Supporting Information

Enantioselectivity Synthesis of Isoquinolin-1-one Derivatives with C–N Axial Chirality via Cobalt-Catalyzed Oxidative Formal (4+2) Cycloaddition: Light or Not

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1. General Information

^{1}H NMR spectra were recorded on 400 MHz spectrophotometers. Chemical shifts (δ) are reported in ppm from the resonance of tetramethyl silane as the internal standard (TMS: 0.00 ppm). Data are reported as follows: chemical shift, multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet), coupling constants (Hz) and integration. All NMR spectra were recorded on a Bruker spectrometer at 400 MHz (^{1}H NMR), 100 MHz (^{13}C NMR), 376 MHz (^{19}F NMR). HRMS was recorded on Waters GCT Premier ESI-TOF. Enantiomeric excesses (ee) values were determined by chiral HPLC with chiral AD-H, AS-H, IA-H, IG-H, OD-H columns with hexane and *i*-PrOH as eluent. Optical rotations were measured with a polarimeter. $[\alpha]_D$ values are reported at a given temperature (°C) in degrees cm^2/g with concentration in mg/mL. Unless otherwise noted, all reactions were carried out under an atmosphere of air in oven-dried glassware. The photoreactor used for the reaction is a multi-channel photoreactor (Figure S1) independently developed by us (32 reaction holes, each hole corresponds to a 5 W LED (456 nm or 390 nm), and the light intensity is about 100 mw/cm^2; Patent No CN201921741216.8).

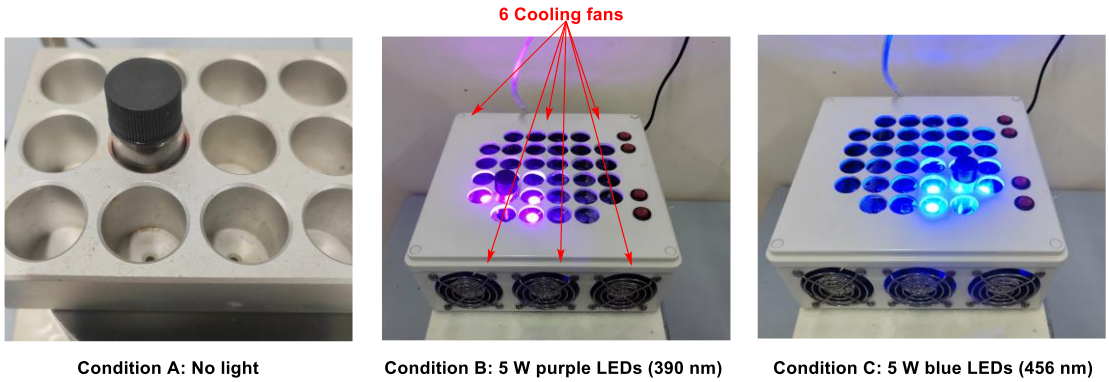
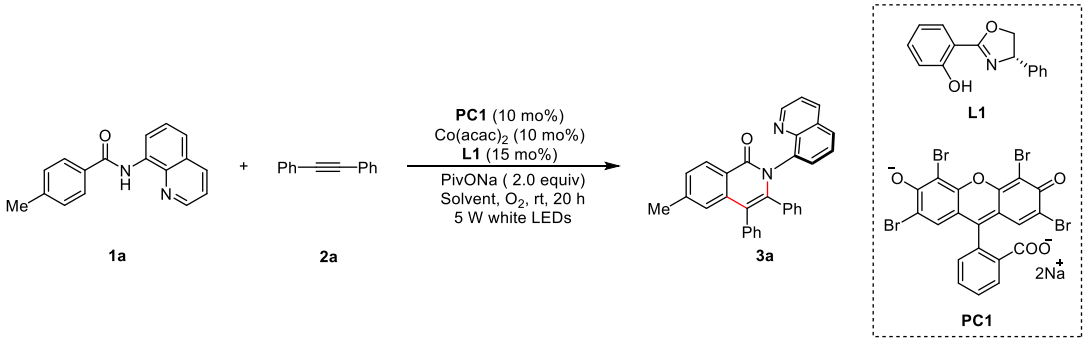


Figure S1. Multi-channel photoreactor and three reaction devices with different conditions

Analytical thin layer chromatography was performed using Qingdao Puke Parting Materials Co. silica gel plates (Silicagel 60 F254). Flash column chromatography was performed using 200-300 mesh silica gel. Reagents, unless otherwise noted, were used as supplied from commercial sources without further purification. Anhydrous solvent (DCM, MeCN, Toluene, MeOH, DMF) were taken from JC-Meyer solvent purification system. Ligands,[1-2] amides,[3] alkynes[4-5] were prepared according to literature.

2. Details for Condition Opitimization

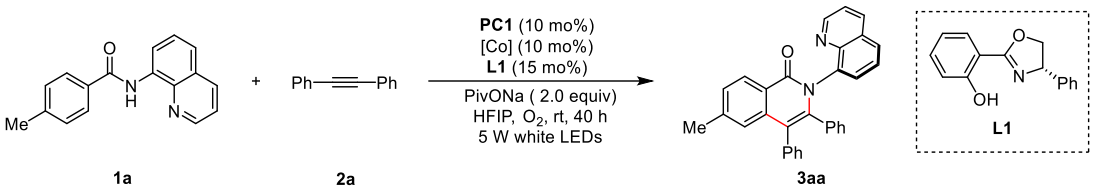
Table S1. The effect of solvent.[a]



Entry	Solvent	Yield/%	ee/%
1	TFE	14	78
2	HFIP	11	87
3	MeOH	10	80
4	^{t}BuOH	trace	67
5	DCE	5	78
6	1,4-dioxane	trace	73
7	MeCN	trace	64
8	DMF	0	0
9	Toluene	trace	65

[a] **1a** (0.1 mmol), **2a** (0.15 mmol), **PC1** (10 mol%), $Co(NO_3)_3$•$6H_2O$ (10 mol%), **L1** (15 mol%), PivONa (2.0 equiv), solvent (1 mL), O_2, under 5 W white LEDs at rt for 20 h. Yields was determined using ^{1}H NMR spectroscopy with 1,3,5-trimethoxybenzene as an internal standard. All the ee values in this work were determined by chiral HPLC analysis of purified products.

Table S2. The effect of cobalt.[a]

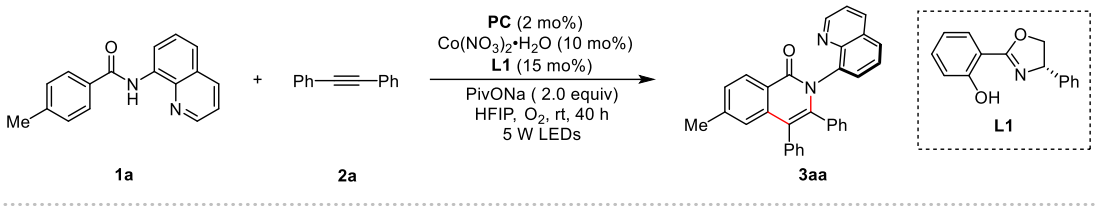


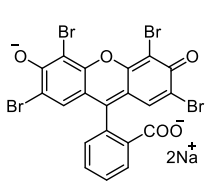
1a **2a** **3aa**

Entry	[Co]	Yield/%	ee/%
1	$Co(acac)_2$	16	87
2	$Co(acac)_3$	17	87
3	$Co(OAc)_2•4H_2O$	23	88
4	$Co(ClO_4)_2•6H_2O$	20	86
5	$Co(NO_3)_2•6H_2O$	46	90
6	$Co(BF_4)_2•6H_2O$	9	90
7	$CoBr_2$	9	87

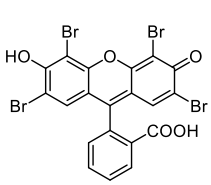
[a] **1a** (0.1 mmol), **2a** (0.15 mmol), **PC1** (10 mol%), [Co] (10 mol%), **L1** (15 mol%), PivONa (2.0 equiv), HFIP (1 mL), O_2, under 5 W white LEDs at rt for 40 h. Yields was determined using ^1H NMR spectroscopy with 1,3,5-trimethoxybenzene as an internal standard. All the ee values in this work were determined by chiral HPLC analysis of purified products.

Table S3. The effect of photocatalyst.[a]

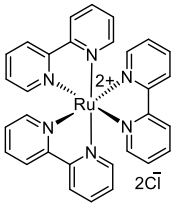




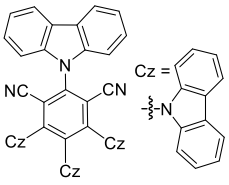
PC1[b]
5 W white LED
46% yield, 90% ee



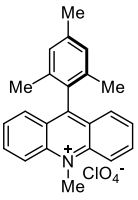
PC2[b]
5 W white LED
51% yield, 89% ee



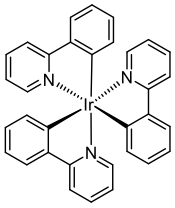
PC3
5 W white LED
14% yield, 85% ee



PC4
5 W blue LED
30% yield, 85% ee



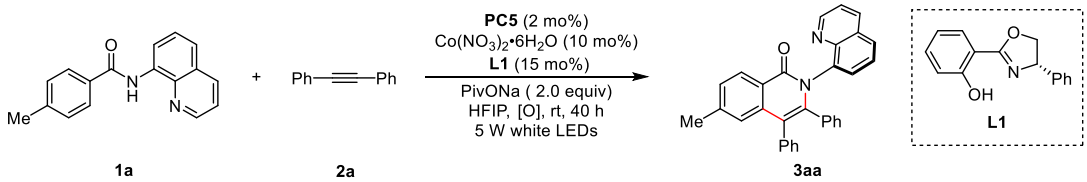
PC5
5 W blue LED
86% yield, 89% ee



PC6
5 W blue LED
10% yield, 76% ee

[a] **1a** (0.1 mmol), **2a** (0.15 mmol), PC (2 mol%), $Co(NO_3)_2$•$6H_2O$ (10 mol%), **L1** (15 mol%), PivONa (2.0 equiv), HFIP (1 mL), O_2, under 5 W LEDs at rt for 40 h. Yields was determined using ^1H NMR spectroscopy with 1,3,5-trimethoxybenzene as an internal standard. All the ee values in this work were determined by chiral HPLC analysis of purified products. [b] Using **PC** (10 mol%).

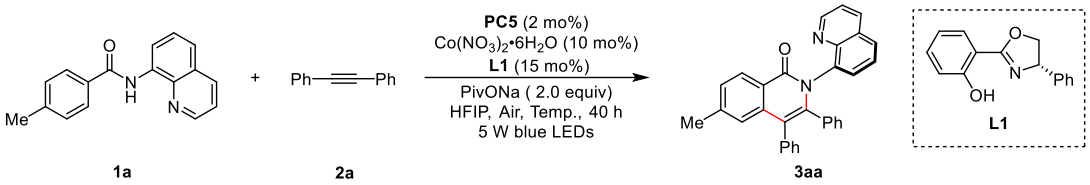
Table S4. The effect of oxidant.[a]



Entry	oxidant	Yield/%	ee/%
1	O_2	86	89
2	Air	85	89
3	Ar	7	86

[a] **1a** (0.1 mmol), **2a** (0.15 mmol), Acr-$Mes^+ClO_4^-$ (2 mol%), [Co] (10 mol%), **L1** (15 mol%), PivONa (2.0 equiv), HFIP (1 mL), under 5 W LEDs at rt for 40 h. Yields was determined using ^1H NMR spectroscopy with 1,3,5-trimethoxybenzene as an internal standard. All the ee values in this work were determined by chiral HPLC analysis of purified products.

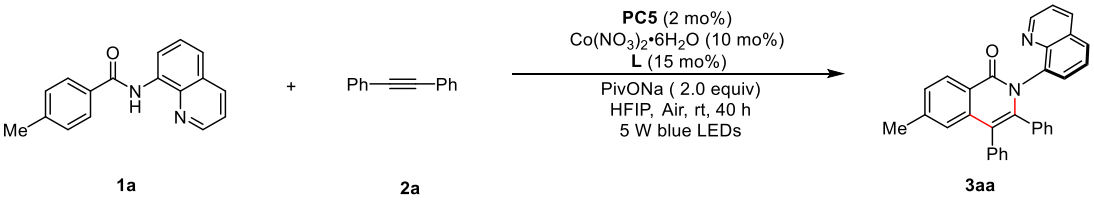
Table S5. The effect of temperature.[a]

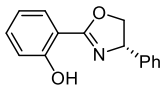


Entry	T/°C	Yield/%	ee/%
1	rt	86	89
2	15	83	89
3	0	38	90

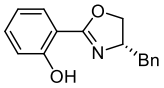
[a] **1a** (0.1 mmol), **2a** (0.15 mmol), Acr-Mes$^+$ClO$_4^-$ (2 mol%), Co(NO$_3$)$_2$•6H$_2$O (10 mol%), **L1** (15 mol%), PivONa (2.0 equiv), HFIP (1 mL), air, under 5 W blue LEDs at T °C for 40 h. Yields was determined using ^{1}H NMR spectroscopy with 1,3,5-trimethoxybenzene as an internal standard. All the ee values in this work were determined by chiral HPLC analysis of purified products.

Table S6. The effect of ligand.[a]

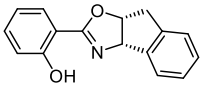




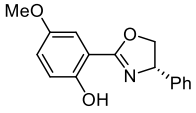
L1
86% yield, 89% ee



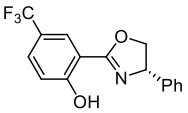
L2
95% yield, 61% ee



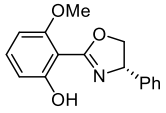
L3
85% yield, 67% ee



L4
94% yield, 95% ee



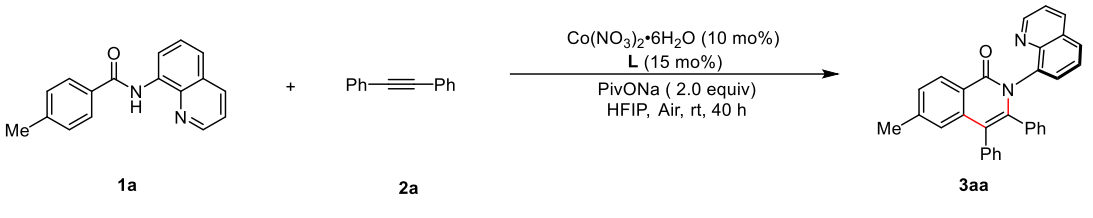
L5
87% yield, 82% ee

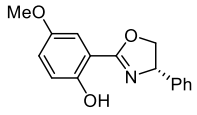


L6
67% yield, 75% ee

[a] **1a** (0.1 mmol), **2a** (0.15 mmol), Acr-Mes$^+$ClO$_4^-$ (2 mol%), Co(NO$_3$)$_2$•6H$_2$O (10 mol%), **L** (15 mol%), PivONa (2.0 equiv), HFIP (1 mL), air, under 5 W blue LEDs at rt for 40 h. Yields was determined using ^{1}H NMR spectroscopy with 1,3,5-trimethoxybenzene as an internal standard. All the ee values in this work were determined by chiral HPLC analysis of purified products.

Table S7. The effect of ligand under 5 W purple LEDs or not *hv*.[a]

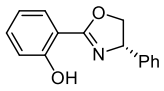




L4

NO *hv* 93% yield, 96% ee

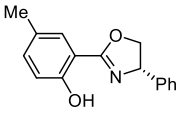
5 W purple LED 94% yield, 96% ee[b]



L1

NO *hv* 37% yield, 87% ee

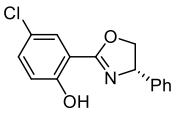
5 W purple LED 85% yield, 87% ee[b]



L7

NO *hv* 54% yield, 87% ee

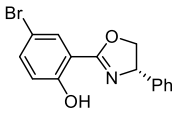
5 W purple LED 93% yield, 87% ee[b]



L8

NO *hv* NR

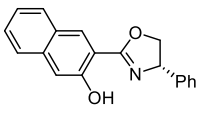
5 W purple LED 94% yield, 79% ee[b]



L9

NO *hv* NR

5 W purple LED 19% yield, 86% ee[b]



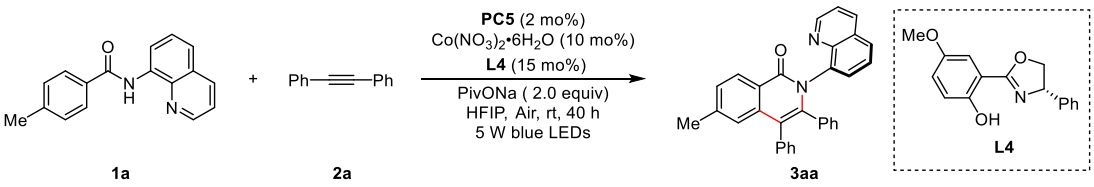
L10

NO *hv* 22% yield, 95% ee

5 W purple LED 76% yield, 89% ee[b]

[a] **1a** (0.1 mmol), **2a** (0.15 mmol), $Co(NO_3)_2$•$6H_2O$ (10 mol%), **L** (15 mol%), PivONa (2.0 equiv), HFIP (1 mL), air, under 5 W purple LEDs at rt for 40 h. Yields was determined using ^1H NMR spectroscopy with 1,3,5-trimethoxybenzene as an internal standard. All the ee values in this work were determined by chiral HPLC analysis of purified products. [b] Under 5 W purple LED.

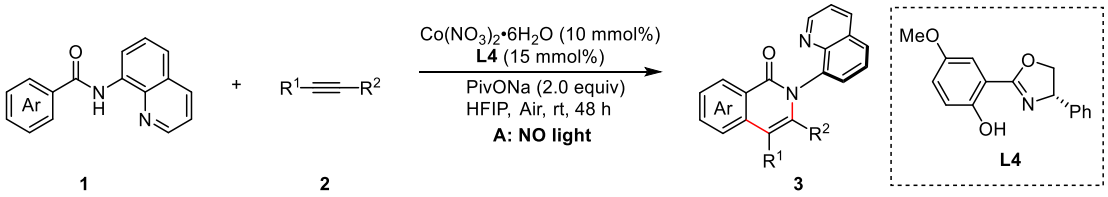
Table S8. Control experiments.[a]



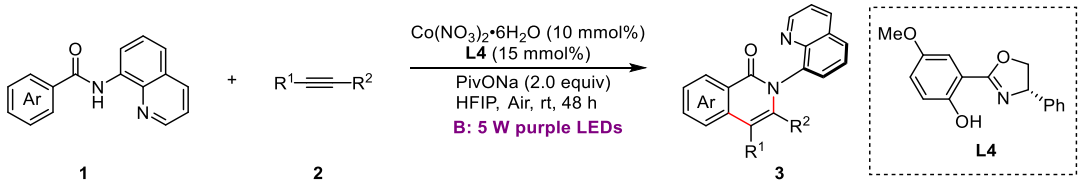
Entry	deviation from standard conditions	Yield/%	ee/%
1	none	94	95
2	no light/ Acr-$Mes^+ClO_4^-$	93	96
3	no $Co(NO_3)_2$•$6H_2O$	0	0
4	no **L4**	55	0
5	No PivONa	94	89
6	degassed	trace	95

[a] **1a** (0.1 mmol), **2a** (0.15 mmol), Acr-$Mes^+ClO_4^-$ (2 mol%), $Co(NO_3)_2$•$6H_2O$ (10 mol%), **L4** (15 mol%), PivONa (2.0 equiv), HFIP (1 mL), air, under 5 W blue LEDs at rt for 40 h. Yields was determined using ^1H NMR spectroscopy with 1,3,5-trimethoxybenzene as an internal standard. All the ee values in this work were determined by chiral HPLC analysis of purified products.

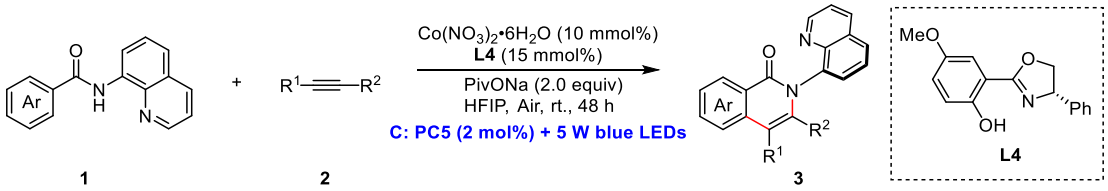
3. General Procedures and Characterization Data of Products



Condition A: Under air, $Co(NO_3)_2$•$6H_2O$ (0.02 mmol, 5.82 mg), **L4** (0.015 mmol, 8.08 mg) and HFIP (2 mL) were added to a 10 mL vial. After stirring at room temperature for 2 h, corresponding substrate **1** (0.2 mmol), alkyne **2** (0.3 mmol) and PivONa (49.9 mg, 0.4 mmol) were added to the resulting mixture. The mixture was stirred at room temperature for approximately 48 h. The concentrated reaction residue was purified by flash column chromatography on silica gel with petroleum ether/ethyl acetate (3:1-1.5:1) as eluent to give corresponding product **3**.



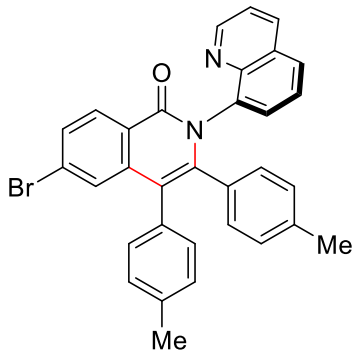
Condition B: Under air, $Co(NO_3)_2$•$6H_2O$ (0.02 mmol, 5.82 mg), **L4** (0.015 mmol, 8.08 mg) and HFIP (2 mL) were added to a 10 mL vial. After stirring at room temperature for 2 h, corresponding substrate **1** (0.2 mmol), alkyne **2** (0.3 mmol) and PivONa (49.9 mg, 0.4 mmol) were added to the resulting mixture. The mixture was stirred at room temperature under 5 W purple LEDs for approximately 48 h. The concentrated reaction residue was purified by flash column chromatography on silica gel with petroleum ether/ethyl acetate (3:1-1.5:1) as eluent to give corresponding product **3**.



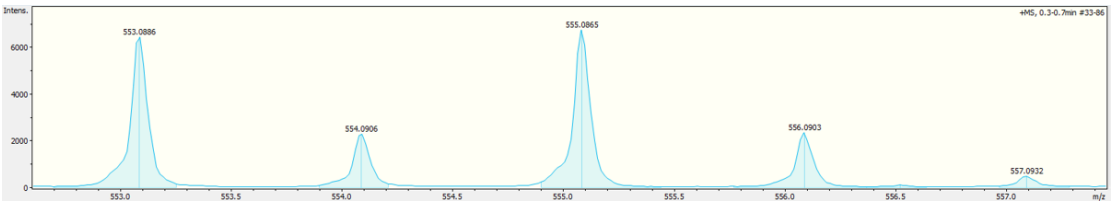
Condition C: Under air, $Co(NO_3)_2$•$6H_2O$ (0.02 mmol, 5.82 mg), **L4** (0.015 mmol, 8.08 mg) and HFIP (2 mL) were added to a 10 mL vial. After stirring at room temperature for 2 h, corresponding substrate **1** (0.2 mmol), alkyne **2** (0.3 mmol), **PC5** (1.64 mg, 0.004 mmol) and PivONa (49.9 mg, 0.4 mmol) were added to the resulting mixture. The mixture was stirred at room temperature under 5 W blue LEDs for approximately 48 h. The concentrated reaction

residue was purified by flash column chromatography on silica gel with petroleum ether/ethyl acetate (3:1-1.5:1) as eluent to give corresponding product **3**.

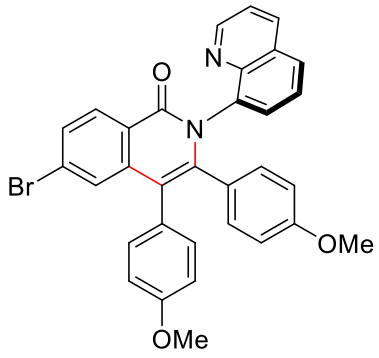
(*R*)-6-Bromo-2-(quinolin-8-yl)-3,4-di-p-tolylisoquinolin-1(2H)-one (**3ab**)



Condition C, White solid, mp: 310-311 °C, 103.3 mg, 97% yield, $[\alpha]_D^{25}$ = +58.0 (c = 0.1 in $CHCl_3$), 94% ee, determined by HPLC analysis (Chiralpak AZ-H column, hexane/*i*-PrOH, 80:20 v/v, flow rate 1.0 mL/min, λ = 254 nm, 25 °C), t_R (minor) = 19.68 min, t_R (major) = 22.82 min. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.90 (d, *J* = 3.5 Hz, 1H), 8.40 (d, *J* = 8.5 Hz, 1H), 8.00 (d, *J* = 8.2 Hz, 1H), 7.62-7.52 (m, 2H), 7.48-7.29 (m, 4H), 7.10 (d, *J* = 7.7 Hz, 1H), 7.05-6.99 (m, 2H), 6.95 (d, *J* = 7.7 Hz, 1H), 6.83 (d, *J* = 7.7 Hz, 1H), 6.63-6.57 (m, 2H), 6.26 (d, *J* = 7.8 Hz, 1H), 2.24 (s, 3H), 1.90 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 162.4, 150.8 144.7, 143.5, 140.0, 137.6, 136.9, 136.5, 136.1, 132.8, 131.8, 131.43 (d, *J* = 17.3 Hz), 130.7, 130.37 (d, *J* = 19.6 Hz), 129.8, 129.3, 129.1, 128.95-128.50 (m), 128.1, 127.9, 127.5, 127.3, 125.8, 124.2, 121.6, 117.6, 21.3 21.1. **HRMS** (ESI) for $C_{32}H_{23}BrN_2NaO$ $[M+Na]^+$ calcd: 553.0886 (^{79}Br) and 555.0871 (^{81}Br); found: 553.0886 (^{79}Br) and 555.0865 (^{81}Br).

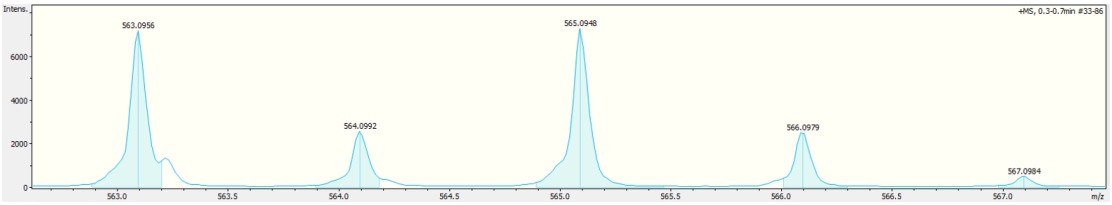


(*R*)-6-Bromo-3,4-bis(4-methoxyphenyl)-2-(quinolin-8-yl)isoquinolin-1(2H)-one (**3ac**)

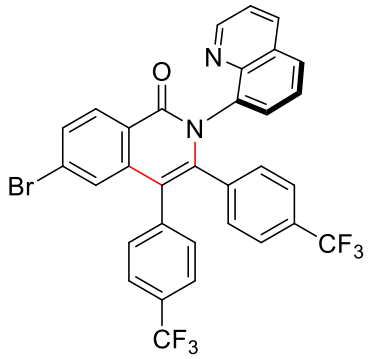


Condition C, White solid, mp: 318-319 °C, 88.0 mg, 78% yield, $[\alpha]_D^{25}$ = +59.6 (c = 0.1 in $CHCl_3$), 97% ee, determined by HPLC analysis (Chiralpak AS-H column, hexane/*i*-PrOH, 80:20 v/v, flow rate 1.0 mL/min, λ = 254 nm, 25 °C), t_R (minor) = 56.51 min, t_R (major) = 62.96 min. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.89 (s, 1H), 8.39 (d, *J* = 8.4 Hz, 1H), 8.03 (d, *J* = 8.0 Hz, 1H), 7.65 (d, *J* = 7.9 Hz, 1H), 7.58 (d, *J* = 8.2 Hz, 1H), 7.46-7.34 (m, 4H), 7.10 (d, *J* = 8.1 Hz, 1H), 7.05 (d, *J* = 8.2 Hz, 1H), 6.85 (d, *J* = 8.1 Hz, 1H), 6.79 (d, *J* = 7.9 Hz, 1H), 6.72 (d, *J* = 7.9 Hz, 1H), 6.61 (d, *J* = 8.1 Hz, 1H), 6.36 (d, *J* = 7.6 Hz, 1H),

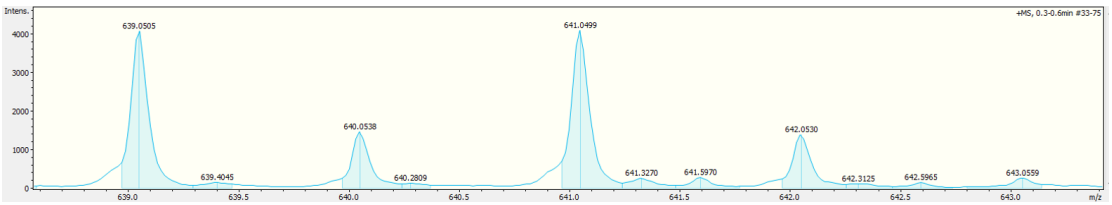
6.01 (d, *J* = 7.7 Hz, 1H), 3.73 (s, 3H), 3.45 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 162.4, 158.3, 158.2, 150.8, 144.6, 143.4, 140.2, 137.6, 136.2, 132.8, 132.6, 131.9, 130.8, 130.7 130.3, 129.8, 128.8, 128.7, 128.1, 127.9, 127.2, 125.9, 124.2, 121.6, 117.5, 113.7, 113.6, 112.2, 112.0, 55.2, 54.8. **HRMS** (ESI) for $C_{32}H_{24}BrN_2O_3$ $[M+H]^+$ calcd: 563.0965 (^{79}Br) and 565.0950 (^{81}Br); found: 563.0956 (^{79}Br) and 565.0948 (^{81}Br).



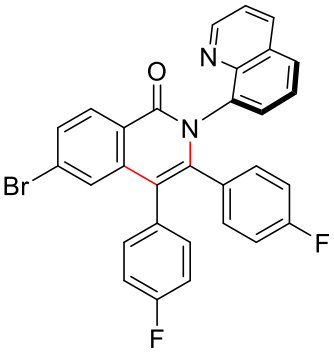
(*R*)-6-Bromo-2-(quinolin-8-yl)-3,4-bis(4-(trifluoromethyl)phenyl)isoquinolin-1(2H)-one (**3ad**)



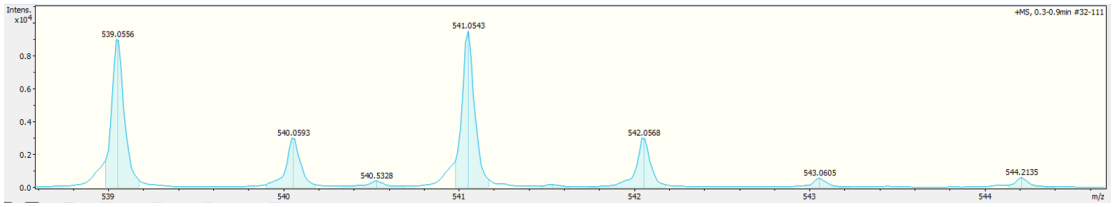
Condition C, White solid, mp: 287-288 °C, 121.5 mg, 95% yield, $[\alpha]_D^{25}$ = +55.6 (c = 0.1 in $CHCl_3$), 96% ee, determined by HPLC analysis (Chiralpak AD-H column, hexane/*i*-PrOH, 80:20 v/v, flow rate 1.0 mL/min, λ = 254 nm, 25 °C), t_R (minor) = 5.82 min, t_R (major) = 12.49 min. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.90 (d, *J* = 3.0 Hz, 1H), 8.43 (d, *J* = 8.5 Hz, 1H), 8.07 (d, *J* = 8.1 Hz, 1H), 7.78-7.63 (m, 2H), 7.54-7.48 (M, 3H), 7.41-7.31 (m, 5H), 7.14-7.18 (m, 2H), 6.88 (d, *J* = 8.1 Hz, 1H), 6.78 (d, *J* = 8.1 Hz, 1H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 162.1, 151.1, 144.3, 142.2, 139.3, 138.9, 137.8, 136.7, 136.4, 132.2, 131.9, 130.9, 130.8, 130.8, 130.6, 130.1, 129.8 (q, *J* = 32.8 Hz), 129.7 (q, *J* = 32.8 Hz), 129.4, 129.0, 128.5, 127.8, 125.9, 125.6 (q, *J* = 3.5 Hz), 125.4 (q, *J* = 3.6 Hz), 124.5, 124.0 (q, *J* = 3.6 Hz), 124.0 (q, *J* = 273.3 Hz), 123.8 (q, *J* = 3.3 Hz), 123.4 (q, *J* = 273.4 Hz), 122.0, 116.5. **^{19}F NMR** (376 MHz, $CDCl_3$) δ -62.6, -63.1. **HRMS** (ESI) for $C_{32}H_{18}BrF_6N_2O$ $[M+H]^+$ calcd: 639.0501 (^{79}Br) and 641.0486 (^{81}Br); found: 639.0505 (^{79}Br) and 641.0499 (^{81}Br).



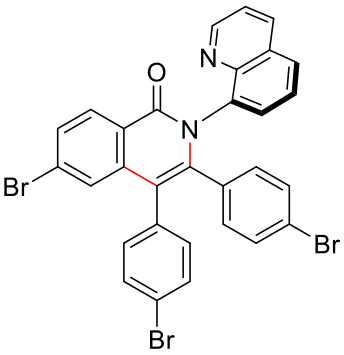
(*R*)-6-Bromo-3,4-bis(4-fluorophenyl)-2-(quinolin-8-yl)isoquinolin-1(2H)-one (**3ae**)



Condition C, White solid, 101.5 mg, mp: 304-305 °C, 94% yield, $[\alpha]_D^{25}$ = +37.8 (c = 0.1 in $CHCl_3$), 97% ee, determined by HPLC analysis (Chiralpak AD-H column, hexane/*i*-PrOH, 80:20 v/v, flow rate 1.0 mL/min, λ = 254 nm, 25 °C), t_R (major) = 15.36 min, t_R (minor) = 17.88 min. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.90 (d, *J* = 3.6 Hz, 1H), 8.42 (d, *J* = 8.5 Hz, 1H), 8.08 (d, *J* = 8.2 Hz, 1H), 7.70 (d, *J* = 8.1 Hz, 1H), 7.63 (d, *J* = 8.5 Hz, 1H), 7.50 (d, *J* = 7.2 Hz, 1H), 7.46-7.32 (m, 3H), 7.16-7.12 (m, 2H), 6.98-6.90 (m, 3H), 6.72-6.69 (m, 1H), 6.57-6.53 (m, 1H), 6.24-6.19 (m, 1H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 162.3, 161.9 (d, *J* = 247.7 Hz), 161.6 (d, *J* = 250.0 Hz), 150.9, 144.5, 142.8, 139.6, 137.2, 136.2, 133.4 (d, *J* = 8.0 Hz), 133.2 (d, *J* = 8.0 Hz), 132.3 (d, *J* = 8.2 Hz), 131.7, 131.6 (d, *J* = 8.6 Hz), 130.8, 130.6, 130.5, 130.3, 129.1, 128.9, 128.2, 128.0, 125.9, 124.5, 121.8, 116.9, 115.6 (d, *J* = 13.8 Hz), 115.4 (d, *J* = 13.8 Hz), 114.1 (d, *J* = 22.5 Hz), 113.9 (d, *J* = 23.0 Hz). **^{19}F NMR** (376 MHz, $CDCl_3$) δ -112.8, -114.4. **HRMS** (ESI) for $C_{30}H_{18}BrF_2N_2O$ $[M+H]^+$ calcd: 539.0565 (^{79}Br) and 541.0549 (^{81}Br); found: 539.0556 (^{79}Br) and 541.0543 (^{81}Br).

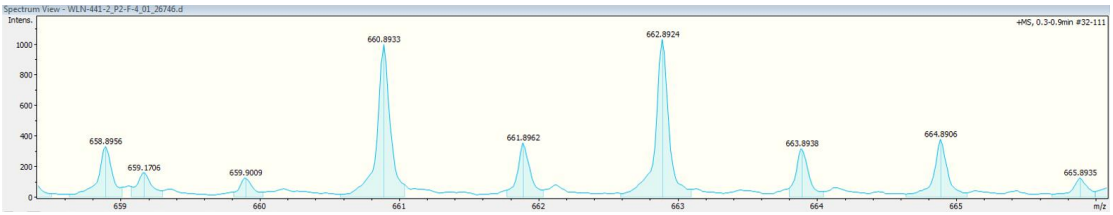


(*R*)-6-Bromo-3,4-bis(4-bromophenyl)-2-(quinolin-8-yl)isoquinolin-1(2H)-one (**3af**)

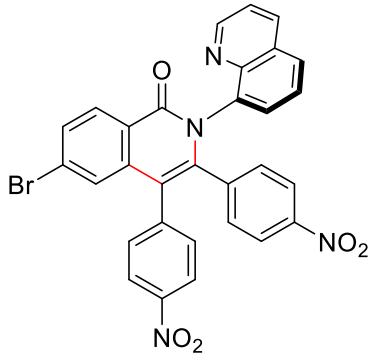


Condition C, White solid, mp: 330-331 °C, 41.1 mg, 31% yield, $[\alpha]_D^{25}$ = +101.6 (c = 0.1 in $CHCl_3$), 93% ee, determined by HPLC analysis (Chiralpak AD-H column, hexane/*i*-PrOH, 80:20 v/v, flow rate 1.0 mL/min, λ = 254 nm, 25 °C), t_R (minor) = 15.62 min, t_R (major) = 19.14 min. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.97-8.85 (m, 1H), 8.40 (d, *J* = 8.5 Hz, 1H), 8.08 (d, *J* = 8.3 Hz, 1H), 7.72 (d, *J* = 8.0 Hz, 1H), 7.63 (dd, *J* = 8.5, 1.6 Hz, 1H), 7.48 (d, *J* = 6.8 Hz, 1H), 7.44-7.34 (m, 5H), 7.09-6.97 (m, 3H), 6.82 (dd, *J* = 8.2, 1.8 Hz, 1H), 6.66 (dd, *J* = 8.3, 1.7 Hz, 1H), 6.60 (dd, *J* = 8.3, 1.8 Hz, 1H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 162.2, 151.0, 144.4, 142.4, 139.2, 137.0, 136.3, 134.6, 133.4, 133.3, 133.2, 132.1, 131.9, 131.7,

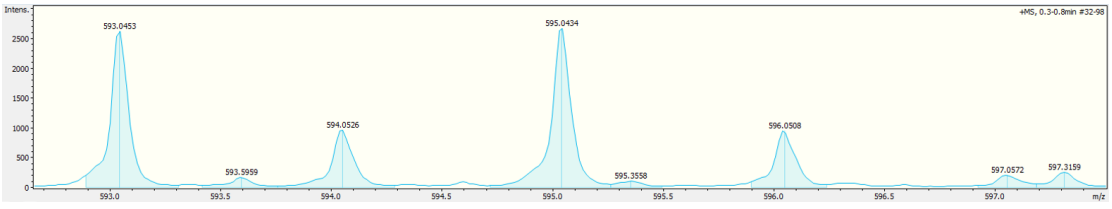
131.2, 130.8, 130.5, 130.3, 130.1, 129.3, 128.9, 128.3, 127.9, 126.0, 124.4, 122.2, 121.9, 121.7, 116.6. **HRMS** (ESI) for $C_{32}H_{18}Br_3N_2O$ $[M+H]^+$ calcd: 658.8964 (^{79}Br, ^{79}Br, ^{79}Br), 660.8945 (^{79}Br, ^{79}Br, ^{81}Br), 662.8927 (^{79}Br, ^{81}Br, ^{81}Br) and 664.8915 (^{81}Br, ^{81}Br, ^{81}Br); found: 658.8956 (^{79}Br, ^{79}Br, ^{79}Br), 660.8933 (^{79}Br, ^{79}Br, ^{81}Br), 662.8924 (^{79}Br, ^{81}Br, ^{81}Br) and 664.8906 (^{81}Br, ^{81}Br, ^{81}Br).



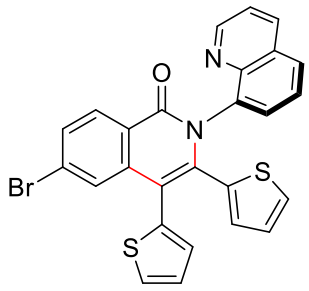
(*R*)-6-Bromo-3,4-bis(4-nitrophenyl)-2-(quinolin-8-yl)isoquinolin-1(2H)-one (**3ag**)



Condition C, White solid, mp: 382-383 °C, 91.2 mg, 77% yield, $[\alpha]_D^{25}$ = +84.8 (c = 0.1 in $CHCl_3$), 96% ee, determined by HPLC analysis (Chiralpak AD-H column, hexane/*i*-PrOH, 70:30 v/v, flow rate 1.0 mL/min, λ = 254 nm, 25 °C), t_R (minor) = 25.06 min, t_R (major) = 33.45 min. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.91 (d, *J* = 3.2 Hz, 1H), 8.44 (d, *J* = 8.5 Hz, 1H), 8.24-8.03 (m, 3H), 7.75-7.69 (m, 3H), 7.57 (d, *J* = 6.6 Hz, 1H), 7.45-7.36 (m, 5H), 7.29 (d, *J* = 1.4 Hz, 1H), 7.19 (d, *J* = 8.0 Hz, 1H), 6.98 (d, *J* = 8.5 Hz, 1H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 161.9, 151.1, 147.3, 146.9, 144.1, 142.2, 141.5, 140.3, 138.2, 136.4, 136.2, 132.7, 132.5, 131.4, 131.2, 130.8, 130.7, 129.7, 129.0, 128.7, 127.6, 125.9, 124.6, 123.9, 123.8, 122.3, 122.1, 115.7. **HRMS** (ESI) for $C_{30}H_{18}BrN_4O_5$ $[M+H]^+$ calcd: 593.0455 (^{79}Br) and 595.0440 (^{81}Br); found: 593.0453 (^{79}Br) and 595.0434 (^{81}Br).

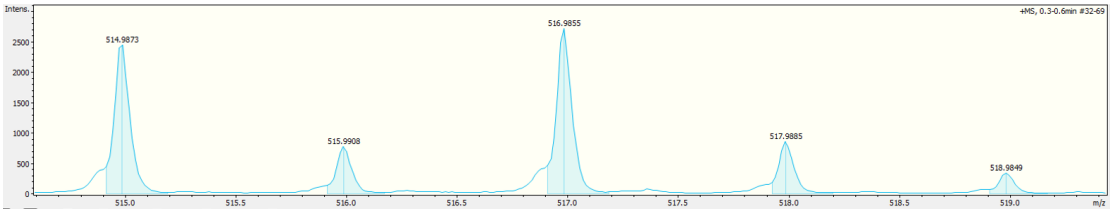


(*R*)-6-Bromo-2-(quinolin-8-yl)-3,4-di(thiophen-2-yl)isoquinolin-1(2H)-one (**3ah**)

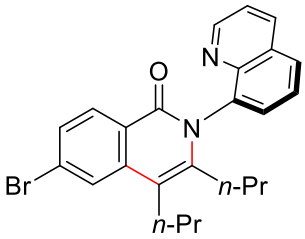


Condition C, White solid, mp: 320-321 °C, 87.4 mg, 85% yield, $[\alpha]_D^{25}$ = +29.2 (c = 0.1 in $CHCl_3$), 96% ee, determined by HPLC analysis (Chiralpak AD-H column, hexane/*i*-PrOH, 80:20 v/v, flow rate 1.0 mL/min, λ = 254 nm, 25 °C), t_R (major) = 19.12 min,

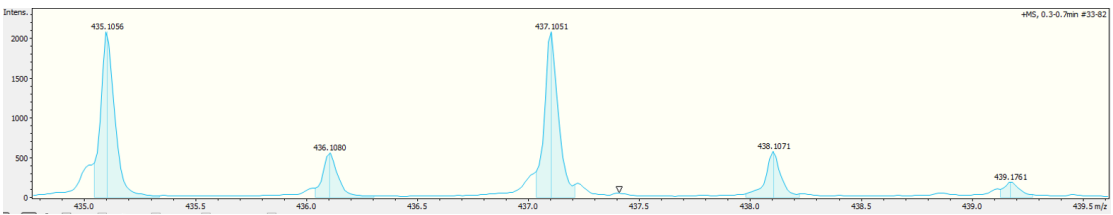
t_R (minor) = 30.22 min. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.91 (d, *J* = 3.1 Hz, 1H), 8.38 (d, *J* = 8.4 Hz, 1H), 8.10 (d, *J* = 8.1 Hz, 1H), 7.73 (d, *J* = 8.1 Hz, 1H), 7.64 (d, *J* = 11.3 Hz, 2H), 7.54 (d, *J* = 7.1 Hz, 1H), 7.44-7.27 (m, 3H), 6.96 (d, *J* = 4.4 Hz, 2H), 6.84 (d, *J* = 4.8 Hz, 1H), 6.45 (d, *J* = 2.9 Hz, 1H), 6.39-6.29 (m, 1H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 162.3, 151.1, 144.8, 139.7, 138.7, 137.2, 136.4, 136.2, 134.6, 130.8, 130.7, 130.5, 130.3, 130.2, 129.1, 128.9, 128.4, 127.5, 127.0, 126.8, 125.9, 125.4, 124.6, 121.8, 112.9. **HRMS** (ESI) for $C_{26}H_{16}BrN_2OS_2$ $[M+H]^+$ calcd: 514.9882 (^{79}Br) and 516.9863 (^{81}Br); found: 514.9873 (^{79}Br) and 516.9855 (^{81}Br).



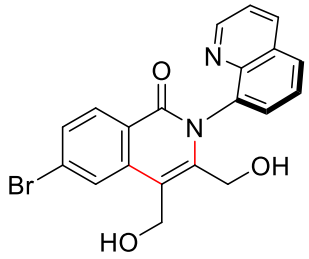
(*R*)-6-Bromo-3,4-dipropyl-2-(quinolin-8-yl)isoquinolin-1(2H)-one (**3ai**)



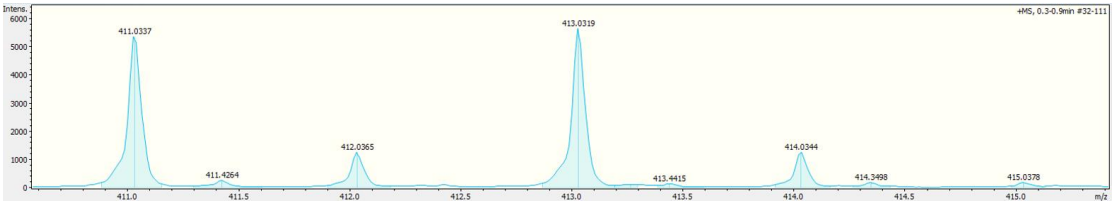
Condition C, White solid, mp: 187-188 °C, 80.2 mg, 93% yield, $[\alpha]_D^{25}$ = -188.4 (c = 0.1 in $CHCl_3$), 96% ee, determined by HPLC analysis (Chiralpak AD-H column, hexane/*i*-PrOH, 80:20 v/v, flow rate 1.0 mL/min, λ = 254 nm, 25 °C), t_R (minor) = 7.98 min, t_R (major) = 10.85 min. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.82 (d, *J* = 2.7 Hz, 1H), 8.27 (d, *J* = 8.5 Hz, 1H), 8.22 (d, *J* = 8.2 Hz, 1H), 7.9-7.86 (m, 2H), 7.71-7.63 (m, 2H), 7.52 (d, *J* = 8.4 Hz, 1H), 7.43-7.40 (m, 1H), 2.78-2.66 (m, 2H), 2.52-2.40 (m, 1H), 1.98-1.86 (m, 1H), 1.74-1.66 (m, 2H), 1.39-1.25 (m, 2H), 1.11 (t, *J* = 7.3 Hz, 3H), 0.53 (t, *J* = 7.3 Hz, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 162.9, 151.5, 144.6, 142.7, 139.3, 137.1, 136.4, 130.6, 130.2, 129.4, 129.0, 128.0, 126.2, 125.8, 124.1, 122.0, 113.0, 33.0, 29.9, 23.6, 23.0, 14.6, 14.3. **HRMS** (ESI) for $C_{24}H_{24}BrN_2O$ $[M+H]^+$ calcd: 435.1067 (^{79}Br) and 437.1047 (^{81}Br); found: 435.1056 (^{79}Br) and 437.1051 (^{81}Br).



(*R*)-6-Bromo-3,4-bis(hydroxymethyl)-2-(quinolin-8-yl)isoquinolin-1(2H)-one (**3aj**)

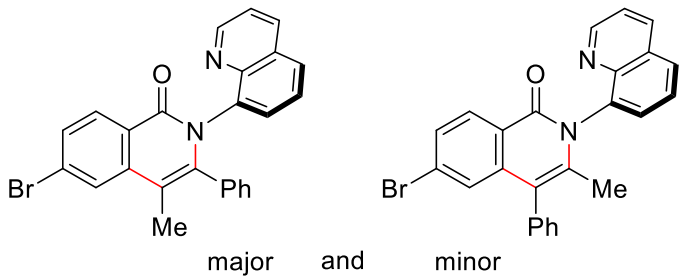


Condition C, White solid, mp: 221-222 °C, 76.6 mg, 93% yield, $[\alpha]_D^{25}$ = +6.4 (c = 0.1 in $CHCl_3$), 96% ee, determined by HPLC analysis (Chiralpak AD-H column, hexane/*i*-PrOH, 70:30 v/v, flow rate 1.0 mL/min, λ = 254 nm, 25 °C), t_R (minor) = 8.17 min, t_R (major) = 11.60 min. **^{1}H NMR** (400 MHz, DMSO) δ 8.80 (s, 1H), 8.51 (d, *J* = 7.9 Hz, 1H), 8.35-8.05 (m, 3H), 7.96-7.65 (m, 3H), 7.59 (d, *J* = 3.5 Hz, 1H), 5.21 (s, 1H), 5.01 (s, 1H), 4.79 (s, 2H), 4.49 (d, *J* = 12.2 Hz, 1H), 3.54 (d, *J* = 12.2 Hz, 1H). **^{13}C NMR** (101 MHz, DMSO) δ 161.9, 151.6, 144.4, 143.3, 139.2, 137.0, 136.1, 131.5, 130.2, 129.7, 129.0, 127.6, 127.5, 126.8, 124.8, 122.5, 114.1, 57.2, 56.5. **HRMS** (ESI) for $C_{20}H_{16}BrN_2O_3$ $[M+H]^+$ calcd: 411.0339 (^{79}Br) and 413.0321 (^{81}Br); found: 411.0337 (^{79}Br) and 413.0319 (^{81}Br).



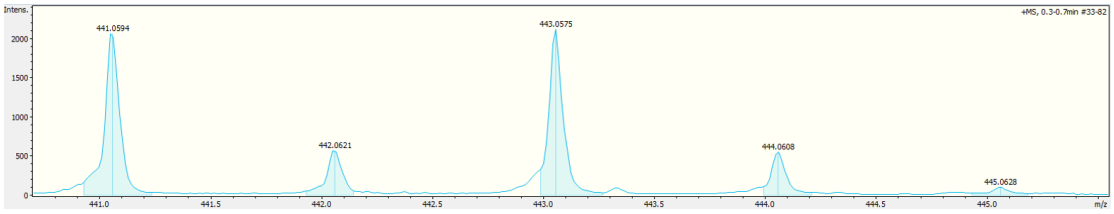
(*R*)-6-Bromo-4-methyl-3-phenyl-2-(quinolin-8-yl)isoquinolin-1(2H)-one (3ak-major)

(*R*)-6-Bromo-3-methyl-4-phenyl-2-(quinolin-8-yl)isoquinolin-1(2H)-one (3ak-minor)

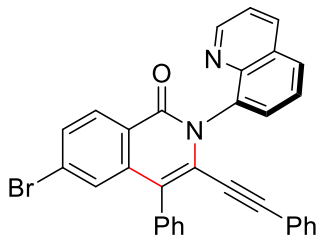


Condition C, White solid, mp: 226-227 °C, 83.9 mg, 95% yield, $[\alpha]_D^{25}$ = -46.5 (c = 0.1 in $CHCl_3$), 96% ee, 96% ee, determined by HPLC analysis (Chiralpak AD-H column, hexane/*i*-PrOH, 80:20 v/v, flow rate 1.0 mL/min, λ = 254 nm, 25 °C), t_R (minor) = 13.07 min for major isomer, t_R (major) = 19.32 min for major isomer, t_R (major) = 23.64 min for minor isomer, t_R (minor) = 43.31 min for minor isomer. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.88 (s, 1.22H, major + minor), 8.40 (d, *J* = 8.8 Hz, 1H, major), 8.32 (d, *J* = 8.4 Hz, 0.22H, minor), 8.23 (d, *J* = 8.4 Hz, 0.22H, minor), 8.02 (d, *J* = 8.0 Hz, 1H, major), 7.96 (s, 0.22H, minor), 7.94 (s, 1H, major), 7.74 (d, *J* = 7.2 Hz, 0.22H, minor), 7.68 (d, *J* = 7.6 Hz, 0.22H, minor), 7.63 (d, *J* = 8.4 Hz, 2.22H, major + minor), 7.52-7.48 (m, 0.66H, minor), 7.43 (d, *J* =

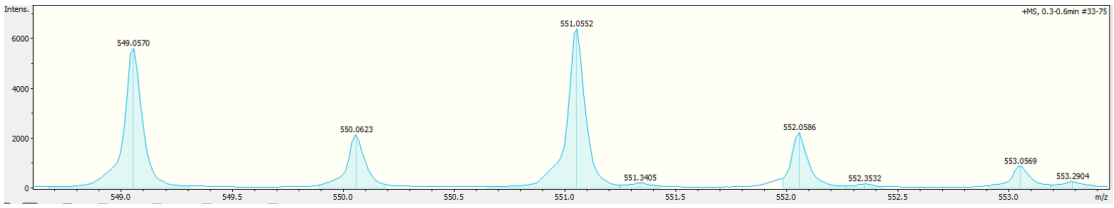
6.8 Hz, 1.22H, major + minor), 7.35-7.32 (m, 2.44H, major + minor), 7.18-7.11 (m, 2.22H, major + minor), 6.99-6.96 (m, 1H, major), 6.82 (d, *J* = 7.6 Hz, 1H, major), 6.74-6.71 (m, 1H, major). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 162.8, 162.2, 151.5, 150.9, 144.6, 142.4, 139.9, 139.8, 139.4, 137.6, 137.3, 136.8, 136.4, 136.1, 135.2, 131.4, 131.1, 130.9, 130.6, 130.2, 130.2, 129.9, 129.8, 129.5, 129.4, 129.2, 129.1, 129.0, 128.8, 128.7, 128.0, 127.9, 127.5, 127.3, 126.5, 126.4, 125.8, 124.7, 123.6, 122.0, 121.6, 116.4, 109.3, 19.2, 14.9. **HRMS** (ESI) for $C_{25}H_{18}BrN_2O$ $[M+H]^+$ calcd: 441.0597 (^{79}Br) and 443.0580 (^{81}Br); found: 441.0594 (^{79}Br) and 443.0574 (^{81}Br).



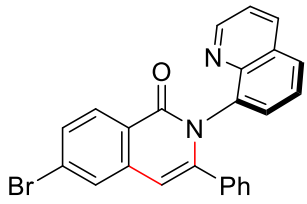
(*R*)-6-Bromo-4-phenyl-3-(phenylethynyl)-2-(quinolin-8-yl)isoquinolin-1(2H)-one (**3al**)



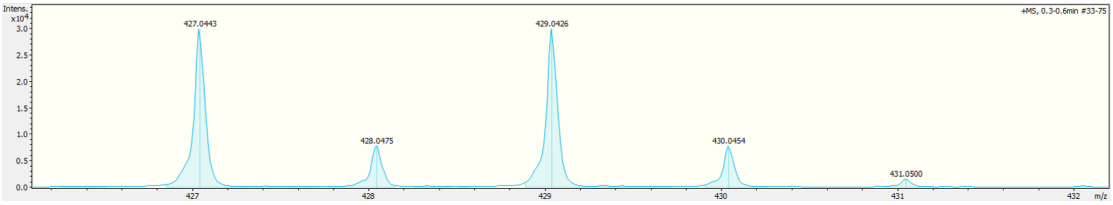
Condition C, White solid, mp: 273-274 °C, 99.0 mg, 94% yield, $[\alpha]_D^{25}$ = -77.2 (c = 0.1 in $CHCl_3$), 96% ee, determined by HPLC analysis (Chiralpak AD-H column, hexane/*i*-PrOH, 80:20 v/v, flow rate 1.0 mL/min, λ = 254 nm, 25 °C), t_R (minor) = 14.33 min, t_R (major) = 16.30 min. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.87 (d, *J* = 2.9 Hz, 1H), 8.40 (d, *J* = 8.5 Hz, 1H), 8.22 (d, *J* = 8.2 Hz, 1H), 8.00 (d, *J* = 8.2 Hz, 1H), 7.88 (d, *J* = 7.2 Hz, 1H), 7.70 (t, *J* = 7.7 Hz, 1H), 7.63-7.46 (m, 7H), 7.39-7.36 (m, 1H), 7.10-6.97 (m, 3H), 6.31 (d, *J* = 7.6 Hz, 2H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 161.8, 151.3, 144.7, 138.8, 137.7, 136.2, 135.5, 131.5, 131.2, 131.0, 130.6, 130.5, 130.2, 129.4, 129.2, 128.9, 128.128.5, 128.2, 128.1, 128.0, 127.0, 126.7, 125.1, 123.4, 121.9, 121.4, 100.0, 83.8. **HRMS** (ESI) for $C_{32}H_{19}BrN_2NaO$ $[M+Na]^+$ calcd: 549.0573 (^{79}Br) and 551.0558 (^{81}Br); found: 549.0570 (^{79}Br) and 551.0552 (^{81}Br).



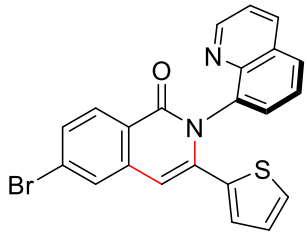
(*R*)-6-Bromo-3-phenyl-2-(quinolin-8-yl)isoquinolin-1(2H)-one (**3am**)



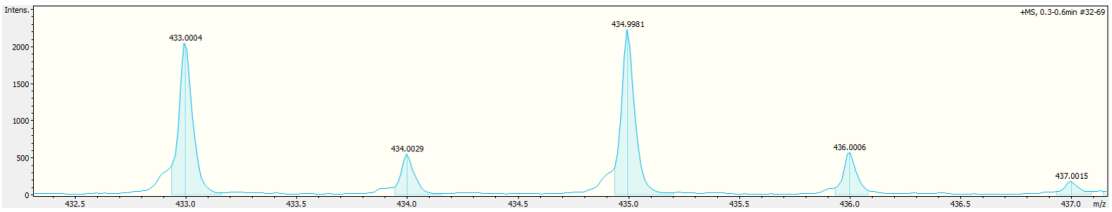
Condition C, White solid, mp: 192-193 °C, 82.2 mg, 96% yield, $[\alpha]_D^{25}$ = -95.0 (c = 0.1 in $CHCl_3$), 96% ee, determined by HPLC analysis (Chiralpak AD-H column, hexane/*i*-PrOH, 80:20 v/v, flow rate 1.0 mL/min, λ = 254 nm, 25 °C), t_R (major) = 46.26 min, t_R (minor) = 51.41 min. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.87 (d, *J* = 2.8 Hz, 1H), 8.29 (d, *J* = 8.6 Hz, 1H), 8.06 (d, *J* = 8.3 Hz, 1H), 7.74 (s, 1H), 7.70 (d, *J* = 8.0 Hz, 1H), 7.57 (d, *J* = 8.5 Hz, 1H), 7.47 (d, *J* = 7.0 Hz, 1H), 7.41-7.32 (m, 2H), 7.08 (d, *J* = 7.5 Hz, 2H), 7.04-6.92 (m, 3H), 6.54 (s, 1H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 162.9, 151.0, 146.1, 144.6, 138.8, 137.0, 136.2, 136.0, 130.7, 130.4, 130.0, 129.0, 128.9, 128.8, 128.6, 128.3, 127.9, 127.5, 125.9, 124.1, 121.7, 106.4. **HRMS** (ESI) for $C_{24}H_{16}BrN_2O$ $[M+H]^+$ calcd: 427.0441 (^{79}Br) and 429.0423 (^{81}Br); found: 427.0443 (^{79}Br) and 429.0426 (^{81}Br).



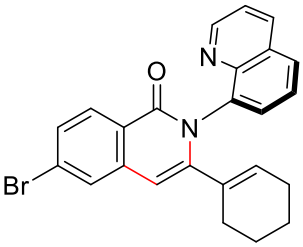
(*R*)-6-Bromo-2-(quinolin-8-yl)-3-(thiophen-2-yl)isoquinolin-1(2H)-one (**3an**)



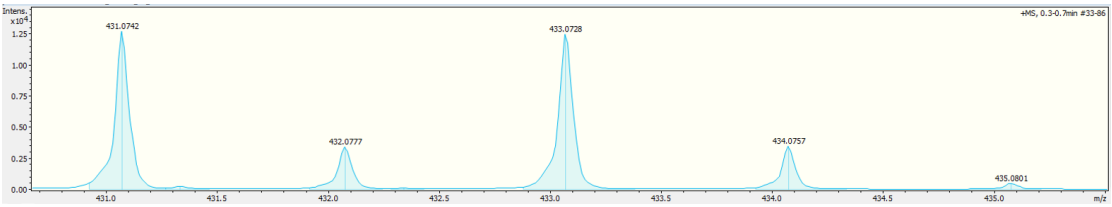
Condition C, White solid, mp: 214-215 °C, 36.5 mg, 42% yield, $[\alpha]_D^{25}$ = -90.8 (c = 0.1 in $CHCl_3$), 95% ee, determined by HPLC analysis (Chiralpak AS-H column, hexane/*i*-PrOH, 70:30 v/v, flow rate 1.0 mL/min, λ = 254 nm, 25 °C), t_R (minor) = 8.29 min, t_R (major) = 12.72 min. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.86-8.85 (m, 1H), 8.28 (d, *J* = 8.6 Hz, 1H), 8.14 (dd, *J* = 8.3, 1.2 Hz, 1H), 7.83 (d, *J* = 8.1 Hz, 1H), 7.75 (d, *J* = 1.4 Hz, 1H), 7.60-7.57 (m, 2H), 7.51 (t, *J* = 7.7 Hz, 1H), 7.39-7.36 (m, 1H), 7.01-7.00 (m, 1H), 6.75 (s, 1H), 6.64-6.52 (m, 2H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 162.9, 151.3, 145.1, 139.1, 138.5, 136.9, 136.6, 136.3, 130.6, 130.4, 130.3, 129.4, 129.1, 128.8, 128.7, 127.9, 127.2, 126.3, 126.1, 124.3, 121.9, 107.7. **HRMS** (ESI) for $C_{22}H_{14}BrN_2OS$ $[M+H]^+$ calcd: 433.0005 (^{79}Br) and 434.9986 (^{81}Br); found: 433.0004 (^{79}Br) and 434.9981 (^{81}Br).



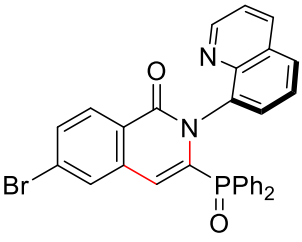
(*R*)-6-Bromo-3-(cyclohex-1-en-1-yl)-2-(quinolin-8-yl)isoquinolin-1(2H)-one (**3ao**)



Condition C, White solid, mp: 229-230 °C, 80.9 mg, 94% yield, $[\alpha]_D^{25}$ = -129.6 (c = 0.1 in $CHCl_3$), 94% ee, determined by HPLC analysis (Chiralpak AD-H column, hexane/*i*-PrOH, 70:30 v/v, flow rate 1.0 mL/min, λ = 254 nm, 25 °C), t_R (major) = 15.85 min, t_R (minor) = 39.70 min. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.92-8.81 (m, 1H), 8.25 (d, *J* = 8.5 Hz, 1H), 8.18 (dd, *J* = 8.3, 1.2 Hz, 1H), 7.89 (dd, *J* = 7.0, 2.4 Hz, 1H), 7.69 (d, *J* = 1.3 Hz, 1H), 7.60 (d, *J* = 7.3 Hz, 2H), 7.52 (dd, *J* = 8.5, 1.5 Hz, 1H), 7.40-7.37 (m, 1H), 6.39 (s, 1H), 5.69 (s, 1H), 1.80-1.76 (m, 2H), 1.66-1.58 (m, 1H), 1.49-1.39 (m, 1H), 1.20-1.16 (m, 2H), 1.11-1.00 (m, 2H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 162.9, 151.1, 148.7, 144.9, 139.3, 137.2, 136.2, 134.1, 131.1, 130.4, 130.3, 129.5, 129.0, 128.3, 127.6, 125.8, 124.0, 121.7, 104.1, 28.9, 25.1, 22.2, 21.4. **HRMS** (ESI) for $C_{24}H_{20}BrN_2O$ $[M+H]^+$ calcd: 431.0754 (^{79}Br) and 433.0736 (^{81}Br); found: 431.0742 (^{79}Br) and 433.0728 (^{81}Br).

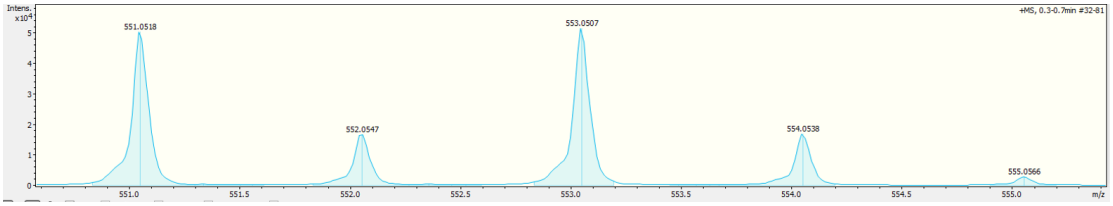


(*R*)-6-Bromo-3-(diphenylphosphoryl)-2-(quinolin-8-yl)isoquinolin-1(2H)-one (**3ap-major**)

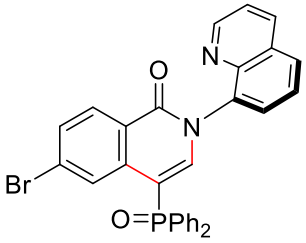


Condition C, White solid, mp: 253-254 °C, 90.2 mg, 82% yield, $[\alpha]_D^{25}$ = -169.0 (c = 0.1 in $CHCl_3$), 96% ee, determined by HPLC analysis (Chiralcel OD-H column, hexane/*i*-PrOH, 70:30 v/v, flow rate 1.0 mL/min, λ = 254 nm, 25 °C), t_R (minor) = 17.69 min, t_R (major) = 25.58 min. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.63 (d, *J* = 3.2 Hz, 1H), 8.30 (d, *J* = 8.5 Hz, 1H), 8.01 (d, *J* = 7.1 Hz, 1H), 7.86-7.74 (m, 3H), 7.68 (d, *J* = 8.6 Hz, 1H), 7.65-7.42 (m, 6H), 7.26-7.18 (m, 3H), 6.99-6.83 (m, 3H), 6.59 (d, *J* = 12.5 Hz, 1H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 162.8 (d, *J* = 4.6 Hz), 150.4, 144.4, 139.9 (d, *J* = 106.4 Hz), 136.6 (d, *J* =

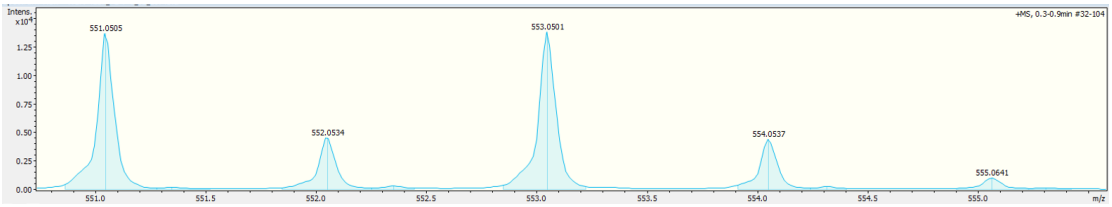
14.3 Hz), 135.8, 135.1 (d, *J* = 2.6 Hz), 132.9, 132.5 (d, *J* = 2.7 Hz), 132.4, 132.2 (d, *J* = 9.3 Hz), 131.1, 131.0 (d, *J* = 2.8 Hz), 130.4 (d, *J* = 6.7 Hz), 130.2, 130.1, 130.0, 129.9, 128.8, 128.7 128.6, 128.2, 127.9, 127.5, 127.3, 127.2, 126.0, 125.6, 121.3, 116.5 (d, *J* = 14.6 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ 23.3. **HRMS** (ESI) for $C_{30}H_{21}BrN_2O_2P$ $[M+H]^+$ calcd: 551.0519 (^{79}Br) and 553.0503 (^{81}Br); found: 551.0518 (^{79}Br) and 553.0507 (^{81}Br).



6-Bromo-4-(diphenylphosphoryl)-2-(quinolin-8-yl)isoquinolin-1(2H)-one (**3ap-minor**)

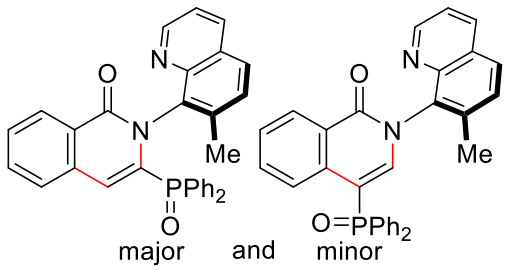


Condition C, Yellow solid, mp: 261-262 °C, 14.3 mg, 13% yield. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.88 (d, *J* = 3.0 Hz, 1H), 8.35 (d, *J* = 8.6 Hz, 1H), 8.31 (s, 1H), 8.22 (d, *J* = 8.2 Hz, 1H), 7.98-7.71 (m, 6H), 7.66-7.58 (m, 2H), 7.46 (dd, *J* = 8.3, 4.2 Hz, 7H), 7.28 (d, *J* = 9.6 Hz, 1H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 162.0, 151.0, 144.27 (d, *J* = 19.6 Hz), 143.2, 137.50 (d, *J* = 7.0 Hz), 136.9, 136.4, 132.4 (d, *J* = 2.6 Hz), 132.2, 132.1, 131.0, 130.5, 129.5, 129.5, 129.2 (d, *J* = 3.8 Hz), 128.9, 128.8, 128.6, 126.1, 125.3 (d, *J* = 9.2 Hz), 122.0, 105.5 (d, *J* = 111.4 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ 27.9. **HRMS** (ESI) for $C_{30}H_{21}BrN_2O_2P$ $[M+H]^+$ calcd: 551.0519 (^{79}Br) and 553.0503 (^{81}Br); found: 551.0505 (^{79}Br) and 553.0501 (^{81}Br).



(*R*)-3-(Diphenylphosphoryl)-2-(7-methylquinolin-8-yl)isoquinolin-1(2H)-one (3aq-major)

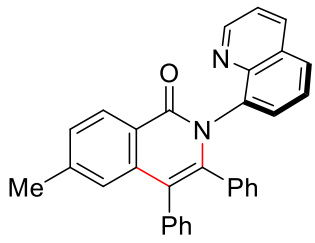
(*R*)-4-(Diphenylphosphoryl)-2-(7-methylquinolin-8-yl)isoquinolin-1(2H)-one (3aq-minor)



Condition C, White solid, mp: 245-246 °C, 71.8 mg, 74% yield, $[\alpha]_D^{25}$ = -56.8 (c = 0.1 in $CHCl_3$), 91% ee, determined by HPLC analysis (Chiralcel OD-H column, hexane/*i*-PrOH, 90:10 v/v, flow rate 1.0 mL/min, λ = 254 nm, 25 °C), t_R

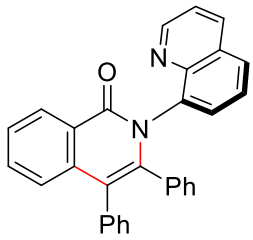
(major) = 46.85 min for major isomer, t_R (minor) = 68.46 min for major isomer. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.84-8.82 (m, 0.13H, minor), 8.51 (d, *J* = 8.0 Hz, 0.13H, minor), 8.46 (d, *J* = 7.6 Hz, 1H, major), 8.44-8.42 (m, 1H, major), 8.14 (d, *J* = 8.4 Hz, 0.26H, minor), 7.92-7.87 (m, 0.26H, minor), 7.82-7.78 (m, 3H, major), 7.75-7.74 (m, 0.13H, minor), 7.71-7.67 (m, 1.13H, major + minor), 7.62-7.58 (m, 2.26H, major + minor), 7.56-7.54 (m, 1H, major), 7.49-7.44 (m, 4.39H, major + minor), 7.37-7.34 (m, 0.26H, minor), 7.24-7.21 (m, 2H, major), 7.09-7.04 (m, 2.26H, major + minor), 6.95-6.90 (m, 2.26H, major + minor), 6.74-6.71 (m, 1.13H, major + minor), 2.49 (s, 3H, major), 2.37 (s, 0.39H, minor). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 162.6 (d, *J* = 5.0 Hz), 161.9, 151.0, 150.3, 145.2, 141.4, 138.8, 137.7, 137.6, 136.1 (d, *J* = 13.8 Hz), 135.7, 135.4 (d, *J* = 14.4 Hz), 135.4, 133.5 (d, *J* = 68.5 Hz), 133.1, 132.8, 132.5, 132.4, 132.3 (d, *J* = 5.7 Hz), 132.3, 132.1 (d, *J* = 10.0 Hz), 131.2, 131.1 (d, *J* = 2.8 Hz), 131.0, 130.9, 129.5, 129.4, 129.3, 129.2, 129.0, 128.8, 128.7 (d, *J* = 2.9 Hz), 128.6, 128.4, 127. 6 (d, *J* = 3.6 Hz), 127.4, 126.8, 121.2 (d, *J* = 3.1 Hz), 120.3, 118.1 (d, *J* = 14.6 Hz), 19.5, 18.7. ^{31}P NMR (162 MHz, $CDCl_3$) δ 28.1 (minor), 21.9 (major). **HRMS** (ESI) for $C_{31}H_{24}BrN_2O_2P$ $[M+H]^+$ calcd: 487.1570; found: 483.1557.

(*R*)-3,4-Diphenyl-2-(quinolin-8-yl)isoquinolin-1(2H)-one (**3aa**)



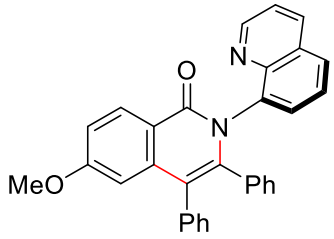
Condition C, White solid, mp: 285-287 °C, 82.3 mg, 94% yield, $[\alpha]_D^{25}$ = +53.6 (c = 0.1 in $CHCl_3$), 95% ee, determined by HPLC analysis (Chiralpak AD-H column, hexane/*i*-PrOH, 80:20 v/v, flow rate 1.0 mL/min, λ = 254 nm, 25 °C), t_R (major) = 12.01 min, t_R (minor) = 25.57 min. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.96-8.90 (m, 1H), 8.47 (d, *J* = 8.2 Hz, 1H), 8.03 (d, *J* = 8.3 Hz, 1H), 7.64 (d, *J* = 8.1 Hz, 1H), 7.48 (d, *J* = 7.1 Hz, 1H), 7.39-7.32 (m, 3H), 7.24-7.11 (m, 5H), 7.07 (s, 1H), 6.95 (d, *J* = 7.6 Hz, 1H), 6.83-6.68 (m, 3H), 6.49-6.45 (m, 1H), 2.38 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 162.7, 150.7, 144.7, 143.0, 141.9, 138.2, 137.7, 136.7, 136.1, 135.0, 131.9, 131.7, 131.0, 130.8, 129.8, 128.7, 128.5, 128.4, 128.3, 128.0, 127.7, 127.1, 126.7, 126.6, 126.4, 125.8, 125.3, 123.4, 121.5, 118.4, 22.1. **HRMS** (ESI) for $C_{31}H_3N_2O$ $[M+H]^+$ calcd: 439.1805; found: 439.1801.

(*R*)-3,4-Diphenyl-2-(quinolin-8-yl)isoquinolin-1(2H)-one (**3ba**)



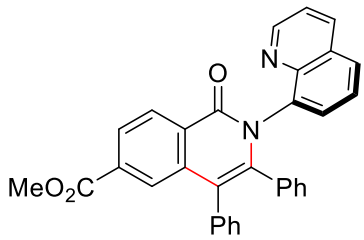
Condition C, White solid, mp: 251-253 °C, 83.3 mg, 98% yield, $[\alpha]_D^{25}$ = +51.6 (c = 0.1 in $CHCl_3$), 96% ee, determined by HPLC analysis (Chiralpak AD-H column, hexane/*i*-PrOH, 80:20 v/v, flow rate 1.0 mL/min, λ = 254 nm, 25 °C), t_R (major) = 10.39 min, t_R (minor) = 24.26 min. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.92 (d, *J* = 2.8 Hz, 1H), 8.58 (d, *J* = 7.9 Hz, 1H), 8.03 (d, *J* = 8.1 Hz, 1H), 7.65-7.48 (m, 4H), 7.41-7.28 (m, 3H), 7.24-7.11 (m, 5H), 6.97 (d, *J* = 7.6 Hz, 1H), 6.84-6.69 (m, 3H), 6.50-6.46 (m, 1H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 162.8, 150.8, 144.7, 141.9, 138.2, 137.7, 136.6, 136.1, 135.0, 132.6, 131.9, 131.7, 131.0, 130.9, 129.8, 128.8, 128.7, 128.5, 128.1, 127.9, 127.3, 126.8, 126.7, 126.5, 125.9125.7, 121.6, 118.6. **HRMS** (ESI) for $C_{30}H_{21}N_2O$ $[M+H]^+$ calcd: 425.1648; found: 425.1646.

(*R*)-6-Methoxy-3,4-diphenyl-2-(quinolin-8-yl)isoquinolin-1(2H)-one (**3ca**)



Condition C, White solid, mp: 299-301 °C, 74.3 mg, 82% yield, $[\alpha]_D^{25}$ = +62.4 (c = 0.1 in $CHCl_3$), 97% ee, determined by HPLC analysis (Chiralpak AD-H column, hexane/*i*-PrOH, 80:20 v/v, flow rate 1.0 mL/min, λ = 254 nm, 25 °C), t_R (major) = 12.28 min, t_R (minor) = 30.55 min. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.93 (d, *J* = 2.5 Hz, 1H), 8.51 (d, *J* = 8.8 Hz, 1H), 8.03 (d, *J* = 7.8 Hz, 1H), 7.63 (d, *J* = 7.8 Hz, 1H), 7.49 (d, *J* = 7.0 Hz, 1H), 7.37-7.08 (m, 8H), 6.96 (d, *J* = 7.5 Hz, 1H), 6.83-6.45 (m, 5H), 3.72 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 163.0, 162.4, 150.7, 144.7, 142.5, 140.3, 137.7, 136.6, 136.1, 135.0, 131.8, 131.6, 131.0, 130.7, 130.6, 129.7, 128.7, 128.5, 128.1, 127.8, 127.2, 126.8, 126.6, 126.4, 125.8, 121.5, 119.5, 118.3, 115.3, 107.6, 55.3. **HRMS** (ESI) for $C_{31}H_{23}N_2O_2$ $[M+H]^+$ calcd: 455.1754; found: 455.1745.

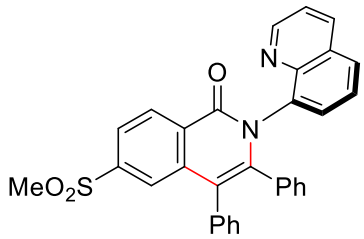
(*R*)-Methyl 1-oxo-3,4-diphenyl-2-(quinolin-8-yl)-1,2-dihydroisoquinoline-6-carboxylate (**3da**)



Condition C, White solid, mp: 329-330 °C, 88.8 mg, 92% yield, $[\alpha]_D^{25}$ = +23.75 (c = 0.1 in $CHCl_3$), 94% ee, determined by HPLC analysis (Chiralpak AD-H column, hexane/*i*-PrOH, 80:20 v/v, flow rate 1.0 mL/min, λ = 254 nm,

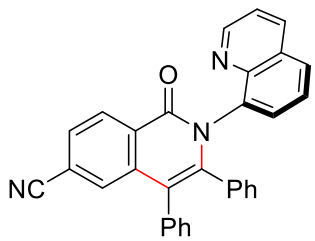
25 °C), t_R (major) = 10.06 min, t_R (minor) = 24.57 min. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.93 (d, *J* = 3.0 Hz, 1H), 8.64 (d, *J* = 8.3 Hz, 1H), 8.12 (d, *J* = 8.3 Hz, 1H), 8.07 (d, *J* = 8.1 Hz, 1H), 8.03 (s, 1H), 7.67 (d, *J* = 8.1 Hz, 1H), 7.49 (d, *J* = 6.9 Hz, 1H), 7.41-7.35 (m, 2H), 7.21 (d, *J* = 29.2 Hz, 5H), 6.96 (d, *J* = 7.6 Hz, 1H), 6.83 (t, *J* = 7.6 Hz, 1H), 6.74 (d, *J* = 7.3 Hz, 2H), 6.49 (t, *J* = 7.5 Hz, 1H), 3.89 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 166.8, 162.3, 150.9, 144.6, 142.9, 138.1, 137.5, 136.2, 135.9, 134.7, 133.6, 131.9, 131.7, 130.9, 130.8, 129.8, 128.9, 128.5, 128.3, 128.1, 127.7, 127.5, 127.2, 126.8, 126.7, 126.6, 125.9, 121.7, 118.8, 52.5. **HRMS** (ESI) for $C_{32}H_{23}N_2O_3$ $[M+H]^+$ calcd: 483.1703; found: 483.1712.

(*R*)-6-(Methylsulfonyl)-3,4-diphenyl-2-(quinolin-8-yl)isoquinolin-1(2H)-one (**3ea**)



Condition C, White solid, mp: 309-310 °C, 96.4 mg, 96% yield, $[\alpha]_D^{25}$ = +11.6 (c = 0.1 in $CHCl_3$), 93% ee, determined by HPLC analysis (Chiralpak AD-H column, hexane/*i*-PrOH, 75:25 v/v, flow rate 1.0 mL/min, λ = 254 nm, 25 °C), t_R (major) = 14.79 min, t_R (minor) = 23.53 min. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.91 (dd, *J* = 4.0, 1.3 Hz, 1H), 8.76 (d, *J* = 8.4 Hz, 1H), 8.06 (dd, *J* = 8.2, 1.1 Hz, 1H), 7.99 (dd, *J* = 8.4, 1.5 Hz, 1H), 7.94 (s, 1H), 7.68 (d, *J* = 7.9 Hz, 1H), 7.49 (d, *J* = 6.9 Hz, 1H), 7.42-7.34 (m, 2H), 7.27-7.15 (m, 5H), 6.96 (d, *J* = 7.7 Hz, 1H), 6.85 (t, *J* = 7.5 Hz, 1H), 6.78-6.67 (m, 2H), 6.50 (t, *J* = 7.6 Hz, 1H), 3.02 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 161.8, 151.0, 144.4, 144.3, 144.0, 138.8, 137.1, 136.2, 135.1, 134.3, 131.7, 131.5, 130.7, 130.5, 130.4, 129.5, 129.0, 128.8, 128.5, 128.4, 127.7, 127.5, 126.9, 126.6, 125.8, 125.4, 123.8, 121.8, 118.3, 44.3. **HRMS** (ESI) for $C_{31}H_{23}N_2O_3S$ $[M+H]^+$ calcd: 503.1424; found: 503.1429.

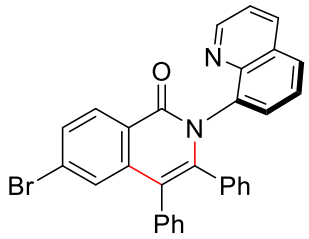
(*R*)-1-Oxo-3,4-diphenyl-2-(quinolin-8-yl)-1,2-dihydroisoquinoline-6-carbonitrile (**3fa**)



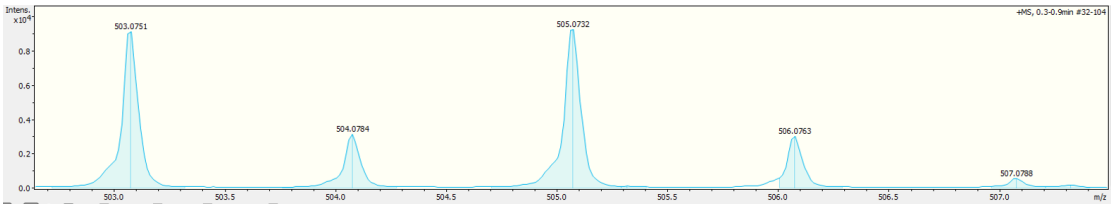
Condition C, White solid, mp: 277-278 °C, 84.4 mg, 94% yield, $[\alpha]_D^{25}$ = +18.6 (c = 0.1 in $CHCl_3$), 93% ee, determined by HPLC analysis (Chiralpak AS-H column, hexane/*i*-PrOH, 80:20 v/v, flow rate 1.0 mL/min, λ = 254 nm, 25 °C), t_R (minor) = 11.65 min, t_R (major) = 37.43 min. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.64 (d, *J* = 8.2 Hz, 1H), 8.03 (d, *J* = 8.0 Hz, 1H), 7.71-7.61 (m, 3H), 7.49 (d, *J* = 7.2 Hz, 1H), 7.37-7.34 (m, 2H), 7.26-7.10 (m, 5H), 6.97 (d, *J* = 7.0 Hz, 1H), 6.87-6.70 (m, 3H), 6.49 (t, *J* = 7.4 Hz, 1H). **^{13}C NMR** (101

MHz, $CDCl_3$) δ 161.7, 150.9, 144.3, 144.1, 138.4, 137.0, 136.1, 135.1, 134.1, 131.7, 131.4, 130.6, 130.5, 129.6, 129.4, 129.0, 128.8, 128.5, 128.3, 127.9, 127.7, 127.4, 126.9, 126.6, 125.8, 121.7, 118.5, 117.6, 115.9. **HRMS** (ESI) for $C_{31}H_{20}N_3O$ $[M+H]^+$ calcd: 450.1601; found: 450.1609.

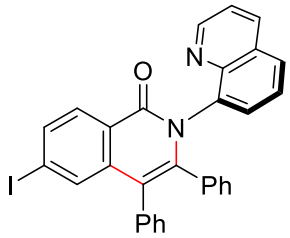
(*R*)-6-Bromo-3,4-diphenyl-2-(quinolin-8-yl)isoquinolin-1(2H)-one (**3ga**)



Condition C, White solid, mp: 307-309 °C, 98.7 mg, 98% yield, $[\alpha]_D^{25}$ = +26.4 (c = 0.1 in $CHCl_3$), 95% ee, determined by HPLC analysis (Chiralpak AD-H column, hexane/*i*-PrOH, 80:20 v/v, flow rate 1.0 mL/min, λ = 254 nm, 25 °C), t_R (major) = 12.57 min, t_R (minor) = 38.87 min. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.92 (d, *J* = 2.7 Hz, 1H), 8.42 (d, *J* = 8.5 Hz, 1H), 8.04 (d, *J* = 8.2 Hz, 1H), 7.72-7.55 (m, 2H), 7.48 (d, *J* = 6.7 Hz, 1H), 7.44 (d, *J* = 1.4 Hz, 1H), 7.39-7.34 (m, 2H), 7.25-7.12 (m, 5H), 6.95 (d, *J* = 7.6 Hz, 1H), 6.83 (t, *J* = 7.5 Hz, 1H), 6.72 (t, *J* = 7.5 Hz, 2H), 6.48 (t, *J* = 7.5 Hz, 1H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 162.4, 150.94, 144.64, 143.5, 139.8, 137.5, 136.1, 135.9, 134.7, 131.8, 131.6, 130.8, 130.7, 130.4, 130.0, 129.7, 128.8, 128.3, 128.2, 128.1, 128.0, 127.5, 127.2, 126.8, 126.6, 125.8, 124.4, 121.7, 117.7. **HRMS** (ESI) for $C_{30}H_{20}BrN_2O$ $[M+H]^+$ calcd: 503.0754 (^{79}Br) and 505.0738 (^{81}Br); found: 503.0751 (^{79}Br) and505.0732 (^{81}Br).



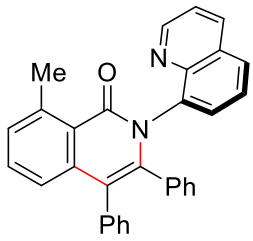
(*R*)-6-Iodo-3,4-diphenyl-2-(quinolin-8-yl)isoquinolin-1(2H)-one (**3ha**)



Condition C, White solid, mp: 320-321 °C, 104.6 mg, 95% yield, $[\alpha]_D^{25}$ = +65.8 (c = 0.1 in $CHCl_3$), 96% ee, determined by HPLC analysis (Chiralpak AD-H column, hexane/*i*-PrOH, 80:20 v/v, flow rate 1.0 mL/min, λ = 254 nm, 25 °C), t_R (major) = 14.33 min, t_R (minor) = 43.58 min. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.91 (s, 1H), 8.26 (d, *J* = 8.3 Hz, 1H), 8.03 (d, *J* = 8.0 Hz, 1H), 7.82 (d, *J* = 8.2 Hz, 1H), 7.72-7.57 (m, 2H), 7.47 (d, *J* = 7.0 Hz, 1H), 7.38-7.32 (m, 2H), 7.24-7.15 (m, 5H), 6.94 (d, *J* = 7.3 Hz, 1H), 6.82 (t, *J* = 7.3 Hz, 1H), 6.70 (d, *J* = 7.2 Hz, 2H), 6.47 (t, *J* = 7.4 Hz, 1H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 162.5, 150.9,

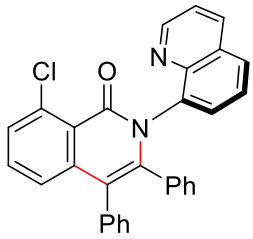
144.6, 143.3, 139.7, 137.5, 136.1, 135.8, 134.7, 134.5, 131.8, 131.6, 130.8, 130.7, 130.1, 129.7, 128.8, 128.3, 128.1, 127.5, 127.2, 126.8, 126.6, 125.8, 124.8, 121.6, 117.4, 100.9. **HRMS** (ESI) for $C_{30}H_{20}IN_2O$ $[M+H]^+$ calcd: 551.0615; found: 551.0621.

(*R*)-8-Methyl-3,4-diphenyl-2-(quinolin-8-yl)isoquinolin-1(2H)-one (**3ia**)

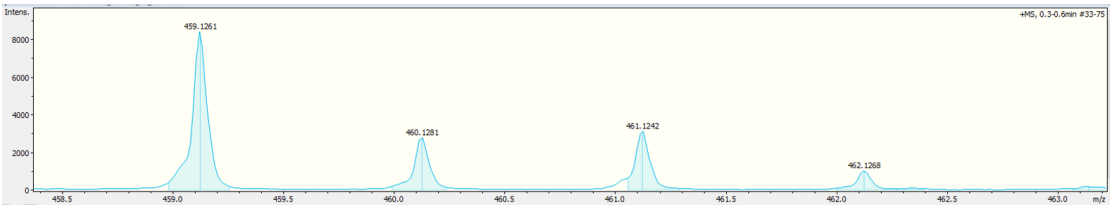


Condition C, White solid, mp: 279-280 °C, 86.8 mg, 99% yield, $[\alpha]_D^{25}$ = +7.0 (c = 0.1 in $CHCl_3$), 93% ee, determined by HPLC analysis (Chiralpak AD-H column, hexane/*i*-PrOH, 80:20 v/v, flow rate 1.0 mL/min, λ = 254 nm, 25 °C), t_R (major) = 5.15 min, t_R (minor) = 9.32 min. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.94 (d, *J* = 2.8 Hz, 1H), 8.03 (d, *J* = 8.3 Hz, 1H), 7.63 (d, *J* = 8.1 Hz, 1H), 7.52 (d, *J* = 7.0 Hz, 1H), 7.43-7.33 (m, 3H), 7.27 (d, *J* = 7.3 Hz, 1H), 7.22-7.09 (m, 6H), 6.95 (d, *J* = 7.7 Hz, 1H), 6.82-6.66 (m, 3H), 6.46 (t, *J* = 7.5 Hz, 1H), 2.96 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 163.6, 150.8, 144.9, 142.6, 142.0, 140.1, 138.2, 137.4, 136.1, 135.1, 132.0, 131.9, 131.7, 131.1, 130.8, 130.1, 129.8, 128.9, 128.5, 128.1, 127.9, 127.2, 126.8, 126.6, 126.4, 125.9, 124.2, 121.6, 118.6, 24.5. **HRMS** (ESI) for $C_{31}H_{23}N_2O$ $[M+H]^+$ calcd: 439.1805; found: 439.1806.

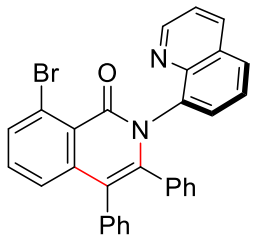
(*R*)-8-Chloro-3,4-diphenyl-2-(quinolin-8-yl)isoquinolin-1(2H)-one (**3ja**)



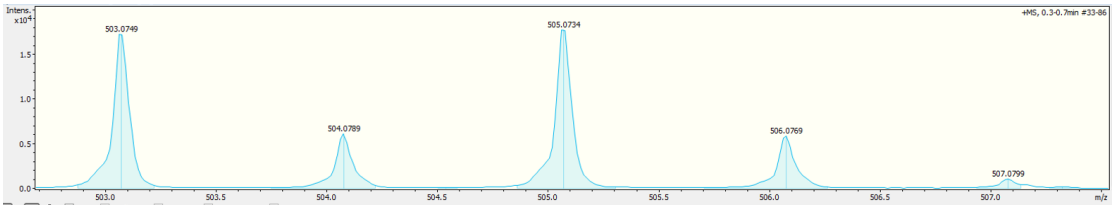
Condition C, White solid, mp: 289-290 °C, 77.1 mg, 84% yield, $[\alpha]_D^{25}$ = +6.25 (c = 0.1 in $CHCl_3$), 87% ee, determined by HPLC analysis (Chiralpak AD-H column, hexane/*i*-PrOH, 80:20 v/v, flow rate 1.0 mL/min, λ = 254 nm, 25 °C), t_R (major) = 7.02 min, t_R (minor) = 13.80 min. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.97-8.85 (m, 1H), 8.02 (d, *J* = 8.3 Hz, 1H), 7.63 (d, *J* = 8.1 Hz, 1H), 7.51 (d, *J* = 7.5 Hz, 2H), 7.42-7.33 (m, 3H), 7.24-7.12 (m, 6H), 6.95 (d, *J* = 7.7 Hz, 1H), 6.82 (t, *J* = 7.5 Hz, 1H), 6.76-6.66 (m, 2H), 6.47 (t, *J* = 7.6 Hz, 1H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 161.1, 150.9, 144.7, 143.2, 1415, 137.7, 136.7, 136.3, 136.1, 134.7, 132.2, 131.8, 131.1, 130.6, 130.0, 129.6, 128.9, 128.7, 128.2, 128.1, 127.4, 127.0, 126.7, 126.5, 125.8, 125.1, 122.2, 121.6, 117.9. **HRMS** (ESI) for $C_{30}H_{20}ClN_2O$ $[M+H]^+$ calcd: 459.1259 (^{35}Cl) and 461.1243 (^{37}Cl); found: 459.1261 (^{35}Cl) and 461.1242 (^{37}Cl).



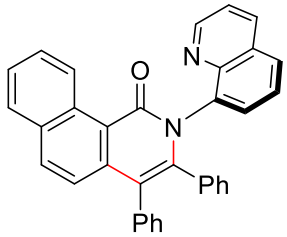
(*R*)-8-Bromo-3,4-diphenyl-2-(quinolin-8-yl)isoquinolin-1(2H)-one (**3ka**)



Condition C, White solid, mp: 291-292 °C, 80.6 mg, 80% yield, $[\alpha]_D^{25}$ = +4.3 (c = 0.1 in $CHCl_3$), 82% ee, determined by HPLC analysis (Chiralpak AD-H column, hexane/*i*-PrOH, 80:20 v/v, flow rate 1.0 mL/min, λ = 254 nm, 25 °C), t_R (major) = 7.56 min, t_R (minor) = 14.53 min. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.97-8.95 (m, k, *J* = 8.3, 1.2 Hz, 1H), 7.81 (d, *J* = 7.2 Hz, 1H), 7.67 (d, *J* = 8.0 Hz, 1H), 7.57 (d, *J* = 7.1 Hz, 1H), 7.43-7.28 (m, 4H), 7.25-7.15 (m, 5H), 6.99 (d, *J* = 7.7 Hz, 1H), 6.86 (t, *J* = 7.5 Hz, 1H), 6.81-6.70 (m, 2H), 6.51 (t, *J* = 7.5 Hz, 1H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 161.0, 150.8, 144.7, 143.1, 141.4, 137.7, 136.7, 136.1, 134.6, 133.9, 132.2, 131.9, 131.8, 131.1, 130.6, 129.6, 128.9, 128.7, 128.2, 128.1 127.4, 127.0, 126.7, 126.5, 125.8, 123.9, 123.0, 121.6, 118.0. **HRMS** (ESI) for $C_{30}H_{20}BrN_2O$ $[M+H]^+$ calcd: 503.0754 (^{79}Br) and505.0738 (^{81}Br); found: 503.0749 (^{79}Br) and 505.0734 (^{81}Br).



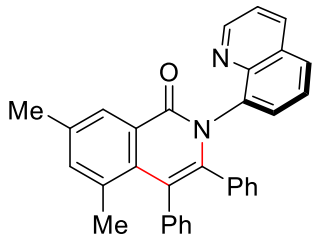
(*R*)-3,4-Diphenyl-2-(quinolin-8-yl)benzo[h]isoquinolin-1(2H)-one (**3la**)



Condition C, White solid, mp: 241-242 °C, 80.7 mg, 85% yield, $[\alpha]_D^{25}$ = +16.25 (c = 0.1 in $CHCl_3$), 97% ee, determined by HPLC analysis (Chiralpak IA-H column, hexane/*i*-PrOH, 70:30 v/v, flow rate 1.0 mL/min, λ = 254 nm, 25 °C), t_R (major) = 10.16 min, t_R (minor) = 29.37 min. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 10.25 (d, *J* = 8.7 Hz, 1H), 8.91 (dd, *J* = 4.2, 1.4 Hz, 1H), 8.06 (dd, *J* = 8.3, 1.3 Hz, 1H), 7.95 (d, *J* = 8.9 Hz, 1H), 7.88 (d, *J* = 7.8 Hz, 1H), 7.69-7.64 (m, 2H), 7.58 (t, *J* = 6.9 Hz, 2H), 7.44-7.35 (m, 3H), 7.26-7.17 (m, 5H), 7.00 (d, *J* = 7.7 Hz, 1H), 6.84 (t, *J* = 7.5 Hz, 1H), 6.78 (d, *J* = 7.7 Hz, 1H), 6.73 (t, *J* = 7.5 Hz, 1H), 6.51 (d, *J* = 7.5 Hz, 1H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 163.2, 150.9, 144.8, 143.6, 139.7,

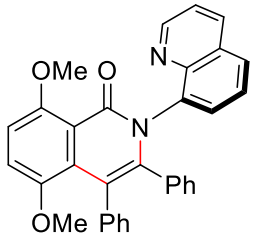
138.4, 137.2, 136.1, 135.0, 133.9, 132.4, 132.3, 132.2, 132.0, 130.9, 130.7, 129.6, 128.9, 128.7, 128.4, 128.2, 128.1, 128.0, 127.4, 126.9, 126.7, 126.5, 126.4, 125.9, 123.9, 121.6, 119.1. **HRMS** (ESI) for $C_{34}H_{23}N_2O$ $[M+H]^+$ calcd: 475.1805; found: 475.1809.

(*R*)-5,7-Dimethyl-3,4-diphenyl-2-(quinolin-8-yl)isoquinolin-1(2H)-one (**3ma**)



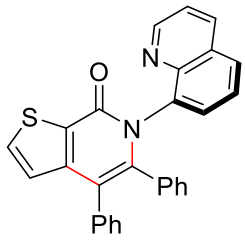
Condition C, White solid, mp: 280-281 °C, 69.7 mg, 77% yield, $[\alpha]_D^{25}$ = +39.25 (c = 0.1 in $CHCl_3$), 90% ee, determined by HPLC analysis (Chiralpak AD-H column, hexane/*i*-PrOH, 80:20 v/v, flow rate 1.0 mL/min, λ = 254 nm, 25 °C), t_R (major) = 8.55 min, t_R (minor) = 17.52 min. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.90 (d, *J* = 2.9 Hz, 1H), 8.37 (s, 1H), 8.01 (dd, *J* = 8.2, 1.0 Hz, 1H), 7.61 (d, *J* = 8.2 Hz, 1H), 7.46 (d, *J* = 6.9 Hz, 1H), 7.35-7.31 (m, 2H), 7.25-7.03 (m, 6H), 6.90 (d, *J* = 7.6 Hz, 1H), 6.77 (t, *J* = 7.4 Hz, 1H), 6.66-6.63 (m, 2H), 6.41 (t, *J* = 7.5 Hz, 1H), 2.45 (s, 3H), 1.79 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 163.0, 150.8, 144.7, 141.5, 140.2, 138.4, 138.0, 136.5, 136.0, 135.4, 135.2, 133.7, 132.3, 132.2, 131.2, 131.0, 130.1, 128.8, 128.5, 127.5, 127.3, 127.1, 127.0, 126.9, 126.5, 126.4, 126.2, 125.8, 121.5, 118.3, 23.9, 21.2. **HRMS** (ESI) for $C_{32}H_{25}N_2O$ $[M+H]^+$ calcd: 453.1961; found: 453.1964.

(*R*)-5,8-Dimethoxy-3,4-diphenyl-2-(quinolin-8-yl)isoquinolin-1(2H)-one (**3na**)



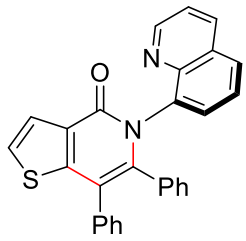
Condition C, White solid, mp: 195-196 °C, 53.5 mg, 55% yield, $[\alpha]_D^{25}$ = +7.4 (c = 0.1 in $CHCl_3$), 73% ee, determined by HPLC analysis (Chiralpak AD-H column, hexane/*i*-PrOH, 70:30 v/v, flow rate 1.0 mL/min, λ = 254 nm, 25 °C), t_R (minor) = 5.50 min, t_R (major) = 6.76 min. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.89 (d, *J* = 3.0 Hz, 1H), 7.97 (d, *J* = 8.1 Hz, 1H), 7.57 (d, *J* = 8.1 Hz, 1H), 7.45 (d, *J* = 7.1 Hz, 1H), 7.34-7.27 (m, 2H), 7.11-6.89 (m, 8H), 6.76 (t, *J* = 7.5 Hz, 1H), 6.72-6.60 (m, 2H), 6.40 (t, *J* = 7.5 Hz, 1H), 3.90 (s, 3H), 3.22 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 160.9, 156.2, 150.6, 150.0, 144.8, 143.2, 140.9, 138.1, 135.9, 135.1, 131.2, 131.1, 131.0, 130.8, 130.7, 129.9, 128.7, 128.3, 126.8, 126.5, 126.4, 126.3, 126.1, 125.6, 125.1, 121.3, 118.0, 116.8, 115.5, 109.8, 57.3, 56.9. **HRMS** (ESI) for $C_{32}H_{25}N_2O_3$ $[M+H]^+$ calcd: 485.1860; found: 485.1868.

(*R*)-4,5-Diphenyl-6-(quinolin-8-yl)thieno[2,3-c]pyridin-7(6H)-one (**3oa**)



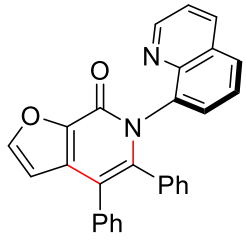
Condition C, White solid, mp: 215-216 °C, 79.3 mg, 92% yield, $[\alpha]_D^{25}$ = +38.0 (c = 0.1 in $CHCl_3$), 98% ee, determined by HPLC analysis (Chiralpak AS-H column, hexane/*i*-PrOH, 80:20 v/v, flow rate 1.0 mL/min, λ = 254 nm, 25 °C), t_R (major) = 10.08 min, t_R (minor) = 12.74 min. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.93 (d, *J* = 2.7 Hz, 1H), 8.04 (d, *J* = 8.2 Hz, 1H), 7.67 (t, *J* = 6.3 Hz, 2H), 7.49 (d, *J* = 7.2 Hz, 1H), 7.42-7.32 (m, 2H), 7.26-7.10 (m, 5H), 7.04 (d, *J* = 5.2 Hz, 1H), 6.95 (d, *J* = 7.5 Hz, 1H), 6.84 (t, *J* = 7.5 Hz, 1H), 6.75 (t, *J* = 7.7 Hz, 2H), 6.52 (t, *J* = 7.6 Hz, 1H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 158.7, 150.9, 146.8, 144.8, 143.2, 137.3, 137.1, 136.1, 134.6, 133.3, 131.1, 131.0, 130.9, 130.1, 129.4, 128.8, 128.0, 127.5, 126.9, 126.6, 125.8, 125.2, 121.6, 117.5. **HRMS** (ESI) for $C_{28}H_{19}N_2OS$ $[M+H]^+$ calcd: 431.1213; found: 431.1216.

(*R*)-6,7-Diphenyl-5-(quinolin-8-yl)thieno[3,2-c]pyridin-4(5H)-one (**3pa**)



Condition C, White solid, mp: 265-266 °C, 80.2 mg, 93% yield, $[\alpha]_D^{25}$ = +101.633 (c = 0.1 in $CHCl_3$), 89% ee, determined by HPLC analysis (Chiralpak AS-H column, hexane/*i*-PrOH, 80:20 v/v, flow rate 1.0 mL/min, λ = 254 nm, 25 °C), t_R (minor) = 10.17 min, t_R (major) = 36.26 min. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.94-8.92 (m, 1H), 8.04 (dd, *J* = 8.3, 1.5 Hz, 1H), 7.78 (d, *J* = 5.4 Hz, 1H), 7.68-7.62 (m, 1H), 7.47 (dd, *J* = 7.3, 1.2 Hz, 1H), 7.39-7.32 (m, 2H), 7.30-7.25 (m, 3H), 7.21-7.13 (m, 3H), 6.96 (d, *J* = 7.6 Hz, 1H), 6.88-6.72 (m, 3H), 6.52 (t, *J* = 7.5 Hz, 1H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 159.3, 151.4, 150.9, 144.8, 141.9, 137.5, 137.1, 136.1, 134.3, 130.9, 130.4, 130.0, 129.8, 128.8, 128.3, 127.6, 127.4, 126.9, 126.7, 126.3, 125.8, 124.9, 121.6, 116.5. **HRMS** (ESI) for $C_{28}H_{19}N_2OS$ $[M+H]^+$ calcd: 431.1213; found: 431.1215.

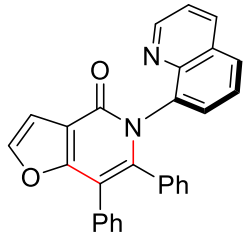
(*R*)-4,5-Diphenyl-6-(quinolin-8-yl)furo[2,3-c]pyridin-7(6H)-one (**3qa**)



Condition C, White solid, mp: 269-271 °C, 48.2 mg, 58% yield, $[\alpha]_D^{25}$ = +303.8 (c = 0.1 in $CHCl_3$), 93% ee, determined by HPLC analysis (Chiralpak AD-H column, hexane/*i*-PrOH, 70:30 v/v, flow rate 1.0 mL/min, λ = 254 nm, 25 °C), t_R (minor) = 6.03 min, t_R (major) = 10.03 min. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.93-8.92 (m, 1H), 8.08-8.00 (m, 1H), 7.80 (d, *J* = 1.8 Hz,

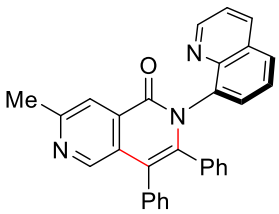
1H), 7.67 (d, *J* = 8.1 Hz, 1H), 7.48 (d, *J* = 7.3 Hz, 1H), 7.41-7.31 (m, 2H), 7.17-7.11 (m, 5H), 6.94 (d, *J* = 7.7 Hz, 1H), 6.85 (t, *J* = 7.4 Hz, 1H), 6.80-6.71 (m, 2H), 6.61 (d, *J* = 1.8 Hz, 1H), 6.52 (t, *J* = 7.6 Hz, 1H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 153.6, 150.9, 148.4, 144.8, 142.6, 142.4, 137.1, 136.4, 136.2, 134.7, 134.5, 131.2, 130.5, 130.4, 129.0, 128.9, 128.0, 127.6, 126.9, 126.8, 126.7, 125.8, 121.7, 114.8, 107.9. **HRMS** (ESI) for $C_{28}H_{19}N_2O_2$ $[M+H]^+$ calcd: 415.1441; found: 415.1451.

(*R*)-6,7-Diphenyl-5-(quinolin-8-yl)furo[3,2-c]pyridin-4(5H)-one (**3ra**)



Condition C, White solid, mp: 291-292 °C, 78.1 mg, 94% yield, $[\alpha]_D^{25}$ = +280.1 (c = 0.1 in $CHCl_3$), 95% ee, determined by HPLC analysis (Chiralpak AD-H column, hexane/*i*-PrOH, 70:30 v/v, flow rate 1.0 mL/min, λ = 254 nm, 25 °C), t_R (minor) = 6.52 min, t_R (major) = 7.17 min. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.98-8.89 (m, 1H), 8.04 (d, *J* = 8.2 Hz, 1H), 7.66 (d, *J* = 8.1 Hz, 1H), 7.54 (d, *J* = 1.9 Hz, 1H), 7.46 (d, *J* = 6.4 Hz, 1H), 7.39-7.32 (m, 2H), 7.25-7.11 (m, 6H), 6.96 (d, *J* = 7.7 Hz, 1H), 6.87 (t, *J* = 7.5 Hz, 1H), 6.82-6.72 (m, 2H), 6.54 (t, *J* = 7.5 Hz, 1H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 159.6, 159.2, 150.9, 144.8, 144.2, 143.6, 137.4, 136.2, 134.1, 132.9, 131.1, 131.0, 130.1, 128.8, 127.9, 127.8, 127.2, 127.0, 126.8, 125.8, 121.6, 115.3, 111.1, 108.3. **HRMS** (ESI) for $C_{28}H_{19}N_2O_2$ $[M+H]^+$ calcd: 415.1441; found: 415.1439.

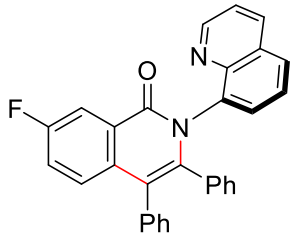
(*R*)-7-Methyl-3,4-diphenyl-2-(quinolin-8-yl)-2,6-naphthyridin-1(2H)-one (**3sa**)



Condition C, White solid, mp: 265-266 °C, 71.2 mg, 81% yield, $[\alpha]_D^{25}$ = +42.3 (c = 0.1 in $CHCl_3$), 90% ee, determined by HPLC analysis (Chiralpak AD-H column, hexane/*i*-PrOH, 70:30 v/v, flow rate 1.0 mL/min, λ = 254 nm, 25 °C), t_R (minor) = 6.49 min, t_R (major) = 11.01 min. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.90 (dd, *J* = 4.1, 1.7 Hz, 1H), 8.66 (s, 1H), 8.16 (s, 1H), 8.04 (d, *J* = 8.4 Hz, 1H), 7.65 (dd, *J* = 8.2, 1.4 Hz, 1H), 7.47 (dd, *J* = 7.3, 1.5 Hz, 1H), 7.40 – 7.31 (m, 2H), 7.28 – 7.20 (m, 2H), 7.16 (d, *J* = 1.9 Hz, 3H), 6.96 (d, *J* = 7.7 Hz, 1H), 6.88 – 6.80 (m, 1H), 6.78 – 6.64 (m, 2H), 6.55 – 6.37 (m, 1H), 2.71 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 161.7, 155.5, 150.91, 149.0, 144.5, 142.5, 137.3, 136.1, 135.0, 134.3, 131.7, 131.5, 130.8, 130.7, 130.0, 129.8, 128.9, 128.8, 128.2, 128.0, 127.6, 127.2,

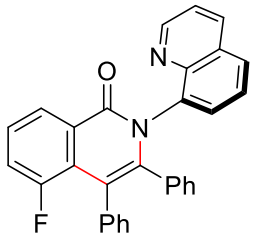
126.6, 125.8, 121.7, 119.0, 116.9, 24.4. **HRMS** (ESI) for $C_{30}H_{22}N_3O$ $[M+H]^+$ calcd: 440.1757; found: 440.1755.

(*R*)-7-Fluoro-3,4-diphenyl-2-(quinolin-8-yl)isoquinolin-1(2H)-one (**3ta-*C2***)



Condition C, White solid, mp: 200-201 °C, 45.8 mg, 52% yield, $[\alpha]_D^{25}$ = +56.4 (c = 0.1 in $CHCl_3$), 93% ee, determined by HPLC analysis (Chiralpak AD-H column, hexane/*i*-PrOH, 65:35 v/v, flow rate 1.0 mL/min, λ = 254 nm, 25 °C), t_R (major) = 6.34 min, t_R (minor) = 15.31 min. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.83 (d, *J* = 2.6 Hz, 1H), 8.14 (d, *J* = 9.1 Hz, 1H), 7.94 (d, *J* = 8.1 Hz, 1H), 7.55 (d, *J* = 8.0 Hz, 1H), 7.40 (d, *J* = 7.0 Hz, 1H), 7.28-7.06 (m, 9H), 6.88 (d, *J* = 7.5 Hz, 1H), 6.77-6.60 (m, 3H), 6.39 (t, *J* = 7.4 Hz, 1H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 161.94 (d, *J* = 2.9 Hz), 161.56 (d, *J* = 247.5 Hz), 150.9, 144.7, 141.3, 137.6, 136.4, 136.1, 134.9, 134.7, 131.8, 131.6, 130.9, 130.8, 129.8, 128.8, 128.3 (d, *J* = 7.6 Hz), 128.2, 128.0, 127.4, 127.3 (d, *J* = 8.0 Hz), 127.0, 126.8, 126.5, 125.8, 121.6, 121.1 (d, *J* = 23.3 Hz), 118.2, 113.4 (d, *J* = 22.8 Hz). **^{19}F NMR** (376 MHz, $CDCl_3$) δ -113.7. **HRMS** (ESI) for $C_{30}H_{20}FN_2O$ $[M+H]^+$ calcd: 443.1552; found: 443.1561.

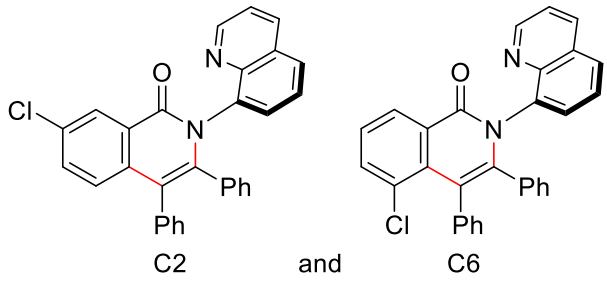
(*R*)-5-Fluoro-3,4-diphenyl-2-(quinolin-8-yl)isoquinolin-1(2H)-one (**3ta-*C6***)



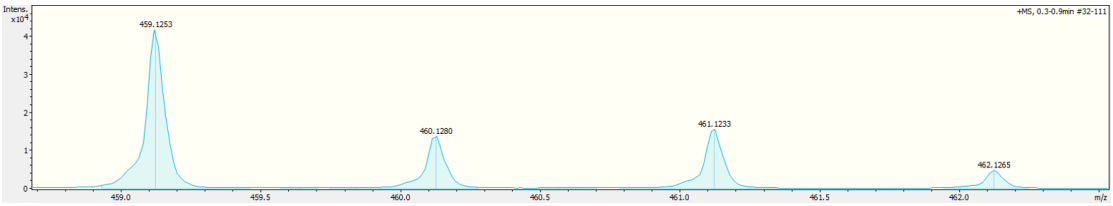
Condition C, White solid, mp: 222-223 °C, 38.1 mg, 43% yield, $[\alpha]_D^{25}$ = +82.2 (c = 0.1 in $CHCl_3$), 95% ee, determined by HPLC analysis (Chiralpak AD-H column, hexane/*i*-PrOH, 65:35 v/v, flow rate 1.0 mL/min, λ = 254 nm, 25 °C), t_R (major) = 7.15 min, t_R (minor) = 17.05 min. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.92 (d, *J* = 2.6 Hz, 1H), 8.43 (d, *J* = 7.9 Hz, 1H), 8.03 (d, *J* = 7.7 Hz, 1H), 7.64 (d, *J* = 8.1 Hz, 1H), 7.48-7.28 (m, 5H), 7.24-7.07 (m, 5H), 6.93 (d, *J* = 7.6 Hz, 1H), 6.80 (t, *J* = 7.5 Hz, 1H), 6.69 (d, *J* = 6.9 Hz, 2H), 6.45 (t, *J* = 7.5 Hz, 1H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 161.8, 158.9 (d, *J* = 256.0 Hz), 150.9, 144.6, 143.4, 138.6 (d, *J* = 3.4 Hz), 137.5, 136.1, 134.5, 131.0 (d, *J* = 2.8 Hz), 131.0, 130.9, 129.9, 128.8 (d, *J* = 2.6 Hz), 127.9, 127.4, 127.3, 127.2, 126.9 (d, *J* = 9.1 Hz), 126.6, 126.4 (d, *J* = 5.2 Hz), 125.8, 124.7 (d, *J* = 3.7 Hz), 121.7, 119.6 (d, *J* = 22.4 Hz), 114.4. **^{19}F NMR** (376 MHz, $CDCl_3$) δ -108.7. **HRMS** (ESI) for $C_{30}H_{20}FN_2O$ $[M+H]^+$ calcd: 443.1554; found: 443.1566.

(*R*)-7-Chloro-3,4-diphenyl-2-(quinolin-8-yl)isoquinolin-1(2H)-one (3ua-*C6*)

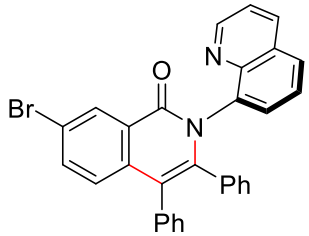
(*R*)-5-Chloro-3,4-diphenyl-2-(quinolin-8-yl)isoquinolin-1(2H)-one (3ua-*C2*)



Condition C, White solid, mp: 238-239 °C, 85.5 mg, 93% yield, $[\alpha]_D^{25}$ = -4.9 (c = 0.1 in $CHCl_3$), 94% ee, determined by HPLC analysis (Chiralpak AD-H column, hexane/*i*-PrOH, 65:35 v/v, flow rate 1.0 mL/min, λ = 220 nm, 25 °C), t_R (major) = 8.68 min for major isomer, t_R (minor) = 31.37 min for major isomer. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.89 (d, *J* = 3.2 Hz, 1.06H, C2 + C6), 8.61 (d, *J* = 8.0 Hz, 0.06H, C6), 8.55 (s, 1H, C2), 7.99 (d, *J* = 8.0 Hz, 1.06H, C2 + C6), 7.60 (d, *J* = 8.0 Hz, 1.06H, C2 + C6), 7.50-7.46 (m, 2.12H, C2 + C6), 7.39 (d, *J* = 7.6 Hz, 0.12H, C6), 7.34-7.30 (m, 2H, C2), 7.25-7.13 (m, 6.36H, C2 + C6), 6.96 (d, *J* = 7.6 Hz, 1.06H, C2 + C6), 6.83-6.67 (m, 3.12H, C2 + C6), 6.62 (d, *J* = 7.6 Hz, 0.06H, C6), 6.48-6.44 (m, 1H, C2), 6.39 (d, *J* = 7.6 Hz, 0.06H, C6). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 162.0, 161.7, 150.8, 144.5, 143.8, 142.7, 142.3, 138.2, 137.4, 136.6, 136.3, 136.1, 136.0, 135.4, 134.7, 134.6, 132.8, 132.7, 132.3, 132.2, 131.7, 131.5, 130.9, 130.8, 130.7, 129.6, 128.8, 128.2, 128.0, 127.7, 127.5, 127.4, 127.2, 127.1, 127.0, 126.7, 126.6, 126.5, 126.2, 125.7, 121.6, 121.4, 118.0, 117.8. **HRMS** (ESI) for $C_{30}H_{20}ClN_2O$ $[M+H]^+$ calcd: 459.1259 (^{35}Cl) and 461.1243 (^{37}Cl); found: 459.1253 (^{35}Cl) and 461.1233 (^{37}Cl).

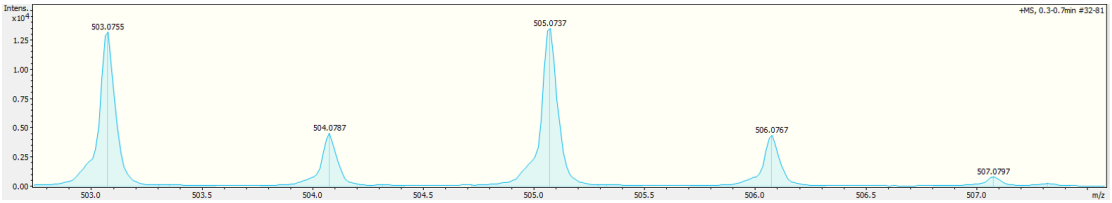


(*R*)-7-Bromo-3,4-diphenyl-2-(quinolin-8-yl)isoquinolin-1(2H)-one (**3va**)

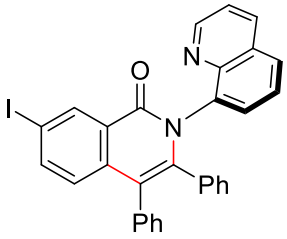


Condition C, White solid, mp: 241-242 °C, 96.8 mg, 96% yield, $[\alpha]_D^{25}$ = -22.23 (c = 0.1 in $CHCl_3$), 94% ee, determined by HPLC analysis (Chiralpak AD-H column, hexane/*i*-PrOH, 65:35 v/v, flow rate 1.0 mL/min, λ = 254 nm, 25 °C), t_R (major) = 9.86 min, t_R (minor) = 39.44 min. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.88 (d, *J* = 3.1 Hz, 1H), 8.71 (s, 1H), 7.99 (d, *J* = 8.1 Hz, 1H), 7.62 (t, *J* = 9.5 Hz, 2H), 7.46 (d, *J* = 7.1 Hz, 1H), 7.33-7.30 (m, 2H), 7.24-7.08 (m, 6H), 6.96 (d, *J* = 7.5 Hz, 1H), 6.83-6.67 (m, 3H), 6.47 (d, *J* = 7.5 Hz, 1H). **^{13}C**

NMR (101 MHz, $CDCl_3$) δ 161.5, 150.8, 144.5, 142.5, 137.4, 136.9, 136.0, 135.5, 134.6, 131.7, 131.5, 130.9, 130.7, 130.6, 129.6, 128.8, 128.2, 128.0, 127.6, 127.4, 127.0, 126.8, 126.5, 125.7, 121.6, 120.6, 118.1. **HRMS** (ESI) for $C_{30}H_{20}BrN_2O$ $[M+H]^+$ calcd: 503.0754 (^{79}Br) and505.0738 (^{81}Br); found: 503.0755 (^{79}Br) and 505.0737 (^{81}Br).

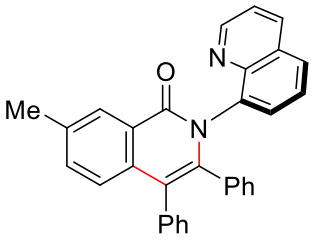


(*R*)-7-Iodo-3,4-diphenyl-2-(quinolin-8-yl)isoquinolin-1(2H)-one (**3wa**)



Condition C, White solid, mp: 261-262 °C, 104.4 mg, 95% yield, $[\alpha]_D^{25}$ = -52.2 (c = 0.1 in $CHCl_3$), 92% ee, determined by HPLC analysis (Chiralpak AD-H column, hexane/*i*-PrOH, 65:35 v/v, flow rate 1.0 mL/min, λ = 254 nm, 25 °C), t_R (major) = 10.04 min, t_R (minor) = 42.16 min. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.96-8.84 (m, 2H), 8.00 (d, *J* = 8.0 Hz, 1H), 7.82 (d, *J* = 7.8 Hz, 1H), 7.61 (d, *J* = 8.0 Hz, 1H), 7.46 (d, *J* = 7.1 Hz, 1H), 7.35-7.11 (m, 7H), 7.02 (d, *J* = 8.6 Hz, 1H), 6.95 (d, *J* = 7.5 Hz, 1H), 6.86-6.64 (m, 3H), 6.46 (t, *J* = 7.5 Hz, 1H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 161.3, 150.8, 144.5, 142.7, 141.1, 137.4, 137.3, 137.2, 136.1, 136.0, 134.6, 131.7, 131.5, 130.7, 130.6, 129.6, 128.8, 128.7, 128.2, 128.0, 127.5, 127.4, 127.1, 127.0, 126.8, 126.5, 125.7, 121.6, 118.1, 91.8. **HRMS** (ESI) for $C_{30}H_{20}IN_2O$ $[M+H]^+$ calcd: 551.0615; found: 551.0619.

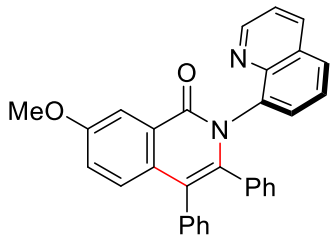
(*R*)-7-Methyl-3,4-diphenyl-2-(quinolin-8-yl)isoquinolin-1(2H)-one (**3xa**)



Condition C, White solid, mp: 263-264 °C, 75.4 mg, 86% yield, $[\alpha]_D^{25}$ = +35.37 (c = 0.1 in $CHCl_3$), 96% ee, determined by HPLC analysis (Chiralpak AD-H column, hexane/*i*-PrOH, 75:25 v/v, flow rate 1.0 mL/min, λ = 254 nm, 25 °C), t_R (major) = 8.47 min, t_R (minor) = 31.48 min. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.90 (dd, *J* = 4.0, 1.4 Hz, 1H), 8.39 (s, 1H), 8.01 (d, *J* = 8.1 Hz, 1H), 7.62 (d, *J* = 8.2 Hz, 1H), 7.51-7.45 (m, 1H), 7.41 (d, *J* = 8.4 Hz, 1H), 7.36-7.31 (m, 2H), 7.24-7.12 (m, 6H), 6.96 (d, *J* = 7.7 Hz, 1H), 6.81 (t, *J* = 7.5 Hz, 1H), 6.73-6.67 (m, 2H), 6.46 (t, *J* = 7.5 Hz, 1H), 2.49 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 162.7, 150.8, 144.8, 141.0, 137.9, 136.8, 136.0, 135.9, 135.1, 134.0, 131.9, 139.8,

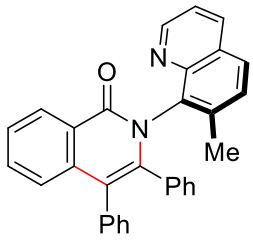
131.0, 130.9, 129.9, 128.8, 128.6, 128.1, 127.8, 127.2, 126.7, 126.5, 125.8, 125.7, 125.6, 121.5, 118.5, 21.5. **HRMS** (ESI) for $C_{31}H_{23}N_2O$ $[M+H]^+$ calcd: 439.1805; found: 439.1807.

(*R*)-7-Methoxy-3,4-diphenyl-2-(quinolin-8-yl)isoquinolin-1(2H)-one (**3ya**)



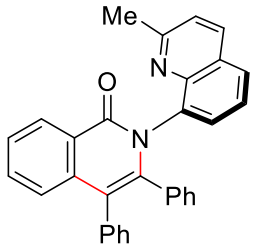
Condition C, White solid, mp: 281-282 °C, 78.2 mg, 86% yield, $[\alpha]_D^{25}$ = +11.8 (c = 0.1 in $CHCl_3$), 94% ee, determined by HPLC analysis (Chiralpak AS-H column, hexane/*i*-PrOH, 80:20 v/v, flow rate 1.0 mL/min, λ = 254 nm, 25 °C), t_R (minor) = 7.62 min, t_R (major) = 12.02 min. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.91 (d, *J* = 2.8 Hz, 1H), 8.01 (d, *J* = 7.3 Hz, 2H), 7.61 (d, *J* = 8.1 Hz, 1H), 7.46 (d, *J* = 7.1 Hz, 1H), 7.36-7.11 (m, 9H), 6.96 (d, *J* = 7.5 Hz, 1H), 6.83-6.67 (m, 3H), 6.47 (t, *J* = 7.5 Hz, 1H), 3.90 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 162.4, 158.7, 150.8, 144.8, 139.6, 137.9, 136.7, 136.0, 135.0, 132.2, 131.8, 131.6, 131.0, 130.8, 129.9, 128.7, 128.6, 128.0, 127.8, 127.5, 127.2, 126.8, 126.7, 126.5, 125.8, 122.8, 121.5, 118.5, 108.2, 55.7. **HRMS** (ESI) for $C_{31}H_{23}N_2O_2$ $[M+H]^+$ calcd: 455.1754; found: 455.1760.

(*R*)-2-(7-Methylquinolin-8-yl)-3,4-diphenylisoquinolin-1(2H)-one (**3za**)



Condition C, White solid, mp: 290-291 °C, 37.4 mg, 41% yield, $[\alpha]_D^{25}$ = +132.25 (c = 0.1 in $CHCl_3$), 93% ee, determined by HPLC analysis (Chiralpak AD-H column, hexane/*i*-PrOH, 80:20 v/v, flow rate 1.0 mL/min, λ = 254 nm, 25 °C), t_R (major) = 7.39 min, t_R (minor) = 10.39 min. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.89 (d, *J* = 3.9 Hz, 1H), 8.60 (d, *J* = 7.9 Hz, 1H), 7.99 (d, *J* = 8.2 Hz, 1H), 7.62-7.50 (m, 3H), 7.34-7.28 (m, 2H), 7.26-7.13 (m, 6H), 6.95 (d, *J* = 7.5 Hz, 1H), 6.80-6.70 (m, 3H), 6.46 (t, *J* = 7.5 Hz, 1H), 2.38 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 162.1, 150.7, 145.2, 142.1, 138.4, 137.6, 136.8, 135.9, 135.8, 134.7, 132.5, 132.0, 131.9, 130.0, 129.2, 129.0, 128.6, 128.2, 128.0, 127.8, 127.5, 127.2, 126.8, 126.7, 126.5, 126.3, 125.8, 120.8, 119.0, 19.1. **HRMS** (ESI) for $C_{31}H_{23}N_2O$ $[M+H]^+$ calcd: 439.1805; found: 439.1817.

(*R*)-2-(2-Methylquinolin-8-yl)-3,4-diphenylisoquinolin-1(2H)-one (**3aaa**)



Condition C, White solid, mp: 262-263 °C, 30.0 mg, 33% yield,

$[\alpha]_D^{25}$ = +38.25 (c = 0.1 in $CHCl_3$), 88% ee, determined by HPLC analysis (Chiralpak AD-H column, hexane/*i*-PrOH, 80:20 v/v, flow rate 1.0 mL/min, λ = 254 nm, 25 °C), t_R (major) = 8.68 min, t_R (minor) = 28.15 min. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.59 (d, *J* = 7.8 Hz, 1H), 7.86 (d, *J* = 8.4 Hz, 1H), 7.62-7.49 (m, 4H), 7.30 (t, *J* = 8.0 Hz, 2H), 7.24-7.13 (m, 6H), 6.95 (d, *J* = 7.6 Hz, 1H), 6.79 (t, *J* = 7.5 Hz, 1H), 6.74 (d, *J* = 7.7 Hz, 1H), 6.69 (t, *J* = 7.4 Hz, 1H), 6.48 (t, *J* = 7.6 Hz, 1H), 2.65 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 163.0, 159.4, 144.2, 142.4, 138.2, 137.2, 136.8, 135.8, 135.1, 132.4, 132.0, 131.8, 130.8, 130.7, 130.4, 128.5, 128.3, 128.0, 127.2, 127.1, 126.8, 126.6, 126.5, 126.2, 125.8, 125.6, 124.8, 122.4, 118.3, 25.9. **HRMS** (ESI) for $C_{31}H_{23}N_2O$ $[M+H]^+$ calcd: 439.1805; found: 439.1807.

4. X-Ray Crystallographic Structures of Products

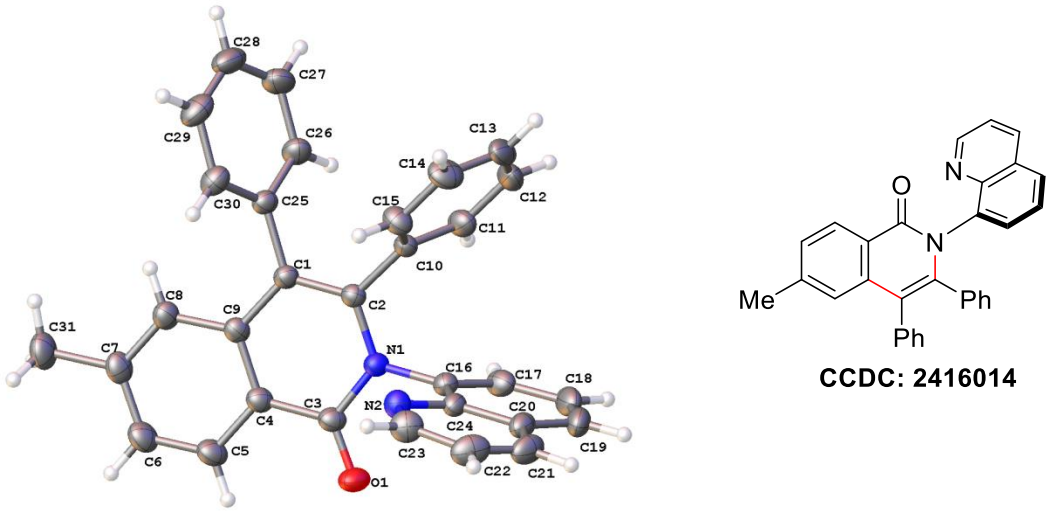


Figure S2. Single-crystal structure of **3aa** (CCDC: 2416014).

Table 9. Crystal data and structure refinement for **3aa**

Identification code	230327c_0m	
Empirical formula	$C_{31}H_{22}N_2O$	
Formula weight	438.50	
Temperature	200.0 K	
Wavelength	1.34139 Å	
Crystal system	Orthorhombic	
Space group	$P2_12_12_1$	
Unit cell dimensions	a = 6.6897(2) Å	= 90°.
	b = 8.5739(3) Å	= 90°.
	c = 40.2002(14) Å	= 90°.
Volume	2305.76(13) $Å^3$	
Z	4	
Density (calculated)	1.263 Mg/m^3	
Absorption coefficient	0.381 mm^{-1}	
F(000)	920	
Crystal size	0.3 x 0.2 x 0.2 mm^3	
Theta range for data collection	4.879 to 72.378°.	
Index ranges	-9<=h<=8, -10<=k<=12, -56<=l<=55	
Reflections collected	51497	
Independent reflections	6644 [R(int) = 0.0412]	
Completeness to theta = 53.594°	95.1 %	

Absorption correction	Semi-empirical from equivalents
Max. and min. transmission	0.7536 and 0.6360
Refinement method	Full-matrix least-squares on F^2
Data / restraints / parameters	6644 / 0 / 309
Goodness-of-fit on F^2	1.164
Final R indices [I>2sigma(I)]	R1 = 0.0449, wR2 = 0.1272
R indices (all data)	R1 = 0.0451, wR2 = 0.1274
Absolute structure parameter	0.03(5)
Extinction coefficient	0.011(2)
Largest diff. peak and hole	0.260 and -0.217 e.$Å^{-3}$

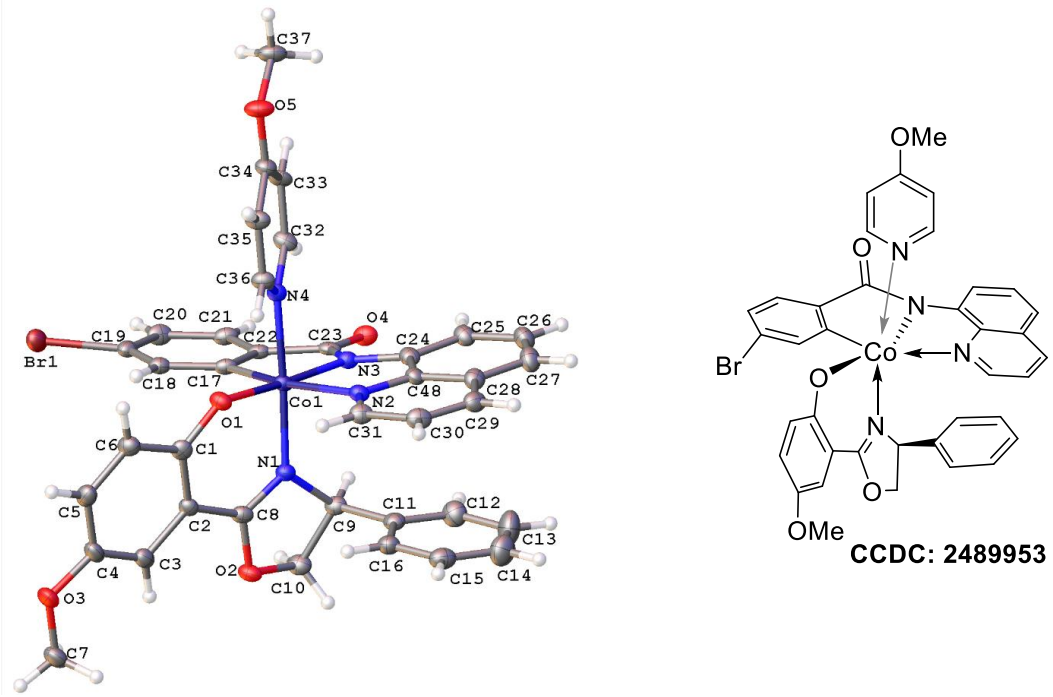


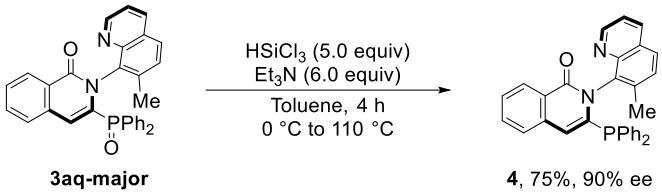
Figure S3. Single-crystal structure of **[Co]-1** (CCDC: 2489953).

Table 10. Crystal data and structure refinement for **[Co]-1**

Identification code	t	
Empirical formula	$C_{41}H_{37}BrCoN_4O_5$	
Formula weight	804.58	
Temperature	100(2) K	
Wavelength	1.34139 Å	
Crystal system	Monoclinic	
Space group	$P2_1$	
Unit cell dimensions	a = 13.4639(6) Å	a= 90°.
	b = 33.6616(14) Å	b= 109.5370(10)°.
	c = 17.1903(7) Å	g = 90°.
Volume	7342.4(5) $Å^3$	
Z	8	
Density (calculated)	1.456 Mg/m^3	
Absorption coefficient	3.712 mm^{-1}	
F(000)	3304	
Crystal size	0.150 x 0.120 x 0.100 mm^3	

Theta range for data collection	2.284 to 57.142°.
Index ranges	-16<=h<=16, -42<=k<=42, -21<=l<=21
Reflections collected	236844
Independent reflections	29970 [R(int) = 0.0528]
Completeness to theta = 53.594°	99.8 %
Absorption correction	Semi-empirical from equivalents
Max. and min. transmission	0.7512 and 0.6311
Refinement method	Full-matrix least-squares on F^2
Data / restraints / parameters	29970 / 0 / 1882
Goodness-of-fit on F^2	1.047
Final R indices [I>2sigma(I)]	R1 = 0.0376, wR2 = 0.0981
R indices (all data)	R1 = 0.0389, wR2 = 0.0988
Absolute structure parameter	0.0056(12)
Extinction coefficient	n/a
Largest diff. peak and hole	1.303 and -1.323 e.$Å^{-3}$

5. Synthetic application

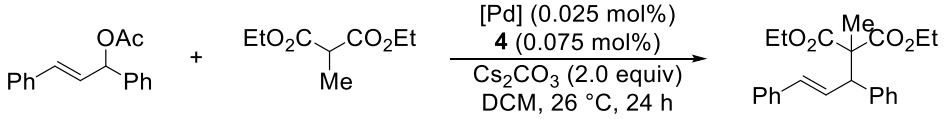


3aq-major **4**, 75%, 90% ee

Procedure for synthesis of 4: According to the reported literature,[6] solution of **3aq-major** (48.6 mg, 0.1 mmol) in toluene (1 mL) was frozen using an EtOH/liquid nitrogen bath, to which trichlorosilane (47.4 mg, 0.5 mmol) and triethylamine (42.5 mg, 0.6 mmol) were added. The mixture was stirred at 110 °C under nitrogen for 4 h. After cooling to room temperature, a saturated aqueous solution of $NaHCO_3$ (1 mL) was added, and the mixture was stirred for 5 min. The mixture was filtered through a pad of alumina and evaporated in vacuo to give the crude product. Purified by flash chromatography (hexane/EtOAc= 3:1) to afford the desired product **4**.

(*R*)-3-(Diphenylphosphanyl)-2-(7-methylquinolin-8-yl)isoquinolin-1(2H)-one (4)

Yellow solid, mp: 220-221 °C, 35.3 mg, 75% yield, $[\alpha]_D^{25}$ = -78.0 (c = 0.1 in $CHCl_3$), 90% ee, determined by HPLC analysis (Chiralpak AD-H column, hexane/*i*-PrOH, 80:20 v/v, flow rate 1.0 mL/min, λ = 254 nm, 25 °C), t_R (major) = 8.39 min, t_R (minor) = 17.01 min. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.58 (d, *J* = 3.0 Hz, 1H), 8.43 (d, *J* = 8.0 Hz, 1H), 8.05 (d, *J* = 7.9 Hz, 1H), 7.81 (d, *J* = 8.4 Hz, 1H), 7.70-7.60 (m, 1H), 7.51-7.47 (m, 1H), 7.44-7.32 (m, 5H), 7.30-7.26 (m, 1H), 7.25-7.07 (m, 7H), 6.39 (s, 1H), 2.06 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 162.8 (d, *J* = 1.7 Hz), 150.8, 145.8 (d, *J* = 11.1 Hz), 145.1 (d, *J* = 2.8 Hz), 139.4 (d, *J* = 3.1 Hz), 136.3 (d, *J* = 140.5 Hz), 135.1 (d, *J* = 4.6 Hz), 134.7, 134.5, 134.0 (d, *J* = 10.8 Hz), 134.0, 133.8, 133.6 (d, *J* = 10.1 Hz), 132.2, 129.7, 129.0, 129.0, 128.8, 128.8, 128.7, 128.5, 128.3, 128.2, 127.2, 126.7 (d, *J* = 115.8 Hz), 126.4, 120.7, 114.5, 18.56 (d, *J* = 4.4 Hz). **^{31}P NMR** (162 MHz, $CDCl_3$) δ -12.2. **HRMS** (ESI) for $C_{31}H_{24}N_2OP$ $[M+H]^+$ calcd: 471.1621; found: 471.1610.



5 **6** **7**, 78%. 45%ee

Procedure for synthesis of 7: According to the reported literature[7], a mixture of $[PdCl(\eta^3\text{-}C_3H_5)]_2$ (0.0025 mmol, 0.92 mg), ligand **4** (0.0075 mmol, 3.4 mg), and Cs_2CO_3 (0.2

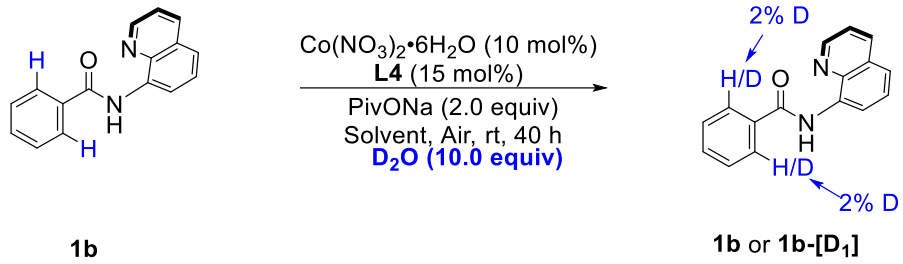
mmol, 65.2 mg) in dichloromethane (0.5 mL) was stirred for 30 min at room temperature. 1,3-Diphenyl-2-propenyl acetate **5** (0.1 mmol, 25.2 mg), diethyl 2-methylmalonate **6** (0.2 mmol, 34μl) were added with additional dichloromethane (1.0 mL). The resulting mixture was stirred for 24 h at 26 °C, and passed through a pad of silica gel with EtOAc, and the solvent removed under vacuum. The residue was chromatographed on silica gel with EtOAc/hexane = 1/4 to afford the product **7**.

Diethyl (E)-2-(1,3-diphenylallyl)-2-methylmalonate (7)

colorless oil, 28.6 mg, 78% yield, $[\alpha]_D^{25}$ = -15.8 (c = 0.1 in $CHCl_3$), 45% ee, determined by HPLC analysis (Chiralpak IG-H column, hexane/*i*-PrOH, 95:5 v/v, flow rate 1.0 mL/min, λ = 254 nm, 25 °C), t_R (minor) = 11.43 min, t_R (major) = 14.50 min. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.34-7.25 (m, 8H), 7.24-7.19 (m, 2H), 6.70 (dd, *J* = 15.7, 8.9 Hz, 1H), 6.44 (d, *J* = 15.7 Hz, 1H), 4.29 (d, *J* = 8.9 Hz, 1H), 4.22-4.13 (m, 2H), 4.08 (q, *J* = 7.1 Hz, 2H), 1.47 (s, 3H), 1.22 (t, *J* = 7.1 Hz, 3H), 1.16 (t, *J* = 7.1 Hz, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 171.3, 171.1, 139.6, 137.5, 132.7, 129.8, 129.0, 128.6, 128.3, 127.4, 127.2, 126.5, 61.5, 61.4, 59.0, 53.9, 18.9, 14.2, 14.1. **HRMS** (ESI) for $C_{23}H_{26}NaO_4$ $[M+H]^+$ calcd: 389.1723; found: 389.1713.

6. Mechanistic studies

6.1. H/D exchange experiments



Under air, $Co(NO_3)_2$•$6H_2O$ (0.01 mmol, 2.91 mg), **L4** (0.015 mmol, 4.04 mg) and HFIP (1 mL) were added to a 10 mL vial. After stirring at room temperature for 2 h, **1b** (0.1 mmol), PivONa (24.8 mg, 0.4 mmol) and D_2O (20 mg, 1 mmol) were added to the resulting mixture. The mixture was stirred at room temperature for approximately 40 h. The concentrated reaction residue was purified by flash column chromatography on silica gel with petroleum ether/ethyl acetate (10:1) as eluent. ^{1}H NMR analysis showed that the D contents in the recovered substrate **1b** was 2%.

6.2. Parallel KIE experiments

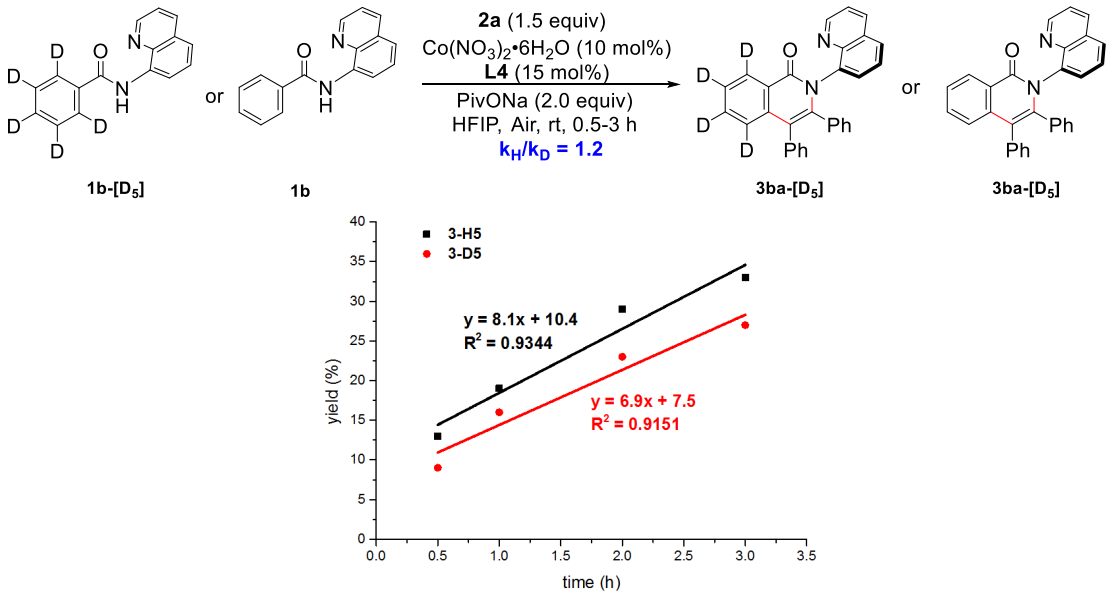
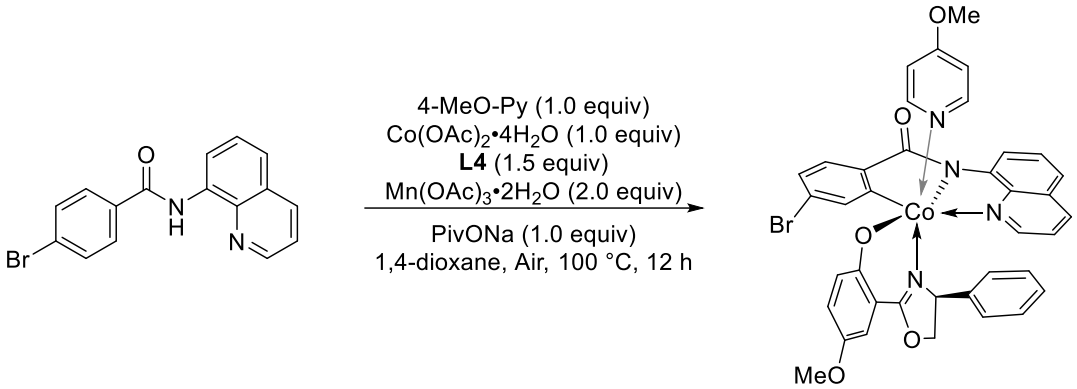


Figure S4 Parallel KIE experiments

Under air, $Co(NO_3)_2$•$6H_2O$ (0.01 mmol, 2.91 mg), **L4** (0.015 mmol, 4.04 mg) and HFIP (1 mL) were added to a 10 mL vial. After stirring at room temperature for 2 h, **1b** (0.1 mmol) or **[*D*$_5$]-1b** (0.1 mmol), alkyne **2a** (26.7 mg, 0.15 mmol) and PivONa (24.8 mg, 0.2 mmol) were added to the resulting mixture. The mixture was stirred at room temperature for

approximately 0.5 h, 1.0 h, 2.0 h, 3.0 h. The concentrated reaction residue was purified by flash column chromatography on silica gel with petroleum ether/ethyl acetate (3:1-1.5:1) as eluent. The KIE was determined as k_H/k_D = 8.1/6.9 = 1.2.

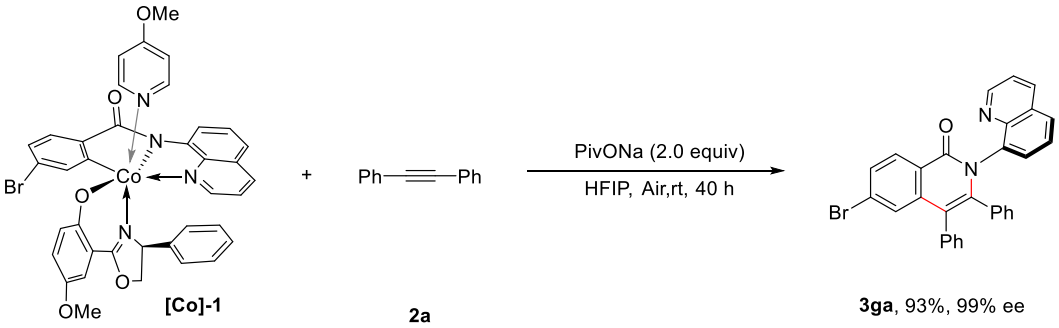
6.3. [Co]-1 via Asymmetric C-H Cleavage



1g **[Co]-1**, 45%

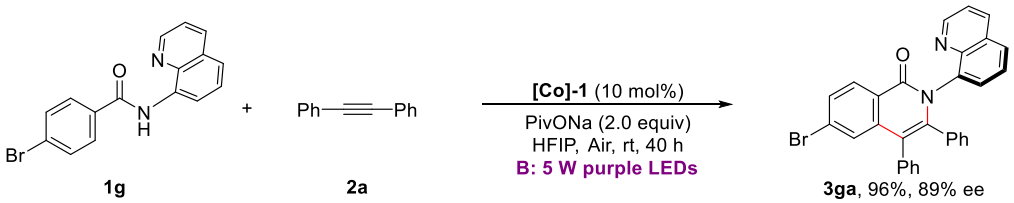
Procedure for synthesis of [Co]-1[(2)]**:** A dried vial equipped with a stirring bar was charged with **1g** (327.0 mg, 1.0 mmol), $Co(OAc)_2•4H_2O$ (249.1 mg, 1.0 equiv), **L4** (404.0 mg, 1.5 equiv), 4-methoxypyridine (109.1 mg, 1.0 equiv), NaOPiv (124.8 mg, 1.0 equiv), $Mn(OAc)_3•3H_2O$ (536.2 mg, 2.0 equiv) and dioxane (15 mL). Then, the vial was instantly placed in a heating block set at 100 ºC under air for 12 h. Then, the reaction mixture was cooLEDsto room temperature. The mixture was diluted with DCM and concentrated in vacuo. Then the mixture was purified by flash column chromatography on silica gel with petroleum ether/ethyl acetate (1:3) as eluent to give the desired **[Co]-1**(343 mg, 45%, yellow solid). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 9.24 (dd, *J* = 4.6, 1.3 Hz, 1H), 9.02 (d, *J* = 7.5 Hz, 1H), 7.85 (dd, *J* = 8.3, 1.1 Hz, 1H), 7.75 (dd, *J* = 4.6, 2.6 Hz, 3H), 7.61 (d, *J* = 7.9 Hz, 1H), 7.43 (dd, *J* = 8.3, 4.6 Hz, 1H), 7.36 (dd, *J* = 7.9, 1.7 Hz, 1H), 7.33-7.27 (m, 1H), 7.15 (d, *J* = 9.2 Hz, 1H), 7.07 (dd, *J* = 9.2, 3.2 Hz, 1H), 6.98 (d, *J* = 7.9 Hz, 1H), 6.95 (d, *J* = 3.2 Hz, 1H), 6.63-6.55 (m, 1H), 6.51-6.44 (m, 2H), 6.32 (d, *J* = 7.3 Hz, 2H), 6.22 (d, *J* = 7.3 Hz, 2H), 4.30 (dd, *J* = 9.3, 3.2 Hz, 1H), 4.06-3.98 (m, 1H), 3.80-3.74 (m, 4H), 3.58 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 175.6, 169.4, 166.2, 165.2, 163.5, 151.5, 148.8, 147.6, 146.8, 146.6, 146.5, 139.4, 137.3, 136.9, 129.2, 128.6, 127.8, 127.4, 127.2, 126.7, 125.0, 124.4, 124.2, 123.7, 121.8, 121.3, 118.4, 109.9, 109.7, 107.6, 74.8, 66.1, 56.1, 55.5. **HRMS** (ESI) for $C_{28}H_{28}NO_4$ $[M+H]^+$ calcd: 761.0804; found: 761.0821.

6.4. Stoichiometric Reaction of [Co]-1



Under air, **[Co]-1** (0.1 mmol, 76.1 mg), alkyne **2a** (0.15 mmol), PivONa (25.0 mg, 0.2 mmol), and HFIP (1 mL) were added to a 10 mL vial. The mixture was stirred at room temperature for approximately 40 h. The concentrated reaction residue was purified by flash column chromatography on silica gel with petroleum ether/ethyl acetate (3:1-1.5:1) as eluent to give corresponding product **3ga** in 93% isolated yield with 99% ee.

6.5. [Co]-1 as a catalyst



Under air, **[Co]-1** (0.01 mmol, 7.61 mg), substrate **1g** (0.2 mmol), alkyne **2a** (0.15 mmol), PivONa (25.0 mg, 0.2 mmol), and HFIP (1 mL) were added to a 10 mL vial. The mixture was stirred at room temperature under 5 W purple LEDs for approximately 40 h. The concentrated reaction residue was purified by flash column chromatography on silica gel with petroleum ether/ethyl acetate (3:1-1.5:1) as eluent to give corresponding product **3ga** in 96% isolated yield with 89% ee.

6.6. Probing involvement of singlet oxygen by EPR studies

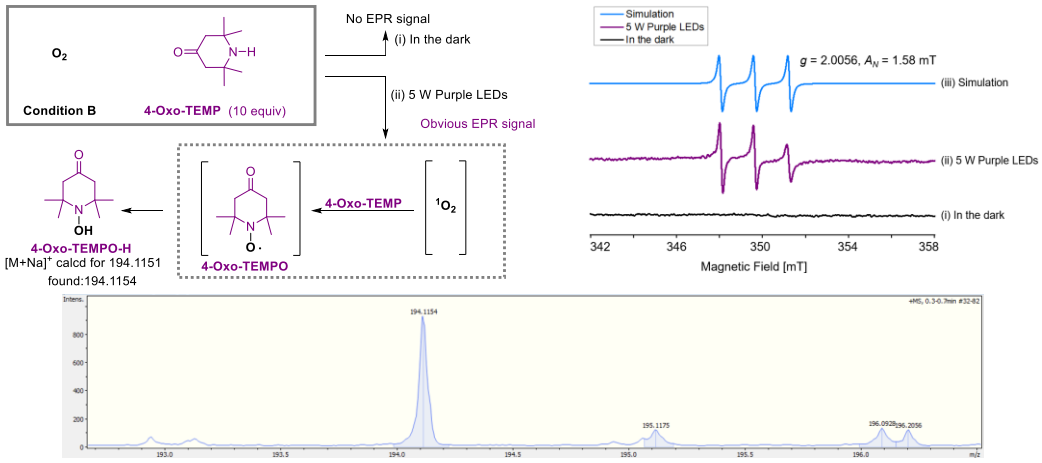
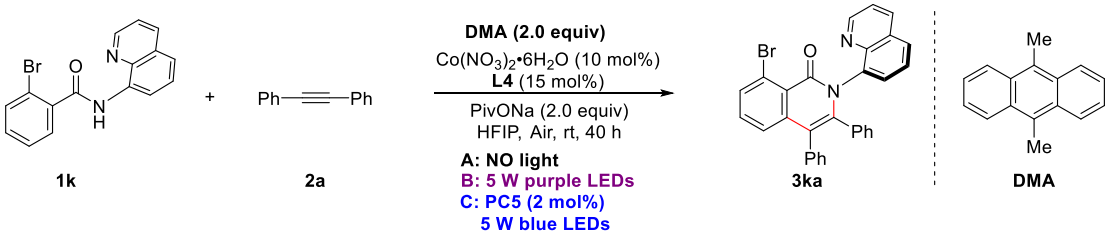


Figure S5 EPR studies and and HRMS spectra

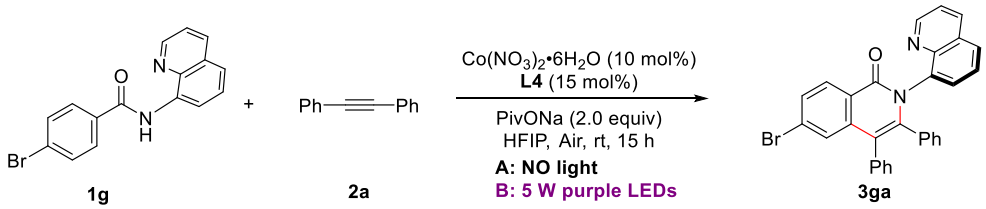
Under air, $Co(NO_3)_2•6H_2O$ (0.01 mmol, 2.91 mg), **L4** (0.015 mmol, 4.04 mg) and HFIP (1 mL) were added to a 10 mL vial. After stirring at room temperature for 2 h, corresponding substrate **1k** (0.1 mmol), alkyne **2a** (0.15 mmol, 26.7 mg), PivONa (24.8 mg, 0.2 mmol) and 4-Oxo-TEMP (155.2 mg, 1.0 mmol) were added to the resulting mixture. The mixture was stirred at room temperature under 5 W purple LEDs or in dark for 10 min. 20 μL of the mixture was transferred to a capillary tube, the tube was charged into a EPR tube and then the mixture was measured in-situ at rt. As shown in Figure S5, no signal was observed in the dark (black trace). When the mixture was irradiated with 5 W Purple LEDs for 10 min, an obvious triplet signal was recorded (purple trace).

6.7. Singlet oxygen quenching experiments



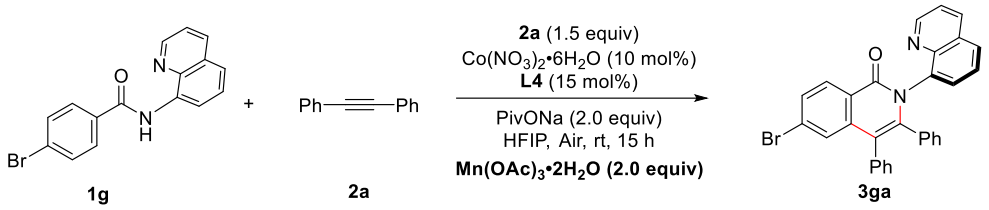
Under air, $Co(NO_3)_2•6H_2O$ (0.01 mmol, 2.91 mg), **L4** (0.015 mmol, 4.04 mg) and HFIP (1 mL) were added to a 10 mL vial. After stirring at room temperature for 2 h, corresponding substrate **1k** (0.1 mmol), alkyne **2a** (0.15 mmol, 26.7 mg), PivONa (24.8 mg, 0.2 mmol) and DMA (22.4 mg, 0.2 mmol) were added to the resulting mixture. The mixture was stirred at room temperature under the corresponding conditions for approximately 40 h. The concentrated reaction residue was purified by flash column chromatography on silica gel with petroleum ether/ethyl acetate (3:1-1.5:1) as eluent to give corresponding product **3ka**.

6.8. Oxidant control



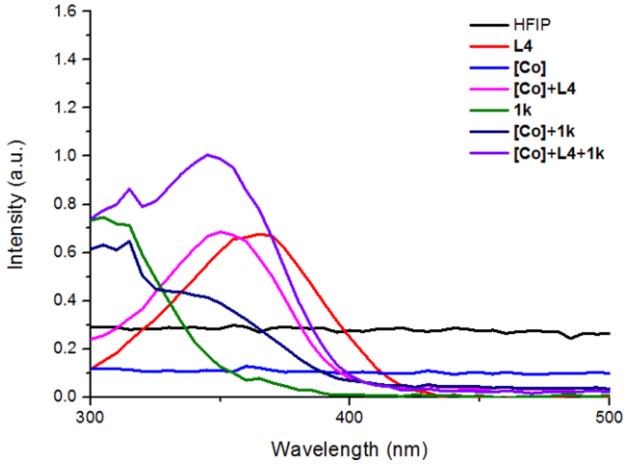
Under air, $Co(NO_3)_2•6H_2O$ (0.01 mmol, 2.91 mg), **L4** (0.015 mmol, 4.04 mg) and HFIP (1 mL) were added to a 10 mL vial. After stirring at room temperature for 2 h, corresponding substrate **1g** (0.1 mmol), alkyne **2a** (0.15 mmol, 26.7 mg), and PivONa (24.8 mg, 0.2 mmol) were added to the resulting mixture. The mixture was stirred at room temperature or under 5

W purple LEDs for approximately 15 h. The concentrated reaction residue was purified by flash column chromatography on silica gel with petroleum ether/ethyl acetate (3:1-1.5:1) as eluent to give corresponding product **3ga**.



Under air, $Co(NO_3)_2•6H_2O$ (0.01 mmol, 2.91 mg), **L4** (0.015 mmol, 4.04 mg) and HFIP (1 mL) were added to a 10 mL vial. After stirring at room temperature for 2 h, corresponding substrate **1g** (0.1 mmol), alkyne **2a** (0.15 mmol, 26.7 mg), PivONa (24.8 mg, 0.2 mmol) and $Mn(OAc)_3•2H_2O$ (53.6 mg, 0.2 mmol) were added to the resulting mixture. The mixture was stirred at room temperature for approximately 15 h. The concentrated reaction residue was purified by flash column chromatography on silica gel with petroleum ether/ethyl acetate (3:1-1.5:1) as eluent to give corresponding product **3ga**.

6.9. UV-Vis Absorption Spectra



6.10.

Figure S6 UV-VIS absorption spectra of the related component recorded in HFIP

UV-Vis spectra of the individual component were recorded, including HFIP, **L4**, $Co(NO_3)_2•6H_2O$, substrate **1k**, [Co]+**L4** (generated in situ by stirring a 1:1.5 mixture of $Co(NO_3)_2•6H_2O$ and **L4)**, [Co]+**1k** (generated in situ by stirring a 1:1 mixture of $Co(NO_3)_2•6H_2O$ and **1k**), [Co]+**L4**+**1k** (generated in situ by stirring a 1:1.5:1 mixture of $Co(NO_3)_2•6H_2O$, **L4** and substrate **1k**). All of the samples were prepared as a 0.1 mM solution and used freshly for the measurement.

6.10. Luminescence quenching experiments

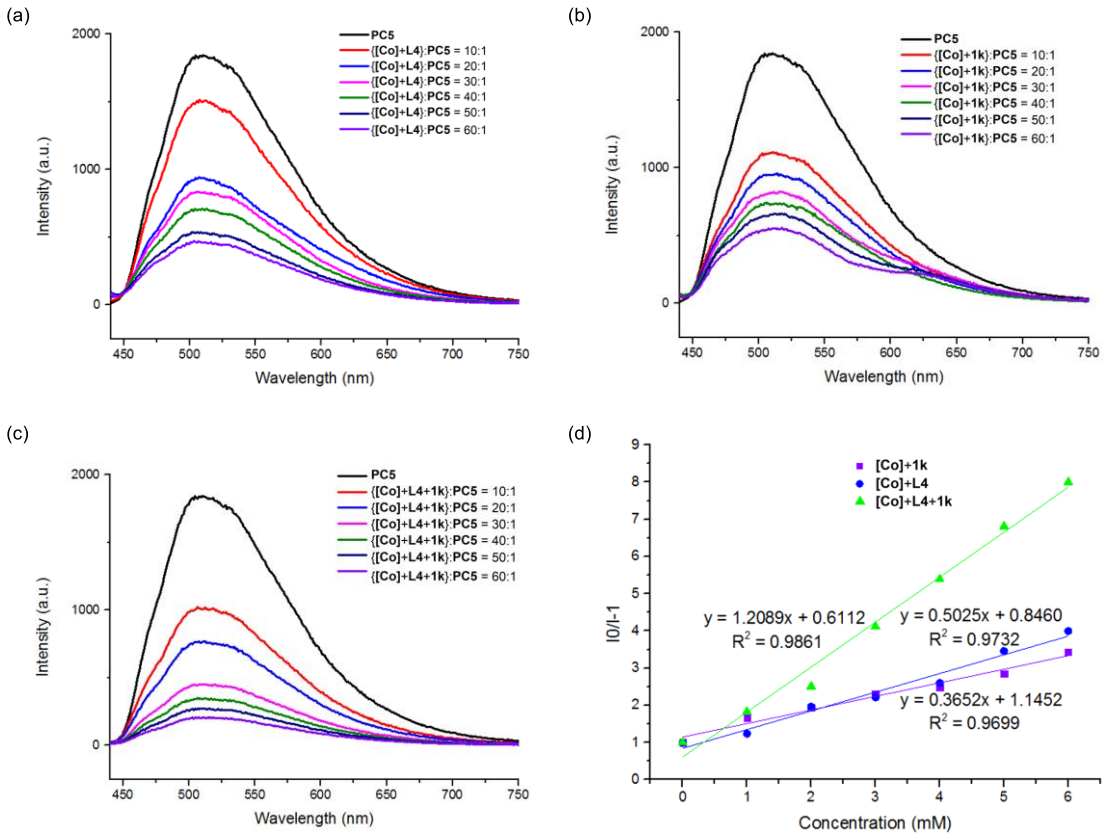
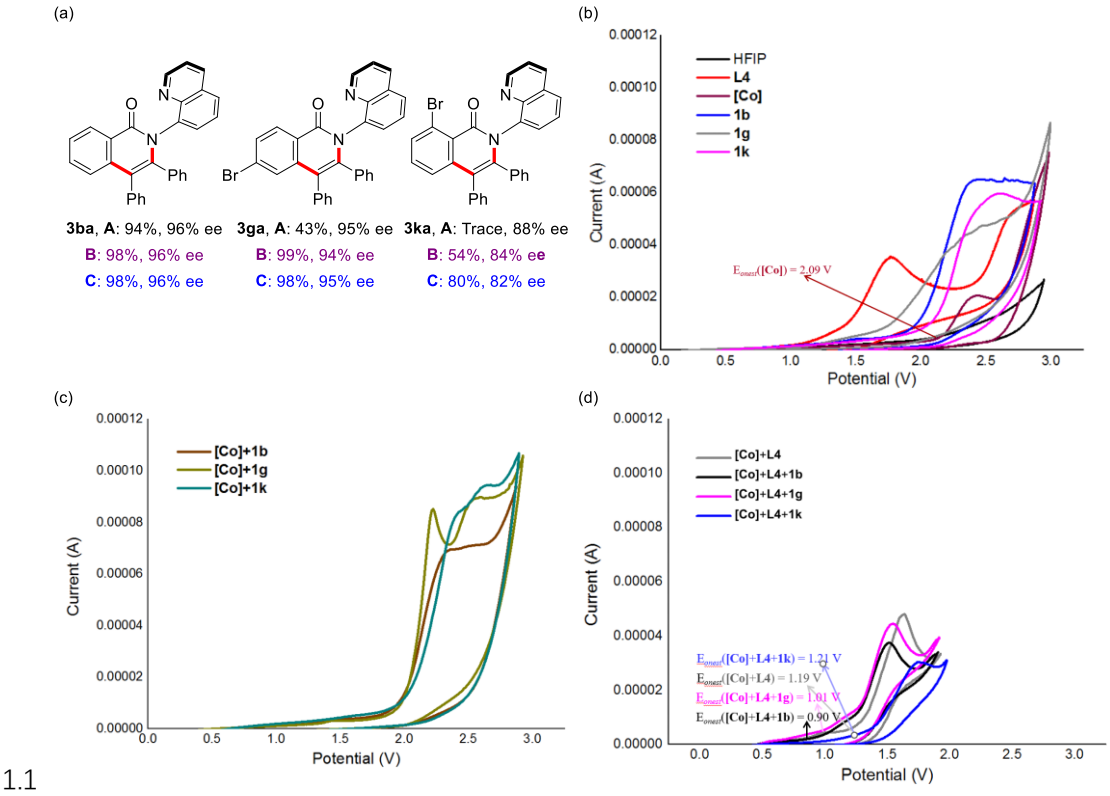


Figure S7 Stern-Volmer plot for the emission quenching of **PC5** by various concentrations of quencher (a) Photocatalyst emission quenching by **[Co]**+**L4**. (b) Photocatalyst emission quenching by **[Co]**+**1k**. (c) Photocatalyst emission quenching by **[Co]**+**L4**+**1k**. (d) Quenching Efficiency Plot. Fluorescence spectra was collected on Agilent Fluorescence Spectrophotometer G9800AS24 for all experiments. All **PC5** solutions were excited at 426 nm and the emission intensity was collected at 505 nm. In a typical experiment, the emission chromatogram of a 1×10^{-4} M solution of **PC5** in HFIP was collected. **[Co]**, $Co(NO_3)_2 \bullet H_2O$.

Fluorescence quenching experiments showed that **Co**+**L4**+**1k** had a more significant quenching effect on the **PC5** as compared to **Co**+ **1k** and **Co**+**L4**.

6.11. Cyclic Voltammetry of [Co]+L4+1



1.1

Figure S8 Cyclic Voltammetry of [Co]+**L4**+**1**

(a) The electrochemical properties of representative substrates were examined by cyclic voltammetry. (b) Cyclic Voltammetry of single component. (c) Cyclic Voltammetry of [Co]+**1**. (d) Cyclic Voltammetry of [Co]+**L4**+**1**. Cyclic voltammetry (CV) was taken using a CHI660D potentio station. CV measurement was carried out in 0.1 M of nBu$_4$NPF$_6$/HFIP at a scan rate of 100 mV/s. The working electrode is a glassy carbon, the counter electrode is a Pt wire, and the reference electrode is saturated calomel electrode (SCE).

7. Additional References

[1] Gott A L, Clarke A J, Clarkson G J, Munslow I J, Wade A R, Scott P. Single Diastereomer Half-Sandwich Salicyloxazoline Complexes of Titanium and Zirconium. *Organometallics*. 2008;27(12):2706-2714. DOI:10.1021/om8002027.

[2] Yao QJ, Chen JH, Song H, Huang FR, Shi BF. Cobalt/Salox-catalyzed enantioselective C–H functionalization of arylphosphinamides. *Angew Chem Int Ed.* 2022;e202202892. DOI:10.1002/anie.202202892.

[3] Grigorjeva L, Daugulis O. Cobalt-Catalyzed, Aminoquinoline-Directed C(sp2)‐H Bond Alkenylation by Alkynes. *Angew Chem Int Ed.* 2014;53:10209-10212. DOI:10.1002/anie.201404579.

[4] Li DK, Zhang B, Ye Q, Deng W, Xu ZY. Synthesis of indenones via palladium-catalyzed carbonylation with $Mo(CO)_6$ as a CO surrogate. *Organometallics*. 2022;41:441-449. DOI:10.1021/acs.organomet.1c00693.

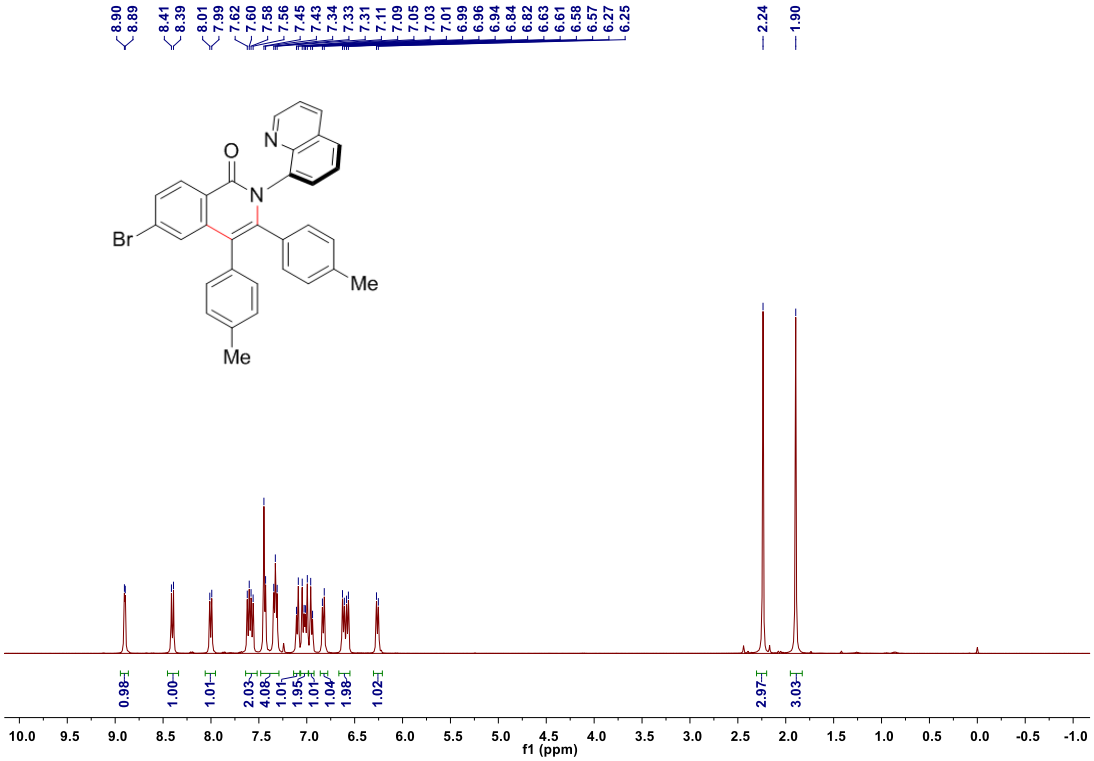
[5] Shinohara K, Nishida T, Wada R, Peng L, Minoda Y, Orita A, Otera J. Synthesis of diarylenynes by olefination of 1-arylpropyne with arylaldehyde and their optical properties. *Tetrahedron* 2016;72:4427-4434. DOI:10.1016/j.tet.2016.06.018.

[6] Baba K, Tobisu M, Chatani N. Palladium-catalyzed direct synthesis of phosphole derivatives from triarylphosphines through cleavage of carbon‐hydrogen and carbon‐phosphorus bonds. *Angew Chem Int Ed.* 2013;52:11892-11895. DOI:10.1002/anie.201307115.

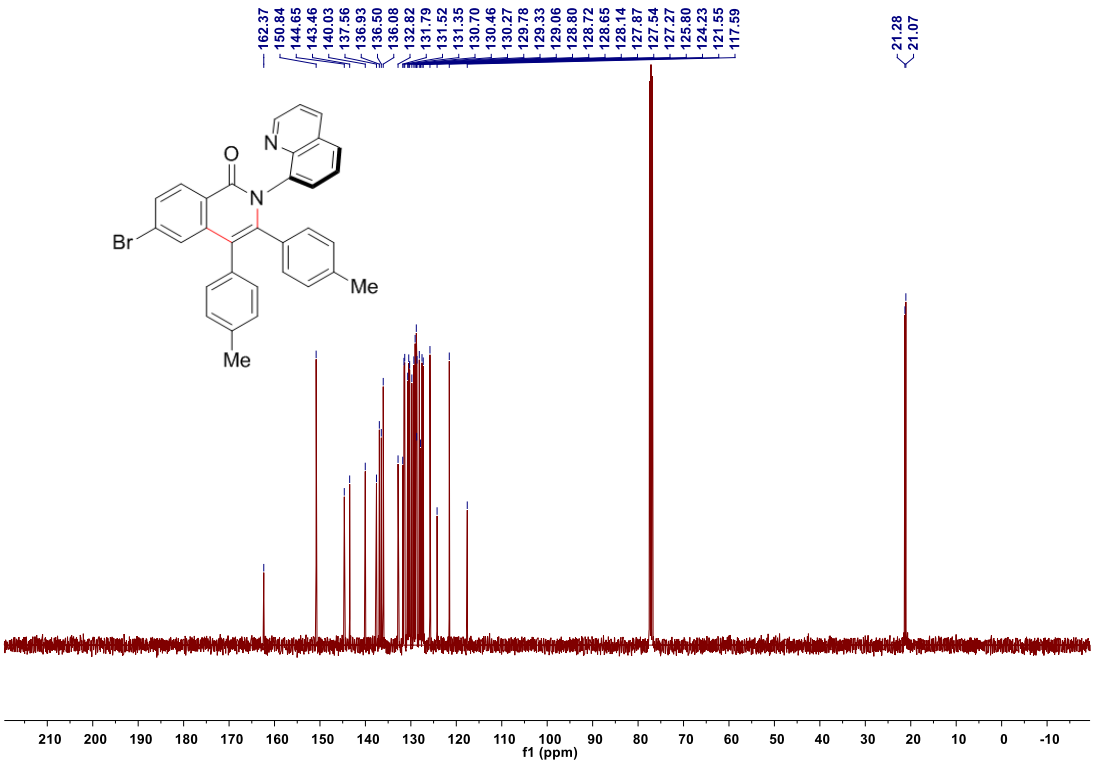
[7] Shintani R, Duan W-L, Okamoto K, Hayashi T. Palladium/chiral phosphine‐olefin complexes: X-ray crystallographic analysis and the use in catalytic asymmetric allylic alkylation. *Tetrahedron: Asymmetry* 2005;16:3400-3405. DOI:10.1016/j.tetasy.2005.08.050.

8. Copies of NMR Spectra

^{1}H NMR Spectrum of **3ab**



^{13}C NMR Spectrum of **3ab**



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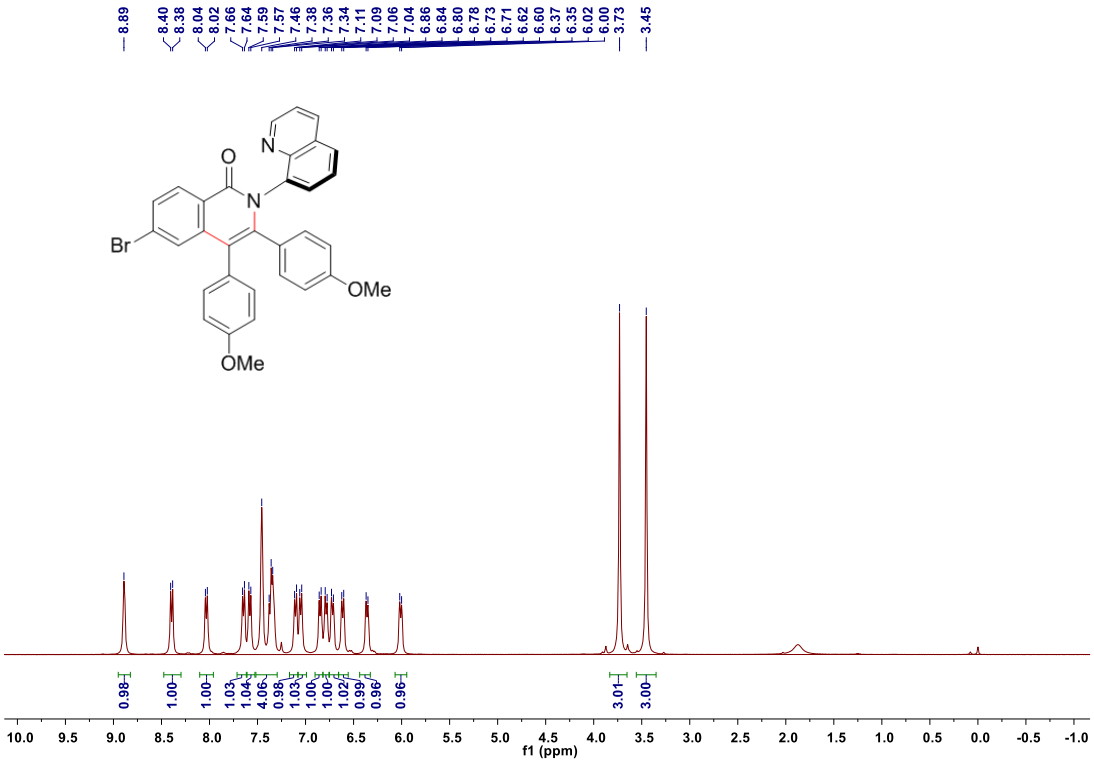

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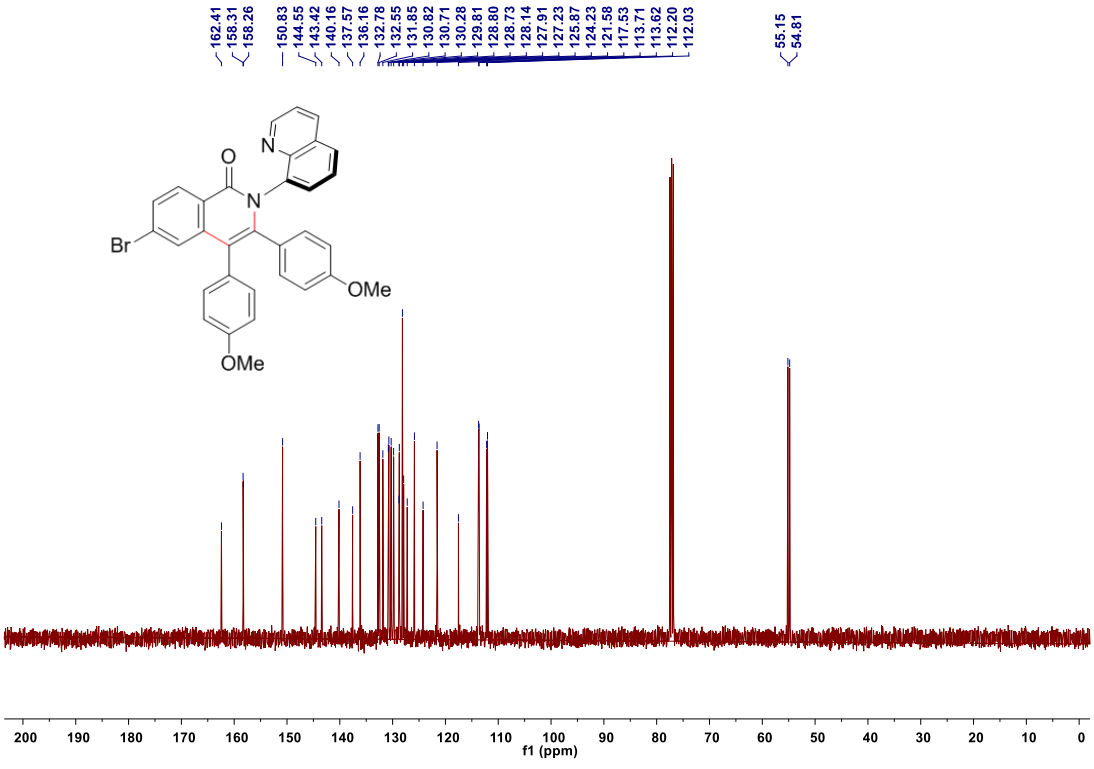

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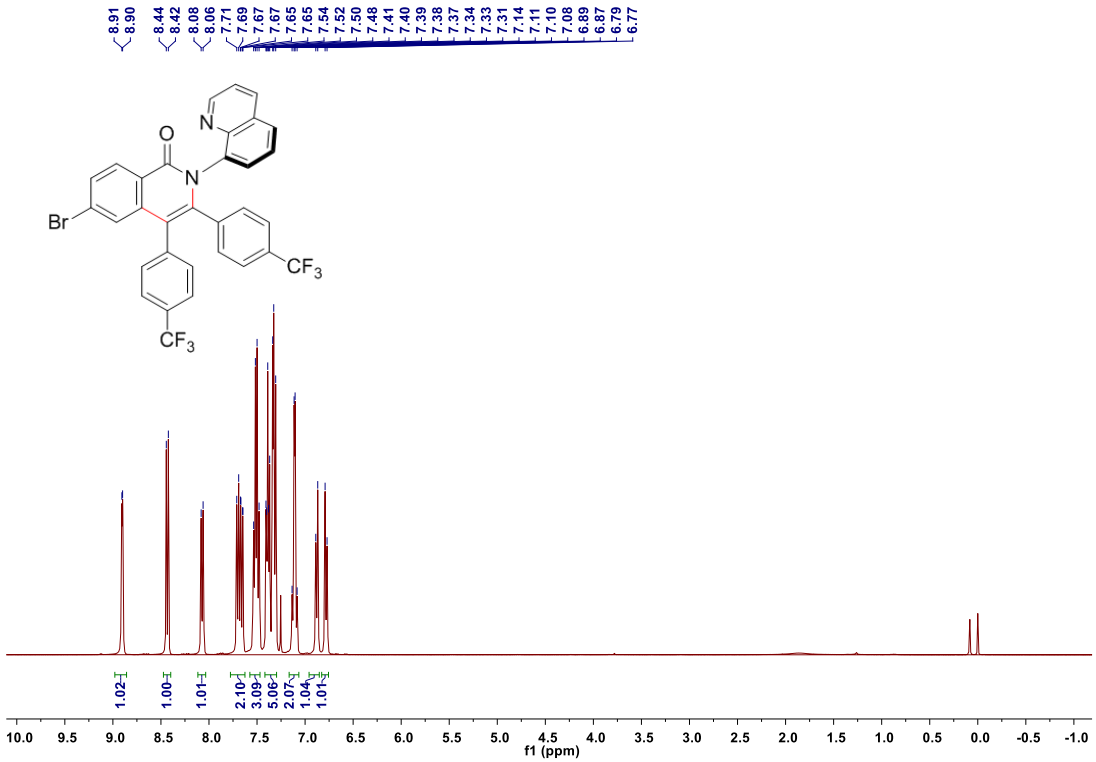

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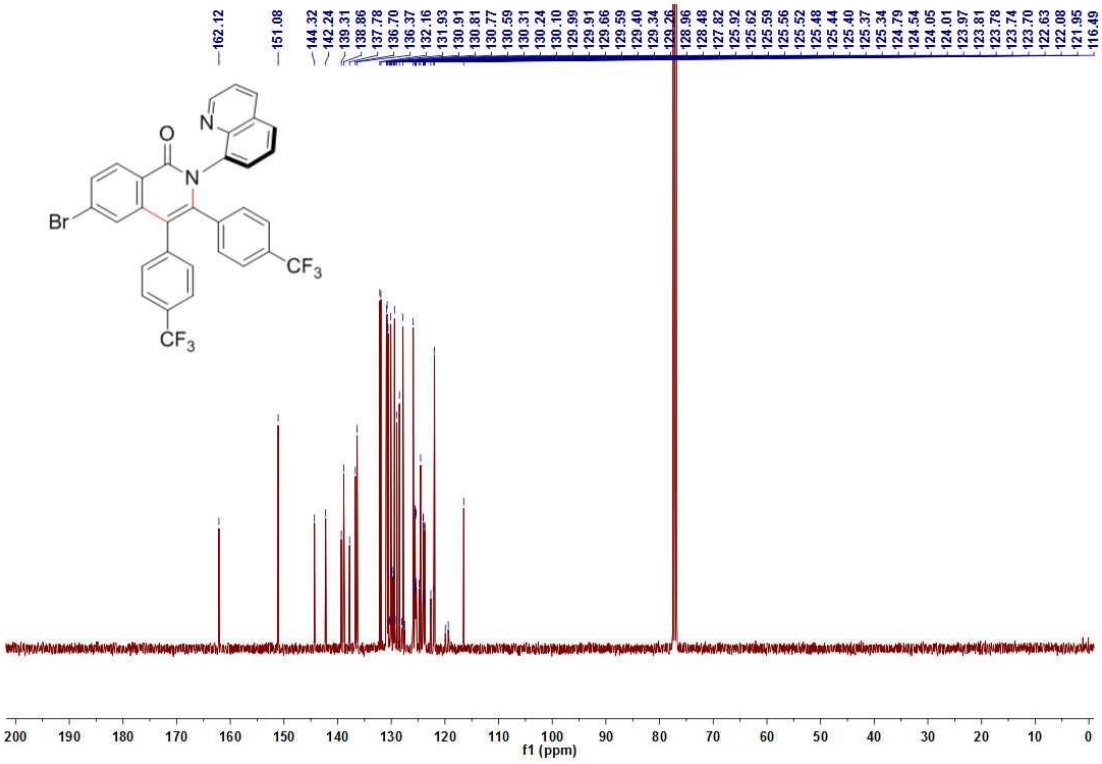

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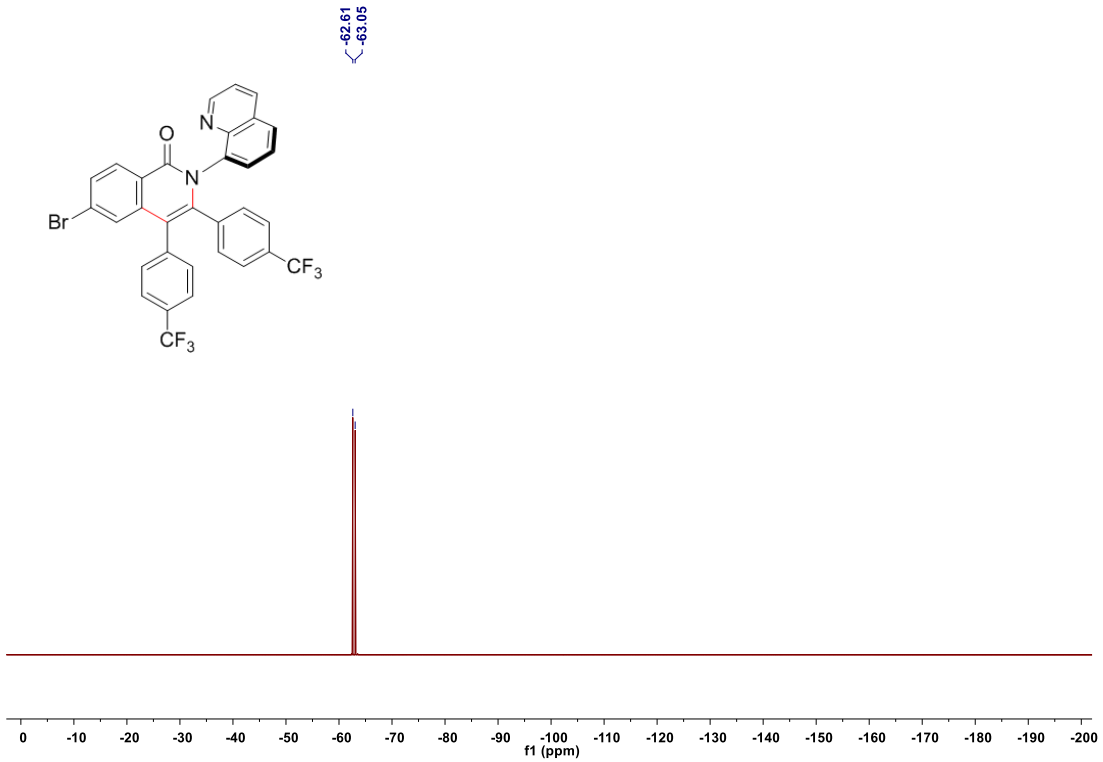

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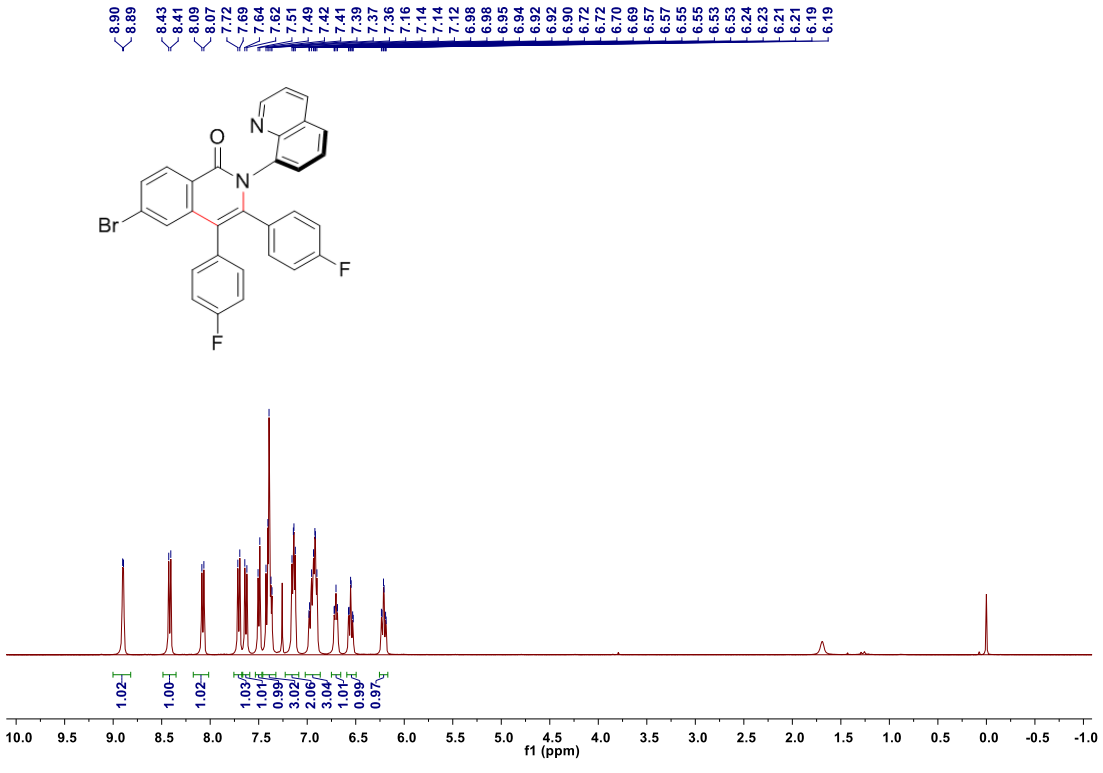
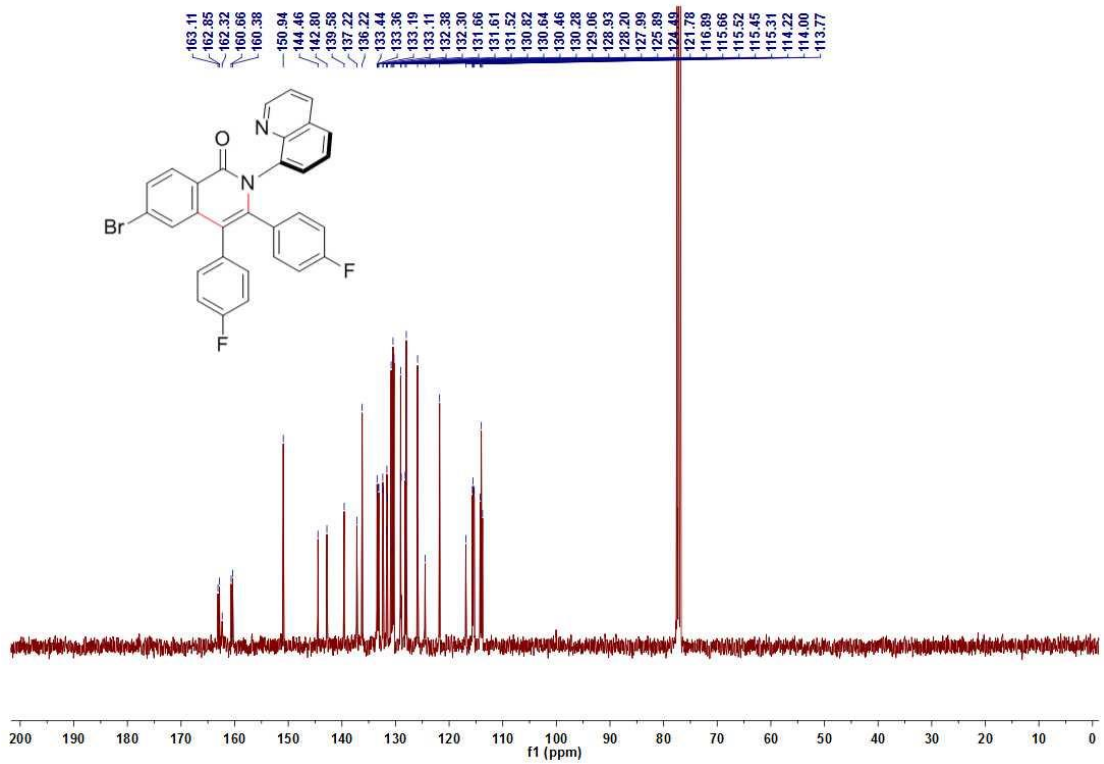


^{13}C NMR Spectrum of **3ae**



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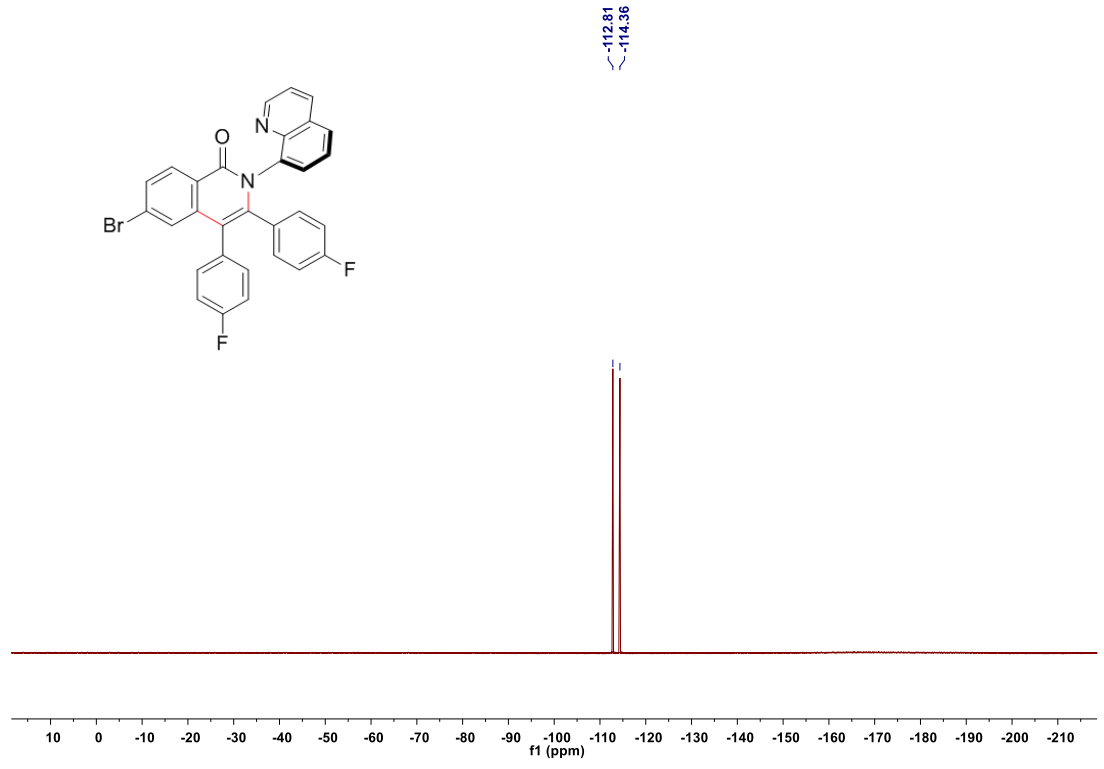

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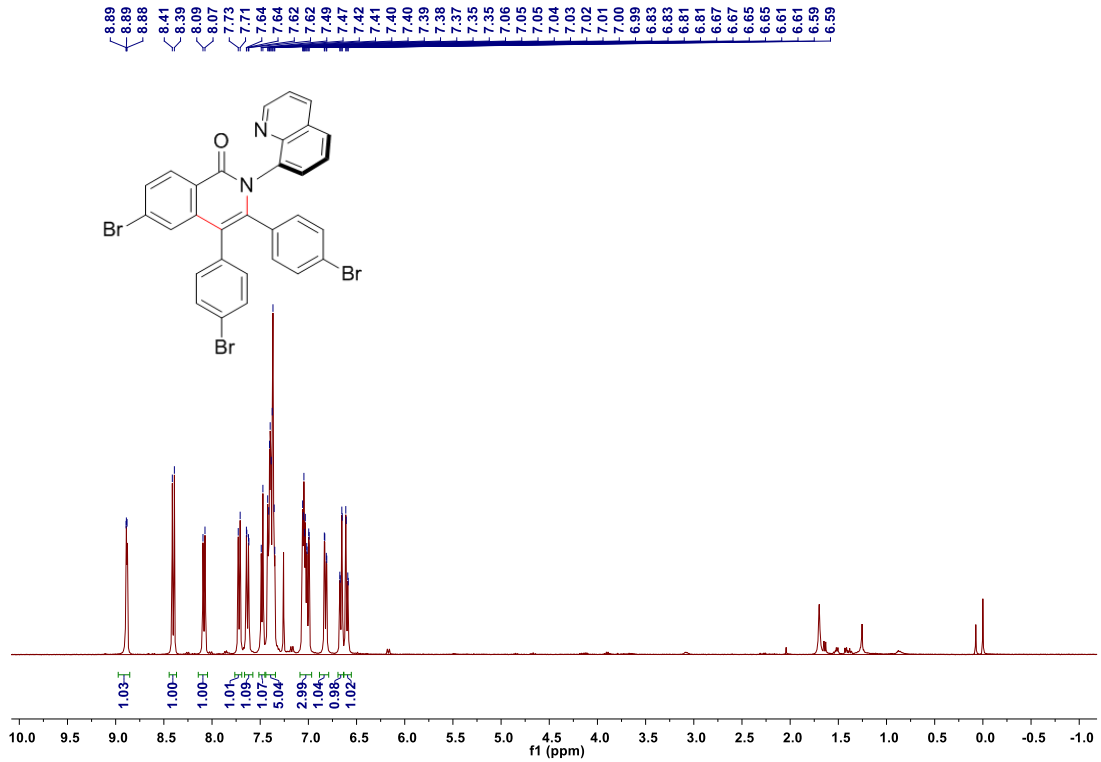

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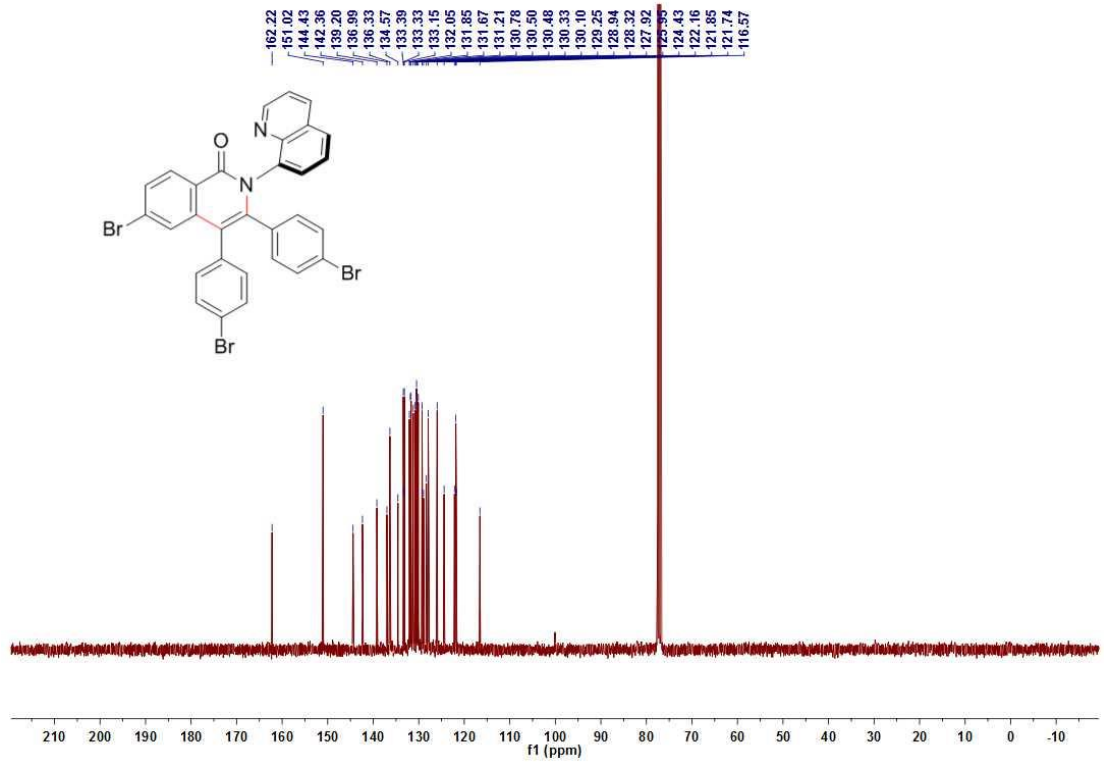

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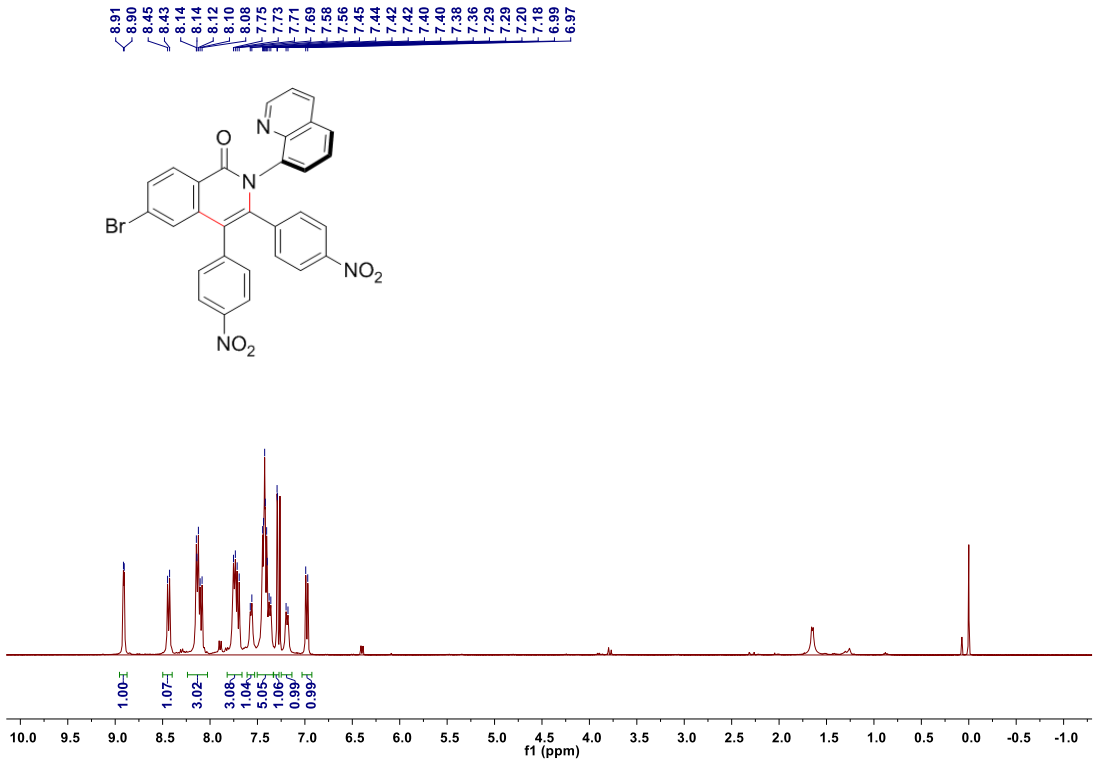

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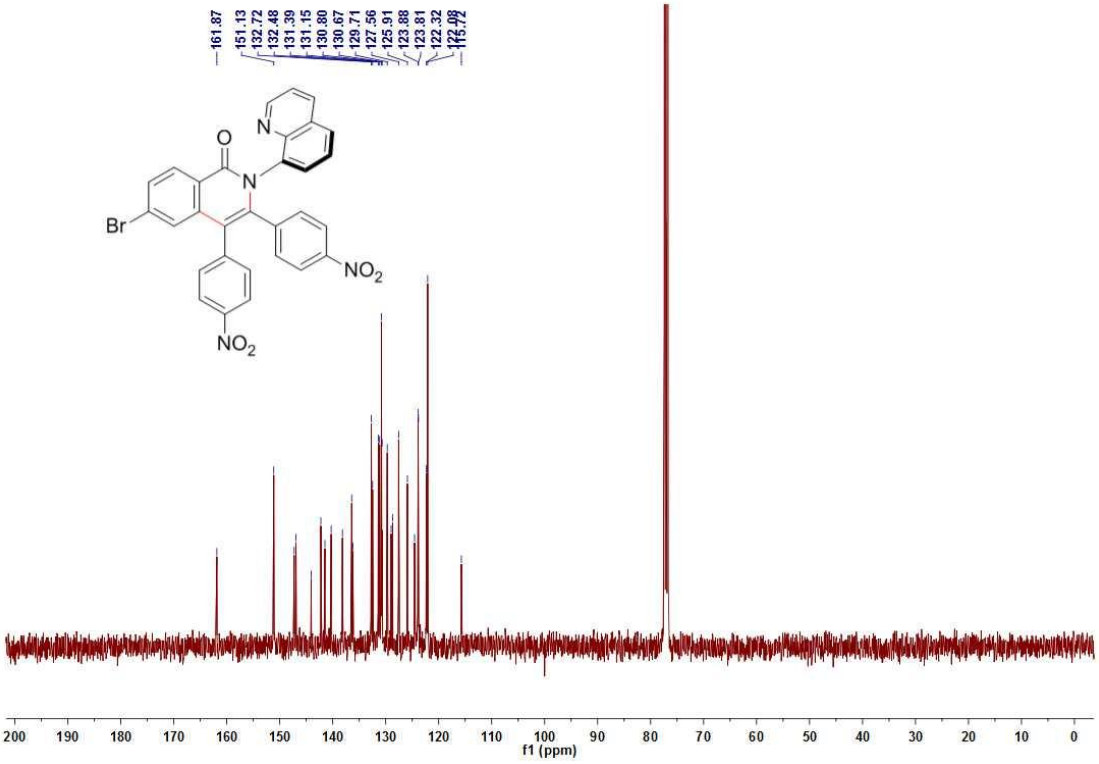
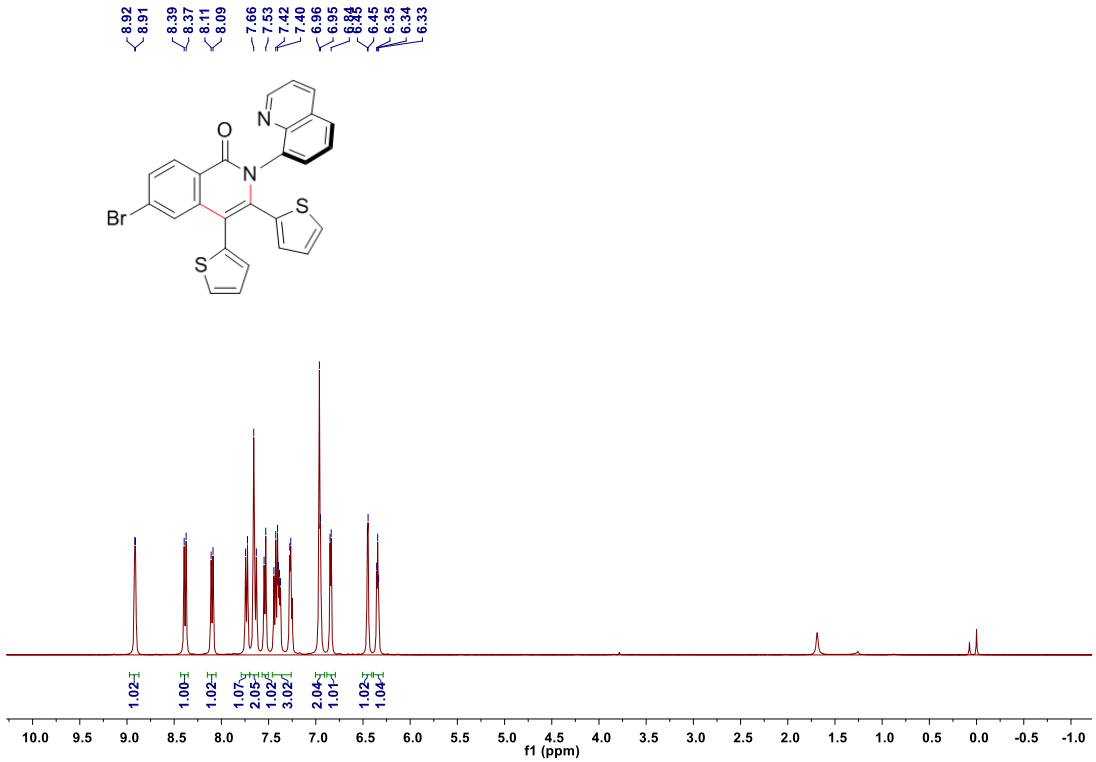


^{1}H NMR Spectrum of **3ah**



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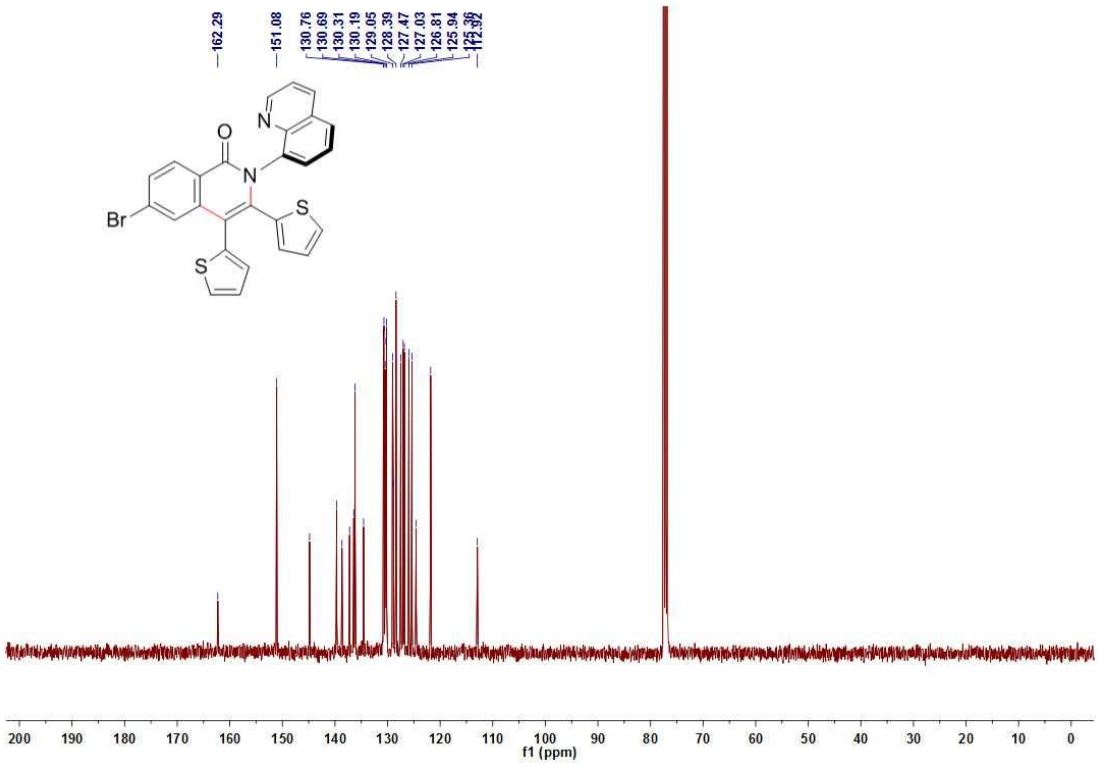

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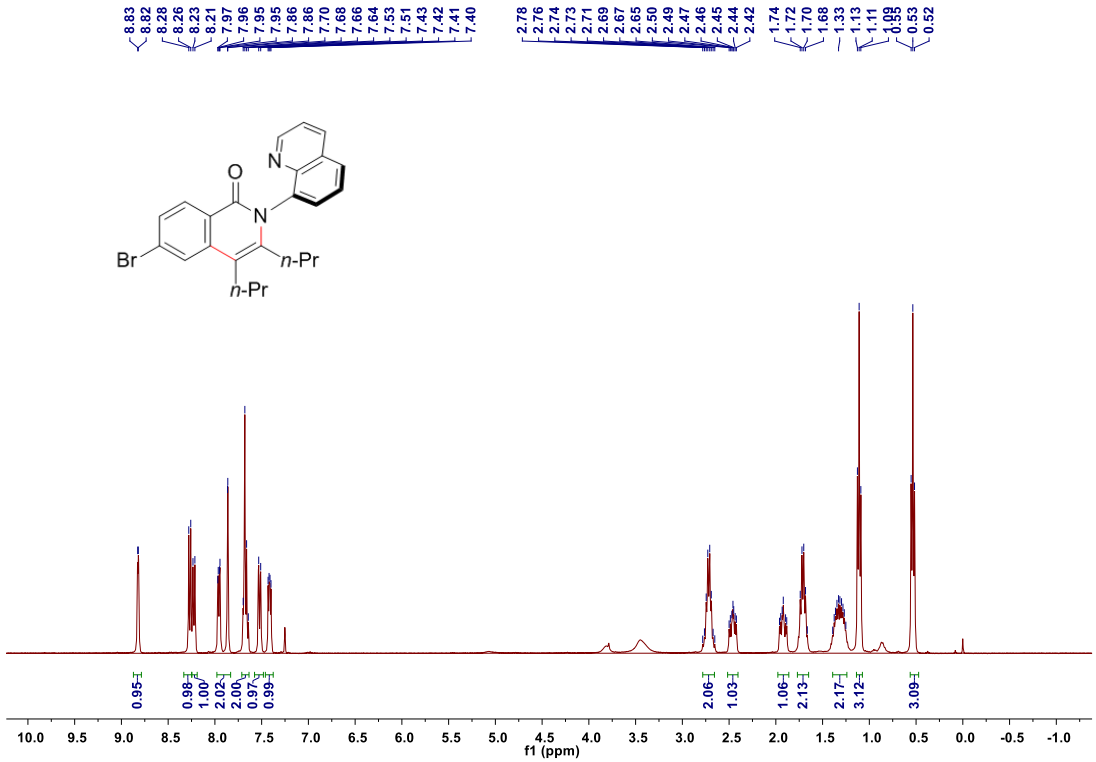

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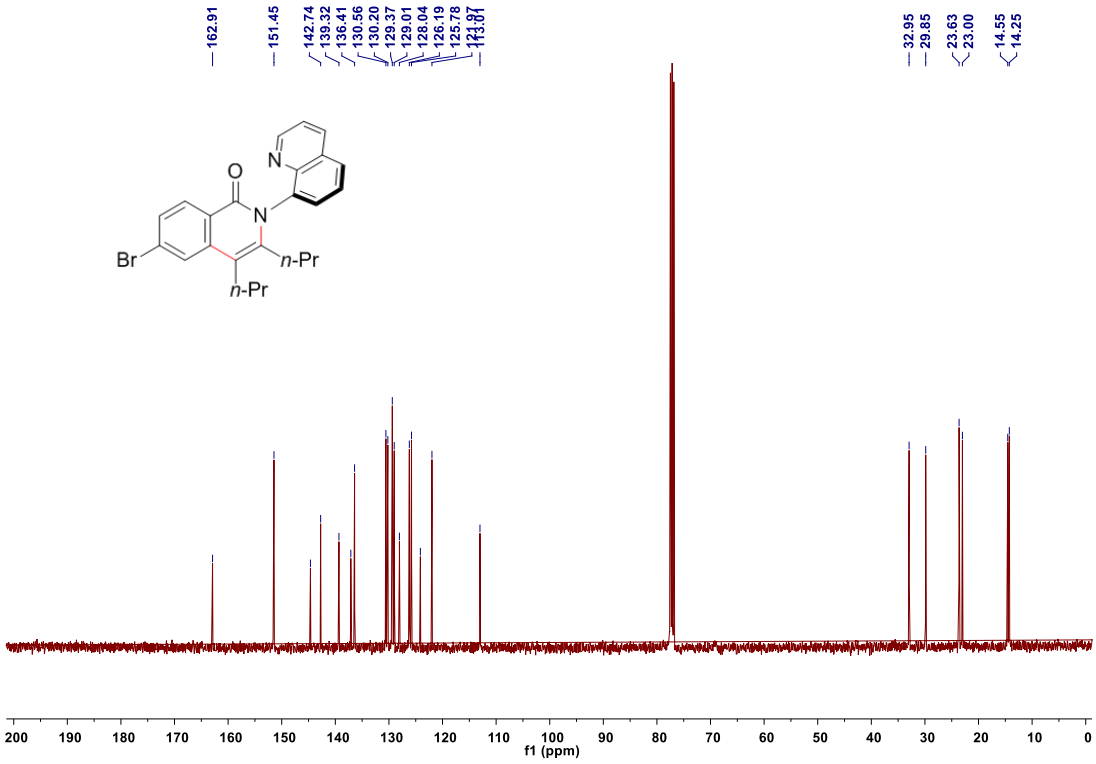

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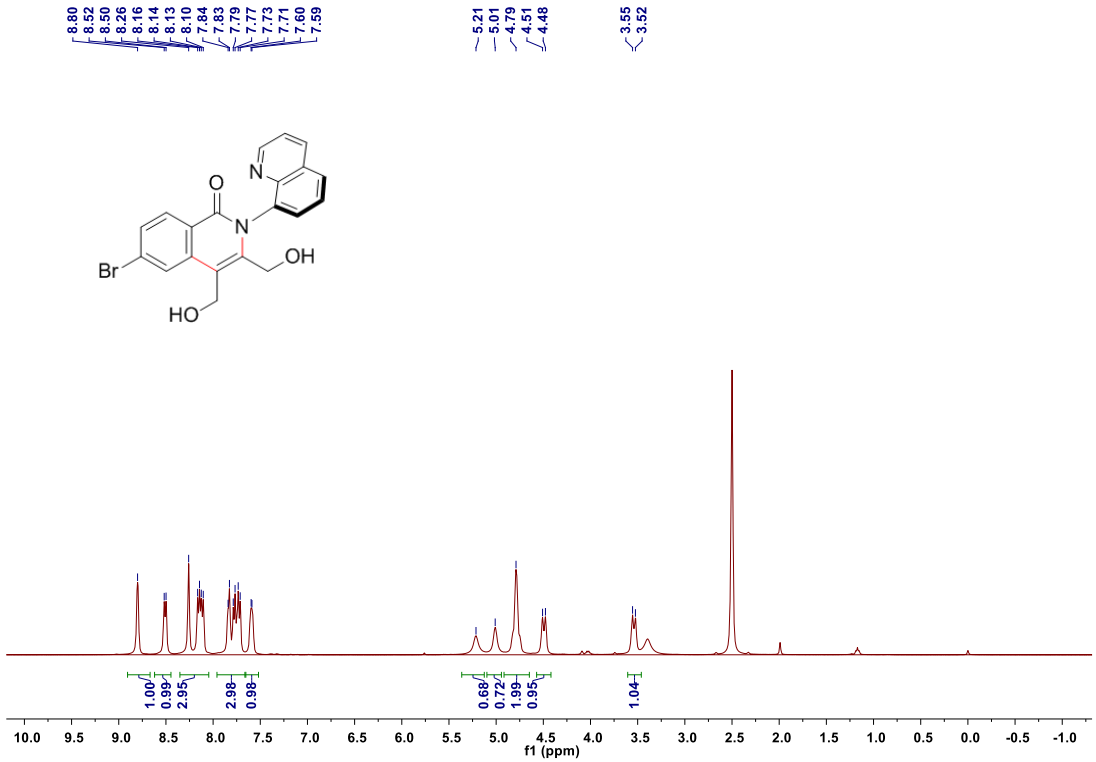

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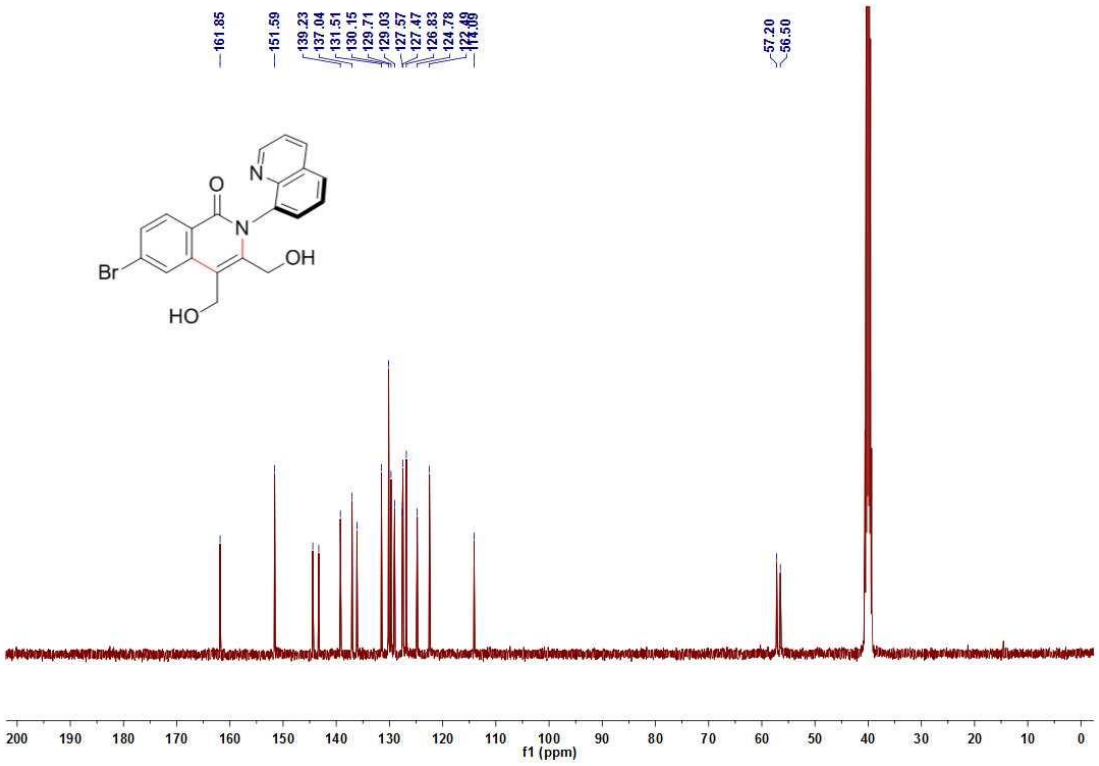

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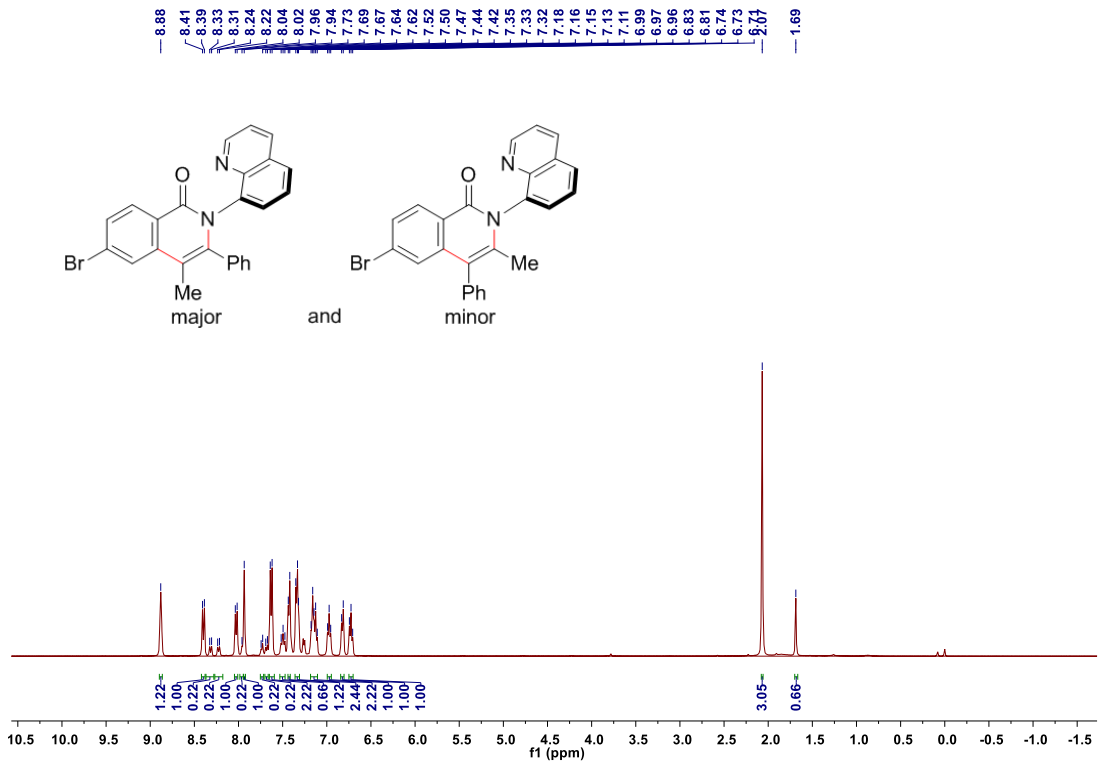
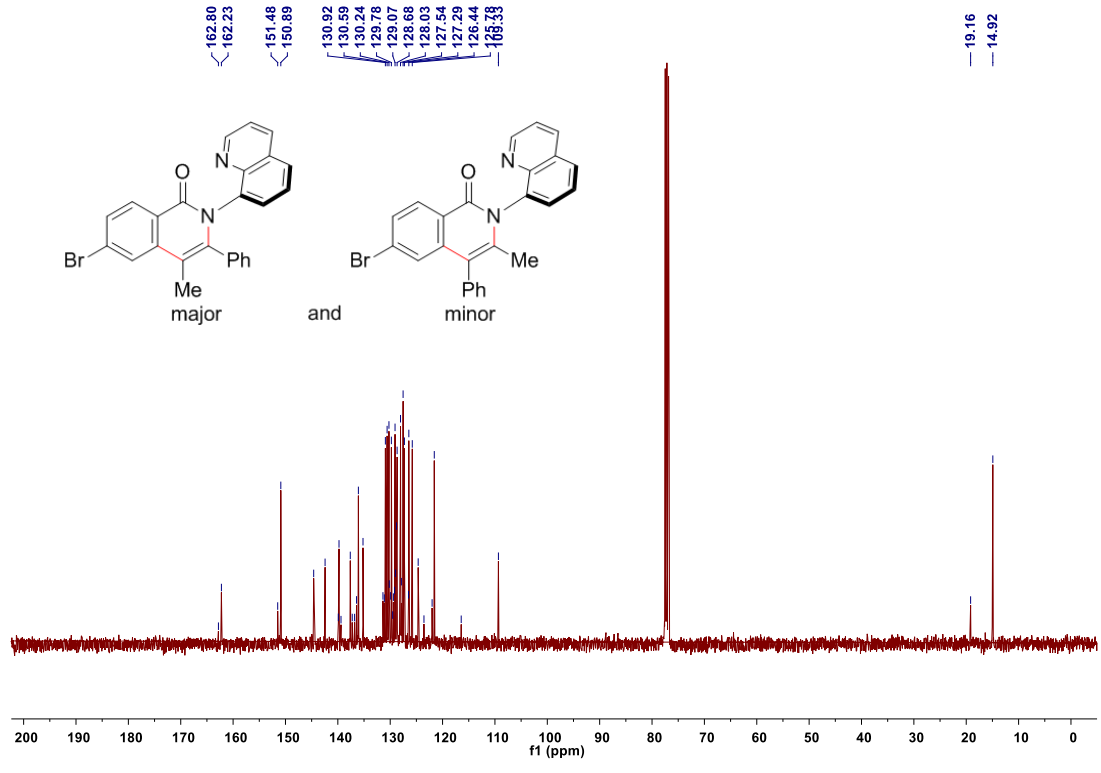


^{13}C NMR Spectrum of **3ak**



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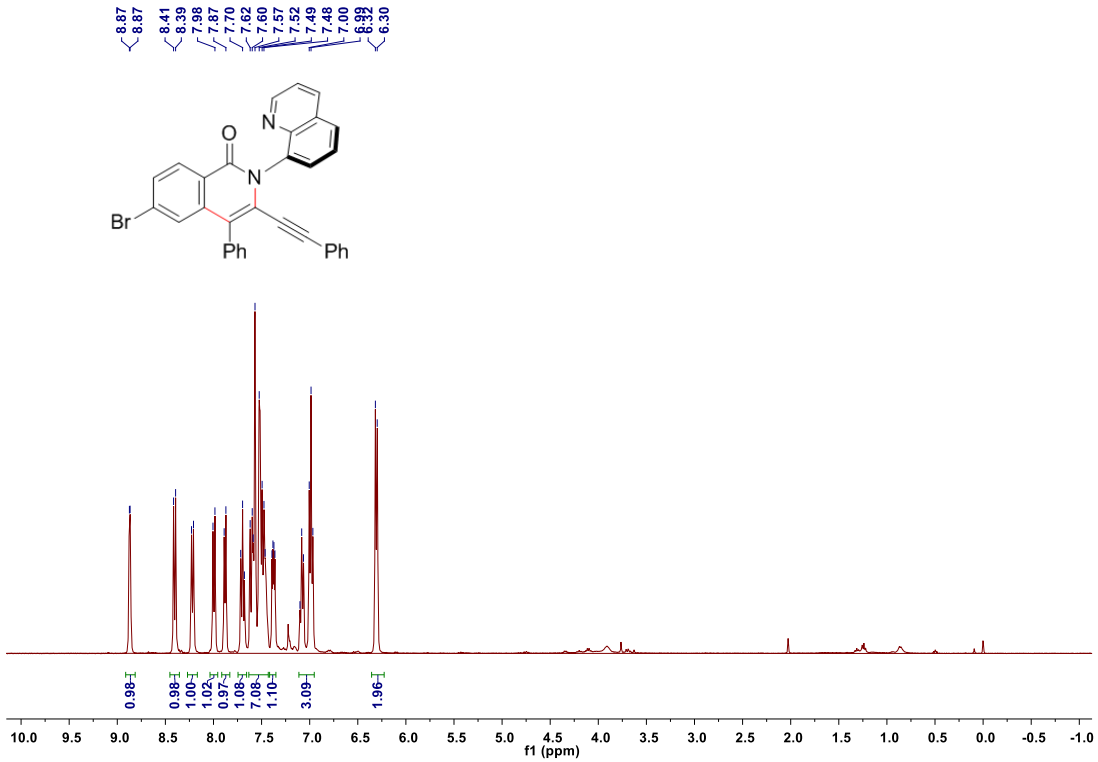

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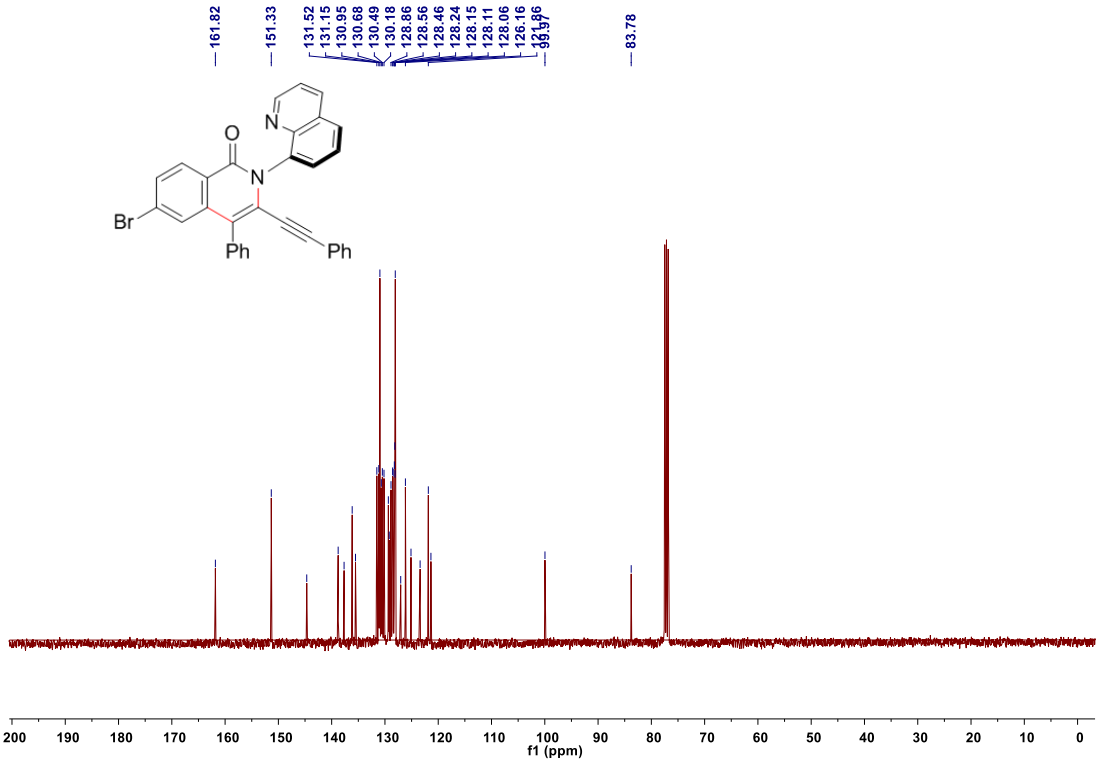
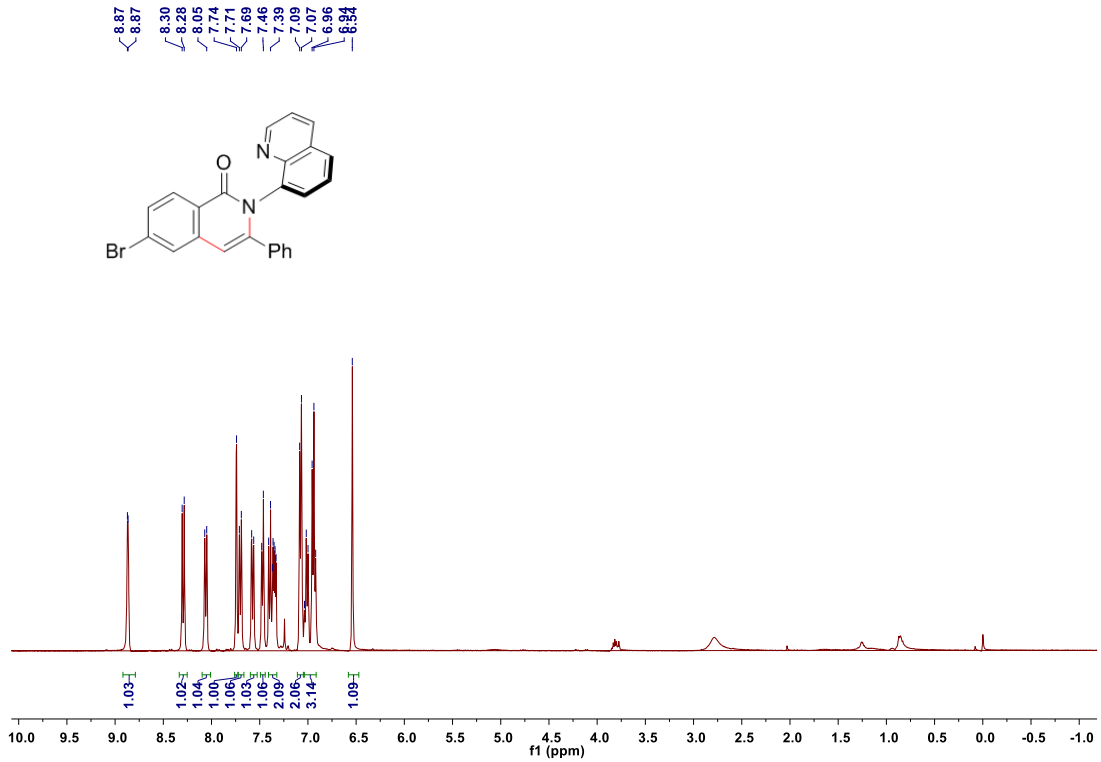
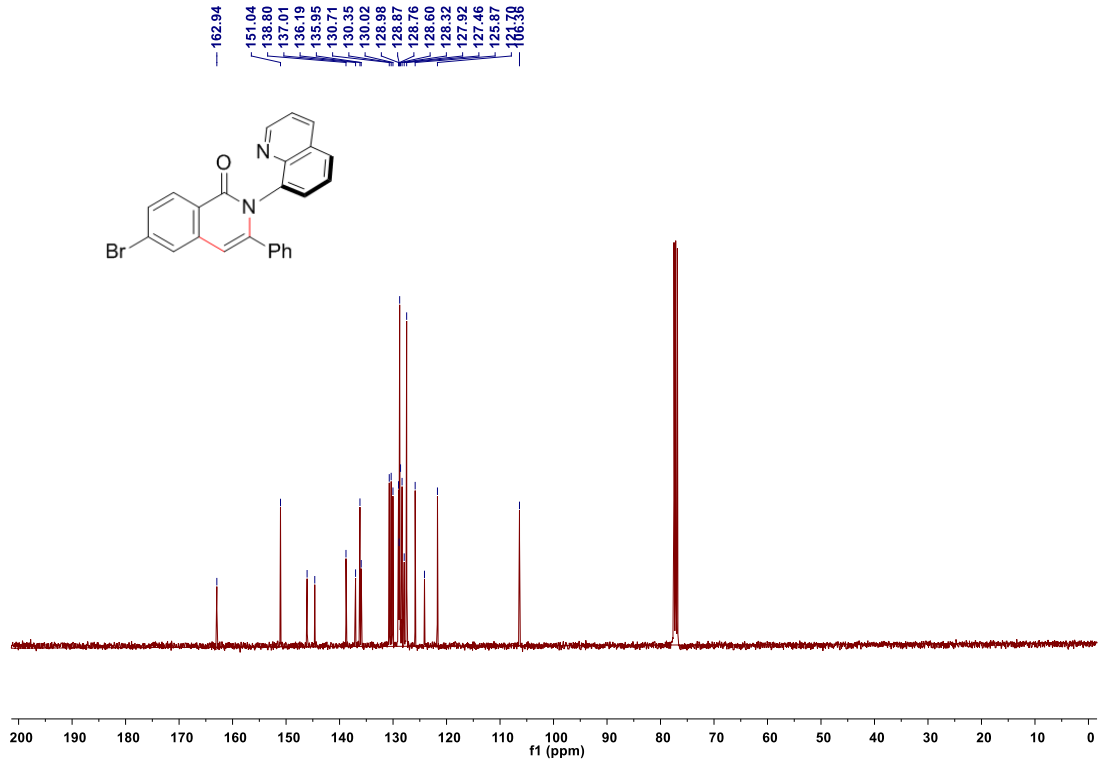


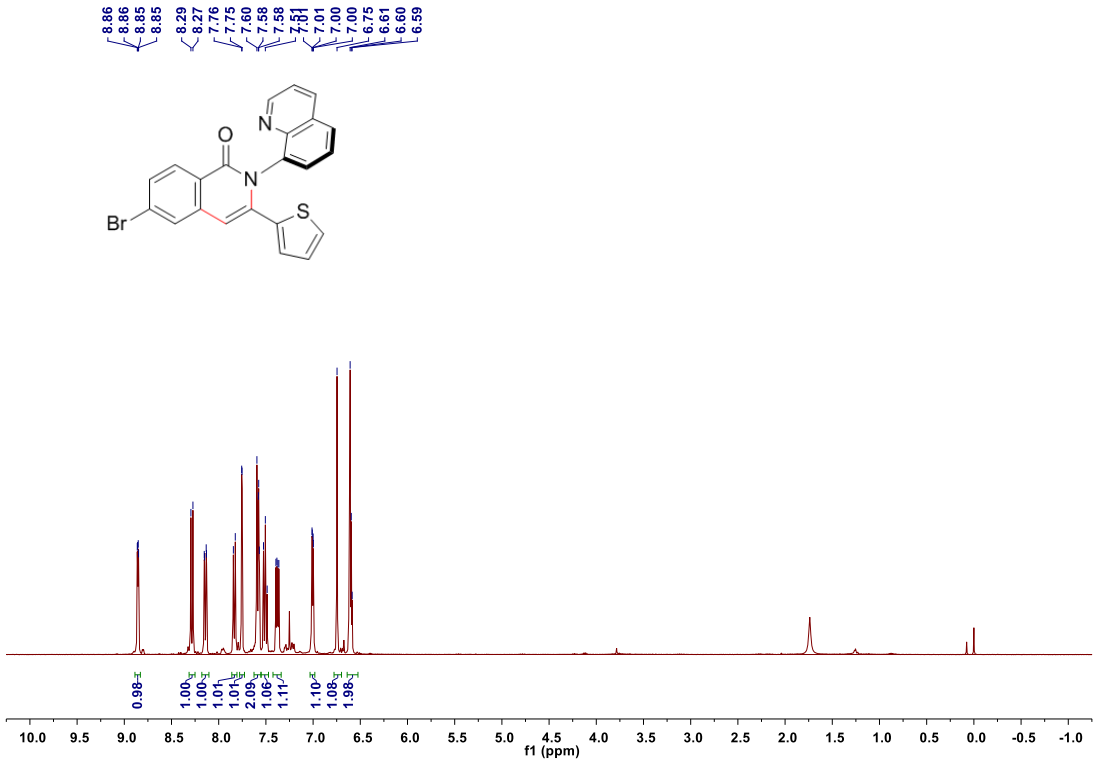
^{1}H NMR Spectrum of **3am**



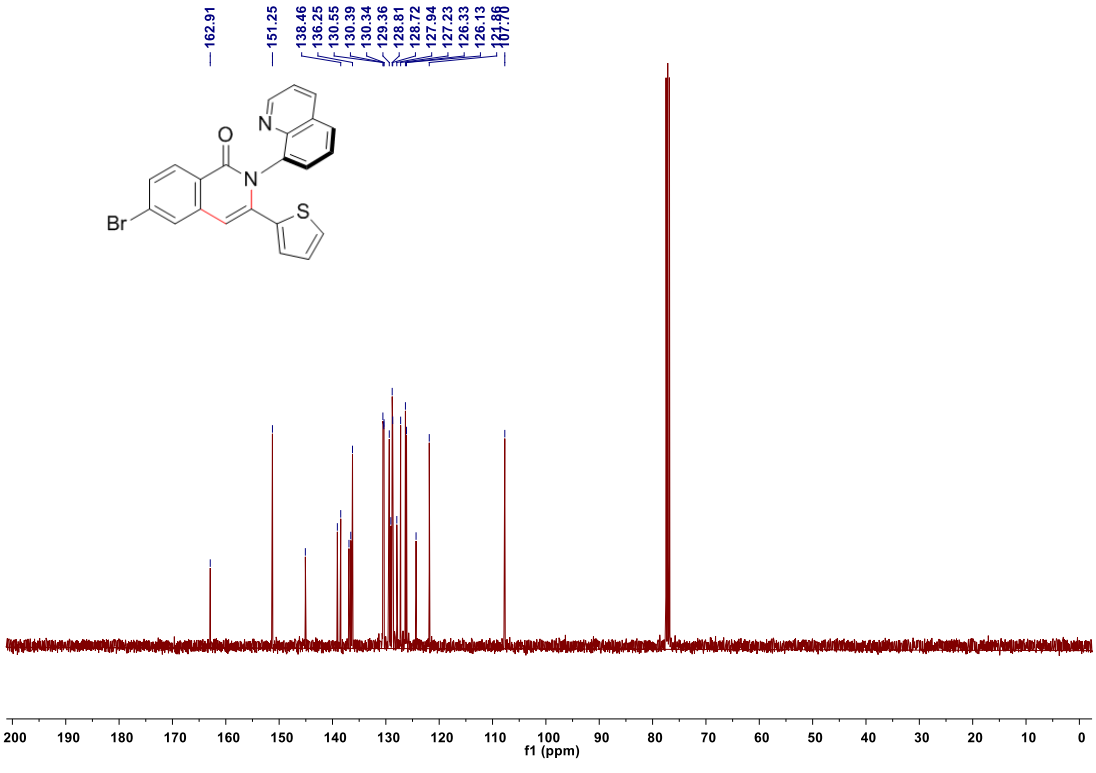
^{13}C NMR Spectrum of **3am**



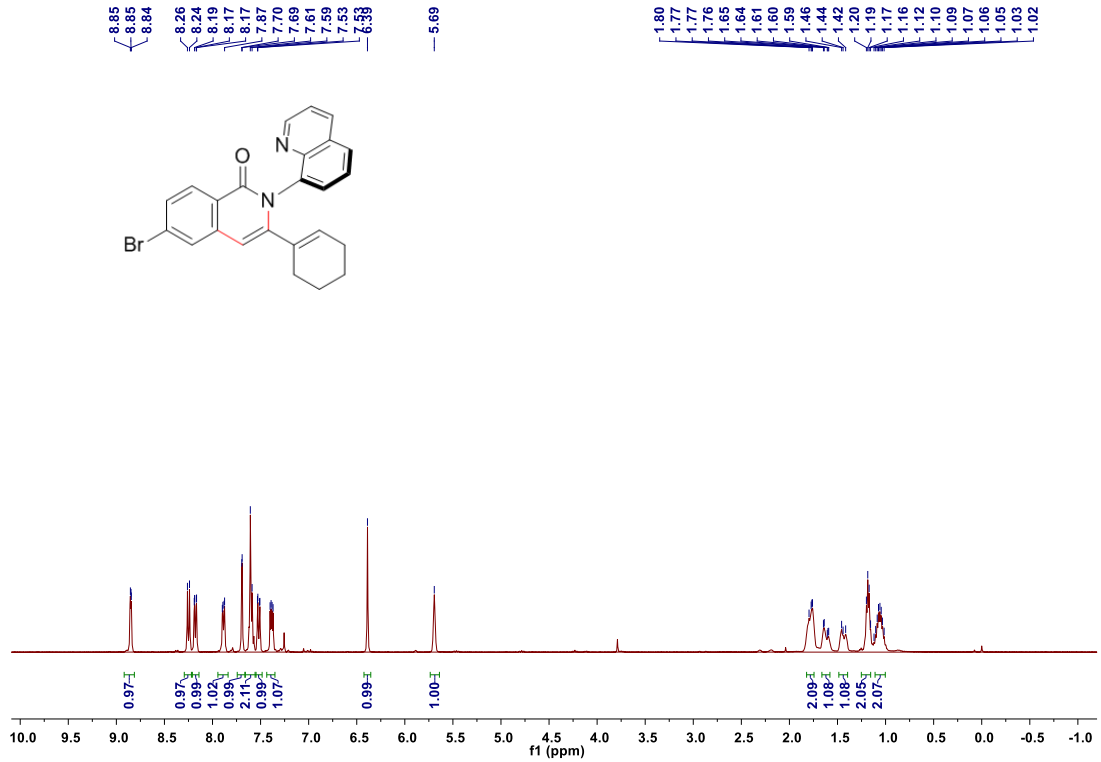
^{1}H NMR Spectrum of **3an**



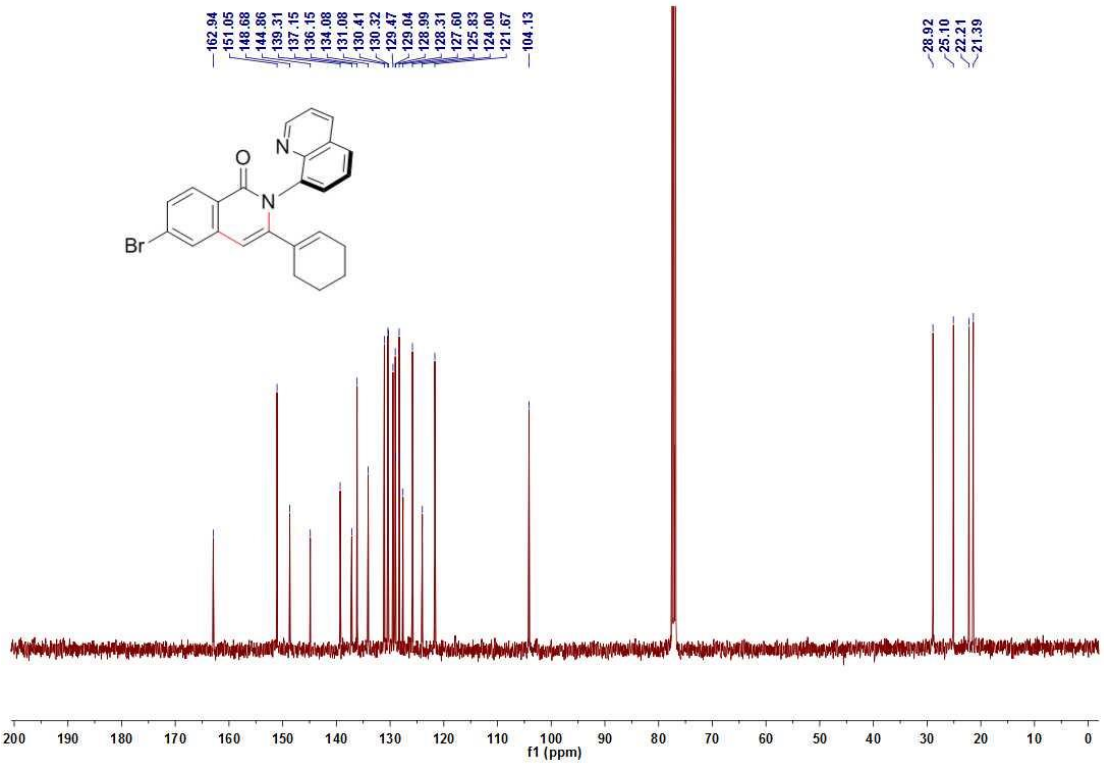
^{13}C NMR Spectrum of **3an**



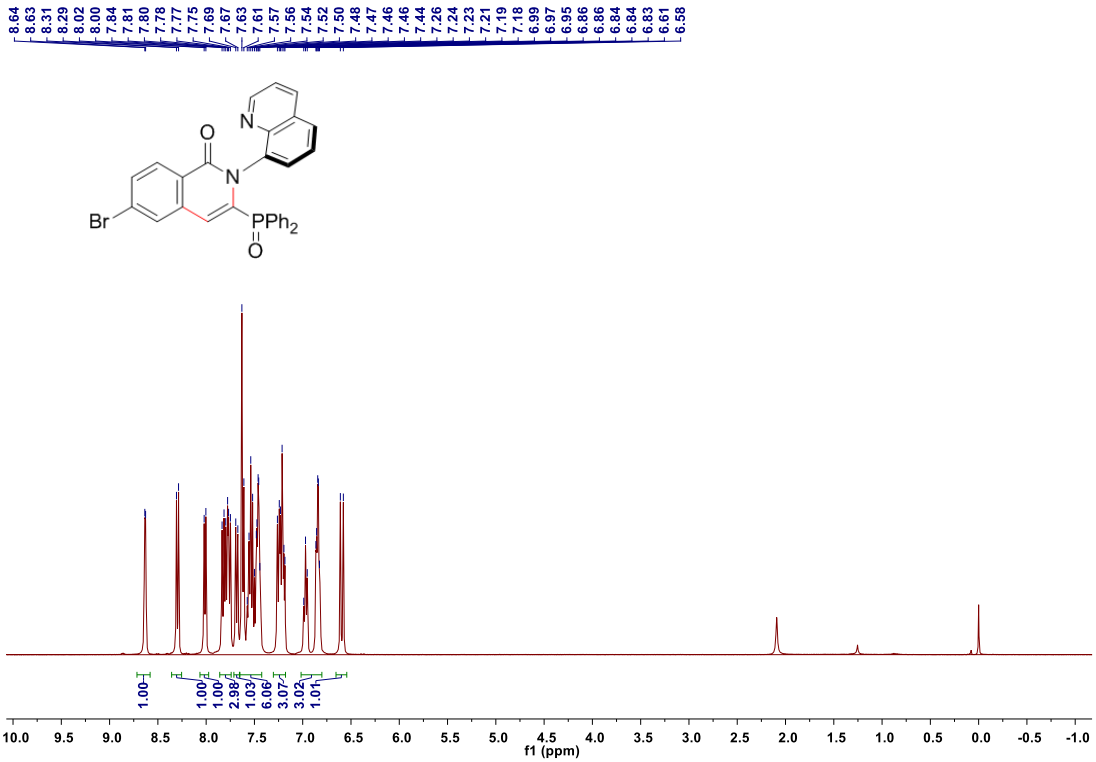
^{1}H NMR Spectrum of **3ao**



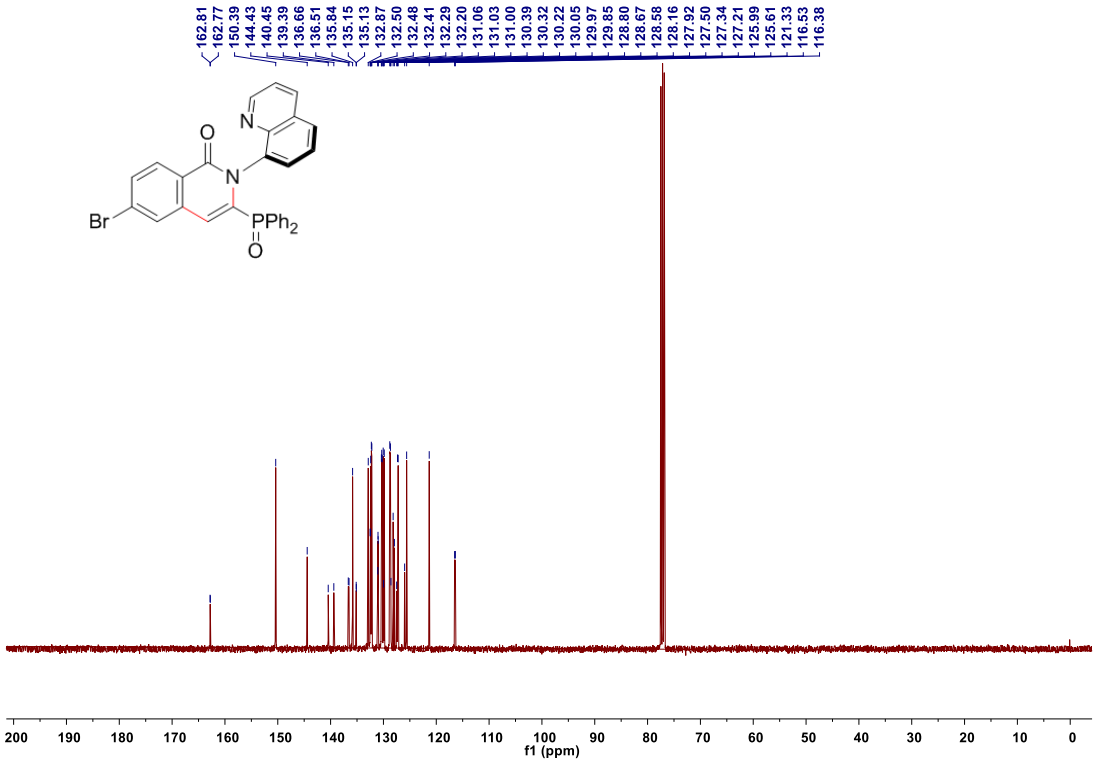
^{13}C NMR Spectrum of **3ao**



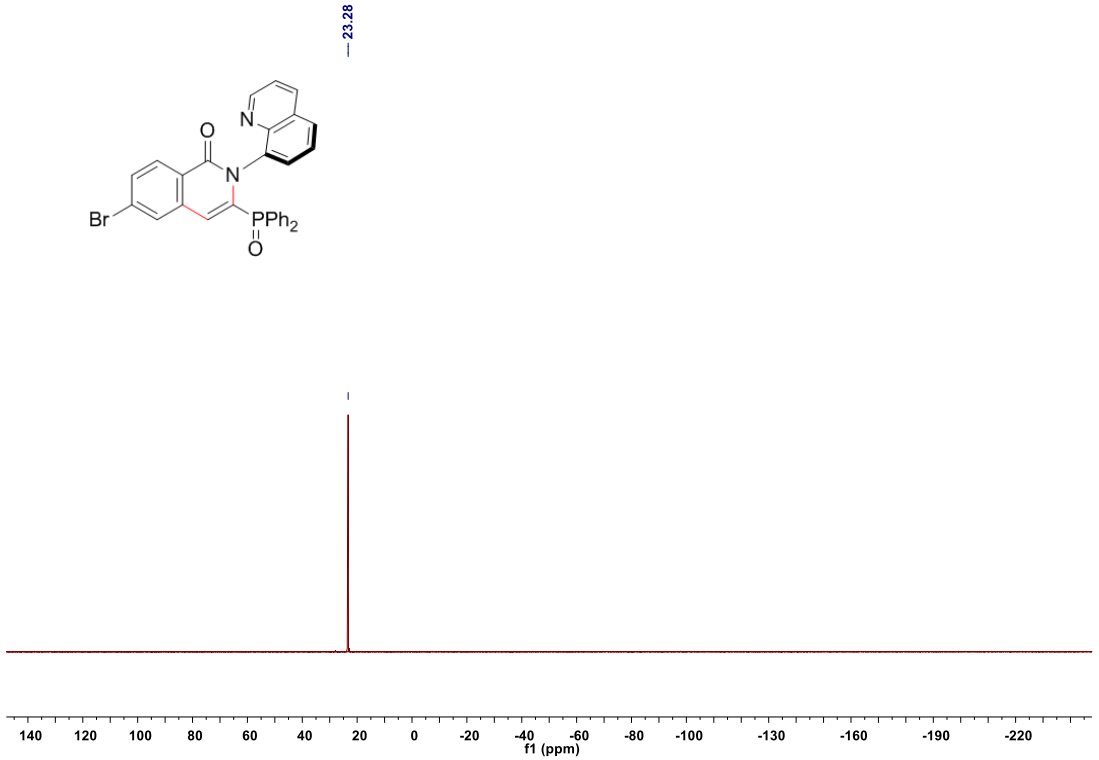
^{1}H NMR Spectrum of **3ap-major**



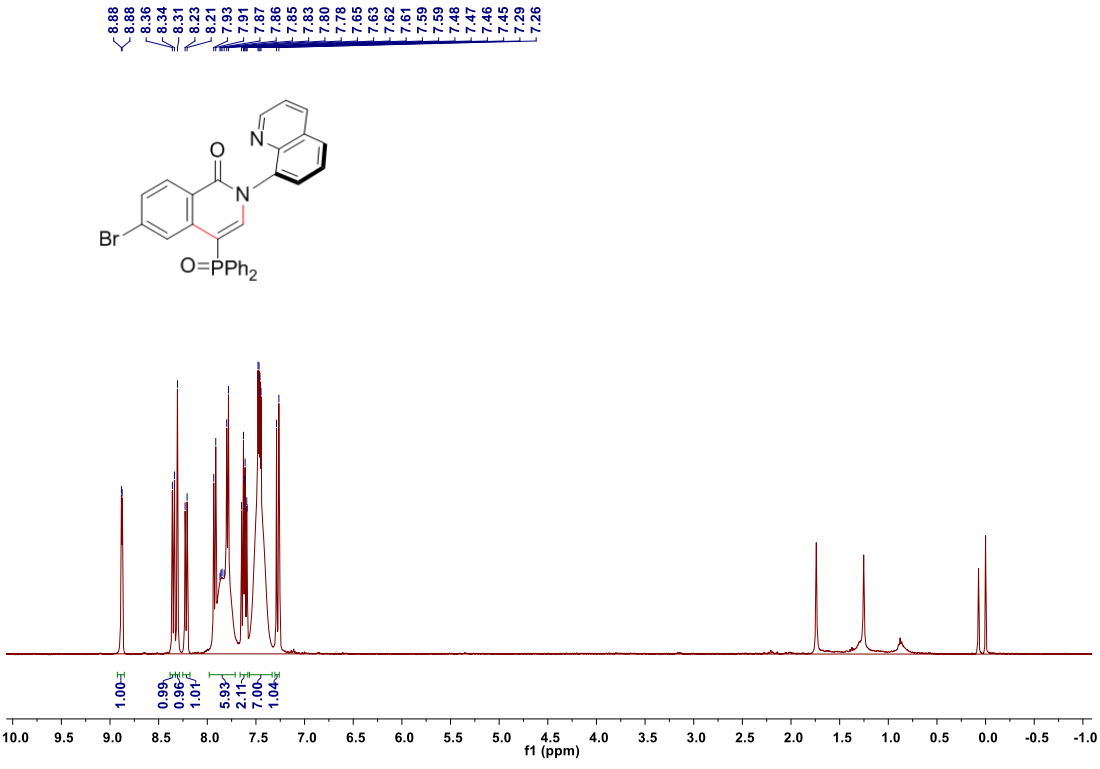
^{13}C NMR Spectrum of **3ap-major**



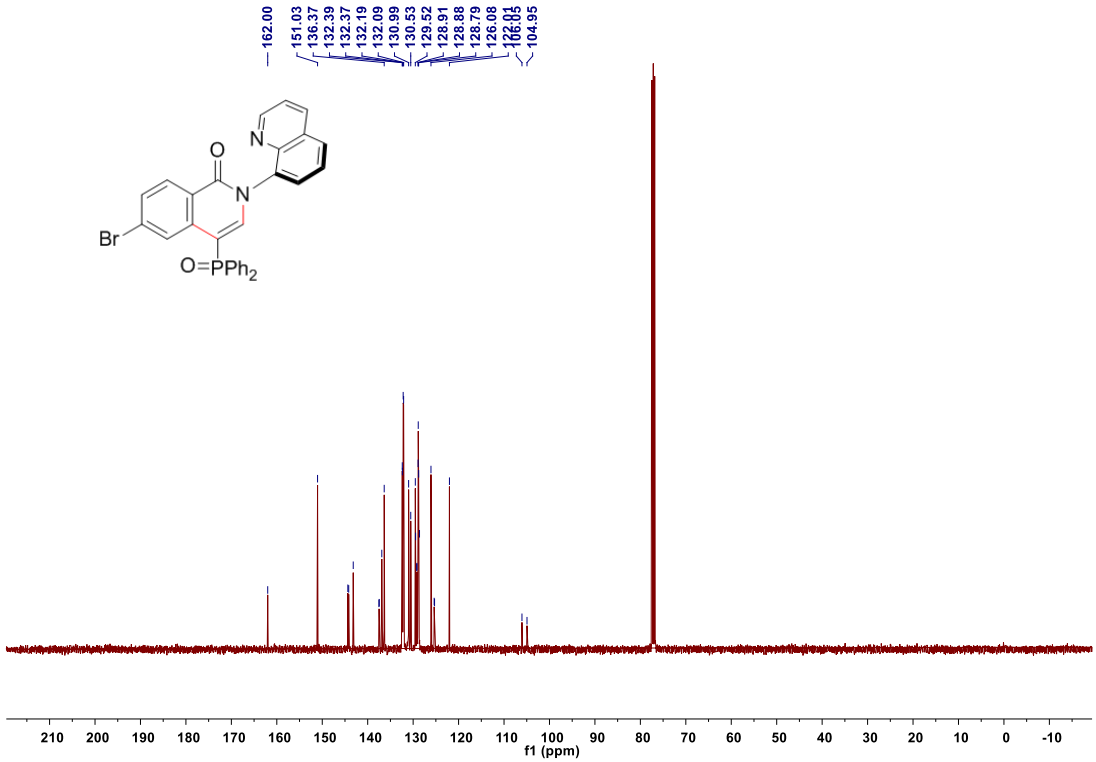
^{31}PNMR Spectrum of **3ap-major**



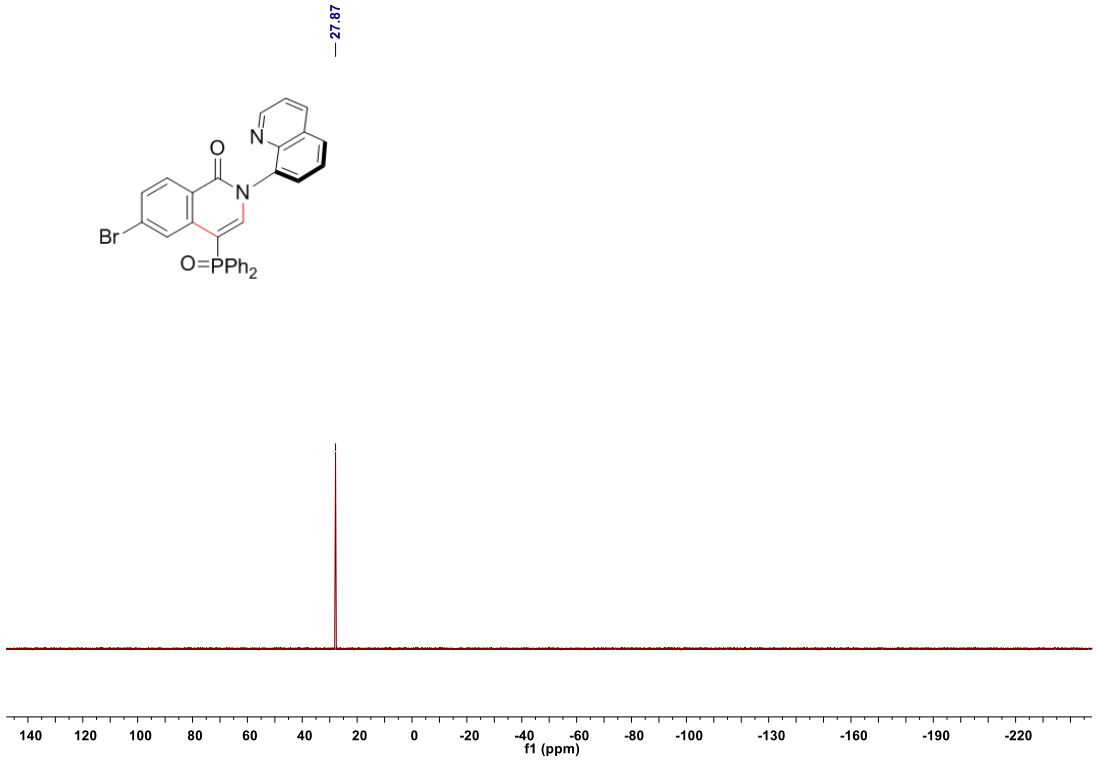
^{1}H NMR Spectrum of **3ap-minor**



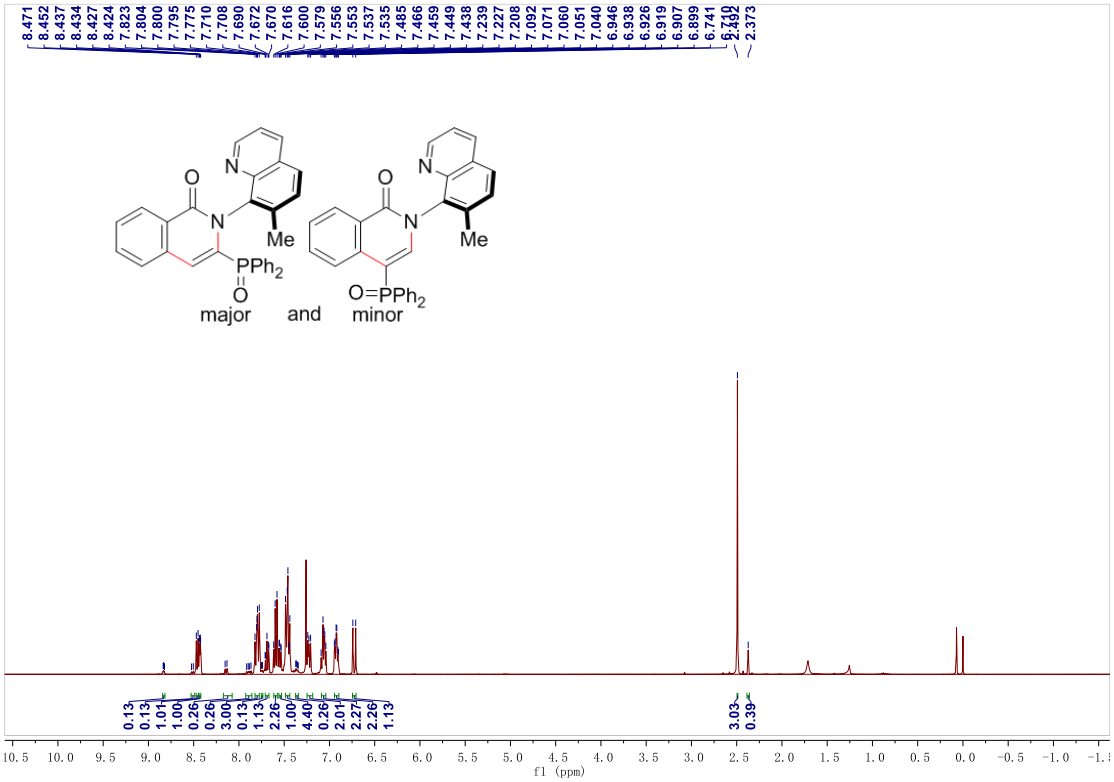
^{13}C NMR Spectrum of **3ap-minor**



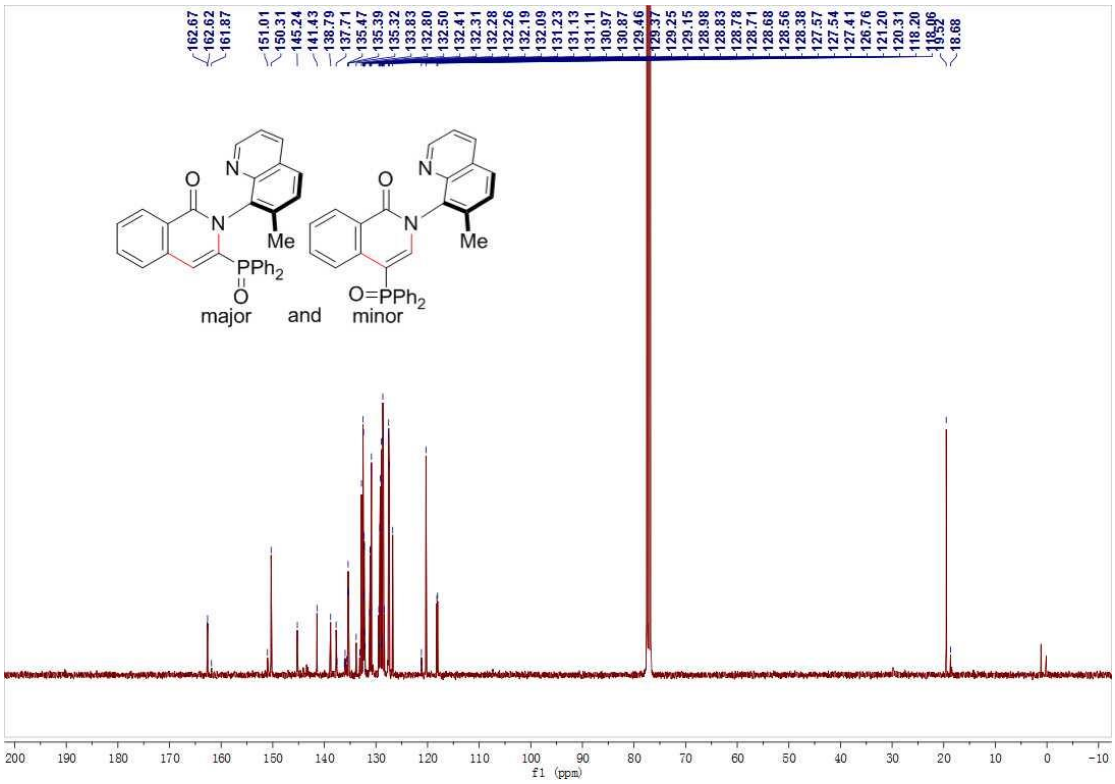
^{31}PNMR Spectrum of **3ap-minor**



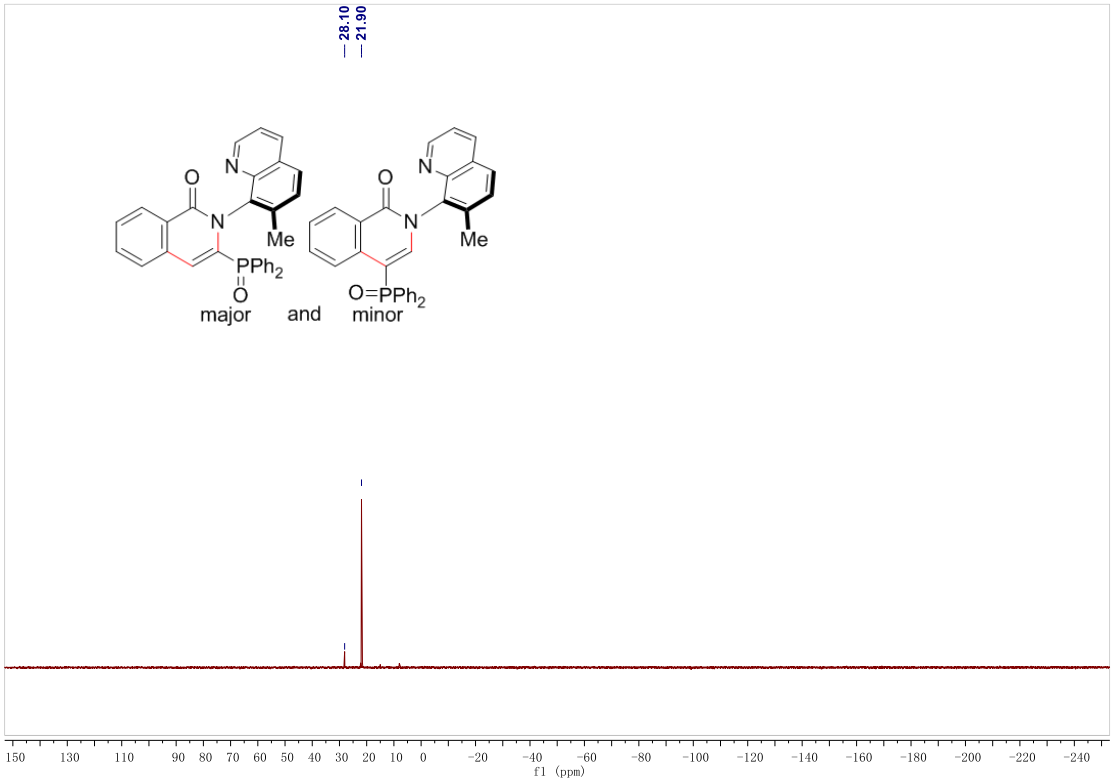
^{1}H NMR Spectrum of **3aq**



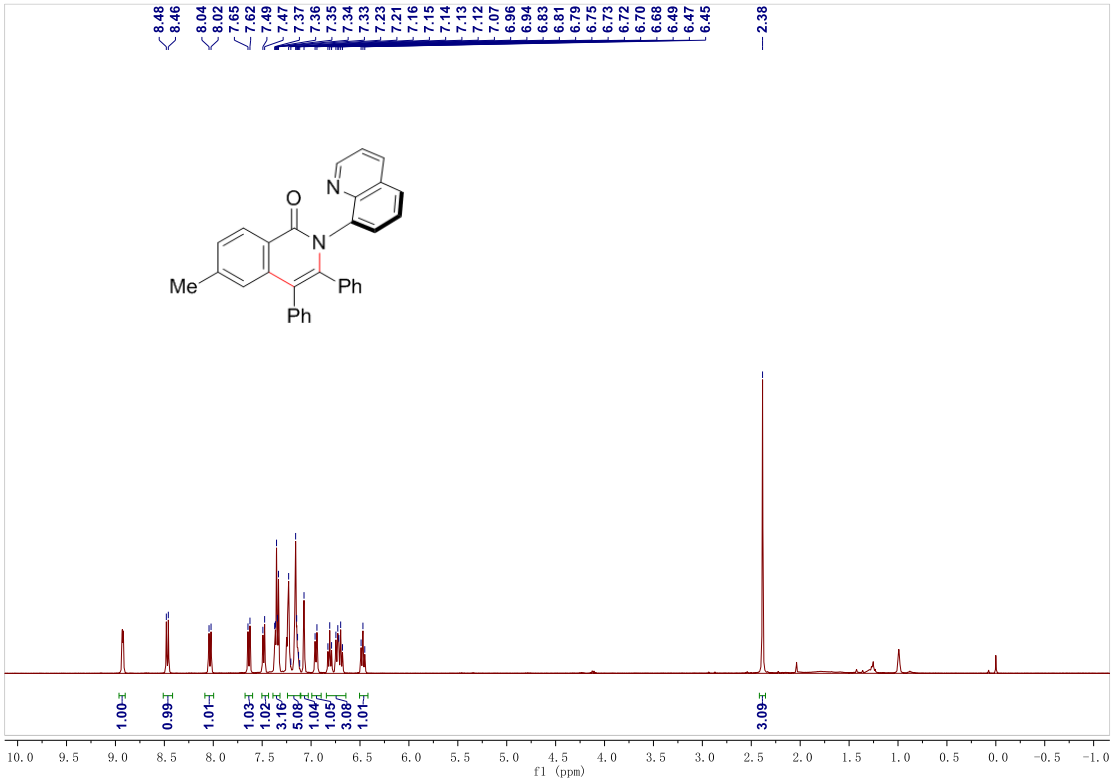
^{13}C NMR Spectrum of **3aq**



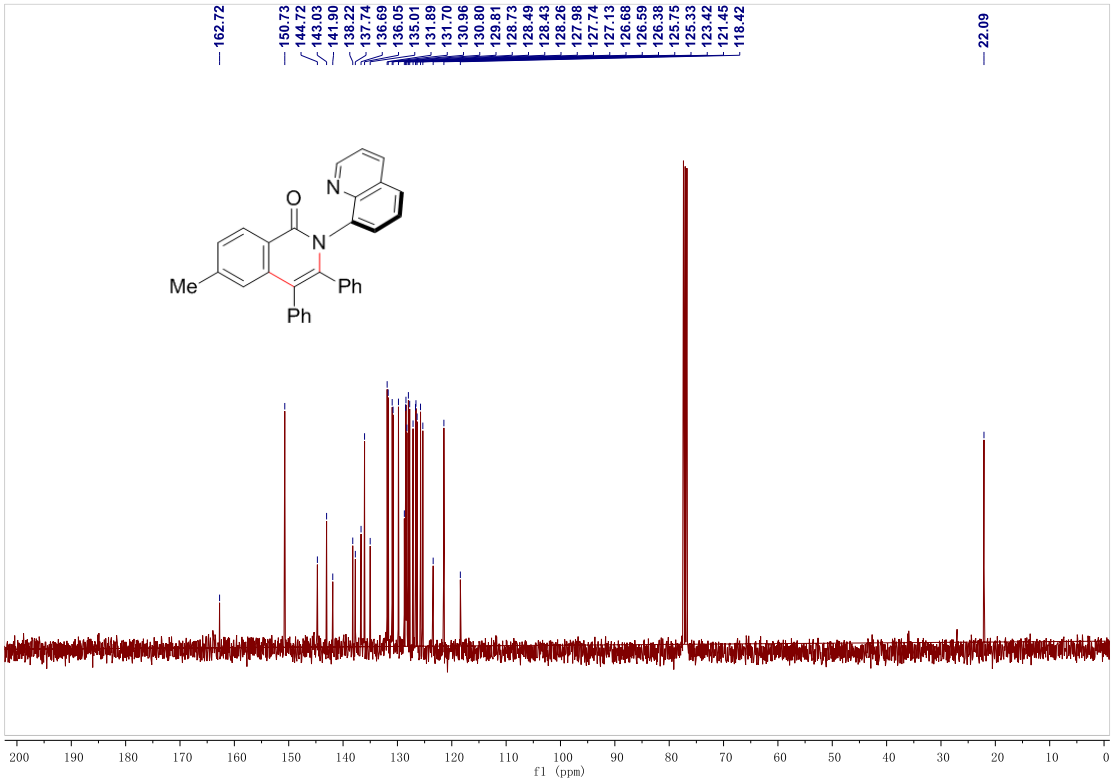
^{31}PNMR Spectrum of **3aq**



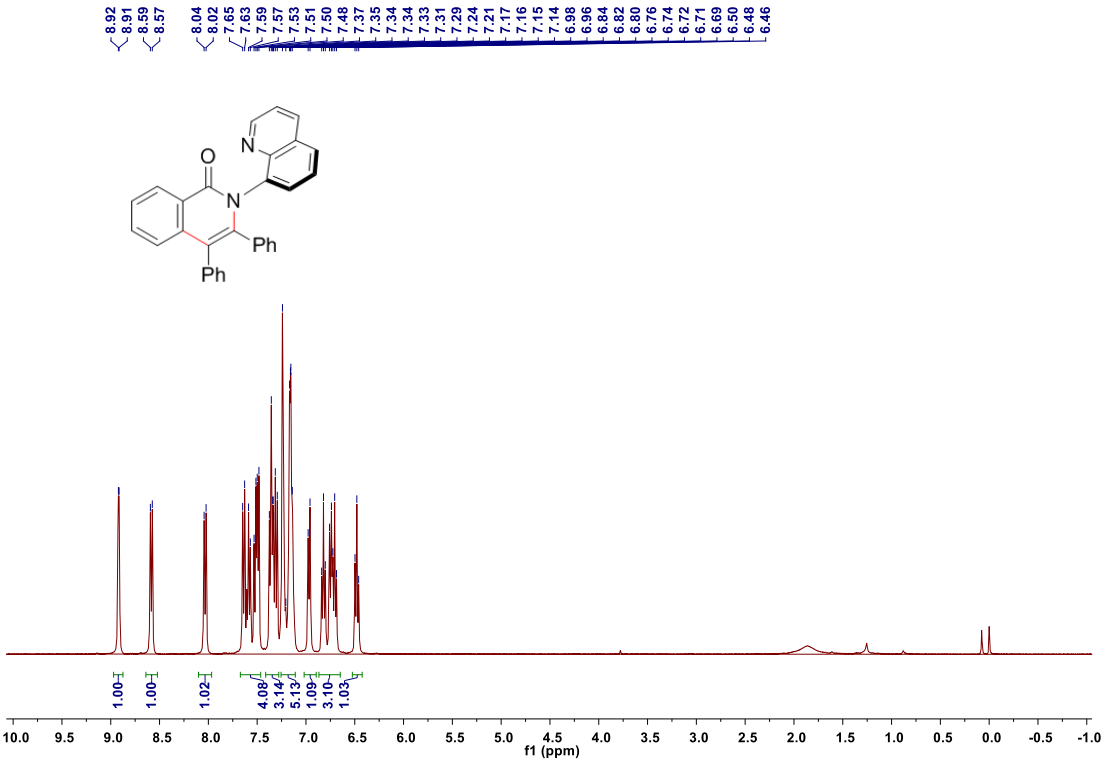
^{1}H NMR Spectrum of **3aa**



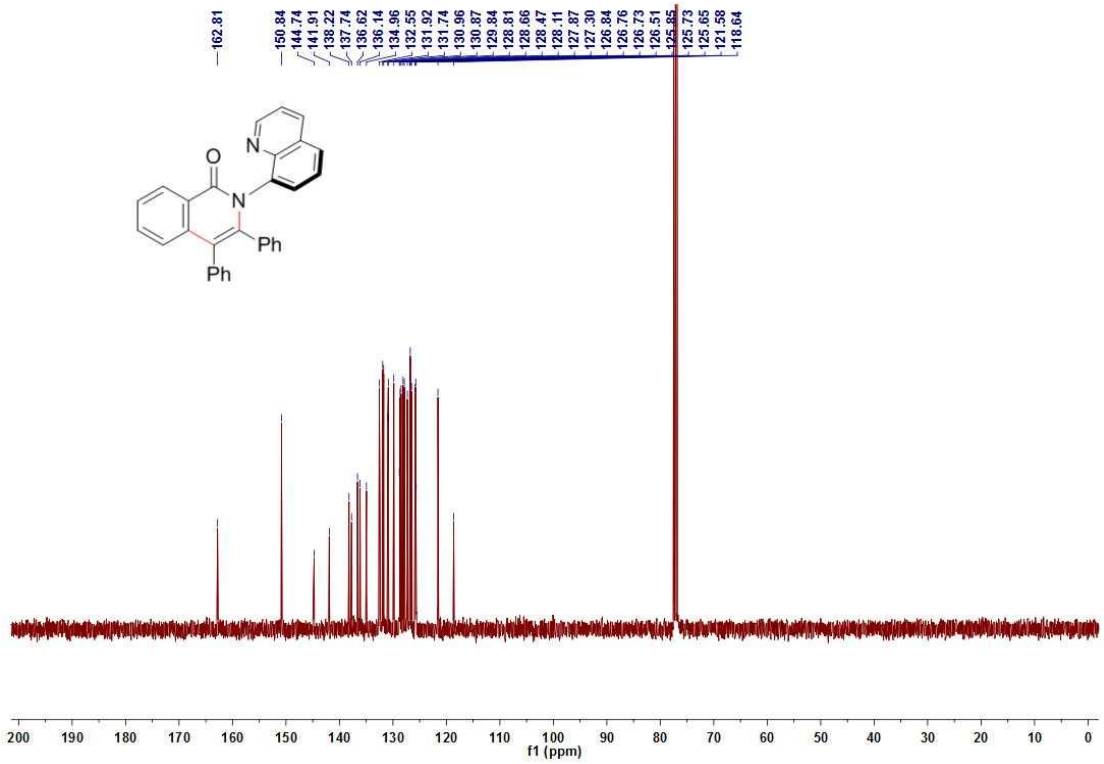
^{13}C NMR Spectrum of **3aa**



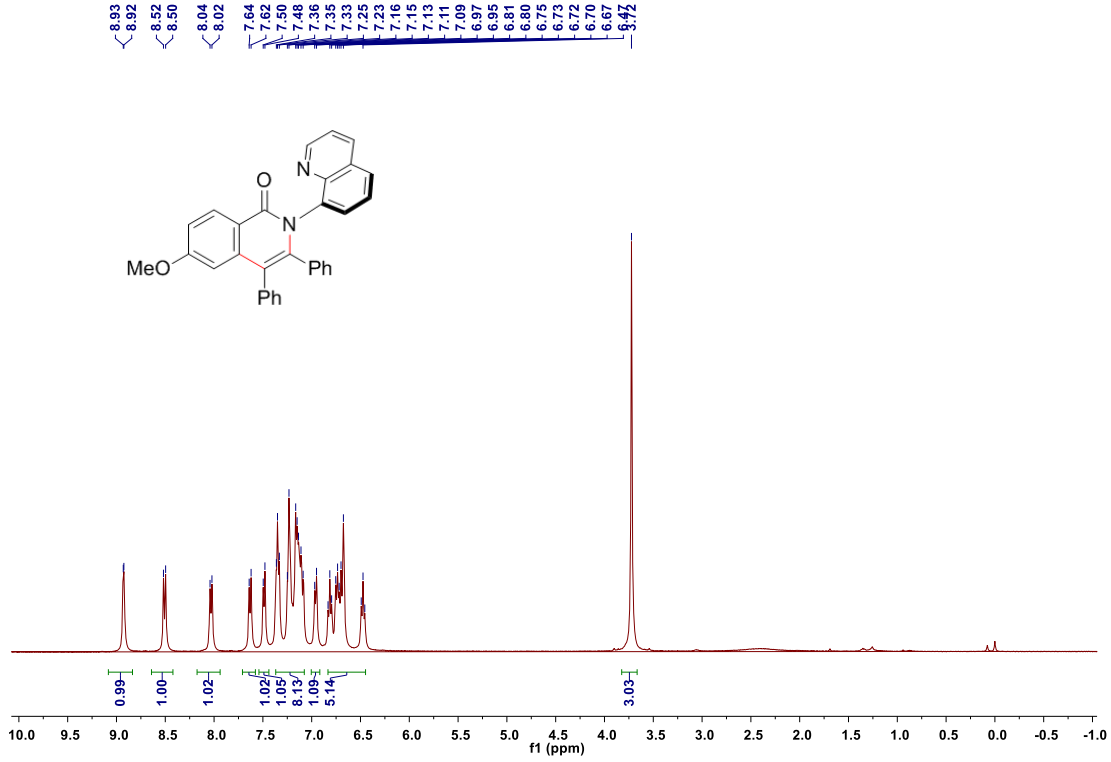
^{1}H NMR Spectrum of **3ba**



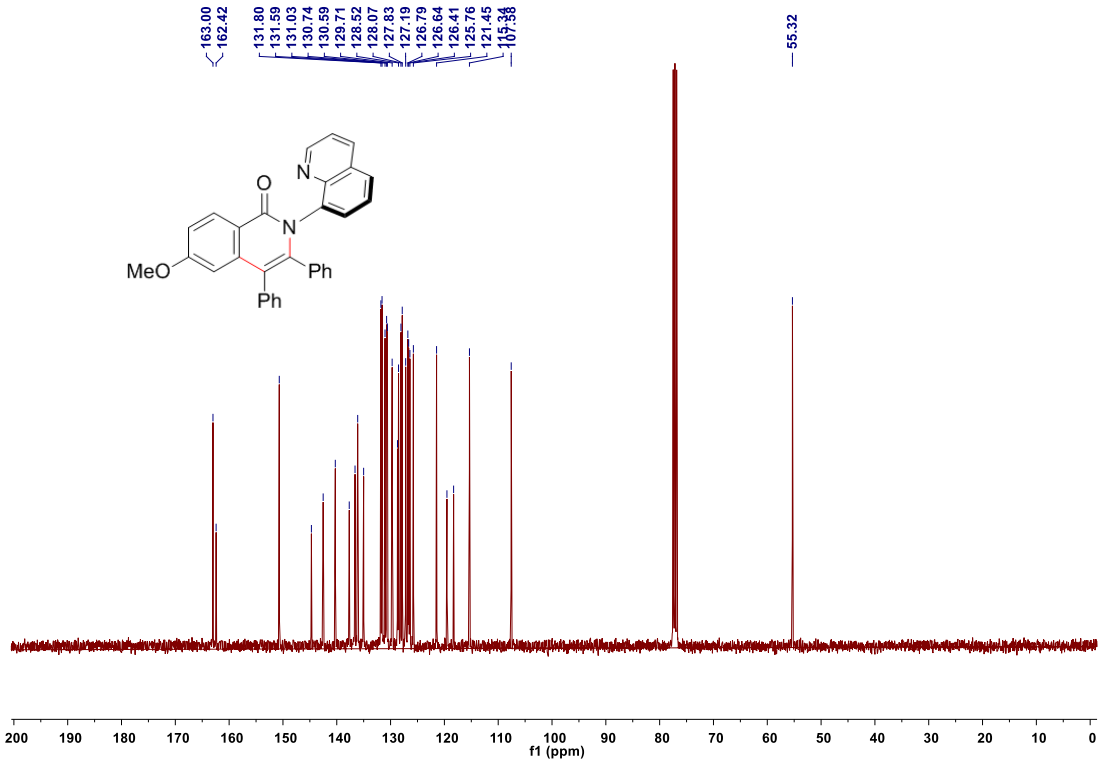
^{13}C NMR Spectrum of **3ba**



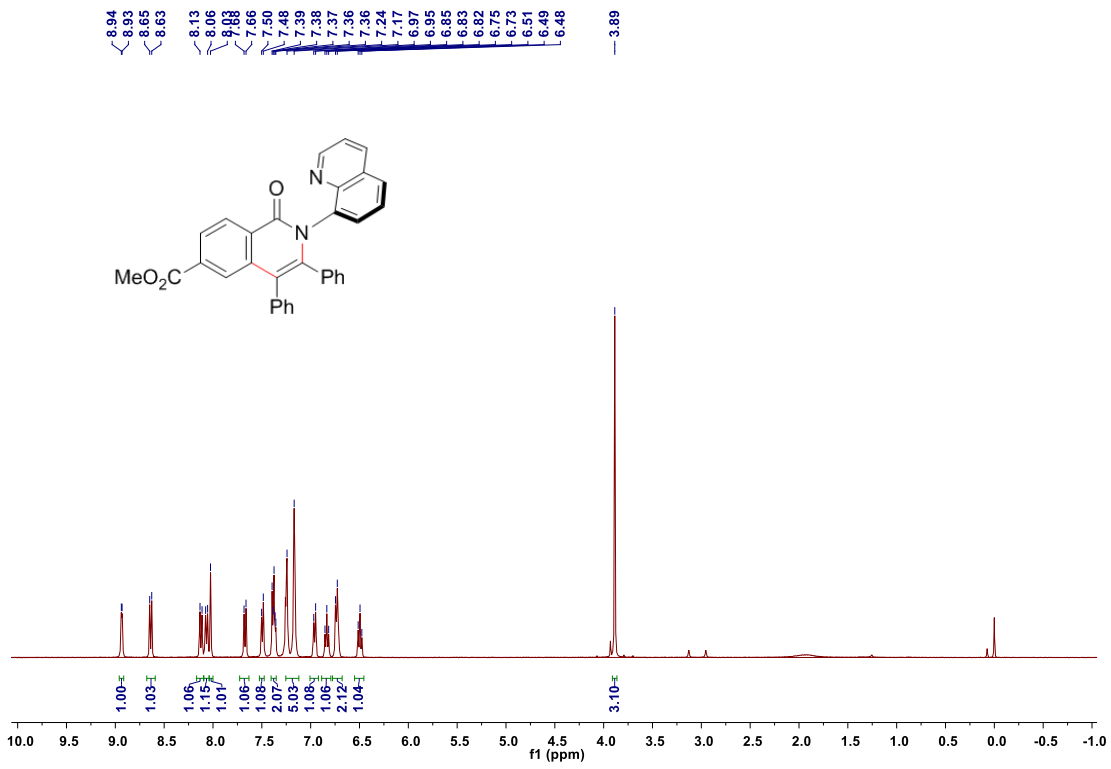
^{1}H NMR Spectrum of **3ca**



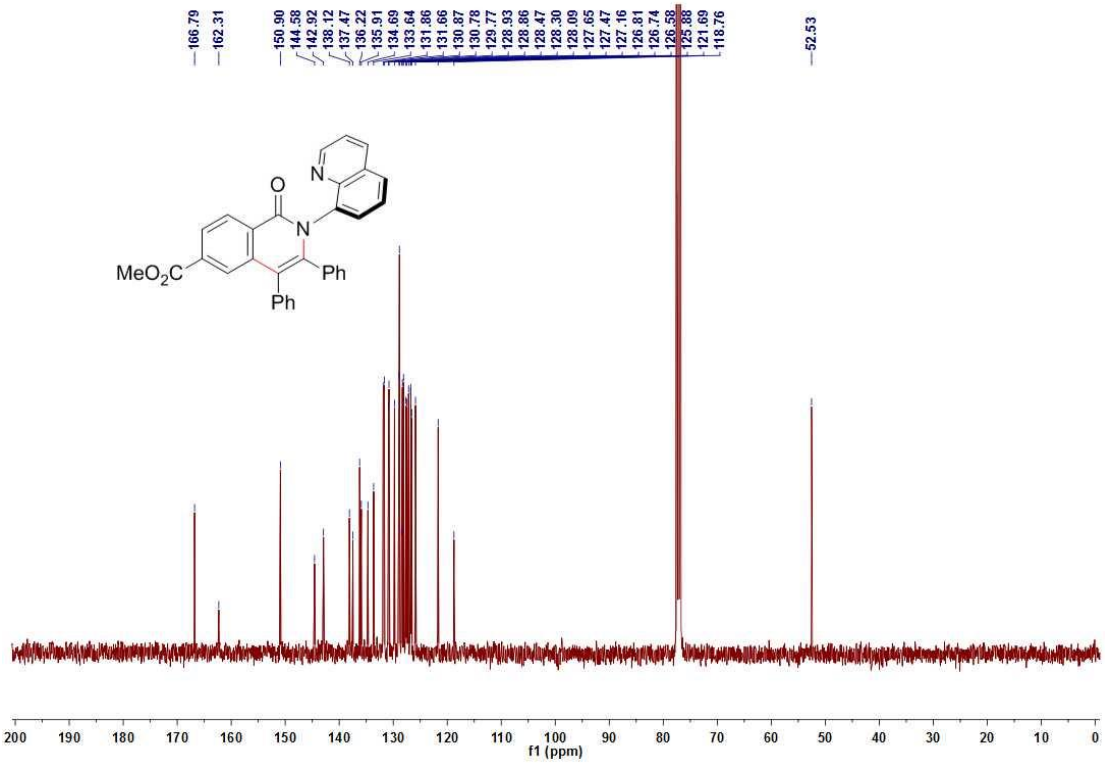
^{13}C NMR Spectrum of **3ca**



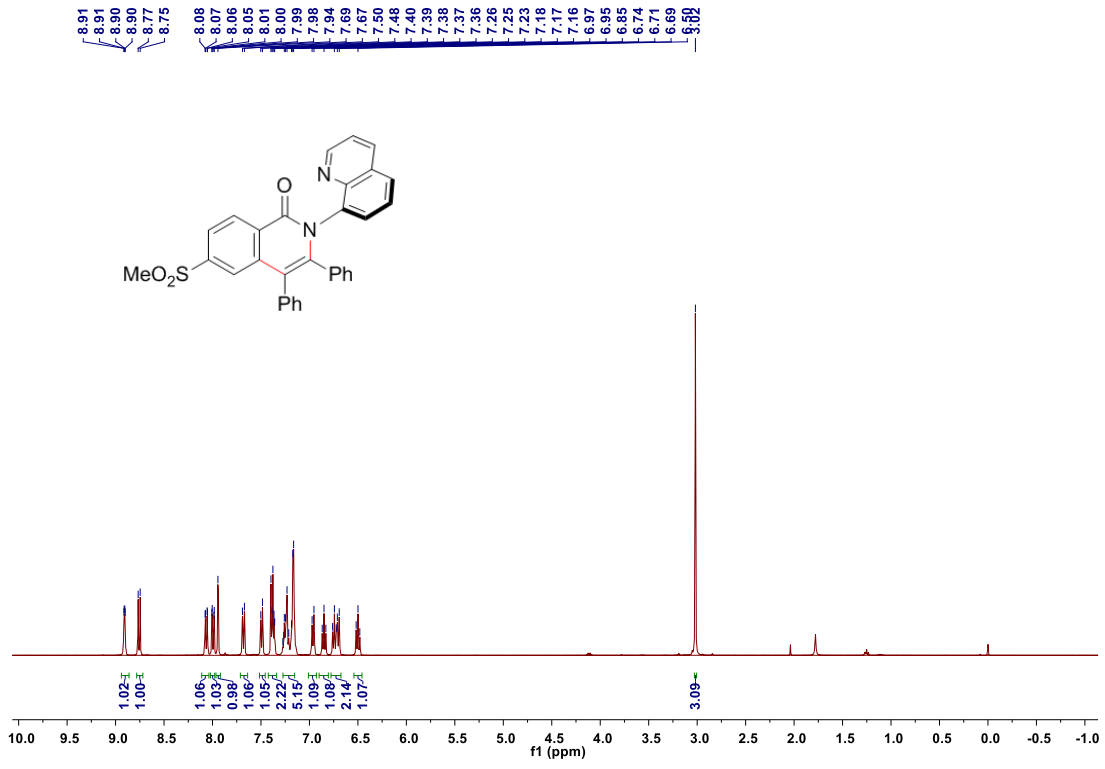
^{1}H NMR Spectrum of **3da**



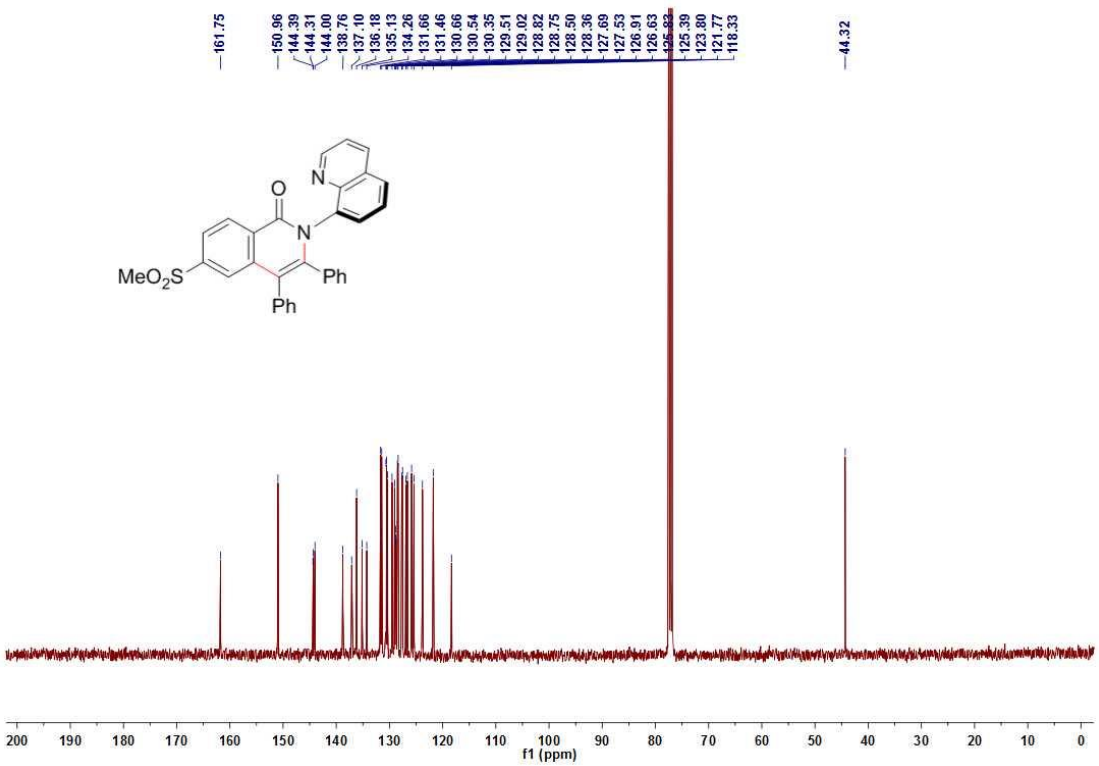
^{13}C NMR Spectrum of **3da**



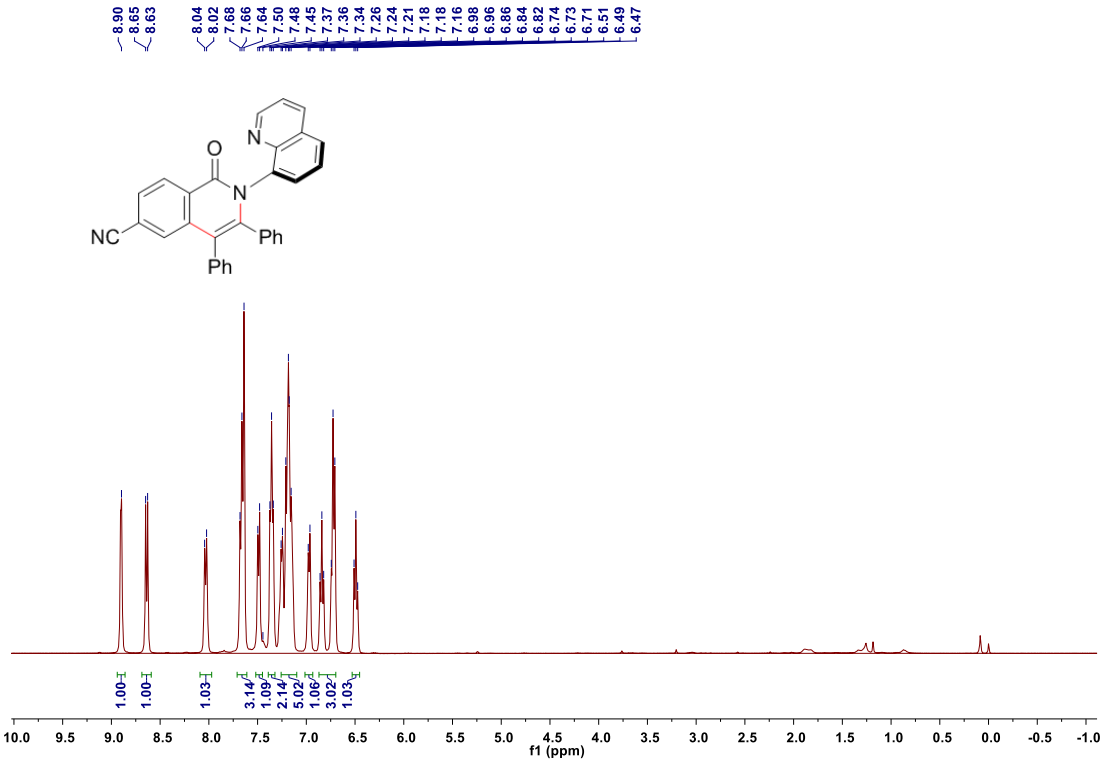
^{1}H NMR Spectrum of **3ea**



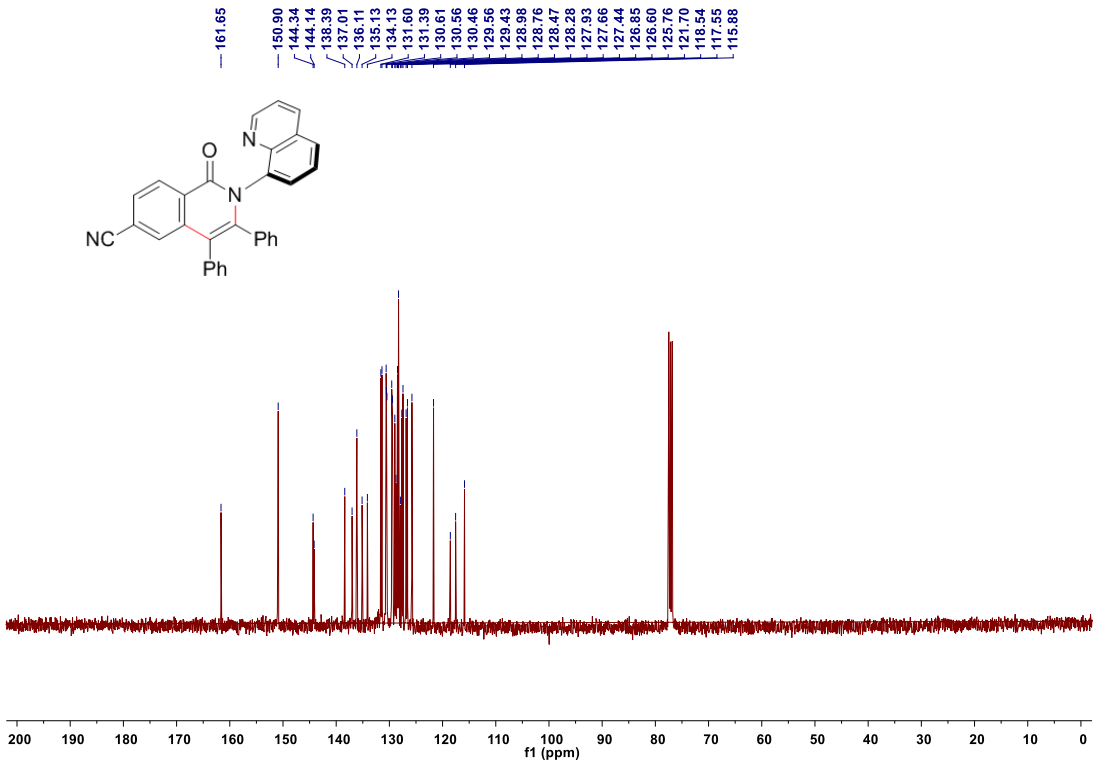
^{13}C NMR Spectrum of **3ea**



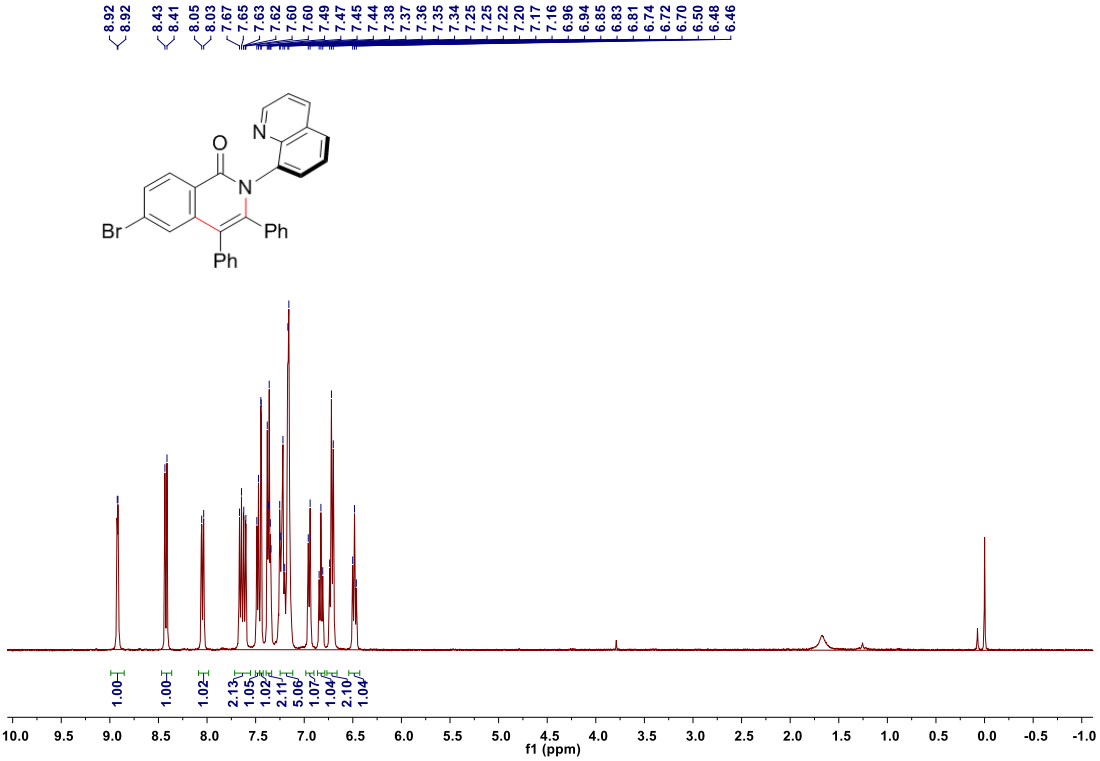
^{1}H NMR Spectrum of **3fa**



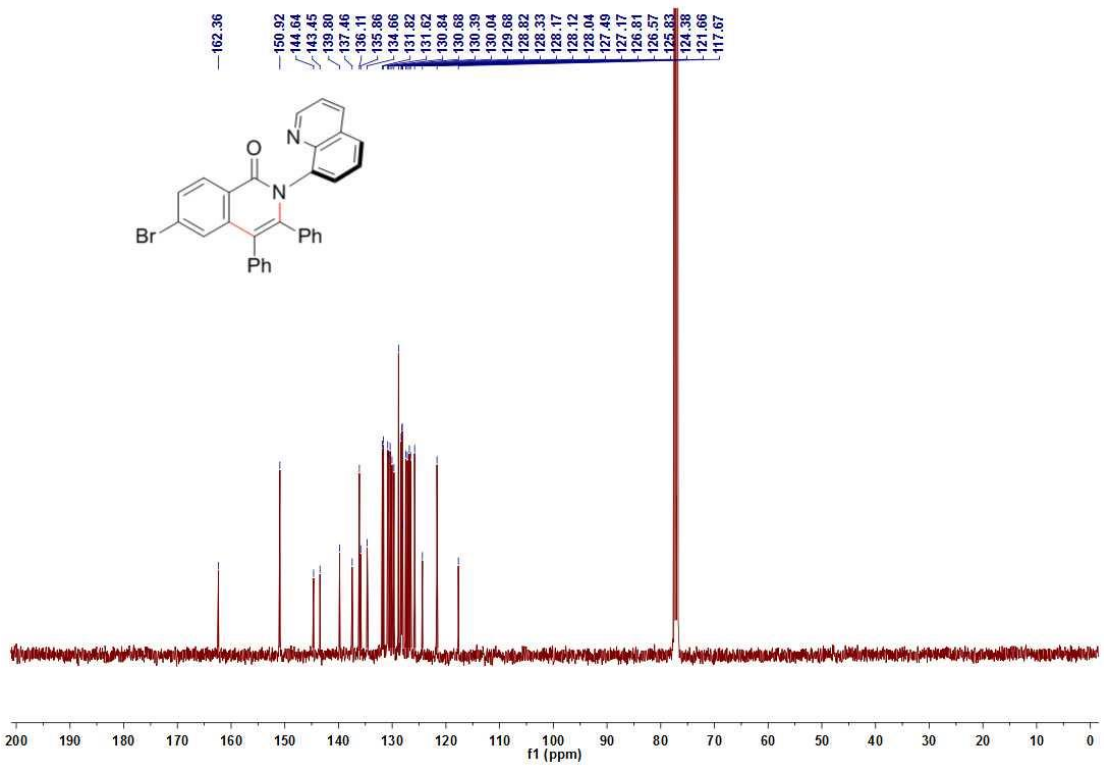
^{13}C NMR Spectrum of **3fa**



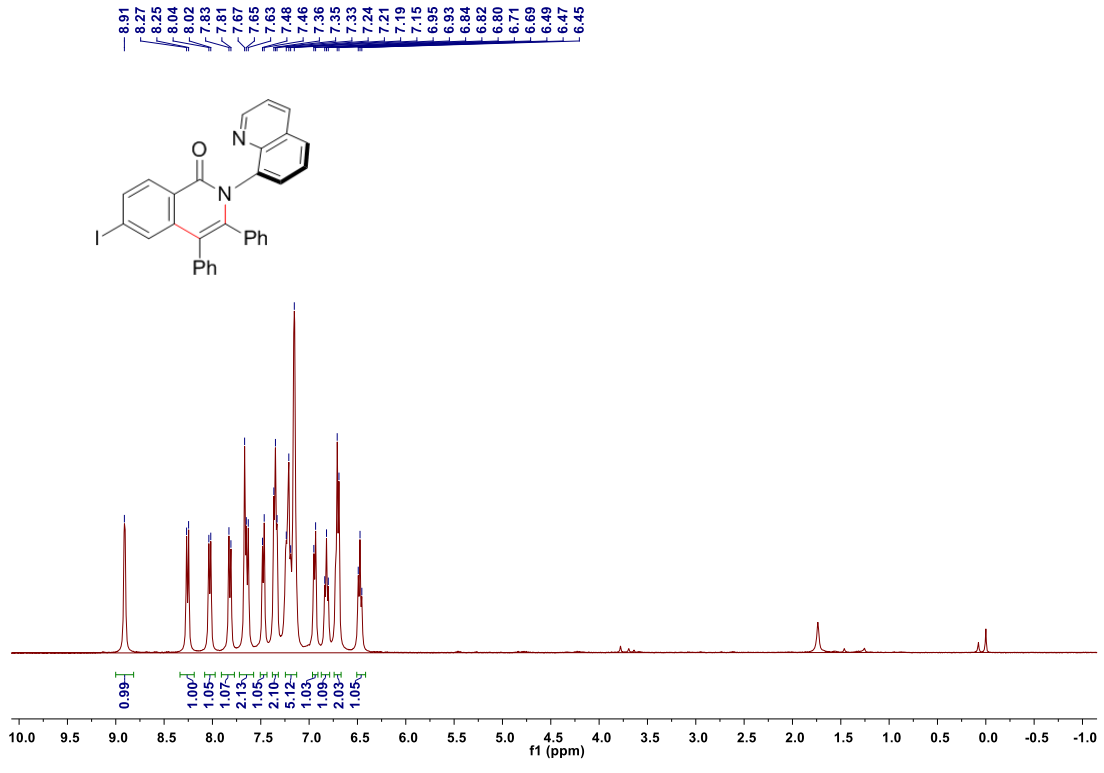
^{1}H NMR Spectrum of **3ga**



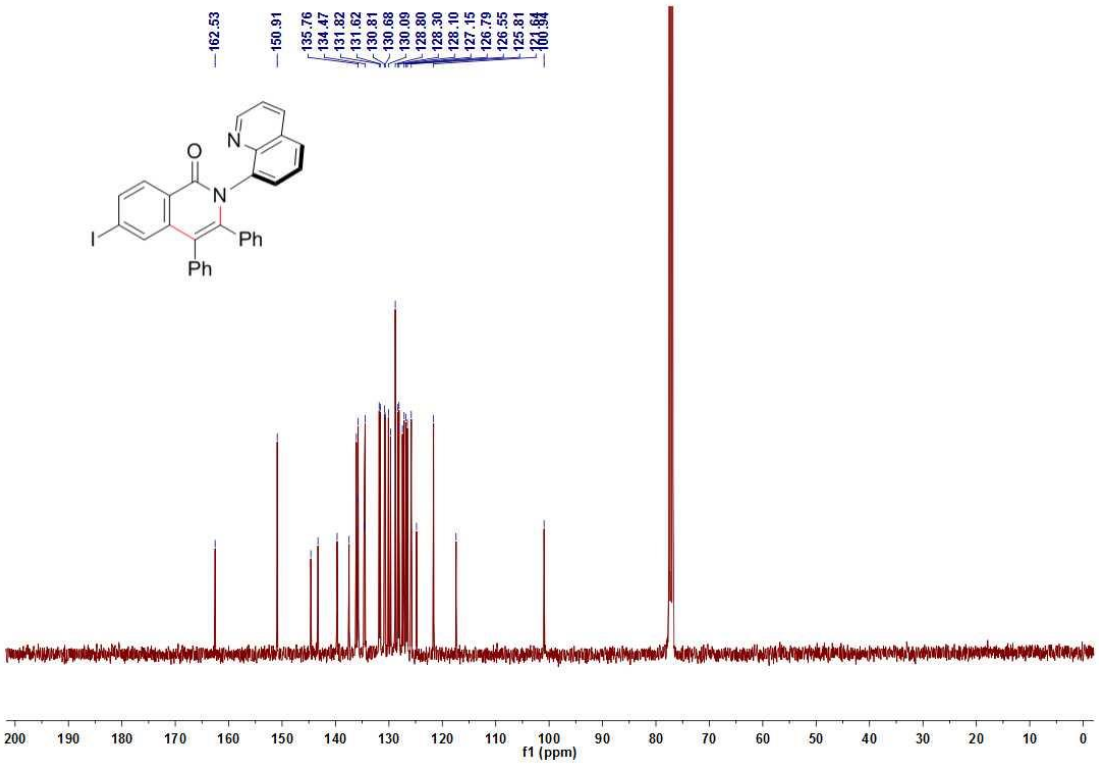
^{13}C NMR Spectrum of **3ga**



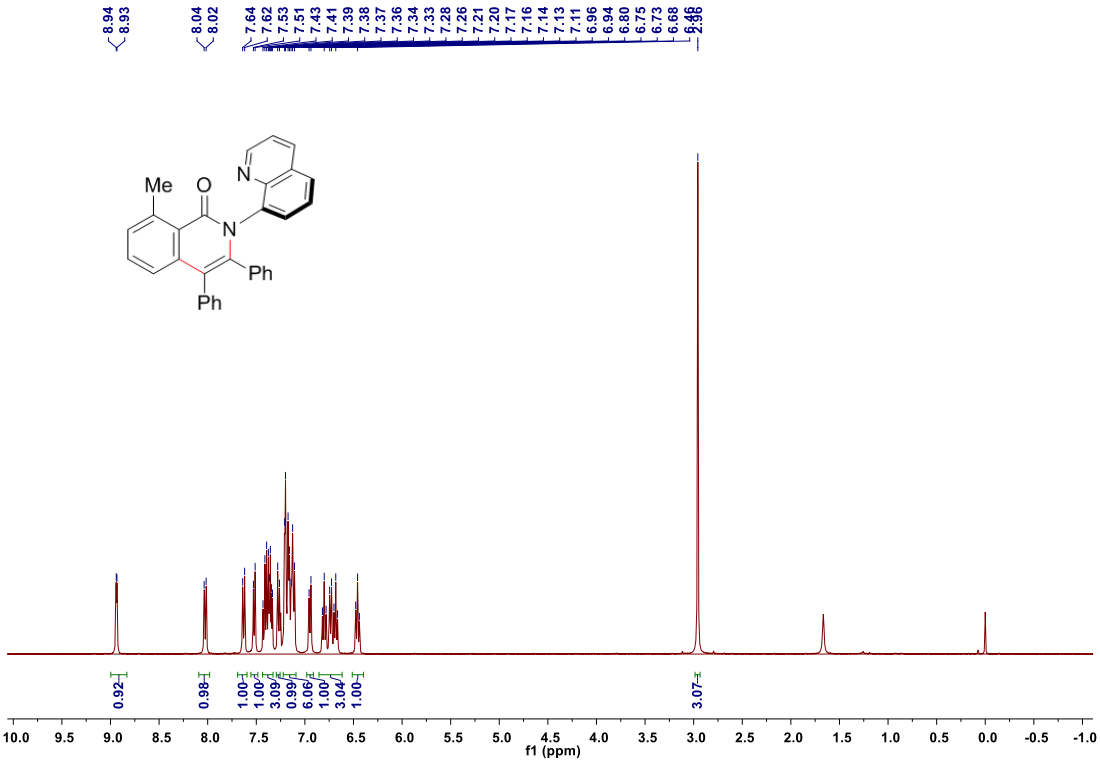
^{1}H NMR Spectrum of **3ha**



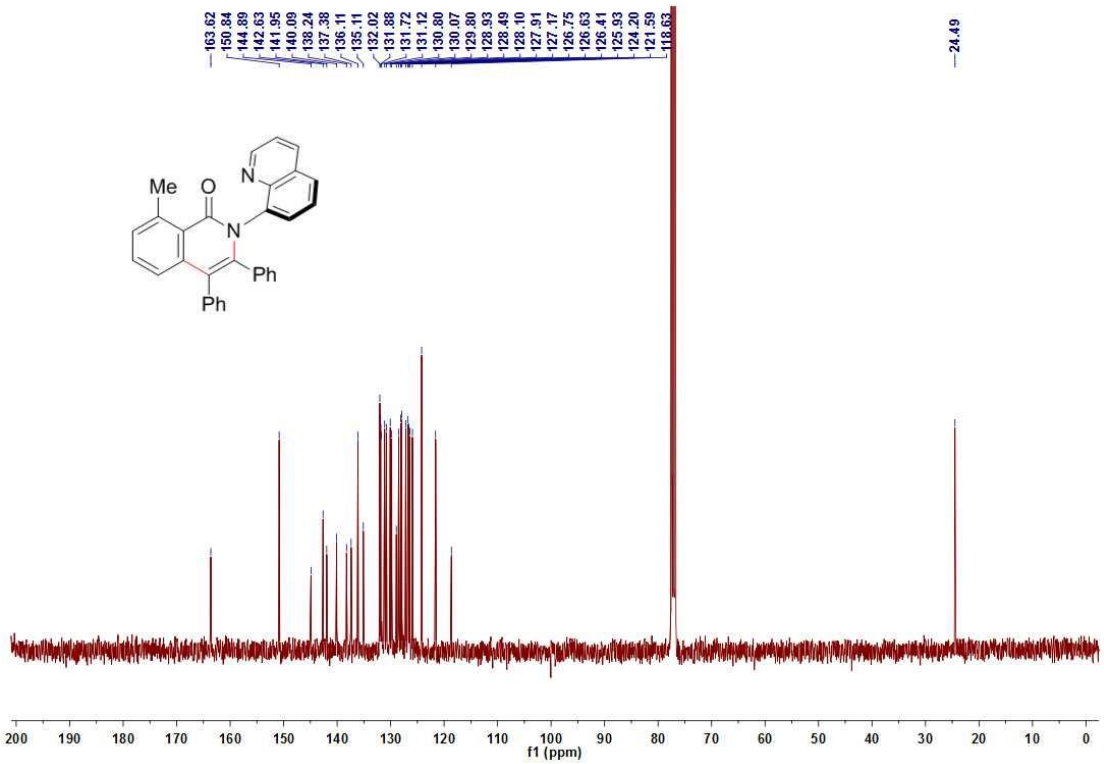
^{13}C NMR Spectrum of **3ha**



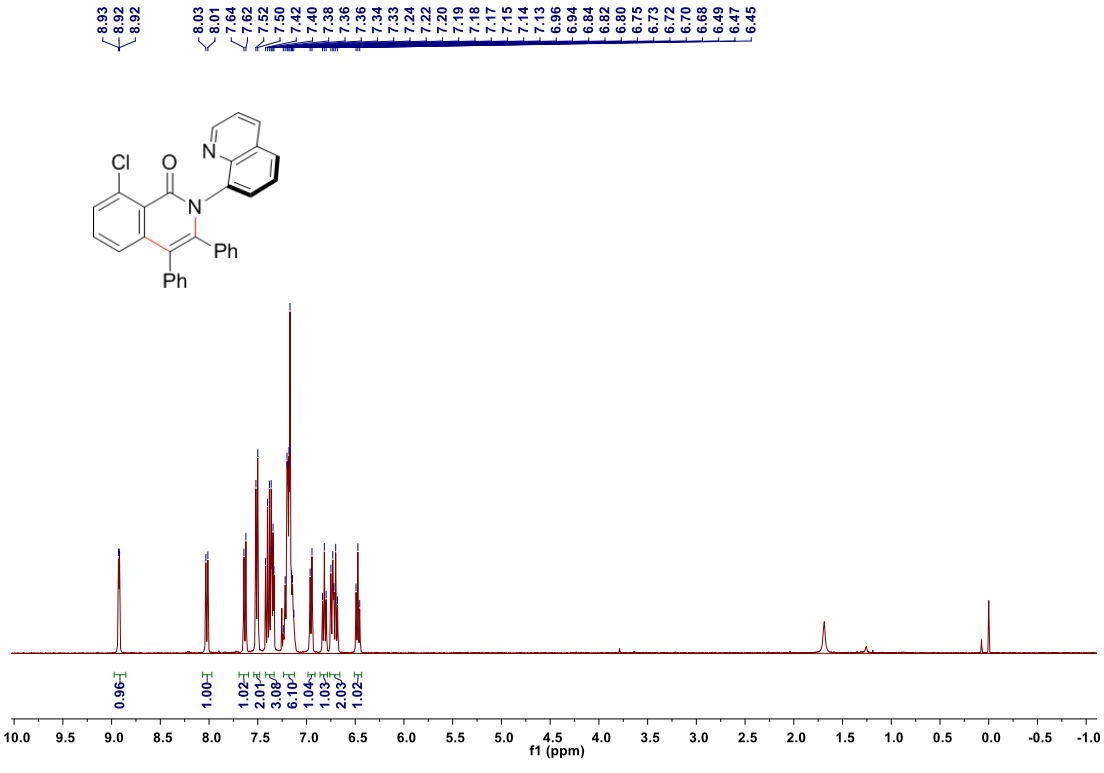
^{1}H NMR Spectrum of **3ia**



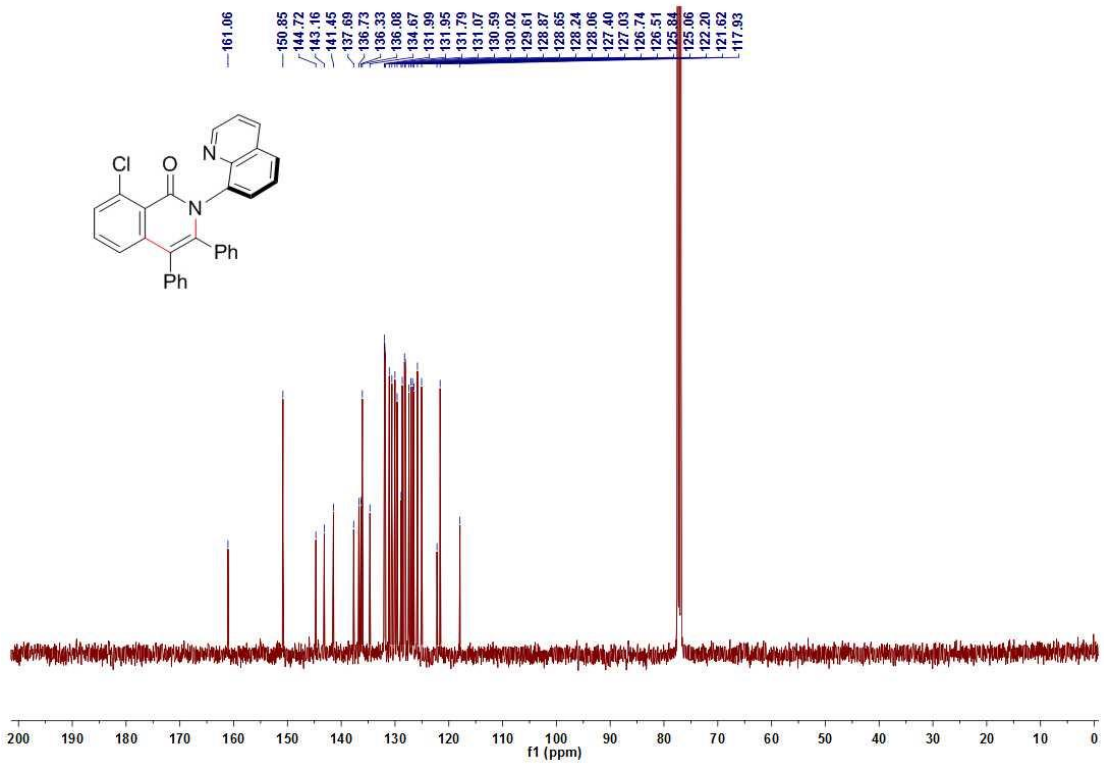
^{13}C NMR Spectrum of **3ia**



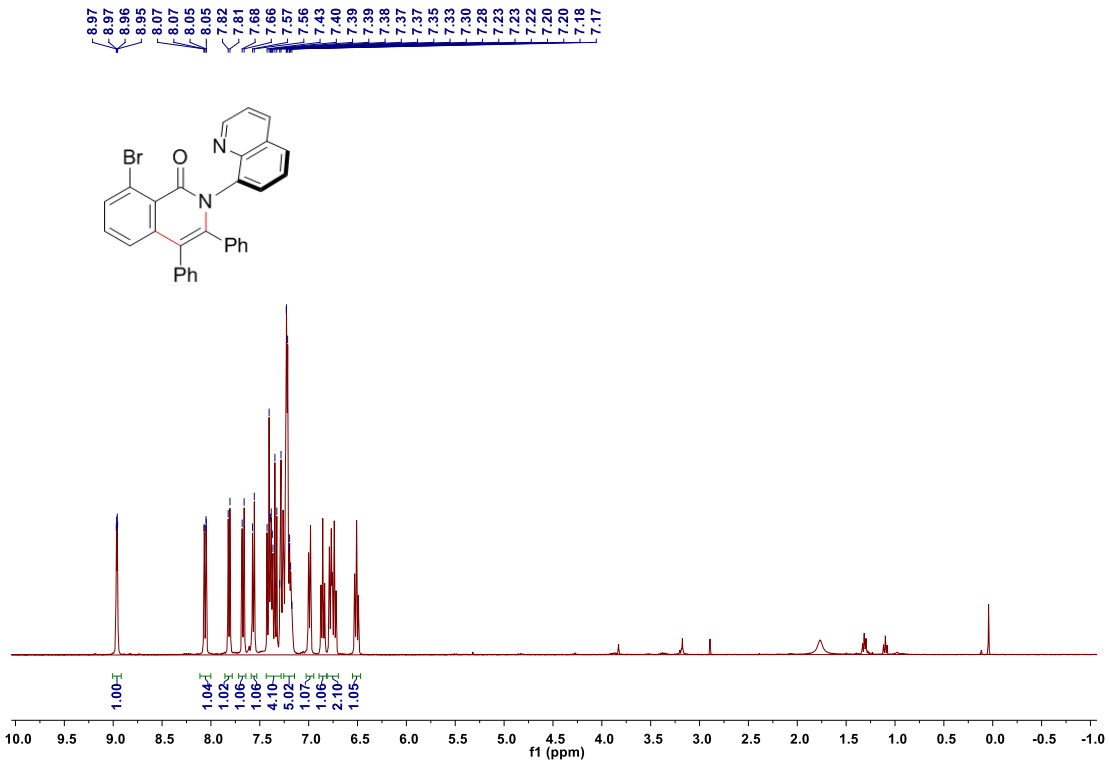
^{1}H NMR Spectrum of **3ja**



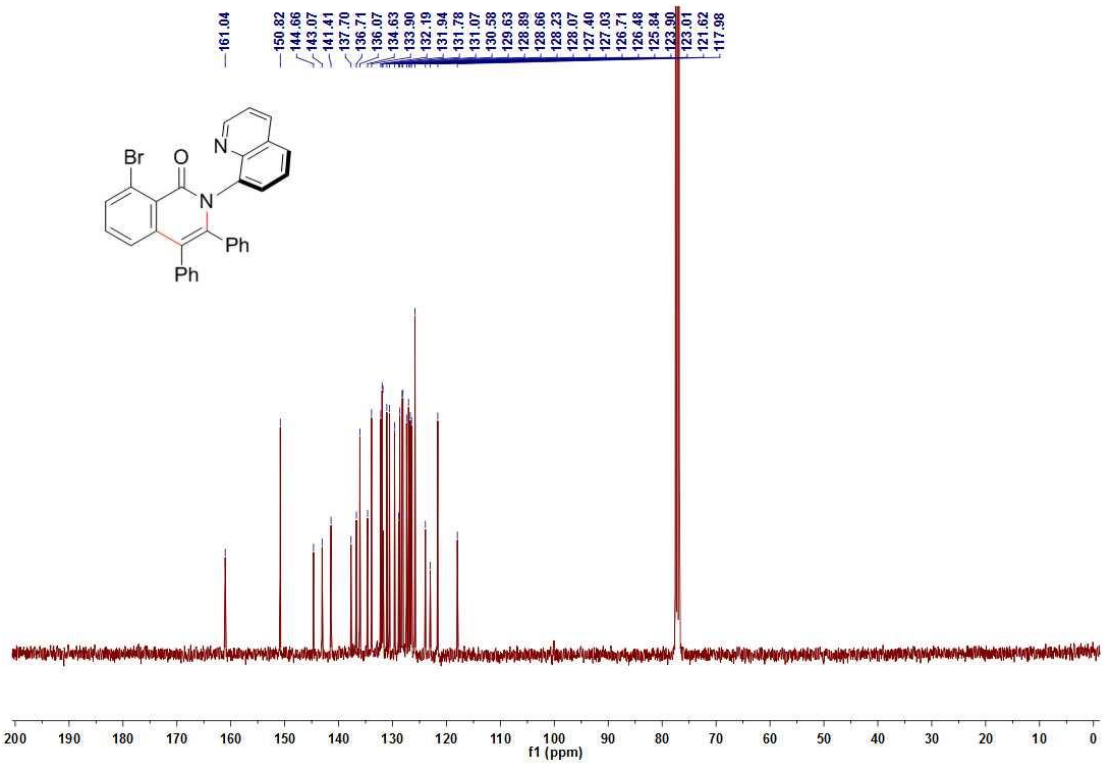
^{13}C NMR Spectrum of **3ja**



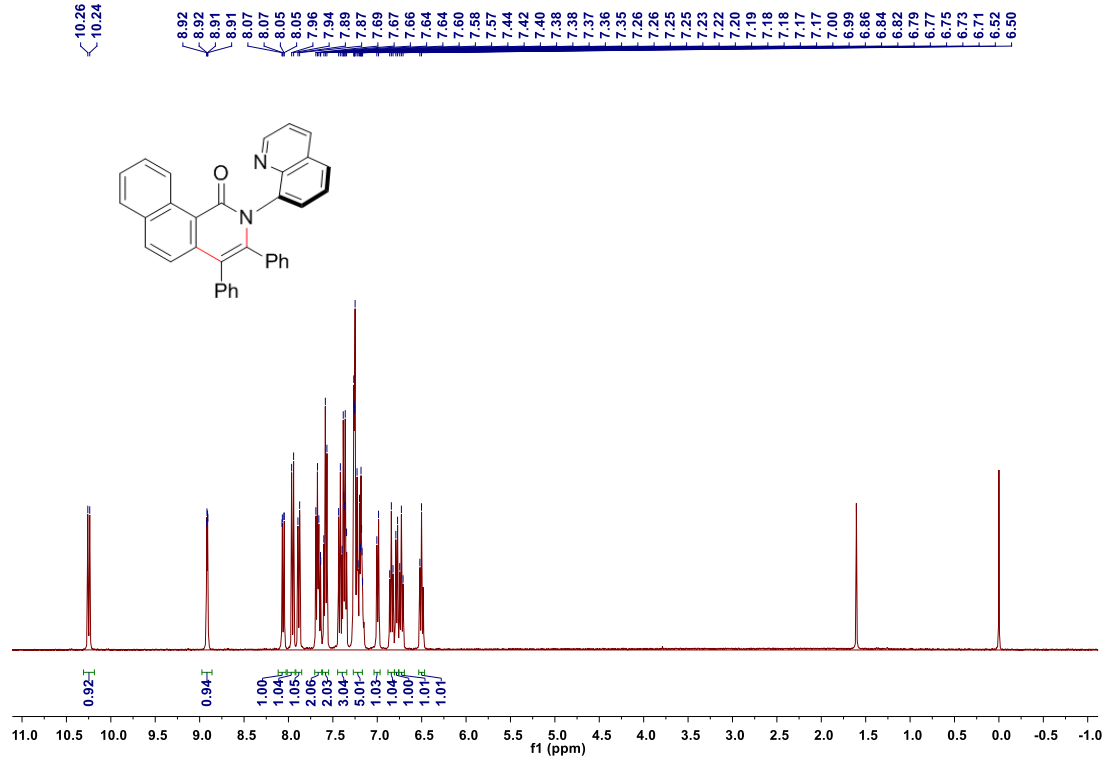
^{1}H NMR Spectrum of **3ka**



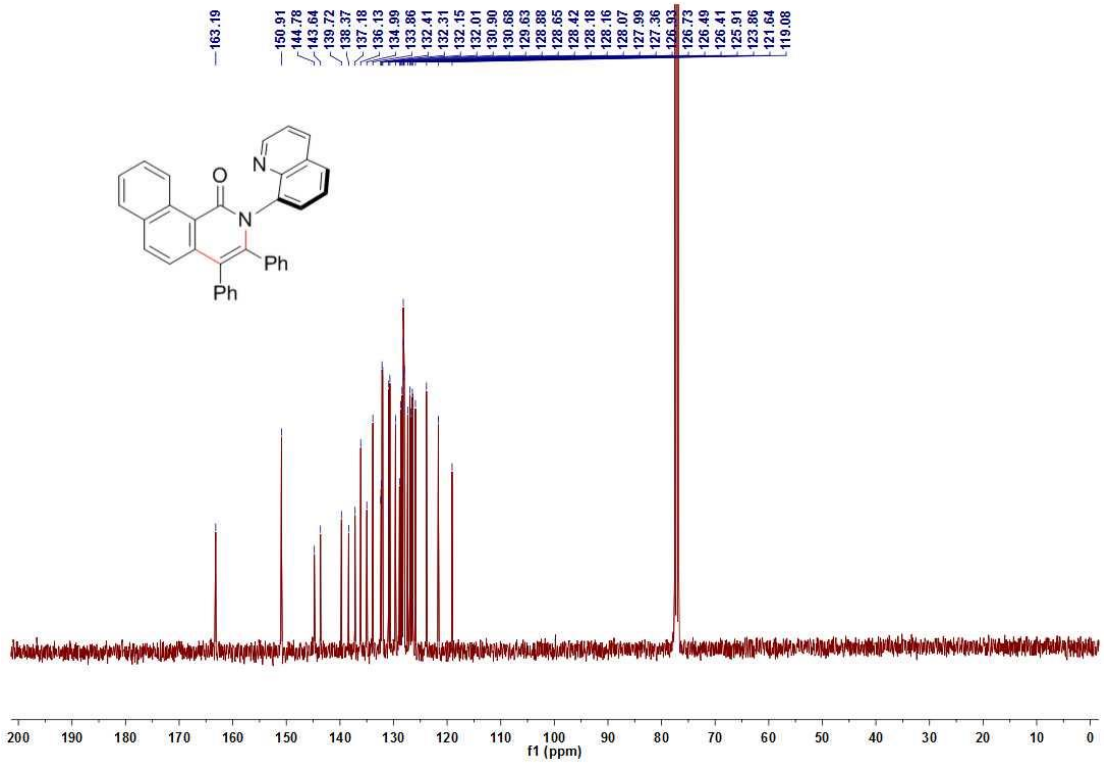
^{13}C NMR Spectrum of **3ka**



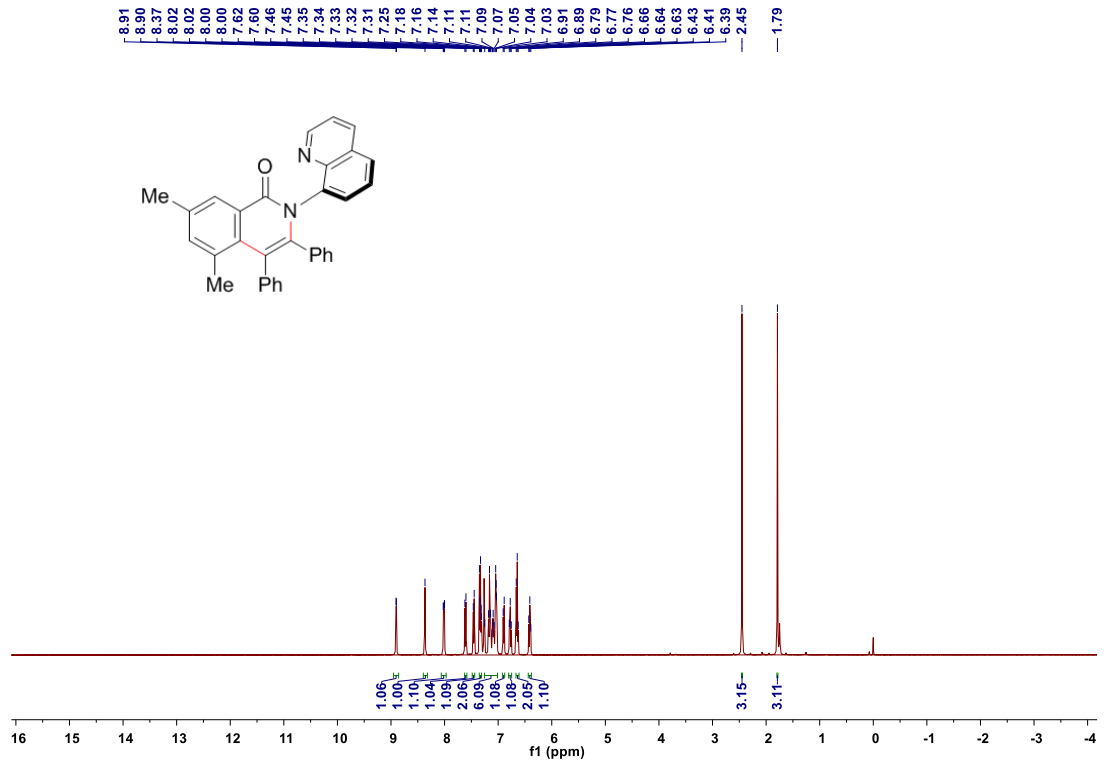
^{1}H NMR Spectrum of **3la**



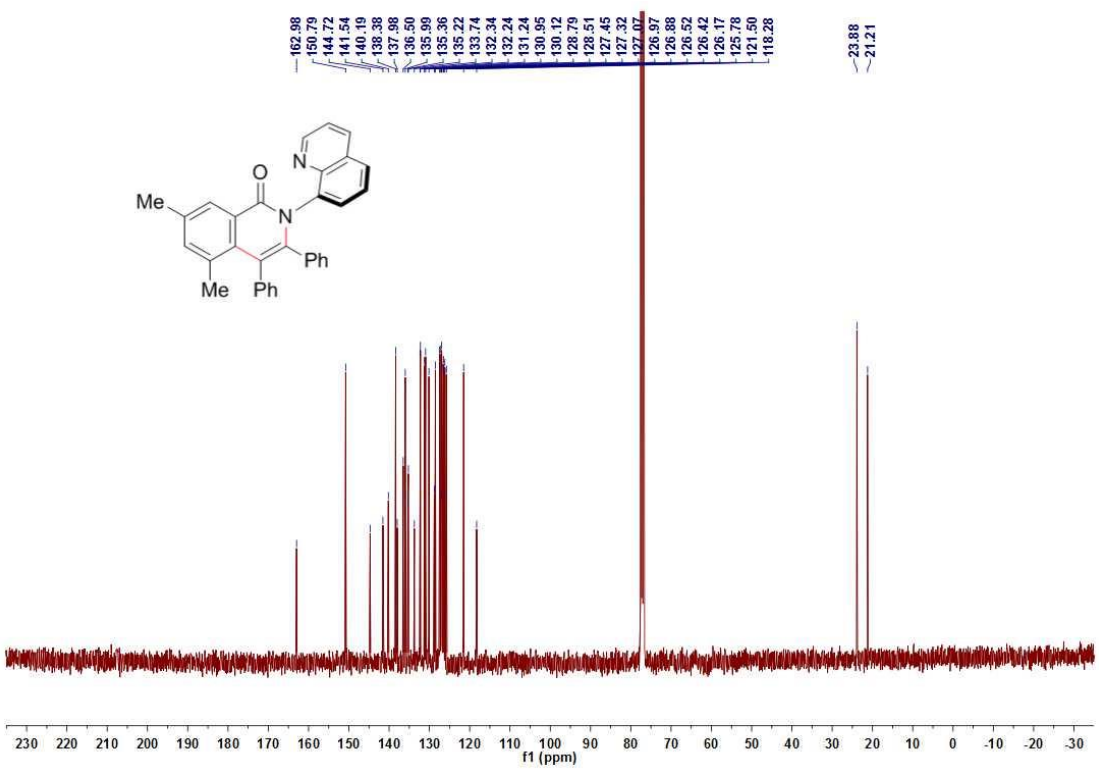
^{13}C NMR Spectrum of **3la**



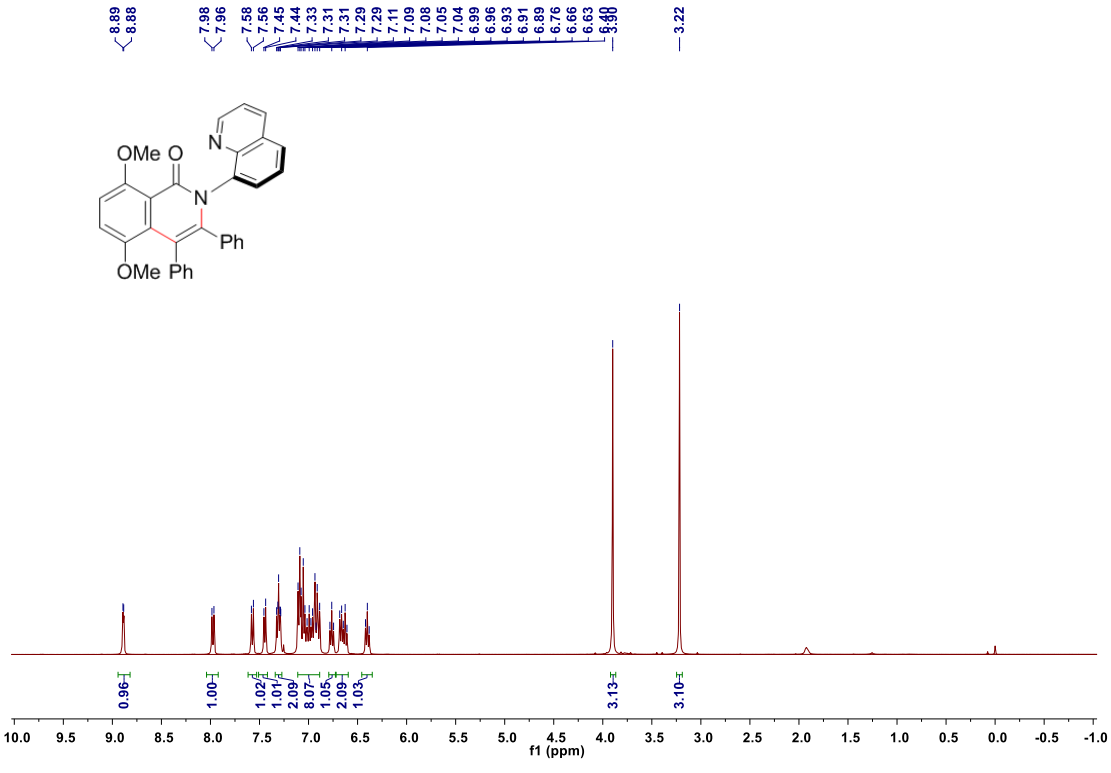
^{1}H NMR Spectrum of **3ma**



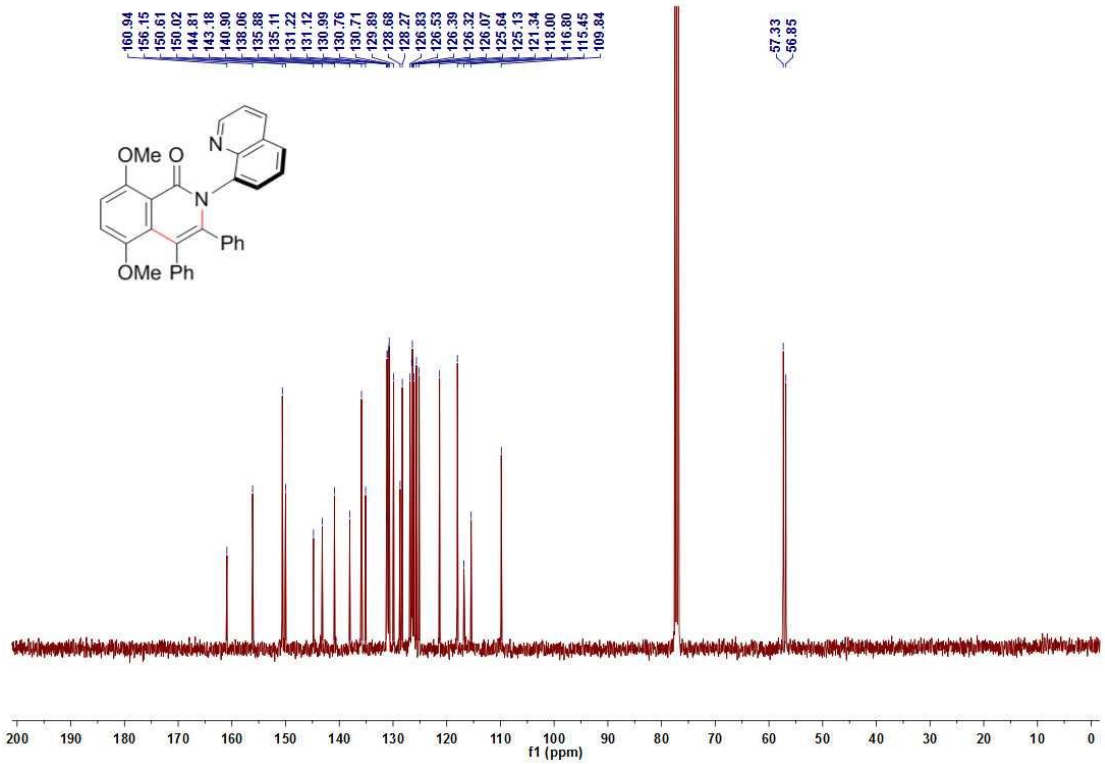
^{13}C NMR Spectrum of **3ma**



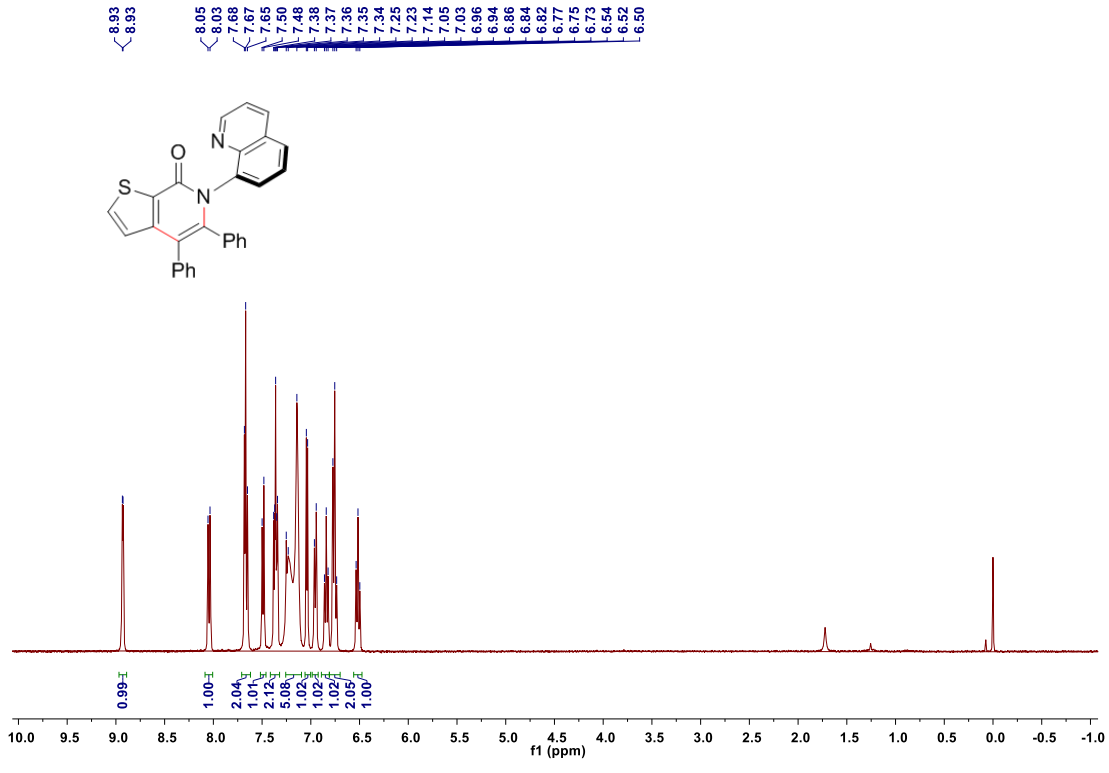
^{1}H NMR Spectrum of **3na**



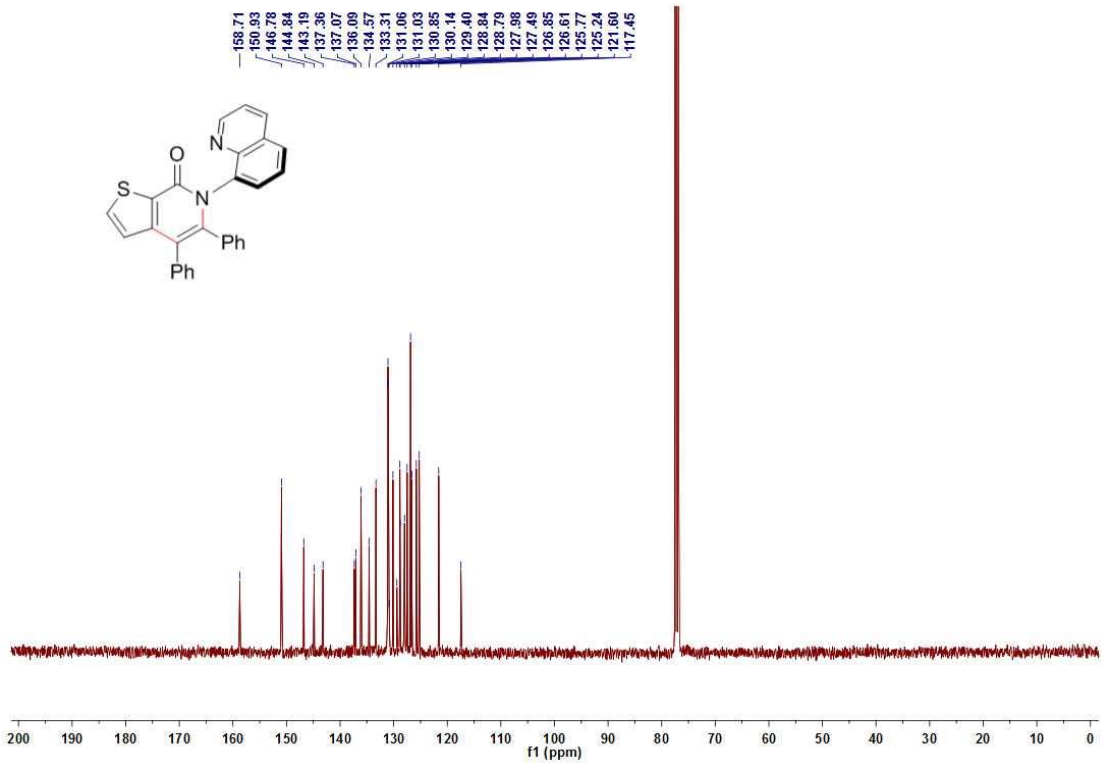
^{13}C NMR Spectrum of **3na**



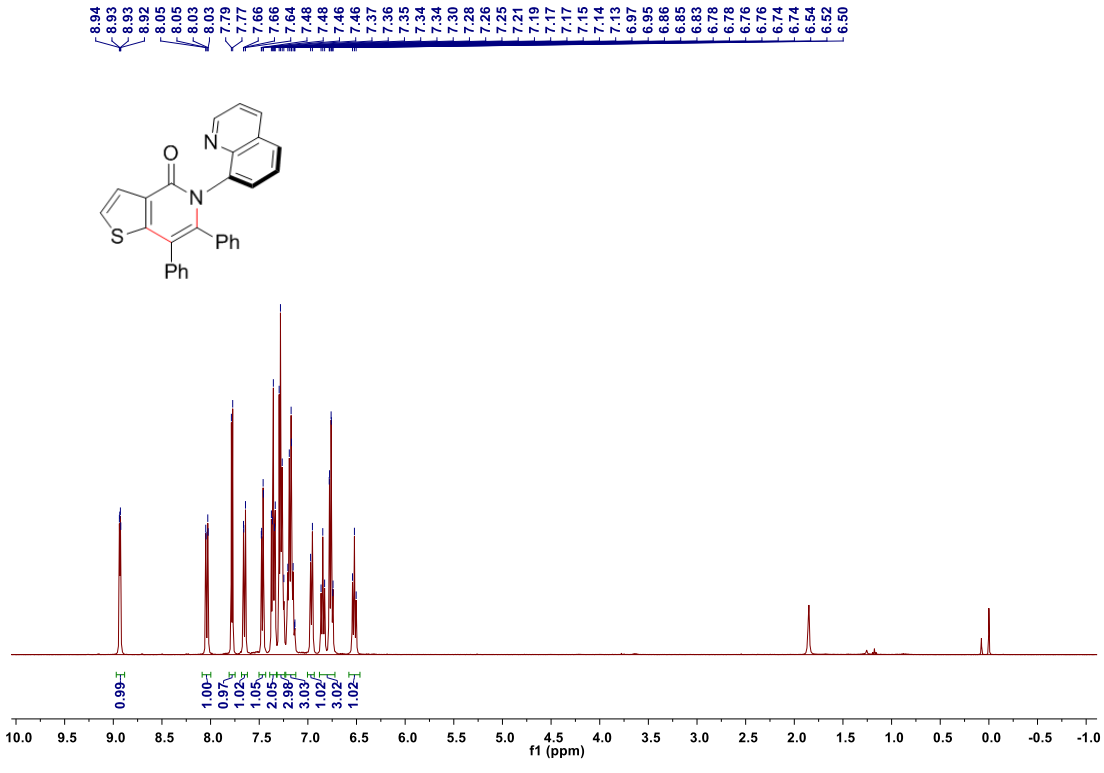
^{1}H NMR Spectrum of **3oa**



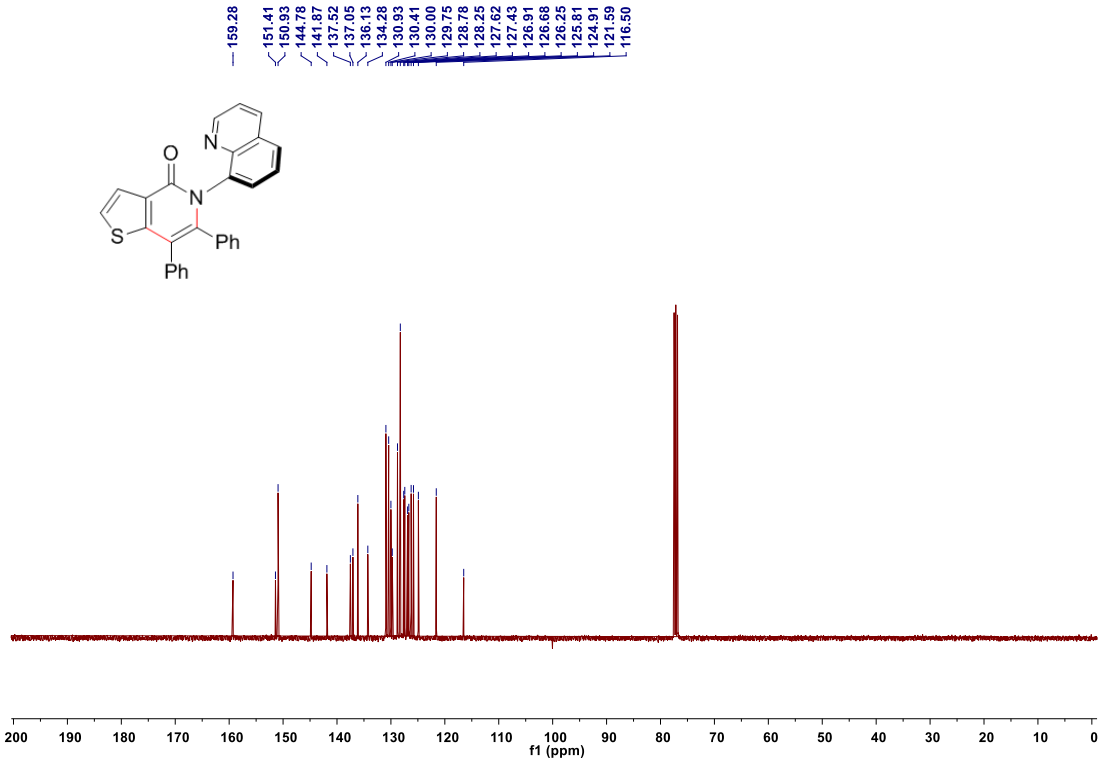
^{13}C NMR Spectrum of **3oa**



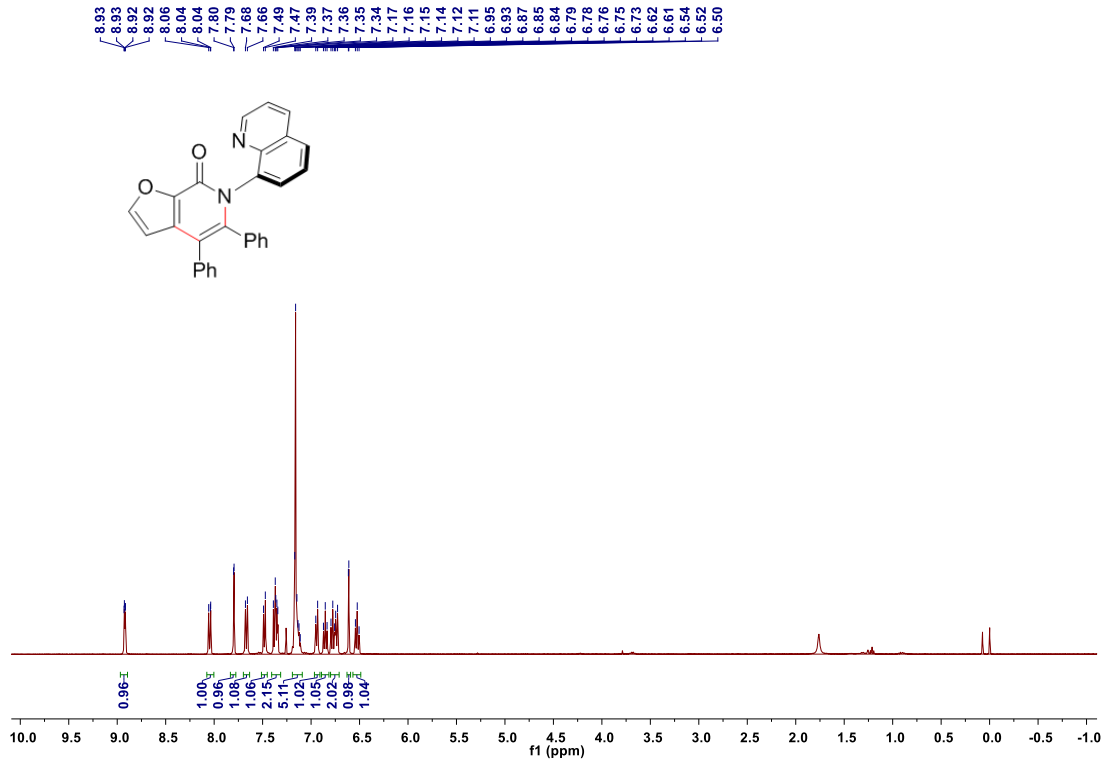
^{1}H NMR Spectrum of **3pa**



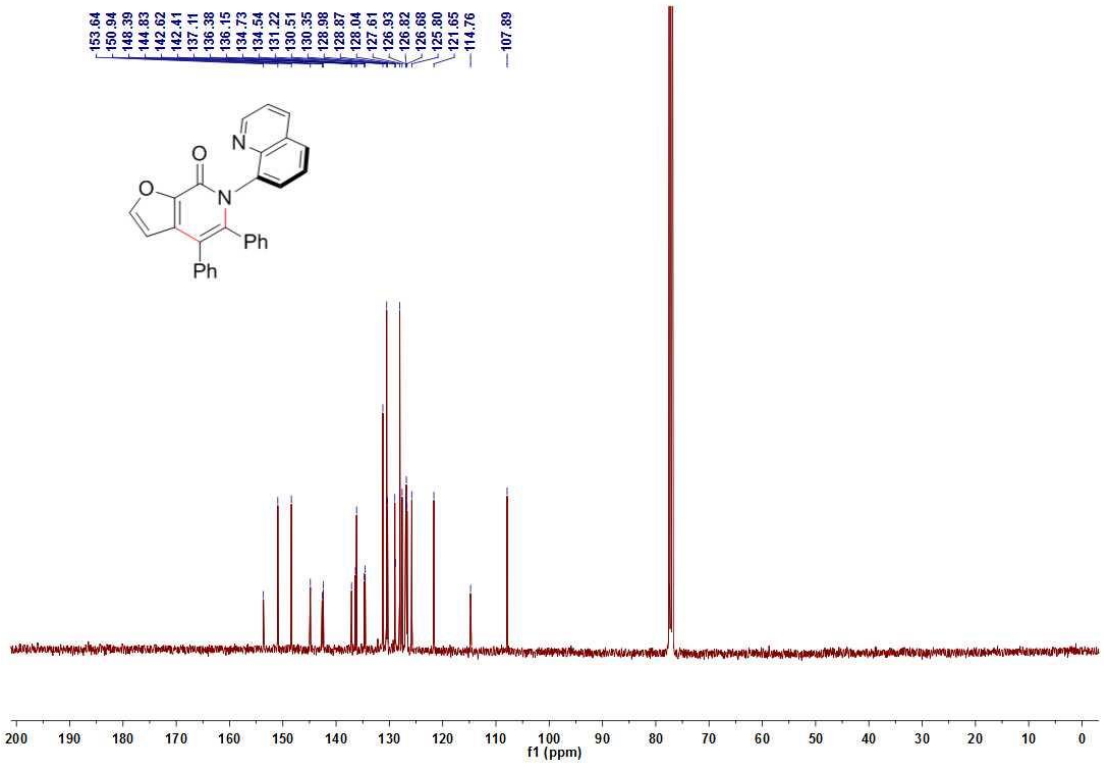
^{13}C NMR Spectrum of **3pa**



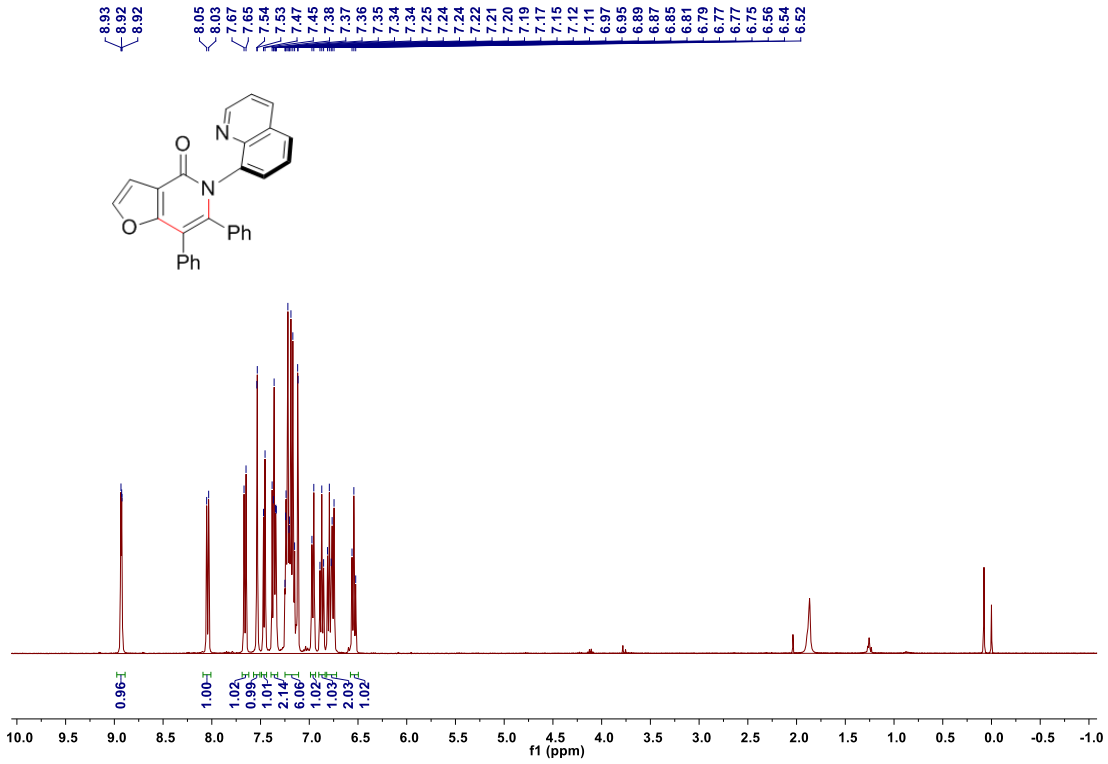
^{1}H NMR Spectrum of **3qa**



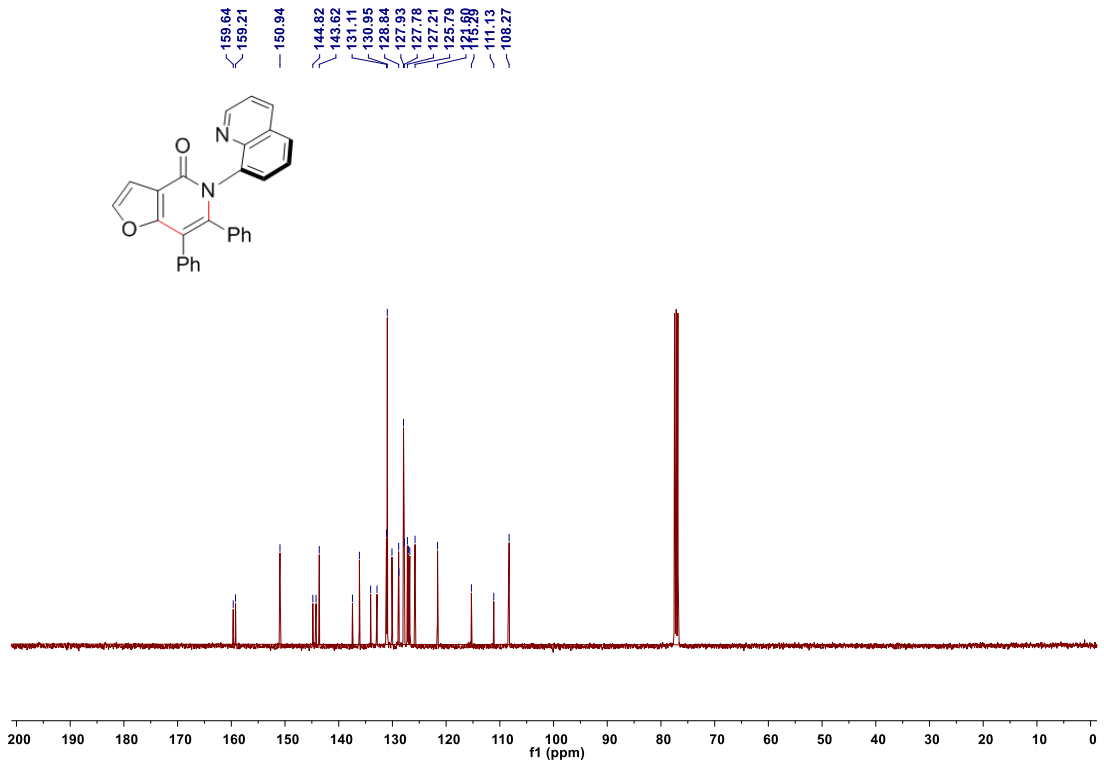
^{13}C NMR Spectrum of **3qa**



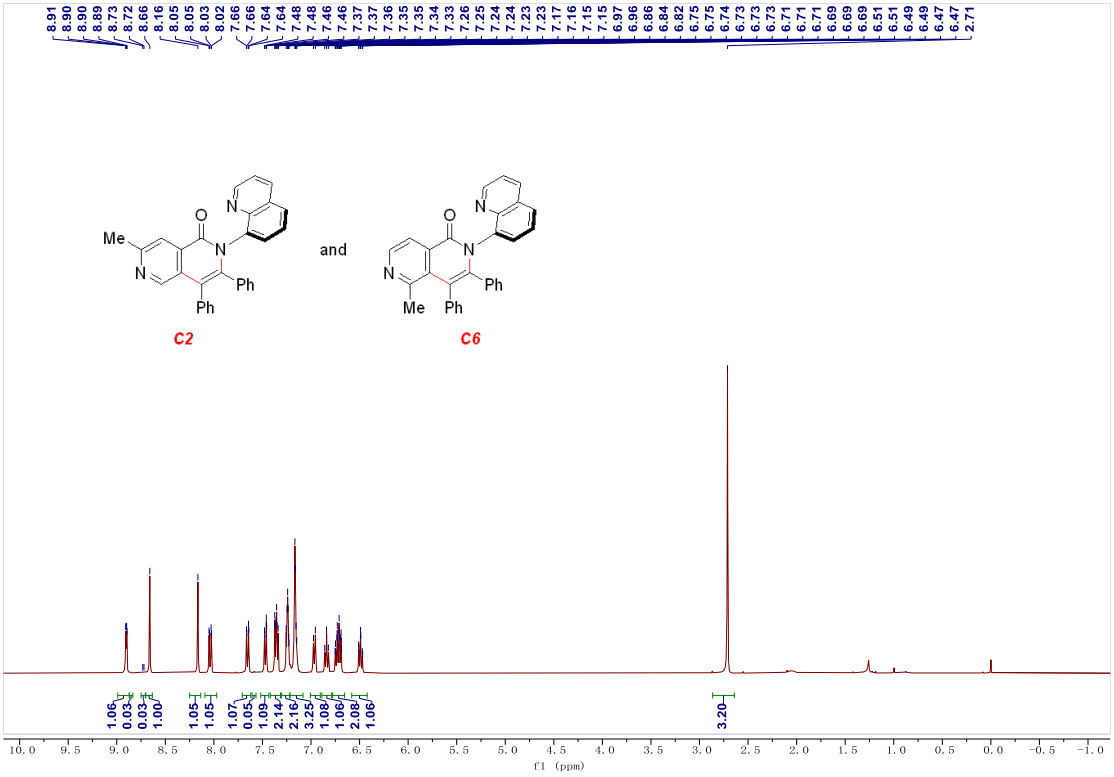
^{1}H NMR Spectrum of **3ra**



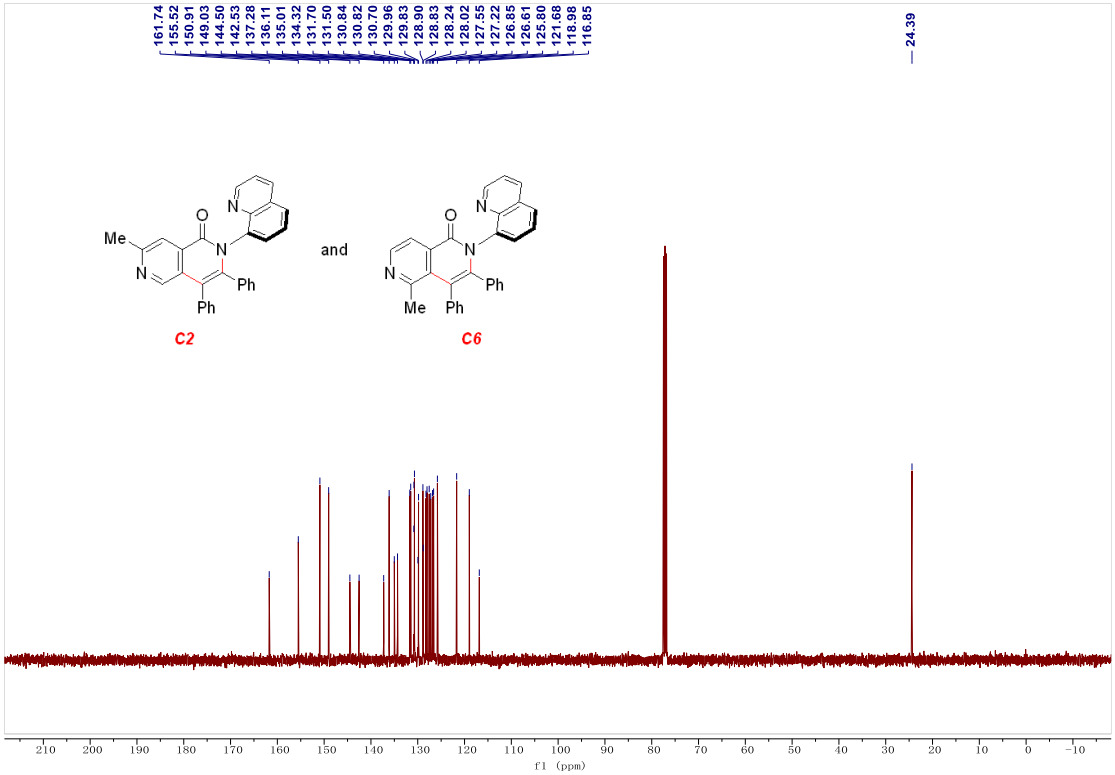
^{13}C NMR Spectrum of **3ra**



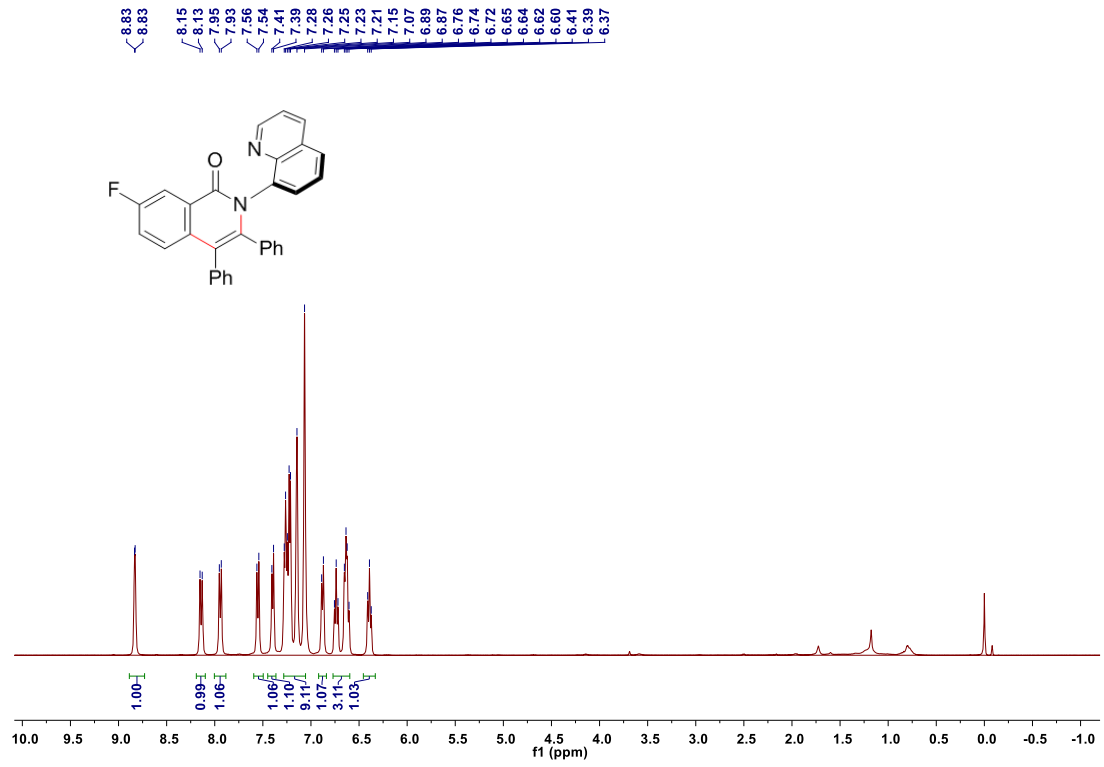
^{1}H NMR Spectrum of **3sa**



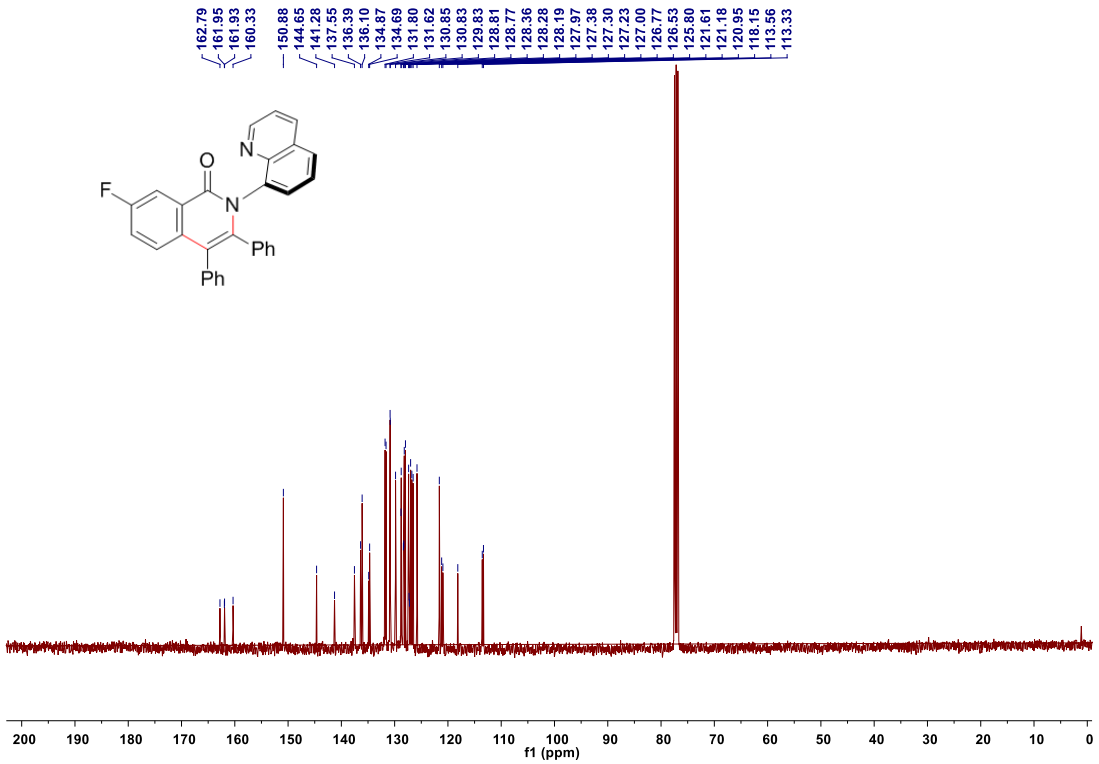
^{13}C NMR Spectrum of **3sa**



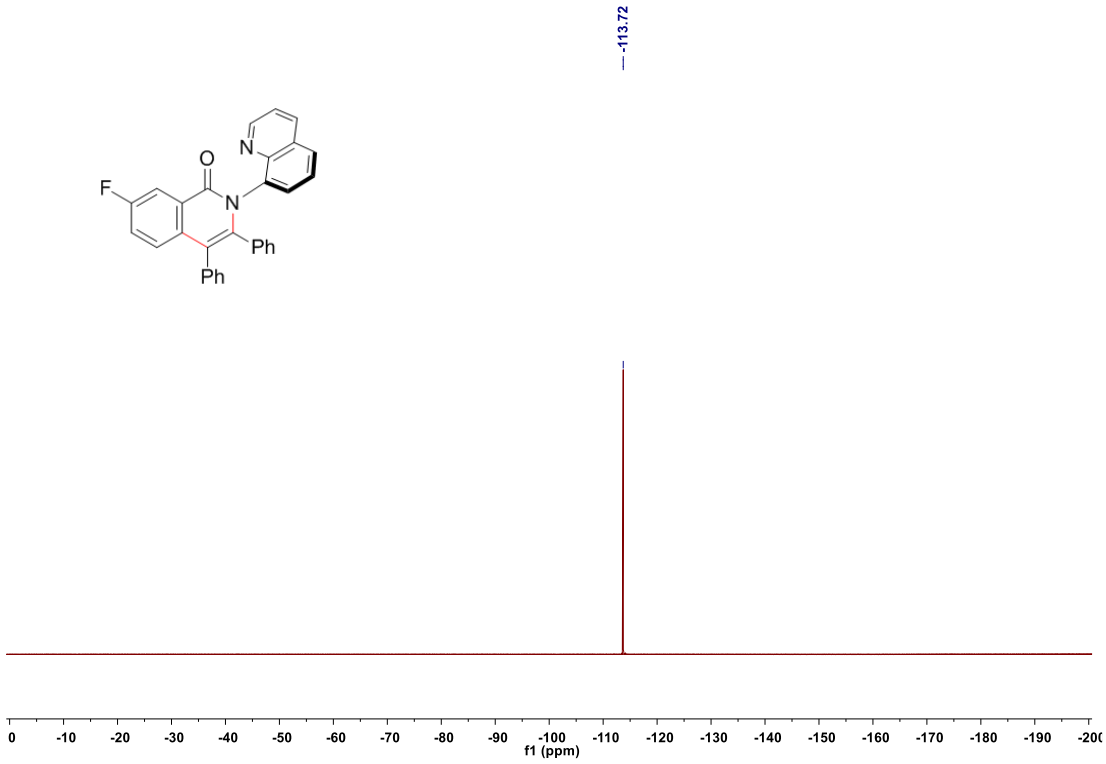
^{1}H NMR Spectrum of **3ta-*C2***



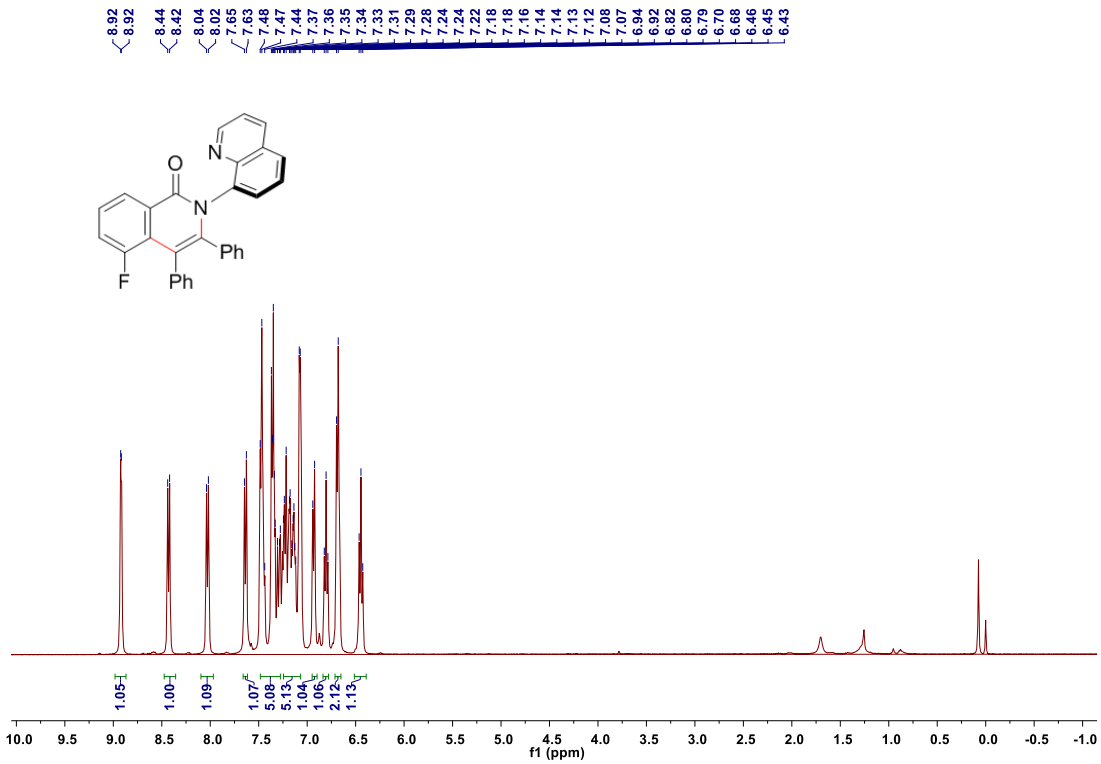
^{13}C NMR Spectrum of **3ta-*C2***



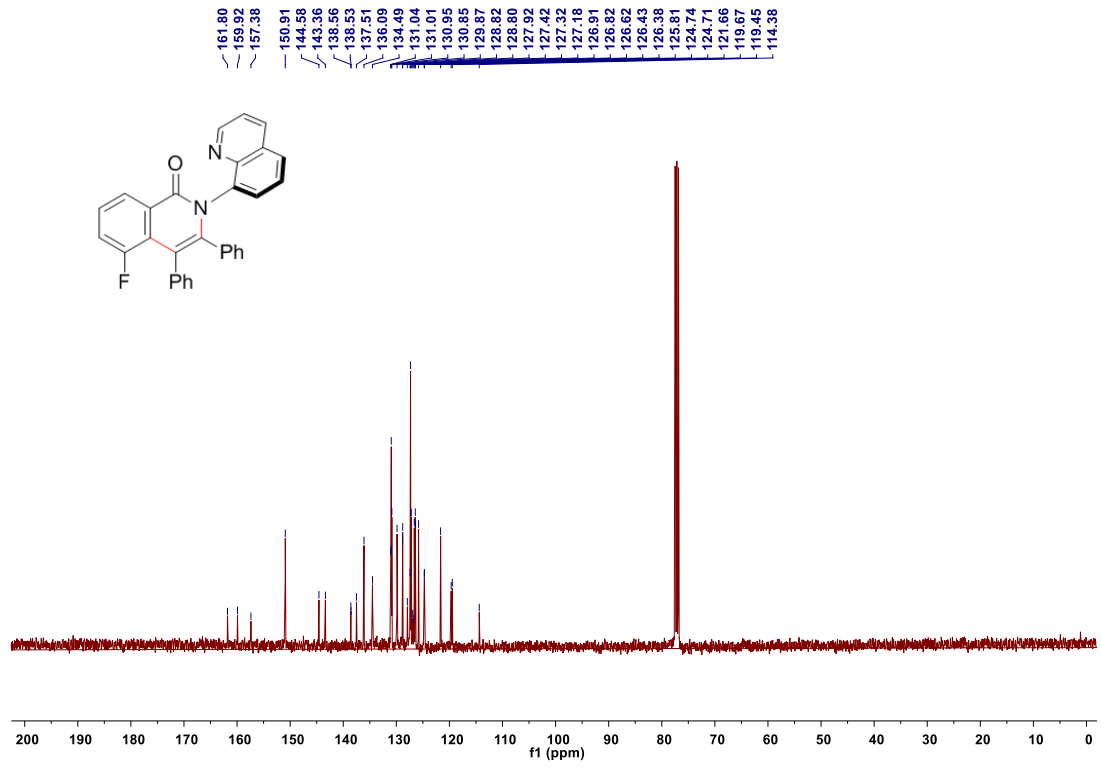
^{19}F NMR Spectrum of **3ta-*C2***



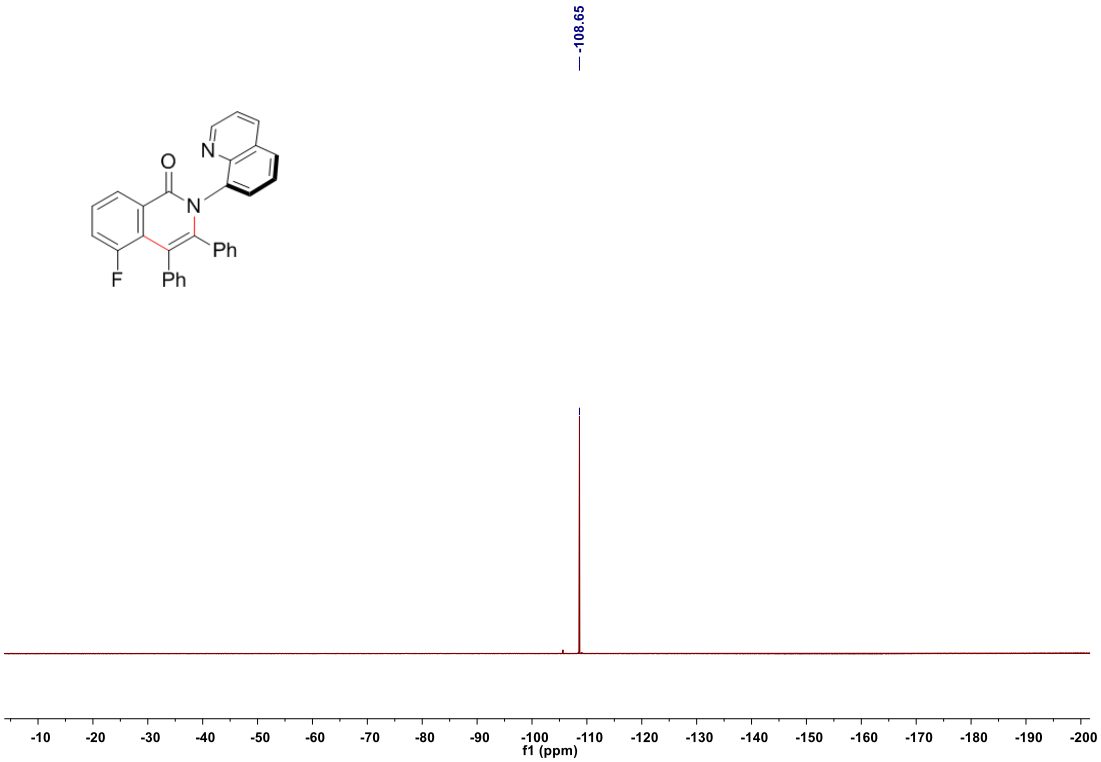
^{1}H NMR Spectrum of **3ta-*C6***



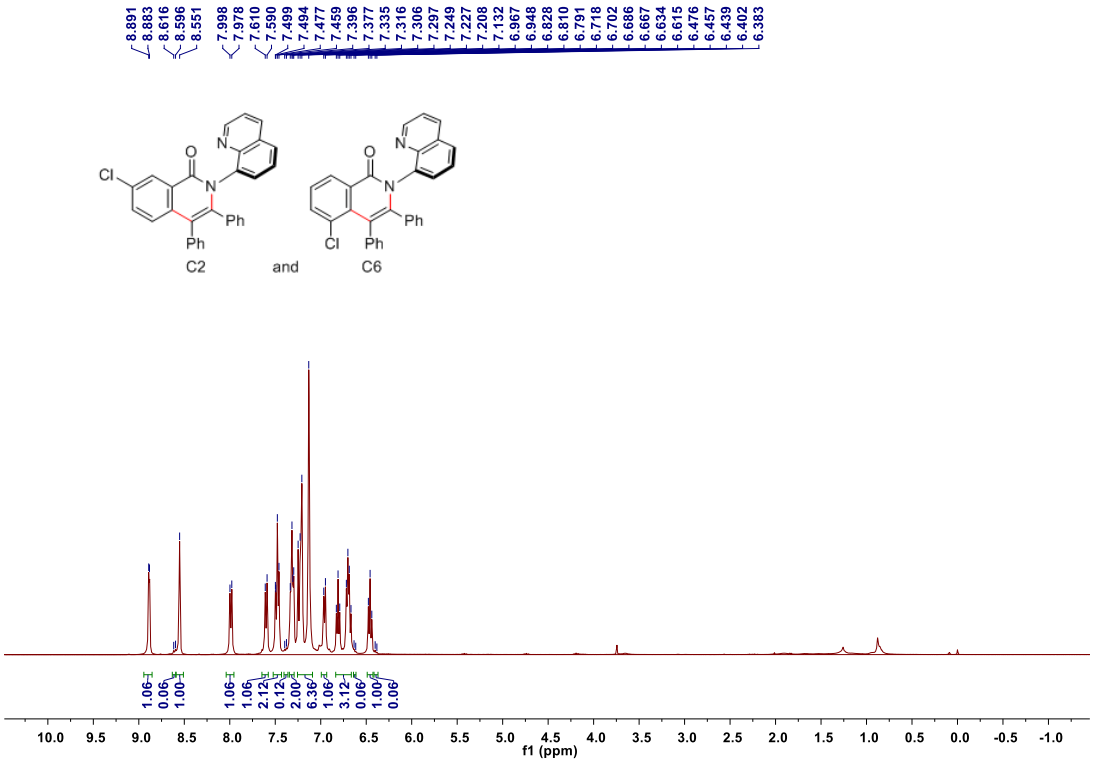
^{13}C NMR Spectrum of **3ta-*C6***



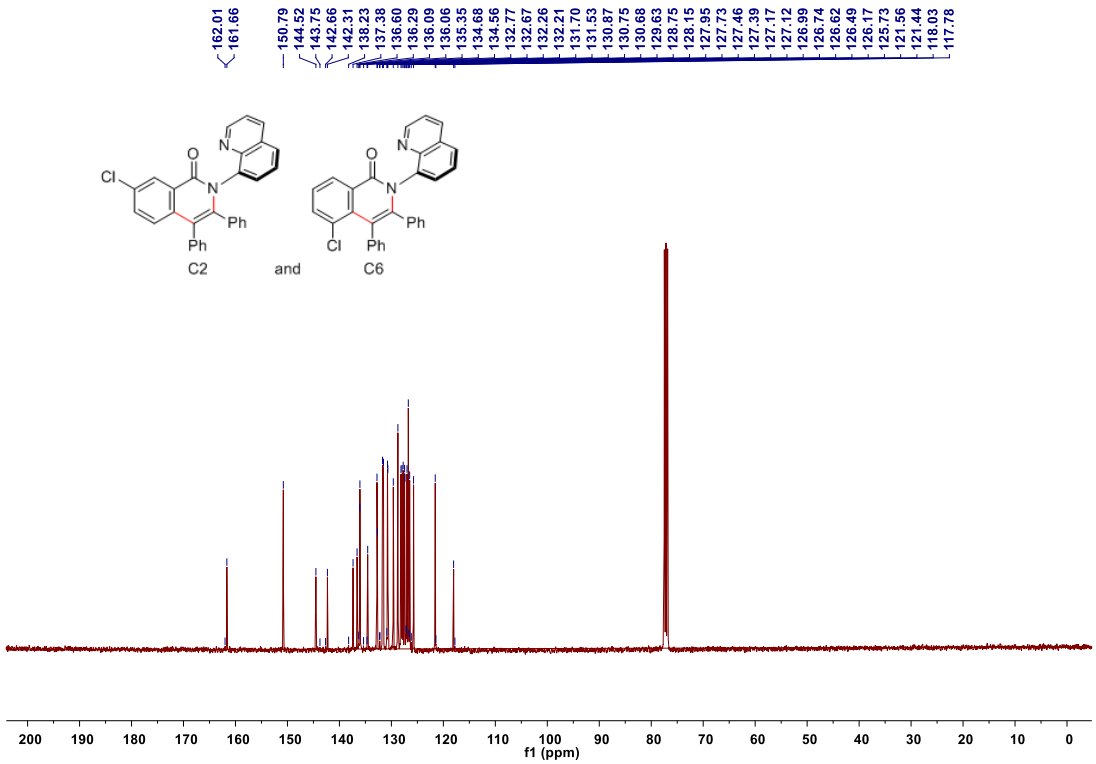
^{19}F NMR Spectrum of **3ta-*C6***



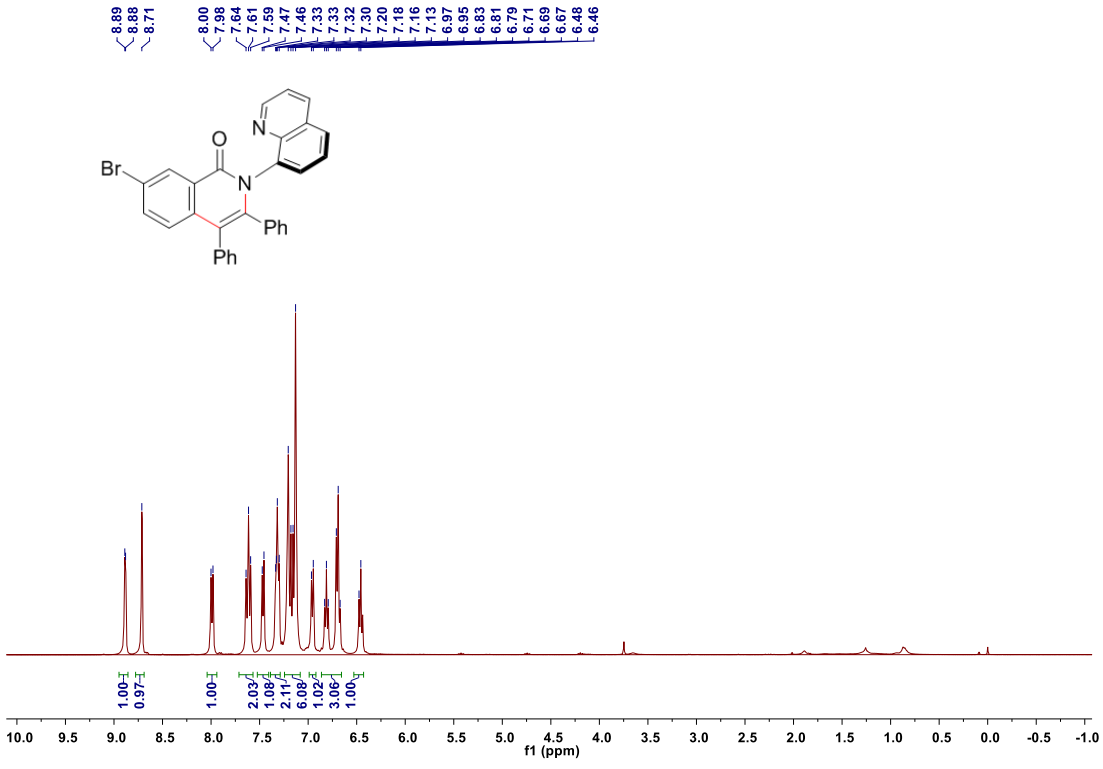
^{1}H NMR Spectrum of **3ua**



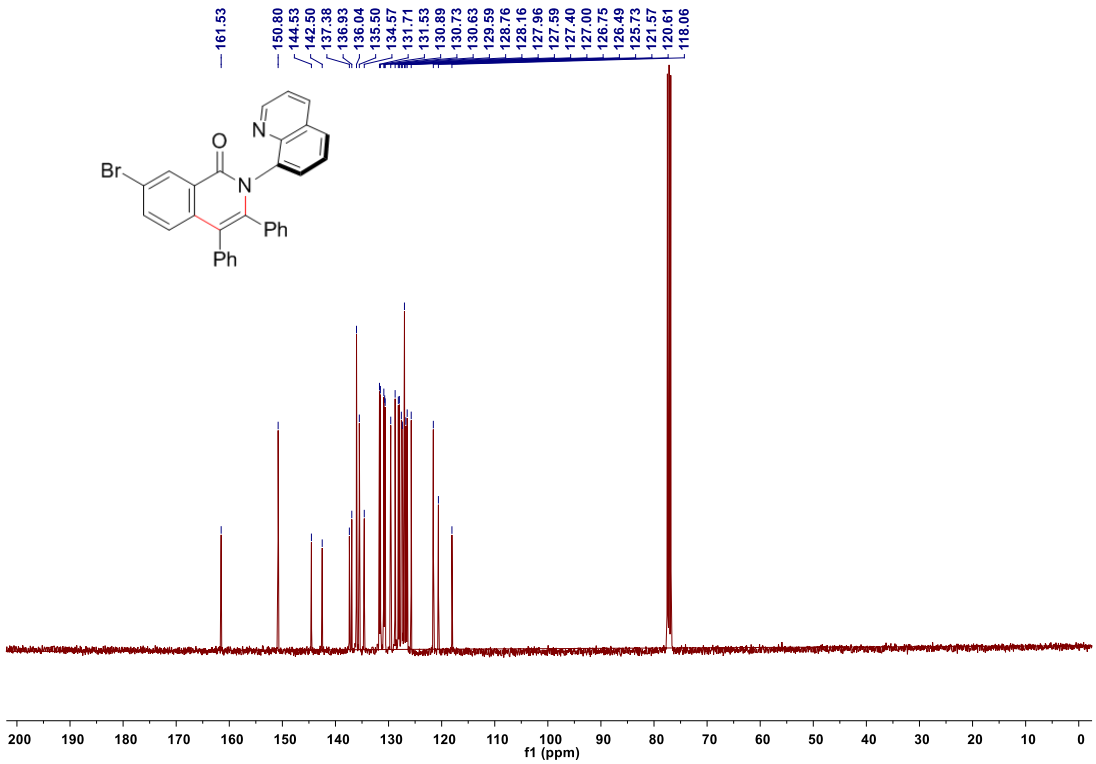
^{13}C NMR Spectrum of **3ua**



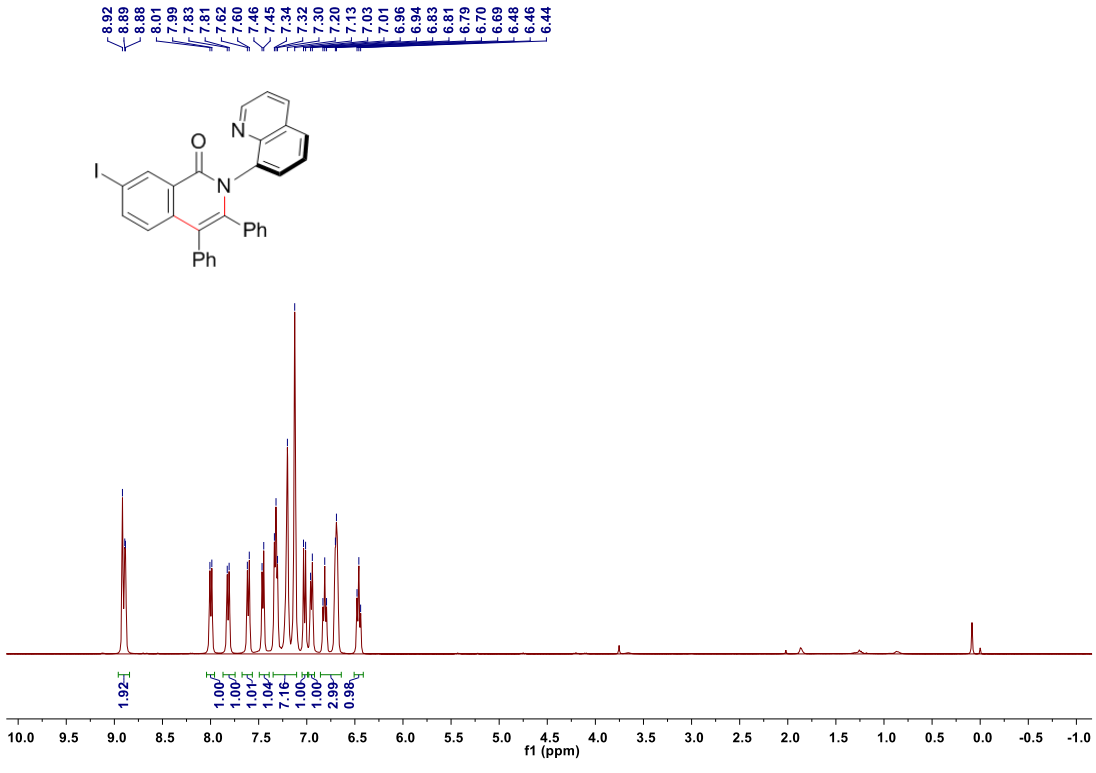
^{1}H NMR Spectrum of **3va**



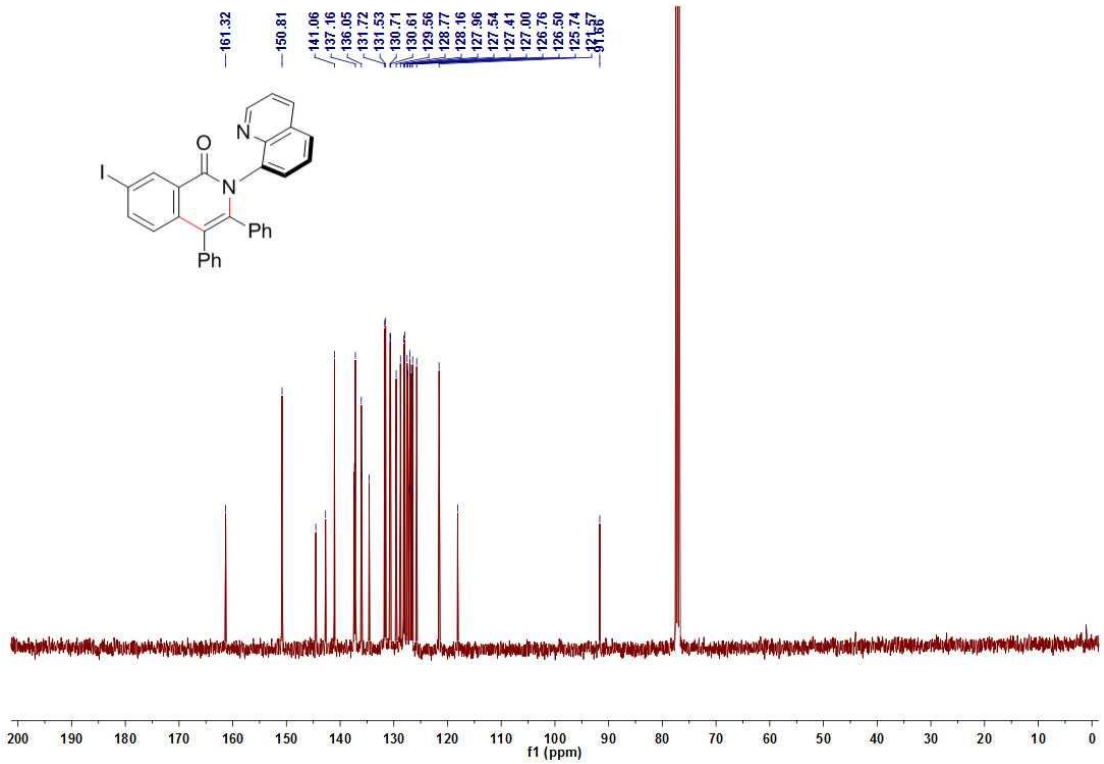
^{13}C NMR Spectrum of **3va**



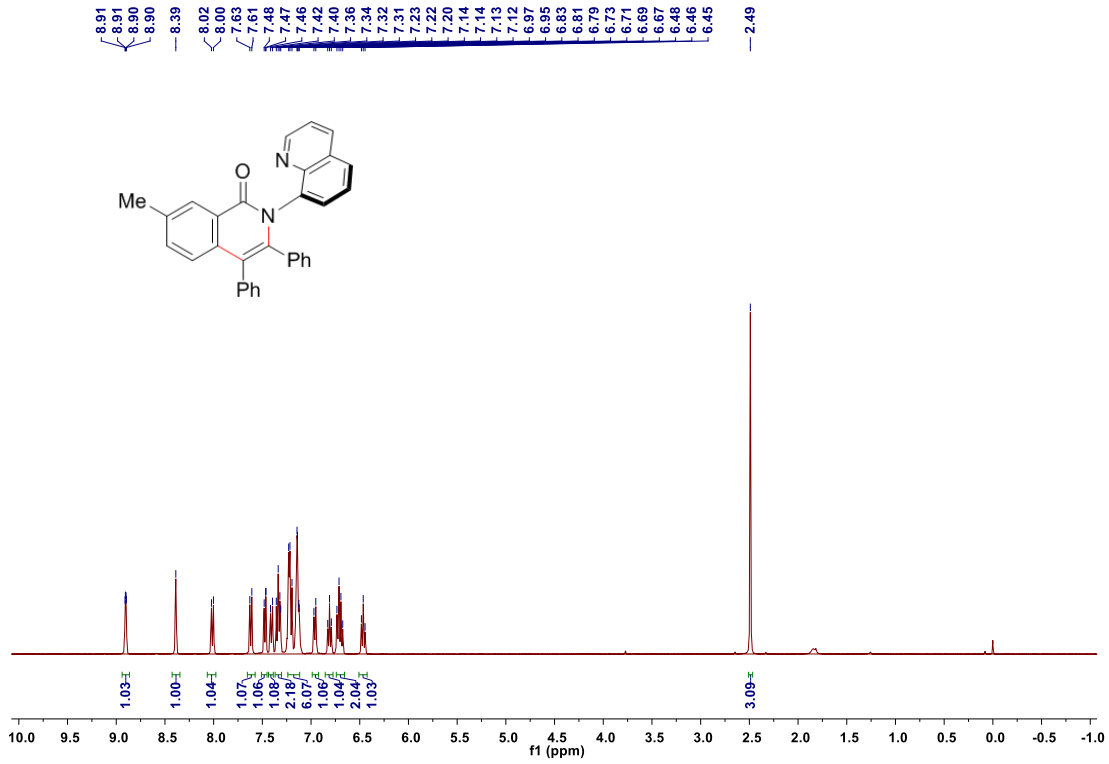
^{1}H NMR Spectrum of **3wa**



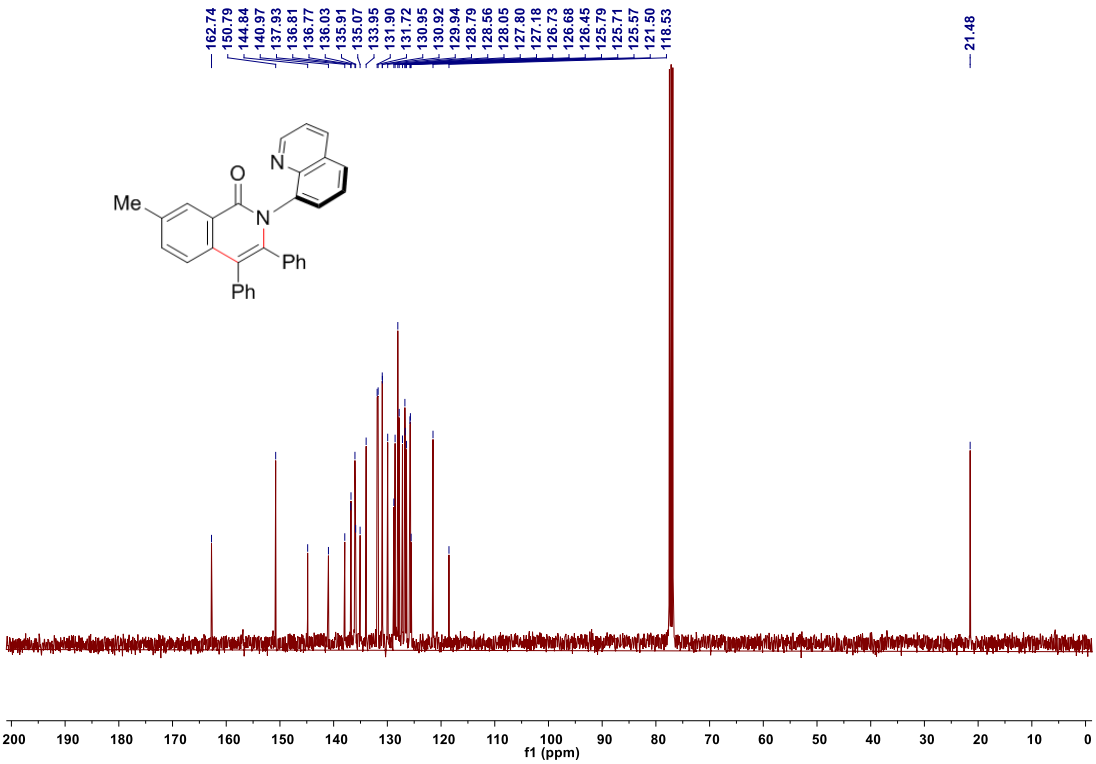
^{13}C NMR Spectrum of **3wa**



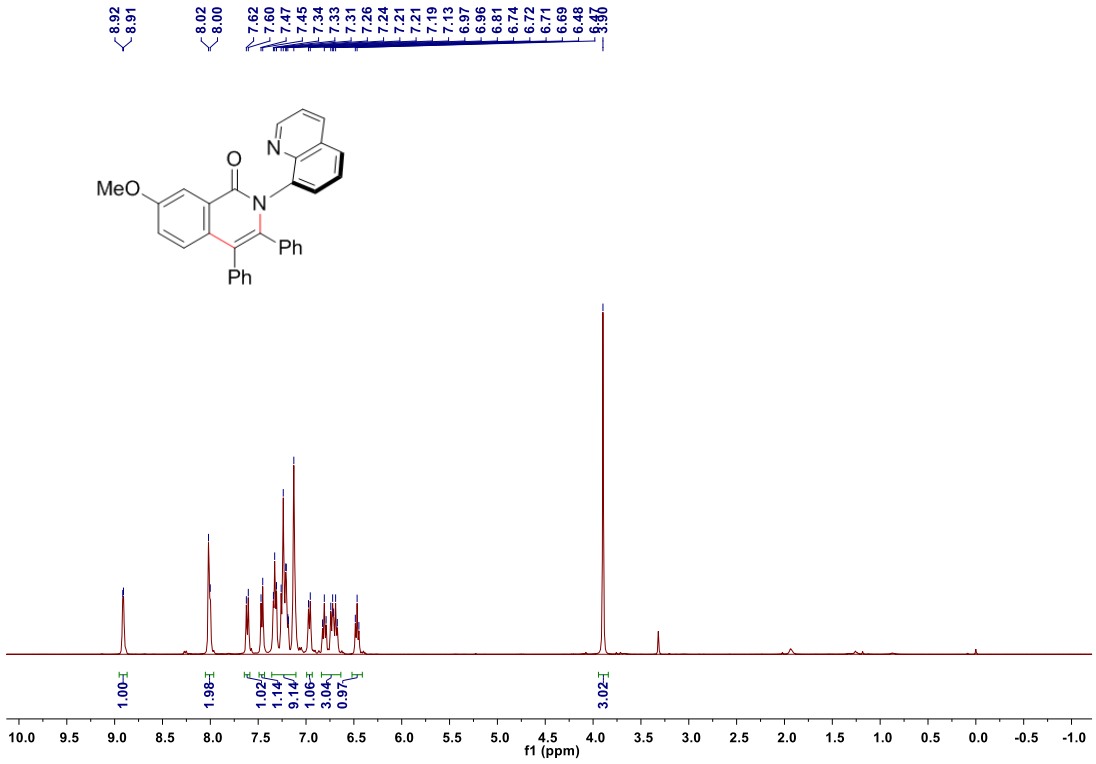
^{1}H NMR Spectrum of **3xa**



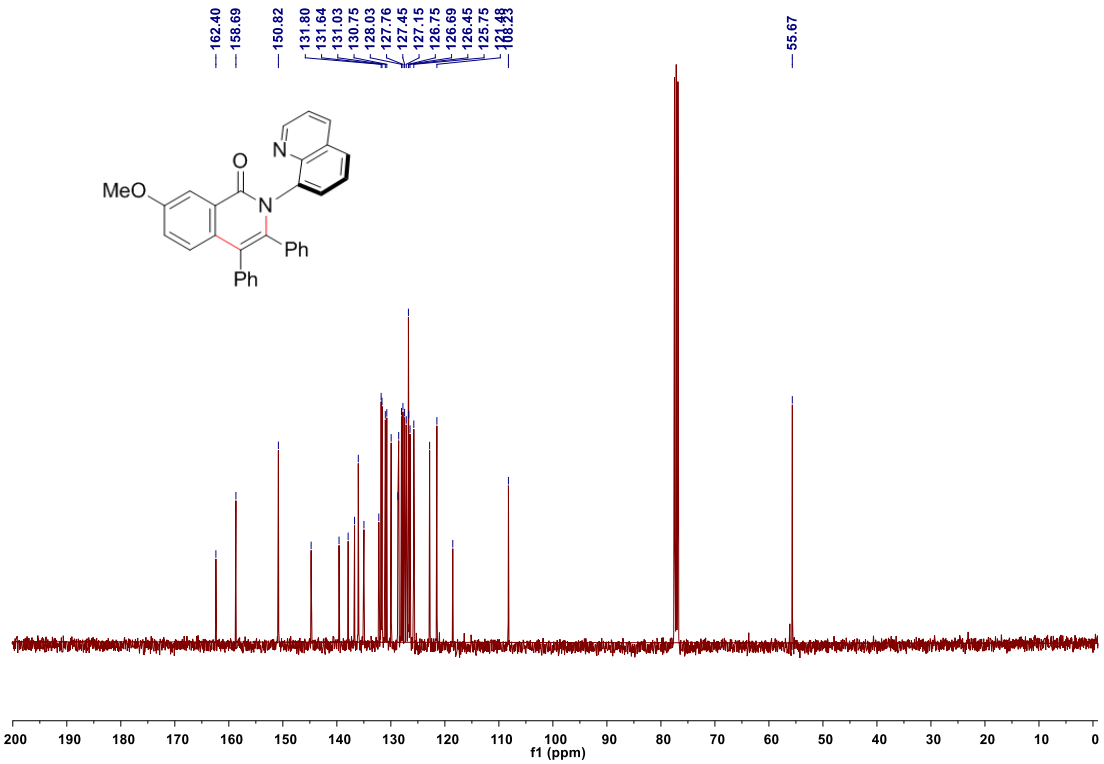
^{13}C NMR Spectrum of **3xa**



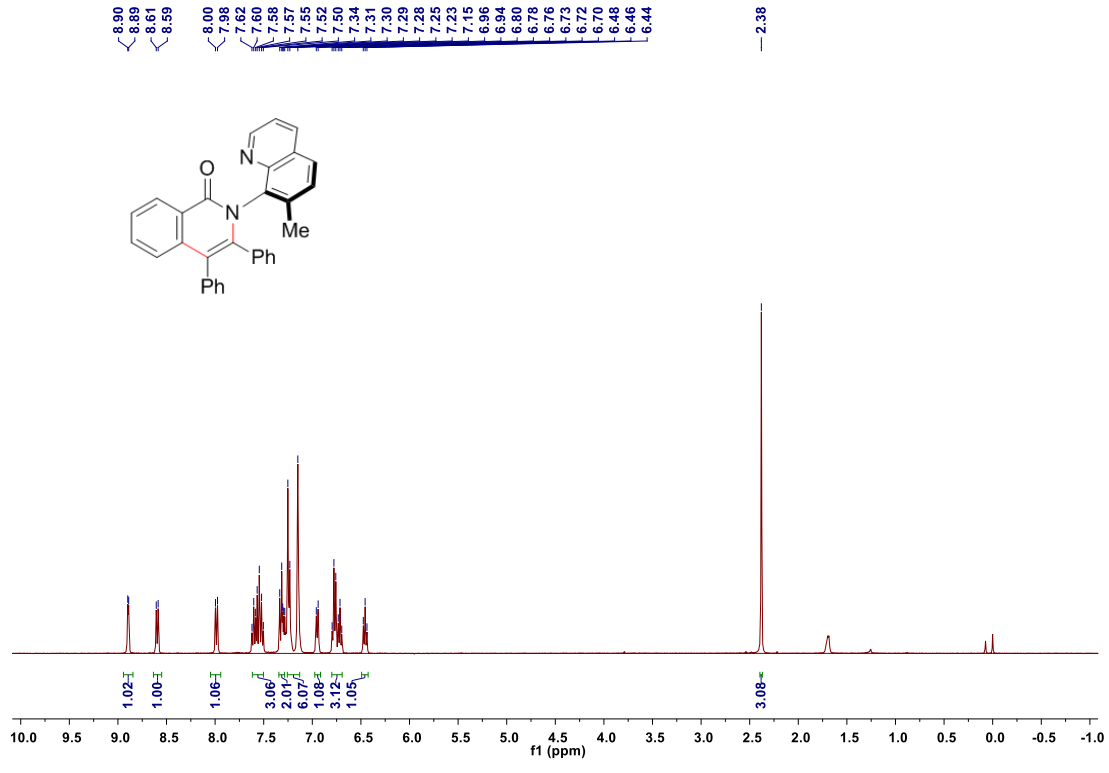
^{1}H NMR Spectrum of **3ya**



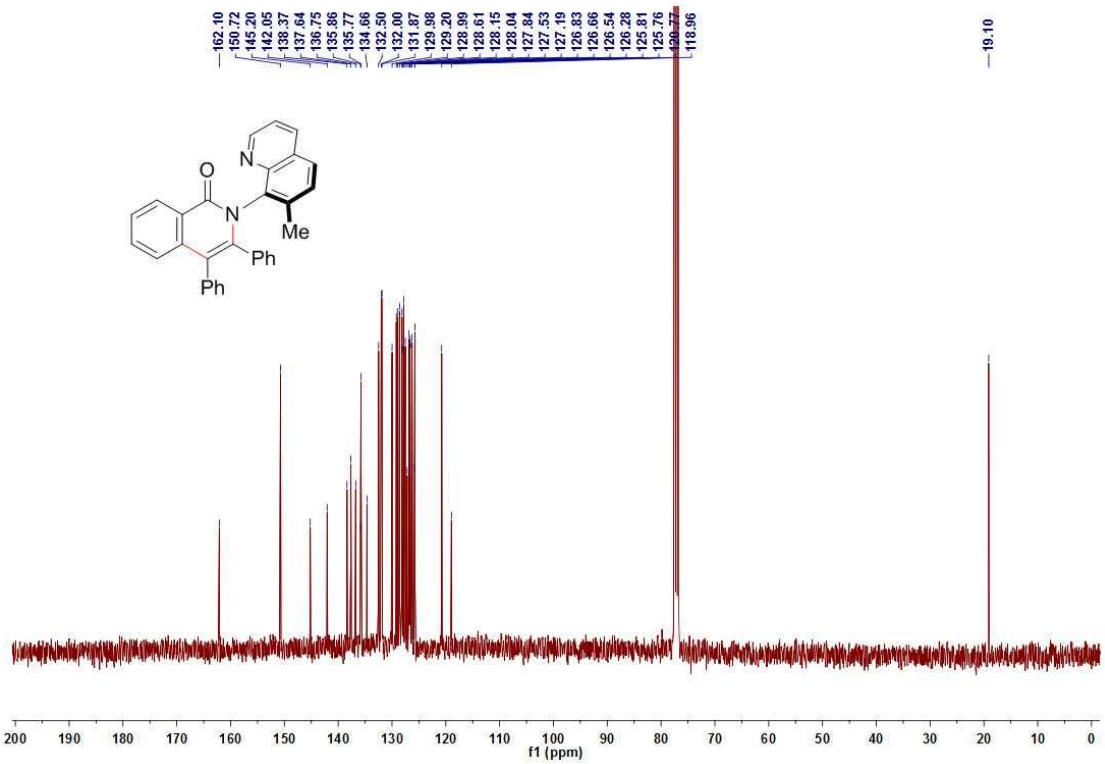
^{13}C NMR Spectrum of **3ya**



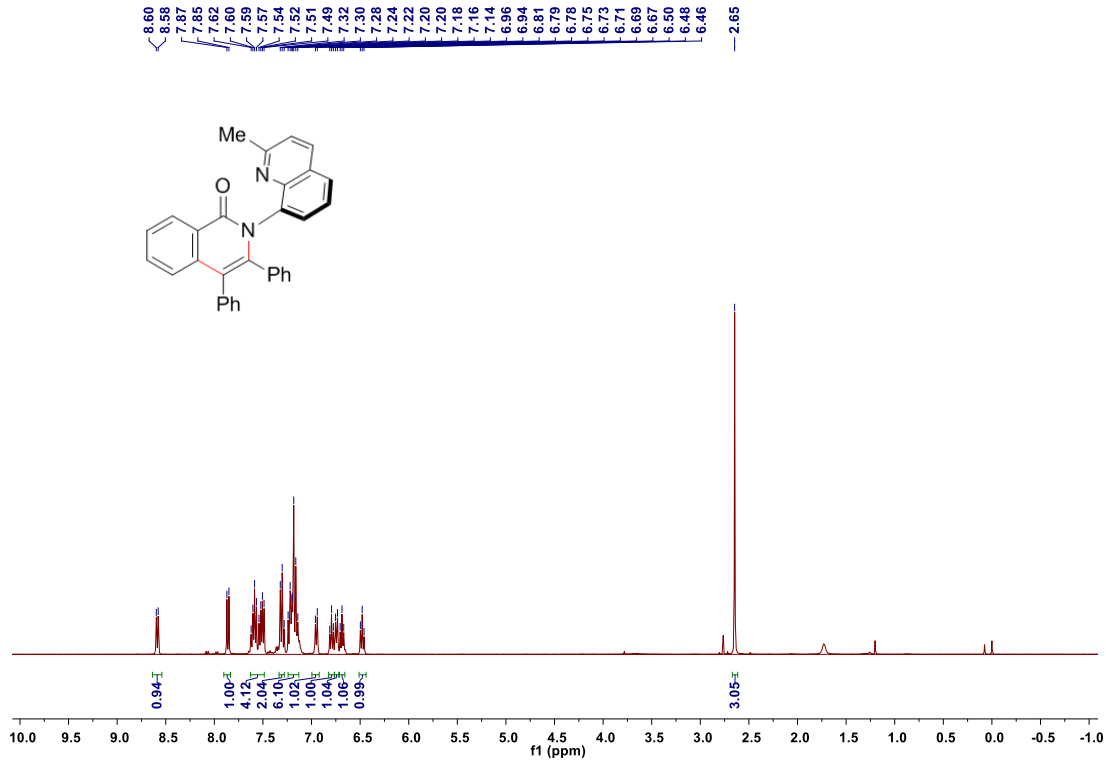
^{1}H NMR Spectrum of **3za**



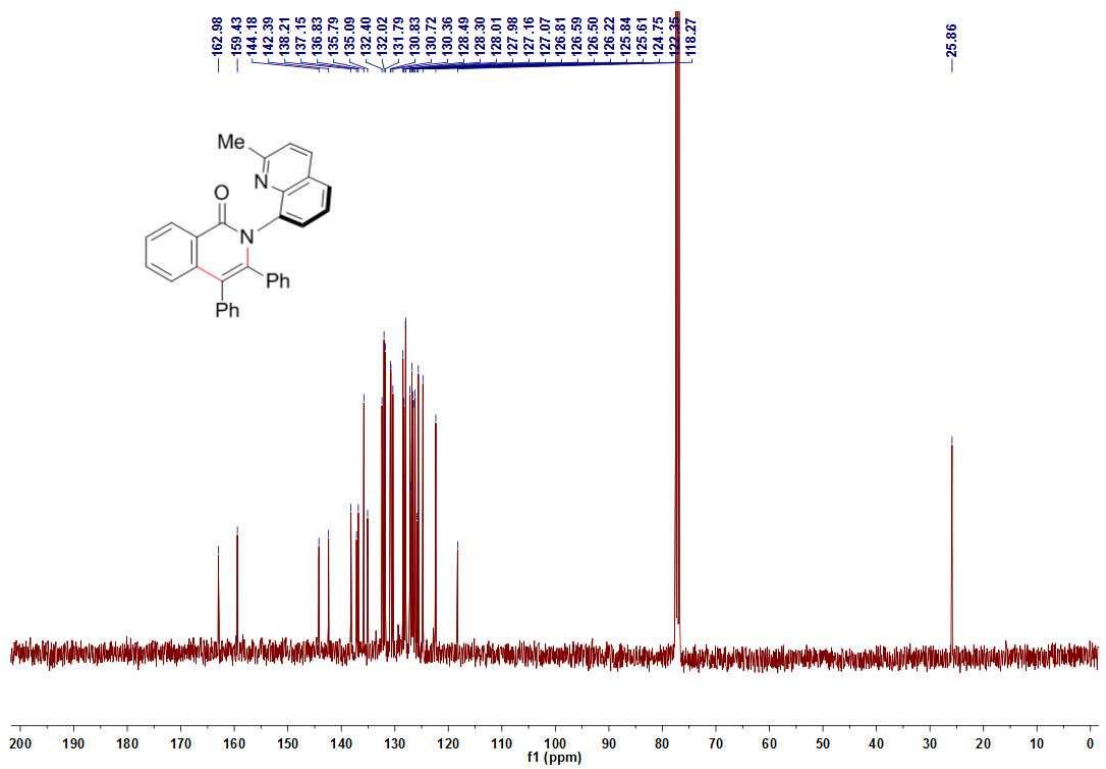
^{13}C NMR Spectrum of **3za**



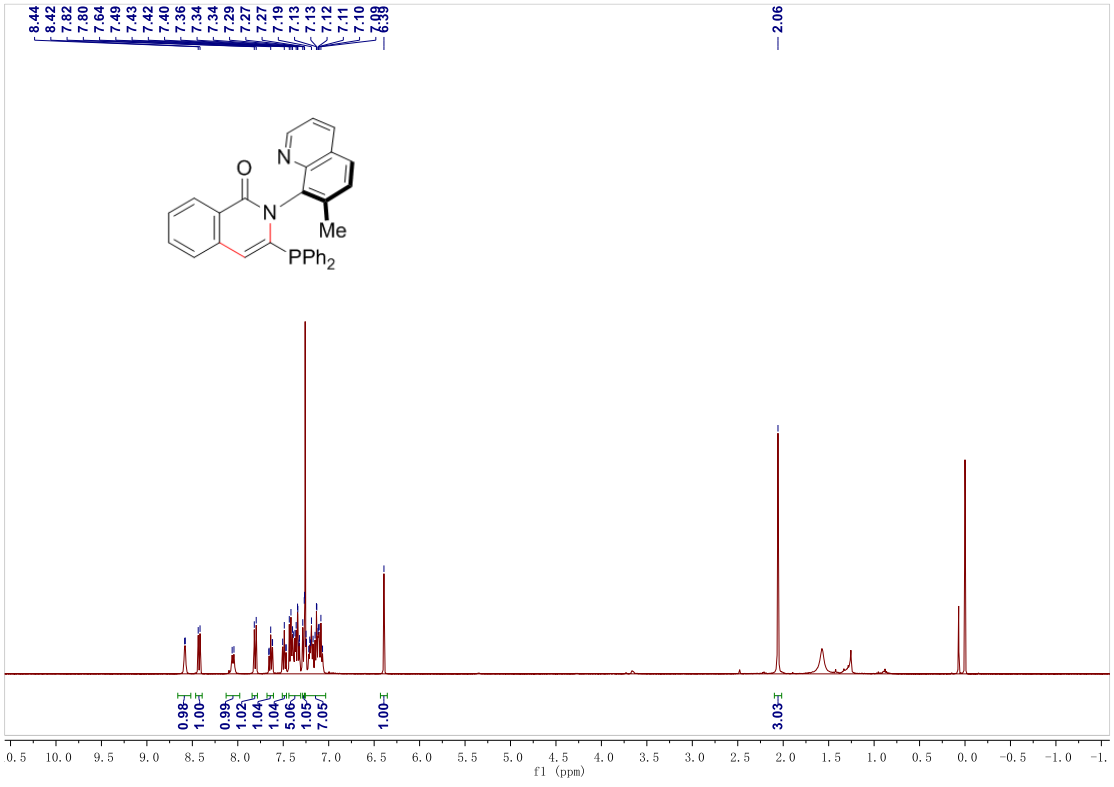
^{1}H NMR Spectrum of **3aaa**



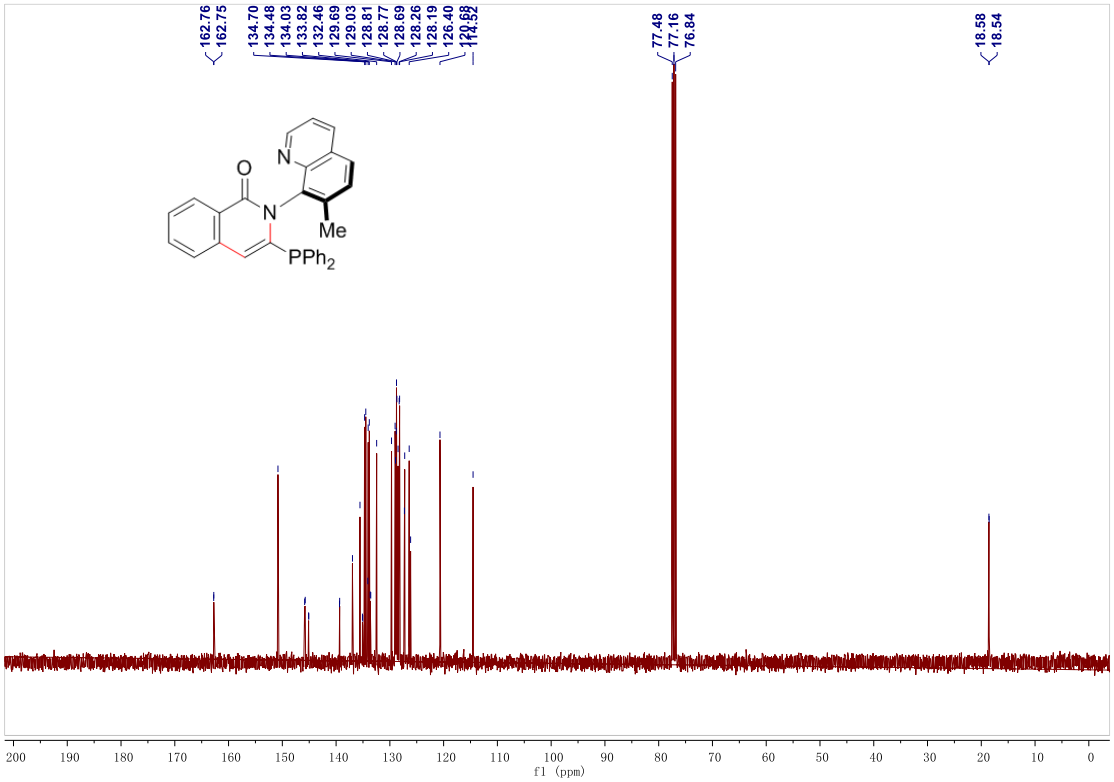
^{13}C NMR Spectrum of **3aaa**



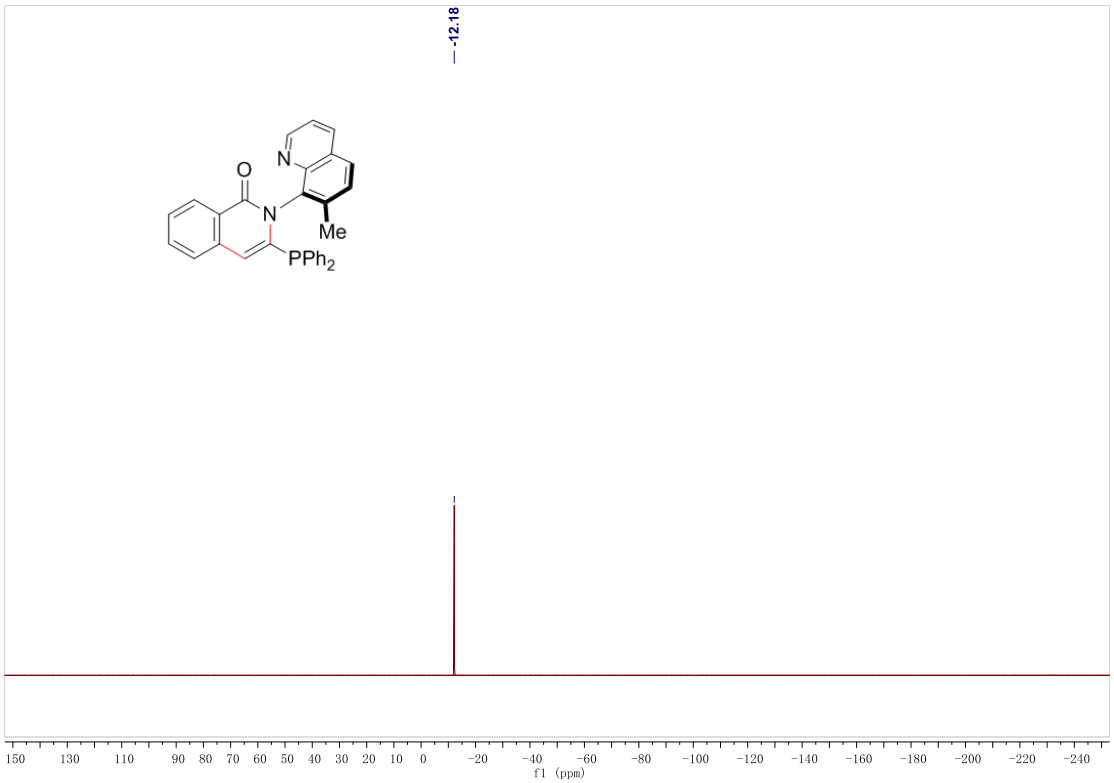
^{1}H NMR Spectrum of **4**



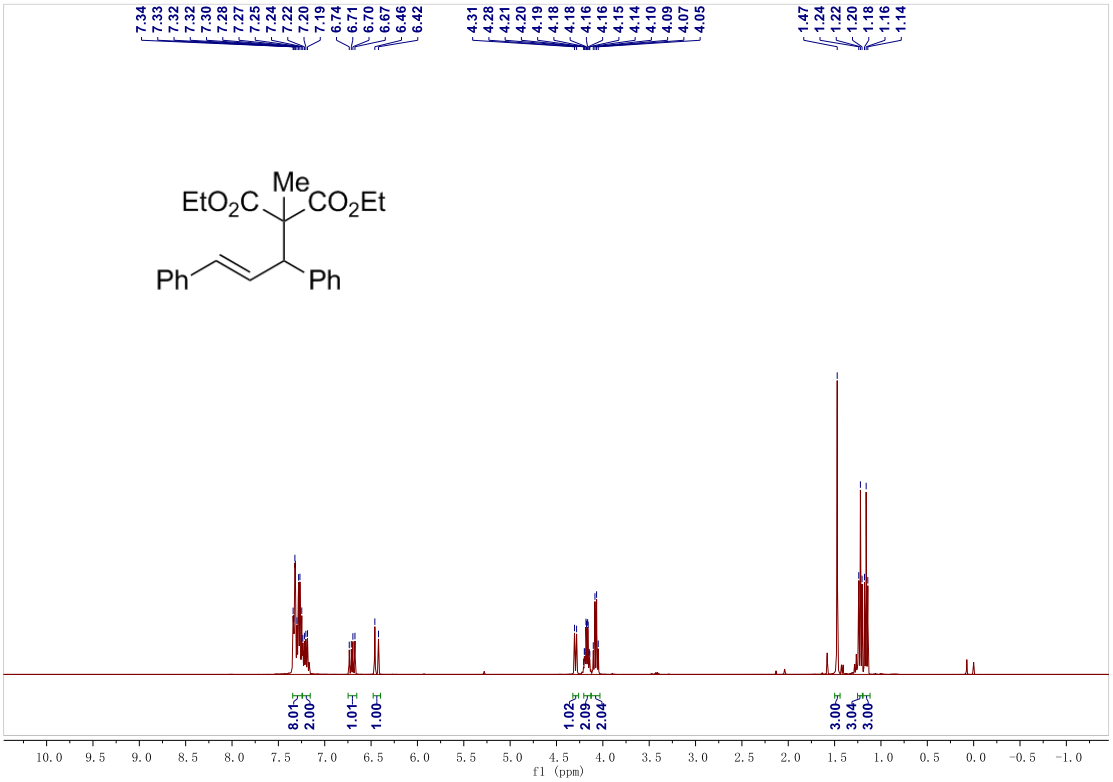
^{13}C NMR Spectrum of **4**



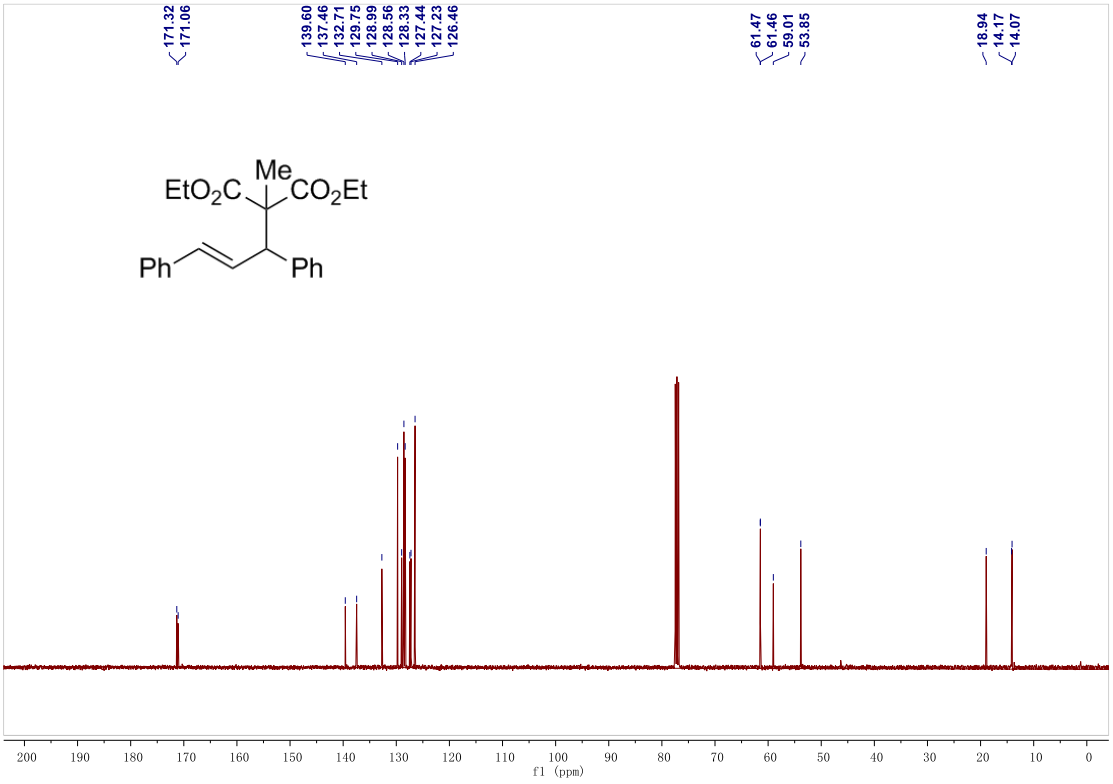
^{19}C NMR Spectrum of **4**



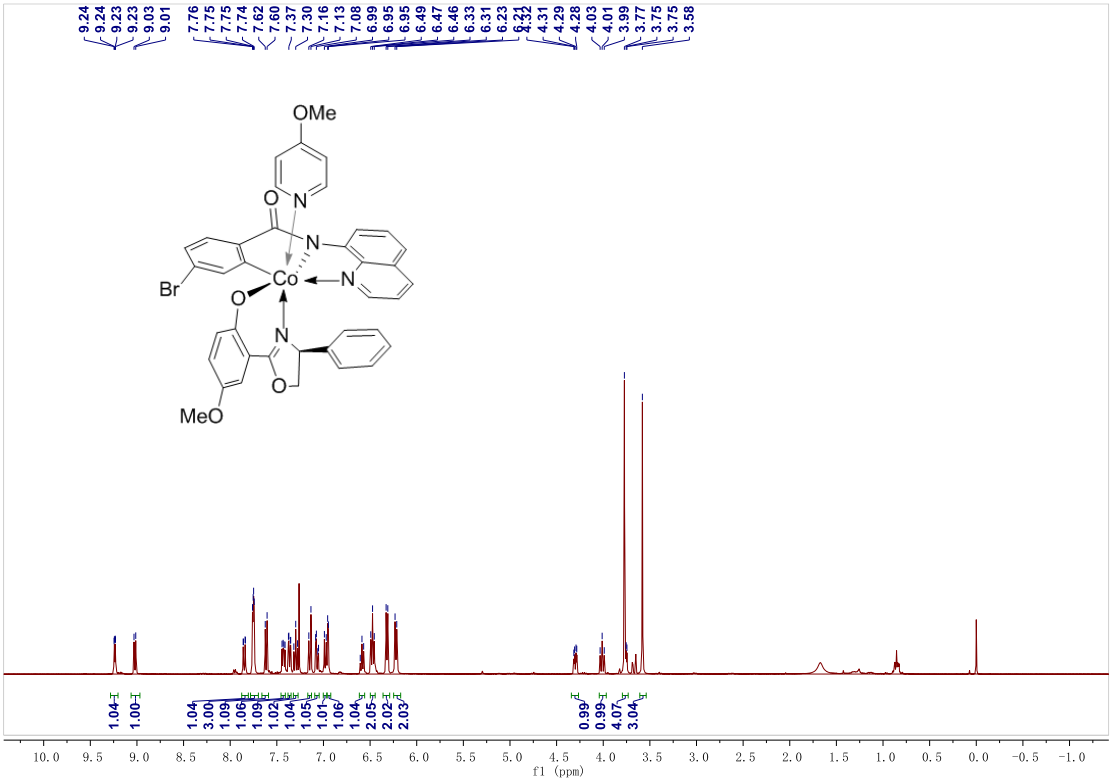
^{1}H NMR Spectrum of **7**



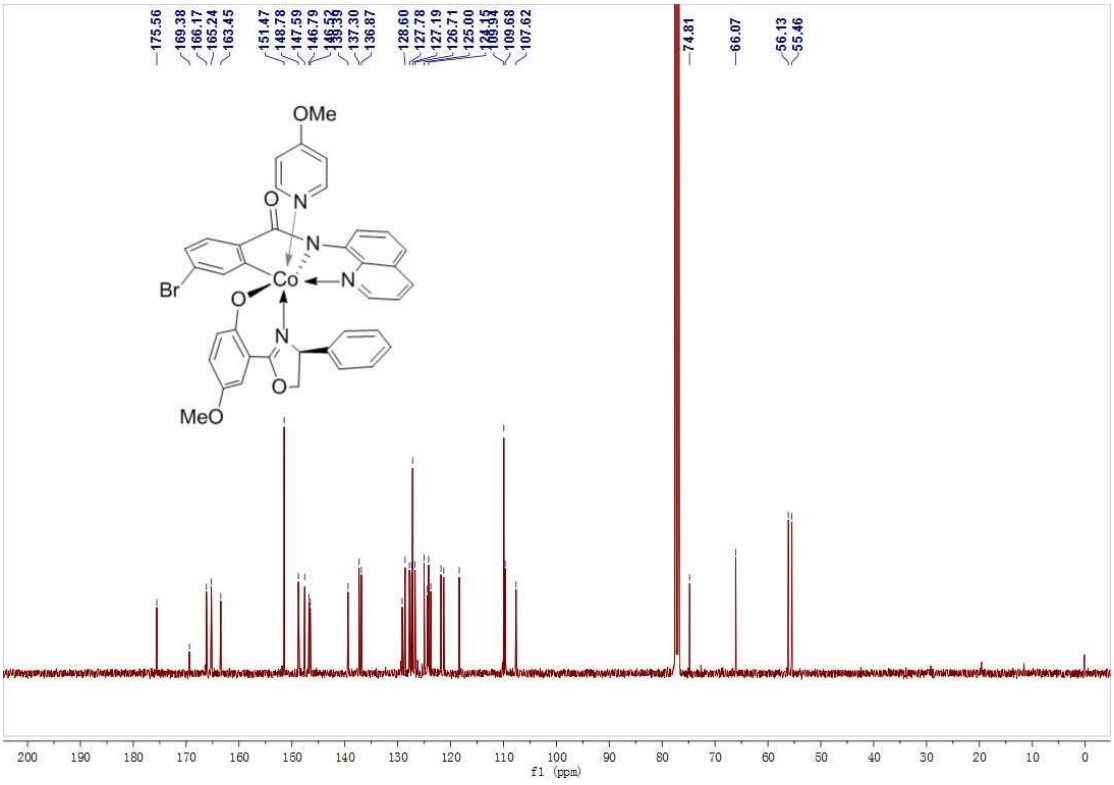
^{13}C NMR Spectrum of **7**



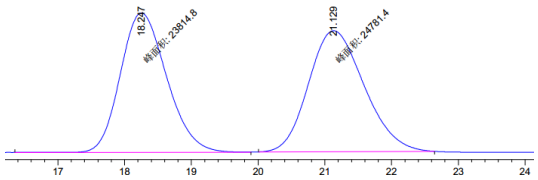
^{1}H NMR Spectrum of **[Co]-1**

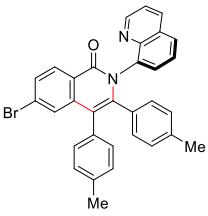


^{13}C NMR Spectrum of **[Co]-1**



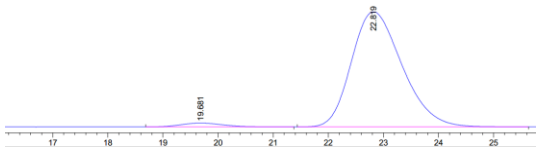
9. Copies of HPLC Spectra

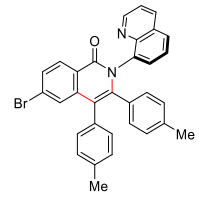




***Rac*-3ab**

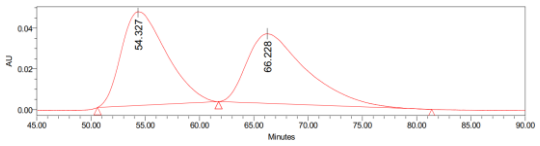
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	18.247	MM	0.8048	2.38148e4	493.19608	49.0055
2	21.129	MM	0.9654	2.47814e4	427.83908	50.9945

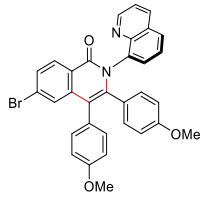




3ab

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	19.681	BB	0.6985	815.39612	15.33174	2.7084
2	22.819	BB	0.9802	2.92911e4	459.17862	97.2916

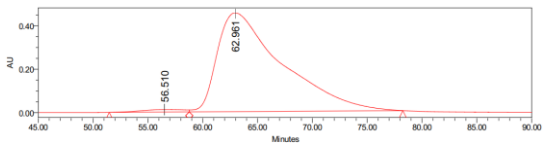


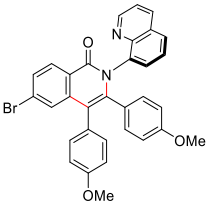


***Rac*-3ac**

Peak Results

	Name	RT	Area	Height	Amount	Units	% Area
1		54.327	13265226	45977			50.45
2		66.228	13028799	34142			49.55

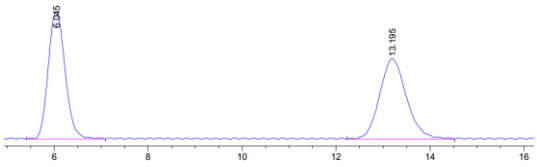


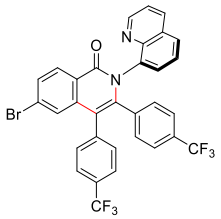


3ac

Peak Results

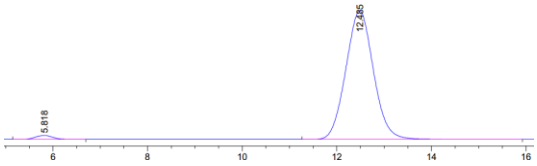
	Name	RT	Area	Height	Amount	Units	% Area
1		56.510	3013896	11449			1.59
2		62.961	186743361	455499			98.41

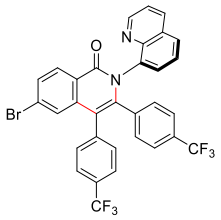




***Rac*-3ad**

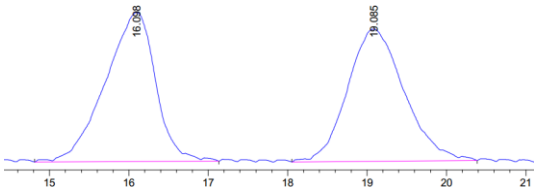
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	6.045	VV R	0.3952	1.77591e4	704.95428	49.9638
2	13.195	VV R	0.5183	1.77849e4	444.44052	50.0362

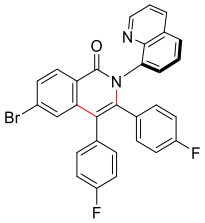




3ad

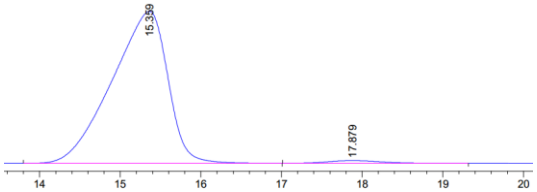
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	5.818	BB	0.4067	933.51129	36.21332	1.8746
2	12.485	BB	0.6244	4.88640e4	1206.87207	98.1254

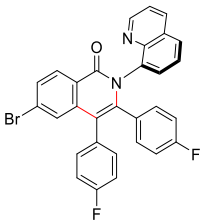




***Rac*-3ae**

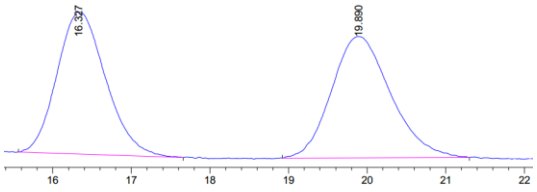
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	16.098	VV R	0.5722	1.85359e4	420.55746	50.0197
2	19.085	VV R	0.6371	1.85213e4	373.18677	49.9803

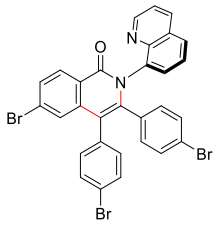




3ae

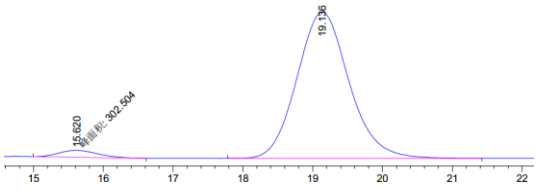
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	15.359	BB	0.7340	3.20145e4	664.55322	98.3021
2	17.879	BB	0.6954	552.97864	11.82943	1.6979

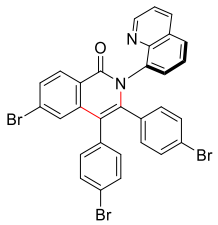




***Rac*-3af**

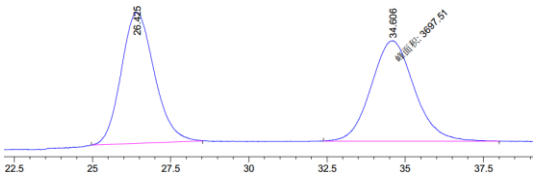
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	16.327	BB	0.5491	860.44141	19.95296	49.1550
2	19.890	BB	0.6314	890.02478	17.04029	50.8450

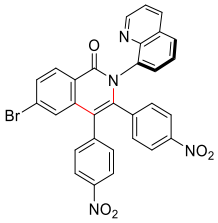




3af

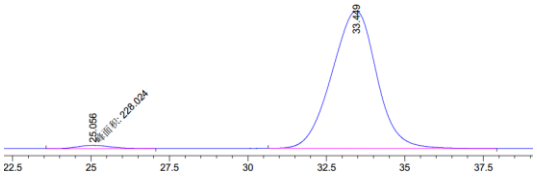
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	15.620	MM	0.6544	302.50357	7.70408	3.4688
2	19.136	BB	0.7964	8418.31543	161.96645	96.5312

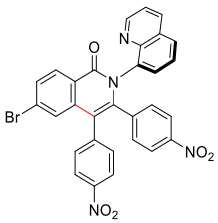




***Rac*-3ag**

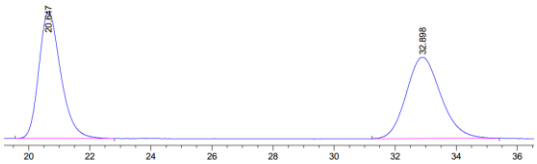
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	26.425	BB	0.8954	3706.46069	50.31774	50.0604
2	34.606	MM	1.5974	3697.51367	38.57820	49.9396

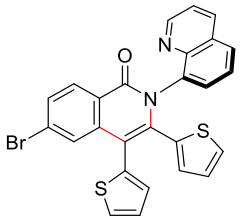




3ag

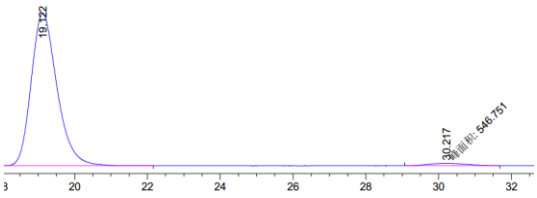
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	25.056	MM	1.2582	228.02400	3.02060	1.8086
2	33.449	BB	1.4798	1.23798e4	124.52622	98.1914

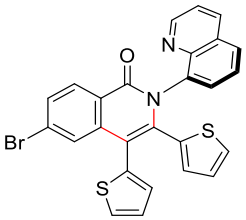




***Rac*-3ah**

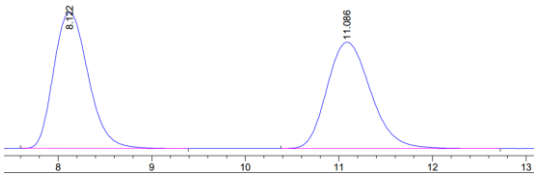
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	20.647	BB	0.7560	7634.36133	153.56555	49.6648
2	32.898	BB	0.9425	7737.41748	98.28225	50.3352

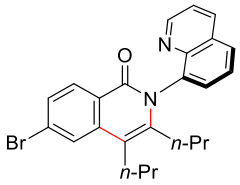




3ah

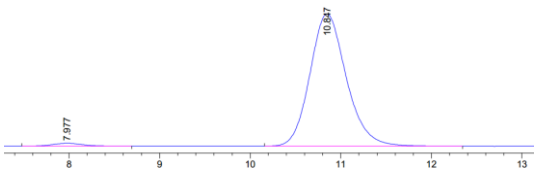
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	19.122	BB	0.7533	2.47551e4	503.73279	97.8391
2	30.217	MM	1.1677	546.75055	7.80394	2.1609

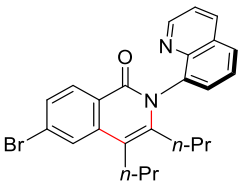




***Rac*-3ai**

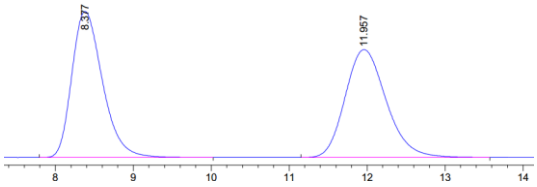
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	8.122	BB	0.4046	9270.40234	362.19122	50.1873
2	11.086	BB	0.5077	9201.22363	282.70105	49.8127

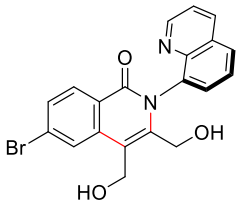




3ai

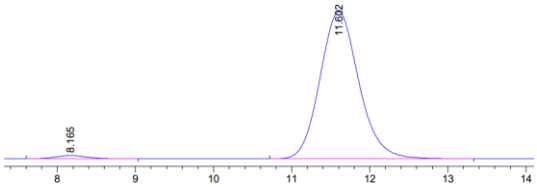
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	7.977	BB	0.3454	347.92865	14.95374	1.7800
2	10.847	BB	0.4256	1.91991e4	687.95673	98.2200

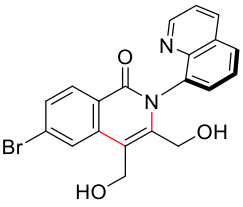




***Rac*-3aj**

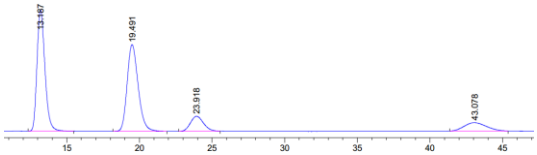
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	8.377	BB	0.4253	1.05188e4	384.33224	50.2688
2	11.957	BB	0.5718	1.04063e4	283.76089	49.7312

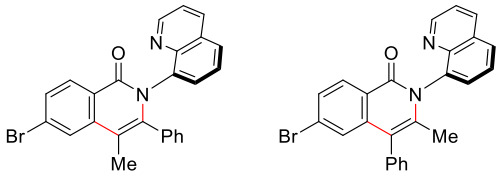




3aj

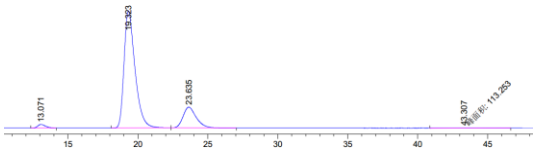
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	8.165	BB	0.3996	296.38284	10.49017	1.8073
2	11.602	BB	0.5245	1.61024e4	466.73746	98.1927

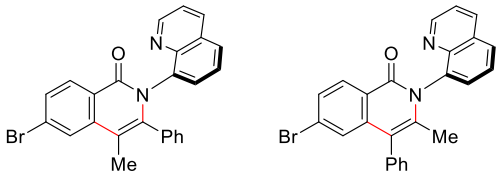




***Rac*-3ak-major and *Rac*-3ak-minor**

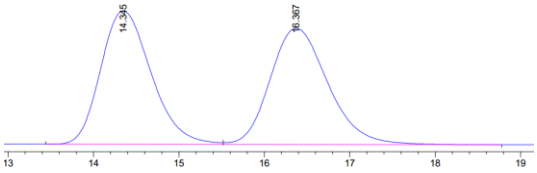
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	13.187	BB	0.5843	8507.71094	224.41943	41.8056
2	19.491	BB	0.8077	8457.98633	160.27213	41.5612
3	23.918	BB	0.7848	1737.39319	27.65944	8.5373
4	43.078	BB	1.2571	1647.57715	15.43755	8.0959

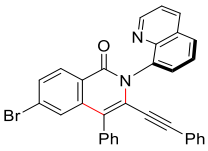




3ak-major and 3ak-minor

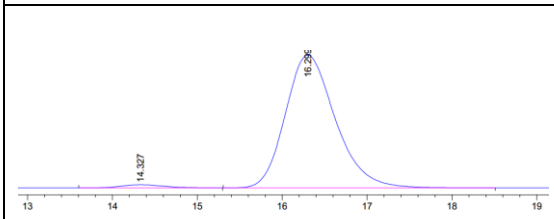
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	13.071	BB	0.5828	539.84094	14.16074	1.7548
2	19.323	BB	0.8147	2.48149e4	457.56366	80.6634
3	23.635	BB	0.9701	5295.50977	81.06588	17.2136
4	43.307	MM	2.0206	113.25286	9.34136e-1	0.3681

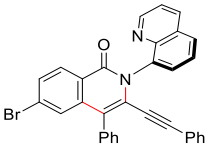




***Rac*-3al**

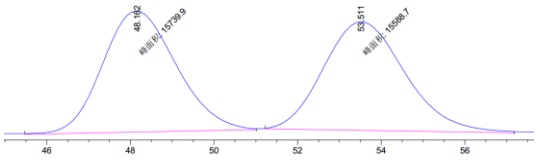
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	14.345	BV	0.6408	1.58115e4	385.26675	50.0401
2	16.367	VB	0.7201	1.57862e4	336.03943	49.9599

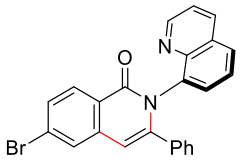




3al

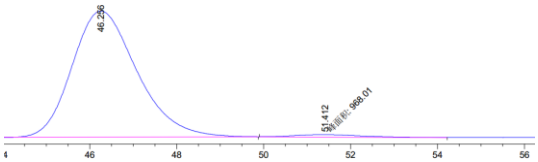
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	14.327	BB	0.5127	765.95532	21.34326	2.0431
2	16.299	BB	0.6240	3.67244e4	896.25427	97.9569

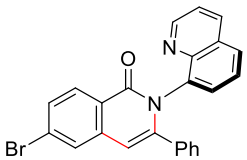




***Rac*-3am**

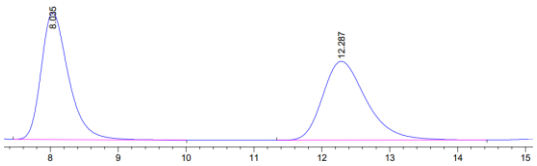
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	48.162	MM	2.0478	1.57399e4	128.10672	50.2414
2	53.511	MM	2.2576	1.55887e4	115.08096	49.7586

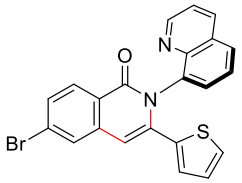




3am

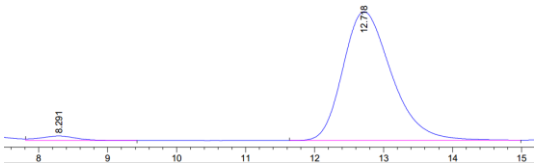
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	46.256	BB	1.2720	4.64397e4	447.77808	97.9581
2	51.412	MM	1.7931	968.00952	8.99759	2.0419

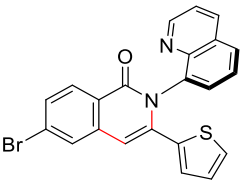




***Rac*-3an**

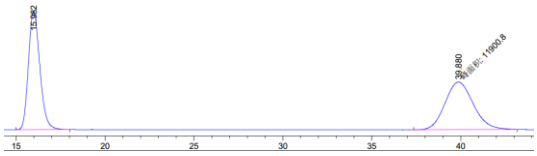
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	8.035	BB	0.4237	7385.69531	264.53314	50.1792
2	12.287	BB	0.6848	7332.94678	164.27812	49.8208

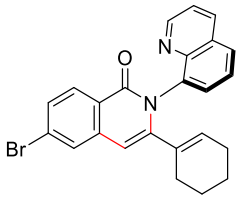




3an

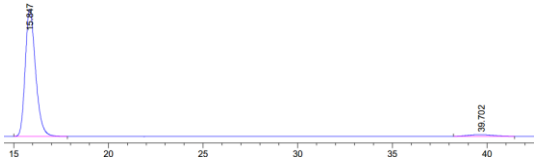
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	8.291	VB	0.5344	615.27606	16.91461	2.5149
2	12.718	BB	0.7528	2.38500e4	489.17172	97.4851

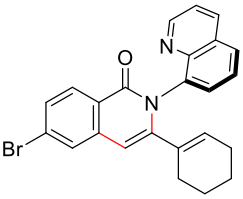




***Rac*-3ao**

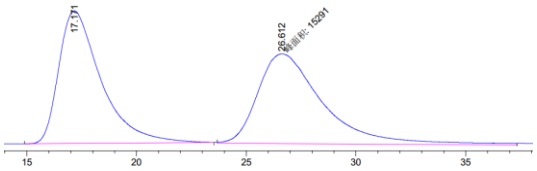
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	15.982	BB	0.6937	1.19046e4	267.24329	50.0080
2	39.880	MM	1.8474	1.19008e4	107.36781	49.9920

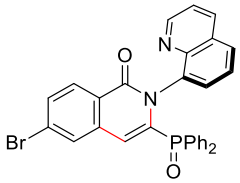




3ao

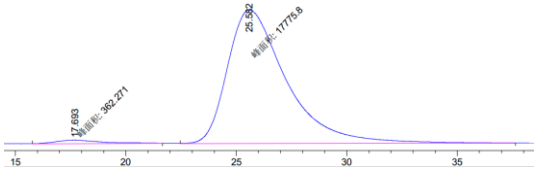
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	15.847	BB	0.5846	1.75672e4	463.09335	96.8677
2	39.702	BB	1.0444	568.05524	6.41934	3.1323

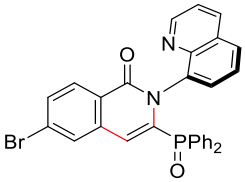




***Rac*-3ap-major**

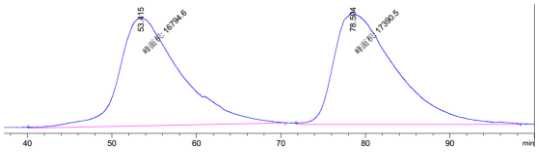
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	17.171	BB	1.9057	1.46966e4	109.93509	49.0090
2	26.612	MM	3.4277	1.52910e4	74.35004	50.9910

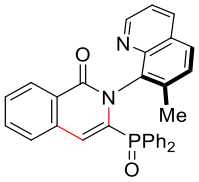




3ap-major

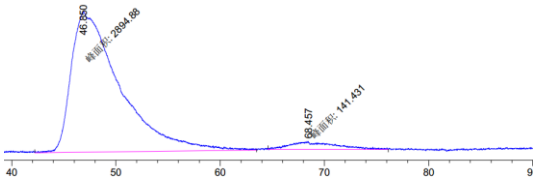
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	17.693	MM	2.4410	362.27130	2.47355	1.9973
2	25.582	MM	3.0910	1.77758e4	95.84570	98.0027

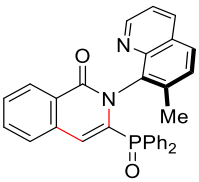




***Rac*-3aq-major**

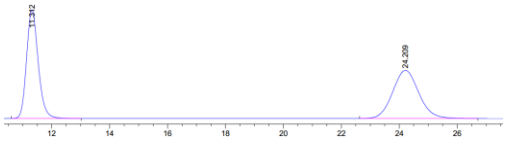
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	53.415	MM	8.4158	1.67946e4	33.25992	49.1283
2	78.504	MM	8.4434	1.73905e4	34.32754	50.8717

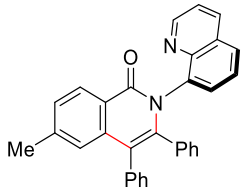




3aq-major

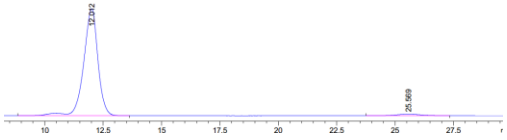
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	46.850	MM	5.4281	2894.88330	8.88857	95.3420
2	68.457	MM	4.8405	141.43098	4.86975e-1	4.6580

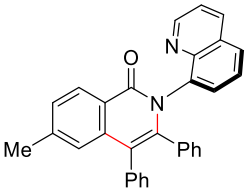




***Rac*-3aa**

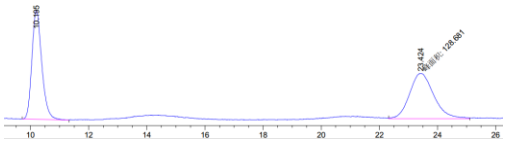
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	11.312	BB	0.4265	4150.40820	149.21095	49.9726
2	24.209	BB	0.9602	4154.96533	66.02279	50.0274

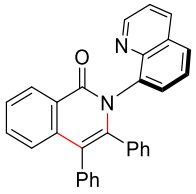




3aa

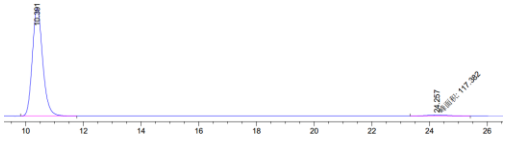
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	12.012	VB R	0.6232	4.34573e4	1025.56116	97.6289
2	25.569	BB	0.8958	1055.46252	14.45610	2.3711

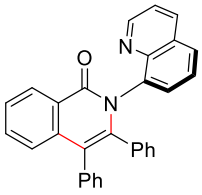




***Rac*-3ba**

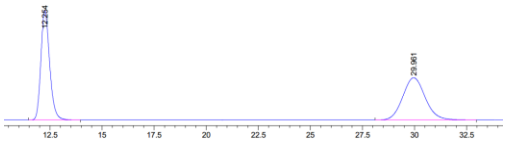
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	10.195	BB	0.3592	124.98302	5.29922	49.2711
2	23.424	MM	0.9692	128.68085	2.21293	50.7289

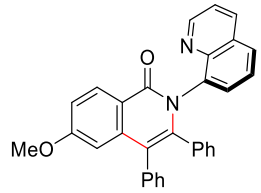




3ba

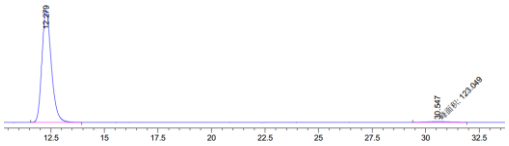
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	10.391	BB	0.3800	6197.16504	249.30396	98.1411
2	24.257	MM	0.9483	117.38180	2.06312	1.8589

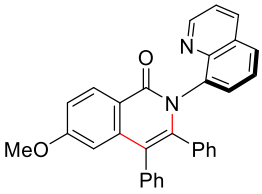




***Rac*-3ca**

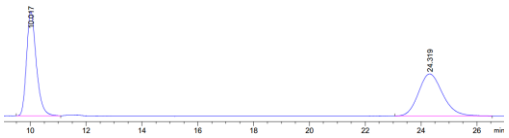
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	12.254	BB	0.4496	1.05024e4	358.65424	50.1921
2	29.961	BB	1.1386	1.04220e4	138.38376	49.8079

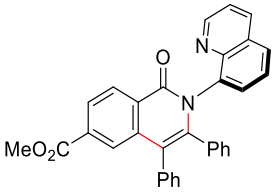




3ca

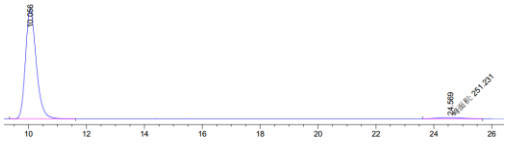
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	12.279	BB	0.4696	7304.82031	238.33360	98.3434
2	30.547	MM	1.2498	123.04949	1.64097	1.6566

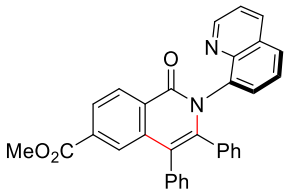




***Rac*-3da**

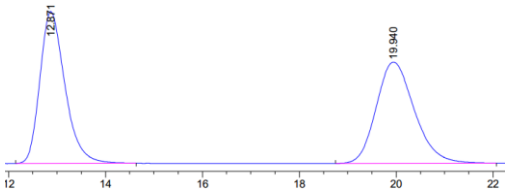
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	10.017	BB	0.3703	574.88300	23.75918	50.0424
2	24.319	BB	0.8467	573.90881	9.55517	49.9576

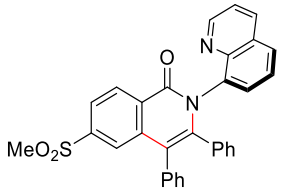




3da

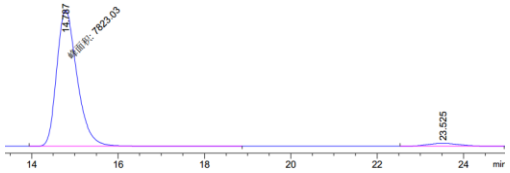
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	10.056	BB	0.3994	8447.14844	326.95456	97.1118
2	24.569	MM	1.0280	251.23070	4.07296	2.8882

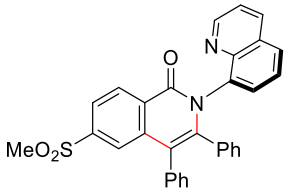




***Rac*-3ea**

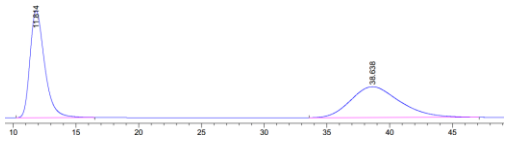
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	12.871	BB	0.5507	3360.53394	93.64193	49.5894
2	19.940	BB	0.8266	3416.18213	62.41036	50.4106

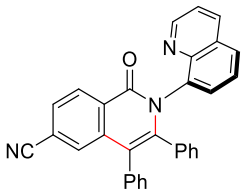




3ea

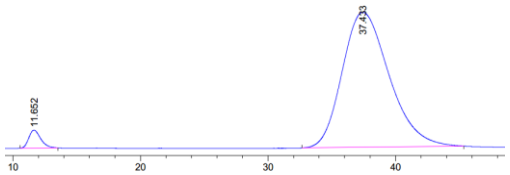
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	14.787	MM	0.5460	7823.03467	238.78339	96.7357
2	23.525	BB	0.6735	263.98373	5.08641	3.2643

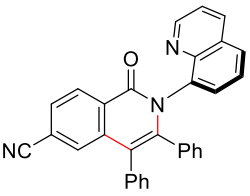




***Rac*-3fa**

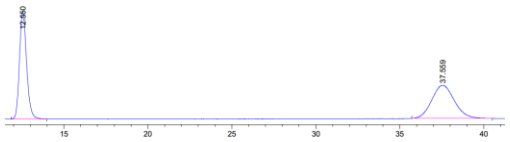
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	11.814	BB	1.2323	1.52099e4	188.70953	50.7110
2	38.638	BB	3.1968	1.47834e4	54.15517	49.2890

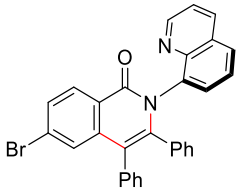




3fa

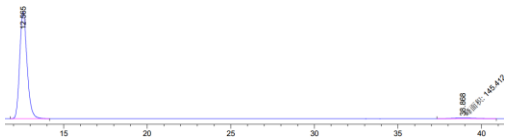
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	11.652	BB	0.8011	492.94778	7.63638	3.2552
2	37.433	BB	3.0050	1.46505e4	57.26081	96.7448

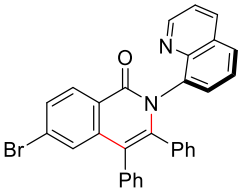




***Rac*-3ga**

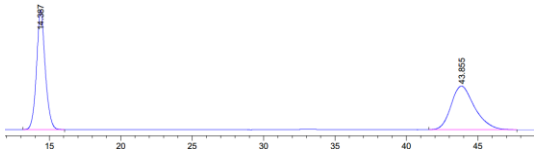
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	12.550	BB	0.4492	860.42078	29.25014	50.5137
2	37.559	BB	1.1086	842.92181	9.00039	49.4863

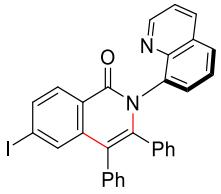




3ga

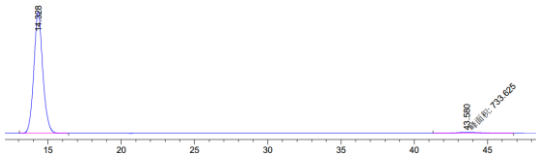
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	12.565	BB	0.4697	5821.27588	190.90700	97.5629
2	38.868	MM	1.6096	145.41203	1.50567	2.4371

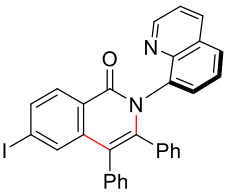




***Rac*-3ha**

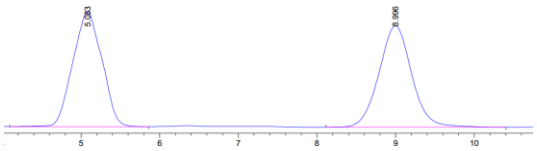
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	14.387	BB	0.6316	1.20857e4	285.65054	50.3425
2	43.855	BB	1.6529	1.19213e4	104.03642	49.6575

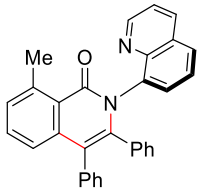




3ha

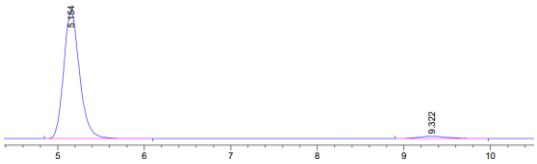
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	14.328	BB	0.6254	3.29366e4	781.99872	97.8211
2	43.580	MM	1.9059	733.62506	6.41524	2.1789

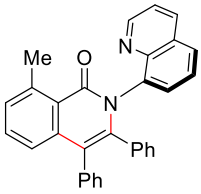




***Rac*-3ia**

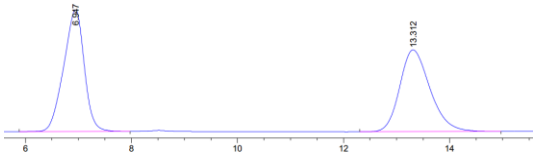
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	5.083	BB	0.3960	6596.25879	256.48309	50.1989
2	8.996	BB	0.4411	6543.99121	226.46921	49.8011

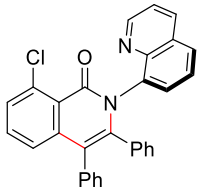




3ia

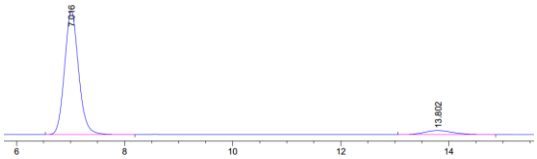
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	5.154	BB	0.1949	6018.07520	471.43573	96.6998
2	9.322	BB	0.3613	205.38449	8.51952	3.3002

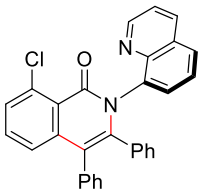




***Rac*-3ja**

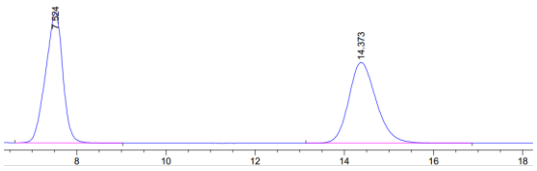
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	6.947	BB	0.4046	1.57125e4	582.61871	50.3225
2	13.312	BB	0.6111	1.55111e4	390.75006	49.6775

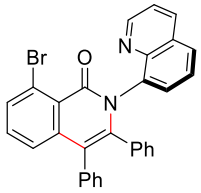




3ja

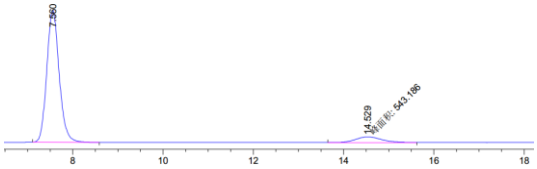
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	7.016	BB	0.2762	6708.27100	372.35162	93.6434
2	13.802	BB	0.5423	455.36288	12.34616	6.3566

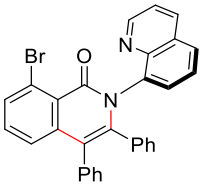




***Rac*-3ka**

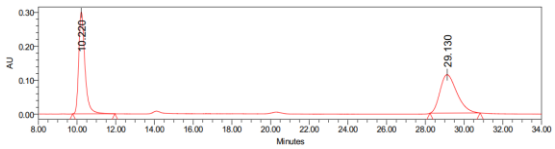
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	7.524	BB	0.4010	1.33040e4	495.89404	50.2851
2	14.373	BB	0.6500	1.31531e4	306.88925	49.7149

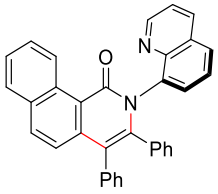




3ka

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	7.560	BB	0.2912	5522.03174	291.18604	91.0442
2	14.529	MM	0.6961	543.18622	13.00598	8.9558

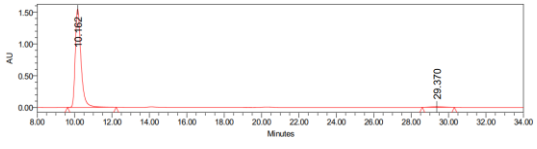


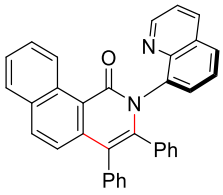


***Rac*-3la**

Peak Results

	Name	RT	Area	Height	Amount	Units	% Area
1		10.220	6624540	299754			49.18
2		29.130	6844272	113358			50.82

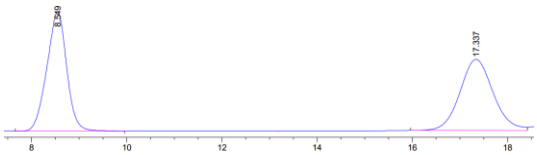


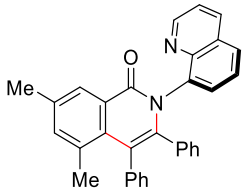


3la

Peak Results

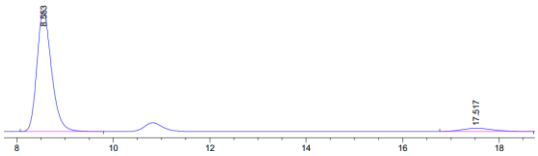
	Name	RT	Area	Height	Amount	Units	% Area
1		10.162	32806109	1545837			98.60
2		29.370	464636	8674			1.40

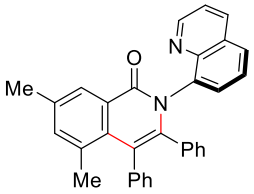




***Rac*-3ma**

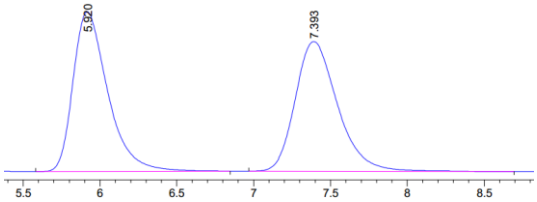
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	8.549	BB	0.4325	6919.75049	239.92329	49.9211
2	17.337	BV	0.7393	6941.62793	142.75163	50.0789

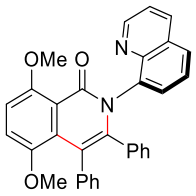




3ma

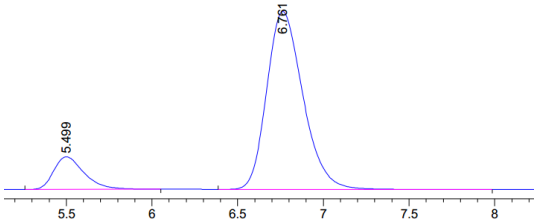
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	8.553	BB	0.3234	3761.54224	178.80400	94.8451
2	17.517	BB	0.5361	204.44304	4.62169	5.1549

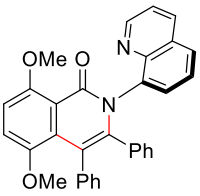




***Rac*-3na**

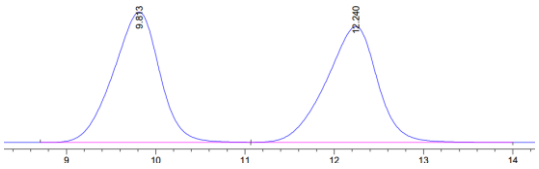
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	5.920	BB	0.2389	2816.35596	179.62920	50.1516
2	7.393	BB	0.2936	2799.32690	146.03270	49.8484

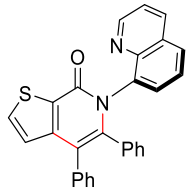




3na

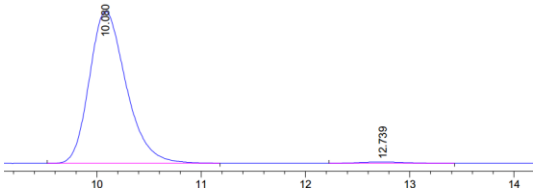
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	5.499	BB	0.1908	383.30219	30.88238	13.3726
2	6.761	BB	0.2271	2483.02026	169.28778	86.6274

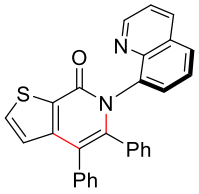




***Rac*-3oa**

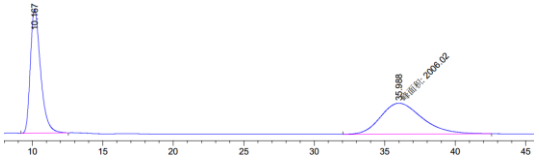
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	9.813	BB	0.5463	1.66228e4	459.27887	50.4410
2	12.240	BB	0.5970	1.63322e4	408.01407	49.5590

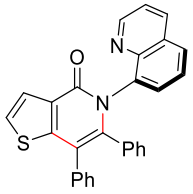




3oa

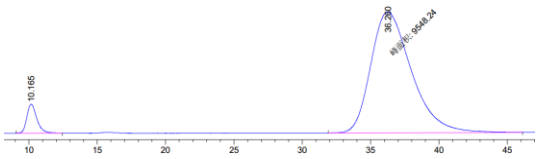
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	10.080	BB	0.3758	4811.84668	196.40164	98.7755
2	12.739	BB	0.3740	59.65347	1.95495	1.2245

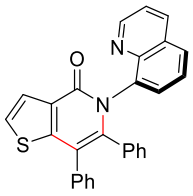




***Rac*-3pa**

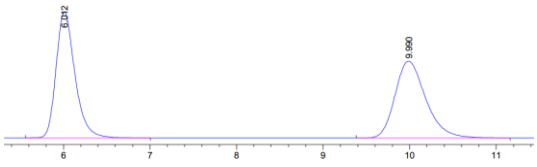
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	10.167	BB	0.7634	1964.50269	39.02128	49.4771
2	35.988	MM	3.4259	2006.02441	9.75899	50.5229

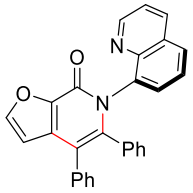




3pa

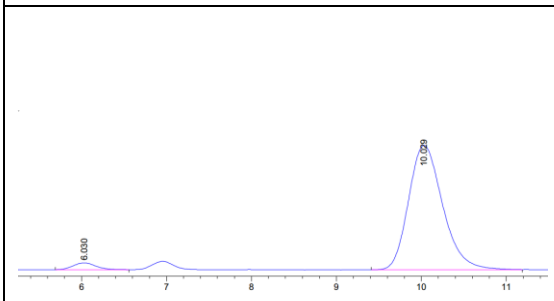
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	10.165	BB	0.7299	557.89508	11.07052	5.5204
2	36.260	MM	3.4490	9548.23926	46.13993	94.4796

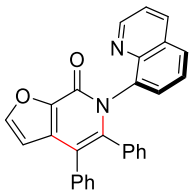




***Rac*-3qa**

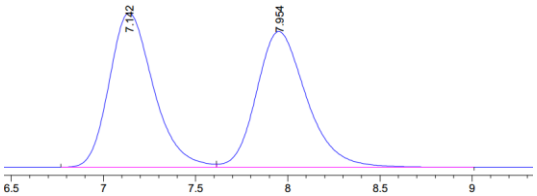
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	6.012	BB	0.2307	1697.42749	112.06480	50.1963
2	9.990	BB	0.3782	1684.15076	68.16767	49.8037

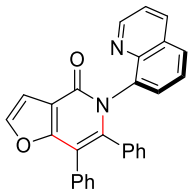




3qa

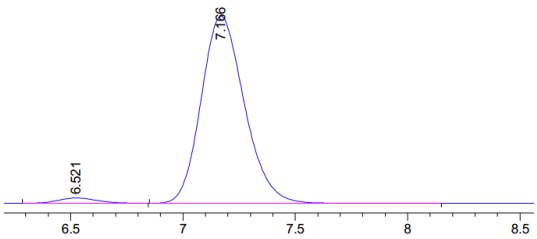
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	6.030	BB	0.2771	105.80864	5.73976	3.4901
2	10.029	BB	0.4314	2925.84570	104.88694	96.5099

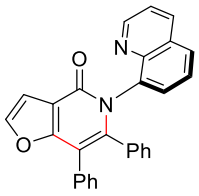




***Rac*-3ra**

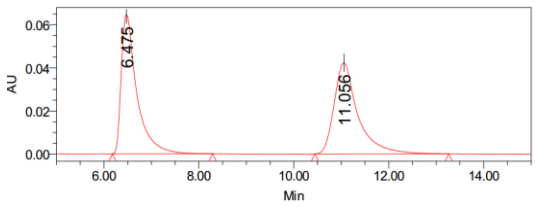
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	7.142	BV	0.2546	2876.23218	172.47978	50.0665
2	7.954	VB	0.2886	2868.58740	151.68057	49.9335

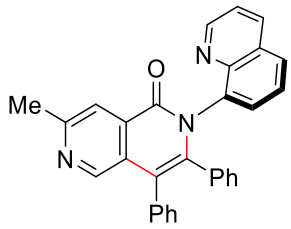




3ra

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	6.521	BB	0.1847	40.82689	3.38463	2.4914
2	7.166	BB	0.2060	1597.85828	119.49137	97.5086

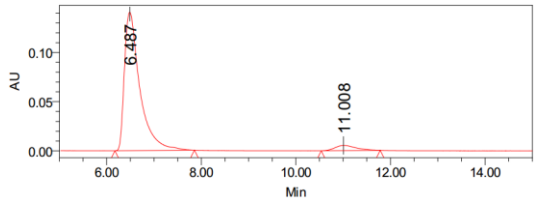


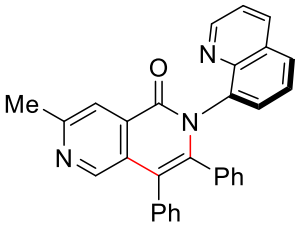


***Rac*-3ra**

Peak Results

	Name	RT	Area	Height	Amount	Units	% Area
1		6.475	1470247	64562			50.04
2		11.056	1467969	42242			49.96

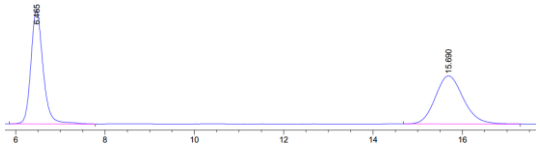


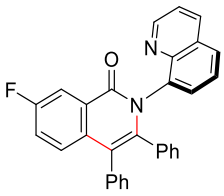


3sa

Peak Results

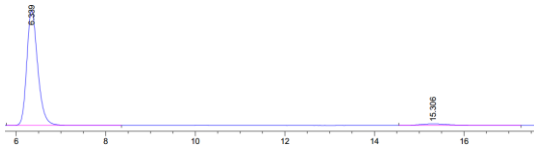
	Name	RT	Area	Height	Amount	Units	% Area
1		6.487	3173646	140671			95.18
2		11.008	160717	5251			4.82

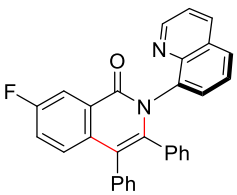




Rac*-3ta-*C2

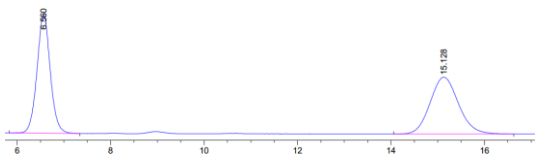
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	6.465	BB	0.2879	4699.35645	249.36087	50.5861
2	15.690	BB	0.6635	4590.45557	105.10640	49.4139

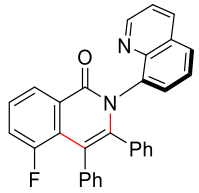




3ta-*C2*

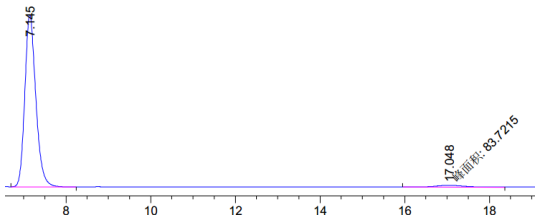
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	6.339	BB	0.2596	5861.12256	346.05618	96.3553
2	15.306	BB	0.6319	221.70181	4.89921	3.6447

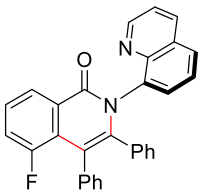




Rac*-3ta-*C6

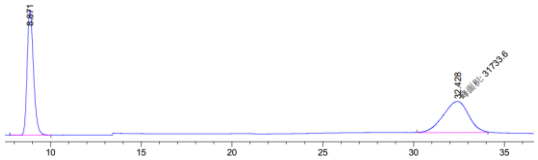
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	6.560	BB	0.2987	5359.47607	271.00064	49.6125
2	15.128	BB	0.6480	5443.19727	129.06407	50.3875

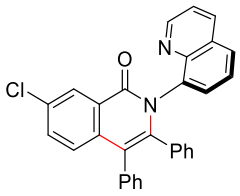




3ta-*C6*

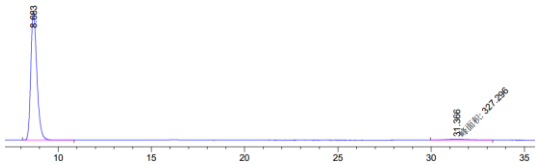
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	7.145	BB	0.2745	3166.21240	175.52397	97.4239
2	17.048	MM	0.7687	83.72147	1.81511	2.5761

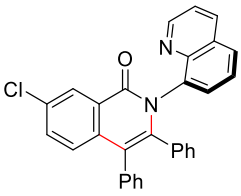




Rac*-3ua-*C2

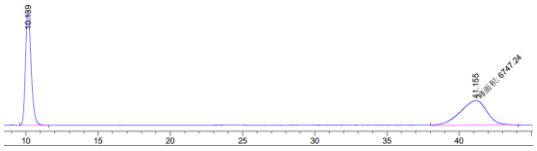
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	8.871	VB R	0.3690	3.16963e4	1304.48486	49.9706
2	32.428	MM	1.6253	3.17336e4	325.40778	50.0294

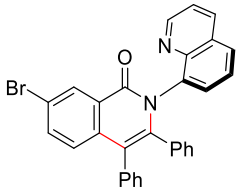




3ua-*C2*

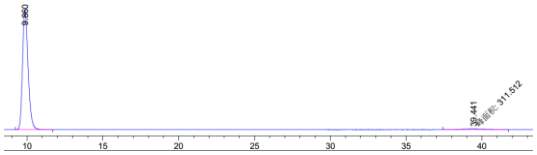
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	8.683	BB	0.3491	1.14848e4	505.35452	97.2291
2	31.366	MM	1.4648	327.29648	3.72410	2.7709

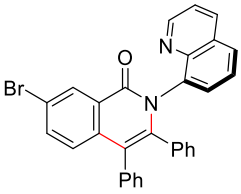




***Rac*-3va**

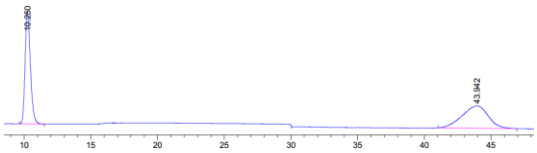
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	10.139	BB	0.4140	6677.56348	246.57343	49.7405
2	41.155	MM	2.1365	6747.24170	52.63509	50.2595

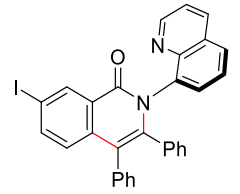




3va

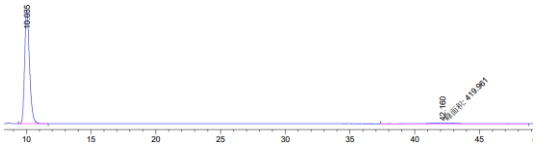
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	9.860	BB	0.3930	1.01036e4	394.24344	97.0091
2	39.441	MM	1.9380	311.51199	2.67892	2.9909

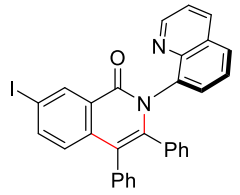




***Rac*-3wa**

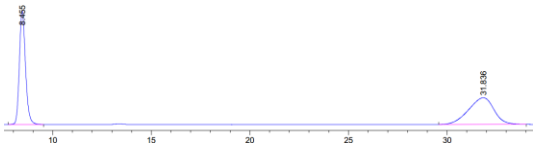
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	10.250	BB	0.4228	7730.43555	281.14813	50.5490
2	43.942	BB	1.5950	7562.52051	55.73669	49.4510

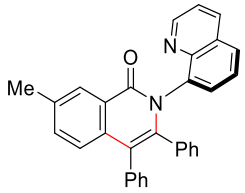




3wa

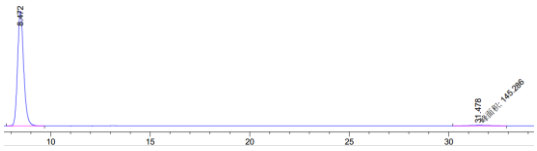
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	10.035	BB	0.4037	1.04959e4	400.56891	96.1528
2	42.160	MM	2.3941	419.96066	2.92356	3.8472

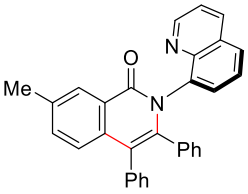




***Rac*-3xa**

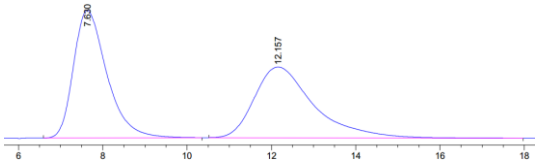
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	8.455	BB	0.3294	3993.71484	185.36739	50.6229
2	31.836	BB	1.0886	3895.43506	43.33953	49.3771

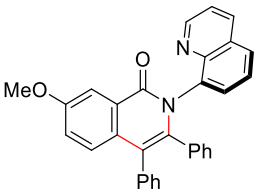




3xa

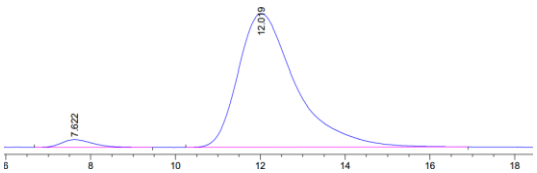
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	8.472	BB	0.3268	6558.32373	307.54611	97.8327
2	31.478	MM	1.3255	145.28601	1.82678	2.1673

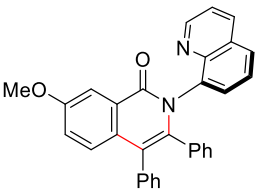




***Rac*-3ya**

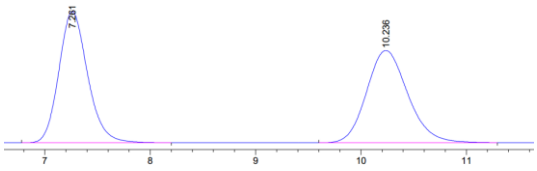
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	7.630	BB	0.8363	7343.65967	133.80492	50.3630
2	12.157	BB	1.4024	7237.80713	74.17764	49.6370

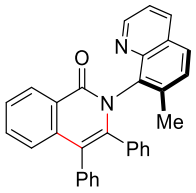




3ya

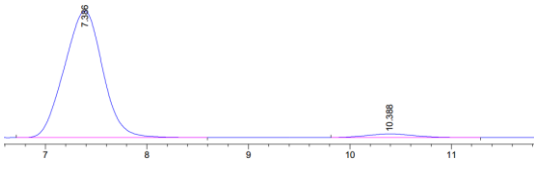
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	7.622	BB	0.6267	211.11412	4.04656	3.1284
2	12.019	BB	1.3965	6537.30029	69.43001	96.8716

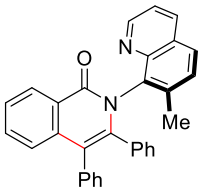




***Rac*-3za**

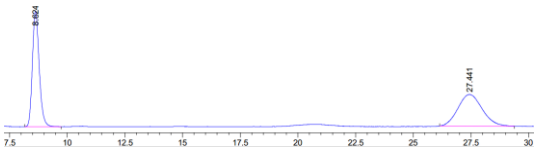
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	7.261	BB	0.2891	1662.65674	87.73969	49.7377
2	10.236	BB	0.4176	1680.19409	61.71933	50.2623

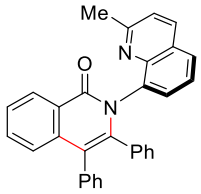




3za

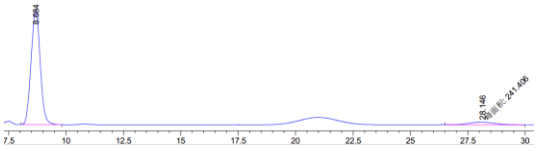
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	7.386	BB	0.4043	8011.32324	305.12387	96.5261
2	10.388	BB	0.4342	288.32034	8.66388	3.4739

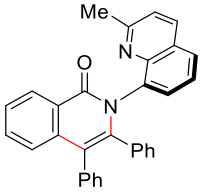




***Rac*-3aaa**

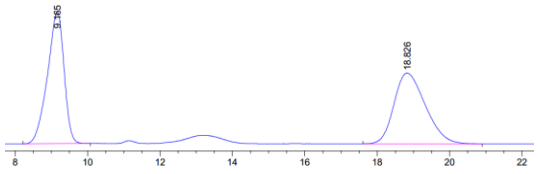
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	8.624	BB	0.3174	1025.27637	49.96420	50.7267
2	27.441	BB	0.8681	995.90015	13.63580	49.2733

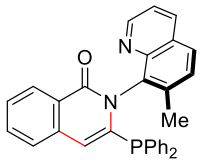




3aaa

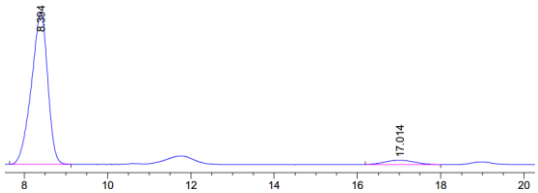
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	8.684	BB	0.4315	3639.46606	131.26686	93.7796
2	28.146	MM	1.3222	241.40619	3.04290	6.2204

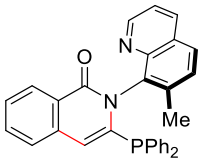




***Rac*-4**

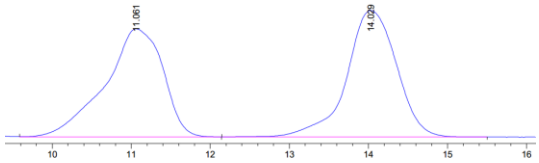
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	9.165	BB	0.4760	9402.06934	296.44104	49.6025
2	18.826	BB	0.8722	9552.75195	158.71529	50.3975

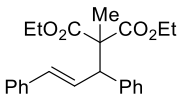




4

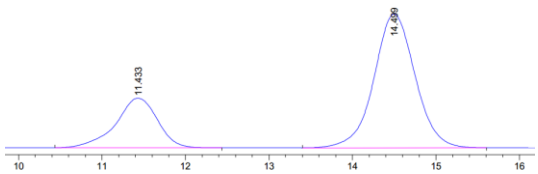
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	8.394	BB	0.4054	5672.18555	208.48030	94.9655
2	17.014	BB	0.5915	300.70673	6.05383	5.0345

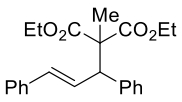




***Rac*-7**

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	11.061	VB	0.7684	2.82923e4	553.49164	49.8718
2	14.029	BB	0.6899	2.84377e4	648.08789	50.1282





7

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
#	[min]		[min]	[mAU*s]	[mAU]	%
1	11.433	BB	0.5314	2012.85864	57.92440	27.3068
2	14.499	BB	0.5299	5358.40771	156.33768	72.6932