Supporting information for

Organocatalytic Conjugate Additions of Acetylacetone to 3-Ylideneoxindoles: A Direct Access to Highly Enantioenriched Oxindole Derivatives

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Supporting Information

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1. General Information.

Unless otherwise noted, materials were used as commercial suppliers. Water-saturated dichloromethane were prepared by shaking dichloromethane (freshly distilled from calcium hydride) and water in separatory funnel. All reactions were monitored by TLC analysis with silica gel-coated plates. Flash column chromatography was performed using 200-300 mesh silica gel. $^1$H NMR spectra were recorded on Varian Mercury 600 (600 MHz) spectrophotometers. Chemical shifts (δ) are reported in ppm from the solvent resonance as the internal standard (CDCl$_3$: 7.26 ppm). Data are reported as follows: chemical shift, multiplicity (s = single, d = doublet, t = triplet, dd = doublet of doublets, m = multiplet), coupling constants (Hz) and integration. $^{13}$C NMR spectra were recorded on Varian Mercury 600 (150MHz) with complete proton decoupling spectrophotometers (CDCl$_3$: 77.0 ppm). Mass spectra were measured on a Finnigan Trace MS spectrometer. Elementary analysis was taken on a Vario EL III elementary analysis instrument. Enantiomeric ratios were determined by chiral HPLC on Agilent 1100 series with chiral columns (chiralpak AS-H column, chiralpak AD-H column, or chiralcel OD-H column) with hexane and $i$-PrOH as solvents. Optical rotations were measured with JASCO P-1020 polarimeter.
2. Detailed optimization of the reaction conditions

2.1 Optimization of the reaction conditions - **Catalysts**

The reaction between 3-ylideneoxindole 9 and acetylacetone 10 in ether in the presence of a variety of organocatalysts was tested firstly at room temperature. The reaction can be completed generally after several hours, only giving conjugate adduct 11 in good yields with highly different stereoselectivities.

**Table 1S.** Catalysts screening for conjugate addition between 3-ylideneoxindole 9 and acetylacetone 10 [a]

<table>
<thead>
<tr>
<th>entry</th>
<th>catalyst</th>
<th>[H]</th>
<th>yield (%)</th>
<th>dr</th>
<th>ee (%)</th>
</tr>
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<tr>
<td>1</td>
<td>1</td>
<td>8</td>
<td>90</td>
<td>64:36</td>
<td>6, 8</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>29</td>
<td>83</td>
<td>63:37</td>
<td>4, 10</td>
</tr>
<tr>
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<td>3</td>
<td>7</td>
<td>93</td>
<td>60:40</td>
<td>85, 84</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>6</td>
<td>81</td>
<td>58:42</td>
<td>80, 80</td>
</tr>
<tr>
<td>5[a]</td>
<td>5</td>
<td>6</td>
<td>91</td>
<td>59:41</td>
<td>78, 93</td>
</tr>
<tr>
<td>6[b]</td>
<td>6</td>
<td>10</td>
<td>83</td>
<td>67:33</td>
<td>82, 79</td>
</tr>
<tr>
<td>7[b]</td>
<td>7</td>
<td>10</td>
<td>87</td>
<td>68:32</td>
<td>71, 71</td>
</tr>
<tr>
<td>8[b]</td>
<td>8</td>
<td>10</td>
<td>80</td>
<td>69:31</td>
<td>84, 83</td>
</tr>
</tbody>
</table>

[a] A mixture of 9 (0.25 mmol, 54.3 mg), catalyst 1-8 (0.025 mmol) and acetylacetone 10 (0.75 mmol, 75 ml) in freshly distill. Et{sub}O was stirred at r.t. [b] Toluene was used as the solvent. [c] Isolated yield. [d] Determined by chiral HPLC analysis.

2.2 Optimization of the reaction conditions – **Protecting group on the nitrogen atom**

3-Ylideneoxindoles 9 with different protecting group on the nitrogen atom were subjected to the conjugate addition reaction. As shown in **Table 2S**, protecting group plays an important role in the enantioselectivities. It was found that excellent ee values were achieved when a methyl group was introduced to the nitrogen atom.
Table 2S. Protecting group effect on the reaction

![Chemical structure](image)

<table>
<thead>
<tr>
<th>entry</th>
<th>R</th>
<th>τ (h)</th>
<th>yield (%)</th>
<th>dr</th>
<th>ee (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>H</td>
<td>5.5</td>
<td>91</td>
<td>58:42</td>
<td>78, 93</td>
</tr>
<tr>
<td>2</td>
<td>Me</td>
<td>2</td>
<td>&gt;99</td>
<td>60:40</td>
<td>96, 96</td>
</tr>
<tr>
<td>3</td>
<td>Bn</td>
<td>2</td>
<td>&gt;99</td>
<td>66:34</td>
<td>88, 87</td>
</tr>
</tbody>
</table>

*S* A mixture of 9 (0.25 mmol), catalyst 5 (0.025 mmol), and acetylacetone 10 (0.75 mmol, 75 mL) in freshly distilled Et₂O was stirred at r.t. *b*Isolated yield. *c* Determined by chiral HPLC analysis.

2.3 Optimization of the reaction conditions – Solvents

To further improve the stereoselectivities, we chose 3-ylideneoxindoles 9 and acetylacetone 10 as the model substrates to examine the effect of solvents. The results in Table 3S revealed that the conjugate addition reaction could be conducted in a broad range of media giving the adducts in good yields and ee values. It was found that the reaction was unsuccessful in CHCl₃ and tert-butyl methyl ether (TBME) and toluene gave the best results in terms of both enantioselectivities and diastereoselectivities.

Table 3S. Solvent effect on the reaction

![Chemical structure](image)

<table>
<thead>
<tr>
<th>entry</th>
<th>solvent</th>
<th>τ (h)</th>
<th>yield (%)</th>
<th>dr</th>
<th>ee (%)</th>
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<tbody>
<tr>
<td>1</td>
<td>Et₂O</td>
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<td>96, 96</td>
</tr>
<tr>
<td>2</td>
<td>THF</td>
<td>3</td>
<td>85</td>
<td>66:36</td>
<td>94, 94</td>
</tr>
<tr>
<td>3</td>
<td>diacane</td>
<td>3</td>
<td>80</td>
<td>66:35</td>
<td>95, 96</td>
</tr>
<tr>
<td>4</td>
<td>TBME</td>
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<td>95</td>
<td>66:34</td>
<td>&gt;99, 98</td>
</tr>
<tr>
<td>5</td>
<td>CH₂Cl₂</td>
<td>2</td>
<td>86</td>
<td>66:34</td>
<td>84, 85</td>
</tr>
<tr>
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<td>CHCl₃</td>
<td>72</td>
<td>NR</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>7</td>
<td>tPrOH</td>
<td>1.5</td>
<td>82</td>
<td>66:35</td>
<td>92, 92</td>
</tr>
<tr>
<td>8</td>
<td>acetyl acetone</td>
<td>1</td>
<td>88</td>
<td>60:40</td>
<td>98, 98</td>
</tr>
<tr>
<td>9</td>
<td>toluene</td>
<td>1.5</td>
<td>92</td>
<td>69:31</td>
<td>95, 95</td>
</tr>
<tr>
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<td>CH₃CN</td>
<td>1</td>
<td>90</td>
<td>56:44</td>
<td>94, 96</td>
</tr>
<tr>
<td>11</td>
<td>H₂O</td>
<td>1</td>
<td>93</td>
<td>64:36</td>
<td>93, 93</td>
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<tr>
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<td>EtOAc</td>
<td>1.5</td>
<td>88</td>
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<td>97, 97</td>
</tr>
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<td>DMF</td>
<td>5</td>
<td>83</td>
<td>54:46</td>
<td>93, 93</td>
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</tbody>
</table>

*S* A mixture of 9 (0.25 mmol), catalyst 5 (0.025 mmol) and acetylacetone 10 (0.75 mmol, 75 mL) in solvent was stirred at r.t. *b* Isolated yield. *c* Determined by chiral HPLC analysis. TBME = tert-butyl methyl ether.

2.4 Optimization of the reaction conditions – The concentration and the ester group

We changed the concentration of the conjugate addition system and the ester group on the
3-ylideneoxindoles 9 in order to upgrade the distereoselectivity. As shown in Table 4S, catalyst 3 was more effective than 5 at attenuant concentration and the n-propyl ester group can slightly increase the dr.

Table 4S. Effect of ester group on 3-ylideneoxindoles

<table>
<thead>
<tr>
<th>entry</th>
<th>R</th>
<th>cat</th>
<th>conc.(X)</th>
<th>t(h)</th>
<th>yield (%)</th>
<th>dr</th>
<th>ee (%)</th>
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<tbody>
<tr>
<td>1</td>
<td>Pr</td>
<td>5</td>
<td>1</td>
<td>0.5</td>
<td>98</td>
<td>68:32</td>
<td>&gt;99, 98</td>
</tr>
<tr>
<td>2</td>
<td>Pr</td>
<td>5</td>
<td>0.5</td>
<td>0.5</td>
<td>98</td>
<td>70:30</td>
<td>&gt;99, 98</td>
</tr>
<tr>
<td>3</td>
<td>Pr</td>
<td>5</td>
<td>0.25</td>
<td>2.5</td>
<td>98</td>
<td>72:28</td>
<td>&gt;99, 98</td>
</tr>
<tr>
<td>4</td>
<td>Pr</td>
<td>5</td>
<td>0.1</td>
<td>5</td>
<td>98</td>
<td>71:29</td>
<td>&gt;99, 98</td>
</tr>
<tr>
<td>5</td>
<td>Pr</td>
<td>3</td>
<td>0.1</td>
<td>3</td>
<td>98</td>
<td>73:27</td>
<td>&gt;99, &gt;99</td>
</tr>
<tr>
<td>6</td>
<td>Et</td>
<td>3</td>
<td>0.1</td>
<td>1.5</td>
<td>92</td>
<td>69:31</td>
<td>&gt;99, 98</td>
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<tr>
<td>7</td>
<td>Bu</td>
<td>3</td>
<td>0.1</td>
<td>3</td>
<td>98</td>
<td>67:33</td>
<td>&gt;99, 98</td>
</tr>
<tr>
<td>8</td>
<td>Bu</td>
<td>3</td>
<td>0.1</td>
<td>6</td>
<td>85</td>
<td>64:36</td>
<td>&gt;99, 91</td>
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</table>

Additive(eqiv.) yield (%b) dr<sup>c</sup> ee (%<sup>c</sup>)

-98 70:30 >99, >99
-98 70:30 >99, >99
-98 70:30 >99, >99
-98 70:30 >99, >99
-98 70:30 >99, >99
-98 70:30 >99, >99

* A mixture of 9 (0.25 mmol), catalyst 3 or 5 (0.025 mmol) and acetylacetone 10 (1.5 mmol, 0.15 mL) in freshly distilled toluene was stirred at r.t. * Determined by chiral HPLC analysis.

2.5 Optimization of the reaction conditions – Additives

We also examined the additives in the conjugate addition reaction to improve the dr. However, the results failed us because no improvement was achieved.

Table 5S. Effect of additives in the conjugate addition

<table>
<thead>
<tr>
<th>entry</th>
<th>additive(eqiv.)</th>
<th>yield (%&lt;sup&gt;b&lt;/sup&gt;)</th>
<th>dr&lt;sup&gt;c&lt;/sup&gt;</th>
<th>ee (%&lt;sup&gt;c&lt;/sup&gt;)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>none</td>
<td>98</td>
<td>72:28</td>
<td>&gt;99, &gt;99</td>
</tr>
<tr>
<td>2</td>
<td>H2O (1.0)</td>
<td>98</td>
<td>70:30</td>
<td>&gt;99, &gt;99</td>
</tr>
<tr>
<td>3</td>
<td>a-C6H7OH (1.0)</td>
<td>98</td>
<td>70:30</td>
<td>&gt;99, &gt;99</td>
</tr>
<tr>
<td>4</td>
<td>3,4,5-(CH2O)3C6H2OH (1.0)</td>
<td>98</td>
<td>70:30</td>
<td>&gt;99, &gt;99</td>
</tr>
<tr>
<td>5</td>
<td>p-NO2C6H4OH (1.0)</td>
<td>98</td>
<td>70:30</td>
<td>&gt;99, &gt;99</td>
</tr>
<tr>
<td>6</td>
<td>CH3CO2NH4 (1.0)</td>
<td>98</td>
<td>70:30</td>
<td>&gt;99, &gt;99</td>
</tr>
<tr>
<td>7</td>
<td>C6H5CO2H (0.05)</td>
<td>98</td>
<td>70:30</td>
<td>&gt;99, &gt;99</td>
</tr>
<tr>
<td>8</td>
<td>3,5-(NO2)2C6H4CO2H (0.05)</td>
<td>98</td>
<td>70:30</td>
<td>&gt;99, &gt;99</td>
</tr>
</tbody>
</table>

* A mixture of 9 (0.25 mmol), catalyst 3 (0.025 mmol), acetylacetone 10 (1.5 mmol, 0.15 mL), and additive in toluene was stirred at r.t. * Isolated yield. * Determined by chiral HPLC analysis.
2.6 Optimization of the reaction conditions – Temperatures

Higher dr. values can be obtained at low temperature in acceptable time. We chose 9c and acetylacetone 10 as the model substrates to examine the effect of temperatures.

Table 6S. Effect of temperatures

<table>
<thead>
<tr>
<th>entry</th>
<th>Temp.(°C)</th>
<th>t(h)</th>
<th>yield(%)a</th>
<th>dr.</th>
<th>ee(%)b</th>
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<tr>
<td>1</td>
<td>rt</td>
<td>2</td>
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<td>72:28</td>
<td>96, 98</td>
</tr>
<tr>
<td>2</td>
<td>-25</td>
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<td>3</td>
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<td>-78</td>
<td>2</td>
<td>96</td>
<td>80:20</td>
<td>&gt;99, &gt;99</td>
</tr>
</tbody>
</table>

a A mixture of 9c (0.25 mmol), cat. 3 (0.025 mmol) and acetyl acetone 10 (1.5mmol, 0.15mL) in toluene was stirred at Temp. b Isolated yield determined by chiral HPLC.

3. General procedure for the synthesis of 3-ylideneoxindoles 9

To a stirred solution of ylidene (22 mmol, 1.1 eq.) in anhydrous THF (50 mL), the N-methylindoline-2, 3-dione[1] (20 mmol, 1.0 eq.) was added at 0 °C. The mixture was stirred at the same temperature until the reaction was completed monitored by TLC analysis. The crude product was purified by flash chromatography on silica gel (petroleum ether/ethyl acetate 5:1). Compound 9a was obtained as a red solid (1.74 g, 87% yield).

The other 3-ylideneoxindoles were prepared according to the above procedure.

4. General procedure for the conjugate addition reaction

To a mixture of 3-ylideneoxindoles 9 (0.25mmol), catalyst 3 (0.025mmol, 14.1mg) in toluene was added acetyl acetone 10 (1.5mmol, 0.15mL) or nitromethane (1.5mmol, 81 μL) at r.t. or -60 °C. The resulting solution was stirred at a constant temperature until the reaction was determined to be complete by TLC analysis. The crude product was purified by silica gel chromatography (petroleum ether/ethyl acetate 2:1 for acetyl acetone adducts or 5:1 for nitromethane adduct) to give the corresponding conjugate adduct 11.

Reference:
5. Spectra data of the compounds

(E)-propyl 2-(1-methyl-2-oxoindolin-3-ylidene)acetate (9a)

Red solid, yield: 88%; \(^1\)H NMR (CDCl\(_3\), 600 MHz) (δ, ppm) 8.55 (d, \(J = 7.6\) Hz, 1H), 7.36 (t, \(J = 7.7\) Hz, 1H), 7.05 (t, \(J = 7.6\) Hz, 1H), 6.90 (s, 1H), 6.78 (d, \(J = 7.7\) Hz, 1H), 4.22 (t, \(J = 6.7\) Hz, 2H), 3.22 (s, 3H), 1.81 – 1.70 (m, 2H), 1.01 (t, \(J = 7.4\) Hz, 3H). \(^1^3\)C NMR (150 MHz, CDCl\(_3\)) (δ, ppm) 167.45, 165.66, 145.86, 137.79, 132.32, 128.64, 122.73, 122.34, 119.75, 108.03, 66.69, 26.15, 21.88, 10.35. MS: m/z = 245.7.

(E)-propyl 2-(5-fluoro-1-methyl-2-oxoindolin-3-ylidene)acetate (9b)

Red solid, yield: 71%; \(^1\)H NMR (CDCl\(_3\), 600 MHz): (δ, ppm) 8.37 (d, \(J = 9.2\) Hz, 1H), 7.08 (td, \(J = 8.6\) Hz, 2.5, 1H), 6.94 (s, 1H), 6.71 (dd, \(J = 8.4\) Hz, 4.1, 1H), 4.24 (t, \(J = 6.7\) Hz, 2H), 3.22 (s, 3H), 1.80 – 1.72 (m, 2H), 1.01 (t, \(J = 7.4\) Hz, 3H). \(^1^3\)C NMR (150 MHz, CDCl\(_3\)): (δ, ppm) 167.20, 165.40, 159.69, 158.10, 141.99, 137.47, 123.72, 120.60, 118.62, 118.46, 116.51, 116.32, 108.40, 108.35, 95.27, 66.94, 26.30, 21.87, 10.35. MS: m/z = 263.4.

(E)-propyl 2-(5-bromo-1-methyl-2-oxoindolin-3-ylidene)acetate (9c)

Red solid, yield: 70%; \(^1\)H NMR (CDCl\(_3\), 600 MHz): (δ, ppm) 8.70 (s, 1H), 7.47 (d, \(J = 8.3\) Hz, 1H), 6.91 (s, 1H), 6.66 (d, \(J = 8.3\) Hz, 1H), 4.24 (t, \(J = 6.6\) Hz, 2H), 3.21 (s, 3H), 1.83 – 1.72 (m, 2H), 1.02 (t, \(J = 7.3\) Hz, 3H). \(^1^3\)C NMR (150 MHz, CDCl\(_3\)): (δ, ppm) 166.86, 165.29, 144.71, 136.66, 134.79, 131.44, 123.85, 121.25, 115.41, 109.42, 67.00, 26.26, 21.85, 10.36. MS: m/z = 323.02.

(E)-propyl 2-(1-methyl-2-oxo-5-(trifluoromethoxy)indolin-3-ylidene)acetate (9d)

Red solid, yield: 87%; \(^1\)HNMR (CDCl\(_3\), 600 MHz): (δ, ppm) 8.55 (s, 1H), 7.26 (d, \(J = 6.6\) Hz, 1H), 6.98 (s, 1H), 6.79 (d, \(J = 2.2\) Hz, 1H), 6.66 (d, \(J = 7.9\) Hz, 1H), 4.30 – 4.16 (m, 2H), 3.19 (s, 3H), 2.34 (s, 3H), 1.82 – 1.71 (m, 2H), 1.01 (t, \(J = 7.4\) Hz, 3H). \(^1^3\)C NMR (150 MHz, CDCl\(_3\)): (δ, ppm) 167.26, 165.34, 144.61, 144.44, 136.95, 125.27, 124.29, 122.64, 121.39, 120.64, 108.41, 67.06, 26.36, 21.87, 10.33. MS: m/z = 329.5.

(E)-propyl 2-(1,5-dimethyl-2-oxoindolin-3-ylidene)acetate (9e)

Red solid, yield: 97%; \(^1\)H NMR (CDCl\(_3\), 600 MHz): (δ, ppm) 8.37 (s, 1H), 7.15 (d, \(J = 7.8\) Hz, 1H), 6.87 (d, \(J = 2.2\) Hz, 1H), 6.66 (d, \(J = 7.9\) Hz, 1H), 4.30 – 4.16 (m, 2H), 3.19 (s, 3H), 2.34 (s, 3H), 1.82 – 1.71 (m, 2H), 1.01 (t, \(J = 7.4\) Hz, 3H). \(^1^3\)C NMR (150 MHz, CDCl\(_3\)): (δ, ppm) 167.44, 165.75, 143.67, 138.10, 123.66, 132.16, 129.24, 121.95, 119.72, 107.73, 66.66, 26.14, 21.88, 21.05, 10.35. MS: m/z = 259.6.

(E)-propyl 2-(6-chloro-1-methyl-2-oxoindolin-3-ylidene)acetate (9f)

Red solid, yield: 82%; \(^1\)HNMR (CDCl\(_3\), 600 MHz): (δ, ppm) 8.50 (d, \(J = 8.3\) Hz, 1H), 7.08 – 6.95 (m, 1H), 6.89 (s, 1H), 6.77 (d, \(J = 1.6\) Hz, 1H), 4.22 (t, \(J = 6.7\) Hz, 2H), 3.20 (s, 3H), 1.79 – 1.71 (m, 2H), 1.01 (t, \(J = 7.4\) Hz, 3H). \(^1^3\)C NMR (150 MHz, CDCl\(_3\)): (δ, ppm) 167.44, 165.55, 146.95, 138.27, 136.78, 129.76, 122.72, 122.61, 118.19, 108.79, 66.84, 26.28, 21.87, 10.35. MS: m/z = 279.7.
(E)-propyl 2-(6-bromo-1-methyl-2-oxoindolin-3-ylidene)acetate (9g)

Red solid, yield: 88%; \(^1\)H NMR (CDCl\(_3\), 600 MHz): (\(\delta\), ppm) 8.43 (d, \(J = 8.3\) Hz, 1H), 7.18 (dd, \(J = 8.3, 1.7\) Hz, 1H), 7.00 – 6.81 (m, 2H), 4.22 (t, \(J = 6.7\) Hz, 2H), 3.20 (s, 3H), 1.80 – 1.71 (m, 2H), 1.01 (t, \(J = 7.4\) Hz, 3H). \(^{13}\)C NMR (150 MHz, CDCl\(_3\)): (\(\delta\), ppm) 167.31, 165.57, 146.90, 136.86, 129.90, 126.62, 125.63, 122.97, 118.61, 111.61, 66.86, 26.29, 21.88, 10.36. MS: m/z = 323.7.

(1E)-propyl 2-(7-fluoro-1-methyl-2-oxoindolin-3-ylidene)acetate (9h)

Red solid, yield: 70%; \(^1\)H NMR (CDCl\(_3\), 600 MHz): (\(\delta\), ppm) 8.37 (d, \(J = 7.7\) Hz, 1H), 7.09 (dd, \(J = 11.4, 8.5\) Hz, 1H), 7.03 – 6.85 (m, 2H), 4.22 (t, \(J = 6.7\) Hz, 2H), 3.49 – 3.40 (m, 3H), 1.80 – 1.70 (m, 2H), 1.01 (t, \(J = 7.4\) Hz, 3H). \(^{13}\)C NMR (150 MHz, CDCl\(_3\)): (\(\delta\), ppm) 167.11, 165.37, 148.30, 146.69, 136.95, 132.29, 124.59, 123.83, 123.11, 123.07, 122.39, 120.22, 120.09, 66.86, 28.84, 28.80, 21.87, 10.34. MS: m/z = 263.7.

(E)-propyl 2-(6-bromo-5-chloro-1-methyl-2-oxoindolin-3-ylidene)acetate (9i)

Red solid, yield: 29%; \(^1\)H NMR (CDCl\(_3\), 600 MHz): (\(\delta\), ppm) 8.70 (s, 1H), 7.05 (s, 1H), 6.96 (s, 1H), 4.24 (t, \(J = 6.7\) Hz, 2H), 3.22 (s, 3H), 1.84 – 1.70 (m, 2H), 1.01 (t, \(J = 7.4\) Hz, 3H). \(^{13}\)C NMR (150 MHz, CDCl\(_3\)): (\(\delta\), ppm) 166.92, 165.34, 144.86, 136.23, 130.05, 129.96, 128.32, 126.29, 124.29, 120.03, 113.07, 67.13, 26.45, 21.86, 10.37. MS: m/z = 359.1.

Propyl 3-acetyl-2-(1-methyl-2-oxoindolin-3-yl)-4-oxopentanoate (11a)

Prepared according to the general procedure from (E)-propyl 2-(1-methyl-2-oxoindolin-3-ylidene)acetate \(9a\) (0.25 mmol), \(10\) (1.50 mmol) and cat. \(5\) (0.025 mmol) in toluene (2.5 mL) at r.t. for 3 h to provide the title compound as a light yellow oil (97% yield; >99%, >99% ee; 73:27 dr.). Isomer mixtures (major isomer: minor isomer= 1: 0.49).

\(^1\)H NMR (600 MHz, CDCl\(_3\)): (\(\delta\), ppm, major+minor) 7.27-7.31 (m, 3H, major+minor), 7.02-7.08 (m, 1.5H, major+minor), 6.80-6.82 (m, 1.5H, major+minor), 4.79 (d, \(J = 12\) Hz, 1H, major), 4.47 (d, \(J = 12\) Hz, 1H, minor), 4.28 (dd, \(J_1 = 12\) Hz, \(J_2 = 6\) Hz, 1H, minor), 4.07 (dd, \(J_1 = 12\) Hz, \(J_2 = 6\) Hz, 1H, major), 3.81 (t, \(J = 6\) Hz, 2H, major), 3.68-3.76 (m, 2H, minor), 3.66 (d, \(J = 6\) Hz, 1H, major), 3.37 (s, 1H, minor), 3.22 (s, 3H, minor), 3.18 (s, 3H, major), 2.35 (s, 3H, major), 2.30 (s, 3H, major), 2.24 (s, 3H, major), 2.20 (s, 3H, minor), 1.26-1.39 (m, 3H, major+minor), 0.72-0.75 (m, 4.5H, major+minor). 

\(^{13}\)C NMR (150 MHz, CDCl\(_3\)): (\(\delta\), ppm, major+minor) 202.11, 201.97, 201.91, 201.55, 175.23, 174.96, 171.12, 170.21, 144.35, 144.07, 128.73, 128.41, 125.69, 124.90, 124.32, 124.28, 122.37, 122.33, 108.00, 107.93, 69.12, 66.86, 66.78, 66.26, 45.83, 45.29, 44.55, 43.85, 30.39, 29.73, 26.20, 25.98, 21.39, 10.03.

HRMS (EI+): m/z [M\(^+\)] calcd for C\(_{19}\)H\(_{23}\)NO\(_5\): 345.1576; found: 345.1573. \([\alpha]_D^{20} = -54.73\) (C = 1.00, CHCl\(_3\)).

HPLC (Chiralpak AD-H column, hexane/2-propanol = 90:10, 1 mL/min, 254 nm, 25 °C, t\(_{major} =\))
26.87 min, t\textsubscript{1\text{minor}} = 33.32 min, t\textsubscript{\text{2\text{major}}} = 39.34 min, t\textsubscript{\text{2\text{minor}}} = 44.43 min).

**Propyl 3-acetyl-2-(5-fluoro-1-methyl-2-oxoindolin-3-yl)-4-oxopentanoate (11b)**

Prepared according to the general procedure from (E)-propyl 2-(5-fluoro-1-methyl-2-oxoindolin-3-ylidene)acetate 9b (0.25 mmol), 10 (1.50 mmol) and cat. 5 (0.025 mmol) in toluene (2.5 mL) at -60 °C for 2 h to provide the title compound as a light yellow oil (98% yield, >99%, 93% ee, 81:19 dr.). Isomer mixtures (major isomer: minor isomer= 1: 0.57).

**\textsuperscript{1}H NMR** (600 MHz, CDCl\textsubscript{3}): (δ, ppm, major+minor) 7.06-7.10(m, 1.6H, major+minor), 6.99-7.02(m, 1.6H, major+minor), 4.84(d, J = 12 Hz, 1H, major), 4.46(d, J = 12Hz, 1H, minor), 4.23(d, J = 12Hz, 1H, minor), 4.03(d, J = 12Hz, 1H, major), 3.74-3.83(m, 3.2H, major+minor), 3.65(s, 1H, major), 3.39(s, 1H, minor), 3.21(s, 3H, minor), 3.17(s, 3H, major), 2.36(s, 3H, minor), 2.28(s, 3H, major), 1.30-1.41(m, 3.4H, major+minor), 0.75(t, J = 6 Hz, 4.7H, major+minor).

**\textsuperscript{13}C NMR** (150 MHz, CDCl\textsubscript{3}): (δ, ppm, major+minor) 201.99, 201.90, 201.87, 201.37, 174.87, 174.62, 170.85, 170.04, 159.70, 159.42, 158.11, 157.86, 140.36, 140.05, 129.23, 127.55, 127.49, 126.57, 114.98, 114.82, 114.66, 114.51, 112.77, 112.61, 112.47, 112.31, 108.44, 108.39, 108.34, 68.67, 67.03, 66.89, 66.15, 45.59, 45.12, 44.77, 44.09, 30.49, 30.34, 29.86, 27.86, 26.34, 26.11, 21.39, 9.99.

**HRMS** (EI+): m/z [M\textsuperscript{+}] calcd for C\textsubscript{19}H\textsubscript{22}FNO\textsubscript{5}: 363.1482; found: 363.1492. [\textsuperscript{a}]= -75.90 (C = 1.00, CHCl\textsubscript{3}).

**HPLC** (Chiralpak OD-H column, hexane/2-propanol = 80:20, 1 mL/min, 254 nm, 25 °C, t\textsubscript{1\text{minor}} = 8.76 min, t\textsubscript{\text{1\text{major}}} = 10.23 min, t\textsubscript{\text{2\text{minor}}} = 11.76 min, t\textsubscript{\text{2\text{major}}} = 15.70min).

**Propyl 3-acetyl-2-(5-bromo-1-methyl-2-oxoindolin-3-yl)-4-oxopentanoate (11c)**

Prepared according to the general procedure from (E)-propyl 2-(5-bromo-1-methyl-2-oxoindolin-3-ylidene)acetate 9c (0.25 mmol), 10 (1.50 mmol) and cat. 5 (0.025 mmol) in toluene (2.5 mL) at -60 °C for 8 h to provide the title compound as a semi-solid (95% yield, >99%, 91% ee, 83:17 dr.). Isomer mixtures (major isomer: minor isomer= 1: 0.25).

**\textsuperscript{1}H NMR** (600 MHz, CDCl\textsubscript{3}): (δ, ppm, major+minor) 7.32-7.59(m, 2.5H, major+minor), 6.69-6.81(m, 1.3H, major+minor), 4.86(d, J = 12 Hz, 1H, major), 4.44(dd, J\textsubscript{1} = 12 Hz, J\textsubscript{2} = 6 Hz, 1H, minor), 4.02(dd, J\textsubscript{1} = 12 Hz, J\textsubscript{2} = 6 Hz, 1H, major), 3.73-3.84(m, 2.5H, major+minor), 3.64(s, 1H, major), 3.40(s, 1H, minor), 3.31(s, 1H, minor), 3.20(s, 3H, minor), 3.16(s, 3H, major), 2.36(s, 3H, minor),2.35(s, 3H, major) 2.29(s, 3H, major), 2.22(s, 3H, minor), 1.31-1.40(m, 2.5H, major+minor), 0.76(t, J = 9 Hz, 3H, major), 0.57-0.66(m, 3H, minor).

**\textsuperscript{13}C NMR** (150 MHz, CDCl\textsubscript{3}): (δ, ppm, major+minor) 201.91, 201.83, 201.25, 174.68, 170.80, 143.14,

HPLC (Chiralpak OD-H column, hexane/2-propanol = 80:20, 1 mL/min, 254 nm, 25 °C, $t_{\text{minor}} = 10.39$ min, $t_{\text{major}} = 11.55$ min, $t_{\text{minor}} = 14.19$ min, $t_{\text{major}} = 18.85$ min).

Propyl 3-acetyl-2-(1-methyl-2-oxo-5-(trifluoromethoxy)indolin-3-yl)-4-oxopentanoate (11d)

Prepared according to the general procedure from 2-(1-methyl-2-oxo-5-(trifluoromethoxy)indolin-3-ylidene)acetate 9d (0.25 mmol), 10 (1.50 mmol) and cat. 5 (0.025 mmol) in toluene (2.5 mL) at -60 °C for 2 h to provide the title compound as a light yellow oil (96% yield, >99%, >99% ee, 80:20 dr.). Isomer mixtures (major isomer: minor isomer= 1: 0.3).

$^1$H NMR (600 MHz, CDCl3): (δ, ppm, major+minor) 7.18-7.24(m, 2.6H, major+minor), 6.80-6.82(m, 1.3H, major+minor), 4.87(d, $J = 12$ Hz, 1H, major), 4.43(d, $J = 12$ Hz, 1H, minor), 4.21(dd, $J_1 = 12$ Hz, $J_2 = 6$ Hz, 1H, minor), 4.04(dd, $J_1 = 12$ Hz, $J_2 = 6$ Hz, 1H, major), 3.78-3.82(m, 2.6H, major+minor), 3.68(s, 1H, major), 3.48(s, 1H, minor), 3.23(s, 3H, minor), 3.19(s, 3H, major), 2.36(s, 3.9H, major+minor), 2.29(s, 3H, major), 2.20(s, 3H, minor), 1.33-1.37(m, 2.6H, major+minor), 0.71-0.77(m, 3.9H, major+minor).

$^{13}$C NMR (150MHz, CDCl3): (δ, ppm, major+minor) 201.99, 201.89, 201.28, 175.06, 174.77, 170.86, 170.04, 144.47, 144.27, 143.18, 142.85, 127.58, 126.74, 121.91, 121.64, 118.68, 118.34, 108.39, 108.32, 68.62, 67.18, 66.99, 66.15, 45.57, 45.20, 44.71, 43.92, 30.61, 30.37, 29.91, 27.92, 26.42, 26.19, 21.39, 9.89.

HRMS (EI+): m/z [M+] calcd for C20H22F3NO6: 429.1399; found: 429.1395. $[\alpha]_D^{20} = -24.52$ ($C = 1.00$, CHCl3).

HPLC (Chiralpak OD-H column, hexane /2-propanol = 80:20, 1 mL/min, 254 nm, 25 °C, $t_{\text{minor}} = 7.54$ min, $t_{\text{major}} = 8.56$ min, $t_{\text{minor}} = 11.78$ min, $t_{\text{major}} = 19.00$ min).

Propyl 3-acetyl-2-(1,5-dimethyl-2-oxoindolin-3-yl)-4-oxopentanoate (11e)

Prepared according to the general procedure from (E)-propyl 2-(1,5-dimethyl-2-oxoindolin-3-ylidene)acetate 9e (0.25 mmol), 10 (1.50 mmol) and cat. 5 (0.025 mmol) in toluene (2.5 mL) at r.t. for 8 h to provide the title compound as a light yellow oil (98% yield, 95%, 92% ee, 43:57 dr.). Isomer mixtures (major isomer: minor isomer= 1: 0.39).

$^1$H NMR (600 MHz, CDCl3): (δ, ppm, major+minor) 7.08-7.13(t, 2.8H, major+minor), 6.68-6.70(m, 1.4H, major+minor), 4.81(d, $J = 12$ Hz, 1H, major), 4.47(d, $J = 12$ Hz, 1H, minor), 4.26(dd, $J_1 = 12$ Hz, $J_2 = 6$ Hz, 1H, minor), 4.03(dd, $J_1 = 12$ Hz, $J_2 = 6$ Hz, 1H, major), 3.78-3.82(m, 2.6H, major+minor), 3.67(s, 1H, major), 3.48(s, 1H, minor), 3.23(s, 3H, minor), 3.19(s, 3H, major), 2.36(s, 3.9H, major+minor), 2.29(s, 3H, major), 2.20(s, 3H, minor), 1.33-1.37(m, 2.6H, major+minor), 0.71-0.77(m, 3.9H, major+minor).
Hz, $J_2 = 6$ Hz, 1H, minor), 4.04(dd, $J_1 = 12$ Hz, $J_2 = 6$ Hz, 1H, major), 3.78-3.85(m, 2H, major), 3.68-3.76(m, 2H, minor), 3.61(d, $J = 6$ Hz 1H, major), 3.32(d, $J = 6$ Hz 1H, minor), 3.20(s, 3H, minor), 3.15(s, 3H, major), 2.35(s, 3H, minor), 2.34(s, 3H, major), 2.33(s, 3H, minor), 2.31(s, 3H, major), 2.25(s, 3H, major), 2.20(s, 3H, minor), 1.26-1.39(m, 3.8H, major+minor), 0.72-0.76(m, 4.2H, major+minor).

$^1$H NMR (150 MHz, CDCl$_3$): ($\delta$, ppm, major+minor) 202.22, 202.04, 201.92, 201.59, 175.15, 174.88, 171.16, 170.26, 141.96, 141.69, 131.90, 131.86, 128.92, 128.59, 125.71, 125.08, 124.93, 107.72, 107.64, 95.16, 69.25, 66.83, 66.74, 66.33, 62.97, 45.84, 45.33, 44.60, 43.90, 30.42, 29.71, 27.62, 26.21, 25.99, 21.40, 20.92, 10.03.

HRMS (EI+): $m/z$ [M+] calcd for C$_{20}$H$_{25}$NO$_5$: 359.1733; found: 359.1734. $\left[\alpha\right]_{D}^{20} = -60.03$ (C = 1.00, CHCl$_3$).

HPLC (Chiralpak AS-H column, hexane/2-propanol = 80:20, 1mL/min, 254 nm, 25 °C, $t_{1\text{minor}} = 7.57$min, $t_{1\text{major}} = 9.51$min, $t_{2\text{minor}} = 11.91$ min, $t_{2\text{major}} = 21.31$ min).

Propyl 3-acetyl-2-(6-chloro-1-methyl-2-oxoindolin-3-yl)-4-oxopentanoate (11f)

Prepared according to the general procedure from (E)-propyl 2-(6-chloro-1-methyl-2-oxoindolin-3-ylidene)acetate 9f (0.25 mmol), 10 (1.50 mmol) and cat. 5 (0.025 mmol) in toluene (2.5 mL) at -60 °C for 84 h to provide the title compound as a light yellow oil (98% yield, >99%, >99% ee, 80:20 dr.).

Isomer mixtures (major isomer: minor isomer= 1: 0.49).

$^1$H NMR (600 MHz, CDCl$_3$): ($\delta$, ppm, major+minor) 7.23(d, $J = 12$ Hz, 1H, major), 7.20(d, $J = 12$ Hz, 1H, minor), 7.04(d, $J = 12$ Hz, 1H, major), 7.00(d, $J = 6$ Hz, 1H, minor), 4.80(d, $J = 12$ Hz, 1H, major), 4.44(d, $J = 12$ Hz, 1H, minor), 4.24(dd, $J_1 = 12$ Hz, $J_2 = 6$ Hz, 1H, minor), 4.03(dd, $J_1 = 12$ Hz, $J_2 = 6$ Hz, 1H, major), 3.83(t, $J = 6$ Hz, 2H, major), 3.70-3.78(m, 2H, minor), 3.63(d, $J = 6$ Hz, 1H, major), 3.35(d, $J = 6$ Hz, 1H, minor), 3.20(s, 3H, minor), 3.15(s, 3H, major), 2.35(s, 3H, minor), 2.26(s, 3H, major), 2.21(s, 3H, minor), 1.32-1.41(m, 2.9H, major+minor), 0.75(t, $J = 9$ Hz, 4.5H, major+minor).

$^{13}$C NMR (150 MHz, CDCl$_3$): ($\delta$, ppm, major+minor) 202.05, 201.88, 201.83, 201.37, 175.23, 174.94, 170.88, 170.01, 145.61, 145.29, 134.59, 134.19, 125.27, 125.10, 124.24, 123.36, 122.16, 122.10, 108.72, 108.66, 68.88, 67.03, 66.91, 66.15, 62.99, 45.68, 45.18, 44.18, 43.45, 30.47, 30.29, 29.84, 27.80, 26.34, 26.10, 21.44, 10.01.

HRMS (EI+): $m/z$ [M+] calcd for C$_{19}$H$_{22}$ClNO$_5$: 379.1187; found: 379.1194. $\left[\alpha\right]_{D}^{20} = -37.69$ (C = 1.00, CHCl$_3$).

HPLC (Chiralpak OD-H column, hexane/2-propanol = 85:15, 1mL/min, 254 nm, 25 °C, $t_{\text{minor}} = 12.82$ min, $t_{\text{major}} = 14.99$ min, $t_{\text{minor}} = 18.45$ min, $t_{\text{major}} = 25.53$ min).
Propyl 3-acetyl-2-(6-bromo-1-methyl-2-oxoindolin-3-yl)-4-oxopentanoate (11g)

Prepared according to the general procedure from (E)-propyl 2-(6-bromo-1-methyl-2-oxoindolin-3-ylidene)acetate 9g (0.25 mmol), 10 (1.50 mmol) and cat. 5 (0.025 mmol) in toluene (2.5 mL) at -60 °C for 35 h to provide the title compound as a light yellow oil (97% yield, >99%, >99% ee, 78:22 dr).

Isomer mixtures (major isomer: minor isomer= 1: 0.33).

$^1$H NMR (600 MHz, CDCl$_3$): (δ, ppm, major+minor) 7.13-7.21(m, 2.7H, major+minor), 6.95(s, 1.3H, major+minor), 4.80(d, J = 12 Hz, 1H, major), 4.43(d, J = 12 Hz, 1H, minor), 4.23(dd, $J_1$ = 12 Hz, $J_2$ = 6 Hz, 1H, major), 4.03(dd, $J_1$ = 12 Hz, $J_2$ = 6 Hz, 1H, minor), 3.71-3.83(m, 2.6H, major+minor), 3.60(s, 1H, major), 3.32(s, 1H, minor), 3.20(s, 3H, minor), 3.16(s, 3H, major), 2.34(s, 4H, major+minor), 2.26(s, 3H, major), 2.21(s, 3H, minor), 1.31-1.42(m, 2.7H, major+minor), 0.75(t, $J$ = 9 Hz, 4H, major+minor).

$^{13}$C NMR (CDCl$_3$, 150 MHz): (δ, ppm, major+minor) 202.06, 201.89, 201.36, 191.28, 175.10, 174.80, 170.88, 170.02, 145.74, 145.44, 125.63, 125.46, 125.13, 124.82, 123.94, 122.39, 121.98, 111.43, 68.90, 67.07, 66.94, 66.17, 45.62, 45.14, 44.25, 43.52, 30.51, 30.31, 29.86, 27.82, 26.36, 26.12, 21.46, 10.03.

HRMS (EI+): m/z [M+] calcd for C$_{19}$H$_{22}$BrNO$_5$: 423.0681; found: 423.0681. [$\alpha$]$^20$D = -26.26 (C = 1.00, CHCl$_3$).

HPLC (Chiralpak OD-H column, hexane/2-propanol = 85:15, 1mL/min, 254 nm, 25 °C, $t_{\text{minor}}$ = 15.06 min, $t_{\text{major}}$ = 17.13 min, $t_{\text{minor}}$ = 20.33 min, $t_{\text{major}}$ = 27.41 min).

Propyl 3-acetyl-2-(7-fluoro-1-methyl-2-oxoindolin-3-yl)-4-oxopentanoate (11h)

Prepared according to the general procedure from (E)-propyl 2-(7-fluoro-1-methyl-2-oxoindolin-3-ylidene)acetate 9h (0.25 mmol), 10 (1.50 mmol) and cat. 5 (0.025 mmol) in toluene (2.5 mL) at r.t. for 3 h to provide the title compound as a light yellow oil (95% yield, >99%, 90% ee, 72:28 dr).

Isomer mixtures (major isomer: minor isomer= 1: 0.4).

$^1$H NMR (600 MHz, CDCl$_3$): (δ, ppm, major+minor) 7.06-7.11(m, 1.4H, major+minor), 6.97-7.03(m, 2.8H, major+minor), 4.86(d, J = 12 Hz, 1H, major), 4.45(d, J = 12 Hz, 1H, minor), 4.27(dd, $J_1$ = 12 Hz, $J_2$ = 6 Hz, 1H, minor), 3.72-3.85(m, 2.8H, major+minor), 3.66(s, 1H, major), 3.43(s, 3H, minor), 3.39(s, 3H, major), 2.35(s, 4.1H, major+minor), 2.28(s, 3H, major), 2.22(s, 3H, minor), 1.32-1.40(m, 2.8H, major+minor), 0.73-0.78(m, 4.2H, major+minor).

$^{13}$C NMR (150 MHz, CDCl$_3$): (δ, ppm, major+minor) 202.11, 201.89, 201.38, 174.94, 174.63, 170.88, 170.06, 145.74, 145.44, 125.63, 125.46, 125.13, 124.82, 123.94, 122.39, 121.98, 111.43, 68.90, 67.07, 66.94, 66.17, 45.62, 45.14, 44.25, 43.52, 30.51, 30.31, 29.86, 27.82, 26.36, 26.12, 21.46, 10.03.
HRMS (EI+): \( m/z \ [M^+] \) calcd for \( C_{19}H_{22}FNO_5 \): 363.1482; found: 363.1475. \( \alpha_{20}D = -40.91 \) (\( C = 1.00, \ CHCl_3 \)).

HPLC (Chiralpak OD-H column, hexane/2-propanol = 80:20, 1mL/min: 254 nm, 25 °C, t_{1\text{minor}} = 7.45 min, t_{1\text{major}} = 9.71 min, t_{2\text{minor}} = 11.86 min, t_{2\text{major}} = 14.59 min).

Propyl 3-acetyl-2-(6-bromo-5-chloro-1-methyl-2-oxoindolin-3-yl)-4-oxopentanoate (11j)

Prepared according to the general procedure from (\( E \))-propyl 2-(6-bromo-5-chloro-1-methyl-2-oxoindolin-3-ylidene)acetate \( 9j \) (0.25 mmol), \( 10 \) (1.50 mmol) and cat. \( 5 \) (0.025 mmol) in toluene (2.5 mL) at -60 °C for 3 h to provide the title compound as semi-solid (94% yield, >99%, 84% ee, 75:25 dr.).

Isomer mixtures (major isomer: minor isomer= 1: 0.31).

1H NMR (600 MHz, CDCl_3): (\( \delta \), ppm, major+minor) 7.41(s, 1H, major), 7.36(s, 1H, minor), 7.06(d, 1.3H, major+minor), 4.84(d, \( J = 12.0 \) Hz, 1H, major), 4.43(d, \( J = 12.0 \) Hz, 1H, minor), 4.19(dd, \( J_1 = 12.0 \) Hz, \( J_2 = 6 \) Hz, 1H, major), 4.01(dd, \( J_1 = 12.0 \) Hz, \( J_2 = 6 \) Hz, 1H, major), 3.78-3.84(m, 2.7H, major+minor), 3.60(d, \( J = 6 \) Hz, 1H, major), 3.37(d, \( J = 6 \) Hz, 1H, minor), 3.19(s, 3H, minor), 3.15( s, 3H, major), 2.36(s ,4H, major+minor), 2.30(s, 3H, major), 2.23(s, 3H, minor), 1.35-1.43(m, 2.7H, major+minor), 0.75-0.79(m, 4H, major+minor).

13C NMR (150 MHz, CDCl_3): (\( \delta \), ppm, major+minor) 201.95, 201.84, 201.15, 191.27, 174.67, 174.36, 170.64, 169.86, 143.93, 143.66, 127.72, 127.61, 126.98, 126.07, 125.69, 122.29, 121.83, 112.86, 68.44, 67.23, 67.07, 66.15, 45.41, 44.98, 44.23, 43.48, 30.59, 30.37, 29.85, 27.97, 26.46, 26.22, 21.45, 10.01.

HRMS (EI+): \( m/z \ [M^+] \) calcd for \( C_{19}H_{21}BrClNO_5 \): 457.0292; found: 457.0298. \( \alpha_{20}D = -15.51 \) (\( C = 1.00, \ CHCl_3 \)).

HPLC (Chiralpak OD-H column, hexane/2-propanol = 80:20, 1mL/min, 254 nm, 25 °C, t_{1\text{minor}} = 15.10 min, t_{1\text{major}} = 17.00 min, t_{2\text{minor}} = 22.20 min, t_{2\text{major}} = 31.37 min).

Propyl 2-(1-methyl-2-oxoindolin-3-yl)-3-nitropropanoate (11k)

Prepared according to the general procedure from (\( E \))-propyl 2-(1-methyl-2-oxoindolin-3-ylidene)acetate \( 9a \) (0.25 mmol), nitromethane (1.50 mmol) and cat. \( 5 \) (0.025 mmol) in toluene (2.5 mL) at r.t. for 15 h to provide the title compound as a light yellow oil (80% yield, 96, 96% ee, 52 :48 dr). Isomer mixtures (major isomer: minor isomer= 1: 0.85)

1H NMR (600 MHz, CDCl_3): (\( \delta \), ppm, major+minor) 7.34(t, \( J = 9 \) Hz, 1.9H, major+minor), 7.24(d, \( J = 6 \) Hz, 1H, minor), 7.17(d, \( J = 6 \) Hz, 1H, major), 7.06-7.09(m, 1.9H, major+minor), 6.87(d, \( J = 6 \) Hz,
1H, major+minor), 4.94(dd, \( J_1 = 18 \text{ Hz}, J_2 = 12 \text{ Hz}, 1H, \text{ minor} \)), 4.72(dd, \( J_1 = 12 \text{ Hz}, J_2 = 12 \text{ Hz}, 1H, \text{ major} \)), 4.36-4.42(m, 1.9H, major+minor), 4.00-4.14(m, 5.7H, major+minor), 3.89-3.92(m, 1.9H, major+minor), 3.22(s, 3H, major), 3.22(s, 3H, minor), 1.52-1.62(m, 3.7H, major+minor), 0.84-0.89(m, 5.7H, major+minor).

\( ^{13}C \text{ NMR} \) (150 MHz, CDCl\(_3\)): (δ, ppm, major+minor) 174.38, 174.12, 169.87, 169.26, 144.38, 144.16, 129.21, 129.06, 124.37, 124.16, 123.94, 123.89, 122.83, 108.49, 72.29, 71.98, 67.57, 67.46, 44.51, 43.31, 43.00, 26.34, 26.28, 21.66, 21.59, 10.14.

HRMS (EI+): \( m/z \) [M⁺] calcd for C\(_{15}\)H\(_{18}\)N\(_2\)O\(_5\): 306.1216; found: 306.1218. \([\alpha]_D^{20} = -17.75 \text{ (C = 1.01, CHCl}_3\text{)}\).

HPLC (Chiralpak AD-H column, hexane/2-propanol = 70:30, 1mL/min, 254 nm, 25 °C, \( t_{1\text{major}} = 7.11 \text{ min, } t_{2\text{major}} = 8.36 \text{ min, } t_{1\text{minor}} = 8.88 \text{ min, } t_{2\text{minor}} = 9.46 \text{ min} \)).
6.0 The copy of NMR spectra
7. The copy of HPLC chromatograms

![HPLC Chromatograms](image)

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**VWD1 A, Wavelength=254 nm (D5W195 D)**

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**VWD1 A, Wavelength=254 nm (D5W594 D)**

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8. The copies of HRMS

Elemental Composition Report

DSC: min = -1.5, max = 50.0
Element prediction: Off

Monoisotopic Mass, Odd and Even Electron Ions
55 formula(s) evaluated with 5 results within limits (all results up to 1000 for each mass)
Elements Used:
C: 0.45
H: 0-6
Br: 0-3
O: 0-6
F: 0-1
Si: 0-1
Cl: 0-1

Minimum:

Molecular Mass: 345.1576

Elemental Composition Report

Single Mass Analysis
Tolerance = 1.5 mDa

Monoisotopic Mass, Odd and Even Electron Ions
55 formula(s) evaluated with 5 results within limits (all results up to 1000 for each mass)
Elements Used:
C: 0.45
H: 0-6
Br: 0-3
O: 0-6
F: 0-1
Si: 0-1
Cl: 0-1

Minimum:

Molecular Mass: 363.1482

Elemental Composition Report

Single Mass Analysis
Tolerance = 1.5 mDa

Monoisotopic Mass, Odd and Even Electron Ions
55 formula(s) evaluated with 5 results within limits (all results up to 1000 for each mass)
Elements Used:
C: 0.45
H: 0-6
Br: 0-3
O: 0-6
F: 0-1
Si: 0-1
Cl: 0-1

Minimum:

Molecular Mass: 429.1380

Elemental Composition Report

Single Mass Analysis
Tolerance = 1.5 mDa

Monoisotopic Mass, Odd and Even Electron Ions
55 formula(s) evaluated with 5 results within limits (all results up to 1000 for each mass)
Elements Used:
C: 0.45
H: 0-6
Br: 0-3
O: 0-6
F: 0-1
Si: 0-1
Cl: 0-1

Minimum:
Elemental Composition Report

Single Mass Analysis
Tolerance = 1.5 mDa / DBE: min = -1.5, max = 50.0
Element prediction: Off

Nonisotopic Mass, Odd and Even Electron Ions
476 formula(s) evaluated with 3 results within limits (all results up to 1000) for each mass

Elements Used:
C: 0-60
H: 0-60
N: 0-3
O: 0-6
F: 0-2
Cl: 0-1

Minimum: 1.5  0.0  0.0  0.0  0.0  0.0
Maximum: 1.5  5.0  50.0  50.0  50.0  50.0

Exact Mass: 359.1733

Elemental Composition Report

Single Mass Analysis
Tolerance = 1.5 mDa / DBE: min = -1.5, max = 50.0
Element prediction: Off

Nonisotopic Mass, Odd and Even Electron Ions
117 formula(s) evaluated with 5 results within limits (all results up to 1000) for each mass

Elements Used:
C: 0-60
H: 0-60
N: 0-3
O: 0-6
F: 0-2
Cl: 0-1

Minimum: 1.5  0.0  0.0  0.0  0.0  0.0
Maximum: 1.5  5.0  50.0  50.0  50.0  50.0

Exact Mass: 370.1187

Elemental Composition Report

Single Mass Analysis
Tolerance = 1.5 mDa / DBE: min = -1.5, max = 50.0
Element prediction: Off

Nonisotopic Mass, Odd and Even Electron Ions
36 formula(s) evaluated with 8 results within limits (all results up to 1000) for each mass

Elements Used:
C: 0-60
H: 0-60
N: 0-3
O: 0-6
F: 0-1
Cl: 0-1
Br: 0-1

Minimum: 1.5  0.0  0.0  0.0  0.0  0.0  0.0
Maximum: 1.5  5.0  50.0  50.0  50.0  50.0  50.0

Exact Mass: 423.0381

Elemental Composition Report

Single Mass Analysis
Tolerance = 1.5 mDa / DBE: min = -1.9, max = 10.0
Element prediction: Off

Nonisotopic Mass, Odd and Even Electron Ions
830 formula(s) evaluated with 8 results within limits (all results up to 1000) for each mass

Elements Used:
C: 0-60
H: 0-60
N: 0-3
O: 0-6
F: 0-1
Cl: 0-1
Br: 0-1
R: 0-1

Minimum: 1.5  0.0  0.0  0.0  0.0  0.0  0.0
Maximum: 1.5  3.0  50.0  50.0  50.0  50.0  50.0  50.0

Exact Mass: 363.1482

- S38 -
Elemental Composition Report

Single Mass Analysis
Tolerance = 1.5 mDa / DBE: min = -1.5, max = +5.0
Element prediction: Off

Monoisotopic Mass, Odd and Even Electron Ions
536 formula(s) evaluated with 4 results within limits (all results up to 1000 for each mass)
Elements Used:
Cl 0-60 Br 0-60 N 0-3 O 0-6 C11 0-1 Hr 0-1

Minimum: 1.5 5.0 -1.5
Maximum: 50.0 90.0 90.0

Mass CDB Mass ppm DBE L+FIT Formula
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457.0290 0.6 1.3 9.6 544025.5 C19 H21 N 0 O Cl Br
457.0286 0.8 1.0 35.5 544025.6 C31 H21 N 0 O
457.0285 1.1 2.4 13.5 544025.6 C31 H21 N 0 O Br

Exact Mass: 457.0292

Elemental Composition Report

Single Mass Analysis
Tolerance = 1.5 mDa / DBE: min = +1.5, max = +5.0
Element prediction: Off

Monoisotopic Mass, Odd and Even Electron Ions
742 formula(s) evaluated with 7 results within limits (all results up to 1000 for each mass)
Elements Used:
Cr 0-60 N 0-60 Br 0-60 N 0-6 F 0-1 C11 0-1

Minimum: 1.5 5.0 -1.5
Maximum: 90.0 90.0 90.0

Mass CDB Mass ppm DBE L+FIT Formula
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304.1220 -0.2 -0.7 3.0 544025.6 C15 H24 O F 8 Cl
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304.1229 0.9 3.9 7.0 544025.6 C18 H23 E C1
304.1227 -0.9 -2.9 4.9 544025.6 C12 H19 N2 O4 F
304.1227 1.2 3.6 3.5 544025.6 C15 H22 N3 F 5 C1
304.1233 -1.4 -0.6 -9.3 544025.5 C19 H22 N3 C5 F Cl

Exact Mass: 303.1216

- S39 -