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Palladium and Copper Cocatalyzed Tandem N−H/C−H Bond Functionalization: Synthesis of CF_3-Containing Indolo- and Pyrrolo[2,1-*a*]isoquinolines

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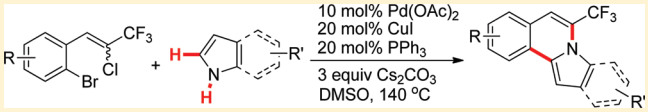
Supporting Information

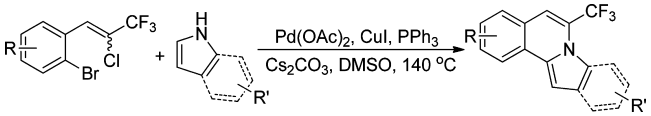
ABSTRACT: A palladium- and copper-catalyzed tandem N−H/C−H bond functionalization reaction of *ortho*-(2-chlorovinyl)bromobenzenes with indoles and pyrroles has been developed. A variety of CF_3-containing indolo- and pyrrolo[2,1-*a*]isoquinolines were prepared in moderate to good yields via the cyclization of 1-bromo-2-(2-chloro-3,3,3-trifluoroprop-1-enyl)benzenes with indoles and pyrroles.



INTRODUCTION

Indolo- and pyrrolo[2,1-*a*]isoquinolines are important class of nitrogen-containing fused polycyclic compounds, which occur widely in pharmaceutical molecules,[1] functional materials,[2] and natural products.[3] Thus, a number of synthetic strategies have been developed for the construction of these entities,[4] most of them requiring complicated multistep procedures involving substantial byproducts.[5] Recently, transition-metal-catalyzed C−H bond functionalization has received considerable attention owing to its atom economy, which could transform the unreactive C−H bond into diverse functional groups.[6] The tandem reactions combining a C−H bond functionalization with a C-heteroatom bond forming reaction have emerged as a powerful tool for the synthesis of multiring heterocyclic compounds because of their efficiency and selectivity.[7] For example, Larock and co-workers reported the synthesis of indolo- and pyrrolo [2,1-*a*]isoquinolines by copper catalyzed tandem C−N bond forming reaction and C−H bond arylation of *ortho*-haloarylalkyne.[8] Xi and co-workers also developed the copper catalyzed consecutive N-alkenylation and C-alkenylation of azoles for the synthesis of N-bridgehead azolopyridines.[9] It is well-known that the introduction of a trifluoromethyl group into organic compounds has a significant effect on biological activity and often manifests changes in chemical and physical properties.[10] As part of a continuing interest in the synthesis of trifluoromethyl-containing heterocyclic compounds,[11] we wish to prepare CF_3-containing isoquinoline derivatives from our previous CF_3-containing building blocks via tandem cyclization. Herein, we report an efficient protocol for the synthesis of trifluoromethyl-containing indolo- and pyrrolo[2,1-*a*]isoquinolines from the palladium and copper cocatalyzed tandem N−H/C−H bond functionalization reaction of 1-bromo-2-(2-chloro-3,3,3-trifluoroprop-1-enyl)-benzenes[12] with indoles and pyrroles (Scheme 1).

Scheme 1



RESULTS AND DISCUSSION

We began our study by examining the reaction between 2-chloro-1-(2-bromophenyl)-3,3,3-trifluoropropylene **1a** and 1*H*-indole **2a** to screen the optimal reaction conditions, and the results are summarized in Table 1. Initially, substrate **1a** was treated with 1*H*-indole **2a**, $Pd(OAc)_2$, and Cs_2CO_3 in DMSO at 140 °C for 5 h, but only trace amounts of the target product **3a** was observed (entry 1). It was found that PPh_3 could promote the reaction and the yield increased to 21% in the presence of 20 mol % PPh_3 (entry 2). Larock and Xi's results revealed that copper catalysts could mediate the amination and alkenylation of indole or imidazole.[8,9] Therefore, various copper salts such as CuI, CuBr, CuCl, $Cu(OTf)_2$, and $Cu(OAc)_2$ were examined (entries 3−7). We found that the desired product **3a** could be isolated in 72% yield by adding 20 mol % of CuI as cocatalyst (entry 3). The other copper catalysts were less effective than CuI. It is noteworthy that CuI could not promote the reaction in the absence of $Pd(OAc)_2$ (entry 8). Subsequently, some phosphine ligands were screened to optimize the reaction conditions, but other ligands were found less effective than PPh_3 (entries 9−12). During the examination of the effect of base (entries 13−15), we found that the reaction yields decreased dramatically in the presence of mild bases such as K_2CO_3 and K_3PO_4. Lower yield was also observed when Cs_2CO_3 was replaced by *t*-BuONa. Finally, the effects of solvents and reaction temperature were evaluated (entries 16−19). The results showed that the reaction proceeded optimally in DMSO at 140 °C.

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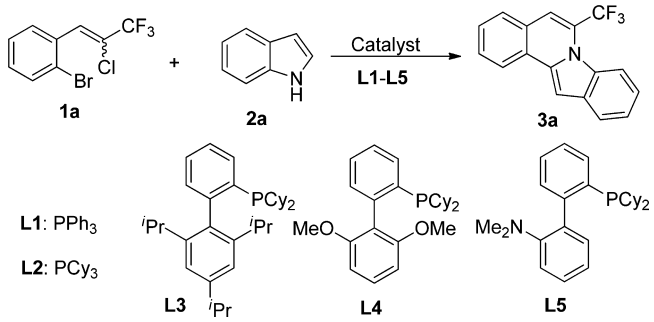
Table 1. Screening Conditions[a]



entry	catalyst	ligand	base	solvent	yield (%)
1	$Pd(OAc)_2$	–	Cs_2CO_3	DMSO	<5
2	$Pd(OAc)_2$	**L1**	Cs_2CO_3	DMSO	21
3	$Pd(OAc)_2$/CuI	**L1**	Cs_2CO_3	DMSO	72
4	$Pd(OAc)_2$/CuBr	**L1**	Cs_2CO_3	DMSO	34
5	$Pd(OAc)_2$/CuCl	**L1**	Cs_2CO_3	DMSO	31
6	$Pd(OAc)_2$/$Cu(OTf)_2$	**L1**	Cs_2CO_3	DMSO	42
7	$Pd(OAc)_2$/$Cu(OAc)_2$	**L1**	Cs_2CO_3	DMSO	49
8	CuI	**L1**	Cs_2CO_3	DMSO	0
9	$Pd(OAc)_2$/CuI	**L2**	Cs_2CO_3	DMSO	37
10	$Pd(OAc)_2$/CuI	**L3**	Cs_2CO_3	DMSO	43
11	$Pd(OAc)_2$/CuI	**L4**	Cs_2CO_3	DMSO	39
12	$Pd(OAc)_2$/CuI	**L5**	Cs_2CO_3	DMSO	47
13	$Pd(OAc)_2$/CuI	**L1**	*t*-BuONa	DMSO	65
14	$Pd(OAc)_2$/CuI	**L1**	K_2CO_3	DMSO	14
15	$Pd(OAc)_2$/CuI	**L1**	K_3PO_4	DMSO	12
16	$Pd(OAc)_2$/CuI	**L1**	Cs_2CO_3	DMF	60
17	$Pd(OAc)_2$/CuI	**L1**	Cs_2CO_3	NMP	25
18	$Pd(OAc)_2$/CuI	**L1**	Cs_2CO_3	toluene	<5
19[b]	$Pd(OAc)_2$/CuI	**L1**	Cs_2CO_3	DMSO	53

[a]Reaction conditions: **1a** (0.2 mmol), **2a** (0.22 mmol), $Pd(OAc)_2$ (10 mol %), [Cu] (20 mol %), ligand (20 mol %) and base (3 equiv) in solvent (2 mL) at 140 °C under N_2 atmosphere for 5 h. [b]At 120 °C.

With the optimal reaction conditions in hand, the substrate scope of both indoles and *ortho*-(2-chlorovinyl)bromobenzenes for this tandem reactions was examined (Table 2). We initially investigated the reaction of a variety of indoles **2b**–**2j** with 1-bromo-2-(2-chloro-3,3,3-trifluoroprop-1-enyl)benzenes **1a** (entries 1–9). The results demonstrated that a wide range of indoles bearing both electron-withdrawing and electron-donating groups were suitable substrates for the cyclization and gave the corresponding products in moderate to excellent yields. For example, electron-rich indoles (**2b**–**2e**) bearing methyl, ethyl or methoxyl substituents provided the desired products in good yields (entries 1–4). The configuration of the product was confirmed by X-ray single-crystal diffraction analysis of compound **3e**. The 5-aminoindole **2f** could be converted to indolo[2,1-*a*]isoquinoline **3f** in 51% yield and the unprotected amino group did not participate in amination (entry 5). Indoles containing halogen atom (Br, F) or electron-withdrawing substituents (cyano, nitro) also underwent the cyclization smoothly to afford the corresponding product in moderate yields (entries 6–9). Subsequently, various *ortho*-(2-chlorovinyl)bromobenzenes **1b**–**1f** bearing different functional groups on the aryl moiety were examined (entries 10–14). The results showed that several substituents (such as methyl, methoxy, chloro, fluoro, and trifluoromethyl groups) were tolerated well under the standard conditions. Substrate **1c** with a 4-methoxy group, for instance, was treated with indole **2a**, $Pd(OAc)_2$, CuI, PPh_3, and Cs_2CO_3 to afford desired product **3l** in 86% yield (entry 11). Interestingly, substrate **1f** bearing an electron-withdrawing trifluoromethyl group also underwent the tandem reactions smoothly with indole **2a** to give product **3o** in 73% yield (entry 14).

The tandem N–H/C–H bond functionalization reaction was successfully extended to pyrroles and various pyrrolo[2,1-*a*]isoquinolines were prepared. As listed in Table 3, the reaction of substrate **1a** with 1*H*-pyrrole **4a** under the standard conditions generated the desired pyrrolo[2,1-*a*]isoquinoline **5a** in 70% yield (entry 1). 2,4-Dimethyl-1*H*-pyrrole **4b** could also react with substrate **1a** successfully to afford product **5b** in 61% yield (entry 2). Subsequently, the reactions of a variety of *ortho*-(2-chlorovinyl)bromobenzenes **1b**–**1f** with 1*H*-pyrrole **4a** were investigated (entries 3–7). Several functional groups (such as Me, MeO, Cl, F, and CF_3 groups) on the aromatic ring of bromobenzenes were suitable for the tandem reactions (entries 3–7). Methyl-substituted substrate **1b**, for instance, underwent the reaction with pyrrole **4a** smoothly to provide product **5c** in 62% yield (entry 3). Other substituents such as methoxyl, Cl, and F groups furnished the desired products in good yields (entries 4–6). Notably, substrate **1f**, bearing an electron-withdrawing CF_3 group, could also be converted to pyrrolo[2,1-*a*]isoquinoline **5g** in 50% yield (entry 7).

To elucidate the mechanism, some control experiments were carried out (Scheme 2). Treatment of (2-chloro-3,3,3-trifluoroprop-1-en-1-yl)benzene **1g** with 1*H*-indole **2a** under the standard conditions afforded the N-alkenylated product **6**

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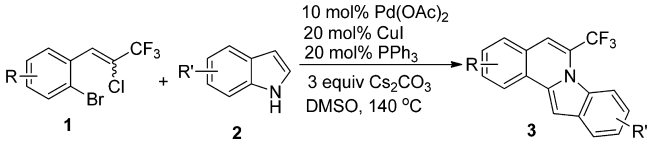
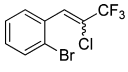
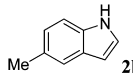
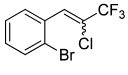
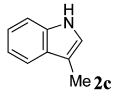
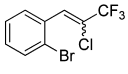
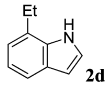
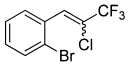
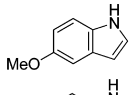
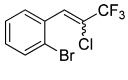
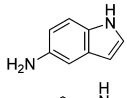
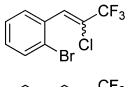
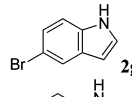
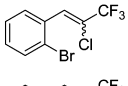
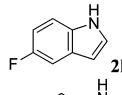
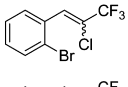
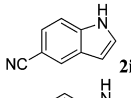
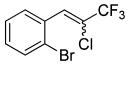
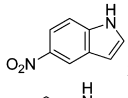
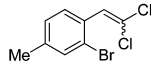
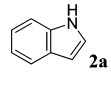
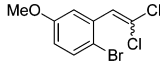
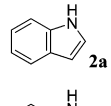
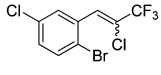
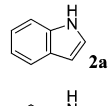
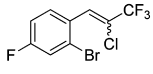
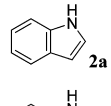
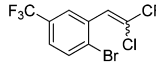
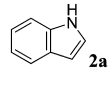
Table 2. $Pd(OAc)_2$/CuI Catalyzed Tandem Reaction of *ortho*-(2-Chlorovinyl)bromobenzenes with Indoles[a]



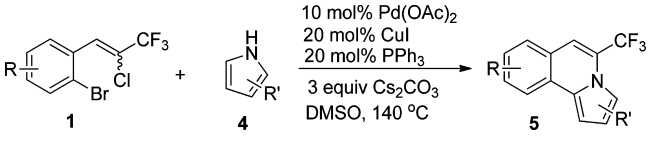
1 2 3

Entry	Substrate 1	Substrate 2	Yield (%)
1	 **1a**	 **2b**	61(**3b**)
2	 **1a**	 **2c**	77(**3c**)
3	 **1a**	 **2d**	67(**3d**)
4	 **1a**	 **2e**	73(**3e**)
5	 **1a**	 **2f**	51(**3f**)
6	 **1a**	 **2g**	58(**3g**)
7	 **1a**	 **2h**	60(**3h**)
8	 **1a**	 **2i**	53(**3i**)
9	 **1a**	 **2j**	57(**3j**)
10	 **1b**	 **2a**	55(**3k**)
11	 **1c**	 **2a**	86(**3l**)
12	 **1d**	 **2a**	56(**3m**)
13	 **1e**	 **2a**	55(**3n**)
14	 **1f**	 **2a**	73(**3o**)

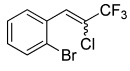
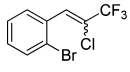
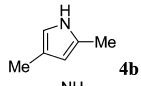
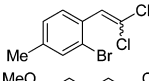
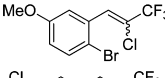
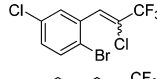
[a]Reaction conditions: **1** (0.2 mmol), **2** (0.22 mmol), $Pd(OAc)_2$ (10 mol %), CuI (20 mol %), PPh_3 (20 mol %) and Cs_2CO_3 (3 equiv) in DMSO (2 mL) at 140 °C under N_2 atmosphere for 5 h.

in 51% yield (Scheme 2, eq 1). The result indicated that the N−H bond was activated preferentially under the standard conditions. Subsequently, a control reaction of substrate **1a** and 1*H*-indole **2a** was carried out in the absence of $Pd(OAc)_2$ (eq 2). However, only the N-alkenylated product **7** could be isolated in 41% yield and cyclization product **3a** could not be observed. This result suggested that the copper-catalyzed amination of vinyl chlorides with indole could proceed successfully. As expected, compound **7** could be converted into the desired product **3a** in 90% yield under the standard conditions (eq 3).

Table 3. $Pd(OAc)_2$/CuI Catalyzed Tandem Reaction of *ortho*-(2-Chlorovinyl)bromobenzenes with Pyrroles[a]



1 4 5

Entry	Substrate 1	Substrate 4	Yield (%)
1	 **1a**	 **4a**	70(**5a**)
2	 **1a**	 **4b**	61(**5b**)
3	 **1b**	 **4a**	62(**5c**)
4	 **1c**	 **4a**	73(**5d**)
5	 **1d**	 **4a**	61(**5e**)
6	**1e**	**4a**	68(**5f**)
7	**1f**	**4a**	50(**5g**)

[a]Reaction conditions: **1** (0.2 mmol), **4** (0.22 mmol), $Pd(OAc)_2$ (10 mol %), CuI (20 mol %), PPh_3 (20 mol %) and Cs_2CO_3 (3 equiv) in DMSO (2 mL) at 140 °C under N_2 atmosphere for 5 h.

Scheme 2. Control Experiments

On the basis of the present results and the reported mechanism,[8,9,13] a possible mechanism was proposed as outlined in Scheme 3. After copper-catalyzed amination of substrate **1a**, the obtained compound **7** undergoes an oxidative addition process with Pd(0) to afford intermediate **A**. The intramolecular coordination of Pd(II) with indole moiety might provide palladium complex **B**, and the following elimination of HBr in the presence of Cs_2CO_3 provides intermediate **C**. Finally, reductive elimination of **C** affords product **3a** and regenerated Pd(0) species.

CONCLUSION

In summary, we have developed an efficient route for the synthesis of trifluoromethyl substituted indolo- and pyrrolo-[2,1-*a*]isoquinolines. In the presence of $Pd(OAc)_2$, CuI, PPh_3, and Cs_2CO_3, a variety of 1-bromo-2-(2-chloro-3,3,3-trifluoroprop-1-enyl)benzenes undergo tandem N−H/C−H bond

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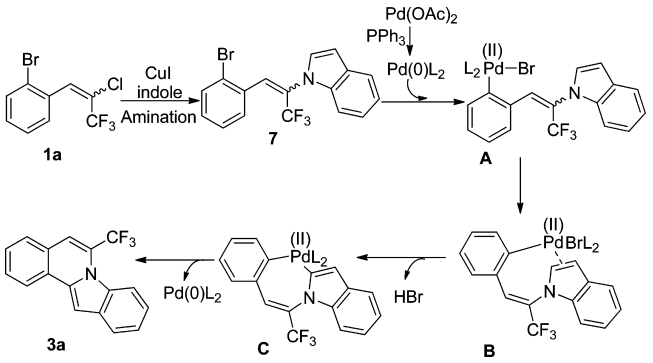
Scheme 3. Possible Mechanism



functionalization reactions with various indoles and pyrroles to afford the corresponding isoquinolines in moderate to good yields. The present process could facilitate the synthetic applications of trifluoromethyl-containing building blocks, and also provides a new optional route for the construction of the isoquinoline ring.

EXPERIMENTAL SECTION

Typical Experimental Procedure for the Palladium and Copper Cocatalyzed Tandem Reaction. A mixture of 1-bromo-2-(2-chloro-3,3,3-trifluoroprop-1-enyl)benzenes **1** (0.2 mmol), indole **2** or pyrrole **4** (0.22 mmol), $Pd(OAc)_2$ (4.5 mg, 10 mol %), CuI (7.6 mg, 20 mol %), PPh_3 (10.5 mg, 20 mol %), Cs_2CO_3 (195.5 mg, 3 equiv), in DMSO (2 mL), was evacuated and backfilled with nitrogen (3 cycles) and then stirred at 140 °C for 5 h or until complete consumption of starting material was indicated by TLC or GC–MS analysis. After the reaction was completed, the mixture was filtered through glass filter and washed with ethyl acetate. The mixture was washed with brine and extracted with ethyl acetate. The organic layers were dried with anhydrous Na_2SO_4 and evaporated under vacuum, and the residue was purified by flash column chromatography (hexane/ethyl acetate) to give products **3**, and **5**–**7**.

*6-(Trifluoromethyl)indolo[2,1-a]isoquinoline (**3a**).* Yellow solid (41.1 mg, 72% yield), mp 90.0–91.0 °C; ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.17 (d, J = 8.0 Hz, 1H), 8.11–8.09 (m, 1H), 7.85–7.83 (m, 1H), 7.64–7.55 (m, 2H), 7.49–7.46 (m, 1H), 7.42 (s, 1H), 7.40–7.35 (m, 2H), 7.27 (s, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 136.0, 131.1, 129.7, 129.5, 127.9, 127.9, 127.3, 125.7, 125.2 (q, J_{C-F} = 34.5 Hz), 123.3, 122.5, 122.1, 121.6 (q, J_{C-F} = 270.0 Hz), 120.7, 113.9 (q, J_{C-F} = 7.6 Hz), 112.1 (q, J_{C-F} = 7.1 Hz), 96.5; ^{19}F NMR (470 MHz, $CDCl_3$) δ: −63.2 (s, 3F); IR (neat, cm^{-1}): 3026, 1601, 1556, 1454, 1416, 1121, 737; LRMS (EI, 70 eV) m/z (%): 285 (M^+, 100), 265 (14), 216 (11), 142 (14); HRMS (ESI) calcd for $C_{17}H_{11}F_3N^+$ ([M + H]$^+$) 286.0838; found, 286.0836.

*10-Methyl-6-(trifluoromethyl)indolo[2,1-a]isoquinoline (**3b**).* Yellow solid (36.3 mg, 61% yield), mp 131.4–132.1 °C; ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.14 (d, J = 8.0 Hz, 1H), 7.97–7.95 (m, 1H), 7.61–7.55 (m, 3H), 7.47–7.43 (m, 1H), 7.32 (s, 1H), 7.23 (s, 1H), 7.20–7.17 (m, 1H), 2.52 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 136.0, 132.0, 129.8, 129.6, 129.4, 127.9, 127.7, 127.3, 125.7, 125.1 (q, J_{C-F} = 34.4 Hz), 123.9, 123.3, 121.6 (q, J_{C-F} = 270.0 Hz), 120.1, 113.6 (q, J_{C-F} = 7.5 Hz), 111.7 (q, J_{C-F} = 7.0 Hz), 96.0, 21.3; ^{19}F NMR (470 MHz, $CDCl_3$) δ: −63.4 (s, 3F); IR (neat, cm^{-1}): 2914, 1627, 1540, 1463, 1417, 1116, 752; LRMS (EI, 70 eV) m/z (%): 299 (M^+, 100), 278 (6), 228 (8), 149 (12), 129 (6); HRMS (ESI) calcd for $C_{18}H_{13}F_3N^+$ ([M + H]$^+$) 300.0995; found, 300.0989.

*12-Methyl-6-(trifluoromethyl)indolo[2,1-a]isoquinoline (**3c**).* Yellow solid (46.0 mg, 77% yield), mp 111.0–112.2 °C; ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.34 (d, J = 8.5 Hz, 1H), 8.08–8.07 (m, 1H), 7.84–7.82 (m, 1H), 7.58–7.55 (m, 2H), 7.43–7.37 (m, 3H), 7.16 (s, 1H), 2.81 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 130.9, 130.3, 129.6, 129.3, 128.9, 127.8, 126.8, 126.7, 125.2 (q, J_{C-F} = 34.1 Hz), 124.4, 122.3, 121.9, 121.7 (q, J_{C-F} = 270.1 Hz), 118.4, 113.7 (q, J_{C-F} = 8.0 Hz), 111.9 (q, J_{C-F} = 7.3 Hz), 107.5, 11.8; ^{19}F NMR (470 MHz, $CDCl_3$) δ: −62.8 (s, 3F); IR (neat, cm^{-1}): 3089, 2903, 1714, 1652, 1599, 1481, 1418, 1314, 1198, 1124, 735; LRMS (EI, 70 eV) m/z (%): 299 (M^+, 100), 278 (7), 228 (12), 150 (8), 130 (23); HRMS (ESI) calcd for $C_{18}H_{13}F_3N^+$ ([M + H]$^+$) 300.0995; found, 300.0991.

*8-Ethyl-6-(trifluoromethyl)indolo[2,1-a]isoquinoline (**3d**).* Yellow oil (41.9 mg, 67% yield); ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.06 (d, J = 7.5 Hz, 1H), 7.61 (d, J = 8.0 Hz, 2H), 7.55–7.52 (m, 1H), 7.46–7.43 (m, 1H), 7.34–7.31 (m, 1H), 7.29 (s, 1H), 7.22–7.20 (m, 2H), 3.08 (q, J = 7.5 Hz, 2H), 1.21 (t, J = 7.5 Hz, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 137.7, 134.4, 132.3, 130.8, 129.5, 129.3 (q, J_{C-F} = 34.8 Hz), 128.0, 127.7, 127.6, 126.5, 123.3, 123.3, 122.4 (q, J_{C-F} = 273.3 Hz), 122.1, 117.7, 115.5 (q, J_{C-F} = 4.9 Hz), 97.5, 25.2, 14.9; ^{19}F NMR (470 MHz, $CDCl_3$) δ: −56.3 (s, 3F); IR (neat, cm^{-1}): 2926, 1714, 1625, 1458, 1418, 1313, 1124, 741; LRMS (EI, 70 eV) m/z (%): 313 (M^+, 100), 298 (21), 244 (70), 229 (21), 114 (13); HRMS (ESI) calcd for $C_{19}H_{15}F_3N^+$ ([M + H]$^+$) 314.1151; found, 314.1146.

*10-Methoxy-6-(trifluoromethyl)indolo[2,1-a]isoquinoline (**3e**).* Yellow solid (46.1 mg, 73% yield), mp 117.0–118.2 °C; ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.15 (d, J = 8.0 Hz, 1H), 7.99–7.96 (m, 1H), 7.63–7.56 (m, 2H), 7.48–7.45 (m, 1H), 7.34 (s, 1H), 7.25 (s, 1H), 7.22 (s, 1H), 7.02–6.99 (m, 1H), 3.92 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 155.7, 136.6, 130.6, 129.6, 127.9, 127.7, 127.0, 126.2, 125.7, 124.9 (q, J_{C-F} = 34.3 Hz), 123.3, 121.6 (q, J_{C-F} = 270.0 Hz), 114.9 (q, J_{C-F} = 7.8 Hz), 112.5, 111.5 (q, J_{C-F} = 7.0 Hz), 101.2, 96.2, 55.6; ^{19}F NMR (470 MHz, $CDCl_3$) δ: −63.6 (s, 3F); IR (neat, cm^{-1}): 2931, 1615, 1462, 1420, 1328, 1129, 741; LRMS (EI, 70 eV) m/z (%): 315 (M^+, 100), 286 (9), 272 (79), 203 (7), 157 (8); HRMS (ESI) calcd for $C_{18}H_{13}F_3NO^+$ ([M + H]$^+$) 316.0944; found, 316.0944.

*6-(Trifluoromethyl)indolo[2,1-a]isoquinolin-10-amine (**3f**).* Yellow solid (30.5 mg, 51% yield), mp 153.3–154.1 °C; ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.12 (d, J = 8.5 Hz, 1H), 7.90–7.86 (m, 1H), 7.61–7.52 (m, 2H), 7.47–7.41 (m, 1H), 7.22–7.20 (m, 2H), 7.04 (s, 1H), 6.81–6.77 (m, 1H), 3.73 (s, 2H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 141.8, 136.5, 130.9, 129.4, 127.8, 127.6, 127.0, 125.8, 125.8, 124.9 (q, J_{C-F} = 34.3 Hz), 123.2, 121.6 (q, J_{C-F} = 270.0 Hz), 114.7 (q, J_{C-F} = 7.6 Hz), 112.9, 111.0 (q, J_{C-F} = 7.0 Hz), 103.9, 95.4; ^{19}F NMR (470 MHz, $CDCl_3$) δ: −63.7 (s, 3F); IR (neat, cm^{-1}): 3421, 3246, 2357, 1621, 1599, 1459, 1419, 1115, 834; LRMS (EI, 70 eV) m/z (%): 300 (M^+, 100), 280 (10), 231 (8), 150 (18), 115 (6); HRMS (ESI) calcd for $C_{17}H_{12}F_3N_2^+$ ([M + H]$^+$) 301.0947; found, 301.0947.

*10-Bromo-6-(trifluoromethyl)indolo[2,1-a]isoquinoline (**3g**).* Yellow solid (42.4 mg, 58% yield), mp 148.5–150.2 °C; ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.12 (d, J = 8.0 Hz, 1H), 7.93–7.91 (m, 2H), 7.63–7.58 (m, 2H), 7.51–7.48 (m, 1H), 7.42–7.40 (m, 1H), 7.29–7.28 (m, 2H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 137.0, 131.1, 129.9, 129.7, 128.3, 128.0, 126.9, 125.8, 124.8, 124.8 (q, J_{C-F} = 34.6 Hz), 123.5, 122.9, 121.5 (q, J_{C-F} = 270.1 Hz), 116.1, 115.3 (q, J_{C-F} = 7.8 Hz), 112.7 (q, J_{C-F} = 6.9 Hz), 95.8; ^{19}F NMR (470 MHz, $CDCl_3$) δ: −63.3 (s, 3F); IR (neat, cm^{-1}): 3082, 1649, 1593, 1455, 1405, 1224, 749; LRMS (EI, 70 eV) m/z (%): 365 (M^+, 96), 363 (M^+, 100), 284 (46), 264 (27), 142 (17), 93 (11); HRMS (ESI) calcd for $C_{17}H_{10}BrF_3N^+$ ([M + H]$^+$) 363.9943; found, 363.9941.

*10-Fluoro-6-(trifluoromethyl)indolo[2,1-a]isoquinoline (**3h**).* Yellow solid (36.5 mg, 60% yield), mp 132.1–132.8 °C; ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.14 (d, J = 8.0 Hz, 1H), 8.02–8.00 (m, 1H), 7.63–7.57 (m, 2H), 7.50–7.47 (m, 1H), 7.43–7.40 (m, 1H), 7.34 (s, 1H), 7.27 (s, 1H), 7.11–7.07 (m, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 159.0 (d, J_{C-F} = 238.3 Hz), 137.4, 130.4 (d, J_{C-F} = 10.4 Hz), 129.8, 128.2, 128.0, 127.7, 126.8, 125.7, 124.9 (q, J_{C-F} = 34.4 Hz), 123.4, 121.5 (q, J_{C-F} = 270.0 Hz), 115.2 (q, J_{C-F} = 8.1 Hz), 112.2 (q, J_{C-F} = 7.1 Hz), 110.6 (d, J_{C-F} = 25.8 Hz), 104.9 (d, J_{C-F} = 23.0 Hz), 96.4 (d, J_{C-F} = 4.5 Hz); ^{19}F NMR (470 MHz, $CDCl_3$) δ: −63.4 (s, 3F), −120.7 (s, 1F); IR (neat, cm^{-1}): 3037, 1607, 1562, 1463, 1416, 1314, 1129, 753; LRMS (EI, 70 eV) m/z (%): 303 (M^+, 100), 283 (16), 234 (15), 151 (13), 117 (5); HRMS (ESI) calcd for $C_{17}H_{10}F_4N^+$ ([M + H]$^+$) 304.0744; found, 304.0738.

*6-(Trifluoromethyl)indolo[2,1-a]isoquinoline-10-carbonitrile (**3i**).* Yellow solid (32.8 mg, 53% yield), mp 207.1–208.8 °C; ^{1}H NMR

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(500 MHz, $CDCl_3$) δ 8.18 (d, J = 8.0 Hz, 1H), 8.16 (s, 1H), 8.12 (d, J = 9.0 Hz, 1H), 7.69−7.65 (m, 2H), 7.58−7.54 (m, 2H), 7.44 (s, 1H), 7.38 (s, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 137.9, 132.2, 130.4, 129.3, 129.1, 128.3, 126.6, 126.0, 125.7, 124.6 (q, J_{C-F} = 34.8 Hz), 124.1, 123.7, 121.3 (q, J_{C-F} = 269.9 Hz), 119.8, 114.8 (q, J_{C-F} = 8.0 Hz), 114.0 (q, J_{C-F} = 6.9 Hz), 105.8, 96.7; ^{19}F NMR (470 MHz, $CDCl_3$) δ: −63.0 (s, 3F); IR (neat, cm^{-1}): 2223, 1644, 1540, 1463, 1413, 1317, 1119, 745; LRMS (EI, 70 eV) m/z (%): 310 (M^+, 100), 290 (6), 241 (8), 207 (8), 155 (7); HRMS (ESI) calcd for $C_{18}H_{10}F_3N_2^+$ ($[M + H]^+$) 311.0791; found, 311.0792.

10-Nitro-6-(trifluoromethyl)indolo[2,1-a]isoquinoline (**3j**). Yellow solid (37.5 mg, 57% yield), mp 184.6−186.0 °C; ^1H NMR (500 MHz, $CDCl_3$) δ 8.75 (s, 1H), 8.23−8.13 (m, 3H), 7.71−7.67 (m, 2H), 7.61−7.57 (m, 2H), 7.42 (s, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 143.2, 138.8, 133.2, 130.5, 129.1, 128.3, 126.8, 126.6, 124.6 (q, J_{C-F} = 34.8 Hz), 123.8, 121.3 (q, J_{C-F} = 270.3 Hz), 117.1, 116.6, 114.4 (q, J_{C-F} = 6.9 Hz), 114.2 (q, J_{C-F} = 8.1 Hz), 107.2, 96.7; ^{19}F NMR (470 MHz, $CDCl_3$) δ: −63.0 (s, 3F); IR (neat, cm^{-1}): 1613, 1556, 1517, 1462, 1341, 1114, 737; LRMS (EI, 70 eV) m/z (%): 330 (M^+, 100), 300 (42), 284 (77), 264 (31), 150 (9); HRMS (ESI) calcd for $C_{17}H_{10}F_3N_2O_2^+$ ($[M + H]^+$) 331.0689; found, 331.0694.

2-Methyl-6-(trifluoromethyl)indolo[2,1-a]isoquinoline (**3k**). Yellow solid (32.9 mg, 55% yield), mp 113.4−114.2 °C; ^1H NMR (500 MHz, $CDCl_3$) δ 8.09 (d, J = 7.5 Hz, 1H), 7.95 (s, 1H), 7.84−7.82 (m, 1H), 7.49 (d, J = 8.0 Hz, 1H), 7.39−7.34 (m, 3H), 7.27 (d, J = 8.0 Hz, 1H), 7.23 (s, 1H), 2.52 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 140.1, 136.0, 131.1, 129.5, 129.3, 127.8, 127.2, 124.3 (q, J_{C-F} = 34.5 Hz), 123.4, 123.3, 122.4, 121.9, 121.7 (q, J_{C-F} = 272.4 Hz), 120.6, 113.9 (q, J_{C-F} = 7.6 Hz), 112.1 (q, J_{C-F} = 7.1 Hz), 96.2, 21.9; ^{19}F NMR (470 MHz, $CDCl_3$) δ: −62.9 (s, 3F); IR (neat, cm^{-1}): 3044, 2920, 1615, 1534, 1454, 1415, 1330, 1136, 735; LRMS (EI, 70 eV) m/z (%): 299 (M^+, 100), 279 (10), 230 (14), 149 (12), 114 (7); HRMS (ESI) calcd for $C_{18}H_{13}F_3N^+$ ($[M + H]^+$) 300.0995; found, 300.0993.

3-Methoxy-6-(trifluoromethyl)indolo[2,1-a]isoquinoline (**3l**). Yellow solid (54.1 mg, 86% yield), mp 107.1−108.5 °C; ^1H NMR (500 MHz, $CDCl_3$) δ 8.07 (d, J = 9.0 Hz, 2H), 7.80 (d, J = 7.5 Hz, 1H), 7.38−7.31 (m, 2H), 7.26 (s, 1H), 7.21 (s, 1H), 7.19−7.17 (m, 1H), 7.04 (s, 1H), 3.89 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 159.4, 136.2, 130.8, 129.8, 127.2, 125.6 (q, J_{C-F} = 34.4 Hz), 125.0, 122.5, 121.6 (q, J_{C-F} = 270.3 Hz), 121.5, 120.9, 120.4, 118.6, 113.8 (q, J_{C-F} = 7.6 Hz), 111.8 (q, J_{C-F} = 7.1 Hz), 109.7, 94.8, 55.5; ^{19}F NMR (470 MHz, $CDCl_3$) δ: −63.2 (s, 3F); IR (neat, cm^{-1}): 2830, 1644, 1607, 1456, 1407, 1253, 1122, 736; LRMS (EI, 70 eV) m/z (%): 315 (M^+, 100), 300 (25), 272 (56), 203 (13), 158 (11); HRMS (ESI) calcd for $C_{18}H_{13}F_3NO^+$ ($[M + H]^+$) 316.0944; found, 316.0946.

3-Chloro-6-(trifluoromethyl)indolo[2,1-a]isoquinoline (**3m**). Yellow solid (36.0 mg, 56% yield), mp 130.0−131.5 °C; ^1H NMR (500 MHz, $CDCl_3$) δ 8.08−8.05 (m, 2H), 7.83−7.81 (m, 1H), 7.58 (s, 1H), 7.52−7.50 (m, 1H), 7.39−7.37 (m, 3H), 7.15 (s, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 135.1, 133.5, 131.1, 130.0, 129.5, 127.1, 126.3 (q, J_{C-F} = 34.6 Hz), 123.6 (q, J_{C-F} = 270.4 Hz), 122.8, 120.8, 113.9 (q, J_{C-F} = 7.6 Hz), 110.8 (q, J_{C-F} = 7.1 Hz), 97.0; ^{19}F NMR (470 MHz, $CDCl_3$) δ: −63.4 (s, 3F); IR (neat, cm^{-1}): 3076, 1568, 1483, 1450, 1403, 1295, 1118, 730; LRMS (EI, 70 eV) m/z (%): 321 (M^+, 34), 319 (M^+, 100), 299 (12), 263 (5), 214 (12), 159 (14) ; HRMS (ESI) calcd for $C_{17}H_{10}ClF_3N^+$ ($[M + H]^+$) 320.0449; found, 320.0448.

2-Fluoro-6-(trifluoromethyl)indolo[2,1-a]isoquinoline (**3n**). Yellow solid (33.3 mg, 55% yield), mp 123.8−125.1 °C; ^1H NMR (500 MHz, $CDCl_3$) δ 8.09−8.08 (m, 1H), 7.85−7.83 (m, 1H), 7.80−7.78 (m, 1H), 7.62−7.59 (m, 1H), 7.41−7.37 (m, 3H), 7.24 (s, 1H), 7.20−7.16 (m, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 163.3 (d, J_{C-F} = 248.5 Hz), 135.0, 131.2, 130.2 (d, J_{C-F} = 9.1 Hz), 129.3, 129.2 (d, J_{C-F} = 9.5 Hz), 124.6 (q, J_{C-F} = 34.8 Hz), 122.7, 122.6, 122.2, 121.6 (q, J_{C-F} = 270.3 Hz), 120.9, 116.2 (d, J_{C-F} = 23.3 Hz), 114.0 (q, J_{C-F} = 7.6 Hz), 111.4 (q, J_{C-F} = 6.6 Hz), 109.2 (d, J_{C-F} = 23.4 Hz), 97.4; ^{19}F NMR (470 MHz, $CDCl_3$) δ: −63.1 (s, 3F), −108.7 (s, 1F); IR (neat, cm^{-1}): 3020, 1607, 1565, 1495, 1416, 1325, 1118, 734; LRMS (EI, 70 eV) m/z (%): 303 (M^+, 100), 283 (12), 234 (20), 152 (14), 127 (7); HRMS (ESI) calcd for $C_{17}H_{10}F_4N^+$ ($[M + H]^+$) 304.0744; found, 304.0740.

3,6-Bis(trifluoromethyl)indolo[2,1-a]isoquinoline (**3o**). Yellow solid (51.5 mg, 73% yield), mp 100.4−102.0 °C; ^1H NMR (500 MHz, $CDCl_3$) δ 8.20 (d, J = 8.5 Hz, 1H), 8.09−8.08 (m, 1H), 7.86−7.83 (m, 2H), 7.75 (d, J = 8.5 Hz, 1H), 7.47 (s, 1H), 7.42−7.40 (m, 2H), 7.25 (s, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 134.6, 131.3, 129.7, 129.6 (q, J_{C-F} = 32.6 Hz), 129.3, 126.5 (q, J_{C-F} = 34.8 Hz), 125.9 (q, J_{C-F} = 3.4 Hz), 125.6, 125.0 (q, J_{C-F} = 4.0 Hz), 123.8, 123.8 (q, J_{C-F} = 270.5 Hz), 123.1, 122.9, 121.3 (q, J_{C-F} = 270.4 Hz), 121.1, 114.0 (q, J_{C-F} = 7.6 Hz), 111.2 (q, J_{C-F} = 7.1 Hz), 98.5; ^{19}F NMR (470 MHz, $CDCl_3$) δ: −62.5 (s, 3F), −63.5 (s, 3F); IR (neat, cm^{-1}): 3028, 1615, 1556, 1458, 1402, 1313, 1118, 737; LRMS (EI, 70 eV) m/z (%): 353 (M^+, 100), 333 (10), 284 (11), 277 (13), 151(6); HRMS (ESI) calcd for $C_{18}H_{10}F_6N^+$ ($[M + H]^+$) 354.0712; found, 354.0703.

5-(Trifluoromethyl)pyrrolo[2,1-a]isoquinoline (**5a**). Yellow oil (32.9 mg, 70% yield); ^1H NMR (300 MHz, $CDCl_3$) δ 8.04 (d, J = 8.1 Hz, 1H), 7.63−7.50 (m, 3H), 7.40−7.35 (m, 1H), 7.24 (s, 1H), 7.07−7.05 (m, 1H), 6.83−6.81 (m, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 130.7, 129.7, 128.2, 127.4, 126.0, 124.2, 123.9, 122.0, 121.3 (q, J_{C-F} = 270.1 Hz), 114.6 (q, J_{C-F} = 2.9 Hz), 112.9, 112.3 (q, J_{C-F} = 5.1 Hz), 101.1; ^{19}F NMR (470 MHz, $CDCl_3$) δ: −68.8 (s, 3F); IR (neat, cm^{-1}): 3058, 1646, 1500, 1447, 1423, 1116, 749; LRMS (EI, 70 eV) m/z (%): 235 (M^+, 100), 216 (5), 166 (16), 139 (8), 117 (8); HRMS (ESI) calcd for $C_{13}H_9F_3N^+$ ($[M + H]^+$) 236.0682; found, 236.0688.

1,3-Dimethyl-5-(trifluoromethyl)pyrrolo[2,1-a]isoquinoline (**5b**). Yellow solid (32.1 mg, 61% yield), mp 122.1−123.5 °C; ^1H NMR (300 MHz, $CDCl_3$) δ 8.27 (d, J = 8.4 Hz, 1H), 7.64 (d, J = 6.9 Hz, 1H), 7.52−7.46 (m, 1H), 7.32−7.28 (m, 2H), 6.41 (s, 1H), 2.91 (s, 3H), 2.39 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 136.7, 129.6, 128.9, 126.4, 123.5 (q, J_{C-F} = 269.8 Hz), 123.3, 122.7 (q, J_{C-F} = 3.6 Hz), 120.6, 120.2 (q, J_{C-F} = 32.5 Hz), 119.4, 117.9 (q, J_{C-F} = 7.4 Hz), 115.8, 112.2, 18.6, 13.0; ^{19}F NMR (470 MHz, $CDCl_3$) δ: −60.3 (s, 3F); IR (neat, cm^{-1}): 3024, 2936, 1643, 1517, 1457, 1327, 1116, 740; LRMS (EI, 70 eV) m/z (%): 263 (M^+, 100), 248 (25), 178 (7), 122 (10); HRMS (ESI) calcd for $C_{15}H_{13}F_3N^+$ ($[M + H]^+$) 264.0995; found, 264.0998.

9-Methyl-5-(trifluoromethyl)pyrrolo[2,1-a]isoquinoline (**5c**). Yellow oil (30.8 mg, 62% yield); ^1H NMR (500 MHz, $CDCl_3$) δ 7.82 (s, 1H), 7.50−7.48 (m, 2H), 7.20−7.18 (m, 2H), 7.02 (d, J = 3.0 Hz, 1H), 6.79 (t, J = 3.0 Hz, 1H), 2.50 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 140.0, 130.7, 128.1, 127.5, 127.4, 123.2 (q, J_{C-F} = 34.6 Hz), 122.0, 121.9, 121.5 (q, J_{C-F} = 270.0 Hz), 114.5 (q, J_{C-F} = 2.9 Hz), 112.7, 112.4 (q, J_{C-F} = 5.1 Hz), 100.8, 21.9; ^{19}F NMR (470 MHz, $CDCl_3$) δ: −68.7 (s, 3F); IR (neat, cm^{-1}): 2974, 1620, 1504, 1408, 1326, 1121, 744; LRMS (EI, 70 eV) m/z (%): 249 (M^+, 100), 180 (15), 152 (9), 124 (8); HRMS (ESI) calcd for $C_{14}H_{11}F_3N^+$ ($[M + H]^+$) 250.0838; found, 250.0844.

8-Methoxy-5-(trifluoromethyl)pyrrolo[2,1-a]isoquinoline (**5d**). Yellow solid (38.6 mg, 73% yield), mp 53.5−54.8 °C; ^1H NMR (500 MHz, $CDCl_3$) δ 7.96 (d, J = 8.5 Hz, 1H), 7.45 (s, 1H), 7.20−7.17 (m, 2H), 7.06 (s, 1H), 6.93−6.92 (m, 1H), 6.80−6.79 (m, 1H), 3.89 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 157.9, 131.0, 125.6, 124.5 (q, J_{C-F} = 34.6 Hz), 123.7, 121.5, 121.4 (q, J_{C-F} = 270.4 Hz), 119.1, 113.7 (q, J_{C-F} = 2.9 Hz), 112.9, 111.9 (q, J_{C-F} = 5.1 Hz),109.6, 99.4, 55.5; ^{19}F NMR (470 MHz, $CDCl_3$) δ: −68.9 (s, 3F); IR (neat, cm^{-1}): 2931, 1615, 1559, 1473, 1309, 1175, 733; LRMS (EI, 70 eV) m/z (%): 265 (M^+, 100), 250 (76), 222 (47), 153 (10), 132 (8); HRMS (ESI) calcd for $C_{14}H_{11}F_3NO^+$ ($[M + H]^+$) 266.0787; found, 266.0795.

8-Chloro-5-(trifluoromethyl)pyrrolo[2,1-a]isoquinoline (**5e**). Yellow solid (33.0 mg, 61% yield), mp 61.3−62.7 °C; ^1H NMR (500 MHz, $CDCl_3$) δ 7.93 (d, J = 8.5 Hz, 1H), 7.58 (s, 1H), 7.50−7.47 (m, 2H), 7.13 (s, 1H), 7.03−7.02 (m, 1H), 6.82 (t, J = 3.5 Hz, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 131.5, 131.1, 130.0, 127.4, 125.7, 125.4, 125.1 (q, J_{C-F} = 34.9 Hz), 123.5, 121.1 (q, J_{C-F} = 270.5 Hz), 114.9 (q, J_{C-F} = 2.9 Hz), 113.3, 111.1 (q, J_{C-F} = 5.3 Hz), 101.5; ^{19}F NMR (470 MHz, $CDCl_3$) δ: −69.0 (s, 3F); IR (neat, cm^{-1}): 3024, 1656, 1550, 1453, 1407, 1124, 741; LRMS (EI, 70 eV) m/z (%): 271 (M^+, 34), 269 (M^+, 100), 234 (11), 200 (9), 117 (6); HRMS (ESI) calcd for $C_{13}H_8ClF_3N^+$ ($[M + H]^+$) 270.0292; found, 270.0300.

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*9-Fluoro-5-(trifluoromethyl)pyrrolo[2,1-a]isoquinoline (**5f**).* Yellow solid (34.8 mg, 68% yield), mp 56.3−57.0 °C; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.67−7.60 (m, 2H), 7.51 (s, 1H), 7.22 (s, 1H), 7.12−7.08 (m, 1H), 7.04−7.03 (m, 1H), 6.83−6.82 (m, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 163.4 (d, J_{C-F} = 248.0 Hz), 130.6 (d, J_{C-F} = 9.4 Hz), 130.0 (d, J_{C-F} = 4.1 Hz), 129.1 (d, J_{C-F} = 10.0 Hz), 123.5 (q, J_{C-F} = 34.9 Hz), 121.3 (q, J_{C-F} = 270.1 Hz), 120.7, 115.2 (q, J_{C-F} = 2.9 Hz), 114.6 (d, J_{C-F} = 23.6 Hz), 113.1, 111.7 (q, J_{C-F} = 4.8 Hz), 107.6 (d, J_{C-F} = 23.3 Hz), 102.1; ^{19}F NMR (470 MHz, $CDCl_3$) δ: −68.8 (s, 3F), −109.0 (s, 1F); IR (neat, cm^{-1}): 3032, 1623, 1505, 1411, 1328, 1112, 740; LRMS (EI, 70 eV) *m*/*z* (%): 253 (M^+, 100), 184 (24), 157 (8), 127 (15); HRMS (ESI) calcd for $C_{13}H_8F_4N^+$ ([M + H]$^+$) 254.0588; found, 254.0582.

*5,8-Bis(trifluoromethyl)pyrrolo[2,1-a]isoquinoline (**5g**).* Yellow solid (30.3 mg, 50% yield), mp 67.2−68.0 °C; ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.10 (d, *J* = 8.5 Hz, 1H), 7.89 (s, 1H), 7.75−7.73 (m, 1H), 7.56 (s, 1H), 7.26−7.25 (m, 1H), 7.16−7.15 (m, 1H), 6.88−6.87 (m, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 129.8, 129.6, 127.8 (q, J_{C-F} = 32.6 Hz), 125.8 (q, J_{C-F} = 3.5 Hz), 125.5 (q, J_{C-F} = 4.2 Hz), 125.1 (q, J_{C-F} = 34.9 Hz), 123.8, 122.6, 121.8 (q, J_{C-F} = 270.3 Hz), 121.0 (q, J_{C-F} = 270.5 Hz), 115.8 (q, J_{C-F} = 2.8 Hz), 113.7, 111.7 (q, J_{C-F} = 5.0 Hz), 103.1; ^{19}F NMR (470 MHz, $CDCl_3$) δ: −62.3 (s, 3F), −69.1 (s, 3F); IR (neat, cm^{-1}): 2974, 1624, 1473, 1410, 1349, 1074, 743; LRMS (EI, 70 eV) *m*/*z* (%): 303 (M^+, 100), 284 (10), 234 (16), 151 (7); HRMS (ESI) calcd for $C_{14}H_8F_6N^+$ ([M + H]$^+$) 304.0556; found, 304.0553.

*(Z)-1-(3,3,3-Trifluoro-1-phenylprop-1-en-2-yl)-1H-indole (**6**).* Colorless oil (29.3 mg, 51% yield); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.64 (d, *J* = 8.0 Hz, 1H), 7.43−7.40 (m, 1H), 7.34−7.31 (m, 2H), 7.26−7.25 (m, 1H), 7.18−7.16 (m, 2H), 7.13−7.10 (m, 1H), 7.05−7.02 (m, 1H), 6.79 (d, *J* = 8.5 Hz, 1H), 6.71−6.70 (m, 1H), 6.18−6.13 (m, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 146.6 (q, J_{C-F} = 5.5 Hz), 136.7, 135.3, 131.0, 129.6 (q, J_{C-F} = 1.9 Hz), 129.2, 129.0, 127.2, 122.5, 122.3 (q, J_{C-F} = 268.1 Hz), 121.0, 120.8, 111.8, 111.5 (q, J_{C-F} = 34.9 Hz), 104.4; ^{19}F NMR (470 MHz, $CDCl_3$) δ: −57.8 (s, 3F); IR (neat, cm^{-1}): 3030, 1651, 1573, 1457, 1398, 1268, 1119, 757; LRMS (EI, 70 eV) *m*/*z* (%): 287 (M^+, 100), 218 (31), 151 (53), 117 (61), 89(14); HRMS (ESI) calcd for $C_{17}H_{13}F_3N^+$ ([M + H]$^+$) 288.0995; found, 288.0996.

*(Z)-1-(1-(2-Bromophenyl)-3,3,3-trifluoroprop-1-en-2-yl)-1H-indole (**7**).* Yellow oil (29.9 mg, 41% yield); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.73 (s, 1H), 7.58−7.56 (m, 1H), 7.55−7.53 (m, 1H), 7.12−7.11 (m, 1H), 7.10−7.05 (m, 3H), 7.02−6.98 (m, 1H), 6.81−6.78 (m, 1H), 6.68−6.67 (m, 1H), 6.38−6.36 (m, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 135.9, 132.9, 132.0 (q, J_{C-F} = 4.1 Hz), 131.4, 131.1, 128.9, 128.7, 127.4, 127.1, 126.4 (q, J_{C-F} = 34.0 Hz), 124.9, 123.0, 121.7 (q, J_{C-F} = 273.8 Hz), 120.9, 120.8, 110.6, 105.4; ^{19}F NMR (470 MHz, $CDCl_3$) δ: −68.3 (s, 3F); IR (neat, cm^{-1}): 3058, 1653, 1517, 1457, 1435, 1266, 1122, 741; LRMS (EI, 70 eV) *m*/*z* (%): 365 (M^+, 18), 367 (M^+, 18), 286 (100), 217 (29), 151 (53), 133 (9), 108(8); HRMS (ESI) calcd for $C_{17}H_{12}BrF_3N^+$ ([M + H]$^+$) 366.0100; found, 366.0097.

■ ASSOCIATED CONTENT

Ⓢ Supporting Information

Copies of ^{1}H and ^{13}C NMR of compounds **3a**−**3o**, **5a**−**5g**, **6**, and **7**, and X-ray data of **3e**. 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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