Supporting Information

Enantioselective Addition of Selenosulfonates to α,β-unsaturated Ketones

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Contents

I. General information .................................................................................................................................2
II. General procedure for the preparation of selenosulfonates. .................................................................2
III. General procedure for the preparation of vinyl ketones ........................................................................2
IV. Screening of the reaction conditions .....................................................................................................3
V. General procedure for the catalytic enantioselective addition ...............................................................4
VI. Substrate scope ......................................................................................................................................5
VII. Synthetic transformations .....................................................................................................................6
VIII. References ..........................................................................................................................................7
IX. $^1$H, $^{13}$C NMR, HRMS data and HPLC traces of compounds (4a-4p, 6a-6i, 7, 8, 9)..................8
X. $^1$H and $^{13}$C NMR spectra of compounds (4a-4p, 6a-6i, 7, 8, 9).....................................................22
XI. X-Ray Crystallographic Information (8) ............................................................................................50
I. General information

$^1$H and $^{13}$C NMR spectra were recorded on Agilent 400MR DD2 (400 MHz) spectrometer and Agilent 600MR DD2 (600 MHz) spectrometer. Chemical shifts were reported in parts per million (ppm), and tetramethylsilane or the residual solvent peak was used as an internal reference: $^1$H (tetramethylsilane $\delta = 0.00$), $^{13}$C (chloroform $\delta = 77.00$). Data are reported as follows: chemical shift, multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet, br = broad), coupling constants (Hz) and integration. Enantiomeric excesses (ee) were determined by HPLC analysis on Hitachi Chromaster using DAICEL CHIRALCEL AD-H, 4.6 mm $\varphi \times 250$ mmL, DAICEL CHIRALCEL OD-H, 4.6 mm $\varphi \times 250$ mmL and DAICEL CHIRALCEL OJ-H, 4.6 mm $\varphi \times 250$ mmL. High resolution mass spectra (HRMS) were performed on Bruker Solarix 7.0 T. X-ray crystallography analysis of single crystal was performed on a Agilent SuperNova-CCD X-Ray diffractometer. Optical Rotation was measured on a Rudolph Autopol I polarimeter. Melting points were measured using SGWX-4A Microscopic melting point meter and are uncorrected. Unless otherwise stated, all reagents were purchased from commercial suppliers and used without further purification.

II. General procedure for the preparation of selenosulfonates

This reaction was carried out according to a literature method.\(^1\) A suspension of PhSO$_2$Na (657 mg, 4.0 mmol) in CH$_2$Cl$_2$ (10 mL) containing diphenyl diselenide (312 mg, 1.0 mmol) was cooled at 0 °C and [bis(trifluoroacetoxoy)iodo]benzene (473 mg, 1.1 mmol) in CH$_2$Cl$_2$ (4 mL) was added dropwise. The mixture was stirred at room temperature for 3 h. Then, the reaction mixture was washed with H$_2$O, dried over anhydrous Na$_2$SO$_4$. The solvent CH$_2$Cl$_2$ was removed under reduced pressure and the residue was purified by a flash chromatography (SiO$_2$, PE/EA = 6:1) to yield the desired product (404 mg, 68%) as a yellow solid.

III. General procedure for the preparation of vinyl ketones

This reaction was carried out according to a literature method.\(^2\) The mixture of aldehyde (3 mmol) in dry THF (5 mL) was cooled to 0 °C in an ice-water bath and vinylmagnesium chloride (2.0 M solution in THF, 3.6 mmol) was added dropwise. The mixture was warmed to room temperature and stirred for overnight. Saturated NH$_4$Cl solution (20 mL) was added to quench the reaction and the aqueous layer was extracted with EA (15 mL $\times$ 3). The combined organic layers were washed with brine (20 mL $\times$ 1), dried over anhydrous Na$_2$SO$_4$ and concentrated. The residue was dissolved in CH$_2$Cl$_2$ (10 mL) and Dess-Martin periodinane (4.0 mmol) was added. The mixture was stirred at room temperature for overnight. The solvent was removed under reduced pressure and the residue was chromatographed on silica gel (PE/EA = 15:1) to get the desired product (75-88% yield for 2 steps). 3-Pridyl vinyl ketone and 2-furanyl vinyl ketone were prepared according to a literature method.\(^3\) The beta-substituted vinyl ketones were prepared according to the known method.\(^4\)
IV. Screening of the reaction conditions

Table 1. Equivalent of 2a screening

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<th>4a</th>
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V. General procedure for the catalytic enantioselective addition

A flame-dried Schlenk tube equipped with a magnetic stirring bar, was charged with Se-phenyl benzeneselenosulfonate 2 (0.20 mmol) and the catalyst 1e (6.30 mg, 10 mol%). Vinyl ketones 3 (0.10 mmol) was dissolved in CH₂Cl₂ (1.0 mL), and the solution was injected into the tube at 25 °C. After stirring for 1 hour, the mixture was purified by silica gel chromatography (PE/EA = 8/1) to afford the product 4. Racemic samples were prepared by using the same procedure with DABCO as catalyst.
A flame-dried Schlenk tube equipped with a magnetic stirring bar, was charged with Se-phenyl 4-methyl benzeneselenosulfonate 2b (0.20 mmol) and the catalyst 1e (6.30 mg, 10 mol%). Vinyl ketones 5 (0.10 mmol) was dissolved in CH₂Cl₂ (1.0 mL), and the solution was injected into the tube at 25 °C. After stirring for 24 h, the mixture was purified by silica gel chromatography (PE/EA = 10/1) to afford the product 6. Racemic samples were prepared by using the same procedure with DABCO as catalyst.

VI. Substrate scope

Table 6. Substrate scope 1

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<td>24</td>
<td>67</td>
<td>72</td>
</tr>
<tr>
<td>9</td>
<td>(CH₂)₂Ph</td>
<td>24</td>
<td>75</td>
<td>63</td>
</tr>
</tbody>
</table>

VII. Synthetic transformations

![Diagram](image)

4h: 65% yield, 96% ee after recrystallization  
[a]⁺D = -22.6

7: 90% yield, 98% ee  
d.r. > 20:1

This reaction was carried out according to a literature method.  
4h (50 mg, 0.1 mmol, 1.0 equiv.) and CeCl₃ (49.3 mg, 0.2 mmol, 2.0 equiv.) were weighed and added into an oven dried flask, evacuated and backfilled with nitrogen (3 times). Freshly distilled CH₃OH (1 mL) was introduced, and the resulting mixture was cooled down to 0 °C. NaBH₄ (7.6 mg, 0.2 mmol, 2.0 equiv.) solved in CH₃OH (0.5 mL) was added dropwise. The mixture was kept stirring for 5 minutes at 0 °C, quenched with H₂O, extracted with EA, concentrated under reduced pressure and purified by flash column chromatography (SiO₂, PE/EA = 6:1) to afford the product 7 as a white solid (45 mg, 0.09 mmol, 90%).
This reaction was carried out according to a literature method.\textsuperscript{6} To a stirred solution of 7 (50 mg, 0.1 mmol, 1.0 equiv.) in CH\textsubscript{2}Cl\textsubscript{2} was added 4-bromobenzoyl chloride (32.9 mg, 0.15 mmol, 1.5 equiv.) and DMAP (24.4 mg, 0.2 mmol, 2.0 equiv.) at 0 °C, Et\textsubscript{3}N (20.2 mg, 0.2 mmol, 2.0 equiv.) was added dropwise. The mixture was allowed to warm to r.t. and stirred for another 4 h. Diluted with EA, quenched with sat. NaHCO\textsubscript{3} aq. solution, extracted with EA, washed with brine dried over Na\textsubscript{2}SO\textsubscript{4} and filtered, concentrated under reduced pressure and purified by flash column chromatography (SiO\textsubscript{2}, PE/EA = 8:1) to afford the desired product 8 as a white solid (62.3 mg, 0.09 mmol, 91%).

This reaction was carried out according to a literature method.\textsuperscript{7} To a stirred solution of 8 (68.5 mg, 0.1 mmol, 1.0 equiv.) in CH\textsubscript{2}Cl\textsubscript{2} (1 mL) was added \textit{m}-CPBA (85\% purity; 40.6 mg, 0.2 mmol, 2.0 equiv.) at r.t. and with stirring. The resulting solution was stirred for 1 h and then ca. 0.5M-Na\textsubscript{2}S\textsubscript{2}O\textsubscript{3} (3 mL) was added followed by saturated aqueous NaHCO\textsubscript{3} (10 mL). The mixture was extracted with CH\textsubscript{2}Cl\textsubscript{2}, washed with brine dried over Na\textsubscript{2}SO\textsubscript{4} and filtered, concentrated under reduced pressure and purified by flash column chromatography (SiO\textsubscript{2}, PE/EA = 15:1) to afford the desired product 9 as a white solid (50.1 mg, 0.095 mmol, 95%).

\textbf{VIII. References}

IX. \textsuperscript{1}H, \textsuperscript{13}C NMR, HRMS data and HPLC traces of compounds (4a–4p, 6a–6i, 7, 8, 9)

(R)-1-phenyl-2-(phenylselanyl)-3-(phenylsulfonyl)propan-1-one (4a)

\textbf{\textsuperscript{1}H NMR} (600 MHz, CDCl\textsubscript{3}): $\delta$ 7.816 (d, $J = 7.8$ Hz, 2H), 7.751 (d, $J = 7.8$ Hz, 2H), 7.585 – 7.510 (m, 2H), 7.431 (t, $J = 7.5$ Hz, 2H), 7.411 – 7.336 (m, 5H), 7.288 – 7.238 (m, 2H), 5.046 (dd, $J = 10.5$, 2.1 Hz, 1H), 4.209 (dd, $J = 14.4$, 10.8 Hz, 1H), 3.685 (dd, $J = 14.1$, 2.1 Hz, 1H).

\textbf{\textsuperscript{13}C NMR} (150 MHz, CDCl\textsubscript{3}): $\delta$ 191.722, 138.762, 136.439, 134.790, 133.823, 133.343, 129.735, 129.411, 129.156, 128.566, 128.390, 128.110, 125.481, 58.157, 36.506.

HRMS (ESI) m/z Calcd for [C\textsubscript{21}H\textsubscript{18}O\textsubscript{3}SSeNa, M + Na]: 453.00344, Found: 453.00354.

HPLC analysis: Chiralcel OD-H (Hexane/i-PrOH = 85:15, flow rate = 1.0 mL/min, wave length = 254 nm), $t_R$ = 10.597 min (minor), $t_R$ = 11.498 min (major).

Optical Rotation: $[\alpha]_{D}^{25}$ = -5.7 (c = 1.0, CHCl\textsubscript{3}); physical properties: colorless liquid; Yield: 75%, 32.2 mg.

(R)-1-phenyl-2-(phenylselanyl)-3-tosylpropan-1-one (4b)

\textbf{\textsuperscript{1}H NMR} (400 MHz, CDCl\textsubscript{3}): $\delta$ 7.806 (d, $J = 7.2$ Hz, 2H), 7.614 (d, $J = 8.0$ Hz, 2H), 7.563 (t, $J = 7.4$ Hz, 1H), 7.428 (t, $J = 7.6$ Hz, 2H), 7.440 – 7.330 (m, 3H), 7.265 (t, $J = 7.6$ Hz, 2H), 7.164 (d, $J = 8.0$ Hz, 2H), 5.023 (dd, $J = 10.4$, 2.0 Hz, 1H), 4.188 (dd, $J = 14.0$, 10.8 Hz, 1H), 3.663 (dd, $J = 14.0$, 2.0 Hz, 1H), 2.349 (s, 3H).

\textbf{\textsuperscript{13}C NMR} (100 MHz, CDCl\textsubscript{3}): $\delta$ 191.759, 144.864, 136.440, 135.769, 134.856, 133.304, 129.774, 129.702, 129.400, 128.515, 128.390, 128.187, 125.575, 58.309, 36.588, 21.542.

HRMS (ESI) m/z Calcd for [C\textsubscript{22}H\textsubscript{20}O\textsubscript{3}SSeNa, M + Na]: 467.01909, Found: 467.01922.

HPLC analysis: Chiralcel AD-H (Hexane/i-PrOH = 80:20, flow rate = 1.0 mL/min, wave length = 254 nm), $t_R$ = 17.533 min (minor), $t_R$ = 18.795 min (major).

Optical Rotation: $[\alpha]_{D}^{20}$ = -15.8 (c = 1.0, CHCl\textsubscript{3}); physical properties: white solid; m.p. 97–98\textdegree C; yield: 80%, 35.5 mg.
(R)-3-((4-chlorophenyl)sulfonyl)-1-phenyl-2-(phenylselanyl) propan-1-one (4c)

\[ \text{R} \rightarrow 3-((4\text{-chlorophenyl})\text{sulfonyl})-1\text{-phenyl}-2\text{-(phenylselanyl)} \text{propan-1-one (4c)} \]

\[^1\text{H NMR} (400 MHz, CDCl}_3): \delta 7.814 (d, J = 7.2 \text{ Hz}, 2H), 7.653 (d, J = 8.4 \text{ Hz}, 2H), 7.577 (t, J = 7.4 \text{ Hz}, 1H), 7.443 (t, J = 7.6 \text{ Hz}, 2H), 7.410 – 7.302 (m, 5H), 7.301 – 7.233 (m, 2H), 5.019 (dd, J = 10.8, 2.0 \text{ Hz}, 1H), 4.194 (dd, J = 14.0, 10.8 \text{ Hz}, 1H), 3.689 (dd, J = 14.2, 2.2 \text{ Hz}, 1H).

\[^1\text{C NMR} (100 MHz, CDCl}_3): \delta 191.656, 140.614, 137.211, 136.510, 134.663, 133.488, 129.836, 129.636, 129.439, 128.627, 128.344, 125.327, 58.328, 36.437.

HRMS (ESI) m/z Calcd for [C\(_{21}\)H\(_{17}\)ClO\(_3\)SSeNa, M + Na\]^+: 486.96422, Found: 486.96433.

HPLC analysis: Chiralcel OD-H (Hexane/i-PrOH = 80:20, flow rate = 1.0 mL/min, wave length = 254 nm), \( t_R = 9.947 \text{ min (minor)}, t_R = 11.020 \text{ min (major)}. \)

Optical Rotation: \([\alpha]^{20}_D = -15.0 \text{ (c = 1.0, CHCl}_3). \) Physical properties: colorless liquid; Yield: 79\%, 36.6 mg.

(r)-1-(4-fluorophenyl)-2-(phenylselanyl)-3-tosylpropan-1-one (4d)

\[ \text{R} \rightarrow 1-(4\text{-fluorophenyl})-2\text{-(phenylselanyl)-3-tosylpropan-1-one (4d)} \]

\[^1\text{H NMR} (400 MHz, CDCl}_3): \delta 7.834 (dd, J = 8.6, 5.4 \text{ Hz}, 2H), 7.622 (d, J = 8.0 \text{ Hz}, 2H), 7.414 – 7.322 (m, 3H), 7.300 – 7.235 (m, 2H), 7.194 (d, J = 8.0 \text{ Hz}, 2H), 7.099 (t, J = 8.6 \text{ Hz}, 2H), 4.981 (dd, J = 10.4, 2.0 \text{ Hz}, 1H), 4.184 (dd, J = 14.0, 10.8 \text{ Hz}, 1H), 3.659 (dd, J = 14.0, 2.0 \text{ Hz}, 1H), 2.368 (s, 3H).

\[^1\text{C NMR} (100 MHz, CDCl}_3): \delta 190.471, 165.813 (d, J_{C-F} = 254.0 \text{ Hz}), 144.944, 136.408, 135.847, 131.285 (d, J_{C-F} = 2.9 \text{ Hz}), 131.072 (d, J_{C-F} = 9.3 \text{ Hz}), 129.806, 129.782, 129.461, 128.167, 125.576, 115.693 (d, J_{C-F} = 21.8 \text{ Hz}), 58.320, 36.571, 21.561.

HRMS (ESI) m/z Calcd for [C\(_{22}\)H\(_{19}\)FO\(_3\)SSeNa, M + Na\]^+: 485.00967, Found: 485.00953.

HPLC analysis: Chiralcel OD-H (Hexane/i-PrOH = 80:20, flow rate = 1.0 mL/min, wave length = 254 nm), \( t_R = 11.210 \text{ min (minor)}, t_R = 16.071 \text{ min (major)}. \)

Optical Rotation: \([\alpha]^{20}_D = -33.2 \text{ (c = 1.0, CHCl}_3); \) physical properties: white solid; m.p. 91–92 °C; yield: 73\%, 33.7 mg.
(R)-1-(4-chlorophenyl)-2-(phenylselanyl)-3-tosylpropan-1-one (4e)

\[
\text{\textsuperscript{1}H NMR (400 MHz, CDCl}_3\text{): } \delta 7.749 (d, J = 8.4 \text{ Hz}, 2H), 7.621 (d, J = 8.0 \text{ Hz}, 2H), 7.439 – 7.365 (m, 3H), 7.350 (d, J = 8.0 \text{ Hz}, 2H), 7.268 (t, J = 7.6 \text{ Hz}, 2H), 7.195 (d, J = 8.0 \text{ Hz}, 2H), 4.963 (dd, J = 10.6, 1.8 \text{ Hz}, 1H), 4.165 (dd, J = 13.8, 11.0 \text{ Hz}, 1H), 3.667 (dd, J = 14.0, 1.6 \text{ Hz}, 1H), 2.365 (s, 3H).
\]

\text{\textsuperscript{13}C NMR (100 MHz, CDCl}_3\text{): } \delta 190.653, 144.956, 139.733, 136.430, 135.805, 133.253, 129.816, 129.805, 135.805, 133.253, 129.784, 129.460, 128.844, 128.131, 125.434, 58.236, 36.605, 21.549.

HRMS (ESI) m/z Calcd for [C\textsubscript{22}H\textsubscript{19}ClO\textsubscript{3}SSeNa, M + Na\textsuperscript{+}]: 500.97988, Found: 500.97973.

HPLC analysis: Chiralcel OD-H (Hexane/i-PrOH = 80:20, flow rate = 1.0 mL/min, wave length = 254 nm), \( t_R = 10.325 \text{ min (minor)}, \ t_R = 17.196 \text{ min (major)}. \)

Optical Rotation: \([\alpha]_{20}^D = -16.3 \text{ (c = 1.0, CHCl}_3\text{); physical properties: white solid; m.p. 92–93 °C; yield: 67\%, 32 mg.}\]

(–)-1-(4-bromophenyl)-2-(phenylselanyl)-3-tosylpropan-1-one (4f)

\[
\text{\textsuperscript{1}H NMR (400 MHz, CDCl}_3\text{): } \delta 7.670 (d, J = 8.4 \text{ Hz}, 2H), 7.620 (d, J = 8.0 \text{ Hz}, 2H), 7.570 (d, J = 8.8 \text{ Hz}, 2H), 7.41 – 7.320 (m, 3H), 7.300 – 7.245 (m, 2H), 7.198 (d, J = 8.0 \text{ Hz}, 2H), 4.953 (dd, J = 10.6, 2.0 \text{ Hz}, 1H), 4.163 (dd, J = 14.0, 10.8 \text{ Hz}, 1H), 3.662 (dd, J = 14.0, 2.0 Hz, 1H), 2.370 (s, 3H).
\]

\text{\textsuperscript{13}C NMR (100 MHz, CDCl}_3\text{): } \delta 190.842, 144.973, 136.442, 135.815, 131.848, 129.877, 129.833, 129.476, 128.474, 128.138, 125.432, 58.237, 36.605, 21.564.

HRMS (ESI) m/z Calcd for [C\textsubscript{22}H\textsubscript{19}BrO\textsubscript{3}SSeNa, M + Na\textsuperscript{+}]: 544.92933, Found: 544.92945.

HPLC analysis: Chiralcel OD-H (Hexane/i-PrOH = 80:20, flow rate = 1.0 mL/min, wave length = 254 nm), \( t_R = 12.498 \text{ min (minor)}, \ t_R = 21.803 \text{ min (major)}. \)

Optical Rotation: \([\alpha]_{20}^D = -10.7 \text{ (c = 1.0, CHCl}_3\text{); physical properties: white solid; m.p. 99–101 °C; yield: 71\%, 37.2 mg.}\]
**(R)-2-(phenylselanyl)-1-(m-tolyl)-3-tosylpropan-1-one (4g)**

\[\text{R} \rightarrow 2-(\text{phenylselanyl})-1-\text{(m-tolyl)}-3\text{-tosylpropan-1-one (4g)}\]

**\(^1\)H NMR** (400 MHz, CDCl\(_3\)): \(\delta\) 7.618 (d, \(J = 8.0\) Hz, 3H), 7.571 (s, 1H), 7.433 – 7.349 (m, 4H), 7.328 (d, \(J = 7.6\) Hz, 1H), 7.306 – 7.260 (m, 2H), 7.177 (d, \(J = 8.0\) Hz, 2H), 5.008 (d, \(J = 10.4\) Hz, 1H), 4.174 (dd, \(J = 14.0, 10.8\) Hz, 1H), 3.661 (d, \(J = 14.0\) Hz, 1H), 2.382 (s, 3H), 2.362 (s, 3H).

**\(^{13}\)C NMR** (100 MHz, CDCl\(_3\)): \(\delta\) 191.982, 144.851, 138.326, 136.485, 135.795, 134.837, 134.126, 129.772, 129.689, 129.381, 128.981, 128.395, 128.196, 125.700, 125.592, 58.292, 36.638, 21.566, 21.335.

**HRMS (ESI)** m/z Calcd for [\(\text{C}_{23}\text{H}_{22}\text{O}_3\text{SSeNa, M + Na}^+\)]+: 481.03475, Found: 481.03463.

**HPLC analysis**: Chiralcel OD-H (Hexane/i-PrOH = 80:20, flow rate = 1.0 mL/min, wave length = 254 nm), \(t_R = 9.281\) min (minor), \(t_R = 11.939\) min (major).

**Optical Rotation**: \([\alpha]^{20}_{D} = -25.4\) (c = 1.0, CHCl\(_3\)); **physical properties**: white solid; m.p. 92–93 °C; yield: 66%, 30.2 mg.

---

**(R)-1-(4-(tert-butyl)phenyl)-2-(phenylselanyl)-3-tosylpropan-1-one (4h).**

\[\text{R} \rightarrow 1-(4-\text{(tert-butyl)phenyl})-2-(\text{phenylselanyl})-3\text{-tosylpropan-1-one (4h)}\]

**\(^1\)H NMR** (400 MHz, CDCl\(_3\)): \(\delta\) 7.749 (d, \(J = 8.0\) Hz, 2H), 7.610 (d, \(J = 8.0\) Hz, 2H), 7.434 (d, \(J = 8.4\) Hz, 2H), 7.368 (t, \(J = 8.0\) Hz, 3H), 7.261 (t, \(J = 7.6\) Hz, 2H), 7.155 (d, \(J = 8.0\) Hz, 2H), 5.015 (dd, \(J = 10.4, 1.6\) Hz, 1H), 4.191 (dd, \(J = 14.0, 10.8\) Hz, 1H), 3.640 (dd, \(J = 14.0, 2.0\) Hz, 1H), 2.348 (s, 3H), 1.355 (s, 9H).


**HRMS (ESI)** m/z Calcd for [\(\text{C}_{26}\text{H}_{28}\text{O}_3\text{SSeNa, M + Na}^+\)]+: 523.08174, Found: 523.08188.

**HPLC analysis**: Chiralcel AD-H (Hexane/i-PrOH = 80:20, flow rate = 1.0 mL/min, wave length = 254 nm), \(t_R = 15.069\) min (minor), \(t_R = 17.093\) min (major).

**Optical Rotation**: \([\alpha]^{20}_{D} = -15.5\) (c = 1.0, CHCl\(_3\)); **physical properties**: white solid; m.p. 137–138 ºC; yield: 78%, 38.9 mg.
(R)-1-(4-isopropylphenyl)-2-(phenylselanyl)-3-tosylpropan-1-one (4i)

\[
\begin{align*}
\text{IR} & \quad 1679 (s, \text{C=O}), 1566 (s, \text{Ar}), 1497 (s, \text{Ar}), 1388 (s, \text{Ar}), 1288 (s, \text{Ar}), 1153 (s, \text{Ar}), 1028 (m, \text{Ar}) \\
\text{MS} & \quad m/z \text{ Calcd for } [\text{C}_{25}H_{26}O_{3}SSeNa, M + Na]^+ : 509.06608, \text{ Found: } 509.06627.
\end{align*}
\]

1H NMR (400 MHz, CDCl3): \( \delta \) 7.742 (d, \( J = 8.0 \) Hz, 2H), 7.607 (d, \( J = 8.4 \) Hz, 2H), 7.415 – 7.315 (m, 3H), 7.305 – 7.224 (m, 4H), 7.153 (d, \( J = 8.0 \) Hz, 2H), 5.008 (dd, \( J = 10.6, 2.2 \) Hz, 1H), 4.185 (dd, \( J = 14.2, 10.6 \) Hz, 1H), 3.645 (dd, \( J = 14.0, 2.0 \) Hz, 1H), 2.972 (dp, \( J = 13.6, 7.0 \) Hz, 1H), 2.343 (s, 3H), 1.290 (s, 3H), 1.273 (s, 3H).


HRMS (ESI) m/z Calcd for [C_{25}H_{26}O_{3}SSeNa, M + Na]^+: 509.06608, Found: 509.06627.

HPLC analysis: Chiralcel OD-H (Hexane/i-PrOH = 80:20, flow rate = 1.0 mL/min, wave length = 254 nm), \( t_R = 9.754 \) min (minor), \( t_R = 11.302 \) min (major).

Optical Rotation: \( \left[ \alpha \right]_{D}^{20} = -7.6 \) (c = 1.0, CHCl3); physical properties: white solid; m.p. 102–103°C; yield: 76%, 36.7 mg.

(R)-2-(phenylselanyl)-1-(p-tolyl)-3-tosylpropan-1-one (4j)

\[
\begin{align*}
\text{IR} & \quad 1679 (s, \text{C=O}), 1566 (s, \text{Ar}), 1497 (s, \text{Ar}), 1388 (s, \text{Ar}), 1288 (s, \text{Ar}), 1153 (s, \text{Ar}), 1028 (m, \text{Ar}) \\
\text{MS} & \quad m/z \text{ Calcd for } [\text{C}_{23}H_{22}O_{3}SSeNa, M + Na]^+ : 481.03475, \text{ Found: } 481.03486.
\end{align*}
\]

1H NMR (400 MHz, CDCl3): \( \delta \) 7.710 (d, \( J = 8.0 \) Hz, 2H), 7.607 (d, \( J = 8.4 \) Hz, 2H), 7.408 – 7.321 (m, 3H), 7.273 (d, \( J = 7.6 \) Hz, 2H), 7.229 (d, \( J = 8.2 \) Hz, 2H), 7.166 (d, \( J = 8.4 \) Hz, 2H), 5.003 (dd, \( J = 10.6, 2.2 \) Hz, 1H), 4.185 (dd, \( J = 14.0, 10.8 \) Hz, 1H), 3.640 (dd, \( J = 14.0, 2.0 \) Hz, 1H), 2.426 (s, 3H), 2.353 (s, 3H).


HRMS (ESI) m/z Calcd for [C_{23}H_{22}O_{3}SSeNa, M + Na]^+: 481.03475, Found: 481.03486.

HPLC analysis: Chiralcel OD-H (Hexane/i-PrOH = 80:20, flow rate = 1.0 mL/min, wave length = 254 nm), \( t_R = 10.253 \) min (minor), \( t_R = 11.399 \) min (major).

Optical Rotation: \( \left[ \alpha \right]_{D}^{20} = -17.8 \) (c = 1.0, CHCl3); physical properties: white solid; m.p. 115–116°C; yield: 57%, 26.0 mg.
(R)-1-(4-methoxyphenyl)-2-(phenylselanyl)-3-tosylpropan-1-one (4k)

\[ \text{H NMR (400 MHz, CDCl}_3\): } \delta 7.782 (d, J = 8.8 Hz, 2H), 7.602 (d, J = 8.0 Hz, 2H), 7.416 – 7.319 (m, 3H), 7.262 (t, J = 7.6 Hz, 2H), 7.164 (d, J = 8.0 Hz, 2H), 6.898 (d, J = 8.8 Hz, 2H), 4.991 (dd, J = 10.4, 2.0 Hz, 1H), 4.212 (dd, J = 14.0, 10.8 Hz, 1H), 3.876 (s, 3H), 3.629 (dd, J = 14.2, 2.2 Hz, 1H), 2.352 (s, 3H). 

\[ \text{C NMR (100 MHz, CDCl}_3\): } \delta 190.552, 163.720, 144.765, 136.277, 135.799, 130.716, 129.702, 129.543, 129.357, 128.186, 127.654, 125.890, 113.721, 58.370, 55.487, 36.346, 21.537. 

HRMS (ESI) m/z Calcd for [C\(_{23}\)H\(_{22}\)O\(_4\)SSeNa, M + Na\]^+\: 497.02967, Found: 497.02951.

HPLC analysis: Chiralcel AD-H (Hexane/i-PrOH = 80:20, flow rate = 1.0 mL/min, wave length = 254 nm), \( t_R = 30.227 \) min (minor), \( t_R = 35.064 \) min (major).

Optical Rotation: [\( \alpha \)]\(_{20}^\text{D}\) = +32 (c = 1.0, CHCl\(_3\)); physical properties: white solid; m.p. 95–96°C; yield: 78%, 36.9 mg.

(R)-1-(3-methoxyphenyl)-2-(phenylselanyl)-3-tosylpropan-1-one (4l)

\[ \text{H NMR (400 MHz, CDCl}_3\): } \delta 7.617 (d, J = 8.0 Hz, 2H), 7.432 – 7.345 (m, 4H), 7.318 (d, J = 8.0 Hz, 2H), 7.290 – 7.230 (m, 2H), 7.172 (d, J = 8.0 Hz, 2H), 7.132 – 7.073 (m, 1H), 4.987 (dd, J = 10.8, 2.0 Hz, 1H), 4.180 (dd, J = 14.0, 10.8 Hz, 1H), 3.805 (s, 3H), 3.661 (dd, J = 14.0, 2.0 Hz, 1H), 2.349 (s, 3H). 

\[ \text{C NMR (100 MHz, CDCl}_3\): } \delta 191.556, 159.696, 144.819, 136.360, 136.178, 135.719, 130.741, 129.640, 129.458, 129.352, 128.135, 125.636, 120.751, 119.768, 112.837, 58.282, 55.329, 36.712, 21.492. 

HRMS (ESI) m/z Calcd for [C\(_{23}\)H\(_{22}\)O\(_4\)SSeNa, M + Na\]^+\: 497.02967, Found: 497.02985.

HPLC analysis: Chiralcel OD-H (Hexane/i-PrOH = 80:20, flow rate = 1.0 mL/min, wave length = 254 nm), \( t_R = 11.865 \) min (minor), \( t_R = 14.183 \) min (major).

Optical Rotation: [\( \alpha \)]\(_{20}^\text{D}\) = -10 (c = 1.0, CHCl\(_3\)); physical properties: white solid; m.p. 99–100°C; yield: 87%, 41.3 mg.
(R)-1-(2-methoxyphenyl)-2-(phenylselanyl)-3-tosylpropan-1-one (4m)

$^1$H NMR (400 MHz, CDCl$_3$): $\delta$ 7.699 (dd, $J$ = 7.8, 1.4 Hz, 1H), 7.665 (d, $J$ = 8.0 Hz, 2H), 7.519 – 7.451 (m, 1H), 7.396 – 7.300 (m, 3H), 7.266 – 7.217 (m, 2H), 7.185 (d, $J$ = 8.0 Hz, 2H), 6.999 (t, $J$ = 7.4 Hz, 1H), 6.945 (d, $J$ = 8.4 Hz, 1H), 5.387 (dd, $J$ = 10.2, 6.5 Hz, 1H), 4.072 (dd, $J$ = 14.2, 10.2 Hz, 1H), 3.871 (s, 3H), 3.559 (dd, $J$ = 14.2, 2.6 Hz, 1H), 2.354 (s, 3H).

$^{13}$C NMR (100 MHz, CDCl$_3$): $\delta$ 191.406, 158.449, 144.635, 136.442, 136.001, 134.248, 132.012, 129.641, 129.330, 129.115, 128.265, 125.483, 124.674, 120.727, 111.623, 57.726, 55.595, 41.118, 21.547.

HRMS (ESI) m/z Calcd for [C$_{23}$H$_{22}$O$_4$SSeNa, M + Na]$^+$: 497.02967, Found: 497.02977.

HPLC analysis: Chiralcel OD-H (Hexane/i-PrOH = 80:20, flow rate = 1.0 mL/min, wave length = 254 nm), $t_R$ = 13.252 min (minor), $t_R$ = 14.499 min (major).

Optical Rotation: $[\alpha]_{D}^{20}$ = +45 (c = 1.0, CHCl$_3$); physical properties: white solid; m.p. 106–108 °C; yield: 66%, 31.2 mg.

(R)-1-(2-bromophenyl)-2-(phenylselanyl)-3-tosylpropan-1-one (4n)

$^1$H NMR (400 MHz, CDCl$_3$): $\delta$ 7.747 (d, $J$ = 8.4 Hz, 2H), 7.661 – 7.579 (m, 2H), 7.410 (d, $J$ = 7.6 Hz, 2H), 7.365 – 7.258 (m, 5H), 7.216 (t, $J$ = 7.4 Hz, 2H), 4.990 (dd, $J$ = 9.6, 3.2 Hz, 1H), 4.113 (dd, $J$ = 14.4, 9.6 Hz, 1H), 3.612 (dd, $J$ = 14.2, 3.4 Hz, 1H), 2.399 (s, 3H).


HRMS (ESI) m/z Calcd for [C$_{22}$H$_{19}$BrO$_3$SSeNa, M + Na]$^+$: 544.92933, Found: 544.92954.

HPLC analysis: Chiralcel AD-H (Hexane/i-PrOH = 80:20, flow rate = 1.0 mL/min, wave length = 254 nm), $t_R$ = 24.183 min (major), $t_R$ = 39.971 min (minor).

Optical Rotation: $[\alpha]_{D}^{20}$ = -25.2 (c = 1.0, CHCl$_3$); physical properties: white solid; m.p. 97–98 °C; yield: 75%, 39.3 mg.
(R)-2-(phenylselanyl)-1-(pyridin-3-yl)-3-tosylpropan-1-one (4o)

\[ \delta 9.016 (s, 1H), 8.772 (d, J = 4.8 Hz, 1H), 8.095 (d, J = 8.0 Hz, 1H), 7.642 (d, J = 8.4 Hz, 2H), 7.427 - 7.318 (m, 4H), 7.272 (t, J = 7.4 Hz, 2H), 7.216 (d, J = 8.0 Hz, 2H), 4.952 (d, J = 10.8 Hz, 1H), 4.191 (dd, J = 13.8, 11.0 Hz, 1H), 3.694 (dd, J = 10.0, 1.6 Hz, 1H), 2.375 (s, 3H). \]

HRMS (ESI) m/z Calcd for \([C_{21}H_{19}NO_{3}SSeNa, M + Na]^+\): 468.01433, Found: 468.01421.

HPLC analysis: Chiralcel OD-H (Hexane/i-PrOH = 80:20, flow rate = 1.0 mL/min, wave length = 254 nm), \( t_R = 19.319 \) min (minor), \( t_R = 24.279 \) min (major).

Optical Rotation: \([\alpha]_{20}^D = +11.9 \) (c = 1.0, CHCl\(_3\)); physical properties: white solid; m.p. 97–98°C; yield: 70%, 31.1 mg.

(R)-1-(furan-2-yl)-2-(phenylselanyl)-3-tosylpropan-1-one (4p)

\[ \delta 7.630 (d, J = 8.0 Hz, 2H), 7.541 (s, 1H), 7.410 (d, J = 7.2 Hz, 2H), 7.361 (t, J = 7.2 Hz, 1H), 7.258 (t, J = 7.4 Hz, 2H), 7.198 (d, J = 7.6 Hz, 2H), 7.087 (d, J = 2.8 Hz, 1H), 6.522 (s, 1H), 4.852 (d, J = 10.4 Hz, 1H), 4.071 (dd, J = 13.8, 11.4 Hz, 1H), 3.570 (d, J = 14.0 Hz, 1H), 2.360 (s, 3H). \]

HRMS (ESI) m/z Calcd for \([C_{20}H_{18}O_4SSeNa, M + Na]^+\): 456.99835, Found: 456.99817.

HPLC analysis: Chiralcel OD-H (Hexane/i-PrOH = 80:20 flow rate = 1.0 mL/min, wave length = 254 nm), \( t_R = 12.883 \) min (minor), \( t_R = 21.454 \) min (major).

Optical Rotation: \([\alpha]_{20}^D = +25.5 \) (c = 1.0, CHCl\(_3\)); physical properties: white solid; m.p. 101–103°C; yield: 81%, 35.1 mg.
(R)-2-(phenylselanyl)-1-tosylhexan-3-one (6a)

\[ ^1H \text{ NMR} \ (400 \text{ MHz, CDCl}_3): \delta \ 7.688 \ (d, J = 8.0 \text{ Hz}, 2H), 7.450 – 7.378 \ (m, 2H), 7.361 \ (d, J = 7.6 \text{ Hz}, 1H), 7.335 – 7.255 \ (m, 4H), 4.124 \ (d, J = 10.8 \text{ Hz}, 1H), 3.960 \ (dd, J = 13.6, 10.8 \text{ Hz}, 1H), 3.449 \ (dd, J = 14.0, 2.0 \text{ Hz}, 1H), 2.833 – 2.727 \ (m, 1H), 2.540 – 2.455 \ (m, 1H), 2.431 \ (s, 3H), 1.640 – 1.530 \ (m, 2H), 0.916 \ (t, J = 7.4 \text{ Hz}, 3H). \]

\[ ^13C \text{ NMR} \ (100 \text{ MHz, CDCl}_3): \delta \ 202.203, 144.966, 136.256, 129.899, 129.533, 129.463, 128.045, 125.548, 57.651, 42.682, 41.131, 21.627, 17.283, 13.654. \]

HRMS (ESI) m/z Calcd for [C\(_{19}\)H\(_{22}\)O\(_3\)SSeNa, M + Na\]^+: 433.03472, Found: 433.03451.

HPLC analysis: Chiralcel OD-H (Hexane/i-PrOH = 85:15 flow rate = 1.0 mL/min, wave length = 210 nm), \( t_R \) = 9.350 min (minor), \( t_R \) = 10.523 min (major).

Optical Rotation: \([\alpha]^{20}_D = -85.2 \ (c = 1.0, \text{ CHCl}_3); \) physical properties: white solid; m.p. 73–74 \(^\circ\text{C};\) yield: 52%, 21.1 mg.

(\(R\))-2-(phenylselanyl)-1-tosylheptan-3-one (6b)

\[ ^1H \text{ NMR} \ (400 \text{ MHz, CDCl}_3): \delta \ 7.688 \ (d, J = 8.0 \text{ Hz}, 2H), 7.440 – 7.391 \ (m, 2H), 7.390 – 7.345 \ (m, 1H), 7.344 – 7.265 \ (m, 4H), 4.123 \ (dd, J = 10.6, 2.2 \text{ Hz}, 1H), 3.946 \ (dd, J = 14.0, 10.8 \text{ Hz}, 1H), 3.453 \ (dd, J = 14.0, 2.0 \text{ Hz}, 1H), 2.865 – 2.765 \ (m, 1H), 2.528 – 2.456 \ (m, 1H), 2.434 \ (s, 3H), 1.564 – 1.465 \ (m, 2H), 1.360 – 1.265 \ (m, 2H), 0.906 \ (t, J = 7.2 \text{ Hz}, 3H). \]

\[ ^13C \text{ NMR} \ (100 \text{ MHz, CDCl}_3): \delta \ 202.268, 144.984, 136.129, 136.025, 129.885, 129.570, 129.441, 128.030, 125.320, 57.517, 40.978, 40.449, 25.852, 22.171, 21.646, 13.861. \]

HRMS (ESI) m/z Calcd for [C\(_{20}\)H\(_{24}\)O\(_3\)SSeNa, M + Na\]^+: 447.05038, Found: 447.05049.

HPLC analysis: Chiralcel OD-H (Hexane/i-PrOH = 85:15 flow rate = 1.0 mL/min, wave length = 210 nm), \( t_R \) = 8.863 min (minor), \( t_R \) = 9.957 min (major).

Optical Rotation: \([\alpha]^{20}_D = -103 \ (c = 1.0, \text{ CHCl}_3); \) physical properties: white solid; m.p. 51–52 \(^\circ\text{C};\) yield: 57%, 24.1 mg.
\[(\mathcal{R})-2\text{-}(\text{phenylselanyl})\text{-}1\text{-}\text{tosyloctan-3-one } (6c)\]

\[1^H \text{NMR} (400 \text{ MHz, CDCl}_3): \delta 7.686 (d, J = 8.0 \text{ Hz}, 2H), 7.450 - 7.385 (m, 2H), 7.360 (d, J = 7.6 \text{ Hz}, 1H), 7.337 - 7.262 (m, 4H), 4.128 (dd, J = 10.4, 2.0 \text{ Hz}, 1H), 3.962 (dd, J = 14.0, 10.8 \text{ Hz}, 1H), 3.449 (dd, J = 14.0, 1.6 \text{ Hz}, 1H), 2.846 - 2.739 (m, 1H), 2.529 - 2.448 (m, 1H), 2.428 (s, 3H), 1.581 - 1.477 (m, 2H), 1.347 - 1.223 (m, 4H), 0.896 (t, J = 6.8 \text{ Hz}, 3H).

\[1^3C \text{NMR} (100 \text{ MHz, CDCl}_3): \delta 202.328, 144.938, 136.201, 136.035, 129.880, 129.519, 129.446, 128.041, 125.531, 57.611, 41.133, 40.746, 31.210, 23.465, 21.613, 13.901.

HRMS (ESI) m/z Calcd for [C_{21}H_{26}O_3SSeNa, M + Na]^+: 461.06604, Found: 461.06619.

HPLC analysis: Chiralcel AD-H (Hexane/i-PrOH = 80:20 flow rate = 1.0 mL/min, wave length = 210 nm), t\(_R\) = 10.029 min (major), t\(_R\) = 11.578 min (minor).

Optical Rotation: \([\alpha]_{D}^{20} = -83.8 \text{ (c = 1.0, CHCl}_3); \text{ physical properties: white solid; m.p. 59-60 °C; yield: 73%, 32.1 mg.}

\[(\mathcal{R})-2\text{-}(\text{phenylselanyl})\text{-}1\text{-}\text{tosynonan-3-one } (6d)\]

\[1^H \text{NMR} (400 \text{ MHz, CDCl}_3): \delta 7.685 (d, J = 8.0 \text{ Hz}, 2H), 7.443 - 7.380 (m, 2H), 7.359 (d, J = 7.6 \text{ Hz}, 1H), 7.335 - 7.262 (m, 4H), 4.127 (dd, J = 10.8, 2.0 \text{ Hz}, 1H), 3.959 (dd, J = 13.8, 10.6 \text{ Hz}, 1H), 3.447 (dd, J = 14.0, 2.0 \text{ Hz}, 1H), 2.843 - 2.738 (m, 1H), 2.531 - 2.445 (m, 1H), 2.428 (s, 3H), 1.575 - 1.475 (m, 2H), 1.331 - 1.235 (m, 6H), 0.891 (t, J = 6.8 \text{ Hz}, 3H).


HRMS (ESI) m/z Calcd for [C_{22}H_{28}O_3SSeNa, M + Na]^+: 475.08169, Found: 475.08143.

HPLC analysis: Chiralcel OD-H (Hexane/i-PrOH = 80:20 flow rate = 1.0 mL/min, wave length = 210 nm), t\(_R\) = 6.855 min (minor), t\(_R\) = 7.553 min (major).

Optical Rotation: \([\alpha]_{D}^{20} = -77.3 \text{ (c = 1.0, CHCl}_3); \text{ physical properties: white solid; m.p. 53-54 °C; yield: 69%, 31 mg.}
(R)-2-(phenylselanyl)-1-tosylecan-3-one (6e)

1H NMR (400 MHz, CDCl3): δ 7.688 (d, J = 8.4 Hz, 2H), 7.445 – 7.388 (m, 2H), 7.368 (d, J = 7.2 Hz, 1H), 7.344 – 7.265 (m, 4H), 4.122 (dd, J = 10.6, 2.2 Hz, 1H), 3.948 (dd, J = 13.6, 10.8 Hz, 1H), 3.454 (dd, J = 14.0, 2.4 Hz, 1H), 2.853 – 2.752 (m, 1H), 2.530 – 2.450 (m, 1H), 2.434 (s, 3H), 1.570 – 1.475 (m, 2H), 1.333 – 1.210 (m, 8H), 0.891 (t, J = 6.6 Hz, 3H).


HPLC analysis: Chiralcel OD-H (Hexane/i-PrOH = 85:15 flow rate = 1.0 mL/min, wave length = 210 nm), tR = 8.163 min (minor), tR = 9.073 min (major).

Optical Rotation: [α]20D = -106.5 (c = 1.0, CHCl3); physical properties: white solid; m.p. 67–68°C; yield: 61%, 28.2 mg.

(R)-2-(phenylselanyl)-1-tosylundecan-3-one (6f)

1H NMR (400 MHz, CDCl3): δ 7.687 (d, J = 8.0 Hz, 2H), 7.447 – 7.388 (m, 2H), 7.392 – 7.346 (m, 1H), 7.345 – 7.264 (m, 4H), 4.121 (dd, J = 10.6, 2.2 Hz, 1H), 3.946 (dd, J = 13.8, 10.6 Hz, 1H), 3.453 (dd, J = 14.0, 2.4 Hz, 1H), 2.855 – 2.755 (m, 1H), 2.528 – 2.445 (m, 1H), 2.435 (s, 3H), 1.564 – 1.468 (m, 2H), 1.353 – 1.216 (m, 10H), 0.888 (t, J = 6.8 Hz, 3H).


HPLC analysis: Chiralcel OD-H (Hexane/i-PrOH = 85:15 flow rate = 1.0 mL/min, wave length = 210 nm), tR = 7.650 min (minor), tR = 8.560 min (major).

Optical Rotation: [α]20D = -76 (c = 1.0, CHCl3); physical properties: white solid; m.p. 57–58°C; yield: 58%, 27.7 mg.
(R)-2-(phenylselanyl)-1-tosyldodecan-3-one (6g)

\[ \text{Ts} \text{SePh} \]

**1H NMR** (400 MHz, CDCl₃): \( \delta 7.687 \) (d, \( J = 8.2 \) Hz, 2H), \( 7.443 – 7.389 \) (m, 2H), \( 7.390 – 7.342 \) (m, 1H), \( 7.340 – 7.262 \) (m, 4H), 4.121 (dd, \( J = 10.8, 2.0 \) Hz, 1H), 3.946 (dd, \( J = 14.0, 10.8 \) Hz, 1H), 3.453 (dd, \( J = 14.0, 2.4 \) Hz, 1H), \( 2.850 – 2.755 \) (m, 1H), \( 2.525 – 2.447 \) (m, 1H), \( 2.434 \) (s, 3H), \( 1.569 – 1.468 \) (m, 2H), \( 1.335 – 1.220 \) (m, 12H), 0.886 (t, \( J = 6.8 \) Hz, 3H).


**HRMS (ESI)** m/z Calcd for [C₂₅H₃₄O₃SSeNa, M + Na]⁺: 517.12868, Found: 517.12853.

**HPLC analysis:** Chiralcel OD-H (Hexane/i-PrOH = 85:15 flow rate = 1.0 mL/min, wave length = 210 nm), \( t_R = 7.623 \) min (minor), \( t_R = 8.677 \) min (major).

**Optical Rotation:** \( [\alpha]_{20}^D = -89.1 \) (c = 1.0, CHCl₃); **physical properties:** white solid; m.p. 63–64 °C; yield: 59%, 29.1 mg.

(r)-1-cyclohexyl-2-(phenylselanyl)-3-tosylpropan-1-one (6h)

\[ \text{Ts} \text{SePh} \]

**1H NMR** (400 MHz, CDCl₃): \( \delta 7.691 \) (d, \( J = 8.2 \) Hz, 2H), \( 7.403 \) (d, \( J = 7.6 \) Hz, 2H), \( 7.378 – 7.336 \) (m, 1H), \( 7.338 – 7.260 \) (m, 4H), 4.289 (dd, \( J = 10.4, 2.0 \) Hz, 1H), 3.952 (dd, \( J = 14.0, 10.4 \) Hz, 1H), 3.428 (dd, \( J = 14.0, 2.0 \) Hz, 1H), \( 2.771 – 2.673 \) (m, 1H), \( 2.430 \) (s, 3H), \( 1.992 – 1.847 \) (m, 2H), \( 1.841 – 1.756 \) (m, 2H), \( 1.710 – 1.632 \) (m, 1H), \( 1.590 – 1.500 \) (m, 1H), \( 1.301 – 1.190 \) (m, 4H).


**HPLC analysis:** Chiralcel AD-H (Hexane/i-PrOH = 80:20 flow rate = 1.0 mL/min, wave length = 210 nm), \( t_R = 12.494 \) min (major), \( t_R = 16.884 \) min (minor).

**Optical Rotation:** \( [\alpha]_{20}^D = -124.5 \) (c = 1.0, CHCl₃); **physical properties:** white solid; m.p. 71–72 °C; yield: 67%, 30 mg.
(R)-5-phenyl-2-(phenylselanyl)-1-tosylpentan-3-one (6i)

\[ \text{H NMR (400 MHz, CDCl}_3\): } \delta 7.682 \text{ (d, } J = 8.0 \text{ Hz, 2H)}, 7.376 - 7.167 \text{ (m, 12H), } 4.112 \text{ (d, } J = 10.4 \text{ Hz, 1H), 3.929 \text{ (dd, } J = 13.6, 11.2 \text{ Hz, 1H), 3.459 \text{ (d, } J = 13.6 \text{ Hz, 1H), 3.242 - 3.141 \text{ (m, 1H), 2.902 - 2.825 \text{ (m, 2H), 2.820 - 2.729 \text{ (m, 1H), 2.430 \text{ (s, 3H).}}}

\[ \text{C NMR (100 MHz, CDCl}_3\): } \delta 200.990, 144.998, 140.639, 136.259, 136.152, 129.912, 129.580, 129.404, 128.415, 128.039, 126.122, 125.126, 57.569, 42.133, 40.987, 29.987, 21.624.

\[ \text{HRMS (ESI) m/z Calcd for [C}_{24}\text{H}_{24}\text{O}_3\text{SSeNa, M + Na}\]: 495.05041, Found: 495.05032.}

\[ \text{HPLC analysis: Chiralcel OD-H (Hexane/i-PrOH = 85:15, flow rate = 1.0 mL/min, wave length = 210 nm), } t_R = 18.687 \text{ min (major), } t_R = 23.237 \text{ min (minor).}

\[ \text{Optical Rotation: } } [\alpha]_{D}^{20} = -111.8 \text{ (c = 1.0, CHCl}_3\}; \text{ physical properties: white solid; m.p.} 107–108^\circ \text{C; yield: 75%, 35.3 mg.}

(15,2R)-1-(4-(tert-butyl)phenyl)-2-(phenylselanyl)-3-tosylopropan-1-ol (7)

\[ \text{H NMR (400 MHz, CDCl}_3\): } \delta 7.656 \text{ (d, } J = 8.4 \text{ Hz, 2H), 7.364 - 7.318 \text{ (m, 2H), 7.317 - 7.257 \text{ (m, 4H), 7.200 \text{ (t, } J = 7.0 \text{ Hz, 1H), 7.154 - 7.040 \text{ (m, 4H), 5.296 \text{ (s, 1H), 3.851 \text{ (dd, } J = 14.4, 9.2 \text{ Hz, 1H), 3.714 - 3.644 \text{ (m, 1H), 3.439 \text{ (dd, } J = 14.6, 3.8 \text{ Hz, 1H), 2.894 \text{ (d, } J = 4.8 \text{ Hz, 1H), 2.439 \text{ (s, 3H), 1.319 \text{ (s, 9H).}}}

\[ \text{C NMR (100 MHz, CDCl}_3\): } \delta 150.800, 144.777, 138.157, 136.103, 134.584, 129.936, 129.063, 127.912, 127.856, 127.781, 125.759, 125.165, 73.007, 58.731, 47.161, 34.528, 31.334, 21.635.

\[ \text{HRMS (ESI) m/z Calcd for [C}_{26}\text{H}_{30}\text{O}_3\text{SSeNa, M + Na}\]: 525.09739, Found: 525.09761.}

\[ \text{HPLC analysis: Chiralel OD-H (Hexane/i-PrOH = 80:20, flow rate = 1.0 mL/min, wave length = 210 nm), } t_R = 8.462 \text{ min (major), } t_R = 9.955 \text{ min (minor).}

\[ \text{Optical Rotation: } [\alpha]_{D}^{20} = -23.5 \text{ (c = 1.0, CHCl}_3\}; \text{ physical properties: white solid; m.p.} 106–108^\circ \text{C; yield: 90%, 45.0 mg.}
(15,2R)-1-(4-(tert-butyl)phenyl)-2-(phenylselanyl)-3-tosylpropyl 4-bromobenzoate (8)

$^1$H NMR (400 MHz, CDCl$_3$): $\delta$ 7.914 (d, $J = 8.0$ Hz, 2H), 7.618 (dd, $J = 15.8$, 8.2 Hz, 4H), 7.351 (s, 4H), 7.273 – 7.207 (m, 3H), 7.187 (d, $J = 7.2$ Hz, 2H), 7.124 (t, $J = 7.4$ Hz, 2H), 6.527 (d, $J = 2.4$ Hz, 1H), 3.889 – 3.816 (m, 1H), 3.753 (dd, $J = 14.6$, 8.6 Hz, 1H), 3.484 (dd, $J = 14.6$, 3.8 Hz, 1H), 2.406 (s, 3H), 1.305 (s, 9H).

$^{13}$C NMR (100 MHz, CDCl$_3$): $\delta$ 164.325, 151.326, 144.769, 136.132, 134.654, 134.292, 131.827, 131.343, 129.912, 129.202, 128.497, 128.025, 127.975, 127.923, 126.043, 125.359, 76.364, 58.965, 44.201, 34.562, 31.264, 21.607.

HRMS (ESI) m/z Calcd for [C$_{33}$H$_{33}$BrO$_4$SSeNa, M + Na]$^+$: 707.03398, Found: 707.03383.

HPLC analysis: Chiralcel OD-H (Hexane/i-PrOH = 80:20, flow rate = 1.0 mL/min, wave length = 254 nm), $t_R$ = 7.068 min (major), $t_R$ = 9.582 min (minor).

Optical Rotation: $\left[\alpha\right]_{D}^{20} = -38.8$ (c = 1.0, CHCl$_3$); physical properties: white solid; m.p. 114–115$^\circ$C; yield: 91%, 62.3 mg.

(R,E)-1-(4-(tert-butyl)phenyl)-3-tosylallyl 4-bromobenzoate (9)

$^1$H NMR (400 MHz, CDCl$_3$): $\delta$ 7.879 (d, $J = 8.0$ Hz, 2H), 7.761 (d, $J = 7.2$ Hz, 2H), 7.567 (d, $J = 8.0$ Hz, 2H), 7.399 (d, $J = 7.6$ Hz, 2H), 7.321 (t, $J = 8.8$ Hz, 4H), 7.130 (dd, $J = 14.8$, 3.2 Hz, 1H), 6.648 (s, broad, 1H), 6.604 (d, $J = 15.6$ Hz, 1H), 2.433 (s, 3H), 1.305 (s, 9H).

$^{13}$C NMR (100 MHz, CDCl$_3$): $\delta$ 164.242, 152.453, 144.710, 142.253, 136.838, 132.892, 131.856, 131.217, 130.009, 128.684, 128.266, 127.852, 127.329, 126.000, 73.790, 34.681, 31.200, 21.623.

HRMS (ESI) m/z Calcd for [C$_{27}$H$_{27}$BrO$_4$SSNa, M + Na]$^+$: 551.06862, Found: 551.06836.

HPLC analysis: Chiralcel AD-H (Hexane/i-PrOH = 75:25, flow rate = 1.0 mL/min, wave length = 254 nm), $t_R$ = 9.530 min (minor), $t_R$ = 10.657 min (major).

Optical Rotation: $\left[\alpha\right]_{D}^{20} = +45.6$ (c = 1.0, CHCl$_3$); physical properties: white solid; m.p. 123–125$^\circ$C; yield: 95%, 50.1 mg.
X. $^1$H and $^{13}$C NMR spectra of compounds (4a-4p, 6a-6i, 7, 8, 9)
XI. X-Ray Crystallographic Information (8)

![Chemical Structure](image)

Bond precision: 

- \(C-C = 0.0246 \text{ Å}\)  
- Wavelength = 0.71073 Å

Cell: 

- \(a = 7.9327(4)\)  
- \(b = 18.8397(9)\)  
- \(c = 22.3499(16)\)

- \(\alpha = 90^\circ\)  
- \(\beta = 100.199(5)\)  
- \(\gamma = 90^\circ\)

Temperature: 293 K

Volume: 

- Calculated: 3287.4(3)  
- Reported: 3287.4(3)

Space group: 

- P 21  
- P 1 21 1

Hall group: 

- P 2yb  
- P 2yb

Moiety formula: 

- \(\text{C}_{33} \text{H}_{33} \text{Br O}_4 \text{S Se}\)

Sum formula: 

- \(\text{C}_{33} \text{H}_{33} \text{Br O}_4 \text{S Se}\)

Mr: 684.51  

Dx, g cm\(^{-3}\): 1.383

Z: 4

\(\mu (\text{mm}^{-1})\): 2.454

\(F_{000}\): 1392.0  

\(F_{000}'\): 1391.51

\(h, k, l_{\text{max}}\): 9, 23, 27

\(N_{\text{ref}}\): 13419 [6921]

\(T_{\text{min}}, T_{\text{max}}\): 0.428, 0.541  

\(T_{\text{min}}'\): 0.419

Correction method = # Reported T Limits: \(T_{\text{min}} = 0.467, T_{\text{max}} = 1.000\)

AbsCorr = MULTI-SCAN

Data completeness = 1.51/0.78

\(R(\text{reflections}) = 0.0676(6712)\)

\(wR^2(\text{reflections}) = 0.1658(10418)\)

\(S = 1.054\)

\(N_{\text{par}} = 699\)

The Flack parameter is 0.046(6) for 8, CCDC 1820345 contain the supplementary crystallographic data of adducts for this paper. These data can be obtained free of charge from The Cambridge Crystallographic Data Centre via www.ccdc.cam.ac.uk/data_request/cif

Explaination of B errors: the thermal vibration due to the structure disorder of the tert-butyl groups is violent that include the rotation around the C-C bonds and the stretching from the center carbon atoms. If we use splitting treatment on the tert-butyl groups, the whole system could not converge to near zero because the hydrogen atoms on the tert-butyl carbon could not be fixed on their positions. So we have to adopt a EADP treatment on the tert-butyl carbon atoms to restrain the linked hydrogen atoms, which inevitably leads to some B errors when the checking cif file.