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# Terminal-Selective C(sp$^3$)–H Arylation: NiH-Catalyzed Remote Hydroarylation of Unactivated Internal Olefins

Yuli He, Bo Han, and Shaolin Zhu*

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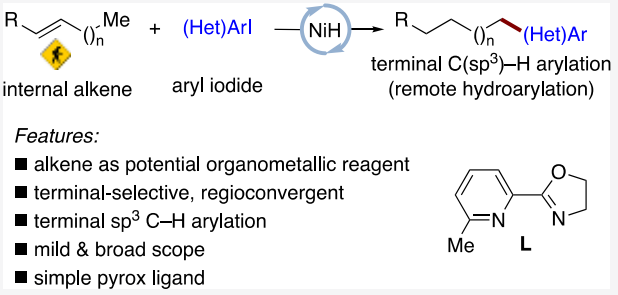
**ABSTRACT:** A terminal-selective migratory hydroarylation of unactivated olefins has been developed though a NiH-catalyzed alkene isomerization–hydroarylation relay process. This sp$^3$ C–H arylation was achieved with a simple pyrox ligand under mild conditions. The practicality and synthetic flexibility of the method is highlighted by the successful regioconvergent conversion of isomeric mixtures of alkenes to value-added linear arylation products on a gram scale.




## INTRODUCTION

Alkyl–aryl cross-coupling catalyzed by transition metals is a valuable process in a wide variety of C–C bond formation reactions and enables the production of valuable alkyl–aryl structural motifs (Figure 1a).[1,2] In these couplings, however, reaction sites are limited to the preactivated *ipso* positions. A further difficulty is that the synthesis of the preformed organometallic nucleophiles used in these processes is nontrivial and these nucleophiles can be highly reactive and unstable. Selective remote functionalization of hydrocarbons has the potential to assist in chemical synthesis but often suffers from the difficulty of discriminating between C(sp$^3$)–H bonds in both the starting material and product. A powerful alternative approach is the use of an unsaturated alkene or its precursor alkyl halide, abundant feedstock starting materials, to undergo metal hydride[3,4] catalyzed site-selective remote hydrofunctionalization.[5−12] Encouraged by the recent progress on NiH-catalyzed remote hydrofunctionalization (Figure 1b),[9−12] we wondered if the migratory arylation site[9e] could be located at the least sterically hindered terminal C(sp$^3$)–H position, thus producing the linear arylation product (Figure 1c).[13] In this case, the reaction would serve as a useful addition to the current remote hydroarylation methods and broaden their applications, including the retrosynthesis of complex molecules or late-stage functionalization in drug discovery. Herein, we report a nickel hydride catalyst modified by a pyrox ligand which delivers distal terminal arylation products with high functional group compatibility under mild conditions.

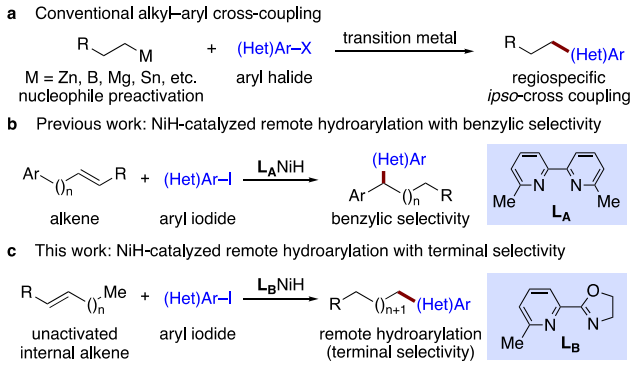



**Figure 1.** Design plan: terminal-selective migratory hydroarylation enabled by alkene isomerization and sequential hydroarylation.

Details of the presumed mechanism for this terminal-selective migratory hydroarylation reaction are shown in Figure 2. It is envisioned that the nickel(I) hydride (**I**)[4] generated *in situ* could promote a rapid and reversible isomerization between a series of alkylnickel intermediates (**II**, **IV**, **V**, etc.) along the alkyl chain through an iterative $\beta$-hydride elimination/$\beta$-migratory reinsertion process. With a suitable ligand, selective cross-coupling of the least sterically hindered linear alkylnickel(I) intermediate (**V**) generated in this way with aryl iodide (**2**) would be favored over other branched alkylnickel(I) intermediates and regiocontrol would thus be possible. The desired formal terminal C(sp$^3$)–H arylation product (**3**) would be formed and the nickel hydride species could be regenerated *in situ* in the presence of a fluoride salt

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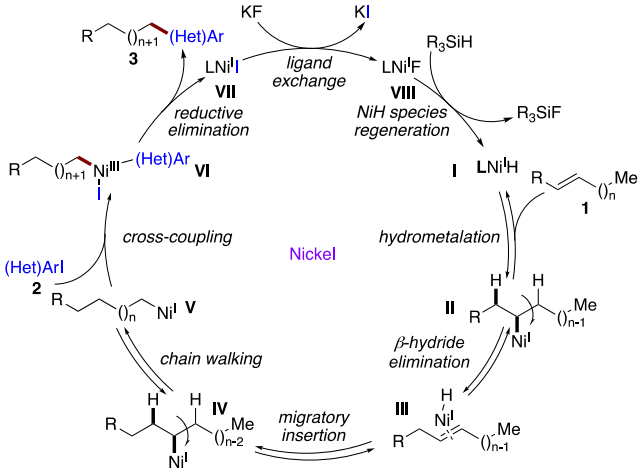



**Figure 2.** Proposed pathway of terminal-selective remote hydroarylation.

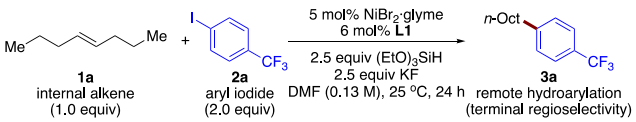
and hydrosilane to complete a net catalytic cycle. Here we present our achievement of this reaction under mild conditions with high functional group compatibility.

## RESULTS AND DISCUSSION

We began by studying the coupling of *trans*-4-octene (**1a**) with 1-iodo-4-(trifluoromethyl)benzene (**2a**). An investigation of various parameters showed that the desired terminal-selective arylation product (**3a**) could be obtained in 80% yield by using a combination of $NiBr_2$·glyme and a suitable pyrox ligand (**L1**). The reaction showed excellent regioselectivity (rr (linear isomer:all other isomers) = 98:2) (Table 1, entry 1). Use of other nickel sources led to diminished yields (entries 2 and 3). The pyrox ligand (**L1**) is easily prepared and is stable in air (see the Supporting Information for details). Screening of ligands revealed that both the dihydrooxazole ring and the 6-alkyl group of **L1** are critical (entries 4–6). Modification of the dihydrooxazole ring led to lower yields (entries 4 and 5). The use of ligand **L4** without an *o*-methyl substituent or replacement of the pyrox ligand (**L1**) with bipyridine type ligands (**L5**–**L7**) resulted in no desired product (entry 6). An evaluation of other silanes showed that polymethylhydrosiloxane (PMHS) was less effective (entry 7). The replacement of KF with CsF resulted in almost a complete loss of reactivity (entry 8). Less polar solvents such as THF, toluene, and acetonitrile were found to be unsuitable (entries 9–11), and the polar solvent DMA was less effective (entry 12). Conducting the reaction at 40 °C instead of at room temperature (rt) also led to a lower yield (entry 13). When a less reactive aryl bromide was used, cross-coupling happened with considerably lower yield and regioselectivity in comparison to that of aryl iodide (entry 14). Use of only 1.5 equiv of the aryl iodide (**2a**) also led to a reduced yield (entry 15). Control experiments revealed that all of the reaction parameters were important for the success of the reaction.

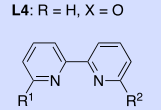
With this protocol in hand, we sought to demonstrate the generality of this transformation. As shown in Table 2, a variety of unactivated internal aliphatic alkenes undergo alkene isomerization–hydroarylation smoothly. Both *E* (**1b**) and *Z* (**1c**,**h**,**l**) alkenes, as well as *E*/*Z* mixtures (**1d**–**g**,**i**–**k**), were well-tolerated, and high terminal-selective arylation was observed, regardless of the starting position of the C=C double bond (**1c** vs **1d**). Furthermore, a wide variety of functional groups (**1e**–**l**) are well-tolerated, demonstrating the high chemo- and regioselectivity of the reaction. For example,

**Table 1. Variation of Reaction Parameters**




| entry | deviation from standard conditions | yield of **3a** (%)[a] | rr[b] |
|---|---|---|---|
| 1 | none | 86 (80) | 98:2 |
| 2 | $NiBr_2$ instead of $NiBr_2$·glyme | 75 | 97:3 |
| 3 | $NiCl_2$·glyme instead of $NiBr_2$·glyme | 66 | 95:5 |
| 4 | **L2** instead of **L1** | 58 | 93:7 |
| 5 | **L3** instead of **L1** | 39 | 92:8 |
| 6 | **L4**–**L7** instead of **L1** | 0 | – |
| 7 | $(EtO)_2MeSiH$ instead of $(EtO)_3SiH$ | 76 | 95:5 |
| 8 | CsF instead of KF | 0 | – |
| 9 | THF instead of DMF | 0 | – |
| 10 | toluene instead of DMF | 0 | – |
| 11 | MeCN instead of DMF | <5 | – |
| 12 | DMA instead of DMF | 32 | 90:10 |
| 13 | 40 °C | 60 | 97:3 |
| 14 | 4-bromobenzotrifluoride instead of **2a** | 16 | 83:17 |
| 15 | 1.5 equiv **2a** | 69 | 95:5 |

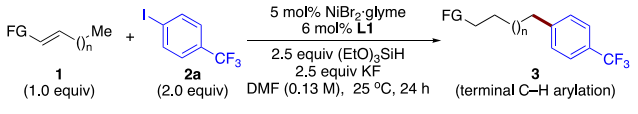
**L1**: R = Me, X = O
**L2**: R = Me, X = NH
**L3**: R = Me, X = $CH_2$
**L4**: R = H, X = O

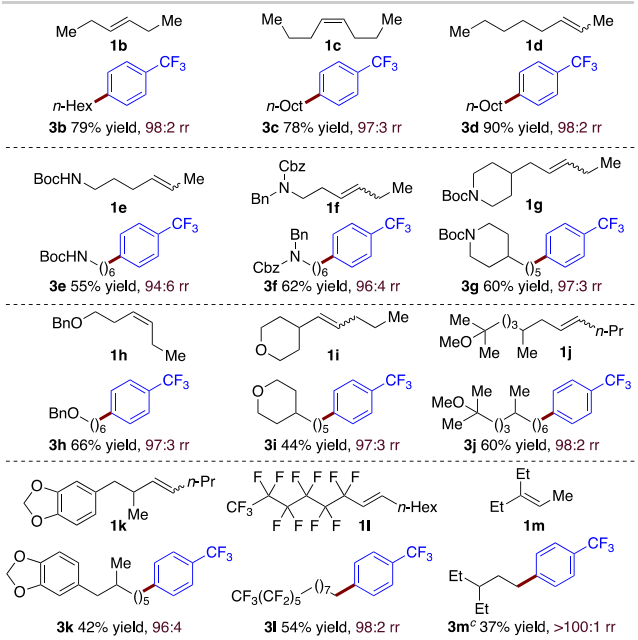


**L5**: $R^1$ = H, $R^2$ = H
**L6**: $R^1$ = Me, $R^2$ = H
**L7**: $R^1$ = Me, $R^2$ = Me

[a]Yields were determined by GC using dodecane as the internal standard. The yield in parentheses is the isolated yield of purified product and is an average of two experiments (0.5 mmol scale). [b]rr refers to regioisomeric ratio and represents the ratio of the major (terminal arylation) product to the sum of all other isomers as determined by GC analysis (see Supporting Information for experimental details).

**Table 2. Scope of Alkene Coupling Partners**[a,b]




[a]Isolated yields on a 0.50 mmol scale (average of two runs). [b]rr refers to regioisomeric ratio and represents the ratio of the major (terminal arylation) product to the sum of all other isomers as determined by GC analysis. [c]10 mol % of $NiBr_2$·glyme and 11 mol % of **L1** used.


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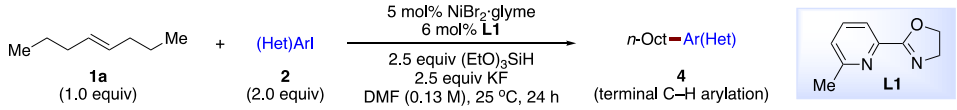
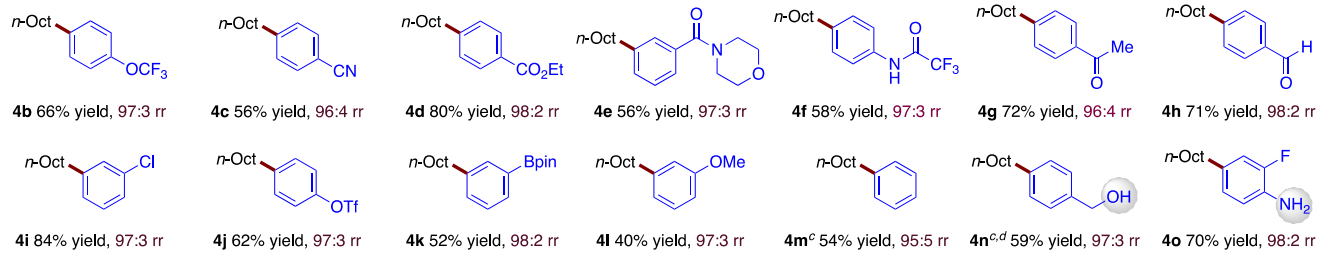
**Table 3. Scope of Aryl Iodide Coupling Partners**[a,b]



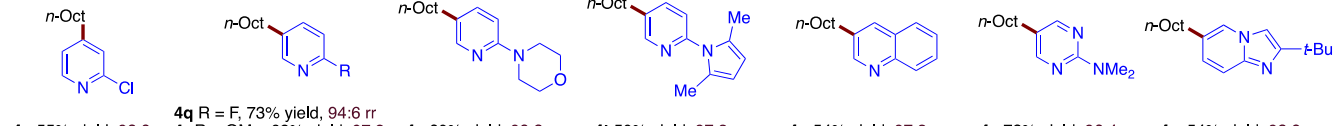

(a) aryl iodides




**4b** 66% yield, 97:3 rr; **4c** 56% yield, 96:4 rr; **4d** 80% yield, 98:2 rr; **4e** 56% yield, 97:3 rr; **4f** 58% yield, 97:3 rr; **4g** 72% yield, 96:4 rr; **4h** 71% yield, 98:2 rr

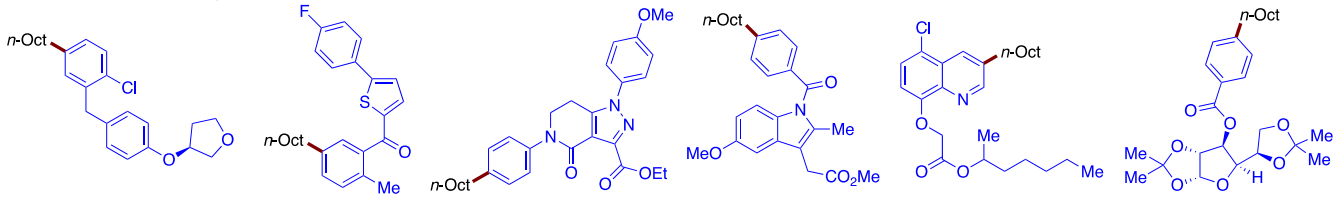
**4i** 84% yield, 97:3 rr; **4j** 62% yield, 97:3 rr; **4k** 52% yield, 98:2 rr; **4l** 40% yield, 97:3 rr; **4m**[c] 54% yield, 95:5 rr; **4n**[c,d] 59% yield, 97:3 rr; **4o** 70% yield, 98:2 rr

(b) heteroaryl iodides




**4p** 55% yield, 92:8 rr; **4q** R = F, 73% yield, 94:6 rr; **4r** R = OMe, 62% yield, 97:3 rr; **4s** 60% yield, 98:2 rr; **4t** 50% yield, 97:3 rr; **4u** 54% yield, 97:3 rr; **4v** 72% yield, 96:4 rr; **4w** 54% yield, 92:8 rr

(c) pharmaceutical and biological compounds




**4x** 75% yield, >95:5 rr empagliflozin derivative (anti-diabetes drug); **4y** 51% yield, >95:5 rr canagliflozin derivative (anti-diabetes drug); **4z**[e] 51% yield, >95:5 rr apixaban derivative (prevention of VIE drug); **4a'** 45% yield, >95:5 rr indomethacin derivative (anti-inflammatory drug); **4b'** 71% yield, >95:5 rr cloquintocet-mexyl derivative (herbicide); **4c'** 81% yield, >100:1 rr glucose derivative

[a]Isolated yields on a 0.50 mmol scale (average of two runs). [b]rr refers to regioisomeric ratio and represents the ratio of the major (terminal arylation) product to the sum of all other isomers as determined by GC analysis; ratios reported as >95:5 were determined by a crude $^1$H NMR analysis. [c]10 mol % of $NiBr_2$·glyme and 11 mol % **L1** used. [d]4.5 equiv of $(EtO)_3SiH$ used. [e]0.2 mmol of **2z** used.

even with a heteroatomic substituent at the other terminus of the alkyl chain, including carbamates (**1e–g**) or ethers (**1h–j**), migration toward the terminal position and the subsequent linear adduct is still preferred. Of particular interest, good terminal chemo- and regioselectivity is still observed for olefins bearing a remote phenyl group[14] (**1k**) or a perfluoroalkyl-substituted electron-withdrawing substituent (**1l**). In addition, the isomerization–hydroarylation could be extended to a more sterically hindered trisubstituted alkene (**1l**), although the linear product was formed in a lower yield.

Next, we explored the scope of the aryl iodide coupling partner. As shown in Table 3a, we found that aryl iodides bearing either electron-deficient (**2b–l**) or electron-donating (**2n,o**) groups were competent substrates with excellent regioselectivity.[15] Under these exceptionally mild conditions, not only were ethers (**2b,e,l**), a nitrile (**2c**), an ester (**2d**), and amides (**2e,f**) tolerated, even normally easily reduced functional groups such as a ketone (**2g**) and an aldehyde (**2h**) remained intact. The reaction is orthogonal to aryl chloride (**2i**), aryl triflates (**2j**), and boronates (**2k**), which could be used for further derivatization. Notably, various acidic and basic functional groups, including a N–H-bearing amide (**2f**), a primary alcohol (**2n**), and a primary aniline (**2o**), were compatible with the current protocol.

Heterocyclic arenes products are common scaffolds in pharmaceutically relevant targets, and with respect to heteroaromatic iodide coupling partners (Table 3b), we found that a range of pyridines (**2p–t**) were suitable substrates. Extended aromatic systems such as a pyrrole-substituted pyridine (**2t**) and quinoline (**2u**) were also effective electrophiles in this transformation. Finally, multi-nitrogen-containing heterocycles including 2-pyrimidinamine (**2v**) and imidazo[1,2-*a*]pyridine (**2w**) were also competent coupling partners, making this an attractive method for preparing potential biochemically active agents.

This methodology can also be used for the late-stage functionalization of structurally complex and pharmaceutically relevant intermediates (Table 3c). A variety of (hetero)aryl iodides derived from commercially available pharmaceuticals, such as empagliflozin (**2x**), as well as heteroaryl-containing drugs, including canagliflozin (**2y**), apixaban (**2z**), indomethacin (**2a′**), and cloquintocet-mexyl (**2b′**), underwent migratory cross-coupling. Interestingly, carbohydrate derivatives such as the glucose (**2c′**) could also undergo the remote arylation successfully.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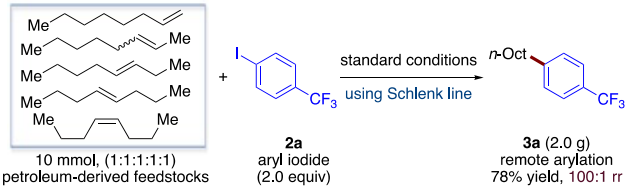
Isomeric mixtures of olefins derived directly from petrochemical sources are substantially cheaper than pure olefin isomers and their value-added regioconvergent conversion is therefore of considerable interest. As a proof of concept, equimolar mixtures of five isomeric octanes were utilized on a 10 mmol scale and the linear arylation product was obtained on a gram scale in a highly regioconvergent manner (Scheme 1).

**Scheme 1. Regioconvergent, 10 mmol Scale Benchtop Experiment**




## CONCLUSION

A mild, regioconvergent, and terminal-selective nickel-catalyzed migratory hydroarylation has been established. Excellent regio- and chemoselectivities were observed with a wide variety of both functionalized and unfunctionalized alkenes and (hetero)aryl iodide partners. Research into remote hydroarylation with branched selectivity is currently in progress and will be reported in due course.

## EXPERIMENTAL SECTION

**General Information.** Commercial reagents were purchased from commercial sources unless otherwise noted. Flash chromatography was performed using glass columns with 230−400 mesh silica gel. $^{1}$H NMR and $^{13}$C NMR spectra were recorded on Bruker 400 and 500 MHz spectrometers. IR spectra were obtained on a Bruker Alpha spectrometer and are reported in terms of frequency of absorption ($cm^{-1}$). GC analysis was performed on an Agilent 7890B gas chromatograph with an FID detector using a J&W DB-1 column (10 m, 0.1 mm I.D.). High-resolution mass spectra were obtained using a Bruker Daltonics, Inc. APEXIII 7.0 TESLA FTMS instrument (ESI) or a Waters Micromass GCT Premier Instrument (EI).

**General Procedure for the NiH-Catalyzed Remote Hydroarylation.** **L1** (6.0 mol %), $NiBr_2$·glyme (5.0 mol %), KF (2.5 equiv), and anhydrous DMF (3.75 mL) were placed in an oven-dried 8 mL screw-cap vial equipped with a magnetic stirring bar. The vial was placed in a nitrogen-filled glovebox, and the mixture was stirred for 20 min, at which time $(EtO)_3SiH$ (2.5 equiv) (a mixture stirred not more than 1 min), alkene (0.5 mmol, 1.0 equiv), and aryl iodide (1.0 mmol, 2.0 equiv) were added to the resulting mixture in that order. The tube was sealed with a Teflon-lined screw cap, removed from the glovebox, and stirred at rt (22−26 °C) for up to 24 h. The reaction mixture was then directly filtered through a short pad of silica gel using EtOAc in hexanes to give the crude product. Dodecane (50 μL) was added as an internal standard for GC analysis. 1,1,2,2-Tetrachloroethane (41.0 mg, 0.25 mmol) was added as an internal standard for $^{1}$H NMR analysis of the crude material. The product was purified by chromatography on silica gel for each substrate. The yields reported are the average of at least two experiments, unless otherwise indicated.

*1-Octyl-4-(trifluoromethyl)benzene (Table 2, **3a**).* The title compound was prepared from (*E*)-oct-4-ene (87.5 μL, 62.4 mg, 0.50 mmol), following the general procedure and using $NiBr_2$·glyme (7.8 mg, 0.025 mmol, 5.0 mol %), **L1** (4.8 mg, 0.030 mmol, 6.0 mol %), KF (73.0 g, 1.25 mmol, 2.5 equiv), 4-iodobenzotrifluoride (272.0 mg, 150 μL, 1.0 mmol, 2.0 equiv), $(EtO)_3SiH$ (230 μL, 1.25 mmol, 2.5 equiv), and DMF (3.75 mL). The reaction mixture was stirred for 24 h at rt. The crude material was purified by flash column chromatography and eluted with hexanes to provide the title compound as a colorless liquid in 80% yield (103.3 mg). IR (neat, $cm^{-1}$): 2926, 1323, 1118, 1018, 732. $^{1}$H NMR (400 MHz, $CDCl_3$): δ 7.54 (d, *J* = 8.0 Hz, 2H), 7.30 (d, *J* = 7.9 Hz, 2H), 2.67 (t, *J* = 7.8 Hz, 2H), 1.68−1.61 (m, 2H), 1.33−1.30 (m, 10H), 0.91 (t, *J* = 6.8 Hz, 3H). $^{13}$C NMR (101 MHz, $CDCl_3$): δ 147.2, 128.3, 128.2 (q, *J* = 32.3 Hz), 125.3 (q, *J* = 3.8 Hz), 124.6 (q, *J* = 271.6 Hz), 36.0, 32.1, 31.4, 29.9, 29.5, 29.4, 22.9, 14.2. $^{19}$F NMR (376 MHz, $CDCl_3$): δ −62.3. HRMS-EI (*m*/*z*): calcd for $C_{15}H_{21}F_3$ $[M]^+$ 258.1595, found 258.1598.

*1-Hexyl-4-(trifluoromethyl)benzene (Table 2, **3b**).* The title compound was prepared from (*E*)-hex-3-ene (62 μL, 0.50 mmol), following the general procedure and using $NiBr_2$·glyme (7.8 mg, 0.025 mmol, 5.0 mol %), **L1** (4.8 mg, 0.030 mmol, 6.0 mol %), KF (73.0 g, 1.25 mmol, 2.5 equiv), 4-iodobenzotrifluoride (272.0 mg, 150 μL, 1.0 mmol, 2.0 equiv), $(EtO)_3SiH$ (230 μL, 1.25 mmol, 2.5 equiv), and DMF (3.75 mL). The reaction mixture was stirred for 24 h at rt. The crude material was purified by flash column chromatography and eluted with pentanes to provide the title compound as a colorless liquid in 79% yield (90.8 mg). IR (neat, $cm^{-1}$): 2929, 1618, 1322, 1116, 1066, 820. $^{1}$H NMR (400 MHz, $CDCl_3$): δ 7.56 (d, *J* = 7.9 Hz, 2H), 7.31 (d, *J* = 7.9 Hz, 2H), 2.69 (t, *J* = 7.8 Hz, 2H), 1.70−1.62 (m, 2H), 1.40−1.31 (m, 6H), 0.93 (t, *J* = 6.4 Hz, 3H). $^{13}$C NMR (101 MHz, $CDCl_3$): δ 147.2, 128.8, 128.1 (q, *J* = 32.3 Hz), 125.3 (q, *J* = 3.9 Hz), 124.6 (q, *J* = 272.7 Hz), 36.0, 31.9, 31.4, 29.1, 22.8, 14.2. $^{19}$F NMR (376 MHz, $CDCl_3$): δ −62.3. HRMS-EI (*m*/*z*): calcd for $C_{13}H_{17}F_3$ $[M]^+$ *m*/*z* 230.1282, found 230.1279.

*1-Octyl-4-(trifluoromethyl)benzene (Table 2, **3c**).* The title compound was prepared from (*E*)-oct-3-ene (56.1 mg, 0.50 mmol), following the general procedure and using $NiBr_2$·glyme (7.8 mg, 0.025 mmol, 5.0 mol %), **L1** (4.8 mg, 0.030 mmol, 6.0 mol %), KF (73.0 g, 1.25 mmol, 2.5 equiv), 4-iodobenzotrifluoride (272.0 mg, 150 μL, 1.0 mmol, 2.0 equiv), $(EtO)_3SiH$ (230 μL, 1.25 mmol, 2.5 equiv), and DMF (3.75 mL). The reaction mixture was stirred for 24 h at rt. The crude material was purified by flash column chromatography and eluted with hexanes to provide the title compound as a colorless liquid in 78% yield (94.4 mg). IR (neat, $cm^{-1}$): 2926, 1323, 1118, 1018, 732. $^{1}$H NMR (400 MHz, $CDCl_3$): δ 7.54 (d, *J* = 8.0 Hz, 2H), 7.30 (d, *J* = 7.9 Hz, 2H), 2.67 (t, *J* = 7.8 Hz, 2H), 1.68−1.61 (m, 2H), 1.33−1.30 (m, 10H), 0.91 (t, *J* = 6.8 Hz, 3H). $^{13}$C NMR (101 MHz, $CDCl_3$): δ 147.2, 128.3, 128.2 (q, *J* = 32.3 Hz), 125.3 (q, *J* = 3.8 Hz), 124.6 (q, *J* = 271.6 Hz), 36.0, 32.1, 31.4, 29.9, 29.5, 29.4, 22.9, 14.2. $^{19}$F NMR (376 MHz, $CDCl_3$): δ −62.3. HRMS-EI (*m*/*z*): calcd for $C_{15}H_{21}F_3$ $[M]^+$ 258.1595, found 258.1598.

*1-Octyl-4-(trifluoromethyl)benzene (Table 2, **3d**).* The title compound was prepared from oct-2-ene (56.1 mg, 0.50 mmol), following the general procedure and using $NiBr_2$·glyme (7.8 mg, 0.025 mmol, 5.0 mol %), **L1** (4.8 mg, 0.030 mmol, 6.0 mol %), KF (73.0 g, 1.25 mmol, 2.5 equiv), 4-iodobenzotrifluoride (272.0 mg, 150 μL, 1.0 mmol, 2.0 equiv), $(EtO)_3SiH$ (230 μL, 1.25 mmol, 2.5 equiv), and DMF (3.75 mL). The reaction mixture was stirred for 24 h at rt. The crude material was purified by flash column chromatography and eluted with hexanes to provide the title compound as a colorless liquid in 90% yield (116.2 mg). IR (neat, $cm^{-1}$): 2926, 1323, 1118, 1018, 732. $^{1}$H NMR (400 MHz, $CDCl_3$): δ 7.54 (d, *J* = 8.0 Hz, 2H), 7.30 (d, *J* = 7.9 Hz, 2H), 2.67 (t, *J* = 7.8 Hz, 2H), 1.68−1.61 (m, 2H), 1.33−1.30 (m, 10H), 0.91 (t, *J* = 6.8 Hz, 3H). $^{13}$C NMR (101 MHz, $CDCl_3$): δ 147.2, 128.3, 128.2 (q, *J* = 32.3 Hz), 125.3 (q, *J* = 3.8 Hz), 124.6 (q, *J* = 271.6 Hz), 36.0, 32.1, 31.4, 29.9, 29.5, 29.4, 22.9, 14.2. $^{19}$F NMR (376 MHz, $CDCl_3$): δ −62.3. HRMS-EI (*m*/*z*): calcd for $C_{15}H_{21}F_3$ $[M]^+$ 258.1595, found 258.1598.

*tert-Butyl (6-(4-(Trifluoromethyl)phenyl)hexyl)carbamate (Table 2, **3e**).* The title compound was prepared from *tert*-butyl hex-4-en-1-ylcarbamate (100.0 mg, 0.50 mmol), following the general procedure and using $NiBr_2$·glyme (7.8 mg, 0.025 mmol, 5.0 mol %), **L1** (4.8 mg, 0.030 mmol, 6.0 mol %), KF (73.0 g, 1.25 mmol, 2.5 equiv), 4-iodobenzotrifluoride (272.0 mg, 150 μL, 1.0 mmol, 2.0 equiv), $(EtO)_3SiH$ (230 μL, 1.25 mmol, 2.5 equiv), and DMF (3.75 mL). The reaction mixture was stirred for 24 h at rt. The crude material was purified by flash column chromatography and eluted with 2% EtOAc in hexanes to provide the title compound as a colorless liquid in 55%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yield (95.6 mg). IR (neat, $cm^{-1}$): 2931, 1691, 1510, 1323, 1116, 1017, 842. $^1H$ NMR (400 MHz, $CDCl_3$): $\delta$ 7.43 (d, $J$ = 7.9 Hz, 2H), 7.18 (d, $J$ = 7.8 Hz, 2H), 4.50 (s, 1H), 3.02 (q, $J$ = 6.8 Hz, 2H), 2.57 (t, $J$ = 7.7 Hz, 2H), 1.58−1.50 (m, 2H), 1.40−1.33 (m, 11H), 1.27−1.24 (m, 4H). $^{13}C$ NMR (101 MHz, $CDCl_3$): $\delta$ 156.1, 146.9, 128.8, 128.1 (q, $J$ = 32.3 Hz), 125.3 (q, $J$ = 3.8 Hz), 124.5 (q, $J$ = 271.8 Hz), 79.1, 40.6, 35.8, 31.2, 30.1, 28.9, 28.5, 26.7. $^{19}F$ NMR (376 MHz, $CDCl_3$): $\delta$ −62.3. HRMS-ESI ($m/z$): calcd for $C_{18}H_{26}F_3NNaO_2$ $[M + Na]^+$ 368.1808, found 368.1805.

*Benzyl Benzyl(6-(4-(trifluoromethyl)phenyl)hexyl)carbamate (Table 2, **3f**).* The title compound was prepared from benzyl benzyl(hex-3-en-1-yl)carbamate (161.5 mg, 0.50 mmol), following the general procedure and using $NiBr_2$·glyme (7.8 mg, 0.025 mmol, 5.0 mol %), **L1** (4.8 mg, 0.030 mmol, 6.0 mol %), KF (73.0 g, 1.25 mmol, 2.5 equiv), 4-iodobenzotrifluoride (272.0 mg, 150 $\mu$L, 1.0 mmol, 2.0 equiv), $(EtO)_3SiH$ (230 $\mu$L, 1.25 mmol, 2.5 equiv), and DMF (3.75 mL). The reaction mixture was stirred for 24 h at rt. The crude material was purified by flash column chromatography and eluted with 5% EtOAc in hexanes to provide the title compound as a colorless liquid in 62% yield (145.1 mg). IR (neat, $cm^{-1}$): 2931, 1696, 1418, 1323, 1116, 1028, 631. $^1H$ NMR (400 MHz, $CDCl_3$): $\delta$ 7.57 (d, $J$ = 7.9 Hz, 2H), 7.53−7.01 (m, 12H), 5.22 (s, 2H), 4.54 (s, 2H), 3.32−3.25 (m, 2H), 2.66 (t, $J$ = 6.8 Hz, 2H), 1.64−1.54 (m, 4H), 1.38−1.27 (m, 4H). $^{13}C$ NMR (101 MHz, $CDCl_3$): $\delta$ 156.9 and 156.3 (due to rotamers), 146.9, 138.1, 137.0, 128.8, 128.6, 128.5, 128.3, 128.0, 127.9, 127.7, 127.6, 127.4, 127.3, 125.3 (q, $J$ = 3.9 Hz), 124.5 (q, $J$ = 271.6 Hz), 67.25, 50.6, and 50.3 (due to rotamers), 47.3 and 46.3 (due to rotamers), 35.7, 31.1, 28.9, 28.1, and 27.7 (due to rotamers), 26.7. $^{19}F$ NMR (376 MHz, $CDCl_3$): $\delta$ −62.2. HRMS-ESI ($m/z$): calcd for $C_{28}H_{30}F_3NNaO_2$ $[M + Na]^+$ 492.2121, found 492.2125.

*tert-Butyl 4-(5-(4-(Trifluoromethyl)phenyl)pentyl)piperidine-1-carboxylate (Table 2, **3g**).* The title compound was prepared from *tert*-butyl 4-(pent-2-en-1-yl)piperidine-1-carboxylate (127.0 mg, 0.50 mmol), following the general procedure and using $NiBr_2$·glyme (7.8 mg, 0.025 mmol, 5.0 mol %), **L1** (4.8 mg, 0.030 mmol, 6.0 mol %), KF (73.0 g, 1.25 mmol, 2.5 equiv), 4-iodobenzotrifluoride (272.0 mg, 150 $\mu$L, 1.0 mmol, 2.0 equiv), $(EtO)_3SiH$ (230 $\mu$L, 1.25 mmol, 2.5 equiv), and DMF (3.75 mL). The reaction mixture was stirred for 24 h at rt. The crude material was purified by flash column chromatography and eluted with 2% EtOAc in hexanes to provide the title compound as a colorless liquid in 60% yield (119.7 mg). IR (neat, $cm^{-1}$): 2928, 1988, 1418, 1324, 1119, 843. $^1H$ NMR (400 MHz, $CDCl_3$): $\delta$ 7.44 (d, $J$ = 7.9 Hz, 2H), 7.20 (d, $J$ = 8.0 Hz, 2H), 3.99 (d, $J$ = 13.1 Hz, 2H), 2.61−2.55 (m, 4H), 1.57−1.53 (m, 4H), 1.38 (s, 9H), 1.25−1.23 (m, 5H), 1.16−1.11 (m, 2H), 1.00−0.96 (m, 2H). $^{13}C$ NMR (101 MHz, $CDCl_3$): $\delta$ 155.1, 147.0, 128.8, 128.1 (q, $J$ = 32.1 Hz), 125.3 (q, $J$ = 3.9 Hz), 124.5 (q, $J$ = 271.7 Hz), 79.3, 44.2, 36.6, 36.1, 35.9, 32.4, 31.3, 29.5, 28.6, 26.6. $^{19}F$ NMR (376 MHz, $CDCl_3$): $\delta$ −62.3. HRMS-ESI ($m/z$): calcd for $C_{22}H_{32}F_3NNaO_2$ $[M + Na]^+$ 422.2277, found 422.2278.

*1-(6-(Benzyloxy)hexyl)-4-(trifluoromethyl)benzene (Table 2, **3h**).* The title compound was prepared from (Z)-((hex-3-en-1-yloxy)-methyl)benzene (95.1 mg, 0.50 mmol), following the general procedure and using $NiBr_2$·glyme (7.8 mg, 0.025 mmol, 5.0 mol %), **L1** (4.8 mg, 0.030 mmol, 6.0 mol %), KF (73.0 g, 1.25 mmol, 2.5 equiv), 4-iodobenzotrifluoride (272.0 mg, 150 $\mu$L, 1.0 mmol, 2.0 equiv), $(EtO)_3SiH$ (230 $\mu$L, 1.25 mmol, 2.5 equiv), and DMF (3.75 mL). The reaction mixture was stirred for 24 h at rt. The crude material was purified by flash column chromatography and eluted with hexanes to provide the title compound as a colorless liquid in 66% yield (111.0 mg). IR (neat, $cm^{-1}$): 2932, 2856, 1322, 1114, 1018, 696. $^1H$ NMR (400 MHz, $CDCl_3$): $\delta$ 7.42 (d, $J$ = 7.9 Hz, 2H), 7.29−7.10 (m, 7H), 4.40 (s, 2H), 3.37 (t, $J$ = 6.5 Hz, 2H), 2.55 (t, $J$ = 7.7 Hz, 2H), 1.56−1.49 (m, 4H), 1.35−1.24 (m, 4H). $^{13}C$ NMR (101 MHz, $CDCl_3$): $\delta$ 147.0, 138.8, 128.8, 128.5, 128.1 (q, $J$ = 32.3 Hz), 127.7, 127.6, 125.3 (q, $J$ = 3.8 Hz), 124.6 (q, $J$ = 271.8 Hz), 73.0, 70.5, 35.8, 31.2, 29.8, 29.1, 26.2. $^{19}F$ NMR (376 MHz, $CDCl_3$): $\delta$ −62.2. HRMS-EI ($m/z$): calcd for $C_{20}H_{23}F_3O$ $[M]^+$ 336.1701, found 336.1707.

*4-(5-(4-(Trifluoromethyl)phenyl)pentyl)tetrahydro-2H-pyran (Table 2, **3i**).* The title compound was prepared from 4-(pent-1-en-1-yl)tetrahydro-2*H*-pyran (77.0 mg, 0.50 mmol), following the general procedure and using $NiBr_2$·glyme (7.8 mg, 0.025 mmol, 5.0 mol %), **L1** (4.8 mg, 0.030 mmol, 6.0 mol %), KF (73.0 g, 1.25 mmol, 2.5 equiv), 4-iodobenzotrifluoride (272.0 mg, 150 $\mu$L, 1.0 mmol, 2.0 equiv), $(EtO)_3SiH$ (230 $\mu$L, 1.25 mmol, 2.5 equiv), and DMF (3.75 mL). The reaction mixture was stirred for 24 h at rt. The crude material was purified by flash column chromatography and eluted with 1% EtOAc in hexanes to provide the title compound as a colorless liquid in 44% yield (65.8 mg). IR (neat, $cm^{-1}$): 2926, 1324, 1119, 1067, 842. $^1H$ NMR (400 MHz, $CDCl_3$): $\delta$ 7.45 (d, $J$ = 7.9 Hz, 2H), 7.20 (d, $J$ = 9.2 Hz, 2H), 3.89−3.85 (m, 2H), 3.35−3.23 (m, 2H), 2.58 (t, $J$ = 6.8 Hz, 2H), 1.58−1.47 (m, 4H), 1.28−1.11 (m, 9H). $^{13}C$ NMR (101 MHz, $CDCl_3$): $\delta$ 147.0, 128.8, 128.1 (q, $J$ = 32.2 Hz), 125.3 (q, $J$ = 3.9 Hz), 124.5 (q, $J$ = 271.7 Hz), 68.3, 37.0, 35.9, 35.1, 33.3, 31.3, 29.5, 26.3. $^{19}F$ NMR (376 MHz, $CDCl_3$): $\delta$ −62.3. HRMS-EI ($m/z$): calcd for $C_{17}H_{23}F_3O$ $[M]^+$ 300.1701, found 300.1709.

*1-(11-Methoxy-7,11-dimethyldodecyl)-4-(trifluoromethyl)-benzene (Table 2, **3j**).* The title compound was prepared from 11-methoxy-7,11-dimethyldodec-4-ene (108.1 mg, 0.50 mmol), following the general procedure and using $NiBr_2$·glyme (7.8 mg, 0.025 mmol, 5.0 mol %), **L1** (4.8 mg, 0.030 mmol, 6.0 mol %), KF (73.0 g, 1.25 mmol, 2.5 equiv), 4-iodobenzotrifluoride (272.0 mg, 150 $\mu$L, 1.0 mmol, 2.0 equiv), $(EtO)_3SiH$ (230 $\mu$L, 1.25 mmol, 2.5 equiv), and DMF (3.75 mL). The reaction mixture was stirred for 24 h at rt. The crude material was purified by flash column chromatography and eluted with hexanes to provide the title compound as a colorless liquid in 60% yield (108.7 mg). IR (neat, $cm^{-1}$): 2928, 1323, 1121, 1066, 842. $^1H$ NMR (400 MHz, $CDCl_3$): $\delta$ 7.45 (d, $J$ = 8.0 Hz, 2H), 7.20 (d, $J$ = 8.0 Hz, 2H), 3.10 (s, 3H), 2.58 (t, $J$ = 7.8 Hz, 2H), 1.58−1.51 (m, 2H), 1.37−1.18 (m, 15H), 1.06 (s, 6H), 0.78 (d, $J$ = 6.5 Hz, 3H). $^{13}C$ NMR (101 MHz, $CDCl_3$): $\delta$ 147.2, 128.8, 128.1 (q, $J$ = 32.2 Hz), 125.3 (q, $J$ = 3.9 Hz), 124.5 (q, $J$ = 272.7 Hz), 74.8, 49.2, 40.3, 37.8, 37.2, 36.0, 32.9, 31.4, 30.0, 29.4, 27.1, 25.2, 21.5, 19.8. $^{19}F$ NMR (376 MHz, $CDCl_3$): $\delta$ −62.3. HRMS-EI ($m/z$): calcd for $C_{21}H_{32}F_3O$ $[M - 15]^+$ 357.2405, found 357.2403.

*5-(2-Methyl-7-(4(Trifluoromethyl)phenyl)heptyl)benzo[d][1,3]-dioxole (Table 2, **3k**).* The title compound was prepared from 5-(2-methylhept-3-en-1-yl)benzo[*d*][1,3]dioxole (123.2 mg, 0.50 mmol), following the general procedure and using $NiBr_2$·glyme (7.8 mg, 0.025 mmol, 5.0 mol %), **L1** (4.8 mg, 0.030 mmol, 6.0 mol %), KF (73.0 g, 1.25 mmol, 2.5 equiv), 4-iodobenzotrifluoride (272.0 mg, 150 $\mu$L, 1.0 mmol, 2.0 equiv), $(EtO)_3SiH$ (230 $\mu$L, 1.25 mmol, 2.5 equiv), and DMF (3.75 mL). The reaction mixture was stirred for 24 h at rt. The crude material was purified by flash column chromatography and eluted with 2% EtOAc in hexanes to provide the title compound as a colorless liquid in 42% yield (82.3 mg). IR (neat, $cm^{-1}$): 2926, 1488, 1322, 1116, 770. $^1H$ NMR (400 MHz, $CDCl_3$): $\delta$ 7.45 (d, $J$ = 8.0 Hz, 2H), 7.20 (d, $J$ = 7.6 Hz, 2H), 6.64 (d, $J$ = 7.9 Hz, 1H), 6.55 (s, 1H), 6.51−6.48 (m, 1H), 5.84 (s, 2H), 2.57 (t, $J$ = 7.7 Hz, 2H), 2.45 (dd, $J$ = 13.5, 6.2 Hz, 1H), 2.21 (dd, $J$ = 13.5, 8.0 Hz, 1H), 1.55−1.50 (m, 4H), 1.26−1.18 (m, 4H), 1.08−0.99 (m, 1H), 0.76 (d, $J$ = 6.6 Hz, 3H). $^{13}C$ NMR (126 MHz, $CDCl_3$): $\delta$ 147.5, 147.1, 145.6, 135.6, 128.8, 128.1 (q, $J$ = 32.2 Hz), 125.3 (q, $J$ = 3.8 Hz), 124.6 (q, $J$ = 271.6 Hz), 122.0, 109.6, 108.0, 100.8, 43.6, 36.5, 35.9, 35.3, 31.3, 29.6, 27.0, 19.5. $^{19}F$ NMR (471 MHz, $CDCl_3$): $\delta$ −62.2. HRMS-EI ($m/z$): calcd for $C_{22}H_{25}F_3O_2$ $[M]^+$ 378.1808, found 378.1807.

*1-(9,9,10,10,11,11,12,12,13,13,14,14,14-Tridecafluorotetradecyl)-4-(trifluoromethyl)benzene (Table 2, **3l**).* The title compound was prepared from 1-perfluorohexyl-1-octene (215.1 mg, 0.50 mmol), following the general procedure and using $NiBr_2$·glyme (7.8 mg, 0.025 mmol, 5.0 mol %), **L1** (4.8 mg, 0.030 mmol, 6.0 mol %), KF (73.0 g, 1.25 mmol, 2.5 equiv), 4-iodobenzotrifluoride (272.0 mg, 150 $\mu$L, 1.0 mmol, 2.0 equiv), $(EtO)_3SiH$ (230 $\mu$L, 1.25 mmol, 2.5 equiv), and DMF (3.75 mL). The reaction mixture was stirred for 24 h at rt. The crude material was purified by flash column chromatography and eluted with hexanes to provide the title compound as a colorless liquid in 54% yield (155.4 mg). IR (neat, $cm^{-1}$): 2932, 1325, 1119, 1019,


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696. $^1$H NMR (400 MHz, $CDCl_3$): $\delta$ 7.5 (d, $J$ = 7.9 Hz, 2H), 7.2 (d, $J$ = 7.9 Hz, 2H), 2.6 (t, $J$ = 7.7 Hz, 2H), 2.03−1.89 (m, 2H), 1.57−1.47 (m, 4H), 1.31−1.24 (m, 8H). $^{13}$C NMR (101 MHz, $CDCl_3$): $\delta$ 147.1, 128.8, 128.3 (q, $J$ = 32.3 Hz), 125.4 (q, $J$ = 3.7 Hz), 124.6 (q, $J$ = 271.5 Hz), 118.8−110.1 ($^{13}$C−$^{19}$F coupling from $C_6F_{13}$), 35.9, 31.3, 31.0 (t, $J$ = 22.5 Hz), 29.4, 29.3, 29.2, 29.2, 20.2. $^{19}$F NMR (376 MHz, $CDCl_3$): $\delta$ −62.4 (s, 3F), −80.9 (t, $J$ = 9.9 Hz, 3F), −114.5 to −114.5 (m, 2F), −121.9 to −122.1 (m, 2F), −122.9 to −123.1 (m, 2F), −123.6 to −123.8 (m, 2F), −126.2 to −126.4 (m, 2F). HRMS-EI ($m/z$): calcd for $C_{21}H_{20}F_{16}$ $[M]^+$ 576.1310, found 576.1317.

*1-(3-Ethylpentyl)-4-(trifluoromethyl)benzene (Table 2, **3m**).* The title compound was prepared from 3-ethyl-2-pentene (68 μL, 0.5 mmol), following the general procedure and using $NiBr_2$·glyme (15.6 mg, 0.05 mmol, 5.0 mol %), **L1** (8.8 mg, 0.055 mmol, 11.0 mol %), KF (73.0 g, 1.25 mmol, 2.5 equiv), 4-iodobenzotrifluoride (272.0 mg, 150 μL, 1.0 mmol, 2.0 equiv), $(EtO)_3SiH$ (230 μL, 1.25 mmol, 2.5 equiv), and DMF (3.75 mL). The reaction mixture was stirred for 24 h at rt. The crude material was purified by flash column chromatography and eluted with pentanes to provide the title compound as a colorless liquid in 37% yield (45.2 mg). IR (neat, $cm^{-1}$): 2962, 2925, 1618, 1322, 1119, 1018, 835. $^1$H NMR (400 MHz, $CDCl_3$): $\delta$ 7.44 (d, $J$ = 8.1 Hz, 2H), 7.21 (d, $J$ = 7.9 Hz, 2H), 2.55 (t, $J$ = 6.8 Hz, 2H), 1.52−1.45 (m, 2H), 1.28−1.24 (m, 5H), 0.79 (t, $J$ = 7.4 Hz, 6H). $^{13}$C NMR (101 MHz, Chloroform-*d*): $\delta$ 147.6, 128.8, 128.1 (q, $J$ = 32.3 Hz), 125.3 (q, $J$ = 3.7 Hz), 124.6 (q, $J$ = 271.6 Hz), 40.1, 34.7, 33.2, 25.4, 11.0. $^{19}$F NMR (376 MHz, $CDCl_3$): $\delta$ −62.3. HRMS-EI ($m/z$): calcd for $C_{14}H_{19}F_3$ $[M]^+$ 244.1439, found 244.1445.

*1-Octyl-4-(trifluoromethoxy)benzene (Table 3a, **4b**).* The title compound was prepared from 1-iodo-4-(trifluoromethoxy)benzene (288.0 mg, 1.0 mmol, 2.0 equiv), following the general procedure and using $NiBr_2$·glyme (7.8 mg, 0.025 mmol, 5.0 mol %), **L1** (4.8 mg, 0.030 mmol, 6.0 mol %), KF (73.0 g, 1.25 mmol, 2.5 equiv), (*E*)-oct-4-ene (87.5 μL, 62.4 mg, 0.50 mmol), $(EtO)_3SiH$ (230 μL, 1.25 mmol, 2.5 equiv), and DMF (3.75 mL). The reaction mixture was stirred for 24 h at rt. The crude material was purified by flash column chromatography and eluted with hexanes to provide the title compound as a colorless liquid in 66% yield (90.1 mg). IR (neat, $cm^{-1}$): 2926, 1508, 1254, 1115, 812. $^1$H NMR (400 MHz, $CDCl_3$): $\delta$ 7.10 (d, $J$ = 8.6 Hz, 2H), 7.03 (d, $J$ = 8.3 Hz, 2H), 2.52 (t, $J$ = 7.6 Hz, 2H), 1.56−1.46 (m, 2H), 1.28−1.13 (m, 10H), 0.80 (t, $J$ = 6.8 Hz, 3H). $^{13}$C NMR (101 MHz, $CDCl_3$): $\delta$ 147.4, 141.8, 129.7, 121.0, 120.7 (q, $J$ = 256.4 Hz), 35.5, 32.0, 31.6, 29.8, 29.6, 29.4, 22.8, 14.2. $^{19}$F NMR (376 MHz, $CDCl_3$): $\delta$ −58.0. HRMS-EI ($m/z$): calcd for $C_{15}H_{21}F_3O$ $[M]^+$ 274.1542, found 274.1544.

*4-Octylbenzonitrile (Table 3a, **4c**).* The title compound was prepared from 4-iodobenzonitrile (229.0 mg, 1.0 mmol, 2.0 equiv), following the general procedure and using $NiBr_2$·glyme (7.8 mg, 0.025 mmol, 5.0 mol %), **L1** (4.8 mg, 0.030 mmol, 6.0 mol %), KF (73.0 g, 1.25 mmol, 2.5 equiv), (*E*)-oct-4-ene (87.5 μL, 62.4 mg, 0.50 mmol), $(EtO)_3SiH$ (230 μL, 1.25 mmol, 2.5 equiv), and DMF (3.75 mL). The reaction mixture was stirred for 24 h at rt. The crude material was purified by flash column chromatography and eluted with hexanes to provide the title compound as a colorless liquid in 56% yield (60.2 mg). IR (neat, $cm^{-1}$): 2954, 2854, 2227, 1607, 1413, 819, 560. $^1$H NMR (400 MHz, $CDCl_3$): $\delta$ 7.48 (d, $J$ = 8.2 Hz, 2H), 7.19 (d, $J$ = 8.1 Hz, 2H), 2.58 (d, $J$ = 7.8 Hz, 2H), 1.57−1.50 (m, 2H), 1.23−1.18 (m, 10H), 0.80 (t, $J$ = 6.8 Hz, 3H). $^{13}$C NMR (101 MHz, $CDCl_3$): $\delta$ 148.7, 132.2, 129.3, 119.3, 109.6, 36.2, 32.0, 31.1, 29.5, 29.4, 29.3, 22.8, 14.2. HRMS-ESI ($m/z$): calcd for $C_{15}H_{21}NNa$ $[M + Na]^+$ 238.1566, found 238.1559.

*Ethyl 4-Octylbenzoate (Table 3a, entry **4d**).* The title compound was prepared from ethyl 4-iodobenzoate (276.1 mg, 1.0 mmol, 2.0 equiv), following the general procedure and using $NiBr_2$·glyme (7.8 mg, 0.025 mmol, 5.0 mol %), **L1** (4.8 mg, 0.030 mmol, 6.0 mol %), KF (73.0 g, 1.25 mmol, 2.5 equiv), (*E*)-oct-4-ene (87.5 μL, 62.4 mg, 0.50 mmol), $(EtO)_3SiH$ (230 μL, 1.25 mmol, 2.5 equiv), and DMF (3.75 mL). The reaction mixture was stirred for 24 h at rt. The crude material was purified by flash column chromatography and eluted with 1% EtOAc in hexanes to provide the title compound as a colorless liquid in 82% yield (105.3 mg). IR (neat, $cm^{-1}$): 2924, 1716, 1610, 1270, 1104, 761. $^1$H NMR (400 MHz, $CDCl_3$): $\delta$ 7.95 (d, $J$ = 8.3 Hz, 2H), 7.23 (d, $J$ = 8.2 Hz, 2H), 4.36 (q, $J$ = 7.1 Hz, 2H), 2.65 (t, $J$ = 7.8 Hz, 2H), 1.65−1.58 (m, 2H), 1.38 (t, $J$ = 7.1 Hz, 3H), 1.34−1.21 (m, 10H), 0.87 (t, $J$ = 6.7 Hz, 3H). $^{13}$C NMR (101 MHz, $CDCl_3$): $\delta$ 166.9, 148.5, 129.7, 128.5, 128.0, 60.9, 36.1, 32.0, 31.3, 29.6, 29.4, 29.4, 22.8, 14.5, 14.2. HRMS-ESI ($m/z$): calcd for $C_{17}H_{26}NaO_2$ $[M + Na]^+$ 285.1825, found 285.1817.

*Morpholino(3-octylphenyl)methanone (Table 3a, **4e**).* The title compound was prepared from (3-iodophenyl)(morpholino)-methanone (317.1 mg, 1.0 mmol, 2.0 equiv), following the general procedure and using $NiBr_2$·glyme (7.8 mg, 0.025 mmol, 5.0 mol %), **L1** (4.8 mg, 0.030 mmol, 6.0 mol %), KF (73.0 g, 1.25 mmol, 2.5 equiv), (*E*)-oct-4-ene (87.5 μL, 62.4 mg, 0.50 mmol), $(EtO)_3SiH$ (230 μL, 1.25 mmol, 2.5 equiv), and DMF (3.75 mL). The reaction mixture was stirred for 24 h at rt. The crude material was purified by flash column chromatography and eluted with 10% EtOAc in hexanes to provide the title compound as a colorless liquid in 56% yield (84.6 mg). IR (neat, $cm^{-1}$): 2922, 1605, 1490, 1242, 1120, 942, 808. $^1$H NMR (400 MHz, $CDCl_3$): $\delta$ 7.25−7.20 (m, 1H), 7.18−7.10 (m, 3H), 3.78−3.30 (m, 8H), 2.55 (t, $J$ = 7.6 Hz, 2H), 1.58−1.48 (m, 2H), 1.29−1.15 (m, 10H), 0.80 (t, $J$ = 6.9 Hz, 3H). $^{13}$C NMR (101 MHz, $CDCl_3$): $\delta$ 170.8, 143.6, 135.3, 130.1, 128.5, 127.1, 124.4, 67.0, 48.4, and 42.6 (due to rotamers), 35.9, 32.0, 31.4, 29.6, 29.4, 29.4, 22.8, 14.2. HRMS-ESI ($m/z$): calcd for $C_{19}H_{30}NO_2$ $[M + H]^+$ 304.2271, found 304.2271.

*2,2,2-Trifluoro-N-(4-octylphenyl)acetamide (Table 3a, **4f**).* The title compound was prepared from 2,2,2-trifluoro-*N*-(4-iodophenyl)-acetamide (315.2 mg, 1.0 mmol, 2.0 equiv), following the general procedure and using $NiBr_2$·glyme (7.8 mg, 0.025 mmol, 5.0 mol %), **L1** (4.8 mg, 0.030 mmol, 6.0 mol %), KF (73.0 g, 1.25 mmol, 2.5 equiv), (*E*)-oct-4-ene (87.5 μL, 62.4 mg, 0.50 mmol), $(EtO)_3SiH$ (230.0 μL, 1.25 mmol, 2.5 equiv), and DMF (3.75 mL). The reaction mixture was stirred for 24 h at rt. The crude material was purified by flash column chromatography and eluted with 2% EtOAc in hexanes to provide the title compound as a white solid in 58% yield (91.4 mg). Mp: 84−86 °C. IR (neat, $cm^{-1}$): 3295, 2917, 1702, 1147, 831. $^1$H NMR (400 MHz, $CDCl_3$): $\delta$ 7.97 (s, 1H), 7.38 (d, $J$ = 8.5 Hz, 2H), 7.10 (d, $J$ = 8.4 Hz, 2H), 2.51 (t, $J$ = 7.6 Hz, 2H), 1.57−1.45 (m, 2H), 1.27−1.16 (m, 10H), 0.80 (t, $J$ = 6.8 Hz, 3H). $^{13}$C NMR (101 MHz, $CDCl_3$): $\delta$ 155.0 (q, $J$ = 37.4 Hz), 141.5, 132.8, 129.3, 120.7, 116.0 (q, $J$ = 288.4 Hz), 35.6, 32.0, 31.5, 29.6, 30.0, 29.4, 22.8, 14.2. $^{19}$F NMR (376 MHz, $CDCl_3$): $\delta$ −75.7. HRMS-ESI ($m/z$): calcd for $C_{16}H_{22}F_3NNaO$ $[M + Na]^+$ 324.1546, found 324.1542.

*1-(4-Octylphenyl)ethan-1-one (Table 3a, **4g**).* The title compound was prepared from 1-(4-iodophenyl)ethan-1-one (246.1 mg, 1.0 mmol, 2.0 equiv), following the general procedure and using $NiBr_2$·glyme (7.8 mg, 0.025 mmol, 5.0 mol %), **L1** (4.8 mg, 0.030 mmol, 6.0 mol %), KF (73.0 g, 1.25 mmol, 2.5 equiv), (*E*)-oct-4-ene (87.5 μL, 62.4 mg, 0.50 mmol), $(EtO)_3SiH$ (230 μL, 1.25 mmol, 2.5 equiv), and DMF (3.75 mL). The reaction mixture was stirred for 24 h at rt. The crude material was purified by flash column chromatography and eluted with hexanes to provide the title compound as a colorless liquid in 72% yield (83.5 mg). IR (neat, $cm^{-1}$): 2923, 1681, 1605, 1356, 1285, 596. $^1$H NMR (400 MHz, $CDCl_3$): $\delta$ 7.79 (d, $J$ = 8.3 Hz, 2H), 7.18 (d, $J$ = 8.2 Hz, 2H), 2.57 (t, $J$ = 7.6 Hz, 2H), 2.49 (s, 3H), 1.56−1.50 (m, 2H), 1.26−1.14 (m, 10H), 0.80 (t, $J$ = 6.8 Hz, 3H). $^{13}$C NMR (101 MHz, $CDCl_3$): $\delta$ 197.9, 148.9, 135.0, 128.7, 128.6, 36.1, 32.0, 31.3, 29.5, 29.4, 29.3, 26.7, 22.8, 14.2. HRMS-ESI ($m/z$): calcd for $C_{16}H_{25}O$ $[M + H]^+$ 233.1900, found 233.1897.

*4-Octylbenzaldehyde (Table 3a, **4h**).* The title compound was prepared from 4-iodobenzaldehyde (232.0 mg, 1.0 mmol, 2.0 equiv), following the general procedure and using $NiBr_2$·glyme (7.8 mg, 0.025 mmol, 5.0 mol %), **L1** (4.8 mg, 0.030 mmol, 6.0 mol %), KF (73.0 g, 1.25 mmol, 2.5 equiv), (*E*)-oct-4-ene (87.5 μL, 62.4 mg, 0.50 mmol), $(EtO)_3SiH$ (230 μL, 1.25 mmol, 2.5 equiv), and DMF (3.75 mL). The reaction mixture was stirred for 24 h at rt. The crude material was purified by flash column chromatography and eluted with hexanes to provide the title compound as a white solid in 71% yield (77.3 mg).


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Mp: 34−35 °C. IR (neat, $cm^{-1}$): 2923, 1698, 1605, 1167, 824. $^1H$ NMR (400 MHz, $CDCl_3$): $\delta$ 9.96 (s, 1H), 7.79 (d, $J$ = 8.1 Hz, 2H), 7.33 (d, $J$ = 8.0 Hz, 2H), 2.67 (t, $J$ = 7.6 Hz, 2H), 1.70−1.54 (m, 2H), 1.30−1.26 (m, 10H), 0.87 (t, $J$ = 6.7 Hz, 3H). $^{13}C$ NMR (101 MHz, $CDCl_3$): $\delta$ 192.2, 150.6, 134.5, 130.0, 129.2, 36.4, 32.0, 31.2, 29.5, 29.4, 29.3, 22.8, 14.2. HRMS-ESI ($m/z$): calcd for $C_{15}H_{23}O$ $[M + H^+]$ 219.1743, found 219.1746.

*1-Chloro-3-octylbenzene (Table 3a, **4i**).* The title compound was prepared from 1-chloro-3-iodobenzene (238.5 mg, 1.0 mmol, 2.0 equiv), following the general procedure and using $NiBr_2$·glyme (7.8 mg, 0.025 mmol, 5.0 mol %), **L1** (4.8 mg, 0.030 mmol, 6.0 mol %), KF (73.0 g, 1.25 mmol, 2.5 equiv), (*E*)-oct-4-ene (87.5 μL, 62.4 mg, 0.50 mmol), $(EtO)_3SiH$ (230 μL, 1.25 mmol, 2.5 equiv), and DMF (3.75 mL). The reaction mixture was stirred for 24 h at rt. The crude material was purified by flash column chromatography and eluted with hexanes to provide the title compound as a colorless liquid in 84% yield (93.8 mg). IR (neat, $cm^{-1}$): 2923, 1597, 1466, 1078, 777. $^1H$ NMR (400 MHz, $CDCl_3$): $\delta$ 7.27−7.16 (m, 3H), 7.09 (d, $J$ = 7.2 Hz, 1H), 2.62 (t, $J$ = 7.6 Hz, 2H), 1.68−1.60 (m, 2H), 1.41−1.27 (m, 10H), 0.93 (t, $J$ = 6.8 Hz, 3H). $^{13}C$ NMR (101 MHz, $CDCl_3$): $\delta$ 145.1, 134.1, 129.6, 128.7, 126.8, 125.9, 35.8, 32.0, 31.4, 29.6, 29.4, 29.3, 22.8, 14.3. HRMS-EI ($m/z$): calcd for $C_{14}H_{21}Cl$ $[M]^+$ 224.1332, found 224.1327.

*4-Octylphenyl Trifluoromethanesulfonate (Table 3a, entry **4j**).* The title compound was prepared from 4-iodophenyl trifluoromethanesulfonate (352.1 mg, 1.0 mmol, 2.0 equiv), following the general procedure and using $NiBr_2$·glyme (7.8 mg, 0.025 mmol, 5.0 mol %), **L1** (4.8 mg, 0.030 mmol, 6.0 mol %), KF (73.0 g, 1.25 mmol, 2.5 equiv), (*E*)-oct-4-ene (87.5 μL, 62.4 mg, 0.50 mmol), $(EtO)_3SiH$ (230 μL, 1.25 mmol, 2.5 equiv), and DMF (3.75 mL). The reaction mixture was stirred for 24 h at rt. The crude material was purified by flash column chromatography and eluted with 0.5% EtOAc in hexanes to provide the title compound as a colorless liquid in 62% yield (104.6 mg). IR (neat, $cm^{-1}$): 2926, 1500, 1422, 1205, 1135, 883, 607. $^1H$ NMR (400 MHz, $CDCl_3$): $\delta$ 7.16 (d, $J$ = 8.7 Hz, 2H), 7.09 (d, $J$ = 8.7 Hz, 2H), 2.54 (t, $J$ = 7.6 Hz, 2H), 1.58−1.48 (m, 2H), 1.24−1.18 (m, 10H), 0.80 (t, $J$ = 6.8 Hz, 3H). $^{13}C$ NMR (101 MHz, $CDCl_3$): $\delta$ 147.8, 143.7, 130.2, 121.1, 118.9 (q, $J$ = 320.8 Hz), 35.5, 32.0, 31.45, 29.6, 29.5, 29.4, 22.8, 14.2. $^{19}F$ NMR (376 MHz, $CDCl_3$): $\delta$ −72.9. HRMS-EI ($m/z$): calcd for $C_{15}H_{21}F_3O_3S$ $[M]^+$ 338.1163, found 338.1165.

*4,4,5,5-Tetramethyl-2-(3-octylphenyl)-1,3,2-dioxaborolane (Table 3a, **4k**).* The title compound was prepared from 2-(3-iodophenyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (330.1 mg, 1.0 mmol, 2.0 equiv), following the general procedure and using $NiBr_2$·glyme (7.8 mg, 0.025 mmol, 5.0 mol %), **L1** (4.8 mg, 0.030 mmol, 6.0 mol %), KF (73.0 g, 1.25 mmol, 2.5 equiv), (*E*)-oct-4-ene (87.5 μL, 62.4 mg, 0.50 mmol), $(EtO)_3SiH$ (230 μL, 1.25 mmol, 2.5 equiv), and DMF (3.75 mL). The reaction mixture was stirred for 24 h at rt. The crude material was purified by flash column chromatography and eluted with 2% EtOAc in hexanes to provide the title compound as a colorless liquid in 52% yield (82.3 mg). IR (neat, $cm^{-1}$): 2924, 1357, 1144, 708. $^1H$ NMR (400 MHz, $CDCl_3$): $\delta$ 7.58−7.52 (m, 2H), 7.24−7.20 (m, 2H), 2.53 (t, $J$ = 7.6 Hz, 2H), 1.56−1.50 (m, 2H), 1.30−1.27 (m, 12H), 1.23−1.18 (m, 10H), 0.81 (t, $J$ = 6.7 Hz, 3H). $^{13}C$ NMR (101 MHz, $CDCl_3$): $\delta$ 142.4, 134.9, 132.2, 131.6, 127.8, 83.89, 36.1, 32.1, 31.9, 29.7, 29.6, 29.4, 25.1, 22.8, 14.3. HRMS-ESI ($m/z$): calcd for $C_{20}H_{33}BNaO_2$ $[M + Na]^+$ 339.2466, found 339.2474.

*1-Methoxy-3-octylbenzene (Table 3a, **4l**).* The title compound was prepared from 1-iodo-3-methoxybenzene (234 mg, 1.0 mmol, 2.0 equiv), following the general procedure and using $NiBr_2$·glyme (7.8 mg, 0.025 mmol, 5.0 mol %), **L1** (4.8 mg, 0.030 mmol, 6.0 mol %), KF (73.0 g, 1.25 mmol, 2.5 equiv), (*E*)-oct-4-ene (87.5 μL, 62.4 mg, 0.50 mmol), $(EtO)_3SiH$ (230 μL, 1.25 mmol, 2.5 equiv), and DMF (3.75 mL). The reaction mixture was stirred for 24 h at rt. The crude material was purified by flash column chromatography and eluted with hexanes to provide the title compound as a colorless liquid in 40% yield (44.1 mg). IR (neat, $cm^{-1}$): 2923, 1584, 1259, 1151, 694. $^1H$ NMR (400 MHz, $CDCl_3$): $\delta$ 7.11 (t, $J$ = 7.7 Hz, 1H), 6.70−6.63 (m, 3H), 3.72 (s, 3H), 2.50 (t, $J$ = 7.8 Hz, 2H), 1.56−1.49 (m, 2H), 1.25−1.17 (m, 10H), 0.80 (t, $J$ = 6.6 Hz, 3H). $^{13}C$ NMR (101 MHz, $CDCl_3$): $\delta$ 159.7, 144.8, 129.3, 121.0, 114.3, 110.9, 55.3, 36.2, 32.1, 31.6, 29.7, 29.5, 29.4, 22.9 14.3. HRMS-EI ($m/z$): calcd for $C_{15}H_{24}O$ $[M]^+$ 220.1827, found 220.1828.

*Octylbenzene (Table 3a, **4m**).* The title compound was prepared from iodobenzene (204 mg, 1.0 mmol, 2.0 equiv), following the general procedure and using $NiBr_2$·glyme (15.6 mg, 0.05 mmol, 10.0 mol %), **L1** (8.8 mg, 0.055 mmol, 11.0 mol %), KF (73.0 g, 1.25 mmol, 2.5 equiv), (*E*)-oct-4-ene (87.5 μL, 62.4 mg, 0.50 mmol), $(EtO)_3SiH$ (230 μL, 1.25 mmol, 2.5 equiv), and DMF (3.75 mL). The reaction mixture was stirred for 24 h at rt. The crude material was purified by flash column chromatography and eluted with pentanes to provide the title compound as a colorless liquid in 54% yield (51.3 mg). IR (neat, $cm^{-1}$): 2923, 2853, 1454, 743, 696. $^1H$ NMR (400 MHz, $CDCl_3$): $\delta$ 7.42−7.36 (m, 2H), 7.32−7.26 (m, 3H), 2.73 (t, $J$ = 7.8 Hz, 2H), 1.78−1.70 (m, 2H), 1.52−1.40 (m, 10H), 1.02 (t, $J$ = 6.2 Hz, 3H). $^{13}C$ NMR (101 MHz, $CDCl_3$): $\delta$ 143.1, 128.6, 128.4, 125.7, 36.2, 32.1, 31.8, 29.7, 29.6, 29.5, 22.9, 14.3. HRMS-EI ($m/z$): calcd for $C_{14}H_{22}$ $[M]^+$ 190.1722, found 190.1724.

*(4-Octylphenyl)methanol (Table 3a, **4n**).* The title compound was prepared from (4-iodophenyl)methanol (234.0, 1.0 mmol, 2.0 equiv), following the general procedure and using $NiBr_2$·glyme (15.6 mg, 0.05 mmol, 10.0 mol %), **L1** (8.8 mg, 0.055 mmol, 11.0 mol %), KF (73.0 g, 1.25 mmol, 2.5 equiv), (*E*)-oct-4-ene (87.5 μL, 62.4 mg, 0.50 mmol), $(EtO)_3SiH$ (414.0 μL, 2.25 mmol, 4.5 equiv), and DMF (3.75 mL). The reaction mixture was stirred for 24 h at rt.

The workup procedure was modified and is detailed below. After completion, the reaction mixture was transferred to a 25 mL round-bottom flask and the volatiles were removed under reduced pressure, A MeOH solution of $NH_4F$ (10 mL, saturated) was added, and the reaction mixture was stirred at room temperature for 30 min. EtOAc (30 mL) and water were added, and the aqueous layer was extracted with EtOAc (10 mL × 3). The combined organic layers were dried over $Na_2SO_4$ and concentrated *in vacuo*. The crude material was purified by flash column chromatography and eluted with 2% EtOAc in hexanes to provide the title compound as a colorless liquid in 59% yield (65 mg). IR (neat, $cm^{-1}$): 3320, 2922, 1463, 1027, 755. $^1H$ NMR (400 MHz, $CDCl_3$): $\delta$ 7.29 (d, $J$ = 8.0 Hz, 2H), 7.21 (d, $J$ = 7.8 Hz, 2H), 4.67 (s, 2H), 2.63 (t, $J$ = 7.6 Hz, 2H), 1.84 (s, 1H), 1.68−1.58 (m, 2H), 1.37−1.29 (m, 10H), 0.92 (t, $J$ = 6.7 Hz, 3H). $^{13}C$ NMR (101 MHz, $CDCl_3$): $\delta$ 142.7, 138.3, 128.8, 127.3, 65.4, 35.8, 32.0, 31.7, 29.6, 29.5, 29.4, 22.8, 14.3. HRMS-EI ($m/z$): calcd for $C_{15}H_{24}O$ $[M]^+$ 220.1827, found 220.1825.

*2-Fluoro-4-octylaniline (Table 3a, **4o**).* The title compound was prepared from 2-fluoro-4-iodoaniline (237.0 mg, 1.0 mmol, 2.0 equiv), following the general procedure and using $NiBr_2$·glyme (7.8 mg, 0.025 mmol, 5.0 mol %), **L1** (4.8 mg, 0.030 mmol, 6.0 mol %), KF (73.0 g, 1.25 mmol, 2.5 equiv), (*E*)-oct-4-ene (87.5 μL, 62.4 mg, 0.50 mmol), $(EtO)_3SiH$ (230 μL, 1.25 mmol, 2.5 equiv), and DMF (3.75 mL). The reaction mixture was stirred for 24 h at rt. The crude material was purified by flash column chromatography and eluted with 1% EtOAc in hexanes to provide the title compound as a colorless liquid in 70% yield (78 mg). IR (neat, $cm^{-1}$): 3383, 2923, 1519, 896, 618. $^1H$ NMR (400 MHz, $CDCl_3$): $\delta$ 6.75−6.71 (m, 1H), 6.69−6.57 (m, 2H), 3.38 (s, 2H), 2.41 (t, $J$ = 7.6 Hz, 2H), 1.52−1.41 (m, 2H), 1.23−1.16 (m, 10H), 0.80 (t, $J$ = 6.6 Hz, 3H). $^{13}C$ NMR (101 MHz, chloroform-*d*): $\delta$ 151.9 (d, $J$ = 238.5 Hz), 134.3 (d, $J$ = 5.8 Hz), 131.8 (d, $J$ = 13.3 Hz), 124.3 (d, $J$ = 3.2 Hz), 117.1 (d, $J$ = 3.7 Hz), 115.2 (d, $J$ = 18.2 Hz), 35.1, 32.0, 31.7, 29.7, 29.4, 29.3, 22.8, 14.3. $^{19}F$ NMR (471 MHz, $CDCl_3$): $\delta$ −135.4. HRMS-ESI ($m/z$): calcd for $C_{14}H_{23}FN$ $[M + H]^+$ 224.1809, found 224.1807.

*2-Chloro-4-octylpyridine (Table 3b, **4p**).* The title compound was prepared from 2-chloro-4-iodopyridine (239.4 mg, 1.0 mmol, 2.0 equiv), following the general procedure and using $NiBr_2$·glyme (7.8 mg, 0.025 mmol, 5.0 mol %), **L1** (4.8 mg, 0.030 mmol, 6.0 mol %), KF (73.0 g, 1.25 mmol, 2.5 equiv), (*E*)-oct-4-ene (87.5 μL, 62.4 mg, 0.50 mmol), $(EtO)_3SiH$ (230 μL, 1.25 mmol, 2.5 equiv), and DMF (3.75 mL). The reaction mixture was stirred for 24 h at rt. The crude material was purified by flash column chromatography and eluted with 1% EtOAc in hexanes to provide the title compound as a pale


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yellow liquid in 65% yield (73.1 mg). IR (neat, $cm^{-1}$): 2924, 1591, 1384, 1085, 717. $^1H$ NMR (400 MHz, $CDCl_3$): $\delta$ 8.18 (d, $J$ = 5.0 Hz, 1H), 7.07 (s, 1H), 6.95 (d, $J$ = 5.0 Hz, 1H), 2.51 (t, $J$ = 7.6 Hz, 2H), 1.59−1.48 (m, 2H), 1.28−1.15 (m, 10H), 0.80 (t, $J$ = 6.8 Hz, 3H). $^{13}C$ NMR (101 MHz, $CDCl_3$): $\delta$ 155.4, 151.6, 149.5, 124.3, 122.9, 35.1, 31.9, 30.2, 29.4, 29.3, 29.2, 22.8, 14.2. HRMS-ESI ($m/z$): calcd for $C_{13}H_{21}ClN$ $[M + H]^+$ 226.1357, found 226.1358.

*2-Fluoro-5-octylpyridine (Table 3b, **4q**).* The title compound was prepared from 2-fluoro-5-iodopyridine (223.0 mg, 1.0 mmol, 2.0 equiv), following the general procedure and using $NiBr_2$·glyme (7.8 mg, 0.025 mmol, 5.0 mol %), **L1** (4.8 mg, 0.030 mmol, 6.0 mol %), KF (73.0 g, 1.25 mmol, 2.5 equiv), (*E*)-oct-4-ene (87.5 $\mu$L, 62.4 mg, 0.50 mmol), $(EtO)_3SiH$ (230 $\mu$L, 1.25 mmol, 2.5 equiv), and DMF (3.75 mL). The reaction mixture was stirred for 24 h at rt. The crude material was purified by flash column chromatography and eluted with 1% EtOAc in hexanes to provide the title compound as a colorless liquid in 73% yield (76.2 mg). IR (neat, $cm^{-1}$): 2925, 1592, 1482, 1393, 1247, 829. $^1H$ NMR (400 MHz, $CDCl_3$): $\delta$ 7.93 (s, 1H), 7.53−7.48 (m, 1H), 6.76 (dd, $J$ = 8.3, 2.9 Hz, 1H), 2.51 (t, $J$ = 7.6 Hz, 2H), 1.57−1.46 (m, 2H), 1.24−1.16 (m, 10H), 0.80 (t, $J$ = 6.8 Hz, 3H). $^{13}C$ NMR (101 MHz, chloroform-*d*): $\delta$ 162.3 (d, $J$ = 236.5 Hz), 147.0 (d, $J$ = 14.1 Hz), 141.1 (d, $J$ = 7.6 Hz), 135.7 (d, $J$ = 4.5 Hz), 109.0 (d, $J$ = 37.3 Hz), 32.1, 31.9, 31.3, 29.5, 29.3, 29.2, 22.8, 14.2. $^{19}F$ NMR (376 MHz, $CDCl_3$): $\delta$ −72.7. HRMS-ESI ($m/z$): calcd for $C_{13}H_{21}FN$ $[M + H]^+$ 210.1653, found 210.1650.

*2-Methoxy-5-octylpyridine (Table 3b, **4r**).* The title compound was prepared from 5-iodo-2-methoxypyridine (235.2 mg, 1.0 mmol, 2.0 equiv), following the general procedure and using $NiBr_2$·glyme (7.8 mg, 0.025 mmol, 5.0 mol %), **L1** (4.8 mg, 0.030 mmol, 6.0 mol %), KF (73.0 g, 1.25 mmol, 2.5 equiv), (*E*)-oct-4-ene (87.5 $\mu$L, 62.4 mg, 0.50 mmol), $(EtO)_3SiH$ (230 $\mu$L, 1.25 mmol, 2.5 equiv), and DMF (3.75 mL). The reaction mixture was stirred for 24 h at rt. The crude material was purified by flash column chromatography and eluted with 1% EtOAc in hexanes to provide the title compound as a colorless liquid in 62% yield (68.5 mg). IR (neat, $cm^{-1}$): 2923, 1607, 1490, 1285, 1028, 826. $^1H$ NMR (400 MHz, $CDCl_3$): $\delta$ 7.88 (s, 1H), 7.30 (dd, $J$ = 8.4, 2.4 Hz, 1H), 6.58 (d, $J$ = 8.4 Hz, 1H), 3.82 (s, 3H), 2.42 (t, $J$ = 7.7 Hz, 2H), 1.53−1.42 (m, 2H), 1.25−1.13 (m, 10H), 0.79 (t, $J$ = 6.8 Hz, 3H). $^{13}C$ NMR (101 MHz, $CDCl_3$): $\delta$ 162.7, 146.0, 139.0, 130.7, 110.4, 53.3, 32.2, 32.0, 31.5, 29.5, 29.4, 29.2, 22.8, 14.2. HRMS-ESI ($m/z$): calcd for $C_{14}H_{23}NNaO$ $[M + Na]^+$ 244.1672, found 244.1669.

*4-(5-Octylpyridin-2-yl)morpholine (Table 3b, **4s**).* The title compound was prepared from 4-(5-iodopyridin-2-yl)morpholine (290.0 mg, 1.0 mmol, 2.0 equiv), following the general procedure and using $NiBr_2$·glyme (7.8 mg, 0.025 mmol, 5.0 mol %), **L1** (4.8 mg, 0.030 mmol, 6.0 mol %), KF (73.0 g, 1.25 mmol, 2.5 equiv), (*E*)-oct-4-ene (87.5 $\mu$L, 62.4 mg, 0.50 mmol), $(EtO)_3SiH$ (230 $\mu$L, 1.25 mmol, 2.5 equiv), and DMF (3.75 mL). The reaction mixture was stirred for 24 h at rt. The crude material was purified by flash column chromatography and eluted with 2% EtOAc in hexanes to provide the title compound as a colorless liquid in 60% yield (82.8 mg). IR (neat, $cm^{-1}$): 2922, 1605, 1490, 1242, 1120, 942, 808. $^1H$ NMR (400 MHz, $CDCl_3$): $\delta$ 7.96 (d, $J$ = 2.4 Hz, 1H), 7.28 (dd, $J$ = 8.6, 2.5 Hz, 1H), 6.53 (d, $J$ = 8.5 Hz, 1H), 3.76 (t, $J$ = 4.8 Hz, 4H), 3.40 (t, $J$ = 4.8 Hz, 4H), 2.41 (t, $J$ = 7.6 Hz, 2H), 1.53−1.42 (m, 2H), 1.24−1.17 (m, 10H), 0.80 (t, $J$ = 6.7 Hz, 3H). $^{13}C$ NMR (101 MHz, $CDCl_3$): $\delta$ 158.3, 147.4, 138.1, 128.2, 107.1, 67.0, 46.2, 32.2, 32.0, 31.6, 29.6, 29.4, 29.2, 22.8, 14.3. HRMS-ESI ($m/z$): calcd for $C_{17}H_{28}N_2NaO$ $[M + Na]^+$ 299.2094, found 299.2092.

*2-(2,5-Dimethyl-1H-pyrrol-1-yl)-5-octylpyridine (Table 3b, **4t**).* The title compound was prepared from 2-(2,5-dimethyl-1*H*-pyrrol-1-yl)-5-iodopyridine (298.0 mg, 1.0 mmol, 2.0 equiv), following the general procedure and using $NiBr_2$·glyme (7.8 mg, 0.025 mmol, 5.0 mol %), **L1** (4.8 mg, 0.030 mmol, 6.0 mol %), KF (73.0 g, 1.25 mmol, 2.5 equiv), (*E*)-oct-4-ene (87.5 $\mu$L, 62.4 mg, 0.50 mmol), $(EtO)_3SiH$ (230 $\mu$L, 1.25 mmol, 2.5 equiv), and DMF (3.75 mL). The reaction mixture was stirred for 24 h at rt. The crude material was purified by flash column chromatography and eluted with 2% EtOAc in hexanes to provide the title compound as a pale yellow liquid in 50% yield (70.0 mg). IR (neat, $cm^{-1}$): 2923, 1645, 1481, 1405, 754. $^1H$ NMR (400 MHz, $CDCl_3$): $\delta$ 8.33 (d, $J$ = 2.1 Hz, 1H), 7.54 (dd, $J$ = 8.1, 2.5 Hz, 1H), 7.05 (d, $J$ = 8.0 Hz, 1H), 5.80 (s, 2H), 2.59 (t, $J$ = 7.6 Hz, 2H), 2.03 (s, 6H), 1.65−1.54 (m, 2H), 1.33−1.16 (m, 10H), 0.81 (t, $J$ = 6.8 Hz, 3H). $^{13}C$ NMR (101 MHz, $CDCl_3$): $\delta$ 150.0, 149.3, 137.8, 137.0, 128.7, 121.7, 106.7, 32.7, 32.0, 31.2, 29.5, 29.4, 29.4, 22.8, 14.3, 13.2. HRMS-ESI ($m/z$): calcd for $C_{19}H_{29}N_2$ $[M + H]^+$ 285.2325, found 285.2326.

*3-Octylquinoline (Table 3b, **4u**).* The title compound was prepared from 3-iodoquinoline (255.0 mg, 1.0 mmol, 2.0 equiv), following the general procedure and using $NiBr_2$·glyme (7.8 mg, 0.025 mmol, 5.0 mol %), **L1** (4.8 mg, 0.030 mmol, 6.0 mol %), KF (73.0 g, 1.25 mmol, 2.5 equiv), (*E*)-oct-4-ene (87.5 $\mu$L, 62.4 mg, 0.50 mmol), $(EtO)_3SiH$ (230 $\mu$L, 1.25 mmol, 2.5 equiv), and DMF (3.75 mL). The reaction mixture was stirred for 24 h at rt. The crude material was purified by flash column chromatography and eluted with 5% EtOAc in hexanes to provide the title compound as a colorless liquid in 54% yield (65.1 mg). IR (neat, $cm^{-1}$): 2923, 1494, 748, 723. $^1H$ NMR (400 MHz, $CDCl_3$): $\delta$ 8.79 (d, $J$ = 2.2 Hz, 1H), 8.10 (d, $J$ = 8.4 Hz, 1H), 7.90 (s, 1H), 7.76 (d, $J$ = 8.1 Hz, 1H), 7.70−7.60 (m, 1H), 7.51 (t, $J$ = 7.5 Hz, 1H), 2.78 (t, $J$ = 7.7 Hz, 2H), 1.77−1.66 (m, 2H), 1.40−1.24 (m, 10H), 0.89 (t, $J$ = 6.8 Hz, 3H). $^{13}C$ NMR (101 MHz, $CDCl_3$): $\delta$ 152.2, 146.8, 135.5, 134.2, 129.2, 128.6, 128.3, 127.4, 126.6, 33.3, 31.9, 31.3, 29.5, 29.3, 29.3, 22.8, 14.2. HRMS-ESI ($m/z$): calcd for $C_{17}H_{24}N$ $[M + H]^+$ 242.1903, found 242.1902.

*N,N-Dimethyl-5-octylpyrimidin-2-amine (Table 3b, **4v**).* The title compound was prepared from 5-iodo-*N,N*-dimethylpyrimidin-2-amine (249.0 mg, 1.0 mmol, 2.0 equiv), following the general procedure and using $NiBr_2$·glyme (7.8 mg, 0.025 mmol, 5.0 mol %), **L1** (4.8 mg, 0.030 mmol, 6.0 mol %), KF (73.0 g, 1.25 mmol, 2.5 equiv), (*E*)-oct-4-ene (87.5 $\mu$L, 62.4 mg, 0.50 mmol), $(EtO)_3SiH$ (230 $\mu$L, 1.25 mmol, 2.5 equiv), and DMF (3.75 mL). The reaction mixture was stirred for 24 h at rt. The crude material was purified by flash column chromatography and eluted with 5% EtOAc in hexanes to provide the title compound as a pale yellow liquid in 72% yield (84.6 mg). IR (neat, $cm^{-1}$): 2922, 1602, 1526, 1403, 974, 797, 523. $^1H$ NMR (400 MHz, $CDCl_3$): $\delta$ 8.08 (s, 2H), 3.09 (s, 6H), 2.32 (t, $J$ = 7.6 Hz, 2H), 1.48−1.39 (m, 2H), 1.24−1.16 (m, 10H), 0.80 (t, $J$ = 6.8 Hz, 3H). $^{13}C$ NMR (101 MHz, $CDCl_3$): $\delta$ 161.4, 157.5, 122.2, 37.3, 32.0, 31.5, 29.5, 29.5, 29.4, 29.1, 22.8, 14.2. HRMS-ESI ($m/z$): calcd for $C_{14}H_{26}N_3$ $[M + H]^+$ 236.2121, found 236.2128.

*2-(tert-Butyl)-6-octylimidazo[1,2-a]pyridine (Table 3b, **4w**).* The title compound was prepared from 2-(*tert*-butyl)-6-iodoimidazo[1,2-*a*]pyridine (300.1 mg, 1.0 mmol, 2.0 equiv), following the general procedure and using $NiBr_2$·glyme (7.8 mg, 0.025 mmol, 5.0 mol %), **L1** (4.8 mg, 0.030 mmol, 6.0 mol %), KF (73.0 g, 1.25 mmol, 2.5 equiv), (*E*)-oct-4-ene (87.5 $\mu$L, 62.4 mg, 0.50 mmol), $(EtO)_3SiH$ (230 $\mu$L, 1.25 mmol, 2.5 equiv), and DMF (3.75 mL). The reaction mixture was stirred for 24 h at rt. The crude material was purified by flash column chromatography and eluted with 2% EtOAc in hexanes to provide the title compound as a colorless liquid in 54% yield (77.2 mg). IR (neat, $cm^{-1}$): 2923, 1507, 1235, 803, 686. $^1H$ NMR (400 MHz, $CDCl_3$): $\delta$ 7.73 (s, 1H), 7.42 (d, $J$ = 9.2 Hz, 1H), 7.18 (s, 1H), 6.90 (dd, $J$ = 9.2, 1.7 Hz, 1H), 2.46 (t, $J$ = 7.6 Hz, 2H), 1.56−1.45 (m, 2H), 1.32 (s, 9H), 1.24−1.17 (m, 10H), 0.80 (t, $J$ = 6.8 Hz, 3H). $^{13}C$ NMR (101 MHz, $CDCl_3$): $\delta$ 157.0, 144.3, 126.4, 126.3, 123.1, 116.7, 106.7, 32.7, 32.4, 32.0, 30.9, 30.4, 29.5, 29.4, 29.3, 22.8, 14.2. HRMS-ESI ($m/z$): calcd for $C_{19}H_{30}N_2Na$ $[M + Na]^+$ 309.2301, found 309.2300.

*(S)-3-(4-(2-Chloro-5-octylbenzyl)phenoxy)tetrahydrofuran (Table 3c, **4x**).* The title compound was prepared from (*S*)-3-(4-(2-chloro-5-iodobenzyl)phenoxy)tetrahydrofuran (414.7 mg, 1.0 mmol, 2.0 equiv), following the general procedure and using $NiBr_2$·glyme (7.8 mg, 0.025 mmol, 5.0 mol %), **L1** (4.8 mg, 0.030 mmol, 6.0 mol %), KF (73.0 g, 1.25 mmol, 2.5 equiv), (*E*)-oct-4-ene (87.5 $\mu$L, 62.4 mg, 0.50 mmol), $(EtO)_3SiH$ (230 $\mu$L, 1.25 mmol, 2.5 equiv), and DMF (3.75 mL). The reaction mixture was stirred for 24 h at rt. The crude material was purified by flash column chromatography and eluted with 1% EtOAc in hexanes to provide the title compound as a colorless liquid in 78% yield (155.8 mg). IR (neat, $cm^{-1}$): 2923, 1611,


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1507, 1238, 817. $^1$H NMR (400 MHz, $CDCl_3$): $\delta$ 7.15 (s, 1H), 7.01 (d, $J$ = 8.5 Hz, 2H), 6.90−6.83 (m, 2H), 6.69 (d, $J$ = 8.6 Hz, 2H), 4.82−4.75 (m, 1H), 3.94−3.84 (m, 5H), 3.82−3.74 (m, 1H), 2.42 (t, $J$ = 7.6 Hz, 2H), 2.13−2.00 (m, 2H), 1.47−1.40 (m, 2H), 1.21−1.15 (m, 10H), 0.79 (t, $J$ = 6.7 Hz, 3H). $^{13}$C NMR (101 MHz, $CDCl_3$): $\delta$ 155.9, 141.8, 138.5, 132.3, 131.3, 131.2, 130.0, 129.3, 127.8, 115.4, 77.4, 73.3, 67.3, 38.5, 35.4, 33.2, 32.0, 31.5, 29.6, 29.4, 29.4, 22.8, 14.3. HRMS-ESI ($m/z$): calcd for $C_{25}H_{33}ClNaO_2$ $[M + Na]^+$ 423.2061, found 423.2058.

*(5-(4-Fluorophenyl)thiophen-2-yl)(2-methyl-5-octylphenyl)-methanone (Table 3c, **4y**).* The title compound was prepared from (5-(4-fluorophenyl)thiophen-2-yl)(5-iodo-2-methylphenyl)-methanone (422.3 mg, 1.0 mmol, 2.0 equiv), following the general procedure and using $NiBr_2$·glyme (7.8 mg, 0.025 mmol, 5.0 mol %), **L1** (4.8 mg, 0.030 mmol, 6.0 mol %), KF (73.0 g, 1.25 mmol, 2.5 equiv), (*E*)-oct-4-ene (87.5 μL, 62.4 mg, 0.50 mmol), $(EtO)_3SiH$ (230 μL, 1.25 mmol, 2.5 equiv), and DMF (3.75 mL). The reaction mixture was stirred for 24 h at rt. The crude material was purified by flash column chromatography and eluted with 2% EtOAc in hexanes to provide the title compound as a colorless liquid in 51% yield (103.3 mg). IR (neat, cm$^{-1}$): 2923, 1634, 1410, 1206, 807. $^1$H NMR (400 MHz, $CDCl_3$): $\delta$ 7.57−7.51 (m, 2H), 7.28 (d, $J$ = 3.9 Hz, 1H), 7.18 (s, 1H), 7.14 (d, $J$ = 4.0 Hz, 1H), 7.11 (d, $J$ = 1.8 Hz, 2H), 7.05−6.97 (m, 2H), 2.52 (t, $J$ = 7.6 Hz, 2H), 2.27 (s, 3H), 1.57−1.46 (m, 2H), 1.23−1.15 (m, 10H), 0.81−0.74 (m, 3H). $^{13}$C NMR (101 MHz, $CDCl_3$): $\delta$ 190.6, 163.4 (d, $J$ = 249.8 Hz), 152.6, 143.8, 140.0, 138.2, 136.5, 133.7, 131.4, 130.6, 129.8 (d, $J$ = 3.5 Hz), 128.2 (d, $J$ = 8.3 Hz), 128.1, 124.1, 116.3 (d, $J$ = 22.0 Hz), 35.5, 32.0, 31.6, 29.6, 29.4, 29.4, 22.8, 19.4, 14.2. $^{19}$F NMR (376 MHz, $CDCl_3$): $\delta$ −111.7. HRMS-ESI ($m/z$): calcd for $C_{26}H_{29}FNaOS$ $[M + Na]^+$ 431.1815, found 431.1813.

*Ethyl 1-(4-Methoxyphenyl)-5-(4-octylphenyl)-4-oxo-4,5,6,7-tetrahydro-1H-pyrazolo[4,3-c]pyridine-3-carboxylate (Table 3c, **4z**).* The title compound was prepared from ethyl 5-(4-iodophenyl)-1-(4-methoxyphenyl)-4-oxo-4,5,6,7-tetrahydro-1*H*-pyrazolo[4,3-*c*]-pyridine-3-carboxylate (103.5 mg, 0.4 mmol, 2.0 equiv), following the general procedure and using $NiBr_2$·glyme (3.1 mg, 0.01 mmol, 5.0 mol %), **L1** (1.9 mg, 0.012 mmol, 6.0 mol %), KF (29.2 g, 0.5 mmol, 2.5 equiv), (*E*)-oct-4-ene (35.0 μL, 0.2 mmol), $(EtO)_3SiH$ (92 μL, 0.5 mmol, 2.5 equiv), and DMF (1.5 mL). The reaction mixture was stirred for 24 h at rt. The crude material was purified by flash column chromatography and eluted with 10% EtOAc in hexanes to provide the title compound as a colorless liquid in 51% yield (51.3 mg). IR (neat, cm$^{-1}$): 2924, 1712, 1672, 1511, 1247, 1085, 789. $^1$H NMR (400 MHz, $CDCl_3$): $\delta$ 7.40 (d, $J$ = 8.9 Hz, 2H), 7.16−7.06 (m, 4H), 6.82 (d, $J$ = 8.8 Hz, 2H), 4.38 (q, $J$ = 7.0 Hz, 2H), 4.02 (t, $J$ = 6.6 Hz, 2H), 3.72 (s, 3H), 3.23 (t, $J$ = 6.6 Hz, 2H), 2.49 (t, $J$ = 7.6 Hz, 2H), 1.55−1.44 (m, 2H), 1.35 (t, $J$ = 7.0 Hz, 3H), 1.22−1.16 (m, 10H), 0.80 (t, $J$ = 6.5 Hz, 3H). $^{13}$C NMR (126 MHz, $CDCl_3$): $\delta$ 168.3, 153.0, 151.6, 139.1, 137.3, 131.1, 127.2, 126.0, 123.0, 108.4, 72.7, 66.4, 35.7, 33.4, 31.9, 31.6, 31.2, 29.4, 29.3, 29.2, 25.0, 22.7, 22.5, 19.9, 14.1, 14.0. HRMS-ESI ($m/z$): calcd for $C_{30}H_{38}N_3O_4$ $[M + H]^+$ 504.2857, found 504.2856.

*Methyl 2-(5-Methoxy-2-methyl-1-(4-octylbenzoyl)-1H-indol-3-yl)acetate (Table 3c, **4a′**).* The title compound was prepared from methyl 2-(1-(4-iodobenzoyl)-5-methoxy-2-methyl-1*H*-indol-3-yl)-acetate (463.3 mg, 1.0 mmol, 2.0 equiv), following the general procedure and using $NiBr_2$·glyme (7.8 mg, 0.025 mmol, 5.0 mol %), **L1** (4.8 mg, 0.030 mmol, 6.0 mol %), KF (73.0 g, 1.25 mmol, 2.5 equiv), (*E*)-oct-4-ene (87.5 μL, 62.4 mg, 0.50 mmol), $(EtO)_3SiH$ (230 μL, 1.25 mmol, 2.5 equiv), and DMF (3.75 mL). The reaction mixture was stirred for 24 h at rt. The crude material was purified by flash column chromatography and eluted with 15% EtOAc in hexanes to provide the title compound as a white solid in 45% yield (101.1 mg). Mp: 72−73 °C. IR (neat, cm$^{-1}$): 2925, 1731, 1667, 1605, 1323, 729. $^1$H NMR (500 MHz, $CDCl_3$): $\delta$ 7.66 (d, $J$ = 8.2 Hz, 2H), 7.31 (d, $J$ = 8.2 Hz, 2H), 6.99 (d, $J$ = 2.5 Hz, 1H), 6.92 (d, $J$ = 9.0 Hz, 1H), 6.68 (dd, $J$ = 9.0, 2.6 Hz, 1H), 3.86 (s, 3H), 3.73 (s, 3H), 3.70 (s, 2H), 2.73 (d, $J$ = 7.5 Hz, 2H), 2.41 (s, 3H), 1.73−1.64 (m, 2H), 1.39−1.27 (m, 10H), 0.91 (t, $J$ = 6.9 Hz, 3H). $^{13}$C NMR (126 MHz, $CDCl_3$): $\delta$ 171.6, 169.6, 155.9, 148.8, 136.2, 132.9, 131.2, 130.6, 130.1, 128.9, 127.5, 115.1, 111.9, 111.5, 101.1, 55.8, 52.2, 36.2, 36.1 31.2, 30.3, 29.5, 29.4, 22.8, 14.2, 13.4. HRMS-ESI ($m/z$): calcd for $C_{28}H_{36}NO_4$ $[M + H]^+$ 450.2639, found 450.2636.

*Heptan-2-yl 2-((5-Chloro-3-octylquinolin-8-yl)oxy)acetate (Table 3c, **4b′**).* The title compound was prepared from heptan-2-yl 2-((5-chloro-3-iodoquinolin-8-yl)oxy)acetate (461.0 mg, 1.0 mmol, 2.0 equiv), following the general procedure and using $NiBr_2$·glyme (7.8 mg, 0.025 mmol, 5.0 mol %), **L1** (4.8 mg, 0.030 mmol, 6.0 mol %), KF (73.0 g, 1.25 mmol, 2.5 equiv), (*E*)-oct-4-ene (87.5 μL, 62.4 mg, 0.50 mmol), $(EtO)_3SiH$ (230 μL, 1.25 mmol, 2.5 equiv), and DMF (3.75 mL). The reaction mixture was stirred for 24 h at rt. The crude material was purified by flash column chromatography and eluted with 10% EtOAc in hexanes to provide the title compound as a yellow liquid in 71% yield (158.3 mg). IR (neat, cm$^{-1}$): 2925, 1754, 1491, 1203, 1107, 728. $^1$H NMR (400 MHz, $CDCl_3$): $\delta$ 8.82 (s, 1H), 8.24 (s, 1H), 7.43 (d, $J$ = 8.4 Hz, 1H), 6.80 (d, $J$ = 8.3 Hz, 1H), 5.00 (q, $J$ = 6.3 Hz, 1H), 4.91 (s, 2H), 2.82 (t, $J$ = 7.8 Hz, 2H), 1.75−1.67 (m, 2H), 1.59−1.44 (m, 2H), 1.36−1.15 (m, 19H), 0.89−0.76 (m, 6H). $^{13}$C NMR (126 MHz, $CDCl_3$): $\delta$ 168.3, 153.0, 151.6, 139.1, 137.3, 131.1, 127.2, 126.0, 123.0, 108.4, 72.7, 66.4, 35.7, 33.4, 31.9, 31.6, 31.2, 29.4, 29.3, 29.2, 25.0, 22.7, 22.5, 19.9, 14.1, 14.0. HRMS-ESI ($m/z$): calcd for $C_{26}H_{39}ClNO_3$ $[M + H]^+$ 448.2613, found 448.2616.

*(3aR,5R,6S,6aR)-5-((R)-2,2-Dimethyl-1,3-dioxolan-4-yl)-2,2-dimethyltetrahydrofuro[2,3-d][1,3]dioxol-6-yl 4-Octylbenzoate (Table 3c, **4c′**).* The title compound was prepared from (3a*R*,5*R*,6*S*,6a*R*)-5-((*R*)-2,2-dimethyl-1,3-dioxolan-4-yl)-2,2-dimethyltetrahydrofuro[2,3-*d*][1,3]dioxol-6-yl 4-iodobenzoate (490.3 mg, 1.0 mmol, 2.0 equiv), following the general procedure and using $NiBr_2$·glyme (7.8 mg, 0.025 mmol, 5.0 mol %), **L1** (4.8 mg, 0.030 mmol, 6.0 mol %), KF (73.0 g, 1.25 mmol, 2.5 equiv), (*E*)-oct-4-ene (87.5 μL, 62.4 mg, 0.50 mmol), $(EtO)_3SiH$ (230 μL, 1.25 mmol, 2.5 equiv), and DMF (3.75 mL). The reaction mixture was stirred for 24 h at rt. The crude material was purified by flash column chromatography and eluted with 2% EtOAc in hexanes to provide the title compound as a colorless oil in 81% yield (192.9 mg). IR (neat, cm$^{-1}$): 2926, 1723, 1610, 1263, 1017, 732. $^1$H NMR (400 MHz, $CDCl_3$): $\delta$ 7.86 (d, $J$ = 8.3 Hz, 2H), 7.18 (d, $J$ = 8.2 Hz, 2H), 5.87 (d, $J$ = 3.6 Hz, 1H), 5.41 (d, $J$ = 2.7 Hz, 1H), 4.54 (d, $J$ = 3.7 Hz, 1H), 4.33−4.22 (m, 2H), 4.03 (dd, $J$ = 5.1, 3.2 Hz, 2H), 2.58 (t, $J$ = 7.6 Hz, 2H), 1.60−1.46 (m, 2H), 1.48 (s, 3H), 1.34 (s, 3H), 1.22 (d, $J$ = 17.7 Hz, 16H), 0.80 (t, $J$ = 6.5 Hz, 3H). $^{13}$C NMR (101 MHz, $CDCl_3$): $\delta$ 165.4, 149.4, 129.9, 128.7, 127.1, 112.5, 109.5, 105.3, 83.5, 80.1, 76.6, 72.8, 67.3, 36.2, 32.0, 31.3, 29.5, 29.4, 29.3, 27.0, 26.9, 26.3, 25.4, 22.8, 14.2. HRMS-ESI ($m/z$): calcd for $C_{27}H_{41}NaO_7$ $[M + Na]^+$ 499.2666, found 499.2666.

## ■ ASSOCIATED CONTENT

### Supporting Information

The Supporting Information is available free of charge at https://pubs.acs.org/doi/10.1021/acs.organomet.0c00819.

Experimental procedures and characterization data for all compounds (PDF)

## ■ AUTHOR INFORMATION


### Corresponding Author

**Shaolin Zhu** − *State Key Laboratory of Coordination Chemistry, Chemistry and Biomedicine Innovation Center (ChemBIC), Jiangsu Key Laboratory of Advanced Organic Materials, School of Chemistry and Chemical Engineering, Nanjing University, Nanjing 210093, People's Republic of China;* orcid.org/0000-0003-1516-6081; Email: shaolinzhu@nju.edu.cn

### Authors

**Yuli He** − *State Key Laboratory of Coordination Chemistry, Chemistry and Biomedicine Innovation Center (ChemBIC),*




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*Jiangsu Key Laboratory of Advanced Organic Materials, School of Chemistry and Chemical Engineering, Nanjing University, Nanjing 210093, People's Republic of China*

**Bo Han** − *State Key Laboratory of Coordination Chemistry, Chemistry and Biomedicine Innovation Center (ChemBIC), Jiangsu Key Laboratory of Advanced Organic Materials, School of Chemistry and Chemical Engineering, Nanjing University, Nanjing 210093, People's Republic of China*

Complete contact information is available at: https://pubs.acs.org/10.1021/acs.organomet.0c00819

### Notes

The authors declare no competing financial interest.

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(15) For an *ortho*-substituted aryl iodide, although the regioselectivity is excellent, the yield is low.



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