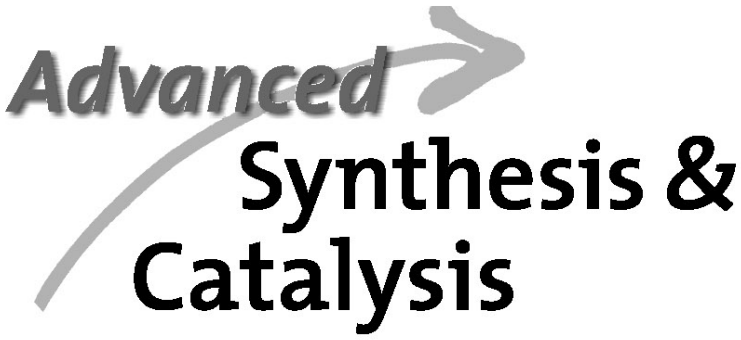

Supporting Information

One-pot Synthesis of *cis*-Isoquinolonic Acids Derivatives via Three-component Reaction of Homophthalic Anhydride with Aldehydes and Amines Using Ytterbium(III) Triflate as Catalyst

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Supporting Information

Characterization data for *cis*-isoquinolonic acid derivatives 4

1-Oxo-2,3-diphenyl-1,2,3,4-tetrahydro-4-isoquinoline-carboxylic acid (4a). mp 198-199 °C; ^{1}H NMR ($CDCl_3$-d) δ 8.32 (d, 1H, *J*=7.04Hz), 7.50-7.56 (m, 3H), 7.22-7.31 (m, 2H), 7.17 (t, 4H, *J*=10.8Hz), 7.06 (d, 2H, *J*=7.2 Hz), 5.41 (d, 1H, *J*=5.2 Hz), 4.96 (d, 1H, *J*=5.1Hz); ^{13}C NMR δ 170.3, 162.8, 141.6, 137.2, 134.2, 132.2, 129.1, 128.5, 128.1, 127.9, 127.8, 127.7, 127.7, 127.6, 127.3, 126.5; IR (KBr) ν: 3033, 1724, 1633, 1494, 1222, 1023, 770, 696 cm^{-1}; EIMS (m/z) (%): 344 (M+1, 8), 343 (M, 30), 181 (100). HRMS for $C_{22}H_{17}NO_3$ 343.3819; found 343.3816.

2-(4-Methylphenyl)-1-oxo-3-phenyl-1,2,3,4-tetrahydro-4-isoquinoline-carboxylic acid (4b). mp 178-179 °C; ^{1}H NMR ($CDCl_3$-d) δ 8.31 (d, 1H, *J*=7.22Hz), 7.47-7.58 (m, 3H), 7.21-7.24 (m, 1H), 7.16 (t, 2H, *J*=7.74Hz), 7.11 (d, 2H, *J*=8.12Hz), 7.05 (q, 2H, *J*=8.5Hz), 7.02 (d, 2H, *J*=8.2Hz), 5.37 (d, 1H, *J*=5.9 Hz), 4.97 (d, 1H, *J*=6.0Hz), 2.31 (s, 3H). ^{13}C NMR δ 170.4, 162.7, 142.6, 136.2, 134.2, 133.2, 128.1, 128.5, 128.3, 127.8, 127.4, 127.7, 127.6, 127.7, 127.6, 126.8; IR (KBr) ν: 2928, 1737, 1623, 1510, 1433, 1173, 698 cm^{-1}; EIMS (m/z) (%): 358 (M+1, 12), 357 (M, 34), 191 (100).

2-(3,4-Dimethylphenyl)-1-oxo-3-phenyl-1,2,3,4-tetrahydro-4-isoquinoline-carboxylic acid (4c). mp 206-207 °C; ^{1}H NMR ($CDCl_3$-d) δ 8.31 (d, 1H, *J*=7.2Hz), 7.47-7.57 (m, 3H), 7.21-7.26 (m, 1H), 7.15 (t, 2H, *J*=7.6Hz), 7.04 (d, 3H, *J*=7.8Hz), 6.95 (s, 1H), 6.80 (d, 1H, *J*=6.83Hz), 5.34

(d, 1H, *J*=5.8 Hz), 4.96 (1H, d, *J*=5.7Hz), 2.19 (d, 6H). ^{13}C NMR δ 171.4, 163.7, 142.6, 136.4, 134.4, 133.1, 128.1, 127.5, 128.4, 127.5, 127.2, 127.7, 127.6, 127.5, 127.6, 126.6; IR (KBr) ν: 2929, 1736, 1624, 1512, 1430, 1171, 696 cm^{-1}; EIMS (m/z) (%): 372 (M+1, 6), 371 (M, 26), 209 (100).

3-(4-Methoxyphenyl)-2-(4-methylphenyl)-1-oxo-1,2,3,4-tetrahydro-4-isoquinoline-carboxylic acid (4d). mp 180-182 °C; ^{1}H NMR ($CDCl_3$-d) δ 8.30 (d, 1H, *J*=7.43Hz), 7.47-7.58 (m, 3H), 7.11 (d, 2H, *J*=8.0Hz), 7.03 (d, 2H, *J*=8.1Hz), 6.95 (d, 2H, *J*=8.7Hz), 6.67 (d, 2H, *J*=8.8Hz), 5.31(1H, d, *J*=6.0 Hz), 4.93 (1H, d, *J*=5.8Hz), 3.71 (s, 3H), 2.31 (s, 3H). IR (KBr) ?: 2932, 1747, 1612, 1580, 1430, 1249, 1182, 1034, 778, 681 cm^{-1}; EIMS (m/z) (%): 388 (M+1, 10), 387 (M, 25), 136(100).

3-(4-Methoxyphenyl)-1-oxo-2-isopropyl-1,2,3,4-tetrahydro-4-isoquinoline-carboxylic acid (4e). mp 171-173 °C; ^{1}H NMR ($CDCl_3$-d) δ 8.24 (m, 1H), 7.43-7.52 (m, 3H), 6.92 (d, 2H, *J*=8.6 Hz), 6.65 (d, 2H, *J*=8.7 Hz), 5.13 (d, 1H, *J*=5.7 Hz), 4.98 (m, 1H), 4.65 (d, 1H, *J*=5.6Hz), 3.69 (s, 3H), 1.36 (d, 3H, *J*=6.7Hz), 0.91 (d, 3H, *J*=6.9Hz). IR (KBr) ν: 2933, 1748, 1614, 1582, 1431, 1249, 1172, 1036, 778, 671 cm^{-1}; EIMS (m/z) (%): 340 (M+1, 2), 339 (M, 7), 162(100).

3-(4-Dimethylaminophenyl)-1-oxo-2-isopropyl-1,2,3,4-tetrahydro-4-isoquinoline-carboxylic acid (4f). mp 193-195 °C; ^{1}H NMR ($CDCl_3$-d) δ 8.23 (m, 1H), 7.42-7.53 (m, 3H), 6.99 (d, 2H, *J*=7.8Hz), 6.87 (m, 2H), 5.15 (d, 1H, *J*=5.6Hz), 5.01 (m, 1H), 4.64 (d, 1H, *J*=5.5Hz), 2.91 (s, 6H), 1.35-1.40 (m, 3H), 0.87-0.94 (m, 3H).

2-Cyclohexyl-1-oxo-3-propyl-1,2,3,4-tetrahydro-4-isoquinoline-carboxylic acid (4g). mp 168-170 °C; ^{1}H NMR ($CDCl_3$-d) δ 8.07 (dd, 1H, *J*=0.96, 8.74Hz), 7.67 (d, 1H, *J*=7.77Hz), 7.48 -7.51 (m, 1H), 7.40 (t, 1H, *J*=7.57Hz), 4.42-4.47 (m, 1H), 4.32 (d, 1H, *J*=4.2Hz), 4.99(dd, 1H, *J*=4.5, 5.9Hz), 1.16-1.94(m, 14H), 0.76 (t, 3H, *J*=7.3Hz). ^{13}C NMR δ 178.0, 166.5, 137.6, 134.4, 129.4, 128.1, 126.1, 125.5, 45.8, 45.5, 45.8, 33.5, 31.3, 27.1, 22.3; IR (KBr) ν: 2934, 1744, 1611, 1585, 1431, 1246, 1172, 836, 778, 671 cm^{-1}; EIMS (m/z) (%): 316 (M+1, 3), 315 (M, 13), 118 (100).

2-Cyclohexyl-1-oxo-3-phenyl-1,2,3,4-tetrahydro-4-isoquinoline-carboxylic acid (4h). mp176-178 °C; ^{1}H NMR($CDCl_3$-d) δ 8.24-8.26 (m 1H), 7.43-7.51 (m, 3H), 7.20 (t, 1H, *J*=7.32Hz), 7.13 (t, 2H, *J*=7.8Hz), 7.01 (d, 2H, *J*=7.5Hz), 5.20 (d, 1H, *J*=5.6Hz), 4.64-4.69 (m, 2H), 0.87-1.89 (m, 10H). ^{13}C NMR δ 177.0, 165.8, 137.8, 135.4, 133.4, 129.1, 128.3, 127.5, 127.1, 126.8, 22.3,

27.1, 22.3; IR (KBr) ν: 2938, 1746, 1616, 1584, 1433, 1244, 1762, 835, 776, 678 cm^{-1} ; EIMS (m/z) (%): 350 (M+1, 2), 349 (M, 12), 304 (100).

1-Oxo-2, 3-diisopropyl-1,2,3,4-tetrahydro-4-isoquinoline-carboxylic acid (4i). 136-138 °C; ^{1}H NMR ($CDCl_3$-d) δ 8.03 (d, 1H, *J*=7.5Hz), 7.78 (d, 1H, *J*=7.8Hz), 7.46-7.54(m, 1H), 7.29-7.40 (m 1H), 4.46-4.51 (m, 1H), 4.37 (d, 1H, *J*=4.6Hz), 3.84-3.85 (m, 1H), 1.99-2.05 (m, 1H), 1.44-1.47 (d, 3H, *J*=6.7Hz), 1.37-1.38 (d, 3H, *J*=6.8Hz), 0.89-0.90 (d, 3H, *J*=6.9Hz), 0.71-0.73 (d, 3H, *J*=7.2Hz). ^{13}C NMR δ 178.0, 165.6, 137.9, 134.4, 129.4, 128.1, 126.8, 125.5, 52.6, 43.0, 42.3, 21.8, 17.3; IR (KBr) ν: 2940, 1747, 1616, 1588, 1437, 1246, 1766, 836, 776, 671 cm^{-1} ; EIMS (m/z) (%): 276 (M+1, 17), 275 (M, 12), 118 (100). HRMS for $C_{16}H_{21}NO_3$, 275.1521, found 275.1525.

2-(4-Chlorophenyl)-3-(2-Methylphenyl)-1-Oxo-1,2,3,4-tetrahydro-4-isoquinoline-carboxylic acid (4j). 186-187 °C; ^{1}H NMR ($CDCl_3$-d) δ 8.23 (dd, 1H, *J*=2.2, 8.1Hz), 7.12-7.35 (m, 5H), 7.40-7.56 (m, 5H), 7.65 (d, 1H, *J*=8.0Hz), 5.38 (d, 1H, *J*=8.1Hz), 4.80 (d, 1H, *J*=6.0Hz), 2.25 (s, 3H). ^{13}C NMR δ 178.8, 165.8, 137.5, 135.4, 133.4, 129.7, 127.1, 128.1, 127.4, 126.8; IR (KBr) ν: 2928, 1748, 1617, 1589, 1437, 1241, 1763, 836, 774, 672 cm^{-1} ; EIMS (m/z) (%): 392 (M+1, 21), 391 (M, 23), 127 (100). HRMS for $C_{23}H_{18}ClNO_3$, 391.85356, found 391.85323.

2-(4-Chlorophenyl)-1-oxo-3-phenyl-1,2,3,4-tetrahydro-4-isoquinoline-carboxylic acid (4k). mp 182-183 °C; ^{1}H NMR ($CDCl_3$-d) δ 8.15 (d, 1H, *J*=8.1Hz), 7.15-7.67 (m, 12H), 5.50 (d, 1H, *J*=6.0Hz), 4.95 (d, 1H, *J*=6.3Hz). ^{13}C NMR δ 178.5, 166.7, 146.7, 143.4, 133.3, 135.7, 129.7, 123.4; IR (KBr) ν: 2990, 1744, 1613, 1584, 1435, 1240, 1263, 836, 776, 671 cm^{-1} ; EIMS (m/z) (%): 378 (M+1, 21), 377 (M, 23), 176 (100).

2-(4-Bromophenyl)-1-oxo-3-phenyl-1,2,3,4-tetrahydro-4-isoquinoline-carboxylic acid (4l). mp 181-182 °C; ^{1}H NMR ($CDCl_3$-d) δ 8.19 (d, 1H, *J*=8.0Hz), 7.68 (d, 1H, *J*=8.2Hz), 7.35-7.45 (m, 5H), 7.05-7.21 (m, 6H), 5.40 (d, 1H, *J*=6.2Hz), 4.80 (d, 1H, *J*=6.0Hz). ^{13}C NMR δ 178.4, 163.7, 138.7, 136.8, 131.4, 130.3, 129.7, 127.7, 125.4; IR (KBr) ν: 3034, 2998, 1747, 1618, 1583, 1435, 1243, 1262, 836, 774, 672 cm^{-1}; EIMS (m/z) (%): 422 (M, 14), 178 (100).

3-(2-Nitrophenyl)-1-oxo-2-phenyl-1,2,3,4-tetrahydro-4-isoquinoline-carboxylic acid (4m). mp 222-223 °C; ^{1}H NMR ($CDCl_3$-d) δ 8.25 (dd, 1H, *J*=8.1Hz, *J*=2.0Hz), 8.10 (d, 1H, *J*=8.0Hz), 7.95 (d, 1H, *J*=2.0Hz), 7.18-7.75 (m, 10H), 5.60 (d, 1H, *J*=5.9Hz), 4.90 (d, 1H, *J*=6.0Hz). ^{13}C NMR δ 177.8, 168.7, 135.7, 133.8, 130.4, 129.7, 129.1, 128.1; IR (KBr) ν: 3130, 1748, 1616,

1584, 1435, 1244, 1263, 832, 774, 674 cm^{-1}; EIMS (m/z) (%): 388 (M, 20), 289 (100). HRMS for $C_{22}H_{16}N_2O_5$, 388.37952, found 388.37912.

2-Benzyl-3-(4-methoxyphenyl)-1-Oxo-1,2,3,4-tetrahydro-4-isoquinoline-carboxylic acid (**4n**). mp 198-199 °C, ^{1}H NMR ($CDCl_3$-d) δ 8.25 (dd, 1H, *J*=2.0, 8.0Hz), 7.58-7.60 (m, 2H), 7.20-7.35 (m, 6H), 6.90 (d, 2H, *J*=8.0Hz), 6.70 (d, 2H, *J*=8.0Hz), 5.70 (d, 1H, *J*=11.1Hz), 5.85 (d, 1H, *J*=6.1Hz), 4.80 (d, 1H, *J*=6.1Hz), 3.78 (s, 3H), 3.63 (d, 1H, *J*=9.0Hz). ^{13}C NMR δ 178.9, 165.7, 137.6, 134.8, 129.6, 128.1, 126.8, 125.7; IR (KBr) ν: 3438, 1743, 1613, 1513, 1247, 1263, 829, 776cm^{-1}; EIMS (m/z) (%): 388 (M+1, 3), 387 (M, 19), 237 (100). HRMS for $C_{24}H_{21}NO_4$, 387.43508, found 387.43501.

2-((E-1,2-benzamide-(4-nitrobenzo)ethenyl)benzoic acid (**4'o**). mp 211-212 °C; ^{1}H NMR δ 8.17-8.19 (m, 1H), 8.05 (d, 2H, *J*=8.9Hz), 7.70 (s, 1H), 7.67 (d, 2H, *J*=7.8Hz), 7.58-7.62 (m, 2H), 7.36 (s, 1H), 7.23-7.32 (m, 5H), 7.08 (t, 1H, *J*=7.4Hz), ^{13}C NMR δ 172.0, 163.7, 147.7, 141.1, 138.6, 136.4, 130.1, 128.8, 127.7, 126.3, 124.5, 123.5, 120.4; EIMS (m/z) (%): 389 (M+1, 1), 388 (M, 2), 176 (100). HRMS for $C_{22}H_{16}N_2O_5$, 388.1059, found 388.3795.

X-Ray Crystallography Data of 4'o

The single crystal of **4'o** with dimensions of 0.467 × 0.422×0.163 suitable for an X-ray diffraction investigation was obtained by recrystallization from EtOAc at room temperature, and it was mounted on Bruker SMART CCD automated diffractometer with a graphite monochromated Mo*Ka* (?= 0.71073 Å) radiation. The data were collected at 293 (2) K with an *?-2?* scan technique (1.84 (º)<*?*<28.31 (º)). A total of 10984 reflections were collected and 4288 were independent (Rint = 0.0585). The corrections for *Lp* factors were applied. The structure was solved by direct methods with SHELXS-97 program and expanded by Fourier technique. All non-hydrogen atoms were refined anisotropically, and the hydrogen atoms were determined with theoretical calculation. A full-matrix least squares refinement gave the final R=0.0479 and wR=0.0929 (w=1/[s ^{2}(F_o^2) + (0.0404P)^2 + 0.0000P], where P=(F_o^2 + 2F_c^2)/3). In the final circle of refinement the largest parameter shift (D/s) max was 0.003. The goodness of fit indicator was 0.848. The maximum and minimum peaks in the final difference Fourier map are 0.172 and -0.190e/Å^3, respectively. Crystallographic data and experimental details are listed in Table S1. The crystal structure **4'o** has been deposited at the Cambridge Crystallographic Data Centre and

allocated the deposition number (CCDC 259762).

Table S1. Crystal data and summary of data collection and refinement details for **4'o**

Empirical formula	$C_{22}\,H_{16}\,N_2\,O_5$
Formula weight	388.37
Temperature	293(2) K
Wavelength (?)	0.71073 Å
Crystal system, space group	Monoclinic, P2 (1)/n
Unit cell dimensions	a = 7.5687(17) Å a (º)= 90
	b = 11.072(3) Å ß (º)= 94.715(4)
	c = 22.247(5) Å ? (º) = 90
Volume (*V*)	1858.0(7) $Å^3$
Z, Calculated density	4, 1.388 Mg/m^3
Absorption coefficient (µ)	0.100 mm^{-1}
F (000)	808
Crystal size	0.467 × 0.422×0.163 mm
? range for data collection	1.84 to 28.31 (º)
Limiting indices	-9=h=7, -12=k=14, -29=l=8
Reflections collected / unique	10984 / 4288 [R (int) = 0.0585]
Completeness to *?*	28.31, 92.90%
Absorption correction	Sadabs
Max. and min. transmission	1.00000 and 0.41231
Refinement method	Full-matrix least-squares on F^2
Data / restraints / parameters	4288 / 0 / 326
Goodness-of-fit on F^2	0.848
Final R indices [I>2d (I)]	R_1 = 0.0479, wR2 = 0.0929
R indices (all data)	R_1 = 0.0933, wR2 = 0.1052
Largest diff. peak and hole	0.172 and -0.190 e. $Å^3$