Enantioselective Construction of Quaternary N-Heterocycles by Palladium-Catalysed Decarboxylative Allylic Alkylation of Lactams

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Materials and Methods

Unless otherwise stated, reactions were performed in flame-dried glassware under an argon or nitrogen atmosphere using dry, deoxygenated solvents. Solvents were dried by passage through an activated alumina column under argon. Brine solutions are saturated aqueous sodium chloride solutions. Tris(dibenzylideneacetone)dipalladium(0) (Pd$_2$(dba)$_3$) was purchased from Strem and stored in a glovebox. Lithium bis(trimethylsilyl)amide was purchased from Aldrich and stored in a glove box. Tris[ bis(p-methoxybenzylidene)-acetone]dipalladium(0) (Pd$_2$(pmdba)$_3$) was prepared by known methods and stored in a glovebox. Selectfluor, methyl iodide, and ethyl iodide were purchased from Aldrich, Acros Organics, Strem, or Alfa Aesar and used as received unless otherwise stated. Sodium hydride (NaH) was purchased as a 60% dispersion in mineral oil from Acros and used as such unless otherwise stated. Triethylamine was distilled from CaH$_2$ prior to use. Acrolein, acrylonitrile, methyl acrylate, and benzyol chloride were distilled prior to use. Reaction temperatures were controlled by an IKA mag temperature modulator. Thin-layer chromatography (TLC) was performed using E. Merck silica gel 60 F254 precoated plates (0.25 mm) and visualized by UV fluorescence quenching, anisaldehyde, KMnO$_4$, or CAM staining. ICN Silica gel (particle size 0.032 - 0.063 mm) was used for flash chromatography. Analytical chiral HPLC was performed with an Agilent 1100 Series HPLC utilizing a Chiralpak (AD-H or AS) or Chiralcel (OD-H, OJ-H, or OB-H) columns (4.6 mm x 25 cm) obtained from Daicel Chemical Industries, Ltd. with visualization at 220 or 254 nm. Analytical chiral SFC was performed with a JACSO 2000 series instrument utilizing Chiralpak (AD-H or AS-H) or Chiralcel (OD-H, OJ-H, or OB-H) columns (4.6 mm x 25 cm), or a Chiralpak IC column (4.6 mm x 10 cm) obtained from Daicel Chemical Industries, Ltd with visualization at 210 or 254 nm. Optical rotations were measured with a Jasco P-2000 polarimeter at 589 nm. $^1$H and $^{13}$C NMR spectra were recorded on a Varian Inova 500 (at 500 MHz and 126 MHz, respectively) or a Mercury 300 (at 300 MHz and 75 MHz, respectively), and are reported relative to residual protoio solvent (CDCl$_3$ = 7.26 and 77.0 ppm and C$_6$D$_6$ = 7.16 and 128.0 ppm, respectively). Data for $^1$H NMR spectra are reported as follows: chemical shift (δ ppm) (multiplicity, coupling constant (Hz), integration). IR spectra were recorded on a Perkin Elmer Paragon 1000 spectrometer and are reported in frequency of absorption (cm$^{-1}$). High resolution mass spectra were obtained using an Agilent 6200 Series TOF with an Agilent G1978A Multimode source in electrospray ionization (ESI), atmospheric pressure chemical ionization (APCI) or mixed (MM) ionization mode or from the Caltech Mass Spectral Facility.
Synthesis of Lactam Substrates

Representative Method 1: Diallyl Malonate Method

**Aldehyde SI2:** To a cooled (0 °C) solution of diallyl 2-methylmalonate (SI1)\(^3\) (17.0 g, 84.7 mmol, 1.00 equiv) and acrolein (6.23 mL, 93.2 mmol, 1.10 equiv) in MeCN (282 mL) was added DBU (253 µL, 1.70 mmol, 0.02 equiv). After 15 min, the reaction mixture was diluted with saturated aqueous NH\(_4\)Cl (200 mL) and EtOAc (100 mL) and the phases were separated. The aqueous phase was extracted with EtOAc (3 x 200 mL) and the combined organic phases were dried (Na\(_2\)SO\(_4\)), filtered, and concentrated under reduced pressure. The resulting oil was purified by flash chromatography (8 x 16 cm SiO\(_2\), 10 to 20% EtOAc in hexanes) to afford aldehyde SI2 as a colorless oil (19.7 g, 92% yield). \(R_f = 0.32\) (20% EtOAc in hexanes); \(^{1}H\) NMR (300 MHz, CDCl\(_3\)) \(\delta 9.71\) (t, \(J = 1.2\) Hz, 1H), 5.83 (ddt, \(J = 17.2, 10.5, 5.7\) Hz, 2H), 5.26 (dq, \(J = 17.2, 1.5\) Hz, 1H), 4.57 (dt, \(J = 5.6, 1.4\) Hz, 4H), 2.55–2.45 (m, 2H), 2.20–2.10 (m, 2H), 1.41 (s, 3H); \(^{13}C\) NMR (75 MHz, CDCl\(_3\)) \(\delta 200.6, 171.2, 131.3, 118.5, 65.9, 52.8, 39.2, 27.7, 20.3\); IR (Neat Film NaCl) 2988, 2945, 1732, 1230, 1186, 1116, 984, 935 cm\(^{-1}\); HRMS (MM: ESI-APCI) \(m/z\) calc’d for C\(_{13}\)H\(_{19}\)O\(_{5}\) [M+H]\(^+\): 255.1227, found 255.1223.

**Carbamate SI3:** To a cooled (0 °C) solution of aldehyde SI2 (19.7 g, 77.5 mmol, 1.00 equiv), BocNH\(_2\)\(^6\) (22.7 g, 194 mmol, 2.50 equiv), and Et\(_3\)SiH (31.0 mL, 194 mmol, 2.50 equiv) in MeCN (310 mL) was added trifluoroacetic acid (12.1 mL, 163 mmol, 2.10 equiv) dropwise over 5 min. The reaction mixture was stirred at 0°C for 2 h and at ambient temperature for an additional 18 h, at which point the reaction mixture was cooled (0 °C), treated with saturated aqueous NaHCO\(_3\) (150 mL), stirred for 40 min, and concentrated under reduced pressure to remove MeCN (~250 mL). The remaining material was diluted with Et\(_2\)O (200 mL) and the phases were separated. The aqueous phase was extracted with Et\(_2\)O (4 x 100 mL) and EtOAc (1 x 150 mL), and the combined organic phases were washed with brine (2 x 150 mL), dried over Na\(_2\)SO\(_4\), filtered, and concentrated under reduced pressure. The resulting oil was purified by flash chromatography (8 x 25 cm SiO\(_2\), 5 to 15% EtOAc in hexanes) to afford carbamate SI3 as a colorless oil (19.7 g, 87% yield). \(R_f = 0.32\) (20% EtOAc in hexanes); \(^{1}H\) NMR (300 MHz, CDCl\(_3\)) \(\delta 5.88\) (ddt, \(J = 17.3, 10.4, 5.7\) Hz, 2H), 5.30 (dq, \(J = 17.2, 1.6, 1.5\) Hz, 2H), 5.23 (dq, \(J = 10.4, 1.3, 1.3\) Hz, 2H), 4.61 (dt, \(J = 5.6, 1.4\) Hz, 1H), 4.55 (br s, 1H), 3.12 (q, \(J = 6.7\) Hz, 2H), 2.00–1.75 (m, 2H), 1.44 (m, 14H); \(^{13}C\) NMR (75 MHz, CDCl\(_3\)) \(\delta 171.6, 155.8, 131.5, 118.4, 79.0, 65.7, 53.4, 40.4, 32.7, 28.3, 24.9, 19.9\); IR (Neat Film NaCl) 3403, 2977, 2939, 1734, 1517, 1366, 1250, 1173, 984, 934 cm\(^{-1}\); HRMS (MM: ESI-APCI) \(m/z\) calc’d for C\(_{18}\)H\(_{29}\)NO\(_{6}\)Na [M+Na]\(^+\): 378.1887, found 378.1892.
**Lactam SI4:** To a cooled (0 °C) solution of carbamate SI3 (10.4 g, 30.6 mmol, 1.00 equiv) in toluene (306 mL) was added trimethylaluminum (11.7 mL, 61.1 mmol, 2.00 equiv) dropwise over 10 min. After 5 h the reaction was allowed to warm to ambient temperature and stirred for an additional 17 h. The reaction was cooled (0 °C), treated with brine (100 mL, CAUTION: Gas evolution and exotherm) in a dropwise manner over 30 min, and stirred until gas evolution ceased. The reaction mixture was then treated with saturated aqueous sodium potassium tartrate (200 mL) and stirred for 4 h. The phases were separated and the aqueous phase was extracted with EtOAc (5 x 150 mL). The combined organic phases were dried over Na₂SO₄, filtered, and concentrated under reduced pressure. The resulting oil was purified by flash chromatography (5 x 16 cm SiO₂, 45 to 65% EtOAc in hexanes) to afford lactam SI4 as a colorless oil (3.99 g, 66% yield). \[ R_f = 0.41 \] (100% EtOAc); \[^1^H\] NMR (300 MHz, CDCl₃) \( \delta \) 6.85 (s, 1H), 6.00–5.75 (m, 1H), 5.30 (d, \( J = 17.1 \) Hz, 1H), 5.20 (d, \( J = 10.4 \) Hz, 1H), 4.70–4.50 (m, 2H), 3.40–3.20 (m, 2H), 2.30–2.15 (m, 1H), 1.94–1.59 (m, 3H), 1.48 (s, 3H); \[^{13}\]C NMR (75 MHz, CDCl₃) \( \delta \) 173.1, 172.0, 131.7, 118.1, 65.7, 50.1, 42.3, 33.0, 22.4, 19.3; IR (Neat Film NaCl) 3207, 3083, 2942, 2873, 1737, 1668, 1194, 1132 cm⁻¹; HRMS (MM: ESI-APCI) \( m/z \) calc'd for C₁₀H₁₆NO₃ \([\text{M+H}]^+\): 198.1125, found 198.1117.

**Benzoyl Lactam 1h:** To a cooled (0 °C) solution of lactam SI4 (394 mg, 2.00 mmol, 1.00 equiv), triethylamine (840 µL, 6.00 mmol, 3.00 equiv), and DMAP (25.0 mg, 205 µmol, 0.102 equiv) in THF (8.00 mL) was added benzoyl chloride (470 µL, 4.00 mmol, 2.00 equiv) dropwise over 5 min. The reaction mixture was allowed to warm to ambient temperature and stirred for 14 h. The reaction mixture was then diluted with brine (10 mL) and EtOAc (10 mL), and the phases were separated. The aqueous phase was extracted with EtOAc (3 x 15 mL), and the combined organic phases were washed with brine (2 x 30 mL), dried over Na₂SO₄, filtered, and concentrated under reduced pressure. The resulting oil was purified by flash chromatography (3 x 25 cm SiO₂, 15 to 25% Et₂O in hexanes) to afford benzoyl lactam 1h as an amorphous solid (550 mg, 91% yield). \[ R_f = 0.38 \] (25% EtOAc in hexanes); \[^1^H\] NMR (500 MHz, CDCl₃) \( \delta \) 7.78–7.63 (m, 2H), 7.52–7.42 (m, 1H), 7.42–7.32 (m, 2H), 5.98 (ddt, \( J = 17.2, 10.4, 5.9 \) Hz, 1H), 5.40 (dq, \( J = 17.2, 1.4 \) Hz, 1H), 5.33 (dq, \( J = 10.4, 1.2 \) Hz, 1H), 4.72 (dt, \( J = 6.0, 1.3 \) Hz, 2H), 3.93–3.82 (m, 1H), 3.83–3.73 (m, 1H), 2.56–2.43 (m, 1H), 2.13–1.90 (m, 2H), 1.87–1.76 (m, 1H), 1.49 (s, 3H); \[^{13}\]C NMR (126 MHz, CDCl₃) \( \delta \) 174.9, 172.8, 172.4, 135.9, 131.6, 131.4, 128.0, 127.9, 119.5, 66.5, 52.9, 46.8, 33.8, 22.5, 20.2; IR (Neat Film NaCl) 3063, 2941, 2873, 1735, 1681, 1449, 1279, 1194, 1132 cm⁻¹; HRMS (MM: ESI-APCI) \( m/z \) calc'd for C₁₇H₂₀NO₄ \([\text{M+H}]^+\): 302.1387, found 302.1388.

**Tosyl Lactam 1a:** To a cooled (–78 °C) solution of LiHMDS (385 mg, 2.30 mmol, 1.15 equiv) in THF (8.0 mL) was added lactam SI4 (394 mg, 2.00 mmol, 1.00 equiv). The reaction mixture warmed to 0 °C and stirred for 30 min, then cooled to –78 °C and treated with TsCl (572 mg, 3.00 mmol, 1.50 equiv). After 5 min, the reaction mixture was allowed to warm to ambient temperature for 30 min and treated with saturated aqueous NH₄Cl (10 mL). The phases were separated, and the aqueous phase was extracted with EtOAc (3 x 20 mL). The combined organic phases were washed with saturated aqueous NaHCO₃ (20 mL) and brine (20 mL), dried over Na₂SO₄, filtered, and concentrated under reduced pressure. The resulting oil was purified by flash chromatography (3 x 30 cm SiO₂, 4:1:1 hexanes-EtOAc-DCM) to afford tosyl lactam 1a as a colorless oil (571 mg, 81% yield). \[ R_f = 0.58 \] (33% EtOAc in hexanes); \[^1^H\]
**NMR (500 MHz, CDCl₃):** 
- δ 7.93–7.83 (m, 2H)
- δ 7.35–7.27 (m, 2H)
- δ 5.68 (ddt, J = 17.2, 10.5, 5.6 Hz, 1H)
- δ 5.17 (dq, J = 9.1, 1.4 Hz, 1H)
- δ 5.14 (q, J = 1.4 Hz, 1H)
- δ 4.47 (qdt, J = 13.2, 5.6, 1.4 Hz, 2H)
- δ 3.98 (ddd, J = 12.8, 6.9, 6.1 Hz, 1H)
- δ 3.90 (ddt, J = 12.4, 6.0, 0.8 Hz, 1H)
- δ 2.34–2.26 (m, 1H)
- δ 1.95 (tt, J = 6.5, 5.5 Hz, 2H)
- δ 1.71 (ddd, J = 14.2, 8.1, 6.6 Hz, 1H)
- δ 2.42 (s, 3H)
- δ 1.41 (s, 3H)

**13C NMR (126 MHz, CDCl₃):**
- δ 171.8, 169.9, 144.6, 135.7, 131.1, 129.2, 128.6, 118.7, 66.1, 52.8, 46.4, 32.4, 22.3, 21.6, 20.4

**IR (Neat Film NaCl):**
- 2942, 1740, 1691, 1353, 1284, 1167, 1090 cm⁻¹

**HRMS (MM: ESI-APCI):**
- m/z calc'd for C₁₇H₂₁NO₅SNa [M+Na]^+: 374.1033, found 374.1042

**Representative Method 2: Acylation and Alkylation Method**

**Acyl Lactam SI6:** To a cooled (0 °C) solution of diisopropylamine (3.33 mL, 23.6 mmol, 1.20 equiv) in THF (131 mL) was added a solution of n-BuLi (8.84 mL, 21.7 mmol, 2.45 M in hexanes, 1.10 equiv) dropwise over 10 min. After 30 min at 0 °C, the reaction mixture was cooled to –78 °C. A solution of benzoyl lactam SI5 (4.00 g, 19.7 mmol, 1.00 equiv) in THF (25 mL) was added dropwise over 10 min. After an additional 2 h, the reaction mixture was warmed to –30 °C for 1 h, cooled to –78 °C, and treated with allyl cyanoformate (2.41 g, 21.7 mmol, 1.10 equiv). The reaction mixture was maintained at –78 °C for 2 h, allowed to warm to ambient temperature with stirring over 14 h, and diluted with half-saturated brine (100 mL) and EtOAc (100 mL). The phases were separated, and the aqueous phase was extracted with EtOAc (4 x 100 mL). The combined organic phases were washed with brine (2 x 100 mL), dried over Na₂SO₄, filtered, and concentrated under reduced pressure. The resulting oil was purified by flash chromatography (5 x 30 cm SiO₂, 15 to 30% EtOAc in hexanes) to afford acyl lactam SI6 as a colorless oil (4.18 g, 74% yield). 

**Rf = 0.43 (35% EtOAc in hexanes);**

**1H NMR (500 MHz, CDCl₃):**
- δ 7.75–7.62 (m, 2H)
- δ 7.52–7.43 (m, 1H)
- δ 7.42–7.33 (m, 2H)
- δ 5.95 (ddt, J = 17.2, 10.4, 5.9 Hz, 1H)
- δ 5.37 (dq, J = 10.4, 1.2 Hz, 1H)
- δ 4.75–4.60 (m, 2H)
- δ 3.95–3.72 (m, 2H)
- δ 3.59 (t, J = 6.4 Hz, 1H)
- δ 2.42–2.25 (m, 1H)

**13C NMR (126 MHz, CDCl₃):**
- δ 174.5, 169.5, 169.2, 135.4, 131.9, 131.4, 128.2, 128.1, 119.3, 66.4, 51.1, 46.3, 25.5, 20.7

**IR (Neat Film NaCl):**
- 3063, 2952, 1738, 1682, 1449, 1284, 1152, 730, 700 cm⁻¹

**HRMS (MM: ESI-APCI):**
- m/z calc'd for C₁₆H₁₈NO₄ [M+H]^+: 288.1230, found 288.1221

**Benzoyl Lactam SI7:** To a mixture of acyl lactam SI6 (750 mg, 2.61 mmol, 1.00 equiv) K₂CO₃ (1.80 g, 13.1 mmol, 5.00 equiv) in acetone (10.5 mL) was added acrylonitrile (344 µL, 5.22 mmol, 2.00 equiv). The reaction mixture was heated (55 °C) for 6 h, then cooled to ambient temperature and filtered. The retentate was washed with acetone (2 x 10 mL). The combined organic phases were concentrated under reduced pressure. The resulting oil was purified by flash chromatography (3 x 30 cm SiO₂, 5 to 30% EtOAc in hexanes) to afford benzoyl lactam SI7 as a colorless oil (654 mg, 74% yield). 

**Rf = 0.23 (20% EtOAc in hexanes developed twice);**

**1H NMR (500 MHz, CDCl₃):**
- δ 7.77–7.66 (m, 2H)
- δ 7.56–7.45 (m, 1H)
- δ 7.43–7.34 (m, 2H)
- δ 6.00 (ddt, J = 17.2, 10.3, 6.2 Hz, 1H)
- δ 5.44 (dq, J = 17.1, 1.3 Hz, 1H)
- δ 5.38 (dq, J = 10.3, 1.1 Hz, 1H)
- δ 4.77 (ddt, J = 6.1, 3.1, 1.2 Hz, 2H)
- δ 3.85 (dd, J = 13.0, 9.6, 5.4 Hz, 1H)
- δ 3.76 (ddt, J = 13.0, 4.9, 1.4 Hz, 1H)
- δ 2.61 (dd, J = 17.0, 8.4, 6.9 Hz, 1H)
- δ 2.53–2.35 (m, 2H)
- δ 2.22 (ddd, J = 8.8, 6.7, 1.2 Hz, 1H)
1.6 Hz, 2H), 2.12–1.95 (m, 2H), 1.89 (ddd, $J = 13.6, 10.1, 5.3$ Hz, 1H); $^{13}$C NMR (126 MHz, CDCl$_3$) $\delta$ 174.6, 171.2, 170.6, 135.4, 132.0, 130.8, 128.2, 128.1, 120.5, 119.1, 67.0, 55.4, 46.4, 31.7, 31.5, 20.0, 13.5; IR (Neat Film NaCl) 3067, 2952, 2248, 1733, 1683, 1449, 1271, 1196, 1175, 1152, 943, 725 cm$^{-1}$; HRMS (MM: ESI-APCI) $m/z$ calc’d for C$_{19}$H$_{21}$N$_2$O$_4$ [M+H]$^+$: 341.1496, found 341.1492.

**Preparation of Lactam Substrates Used in Figure 2**

**Boc Lactam 1b:** Prepared in a manner analogous to tosyl lactam 1a using lactam SI4 (394 mg, 2.00 mmol, 1.00 equiv) and Boc$_2$O (873 mg, 4.00 mmol, 2.00 equiv). Boc lactam 1b (407 mg, 68% yield) was isolated as an amorphous solid by flash chromatography (SiO$_2$, 9 to 11% Et$_2$O in hexanes). $R_f = 0.54$ (25% EtOAc in hexanes); $^1$H NMR (500 MHz, CDCl$_3$) $\delta$ 5.95–5.81 (m, 1H), 5.33 (dq, $J = 17.2, 1.5$ Hz, 1H), 5.22 (dq, $J = 10.5, 1.5$ Hz, 1H), 4.64 (m, 2H), 3.80–3.70 (m, 1H), 3.63–3.49 (m, 1H), 2.43–2.33 (m, 1H), 1.98–1.77 (m, 2H), 1.75–1.66 (m, 1H), 1.52 (s, 9H), 1.50 (s, 3H); $^{13}$C NMR (126 MHz, CDCl$_3$) $\delta$ 172.5, 170.9, 153.1, 131.5, 118.4, 83.0, 65.9, 53.1, 46.0, 32.6, 28.0, 22.9, 20.1; IR (Neat Film NaCl) 2981, 2939, 1772, 1719, 1457, 1393, 1294, 1282, 1254, 1152, 988, 945, 852 cm$^{-1}$; HRMS (MM: ESI-APCI) $m/z$ calc’d for C$_{15}$H$_{23}$NO$_5$Na [M+Na]$^+$: 320.1468, found 320.1470.

**Cbz Lactam 1c:** Prepared in a manner analogous to tosyl lactam 1a using lactam SI4 (394 mg, 2.00 mmol, 1.00 equiv) and CbzCl (682 mg, 4.00 mmol, 2.00 equiv). Cbz lactam 1c (325 mg, 49% yield) was isolated as a colorless oil by flash chromatography (SiO$_2$, 14 to 17% Et$_2$O in hexanes). $R_f = 0.34$ (25% EtOAc in hexanes); $^1$H NMR (500 MHz, CDCl$_3$) $\delta$ 7.47–7.40 (m, 2H), 7.39–7.28 (m, 3H), 5.85 (ddt, $J = 17.1, 10.5, 5.6$ Hz, 1H), 5.30 (dq, $J = 10.5, 1.3$ Hz, 1H), 5.29 (s, 2H), 5.19 (dq, $J = 10.5, 1.3$ Hz, 1H), 4.69–4.54 (m, 2H), 3.86–3.79 (m, 1H), 3.71–3.60 (m, 1H), 2.44–2.37 (m, 1H), 1.98–1.78 (m, 2H), 1.73 (ddd, $J = 14.0, 9.1, 5.1$ Hz, 1H), 1.52 (s, 3H); $^{13}$C NMR (126 MHz, CDCl$_3$) $\delta$ 172.3, 170.9, 154.4, 135.4, 131.3, 128.5, 128.2, 128.0, 118.7, 68.6, 66.1, 53.3, 46.4, 32.5, 22.8, 20.0; IR (Neat Film NaCl) 2943, 2876, 1776, 1721, 1456, 1378, 1270, 1191, 1167, 1125, 1002, 941, 739, 698 cm$^{-1}$; HRMS (MM: ESI-APCI) $m/z$ calc’d for C$_{18}$H$_{21}$NO$_5$Na [M+Na]$^+$: 354.1312, found 354.1310.

**Fmoc Lactam 1d:** Prepared in a manner analogous to tosyl lactam 1a using lactam SI4 (394 mg, 2.00 mmol, 1.00 equiv) and FmocCl (621 mg, 2.40 mmol, 1.20 equiv). Fmoc lactam 1d (352 mg, 42% yield) was isolated as a colorless oil by flash chromatography (SiO$_2$, 2 to 12% Et$_2$O in hexanes). $R_f = 0.28$ (25%
**EtOAc in hexanes:** $^1$H NMR (500 MHz, CDCl$_3$) $\delta$ 7.77 (dt, $J$ = 7.6, 0.9 Hz, 2H), 7.73 (ddt, $J$ = 7.5, 5.0, 1.0 Hz, 2H), 7.43–7.38 (m, 2H), 7.32 (tdd, $J$ = 7.4, 4.8, 1.2 Hz, 2H), 5.91 (ddt, $J$ = 17.2, 10.5, 5.6 Hz, 1H), 5.36 (dq, $J$ = 17.2, 1.5 Hz, 1H), 5.25 (dq, $J$ = 10.5, 1.3 Hz, 1H), 4.69 (ddt, $J$ = 5.6, 2.8, 1.4 Hz, 2H), 4.56–4.43 (m, 2H), 4.33 (t, $J$ = 7.5 Hz, 1H), 3.86–3.79 (m, 1H), 3.73–3.61 (m, 1H), 2.44 (dddd, $J$ = 13.8, 6.8, 5.0, 0.9 Hz, 1H), 2.00–1.83 (m, 2H), 1.78 (ddd, $J$ = 14.0, 9.1, 5.0 Hz, 1H), 1.59 (s, 3H); $^{13}$C NMR (126 MHz, CDCl$_3$) $\delta$ 172.3, 170.9, 154.5, 143.6, 141.2, 131.4, 127.8, 127.1, 125.4, 119.9, 118.7, 69.3, 66.1, 53.4, 46.6, 46.4, 32.6, 22.9, 20.0; IR (Neat Film NaCl) 2948, 2892, 1776, 1721, 1451, 1378, 1269, 1191, 997, 759, 742 cm$^{-1}$; HRMS (MM: ESI-APCI) m/z calc'd for C$_{25}$H$_{25}$NO$_5$Na [M+Na]$^+$: 442.1625, found 442.1610.

**Acetyl Lactam 1e:** Prepared in a manner analogous to benzoyl lactam 1h using lactam SI4 (394 mg, 2.00 mmol, 1.00 equiv), acetic anhydride (940 µL, 10.0 mmol, 5.00 equiv), and triethylamine (2.80 mL, 20.0 mmol, 10.0 equiv). Acetyl lactam 1e (347 mg, 72% yield) was isolated as a colorless oil by flash chromatography (SiO$_2$, 12 to 25% Et$_2$O in hexanes). $R_f$ = 0.44 (25% EtOAc in hexanes); $^1$H NMR (500 MHz, CDCl$_3$) $\delta$ 5.88 (ddt, $J$ = 17.1, 10.4, 5.7 Hz, 1H), 5.31 (dq, $J$ = 17.2, 1.5 Hz, 1H), 5.25 (dq, $J$ = 10.5, 1.2 Hz, 1H), 4.66–4.60 (m, 2H), 3.78 (dd, $J$ = 13.1, 7.6, 5.3 Hz, 1H), 3.71–3.62 (m, 1H), 2.49 (s, 3H), 2.44–2.37 (m, 1H), 1.93–1.77 (m, 2H), 1.78–1.70 (m, 1H), 1.52 (s, 3H); $^{13}$C NMR (126 MHz, CDCl$_3$) $\delta$ 174.0, 173.5, 172.4, 131.3, 119.1, 66.2, 53.2, 44.0, 32.9, 27.0, 22.7, 19.9; IR (Neat Film NaCl) 2985, 2942, 1739, 1699, 1457, 1368, 1261, 1190, 1132, 1048, 990, 959, 936 cm$^{-1}$; HRMS (MM: ESI-APCI) m/z calc'd for C$_{12}$H$_{18}$NO$_4$ [M+H]$^+$: 240.1230, found 240.1237.

**4-Methoxybenzoyl Lactam 1f:** Prepared in a manner analogous to benzoyl lactam 1h using lactam SI4 (394 mg, 2.00 mmol, 1.00 equiv), 4-methoxybenzoyl chloride (682 mg, 4.00 mmol, 2.00 equiv), and triethylamine (840 µL, 6.00 mmol, 3.00 equiv). 4-Methoxybenzoyl lactam 1f (425 mg, 64% yield) was isolated as a colorless oil by flash chromatography (SiO$_2$, CHCl$_3$-hexanes-Et$_2$O 6.5:5:1). $R_f$ = 0.76 (50% EtOAc in hexanes); $^1$H NMR (500 MHz, CDCl$_3$) $\delta$ 7.81–7.67 (m, 2H), 6.93–6.79 (m, 2H), 6.05–5.88 (m, 1H), 5.39 (dq, $J$ = 17.2, 1.4 Hz, 1H), 5.31 (dq, $J$ = 10.4, 1.2 Hz, 1H), 4.71 (dt, $J$ = 6.0, 1.3 Hz, 2H), 3.90–3.77 (m, 1H), 3.82 (s, 3H), 3.76–3.63 (m, 1H), 2.48 (ddd, $J$ = 13.7, 5.7, 4.3 Hz, 1H), 2.06–1.89 (m, 2H), 1.80 (ddd, $J$ = 13.5, 10.0, 5.0 Hz, 1H), 1.49 (s, 3H); $^{13}$C NMR (126 MHz, CDCl$_3$) $\delta$ 174.3, 172.6 (2C), 162.7, 131.4, 130.7, 127.7, 119.3, 113.3, 66.3, 55.3, 52.8, 46.9, 33.7, 22.5, 20.2; IR (Neat Film NaCl) 3080, 2941, 1732, 1682, 1604, 1512, 1456, 1390, 1257, 1173, 1139, 1029, 939, 844, 770 cm$^{-1}$; HRMS (MM: ESI-APCI) m/z calc'd for C$_{18}$H$_{22}$NO$_5$ [M+H]$^+$: 332.1492, found 332.1501.
4-Fluorobenzoyl Lactam **1g**: Prepared in a manner analogous to benzoyl lactam **1h** using lactam **SI4** (394 mg, 2.00 mmol, 1.00 equiv), 4-fluorobenzoyl chloride (470 µL, 4.00 mmol, 2.00 equiv), and triethylamine (840 µL, 6.00 mmol, 3.00 equiv). 4-Fluorobenzoyl lactam **1g** (557 mg, 87% yield) was isolated as an amorphous white solid by flash chromatography (SiO₂, 15 to 25% Et₂O in hexanes). *R* <sub>f</sub> = 0.37 (25% EtOAc in hexanes); ¹H NMR (500 MHz, CDCl₃) δ 7.84–7.72 (m, 2H), 7.12–6.97 (m, 2H), 5.99 (ddt, *J* = 17.2, 10.4, 5.9 Hz, 1H), 5.41 (dq, *J* = 17.2, 1.4 Hz, 1H), 5.35 (dq, *J* = 10.4, 1.2 Hz, 1H), 4.73 (dt, *J* = 6.0, 1.3 Hz, 2H), 3.89–3.82 (m, 1H), 3.81–3.75 (m, 1H), 2.57–2.42 (m, 1H), 2.09–1.91 (m, 2H), 1.89–1.75 (m, 1H), 1.50 (s, 3H); ¹³C NMR (126 MHz, CDCl₃) δ 173.8, 172.9, 172.5, 164.8 (*J*<sub>C-F</sub> = 252.5 Hz), 131.8 (*J*<sub>C-F</sub> = 3.3 Hz), 131.3, 130.7 (*J*<sub>C-F</sub> = 9.0 Hz), 119.5, 115.2 (*J*<sub>C-F</sub> = 22.0 Hz), 66.5, 52.9, 47.0, 33.8, 22.4, 20.2; IR (Neat Film NaCl) 3079, 2943, 2874, 1734, 1684, 1602, 1508, 1277, 1240, 1193, 1140, 939, 849, 770 cm⁻¹; HRMS (MM: ESI-APCI) *m/z* calc’d for C₁₇H₁₉NO₄F [M+H]⁺: 320.1293, found 320.1297.

**Preparation of Lactam Substrates Used in Figure 3**

**Benzoyl Lactam **SI8**: Prepared by representative method 1 using diallyl 2-ethylmalonate as a starting material. Benzoyl lactam **SI8** was isolated by flash chromatography (SiO₂, 15 to 25% Et₂O in hexanes) as a colorless oil. *R* <sub>f</sub> = 0.38 (35% Et₂O in hexanes); ¹H NMR (500 MHz, CDCl₃) δ 7.72–7.67 (m, 2H), 7.51–7.43 (m, 1H), 7.37 (dd, *J* = 8.3, 7.1 Hz, 2H), 5.99 (ddt, *J* = 17.3, 10.4, 5.9 Hz, 1H), 5.40 (dq, *J* = 17.2, 1.4 Hz, 1H), 5.33 (dq, *J* = 10.4, 1.2 Hz, 1H), 4.73 (dt, *J* = 6.0, 1.3 Hz, 2H), 3.93–3.63 (m, 2H), 2.43 (ddt, *J* = 13.7, 4.4, 1.4 Hz, 1H), 2.17–1.65 (m, 5H), 0.91 (t, *J* = 7.4 Hz, 3H); ¹³C NMR (126 MHz, CDCl₃) δ 175.0, 172.0, 171.8, 135.9, 131.6, 131.4, 128.0 (2C), 119.5, 66.4, 56.9, 46.4, 29.8, 28.6, 20.3, 9.0; IR (Neat Film NaCl) 3062, 2943, 2882, 1732, 1678, 1449, 1385, 1268, 1188, 1137, 980, 937, 723, 693, 660 cm⁻¹; HRMS (MM: ESI-APCI) *m/z* calc’d for C₈H₁₂NO₄ [M+H]⁺: 316.1543, found 316.1545.

**Benzoyl Lactam **SI9**: Prepared by representative method 1 using diallyl 2-benzylmalonate as a starting material. Benzoyl lactam **SI9** was isolated by flash chromatography (SiO₂, 15 to 35% Et₂O in hexanes) as a colorless oil. *R* <sub>f</sub> = 0.32 (35% Et₂O in hexanes); ¹H NMR (500 MHz, CDCl₃) δ 7.72 (dt, *J* = 8.2, 0.9 Hz, 2H), 7.56–7.45 (m, 1H), 7.45–7.35 (m, 2H), 7.30–7.18 (m, 3H), 7.17–7.10 (m, 2H), 6.00 (ddt, *J* = 17.2, 10.4, 6.0 Hz, 1H), 5.43 (dq, *J* = 17.2, 1.4 Hz, 1H), 5.36 (dq, *J* = 10.4, 1.1 Hz, 1H), 4.75 (dq, *J* = 6.1, 1.1 Hz, 2H), 3.70 (dddd, *J* = 12.9, 5.0, 4.3, 1.7 Hz, 1H), 3.59 (ddd, *J* = 12.9, 10.5, 4.6 Hz, 1H), 3.47 (d, *J* = 13.7 Hz, 1H), 3.14 (d, *J* = 13.7 Hz, 1H), 2.36 (ddt, *J* = 13.7, 4.3, 1.7 Hz, 1H), 2.07–1.92 (m, 1H), 1.91–
1.75 (m, 2H); $^{13}$C NMR (126 MHz, CDCl$_3$) δ 175.0, 171.5, 171.3, 135.9, 135.7, 131.8, 131.2, 130.9, 128.3, 128.2, 128.0, 127.0, 119.8, 66.7, 57.8, 46.2, 40.6, 29.8, 20.1; IR (Neat Film NaCl) 3062, 3029, 2941, 2890, 1731, 1701, 1683, 1449, 1273, 1190, 1147, 934, 723, 702, 661 cm$^{-1}$; HRMS (MM: ESI-APCI) $m/z$ calc’d for C$_{23}$H$_{24}$NO$_4$ [M+H]$^+$: 378.1700, found 378.1706.

**Benzoyl Lactam SI10:** Prepared by representative method 2 using methyl acrylate as an alkylating reagent. Benzoyl lactam SI10 was isolated by flash chromatography (SiO$_2$, 40 to 50% Et$_2$O in hexanes) as a colorless oil. $R_f = 0.28$ (35% Et$_2$O in hexanes); $^1$H NMR (500 MHz, CDCl$_3$) δ 7.78–7.66 (m, 2H), 7.52–7.42 (m, 1H), 7.38 (t, $J = 7.7$ Hz, 2H), 6.04–5.93 (m, 1H), 5.41 (dq, $J = 17.1, 1.1$ Hz, 1H), 5.35 (dt, $J = 10.4, 1.0$ Hz, 1H), 4.79–4.68 (m, 2H), 3.88–3.79 (m, 1H), 3.79–3.72 (m, 1H), 3.63 (s, 3H), 2.56–2.41 (m, 2H), 2.40–2.28 (m, 1H), 2.27–2.18 (m, 2H), 2.08–1.92 (m, 2H), 1.85 (ddd, $J = 15.2, 9.8, 5.7$ Hz, 1H); $^{13}$C NMR (126 MHz, CDCl$_3$) δ 174.8, 173.1, 171.6, 171.3, 135.7, 131.7, 131.1, 128.0 (2C), 119.9, 66.6, 55.8, 51.7, 46.4, 31.0, 30.5, 29.7, 20.1; IR (Neat Film NaCl) 2952, 1735, 1685, 1449, 1273, 1194, 1174, 726 cm$^{-1}$; HRMS (MM: ESI-APCI) $m/z$ calc’d for C$_{20}$H$_{24}$NO$_6$ [M+H]$^+$: 374.1598, found 374.1592.

**Benzoyl Lactam SI11:** Prepared by representative method 2 using (2-bromoethoxy)-tert-butyldimethylsilane as an alkylating reagent. Benzoyl lactam SI11 was isolated by flash chromatography (SiO$_2$, 10 to 40% Et$_2$O in hexanes) as a colorless oil. $R_f = 0.18$ (10% Et$_2$O in hexanes); $^1$H NMR (500 MHz, CDCl$_3$) δ 7.74–7.62 (m, 2H), 7.52–7.42 (m, 1H), 7.40–7.30 (m, 2H), 5.98 (ddt, $J = 17.1, 10.4, 6.0$ Hz, 1H), 5.40 (dq, $J = 17.2, 1.4$ Hz, 1H), 5.33 (dq, $J = 10.4, 1.2$ Hz, 1H), 4.72 (dt, $J = 6.0, 1.3$ Hz, 2H), 3.80 (ddt, $J = 6.4, 4.8, 2.4$ Hz, 2H), 3.72 (td, $J = 6.4, 0.8$ Hz, 2H), 2.55–2.31 (m, 1H), 2.23 (dt, $J = 14.1, 6.6$ Hz, 1H), 2.16–2.03 (m, 2H), 2.02–1.92 (m, 2H), 0.86 (s, 9H), 0.01 (s, 3H), 0.00 (s, 3H); $^{13}$C NMR (126 MHz, CDCl$_3$) δ 175.0, 171.7 (2C), 136.0, 131.6, 131.4, 128.0 (2C), 119.6, 66.5, 59.5, 55.3, 46.4, 37.8, 30.6, 25.9, 20.3, 18.2, –5.45, –5.47; IR (Neat Film NaCl) 2954, 2929, 2884, 2856, 1735, 1703, 1683, 1276, 1255, 1143, 1092, 836 cm$^{-1}$; HRMS (MM: ESI-APCI) $m/z$ calc’d for C$_{24}$H$_{36}$NO$_5$Si [M+H]$^+$: 446.2357, found 446.2361.
**Benzoyl Lactam SI12:** Prepared by representative method 1 using dimethallyl malonate as a starting material. Benzoyl lactam SI12 was isolated by flash chromatography (SiO$_2$, 14 to 20% Et$_2$O in hexanes) as an amorphous white solid. $R_f = 0.47$ (25% EtOAc in hexanes); $^1$H NMR $\delta$ 7.73–7.68 (m, 2H), 7.49–7.44 (m, 1H), 7.37 (dd, $J = 8.1, 6.7, 1.2$ Hz, 2H), 5.05 (s, 1H), 5.01 (s, 1H), 4.65 (dd, $J = 17.5, 10.0$ Hz, 2H), 3.87 (dd, $J = 12.9, 8.8, 5.6$ Hz, 1H), 3.80 (ddt, $J = 12.9, 5.2, 1.4$ Hz, 1H), 2.55–2.46 (m, 1H), 1.86–1.79 (m, 1H), 1.79 (s, 3H), 1.50 (s, 3H) ; $^{13}$C NMR (126 MHz, CDCl$_3$) $\delta$ 174.9, 172.8, 172.5, 139.3, 135.9, 131.6, 128.0 (2C), 114.2, 69.1, 53.0, 46.8, 33.8, 22.5, 20.3, 19.6; IR (Neat Film NaCl) 2941, 2873, 1735, 1682, 1449, 1276, 1192, 1140, 940, 724, 694, 659 cm$^{-1}$; HRMS (MM: ESI-APCI) $m/z$ calc'd for C$_{18}$H$_{21}$NO$_4$Na [M+Na]$^+$: 338.1363, found 338.1373.

**Benzoyl Lactam SI13:** Prepared by representative method 1 using di-2-chloroallyl malonate as a starting material. Benzoyl lactam SI13 was isolated by flash chromatography (SiO$_2$, 14 to 20% Et$_2$O in hexanes) as a colorless oil. $R_f = 0.47$ (25% EtOAc in hexanes); $^1$H NMR (500 MHz, CDCl$_3$) $\delta$ 7.76–7.64 (m, 2H), 7.56–7.41 (m, 1H), 7.43–7.31 (m, 2H), 5.54 (dt, $J = 2.0, 1.1$ Hz, 1H), 5.48 (d, $J = 1.8$ Hz, 1H), 4.80 (qd, $J = 13.4, 1.0$ Hz, 2H), 3.89 (ddd, $J = 12.9, 8.9, 5.1$ Hz, 1H), 3.80 (ddt, $J = 13.8, 5.3, 1.3$ Hz, 1H), 2.52 (dddd, $J = 13.8, 5.6, 4.1, 1.3$ Hz, 1H), 2.11–1.94 (m, 2H), 1.85 (dd, $J = 13.8, 10.2, 4.5$ Hz, 1H), 1.53 (s, 3H) ; $^{13}$C NMR (126 MHz, CDCl$_3$) $\delta$ 174.9, 172.5, 172.1, 135.8, 135.3, 131.7, 128.1, 128.0, 116.4, 67.1, 52.9, 46.7, 33.7, 22.5, 20.1; IR (Neat Film NaCl) 2943, 2873, 1735, 1682, 1449, 1390, 1276, 1192, 1124, 1061, 943, 724, 695 cm$^{-1}$; HRMS (MM: ESI-APCI) $m/z$ calc'd for C$_{17}$H$_{18}$NO$_4$ClNa [M+Na]$^+$: 358.0817, found 358.0819.

**Benzoyl Lactam SI14:** Prepared by representative method 2 using N-benzoyl pyrrolidinone$^8$ as a starting material and methyl iodide as an alkylating reagent. Benzoyl lactam SI14 was isolated by flash chromatography (SiO$_2$, 5 to 20% EtOAc in hexanes) as a colorless oil. $R_f = 0.45$ (35% EtOAc in hexanes); $^1$H NMR (500 MHz, CDCl$_3$) $\delta$ 7.64–7.55 (m, 2H), 7.56–7.46 (m, 1H), 7.45–7.35 (m, 2H), 5.92 (ddt, $J = 17.2, 10.5, 5.7$ Hz, 1H), 5.34 (dq, $J = 17.2, 1.5$ Hz, 1H), 5.28 (dq, $J = 10.4, 1.2$ Hz, 1H), 4.67 (dt, $J = 5.7, 1.4$ Hz, 2H), 4.02 (dd, $J = 11.3, 8.4, 4.6$ Hz, 1H), 3.95 (dt, $J = 11.3, 7.7$ Hz, 1H), 2.64 (ddd, $J = 13.2, 7.7, 4.5$ Hz, 1H), 2.06 (dd, $J = 13.2, 8.5, 7.6$ Hz, 1H), 1.51 (s, 3H) ; $^{13}$C NMR (126 MHz, CDCl$_3$) $\delta$ 173.0, 170.9, 170.5, 133.9, 132.0, 131.2, 128.8, 127.8, 119.0, 66.4, 53.8, 43.3, 30.5, 20.0; IR (Neat Film NaCl) 2985, 2938, 1750, 1738, 1733, 1683, 1449, 1362, 1307, 1247, 1196, 1136, 972, 937, 860, 730, 699, 656 cm$^{-1}$; HRMS (MM: ESI-APCI) $m/z$ calc'd for C$_{16}$H$_{18}$NO$_4$ [M+H]$^+$: 288.1230, found 288.1228.
Benzoyl Lactam SI15: Prepared by representative method 2 using N-benzoyl pyrrolidinone as a starting material and 4-(trifluoromethyl)benzyl bromide as an alkylating reagent. Benzoyl lactam SI15 was isolated by flash chromatography (SiO₂, 10 to 20% EtOAc in hexanes) as a colorless oil. Rₜ = 0.28 (20% EtOAc in hexanes); ¹H NMR (500 MHz, CDCl₃) δ 7.58 (d, J = 7.9 Hz, 2H), 7.56–7.49 (m, 3H), 7.44–7.38 (m, 2H), 5.92 (ddt, J = 17.3, 10.4, 5.8 Hz, 1H), 5.36 (dq, J = 17.2, 1.4 Hz, 1H), 5.30 (dq, J = 10.5, 1.2 Hz, 1H), 4.70 (dq, J = 5.8, 1.2 Hz, 2H), 3.84 (ddd, J = 11.2, 8.6, 7.6 Hz, 1H), 3.66 (ddd, J = 11.2, 8.8, 3.2 Hz, 1H), 3.39 (d, J = 13.3, 7.6, 3.3 Hz, 1H), 2.15 (dt, J = 13.3, 8.7 Hz, 1H); ¹³C NMR (126 MHz, CDCl₃) δ 171.3, 170.2, 169.8, 133.7, 132.3, 130.9, 129.8 (q, J_C-F = 32.5 Hz), 128.9, 127.9, 125.5 (q, J_C-F = 3.8 Hz), 124.0 (q, J_C-F = 272.0 Hz), 119.5, 66.8, 59.0, 43.6, 38.4, 26.2; IR (Neat Film NaCl) 3062, 2938, 2913, 1751, 1733, 1683, 1449, 1366, 1326, 1294, 1250, 1193, 1165, 1068, 861, 728 cm⁻¹; HRMS (MM: ESI-APCI) m/z calc’d for C₂₃H₂₁NO₄F₃ [M+H]+: 432.1417, found 432.1425.

Benzoyl Lactam SI16: Prepared by representative method 2 using N-benzoyl pyrrolidinone as a starting material and using Selectfluor as a fluorinating agent. Benzoyl lactam SI16 was isolated by flash chromatography (SiO₂, 10 to 20% EtOAc in hexanes) as a colorless oil. Rₜ = 0.28 (20% EtOAc in hexanes); ¹H NMR (500 MHz, CDCl₃) δ 7.66–7.59 (m, 2H), 7.59–7.50 (m, 1H), 7.46–7.37 (m, 2H), 5.92 (ddt, J = 17.2, 10.4, 5.8 Hz, 1H), 5.38 (dq, J = 17.2, 1.4 Hz, 1H), 5.32 (dq, J = 10.4, 1.1 Hz, 1H), 4.77 (dt, J = 5.9, 1.3 Hz, 2H), 4.15 (dd, J = 11.2, 8.8, 4.2 Hz, 1H), 4.01 (ddd, J = 11.3, 7.7, 7.0, 2.0 Hz, 1H), 2.80 (ddd, J = 14.1, 13.4, 7.8, 4.2 Hz, 1H), 2.53 (ddd, J = 23.0, 14.2, 8.8, 7.1 Hz, 1H); ¹³C NMR (126 MHz, CDCl₃) δ 169.8, 166.0 (d, J = 10.2 Hz), 165.8 (d, J = 5.5 Hz), 132.9, 132.7, 130.4, 129.0, 128.0, 120.0, 94.4 (d, J = 203.6 Hz), 67.2, 42.3 (d, J = 2.9 Hz), 29.0 (d, J = 21.7 Hz); IR (Neat Film NaCl) 3062, 2987, 2917, 1773, 1690, 1449, 1373, 1290, 1257, 1198, 1161, 1118, 1076, 983, 942, 859, 796, 731 cm⁻¹; HRMS (MM: ESI-APCI) m/z calc’d for C₁₆H₁₉NO₅F [M+MeOH+H]+: 324.1242, found 324.1244.

4-Methoxybenzoyl Lactam SI17: Prepared by combination of known methods and representative method 1. Benzoyl lactam SI17 was isolated by flash chromatography (SiO₂, 15 to 25% Et₂O in hexanes) as a colorless oil. Rₜ = 0.38 (35% Et₂O in hexanes); ¹H NMR (500 MHz, CDCl₃) δ 7.79–7.68 (m, 2H), 6.94–6.80 (m, 2H), 5.99 (ddt, J = 17.1, 10.4, 6.1 Hz, 1H), 5.43 (dq, J = 17.2, 1.4 Hz, 1H), 5.34 (dq, J =
10.4, 1.1 Hz, 1H), 4.76 (dt, J = 6.1, 1.2 Hz, 2H), 4.28–4.16 (m, 1H), 3.84 (s, 3H), 3.15 (ddd, J = 15.6, 11.1, 1.2 Hz, 1H), 2.28–2.17 (m, 1H), 2.01–1.87 (m, 2H), 1.87–1.76 (m, 1H), 1.63 (ddd, J = 14.8, 11.8, 3.7 Hz, 2H), 1.48 (s, 3H); 13C NMR (126 MHz, CDCl3) δ 175.1, 174.6, 172.8, 162.6, 131.3, 130.7, 128.2, 119.9, 113.5, 66.2, 55.3, 44.6, 34.3, 28.1, 26.9, 24.9; IR (Neat Film NaCl) 2939, 1679, 1604, 1512, 1456, 1281, 1256, 1169, 1139, 1054, 961 cm⁻¹; HRMS (MM: ESI-APCI) m/z calc’d for C19H24NO5 [M+H]+: 346.1649, found 346.1642.

Benzoyl Lactam SI18: Prepared by representative method 2 using 3-morpholinone as a starting material and methyl iodide as an alkylating reagent. Benzoyl lactam SI18 was isolated by flash chromatography (SiO2, 5 to 15% EtOAc in hexanes) as a colorless oil. Rf = 0.40 (20% EtOAc in hexanes); 1H NMR (500 MHz, CDCl3) δ 7.70–7.61 (m, 2H), 7.56–7.44 (m, 1H), 7.46–7.33 (m, 2H), 5.98 (ddt, J = 17.1, 10.4, 5.9 Hz, 1H), 5.41 (dq, J = 17.2, 1.4 Hz, 1H), 5.34 (dq, J = 10.4, 1.1 Hz, 1H), 4.76 (dt, J = 6.0, 1.3 Hz, 2H), 4.24 (ddd, J = 12.4, 10.1, 3.2 Hz, 1H), 4.12 (ddd, J = 12.4, 4.1, 3.3 Hz, 1H), 4.02 (ddd, J = 13.2, 10.1, 4.1 Hz, 1H), 3.91 (dt, J = 13.2, 3.3 Hz, 1H), 1.68 (s, 3H); 13C NMR (126 MHz, CDCl3) δ 173.0, 169.0 (2C), 134.9, 132.2, 131.0, 128.3, 128.1, 119.8, 81.5, 66.8, 61.6, 45.3, 22.2; IR (Neat Film NaCl) 2943, 2892, 1749, 1689, 1149, 1375, 1311, 1281, 1246, 1124, 1080, 938, 727 cm⁻¹; HRMS (MM: ESI-APCI) m/z calc’d for C16H18NO5 [M+H]+: 304.1179, found 304.1171.

Benzoyl Lactam SI19: Prepared by representative method 2 using Selectfluor as a fluorinating agent. Benzoyl lactam SI19 was isolated by flash chromatography (SiO2, 20 to 35% Et2O in hexanes) as a colorless oil. Rf = 0.57 (35% Et2O in hexanes developed three times); 1H NMR (500 MHz, CDCl3) δ 7.69–7.61 (m, 2H), 7.53–7.45 (m, 1H), 7.42–7.34 (m, 2H), 5.94 (ddt, J = 17.2, 10.4, 5.9 Hz, 1H), 5.39 (dq, J = 10.4, 1.1 Hz, 1H), 4.76 (dt, J = 6.0, 1.3 Hz, 2H), 4.24 (ddd, J = 12.9, 6.0, 4.7, 1.1 Hz, 1H), 3.80 (ddd, J = 14.8, 8.8, 4.4, 1.7 Hz, 1H), 2.62–2.45 (m, 1H), 2.45–2.30 (m, 1H), 2.25–2.05 (m, 2H); 13C NMR (126 MHz, CDCl3) δ 173.8, 166.7 (d, J = 26.0 Hz), 166.3 (d, J = 23.5 Hz), 134.3, 132.3, 130.6, 128.3, 128.2, 119.9, 92.4 (d, J = 194.8 Hz), 67.1, 46.2, 31.9 (d, J = 22.4 Hz), 18.6 (d, J = 4.0 Hz); IR (Neat Film NaCl) 3064, 2956, 2968, 1711, 1691, 1450, 1396, 1304, 1271, 1190, 1137, 1102, 994, 944, 912, 726, 694, 658 cm⁻¹; HRMS (MM: ESI-APCI) m/z calc’d for C16H17NO4F [M+H]+: 306.1136, found 306.1131.

Benzoyl Glutarimide SI20: Prepared from glutarimide by combination of known methods and representative method 1. Benzoyl glutarimide SI20 (32 mg, 72% yield) was isolated as a colorless oil by...
Benzoyl Glutarimide SI21: Prepared from glutarimide by combination of known methods and representative method 1. Benzoyl glutarimide SI21 (67 mg, 85% yield) was isolated as a colorless oil by flash chromatography (SiO₂, 17 to 25% EtOAc in hexanes). \( R_f = 0.24 \) (25% EtOAc in hexanes); \( ^1H \) NMR (500 MHz, CDCl₃) \( \delta \): 7.95 (d, \( J = 8.28 \) Hz, 2H), 7.62 (t, \( J = 7.46 \) Hz, 1H), 7.46 (dd, \( J = 8.28, 7.46 \) Hz, 2H), 5.93 (ddt, \( J = 17.0, 6.0, 1.2 \) Hz, 1H), 5.39 (dq, \( J = 17.0, 1.2 \) Hz, 1H), 5.32 (ddq, \( J = 10.4, 1.2 \) Hz, 1H), 4.77 (ddt, \( J = 12.9, 6.0, 1.2 \) Hz, 1H), 2.84–2.72 (m, 2H), 2.34 (ddd, \( J = 14.1, 5.2, 3.3 \) Hz, 1H), 2.19 (dd, \( J = 14.1, 12.2, 5.8 \) Hz, 1H), 2.15–2.02 (m, 2H), 1.01 (t, \( J = 7.44 \) Hz, 3H); \( ^13C \) NMR (126 MHz, CDCl₃) \( \delta \): 173.9, 172.3, 171.6, 135.8, 131.2, 130.6, 128.3, 127.1, 119.3, 66.8, 58.1, 43.6, 41.2, 29.4, 27.2, 19.8; IR (Neat Film NaCl) 3063, 3029, 2942, 1733, 1699, 1496, 1455, 1368, 1296, 1234, 1177, 1116, 1034, 992, 975, 934, 746, 703 cm⁻¹; HRMS (MM: ESI-APCI) \( m/z \) calc'd for C₁₈H₂₀NO₄ [M+H]⁺: 330.1336, found 330.1334.

Acetyl Lactam SI22: Prepared by representative method 1 using diallyl 2-benzylmalonate as a starting material and acetic anhydride as an acetylating reagent. Acetyl lactam SI22 was isolated by flash chromatography (SiO₂, 5 to 20% EtOAc in hexanes) as a colorless oil. \( R_f = 0.46 \) (20% EtOAc in hexanes); \( ^1H \) NMR (500 MHz, CDCl₃) \( \delta \): 7.30–7.20 (m, 3H), 7.20–7.14 (m, 2H), 5.88 (ddt, \( J = 17.2, 10.4, 5.8 \) Hz, 1H), 5.33 (dq, \( J = 17.2, 1.5 \) Hz, 1H), 5.27 (dq, \( J = 10.4, 1.2 \) Hz, 1H), 4.65 (dq, \( J = 5.8, 1.4 \) Hz, 2H), 3.73–3.62 (m, 1H), 3.53 (d, \( J = 13.6 \) Hz, 1H), 3.35 (dd, \( J = 13.8, 9.1, 4.8 \) Hz, 1H), 3.16 (d, \( J = 13.6 \) Hz, 1H), 2.52 (s, 3H), 2.29–2.19 (m, 1H), 1.89–1.71 (m, 2H), 1.70–1.56 (m, 1H); \( ^13C \) NMR (126 MHz, CDCl₃) \( \delta \): 173.9, 172.3, 171.6, 135.8, 131.2, 130.6, 128.3, 127.1, 119.3, 66.4, 58.1, 43.6, 41.2, 29.4, 27.2, 19.8; IR (Neat Film NaCl) 3063, 3029, 2942, 1733, 1699, 1496, 1455, 1368, 1296, 1234, 1177, 1116, 1034, 992, 975, 934, 746, 703 cm⁻¹; HRMS (MM: ESI-APCI) \( m/z \) calc'd for C₁₈H₂₂NO₄ [M+H]⁺: 316.1543, found 316.1541.
**Phenyl Carbamate Lactam SI23:** Prepared in a manner analogous to tosyl lactam 1a using lactam SI4 and phenyl chloroformate. Phenyl carbamate lactam SI23 was isolated by flash chromatography (SiO2, 5 to 20% EtOAc in hexanes) as a colorless oil. Rf = 0.42 (50% EtOAc in hexanes); 1H NMR (500 MHz, CDCl3) δ 7.40–7.35 (m, 2H), 7.26–7.21 (m, 1H), 7.20–7.16 (m, 2H), 5.91 (ddt, J = 17.2, 10.4, 5.6 Hz, 1H), 5.36 (dq, J = 17.2, 1.5 Hz, 1H), 5.26 (dq, J = 10.5, 1.3 Hz, 1H), 4.77–4.59 (m, 2H), 3.90 (ddt, J = 12.9, 10.4, 5.6 Hz, 1H), 3.85–3.74 (m, 1H), 2.47 (dddd, J = 13.8, 6.2, 5.0, 1.0 Hz, 1H), 2.06–1.86 (m, 2H), 1.80 (ddd, J = 14.2, 9.3, 5.0 Hz, 1H), 1.56 (s, 3H); 13C NMR (126 MHz, CDCl3) δ 172.1, 171.2, 153.3, 150.8, 131.3, 129.4, 126.0, 121.4, 118.8, 66.2, 53.4, 46.8, 32.7, 22.7, 20.1; IR (Neat Film NaCl) 2943, 1786, 1732, 1494, 1457, 1297, 1267, 1204, 1161, 1134, 982, 943, 752, 689, 665 cm⁻¹; HRMS (MM: ESI-APCI) m/z calc’d for C17H20NO5 [M+H]+: 318.1336, found 318.1332.

**Benzyl Carbamate Lactam SI24:** Prepared by representative method 2 using N-benzyloxy carbonyl pyrrolidin-2-one12 as a starting material and methyl iodide as an alkylating reagent. Cbz lactam SI24 was isolated by flash chromatography (SiO2, 5 to 15% EtOAc in hexanes) as a colorless oil. Rf = 0.40 (20% EtOAc in hexanes); 1H NMR (500 MHz, CDCl3) δ 7.46–7.40 (m, 2H), 7.40–7.28 (m, 3H), 5.87 (ddt, J = 17.1, 10.4, 5.6 Hz, 1H), 5.30 (dq, J = 17.2, 1.5 Hz, 1H) 5.30 (s, 2H), 5.23 (dq, J = 10.5, 1.2 Hz, 1H), 4.69–4.55 (m, 2H), 3.82 (ddq, J = 10.7, 8.4, 5.8 Hz, 2H), 2.54 (dddd, J = 14.2, 9.3, 5.0 Hz, 1H), 1.93 (dt, J = 13.2, 8.3 Hz, 1H), 1.50 (s, 3H); 13C NMR (126 MHz, CDCl3) δ 171.9, 170.7, 151.4, 135.1, 131.3, 128.6, 128.4, 128.1, 118.8, 68.3, 66.3, 53.3, 43.7, 30.5, 20.2; IR (Neat Film NaCl) 2984, 2939, 1793, 1758, 1725, 1456, 1383, 1300, 1202, 1138, 1009, 983, 774, 739, 698 cm⁻¹; HRMS (MM: ESI-APCI) m/z calc’d for C17H20NO5 [M+H]+: 318.1336, found 318.1136.

**4-Phenylbenzoyl Lactam SI25:** Prepared by representative method 1 using lactam SI4 and 4-phenylbenzoyl chloride. 4-Phenylbenzoyl lactam SI25 was isolated by flash chromatography (SiO2, 5 to 15% EtOAc in hexanes) as an off-white solid. Rf = 0.27 (20% EtOAc in hexanes); 1H NMR (500 MHz, CDCl3) δ 7.84–7.77 (m, 2H), 7.65–7.54 (m, 4H), 7.49–7.40 (m, 2H), 7.40–7.34 (m, 1H), 6.00 (ddt, J = 17.2, 10.4, 5.9 Hz, 1H), 5.41 (dq, J = 17.2, 1.5 Hz, 1H), 5.34 (dq, J = 10.4, 1.2 Hz, 1H), 4.75 (dt, J = 5.9, 1.3 Hz, 2H), 3.95–3.84 (m, 1H), 3.81 (ddt, J = 12.9, 5.1, 1.4 Hz, 1H), 2.52 (dddd, J = 13.8, 5.7, 4.3, 1.4 Hz, 1H), 2.10–1.94 (m, 2H), 1.90–1.76 (m, 1H), 1.52 (s, 3H); 13C NMR (126 MHz, CDCl3) δ 174.7, 172.9, 172.5, 144.5, 140.3, 134.5, 131.4, 128.8, 128.7, 127.8, 127.3, 126.8, 119.5, 66.5, 52.9, 46.89, 33.8, 22.5, 20.3; IR (Neat Film NaCl) 3030, 2942, 2874, 1733, 1679, 1607, 1486, 1449, 1389, 1278, 1191, 1139, 939, 749, 698 cm⁻¹; HRMS (MM: ESI-APCI) m/z calc’d for C23H24NO4 [M+H]+: 388.1700, found 378.1708.
1-Naphthoyl Lactam SI26: Prepared by representative method 1 using lactam SI4 and 1-naphthoyl chloride. 1-Naphthoyl lactam SI26 was isolated by flash chromatography (SiO₂, 10 to 20% EtOAc in hexanes) as a colorless oil. \( R_f = 0.50 \) (35% EtOAc in hexanes); \(^1\)H NMR (500 MHz, CDCl₃) \( \delta 8.07–8.01 \) (m, 1H), 7.90 (dd, \( J = 8.2, 1.4 \) Hz, 1H), 7.88–7.83 (m, 1H), 7.57–7.47 (m, 3H), 7.42 (td, \( J = 7.6, 7.0, 1.2 \) Hz, 1H), 5.99–5.86 (m, 1H), 5.35 (dq, \( J = 17.3, 1.3 \) Hz, 1H), 5.30 (dq, \( J = 10.6, 1.0 \) Hz, 1H), 4.66 (ddt, \( J = 5.4, 4.2, 1.3 \) Hz, 2H), 4.13–3.91 (m, 2H), 2.49 (ddd, \( J = 13.6, 6.1, 4.5 \) Hz, 1H), 2.14–1.97 (m, 2H), 1.83 (ddd, \( J = 14.3, 9.9, 4.6 \) Hz, 1H), 1.42 (s, 3H); \(^{13}\)C NMR (126 MHz, CDCl₃) \( \delta 173.8, 172.4, 172.1, 134.9, 133.6, 131.3, 130.3, 129.8, 128.4, 127.0, 126.1, 124.9, 124.4, 123.9, 119.3, 66.3, 52.9, 45.7, 33.4, 22.4, 20.1; IR (Neat Film NaCl) 3050, 2984, 2942, 1737, 1704, 1682, 1509, 1456, 1387, 1290, 1254, 1194, 1144, 1130, 935, 806, 783 cm⁻¹; HRMS (MM: ESI-APCI) \( m/z \) calc’d for C₂₁H₂₂NO₄ [M+H]+: 352.1543, found 352.1542.

2-Naphthoyl Lactam SI27: Prepared by representative method 1 using lactam SI4 and 2-naphthoyl chloride. 2-Naphthoyl lactam SI27 was isolated by flash chromatography (SiO₂, 20 to 33% Et₂O in hexanes) as a colorless oil. \( R_f = 0.25 \) (35% Et₂O in hexanes); \(^1\)H NMR (500 MHz, CDCl₃) \( \delta 8.30 \) (t, \( J = 1.2 \) Hz, 1H), 7.90 (dd, \( J = 8.1, 1.4 \) Hz, 1H), 7.85–7.79 (m, 2H), 7.76 (dd, \( J = 8.6, 1.7 \) Hz, 1H), 7.54 (ddd, \( J = 8.1, 6.8, 1.4 \) Hz, 1H), 7.50 (ddd, \( J = 8.1, 6.9, 1.4 \) Hz, 1H), 6.01 (ddd, \( J = 17.2, 10.4, 5.8 \) Hz, 1H), 5.42 (dq, \( J = 17.2, 1.4 \) Hz, 1H), 5.34 (dq, \( J = 10.4, 1.1 \) Hz, 1H), 4.77 (dt, \( J = 5.9, 1.3 \) Hz, 2H), 3.93 (ddd, \( J = 12.8, 8.9, 5.3 \) Hz, 1H), 3.85 (ddd, \( J = 12.9, 5.1, 1.3 \) Hz, 1H), 2.52 (ddd, \( J = 13.8, 5.6, 4.2, 1.3 \) Hz, 1H), 2.12–1.93 (m, 2H), 1.84 (ddd, \( J = 13.7, 10.2, 4.7 \) Hz, 1H), 1.51 (s, 3H); \(^{13}\)C NMR (126 MHz, CDCl₃) \( \delta 174.9, 172.8, 172.5, 134.8, 133.2, 132.5, 131.4, 129.2, 129.0, 127.7 (2C), 127.6, 126.3, 124.4, 119.4, 66.4, 52.9, 46.8, 33.7, 22.4, 20.2; IR (Neat Film NaCl) 3050, 2941, 2873, 1730, 1682, 1509, 1456, 1385, 1285, 1234, 1186, 1131, 936, 778, 762 cm⁻¹; HRMS (MM: ESI-APCI) \( m/z \) calc’d for C₂₁H₂₂NO₄ [M+H]+: 352.1543, found 352.1530.

General Procedure for Allylic Alkylation Screening Reactions

All reagents were dispensed as solutions using a Symyx Core Module within a nitrogen-filled glovebox. Oven-dried half-dram vials were charged with a solution of the palladium source (Pd₂dba₃ or Pd₂pmdba₃, 1.68 μmol, 0.05 equiv) in THF (368 μL). The palladium solutions were evaporated to dryness under reduced pressure using a Genevac centrifugal evaporator within the glovebox, and stirbars were added to the vials. The reaction vials were then charged with the desired reaction solvent (500 μL) and a solution of the PHOX ligand (4.20 μmol, 0.125 equiv) in the reaction solvent (250 μL) and stirred at ambient glovebox temperature (−28 °C). After 30 min, solutions of the lactam substrate (33.6 μmol, 1.0 equiv) in
the reaction solvent (250 μL) were added. The reaction vials were tightly capped and heated to the desired temperature. When complete consumption of the starting material was observed by colorimetric change (from light green to red-orange) and confirmed by thin layer chromatography on SiO₂ (typically less than 72 h), the reaction mixtures were removed from the glovebox, concentrated under reduced pressure, resuspended in an appropriate solvent for analysis (e.g., hexanes), filtered, and analyzed for enantiomeric excess (see Methods for the Determination of Enantiomeric Excess).

Results of Screening Various Reaction Parameters

\[
\begin{array}{cccc}
\text{R} & \text{THF} & \text{MTBE} & \text{Toluene} & \text{Hex:Tol 2:1} \\
\hline
\text{Ts} & 4.1 & 35.2 & 36.3 & 57.3 \\
\text{Boc} & 35.2 & 70.3 & 79.9 & 73.6 \\
\text{Cbz} & 45.7 & 78.9 & 64.9 & 75.2 \\
\text{Fmoc} & 20.0 & 75.1 & 84.6 & 73.1 \\
\text{Ac} & 59.5 & 97.1 & 90.7 & 99.2 \\
\text{4-MeO-Bz} & 42.3 & 95.3 & 83.2 & 96.8 \\
\text{4-F-Bz} & 52.2 & 96.2 & 85.8 & 96.4 \\
\text{Bz} & 78.9 & 64.1 & 87.3 & 83.2 \\
\end{array}
\]

%ee

\[a \text{ Reactions for these substrates run at } 50 \, ^\circ\text{C. } b \text{ Reaction performed at } 60 \, ^\circ\text{C.}\]

\[
\begin{array}{cccc}
\text{entry} & \text{temperature (°C)} & \text{concentration (M)} & \text{time (h)} & \% \text{ ee} \\
\hline
1 & 40 & 0.033 & 43 & 99.2 \\
2 & 45 & 0.033 & 22 & 98.9 \\
3 & 50 & 0.033 & 12 & 98.7 \\
4 & 55 & 0.033 & 6 & 98.2 \\
5 & 40 & 0.10 & 43 & 98.9 \\
6 & 40 & 0.20 & 43 & 97.4 \\
\end{array}
\]
Characterization Data for New Product Compounds in Figure 2

**Tosyl Lactam 2a:** Reaction performed in MTBE at 40 °C. Tosyl lactam 2a was isolated by flash chromatography (SiO₂, 3 to 15% Et₂O in hexanes) as a light yellow solid. 90.0% yield. \( R_f = 0.29 \) (35% Et₂O in hexanes); \( \delta \) 7.89–7.84 (m, 2H), 7.33–7.27 (m, 2H), 5.41 (dddd, \( J = 16.9, 10.2, 8.1, 6.7 \) Hz, 1H), 4.99–4.86 (m, 2H), 3.99 (dddd, \( J = 11.9, 5.9, 4.9, 1.3 \) Hz, 1H), 3.82–3.71 (m, 1H), 2.42 (s, 3H), 2.41–2.34 (m, 1H), 2.07 (ddt, \( J = 13.6, 8.1, 1.0 \) Hz, 1H), 1.98–1.83 (m, 2H), 1.83–1.75 (m, 1H), 1.55–1.48 (m, 1H), 1.12 (s, 3H); 13C NMR (126 MHz, CDCl₃) δ 175.7, 144.4, 136.2, 132.9, 129.2, 128.5, 118.9, 47.6, 44.2, 44.0, 32.1, 25.5, 21.6, 20.1; IR (Neat Film NaCl) 3074, 2938, 1689, 1597, 1454, 1351, 1283, 1171, 1103, 1089, 921, 748 cm⁻¹; HRMS (MM: ESI-APCI) \( m/z \) calc'd for C₁₆H₂₁NO₃SNa [M+Na]⁺: 330.1134, found 330.1141; \( [\alpha]_D^{25} = -69.2^\circ \) (c 1.16, CHCl₃, 75% ee).

**Boc Lactam 2b:** Reaction performed in toluene at 40 °C. Boc lactam 2b was isolated by flash chromatography (SiO₂, 8 to 9% Et₂O in hexanes) as a colorless oil. 87.1% yield. \( R_f = 0.57 \) (35% Et₂O in hexanes); \( \delta \) 5.74 (dddd, \( J = 17.1, 10.4, 7.8, 7.0 \) Hz, 1H), 5.14–5.02 (m, 2H), 3.71–3.61 (m, 1H), 3.58–3.48 (m, 1H), 2.48 (dd, \( J = 13.6, 7.0 \) Hz, 1H), 2.26 (dd, \( J = 13.6, 7.9 \) Hz, 1H), 1.87–1.76 (m, 3H), 1.61–1.52 (m, 1H), 1.50 (s, 9H), 1.22 (s, 3H); 13C NMR (126 MHz, CDCl₃) δ 177.1, 153.7, 133.7, 118.5, 82.5, 47.4, 44.5, 44.2, 33.0, 28.0, 25.4, 19.7; IR (Neat Film NaCl) 3076, 2978, 2936, 1768, 1715, 1457, 1392, 1368, 1298, 1280, 1252, 1149, 999, 917, 854 cm⁻¹; HRMS (MM: ESI-APCI) \( m/z \) calc'd for C₁₄H₂₃NO₃Na [M+Na]⁺: 276.1574, found 276.1574; \( [\alpha]_D^{25} = -73.6^\circ \) (c 1.025, CHCl₃, 81% ee).

**Cbz Lactam 2c:** Reaction performed in toluene at 40 °C. Cbz lactam 2c was isolated by flash chromatography (SiO₂, 8 to 10% EtOAc in hexanes) as a colorless oil. 84.6% yield. \( R_f = 0.49 \) (25% EtOAc in hexanes); \( \delta \) 7.44–7.40 (m, 2H), 7.36 (ddd, \( J = 7.9, 7.0, 1.0 \) Hz, 2H), 7.33–7.29 (m, 1H), 5.74 (ddd, \( J = 16.6, 10.5, 7.8 \) Hz, 1H), 5.26 (s, 2H), 5.13–5.02 (m, 2H), 3.80–3.72 (m, 1H), 3.67–3.58 (m, 1H), 2.51 (dd, \( J = 13.6, 7.0 \) Hz, 1H), 2.26 (dd, \( J = 13.6, 7.9 \) Hz, 1H), 1.90–1.77 (m, 3H), 1.62–1.53 (m, 1H), 1.25 (s, 3H); 13C NMR (126 MHz, CDCl₃) δ 177.0, 154.8, 135.6, 133.4, 128.5, 128.2, 128.0, 118.8, 68.3, 47.8, 44.8, 44.2, 32.8, 25.5, 19.6; IR (Neat Film NaCl) 2940, 1772, 1712, 1456, 1377, 1296, 1270, 1218, 1161, 1001, 918 cm⁻¹; HRMS (MM: ESI-APCI) \( m/z \) calc'd for C₁₇H₂₀NO₅Na [M+Na]⁺: 310.1414, found 310.1414; \( [\alpha]_D^{25} = -65.8^\circ \) (c 1.48, CHCl₃, 86% ee).
**Fmoc Lactam 2d:** Reaction performed in toluene at 40 °C. Fmoc lactam 2d was isolated by flash chromatography (SiO2, 6 to 8% Et2O in hexanes) as a colorless oil. 82.4% yield. \( R_f = 0.45 \) (25% EtOAc in hexanes); \(^1\)H NMR (500 MHz, CDCl3) \( \delta \) 7.77 (dt, \( J = 7.6, 1.0 \) Hz, 2H), 7.71 (dd, \( J = 7.5, 3.6, 1.0 \) Hz, 2H), 7.41 (tt, \( J = 7.5, 0.9 \) Hz, 2H), 7.33 (ddt, \( J = 7.5, 2.0, 1.2 \) Hz, 2H), 5.80 (dddd, \( J = 17.9, 8.7, 7.9, 6.9 \) Hz, 1H), 5.18–5.10 (m, 2H), 4.53–4.42 (m, 2H), 4.33 (t, \( J = 7.4 \) Hz, 1H), 3.80–3.71 (m, 1H), 3.65–3.57 (m, 1H), 2.58 (dd, \( J = 13.6, 7.0 \) Hz, 1H), 2.32 (ddt, \( J = 13.6, 7.8, 1.1 \) Hz, 1H), 1.93–1.79 (m, 3H), 1.64–1.57 (m, 1H), 1.31 (s, 3H); \(^{13}\)C NMR (126 MHz, CDCl3) \( \delta \) 177.0, 154.9, 143.7, 141.2, 133.5, 127.1, 125.4, 119.9, 118.8, 68.9, 47.7, 46.7, 44.8, 44.2, 32.8, 25.5, 19.6; IR (Neat Film NaCl) 3067, 2945, 1770, 1712, 1478, 1451, 1377, 1297, 1269, 1161, 1000, 759, 740 cm\(^{-1}\); HRMS (MM: ESI-APCI) \( m/z \) calc'd for C\(_{24}\)H\(_{26}\)NO\(_3\) [M+H]+: 376.1907, found 376.1914; \([\alpha]\)\(_D\)\(^{25}\) –38.5° (c 2.17, CHCl\(_3\), 89% ee).

**Acetyl Lactam 2e:** Reaction performed in toluene at 40 °C. Acetyl lactam 2e was isolated by flash chromatography (SiO2, 8 to 10% Et2O in hexanes) as a colorless oil. 47.2% yield. \( R_f = 0.38 \) (25% EtOAc in hexanes); \(^1\)H NMR (500 MHz, CDCl3) \( \delta \) 5.73 (dddd, \( J = 16.6, 10.4, 7.8, 7.0 \) Hz, 1H), 5.14–5.04 (m, 2H), 3.82–3.72 (m, 1H), 3.60–3.49 (m, 1H), 2.50 (ddt, \( J = 13.6, 7.0, 1.2 \) Hz, 1H), 2.44 (s, 3H), 2.25 (ddt, \( J = 13.7, 7.6, 1.1 \) Hz, 1H), 1.91–1.71 (m, 3H), 1.64–1.52 (m, 1H), 1.25 (s, 3H); \(^{13}\)C NMR (126 MHz, CDCl3) \( \delta \) 179.3, 174.4, 133.3, 118.9, 45.4, 44.8, 44.4, 32.8, 27.2, 25.7, 19.4; IR (Neat Film NaCl) 2941, 1694, 1387, 1367, 1293, 1248, 1177, 1114, 1046, 920 cm\(^{-1}\); HRMS (MM: ESI-APCI) \( m/z \) calc'd for C\(_{11}\)H\(_{18}\)NO\(_2\) [M+H]+: 196.1332, found 196.1329; \([\alpha]\)\(_D\)\(^{25}\) –100.9° (c 0.99, CHCl\(_3\), 91% ee).

**4-Methoxybenzoyl Lactam 2f:** Reaction performed in toluene at 40 °C. 4-Methoxybenzoyl lactam 2f was isolated by flash chromatography (SiO2, 15% EtOAc in hexanes) as a colorless oil. 92.7% yield. \( R_f = 0.36 \) (25% EtOAc in hexanes); \(^1\)H NMR (500 MHz, CDCl3) \( \delta \) 7.60–7.48 (m, 2H), 6.92–6.82 (m, 2H), 5.76 (dddd, \( J = 17.2, 10.3, 7.7, 7.0 \) Hz, 1H), 5.19–5.03 (m, 2H), 3.83 (s, 3H), 3.80 (dd, \( J = 12.1, 5.3, 1.4 \) Hz, 1H), 3.73–3.64 (m, 1H), 2.57 (ddt, \( J = 13.6, 7.1, 1.2 \) Hz, 1H), 2.29 (ddt, \( J = 13.7, 7.6, 1.1 \) Hz, 1H), 2.05–1.91 (m, 3H), 1.72–1.63 (m, 1H), 1.32 (s, 3H); \(^{13}\)C NMR (126 MHz, CDCl3) \( \delta \) 179.0, 174.9, 162.4, 133.4, 130.1, 128.4, 118.9, 113.5, 55.4, 47.3, 43.9, 43.4, 33.3, 25.3, 19.6; IR (Neat Film NaCl) 2937, 1675, 1604, 1511, 1254, 1164, 1042, 922, 840, 770 cm\(^{-1}\); HRMS (MM: ESI-APCI) \( m/z \) calc'd for C\(_{17}\)H\(_{22}\)NO\(_3\) [M+H]+: 288.1594, found 288.1595; \([\alpha]\)\(_D\)\(^{25}\) –94.2° (c 1.00, CHCl\(_3\), 99% ee).
**4-Fluorobenzoyl Lactam 2g:** Reaction performed in toluene at 40 °C. 4-Fluorobenzoyl lactam 2g was isolated by flash chromatography (SiO₂, 9% Et₂O in hexanes) as a colorless oil. 89.4% yield. Rf = 0.41 (17% EtOAc in hexanes); ¹H NMR (500 MHz, CDCl₃) δ 7.59–7.47 (m, 2H), 7.12–6.99 (m, 2H), 5.74 (ddt, J = 17.0, 10.4, 7.3 Hz, 1H), 5.18–5.05 (m, 2H), 3.89–3.77 (m, 1H), 3.77–3.63 (m, 1H), 2.55 (dd, J = 13.7, 7.0 Hz, 1H), 2.28 (dd, J = 13.7, 7.6 Hz, 1H), 2.07–1.88 (m, 3H), 1.76–1.62 (m, 1H), 1.31 (s, 3H); ¹³C NMR (126 MHz, CDCl₃) δ 179.1, 174.2, 164.6 (d, Jₑ,F = 252.4 Hz), 133.2, 132.5 (d, Jₑ,F = 3.4 Hz), 123.0 (d, Jₑ,F = 8.9 Hz), 119.1, 115.3 (d, Jₑ,F = 22.1 Hz), 47.3, 44.0, 43.3, 33.3, 25.2, 19.5; IR (Neat Film NaCl) 3076, 2940, 1679, 1602, 1507, 1384, 1280, 1145, 922, 769 cm⁻¹; HRMS (MM: ESI-APCI) m/z calc'd for C₁₆H₁₉NO₂F [M+H]+: 276.1394, found 276.1392; [α]D²⁵ –85.5° (c 1.02, CHCl₃, 99% ee).

**Benzoyl Lactam 2h:** Reaction performed in toluene at 40 °C. Benzoyl lactam 2h was isolated by flash chromatography (SiO₂, 5 to 9% Et₂O in pentane) as a colorless oil. 84.7% yield. Rf = 0.55 (25% EtOAc in hexanes); ¹H NMR (500 MHz, CDCl₃) δ 7.54–7.50 (m, 2H), 7.49–7.43 (m, 1H), 7.40–7.35 (m, 2H), 5.75 (dddd, J = 17.1, 10.2, 7.7, 7.0 Hz, 1H), 5.19–5.03 (m, 2H), 3.92–3.78 (m, 1H), 3.72 (ddt, J = 12.6, 6.4, 6.0, 1.2 Hz, 1H), 2.55 (ddt, J = 13.7, 7.0, 1.2 Hz, 1H), 2.29 (ddt, J = 13.7, 7.7, 1.1 Hz, 1H), 2.07–1.87 (m, 3H), 1.75–1.60 (m, 1H), 1.31 (s, 3H); ¹³C NMR (126 MHz, CDCl₃) δ 179.0, 175.3, 136.5, 133.3, 131.3, 128.1, 127.4, 118.9, 47.1, 44.0, 43.3, 33.3, 25.1, 19.5; IR (Neat Film NaCl) 3074, 2939, 2870, 1683, 1478, 1449, 1386, 1282, 1151, 919, 726, 695 cm⁻¹; HRMS (MM: ESI-APCI) m/z calc'd for C₁₆H₂₀NO₂ [M+H]+: 258.1489, found 258.1491; [α]D²⁵ –91.2° (c 1.07, CHCl₃, 99% ee).

**General Procedure for Preparative Allylic Alkylation Reactions**

In a nitrogen-filled glovebox, an oven-dried 20 mL vial was charged with Pd₂dba₃ (27.4 mg, 0.025 mmol, 0.05 equiv) or Pd₂pmdba₃ (22.9 mg, 0.025 mmol, 0.05 equiv), (S)-(CF₃)₃-t-BuPHOX (37.0 mg, 0.0625 mmol, 0.125 equiv), toluene (15 mL or 13 mL if the substrate is an oil), and a magnetic stir bar. The vial was stirred at ambient glovebox temperature (~28 °C) for 30 min and the substrate (0.50 mmol, 1.00 equiv) was added either as a solid or as a solution of an oil dissolved in toluene (2 mL). The vial was sealed and heated to 40 °C. When complete consumption of the starting material was observed by colorimetric change (from light green to red-orange) and confirmed by thin layer chromatography on SiO₂, the reaction mixtures were removed from the glovebox, concentrated under reduced pressure, and purified by flash chromatography to afford the desired alkylated product.
Characterization Data for New Product Compounds in Figure 3

**Benzoyl Lactam 3:** Benzoyl lactam 3 was isolated by flash chromatography (SiO2, 15 to 20% Et2O in hexanes) as a colorless oil. 97.2% yield. \( R_f = 0.39 \) (20% Et2O in hexanes); \( ^1H \) NMR (500 MHz, CDCl3) \( \delta 7.53–7.49 \) (m, 2H), 7.48–7.43 (m, 1H), 7.41–7.34 (m, 2H), 5.74 (dddd, \( J = 16.7, 10.4, 7.6, 7.0 \) Hz, 1H), 5.19–5.02 (m, 2H), 3.84–3.70 (m, 2H), 2.51 (ddt, \( J = 13.8, 7.0, 1.3 \) Hz, 1H), 2.28 (ddt, \( J = 13.8, 7.6, 1.2 \) Hz, 1H), 2.06–1.91 (m, 2H), 1.91–1.74 (m, 3H), 1.74–1.63 (m, 1H), 0.91 (t, \( J = 7.4 \) Hz, 3H); \( ^13C \) NMR (126 MHz, CDCl3) \( \delta 178.0, 175.6, 136.7, 133.6, 131.2, 128.1, 127.4, 118.6, 47.4, 46.9, 41.3, 30.3 \) (2C), 19.6, 8.3; IR (Neat Film NaCl) 3072, 2970, 2941, 2880, 1678, 1448, 1384, 1283, 1147, 916, 725, 694 cm\(^{-1}\); HRMS (MM: ESI-APCI) \( m/z \) calc’d for C\(_{17}\)H\(_{22}\)NO\(_2\) [M+H]+: 272.1645, found 272.1649; \([\alpha]_D^{25} – 28.6^\circ \) (c 1.15, CHCl3, 99% ee).

**Benzoyl Lactam 4:** Benzoyl lactam 4 was isolated by flash chromatography (SiO2, 10% Et2O in hexanes) as a white solid. 84.8% yield. \( R_f = 0.48 \) (35% Et2O in hexanes); \( ^1H \) NMR (500 MHz, CDCl3) \( \delta 7.54\) (dd, \( J = 8.1, 1.4 \) Hz, 2H), 7.52–7.46 (m, 1H), 7.43–7.37 (m, 2H), 7.32–7.22 (m, 3H), 7.18–7.11 (m, 2H), 5.80 (dddd, \( J = 16.9, 10.0, 4.7, 3.6 \) Hz, 1H), 5.21–5.06 (m, 2H), 3.70 (ddd, \( J = 12.2, 7.0, 4.8 \) Hz, 1H), 3.63 (dd, \( J = 12.5, 7.7, 4.4 \) Hz, 1H), 3.34 (d, \( J = 13.4 \) Hz, 1H), 2.73–2.64 (m, 1H), 2.68 (d, \( J = 13.3 \) Hz, 1H), 2.25 (ddt, \( J = 13.8, 7.7, 1.1 \) Hz, 1H), 2.03–1.91 (m, 1H), 1.91–1.83 (m, 1H), 1.81 (dd, \( J = 6.7, 5.3 \) Hz, 2H); \( ^13C \) NMR (126 MHz, CDCl3) \( \delta 177.4, 175.5, 136.9, 136.6, 133.2, 131.4, 130.8, 128.2, 128.1, 127.6, 126.7, 119.3, 48.8, 46.8, 43.0, 42.9, 28.9, 19.6; IR (Neat Film NaCl) 3061, 3028, 2942, 1679, 1449, 1286, 1149, 919, 724, 704, 695 cm\(^{-1}\); HRMS (MM: ESI-APCI) \( m/z \) calc’d for C\(_{22}\)H\(_{24}\)NO\(_2\) [M+H]+: 334.1802, found 334.1800; \([\alpha]_D^{25} +48.1^\circ \) (c 0.825, CHCl3, 99% ee).

**Benzoyl Lactam 5:** Benzoyl lactam 5 was isolated by flash chromatography (SiO2, 25% Et2O in hexanes) as a light yellow oil. 91.8% yield. \( R_f = 0.39 \) (35% Et2O in hexanes); \( ^1H \) NMR (500 MHz, CDCl3) \( \delta 7.53–7.49 \) (m, 2H), 7.49–7.44 (m, 1H), 7.41–7.31 (m, 2H), 5.72 (ddt, \( J = 17.4, 10.3, 7.3 \) Hz, 1H), 5.23–5.05 (m, 2H), 3.78 (t, \( J = 6.0 \) Hz, 2H), 3.67 (s, 3H), 2.58–2.47 (m, 1H), 2.42–2.24 (m, 3H), 2.08–1.97 (m, 4H), 1.93 (dd, \( J = 14.0, 7.8, 4.6 \) Hz, 1H), 1.78 (dd, \( J = 13.9, 7.1, 4.9 \) Hz, 1H); \( ^13C \) NMR (126 MHz, CDCl3) \( \delta 177.4, 175.5, 173.7, 136.5, 132.6, 131.4, 128.2, 127.4, 119.4, 51.7, 47.0, 46.6, 41.2, 32.2, 31.2, 29.0, 19.4; IR (Neat Film NaCl) 3073, 2950, 2874, 1736, 1679, 1448, 1281, 1150, 920, 727, 696, 665 cm\(^{-1}\).
cm$^{-1}$; HRMS (MM: ESI-APCI) $m/z$ calc'd for C$_{19}$H$_{24}$NO$_4$ [M+H]$^+$: 330.1700, found 330.1704; $\alpha_D^{25} +14.0^\circ$ (c 0.72, CHCl$_3$, 99% ee).

**Benzoyl Lactam 6**: Benzoyl lactam 6 was isolated by flash chromatography (SiO$_2$, 15 to 25% EtOAc in hexanes) as a colorless oil. 88.2% yield. $R_f = 0.43$ (35% EtOAc in hexanes); $^1$H NMR (500 MHz, CDCl$_3$) $\delta$ 7.52–7.47 (m, 3H), 7.41 (ddt, $J = 8.7, 6.6, 1.0$ Hz, 2H), 5.71 (ddt, $J = 17.4, 10.1, 7.3$ Hz, 1H), 5.28–5.15 (m, 2H), 3.88–3.79 (m, 1H), 3.76 (ddd, $J = 12.9, 8.7, 4.2$ Hz, 1H), 2.57 (ddt, $J = 14.1, 7.3, 1.2$ Hz, 1H), 2.44–2.29 (m, 2H), 2.13–2.04 (m, 2H), 2.03–1.89 (m, 3H), 1.87–1.78 (m, 1H); $^{13}$C NMR (126 MHz, CDCl$_3$) $\delta$ 176.8, 175.2, 136.2, 131.7, 131.5, 128.3, 127.3, 120.3, 119.5, 47.0, 46.5, 41.1, 32.7, 30.8, 19.2, 12.5; IR (Neat Film NaCl) 3074, 2945, 2876, 1678, 1448, 1389, 1282, 1151, 922, 727, 696 cm$^{-1}$; HRMS (MM: ESI-APCI) $m/z$ calc'd for C$_{18}$H$_{21}$N$_2$O$_2$ [M+H]$^+$: 297.1598, found 297.1603; $\alpha_D^{25} +46.9^\circ$ (c 0.83, CHCl$_3$, 99% ee).

**Benzoyl Lactam 7**: Benzoyl lactam 7 was isolated by flash chromatography (SiO$_2$, 5 to 15% Et$_2$O in hexanes) as a colorless oil. 85.4% yield. $R_f = 0.32$ (10% Et$_2$O in hexanes); $^1$H NMR (500 MHz, CDCl$_3$) $\delta$ 7.54–7.48 (m, 2H), 7.48–7.42 (m, 1H), 7.41–7.33 (m, 2H), 5.76 (ddt, $J = 17.3, 10.2, 7.3$ Hz, 1H), 5.18–5.06 (m, 2H), 3.81–3.75 (m, 2H), 3.75–3.64 (m, 2H), 2.55 (ddt, $J = 13.8, 7.1, 1.2$ Hz, 1H), 2.33 (ddt, $J = 13.8, 7.5, 1.1$ Hz, 1H), 2.10–1.94 (m, 4H), 1.94–1.85 (m, 1H), 1.81 (ddd, $J = 13.9, 7.3, 5.6$ Hz, 1H), 0.88 (s, 9H), 0.04 (s, 6H); $^{13}$C NMR (126 MHz, CDCl$_3$) $\delta$ 177.6, 175.5, 136.8, 133.4, 131.2, 128.1, 127.4, 118.9, 59.2, 46.9, 46.3, 42.2, 39.7, 30.8, 25.9, 19.6, 18.2, −5.4; IR (Neat Film NaCl) 2953, 2928, 2884, 2856, 1681, 1280, 1257, 1151, 1093, 836, 776, 725, 694 cm$^{-1}$; HRMS (MM: ESI-APCI) $m/z$ calc'd for C$_{23}$H$_{36}$NO$_3$Si [M+H]$^+$: 402.2459, found 402.2467; $\alpha_D^{25} −3.71^\circ$ (c 1.40, CHCl$_3$, 96% ee).

**Benzoyl Lactam 8**: Benzoyl lactam 8 was isolated by flash chromatography (SiO$_2$, 5 to 9% EtOAc in hexanes) as a colorless oil. 78.0% yield. $R_f = 0.54$ (25% EtOAc in hexanes); $^1$H NMR (500 MHz, CDCl$_3$) $\delta$ 7.54–7.50 (m, 2H), 7.48–7.43 (m, 1H), 7.41–7.35 (m, 2H), 4.89 (t, $J = 1.8$ Hz, 1H), 4.70 (dt, $J = 2.1, 1.0$ Hz, 1H), 3.94–3.84 (m, 1H), 3.74–3.63 (m, 1H), 2.75 (dd, $J = 13.8, 1.3$ Hz, 1H), 2.13 (dd, $J = 13.8, 0.8$ Hz, 1H), 2.08–1.94 (m, 3H), 1.69 (s, 3H), 1.68–1.61 (m, 1H), 1.37 (s, 3H); $^{13}$C NMR (126 MHz, CDCl$_3$) $\delta$ 178.8, 175.5, 141.9, 136.5, 131.3, 128.1, 127.4, 115.5, 47.2, 46.2, 44.0, 32.9, 26.9, 24.7, 19.8; IR (Neat Film NaCl) 3070, 2940, 1678, 1448, 1374, 1144, 726 cm$^{-1}$; HRMS (MM: ESI-APCI) $m/z$ calc'd for C$_{17}$H$_{22}$NO$_2$ [M+H]$^+$: 272.1645, found 272.1655; $\alpha_D^{25} −105.6^\circ$ (c 0.99, CHCl$_3$, 97% ee).
Benzoyl Lactam 9: Benzoyl lactam 9 was isolated by flash chromatography (SiO₂, 8 to 10% Et₂O in hexanes) as a colorless oil. 60.3% yield. \( R_f = 0.39 \) (25% EtOAc in hexanes); \(^1\)H NMR (500 MHz, CDCl₃) \( \delta 7.55-7.49 \) (m, 2H), 7.49–7.43 (m, 1H), 7.42–7.34 (m, 2H), 5.32 (d, \( J = 1.7 \) Hz, 1H), 5.18 (s, 1H), 3.92 (ddt, \( J = 12.7, 4.8, 1.7 \) Hz, 1H), 3.75–3.66 (m, 1H), 3.04 (dd, \( J = 14.5, 1.0 \) Hz, 1H), 2.50 (d, \( J = 14.5 \) Hz, 1H), 2.16 (dd, \( J = 13.4, 10.2, 4.4 \) Hz, 1H), 2.12–1.98 (m, 2H), 1.86–1.77 (m, 1H), 1.43 (s, 3H); \(^1^C\) NMR (126 MHz, CDCl₃) \( \delta 177.9, 175.3, 138.3, 136.4, 131.4, 128.1, 127.4, 117.1, 47.0 \) (2C), 44.2, 32.8, 26.3, 19.7; IR (Neat Film NaCl) 2944, 2872, 1679, 1628, 1448, 1386, 1277, 1151, 894, 726 cm⁻¹; HRMS (MM: ESI-APCI) \( m/z \) calc’d for C₁₆H₁₉NO₂Cl [M+H]+: 292.1099, found 292.1102; \([\alpha]_D^{25} –91.4° \) (c 0.94, CHCl₃, 95% ee).

Benzoyl Lactam 10: Benzoyl lactam 10 was isolated by flash chromatography (SiO₂, 5 to 10% Et₂O in hexanes) as a colorless oil. 90.3% yield. \( R_f = 0.35 \) (35% EtOAc in hexanes); \(^1\)H NMR (500 MHz, CDCl₃) \( \delta 7.58–7.54 \) (m, 2H), 7.53–7.48 (m, 1H), 7.43–7.38 (m, 2H), 5.78 (dddd, \( J = 17.1, 10.2, 7.8, 7.0 \) Hz, 1H), 5.22–5.09 (m, 2H), 3.87 (dd, \( J = 7.7, 6.7 \) Hz, 2H), 2.36 (dd, \( J = 13.8, 7.0 \) Hz, 1H), 2.24 (dd, \( J = 13.7, 7.8 \) Hz, 1H), 2.15 (dt, \( J = 12.9, 7.6 \) Hz, 1H), 1.85 (dt, \( J = 13.1, 6.7 \) Hz, 1H), 1.22 (s, 3H); \(^1^C\) NMR (126 MHz, CDCl₃) \( \delta 178.6, 170.8, 134.4, 133.0, 131.8, 128.8, 127.7, 119.3, 46.2, 42.8, 41.8, 29.3, 22.8; IR (Neat Film NaCl) 3075, 2974, 2902, 1742, 1674, 1448, 1377, 1357, 1306, 1243, 1156, 921, 860, 731, 694, 656 cm⁻¹; HRMS (MM: ESI-APCI) \( m/z \) calc’d for C₁₅H₁₈NO₂ [M+H]+: 244.1332, found 244.1336; \([\alpha]_D^{25} –31.6° \) (c 1.04, CHCl₃, 98% ee).

Benzoyl Lactam 11: Benzoyl lactam 11 was isolated by flash chromatography (SiO₂, 10 to 20% Et₂O in hexanes) as a colorless oil. 89.3% yield. \( R_f = 0.24 \) (20% Et₂O in hexanes); \(^1\)H NMR (500 MHz, CDCl₃) \( \delta 7.60–7.56 \) (m, 2H), 7.56–7.51 (m, 1H), 7.49–7.45 (m, 2H), 7.42 (ddt, \( J = 17.1, 10.1, 7.8, 6.9 \) Hz, 1H), 5.28–5.10 (m, 2H), 3.70 (dt, \( J = 11.4, 6.9 \) Hz, 1H), 3.10 (d, \( J = 13.4 \) Hz, 1H), 2.76 (d, \( J = 13.5 \) Hz, 1H), 2.48 (dd, \( J = 13.8, 7.0 \) Hz, 1H), 2.32 (dd, \( J = 13.8, 7.8 \) Hz, 1H), 2.05 (t, \( J = 7.3 \) Hz, 2H); \(^1^C\) NMR (126 MHz, CDCl₃) \( \delta 177.1, 170.5, 140.9, 134.2, 132.3, 131.9, 130.7, 129.4 \) (q, \( J_{CF} = 32.5 \) Hz), 128.7, 127.7, 125.3 (q, \( J_{CF} = 3.7 \) Hz), 124.1 (q, \( J_{CF} = 272.2 \) Hz), 120.1, 51.3, 43.0, 41.9 (2C), 25.2; IR (Neat Film NaCl) 3080, 2977, 2913, 1738, 1677, 1325, 1294, 1244, 1164, 1121, 1067, 859, 728, 701, 665 cm⁻¹; HRMS (FAB) \( m/z \) calc’d for C₂₂H₂₁NO₂F₃ [M+H]+: 388.1524, found 388.1525; \([\alpha]_D^{25} +78.3° \) (c 1.90, CHCl₃, 93% ee).
Benzoyl Lactam 12: Benzoyl lactam 12 was isolated by flash chromatography (SiO2, 10 to 20% Et2O in hexanes) as a white solid. 85.7% yield. \( R_f = 0.35 \) (35% Et2O in hexanes); \(^1\)H NMR (500 MHz, CDCl3) \( \delta 7.63–7.58 \) (m, 2H), 7.58–7.52 (m, 1H), 7.49–7.40 (m, 2H), 5.87–5.73 (m, 1H), 5.32–5.20 (m, 2H), 4.00 (ddd, \( J = 11.5, 7.7, 6.5 \) Hz, 1H), 3.90–3.80 (m, 1H), 2.81–2.70 (m, 1H), 2.62–2.48 (m, 1H), 2.46–2.27 (m, 2H); \(^13\)C NMR (126 MHz, CDCl3) \( \delta 170.3, 169.7 \) (d, \( J_{C-F} = 23.1 \) Hz), 133.4, 132.4, 129.7 (d, \( J_{C-F} = 7.1 \) Hz), 129.0, 127.9, 121.0, 97.0 (d, \( J_{C-F} = 185.4 \) Hz), 42.0 (d, \( J_{C-F} = 2.3 \) Hz), 38.4 (d, \( J_{C-F} = 25.2 \) Hz), 28.5 (d, \( J_{C-F} = 22.6 \) Hz); IR (Neat Film NaCl) 3076, 1760, 1676, 1365, 1314, 1253, 1132, 1058, 1008, 980, 920, 863, 791, 729 cm\(^{-1}\); HRMS (MM: ESI-APCI) \( m/z \) calc’d for C14H15NO2F [M+H]^+: 248.1081, found 248.1092; [\( \alpha \)]\( _D \)\(^{25} \) –120.5° (c 1.11, CHCl3, 98% ee).

4-Methoxybenzoyl Lactam 13: Reaction performed in MTBE at 40 °C. 4-Methoxybenzoyl lactam 13 was isolated by flash chromatography (SiO2, 8% Et2O in hexanes) as a colorless oil. 83.2% yield. \( R_f = 0.48 \) (25% EtOAc in hexanes); \(^1\)H NMR (500 MHz, CDCl3) \( \delta 7.56–7.48 \) (m, 2H), 6.91–6.82 (m, 2H), 5.86–5.66 (m, 1H), 5.18–5.02 (m, 2H), 4.03 (ddd, \( J = 15.0, 8.0, 2.4 \) Hz, 1H), 3.88 (ddd, \( J = 15.1, 8.5, 2.1 \) Hz, 1H), 3.83 (s, 3H), 2.50 (ddt, \( J = 13.6, 7.0, 1.2 \) Hz, 1H), 2.35 (ddt, \( J = 13.7, 7.6, 1.1 \) Hz, 1H), 1.92–1.77 (m, 4H), 1.77–1.62 (m, 2H), 1.31 (s, 3H); \(^13\)C NMR (126 MHz, CDCl3) \( \delta 182.3, 174.7, 162.2, 133.9, 130.0, 128.9, 118.6, 113.5, 55.4, 47.7, 44.7, 43.0, 35.1, 28.2, 25.0, 23.4; IR (Neat Film NaCl) 3074, 2932, 1673, 1605, 1511, 1279, 1255, 1168, 1112, 1025, 837 cm\(^{-1}\); HRMS (MM: ESI-APCI) \( m/z \) calc’d for C18H24NO3 [M+H]^+: 302.1751, found 302.1744; [\( \alpha \)]\( _D \)\(^{25} \) –34.7° (c 0.75, CHCl3, 93% ee).

Benzoyl Lactam 14: Benzoyl lactam 14 was isolated by flash chromatography (SiO2, 10 to 20% Et2O in hexanes) as a colorless oil. 91.4% yield. \( R_f = 0.36 \) (25% EtOAc in hexanes); \(^1\)H NMR (500 MHz, CDCl3) \( \delta 7.55–7.52 \) (m, 2H), 7.52–7.47 (m, 1H), 7.42–7.37 (m, 2H), 5.90 (ddt, \( J = 17.3, 10.3, 7.2 \) Hz, 1H), 5.26–5.10 (m, 2H), 4.12–3.95 (m, 3H), 3.94–3.81 (m, 1H), 2.71 (ddt, \( J = 14.1, 7.3, 1.2 \) Hz, 1H), 2.47 (ddt, \( J = 14.1, 7.0, 1.3 \) Hz, 1H), 1.48 (s, 3H); \(^13\)C NMR (126 MHz, CDCl3) \( \delta 174.3, 173.1, 135.7, 132.1, 131.7, 128.1, 127.7, 119.3, 80.3, 59.4, 45.7, 43.1, 23.3; IR (Neat Film NaCl) 3075, 2978, 2894, 1685, 1448, 1373, 1283, 1227, 1111, 1092, 921, 726, 694 cm\(^{-1}\); HRMS (FAB) \( m/z \) calc’d for C15H18NO3 [M+H]^+: 260.1287, found 260.1277; [\( \alpha \)]\( _D \)\(^{25} \) –72.1° (c 0.97, CHCl3, 99% ee).
Benzoyl Lactam 15: Benzoyl lactam 15 was isolated by flash chromatography (SiO₂, 5 to 10% EtOAc in hexanes) as a colorless oil. 88.8% yield. \( R_f = 0.35 \) (35% EtO in hexanes); \( ^1H \) NMR (500 MHz, CDCl₃) \( \delta 7.62–7.57 \) (m, 2H), \( 7.53–7.47 \) (m, 1H), \( 7.44–7.37 \) (m, 2H), \( 5.87–5.70 \) (m, 1H), \( 5.28–5.15 \) (m, 2H), \( 3.91 \) (dddd, \( J = 12.8, 6.0, 4.7, 1.4 \) Hz, 1H), \( 3.74 \) (dddd, \( J = 13.6, 9.2, 4.5, 2.4 \) Hz, 1H), \( 2.86–2.60 \) (m, 2H), \( 2.33–2.14 \) (m, 2H), \( 2.13–1.89 \) (m, 2H), \( 13C \) NMR (126 MHz, CDCl₃) \( 174.5, 170.8 \) (d, \( J_{CF} = 23.5 \) Hz), \( 135.0, 132.0, 130.6 \) (d, \( J_{CF} = 6.5 \) Hz), \( 128.3, 128.0, 120.4, 93.9 \) (d, \( J_{CF} = 179.3 \) Hz), \( 46.4, 40.0 \) (d, \( J_{CF} = 23.6 \) Hz), \( 32.1 \) (d, \( J_{CF} = 22.5 \) Hz), \( 19.1 \) (d, \( J_{CF} = 4.6 \) Hz); IR (Neat Film NaCl) 3078, 2956, 1715, 1687, 1478, 1449, 1435, 1390, 1273, 1175, 1152, 1000, 725, 694, 662 cm⁻¹; HRMS (MM: ESI-APCI) \( m/z \) calc'd for C₁₅H₁₆NO₂F [M+H]⁺: 262.1238, found 262.1244; \( [\alpha]_D^{25} -120.6^\circ \) (c 1.09, CHCl₃, 99% ee).

Benzoyl Glutarimide 16: Benzoyl glutarimide 16 was isolated by flash chromatography (SiO₂, 17 to 25% EtOAc in hexanes) as a colorless oil. 81% yield. \( R_f = 0.21 \) (25% EtOAc in hexanes); \( ^1H \) NMR (500 MHz, CDCl₃) \( 7.83 \) (d, \( J = 8.29 \) Hz, 2H), \( 7.63 \) (t, \( J = 7.45 \) Hz, 1H), \( 7.48 \) (dd, \( J = 8.29, 7.45 \) Hz, 2H), \( 5.77 \) (dddd, \( J = 17.4, 10.2, 7.4, 7.0 \) Hz, 1H), \( 5.22–5.16 \) (m, 2H), \( 2.87–2.77 \) (m, 2H), \( 2.59 \) (ddt, \( J = 13.8, 7.0, 1.0 \) Hz, 1H), \( 2.40 \) (ddt, \( J = 13.8, 7.4, 1.0 \) Hz, 1H), \( 2.12 \) (dd, \( J = 14.2, 6.5, 6.1 \) Hz, 1H), \( 1.37 \) (s, 3H); \( ^13C \) NMR (126 MHz, CDCl₃) \( 176.6, 171.6, 171.0, 134.8, 132.0, 131.9, 130.0, 129.1, 120.0, 41.9, 41.7, 29.2, 28.2, 22.8 \); IR (Neat Film NaCl) 3077, 2975, 2935, 2882, 1750, 1713, 1683, 1450, 1340, 1239, 1198, 981, 776 cm⁻¹; HRMS (MM: ESI-APCI) \( m/z \) calc'd for C₁₆H₁₈NO₃ [M+H]⁺: 272.1281, found 272.1281; \( [\alpha]_D^{25} -31.3^\circ \) (c 1.00, CHCl₃, 94% ee).

Benzoyl Glutarimide 17: Benzoyl glutarimide 17 was isolated by flash chromatography (SiO₂, 17 to 25% EtOAc in hexanes) as a colorless oil. 86% yield. \( R_f = 0.24 \) (25% EtOAc in hexanes); \( ^1H \) NMR (500 MHz, CDCl₃) \( 7.83 \) (d, \( J = 8.38 \) Hz, 2H), \( 7.64 \) (t, \( J = 7.46 \) Hz, 1H), \( 7.48 \) (dd, \( J = 8.38, 7.46 \) Hz, 2H), \( 5.75 \) (dddd, \( J = 17.2, 10.2, 7.7, 7.0 \) Hz, 1H), \( 5.20–5.15 \) (m, 2H), \( 2.86–2.76 \) (m, 2H), \( 2.60 \) (ddt, \( J = 14.0, 7.0, 1.1 \) Hz, 1H), \( 2.37 \) (ddt, \( J = 14.0, 7.7, 1.1 \) Hz, 1H), \( 2.05 \) (dd, \( J = 14.3, 7.85, 6.81 \) Hz, 1H), \( 1.97 \) (dd, \( J = 14.3, 6.56, 6.24 \) Hz, 1H), \( 1.87–1.75 \) (m, 2H), \( 0.97 \) (t, \( J = 7.46, 3H \)); \( ^13C \) NMR (126 MHz, CDCl₃) \( 175.9, 171.6, 171.0, 134.8, 132.4, 131.9, 130.0, 129.0, 119.8, 45.4, 39.3, 29.0, 28.1, 25.4, 8.1 \); IR (Neat Film NaCl) 3076, 2974, 2940, 2882, 1750, 1713, 1683, 1450, 1340, 1239, 1195, 1001, 923, 778 cm⁻¹; HRMS (MM: ESI-APCI) \( m/z \) calc'd for C₁₇H₂₀NO₃ [M+H]⁺: 286.1438, found 286.1432; \( [\alpha]_D^{25} -16.2^\circ \) (c 1.00, CHCl₃, 96% ee).

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**Acyl Lactam 18**: Acyl lactam 18 was isolated by flash chromatography (SiO₂, 10 to 20% Et₂O in hexanes) as a colorless oil. 88.4% yield. Rₖ = 0.40 (35% Et₂O in hexanes); ¹H NMR (500 MHz, CDCl₃) δ 7.32–7.17 (m, 3H), 7.17–7.09 (m, 2H), 5.77 (dddd, J = 17.0, 10.3, 7.9, 6.8 Hz, 1H), 5.19–5.05 (m, 2H), 3.60–3.48 (m, 1H), 3.44 (dddd, J = 13.0, 7.0, 4.6, 1.0 Hz, 1H), 3.27 (d, J = 13.3 Hz, 1H), 2.68 (d, J = 13.2 Hz, 1H), 2.66–2.62 (m, 1H), 2.51 (s, 3H), 2.23 (ddt, J = 13.5, 7.9, 1.1 Hz, 1H), 1.90–1.61 (m, 3H), 1.57–1.38 (m, 1H); ¹³C NMR (126 MHz, CDCl₃) δ 178.0, 174.2, 137.1, 133.2, 130.4, 128.3, 126.8, 119.2, 49.7, 45.1, 44.8, 44.5, 29.0, 27.6, 19.6; IR (Neat Film NaCl) 3028, 2941, 1691, 1367, 1291, 1247, 1111, 1131, 1031, 923 cm⁻¹; HRMS (MM: ESI-APCI) m/z calc'd for C₁₇H₂₂NO₂ [M+H]+: 272.1645, found 272.1646; [α]₂⁵° +11.4° (c 1.03, CHCl₃, 88% ee).

**Phenyl Carbamate Lactam 19**: Phenyl Carbamate lactam 19 was isolated by flash chromatography (SiO₂, 10 to 20% Et₂O in hexanes) as a colorless oil. 82.2% yield. Rₖ = 0.39 (35% Et₂O in hexanes); ¹H NMR (500 MHz, CDCl₃) δ 7.40–7.35 (m, 2H), 7.25–7.21 (m, 1H), 7.20–7.15 (m, 2H), 5.79 (dddd, J = 16.7, 10.4, 7.8, 7.0 Hz, 1H), 5.18–5.08 (m, 2H), 3.89–3.82 (m, 1H), 3.78–3.70 (m, 1H), 2.55 (ddt, J = 13.6, 7.0, 1.2 Hz, 1H), 2.33 (ddt, J = 13.6, 7.8, 1.1 Hz, 1H), 2.00–1.85 (m, 3H), 1.70–1.59 (m, 1H), 1.30 (s, 3H); ¹³C NMR (126 MHz, CDCl₃) δ 177.3, 153.8, 150.8, 133.3, 129.3, 125.9, 121.5, 118.9, 48.2, 45.0, 44.1, 33.0, 25.3, 19.6; IR (Neat Film NaCl) 3074, 2939, 2870, 1783, 1733, 1718, 1494, 1299, 1265, 1203, 1153, 991, 920 cm⁻¹; HRMS (MM: ESI-APCI) m/z calc'd for C₁₆H₂₀NO₃ [M+H]+: 274.1438, found 274.1444; [α]₂⁵° −81.6° (c 1.11, CHCl₃, 94% ee).

**Benzyl Carbamate Lactam 20**: Benzyl carbamate lactam 20 was isolated by flash chromatography (SiO₂, 10 to 30% Et₂O in hexanes) as a colorless oil. 85.9% yield. Rₖ = 0.41 (35% Et₂O in hexanes); ¹H NMR (500 MHz, CDCl₃) δ 7.46–7.42 (m, 2H), 7.37 (ddd, J = 7.4, 6.3, 1.5 Hz, 2H), 7.35–7.30 (m, 1H), 5.74 (dddt, J = 15.9, 11.0, 7.9, 6.9 Hz, 1H), 5.28 (s, 2H), 5.18–5.06 (m, 2H), 3.77–3.63 (m, 2H), 2.33 (ddt, J = 13.8, 6.9, 1.2 Hz, 1H), 2.24 (ddt, J = 13.8, 7.9, 1.0 Hz, 1H), 2.03 (dddt, J = 12.9, 8.1, 6.9 Hz, 1H), 1.74 (dddt, J = 13.2, 7.7, 5.9 Hz, 1H), 1.19 (s, 3H); ¹³C NMR (126 MHz, CDCl₃) δ 178.0, 151.7, 135.3, 133.0, 128.6, 128.3, 128.1, 119.1, 68.0, 45.5, 42.9, 41.7, 29.5, 22.6; IR (Neat Film NaCl) 3066, 2973, 2930, 2903, 1789, 1750, 1719, 1456, 1380, 1363, 1301, 1217, 1001, 919, 776, 736 cm⁻¹; HRMS (MM: ESI-APCI) m/z calc'd for C₁₆H₂₀NO₃ [M+H]+: 274.1438, found 274.1438; [α]₂⁵° −41.4° (c 1.02, CHCl₃, 91% ee).
4-Phenylbenzoyl Lactam 21: 4-Phenylbenzoyl lactam 21 was isolated by flash chromatography (SiO2, 10 to 15% Et2O in pentane) as a colorless oil. 84.6% yield.  \( R_f = 0.43 \) (35% Et2O in hexanes); \(^1\)H NMR (500 MHz, CDCl3) \( \delta \) 7.64–7.57 (m, 6H), 7.45 (ddd, \( J = 7.8, 6.7, 1.1 \text{ Hz}, 2H \)), 7.40–7.34 (m, 1H), 5.84–5.70 (m, 1H), 5.20–5.09 (m, 2H), 3.91–3.82 (m, 1H), 3.74 (ddd, \( J = 12.1, 7.4, 5.7 \text{ Hz}, 1H \)), 2.59 (ddd, \( J = 13.7, 7.0, 1.3 \text{ Hz}, 1H \)), 2.32 (ddt, \( J = 13.7, 7.7, 1.2 \text{ Hz}, 1H \)), 2.10–1.91 (m, 3H), 1.77–1.64 (m, 1H), 1.34 (s, 3H); \(^{13}\)C NMR (126 MHz, CDCl3) \( \delta \) 179.1, 175.1, 144.2, 140.2, 135.1, 133.3, 128.8, 128.1, 127.8, 127.2, 119.0, 47.2, 44.0, 43.3, 33.3, 25.2, 19.5; IR (Neat Film NaCl) 3073, 2938, 2869, 1677, 1607, 1478, 1383, 1295, 1279, 1145, 922, 849, 743, 698 cm\(^{-1}\); HRMS (MM: ESI-APCI) \text{m/z} \) calc’d for \( \text{C}_{22}\text{H}_{24}\text{NO}_2 \ [\text{M+H}]^+: 334.1802 \), found 334.1812; \( \left[\alpha\right]_D^{25} = -82.6^\circ \) (c 0.75, CHCl\(_3\), 99% ee).

1-Naphthoyl Lactam 22: 1-Naphthoyl lactam 22 was isolated by flash chromatography (SiO2, 10 to 20% Et\(_2\)O in hexanes) as a white solid. 86.3% yield. \( R_f = 0.42 \) (35% Et\(_2\)O in hexanes); \(^1\)H NMR (500 MHz, CDCl3) \( \delta \) 8.03–7.97 (m, 1H), 7.90–7.83 (m, 2H), 7.55–7.46 (m, 2H), 7.42 (dd, \( J = 8.1, 7.1 \text{ Hz}, 1H \)), 7.37 (ddd, \( J = 7.1, 1.3 \text{ Hz}, 1H \)), 5.64 (ddd, \( J = 17.2, 10.2, 7.6, 7.1 \text{ Hz}, 1H \)), 5.16–4.97 (m, 2H), 4.05 (ddt, \( J = 12.8, 6.3, 5.2, 1.3 \text{ Hz}, 1H \)), 2.43 (ddt, \( J = 13.7, 7.1, 1.2 \text{ Hz}, 1H \)), 2.19 (ddt, \( J = 13.7, 7.6, 1.1 \text{ Hz}, 1H \)), 2.11–1.99 (m, 2H), 1.99–1.91 (m, 1H), 1.73–1.64 (m, 1H), 1.18 (s, 3H); \(^{13}\)C NMR (126 MHz, CDCl3) \( \delta \) 178.5, 174.3, 135.8, 133.6, 133.1, 130.0, 129.8, 128.4, 126.9, 126.2, 124.9, 124.5, 123.3, 118.9, 46.4, 44.1, 43.3, 33.2, 24.8, 19.5; IR (Neat Film NaCl) 3062, 2937, 2869, 1702, 1677, 1467, 1381, 1289, 1145, 922, 849, 743, 698 cm\(^{-1}\); HRMS (MM: ESI-APCI) \text{m/z} \) calc’d for \( \text{C}_{20}\text{H}_{22}\text{NO}_2 \ [\text{M+H}]^+: 308.1645 \), found 308.1648; \( \left[\alpha\right]_D^{25} = -102.3^\circ \) (c 1.12, CHCl\(_3\), 99% ee).

2-Naphthoyl Lactam 23: 2-Naphthoyl lactam 23 was isolated by flash chromatography (SiO2, 10 to 20% Et\(_2\)O in hexanes) as a colorless oil. 82.1% yield. \( R_f = 0.42 \) (35% Et\(_2\)O in hexanes); \(^1\)H NMR (500 MHz, CDCl3) \( \delta \) 8.10 (dd, \( J = 1.8, 0.8 \text{ Hz}, 1H \)), 7.93–7.76 (m, 3H), 7.63–7.43 (m, 3H), 5.87–5.67 (m, 1H), 5.21–5.06 (m, 2H), 3.95–3.82 (m, 1H), 3.84–3.72 (m, 1H), 2.58 (ddt, \( J = 13.8, 7.1, 1.2 \text{ Hz}, 1H \)), 2.33 (ddt, \( J = 13.7, 7.6, 1.1 \text{ Hz}, 1H \)), 2.12–1.89 (m, 3H), 1.71 (ddt, \( J = 10.9, 4.9, 4.3, 2.4 \text{ Hz}, 1H \)), 1.34 (s, 3H); \(^{13}\)C NMR (126 MHz, CDCl3) \( \delta \) 179.0, 175.3, 134.6, 133.7, 133.3, 132.5, 128.9, 128.1, 127.7 (2C), 127.5, 126.4, 124.1, 118.9, 47.2, 44.0, 43.3, 33.3, 25.1, 19.5; IR (Neat Film NaCl) 3059, 2937, 2869, 1702, 1677, 1467, 1383, 1293, 1279, 1145, 922, 849, 743, 698 cm\(^{-1}\); HRMS (FAB) \text{m/z} \) calc’d for \( \text{C}_{20}\text{H}_{22}\text{NO}_2 \ [\text{M+H}]^+: 308.1645 \), found 308.1648; \( \left[\alpha\right]_D^{25} = -257.4^\circ \) (c 0.92, CHCl\(_3\), 97% ee).
**Procedures for the Conversion of Benzoyl Lactam 3 to Various Derivatives**

**Piperidin-2-one 24:** To a solution of lactam 3 (2.00 g, 7.37 mmol, 1.00 equiv) in MeOH (188 mL) was added a solution of LiOH•H2O (464 mg, 11.1 mmol, 1.50 equiv) in H2O (75 mL). After 20 h, the reaction mixture was concentrated under reduced pressure and diluted with saturated aqueous NaHCO3 (100 mL) and EtOAc (75 mL). The phases were separated, and the aqueous phase was extracted with EtOAc (4 x 75 mL). The combined organic phases were washed with brine (2 x 30 mL), dried (Na2SO4), filtered, and concentrated under reduced pressure. The resulting oil was purified by flash chromatography (3 x 25 cm SiO2, 40 to 60% EtOAc in hexanes) to afford known14 lactam 24 as a colorless oil (1.18 g, 96% yield).

\[ R_f = 0.21 \text{ (50\% EtOAc in hexanes)}; \] 
\[ ^{1}H \text{ NMR (500 MHz, CDCl}_3\] 
\[ \delta 6.05 \text{ (br s, 1H), 5.88 –5.66 (m, 1H), 5.12–4.95 (m, 2H), 3.25 (td, } J = 5.8, 1.9 \text{ Hz, 2H), 2.48 (ddt, } J = 13.6, 6.7, 1.3 \text{ Hz, 1H), 2.18 (dtt, } J = 13.6, 8.1, 1.0 \text{ Hz, 1H), 1.87–1.62 (m, 5H), 1.49 (dq, } J = 13.5, 7.4 \text{ Hz, 1H), 0.89 (t, } J = 7.5 \text{ Hz, 3H); }^{[\alpha]}_D^{25} = 13.7^\circ \text{ (c 0.57, CHCl}_3, 99\% \text{ ee).} \]

**Piperidine 25:** To a solution of piperidin-2-one 24 (250 mg, 1.49 mmol, 1.00 equiv) in ether (14.9 mL) was added lithium aluminum hydride (170 mg, 4.48 mmol, 3.0 equiv) (Caution: Gas evolution and exotherm). After stirring at ambient temperature for 5 min, the reaction mixture was heated to reflux for 36 h, cooled (0 °C), and quenched with saturated aqueous K2CO3 (20 mL, Caution: Gas evolution and exotherm). The phases were separated, and the aqueous phase was extracted with Et2O (4 x 75 mL). The combined organic phases were washed with brine (2 x 30 mL), dried (Na2SO4), filtered, and concentrated under reduced pressure to provide piperidine 23 (206 mg, 90% yield) as a colorless oil.

\[ R_f = 0.29 \text{ (20\% MeOH in DCM)}; \] 
\[ ^{1}H \text{ NMR (500 MHz, CDCl}_3\] 
\[ \delta 5.76 \text{ (ddt, } J = 16.4, 10.6, 7.5 \text{ Hz, 1H), 5.10–4.96 (m, 2H), 2.81–2.68 (m, 2H), 2.53 (dd, } J = 13.0, 20.0 \text{ Hz, 2H), 2.06 (d, } J = 7.5 \text{ Hz, 2H), 2.02 (br s, 1H), 1.55–1.42 (m, 2H), 1.40–1.30 (m, 2H), 1.32 (q, } J = 7.5 \text{ Hz, 2H), 0.80 (t, } J = 7.6 \text{ Hz, 3H); }^{13}C \text{ NMR (126 MHz, CDCl}_3\] 
\[ \delta 134.6, 116.9, 55.1, 47.0, 39.2, 34.9, 33.6, 27.7, 22.4, 7.1; IR (Neat Film NaCl) 3298, 3073, 2963, 2931, 2853, 2799, 1638, 1462, 1125, 996, 911 \text{ cm}^{-1}; \text{ HRMS (MM: ESI-APCI) } m/z \text{ calc'd for } C_{10}H_{20}N \text{ [M+H]}^+: 154.1590, \text{ found 154.1590; }^{[\alpha]}_D^{25} = 7.5^\circ \text{ (c 0.80, MeOH, 96\% ee).} \]

**Alcohol SI28:**15 To a vigorously stirred mixture of benzoyl lactam 3 (291 mg, 1.07 mmol, 1.00 equiv) and NaIO4 (915 mg, 4.28 mmol, 4.00 equiv) in CCl4 (4.3 mL), MeCN (4.3 mL), and H2O (6.5 mL) was added RuCl3•H2O (11.0 mg, 0.053 mmol, 0.05 equiv). After 28 h, the reaction mixture was diluted with half-saturated brine (30 mL) and extracted with DCM (5 x 25 mL). The combined organics were washed with half-saturated brine, dried (Na2SO4), and concentrated under reduced pressure. The resulting residue was suspended in Et2O (30 mL) and filtered through a pad of celite. The celite pad was washed with Et2O...
(2 x 15 mL), and the combined filtrate was concentrated under reduced pressure. This crude residue was used in the next step without further purification.

With cooling from a room temperature bath, the above residue was dissolved in THF (19 mL) and then treated with lithium aluminum hydride (487 mg, 12.9 mmol, 12.0 equiv) (Caution: Gas evolution and exotherm). The reaction mixture was stirred at ambient temperature for 12 h and then warmed to 40 °C for an addition 12 h. The reaction mixture was then cooled (0 °C) and dropwise treated with brine (20 mL, Caution: Gas evolution and exotherm). Once gas evolution had ceased the reaction mixture was diluted with half-saturated brine (20 mL) and EtOAc (20 mL). The phases were separated and the aqueous phase was extracted with EtOAc (5 x 50 mL). The combined organic phases were dried (Na₂SO₄), filtered, and concentrated under reduced pressure. The resulting oil was purified by flash chromatography (3 x 12 cm SiO₂, 35 to 70% EtOAc in hexanes) to afford alcohol SI28 as a colorless oil (162 mg, 61% yield for two steps). \( R_f = 0.36 \) (75% EtOAc in hexanes); ¹H NMR (500 MHz, CDCl₃) \( \delta \) 7.35–7.24 (m, 5H), 3.80–3.72 (m, 1H), 3.71–3.60 (m, 2H), 3.31 (br s, 1H), 2.85–2.70 (br s, 2H), 2.00–1.70 (br s, 4H), 1.66–1.45 (m, 3H), 1.35–1.10 (m, 3H), 0.81 (t, \( J = 7.5 \) Hz, 3H); ¹³C NMR (126 MHz, CDCl₃) \( \delta \) 129.5, 128.4, 127.4, 63.9, 63.4, 59.4, 52.9, 39.9, 35.9, 35.1, 33.4, 22.4, 7.5; IR (Neat Film NaCl) 3345 (br), 2933, 2793, 1453, 1350, 1115, 1040, 1028, 739 cm⁻¹; HRMS (MM: ESI-APCI) \( m/z \) calc’d for C₁₆H₂₆NO [M+H]⁺: 248.2009, found 248.2016.

Alcohol SI29: A mixture of alcohol SI28 (162.3 mg, 0.656 mmol, 1.00 equiv) and 20% Pd(OH)₂/C (50 mg) in MeOH (15 mL) was stirred under an H₂ atmosphere for 3.5 h. The reaction mixture was filtered through a pad of celite. The celite pad was washed with MeOH (2 x 15 mL), and the combined filtrate was concentrated under reduced pressure. This crude residue was used in the next step without further purification.

To a solution of the above residue in THF (10 mL) was added Boc₂O (150 mg, 0.689 mmol, 1.05 equiv). After stirring for 24 h, the reaction mixture was concentrated under reduced pressure and partitioned between DCM (20 mL) and saturated aqueous NaHCO₃ (20 mL). The organic layer was dried (Na₂SO₄), filtered, and concentrated under reduced pressure. The resulting oil was purified by flash chromatography (2 x 20 cm SiO₂, 15 to 35% EtOAc in hexanes) to afford alcohol SI29 as a colorless oil (130 mg, 77% yield for two steps). \( R_f = 0.34 \) (35% EtOAc in hexanes); ¹H NMR (500 MHz, CDCl₃) \( \delta \) 3.74–3.60 (m, 2H), 3.48 (br s, 1H), 3.31 (br s, 1H), 3.20 (br s, 1H), 2.96 (br s, 1H), 2.16 (br s, 1H), 1.66–1.55 (m, 1H), 1.55–1.42 (m, 3H), 1.44 (s, 9H), 1.40–1.27 (m, 2H), 1.25–1.15 (m, 1H), 0.83 (t, \( J = 7.5 \) Hz, 3H); ¹³C NMR (126 MHz, CDCl₃) \( \delta \) 155.2, 79.4, 58.7, 52.5, 44.5, 36.1, 35.3, 34.6, 28.4, 27.6, 21.2, 7.4; IR (Neat Film NaCl) 3439 (br), 2967, 2934, 2861, 1693, 1670, 1429, 1365, 1275, 1248, 1162, 1045, 865, 767 cm⁻¹; HRMS (MM: ESI-APCI) \( m/z \) calc’d for C₁₄H₂₆NO₃ [M+H]⁺: 258.2064, found 258.2069; [α]D²⁵⁻7.0° (c 1.13, CHCl₃, 96% ee).
Methods for the Determination of Enantiomeric Excess

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$^1$H and $^{13}$C NMR Spectra for New Compounds
Alkylation Substrates
SI21

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Other Compounds Reported
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Do not use Multiplier & Dilution Factor with ISTDs

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Last changed: 7/29/2011 10:25:04 AM by BM
(modified after loading)

Method Info: 5% IPA 10 min equil 1 mL/min

Area Percent Report

Sorted By: Signal
Multiplier: 1.0000
Dilution: 1.0000

Do not use Multiplier & Dilution Factor with ISTDs

Signal 1: VWD1 A, Wavelength=220 nm, TT

<table>
<thead>
<tr>
<th>#</th>
<th>RetTime [min]</th>
<th>Type</th>
<th>Width [min]</th>
<th>Area [mAU]</th>
<th>Height [mAU]</th>
<th>Area [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>15.219</td>
<td>BV</td>
<td>0.6191</td>
<td>1.0982e4</td>
<td>252.37016</td>
<td>90.5780</td>
</tr>
<tr>
<td>2</td>
<td>18.100</td>
<td>VB</td>
<td>0.6014</td>
<td>1142.37195</td>
<td>22.43169</td>
<td>9.4220</td>
</tr>
</tbody>
</table>

Totals: 1.21245e4 274.80185

HPLC 1 7/29/2011 10:26:22 AM BM
Data File C:\CHEM321\DATA\YLII\YLII_61_CBZ_RAC_3ETO30_220.D
Sample Name: YLII_61_CBz_rac

Acq. Operator : YL  Seq. Line : 9
Acq. Instrument : HPLC 1  Location : Vial 10
Injection Date : 5/20/2011 2:47:41 AM  Inj : 1
                     Inj Volume : 5.0 µl

Acq. Method : C:\CHEM32\2\METHODS\3ETO30_220.M
Last changed : 11/7/2010 11:44:02 AM by tkim
Analysis Method : C:\CHEM32\2\METHODS\5IPA_EQUIL.M
(modified after loading)
Method Info : 5% IPA  10 min equil  1 mL/min

Area Percent Report

Sorted By : Signal
Multiplier:  1.0000
Dilution:  1.0000
Do not use Multiplier & Dilution Factor with ISTDs

Signal 1: VWD1 A, Wavelength=220 nm, TT

<table>
<thead>
<tr>
<th>Peak RetTime</th>
<th>Type</th>
<th>Width</th>
<th>Area</th>
<th>Height</th>
<th>Area</th>
</tr>
</thead>
<tbody>
<tr>
<td># [min]</td>
<td></td>
<td>[min]</td>
<td>[mAU]</td>
<td>[s] [mAU]</td>
<td>%</td>
</tr>
<tr>
<td>-------------</td>
<td>------</td>
<td>-------</td>
<td>------</td>
<td>---------</td>
<td>-------</td>
</tr>
<tr>
<td>1</td>
<td>16.682</td>
<td>VV</td>
<td>0.3757</td>
<td>2.84287e+04</td>
<td>1124.77881</td>
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<tr>
<td>2</td>
<td>17.893</td>
<td>VB</td>
<td>0.4539</td>
<td>2.72778e+04</td>
<td>933.05023</td>
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Totals : 5.57065e+04  2057.82904

HPLC 1 7/29/2011 10:28:49 AM BM
Data File C:\CHEM32\1\DATA\YLII\YLII_79CBZ_3ETOH30_220.D
Sample Name: YLII_79CBz

Acq. Operator : YL
Seq. Line : 12
Acq. Instrument : HPLC 1
Location : Vial 24
Injection Date : 6/2/2011 3:00:38 PM
Inj : 1
Inj Volume : 5.0 µl

Acq. Method : C:\CHEM32\2\METHODS\3ETOH30_220.M
Last changed : 11/7/2010 11:44:02 AM by tkim
Analysis Method : C:\CHEM32\2\METHODS\5IPA_EQUIL.M
Last changed : 7/29/2011 10:30:08 AM by BM
(modified after loading)
Method Info : 5% IPA 10 min equil 1 mL/min

Area Percent Report

Sorted By : Signal
Multiplier: 1.0000
Dilution: 1.0000
Do not use Multiplier & Dilution Factor with ISTDs

Signal 1: VWD1 A, Wavelength=220 nm, TT

Peak RetTime Type Width Area Height Area %
# [min] [min] mAU *s [mAU] |
1 17.595 BV 0.3304 1283.26135 60.50865 6.9133
2 18.683 VB 0.4244 1.72789e4 641.04041 93.0867
Totals : 1.85622e4 701.54906

HPLC 1 7/29/2011 10:30:13 AM BM
Data File C:\CHEM32\1\DATA\YLIJ\YLIJ_71RAC_OD_8IP45_254.D
Sample Name: YLII_71rac

Acq. Operator : YL
Acq. Instrument : HPLC 1
Injection Date : 5/26/2011 4:10:23 PM
Inj Volume : 5.0 µl

Acq. Method : C:\CHEM32\2\METHODS\8IP45_254.M
Last changed : 4/26/2010 10:45:46 PM
Analysis Method : C:\CHEM32\2\METHODS\5IPEQUL.EQUIL.M
Last changed : 7/29/2011 10:33:47 AM by BM
(modified after loading)
Method Info : 5% IPA 10 min equil 1 mL/min

Area Percent Report

Sorted By : Signal
Multiplier: 1.0000
Dilution: 1.0000
Do not use Multiplier & Dilution Factor with ISTDs

Signal 1: VWD1 A, Wavelength=254 nm, TT

Peak RetTime Type Width Area Height Area
# [min] [min] mAU s [mAU] %
---|---|---|---|---|---|---|---|
1 20.669 BB 0.7256 1.83637e4 383.83423 49.9785
2 28.001 BB 1.1624 1.83795e4 230.88930 50.0215

Totals : 3.67433e4 614.72353

HPLC 1 7/29/2011 10:33:51 AM BM
Data File C:\CHEM32\1\DATA\YLII\YLII_65-2_OD_3ETOH45_254.D
Sample Name: YLII_65-2

Acq. Operator : YL
Acq. Instrument : HPLC 1
Injection Date : 5/23/2011 9:38:54 AM
Injection : 1
Inj Volume : 5.0 µl

Acq. Method : C:\CHEM32\1\METHODS\8IPA45_254.M
Last changed : 4/26/2011 10:45:46 PM
Analysis Method : C:\CHEM32\2\METHODS\5IPA_EQUIL.M
Last changed : 7/29/2011 10:31:43 AM by BM
(modified after loading)
Method Info : 5% IPA 10 min equil 1 mL/min

---

Area Percent Report

Sorted By : Signal
Multiplier: 1.0000
Dilution: 1.0000
Do not use Multiplier & Dilution Factor with ISTDs

Signal 1: WVD1 A, Wavelength=254 nm, TT

Peak RetTime Type Width Area Height Area
# [min] [min] mAU *s [mAU ] %
---|--------|---------|--------|----------------|--------|------|
1 21.474 BB 0.6472 660.55054 13.38225 5.6849
2 28.887 BB 1.1350 1.09588e4 137.30792 94.3151
Totals : 1.16193e4 150.69018

---

HPLC 1 7/29/2011 10:32:43 AM BM
Supplementary Information for Behenna, Liu, Yurino, Kim, White, Virgil, and Stoltz

Data File C:\CHEM32\1\DATA\YLII\YLII_59AC_RAC_O1IIPA30_254.D
Sample Name: YLII_59Ac_rac

Acq. Operator : YL  Seq. Line :  4
Acq. Instrument : HPLC 1  Location : Vial 19
Injection Date : 5/27/2011 12:25:33 PM  Inj :  1
Inj Volume : 5.0 µl

Acq. Method : C:\CHEM32\2\METHODS\IIPA30_254.M
Last changed : 4/26/2010 8:33:00 PM
Analysis Method : C:\CHEM32\2\METHODS\5IPA_EQUIL.M
Last changed : 7/29/2011 10:35:37 AM by BM
(modified after loading)
Method Info : 5% IPA  10 min equil  1 mL/min

Area Percent Report

Sorted By : Signal
Multiplier: : 1.0000
Dilution: : 1.0000
Do not use Multiplier & Dilution Factor with ISTDs

Signal 1: WVD1 A, Wavelength=254 nm, TT

Peak RetTime Type Width Area Height Area
# [min]   [min]  mAU  *s [mAU ] %
---|--------|--------|--------|--------|--------|
 1  9.549  BV  0.1998 2742.82764 210.81544  49.6222 |
 2 10.069  VV  0.2239 2784.58911 189.43260  50.3778 |

Totals : 5527.41675  400.24805

HPLC 1 7/29/2011 10:35:50 AM BM
Data File C:\CHEM32\1\DATA\YLII\YLII_53_OJ_1IPA30_254.D
Sample Name: YLII_53

Acq. Operator : YL
Acq. Instrument : HPLC 1
Injection Date : 5/27/2011 11:13:11 AM
Injection: 1
Inj Volume: 5.0 µl

Acq. Method : C:\CHEM32\2\METHODS\1IPA30_254.M
Last changed : 4/26/2010 8:33:09 PM
Analysis Method : C:\CHEM32\2\METHODS\5IPA_EQUIL.M
Last changed : 7/29/2011 10:36:36 AM by BM
(modified after loading)
Method Info : 5% IPA 10 min equil 1 mL/min

Area Percent Report

Sorted By : Signal
Multiplier: 1.0000
Dilution: 1.0000
Do not use Multiplier & Dilution Factor with ISTDs

Signal 1: VWD1 A, Wavelength=254 nm, TT

<table>
<thead>
<tr>
<th>Peak</th>
<th>RetTime</th>
<th>Type</th>
<th>Width</th>
<th>Area</th>
<th>Height</th>
<th>Area</th>
<th>%</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>9.709</td>
<td>BV</td>
<td>0.1726</td>
<td>118.91815</td>
<td>10.70099</td>
<td>4.624</td>
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<tr>
<td>2</td>
<td>10.149</td>
<td>VB</td>
<td>0.2166</td>
<td>2452.69287</td>
<td>172.73965</td>
<td>95.3757</td>
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</tr>
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Totals : 2571.61102 183.44065

HPLC 1 7/29/2011 10:36:42 AM BM
Data File: C:\CHEM32\YLI\YLI_153_OME_OD_3IPA.D
Sample Name: YLI_153
Acq. Operator: YL Seq. Line: 29
Acq. Instrument: HPLC 1 Location: Vial 13
Injection Date: 2/21/2011 6:57:45 AM Inj: 1
Injection Volume: 5.0 μL
Acq. Method: C:\CHEM32\METHODS\3IPA30_254.M
Last changed: 4/26/2010 8:31:20 PM
Analysis Method: C:\CHEM32\METHODS\5IPA_EQUIL.M
Last changed: 7/29/2011 10:50:17 AM by BM
(modified after loading)
Method Info: 5% IPA 10 min equil 1 mL/min

Area Percent Report

Sorted By: Signal Multiplier: 1.0000
Dilution: 1.0000
Do not use Multiplier & Dilution Factor with ISTDs

<table>
<thead>
<tr>
<th></th>
<th>RetTime</th>
<th>Type</th>
<th>Width</th>
<th>Area</th>
<th>Height</th>
<th>Area</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>15.909</td>
<td>BB</td>
<td>0.4485</td>
<td>4780.88037</td>
<td>164.41164</td>
<td>50.0182</td>
<td></td>
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<tr>
<td>2</td>
<td>17.697</td>
<td>BB</td>
<td>0.5172</td>
<td>4777.40430</td>
<td>140.88832</td>
<td>49.9818</td>
<td></td>
</tr>
</tbody>
</table>

Totals: 9558.28467 305.29996

HPLC 1 7/29/2011 10:51:09 AM BM

Page 1 of 2
Data File C:\CHEM32\1\DATA\YLI\YLI_263_OD_3IPA30_254.D
Sample Name: YLI_263

Acq. Operator : YL  Seq. Line : 4
Acq. Instrument : HPLC 1  Location : Vial 46
Injection Date : 4/18/2011 11:50:03 AM  Inj : 1
  Inj Volume : 5.0 µl
Acq. Method : C:\CHEM32\1\METHODS\3IPA30_254.M
Last changed : 4/26/2010 8:31:20 PM
Analysis Method : C:\CHEM32\2\METHODS\5IPA_EQUIL.M
Last changed : 7/29/2011 10:47:21 AM by BM
(modified after loading)
Method Info : 5% IPA  10 min equil  1 ml/min

Area Percent Report

Sorted By : Signal
Multiplier: : 1.0000
Dilution: : 1.0000
Do not use Multiplier & Dilution Factor with ISTDs

Signal 1: WWD1 A, Wavelength=254 nm, TT

Peak RetTime Type Width Area Height Area
# [min] [min] mAU *s [mAU] %
---|-------|--|-------------|--|--------|--|-------------|--|--------|--|--------|--|--------|--|--------|--|--------|
1 15.731 BB 0.4938 2.76283e4 831.88440 99.4584
2 18.118 BB 0.4850 150.44589 3.79598 0.5416
Totals : 2.77788e4 835.68038
Data File C:\CHEM32\1\DATA\YLI\YLI_151_OJ_2IPA45_254.D
Sample Name: YLI_151

Acq. Operator : YL
Acq. Instrument : HPLC I
Injection Date : 3/9/2011 4:44:24 PM
Injection : 1
Location : Vial 12
Inj Volume : 5.0 µl

Acq. Method : C:\CHEM32\1\METHODS\2IPA45_254.M
Analysis Method : C:\CHEM32\2\METHODS\5IPA_EQUIL.M
Last changed : 7/29/2011 10:58:11 AM by BM
(modified after loading)
Method Info : 5% IPA 10 min equil 1 mL/min

Area Percent Report

Sorted By : Signal
Multiplier : 1.0000
Dilution : 1.0000
Do not use Multiplier & Dilution Factor with ISTDs

Signal 1: VWD1 A, Wavelength=254 nm, TT

Peak RetTime Type Width Area Height Area
# [min] [min] mAU *s [mAU] %
1 19.172 BB 0.4233 4942.04053 180.23906 50.1212
2 29.171 BB 0.6854 4918.13232 108.64030 49.8788
Totals : 9860.17285 288.87936

HPLC I 7/29/2011 11:00:29 AM BM
Data File C:\CHEM32\1\DATA\YL\YL_265_OJ_2IPA45_254.D
Sample Name: YLI_265

Acq. Operator : YL                Seq. Line : 9
Acq. Instrument : HPLC 1          Location : Vial 47
Injection Date : 4/18/2011 12:53:11 PM Inj : 1
Inj Volume : 5.0 µl

Acq. Method : C:\CHEM32\1\METHODS\2IPA45_254.M
Analysis Method : C:\CHEM32\2\METHODS\5IPA_EQUIL.M
Last changed : 7/29/2011 11:01:34 AM by BM
(modified after loading)
Method Info : 5% IPA 10 min equil 1 mL/min

Area Percent Report

Sort by          Signal
Multiplier: 1.0000
Dilution: 1.0000
Do not use Multiplier & Dilution Factor with ISTDs

Signal 1: VWD1 A, Wavelength=254 nm, TT
Peak RetTime Type Width Area Height Area
# [min] [min] mAU *s [mAU] %
---|--------|----------|---------|--------|--------|---------|
1 19.736 BV 0.3262 78.32276 2.89796 0.3201
2 29.119 BB 0.7849 3.40999 437.12598 99.6799
Totals: 2.44682e4 440.02394

HPLC 1 7/29/2011 11:01:42 AM BM
Data File C:\CHEM32\1\DATA\YLI\YLI_149_OJ_SIPAPA254.D
Sample Name: YLI_149

Acq. Operator : YL Seq. Line : 40
Acq. Instrument : HPLC 1 Location : Vial 13
Injection Date : 3/10/2011 3:59:08 AM Inj : 1
Injection Volume : 5.0 µl

Acq. Method : C:\CHEM32\1\METHODS\SIPAPA254.M
Last changed : 4/26/2010 10:44:29 PM
Analysis Method : C:\CHEM32\2\METHODS\SIPAPA_EQUIL.M
Last changed : 7/29/2011 11:06:10 AM by BM
(modified after loading)
Method Info : 5% IPA 10 min equil 1 mL/min

Area Percent Report

Sorted By : Signal
Multiplier: 1.0000
Dilution: 1.0000
Do not use Multiplier & Dilution Factor with ISTDs

Signal 1: WVD1 A, Wavelength=254 nm, TT

<table>
<thead>
<tr>
<th>#</th>
<th>RetTime [min]</th>
<th>Type</th>
<th>Width [min]</th>
<th>Area [mAU]</th>
<th>Height [mAU]</th>
<th>Area %</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>29.897</td>
<td>BB</td>
<td>0.7021</td>
<td>3840.42310</td>
<td>83.35200</td>
<td>49.6362</td>
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<tr>
<td>2</td>
<td>32.396</td>
<td>BB</td>
<td>0.7817</td>
<td>3896.71704</td>
<td>73.40163</td>
<td>50.3638</td>
</tr>
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</table>

Totals : 7737.14014 156.75362
Supplementary Information for Behenna, Liu, Yurino, Kim, White, Virgil, and Stoltz

Data File C:\CHEM32\1\DATA\YL\YL\227_GJ_5IPA45_254.D
Sample Name: YLI_227

Acq. Operator : YL                Seq. Line :  4
Acq. Instrument : HPLC 1           Location : Vial 26
Injection Date : 3/27/2011 5:59:05 PM     Inj :  1
                        Inj Volume : 5.0 μL
Acq. Method : C:\CHEM32\1\METHODS\5IPA45_254.M
Last changed : 4/26/2010 10:44:29 PM
Analysis Method : C:\CHEM32\2\METHODS\5IPA_EQUIL.M
Last changed : 7/29/2011 11:04:39 AM by BM
                        (modified after loading)
Method Info : 5% IPA  10 min equil  1 mL/min

Area Percent Report

Sorted By : Signal
Multiplier: 1.0000
Dilution: 1.0000
Do not use Multiplier & Dilution Factor with ISTDs

Signal 1: VWD1 A, Wavelength=254 nm, TT
Peak RetTime Type Width Area Height Area
# [min] [min] mAU *s [mAU ] %
---|--------|--------|--------|--------|--------|--------|--------|--------|
1 | 31.161 | BV     | 0.5177 | 87.67049 | 2.00378 | 0.5279 |
2 | 32.973 | VB     | 0.9216 | 1.65184e4 | 252.59338 | 99.4721 |
Totals : 1.66060e4 254.59716

Page 1 of 2
Analytical Report SFC

Chromatogram Information
User Name: User
HPLC System Name: Jasco SFC w PDA
Injection Date: 4/11/2011 10:57:09 AM
Volume: 5.00 [μL]
Sample #: 4
Project Name: Cal Tech SFC
Executed Sequence: DCBII279a
Chromatogram Name: DCBII279_C3_3MeOH
Sample Name: 
Acqulition Time: 7.0 [min]
Acquisition Sequence: DCBII279a
Control Method: Solv 1 Col 3 Isocratic 3B 5mL_min 10MPa 15 min

![Chromatogram Image]

Peak Information

<table>
<thead>
<tr>
<th>#</th>
<th>Peak Name</th>
<th>tR [min]</th>
<th>Area [μV·sec]</th>
<th>Height [μV]</th>
<th>Area%</th>
<th>Peak Start</th>
<th>Peak End</th>
<th>Peak Width</th>
<th>Resolution</th>
<th>Symmetry Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Unknown</td>
<td>2.507</td>
<td>268288</td>
<td>82473</td>
<td>50.787</td>
<td>2.387</td>
<td>2.880</td>
<td>0.065</td>
<td>10.039</td>
<td>1.415</td>
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<tr>
<td>2</td>
<td>Unknown</td>
<td>3.882</td>
<td>258018</td>
<td>40569</td>
<td>49.213</td>
<td>3.733</td>
<td>4.107</td>
<td>0.067</td>
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<td>1.365</td>
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</table>
Analytical Report SFC

Chromatogram Information
User Name
HPLC System Name
Injection Date
Volume
Sample #
Project Name
Executed Sequence
Chromatogram Name
Sample Name
Acquisition Time
Acquisition Sequence
Control Method

Peak Information

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<th>Peak Name</th>
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<th>Area [µV-sec]</th>
<th>Height [µV]</th>
<th>Area%</th>
<th>Peak Start</th>
<th>Peak End</th>
<th>Peak Width</th>
<th>Resolution</th>
<th>Symmetry Factor</th>
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<td>2.493</td>
<td>5222</td>
<td>141</td>
<td>0.471</td>
<td>2.440</td>
<td>2.567</td>
<td>0.059</td>
<td>10.978</td>
<td>1.322</td>
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<tr>
<td>2</td>
<td>Unknown</td>
<td>3.652</td>
<td>1103546</td>
<td>177127</td>
<td>99.529</td>
<td>3.707</td>
<td>4.086</td>
<td>0.069</td>
<td>N/A</td>
<td>1.241</td>
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</table>
Analytical Report SFC

Chromatogram Information
User Name: User
HPLC System Name: Jasco SFC w PDA
Injection Date: 4/5/2011 11:21:25 PM
Volume: 5.00 [µL]
Sample #: 2
Project Name: Cal Tech SFC
Executed Sequence: DCBI269
Chromatogram Name: DCBI269_C2_10MeOH
Sample Name: DCBI269
Acquisition Time: 7.0 [min]
Acquisition Sequence: DCBI269
Control Method: Solv 1 Col 2 Isocratic 10B 5mL_min 10MPa 10min

Chromatogram

Intensity [µA]

0.000 2.000 4.000 6.000
Retention Time [min]

Peak Information

<table>
<thead>
<tr>
<th>#</th>
<th>Peak Name</th>
<th>tR [min]</th>
<th>Area [µV-sec]</th>
<th>Height [µA]</th>
<th>Area%</th>
<th>Peak Start</th>
<th>Peak End</th>
<th>Peak Width</th>
<th>Resolution</th>
<th>Symmetry Factor</th>
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<tbody>
<tr>
<td>1</td>
<td>Unknown</td>
<td>3.215</td>
<td>239394</td>
<td>4509</td>
<td>50.317</td>
<td>3.067</td>
<td>3.387</td>
<td>0.083</td>
<td>4.119</td>
<td>1.032</td>
</tr>
<tr>
<td>2</td>
<td>Unknown</td>
<td>4.040</td>
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<td>3.889</td>
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<td>0.154</td>
<td>N/A</td>
<td>1.581</td>
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</table>
Data File: C:\CHEM32\1\DATA\DCB\DCBII_281_AD_3ETOH.D
Sample Name: DCBII_281_esterRac

Acq. Operator: DCB                      Seq. Line: 25
Acq. Instrument: HPLC 1                 Location: Vial 41
Injection Date: 4/9/2011 6:28:20 AM    Inj: 1
Injection Volume: 5.0 µl
Different Inj Volume from Sequence!   Actual Inj Volume: 2.0 µl
Acq. Method: C:\CHEM32\METHODS\3ETOH45_254.M
Last changed: 4/26/2010 10:54:15 PM
Analysis Method: C:\CHEM32\METHODS\5IPA_EQUIL.M
Last changed: 7/29/2011 12:50:07 PM by BM
(modified after loading)
Method Info: 5% IPA 10 min equil 1 mL/min

Area Percent Report

Sorted By: Signal
Multiplier: 1.0000
Dilution: 1.0000
Do not use Multiplier & Dilution Factor with ISTDs

Signal 1: UV210 A, Wavelength=254 nm, TT

<table>
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<th>Peak RetTime Type</th>
<th>Width</th>
<th>Area</th>
<th>Height</th>
<th>Area of</th>
<th>%</th>
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<tbody>
<tr>
<td></td>
<td>[min]</td>
<td>[min]</td>
<td>[mAU]</td>
<td>[mAU]</td>
<td></td>
</tr>
<tr>
<td>-------------------</td>
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<td>--------</td>
<td>---------</td>
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</tr>
<tr>
<td>1</td>
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<td>8334.97266</td>
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<tr>
<td>2</td>
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<td>BB</td>
<td>0.6752</td>
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<td>50.0479</td>
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Totals: 391.54250

HPLC 1 7/29/2011 12:50:17 PM BM
Supporting Information for Behenna, Liu, Yurino, Kim, White, Virgil, and Stoltz

Data File C:\CHEM32\1\DATA\DCBI\DCBII_285_AD_3ETOH.D
Sample Name: DCBII_285

Acq. Operator : DCB
Acq. Instrument : HPLC 1
Injection Date : 4/10/2011 9:14:43 PM
Inj Volume : 5.0 µl

Acq. Method : C:\CHEM32\1\METHODS\3ETOH45_254.M
Last changed : 4/26/2010 10:54:15 PM
Analysis Method : C:\CHEM32\2\METHODS\5IPA_EQUL.M
(modified after loading)
Method Info : 5% IPA 10 min equil 1 mL/min

-----

Area Percent Report

Sorted By : Signal
Multiplier: : 1.0000
Dilution: : 1.0000
Do not use Multiplier & Dilution Factor with ISTDs

Signal 1: VWD1_A, Wavelength=254 nm, TT

Peak RetTime Type Width Area Height Area
# [min] [min] mAU s [mAU ] %
---|-----|-------|-------|-------|------|-----|
1 27.826 BB 0.4591 123.43498 3.25033 0.4504
2 32.691 BB 0.7959 2.72792e4 483.95120 99.5496

Totals : 2.74026e4 487.20153

-----
**Analytical Report SFC**

**Chromatogram Information**
- **User Name**: User
- **HPLC System Name**: Jasco SFC w PDA
- **Injection Date**: 4/12/2011 8:16:48 PM
- **Volume**: 5.00 [μL]
- **Sample #**: 1
- **Project Name**: Cal Tech SFC
- **Executed Sequence**: DCSBII_287
- **Chromatogram Name**: DCSBII_287_C6_10MeOH
- **Sample Name**: 
- **Acquisition Time**: 7.0 [min]
- **Acquisition Sequence**: DCSBII_287
- **Control Method**: Solv 1 Col 6 Isocratic 10B 5mL_min 10MPa 10min

**Chromatogram**

<table>
<thead>
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<th>#</th>
<th>Peak Name</th>
<th>tR [min]</th>
<th>Area [μV-sec]</th>
<th>Height [μV]</th>
<th>Area%</th>
<th>Peak Start</th>
<th>Peak End</th>
<th>Peak Width</th>
<th>Resolution</th>
<th>Symmetry Factor</th>
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<td>10</td>
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<td>207381</td>
<td>32931</td>
<td>50.077</td>
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<td>0.697</td>
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Analytical Report SFC

Chromatogram Information
User Name: User
HPLC System Name: Jasoo SFC w PDA
Injection Date: 4/17/2011 3:40:55 PM
Volume: 5.00 [µL]
Sample #: 4
Project Name: Cal Tech SFC
Executed Sequence: DCBI291
Chromatogram Name: DCBI291_C6_10MeOHA
Sample Name: 7.0 [min]
Acquisition Time: DCBI291
Acquisition Sequence: Solv 1 Col 6 Isocratic 10B 5mL_min 10MPa 10min

Peak Information

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<th>Height [µA]</th>
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<th>Peak End</th>
<th>Peak Width</th>
<th>Resolution</th>
<th>Symmetry Factor</th>
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<td>912578</td>
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<td>745</td>
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<td>4.000</td>
<td>0.253</td>
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<td>1.282</td>
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Data File C:\CHEM32\2\DATA\DCBIII\DCBIII_113A 2011-06-17 11-45-44\DCBIII_113_OJ_3IPA.D
Sample Name: DCBIII_113

Acq. Operator : DCB  Seq. Line : 4
Acq. Instrument : HPLC 2  Location : Vial 21
Injection Date : 6/17/2011 12:08:19 PM  Inj : 1
Inj Volume : 5.0 µl
Different Inj Volume from Sequence : Actual Inj Volume : 3.0 µl
Acq. Method : C:\CHEM32\2\DATA\DCBIII\DCBIII_113A 2011-06-17 11-45-44\3IPA30_254.M
Last changed : 4/26/2010 8:31:20 PM
Analysis Method : C:\CHEM32\2\METHODS\POS1.M
Last changed : 7/29/2011 12:59:34 PM by DCB
(modified after loading)
Method Info : Position # 1 METHOD : (No Column) Valve to Position # 1 (By-Pass / Flush Line).

VWD1 A, Wavelength=254 nm, TT (DCBIII\DCBIII_113A 2011-06-17 11-45-44\DCBIII_113_OJ_3IPA.D)

Area Percent Report

sorted by : Signal
Multiplier: : 1.0000
Dilution: : 1.0000
Do not use Multiplier & Dilution Factor with ISTDs

Signal 1: VWD1 A, Wavelength=254 nm, TT

<table>
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<th>Peak RetTime</th>
<th>Type</th>
<th>Width</th>
<th>Area</th>
<th>Height</th>
<th>Area</th>
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<tbody>
<tr>
<td>#</td>
<td>[min]</td>
<td>[min]</td>
<td>mAU *s</td>
<td>[mAU]</td>
<td>%</td>
</tr>
<tr>
<td>-------------</td>
<td>-----</td>
<td>-------</td>
<td>-------</td>
<td>--------</td>
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</tr>
<tr>
<td>1</td>
<td>6.132</td>
<td>0.3811</td>
<td>1.39639e4</td>
<td>577.44043</td>
<td>50.2375</td>
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<tr>
<td>2</td>
<td>8.348</td>
<td>0.6667</td>
<td>1.38318e4</td>
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<td>2.77957e4</td>
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Summed Peaks Report

HPLC 2 7/29/2011 1:00:11 PM DCB
Data File C:\CHEM32\2\DATA\DCBI\DCBI\DCBIII_DCBI\115 2011-06-17 20-15-38\DCBIII_115_22_OJ_3PA.D
Sample Name: DCBIII_115_22

Acq. Operator : DCB  Seq. Line : 11
Acq. Instrument : HPLC 2  Location : Vial 41
Injection Date : 6/17/2011 10:13:45 PM  Inj : 1
Injection Volume : 5.0 ul
Acq. Method : C:\CHEM12\2\DATA\DCBIII\DCBIII_DCBI\115 2011-06-17 20-15-38\3IPA15_254.M
Last changed : 6/23/2010 11:23:00 AM by LREPKA
Analysis Method : C:\CHEM12\2\METHODS\POS1.M
Last changed : 7/29/2011 12:56:33 PM by DCB
(modified after loading)
Method Info : Position # 1 METHOD : (No Column) Valve to Position # 1 (By-Pass / Flush Line).

Area Percent Report

Sorted By : Signal
Multiplier:  1.0000
Dilution:  1.0000
Do not use Multiplier & Dilution Factor with ISTDs

Signal 1: VWD1 A, Wavelength=254 nm, TT

Peak RetTime Type Width Area Height Area %
# [min] [min] mAU *s [mAU] %

1  5.948 MM  0.3963 243.82837 10.25436 2.0385
2  7.750 MM  0.7041 1.17172e4 277.35931 97.9615

Totals :  1.19610e4 287.61367

Summed Peaks Report

HPLC 2 7/29/2011 12:56:45 PM DCB
Data File C:\CHEM32\1\DATA\ALLIM\YLI_221_OJ_8IPA254.D
Sample Name: YLI_221

Acq. Operator : AOL
Acq. Instrument : HPLC 1
Injection Date : 3/24/2011 3:55:13 AM
Injection Volume : 5.0 µl

Acq. Method : C:\CHEM32\1\METHODS\8IPA45_254.M
Analysis Method : C:\CHEM32\2\METHODS\5IPA_EQUI.M
Last changed : 7/29/2011 11:12:34 AM by BM
(method modified after loading)

Method Info : 5% IPA 10 min equil 1 mL/min

Area Percent Report

Sorted By : Signal
Multiplier : 1.0000
Dilution : 1.0000
Do not use Multiplier & Dilution Factor with ISTDs

Signal 1: VWD1, Wavelength=254 nm, TT

Peak RetTime Type Width Area Height Area %
# [min] [min] mAU s [mAU] |
1 17.899 BB 0.5203 7701.64990 225.75133 50.0205
2 25.043 BB 0.7410 7695.34424 155.73499 49.9795
Totals : 1.53970e4 381.48631

HPLC 1 7/29/2011 11:12:39 AM BM
Data File C:\CHEM32\1\DATA\YLI\YLI_247_GJ_8IPA45_254.D
Sample Name: YLI_247

Acq. Operator : YL  Seq. Line :  4
Acq. Instrument : HPLC 1  Location : Vial 35
Injection Date : 4/11/2011 10:58:08 AM  Inj :  1
Injection Volume : 5.0 µl

Acq. Method : C:\CHEM32\1\METHODS\8IPA45_254.M
Last changed : 4/26/2010 10:45:46 PM
Analysis Method : C:\CHEM32\2\METHODS\5IPA_EQUIL.M
Last changed : 7/29/2011 11:11:21 AM by BM
(modified after loading)
Method Info : 5% IPA  10 min equil  1 mL/min

VWD1A, Wavelength=254 nm, TT (YLI/YLI_247_GJ_8IPA45_254.D)

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<tr>
<th>Peak RetTime Type</th>
<th>Width</th>
<th>Area Height Area</th>
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<th>[min]</th>
<th>mAU • s [mAU</th>
<th>%</th>
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<tbody>
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<td>1</td>
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<td>BB</td>
<td>0.4655</td>
<td>231.12241</td>
<td>6.51539</td>
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<td>2</td>
<td>25.943</td>
<td>BB</td>
<td>0.8181</td>
<td>1.38954E-4</td>
<td>244.75729</td>
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</table>

Totals: 1.41265e4 251.27269

HPLC 1 7/29/2011 11:11:25 AM BM
Data File: C:\CHEM32\2\DATA\YLLI\YLLI_29-2 2011-07-03 23-23-37\YLLI_239rac-2_AD_2IPA45_254.D
Sample Name: YLLI_239rac

Acq. Instrument: HPLC 2  Location: Vial 13
Injection Date: 7/4/2011 12:54:50 AM  Inj: 1
Inj Volume: 5.0 μl

Acq. Method: C:\CHEM32\2\DATA\YLLI\YLLI_29-2 2011-07-03 23-23-37\2IPA45_254.M
Analysis Method: C:\CHEM32\2\METHODS\POS1.M
Last changed: 7/29/2011 11:27:02 AM by DCB (modified after loading)
Method Info: Position # 1 METHOD: (No Column) Valve to Position # 1 (By-Pass / Flush Line).

Area Percent Report
Sorted By: Signal
Multiplier: 1.0000
Dilution: 1.0000
Do not use Multiplier & Dilution Factor with ISTDs

Signal 1: VWD1 A, Wavelength=254 nm, TT

<table>
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<tr>
<th>Peak RetTime</th>
<th>Type</th>
<th>Width</th>
<th>Area</th>
<th>Height</th>
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<tbody>
<tr>
<td>#</td>
<td>[min]</td>
<td>[min]</td>
<td>mAU *s</td>
<td>[mAU]</td>
<td>%</td>
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<tr>
<td>1</td>
<td>18.671</td>
<td>BB</td>
<td>0.5043</td>
<td>1559.92273</td>
<td>46.92644</td>
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<td>2</td>
<td>26.723</td>
<td>BB</td>
<td>0.7288</td>
<td>1563.49976</td>
<td>32.24076</td>
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Totals: 3123.42240 79.16720

Summed Peaks Report

HPLC 2 7/29/2011 11:27:05 AM DCB
Data File C:\CHEM32\2\DATA\YLII\YLII_29-2 2011-07-03 23-23-37\YLII_29-2_AD_ZIPA45_254.D
Sample Name: YLII_29

Distribution:

Acq. Operator : YL  Seq. Line : 4
Acq. Instrument : HPLC 2  Location : Vial 12
Injection Date : 7/3/2011 11:47:34 PM  Inj : 1
Inj Volume : 5.0 ml

Acq. Method : C:\CHEM32\2\DATA\YLII\YLII_29-2 2011-07-03 23-23-37\ZIPA45_254.M
Analysis Method : C:\CHEM32\2\METHODS\METHOD1.M
(modified after loading)
Method Info : Position # 1 METHOD : (No Column) Valve to Position # 1 (By-Pass / Flush Line).


Area Percent Report

Sorted By : Signal
Multiplier: 1.0000
Dilution: 1.0000
Do not use Multiplier & Dilution Factor with ISTDs

Signal 1: VWD1 A, Wavelength=254 nm, TT

<table>
<thead>
<tr>
<th>Peak RetTime Type</th>
<th>Width</th>
<th>Area</th>
<th>Height</th>
<th>Area %</th>
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</thead>
<tbody>
<tr>
<td># (min)</td>
<td>[min]</td>
<td>mAU</td>
<td>['s]</td>
<td>[mAU ]</td>
</tr>
<tr>
<td>1 18.717 MM</td>
<td>0.6129</td>
<td>1.64769e4</td>
<td>448.08109</td>
<td>97.6407</td>
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<tr>
<td>2 27.053 MM</td>
<td>0.8333</td>
<td>398.13113</td>
<td>7.91549</td>
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Totals: 1.689751e4 455.99618

Analytical Report SFC

Chromatogram Information
User Name
HPLC System Name
Injection Date
Volume
Sample #
Project Name
Executed Sequence
Chromatogram Name
Sample Name
Acquisition Time
Acquisition Sequence
Control Method

Peak Information

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<th>Area [pV·sec]</th>
<th>Height [µV]</th>
<th>Area%</th>
<th>Peak Start</th>
<th>Peak End</th>
<th>Peak Width</th>
<th>Resolution</th>
<th>Symmetry Factor</th>
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</thead>
</table>
Analytical Report SFC

Chromatogram Information
User Name
HPLC System Name
Injection Date
Volume
Sample #
Project Name
Executed Sequence
Chromatogram Name
Sample Name
Acquisition Time
Acquisition Sequence
Control Method

Supporting Information for Behenna, Liu, Yurino, Kim, White, Virgil, and Stoltz

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Analytical Report SFC

Chromatogram Information
User Name: User
HPLC System Name: Jasco SFC w PDA
Injection Date: 5/26/2011 3:26:08 PM
Volume: 5.00 [μL]
Sample #: 31
Project Name: Cal Tech SFC
Executed Sequence: DCBIII_77a
Chromatogram Name: DCBIII_77_C3_5MeOH
Sample Name: 
Acquisition Time: 7.0 [min]
Acquisition Sequence: DCBIII_77a
Control Method: Solv 1 Col 3 Isocratic 5B 5mL/min 10MPa 10min

Chromatogram

Peak Information

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Analytical Report SFC

Chromatogram Information
User Name
HPLC System Name
Injection Date
Volume
Sample #
Project Name
Executed Sequence
Chromatogram Name
Sample Name
Acquisition Time
Acquisition Sequence
Control Method

Peak Information
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<th>Height [µV]</th>
<th>Area%</th>
<th>Peak Start</th>
<th>Peak End</th>
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<td>1.210</td>
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<tr>
<td>2</td>
<td>Unknown</td>
<td>3.733</td>
<td>30722</td>
<td>4115</td>
<td>3.41%</td>
<td>3.613</td>
<td>3.807</td>
<td>0.194</td>
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<td>1.214</td>
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Analytical Report SFC

Chromatogram Information
User Name
HPLC System Name
Injection Date
Volume
Sample #
Project Name
Executed Sequence
Chromatogram Name
Sample Name
Acquiliation Time
Acqisition Sequence
Control Method

Chromatogram

Peak Information
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<th>Height [µA]</th>
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<th>Peak Width</th>
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<td>24176</td>
<td>40.992</td>
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<td>18270</td>
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Supplementary Information for Behenna, Liu, Yurino, Kim, White, Virgil, and Stoltz

Analytical Report SFC

Chromatogram Information
User Name
HPLC System Name
Injection Date
Volume
Sample #
Project Name
Executed Sequence
Chromatogram Name
Sample Name
Acquisition Time
Acquisition Sequence
Control Method

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SUPPLEMENTARY INFORMATION

Data File C:\CHEM32\1\DATA\YLII\YLII_11RAC_OJ_3IPA45_254.D
Sample Name: YLII_11rac

Acq. Operator : YL  Seq. Line : 9
Acq. Instrument : HPLC 1  Location : Vial 4
Injection Date : 5/3/2011 8:52:20 PM  Inj : 1
Inj Volume : 5.0 µl

Acq. Method : C:\CHEM32\1\METHODS\5IPA45_254.M
Last changed : 4/26/2010 10:44:29 PM
Analysis Method : C:\CHEM32\2\METHODS\5IPA_EQUL.M
Last changed : 7/29/2011 11:30:53 AM by BM
(modified after loading)
Method Info : 5% IPA  10 min equil  1 mL/min

Area Percent Report

Sorted By : Signal
Multiplier: : 1.0000
Dilution: : 1.0000
Do not use Multiplier & Dilution Factor with ISTDs

Signal 1: VWD1 A, Wavelength=254 nm, TT

Peak RetTime Type Width Area Height Area
# [min] [min] mAU *s [mAU ] %
---|---|---|---|---|---|---|---|---|
1 23.851 BB 0.6710 1.12818e4 254.06015 49.4580
2 29.088 VB 0.8701 1.15291e4 196.94516 50.5420
Totals : 2.28109e4 451.00531

HPLC 1 7/29/2011 11:30:57 AM BM
Data File C:\CHEM32\1\DATA\YLII\YLII_31_OJ_SIIPA45_254.D
Sample Name: YLII_31

Acq. Operator : YL
Acq. Instrument : HPLC 1
Injection Date : 5/9/2011 2:57:13 PM
Injection Volume : 5.0 µl

Acq. Method : C:\CHEM32\1\METHODS\SIIPA45_254.M
Last changed : 4/26/2010 10:44:29 PM
Analysis Method : C:\CHEM32\2\METHODS\SIIPA_EQUI.L
Last changed : 7/29/2011 11:29:37 AM by BM
(modified after loading)
Method Info : 5% IPA 10 min equil 1 mL/min

Area Percent Report

Signal 1: VWD1 A, Wavelength=254 nm, TT

Peak RetTime Type Width Area Height Area %
# [min] [min] mAU *s [mAU ]
---|------|-----|--------|-----|---|--------|
1 24.822 BB 0.6578 1514.60022 34.20794 3.6393
2 29.162 BB 1.0397 4.01027e4 535.49139 96.3607
Totals :
4.16173e4 569.69933

HPLC 1 7/29/2011 11:29:48 AM BM
Analytical Report SFC

Chromatogram Information
User Name: User
HPLC System Name: Jasco SFC w PDA
Injection Date: 5/26/2011 3:57:24 PM
Volume: 5.00 [µL]
Sample #: 32
Project Name: Cal Tech SFC
Executed Sequence: DCBIII_77a
Chromatogram Name: DCBIII_79_C1_10MeOH
Sample Name: 7.0 [min]
Acquisition Time: 10
Acquisition Sequence: DCBIII_77a
Control Method: Solv 1 Col 1 Isocratic 10B 5mL_min 10MPa 10min

Chromatogram

Peak Information
<table>
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<th>tR [min]</th>
<th>Area [µV·sec]</th>
<th>Height [µV]</th>
<th>Area%</th>
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Supplementary Information for Behenna, Liu, Yurino, Kim, White, Virgil, and Stoltz

Analytical Report SFC

Chromatogram Information
User Name: User
HPLC System Name: Jascoo SFC w PDA
Injection Date: 5/27/2011 10:04:14 PM
Volume: 5.00 [µL]
Sample #: 3
Project Name: Cal Tech SFC
Executed Sequence: DCBIII_83
Chromatogram Name: DCBIII_85_C1_10MeOH
Sample Name: Acquision Time: 7.0 [min]
Acquisition Sequence: DCBIII_83
Control Method: Solv 1 Col 1 Isocratic 10B 5mL_min 10MPa 10min

Chromatogram

<table>
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<th>tR (min)</th>
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<th>Height [µA]</th>
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<th>Peak End</th>
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Analytical Report SFC

Chromatogram Information
User Name: User
HPLC System Name: Jasco SFC w PDA
Injection Date: 4/15/2011 1:15:35 PM
Volume: 5.00 [µL]
Sample #: 2
Project Name: Cal Tech SFC
Executed Sequence: DCBII_289
Chromatogram Name: DCBII_289_C3_5MeOH
Sample Name: Acquisition Time: 7.0 [min]
Acquisition Sequence: DCBII_289
Control Method: Solv 1 Col 3 Isocratic 5B 5mL_min 10MPa 10min

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Supplementary Information for Behenna, Liu, Yurino, Kim, White, Virgil, and Stoltz

Analytical Report SFC

Chromatogram Information
User Name: User
HPLC System Name: Jasoo SFC w PDA
Injection Date: 4/17/2011 3:51:23 PM
Volume: 5.00 [μL]
Sample #: 5
Project Name: Cal Tech SFC
Executed Sequence: DCBII291
Chromatogram Name: DCBII293_C3_5MeOHA
Sample Name: N/A
Acquisition Time: 7.0 [min]
Acquisition Sequence: DCBII291
Control Method: Solv 1 Col 3 Isocratic 5B 5mL_min 10MPa 10min

Chromatogram

Peak Information

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Analytical Report SFC

Chromatogram Information
User Name       User
HPLC System Name Jasco SFC w PDA
Injection Date  8/21/2011 11:44:55 AM
Volume          5.00 [μL]
Sample #        4
Project Name    Cal Tech SFC
Executed Sequence JK-III-295-racemic
Chromatogram Name JK-III-295-r-4
Sample Name     
Acquisition Time 12.0 [min]
Acquisition Sequence JK-III-295-racemic
Control Method  Solv 1 Col 3 Isocratic 3B 5mL min 10MPa 15 min

Peak Information

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<th>Area [μV·sec]</th>
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<th>Peak Start</th>
<th>Peak End</th>
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<th>Symmetry Factor</th>
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Analytical Report SFC

Chromatogram Information
User Name: User
HPLC System Name: Jasco SFC w PDA
Injection Date: 8/21/2011 12:19:23 PM
Volume: 2.00 [μL]
Sample #: 5
Project Name: Cal Tech SFO
Executed Sequence: JK-III-289-c
Chromatogram Name: JK-III-289-c-2
Sample Name: 12.0 [min]
Acquisition Sequence: JK-III-289-c
Control Method: Solv 1 Col 3 Isocratic 3B 5mL_min 10MPa 15 min

Chromatogram

Peak Information

<table>
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<th>Area [μV·sec]</th>
<th>Height [μV]</th>
<th>Area%</th>
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<th>Peak End</th>
<th>Peak Width</th>
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Analytical Report SFC

Chromatogram Information
User Name: User
HPLC System Name: Jasco SFC w PDA
Injection Date: 8/24/2011 8:17:20 PM
Volume: 5.00 [μL]
Sample #: 4
Project Name: Cal Tech SFC
Executed Sequence: JK-IV-33-racemic
Chromatogram Name: JK-IV-33-racemic
Sample Name: JK-IV-33-racemic
Acquisition Time: 12.0 [min]
Acquisition Sequence: JK-IV-33-racemic
Control Method: Solv 1 Col 3 Isocratic 3B 5mL_min 10MPa 15 min

Chromatogram

Peak Information

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<th>Peak Name</th>
<th>tR [min]</th>
<th>Area [μV·sec]</th>
<th>Height [μV]</th>
<th>Area%</th>
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<th>Peak End</th>
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</table>
Analytical Report SFC

Chromatogram Information

User Name
HPLC System Name
Injection Date
Volume
Sample #
Project Name
Executed Sequence
Chromatogram Name
Sample Name
Acquisition Time
Acquisition Sequence
Control Method

User
Jasco SFC w PDA
8/24/2011 8:39:15 PM
5.00 [µL]
5
Cal Tech SFC
JK-IV-33-chiral
JK-IV-33-chiral-2

12.0 [min]
JK-IV-33-chiral
Solv 1 Col 3 Isocratic 3B 5mL min 10MPa 15 min

Chromatogram

Jay

Intensity [µAU]

20000
15000
10000
5000
0

Retention Time [min]

0.000
2.000
4.000
6.000
8.000

Peak Information

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Data File: C:\CHEM32\DATA\DCBIII\DCB_39 2011-05-19 21-05-28\DCBIII_39_AD_3MEOH.D
Sample Name: DCBIII_39

Acq. Operator : DCB  Seq. Line : 2
Injection Date : 5/19/2011 9:09:14 PM  Inj : 1
Injection Volume : 5 µl
Analysis Method : C:\CHEM32\DATA\DCBIII\DCB_39 2011-05-19 21-05-28\SIC2 12MIN 3.M
Last changed : 5/19/2011 9:00:10 PM by DCB
Analysis Method : C:\CHEM32\DATA\DCBIII\DCB_39 2011-05-19 21-05-28\DCBIII_39_AD_3MEOH.D\DA.M (modified after loading)
Method Info : SIC2 12min 3.M: 3% MeOH, AD-H 3 mL/min, 12 min

Area Percent Report

Signal 1: DADI B, Sig=235.8 Ref=360.100
Peak RetTime Type  Width  Area  Height  Area %
  # [min] [min] [mAU^2] [mAU]  
  1 3.932 VV 0.1458 4057.47485 447.28933 49.9567
  2 4.555 VV 0.1724 4063.05298 381.06855 50.0343

Totals : 8120.52783 828.35718

*** End of Report ***
### Supporting Information for Behenna, Liu, Yurino, Kim, White, Virgil, and Stoltz

**Data File:** C:\CHEN32\DATA\DCBIII\DCB_47 2011-05-20 00-21-40\DCBIII_47_AD_3MeOH.D

**Sample Name:** DCBIII_47

---

**Acq. Operator:** DGB  **Seq. Line:** 1  
**Acq. Instrument:** Instrument 1  **Location:** F4-A-02  
**Injection Date:** 5/20/2011 12:22:07 AM  **Inj:** 1  
**Injection Volume:** 5 µl  
**Acq. Method:** C:\CHEN32\DATA\DCBIII\DCB_47 2011-05-20 00-21-40\SIC2 12MIN 3.M  
**Last changed:** 5/19/2011 9:00:10 PM by DGB  
**Analysis Method:** C:\CHEN32\DATA\DCBIII\DCB_39 2011-05-19 21-05-28\DCBIII_39_AD_3MeOH.D\DA.M (SIC2 12MIN 3.M)  
**Last changed:** 7/29/2011 1:11:23 PM by MEK  
**Method Info:** SIC2 12min 3.M; 3% MeOH, AD-H 3 mL/min, 12 min

---

**Area Percent Report**

**Sorted By:**  Signal  
**Multiplier:** 1.0000  
**Dilution:** 1.0000  
**Use Multiplier & Dilution Factor with ISTDs**

**Signal:** DADI B, Sig=235.8 Ref=360.100

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**Totals:** 1.00465e4 975.66313

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*** End of Report ***

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**Instrument 1 7/29/2011 1:11:32 PM MEK**
Analytical Report SFC

Chromatogram Information
User Name
HPLC System Name
Injection Date
Volume
Sample #
Project Name
Executed Sequence
Chromatogram Name
Sample Name
Acquisition Time
Acquisition Sequence
Control Method

Peak Information

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<th>Area [µV·sec]</th>
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Analytical Report SFC

Chromatogram Information
User Name: User
HPLC System Name: Jasco SFC w PDA
Injection Date: 5/5/2011 12:41:22 AM
Volume: 5.00 [µL]
Sample #: 8
Project Name: Cal Tech SFC
Executed Sequence: DCBIII_35
Chromatogram Name: DCBIII_35_C5_10MeOH
Sample Name: 
Acquisition Time: 7.0 [min]
Acquisition Sequence: DCBIII_35
Control Method: Solv 1 Col 5 Isocratic 10B 5mL_min 10MPa 10min

Peaks Information

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DCBIII_35_C5_10MeOH+CH9
Analytical Report SFC

Chromatogram Information
User Name: User
HPLC System Name: Jasco SFC w PDA
Injection Date: 5/18/2011 12:33:33 AM
Volume: 1.00 [μL]
Sample #: 10
Project Name: Cal Tech SFC
Executed Sequence: DCBlI_57
Chromatogram Name: DCBlI_57_C1_15MeOH
Sample Name: 
Acquisition Time: 7.0 [min]
Acquisition Sequence: DCBlI_57
Control Method: Solv 1 Col 1 Isocratic 15B 5mL_min 10MPa 10min

Peak Information
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<th>Area [μV-sec]</th>
<th>Height [μV]</th>
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<th>Peak Start</th>
<th>Peak End</th>
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Analytical Report SFC

Chromatogram Information
User Name
HPLC System Name
Injection Date
Volume
Sample #
Project Name
Executed Sequence
Chromatogram Name
Sample Name
Acquisition Time
Acquisition Sequence
Control Method

User
Jasco SFC w PDA
5/18/2011 11:47:09 PM
4.00 [µL]
2
Col Tech SFC
DCBIIL_53
DCBIIL_53_C1_15MeOH

7.0 [min]
DCBIIL_53
Solv 1 Col 1 Isocratic 15B 5mL_min 10MPa 10min

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### Analytical Report SFC

**Chromatogram Information**
- **User Name**: User
- **HPLC System Name**: Jasco SFC w PDA
- **Injection Date**: 4/8/2011 4:21:27 PM
- **Volume**: 5.00 [$\mu$L]
- **Sample #**: 2
- **Project Name**: Cal Tech SFC
- **Executed Sequence**: DCBII_271
- **Chromatogram Name**: DCBII_271_C3_10MeOH
- **Sample Name**: DCBII_271
- **Acquisition Time**: 7.0 [min]
- **Acquisition Sequence**: DCBII_271
- **Control Method**: Solv 1 Col 3 Isocratic 10B 5mL_min 10MPa 10min

![Chromatogram Image]

**Peak Information**

<table>
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<th>#</th>
<th>Peak Name</th>
<th>tR [min]</th>
<th>Area [µV-sec]</th>
<th>Height [µA]</th>
<th>Area%</th>
<th>Peak Start</th>
<th>Peak End</th>
<th>Peak Width</th>
<th>Resolution</th>
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Analytical Report SFC

Chromatogram Information
User Name: User
HPLC System Name: Jasoo SFC w PDA
Injection Date: 4/8/2011 4:30:22 PM
Volume: 5.00 [μL]
Sample #: 3
Project Name: Cal Tech SFC
Executed Sequence: FV-III-289-105MeOH-5mL-ColumnScreen
Chromatogram Name: DCBII_277_Conc_C3_10MeOH
Sample Name: DCBII_277_Conc_C3_10MeOH
Acquisition Time: 7.0 [min]
Acquisition Sequence: FV-III-289-105MeOH-5mL-ColumnScreen
Control Method: Solv 1 Col 3 Isocratic 10B 5mL_min 10MPa 10min

Peak Information
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<th>Height [μA]</th>
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Analytical Report SFC

Chromatogram Information

User Name
HPLC System Name
Injection Date
Volume
Sample #
Project Name
Executed Sequence
Chromatogram Name
Sample Name
Acquisition Time
Acquisition Sequence
Control Method

User
Jascoo SFC w PDA
5/1/2011 12:32:46 PM
5.00 [µL]
2
Cal Tech SFC
DCBIII_17
DCBIII_19_C5_10MeOH

7.0 [min]
DCBIII_17
Solv 1 Col 5 Isocratic 10B 5mL_min 10MPa 10min

Peak Information

Peak Name | tR [min] | Area [µV·sec] | Height [µV] | Area% | Peak Start | Peak End | Peak Width | Retention Time [min] | Resolution | Symmetry Factor
---|---|---|---|---|---|---|---|---|---|---
Unknown 9 | 3.807 | 2599977 | 382239 | 50.066 | 3.860 | 4.147 | 0.112 | 2.197 | 1.068
Unknown 9 | 4.440 | 2592906 | 232330 | 49.932 | 4.160 | 4.747 | 0.175 | N/A | 1.073

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Analytical Report SFC

Chromatogram Information
User Name
HPLC System Name
Injection Date
Volume
Sample #
Project Name
Executed Sequence
Chromatogram Name
Sample Name
Acquisition Time
Acquisition Sequence
Control Method

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Analytical Report SFC

Chromatogram Information
User Name: User
HPLC System Name: Jasco SFC w PDA
Injection Date: 5/26/2011 8:49:48 PM
Volume: 5.00 [µL]
Sample #: 33
Project Name: Cal Tech SFC
Executed Sequence: DCBIII_81
Chromatogram Name: DCBIII_81_C1_20MeOH
Sample Name: 7.0 [min]
Acquisition Time: DCBIII_81
Acquisition Sequence: Solv 1 Col 1 Isocratic 20B 5mL_min 10MPa 10min

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Analytical Report SFC

Chromatogram Information
User Name: User
HPLC System Name: Jasoo SFC w PDA
Injection Date: 5/27/2011 9:53:48 PM
Volume: 5.00 [µL]
Sample #: 4
Project Name: Cal Tech SFC
Executed Sequence: DCBIII_83
Chromatogram Name: DCBIII_87_C1_20MeOH
Sample Name: DCBIII_83
Acquisition Time: 7.0 [min]
Acquisition Sequence: 23
Control Method: Solv 1 Col 1 Isocratic 20B 5mL_min 10MPa 10min

Chromatogram

Intensity [µAU]

Retention Time [min]

300000
250000
200000
150000
100000
50000
0

Peak Information

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References


(9) The fluorination was performed in a manner analogous to β-ketoesters, see: Mohr, J. T.; Behenna, D. C.; Harned, A. M.; Stoltz, B. M. Angew. Chem. Int. Ed. 2005, 44, 6924.


(13) The palladium source was chosen solely to simplify the chromatographic separation of the dba from the lactam product.

(14) Benzyol lactam 3 and benzyol lactam 4 were determined to be of the (S) configuration using anomalous scattering methods during single crystal X-ray studies of derivative compounds obtained by exchanging the benzyol group with a 4-bromobenzyol group and performing an olefin cross metathesis with 3-nitrostyrene. The absolute configurations of all other compounds were assigned by analogy. Crystallographic data for the derivative compounds of benzyol lactam 3 and benzyol lactam 4 have been deposited at the CCDC, 12 Union Road, Cambridge CB2 1EZ, UK and copies can be obtained on request, free of charge, by quoting the publication citation and deposition numbers 845601 and 845602, respectively.
(15) Adapted from a related sequence, see: Amat, M.; Lozano, O.; Escolano, C.; Molins, E.; Bosch, J. J. Org. Chem. 2007, 72, 4431.