Electronic Supplementary Information (ESI)

Transition-metal-free oxidative trifluoromethylation of unsymmetrical biaryls with trifluoromethanesulfinate

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Experimental
General experimental details
All reactions were performed in oven-dried glassware under a positive pressure of nitrogen. Solvents were transferred via syringe and were introduced into the reaction vessels through a rubber septum. All of the reactions were monitored by thin-layer chromatography (TLC) carried out on 0.25 mm Merck silica gel (60-F254). The TLC plates were visualized with UV light and 7% phosphomolybdic acid or KMnO₄ in water/heat. Column chromatography was carried out on a column packed with silica gel 60N spherical neutral size 63-210 μm. The ¹H NMR (300 MHz) and ¹⁹F NMR (282 MHz) spectra for solution in CDCl₃, were recorded on a Varian Mercury 300. ¹³C NMR (150.9 MHz) spectra were recorded on a BRUKER 600 UltraShieldTR. Chemical shifts (δ) are expressed in ppm downfield from internal TMS or CFCl₃. Mass spectra were recorded on a SHIMADZU GCMS-QP5050A (EI-MS) and SHIMAZU LCMS-2010EV (ESI-MS and APCI-MS). Infrared spectra were recorded on a JASCO FT/IR-200 or a JASCO FT/IR-4100 spectrometer.

1-iodo-2,3-dimethoxybenzene was synthesized according to literature¹ and 2,3-dimethoxy phenyl boronic acid was synthesized according to previous report². The ¹H NMR spectrums of compounds 3a, 3d-f were in accordance with that reported². The ¹H NMR, ¹³C NMR, ¹⁹F NMR spectrums of compounds 2a, 2c, 2e, 2f were in accordance with literatures.

Synthesis of diaryl compounds
2,3-Dimethoxy-1,1'-biphenyl³

To a 30 mL schlenk tube, 1-iodo-2,3-dimethoxybenzene (264.0 mg, 1.0 mmol), phenyl boronic acid (183.0 mg, 1.5 mmol), Pd(PPh₃)₄ (12.0 mg, 0.01 mmol) and K₂PO₄ (637.0 mg, 3.0 mmol) was added. Excluding the air under vacuum and recharged with N₂ for 3 times. Then EtOH (5 mL) was added
and changed the septum to a glass cap. The mixture was stirred at 80 °C overnight. After the reaction was completed, the solvent was removed under reduced pressure, then water was added and extracted with CH₂Cl₂. The combined organic phase was washed with brine and dried over Na₂SO₄. Then filtered and removed the solvent under reduced pressure. The resulting mixture was purified by flash column chromatography (Hexane/Ether 95/5) to afford the desired product.

Yield: 89%; yellow solid. ¹H NMR (300 MHz, CDCl₃) δ 7.57-7.53 (m, 2H), 7.44-7.33 (m, 3H), 7.11 (t, J = 8.1 Hz, 1H), 6.97-6.91 (m, 2H), 3.92 (s, 3H), 3.59 (s, 2H); EI-MS: m/z (%) 214 (M⁺, 100), 199 (49), 184 (37).

2'-Fluoro-2,3-dimethoxy-1,1'-biphenyl

To a 30 mL schlenk tube, 2,3-dimethoxy phenyl boronic acid (273.0 mg, 1.5 mmol), 1-bromo-2-fluorobenzene (315.0 mg, 1.8 mmol), Pd(PPh₃)₄ (17.3 mg, 0.015 mmol) and K₃PO₄ (955.2 mg, 4.5 mmol) was added. Excluding the air under vacuum and recharged with N₂ for 3 times. Then EtOH (5 mL) was added and changed the septum to a glass cap. The mixture was stirred at 80 °C overnight. After the reaction was completed, the solvent was removed under reduced pressure, then water was added and extracted with CH₂Cl₂. The combined organic phase was washed with brine and dried over Na₂SO₄. Then filtered and removed the solvent under reduced pressure. The resulting mixture was purified by flash column chromatography (Hexane/Ether 95/5) to afford the desired product.

Yield: 87%; slightly yellow oil. IR (neat) 2939, 2835, 1584, 1499, 1424, 1265, 1023, 756 cm⁻¹; ¹H NMR (300 MHz, CDCl₃) δ 7.39-7.29 (m, 2H), 7.17-7.08 (m, 3H), 6.96 (d, J = 8.4 Hz, 1H), 6.89 (d, J = 7.5 Hz, 1H), 3.90 (s, 3H), 3.65 (s, J = 3.0 Hz, 3H); ¹³C NMR (150.9 MHz, CDCl₃) δ 159.9 (d, J = 247.5 Hz), 153.0, 147.1, 131.9 (d, J = 3.0 Hz), 130.2, 129.2 (d, J = 3.0 Hz), 126.1 (d, J = 15.0 Hz), 123.9 (d, J = 4.5 Hz), 123.8, 123.2 (d, J = 1.5 Hz), 115.5 (d, J = 22.6 Hz), 112.5, 60.8, 56.0; ¹⁹F NMR (282 MHz, CDCl₃) δ -114.9 (m, 1F); EI-MS: m/z (%) 232 (M⁺, 100), 217 (61), 202 (23), 146 (35); HRMS (EI) Calcd. for C₁₄H₁₃FO₂ [M⁺], 232.0900, found 232.0901.

4'-Bromo-2,3-dimethoxy-1,1'-biphenyl

Electronic Supplementary Material (ESI) for Chemical Communications
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To a 30 mL schlenk tube, 1-iodo-2,3-dimethoxybenzene (316.8 mg, 1.2 mmol), 4-bromophenyl boronic acid (200.8 mg, 1.0 mmol), Pd(PPh$_3$)$_4$ (12.0 mg, 0.01 mmol) and K$_3$PO$_4$ (637.0 mg, 3.0 mmol) was added. Excluding the air under vacuum and recharged with N$_2$ for 3 times. Then EtOH (5 mL) was added and changed the septum to a glass cap. The mixture was stirred at 80 °C overnight. After the reaction was completed, the solvent was removed under reduced pressure, then water was added and extracted with CH$_2$Cl$_2$. The combined organic phase was washed with brine and dried over Na$_2$SO$_4$. Then filtered and removed the solvent under reduced pressure. The resulting mixture was purified by flash column chromatography (Hexane/Acetone 97/3) to afford the desired product.

Yield: 66%; white solid. m.p.: 54-56 °C; IR (KBr) 2962, 2936, 1578, 1492, 1264, 1116, 995 cm$^{-1}$; $^1$H NMR (300 MHz, CDCl$_3$) $\delta$ 7.53 (d, $J = 8.4$ Hz, 2H), 7.42 (d, $J = 8.4$ Hz, 2H), 7.11 (t, $J = 8.1$ Hz, 1H), 6.96-6.89 (m, 2H), 3.91 (s, 3H), 3.60 (s, 3H); $^{13}$C NMR (150.9 MHz, CDCl$_3$) $\delta$ 153.3, 146.5, 137.2, 134.8, 131.4, 131.1, 124.4, 122.4, 121.5, 111.9, 60.7, 56.1; EI-MS: m/z (%) 294 (M$^+$ 2$^+$, 43), 292 (M$^+$, 43), 198 (100); HRMS (EI) Calcd. for C$_{14}$H$_{13}$BrO$_2$ [M$^+$], 292.0099, found 292.0092.

2'-Chloro-2,3-dimethoxy-1,1'-biphenyl

To a 30 mL schlenk tube, 2,3-dimethoxy phenyl boronic acid (182.0 mg, 1.0 mmol), 1-iodo-2-chlorobenzene (286.1 mg, 1.2 mmol), Pd(PPh$_3$)$_4$ (12.0 mg, 0.01 mmol) and K$_3$PO$_4$ (637.0 mg, 3.0 mmol) was added. Excluding the air under vacuum and recharged with N$_2$ for 3 times. Then EtOH (5 mL) was added and changed the septum to a glass cap. The mixture was stirred at 80 °C overnight. After the reaction was completed, the solvent was removed under reduced pressure, then water was added and extracted with CH$_2$Cl$_2$. The combined organic phase was washed with brine and dried over Na$_2$SO$_4$. Then filtered and removed the solvent under reduced pressure. The resulting mixture was purified by flash column chromatography (Hexane/EtOAc 95/5) to afford the desired product.

Yield: 96%; slightly yellow oil. $^1$H NMR (300 MHz, CDCl$_3$) $\delta$ 7.49-7.45 (m, 1H), 7.32-7.25 (m, 3H),...
7.11 (t, $J = 7.8$ Hz, 1H), 6.97 (dd, $J = 8.4, 1.2$ Hz, 1H), 6.82 (d, $J = 8.4, 1.2$ Hz, 1H), 3.91 (s, 3H), 3.61 (s, 3H); EI-MS: m/z (%) 250 (M+2+, 33), 248 (M+, 95), 198 (100).

3'-Chloro-2,3-dimethoxy-1,1'-biphenyl

To a 30 mL schlenk tube, 2,3-dimethoxy phenyl boronic acid (182.0 mg, 1.0 mmol), 1-iodo-3-chlorobenzene (286.1 mg, 1.2 mmol), Pd(PPh₃)₄ (12.0 mg, 0.01 mmol) and K₂PO₄ (637.0 mg, 3.0 mmol) was added. Excluding the air under vacuum and recharged with N₂ for 3 times. Then EtOH (5 mL) was added and changed the septum to a glass cap. The mixture was stirred at 80 °C overnight. After the reaction was completed, the solvent was removed under reduced pressure, then water was added and extracted with CH₂Cl₂. The combined organic phase was washed with brine and dried over Na₂SO₄. Then filtered and removed the solvent under reduced pressure. The resulting mixture was purified by flash column chromatography (Hexane/Et₂O 95/5) to afford the desired product.

Yield: 96%; slightly yellow oil. ¹H NMR (300 MHz, CDCl₃) δ 7.54 (s, 1H), 7.46-7.43 (m, 1H), 7.36-7.31 (m, 2H), 7.11 (t, $J = 8.1$ Hz, 1H), 6.96-6.90 (m, 1H), 6.91 (s, 3H), 3.60 (s, 3H); EI-MS: m/z (%) 250 (M+2+, 33), 248 (M+, 97), 198 (100).

4'-Chloro-2,3-dimethoxy-1,1'-biphenyl

To a 30 mL schlenk tube, 1-iodo-2,3-dimethoxybenzene (264.0 mg, 1.0 mmol), 4-chlorophenyl boronic acid (235.0 mg, 1.5 mmol), Pd(PPh₃)₄ (12.0 mg, 0.01 mmol) and K₂PO₄ (637.0 mg, 3.0 mmol) was added. Excluding the air under vacuum and recharged with N₂ for 3 times. Then EtOH (5 mL) was added and changed the septum to a glass cap. The mixture was stirred at 80 °C overnight. After the reaction was completed, the solvent was removed under reduced pressure, then water was added and extracted with CH₂Cl₂. The combined organic phase was washed with brine and dried over Na₂SO₄. Then filtered and removed the solvent under reduced pressure. The resulting mixture was purified by flash column chromatography (Hexane/Acetone 97/3) to afford the desired product.
Yield: 90%; colorless oil. $^1$H NMR (300 MHz, CDCl$_3$) δ 7.51 (d, $J = 8.7$ Hz, 2H), 7.40 (d, $J = 8.7$ Hz, 2H), 7.12 (t, $J = 8.1$ Hz, 1H), 6.96-6.91 (m, 2H), 3.92 (s, 3H), 3.60 (s, 3H); EI-MS: m/z (%) 250 (M+2$, 30), 248 (M$, 89), 233 (25), 198 (100).

2,3-Dimethoxy-2'-{(trifluoromethoxy)-1,1'-biphenyl

To a 30 mL schlenk tube, 1-iodo-2,3-dimethoxybenzene (264.0 mg, 1.0 mmol), (2-(trifluoromethoxy)phenyl)boronic acid (308.9 mg, 1.0 mmol), Pd(PPh$_3$)$_4$ (12.0 mg, 0.01 mmol) and K$_3$PO$_4$ (637.0 mg, 3.0 mmol) was added. Excluding the air under vacuum and recharged with N$_2$ for 3 times. Then EtOH (5 mL) was added and changed the septum to a glass cap. The mixture was stirred at 80 °C overnight. After the reaction was completed, the solvent was removed under reduced pressure, then water was added and extracted with CH$_2$Cl$_2$. The combined organic phase was washed with brine and dried over Na$_2$SO$_4$. Then filtered and removed the solvent under reduced pressure. The resulting mixture was purified by flash column chromatography (Hexane/Et$_2$O 95/5) to afford the desired product.

Yield: 75%; white solid. m.p.: 71-73 °C; IR (KBr) 3011, 2993, 2939, 1583, 1499, 1468, 1255, 1131, 922 cm$^{-1}$; $^1$H NMR (300 MHz, CDCl$_3$) δ 7.41-7.31 (m, 4H), 7.09 (t, $J = 8.4$ Hz, 1H), 6.96 (d, $J = 8.4$ Hz, 1H), 6.84 (d, $J = 8.4$ Hz, 1H), 3.90 (s, 3H), 3.62 (s, 3H); $^{13}$C NMR (150.9 MHz, CDCl$_3$) δ 152.9, 146.9, 146.8, 146.8, 132.4, 131.9, 131.1, 128.9, 126.5, 123.6, 123.2, 120.6 (q, $J = 256.5$ Hz), 120.7, 112.5, 60.7, 56.0; $^{19}$F NMR (282 MHz, CDCl$_3$) δ -57.4 (s, 3F); EI-MS: m/z (%) 298 (M$^+$, 100), 283.2 (29), 197 (38); HRMS (EI) Calcd. for C$_{15}$H$_{13}$F$_3$O$_3$ [M$^+$], 298.0817, found 298.0823.

2',4'-Difluoro-2,3-dimethoxy-1,1'-biphenyl

To a 30 mL schlenk tube, 2,3-dimethoxy phenyl boronic acid (273.0 mg, 1.5 mmol), 1-iodo-2,4-difluorobenzene (430.0 mg, 1.8 mmol), Pd(PPh$_3$)$_4$ (17.3 mg, 0.015 mmol) and K$_3$PO$_4$ (955.2 mg, 4.5 mmol) was added. Excluding the air under vacuum and recharged with N$_2$ for 3 times. Then EtOH (5 mL) was added and changed the septum to a glass cap. The mixture was stirred at
80 °C overnight. After the reaction was completed, the solvent was removed under reduced pressure, then water was added and extracted with CH₂Cl₂. The combined organic phase was washed with brine and dried over Na₂SO₄. Then filtered and removed the solvent under reduced pressure. The resulting mixture was purified by flash column chromatography (Hexane/Et₂O 95/5) to afford the desired product.

Yield: 90%; white solid. m.p.: 54-56 °C; IR (KBr) 3073, 2988, 2933, 1616, 1507, 1419, 1317, 1121, 856 cm⁻¹; ¹H NMR (300 MHz, CDCl₃) δ 7.47 (m, 1H), 7.10 (t, J = 7.8 Hz, 1H), 6.98-6.85 (m, 4H), 3.90 (s, 3H), 3.66 (s, 3H); ¹³C NMR (150.9 MHz, CDCl₃) δ 162.5 (dd, J = 249.0, 12.0 Hz), 160.0 (dd, J = 249.0, 12.0 Hz), 153.0, 147.1, 132.6 (q, J = 4.5 Hz), 129.4, 123.9, 123.1, 122.1 (dd, J = 16.6, 4.5 Hz), 112.6, 111.0 (dd, J = 21.1, 4.5 Hz), 104.0 (apparent t, J = 25.6 Hz), 60.8, 56.0; ¹⁹F NMR (282 MHz, CDCl₃) δ -110.5 (q, J = 7.9 Hz, 1F), 112.0 (quint, J = 7.9 Hz, 1F); EI-MS: m/z (%) 250 (M⁺, 100), 235 (67), 164 (37); HRMS (EI) Calcd. for C₁₄H₁₂F₂O₂ [M⁺]^+, 250.0805, found 250.0781.

2',6'-Difluoro-2,3-dimethoxy-1,1'-biphenyl

To a 30 mL schlenk tube, 2,3-dimethoxy phenyl boronic acid (273.0 mg, 1.5 mmol), 1-bromo-2,6-difluorobenzene (347.4 mg, 1.8 mmol), Pd(PPh₃)₄ (17.3 mg, 0.015 mmol) and K₂PO₄ (955.2 mg, 4.5 mmol) was added. Excluding the air under vacuum and recharged with N₂ for 3 times. Then EtOH (5 mL) was added and changed the septum to a glass cap. The mixture was stirred at 80 °C overnight. After the reaction was completed, the solvent was removed under reduced pressure, then water was added and extracted with CH₂Cl₂. The combined organic phase was washed with brine and dried over Na₂SO₄. Then filtered and removed the solvent under reduced pressure. The resulting mixture was purified by flash column chromatography (Hexane/Et₂O 95/5) to afford the desired product.

Yield: 67%; slightly yellow oil. IR (neat) 3065, 2941, 2836, 1626, 1460, 1234, 1120, 999, 750 cm⁻¹; ¹H NMR (300 MHz, CDCl₃) δ 7.33-7.25 (m, 1H), 7.13 (t, J = 7.8 Hz, 1H), 7.01-6.94 (m, 3H), 6.87 (d, J = 7.8 Hz, 1H), 3.90 (s, 3H), 3.71 (s, 3H); ¹³C NMR (150.9 MHz, CDCl₃) δ 160.6 (dd, J = 249.0, 7.5 Hz), 153.0, 147.6, 129.3 (t, J = 10.6 Hz), 123.8, 123.6, 123.5, 115.3 (t, J = 6.0 Hz), 113.2, 111.3 (dd, J = 21.1, 6.0 Hz), 60.9, 56.0; ¹⁹F NMR (282 MHz, CDCl₃) δ -112.5 (t, J = 6.0 Hz, 1F); EI-MS: m/z (%) 250 (M⁺, 100), 235 (31), 207 (22); HRMS (EI) Calcd. for C₁₄H₁₂F₂O₂ [M⁺]^+, 250.0805, found 250.0784.
General procedure for metal-free oxidative trifluoromethylation of arenes at room temperature

To a mixture of arenes (0.2 mmol) and NaSO₂CF₃ (0.4 mmol) in HFIP (0.5 mL), PIFA (0.4 mmol) was added. After stirring vigorously at room temperature over 5 minutes, water was added to quench the reaction. And the resulting mixture was extracted with CH₂Cl₂, the combined organic phase was dried over anhydrous Na₂SO₄. Then filtered, the filtrate was evaporated under vacuum and purified by flash column chromatography (Hexane/Ether or Hexane/EtOAc) to afford the desired product. Further purification could be attempted on preparative thin-layer plate with Hexane/CH₂Cl₂ or Hexane/Toluene. (Note: For 2e, PIDA (2.0 eq.) and NaSO₂CF₃ (10.0 eq.) were added instead; For 4b, 4d, 4e, 4h and 4i, PIFA (2.3 eq.) and NaSO₂CF₃ (2.3 eq.) were added)

1,2-Dimethoxy-4-(trifluoromethyl)benzene

Yield: 56%; Colorless oil. ¹H NMR (300 MHz, CDCl₃) δ 7.21 (d, J = 8.1 Hz, 1H), 7.07 (s, 1H), 6.91 (d, J = 8.4 Hz, 1H), 3.92 (s, 6H); ¹³C NMR (150.9 MHz, CDCl₃) δ 151.7, 149.1, 124.5 (q, J = 271.6 Hz), 123.0 (q, J = 33.2 Hz), 118.4 (q, J = 4.5 Hz), 110.7, 108.0 (q, J = 3.0 Hz), 56.1 (overlapped), 56.1 (overlapped); ¹⁹F NMR (282 MHz, CDCl₃) δ -62.0 (s, 3F); EI-MS: m/z (%) 206 (M⁺, 100), 191 (27), 163 (25), 143 (59);

1,2-Diethoxy-4-(trifluoromethyl)benzene

Yield: 48%; Slightly yellow solid. IR (KBr) 3092, 2992, 2940, 1608, 1432, 1323, 1224, 1106, 861 cm⁻¹; ¹H NMR (300 MHz, CDCl₃) δ 7.17 (d, J = 8.7 Hz, 1H), 7.08 (s, 1H), 6.90 (d, J = 8.4 Hz, 1H), 4.16-4.08 (m, 4H), 1.47 (t, J = 7.2 Hz, 6H); ¹³C NMR (150.9 MHz, CDCl₃) δ 152.4, 151.0, 123.6 (q, J = 273.1 Hz), 120.1 (q, J = 31.7 Hz), 119.0, 115.1, 113.5 (q, J = 6.0 Hz), 65.5, 64.4, 14.9, 14.8; ¹⁹F NMR (282 MHz, CDCl₃) δ -62.0 (s, 3F); EI-MS: m/z (%) 362 234 (M⁺, 22), 206 (6), 178 (100); HRMS (EI) Calcd. for C₁₁H₁₃F₃O₂ [M⁺], 234.0868, found 234.0875.
5-(Trifluoromethyl)benzo[d][1,3]dioxole

Yield: 32%; Colorless oil. $^1$H NMR (300 MHz, CDCl$_3$) $\delta$ 7.15 (d, $J = 9.0$ Hz, 1H), 7.04 (s, 1H), 6.86 (d, $J = 8.4$ Hz, 1H), 6.04 (s, 2H); $^{13}$C NMR (150.9 MHz, CDCl$_3$) $\delta$ 150.4, 148.1, 124.2 (q, $J = 271.6$ Hz), 124.4 (q, $J = 33.2$ Hz), 120.0 (q, $J = 4.5$ Hz), 108.4, 106.0, 102.0; $^{19}$F NMR (282 MHz, CDCl$_3$) $\delta$ -62.0 (s, 3F).

6-(Trifluoromethyl)-2,3-dihydrobenzo[b][1,4]dioxine

Yield: 43%; Colorless oil. IR (neat) 2989, 2884, 1591, 1463, 1328, 1123, 900 cm$^{-1}$; $^1$H NMR (300 MHz, CDCl$_3$) $\delta$ 7.13 (s, 1H), 7.10 (d, $J = 8.7$ Hz, 1H), 6.93 (d, $J = 8.1$ Hz, 1H), 4.29 (t, $J = 5.1$ Hz, 4H); $^{13}$C NMR (150.9 MHz, CDCl$_3$) $\delta$ 146.4, 143.6, 124.2 (q, $J = 270.1$ Hz), 123.8 (q, $J = 33.2$ Hz), 118.7 (q, $J = 4.5$ Hz), 117.7, 115.0 (q, $J = 4.5$ Hz), 64.6, 64.4; $^{19}$F NMR (282 MHz, CDCl$_3$) $\delta$ -62.3 (s, 3F); MS (EI): m/z (%) 204.2 (M$^+$, 100); HRMS (EI) Calcd. for C$_9$H$_7$F$_3$O$_2$ [M$^+$], 204.0398, found 204.0424.

1,4-Dimethoxy-2-(trifluoromethyl)benzene

Yield: 31%; Slightly yellow oil. $^1$H NMR (300 MHz, CDCl$_3$) $\delta$ 7.12 (s, 1H), 7.02 (d, $J = 9.0$ Hz, 1H), 6.95 (d, $J = 9.0$ Hz, 1H), 3.86 (s, 3H), 3.80 (s, 3H); $^{13}$C NMR (150.9 MHz, CDCl$_3$) $\delta$ 153.3, 151.9, 123.8 (q, $J = 272.5$ Hz), 119.8 (q, $J = 31.2$ Hz), 118.5, 114.0, 113.2 (q, $J = 5.4$ Hz), 57.0, 56.3; $^{19}$F NMR (282 MHz, CDCl$_3$) $\delta$ -62.9 (s, 3F); MS (EI): m/z (%) 206 (M$^+$, 69), 191 (100);

1,2,3-Trimethoxy-5-(trifluoromethyl)benzene

S8
Yield: 34%; slightly yellow solid. $^1$H NMR (300 MHz, CDCl$_3$) δ 6.83 (s, 2H) 3.91 (s, 3H), 3.90 (s, 6H); $^{13}$C NMR (150.9MHz, CDCl$_3$) δ 153.5, 140.7, 124.2 (q, $J = 271.6$ Hz), 125.8 (q, $J = 33.2$ Hz), 102.6 (q, $J = 4.5$ Hz), 61.0, 56.4; $^{19}$F NMR (282 MHz, CDCl$_3$) δ -62.6 (s, 3F); MS (EI): m/z (%) 236 (M$^+$, 100), 221(51), 193 (26);

**Trifluoromethyl-2,3-dimethoxy-1,1'-biphenyl**

Yield: 34%, C$_5$:C$_4$ = 9:4; Data for 4a-C$_5$: slightly yellow oil. IR (neat) 2940, 2832, 1593, 1499, 1366, 1258, 904 cm$^{-1}$; $^1$H NMR (300 MHz, CDCl$_3$) δ 7.54-7.51 (m, 2H), 7.46-7.35 (m, 3H), 7.24 (s, 1H), 7.13 (s, 1H), 3.95 (s, 3H), 3.63 (s, 3H), $^{13}$C NMR (150.9 MHz, CDCl$_3$) δ 153.4, 149.3, 137.2, 136.4, 129.3, 128.5, 127.9, 124.2 (q, $J = 271.6$ Hz), 126.2 (q, $J = 33.2$ Hz), 120.0 (q, $J = 4.5$ Hz), 108.3 (q, $J = 4.5$ Hz), 60.9, 56.3; $^{19}$F NMR (282 MHz, CDCl$_3$) δ -62.5 (s, 3F); EI-MS: m/z (%) 282 (M$^+$, 100), 267 (24), 247 (18), 198 (44); HRMS (EI) Calcd. for C$_{15}$H$_{13}$F$_3$O$_2$ [M$^+$], 282.0868, found 282.0852. Data for 4a-C$_4$: slightly yellow solid. m.p.: 52-54 °C; IR (KBr) 3009, 2971, 2941, 1600, 1577, 1456, 1321, 1280, 1115, 816 cm$^{-1}$; $^1$H NMR (300 MHz, CDCl$_3$) δ 7.47 (d, $J = 8.7$ Hz), 7.41-7.38 (m, 3H), 7.28 (d, $J = 5.4$ Hz), 6.98 (d, $J = 8.4$ Hz), 3.95 (s, 3H), 3.52 (s, 3H); $^{13}$C NMR (150.9MHz, CDCl$_3$) δ 155.6, 147.6, 136.3, 134.7, 129.8, 127.7, 127.6, 124.1 (q, $J = 273.1$ Hz), 122.2 (q, $J = 30.0$ Hz), 122.2 (q, $J = 6.0$ Hz), 110.6, 60.9, 56.1; $^{19}$F NMR (282 MHz, CDCl$_3$) δ -57.1 (s, 3F); EI-MS: m/z (%) 282 (M$^+$, 100), 267 (28), 247 (38), 198 (54); HRMS (EI) Calcd. for C$_{15}$H$_{13}$F$_3$O$_2$ [M$^+$], 282.0868, found 282.0872.

**Trifluoromethyl-2'-fluoro-2,3-dimethoxy-1,1'-biphenyl**
Trifluoromethyl-4'-bromo-2,3-dimethoxy-1,1'-biphenyl

![Diagram](image_url)

Yield: 34%, **C5:C4** = 2:1; Data for **4c-C5**: Slightly yellow solid, m.p.: 56-58 °C; IR (KBr) 2945, 2842, 1594, 1495, 1368, 1136, 824 cm⁻¹; ¹H NMR (300 MHz, CDCl₃) δ 7.48 (dd, J = 32.4, 8.4 Hz, 4H), 7.19 (s, 1H), 7.13 (s, 1H), 3.96 (s, 3H), 3.64 (s, 3H); ¹³C NMR (150.9 MHz, CDCl₃) δ 153.8, 149.4, 136.3, 135.4, 131.9, 131.2, 126.7 (q, J = 33.2 Hz), 124.4 (q, J = 273.1 Hz), 122.5, 119.8 (q, J = 3.0 Hz), 109.0 (q, J = 3.0 Hz), 61.1, 56.6; ¹⁹F NMR (282 MHz, CDCl₃) δ -62.6 (s, 3F); EI-MS: m/z (%) 362 (M⁺² +, 52), 360 (M⁺, 60), 266 (100); HRMS (EI) Calcd. for C₁₅H₁₁BrF₃O₂ [M⁺], 359.9973, found 359.9945. Data for **4c-C4**: Slightly yellow solid, m.p.: 796-98 °C; IR (KBr) 2932, 2853, 1602, 1453, 1278, 1115, 811 cm⁻¹; ¹H NMR (300 MHz, CDCl₃) δ 7.47 (q, J = 8.7 Hz, 1H), 7.14 (d, J = 8.4 Hz, 2H), 6.98 (d, J = 8.7 Hz, 1H), 3.94 (s, 3H), 3.53 (s, 3H); ¹³C NMR (150.9 MHz, CDCl₃) δ 155.6, 147.4, 134.9, 133.7, 131.5, 130.9, 124.0 (q, J = 273.1 Hz), 122.3 (q, J = 6.0 Hz), 122.1 (q, J = 28.7 Hz), 122.0, 110.9, 60.9, 56.1; ¹⁹F NMR (282 MHz, CDCl₃) δ -57.0 (s, 3F); EI-MS: m/z (%) 362 (M⁺², 55), 360 (M⁺, 58), 266 (100); HRMS (EI) Calcd. for C₁₅H₁₁BrF₃O₂ [M⁺], 359.9973, found 360.0000.

Trifluoromethyl-2'-chloro-2,3-dimethoxy-1,1'-biphenyl

Yield: 35%, **C5:C4** = 7:3; Data for **4b-C5**: yellow oil. IR (neat) 2944, 2840, 1594, 1498, 1367, 1138, 907 cm⁻¹; ¹H NMR (300 MHz, CDCl₃) δ 7.38-7.31 (m, 2H), 7.23-7.12 (m, 4H), 3.95 (s, 3H), 3.73 (s, 3H); ¹³C NMR (150.9 MHz, CDCl₃) δ 160.0 (d, J = 247.5 Hz), 153.1, 149.8, 131.7 (d, J = 3.0 Hz), 130.5, 129.9 (d, J = 9.1 Hz), 124.1 (q, J = 273.1 Hz), 125.9 (q, J = 33.2 Hz), 125.0 (d, J = 18.1 Hz), 124.1 (d, J = 3.0 Hz), 120.4 (q, J = 3.0 Hz), 115.8 (d, J = 22.6 Hz), 109.3 (q, J = 3.0 Hz), 61.0, 56.2; ¹⁹F NMR (282 MHz, CDCl₃) δ -62.5 (s, 3F), -114.8 (t, J = 14.7 Hz, 1F); EI-MS: m/z (%) 300 (M⁺, 100), 285 (28), 216 (57); HRMS (EI) Calcd. for C₁₅H₁₁F₄O₂ [M⁺], 300.0773, found 300.0761. Data for **4b-C4**: yellow oil. IR (neat) 2942, 2845, 1594, 1457, 1321, 1119, 815 cm⁻¹; ¹H NMR (300 MHz, CDCl₃) δ 7.38-7.31 (m, 2H), 7.23-7.12 (m, 4H), 3.95 (s, 3H), 3.73 (s, 3H); ¹³C NMR (150.9 MHz, CDCl₃) δ 160.0 (d, J = 247.5 Hz), 153.1, 149.8, 131.7 (d, J = 3.0 Hz), 130.5, 129.9 (d, J = 9.1 Hz), 124.1 (q, J = 273.1 Hz), 125.9 (q, J = 33.2 Hz), 125.0 (d, J = 18.1 Hz), 124.1 (d, J = 3.0 Hz), 120.4 (q, J = 3.0 Hz), 115.8 (d, J = 22.6 Hz), 109.3 (q, J = 3.0 Hz), 61.0, 56.2; ¹⁹F NMR (282 MHz, CDCl₃) δ -62.5 (s, 3F), -114.8 (t, J = 14.7 Hz, 1F); EI-MS: m/z (%) 300 (M⁺, 100), 285 (28), 216 (57); HRMS (EI) Calcd. for C₁₅H₁₁F₄O₂ [M⁺], 300.0773, found 300.0761.
Trifluoromethyl-3'-chloro-2,3-dimethoxy-1,1'-biphenyl

Yield: 38%, C5:C4 = 7:3; Data for 4e-C5: yellow oil. IR (neat) 2941, 2841, 1592, 1464, 1364, 1233, 911 cm⁻¹; ¹H NMR (300 MHz, CDCl₃) δ 7.52 (s, 1H), 7.42-7.35 (m, 3H), 7.20 (s, 1H), 7.14 (s, 1H), 3.96 (s, 3H), 3.66 (s, 3H); ¹³C NMR (150.9 MHz, CDCl₃) δ 153.5, 149.2, 138.9, 134.3, 134.3, 129.7, 129.4, 128.0, 127.6, 126.4 (q, J = 33.2 Hz), 124.1 (q, J = 271.6 Hz), 119.6 (q, J = 4.5 Hz), 108.8 (q, J = 4.5 Hz), 61.0, 56.3; ¹⁹F NMR (282 MHz, CDCl₃) δ -62.6 (s, 3F); EI-MS: m/z (%) 318 (M⁺, 30), 316 (M⁺, 84), 281 (16), 266 (100); HRMS (EI) Calcd. for C₁₅H₁₂ClF₃O₂ [M⁺], 316.0477, found 316.0476.

Electronic Supplementary Material (ESI) for Chemical Communications
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Trifluoromethyl-4′-chloro-2,3-dimethoxy-1,1′-biphenyl

Yield: 39%, **C5:C4** = 5:2; Data for **4f-C5**: slightly yellow solid. m.p.: 54-56 °C; IR (KBr) 2945, 2843, 1594, 1498, 1455, 1367, 1094, 997; $^1$H NMR (300 MHz, CDCl$_3$) $\delta$ 7.43 (dd, $J$ = 20.1, 6.6 Hz, 4H), 7.20 (s, 1H), 7.13 (s, 1H), 3.95 (s, 3H), 3.63 (s, 3H); $^{13}$C NMR (150.9 MHz, CDCl$_3$) $\delta$ 153.5, 149.2, 135.5, 135.1, 134.0, 130.7, 128.7, 126.4 (q, $J$ = 33.2 Hz), 124.1 (q, $J$ = 271.6 Hz), 119.6 (q, $J$ = 3.0 Hz), 108.6 (q, $J$ = 3.0 Hz), 60.9, 56.3; $^{19}$F NMR (282 MHz, CDCl$_3$) $\delta$ -62.6 (s, 3F); EI-MS: m/z (%) 318 (M+2 +, 31), 316 (M +, 100), 301 (23), 266 (63); HRMS (EI) Calcd. for C$_{15}$H$_{12}$ClF$_3$O$_2$ [M]$^+$, 316.0478, found 316.0504.

Trifluoromethyl-2,3-dimethoxy-2′-(trifluoromethoxy)-1,1′-biphenyl

Yield: 43%, **C5-C4** = 5:2; Data for **4g-C5**: yellow oil. IR (neat) 2945, 2842, 1594, 1423, 1259, 1141, 907 cm$^{-1}$; $^1$H NMR (300 MHz, CDCl$_3$) $\delta$ 7.45-7.34 (m, 4H), 7.17 (s, 1H), 7.15 (s, 1H), 3.95 (s, 3H), 3.70 (s, 3H); $^{13}$C NMR (150.9 MHz, CDCl$_3$) $\delta$ 153.0, 149.6, 146.8, 132.1, 131.3, 129.5, 126.7, 125.7 (q, $J$ = 33.2 Hz), 124.1 (q, $J$ = 271.6 Hz); 120.8, 120.5 (q, $J$ = 256.5 Hz), 120.4 (q, $J$ = 3.0 Hz), 109.3 (q, $J$ = 3.0 Hz), 60.8, 56.2; $^{19}$F NMR (282 MHz, CDCl$_3$) $\delta$ -57.6 (s, 3F), -62.5 (s, 3F); EI-MS: m/z (%) 366 (M$,^+$, 100), 282 (30), 265 (39); HRMS (EI) Calcd. for C$_{16}$H$_{12}$F$_6$O$_3$ [M]$^+$, 366.0691, found 366.0668.
Trifluoromethyl-2',4'-difluoro-2,3-dimethoxy-1,1'-biphenyl

Yield: 45%, C5:C4 = 5:2; Data for 4h-C5: yellow oil. IR (neat) 2945, 2846, 1599, 1465, 1368, 1139, 968 cm⁻¹; ¹H NMR (300 MHz, CDCl₃) δ 7.31 (dd, J = 14.7, 4.1 Hz, 1H), 7.17 (s, 1H), 7.15 (s, 1H), 6.93 (dd, J = 18.9, 10.2 Hz, 2H), 3.95 (s, 3H), 3.72 (s, 3H); ¹³C NMR (150.9 MHz, CDCl₃) δ 162.9 (dd, J = 250.5, 12.1 Hz), 160.0 (dd, J = 250.5, 12.1 Hz), 153.1, 149.8, 132.4 (q, J = 4.5 Hz), 129.6, 126.0 (q, J = 33.2 Hz), 124.1 (q, J = 271.6 Hz), 121.0 (dd, J = 12.0, 4.5 Hz), 120.3 (d, J = 4.5 Hz), 111.4 (dd, J = 21.1, 3.0 Hz), 109.4 (q, J = 3.0 Hz), 104.2 (t, J = 27.2 Hz), 60.9, 56.2; ¹⁹F NMR (282 MHz, CDCl₃) δ 62.5 (s, 3F), -110.3 (q, J = 9.0 Hz, 1F), -110.8 (quint, J = 7.9 Hz, 1F); EI-MS: m/z (%) 318 (M⁺, 100), 303 (35), 234 (55); HRMS (EI) Calcd. for C₁₅H₁₁F₅O₂ [M⁺], 318.0679, found 318.0696. Data for 4h-C₄: yellow oil. IR (neat) 2942, 2846, 1600, 1492, 1321, 1015, 812 cm⁻¹; ¹H NMR (300 MHz, CDCl₃) δ 7.49 (d, J = 8.7 Hz, 1H), 7.18 (dd, J = 15, 8.1 Hz, 1H), 7.02 (d, J = 8.7 Hz, 1H), 6.91 (dd, J = 16.5, 7.8 Hz, 2H), 3.95 (s, 3H), 3.62 (s, 3H); ¹³C NMR (150.9 MHz, CDCl₃) δ 163.0 (dd, J = 249.0, 12.1 Hz), 160.2 (dd, J = 249.0, 12.1 Hz), 155.5, 148.0, 132.5 (q, J = 4.5 Hz), 128.5, 123.8 (q, J = 273.1 Hz), 122.7 (q, J = 31.7 Hz), 122.4 (q, J = 4.5 Hz), 118.4 (dd, J = 18.1, 4.5 Hz), 111.5, 110.8 (q, J = 3.0 Hz), 103.7 (t, J = 25.6 Hz), 60.9, 56.0; ¹⁹F NMR (282 MHz, CDCl₃) δ 58.8 (s, 3F), -109.5 (d, J = 6.8 Hz, 1F), -110.9 (quint, J = 7.9 Hz, 1F); EI-MS: m/z (%) 318 (M⁺, 100), 303 (31), 234 (53); HRMS (EI) Calcd. for C₁₅H₁₁F₅O₂ [M⁺], 318.0679, found 318.0686.

Trifluoromethyl-2',6'-difluoro-2,3-dimethoxy-1,1'-biphenyl

Yield: 45%, C5:C4 = 5:2; Data for 4i-C₅: slightly yellow solid. m.p.: 58-60 °C; IR (KBr) 2977, 2942, 1587, 1500, 1363, 1230, 1138, 872 cm⁻¹; ¹H NMR (300 MHz, CDCl₃) δ 7.49 (d, J = 8.7 Hz, 1H), 7.19 (s, 1H), 7.17 (s, 1H), 6.98 (t, J = 11.3 Hz, 2H), 3.95 (s, 3H), 3.72 (s, 3H); ¹³C NMR (150.9 MHz, CDCl₃) δ 161.2 (d, J = 6.0 Hz), 159.6 (d, J = 6.0 Hz), 153.1, 150.3, 129.9 (t, J = 10.6 Hz), 125.9 (q, J = 33.2 Hz), 124.1 (q, J = 271.6 Hz), 123.9, 120.8 (q, J = 3.0 Hz), 114.2 (t, J = 21.1 Hz), 111.5 (dd, J = 21.1, 4.5 Hz), 109.9 (q, J = 3.0 Hz), 61.0, 56.2; ¹⁹F NMR (282 MHz, CDCl₃) δ -62.4

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(s, 3F), -112.4 (m, 2F); EI-MS: m/z (%) 318 (M+, 100), 303 (29), 138 (31); HRMS (EI) Calcd. for C₁₅H₁₁F₅O₂ [M]+, 318.0679, found 318.0675. Data for 4i-C₄: slightly yellow solid. m.p.: 89-91 °C; IR (KBr) 2946, 2846, 1630, 1466, 1281, 1119, cm⁻¹; ¹H NMR (300 MHz, CDCl₃) δ 7.52 (d, J = 8.7 Hz), 7.37 (quint, J = 6.6 Hz), 7.05 (d, J = 8.7 Hz), 6.98 (t, J = 6.9 Hz), 3.96 (s, 3H), 3.67 (s, 3H); ¹³C NMR (150.9 MHz, CDCl₃) δ 161.4 (d, J = 6.0 Hz), 159.8 (d, J = 6.0 Hz), 155.6, 148.1, 130.3 (t, J = 10.6 Hz), 123.7 (q, J = 271.6 Hz), 122.9 (q, J = 31.7 Hz), 122.8 (d, J = 1.5 Hz), 122.5 (d, J = 6.0 Hz), 112.0, 111.8 (t, J = 22.6 Hz), 111.1 (dd, J = 21.1, 4.5 Hz), 60.9, 56.0; ¹⁹F NMR (282 MHz, CDCl₃) δ -61.0 (s, 3F), -111.4 (s, 2F); EI-MS: m/z (%) 318 (M+, 100), 303 (33); HRMS (EI) Calcd. for C₁₅H₁₁F₅O₂ [M]+, 318.0679, found 318.0672.

**Synthesis of authentic sample compound 4a-C₄**

![Diagram](image)

1.0 eq. 2.0 eq. yield 40%

The authentic sample was synthesized according to a literature procedure.⁵ In a 10 mL test tube, 6-iodo-2,3-dimethoxy-1,1'-biphenyl (68.0 mg, 0.2 mmol) and [Ph₂SCF₃][OTf]⁻ (161.7 mg, 0.4 mmol) were dissolved in DMF (1 mL), then Cu (38.1 mg, 0.6 mmol) was added. The mixture was stirred at 60 °C for 20 h. After cooling to room temperature, the mixture was diluted with diethyl ether, washed with water, dried over Na₂SO₄, and concentrated under reduced pressure. The crude residue was purified through column chromatography on silica gel (Hexane/EtOAc 95/5) to afford slightly yellow solid (22.7 mg, 40%). ¹H NMR (300 MHz, CDCl₃) δ 7.47 (d, J = 8.7 Hz), 7.41-7.37 (m, 3H), 7.28 (d, J = 5.4 Hz), 6.97 (d, J = 9.0 Hz), 3.94 (s, 3H), 3.52 (s, 3H).

**References**

(2c) 
$^1$H NMR

(2c) 
$^{13}$C NMR
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$^1$H NMR

$^{13}$C NMR
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