SUPPORTING INFORMATION

FOR

Water as a green solvent for efficient synthesis of isocoumarins through microwave-accelerated and Rh/Cu-catalyzed C-H/O-H bond functionalizations

Qiu Li[1,3], Yunnan Yan[1,4], Xiaowei Wang[1,5], Binwei Gong[1,5], Xiaobo Tang[1], JingJing Shi[1], H. Eric Xu[1,2*], Wei Yi[1*].

[1]*VARI/SIMM Center, Center for Structure and Function of Drug Targets, CAS-Key Laboratory of Receptor Research, Shanghai Institute of Materia Medica, Chinese Academy of Sciences, Shanghai 201203, P.R. China*

[2]*Laboratory of Structural Sciences, Program on Structural Biology and Drug Discovery, Van Andel Research Institute, Grand Rapids, Michigan 49503, USA*

[3]*Nano Science and Technology Institute, University of Science and Technology of China, Suzhou, Jiangsu 215123, P.R.China*

[4] *College of Pharmaceutical Sciences, Gannan Medical University, Ganzhou, Jiangxi 341000,P.R. China*

[5] *College of Pharmaceutical and Biological Engineering, Shenyang University of Chemical Technology, Shenyang 110142, P. R. China*

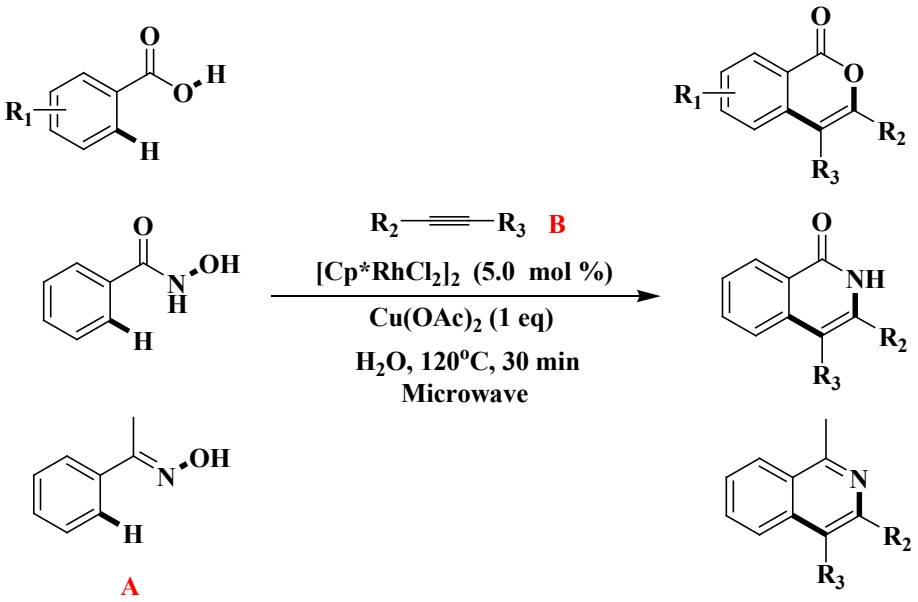
[*] Correspondence to Prof H. Eric Xu and Dr Wei Yi. Tel: 86-21-20231000-2507 Fax: 86-21-20231000-1715, E-mail:eric.xu@vai.org and yiwei.simm@simm.ac.cn.

General methods and materials

Catalysts $[Cp^*RhCl_2]_2$ and $[RuCl_2(p\text{-cymene})]_2$ were purchased from Suzhou Sinocompound Technology Co., Ltd. Other chemicals were purchased from adamas-beta or other commercial suppliers and were dried and purified when necessary. The water used was re-distillated and ion-free.

Melting points were determined on a WRS-1B digital instrument without correction. ^1H and ^{13}C NMR spectra were recorded on a Varian Mercury-Plus 400 or 500 NMR instrument (^1H 400 MHz; ^{13}C 125 MHz) in either $CDCl_3$ or DMSO-d_6. Abbreviations for data quoted are s, singlet; br s, broad singlet; d, doublet; t, triplet; dd, doublet of doublets; m, multiplet. Mass spectra and high-resolution mass spectra were measured on a Finnigan MAT-95 mass spectrometer. All the experiments involving microwave irradiation were performed on a *Biotage Initiator* Microwave Synthesizer. Thin-layer chromatographies were done on pre-coated silica gel 60 F254 plates (Merck). Silica gel 60H (200-300 mesh) manufactured by Qingdao Haiyang Chemical Group Co. (China) was used for general chromatography.

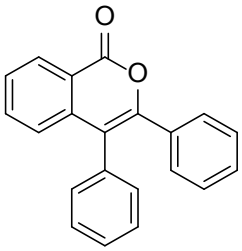
General procedure for preparation of isocoumarins and isoquinolones



A biotage microwave vial was charged with Rh catalyst (5 mol%) H_2O (1 mL), substrate A (0.25 mmol), substrate B (0.3 mmol) and $Cu(OAc)_2 \cdot H_2O$ (0.5 mmol). The vial was capped and heated in the microwave reactor at 120 ^oC for 30 min. A sample of the cool reaction mixture was extracted with ethyl acetate. The organic phase was dried over anhydrous sodium sulfate, filtered and evaporated. The crude product was purified by chromatography on a silica gel column to afford the corresponding product.

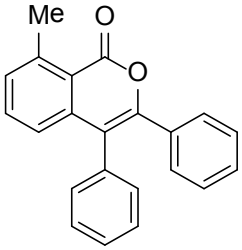
Characterization data of compounds

3, 4-diphenyl-1H-isochromen-1-one
(Scheme 1, 3aa, CAS 1684-07-7)[1]



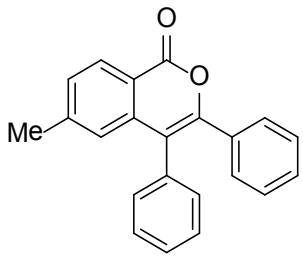
The general procedure was followed using benzoic acid (**1a,** 0.25mmol) and 1, 2-diphenylethyne (**2a**, 0.3mmol). Purification by column chromatography (n-hexane/EtOAc: 40/1→20/1) yield **3aa** (85%) as a colorless solid; m p 170-171 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 8.44-8.40 (m, 1H), 7.65 (ddd, *J* = 8.0, 7.3, 1.5 Hz, 1H), 7.57-7.51 (m, 1H), 7.47-7.38 (m, 3H), 7.36 -7.32 (m, 2H), 7.29-7.17 (m, 6H).

8-methyl-3,4-diphenyl-1H-isochromen-1-one
(Scheme 1, 3ba, CAS 935762-78-0)[1]



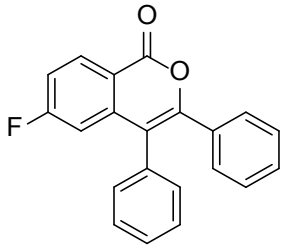
The general procedure was followed using 2-methyl benzoic acid (**1b**, 0.25mmol) and 1, 2-diphenylethyne (**2a**, 0.3mmol). Purification by column chromatography (n-hexane/EtOAc : 40/1→20/1) yield **3ba** (82%) as a colorless solid; mp 139-140 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.49-7.37 (m, 4H), 7.34-7.28 (m, 3H), 7.26-7.16 (m, 5H), 7.01 (ddd, *J* = 8.2, 1.2, 0.6 Hz, 1H), 2.92 (d, *J* = 0.8 Hz, 3H).

6-methyl-3,4-diphenyl-1H-isochromen-1-one (Scheme 1, 3ca, CAS 935762-75-7)[1]



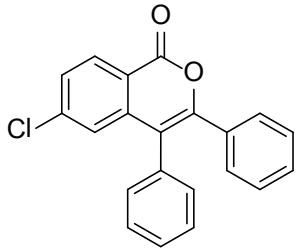
The general procedure was followed using 4-methylbenzoic acid (**1c**, 0.25mmol) and 1, 2-diphenylethyne (**2a**, 0.3mmol). Purification by column chromatography (*n*-hexane/EtOAc : 40/1→20/1) yield **3ca** (78%) as a colorless solid; mp 183-184 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 8.30 (d, *J* = 8.1 Hz, 1H), 7.45-7.38 (m, 3H), 7.35-7.30 (m, 3H), 7.25-7.15 (m, 5H), 6.99-6.94 (m, 1H), 2.37 (s, 3H).

6-fluoro-3,4-diphenyl-1H-isochromen-1-one (Scheme 1, 3da)



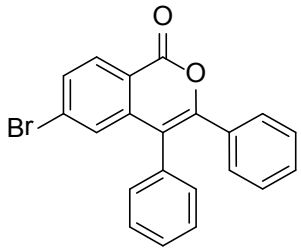
The general procedure was followed using 4-fluorobenzoic acid (**1d**, 0.25mmol) and 1, 2-diphenylethyne (**2a**, 0.3mmol). Purification by column chromatography (*n*-hexane/EtOAc: 40/1→20/1) yield **3da** (52%) as a colorless solid. mp 154-155 °C. ^{1}H-NMR (400 MHz, $CDCl_3$) δ: ^{1}H-NMR (400 MHz, $CDCl_3$) δ: 8.43 (dd, *J* = 8.8, 5.8 Hz, 1H), 7.43 (dd, *J* = 5.1, 1.9 Hz, 3H), 7.36-7.29 (m, 3H), 7.26-7.15 (m, 5H), 6.84 (dd, *J* = 10.1, 2.5 Hz, 1H); ^{13}C NMR (125MHz, $CDCl_3$) δ: 166.3 (d, *J* = 255.7 Hz), 160.9, 151.7, 141.4 (d, *J* = 10.4 Hz), 133.3, 132.4, 132.2 (d, *J* = 10.2 Hz), 130.6, 128.8, 128.8, 128.0, 127.4, 116.4, 115.9 (d, *J* = 23.4 Hz), 115.9 (d, *J* = 2.5 Hz), 110.9 (d, *J* = 24.1 Hz); MS (EI): *m/z* 316 $[M]^+$, 288, 239, 183, 105, 77; HRMS (EI) calcd for $C_{21}H_{13}FO_2$ $[M]^+$: 316.0900, found 316.0897.

6-Chloro-3,4-diphenyl-1H-isochromen-1-one
(Scheme 1, 3ea, CAS 935762-76-8)[1]



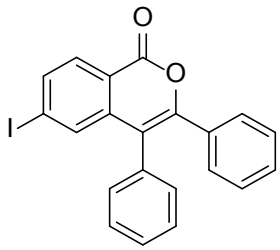
The general procedure was followed using 4-chlorobenzoic acid (**1e**, 0.25mmol) and 1, 2-diphenylethyne (**2a**, 0.3mmol). Purification by column chromatography (*n*-hexane/EtOAc: 40/1) yield **3ea** (64%) as a colorless solid; mp 166−167 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ: ^{1}H NMR (400 MHz, $CDCl_3$) δ: 8.25 (d, J = 8.4 Hz, 1H), 7.64 (dd, *J* = 8.4, 1.9 Hz, 1H), 7.44 (dd, *J* = 5.1, 2.0 Hz, 3H), 7.36-7.31 (m, 2H), 7.30 (d, *J* = 1.7 Hz, 1H), 7.26-7.22 (m, 3H), 7.21 (t, *J* = 1.1 Hz, 1H), 7.20-7.17 (m, 1H); ^{13}C-NMR (125MHz, $CDCl_3$) δ: 161.4, 152.1, 141.6, 140.3, 133.6, 132.5, 131.2, 131.1, 129.3, 129.2, 128.5, 128.4, 127.8, 124.9, 118.7, 116.0.

6-Bromo-3,4-diphenyl-1H-isochromen-1-one
(Scheme 1, 3fa)



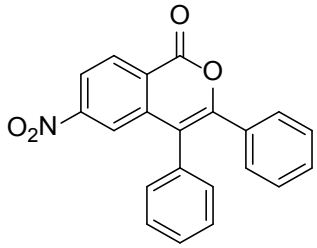
The general procedure was followed using 4-bromobenzoic acid (**1f**, 0.25mmol) and 1, 2-diphenylethyne (**2a**, 0.3mmol). Purification by column chromatography (*n*-hexane/EtOAc: 80/1) yield **3fa** (68%) as a colorless solid; mp 196-197 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ: ^{1}H NMR (400 MHz, $CDCl_3$) δ: 8.25 (d, *J* = 8.4 Hz, 1H), 7.64 (dd, *J* = 8.5, 1.8 Hz, 1H), 7.51-7.38 (m, 4H), 7.38-7.28 (m, 4H), 7.20 (t, *J* = 7.4 Hz, 3H); ^{13}C-NMR (125MHz, $CDCl_3$) δ: 161.6, 152.1, 140.4, 133.5, 132.5, 131.4, 131.1, 131.1, 130.4, 129.3, 129.2, 129.2, 128.4, 128.0, 127.9, 119.1, 115.9; MS (EI): *m/z* 376[M]$^{+}$, 348, 332, 301, 269, 239, 163, 105, 77; HRMS (EI) calcd for $C_{21}H_{13}BrO_2$ [M]$^{+}$: 376.0099, found 376.0092.

6-Iodo-3,4-diphenyl-1H-isochromen-1-one
(Scheme 1, 3ga)



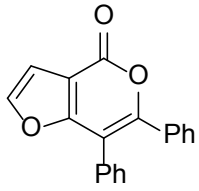
The general procedure was followed using 4-iodobenzoic acid (**1g**, 0.25mmol) and 1, 2-diphenylethyne (**2a**, 0.3mmol). Purification by column chromatography (*n*-hexane/EtOAc: 40/1) yield **3ga** (47%) as a pale yellow solid. mp 215-16 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 8.08 (d, J = 8.3 Hz, 1H), 7.86 (dd, J = 8.2, 1.8 Hz, 1H), 7.55 (d, J = 1.8 Hz, 1H), 7.42 (q, J = 3.9, 3.3 Hz, 3H), 735-7.16 (m, 7H); ^{13}C NMR(125 MHz, $CDCl_3$) δ: 161.4, 151.6, 139.7, 136.8, 134.2, 133.8, 133.1, 132.1, 130.8, 130.7, 130.3, 129,1, 128.8, 128.8, 128.6, 128.0, 127.6, 127.4, 127.4, 124.9, 119.1, 115.2, 103.1; MS (EI): *m/z* 424$[M]^+$, 396, 347, 269, 239, 163, 105, 77; HRMS (EI) calcd for $C_{21}H_{13}IO_2$ $[M]^+$: 423.9960, found 423.9953.

6-Nitro-3,4-diphenyl-1H-isochromen-1-one
(Scheme 1, 3ha)



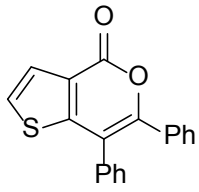
The general procedure was followed using 4-nitrobenzoic acid (**1h**, 0.25mmol) and 1, 2-diphenylethyne (**2a**, 0.3mmol). Purification by column chromatography (*n*-hexane/EtOAc: 40/1) yield **3ha** (31%) as a yellow solid; mp 177−178 °C. ^{1}H-NMR (400 MHz, $CDCl_3$) δ: 8.58 (d, J = 8.6 Hz, 1H), 8.28 (dd, J = 8.5, 2.1 Hz, 1H), 8.04 (d, J = 2.1 Hz, 1H), 7.52-7.40 (m, 3H), 7.39-6.91 (m, 7H); ^{13}C-NMR (125MHz, $CDCl_3$) δ: 160.5, 153.1, 151.7, 140.3, 132.8, 132.0, 131.5, 131.2, 130.9, 129.7, 129.6, 129.4, 129.2, 128.9, 128.0, 124.2, 121.9, 120.5, 116.2; MS (EI): *m/z* 343$[M]^+$, 315, 298, 296, 268, 239, 163, 149, 105, 77; HRMS (ESI) *m/z* calcd for $C_{21}H_{13}NO_4$ $[M]^+$: 343.0845, found 343.0836.

6, 7-Diphenyl-4H-furo[3,2-c]pyran-4-one
(Scheme 2, 3ia, CAS 1147304-41-3)



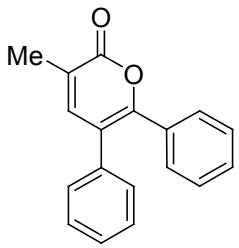
The general procedure was followed using furan-3-carboxylic acid (**1i**, 0.25mmol) and 1, 2-diphenylethyne (**2a**, 0.3mmol). Purification by column chromatography (*n*-hexane/EtOAc: 40/1) yield **3ia** (37%) as a yellow solid; mp 172-173 °C. ^{1}H-NMR (400 MHz, $CDCl_3$) δ: 8.04 (d, *J* = 2.1 Hz, 1H), 7.47-7.27 (m, 10H), 7.16 (d, *J* = 2.1 Hz, 1H); ^{13}C-NMR (125MHz, $CDCl_3$) δ: 161.3, 159.0, 155.2, 144.6, 131.9, 130.4, 129.7, 129.4, 128.9, 128.5, 128.1, 110.6, 109.6, 107.9; MS (EI): *m/z* 288$[M]^+$, 211, 105, 77; HRMS (EI) calcd for $C_{19}H_{12}O_3$ $[M]^+$: 288.0786, found 288.0782.

6, 7-Diphenyl-4H-thieno[3,2-c]pyran-4-one
(Scheme 2, 3ja, CAS 1147304-41-3)[2]



Following the general procedure was followed using thiophene-3-carboxylic acid (**1j**, 0.25mmol) and 1, 2-diphenylethyne (**2a**, 0.3mmol). Purification by column chromatography (*n*-hexane/EtOAc: 40/1) yield **3ka** (45%) as a maize yellow solid; mp 163-164 °C; ^{1}H-NMR (400 MHz, $CDCl_3$) δ: 7.68 (d, *J* = 5.4 Hz, 1H), 7.44-7.33 (m, 9H), 7.26-7.20 (m, 2H); ^{13}C-NMR (125MHz, $CDCl_3$) δ: 162.8, 154.9, 143.6, 136.1, 131.7, 129.1, 128.8, 128.6, 128.4, 127.6, 127.3, 123.3, 117.6.

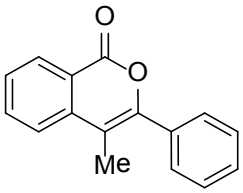
3-methyl-5, 6-diphenyl-3, 4-dihydro-2H-pyran-2-one
(Scheme 2, 3ka, CAS 212315-82-7)[3]



The general procedure was followed using furan-3-carboxylic acid (**1k**, 0.25mmol) and 1, 2-diphenylethyne (**2a**, 0.3mmol). Purification by column chromatography

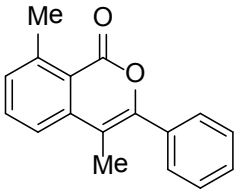
(*n*-hexane/EtOAc: 40/1) yield **3ka** (61%) as a colorless solid; mp 142-143 °C; ^{1}H-NMR (400 MHz, $CDCl_3$) δ: 7.39-7.14 (m, 11H), 2.30 (d, *J* = 1.3 Hz, 3H); ^{13}C-NMR (125MHz,$CDCl_3$) δ: 157.9, 154.3, 151.4, 134.4, 131.6, 129.4, 129.1, 128.3, 127.6, 126.0, 125.6, 123.1, 114.7, 13.8.

4-methyl-3-phenyl-1H-isochromen-1-one (Scheme 3, 3ab, CAS 550365-37-2)[1]



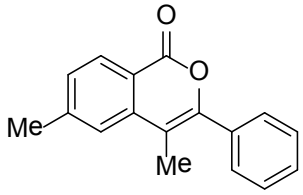
The general procedure was followed using benzoic acid (**1a**, 0.25mmol) and prop-1-yn-1-ylbenzene (**2b**, 0.3mmol). Purification by column chromatography (*n*-hexane/EtOAc: 40/1→20/1) yield **3ab** (88%) as a colorless solid; mp 110-111 °C; ^{1}H-NMR (400 MHz, $CDCl_3$) δ: 8.37 (ddd, *J* = 7.9, 1.4, 0.6 Hz, 1H), 7.80 (ddd, *J* = 8.1, 7.2, 1.4 Hz, 1H), 7.64 (ddd, *J* = 8.1, 1.1, 0.6 Hz, 1H), 7.61-7.59 (m, 1H), 7.58 (dd, *J* = 2.4, 1.3 Hz, 1H), 7.55 (ddd, *J* = 7.9, 7.2, 1.1 Hz, 1H), 7.50-7.41 (m, 3H), 2.32 (s, 3H).

3,8-Dimethyl-4-phenyl-1H-isochromen-1-one (Scheme 3, 3bb)



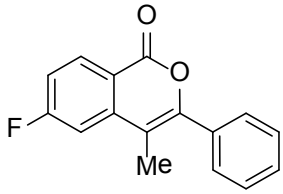
The general procedure was followed using 2-methylbenzoic acid (**1b**, 0.25mmol) and prop-1-yn-1-ylbenzene (**2b**, 0.3mmol). Purification by column chromatography (*n*-hexane/EtOAc: 40/1→20/1) yield **3bb** (92%) as a pale yellow solid; mp 131-132 °C; ^{1}H-NMR (400 MHz, $CDCl_3$) *δ*: 7.66-7.58 (m, 3H), 7.52-7.41 (m, 4H), 7.35 (d, *J*=8.0Hz, 1H), 2.88 (s,3H),2.28 (s,3H); ^{13}C-NMR (125MHz, $CDCl_3$) *δ*: 161.3, 150.6, 143.3, 139.9, 133.4, 133.0, 130.5, 129.1, 128.8, 127.8, 120.9, 118.9, 108.5, 23.2, 13.6; MS (EI): *m/z* 250$[M]^+$, 222, 207, 178, 115, 105, 77. HRMS (EI) calcd for $C_{17}H_{14}O_2$ $[M]^+$: 250.0994, found 250.0953.

3, 6-Dimethyl-4-phenyl-1H-isochromen-1-one
(Scheme 3, 3cb)



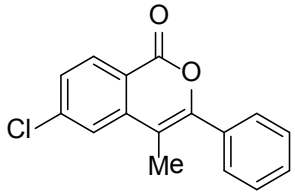
The general procedure was followed using 4-methylbenzoic acid (**1c**, 0.25mmol) and prop-1-yn-1-ylbenzene (**2b**, 0.3mmol). Purification by column chromatography (*n*-hexane/EtOAc: 40/1→20/1) yield **3cb** (94%) as a colorless solid; mp 100-101 °C. ^{1}H-NMR (400 MHz, $CDCl_3$) δ: 8.26 (d, J = 8Hz,1H), 7.60-7.57 (m, 2H), 7.48-7.40 (m, 4H), 7.36(dd, J = 8.0Hz,1H),2.54 (s, 3H),2.30(s, 3H). ^{13}C-NMR (125MHz, $CDCl_3$) δ: 162.1, 150.8, 145.3, 138.4, 132.9, 129.3, 129.0, 128.8, 128.8, 127.8, 123.0, 117.9, 108.6, 21.9, 13.1; MS (EI): *m/z* 250$[M]^+$, 222, 221, 207, 178, 161, 115, 105, 77; HRMS (EI) calcd for $C_{17}H_{14}O_2$ $[M]^+$: 250.0994, found 250.0988.

6-Fluoro-3-methyl-4-phenyl-1H-isochromen-1-one
(Scheme 3, 3db)



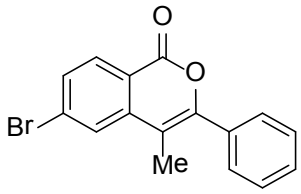
The general procedure was followed using 4-fluorobenzoic acid (**1d**, 0.25mmol) and prop-1-yn-1-ylbenzene (**2b**, 0.3mmol). Purification by column chromatography (*n*-hexane/EtOAc: 40/1) yield **3db** (65%) as a colorless solid; mp 128-129 °C; δ: ^{1}H-NMR (400 MHz,$CDCl_3$) δ: 8.40 (dd, J = 8.6, 5.8 Hz, 1H), 7.58 (dq, J = 4.8, 2.7 Hz, 2H), 7.53-7.42 (m, 3H), 7.26 (s, 3H), 2.28 (s, 3H); ^{13}C-NMR (125 MHz, $CDCl_3$) δ: 166.5 (d, J = 256.0 Hz), 161.1, 152.0, 141.4 (d, J = 9.8 Hz), 132.6(d, J = 10.3 Hz), 132.4, 129.9, 129.2, 129.0, 128.7, 128.0, 127.9, 116.8, 115.6 (d, J = 23.1 Hz), 109.1 (d, J = 23.3 Hz), 108.2 (d, J = 3.0 Hz), 13.2; MS (EI): *m/z* 254$[M]^+$, 226, 225, 196, 105, 77; HR-MS (EI) calcd for $C_{16}H_{11}FO_2$ $[M]^+$: 254.0743, found 254.0740.

6-Chloro-3-methyl-4-phenyl-1H-isochromen-1-one (Scheme 3, 3eb, CAS 1357398-36-7)[4]



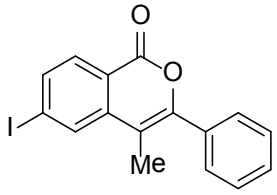
The general procedure was followed using 4-chlorobenzoic acid (**1e**, 0.25mmol) and prop-1-yn-1-ylbenzene (**2b**, 0.3mmol). Purification by column chromatography (*n*-hexane/EtOAc: 40/1→20/1) yield **3eb** (66%) as a pale yellow solid; mp 130-131 °C; ^{1}H-NMR (400 MHz,$CDCl_3$) δ: 8.31 (d, J = 8.0 Hz, 1H), 7.63-7.55 (m, 3H), 7.53-7.42 (m, 4H), 2.30 (d, J = 7.3 Hz, 3H); MS (EI): *m/z* 270$[M]^+$, 255, 221, 178, 163, 105, 77; HRMS (EI) calcd for $C_{16}H_{11}ClO_2$ $[M]^+$: 270.0448,found 270.0438.

6-Bromo-3-methyl-4-phenyl-1H-isochromen-1-one (Scheme 3, 3fb, CAS 1357398-35-6)[4]



The general procedure was followed using 4-bromobenzoic acid (**1f**, 0.25mmol) and prop-1-yn-1-ylbenzene (**2b**, 0.3mmol). Purification by column chromatography (*n*-hexane/EtOAc: 40/1) yield **3fb** (51%) as a colorless solid. mp 113-114 °C; ^{1}H-NMR (400 MHz, $CDCl_3$) δ: 8.23 (d, J = 8.4 Hz, 1H), 7.79 (d, J = 1.9 Hz, 1H), 7.67 (ddd, J = 8.5, 1.8, 0.5 Hz, 1H), 7.63-7.53 (m, 2H), 7.55-7.41 (m, 3H), 2.30 (s, 3H); MS (EI): *m/z* 314$[M]^+$, 286, 207, 178, 105, 77; HRMS (EI) calcd for $C_{16}H_{11}BrO_2$ $[M]^+$: 313.9942, found 313.9954.

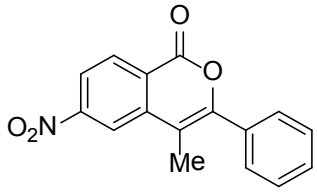
6-Iodo-3-methyl-4-phenyl-1H-isochromen-1-one (Scheme 3, 3gb, CAS 1357398-37-8)[4]



The general procedure was followed using 4-fluorobenzoic acid (**1g**, 0.25mmol) and prop-1-yn-1-ylbenzene (**2b**, 0.3mmol). Purification by column chromatography (*n*-hexane/EtOAc: 40/1) yield **3gb** (32%) as a colorless solid; mp 139-140 °C. ^{1}H-NMR (400 MHz,

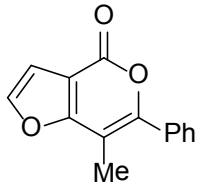
$CDCl_3$) δ: 8.08-7.97 (m, 2H), 7.87 (dd, *J* = 8.4, 1.6 Hz, 1H), 7.57 (tq, *J* = 5.9, 2.6 Hz, 2H), 7.46 (dd, *J* = 5.2, 2.3 Hz, 3H), 2.28 (d, *J* = 2.1 Hz, 3H); MS (EI): *m/z* 362$[M]^+$, 334, 207, 178, 105, 77; HRMS (EI) calcd for $C_{16}H_{11}IO_2$ $[M]^+$: 361.9804, found 361.9815.

3-Methyl-6-nitro-4-phenyl-1H-isochromen-1-one
(Scheme 3, 3hb)



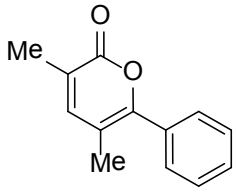
The general procedure was followed using 4-nitrobenzoic acid (**1h**, 0.25mmol) and prop-1-yn-1-ylbenzene (**2b**, 0.3mmol). Purification by column chromatography (*n*-hexane/EtOAc: 40/1) yield **3hb** (29%) as a yellow solid; mp 198-199 °C; ^{1}H-NMR (400 MHz, $CDCl_3$) δ: 8.55 (d, *J* = 8.6 Hz, 1H), 8.49 (d, *J* = 2.1 Hz, 1H), 8.32 (dd, *J* = 8.6, 2.1 Hz, 1H), 7.65-7.56 (m, 2H), 7.56-7.41 (m, 3H), 2.40 (s, 3H); ^{13}C-NMR (125MHz, $CDCl_3$) δ: 160.2, 152.9, 151.3, 139.8, 131.9, 131.3, 129.8, 129.6, 129.1, 129.0, 128.0, 124.4, 121.4, 120.9, 118.4, 108.2, 13.3; MS (EI): *m/z* 281$[M]^+$, 266, 253, 234, 207, 206, 164, 163, 105, 77; HRMS (EI) calcd for $C_{16}H_{11}NO_4$ $[M]^+$:281.0688,found 281.0693.

3, 6-Dimethyl-4-phenyl-1H-isochromen-1-one
(Scheme 3, 3ib)



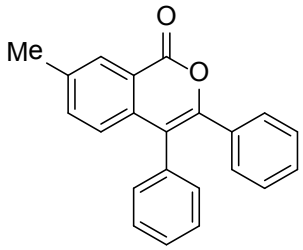
The general procedure was followed using furan-3-carboxylic acid (**1i**, 0.25mmol) and prop-1-yn-1-ylbenzene (**2b**, 0.3mmol). Purification by column chromatography (*n*-hexane/EtOAc: 40/1) yield **3ib** (78%) as a wheat solid; mp 65-66 °C; ^{1}H-NMR (400 MHz, $CDCl_3$) δ: 7.69-7.53 (m, 3H), 7.47 (dt, *J* = 6.6, 3.0 Hz, 3H), 6.96 (d, *J* = 2.1 Hz, 1H), 2.36 (s, 3H); ^{13}C-NMR(125MHz, $CDCl_3$) δ: 162.7, 159.4, 155.0, 144.2, 132.0, 129.6, 128.8, 128.3, 109.2, 107.9, 104.3, 10.7; MS (EI): *m/z* 226$[M]^+$, 198, 197, 105, 77; HRMS (EI) calcd for $C_{14}H_{10}O_3$[M] $^+$: 226.0630,found 226.0627.

3, 5-dimethyl-6-phenyl-2H-pyran-2-one
(Scheme 3, 3kb, CAS 19611-15-5)[5]



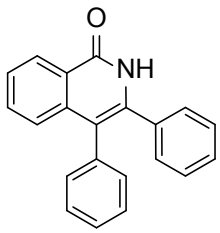
The general procedure was followed using furan-3-carboxylic acid (**1k**, 0.25mmol) and prop-1-yn-1-ylbenzene (**2b**, 0.3mmol). Purification by column chromatography (*n*-hexane/EtOAc: 40/1) yield **3kb** (66%) as a colorless solid; mp 124-126 °C; ^{1}H-NMR (400 MHz, $CDCl_3$) δ=7.58-7.54 (m, 2H), 7.47-7.39 (m, 3H), 7.11 (q, J = 1.1 Hz, 1H), 2.15 (s, 3H), 2.14 (s, 3H); MS (EI): *m/z* 200[M]$^+$, 172, 129, 105, 77; HRMS (EI) calcd for $C_{13}H_{12}O_2$ [M] $^+$: 200.0837,found 200.0831.

7-methyl-3, 4-diphenyl-1H-isochromen-1-one
(Scheme 4, 3la, CAS 93743-65-8)[1]



The general procedure was followed using 3-methylbenzoic acid (**1l**, 0.25mmol) and 1, 2-diphenylethyne (**2a**, 0.3mmol). Purification by column chromatography (n-hexane/EtOAc=40/1→20/1) yield **3la** (75%) as a colorless solid. mp 172-173°C. ^{1}H-NMR (400 MHz, $CDCl_3$) δ: 8.22 (s, 1H), 7.51-7.36 (m, 4H), 7.32 (d, J = 7.1 Hz, 2H), 7.25-7.05 (m, 6H), 2.48 (s, 3H).

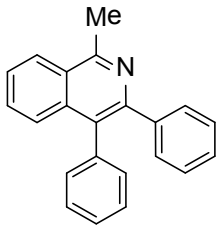
3, 4-diphenylisoquinolin-1(2H)-one
(Scheme 6, 5, CAS 93119-96-1)[6]



The general procedure was followed using Benzohydroxamic acid (**4**, 0.25mmol) and 1, 2-diphenylethyne (**2a**, 0.3mmol). Purification by column chromatography

(*n*-hexane/EtOAc:4/1→2/1) yield **5** (51%) as a colorless solid; mp 251-252 °C; ^{1}H-NMR (400 MHz, DMSO-d_6) δ: 11.55 (s, 1H), 8.32 (dd, J = 8.2, 1.5 Hz, 1H), 7.65 (ddd, J = 8.4, 7.1, 1.5 Hz, 1H), 7.52 (ddd, J = 8.1, 7.1, 1.2 Hz, 1H), 7.33 -7.25 (m, 3H), 7.23 (s, 5H), 7.19-7.11 (m, 3H); MS (ESI): *m*/*z* 298.1[M+H]$^+$; HRMS (ESI) calcd for $C_{22}H_{17}N$ [M+H]$^+$: 298.1154, found 298.1226.

1-methyl-3, 4-diphenylisoquinoline (Scheme 6, 7, CAS93472-50-5)[7]

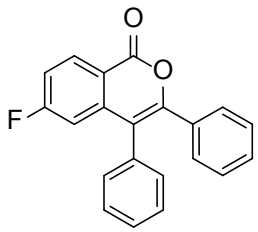


The general procedure was followed using (E)-acetophenone oxime (**6**, 0.25mmol) and 1, 2-diphenylethyne (**2a**, 0.3mmol). Purification by column chromatography (n-hexane/EtOAc: 40/1) yield **7** (47%) as a colorless solid; mp 145-146 °C; ^{1}H-NMR (400 MHz, DMSO-d_6) δ: 8.24-8.16 (m, 1H), 7.66 (ddd, J = 6.9, 3.8, 2.7 Hz, 1H), 7.62-7.54 (m, 2H), 7.42-7.29 (m, 5H), 7.27-7.13 (m, 5H), 3.08 (s, 3H); MS (ESI): *m*/*z* 296.4[M+H]$^+$; HRMS (ESI) calcd for $C_{22}H_{17}N$ [M+H]$^+$: 296.1361,found 296.1438.

Notes and references

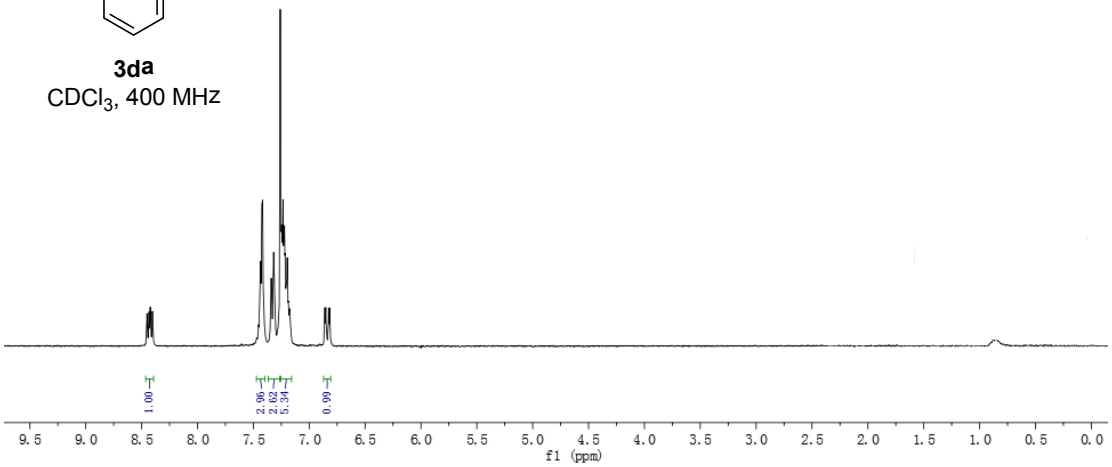
1. K. Ueura, T. Satoh and M. Miura. *Org. Lett.*, 2007, **9**, 1407-1409.
2. S. Mochida, K. Hirano, T. Satoh and M. Miura, *J. Org. Chem.*, 2009, **74**, 3478-3483.
3. L. Ackermann, J. Pospech , K. Graczyk and K. Rauch, *Org. Lett.*, 2012, **14***,* 930-933.
4. R. K. Chinnagolla and M. Jeganmohan, *Chem. Commun.*, 2012, **48**, 2030- 2032 .
5. S. Mochida, K. Hirano, T. Satoh and M. Miura, *J. Org. Chem.*, 2009, **74**, 6295-6298.
6. H. Shiota , Y. Ano, Y. Aihara, Y. Fukumoto and N. Chatani, *J. Am. Chem. Soc.*, 2011, **133**, 14952-14955.
7. K. Parthasarathy, M. Jeganmohan, and C.H. Cheng, *Org. Lett.*, 2008, **10**, 325-328.

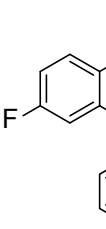
^{1}H- and ^{13}C- Spectra of all the new compounds



3da

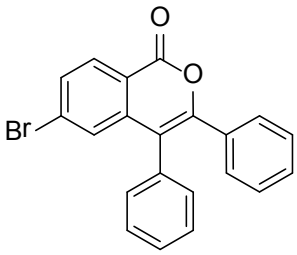
$CDCl_3$, 400 MHz





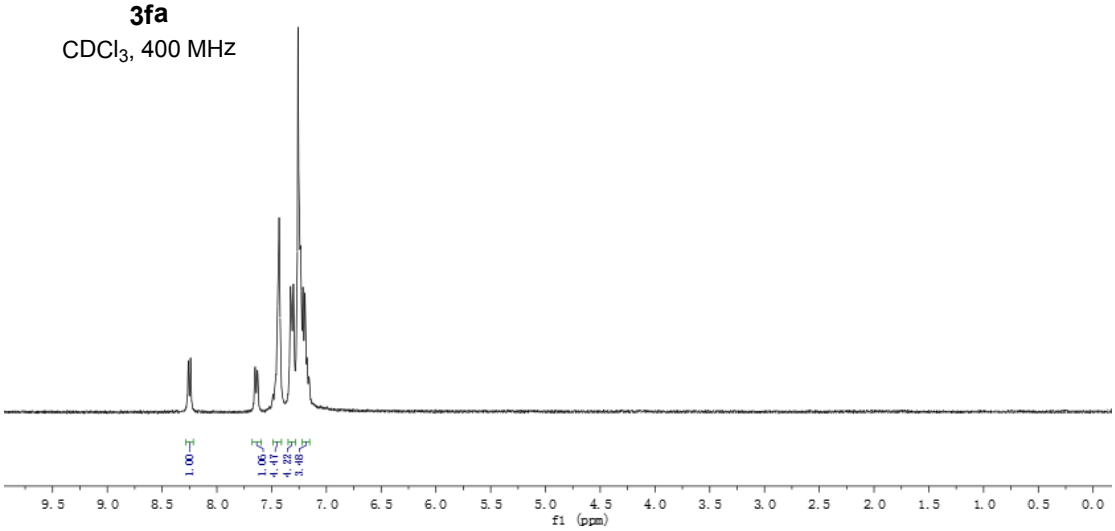
3da

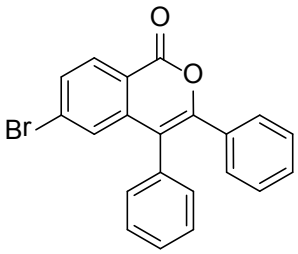
$CDCl_3$, 125 MHz



3fa

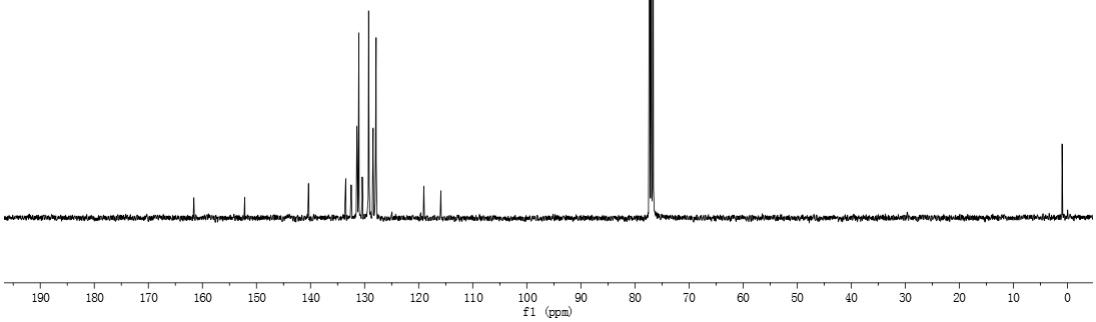
$CDCl_3$, 400 MHz

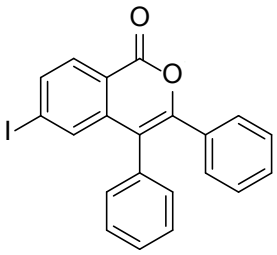




3fa

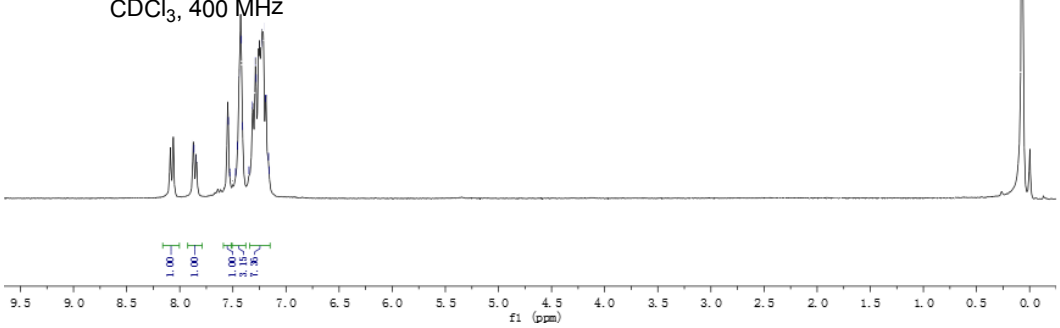
$CDCl_3$, 125 MHz

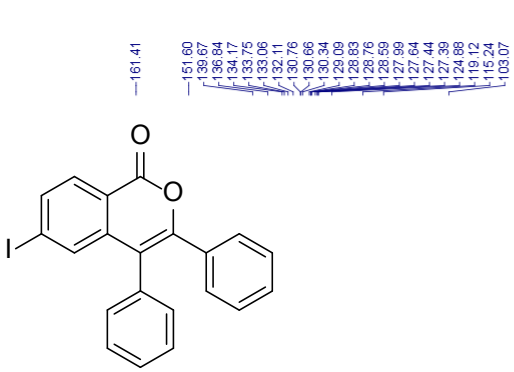




3ga

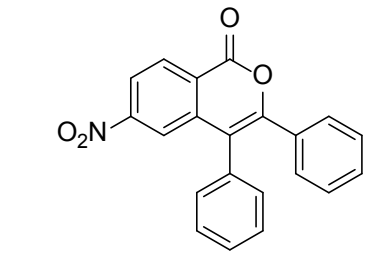
$CDCl_3$, 400 MHz





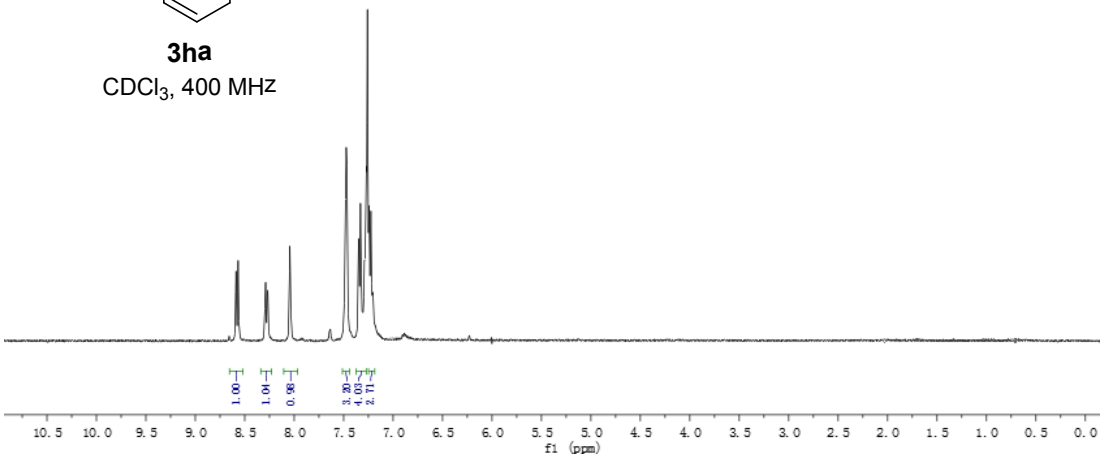
3ga

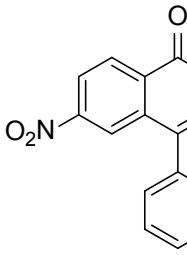
$CDCl_3$, 125 MHz



3ha

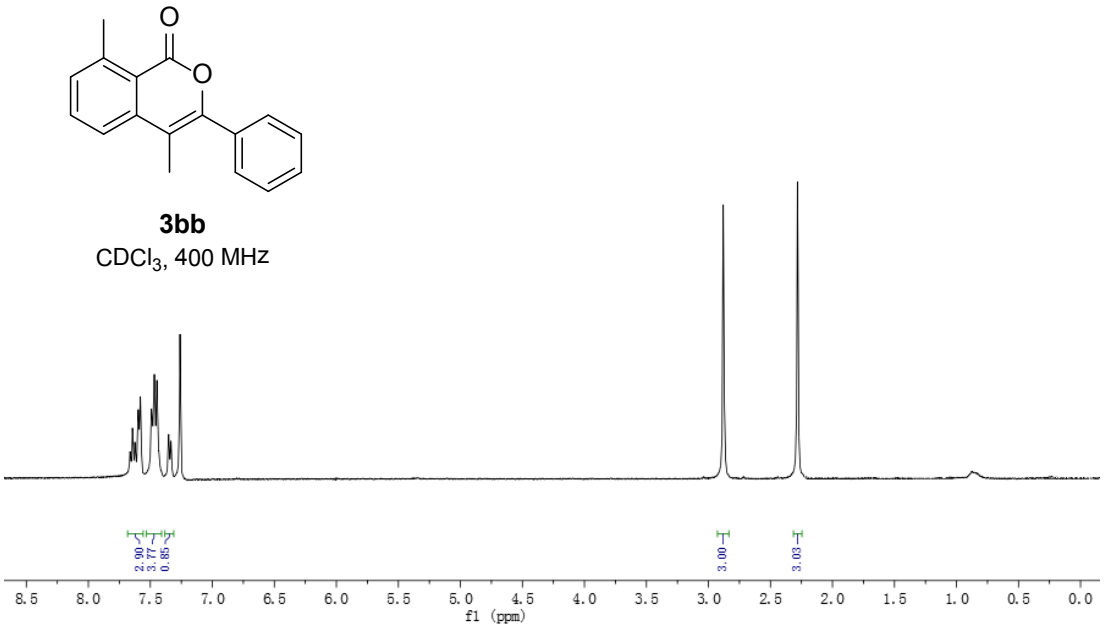
$CDCl_3$, 400 MHz

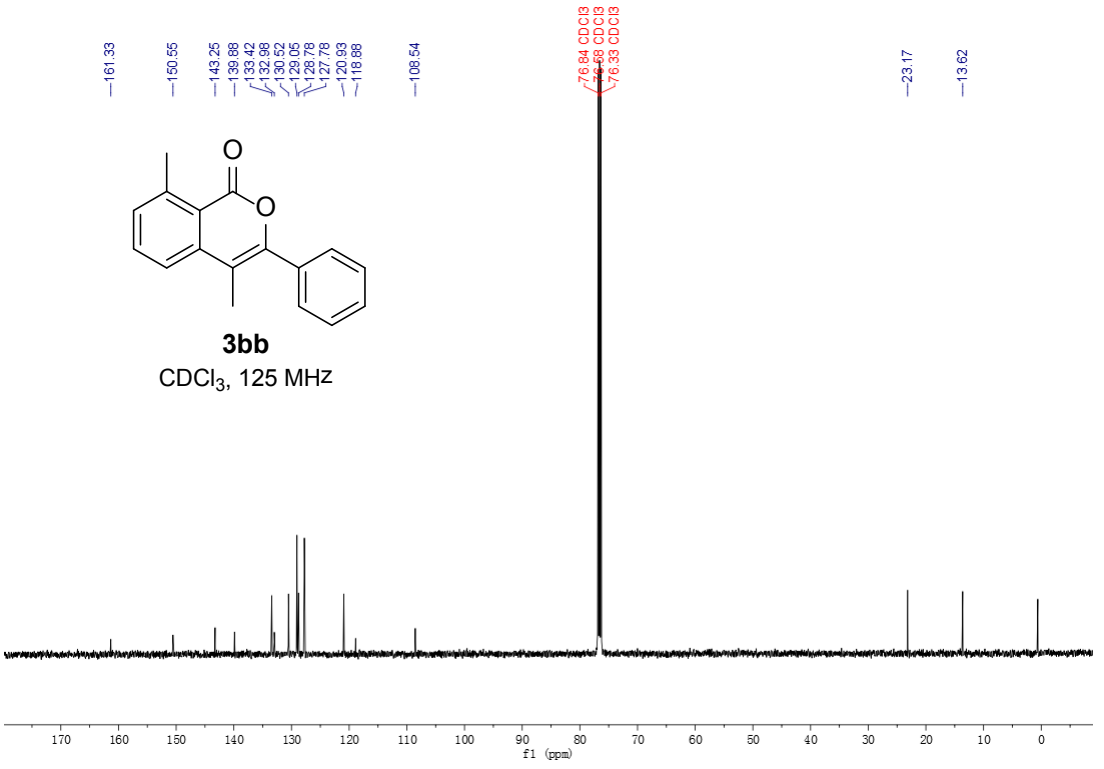


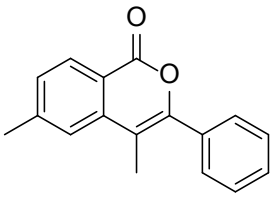


3ha

$CDCl_3$, 125 MHz

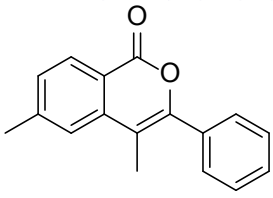

O
O
3bb
CDCl3, 400 MHz
2.90
3.77
0.85
3.00
3.03
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


161.33
150.55
143.25
139.88
133.42
132.98
130.52
129.05
128.78
127.78
120.93
118.88
108.54
76.84 CDCl3
77.16 CDCl3
76.33 CDCl3
23.17
13.62
O
O
3bb
CDCl3, 125 MHz
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)



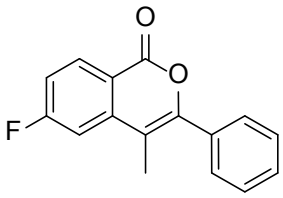
3cb

$CDCl_3$, 400 MHz



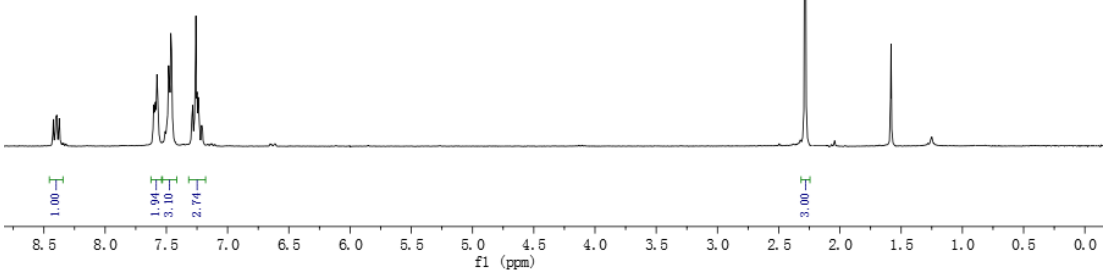
3cb

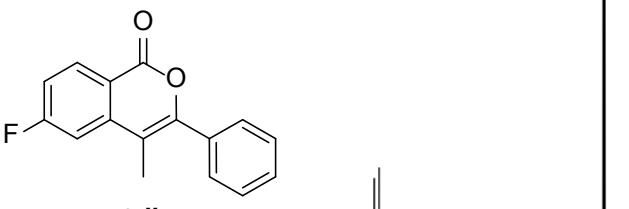
$CDCl_3$, 125 MHz



3db

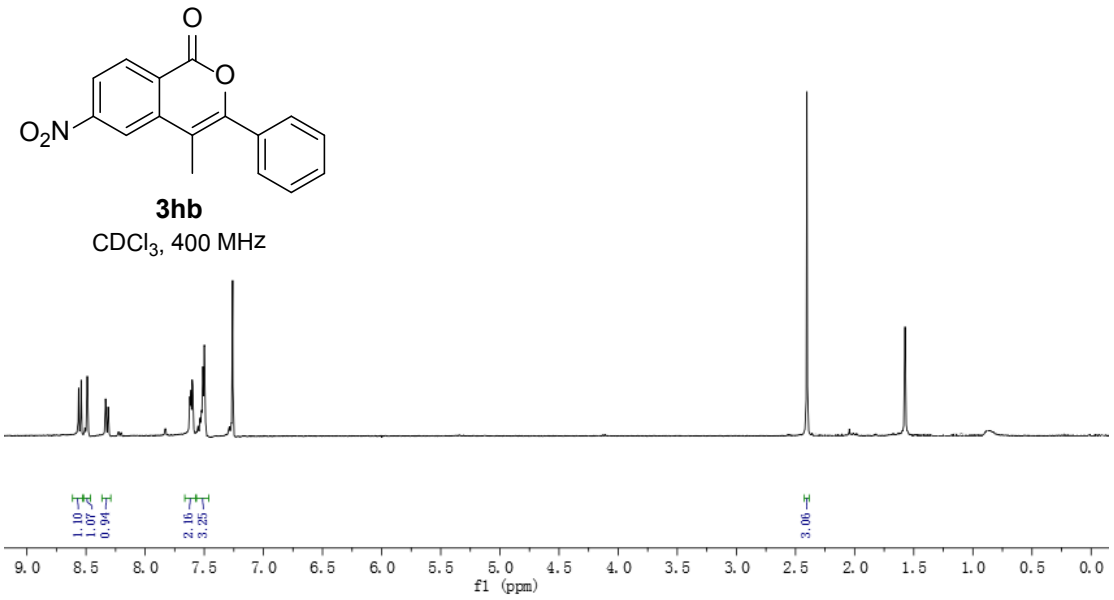
$CDCl_3$, 400 MHz

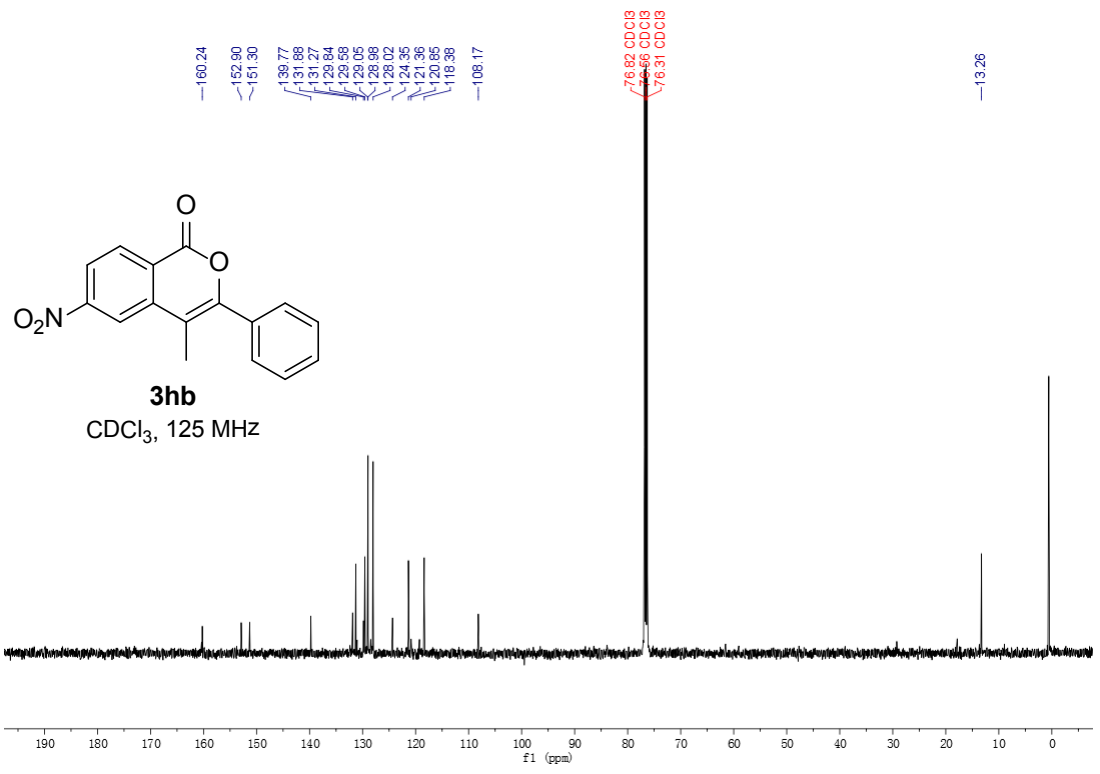


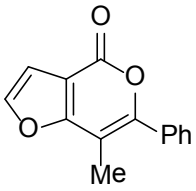


3db

$CDCl_3$,125 MHz

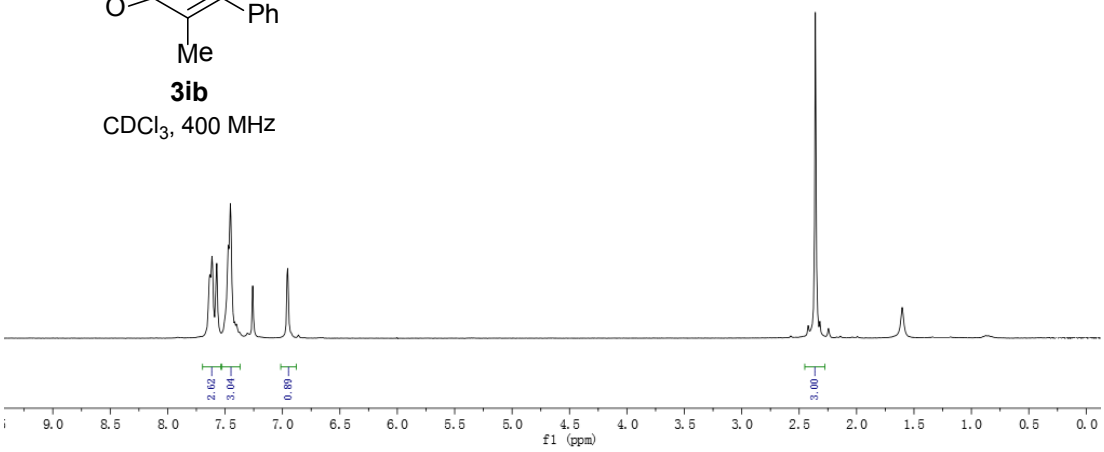

O
O
O2N
3hb
CDCl3, 400 MHz
1.10
1.07
0.94
2.16
3.25
3.06
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

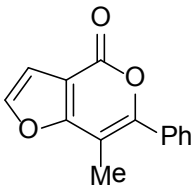

160.24
152.90
151.30
139.77
131.88
131.27
129.84
129.58
129.05
128.98
128.02
124.35
121.36
120.85
118.38
108.17
76.82 CDCl3
76.56 CDCl3
76.31 CDCl3
13.26
O
O
O2N
3hb
CDCl3, 125 MHz
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)



3ib

$CDCl_3$, 400 MHz





3ib

$CDCl_3$, 125 MHz