Supporting Information
One-Pot Multistep Synthesis of Tri-substituted Alkenes from N-Tosylhydrazones and Alcohols

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.General Information and Materials

Toluene was distilled using Na prior to use. N-tosylhydrazones were prepared by condensation of carbonyl compounds with 4-methylbenzenesulfonylhydrazide,[1] Trifluoromethyl-substituted carbinols were prepared from the addition of trimethylsilyl trifluoromethane on aldehydes.[2] Other chemicals (AR grade) were obtained from commercial sources and were used without further purification. Petroleum ether (PE) refers to the fraction boiling in the 60-90 °C range. The progress of the reactions was monitored by TLC (silica gel, Polygram SILG/UV 254 plates). Column chromatography was performed on Silicycle silica gel (200–300 mesh). Melting Experimental Section points were obtained using a Yamato melting point apparatus Model MP-21 and are uncorrected. $^1$H, $^{13}$C and $^{19}$F NMR spectra were obtained using a Bruker DRX 500 (500 MHz) spectrometer in CDCl$_3$ with TMS as the internal standard. Ms spectra were recorded using a Thermo Scientific TSQ Quantum analyzer. The known compounds were identified by comparison of their physical and spectral data with those reported in the literature.

II. General Procedure

Catalytic one-pot oxidation-olefination.

CuCl (2.5 mg, 0.025 mmol) and 1,10-phenanthroline (4.5 mg, 0.025 mmol) were placed in a vessel and toluene (5 mL) was added. The resulting solution was stirred at room temperature until the solution became green and clear (5 to 10 minutes). Then K$_2$CO$_3$ (138 mg, 1 mmol), DEAD-H$_2$ (18.5 mg, 0.125 mmol) were added. The solution was stirred at room temperature for another 10 min. Alcohol (0.60 mmol) was added, the reaction mixture was heated at 90 °C under O$_2$ atmosphere (O$_2$ balloon) until the reaction was completed as gauged by TLC analysis. The vessel was backfilled with N$_2$. Triphenylphosphine (157.2 mg, 0.6 mmol), Cul (9.5 mg, 0.05 mmol), LiO$_2$-Bu (56.0 mg, 0.7 mmol), Tosylhydrazone (0.5 mmol) were added. The solution was stirred at 90 °C for 10 h. The solvent was removed under reduced pressure and the crude alkene was purified by flash chromatography on silica gel.
III. Spectroscopic Data of Products

(E)-prop-1-ene-1,2-diyl dibenzene (3a)[3]

Colorless liquid; yield (Z+E): 65.0 mg (67%); R_f = 0.41 (PE).

^1H NMR (500 MHz, CDCl_3, E-isomer): δ = 7.57-7.55 (m, 2H), 7.42-7.39 (m, 6H), 7.33-7.26 (m, 2H), 6.87 (d, J = 1 Hz, 1H), 2.32 (d, J = 1 Hz, 3H). ^1H NMR (500 MHz, CDCl_3, Z-isomer): δ = 6.51 (s, 0.14 H). Integrations indicate a Z/E ratio of 12:88.

^13C NMR (125 MHz, CDCl_3, E-isomer): δ = 144.06, 138.45, 137.51, 129.23, 128.40, 128.25, 127.79, 127.26, 126.54, 126.09, 17.55.

(E)-1-chloro-4-(1-phenylprop-1-en-2-yl)benzene (3b)[4]

Colorless liquid; yield (Z+E): 65.0 mg (57%); R_f = 0.41 (PE).

^1H NMR (500 MHz, CDCl_3, E-isomer): δ = 7.50 (d, J = 8.5 Hz, 2H), 7.44-7.38 (m, 6H), 7.32-7.29 (m, 1H), 6.88 (s, 1H), 2.31 (s, 3H). ^1H NMR (500 MHz, CDCl_3, Z-isomer): δ = 6.56 (s, 0.23 H). Integrations indicate a Z/E ratio of 19:81.

^13C NMR (125 MHz, CDCl_3, E-isomer): δ = 142.43, 138.11, 136.30, 133.02, 129.22, 128.51, 128.31, 128.23, 127.36, 126.76, 17.46.

(E)-2-(1-phenylprop-1-en-2-yl)thiophene (3c)[5]

Colorless liquid; yield (Z+E): 58.0 mg (58%); R_f = 0.41 (PE).

^1H NMR (500 MHz, CDCl_3, E-isomer): δ = 7.43-7.41 (m, 4H), 7.32-7.30 (m, 1H), 7.25 (d, J = 5 Hz, 1H), 7.20 (d, J = 3.5 Hz, 1H), 7.09 (s, 1H), 7.37 (s, 3H). ^1H NMR (500 MHz, CDCl_3, Z-isomer): δ = 6.60 (s, 0.19 H). Integrations indicate a Z/E ratio of 16:84.

^13C NMR (125 MHz, CDCl_3, E-isomer): δ = 148.04, 137.70, 131.11, 129.34, 128.30, 127.57, 126.72, 126.21, 124.05, 123.43, 17.46.

(E)-1-chloro-4-(2-phenylprop-1-en-1-yl)benzene (3d)[4]

Colorless liquid; yield (Z+E): 75.2 mg (66%); R_f = 0.41 (PE).

^1H NMR (500 MHz, CDCl_3, E-isomer): δ = 7.53 (d, J = 8 Hz, 2H), 7.41-7.37 (m, 4H), 7.35-7.27 (m, 3H), 6.79 (s, 1H), 2.28 (s, 3H). ^1H NMR (500 MHz, CDCl_3, Z-isomer): δ = 6.43 (s, 0.12 H). Integrations indicate a Z/E ratio of 11:89.

^13C NMR (125 MHz, CDCl_3, E-isomer): δ = 143.69, 138.20, 136.79, 132.19, 130.46, 128.42, 128.38, 127.43, 126.50, 126.02, 17.54.

(E)-but-1-ene-1,2-diyl dibenzene (3e)[6]
Colorless liquid; yield (Z+E): 57.2 mg (55%); R_f = 0.46 (PE).

1H NMR (500 MHz, CDCl_3, E-isomer): δ = 7.57 (d, J = 8 Hz, 2H), 7.48-7.43 (m, 6H), 7.40-7.33 (m, 2H), 6.81 (s, 1H), 2.85 (q, J = 7 Hz, 2H), 1.18 (t, J = 7 Hz, 3H). 1H NMR (500 MHz, CDCl_3, Z-isomer): δ = 6.49 (s, 0.01 H). Integrations indicate a Z/E ratio of 1:99.

13C NMR (125 MHz, CDCl_3, E-isomer): δ = 144.61, 142.85, 138.45, 128.86, 128.48, 128.38, 127.75, 127.29, 126.66, 23.41, 13.63.


13C NMR (125 MHz, CDCl_3, E-isomer): δ = 145.38, 142.44, 137.25, 131.45, 130.44, 128.49, 127.46, 126.68, 126.43, 120.46, 23.37, 13.50.

IR (film): 1651, 1466, 1378, 1155, 1011, 696 cm⁻¹.

Ms (EI, 70 eV): m/z = 286.

HRMS (EI, 70 eV) calcd for C_16H_15Br: 286.0357, found 286.0360.

Colorless liquid; yield (Z+E): 57.7 mg (52%); R_f = 0.49 (PE).

1H NMR (500 MHz, CDCl_3, E-isomer): δ = 7.48 (d, J = 8 Hz, 2H), 7.40-7.34 (m, 6H), 7.32-7.26 (m, 2H), 2.71 (t, J = 8 Hz, 2H), 1.54-1.46 (m, 2H), 0.92 (d, J = 7.5 Hz, 3H). 1H NMR (500 MHz, CDCl_3, Z-isomer): δ = 6.46 (s, 0.01 H). Integrations indicate a Z/E ratio of 1:99.


13C NMR (125 MHz, CDCl_3, E-isomer): δ = 144.61, 142.85, 138.45, 128.86, 128.48, 128.38, 127.75, 127.29, 126.66, 23.41, 13.63.

13C NMR (125 MHz, CDCl_3, E-isomer): δ = 146.59, 142.13, 141.92, 128.98, 128.52, 128.35, 127.66, 126.71, 126.24, 125.24, 23.38, 13.49.
$(E)$-$2$-(2-phenylbut-1-en-1-yl)thiophene (3i)\[8\]

Colorless liquid; yield ($Z+E$): 54.6 mg (51%); $R_f$ = 0.35 (PE).

$^1$H NMR (500 MHz, CDCl$_3$, $E$-isomer): $\delta$ = 7.49 (d, $J = 7.5$ Hz, 2H), 7.39-7.36 (m, 2H), 7.31-7.29 (m, 2H), 7.09-7.05 (m, 2H), 6.85 (s, 1H), 2.93 (q, $J = 7.5$ Hz, 2H), 1.17 (t, $J = 7.5$ Hz, 3H). $^1$H NMR (500 MHz, CDCl$_3$, $Z$-isomer): $\delta$ = 6.62 (s, 0.01 H). Integrations indicate a $Z/E$ ratio of 1:99.

$^{13}$C NMR (125 MHz, CDCl$_3$, $E$-isomer): $\delta$ = 142.75, 142.61, 140.91, 128.44, 127.69, 127.23, 126.99, 126.42, 125.01, 120.37, 24.57, 12.99.

$(E)$-$1$-(2-phenylbut-1-en-1-yl)naphthalene (3j)\[8\]

Colorless liquid; yield ($Z+E$): 76.1 mg (59%); $R_f$ = 0.28 (PE).

$^1$H NMR (500 MHz, CDCl$_3$, $E$-isomer): $\delta$ = 8.04 (dd, $J = 7$ Hz, 1.5 Hz, 1H), 7.89 (dd, $J = 7$ Hz, 2 Hz, 1H), 7.82 (d, $J = 8$ Hz, 1H), 7.60 (d, $J = 7.5$ Hz, 2H), 7.52-7.49 (m, 3H), 7.37-7.34 (m, 1H), 7.12 (q, $J = 7$ Hz, 2H), 0.98 (t, $J = 7.5$ Hz, 3H). $^1$H NMR (500 MHz, CDCl$_3$, $Z$-isomer): $\delta$ = 6.71 (s, 0.01 H). Integrations indicate a $Z/E$ ratio of 1:99.

$^{13}$C NMR (125 MHz, CDCl$_3$, $E$-isomer): $\delta$ = 145.83, 142.15, 135.84, 133.60, 132.33, 129.83, 128.49, 128.41, 127.35, 127.28, 126.80, 126.04, 125.88, 125.56, 125.45, 125.30, 23.63, 13.71.

$(E)$-$1$-methyl-$2$-(2-phenylbut-1-en-1-yl)benzene (3k)\[8\]

Colorless liquid; yield ($Z+E$): 52.2 mg (47%); $R_f$ = 0.48 (PE).

$^1$H NMR (500 MHz, CDCl$_3$, $E$-isomer): $\delta$ = 7.53-7.51 (m, 2H), 7.42-7.39 (m, 2H), 7.34-7.31 (m, 1H), 7.26-7.22 (m, 4H), 6.69 (s, 1H), 2.61 (q, $J = 7.5$ Hz, 2H), 2.31 (s, 3H), 0.99 (t, $J = 7.5$ Hz, 3H). $^1$H NMR (500 MHz, CDCl$_3$, $Z$-isomer): $\delta$ = 6.53 (s, 0.01 H). Integrations indicate a $Z/E$ ratio of 1:99.

$^{13}$C NMR (125 MHz, CDCl$_3$, $E$-isomer): $\delta$ = 144.19, 142.40, 137.75, 136.76, 129.82, 128.77, 128.37, 127.14, 126.89, 126.76, 125.51, 23.25, 20.11, 13.49.

$(E)$-$1$-methyl-4-(3,3,3-trifluoro-2-phenylprop-1-en-1-yl)benzene (4b)\[9\]

Colorless liquid; yield ($Z+E$): 99.2 mg (80%); $R_f$ = 0.69 (PE).

$^1$H NMR (500 MHz, CDCl$_3$, $E$-isomer): $\delta$ = 7.44-7.43 (m, 3H), 7.36-7.34 (m, 2H), 7.28 (s, 1H), 7.24 (d, $J = 7$ Hz, 1H), 7.21-7.18 (m, 2H), 7.05 (d, $J = 7.5$ Hz, 2H). $^1$H NMR (500 MHz, CDCl$_3$, $Z$-isomer): $\delta$ = 7.10 (s, 0.09 H). Integrations indicate a $Z/E$ ratio of 8:92.

$(E)$-$1$-methyl-$2$-(3,3,3-trifluoro-2-phenylprop-1-en-1-yl)benzene (4b)\[9\]
Colorless liquid; yield (Z+E): 95.6 mg (73%); Rf = 0.66 (PE).

\(^1\)H NMR (500 MHz, CDCl\(_3\), E-isomer): \(\delta = 7.45-7.44\) (m, 3H), 7.37-7.36 (m, 2H), 7.25 (s, 1H), 7.03-7.01 (m, 2H), 6.96-6.95 (m, 2H), 2.31 (s, 3H). \(^1\)H NMR (500 MHz, CDCl\(_3\), Z-isomer): \(\delta = 7.10\) (s, 0.12 H). Integrations indicate a Z/E ratio of 11:89.

\((E)-1\)-bromo-2-(3,3,3-trifluoro-2-phenylprop-1-en-1-yl)benzene (4c)

Colorless liquid; yield (Z+E): 85.9 mg (76%); Rf = 0.70 (PE).

\(^1\)H NMR (500 MHz, CDCl\(_3\), E-isomer): \(\delta = 7.58\) (dd, \(J = 8\) Hz, 1.5 Hz, 1H), 7.48 (d, \(J = 1.5\) Hz, 1H), 7.33-7.32 (m, 3H), 7.28-7.26 (m, 2H), 7.06 (td, \(J = 7.5\) Hz, 1.5 Hz, 1H), 6.97 (td, \(J = 7.5\) Hz, 1H, 1H), 6.81 (dd, \(J = 8\) Hz, 1.5 Hz, 1H).

\(^1\)C NMR (125 MHz, CDCl\(_3\), E-isomer): \(\delta = 134.43, 133.08 (J = 5\) Hz\), 133.04, 132.71, 131.93, 131.17, 129.88, 128.83, 128.69, 126.92, 124.83.

\(^1\)F NMR (470 MHz, CDCl\(_3\)): \(\delta = -65.41\) (s, 0.90F, E-isomer), -56.75 (s, 0.10F, Z-isomer). Integrations indicate a Z/E ratio of 10:90.

IR (film): 1651, 1463, 1379, 1295, 1129, 962, 724 cm\(^{-1}\).

Ms (EI, 70 eV): \(m/z = 326\).

HRMS (EI, 70 eV) calcd for C\(_{15}\)H\(_{10}\)BrF\(_3\): 325.9918, found 325.9921.

\((E)-1\)-bromo-3-(3,3,3-trifluoro-2-phenylprop-1-en-1-yl)benzene (4d)

Colorless liquid; yield (Z+E): 61.0 mg (54%); Rf = 0.70 (PE).

\(^1\)H NMR (500 MHz, CDCl\(_3\), E-isomer): \(\delta = 7.43-7.40\) (m, 3H), 7.35-7.33 (m, 1H), 7.30-7.28 (m, 2H), 7.18-7.17 (m, 2H), 7.02 (t, \(J = 7.5\) Hz, 1H), 6.91 (d, \(J = 8\) Hz, 1H).

\(^1\)C NMR (125 MHz, CDCl\(_3\), E-isomer): \(\delta = 135.66, 132.99, 131.81, 131.75, 131.70, 129.73, 129.12, 128.44, 122.34.

\(^1\)F NMR (470 MHz, CDCl\(_3\)): \(\delta = -66.08\) (s, 0.92F, E-isomer), -56.30 (s, 0.08F, Z-isomer). Integrations indicate a Z/E ratio of 8:92.

IR (film): 1592, 1469, 1293, 1158, 962, 668 cm\(^{-1}\).

Ms (EI, 70 eV): \(m/z = 326\).

HRMS (EI, 70 eV) calcd for C\(_{15}\)H\(_{10}\)BrF\(_3\): 325.9918, found 325.9922.

\((E)-1\)-bromo-4-(3,3,3-trifluoro-2-phenylprop-1-en-1-yl)benzene (4e)

Colorless liquid; yield (Z+E): 71.2 mg (63%); Rf = 0.70 (PE).
1H NMR (500 MHz, CDCl₃, E-isomer): δ = 7.42-7.41 (m, 3H), 7.31-7.29 (m, 4H), 7.18 (s, 1H), 6.87 (d, J = 8 Hz, 2H).
13C NMR (125 MHz, CDCl₃, E-isomer): δ = 132.50, 132.36, 132.02 (J = 5 Hz), 131.57, 131.51, 129.77, 129.14, 129.06, 123.22.
19F NMR (470 MHz, CDCl₃): δ = -65.96 (s, 0.92F, E-isomer), -56.27 (s, 0.08F, Z-isomer). Integrations indicate a Z/E ratio of 8:92.
IR (film): 1588, 1464, 1379, 1267, 1128, 1073, 958, 819, 702 cm⁻¹.
Ms (EI, 70 eV): m/z = 326.
HRMS (EI, 70 eV) calcd for C₁₅H₁₀BrF₃: 325.9918, found 325.9916.

(E)-2-(3,3,3-trifluoro-2-phenylprop-1-en-1-yl)furan (4f)

\[
\begin{array}{c}
\text{O} \\
\text{CF₃}
\end{array}
\]

Colorless liquid; yield (Z+E): 71.4 mg (60%); R_f = 0.67 (PE).
1H NMR (500 MHz, CDCl₃, E-isomer): δ = 7.47-7.45 (m, 3H), 7.35-7.32 (m, 3H), 7.12 (d, J = 1.5 Hz, 1H), 6.24 (dd, J = 3.5 Hz, 2 Hz, 1H), 5.73 (d, J = 3.5 Hz, 1H).
13C NMR (125 MHz, CDCl₃, E-isomer): δ = 149.60, 143.63, 132.83, 129.57, 128.96, 128.38, 128.32, 121.87, 121.84 (J = 5 Hz), 113.23, 118.85.
19F NMR (470 MHz, CDCl₃): δ = -65.88 (s, 0.90F, E-isomer), -58.69 (s, 0.10F, Z-isomer). Integrations indicate a Z/E ratio of 10:90.
IR (film): 1650, 1468, 1369, 1296, 1167, 1122, 668 cm⁻¹.
Ms (EI, 70 eV): m/z = 238.
HRMS (EI, 70 eV) calcd for C₁₃H₉F₃O: 238.0605, found 238.0606.

(E)-4-(3,3,3-trifluoro-2-phenylprop-1-en-1-yl)benzonitrile (4g)

\[
\begin{array}{c}
\text{CF₃} \\
\text{NC}
\end{array}
\]

Colorless liquid; yield (Z+E): 41.0 mg (30%); R_f = 0.08 (PE).
1H NMR (500 MHz, CDCl₃, E-isomer): δ = 7.44-7.40 (m, 4H), 7.32 (d, J = 2 Hz, 1H), 7.26-7.23 (m, 3H), 7.09 (d, J = 7.5 Hz, 2H).
13C NMR (125 MHz, CDCl₃, E-isomer): δ = 138.17, 133.85, 133.69, 132.00, 131.68, 131.36 (J = 5 Hz), 130.41, 129.58, 129.41, 129.23, 128.75, 128.55, 128.50.
19F NMR (470 MHz, CDCl₃): δ = -66.33 (s, 1F, E-isomer).
IR (film): 1681, 1463, 1379, 1268, 1132, 701 cm⁻¹.
Ms (EI, 70 eV): m/z = 273.
HRMS (EI, 70 eV) calcd for C₁₆H₁₀F₃N: 273.0765, found 273.0761.

(E)-1-bromo-2-(3,3,3-trifluoro-1-phenylprop-1-en-2-yl)benzene (4h)

\[
\begin{array}{c}
\text{Br} \\
\text{CF₃}
\end{array}
\]

Colorless liquid; yield (Z+E): 79.1 mg (70%); R_f = 0.53 (PE).
\(^1\)H NMR (500 MHz, CDCl\(_3\), \(E\)-isomer): \(\delta = 7.67\) (d, \(J = 8\) Hz, 1H), 7.42-7.36 (m, 3H), 7.33 (s, 1H), 7.25 (d, \(J = 7\) Hz, 1H), 7.21-7.18 (m, 2H), 7.02 (d, \(J = 7.5\) Hz, 2H).

\(^13\)C NMR (125 MHz, CDCl\(_3\), \(E\)-isomer): \(\delta = 141.18, 135.14\) (\(J = 5\) Hz), 133.50, 131.85, 130.53, 129.62, 129.44, 128.53, 128.33, 127.91, 124.76.

\(^19\)F NMR (470 MHz, CDCl\(_3\)): \(\delta = -65.58\) (s, 0.85F, \(E\)-isomer), -57.02 (s, 0.15F, \(Z\)-isomer). Integrations indicate a \(Z/E\) ratio of 15:85.

IR (film): 1464, 1379, 1274, 1127, 736 cm\(^{-1}\).

Ms (EI, 70 eV): \(m/z = 326\).

HRMS (EI, 70 eV) calcd for C\(_{15}\)H\(_{10}\)BrF\(_3\): 325.9918, found 325.9913.

\((E)-1\)-bromo-3-(3,3,3-trifluoro-1-phenylprop-1-en-2-yl)benzene (4i)

\[
\begin{align*}
&\text{Colorless liquid; yield (Z+E): 91.5 mg (81\%); } R_f = 0.72 (\text{PE}). \\
&\text{\(^1\)H NMR (500 MHz, CDCl\(_3\), \(E\)-isomer): \(\delta = 7.55\) (d, \(J = 7.5\) Hz, 1H), 7.50 (s, 1H), 7.27-7.20 (m, 6H), 7.03 (d, \(J = 7.5\) Hz, 2H).} \\
&\text{\(^13\)C NMR (125 MHz, CDCl\(_3\), \(E\)-isomer): \(\delta = 134.80, 134.11\) (\(J = 5\) Hz), 133.04, 132.74, 132.05, 130.54, 130.10, 129.31, 128.80, 128.49, 122.92.} \\
&\text{\(^19\)F NMR (470 MHz, CDCl\(_3\)): \(\delta = -65.62\) (s, 0.92F, \(E\)-isomer), -56.31 (s, 0.08F, \(Z\)-isomer). Integrations indicate a \(Z/E\) ratio of 8:92.} \\
&\text{IR (film): 1466, 1379, 1274, 1128, 965, 779, 719 cm\(^{-1}\).} \\
&\text{Ms (EI, 70 eV): \(m/z = 326\).} \\
&\text{HRMS (EI, 70 eV) calcd for C\(_{15}\)H\(_{10}\)BrF\(_3\): 325.9918, found 325.9924.} \\
\end{align*}
\]

\((E)-1\)-bromo-4-(3,3,3-trifluoro-1-phenylprop-1-en-2-yl)benzene (4j)

\[
\begin{align*}
&\text{Colorless liquid; yield (Z+E): 114.1 mg (70\%); } R_f = 0.68 (\text{PE}). \\
&\text{\(^1\)H NMR (500 MHz, CDCl\(_3\), \(E\)-isomer): \(\delta = 7.54\) (d, \(J = 8\) Hz, 2H), 7.28 (s, 1H), 7.26-7.19 (m, 5H), 7.05 (d, \(J = 7.5\) Hz, 2H).} \\
&\text{\(^13\)C NMR (125 MHz, CDCl\(_3\), \(E\)-isomer): \(\delta = 133.86, 133.22, 132.30, 131.67, 130.53, 129.31, 128.48, 123.28.} \\
&\text{\(^19\)F NMR (470 MHz, CDCl\(_3\)): \(\delta = -65.70\) (s, 0.89F, \(E\)-isomer), -56.39 (s, 0.08F, \(Z\)-isomer). Integrations indicate a \(Z/E\) ratio of 11:89.} \\
&\text{IR (film): 1464, 1379, 1274, 1128, 965, 822, 731 cm\(^{-1}\).} \\
&\text{Ms (EI, 70 eV): \(m/z = 326\).} \\
&\text{HRMS (EI, 70 eV) calcd for C\(_{15}\)H\(_{10}\)BrF\(_3\): 325.9918, found 325.9919.} \\
\end{align*}
\]

\((E)-1\)-chloro-4-(3,3,3-trifluoro-1-phenylprop-1-en-2-yl)benzene (4k)

\[
\begin{align*}
&\text{Colorless liquid; yield (Z+E): 100.1 mg (71\%); } R_f = 0.72 (\text{PE}). \\
&\text{\(^1\)H NMR (500 MHz, CDCl\(_3\), \(E\)-isomer): \(\delta = 7.51\) (d, \(J = 8\) Hz, 2H), 7.28 (s, 1H), 7.26-7.19 (m, 5H), 7.05 (d, \(J = 7.5\) Hz, 2H).} \\
&\text{\(^13\)C NMR (125 MHz, CDCl\(_3\), \(E\)-isomer): \(\delta = 133.86, 133.22, 132.30, 131.67, 130.53, 129.31, 128.48, 123.28.} \\
&\text{\(^19\)F NMR (470 MHz, CDCl\(_3\)): \(\delta = -65.70\) (s, 0.89F, \(E\)-isomer), -56.39 (s, 0.11F, \(Z\)-isomer). Integrations indicate a \(Z/E\) ratio of 11:89.} \\
&\text{IR (film): 1464, 1379, 1274, 1127, 960, 822, 731 cm\(^{-1}\).} \\
&\text{Ms (EI, 70 eV): \(m/z = 326\).} \\
&\text{HRMS (EI, 70 eV) calcd for C\(_{15}\)H\(_{10}\)BrF\(_3\): 325.9918, found 325.9919.} \\
\end{align*}
\]
1H NMR (500 MHz, CDCl₃, E-isomer): \( \delta = 7.38 \) (d, \( J = 8.5 \) Hz, 2H), 7.28-7.25 (m, 4H), 7.21 (d, \( J = 7.5 \) Hz, 2H), 7.04 (d, \( J = 7.5 \) Hz, 2H).

13C NMR (125 MHz, CDCl₃, E-isomer): \( \delta = 135.05, 133.89 \) (\( J = 5 \) Hz), 133.25, 131.40, 131.20, 129.35, 129.17, 128.47.

19F NMR (470 MHz, CDCl₃): \( \delta = -65.72 \) (s, 0.92F, E-isomer), -56.38 (s, 0.08F, Z-isomer). Integrations indicate a Z/E ratio of 8:92.

IR (film): 1465, 1379, 1274, 1126, 960, 824, 692 cm\(^{-1}\).

Ms (EI, 70 eV): \( m/z = 282 \).

HRMS (EI, 70 eV) calcd for C₆H₁₀ClF₃: 282.0423, found 282.0420.

\((E)-1\)-methoxy-4-(3,3,3-trifluoro-1-phenylprop-1-en-2-yl)benzene (4l)

\[
\begin{align*}
\text{Colorless liquid; yield (Z+E): 79.2 mg (57%); } R_f &= 0.20 \text{ (PE).} \\
\text{1H NMR (500 MHz, CDCl₃, E-isomer): } \delta &= 7.38-7.33 \text{ (m, 2H), 7.21-7.17 (m, 4H), 7.04 (d, } J = 7.5 \text{ Hz, 2H), 6.91 (d, } J = 7.5 \text{ Hz, 2H), 3.83 (s, 3H).} \\
\text{13C NMR (125 MHz, CDCl₃, E-isomer): } \delta &= 159.94, 133.81, 132.99 \text{ (} J = 5 \text{ Hz), 132.94, 131.13, 130.04, 129.59, 128.78, 128.61, 128.55, 128.49, 128.29, 128.13, 114.45, 113.85, 55.25.} \\
\text{19F NMR (470 MHz, CDCl₃): } \delta &= -66.01 \text{ (s, 0.83F, E-isomer), -56.50 (s, 0.17F, Z-isomer). Integrations indicate a Z/E ratio of 17:83.} \\
\text{IR (film): 1611, 1463, 1379, 1272, 1173, 693 cm}\text{.} \\
\text{Ms (EI, 70 eV): } m/z &= 278.} \\
\text{HRMS (EI, 70 eV) calcd for C}_{16}\text{H}_{13}\text{F}_3\text{O: 278.0918, found 278.0914.}
\end{align*}
\]

\((E)-1\)-methyl-4-(3,3,3-trifluoro-1-phenylprop-1-en-2-yl)benzene (4m)

\[
\begin{align*}
\text{Colorless liquid; yield (Z+E): 110.0 mg (84%); } R_f &= 0.53 \text{ (PE).} \\
\text{1H NMR (500 MHz, CDCl₃, E-isomer): } \delta &= 7.25-7.19 \text{ (m, 8H), 7.07 (d, } J = 7.5 \text{ Hz, 2H), 2.42 (s, 3H).} \\
\text{13C NMR (125 MHz, CDCl₃, E-isomer): } \delta &= 138.71, 133.79, 132.98 \text{ (} J = 5 \text{ Hz), 132.94, 131.13, 130.04, 129.75, 128.84, 128.30, 21.37.} \\
\text{19F NMR (470 MHz, CDCl₃): } \delta &= -65.85 \text{ (s, 0.89F, E-isomer), -56.30 (s, 0.11F, Z-isomer). Integrations indicate a Z/E ratio of 11:89.} \\
\text{IR (film): 1651, 1463, 1379, 1273, 1126, 960, 814, 693 cm}\text{.} \\
\text{Ms (EI, 70 eV): } m/z &= 262.} \\
\text{HRMS (EI, 70 eV) calcd for C}_{16}\text{H}_{13}\text{F}_3: 262.0969, found 262.0972.}
\end{align*}
\]

\((Z)-2\)-(3,3,3-trifluoro-1-phenylprop-1-en-2-yl)thiophene (4n)

\[
\begin{align*}
\text{Colorless liquid; yield (Z+E): 94.0 mg (74%); } R_f &= 0.53 \text{ (PE).}
\end{align*}
\]
$^1$H NMR (500 MHz, CDCl$_3$, Z-isomer): $\delta = 7.41$ (d, $J = 5$ Hz, 1H), 7.34 (s, 1H), 7.30-7.24 (m, 3H), 7.17 (d, $J = 7.5$ Hz, 2H), 7.10-7.08 (m, 2H).

$^{13}$C NMR (125 MHz, CDCl$_3$, Z-isomer): $\delta = 135.58$ (J = 5 Hz), 133.49, 132.33, 129.98, 129.41, 129.34, 128.46, 127.94, 127.50.

$^{19}$F NMR (470 MHz, CDCl$_3$): $\delta = -66.54$ (s, 0.93F, Z-isomer), -57.62 (s, 0.07F, E-isomer). Integrations indicate a Z/E ratio of 93:7.

IR (film): 1466, 1379, 1274, 1133, 985, 700 cm$^{-1}$.

Ms (EI, 70 eV): $m/z = 254$.

HRMS (EI, 70 eV) calcd for C$_{13}$H$_{9}$F$_3$S: 254.0377, found 254.0382.

References:

Copies of $^1$H, $^{13}$C and $^{19}$F NMR Spectra

(E)-prop-1-ene-1,2-diyl dibenzene (3a)

$^1$H NMR (500 MHz, CDCl$_3$)

$^{13}$C NMR (125 MHz, CDCl$_3$)
(E)-1-chloro-4-(1-phenylprop-1-en-2-yl)benzene (3b)

$^1$H NMR (500 MHz, CDCl$_3$)

$^{13}$C NMR (125 MHz, CDCl$_3$)
(E)-2-(1-phenylprop-1-en-2-yl)thiophene (3c)

$^1$H NMR (500 MHz, CDCl$_3$)

$^{13}$C NMR (125 MHz, CDCl$_3$)
**(E)-1-chloro-4-(2-phenylprop-1-en-1-yl)benzene (3d)**

$^1$H NMR (500 MHz, CDCl$_3$)

$^{13}$C NMR (125 MHz, CDCl$_3$)

![NMR spectra and chemical structures](Image)

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(E)-but-1-ene-1,2-diyl dibenzene (3e)

$^1$H NMR (500 MHz, CDCl₃)

$^{13}$C NMR (125 MHz, CDCl₃)
(E)-pent-1-ene-1,2-diyl dibenzene (3f)

$^1$H NMR (500 MHz, CDCl$_3$)

$^{13}$C NMR (125 MHz, CDCl$_3$)
(E)-1-bromo-4-(2-phenylbut-1-en-1-yl)benzene (3g)

$^1$H NMR (500 MHz, CDCl$_3$)

$^{13}$C NMR (125 MHz, CDCl$_3$)
(E)-1-(2-phenylbut-1-en-1-yl)-4-(trifluoromethyl)benzene (3h)

$^1$H NMR (500 MHz, CDCl$_3$)

13C NMR (125 MHz, CDCl$_3$)
(E)-2-(2-phenylbut-1-en-1-yl)thiophene (3i)

$^1$H NMR (500 MHz, CDCl$_3$)

$^{13}$C NMR (125 MHz, CDCl$_3$)
(E)-1-(2-phenylbut-1-en-1-yl)naphthalene (3j)

$^1$H NMR (500 MHz, CDCl$_3$)

$^{13}$C NMR (125 MHz, CDCl$_3$)
**(E)-1-methyl-2-(2-phenylbut-1-en-1-yl)benzene (3k)**

$^1$H NMR (500 MHz, CDCl$_3$)

$^{13}$C NMR (125 MHz, CDCl$_3$)
(E)-(3,3,3-trifluoroprop-1-ene-1,2-diyl)dibenzene (4a)

$^1$H NMR (500 MHz, CDCl$_3$)

(E)-1-methyl-4-(3,3,3-trifluoro-2-phenylprop-1-en-1-yl)benzene (4b)

$^1$H NMR (500 MHz, CDCl$_3$)
(E)-1-bromo-2-(3,3,3-trifluoro-2-phenylprop-1-en-1-yl)benzene (4c)

$\text{H NMR (500 MHz, CDCl}_3\text{)}$

$\text{C NMR (125 MHz, CDCl}_3\text{)}$

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\[ ^{19}\text{F NMR (470 MHz, CDCl}_3 \text{)} \]

\[ (E)-1\text{-bromo-3-(3,3,3-trifluoro-2-phenylprop-1-en-1-yl)benzene (4d)} \]

\[ ^{1}\text{H NMR (500 MHz, CDCl}_3 \text{)} \]
$^{13}$C NMR (125 MHz, CDCl$_3$)

$^{19}$F NMR (470 MHz, CDCl$_3$)
(E)-1-bromo-4-(3,3,3-trifluoro-2-phenylprop-1-en-1-yl)benzene (4e)

$^1$H NMR (500 MHz, CDCl$_3$)

$^{13}$C NMR (125 MHz, CDCl$_3$)
$^{19}$F NMR (470 MHz, CDCl$_3$)

(E)-2-(3,3,3-trifluoro-2-phenylprop-1-en-1-yl)furan (4f)

$^1$H NMR (500 MHz, CDCl$_3$)
$^{13}$C NMR (125 MHz, CDCl$_3$)

$^{19}$F NMR (470 MHz, CDCl$_3$)
(E)-4-(3,3,3-trifluoro-2-phenylprop-1-en-1-yl)benzonitrile (4g)

$^1$H NMR (500 MHz, CDCl$_3$)

$^{13}$C NMR (125 MHz, CDCl$_3$)
$^{19}$F NMR (470 MHz, CDCl$_3$)

(E)-1-bromo-2-(3,3,3-trifluoro-1-phenylprop-1-en-2-yl)benzene (4h)

$^1$H NMR (500 MHz, CDCl$_3$)
$^{13}$C NMR (125 MHz, CDCl$_3$)

$^{19}$F NMR (470 MHz, CDCl$_3$)
\((E)-1\text{-bromo-3-(3,3,3-trifluoro-1-phenylprop-1-en-2-yl)}\text{benzene (4i)}\)

\(^1\text{H NMR (500 MHz, CDCl}_3\text{)}\): 

\[\begin{array}{c}
\text{major} \\
\text{minor}
\end{array}\]

\[^{13}\text{C NMR (125 MHz, CDCl}_3\text{)}\): 

\[\begin{array}{c}
\text{major} \\
\text{minor}
\end{array}\]
$^{19}$F NMR (470 MHz, CDCl$_3$)

$(E)$-1-bromo-4-(3,3,3-trifluoro-1-phenylprop-1-en-2-yl)benzene (4j)

$^1$H NMR (500 MHz, CDCl$_3$)

$(E)$-1-bromo-4-(3,3,3-trifluoro-1-phenylprop-1-en-2-yl)benzene (4j)
$^{13}$C NMR (125 MHz, CDCl$_3$)

$^{19}$F NMR (470 MHz, CDCl$_3$)
(E)-1-chloro-4-(3,3,3-trifluoro-1-phenylprop-1-en-2-yl)benzene (4k)

$^1$H NMR (500 MHz, CDCl$_3$)

$^{13}$C NMR (125 MHz, CDCl$_3$)
$^{19}$F NMR (470 MHz, CDCl$_3$)

$(E)$-1-methoxy-4-(3,3,3-trifluoro-1-phenylprop-1-en-2-yl)benzene (4l)

$^1$H NMR (500 MHz, CDCl$_3$)
$^{13}$C NMR (125 MHz, CDCl$_3$)

$^{19}$F NMR (470 MHz, CDCl$_3$)
(E)-1-methyl-4-(3,3,3-trifluoro-1-phenylprop-1-en-2-yl)benzene (4m)

$^1$H NMR (500 MHz, CDCl$_3$)

$^{13}$C NMR (125 MHz, CDCl$_3$)
$^{19}$F NMR (470 MHz, CDCl$_3$)

(Z)-2-(3,3,3-trifluoro-1-phenylprop-1-en-2-yl)thiophene (4n)

$^1$H NMR (500 MHz, CDCl$_3$)
**13C NMR (125 MHz, CDCl₃)**

![13C NMR spectrum](image1)

**19F NMR (470 MHz, CDCl₃)**

![19F NMR spectrum](image2)