Electronic Supplementary Material (ESI) for Organic & Biomolecular Chemistry. This journal is © The Royal Society of Chemistry 2021

Supporting Information for

Photocatalyzed Csp³-Csp³ cross-dehydrogenative coupling of

N-Boc-tetrahydroisoquinolines with α , β -unsaturated ketones

Na-Ri-Mei Ao, Xue-Qing Zhu, Chun-Xin Zhao, Ya-Ru Gao,* Yong-Qiang Wang*

Key Laboratory of Synthetic and Natural Functional Molecule Chemistry of Ministry of Education,

Department of Chemistry & Materials Science, Northwest University, Xi'an 710069, P.R. China.

E-mail: wangyq@nwu.edu.cn; gyaru@nwu.edu.cn

Table of content

1. General information	2
2.Synthesis and characterization of substrates	3
2.1 Preparation of <i>N</i> -Boc-THIQs	3
2.2 Preparation of α , β -unsaturated ketones	5
3. Synthesis and characterization of benzo[a]quinolizidines	10
4. Reference	11
5. ¹ H NMR and ¹³ C NMR Spectra for Products	12

1. General information

All dry reactions were carried out under argon. Unless otherwise noted, all commercial reagents and solvents were used as received without further purification. The progress of the reactions was monitored by TLC with silica gel plates (GF254), and the visualization was carried out under UV light. Melting points (m. p.) were measured on electrothermal digital melting point apparatus and were uncorrected. The ¹H and the ¹³C NMR spectroscopic data were recorded with a Varian Unity Inova-400 spectrometer or Bruker Ascend 400 (400 MHz and 600 MHz) spectrometer (¹H and ¹³C NMR at 400 and 100 MHz, respectively). Spectra were referenced internally to the residual proton resonance in CDCl₃ (δ 7.26 ppm), or with tetramethylsilane (TMS, δ 0.00 ppm) as the internal standard. Chemical shifts (δ) were reported as part per million (ppm) in δ scale downfield from TMS. Multiplicities are reported as follows: s = singlet, d = doublet, t = triplet, m = multiplet, br. s = broad singlet. Infrared (IR) data were recorded as films on potassium bromide plates on a Bruker Invenio-R FT-IR spectrometer. Absorbance frequencies are reported in reciprocal centimeters (cm⁻¹). High resolution mass spectra were acquired on a Bruker Daltonics MicroTof-QII mass spectrometer.

2.Synthesis and characterization of substrates

2.1 Preparation of N-Boc-THIQs



tert-butyl 3,4-dihydroisoquinoline-2(1*H*)-carboxylate (1a): was prepared according to a published procedure; spectral data were in agreement with literature values.^[1] ¹H NMR (400 MHz, CDCl₃) δ 7.19-7.10 (m, 4H), 4.58 (s, 2H), 3.65 (t, *J* = 5.7 Hz, 2H), 2.84 (t, *J* = 5.7 Hz, 2H), 1.50 (s, 9H);¹³C NMR (100 MHz, CDCl₃) δ 154.9, 134.8, 133.7, 128.7, 126.3, 126.2, 79.7, 45.9, 40.7, 29.0, 28.5; HRMS (ESI) m/z calculated for C₁₄H₂₀NO₂ [M+H]⁺: 234.1489; found: 234.1488.



tert-butyl 6,7-dimethoxy-3,4-dihydroisoquinoline-2(1*H*)-carboxylate (1b): was prepared according to a published procedure; spectral data were in agreement with literature values.^[1] m. p. = 108-109 °C; ¹H NMR (400 MHz, CDCl₃) δ 6.60 (s, 1H), 6.57 (s, 1H), 4.48 (s, 2H), 3.84 (s, 6H), 3.66-3.55 (m, 2H), 2.68-2.78 (m, 2H), 1.48 (s, 9H); ¹³C NMR (100 MHz, CDCl₃) δ 154.9, 147.6, 147.5, 126.5, 125.3, 111.5, 109.1, 79.7, 55.94, 55.91, 45.6, 40.7, 28.5, 28.3; HRMS (ESI) m/z calculated for C₁₆H₂₃NNaO₄⁺ [M+Na]⁺: 316.1519; found: 316.1518.



tert-butyl 5-bromo-3,4-dihydroisoquinoline-2(1*H*)-carboxylate (1c): was prepared according to a published procedure.^[2] m. p. = 80-81 °C; ¹H NMR (400 MHz, CDCl₃) δ 7.44-7.42 (m, 1H), 7.06-7.05 (m, 2H), 4.57 (s, 2H), 3.66 (t, *J* = 6.0 Hz, 2H), 2.85 (t, *J* = 6.0 Hz, 2H), 1.49 (s, 9H); ¹³C NMR (100 MHz, CDCl₃) δ 154.7, 136.4, 134.5,

130.4, 127.4, 125.5, 80.0, 45.8, 41.7, 29.6, 28.5; HRMS (ESI) m/z calculated for $C_{14}H_{18}BrNNaO_2^+[M+Na]^+$: 334.0413; found: 334.0412.



tert-butyl 7-nitro-3,4-dihydroisoquinoline-2(1H)-carboxylate (1d) was prepared according the following procedure: The mixture of to 1,2,3,4-tetrahydro-7-nitroisoquinoline (1.0 g, 5.61mmol), 1,4-dioxane (15mL), H₂O (7.5 mL) and 1M NaOH (4.8 mL) was cooled in an ice-bath, and di-tert-butyl dicarbonate (1.12 g, 5.13mmol) was added. The mixture was stirred at room temperature for 2.5 h, acidified with a 1M HCI solution to pH 2-3, and then extracted with EtOAc. The organic layer was dried over MgSO4 and filtered. The residue was purified by flash column chromatography (1:20=EtOAc/petroleum ether; $R_{\rm f}$ =0.30) to give the title compound (1.5g, 98% yield) as a white soild. m. p. = 75-76 °C; ¹H NMR (400 MHz, CDCl₃) δ 8.01 (d, J = 8.2 Hz, 1H), 7.98 (s, 1H), 7.28 (d, J = 8.2 Hz, 1H), 4.65 (s, 2H), 3.68 (t, J = 5.8 Hz, 2H), 2.92 (t, J = 5.8 Hz, 2H), 1.49 (s, 9H); ¹³C NMR (100 MHz, CDCl₃) & 154.6, 146.4, 142.5, 135.2, 129.7, 121.4, 121.2, 80.3, 45.7, 40.0, 29.1, 28.3; HRMS (ESI) m/z calculated for C₁₄H₁₈N₂NaO₄[M+Na]⁺: 301.1159; found: 301.1161.



di*-tert*-butyl 3,4-dihydro-1*H*-pyrido[3,4-*b*]indole-2,9-dicarboxylate (1d): was prepared according to a published procedure; spectral data were in agreement with literature values.^[3] m. p. = 127-128 °C; ¹H NMR (600 MHz, CDCl₃) δ 8.19 (d, *J* = 5.6 Hz, 1H), 7.40 (d, *J* = 4.4 Hz, 1H), 7.29-7.21 (m, 2H), 4.80 (s, 2H), 3.73 (s, 2H), 2.73 (s, 2H), 1.67 (s, 9H), 1.50 (s, 9H); ¹³C NMR (100 MHz, CDCl₃) δ 154.9, 149.9, 135.8, 131.8, 131.2, 128.8, 123.9, 122.6, 117.6, 115.4, 83.8, 79.9, 44.4, 40.1, 28.4, 28.2, 21.1; HRMS (ESI) m/z calculated for C₂₁H₂₉N₂O₄⁺ [M+H]⁺: 373.2122; found:373.2119.

2.2 Preparation of α,β-unsaturated ketones



(*E*)-4-(4-ethylphenyl)but-3-en-2-one (2c): was prepared according to a published procedure.^{[4] 1}H NMR (400 MHz, CDCl₃) δ 7.51-7.45 (m, 3H), 7.22 (d, *J* = 8.0 Hz, 2H), 6.68 (d, *J* = 16.2 Hz, 1H), 2.66 (q, *J* = 7.6 Hz, 2H), 2.36 (s, 3H), 1.24 (t, *J* = 7.6 Hz, 3H).; ¹³C NMR (100 MHz, CDCl₃) δ 198.5, 147.3, 143.6, 131.9, 128.6, 128.4, 126.3, 28.8, 27.4, 15.3; HRMS (ESI) m/z calculated for C₁₂H₁₄ONa⁺ [M+Na]⁺: 197.0937; found: 197.0937.



(*E*)-4-(4-isopropylphenyl)but-3-en-2-one (2e): was prepared according to a published procedure;^[4] spectral data were in agreement with literature values.^[5] ¹H NMR (400 MHz, CDCl₃) δ 7.50 (d, *J* = 16.3 Hz, 1H), 7.47 (d, *J* = 8.4 Hz, 2H), 7.25 (d, *J* = 8.4 Hz, 2H), 6.68 (d, *J* = 16.3 Hz, 1H), 2.92 (septet, *J* = 6.9 Hz 1H), 2.36 (s, 3H), 1.25 (d, *J* = 6.9 Hz, 6H); ¹³C NMR (100 MHz, CDCl₃) δ 198.5, 151.9, 143.5, 132.0, 128.4, 127.1, 126.3, 34.1, 27.4, 23.7; HRMS (ESI) m/z calculated for C₁₃H₁₇O⁺ [M+H]⁺: 189.1274; found: 189.1273.



(*E*)-4-(4-isobutylphenyl)but-3-en-2-one (2e): was prepared according to a published procedure.^[4] ¹H NMR (400 MHz, CDCl₃) δ 7.49 (d, *J* = 16.3 Hz, 1H), 7.44 (d, *J* = 8.1 Hz, 2H), 7.16 (d, *J* = 8.1 Hz, 2H), 6.67 (d, *J* = 16.3 Hz, 1H), 2.48 (d, *J* = 7.2 Hz, 2H), 2.35 (s, 3H), 1.87 (septet, *J* = 6.8 Hz, 1H), 0.90 (d, *J* = 6.6 Hz, 6H); ¹³C NMR (100

MHz, CDCl₃) δ 198.4, 144.8, 143.6, 131.9, 129.8, 128.2, 126.3, 45.3, 30.2, 27.4, 22.3; HRMS (ESI) m/z calculated for C₁₄H₁₉O⁺ [M+H]⁺: 203.1430; found: 203.1430.



(*E*)-4-(4-(*tert*-butyl)phenyl)but-3-en-2-one (2g): was prepared according to a published procedure;^[4] spectral data were in agreement with literature values.^[6] m. p. = 45-46 °C; ¹H NMR (400 MHz, CDCl₃) δ 7.50 (d, *J* = 16.3 Hz, 1H), 7.48 (d, *J* = 8.5 Hz, 2H), 7.42 (d, *J* = 8.5 Hz, 2H), 6.69 (d, *J* = 16.3 Hz, 1H), 2.37 (s, 3H), 1.33 (s, 9H); ¹³C NMR (100 MHz, CDCl₃) δ 198.6, 154.2, 143.5, 131.7, 128.2, 126.5, 126.0, 34.9, 31.2, 27.5; HRMS (ESI) m/z calculated for C₁₄H₁₈ONa⁺ [M+Na]⁺: 225.1250; found: 225.1250.



(*E*)-4-(4-iodophenyl)but-3-en-2-one (2j): was prepared according to a published procedure.^[4] m. p. = 105-106 °C; ¹H NMR (400 MHz, CDCl₃) δ 7.74 (d, *J* = 8.4 Hz, 2H), 7.42 (d, *J* = 16.3 Hz, 1H), 7.26 (d, *J* = 8.3 Hz, 2H), 6.71 (d, *J* = 16.3 Hz, 1H), 2.38 (s, 3H); ¹³C NMR (100 MHz, CDCl₃) δ 198.2, 142.2, 138.3, 134.0, 129.8, 127.7, 96.9, 27.8; HRMS (ESI) m/z calculated for C₁₀H₁₀IO⁺ [M+H]⁺: 272.9771; found: 272.9771.



(*E*)-4-(2-fluorophenyl)but-3-en-2-one (2m): was prepared according to a published procedure; ^[4] spectral data were in agreement with literature values.^[7] ¹H NMR (400 MHz, CDCl₃) δ 7.66 (d, *J* = 16.5 Hz, 1H), 7.56 (td, *J* = 7.6, 1.7 Hz, 1H), 7.39-7.34 (m, 1H), 7.17 (td, *J* = 7.6, 0.8 Hz, 1H), 7.12-7.07 (m, 1H), 6.77 (d, *J* = 16.5 Hz, 1H), 2.39

(s, 3H); ¹³C NMR (100 MHz, CDCl₃) δ 198.5, 161.4 (d, *J* = 253.0 Hz), 135.7 (d, *J* = 4.0 Hz), 132.0 (d, *J* = 8.0 Hz), 129.3 (d, *J* = 6.0 Hz), 128.7 (d, *J* = 2.0 Hz), 124.6 (d, *J* = 4.0 Hz), 122.5 (d, *J* = 12.0 Hz), 116.3 (d, *J* = 21.0 Hz), 27.5; HRMS (ESI) m/z calculated for C₁₀H₉FONa⁺ [M+Na]⁺: 187.0530; found: 187.0528.



(*E*)-4-(2-bromophenyl)but-3-en-2-one (2o): was prepared according to a published procedure; ^[4] spectral data were in agreement with literature values.^[8] ¹H NMR (400 MHz, CDCl₃) δ 7.86 (d, *J* = 16.3 Hz, 1H), 7.59 (dd, *J* = 8.1, 1.2 Hz, 2H), 7.33-7.29 (m, 1H), 7.23-7.19 (m, 1H), 6.59 (d, *J* = 16.3 Hz, 1H), 2.39 (s, 3H); ¹³C NMR (100 MHz, CDCl₃) δ 198.2, 141.8, 134.4, 133.4, 131.4, 129.8, 127.83, 127.75, 125.6, 27.2; HRMS (ESI) m/z calculated for C₁₀H₁₀BrO⁺ [M+H]⁺: 223.9837; found: 223.9833.



methyl (*E*)-2-(3-oxobut-1-en-1-yl)benzoate (2p): was prepared according to a published procedure; spectral data were in agreement with literature values.^{[9] 1}H NMR (400 MHz, CDCl₃) δ 8.35 (d, *J* = 16.3 Hz, 1H), 7.96 (d, *J* = 7.0 Hz, 1H), 7.58-7.48 (m, 2H), 7.43-7.38 (m, 1H), 6.48 (d, *J* = 16.3 Hz, 1H), 3.89 (s, 3H), 2.38 (s, 3H); ¹³C NMR (100 MHz, CDCl₃) 198.5, 166.8, 142.6, 136.4, 132.3, 130.7, 130.0, 129.9, 129.3, 127.6, 52.1, 26.6; HRMS (ESI) m/z calculated for C₁₂H₁₃O₃⁺ [M+H]⁺: 205.0859; found: 205.0856.



(*E*)-4-(*m*-tolyl)but-3-en-2-one (2q): was prepared according to a published procedure; ^[4] spectral data were in agreement with literature values.^[5] ¹H NMR (400 MHz, CDCl₃) δ 7.47 (d, J = 16.3 Hz, 1H), 7.33(d, J = 6.6 Hz, 1H), 7.27-7.25 (m, 1H), 7.19 (d, J = 7.4 Hz, 1H), 6.69 (d, J = 16.3 Hz, 1H), 2.36 (s, 6H);¹³C NMR (100 MHz, CDCl₃) δ 198.4, 143.6, 138.6, 134.3, 131.3, 128.9, 128.8, 126.9, 125.4, 27.4, 21.2; HRMS (ESI) m/z calculated for C₁₁H₁₂ONa⁺ [M+Na]⁺: 183.0780; found:183.0786.



(*E*)-4-(3-fluorophenyl)but-3-en-2-one (2r): was prepared according to a published procedure; ^[4] spectral data were in agreement with literature values.^{[5] 1}H NMR (400 MHz, CDCl₃) δ 7.45 (d, *J* = 16.3 Hz,1H), 7.38-7.28 (m, 2H), 7.23-7.20 (m, 1H), 7.10-7.06 (m, 1H), 6.68 (d, *J* = 16.3 Hz, 1H), 2.37 (s, 3H); ¹³C NMR (100 MHz, CDCl₃) δ 198.1, 163.1 (d, *J* = 245.0 Hz), 141.9 (d, *J* = 3.0 Hz), 136.7 (d, *J* = 8.0 Hz), 130.6 (d, *J* = 8.0 Hz), 128.2, 124.3 (d, *J* = 3.0 Hz), 117.4 (d, *J* = 21.0 Hz), 114.5 (d, *J* = 22.0 Hz), 27.8; HRMS (ESI) m/z calculated for C₁₀H₉FONa⁺ [M+Na]⁺: 187.0530; found: 187.0530.



(*E*)-4-(2-fluoro-4-methoxyphenyl)but-3-en-2-one (2t): was prepared according to a published procedure;^[4] spectral data were in agreement with literature values.^[10] m. p. = 89-90 °C; ¹H NMR (400 MHz, CDCl₃) δ 7.41 (d, *J* = 16.2 Hz, 1H), 7.31-7.25 (m, 2H), 6.96 (t, *J* = 8.4 Hz, 1H), 6.58 (d, *J* = 16.2 Hz, 1H), 3.92 (s, 3H), 2.36 (s, 3H); ¹³C NMR (100 MHz, CDCl₃) δ 198.1, 152.5 (d, *J* = 246.0 Hz), 149.7 (d, *J* = 10.0 Hz), 142.1 (d, *J* = 3.0 Hz), 127.7 (d, *J* = 7.0 Hz), 126.1, 125.7 (d, *J* = 4.0 Hz), 114.9 (d, *J* = 19.0 Hz), 113.3 (d, *J* = 3.0 Hz), 56.3, 27.7; HRMS (ESI) m/z calculated for C₁₁H₁₂FO₂⁺ [M+H]⁺: 195.0816; found: 195.0816.



(*E*)-6-phenylhex-3-en-2-one (2w): was prepared according to a published procedure; ^[4] spectral data were in agreement with literature values.^[11] ¹H NMR (400 MHz, CDCl₃) δ 7.32-7.28 (m, 2H), 7.23-7.18 (m, 3H), 6.86-6.78 (m, 1H), 6.10 (d, *J* = 16.0 Hz, 1H), 2.79 (t, *J* = 7.7 Hz, 2H), 2.55 (td, *J* = 7.6, 3.7 Hz, 2H), 2.22 (s, 3H); ¹³C NMR (100 MHz, CDCl₃) δ 198.6, 147.1, 140.7, 131.7, 128.5, 128.3, 126.3, 34.4, 34.1, 26.9; HRMS (ESI) m/z calculated for C₁₂H₁₅O⁺ [M+H]⁺: 175.1117; found: 175.1116; All data were in agreement with those reported.

3. Synthesis and characterization of benzo[a]quinolizidines



4a and **4b** was prepared according to a published procedure; The spectral data were in agreement with literature values.^[12]

(4*S*,11*bS*)-4-Phenyl-1,3,4,6,7,11*b*-hexahydro-2*H*-pyrido[2,1-*a*]isoquinolin-2-one (4a): Orange gum; ¹H NMR (400 MHz, CDCl₃) δ 7.34-7.28 (m, 4H), 7.25-7.20 (m, 1H), 7.11-7.06 (m, 3H), 6.96-6.94 (m, 1H), 4.40 (t, *J* = 5.0 Hz, 1H), 4.14 (dd, *J* = 9.8, 3.9 Hz, 1H), 3.27-3.21 (m, 1H), 3.02-2.66 (m, 7H); ¹³C NMR (100 MHz, CDCl₃) δ 208.7, 139.4, 136.8, 134.0, 129.0, 128.3, 128.1, 127.5, 126.4, 126.1, 126.0, 63.8, 54.4, 46.8, 46.2, 43.7, 29.0; IR (thin film): 2913, 1709, 1494, 1452, 1331, 1249, 1141, 1111, 754, 702, 622cm⁻¹; HRMS (ESI) m/z calculated for C₁₉H₁₉NONa⁺ [M+Na]⁺: 300.1359; found: 300.1362.

(4*R*,11b*R*)-4-Phenyl-1,3,4,6,7,11b-hexahydro-2*H*-pyrido[2,1-α]isoquinolin-2-one

(**4b**): Orange solid; m. p. = 102-103 °C; ¹H NMR (400 MHz, CDCl₃) δ 7.42-7.29 (m, 5H), 7.21-7.06 (m, 4H), 3.85 (d, J = 10.4 Hz, 1H), 3.63 (dd, J = 11.6, 3.6 Hz, 1H), 3.09-2.96 (m, 3H), 2.77-2.56 (m, 4H), 2.24-2.17 (m, 1H); ¹³C NMR (100 MHz, CDCl₃) δ 207.5, 142.4, 137.1, 135.0, 129.03, 128.98, 127.9, 127.3, 126.6, 126.2, 125.0, 68.4, 62.5, 50.0, 47.6, 47.2, 29.9; IR (thin film): 2921, 2801, 1718, 1494, 1454, 1335, 1308, 1253, 1150, 1111, 1045, 1029, 761, 743, 702cm⁻¹; HRMS (ESI) m/z calculated for C₁₉H₁₉NONa⁺ [M+Na]⁺: 300.1359; found: 300.1366.

4. Reference

- J. A. Hickin, A. Ahmed, K. Fucke, M. Ashcroft, K. Jones, *Chem. Commun.*, 2014, **50**, 1238.
- [2] D. Montgomery, J. P. Anand, N. W. Griggs, T. J. Fernandez, G. Joshua, J. G. Hartman, A. A. Sánchez-Santiago, I. D. Pogozheva, J. R. Traynor, ACS Chem. Neurosci., 2019, 10, 3682.
- [3] O. R. Suarez-Castillo, M. Meléndez-Rodríguez, Y. M. A. Contreras-Martínez, A. Álvarez-Hernández, M. S. Morales-Ríos, P. Joseph-Natha, *Nat. Prod. Commun.*, 2009, 4, 797.
- [4] W. Gładkowski, A. Skrobiszewski, M. Mazur, M. Siepka, A. Pawlak, B. Obmińska-Mrukowicz, A. Białońska, D. Poradowski, A. Drynda, M. Urbaniak, *Tetrahedron*, 2013, 69, 10414.
- [5] A. Skrobiszewski, R. Ogórek, E. Pląskowska, W. Gładkowski, *Biocatalysis and Agricultural Biotechnology*, 2013, **2**, 26.
- [6] A. Rayar, M. S.-I. Veitía, C. Ferroud, SpringerPlus, 2015, 4, 2.
- [7] G.-F. Pan, X.-Q. Zhu, R.-L. Guo, Y.-R. Gao, Y.-Q. Wang, Adv. Synth. Catal., 2018, 360, 4774.
- [8] L. Minuti, F. Piazzolla, A. Temperini, Eur. J. Org. Chem., 2017, 5370.
- [9] S. Zhang, Y. Liu, Y. Mao, Y. Hu, J. Gui, L. Wang, W. Wang, Adv. Synth. Catal., 2019, 361, 1554.
- [10] J. Tatsuzaki, K. F. Bastow, K. Nakagawa-Goto, S. Nakamura, H. Itokawa, K.-H. Lee, J. Nat. Prod., 2006, 69, 1445.
- [11] A. Armstrong, R. D. C. Pullina, J. N. Scutt, Synlett, 2016, 27, 151.
- [12] H. B. Zheng, Y. W. Dong, L. Li, B. Sun, L. Liu, H. X. Lou, J. Med. Chem., 2016, 59, 5063.

5. ¹H NMR and ¹³C NMR Spectra for Products

tert-butyl(*E*)-1-(2-oxo-4-phenylbut-3-en-1-yl)-3,4-dihydroisoquinoline-2(1*H*)-carb oxylate (3aa):



38000 7.60 7.54 7.50 7.7.50 7.7.50 7.14 7.14 7.118 7.118 7.118 7.118 7.118 7.118 7.118 7.118 7.5.68 $\begin{array}{c} \overbrace{-4.20}^{-4.23}\\ -3.89\\ \overbrace{-3.89}^{-3.18}\\ \overbrace{-2.37}^{-2.37}\end{array}$ -1.43 -36000 -34000 -32000 0 -30000 0 -28000 -26000 Ö -24000 ſ -22000 -20000 -18000 -16000 -14000 -12000 -10000 -8000 -6000 -4000 -2000 MARINA -0 3.00-6.38-1.00-F00.6 1.00-1.06 -1.24 1.05 3.14 3.09 H --2000 14 13 12 11 10 9 8 7 fl (ppm) 6 2 1 0 5 4 3 54.48 54.21 54.21 154.21 143.01 140.80 136.88 134.22 134.22 134.22 134.22 134.22 134.22 134.22 134.22 134.22 134.22 134.22 134.22 134.22 134.22 134.23 134.25 134.55 135.55 1 197.48 -1700 51.92 51.54 48.53 48.31 -80.25 -79.93 -77.42 -77.30 -77.10 39.31 -28.28 -21.45 -1600 -1500 -1400 0 -1300 0 -1200 0 -1100 -1000 -900 -800 -700 -600 -500 -400 -300 -200 -100 -0 -- 100 --200 110 100 fl (ppm) 210 200 190 180 170 160 150 140 130 120 90 80 70 60 50 40 30 20 10 0

tert-butyl(*E*)-1-(4-(4-chlorophenyl)-2-oxobut-3-en-1-yl)-3,4-dihydroisoquinoline-2 (1*H*)-carboxylate (3ab):

7.57 7.57 7.55 7.55 7.75 7.75 7.75 7.748 7.728 7.728 7.728 7.719 7.716 6.72 6.73 6.73 6.73 -3200 -3000 -2800 .0. -2600 0 -2400 ő -2200 ſ -2000 -1800 -1600 -1400 -1200 -1000 -800 -600 -400 -200 -0 u. 2.96- $1.21 \\ 1.00 \\ 3.00 \\ 2.12 \\ 4$ 9.00 ₹ F00.9 1.00-1.00-1.05---200 14 13 12 11 10 9 7 fl (ppm) 6 4 2 0 8 5 3 1 -136.96 -134.27 -134.27 -131.84 -128.70 -128.49 -126.38 -126.38 $\mathcal{L}^{154.59}_{154.29}$ -147.15-143.10-197.4277.42 77.42 77.30 76.78 -2000 28.83 51.97 51.57 48.58 48.34 39.38 -15.31 -1900 -1800 -1700 -1600 0 -1500 0 -1400 -1300 0 -1200 -1100 -1000 -900 -800 -700 -600 -500 -400 -300 -200 -100 -0 --100 --200 110 100 fl (ppm) 210 200 190 180 170 160 150 140 130 120 90 80 70 60 50 40 30 20 10 0

tert-butyl(*E*)-1-(4-(4-ethylphenyl)-2-oxobut-3-en-1-yl)-3,4-dihydroisoquinoline-2(1*H*)-carboxylate (3ac):



tert-butyl(*E*)-1-(4-(4-isopropylphenyl)-2-oxobut-3-en-1-yl)-3,4-dihydroisoquinolin e-2(1*H*)-carboxylate (3ad):



tert-butyl(*E*)-1-(4-(4-isobutylphenyl)-2-oxobut-3-en-1-yl)-3,4-dihydroisoquinoline -2(1*H*)-carboxylate (3ae):



tert-butyl(*E*)-1-(4-(4-(tert-butyl)phenyl)-2-oxobut-3-en-1-yl)-3,4-dihydroisoquinol ine-2(1*H*)-carboxylate (3af):



tert-butyl(*E*)-1-(4-(4-fluorophenyl)-2-oxobut-3-en-1-yl)-3,4-dihydroisoquinoline-2 (1*H*)-carboxylate (3ag):

7.57 7.52 7.52 7.45 7.145 7.13 7.15 6.70 6.70 6.70 6.70 -1.414.21 4.18 -3.88 -3.88 -3.18 -3.14 -3.14 -3.14 -2.98 -2.98 -2.77 -3800 -3600 -3400 -3200 CI -3000 0 -2800 -2600 ö ير أال -2400 -2200 -2000 -1800 -1600 -1400 -1200 -1000 -800 -600 -400 Mi -200 MAN 14 ľ -0 1.00-[1.04 -1.07 1.01 3.08 F00.6 2.97 \ 2.02 \ 4.05 \ 1.00---200 14 13 12 11 10 9 8 7 fl (ppm) 6 5 3 2 1 0 4 134.23 132.85 129.27 128.78 127.09 126.81 126.31 -197.12154.63 r141.54 -2300 -80.38 -79.99 -77.42 -77.30 -77.10 51.93 51.49 48.75 48.67 39.29 -28.32 -2200 -2100 -2000 -1900 -1800 CI 0 -1700 0 -1600 -1500 C -1400 -1300 -1200 -1100 -1000 -900 -800 -700 -600 -500 -400 -300 -200 -100 -0 -100 --200 110 100 fl (ppm) 210 200 190 180 170 160 150 140 130 120 90 80 70 60 50 40 30 20 10 0

tert-butyl(*E*)-1-(4-(4-chlorophenyl)-2-oxobut-3-en-1-yl)-3,4-dihydroisoquinoline-2 (1*H*)-carboxylate (3ah):



*t*ert-butyl(*E*)-1-(4-(4-bromophenyl)-2-oxobut-3-en-1-yl)-3,4-dihydroisoquinoline-2(1*H*)-carboxylate (3ai):

tert-butyl(*E*)-1-(4-(4-iodophenyl)-2-oxobut-3-en-1-yl)-3,4-dihydroisoquinoline-2(1 *H*)-carboxylate (3aj):





tert-butyl(*E*)-1-(4-(4-methoxyphenyl)-2-oxobut-3-en-1-yl)-3,4-dihydroisoquinolin e-2(1*H*)-carboxylate (3ak):

tert-butyl(*E*)-1-(4-(4-nitrophenyl)-2-oxobut-3-en-1-yl)-3,4-dihydroisoquinoline-2(1*H*)-carboxylate (3al):





tert-butyl(*E*)-1-(4-(2-fluorophenyl)-2-oxobut-3-en-1-yl)-3,4-dihydroisoquinoline-2 (1*H*)-carboxylate (3am):

tert-butyl(*E*)-1-(4-(2-chlorophenyl)-2-oxobut-3-en-1-yl)-3,4-dihydroisoquinoline-2 (1*H*)-carboxylate (3an):





tert-butyl(*E*)-1-(4-(2-bromophenyl)-2-oxobut-3-en-1-yl)-3,4-dihydroisoquinoline-2(1*H*)-carboxylate (3ao):

tert-butyl(*E*)-1-(4-(2-(methoxycarbonyl)phenyl)-2-oxobut-3-en-1-yl)-3,4-dihydroi soquinoline-2(1*H*)-carboxylate (3ap):



7.54 7.50 7.7.50 7.7.45 7.7.45 7.7.15 6.77 6.77 6.77 6.77 5.69 $\int_{-3.90}^{4.23}$ _3.20 _3.00 ~2.82 _2.37 -1.44 -8000 -7500 -7000 0 -6500 0 -6000 ö -5500 / -5000 -4500 -4000 -3500 -3000 -2500 -2000 -1500 -1000 juil V -500 white W -0 3.07 5.27 4 1.00-1.00 -1.19 1.04 3.08 3.17⁻ F00.6 1.07---500 14 13 12 11 10 9 8 7 fl (ppm) 6 5 3 2 1 0 4 197.25 $L_{154.48}^{154.48}$ -143.22 -143.08 -134.31 -129.54 -128.79 -128.30 -128.30 -128.30 -126.91 -126.30 -126.30 -3600 80.22 77.78 77.42 77.10 76.78 51.88 51.48 48.57 48.57 39.28 -28.26 $\sum_{21.24}^{21.43}$ -3400 -3200 -3000 0 -2800 0 -2600 -2400 ő -2200 -2000 -1800 -1600 -1400 -1200 -1000 -800 -600 -400 -200 -0 -200 110 100 fl (ppm) 210 200 190 180 170 160 150 140 130 120 90 80 70 60 50 40 30 20 10 0

tert-butyl(*E*)-1-(2-oxo-4-(m-tolyl)but-3-en-1-yl)-3,4-dihydroisoquinoline-2(1*H*)-ca rboxylate (3aq):



tert-butyl(*E*)-1-(4-(3-fluorophenyl)-2-oxobut-3-en-1-yl)-3,4-dihydroisoquinoline-2 (1*H*)-carboxylate (3ar):



tert-butyl(*E*)-1-(4-(3-chlorophenyl)-2-oxobut-3-en-1-yl)-3,4-dihydroisoquinoline-2 (1*H*)-carboxylate (3as):



tert-butyl(*E*)-1-(4-(3-fluoro-4-methoxyphenyl)-2-oxobut-3-en-1-yl)-3,4-dihydroiso quinoline-2(1*H*)-carboxylate (3at):



tert-butyl(*E*)-1-(4-(2,4-dichlorophenyl)-2-oxobut-3-en-1-yl)-3,4-dihydroisoquinoli ne-2(1*H*)-carboxylate (3au):

-3400 --0.00 ₹2.56 4.16-3.84-3.84-3.31-2.99-2.99-2.56-2.56-2.567.30 7.28 7.28 7.21 7.21 7.21 7.21 6.89 6.81 6.81 6.14 -1.44-3200 -3000 -2800 0. -2600 0 -2400 0 -2200 -2000 -1800 -1600 -1400 -1200 -1000 -800 -600 -400 -200 -0 0.94 1.98 7.00 1.08 1.08 F70.0 1.25 6.08 2.00 − 1 F00.6 1.00--200 14 13 12 11 10 9 6 5 4 3 2 1 0 8 7 fl (ppm) 2000 -154.24-146.54 _131.38 -129.01 -128.54 -128.35 -128.35 -128.35 -126.98 -126.85 -126.33 -126.33 -197.59 77.31 77.31 77.31 77.10 L51.98 L51.56 -47.56 -37.54 -34.17 -28.35 -1900 -1800 -1700 -1600 -1500 0 -1400 0 -1300 -1200 0 -1100 -1000 -900 -800 -700 -600 -500 -400 -300 -200 -100 -0 --100 --200 210 200 190 180 170 160 150 140 130 120 110 100 90 fl (ppm) 80 70 60 50 40 30 20 10 0 -10

tert-butyl(*E*)-1-(2-oxo-6-phenylhex-3-en-1-yl)-3,4-dihydroisoquinoline-2(1*H*)-car boxylate (3av):



tert-butyl(*E*)-1-(2-oxodec-3-en-1-yl)-3,4-dihydroisoquinoline-2(1*H*)-carboxylate (3aw):





tert-butyl(E) - 5 - bromo - 1 - (2 - oxo - 4 - phenylbut - 3 - en - 1 - yl) - 3, 4 - dihydroisoquinoline - 2 - yl) - 3, 4 - yl) -





tert-butyl(*E*)-7-nitro-1-(2-oxo-4-phenylbut-3-en-1-yl)-3,4-dihydroisoquinoline-2(1 *H*)-carboxylate(3da):



di-*tert*-butyl(*E*)-1-(2-methylene-4-phenylbut-3-en-1-ylj)-3,4-dihydro-1*H*-pyrido[3, 4-*b*]indole-2,9-dicarboxylate (3ea):



7.347.327.327.327.327.237.207.237.207.006.966.966.94 $\begin{array}{c} 4.42\\ 4.40\\ 4.43\\ 4.15\\ 4.16\\ 4.14\\ 4.14\\ 3.23\\ 3.23\\ 3.23\\ 2.296\\ -2.296\\ -2.296\\ -2.296\\ -2.296\\ -2.296\\ -2.72\\$ --0.00 -5500 -5000 H -4500 H, |,|, [] / -4000 ő -3500 -3000 -2500 -2000 -1500 -1000 -500 -0 4.12 1.18 3.17 ∄ 1.00 1.00-I 1.00-I 1.00-<u>∓</u> 7.40-<u></u> -- 500 14 13 12 11 10 9 8 6 5 3 2 1 0 7 fl (ppm) 4 $\begin{array}{c} 139.42\\ 136.81\\ -134.03\\ 129.00\\ 129.00\\ 128.32\\ 129.06\\ 128.32\\ 128.06\\ 128.32\\ 126.04\\ 126.04\end{array}$ -208.74 77.42 77.10 76.78 -63.78 -29.02 -54.42 46.78 -11000 -10000 H -9000 H -8000 ö -7000 -6000 -5000 -4000 -3000 -2000 -1000 -0 -1000 110 100 fl (ppm) 210 200 190 180 170 160 150 140 130 120 90 80 70 60 50 40 30 20 10 0

(4*S*,11b*S*)-4-Phenyl-1,3,4,6,7,11b-hexahydro-2*H*-pyrido[2,1-α]isoquinolin-2-one (4a):

3.86 3.64 3.64 3.61 3.61 2.73 2.60 2.23 2.21 2.21 2.21 2.17 ---0.00 $\begin{array}{c} 7.42\\ 7.42\\ 7.42\\ 7.738\\ 7.738\\ 7.733\\ 7.733\\ 7.733\\ 7.733\\ 7.732\\ 7.732\\ 7.732\\ 7.732\\ 7.732\\ 7.712$ -11000 -10000 -9000 H H. [] -8000 -7000 -6000 -5000 -4000 -3000 -2000 -1000 hh MMUL λİ -0 3.00⊣ 4.05⊣ 5.28 4.03 4 1.00 ± 1.00 ± 1.00-1 -- 1000 14 13 12 11 10 9 7 fl (ppm) 6 5 3 2 1 0 8 4 -142.37 -207.52 -62.4849.96 47.55 47.23 -29.91 -7000 -6500 -6000 H -5500 -5000 ö -4500 -4000 -3500 -3000 -2500 -2000 -1500 -1000 -500 -0 -500 110 100 fl (ppm) 210 200 190 180 170 160 150 140 130 120 90 80 70 60 50 40 30 20 10 0

(4*R*,11b*R*)-4-Phenyl-1,3,4,6,7,11b-hexahydro-2*H*-pyrido[2,1-α]isoquinolin-2-one (4b):