

# Hexafluorosilicic Acid as a Novel Reagent for the Desilylation of Silylacetylenes: Application in Sequential Sonogashira Coupling and Click Reaction

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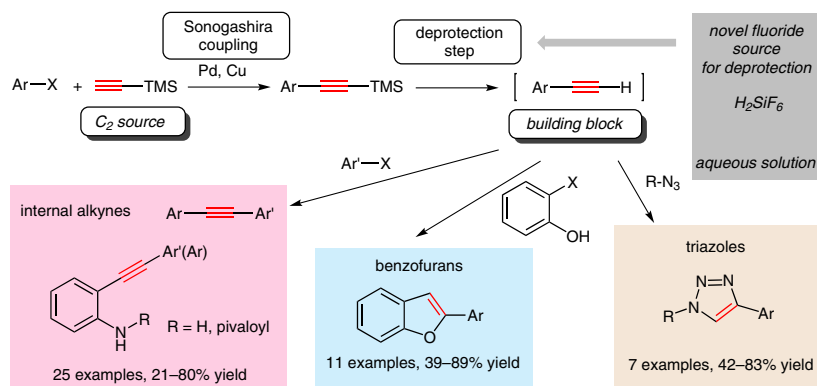
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■ check yield ranges, 21–89% 41–78% ■■



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**Abstract** Hexafluorosilicic acid was utilized as a novel, cheap, readily available, and environmentally benign alternative reagent for the desilylation of 1-trimethylsilylacetylenes. The applicability of the aqueous solution of the hexafluorosilicic acid was demonstrated in the sequential coupling of aryl halides and ethynyltrimethylsilane to afford internal acetylenes, benzofurans, and triazoles in one-pot Sonogashira–Sonogashira and Sonogashira–CuAAC reactions.

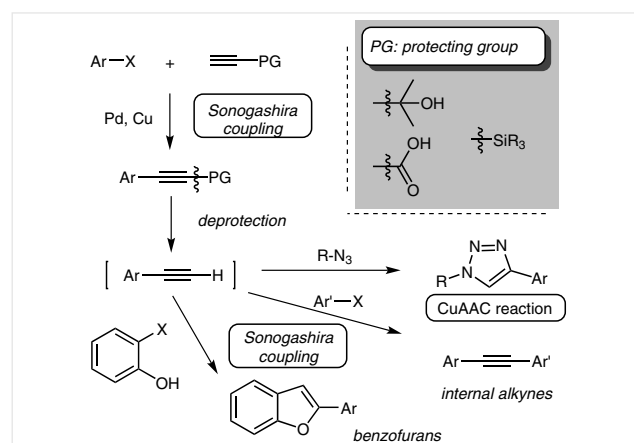
**Key words** alkynes, azides, cycloaddition, click reaction, cross-coupling, fluoride, palladium, heterocycles

Transition-metal-catalyzed transformation of terminal acetylenes is one of the most frequently used synthetic tools for the construction of internal acetylenes and heterocycles.<sup>1</sup> Amongst these transformations, the palladium-catalyzed Sonogashira coupling serves as an efficient tool to form C(sp)–C(sp<sup>2</sup>) bonds between terminal acetylenes and aryl halides.<sup>2</sup>

With the utilization of aryl halides, bearing hydroxyl or amino groups in a position *ortho* to the halide, the Sonogashira reaction provides 2-substituted benzofurans and indoles, respectively, in a coupling-cyclization manner.<sup>3</sup> Another important transformation of terminal acetylenes is the copper-catalyzed azide-alkyne cycloaddition (CuAAC).<sup>4</sup>

Both Sonogashira and the CuAAC reactions require terminal acetylenes as the coupling partner. These alkyne derivatives can be prepared in situ in the Sonogashira reaction of aryl halides with various acetylene surrogates such as silylacetylenes,<sup>5</sup> ethynylcarbinols,<sup>6</sup> and propiolic acid,<sup>7</sup> after the elaboration of the protecting groups. Without the isola-

tion of the terminal alkyne intermediate, internal acetylenes and heterocycles can be prepared in a subsequent Sonogashira reaction.<sup>5–7</sup> In several cases, after the deprotection step, the reaction can be directed to a CuAAC reaction<sup>8</sup> to synthesize triazoles from azides and the in situ generated alkyne reactant (Scheme 1).



**Scheme 1** Synthetic strategies of the synthesis of internal alkynes and heterocycles in sequential couplings and cycloadditions

Among the protecting groups, the silyl groups are widely used in organic synthesis. In general, the removal of silyl protecting groups from the silylethynyl intermediates is usually performed with fluoride sources under mild conditions. The most efficient fluoride sources are the tetraalkylammonium fluoride salts. However, the use of these salts is not economic due to the high price of the salt and the low fluoride content (by mass). Another issue regarding the use of fluorine source is the origin of the fluorinated re-

agents. The major source of fluorides used in organic synthesis is fluorspar.<sup>9</sup> Its limited reserves could be a problem for long-term sustainability of transformations involving fluorine species. An alternative source for fluoride is the

fluorapatite content of phosphate rock. In the production of phosphoric acid from this raw material, fluorosilicic acid forms as a side-product.<sup>10</sup> The utilization of this fluoride source could provide an alternative approach for organic

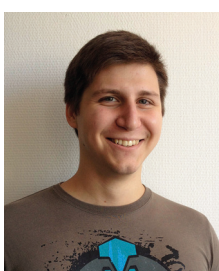
### Biographical Sketches



**Ádám Sinai** performed his M.Sc. studies at Eötvös University, Budapest under the leadership of Professor József Rábai and obtained his degree in 2011. In the same year, he joined the MTA-ELTE 'Lendület' Catalysis and Or-

ganic Research Group led by Zoltán Novák, where he performed his doctoral studies. During his doctoral studies he worked on the copper-catalyzed oxidative cyclization and arylation reactions and transition-metal-

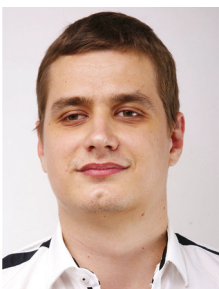
catalyzed sequential coupling reactions. Currently, he is a post-doctoral research fellow at Servier Research Institute of Medicinal Chemistry, Hungary.



**Ádám Mészáros** performed his studies at Budapest University of Technology and Economics as a pharmaceutical engineer. He did his thesis work for B.Sc. in the re-

search group of Zoltán Novák in the field of sequential Sonogashira reaction, and in Servier Research Institute for Medicinal Chemistry for his M.Sc. thesis in

the field of foldamer terminal building blocks' synthesis. He returned to carry out his Ph.D. studies in the Novák Group at Eötvös Loránd University from 2014.



**Ádám Balogh** performed his B.Sc. and M.Sc. diploma thesis work in the research group of Zoltán Novák at Eötvös University at Budapest, and was graduated

in 2014. During his studies he worked on the sequential coupling reaction catalyzed by transition metals. Now he is an analytical chemist at the Quality

Control Lab of Mylan Pharmaceutical Company in Komárom, Hungary.



**Márton Zwillinger** performed his B.Sc. diploma thesis work in the research group of Zoltán Novák at Eötvös University at Budapest. During his bachelor stud-

ies he dealt with N-donor ligand directed C–H activation reactions. Currently he works on his M.Sc. diploma thesis in the research group of Professor András

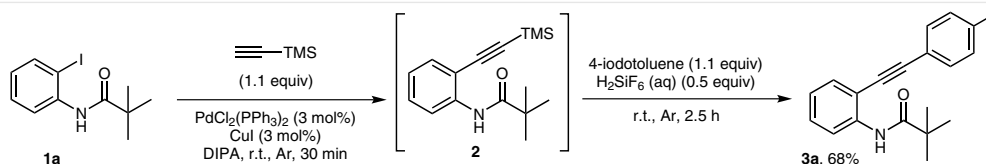
Kotschy at Servier Research Institute of Medicinal Chemistry, Hungary and is expected to graduate in 2017.



**Zoltán Novák** performed his M.Sc. studies at Eötvös University, Budapest with Professor András Kotschy and obtained his degree in 1999. He performed doctoral studies in the same research group and received his Ph.D. in 2004. In 2004, he joined the group of Professor Brian M. Stoltz

at the California Institute of Technology as a postdoctoral researcher. After returning to Hungary in 2005, he continued his research at Eötvös University, again in the group of Professor Kotschy. In September 2007, he started his independent research career at the Department of Or-

ganic Chemistry, Institute of Chemistry at Eötvös University as an assistant professor. Currently, he is the leader of MTA-ELTE 'Lendület' Catalysis and Organic Research Group.



**Scheme 2** Model reaction for the examination of sequential coupling

transformations. The aqueous solution of  $\text{H}_2\text{SiF}_6$  is a cheap, easily available, nontoxic, sustainable, and environmentally benign reagent.<sup>9</sup>

In our work, we aimed to find a new alternative for tetraalkylammonium fluorides, and utilize it as an efficient deprotecting agent of 1-aryl-2-trimethylsilylacetylenes. On the basis of the earlier work of DeShong on the deprotection of silyl ethers by hexafluorosilicic acid,<sup>11</sup> we envisioned that the use of  $\text{H}_2\text{SiF}_6$  could serve as an excellent desilylating alternative for the removal of the silyl protecting group from the alkyne to produce terminal acetylenes.

To exploit the advantage of the in situ generated terminal acetylenes from ethynylsilanes we aimed to develop both sequential Sonogashira–Sonogashira coupling and Sonogashira–CuAAC reaction to afford ethynylpivalanilides<sup>12</sup> and different heterocyclic systems.

For our initial studies, 2-iodopivalanilide (**1a**) was coupled with ethynyltrimethylsilane in diisopropylamine as the solvent at 25 °C in the presence of palladium catalyst and CuI co-catalyst (Scheme 2). The coupling provided the desired intermediate **2** in 30 minutes. The desilylation was attempted by the addition of 0.5 equivalent of  $\text{H}_2\text{SiF}_6$  (34% w/w aq solution) and the subsequent coupling was performed with 4-iodotoluene. To our delight, the deprotection of silylacetylene was observed, and the in situ formed terminal acetylene was coupled with the aryl halide in the presence of palladium–copper catalyst system. We have found that the reaction reached full conversion in 2.5 hours, and provided the desired *p*-tolylethynylpivalanilide (**3a**) in 68% yield after the workup. With this experiment, we demonstrated that the presence of hexafluorosilicate anion serves as efficient fluoride source for the deprotection of ethynylsilanes.

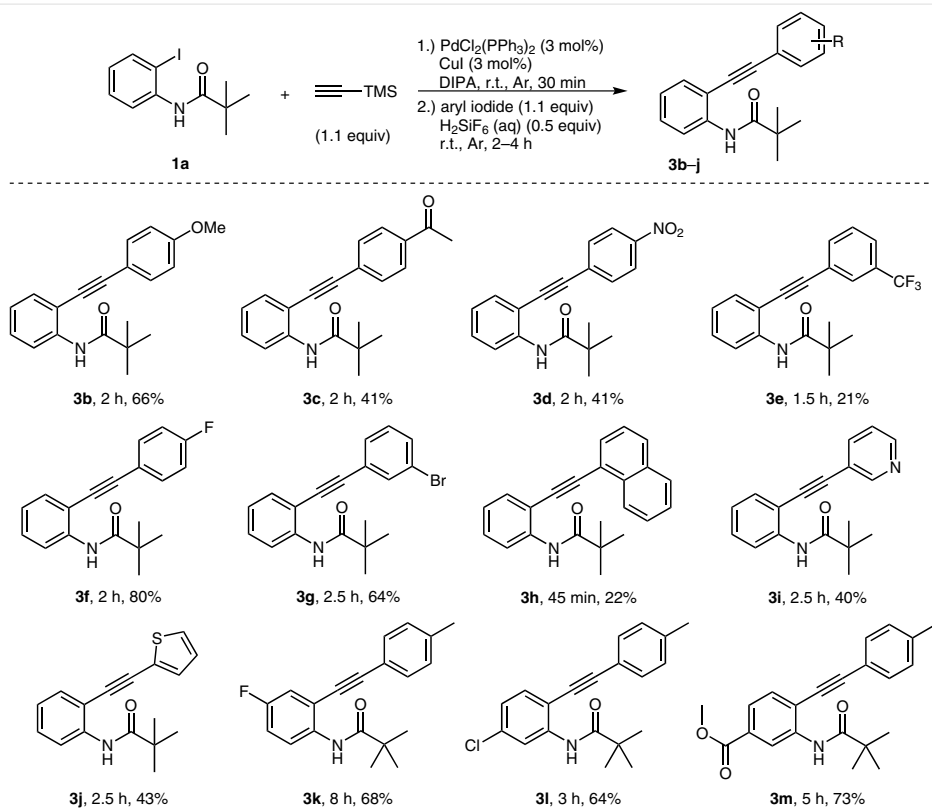
Without the addition of  $\text{H}_2\text{SiF}_6$  or with other acidic species such as HCl the reaction afforded only traces of internal alkyne products in the second step even at 60 °C. These findings support the importance of the fluorosilicate ions in the deprotection step. Regarding the stoichiometry of the reaction, we found that the addition of 0.5 equivalent of  $\text{H}_2\text{SiF}_6$  is optimal for the successful transformation. Unfortunately, decreasing the amount of the acid caused significantly lower conversions under the used reaction conditions.

After demonstrating the applicability of  $\text{H}_2\text{SiF}_6$  as desilylating agent in sequential Sonogashira coupling, the substrate scope of the transformation was explored and vari-

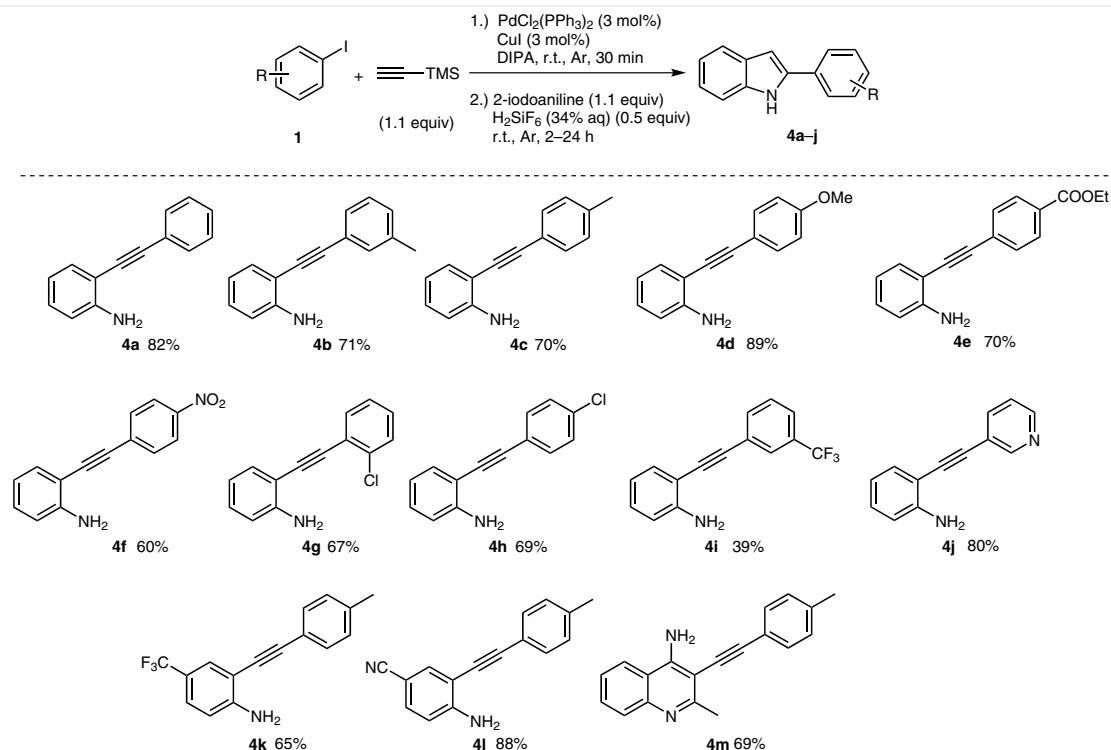
ous arylethynylpivalanilide derivatives with versatile structures were prepared (Scheme 3). These molecules are important building blocks for different heterocycles available by transition-metal-catalyzed cyclizations. 2-Iodopivalanilide was coupled with ethynyltrimethylsilane in the presence of 3 mol%  $\text{PdCl}_2(\text{PPh}_3)_2$  catalyst and 3 mol% CuI co-catalyst in diisopropylamine at 25 °C. After the completion of the coupling, 0.5 equivalent of  $\text{H}_2\text{SiF}_6$  (34% w/w aq. solution) was added, followed by the addition of different aryl iodides. After the removal of the silyl protecting group, the terminal acetylene intermediate was coupled immediately with the appropriate aryl halide in the presence of the catalyst system. In the one-pot coupling–deprotection–coupling sequence, several arylethynylpivalanilides were isolated. Aryl iodide bearing strongly electron-donating group, such as methoxy, provided the desired coupling product **3b** in 66% yield. Electron-deficient aromatic iodides also worked in the ‘one-pot’ transformation, but we obtained the appropriate pivalanilides **3c–e** in lower, 21–41% yield. Fluoro and bromo derivatives of the target compounds **3f** and **3g** were prepared in 80% and 64%, respectively, under the developed conditions. Finally, naphthalene, pyridine, and thiophene rings were also successfully connected to the in situ generated acetylene intermediates **3h–j** (22–43% yield).

The sequential reaction also worked efficiently when the pivalanilide part was substituted with fluoro, chloro, or ester function, and the appropriate products **3k**, **3l**, and **3m** were isolated in 68%, 64%, 73% yield, respectively.

Similar to the synthesis of *o*-ethynylpivalanilides, the same sequence was performed with unprotected anilines to obtain *o*-ethynylaniline (Scheme 4). Utilizing the reaction conditions applied earlier, the coupling sequence was performed with  $\text{H}_2\text{SiF}_6$  as the desilylating agent. The 2-phenylethynylaniline (**4a**) was isolated in 82% yield under the reaction conditions. In the presence of electron-donating groups such as methyl or methoxy on the aryl ring, the appropriate 2-arylethynyl derivatives **4b**, **4c** and **4d** were isolated in 71%, 70% and 89% yield. The presence of ester and nitro function was well tolerated in the transformation, and anilines **4e** and **4f** were obtained in 70% and 60% yield respectively. The chlorophenylethynyl derivatives of the aniline **4g** and **4h** were prepared in 67% and 69% yield, respectively. Although the aniline **4i** bearing trifluoromethylphenyl group in position 2 was isolated in lower 39% yield in the transformation, the pyridyl derivative **4j** was obtained in good 80% yield. In this series, the presence of electron-



**Scheme 3** One-pot synthesis of arylethynylpivalanilides in the Sonogashira–Sonogashira reaction sequence



**Scheme 4** One-pot synthesis of *o*-aminoethynylbenzene derivatives in the Sonogashira–Sonogashira coupling sequence ■■ $R^2$  added to **4a–j**, OK?■■ ■■**4a–j** structure does not match individuals■■

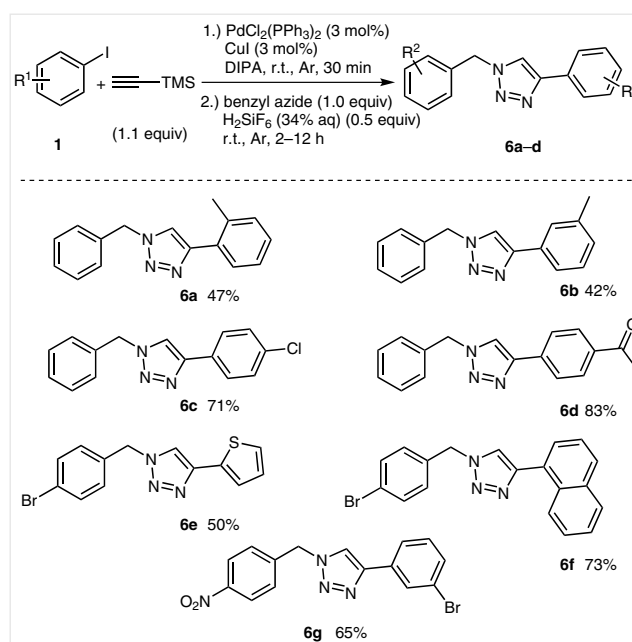
withdrawing substituents in the iodoaniline also allows the efficient sequential coupling reaction and the trifluoro derivative **4k** was isolated in 65%, while the cyano derivative **4l** was obtained in 88% yield. Finally, the reaction was performed with heterocyclic scaffold such as quinoline and the ethynylaminoquinoline derivative **4m** was isolated in 69% yield. These important substrates offer further transformation through the free amino moiety such as N-substitutions, and ring closures to indoles.

Beyond the simple and efficient synthesis of internal acetylenes, the palladium-catalyzed Sonogashira reaction offers excellent synthetic tool for the access of heterocyclic molecules such as benzofurans.<sup>3</sup> Additionally, it was demonstrated earlier that the synthesis of these heterocycles can be achieved in a sequential fashion, starting from aryl halides and an appropriate acetylene surrogate.<sup>5–7</sup> In our work, we also demonstrated that the coupling-deprotection-ring closure sequence can be achieved with the utilization of hexafluorosilicic acid as deprotecting agent. The reaction sequence for the synthesis of 2-arylbenzofurans was started with the coupling of various aryl iodides and ethynyltrimethylsilane with the standard Sonogashira protocol (Scheme 5). After the first coupling step 0.5 equivalent of  $\text{H}_2\text{SiF}_6$  and 2-iodophenol were added and the deprotection of the ethynylsilane, the palladium-catalyzed coupling, and the subsequent ring closure occurred at 25 °C. As a result, we were able to isolate the desired 2-arylbenzofuran derivatives. The 2-phenyl derivative **5a** was obtained in 78% yield. Using the developed reaction conditions the *o*-, *m*- and *p*-methylphenyl-substituted benzofurans **5b**, **5c**, and **5d** were prepared in good 41–73% yield range. Aryl groups equipped with electron-withdrawing nitro substituent, or chloro function was tolerated under the reaction conditions and the appropriate 2-arylbenzofuran derivatives **5e**, **5f**, and **5g** were isolated in 69%, 48%, and 62% yield, respectively. To expand further the scope of the transformation, 3-pyridylbenzofuran (**5h**) was also prepared in the sequential procedure in 53% yield. Further benzofuran

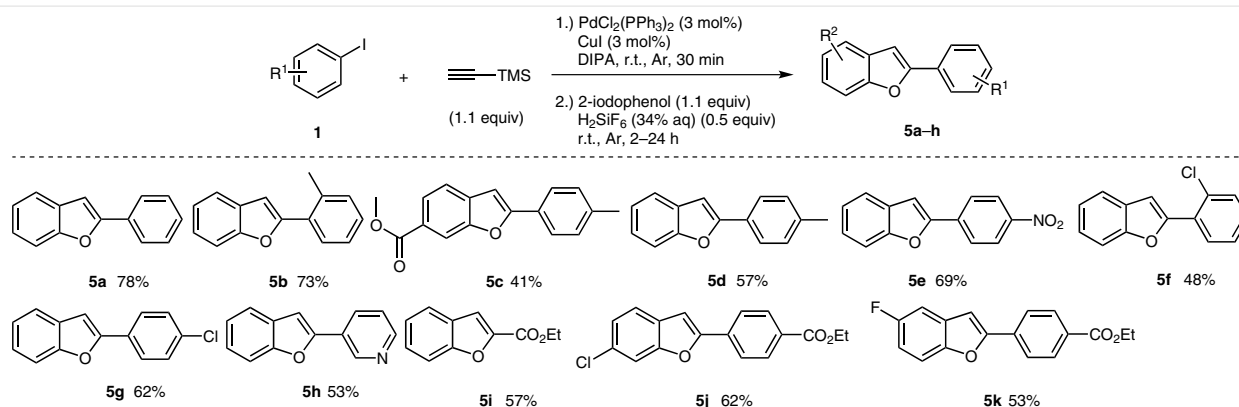
derivatives **5i–k** were prepared containing ester function for further derivatization connected directly to the heterocyclic core or to the phenyl group in position 2 in a similarly efficient manner.

Besides the sequential Sonogashira–Sonogashira coupling, the catalyst composition enables the one-pot synthesis of triazole derivatives from aryl iodides, acetylene surrogate, and azides. The mutual intermediates of Sonogashira and CuAAC reaction, namely the copper acetylide, enables the realization of Sonogashira–CuAAC reaction sequence.

In the last part of our synthetic development, we demonstrated the compatibility of the novel desilylating agent with the CuAAC reaction (Scheme 6). The sequential one-pot synthesis of triazole derivatives was started from



**Scheme 6** One-pot synthesis of triazole derivatives in the Sonogashira–CuAAC sequence ■■ $\text{R}^2$  added to **6a–d**, OK?■■■



**Scheme 5** One-pot synthesis of benzofuran derivatives in the Sonogashira–Sonogashira sequence ■■ $\text{R}^2$  added to **5a–h**, OK?■■■

aryl and heteroaryl iodides. After the coupling and deprotection step performed with 0.5 equivalent of  $\text{H}_2\text{SiF}_6$  solution, various substituted benzyl azides were added to the reaction mixture to complete the reaction sequence. As a result the appropriate triazoles **6a–g** were isolated in 42–83% yields.

In conclusion, we have demonstrated the applicability of cheap, easily available, environmentally benign aqueous  $\text{H}_2\text{SiF}_6$  solution as a deprotecting agent for the desilylation of ethynyltrimethylsilane. This novel reagent was utilized in the sequential one-pot Sonogashira–Sonogashira and Sonogashira–CuAAC reaction for the access of arylethynyl pivalanilides and amines, 2-arylbenzofurans, and *N*-benzyltriazole derivatives.

It was shown that hexafluorosilicic acid serves as efficient reactant, and its presence has no deleterious effect on transition-metal-catalyzed transformations such as cross-coupling and CuAAC reaction. We envisioned that  $\text{H}_2\text{SiF}_6$  reagent could be an excellent, economic, environmentally friendly alternative for the currently used fluoride sources, and gain wide applicability in organic synthesis in the future.

$^1\text{H}$  NMR and  $^{13}\text{C}$  NMR spectra were recorded on a Bruker Avance-250 spectrometer operating at 250 MHz and 62.5 MHz using  $\text{DMSO}-d_6$  or  $\text{CDCl}_3$  as solvent. Chemical shifts are given in ppm relative to TMS, or to the residual solvent peak of  $\text{DMSO}$  and  $\text{CDCl}_3$  as internal standards. Coupling constants ( $J$ ) are reported in hertz (Hz). IR spectra were recorded on a Bruker Alpha single-reflection diamond ATR spectrometer as solids or thin films. In the IR spectra, only the strongest/structurally most important peaks ( $\text{cm}^{-1}$ ) are listed. HRMS were measured on an Agilent Technologies 6210 Time of Flight mass spectrometer. Melting points were recorded on Büchi 501 apparatus and are reported uncorrected. All solvents used were distilled using standard methods. All mixed solvent systems are reported as v/v solutions. All reactions were monitored by TLC using Merck DC precoated TLC plates with 0.25 mm silica gel 60  $\text{F}_{254}$ . Visualization was performed with a 254 nm UV lamp. All other chemicals were used as received without further purification.

#### *N*-(2-Iodophenyl)pivalamide (**1a**)<sup>11</sup>

2-Iodoaniline (32.853 g, 150 mmol, 1.00 equiv) and  $\text{Et}_3\text{N}$  (24.11 mL, 173 mmol, 1.15 equiv) were dissolved in  $\text{Et}_2\text{O}$  (400 mL), and cooled to 0 °C. A solution of pivaloyl chloride (20.32 mL, 165 mmol, 1.10 equiv) in  $\text{Et}_2\text{O}$  (120 mL) was added dropwise. The reaction mixture was stirred at r.t. for 24 h. The precipitated  $\text{Et}_3\text{N}\cdot\text{HCl}$  was filtered, and the filtrate concentrated under reduced pressure. The crude product was recrystallized from  $\text{EtOH}/\text{H}_2\text{O}$  (95:5) to give **1a** as a white solid (38.864 g, 128 mmol, 85%); mp 64–65 °C (Lit.<sup>11</sup> mp 61–62 °C);  $R_f$  = 0.48 (hexanes/ $\text{EtOAc}$  10:1).

IR (solid, ATR): 3261, 2960, 1640, 1499, 1459, 1365, 1173, 1017, 926, 739, 615, 564, 435  $\text{cm}^{-1}$ .

$^1\text{H}$  NMR (250 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 8.29 (dd,  $J_1$  = 8.3 Hz,  $J_2$  = 1.6 Hz, 1 H), 7.80 (s, 1 H), 7.77 (dd,  $J_1$  = 8.0 Hz,  $J_2$  = 1.5 Hz, 1 H), 7.34 (td,  $J_1$  = 7.5 Hz,  $J_2$  = 0.5 Hz, 1 H), 6.83 (td,  $J_1$  = 7.9 Hz,  $J_2$  = 1.5 Hz, 1 H), 1.37 (s, 9 H).

$^{13}\text{C}$  NMR (62.5 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 176.9, 138.8, 138.4, 129.4, 125.8, 121.8, 90.2, 40.3, 27.8.

MS (EI, 70 eV):  $m/z$  (%) = 303 (4), 260 (3), 219 (29), 177 (13), 176 (100), 119 (7), 91 (17), 65 (9), 57 (77).

#### *N*-(2-(Arylethynyl)phenyl)pivalamides; General Procedure

*N*-(2-Iodophenyl)pivalamide (**1a**; 1.516 g, 5.00 mmol, 1.00 equiv),  $\text{PdCl}_2(\text{PPh}_3)_2$  (105.3 mg, 0.15 mmol, 0.03 equiv), and  $\text{CuI}$  (28.6 mg, 0.15 mmol, 0.03 equiv) were placed in a flame-dried round-bottomed flask. The flask was sealed with a rubber septum, evacuated, and filled with argon. *i*- $\text{Pr}_2\text{NH}$  (20 mL) and ethynyltrimethylsilane (777  $\mu\text{L}$ , 5.50 mmol, 1.10 equiv) was added via a syringe. The reaction mixture was stirred under an argon atmosphere at r.t. until the disappearance of **1a** (0.5 h). The reaction was monitored by TLC (hexanes/ $\text{EtOAc}$  7:1). The appropriate aryl iodide (5.50 mmol, 1.10 equiv) was added to the mixture followed by the dropwise addition of  $\text{H}_2\text{SiF}_6$  (809  $\mu\text{L}$ , 2.50 mmol, 0.50 equiv in 34% w/w aq solution). The reaction mixture was stirred under an argon atmosphere at r.t. until the disappearance of *N*-(2-[(trimethylsilyl)ethynyl]phenyl)pivalamide (**2**) (2–4 h). The reaction was monitored by TLC (hexanes/ $\text{EtOAc}$  7:1). The mixture was neutralized with aq 2 M  $\text{HCl}$  solution and the aqueous layer was extracted with  $\text{Et}_2\text{O}$  ( $4 \times 20$  mL). The combined organic layers were washed with aq  $\text{NaHCO}_3$  (5% w/w in  $\text{H}_2\text{O}$ ;  $2 \times 25$  mL) and  $\text{H}_2\text{O}$  ( $2 \times 20$  mL), dried ( $\text{Na}_2\text{SO}_4$ ) and concentrated under reduced pressure. The crude product was purified by column chromatography on silica gel.

#### *N*-(2-[(4-Methylphenyl)ethynyl]phenyl)pivalamide (**3a**)<sup>11</sup>

Prepared according to the general procedure from 4-iodotoluene (1.199 g, 5.50 mmol, 1.10 equiv); reaction time: 2.5 h. The crude product was purified by column chromatography on silica gel with hexanes/ $\text{EtOAc}$  (75:1) to afford **3a** as a yellow solid (984 mg, 3.38 mmol, 68%); mp 90–91 °C (Lit.<sup>11</sup> mp 90–91 °C);  $R_f$  = 0.41 (hexanes/ $\text{EtOAc}$  7:1).

IR (solid, ATR): 3410, 2968, 2867, 1679, 1575, 1509, 1445, 1304, 1161, 917, 812, 764, 588, 550, 522, 476  $\text{cm}^{-1}$ .

$^1\text{H}$  NMR (250 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 8.48 (d,  $J$  = 8.3 Hz, 1 H + 1 H overlapping NH), 7.49 (dd,  $J_1$  = 7.7 Hz,  $J_2$  = 1.4 Hz, 1 H), 7.43 (d,  $J$  = 8.1 Hz, 2 H), 7.34 (t,  $J$  = 7.2 Hz, 1 H), 7.20 (d,  $J$  = 8.0 Hz, 2 H), 7.06 (td,  $J_1$  = 7.6 Hz,  $J_2$  = 0.9 Hz, 1 H), 2.39 (s, 3 H), 1.36 (s, 9 H).

$^{13}\text{C}$  NMR (62.5 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 176.7, 139.3, 139.2, 131.6, 131.4, 129.7, 129.5, 123.3, 119.4, 119.1, 112.3, 96.8, 83.9, 40.3, 27.8, 21.7.

MS (EI, 70 eV):  $m/z$  (%) = 291 (83), 234 (25), 207 (100), 178 (21), 165 (9), 115 (5), 89 (7), 57 (99).

#### *N*-(2-[(4-Methoxyphenyl)ethynyl]phenyl)pivalamide (**3b**)<sup>11</sup>

Prepared according to the general procedure from 4-iodoanisole (1.287 g, 5.50 mmol, 1.10 equiv); reaction time: 2 h. The crude product was purified by column chromatography on silica gel with hexanes/ $\text{EtOAc}$  (20:1) to afford **3b** as a yellow solid (1.018 g, 3.31 mmol, 66%); mp 99–100 °C (Lit.<sup>11</sup> mp 99–100 °C);  $R_f$  = 0.47 (hexanes/ $\text{EtOAc}$  7:1).

IR (solid, ATR): 3413, 2963, 2837, 1680, 1574, 1507, 1441, 1303, 1248, 1157, 1029, 821, 750, 563, 546, 482  $\text{cm}^{-1}$ .

$^1\text{H}$  NMR (250 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 8.47 (d,  $J$  = 8.1 Hz, 2 H), 7.47 (dd,  $J_1$  = 9.0 Hz,  $J_2$  = 2.3 Hz, 3 H), 7.38–7.27 (m, 1 H), 7.05 (td/dd,  $J_1$  = 7.6 Hz,  $J_2$  = 0.9 Hz, 1 H), 6.91 (d,  $J$  = 8.8 Hz, 2 H), 3.84 (s, 3 H), 1.36 (s, 9 H); one peak (NH) is missing due to overlap.

$^{13}\text{C}$  NMR (62.5 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 176.7, 160.2, 139.1, 133.0, 131.5, 129.6, 123.3, 119.1, 114.4, 114.4, 112.5, 96.7, 83.3, 55.5, 40.3, 27.8.

MS (EI, 70 eV):  $m/z$  (%) = 307 (49), 290 (22), 223 (28), 208 (53), 180 (19), 177 (5), 152 (20), 126 (9), 89 (3), 57 (100).

#### ***N*-[2-[(4-Acetylphenyl)ethynyl]phenyl]pivalamide (3c)**

Prepared according to the general procedure from 4-iodoacetophenone (1.353 g, 5.50 mmol, 1.10 equiv); reaction time: 2 h. The crude product was purified by column chromatography on silica gel with hexanes/EtOAc (10:1) to afford **3c** as a yellow solid (658 mg, 2.06 mmol, 41%); mp 83–85 °C;  $R_f$  = 0.21 (hexanes/EtOAc 10:1).

IR (solid, ATR): 3383, 2968, 2873, 2209, 1679, 1595, 1574, 1516, 1442, 1401, 1355, 1299, 1259, 1157, 951, 829, 746, 603  $\text{cm}^{-1}$ .

$^1\text{H}$  NMR (250 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 8.46 (d,  $J$  = 8.2 Hz, 1 H), 8.36 (s, 1 H), 7.96 (d,  $J$  = 8.5 Hz, 2 H), 7.58 (d,  $J$  = 8.5 Hz, 2 H), 7.49 (dd,  $J_1$  = 7.7 Hz,  $J_2$  = 1.3 Hz, 1 H), 7.42–7.28 (m,  $J$  = 1.4 Hz, 1 H), 7.06 (td,  $J_1$  = 7.6 Hz,  $J_2$  = 1.1 Hz, 1 H), 2.60 (s, 3 H), 1.35 (s, 9 H).

$^{13}\text{C}$  NMR (62.5 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 197.1, 176.6, 139.4, 136.8, 131.8, 131.5, 130.4, 128.6, 127.1, 123.4, 119.4, 111.5, 95.6, 87.8, 40.2, 27.7, 26.7.

MS (EI, 70 eV):  $m/z$  (%) = 320 (12), 319 (52), 236 (3), 220 (18), 191 (17), 165 (9), 85 (5), 57 (100).

HRMS:  $m/z$  [ $M + \text{H}$ ] $^+$  calcd for  $\text{C}_{21}\text{H}_{22}\text{NO}_2$ : 320.1645; found: 320.1640.

#### ***N*-[2-[(4-Nitrophenyl)ethynyl]phenyl]pivalamide (3d)<sup>11</sup>**

Prepared according to the general procedure from 1-iodo-4-nitrobenzene (1.370 g, 5.50 mmol, 1.10 equiv); reaction time: 2 h. The crude product was purified by column chromatography on silica gel with hexanes/EtOAc (10:1) to afford **3d** as a bright yellow solid (333 mg, 2.07 mmol, 41%); mp 141–142 °C (Lit.<sup>11</sup> mp 141–142 °C);  $R_f$  = 0.37 (hexanes/EtOAc 7:1).

IR (solid, ATR): 3415, 2956, 2866, 1687, 1577, 1516, 1443, 1338, 1300, 1158, 1105, 844, 759, 745, 681, 581, 551, 479  $\text{cm}^{-1}$ .

$^1\text{H}$  NMR (250 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 8.47 (d,  $J$  = 8.4 Hz, 1 H), 8.30 (s, 1 H), 8.26 (d,  $J$  = 8.9 Hz, 2 H), 7.66 (d,  $J$  = 8.8 Hz, 2 H), 7.52 (dd,  $J_1$  = 7.7 Hz,  $J_2$  = 1.2 Hz, 1 H), 7.41 (t,  $J$  = 8.0 Hz, 1 H), 7.09 (td,  $J$  = 7.6, 0.8 Hz, 1 H), 1.37 (s, 9 H).

$^{13}\text{C}$  NMR (62.5 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 176.6, 147.5, 139.6, 132.2, 132.1, 131.0, 129.3, 124.1, 123.6, 119.6, 111.0, 94.4, 89.8, 40.3, 27.8.

MS (EI, 70 eV):  $m/z$  (%) = 322 (19), 238 (12), 191 (15), 163 (10), 85 (7), 57 (100).

#### ***N*-[2-[(3-(Trifluoromethyl)phenyl)ethynyl]phenyl]pivalamide (3e)<sup>11</sup>**

Prepared according to the general procedure from 1-iodo-3-trifluoromethylbenzene (793  $\mu\text{L}$ , 5.50 mmol, 1.10 equiv); reaction time: 1.5 h. The crude product was purified by column chromatography on silica gel with hexanes/EtOAc (50:1) to afford **3e** as a bright yellow solid (716 mg, 1.03 mmol, 21%); mp 81–83 °C (Lit.<sup>11</sup> mp 82–83 °C);  $R_f$  = 0.48 (hexanes/EtOAc 7:1).

IR (solid, ATR): 3408, 2960, 1677, 1577, 1517, 1448, 1336, 1304, 1158, 1122, 1068, 920, 888, 797, 759, 688, 656, 601, 552  $\text{cm}^{-1}$ .

$^1\text{H}$  NMR (250 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 8.48 (d,  $J$  = 8.4 Hz, 1 H), 8.37 (s, 1 H), 7.79 (s, 1 H), 7.69 (d,  $J$  = 7.6 Hz, 1 H), 7.64 (d,  $J$  = 7.9 Hz, 1 H), 7.52 (t,  $J$  = 7.7 Hz, 2 H), 7.38 (t,  $J$  = 7.9 Hz, 1 H), 7.08 (td,  $J_1$  = 7.6 Hz,  $J_2$  = 0.9 Hz, 1 H), 1.37 (s, 9 H).

$^{13}\text{C}$  NMR (62.5 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 176.7, 139.5, 134.4, 131.9, 131.7, 131.2, 130.5, 129.4, 128.3 (q,  $J$  = 4.0 Hz), 125.5 (q,  $J$  = 3.5 Hz), 123.5, 121.5, 119.5, 111.5, 94.8, 86.2, 40.3, 27.8.

$^{19}\text{F}$  NMR (235 MHz,  $\text{CDCl}_3$ ):  $\delta$  = –63.1.

MS (EI, 70 eV):  $m/z$  (%) = 345 (38), 326 (4), 302 (3), 288 (3), 261 (46), 233 (10), 190 (8), 165 (6), 57 (100).

#### ***N*-[2-[(4-Fluorophenyl)ethynyl]phenyl]pivalamide (3f)<sup>11</sup>**

Prepared according to the general procedure from 1-fluoro-4-iodobenzene (634  $\mu\text{L}$ , 5.50 mmol, 1.10 equiv); reaction time: 2 h. The crude product was purified by column chromatography on silica gel with hexanes/EtOAc (25:1) to afford **3f** as a pale yellow solid (1.188 g, 4.02 mmol, 80%); mp 93–95 °C (Lit.<sup>11</sup> mp 98–100 °C);  $R_f$  = 0.49 (hexanes/EtOAc 10:1).

IR (solid, ATR): 3393, 2960, 2868, 1676, 1574, 1503, 1445, 1304, 1217, 1153, 829, 749, 594  $\text{cm}^{-1}$ .

$^1\text{H}$  NMR (250 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 8.48 (d,  $J$  = 8.3 Hz, 1 H), 8.40 (s, 1 H), 7.50 (tt,  $J_1$  = 3.5 Hz,  $J_2$  = 1.0 Hz, 3 H), 7.41–7.29 (m, 1 H), 7.15–7.00 (m, 3 H), 1.36 (s, 9 H).

$^{13}\text{C}$  NMR (62.5 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 176.6, 164.9, 160.9, 139.3, 133.5, 133.3, 131.6, 130.0, 123.3, 119.3, 118.6, 118.5, 116.3, 115.9, 111.9, 95.4, 84.3, 40.2, 27.8.

MS (EI, 70 eV):  $m/z$  (%) = 296 (8), 295 (40), 238 (6), 211 (46), 183 (29), 89 (6), 57 (100).

#### ***N*-[2-[(3-Bromophenyl)ethynyl]phenyl]pivalamide (3g)<sup>11</sup>**

Prepared according to the general procedure from 3-bromiodobenzene (652  $\mu\text{L}$ , 5.50 mmol, 1.45 g, 1.10 equiv); reaction time: 2.5 h. The crude product was purified by column chromatography on silica gel with hexanes/EtOAc (50:1) to afford **3g** as a pale yellow solid (1.134 g, 3.20 mmol, 64%); mp 73–74 °C (Lit.<sup>11</sup> mp 74–75 °C);  $R_f$  = 0.51 (hexanes/EtOAc 7:1).

IR (solid, ATR): 3399, 2969, 2865, 1670, 1578, 1517, 1476, 1445, 1303, 1157, 1073, 992, 919, 868, 788, 760, 676, 611, 438  $\text{cm}^{-1}$ .

$^1\text{H}$  NMR (250 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 8.39 (d,  $J$  = 8.25 Hz, 1 H), 8.28 (s, 1 H), 7.42 (m, 3 H), 7.27 (m, 3 H), 6.97 (dt,  $J_1$  = 7.5 Hz,  $J_2$  = 1.3 Hz, 1 H), 1.27 (s, 9 H).

$^{13}\text{C}$  NMR (62.5 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 176.5, 139.2, 132.7, 131.9, 131.5, 130.0, 128.2, 123.2, 121.2, 119.2, 111.6, 95.2, 85.6, 40.1, 27.6.

MS (EI, 70 eV):  $m/z$  (%) = 357 (21), 271 (18), 219 (6), 165 (18), 137 (2), 85 (6), 57 (100).

#### ***N*-[2-(Naphthalen-1-ylethynyl)phenyl]pivalamide (3h)<sup>11</sup>**

Prepared according to the general procedure from 1-iodonaphthalene (803  $\mu\text{L}$ , 5.50 mmol, 1.10 equiv); reaction time: 45 min. The crude product was purified by column chromatography on silica gel with hexanes/EtOAc (50:1) to afford **3h** as a pale yellow solid (362 mg, 1.11 mmol, 22%); mp 84–86 °C (Lit.<sup>11</sup> mp 89–91 °C);  $R_f$  = 0.46 (hexanes/EtOAc 10:1).

IR (solid, ATR): 3401, 3060, 2960, 2865, 1686, 1578, 1514, 1442, 1394, 1304, 1151, 798, 773, 746, 593  $\text{cm}^{-1}$ .

$^1\text{H}$  NMR (250 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 8.57 (d,  $J$  = 8.5 Hz, 2 H, ArH, NH overlap), 8.43 (d,  $J$  = 7.7 Hz, 1 H), 7.91 (d,  $J$  = 8.5 Hz, 2 H), 7.78 (dd,  $J_1$  = 7.1 Hz,  $J_2$  = 1.0 Hz, 1 H), 7.61 (ddd,  $J_1$  = 14.9 Hz,  $J_2$  = 7.3 Hz,  $J_3$  = 1.3 Hz, 3 H), 7.50 (dd,  $J_1$  = 8.2 Hz,  $J_2$  = 7.3 Hz, 1 H), 7.41 (t,  $J$  = 7.9 Hz, 1 H), 7.13 (td,  $J_1$  = 7.6 Hz,  $J_2$  = 1.1 Hz, 1 H), 1.35 (s, 9 H).

$^{13}\text{C}$  NMR (62.5 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 176.8, 139.3, 133.4, 133.1, 131.9, 130.5, 130.1, 129.6, 128.6, 127.2, 126.8, 126.0, 125.4, 123.4, 120.0, 119.4, 112.3, 94.6, 89.3, 40.2, 27.8.

MS (EI, 70 eV):  $m/z$  (%) = 328 (25), 327 (100), 270 (25), 243 (53), 242 (76), 240 (21), 213 (11), 57 (92).

***N*-[2-(Pyridin-3-ylethynyl)phenyl]pivalamide (3i)**

Prepared according to the general procedure from 3-iodopyridine (1.035 g, 5.50 mmol, 1.10 equiv); reaction time: 2.5 h. The crude product was purified by column chromatography on silica gel with hexanes/EtOAc (20:1) to afford **3i** as a yellow solid (559 mg, 2.01 mmol, 40%); mp 70–73 °C;  $R_f$  = 0.22 (hexanes/EtOAc 3:1).

IR (solid, ATR): 3393, 2966, 2870, 2210, 1674, 1575, 1520, 1475, 1442, 1304, 1160, 1019, 920, 803, 750, 703, 597  $\text{cm}^{-1}$ .

$^1\text{H}$  NMR (250 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 8.75 (s, 1 H), 8.57 (dd,  $J_1$  = 4.9 Hz,  $J_2$  = 1.5 Hz, 1 H), 8.44 (d,  $J$  = 8.3 Hz, 1 H), 8.32 (s, 1 H), 7.78 (dt,  $J_1$  = 7.9 Hz,  $J_2$  = 1.9 Hz, 1 H), 7.48 (dd,  $J_1$  = 7.7 Hz,  $J_2$  = 1.3 Hz, 1 H), 7.39–7.27 (m, 2 H), 7.04 (td,  $J_1$  = 7.6 Hz,  $J_2$  = 1.0 Hz, 1 H), 1.33 (s, 9 H).

$^{13}\text{C}$  NMR (62.5 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 176.6, 151.9, 149.2, 139.3, 138.3, 131.8, 130.4, 123.4, 119.7, 119.4, 111.4, 92.9, 87.9, 40.2, 27.7.

MS (EI, 70 eV):  $m/z$  (%) = 279 (9), 278 (47), 221 (6), 194 (60), 193 (24), 166 (15), 139 (13), 89 (6), 57 (100).

HRMS:  $m/z$  [ $M + \text{H}$ ] $^+$  calcd for  $\text{C}_{18}\text{H}_{19}\text{N}_2\text{O}^+$ : 279.1492; found: 279.1493.

***N*-[2-(Thiophen-2-ylethynyl)phenyl]pivalamide (3j)**

Prepared according to the general procedure from 2-iodothiophene (607  $\mu\text{L}$ , 5.50 mmol, 1.10 equiv); reaction time: 2.5 h. The crude product was purified by column chromatography on silica gel with hexanes/ethyl acetate (50:1) to afford **3j** as a yellow solid (606 mg, 2.14 mmol, 43%); mp 47–49 °C;  $R_f$  = 0.49 (hexanes/EtOAc 10:1).

IR (solid, ATR): 3410, 3089, 2956, 2865, 1679, 1575, 1510, 1443, 1302, 1154, 920, 831, 761, 713, 588  $\text{cm}^{-1}$ .

$^1\text{H}$  NMR (250 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 8.47 (d,  $J$  = 8.3 Hz, 1 H), 8.37 (s, 1 H), 7.47 (dd,  $J_1$  = 7.7 Hz,  $J_2$  = 1.4 Hz, 1 H), 7.40–7.32 (m, 2 H), 7.30 (dd,  $J_1$  = 3.6 Hz,  $J_2$  = 1.0 Hz, 1 H), 7.06 (ddd,  $J_1$  = 6.3 Hz,  $J_2$  = 5.7 Hz,  $J_3$  = 2.4 Hz, 2 H), 1.37 (s, 9 H).

$^{13}\text{C}$  NMR (62.5 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 176.7, 139.2, 132.3, 131.3, 130.0, 128.1, 127.5, 123.3, 122.2, 119.3, 111.8, 89.7, 88.2, 40.2, 27.8.

MS (EI, 70 eV):  $m/z$  (%) = 284 (17), 283 (82), 226 (12), 198 (29), 199 (75), 171 (25), 154 (20), 127 (15), 89 (6), 57 (100).

HRMS:  $m/z$  [ $M + \text{H}$ ] $^+$  calcd for  $\text{C}_{17}\text{H}_{18}\text{NOS}^+$ : 284.1104; found: 284.1101.

***N*-[4-Fluoro-2-(*p*-tolylethynyl)phenyl]pivalamide (3k)**

Prepared according to the general procedure from 4-iodotoluene (119.9 mg, 0.55 mmol, 1.10 equiv) and *N*-(4-fluoro-2-iodophenyl)pivalamide (105.6 mg, 0.5 mmol, 1.0 equiv); reaction time: 8.0 h. The crude product was purified by column chromatography on silica gel with hexanes/EtOAc (50:1) to afford **3k** as a light brown solid (105.4 mg, 0.341 mmol, 68%); mp 81–84 °C;  $R_f$  = 0.38 (hexanes/EtOAc 10:1).

IR (thin film, ATR): 1687, 1519, 1478, 1420, 1301, 1200, 1187, 1085, 958, 869, 815, 748  $\text{cm}^{-1}$ .

$^1\text{H}$  NMR (250 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 8.44 (dd,  $J_1$  = 9.2 Hz,  $J_2$  = 5.3 Hz, 1 H), 8.35 (s, 1 H), 7.42 (d,  $J$  = 8.1 Hz, 2 H), 7.24–7.14 (m, 3 H), 7.05 (td,  $J_1$  = 8.7 Hz,  $J_2$  = 3.0 Hz, 1 H), 2.40 (s, 3 H), 1.36 (s, 9 H).

$^{13}\text{C}$  NMR (62.5 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 176.6, 158.05 (d,  $J$  = 243.1 Hz), 139.7, 135.6, 131.5, 129.6, 120.76 (d,  $J$  = 8.2 Hz), 118.8, 118.0, 117.6, 116.8, 116.4, 113.9, 113.8, 97.5, 82.94 (d,  $J$  = 3.0 Hz), 40.2, 27.8, 21.7.

$^{19}\text{F}$  NMR (235 MHz,  $\text{CDCl}_3$ ):  $\delta$  = –119.1.

MS (EI, 70 eV):  $m/z$  (%) = 309 (54), 252 (10), 225 (54), 224 (21), 196 (11), 183 (4), 107 (3), 85 (5), 57 (100).

HRMS:  $m/z$  [ $M + \text{H}$ ] $^+$  calcd for  $\text{C}_{20}\text{H}_{21}\text{FNO}^+$ : 310.1607; found: 310.1602.

***N*-[5-Chloro-2-(*p*-tolylethynyl)phenyl]pivalamide (3l)**

Prepared according to the general procedure from 4-iodotoluene (119.9 mg, 0.55 mmol, 1.10 equiv) and *N*-(5-chloro-2-iodophenyl)pivalamide (168.8 mg, 0.5 mmol, 1.0 equiv); reaction time: 3 h. The crude product was purified by column chromatography on silica gel with hexanes/EtOAc (50/1  $\rightarrow$  25:1) to afford **3l** as a light yellow solid (103.5 mg, 0.318 mmol, 64%); mp 120–122 °C;  $R_f$  = 0.43 (hexanes/EtOAc 10:1).

IR (solid, ATR): 1687, 1570, 1510, 1478, 1456, 1415, 1281, 1256, 1154, 1109, 913, 882, 813  $\text{cm}^{-1}$ .

$^1\text{H}$  NMR (250 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 8.52 (d,  $J$  = 2.1 Hz, 1 H), 8.37 (s, 1 H), 7.41–7.24 (m, 3 H), 7.12 (d,  $J$  = 7.9 Hz, 2 H), 6.95 (dd,  $J_1$  = 8.3 Hz,  $J_2$  = 2.1 Hz, 1 H), 2.31 (s, 3 H), 1.27 (s, 9 H).

$^{13}\text{C}$  NMR (62.5 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 176.8, 139.9, 139.6, 135.5, 132.2, 131.4, 129.6, 123.5, 119.3, 119.0, 110.6, 97.6, 83.0, 40.3, 27.7, 21.7.

HRMS:  $m/z$  [ $M + \text{H}$ ] $^+$  calcd for  $\text{C}_{20}\text{H}_{21}\text{ClNO}^+$ : 326.1312; found: 326.1302.

**Methyl 3-Pivalamido-4-(*p*-tolylethynyl)benzoate (3m)**

Prepared according to the general procedure from 4-iodotoluene (119.9 mg, 0.55 mmol, 1.10 equiv) and methyl 4-iodo-3-pivalamido-benzoate (180.6 mg, 0.5 mmol, 1.0 equiv); reaction time: 5 h. The crude product was purified by column chromatography on silica gel with hexanes/EtOAc (50:1  $\rightarrow$  15:1) to afford **3m** as a light brown solid (127.4 mg, 0.365 mmol, 73%); mp 139–142 °C;  $R_f$  = 0.35 (hexanes/EtOAc 5:1).

IR (thin film, ATR): 1724, 1573, 1532, 1512, 1437, 1428, 1288, 1238, 1159, 1120, 999, 816, 764  $\text{cm}^{-1}$ .

$^1\text{H}$  NMR (250 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 9.05 (s, 1 H), 8.40 (s, 1 H), 7.57 (dd,  $J_1$  = 9.2 Hz,  $J_2$  = 5.3 Hz, 2 H), 7.27 (dd,  $J_1$  = 7.4 Hz,  $J_2$  = 0.7 Hz, 4 H), 3.83 (s, 3 H), 2.32 (s, 3 H), 1.30 (s, 9 H).

$^{13}\text{C}$  NMR (62.5 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 176.8, 166.6, 139.9, 139.1, 131.5, 131.4, 130.8, 129.6, 124.4, 119.9, 118.7, 116.6, 99.3, 83.4, 52.4, 40.3, 27.7, 21.7.

MS (EI, 70 eV):  $m/z$  (%) = 349 (40), 318 (5), 292 (7), 265 (25), 234 (29), 207 (23), 190 (13), 176 (7), 147 (8), 73 (20), 57 (100).

HRMS:  $m/z$  [ $M + \text{H}$ ] $^+$  calcd for  $\text{C}_{22}\text{H}_{24}\text{NO}_3^+$ : 350.1756; found: 350.1736.

**2-Arylethynylanilines; General Procedure**

$\text{PdCl}_2(\text{PPh}_3)_2$  (52.6 mg, 0.075 mmol, 3 mol%), CuI (14.3 mg, 0.075 mmol, 3 mol%), and the appropriate aryl iodide (2.50 mmol, 1.00 equiv, if solid) were placed in a round-bottomed flask. The flask was sealed with a rubber septum, evacuated, and filled with argon. *i*-Pr<sub>2</sub>NH (10 mL) was added to the flask followed by the addition of the appropriate aryl iodide (2.50 mmol, 1.00 equiv, if liquid). Ethynyl-trimethylsilane (388  $\mu\text{L}$ , 2.75 mmol, 1.10 equiv) was added dropwise to the reaction mixture. The mixture was stirred under an argon atmosphere at r.t. for 30 min (monitored by TLC). Then 2-iodoaniline (602.3 mg, 2.75 mmol, 1.10 equiv) or a derivative (2.75 mmol, 1.10 equiv) was added to the mixture followed by the dropwise addition of  $\text{H}_2\text{SiF}_6$  (404  $\mu\text{L}$ , 1.25 mmol, 0.50 equiv, 34% w/w aq solution), and the mixture was stirred under an argon atmosphere at r.t. for 24 h. The mixture was diluted with Et<sub>2</sub>O (20 mL) and was poured into distilled H<sub>2</sub>O (40 mL). The layers were separated, and the aqueous layer was extracted with Et<sub>2</sub>O (3  $\times$  20 mL). The combined organic layers were washed with aq 2 M HCl (30 mL) and distilled H<sub>2</sub>O (2  $\times$  20 mL), dried ( $\text{Na}_2\text{SO}_4$ ), and concentrated under reduced pressure. The crude product was purified by column chromatography on silica gel.

**2-(Phenylethynyl)aniline (4a)<sup>13</sup>**

Prepared according to the general procedure from iodobenzene (278  $\mu$ L, 2.50 mmol). The crude product was purified by column chromatography on silica gel with hexanes/EtOAc (10:1) to give **4a** as a white solid (396 mg, 2.05 mmol, 82%); mp 90–91 °C (Lit.<sup>13</sup> mp 89–91 °C);  $R_f$  = 0.48 (hexanes/EtOAc 5:1).

IR (solid, ATR): 3462, 3367, 3029, 2205, 1611, 1482, 1453, 1310, 1258, 744, 688  $\text{cm}^{-1}$ .

<sup>1</sup>H NMR (250 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 7.56 (dd,  $J_1$  = 6.5 Hz,  $J_2$  = 3.1 Hz, 2 H), 7.45–7.33 (m, 4 H), 7.17 (t,  $J$  = 7.7 Hz, 1 H), 6.76 (dd,  $J_1$  = 7.6 Hz,  $J_2$  = 5.2 Hz, 2 H), 4.19 (s, 2 H).

<sup>13</sup>C NMR (62.5 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 147.84, 132.25, 131.57, 129.84, 128.49, 128.32, 123.41, 118.12, 114.48, 108.06, 94.81, 86.01.

MS (EI, 70 eV):  $m/z$  (%) = 193 (100), 165 (43), 139 (7), 115 (5), 95 (6), 89 (15), 63 (4), 51 (3).

**2-(*m*-Tolylethynyl)aniline (4b)<sup>14</sup>**

Prepared according to the general procedure from 3-iodotoluene (321  $\mu$ L, 2.50 mmol). The crude product was purified by column chromatography on silica gel with hexanes/EtOAc (10:1) to give **4b** as a yellow solid (368 mg, 1.78 mmol, 71%); mp 60–62 °C (Lit.<sup>14</sup> mp not given, described as a brown oil);  $R_f$  = 0.50 (hexanes/EtOAc 5:1).

IR (solid, ATR): 3468, 3374, 3029, 2917, 1608, 1568, 1492, 1453, 1307, 1256, 784, 744, 689  $\text{cm}^{-1}$ .

<sup>1</sup>H NMR (250 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 7.27 (m, 3 H), 7.15 (t,  $J$  = 7.5 Hz, 1 H), 7.06 (d,  $J$  = 7.7 Hz, 2 H), 6.67–6.59 (m, 2 H), 4.18 (s, 2 H), 2.27 (s, 3 H).

<sup>13</sup>C NMR (62.5 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 147.9, 139.1, 138.2, 132.2, 132.2, 129.8, 129.4, 129.2, 128.7, 128.4, 123.2, 120.1, 118.1, 114.8, 114.4, 108.2, 95.0, 85.7, 21.5.

MS (EI, 70 eV):  $m/z$  (%) = 207 (100), 206 (30), 191 (9), 178 (15), 165 (18), 152 (7), 102 (6), 89 (16), 63 (6).

**2-(*p*-Tolylethynyl)aniline (4c)<sup>15</sup>**

Prepared according to the general procedure from 4-iodotoluene (545.1 mg, 2.50 mmol). The crude product was purified by column chromatography on silica gel with hexanes/EtOAc (10:1) to give **4c** as a yellow solid (364 mg, 1.76 mmol, 70%); mp 105–106 °C (Lit.<sup>15</sup> 101–102 °C);  $R_f$  = 0.49 (hexanes/EtOAc 5:1).

IR (solid, ATR): 3472, 3372, 3023, 1608, 1562, 1487, 1453, 1307, 1256, 815, 744  $\text{cm}^{-1}$ .

<sup>1</sup>H NMR (250 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 7.44 (d,  $J$  = 8.1 Hz, 2 H), 7.38 (dd,  $J_1$  = 7.9 Hz,  $J_2$  = 1.4 Hz, 1 H), 7.22–7.07 (m, 3 H), 6.80–6.68 (m, 2 H), 4.28 (s, 2 H), 2.39 (s, 3 H).

<sup>13</sup>C NMR (62.5 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 147.8, 138.5, 132.2, 131.5, 129.7, 129.3, 120.4, 118.1, 114.4, 108.3, 95.0, 85.3, 21.6.

MS (EI, 70 eV):  $m/z$  (%) = 208 (16), 207 (100), 206 (47), 191 (8), 178 (15), 165 (13), 152 (6), 139 (5), 102 (7), 89 (13), 77 (5), 63 (4).

**2-[(4-Methoxyphenyl)ethynyl]aniline (4d)<sup>16</sup>**

Prepared according to the general procedure from 1-iodo-4-methoxybenzene (585.1 mg, 2.50 mmol). The crude product was purified by column chromatography on silica gel with hexanes/EtOAc (5:1) to give **4d** as a white solid (498 mg, 2.23 mmol, 89%); mp 111–112 °C (Lit.<sup>16</sup> mp 104–106 °C);  $R_f$  = 0.19 (hexanes/EtOAc 7:1).

IR (solid, ATR): 3484, 3386, 1608, 1489, 1455, 1285, 1243, 1173, 1024, 831, 750  $\text{cm}^{-1}$ .

<sup>1</sup>H NMR (250 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 7.32 (d,  $J$  = 8.3 Hz, 2 H), 7.21 (d,  $J$  = 7.7 Hz, 1 H), 6.97 (t,  $J$  = 7.7 Hz, 1 H), 6.73 (d,  $J$  = 8.3 Hz, 2 H), 6.57 (t,  $J$  = 6.4 Hz, 2 H), 4.11 (s, 2 H), 3.66 (s, 3 H).

<sup>13</sup>C NMR (62.5 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 159.7, 147.7, 133.0, 132.1, 129.5, 118.0, 115.5, 114.4, 114.1, 108.4, 94.7, 84.6, 55.4.

MS (EI, 70 eV):  $m/z$  (%) = 224 (13), 223 (78), 208 (100), 190 (3), 180 (64), 179 (13), 165 (3), 152 (36), 140 (4), 127 (9), 111 (8), 89 (6), 77 (11), 63 (7), 51 (4).

**Ethyl 4-[(2-Aminophenyl)ethynyl]benzoate (4e)<sup>17</sup>**

Prepared according to the general procedure from ethyl 4-iodobenzoate (690.2 mg, 2.50 mmol). The crude product was purified by column chromatography on silica gel with hexanes/EtOAc (5:1) to afford **4e** as a bright yellow solid (466 mg, 1.76 mmol, 70%); mp 92–93 °C (Lit.<sup>17</sup> mp not given);  $R_f$  = 0.14 (hexanes/EtOAc 7:1).

IR (solid, ATR): 3471, 3367, 2983, 2206, 1701, 1621, 1602, 1487, 1454, 1403, 1360, 1287, 1274, 1175, 1107, 1023, 856, 766, 749, 693, 486  $\text{cm}^{-1}$ .

<sup>1</sup>H NMR (250 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 8.03 (d,  $J$  = 8.5 Hz, 2 H), 7.57 (d,  $J$  = 8.5 Hz, 2 H), 7.38 (dd,  $J_1$  = 7.9 Hz,  $J_2$  = 1.4 Hz, 1 H), 7.17 (td,  $J_1$  = 7.8 Hz,  $J_2$  = 1.5 Hz, 1 H), 6.78–6.66 (m, 2 H), 4.39 (q,  $J$  = 7.1 Hz, 2 H), 4.30 (s, 2 H), 1.41 (t,  $J$  = 7.1 Hz, 3 H).

<sup>13</sup>C NMR (62.5 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 166.2, 148.1, 132.4, 131.4, 130.4, 129.8, 129.6, 128.0, 118.2, 114.6, 107.4, 94.2, 89.1, 61.3, 14.4.

MS (EI, 70 eV):  $m/z$  (%) = 266 (19), 265 (100), 237 (74), 221 (6), 220 (31), 193 (11), 191 (54), 190 (28), 165 (47), 164 (21), 152 (4), 139 (9), 115 (5), 110 (27), 95 (21), 87 (4), 82 (16), 75 (4), 63 (6), 51 (3).

**2-[(4-Nitrophenyl)ethynyl]aniline (4f)<sup>14</sup>**

Prepared according to the general procedure from 1-iodo-4-nitrobenzene (622.5 mg, 2.50 mmol). The crude product was purified by column chromatography on silica gel with hexanes/EtOAc (5:1) to afford **4f** as a bright orange solid (355 mg, 1.49 mmol, 60%); mp 135–136 °C (Lit.<sup>14</sup> mp 138 °C);  $R_f$  = 0.11 (hexanes/EtOAc 7:1).

IR (solid, ATR): 3474, 3377, 2203, 1614, 1589, 1566, 1502, 1335, 1311, 1258, 1104, 846, 754, 746, 685, 475  $\text{cm}^{-1}$ .

<sup>1</sup>H NMR (250 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 8.21 (d,  $J$  = 8.9 Hz, 2 H), 7.64 (d,  $J$  = 8.9 Hz, 2 H), 7.38 (dd,  $J_1$  = 7.9 Hz,  $J_2$  = 1.4 Hz, 1 H), 7.20 (td,  $J_1$  = 7.9 Hz,  $J_2$  = 1.5 Hz, 1 H), 6.84–6.67 (m, 2 H), 4.31 (s, 2 H).

<sup>13</sup>C NMR (62.5 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 148.3, 147.0, 132.6, 132.1, 131.0, 130.4, 123.8, 118.3, 114.7, 106.7, 93.1, 91.8.

MS (EI, 70 eV):  $m/z$  (%) = 239 (17), 238 (100), 222 (2), 208 (9), 192 (47), 191 (82), 190 (35), 165 (51), 139 (12), 126 (5), 113 (6), 89 (9), 63 (8), 51 (5).

**2-[(2-Chlorophenyl)ethynyl]aniline (4g)<sup>17</sup>**

Prepared according to the general procedure from 1-chloro-2-iodobenzene (305  $\mu$ L, 2.50 mmol). The crude product was purified by column chromatography on silica gel with hexanes/EtOAc (25:1) to give **4g** as a white solid (381 mg, 1.67 mmol, 67%); mp 68–70 °C (Lit.<sup>17</sup> mp not given);  $R_f$  = 0.47 (hexanes/EtOAc 5:1).

IR (solid, ATR): 3433, 3340, 1616, 1492, 1470, 1434, 1312, 1051, 740  $\text{cm}^{-1}$ .

<sup>1</sup>H NMR (250 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 7.48 (dd,  $J_1$  = 5.9 Hz,  $J_2$  = 3.5 Hz, 1 H), 7.42–7.25 (m, 2 H), 7.16 (dd,  $J_1$  = 5.9 Hz,  $J_2$  = 3.5 Hz, 2 H), 7.07 (td,  $J_1$  = 8.0 Hz,  $J_2$  = 1.4 Hz, 1 H), 6.63 (t,  $J$  = 7.3 Hz, 2 H), 4.37 (s, 2 H).

<sup>13</sup>C NMR (62.5 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 148.5, 135.4, 132.9, 132.1, 130.3, 129.3, 129.2, 126.7, 123.5, 117.9, 114.4, 107.4, 91.8, 91.7.

MS (EI, 70 eV):  $m/z$  (%) = 229 (32), 228 (16), 227 (100), 199 (6), 190 (24), 165 (59), 139 (6), 113 (10), 89 (19), 82 (6), 75 (4), 63 (6).

### 2-[(4-Chlorophenyl)ethynyl]aniline (**4h**)<sup>17</sup>

Prepared according to the general procedure from 1-chloro-4-iodobenzene (596.1 mg, 2.50 mmol). The crude product was purified by column chromatography on silica gel with hexanes/EtOAc (25:1) to give **4h** as a white solid (394 mg, 1.73 mmol, 69%); mp 115–116 °C (Lit.<sup>17</sup> mp not given);  $R_f$  = 0.33 (hexanes/EtOAc 7:1).

IR (solid, ATR): 3462, 3373, 2208, 1612, 1483, 1310, 1259, 1086, 831, 750 cm<sup>-1</sup>.

<sup>1</sup>H NMR (250 MHz, CDCl<sub>3</sub>):  $\delta$  = 7.30 (d,  $J$  = 8.2 Hz, 2 H), 7.19 (t,  $J$  = 9.4 Hz, 3 H), 7.01 (t,  $J$  = 7.6 Hz, 1 H), 6.58 (t,  $J$  = 6.5 Hz, 2 H), 4.11 (s, 2 H).

<sup>13</sup>C NMR (62.5 MHz, CDCl<sub>3</sub>):  $\delta$  = 147.9, 134.3, 132.7, 132.3, 130.1, 128.8, 121.9, 118.1, 114.5, 107.6, 93.7, 87.0.

MS (EI, 70 eV):  $m/z$  (%) = 229 (33), 228 (17), 227 (100), 199 (7), 191 (20), 165 (62), 163 (18), 139 (7), 113 (11), 95 (11), 89 (25), 63 (7).

### 2-[(3-(Trifluoromethyl)phenyl)ethynyl]aniline (**4i**)<sup>18</sup>

Prepared according to the general procedure from 1-iodo-2-(trifluoromethyl)benzene (350  $\mu$ L, 2.50 mmol). The crude product was purified by column chromatography on silica gel with hexanes/EtOAc (10:1) to afford **4i** as a red oil (257 mg, 0.980 mmol, 39%); mp 163–165 °C (Lit.<sup>18</sup> mp 166–167 °C);  $R_f$  = 0.21 (hexanes/EtOAc 7:1).

IR (thin film, ATR): 3484, 3391, 2211, 1615, 1571, 1497, 1483, 1457, 1311, 1259, 1173, 1119, 1105, 1054, 1031, 762, 744, 649, 469 cm<sup>-1</sup>.

<sup>1</sup>H NMR (250 MHz, CDCl<sub>3</sub>):  $\delta$  = 7.68 (d,  $J$  = 8.5 Hz, 2 H), 7.53 (t,  $J$  = 7.6 Hz, 1 H), 7.40 (t,  $J$  = 7.9 Hz, 2 H), 7.17 (t,  $J$  = 7.8 Hz, 1 H), 6.77–6.68 (m, 2 H), 4.37 (s, 2 H).

<sup>13</sup>C NMR (62.5 MHz, CDCl<sub>3</sub>):  $\delta$  = 148.6, 133.8, 132.5, 131.7, 131.0, 130.5, 127.9, 126.0 (q,  $J$  = 5.0 Hz), 121.83, 121.78, 117.9, 114.6, 107.2, 92.2, 90.7.

<sup>19</sup>F NMR (235 MHz, CDCl<sub>3</sub>):  $\delta$  = –62.1.

MS (EI, 70 eV):  $m/z$  (%) = 262 (17), 261 (100), 241 (19), 240 (73), 222 (74), 221 (24), 190 (6), 175 (6), 163 (6), 120 (20), 11 (9), 94 (5), 63 (4), 5 (3).

### 2-(Pyridin-3-ylethynyl)aniline (**4j**)<sup>19</sup>

Prepared according to the general procedure from 3-iodopyridine (512.5 mg, 2.50 mmol). The crude product was purified by column chromatography on silica gel with hexanes/EtOAc (5:1) to give **4j** as a yellow solid (390 mg, 2.01 mmol, 80%); mp 97–98 °C (Lit.<sup>19</sup> mp 104–106 °C);  $R_f$  = 0.08 (hexanes/EtOAc 5:1).

IR (solid, ATR): 3444, 3316, 3207, 2208, 1628, 1560, 1473, 1453, 1407, 1314, 1262, 1022, 804, 760, 699 cm<sup>-1</sup>.

<sup>1</sup>H NMR (250 MHz, CDCl<sub>3</sub>):  $\delta$  = 8.68 (d,  $J$  = 1.6 Hz, 1 H), 8.46 (dd,  $J_1$  = 4.9 Hz,  $J_2$  = 1.5 Hz, 1 H), 7.71 (dt,  $J_1$  = 7.9 Hz,  $J_2$  = 1.9 Hz, 1 H), 7.29 (dd,  $J_1$  = 7.9 Hz,  $J_2$  = 1.4 Hz, 1 H), 7.20 (dd,  $J_1$  = 8.1 Hz,  $J_2$  = 4.6 Hz, 1 H), 7.09 (t,  $J$  = 7.7 Hz, 1 H), 6.64 (dd,  $J_1$  = 7.5 Hz,  $J_2$  = 5.7 Hz, 2 H), 4.05 (s, 2 H).

<sup>13</sup>C NMR (62.5 MHz, CDCl<sub>3</sub>):  $\delta$  = 152.1, 148.6, 148.1, 138.3, 132.4, 130.4, 123.2, 120.7, 118.1, 114.6, 107.2, 91.3, 89.5.

MS (EI, 70 eV):  $m/z$  (%) = 194 (100), 193 (33), 166 (24), 139 (19), 113 (7), 89 (17), 71 (7), 63 (7).

### 2-(4-Tolylethynyl)-4-(trifluoromethyl)aniline (**4k**)

Prepared according to the general procedure from 4-iodotoluene (109.0 mg, 0.50 mmol) and 4-amino-3-iodobenzonitrile (134.2 mg, 0.55 mmol, 1.10 equiv). The crude product was purified by column chromatography on silica gel with hexanes/EtOAc (100:1  $\rightarrow$  10:1) to give **4k** as a light brown solid (89.0 mg, 0.323 mmol, 65%); mp 114–116 °C;  $R_f$  = 0.18 (hexanes/EtOAc 10:1).

IR (thin film, ATR): 1618, 1506, 1432, 1338, 1281, 1264, 1176, 1152, 1104, 1072, 910, 831, 816 cm<sup>-1</sup>.

<sup>1</sup>H NMR (250 MHz, CDCl<sub>3</sub>):  $\delta$  = 7.64 (d,  $J$  = 2.1 Hz, 1 H), 7.44 (d,  $J$  = 8.0 Hz, 2 H), 7.34 (dd,  $J_1$  = 8.6,  $J_2$  = 2.1 Hz, 1 H), 7.15 (d,  $J$  = 7.9 Hz, 2 H), 6.83 (d,  $J$  = 8.5 Hz, 1 H), 5.21 (s, 2 H), 2.37 (s, 3 H).

<sup>13</sup>C NMR (62.5 MHz, CDCl<sub>3</sub>):  $\delta$  = 149.6, 139.1, 131.6, 129.6 (d,  $J$  = 3.9 Hz), 129.4, 126.5 (d,  $J$  = 3.7 Hz), 126.4, 120.6, 120.1, 119.6, 114.1, 108.3, 96.1, 83.7, 21.6. The quartet of trifluoromethyl group was not be detected.

<sup>19</sup>F NMR (235 MHz, CDCl<sub>3</sub>):  $\delta$  = –61.5.

MS (EI, 70 eV):  $m/z$  (%) = 275 (100), 274 (36), 256 (7), 204 (15), 178 (9), 137 (8), 114 (4), 102 (4), 89 (4), 75 (2), 63 (3).

HRMS:  $m/z$  [M + H]<sup>+</sup> calcd for C<sub>16</sub>H<sub>13</sub>F<sub>3</sub>N<sup>+</sup>: 276.1000; found: 276.1001.

### 4-Amino-3-(4-tolylethynyl)benzonitrile (**4l**)

Prepared according to the general procedure from 4-iodotoluene (109.0 mg, 0.50 mmol) and 2-iodo-4-(trifluoromethyl)aniline (120.5 mg, 0.55 mmol, 1.10 equiv). The crude product was purified by column chromatography on silica gel with hexanes/EtOAc (100:1  $\rightarrow$  10:1) to give **4l** as a white solid (102.5 mg, 0.441 mmol, 88%); mp 122–123 °C;  $R_f$  = 0.18 (hexanes/EtOAc 5:1).

IR (thin film, ATR): 2220, 1614, 1510, 1499, 1419, 1331, 1273, 1197, 1159, 900, 816 cm<sup>-1</sup>.

<sup>1</sup>H NMR (250 MHz, CDCl<sub>3</sub>):  $\delta$  = 7.46 (d,  $J$  = 2.0 Hz, 1 H), 7.27 (d,  $J$  = 8.1 Hz, 2 H), 7.19 (dd,  $J_1$  = 8.5,  $J_2$  = 2.0 Hz, 1 H), 7.02 (d,  $J$  = 8.2 Hz, 2 H), 6.57 (d,  $J$  = 8.6 Hz, 1 H), 4.70 (s, 2 H), 2.22 (s, 3 H).

<sup>13</sup>C NMR (62.5 MHz, CDCl<sub>3</sub>):  $\delta$  = 150.7, 139.3, 136.3, 133.1, 131.5, 129.3, 119.5, 119.2, 114.2, 108.7, 100.3, 96.6, 82.8, 21.6.

MS (EI, 70 eV):  $m/z$  (%) = 233 (17), 232 (100), 231 (50), 229 (12), 216 (7), 204 (9), 190 (9), 176 (5), 151 (4), 139 (4), 126 (2), 115 (11), 102 (6), 88 (7), 75 (3), 62 (4).

### 2-Methyl-3-(4-tolylethynyl)quinolin-4-amine (**4m**)

Prepared according to the general procedure from 4-iodotoluene (109.0 mg, 0.50 mmol) and 3-iodo-2-methylquinolin-4-amine (156.3 mg, 0.55 mmol, 1.10 equiv). The crude product was purified by column chromatography on silica gel with hexanes/EtOAc (100:1  $\rightarrow$  5:1) to give **4m** as grey crystals (93.7 mg, 0.344 mmol, 69%); mp 130–133 °C;  $R_f$  = 0.35 (EtOAc).

IR (thin film, ATR): 1571, 1512, 1501, 1370, 1338, 1256, 1186, 1104, 1016, 915, 882, 818, 802, 783, 757, 693 cm<sup>-1</sup>.

<sup>1</sup>H NMR (250 MHz, DMSO-*d*<sub>6</sub>):  $\delta$  = 8.26 (d,  $J$  = 8.3 Hz, 1 H), 7.71 (d,  $J$  = 8.4 Hz, 1 H), 7.57 (d,  $J$  = 8.1 Hz, 3 H), 7.38 (t,  $J$  = 7.5 Hz, 1 H), 7.22 (d,  $J$  = 7.9 Hz, 2 H), 7.01 (s, 2 H), 2.64 (s, 3 H), 2.32 (s, 3 H).

<sup>13</sup>C NMR (62.5 MHz, DMSO-*d*<sub>6</sub>):  $\delta$  = 158.8, 151.9, 146.5, 137.9, 131.1, 129.7, 129.2, 128.4, 123.9, 122.5, 120.2, 116.1, 99.5, 98.8, 84.3, 24.6, 21.1.

MS (EI, 70 eV):  $m/z$  (%) = 259 (100), 230 (8), 202 (8), 130 (8), 115 (5), 101 (5), 91 (3), 77 (4), 63 (3).

HRMS:  $m/z$  [M]<sup>+</sup> calcd for C<sub>19</sub>H<sub>16</sub>N<sub>2</sub><sup>+</sup>: 273.1392; found: 272.1308.

## 2-Arylbenzofurans; General Procedure

$\text{PdCl}_2(\text{PPh}_3)_2$  (52.6 mg, 0.075 mmol, 3 mol%),  $\text{CuI}$  (14.3 mg, 0.075 mmol, 3 mol%), and the appropriate aryl iodide (2.50 mmol, 1.00 equiv, if solid) were placed in a round-bottomed flask. The flask was sealed with a rubber septum, evacuated, and filled with argon.  $i\text{-Pr}_2\text{NH}$  (10 mL) was added to the flask followed by the addition of the appropriate aryl iodide (2.50 mmol, 1.00 equiv, if liquid). Ethynyltrimethylsilane (388  $\mu\text{L}$ , 2.75 mmol, 1.10 equiv) was added dropwise to the reaction mixture. The mixture was stirred under argon at r.t. for 30 min (monitored by TLC). After completion, 2-iodophenol (605.0 mg, 2.75 mmol, 1.10 equiv) was added to the mixture followed by the dropwise addition of  $\text{H}_2\text{SiF}_6$  (404  $\mu\text{L}$ , 1.25 mmol, 0.50 equiv, 34% w/w aq solution), and the mixture was stirred under an argon atmosphere at r.t. for 24 h. The mixture was diluted with  $\text{Et}_2\text{O}$  (20 mL) and poured into distilled  $\text{H}_2\text{O}$  (40 mL). The layers were separated and the aqueous phase was extracted with  $\text{Et}_2\text{O}$  ( $3 \times 20$  mL). The combined organic layers were washed with aq 2 M  $\text{HCl}$  (30 mL) and  $\text{H}_2\text{O}$  ( $2 \times 20$  mL), dried ( $\text{Na}_2\text{SO}_4$ ), and concentrated under reduced pressure. The crude product was purified by column chromatography on silica gel.

## 2-Phenylbenzofuran (5a)<sup>3f</sup>

Prepared according to the general procedure from iodobenzene (274  $\mu\text{L}$ , 2.50 mmol). The crude product was purified by column chromatography on silica gel with hexanes to give **5a** as an off-white solid (377 mg, 1.94 mmol, 78%); mp 114–115 °C (Lit.<sup>3f</sup> mp 119–121 °C);  $R_f$  = 0.56 (hexanes).

IR (solid, ATR): 3048, 1561, 1455, 1256, 1019, 916, 805, 739, 686  $\text{cm}^{-1}$ .

$^1\text{H}$  NMR (250 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 7.78 (d,  $J$  = 7.8 Hz, 2 H), 7.49 (dd,  $J_1$  = 6.7 Hz,  $J_2$  = 1.4 Hz, 1 H), 7.44 (d,  $J$  = 8.1 Hz, 1 H), 7.36 (t,  $J$  = 7.5 Hz, 2 H), 7.26 (t,  $J$  = 7.5 Hz, 1 H), 7.21–7.09 (m, 2 H), 6.93 (s, 1 H).

$^{13}\text{C}$  NMR (62.5 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 156.1, 155.0, 130.6, 129.4, 128.9, 128.7, 125.1, 124.4, 123.1, 121.0, 111.3, 101.4.

MS (EI, 70 eV):  $m/z$  (%) = 194 (100), 165 (65), 139 (10), 115 (4), 97 (8), 82 (7), 63 (5), 51 (3).

## 2-(2-Methylphenyl)benzofuran (5b)<sup>20</sup>

Prepared according to the general procedure from 2-iodotoluene (318  $\mu\text{L}$ , 2.50 mmol). The crude product was purified by column chromatography on silica gel with hexanes/EtOAc (50:1) to give **5b** as a colorless oil (378 mg, 1.82 mmol, 73%);  $R_f$  = 0.37 (hexanes/EtOAc 10:1).

IR (thin film, ATR): 3512, 2956, 2924, 2853, 1575, 1492, 1462, 1289, 1252, 1194, 1066, 842, 747  $\text{cm}^{-1}$ .

$^1\text{H}$  NMR (250 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 7.35 (d,  $J$  = 7.3 Hz, 1 H), 7.28 (dd,  $J_1$  = 7.7 Hz,  $J_2$  = 1.5 Hz, 1 H), 7.15–6.98 (m, 5 H), 6.84 (d,  $J$  = 8.1 Hz, 1 H), 6.76 (t,  $J$  = 7.5 Hz, 1 H), 2.35 (s, 3 H).

$^{13}\text{C}$  NMR (62.5 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 156.5, 140.0, 132.0, 131.7, 130.5, 129.7, 129.0, 125.9, 122.3, 120.5, 114.8, 110.0, 95.5, 87.1, 21.0.

MS (EI, 70 eV):  $m/z$  (%) = 208 (100), 189 (32), 179 (40), 178 (68), 165 (31), 152 (26), 151 (13), 139 (12), 131 (12), 115 (25), 89 (18), 76 (11), 63 (11).

## Methyl 2-(*p*-Tolyl)benzofuran-6-carboxylate (5c)

Prepared according to the general procedure from 4-iodotoluene (109.0 mg, 0.50 mmol) and methyl 3-hydroxy-4-iodobenzoate (152.9 mg, 0.55 mmol, 1.10 equiv). The crude product was purified by column chromatography on silica gel with hexanes  $\rightarrow$  hexanes/EtOAc (10:1) to give an off-white solid (55.1 mg, 0.207 mmol, 41%); mp 139–141 °C,  $R_f$  = 0.50 (hexanes/EtOAc 5:1).

IR (thin film, ATR): 1711, 1504, 1439, 1301, 1230, 1199, 1126, 1081, 893, 846, 824, 803, 766, 744  $\text{cm}^{-1}$ .

$^1\text{H}$  NMR (250 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 8.03 (s, 1 H), 7.78 (dd,  $J_1$  = 8.2 Hz,  $J_2$  = 1.4 Hz, 1 H), 7.61 (d,  $J$  = 8.2 Hz, 2 H), 7.41 (d,  $J$  = 8.2 Hz, 1 H), 7.11 (d,  $J$  = 8.1 Hz, 2 H), 6.82 (s, 1 H), 3.79 (s, 3 H), 2.25 (s, 3 H).

$^{13}\text{C}$  NMR (62.5 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 167.7, 159.6, 154.5, 139.9, 134.1, 130.0, 127.4, 126.1, 125.6, 124.8, 120.6, 113.0, 101.0, 52.5, 21.9.

MS (EI, 70 eV):  $m/z$  (%) = 266 (100), 235 (82), 207 (24), 178 (26), 163 (6), 152 (11), 133 (4), 117 (18), 103 (4), 89 (11), 76 (10), 63 (5).

HRMS:  $m/z$  [M]<sup>+</sup> calcd for  $\text{C}_{17}\text{H}_{14}\text{O}_3$ : 266.0943; found: 266.0944.

## 2-(4-Methylphenyl)benzofuran (5d)<sup>21</sup>

Prepared according to the general procedure from 4-iodotoluene (545.1 mg, 2.50 mmol). The crude product was purified by column chromatography on silica gel with hexanes/EtOAc (25:1) to give **5d** as a white solid (297 mg, 1.43 mmol, 57%); mp 124–125 °C (Lit.<sup>21</sup> mp 126–128 °C);  $R_f$  = 0.63 (hexanes/EtOAc 10:1).

IR (thin film, ATR): 3027, 2912, 1506, 1454, 1258, 1208, 1173, 1113, 1035, 1016, 919, 885, 826, 802, 749, 740  $\text{cm}^{-1}$ .

$^1\text{H}$  NMR (250 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 7.80 (d,  $J$  = 8.2 Hz, 2 H), 7.65–7.51 (m, 2 H), 7.37–7.20 (m, 4 H), 7.00 (d,  $J$  = 0.9 Hz, 1 H), 2.43 (s, 3 H).

$^{13}\text{C}$  NMR (62.5 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 156.6, 155.2, 139.0, 129.9, 129.8, 128.1, 125.3, 124.4, 123.3, 121.2, 111.5, 101.0, 21.8.

MS (EI, 70 eV):  $m/z$  (%) = 208 (100), 207 (29), 178 (22), 165 (23), 152 (10), 139 (5), 89 (9), 76 (6), 63 (6).

## 2-(4-Nitrophenyl)benzofuran (5e)<sup>3d</sup>

Prepared according to the general procedure from 1-iodo-4-nitrobenzene (498 mg, 2.00 mmol) on a 2 mmol scale. The crude product was purified by column chromatography on silica gel with hexanes/EtOAc (20:1) to give **5e** as bright yellow crystals (332 mg, 1.39 mmol, 69%); mp 138–140 °C (EtOH) (Lit.<sup>3d</sup> mp 181–183 °C);  $R_f$  = 0.56 (hexanes/EtOAc 7:1).

IR (solid, ATR): 1601, 1575, 1514, 1446, 1339, 1305, 1278, 1180, 1110, 1029, 921, 850, 810, 751, 687  $\text{cm}^{-1}$ .

$^1\text{H}$  NMR (250 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 8.16 (d,  $J$  = 8.6 Hz, 2 H), 7.84 (d,  $J$  = 8.6 Hz, 2 H), 7.50 (d,  $J$  = 7.5 Hz, 1 H), 7.41 (d,  $J$  = 8.0 Hz, 1 H), 7.23 (t,  $J$  = 7.5 Hz, 1 H), 7.14 (t,  $J$  = 7.5 Hz, 1 H), 7.09 (s, 1 H); traces of EtOH observed.

$^{13}\text{C}$  NMR (62.5 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 155.5, 153.4, 147.3, 136.4, 128.8, 126.0, 125.3, 124.4, 123.7, 121.8, 111.6, 105.2.

MS (EI, 70 eV):  $m/z$  (%) = 239 (82), 209 (30), 192 (6), 181 (29), 165 (100), 163 (36), 152 (13), 139 (20), 115 (11), 87 (7), 75 (6), 63 (11).

## 2-(2-Chlorophenyl)benzofuran (5f)<sup>21</sup>

Prepared according to the general procedure from 1-chloro-2-iodobenzene (305  $\mu\text{L}$ , 2.50 mmol). The crude product was purified by column chromatography on silica gel with hexanes/EtOAc (50:1) to afford **5f** as a slightly yellow solid (324 mg, 1.55 mmol, 57%) ■■48% in *Sch5* ■■; mp 51–53 °C (Lit.<sup>21</sup> mp 47–48 °C);  $R_f$  = 0.77 (hexanes/EtOAc 9:1).

IR (solid, ATR): 2927, 1573, 1471, 1454, 1427, 1313, 1260, 1210, 1175, 1075, 1019, 924, 889, 812, 746, 726  $\text{cm}^{-1}$ .

$^1\text{H}$  NMR (250 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 7.96 (dd,  $J_1$  = 7.9 Hz,  $J_2$  = 1.6 Hz, 1 H), 7.54 (dd,  $J_1$  = 7.5 Hz,  $J_2$  = 0.7 Hz, 1 H), 7.47–7.36 (m, 3 H), 7.32–7.25 (m, 1 H), 7.25–7.11 (m, 3 H).

$^{13}\text{C}$  NMR (62.5 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 154.3, 152.0, 131.4, 131.0, 129.2, 129.1, 127.1, 125.0, 123.1, 121.6, 111.2, 107.5.

MS (EI, 70 eV):  $m/z$  (%) = 228 (100) (M<sup>+</sup>), 199 (6), 165 (80), 139 (10), 126 (3), 114 (9), 99 (4), 89 (3), 82 (10), 74 (5), 63 (9).

### 2-(4-Chlorophenyl)benzofuran (5g)<sup>22</sup>

Prepared according to the general procedure from 1-chloro-4-iodobenzene (596.2 mg, 2.50 mmol). The crude product was purified by column chromatography on silica gel with hexanes/EtOAc (50:1) to afford **5g** as a white solid (355 mg, 1.55 mmol, 62%); mp 150–151 °C (Lit.<sup>22</sup> mp 144–145 °C);  $R_f$  = 0.50 (hexanes).

IR (solid, ATR): 3082, 1579, 1483, 1448, 1404, 1090, 1031, 801, 747 cm<sup>-1</sup>.

<sup>1</sup>H NMR (250 MHz, CDCl<sub>3</sub>):  $\delta$  = 7.71 (d,  $J$  = 7.9 Hz, 2 H), 7.51 (d,  $J$  = 6.9 Hz, 1 H), 7.45 (d,  $J$  = 7.8 Hz, 1 H), 7.34 (d,  $J$  = 7.9 Hz, 2 H), 7.25–7.12 (m, 2 H), 6.93 (s, 1 H).

<sup>13</sup>C NMR (62.5 MHz, CDCl<sub>3</sub>):  $\delta$  = 155.0, 154.9, 134.4, 129.24, 129.16, 129.11, 126.3, 124.7, 123.2, 121.1, 111.3, 101.9.

MS (EI, 70 eV):  $m/z$  (%) = 230 (32), 229 (15), 199 (7), 173 (3), 165 (69), 163 (21), 139 (8), 126 (3), 114 (12), 99 (2), 82 (10), 75 (6), 63 (7), 50 (3).

### 3-(Benzofuran-2-yl)pyridine (5h)<sup>23</sup>

Prepared according to the general procedure from 3-iodopyridine (512.5 mg, 2.50 mmol). The crude product was purified by column chromatography on silica gel with hexanes/EtOAc (2:1) to give **5h** as a yellow solid (258 mg, 1.32 mmol, 53%); mp 75–76 °C (Lit.<sup>23</sup> mp 80 °C);  $R_f$  = 0.65 (hexanes/EtOAc, 1:1).

IR (solid, ATR): 3055, 1581, 1449, 1428, 1348, 1256, 1165, 1012, 919, 798, 747, 703 cm<sup>-1</sup>.

<sup>1</sup>H NMR (250 MHz, CDCl<sub>3</sub>):  $\delta$  = 9.02 (d,  $J$  = 1.7 Hz, 1 H), 8.48 (d,  $J$  = 4.6 Hz, 1 H), 8.01 (d,  $J$  = 8.0 Hz, 1 H), 7.51 (d,  $J$  = 7.5 Hz, 1 H), 7.45 (d,  $J$  = 7.9 Hz, 1 H), 7.31–7.09 (m, 3 H), 7.01 (s, 1 H).

<sup>13</sup>C NMR (62.5 MHz, CDCl<sub>3</sub>):  $\delta$  = 155.2, 153.0, 149.4, 146.5, 131.9, 128.9, 126.7, 125.0, 123.7, 123.4, 121.3, 111.4, 102.8.

MS (EI, 70 eV):  $m/z$  (%) = 195 (100), 167 (10), 166 (26), 140 (16), 139 (32), 113 (5), 87 (5), 63 (7).

### Ethyl 4-(Benzofuran-2-yl)benzoate (5i)<sup>24</sup>

Prepared according to the general procedure from ethyl 4-iodobenzoate (84.1  $\mu$ L, 0.50 mmol) and 2-iodophenol (121.0 mg, 0.55 mmol). The crude product was purified by column chromatography on silica gel with hexanes/EtOAc (0:1  $\rightarrow$  25:1) to give **5i** as white crystals (91.7 mg, 0.345 mmol, 69%) ■■■57% in *Sch5*■; mp 109–111 °C (Lit.<sup>24</sup> mp not given);  $R_f$  = 0.58 (hexanes/EtOAc 5:1).

IR (thin film, ATR): 1711, 1612, 1452, 1413, 1370, 1277, 1186, 1107, 1033, 1018, 923, 856, 809, 772, 749, 697 cm<sup>-1</sup>.

<sup>1</sup>H NMR (250 MHz, CDCl<sub>3</sub>):  $\delta$  = 7.98 (dd,  $J_1$  = ■■?■ Hz,  $J_2$  = ■■?■ Hz, 2 H), 7.78 (d,  $J$  = 8.5 Hz, 2 H), 7.44 (dd,  $J_1$  = 16.7 Hz,  $J_2$  = 7.9 Hz, 2 H), 7.25–7.06 (m, 1 H), 7.00 (s, 1 H), 4.27 (q,  $J$  = 7.1 Hz, 2 H), 1.28 (t,  $J$  = 7.1 Hz, 3 H).

<sup>13</sup>C NMR (62.5 MHz, CDCl<sub>3</sub>):  $\delta$  = 166.3, 155.3, 154.8, 134.5, 130.2, 130.2, 129.0, 125.2, 124.7, 123.3, 121.4, 111.5, 103.5, 61.2, 14.5.

MS (EI, 70 eV):  $m/z$  (%) = 267 (18), 266 (100), 238 (55), 221 (66), 193 (13), 165 (71), 163 (24), 139 (13), 110 (11), 82 (14), 69 (5).

### Ethyl 4-(6-Chlorobenzofuran-2-yl)benzoate (5j)

Prepared according to the general procedure from ethyl 4-iodobenzoate (84.1  $\mu$ L, 0.50 mmol) and 5-chloro-2-iodophenol (139.9 mg, 0.55 mmol, 1.10 equiv). The crude product was purified by column chromatography on silica gel with hexanes  $\rightarrow$  hexanes/EtOAc (10:1) to give **5j** as a light yellow solid (123.4 mg, 0.410 mmol, 82%) ■■■62% in *Sch5*■; mp 141–143 °C;  $R_f$  = 0.55 (hexanes/EtOAc 5:1).

IR (thin film, ATR): 1715, 1611, 1465, 1445, 1409, 1368, 1310, 1283, 1184, 1167, 1113, 1066, 1016, 926, 878, 857, 809, 772, 742, 695 cm<sup>-1</sup>.

<sup>1</sup>H NMR (250 MHz, CDCl<sub>3</sub>):  $\delta$  = 7.97 (d,  $J$  = 8.3 Hz, 2 H), 7.74 (d,  $J$  = 8.2 Hz, 2 H), 7.42 (d,  $J$  = 2.1 Hz, 1 H), 7.30 (d,  $J$  = 8.7 Hz, 1 H), 7.19–7.05 (m, 1 H), 6.92 (s, 1 H), 4.27 (q,  $J$  = 7.1 Hz, 2 H), 1.29 (t,  $J$  = 7.1 Hz, 3 H).

<sup>13</sup>C NMR (62.5 MHz, CDCl<sub>3</sub>):  $\delta$  = 166.2, 156.2, 153.6, 133.9, 130.6, 130.4, 130.2, 128.9, 125.3, 124.8, 120.9, 112.4, 102.9, 61.3, 14.5.

MS (EI, 70 eV):  $m/z$  (%) = 302 (34), 300 (100), 272 (49), 255 (79), 244 (8), 199 (31), 163 (51), 127 (13), 96 (12), 82 (10), 63 (5).

HRMS:  $m/z$  [M]<sup>+</sup> calcd for C<sub>17</sub>H<sub>13</sub>ClO<sub>3</sub><sup>+</sup>: 300.0553; found: 300.0548.

### Ethyl 4-(5-Fluorobenzofuran-2-yl)benzoate (5k)

Prepared according to the general procedure from ethyl 4-iodobenzoate (84.1  $\mu$ L, 0.50 mmol) and 4-fluoro-2-iodophenol (130.9 mg, 0.55 mmol, 1.10 equiv). The crude product was purified by column chromatography on silica gel with hexanes  $\rightarrow$  hexanes/EtOAc (10:1) to give a light yellow solid (67.2 mg, 0.236 mmol, 47%) ■■■53% in *Sch5*■; mp 119–120 °C;  $R_f$  = 0.53 (hexanes/EtOAc 5:1).

IR (solid, ATR): 1715, 1612, 1465, 1411, 1277, 1212, 1195, 1113, 1036, 917, 859, 818, 803, 768, 738, 695 cm<sup>-1</sup>.

<sup>1</sup>H NMR (250 MHz, CDCl<sub>3</sub>):  $\delta$  = 8.11 (d,  $J$  = 8.1 Hz, 2 H), 7.88 (d,  $J$  = 8.0 Hz, 2 H), 7.52–6.93 (m, 4 H), 4.41 (q,  $J$  = 6.9 Hz, 4 H), 1.42 (t,  $J$  = 7.0 Hz, 3 H).

<sup>13</sup>C NMR (62.5 MHz, CDCl<sub>3</sub>):  $\delta$  = 166.5, 156.8, 151.7, 134.3, 130.7, 130.5, 130.0 (d,  $J$  = 11.1 Hz), 125.0, 113.1 (d,  $J$  = 26.3 Hz), 112.4 (d,  $J$  = 9.5 Hz), 107.0 (d,  $J$  = 25.2 Hz), 103.8 (d,  $J$  = 4.1 Hz), 61.5, 14.7.

<sup>19</sup>F NMR (235 MHz, CDCl<sub>3</sub>):  $\delta$  = -120.4.

MS (EI, 70 eV):  $m/z$  (%) = 284 (100), 256 (53), 239 (89), 211 (13), 183 (75), 157 (12), 133 (8), 119 (13), 105 (6), 92 (17), 73 (5), 63 (3).

HRMS:  $m/z$  [M]<sup>+</sup> calcd for C<sub>17</sub>H<sub>13</sub>FO<sub>3</sub><sup>+</sup>: 284.0849; found: 284.0843.

### Substituted Benzyl Azides; General Procedure

Substituted benzyl azide derivatives were synthesized according to the literature.<sup>25,26</sup>

The appropriate benzylamine (10 mmol, 1.0 equiv) was dissolved in acetone (30 mL), then an aq solution of NaN<sub>3</sub> (2.5 g, 10 mmol, 2.0 equiv in 10 mL distilled H<sub>2</sub>O) was added carefully. The mixture was stirred at r.t. overnight (monitored by TLC). The organic solvent was evaporated under reduced pressure, then the aqueous layer was extracted with hexanes (3  $\times$  20 mL). The combined organic layers were dried (Na<sub>2</sub>SO<sub>4</sub>), filtered, and the solvent was removed under reduced pressure.

Their spectral data (<sup>1</sup>H, <sup>13</sup>C NMR, MS, IR) were in agreement with the literature.<sup>25,26</sup>

### 4-Aryl-1-benzyl-1H-1,2,3-triazoles; General Procedure

PdCl<sub>2</sub>(PPh<sub>3</sub>)<sub>2</sub> (21.1 mg, 0.03 mmol, 3 mol%), CuI (5.7 mg, 0.03 mmol, 3 mol%), and the appropriate aryl iodide (1.00 mmol, 1.00 equiv, if solid) were placed in a round-bottomed flask. The flask was sealed with a rubber septum, evacuated, and filled with argon. *i*-Pr<sub>2</sub>NH (4 mL)

was added to the flask followed by the addition of the appropriate aryl iodide (1.00 mmol, 1.00 equiv, if liquid). Ethynyltrimethylsilane (156  $\mu\text{L}$ , 1.10 mmol, 1.10 equiv) was added dropwise to the reaction mixture, then the mixture was stirred under an argon atmosphere at r.t. for 30 min (monitored by TLC). The corresponding benzyl azide (125  $\mu\text{L}$ , 1.00 mmol, 1.00 equiv) was added to the mixture followed by the dropwise addition of  $\text{H}_2\text{SiF}_6$  (162  $\mu\text{L}$ , 0.50 mmol, 0.50 equiv, 34% w/w aq solution). The mixture was stirred under an argon atmosphere at r.t. for 12 h. The mixture was diluted with  $\text{CH}_2\text{Cl}_2$  (10 mL) and poured into distilled  $\text{H}_2\text{O}$  (20 mL). The layers were separated and the aqueous layer was further extracted with  $\text{CH}_2\text{Cl}_2$  ( $3 \times 10$  mL). The combined organic layers were washed with distilled  $\text{H}_2\text{O}$  ( $2 \times 10$  mL), dried ( $\text{MgSO}_4$ ), and concentrated under reduced pressure. The crude product was purified by column chromatography on silica gel.

#### 1-Benzyl-4-(*o*-tolyl)-1*H*-1,2,3-triazole (**6a**)<sup>8f</sup>

Prepared according to the general procedure from 2-iodotoluene (127  $\mu\text{L}$ , 1 mmol). The crude product was purified by column chromatography on silica gel with hexanes/EtOAc (5:1) to give **6a** as white crystals (117 mg, 0.469 mmol, 47%); mp 102–103 °C (Lit.<sup>8f</sup> mp not given);  $R_f$  = 0.74 (hexanes/EtOAc 1:1).

IR (solid, ATR): 1484, 1454, 1442, 1338, 1223, 1208, 1181, 1073, 1049, 977, 824, 769, 735, 708  $\text{cm}^{-1}$ .

<sup>1</sup>H NMR (250 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 7.66 (dt,  $J_1$  = 4.5 Hz,  $J_2$  = 2.5 Hz, 1 H), 7.49 (s, 1 H), 7.34–7.26 (m, 3 H), 7.26–7.19 (m, 2 H), 7.17 (d,  $J$  = 3.0 Hz, 3 H), 5.52 (s, 2 H), 2.35 (s, 3 H).

<sup>13</sup>C NMR (62.5 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 147.6, 135.6, 134.9, 131.0, 129.9, 129.3, 129.0, 128.9, 128.3, 128.1, 126.2, 121.8, 54.3, 21.5.

MS (EI, 70 eV):  $m/z$  (%) = 249 (18), 220 (27), 206 (10), 179 (8), 130 (97), 104 (23), 91 (100), 77 (26), 63 (7), 51 (8).

#### 1-Benzyl-4-(*m*-tolyl)-1*H*-1,2,3-triazole (**6b**)<sup>8a</sup>

Prepared according to the general procedure from 3-iodotoluene (155  $\mu\text{L}$ , 1.00 mmol). The crude product was purified by column chromatography on silica gel with hexanes/EtOAc (5:1) to give **6b** as a light brown solid (105 mg, 0.421 mmol, 42%); mp 148–149 °C (Lit.<sup>8a</sup> mp 144–146 °C);  $R_f$  = 0.78 (hexanes/EtOAc 1:1).

IR (solid, ATR): 3512, 3141, 3033, 2924, 2854, 1589, 1493, 1449, 1346, 1218, 1049, 844, 780, 717  $\text{cm}^{-1}$ .

<sup>1</sup>H NMR (250 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 7.57 (s, 1 H), 7.56 (s, 1 H), 7.48 (d,  $J$  = 7.7 Hz, 1 H), 7.32–7.26 (m, 3 H), 7.25–7.15 (m, 3 H), 7.04 (d,  $J$  = 7.6 Hz, 1 H), 5.48 (s, 2 H), 2.29 (s, 3 H).

<sup>13</sup>C NMR (62.5 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 148.5, 138.6, 134.9, 130.5, 129.3, 129.0, 128.9, 128.8, 128.2, 126.5, 122.9, 119.6, 54.3, 21.5.

MS (EI, 70 eV):  $m/z$  (%) = 249 (9), 220 (33), 206 (7), 179 (11), 130 (100), 115 (8), 103 (17), 91 (82), 77 (19), 65 (19), 51 (8).

#### 1-Benzyl-4-(4-chlorophenyl)-1*H*-1,2,3-triazole (**6c**)<sup>8f</sup>

Prepared according to the general procedure from 1-chloro-4-iodobenzene (238.7 mg, 1.00 mmol) and benzyl azide (125  $\mu\text{L}$ , 1.00 mmol). The product was purified by column chromatography on silica gel with hexanes/EtOAc (3:1). The product was obtained as an off-white solid (192 mg, 0.712 mmol, 71%); mp 140–142 °C (Lit.<sup>8f</sup> mp not given);  $R_f$  = 0.08 (hexanes/EtOAc 7:1).

IR (solid, ATR): 3122, 3067, 2949, 1479, 1449, 1338, 1184, 1090, 1051, 975, 811, 698  $\text{cm}^{-1}$ .

<sup>1</sup>H NMR (250 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 7.62 (d,  $J$  = 8.6 Hz, 2 H), 7.57 (s, 1 H), 7.33–7.25 (m, 4 H), 7.25–7.16 (m, 3 H), 5.45 (s, 2 H).

<sup>13</sup>C NMR (62.5 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 147.2, 134.6, 133.9, 129.4, 129.13, 129.05, 128.9, 128.2, 127.0, 119.7, 54.3.

MS (EI, 70 eV):  $m/z$  (%) = 269 (8), 240 (29), 206 (14), 179 (21), 152 (29), 150 (89), 125 (10), 123 (27), 104 (16), 91 (100), 75 (7), 65 (25), 51 (8).

#### 1-[4-(1-Benzyl-1*H*-1,2,3-triazol-4-yl)phenyl]ethanone (**6d**)<sup>8a</sup>

Prepared according to the general procedure from 4-iodoacetophenone (246.0 mg, 1.00 mmol) and benzyl azide (125  $\mu\text{L}$ , 1.00 mmol). The product was purified by column chromatography on silica gel with hexanes/EtOAc (1:1). The product was obtained as colorless crystals (229 mg, 0.826 mmol, 83%); mp 154–156 °C (Lit.<sup>8a</sup> mp 160–162 °C);  $R_f$  = 0.50 (hexanes/EtOAc 1:1).

IR (solid, ATR): 1673, 1610, 1497, 1456, 1433, 1412, 1358, 1277, 1260, 1226, 1194, 1047, 955, 819, 712  $\text{cm}^{-1}$ .

<sup>1</sup>H NMR (250 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 7.97 (d,  $J$  = 8.5 Hz, 2 H), 7.88 (d,  $J$  = 8.5 Hz, 2 H), 7.77 (s, 1 H), 7.43–7.34 (m, 3 H), 7.34–7.28 (m, 2 H), 5.58 (s, 2 H), 2.59 (s, 3 H).

<sup>13</sup>C NMR (62.5 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 197.6, 147.1, 136.5, 135.1, 134.5, 129.3, 129.1, 129.0, 128.2, 125.7, 120.6, 54.4, 26.7.

MS (EI, 70 eV):  $m/z$  (%) = 277 (8), 248 (25), 206 (23), 179 (11), 158 (88), 115 (15), 91 (100), 65 (21).

#### 1-(4-Bromobenzyl)-4-(thiophen-2-yl)-1*H*-1,2,3-triazole (**6e**)

Prepared according to the general procedure from 2-iodothiophene (55.2  $\mu\text{L}$ , 0.50 mmol, 1.0 equiv) and 4-bromobenzyl azide (106.0 mg, 0.50 mmol). The product was purified by column chromatography on silica gel with hexanes/EtOAc (3:1). The product was obtained as light brown solid (79.3 mg, 0.248 mmol, 50%); mp 140–142 °C;  $R_f$  = 0.38 (hexanes/EtOAc 2:1).

IR (solid, ATR): 1590, 1491, 1456, 1428, 1407, 1223, 1180, 1074, 1046, 1014, 940, 844, 822, 802, 757, 718, 690  $\text{cm}^{-1}$ .

<sup>1</sup>H NMR (250 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 7.62–7.46 (m, 3 H), 7.38–7.01 (m, 4 H), 5.51 (s, 2 H) (solvent residual peak was overlapped with aromatic region).

<sup>13</sup>C NMR (62.5 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 143.8, 133.9, 132.7, 130.1, 128.0, 125.6, 124.7, 123.4, 119.3, 100.4, 54.0.

MS (EI, 70 eV):  $m/z$  (%) = 321 (10), 319 (10), 292 (34), 290 (34), 212 (61), 207 (32), 193 (12), 185 (28), 171 (49), 169 (48), 147 (14), 136 (11), 122 (100), 108 (10), 95 (30), 89 (49), 73 (39), 69 (24), 63 (19).

HRMS:  $m/z$  [ $M + H$ ]<sup>+</sup> calcd for  $\text{C}_{13}\text{H}_{11}\text{BrN}_3\text{S}^+$ : 319.9779; found: 319.9843.

#### 1-(4-Bromobenzyl)-4-(naphthalen-1-yl)-1*H*-1,2,3-triazole (**6f**)

Prepared according to the general procedure from 1-iodonaphthalene (73.0  $\mu\text{L}$ , 0.5 mmol, 1.0 equiv) and 4-bromobenzyl azide (106.0 mg, 0.50 mmol). The product was purified by column chromatography on silica gel with hexanes/EtOAc (3:1  $\rightarrow$  1:1). The product was obtained as an off-white solid (133.4 mg, 0.366 mmol, 73%); mp 70–72 °C;  $R_f$  = 0.23 (hexanes/EtOAc 2:1).

IR (solid, ATR): 1607, 1568, 1521, 1348, 1230, 1072, 1048, 859, 785, 744, 721, 686  $\text{cm}^{-1}$ .

<sup>1</sup>H NMR (250 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 8.25 (dd,  $J_1$  = 6.3 Hz,  $J_2$  = 3.5 Hz, 1 H), 7.84–7.74 (m, 2 H), 7.66 (s, 1 H), 7.63–7.57 (m, 1 H), 7.42 (td,  $J_1$  = 8.1 Hz,  $J_2$  = 5.0 Hz, 5 H), 7.15 (d,  $J$  = 8.2 Hz, 2 H), 5.51 (s, 2 H).

<sup>13</sup>C NMR (62.5 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 147.5, 134.0, 133.7, 132.5, 131.1, 129.9, 129.2, 128.6, 127.7, 127.4, 126.8, 126.2, 125.4, 125.4, 123.1, 122.6, 53.8.

MS (EI, 70 eV): Not recordable; decomposed, probably in injector.

HRMS:  $m/z$   $[M + H]^+$  calcd for  $C_{19}H_{15}BrN_3^+$ : 364.0449; found: 364.0453.

#### 4-(3-Bromophenyl)-1-(4-nitrobenzyl)-1H-1,2,3-triazole (6g)

Prepared according to the general procedure from 3-bromiodobenzene (63.7  $\mu$ L, 0.5 mmol, 1.0 equiv) and 4-nitrobenzyl azide (89.1 mg, 0.50 mmol). The product was purified by column chromatography on silica gel with hexanes/EtOAc (3:1  $\rightarrow$  1:1). The product was obtained as a light brown solid (133.4 mg, 0.366 mmol, 73%); mp 90–93 °C;  $R_f$  = 0.60 (hexanes/EtOAc 1:1).

IR (solid, ATR): 1592, 1506, 1489, 1432, 1409, 1396, 1351, 1260, 1223, 1115, 1072, 1051, 1012, 947, 800, 777, 755  $cm^{-1}$ .

$^1H$  NMR (250 MHz,  $CDCl_3$ ):  $\delta$  = 8.22 (d,  $J$  = 8.5 Hz, 2 H), 7.95 (s, 1 H), 7.76 (d,  $J$  = 15.3 Hz, 2 H), 7.44 (d,  $J$  = 8.0 Hz, 3 H), 7.32–7.23 (m, 1 H), 5.70 (s, 2 H).

$^{13}C$  NMR (62.5 MHz,  $CDCl_3$ ):  $\delta$  = 148.2, 147.3, 141.6, 132.2, 131.5, 130.6, 128.8, 128.7, 124.5, 124.4, 123.1, 120.3, 53.4.

MS (EI, 70 eV):  $m/z$  (%) = 365 (5), 363 (5), 334 (20), 256 (11), 180 (10), 169 (32), 166 (100), 139 (50), 127 (8), 90 (26), 63 (8).

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## Supporting Information

Supporting information for this article is available online at <http://dx.doi.org/10.1055/s-0036-1588981>.

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