylbromides



Scheme 4. One-Pot Pd-Catalyzed Double C-2 and C-3 Arylations of 2a



stitution at position C-3, followed by a C-3 to C-2 palladium migration and reductive elimination.[14]

In the context of the further selective C−H functionalization strategy of the indole moeity, preliminary results demonstrate that compound **3a** can be selectively arylated at position C-3 under conditions identical to those used for the C-2 arylation of **2**. Thus, the C-3 arylated 1-aminoindoles **4a−d** were isolated in yields ranging from 50 and 65% (Scheme 3).

To prepare the highly functionalized 1-aminoindoles of type **4** avoiding direct manipulation and purification of **3**, we next examined one-pot Pd-catalyzed C-2 and C-3 arylations of derivatives **2** as it would be economically and environmentally advantageous over multistep syntheses (Scheme 4). In a typical experiment, we achieved this transformation under a single set of conditions by mixing **2a** with 4-bromoanisole as a partner under optimal reaction conditions. Thus, under this protocol, we were pleased to observe that the double C−H arylation worked well and provided the desired product **4b** in a 45% yield.

3. CONCLUSION

In summary, we have reported a novel palladium-catalyzed direct arylation process to form a series of polcyclic 1-aminoindole derivatives in good yields. The protocol is effective with various *N*-aryl-*N*′-benzyl-1-aminoindoles with good functional group tolerance. Moreover, double C-2 and C-3 direct arylations proved to be useful for the rapid construction of disubstituted 1-aminoindoles **4**.

4. EXPERIMENTAL SECTION

General. All reactions were conducted under an argon atmosphere. Solvents cyclohexane and ethyl acetate (EtOAc) for extraction and chromatography were technical grade. These compounds were all identified by the usual physical methods, that is ^{1}H NMR, ^{13}C NMR (J-MOD), IR, and HR-MS (ESI or APCI). ^{1}H NMR and ^{13}C NMR spectra were recorded in $CDCl_3$. ^{1}H chemical shifts are reported in parts per million from an internal standard TMS or of residual chloroform (7.27 ppm). The following abreviations are used: m (multiplet), s (singlet), bs (broad singlet), d (doublet), t (triplet), dd (doublet of doublet), td (triplet of doublet), q (quadruplet), qui (quintuplet), and sex (sextuplet). ^{13}C chemical shifts are reported in parts per million from the central peak of deuteriochloroform (77.14). High-resolution mass spectra (HR-MS) were recorded on a Micro-TOF spectrometer, using ESI or APCI with methanol as the carrier solvent. Nominal and exact *m*/*z* values are reported in daltons. IR spectra were measured are reported in wave numbers (cm^{-1}). Analytical TLC was performed on precoated silica gel 60-F254 plates. Silica gel 60 (0.0150−0.040 mm) was used for flash chromatography. Melting points were recorded on a B-450 apparatus. Aryl halides and substituted 2-bromobenzyl bromide are commercially available compounds.

General Procedure for the N-Aryation of 1-Aminoindoles. Compounds **1a−k** were synthesized following the procedure of Brachet et al.[8]

1a−c and **1e−k** are known compounds, and their characterization data were compared with the literature data.

*N-(3,5-Dimethoxyphenyl)-1H-indol-1-amine (**1d**).* Following the general procedure, a mixture of *N*-aminoindole (0.25 mmol, 33 mg) and 1-chloro-3,5-dimethoxybenzene was heated for 1 h. The residue was purified by flash chromatography over silica gel (8/2 cyclohexane/EtOAc) to afford the desired product **1d** as a brown oil: yield 62% (0.16 mmol, 42 mg); R_f = 0.47 (8/2 cyclohexane/EtOAc); IR (neat) ν 1756, 1717, 1609, 1508, 1466, 1437, 1366, 1285, 1245, 1223, 1182, 1122, 1035, 912, 829, 758, 743, 618 cm^{-1}; ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.63 (dd, J = 6.7, 1.3 Hz, 1H), 7.30 (d, J = 8.1 Hz, 1H), 7.23−7.12 (m, 3H), 6.58 (s, 1H), 6.52 (dd, J = 3.3, 0.7 Hz, 1H), 6.04 (t, J = 2.2 Hz, 1H), 5.71 (d, J = 2.2 Hz, 2H), 3.67 (s, 6H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 162.0 (2C), 149.7 (C), 136.1 (C), 128.8 (CH), 126.9 (C), 122.6 (CH), 121.2 (CH), 120.5 (CH), 109.5 (CH), 101.0 (CH), 93.2 (CH), 91.7 (2CH), 55.4 (2C); HR-MS (ESI positive) found *m*/*z* 269.1292 ($[M + H]^+$), calcd for $C_{16}H_{17}N_2O_2$ (M + H) *m*/*z* 269.1290.

*General Procedure for the Benzylation of **2a−p**.* A 50 mL flask was charged with KOH (0.8 mmol, 2 equiv), compound **1a−k** (0.4 mmol, 1 equiv), and substituted benzyl bromide derivatives (0.48 mmol, 1.2 equiv), capped with a rubber septum, evacuated, and backfilled with argon, and then 5 mL of DMSO was added through the septum. The mixture was stirred at room temperature for 1−2 h. To the resulting suspension was added 30 mL of distilled water, and the

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aqueous solution was extracted with 30 mL of EtOAc (3 × 10 mL). The combined organic layer was washed with brine (10 mL), dried over $MgSO_4$, and evaporated. The crude products obtained were purified by flash chromatography over silica gel to afford the desired product.

*N-(2-Bromobenzyl)-N-(4-methoxyphenyl)-1H-indol-1-amine (**2a**).* Following the general procedure, a mixture of **1a** (0.63 mmol, 150 mg) and 2-bromobenzyl bromide was stirred for 1 h. The residue was purified by flash chromatography over silica gel (95/5 cyclohexane/EtOAc) to afford the desired product **2a** as a yellow oil: yield 94% (0.59 mmol, 240 mg); R_f = 0.58 (95/5 cyclohexane/EtOAc); IR (neat) ν 1509, 1440, 1247, 1182, 1130, 822, 742, 618 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.62−7.58 (m, 1H), 7.55 (dd, J = 7.6, 1.5 Hz, 1H), 7.34−7.27 (m, 2H), 7.18−7.08 (m, 5H), 6.77 (d, J = 9.2 Hz, 2H), 6.52 (d, J = 9.2 Hz, 2H), 6.46 (dd, J = 3.4, 0.8 Hz, 1H), 4.97 (s, 2H), 3.74 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 154.3 (C), 143.1 (C), 136.0 (C), 135.1 (C), 132.9 (CH), 129.9 (CH), 129.3 (CH), 127.6 (CH), 127.2 (C), 126.5 (C), 123.5 (C), 122.5 (CH), 121.2 (CH), 120.4 (CH), 115.2 (2CH), 114.8 (2CH), 110.1 (CH), 101.1 (CH), 58.8 (CH_2), 55.7 (CH_3); HR-MS (ESI positive) found m/z 407.0759/409.0739 ($[M + H]^+$), calcd for $C_{22}H_{20}N_2OBr$ (M + H) m/z 407.0759.

*N-(2-Bromobenzyl)-N-(4-chlorophenyl)-1H-indol-1-amine (**2b**).* Following the general procedure, a mixture of **1b** (0.41 mmol, 100 mg) and 2-bromobenzyl bromide was stirred for 1 h. The residue was purified by flash chromatography over silica gel (95/5 cyclohexane/EtOAc) to afford the desired product **2b** as a beige oil: yield 91% (0.37 mmol, 153 mg); R_f = 0.41 (95/5 cyclohexane/EtOAc); IR (neat) ν 3473, 3377, 3334, 2371, 2235, 2160, 2141, 1509, 1440, 1247, 1182, 1130, 822, 742, 418 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.58−7.51 (m, 1H), 7.48 (dd, J = 7.5, 1.7 Hz, 1H), 7.20 (d, J = 2.0 Hz, 1H), 7.16−7.02 (m, 7H), 7.01 (d, J = 3.4 Hz, 1H), 6.45−6.26 (m, 3H), 4.92 (d, J = 14.1 Hz, 2H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 147.5 (C), 135.4 (C), 134.6 (C), 133.1 (CH), 129.6 (CH), 129.5 (CH), 129.4 (2CH), 127.7 (CH), 127.3 (CH), 126.7 (C), 125.7 (C), 123.5 (C), 122.8 (CH), 121.5 (CH), 120.7 (CH), 114.6 (2CH), 109.9 (CH), 101.6 (CH), 58.3 (CH_2); HR-MS (ESI positive) found m/z 411.0263/413.0233 ($[M + H]^+$), calcd for $C_{21}H_{17}N_2ClBr$ (M + H) m/z 411.0264.

*N-(2-Bromobenzyl)-N-(m-tolyl)-1H-indol-1-amine (**2c**).* Following the general procedure, a mixture of **1c** (0.2 mmol, 44 mg) and 2-bromobenzyl bromide was stirred for 1 h. The residue was filtered through silica gel (EtOAc) to afford the desired product **2c** (contaminated by 2-bromobenzyl bromide) as a beige oil: yield 92% (0.184 mmol, 72 mg). Compound **2c** is not sufficiently stable for full characterization; it was used directly for the next step: ^1H NMR (300 MHz, $CDCl_3$) δ 7.73−7.56 (m, 3H), 7.45−7.29 (m, 2H), 7.19 (m, 5H), 6.78 (d, J = 7.4 Hz, 1H), 6.53 (d, J = 3.2 Hz, 1H), 6.45 (s, 1H), 6.40 (dd, J = 8.3, 1.9 Hz, 1H), 5.07 (d, J = 6.7 Hz, 2H), 2.29 (s, 3H); HR-MS (ESI positive) found m/z 391.0806 ($[M + H]^+$), calcd for $C_{22}H_{20}N_2Br$ (M + H) m/z 391.0810.

*N-(2-Bromobenzyl)-N-(3,5-dimethoxyphenyl)-1H-indol-1-amine (**2d**).* Following the general procedure, a mixture of **1d** (0.23 mmol, 60 mg) and 2-bromobenzyl bromide was stirred for 1 h. The residue was purified by flash chromatography over silica gel (95/5 cyclohexane/EtOAc) to afford the desired product **2d** as a white solid: yield 94% (0.22 mmol, 94 mg); mp 85−87 °C; R_f = 0.65 (9/1 cyclohexane/EtOAc); IR (neat) ν 1681, 1591, 1476, 1453, 1261, 1204, 1153, 1126, 1104, 1068, 1060, 1027, 930, 818, 800, 762, 741, 716, 682, 660 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.62−7.50 (m, 2H), 7.33 (d, J = 7.6 Hz, 1H), 7.28−7.24 (m, 1H), 7.20−7.05 (m, 5H), 6.44 (dd, J = 3.4, 0.8 Hz, 1H), 6.04 (t, J = 2.1 Hz, 1H), 5.71 (d, J = 2.1 Hz, 2H), 4.99 (d, J = 17.8 Hz, 2H), 3.63 (s, 6H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 161.8 (2C), 151.1 (C), 135.8 (C), 134.9 (C), 133.0 (CH), 129.7 (CH), 129.3 (CH), 127.6 (CH), 126.6 (C), 123.4 (C), 122.6 (CH), 121.3 (CH), 120.5 (CH), 110.0 (CH), 101.3 (CH), 92.7 (2CH), 92.2 (CH), 58.2 (CH_2), 55.3 ($2CH_3$); HR-MS (ESI possitive) found m/z 437.0868/439.0862 ($[M + H]^+$), calcd for $C_{23}H_{22}N_2O_2Br$ (M + H) m/z 437.0865.

*N-(2-Bromobenzyl)-N-(naphthalen-1-yl)-1H-indol-1-amine (**2e**).* Following the general procedure, a mixture of **1e** (0.2 mmol, 52 mg) and 2-bromobenzyl bromide was stirred for 1 h. The residue was purified by flash chromatography over silica gel (95/5 cyclohexane/EtOAc) to afford the desired product **2e** as a beige oil: yield 92% (0.184 mmol, 75 mg); R_f = 0.72 (92/8 cyclohexane/EtOAc); IR (neat) ν 1734, 1590, 1509, 1477, 1452, 1247, 1206, 1155, 1126, 1102, 1060, 1028, 892, 869, 822, 742 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 8.25 (d, J = 8.4 Hz, 1H), 7.73 (d, J = 8.3 Hz, 1H), 7.56 (d, J = 8.2 Hz, 1H), 7.53−7.41 (m, 4H), 7.41−7.24 (m, 4H), 7.19−7.16 (m, 1H), 7.10−7.05 (m, 1H), 7.02−6.95 (m, 3H), 6.34 (d, J = 3.4 Hz, 1H), 4.94 (s, 2H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 144.7 (C), 135.7 (2C), 134.9 (C), 132.8 (CH), 129.5 (CH), 129.2 (CH), 128.8 (C), 128.5 (CH), 127.7 (CH), 126.5 (CH), 126.4 (CH), 126.1 (C), 126.0 (CH), 125.3 (CH), 124.5 (CH), 123.7 (C), 123.0 (CH), 122.5 (CH), 121.1 (CH), 120.2 (CH), 116.6 (CH), 110.0 (CH), 101.2 (CH), 59.9 (CH_2); HR-MS (ESI positive) found m/z 427.0797/429.0787 ($[M + H]^+$), calcd for $C_{25}H_{20}N_2Br$ (M + H) m/z 427.0804.

*N-(2-Bromobenzyl)-N-(2-methoxyphenyl)-1H-indol-1-amine (**2f**).* Following the general procedure, a mixture of **1f** (0.25 mmol, 60 mg) and 2-bromobenzyl bromide was stirred for 1 h. The residue was purified by flash chromatography over silica gel (95/5 cyclohexane/EtOAc) to afford the desired product **2f** as a beige solid: yield 98% (0.245 mmol, 99 mg); mp 103−105 °C; R_f = 0.59 (9/1 cyclohexane/EtOAc); IR (neat) ν 1593, 1496, 1452, 1260, 1240, 1212, 1177, 1127, 1093, 1026, 1009, 794, 738, 707, 662 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.56−7.43 (m, 4H), 7.38 (d, J = 3.4 Hz, 1H), 7.14−6.99 (m, 5H), 6.91 (d, J = 8.0 Hz, 1H), 6.86−6.77 (m, 2H), 6.40 (d, J = 3.3 Hz, 1H), 5.05 (s, 2H), 3.77 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 152.3 (C), 138.4 (C), 136.7 (C), 135.7 (C), 132.6 (CH), 130.4 (CH), 128.9 (CH), 127.3 (CH), 126.5 (CH), 126.0 (C), 125.0 (CH), 123.9 (C), 122.0 (CH), 121.0 (CH), 120.8 (CH), 120.6 (CH), 119.9 (CH), 112.4 (CH), 110.4 (CH), 100.3 (CH), 58.8 (CH_2), 55.8 (CH_3); HR-MS (ESI positive) found m/z 407.0761/409.0737 ($[M + H]^+$), calcd for $C_{22}H_{20}N_2OBr$ (M + H) m/z 407.0759.

*N-(2-Bromobenzyl)-N-(o-tolyl)-1H-indol-1-amine (**2g**).* Following the general procedure, a mixture of **1g** (0.2 mmol, 44 mg) and 2-bromobenzyl bromide was stirred for 1 h. The residue was filtered through silica gel (EtOAc) to afford the desired product **2g** (contaminated by 2-bromobenzyl bromide) as a beige oil: yield 99% (0.198 mmol, 77 mg). Compound **2g** is not sufficiently stable for full characterization; it was used directly for the next step: ^1H NMR (300 MHz, $CDCl_3$) δ 7.57−7.52 (m, 2H), 7.39 (d, J = 7.8 Hz, 1H), 7.33−7.28 (m, 1H), 7.26−7.17 (m, 3H), 7.15 (d, J = 3.4 Hz, 1H), 7.06 (m, 5H), 6.40 (dd, J = 3.4, 0.7 Hz, 1H), 4.88 (s, 2H), 2.07 (s, 3H).

*N-(2-Bromobenzyl)-N-(2-chlorophenyl)-1H-indol-1-amine (**2h**).* Following general procedure 2, a mixture of **1h** (0.41 mmol, 100 mg) and 2-bromobenzyl bromide was stirred for 1 h. The residue was purified by flash chromatography over silica gel (95/5 cyclohexane/EtOAc) to afford the desired product **2h** as a beige solid: yield 90% (0.37 mmol, 140 mg); mp 118−120 °C; R_f = 0.55 (95/5 cyclohexane/EtOAc); IR (neat) ν 1734, 1587, 1477, 1452, 1440, 1364, 1327, 1214, 1123, 1092, 1027, 985, 759. 739, 705, 665 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.60 (dd, J = 7.6, 1.7 Hz, 1H), 7.55−7.49 (m, 2H), 7.47 (dd, J = 2.4, 1.2 Hz, 1H), 7.40 (dd, J = 7.8, 1.4 Hz, 1H), 7.37 (d, J = 3.4 Hz, 1H), 7.18−7.08 (m, 4H), 7.08−7.01 (m, 3H), 6.44 (dd, J = 3.4, 0.8 Hz, 1H), 4.99 (s, 2H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 145.9 (C), 135.7 (C), 135.4 (C), 132.7 (CH), 131.3 (CH), 130.0 (CH), 129.2 (CH), 128.5 (C), 127.6 (CH), 127.6 (C), 126.0 (CH), 125.9 (CH), 125.3 (C), 123.6 (CH), 122.4 (CH), 121.7 (CH), 121.0 (CH), 120.3 (CH), 110.4 (CH), 101.1 (CH), 58.8 (CH_2); HR-MS (ESI positive) found m/z 411.0255/413.0234 ($[M + H]^+$), calcd for $C_{21}H_{17}N_2ClBr$ (M + H) m/z 413.0237.

*N-(2-Bromobenzyl)-5-methoxy-N-(4-methoxyphenyl)-1H-indol-1-amine (**2i**).* Following general procedure 2, a mixture of **1i** (0.4 mmol, 107 mg) and 2-bromobenzyl bromide was stirred for 2 h. The residue was purified by flash chromatography over silica gel (95/5 cyclohexane/EtOAc) to afford the desired product **2i** as a brown oil: yield 79% (0.32 mmol, 140 mg); R_f = 0.5 (9/1 cyclohexane/EtOAc); IR (neat) ν 1735, 1621, 1583, 1506, 1471, 1439, 1278, 1237, 1181,

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1027, 938, 821, 799, 748, 716, 662, 624 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.55 (dd, J = 7.6, 1.4 Hz, 1H), 7.30 (dd, J = 7.4, 1.7 Hz, 1H), 7.19−7.07 (m, 4H), 7.06 (d, J = 2.3 Hz, 1H), 6.83−6.72 (m, 3H), 6.52 (d, J = 9.1 Hz, 2H), 6.36 (d, J = 3.3 Hz, 1H), 4.95 (s, 2H), 3.84 (s, 3H), 3.73 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 154.7 (C), 154.3 (C), 143.2 (C), 136.0 (C), 132.9 (CH), 130.2 (C), 129.9 (CH), 129.3 (CH), 127.8 (CH), 127.6 (CH), 1267.0 (C), 123.5 (C), 115.2 (2CH), 114.8 (2CH), 112.7 (CH), 110.9 (CH), 103.0 (CH), 100.6 (CH), 58.7 (CH_2), 55.9 (CH_3), 55.7 (CH_3); HR-MS (ESI positive) found m/z 437.0862/439.0830 ($[M + H]^+$), calcd for $C_{23}H_{22}N_2O_2Br$ (M + H) m/z 437.0865.

*N-(2-Bromobenzyl)-5-chloro-N-(naphthalen-1-yl)-1H-indol-1-amine (**2j**).* Following the general procedure, a mixture of **1j** (0.4 mmol, 116 mg) and 2-bromobenzyl bromide was stirred for 2 h. The residue was filtered through silica gel (EtOAc) to afford the desired product **2j** (contaminated by 2-bromobenzyl bromide) as a brown oil: yield 80% (0.32 mmol, 147 mg). Compound **2j** is not sufficiently stable for full characterization; it was used directly for the next step. ^1H NMR data were provided: ^1H NMR (300 MHz, $CDCl_3$) δ 8.28 (d, J = 8.5 Hz, 1H), 7.84 (d, J = 7.6 Hz, 1H), 7.68 (d, J = 8.2 Hz, 1H), 7.61−7.51 (m, 3H), 7.50−7.29 (m, 5H), 7.17 (td, J = 7.9, 1.7 Hz, 1H), 7.08 (m, 3H), 6.36 (dd, J = 3.4, 0.7 Hz, 1H), 5.01 (s, 2H); HR-MS (ESI positive) found m/z 461.0418/463.0393 ($[M + H]^+$), calcd for $C_{25}H_{19}N_2ClBr$ (M + H) m/z 461.0420.

*N-[(6-Bromobenzo[d][1,3]dioxol-5-yl)methyl]-5-fluoro-N-(o-tolyl)-1H-indol-1-amine (**2k**).* Following the general procedure, a mixture of **1k** (0.33 mmol, 80 mg) and 2-bromobenzyl bromide was stirred for 2 h. The residue was purified by flash chromatography over silica gel (98/2 cyclohexane/EtOAc) to afford the desired product **2k** as a beige oil: yield 89% (0.27 mmol, 130 mg); R_f = 0.45 (98/2 cyclohexane/EtOAc); IR (neat) ν 1624, 1503, 1479, 1442, 1262, 1242, 1115, 1038, 967, 932, 859, 798, 749, 613 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.29−7.20 (m, 3H), 7.18−7.11 (m, 3H), 7.06 (t, J = 7.1 Hz, 1H), 6.95 (s, 1H), 6.83 (td, J = 9.1, 2.4 Hz, 1H), 6.60 (s, 1H), 6.34 (d, J = 3.2 Hz, 1H), 5.83 (s, 2H), 4.70 (s, 2H), 2.03 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 159.64−156.54 (d, J = 234.4 Hz, C), 148.1 (C), 147.4 (C), 146.8 (C), 133.4 (C), 132.3 (C), 132.1 (CH), 128.7 (C), 126.9 (C), 126.6 (CH), 126.00−125.87 (d, J = 10.1 Hz, C), 125.2 (CH), 119.4 (CH), 114.8 (C), 112.8 (CH), 110.90−110.34 (m, 2CH), 109.9 (CH), 105.96−105.65 (d, J = 23.5 Hz, CH), 101.8 (CH_2), 100.9−100.8 (d, J = 4.4 Hz, CH), 59.2 (CH_2), 19.4 (CH_3); HR-MS (ESI positive) found m/z 453.0612/455.0607 ($[M + H]^+$), calcd for $C_{23}H_{19}N_2O_2BrF$ (M + H) m/z 453.0614.

*N-[(6-Bromobenzo[d][1,3]dioxol-5-yl)methyl]-N-(4-methoxyphenyl)-1H-indol-1-amine (**2l**).* Following the general procedure, a mixture of **1a** (0.41 mmol, 100 mg) and 5-bromo-6-(bromomethyl)-benzo[*d*][1,3]dioxole was stirred for 1 h. The residue was purified by flash chromatography over silica gel (95/5 cyclohexane/EtOAc) to afford the desired product **2l** as a beige oil: yield 99% (0.406 mmol, 182 mg); R_f = 0.41 (98/2 cyclohexane/EtOAc); IR (neat) ν 2234, 2050, 1712, 1504, 1477, 1452, 1412, 1360, 1246, 1182, 1111, 1036, 963. 931, 862, 821, 791, 764, 742, 719, 673 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.52 (dd, J = 6.7, 1.6 Hz, 1H), 7.21−7.17 (m, 1H), 7.10−6.99 (m, 3H), 6.91 (s, 1H), 6.75 (s, 1H), 6.67 (d, J = 9.1 Hz, 2H), 6.42 (d, J = 9.1 Hz, 2H), 6.39 (d, J = 3.3 Hz, 1H), 5.81 (s, 2H), 4.77 (s, 2H), 3.64 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 154.4 (C), 147.9 (C), 147.6 (C), 143.0 (C), 135.2 (C), 129.2 (C), 127.2 (CH), 126.5 (C), 122.5 (CH), 121.3 (CH), 120.4 (CH), 115.3 (2CH), 114.8 (2CH), 113.8 (C), 112.9 (CH), 110.1 (CH), 109.6 (CH), 101.8 (CH_2), 101.2 (CH), 58.7 (CH_2), 55.7 (CH_3); HR-MS (ESI positive) found m/z 451.0657 ($[M + H]^+$), calcd for $C_{23}H_{20}N_2O_3Br$ (M + H) m/z 451.0657.

*N-[(6-Bromobenzo[d][1,3]dioxol-5-yl)methyl]-N-(4-chlorophenyl)-1H-indol-1-amine (**2m**).* Following the general procedure, a mixture of **1b** (0.41 mmol, 100 mg) and 5-bromo-6-(bromomethyl)-benzo[*d*][1,3]dioxole was stirred for 1 h. The residue was purified by flash chromatography over silica gel (95/5 cyclohexane/EtOAc) to afford the desired product **2m** as a beige solid: yield 91% (0.37 mmol, 170 mg); mp 126−128 °C; R_f = 0.74 (95/5 cyclohexane/EtOAc); IR (neat) ν 1594, 1492, 1477, 1452, 1413, 1251, 1251, 1237, 1132, 1096, 1037, 1006, 962, 906, 865, 817, 729, 649 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.67−7.58 (m, 1H), 7.23−7.11 (m, 5H), 7.10 (d, J = 3.4 Hz, 1H), 7.01 (s, 1H), 6.77 (s, 1H), 6.50 (dd, J = 3.4, 0.7 Hz, 1H), 6.44 (d, J = 9.2 Hz, 2H), 5.92 (s, 2H), 4.89 (d, J = 12.5 Hz, 2H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 148.1 (C), 147.7 (C), 147.5 (C), 134.7 (C), 129.4 (2CH), 128.5 (C), 127.2 (CH), 126.7 (C), 125.8 (C), 122.8 (CH), 121.5 (CH), 120.7 (CH), 114.7 (2CH), 113.9 (C), 113.0 (CH), 109.8 (CH), 109.4 (CH), 101.9 (CH2), 101.7 (CH), 58.1 (CH_2); HR-MS (ESI positive) found m/z 455.0166/457.0131 ($[M + H]^+$), calcd for $C_{22}H_{17}N_2O_2BrCl$ (M + H) m/z 455.0166.

*N-(2-Bromo-5-methoxybenzyl)-N-(4-methoxyphenyl)-1H-indol-1-amine (**2n**).* Following the general procedure, a mixture of **1a** (0.41 mmol, 100 mg) and 2-bromo-5-methoxybenzyl bromide was stirred for 1 h. The residue was purified by flash chromatography over silica gel (95/5 cyclohexane/EtOAc) to afford the desired product **2n** as a beige solid: yield 92% (0.38 mmol, 165 mg); mp 87−89 °C; R_f = 0.47 (92/8 cyclohexane/EtOAc); IR (neat) ν 1734, 1590, 1509, 1477, 1452, 1247, 1206, 1155, 1126, 1102, 1060, 1028, 892, 869, 822, 742 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.62 (dd, J = 6.5, 1.7 Hz, 1H), 7.43 (d, J = 8.7 Hz, 1H), 7.31 (d, J = 7.8 Hz, 1H), 7.20−7.11 (m, 3H), 6.88 (d, J = 3.0 Hz, 1H), 6.78 (d, J = 9.1 Hz, 2H), 6.67 (dd, J = 8.7, 3.1 Hz, 1H), 6.56 (d, J = 9.1 Hz, 2H), 6.48 (dd, J = 3.4, 0.6 Hz, 1H), 4.95 (s, 2H), 3.75 (s, 3H), 3.60 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 159.1 (C), 154.3 (C), 143.1 (C), 136.9 (C), 135.1 (C), 133.4 (CH), 127.3 (CH), 126.5 (C), 122.5 (CH), 121.3 (CH), 120.4 (CH), 115.4 (CH), 115.2 (2CH), 115.1 (CH), 114.7 (2CH), 113.6 (C), 110.1 (CH), 101.1 (CH), 58.9 (CH_2), 55.7 (CH_3), 55.5 (CH_3); HR-MS (ESI positive) found m/z 437.0857/439.0849 ($[M + H]^+$), calcd for $C_{23}H_{22}N_2O_2Br$ (M + H) m/z 437.0865.

*(E,Z)-N-(3-Bromoallyl)-N-(4-methoxyphenyl)-1H-indol-1-amine (**2o**).* Following the general procedure, a mixture of **1a** (0.41 mmol, 100 mg) and (*E*,*Z*)-1,3-dibromoprop-1-ene was stirred for 1 h. The residue was purified by flash chromatography over silica gel (95/5 cyclohexane/EtOAc) to afford the desired product **2o** as a pale brown oil. A mixture of *E* and *Z* isomers (1/2 *E*/*Z* ratio, identified by the chemical shift of the proton signal (parts per million) at the CH2 position of the allyl group: 4.50 ppm for the *Z* isomer and 4.29 ppm for for *E* isomer.

(*Z*)-**2o**: yield 56% (0.22 mmol, 82 mg); R_f = 0.67 (9/1 cyclohexane/EtOAc); IR (neat) ν 1590, 1509, 1477, 1452, 1247, 1206, 1155, 1126, 1102, 1060, 1028. 892, 869, 822, 742 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.64 (dd, J = 7.2, 1.4 Hz, 1H), 7.35 (d, J = 8.4 Hz, 1H), 7.23−7.11 (m, 3H), 6.78 (d, J = 9.2 Hz, 2H), 6.57−6.49 (m, 3H), 6.34−6.26 (m, 2H), 4.50 (dd, J = 5.1, 1.1 Hz, 2H), 3.74 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 154.4 (C), 142.8 (C), 135.6 (C), 130.3 (CH), 126.5 (CH), 126.2 (C), 122.7 (CH), 121.2 (CH), 120.5 (CH), 115.4 (2CH), 114.8 (2CH), 110.8 (CH), 109.8 (CH), 101.7 (CH), 55.7 (CH_3), 53.6 (CH_2); HR-MS (ESI positive) found m/z 357.0592 ($[M + H]^+$), calcd for $C_{18}H_{18}N_2OBr$ (M + H) m/z 357.0597.

(*E*)-**2o**: yield 27% (0.11 mmol, 39 mg); R_f = 0.53 (9/1 cyclohexane/EtOAc); IR (neat) ν 1590, 1509, 1477, 1452, 1247, 1206, 1155, 1126, 1102, 1060, 1028. 892, 869, 822, 742 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.64 (dd, J = 7.0, 2.0 Hz, 1H), 7.31−7.24 (m, 1H), 7.23−7.11 (m, 3H), 6.77 (d, J = 9.2 Hz, 2H), 6.54 (dd, J = 3.4, 0.8 Hz, 1H), 6.49 (d, J = 9.2 Hz, 2H), 6.37 (dt, J = 13.6, 6.3 Hz, 1H), 6.25 (dt, J = 13.6, 1.0 Hz, 1H), 4.29 (s, 2H), 3.74 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 154.3 (C), 142.4 (C), 135.2 (C), 132.4 (CH), 127.3 (CH), 126.4 (C), 122.6 (CH), 121.3 (CH), 120.6 (CH), 115.0 (2CH), 114.8 (2CH), 109.9 (CH), 109.8 (CH), 101.4 (CH), 55.7 (CH_3), 55.3 (CH_2); HR-MS (ESI positive) found m/z 357.0594 ($[M + H]^+$), calcd for $C_{18}H_{18}N_2OBr$ (M + H) m/z 357.0597.

*N-[(2-Bromothiophen-3-yl)methyl]-N-(4-methoxyphenyl)-1H-indol-1-amine (**2p**).* Following the general procedure, a mixture of **1a** (0.21 mmol, 50 mg) and 2-bromo-3-(bromomethyl)thiophene was stirred for 1 h. The residue was purified by flash chromatography over silica gel (95/5 cyclohexane/EtOAc) to afford the desired product **2p** as a brown oil: yield 89% (0.18 mmol, 73 mg); R_f = 0.57 (9/1 cyclohexane/EtOAc); IR (neat) ν 1734, 1590, 1509, 1477, 1452, 1247, 1206, 1155, 1126, 1102, 1060, 1028, 892, 869, 822, 742 cm^{-1}; ^1H

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NMR (300 MHz, $CDCl_3$) δ 7.59 (dd, J = 6.4, 1.9 Hz, 1H), 7.25 (d, J = 8.1 Hz, 1H), 7.18−7.04 (m, 4H), 6.81−6.72 (m, 3H), 6.59 (d, J = 9.1 Hz, 2H), 6.46 (d, J = 3.4 Hz, 1H), 4.81 (s, 2H), 3.74 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 143.1 (C), 136.6 (C), 135.3 (C), 128.4 (CH), 127.0 (CH), 126.4 (C), 126.0 (CH), 122.4 (CH), 121.2 (CH), 120.3 (CH), 115.5 (2CH), 114.8 (2CH), 111.5 (C), 110.0 (CH), 101.2 (CH), 55.7 (CH_3), 52.3 (CH_2); HR-MS (ESI positive) found m/z 413.0322/415.0302 ($[M + H]^+$), calcd for $C_{20}H_{18}N_2OBrS$ (M + H) m/z 413.0323.

*General Procedure for Palladium-Catalyzed Intramolecular C-2 Arylation of **2a−p**.* A flame-dried resealable tube was charged with $Pd(OAc)_2$ (5 mol %), Dpephos (10 mol %), TBAB (0.12 mmol, 1 equiv), Cs_2CO_3 (0.24 mmol, 2 equiv), and compounds **2a−p** (0.12 mmol, 1 equiv). The tube was capped with a rubber septum, evacuated, and backfilled under argon, and then DMA (3 mL, 0.04M) was added through the septum under argon. The septum was replaced with a Teflon screw cap. The tube was sealed and the mixture stirred at 130 °C for 1−3 h. The resulting suspension was cooled at room temperature and filtered through a pad of Celite that was eluting with ethyl acetate, and the organic salts were removed. The filtrate was transferred to a separating funnel and extracted with aqueous NH_4Cl (30 mL, twice) and distilled water (30 mL). The combined organic phases was dried with $MgSO_4$, evaporated to dryness, and purified by flash chromatography over silica gel to afford the desired product.

*6-(4-Methoxyphenyl)-5,6-dihydroindolo[2,1-a]phthalazine (**3a**).* Compound **3a** was prepared by using **2a** (0.12 mmol, 50 mg), following the general procedure (reaction time of 3 h). The residue was purified by flash chromatography over silica gel (98/2 cyclohexane/EtOAc) to afford the desired product as a yellow solid: yield 80% (0.096 mmol, 31 mg); R_f = 0.37 (95/5 cyclohexane/EtOAc); mp 139−141 °C; IR (neat) ν 2266, 2241, 2200, 2172, 2139, 2099, 2069, 1995, 1972, 1711, 1506, 1462, 1247, 1182, 1034, 823, 760, 742 cm^{-1}; ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.77 (d, J = 7.6 Hz, 1H), 7.68 (dd, J = 6.9, 2.1 Hz, 1H), 7.37−7.29 (m, 2H), 7.23−7.09 (m, 4H), 6.93 (s, 1H), 6.61 (d, J = 9.1 Hz, 2H), 6.38 (d, J = 9.1 Hz, 2H), 4.88 (s, 2H), 3.63 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 155.5 (C), 143.0 (C), 134.4 (C), 132.5 (C), 129.3 (C), 128.2 (CH), 128.0 (CH), 127.8 (C), 126.9 (CH), 123.8 (CH), 122.7 (CH), 120.9 (CH), 120.7 (CH), 119.2 (2CH), 114.4 (2CH), 110.0 (CH), 95.3 (CH), 58.1 (CH_2), 55.4 (OMe); HR-MS (APCI positive) found m/z 327.1493 ($[M + H]^+$), calcd for $C_{22}H_{19}N_2O$ (M + H) m/z 327.1493.

*6-(4-Chlorophenyl)-5,6-dihydroindolo[2,1-a]phthalazine (**3b**).* Compound **3b** was prepared by using **2b** (0.24 mmol, 100 mg), following the general procedure (reaction time of 1 h). The residue was purified by flash chromatography over silica gel (98/2 cyclohexane/EtOAc) to afford the desired product as a yellow solid: yield 91% (0.22 mmol, 73 mg); R_f = 0.46 (95/5 cyclohexane/EtOAc); mp 105−107 °C; IR (neat) ν 2063, 2031, 1728, 1488, 1462, 1339, 1260, 1193, 1178, 1116, 1097, 1006, 907, 841, 760, 743, 648, 628 cm^{-1}; ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.77 (d, J = 7.7 Hz, 1H), 7.70 (dd, J = 7.1, 2.6 Hz, 1H), 7.37−7.30 (m, 2H), 7.27−7.13 (m, 4H), 7.03 (d, J = 9.0 Hz, 2H), 6.95 (s, 1H), 6.35 (d, J = 9.0 Hz, 2H), 4.92 (s, 2H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 148.2 (C), 134.3 (C), 132.3 (C), 129.2 (3C: 2CH, 1C), 128.4 (CH), 128.1 (CH), 128.0 (C), 127.6 (C), 126.8 (CH), 125.9 (C), 123.9 (CH), 123.0 (CH), 121.1 (CH), 120.9 (CH), 119.0 (CH), 109.8 (2CH), 95.8 (CH), 57.6 (CH_2); HR-MS (APCI positive) found m/z 331.100 ($[M + H]^+$), calcd for $C_{21}H_{16}N_2Cl$ (M + H) m/z 331.0997.

*6-(m-Tolyl)-5,6-dihydroindolo[2,1-a]phthalazine (**3c**).* Compound **3c** was prepared by using **2c** (0.13 mmol, 50 mg), following the general procedure (reaction time of 3 h). The residue was purified by flash chromatography over silica gel (95/5 cyclohexane/EtOAc) to afford the desired product as a beige solid: yield 71% (0.17 mmol, 53 mg); R_f = 0.71 (9/1 cyclohexane/EtOAc); mp 62−65 °C; IR (neat) ν 1605, 1585, 1488, 1462, 1378, 1339, 1262, 1155, 1028, 759, 741, 701 cm^{-1}; ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.76 (d, J = 7.5 Hz, 1H), 7.71−7.65 (m, 1H), 7.35−7.28 (m, 2H), 7.23−7.11 (m, 4H), 6.95−6.89 (m, 2H), 6.66 (d, J = 7.5 Hz, 1H), 6.38 (s, 1H), 6.10 (dd, J = 8.1, 2.3 Hz, 1H), 4.94 (s, 2H), 2.16 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 149.6 (C), 138.9 (2C), 129.6 (C), 129.0 (CH), 128.2 (CH), 127.9 (CH), 127.8 (C), 126.8 (CH), 125.8 (C), 123.8 (CH), 123.7 (CH), 122.7 (CH), 120.9 (CH), 120.6 (CH), 118.4 (CH), 114.7 (CH), 110.0 (CH), 95.5 (CH), 57.5 (CH_2), 21.7 (CH_3); HR-MS (APCI positive) found m/z 311.1551 ($[M + H]^+$), calcd for $C_{22}H_{19}N_2$ (M + H) m/z 311.1543.

*6-(3,5-Dimethoxyphenyl)-5,6-dihydroindolo[2,1-a]phthalazine (**3d**).* Compound **3d** was prepared by using **2d** (0.15 mmol, 65 mg), following the general procedure (reaction time of 2 h). The residue was purified by flash chromatography over silica gel (95/5 cyclohexane/EtOAc) to afford the desired product as a yellow solid: yield 94% (0.14 mmol, 50 mg); R_f = 0.35 (9/1 cyclohexane/EtOAc); mp 145−148 °C; IR (neat) ν 1595, 1461, 1426, 1339, 1261, 1204, 1155, 1059, 797, 761, 745 cm^{-1}; ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.74 (d, J = 7.5 Hz, 1H), 7.65 (dd, J = 7.8, 1.1 Hz, 1H), 7.36−7.28 (m, 2H), 7.24−7.09 (m, 4H), 6.90 (s, 1H), 5.97 (t, J = 2.1 Hz, 1H), 5.61 (d, J = 2.1 Hz, 2H), 4.91 (s, 2H), 3.57 (s, 6H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 161.3 (2C), 151.8 (C), 134.6 (C), 132.5 (C), 128.3 (C), 127.9 (CH), 127.8 (CH), 126.8 (C), 125.8 (CH), 123.9 (C), 122.8 (CH), 121.0 (CH), 120.6 (CH), 109.9 (CH), 96.9 (2CH), 95.6 (CH), 94.2 (CH), 57.4 (CH_2), 55.2 (2CH_3); HR-MS (ESI positive) found m/z 357.1598 ($[M + H]^+$), calcd for $C_{23}H_{21}N_2O_2$ (M + H) m/z 357.1598.

*6-(Naphthalen-1-yl)-5,6-dihydroindolo[2,1-a]phthalazine (**3e**).* Compound **3e** was prepared by using **2e** (0.234 mmol, 100 mg), following the general procedure (reaction time of 2 h). The residue was purified by flash chromatography over silica gel (95/5 cyclohexane/EtOAc) to afford the desired product as a white-yellow solid: yield 98% (0.23 mmol, 80 mg); R_f = 0.59 (9/1 cyclohexane/EtOAc); mp 181−183 °C; IR (neat) ν 1575, 1505, 1461, 1449, 1394, 1339, 1316, 1261, 1222, 1089, 1019, 988, 801, 775, 760, 743, 734, 692 cm^{-1}; ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.68 (d, J = 8.6 Hz, 1H), 7.87 (t, J = 8.4 Hz, 2H), 7.74−7.64 (m, 2H), 7.58 (t, J = 8.1 Hz, 1H), 7.47 (d, J = 8.3 Hz, 1H), 7.37 (t, J = 8.1 Hz, 1H), 7.29−7.23 (m, 1H), 7.19−7.04 (m, 3H), 7.02−6.91 (m, 3H), 6.07 (d, J = 8.4 Hz, 1H), 4.99 (s, 2H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 144.7 (C), 134.7 (C), 133.9 (C), 133.5 (C), 128.7 (CH), 128.6 (C), 128.3 (CH), 128.1 (CH), 127.6 (C), 127.4 (C), 127.2 (CH), 126.3 (CH), 126.2 (CH), 125.7 (CH), 125.1 (CH), 123.7 (CH), 123.1 (CH), 122.6 (CH), 120.8 (CH), 120.7 (CH), 116.7 (CH), 109.9 (CH), 94.7 (CH), 57.6 (CH_2); HR-MS (APCI positive) found m/z 347.1541 ($[M + H]^+$), calcd for $C_{25}H_{19}N_2$ (M + H) m/z 347.1543.

*6-(2-Methoxyphenyl)-5,6-dihydroindolo[2,1-a]phthalazine (**3f**).* Compound **3f** was prepared by using **2f** (0.22 mmol, 90 mg), following the general procedure (reaction time of 2 h). The residue was purified by flash chromatography over silica gel (95/5 cyclohexane/EtOAc) to afford the desired product as a beige solid: yield 98% (0.215 mmol, 70 mg); R_f = 0.44 (9/1 cyclohexane/EtOAc); mp 171−173 °C; IR (neat) ν 1592, 1494, 1460, 1384, 1339, 1244, 1116, 1026, 793, 759, 744, 613 cm^{-1}; ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.81 (d, J = 7.1 Hz, 1H), 7.70−7.63 (m, 1H), 7.37−7.28 (m, 2H), 7.20 (t, J = 7.4 Hz, 1H), 7.15−7.07 (m, 3H), 6.96 (s, 1H), 6.92−6.87 (m, 2H), 6.49−6.41 (m, 1H), 5.55 (d, J = 7.6 Hz, 1H), 4.97 (s, 2H), 4.06 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 150.6 (C), 137.9 (C), 133.9 (C) 133.8 (C), 129.7 (C), 128.2 (CH), 128.1 (CH), 127.7 (C), 127.2 (CH), 126.3 (C), 124.8 (CH), 123.8 (CH), 122.7 (CH), 121.3 (CH), 120.9 (CH), 120.8 (CH), 119.7 (CH), 112.1 (CH), 110.3 (CH), 95.0 (CH), 56.2 (CH_3), 55.6 (CH_2); HR-MS (ESI positive) found m/z 327.1504 ($[M + H]^+$), calcd for $C_{22}H_{19}N_2O$ (M + H) m/z 327.1497.

*6-(o-Tolyl)-5,6-dihydroindolo[2,1-a]phthalazine (**3g**).* Compound **3g** was prepared by using **2g** (0.22 mmol, 90 mg), following the general procedure (reaction time of 2 h). The residue was purified by flash chromatography over silica gel (95/5 cyclohexane/EtOAc) to afford the desired product as a yellow solid: yield 73%; R_f = 0.51 (95/5 cyclohexane/EtOAc); mp 121−123 °C; IR (neat) ν 2367, 2159, 1488, 1461, 1449, 1379, 1340, 1210, 1176, 1110, 908, 759, 742, 712, 684, 647 cm^{-1}; ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.84 (d, J = 7.6 Hz, 1H), 7.67−7.60 (m, 1H), 7.37 (t, J = 7.6 Hz, 1H), 7.23−7.15 (m, 3H), 7.12−7.02 (m, 3H), 6.94 (s, 1H), 6.88 (t, J = 7.4 Hz, 1H), 6.70 (t, J = 7.7 Hz, 1H), 5.93 (d, J = 8.1 Hz, 1H), 4.68 (s, 2H), 2.69 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 147.4 (C), 133.9 (C), 133.5 (C), 131.2 (CH), 130.3 (C), 128.5 (C), 128.2 (CH), 128.1 (CH), 127.9 (C),

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127.0 (CH), 126.7 (CH), 126.2 (C), 124.8 (CH), 123.6 (CH), 122.5 (CH), 120.7 (CH), 120.6 (CH), 120.2 (CH), 109.8 (CH), 94.5 (CH), 56.4 (CH_2), 18.4 (CH_3); HR-MS (ESI positive) found m/z 311.1552 ($[M + H]^+$), calcd for $C_{22}H_{19}N_2$ (M + H) m/z 311.1548.

*6-(2-Chlorophenyl)-5,6-dihydroindolo[2,1-a]phthalazine (**3h**).* Compound **3h** was prepared by using **2h** (0.22 mmol, 100 mg), following the general procedure (reaction time of 3 h). The residue was purified by flash chromatography over silica gel (95/5 cyclohexane/EtOAc) to afford the desired product as a white-yellow solid: yield 76% (0.165 mmol, 63 mg); R_f = 0.76 (9/1 cyclohexane/EtOAc); mp 55.7−57.5 °C; IR (neat) ν 2294, 1720, 1585, 1474, 1446, 1339, 1261, 1197, 1102, 1057, 1047, 1007, 801, 758, 741, 678 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.84 (d, J = 7.8 Hz, 1H), 7.65 (dd, J = 5.9, 2.7 Hz, 1H), 7.41−7.34 (m, 2H), 7.30−7.19 (m, 2H), 7.16−7.08 (m, 3H), 6.95 (s, 1H), 6.90 (t, J = 7.6 Hz, 1H), 6.77 (t, J = 7.7 Hz, 1H), 5.89 (d, J = 8.1 Hz, 1H), 4.92 (s, 2H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 145.6 (C), 133.7 (C), 133.3 (C), 130.6 (CH), 128.6 (C), 128.6 (C), 128.4 (CH), 128.2 (CH), 127.7 (CH), 127.1 (CH), 126.3 (C), 126.2 (C), 125.7 (CH), 123.7 (CH), 122.8 (CH), 121.6 (CH), 120.9 (2CH), 120.8 (CH), 110.0 (CH), 56.1 (CH_2); HR-MS (APCI positive) found m/z 331.0990 ($[M + H]^+$), calcd for $C_{21}H_{16}N_2Cl$ (M + H) 331.0997.

*10-Methoxy-6-(4-methoxyphenyl)-5,6-dihydroindolo[2,1-a]-phthalazine (**3i**).* Compound **3i** was prepared by using **2i** (0.18 mmol, 80 mg) following the general procedure (reaction time of 1 h). The residue was purified by flash chromatography over silica gel (95/5 cyclohexane/EtOAc) to afford the desired product as a yellow solid: yield 94% (0.17 mmol, 60 mg); R_f = 0.57 (9/1 cyclohexane/EtOAc); mp 73−75 °C; IR (neat) ν 1623, 1551, 1505, 1460, 1439, 1378, 1294, 1246, 1219, 1181, 1141, 1120, 1032, 941, 875, 826, 800, 757, 735 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.74 (d, J = 7.6 Hz, 1H), 7.32 (t, J = 7.5 Hz, 1H), 7.27−7.16 (m, 2H), 7.12 (t, J = 4.2 Hz, 2H), 6.85 (dd, J = 8.7, 2.5 Hz, 2H), 6.60 (d, J = 9.0 Hz, 2H), 6.37 (d, J = 9.0 Hz, 2H), 4.86 (s, 2H), 3.88 (s, 3H), 3.63 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 155.5 (C), 154.9 (C), 143.0 (C), 133.1 (C), 129.7 (C), 128.9 (C), 128.2 (CH), 127.9 (CH), 127.7 (C), 126.9 (CH), 126.3 (C), 123.6 (CH), 119.2 (2CH), 114.3 (2CH), 113.2 (CH), 110.7 (CH), 102.3 (CH), 94.8 (CH), 58.1 (CH_2), 55.9 (CH_3), 55.4 (CH_3); HR-MS (APCI positive) found m/z 357.1604 ($[M + H]^+$), calcd for $C_{23}H_{21}N_2O_2$ (M + H) m/z 357.1598.

*10-Chloro-6-(naphthalen-1-yl)-5,6-dihydroindolo[2,1-a]-phthalazine (**3j**).* Compound **3j** was prepared by using **2j** (0.24 mmol, 110 mg) following the general procedure (reaction time of 3 h). The residue was purified by flash chromatography over silica gel (95/5 cyclohexane/EtOAc) to afford the desired product as a white-yellow solid: yield 63% (0.15 mmol, 57 mg); R_f = 0.62 (95/5 cyclohexane/EtOAc); mp 171−173 °C; IR (neat) ν 1531, 1471, 1208, 1150, 1130, 1023, 815, 767, 747, 724, 711 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 8.64 (d, J = 8.4 Hz, 1H), 7.86 (d, J = 8.0 Hz, 2H), 7.70 (t, J = 7.7 Hz, 1H), 7.63 (d, J = 1.9 Hz, 1H), 7.58 (t, J = 7.5 Hz, 1H), 7.49 (d, J = 8.2 Hz, 1H), 7.38 (t, J = 7.6 Hz, 1H), 7.22−7.13 (m, 2H), 7.01−6.88 (m, 4H), 6.01 (d, J = 7.4 Hz, 1H), 4.98 (s, 2H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 144.4 (C), 134.8 (C), 134.7 (C), 132.3 (C), 128.8 (CH), 128.5 (CH), 128.5 (C), 128.4 (CH), 127.3 (C), 127.3 (C), 127.2 (CH), 127.1 (C), 126.5 (CH), 126.3 (CH), 126.3 (C), 125.6 (CH), 125.4 (CH), 123.8 (CH), 123.0 (CH), 122.9 (CH), 120.1 (CH), 116.5 (CH), 110.9 (CH), 94.2 (CH), 57.5 (CH_2); HR-MS (APCI positive) found m/z 381.1141 ($[M + H]^+$), calcd for $C_{25}H_{18}N_2Cl$ (M + H) m/z 381.1153.

*10-Fluoro-6-(o-tolyl)-5,6-dihydro[1,3]dioxolo[4,5-g]indolo[2,1-a]-phthalazine (**3k**).* Compound **3k** was prepared by using **2k** (0.18 mmol, 81 mg) following the general procedure (reaction time of 3 h). The residue was purified by flash chromatography over silica gel (95/5 cyclohexane/EtOAc) to afford the desired product as a white-yellow solid: yield 75% (0.135 mmol, 50 mg); R_f = 0.46 (9/1 cyclohexane/EtOAc); mp 256−158 °C; IR (neat) ν 1502, 1474, 1454, 1383, 1336, 1249, 1198, 1159, 1039, 936, 793, 724 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.27−7.15 (m, 3H), 7.07 (dd, J = 8.8, 4.6 Hz, 1H), 6.90 (t, J = 7.3 Hz, 1H), 6.85−6.65 (m, 3H), 6.52 (s, 1H), 5.95 (s, 2H), 5.87 (d, J = 8.1 Hz, 1H), 4.57 (s, 2H), 2.64 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 158.93−156.82 (d, J = 234.8 Hz, C), 148.0 (C), 147.7 (C), 147.0 (C), 135.2 (C), 131.3 (CH), 130.3 (C), 130.3 (C), 126.7 (CH), 126.46−126.32 (d, J = 10.3 Hz, C), 125.0 (CH), 122.5 (C), 121.5 (C), 120.1 (CH), 110.78−110.43 (d, J = 26.5 Hz, CH), 110.33−110.20 (d, J = 9.7 Hz, CH), 107.6 (CH), 105.43−105.11 (d, J = 23.9 Hz, CH), 104.1 (CH), 101.4 (CH2), 93.49−93.43 (d, J = 4.6 Hz, CH), 56.4 (CH_2), 18.3 (CH_3); HR-MS (APCI positive) found m/z 373.1353 ($[M + H]^+$), calcd for $C_{23}H_{18}N_2O_2F$ (M + H) m/z 373.1347.

*6-(4-Methoxyphenyl)-5,6-dihydro[1,3]dioxolo[4,5-g]indolo[2,1-a]phthalazine (**3l**).* Compound **3l** was prepared by using **2l** (0.24 mmol, 110 mg) following the general procedure (reaction time of 3 h). The residue was purified by flash chromatography over silica gel (95/5 cyclohexane/EtOAc) to afford the desired product as a white-yellow solid: yield 74% (0.178 mmol, 66 mg); R_f = 0.44 (95/5 cyclohexane/EtOAc); mp 203−205 °C; IR (neat) ν 2168, 1504, 1475, 1248, 1180, 1038, 937, 904, 829, 726, 649 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.66−7.61 (m, 1H), 7.33−7.29 (m, 1H), 7.26 (s, 1H), 7.20 (s, 1H), 7.16−7.10 (m, 2H), 6.78 (bs, 1H), 6.64−6.59 (m, 3H), 6.36 (d, J = 9.2 Hz, 2H), 5.93 (s, 2H), 4.77 (s, 2H), 3.64 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 155.4 (C), 147.6 (C), 142.6 (C), 134.0 (C), 132.7 (C), 125.8 (C), 123.2 (C), 122.3 (CH), 121.6 (C), 120.5 (CH, 1C), 120.5 (CH), 119.0 (2CH), 114.2 (2CH), 109.7 (2CH), 107.3 (CH), 104.1 (CH), 101.2 (CH2), 94.1 (CH), 57.9 (CH_2), 55.3 (OMe); HR-MS (APCI positive) found m/z 371.1394 ($[M + H]^+$), calcd for $C_{23}H_{19}N_2O_3$ (M + H) m/z 371.1396.

*6-(4-Chlorophenyl)-5,6-dihydro[1,3]dioxolo[4,5-g]indolo[2,1-a]-phthalazine (**3m**).* Compound **3m** was prepared by using **2m** (0.24 mmol, 109 mg) following the general procedure (reaction time of 3 h). The residue was purified by flash chromatography over silica gel (95/5 cyclohexane/EtOAc) to afford the desired product as a beige solid: yield 60% (0.144 mmol, 54 mg); R_f = 0.42 (9/1 cyclohexane/EtOAc); mp 197−199 °C; IR (neat) ν 3460, 2851, 2365, 2187, 2005, 1977, 1488, 1474, 1310, 1250, 1230, 1160, 1094, 936, 865, 828, 781, 746, 729 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.65 (dd, J = 6.0, 2.4 Hz, 1H), 7.33−7.22 (m, 1H), 7.21−7.11 (m, 3H), 7.03 (d, J = 9.0 Hz, 2H), 6.79 (s, 1H), 6.62 (s, 1H), 6.32 (d, J = 9.0 Hz, 2H), 5.94 (s, 2H), 4.81 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 148.1 (C), 147.9 (C), 147.8 (C), 134.1 (C), 132.5 (C), 129.2 (2CH), 128.1 (C), 125.9 (C), 123.3 (2C), 122.7 (CH), 121.6 (C), 120.8 (2CH), 119.1 (2CH), 109.7 (CH), 107.4 (CH), 104.4 (CH), 101.4 (CH_2), 94.8 (CH), 57.6 (CH_2); HR-MS (APCI positive) found m/z 375.0898 ($[M + H]^+$), calcd for $C_{22}H_{16}N_2O_2Cl$ (M + H) m/z 375.0895.

*3-Methoxy-6-(4-methoxyphenyl)-5,6-dihydroindolo[2,1-a]-phthalazine (**3n**).* Compound **3n** was prepared by using **2n** (0.24 mmol, 105 mg) following the general procedure (reaction time of 2 h). The residue was purified by flash chromatography over silica gel (95/5 cyclohexane/EtOAc) to afford the desired product as a white-yellow solid: yield 56% (0.134 mmol, 48 mg); R_f = 0.44 (95/5 cyclohexane/EtOAc); mp 155−157 °C; IR (neat) ν 2357, 2217, 2168, 2023, 1711, 1610, 1507, 1360, 1248, 1221, 1183, 1221, 1183, 1038, 829, 745 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.69 (d, J = 8.5 Hz, 1H), 7.66−7.60 (m, 1H), 7.32 (dd, J = 6.2, 2.9 Hz, 1H), 7.18−7.09 (m, 2H), 6.87 (dd, J = 8.5, 2.5 Hz, 1H), 6.81 (s, 1H), 6.67 (d, J = 2.5 Hz, 1H), 6.61 (d, J = 9.1 Hz, 2H), 6.37 (d, J = 9.1 Hz, 2H), 4.84 (s, 2H), 3.78 (s, 3H), 3.63 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 159.6 (C), 155.5 (C), 143.0 (C), 134.1 (C), 132.8 (C), 130.9 (C), 126.1 (C), 125.2 (CH), 122.2 (CH), 120.7 (C), 120.6 (CH), 120.5 (CH), 119.2 (2CH), 114.4 (2CH), 114.0 (CH), 112.3 (CH), 109.8 (CH), 93.8 (CH), 58.2 (CH_2), 55.4 (2 CH_3); HR-MS (APCI positive) found m/z 357.1597 ($[M + H]^+$), calcd for $C_{23}H_{21}N_2O_2$ (M + H) m/z 357.1598.

*1-(4-Methoxyphenyl)-1,2-dihydropyridazino[1,6-a]indole (**3o**).* Compound **3o** was prepared by using **2o** (0.25 mmol, 90 mg) following the general procedure (reaction time of 3 h). The residue was purified by flash chromatography over silica gel (95/5 cyclohexane/EtOAc) to afford the desired product as a beige solid: yield 68% (0.17 mmol, 47 mg); mp 58−60 °C; R_f = 0.58 (9/1 cyclohexane/EtOAc); IR (neat) ν 1512, 1492, 1272, 1230, 1200, 1166, 1020, 993, 846, 814, 789, 755, 724, 707, 687 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.60 (d, J = 7.2 Hz, 1H), 7.25 (d, J = 7.3 Hz, 1H), 7.16−7.05 (m, 2H), 6.80 (d, J = 9.9 Hz, 1H), 6.67 (d, J = 9.0 Hz, 2H), 6.48 (s, 1H),

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6.28 (d, J = 9.0 Hz, 2H), 5.84 (dt, J = 9.9, 3.9 Hz, 1H), 4.38 (dd, J = 3.9, 1.1 Hz, 2H), 3.68 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 155.7 (C), 143.4 (C), 134.4 (C), 132.1 (C), 125.7 (C), 122.9 (CH), 121.6 (CH), 120.9 (CH), 120.7 (CH), 120.4 (CH), 119.5 (2CH), 114.3 (2CH), 109.8 (CH), 97.8 (CH), 55.5 (CH_3), 54.8 (CH_2); HR-MS (APCI positive) found m/z 277.1338 ([M + H]$^+$), calcd for $C_{18}H_{17}N_2O$ (M + H) m/z 277.1341.

*5-(4-Methoxyphenyl)-4,5-dihydrothieno[3′,2′:4,5]pyridazino[1,6-a]indole (**3p**).* Compound **3p** was prepared by using **2p** (0.24 mmol, 99 mg) following the general procedure (reaction time of 3 h). The residue was purified by flash chromatography over silica gel (95/5 cyclohexane/EtOAc) to afford the desired product as a white solid: yield 60% (0.144 mmol, 48 mg); R_f = 0.44 (9/1 cyclohexane/EtOAc); mp 79−81 °C; IR (neat) ν 1732, 1504, 1336, 1307, 1244, 1188, 1178, 1065, 1034, 1009, 836, 771, 734, 698, 663 cm^{-1}; ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.62 (dd, J = 7.3, 2.2 Hz, 1H), 7.30 (d, J = 7.6 Hz, 1H), 7.19 (d, J = 5.0 Hz, 1H), 7.16−7.07 (m, 2H), 6.84 (d, J = 5.0 Hz, 1H), 6.70 (s, 1H), 6.61 (d, J = 9.1 Hz, 2H), 6.33 (d, J = 9.1 Hz, 2H), 4.87 (s, 2H), 3.64 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 155.7 (C), 143.2 (C), 134.4 (C), 131.1 (C), 130.4 (C), 128.3 (C), 126.1 (C), 125.8 (CH), 124.5 (CH), 122.9 (CH), 120.8 (CH), 120.7 (CH), 119.4 (2CH), 114.4 (2CH), 110.0 (CH), 94.9 (CH), 55.5 (CH_2), 55.4; HR-MS (APCI positive) m/z found 333.1055 ([M + H]$^+$), calcd for $C_{20}H_{17}N_2OS$ (M + H) m/z 333.1056.

*General Procedure for Palladium-Catalyzed C-3 Arylation of **3a**.* A flame-dried resealable tube was charged with $Pd(OAc)_2$ (5 mol %), Dpephos (10 mol %), Cs_2CO_3 (0.16 mmol, 2 equiv), compound **3a** (0.08 mmol, 1 equiv), and aryl bromide (0.12 mmol, 1.5 equiv). The tube was capped with a rubber septum, evacuated, and backfilled under argon, and then DMA (1.5 mL) was added through the septum under argon. The septum was replaced with a Teflon screw cap. The tube was sealed and the mixture stirred at 130 °C for 12 h. The resulting suspension was cooled at room temperature and filtered through a pad of Celite that was eluted with ethyl acetate, and the organic salts were removed. The filtrate was transferred to a separating funnel and extracted with aqueous NH_4Cl (30 mL, twice) and distilled water (30 mL). The combined organic phase was dried with $MgSO_4$, evaporated to dryness, and purified by flash chromatography over silica gel (95/5 cyclohexane/EtOAc).

*6-(4-Methoxyphenyl)-12-(4-nitrophenyl)-5,6-dihydroindolo[2,1-a]phthalazine (**4a**).* The reaction was conducted with **3a** for 12 h according to the general procedure to obtain **4a** as a yellow solid: yield 65% (0.05 mmol, 22 mg); mp 70−72 °C; R_f = 0.45 (9/1 cyclohexane/EtOAc); IR (neat) ν 1648, 1624, 1594, 1506, 1463, 1340, 1245, 1182, 1109, 1035, 948, 918, 892, 848, 827, 759, 743, 705, 684, 659, 640 cm^{-1}; ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.35 (d, J = 8.9 Hz, 2H), 7.84 (d, J = 8.9 Hz, 2H), 7.65 (d, J = 7.5 Hz, 1H), 7.43 (t, J = 8.2 Hz, 2H), 7.29−7.24 (m, 1H), 7.23−7.16 (m, 3H), 7.13 (dd, J = 7.7, 2.4 Hz, 1H), 6.63 (d, J = 9.1 Hz, 2H), 6.47 (d, J = 9.1 Hz, 2H), 4.92 (s, 2H), 3.64 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 155.7 (C), 146.5 (C), 142.8 (C), 141.7 (C), 133.7 (C), 130.8 (2CH), 130.5 (2C), 128.6 (CH), 128.0 (CH), 127.4 (CH), 126.8 (C), 125.1 (CH), 124.9 (C), 124.3 (2CH), 123.8 (CH), 121.8 (CH), 119.3 (2CH), 118.7 (CH), 114.5 (2CH), 110.4 (CH), 109.9 (C), 58.5 (CH_2), 55.4; HR-MS (ESI positive) found m/z 448.1655 ([M + H]$^+$), calcd for $C_{28}H_{22}N_3O_3$ (M + H) m/z 448.1661.

*6,12-Bis(4-methoxyphenyl)-5,6-dihydroindolo[2,1-a]phthalazine (**4b**).* The reaction was conducted with **3a** for 12 h according to the general procedure: yellow solid; yield 50% (35 mg, 0.081 mmol); mp 53−55 °C; R_f = 0.5 (9/1 cyclohexane/EtOAc); IR (neat) ν 1621, 1597, 1503, 1477, 1458, 1416, 1325, 1205, 1150, 1089, 1067, 930, 821, 763, 742, 717, 682 cm^{-1}; ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.60 (dd, J = 7.7, 1.0 Hz, 1H), 7.55 (d, J = 8.8 Hz, 2H), 7.48 (dd, J = 7.3, 1.3 Hz, 1H), 7.38 (dd, J = 7.9, 1.1 Hz, 1H), 7.23−7.17 (m, 1H), 7.16−7.03 (m, 6H), 6.63 (d, J = 9.1 Hz, 2H), 6.46 (d, J = 9.1 Hz, 2H), 4.90 (s, 2H), 3.92 (s, 3H), 3.63 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 158.8 (C), 155.4 (C) 142.6 (C), 133.4 (C), 131.5 (2CH), 130.0 (2C), 127.9 (C), 127.7 (CH), 127.6 (CH), 127.3 (CH), 127.0 (CH), 126.0 (C), 125.0 (CH), 123.2 (CH), 120.7 (CH), 119.6 (CH), 119.2 (2CH), 114.4 (4CH), 112.2 (C), 109.9 (CH), 58.4 (CH_2), 55.4 (2CH_3); HR-MS (ESI positive) found m/z 433.1951 ([M + H]$^+$), calcd for $C_{29}H_{25}N_2O_2$ (M + H) m/z 433.1916.

*Procedure for the "One-Pot" Palladium-Catalyzed C-2−C-3 Arylation in **2a**.* A flame-dried resealable tube was charged with $Pd(OAc)_2$ (10 mol %), Dpephos (20 mol %), Cs_2CO_3 (2 equiv), compound **2a** (70 mg, 0.17 mmol, 1 equiv), 4-bromomethoxybenzene (0.26 mmol, 1.5 equiv), and TBAB (1 equiv). The tube was capped with a rubber septum, evacuated, and backfilled under argon, and then DMA (3 mL) was added through the septum under argon. The septum was replaced with a Teflon screw cap. The tube was sealed and the mixture stirred at 130 °C for 12 h. The resulting suspension was cooled at room temperature and filtered through a pad of Celite that was eluted with ethyl acetate, and the organic salts were removed. The filtrate was transferred to a separating funnel and extracted with aqueous NH_4Cl (30 mL, twice) and distilled water (30 mL). The combined organic phases were dried with $MgSO_4$, evaporated to dryness, and purified by flash chromatography over silica gel (98/2 cyclohexane/EtOAc) to afford the desired product **4b** as a yellow solid: yield 45% (33 mg, 0.076 mmol).

■ ASSOCIATED CONTENT

Supporting Information

Spectroscopic data of new compounds **1d**, **2a−p**, **3a−p**, **4a**, and **4b**. This material is available free of charge via the Internet at http://pubs.acs.org.

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Notes

The authors declare no competing financial interest.

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