Electronic Supplementary Information (ESI)

Highly enantioselective construction of carbazole derivatives via [4+2] cycloaddition of silyloxyvinylindoles and β,γ-unsaturated α-ketoesters

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1. General remarks

$^1$H NMR spectra were recorded on commercial instruments (400 MHz). Chemical shifts are recorded in ppm relative to tetramethylsilane and with the solvent resonance as the internal standard. Data are reported as follows: chemical shift, multiplicity ($s$ = singlet, $d$ = doublet, $t$ = triplet, $m$ = multiplet), coupling constants (Hz), integration. $^{13}$C NMR data were collected on commercial instruments (100 MHz) with complete proton decoupling. Chemical shifts are reported in ppm from the tetramethylsilane with the solvent resonance as internal standard. Enantiomer excesses were determined by chiral HPLC analysis on Daicel Chiralcel IA, ID and AD-H in comparison with the authentic racemates. Optical rotations were reported as follows: $[\alpha]_D^T$ (c: g/100 mL, in solvent). HRMS was recorded on a commercial apparatus (ESI Source). All the solvents were purified by usual methods before use. Silica gel for Thin-layer chromatography (HG/T2354-92) made in Qingdao Haiyang Chemical Co., Ltd.

The compounds 1a-c were synthesized by the procedure in the literature.$^1$ and the compounds 2 were synthesized by the procedure in the literature.$^2$

5-methoxy-1-((4-methoxyphenyl)sulfonyl)-3-((1-(triisopropylsilyl)oxy)vinyl)-1H-indole (1b)

(C$_{27}$H$_{37}$NO$_5$SSi) White solid, $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 7.82 (d, $J = 9.2$ Hz, 1H), 7.70 (d, $J = 8.8$ Hz, 2H), 7.63 (s, 1H), 7.14 (d, $J = 2.4$ Hz, 1H), 6.86 (dd, $J = 9.2$, 2.4 Hz, 1H), 6.80 – 6.73 (m, 2H), 4.68 (d, $J = 1.2$ Hz, 1H), 4.47 (d, $J = 1.6$ Hz, 1H), 3.75 (s, 3H), 3.70 (s, 3H), 1.25 – 1.16 (m, 3H), 1.04 (d, $J = 7.2$ Hz, 18H). $^{13}$C NMR (101 MHz, CDCl$_3$) $\delta$ 163.75, 156.53, 150.97, 130.23, 129.49, 129.05, 128.97, 125.62, 121.65, 114.59, 114.40, 113.44, 103.90, 92.48, 55.64, 18.09, 12.77.

HRMS (ESI-TOF) calcld for C$_{27}$H$_{37}$NO$_5$SSi ([M+Na$^+$]) = 538.2054, Found 538.2055.

5-bromo-1-((4-methoxyphenyl)sulfonyl)-3-((1-(triisopropylsilyl)oxy)vinyl)-1H-indole (1c)

(C$_{26}$H$_{34}$BrNO$_4$SSi) White solid, $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 7.92 (s, 1H), 7.88 (d, $J = 8.8$ Hz, 1H), 7.78 (d, $J = 8.5$ Hz, 2H), 7.74 (s, 1H), 7.41 (d, $J = 8.8$ Hz, 1H), 6.88 (d, $J = 8.0$ Hz, 2H), 4.76 (s, 1H), 4.56 (s, 1H), 3.80 (s, 3H), 1.34 – 1.23 (m, 3H), 1.12 (d, $J = 7.2$ Hz, 18H). $^{13}$C NMR (101 MHz, CDCl$_3$) $\delta$ 164.01, 150.32, 134.20, 129.60, 129.18, 129.13, 127.52, 125.85, 123.96, 120.98, 117.19, 115.14, 114.57, 92.82, 55.69, 18.07, 12.75.

HRMS (ESI-TOF) calcld for C$_{26}$H$_{34}$BrNO$_4$SSi ([M+Na$^+$]) = 586.1053, Found 588.1054. HRMS (ESI-TOF) calcld for C$_{26}$H$_{34}$BrNO$_4$SSi ([M+Na$^+$]) = 586.1036, Found 588.1036.
2. General procedure for \(N,N'-\)dioxide preparation

The \(N,N'-\)dioxide ligands \(L\) were synthesized by the same procedure in the literature.\(^3\)

\[
\begin{align*}
&L-\text{PrPr}_2: \text{Ar} = 2,6-i\text{Pr}_2C_6H_3, n = 1 \\
&L-\text{PiPr}_2: \text{Ar} = 2,6-i\text{Pr}_2C_6H_3, n = 2 \\
&L-\text{PiEt}_2: \text{Ar} = 2,6-Et_2C_6H_3, n = 2 \\
&L-\text{PiPr}_3: \text{Ar} = 2,4,6-i\text{Pr}_3C_6H_2, n = 2 \\
&L-\text{RaPr}_2: \text{Ar} = 2,6-i\text{Pr}_2C_6H_3
\end{align*}
\]

3. Typical procedure for the asymmetric reaction 1b to 2a

\[
\begin{align*}
&\text{Y(OTf)}_3 (0.01 \text{ mmol}, 10 \text{ mol\%}), \text{ }N,N'-\text{dioxide ligand } L-\text{PrPr}_3 (0.01 \text{ mmol}, 10 \text{ mol\%}), \text{ and } \beta,\gamma-\text{unsaturated } \alpha-\text{ketoester } 2a (0.10 \text{ mmol}) \text{ were stirred in } \text{Cl}_2\text{CHCHCl}_2 (1.0 \text{ mL}) \text{ at } 35 \text{ }^\circ\text{C for 0.5 h under nitrogen atmosphere}. \text{ Subsequently, } 5\text{-methoxy-1-((4-methoxyphenyl)sulfonyl)-3-1-((triisopropylsilyl)oxy)vinyl-1H-indole } 1b (0.12 \text{ mmol}) \text{ was added at } -40 \text{ }^\circ\text{C}. \text{ The reaction was stirred at } -40 \text{ }^\circ\text{C for 96 h, and then directly purified by flash chromatography on silica gel (eluent: petroleum ether/ethyl acetate } = 5/1) \text{ to afford the desired product } 3ba (98\% \text{ yield, } 92\% \text{ ee and } >19:1 \text{ d.r.}).
\end{align*}
\]

4. Optimization of the reaction conditions.

4.1 Screening of the metal salts\(^{[a]}\)

\[
\begin{align*}
&\text{TIPS}O \rightleftharpoons \text{MeO} + \text{Ph-}O\text{C-O} \text{Me} \xrightarrow{L-\text{PrPr}_3/Y(OTf)_3 (10 mol\%)} \text{TIPS}O \text{MeO} \text{ArO}_2\text{S} \text{H-CO}_2\text{Me} \text{Ph} \text{Ar}\text{SO}_2\text{Ar} & 1b \text{a} & 2a \text{a} & 3ba \text{a} & 4\text{.1 Screening of the metal salts[a]}
\end{align*}
\]
<table>
<thead>
<tr>
<th>Entry[a]</th>
<th>Ligand</th>
<th>Metal salt</th>
<th>Yield [%][b]</th>
<th>d.r.[c]</th>
<th>ee of 3aa[%][c]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>L-PrPr₂</td>
<td>Fe(acac)₃</td>
<td>trace</td>
<td>&gt;95:5</td>
<td>19 (−)</td>
</tr>
<tr>
<td>2</td>
<td>L-PrPr₂</td>
<td>Co(BF₄)₂·6H₂O</td>
<td>11</td>
<td>&gt;95:5</td>
<td>37 (−)</td>
</tr>
<tr>
<td>3</td>
<td>L-PrPr₂</td>
<td>Ni(OTf)₂</td>
<td>6</td>
<td>&gt;95:5</td>
<td>30 (−)</td>
</tr>
<tr>
<td>4</td>
<td>L-PrPr₂</td>
<td>Cu(OTf)₂</td>
<td>trace</td>
<td>&gt;95:5</td>
<td>19 (−)</td>
</tr>
<tr>
<td>5</td>
<td>L-PrPr₂</td>
<td>Zn(OTf)₂</td>
<td>trace</td>
<td>&gt;95:5</td>
<td>42 (−)</td>
</tr>
<tr>
<td>6</td>
<td>L-PrPr₂</td>
<td>Mg(OTf)₂</td>
<td>trace</td>
<td>&gt;95:5</td>
<td>7(−)</td>
</tr>
<tr>
<td>7</td>
<td>L-PrPr₂</td>
<td>Y(OTf)₃</td>
<td>95</td>
<td>&gt;95:5</td>
<td>65</td>
</tr>
<tr>
<td>8</td>
<td>L-PrPr₂</td>
<td>La(OTf)₃</td>
<td>89</td>
<td>&gt;95:5</td>
<td>12 (−)</td>
</tr>
<tr>
<td>9</td>
<td>L-PrPr₂</td>
<td>Yb(OTf)₃</td>
<td>95</td>
<td>&gt;95:5</td>
<td>56</td>
</tr>
<tr>
<td>10</td>
<td>L-PrPr₂</td>
<td>Er(OTf)₃</td>
<td>90</td>
<td>&gt;95:5</td>
<td>60</td>
</tr>
</tbody>
</table>

[a] Reaction conditions: metal salt/L-PrPr₂ (1:1, 10 mol%), 1a (0.12 mmol), 2a (0.10 mmol) in CH₂Cl₂ (1.0 mL) at 0 °C for 4 h, and the products were purified by silica gel column chromatography. [b] Isolated yield. [c] Determined by chiral HPLC analysis.

4.2 Screening of the Ligands[a]

4.3 Screening of the solvents[a]
4.4 Screening of the electronic nature of substrate 1

<table>
<thead>
<tr>
<th>Entry[a]</th>
<th>solvent</th>
<th>Yield [%][b]</th>
<th>ee of 3 [%][c]</th>
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<tbody>
<tr>
<td>1</td>
<td>CH₂Cl₂</td>
<td>93</td>
<td>85</td>
</tr>
<tr>
<td>2</td>
<td>CIC₅H₄Cl</td>
<td>81</td>
<td>82</td>
</tr>
<tr>
<td>3</td>
<td>CHCl₃</td>
<td>43</td>
<td>85</td>
</tr>
<tr>
<td>4</td>
<td>CIC₅H₄Cl₂</td>
<td>61</td>
<td>84</td>
</tr>
<tr>
<td>5</td>
<td>CH₃CCl₃</td>
<td>Trace</td>
<td>---</td>
</tr>
<tr>
<td>6</td>
<td>Cl₂C₅H₄Cl₂</td>
<td>80</td>
<td>87</td>
</tr>
<tr>
<td>7</td>
<td>Toluene</td>
<td>&lt;5</td>
<td>12</td>
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<tr>
<td>8</td>
<td>THF</td>
<td>6</td>
<td>55</td>
</tr>
<tr>
<td>9</td>
<td>EtOAc</td>
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<td>18</td>
</tr>
<tr>
<td>10</td>
<td>CH₃CN</td>
<td>10</td>
<td>0</td>
</tr>
</tbody>
</table>

[a] Reaction conditions: Y(OTf)₃/L-PiPr₃ (1:1, 10 mol%), 1 (0.12 mmol), 2a (0.10 mmol) in solvent (1.0 mL) at 0 °C for 4 h, and the products were purified by silica gel column chromatography. [b] Isolated yield. [c] Determined by chiral HPLC analysis.

4.4 Screening of the reaction temperature

<table>
<thead>
<tr>
<th>Entry[a]</th>
<th>R</th>
<th>Pg</th>
<th>Yield [%][b]</th>
<th>ee of 3 [%][c]</th>
</tr>
</thead>
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<tr>
<td>1</td>
<td>H</td>
<td>4-MeOC₆H₄SO₂</td>
<td>80</td>
<td>87</td>
</tr>
<tr>
<td>2</td>
<td>H</td>
<td>3,4-(MeO)₂C₆H₄SO₂</td>
<td>94</td>
<td>77</td>
</tr>
<tr>
<td>3</td>
<td>5-MeO</td>
<td>4-MeOC₆H₄SO₂</td>
<td>96</td>
<td>87</td>
</tr>
</tbody>
</table>

[a] Reaction conditions: Y(OTf)₃/L-PiPr₃ (1:1, 10 mol%), 1 (0.12 mmol), 2a (0.10 mmol) in Cl₂C₅H₄Cl₂ (1.0 mL) at 0 °C for 4 h, and the products were purified by silica gel column chromatography. [b] Isolated yield. [c] Determined by chiral HPLC analysis.
<table>
<thead>
<tr>
<th>Entry[^a]</th>
<th>T °C</th>
<th>t (h)</th>
<th>Yield [%][^b]</th>
<th>ee of 3ba [%][^c]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>4</td>
<td>96</td>
<td>87</td>
</tr>
<tr>
<td>2</td>
<td>−30</td>
<td>17</td>
<td>85</td>
<td>90</td>
</tr>
<tr>
<td>3</td>
<td>−40</td>
<td>17</td>
<td>63</td>
<td>92</td>
</tr>
<tr>
<td>4</td>
<td>−40</td>
<td>96</td>
<td>98</td>
<td>92</td>
</tr>
</tbody>
</table>

[^a] Reaction conditions: Y(OTf),/L-PrPi (1:1, 10 mol%), 1b (0.12 mmol), 2a (0.10 mmol) in Cl$_2$CHCHCl$_2$ (1.0 mL) at T °C, and the products were purified by silica gel column chromatography. [^b] Isolated yield. [^c] Determined by chiral HPLC analysis.

5. The transformation of the product 3au

Lithium aluminum hydride (30.0 mg, 6 equiv) was added to 3au (85.5 mg, 0.13 mmol) in THF (3.5 mL) at 0 °C. Then, the mixture was stirred for 2.5 h at room temperature. Subsequently, the reaction was quenched with saturated NH$_4$Cl(aq). The aqueous layer was extracted with CH$_2$Cl$_2$ three times. The organic phases were dried over Na$_2$SO$_4$ and the solvents evaporated. The residue was purified by flash chromatography (SiO$_2$, eluent: petroleum ether/ethyl acetate = 2/1) to afford the desired product 4au as a white foam (46% yield, 98% ee, >19:1 d.r.).

1-((1R,2S,9aS)-9-((4-methoxyphenyl)sulfonyl)-2-propyl-4-((triisopropylsilyl)oxy)-2,3,9,9a-tetrahydro-1H-carbazol-1-yl)ethane-1,2-diol (4au)

4au: (C$_{33}$H$_{49}$NO$_6$Si) white foam, 46% yield, 98% ee, 9:1 d.r. by $^1$H NMR, HPLC DAICEL CHIRALCEL AD-H, n-hexane/2-propanol = 90/10, flow rate = 1.0 mL/min, $\lambda$ = 254 nm, retention time: 7.63 min, 11.25 min, 19.72 min.
$^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 7.68 (d, $J = 7.6$ Hz, 1H), 7.45 (d, $J = 7.2$ Hz, 1H), 7.36 – 7.28 (m, 2H), 7.20 – 7.07 (m, 2H), 6.70 (d, $J = 8.8$ Hz, 2H), 4.26 (d, $J = 10$ Hz, 1H), 4.22 (d, $J = 10.4$ Hz, 1H), 3.98 (t, $J = 8.8$ Hz, 1H), 3.81 – 3.72 (m, 4H), 3.68 (d, $J = 10.0$ Hz, 1H), 2.29 (dd, $J = 15.2$, 7.6 Hz, 2H), 2.08 (d, $J = 15.6$ Hz, 1H), 1.07 – 1.88 (m, 1H), 1.34 – 1.21 (m, 4H), 1.19 – 1.11 (m, 4H), 0.98 (t, $J = 7.6$ Hz, 18H), 0.85 (t, $J = 6.8$ Hz, 3H). $^{13}$C NMR (101 MHz, CDCl$_3$) $\delta$ 163.49, 145.92, 141.79, 130.83, 129.67, 126.34, 126.26, 126.18, 123.02, 120.04, 114.07, 113.87, 74.88, 66.06, 64.01, 55.41, 50.06, 39.01, 35.08, 34.99, 20.44, 17.67, 17.56, 14.02, 13.18. HRMS (ESI-TOF) calcd for C$_{33}$H$_{49}$NO$_6$SSi ([M+Na$^+$]) = 638.2942, Found 638.2946.

The compound 4au (35.7 mg, 0.058 mmol) was stirred in acetone/H$_2$O (3 mL, 1:1, v:v), then NaIO$_4$ (50 mg, 4 equiv) was added slowly to the mixture at room temperature, and the mixture was stirred for 3 h at room temperature, After the aqueous layer was extracted with CH$_2$Cl$_2$ and solvent evaporation, the residue was purified by flash chromatography (SiO$_2$, eluent: petroleum ether/ethyl acetate = 5/1) to afford the desired product 5au as a white foam (86 yield, 98% ee, >19:1 d.r.) (1R,2S,9aS)-9-((4-methoxyphenyl)sulfonyl)-2-propyl-4-((triisopropylsilyl)oxy)-2,3,9,9a-tetrahydro-1H-carbazole-1-carbaldehyde (5au)

5au: (C$_{32}$H$_{45}$NO$_5$SSi) white foam, 86% yield, 98% ee, >19:1 d.r. by HNMR, $[\alpha]_D^{27.2} = +274.8$ (c = 0.44, CH$_2$Cl$_2$). HPLC DAICEL CHIRALCEL AD-H, n-hexane/2-propanol = 90/10, flow rate = 1.0 mL/min,
\[ \lambda = 254 \text{ nm}, \text{retention time: } 7.46 \text{ min}, 8.26 \text{ min}, 9.51 \text{ min}. \]

\(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 9.95 (d, \(J = 2.4 \text{ Hz}, 1\text{H}\)), 7.63 (d, \(J = 8.4 \text{ Hz}, 3\text{H}\)), 7.55 (d, \(J = 7.2 \text{ Hz}, 1\text{H}\)), 7.11 (t, \(J = 7.6 \text{ Hz}, 1\text{H}\)), 7.00 (t, \(J = 7.2 \text{ Hz}, 1\text{H}\)), 6.85 (d, \(J = 8.8 \text{ Hz}, 2\text{H}\)), 4.79 (d, \(J = 8.0 \text{ Hz}, 1\text{H}\)), 3.79 (s, 3\text{H}), 2.77 (t, \(J = 5.2 \text{ Hz}, 1\text{H}\)), 2.41 (dd, \(J = 16.0, 6.0 \text{ Hz}, 1\text{H}\)), 2.24 – 1.99 (m, 2\text{H}), 1.47 – 1.34 (m, 2\text{H}), 1.33 – 1.25 (m, 2\text{H}), 1.24 – 1.14 (m, 3\text{H}), 1.07 (d, \(J = 7.2 \text{ Hz}, 18\text{H}\)), 0.89 (t, \(J = 6.0 \text{ Hz}, 3\text{H}\)). \(^{13}\)C NMR (101 MHz, CDCl\(_3\)) \(\delta\) 201.95, 163.48, 144.34, 141.94, 130.06, 128.74, 127.74, 126.96, 124.25, 123.42, 115.93, 114.09, 111.25, 62.69, 57.56, 55.51, 55.49, 36.95, 34.99, 32.95, 19.96, 17.89, 13.90, 13.51. HRMS (ESI-TOF) calcd for C\(_{32}\)H\(_{45}\)NO\(_5\)SSi ([M+Na\(^+\)]\(^{-}\)) = 606.2680, Found 606.2683.

6. The analytical and spectral characterization data of the reaction products 3

Methyl 2-(((1R,2S,9aS)-6-methoxy-9-((4-methoxyphenyl)sulfonyl)-2-phenyl-4-(triisopropylsilyloxy)-2,3,9,9a-tetrahydro-1H-carbazol-1-yl)-2-oxoacetate (3ba)

(C\(_3\)H\(_4\)NTIPSO\(_2\)O\(_2\)) white foam, 98% yield, 92% ee, [\(\alpha\)]\(_D\)\(^{16.9\,+}\) = +108.9 (c = 1.09, CH\(_2\)Cl\(_2\)). HPLC DAICEL CHIRALCEL IA, \(n\)-hexane/2-propanol = 70/30, flow rate = 1.0 mL/min, \(\lambda = 254 \text{ nm}, \)retention time: 5.23 min, 8.85 min.

\(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 7.63 (d, \(J = 8.8 \text{ Hz}, 1\text{H}\)), 7.53 (d, \(J = 8.8 \text{ Hz}, 2\text{H}\)), 7.30 – 7.02 (m, 7\text{H}), 6.82 (d, \(J = 8.8 \text{ Hz}, 2\text{H}\)), 6.63 (dd, \(J = 8.8, 2.0 \text{ Hz}, 1\text{H}\)), 4.79 (d, \(J = 9.2 \text{ Hz}, 1\text{H}\)), 4.26 (t, \(J = 9.6 \text{ Hz}, 1\text{H}\)), 3.73 (s, 3\text{H}), 3.69 (s, 3\text{H}), 3.61 (s, 3\text{H}), 3.36 – 3.17 (m, 1\text{H}), 2.69 – 2.44 (m, 2\text{H}), 1.11 – 1.03 (m, 3\text{H}), 0.97 (dd, \(J = 7.2, 4.4 \text{ Hz}, 18\text{H}\)). \(^{13}\)C NMR (101 MHz, CDCl\(_3\)) \(\delta\) 193.18, 163.59, 160.14, 156.61, 144.63, 140.39, 135.64, 130.29, 129.69, 128.82, 128.41, 127.50, 126.56, 126.58, 114.33, 113.38, 112.23, 108.76, 65.77, 55.53, 55.49, 52.90, 51.47, 44.32, 38.58, 17.90, 13.65. HRMS (ESI-TOF) calcd for C\(_{32}\)H\(_{45}\)NO\(_5\)SSi ([M+Na\(^+\)]\(^{-}\)) = 728.2684, Found 728.2689.
Ethyl 2-((1R,2S,9aS)-6-methoxy-9-((4-methoxyphenyl)sulfonyl)-2-phenyl-4-((triisopropylsilyl)oxy)-2,3,9,9a-tetrahydro-1H-carbazol-1-yl)-2-oxoacetate (3bb)

(C$_{39}$H$_{49}$NO$_8$SSi) white foam, 98% yield, 93% ee, $[\alpha]_D^{14.6} = +110.8$ (c = 1.16, CH$_2$Cl$_2$). HPLC DAICEL CHIRALCEL IA, n-hexane/2-propanol = 70/30, flow rate = 1.0 mL/min, λ = 254 nm, retention time: 4.53 min, 7.53 min.

$^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 7.71 (d, $J = 8.8$ Hz, 1H), 7.61 (d, $J = 9.2$ Hz, 2H), 7.29 – 7.24 (m, 2H), 7.23 – 7.12 (m, 4H), 6.89 (d, $J = 8.8$ Hz, 2H), 6.71 (dd, $J = 8.8, 2.8$ Hz, 1H), 4.88 (d, $J = 8.8$ Hz, 1H), 4.34 (t, $J = 9.2$ Hz, 1H), 4.25 – 4.05 (m, 2H), 3.80 (s, 3H), 3.76 (s, 3H), 3.37 (dd, $J = 17.2, 9.6$ Hz, 1H), 2.70 – 2.56 (m, 2H), 1.22 – 1.12 (m, 6H), 1.04 (dd, $J = 7.2, 3.6$ Hz, 18H). $^{13}$C NMR (101 MHz, CDCl$_3$) $\delta$ 193.54, 163.56, 159.55, 156.58, 144.60, 140.44, 135.70, 130.30, 129.69, 128.81, 128.49, 127.45, 126.65, 116.10, 114.12, 113.37, 111.26, 108.76, 65.75, 62.24, 55.53, 55.50, 51.39, 44.34, 38.54, 17.90, 13.91, 13.66. HRMS (ESI-TOF) calcd for C$_{39}$H$_{49}$NO$_8$SSi ([M+Na$^+$]) = 742.2840, Found 742.2838.
Isopropyl 2-((1R,2S,9aS)-6-methoxy-9-((4-methoxyphenyl)sulfonyl)-2-phenyl-4-((triisopropylsilyl)oxy)-2,3,9a-tetrahydro-1H-carbazol-1-yl)-2-oxoacetate (3bc) 

\[
\text{(C}_{40}\text{H}_{16}\text{NO}_{5}\text{SSi}) \text{ white foam, 95% yield, 89% ee. } [\alpha]_{D}^{22.1} = +110.4 \text{ (c = 1.09, CH}_2\text{Cl}_2). \text{ HPLC DAICEL CHIRALCEL IA,} \\
\text{ retention time: 4.74 min, 8.62 min.}
\]

\[
\text{H NMR (400 MHz, CDCl}_3) \; \delta = 7.64 \text{ (d, } J = 8.8 \text{ Hz, 1H), 7.58 – 7.48 (m, 2H), 7.22 – 7.16 (m, 2H), 7.15 – 7.07 (m, 4H), 6.81 (d, } J = 7.2 \text{ Hz, 2H), 6.63 (dd, } J = 8.8, 2.8 \text{ Hz, 1H), 5.86 – 5.60 (m, 1H), 5.23 – 5.02 (m, 2H), 4.80 (d, } J = 8.8 \text{ Hz, 1H), 4.58 – 4.42 (m, 2H), 4.27 (t, } J = 9.6 \text{ Hz, 1H), 3.73 (s, 3H), 3.69 (s, 3H), 3.40 – 3.22 (m, 1H), 2.64 – 2.46 (m, 2H), 1.01 – 1.03 (m, 3H), 0.97 (dd, } J = 7.2, 4.0 \text{ Hz, 18H).}
\]

\[
\text{C NMR (101 MHz, CDCl}_3) \; \delta = 193.17, 163.57, 159.22, 156.58, 144.60, 140.35, 135.68, 131.08, 130.31, 129.67, 128.85, 128.48, 127.48, 126.62, 118.96, 116.09, 114.13, 113.38, 111.23, 108.77, 66.63, 65.76,
\]

\[
\text{Found } 756.2997.
\]

Allyl 2-((1R,2S,9aS)-6-methoxy-9-((4-methoxyphenyl)sulfonyl)-2-phenyl-4-((triisopropylsilyl)oxy)-2,3,9a-tetrahydro-1H-carbazol-1-yl)-2-oxoacetate (3bd) 

\[
\text{(C}_{40}\text{H}_{49}\text{NO}_{3}\text{SSi}) \text{ white foam, 95% yield, 93% ee. } [\alpha]_{D}^{22.1} = +110.4 \text{ (c = 1.09, CH}_2\text{Cl}_2). \text{ HPLC DAICEL CHIRALCEL IA,} \\
\text{ retention time: 4.74 min, 8.62 min.}
\]

\[
\text{H NMR (400 MHz, CDCl}_3) \; \delta = 7.64 \text{ (d, } J = 8.8 \text{ Hz, 1H), 7.58 – 7.48 (m, 2H), 7.22 – 7.16 (m, 2H), 7.15 – 7.07 (m, 4H), 6.81 (d, } J = 7.2 \text{ Hz, 2H), 6.63 (dd, } J = 8.8, 2.8 \text{ Hz, 1H), 5.86 – 5.60 (m, 1H), 5.23 – 5.02 (m, 2H), 4.80 (d, } J = 8.8 \text{ Hz, 1H), 4.58 – 4.42 (m, 2H), 4.27 (t, } J = 9.6 \text{ Hz, 1H), 3.73 (s, 3H), 3.69 (s, 3H), 3.40 – 3.22 (m, 1H), 2.64 – 2.46 (m, 2H), 1.01 – 1.03 (m, 3H), 0.97 (dd, } J = 7.2, 4.0 \text{ Hz, 18H).}
\]

\[
\text{C NMR (101 MHz, CDCl}_3) \; \delta = 193.17, 163.57, 159.22, 156.58, 144.60, 140.35, 135.68, 131.08, 130.31, 129.67, 128.85, 128.48, 127.48, 126.62, 118.96, 116.09, 114.13, 113.38, 111.23, 108.77, 66.63, 65.76,
\]
55.53, 55.49, 51.41, 44.37, 38.57, 17.90, 13.66. HRMS (ESI-TOF) calcd for C₄₀H₄₉NO₅Si ([M+Na⁺]) = 754.2840, Found 754.2844.

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Benzyl 2-((1R,2S,9aS)-6-methoxy-9-((4-methoxyphenyl)sulfonyl)-2-phenyl-4-((triisopropylsilyl)oxy)-2,3,9,9a-tetrahydro-1H-carbazol-1-yl)-2-oxoacetate (3be)

(C₄₄H₄₉NO₅Si) white foam, 92% yield, 94% ee, [α]D¹⁷ = +92.2 (c = 0.51, CH₂Cl₂); HPLC DAICEL CHIRALCEL IA, n-hexane/2-propanol = 70/30, flow rate = 1.0 mL/min, λ = 254 nm, retention time: 5.73 min, 12.46 min.

1H NMR (400 MHz, CDCl₃) δ 7.71 (d, J = 8.8 Hz, 1H), 7.59 (d, J = 8.8 Hz, 2H), 7.38 – 7.05 (m, 12H), 6.87 (d, J = 8.8 Hz, 2H), 6.71 (dd, J = 8.8, 2.0 Hz, 1H), 5.13 (q, J = 12.4 Hz, 2H), 4.89 (d, J = 8.4 Hz, 1H), 4.33 (t, J = 8.4 Hz, 1H), 3.78 (s, 3H), 3.75 (s, 3H), 3.46 – 3.27 (m, 1H), 2.70 – 2.49 (m, 2H), 1.18 – 1.09 (m, 3H), 1.03 (d, J = 4.8 Hz, 18H). ¹³C NMR (101 MHz, CDCl₃) δ 193.01, 163.58, 159.37, 156.63, 144.60, 140.38, 135.71, 134.93, 130.32, 129.69, 128.81, 128.47, 128.29, 128.25, 127.43, 126.66, 116.12, 114.15, 113.40, 111.28, 108.80, 67.68, 65.76, 55.52, 51.74, 44.25, 38.60, 17.91, 13.66. HRMS (ESI-TOF) calcd for C₄₄H₅₁NO₅Si ([M+Na⁺]) = 804.2997, Found 804.2997.

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11
Methy12-((1R,2S,9aS)-6-methoxy-9-((4-methoxyphenyl)sulfonyl)-2-(m-toly1)-4-((triisopropylsilyl)oxy)-2,3,9,9a-tetrahydro-1H-carbazol-1-yl)-2-oxoacetate (3bf)

\( \text{C}_{39}\text{H}_{49}\text{NO}_{3}\text{SSi} \) white foam, 98% yield, 94% ee. \( [\alpha]_D^{18.9} = +112.3 \) (c = 1.32, CHCl3). HPLC DAICEL CHIRALCEL IA, n-hexane/2-propanol = 70/30, flow rate = 1.0 mL/min, \( \lambda = 254 \) nm, retention time: 4.66 min, 7.81 min.

\(^1\text{H} \) NMR (400 MHz, CDCl3) \( \delta \) 7.63 (d, \( J = 8.8 \) Hz, 1H), 7.52 (d, \( J = 8.8 \) Hz, 2H), 7.13 – 7.04 (m, 2H), 6.97 – 6.87 (m, 3H), 6.81 (d, \( J = 9.2 \) Hz, 2H), 6.63 (dd, \( J = 8.8 \), 2.8 Hz, 1H), 4.78 (d, \( J = 9.2 \) Hz, 1H), 4.23 (t, \( J = 9.6 \) Hz, 1H), 3.73 (s, 3H), 3.68 (s, 3H), 3.62 (s, 3H), 3.33 – 3.19 (m, 1H), 2.62 – 2.47 (m, 2H), 2.21 (s, 3H), 1.12 – 1.04 (m, 3H), 0.97 (dd, \( J = 7.2 \), 4.4 Hz, 18H). \(^{13}\text{C} \) NMR (101 MHz, CDCl3) \( \delta \) 193.21, 163.58, 160.12, 156.60, 144.74, 140.32, 138.41, 135.65, 130.29, 129.73, 129.32, 128.72, 128.19, 126.56, 125.19, 116.13, 114.13, 113.36, 111.24, 108.73, 65.82, 55.53, 55.29, 52.87, 51.53, 44.24, 38.62, 21.40, 17.90, 13.66. HRMS (ESI-TOF) calcd for \( \text{C}_{39}\text{H}_{49}\text{NO}_{3}\text{SSi} \) ([M+Na\(^+\)]) = 742.2840, Found 742.2839.

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Methy12-((1R,2S,9aS)-6-methoxy-9-((4-methoxyphenyl)sulfonyl)-2-(p-toly1)-4-((triisopropylsilyl)oxy)-2,3,9,9a-tetrahydro-1H-carbazol-1-yl)-2-oxoacetate (3bg)

\( \text{C}_{39}\text{H}_{49}\text{NO}_{3}\text{SSi} \) white foam, 94% yield, 93% ee. \( [\alpha]_D^{17.0} = +122.8 \) (c = 1.14, CHCl3). HPLC DAICEL CHIRALCEL IA, n-hexane/2-propanol = 70/30, flow rate = 1.0 mL/min, \( \lambda = 254 \) nm, retention time: 5.33 min, 9.08 min.

\(^1\text{H} \) NMR (400 MHz, CDCl3) \( \delta \) 7.70 (d, \( J = 8.8 \) Hz, 1H), 7.60 (d, \( J = 8.8 \) Hz, 2H), 7.17 (d, \( J = 2.6 \) Hz, 1H), 7.10 – 7.03 (m, 4H), 6.89 (d, \( J = 9.2 \) Hz, 2H), 6.70 (dd, \( J = 8.8 \), 2.8 Hz, 1H), 4.87 (d, \( J = 8.8 \) Hz, 1H), 4.29 (t, \( J = 9.6 \) Hz, 1H), 3.80 (s, 3H), 3.76 (s, 3H), 3.69 (s, 3H), 3.47 – 3.28 (m, 1H), 2.73 – 2.52 (m, 2H), 2.29 (s, 3H), 1.19 – 1.11 (m, 3H), 1.08 – 0.99 (m, 18H). \(^{13}\text{C} \) NMR (101 MHz, CDCl3) \( \delta \) 193.18, 163.57, 160.12, 156.59, 144.76, 137.24, 137.13, 135.65, 130.31, 129.74, 129.48,
128.27, 126.57, 116.12, 114.13, 113.35, 111.21, 108.76, 65.85, 55.53, 55.49, 52.88, 51.60, 43.95, 38.73, 21.05, 17.91, 13.67. HRMS (ESI-TOF) calcd for C_{39}H_{49}NO_8SSi ([M+Na]) = 742.2840, Found 742.2841

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Methyl 2-(((1R,2S,9aS)-6-methoxy-2-(3-methoxyphenyl)-9-((4-methoxyphenyl)sulfonyl)-4-((triisopropylsilyloxy)-2,3,9,9a-tetrahydro-1H-carbazol-1-yl)-2-oxoacetate (3bh)

(C_{39}H_{49}NO_8SSi) white foam, 96% yield, 90% ee. [α]_D^{17.2} = +115.6 (c = 1.35, CH_2Cl_2). HPLC DAICEL CHIRALCEL IA, n-hexane/2-propanol = 70/30, flow rate = 1.0 mL/min, λ = 254 nm, retention time: 5.15 min, 7.63 min.

^1H NMR (400 MHz, CDCl_3) δ 7.63 (d, J = 8.8 Hz, 1H), 7.52 (d, J = 8.8 Hz, 2H), 7.10 (t, J = 7.6 Hz, 2H), 3.73 (s, 3H), 3.37 – 3.21 (m, 1H), 2.65 – 2.43 (m, 2H), 1.10 – 1.03 (m, 3H), 0.96 (dd, J = 7.2, 2.8 Hz, 18H). ^13C NMR (101 MHz, CDCl_3) δ 193.03, 163.59, 160.22, 159.76, 156.63, 144.58, 142.19, 135.59, 130.29, 129.85, 129.71, 126.51, 120.49, 116.16, 114.15, 113.69, 113.40, 113.20, 111.26, 108.69, 65.66, 55.53, 55.49, 55.13, 52.96, 51.55, 44.06, 38.58, 17.89, 13.64. HRMS (ESI-TOF) calcd for C_{39}H_{49}NO_8SSi ([M+Na]) = 758.2790, Found 758.2789.

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Methyl 2-((1R,2S,9aS)-6-methoxy-2-(4-methoxyphenyl)-9-((4-methoxyphenyl)sulfonyl)-4-((triisopropylsilyl)oxy)-2,3,9a-tetrahydro-1H-carbazol-1-yl)-2-oxoacetate (3bi)

(C$_{39}$H$_{47}$NO$_5$Si) white foam, 97% yield, 92% ee. [α]$_D^{17.4}$ = +109.6 (c = 1.17, CH$_2$Cl$_2$). HPLC DAICEL CHIRALCEL IA, n-hexane/2-propanol = 70/30, flow rate = 1.0 mL/min, λ = 254 nm, retention time: 5.82 min, 10.83 min.

$^1$H NMR (400 MHz, CDCl$_3$) δ 7.61 (d, J = 9.2 Hz, 1H), 7.18 (d, J = 2.8 Hz, 1H), 7.09 (d, J = 8.8 Hz, 2H), 6.89 (d, J = 8.8 Hz, 2H), 6.80 (d, J = 8.8 Hz, 2H), 6.70 (dd, J = 9.2, 2.4 Hz, 1H), 4.87 (d, J = 9.2 Hz, 1H), 4.29 (t, J = 9.6 Hz, 1H), 3.80 (s, 3H), 3.76 (s, 6H), 3.71 (s, 3H), 3.41 – 3.27 (m, 1H), 2.66 – 2.52 (m, 2H), 1.19 – 1.11 (m, 3H), 1.08 – 1.01 (m, 18H).

$^{13}$C NMR (101 MHz, CDCl$_3$) δ 193.27, 163.59, 160.17, 156.63, 147.90, 146.81, 144.57, 135.65, 132.19, 130.30, 129.71, 129.49, 126.57, 116.07, 114.14, 113.34, 111.18, 108.78, 65.79, 55.53, 55.49, 55.24, 52.91, 51.67, 43.58, 38.86, 17.91, 13.66. HRMS (ESI-TOF) calced for C$_{39}$H$_{47}$NO$_5$Si ([M+Na$^+$]) = 758.2790, Found 758.2790.

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Methyl 2-((1R,2S,9aS)-2-(benzo[d][1,3]dioxol-5-yl)-6-methoxy-9-((4-methoxyphenyl)sulfonyl)-4-((triisopropylsilyl)oxy)-2,3,9a-tetrahydro-1H-carbazol-1-yl)-2-oxoacetate (3bj)

(C$_{39}$H$_{47}$NO$_5$Si) white foam, 97% yield, 91% ee. [α]$_D^{14.3}$ = +119.4 (c = 1.25, CH$_2$Cl$_2$). HPLC DAICEL CHIRALCEL IA, n-hexane/2-propanol = 70/30, flow rate = 1.0 mL/min, λ = 254 nm, retention time: 5.94 min, 11.83 min.

$^1$H NMR (400 MHz, CDCl$_3$) δ 7.59 (d, J = 9.2 Hz, 2H), 7.17 (d, J = 2.8 Hz, 1H), 6.89 (d, J = 8.8 Hz, 2H), 6.74 – 6.65 (m, 3H), 6.62 (d, J = 8.0 Hz, 1H), 5.92 (s, 2H), 4.85 (d, J = 8.8 Hz, 1H), 4.24 (d, J = 9.6 Hz, 1H), 3.80 (s, 3H), 3.76 (d, J = 4.0 Hz, 6H), 3.44 – 3.25 (m, 1H), 2.73 – 2.41 (m, 2H), 1.20 – 1.12 (m, 3H), 1.05 (dd, J = 7.2, 4.0 Hz, 18H). $^{13}$C NMR (101 MHz, CDCl$_3$) δ 192.95, 163.59, 160.17, 156.63, 147.90, 146.81, 144.57, 135.60, 134.26, 130.30, 129.68,
126.48, 121.66, 116.20, 114.14, 113.39, 111.28, 108.73, 108.49, 108.44, 101.10, 65.81, 55.53, 55.49, 53.00, 51.89, 43.87, 38.98, 17.91, 13.66. HRMS (ESI-TOF) calcd for C$_{39}$H$_{47}$NO$_{10}$SSi ([M+Na$^+$]) = 772.2582, Found: 772.2595.

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Methyl 2-((1R,2S,9aS)-2-((1,1’-biphenyl)-4-yl)-6-methoxy-9-((4-methoxyphenyl)sulfonyl)-4-((triisopropylsilyl)oxy)-2,3,9,9a-tetrahydro-1H-carbazol-1-yl)-2-oxoacetate (3bk)

(C$_{44}$H$_{51}$NO$_{8}$SSi) white foam, 94% yield, 92% ee. [α]$_D$$^{17.4}$ = +146.5 (c = 1.34, CH$_2$Cl$_2$). HPLC DAICEL CHIRALCEL IA, n-hexane/2-propanol = 70/30, flow rate = 1.0 mL/min, λ = 254 nm, retention time: 7.34 min, 13.89 min.

H NMR (400 MHz, CDCl$_3$) δ 7.71 (d, $J$ = 8.8 Hz, 1H), 7.61 (d, $J$ = 9.2 Hz, 2H), 7.59 – 7.53 (m, 2H), 7.50 (d, $J$ = 8.4 Hz, 2H), 7.42 (t, $J$ = 8.0 Hz, 2H), 7.33 (t, $J$ = 7.2 Hz, 1H), 7.24 (d, $J$ = 8.4 Hz, 2H), 7.19 (d, $J$ = 2.4 Hz, 1H), 6.90 (d, $J$ = 9.2 Hz, 2H), 6.72 (dd, $J$ = 9.2, 2.8 Hz, 1H), 4.89 (d, $J$ = 8.8 Hz, 1H), 4.37 (t, $J$ = 9.6 Hz, 1H), 3.81 (s, 3H), 3.77 (s, 3H), 3.69 (s, 3H), 3.52 – 3.33 (m, 1H), 2.79 – 2.55 (m, 2H), 1.20 – 1.12 (m, 3H), 1.05 (dd, $J$ = 7.2, 2.8 Hz, 18H). $^{13}$C NMR (101 MHz, CDCl$_3$) δ 193.22, 163.61, 160.24, 156.65, 144.57, 140.47, 140.31, 139.57, 135.64, 130.31, 129.70, 128.82, 127.48, 127.41, 126.98, 126.58, 116.15, 114.17, 113.42, 111.29, 108.76, 65.68, 55.55, 55.51, 52.99, 51.61, 43.83, 38.55, 17.92, 13.67. HRMS (ESI-TOF) calcd for C$_{44}$H$_{51}$NO$_{8}$SSi ([M+Na$^+$]) = 804.2994, Found. 804.3008.
Retention Time | Area  | % Area  
--- | --- | ---
1 | 7.342 | 3.95 
2 | 13.894 | 96.05 

Methyl 2-((1R,2S,9aS)-2-(4-fluorophenyl)-6-methoxy-9-((4-methoxyphenyl)sulfonyl)-4-((triisopropylsilyl)oxy)-2,3,9,9a-tetrahydro-1H-carbazol-1-yl)-2-oxoacetate (3b) (C_{38}H_{46}FNO_8SSi) white foam, 95% yield, 90% ee. [α]_{D}^{14.4} = +99.7 (c = 1.06, CH_{2}Cl_{2}). HPLC DAICEL CHIRALCEL IA, n-hexane/2-propanol = 70/30, flow rate = 1.0 mL/min, λ = 254 nm, retention time: 5.17 min, 8.88 min.

1H NMR (400 MHz, CDCl_{3}) δ 7.70 (d, J = 8.8 Hz, 1H), 7.59 (d, J = 8.8 Hz, 2H), 7.21 – 7.09 (m, 3H), 6.96 (t, J = 8.8 Hz, 2H), 6.89 (d, J = 8.8 Hz, 2H), 6.71 (dd, J = 8.8 Hz, 2H, 1H), 4.84 (d, J = 8.8 Hz, 1H), 4.30 (t, J = 9.2 Hz, 1H), 3.81 (s, 3H), 3.76 (s, 3H), 3.73 (s, 3H), 3.46 – 3.28 (m, 1H), 2.74 – 2.33 (m, 2H), 1.18 – 1.09 (m, 3H), 1.04 (d, J = 5.6 Hz, 18H). 13C NMR (101 MHz, CDCl_{3}) δ 193.10, 163.62, 163.17, 160.72, 160.24, 156.64, 144.34, 136.39, 136.36, 135.58, 130.27, 129.98, 129.90, 129.57, 126.48, 116.13, 115.82, 115.61, 114.16, 113.45, 111.29, 108.75, 65.60, 55.49, 55.49, 54.05, 51.59, 43.39, 38.73, 37.83, 17.88, 13.63. HRMS (ESI-TOF) calcd for C_{38}H_{46}FNO_8SSi ([M+Na]^{+}) = 746.2590, Found 746.2588.

Retention Time | Area  | % Area  
--- | --- | ---
1 | 5.123 | 50.50 
2 | 8.885 | 49.50 

Methyl 2-((1R,2S,9aS)-2-(3-chlorophenyl)-6-methoxy-9-((4-methoxyphenyl)sulfonyl)-4-((triisopropydsilyl)oxy)-2,3,9,9a-tetrahydro-1H-carbazol-1-yl)-2-oxoacetate (3bm) (C_{38}H_{46}ClNO_8SSi) white foam, 84% yield, 90% ee. [α]_{D}^{14.8} = +131.6 (c = 0.87, CH_{2}Cl_{2}). HPLC DAICEL CHIRALCEL IA, n-hexane/2-propanol = 70/30, flow rate = 1.0 mL/min, λ = 254 nm, retention time: 5.05 min, 7.90 min.
\[ {^1}H\text{ NMR (400 MHz, CDCl}_3 \] \( \delta \) 7.70 (d, \( J = 8.8 \text{ Hz, 1H} \)), 7.58 (d, \( J = 9.2 \text{ Hz, 2H} \)), 7.23 – 7.11 (m, 4H), 7.10 – 7.02 (m, 1H), 6.89 (d, \( J = 8.8 \text{ Hz, 2H} \)), 6.72 (dd, \( J = 8.8, 2.8 \text{ Hz, 1H} \)), 4.83 (d, \( J = 8.8 \text{ Hz, 1H} \)), 4.29 (t, \( J = 9.2 \text{ Hz, 1H} \)), 3.81 (s, 3H), 3.77 (d, \( J = 3.8 \text{ Hz, 6H} \)), 3.42 – 3.32 (m, 1H), 2.73 – 2.44 (m, 2H), 1.18 – 1.10 (m, 3H), 1.04 (d, \( J = 6.8 \text{ Hz, 18H} \)). \[ {^13}C\text{ NMR (101 MHz, CDCl}_3 \] \( \delta \) 192.86, 163.63, 160.23, 156.69, 144.16, 142.94, 135.55, 134.52, 130.26, 130.21, 129.54, 128.61, 127.69, 126.33, 116.23, 114.17, 113.53, 111.45, 108.68, 65.56, 55.55, 55.50, 53.12, 51.57, 43.59, 38.45, 17.88, 17.87, 13.63. HRMS (ESI-TOF) cалд for \( C_{38}H_{46}ClO_3N_2O_6S_2Si \) (\([M+Na]^+\)) = 762.2294, Found 762.2306. HRMS (ESI-TOF) cалд for \( C_{38}H_{46}ClO_3N_2O_6S_2Si \) (\([M+Na]^+\)) = 764.2265, Found 764.2293.

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Methyl 2-((1R,2S,9aS)-2-(4-chlorophenyl)-6-methoxy-9-(4-methoxyphenyl)sulfonyl)-4-((triisopropylsilyl)oxy)-2,3,9,9a-tetrahydro-1H-carbazol-1-yl)-2-oxoacetate (3bn)

\( (C_{38}H_{46}ClO_3N_2O_6S_2Si) \) white foam, 85% yield, 87% ee, [\( \alpha \)]\(^{18}\)\(_D = +123.6 \) (c = 1.07, CH\(_2\)Cl\(_2\)). HPLC DAICEL CHIRALCEL IA, \( \alpha \)-hexane/2-propanol = 70/30, flow rate = 1.0 mL/min, \( \lambda = 254 \) nm, retention time: 5.64 min, 9.69 min.

\[ {^1}H\text{ NMR (400 MHz, CDCl}_3 \] \( \delta \) 7.62 (d, \( J = 8.8 \text{ Hz, 1H} \)), 7.51 (d, \( J = 8.8 \text{ Hz, 2H} \)), 7.17 (d, \( J = 8.4 \text{ Hz, 2H} \)), 7.09 (d, \( J = 2.8 \text{ Hz, 1H} \)), 7.03 (d, \( J = 8.4 \text{ Hz, 2H} \)), 6.81 (d, \( J = 8.8 \text{ Hz, 2H} \)), 6.64 (dd, \( J = 8.8, 2.8 \text{ Hz, 1H} \)), 4.76 (d, \( J = 9.2 \text{ Hz, 1H} \)), 4.22 (t, \( J = 9.2 \text{ Hz, 1H} \)), 3.73 (s, 3H), 3.68 (s, 3H), 3.67 (s, 3H), 3.39 – 3.21, 2.63 – 2.36 (m, 2H), 1.08 – 1.01 (m, 3H), 0.96 (d, \( J = 6.4 \text{ Hz, 18H} \)). \[ {^13}C\text{ NMR (101 MHz, CDCl}_3 \] \( \delta \) 192.96, 163.63, 160.29, 156.67, 144.22, 139.30, 135.54, 133.26, 130.27, 129.63,129.55, 129.02, 126.42, 116.19, 114.17, 113.49, 111.36, 108.71, 65.57, 55.50, 55.49, 53.10, 51.51, 43.36, 38.58, 17.88, 13.63. HRMS (ESI-TOF) cалд for \( C_{38}H_{46}ClO_3N_2O_6S_2Si \) (\([M+Na]^+\)) = 762.2294, Found 762.2294. HRMS (ESI-TOF) cалд for \( C_{38}H_{46}ClO_3N_2O_6S_2Si \) (\([M+Na]^+\)) = 764.2265, Found 764.2181.
Methyl 2-((1R,2S,9aS)-2-(3,4-dichlorophenyl)-6-methoxy-9-((4-methoxyphenyl)sulfonyl)-4-((triisopropylsilyloxy)-2,3,9,9a-tetrahydro-1H-carbazol-1-yl)-2-o xoacetate (3bo)

(C_{39}H_{42}Cl_{2}NO_5SSi) white foam, 85% yield, 86% ee, [α]D^{21.4} = +126.4 (c = 1.23, CH_{2}Cl_{2}). HPLC DAICEL CHIRALCEL IA, n-hexane/2-propanol = 70/30, flow rate = 1.0 mL/min, λ = 254 nm, retention time: 5.51 min, 9.21 min.

1H NMR (400 MHz, CDCl_{3}) δ 7.62 (d, J = 9.2 Hz, 1H), 7.50 (d, J = 8.8 Hz, 2H), 7.27 (d, J = 8.4 Hz, 1H), 7.19 (d, J = 1.2 Hz, 1H), 7.08 (d, J = 2.4 Hz, 1H), 6.95 (dd, J = 8.4, 2.0 Hz, 1H), 6.81 (d, J = 8.8 Hz, 2H), 6.65 (dd, J = 8.8, 2.8 Hz, 1H), 4.73 (d, J = 8.8 Hz, 1H), 4.18 (t, J = 9.2 Hz, 1H), 3.73 (s, 6H), 3.68 (s, 3H), 3.35 – 3.21 (m, 1H), 2.64 – 2.50 (ddd, J = 17.2, 6.1, 2.1 Hz, 1H), 2.44 – 2.31 (m, 1H), 1.09 – 1.01 (m, 3H), 0.96 (dd, J = 7.2, 1.6 Hz, 18H).

13C NMR (101 MHz, CDCl_{3}) δ 192.72, 163.66, 160.36, 156.75, 143.86, 141.43, 135.48, 132.78, 131.54, 130.90, 130.37, 130.25, 129.44, 127.27, 126.31, 116.29, 114.19, 113.62, 111.58, 108.64, 65.40, 55.55, 55.50, 53.25, 51.64, 42.80, 38.40, 17.86, 17.84, 13.61. HRMS (ESI-TOF) cale for C_{39}H_{42}Cl_{2}NO_5SSi ([M+Na^+] = 796.1904, Found 796.1901. HRMS (ESI-TOF) cale for C_{39}H_{42}Cl_{2}NO_5SSi ([M+Na^+] = 798.1875, Found 798.1787.

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Methyl 2-((1R,2S,9aS)-2-(naphthalen-2-yl)-4-((triisopropylsilyloxy)-2,3,9,9a-tetra hydro-1H-carbazol-1-yl)-2-o xoacetate (3bp)

(C_{40}H_{49}NO_5SSi) white foam, 91% yield, 92% ee. [α]D^{22.2} = +138.2 (c = 1.04, CH_{2}Cl_{2}). HPLC DAICEL CHIRALCEL IA,

Retention Time | Area   | % Area
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Methyl 2-((1R,2S,9aS)-6-methoxy-9-((4-methoxyphenyl)sulfonyl)-2-(3,4-dimethoxyphenyl)sulfonyl)-2-oxoacetate (3bp)

C_{40}H_{49}NO_5SSi white foam, 91% yield, 92% ee. [α]D^{22.2} = +138.2 (c = 1.04, CH_{2}Cl_{2}). HPLC DAICEL CHIRALCEL IA,
n-hexane/2-propanol = 70/30, flow rate = 1.0 mL/min, λ = 254 nm, retention time: 5.57 min, 9.15 min. 

$^1$H NMR (400 MHz, CDCl$_3$) δ 7.73 – 7.62 (m, 4H), 7.54 (d, $J$ = 8.8 Hz, 3H), 7.42 – 7.33 (m, 2H), 7.27 (dd, $J$ = 8.8, 1.6 Hz, 1H), 7.12 (d, $J$ = 2.4 Hz, 1H), 6.82 (d, $J$ = 9.2 Hz, 2H), 6.65 (dd, $J$ = 9.2, 2.8 Hz, 1H), 4.84 (d, $J$ = 9.2 Hz, 1H), 4.37 (t, $J$ = 9.6 Hz, 1H), 3.73 (s, 3H), 3.69 (s, 3H), 3.57 – 3.46 (m, 1H), 3.49 (s, 3H), 2.72 – 2.54 (m, 2H), 1.09 – 1.02 (m, 3H), 0.95 (dd, $J$ = 7.2, 2.4 Hz, 18H). $^{13}$C NMR (101 MHz, CDCl$_3$) δ 193.17, 163.57, 159.22, 156.58, 144.60, 140.35, 135.68, 131.08, 130.31, 129.67, 128.85, 128.48, 127.48, 126.62, 118.96, 116.09, 114.13, 113.38, 111.23, 108.77, 66.63, 65.76, 55.53, 55.49, 51.41, 44.37, 38.57, 17.90, 13.66. HRMS (ESI-TOF) calcd for C$_{42}$H$_{39}$NO$_5$SSi ([M+Na$^+$]) = 778.2840, Found 778.2848.

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Methyl 12-((1R,2R,9aS)-6-methoxy-9-((4-methoxyphenyl)sulfonyl)-2-((E)-styryl)-4-((triisopropylsil)oxy)-2,3,9a-tetrahydro-1H-carbazol-1-yl)-2-oxoacetate (3bq)

(C$_{42}$H$_{39}$NO$_5$SSi) white foam, 82% yield, 90% ee. [α]$_D$$^{16.5}$ = +180.3 (c = 0.58, CH$_2$Cl$_2$). HPLC DAICEL CHIRALCEL IA, n-hexane/2-propanol = 70/30, flow rate = 1.0 mL/min, λ = 254 nm, retention time: 5.48 min, 8.06 min.

$^1$H NMR (400 MHz, CDCl$_3$) δ 7.58 (dd, $J$ = 12.4, 8.8 Hz, 3H), 7.21 (d, $J$ = 4.4 Hz, 4H), 7.18 – 7.13 (m, 1H), 7.09 (d, $J$ = 2.4 Hz, 1H), 6.83 (d, $J$ = 9.2 Hz, 2H), 6.62 (dd, $J$ = 8.8, 2.8 Hz, 1H), 6.27 (d, $J$ = 15.6 Hz, 1H), 5.93 (dd, $J$ = 15.6, 9.6 Hz, 1H), 4.79 (d, $J$ = 8.8 Hz, 1H), 4.01 (t, $J$ = 9.6 Hz, 1H), 3.74 (s, 3H), 3.71 (s, 3H), 3.68 (s, 3H), 2.91 – 2.77 (m, 1H), 2.46 – 2.27 (m, 2H), 1.18 – 1.10 (m, 3H), 1.00 (t, $J$ = 7.2 Hz, 18H). $^{13}$C NMR (101 MHz, CDCl$_3$) δ 193.30, 163.54, 160.87, 156.52, 144.14, 136.23, 135.46, 133.03, 130.17, 129.66, 129.01, 128.57, 127.90, 127.01, 126.36, 115.84, 114.15, 113.35, 110.89, 108.87, 64.92, 55.52, 53.17, 50.26, 42.72, 36.50, 17.96, 17.95, 13.70. HRMS (ESI-TOF) calcd for C$_{42}$H$_{39}$NO$_5$SSi ([M+Na$^+$]) = 754.2840, Found 754.2843.

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Methyl 2-((1R,2S,9aS)-6-methoxy-9-((4-methoxyphenyl)sulfonyl)-2-(thiophen-2-yl)-4-((triisopropylsilyl)oxy)-2,3,9,9a-tetrahydro-IH-carbazol-1-yl)-2-oxoacetate (3br)

(C_{36}H_{45}NO_{16}Si) white foam, 94% yield, 92% ee. [α]_{D}^{21.9} = +106.6 (c = 1.11, CH_{2}Cl_{2}). HPLC DAICEL CHIRALCEL IA, n-hexane/2-propanol = 70/30, flow rate = 1.0 mL/min, λ = 254 nm, retention time: 5.13 min, 8.38 min.

{\textsuperscript{1}}H NMR (400 MHz, CDCl_{3}) δ 7.60 (d, J = 8.8 Hz, 1H), 7.52 (d, J = 8.8 Hz, 2H), 7.10 (d, J = 2.7 Hz, 1H), 7.06 (d, J = 4.4 Hz, 1H), 6.81 (d, J = 9.2 Hz, 2H), 6.77 (dd, J = 5.2, 3.6 Hz, 1H), 6.70 (d, J = 2.8 Hz, 1H), 6.63 (dd, J = 8.8, 2.8 Hz, 1H), 4.79 (d, J = 8.8 Hz, 1H), 4.16 (t, J = 8.8 Hz, 1H), 3.72 (d, J = 4.0 Hz, 6H), 3.68 (s, 3H), 2.73 – 2.49 (m, 2H), 1.13 – 1.05 (m, 3H), 0.98 (d, J = 6.8 Hz, 18H). {\textsuperscript{13}}C NMR (101 MHz, CDCl_{3}) δ 192.89, 163.60, 160.12, 156.65, 144.30, 144.05, 135.54, 130.23, 129.58, 126.67, 126.60, 126.13, 124.67, 116.10, 114.16, 113.49, 111.27, 108.66, 64.99, 55.53, 55.49, 53.44, 53.07, 39.02, 38.85, 17.89, 17.86, 13.60. HRMS (ESI-TOF) calcd for C_{36}H_{45}NO_{16}Si ([M+Na]^{+}) = 734.2248, Found 734.2251.

Methyl 2-((1R,2S,9aS)-6-methoxy-9-((4-methoxyphenyl)sulfonyl)-2-(thiophen-3-yl)-4-((triisopropylsilyl)oxy)-2,3,9,9a-tetrahydro-IH-carbazol-1-yl)-2-oxoacetate (3bs)

(C_{36}H_{45}NO_{16}Si) white foam, 92% yield, 92% ee. [α]_{D}^{17.5} = +107.6 (c = 1.22, CH_{2}Cl_{2}). HPLC DAICEL CHIRALCEL IA, n-hexane/2-propanol = 70/30, flow rate = 1.0 mL/min, λ = 254 nm, retention time: 5.19 min, 8.50 min.
$^1$H NMR (400 MHz, CDCl$_3$) δ 7.61 (d, $J = 8.8$ Hz, 1H), 7.56 – 7.49 (m, 2H), 7.17 (dd, $J = 4.8, 2.8$ Hz, 1H), 7.10 (d, $J = 2.8$ Hz, 1H), 6.94 – 6.89 (m, 1H), 6.86 (dd, $J = 5.2, 1.2$ Hz, 1H), 6.82 (d, $J = 9.2$ Hz, 2H), 6.63 (dd, $J = 9.2, 2.8$ Hz, 1H), 4.81 – 4.72 (m, 1H), 4.18 (t, $J = 9.2$ Hz, 1H), 3.73 (s, 3H), 3.68 (s, 3H), 3.58 (t, 2H), 2.42 (m, 2H), 1.15 – 1.05 (m, 3H), 0.98 (dd, $J = 7.2, 3.2$ Hz, 18H). $^{13}$C NMR (101 MHz, CDCl$_3$) δ 193.27, 163.58, 160.11, 156.60, 145.35, 141.28, 135.54, 129.82, 126.94, 126.64, 126.42, 122.81, 116.02, 114.15, 113.41, 111.16, 108.73, 65.23, 55.54, 53.00, 51.87, 39.29, 37.79, 17.89, 13.64. HRMS (ESI-TOF) calcd for C$_{39}$H$_{41}$NO$_5$S$_2$Si ([M+Na$^+$]) = 734.2248, Found 734.2247.

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Methyl 2-((1R,2R,9aS)-2-cyclohexyl-6-methoxy-9-((4-methoxyphenyl)sulfonyl)-4-((triisopropylsilyloxy)-2,3,9a-tetrahydro-1H-carbazol-1-yl)-2-oxoacetate (3bt)

(C$_{39}$H$_{39}$NO$_5$SSi) white foam, 78% yield, 99% ee. [α]$_D^{18.9}$ = +183.4 (c = 0.57, CH$_2$Cl$_2$). HPLC DAICEL CHIRALCEL ID, $n$-hexane/2-propanol = 80/20, flow rate = 1.0 mL/min, $λ$ = 254 nm, retention time: 15.04 min, 19.81 min.

$^1$H NMR (400 MHz, CDCl$_3$) δ 7.55 (d, $J = 8.8$ Hz, 1H), 7.44 (d, $J = 8.8$ Hz, 2H), 7.01 (d, $J = 2.4$ Hz, 1H), 6.77 (d, $J = 8.8$ Hz, 2H), 6.62 (dd, $J = 8.8, 2.4$ Hz, 1H), 4.65 (d, $J = 8.4$ Hz, 1H), 3.90 (s, 3H), 3.72 (s, 3H), 3.68 (s, 3H), 3.58 (t, $J = 7.6$ Hz, 1H), 2.28 – 2.12 (m, 2H), 2.09 – 1.99 (m, 1H), 1.65 – 1.51 (m, 5H), 1.22 – 1.06 (m, 6H), 0.99 (dd, $J = 7.2, 1.2$ Hz, 18H), 0.94 – 0.76 (m, 3H). $^{13}$C NMR (101 MHz, CDCl$_3$) δ 194.16, 163.43, 160.69, 156.91, 145.35, 135.45, 129.97, 126.77, 117.01, 114.02, 113.25, 111.60, 108.02, 65.25, 55.48, 55.46, 53.18, 51.62, 41.60, 41.44, 31.61, 31.10, 28.37, 26.48, 26.34, 26.29, 17.86, 13.49. HRMS (ESI-TOF) calcd for C$_{39}$H$_{41}$NO$_5$SSi ([M+Na$^+$]) = 734.3153, Found 734.3156.

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Ethyl 2-((1R,2S,9aS)-9-((4-methoxyphenyl)sulfonyl)-2-propyl-4-((triisopropylsilyl)oxy)-2,3,9,9a-tetrahydro-1H-carbazol-1-yl)-2-oxoacetate (3au)

(C_{35}H_{49}NO_{7}SSi) white foam, 47% yield, 97% ee. >19:1 by $^1$H NMR, 

$[\alpha]_{D}^{25.0}=+207.3$ (c = 0.44, CH$_2$Cl$_2$). HPLC DAICEL CHIRALCEL ID, n-hexane/2-propanol = 85/15, flow rate = 1.0 mL/min, $\lambda = 254$ nm, retention time: 9.93 min, 11.72 min, 12.19 min. $^1$H NMR (400 MHz, CDCl$_3$) δ 7.72 (d, $J = 8.0$ Hz, 1H), 7.59 (dd, $J = 15.6$, 8.0 Hz, 3H), 7.12 (t, $J = 7.6$ Hz, 1H), 6.99 (t, $J = 7.6$ Hz, 1H), 6.87 (d, $J = 8.8$ Hz, 2H), 4.82 (d, $J = 7.6$ Hz, 1H), 4.43 (q, $J = 7.2$ Hz, 2H), 3.79 (s, 3H), 3.74 (t, $J = 7.2$ Hz, 1H), 2.48 – 2.35 (m, 1H), 2.17 – 2.03 (m, 2H), 1.43 (t, $J = 7.2$ Hz, 2H), 3.79 (s, 3H), 3.74 (t, $J = 7.2$ Hz, 1H), 2.48 – 2.35 (m, 1H), 2.17 – 2.03 (m, 2H), 1.43 (t, $J = 7.2$ Hz, 2H), 1.25 – 1.16 (m, 3H), 1.08 (d, $J = 6.8$ Hz, 18H), 0.85 (t, $J = 6.4$ Hz, 3H). $^{13}$C NMR (101 MHz, CDCl$_3$) δ 194.39, 163.54, 160.40, 144.65, 141.77, 130.03, 128.44, 127.29, 127.00, 123.93, 123.52, 115.12, 114.13, 110.42, 64.35, 62.59, 55.49, 52.64, 37.00, 36.55, 34.91, 20.05, 17.92, 14.05, 13.84, 13.53. HRMS (ESI-TOF) calcd for C$_{35}$H$_{49}$NO$_7$SSi ([M+Na$^+$]) = 678.2891, Found 678.2893

Methyl 12-((1R,2S,9aS)-9-((4-methoxyphenyl)sulfonyl)-2-phenyl-4-((triisopropylsilyl)oxy)-2,3,9,9a-tetrahydro-1H-carbazol-1-yl)-2-oxoacetate (3aa)

(C$_{37}$H$_{45}$NO$_7$SSi) white foam, 85% yield, 90% ee, $[\alpha]_{D}^{17.2}=+155.6$ (c = 0.96, CH$_2$Cl$_2$). HPLC DAICEL CHIRALCEL IA, n-hexane/2-propanol = 70/30, flow rate = 1.0 mL/min, $\lambda = 254$ nm, retention time: 4.75 min, 7.29 min.
$^1$H NMR (400 MHz, CDCl$_3$) δ 7.80 (d, $J = 8.4$ Hz, 1H), 7.63 (t, $J = 6.4$ Hz, 3H), 7.31 – 7.12 (m, 7H), 7.01 (t, $J = 7.6$ Hz, 1H), 6.89 (d, $J = 8.8$ Hz, 2H), 4.93 (d, $J = 9.2$ Hz, 1H), 4.37 (t, $J = 9.6$ Hz, 1H), 3.80 (s, 3H), 3.67 (s, 3H), 3.44 – 3.31 (m, 1H), 2.73 – 2.56 (m, 2H), 1.18 – 1.10 (m, 3H), 1.04 (t, $J = 7.2$ Hz, 18H). $^{13}$C NMR (101 MHz, CDCl$_3$) δ 193.27, 163.66, 160.11, 144.54, 142.02, 140.17, 130.24, 128.81, 128.52, 128.43, 127.54, 127.33, 126.82, 123.88, 123.85, 115.07, 114.19, 111.02, 65.60, 55.55, 52.89, 51.21, 44.63, 38.53, 17.93, 17.91, 13.60. HRMS (ESI-TOF) calcd for C$_{37}$H$_{46}$NO$_7$SSi ([M+Na$^+$]) = 698.2578, Found 698.2582.

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Methyl 12-((1R,2S,9aS)-6-bromo-9-((4-methoxyphenyl)sulfonyl)-2-phenyl-4-((triisopropylsilyl)oxo)oxy)-2,3,9,9a-tetrahydro-1H-carbazol-1-yl)-2-oxoacetate (3ca)

(C$_{37}$H$_{46}$BrNO$_7$SSi) white foam, 91% yield, 90% ee. $[\alpha]_D^{21.8} = +59.4$ (c = 1.01, CH$_2$Cl$_2$). HPLC DAICEL CHIRALCEL IA, n-hexane/2-propanol = 70/30, flow rate = 1.0 mL/min, λ = 254 nm, retention time: 4.81 min, 7.60 min.

$^1$H NMR (400 MHz, CDCl$_3$) δ 7.68 (d, $J = 2.0$ Hz, 1H), 7.59 (d, $J = 8.8$ Hz, 1H), 7.54 (d, $J = 9.2$ Hz, 2H), 7.23 – 7.14 (m, 4H), 7.12 – 7.06 (m, 2H), 6.85 (d, $J = 8.8$ Hz, 2H), 4.84 (d, $J = 9.2$ Hz, 1H), 4.29 (t, $J = 9.6$ Hz, 1H), 3.75 (s, 3H), 3.59 (s, 3H), 3.35 – 3.21 (m, 1H), 2.62 – 2.49 (m, 2H), 1.13 – 1.04 (m, 3H), 0.98 (dd, $J = 7.2$, 4.8 Hz, 18H). $^{13}$C NMR (101 MHz, CDCl$_3$) δ 193.15, 163.84, 160.04, 145.96, 141.09, 139.80, 130.54, 130.24, 129.75, 128.88, 128.48, 127.66, 126.67, 126.44, 116.94, 116.39, 114.33, 109.88, 65.83, 55.61, 52.93, 50.95, 44.61, 38.49, 17.93 17.89, 13.53. HRMS (ESI-TOF) calcd for C$_{37}$H$_{46}$Br$_{79.918}$NO$_7$SSi ([M+Na$^+$]) = 776.1683, Found 776.1685. HRMS (ESI-TOF) calcd for C$_{37}$H$_{46}$Br$_{80.916}$NO$_7$SSi ([M+Na$^+$]) = 778.1663, Found 778.1659.

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</table>
Methyl 2-((6S,7R,7aS)-1-((4-methoxyphenyl)sulfonyl)-6-phenyl-4-((triisopropylsilyl)oxy)-5,6,7,7a-tetrahydro-1H-indol-7-yl)-2-oxoacetate (3da)

(C\textsubscript{33}H\textsubscript{43}NO\textsubscript{7}SSi) white foam, 93% yield, 84% ee. \([\alpha]\)\textsubscript{D}\textsuperscript{17.9} = +422.6 (c = 0.67, CH\textsubscript{2}Cl\textsubscript{2}). HPLC DAICEL CHIRALCEL IA, n-hexane/2-propanol = 70/30, flow rate = 1.0 mL/min, \(\lambda = 254\) nm, retention time: 6.03 min, 7.35 min.

\(^1\)H NMR (400 MHz, CDCl\textsubscript{3}) \(\delta\) 7.52 (d, \(J = 8.8\) Hz, 2H), 7.22-7.16 (dd, \(J = 8.1, 6.2\) m, 2H), 7.15 – 7.08 (m, 3H), 6.99 – 6.88 (m, 2H), 6.44 (d, \(J = 4.0\) Hz, 1H), 5.86 (d, \(J = 4.0\) Hz, 1H), 4.31 (d, \(J = 8.0\) Hz, 2H), 3.81 (s, 3H), 3.57 (s, 3H), 3.20 – 3.05 (m, 1H), 2.57 – 2.33 (m, 2H), 1.03 – 0.91 (m, 21H).

\(^{13}\)C NMR (101 MHz, CDCl\textsubscript{3}) \(\delta\) 194.43, 163.56, 159.82, 139.81, 139.08, 132.02, 130.41, 128.79, 128.36, 127.54, 126.05, 117.28, 114.30, 110.75, 64.08, 55.63, 52.92, 49.42, 45.53, 38.47, 17.91, 12.94. HRMS (ESI-TOF) calcd for C\textsubscript{33}H\textsubscript{43}NO\textsubscript{7}SSi ([M+Na\textsuperscript{+}]) = 648.2422, Found 648.2418.
7. Copies of NMR spectra for the reaction products
Current Data Parameters

F1 – Acquisition Parameters
NAME: 2018-05-02T17:50:01
QUALNAME: .npl
TD: 52.98
Solvent: CDCl3
MH: 14
SG: undefined
RM: 252.1 g
AQ: undefined
MT: 25 C

--- CHANNEL F1 ---
WX: 1.6
F1: 1.68 g
AP: undefined
MP: undefined

F2 – Processing Parameters
F1: 6544.6
DC: 1.56
LB: 1.00 Hz
FP: 1.00 Hz
FT: 1.00 Hz
Phase: Manual
RA: 0.10
PHI: 0.05

Current Data Parameters

F2 – Acquisition Parameters
NAME: 2018-05-02T17:53:15
QUALNAME: .npl
TD: 52.76
Solvent: CDCl3
MH: 112
SG: undefined
RM: 203.9 g
AQ: undefined
MT: 25 C

--- CHANNEL F1 ---
WX: 1.6
F1: 1.68 g
AP: undefined
MP: undefined

F2 – Processing Parameters
F1: 6544.6
DC: 1.56
LB: 1.00 Hz
FP: 1.00 Hz
FT: 1.00 Hz
Phase: Manual
RA: 0.10
PHI: 0.05
8. NOESY spectra for the compound 5au
9. CD datas

3ba

3bb
3bg

[Graph showing circular dichroism vs. wavelength (nm) for 3bg]

3bh

[Graph showing circular dichroism vs. wavelength (nm) for 3bh]
3ca

3da
10. References