Electronic Supplementary Material (ESI) for Organic & Biomolecular Chemistry

A catalytic metal-free Ritter reaction to 3-substituted 3-aminooxindoles

Feng Zhou, Miao Ding and Jian Zhou*

(Part I)

Shanghai Key Laboratory of Green Chemistry and Chemical Processes, Department of Chemistry, East China Normal University, 3663N Zhongshan Road, Shanghai 200062, China.

Content **Page**

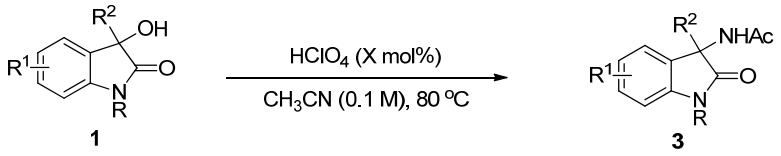
The NMR spectra were shown in Part II.

General: Reactions were monitored by thin layer chromatography using UV light to visualize the course of reaction. Purification of reaction products was carried out by flash chromatography on silica gel. Chemical yields refer to pure isolated substances. ^{1}H and ^{13}C NMR spectra were obtained using a Bruker DPX-400 spectrometer. Chemical shifts are reported in ppm from tetramethylsilane with the solvent resonance as the internal standard. The following abbreviations were used to designate chemical shift multiplicities: s = singlet, d = doublet, t = triplet, q = quartet, h = heptet, m = multiplet, br = broad.

All reactions were run under air except noted. Anhydrous THF and toluene were prepared by distillation over sodium-benzophenone ketyl prior to use. Anhydrous acetone was distilled over anhydrous $CaSO_4$ and stored over MS 4Å. Anhydrous halogenated solvents and CH_3CN were prepared by first distillation over P_2O_5 and then from CaH_2. $Hg(ClO_4)_2 \cdot 3H_2O$, $In(ClO_4)_3 \cdot 8H_2O$, $Cu(ClO_4)_2 \cdot 6H_2O$ were purchased from Alfa-Aesar and $Fe(ClO_4)_3 \cdot xH_2O$ from Aldrich. $HClO_4$ (70% solution in water) was purchased from Acros which was directly used without further purification. 3-Substituted 3-hydroxyoxindoles[1] were prepared from the corresponding isatins according to literature reports.

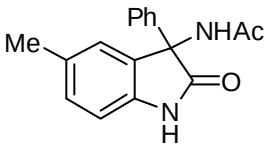
[1] (a) Y. Hamashima, T. Suzuki, H. Takano, Y. Shimura and M. Sodeoka, *J. Am. Chem. Soc.,* 2005, **127**, 10164; (b) H.-X. Wu, F. Xue, X. Xiao and Y. Qin, *J. Am. Chem. Soc.,* 2010, **132**, 14052; (c) Z.-Y. Cao, Y. Zhang, C.-B. Ji and Zhou, J. *Org. Lett.,* 2011, **13**, 6398.

General Procedure for the Ritter Reaction of 3-hydrooxindole with acetonitrile.



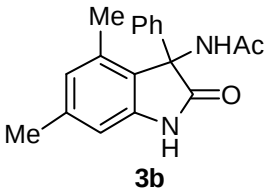
1 3

To a screw-capped pressure tube were added oxindole **1** (0.30 mmol), 3.0 mL of anhydrous CH_3CN and 10-50 mol% of $HClO_4$ (70%, aq.) as indicated in the Scheme 2. The resulting mixture was stirred at 80 °C till almost full conversion of **1** by TLC analysis. After concentration, the residue was directly subjected to column chromatography (10%~20% ethyl acetate in petroleum ether) to afford the desired product **3**.



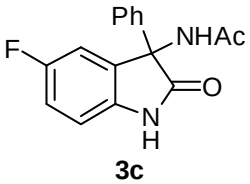
3a

Column chromatography afforded the desired product **3a** in 47% yield as white solid. Mp: 293-295 °C; IR (neat): 3277, 2859, 1722, 1652, 1493, 1211, 1026, 696 cm^{-1}; ^1H NMR (400 MHz, DMSO-d_6): 10.23 (s, 1 H), 8.91 (s, 1 H), 7.35-7.28 (m, 5 H), 7.03 (ABd, J = 8.0 Hz, 1H), 6.99 (s, 1 H), 6.72 (ABd, J = 7.6 Hz, 1H), 2.27 (s, 3 H), 1.86 (s, 3 H). ^{13}C NMR (100 MHz, DMSO-d_6): δ 176.35, 168.92, 140.02, 138.25, 131.34, 130.36, 128.77, 128.37, 128.15, 126.89, 124.35, 109.28, 64.52, 22.08, 20.80; GC-MS (EI): 280 (M^+, 8), 281 [$(M+1)^+$, 4], 44 (100), 237 (32), 209 (12), 186 (7), 77 (6); HRMS (EI): Exact mass calcd for $C_{17}H_{16}N_2O_2$ $[M]^+$: 280.1212, Found: 280.1212.



3b

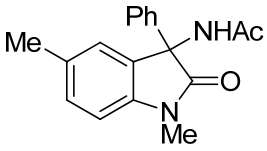
Column chromatography afforded the desired product **3b** in 73% yield as white solid. Mp: 343-345 °C; IR (neat): 3371, 3293, 1713, 1673, 1627, 1025, 992 cm^{-1}; ^1H NMR (400 MHz, DMSO-d_6): 10.14 (s, 1 H), 8.90 (s, 1 H), 7.35-7.34 (m, 3 H), 7.22-7.20 (m, 2 H), 6.60 (s, 1 H), 6.49 (s, 1 H), 2.27 (s, 3 H), 2.00 (s, 3 H), 1.87 (s, 3 H) . ^{13}C NMR (100 MHz, DMSO-d_6): δ 176.28, 168.69, 142.94, 137.99, 136.84, 134.01, 128.51, 128.33, 126.69, 124.81, 124.22, 108.04, 64.52, 21.80, 21.26, 17.59; GC-MS (EI): 294 (M^+, 5), 295 [$(M+1)^+$, 1], 44 (100), 251 (8), 235 (10), 207 (13), 104 (4); HRMS (EI): Exact mass calcd for $C_{18}H_{18}N_2O_2$ $[M]^+$: 294.1368, Found: 294.1366.



3c

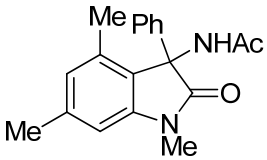
Column chromatography afforded the desired product **3c** in 41% yield as white solid. Mp: 263-265 °C; IR (neat): 3243, 2924, 1729, 1656, 1487, 696 cm^{-1}; ^1H NMR (400 MHz, DMSO-d_6): 10.38 (s, 1 H), 8.96 (s, 1 H), 7.38-7.30 (m, 5 H), 7.08-7.05 (m, 2 H), 6.84-6.81 (m, 1 H), 1.87 (s, 3 H). ^{13}C NMR (100 MHz,

DMSO-d_6): δ 176.89, 169.72, 159.65, 157.29, 139.05, 137.99, 133.55, 133.47, 128.98, 128.86, 127.26, 115.32, 115.09, 112.06, 111.82, 110.79, 110.71, 65.28, 22.46; GC-MS (EI): 284 (M^+, 18), 285 [$(M+1)^+$, 4], 44 (100), 241 (85), 213 (43), 190 (32), 77 (15); HRMS (EI): Exact mass calcd for $C_{16}H_{13}N_2O_2F$ $[M]^+$: 284.0961, Found: 284.0960.



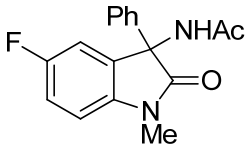
3d

Column chromatography afforded the desired product **3d** in 95% yield as white solid. Mp: 196-198 °C; IR (neat): 3345, 2973, 2928, 1740, 1648, 1090, 1049, 881 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): 7.40-7.38 (m, 2H), 7.30-7.28 (m, 3H), 7.14-7.13 (m, 2H), 6.81-6.75 (m, 2H), 3.13 (s, 3H), 2.36 (s, 3H), 1.87 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 175.10, 169.31, 141.73, 137.52, 132.02, 129.39, 128.70, 128.61, 126.66, 124.93, 108.05, 64.64, 26.61, 22.43, 21.11; GC-MS (EI): 294 (M^+, 96), 295 [$(M+1)^+$, 20], 251 (100), 200 (96), 208 (33), 223 (25), 236 (20); HRMS (EI): Exact mass calcd for $C_{18}H_{18}N_2O_2$ $[M]^+$: 294.1368, Found: 294.1369.



3e

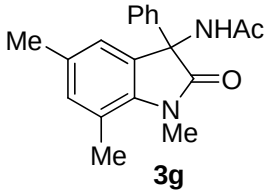
Column chromatography afforded the desired product **3e** in 88% yield as white solid. Mp: 303-305 °C; IR (neat): 3285, 2925, 1723, 1262, 1067, 719, 696 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): 7.31-7.24 (m, 5H), 6.64 (s, 1H), 6.50 (s, 1H), 6.39 (s, 1H), 3.06 (s, 3H), 2.30 (s, 3H), 2.02 (s, 3H), 1.91 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 175.03, 168.91, 144.78, 139.35, 136.38, 134.17, 129.09, 129.00, 126.49, 125.62, 123.02, 107.23, 64.78, 26.81, 22.45, 21.85, 18.13; GC-MS (EI): 308 (M^+, 64), 309 [$(M+1)^+$, 14], 248 (100), 265 (31), 234 (38), 214 (28), 77 (14); HRMS (EI): Exact mass calcd for $C_{19}H_{20}N_2O_2$ $[M]^+$:308.1525, Found: 308.1527.



3f

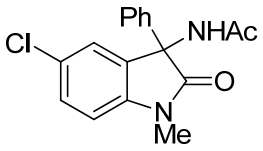
Column chromatography afforded the desired product **3f** in 87% yield as white solid. Mp: 221-223 °C; IR (neat): 3245, 3051, 2257, 1729, 1496, 1115, 919, 730 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): 7.44-7.41 (m, 2H), 7.36-7.34 (m, 3H), 7.11-7.04 (m, 2H), 6.83-6.80 (m, 1H), 6.46 (s, 1H), 3.20 (s, 3H), 2.00 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 175.06, 169.32, 160.48, 158.09, 140.26, 136.90, 130.98, 130.91, 129.14, 129.09, 126.62, 115.61, 115.38, 112.63, 112.38, 109.06, 108.98, 64.82, 26.93, 22.65. GC-MS (EI): 298(M^+, 55), 299 [$(M+1)^+$, 11], 204 (100), 255 (64), 239 (15), 212 (28), 77 (14), 44 (32);

HRMS (EI): Exact mass calcd for $C_{17}H_{15}N_2O_2F$ $[M]^+$: 298.1118, Found: 298.1116.



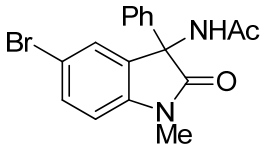
3g

Column chromatography afforded the desired product **3g** in 86% yield as white solid. Mp: 209-211 ^oC; IR (neat): 3009, 2953, 2924, 1719, 1656, 1484, 1103, 1029 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): 7.42-7.40 (m, 2H), 7.33-7.31 (m, 3H), 6.95 (s, 1H), 6.88 (s, 1H), 6.38 (s, 1H), 3.45 (s, 3H), 2.54 (s, 3H), 2.30 (s, 3H), 2.00 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 175.83, 169.16, 139.43, 137.89, 133.37, 131.79, 130.14, 128.67, 128.55, 126.72, 122.66, 119.52, 64.14, 30.00, 22.44, 20.79, 18.88. GC-MS (EI): 308 (M^+, 92), 309 [$(M+1)^+$, 21], 214 (100), 265 (71), 221 (47), 250 (23), 77(17); HRMS (EI): Exact mass calcd for $C_{19}H_{20}N_2O_2$ $[M]^+$: 308.1525, Found: 308.1526.



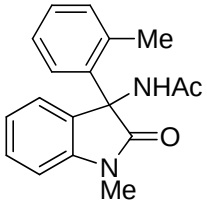
3h

Column chromatography afforded the desired product **3h** in 95% yield as white solid. Mp: 228-230 ^oC; IR (neat): 3292, 2930, 1953, 1744, 1649, 1514, 1493, 807 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): 7.42-7.40 (m, 2H), 7.37-7.30 (m, 5H), 6.82 (ABd, J = 8.4 Hz, 1H), 6.50 (br, 1H), 3.19 (s, 3H), 1.98 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 174.81, 169.37, 142.81, 136.63, 131.05, 129.12, 129.03, 127.94, 126.59, 124.53, 109.39, 64.53, 26.81, 22.47. GC-MS (EI): 314, 316 (M^+, 47, 16), 219 (100), 271 (50), 273 (16), 221 (35), 77 (19); HRMS (EI): Exact mass calcd for $C_{17}H_{15}N_2O_2{}^{35}Cl$ $[M]^+$: 314.0822, Found: 314.0823.



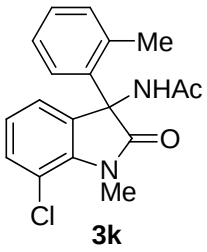
3i

Column chromatography afforded the desired product **3i** in 85% yield as white solid. Mp: 234-236 ^oC; IR (neat): 3296, 1742, 1648, 1514, 1487, 1338, 1095, 806 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): 7.49-7.47 (m, 1H), 7.43-7.41 (m, 3H), 7.36-7.35 (m, 3H), 6.77 (ABd, J = 8.4 Hz, 1H), 6.44 (br, 1H), 3.19 (s, 3H), 2.00 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 174.69, 169.43, 143.26, 136.57, 131.97, 131.45, 129.06, 128.99, 127.14, 126.58, 115.20, 109.87, 64.45, 26.75, 22.38. GC-MS (EI): 358, 360 (M^+, 51, 51), 264 (100), 265 (98), 315 (39), 317 (39), 77 (29), 43 (31); HRMS (EI): Exact mass calcd for $C_{17}H_{15}N_2O_2{}^{79}Br$ $[M]^+$: 358.0317, Found: 358.0315.



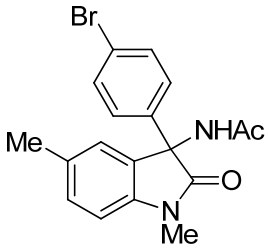
3j

Column chromatography afforded the desired product **3j** in 73% yield as white solid. Mp: 117-119 ^{o}C; IR (neat): 3257, 1724, 1656, 1493, 1371, 754, 737 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$): 7.36-7.26 (m, 2H), 7.19-7.17 (m, 2H), 7.10-7.04 (m, 2H), 6.98-6.96 (m, 1H), 6.87 (ABd, J = 8.0 Hz, 1H), 6.60 (s, 1H), 3.20 (s, 3H), 2.54 (s, 3H), 1.96 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 175.34, 168.84, 144.10, 137.18, 135.17, 133.27, 130.24, 129.18, 128.49, 127.80, 126.02, 125.16, 122.81, 108.15, 66.20, 26.58, 22.77, 21.27. GC-MS (EI): 294 (M^+, 59), 295 [$(M+1)^+$, 20], 186 (100), 251 (25), 236 (10), 223 (24), 207 (22), 43 (17); HRMS (EI): Exact mass calcd for $C_{18}H_{18}N_2O_2$ $[M]^+$: 294.1368, Found: 294.1367.



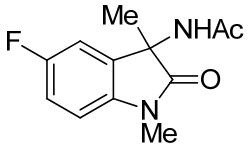
3k

Column chromatography afforded the desired product **3k** in 88% yield as white solid. Mp: 218-220 ^{o}C; IR (neat): 3228, 1735, 1639, 1537, 1468, 1101, 1059 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$): 7.27-7.18 (m, 3H), 7.12-7.10 (m, 1H), 7.07-7.03 (m, 1H), 7.00-6.96 (m, 1H), 6.84 (ABd, J = 8.0 Hz, 1H), 6.74 (s, 1H), 3.55 (s, 3H), 2.61 (s, 3H), 1.93 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 175.57, 168.83, 140.11, 137.36, 134.77, 133.50, 133.21, 131.49, 128.77, 127.75, 126.13, 123.46, 123.30, 115.63, 65.68, 30.00, 22.62, 21.42. GC-MS (EI): 328, 330 (M^+, 36, 13), 220 (100), 285 (19), 287 (6), 234 (59), 222 (35), 77(7), 43 (14); HRMS (EI): Exact mass calcd for $C_{18}H_{17}N_2O_2{}^{35}Cl$ $[M]^+$: 328.0979, Found: 328.0978.



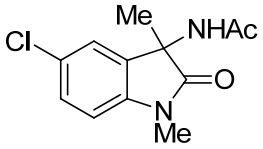
3l

Column chromatography afforded the desired product **3l** in 91% yield as white solid. Mp: 269-271 ^{o}C; IR (neat): 3015, 2955, 1737, 1648, 1499, 1074, 1008, 813 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$): 7.42 (ABd, J = 8.4 Hz, 2H), 7.27 (ABd, J = 8.8 Hz, 2H), 7.17-7.15 (m, 2H), 6.78 (ABd, J = 8.4 Hz, 1H), 6.57 (s, 1H), 3.17 (s, 1H), 2.36 (s, 3H), 1.95 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ174.68, 169.29, 141.69, 136.58, 132.39, 131.85, 129.79, 128.83, 128.53, 125.23, 123.05, 108.32, 64.30, 26.77, 22.65, 21.20. GC-MS (EI): 372, 374 (M^+, 27, 28), 200 (100), 329 (23), 331 (23), 301 (5), 303 (5), 77 (5); HRMS (EI): Exact mass calcd for $C_{18}H_{17}N_2O_2{}^{79}Br$ $[M]^+$: 372.0473, Found: 372.0471.



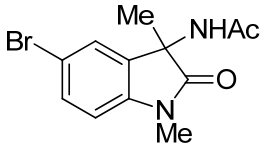
3m

Column chromatography afforded the desired product **3m** in 95% yield as white solid. Mp: 188-190 ^{o}C; IR (neat): 3251, 2929, 1736, 1654, 1495, 1269, 1108, 699 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$): 7.24-7.15 (m, 1H), 7.00-6.93 (m, 2H), 6.80-6.77 (m, 1H), 3.26 (s, 3H), 1.90 (s, 3H), 1.45 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 176.95, 169.61, 160.50, 158.11, 138.79, 133.26, 133.19, 114.72, 114.48, 110.00, 109.75, 108.80, 108.72, 58.38, 58.37, 26.58, 23.49, 22.23. GC-MS (EI): 236 (M^+, 100), 237 [$(M+1)^+$, 14], 179 (85), 193 (56), 148 (41), 135 (15), 43 (36); HRMS (EI): Exact mass calcd for $C_{12}H_{13}N_2O_2F$ $[M]^+$: 236.0961, Found: 236.0960.



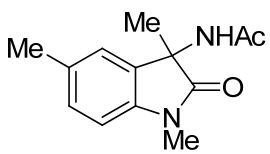
3n

Column chromatography afforded the desired product **3n** in 74% yield as white solid. Mp: 229-231 ^{o}C; IR (neat): 3319, 1713, 1673, 1489, 1373, 1298, 820, 736 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$): 7.56 (s, 1H), 7.24 (dd, J = 2.4 Hz, 8.0 Hz, 1H), 7.14 (ABd, J = 2.0 Hz, 1H), 6.81 (ABd, J = 8.0 Hz, 1H), 3.26 (s, 3H), 1.88 (s, 3H), 1.40 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 176.74, 169.68, 141.39, 133.30, 128.29, 127.80, 122.04, 109.17, 58.06, 26.50, 23.29, 22.06. GC-MS (EI): 252, 254 (M^+, 93, 31), 195 (100), 197 (27), 209 (28), 211 (18), 77 (12), 43 (41); HRMS (EI): Exact mass calcd for $C_{12}H_{13}N_2O_2{}^{35}Cl$ $[M]^+$: 252.0666, Found: 252.0667.



3o

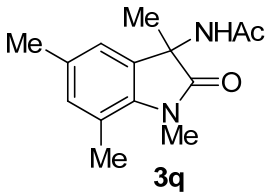
Column chromatography afforded the desired product **3o** in 92% yield as white solid. Mp: 248-250 ^{o}C; IR (neat): 3319, 1716, 1673, 1610, 1542, 1486, 1072, 818 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$): 7.40 (dd, J = 1.6 Hz, 8.4 Hz, 1H), 7.30 (ABd, J = 1.6 Hz, 1H), 6.74 (ABd, J = 8.4 Hz, 1H), 6.33 (s, 1H), 3.25 (s, 3H), 1.95 (s, 3H), 1.49 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 176.48, 169.41, 142.10, 133.46, 131.40, 124.99, 115.27, 109.79, 58.13, 26.59, 23.58, 22.37. GC-MS (EI): 296, 298 (M^+, 53, 52), 239 (100), 253 (36), 255 (33), 241 (55), 77 (14), 43 (46); HRMS (EI): Exact mass calcd for $C_{12}H_{13}N_2O_2{}^{79}Br$ $[M]^+$: 296.0160, Found: 296.0161.



3p

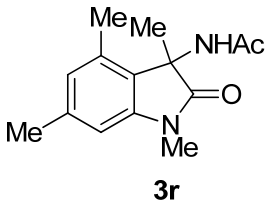
Column chromatography afforded the desired product **3p** in 78% yield as white solid. Mp: 115-117 ^{o}C; IR (neat): 3277, 2928, 1704, 1659, 1500, 1361, 808 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$): 7.15 (s, 1H), 7.05 (ABd, J = 8.0 Hz, 1H), 7.00 (s, 1H), 6.74 (ABd, J = 7.6 Hz, 1H), 3.25 (s, 3H), 2.31 (s, 3H),

1.89 (s, 3H), 1.44 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 177.09, 169.38, 140.48, 132.01, 131.56, 128.73, 122.46, 107.91, 58.23, 26.43, 23.71, 22.33, 21.00. GC-MS (EI): 232 (M^+, 100), 233 [$(M+1)^+$, 15], 175 (97), 189 (55), 173 (52), 145 (32), 147 (22), 43 (17); HRMS (EI): Exact mass calcd for $C_{13}H_{16}N_2O_2$ $[M]^+$: 232.1212, Found: 232.1213.



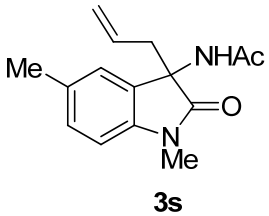
3q

Column chromatography afforded the desired product **3q** in 66% yield as white solid. Mp: 238-240 °C; IR (neat): 3296, 1712, 1656, 1544, 1352, 1308, 1141, 1089 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$): 7.08 (s, 1H), 6.83 (s, 1H), 6.79 (s, 1H), 3.52 (s, 3H), 2.52 (s, 3H), 2.25 (s, 3H), 1.89 (s, 3H), 1.42 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 177.89, 169.29, 138.10, 132.73, 132.39, 131.88, 120.21, 119.46, 57.74, 29.81, 24.15, 22.34, 20.67, 18.76. GC-MS (EI): 246 (M^+, 100), 247 [$(M+1)^+$, 16], 189 (98), 159 (36), 203 (20), 247 (16), 43 (10); HRMS (EI): Exact mass calcd for $C_{14}H_{18}N_2O_2$ $[M]^+$: 246.1368, Found: 246.1367.



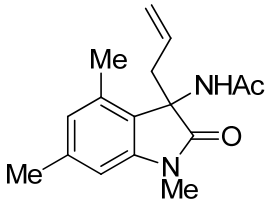
3r

Column chromatography afforded the desired product **3r** in 68% yield as white solid. Mp: 213-215 °C; IR (neat): 3246, 2921, 1724, 1620, 1070, 831 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$): 6.62 (s, 1H), 6.54 (s, 2H), 3.25 (s, 3H), 2.33 (s, 3H), 2.30 (s, 3H), 1.94 (s, 3H), 1.54 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 177.15, 168.95, 143.35, 138.37, 132.66, 125.53, 124.92, 107.05, 58.52, 26.49, 22.25, 21.87, 21.59, 26.99. GC-MS (EI): 246 (M^+, 47), 247 [$(M+1)^+$, 8], 187 (100), 173 (6), 159 (15), 144 (21), 77 (5); HRMS (EI): Exact mass calcd for $C_{14}H_{18}N_2O_2$ $[M]^+$: 246.1368, Found: 246.1367.



3s

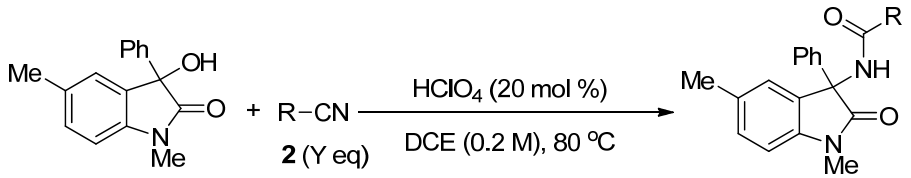
Column chromatography afforded the desired product **3s** in 52% yield as white solid. Mp: 161-163 °C; IR (neat): 3274, 1732, 1652, 1499, 1362, 802, 680 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$): 7.08 (ABd, J = 8.0 Hz, 1H), 7.01 (s, 1H), 6.74 (ABd, J = 8.0 Hz, 1H), 6.30 (s, 1H), 5.77-5.67 (m, 1H), 5.25-5.19 (m, 2H), 3.23 (s, 3H), 2.60 (dd, J = 8.0 Hz, 13.6 Hz, 1H), 2.45 (dd, J = 7.2 Hz, 13.6 Hz, 1H), 2.32 (s, 3H), 1.94 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 175.96, 169.00, 141.07, 131.85, 130.33, 129.61, 129.05, 123.32, 121.00, 107.93, 60.65, 41.36, 26.46, 22.61, 21.12. GC-MS (EI): 258 (M^+, 13), 259 [$(M+1)^+$, 3], 175 (100), 217 (25), 145 (6), 132 (8), 77 (3); HRMS (EI): Exact mass calcd for $C_{15}H_{18}N_2O_2$ $[M]^+$: 258.1368, Found: 258.1369.



3t

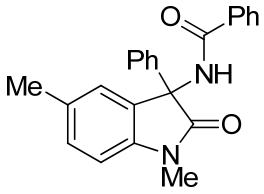
Column chromatography afforded the desired product **3t** in 25% yield as white solid. Mp: 97-99 °C; IR (neat): 3276, 2924, 1716, 1621, 1372, 1301, 1065 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): 6.60 (s, 1H), 6.49 (s, 1H), 6.29 (s, 1H), 5.51-5.40 (m, 1H), 5.12-5.02 (m, 2H), 3.20 (s, 3H), 2.72-2.62 (m, 2H), 2.30 (s, 3H), 2.27 (s, 3H), 1.94 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 175.92, 168.83, 143.93, 138.53, 132.80, 130.04, 125.58, 122.91, 120.25, 106.93, 61.54, 39.60, 26.35, 22.38, 21.65, 17.29. GC-MS (EI): 272 (M^+, 21), 273 [$(M+1)^+$, 4], 189 (100), 231 (6), 213 (10), 44 (24); HRMS (EI): Exact mass calcd for $C_{16}H_{20}N_2O_2$ $[M]^+$: 272.1525, Found: 272.1524.

General Procedure for the Ritter Reaction of 3-hydrooxindole with different nitries.



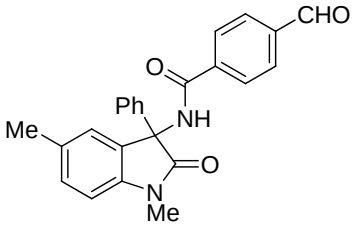
1 **4**

To a screw-capped pressure tube were added oxindole **1a** (0.30 mmol), 1.5 mL of anhydrous DCE, nitriles **2** (0.45 to 3.0 mmol) as indicated in Table 2, and $HClO_4$ (70% aq., 8.6 mg, 0.06 mmol). The resulting mixture was stirred at 80 °C till almost full conversion of **1a** by TLC analysis. After removing the solvent under reduced pressure, the residue was directly subjected to column chromatography (10%~20% ethyl acetate in petroleum ether) to afford the desired product **4**.



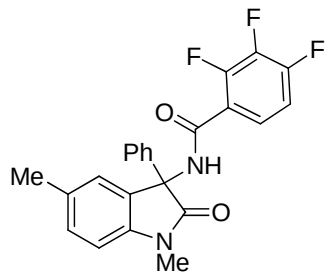
4a

Column chromatography afforded the desired product **4a** in 82% yield as white solid. Mp: 239-241 °C; IR (neat): 3328, 1714, 1654, 1504, 1354, 1295, 717, 690 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): 7.80-7.78 (m, 2H), 7.53-7.48 (m, 3H), 7.42-7.35 (m, 5H), 7.21-7.17 (m, 2H), 7.02 (s, 1H), 6.83 (ABd, J = 7,6 Hz, 1H), 3.25 (s, 3H), 2.35 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 175.02, 166.10, 141.99, 137.90, 133.10, 132.24, 131.91, 129.72, 129.14, 129.03, 128.91, 128.52, 127.21, 126.80, 125.29, 108.27, 64.91, 26.87, 21.21. GC-MS (EI): 356 (M^+, 78), 357 [$(M+1)^+$, 21], 262 (100), 251 (61), 207 (34), 105 (74), 77(80); HRMS (EI): Exact mass calcd for $C_{23}H_{20}N_2O_2$ $[M]^+$: 356.1525, Found: 356.1526.



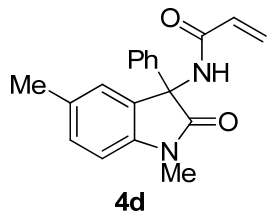
4b

Column chromatography afforded the desired product **4b** in 66% yield as white solid. Mp: 134-136 ^{o}C; IR (neat): 3055, 2947, 2246, 1708, 1670, 1497, 1207, 813, 732 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$): 10.04 (s, 1H), 7.95 (ABd, J = 8.4 Hz, 2H), 7.91 (ABd, J = 8.4 Hz, 2H), 7.53-7.50 (m, 2H), 7.38-7.37 (m, 3H), 7.22-7.19 (m, 2H), 7.14 (s, 1H), 6.85 (ABd, J = 7.6 Hz, 1H), 3.25 (s, 3H), 2.36 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 191.43, 174.73, 165.04, 141.95, 138.42, 138.11, 137.48, 132.39, 129.92, 129.76, 129.11, 129.09, 128.71, 127.95, 126.79, 125.29, 108.40, 65.05, 26.89, 21.22. MS (EI): 384 (M^+, 5), 385 [$(M+1)^+$, 1] ,236 (100), 306 (39), 237 (34), 77 (25), 208 (24), 224 (22); HRMS (EI): Exact mass calcd for $C_{24}H_{20}N_2O_3$ $[M]^+$: 384.1474, Found: 384.1472.



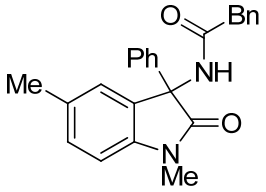
4c

Column chromatography afforded the desired product **4c** in 35% yield as white solid. Mp: 95-97 ^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$): 7.78-7.76 (m, 1H), 7.55-7.47 (m, 3H), 7.41-7.36 (m, 3H), 7.20-7.16 (m, 2H), 7.08-7.01 (m, 1H), 6.84 (ABd, J = 8.0 Hz, 1H), 3.26 (s, 3H), 2.35 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): see below. GC-MS (EI): 410 (M^+, 100), 411 [$(M+1)^+$, 28], 316 (78), 351 (11), 251 (89), 207 (50), 159 (75), 131 (27); HRMS (EI): Exact mass calcd for $C_{23}H_{17}N_2O_2F_3$ $[M]^+$: 410.1242, Found: 410.1244.



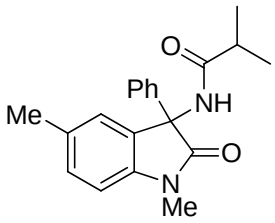
4d

Column chromatography afforded the desired product **4d** in 94% yield as white solid. Mp: 126-128 ^{o}C; IR (neat): 3247, 1716, 1656, 1625, 1499, 808, 719 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$): 7.44-7.42 (m, 2H), 7.33-7.31 (m, 3H), 7.15 (m, 2H), 6.80-6.78 (m, 1H), 6.65 (s, 1H), 6.26-6.09 (m, 2H), 5.63 (ABd, J = 10.4 Hz, 1H), 3.19 (s, 3H), 2.35 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 174.90, 164.46, 141.83, 137.54, 132.21, 129.65, 129.40, 129.09, 128.88, 128.82, 127.88, 126.75, 125.20, 108.22, 64.71, 26.78, 21.19. GC-MS (EI): 306 (M^+, 78), 307 [$(M+1)^+$, 17], 212 (100), 251 (78), 236 (13), 207 (31), 77 (15); HRMS (EI): Exact mass calcd for $C_{19}H_{18}N_2O_2$ $[M]^+$: 306.1368, Found: 306.1369.



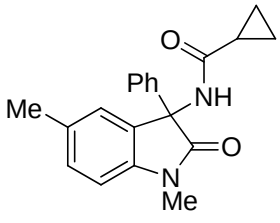
4e

Column chromatography afforded the desired product **4e** in 70% yield as white solid. Mp: 95-97 ^{o}C; IR (neat): 3265, 2922, 1722, 1653, 1497, 1354, 1076, 695 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$): 7.38-7.34 (m, 2H), 7.30-7.24 (m, 8H), 7.14 (ABd, J = 8.0 Hz, 1H), 7.00 (s, 1H), 6.77 (ABd, J = 8.0 Hz, 1H), 6.30 (s, 1H), 3.61 (ABd, J = 16 Hz, 1H), 3.54 (ABd, J = 16 Hz, 1H), 3.17 (s, 3H), 2.34 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 174.77, 170.05, 141.76, 137.48, 134.50, 131.88, 129.37, 129.13, 129.06, 128.66, 128.61, 128.50, 126.99, 126.39, 124.65, 108.01, 64.50, 42.55, 26.52, 21.00. GC-MS (EI): 370 (M^+, 36), 371 [$(M+1)^+$, 10], 236 (100), 251 (20), 276 (17), 91(16); HRMS (EI): Exact mass calcd for $C_{24}H_{22}N_2O_2$ $[M]^+$: 370.1681, Found: 370.1680.



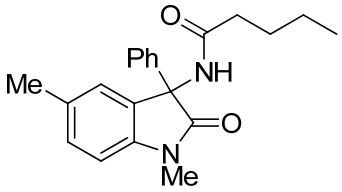
4f

Column chromatography afforded the desired product **4f** in 90% yield as white solid. Mp: 197-199 ^{o}C; IR (neat): 3260, 2969, 2932, 1734, 1650, 1526, 1502, 1095, 804 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$): 7.44-7.42 (m, 2H), 7.34-7.32 (m, 3H), 7.16-7.11 (m, 2H), 6.77 (ABd, J = 8.0 Hz, 1H), 6.36 (s, 1H), 3.19 (s, 3H), 2.43 (sep, J = 6.8 Hz, 1H), 2.36 (s, 3H), 1.17 (d, J = 7.2 Hz, 3H), 1.11 (d, J = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 175.87, 175.07, 141.86, 137.96, 132.09, 129.53, 129.34, 128.89, 128.76, 126.68, 124.80, 108.20, 64.37, 34.79, 26.78, 21.20, 19.41, 19.19. GC-MS (EI): 322 (M^+, 17), 323 [$(M+1)^+$, 4], 44 (100), 251 (20), 228 (15), 211 (10); HRMS (EI): Exact mass calcd for $C_{20}H_{22}N_2O_2$ $[M]^+$: 322.1681, Found: 322.1683.



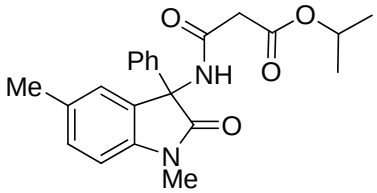
4g

Column chromatography afforded the desired product **4g** in 92% yield as white solid. Mp: 192-194 ^{o}C; IR (neat): 3293, 3016, 2918, 2245, 1720, 1653, 1524, 921, 809, 731, 652 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$): 7.47-7.44 (m, 2H), 7.33-7.32 (m, 3H), 7.15-7.13 (m, 2H), 6.76 (ABd, J = 8.0 Hz, 1H), 6.57(s, 1H), 3.18 (s, 3H), 2.36 (s, 3H), 1.47-1.41 (m, 1H), 1.01-0.95 (m, 1H), 0.87-0.81 (m, 1H), 0.78-0.72 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 175.03, 172.59, 141.58, 137.72, 131.92, 129.50, 129.34, 128.65, 128.55, 126.65, 124.82, 108.04, 64.63, 26.59, 21.11, 14.06, 7.43, 7.36. GC-MS (EI): 320 (M^+, 71), 321 [$(M+1)^+$, 16] ,226 (100), 251 (60), 207 (24), 77 (9), 69 (16), 41 (18); HRMS (EI): Exact mass calcd for $C_{20}H_{20}N_2O_2$ $[M]^+$: 320.1525, Found: 320.1524.



4h

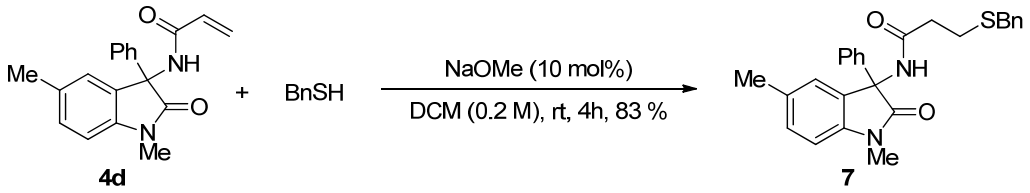
Column chromatography afforded the desired product **4h** in 81% yield as white solid. Mp: 79-81 ^{o}C; IR (neat): 3024, 2932, 2858, 1727, 1651, 1450, 1351, 1076, 808, 694 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$): 7.43-7.41 (m, 2H), 7.32-7.31 (m, 3H), 7.15-7.13 (m, 2H), 6.77 (d, J = 7.6 Hz, 1H), 6.45 (s, 1H), 3.17 (s, 3H), 2.35 (s, 3H), 2.26-2.12 (m, 2H), 1.60-1.52 (m, 2H), 1.35-1.26 (m, 2H), 0.89 (t, J = 7.6 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 175.06, 172.14, 141.83, 137.78, 132.00, 129.45, 129.34, 128.81, 128.70, 126.68, 124.92, 108.14, 64.52, 35.51, 27.31, 26.71, 22.11, 21.16, 13.70. GC-MS (EI): 336 (M^+, 91), 337 [$(M+1)^+$, 22], 251 (100), 277 (27), 242 (95), 236 (55), 208 (26), 175 (19); HRMS (EI): Exact mass calcd for $C_{21}H_{24}N_2O_2$ $[M]^+$: 336.1838, Found: 336.1838.



4i

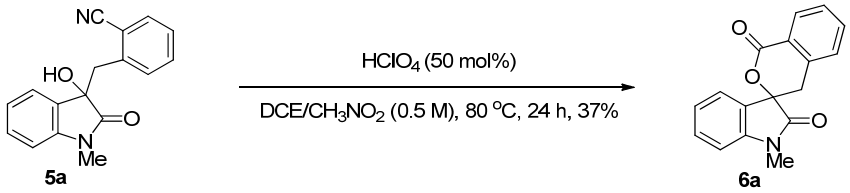
Column chromatography afforded the desired product **4i** in 41% yield as white solid. Mp: 65-67 ^{o}C; IR (neat): 3033, 2945, 1727, 1682, 1500, 1354, 1106, 809, 696 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$): 8.49 (s, 1H), 7.42-7.40 (m, 2H), 7.35-7.33 (m, 3H), 7.15 (ABd, J = 7.6 Hz, 1H), 7.11 (s, 1H), 6.78 (ABd, J = 8.0 Hz, 1H), 5.08 (sep, J = 6.4 Hz, 1H), 3.35 (ABd, J = 18.4 Hz, 1H), 3.24 (ABd, J = 18.4 Hz, 1H), 3.19 (s, 3H), 2.34 (s, 3H), 1.27 (t, J = 6.8 Hz, 6H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 174.89, 169.16, 164.18, 142.01, 137.58, 132.18, 129.62, 129.31, 128.94, 128.75, 126.51, 125.00, 108.10, 69.59, 64.65, 40.71, 26.77, 21.65, 21.17. GC-MS (EI): 380 (M^+, 69), 381 [$(M+1)^+$, 17], 251 (100), 236 (39), 226 (38), 175 (15), 321 (11), 286 (16); HRMS (EI): Exact mass calcd for $C_{22}H_{24}N_2O_4$ $[M]^+$: 380.1736, Found: 380.1737.

General Procedure for the Transformation of 4d into 7.



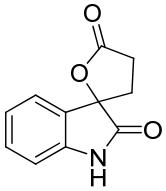
To a solution of **4d** (30.6 mg, 0.1 mmol) in CH_2Cl_2 (0.5 mL) was added NaOMe (0.5 mg, 0.01 mmol) at 0 ^oC. The reaction mixture was stirred for 10 min at 0 ^oC, followed by the addition of BnSH (18.6 mg, 0.15 mmol). The resulting mixture was stirred for 5 hours at room temperature. After concentrated under reduced pressure, flash chromatography (CH_2Cl_2/ethyl acetate = 15:1 to 10:1) provided **7** as white solid (35.5 mg, 83 %). Mp: 69-71 ^oC; IR (neat): 3286, 3025, 2919, 1724, 1497, 1354, 1076, 697 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): 7.42-7.40 (m, 2H), 7.33-7.32 (m, 3H), 7.26-7.20 (m, 5H), 7.14-7.10 (m, 2H), 6.76 (ABd, J = 7.6 Hz, 1H), 6.65 (s, 1H), 3.68 (s, 2H), 3.16 (s, 3H), 2.66 (td, J = 7.4 Hz, J = 2.0 Hz, 2H), 2.48-2.36 (m, 2H), 2.33 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): 174.89, 170.24, 141.79, 138.20, 137.57, 132.09, 129.55, 129.14, 128.85, 128.78, 128.75, 128.49, 127.02, 126.72, 125.10, 108.13, 64.66, 36.64, 35.79, 26.96, 26.73, 21.17. GC-MS (EI): 430 (M^+, 10), 431 [$(M+1)^+$, 3], 236 (100), 91 (94), 308 (15), 339 (8), 251 (8), 221 (19); HRMS (EI): Exact mass calcd for $C_{26}H_{26}N_2O_2S$ $[M]^+$: 430.1715, Found: 430.1716.

General Procedure for the Transformation of 5 into 6.



To a solution of **5a** (83.4 mg, 0.3 mmol) in 0.6 mL of mixed solvent of 1,2-dichloroethane and CH_3NO_2 (1:1, v/v) was added 70% $HClO_4$ (21.4 mg, 0.15 mmol), the resulting mixture was stirred at 80 ^oC for 24 hours till full consumption of **5a** by TLC analysis. The reaction mixture was directly subjected to column chromatography (10%~20% ethyl acetate in petroleum ether) to afford the desired product **6a** as yellow solid in 37% yield. Mp: 202-204 ^oC; IR (neat): 3069, 2937, 1712, 1612, 1469, 1282, 1081, 7498 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): 8.19 (d, J = 7.6 Hz, 1H), 7.60 (td, J = 7.6 Hz, J = 1.2 Hz, 1H), 7.49 (t, J = 7.6 Hz, 1H), 7.36 (td, J = 7.6 Hz, J = 1.2 Hz, 1H), 7.26 (ABd, J = 8.4 Hz, 1H), 6.98-6.86 (m, 3H), 3.56 (ABd, J = 16.8 Hz, 1H), 3.29 (ABd, J = 16.4 Hz, 1H), 3.20 (s,

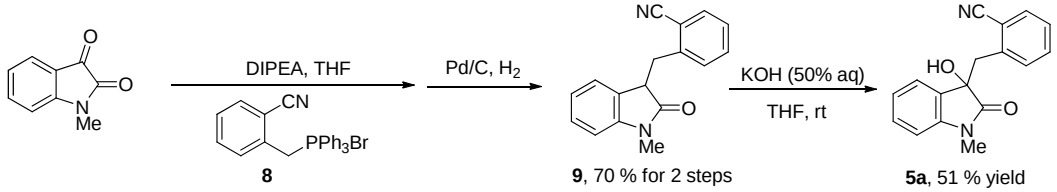
3H); ^{13}C NMR (100 MHz, $CDCl_3$): 172.25, 163.62, 143.20, 135.83, 134.17, 130.97, 130.01, 128.14, 127.96, 127.19, 124.85, 123.91, 123.23, 108.84, 80.37, 34.01, 26.37. GC-MS (EI): 279 (M^+, 20), 280 [$(M+1)^+$, 4], 44 (100), 234 (9), 207 (4), 118 (30), 77 (3); HRMS (EI): Exact mass calcd for $C_{17}H_{13}NO_3$ $[M]^+$: 279.0895, Found: 279.0894.



6b

Column chromatography afforded the desired product **6b** in 61% yield as yellow oil. IR (neat): 3264, 1773, 1723, 1621, 1471, 1180, 1054, 752 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$): 9.19 (s, 1H), 7.34-7.28 (m, 2H), 7.10-7.07 (m, 1H), 6.94 (ABd, J = 8.0 Hz, 1H), 3.21-3.11 (m, 1H), 2.84-2.76 (m, 1H), 2.65-2.58 (m, 1H), 2.52-2.44 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): 176.64, 176.54, 141.04, 131.10, 126.49, 124.34, 123.43, 110.96, 82.85, 31.11, 28.12. GC-MS (EI): 203 (M^+, 100), 175 (44), 161 (85), 147 (54), 133 (49), 120 (92), 77 (25); HRMS (EI): Exact mass calcd for $C_{11}H_9NO_3$ $[M]^+$: 203.0852, Found: 203.0853.

Preparation of 3-hydroxyoxindole 5a



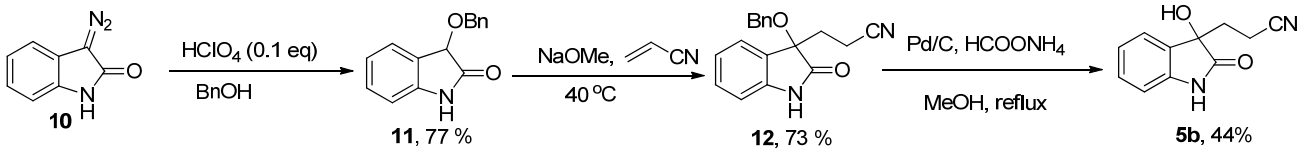
Ph_3P (5.2 g, 20.0 mmol) was added to the solution of 2-cyanobenzyl bromide (3.9 g, 20.0 mmol) in toluene (40 mL) at room temperature, then the reaction mixture was refluxed for 4 hours, cooled to room temperature, filtered and washed three times with petroleum ether. After removing the volatiles in vacuum, white solid **8** (6.0 g, 18.9 mmol) was obtained and used without purification.

A mixture of **8** (2.7 g, 6.0 mmol) and THF (10 mol) was stirred at 0 ^{o}C, thereafter diisopropylethyl amine (1.2 ml, 7.2 mmol) was added to the mixture and a solution of *N*-methyl isatin (800 mg, 5 mmol) in 10 mL of THF. The mixture was stirred at 70 ^{o}C overnight, and then saturated NH_4Cl solution was added. After extracting with ethyl acetate (20 mL × 3), the combined organic layer was washed with saturated NaCl solution, dried over Na_2SO_4, and concentrated under reduced pressure. The residue was dissolved with MeOH (25 ml), followed by the addition of 10% Pd/C (500 mg, 0.5 mmol). The mixture was stirred at room temperature under H_2 atmosphere for three hours. After filtration, concentration and flash chromatography (CH_2Cl_2/ethyl acetate = 15:1 to 10:1), product **9**

was obtained as yellow solid (924 mg, 70 %). Mp: 100-103 °C; IR (neat): 1702, 1610, 1491, 1468, 1377, 1348, 1130, 766, 752 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): 7.59-7.50 (m, 2H), 7.44-7.30 (m, 1H), 7.34-7.30 (m, 1H), 7.25-7.21 (m, 1H), 7.97-6.89 (m, 2H), 6.77 (ABd, J = 7.6 Hz, 1H), 3.79 (t, J = 6.8 Hz, 1H), 3.60-3.55 (m, 1H), 3.31-3.25 (m, 1H), 3.18 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): 176.15, 143.81, 141.76, 132.59, 132.50, 130.11, 128.19, 127.15, 126.97, 124.25, 122.19, 117.76, 113.14, 107.91, 45.83, 34.71, 26.00. GC-MS (EI): 262 (M^+, 81), 263 [$(M+1)^+$, 17], 146 (100), 147 (34), 160 (4), 118 (19), 91 (34), 77 (9); HRMS (EI): Exact mass calcd for $C_{17}H_{14}N_2O$ $[M]^+$: 262.1106, Found: 262.1109.

A solution of **9** (924 mg, 3.5 mol) in THF (20 mL) was cooled to 0 °C, and then 50% KOH (2.0 mL) was added. The reaction mixture was vigorously stirred for about 4 hours at room temperature till almost full conversion of **9** by TLC analysis. After the neutralization of the reaction mixture by HCl (1N, aq.) at 0 °C, the mixture was extracted with ethyl acetate. The combined organic phase was washed with brine, dried over Na_2SO_4, and concentrated. Flash chromatography (CH_2Cl_2/ethyl acetate = 15:1 to 10:1) provided **5a** as pink solid (500 mg, 51 %). Mp: 175-177 °C; IR (neat): 3333, 1693, 1615, 1234, 998, 763 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): 7.51-7.49 (m, 3H), 7.34-7.27 (m, 2H), 7.04-6.97 (m, 2H), 6.76 (ABd, J = 7.6 Hz, 1H), 3.89 (s, 1H), 3.54 (ABd, J = 13.6 Hz, 1H), 3.28 (ABd, J = 13.6 Hz, 1H), 3.15 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): 177.60, 142.65, 138.24, 132.37, 132.06, 131.44, 129.95, 128.38, 127.51, 124.76, 123.06, 117.71, 114.35, 108.47, 42.37, 26.23. GC-MS (EI): 278 (M^+, 6), 279 [$(M+1)^+$, 1], 162 (100), 262 (1), 146 (3), 116 (10), 77 (11); HRMS (EI): Exact mass calcd for $C_{17}H_{14}N_2O_2$ $[M]^+$: 278.1055, Found: 278.1054.

Preparation of 3-hydroxyoxindole 5b



The 3-diazoxindole **10**[2] (2.0 g, 12.5 mmol) was dissolved in BnOH (80 mL), and then $HClO_4$ (70%, aq., 143 mg, 1.0 mmol) was added at 0 °C. The mixture was stirred at room temperature until the full conversion of **10** by TLC analysis. The BnOH was removed by distillation under reduced pressure, the residue was purified by flash column chromatography to give **11** as a orange solid (2.3

[2] C. Marti and E. M. Carreira, *J. Am. Chem. Soc.*, 2005, **127**, 11505.

g, 77%). IR (neat): 1703, 1621, 1497, 1116, 719 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): 7.83 (s, 1H), 7.45-7.43 (m, 2H), 7.39-7.27 (m, 5H), 7.06 (t, *J* = 7.2 Hz, 1H), 6.85 (ABd, *J* = 7.6 Hz, 1H), 4.99 (s, 1H), 4.90 (ABd, *J* = 11.2 Hz, 1H), 4.82 (ABd, *J* = 11.2 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): 177.62, 141.54, 137.24, 129.86, 128.35, 128.16, 127.91, 125.44, 122.75, 110.49, 75.34, 70.49. GC-MS (EI): 239 (M^+, 11), 240 [$(M+1)^+$, 2], 148 (100), 130 (4), 119 (7), 91 (32), 77 (5); HRMS (EI): Exact mass calcd for $C_{15}H_{13}NO_2$ $[M]^+$: 239.0946, Found: 239.0948.

A solution of **11** (1.9 g, 8 mmol) in toluene (30 mL) was cooled to 0 °C, followed by the addition of NaOMe (88 mg, 1.6 mmol). After 10 minutes, the vinyl cyanide (0.53 mL, 8 mmol) was added. The reaction mixture was stirred at 40 °C till almost full conversion of **11** by TLC analysis. After the addition of NH_4Cl (aq.), the mixture was extracted with ethyl acetate (30 mL × 3). The combined organic phase was washed with brine, dried over Na_2SO_4 and concentrated. Flash chromatography (petroleum ether / ethyl acetate = 5:1 to 2:1) provided **12** as pink oil (1.6 g, 73 %). IR (neat): 2925, 2855, 1720, 1619, 1470, 1108, 752, 696 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): 7.90 (s, 1H), 7.38-7.27 (m, 7H), 7.16 (t, *J* = 7.2 Hz, 1H), 6.95 (ABd, *J* = 7.6 Hz, 1H), 4.27 (ABd, *J* = 10.4 Hz, 1H), 4.10 (ABd, *J* = 10.4 Hz, 1H), 2.83-2.69 (m, 2H), 2.46-2.39 (m, 1H), 2.24-2.17 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): 177.54, 140.84, 137.06, 130.66, 128.36, 127.99, 127.88, 126.73, 124.47, 123.55, 119.43, 111.14, 80.44, 68.03, 33.66, 11.06. MS (EI): 292 (M^+, 1), 91 (100), 146 (88), 186 (51), 65 (34), 77 (30); HRMS (EI): Exact mass calcd for $C_{18}H_{16}N_2O_2$ $[M]^+$: 292.1212, Found: 292.1211.

Under nitrogen atmosphere, to a solution of **12** (726 mg, 2.5 mmol) and 700 mg 10% Pd/C in dry methanol (20 mL), ammonium formate (790 mg, 12.5 mmol) was added in a single portion. The mixture was stirred at reflux temperature for about 3 hours. After completion of the reaction monitored by TLC analysis, the catalyst was removed by filtration and washed with methanol for three times. The combined organic filtrate was concentrated under reduced pressure. Flash chromatography (petroleum ether / ethyl acetate = 2:1 to 1:1) provided **5b** as yellow oil (223 g, 44 %). IR (neat): 3258, 1712, 1620, 1471, 1112, 753 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): 9.00 (s, 1H), 7.27-7.22 (m, 2H), 7.06 (t, *J* = 7.6 Hz, 1H), 6.87 (ABd, *J* = 7.6 Hz, 1H), 4.76 (s, 1H), 2.45-2.32 (m, 2H), 2.17-2.00 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): 179.70, 140.05, 130.26, 129.52, 123.97, 123.47, 119.23, 111.08, 75.00, 33.14, 11.17. GC-MS (EI): 202 (M^+, 32), 203 [$(M+1)^+$, 5], 44 (100), 148 (96), 120 (55), 77 (11); HRMS (EI): Exact mass calcd for $C_{11}H_{10}N_2O_2$ $[M]^+$: 202.0742, Found: 202.0742.

Single-Crystal X-ray Crystollgraphy[3]

Data intensity of **6a** was collected using a Bruker SMART APEX II (Mo radiation). The X-ray condition of was 50 kV × 30 mA. Data collection and reduction were done by using the Bruker ApexII software package. The structure was solved by direct methods and refined by full-matrix least-squares on F^2 with anisotropic displacement parameters for non-H atoms using SHELX-97. Hydrogen atoms were added at their geometrically idea positions and refined isotropically. Crystal data for **6a**: $C_{17}H_{13}NO_3$, M = 279.28, T = 296(2) K, λ = 0.71073 Å, Orthorhombic, space group P2(1)2(1)2(1), a = 7.3660(4) Å, b = 9.0252(5) Å, c = 10.1518(5) Å, V = 671.74(6) Å^3, z = 2, d_{calc} = 1.381 mg/m^3, 7853 reflections measured, 2353 unique [R_{int} = 0.0184], R_1 = 0.0453, wR_2 = 0.1290 ($I > 2\sigma(I)$, final R_1 = 0.0554, wR_2 = 0.1378 (all data), GOF = 1.093, and 190 parameters.

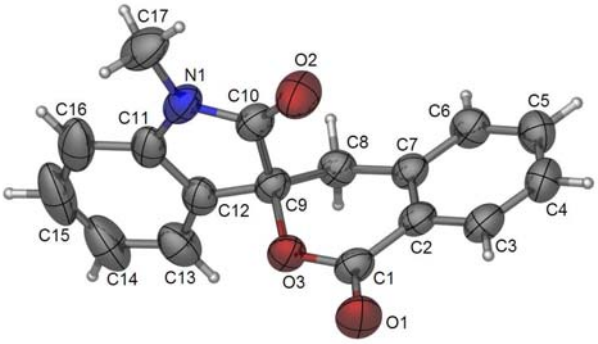


Table 1. Crystal data and structure refinement for z.

Identification code	z
Empirical formula	C17 H13 N O3
Formula weight	279.28
Temperature	296(2) K
Wavelength	0.71073 A
Crystal system, space group	Triclinic, P-1
Unit cell dimensions	a = 7.3660(4) A alpha = 84.572(2) deg.
	b = 9.0252(5) A beta = 88.905(2) deg.
	c = 10.1518(5) A gamma = 89.911(2) deg.
Volume	671.74(6) A^3
Z, Calculated density	2, 1.381 Mg/m^3
Absorption coefficient	0.095 mm^-1
F(000)	292
Crystal size	0.39 x 0.31 x 0.23 mm

[3] Supplementary crystallographic data have been deposited at the Cambridge Crystallographic Data Center. (CCDC 859777)

Theta range for data collection	2.27 to 25.00 deg.
Limiting indices	-8<=h<=8, -10<=k<=10, -12<=l<=11
Reflections collected / unique	7853 / 2353 [R(int) = 0.0184]
Completeness to theta = 25.00	99.3 %
Absorption correction	Semi-empirical from equivalents
Max. and min. transmission	0.9784 and 0.9637
Refinement method	Full-matrix least-squares on F^2
Data / restraints / parameters	2353 / 0 / 190
Goodness-of-fit on F^2	1.093
Final R indices [I>2sigma(I)]	R1 = 0.0453, wR2 = 0.1290
R indices (all data)	R1 = 0.0554, wR2 = 0.1378
Largest diff. peak and hole	0.304 and -0.159 e.A^-3

Table 2. Atomic coordinates (x 10^4) and equivalent isotropic displacement parameters (A^2 x 10^3) for z. U(eq) is defined as one third of the trace of the orthogonalized Uij tensor.

	x	y	z	U(eq)
O(1)	6849(2)	3361(2)	9454(2)	72(1)
O(2)	3175(3)	1499(2)	7056(2)	76(1)
O(3)	4696(2)	4238(2)	8152(1)	52(1)
N(1)	2724(2)	3424(2)	5454(2)	56(1)
C(1)	5245(3)	3328(2)	9205(2)	50(1)
C(2)	3884(3)	2411(2)	9988(2)	48(1)
C(3)	4449(3)	1318(2)	10934(2)	55(1)
C(4)	3209(3)	455(3)	11672(2)	61(1)
C(5)	1378(3)	678(3)	11470(2)	62(1)
C(6)	802(3)	1774(3)	10523(2)	57(1)
C(7)	2048(3)	2651(2)	9771(2)	47(1)
C(8)	1481(3)	3859(2)	8740(2)	50(1)
C(9)	2874(3)	4091(2)	7627(2)	46(1)
C(10)	2946(3)	2811(3)	6708(2)	52(1)
C(11)	2493(3)	4976(3)	5408(2)	54(1)
C(12)	2566(3)	5423(2)	6673(2)	50(1)
C(13)	2384(3)	6902(3)	6879(3)	66(1)
C(14)	2123(4)	7931(3)	5807(4)	89(1)
C(15)	2035(4)	7469(4)	4565(4)	96(1)
C(16)	2222(3)	5984(4)	4323(3)	79(1)
C(17)	2791(4)	2581(3)	4306(2)	79(1)

Table 3. Bond lengths [A] and angles [deg] for z.

O(1)-C(1)	1.214(2)
O(2)-C(10)	1.216(3)
O(3)-C(1)	1.353(2)
O(3)-C(9)	1.464(2)
N(1)-C(10)	1.351(3)
N(1)-C(11)	1.407(3)
N(1)-C(17)	1.451(3)
C(1)-C(2)	1.473(3)
C(2)-C(3)	1.380(3)
C(2)-C(7)	1.387(3)
C(3)-C(4)	1.366(3)
C(3)-H(3A)	0.9300
C(4)-C(5)	1.380(3)
C(4)-H(4A)	0.9300
C(5)-C(6)	1.385(3)
C(5)-H(5A)	0.9300
C(6)-C(7)	1.383(3)
C(6)-H(6A)	0.9300
C(7)-C(8)	1.503(3)
C(8)-C(9)	1.512(3)
C(8)-H(8A)	0.9700
C(8)-H(8B)	0.9700
C(9)-C(12)	1.490(3)
C(9)-C(10)	1.552(3)
C(11)-C(16)	1.378(3)
C(11)-C(12)	1.384(3)
C(12)-C(13)	1.377(3)
C(13)-C(14)	1.378(4)
C(13)-H(13A)	0.9300
C(14)-C(15)	1.367(5)
C(14)-H(14A)	0.9300
C(15)-C(16)	1.392(5)
C(15)-H(15A)	0.9300
C(16)-H(16A)	0.9300
C(17)-H(17A)	0.9600
C(17)-H(17B)	0.9600
C(17)-H(17C)	0.9600
C(1)-O(3)-C(9)	120.51(15)
C(10)-N(1)-C(11)	111.44(18)
C(10)-N(1)-C(17)	123.7(2)
C(11)-N(1)-C(17)	124.8(2)
O(1)-C(1)-O(3)	116.48(19)

O(1)-C(1)-C(2)	124.55(19)
O(3)-C(1)-C(2)	118.94(17)
C(3)-C(2)-C(7)	120.5(2)
C(3)-C(2)-C(1)	119.53(18)
C(7)-C(2)-C(1)	119.97(18)
C(4)-C(3)-C(2)	120.5(2)
C(4)-C(3)-H(3A)	119.8
C(2)-C(3)-H(3A)	119.8
C(3)-C(4)-C(5)	119.8(2)
C(3)-C(4)-H(4A)	120.1
C(5)-C(4)-H(4A)	120.1
C(4)-C(5)-C(6)	120.0(2)
C(4)-C(5)-H(5A)	120.0
C(6)-C(5)-H(5A)	120.0
C(7)-C(6)-C(5)	120.6(2)
C(7)-C(6)-H(6A)	119.7
C(5)-C(6)-H(6A)	119.7
C(6)-C(7)-C(2)	118.66(19)
C(6)-C(7)-C(8)	122.28(18)
C(2)-C(7)-C(8)	119.05(18)
C(7)-C(8)-C(9)	111.58(16)
C(7)-C(8)-H(8A)	109.3
C(9)-C(8)-H(8A)	109.3
C(7)-C(8)-H(8B)	109.3
C(9)-C(8)-H(8B)	109.3
H(8A)-C(8)-H(8B)	108.0
O(3)-C(9)-C(12)	106.95(16)
O(3)-C(9)-C(8)	110.65(15)
C(12)-C(9)-C(8)	115.02(16)
O(3)-C(9)-C(10)	107.30(15)
C(12)-C(9)-C(10)	102.34(16)
C(8)-C(9)-C(10)	113.91(17)
O(2)-C(10)-N(1)	126.4(2)
O(2)-C(10)-C(9)	126.02(19)
N(1)-C(10)-C(9)	107.55(18)
C(16)-C(11)-C(12)	121.5(2)
C(16)-C(11)-N(1)	128.7(2)
C(12)-C(11)-N(1)	109.77(18)
C(13)-C(12)-C(11)	120.5(2)
C(13)-C(12)-C(9)	130.6(2)
C(11)-C(12)-C(9)	108.90(19)
C(12)-C(13)-C(14)	119.0(3)
C(12)-C(13)-H(13A)	120.5
C(14)-C(13)-H(13A)	120.5

C(15)-C(14)-C(13)	119.8(3)
C(15)-C(14)-H(14A)	120.1
C(13)-C(14)-H(14A)	120.1
C(14)-C(15)-C(16)	122.6(3)
C(14)-C(15)-H(15A)	118.7
C(16)-C(15)-H(15A)	118.7
C(11)-C(16)-C(15)	116.6(3)
C(11)-C(16)-H(16A)	121.7
C(15)-C(16)-H(16A)	121.7
N(1)-C(17)-H(17A)	109.5
N(1)-C(17)-H(17B)	109.5
H(17A)-C(17)-H(17B)	109.5
N(1)-C(17)-H(17C)	109.5
H(17A)-C(17)-H(17C)	109.5
H(17B)-C(17)-H(17C)	109.5

Symmetry transformations used to generate equivalent atoms:

Table 4. Anisotropic displacement parameters (A^2 x 10^3) for z.
The anisotropic displacement factor exponent takes the form:
-2 pi^2 [h^2 a*^2 U11 + ... + 2 h k a* b* U12]

	U11	U22	U33	U23	U13	U12
O(1)	42(1)	97(1)	75(1)	-1(1)	-10(1)	-5(1)
O(2)	101(1)	61(1)	68(1)	-14(1)	-8(1)	12(1)
O(3)	36(1)	69(1)	50(1)	-5(1)	-1(1)	-5(1)
N(1)	47(1)	81(1)	42(1)	-12(1)	0(1)	-1(1)
C(1)	40(1)	65(1)	48(1)	-12(1)	-6(1)	1(1)
C(2)	44(1)	59(1)	41(1)	-14(1)	-3(1)	0(1)
C(3)	51(1)	69(1)	46(1)	-13(1)	-8(1)	6(1)
C(4)	69(2)	66(1)	46(1)	-1(1)	-4(1)	6(1)
C(5)	63(2)	71(2)	52(1)	-1(1)	8(1)	-6(1)
C(6)	42(1)	73(1)	55(1)	-7(1)	2(1)	0(1)
C(7)	45(1)	56(1)	40(1)	-11(1)	0(1)	1(1)
C(8)	38(1)	60(1)	53(1)	-6(1)	1(1)	1(1)
C(9)	40(1)	57(1)	42(1)	-6(1)	-3(1)	0(1)
C(10)	46(1)	63(1)	46(1)	-9(1)	-3(1)	2(1)
C(11)	32(1)	78(2)	51(1)	8(1)	4(1)	-4(1)
C(12)	38(1)	62(1)	49(1)	2(1)	3(1)	-3(1)
C(13)	55(1)	59(1)	82(2)	2(1)	6(1)	-3(1)
C(14)	73(2)	69(2)	116(3)	27(2)	16(2)	-2(1)
C(15)	63(2)	105(2)	107(3)	57(2)	15(2)	2(2)
C(16)	50(1)	119(2)	62(2)	24(2)	7(1)	-3(1)

C(17)	69(2)	119(2)	54(1)	-31(1)	2(1)	-8(2)

Table 5. Hydrogen coordinates (x 10^4) and isotropic displacement parameters (A^2 x 10^3) for z.

	x	y	z	U(eq)
H(3A)	5683	1167	11071	66
H(4A)	3598	-280	12308	73
H(5A)	530	93	11970	75
H(6A)	-434	1922	10391	68
H(8A)	1320	4781	9148	60
H(8B)	325	3598	8383	60
H(13A)	2436	7203	7728	79
H(14A)	2008	8935	5927	106
H(15A)	1841	8176	3854	115
H(16A)	2168	5686	3472	95
H(17A)	2966	1546	4587	119
H(17B)	3779	2933	3731	119
H(17C)	1670	2707	3841	119

Table 6. Torsion angles [deg] for z.

C(9)-O(3)-C(1)-O(1)	168.98(17)
C(9)-O(3)-C(1)-C(2)	-12.8(3)
O(1)-C(1)-C(2)-C(3)	-11.7(3)
O(3)-C(1)-C(2)-C(3)	170.19(18)
O(1)-C(1)-C(2)-C(7)	168.2(2)
O(3)-C(1)-C(2)-C(7)	-9.9(3)
C(7)-C(2)-C(3)-C(4)	0.1(3)
C(1)-C(2)-C(3)-C(4)	179.95(19)
C(2)-C(3)-C(4)-C(5)	-0.1(3)
C(3)-C(4)-C(5)-C(6)	0.0(3)
C(4)-C(5)-C(6)-C(7)	0.1(3)
C(5)-C(6)-C(7)-C(2)	-0.1(3)
C(5)-C(6)-C(7)-C(8)	-179.56(19)
C(3)-C(2)-C(7)-C(6)	0.0(3)
C(1)-C(2)-C(7)-C(6)	-179.87(18)
C(3)-C(2)-C(7)-C(8)	179.50(18)
C(1)-C(2)-C(7)-C(8)	-0.4(3)
C(6)-C(7)-C(8)-C(9)	-150.19(19)
C(2)-C(7)-C(8)-C(9)	30.4(3)

C(1)-O(3)-C(9)-C(12)	168.72(16)
C(1)-O(3)-C(9)-C(8)	42.7(2)
C(1)-O(3)-C(9)-C(10)	-82.1(2)
C(7)-C(8)-C(9)-O(3)	-49.4(2)
C(7)-C(8)-C(9)-C(12)	-170.75(17)
C(7)-C(8)-C(9)-C(10)	71.6(2)
C(11)-N(1)-C(10)-O(2)	-179.9(2)
C(17)-N(1)-C(10)-O(2)	-2.2(3)
C(11)-N(1)-C(10)-C(9)	-0.5(2)
C(17)-N(1)-C(10)-C(9)	177.23(18)
O(3)-C(9)-C(10)-O(2)	67.7(3)
C(12)-C(9)-C(10)-O(2)	-180.0(2)
C(8)-C(9)-C(10)-O(2)	-55.2(3)
O(3)-C(9)-C(10)-N(1)	-111.77(17)
C(12)-C(9)-C(10)-N(1)	0.6(2)
C(8)-C(9)-C(10)-N(1)	125.40(18)
C(10)-N(1)-C(11)-C(16)	-179.6(2)
C(17)-N(1)-C(11)-C(16)	2.7(3)
C(10)-N(1)-C(11)-C(12)	0.1(2)
C(17)-N(1)-C(11)-C(12)	-177.55(19)
C(16)-C(11)-C(12)-C(13)	-0.6(3)
N(1)-C(11)-C(12)-C(13)	179.65(18)
C(16)-C(11)-C(12)-C(9)	-179.91(18)
N(1)-C(11)-C(12)-C(9)	0.3(2)
O(3)-C(9)-C(12)-C(13)	-67.2(3)
C(8)-C(9)-C(12)-C(13)	56.1(3)
C(10)-C(9)-C(12)-C(13)	-179.8(2)
O(3)-C(9)-C(12)-C(11)	112.11(17)
C(8)-C(9)-C(12)-C(11)	-124.58(19)
C(10)-C(9)-C(12)-C(11)	-0.5(2)
C(11)-C(12)-C(13)-C(14)	0.1(3)
C(9)-C(12)-C(13)-C(14)	179.3(2)
C(12)-C(13)-C(14)-C(15)	0.5(4)
C(13)-C(14)-C(15)-C(16)	-0.9(4)
C(12)-C(11)-C(16)-C(15)	0.2(3)
N(1)-C(11)-C(16)-C(15)	180.0(2)
C(14)-C(15)-C(16)-C(11)	0.5(4)

Symmetry transformations used to generate equivalent atoms:

Table 7. Hydrogen bonds for z [A and deg.].

D-H...A	d(D-H)	d(H...A)	d(D...A)	<(DHA)