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Pseudo-Multicomponent Reactions of Arynes with *N*-Aryl Imines

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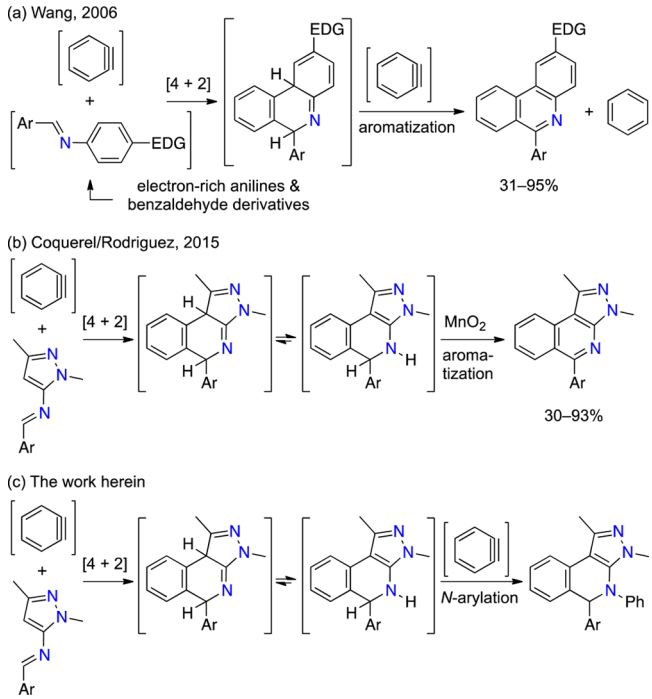
Supporting Information

ABSTRACT: Pseudo-three-component reactions are described for the conversion of simple *N*-aryl imines into 1,2-dihydroisoquinoline-type products. The approach relies on a regioselective cascade reaction involving two equivalents of the aryne component iteratively as a dienophile and as an electrophile. Some examples of related, more complex pseudo-four-component cascade processes are also reported.

Multicomponent reactions (MCRs) designate reactions in which three or more reactants introduced simultaneously are combined through covalent bonds to form a single product regardless of the mechanisms and protocols involved.[1] MCRs are now firmly established as useful synthetic tools for the rapid preparation of collections of compounds. When two of the three (or more) components are identical, the processes are better described as pseudo-MCRs. These processes are actually quite common, often undesired, and usually revealed by the analysis of the minor over-reaction products of a chemical reaction. This situation is particularly true for transformations involving reactive substrates or intermediates. Although the incorporation of two identical components in the product of a pseudo-MCR is certainly a severe limitation in terms of scope and functional flexibility, these transformations do have the advantage of being very time-efficient, allowing for the rapid, sometimes spectacular, generation of molecular complexity. Particularly valuable are pseudo-MCRs involving successive but distinct and complementary reactivities of the same component. The Hantzsch dihydropyridine synthesis is a famous historical example of this concept.[2] Arynes are in situ-generated reactive intermediates particularly prone to the serendipitous discovery of valuable pseudo-MCRs.[3] In most known cases, pseudo-MCRs with arynes are initiated by a formal or true [4 + 2] or [2 + 2] cycloaddition followed by another pericyclic reaction or more often by a net arylation step.[4] For the present work, and in the context of our interest in the applications of reactive intermediates to the discovery and development of multiple bond-forming transformations (MBFTs),[5] it was questioned if related transformations could occur from functionalized 2-aza-dienes to access *N*-arylated 1,2-dihydroisoquinoline-type products, a class of heterocycles with interesting biological properties.[6] In 2006, Wang and co-workers reported a three-component reaction for the preparation of phenanthridines involving an imination/aza-Diels–Alder/aromatization sequence from electron-enriched anilines, benzaldehyde derivatives, and benzyne (Scheme 1a).[7] The procedure requires two equivalents of benzyne generated in situ from benzenediazonium-2-carboxylate: the first equivalent reacts with the *N*-phenyl imine generated in situ to form the intermediate aza-Diels–Alder adduct, and it was reasonably postulated that the second equivalent is responsible for a 1,4-dehydrogenative aromatization step affording the phenanthridine product together with coproduction of benzene. The reaction worked best with polarized 2-aza-diene substrates ("push–pull" systems). We have recently examined the aryne

Scheme 1. Aryne Aza-Diels–Alder Reaction with 2-Aza-Dienes[a]



[a]EDG = electron-donating group.

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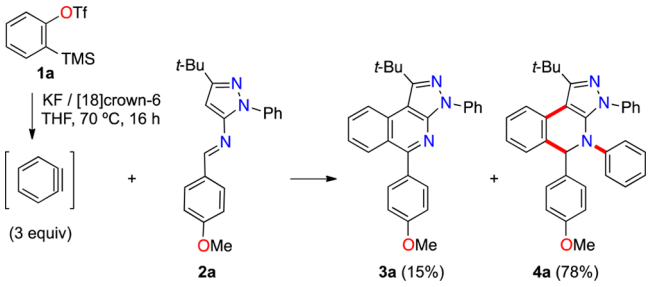
aza-Diels–Alder reaction for the synthesis of functionalized isoquinolines using electron-rich *N*-heteroaryl imines.[8] During this work, a significant difference of reactivity was observed, and an additional oxidant, manganese dioxide for instance, was necessary to achieve the final 1,2-dehydrogenative aromatization efficiently (Scheme 1b). We have found that the resulting 1,2-dihydroisoquinoline intermediate reacts with an excess of aryne to afford the *N*-arylated 1,2-dihydroisoquinoline product in an overall efficient pseudo-three-component process involving the formation of three covalent bonds (Scheme 1c). On the basis of this observation, we describe herein a series of pseudo-three- and pseudo-four-component reactions for the preparation of heteropolycyclic products with a 1,2-dihydroisoquinoline core.

The reaction of the model *N*-pyrazolyl aldimine **2a** with three equivalents of benzyne, generated by fluoride-induced 1,2-elimination from the *o*-silylated phenyltriflate (**1a**)[9] in THF afforded the expected *N*-phenyl-1,2-dehydroisoquinoline product **4a** in good yield (78%) together with the isoquinoline side-product **3a** (Scheme 2). The latter most probably resulted from

Scheme 2. Pseudo-Multicomponent Reaction of Benzyne with an *N*-Aryl Imine



the oxidation of the intermediate aza-Diels–Alder cycloadduct with benzyne according to Wang's hypothesis.[7a] The pseudo-three-component reaction was successfully generalized to a series of diversely substituted *N*-pyrazolyl aldimines and electron-rich *N*-phenyl aldimines to afford the corresponding *N*-aryl 1,2-dehydroisoquinoline products **4b–p** (Figure 1). Notably, substituted arynes could be used with good regioselectivity with nonsymmetric ones: product **4l** was obtained as a single regioisomer, whereas product **4m** was obtained as a 7:1 mixture of regioisomers. The structures of products **4e** and **4l** could be confirmed by X-ray diffraction techniques.[10] With electron-rich *N*-phenyl aldimines, the reaction afforded the *N*-phenyl-5,6-dihydrophenanthridine products **4n–p**. Interestingly, in the case of product **4n**, the result is in apparent contradiction with the earlier result reported by Wang, who instead isolated the corresponding phenanthridine in 43% yield (Scheme 1a).[7a] In agreement with Wang's work, the NMR analysis of the crude reaction mixture showed that the corresponding phenanthridine was formed in 44% yield together with the pseudo-three-component product **4n** (48%). Notably, the different aryne generation methods used in the two studies afforded very similar results in this case. This example appears as a border case for both reactivities and allows for the understanding of some of the factors governing the fate of the reaction: in the presence of excess aryne, "push–pull" *N*-aryl aldimines react preferentially following an aza-Diels–Alder/aromatization sequence, whereas more electron-rich systems undergo an *N*-arylation after the pericyclic event. More generally, our work on the aryne aza-Diels–Alder

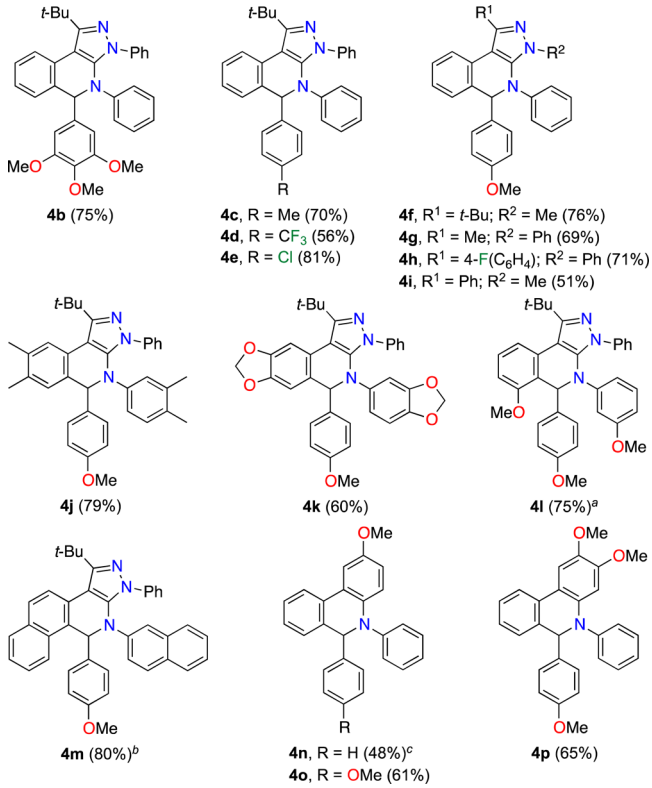


Figure 1. Scope of the Pseudo-MCR. All reactions were performed with 3 equiv of the aryne precursor using KF/[18]crown-6 (4.8 equiv) at 70 °C in THF for 12–48 h. (a) Isolated as a single regioisomer. (b) Isolated as a 7:1 mixture of two regioisomers. (c) The corresponding phenanthridine was also formed in 44% yield.

reaction with 2-aza-dienes indicates that the periselectivity ([4 + 2] vs [2 + 2]) of the cycloaddition between 2-aza-dienes and arynes is governed by the relative nucleophilicities of the nitrogen atom and the *N*-aryl moiety with electron-enriched *N*-(hetero)aryl moieties favoring the aza-Diels–Alder reaction rather than the competitive formal [2 + 2] cycloaddition.[8] The final outcome of the reaction after the aza-Diels–Alder pericyclic event is dictated by the electronics of the imine moiety: "push–pull" aldimines preferentially undergo 1,4-dehydrogenation with the excess aryne, whereas 1,2-dihydroisoquinoline intermediates derived from electron-rich aldimines undergo *N*-arylation to a greater extent.

In a more challenging version of the reaction, the *N*-pyrazolyl ketimine derived from *N*-benzyl isatin afforded the spirooxindole product **4q** exhibiting an original ring system. In this case, functionalization at the nitrogen atom of the intermediate dihydroisoquinoline occurred with incorporation of a molecule of THF in a pseudo-four-component process with the formation of four covalent bonds (Scheme 3).[11] The standard *N*-arylation reactivity was recovered when the reaction was performed in acetonitrile instead of THF to give spirooxindole product **4r**. However, with an *N*-pyrazolyl cyclopentanoneimine capable of enamine equilibration, the aza-Diels–Alder product was not observed and triple arylation occurred as in product **5**. Finally, the reaction of excess benzyne with the *N*-pyrrolyl aldimine **2o** afforded product **6** incorporating three benzyne units, probably through a regioselective aza-Diels–Alder/*N*-arylation/Diels–Alder/ring fragmentation cascade[12] allowing the formation of five covalent bonds via the

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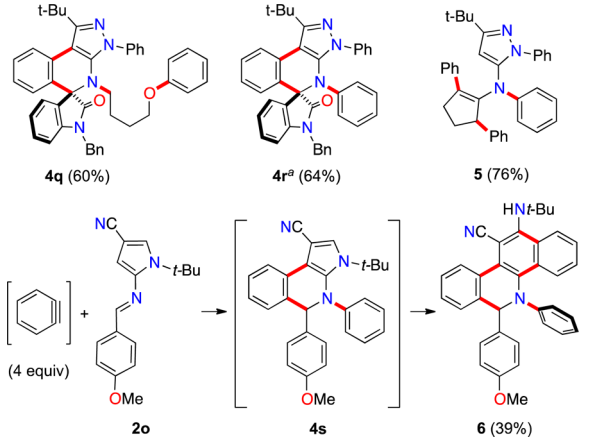
Scheme 3. Pseudo-Four-Component Sequences Involving the Aryne Aza-Diels–Alder Reaction



[a]Reaction performed in acetonitrile.

intermediate **4s** (Scheme 3). The structure of **6** could be secured by X-ray diffraction analysis.[10]

In summary, electron-rich 2-aza-dienes react with excess arynes following an aza-Diels–Alder/*N*-arylation reaction sequence, thereby providing a time-efficient pseudo-three-component entry to various functionalized heterocycles with an *N*-aryl 1,2-dihydroisoquinoline core. This approach adds to the arsenal of disconnections for 1,2-substituted 1,2-dihydroisoquinolines.[6a] On the basis of this reactivity, some more complex cascade reactions are also possible for the controlled assembly of up to four components and the formation of up to five covalent bonds in the process. The reactions described herein further illustrate the potential of reactive intermediates, especially arynes, for the discovery and development of multiple bond-forming transformations (MBFTs).

EXPERIMENTAL SECTION

General Methods. Reactions were carried out under an argon atmosphere in oven-dried reaction vessels sealed with Teflon screw caps. All reagents were weighed and handled in air at room temperature. Unless otherwise stated, all commercially available reagents were used as received. 18-Crown-6 was recrystallized from dry acetonitrile and was stored under argon. Anhydrous tetrahydrofuran was obtained from a solvent purification system. The reactions were monitored by TLC visualized by UV (254 nm) and/or with *p*-anisaldehyde and H_2SO_4 in EtOH. Flash chromatography was performed on 40–63 μm silica gel eluted with EtOAc/petroleum ether (bp 40–60 °C, herein abbreviated PE). ^{1}H NMR data were recorded in $CDCl_3$ at 294 K at 300 MHz using the residual nondeuterated solvent as an internal standard (δ = 7.26 ppm). $^{13}C\{^1H\}$ NMR spectra were recorded in $CDCl_3$ at 294 K at 75 MHz using the deuterated solvent as an internal standard (δ = 77.16 ppm). Coupling constants (J) are in hertz (Hz), and the classical abbreviations are used to describe the signal multiplicities. Melting points were measured with a Büchi B-540 apparatus and are uncorrected. High-resolution mass spectra were recorded at the Spectropole (http://www.spectropole.u-3mrs.fr/). The *N*-aryl imine substrates **2a–o** were prepared following our previously described procedure.[8] The known *N*-heteroaryl imines **2b**,[13a] **2c**,[13b] **2e**,[13a] **2h**,[13b] and **2i**[13b] showed characterization data in full agreement with previously reported data. The aryne precursor **1e** was prepared by known methods.[14] The isoquinoline **3a** was previously fully characterized.[8]

Compound ***2j***. Following the general procedure,[8] the reaction between 4-methoxyaniline (401 mg, 3.26 mmol) and benzaldehyde (328 μL, 3.25 mmol) afforded compound **2j** as a brown solid (650 mg, 95%). R_f (EtOAc/PE: 1/4) = 0.65; mp = 69–70 °C (amorphous); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 158.6 (CH), 158.4 (C), 145.0 (C), 136.5 (C), 131.1 (CH), 128.8 (CH), 128.7 (CH), 122.3 (CH), 114.5 (CH), 55.6 (CH_3); ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.51 (s, 1H), 7.93–7.90 (m, 2H), 7.50–7.48 (m, 3H), 7.27 (d, J = 8.8 Hz, 2H), 6.96 (d, J = 8.8 Hz, 2H), 3.86 (s, 3H); HRMS (ESI+) $[M + H]^+$ calcd for $C_{14}H_{14}NO^+$ 212.1070, found 212.1073.

Compound ***2k***. Following the general procedure,[8] the reaction between 4-methoxyaniline (400 mg, 3.25 mmol) and 4-methoxybenzaldehyde (394 μL, 3.25 mmol) afforded compound **2k** as a brown solid (751 mg, 96%). R_f (EtOAc/PE: 1/4) = 0.54; mp = 143–144 °C (amorphous); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 162.1 (C), 158.0 (C), 158.0 (CH), 145.3 (C), 130.3 (CH), 129.5 (C), 122.1 (CH), 114.4 (CH), 114.2 (CH), 55.6 (CH_3), 55.5 (CH_3); ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.40 (s, 1H), 7.83 (d, J = 8.7 Hz, 2H), 7.21 (d, J = 8.8 Hz, 2H), 6.97 (d, J = 8.7 Hz, 2H), 6.92 (d, J = 8.8 Hz, 2H), 3.86 (s, 3H), 3.82 (s, 3H); HRMS (ESI+) $[M + H]^+$ calcd for $C_{15}H_{16}NO_2^+$ 242.1176, found 242.1177.

Compound ***2l***. Following the general procedure,[8] the reaction between 3,4-dimethoxyaniline (200 mg, 1.30 mmol) and 4-methoxybenzaldehyde (159 μL, 1.30 mmol) afforded compound **2l** as a brown solid (347 mg, 98%). R_f (EtOAc/PE: 1/5) = 0.25; mp = 84–85 °C (amorphous); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 162.1 (C), 158.2 (CH), 149.4 (C), 147.4 (C), 145.8 (C), 130.4 (CH), 129.4 (C), 114.2 (CH), 111.9 (CH), 111.5 (CH), 105.7 (CH), 56.2 (CH_3), 55.9 (CH_3), 55.5 (CH_3); ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.41 (s, 1H), 7.83 (d, J = 8.7 Hz, 2H), 6.97 (d, J = 8.8 Hz, 2H), 6.87 (d, J = 8.7 Hz, 1H), 6.85 (s, 1H), 6.78 (dd, J = 2.4, 8.4 Hz, 1H), 3.91 (s, 3H), 3.89 (s, 3H), 3.85 (s, 3H); HRMS (ESI+) $[M + H]^+$ calcd for $C_{16}H_{18}NO_3^+$ 272.1281, found 272.1281.

Compound ***2m*** *(4:1 Mixture of Diastereomers)*. Following the general procedure,[8] the reaction between 3-*tert*-butyl-1-phenyl-1*H*-pyrazol-5-amine (272 mg, 1.26 mmol) and *N*-benzylindoline-2,3-dione (300 mg, 1.26 mmol) afforded compound **2m** as a red solid (451 mg, 82%, *Z*:*E* = 4:1). R_f (EtOAc/PE: 1/4) = 0.54; mp = 111–112 °C (amorphous); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) major diastereomer δ 162.3 (C), 159.1 (C), 145.7 (C), 144.9 (C), 144.0 (C), 139.7 (C), 135.4 (C), 132.9 (CH), 129.0 (CH), 128.4 (CH), 127.9 (CH), 127.4 (CH), 126.9 (CH), 125.6 (CH), 123.2 (CH), 123.1 (C), 122.8 (CH), 109.5 (CH), 100.2 (CH), 43.8 (CH_2), 32.7 (C), 30.5 (CH_3); minor diastereomer δ 163. (C), 162.4 (C), 153.5 (C), 147.4 (C), 145.6 (C), 139.5 (C), 135.1 (C), 134.9 (CH), 129.4 (CH), 128.9 (CH), 128.0 (CH), 127.5 (CH), 126.6 (CH), 125.5 (CH), 124.0 (CH), 123.3 (CH), 116.6 (C), 110.6 (CH), 94.1 (CH), 44.1 (CH_2), 32.7 (C), 30.4 (CH_3); ^{1}H NMR (300 MHz, $CDCl_3$) major diastereomer δ 6.16 (d, J = 8.1 Hz, 2H), 7.45 (s, 1H), 7.42–7.37 (m, 3H), 7.32–7.16 (m, 7H), 6.94 (t, J = 7.5 Hz, 1H), 6.64 (d, J = 7.8 Hz, 1H), 4.91 (s, 2H), 1.36 (s, 9H); minor diastereomer δ 7.77 (d, J = 7.5 Hz, 1H), 7.67–7.61 (m, 2H), 7.42–7.37 (m, 1H), 7.32–7.16 (m, 8H), 6.84 (t, J = 7.5 Hz, 1H), 6.68 (d, J = 7.8 Hz, 1H), 6.18 (s, 1H), 4.91 (s, 2H), 1.33 (s, 9H); HRMS (ESI+) $[M + H]^+$ calcd for $C_{28}H_{27}N_4O^+$ 435.2179, found 435.2180.

Compound ***2n***. Following the general procedure[8] at 120 °C for 2 h, the reaction between 3-(*tert*-butyl)-1-phenyl-1*H*-pyrazol-5-amine (250 mg, 1.16 mmol) and cyclopentanone (98 mg, 1.16 mmol) in 2.0 mL of anhydrous toluene afforded compound **2n** as a yellow solid (212 mg, 65%) after silica gel purification. R_f (EtOAc/PE: 1/15) = 0.32; mp = 98 °C (amorphous); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 185.1 (C), 161.6 (C), 147.6 (C), 140.0 (C), 128.6 (CH), 126.1 (CH), 124.0 (CH), 93.5 (CH), 37.3 (CH_2), 33.2 (CH_2), 32.5 (C), 30.5 (CH_3), 25.3 (CH_2), 24.1 (CH_2); ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.64 (d, J = 8.1 Hz, 2H), 7.39 (t, J = 7.8 Hz, 2H), 7.23 (t, J = 7.8 Hz, 1H), 5.82 (s, 1H), 2.53 (t, J = 7.1 Hz, 2H), 2.44 (t, J = 7.1 Hz, 2H), 1.92–1.82 (m, 4H), 1.36 (s, 9H); HRMS (ESI+) $[M + H]^+$ calcd for $C_{18}H_{24}N_3^+$ 282.1965, found 282.1964.

General Procedure for the Synthesis of *N*-Aryl 1,2-Dihydroisoquinolines 4a–r and 6. A sealable (Teflon screw cap) oven-dried tubular reaction vessel was charged with the imine **2** (0.25 mmol), KF (1.2 mmol), and 18-crown-6 (1.2 mmol) and subjected to vacuum for 30 min. The mixture was then placed under an argon atmosphere, and anhydrous THF (3.0 mL) was added. To this stirred

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solution kept at room temperature was added the aryne precursor **1** (0.75 mmol) in one portion, and the resulting reaction mixture was stirred at 70 °C for 12−48 h. Then, the reaction mixture was diluted with EtOAc and hydrolyzed with water. The organic layer was separated, and the aqueous layer was extracted twice with EtOAc. The combined organic layers were washed with brine, dried over anhydrous sodium sulfate, filtered, and concentrated under vacuum to give the crude product. Flash chromatography of this material afforded pure products **4a−r** or **6**. Product **6** was obtained following the general procedure with 4 equiv of 2-(trimethylsilyl)phenyl triflate (**1a**).

Compound ***4a***. Following the general procedure, the reaction of aldimine **2a** (50 mg, 0.15 mmol) with 2-(trimethylsilyl)phenyl triflate (**1a**, 109 μL, 0.45 mmol) in the presence of KF (42 mg, 0.72 mmol) and 18-crown-6 (190 mg, 0.72 mmol) in 3.0 mL of anhydrous tetrahydrofuran at 70 °C for 48 h afforded compound **4a** as a yellow solid (57 mg, 78%) after silica gel purification. R_f (EtOAc/PE: 1/10) = 0.38; mp = 157 °C (amorphous); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 159.0 (C), 156.8 (C), 146.7 (C), 141.5 (C), 139.4 (C), 133.6 (C), 132.0 (C), 129.8 (C), 129.2 (CH), 128.6 (CH), 128.5 (CH), 127.9 (CH), 127.6 (CH), 125.9 (CH), 125.8 (CH), 125.1 (CH), 122.5 (CH), 121.7 (CH), 119.5 (CH), 113.8 (CH), 109.5 (C), 69.8 (CH), 55.3 (CH_3), 33.6 (C), 29.7 (CH_3); ^1H NMR (300 MHz, $CDCl_3$) δ 7.96 (d, *J* = 7.8 Hz, 1H), 7.52 (d, *J* = 8.1 Hz, 2H), 7.37 (td, *J* = 7.1, 2.7 Hz, 1H), 7.20−6.99 (m, 9H), 6.92 (d, *J* = 7.8 Hz, 2H), 6.81 (t, *J* = 7.2 Hz, 1H), 6.76 (d, *J* = 8.7 Hz, 2H), 5.96 (s, 1H), 3.74 (s, 3H), 1.59 (s, 9H); HRMS (ESI+) $[M + H]^+$ calcd for $C_{33}H_{32}N_3O^+$ 486.2540, found 486.2541.

Compound ***4b***. Following the general procedure, the reaction of aldimine **2b** (100 mg, 0.25 mmol) with 2-(trimethylsilyl)phenyl triflate (**1a**, 185 μL, 0.76 mmol) in the presence of KF (71 mg, 1.22 mmol) and 18-crown-6 (322 mg, 1.22 mmol) in 3.0 mL of anhydrous tetrahydrofuran at 70 °C for 48 h afforded compound **4b** as a yellow solid (104 mg, 75%) after silica gel purification. R_f (EtOAc/PE: 1/10) = 0.14; mp = 171 °C (amorphous); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 156.8 (C), 153.1 (C), 147.0 (C), 141.7 (C), 139.3 (C), 137.3 (C), 137.2 (C), 132.0 (C), 129.7 (C), 129.4 (CH), 128.6 (CH), 128.1 (CH), 127.9 (CH), 126.0 (CH), 125.9 (CH), 125.2 (CH), 122.8 (CH), 121.5 (CH), 119.5 (CH), 109.8 (C), 104.5 (CH), 70.5 (CH), 60.9 (CH_3), 55.9 (CH_3), 33.6 (C), 29.7 (CH_3); ^1H NMR (300 MHz, $CDCl_3$) δ 7.96 (d, *J* = 7.8 Hz, 1H), 7.59 (d, *J* = 8.1 Hz, 2H), 7.39 (td, *J* = 7.4, 1.8 Hz, 1H), 7.22−7.00 (m, 7H), 6.94 (d, *J* = 7.8 Hz, 2H), 6.86 (t, *J* = 7.4 Hz, 1H), 6.48 (s, 2H), 5.93 (s, 1H), 3.78 (s, 3H), 3.59 (s, 6H), 1.58 (s, 9H); HRMS (ESI+) $[M + H]^+$ calcd for $C_{35}H_{36}N_3O_3^+$ 546.2751, found 546.2749.

Compound ***4c***. Following the general procedure, the reaction of aldimine **2c** (90 mg, 0.28 mmol) with 2-(trimethylsilyl)phenyl triflate (**1a**, 206 μL, 0.85 mmol) in the presence of KF (79 mg, 1.36 mmol) and 18-crown-6 (360 mg, 1.36 mmol) in 3.0 mL of anhydrous tetrahydrofuran at 70 °C for 48 h afforded compound **4c** as a brown solid (93 mg, 70%) after silica gel purification. R_f (EtOAc/PE: 1/60) = 0.28; mp = 216 °C (amorphous); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 156.8 (C), 146.8 (C), 146.8 (C), 141.5 (C), 139.4 (C), 138.6 (C), 137.3 (C), 131.9 (C), 129.8 (C), 129.1 (CH), 129.1 (CH), 128.5 (CH), 128.0 (CH), 127.6 (CH), 127.4 (CH), 125.9 (CH), 125.8 (CH), 125.1 (CH), 122.5 (CH), 121.7 (CH), 119.5 (CH), 70.1 (CH), 33.6 (C), 29.7 (CH_3), 21.1 (CH_3); ^1H NMR (300 MHz, $CDCl_3$) δ 7.96 (d, *J* = 7.8 Hz, 1H), 7.54 (d, *J* = 8.1 Hz, 2H), 7.37 (td, *J* = 7.4, 2.1 Hz, 1H), 7.19−7.00 (m, 11H), 6.93 (d, *J* = 7.8 Hz, 2H), 6.81 (t, *J* = 7.2 Hz, 1H), 5.98 (s, 1H), 2.28 (s, 3H), 1.59 (s, 9H); HRMS (ESI+) $[M + H]^+$ calcd for $C_{33}H_{32}N_3^+$ 470.2591, found 470.2591.

Compound ***4d***. Following the general procedure, the reaction of aldimine **2d** (100 mg, 0.27 mmol) with 2-(trimethylsilyl)phenyl triflate (**1a**, 196 μL, 0.81 mmol) in the presence of KF (75 mg, 1.29 mmol) and 18-crown-6 (342 mg, 1.29 mmol) in 3.0 mL of anhydrous tetrahydrofuran at 70 °C for 48 h afforded compound **4d** as a yellow solid (79 mg, 56%) after silica gel purification. R_f (EtOAc/pentane: 1/30) = 0.46; mp = 165−166 °C (amorphous); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 156.9 (C), 146.7 (C), 145.5 (C), 141.4 (C), 139.2 (C), 130.8 (C), 129.8 (C), 129.9 (C, q, *J* = 32.1 Hz), 129.4 (CH), 128.7 (CH), 128.2 (CH), 128.1 (CH), 127.7 (CH), 126.2 (CH), 126.1 (CH), 125.4 (CH, q, *J* = 3.7 Hz), 125.3 (CH), 123.2 (CH), 124.1 (C, q, *J* = 270.4 Hz), 121.7 (CH), 119.8 (CH), 109.5 (C), 70.3 (CH), 33.6 (C), 29.7 (CH_3); ^1H NMR (300 MHz, $CDCl_3$) δ 7.98 (d, *J* = 7.8 Hz, 1H), 7.52−7.48 (m, 4H), 7.44−7.39 (m, 3H), 7.19−7.03 (m, 7H), 6.92 (d, *J* = 7.8 Hz, 2H), 6.87 (t, *J* = 7.4 Hz, 1H), 6.00 (s, 1H), 1.58 (s, 9H); HRMS (ESI+) $[M + H]^+$ calcd for $C_{33}H_{29}N_3F_3^+$ 524.2308, found 524.2310.

Compound ***4e***. Following the general procedure, the reaction of aldimine **2e** (100 mg, 0.29 mmol) with 2-(trimethylsilyl)phenyl triflate (**1a**, 216 μL, 0.89 mmol) in the presence of KF (82 mg, 1.42 mmol) and 18-crown-6 (376 mg, 1.42 mmol) in 3.0 mL of anhydrous tetrahydrofuran at 70 °C for 48 h afforded compound **4e** as a white solid (118 mg, 81%) after silica gel purification. Recrystallization of **4e** from methanol afforded crystalline colorless prisms suitable for X-ray diffraction analysis.[10] R_f (EtOAc/PE: 1/20) = 0.41; mp = 212−213 °C (methanol); ^{13}C NMR (75 MHz, $CDCl_3$) δ 156.8 (C), 146.7 (C), 141.4 (C), 140.0 (C), 139.3 (C), 133.4 (C), 131.2 (C), 129.8 (C), 129.3 (CH), 128.8 (CH), 128.7 (CH), 128.6 (CH), 128.6 (CH), 128.0 (CH), 126.1 (CH), 126.0 (CH), 125.2 (CH), 123.0 (CH), 121.7 (CH), 119.7 (CH), 109.6 (C), 69.9 (CH), 33.6 (C), 29.7 (CH_3); ^1H NMR (300 MHz, $CDCl_3$) δ 8.02 (d, *J* = 8.1 Hz, 1H), 7.56 (d, *J* = 8.1 Hz, 2H), 7.48−7.42 (m, 1H), 7.26−7.08 (m, 11H), 6.97 (d, *J* = 7.8 Hz, 2H), 6.90 (t, *J* = 7.2 Hz, 1H), 6.00 (s, 1H), 1.63 (s, 9H); HRMS (ESI+) $[M + H]^+$ calcd for $C_{32}H_{29}N_3Cl^+$ 490.2045, found 490.2041.

Compound ***4f***. Following the general procedure, the reaction of aldimine **2f** (100 mg, 0.37 mmol) with 2-(trimethylsilyl)phenyl triflate (**1a**, 268 μL, 1.10 mmol) in the presence of KF (103 mg, 1.77 mmol) and 18-crown-6 (467 mg, 1.77 mmol) in 3.0 mL of anhydrous tetrahydrofuran at 70 °C for 48 h afforded compound **4f** as a yellow solid (118 mg, 76%) after silica gel purification. R_f (EtOAc/PE: 1/20) = 0.13; mp = 163−164 °C (amorphous); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 158.9 (C), 155.4 (C), 147.1 (C), 142.2 (C), 134.0 (C), 131.8 (C), 130.2 (C), 129.6 (CH), 128.2 (CH), 128.1 (CH), 127.6 (CH), 125.7 (CH), 124.5 (CH), 122.5 (CH), 119.2 (CH), 113.7 (CH), 107.3 (C), 69.6 (CH), 55.3 (CH_3), 35.6 (CH_3), 33.3 (C), 29.7 (CH_3); ^1H NMR (300 MHz, $CDCl_3$) δ 7.87 (d, *J* = 7.8 Hz, 1H), 7.35 (td, *J* = 7.5, 1.6 Hz, 1H), 7.29−7.24 (m, 2H), 7.19−7.10 (m, 4H), 7.00−6.95 (m, 3H), 6.75 (d, *J* = 8.0 Hz, 2H), 5.89 (s, 1H), 3.74 (s, 3H), 3.39 (s, 3H), 1.50 (s, 9H); HRMS (ESI+) $[M + H]^+$ calcd for $C_{28}H_{30}N_3O^+$ 424.2383, found 424.2382.

Compound ***4g***. Following the general procedure, the reaction of aldimine **2g** (80 mg, 0.27 mmol) with 2-(trimethylsilyl)phenyl triflate (**1a**, 200 μL, 0.82 mmol) in the presence of KF (76 mg, 1.32 mmol) and 18-crown-6 (348 mg, 1.32 mmol) in 3.0 mL of anhydrous tetrahydrofuran at 70 °C for 48 h afforded compound **4g** as a yellow solid (84 mg, 69%) after silica gel purification. R_f (EtOAc/PE: 1/10) = 0.21; mp = 70 °C (amorphous); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 159.1 (C), 146.6 (C), 145.2 (C), 141.0 (C), 139.2 (C), 134.7 (C), 131.0 (C), 129.1 (CH), 128.9 (C), 128.6 (CH), 128.1 (CH), 128.1 (CH), 127.8 (CH), 126.2 (CH), 125.3 (CH), 122.9 (CH), 122.0 (CH), 121.7 (CH), 119.8 (CH), 114.0 (CH), 109.0 (C), 70.4 (CH), 55.3 (CH_3), 15.0 (CH_3); ^1H NMR (300 MHz, $CDCl_3$) δ 7.68 (d, *J* = 7.8 Hz, 1H), 7.47 (d, *J* = 8.1 Hz, 2H), 7.35 (td, *J* = 7.2, 2.1 Hz, 1H), 7.27 (d, *J* = 8.4 Hz, 2H), 7.19−7.12 (m, 4H), 7.07−7.00 (m, 3H), 6.91 (d, *J* = 7.8 Hz, 2H), 6.83−6.79 (m, 3H), 5.96 (s, 1H), 3.75 (s, 3H), 2.66 (s, 3H); HRMS (ESI+) $[M + H]^+$ calcd for $C_{30}H_{26}N_3O^+$ 444.2070, found 444.2071.

Compound ***4h***. Following the general procedure, the reaction of aldimine **2h** (77 mg, 0.21 mmol) with 2-(trimethylsilyl)phenyl triflate (**1a**, 151 μL, 0.62 mmol) in the presence of KF (58 mg, 0.99 mmol) and 18-crown-6 (263 mg, 0.99 mmol) in 3.0 mL of anhydrous tetrahydrofuran at 70 °C for 48 h afforded compound **4h** as a brown solid (77 mg, 71%) after silica gel purification. R_f (EtOAc/PE: 1/20) = 0.31; mp = 173−174 °C (amorphous); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 163.0 (C, d, *J* = 245.6 Hz), 159.2 (C), 147.5 (C), 146.3 (C), 142.0 (C), 139.2 (C), 134.0 (C), 130.9 (C), 130.3 (CH, d, *J* = 8.1 Hz), 130.1 (C, d, *J* = 3.2 Hz), 129.2 (CH), 128.7 (CH), 128.4 (C), 128.3 (CH), 128.0 (CH), 127.9 (CH), 126.6 (CH), 125.7 (CH), 123.2 (CH), 122.4 (CH), 122.0 (CH), 120.2 (CH), 115.6 (CH, d, *J* = 21.4

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J. Org. Chem. 2015, 80, 9767−9773

Hz), 114.0 (CH), 108.5 (C), 70.6 (CH), 55.4 (CH_3); ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.84−7.80 (m, 2H), 7.56 (d, J = 8.0 Hz, 2H), 7.49 (d, J = 7.2 Hz, 1H), 7.36 (d, J = 8.0 Hz, 2H), 7.22−7.15 (m, 7H), 7.10−7.05 (m, 3H), 6.96 (d, J = 7.8 Hz, 2H), 6.88−6.82 (m, 3H), 6.01 (s, 1H), 3.77 (s, 3H); HRMS (ESI+) $[M + H]^+$ calcd for $C_{35}H_{27}N_3OF^+$ 524.2133, found 524.2133.

Compound ***4i***. Following the general procedure, the reaction of aldimine **2i** (90 mg, 0.31 mmol) with 2-(trimethylsilyl)phenyl triflate (**1a**, 225 μL, 0.93 mmol) in the presence of KF (86 mg, 1.48 mmol) and 18-crown-6 (392 mg, 1.48 mmol) in 3.0 mL of anhydrous tetrahydrofuran at 70 °C for 48 h afforded compound **4i** as a yellow solid (69 mg, 51%) after silica gel purification. R_f (EtOAc/PE: 1/7) = 0.14; mp = 87 °C (amorphous); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 159.1 (C), 147.0 (C), 146.8 (C), 142.5 (C), 134.2 (C), 134.1 (C), 130.9 (C), 129.7 (CH), 128.9 (C), 128.5 (CH), 128.3 (CH), 128.2 (CH), 128.1 (CH), 128.0 (CH), 127.8 (CH), 125.2 (CH), 123.2 (CH), 122.6 (CH), 120.0 (CH), 113.8 (CH), 107.1 (C), 70.5 (CH), 55.3 (CH_3), 36.1 (CH_3); ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.71 (dd, J = 8.0, 1.4 Hz, 2H), 7.49−7.26 (m, 8H), 7.21−7.02 (m, 6H), 6.81 (d, J = 8.7 Hz, 2H), 5.93 (s, 1H), 3.76 (s, 3H), 3.50 (s, 3H); HRMS (ESI+) $[M + H]^+$ calcd for $C_{30}H_{26}N_3O^+$ 444.2070, found 444.2070.

Compound ***4j***. Following the general procedure, the reaction of aldimine **2a** (90 mg, 0.27 mmol) with 4,5-dimethyl-2-(trimethylsilyl)-phenyl triflate (**1b**, 264 mg, 0.81 mmol) in the presence of KF (75 mg, 1.29 mmol) and 18-crown-6 (342 mg, 1.29 mmol) in 3.0 mL of anhydrous tetrahydrofuran at 70 °C for 48 h afforded compound **4j** as a yellow solid (115 mg, 79%) after silica gel purification. R_f (EtOAc/PE: 1/30) = 0.19; mp = 88 °C (amorphous); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 158.9 (C), 156.4 (C), 145.1 (C), 141.8 (C), 139.7 (C), 137.2 (C), 135.4 (C), 134.2 (C), 133.2 (C), 130.6 (C), 130.2 (CH), 129.7 (C), 129.1 (CH), 128.7 (CH), 128.5 (CH), 127.5 (C), 127.2 (CH), 125.6 (CH), 121.5 (CH), 121.0 (CH), 117.0 (CH), 113.7 (CH), 109.6 (C), 69.8 (CH), 55.3 (CH_3), 33.6 (C), 29.8 (CH_3), 20.2 (CH_3), 20.0 (CH_3), 19.4 (CH_3), 19.0 (CH_3); ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.73 (s, 1H), 7.56 (d, J = 7.8 Hz, 2H), 7.21−7.13 (m, 4H), 7.02 (t, J = 7.4 Hz, 1H), 6.93 (s, 1H), 6.82 (d, J = 8.1 Hz, 1H), 6.75 (d, J = 8.7 Hz, 2H), 6.69−6.62 (m, 2H), 5.85 (s, 1H), 3.73 (s, 3H), 2.35 (s, 3H), 2.21 (s, 3H), 2.07 (s, 3H), 2.06 (s, 3H), 1.61 (s, 9H); HRMS (ESI+) $[M + H]^+$ calcd for $C_{37}H_{40}N_3O^+$ 542.3166, found 542.3165.

Compound ***4k***. Following the general procedure, the reaction of aldimine **2a** (80 mg, 0.24 mmol) with 6-(trimethylsilyl)-2*H*-1,3-benzodioxol-5-yl triflate (**1c**, 246 mg, 0.72 mmol) in the presence of KF (67 mg, 1.15 mmol) and 18-crown-6 (304 mg, 1.15 mmol) in 3.0 mL of anhydrous tetrahydrofuran at 70 °C for 48 h afforded compound **4k** as a brown solid (82 mg, 60%) after silica gel purification. R_f (EtOAc/PE: 1/4) = 0.22; mp = 198−199 °C (amorphous); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 159.0 (C), 156.0 (C), 148.2 (C), 147.2 (C), 145.2 (C), 143.6 (C), 142.2 (C), 141.5 (C), 139.3 (C), 133.3 (C), 128.7 (CH), 128.6 (CH), 125.8 (CH), 125.1 (C), 124.0 (C), 121.5 (CH), 113.7 (CH), 113.5 (CH), 109.9 (C), 108.5 (CH), 108.3 (CH), 106.7 (CH), 102.7 (CH), 101.2 (CH_2), 101.1 (CH_2), 71.3 (CH), 55.3 (CH_3), 33.5 (C), 29.8 (CH_3); ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.56 (d, J = 8.1 Hz, 2H), 7.47 (s, 1H), 7.26−7.13 (m, 4H), 7.06 (t, J = 7.3 Hz, 1H), 6.74 (d, J = 8.7 Hz, 2H), 6.64 (s, 1H), 6.54 (d, J = 8.4 Hz, 1H), 6.48 (d, J = 2.4 Hz, 1H), 6.37 (dd, J = 8.4, 2.1 Hz, 1H), 5.97 (dd, J = 12.6, 1.2 Hz, 2H), 5.82 (d, J = 1.0 Hz, 2H), 5.65 (s, 1H), 3.73 (s, 3H), 1.55 (s, 9H); HRMS (ESI+) $[M + H]^+$ calcd for $C_{35}H_{32}N_3O_5^+$ 574.2336, found 574.2336.

Compound ***4l***. Following the general procedure, the reaction of aldimine **2a** (80 mg, 0.24 mmol) with 2-methoxy-6-(trimethylsilyl)-phenyl triflate (**1d**, 197 mg, 0.60 mmol) in the presence of KF (67 mg, 1.15 mmol) and 18-crown-6 (304 mg, 1.15 mmol) in 3.0 mL of anhydrous tetrahydrofuran at 70 °C for 48 h afforded compound **4l** as a white solid (98 mg, 75%) after silica gel purification. Recrystallization of **4l** from methanol afforded crystalline colorless prisms suitable for X-ray diffraction analysis.[10] R_f (EtOAc/PE: 1/9) = 0.24; mp = 96−97 °C (methanol); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 160.3 (C), 158.9 (C), 156.8 (C), 155.8 (C), 148.2 (C), 141.5 (C), 139.6 (C), 133.2 (C), 131.1 (C), 129.8 (CH), 128.7 (CH), 128.6 (CH), 127.9 (CH), 125.9 (CH), 121.7 (CH), 121.4 (C), 118.6 (CH), 113.7 (CH), 111.8 (CH), 109.5 (C), 107.5 (CH), 107.3 (CH), 105.6 (CH), 62.2 (CH), 55.7 (CH_3), 55.3 (CH_3), 55.3 (CH_3), 33.6 (C), 29.8 (CH_3); ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.58 (d, J = 7.8 Hz, 1H), 7.51 (d, J = 7.8 Hz, 2H), 7.32 (t, J = 8.1 Hz, 1H), 7.23−7.13 (m, 4H), 7.03 (t, J = 7.4 Hz, 1H), 6.98 (t, J = 8.2 Hz, 1H), 6.77−6.72 (m, 3H), 6.58 (dd, J = 8.1, 1.5 Hz, 1H), 6.51 (s, 1H), 6.45 (t, J = 2.1 Hz, 1H), 6.35 (dd, J = 8.1, 1.8 Hz, 1H), 3.74 (s, 3H), 3.73 (s, 3H), 3.62 (s, 3H), 1.58 (s, 9H); HRMS (ESI+) $[M + H]^+$ calcd for $C_{35}H_{36}N_3O_3^+$ 546.2751, found 546.2755.

Compound ***4m***. Following the general procedure, the reaction of aldimine **2a** (80 mg, 0.24 mmol) with 2-(trimethylsilyl)naphthalen-1-yl triflate (**1e**, 251 mg, 0.72 mmol) in the presence of KF (67 mg, 1.15 mmol) and 18-crown-6 (304 mg, 1.15 mmol) in 3.0 mL of anhydrous tetrahydrofuran at 70 °C for 48 h afforded compound **4m** as a yellow solid (112 mg, 80%, 7:1 mixture of regioisomers) after silica gel purification. R_f (EtOAc/PE: 1/20) = 0.13; mp = not determined; $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 159.2 (C), 156.9 (C), 144.6 (C), 141.3 (C), 139.3 (C), 134.0 (C), 131.9 (C), 131.6 (C), 131.1 (C), 129.9 (C), 129.4 (CH), 129.2 (CH), 128.7 (CH), 128.6 (CH), 128.0 (C), 127.7 (CH), 127.5 (CH), 127.0 (CH), 126.9 (CH), 126.6 (C), 126.4 (CH), 126.0 (CH), 124.9 (CH), 124.8 (CH), 124.4 (CH), 123.2 (CH), 121.5 (CH), 119.9 (CH), 115.6 (CH), 113.9 (CH), 111.0 (C), 65.6 (CH), 55.2 (CH_3), 33.8 (C), 30.2 (CH_3); ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.20 (d, J = 8.7 Hz, 1H), 7.87−7.75 (m, 3H), 7.58−7.50 (m, 6H), 7.35−7.06 (m, 9H), 6.93 (t, J = 7.4 Hz, 1H), 6.88 (s, 1H), 6.72 (d, J = 8.7 Hz, 2H), 3.66 (s, 3H), 1.63 (s, 9H); HRMS (ESI+) $[M + H]^+$ calcd for $C_{41}H_{36}N_3O^+$ 586.2853, found 586.2853.

Compound ***4n***. Following the general procedure, the reaction of aldimine **2j** (90 mg, 0.43 mmol) with 2-(trimethylsilyl)phenyl triflate (**1a**, 310 μL, 1.28 mmol) in the presence of KF (48 mg, 2.04 mmol) and 18-crown-6 (544 mg, 2.04 mmol) in 3.0 mL of anhydrous tetrahydrofuran at 70 °C for 48 h afforded compound **4n** as a white solid (75 mg, 48%) after silica gel purification. The NMR analysis of the crude product mixture showed that the corresponding phenanthridine product, previously isolated by Wang and co-workers,[7a] was formed in 44% yield together with **4n** in this reaction. R_f (EtOAc/PE: 1/9) = 0.44; mp = 254 °C (amorphous); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 154.6 (C), 148.2 (C), 142.3 (C), 135.6 (C), 134.6 (C), 130.6 (C), 129.2 (CH), 128.4 (CH), 127.9 (CH), 127.5 (CH), 127.4 (CH), 127.2 (C), 127.0 (CH), 126.7 (CH), 123.5 (CH), 122.2 (CH), 121.4 (CH), 119.9 (CH), 115.2 (CH), 108.6 (CH), 65.2 (CH), 55.7 (CH_3); ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.76 (d, J = 7.5 Hz, 1H), 7.37−7.13 (m, 14H), 6.91 (td, J = 6.9, 1.5 Hz, 1H), 6.77 (dd, J = 7.8, 2.8 Hz, 1H), 5.95 (s, 1H), 3.81 (s, 3H); HRMS (ESI+) $[M + H]^+$ calcd for $C_{26}H_{22}NO^+$ 364.1696, found 364.1703.

Compound ***4o***. Following the general procedure, the reaction of aldimine **2k** (90 mg, 0.37 mmol) with 2-(trimethylsilyl)phenyl triflate (**1a**, 272 μL, 1.12 mmol) in the presence of KF (104 mg, 1.79 mmol) and 18-crown-6 (477 mg, 1.79 mmol) in 3.0 mL of anhydrous tetrahydrofuran at 70 °C for 48 h afforded compound **4o** as a yellow solid (90 mg, 61%) after silica gel purification. R_f (EtOAc/PE: 1/20) = 0.23; mp = 240−241 °C (amorphous); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 158.6 (C), 154.5 (C), 148.2 (C), 135.9 (C), 134.6 (C), 134.3 (C), 130.5 (C), 129.2 (CH), 127.9 (CH), 127.8 (CH), 127.4 (CH), 127.3 (CH), 127.2 (C), 123.5 (CH), 122.2 (CH), 121.3 (CH), 119.9 (CH), 115.1 (CH), 113.7 (CH), 108.6 (CH), 64.7 (CH), 55.7 (CH_3), 55.2 (CH_3); ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.76 (d, J = 7.2 Hz, 1H), 7.38−7.13 (m, 11H), 6.90 (t, J = 7.0 Hz, 1H), 6.76 (dd, J = 8.8, 2.8 Hz, 1H), 6.69 (d, J = 8.7 Hz, 2H), 5.89 (s, 1H), 3.80 (s, 3H), 3.67 (s, 3H); HRMS (ESI+) $[M + H]^+$ calcd for $C_{27}H_{24}NO_2^+$ 394.1807, found 394.1809.

Compound ***4p***. Following the general procedure, the reaction of aldimine **2l** (90 mg, 0.33 mmol) with 2-(trimethylsilyl)phenyl triflate (**1a**, 242 μL, 0.99 mmol) in the presence of KF (92 mg, 1.59 mmol) and 18-crown-6 (424 mg, 1.59 mmol) in 3.0 mL of anhydrous tetrahydrofuran at 70 °C for 48 h afforded compound **4p** as a yellow solid (91 mg, 65%) after silica gel purification. R_f (EtOAc/PE: 1/10) = 0.17; mp = 104−105 °C (amorphous); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 158.6 (C), 149.8 (C), 148.0 (C), 144.5 (C), 134.9 (C), 134.7 (C), 134.5 (C), 130.5 (C), 129.3 (CH), 127.8 (CH), 127.7

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J. Org. Chem. 2015, 80, 9767−9773

(CH), 127.2 (CH), 126.4 (CH), 122.6 (CH), 121.5 (CH), 120.2 (CH), 118.7 (C), 113.8 (CH), 106.8 (CH), 104.5 (CH), 65.0 (CH), 56.3 (CH_3), 56.1 (CH_3), 55.2 (CH_3); ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.71 (d, J = 7.8 Hz, 1H), 7.37 (td, J = 7.0, 2.5 Hz, 1H), 7.31−7.21 (m, 9H), 6.97 (td, J = 6.6, 2.2 Hz, 1H), 6.89 (s, 1H), 6.75 (d, J = 8.5 Hz, 2H), 5.92 (s, 1H), 3.94 (s, 3H), 3.79 (s, 3H), 3.72 (s, 3H); HRMS (ESI+) $[M + H]^+$ calcd for $C_{27}{}^{13}CH_{26}NO_3^+$ 425.1940, found 425.1939.

Compound ***4q***. Following the general procedure, the reaction of ketimine **2m** (80 mg, 0.18 mmol) with 2-(trimethylsilyl)phenyl triflate (**1a**, 134 μL, 0.55 mmol) in the presence of KF (51 mg, 0.88 mmol) and 18-crown-6 (234 mg, 0.88 mmol) in 3.0 mL of anhydrous tetrahydrofuran at 70 °C for 24 h afforded compound **4q** as a yellow solid (72 mg, 60%) after silica gel purification. R_f (EtOAc/PE: 1/5) = 0.33; mp = 83 °C; $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 174.0 (C), 158.9 (C), 156.6 (C), 146.6 (C), 141.9 (C), 139.7 (C), 135.7 (C), 131.7 (C), 131.5 (C), 130.3 (C), 129.6 (CH), 129.4 (CH), 129.0 (CH), 129.0 (CH), 128.2 (CH), 127.8 (CH), 127.2 (CH), 126.9 (CH), 126.2 (CH), 126.2 (CH), 125.5 (CH), 125.2 (CH), 123.7 (CH), 123.0 (CH), 120.5 (CH), 114.6 (CH), 109.7 (CH), 108.7 (C), 70.1 (C), 67.1 (CH_2), 50.7 (CH_2), 43.7 (CH_2), 33.6 (C), 29.8 (CH_3), 26.5 (CH_2), 24.1 (CH_2); ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.85 (d, J = 7.8 Hz, 1H), 7.39 (d, J = 7.5 Hz, 2H), 7.28−7.04 (m, 12H), 6.98 (t, J = 7.5 Hz, 1H), 6.86−6.76 (m, 3H), 6.71−6.64 (m, 2H), 6.58 (d, J = 7.8 Hz, 2H), 5.06 (d, J = 15.6 Hz, 1H), 4.75 (d, J = 15.6 Hz, 1H), 3.41 (t, J = 5.7 Hz, 2H), 3.07−2.99 (m, 1H), 2.85−2.76 (m, 1H), 1.52 (s, 9H), 1.16−1.05 (m, 4H); HRMS (ESI+) $[M + H]^+$ calcd for $C_{44}H_{43}N_4O_2^+$ 659.3381, found 659.3381.

Compound ***4r***. Following the general procedure, the reaction of ketimine **2m** (60 mg, 0.14 mmol) with 2-(trimethylsilyl)phenyl triflate (**1a**, 101 μL, 0.41 mmol) in the presence of KF (16 mg, 0.66 mmol) and 18-crown-6 (175 mg, 0.66 mmol) in 3.0 mL of anhydrous acetonitrile at 70 °C for 12 h afforded compound **4r** as a white solid (52 mg, 64%) after silica gel purification. R_f (EtOAc/PE: 1/6) = 0.36; mp = 308 °C (amorphous); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 178.3 (C), 166.3 (C), 165.3 (C), 143.4 (C), 143.3 (C), 140.0 (C), 136.4 (C), 136.0 (C), 133.5 (C), 132.5 (C), 129.2 (CH), 129.1 (CH), 128.9 (CH), 128.6 (CH), 128.5 (CH), 128.2 (CH), 128.0 (CH), 127.7 (CH), 127.6 (CH), 127.5 (CH), 127.4 (CH), 127.4 (CH), 125.2 (CH), 123.5 (CH), 122.8 (CH), 119.4 (CH), 109.4 (CH), 71.9 (C), 61.5 (C), 44.1 (CH_2), 37.2 (C), 31.0 (CH_3); ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.14−8.06 (m, 3H), 7.50−7.20 (m, 13H), 7.09 (d, J = 7.2 Hz, 2H), 6.99 (t, J = 7.6 Hz, 1H), 6.86 (d, J = 7.2 Hz, 2H), 6.73 (d, J = 7.8 Hz, 1H), 5.07 (d, J = 15.6 Hz, 1H), 4.99 (d, J = 15.6 Hz, 1H), 4.94 (d, J = 7.8 Hz, 1H), 1.34 (s, 9H); HRMS (ESI+) $[M + H]^+$ calcd for $C_{40}H_{35}N_4O^+$ 587.2805, found 587.2805.

Compound ***5***. Following the general procedure, the reaction of ketimine **2n** (89 mg, 0.32 mmol) with 2-(trimethylsilyl)phenyl triflate (**1a**, 230 μL, 0.95 mmol) in the presence of KF (92 mg, 1.58 mmol) and 18-crown-6 (418 mg, 1.58 mmol) in 3.0 mL of anhydrous tetrahydrofuran at 70 °C for 48 h afforded compound **5** as a brown solid (122 mg, 76%) after silica gel purification. R_f (EtOAc/PE: 1/6) = 0.75; mp = 107−108 °C (amorphous); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 161.8 (C), 144.6 (C), 144.2 (C), 143.0. (C), 140.4 (C), 139.5 (C), 136.2 (C), 128.6 (CH), 128.2 (CH), 128.1 (CH), 127.9 (CH), 127.2 (CH), 127.1 (CH), 126.7 (CH), 126.4 (CH), 126.3 (CH), 125.7 (C), 124.0 (CH), 121.2 (CH), 120.3 (CH), 99.5 (CH), 52.9 (CH), 34.8 (CH_2), 32.5 (C), 30.5 (CH_2), 30.4 (CH_3); ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.30−7.17 (m, 5H), 7.10−7.01 (m, 10H), 6.78 (t, J = 7.9 Hz, 2H), 6.60 (d, J = 7.8 Hz, 2H), 6.55 (t, J = 7.5 Hz, 1H), 5.77 (s, 1H), 4.08 (d, J = 9.3 Hz, 1H), 3.37−3.25 (m, 1H), 2.74−2.64 (m, 1H), 2.47−2.34 (m, 1H), 2.12−2.03 (m, 1H), 1.38 (s, 9H); HRMS (ESI+) $[M + H]^+$ calcd for $C_{36}H_{36}N_3^+$ 510.2904, found 510.2905.

Compound ***6***. Following the general procedure, the reaction of aldimine **2o** (90 mg, 0.32 mmol) with 2-(trimethylsilyl)phenyl triflate (**1a**, 311 μL, 1.28 mmol) in the presence of KF (89 mg, 1.54 mmol) and 18-crown-6 (406 mg, 1.54 mmol) in 3.0 mL of anhydrous tetrahydrofuran at 70 °C for 48 h afforded compound **6** as a yellow solid (68 mg) after silica gel purification. Recrystallization of this material from methanol afforded pure compound **6** (62 mg, 39%) as crystalline colorless prisms suitable for X-ray diffraction analysis.[10] R_f (EtOAc/PE: 1/10) = 0.25; mp = 220−221 °C (methanol); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 158.8 (C), 149.5 (C), 149.0 (C), 135.7 (C), 133.5 (C), 132.6 (C), 132.2 (C), 131.8 (C), 129.5 (C), 129.4 (CH), 128.9 (CH), 128.3 (CH), 128.1 (CH), 128.0 (CH), 127.6 (CH), 126.8 (C), 126.7 (CH), 126.5 (CH), 125.9 (CH), 125.4 (CH), 122.1 (CH), 120.5 (CH), 120.4 (C), 113.4 (CH), 103.0 (C), 67.3 (CH), 57.5 (C), 55.2 (CH_3), 31.3 (CH_3); ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.43 (d, J = 7.8 Hz, 1H), 8.25−8.22 (m, 1H), 7.89−7.86 (m, 1H), 7.47 (td, J = 1.2, 7.6 Hz, 1H), 7.39−7.34 (m, 3H), 7.28 (d, J = 7.5 Hz, 1H), 7.20 (d, J = 8.7 Hz, 2H), 7.13 (t, J = 8.0 Hz, 2H), 6.89−6.85 (m, 3H), 6.60 (d, J = 8.7 Hz, 2H), 6.13 (s, 1H), 3.83 (br s, 1H), 3.61 (s, 3H), 1.32 (s, 9H); HRMS (ESI+) $[M + H]^+$ calcd for $C_{35}H_{32}N_3O^+$ 510.2540, found 510.2540.

■ ASSOCIATED CONTENT

Supporting Information

The Supporting Information is available free of charge on the ACS Publications website at DOI: 10.1021/acs.joc.5b01564.

Copies of ^{1}H and $^{13}C\{^1H\}$ NMR spectra for all compounds (PDF)
CIF file for compound **4e** (CIF)
CIF file for compound **4l** (CIF)
CIF file for compound **6** (CIF)

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Notes

The authors declare no competing financial interest.

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