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N-H Carbazole Synthesis from 2-Chloroanilines via Consecutive Amination and C−H Activation

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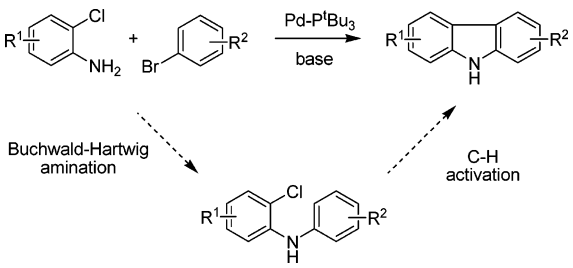
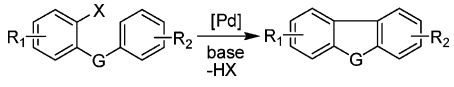


N-H carbazoles can be produced from 2-chloroanilines and aryl bromides via consecutive catalytic amination and C−H activation. In many instances, this can be done in a tandem manner in one pot. The methodologies developed can be used in the synthesis of a range of carbazoles, including the natural products Clausine P and glycozolidine and a precursor in the synthesis of Clausines H, K, O, and 7-methoxy-*O*-methylmukonal, and can be extended to the synthesis of indoles.

Introduction

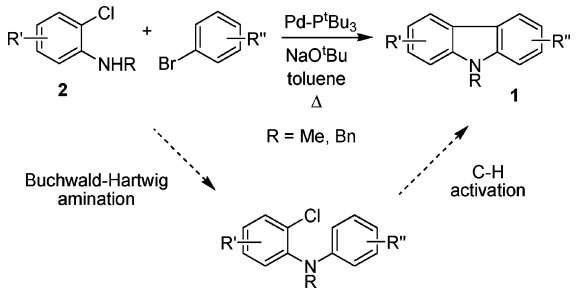
Catalytic C−H activation is rapidly becoming an important tool for the formation of C−C bonds in organic synthesis.[1,2] Palladium-catalyzed C−H activation is proving to be particularly useful for the synthesis of biaryls from "tethered" aryl halide and triflate substrates (Scheme 1). This technique has proved useful in the synthesis of six-membered heterocycles[3] such as quinolinones,[4,5] pyrans, thiazine dioxides, and pyranones.[4] Five-membered rings are also readily synthesized using this coupling methodology, allowing for the production of dibenzo-[b,d]-fused heterocycles such as dibenzofurans,[4,6] carbazoles[6,7] (Scheme 1, G = O, NR, respectively), and related compounds.[7,8] In all these examples, the halide substrates are limited to bromides and iodides.

SCHEME 1. Direct Arylation of Tethered Aryl Halides via C−H Activation



The greater availability of 2-chloro hetero-substituted aromatics and the fact that they are typically far cheaper than their heavier halide counterparts make them more attractive starting materials. However, the greater C−Cl bond strength can prove challenging for the development of catalytic processes that employ aryl chloride substrates.[9] There have been considerable advances made in the past few years in the use of aryl chlorides in coupling chemistry;[10] by contrast, there have been very few reports on the use of these substrates in couplings that proceed via C−H activation.[11] We previously reported the one-pot synthesis of N-alkylated carbazoles **1** from appropriate *N*-alkyl-2-chloroanilines, **2**, and aryl bromides (Scheme 2), in which the product is formed by Buchwald−Hartwig amination followed by ring closure via C−H activation.

SCHEME 2. One-Pot Synthesis of N-Alkylated Carbazoles



(1) For a recent overview of C−H activation reactions, see: *Handbook of C−H Transformations*; Dyker, G., Ed.; Wiley-VCH: Weinheim, 2005.

(2) For recent reviews, see: (a) Campeau, L.-C.; Fagnou, K. *Chem. Commun.* **2006**, *1253*. (b) Kakiuchi, F.; Chatani, N. *Adv. Synth. Catal.* **2003**, *345*, 1077. (c) Ritleng, V.; Sirlin, C.; Pfeffer, M. *Chem. Rev.* **2002**, *102*, 1731. (d) Kakiuchi, F.; Murai, S. *Acc. Chem. Res.* **2002**, *35*, 826.

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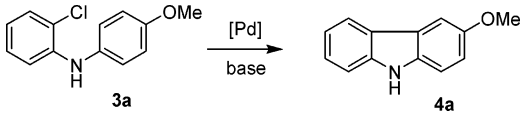
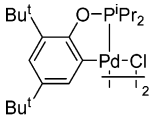
TABLE 1. Optimization of the Ring Closing of 3a to Give Carbazole 4a[a]



3a 4a

entry	palladium precursor	ligand	base	solvent	conversion %
1	$Pd(OAc)_2$	$[HP^tBu_3][BF_4]$	NaO^tBu	toluene	28
2	 **5**	$[HP^tBu_3][BF_4]$	NaO^tBu	toluene	13
3	$Pd_2(dba)_3$	$[HP^tBu_3][BF_4]$	NaO^tBu	toluene	20
4	$Pd(OAc)_2$	PCy_3	NaO^tBu	toluene	20
5	$Pd(OAc)_2$	$[HP^tBu_3][BF_4]$	$CsCO_3$	toluene	5
6	$Pd(OAc)_2$	$[HP^tBu_3][BF_4]$	K_3PO_4	toluene	10
7	$Pd(OAc)_2$	$[HP^tBu_3][BF_4]$	NaO^tBu	dioxane	83[b]
8	**5**	$[HP^tBu_3][BF_4]$	NaO^tBu	dioxane	23
9	$Pd_2(dba)_3$	P^tBu_3	NaO^tBu	dioxane	12
10	$Pd(OAc)_2$	PCy_3	NaO^tBu	dioxane	37
11	$Pd(OAc)_2$	$[HP^tBu_3][BF_4]$	Cs_2CO_3	dioxane	11
12	$Pd(OAc)_2$	$[HP^tBu_3][BF_4]$	K_3PO_4	dioxane	10

[a] Conditions: **3a** (1.0 mmol), Pd precursor (4 mol % of Pd), ligand (5 mol %), base (5 mmol), solvent (4 mL), reflux, 18 h. [b] Isolated yield.

We now report the adaptation and extension of this methodology to the production of synthetically more useful *N*-H carbazoles and illustrate the technique with selected carbazole alkaloid natural products.

Results and Discussion

We previously found that the reaction of 2-chloroaniline with 4-bromoanisole stops at the intermediate species **3a** on heating in toluene with NaO^tBu as base in the presence of palladium acetate and P^tBu_3.[11a] We therefore concentrated on optimizing the ring-closing, C−H activation step for the production of **4a**. Various palladium sources, including a palladacyclic precatalyst, **5**, were examined as well as was the effect of changing the solvent, base and coligand. The results from this brief optimization process are presented in Table 1.

We were pleased to find that replacing toluene with 1,4-dioxane and using a catalyst formed in situ from palladium acetate and P^tBu_3[12] lead to the essentially quantitative conversion of **3a** to the desired *N*-H carbazole **4a** which can be isolated in 83% yield. Having optimized the cyclization step, we investigated whether the initial amination step would proceed under the same conditions, thus facilitating a one-pot process. Unfortunately, neither the carbazole **4a** nor the intermediate **3a** is produced from 2-chloroaniline and 4-bromoanisole in either dioxane or in toluene/dioxane mixtures under these conditions.

The use of the two-step methodology leads to the first synthesis of the natural carbazole alkaloid, Clausine P (**4b**) (Scheme 3).[13] The 2-chloroaniline precursor **6** is readily prepared in one step from the commercially available benzoic acid **7** using the method developed by Le Corre and co-workers.[14] In an attempt to accelerate the formation of **3b** from **6**, we subjected the reaction to microwave heating ($\mu\nu$) at 160 °C in toluene and were delighted to find that under these conditions the major product is the carbazole Clausine P; it appears that the higher temperature facilitates the one-pot reaction.

This one-pot tandem process appears to be fairly general for the production of carbazoles from **6** and 2-substituted aryl

(3) This methodology is also applicable to the synthesis of carbocyclic compounds. For examples, see: (a) Rice, J. E.; Cai, Z.-W. *Tetrahedron Lett.* **1992**, *33*, 1675. (b) Rice, J. E.; Chen, Z.-W. *J. Org. Chem.* **1993**, *58*, 1415. (c) Gómez-Lor, B. E.; de Frutos, O.; Echavarren, A. M. *Chem. Commun.* **1999**, 2431. (d) Rice, J. E.; Cai, Z.-W.; He, Z.-M.; LaVoie, E. J. *J. Org. Chem.* **1995**, *60*, 8101. (e) Gonzáles, J. J.; García, N.; Gómez-Lor, B.; Echavarren, A. M. *J. Org. Chem.* **1997**, *62*, 1286. (f) de Frutos, O.; Gómez-Lor, B.; Granier, T.; Monge, M. Á.; Gutiérrez-Puebla, E.; Echavarren, A. M. *Angew. Chem., Int. Ed.* **1999**, *38*, 205. (g) Wang, L.; Shevlin, P. B. *Tetrahedron Lett.* **2000**, *41*, 285.

(4) (a) Ames, D. E.; Opalko, A. *Tetrahedron* **1984**, *40*, 1919. (b) Deshpande, P. P.; Martin, O. R. *Tetrahedron Lett.* **1990**, *31*, 6313. (c) Bringmann, G.; Jansen, J. R.; Reuscher, H.; Rübenacker, M.; Peters, K.; von Schnering, H. G. *Tetrahedron Lett.* **1990**, *31*, 643. (d) Bringmann, G.; Walter, R.; Weirich, R. *Angew. Chem., Int. Ed.* **1990**, *29*, 977. (e) Bringmann, G.; Pabst, T.; Henschel, P.; Kraus, J.; Peters, K.; Peters, E.-M.; Rycroft, D. S.; Connolly, J. D. *J. Am. Chem. Soc.* **2000**, *122*, 9127.

(5) Kuroda, T.; Suzuki, F. *Tetrahedron Lett.* **1991**, *32*, 6915.

(6) Ames, D. E.; Opalko, A. *Synthesis* **1983**, *235*.

(7) Iwaki, T.; Yasuhara, A.; Sakamoto, T. *J. Chem. Soc., Perkin Trans. 1* **1999**, 1505.

(8) Ames, D. E.; Bull, D. *Tetrahedron* **1982**, *38*, 383.

(9) For a discussion, see: Grushin, V. V.; Alper, H. *Chem. Rev.* **1994**, *94*, 1047.

(10) For reviews on aryl chloride coupling reactions, see: (a) Littke, A. F.; Fu, G. C. *Angew. Chem., Int. Ed.* **2002**, *41*, 4176. (b) Bedford, R. B.; Cazin, C. S. J.; Holder, D. *Coord. Chem. Rev.* **2004**, *248*, 2283.

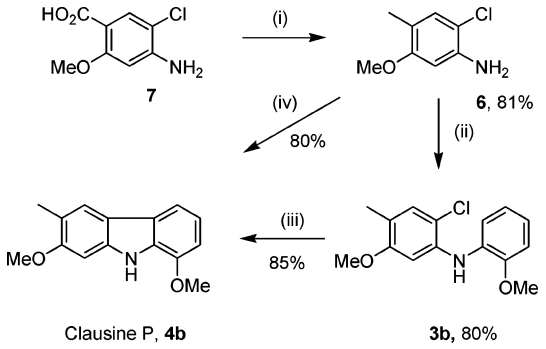
(11) (a) Bedford, R. B.; Cazin, C. S. J. *Chem. Commun*, **2002**, 2310. (b) Rieth, R. D.; Mankad, N. P.; Calimano, E.; Sadighi, J. P. *Org. Lett.* **2004**, *6*, 3981. (c) Leblanc, M.; Fagnou, K. *Org. Lett.* **2005**, *7*, 2849. (d) Ackermann, L. *Org. Lett.* **2005**, *7*, 3123. (e) Gürbüz, N.; Özdemir, I.; Çetinkaya, B. *Tetrahedron Lett.* **2005**, *46*, 2273. (f) Campeau, L.-C.; Thansandote, P.; Fagnou, K. *Org. Lett.* **2005**, *7*, 1857. (g) Campeau, L.-C.; Parisien, M.; Jean, A.; Fagnou, K. *J. Am. Chem. Soc.* **2006**, *128*, 581.

(12) The phosphonium salt $[HP^tBu_3][BF_4]$ was typically employed in this study as an air- and moisture-stable equivalent of the free phosphine with little or no reduction in performance. Thus, the reaction shown in Scheme 2 with R = benzyl, R′ = H, and R″= 4-OMe gives 89% conversion to the carbazole using P^tBu_3 and 87% with $[HP^tBu_3][BF_4]$. For the use of $[HP^tBu_3][BF_4]$ as a replacement for P^tBu_3 in a range of coupling reactions, see: Netherton, M. R.; Fu, G. C. *Org. Lett.* **2001**, *3*, 4295.

(13) Clausine P was originally isolated from the roots of *Clausina excavate*: Wu, T. S.; Huang, S. C.; Wu, P. L.; Kuoh, C. C. *Phytochemistry* **1999**, *52*, 523.

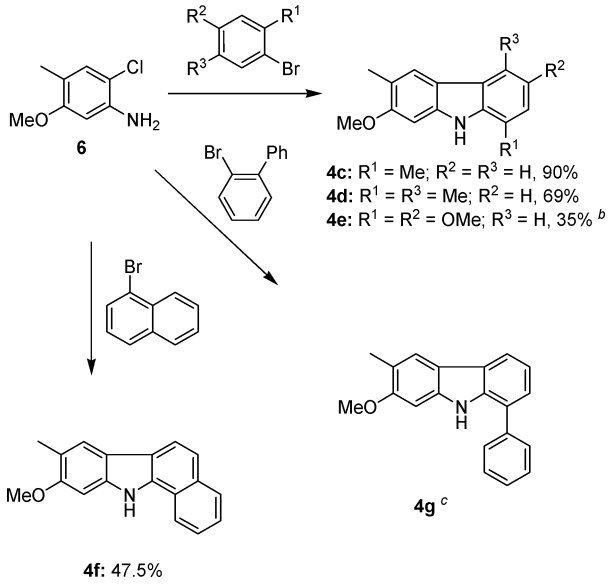
(14) Le Deit, H.; Cron, S.; Le Corre, M. *Tetrahedron Lett.* **1991**, *32*, 2759.

SCHEME 3. Synthesis of Clausine P[a]



[a] Conditions: (i) BH_3·SMe_2, C_6H_5Cl, 0 °C for 15 min, then 80 °C for 3 h, 130 °C for 18 h; (ii) 4-bromoanisole, $Pd(OAc)_2$ (4 mol %), P^tBu_3 (5 mol %), NaO^tBu, toluene, reflux, 18 h; (iii) $Pd(OAc)_2$ (4 mol %), P^tBu_3 (5 mol %), NaO^tBu, 1,4-dioxane, reflux, 18 h; (iv) 4-bromoanisole, $Pd(OAc)_2$ (4 mol %), P^tBu_3 (5 mol %), NaO^tBu, toluene, $\mu\nu$, 160 °C, 3 h.

SCHEME 4. Synthesis of Carbazoles from 6[a]

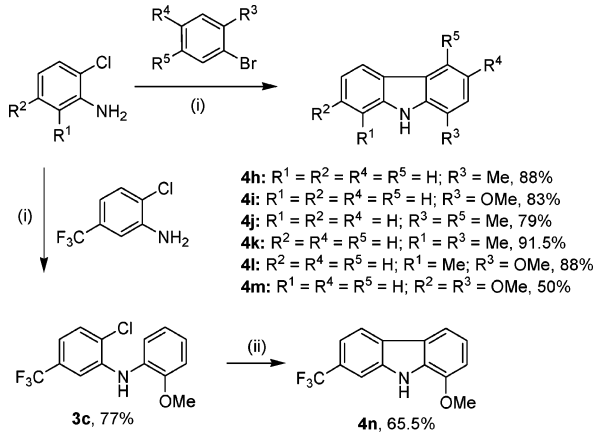


[a] Conditions: $Pd(OAc)_2$ (4 mol %), P^tBu_3 (5 mol %), NaO^tBu, toluene, $\mu\nu$, 160 °C, 3 h. [b]Impure after 2 columns. [c]Compound **4g** contaminated with a second compound, **8**, with the same mass as **4g** (GC-MS) in a **4g**/**8** ratio of 85:15. Combined yield = 60% after two columns.

bromides (Scheme 4). Thus, the novel carbazoles **4c**−**f** can be isolated in modest to excellent yields. Interestingly, the reaction between **6** and 2-bromobiphenyl yields an inseparable mixture of the expected carbazole **4g** and a product **8** which we tentatively assign as an isomeric species.[15]

The microwave reactor seems only to be functioning as an efficient way of heating the samples, rather than providing any "microwave effect"; when the coupling of 2-chloroaniline with 2-bromotoluene is repeated in a microwave sample vial and heated conventionally at 160 °C, as with the microwave-assisted reaction, essentially quantitative conversion to **4h** is observed. The use of PCy_3 in place of P^tBu_3 under microwave heating gives only 55% conversion to **4h**. Moving away from **6** as the substrate, we find that a range of 2-chloroanilines can be employed in the microwave-assisted one-pot procedure as shown in Scheme 5, provided the aryl bromide used is substituted in the 2-position. The exception to this is the reaction of 3-amino-4-chlorobenzotriflouride with 2-bromoanisole which stops after the amination step to give the 2-chloro(*N*-aryl)aniline **3c**. Subsequent ring closure under thermal conditions in 1,4-dioxane yielded the desired carbazole **4n** in 65.5% yield.

SCHEME 5[a]

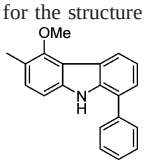


[a] Conditions: (i) $Pd(OAc)_2$ (4 mol %), P^tBu_3 (5 mol %), NaO^tBu, toluene, $\mu\nu$, 160 °C, 3 h; (ii) $Pd(OAc)_2$ (4 mol %), P^tBu_3 (5 mol %), NaO^tBu, 1,4-dioxane, reflux, 18 h.

This two-step process can be applied to the synthesis of glycozolidine, **4o**,[16] a naturally occurring alkaloid with antitumor properties (Scheme 6).[17] Similarly, this method can be used to produce both 2,7-dimethoxy-3-methylcarbazole, **4p**, an intermediate in the synthesis of the natural products 7-methoxy-*O*-methylmukonal and Clausines H, K, and O,[18] and the novel carbazole **4q**.

We were interested to see if the one-pot, microwave-assisted method could be extended to the synthesis of indoles. As can be seen in Scheme 7, α-bromostyrene reacts with both 2-chloroaniline and **6** to produce the indoles **9a** and **b**, respectively.[19] Similarly, the *N*-benzyl indoles **9c** and **d** can be prepared, although the yields are higher when the reaction is performed under milder thermal conditions, possibly due to early catalyst deactivation at the higher temperatures employed in the microwave reaction. When the milder thermal conditions are applied to the coupling of 2-chloroaniline with α-bromostyrene, the reaction stops at the aminated intermediate which proves to be the imine **10** rather than the enamine **11**. At this stage, we cannot say whether the C−C bond-forming step occurs via an intramolecular Heck reaction of the eneamine **11**, formed by

(15) Tenative assignment for the structure of **8**:



Investigations into the structure and mechanism of formation of this product are ongoing.

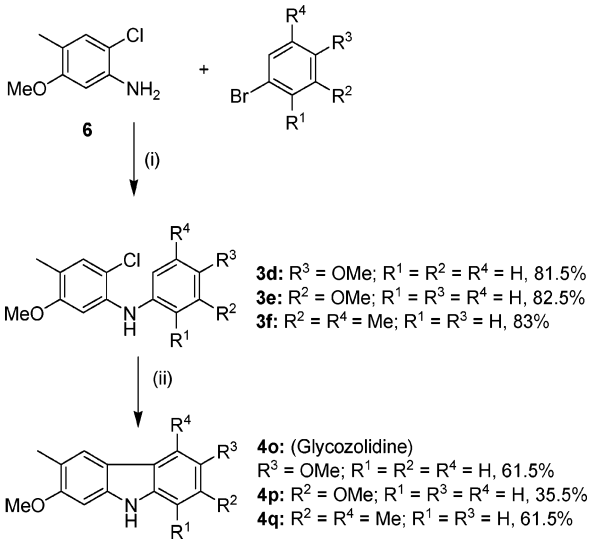
(16) For a previous synthesis of glycozolidine, see: Iwao, M.; Takehara, H.; Furukawa, S.; Watanabe, M. *Heterocycles* **1993**, *36*, 1483.

(17) Ito, C.; Itoigawa, M.; Sato, A.; Hasan, C. M.; Rashid, M. A.; Tokuda, H.; Mukainaka, T.; Nishino, H.; Furukawa, H. *J. Nat. Prod.* **2004**, *67*, 1488.

(18) Kataeva, O.; Krahl, M. P.; Knölker, H.-J. *Org. Biomol. Chem.* **2005**, *3*, 3099.

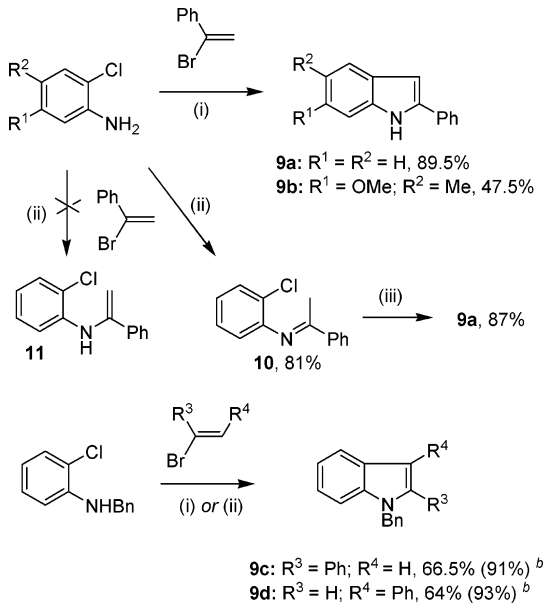
(19) For related indole syntheses via C−H activation, see: (a) Venkat Reddy, C.; Urgaonkar, S.; Verkade, J. G. *Org. Lett.* **2005**, *7*, 4427. (b) Barluenga, J.; Fernández, M. A.; Aznar, F.; Valdés, C. *Chem.*−*Eur. J.* **2005**, *11*, 2276. (c) Nazaré, M.; Schneider, C.; Lindenschmidt, A.; Will, D. W. *Angew. Chem., Int. Ed.* **2004**, *43*, 4526.

SCHEME 6[a]



[a] Conditions: (i) $Pd(OAc)_2$ (4 mol %), P^tBu_3 (5 mol %), NaO^tBu, toluene, μv, 160 °C, 3 h; (ii) $Pd(OAc)_2$ (4 mol %), P^tBu_3 (5 mol %), NaO^tBu, 1,4-dioxane, reflux, 18 h.

SCHEME 7. Indole Synthesis[a]



[a] Conditions: (i) $Pd(OAc)_2$ (4 mol %), P^tBu_3 (5 mol %), NaO^tBu, toluene, μv, 160 °C, 3 h; (ii) $Pd(OAc)_2$ (4 mol %), P^tBu_3 (5 mol %), NaO^tBu, toluene, reflux, 18 h; (iii) NaO^tBu, $Pd(OAc)_2$ (4 mol %), P^tBu_3 (5 mol %), dioxane, reflux, 18 h. [b] Yield in parantheses refers to yield from method ii.

ene-imine tautomism of **10** under the reaction conditions, or via the deprotonation of the α-methyl group of imine **10** by analogy with the α-arylation of ketones and related enolizable compounds.[20] Certainly, the former pathway must be operative in the formation of **9c** and **d**, where imine intermediates cannot form.

In summary, the consecutive amination/C−H activation reactions of 2-chloroanilines with aryl bromides yields *N*-H carbazoles, often in a tandem, one-pot manner. We are currently investigating the application of this methodology to a range of significant targets.

Experimental Section

Optimization of the Ring Closing of 3a to Give Carbazole 4a (Table 1). Base (5 mmol), the catalyst precursor (0.04 mmol), and the ligand (0.05 mmol) were suspended in solvent (4 mL). 2-Chloro-*N*-(4-methoxyphenyl)aniline, **3a** (0.233 g, 1.0 mmol), was then added as a solution of the same solvent (2 mL). The reaction was then heated at reflux temperature for 18 h. The reaction was quenched by addition of $HCl_{(aq)}$ (2 M, 6 mL). The organic phase was extracted with CH_2Cl_2 (2 × 40 mL), dried ($MgSO_4$), then filtered, and the solvent was removed under reduced pressure. The product mixture was dissolved in a $CDCl_3$ solution of mesitylene (internal standard, 1.0 M, 1.00 mL), and the conversion to **4a** was determined by ^1H NMR spectroscopy. The product was isolated from the reaction shown in Table 1, entry 7, by column chromatography (SiO_2) to give pure **4a** as a white solid: 0.163 g (83.0%); R_f 0.8 ($CHCl_3$); mp 146−148 °C; ^1H NMR (400 MHz, $CDCl_3$) δ 3.86 (s, 3H, OMe), 7.00 (dd, J = 2.5 & 9.0 Hz, 1H, Ar H^2), 7.12 (m, 1H, Ar H^6), 7.26 (d, J = 9.0 Hz, 1H, Ar H^1), 7.33 (d, J = 2.5 Hz, 1H, H^4), 7.34 (br s, 1H, Ar H^5), 7.48 (d, J = 3.0 Hz, 1H, Ar H^8), 7.86 (br s, 1H, NH), 7.95 (br d, J_{HH} = 9.0 Hz, 1H, Ar H^7); ^{13}C NMR (100 MHz, $CDCl_3$) δ 56.0 (s, OMe), 104.1 (s, CH), 110.8 (s, CH), 111.3 (s, CH), 115.1 (s, CH), 119.1 (s, CH), 120.2 (s, CH), 124.1 (s, C), 124.5 (s, C), 125.8 (s, CH), 135.8 (s, C), 140.3 (s, C), 154.1 (s, C); HRMS (EI) calcd for $C_{13}H_{11}NO$ [M^+] 197.0841, found 197.0842. Anal. calcd for $C_{13}H_{11}NO$: C, 79.17; H, 5.62; N, 7.10. Found: C, 78.76; H, 5.97; N, 6.81.

Preparation of 6. 5-Amino-4-chloro-2-methyl-benzoic acid (3.05 g, 15.1 mmol) was suspended in chlorobenzene (30 mL) and cooled to 0 °C. $BH_3{\cdot}SMe_2$ (4.3 mL, 45.3 mmol) was added with vigorous stirring. When effervescence ceased, the reaction mixture was heated for 3 h at 80 °C and then for 18 h at 130 °C. The reaction was quenched by addition of aqueous $Na_2CO_{3(aq)}$ (1 M, 50 mL). The crude product was extracted with CH_2Cl_2 (3 × 50 mL), dried ($MgSO_4$), then filtered, and the solvent was removed under reduced pressure to give a yellow solid. The crude product was purified by column chromatography (SiO_2) to give **6** as a light yellow powder: 2.10 g (81.0%); R_f 0.44 (CH_2Cl_2); mp 65−67 °C; ^1H NMR (400 MHz, $CDCl_3$) δ 2.08 (s, 3H, Me), 3.75 (s, 3H, OMe), 3.89 (br s, 1H, NH), 6.26 (s, 1H, Ar H^6), 6.97 (s, 1H, Ar H^2); ^{13}C NMR (67.9 MHz, $CDCl_3$) δ 15.2 (s, CH_3), 55.5 (s, OCH_3), 98.9 (s, C^6H), 110.1 (s, C^2), 117.8 (s, C^4), 130.5 (s, C^3H), 141.3 (s, C^1), 157.2 (s, C^5); HRMS (EI) calcd for $C_8H_{10}ClNO$ [M^+] 171.046 784, found 171.046 391. Anal. calcd for $C_8H_{10}ClNO$: C, 55.97; H, 5.87; N, 8.16. Found: C, 55.77; H, 5.74; N, 8.10.

Thermal Synthesis of 3b. NaO^tBu (0.240 g, 2.5 mmol), $Pd(OAc)_2$ (0.005 g, 0.02 mmol), and $[HP^tBu_3][BF_4]$ (0.008 g, 0.025 mmol) were suspended in toluene (3 mL). 2-Chloro-5-methoxy-4-methylaniline (85.8 mg, 0.5 mmol) and 2-bromoanisole (63.5 μL, 0.51 mmol) were added, and the reaction was then heated at reflux temperature for 18 h. The reaction was quenched by addition of $HCl_{(aq)}$ (2 M, 3 mL). The product was extracted with dichloromethane (2 × 20 mL), dried ($MgSO_4$), then filtered, and the solvent was removed under reduced pressure. The crude product mixture was then subjected to column chromatography (SiO_2 plug) to give **3b** as a thick brown oil: 126 mg (91.0%, the crude product was used in the subsequent cyclization step without further purification); R_f 0.41 ($CHCl_3$); ^1H NMR (400 MHz, $CDCl_3$) δ 2.16 (s, 3H, Me), 3.75 (s, 3H, OMe), 3.92 (s, 3H, OMe), 6.34 (br s, 1H, NH), 6.90−6.95 (m, 4H, Ar H), 7.13 (s, 1H, Ar H), 7.28 (1H, m, Ar H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 15.5 (s, Me), 55.7 (s, OMe), 55.8 (s, OMe), 100.8 (s, CH), 110.9 (s, CH), 114.3 (s, C), 115.7 (s, CH), 120.2 (s, C), 120.8 (s, CH), 120.9 (s, CH), 131.0 (s, CH), 132.3 (s, C), 137.8 (s, C), 149.1 (s, C), 156.9 (s, C).

Thermal Synthesis of Clausine P, 4b. NaO^tBu (0.240 g, 2.5 mmol), $Pd(OAc)_2$ (0.005 g, 0.02 mmol), and $[HP^tBu_3][BF_4]$ (0.008

(20) For a review on the α-arylation of ketones, see: Culkin, D. A.; Hartwig, J. F. *Acc. Chem. Res.* **2003**, *36*, 234.

g, 0.025 mmol) were suspended in dioxane (2 mL). **3b** (114 mg, 0.41 mmol) was then added as a solution in dioxane (1 mL). The reaction was then heated at reflux temperature for 18 h. The reaction was quenched by addition of $HCl_{(aq)}$ (2 M, 3 mL). The organic phase was extracted with CH_2Cl_2 (2 × 20 mL), dried ($MgSO_4$), then filtered, and the solvent was removed under reduced pressure. The crude product mixture was then subjected to column chromatography (SiO_2) to give **4b** as an off-white solid: 79 mg (80.0%); R_f 0.41 ($CHCl_3$); mp 142−144 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.28 (s, 3H, Me), 3.82 (s, 3H, OMe), 3.92 (s, 3H, OMe), 6.75 (d, J = 7.8 Hz, 1H, Ar H^2), 6.78 (s, 1H, Ar H^8), 7.04 (t, J = 7.8 Hz, 1H, Ar H^3), 7.48 (d, J = 7.8 Hz, 1H, Ar H^4), 7.68 (s, 1H, Ar H^5), 8.03 (br s, 1H, NH); ^{13}C NMR (100 MHz, $CDCl_3$) δ 16.7 (s, Me), 55.4 (s, OMe), 55.5 (s, OMe), 92.6 (s, C), 104.6 (s, C), 112.1 (s, C), 116.6 (s, C), 119.3 (s, C), 119.6 (s, CH), 121.6 (s, CH), 124.5 (s, C), 129.3 (s, C), 138.8 (s, C), 145.5 (s, C), 157.3 (s, C); HRMS (EI) calcd for $C_{15}H_{15}NO_2$ [M^+ + H] 242.118 104, found 242.117 279. Anal. calcd for $C_{15}H_{15}NO_2 \cdot 0.2H_2O$: C, 73.98; H, 6.41; N, 5.75. Found: C, 73.78; H, 6.24; N, 5.71.

General Method for the Microwave-Assisted, One-Pot Synthesis of Carbazoles, 4b−m. NaO^{t}Bu (0.240 g, 2.5 mmol), $Pd(OAc)_2$ (0.005 g, 0.02 mmol), and [HP^{t}Bu$_3$][BF_4] (0.008 g, 0.025 mmol) were suspended in toluene (3 mL). The appropriate 2-chloroaniline (0.5 mmol) and aryl bromide (0.51 mmol) were then added, and the microwave vial was sealed. The reaction was then heated in the microwave reactor at 160 °C for 3 h, allowed to cool, and then quenched by addition of $HCl_{(aq)}$ (2 M, 3 mL). The organic phase was extracted with CH_2Cl_2 (2 × 20 mL), dried ($MgSO_4$), then filtered, and the solvent was removed under reduced pressure. The crude product mixture was then subjected to column chromatography (SiO_2).

4b. 2-Chloro-5-methoxy-4-methylaniline (85.8 mg, 0.5 mmol) and 2-bromoanisole (63.8 μL, 0.51 mmol) gave **4b** as an off-white powder: 96 mg (80.0%). (Data as above.)

4c. 2-Chloro-5-methoxy-4-methylaniline (85.8 mg, 0.5 mmol) and 2-bromotoluene (61.4 μL, 0.51 mmol) gave **4c** as a light brown powder: 101 mg (90.0%); R_f 0.41 ($CHCl_3$); mp 193−195 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.29 (s, 3H, Me), 2.45 (s, 3H, Me), 3.83 (s, 3H, OMe), 6.81 (s, 1H, Ar H^1), 7.04 (t, J = 7.4 Hz, 1H, Ar H^6), 7.05 (s, 1H, Ar H^4), 7.70 (br s, 1H, NH), 7.72 (d, J = 7.4 Hz, 2H, Ar H^7), 7.73 (d, J = 7.4 Hz, 2H, Ar H^5); ^{13}C NMR (100 MHz, $CDCl_3$) δ 16.7 (s, Me), 16.8 (s, Me), 55.5 (s, OMe), 92.5 (s, CH), 116.7 (s, C), 117.0 (s, CH), 119.3 (s, CH), 119.4 (s, CH), 121.6 (s, CH), 123.0 (s, C), 124.8 (s, CH), 115.9 (s, C), 138.6 (s, C), 139.0 (s, C), 157.3 (s, C); HRMS (EI) calcd for $C_{15}H_{15}NO$ [M^+ + H] 226.123 189, found 226.122 210. Anal. calcd for $C_{15}H_{15}NO \cdot 0.25H_2O$: C, 78.40; H, 7.01; N, 6.10. Found: C, 78.47; H, 6.76; N, 6.36.

4d. 2-Chloro-5-methoxy-4-methylaniline (85.8 mg, 0.5 mmol) and 2-bromo-*p*-xylene (70.5 μL, 0.51 mmol) gave **4d** as an off-white powder: 83 mg (69.0%); R_f 0.43 ($CHCl_3$); mp 203−205 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.30 (s, 3H, Me), 2.42 (s, 3H, Me), 2.73 (s, 3H, Me), 3.83 (s, 3H, OMe), 6.80 (d, J = 7.3 Hz, 1H, Ar H^6), 6.84 (s, 1H, Ar H^1), 6.95 (d, J = 7.3 Hz, 1H, Ar H^7), 7.76 (br s, 1H, NH), 7.79 (s, 1H, Ar H^4); ^{13}C NMR (100 MHz, $CDCl_3$) δ 16.5 (s, Me), 16.8 (s, Me), 20.4 (s, Me), 55.5 (s, OMe), 92.4 (s, CH), 116.6 (s, CH), 117.5 (s, C), 119.0 (s, CH), 120.7 (s, CH), 121.5 (s, C), 123.8 (s, CH), 124.7 (s, CH), 129.7 (s, C), 138.5 (s, C), 139.1 (s, C), 156.7 (s, C); HRMS (EI) calcd for $C_{16}H_{17}NO$ [M^+] 239.131 014, found 239.131 093. Anal. calcd for $C_{16}H_{17}NO \cdot 0.2H_2O$: C, 79.11; H, 7.38; N, 5.76. Found: C, 79.24; H, 7.00; N, 5.74.

4e. 2-Chloro-5-methoxy-4-methylaniline (85.8 mg, 0.5 mmol) and 1-bromo-2,4-dimethoxybenzene (74.0 μL, 0.51 mmol) gave **4e** as an off-white powder: 47 mg (35.0% after 2 columns; contaminated with ~25% of 2,4-dimethoxy-*N*-(3-methoxy-4-methylphenyl)-aniline); R_f 0.25 ($CHCl_3$), 0.21 (CH_2Cl_2); mp 116−118 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.28 (s, 3H, Me), 3.83 (s, 3H, OMe), 3.84 (s, 3H, OMe), 3.88 (s, 3H, OMe), 6.44 (d, J = 2.0 Hz, 1H, Ar H^2), 6.73 (s, 1H, Ar H^8), 6.96 (d, J = 2.0 Hz, 1H, Ar H^4), 7.64 (s, 1H, Ar H^5), 7.89 (br s, 1H, NH); ^{13}C NMR (100 MHz, $CDCl_3$) δ 16.8 (s, Me), 55.4 (s, OMe), 55.5 (s, OMe), 56.1 (s, OMe), 92.7 (s, CH), 93.7 (s, CH), 96.0 (s, CH), 116.7 (s, C), 119.0 (s, C), 121.4 (s, CH), 123.9 (s, C), 124.4 (s, C), 139.4 (s, C), 145.9 (s, C), 154.7 (s, C), 157.4 (s, C); HRMS (EI) calcd for $C_{16}H_{17}NO_3$ [M^+] 271.120 844, found 271.120 528. **2,4-Dimethoxy-*N*-(3-methoxy-4-methylphenyl)aniline:** R_f 0.28 ($CHCl_3$), 0.26 (CH_2Cl_2); ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.08 (s, 3H, Me), 3.70 (s, 3H, OMe), 3.72 (s, 3H, OMe), 3.76 (s, 3H, OMe), 5.65 (br s, 1H, NH), 6.36 (dd, J = 2.7 & 8.7 Hz, 1H, Ar H^5$_{anisole}$), 6.48−6.50 (m, 3H, Ar H^3$_{anisole}$ & Ar H^{1,6}$_{aniline}$), 6.91 (br d, J = 8.7 Hz, 1H, Ar H^6$_{anisole}$), 7.11 (d, J = 8.7 Hz, 1H, Ar H^5$_{aniline}$); ^{13}C NMR (100 MHz, $CDCl_3$) δ 15.6 (s, Me), 55.3 (s, OMe), 55.7 (s, OMe), 55.7 (s, OMe), 99.5 (s, CH), 100.6 (s, CH), 103.8 (s, CH), 108.9 (s, CH), 118.1 (s, C), 118.5 (s, CH), 126.5 (s, C), 130.9 (s, CH), 143.4 (s, C), 150.6 (s, C), 154.4 (s, C), 158.4 (s, C). HRMS (EI) calcd for $C_{16}H_{19}NO_3$ [M^+] 273.136 494, found 273.135 381.

4f. 2-Chloro-5-methoxy-4-methylaniline (85.8 mg, 0.5 mmol) and 1-bromonaphthalene (71.1 μL, 0.51 mmol) gave **4f** as an off-white powder: 61 mg (47.5%); R_f 0.45 ($CHCl_3$); mp 99−101 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.32 (s, 3H, Me), 3.86 (s, 3H, OMe), 6.94 (s, 1H, Ar H^{10}), 7.39 (ddd, J = 1.3, 7.1, & 8.0 Hz, 1H, Ar H^2), 7.48 (ddd, J = 1.4, 7.0 & 8.2 Hz, 1H, Ar H^3), 7.54 (d, J = 8.5 Hz, 1H, Ar H^5), 7.75 (s, 1H, Ar H^7), 7.90 (d, J = 8.0 Hz, 1H, Ar H^1), 7.96 (d, J = 8.5 Hz, 1H, Ar H^4), 7.99 (d, J = 10 Hz, 1H, Ar H^6), 8.56 (br s, 1H, NH); ^{13}C NMR (100 MHz, $CDCl_3$) δ 17.0 (s, Me), 55.7 (s, OMe), 92.9 (s, CH), 117.4 (s, C), 118.7 (s, C), 119.1 (s, CH), 120.1 (s, CH), 120.1 (s, C), 120.2 (s, CH), 121.1 (s, CH), 121.2 (s, C), 124.6 (s, CH), 125.3 (s, C), 125.5 (s, CH), 129.1 (s, CH), 131.6 (s, C), 138.2 (s, C), 157.0 (s, C); HRMS (EI) calcd for $C_{18}H_{15}NO$ [M^+] 261.115 436, found 261.115 364. Anal. calcd for $C_{18}H_{15}NO \cdot 0.5H_2O$: C, 79.98; H, 6.03; N, 5.18. Found: C, 80.24; H, 5.82; N, 5.27.

4g. 2-Chloro-5-methoxy-4-methylaniline (85.8 mg, 0.5 mmol) and 2-bromobiphenyl (86.4 μL, 0.51 mmol) gave **4g** as an off-white powder: 86 mg, (60.0%, after two columns, mixture of product **4g** and heterocyclic byproduct **8** in an approximately 85: 15 ratio). **4g**: R_f 0.71 ($CHCl_3$), 0.60 (CH_2Cl_2); mp 121−123 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.29 (s, 3H, Me), 3.81 (s, 3H, OMe), 6.77 (s, 1H, Ar H^1), 7.20 (t, J = 7.6 Hz, 1H, Ar H^6), 7.27 (dd, J = 1.3 & 7.3 Hz, 1H, Ar H^7), 7.35 (tt, J = 1.2 & 7.6 Hz, 1H, Ph *p*-H), 7.46 (t, J = 7.6 Hz, 2H, Ph *m*-H), 7.62 (dd, J = 1.2 & 7.6 Hz, 2H, Ph *o*-Ph), 7.73 (s, 1H, Ar H^4), 7.86 (dd, J = 0.7 & 7.3 Hz, 1H, Ar H^5), 8.10 (br s, 1H, NH); ^{13}C NMR (100 MHz, $CDCl_3$) δ 16.7 (s, Me), 55.5 (s, OMe), 92.4 (s, C^{1}H), 116.3 (s, C$^{4'}$), 118.5 (s, C^{5}H), 119.4 (s, C^3), 119.8 (s, C^{6}H), 121.6 (s, C^{4}H), 121.9 (s, Ph C), 124.1 (s, C^{7}H), 124.7 (s, C$^{5'}$), 125.3 (s, C^8), 127.4 (s, Ph *p*-CH), 128.4 (s, Ph *o*-CH), 129.1 (s, Ph *m*-CH), 136.9 (s, C$^{8'}$), 139.4 (s, C$^{1'}$), 157.5 (s, C^2); GC-MS (EI) found 287 corresponding to $C_{20}H_{17}NO$; HRMS (EI) calcd for $C_{20}H_{17}NO$ [M^+] 287.131 014, found 287.130 352. Anal. calcd for $C_{20}H_{17}NO$: C, 83.60; H, 5.96; N, 4.87. Found: C, 83.30; H, 6.19; N, 4.46. **8.** See spectrum of **4g** for peaks associated with compound **8**: GC-MS (EI) found 287 corresponding to $C_{20}H_{17}NO$.

4h. 2-Chloroaniline (52.5 μL, 0.5 mmol) and 2-bromotoluene (61.4 μL, 0.51 mmol) gave **4h** as an off-white powder: 80 mg (88.0%); R_f 0.77 ($CHCl_3$); mp 120−122 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.49 (s, 3H, Me), 7.10 (t, J = 7.3 Hz, 1H, Ar H^6), 7.18 (m, 1H, Ar H^4), 7.34 (t, J = 7.3 Hz, 1H, Ar H^7), 7.37 (m, 2H, Ar H^2 & H^3), 7.87 (d, J = 7.3 Hz, 1H, Ar H^8), 7.90 (br s, 1H, NH), 8.00 (d, J = 7.3 Hz, 1H, Ar H^5); ^{13}C NMR (100 MHz, $CDCl_3$) δ 29.0 (s, Me), 110.7 (s, CH), 117.9 (s, CH), 119.5 (s, C), 119.6 (s, CH), 119.7 (s, CH), 120.4 (s, CH), 122.8 (s, C), 123.8 (s, C), 125.6 (s, CH), 126.4 (s, CH), 138.8 (s, C), 139.4 (s, C); HRMS (EI) calcd for $C_{13}H_{11}N$ [M^+]:= 181.089 149, found 181.080 952. Anal. calcd for $C_{13}H_{11}N$: C, 86.15; H, 6.12; N, 7.73. Found: C, 86.16; H, 6.09; N, 7.63.

4i. 2-Chloroaniline (52.5 μL, 0.5 mmol) and 2-bromoanisole (63.5 μL, 0.51 mmol) gave **4i** as an off-white solid: 82 mg (83.0%); R_f 0.62 ($CHCl_3$); mp 65−67 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 3.92 (s, 3H, OMe), 6.82 (d, J = 7.8 Hz, 1H, Ar H^2), 7.08 (t, J = 7.8 Hz, 1H, Ar H^3), 7.14 (ddd, J = 1.0, 6.8 & 7.8 Hz, 1H, Ar H^7), 7.33 (dd, J = 1.0, & 7.8 Hz, 1H, Ar H^8), 7.36 (ddd, J = 1.0, 6.8 & 7.8 Hz, 1H, Ar H^6), 7.60 (d, J = 7.8 Hz, 1H, Ar H^4), 7.98 (dd, J = 1.0 & 7.8 Hz, 1H, Ar H^5), 8.17 (br s, 1H, NH); ^{13}C NMR (100 MHz, $CDCl_3$) δ 55.50 (s, OMe), 105.9 (s, CH), 110.9 (s, CH), 112.8 (s, CH), 119.4 (s, CH), 119.7 (s, CH), 120.5 (s, CH), 123.6 (s, C), 124.3 (s, C), 125.7 (s, CH), 129.8 (s, C), 139.2 (s, C), 145.7 (s, Ar C−O); HRMS (EI) calcd for $C_{13}H_{11}NO$ [M$^+$] 197.084 064, found 197.084 053. Anal. calcd for $C_{13}H_{11}NO$: C, 79.17; H, 5.62; N, 7.10. Found: C, 79.26; H, 5.20; N, 6.88.

4j. 2-Chloroaniline (52.5 μL, 0.5 mmol) and 2-bromo-*p*-xylene (70.5 μL, 0.51 mmol) gave **4j** as an off-white powder: 77 mg (79.0%); R_f 0.53 ($CHCl_3$); mp 90−92 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.46 (s, 3H, 1-Me), 2.78 (s, 3H, 4-Me), 6.86 (d, J = 7.3 Hz, 1H, Ar H^3), 7.06 (d, J = 7.3 Hz, 1H, Ar H^2), 7.17 (dt, J = 1.0 & 8.1 Hz, 1H, Ar H^6), 7.33 (dt, J = 1.2 & 7.7 Hz, 1H, Ar H^7), 7.40 (dd, J = 1.0 & 8.0 Hz, 1H, Ar H^8), 7.90 (br s, 1H, NH), 8.10 (br d, J = 7.7 Hz, 1H, Ar H^5); ^{13}C NMR (100 MHz, $CDCl_3$) δ 16.6 (s, 1-Me), 20.5 (s, 4-Me), 110.4 (s, CH), 116.9 (s, C), 119.4 (s, CH), 120.9 (s, CH), 121.4 (s, C), 122.6 (s, CH), 124.5 (s, C), 125.0 (s, CH), 126.1 (s, CH), 130.8 (s, C), 138.7 (s, C), 139.3 (s, C); HRMS (EI) calcd for $C_{14}H_{13}N$ [M$^+$] 195.104 800, found 195.105 160. Anal. calcd for $C_{14}H_{13}N$: C, 86.12; H, 6.71; N, 7.17. Found: C, 86.27; H, 6.70; N, 7.12.

4k. 2-Chloro-6-methylaniline (60.3 μL, 0.5 mmol) and 2-bromotoluene (61.4 μL, 0.51 mmol) gave **4k** as a white powder: 89 mg (91.5%); R_f 0.90 ($CHCl_3$); mp 171−173 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.63 (s, 6H, Me), 7.21 (t, J = 7.3 Hz, 2H, Ar H^3 & H^6), 7.27 (d, J = 7.3 Hz, 2H, Ar H^2 & H^7), 7.82 (br s, 1H, NH), 7.96 (d, J = 7.3 Hz, 2H, Ar H^4 & H^5); ^{13}C NMR (100 MHz, $CDCl_3$) δ 16.9 (s, Me), 118.0 (s, Ar CH), 119.6 (s, Ar CH), 119.8 (s, Ar C), 123.3 (s, Ar C), 126.2 (s, Ar CH), 138.7 (s, Ar C); HRMS (EI) calcd for $C_{14}H_{13}N$ [M$^+$] 195.104 800, found: 195.108 132. Anal. calcd for $C_{14}H_{13}N$: C, 86.12; H, 6.71; N, 7.17. Found: C, 85.99; H, 6.74; N, 7.05.

4l. 2-Chloro-6-methylaniline (60.3 μL, 0.5 mmol) and 2-bromoanisole (63.5 μL, 0.51 mmol) gave **4l** as a light brown solid: 93 mg (88.0%); R_f 0.67 ($CHCl_3$); mp 104−106 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.58 (s, 3H, Me), 4.04 (s, 3H, OMe), 6.90 (d, J = 7.8 Hz, 1H, Ar H^2), 7.16 (t, J = 7.3 Hz, 1H, Ar H^3), 7.16 (t, J = 7.8 Hz, 1H, Ar H^6), 7.23 (d, J = 7.3 Hz, 1H, Ar H^4), 7.67 (d, J = 7.8 Hz, 1H, Ar H^7), 7.91 (d, J = 7.8 Hz, 1H, Ar H^5), 8.15 (br s, 1H, NH); ^{13}C NMR (100 MHz, $CDCl_3$) δ 16.9 (s, Me), 55.5 (s, OMe), 105.7 (s, CH), 113.0 (s, CH), 118.2 (s, CH), 119.5 (s, CH), 119.8 (s, CH), 120.1 (s, C), 123.1 (s, C), 124.8 (s, C), 126.2 (s, CH), 129.6 (s, C), 138.6 (s, C), 145.7 (s, C); HRMS (EI) calcd for $C_{14}H_{13}NO$ [M$^+$] 211.099 714, found 211.098 998. Anal. calcd for $C_{14}H_{13}NO{\cdot}0.2H_2O$: C, 78.75; H, 6.37; N, 6.56. Found: C, 78.82; H, 6.19; N, 6.51.

4m. 2-Chloro-5-methoxyaniline hydrochloride (97.0 mg, 0.5 mmol) and 2-bromoanisole (63.5 μL, 0.51 mmol) gave **4m** as an off-white powder: 57 mg (50.0%); R_f 0.38 ($CHCl_3$); mp 164−166 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 3.81 (s, 3H, OMe), 3.92 (s, 3H, OMe), 6.76 (d, J = 7.8 Hz, 1H, Ar H^2), 6.77 (dd, J = 2.4 & 8.5 Hz, 1H, Ar H^6), 6.84 (d, J = 2.4 Hz, 1H, Ar H^8), 7.04 (t, J = 7.8 Hz, 1H, Ar H^3), 7.49 (d, J = 7.8 Hz, 1H, Ar H^4), 7.82 (d, J = 8.6 Hz, 1H, Ar H^5), 8.07 (br s, 1H, NH); ^{13}C NMR (100 MHz, $CDCl_3$) δ 55.5 (s, OMe), 55.6 (s, OMe), 94.8 (s, CH), 105.0 (s, CH), 108.3 (s, CH), 112.2 (s, CH), 117.6 (s, C), 119.9 (s, CH), 121.2 (s, CH), 124.5 (s, C), 129.5 (s, C), 140.4 (s, C), 145.4 (s, C), 159.0 (s, C); HRMS (EI) calcd for $C_{14}H_{13}NO_2$ [M$^+$] 227.094 629, found 227.094 402. Anal. calcd for $C_{14}H_{13}NO_2{\cdot}0.2H_2O$: C, 73.27; H, 5.92; N, 6.10. Found: C, 73.21; H, 5.83; N, 5.74.

General Method for the Syntheses of 2-Chloro(*N*-aryl)-anilines, 3c−f. NaO^{t}Bu (0.240 g, 2.5 mmol), $Pd(OAc)_2$ (0.005 g, 0.02 mmol), and [HP^{t}Bu$_3$][BF_4] (0.008 g, 0.025 mmol) were suspended in toluene (3 mL). The appropriate 2-chloroaniline (0.5 mmol) and aryl bromide (0.51 mmol) were then added, and the microwave vial was sealed. The reaction was then heated in the microwave reactor at 160 °C for 3 h, allowed to cool, and then quenched by addition of $HCl_{(aq)}$ (2 M, 3 mL). The organic phase was extracted with CH_2Cl_2 (2 × 20 mL), dried ($MgSO_4$), then filtered, and the solvent was removed under reduced pressure. The crude product mixture was then filtered through a SiO_2 plug and used in the cyclization step without further purification.

3c. 3-Amino-4-chlorobenzotrifluoride (68.7 μL, 0.50 mmol) and 2-bromoanisole (63.5 μL, 0.51 mmol) gave **3c** as a light brown oil: 116 mg (77.0%); R_f 0.91 ($CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 3.81 (s, 3H, OMe), 6.45 (br s, 1H, NH), 6.86−6.91 (m, 2H), 6.91−6.99 (m, 2H), 7.23 (br d, J = 7.8 Hz, 1H$_{anisole}$), 7.36 (br d, J = 8.3 Hz, 1H, Ar H$_{aniline}$), 7.42 (br d, J = 2.0 Hz, 1H, Ar H$_{aniline}$); ^{13}C NMR (100 MHz, $CDCl_3$) δ 55.7 (s, OMe), 111.4 (s, CH), 111.6 (s, CH), 116.3 (q, J_{CF} = 4 Hz, CH), 119.0 (s, CH), 121.0 (s, CH), 123.4 (s, CH), 125.0 (s, C), 125.1 (s, C), 129.7 (q, J_{CF} = 140 Hz, CH), 130.1 (s, CH), 140.9 (s, C), 150.5 (s, C).

3d. 2-Chloro-5-methoxy-4-methylaniline (85.8 mg, 0.5 mmol) and 4-bromoanisole (63.8 μL, 0.51 mmol) gave **3d** as a light brown oil: 98 mg (81.5%); R_f 0.62 ($CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.02 (s, 3H, Me), 3.57 (s, 3H, OMe), 3.73 (s, 3H, OMe), 5.73 (br s, 1H, NH), 6.44 (s, 1H, Ar H$^6_{aniline}$), 6.81 (d, J = 8.8 Hz, 2H, Ar H$^{2,6}_{anisole}$), 6.97 (s, 1H, Ar H$^3_{aniline}$), 7.03 (d, J = 8.8 Hz, 2H, Ar H$^{3,5}_{anisole}$); ^{13}C NMR (100 MHz, $CDCl_3$) δ 15.3 (s, Me), 55.6 (s, OMe), 97.9 (s, CH), 111.3 (s, C), 114.9 (s, CH), 118.2 (s, C), 123.5 (s, CH), 130.8 (s, CH), 135.0 (s, C), 140.4 (s, C), 156.0 (s, C), 157.1 (s, C).

3e. 2-Chloro-5-methoxy-4-methylaniline (85.8 mg, 0.5 mmol) and 3-bromoanisole (64.1 μL, 0.51 mmol) gave **3e** as a clear oil: 121 mg (82.5%); R_f 0.69 ($CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.02 (s, 3H, Me), 3.64 (s, 3H, OMe), 3.70 (s, 3H, OMe), 5.86 (br s, 1H, NH), 6.45 (ddd, J = 0.8, 2.5 & 8.2 Hz, 1H, Ar H$^6_{anisole}$), 6.59 (dd, J = 2.4 & 2.5 Hz, 1H, Ar H$^2_{anisole}$), 6.62 (ddd, J = 0.8, 2.0 & 7.8 Hz, 1H, Ar H$^4_{anisole}$), 6.77 (s, 1H, Ar H$^4_{aniline}$), 7.02 (s, 1H, Ar H$^3_{aniline}$), 7.11 (t, J = 8.0 Hz, 1H, Ar H$^5_{anisole}$); ^{13}C NMR (100 MHz, $CDCl_3$) δ 15.5 (s, CH_3), 55.3 (s, OMe), 55.5 (s, OMe), 100.6 (s, CH), 107.4 (s, CH), 111.3 (s, CH), 113.2 (s, CH), 113.4 (s, C), 120.2 (s, C), 122.9 (s, C), 123.9 (s, CH), 130.6 (s, CH), 138.0 (s, C), 156.9 (s, C), 160.8 (s, C) (sample contaminated with ∼5% 3-bromoanisole).

3f. 2-Chloro-5-methoxy-4-methylaniline (85.8 mg, 0.5 mmol) and 3-bromo-*m*-xylene (69.3 μL, 0.51 mmol) gave **3f** as a clear oil: 115 mg (83.0%); R_f 0.9 ($CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.04 (s, 3H, Me), 2.20 (s, 6H, Me), 3.63 (s, 3H, OMe), 5.78 (br s, 1H, NH), 6.56 (br s, 1H, Ar H$^{2,5}_{xylene}$), 6.68 (br s, 2H, Ar H$^4_{xylene}$), 6.74 (s, 1H, Ar H$^6_{aniline}$), 7.01 (s, 1H, Ar H$^3_{aniline}$). R_f 0.9 ($CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.04 (s, 3H, Me), 2.20 (s, 6H, Me), 3.63 (s, 3H, OMe), 5.78 (br s, 1H, NH), 6.56 (br s, 1H, Ar H$^{2,5}_{xylene}$), 6.68 (br s, 2H, Ar H$^4_{xylene}$), 6.74 (s, 1H, Ar H$^6_{aniline}$), 7.01 (s, 1H, Ar H$^3_{aniline}$); ^{13}C NMR (100 MHz, $CDCl_3$) δ 15.7 (s, CH_3), 21.4 (s, CH_3), 55.7 (s, OMe), 100.4 (s, CH), 116.9 (s, CH), 119.7 (s, C), 123.8 (s, CH), 130.8 (s, CH), 138.5 (s, C), 138.6 (s, C), 139.2 (s, C), 142.4 (s, C), 156.9 (s, C) (sample contaminated with ∼5% 3-bromo-*m*-xylene).

General Method for the Synthesis of Carbazoles, 4n−q. NaO^{t}Bu (0.240 g, 2.5 mmol), $Pd(OAc)_2$ (0.005 g, 0.02 mmol), and [HP^{t}Bu$_3$][BF_4] (0.008 g, 0.025 mmol) were suspended in dioxane (2 mL). The crude 2-chloro-*N*-arylaniline was then added as a solution in dioxane (1 mL), and the mixture was then heated at reflux temperature overnight, allowed to cool, and then quenched by addition of $HCl_{(aq)}$ (2 M, 3 mL). The organic phase was extracted with CH_2Cl_2 (2 × 20 mL), dried ($MgSO_4$), then filtered, and the solvent was removed under reduced pressure. The crude product mixture was then subjected to column chromatography (SiO_2).

4n. 2-Chloro-5-trifluoromethyl-*N*-(2-methoxyphenyl)aniline (116 mg, 0.38 mmol) gave **4n** as an off-white powder: 76 mg (65.5%);

R_f 0.69 ($CHCl_3$); mp 133−135 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 3.92 (s, 3H, OMe), 6.87 (br d, J = 8.0 Hz, 1H, Ar H^2), 7.13 (t, J = 8.0 Hz, 1H, Ar H^3), 7.38 (dd, J = 1.0 & 8.0 Hz, 1H, Ar H^6), 7.62 (d, J = 8.0 Hz, 1H, Ar H^4), 7.64 (m, 1H, Ar H^8), 8.04 (d, J = 8.0 Hz, 1H, Ar H^5), 8.35 (br s, 1H, NH); ^{13}C NMR (100 MHz, $CDCl_3$) δ 55.6 (s, OMe), 106.9 (s, CH), 108.2 (q, $^2J_{CF}$ = 4.1 Hz, C), 113.2 (s, CH), 116.1 (q, J_{CF} = 4 Hz, CH), 120.5 (s, CH), 120.8 (s, CH), 123.3 (s, C), 123.5 (s, C), 126.0 (s, C), 127.5 (q, J_{CF} = 145 Hz, CF_3), 138.1 (s, C), 145.8 (s, C); ^{19}F NMR (282.2 MHz, $CDCl_3$) δ −60.8 (s); HRMS (EI) calcd for $C_{14}H_{10}F_3NO$ [M^+] 265.071 449, found 265.070 582. Anal. calcd for $C_{14}H_{10}F_3NO$: C, 63.40; H, 3.80; N, 5.28. Found: C, 63.65; H, 4.02; N, 5.08.

Glycozolidine, 4o. 2-Chloro-5-methoxy-4-methyl-*N*-(4-methoxyphenyl)aniline (98.0 mg, 0.35 mmol) gave **4o** as an off-white solid: 52 mg (61.5%); R_f 0.25 ($CHCl_3$); mp 160−162 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.27 (s, 3H, Me), 3.81 (s, 3H, OMe), 3.83 (s, 3H, OMe), 6.72 (br s, 1H, Ar H^1), 6.86 (dd, J = 2.4 & 8.6 Hz, 1H, Ar H^7), 7.16 (dd, J = 1.0 & 8.6 Hz, 1H, Ar H^8), 7.35 (d, J = 2.4 Hz, 1H, Ar H^5), 7.63 (br s, 1H, NH), 7.66 (s, 1H, Ar H^4); ^{13}C NMR (100 MHz, $CDCl_3$) δ 16.7 (s, Me), 55.5 (s, OMe), 56.0 (s, OMe), 92.4 (s, CH), 102.6 (s, CH), 110.9 (s, CH), 113.0 (s, CH), 116.2 (s, C), 119.0 (s, C), 121.4 (s, CH), 124.0 (s, C), 134.2 (s, C), 140.0 (s, C), 153.9 (s, C), 157.4 (s, C); HRMS (EI) calcd for $C_{15}H_{15}NO_2$ [M^+] 241.110 279, found 241.109 351. Anal. calcd for $C_{15}H_{15}NO_2 \cdot 0.2H_2O$: C, 73.98; H, 6.41; N, 5.75. Found: C, 73.75; H, 6.23; N, 5.77.

4p. 2-Chloro-5-methoxy-4-methyl-*N*-(3-methoxyphenyl)aniline (121 mg, 0.43 mmol) gave **4p** as an off-white solid: 37 mg (35.5%); R_f 0.22 ($CHCl_3$); mp 227−229 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.26 (s, 3H, Me), 3.80 (s, 3H, OMe), 3.81 (s, 3H, OMe), 6.72 (dd, J = 2.4 & 8.6 Hz, 1H, Ar H^6), 6.75 (s, 1H, Ar H^1), 6.72 (d, J = 8.6 Hz, 1H, Ar H^5), 7.60 (s, 1H, Ar H^4), 7.71 (br s, 1H, NH), 7.71 (d, J = 8.4 Hz, 1H, Ar H^8); ^{13}C NMR (100 MHz, $CDCl_3$) δ 16.6 (s, Me), 55.5 (s, OMe), 55.6 (s, OMe), 92.5 (s, CH), 102.5 (s, CH), 111.0 (s, CH), 112.9 (s, CH), 116.2 (s, C), 119.1 (s, C), 121.2 (s, CH), 124.1 (s, C), 134.4 (s, C), 139.9 (s, C), 154.7 (s, C), 157.1 (s, C); HRMS (EI) calcd for $C_{15}H_{15}NO_2$ [M^+] 241.110 279, found 241.109 872. Anal. calcd for $C_{15}H_{15}NO_2 \cdot 0.25H_2O$: C, 73.30; H, 6.15; N, 5.70. Found: C, 73.65; H, 6.44; N, 5.35.

4q. 2-Chloro-5-methoxy-4-methyl-*N*-(3,5-dimethylphenyl)aniline (115 mg, 0.42 mmol) gave **4q** as an off-white powder: 62 mg (61.5%); R_f 0.61 ($CHCl_3$); mp 198−200 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.28 (s, 3H, Me), 2.38 (s, 3H, Me), 2.70 (s, 3H, Me), 3.82 (s, 3H, OMe), 6.72 (s, 1H, Ar H^6), 6.76 (s, 1H, Ar H^1), 6.93 (s, 1H, Ar H^8), 7.71 (br s, 1H, NH), 7.73 (s, 1H, Ar H^4); ^{13}C NMR (100 MHz, $CDCl_3$) δ 16.8 (s, Me), 20.5 (s, Me), 21.7 (s, Me), 55.5 (s, OMe), 92.3 (s, CH), 108.0 (s, CH), 117.0 (s, C), 118.7 (s, CH), 119.8 (s, C), 122.3 (s, CH), 123.4 (s, C), 131.8 (s, C), 134.1 (s, C), 139.1 (s, C), 139.7 (s, C), 156.4 (s, C); HRMS (EI) calcd for $C_{16}H_{17}NO$ [M^+] 239.131 014, found 239.130 293. Anal. calcd for $C_{16}H_{17}NO$: C, 80.30; H, 7.16; N, 5.85. Found: C, 80.09; H, 7.38; N, 5.54.

General Method for the Microwave-Assisted, One-Pot Synthesis of Indoles 9a−d. NaO^{t}Bu (0.240 g, 2.5 mmol), $Pd(OAc)_2$ (0.005 g, 0.02 mmol), and [HP^{t}Bu$_3$][BF_4] (0.008 g, 0.025 mmol) were suspended in toluene (3 mL). The appropriate 2-chloroaniline (0.5 mmol) and bromostyrene (0.51 mmol) were then added, and the microwave vial was sealed. The reaction was then heated in the microwave reactor at 160 °C for 3 h, allowed to cool, and then quenched by addition of $HCl_{(aq)}$ (2 M, 3 mL). The organic phase was extracted with CH_2Cl_2 (2 × 20 mL), dried ($MgSO_4$), then filtered, and the solvent was removed under reduced pressure. The crude product mixture was then subjected to column chromatography (SiO_2).

9a. 2-Chloroaniline (52.5 μL, 0.5 mmol) and α-bromostyrene (66.2 μL, 0.51 mmol) gave **9a** as an off-white powder: 86 mg (89.5%); R_f 0.63 ($CHCl_3$); mp 188−190 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.75 (dd, J = 1.0 & 2.0 Hz, 1H, =CH), 7.03 (ddd, J = 1.0, 7.3 & 8.3 Hz, 1H, Ar H), 7.10 (ddd, J = 1.0, 6.8 & 8.3 Hz, 1H, Ar H), 7.24 (m, 1H, Ar H), 7.30 (d, J = 7.8 Hz, 1H, Ph), 7.36−7.39 (m, 2H, Ph), 7.55 (dd, J = 1.0 & 7.8 Hz, 1H, Ar H), 7.57−7.60 (m, 2H, Ph), 8.25 (br s, 1H, NH); ^{13}C NMR (100 MHz, $CDCl_3$) δ 100.0 (s, =CH), 110.9 (s, CH), 120.3 (s, CH), 120.7 (s, CH), 122.4 (s, CH), 125.1 (s, CH), 127.7 (s, CH), 129.0 (s, CH), 129.3 (s, C), 132.4 (s, C), 136.8 (s, C), 137.9 (s, C); HRMS (EI) calcd for $C_{14}H_{11}N$ [M^+] 193.089 149, found 193.089 607. Anal. calcd for $C_{14}H_{11}N \cdot 0.4H_2O$: C, 83.89; H, 6.39; N, 6.99. Found: C, 83.82; H, 5.95; N, 6.62.

9b. 2-Chloro-5-methoxy-4-methylaniline (85.8 mg, 0.5 mmol) and α-bromostyrene (66.2 μL, 0.51 mmol) gave **9b** as an off-white powder: 56 mg (47.5%); R_f 0.48 ($CHCl_3$); mp 143−145 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.21 (s, 3H, Me), 3.79 (s, 3H, OMe), 6.61 (d, J = 1.9 Hz, 1H, =CH), 6.76 (s, 1H, Ar H^7), 7.19 (d, J = 7.8 Hz, 1H, Ph), 7.26 (s, 1H, Ar H^4), 7.30−7.35 (m, 2H, Ph), 7.51−7.54 (m, 2H, Ph), 8.08 (br s, 1H, NH); ^{13}C NMR (100 MHz, $CDCl_3$) δ 16.8 (s, Me), 55.5 (s, OMe), 92.5 (s, CH), 99.4 (s, =CH), 121.5 (s, CH), 122.8 (s, CH), 124.5 (s, CH), 124.7 (s, C), 127.0 (s, C), 128.3 (s, C), 129.0 (s, CH), 136.1 (s, C), 136.2 (s, C), 155.3 (s, C); HRMS (EI) calcd for $C_{16}H_{15}NO$ [M^+] 237.115 364, found 237.114 449. Anal. calcd for $C_{16}H_{15}NO$: C, 80.99; H, 6.37; N, 5.90. Found: C, 80.78; H, 6.05; N, 5.59.

9c. *N*-Benzyl-2-chloroaniline (109 mg, 0.5 mmol) and α-bromostyrene (66.2 μL, 0.51 mmol) gave **9c** as a yellow solid: 94 mg (66.5%); R_f 0.72 ($CHCl_3$); mp 62−64 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.39 (s, 2H, CH_2Ph), 7.18−7.38 (m, 10H, Ph), 7.46 (m, 2H, Ph), 7.70 (dd, J = 1.5 & 6.5 Hz, 2H, Ar H^8), 8.00 (dd, J = 1.5 & 6.8 Hz, 1H, Ar H^4); ^{13}C NMR (100 MHz, $CDCl_3$) δ 50.0 (s, CH_2), 110.0 (s, CH), 117.4 (s, CH), 120.0 (s, CH), 120.1 (s, CH), 122.2 (s, CH), 125.8 (s, C), 125.9 (s, CH), 126.4 (s, C), 126.9 (s, CH), 127.4 (s, CH), 127.7 (s, CH), 128.7 (s, CH), 128.8 (s, CH), 135.5 (s, C), 137.1 (s, C), 137.2 (s, C); HRMS (EI) calcd for $C_{21}H_{17}N$ [M^+] 283.136 100, found 283.135 374. Anal. calcd for $C_{21}H_{17}N$: C, 89.01; H, 6.05; N, 4.94. Found: C, 88.60; H, 5.98; N, 4.61.

9d. *N*-Benzyl-2-chloroaniline (52.5 μL, 0.5 mmol) and β-bromostyrene (65.4 μL, 0.51 mmol) gave **9d** as a yellow solid: 90 mg (64.0%); R_f 0.85 ($CHCl_3$); mp 83−85 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.40 (s, 2H, CH_2Ph), 6.69 (s, 1H, =CH), 7.06 (br d, J = 6.8 Hz, 2H, Ph), 7.17−7.24 (m, 3H), 7.26−7.32 (m, 4H), 7.39−7.43 (m, 2H), 7.46−7.49 (m, 2H), 7.70−7.72 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 47.7 (s, CH_2), 102.3 (s, CH), 110.5 (s, CH), 120.14 (s, CH), 121.9 (s, CH), 125.9 (s, C), 127.1 (s, CH), 128.0 (s, CH), 128.2 (s, CH), 128.3 (s, C), 128.5 (s, CH), 128.7 (s, CH), 129.0 (s, CH), 129.2 (s, CH), 132.7 (s, C), 138.0 (s, C), 138.2 (s, C); HRMS (EI) calcd for $C_{21}H_{17}N$ [M^+] 283.136 100, found 283.135 937. Anal. calcd for $C_{21}H_{17}N$: C, 89.01; H, 6.05; N, 4.94. Found: C, 88.85; H, 5.94; N, 4.86.

Thermal Syntheses of Indoles, 9c,d. NaO^{t}Bu (0.240 g, 2.5 mmol), $Pd(OAc)_2$ (0.005 g, 0.02 mmol), and [HP^{t}Bu$_3$][BF_4] (0.008 g, 0.025 mmol) were suspended in toluene (3 mL). *N*-Benzyl-2-chloroaniline (52.5 μL, 0.5 mmol) and bromostyrene (0.51 mmol) were added, and the reaction was then heated at reflux temperature for 18 h. The reaction was quenched by addition of $HCl_{(aq)}$ (2 M, 3 mL). The organic phase was extracted with CH_2Cl_2 (2 × 20 mL), dried ($MgSO_4$), then filtered, and the solvent was removed under reduced pressure. The products were purified as above to give **9c** and **9d** in 91.0% and 93.0% yields, respectively.

Synthesis of Imine, 10. NaO^{t}Bu (0.240 g, 2.5 mmol), $Pd(OAc)_2$ (0.005 g, 0.02 mmol), and [HP^{t}Bu$_3$][BF_4] (0.008 g, 0.025 mmol) were suspended in toluene (3 mL). 2-Chloroaniline (52.5 μL, 0.5 mmol) and α-bromostyrene (66.2 μL, 0.51 mmol) were added, and the reaction was then heated at reflux temperature for 18 h. The reaction was quenched by addition of $HCl_{(aq)}$ (2 M, 3 mL). The organic phase was extracted with CH_2Cl_2 (2 × 20 mL), dried ($MgSO_4$), then filtered, and the solvent was removed under reduced pressure. The crude product mixture was then subjected to column chromatography (SiO_2 plug) to give **10** as a light brown oil: 93 mg (81.0%, compound not isolated cleanly but used in the

subsequent cyclization step without further purification); R_f 0.90 ($CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.06 (s, 3H, Me), 6.66 (dd, J = 2.0 & 7.8 Hz, 1H, Ar H), 6.87 (dt, J = 2.0 & 7.8 Hz, 1H, Ar H), 6.99−7.13 (m, 2H, Ar H), 7.21−7.35 (m, 3H, Ar H), 7.87 (dd, J = 2.1 & 8.0 Hz, 1H, Ar H).

Conversion of Imine, 10, to Indole, 9a. NaO^{t}Bu (0.240 g, 2.5 mmol), $Pd(OAc)_2$ (0.005 g, 0.02 mmol), and [HP^{t}Bu$_3$][BF_4] (0.008 g, 0.025 mmol) were suspended in dioxane (2 mL). Imine, **10** (93.0 mg, 4.05 mmol), was then added as a solution in dioxane (1 mL), and the mixture was then heated at reflux temperature overnight, allowed to cool, and then quenched by addition of $HCl_{(aq)}$ (2 M, 3 mL). The organic phase was extracted with CH_2Cl_2 (2 × 20 mL), dried ($MgSO_4$), then filtered, and the solvent was removed under reduced pressure. The crude product mixture was then subjected to column chromatography (SiO_2) to give **9a** as an off-white powder: 68 mg (87.0%). (Data as above.)

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Supporting Information Available: General experimental details and product ^{1}H and ^{13}C NMR spectra. This material is available free of charge via the Internet at http://pubs.acs.org.

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