Supporting Information
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Supplementary Data

Synthesis of pyranopyrazolo[3,4-c]dihydro quinolones by Domino Aldol / Hetero Diels–Alder Reactions

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(A) Experimental

General

N-acrylated anthranilaldehydes 1a-d were synthesized according to the literature.\textsuperscript{5} Commercially available chemicals were purchased from Sigma, Aldrich and ACROS and used without further purification. Analytical thin layer chromatography was performed on 0.20 mm 60 A silica gel plates. Column chromatography was performed using 60 A silica gel (60–200 mesh). IR spectra: ATR apparatus. Mass spectrometric data (MS) were obtained by electron ionization (EI, 70 eV), chemical ionization (CI, isobutane) or electrospray ionization (ESI). Melting points are uncorrected. \textsuperscript{1}H NMR, \textsuperscript{13}C NMR and DEPT spectra in CDCl\textsubscript{3} at r.t.; \( \delta \) in ppm rel. to Me\textsubscript{4}Si as internal standard, \( J \) in Hz. The computational results were calculated at B3LYP/6-31+G(d) level using Spartan 14 program, Wavefunction, Inc, Irvine, CA.

General procedure to synthesis of products 3a-h via DKIHDA reaction

\( N \)-acrylated anthranilaldehydes 1 (0.5 mmol), \( N \)-phenyl pyrazolones 2 (0.5 mmol) and ZnBr\textsubscript{2} (50 mol\%) was stirred in refluxing EtOH (5 ml). The progress of termination of the reaction was observed by TLC. After completion (5 h) and cooling down, 20 ml ice-cold water was poured to the reaction mixture. The resulted precipitate was filtered after 5 min stirring and washed by cold water. After air drying at room temperature, the pure products 3 were obtained by column chromatography on a silica gel with eluent of n-hexane/ethyl acetate (2:1).
(B) Data of compounds 3a-h

\((5aS^*,11bS^*)\)-1,7-dimethyl-3-phenyl-5,5a,7,11b-tetrahydropyrazolo[4',3':5,6]pyrano[3,4-c]quinolin-6(3H)-one (3a). Pale yellow solid, mp: 169-171 °C, yield 85% (147 mg). $^1$H NMR (250 MHz, CDCl$_3$): $\delta$ 2.10 (3H, s, CH$_3$), 3.10-3.16 (1H, m, H$_b$), 3.33 (3H, s, NCH$_3$), 4.28 (1H, d, J = 5.5 Hz, H$_c$), 4.37 (1H, dd, J = 10.5, 2.2 Hz, H$_a$), 4.52-4.78 (1H, m, HR$_2$), 7.00 (1H, d, J = 7.9 Hz, Ar-H), 7.19-7.21 (2H, m, Ar-H), 7.29-7.39 (4H, m, Ar-H), 7.66 (2H, d, J = 8.0 Hz, Ar-H); $^{13}$C NMR (62.5 MHz, CDCl$_3$): $\delta$ 13.6 (CH$_3$), 30.0 (NCH$_3$), 30.6 (CH), 40.5 (CH), 66.8 (OCH$_2$), 115.1 (CH), 120.5 (CH), 121.5 (C), 123.3 (CH), 125.8 (CH), 126.5 (C), 128.4 (CH), 128.9 (CH), 129.8 (CH), 138.2 (C), 138.6 (C), 146.9 (C), 149.6 (C), 167.6 (CON). IR (ATR, cm$^{-1}$): $\tilde{\nu}$ = 3067, 2925, 1651, 1598, 1496, 1126, 758. HRMS (ESI): calcd for C$_{21}$H$_{19}$N$_3$O$_2$ (M$^+$) 345.1472, found 345.1474.

\((5R^*,5aS^*,11bS^*)\)-1,5,7-trimethyl-3-phenyl-5,5a,7,11b-tetrahydropyrazolo[4',3':5,6]pyrano[3,4-c]quinolin-6(3H)-one (3b). Pale yellow solid, mp: 175-177 °C, yield 83% (149 mg). $^1$H NMR (250 MHz, CDCl$_3$): $\delta$ 1.51 (3H, d, J = 6.5 Hz, CH$_3$), 2.18 (3H, s, CH$_3$), 2.88 (1H, dd, J = 6.6, 5.7 Hz, H$_b$), 3.39 (3H, s, NCH$_3$), 3.39-3.48 (1H, m, H$_a$), 4.28 (1H, d, J = 4.9 Hz, H$_c$), 7.00-7.42 (7H, m, Ar-H), 7.74 (2H, d, J = 7.7 Hz, Ar-H); $^{13}$C NMR (62.5 MHz, CDCl$_3$): $\delta$ 13.4 (CH$_3$), 18.7 (CH$_3$), 29.6 (NCH$_3$), 30.8 (CH), 31.0 (CH), 77.2 (OCH), 115.1 (CH), 120.4 (CH), 122.7 (CH), 123.4 (C), 125.7 (CH), 127.1 (C), 128.3 (CH), 129.5 (C), 131.2 (CH), 133.1 (CH), 138.5 (C), 142.6 (C), 146.7 (C), 167.7 (CON). IR
(ATR, cm⁻¹): ʋ = 3080, 2928, 1658, 1597, 1498, 1128, 758. HRMS (ESI): calcd for C₂₂H₂₁N₃O₂ (M⁺) 359.1628, found 359.1621.

\((5aS^*,11bS^*)-7\text{-ethyl-1-methyl-3-phenyl-5,5a,7,11b-tetrahydropyrazolo}[4',3':5,6]pyrano[3,4-c]quinolin-6(3H)-one\) (3c). Pale yellow solid, mp: 176-178 °C, yield 80% (144 mg). \(^1\)H NMR (250 MHz, CDCl₃): δ 1.23 (3H, t, \(J = 7.1\) Hz, CH₃), 2.13 (3H, s, CH₃), 3.17 (1H, m, Hₐ), 4.29 (1H, d, \(J = 5.5\) Hz, Hₜ), 4.42 (1H, dd, \(J = 10.5, 2.7\) Hz, Hₐ), 4.69-4.85 (1H, m, Hᵣ), 7.04-7.14 (2H, m, Hₐ, Hᵣ), 7.21-7.44 (5H, m, Ar-H); \(^1\)C NMR (62.5 MHz, CDCl₃): δ 12.5 (CH₃), 13.1 (CH₃), 32.3 (CH), 37.9 (NCH₂), 40.3 (CH), 67.1 (OCH₂), 115.1 (CH), 120.3 (CH), 121.1 (C), 123.2 (CH), 125.1 (C), 126.4 (CH), 128.6 (CH), 129.0 (CH), 130.0 (CH), 137.1 (C), 137.6 (C), 146.6 (C), 149.8 (C), 166.4 (CON). IR (ATR, cm⁻¹): ʋ = 3068, 2929, 1653, 1598, 1495, 1129, 758. HRMS (ESI): calcd for C₂₂H₂₁N₃O₂ (M⁺) 359.1628, found 359.1622.

\((5R^* ,5aS^*,11bS^*)-7\text{-ethyl-1,5-dimethyl-3-phenyl-5,5a,7,11b-tetrahydropyrazolo}[4',3':5,6]pyrano[3,4-c]quinolin-6(3H)-one\) (3d). Pale yellow solid, mp: 180-182 °C, yield 84% (157 mg). \(^1\)H NMR (300 MHz, CDCl₃): δ 1.24 (3H, t, \(J = 6.4\) Hz, CH₃), 1.49 (3H, d, \(J = 6.5\) Hz, CH₃), 2.17 (3H, s, CH₃), 2.84 (1H, dd, \(J = 7.3, 5.2\) Hz, Hₐ), 3.88-4.03 (3H, m, Hₐ, NCH₂), 4.25 (1H, d, \(J = 5.1\) Hz, Hₜ), 7.02-7.21 (3H, m, Ar-H), 7.27-7.40 (4H, m, Ar-H), 7.73 (2H, d, \(J = 8.51\) Hz, Ar-H); \(^1\)C NMR (75 MHz, CDCl₃): δ 12.7 (CH₃), 13.4 (CH₃), 18.8 (CH₃), 31.0 (CH), 38.0 (NCH₂), 46.3 (CH), 72.4 (OCH), 115.0 (CH),
(5aS*,11bS*)-3-(4-chlorophenyl)-1,7-dimethyl-5,5a,7,11b-tetrahydropyrazolo[4',3':5,6]pyrano[3,4-c]quinolin-6(3H)-one (3e). Pale yellow solid, mp: 178-180 °C, yield 92% (174 mg). $^1$H NMR (250 MHz, CDCl$_3$): $\delta$ 2.08 (3H, s, CH$_3$), 3.14-3.20 (1H, m, H$_b$), 3.36 (3H, s, NCH$_3$), 4.31 (1H, d, $J = 5.7$ Hz, H$_c$), 4.41 (1H, dd, $J = 10.4$, 2.6 Hz, H$_a$), 4.74-4.76 (1H, m, HR$_2$), 7.03 (1H, d, $J = 8.1$ Hz, Ar-H), 7.12 (1H, dt, $J = 7.5$, 0.7 Hz, Ar-H), 7.28-7.38 (4H, m, Ar-H), 7.66-7.72 (2H, m, Ar-H); $^{13}$C NMR (62.5 MHz, CDCl$_3$): $\delta$ 13.5 (CH$_3$), 30.1 (NCH$_3$), 32.3 (CH), 40.3 (CH), 67.2 (OCH$_2$), 115.1 (CH), 121.6 (CH), 123.3 (CH), 124.9 (C), 128.6 (CH), 129.1 (CH), 129.8 (CH), 129.84 (C), 131.3 (C), 136.3 (C), 138.7 (C), 147.1 (C), 149.8 (C), 167.2 (CON). IR (ATR, cm$^{-1}$): $\tilde{\nu} = 3069, 2926, 1664, 1597, 1512, 1490, 1373, 1090, 829, 757$. HRMS (ESI): calcd for C$_{21}$H$_{18}$ClN$_3$O$_2$ (M$^+$) 379.1082, found 379.1080.

(5R*,5aS*,11bS*)-3-(4-chlorophenyl)-1,5,7-trimethyl-5,5a,7,11b-tetrahydropyrazolo[4',3':5,6]pyrano[3,4-c]quinolin-6(3H)-one (3f). Pale yellow solid, mp: 184-186 °C, yield 90% (177 mg). $^1$H NMR (250 MHz, CDCl$_3$): $\delta$ 1.43 (3H, d, $J = 6.5$ Hz, CH$_3$), 2.06 (3H, s, CH$_3$), 2.77-2.82 (1H, m, H$_b$), 3.23-3.30 (4H, m, NCH$_3$, H$_a$), 4.20 (1H, d, $J = 5.0$ Hz, H$_c$), 6.95 (1H, d, $J = 8.0$ Hz, Ar-H), 7.00-7.06 (1H, m, Ar-H), 7.19-7.29 (4H, m, Ar-H), 7.63 (2H, d, $J = 8.9$ Hz, Ar-
H). \(^{13}\text{C} \text{NMR} (62.5 \text{ MHz, CDCl}_3)\): \(\delta\) 13.1 (CH\(_3\)), 18.5 (CH\(_3\)), 30.0 (NCH\(_3\)), 30.6 (CH), 31.0 (CH), 72.8 (OCH), 115.1 (CH), 121.4 (CH), 123.4 (CH), 126.9 (C), 128.4 (CH), 128.9 (CH), 129.4 (CH), 129.5 (C), 131.0 (C), 136.6 (C), 138.3 (C), 147.2 (C), 149.3 (C), 167.7 (CON). IR (ATR, cm\(^{-1}\)):\(\nu = 3067, 2929, 1664, 1596, 1491, 1454, 1386, 1089, 827, 755\). HRMS (ESI): calced for C\(_{22}\)H\(_{20}\)ClN\(_3\)O\(_2\) (M\(^+\)) 393.1239, found 393.1237.

\((5\text{aS}^*,1\text{IbS}^*)-3-(4\text{-chlorophenyl})-7\text{-ethyl-1-methyl-5,5a,7,11b-tetrahydropyrazolo[4',3':5,6]pyrano[3,4-c]quinolin}-6(3H)-\text{one (3g)}\). Pale yellow solid, mp: 183-185 °C, yield 87% (171 mg). \(^1\)H NMR (250 MHz, CDCl\(_3\)\): \(\delta\) 1.23 (3H, t, \(J = 7.1\) Hz, CH\(_3\)), 2.09 (3H, s, CH\(_3\)), 3.14-3.19 (1H, m, H\(_b\)), 3.81-4.13 (2H, m, NCH\(_2\)), 4.24-4.43 (2H, m, H\(_a\), H\(_c\)), 4.42 (1H, dd, \(J = 10.6, 2.7\) Hz, H\(_a\)), 7.07 (1H, d, \(J = 8.3\) Hz, Ar-H), 7.13 (1H, dd, \(J = 7.4, 0.6\) Hz, Ar-H), 7.28-7.40 (6H, m, Ar-H); \(^{13}\text{C} \text{NMR} (62.5 \text{ MHz, CDCl}_3)\): \(\delta\) 12.5 (CH\(_3\)), 13.1 (CH\(_3\)), 21.7 (CH), 37.2 (NCH\(_2\)), 48.3 (CH), 79.3 (OCH\(_2\)), 115.2 (CH), 121.9 (CH), 123.2 (C), 127.4 (CH), 128.7 (CH), 128.8 (CH), 129.1 (CH), 129.8 (C), 131.8 (C), 134.2 (C), 137.6 (C), 147.6 (C), 149.9 (C), 166.3 (CON). IR (ATR, cm\(^{-1}\)):\(\nu = 3072, 2927, 1664, 1597, 1513, 1491, 1376, 1124, 1091, 831, 757\). HRMS (ESI): calced for C\(_{22}\)H\(_{20}\)ClN\(_3\)O\(_2\) (M\(^+\)) 393.1239, found 393.1236.

\((5\text{R}^*,5\text{aS}^*,1\text{IbS}^*)-3-(4\text{-chlorophenyl})-7\text{-ethyl-1,5-dimethyl-5,5a,7,11b-tetrahydropyrazolo[4',3':5,6]pyrano[3,4-c]quinolin}-6(3H)-\text{one (3h)}\). Pale yellow solid, mp: 189-191 °C, yield 80% (163 mg). \(^1\)H NMR (250 MHz, CDCl\(_3\)\): \(\delta\) 1.24 (3H, t, \(J = 7.0\) Hz, CH\(_3\)), 1.51 (3H, d, \(J = 6.5\) Hz, CH\(_3\)), 2.19 (3H, s, CH\(_3\)), 2.87 (1H, dd, \(J = 6.7, 5.3\) Hz, H\(_b\)), 3.94-4.06 (3H, m, H\(_a\), NCH\(_2\)), 4.26 (1H, d, \(J = 5.0\) Hz, H\(_c\)), 7.04-7.40 (6H, m, Ar-H), 7.71 (2H, d, \(J = 9.0\) Hz, Ar-H); \(^{13}\text{C} \text{NMR} (62.5 \text{ MHz, CDCl}_3)\): \(\delta\) 12.5 (CH\(_3\)), 13.1 (CH\(_3\)), 21.7 (CH), 37.2 (NCH\(_2\)), 48.3 (CH), 79.3 (OCH\(_2\)), 115.2 (CH), 121.9 (CH), 123.2 (C), 127.4 (CH), 128.7 (CH), 128.8 (CH), 129.1 (CH), 129.8 (C), 131.8 (C), 134.2 (C), 137.6 (C), 147.6 (C), 149.9 (C), 166.3 (CON). IR (ATR, cm\(^{-1}\)):\(\nu = 3072, 2927, 1664, 1597, 1513, 1491, 1376, 1124, 1091, 831, 757\). HRMS (ESI): calced for C\(_{22}\)H\(_{20}\)ClN\(_3\)O\(_2\) (M\(^+\)) 393.1239, found 393.1236.
CDCl₃: δ 12.6 (CH₃), 12.9 (CH₃), 18.6 (CH₃), 30.7 (CH), 38.0 (NCH₂), 56.4 (CH), 77.2 (OCH), 115.1 (CH), 121.7 (CH), 123.3 (CH), 126.8 (C), 128.6 (CH), 129.1 (CH), 129.7 (CH), 130.6 (C), 131.7 (C), 136.1 (C), 137.4 (C), 146.9 (C), 149.6 (C), 166.6 (CON). IR (ATR, cm⁻¹): ʋ= 3069, 2931, 1664, 1598, 1492, 1454, 1388, 1091, 829, 756. HRMS (ESI): calcd for C₂₃H₂₂ClN₃O₂ (M⁺) 407.1395, found 407.1396.
(C) Copies of $^1$H NMR, $^{13}$C NMR and DEPT 135 spectra for compounds 3a-h
$^1$H NMR spectra for compound 3a
$^{13}$C NMR for compound 3a
DEPT 135 for compound 3a

1H NMR spectra for compound 3b
$^{13}$C NMR for compound 3b
DEPT 135 for compound 3b
$^1$H NMR spectra for compound 3c
$^{13}$C NMR for compound 3c
$^1$H NMR spectra for compound $3d$
DEPT 135 for compound 3d
$^1$H NMR spectra for compound 3e
$^{13}$C NMR for compound 3e
DEPT 135 for compound 3e
$^1$H NMR spectra for compound 3f
DEPT 135 for compound 3f
$^1$H NMR spectra for compound 3g
$^{13}$C NMR for compound 3g
DEPT 135 for compound 3g
$^{1}$$H$ NMR spectra for compound $3h$
$^{13}$C NMR for compound $3h$
DEPT 135 for compound 3h