Supplemental Information

Umpolung cross-coupling of polyfluoroarenes with hydrazones via activation of C–F bonds

Dawei Cao, Pan Pan, Huiying Zeng* and Chao-Jun Li*

aThe State Key Laboratory of Applied Organic Chemistry, Lanzhou University, 222 Tianshui Road, Lanzhou, 730000, P. R. China

bDepartment of Chemistry and FQRNT Centre for Green Chemistry and Catalysis, McGill University, 801 Sherbrooke St. West, Montreal, Quebec H3A 0B8, Canada

*Corresponding Authors: zenghy@lzu.edu.cn and cj.li@mcgill.ca

Table of Contents

I. General Methods .............................................................................................................S2

II. Optimization of Reaction Conditions ...........................................................................S2

III. Other Substrates .......................................................................................................S6

IV. Synthesis of the Hydrazone Substrates ...................................................................S6

V. General Procedure for the Coupling of Polyfluoroarenes with Hydrazones ..........S7

VI. References ..............................................................................................................S19

VII. Copies of $^1$H NMR, $^{19}$F NMR and $^{13}$C NMR ....................................................S20
I. General Methods

All reagents and solvents were purchased from commercial sources (Adamas-beta, TCI, Alfa and Ark) and used without further purification unless otherwise stated. All reactions were monitored by thin-layer chromatography (TLC). All reactions were carried out under argon atmosphere unless otherwise stated. Column chromatography was performed on silica gel (200-300 mesh) and visualized with ultraviolet light. Ethyl acetate and petroleum ether were used as eluents. $^1$H, $^{19}$F and $^{13}$C NMR spectra were taken on Bruker AV300, Bruker AV400, Varian Mercury plus 600 with TMS as an internal standard and CDCl$_3$ as solvent. Melting points were measured on micro melting point apparatus and uncorrected. GC-MS analyses were performed with a Thermo TRACE 1300 ISQ LT spectrometer. HRMS analyses were made at Lanzhou University by means of ESI.

II. Optimization of Reaction Conditions

1) Screening catalysts

<table>
<thead>
<tr>
<th>Entry</th>
<th>Catalyst</th>
<th>Yielda/%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Fe(acac)$_3$</td>
<td>n.p.</td>
</tr>
<tr>
<td>2</td>
<td>NiCl$_2$</td>
<td>n.p.</td>
</tr>
<tr>
<td>3</td>
<td>Cul</td>
<td>n.p.</td>
</tr>
<tr>
<td>4</td>
<td>RuCl$_3$</td>
<td>trace</td>
</tr>
<tr>
<td>5</td>
<td>RuCl(bpy)$_2$·6H$_2$O</td>
<td>n.p.</td>
</tr>
<tr>
<td>6</td>
<td>[Ru(p-cymene)Cl$_3$]</td>
<td>75%</td>
</tr>
</tbody>
</table>

General conditions: 1a (0.2 mmol), 2a (0.2 mmol), catalyst (5 mol%), dppp (10 mol%), KOH (1 equiv.) and THF (1 mL) at rt for 24 h under an argon atmosphere. aYields were determined by $^1$H NMR with nitromethane as internal standard.
2) Control experiments

![Chemical reaction diagram]

<table>
<thead>
<tr>
<th>Entry</th>
<th>Catalyst</th>
<th>Yield/%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>without cat.</td>
<td>n.p.</td>
</tr>
<tr>
<td>2</td>
<td>without ligand</td>
<td>n.p.</td>
</tr>
<tr>
<td>3</td>
<td>without base</td>
<td>n.p.</td>
</tr>
<tr>
<td>4</td>
<td>under air</td>
<td>n.p.</td>
</tr>
</tbody>
</table>

General conditions: 1a (0.2 mmol), 2a (0.2 mmol), [Ru(p-cymene)Cl\(_2\)]\(_2\) (5 mol%), dppp (10 mol%), KOH (1 equiv.) and THF (1 mL) at rt for 24 h under an argon atmosphere. \(^a\)Yields were determined by \(^1\)H NMR with nitromethane as internal standard.

3) Screening bases

![Chemical reaction diagram]

<table>
<thead>
<tr>
<th>Entry</th>
<th>base</th>
<th>Yield/%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>DABCO</td>
<td>n.p.</td>
</tr>
<tr>
<td>2</td>
<td>DBU</td>
<td>n.p.</td>
</tr>
<tr>
<td>3</td>
<td>NaOH</td>
<td>64.</td>
</tr>
<tr>
<td>4</td>
<td>KOH (flake)</td>
<td>75</td>
</tr>
<tr>
<td>5</td>
<td>KOH (powder)</td>
<td>68</td>
</tr>
</tbody>
</table>

General conditions: 1a (0.2 mmol), 2a (0.2 mmol), [Ru(p-cymene)Cl\(_2\)]\(_2\) (5 mol%), dppp (10 mol%), base (1 equiv.) and THF (1 mL) at rt for 24 h under an argon atmosphere. \(^a\)Yields were determined by \(^1\)H NMR with nitromethane as internal standard.

4) Screening the ratio of substrates
General conditions: 1a (x mmol), 2a (y mmol), [Ru(p-cymene)Cl\(_2\)]\(_2\) (5 mol%), dppp (10 mol%), KOH (1 equiv.) and THF (1 mL) at rt for 24 h under an argon atmosphere. *Yields were determined by \(^1\)H NMR with nitromethane as internal standard.

5) Screening the amount of catalyst

General conditions: 1a (0.2 mmol), 2a (0.3 mmol), [Ru(p-cymene)Cl\(_2\)]\(_2\) (x mol%), dppp (10 mol%), KOH (1 equiv.) and THF (1 mL) at rt for 24 h under an argon atmosphere. *Yields were determined by \(^1\)H NMR with nitromethane as internal standard.

6) Screening ligands and the amount of ligand
General conditions: 1a (0.2 mmol), 2a (0.3 mmol), [Ru(p-cymene)Cl\(_2\)]\(_2\) (5 mol%), ligand (x mol%), KOH (1 equiv.) and THF (1 mL) at rt for 24 h under an argon atmosphere. *Yields were determined by \(^1\)H NMR with nitromethane as internal standard.

7) Screening solvents

<table>
<thead>
<tr>
<th>Entry</th>
<th>Solvent</th>
<th>Yield a/%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Et(_2)O</td>
<td>76</td>
</tr>
<tr>
<td>2</td>
<td>toluene</td>
<td>n.p.</td>
</tr>
<tr>
<td>3</td>
<td>MeCN</td>
<td>n.p.</td>
</tr>
<tr>
<td>4</td>
<td>DMSO</td>
<td>n.p.</td>
</tr>
<tr>
<td>5</td>
<td>DMF</td>
<td>n.p.</td>
</tr>
</tbody>
</table>

General conditions: 1a (0.2 mmol), 2a (0.3 mmol), [Ru(p-cymene)Cl\(_2\)]\(_2\) (5 mol%), dppp (15 mol%), base (1 equiv.) and solvent (1 mL) at rt for 24 h under an argon atmosphere. *Yields were determined by \(^1\)H NMR with nitromethane as internal standard.

8) Screening the amount of THF

<table>
<thead>
<tr>
<th>Entry</th>
<th>THF</th>
<th>Yield a/%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.5 mL</td>
<td>87</td>
</tr>
<tr>
<td>2</td>
<td>1.5 mL</td>
<td>62</td>
</tr>
</tbody>
</table>

General conditions: 1a (0.2 mmol), 2a (0.3 mmol), [Ru(p-cymene)Cl\(_2\)]\(_2\) (5 mol%), dppp (15 mol%), KOH (1 equiv.) and THF (x mL) at rt for 24 h under an argon atmosphere. *Yields were determined by \(^1\)H NMR with nitromethane as internal standard.
### III. Other Substrates

![Chemical structure](image)

**General conditions:** 1 (0.2 mmol), 2 (0.3 mmol), [Ru(p-cymene)Cl$_2$]$_2$ (5 mol%), dpdp (15 mol%), KOH (1 equiv) and THF (0.5 mL) at 40 °C for 24 h under argon atmosphere. Products were determined by GC-MS (EI).

### IV. Synthesis of the Hydrazone Substrates

A round-bottom flask, equipped with dropping funnel, was charged with magnetic stirring bar and hydrazine hydrate (98% purity, 12 mmol, 1.2 equiv), and then the
solution of aldehyde (10 mmol) in methanol (25 mL) was added dropwise. The mixture was stirred at room temperature for 1 h. After the aldehyde was consumed completely, methanol and the extra hydrazine were removed under reduced pressure at room temperature (25 °C). Water (30 mL) was added and the mixture was extracted with dichloromethane (3×20 mL). The combined extracts were washed with brine and dried with anhydrous sodium sulfate. Solvent was removed by rotary evaporation at room temperature (25 °C) to provide the desired hydrazone (> 95%, as shown by 1H NMR), which was used directly without further purification.

**V. General Procedure for the Coupling of Polyfluoroarenes with Hydrazones**

A 20 mL microwave vial was charged with a magnetic stir-bar, [Ru(p-cymene)Cl₂]₂ (6.1 mg, 5 mol%), dppp (11.6 mg, 15 mol%), KOH (11.2 mg, 0.2 mmol), hydrazone 1 (0.2 mmol) and polyfluoroarenes 2 (0.6 mmol). The tube was then evacuated and backfilled with argon three times. THF (0.5 mL) was added by syringe and microsyringe. The tube was placed in a preheated oil bath at 40 °C and the mixture was stirred under an argon atmosphere for 24 h. The reaction mixture was cooled to room temperatures and concentrated, and then purified by preparative TLC on silica gel eluting with hexane: EtOAc (100:1-10:1) to afford the products.

The products were characterized by 1H NMR, 19F NMR, 13C NMR and HRMS (ESI). However, a large mass discrepancy was observed when testing such polyfluoro-substituted products using HRMS with ESI resource. Because most of those compounds were only composed of C, F and H, which were difficult to abstract the ion from the ESI resource. This reason made the error range greater than 5ppm. The same results of such compounds were seen in the literature, and the HRMS (ESI) of polyfluoroaryl compounds were not within the 5 ppm error range (please see SI in ref. 11). In contrast, the MS (EI resource) gave better results for those compounds. Therefore, all of those compounds were analyzed by MS (EI). Polyfluoroaryl compounds were also analyzed by MS (EI) in literature (please see SI in ref. 14a).
4-benzyl-2,2',3,3',4',5',5',6,6'-nonafluoro-1,1'-biphenyl
White solid, m.p. 65–66 °C. \(^1\)H NMR (CDCl\(_3\), 400 MHz) \(\delta\): 7.36–7.26 (m, 5H), 4.15 (s, 2H). \(^{19}\)F NMR (376 MHz, CDCl\(_3\)) \(\delta\): -136.98 to -137.94 (m, 2F), -138.72 to -139.47 (m, 2F), -142.38 (dd, \(J = 20.7, 10.9\) Hz, 2F), -150.62 (tt, \(J = 21.0, 2.7\) Hz, 1F), -160.65 to -160.84 (m, 2F). \(^{13}\)C NMR (CDCl\(_3\), 101 MHz) \(\delta\): 146.2–143.6 (m), 145.8–142.7 (m), 144.1 (ddt, \(J = 252.5, 15.2, 5.1\) Hz), 139.1–137.2 (m), 137.1, 141.0–136.6 (m), 128.9, 128.6, 127.1, 122.2 (t, \(J = 19.2\) Hz), 104.4–102.5 (m), 28.9. GC-MS (EI) m/z: 406(100), 386(34), 385(38), 367(17), 219(19), 203(17), 108(17), 91(41).

2,2',3,3',4,5,5',6,6'-nonafluoro-4'-(4-methylbenzyl)-1,1'-biphenyl
White solid, m.p. 55–56 °C. \(^1\)H NMR (CDCl\(_3\), 400 MHz) \(\delta\): 7.23 (d, \(J = 7.9\) Hz, 2H), 7.15 (d, \(J = 7.9\) Hz, 2H), 4.10 (s, 2H), 2.34 (s, 3H). \(^{19}\)F NMR (376 MHz, CDCl\(_3\)) \(\delta\): -137.35 to -137.66 (m, 2F), -139.07 (qd, \(J = 9.5, 4.5\) Hz, 2F), -142.63 (dd, \(J = 21.2, 11.5\) Hz, 2F), -150.89 (t, \(J = 20.8\) Hz, 1F), -161.00 (qd, \(J = 10.4, 4.6\) Hz, 2F). \(^{13}\)C NMR (CDCl\(_3\), 101 MHz) \(\delta\): 146.2–143.7 (m), 145.2–142.9 (m), 144.2 (ddt, \(J = 257.6, 16.2, 6.0\) Hz), 139.1–137.0 (m), 136.9, 141.2–136.6 (m), 134.1, 129.6, 128.5, 122.5 (t, \(J = 18.2\) Hz), 104.3–102.4 (m), 28.5, 20.9. GC-MS (EI) m/z: 420(46), 405(36), 385(24), 91(100), 77(18), 65(22).

2,2',3,3',4,5,5',6,6'-nonafluoro-4'-(3-methylbenzyl)-1,1'-biphenyl
White solid, m.p. 67–68 °C. \(^1\)H NMR (CDCl\(_3\), 400 MHz) \(\delta\): 7.28–7.20 (m, 1H), 7.19–7.07 (m, 3H),
4.11 (s, 2H), 2.37 (s, 3H). $^{19}$F NMR (376 MHz, CDCl$_3$) $\delta$: -137.49 (dddd, $J = 20.3$, 11.6, 5.8, 2.9 Hz, 2F), -138.64 to -139.51 (m, 2F), -150.68 to -151.13 (m, 1F), -160.76 to -161.31 (m, 2F). $^{13}$C NMR (CDCl$_3$, 101 MHz) $\delta$: 146.3–143.5 (m), 145.2–142.8 (m), 144.2 (ddt, $J = 252.5$, 16.1, 5.8 Hz), 139.2–136.7 (m), 138.7, 137.0, 141.5–136.2 (m), 129.4, 128.8, 127.9, 125.6, 122.3 (t, $J = 18.3$ Hz), 104.3–102.4 (m), 28.8, 21.3. GC-MS (EI) m/z: 420(44), 405(30), 385(24), 104(18), 91(100), 77(15), 65(20).

2,2',3,3',4,4',5,5',6,6'-nonafluoro-4'-(2-methylbenzyl)-1,1'-biphenyl
White solid, m.p. 140–141 °C. $^1$H NMR (CDCl$_3$, 400 MHz) $\delta$: 7.24–7.14 (m, 3H), 7.08 (d, $J = 6.6$ Hz, 1H), 4.14 (s, 2H), 2.45 (s, 3H). $^{19}$F NMR (376 MHz, CDCl$_3$) $\delta$: -137.20 to -137.64 (m, 2F), -138.92 (qdd, $J = 12.6$, 8.4, 4.0 Hz, 2F), -141.19 to -141.50 (m, 2F), -150.59 (tt, $J = 21.0$, 2.7 Hz, 1F), -160.45 to -161.03 (m, 2F). $^{13}$C NMR (CDCl$_3$, 101 MHz) $\delta$: 146.6–143.7 (m), 145.9–143.2 (m), 144.2 (ddt, $J = 252.5$, 16.0, 4.1 Hz), 139.2–136.6 (m), 141.2–136.2 (m), 136.2, 134.9, 130.5, 128.5, 127.1, 126.3, 121.5 (t, $J = 18.2$ Hz), 104.5–102.4 (m), 26.3, 19.6. GC-MS (EI) m/z: 420(55), 400(27), 385(20), 309(20), 105(32), 91(100), 77(32), 65(31).

4-((1,1'-biphenyl)-4-ylmethyl)-2,2',3,3',4,4',5,5',6,6'-nonafluoro-1,1'-biphenyl
White solid, m.p. 139–140 °C. $^1$H NMR (CDCl$_3$, 400 MHz) $\delta$: 7.59 (dd, $J = 8.6$, 2.2 Hz, 4H), 7.48–7.40 (m, 4H), 7.39–7.33 (m, 1H), 4.20 (s, 2H). $^{19}$F NMR (376 MHz, CDCl$_3$) $\delta$: -137.15 to -137.51 (m, 2F), -138.92 (qdd, $J = 12.6$, 8.4, 4.0 Hz, 2F), -142.32 (dd, $J = 20.9$, 11.2 Hz, 2F), -150.60 (tt, $J = 20.8$, 2.7 Hz, 1F), -160.29 to -161.37 (m, 2F). $^{13}$C NMR (CDCl$_3$, 101 MHz) $\delta$: 146.3–143.4 (m), 145.9–143.2 (m), 144.0 (ddt, $J = 252.5$, 15.2, 5.1 Hz), 140.6, 140.2, 139.2–136.5 (m), 141.2–136.4 (m), 136.0, 129.0, 128.8, 127.6, 127.4, 127.0, 122.1 (t, $J = 18.2$ Hz), 104.5–102.3 (m), 28.6. GC-MS (EI) m/z: 482(79), 167(60), 165(100), 152(89), 115(27), 77(18).
2,2',3,3',4,5,5',6,6'-nonafluoro-4'-(4-methoxybenzyl)-1,1'-biphenyl
White solid, m.p. 107–108 °C. \(^1\)H NMR (CDCl\(_3\), 400 MHz) \(\delta:\) 7.26 (d, \(J = 8.5\) Hz, 2H), 6.86 (d, \(J = 8.7\) Hz, 2H), 4.07 (s, 2H), 3.79 (s, 3H). \(^{19}\)F NMR (376 MHz, CDCl\(_3\)) \(\delta:\) -137.17 to -137.70 (m, 2F), -142.78 (dd, \(J = 20.9, 11.1\) Hz, 2F), -150.74 (tt, \(J = 21.0, 2.7\) Hz, 1F), -160.67 to -161.08 (m, 2F). \(^{13}\)C NMR (CDCl\(_3\), 101 MHz) \(\delta:\) 146.3–143.6 (m), 145.7–142.6 (m), 144.0 (ddt, \(J = 252.5, 16.1, 5.1\) Hz), 139.2–136.7 (m), 141.1–136.4 (m), 129.7, 129.1, 122.6 (t, \(J = 19.2\) Hz), 114.2, 104.2–102.3 (m), 55.2, 28.1. GC-MS (EI) m/z: 436(56), 218(14), 206(14), 121(100), 77(69).

2,2',3,3',4,5,5',6,6'-nonafluoro-4'-(3-methoxybenzyl)-1,1'-biphenyl
White solid, m.p. 121–122 °C. \(^1\)H NMR (CDCl\(_3\), 400 MHz) \(\delta:\) 7.28–7.22 (m, 1H), 7.15 (d, \(J = 7.3\) Hz, 1H), 6.90 (dd, \(J = 15.9, 8.0\) Hz, 2H), 4.13 (s, 2H), 3.85 (s, 3H). \(^{19}\)F NMR (376 MHz, CDCl\(_3\)) \(\delta:\) -137.30 to -137.62 (m, 2F), -139.59 to -140.09 (m, 2F), -141.34 to -141.88 (m, 2F), -150.93 (tt, \(J = 20.9, 2.6\) Hz, 1F), -160.71 to -161.25 (m, 2F). \(^{13}\)C NMR (CDCl\(_3\), 101 MHz) \(\delta:\) 157.2, 146.7–144.1 (m), 145.8–143.3 (m), 143.9 (ddt, \(J = 251.5, 15.2, 5.1\) Hz), 139.2–136.6 (m), 141.0–136.3 (m), 129.8, 128.4, 125.1, 121.8 (t, \(J = 18.2\) Hz), 120.5, 110.3, 104.1–102.5 (m), 55.3, 23.8. GC-MS (EI) m/z: 436(100), 420(27), 401(14), 385(20), 218(18), 121(30), 91(41), 77(65).

2,2',3,3',4,5,5',6,6'-nonafluoro-4'-(4-fluorobenzyl)-1,1'-biphenyl
White solid, m.p. 52–53 °C. \(^1\)H NMR (CDCl\(_3\), 400 MHz) \(\delta:\) 7.36 (d, \(J = 5.3\) Hz, 2H), 7.06 (td, \(J =
2,2',3,3',4,5,5',6,6'-nonafluoro-4'-(3-fluorobenzyl)-1,1'-biphenyl
White solid, m.p. 81–82 °C. \(^1\)H NMR (CDCl\(_3\), 400 MHz) \(\delta\): 7.36–7.30 (m, 1H), 7.13 (d, \(J = 7.6\) Hz, 1H), 7.05 (d, \(J = 9.6\) Hz, 1H), 6.99 (td, \(J = 8.4, 2.3\) Hz, 1H), 4.16 (s, 2H). \(^19\)F NMR (376 MHz, CDCl\(_3\)) \(\delta\): -112.50 (td, \(J = 9.0, 6.0\) Hz, 1F), -137.09 to -137.86 (m, 2F), -137.96 to -139.09 (m, 2F), -142.34 (dd, \(J = 20.1, 10.5\) Hz, 2F), -150.51 (ddd, \(J = 20.1, 10.5, 10.5\) Hz, 2F), -160.21 to -161.63 (m, 2F). \(^{13}\)C NMR (CDCl\(_3\), 101 MHz) \(\delta\): 162.9 (d, \(J = 248.2\) Hz), 146.2–143.5 (m), 145.8–143.2 (m), 144.0 (ddt, \(J = 235.3, 15.2, 5.0\) Hz), 139.3 (d, \(J = 7.1\) Hz), 139.3–136.7 (m), 141.2–136.4 (m), 130.4 (d, \(J = 8.1\) Hz), 124.2, 121.4 (t, \(J = 18.2\) Hz), 115.6 (d, \(J = 22.2\) Hz), 114.1 (d, \(J = 25.3\) Hz), 104.8–102.2 (m), 28.6. GC-MS (EI) m/z: 424(100), 403(34), 329(22), 237(27), 167(26), 126(40), 109(92), 83(34).

2,2',3,3',4,5,5',6,6'-nonafluoro-4'-(2-fluorobenzyl)-1,1'-biphenyl
White solid, m.p. 90–91 °C. \(^1\)H NMR (CDCl\(_3\), 400 MHz) \(\delta\): 7.28–7.26 (m, 2H), 7.15–7.04 (m, 2H), 4.19 (s, 2H). \(^19\)F NMR (376 MHz, CDCl\(_3\)) \(\delta\): -116.52 to -117.86 (m, 1F), -136.21 to -138.09 (m, 2F), -138.19 to -139.86 (m, 2F), -141.77 (dd, \(J = 19.8, 9.6\) Hz, 2F), -150.13 to -151.13 (m, 1F), -160.21 to -161.63 (m, 2F). \(^{13}\)C NMR (CDCl\(_3\), 101 MHz) \(\delta\): 160.7 (d, \(J = 247.1\) Hz), 146.5–143.8 (m), 145.7–143.2 (m), 144.1 (ddt, \(J = 253.5, 15.2, 5.0\) Hz), 139.2–136.6 (m), 141.2–136.5 (m), 130.5 (d, \(J = 4.0\) Hz), 129.0 (d, \(J = 8.1\) Hz), 124.3 (d, \(J = 3.0\) Hz), 123.8 (d, \(J = 8.1\) Hz), 120.6 (t, \(J = 18.2\) Hz), 115.6 (d, \(J = 22.2\) Hz), 104.8–102.3 (m), 22.2. GC-MS (EI) m/z: 424(100), 403(30), 385(17), 329(20) 237(24), 145(19), 126(34), 109(85), 83(31).
4-(4-chlorobenzyl)-2,2',3,3',4',5,5',6,6'-nonafluoro-1,1'-biphenyl
White solid, m.p. 98–99 °C. ¹H NMR (CDCl₃, 400 MHz) δ: 7.31–7.25 (m, 4H), 4.10 (s, 2H). ¹³F NMR (376 MHz, CDCl₃) δ: -137.15 to -137.59 (m, 2F), -138.34 to -138.79 (m, 2F), -142.47 (dd, J = 20.7, 11.1 Hz, 2F), -150.49 (tt, J = 20.9, 2.8 Hz, 1F), -160.43 to -160.96 (m, 2F). ¹³C NMR (CDCl₃, 101 MHz) δ: 146.2–143.6 (m), 145.7–143.1 (m), 144.1 (ddt, J = 252.5, 16.1, 5.1 Hz), 139.2–136.6 (m), 141.2–136.5 (m), 135.5, 133.1, 129.9, 129.0, 121.6 (t, J = 18.2 Hz), 114.2, 104.7–102.2 (m), 28.3. GC-MS (EI) m/z: 442 (17), 440 (49), 405(100), 385(68), 203(36), 125(26), 89(29).

4-(3-chlorobenzyl)-2,2',3,3',4',5,5',6,6'-nonafluoro-1,1'-biphenyl
White solid, m.p. 90–91 °C. ¹H NMR (CDCl₃, 400 MHz) δ: 7.31–7.20 (m, 4H), 4.11 (s, 2H). ¹³F NMR (376 MHz, CDCl₃) δ: -137.09 to -137.61 (m, 2F), -138.06 to -138.52 (m, 2F), -142.26 (dd, J = 21.5, 12.4 Hz, 2F), -150.50 (tt, J = 20.9 Hz, 1F), -160.73 (td, J = 20.2, 5.7 Hz, 2F). ¹³C NMR (CDCl₃, 101 MHz) δ: 146.2–143.4 (m), 145.8–143.2 (m), 144.0 (ddt, J = 251.5, 15.2, 5.1 Hz), 138.8, 139.3–136.7 (m), 141.0–136.4 (m), 134.6, 130.1, 128.7, 127.4, 126.8, 121.2 (t, J = 18.2 Hz), 104.8–102.2 (m), 28.5. GC-MS (EI) m/z: 442 (18), 440 (56), 405(100), 385(73), 203(19), 192(28), 89(29).

4-(2-bromobenzyl)-2,2',3,3',4',5,5',6,6'-nonafluoro-1,1'-biphenyl
White solid, m.p. 124–125 °C. ¹H NMR (CDCl₃, 400 MHz) δ: 7.61 (dd, J = 7.9, 0.8 Hz, 1H),
7.30–7.22 (m, 1H), 7.14 (td, J = 7.8, 1.3 Hz, 1H), 7.08 (d, J = 7.7 Hz, 1H), 4.28 (s, 2H). $^{19}$F NMR (376 MHz, CDCl$_3$) δ: -136.99 to -137.64 (m, 2F), -138.51 to -139.19 (m, 2F), -140.41 to -140.84 (m, 2F), 150.03 to -150.91 (m, 1F), -160.69 (ddt, J = 21.0, 10.5, 5.2 Hz, 2F). $^{13}$C NMR (CDCl$_3$, 101 MHz) δ: 146.6–143.7 (m), 145.9–143.2 (m), 144.1 (ddt, J = 251.5, 15.2, 5.1 Hz), 139.3–136.6 (m), 141.2–136.1 (m), 136.1, 133.1, 129.7, 128.7, 12.4, 120.4 (t, J = 18.2 Hz), 105.0–102.2 (m), 29.5. GC-MS (EI) m/z: 486(29), 484(28), 405(97), 385(100), 237(35), 193(62), 167(34), 90(31), 89(42), 63(26).

4-(3,4-dichlorobenzyl)-2,2',3,3',4',5,5',6,6'-nonafluoro-1,1'-biphenyl

White solid, m.p. 122–123 °C. $^1$H NMR (CDCl$_3$, 400 MHz) δ: 7.41 (dd, J = 5.1, 3.1 Hz, 2H), 7.17 (dd, J = 8.2, 1.8 Hz, 1H), 4.10 (s, 2H). $^{19}$F NMR (376 MHz, CDCl$_3$) δ: -137.09 to -137.64 (m, 2F), -138.12 (qdd, J = 12.2, 8.4, 3.7 Hz, 2F), -142.24 (dd, J = 20.8, 11.2 Hz, 2F), -150.30 (tt, J = 20.9, 2.8 Hz, 1F). $^{13}$C NMR (CDCl$_3$, 101 MHz) δ: 146.6–143.5 (m), 145.8–143.2 (m), 144.0 (ddt, J = 253.5, 16.2, 4.1 Hz), 137.0, 139.3–136.6 (m), 141.3–136.4 (m), 132.9, 131.4, 130.8, 130.5, 128.0, 120.8 (t, J = 18.2 Hz), 105.1–102.1 (m), 28.1. GC-MS (EI) m/z: 476(22), 474(58), 438(100), 403(54), 237(44), 202(59), 177(43), 167(53), 158(26), 123(58).

methyl 4-((perfluoro-[1,1'-biphenyl]-4-yl)methyl)benzoate

White solid, m.p. 87–88 °C. $^1$H NMR (CDCl$_3$, 400 MHz) δ: 8.01 (d, J = 8.1 Hz, 2H), 7.39 (d, J = 8.1 Hz, 2H), 4.20 (s, 2H), 3.92 (s, 3H). $^{19}$F NMR (376 MHz, CDCl$_3$) δ: -138.09 to -138.74 (m, 2F), -142.14 (dd, J = 20.8, 11.2 Hz, 2F), -150.35 (tt, J = 21.1, 2.8 Hz, 1F), -160.21 to -161.08 (m, 2F). $^{13}$C NMR (CDCl$_3$, 101 MHz) δ: 166.6, 146.5–143.5 (m), 145.8–143.2 (m), 144.0 (ddt, J = 253.5, 16.2, 4.1 Hz), 142.1, 139.3–136.6 (m), 141.2–136.4 (m), 130.2, 129.1, 128.6, 121.2 (t, J = 18.2 Hz), 104.9–102.2 (m), 52.1, 28.9. GC-MS (EI) m/z: 464(39), 432(100), 384(40), 216(55), 192(29), 63(13).
4-(3,4-dimethoxybenzyl)-2,2',3,3',4,5,5',6,6'-nonafluoro-1,1'-biphenyl
White solid, m.p. 78–79 °C. \(^1\)H NMR (CDCl\(_3\), 400 MHz) \(\delta\): 6.90 (s, 2H), 6.85 (d, \(J = 8.7\) Hz, 1H), 4.10 (s, 2H), 3.93 (s, 3H), 3.89 (s, 3H). \(^{19}\)F NMR (376 MHz, CDCl\(_3\)) \(\delta\): -137.09 to -137.76 (m, 2F), -138.82 (tdd, \(J = 12.7, 8.4, 4.0\) Hz, 2F), -142.76 (dd, \(J = 20.9, 11.1\) Hz, 2F), -150.63 (tt, \(J = 21.0, 2.7\) Hz, 1F), -160.43 to -161.31 (m, 2F). \(^{13}\)C NMR (CDCl\(_3\), 101 MHz) \(\delta\): 149.0, 148.0, 146.2–143.4 (m), 145.7–143.1 (m), 144.0 (ddt, \(J = 252.5, 15.2, 5.1\) Hz), 139.2–136.5 (m), 141.0–136.3 (m), 129.45, 121.4 (t, \(J = 18.2\) Hz), 120.6, 111.7, 111.2, 104.2–102.3 (m), 55.8 (2C), 28.5. GC-MS (EI) m/z: 466(46), 329(100), 233(14), 151(11), 77(27), 51(17).

2,2',3,3',4,5,5',6,6'-nonafluoro-4'-(3,4,5-trimethoxybenzyl)-1,1'-biphenyl
White solid, m.p. 82–83 °C. \(^1\)H NMR (CDCl\(_3\), 400 MHz) \(\delta\): 6.57 (s, 2H), 4.07 (s, 2H), 3.88 (s, 6H), 3.84 (s, 3H). \(^{19}\)F NMR (376 MHz, CDCl\(_3\)) \(\delta\): -136.99 to -137.96 (m, 2F), -138.62 (tdd, \(J = 12.6, 8.4, 3.9\) Hz, 2F), -142.54 (dd, \(J = 21.0, 11.1\) Hz, 2F), -150.46 (tt, \(J = 20.9, 2.8\) Hz, 1F), -160.31 to -161.21 (m, 2F). \(^{13}\)C NMR (CDCl\(_3\), 101 MHz) \(\delta\): 153.4, 146.2–143.4 (m), 145.6–143.1 (m), 144.0 (ddt, \(J = 252.5, 16.2, 5.1\) Hz), 137.1, 139.2–136.5 (m), 141.1–136.4 (m), 132.6, 122.1 (t, \(J = 18.2\) Hz), 105.6, 104.4–102.1 (m), 60.7, 56.0 (2C), 29.1. GC-MS (EI) m/z: 496(43), 309(67), 208(45), 207(100), 128(29), 77(86), 55(66).

5-((perfluoro-[1,1'-biphenyl]-4-yl)methyl)benzo[d][1,3]dioxole
White solid, m.p. 92–93 °C. \(^1\)H NMR (CDCl\(_3\), 400 MHz) \(\delta\): 6.82–6.76 (m, 3H), 5.96 (s, 2H), 4.06
(s, 2H). $^{19}$F NMR (376 MHz, CDCl$_3$) $\delta$: -136.99 to -137.76 (m, 2F), -138.78 (tt, $J = 12.5, 8.3, 4.0$ Hz, 2F), -142.65 (dd, $J = 20.8, 11.0$ Hz, 2F), -150.63 (tt, $J = 20.9, 2.7$ Hz, 1F), -160.43 to -161.41 (m, 2F). $^{13}$C NMR (CDCl$_3$, 101 MHz) $\delta$: 147.9, 146.6, 146.1–143.4 (m), 145.7–143.1 (m), 144.0 (ddt, $J = 252.5, 15.2, 5.1$ Hz), 139.2–136.5 (m), 130.7, 122.2 (t, $J = 18.2$ Hz), 121.7, 109.0, 108.5, 104.4–102.1 (m), 101.1, 28.6. GC-MS (EI) m/z: 450(100), 449(26), 391(28), 372(22), 225(36), 135(73), 77(50), 51(28).

$N,N$-dimethyl-4-((perfluoro-[1,1'-biphenyl]-4-yl)methyl)aniline
White solid, m.p. 141–142 °C. $^1$H NMR (CDCl$_3$, 600 MHz) $\delta$: 7.21 (d, $J = 8.5$ Hz, 2H), 6.69 (d, $J = 8.7$ Hz, 2H), 4.04 (s, 2H), 2.93 (s, 6H). $^{19}$F NMR (376 MHz, CDCl$_3$) $\delta$: -137.07 to -137.58 (m, 2F), -138.83 to -139.51 (m, 2F), -138.52 (td, $J = 14.8, 6.0$ Hz, 1F), -142.52 (dd, $J = 20.9, 11.2$ Hz, 2F), -149.89 to -150.52 (m, 1F), -152.68 (td, $J = 11.8, 4.6$ Hz, 1F), -160.28 to -160.76 (m, 2F). $^{13}$C NMR (CDCl$_3$, 151 MHz) $\delta$: 156.0, 146.0–143.4 (m), 145.0–142.8 (m), 144.1 (ddt, $J = 257.6, 16.2, 6.0$ Hz), 138.8–136.9 (m), 129.3, 124.8, 123.2 (t, $J = 18.2$ Hz), 112.8, 103.9–102.6 (m), 40.5, 28.0. GC-MS (EI) m/z: 449(100), 448(62), 385(12), 225(23), 134(73), 118(49), 91(14).

4-((perfluoro-[1,1'-biphenyl]-4-yl)methyl)phenol
Colorless liquid. $^1$H NMR (CDCl$_3$, 600 MHz) $\delta$: 7.33 (d, $J = 8.5$ Hz, 2H), 7.02 (d, $J = 8.6$ Hz, 2H), 4.14 (s, 2H). $^{19}$F NMR (376 MHz, CDCl$_3$) $\delta$: -137.16 to -137.46 (m, 2F), -137.80 to -138.06 (m, 1F), -138.52 (td, $J = 14.8, 6.0$ Hz, 1F), -142.52 (dd, $J = 20.9, 11.2$ Hz, 1F), -149.89 to -150.52 (m, 1F), -152.68 (td, $J = 11.8, 4.6$ Hz, 1F), -160.28 to -160.76 (m, 2F). $^{13}$C NMR (CDCl$_3$, 151 MHz) $\delta$: 156.0, 146.0–143.4 (m), 145.0–142.8 (m), 144.1 (ddt, $J = 257.6, 16.2, 6.0$ Hz), 138.9–137.1 (m), 141.2–137.1 (m), 133.0, 130.1, 121.9 (t, $J = 18.2$ Hz), 116.3, 104.6–102.3 (m), 28.2. GC-MS (EI) m/z: 422(32), 91(100), 77(8), 65(38).
2-((perfluoro-[1,1'-biphenyl]-4-yl)methyl)furan
White solid, m.p. 85–86 °C. $^1$H NMR (CDCl$_3$, 600 MHz) $\delta$: 7.33 (d, $J = 1.6$ Hz, 1H), 6.31 (dd, $J = 4.7$, 2.9 Hz, 1H), 6.17 (d, $J = 4.7$ Hz, 1H), 4.16 (s, 2H). $^{19}$F NMR (376 MHz, CDCl$_3$) $\delta$: -137.25 – -137.42 (m, 2F), -138.76 (dt, $J = 10.7$, 7.4 Hz, 2F), -142.49 (dd, $J = 21.2$, 11.8 Hz, 2F), -150.48 (t, $J = 20.9$ Hz, 1F), -160.68 (tt, $J = 10.4$, 5.3 Hz, 2F). $^{13}$C NMR (CDCl$_3$, 151 MHz) $\delta$: 149.7, 146.0 – 144.2 (m), 145.5–143.7 (m), 145.0–143.1 (m), 142.1, 138.8–137.0 (m), 119.2 (t, $J = 18.2$ Hz), 110.6, 107.0, 104.9–102.4 (m), 21.9. GC-MS (EI) m/z: 396(100), 349(65), 329(33) 299(29), 198 (21), 81(69).

2-benzyl-1,3,4,5,6,7,8-heptafluoronaphthalene
White solid, m.p. 115–116 °C. $^1$H NMR (CDCl$_3$, 400 MHz) $\delta$: 7.32–7.18 (m, 5H), 4.18 (s, 2H). $^{19}$F NMR (376 MHz, CDCl$_3$) $\delta$: -122.05 (dd, $J = 67.6$, 18.7 Hz, 1F), -137.50 (d, $J = 17.6$ Hz, 1F), -144.54 (dt, $J = 67.6$, 16.8 Hz, 1F), -145.94 to -147.04 (m, 1F), -148.14 to -150.13 (m, 1F), -154.33 (t, $J = 18.6$ Hz, 1F), -156.00 (ddd, $J = 13.4$, 6.6, 3.3 Hz, 1F). $^{13}$C NMR (CDCl$_3$, 101 MHz) $\delta$: 151.4–147.7 (m), 148.9–145.3 (m), 142.5–139.6 (m), 141.9–139.1 (m), 140.7–137.9 (m), 137.4, 128.8, 128.5, 127.0, 118.8–118.3 (m), 111.4–107.8 (m), 28.7. GC-MS (EI) m/z: 344(100), 324(37), 323(46), 305(27), 267(14), 137(27), 91(25).

1-benzyl-2,3,5,6-tetrafluoro-4-(trifluoromethyl)benzene
White solid, m.p. 60–61 °C. $^1$H NMR (CDCl$_3$, 400 MHz) $\delta$: 7.43 - 7.28 (m, 5H), 4.17 (s, 2H). $^{19}$F
NMR (376 MHz, CDCl$_3$) $\delta$: -56.32 (t, $J = 21.5$ Hz, 3F), -140.34 to -141.17 (m, 2F), -141.30 to -141.59 (m, 2F). $^{13}$C NMR (CDCl$_3$, 101 MHz) $\delta$: 146.4–143.7 (m), 145.6–145.5 (m), 136.5, 129.0, 128.5, 127.3, 124.4 (t, $J = 18.2$ Hz), 125.0–116.8 (m), 108.5–107.5 (m), 28.8. GC-MS (EI) m/z: 308(100), 289(29), 287(24), 237(24), 91(44).

1-benzyl-2,3,4,5,6-pentafluorobenzene
White solid, m.p. 56–57 $^\circ$C. $^1$H NMR (CDCl$_3$, 400 MHz) $\delta$: 7.48–7.19 (m, 5H), 4.08 (s, 2H). $^{19}$F NMR (376 MHz, CDCl$_3$) $\delta$: -143.34 (dd, $J = 22.4$, 8.3 Hz, 2F), -157.17 (t, $J = 20.8$ Hz, 1F), -162.42 (dt, $J = 22.3$, 8.4 Hz, 2F). $^{13}$C NMR (CDCl$_3$, 101 MHz) $\delta$: 146.3–143.6 (m), 141.3–138.6 (m), 138.9–136.1 (m), 137.4, 128.8, 128.3, 127.0, 114.4 (td, $J = 19.2$, 4.0 Hz), 28.1. HRMS (ESI) calcd. for C$_{11}$H$_{18}$N ([M+H]$^+$): 164.1434, found: 164.1431. MS (EI) m/z: 181, 138, 124, 110, 98, 68. GC-MS (EI) m/z: 258(100), 237(51), 219(27), 181(27), 181(11), 91(23).

1,2,3,4,5,6,8-heptafluoro-7-(4-methylbenzyl)naphthalene
White solid, m.p. 132–133 $^\circ$C. $^1$H NMR (CDCl$_3$, 600 MHz) $\delta$: 7.19 (d, $J = 7.7$ Hz, 2H), 7.10 (d, $J = 7.8$ Hz, 2H), 4.15 (s, 2H), 2.30 (s, 3H). $^{19}$F NMR (564 MHz, CDCl$_3$) $\delta$: -122.19 (dd, $J = 67.1$, 19.1 Hz, 1F), -137.54 (d, $J = 16.9$ Hz, 1F), -144.60 (dt, $J = 67.5$, 16.8 Hz, 1F), -146.30 to -146.66 (m, 1F), -149.08 (dt, $J = 57.1$, 18.3 Hz, 1F), -154.46 (t, $J = 18.5$ Hz, 1F), -156.10 (t, $J = 16.9$ Hz, 1F). $^{13}$C NMR (CDCl$_3$, 151 MHz) $\delta$: 151.0–147.4 (m), 149.1–145.7 (m), 142.1–140.2 (m), 141.5–138.8 (m), 139.7–136.6 (m), 136.7, 134.4, 129.5, 128.4, 119.0–118.0 (m), 110.5–107.9 (m), 28.4, 21.0. GC-MS (EI) m/z: 358(100), 343(67), 323(71), 105(30), 91(58), 77(24), 65(19).
1,2,4,5-tetrafluoro-3-(4-methylbenzyl)-6-(trifluoromethyl)benzene
Colorless liquid. $^1$H NMR (CDCl$_3$, 600 MHz) $\delta$: 7.20 (d, $J = 7.9$ Hz, 2H), 7.15 (d, $J = 7.9$ Hz, 2H), 4.09 (s, 2H), 2.35 (s, 3H). $^{19}$F NMR (564 MHz, CDCl$_3$) $\delta$: -56.35 (t, $J = 21.6$ Hz, 3F), -140.97 to -141.24 (m, 2F), -141.48 to -141.72 (m, 2F). $^{13}$C NMR (CDCl$_3$, 151 MHz) $\delta$: 145.9–144.1 (m), 145.0–143.2 (m), 137.0, 133.5, 129.6, 128.4, 124.8 (t, $J = 18.2$ Hz), 127.2–120.8 (m), 108.1–107.5 (m), 28.5, 20.9. GC-MS (EI) m/z: 322(62), 307(52), 287(16), 238(19), 91(100), 77(15), 65 (16).

1,2,3,4,5-pentafluoro-6-(4-methylbenzyl)benzene
White solid, m.p. 30–32 °C. $^1$H NMR (CDCl$_3$, 600 MHz) $\delta$: 7.18 (d, $J = 8.0$ Hz, 2H), 7.15 (d, $J = 8.6$ Hz, 2H), 4.02 (s, 2H), 2.36 (s, 3H). $^{19}$F NMR (564 MHz, CDCl$_3$) $\delta$: -143.47 (dd, $J = 22.3$, 8.1 Hz, 2F), -157.42 (t, $J = 20.8$ Hz, 1F), -162.43 to -162.64 (m, 2F). $^{13}$C NMR (CDCl$_3$, 151 MHz) $\delta$: 145.9–144.2 (m), 140.8–138.9 (m), 138.6–136.8 (m), 136.8, 134.5, 129.5, 128.2, 114.8 (td, $J = 19.2$, 4.0 Hz), 27.7, 20.9. GC-MS (EI) m/z: 272(100), 257(92), 237(51), 135(17), 91(76), 77(18).

2-(4-chlorobenzyl)-1,3,4,5,6,7,8-heptafluoronaphthalene
White solid, m.p. 110–112 °C. $^1$H NMR (CDCl$_3$, 600 MHz) $\delta$: 7.28–7.20 (m, 4H), 4.16 (s, 2H). $^{19}$F NMR (564 MHz, CDCl$_3$) $\delta$: -122.10 (dd, $J = 67.5$, 18.6 Hz, 1F), -137.84 (d, $J = 17.1$ Hz, 1F), -144.46 (dt, $J = 67.6$, 16.8 Hz, 1F), -146.09 to -146.41 (m, 1F), -148.56 to -148.90 (m, 1F), -154.03 (t, $J = 18.6$ Hz, 1F), -155.68 to -155.89 (m, 1F). $^{13}$C NMR (CDCl$_3$, 151 MHz) $\delta$: 151.0–147.1 (m), 149.3–145.5 (m), 142.1–139.7 (m), 141.6–139.5 (m), 138.7–137.2 (m), 135.8, 133.0, 129.9, 129.0,
118.2–117.9 (m), 110.6–107.9 (m), 28.1. GC-MS (EI) m/z: 380(25), 378(87), 343(93), 323(100), 162(54), 146(66), 125(30), 89(36), 75(11).

1-(4-chlorobenzyl)-2,3,5,6-tetrafluoro-4-(trifluoromethyl)benzene
Colorless liquid. $^1$H NMR (CDCl$_3$, 600 MHz) $\delta$: 7.28 (d, $J = 8.2$ Hz, 2H), 7.21 (d, $J = 8.1$ Hz, 2H), 4.07 (s, 2H). $^{19}$F NMR (564 MHz, CDCl$_3$) $\delta$: -56.38 (t, $J = 21.6$ Hz, 3F), -140.50 to -140.82 (m, 2F), -141.25 to -141.69 (m, 2F). $^{13}$C NMR (CDCl$_3$, 151 MHz) $\delta$: 145.9–144.2 (m), 145.1–143.3 (m), 134.9, 133.4, 129.8, 129.1, 123.8 (t, $J = 18.2$ Hz), 125.2–120.0 (m), 108.9–108.0 (m), 28.3. GC-MS (EI) m/z: 344(15), 342(51), 307(100), 287(31), 238(41), 125(19), 89(20), 75(12).

3-benzyl-1,2,4,5-tetrafluorobenzene Colorless liquid. $^1$H NMR (CDCl$_3$, 400 MHz) $\delta$: 7.41 – 7.11 (m, 5H), 6.93 (tt, $J = 9.7$, 7.4 Hz, 1H), 4.06 (s, 2H). $^{19}$F NMR (376 MHz, CDCl$_3$) $\delta$: -137.70 to -143.78 (m, 2F), -137.70 to -143.78 (m, 2F). $^{13}$C NMR (CDCl$_3$, 101 MHz) $\delta$: 145.8 (dm, $J = 248.5$ Hz), 144.7 (dm, $J = 245.4$ Hz), 137.6, 128.7, 128.4, 126.8, 120.3 (t, $J = 18.2$ Hz), 104.1 (t, $J = 22.2$ Hz), 28.7. GC-MS (EI) m/z: 240, 220, 219, 201, 189, 163, 143, 109, 91, 85, 51.

VI. References

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

$^1$H, $^{19}$F and $^{13}$C NMR spectra of 4-benzyl-2,2',3,3',4',5,5',6,6'-nonafluoro-1,1'-biphenyl
$^1$H, $^{19}$F and $^{13}$C NMR spectra of 2,2',3,3',4,5,5',6,6'-nonafluoro-4'- (4-methylbenzyl)-1,1'-biphenyl
$^1$H, $^{19}$F and $^{13}$C NMR spectra of 2,2',3,3',4,5,5',6,6'-nonafluoro-4'-(3-methylbenzyl)-1,1'-biphenyl
$^1$H, $^{19}$F and $^{13}$C NMR spectra of 2,2',3,3',4,5,5',6,6'-nonafluoro-4'-(2-methylbenzyl)-1,1'-biphenyl
$^1$H, $^{19}$F and $^{13}$C NMR spectra of 4-((1,1'-biphenyl)-4-ylmethyl)-2,2',3,3',4',5,5',6,6'-nonafluoro-1,1'-biphenyl
$^1$H, $^{19}$F and $^{13}$C NMR spectra of 2,2',3,3',4,5,5',6,6'-nonafluoro-4'-(4-methoxybenzyl)-1,1'-biphenyl
$^1$H, $^{19}$F and $^{13}$C NMR spectra of 2,2',3,3',4,5,5',6,6'-nonafluoro-4'-(3-methoxybenzyl)-1,1'-biphenyl
$^1$H, $^{19}$F and $^{13}$C NMR spectra of 2,2',3,3',4,5,5',6,6'-nonafluoro-4'-(4-fluorobenzyl)-1,1'-biphenyl
$^{1}$H, $^{19}$F and $^{13}$C NMR spectra of 2,2',3,3',4,4',5,5',6,6'-nonafluoro-4'-(3-fluorobenzyl)-1,1'-biphenyl
$^1$H, $^{19}$F and $^{13}$C NMR spectra of \textit{2,2',3,3',4,5,5',6,6'-nonafluoro-4'-(2-fluorobenzyl)-1,1'-biphenyl}
$^1$H, $^{19}$F and $^{13}$C NMR spectra of 4-(4-chlorobenzyl)-2,2',3,3',4',5,5',6,6'-nonafluoro-1,1'-biphenyl
$^1$H, $^{19}$F and $^{13}$C NMR spectra of 4-(3-chlorobenzyl)-2,2',3,3',4',5,5',6,6'-nonafluoro-1,1'-biphenyl
$^{1}H$, $^{19}F$ and $^{13}C$ NMR spectra of 4-(2-bromobenzyl)-2,2',3,3',4',5,5',6,6'-nonafluoro-1,1'-biphenyl
$^1$H, $^{19}$F and $^{13}$C NMR spectra of 4-(3,4-dichlorobenzyl)-2,2',3,3',4',5,5',6,6'-nonafluoro -1,1'-biphenyl
$^1$H, $^{19}$F and $^{13}$C NMR spectra of methyl 4-((perfluoro-[1,1'-biphenyl]-4-yl)methyl)benzoate
$^1$H, $^{19}$F and $^{13}$C NMR spectra of 4-(3,4-dimethoxybenzyl)-2,2',3,3',4',5,5',6,6'-nonafluoro-1,1'-biphenyl
$^1$H, $^{19}$F and $^{13}$C NMR spectra of 2,2',3,3',4,5,5',6,6'-nonafluoro-4'- (3,4,5-trimethoxybenzyl) - 1,1'-biphenyl
$^1$H, $^{19}$F and $^{13}$C NMR spectra of 5-((perfluoro-[1,1'-biphenyl]-4-yl)methyl)benzo[d][1,3]dioxole
$^1$H, $^{19}$F and $^{13}$C NMR spectra of $N,N$-dimethyl-4-((perfluoro-[1,1'-biphenyl]-4-yl)methyl) aniline
$^1$H, $^{19}$F and $^{13}$C NMR spectra of 4-((perfluoro-[1,1'-biphenyl]-4-yl)methyl)phenol
$^1$H, $^{19}$F and $^{13}$C NMR spectra of 2-((perfluoro-[1,1'-biphenyl]-4-yl)methyl)furan
$^1$H, $^{19}$F and $^{13}$C NMR spectra of 2-benzyl-1,3,4,5,6,7,8-heptafluoronaphthalene
$^1$H, $^{19}$F and $^{13}$C NMR spectra of 1-benzyl-2,3,5,6-tetrafluoro-4-(trifluoromethyl)benzene
$^1$H, $^{19}$F and $^{13}$C NMR spectra of 1-benzyl-2,3,4,5,6-pentafluorobenzene
\(^1\text{H}, \, ^{19}\text{F} \text{ and } ^{13}\text{C} \text{ NMR spectra of 1,2,3,4,5,6,8-heptafluoro-7-(4-methylbenzyl)naphthalene} \)
$^1$H, $^{19}$F and $^{13}$C NMR spectra of $1,2,4,5$-tetrafluoro-$3$-(4-methylbenzyl)-6-(trifluoromethyl) benzene
$^1\text{H}$, $^{19}\text{F}$ and $^{13}\text{C}$ NMR spectra of 1,2,3,4,5-pentafluoro-6-(4-methylbenzyl)benzene
$^1$H, $^{19}$F and $^{13}$C NMR spectra of 2-(4-chlorobenzyl)-1,3,4,5,6,7,8-heptafluoronaphthalene
$^1$H, $^{19}$F and $^{13}$C NMR spectra of 1-(4-chlorobenzyl)-2,3,5,6-tetrafluoro-4-(trifluoromethyl) benzene
$^1$H, $^{19}$F and $^{13}$C NMR spectra of 3-benzyl-1,2,4,5-tetrafluorobenzene