Supporting Information for:
Catalytic, Enantioselective Bifunctional Inverse Electron Demand Hetero-Diels-Alder Reactions of Ketene Enolates and *o*-Benzoquinone Diimides

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General. Unless otherwise stated, all reactions were carried out under anhydrous, air-free conditions. All solvents were dried and distilled by standard procedures. The ^1H and ^{13}C NMR spectra were acquired on a Bruker Avance 400 MHz spectrometer. The ^1H (400 MHz) and ^{13}C (101 MHz) chemical shifts are given in parts per million (δ) with respect to internal TMS standards and residual chloroform or DMSO. FT-IR spectra were recorded on a Bruker IFS-55 spectrometer and optical rotations were recorded on a Perkin Elmer 120 polarimeter at room temperature. Enantiomeric ratios were obtained by HPLC using the Chiracel OD or Whelk-01. Benzoylquinidine **3a** was formed from quinidine (Sigma) and benzoyl chloride according to the method of Pracejus.¹ All other chemicals were purchased from Aldrich Chemical Corporation, Alfa Aesar, and Acros Organics.

Table A. A series of metal triflates (10 mol%) screened to form quinoxalinone **4a.**

entry	metal	% ee	% yield
1	Al(OTf) ₃	>99	64
2	In(OTf) ₃	>99	65
3	Sc(OTf) ₃	>99	78
4	Zn(OTf) ₂	>99	82

Rate Study:

A standard reaction with BQd (10 mol%) was compared to a standard reaction run in the presence of four different metals (Al(OTf)₃, In(OTf)₃, Sc(OTf)₃ and Zn(OTf)₂). Conversions were plotted against time and extrapolated to time zero in order to estimate k_{rel} . For example, a standard control was compared to a reaction run in the presence of 10 mol% Zn(II) cocatalyst. After 3 min, both reactions were quenched, and it was found that the metal cocatalyzed reaction produced >20 times the product of the control, etc.

Benzoylquinidine (**3a**) (0.055 mmol) and metal cocatalyst (0.055 mmol) were placed into a 25 mL round bottom flask equipped with a magnetic stir bar and 3 mL of THF. The reaction was cooled to $-78\text{ }^\circ\text{C}$

and the acid chloride (1.1 mmol) as a solution in 2 mL of THF was added followed by Hünig's base (1.1 mmol). 4,5-Dichloro-*o*-quinonedibenzimide **1a** (0.55 mmol), as a solution in 3 mL of THF, was then added to the reaction. The reaction was quenched with 1.0 M methanolic HCl once **4a** was formed and the time recorded. The reaction was warmed to room temperature, and diluted with CH₂Cl₂. The organic layer was collected, washed with saturated NaHCO₃ (10 mL), and dried over MgSO₄. The reaction mixture was then adsorbed onto silica gel and purified by flash chromatography using Et₂O/hexanes.

General procedure for the acylation of diamines,² to make dianilides 9c – 9d:

4-(Trifluoromethyl)-1,2-phenylenediamine (10 mmol) was placed into a 100 mL round bottom flask equipped with a magnetic stir bar and was dissolved in 40 mL of CH₂Cl₂. The flask was cooled to 0 °C and triethylamine (22 mmol) was added followed by benzoyl chloride (22 mmol). The reaction was allowed to warm to room temperature and monitored by TLC. Once complete, the white solid product (**9c**) was collected by filtration, washed with a small amount of CH₂Cl₂ and no further purification was needed. The synthesis of 4,5-dichloro-*o*-phenylenedibenzamide³ (**9a**) and *o*-phenylenedibenzamide² (**9b**) have been reported.

4-(Trifluoromethyl)-*o*-phenylenedibenzamide (9c). Purple crystalline solid: % yield = 87; mp = 237-239 °C; ¹H NMR (DMSO) δ 10.28 (s, 2H), 8.11 (m, 1H), 8.05 (m, 4H), 7.81 (m, 2H), 7.73 (m, 3H), 7.55 (m, 3H) ppm; ¹³C NMR (DMSO) δ 173.1, 167.8, 166.8, 136.4, 135.3, 134.1, 132.8, 132.4, 131.3, 129.8, 128.6, 129.4, 129.3, 128.5, 128.4, 127.9, 127.8, 127.1, 126.2, 125.9, 118.4 ppm; IR (MeCN) 3412, 3410, 1691, 1688 cm⁻¹. Anal Calcd for C₂₁H₁₅F₃N₂O₂ C, 65.62; H, 3.93; N, 7.29. Found C, 65.68; H, 3.98; N, 7.22.

1,2-Phenylenedibenzamide-4-phenylmethanone (9d). White crystalline solid: % yield = 79; mp = 188-191 °C; ^1H NMR (DMSO) δ 10.31 (s, 2H), 8.15 (m, 1H), 8.09 (m, 5H), 7.89 (m, 2H), 7.78 (m, 2H), 7.61 (m, 8H) ppm; ^{13}C NMR (DMSO) δ 195.3, 166.7, 166.4, 137.9, 136.4, 134.8, 134.7, 134.1, 133.4, 132.8, 132.7, 132.1, 131.3, 130.3, 129.8, 128.6, 129.4, 129.3, 128.5, 128.4, 127.9, 127.8, 127.1, 126.9, 126.5, 126.2, 125.9 ppm; IR (MeCN) 3397, 3388, 1690, 1686, 1677 cm^{-1} . Anal Calcd for $\text{C}_{27}\text{H}_{20}\text{N}_2\text{O}_3$ C, 77.13; H, 4.79; N, 6.66. Found C, 77.21; H, 4.84; N, 6.72.

4-Chloro-*o*-phenylenediisopropylcarbamate (9e). 4-chloro-1,2-phenylenediamine (7 mmol) was placed into a 100 mL round bottom flask equipped with a magnetic stir bar and was dissolved in 20 mL of toluene. Isopropyl chloroformate (1.0 M in toluene, 21 mmol) was added and the reaction was refluxed for 3 hours and monitored by TLC. Once complete, the reaction was adsorbed directly onto silica and purified by flash chromatography using ethyl acetate/hexanes. White crystalline solid **9e** was obtained by recrystallization from ethyl acetate/hexanes: % yield = 88; mp = 125-128 °C; ^1H NMR (CDCl_3) δ 7.61 (m, 1H), 7.35 (m, 1H), 7.07 (m, 1H), 6.85 (m, 1H), 6.64 (m, 1H), 5.00 (m, 2H), 1.29 (m, 12H) ppm; ^{13}C NMR (CDCl_3) δ 154.3, 153.9, 131.4, 130.8, 127.8, 125.6, 125.0, 123.4, 69.5, 21.9 ppm; IR (CHCl_3) 3388, 3371, 1722, 1718 cm^{-1} . Anal Calcd for $\text{C}_{14}\text{H}_{19}\text{ClN}_2\text{O}_4$ C, 53.42; H, 6.08; N, 8.90. Found C, 53.49; H, 6.14; N, 8.85.

General procedure for the oxidation of diamides,⁴ to make diimides 1c – 1d, 5:

4-(Trifluoromethyl)-*o*-phenylenedibenzamide (**9c**) (5 mmol) was placed into a 250 mL round bottom flask equipped with a magnetic stir bar and was suspended in 150 mL of chloroform. The suspension was heated to 40 °C and solid lead (IV) acetate (6 mmol) was added. The reaction was stirred for 10 min and monitored by TLC. Once complete, the reaction was immediately filtered through Celite. The filtrate was washed with 5% NaHCO₃ (2 x 100 mL) and water (100 mL). The organic layer was dried over MgSO₄, filtered, and concentrated *in vacuo*. Reaction product **1c** was purified by crystallization from CH₂Cl₂/hexanes. The synthesis of 4,5-dichloro-*o*-quinonedibenzimide (**1a**)⁵ and *o*-quinonedibenzimide (**1b**) have been reported by Adams.⁴

4-(Trifluoromethyl)-*o*-quinonedibenzimide (1c). Yellow crystalline solid: % yield = 85; mp = 77-80 °C; ¹H NMR (CDCl₃) δ 7.74 (m, 3H), 7.68 (m, 3H), 7.56 (m, 3H), 7.44-7.37 (m, 4H) ppm; ¹³C NMR (CDCl₃) δ 179.0, 178.9, 133.8, 133.7, 131.5, 131.3, 129.3, 129.1, 128.9, 128.8, 128.3, 127.5, 127.1, 126.3, 125.4, 125.1, 123.9, 123.5, 122.2, 121.5, 118.9 ppm; IR (CHCl₃) 1681, 1677, 1647, 1622 cm⁻¹. Anal Calcd for C₂₁H₁₃F₃N₂O₂ C, 65.97; H, 3.43; N, 7.33. Found C, 66.04; H, 3.49; N, 7.41.

4-Benzoyl-*o*-quinonedibenzimide (1d). Yellow crystalline solid was obtained by washing crystallized product with ethyl acetate: % yield = 70; mp = 62-64 °C; ¹H NMR (CDCl₃) δ 7.85 (m, 2H), 7.75 (d, 2H), 7.71 (d, 2H), 7.67 (m, 1H), 7.60-7.51 (m, 4H), 7.45-7.38 (m, 4H), 7.25 (m, 1H), 7.01 (m, 1H), 6.69 (m, 1H) ppm; ¹³C NMR (CDCl₃) δ 193.3, 179.4, 179.2, 141.3, 135.1, 133.9, 133.8, 133.7, 133.5, 131.8, 131.5, 129.7, 129.2, 128.9, 128.8, 128.7, 127.8, 127.6, 127.2, 126.9, 125.8, 124.8, 124.6, 124.1, 123.6,

123.1, 122.2 ppm; IR (CHCl₃) 1678, 1677, 1671, 1641, 1618 cm⁻¹. Anal Calcd for C₂₇H₁₈N₂O₃ C, 77.50; H, 4.34; N, 6.69. Found C, 77.59; H, 4.31; N, 6.66.

4-Chloro-*o*-quinonediiisopropylcarbamate (5). Crude red-yellow oil: % yield = 97; ¹H NMR (CDCl₃) δ 6.75-6.60 (m, 2H), 6.44 (m, 1H), 5.06 (m, 2H), 1.28 (m, 12H) ppm; ¹³C NMR (CDCl₃) δ 161.1, 159.7, 152.9, 149.8, 143.7, 135.7, 133.2, 120.4, 31.6, 29.1, 22.6, 15.2, 14.1, 11.4 ppm. IR (CHCl₃) 1701, 1694, 1649, 1624 cm⁻¹ Anal Calcd for C₁₄H₁₇ClN₂O₄ C, 53.77; H, 5.48; N, 8.96. Found C, 53.72; H, 5.53; N, 8.90.

General procedure for the synthesis of quinoxalinones 4a – 4x, 6:

Benzoylquinidine (**3a**) (0.055 mmol) and zinc (II) triflate (0.055 mmol) were placed into a 25 mL round bottom flask equipped with a magnetic stir bar and 3 mL of THF. The reaction was cooled to –78 °C and the acid chloride (1.1 mmol) as a solution in 2 mL of THF was added followed by Hünig's base (1.1 mmol). The diimide (0.55 mmol), as a solution in 3 mL of THF, was then added to the reaction via syringe pump (**4a** – **4f**, 7h; **4g** – **4j**, 10h; **4k** – **4o**, 8h; **4p** – **4x**, 6h, **6**, 12h). The reaction was kept at –78 °C during the entire addition. The reaction was quenched at –78 °C with 3 mL of 1 M HCl, warmed to room temperature, and diluted with CH₂Cl₂. The organic layer was collected, washed with saturated NaHCO₃ (10 mL), and dried over MgSO₄. The reaction mixture was then adsorbed onto silica gel and purified by flash chromatography using Et₂O/hexanes.

(R)-1,4-dibenzoyl-6,7-dichloro-3-ethyl-3,4-dihydroquinoxalin-2(1H)-one (4a). White crystalline solid: % yield = 82; % ee = > 99; mp = 147-149 °C; $[\alpha]_D^{25} = -123.3$ (c = 0.012, CHCl₃); ¹H NMR (CDCl₃) δ 7.88 (m, 2H), 7.69 (m, 1H), 7.52 (m, 7H), 7.28 (s, 1H), 6.99 (m, 1H), 5.29 (m, 1H), 1.86 (m, 1H), 1.66 (m, 1H), 1.11 (m, 3H) ppm; ¹³C NMR (CDCl₃) δ 168.4, 166.5, 166.3, 135.4, 134.2, 132.4, 131.8, 131.6, 131.4, 130.8, 130.2, 129.8, 127.3, 126.8, 126.1, 125.8, 125.1, 124.7, 124.2, 123.5, 122.8, 58.6, 23.2, 10.8 ppm; IR (CHCl₃) 1721, 1708, 1691 cm⁻¹. HPLC (OD, 20% *i*-PrOH/hexanes, 1.0 mL/min) (R) = 6.30, (S) = 6.85. Anal Calcd for C₂₄H₁₈Cl₂N₂O₃ C, 63.59; H, 4.00; N, 6.18. Found C, 63.51; H, 4.06 N, 6.21.

(R)-1,4-dibenzoyl-6,7-dichloro-3-isopropyl-3,4-dihydroquinoxalin-2(1H)-one (4b). White crystalline solid: % yield = 79; % ee = > 99; mp = 156-158 °C; $[\alpha]_D^{25} = -77.3$ (c = 0.011, CHCl₃); ¹H NMR (CDCl₃) δ 7.83 (m, 2H), 7.71 (m, 1H), 7.49 (m, 7H), 7.29 (s, 1H), 7.02 (m, 1H), 5.31 (m, 1H), 1.85 (m, 1H), 1.15 (d, 3H), 1.02 (d, 3H) ppm; ¹³C NMR (CDCl₃) δ 167.5, 166.1, 165.4, 135.9, 135.5, 133.2, 132.8, 131.9, 131.7, 131.1, 130.5, 129.7, 128.1, 127.8, 126.4, 125.9, 125.0, 124.5, 124.1, 123.9, 123.3, 55.6, 21.4, 10.8, 9.8 ppm; IR (CHCl₃) 1723, 1709, 1682 cm⁻¹. HPLC (OD, 10% *i*-PrOH/hexanes, 1.0 mL/min) (R) = 5.96, (S) = 6.90. Anal Calcd for C₂₅H₂₀Cl₂N₂O₃ C, 64.25; H, 4.31; N, 5.99. Found C, 64.18; H, 4.28; N, 6.01.

(S)-1,4-dibenzoyl-6,7-dichloro-3-(methylthiomethyl)-3,4-dihydroquinoxalin-2(1H)-one (4c). White crystalline solid: % yield = 84; % ee = > 99; mp = 112-114 °C; $[\alpha]_D^{25} = -79.4$ (c = 0.008, CHCl₃); ¹H NMR (CDCl₃) δ 7.95 (m, 2H), 7.72 (m, 1H), 7.55 (m, 5H), 7.42 (m, 2H), 7.28 (s, 1H), 7.01 (s, 1H), 5.58 (m, 1H), 2.88 (m, 1H), 2.71 (m, 1H), 2.21 (m, 3H) ppm; ¹³C NMR (CDCl₃) δ 171.1, 169.2, 168.2, 135.5, 134.3, 133.8, 133.5, 132.6, 132.1, 129.8, 128.7, 127.2, 127.1, 126.5, 125.5, 124.8, 123.5, 123.2, 122.5, 121.5, 120.5, 56.1, 33.5, 15.8 ppm; IR (CHCl₃) 1719, 1711, 1680 cm⁻¹. HPLC (Whelk-01, %10 *i*-

PrOH/hexanes, 1.0 mL/min) (R) = 18.34, (S) = 25.16. Anal Calcd for C₂₄H₁₈Cl₂N₂O₃S C, 59.39; H, 3.74; N, 5.77. Found C, 59.46; H, 3.69; N, 5.72.

(R)-1,4-dibenzoyl-6,7-dichloro-3-(3-chloropropyl)-3,4-dihydroquinoxalin-2(1H)-one (4d). White crystalline solid: % yield = 81; % ee = > 99; mp = 137-139 °C; [α]_D = -101.8 (c = 0.009, CHCl₃); ¹H NMR (CDCl₃) δ 7.91 (m, 2H), 7.68 (m, 1H), 7.53 (m, 5H), 7.38 (m, 2H), 7.22 (s, 1H), 6.95 (s, 1H), 5.39 (m, 1H), 3.54 (m, 1H), 3.47 (m, 1H), 2.61 (m, 1H), 2.45 (m, 1H), 1.98 (m, 1H) 1.88 (m, 1H) ppm; ¹³C NMR (CDCl₃) δ 170.6, 169.1, 168.4, 135.7, 134.2, 133.4, 133.1, 132.8, 132.4, 130.4, 129.7, 127.4, 126.6, 126.3, 125.7, 124.9, 124.5, 123.8, 122.2, 121.6, 120.7, 55.2, 41.7, 27.5, 26.8 ppm; IR (CHCl₃) 1728, 1712, 1678 cm⁻¹. HPLC (Whelk-01, 15% *i*-PrOH/hexanes, 1.0 mL/min) (R) = 17.36, (S) = 23.64. Anal Calcd for C₂₅H₁₉Cl₃N₂O₃ C, 59.84; H, 3.82; N, 5.58. Found C, 59.77; H, 3.89; N, 5.56.

(R)-1,4-dibenzoyl-3-benzyl-6,7-dichloro-3,4-dihydroquinoxalin-2(1H)-one (4e). White crystalline solid: % yield = 85; % ee = > 99; mp = 172-173 °C; [α]_D = -55.9 (c = 0.008, CHCl₃); ¹H NMR (CDCl₃) δ 7.88 (m, 2H), 7.74 (m, 1H), 7.53 (m, 8H), 7.44 (m, 3H), 7.31 (m, 3H), 5.38 (m, 1H), 3.28 (m, 1H), 3.19 (m, 1H) ppm; ¹³C NMR (CDCl₃) δ 175.3, 163.7, 163.4, 137.3, 136.1, 135.8, 134.2, 134.0, 133.8, 133.1, 132.8, 132.5, 131.2, 130.8, 129.3, 128.2, 128.1, 127.8, 127.5, 126.4, 125.9, 125.8, 125.1, 124.9, 124.5, 123.9, 122.9, 57.8, 36.5 ppm; IR (CHCl₃) 1724, 1709, 1694 cm⁻¹. HPLC (OD, 10% *i*-PrOH/hexanes, 1.0 mL/min) (R) = 9.60, (S) = 12.70. Anal Calcd for C₂₉H₂₀Cl₂N₂O₃ C, 67.58; H, 3.91; N, 5.44. Found C, 67.51; H, 3.98; N, 5.49.

(R)-2-((1,4-dibenzoyl-6,7-dichloro-3-oxo-1,2,3,4-tetrahydroquinoxalin-2-yl)methyl)isoindoline-1,3-dione (4f). White crystalline solid: % yield = 93; % ee = > 99; mp = 148-150 °C; $[\alpha]_D^{25} = -99.8$ (c = 0.011, CHCl₃); ¹H NMR (CDCl₃) δ 7.97 (m, 2H), 7.81 (m, 2H), 7.75 (m, 3H), 7.51 (m, 3H), 7.44 (m, 4 H), 7.26 (s, 1H), 6.89 (s, 1H), 5.62 (m, 1H), 4.33 (dd, 1H), 4.07 (dd, 1H) ppm; ¹³C NMR (CDCl₃) δ 171.4, 169.7, 168.9, 168.4, 166.2, 135.7, 135.2, 134.7, 133.5, 133.1, 132.8, 132.6, 132.1, 131.8, 131.4, 130.8, 130.5, 129.7, 128.3, 127.7, 127.0, 126.2, 125.8, 124.2, 124.0, 123.5, 122.8, 121.2, 120.3, 57.2, 36.4 ppm; IR (CHCl₃) 1721, 1710, 1688, 1672, 1670 cm⁻¹. HPLC (Whek-01, 25% *i*-PrOH/hexanes, 1.0 mL/min) (R) = 16.16, (S) = 22.32. Anal Calcd for C₃₁H₁₉Cl₂N₃O₅ C, 63.71; H, 3.28; N, 7.19. Found C, 63.66; H, 3.33; N, 7.14.

(R)-1,4-dibenzoyl-3-ethyl-3,4-dihydroquinoxalin-2(1H)-one (4g). White crystalline solid: % yield = 76; % ee = > 99; mp = 122-124 °C; $[\alpha]_D^{25} = -171.3$ (c = 0.020, CHCl₃); ¹H NMR (CDCl₃) δ 7.91 (m, 2H), 7.66 (m, 1H), 7.52 (m, 2H), 7.42 (m, 3H), 7.33 (m, 2H), 7.05 (m, 2H), 6.85 (m, 2H) 5.10 (m, 1H), 1.76 (m, 1H), 1.67 (m, 1H), 1.02 (m, 3H) ppm; ¹³C NMR (CDCl₃) δ 165.2, 164.8, 163.5, 134.2, 133.5, 133.1, 132.5, 131.9, 131.7, 131.1, 130.3, 129.4, 128.4, 127.8, 126.5, 125.9, 125.3, 124.5, 124.1, 123.8, 122.9, 58.3, 22.2, 16.8 ppm; IR (CHCl₃) 1721, 1709, 1681 cm⁻¹. HPLC (OD, 5% *i*-PrOH/hexanes, 1.0 mL/min) (R) = 14.28, (S) = 13.48. Anal Calcd for C₂₄H₂₀N₂O₃ C, 74.98; H, 5.24; N, 7.29. Found C, 74.92; H, 5.21; N, 7.33.

(R)-1,4-dibenzoyl-3-isopropyl-3,4-dihydroquinoxalin-2(1H)-one (4h). White crystalline solid: % yield = 71; % ee = > 99; mp = 133-135 °C; $[\alpha]_D^{25} = -116.5$ ($c = 0.010$, CHCl_3); ^1H NMR (CDCl_3) δ 7.93 (m, 2H), 7.70 (m, 1H), 7.51 (m, 2H), 7.44 (m, 3H), 7.35 (m, 2H), 7.09 (m, 2H), 6.91 (m, 1H), 6.72 (m, 1H) 5.06 (m, 1H), 1.85 (m, 1H), 1.15 (d, 3H), 1.04 (d, 3H) ppm; ^{13}C NMR (CDCl_3) δ 167.2, 165.3, 164.7, 133.9, 133.6, 133.0, 132.8, 132.2, 131.6, 131.3, 130.8, 129.8, 128.7, 127.9, 127.5, 126.3, 125.8, 124.5, 124.1, 123.6, 122.4, 59.2, 22.8, 16.2, 15.8 ppm; IR (CHCl_3) 1718, 1704, 1673 cm^{-1} . HPLC (OD, 10% *i*-PrOH/hexanes, 1.0 mL/min) (R) = 8.20, (S) = 7.76. Anal Calcd for $\text{C}_{25}\text{H}_{22}\text{N}_2\text{O}_3$ C, 75.36; H, 5.57; N, 7.03. Found C, 75.31; H, 5.61; N, 7.09.

(R)-1,4-dibenzoyl-3-isobutyl-3,4-dihydroquinoxalin-2(1H)-one (4i). White crystalline solid: % yield = 73; % ee = > 99; mp = 138-141 °C; $[\alpha]_D^{25} = -123.4$ ($c = 0.011$, CHCl_3); ^1H NMR (CDCl_3) δ 7.91 (m, 2H), 7.64 (m, 1H), 7.48 (m, 2H), 7.41 (m, 3H), 7.38 (m, 2H), 7.11 (m, 2H), 6.88 (m, 2H) 5.14 (m, 1H), 1.75 (m, 1H), 1.69 (m, 1H), 1.09 (m, 1H) 1.01 (d, 3H), 0.92 (d, 3H) ppm; ^{13}C NMR (CDCl_3) δ 165.0, 163.8, 163.2, 135.9, 134.7, 134.1, 133.7, 132.9, 132.7, 131.4, 130.9, 130.5, 129.4, 128.9, 127.9, 126.4, 125.7, 125.1, 124.5, 123.9, 122.4, 58.4, 21.2, 13.8, 10.7, 9.8 ppm; IR (CHCl_3) 1720, 1704, 1673 cm^{-1} . HPLC (OD, 10% *i*-PrOH/hexanes, 1.0 mL/min) (R) = 7.69, (S) = 6.96. Anal Calcd for $\text{C}_{26}\text{H}_{24}\text{N}_2\text{O}_3$ C, 75.71; H, 5.86; N, 6.79. Found C, 75.70; H, 5.79; N, 6.81.

(R)-1,4-dibenzoyl-3-benzyl-3,4-dihydroquinoxalin-2(1H)-one (4j). White crystalline solid: % yield = 83; % ee = > 99; mp = 121-122 °C; $[\alpha]_D^{25} = -152.7$ ($c = 0.012$, CHCl_3); ^1H NMR (CDCl_3) δ 7.90 (m, 2H), 7.64 (m, 1H), 7.55 (m, 3H), 7.52 (m, 2H), 7.44 (m, 2H), 7.40 (m, 3H), 7.32 (m, 2H), 7.01 (m, 2H), 6.82 (m, 2H), 5.28 (m, 1H), 3.21 (m, 1H), 3.11 (m, 1H) ppm; ^{13}C NMR (CDCl_3) δ 168.3, 164.3, 162.4, 135.8, 135.1, 134.5, 134.1, 133.4, 132.8, 132.1, 131.6, 131.5, 131.1, 130.7, 130.3, 128.7, 128.4, 127.9, 127.2, 126.8, 125.5, 125.3, 125.0, 124.7, 124.2, 123.9, 123.4, 59.2, 35.4 ppm; IR (CHCl_3) 1723, 1702, 1674 cm^{-1} . HPLC (OD, 5% *i*-PrOH/hexanes, 1.0 mL/min) (R) = 22.39, (S) = 18.30. Anal Calcd for $\text{C}_{29}\text{H}_{22}\text{N}_2\text{O}_3$ C, 78.01; H, 4.97; N, 6.27. Found C, 78.08; H, 5.02; N, 6.32.

(R)-1,4-dibenzoyl-3-ethyl-6-(trifluoromethyl)-3,4-dihydroquinoxalin-2(1H)-one (4k). White crystalline solid: % yield = 81; % ee = > 99; mp = 147-150 °C; $[\alpha]_D^{25} = -73.2$ ($c = 0.020$, CHCl_3); ^1H NMR (CDCl_3) δ 7.98 (m, 2H), 7.68 (m, 1H), 7.54 (m, 2H), 7.46 (m, 2H), 7.37 (m, 5H), 7.13 (m, 1H), 5.19 (m, 1H), 1.92 (m, 1H), 1.76 (m, 1H), 1.21 (m, 3H) ppm; ^{13}C NMR (CDCl_3) δ 177.4, 172.5, 167.3, 151.4, 135.8, 134.2, 133.4, 133.1, 132.8, 131.2, 130.1, 129.8, 128.7, 128.2, 127.6, 126.8, 126.1, 125.6, 124.4, 123.7, 122.9, 118.5, 60.3, 24.1, 15.1 ppm; IR (CHCl_3) 1727, 1705, 1661 cm^{-1} . HPLC (OD, 10% *i*-PrOH/hexanes, 1.0 mL/min) (R) = 8.15, (S) = 7.87. Anal Calcd for $\text{C}_{25}\text{H}_{19}\text{F}_3\text{N}_2\text{O}_3$ C, 66.37; H, 4.23; N, 6.19. Found C, 66.42; H, 4.27; N, 6.23.

(R)-1,4-dibenzoyl-3-isopropyl-6-(trifluoromethyl)-3,4-dihydroquinoxalin-2(1H)-one (4l). White crystalline solid: % yield = 79; % ee = > 99; mp = 166-168 °C; $[\alpha]_D^{25} = -56.3$ (c = 0.010, CHCl₃); ¹H NMR (CDCl₃) δ 7.94 (m, 2H), 7.63 (m, 1H), 7.52 (m, 2H), 7.46 (m, 2H), 7.38 (m, 5H), 7.15 (m, 1H) 5.13 (m, 1H), 1.86 (m, 1H), 1.15 (d, 3H), 1.08 (d, 3H) ppm; ¹³C NMR (CDCl₃) δ 176.2, 171.8, 168.5, 152.1, 134.9, 134.7, 134.4, 133.7, 133.1, 132.7, 131.1, 130.2, 129.7, 129.4, 128.5, 127.9, 127.4, 126.8, 125.9, 124.4, 123.8, 119.1 60.7, 23.4, 15.1, 14.7 ppm; IR (CHCl₃) 1728, 1706, 1671 cm⁻¹. HPLC (OD, 10% *i*-PrOH/hexanes, 1.0 mL/min) (R) = 7.03, (S) = 6.71. Anal Calcd for C₂₆H₂₁F₃N₂O₃ C, 66.95; H, 4.54; N, 6.01. Found C, 66.91; H, 4.60; N, 6.03.

(R)-1,4-dibenzoyl-3-isobutyl-6-(trifluoromethyl)-3,4-dihydroquinoxalin-2(1H)-one (4m). White crystalline solid: % yield = 83; % ee = > 99; mp = 178-179 °C; $[\alpha]_D^{25} = -47.4$ (c = 0.008, CHCl₃); ¹H NMR (CDCl₃) δ 7.93 (m, 2H), 7.61 (m, 1H), 7.50 (m, 2H), 7.44 (m, 2H), 7.36 (m, 5H), 7.17 (m, 1H) 5.17 (m, 1H), 1.87 (m, 1H), 1.72 (m, 1H), 1.12 (m, 1H), 0.98 (d, 3H), 0.91 (d, 3H) ppm; ¹³C NMR (CDCl₃) δ 175.8, 170.9, 167.2, 151.0, 135.4, 134.8, 134.6, 133.6, 133.0, 132.8, 132.3, 131.7, 130.8, 130.3, 129.7, 128.9, 127.8, 127.3, 126.9, 125.8, 124.5, 118.6 61.2, 21.2, 12.3, 10.7, 9.8 ppm; IR (CHCl₃) 1727, 1710, 1668 cm⁻¹. HPLC (OD, 10% *i*-PrOH/hexanes, 1.0 mL/min) (R) = 6.15, (S) = 5.49. Anal Calcd for C₂₇H₂₃F₃N₂O₃ C, 67.49; H, 4.82; N, 5.83. Found C, 67.43; H, 4.87; N, 5.88.

(R)-1,4-dibenzoyl-3-benzyl-6-(trifluoromethyl)-3,4-dihydroquinoxalin-2(1H)-one (4n). White crystalline solid: % yield = 77; % ee = > 99; mp = 134-135 °C; $[\alpha]_D^{25} = -77.1$ (c = 0.010, CHCl₃); ¹H NMR (CDCl₃) δ 7.89 (m, 2H), 7.71 (m, 1H), 7.51 (m, 8H), 7.42 (m, 4H), 7.26 (m, 3H), 5.38 (m, 1H), 3.27 (m, 1H), 3.16 (m, 1H) ppm; ¹³C NMR (CDCl₃) δ 168.1, 164.5, 163.2, 136.7, 136.4, 135.9, 135.6, 134.4, 133.4, 133.1, 132.7, 132.2, 131.6, 130.4, 129.7, 128.6, 128.3, 127.6, 127.5, 126.3, 125.8, 125.5, 125.3, 124.9, 124.7, 123.4, 122.6, 117.6, 60.6, 36.1 ppm; IR (CHCl₃) 1728, 1711, 1669 cm⁻¹. HPLC (OD, 10% *i*-PrOH/hexanes, 1.0 mL/min) (R) = 13.31, (S) = 11.49. Anal Calcd for C₃₀H₂₁F₃N₂O₃ C, 70.03; H, 4.11; N, 5.44. Found C, 70.11; H, 4.18; N, 5.51.

(R)-3-(4-bromobenzyl)-1,4-dibenzoyl-6-(trifluoromethyl)-3,4-dihydroquinoxalin-2(1H)-one (4o). White crystalline solid: % yield = 78; % ee = >99; mp = 148-149 °C; $[\alpha]_D^{25} = -49.5$ (c = 0.005, CHCl₃); ¹H NMR (CDCl₃) δ 7.91 (m, 2H), 7.72 (m, 1H), 7.57 (m, 2H), 7.48 (m, 3H), 7.38 (m, 3H), 7.25 (m, 2H), 7.17 (m, 1H), 7.06 (m, 1H), 6.98 (m, 2H), 5.63 (m, 1H), 3.15 (m, 1H), 2.92 (m, 1H) ppm; ¹³C NMR (CDCl₃) δ 168.4, 164.3, 163.2, 136.5, 136.2, 135.8, 135.6, 134.3, 133.2, 133.1, 132.8, 132.4, 131.5, 130.8, 129.4, 128.7, 128.2, 127.6, 127.5, 126.2, 125.9, 125.4, 125.1, 124.8, 124.4, 123.3, 122.3, 117.2, 60.1, 36.5 ppm; IR (CHCl₃) 1727, 1710, 1669 cm⁻¹. HPLC (OD, 10% *i*-PrOH/hexanes, 1.0 mL/min) (R) = 14.99, (S) = 12.79. Anal Calcd for C₃₀H₂₀BrF₃N₂O₃ C, 60.72; H, 3.40; N, 4.72. Found C, 60.67; H, 3.34; N, 4.68.

(R)-1,4,6-tribenzoyl-3-ethyl-3,4-dihydroquinoxalin-2(1H)-one (4p). White crystalline solid: % yield = 84; % ee = > 99; mp = 112-115 °C; $[\alpha]_D^{25} = -87.7$ (c = 0.006, CHCl₃); ¹H NMR (CDCl₃) δ 7.94 (m, 2H), 7.69 (m, 2H), 7.60-7.40 (m, 8H), 7.30-7.15 (m, 6H), 5.39 (m, 1H), 1.87 (m, 1H), 1.65 (m, 1H), 1.05 (m, 3H) ppm; ¹³C NMR (CDCl₃) δ 193.9, 171.8, 168.9, 168.1, 136.6, 135.0, 133.8, 133.5, 133.2, 132.9, 132.5, 131.5, 130.1, 129.5, 129.4, 129.3, 128.8, 128.4, 128.1, 126.8, 118.1, 58.7, 25.3, 22.5 ppm; IR (CHCl₃) 1726, 1710, 1692, 1666 cm⁻¹. HPLC (OD, 50% *i*-PrOH/hexanes, 1.0 mL/min) (R) = 6.83, (S) = 11.44. Anal Calcd for C₃₁H₂₄N₂O₄ C, 76.21; H, 4.95; N, 5.73. Found C, 76.28; H, 5.02; N, 5.68.

(R)-1,4,6-tribenzoyl-3-isopropyl-3,4-dihydroquinoxalin-2(1H)-one (4q). White crystalline solid: % yield = 84; % ee = > 99; mp = 104-106 °C; $[\alpha]_D^{25} = -226.8$ (c = 0.006, CHCl₃); ¹H NMR (CDCl₃) δ 7.94 (m, 2H), 7.70 (m, 2H), 7.60-7.41 (m, 8H), 7.33-7.18 (m, 6H), 5.12 (m, 1H), 1.84 (m, 1H), 1.15 (d, 3H), 0.99 (d, 3H) ppm; ¹³C NMR (CDCl₃) δ 193.8, 172.2, 168.8, 167.2, 136.5, 134.8, 133.8, 133.7, 133.2, 132.1, 132.4, 131.3, 129.9, 129.5, 129.4, 129.2, 128.7, 128.4, 128.2, 128.1, 127.4, 118.3, 62.9, 28.0, 18.9, 18.8 ppm; IR (CHCl₃) 1726, 1711, 1694, 1668 cm⁻¹. HPLC (OD, 50% *i*-PrOH/hexanes, 1.0 mL/min) (R) = 6.05, (S) = 7.19. Anal Calcd for C₃₂H₂₆N₂O₄ C, 76.48; H, 5.21; N, 5.57. Found C, 76.51; H, 5.18; N, 5.61.

(R)-1,4,6-tribenzoyl-3-isobutyl-3,4-dihydroquinoxalin-2(1H)-one (4r). White crystalline solid: % yield = 84; % ee = > 99; mp = 97-100 °C; $[\alpha]_D = -148.3$ ($c = 0.011$, CHCl_3); ^1H NMR (CDCl_3) δ 7.94 (m, 2H), 7.70 (m, 2H), 7.59-7.41 (m, 8H), 7.32-7.15 (m, 6H), 5.55 (m, 1H), 1.73 (m, 1H), 1.63-1.47 (m, 3H), 1.05 (d, 3H), 0.93 (d, 3H) ppm; ^{13}C NMR (CDCl_3) δ 193.8, 171.8, 168.6, 168.3, 136.5, 134.9, 133.8, 133.6, 133.1, 132.9, 132.4, 131.3, 130.0, 129.5, 129.3, 129.2, 128.8, 128.6, 128.4, 128.2, 126.8, 118.1, 56.1, 29.7, 24.7, 22.7, 22.1 ppm; IR (CHCl_3) 1723, 1708, 1688, 1667 cm^{-1} . HPLC (OD, 50% *i*-PrOH/hexanes, 1.0 mL/min) (R) = 7.24, (S) = 7.88. Anal Calcd for $\text{C}_{33}\text{H}_{28}\text{N}_2\text{O}_4$ C, 76.73; H, 5.46; N, 5.42. Found C, 76.71; H, 5.44; N, 5.38.

(S)-1,4,6-tribenzoyl-3-(methylthiomethyl)-3,4-dihydroquinoxalin-2(1H)-one (4s). White crystalline solid: % yield = 92; % ee = > 99; mp = 94-96 °C; $[\alpha]_D = -56.4$ ($c = 0.010$, CHCl_3); ^1H NMR (CDCl_3) δ 7.99 (m, 2H), 7.70 (m, 2H), 7.60-7.42 (m, 8H), 7.32-7.21 (m, 5H), 7.19 (d, 1H), 5.64 (m, 1H), 2.91 (dd, 1H), 2.67 (dd, 1H), 2.23 (s, 3H) ppm; ^{13}C NMR (CDCl_3) δ 193.7, 171.6, 168.8, 166.7, 136.4, 135.1, 133.5, 133.3, 133.2, 132.6, 132.4, 131.4, 130.2, 129.4, 129.3, 129.2, 128.8, 128.7, 128.4, 128.1, 126.3, 118.3, 55.6, 32.7, 15.6, ppm; IR 1726, 1716, 1686, 1660 (CHCl_3) cm^{-1} . HPLC (Whelk-01, %50 *i*-PrOH/hexanes, 1.0 mL/min) (R) = 36.89, (S) = 29.15. Anal Calcd for $\text{C}_{31}\text{H}_{24}\text{N}_2\text{O}_4\text{S}$ C, 71.52; H, 4.65; N, 5.38. Found C, 71.58; H, 4.59; N, 5.39.

(R)-1,4,6-tribenzoyl-3-(3-chloropropyl)-3,4-dihydroquinoxalin-2(1H)-one (4t). White crystalline solid: % yield = 87; % ee = > 99; mp = 108-110 °C; $[\alpha]_D^{25} = -47.1$ (c = 0.008, CHCl₃); ¹H NMR (CDCl₃) δ 7.95 (m, 2H), 7.70 (m, 2H), 7.60-7.41 (m, 8H), 7.32-7.14 (m, 6H), 5.46 (m, 1H), 3.59, (m, 2H), 2.07-1.89 (m, 3H), 1.78 (m, 1H) ppm; ¹³C NMR (CDCl₃) δ 193.7, 171.6, 168.9, 167.7, 136.4, 135.1, 133.3, 133.2, 133.1, 132.6, 132.4, 131.6, 130.1, 129.5, 129.4, 129.3, 128.8, 128.4, 128.3, 128.2, 126.4, 118.1, 56.7, 43.8, 28.3, 26.2 ppm; IR (CHCl₃) 1722, 1712, 1687, 1662 cm⁻¹. HPLC (Whelk-01, %50 *i*-PrOH/hexanes, 1.0 mL/min) (R) = 22.56, (S) = 25.64. Anal Calcd for C₃₂H₂₅ClN₂O₄ C, 71.57; H, 4.69; N, 5.22. Found C, 71.50; H, 4.76; N, 5.29.

(R)-1,4,6-tribenzoyl-3-benzyl-3,4-dihydroquinoxalin-2(1H)-one (4u). White crystalline solid: % yield = 86; % ee = > 99; mp = 125-128 °C; $[\alpha]_D^{25} = -97.7$ (c = 0.005, CHCl₃); ¹H NMR (CDCl₃) δ 8.21 (m, 2H), 8.09 (m, 3H), 7.82 (m, 2H), 7.70 (m, 1H), 7.50 (m, 8H), 7.41 (m, 4H), 7.23 (m, 3H), 5.31 (m, 1H), 3.22 (m, 1H), 3.11 (m, 1H) ppm; ¹³C NMR (CDCl₃) δ 192.7, 175.8, 165.1, 163.2, 136.2, 135.7, 135.4, 134.8, 134.5, 134.2, 133.8, 133.4, 133.2, 132.7, 132.3, 131.8, 131.1, 130.8, 130.4, 129.8, 129.6, 129.1, 128.6, 128.2, 128.0, 127.7, 127.2, 126.5, 125.8, 125.4, 125.2, 124.8, 124.1, 123.4, 122.3, 50.4, 35.3 ppm; IR (CHCl₃) 1724, 1706, 1685, 1660 cm⁻¹. HPLC (OD, 50% *i*-PrOH/hexanes, 1.0 mL/min) (R) = 16.40, (S) = 17.87. Anal Calcd for C₃₆H₂₆N₂O₄ C, 78.53; H, 4.76; N, 5.09. Found C, 78.48; H, 4.81; N, 5.11.

(R)-2-((1,4,7-tribenzoyl-3-oxo-1,2,3,4-tetrahydroquinoxalin-2-yl)methyl)isoindoline-1,3-dione (4v).

White crystalline solid: % yield = 90; % ee = > 99; mp = 193-196 °C; $[\alpha]_D^{25} = -84.6$ (c = 0.011, CHCl₃); ¹H NMR (CDCl₃) δ 8.05 (m, 2H), 7.75 (m, 2H), 7.69 (m, 3H), 7.60-7.47 (m, 5H), 7.44 (m, 2H), 7.40 (m, 2H), 7.34-7.24 (m, 4H), 7.17 (d, 1H), 7.10 (m, 1H), 5.75 (m, 1H), 4.28 (dd, 1H), 4.08 (dd, 1H) ppm; ¹³C NMR (CDCl₃) δ 193.3, 171.3, 168.9, 167.9, 167.5, 166.2, 136.4, 134.8, 134.2, 133.9, 133.8, 133.1, 133.0, 132.9, 132.7, 132.3, 131.9, 131.6, 131.5, 130.3, 130.2, 129.4, 129.2, 129.1, 128.7, 128.4, 128.3, 127.7, 127.1, 123.3, 123.2, 118.9, 60.3, 57.1 ppm; IR (CHCl₃) 1727, 1712, 1691, 1669, 1662, 1659 cm⁻¹. HPLC (Whelk-01, 60% *i*-PrOH/hexanes, 1.0 mL/min) (R) = 15.97, (S) = 19.86. Anal Calcd for C₃₈H₂₅N₃O₆ C, 76.66; H, 4.07; N, 6.78. Found C, 76.73; H, 4.02; N, 6.84.

(R)-3-(4-bromobenzyl)-1,4,6-tribenzoyl-3,4-dihydroquinoxalin-2-(1H)-one (4w).

White crystalline solid: % yield = 69; % ee = > 99; mp = 162-163 °C; $[\alpha]_D^{25} = -107.5$ (c = 0.011, CHCl₃); ¹H NMR (CDCl₃) δ 7.90 (m, 2H), 7.69 (m, 2H), 7.53 (m, 4H), 7.38 (m, 8H), 7.28 (m, 2H), 7.23 (m, 1H), 7.17 (m, 1H), 7.00 (m, 2H), 5.65 (m, 1H), 3.08 (dd, 1H), 2.94 (dd, 1H) ppm; ¹³C NMR (CDCl₃) δ 193.9, 171.2, 167.3, 165.4, 136.5, 135.1, 135.0, 134.6, 133.9, 133.6, 133.5, 133.4, 133.2, 132.6, 132.5, 132.4, 131.7, 131.4, 131.1, 131.0, 130.3, 130.2, 129.5, 129.3, 129.2, 128.8, 128.7, 128.6, 128.5, 128.2, 128.0, 127.6, 127.5, 118.1, 52.3, 35.5 ppm; IR (CHCl₃) 1722, 1709, 1694, 1669 cm⁻¹. HPLC (OD, 50% *i*-PrOH/hexanes, 1.0 mL/min) (R) = 7.30, (S) = 8.10. Anal Calcd for C₃₆H₂₅BrN₂O₄ C, 68.59; H, 4.00; N, 4.45. Found C, 68.64; H, 4.07; N, 4.42.

(S)-3-(4-bromobenzyl)-1,4,6-tribenzoyl-3,4-dihydroquinoxalin-2-(1H)-one (4x). White crystalline solid: % yield = 72; % ee = > 99; $[\alpha]_D^{25} = +110.4$ ($c = 0.010$, CHCl_3); HPLC (OD, 50% *i*-PrOH/hexanes, 1.0 mL/min) (R) = 7.30, (S) = 8.10.

(R)-diisopropyl 6-chloro-3-(methylthiomethyl)-2-oxo-2,3-dihydroquinoxaline-1,4-dicarboxylate (6). Clear oil: % yield = 62; % ee = > 99; $[\alpha]_D^{25} = +237.5$ ($c = 0.033$, CHCl_3); ^1H NMR (CDCl_3) δ 7.70 (m, 1H), 7.17 (m, 2H), 5.32-5.17 (m, 2H), 5.10 (m, 1H), 2.73 (m, 1H), 2.34 (m, 1H), 2.14 (s, 3H), 1.42 (m, 6H), 1.37 (m, 6H) ppm; ^{13}C NMR (CDCl_3) δ 166.1, 152.8, 150.9, 130.6, 129.6, 126.5, 125.2, 124.3, 118.6, 74.1, 71.2, 55.9, 33.4, 27.8, 21.9, 21.5, 15.7, 15.4 ppm; IR (CHCl_3) 1729, 1718, 1688, cm^{-1} . HPLC (OD, 30% *i*-PrOH/hexanes, 1.0 mL/min) (R) = 5.09, (S) = 6.78. Anal Calcd for $\text{C}_{18}\text{H}_{23}\text{ClN}_2\text{O}_5\text{S}$ C, 52.11; H, 5.59; N, 6.75. Found C, 52.14; H, 5.61; N, 6.71.

(R)-isopropyl 7-chloro-2-(methylthiomethyl)-3-oxo-3,4-dihydroquinoxaline-1-(2H)-carboxylate (7). 6 (0.048 mmol) was dissolved in 15 mL trifluoroacetic acid and refluxed for 12 hours (monitored by TLC).

When complete, the solvent was removed *in vacuo* and the residue was dissolved in 20 mL CH₂Cl₂ and adsorbed onto silica and purified by column chromatography using ether/hexanes to yield white crystalline solid **7**: % yield = 94; % ee = > 99; HPLC (OD, 30% *i*-PrOH/hexanes, 1.0 mL/min) (R) = 12.47, (S) = 17.32. Compound **7** has been reported.⁶

Synthesis of (R)-2-ethyl-1,2,3,4-tetrahydroquinoxaline (8). **4g** (10 mmol) was placed into a 25 mL round bottom flask equipped with a magnetic stir bar and was dissolved in 15 mL of THF and cooled to 0 °C. LAH⁷ (90 mmol) was added to the reaction flask and allowed to warm to room temperature in 30 min. The reaction mixture was then refluxed for 12 h and quenched dropwise with 5 mL of water at room temperature. The reaction was extracted with CH₂Cl₂ and dried with MgSO₄. The solution was concentrated *in vacuo* to yield **8**. % Yield = quantitative; % ee = > 99; HPLC (OD, 15% *i*-PrOH/hexanes, 1.0 mL/min) (R) = 10.36, (S) = 14.25. Compound **8** has been reported.⁸

Current Data Parameters
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 PROCNO 1

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HRLEN

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HPLC (Wheik-01)
 25% i-PROH/hexanes
 1.0 mL/min
 UV detection: 254 nm
 (R) = 16.16
 (S) = 22.32

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