Supporting Information

Rh(III)-Catalyzed Three-Component Cascade Annulation to Produce *N*-oxopropyl Chain of Isoquinolone Derivatives

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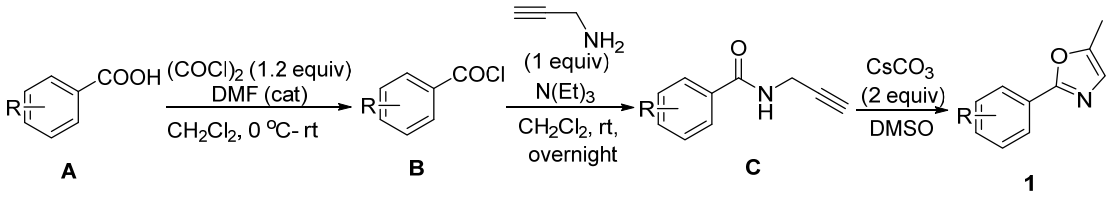
1. General Information

All reactions were carried out in high-pressure reaction tube. Column chromatography was performed with silica gel (200–300 mesh). High-resolution mass spectra (HRMS) were obtained with a Waters-Q-TOF-Premier (ESI). ^{1}H NMR and ^{13}C NMR spectra were recorded on a Bruker 400 MHz and 100MHz instrument. Spectra were reported relative to Me_4Si (δ 0.0 ppm), $CDCl_3$ (δ 7.26 ppm). ^{13}C NMR were reported relative to $CDCl_3$ (δ 77.16 ppm). Splitting patterns are designated as follows: s, singlet; d, doublet; t, triplet; q, quartet; m, multiplet. Compounds were characterized by ^{1}H NMR, ^{13}C NMR, ^{19}F NMR and HRMS.

2. Material

Unless otherwise noted, all reagents were obtained from commercial suppliers and used without further purification. Solvents were dried over sodium (for THF and ether) by refluxing for overnight and freshly distilled prior to use. Unless otherwise noted, all methanol was obtained from commercial suppliers and used without further purification. Methanol was dried and distilled from magnesium powder under nitrogen atmosphere. 2,5-diphenyloxazole,[1] 5-(*tert*-butyl)-2-phenyloxazole,[1] 2-phenyl-5-(p-tolyl)oxazole,[2] 5-(4-methoxyphenyl)-2-phenyloxazole[2], 2-phenyl-5-(m-tolyl)oxazole,[2] 5-(3-methoxyphenyl)-2-phenyloxazole[2] were all prepared following literature procedures.

Preparation of 2-aryloxazoline

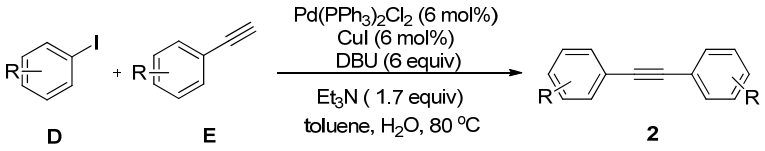


A 100 mL oven-dried round bottom flask with a stir bar was purged with argon and charged with benzoic acid **A** (5 mmol) in anhydrous CH_2Cl_2 (15 mL), which was added DMF (3 drop) at 0 °C and $(COCl)_2$ (1.2 equiv) was subsequently added dropwise by syringe. After 15 min, the reaction mixture was allowed to warm to room temperature overnight. After removal of the volatiles under vacuum, the crude product **B** was used directly without any further purification.[3]

To a solution of the propargylic amine (5.0 mmol) in anhydrous CH_2Cl_2 (15 mL) at 0 °C, Et_3N (1.5 equiv) and DMAP (2 mol%) were added, and the acid chloride (1.0 equiv) was added dropwise at 0 °C. After 15 min, the mixture was stirred overnight at room temperature overnight. After the reaction was completed, the mixture was quenched with water and extracted with CH_2Cl_2 (3 × 20 mL), the combined organic layer was washed with brine and then the combined organic layers were dried ($MgSO_4$), filtered, and concentrated in vacuo. Purification of the residue by column chromatography (petroleum ether/ethyl acetate = 3/1, v/v) afforded the product **C**. [4]

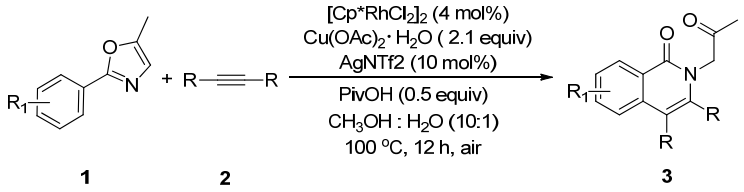
A mixture of propargylamides **C**, Cs_2CO_3 (2 equiv), DMSO (10 mL), was heated at 100 °C for 2 h and cooled to room temperature. The mixture was quenched with water and extracted with EtOAc (3 × 20 mL), the combined organic layer was washed with brine and then the combined organic layers were dried ($MgSO_4$), filtered, and concentrated in vacuo. Purification of the residue by column chromatography (petroleum ether/ethyl acetate =10/1, v/v) afforded the product **1**. [5]

Preparation of diphenylacetylene derivatives



To a solution of the $Pd(PPh_3)_2Cl_2$ (6 mol%), CuI (6 mol%), DBU (6 equiv), Et_3N (1.7 equiv) in toluene (30 mL) and H_2O (0.4 equiv), iodide derivatives **D** (6 mmol, 1 equiv) and alkyne derivatives **E** (1.1 equiv) were added and stirred at 80 °C for 18 h. The mixture was quenched with water and extracted with EtOAc (3 × 20 mL), the combined organic layer was washed with brine and then the combined organic layers were dried ($MgSO_4$), filtered, and concentrated in vacuo. Purification of the residue by column chromatography (petroleum ether) afforded the product **2**. [6]

3. General Procedure for the Synthesis of Isoquinolone Derivatives



A mixture of 2-phenyloxazole **1** (0.05 mmol), acetylene derivatives **2** (1.5 equiv), $[Cp^*RhCl_2]_2$ (4 mol%), $Cu(OAc)_2{\cdot}H_2O$ (2.1 equiv), $AgNTf_2$ (10 mol%) and PivOH (0.5 equiv) were added to an oven dried high pressure tube under air atmosphere. MeOH (0.5 mL) and H_2O (50 μL) were then added by syringe. The reaction mixture was stirred at 100 °C for 12 h. After removal of the volatiles under vacuum, the crude product was purified by column chromatography on silica gel afforded the pure product **3**.

4. Optimization of the Reaction Conditions

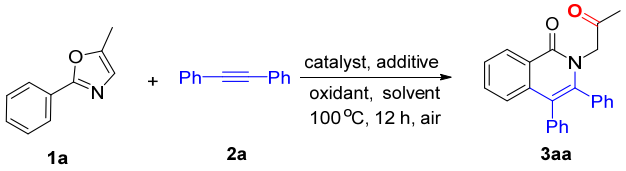


Table S1. The effect of catalysts on the reaction[a]

Entry	Catalyst	Oxidant	Solvent	Yield[b]/%
1	$[RhCl(C_2H_4)_2]_2$	$Cu(OAc)_2{\cdot}H_2O$	CH_3OH	ND
2	$[Rh(OAc)_2]_2$	$Cu(OAc)_2{\cdot}H_2O$	CH_3OH	ND
3	$[Rh(COD)Cl]_2$	$Cu(OAc)_2{\cdot}H_2O$	CH_3OH	ND
4	$[Rh(COD)_2BF_4]$	$Cu(OAc)_2{\cdot}H_2O$	CH_3OH	ND
5	$Cp^*Rh(OAc)_2{\bullet}H_2O$	$Cu(OAc)_2{\cdot}H_2O$	CH_3OH	18

6	$Cp^*Rh(CH_3CN)_3(SbF_6)_2$	$Cu(OAc)_2·H_2O$	CH_3OH	44
7	$[Cp^*RhCl_2]_2$	$Cu(OAc)_2·H_2O$	CH_3OH	57

[a]Reaction conditions: **1a** (0.05 mmol), **2a** (2.0 equiv), Catalyst (5 mol%), $Cu(OAc)_2·H_2O$ (2.1 equiv), $AgNTf_2$ (20 mol%), CH_3OH (0.5 mL), 100 °C, 12 h under air. [b]Isolated yields.

Table S2. The effect of oxidants and additives on the reaction[a]

Entry	Oxidant	Additive	Yield[b]/%
1	$Cu(acac)_2$	$AgNTf_2$	ND
2	$Cu(OTf)_2$	$AgNTf_2$	ND
3	$AgCO_3$	$AgNTf_2$	ND
4	AgOAc	$AgNTf_2$	ND
5	$Cu(OAc)_2$	$AgNTf_2$	Trace
6	$Cu(OAc)_2·H_2O$	$AgNTf_2$	57
7	$Cu(OAc)_2·H_2O$	$AgSbF_6$	52
8	$Cu(OAc)_2·H_2O$	AgOTf	14
9	$Cu(OAc)_2·H_2O$	$AgSO_3CH_3$	40
10	$Cu(OAc)_2·H_2O$	$AgBF_4$	51
11	$Cu(OAc)_2·H_2O$	$AgNTf_2/H_2O$	65
12	$Cu(OAc)_2·H_2O$	$AgNTf_2/PhSO_3H/H_2O$	ND
13	$Cu(OAc)_2·H_2O$	$AgNTf_2$/AcOH/H_2O	42
14	$Cu(OAc)_2·H_2O$	$AgNTf_2$/PhCOOH/H_2O	65
15	$Cu(OAc)_2·H_2O$	$AgNTf_2$/TFA/H_2O	40
16	$Cu(OAc)_2·H_2O$	$AgNTf_2/PhOCH_2COOH/H_2O$	64
17	$Cu(OAc)_2·H_2O$	$AgNTf_2$/1-AdCOOH/H_2O	66
18	$Cu(OAc)_2·H_2O$	$AgNTf_2$/PivOH/H_2O	74
19[c]	$Cu(OAc)_2·H_2O$	$AgNTf_2$/PivOH/H_2O	53
20[d]	$Cu(OAc)_2·H_2O$	$AgNTf_2$/PivOH/H_2O	52
21	$Cu(OAc)_2·H_2O$	$AgNTf_2/K_3PO_4/H_2O$	67
22	$Cu(OAc)_2·H_2O$	$AgNTf_2/Na_2CO_3/H_2O$	40
23	$Cu(OAc)_2·H_2O$	$AgNTf_2/NaHCO_3/H_2O$	54

[a]Reaction conditions: **1a** (0.05 mmol), **2a** (2.0 equiv), $[Cp^*RhCl_2]_2$ (5 mol%), Oxidant (2.1 equiv), silver salt (20 mol%)/Additive (1 equiv)/ H_2O (50 μL), CH_3OH (0.5 mL), 100 °C, 12 h under air. [b]Isolated yields. [c]80 °C. [d]120 °C.

Table S3. The effect of solvents on the reaction[a]

Entry	Solvent	Yield[b]/%
1	THF	56
2	DCE	41
3	CH_3CN	57
4	Toluene	Trace
5	1,4-Dioxane	42
6	EtOH	64

7	H_2O	ND
8[c]	CH_3OH	60
9	CH_3OH	74
10[d]	CH_3OH	46

[a]Reaction conditions: **1a** (0.05 mmol), **2a** (2.0 equiv), $[Cp^*RhCl_2]_2$ (5 mol%), $Cu(OAc)_2·H_2O$ (2.1 equiv), $AgNTf_2$ (20 mol%), PivOH (1 equiv), Solvent (0.5 mL), H_2O (50 μL), 100 °C, 12 h under air. [b]Isolated yields. [c]30 μL H_2O. [d]70 μL H_2O.

Table S4. The effect of equivalant on the reaction[a]

Entry	**2a**/equiv	Catalyst/mol%	Oxidant/equiv	$AgNTf_2$/mol%	PivOH/equiv	Yield[b]/%
1	2	$[Cp^*RhCl_2]_2$/2	$Cu(OAc)_2·H_2O$/2.1	$AgNTf_2$/20	PivOH/1	70
2	2	$[Cp^*RhCl_2]_2$/3	$Cu(OAc)_2·H_2O$/2.1	$AgNTf_2$/20	PivOH/1	72
3	2	$[Cp^*RhCl_2]_2$/4	$Cu(OAc)_2·H_2O$/2.1	$AgNTf_2$/20	PivOH/1	80
4	2	$[Cp^*RhCl_2]_2$/5	$Cu(OAc)_2·H_2O$/2.1	$AgNTf_2$/20	PivOH/1	74
5	1.2	$[Cp^*RhCl_2]_2$/4	$Cu(OAc)_2·H_2O$/2.1	$AgNTf_2$/20	PivOH/1	75
6	1.5	$[Cp^*RhCl_2]_2$/4	$Cu(OAc)_2·H_2O$/2.1	$AgNTf_2$/20	PivOH/1	82
7	1.8	$[Cp^*RhCl_2]_2$/4	$Cu(OAc)_2·H_2O$/2.1	$AgNTf_2$/20	PivOH/1	80
8	1.5	$[Cp^*RhCl_2]_2$/4	$Cu(OAc)_2·H_2O$/1.5	$AgNTf_2$/20	PivOH/1	62
9	1.5	$[Cp^*RhCl_2]_2$/4	$Cu(OAc)_2·H_2O$/2.5	$AgNTf_2$/20	PivOH/1	66
10	1.5	$[Cp^*RhCl_2]_2$/4	$Cu(OAc)_2·H_2O$/2.1	$AgNTf_2$/20	PivOH/1.5	75
11	1.5	$[Cp^*RhCl_2]_2$/4	$Cu(OAc)_2·H_2O$/2.1	$AgNTf_2$/20	PivOH/0.5	82
12	1.5	$[Cp^*RhCl_2]_2$/4	$Cu(OAc)_2·H_2O$/2.1	$AgNTf_2$/30	PivOH/0.5	73
13	1.5	$[Cp^*RhCl_2]_2$/4	$Cu(OAc)_2·H_2O$/2.1	$AgNTf_2$/10	PivOH/0.5	86

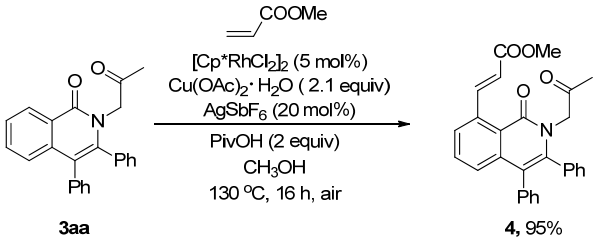
[a]Reaction conditions: **1a** (0.05 mmol), **2a** (x equiv), $[Cp^*RhCl_2]_2$ (x mol%), $Cu(OAc)_2·H_2O$ (x equiv), $AgNTf_2$ (x mol%), PivOH (x equiv), CH_3OH (0.5 mL), 50 μL H_2O, 100 °C, 12 h under air. [b]Isolated yields.

Table S5. The effect of methanol on the reaction[a]

Entry	Catalyst/mol%	Oxidant/equiv	$AgNTf_2$/mol%	Solvent	Yield[b]/%
1	$[Cp^*RhCl_2]_2$/4	$Cu(OAc)_2·H_2O$/2.1	$AgNTf_2$/10	MeOH	40
2	$[Cp^*RhCl_2]_2$/4	$Cu(OAc)_2$/2.1	$AgNTf_2$/10	MeOH	9
3	$[Cp^*RhCl_2]_2$/4	$Cu(OAc)_2$ /2.1	$AgNTf_2$/10	MeOH[c]	33%

[a]Reaction conditions: **1a** (0.05 mmol), **2a** (1.5 equiv), $[Cp^*RhCl_2]_2$ (4 mol%), Oxidant (2.1 equiv), $AgNTf_2$ (10mol%), treated anhydrous CH_3OH (0.5 mL), 100 °C, 12 h under air. [b]Isolated yields. [c]untreated MeOH .

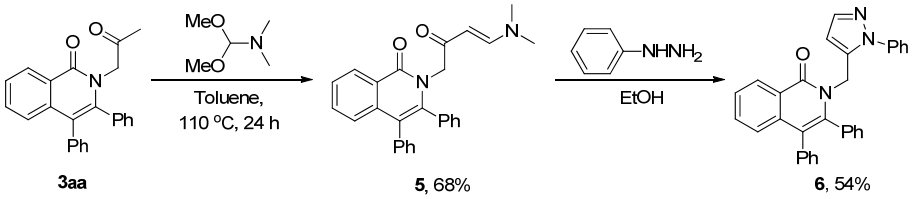
5. Synthetic Applications



Synthesis of 4

A mixture of **3aa** (0.05 mmol), methyl acrylate (3 equiv), $[Cp^*RhCl_2]_2$ (5 mol%), $Cu(OAc)_2•H_2O$ (2.1 equiv), $AgSbF_6$ (20 mol%) and PivOH (2 equiv) were added to an oven dried high pressure tube under air atmosphere. MeOH (0.5 mL) was then added by syringe. The reaction mixture was stirred at 130 °C for 16 h. After removal of the solvent, the crude product was separated by column chromatography (petroleum ether/ethyl acetate = 4/1, v/v) to afford the product **4** as a white solid (95% yield). Melting point: 178.3 – 181.7 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ = 9.04 (d, *J* = 15.8 Hz, 1H), 7.53 – 7.42 (m, 2H), 7.21–7.13 (m, 7H), 7.11–7.04 (m, 4H), 6.17 (d, *J* = 15.9 Hz, 1H), 4.61 (s, 2H), 3.81 (s, 3H), 2.04 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 201.8, 167.3, 162.1, 147.8, 141.4, 139.1, 138.5, 136.5, 134.4, 132.0, 131.6, 129.9, 128.7, 128.3, 128.2, 127.4, 127.3, 127.1, 122.5, 119.7, 118.9, 55.7, 51.8, 27.4. HRMS (ESI): m/z calcd for $C_{28}H_{23}O_4NNa$ $[M+Na]^+$: 460.1525, found: 460.1527.

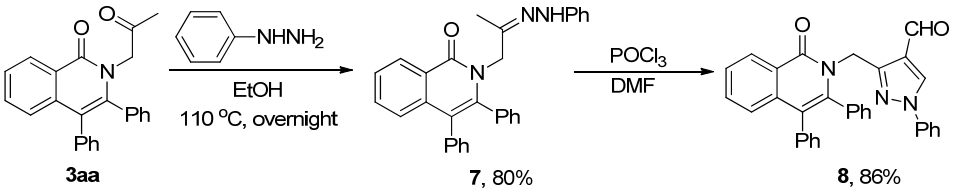
Synthesis of 6



To a stirred solution of **3aa** (0.05 mmol, 1.0 equiv) in toluene (0.5 mL), 1,1-dimethoxy-N,N-dimethylmethanamine (3 equiv) was added, and the mixture was stirred at 110 °C. After completion of the reaction (monitored by TLC), The reaction mixture was allowed to cool to room temperature. The resulting solid was filtered off, washed with toluene, the crude product **5** was used directly without any further purification.[7]

A mixture of **5** (0.04 mmol) and phenylhydrazine (0.05 mL) in ethanol (0.5 mL) was refluxed at 110 °C overnight. After removal of the solvent, the crude product was separated by column chromatography on silica gel (petroleum ether/ethyl acetate = 8/1, v/v) to afford the pure product **6** as a white solid (54% yield). [8] Melting point: 162.1 – 163.3 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.61 (d, *J* = 5.6 Hz, 1H), 7.79 (d, *J* = 2.4 Hz, 1H), 7.64 – 7.46 (m, 4H), 7.40 (t, *J* = 7.8 Hz, 2H), 7.26 – 7.11 (m, 10H), 7.11 – 7.05 (m, 2H), 6.37 (d, *J* = 2.4 Hz, 1H), 5.24 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 162.6, 150.9, 141.6, 140.2, 137.6, 136.7, 134.5, 132.4, 131.7, 130.8, 129.4, 128.4, 128.2, 128.0, 127.8, 127.3, 126.9, 126.7, 126.2, 125.6, 125.3, 119.4, 118.9, 107.3, 44.3. HRMS (ESI): m/z calcd for $C_{31}H_{23}ON_3Na$ $[M+Na]^+$: 476.1739, found: 476.1736.

Synthesis of 8

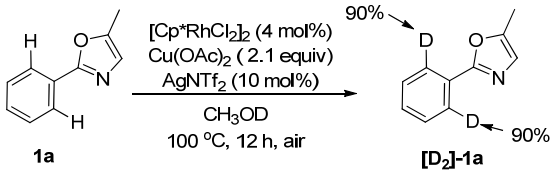


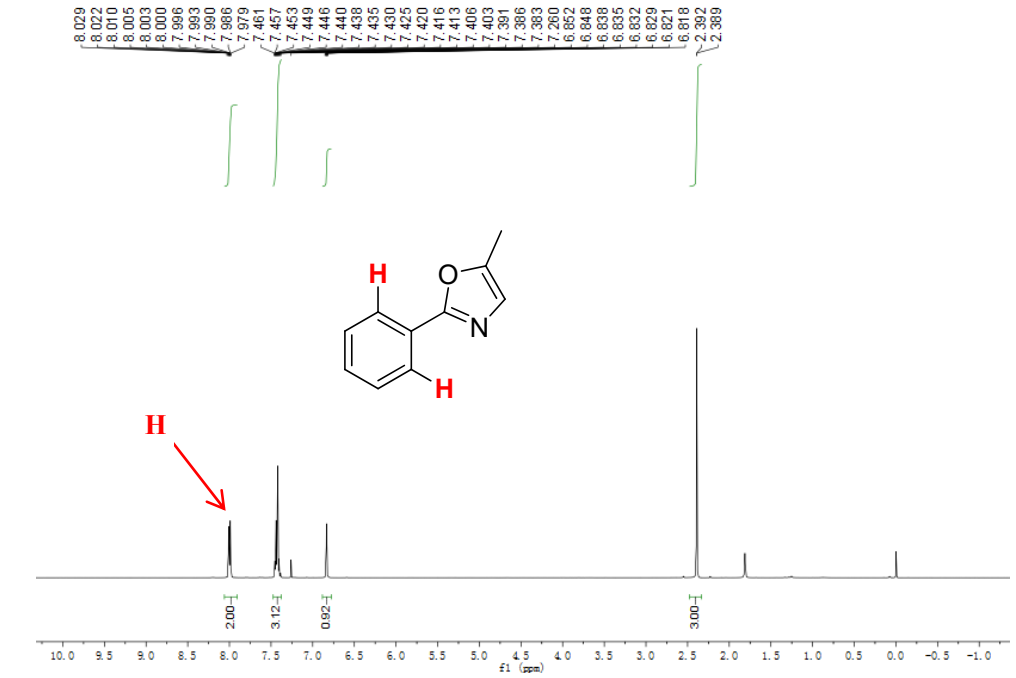
A mixture of **3aa** (0.1 mmol), AcOH (3drop) and phenylhydrazine (0.05 mL) in ethanol (0.5 mL) was refluxed at 110 °C overnight. The reaction mixture was refluxed overnight, and allowed to cool at room temperature. The solid product formed was collected by filtration and recrystallized from ethanol to afford the product **7**.

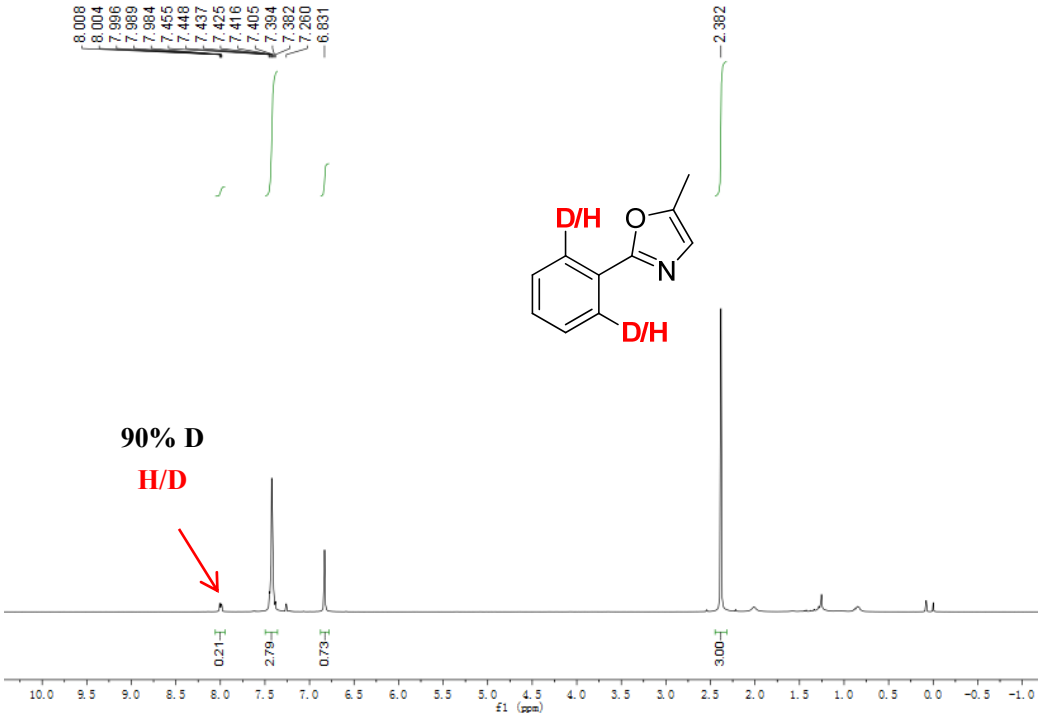
$POCl_3$ (0.1 mol) was added dropwise to DMF (2 mL) at 0 C. After 1 h, a solution of **7** (0.05 mol) in DMF (1 mL) was added dropwise at 0 °C. The mixture was stirred at 0 °C for 1 h and at 80 °C for 1 h, then cooled to room temperature and 100 g ice was added. The solid product formed was collected by filtration to give the crude product, the crude product was separated by column chromatography on silica gel (petroleum ether/ethyl acetate =2/1, v/v) afforded the pure products **8** as a white solid (86% yield). [9] Melting point: 201.1 – 203.7 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ = 9.85 (s, 1H), 8.56 (dd, *J* = 7.9, 1.5 Hz, 1H), 8.29 (s, 1H), 7.63 – 7.47 (m, 4H), 7.43 (t, *J* = 7.8 Hz, 2H), 7.32 (t, *J* = 7.4 Hz, 1H), 7.23 – 7.06 (m, 11H), 5.47 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 184.0, 162.5, 151.5, 141.5 ,139.1, 137.7, 136.7, 134.8, 132.4, 131.9, 131.7, 130.5, 129.7, 128.4, 128.3, 128.0, 127.9, 127.7, 126.9, 126.7, 125.6, 125.2, 122.5, 119.6, 119.3, 43.5. HRMS (ESI): m/z calcd for $C_{32}H_{23}O_2N_3Na$ $[M+Na]^+$: 504.1688, found: 504.1690.

6. Mechanism Study

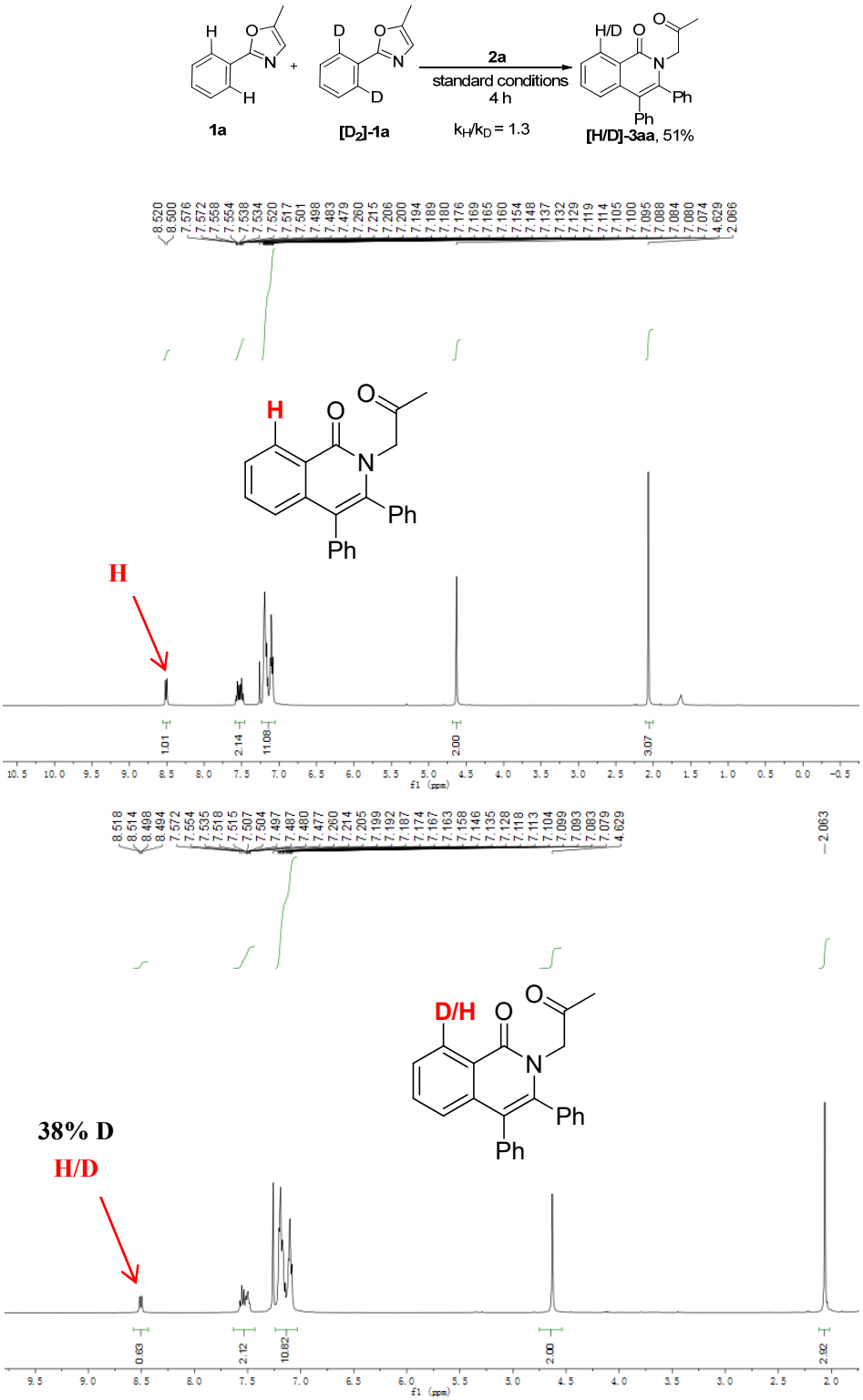
Deuterium-labeling experiments were carried out to study the mechanism of this reaction. **1a** (0.2 mmol), $[Cp^*RhCl_2]_2$ (4 mol%), $Cu(OAc)_2$ (2.1 equiv), $AgNTf_2$ (10 mol%) were stirred in CH_3OD (1 mL) under air atmosphere at 100 °C for 12 h. After completion, the crude product was separated by column chromatography (petroleum ether/ethyl acetate =10/1, v/v) to afford the product **1a**+**[D$_2$]-1a**. The deuterium rate (90%) was obtained from ^{1}H NMR. Deuterium was observed at both *ortho*-positions, which indicated the possibility of the reaction pathway via *ortho* C–H activation.



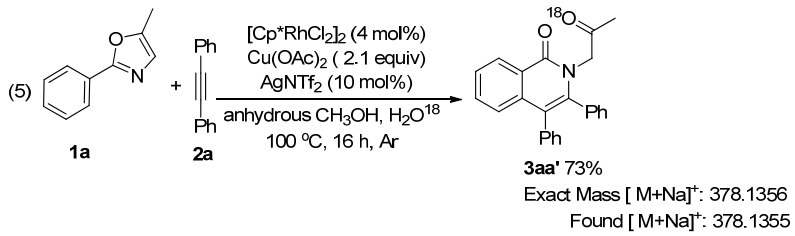




In addition, the kinetic isotope effect (KIE) study was conducted. **1a** (0.05 mmol), **[D_2]-1a** (0.05 mmol, 90% D), and diphenylacetylene **2a** (3 equiv) were stirred at 100 ºC for 4 h under standard conditions. After completion, the reaction mixture was purified by flash chromatography eluting with ethyl acetate and petroleum ether (1:3) to give **3aa** + **[D]-3aa**. The ratio of two products was determined by ^{1}H NMR integration method to give kinetic isotopic effect (KIE) k_H/k_D =1.3, thus indicating that the first C-H bond cleavage might be not involved in the product determining step.



^{18}O labeling experiments were carried out to study the mechanism of this reaction. **1a** (0.05 mmol), $[Cp^*RhCl_2]_2$ (4 mol%), $Cu(OAc)_2$ (2.1 equiv), $AgNTf_2$ (10 mol%) were stirred in treated anhydrous CH_3OH (0.5 mL) under Ar atmosphere at 100 °C for 16 h. After completion, the crude product was separated by column chromatography (petroleum ether/ethyl acetate =10/1, v/v) to afford the product **3aa'**.



7. References

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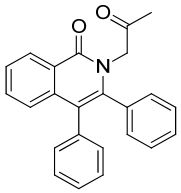
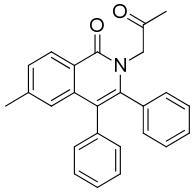
8. Characterization Data and NMR Spectra of isoquinolone derivatives

2-(2-oxopropyl)-3,4-diphenylisoquinolin-1(2H)-one (**3aa**)



The general procedure was applied to **1a** (0.05 mmol), **2a** (1.5 equiv), $[Cp^*RhCl_2]_2$ (4 mol%), $Cu(OAc)_2•H_2O$ (2.1 equiv), $AgNTf_2$ (10 mol%), PivOH (0.5 equiv) and H_2O (50 μL) in MeOH (0.5 mL) at 100 °C for 12 h under air. Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 3/1, v/v) afforded **3aa** as a white solid (86% yield). Melting point: 183.6 – 184.4 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.51 (d, *J* = 7.9 Hz, 1H), 7.53 (m, 2H), 7.23 – 7.05 (m, 11H), 4.63 (s, 2H), 2.07 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 201.9, 162.3, 140.6, 137.6, 136.4, 134.7, 132.6, 131.6, 130.1, 128.7, 128.3, 128.1, 128.0, 127.0, 126.9, 125.7, 124.8, 119.2, 55.7, 27.4. HRMS (ESI): m/z calcd for $C_{24}H_{19}O_2NNa$ $[M+Na]^+$: 376.1313, found: 376.1315.

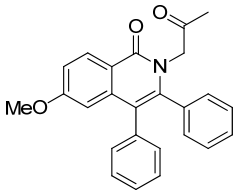
6-methyl-2-(2-oxopropyl)-3,4-diphenylisoquinolin-1(2*H*)-one (**3ba**)



The general procedure was applied to **1b** (0.05 mmol), **2a** (1.2 equiv), $[Cp^*RhCl_2]_2$ (4 mol%), $Cu(OAc)_2•H_2O$ (2.1 equiv), $AgNTf_2$ (10 mol%), PivOH (0.5 equiv) and H_2O (50 μL) in MeOH

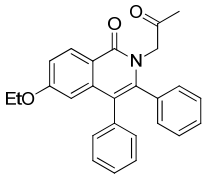
(0.5 mL) at 100 ºC for 12 h under air. Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 3/1, v/v) afforded **3ba** as a white solid (75% yield). Melting point: 185.5 – 187.6 °C; ^{1} H NMR (400 MHz, $CDCl_3$): δ = 8.39 (d, *J* = 8.2 Hz, 1H), 7.32 (dd, *J* = 8.2, 1.6 Hz, 1H), 7.24 – 7.14 (m, 6H), 7.13 – 7.05 (m, 4H), 6.94 (s, 1H), 4.61 (s, 2H), 2.35 (s, 3H), 2.06 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 202.1, 162.3, 143.2, 140.7, 137.7, 136.6, 134.8, 131.6, 130.2, 128.6, 128.5, 128.3, 128.1, 128.0, 126.9, 125.3, 122.7, 119.1, 55.6, 27.4, 22.2. HRMS (ESI): m/z calcd for $C_{25}H_{21}O_2NNa$ $[M+Na]^+$: 390.1470, found: 390.1474.

6-methoxy-2-(2-oxopropyl)-3,4-diphenylisoquinolin-1(2*H*)-one (**3ca**)



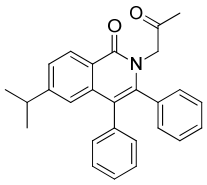
The general procedure was applied to **1c** (0.05 mmol), **2a** (1.5 equiv), $[Cp^*RhCl_2]_2$ (4 mol%), $Cu(OAc)_2•H_2O$ (2.1 equiv), $AgNTf_2$ (10 mol%), PivOH (0.5 equiv) and H_2O (50 μL) in MeOH (0.5 mL) at 100 ºC for 10 h under air. Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 3/1, v/v) afforded **3ca** as a white solid (93% yield). Melting point: 180.1 – 181.7 °C; ^{1} H NMR (400 MHz, $CDCl_3$): δ = 8.42 (d, *J* = 8.9 Hz, 1H), 7.23 – 7.12 (m, 6H), 7.12 – 7.04 (m, 5H), 6.52 (d, *J* = 2.5 Hz, 1H), 4.59 (s, 2H), 3.69 (s, 3H), 2.05 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 202.1, 163.0, 161.9, 141.3, 139.8, 136.4, 134.8, 131.5, 130.2, 130.0, 128.6, 128.3, 128.1, 127.0, 118.9, 118.8, 115.7, 107.4, 55.5, 55.4 (d, *J* = 8.1 Hz), 27.4. HRMS (ESI): m/z calcd for $C_{25}H_{21}O_3NNa$ $[M+Na]^+$: 406.1419, found: 406.1420.

6-ethoxy-2-(2-oxopropyl)-3,4-diphenylisoquinolin-1(2*H*)-one (**3da**)



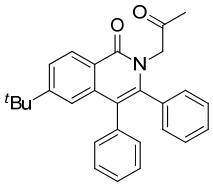
The general procedure was applied to **1d** (0.05 mmol), **2a** (1.2 equiv), $[Cp^*RhCl_2]_2$ (4 mol%), $Cu(OAc)_2•H_2O$ (2.1 equiv), $AgNTf_2$ (10 mol%), PivOH (0.5 equiv) and H_2O (50 μL) in MeOH (0.5 mL) at 100 ºC for 10 h under air. Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 3/1, v/v) afforded **3da** as a white solid (82% yield). Melting point: 195.9 – 198.6 °C; ^{1} H NMR (400 MHz, $CDCl_3$): δ = 8.41 (d, *J* = 8.9 Hz, 1H), 7.22 – 7.11 (m, 6H), 7.10 – 7.00(m, 5H), 6.51 (s, 1H), 4.59 (s, 2H), 3.90 (q, *J* = 7.0 Hz, 2H), 2.04 (s, 3H), 1.32 (t, *J* = 7.0 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 202.0, 162.4, 161.9, 141.2, 139.7, 136.5, 134.8, 131.5, 130.1, 130.0, 128.5, 128.2, 128.0, 126.9, 118.9, 118.6, 115.9, 108.1, 63.6, 55.4, 27.3, 14.6. HRMS (ESI): m/z calcd for $C_{26}H_{23}O_3NNa$ $[M+Na]^+$: 420.1576, found: 420.1578.

6-isopropyl-2-(2-oxopropyl)-3,4-diphenylisoquinolin-1(2*H*)-one (**3ea**)



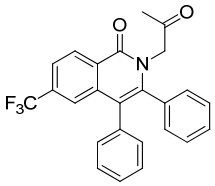
The general procedure was applied to **1e** (0.05 mmol), **2a** (1.2 equiv), $[Cp^*RhCl_2]_2$ (4 mol%), $Cu(OAc)_2•H_2O$ (2.1 equiv), $AgNTf_2$ (10 mol%), PivOH (0.5 equiv) and H_2O (50 μL) in MeOH (0.5 mL) at 100 ºC for 10 h under air. Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 3/1, v/v) afforded **3ea** as a white solid (83% yield). Melting point: 158.8 – 160.1 °C; ^{1} H NMR (400 MHz, $CDCl_3$): δ = 8.44 (d, *J* = 8.3 Hz, 1H), 7.40 (dd, *J* = 8.3, 1.8 Hz, 1H), 7.22 – 7.14 (m, 6H), 7.13 – 7.06 (m, 4H), 6.99 (s, 1H), 4.61 (s, 2H), 2.88 (m, 1H), 2.05 (s, 3H), 1.17 (d, *J* = 6.9 Hz, 6H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 202.0, 162.2, 153.9, 140.6, 137.8, 136.5, 134.8, 131.6, 130.2, 128.6, 128.3, 128.2, 128.0, 126.9, 125.6, 123.1, 123.0, 119.3, 55.6, 34.6, 27.4, 23.8. HRMS (ESI): m/z calcd for $C_{27}H_{25}O_2NNa$ $[M+Na]^+$: 418.1783, found: 418.1780.

6-(*tert*-butyl)-2-(2-oxopropyl)-3,4-diphenylisoquinolin-1(2*H*)-one (**3fa**)



The general procedure was applied to **1f** (0.05 mmol), **2a** (1.2 equiv), $[Cp^*RhCl_2]_2$ (4 mol%), $Cu(OAc)_2•H_2O$ (2.1 equiv), $AgNTf_2$ (10 mol%), PivOH (0.5 equiv) and H_2O (50 μL) in MeOH (0.5 mL) at 100 ºC for 10 h under air. Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 3/1, v/v) afforded **3fa** as a white solid (73% yield). Melting point: 167.2 – 169.4 °C; ^{1} H NMR (400 MHz, $CDCl_3$): δ = 8.43 (d, *J* = 8.5 Hz, 1H), 7.57 (dd, *J* = 8.5, 1.9 Hz, 1H), 7.24 – 7.13 (m, 7H), 7.13 – 7.07 (m, 4H), 4.61 (s, 2H), 2.06 (s, 3H), 1.22 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 202.0, 162.2, 156.1, 140.5, 137.5, 136.5, 134.9, 131.6, 130.2, 128.6, 128.3, 128.0, 127.8, 126.9, 125.0, 122.6, 121.7, 119.5, 55.6, 35.4, 31.1, 27.4. HRMS (ESI): m/z calcd for $C_{28}H_{27}O_2NNa$ $[M+Na]^+$: 432.1939, found: 432.1934.

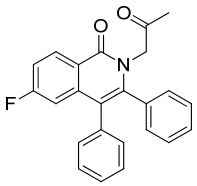
2-(2-oxopropyl)-3,4-diphenyl-6-(trifluoromethyl)isoquinolin-1(2*H*)-one (**3ga**)



The general procedure was applied to **1g** (0.05 mmol), **2a** (1.5 equiv), $[Cp^*RhCl_2]_2$ (4 mol%), $Cu(OAc)_2•H_2O$ (2.1 equiv), $AgNTf_2$ (10 mol%), PivOH (0.5 equiv) and H_2O (50 μL) in MeOH (0.5 mL) at 100 ºC for 12 h under air. Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 3/1, v/v) afforded **3ga** as a white solid (74% yield). Melting point: 163.9 – 165.4 °C; ^{1} H NMR (400 MHz, $CDCl_3$): δ = 8.61 (d, *J* = 8.4 Hz, 1H), 7.69 (dd, *J* = 8.4, 1.7 Hz, 1H), 7.45 (s, 1H), 7.25 – 7.16 (m, 6H), 7.13 – 7.03 (m, 4H), 4.65 (s, 2H), 2.06 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 201.4, 161.5, 142.3, 137.7, 135.3, 134.2, 134.1 (q, *J* = 32.3 Hz),

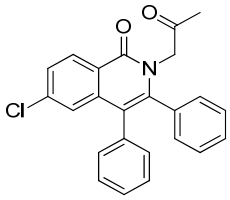
131.4, 129.9, 129.2, 129.0, 128.5, 128.4, 127.5, 126.9, 123.8 (q, J = 271.2 Hz), 122.9 (d, J = 11.3 Hz), 122.9 (d, J = 3.8 Hz), 118.9, 55.8, 27.4. ^{19}F NMR (376 MHz, $CDCl_3$): δ = -63.00. HRMS (ESI): m/z calcd for $C_{25}H_{18}F_3O_2NNa$ $[M+Na]^+$: 444.1187, found: 444.1189.

6-fluoro-2-(2-oxopropyl)-3,4-diphenylisoquinolin-1(2*H*)-one (**3ha**)



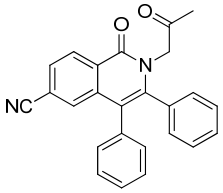
The general procedure was applied to **1h** (0.05 mmol), **2a** (1.5 equiv), $[Cp^*RhCl_2]_2$ (4 mol%), $Cu(OAc)_2•H_2O$ (2.1 equiv), $AgNTf_2$ (10 mol%), PivOH (0.5 equiv) and H_2O (50 μL) in MeOH (0.5 mL) at 100 ºC for 12 h under air. Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 3/1, v/v) afforded **3ha** as a white solid (35% yield). Melting point: 169.8 – 171.1 °C; ^{1} H NMR (400 MHz, $CDCl_3$): δ = 8.51 (dd, J = 8.9, 5.9 Hz, 1H), 7.24 – 7.16 (m, 7H), 7.12 – 7.06 (m, 4H), 6.80 (dd, J = 10.4, 2.5 Hz, 1H), 4.61 (s, 2H), 2.06 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 201.8, 165.6 (d, J = 250.5 Hz), 161.6, 142.0, 140.2 (d, J = 9.9 Hz), 135.9, 134.4, 131.4, 131.3 (d, J = 9.9 Hz), 129.9, 128.9, 128.4, 128.3, 127.3, 121.5 (d, J = 1.7 Hz), 118.7 (d, J = 3.3 Hz), 115.5 (d, J = 23.5 Hz), 110.8 (d, J = 23.2 Hz), 55.6, 27.4. ^{19}F NMR (376 MHz, $CDCl_3$): δ = -105.39. HRMS (ESI): m/z calcd for $C_{24}H_{19}O_2NF$ $[M+H]^+$: 372.1400, found: 372.1404.

6-chloro-2-(2-oxopropyl)-3,4-diphenylisoquinolin-1(2*H*)-one (**3ia**)



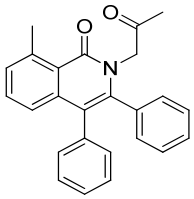
The general procedure was applied to **1i** (0.05 mmol), **2a** (1.5 equiv), $[Cp^*RhCl_2]_2$ (4 mol%), $Cu(OAc)_2•H_2O$ (2.1 equiv), $AgNTf_2$ (10 mol%), PivOH (0.5 equiv) and H_2O (50 μL) in MeOH (0.5 mL) at 100 ºC for 12 h under air. Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 3/1, v/v) afforded **3ia** as a white solid (41 % yield). Melting point: 175.1 – 177.1 °C; ^{1} H NMR (400 MHz, $CDCl_3$): δ = 8.43 (d, J = 8.6 Hz, 1H), 7.44 (dd, J = 8.6, 2.0 Hz, 1H), 7.24 – 7.15 (m, 6H), 7.14 (d, J = 2.0 Hz, 1H), 7.12 – 7.04 (m, 4H), 4.61 (s, 2H), 2.06 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 201.6, 161.7, 142.1, 139.3, 139.0, 135.7, 134.4, 131.5, 129.9, 128.9, 128.4, 128.3, 127.5, 127.3, 125.0, 123.2, 118.4, 55.7, 27.4. HRMS (ESI): m/z calcd for $C_{24}H_{19}ClO_2N$ $[M+H]^+$: 388.1104, found: 388.1104.

1-oxo-2-(2-oxopropyl)-3,4-diphenyl-1,2-dihydroisoquinoline-6-carbonitrile (**3ja**)



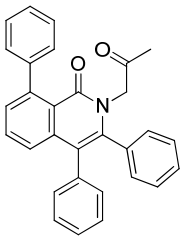
The general procedure was applied to **1j** (0.05 mmol), **2a** (1.5 equiv), $[Cp^*RhCl_2]_2$ (4 mol%), $Cu(OAc)_2•H_2O$ (2.1 equiv), $AgNTf_2$ (10 mol%), PivOH (0.5 equiv) and H_2O (50 μL) in MeOH (0.5 mL) at 100 ºC for 12 h under air. Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 3/1, v/v) afforded **3ja** as a white solid (51 % yield). Melting point: 131.5 – 133.4 °C; ^{1} H NMR (400 MHz, $CDCl_3$): δ = 8.58 (d, *J* = 8.3 Hz, 1H), 7.68 (dd, *J* = 8.3, 1.6 Hz, 1H), 7.50 (d, *J* = 1.5 Hz, 1H), 7.25 – 7.17 (m, 6H), 7.13 – 7.02 (m, 4H), 4.64 (s, 2H), 2.06 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 201.2, 161.3, 142.9, 137.8, 135.0, 133.9, 131.4, 130.7, 129.8, 129.3, 129.1, 128.6, 128.5, 127.7, 127.1, 118.4, 118.3, 116.1, 55.8, 27.4. HRMS (ESI): m/z calcd for $C_{25}H_{19}O_2N_2$ $[M+H]^+$: 379.1447, found: 379.1446.

8-methyl-2-(2-oxopropyl)-3,4-diphenylisoquinolin-1(2*H*)-one (**3ka**)



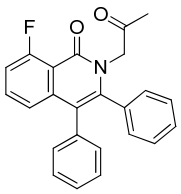
The general procedure was applied to **1k** (0.05 mmol), **2a** (1.5 equiv), $[Cp^*RhCl_2]_2$ (4 mol%), $Cu(OAc)_2•H_2O$ (2.1 equiv), $AgNTf_2$ (10 mol%), PivOH (0.5 equiv) and H_2O (50 μL) in MeOH (0.5 mL) at 100 ºC for 12 h under air. Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 4/1, v/v) afforded **3ka** as a white solid (51% yield). Melting point: 140.1 – 141.1 °C; ^{1} H NMR (400 MHz, $CDCl_3$): δ = 7.36 (t, *J* = 7.7 Hz, 1H), 7.24 (d, *J* = 7.4 Hz, 1H), 7.22 – 7.12 (m, 6H), 7.12 – 7.04 (m, 4H), 6.99 (d, *J* = 8.1 Hz, 1H), 4.57 (s, 2H), 2.97 (s, 3H), 2.07 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 202.3, 162.9, 142.0, 140.7, 139.4, 137.1, 134.9, 131.7, 130.1, 130.0, 128.5, 128.3, 128.0, 126.9, 124.1, 123.5, 119.1, 55.7, 27.4, 24.4. HRMS (ESI): m/z calcd for $C_{25}H_{21}O_2NNa$ $[M+Na]^+$: 390.1470, found: 390.1469.

2-(2-oxopropyl)-3,4,8-triphenylisoquinolin-1(2*H*)-one (**3la**)



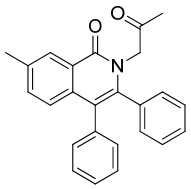
The general procedure was applied to **1l** (0.05 mmol), **2a** (1.5 equiv), $[Cp^*RhCl_2]_2$ (4 mol%), $Cu(OAc)_2•H_2O$ (2.1 equiv), $AgNTf_2$ (10 mol%), PivOH (0.5 equiv) and H_2O (50 μL) in MeOH (0.5 mL) at 100 ºC for 12 h under air. Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 3/1, v/v) afforded **3la** as a white solid (21% yield). Melting point: 221.5 – 224.1 °C; ^{1} H NMR (400 MHz, $CDCl_3$): δ = 7.55 – 7.47 (m, 1H), 7.44 – 7.33 (m, 5H), 7.29 – 7.25 (m, 1H), 7.25 – 7.11 (m, 9H), 7.11 – 7.06 (m, 2H), 4.56 (s, 2H), 1.89 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 202.0, 161.4, 144.7, 143.9, 141.2, 139.2, 137.0, 134.9, 131.8, 131.2, 130.6, 130.0, 128.6, 128.5, 128.3, 128.1, 127.5, 127.0, 126.6, 125.6, 122.1, 118.8, 55.4, 27.2. HRMS (ESI): m/z calcd for $C_{30}H_{23}O_2NNa$ $[M+Na]^+$: 452.1626, found:452.1629.

8-fluoro-2-(2-oxopropyl)-3,4-diphenylisoquinolin-1(2*H*)-one (**3ma**)



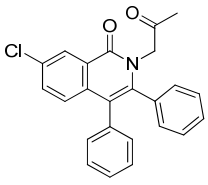
The general procedure was applied to **1m** (0.05 mmol), **2a** (1.5 equiv), $[Cp^*RhCl_2]_2$ (4 mol%), $Cu(OAc)_2•H_2O$ (2.1 equiv), $AgNTf_2$ (10 mol%), PivOH (0.5 equiv) and H_2O (50 μL) in MeOH (0.5 mL) at 100 ºC for 12 h under air. Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 4/1, v/v) afforded **3ma** as a white solid (50% yield). Melting point: 191.9 – 192.5 °C; ^{1} H NMR (400 MHz, $CDCl_3$): δ = 7.44 (td, *J* = 8.1, 4.9 Hz, 1H), 7.24 – 7.12 (m, 6H), 7.12 – 7.03 (m, 5H), 6.91 (d, *J* = 8.2 Hz, 1H), 4.55 (s, 2H), 2.08 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 201.8, 162.7 (d, *J* = 262.7 Hz), 159.4 (d, *J* = 4.7 Hz), 142.1, 140.4, 136.3, 134.4, 133.2 (d, *J* = 10 Hz), 131.5, 129.8, 128.8, 128.3, 128.1, 127.1, 121.6 (d, *J* = 4.4 Hz), 118.3 (d, *J* = 2.5 Hz), 114.0 (d, *J* = 4.9 Hz), 113.6 (d, *J* = 21.6 Hz), 55.4, 27.5. ^{19}F NMR (376 MHz, $CDCl_3$): δ = -110.67. HRMS (ESI): m/z calcd for $C_{24}H_{19}O_2FNH$ $[M+H]^+$: 372.1400, found: 372.1396.

7-methyl-2-(2-oxopropyl)-3,4-diphenylisoquinolin-1(2*H*)-one (**3na**)



The general procedure was applied to **1n** (0.05 mmol), **2a** (1.2 equiv), $[Cp^*RhCl_2]_2$ (4 mol%), $Cu(OAc)_2•H_2O$ (2.1 equiv), $AgNTf_2$ (10 mol%), PivOH (0.5 equiv) and H_2O (50 μL) in MeOH (0.5 mL) at 100 ºC for 10 h under air. Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 3/1, v/v) afforded **3na** as a white solid (84% yield). Melting point: 138.8 – 140.4 °C; ^{1} H NMR (400 MHz, $CDCl_3$): δ = 8.31 (s, 1H), 7.35 (dd, *J* = 8.3, 1.9 Hz, 1H), 7.22 – 7.11 (m, 6H), 7.08 (m, 5H), 4.62 (s, 2H), 2.47 (s, 3H), 2.04 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 201.9, 162.1, 139.6, 136.8, 136.4, 135.2, 134.6, 133.9, 131.4, 130.1, 128.5, 128.2, 127.9, 127.5, 126.8, 125.5, 124.6, 119.0, 55.5, 27.3, 21.4. HRMS (ESI): m/z calcd for $C_{25}H_{21}O_2NNa$ $[M+Na]^+$: 390.1470, found: 390.1470.

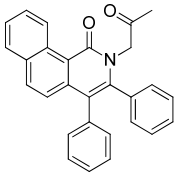
7-chloro-2-(2-oxopropyl)-3,4-diphenylisoquinolin-1(2*H*)-one (**3oa**)



The general procedure was applied to **1o** (0.05 mmol), **2a** (1.5 equiv), $[Cp^*RhCl_2]_2$ (4 mol%), $Cu(OAc)_2•H_2O$ (2.1 equiv), $AgNTf_2$ (10 mol%), PivOH (0.5 equiv) and H_2O (50 μL) in MeOH (0.5 mL) at 100 ºC for 12 h under air. Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 3/1, v/v) afforded **3oa** as a white solid (49% yield). Melting point: 157.8 – 159.5 °C; ^{1} H NMR (400 MHz, $CDCl_3$): δ = 8.46 (d, *J* = 2.3 Hz, 1H), 7.47 (dd, *J* = 8.7, 2.3 Hz, 1H), 7.18 (m, 6H), 7.14 – 7.04 (m, 5H), 4.62 (s, 2H), 2.05 (s, 3H); ^{13}C NMR (100 MHz,

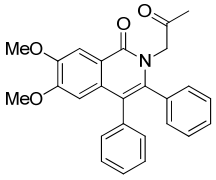
$CDCl_3$): δ = 201.6, 161.3, 141.0, 136.0, 135.9, 134.3, 133.0, 132.9, 131.5, 130.0, 128.8, 128.4, 128.2, 127.5, 127.4, 127.2, 125.9, 118.7, 55.7, 27.4. HRMS (ESI): m/z calcd for $C_{24}H_{18}O_2ClNNa$ $[M+Na]^+$: 410.0924, found: 410.0925.

2-(2-oxopropyl)-3,4-diphenylbenzo[*h*]isoquinolin-1(2*H*)-one (**3pa**)



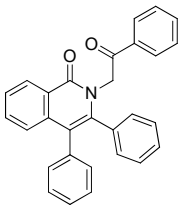
The general procedure was applied to **1p** (0.05 mmol), **2a** (1.5 equiv), $[Cp^*RhCl_2]_2$ (4 mol%), $Cu(OAc)_2•H_2O$ (2.1 equiv), $AgNTf_2$ (10 mol%), PivOH (0.5 equiv) and H_2O (50 μL) in MeOH (0.5 mL) at 100 ºC for 12 h under air. Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 3/1, v/v) afforded **3pa** as a white solid (66% yield). Melting point: 161.3 – 162.6 °C; ^{1} H NMR (400 MHz, $CDCl_3$): δ = 10.23 (d, *J* = 8.7 Hz, 1H), 7.89 (t, *J* = 9.2 Hz, 2H), 7.74 (t, *J* = 7.1 Hz, 1H), 7.61 (t, *J* = 7.4 Hz, 1H), 7.25 – 7.17 (m, 7H), 7.17 – 7.11 (m, 4H), 4.73 (s, 2H), 2.16 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 202.0, 162.4, 142.6, 139.0, 137.0, 134.9, 133.9, 132.3, 132.0, 131.9, 129.9, 128.7, 128.6, 128.4, 128.3, 128.2, 127.8, 127.1, 126.6, 123.6, 119.5, 118.4, 56.3, 27.6. HRMS (ESI): m/z calcd for $C_{28}H_{21}O_2NNa$ $[M+Na]^+$: 426.1470, found: 426.1470.

6,7-dimethoxy-2-(2-oxopropyl)-3,4-diphenylisoquinolin-1(2*H*)-one (**3qa**)



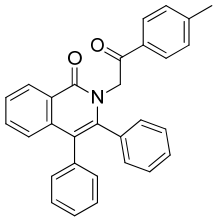
The general procedure was applied to **1q** (0.05 mmol), **2a** (1.5 equiv), $[Cp^*RhCl_2]_2$ (4 mol%), $Cu(OAc)_2•H_2O$ (2.1 equiv), $AgNTf_2$ (10 mol%), PivOH (0.5 equiv) and H_2O (50 μL) in MeOH (0.5 mL) at 100 ºC for 12 h under air. Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 3/1, v/v) afforded **3qa** as a white solid (50% yield). Melting point: 252.2 – 253.7 °C; ^{1} H NMR (400 MHz, $CDCl_3$): δ = 7.88 (s, 1H), 7.22 – 7.13 (m, 6H), 7.13 – 7.06 (m, 4H), 6.52 (s, 1H), 4.61 (s, 2H), 4.01 (s, 3H), 3.69 (s, 3H), 2.07 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 202.1, 161.5, 153.6, 149.3, 139.4, 136.7, 134.8, 133.2, 131.5, 130.3, 128.6, 128.3, 128.1, 127.0, 118.9, 118.8, 107.9, 106.0, 56.3 (d, *J* = 2.6 Hz), 55.9 (d, *J* = 2.3 Hz), 55.8, 27.5. HRMS (ESI): m/z calcd for $C_{26}H_{24}O_4N$ $[M+H]^+$: 414.1705, found: 414.1699.

2-(2-oxo-2-phenylethyl)-3,4-diphenylisoquinolin-1(2*H*)-one (**3ra**)



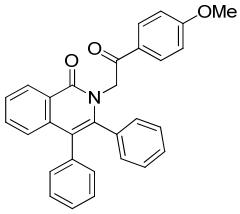
The general procedure was applied to **1r** (0.05 mmol), **2a** (1.5 equiv), $[Cp^*RhCl_2]_2$ (4 mol%), $Cu(OAc)_2•H_2O$ (2.1 equiv), $AgNTf_2$ (10 mol%), PivOH (0.5 equiv) and H_2O (50 μL) in MeOH (0.5 mL) at 100 ºC for 12 h under air. Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 4/1, v/v) afforded **3ra** as a white solid (62% yield). Melting point: 224.3 – 225.8 °C; ^{1} H NMR (400 MHz, $CDCl_3$): δ = 8.54 (d, J = 7.9 Hz, 1H), 7.82 (d, J = 7.5 Hz, 2H), 7.60 – 7.47 (m, 3H), 7.40 (t, J = 7.7 Hz, 2H), 7.24 – 7.07 (m, 11H), 5.27 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 193.6, 162.4, 141.0, 137.7, 136.5, 135.2, 134.7, 133.6, 132.5, 131.6, 130.1, 128.7, 128.6, 128.3, 128.1, 128.0, 128.0, 126.9, 126.8, 125.6, 124.9, 119.2, 52.6. HRMS (ESI): m/z calcd for $C_{29}H_{21}O_2NNa$ $[M+Na]^+$: 438.1470, found: 438.1472.

2-(2-oxo-2-phenylethyl)-3,4-diphenylisoquinolin-1(2*H*)-one (**3sa**)



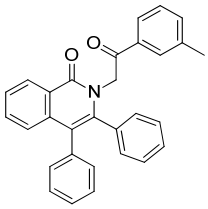
The general procedure was applied to **1s** (0.05 mmol), **2a** (1.5 equiv), $[Cp^*RhCl_2]_2$ (4 mol%), $Cu(OAc)_2•H_2O$ (2.1 equiv), $AgNTf_2$ (10 mol%), PivOH (0.5 equiv) and H_2O (50 μL) in MeOH (0.5 mL) at 100 ºC for 12 h under air. Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 4/1, v/v) afforded **3sa** as a white solid (29% yield). Melting point: 239.3 – 241.5 °C; ^{1} H NMR (400 MHz, $CDCl_3$): δ = 8.53 (d, *J* = 8, 1H), 7.71 (d, *J* = 8.1 Hz, 2H), 7.60 – 7.47 (m, 2H), 7.23 – 7.08 (m, 13H), 5.24 (s, 2H), 2.38 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): 193.2, 162.5, 144.5, 141.0, 137.7, 136.6, 134.8, 132.8, 132.5, 131.7, 130.2, 129.4, 128.6, 128.3, 128.2, 128.1, 128.1, 127.0, 126.8, 125.7, 125.0, 119.2, 52.5, 21.8. HRMS (ESI): m/z calcd for $C_{30}H_{23}O_2NNa$ $[M+Na]^+$: 452.1626, found: 452.1627.

2-(2-(4-methoxyphenyl)-2-oxoethyl)-3,4-diphenylisoquinolin-1(2*H*)-one (**3ta**)



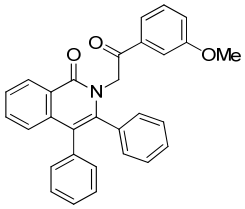
The general procedure was applied to **1t** (0.05 mmol), **2a** (1.5 equiv), $[Cp^*RhCl_2]_2$ (4 mol%), $Cu(OAc)_2•H_2O$ (2.1 equiv), $AgNTf_2$ (10 mol%), PivOH (0.5 equiv) and H_2O (50 μL) in MeOH (0.5 mL) at 100 ºC for 12 h under air. Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 4/1, v/v) afforded **3ta** as a white solid (42% yield). Melting point: 247.5 – 248.7 ºC ; ^{1} H NMR (400 MHz, $CDCl_3$): δ = 8.53 (d, *J* = 7.8 Hz, 1H), 7.81 (d, *J* = 8.6 Hz, 2H), 7.53 (dt, *J* = 26.0, 7.3 Hz, 2H), 7.23 – 7.08 (m, 11H), 6.87 (d, *J* = 8.6 Hz, 2H), 5.23 (s, 2H), 3.84 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 192.0, 163.9, 162.5, 141.1, 137.7, 136.6, 134.8, 132.5, 131.7, 130.3, 130.2, 128.6, 128.3, 128.2, 128.1, 127.0, 126.8, 125.7, 125.0, 119.2, 113.9, 55.6, 52.3. HRMS (ESI): m/z calcd for $C_{30}H_{23}O_3NNa$ $[M+Na]^+$: 468.1576, found: 468.1576.

2-(2-oxo-2-phenylethyl)-3,4-diphenylisoquinolin-1(2*H*)-one (**3ua**)



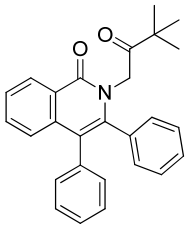
The general procedure was applied to **1u** (0.05 mmol), **2a** (1.5 equiv), $[Cp^*RhCl_2]_2$ (4 mol%), $Cu(OAc)_2•H_2O$ (2.1 equiv), $AgNTf_2$ (10 mol%), PivOH (0.5 equiv) and H_2O (50 μL) in MeOH (0.5 mL) at 100 ºC for 12 h under air. Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 4/1, v/v) afforded **3ua** as a white solid (20% yield). Melting point: 219.1 – 222.8 °C; ^{1} H NMR (400 MHz, $CDCl_3$): δ = 8.53 (d, *J* = 7.5 Hz, 1H), 7.67 – 7.46 (m, 4H), 7.32 (dd, *J* = 22.5, 7.6 Hz, 2H), 7.24 – 7.09 (m, 11H), 5.24 (s, 2H), 2.36 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 193.9, 162.4, 141.1, 138.6, 137.7, 136.6, 135.3, 134.8, 134.4, 132.5, 131.7, 130.2, 128.6, 128.6, 128.3, 128.2, 128.1, 127.0, 126.8, 125.7, 125.2, 125.0, 119.3, 52.7, 21.4. HRMS (ESI): m/z calcd for $C_{30}H_{23}O_2NNa$ $[M+Na]^+$: 452.1626, found: 452.1624.

2-(2-(3-methoxyphenyl)-2-oxoethyl)-3,4-diphenylisoquinolin-1(2*H*)-one (**3va**)



The general procedure was applied to **1v** (0.05 mmol), **2a** (1.5 equiv), $[Cp^*RhCl_2]_2$ (4 mol%), $Cu(OAc)_2•H_2O$ (2.1 equiv), $AgNTf_2$ (10 mol%), PivOH (0.5 equiv) and H_2O (50 μL) in MeOH (0.5 mL) at 100 ºC for 12 h under air. Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 4/1, v/v) afforded **3va** as a white solid (27% yield). Melting point: 262.7 – 265.4 °C; ^{1} H NMR (400 MHz, $CDCl_3$): δ = 8.53 (d, *J* = 7.9 Hz, 1H), 7.61 – 7.47 (m, 2H), 7.35 (dt, *J* = 5.9, 1.7 Hz, 2H), 7.30 (t, *J* = 8.1 Hz, 1H), 7.25 – 7.05 (m, 12H), 5.24 (s, 2H), 3.82 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 193.5, 162.4, 159.9, 141.0, 137.7, 136.6, 134.7, 132.6, 131.7, 130.2, 129.8, 128.7, 128.3, 128.2, 128.1, 127.0, 126.9, 125.7, 124.9, 120.5, 120.2, 119.3, 112.3, 55.6, 52.8. HRMS (ESI): m/z calcd for $C_{30}H_{23}O_3NNa$ $[M+Na]^+$: 468.1576, found: 468.1576.

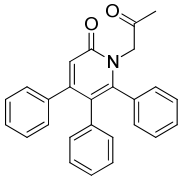
2-(3,3-dimethyl-2-oxobutyl)-3,4-diphenylisoquinolin-1(2*H*)-one (**3wa**)



The general procedure was applied to **1w** (0.05 mmol), **2a** (1.5 equiv), $[Cp^*RhCl_2]_2$ (4 mol%), $Cu(OAc)_2•H_2O$ (2.1 equiv), $AgNTf_2$ (10 mol%), PivOH (0.5 equiv), and H_2O (50 μL) in MeOH (0.5 mL) at 100 ºC for 12 h under air. Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 3/1, v/v) afforded **3wa** as a white solid (60% yield). Melting point:

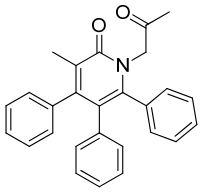
226.9 – 229.8 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ =8.51 (d, *J* = 6.4 Hz, 1H), 7.50 (dt, *J* = 21.9, 6.4 Hz, 2H), 7.23 – 7.03 (m, 11H), 4.89 (s, 2H), 1.01 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 208.5, 162.3, 140.8, 137.6, 136.5, 134.7, 132.4, 131.6, 130.2, 128.6, 128.1, 128.0, 126.9, 126.7, 125.6, 124.9, 119.1, 51.1, 43.2, 26.4. HRMS (ESI): m/z calcd for $C_{27}H_{25}O_2NNa$ $[M+Na]^+$: 418.1783, found: 418.1783.

1-(2-oxopropyl)-4,5,6-triphenylpyridin-2(1*H*)-one (**3xa**)



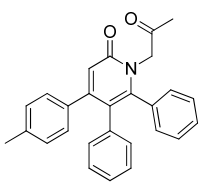
The general procedure was applied to **1x** (0.05 mmol), **2a** (1.5 equiv), $[Cp^*RhCl_2]_2$ (4 mol%), $Cu(OAc)_2•H_2O$ (2.1 equiv), $AgNTf_2$ (10 mol%), PivOH (0.5 equiv) and H_2O (50 μL) in MeOH (0.5 mL) at 100 ºC for 12 h under air. Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 2/1, v/v) afforded **3xa** as a white solid (26% yield). Melting point: 160.7 – 161.6 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.24 – 7.17 (m, 3H), 7.17 – 7.10 (m, 3H), 7.10 – 6.99 (m, 4H), 6.95 – 6.81 (m, 3H), 6.77 – 6.66 (m, 3H), 4.61 (s, 2H), 2.07 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 201.4, 161.9, 154.2, 147.3, 138.8, 136.7, 134.4, 131.7, 129.7, 128.9, 128.4, 127.8, 127.4, 126.3, 120.8, 119.0, 55.7, 27.6. HRMS (ESI): m/z calcd for $C_{26}H_{21}O_2NNa$ $[M+Na]^+$: 402.1470, found: 402.1465.

3-methyl-1-(2-oxopropyl)-4,5,6-triphenylpyridin-2(1*H*)-one (**3ya**)



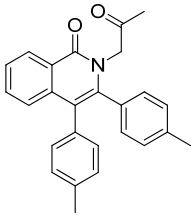
The general procedure was applied to **1y** (0.05 mmol), **2a** (1.5 equiv), $[Cp^*RhCl_2]_2$ (4 mol%), $Cu(OAc)_2•H_2O$ (2.1 equiv), $AgNTf_2$ (10 mol%), PivOH (0.5 equiv) and H_2O (50 μL) in MeOH (0.5 mL) at 100 ºC for 12 h under air. Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 2/1, v/v) afforded **3ya** as a white solid (48% yield). Melting point: 188.3 – 193.8 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.23 – 7.04 (m, 8H), 6.98 – 6.93 (m, 2H), 6.83 – 6.74 (m, 3H), 6.73 – 6.64 (m, 2H), 4.59 (s, 2H), 2.12 (s, 3H), 2.00 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 201.7, 162.4, 150.8, 143.6, 138.4, 137.3, 134.5, 131.6, 129.9, 128.9, 128.7, 128.3, 127.7, 127.0, 126.9, 125.8, 125.6, 121.5, 56.2, 27.7, 15.0. HRMS (ESI): m/z calcd for $C_{27}H_{23}O_2NNa$ $[M+Na]^+$: 416.1626, found: 416.1624.

1-(2-oxopropyl)-5,6-diphenyl-4-(*p*-tolyl)pyridin-2(1*H*)-one (**3za**)



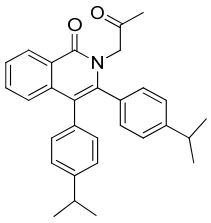
The general procedure was applied to **1z** (0.05 mmol), **2a** (1.5 equiv), $[Cp^*RhCl_2]_2$ (4 mol%), $Cu(OAc)_2•H_2O$ (2.1 equiv), $AgNTf_2$ (10 mol%), PivOH (0.5 equiv) and H_2O (50 μL) in MeOH (0.5 mL) at 100 ºC for 12 h under air. Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 2/1, v/v) afforded **3za** as a white solid (47% yield). Melting point: 162.3 – 163.9 °C; ^{1} H NMR (400 MHz, $CDCl_3$): δ = 7.23 – 7.15 (m, 3H), 7.11 – 7.04 (m, 2H), 6.94 (s, 4H), 6.92 – 6.86 (m, 3H), 6.78 – 6.72 (m, 2H), 6.70 (s, 1H), 4.60 (s, 2H), 2.24 (s, 3H), 2.07 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 201.5, 162.0, 154.1, 147.3, 137.7, 136.8, 135.8, 134.5, 131.7, 129.7, 128.9, 128.6, 128.4, 127.4, 126.2, 120.9, 118.9, 55.7, 27.6, 21.3. HRMS (ESI): m/z calcd for $C_{27}H_{23}O_2NNa$ $[M+Na]^+$: 416.1626, found: 416.1626.

2-(2-oxopropyl)-3,4-di-*p*-tolylisoquinolin-1(2*H*)-one (**3ab**)



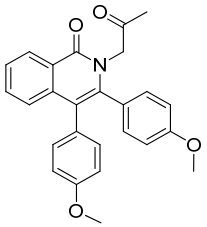
The general procedure was applied to **1a** (0.05 mmol), **2b** (1.5 equiv), $[Cp^*RhCl_2]_2$ (4 mol%), $Cu(OAc)_2•H_2O$ (2.1 equiv), $AgNTf_2$ (10 mol%), PivOH (0.5 equiv) and H_2O (50 μL) in MeOH (0.5 mL) at 100 ºC for 12 h under air. Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 3/1, v/v) afforded **3ab** as a white solid (75% yield). Melting point: 145.1 – 148.3 °C; ^{1} H NMR (400 MHz, $CDCl_3$): δ = 8.49 (d, *J* = 6.4 Hz, 1H), 7.50 (dt, *J* = 21.1, 7.0 Hz, 2H), 7.17 (d, *J* = 7.5 Hz, 1H), 7.03 – 6.95 (m, 8H), 4.61 (s, 2H), 2.27 (d, *J* = 2.9 Hz, 6H), 2.07 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 202.0, 162.4, 140.7, 138.4, 137.9, 136.4, 133.4, 132.4, 131.8, 131.4, 129.9, 129.0, 128.8, 127.9, 126.7, 125.7, 124.8, 119.2, 55.7, 27.4, 21.4 (d, *J* = 1.9 Hz), 21.3 (d, *J* = 1.7 Hz). HRMS (ESI): m/z calcd for $C_{26}H_{24}O_2N$ $[M+H]^+$: 382.1807, found: 382.1813.

3,4-bis(4-isopropylphenyl)-2-(2-oxopropyl)isoquinolin-1(2*H*)-one (**3ac**)



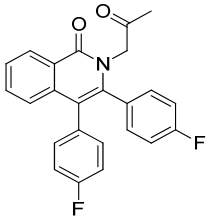
The general procedure was applied to **1a** (0.05 mmol), **2c** (1.5 equiv), $[Cp^*RhCl_2]_2$ (4 mol%), $Cu(OAc)_2•H_2O$ (2.1 equiv), $AgNTf_2$ (10 mol%), PivOH (0.5 equiv) and H_2O (50 μL) in MeOH (0.5 mL) at 100 ºC for 12 h under air. Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 3/1, v/v) afforded **3ac** as a white solid (63% yield). Melting point: 132 – 137 °C; ^{1} H NMR (400 MHz, $CDCl_3$): δ = 8.51 (d, *J* = 6.4 Hz, 1H), 7.59 – 7.45 (m, 2H), 7.28 (s, 1H), 7.07 – 6.95 (m, 8H), 4.68 (s, 2H), 2.88 – 2.74 (m, 2H), 2.09 (s, 3H), 1.16 (t, *J* = 7.2 Hz, 12H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 202.1, 162.3, 149.2, 147.3, 140.9, 137.8, 133.7, 132.4, 132.1, 131.4, 130.1, 127.9, 126.7, 126.1, 125.9, 125.8, 124.7, 119.4, 55.7, 33.9, 33.8, 27.5, 24.0, 23.8. HRMS (ESI): m/z calcd for $C_{30}H_{32}O_2N$ $[M+H]^+$: 438.2433, found: 438.2428.

3,4-bis(4-methoxyphenyl)-2-(2-oxopropyl)isoquinolin-1(2*H*)-one (**3ad**)



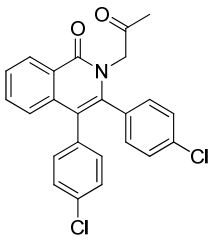
The general procedure was applied to **1a** (0.05 mmol), **2d** (1.2 equiv), $[Cp^*RhCl_2]_2$ (4 mol%), $Cu(OAc)_2•H_2O$ (2.1 equiv), $AgNTf_2$ (10 mol%), PivOH (0.5 equiv) and H_2O (50 μL) in MeOH (0.5 mL) at 100 ºC for 12 h under air. Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 3/1, v/v) afforded **3ad** as a white solid (76% yield). Melting point: 204.7 – 206.5 °C; ^{1} H NMR (400 MHz, $CDCl_3$): δ = 8.48 (d, *J* = 6.4, 1H), 7.58 – 7.42 (m, 2H), 7.19 (d, *J* = 9.2 Hz, 1H), 7.04 – 6.95 (m, 4H), 6.80 – 6.67 (m, 4H), 4.63 (s, 2H), 3.74 (d, *J* = 4.4 Hz, 6H), 2.08 (s, 3H) ; ^{13}C NMR (100 MHz, $CDCl_3$): δ = 202.1, 162.4, 159.4, 158.3, 140.7, 138.0, 132.6, 132.5, 131.3, 128.8, 128.0, 127.2, 126.7, 125.7, 124.8, 119.2, 113.7, 113.5, 55.7, 55.3 (d, *J* = 2.7), 55.2 (d, *J* = 2.6), 27.5. HRMS (ESI): m/z calcd for $C_{26}H_{23}O_4NNa$ $[M+Na]^+$: 436.1525, found: 436.1530.

3,4-bis(4-fluorophenyl)-2-(2-oxopropyl)isoquinolin-1(2*H*)-one (**3ae**)



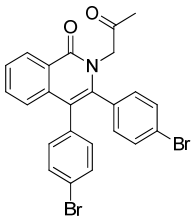
The general procedure was applied to **1a** (0.05 mmol), **2e** (1.2 equiv), $[Cp^*RhCl_2]_2$ (4 mol%), $Cu(OAc)_2•H_2O$ (2.1 equiv), $AgNTf_2$ (10 mol%), PivOH (0.5 equiv) and H_2O (50 μL) in MeOH (0.5 mL) at 100 ºC for 10 h under air. Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 3/1, v/v) afforded **3ae** as a white solid (71% yield). Melting point: 172.5 – 173.8 °C; ^{1} H NMR (400 MHz, $CDCl_3$): δ = 8.48 (d, *J* = 7.5 Hz, 1H), 7.53 (dt, *J* = 24.6, 7.4 Hz, 2H), 7.18 – 6.98 (m, 5H), 6.90 (t, *J* = 8.5 Hz, 4H), 4.61 (s, 2H), 2.08 (s, 3H) ;^{13}C NMR (100 MHz, $CDCl_3$): δ =201.8, 162.5 (d, *J* = 248.3 Hz), 162.1, 161.8 (d, *J* = 245.2 Hz), 139.9, 137.4, 133.1 (d, *J* = 7.9 Hz), 132.7, 132.2 (d, *J* = 3.4 Hz), 132.0 (d, *J* = 8.1 Hz), 130.5 (d, *J* = 3.7 Hz), 128.1, 127.1, 125.4, 124.9, 118.5, 115.6 (d, *J* = 21.5 Hz), 115.3 (d, *J* = 21.4 Hz), 55.5, 27.5. ^{19}F NMR (376 MHz, $CDCl_3$): δ = -111.32, -114.74. HRMS (ESI): m/z calcd for $C_{24}H_{17}O_2F_2NNa$ $[M+Na]^+$: 412.1125, found: 412.1127.

3,4-bis(4-chlorophenyl)-2-(2-oxopropyl)isoquinolin-1(2*H*)-one (**3af**)



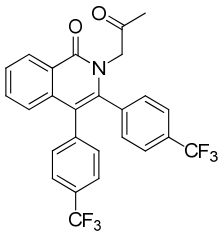
The general procedure was applied to **1a** (0.05 mmol), **2f** (1.2 equiv), $[Cp^*RhCl_2]_2$ (4 mol%), $Cu(OAc)_2•H_2O$ (2.1 equiv), $AgNTf_2$ (10 mol%), PivOH (0.5 equiv) and H_2O (50 μL) in MeOH (0.5 mL) at 100 ºC for 12 h under air. Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 3/1, v/v) afforded **3af** as a white solid (58% yield). Melting point: 197.3 – 200.6 °C; ^{1} H NMR (400 MHz, $CDCl_3$): δ = 8.48 (d, *J* = 6.4 Hz, 1H), 7.61 – 7.47 (m, 2H), 7.20 (d, *J* = 7.5 Hz, 4H), 7.11 (d, *J* = 7.3 Hz, 1H), 7.03 (dd, *J* = 14.2, 8.4 Hz, 4H), 4.59 (s, 2H), 2.10 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 201.8, 162.1, 139.6, 137.1, 135.1, 134.6, 133.3, 132.8, 131.4, 128.9, 128.6, 128.2, 127.3, 125.4, 124.9, 118.2, 55.6, 27.6. HRMS (ESI): m/z calcd for $C_{24}H_{17}Cl_2O_2NNa$ $[M+Na]^+$: 444.0534, found: 444.0528.

3,4-bis(4-bromophenyl)-2-(2-oxopropyl)isoquinolin-1(2*H*)-one (**3ag**)



The general procedure was applied to **1a** (0.05 mmol), **2g** (1.5 equiv), $[Cp^*RhCl_2]_2$ (4 mol%), $Cu(OAc)_2•H_2O$ (2.1 equiv), $AgNTf_2$ (10 mol%), PivOH (0.5 equiv) and H_2O (50 μL) in MeOH (0.5 mL) at 100 ºC for 12 h under air. Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 3/1, v/v) afforded **3ag** as a white solid (62% yield). Melting point: 219.3 – 220.7 °C; ^{1} H NMR (400 MHz, $CDCl_3$): δ = 8.48 (d, *J* = 7.8 Hz, 1H), 7.63 – 7.47 (m, 2H), 7.36 (dd, *J* = 8.4, 2.6 Hz, 4H), 7.11 (d, *J* = 8.7 Hz, 1H), 6.97 (dd, *J* = 12.8, 8.4 Hz, 4H), 4.58 (s, 2H), 2.10 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 201.8 ,162.1, 139.6, 137.0, 135.1, 133.2, 133.1, 132.8, 131.8, 131.6, 131.6, 128.1, 127.3, 125.4, 124.9, 123.4, 121.6, 118.1, 55.6, 27.6. HRMS (ESI): m/z calcd for $C_{24}H_{17}O_2NBr_2Na$ $[M+Na]^+$:531.9524, found:531.9526.

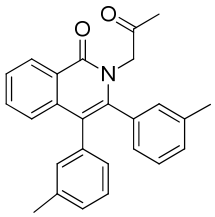
2-(2-oxopropyl)-3,4-bis(4-(trifluoromethyl)phenyl)isoquinolin-1(2*H*)-one (**3ah**)



The general procedure was applied to **1a** (0.05 mmol), **2h** (1.5 equiv), $[Cp^*RhCl_2]_2$ (4 mol%), $Cu(OAc)_2•H_2O$ (2.1 equiv), $AgNTf_2$ (10 mol%), PivOH (0.5 equiv) and H_2O (50 μL) in MeOH (0.5 mL) at 100 ºC for 12 h under air. Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 3/1, v/v) afforded **3ah** as a white solid (39% yield). Melting point:

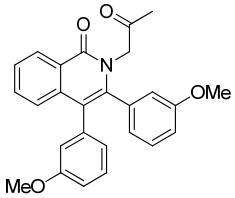
210.7 – 213.1 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.49 (d, *J* = 7.8 Hz, 1H), 7.60 – 7.50 (m, 2H), 7.50 – 7.44 (m, 4H), 7.22 (dd, *J* = 19.7, 8.1 Hz, 4H), 7.05 (d, *J* = 8.4 Hz, 1H), 4.55 (s, 2H), 2.09 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 201.7, 162.1, 139.9, 139.4, 137.8, 136.8, 133.1, 131.9, 131.3 (d, *J* = 33.0 Hz), 130.6, 129.7 (d, *J* = 32.4 Hz), 129.6, 128.3, 127.7, 125.6 (d, *J* = 10.7 Hz), 125.6 (d, *J* = 3.7 Hz), 125.4 (d, *J* = 11 Hz), 125.4 (d, *J* = 3.9 Hz), 125.0, 124.0 (q, *J* = 271.0 Hz), 123.6 (q, *J* = 271.0 Hz), 118.2, 55.6, 27.6. ^{19}F NMR (376 MHz, $CDCl_3$): δ = -62.72, -62.99. HRMS (ESI): m/z calcd for $C_{26}H_{17}O_2F_6NNa$ $[M+Na]^+$:512.1061, found:512.1060.

2-(2-oxopropyl)-3,4-di-*m*-tolylisoquinolin-1(2*H*)-one (**3ai**)



The general procedure was applied to **1a** (0.05 mmol), **2i** (1.2 equiv), $[Cp^*RhCl_2]_2$ (4 mol%), $Cu(OAc)_2•H_2O$ (2.1 equiv), $AgNTf_2$ (10 mol%), PivOH (0.5 equiv) and H_2O (50 μL) in MeOH (0.5 mL) at 100 ºC for 10 h under air. Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 3/1, v/v) afforded **3ai** as a white solid (75% yield). Melting point: 152.9 – 154.4 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.50 (d, *J* = 7.5 Hz, 1H), 7.51 (dt, *J* = 25.2, 7.0 Hz, 2H), 7.19 (d, *J* = 8.0 Hz, 1H), 7.12 – 7.04 (m, 2H), 7.00 (d, *J* = 7.7 Hz, 1H), 6.98 – 6.86 (m, 5H), 4.70 – 4.53 (m, 2H), 2.22 (s, 6H), 2.07 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 201.9, 162.3, 140.7, 137.9 (d, *J* = 7.2 Hz), 137.7, 137.4 (d, *J* = 6.9 Hz), 136.3, 134.6, 132.5, 132.3 (d, *J* = 6.5 Hz), 130.7 (d, *J* = 7.2 Hz), 129.3 (d, *J* = 2.1 Hz), 128.6, 128.1 (d, *J* = 7.7 Hz), 128.0, 127.8 (d, *J* = 6 Hz), 127.7 (d, *J* = 1.5 Hz), 127.1 (d, *J* = 3.6 Hz), 126.8, 125.7, 124.8, 119.2, 55.7, 27.4, 21.4 (d, *J* = 1.1 Hz), 21.3 (d, *J* = 2.4 Hz). HRMS (ESI): m/z calcd for $C_{26}H_{23}O_2NNa$ $[M+Na]^+$: 404.1626, found: 404.1630.

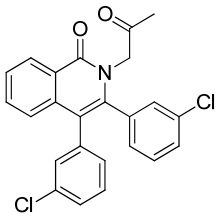
3,4-bis(3-methoxyphenyl)-2-(2-oxopropyl)isoquinolin-1(2*H*)-one (**3aj**)



The general procedure was applied to **1a** (0.05 mmol), **2j** (1.2 equiv), $[Cp^*RhCl_2]_2$ (4 mol%), $Cu(OAc)_2•H_2O$ (2.1 equiv), $AgNTf_2$ (10 mol%), PivOH (0.5 equiv) and H_2O (50 μL) in MeOH (0.5 mL) at 100 ºC for 10 h under air. Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 3/1, v/v) afforded **3aj** as a white solid (78% yield). Melting point: 174.2 – 175.6 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.49 (d, *J* = 7.9 Hz, 1H), 7.60 – 7.45 (m, 2H), 7.22 (dd, *J* = 8.6, 4.2 Hz, 1H), 7.12 (qd, *J* = 8.1, 2.1 Hz, 2H), 6.81 – 6.67 (m, 5H), 6.63 (s, 1H), 4.73 – 4.53 (m, 2H), 3.68 (d, *J* = 3.8 Hz, 3H), 3.65 (d, *J* = 2.6 Hz, 3H), 2.10 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 202.0 (d, *J* = 1.5 Hz), 202.0, 162.3, 159.3 (d, *J* = 6.2 Hz), 140.3, 137.7 (d, *J* = 2.1 Hz), 137.5 (d, *J* = 2.1 Hz), 135.8 (d, *J* = 2.4 Hz), 132.6, 129.5 (d, *J* = 9.5 Hz), 129.0 (d, *J* = 7.4 Hz), 128.0, 126.9, 125.7, 124.8, 124.1 (d, *J* = 8.8 Hz), 122.4 (d, *J* = 12.2 Hz), 118.9, 116.9 (d,

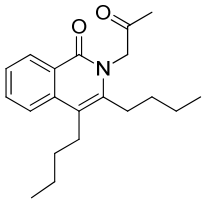
J = 7.2 Hz), 115.3 (d, *J* = 14.6 Hz), 114.9, 113.0, 55.7 (d, *J* = 2.7 Hz), 55.4, 55.3, 27.5. HRMS (ESI): m/z calcd for $C_{26}H_{24}O_4N$ $[M+H]^+$: 414.1705, found: 414.1704.

3,4-bis(3-chlorophenyl)-2-(2-oxopropyl)isoquinolin-1(2*H*)-one (**3ak**)



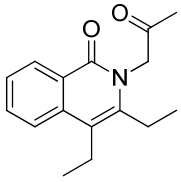
The general procedure was applied to **1a** (0.05 mmol), **2k** (1.2 equiv), $[Cp^*RhCl_2]_2$ (4 mol%), $Cu(OAc)_2•H_2O$ (2.1 equiv), $AgNTf_2$ (10 mol%), PivOH (0.5 equiv) and H_2O (50 μL) in MeOH (0.5 mL) at 100 ºC for 12 h under air. Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 3/1, v/v) afforded **3ak** as a white solid (37% yield). Melting point: 154.1 – 155.9 °C; ^{1} H NMR (400 MHz, $CDCl_3$): δ = 8.49 (d, *J* = 7.9 Hz, 1H), 7.70 – 7.46 (m, 2H), 7.25 – 7.08 (m, 7H), 7.08 – 6.94 (m, 2H), 4.80 – 4.46 (m, 2H), 2.11 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 201.7 (d, *J* = 1.8 Hz), 162.1, 139.4, 137.9 (d, *J* = 2.0 Hz), 136.9, 135.9, 134.5 (d, *J* = 14.9 Hz), 134.1 (d, *J* = 13 Hz), 132.9, 131.5 (d, *J* = 10.3 Hz), 130.0 (d, *J* = 8.9 Hz), 129.8, 129.6 (d, *J* = 8.6 Hz), 129.3, 128.3 (d, *J* = 8 Hz), 128.2, 127.6, 127.4, 125.5, 124.9, 118.1, 55.6, 27.5. HRMS (ESI): m/z calcd for $C_{24}H_{17}O_2NCl_2Na$ $[M+Na]^+$: 444.0534, found: 444.0534.

3,4-dibutyl-2-(2-oxopropyl)isoquinolin-1(2*H*)-one (**3al**)



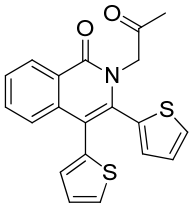
The general procedure was applied to **1a** (0.05 mmol), **2l** (1.2 equiv), $[Cp^*RhCl_2]_2$ (4 mol%), $Cu(OAc)_2•H_2O$ (2.1 equiv), $AgNTf_2$ (10 mol%), PivOH (0.5 equiv) and H_2O (50 μL) in MeOH (0.5 mL) at 100 ºC for 10 h under air. Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 3/1, v/v) afforded **3al** as a white solid (81% yield). Melting point: 107.6 – 110.3 °C; ^{1} H NMR (400 MHz, $CDCl_3$): δ = 8.40 (d, *J* = 8.0 Hz, 1H), 7.66 (d, *J* = 3.8 Hz, 2H), 7.46 – 7.39 (m, 1H), 4.91 (s, 2H), 2.72 (t, *J* = 7.2 Hz, 2H), 2.54 (t, *J* = 7.2 Hz,2H), 2.28 (s, 3H), 1.52 (m, 8H), 1.03 – 0.93 (q, *J* = 6.8 Hz, 6H) ; ^{13}C NMR (100 MHz, $CDCl_3$): δ = 202.8, 162.7, 139.0, 137.0, 132.5, 128.5, 126.0, 124.7, 122.9, 114.5, 53.9, 32.6, 31.5, 29.7, 27.6, 27.6 (d, *J* = 1.6 Hz), 23.2, 23.0, 14.1, 13.8. HRMS (ESI): m/z calcd for $C_{20}H_{27}O_2NNa$ $[M+Na]^+$: 336.1939, found: 336.1938.

3,4-diethyl-2-(2-oxopropyl)isoquinolin-1(2*H*)-one (**3am**)



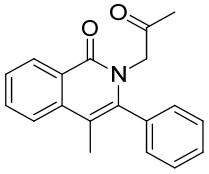
The general procedure was applied to **1a** (0.05 mmol), **2m** (2 equiv), $[Cp^*RhCl_2]_2$ (4 mol%), $Cu(OAc)_2•H_2O$ (3 equiv), $AgNTf_2$ (10 mol%), PivOH (0.5 equiv) and H_2O (50 μL) in MeOH (0.5 mL) at 100 ºC for 12 h under air. Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 3/1, v/v) afforded **3am** as a white solid (95% yield). Melting point: 105.3 – 106.8 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.40 (d, *J* = 7.5 Hz, 1H), 7.73 – 7.61 (m, 2H), 7.42 (t, *J* = 7.3 Hz, 1H), 4.92 (s, 2H), 2.78 (q, *J* = 7.5 Hz, 2H), 2.61 (q, *J* = 7.6 Hz, 2H), 2.29 (s, 3H), 1.22 (dt, *J* = 12.2, 7.5 Hz, 6H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 202.7, 162.7, 139.9, 136.8, 132.6, 128.5, 126.0, 124.8, 122.8, 115.4, 53.7, 27.6, 22.9, 20.8, 14.9, 13.8. HRMS (ESI): m/z calcd for $C_{16}H_{19}O_2NNa$ $[M+Na]^+$: 280.1313, found: 280.1314.

2-(2-oxopropyl)-3,4-di(thiophen-2-yl)isoquinolin-1(2*H*)-one (**3an**)



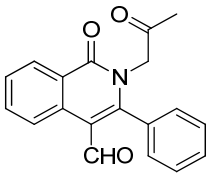
The general procedure was applied to **1a** (0.05 mmol), **2n** (1.5 equiv), $[Cp^*RhCl_2]_2$ (4 mol%), $Cu(OAc)_2•H_2O$ (2.1 equiv), $AgNTf_2$ (10 mol%), PivOH (0.5 equiv) and H_2O (50 μL) in MeOH (0.5 mL) at 100 ºC for 12 h under air. Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 3/1, v/v) afforded **3an** as a white solid (52% yield). Melting point: 164.3 – 167.9 °C; ^{1}H NMR (400 MHz, $CDCl_3$): 8.47 (d, *J* = 6.4 Hz, 1H), 7.60 (t, *J* = 7.6 Hz, 1H), 7.52 (t, *J* = 7.5 Hz, 1H), 7.38 (d, *J* = 8.1 Hz, 1H), 7.31 (t, *J* = 2.8 Hz, 1H), 7.28 – 7.23 (m, 1H), 6.96 – 6.87 (m, 3H), 6.85 (d, *J* = 2.9 Hz, 1H), 4.72 (s, 2H), 2.13 (s, 3H) ; ^{13}C NMR (100 MHz, $CDCl_3$): δ = 201.8, 162.2, 137.5, 136.8, 135.6, 134.4, 132.9, 130.9, 130.2,129.9, 128.4, 128.0, 127.7, 126.9, 126.7, 126.6, 125.8, 125.1, 114.8, 55.8, 27.4. HRMS (ESI): m/z calcd for $C_{20}H_{15}O_2NS_2Na$ $[M+Na]^+$: 388.0442, found: 388.0445.

4-methyl-2-(2-oxopropyl)-3-phenylisoquinolin-1(2*H*)-one (**3ao**)



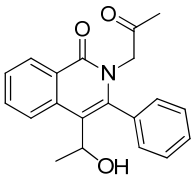
The general procedure was applied to **1a** (0.05 mmol), **2o** (1.5 equiv), $[Cp^*RhCl_2]_2$ (4 mol%), $Cu(OAc)_2•H_2O$ (2.1 equiv), $AgNTf_2$ (10 mol%), PivOH (0.5 equiv) and H_2O (50 μL) in MeOH (0.5 mL) at 100 ºC for 10 h under air. Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 3/1, v/v) afforded **3ao** as a white solid (91% yield). Melting point: 153.2 – 154.1 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.48 (d, *J* = 8.0 Hz, 1H), 7.75 – 7.67 (m, 2H), 7.55 – 7.49 (m, 1H), 7.47 – 7.43 (m, 3H), 7.25 – 7.20 (m, 2H), 4.54 (s, 2H), 2.01 (d, *J* = 2.2 Hz, 6H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 202.0, 162.2, 139.5, 137.5, 135.4, 132.7, 129.9, 129.6, 129.2, 129.1, 128.3, 126.7, 125.2, 123.5, 115.4, 110.8, 55.6, 27.3, 14.9. HRMS (ESI): m/z calcd for $C_{19}H_{17}O_2NNa$ $[M+Na]^+$: 314.1157, found: 314.1158.

1-oxo-2-(2-oxopropyl)-3-phenyl-1,2-dihydroisoquinoline-4-carbaldehyde (**3ap**)



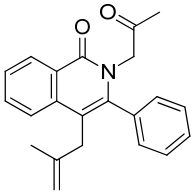
The general procedure was applied to **1a** (0.05 mmol), **2p** (1.2 equiv), $[Cp^*RhCl_2]_2$ (4 mol%), $Cu(OAc)_2•H_2O$ (2.1 equiv), $AgNTf_2$ (10 mol%), PivOH (0.5 equiv) and H_2O (50 μL) in MeOH (0.5 mL) at 100 ºC for 12 h under air. Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 3/1, v/v) afforded **3ap** as a white solid (64% yield). Melting point: 188.5 – 190.7 °C; ^{1} H NMR (400 MHz, $CDCl_3$): δ = 9.44 (s, 1H), 9.18 (d, *J* = 8.4 Hz, 1H), 8.42 (d, *J* = 8.1 Hz, 1H), 7.78 (t, *J* = 7.7 Hz, 1H), 7.63 – 7.46 (m, 4H), 7.34 (d, *J* = 7.3 Hz, 2H), 4.58 (s, 2H), 2.06 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 200.7, 191.3, 162.1, 156.6, 134.2, 133.4, 131.4, 130.5, 129.5, 129.2, 128.0, 127.9, 125.6, 124.3, 113.8, 55.0, 27.4. HRMS (ESI): m/z calcd for $C_{19}H_{15}O_3NNa$ $[M+Na]^+$: 328.0950, found: 328.0948.

4-(1-hydroxyethyl)-2-(2-oxopropyl)-3-phenylisoquinolin-1(2*H*)-one (**3aq**)



The general procedure was applied to **1a** (0.05 mmol), **2q** (1.2 equiv), $[Cp^*RhCl_2]_2$ (4 mol%), $Cu(OAc)_2•H_2O$ (2.1 equiv), $AgNTf_2$ (10 mol%), PivOH (0.5 equiv) and H_2O (50 μL) in MeOH (0.5 mL) at 100 ºC for 12 h under air. Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 3/1, v/v) afforded **3aq** as a white solid (60% yield). Melting point: 167.9 – 169.2 °C; ^{1} H NMR (400 MHz, $CDCl_3$): δ = 8.55 (d, *J* = 8.4 Hz, 1H), 8.46 (d, *J* = 8.0 Hz, 1H), 7.68 (t, *J* = 7.7 Hz, 1H), 7.52 – 7.37 (m, 4H), 7.13 (d, *J* = 6.6 Hz, 2H), 4.64 (q, *J* = 6.7 Hz, 1H), 4.49 – 4.22 (m, 2H), 2.38 (s, 1H), 1.94 (s, 3H), 1.54 (d, *J* = 6.7 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 201.9, 162.1, 139.6, 135.1, 134.5, 132.1, 129.5, 129.4, 129.1, 128.7, 128.5, 126.8, 126.5, 126.0, 117.8, 68.5, 55.3, 27.3, 22.7. HRMS (ESI): m/z calcd for $C_{20}H_{19}O_3NNa$ $[M+Na]^+$: 344.1263, found: 344.1263.

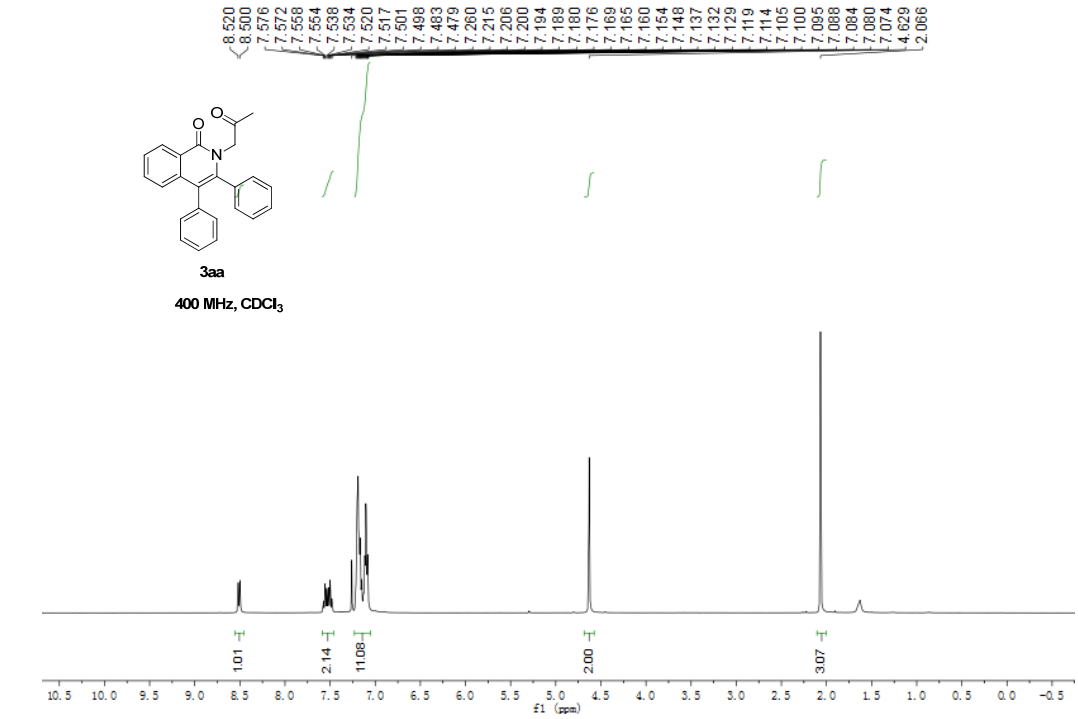
4-(2-methylallyl)-2-(2-oxopropyl)-3-phenylisoquinolin-1(2*H*)-one (**3ar**)

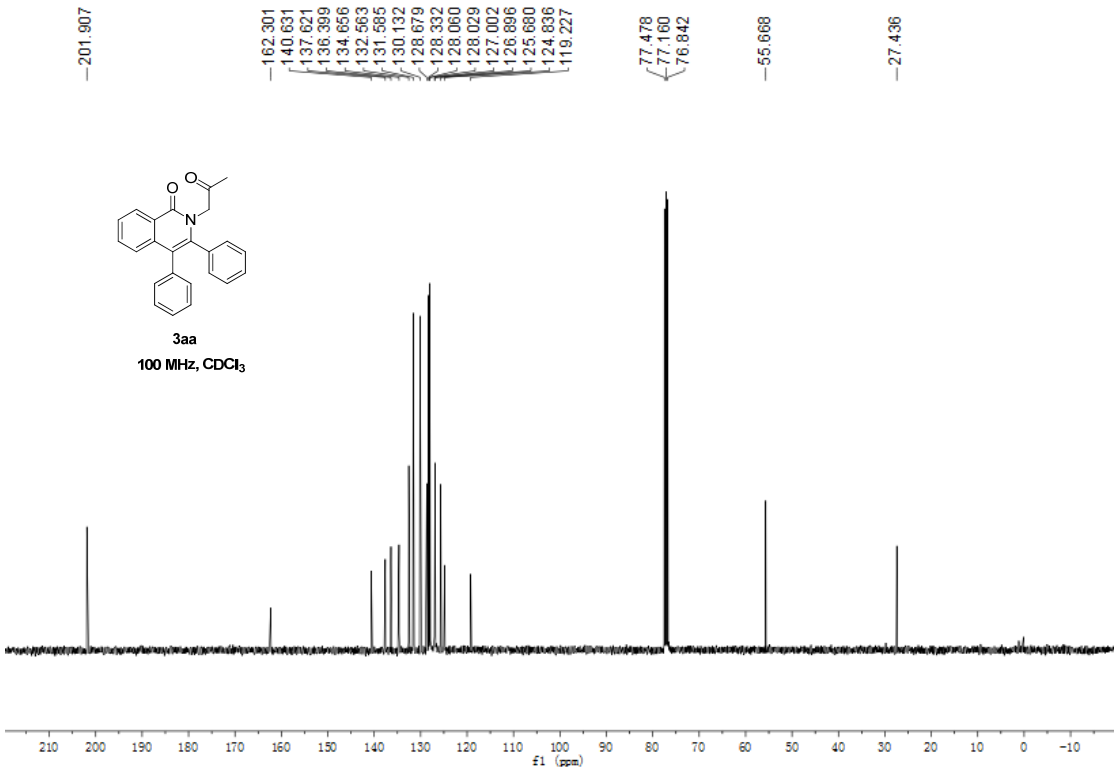


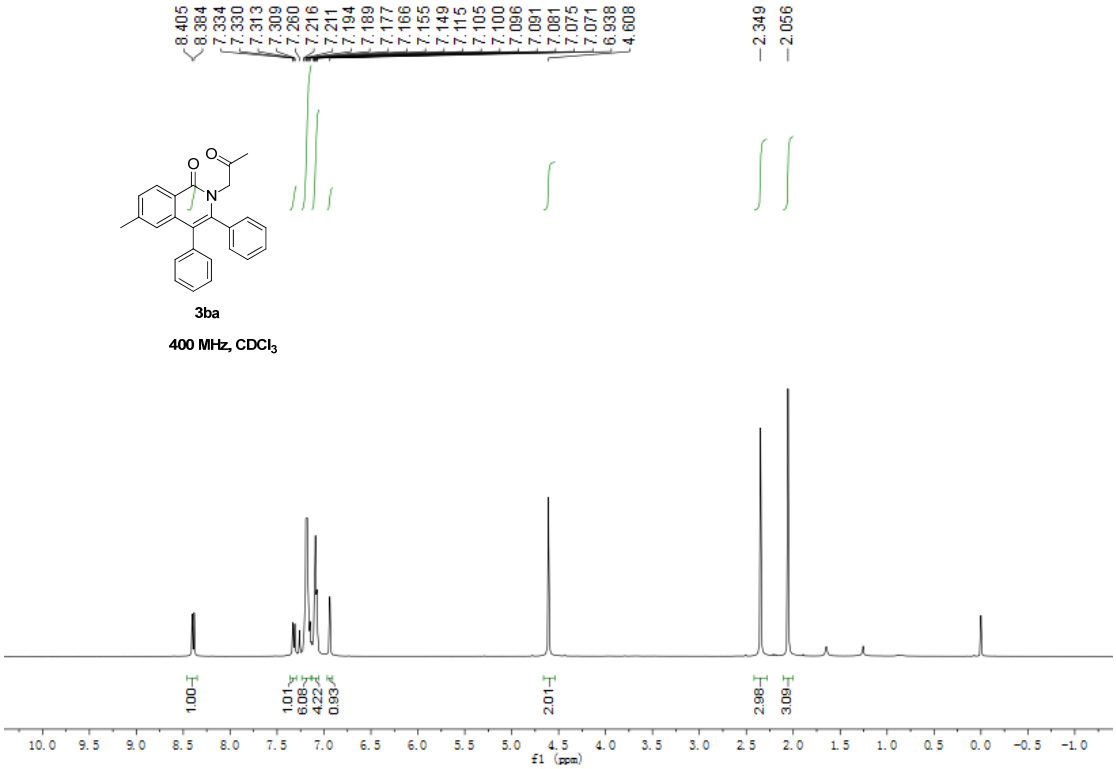
The general procedure was applied to **1a** (0.05 mmol), **2r** (1.2 equiv), $[Cp^*RhCl_2]_2$ (4 mol%), $Cu(OAc)_2•H_2O$ (2.1 equiv), $AgNTf_2$ (10 mol%), PivOH (0.5 equiv) and H_2O (50 μL) in MeOH (0.5 mL) at 100 ºC for 12 h under air. Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 3/1, v/v) afforded **3ar** as a white solid (88% yield). Melting point: 153.2 – 154.9 °C; ^{1} H NMR (400 MHz, $CDCl_3$): δ = 8.47 (d, *J* = 6.8 Hz, 1H), 7.66 (ddd, *J* = 8.3, 6.9, 1.5 Hz, 1H), 7.59 (d, *J* = 7.0 Hz, 1H), 7.49 (ddd, *J* = 8.1, 6.9, 1.2 Hz, 1H), 7.46 – 7.39 (m, 3H),

7.26 – 7.22 (m, 2H), 4.80-4.75 (m, 1H), 4.55 (s, 2H), 4.51 (s, 1H), 3.04 (s, 2H), 2.02 (s, 3H), 1.65 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 201.9, 162.3, 144.0, 140.9, 137.1, 134.9, 132.5, 129.3, 129.1, 128.9, 128.3, 126.7, 125.3, 124.4, 112.9, 111.8, 55.7, 36.8, 27.3, 23.4. HRMS (ESI): m/z calcd for $C_{22}H_{21}O_2NNa$ $[M+Na]^+$: 354.1470, found: 354.1474.

9. ^1H , ^{13}C and ^{19}F NMR spectra

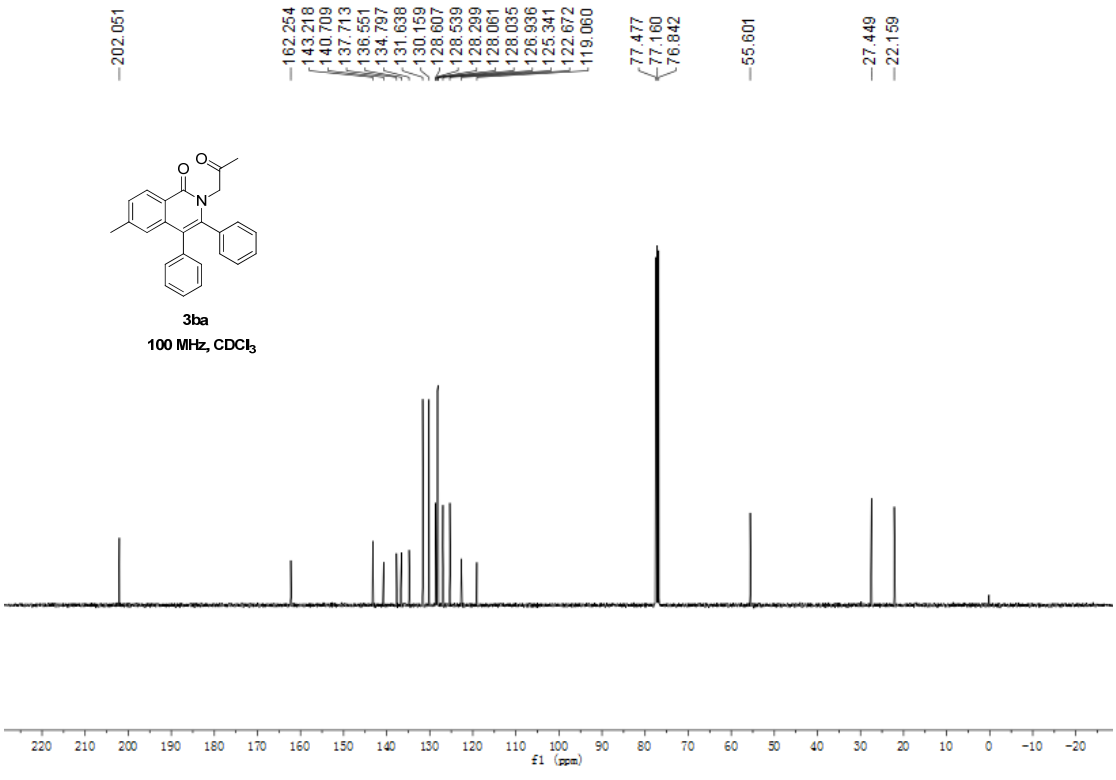






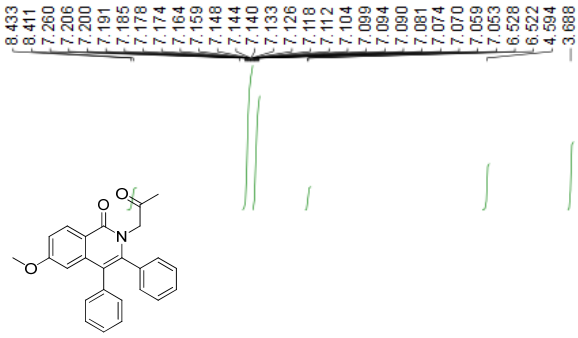
3ba

400 MHz, $CDCl_3$



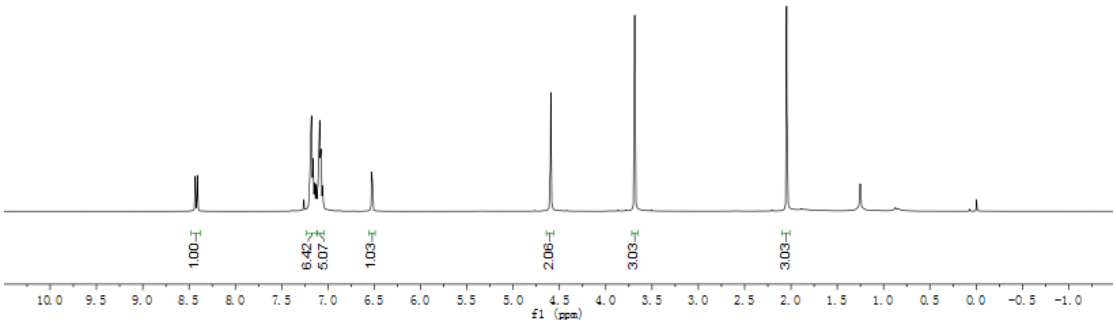
3ba

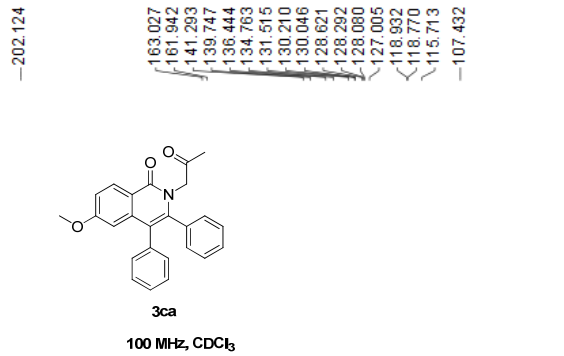
100 MHz, $CDCl_3$



3ca

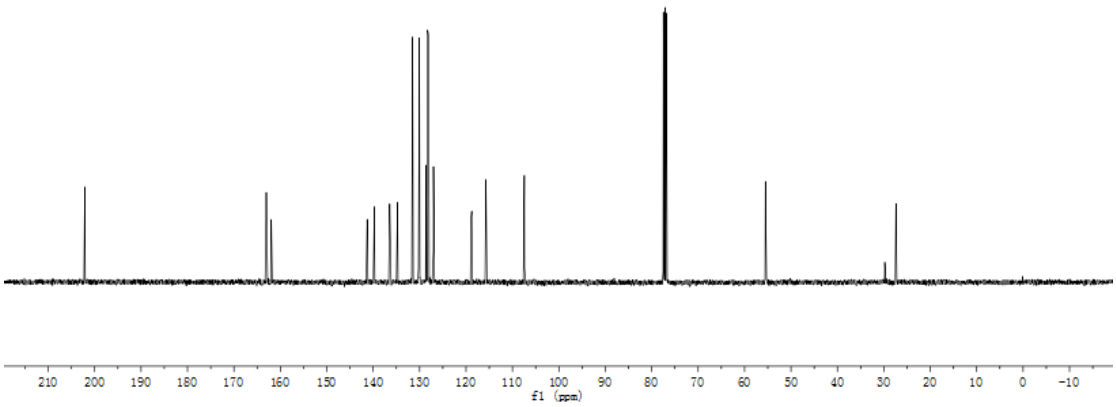
400 MHz, $CDCl_3$

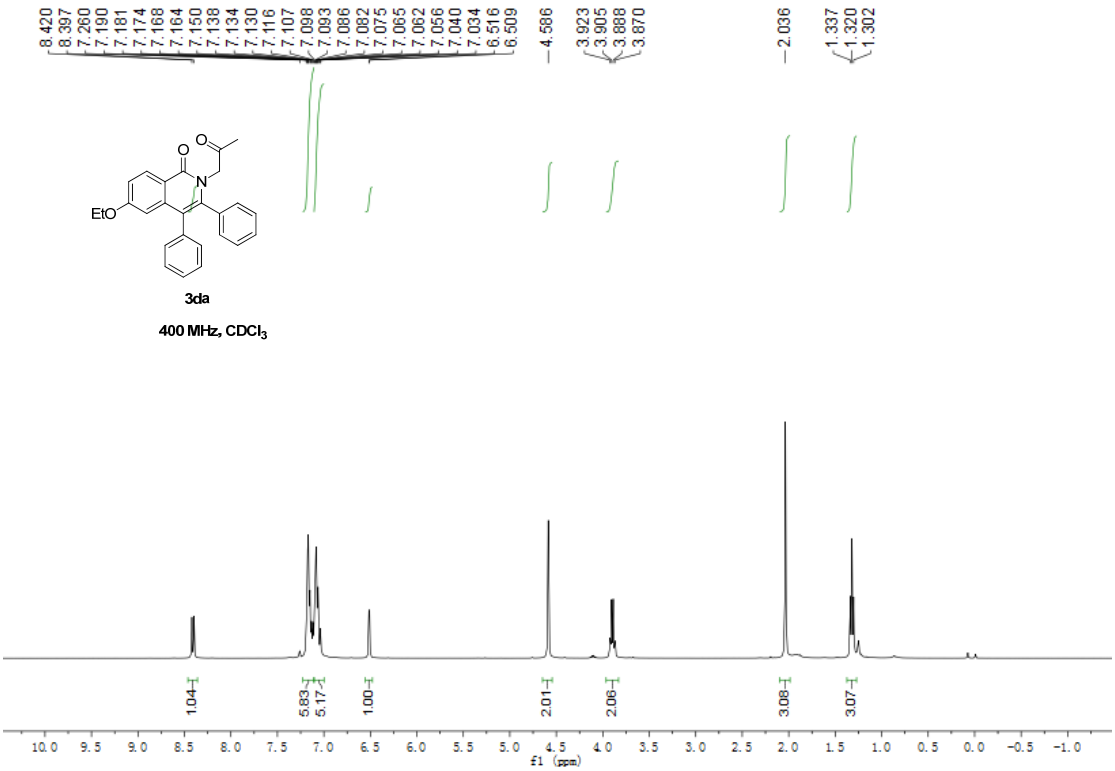




3ca

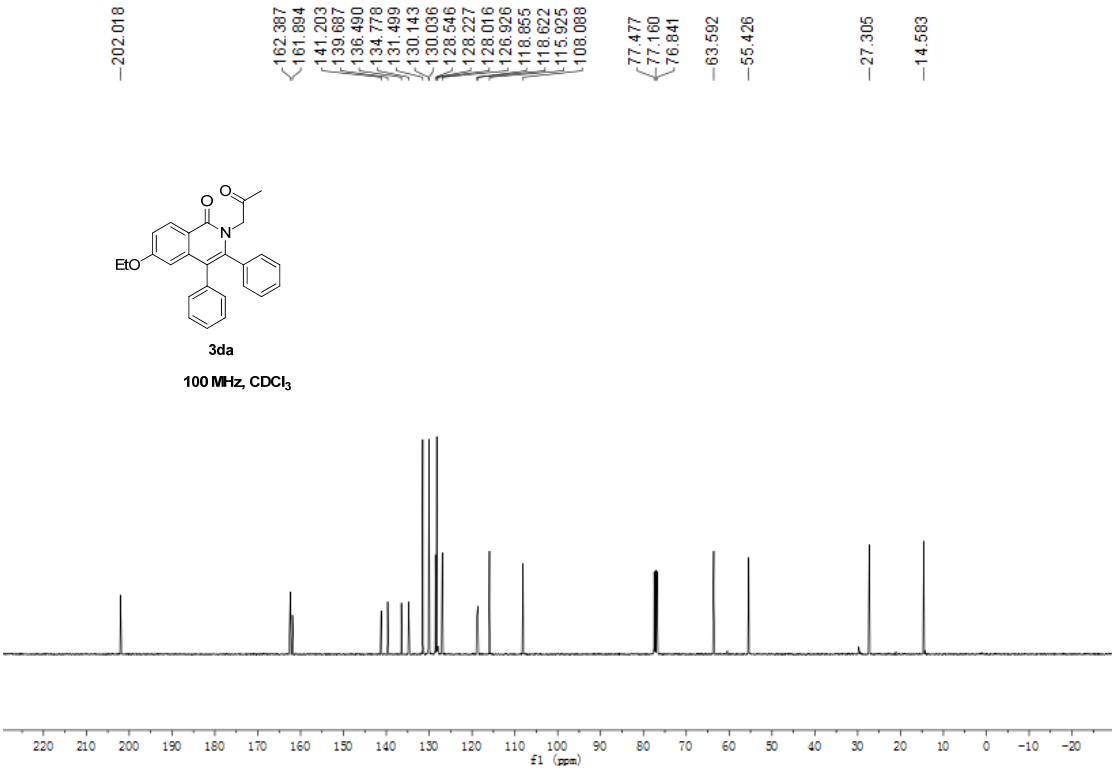
100 MHz, $CDCl_3$





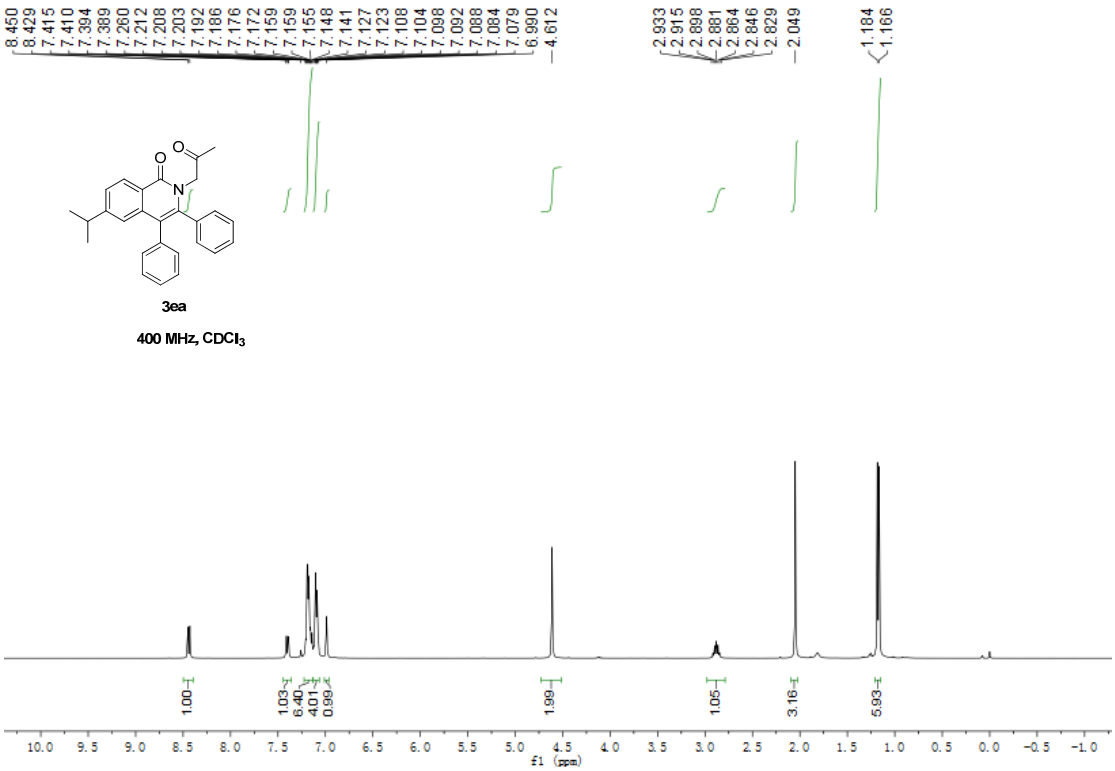
3da

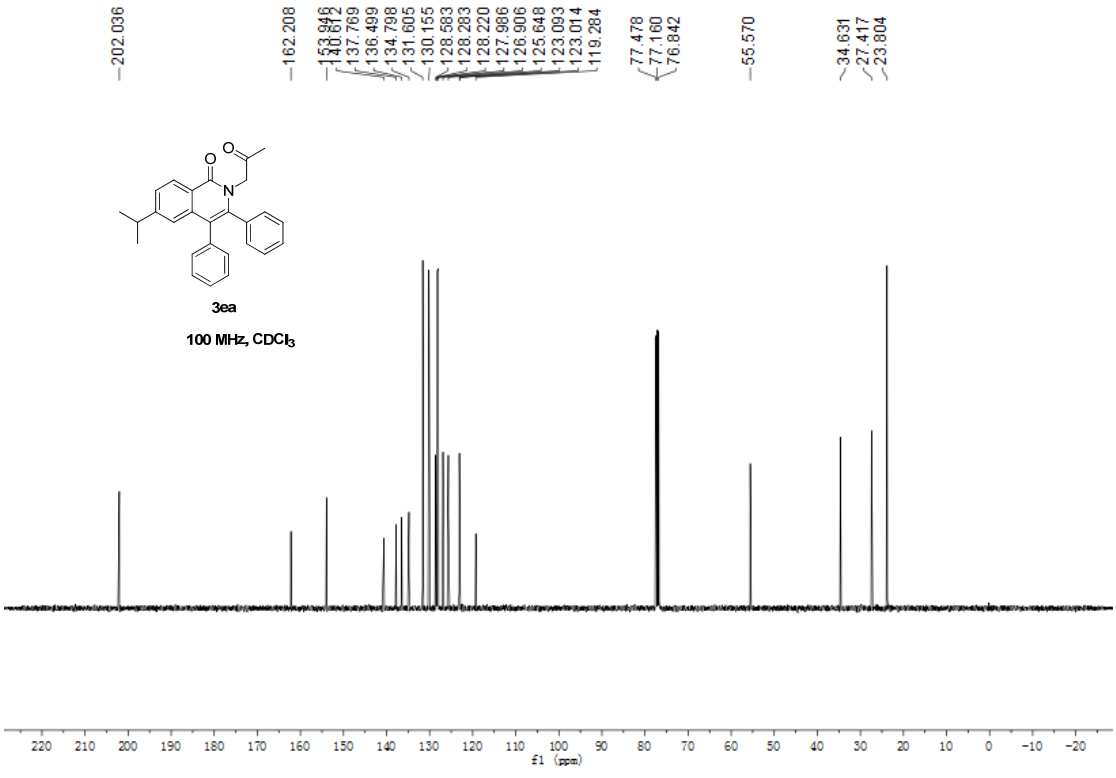
400 MHz, $CDCl_3$

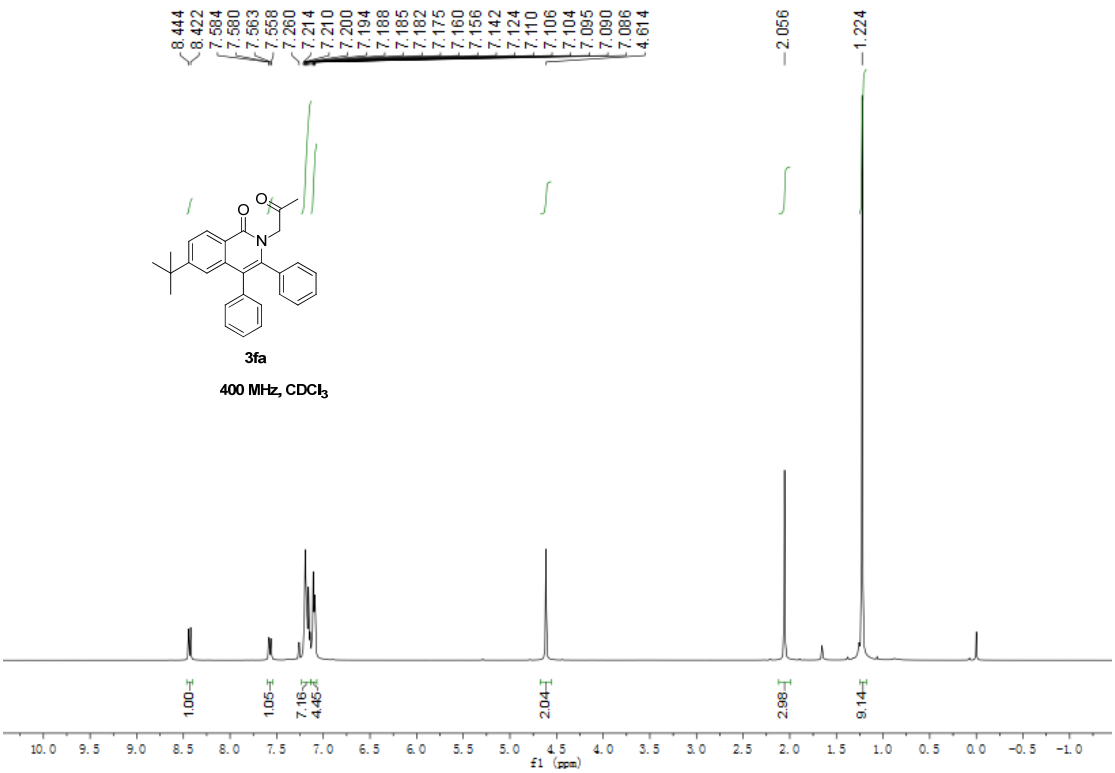


3da

100 MHz, $CDCl_3$

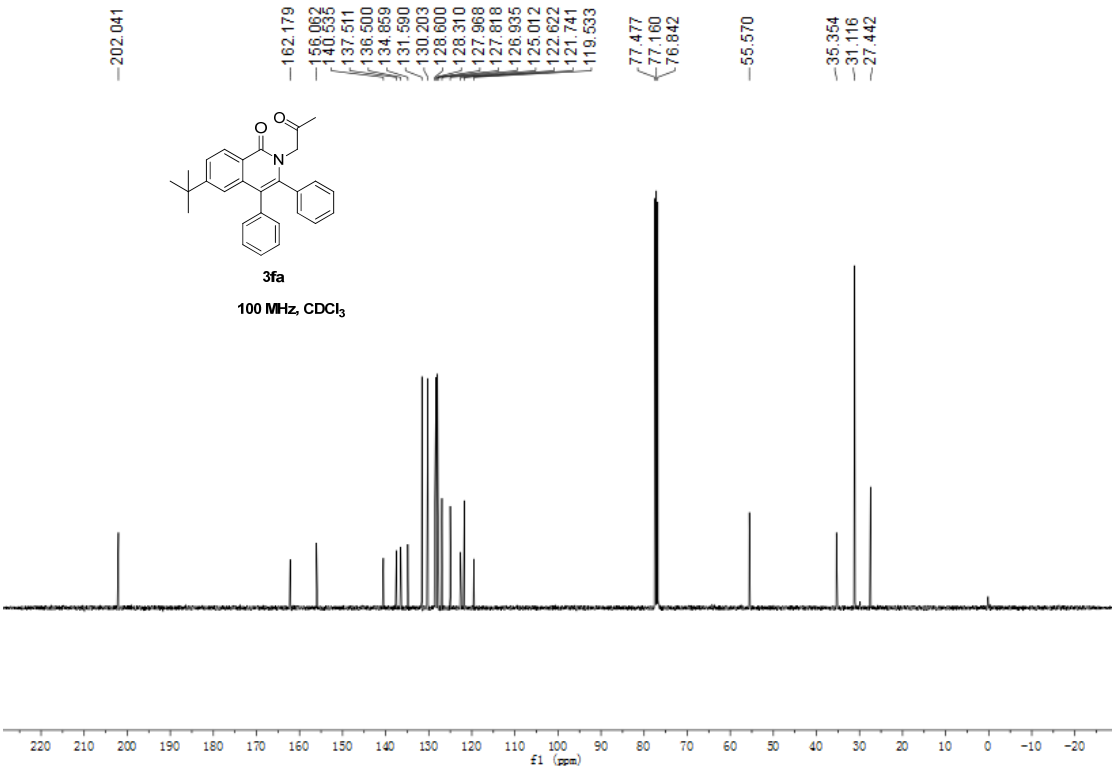

8.450
8.429
7.415
7.410
7.394
7.389
7.260
7.212
7.208
7.203
7.192
7.186
7.176
7.172
7.159
7.159
7.155
7.148
7.141
7.127
7.123
7.108
7.104
7.098
7.092
7.088
7.084
7.079
6.990
4.612
2.933
2.915
2.898
2.881
2.864
2.846
2.829
2.049
1.184
1.166
O
O
N
3ea
400 MHz, CDCl3
1.00
1.03
6.40
4.01
0.99
1.99
1.05
3.16
5.93
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0
f1 (ppm)


202.036
162.208
153.946
137.769
136.499
134.798
131.605
130.155
128.583
128.283
128.220
127.986
126.906
125.648
123.093
123.014
119.284
77.478
77.160
76.842
55.570
34.631
27.417
23.804
O
O
N
3ea
100 MHz, CDCl3
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10 -20
f1 (ppm)



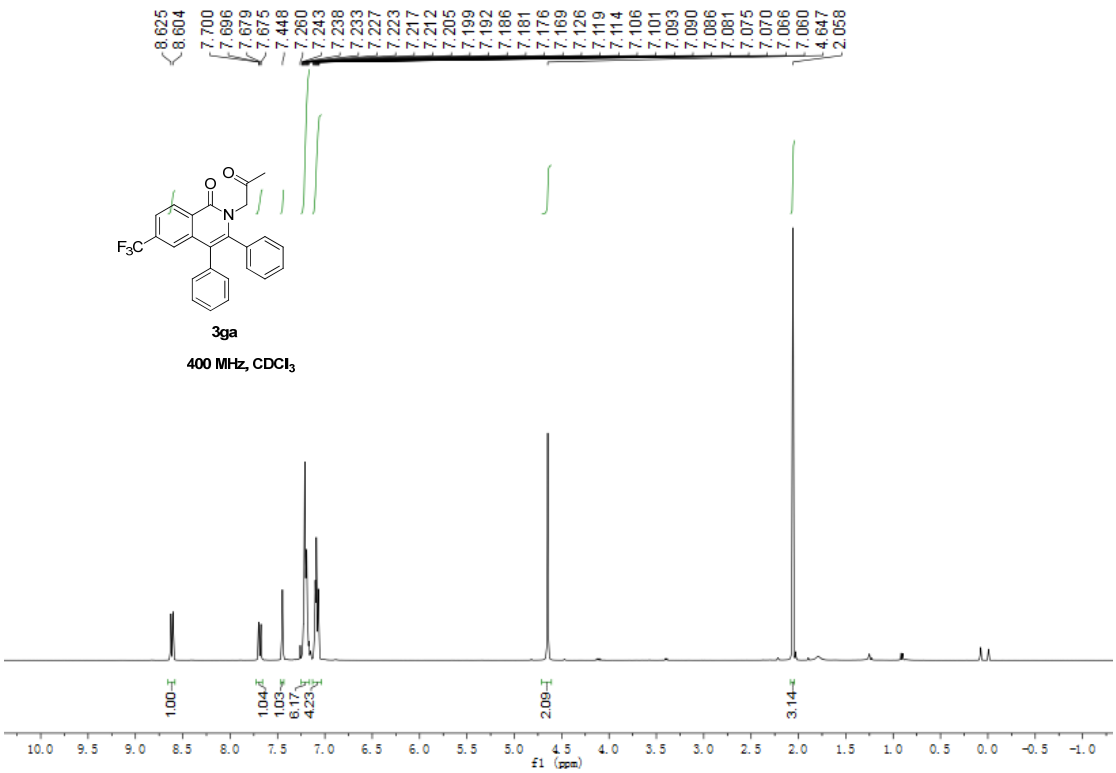
3fa

400 MHz, $CDCl_3$



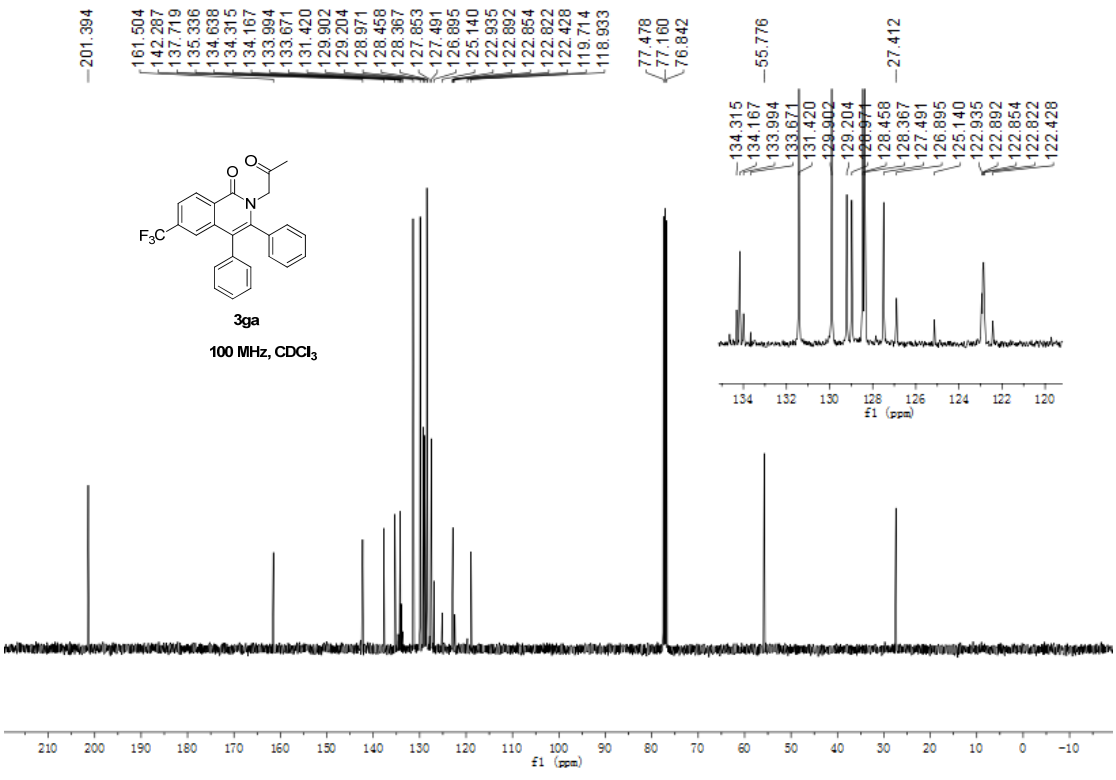
3fa

100 MHz, $CDCl_3$



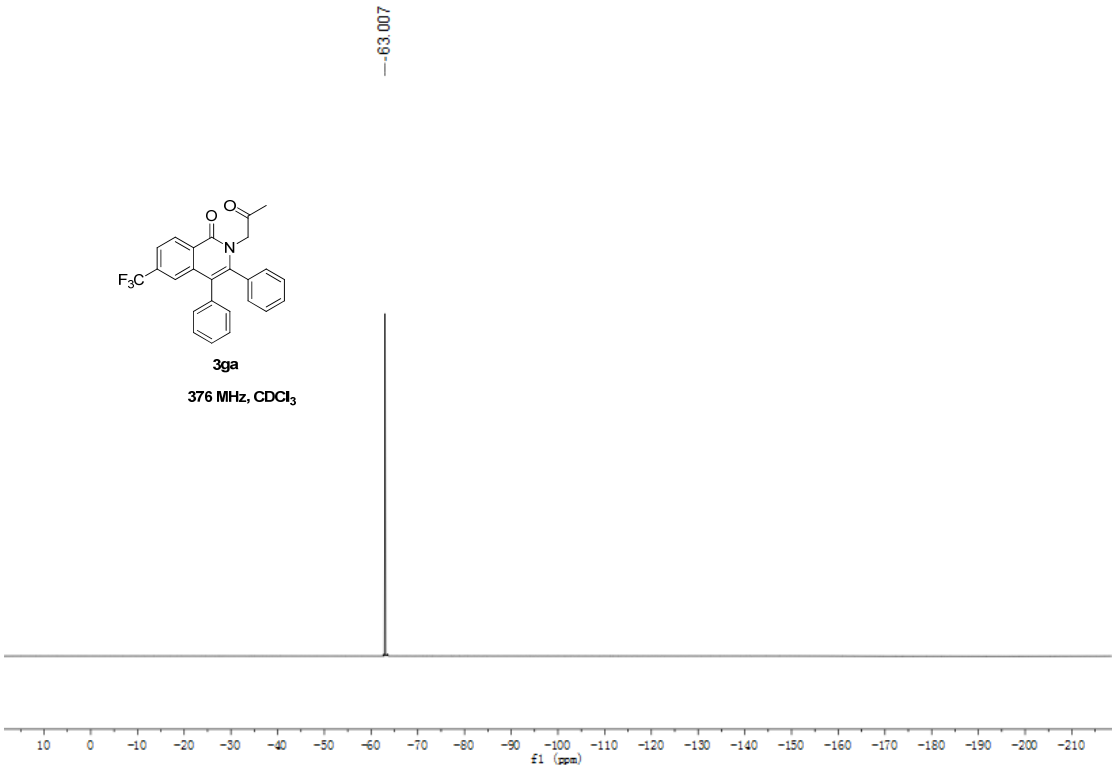
3ga

400 MHz, $CDCl_3$



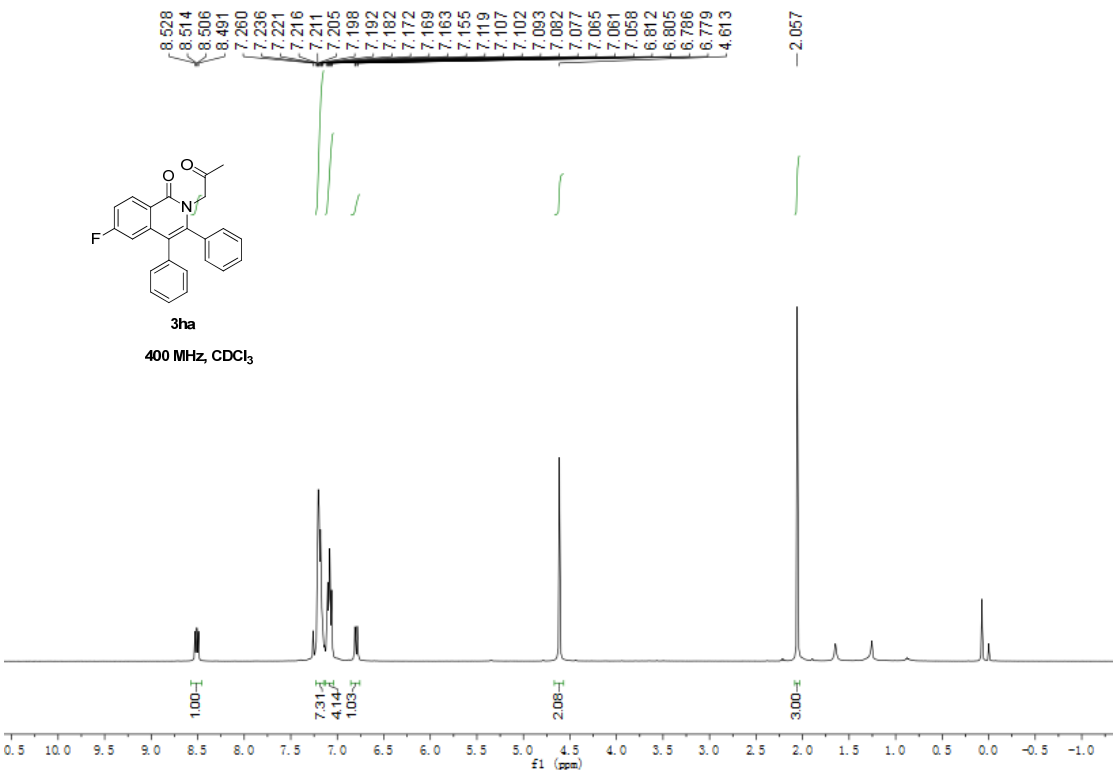
3ga

100 MHz, $CDCl_3$



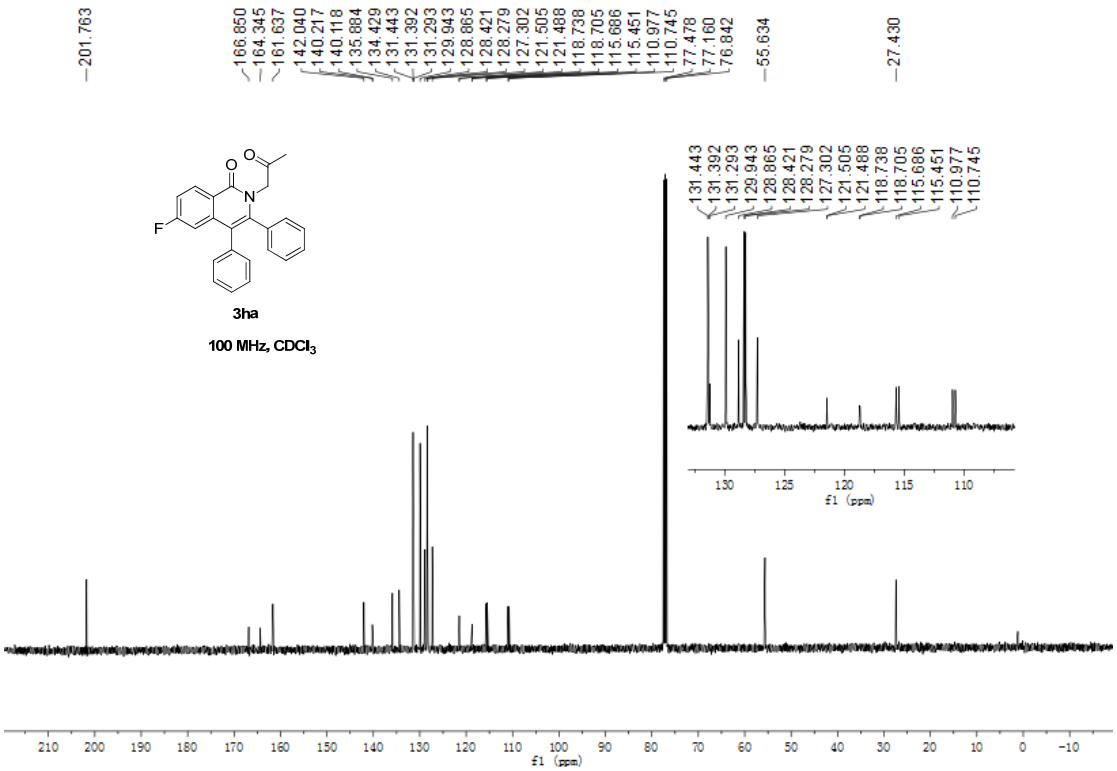
3ga

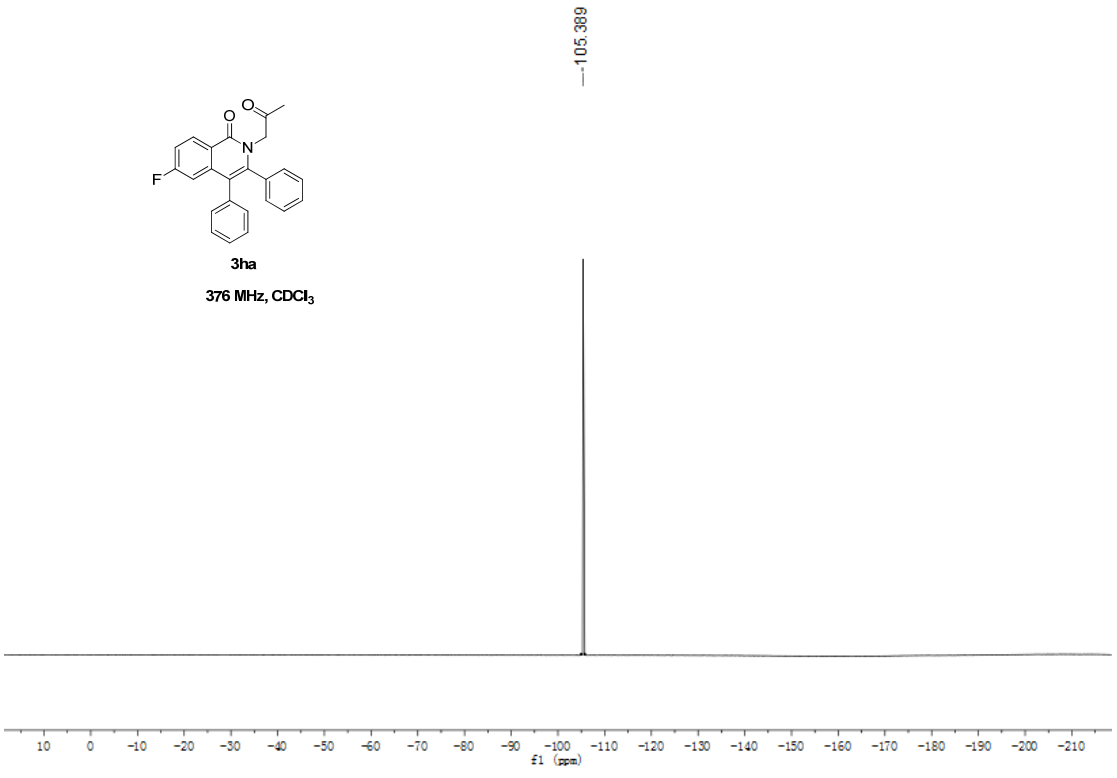
376 MHz, $CDCl_3$

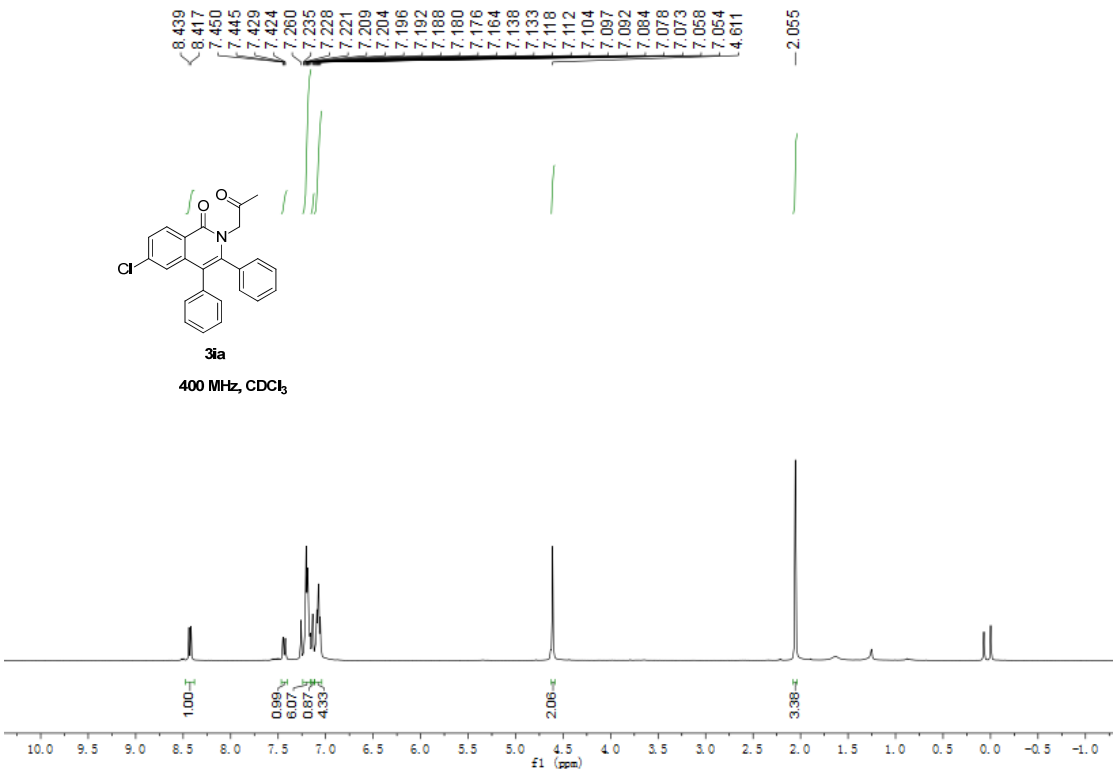


3ha

400 MHz, $CDCl_3$

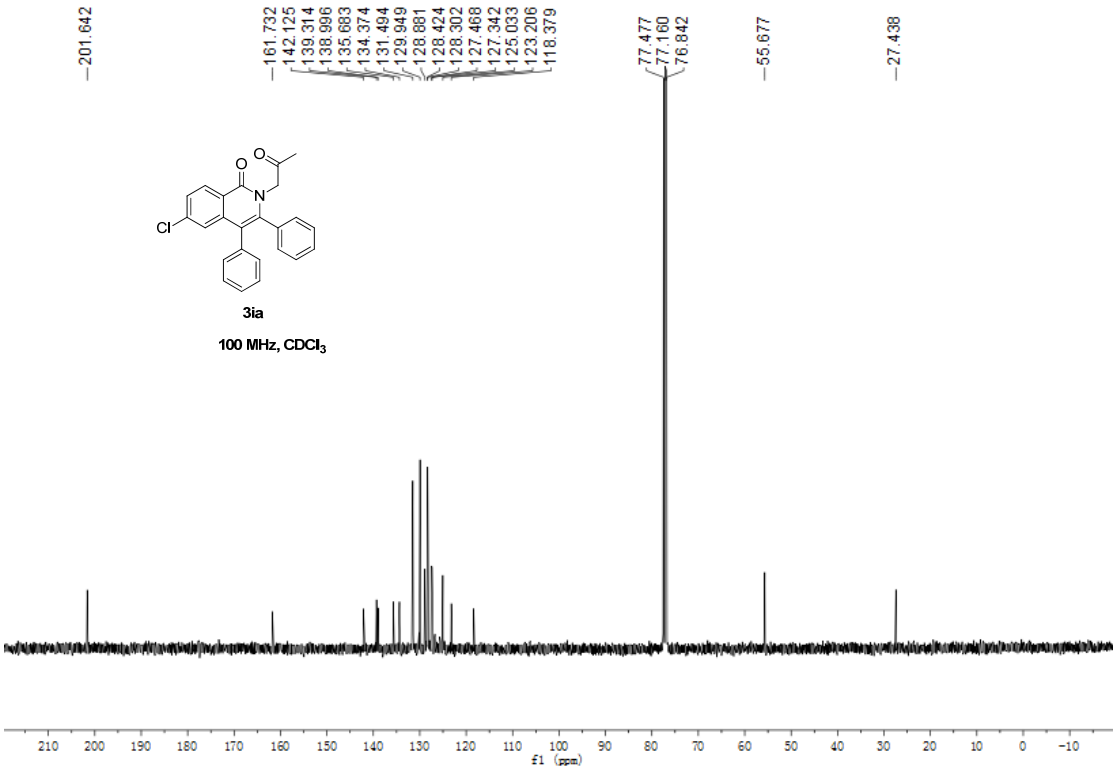

201.763
166.850
164.345
161.637
142.040
140.217
140.118
135.884
134.429
131.443
131.392
131.293
129.943
128.865
128.421
128.279
127.302
121.505
121.488
118.738
118.705
115.686
115.451
110.977
110.745
77.478
77.160
76.842
55.634
27.430
O
O
N
F
3ha
100 MHz, CDCl3
f1 (ppm)


105.389
O
O
N
F
3ha
376 MHz, CDCl3
f1 (ppm)



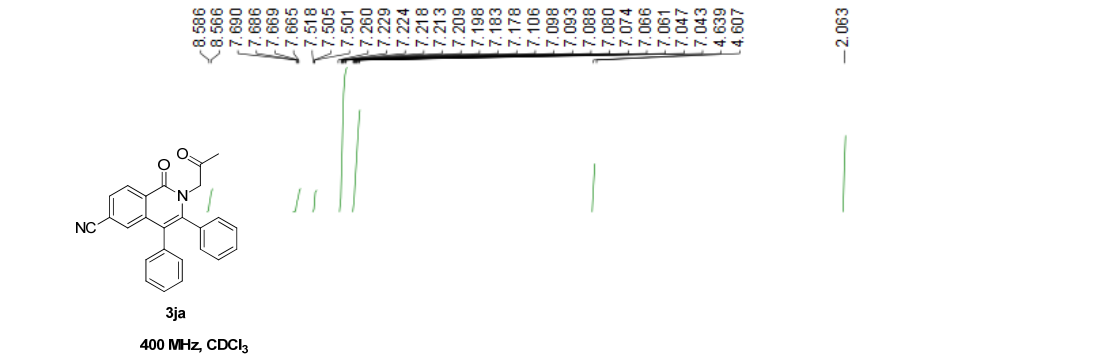
3ia

400 MHz, $CDCl_3$



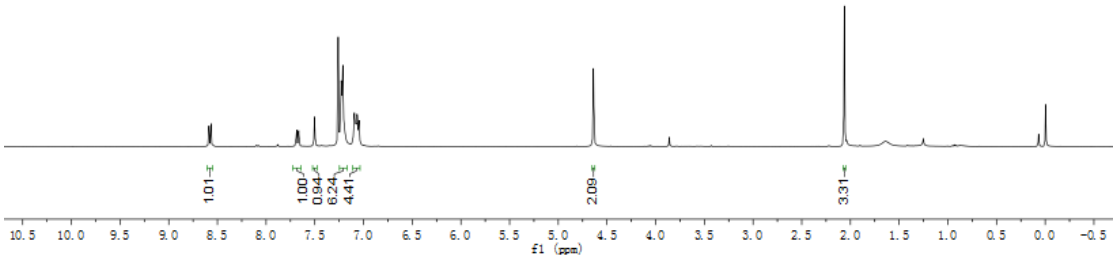
3ia

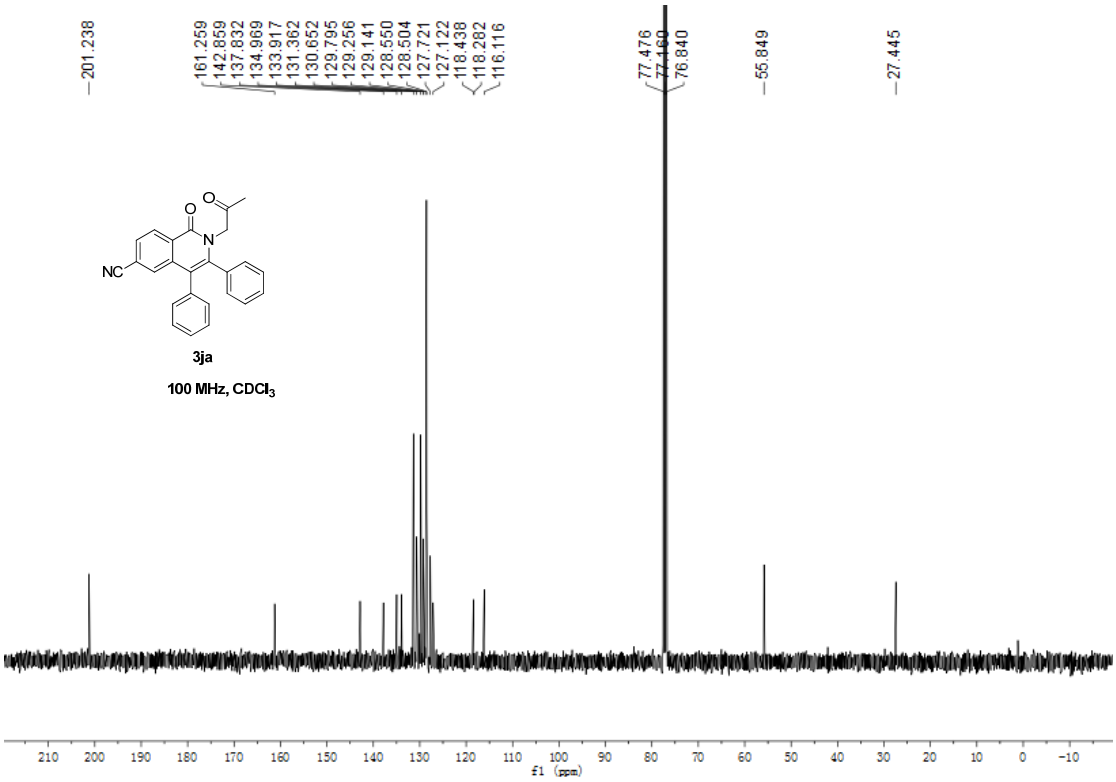
100 MHz, $CDCl_3$



3ja

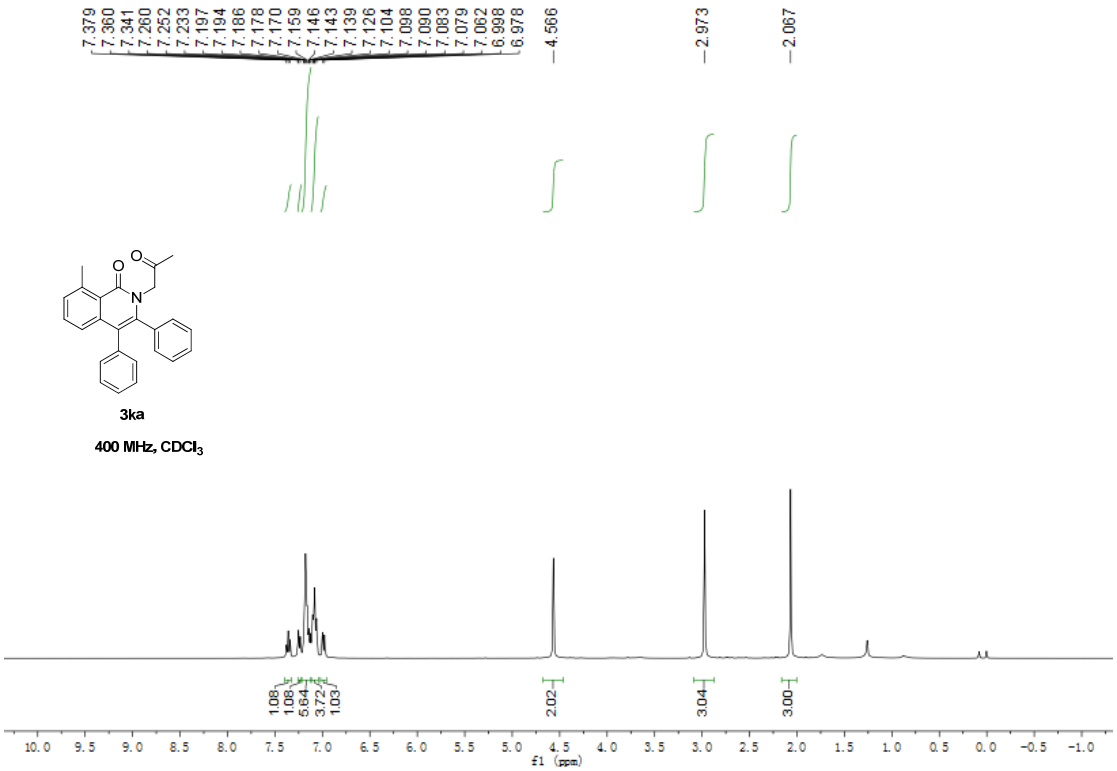
400 MHz, $CDCl_3$

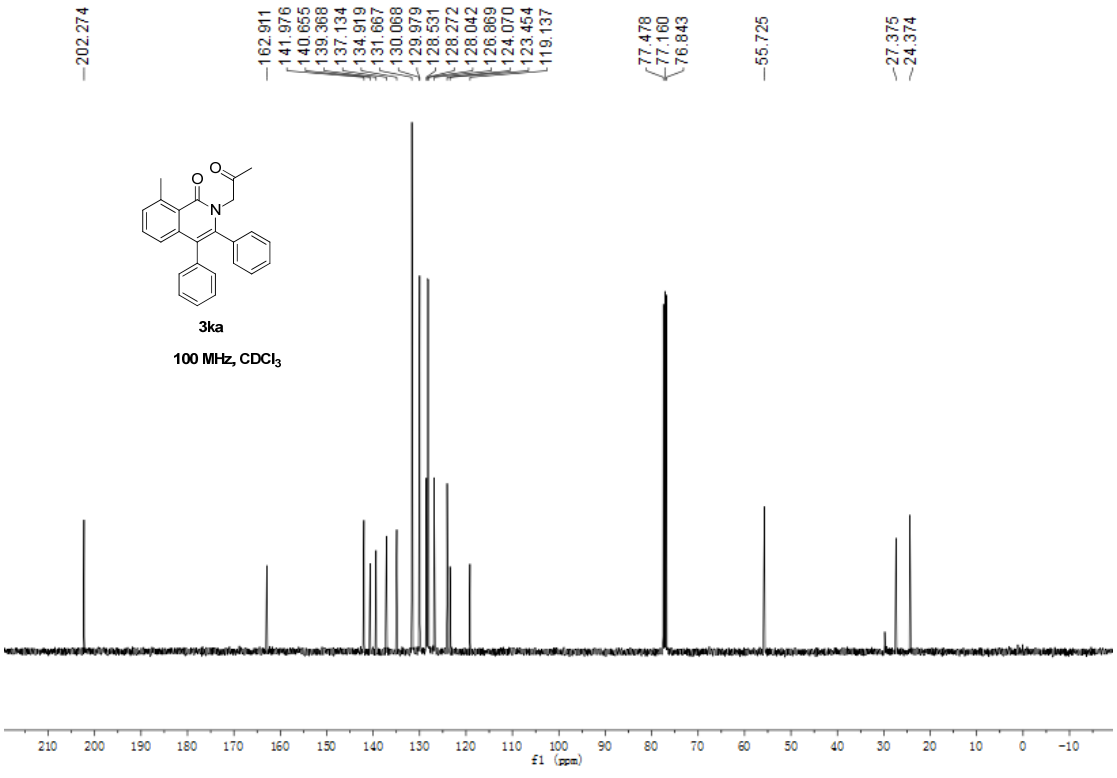


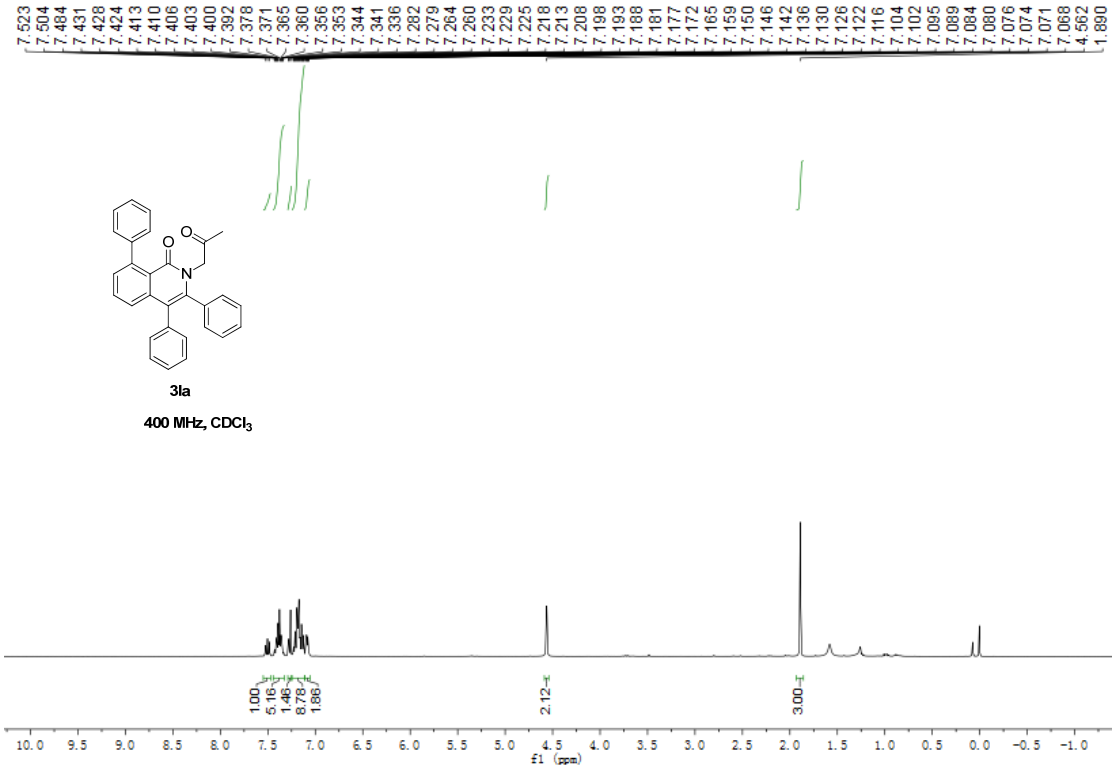


3ja

100 MHz, $CDCl_3$

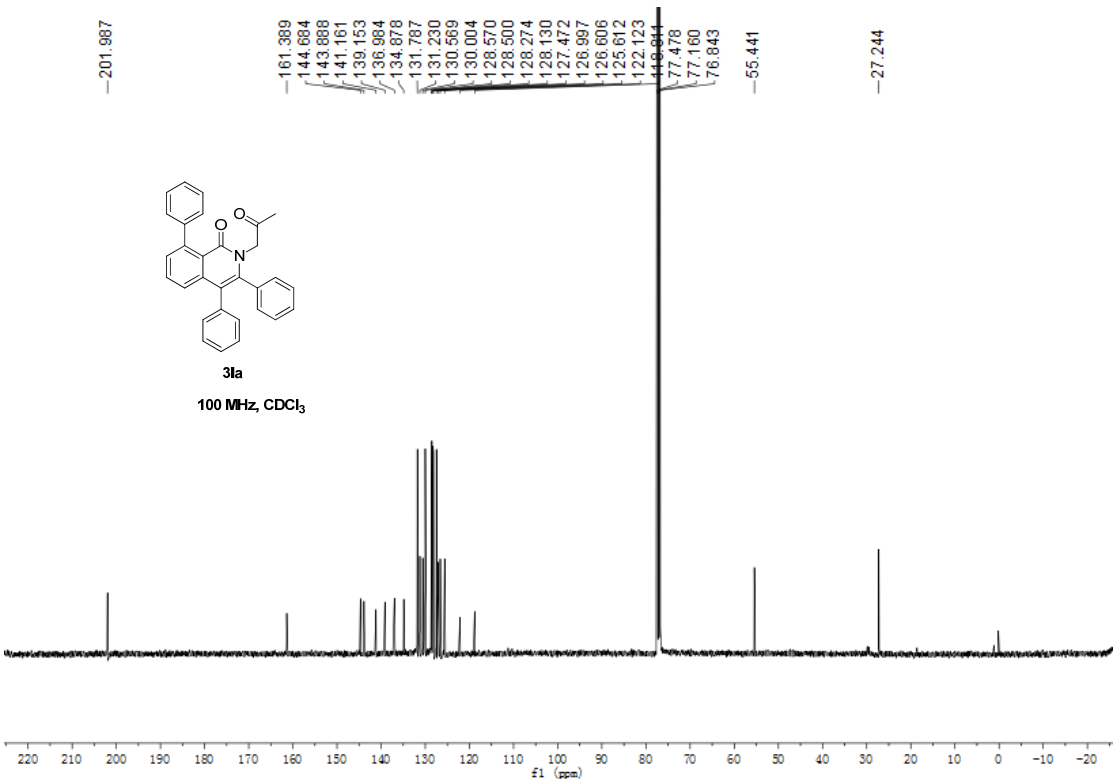

7.379
7.360
7.341
7.260
7.252
7.233
7.197
7.194
7.186
7.178
7.170
7.159
7.146
7.143
7.139
7.126
7.104
7.098
7.090
7.083
7.079
7.062
6.998
6.978
4.566
2.973
2.067
3ka
400 MHz, CDCl3
1.08
1.08
5.64
3.72
1.03
2.02
3.04
3.00
f1 (ppm)


202.274
162.911
141.976
140.655
139.368
137.134
134.919
131.667
130.068
129.979
128.531
128.272
128.042
126.869
124.070
123.454
119.137
77.478
77.160
76.843
55.725
27.375
24.374
3ka
100 MHz, CDCl3
f1 (ppm)



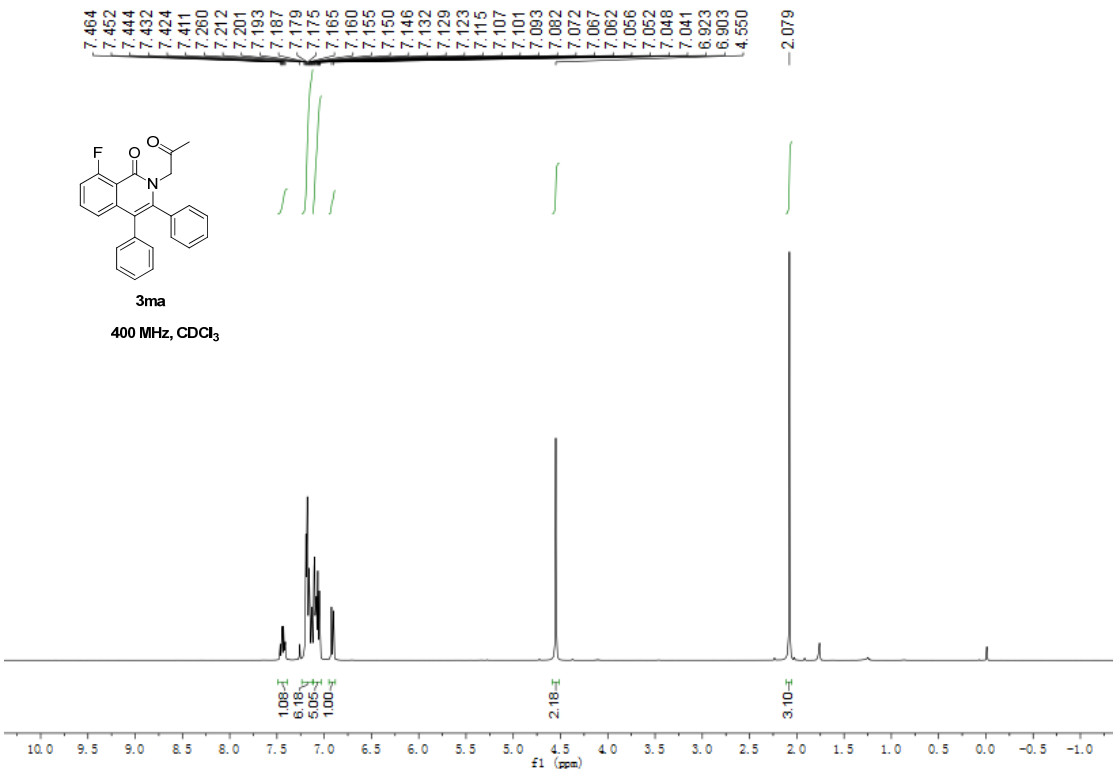
3la

400 MHz, $CDCl_3$



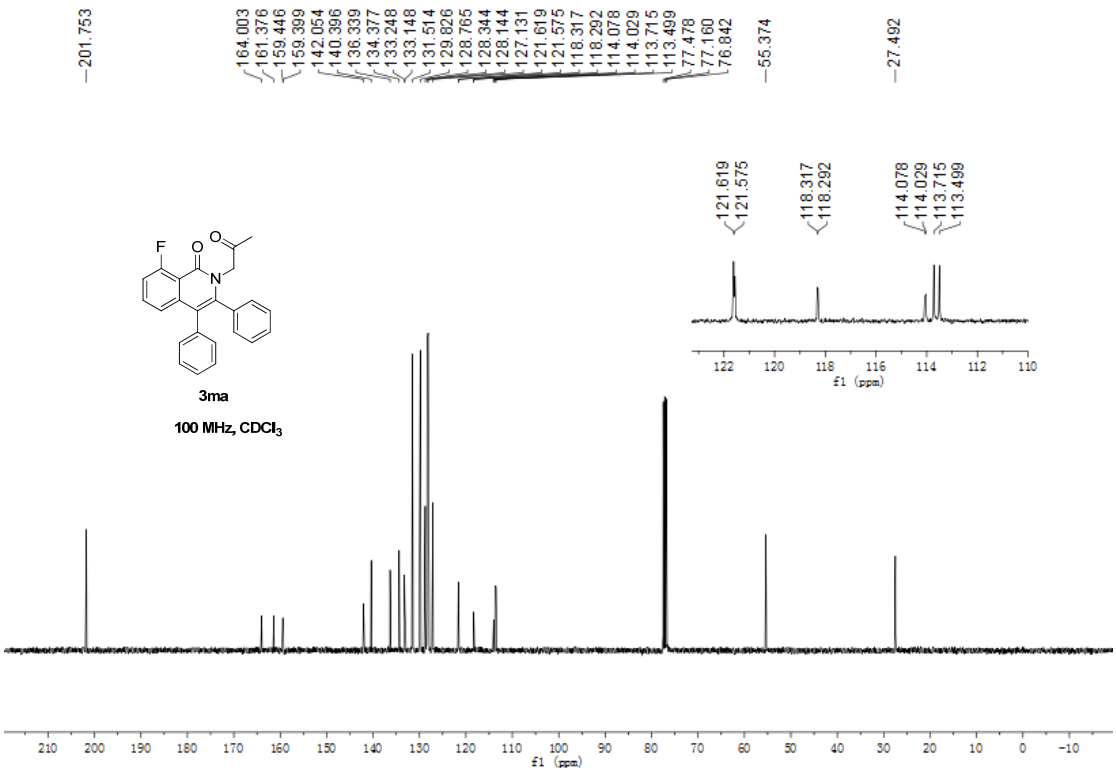
3la

100 MHz, $CDCl_3$



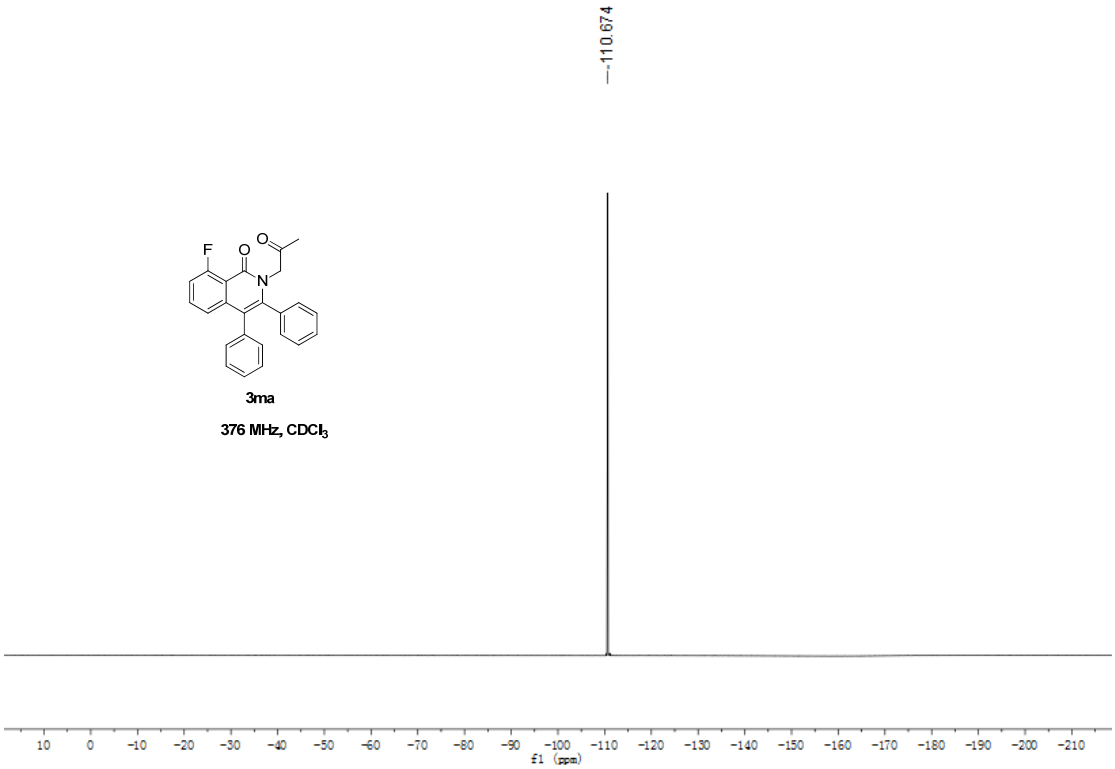
3ma

400 MHz, $CDCl_3$



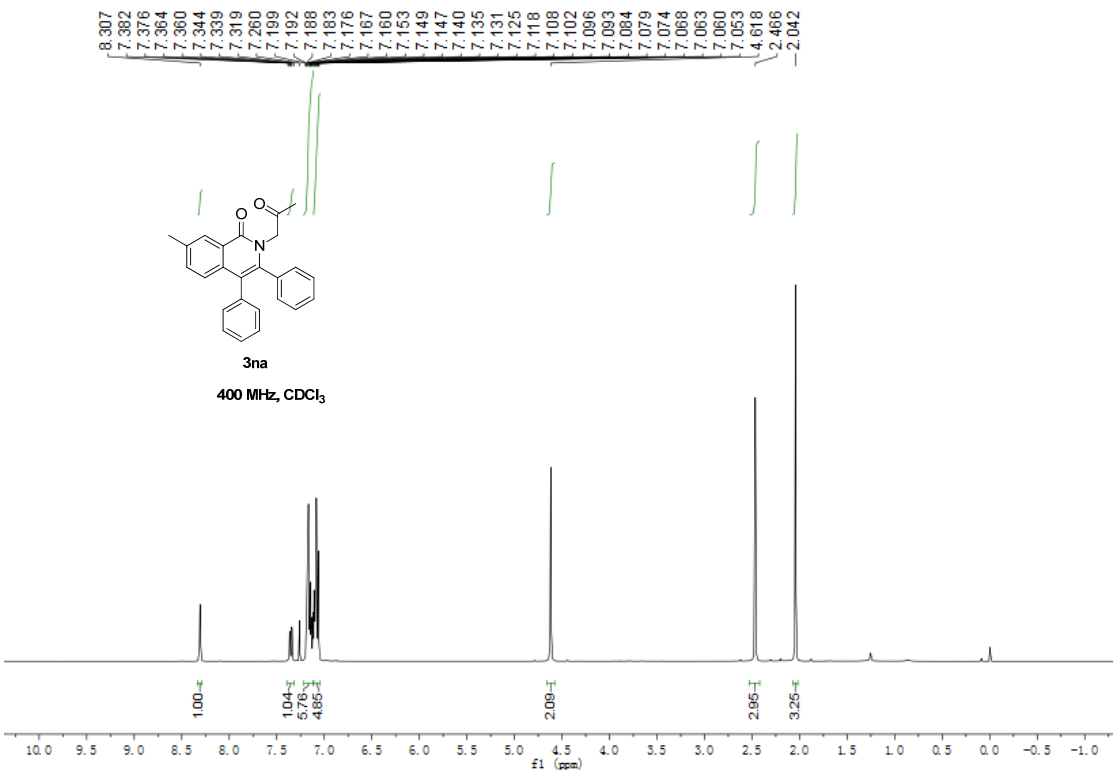
3ma

100 MHz, $CDCl_3$



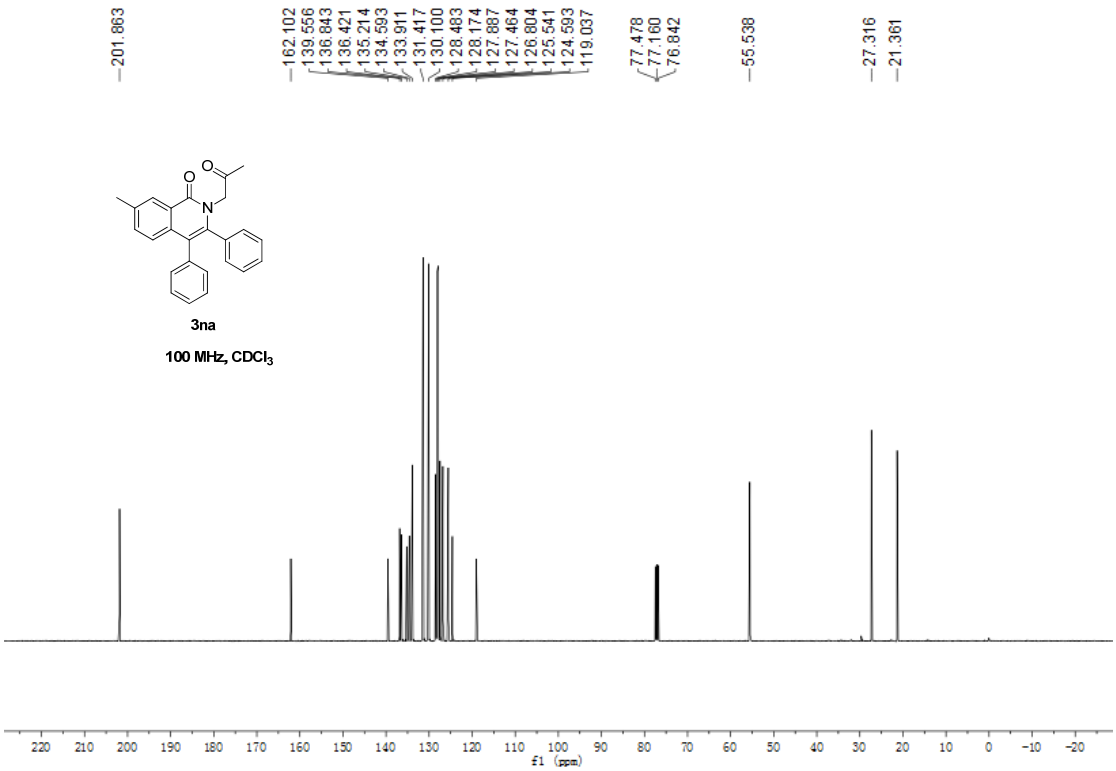
3ma

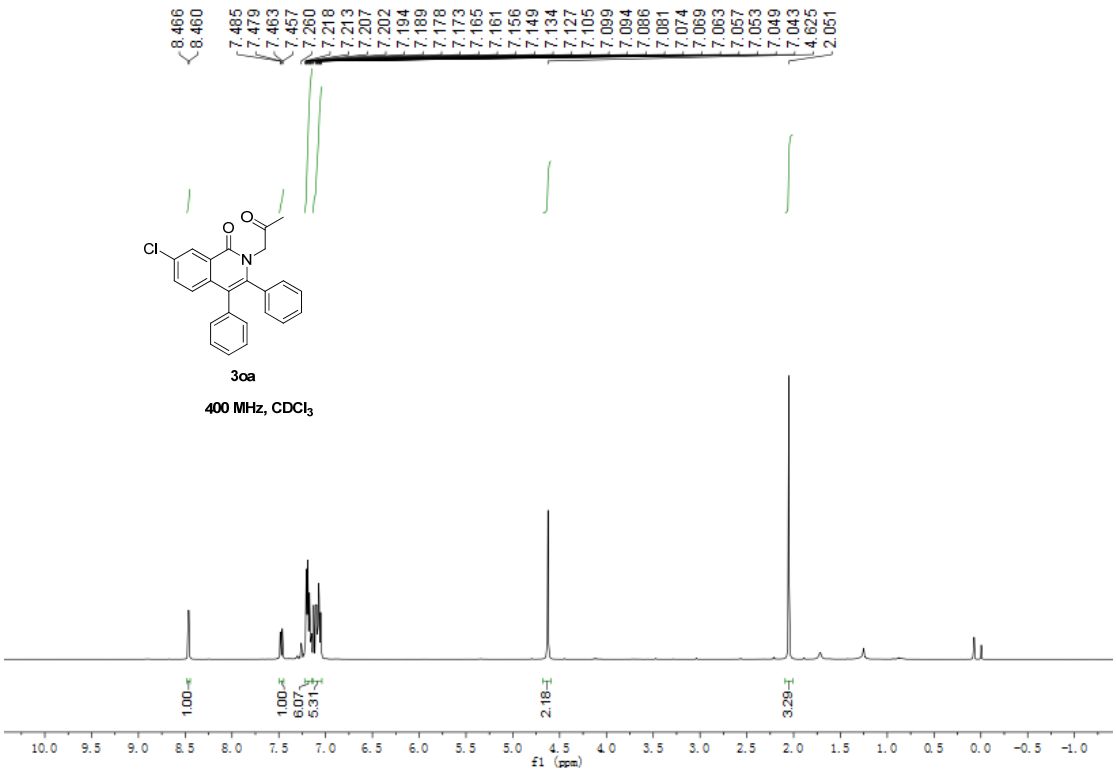
376 MHz, $CDCl_3$

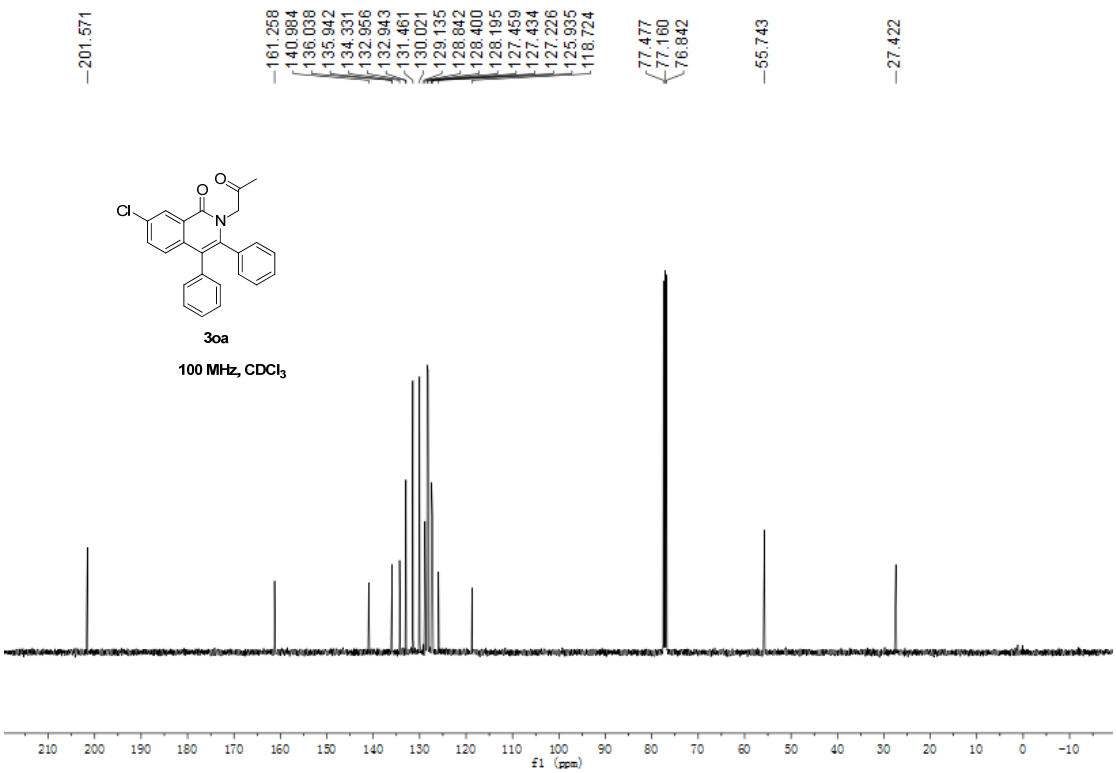


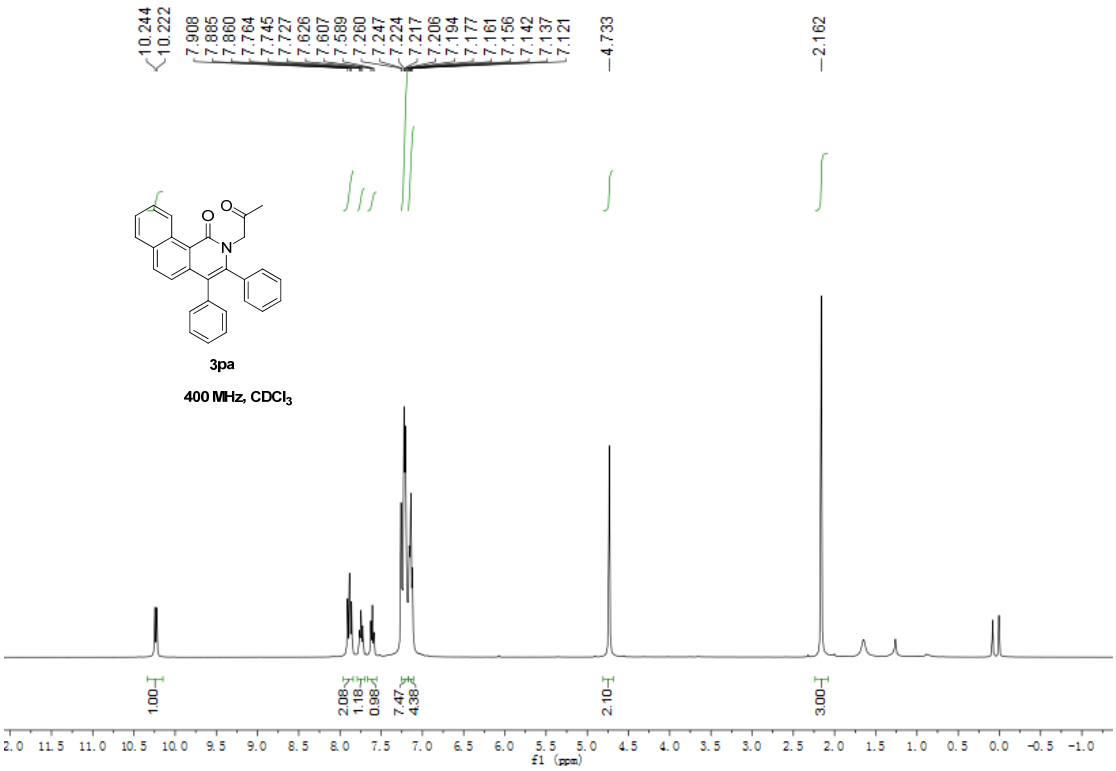
3na

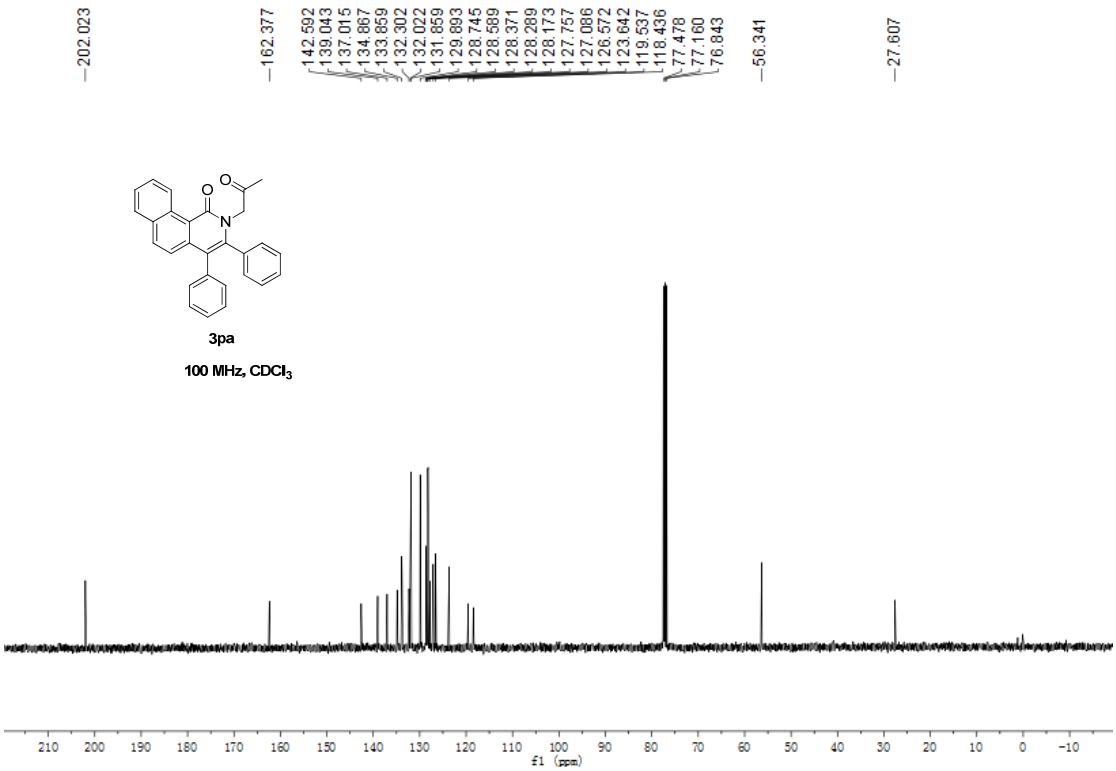
400 MHz, $CDCl_3$

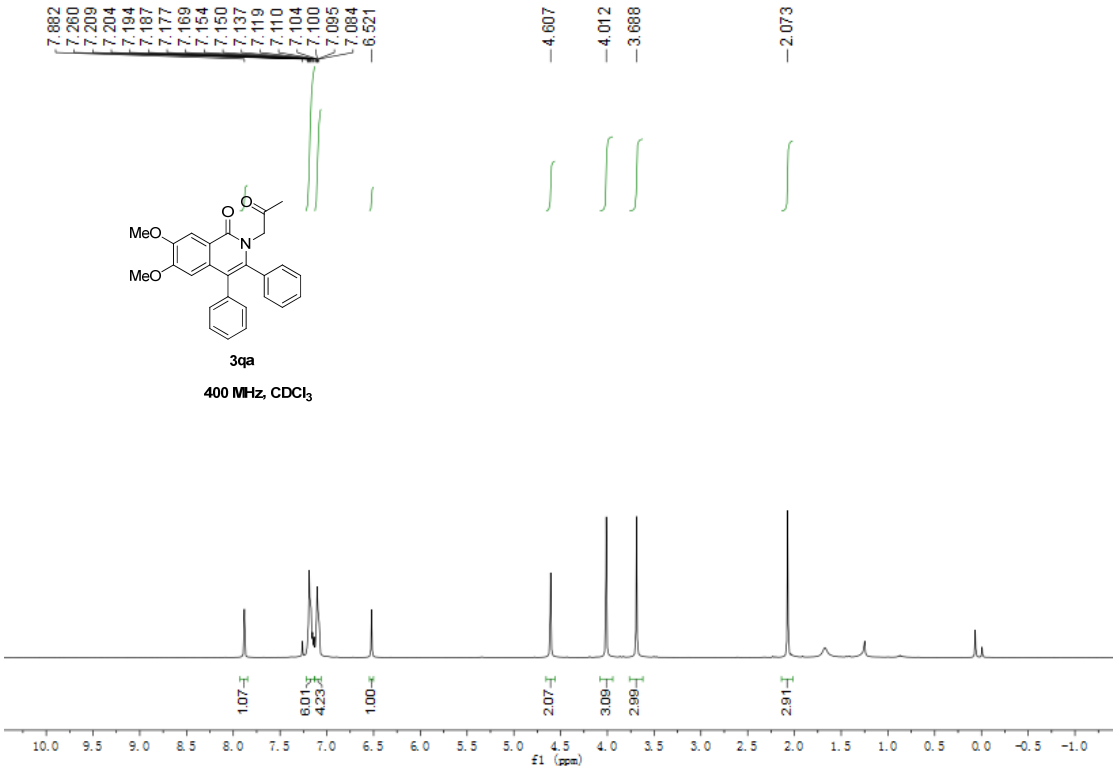

201.863
162.102
139.556
136.843
136.421
135.214
134.593
133.911
131.417
130.100
128.483
128.174
127.887
127.464
126.804
125.541
124.593
119.037
77.478
77.160
76.842
55.538
27.316
21.361
3na
100 MHz, CDCl3
f1 (ppm)

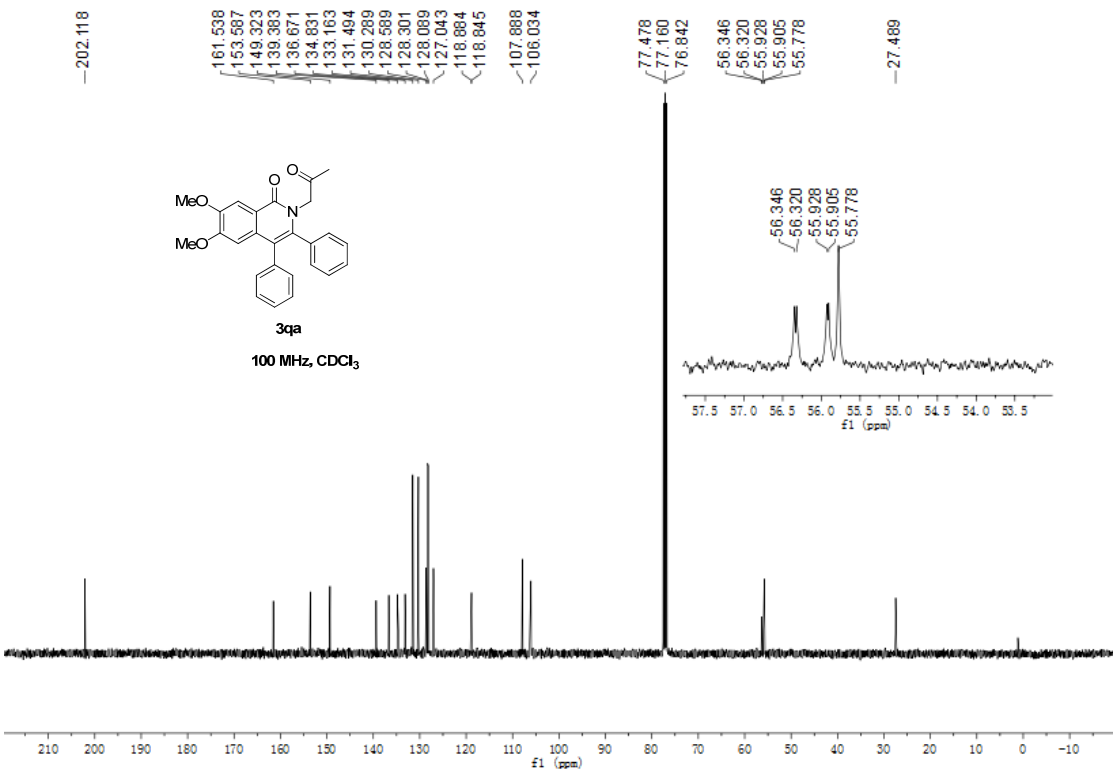

8.466
8.460
7.485
7.479
7.463
7.457
7.260
7.218
7.213
7.207
7.202
7.194
7.189
7.178
7.173
7.165
7.161
7.156
7.149
7.134
7.127
7.105
7.099
7.094
7.086
7.081
7.074
7.069
7.063
7.057
7.053
7.049
7.043
4.625
2.051
Cl
3oa
400 MHz, CDCl3
1.00
1.00
6.07
5.31
2.18
3.29
f1 (ppm)

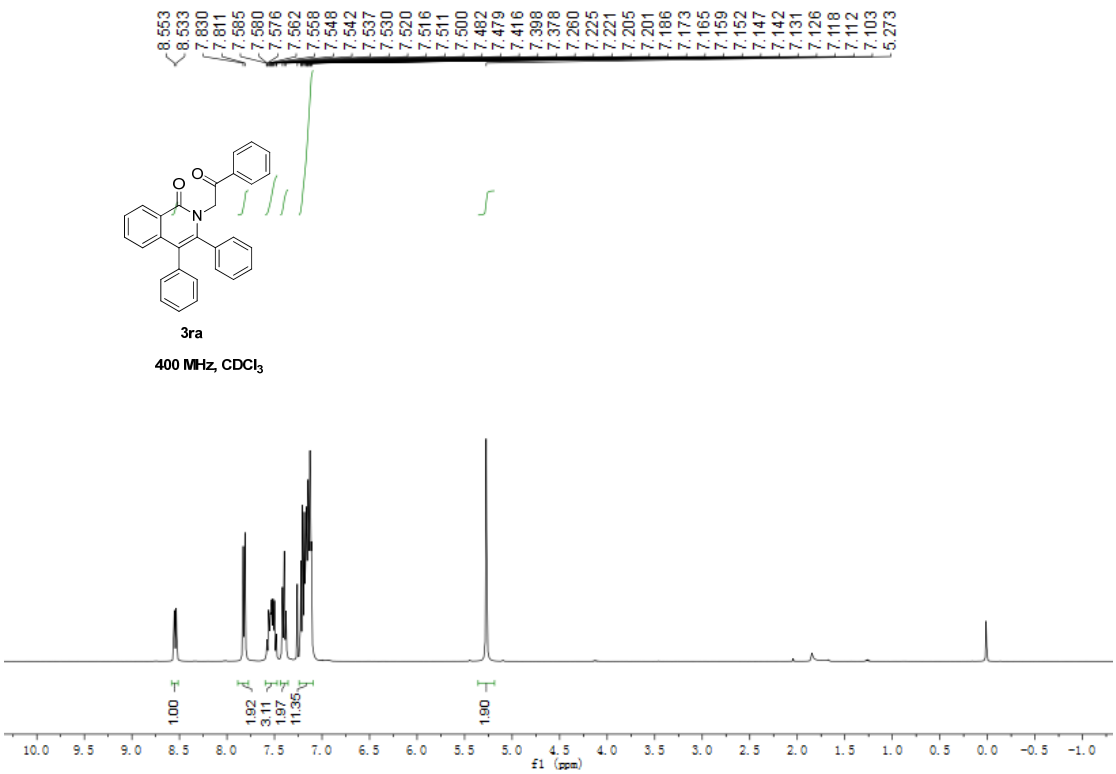

201.571
161.258
140.984
136.038
135.942
134.331
132.956
132.943
131.461
130.021
129.135
128.842
128.400
128.195
127.459
127.434
127.226
125.935
118.724
77.477
77.160
76.842
55.743
27.422
Cl
O
N
O
3oa
100 MHz, CDCl3
f1 (ppm)

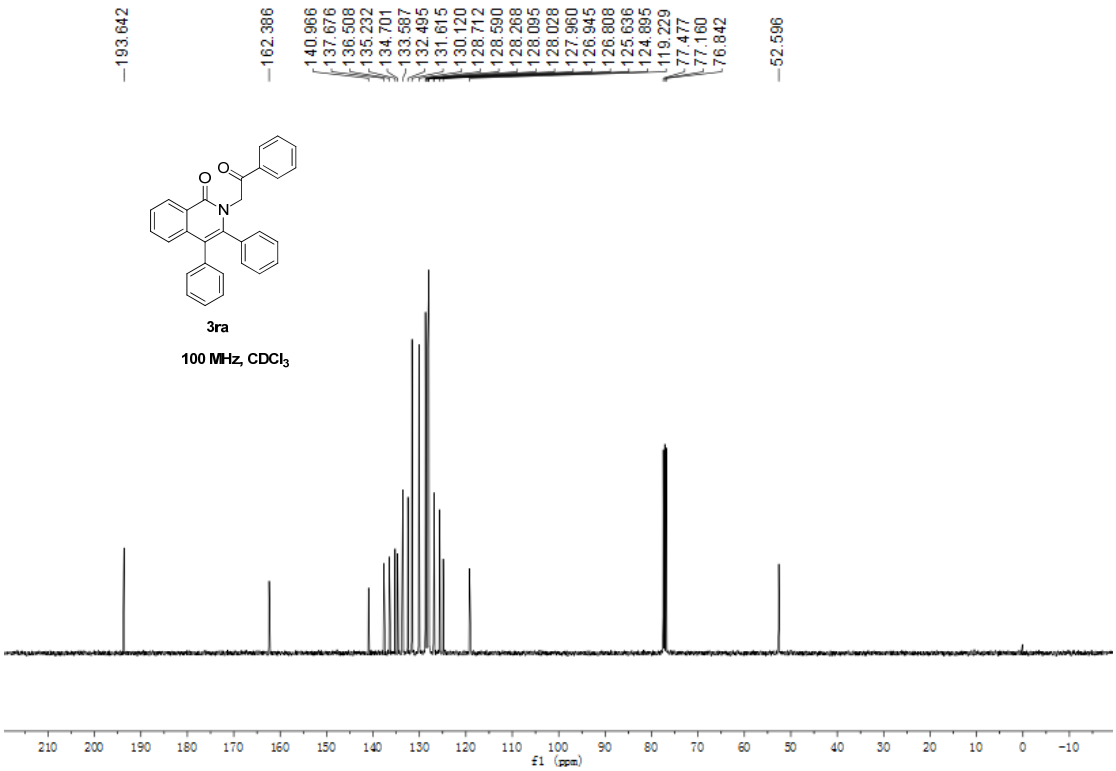

10.244
10.222
7.908
7.885
7.860
7.764
7.745
7.727
7.626
7.607
7.589
7.260
7.247
7.224
7.217
7.206
7.194
7.177
7.161
7.156
7.142
7.137
7.121
4.733
2.162
O
N
O
3pa
400 MHz, CDCl3
1.00
2.08
1.18
0.98
7.47
4.38
2.10
3.00
f1 (ppm)

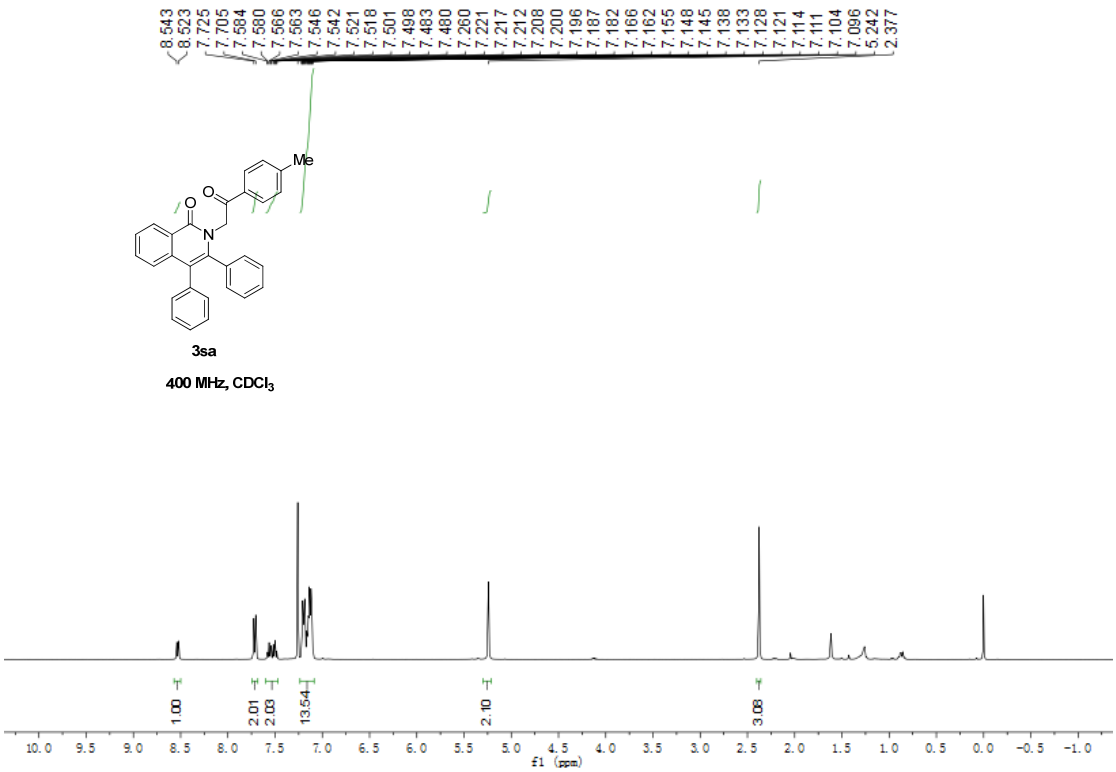

202.023
162.377
142.592
139.043
137.015
134.867
133.859
132.302
132.022
131.859
129.893
128.745
128.589
128.371
128.289
128.173
127.757
127.086
126.572
123.642
119.537
118.436
77.478
77.160
76.843
56.341
27.607
O
O
N
3pa
100 MHz, CDCl3
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

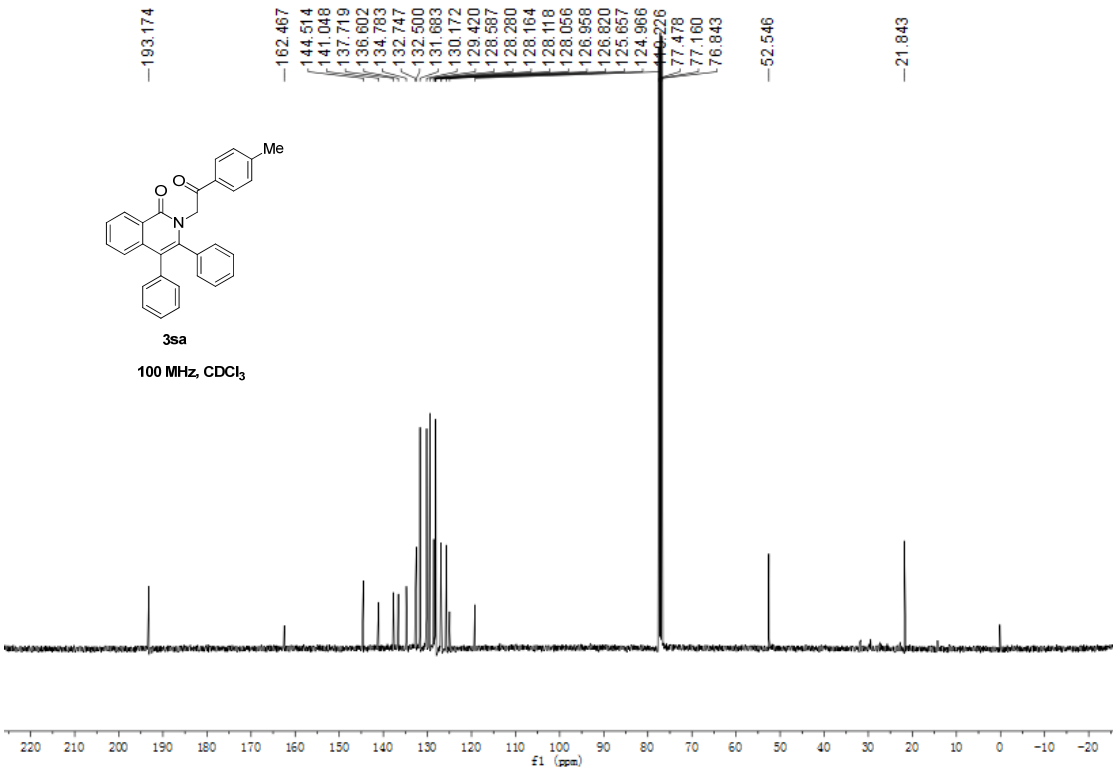

7.882
7.260
7.209
7.204
7.194
7.187
7.177
7.169
7.154
7.150
7.137
7.119
7.110
7.104
7.100
7.095
7.084
6.521
4.607
4.012
3.688
2.073
O
O
N
MeO
MeO
3qa
400 MHz, CDCl3
1.07
6.01
4.23
1.00
2.07
3.09
2.99
2.91
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0
f1 (ppm)


202.118
161.538
153.587
149.323
139.383
136.671
134.831
133.163
131.494
130.289
128.589
128.301
128.089
127.043
118.884
118.845
107.888
106.034
77.478
77.160
76.842
56.346
56.320
55.928
55.905
55.778
27.489
MeO
MeO
O
N
O
3qa
100 MHz, CDCl3
f1 (ppm)


8.553
8.533
7.830
7.811
7.585
7.580
7.576
7.562
7.558
7.548
7.542
7.537
7.530
7.520
7.516
7.511
7.500
7.482
7.479
7.416
7.398
7.378
7.260
7.225
7.221
7.205
7.201
7.186
7.173
7.165
7.159
7.152
7.147
7.142
7.131
7.126
7.118
7.112
7.103
5.273
O
O
N
3ra
400 MHz, CDCl3
1.00
1.92
3.11
1.97
11.35
1.90
f1 (ppm)

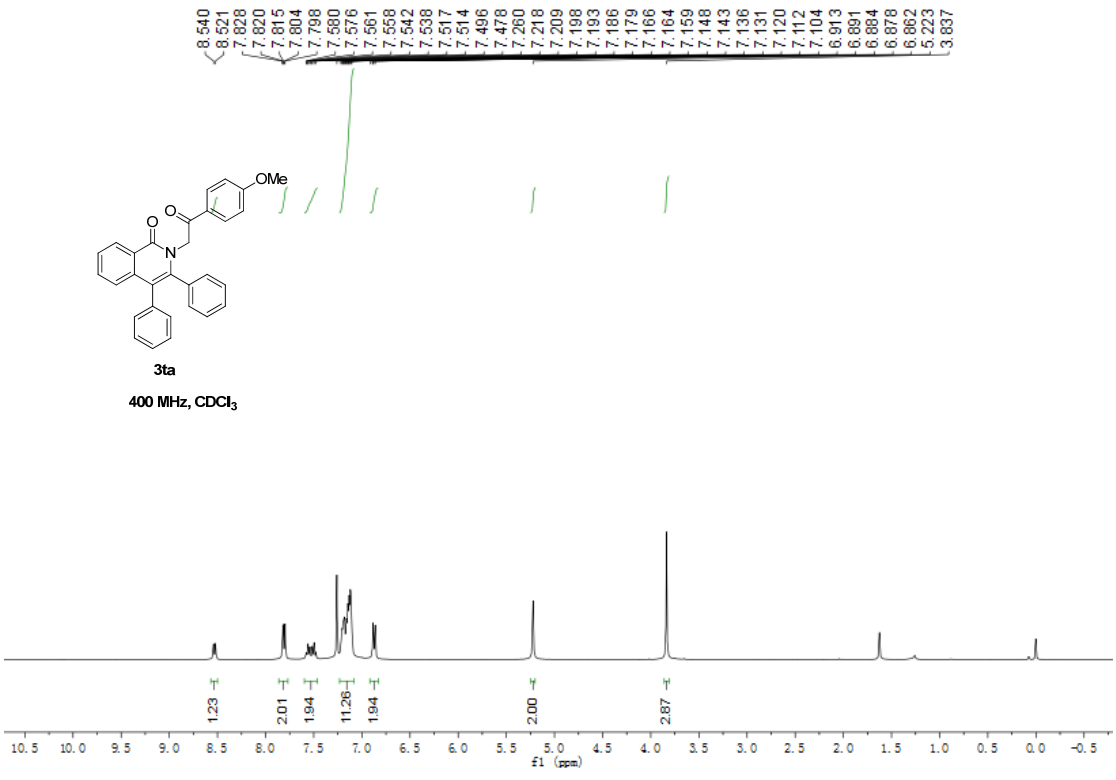

193.642
162.386
140.966
137.676
136.508
135.232
134.701
133.587
132.495
131.615
130.120
128.712
128.590
128.268
128.095
128.028
127.960
126.945
126.808
125.636
124.895
119.229
77.477
77.160
76.842
52.596
O
O
N
3ra
100 MHz, CDCl3
f1 (ppm)


8.543
8.523
7.725
7.705
7.584
7.580
7.566
7.563
7.546
7.542
7.521
7.518
7.501
7.498
7.483
7.480
7.260
7.221
7.217
7.212
7.208
7.200
7.196
7.187
7.182
7.166
7.162
7.155
7.148
7.145
7.138
7.133
7.128
7.121
7.114
7.111
7.104
7.096
5.242
2.377
Me
O
O
N
3sa
400 MHz, CDCl3
1.00
2.01
2.03
13.54
2.10
3.08
f1 (ppm)



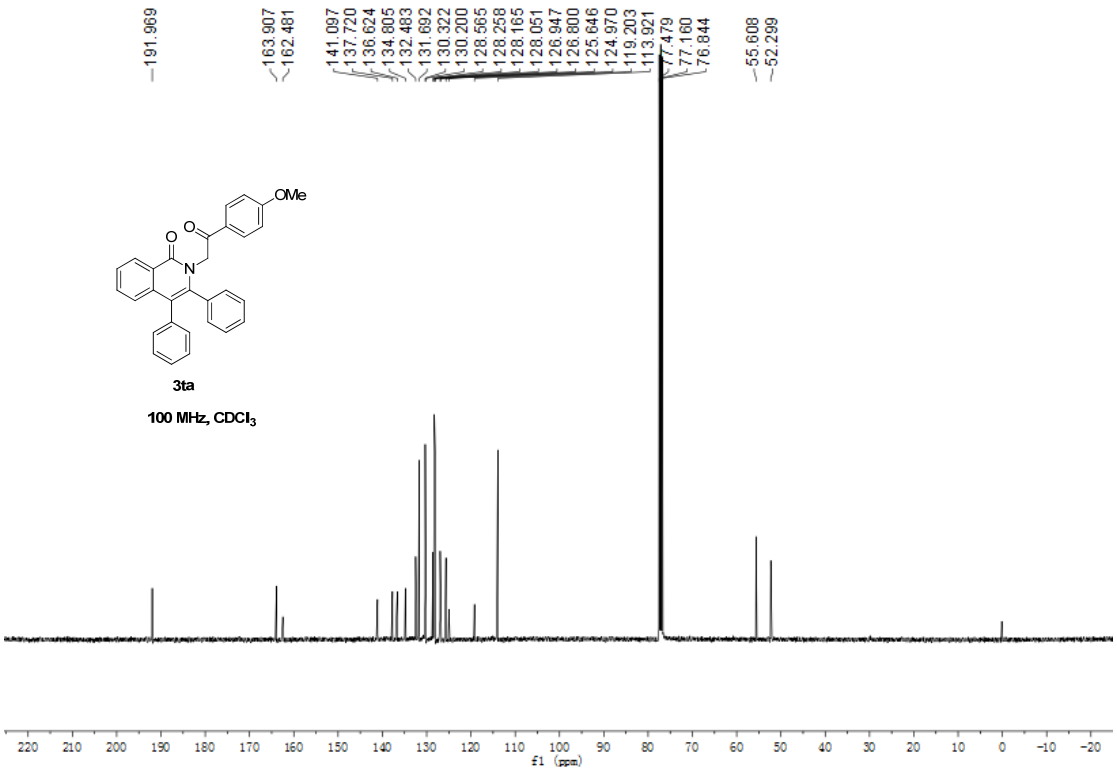
3sa

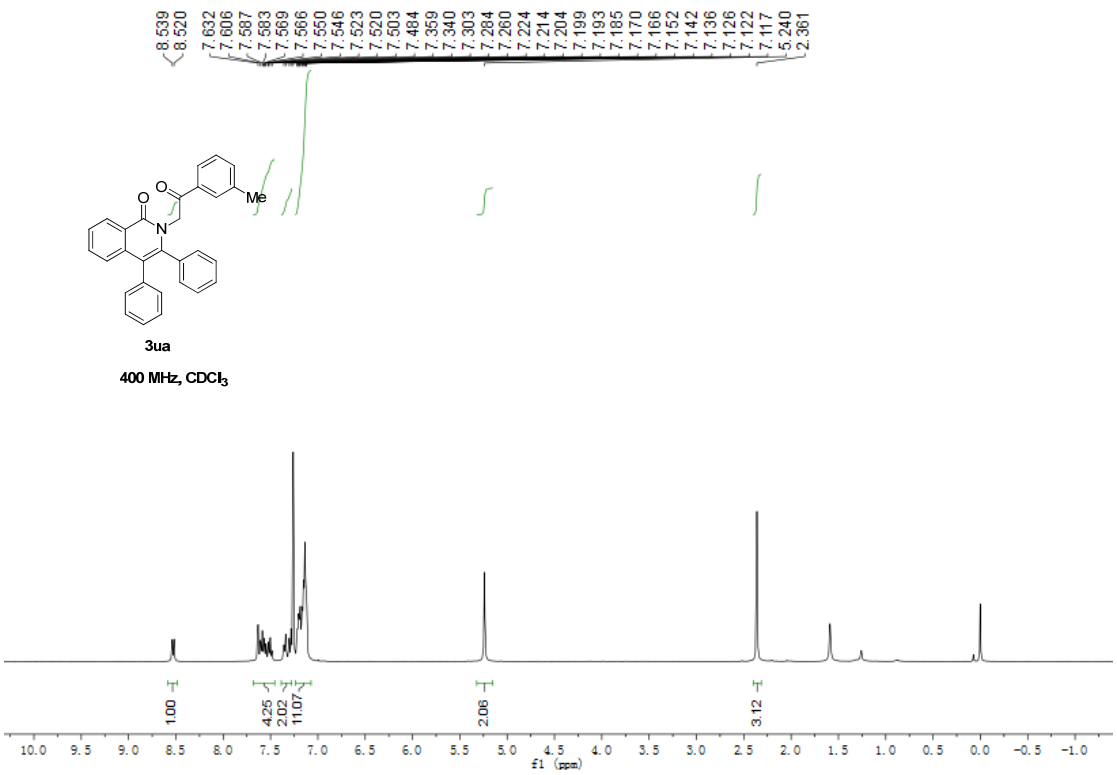
100 MHz, $CDCl_3$

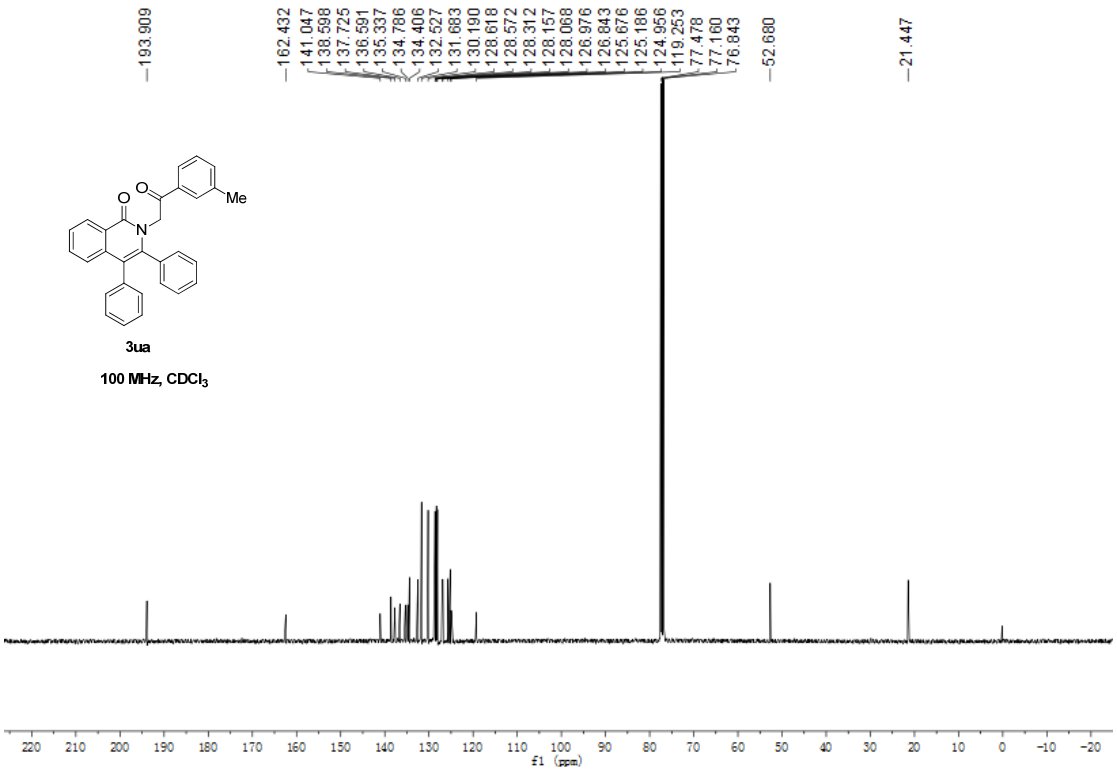


3ta

400 MHz, $CDCl_3$

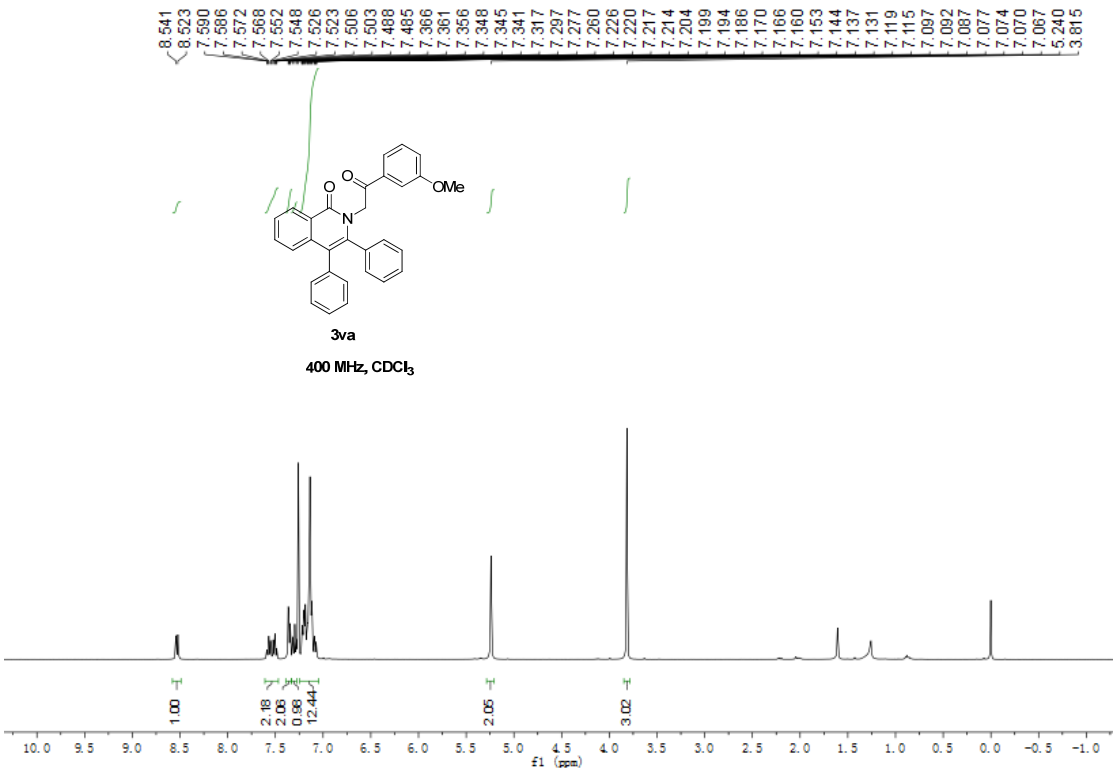

191.969
163.907
162.481
141.097
137.720
136.624
134.805
132.483
131.692
130.322
130.200
128.565
128.258
128.165
128.051
126.947
126.800
125.646
124.970
119.203
113.921
77.479
77.160
76.844
55.608
52.299
OMe
O
O
N
3ta
100 MHz, CDCl3
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10 -20
f1 (ppm)


8.539
8.520
7.632
7.606
7.587
7.583
7.569
7.566
7.550
7.546
7.523
7.520
7.503
7.484
7.359
7.340
7.303
7.284
7.260
7.224
7.214
7.204
7.199
7.193
7.185
7.170
7.166
7.152
7.142
7.136
7.126
7.122
7.117
5.240
2.361
Me
O
O
N
3ua
400 MHz, CDCl3
1.00
4.25
2.02
11.07
2.06
3.12
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0
f1 (ppm)



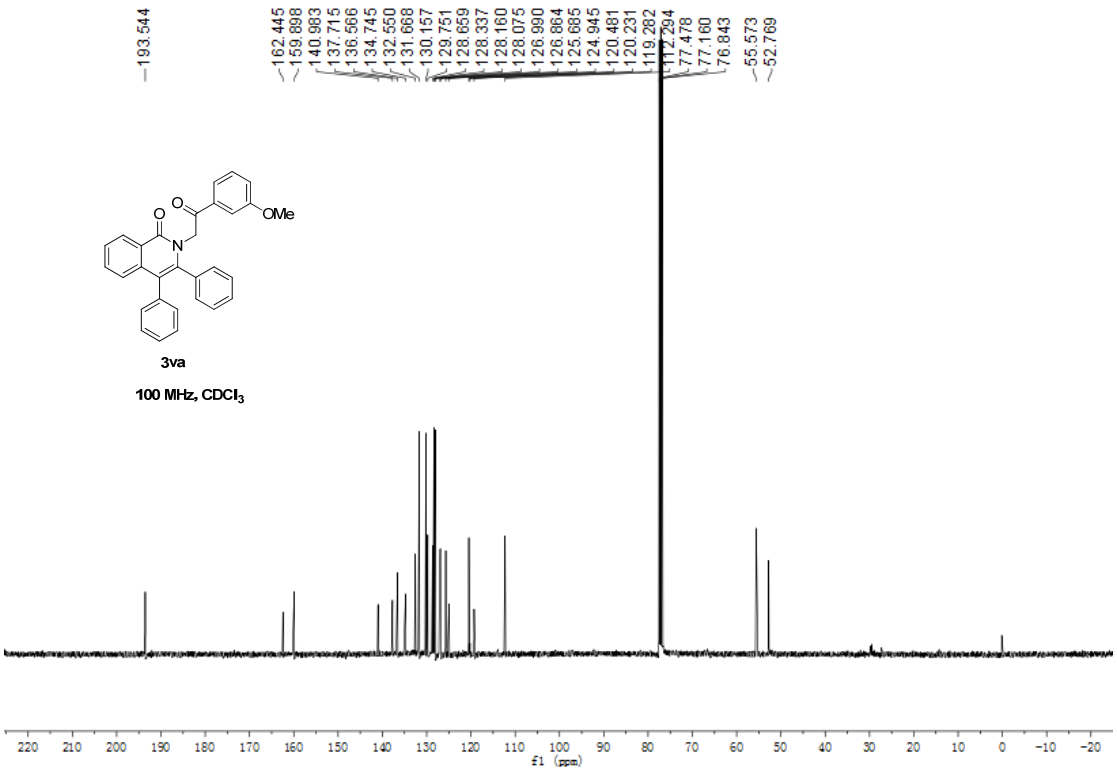
3ua

100 MHz, $CDCl_3$



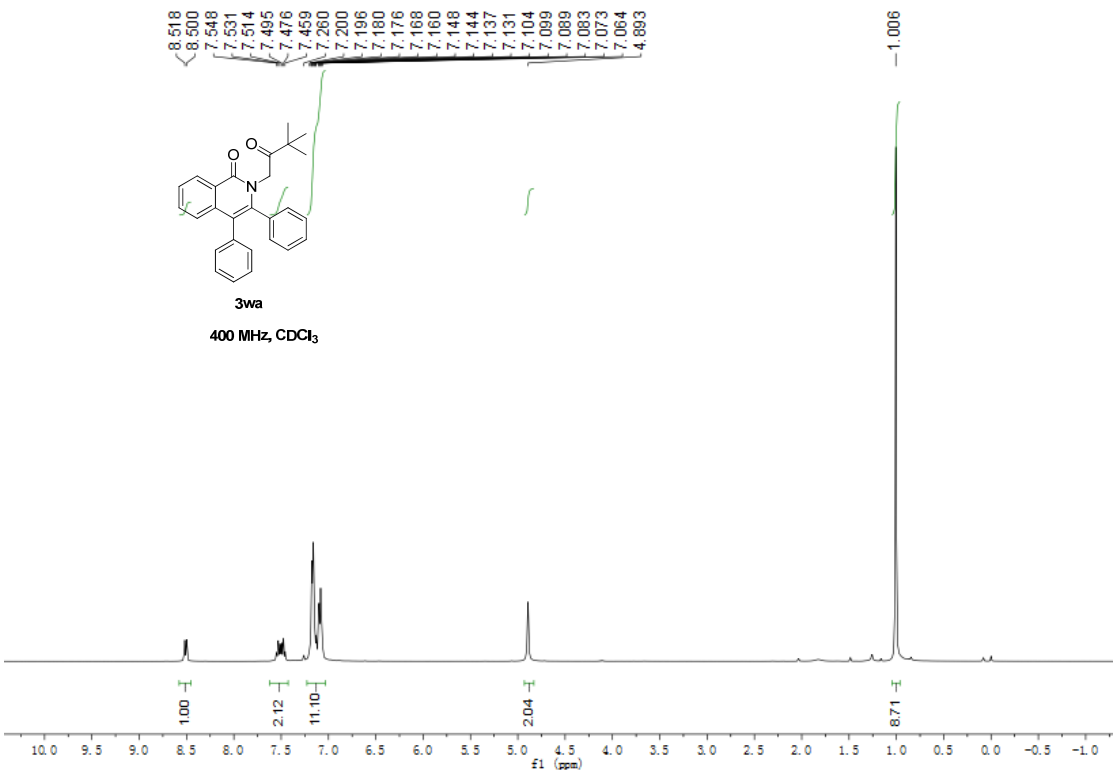
3va

400 MHz, $CDCl_3$



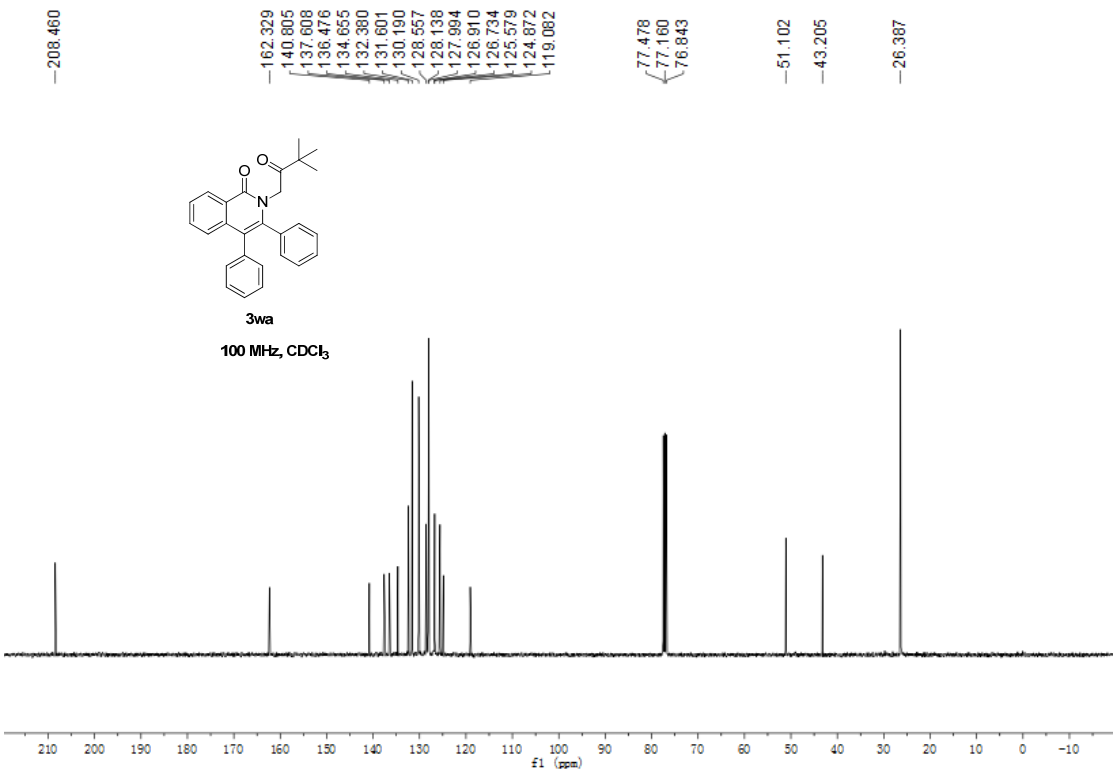
3va

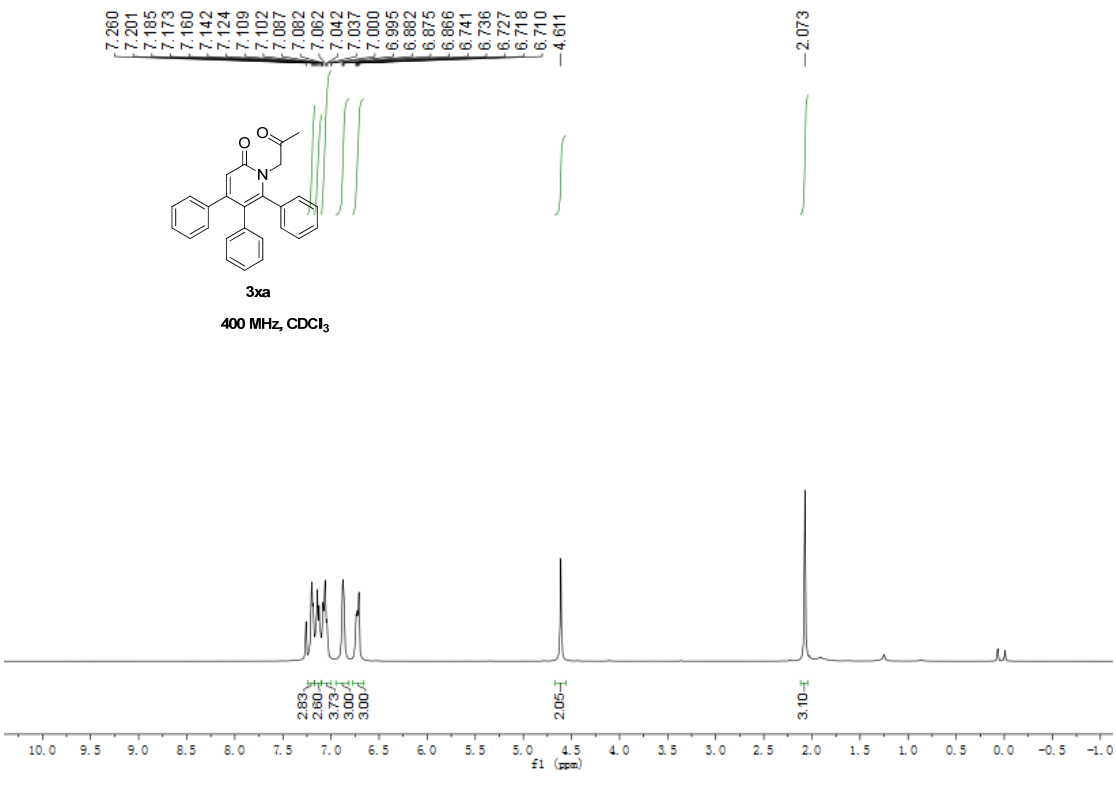
100 MHz, $CDCl_3$

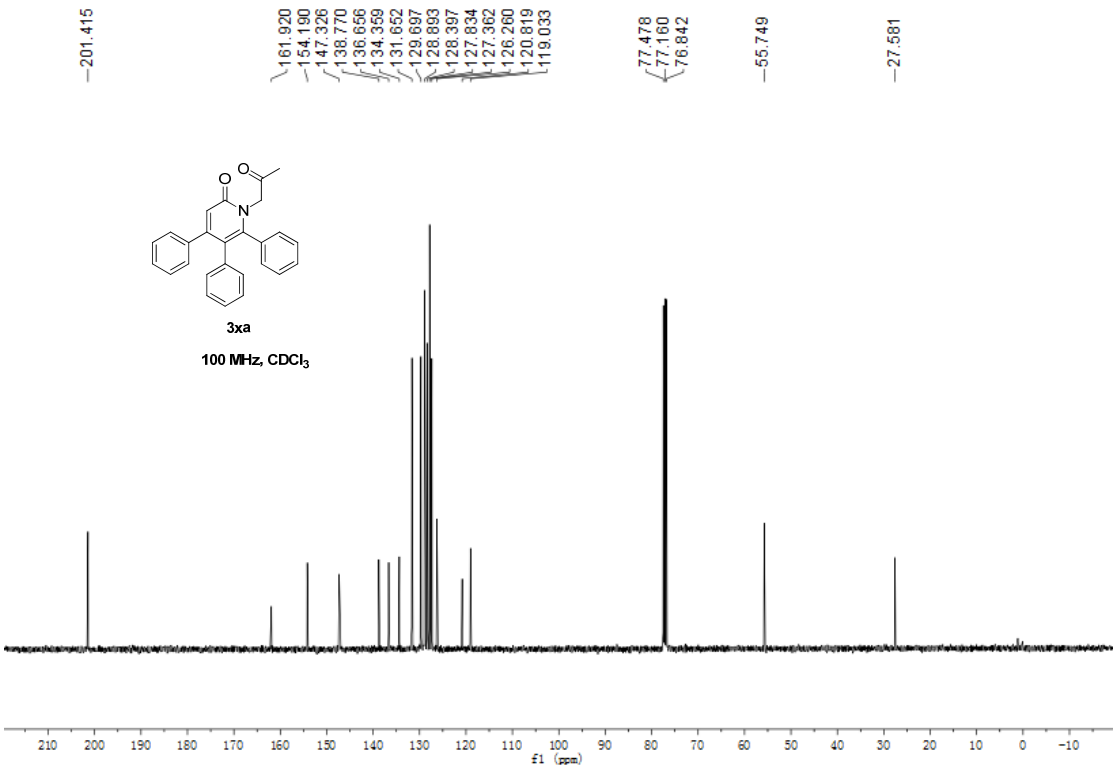


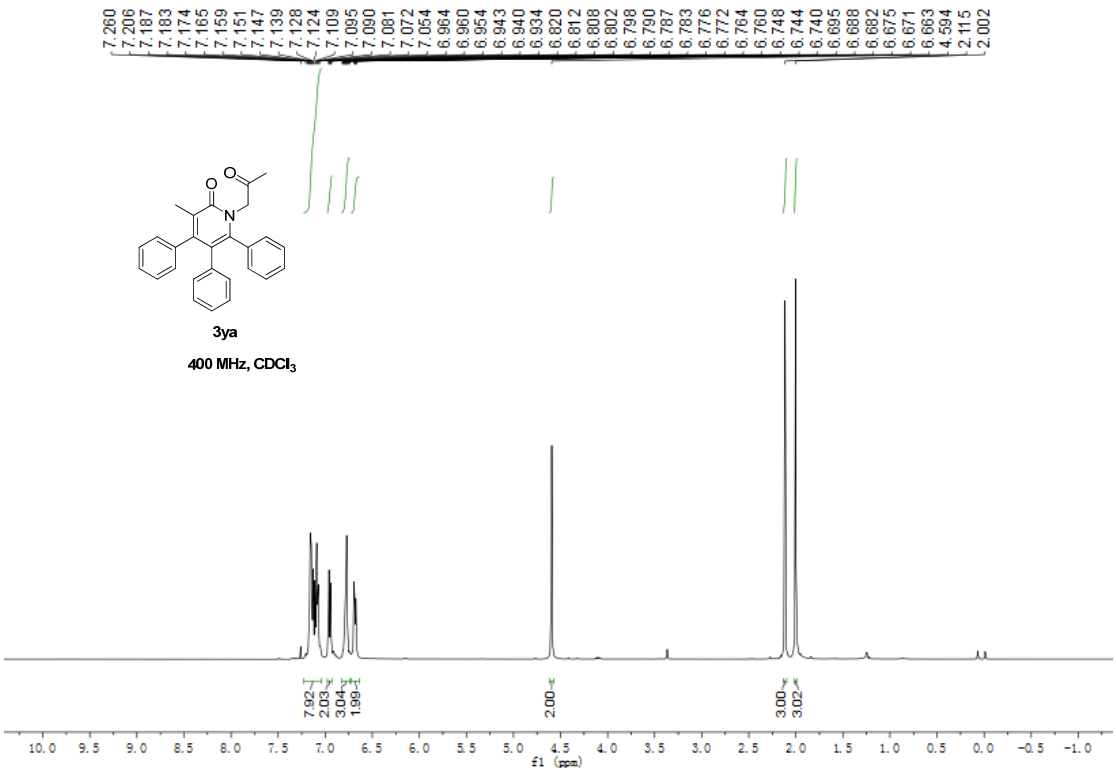
3wa

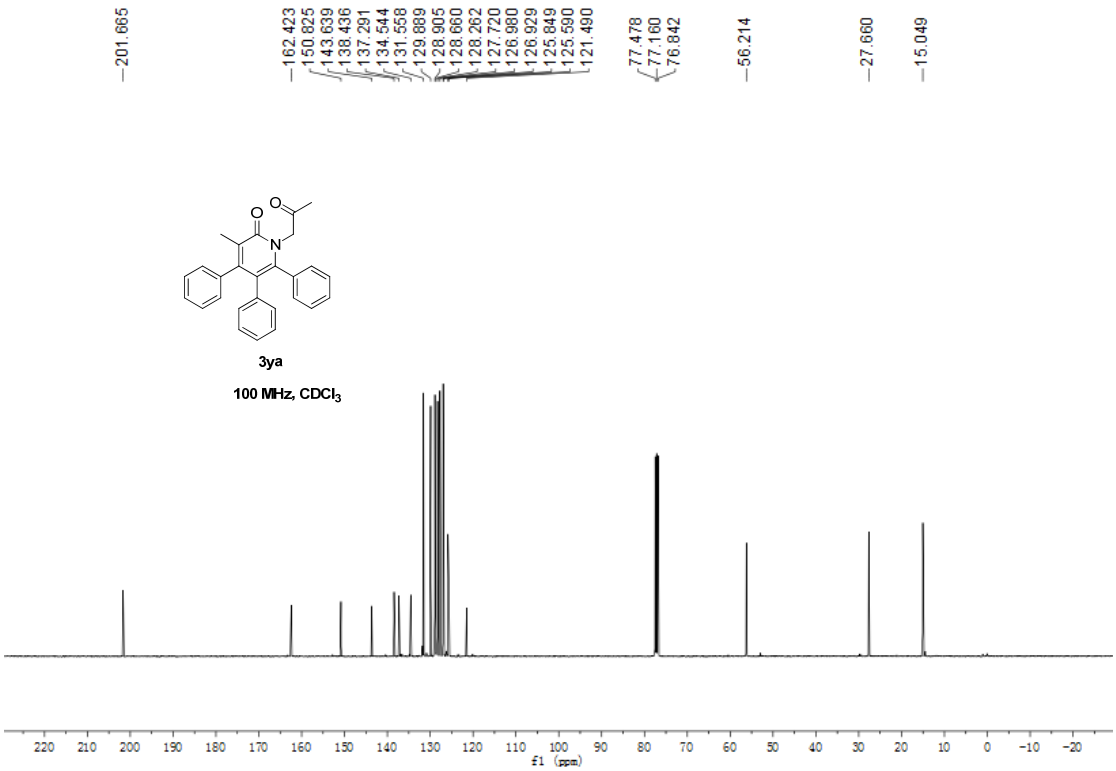
400 MHz, $CDCl_3$

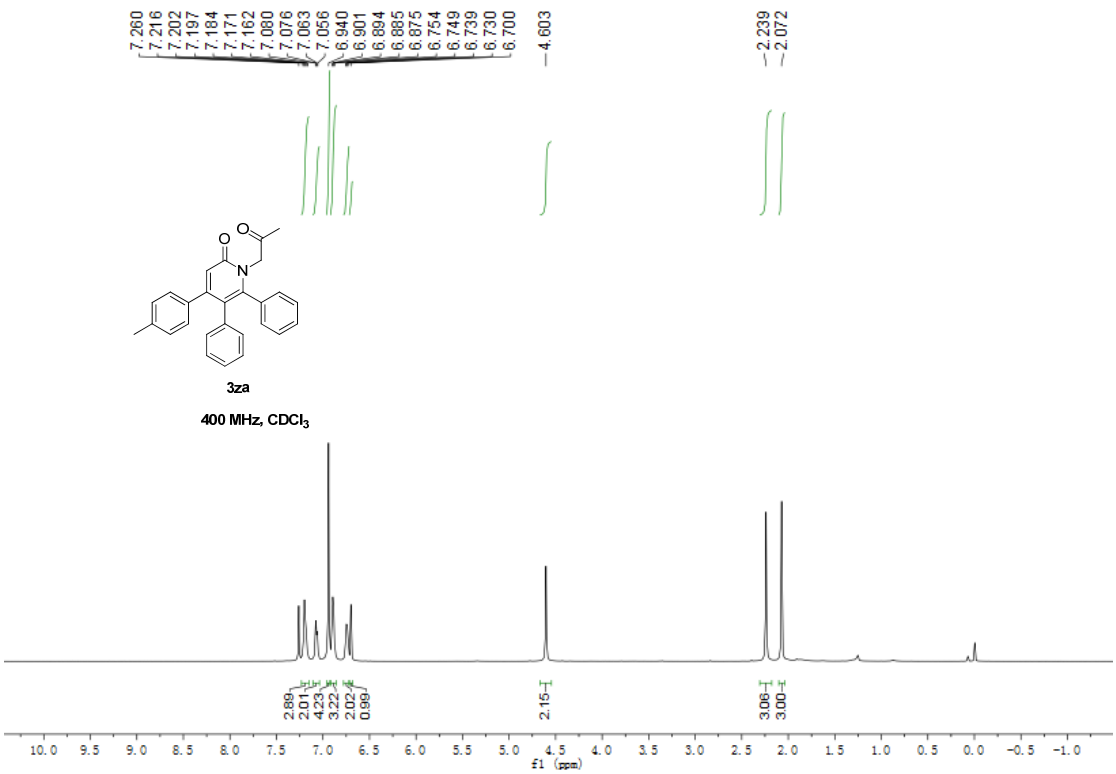

208.460
162.329
140.805
137.608
136.476
134.655
132.380
131.601
130.190
128.557
128.138
127.994
126.910
126.734
125.579
124.872
119.082
77.478
77.160
76.843
51.102
43.205
26.387
O
O
N
3wa
100 MHz, CDCl3
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

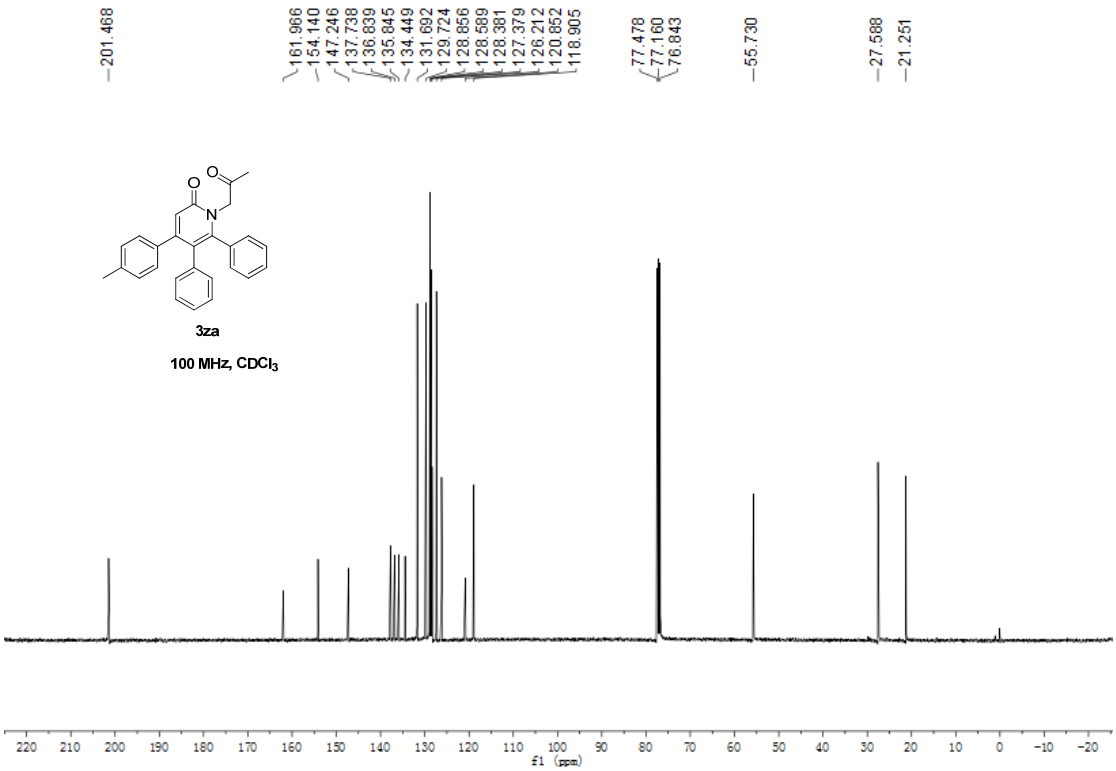

7.260
7.201
7.185
7.173
7.160
7.142
7.124
7.109
7.102
7.087
7.082
7.062
7.042
7.037
7.000
6.995
6.882
6.875
6.866
6.741
6.736
6.727
6.718
6.710
4.611
2.073
O
O
N
3xa
400 MHz, CDCl3
2.83
2.60
3.73
3.00
3.00
2.05
3.10
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0
f1 (ppm)

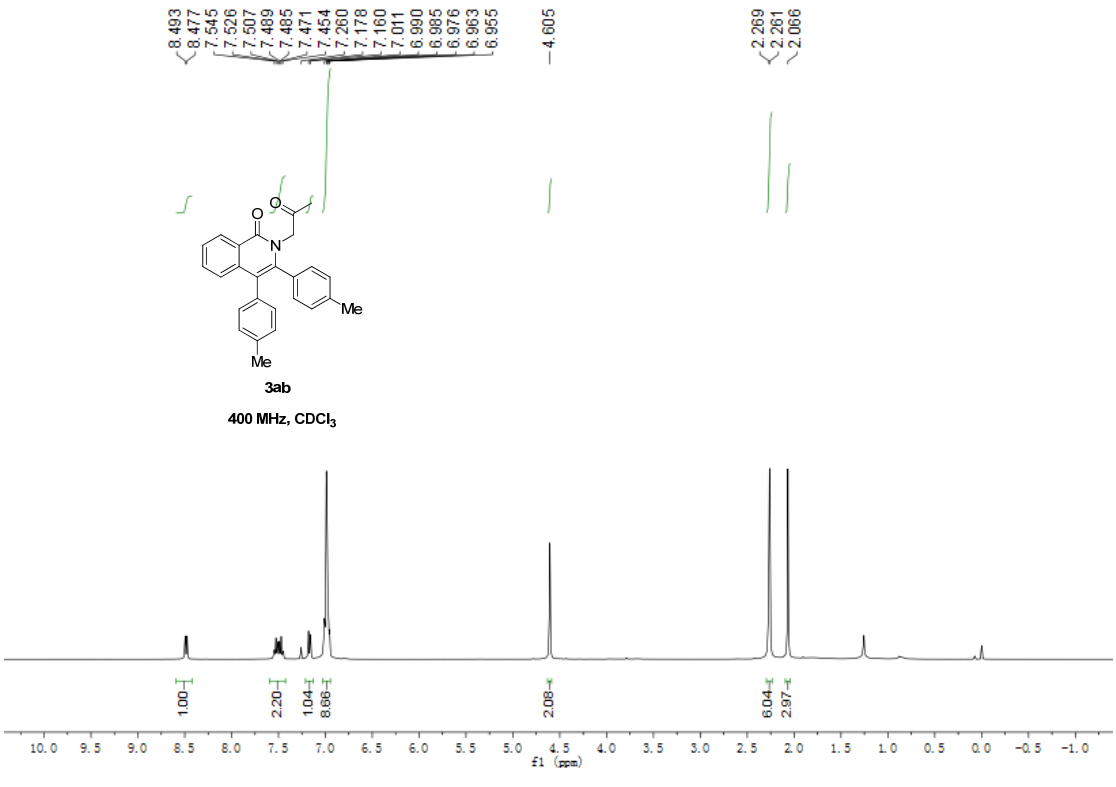

201.415
161.920
154.190
147.326
138.770
136.656
134.359
131.652
129.697
128.893
128.397
127.834
127.362
126.260
120.819
119.033
77.478
77.160
76.842
55.749
27.581
3xa
100 MHz, CDCl3
f1 (ppm)

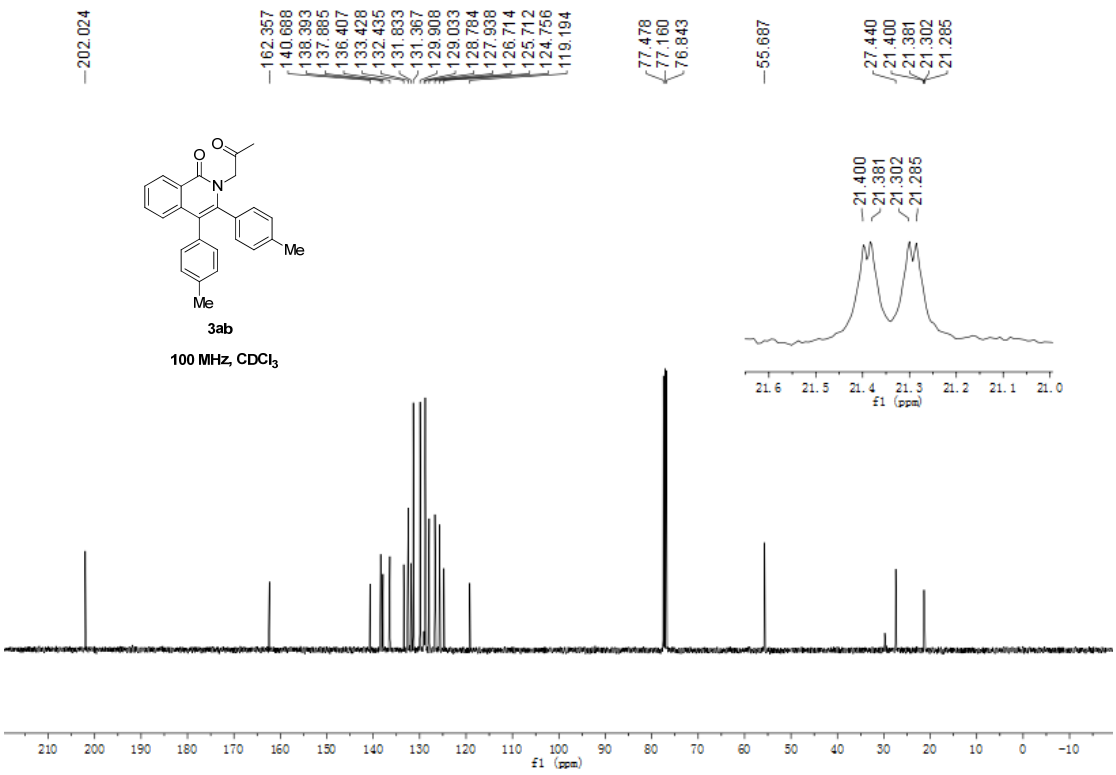

7.260
7.206
7.187
7.183
7.174
7.165
7.159
7.151
7.147
7.139
7.128
7.124
7.109
7.095
7.090
7.081
7.072
7.054
6.964
6.960
6.954
6.943
6.940
6.934
6.820
6.812
6.808
6.802
6.798
6.790
6.787
6.783
6.776
6.772
6.764
6.760
6.748
6.744
6.740
6.695
6.688
6.682
6.675
6.671
6.663
4.594
2.115
2.002
7.92
2.03
3.04
1.99
2.00
3.00
3.02
3ya
400 MHz, CDCl3
f1 (ppm)

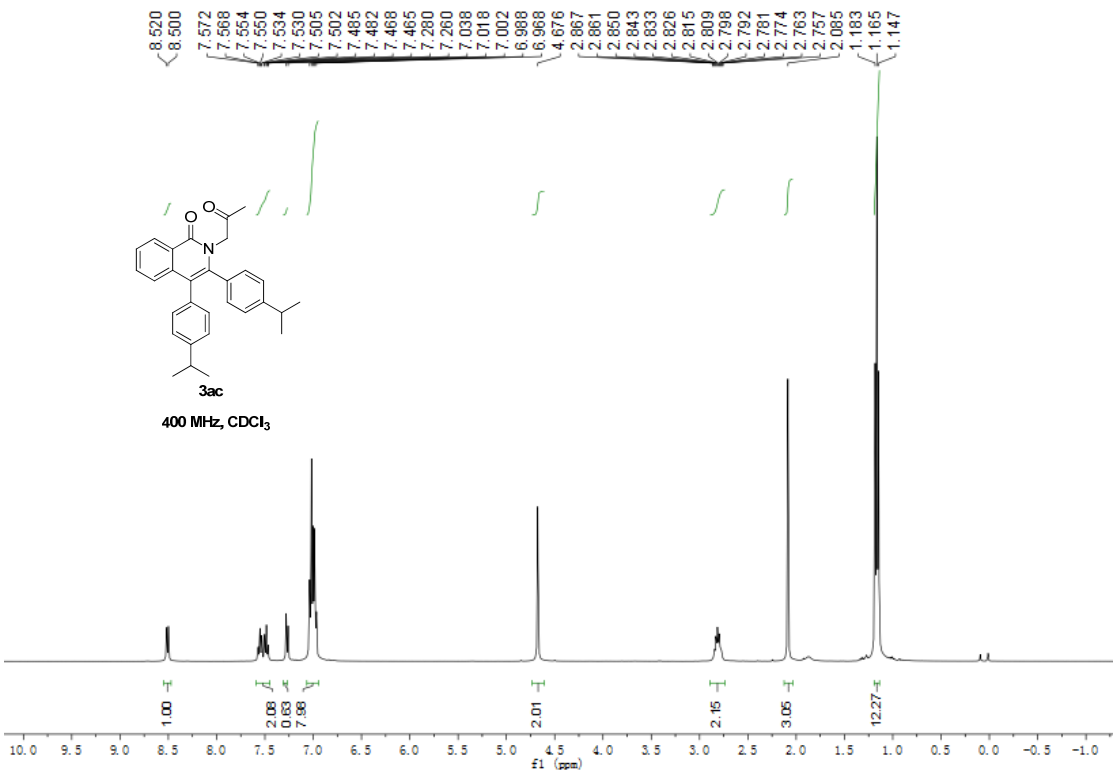

201.665
162.423
150.825
143.639
138.436
137.291
134.544
131.558
129.889
128.905
128.660
128.262
127.720
126.980
126.929
125.849
125.590
121.490
77.478
77.160
76.842
56.214
27.660
15.049
3ya
100 MHz, CDCl3
f1 (ppm)

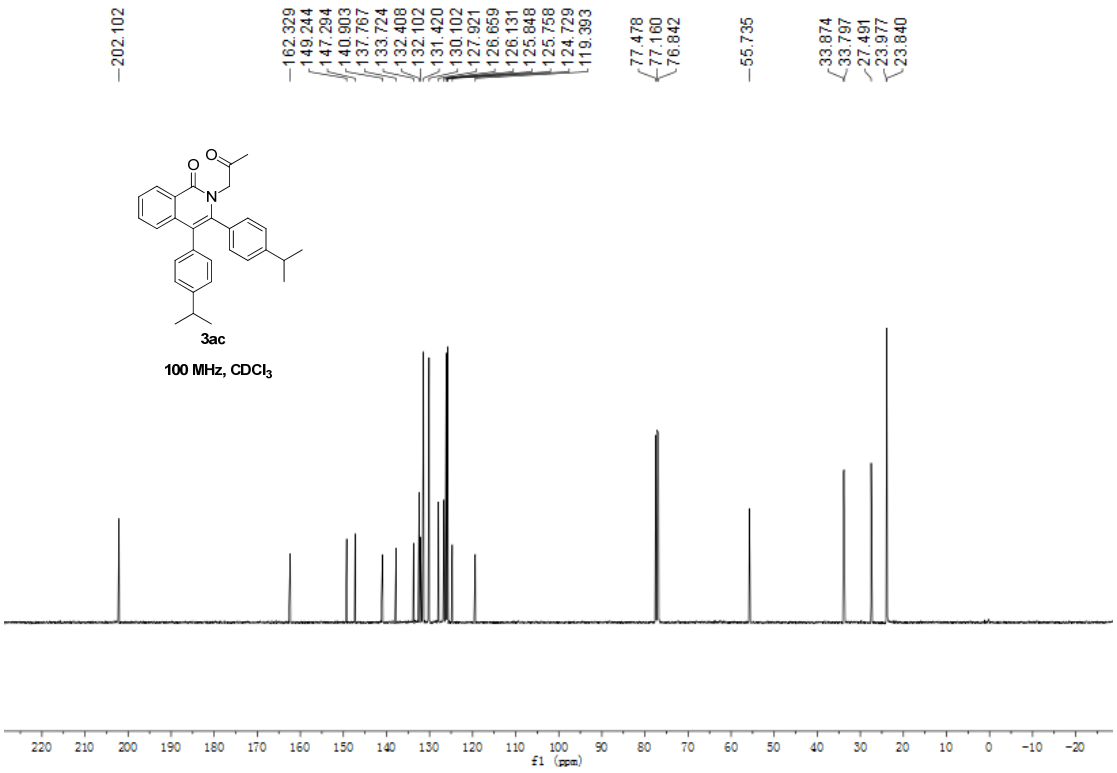

7.260
7.216
7.202
7.197
7.184
7.171
7.162
7.080
7.076
7.063
7.056
6.940
6.901
6.894
6.885
6.875
6.754
6.749
6.739
6.730
6.700
4.603
2.239
2.072
3za
400 MHz, CDCl3
2.89
2.01
4.23
3.22
2.02
0.99
2.15
3.06
3.00
f1 (ppm)

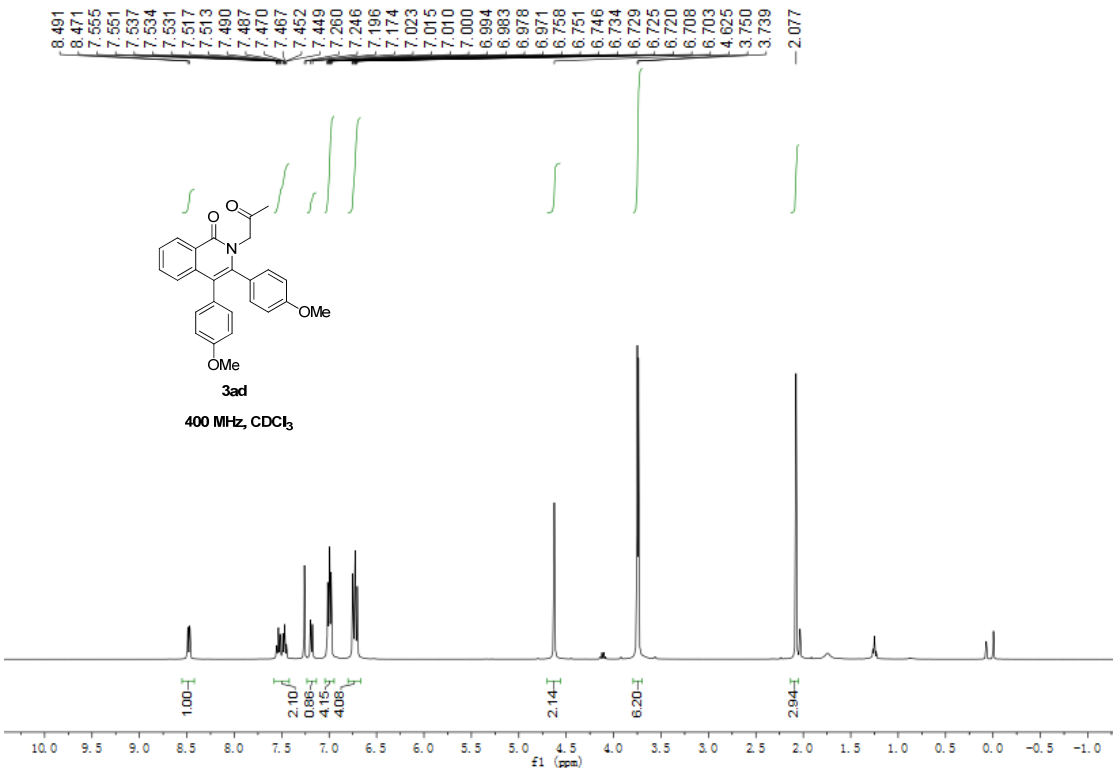

201.468
161.966
154.140
147.246
137.738
136.839
135.845
134.449
131.692
129.724
128.856
128.589
128.381
127.379
126.212
120.852
118.905
77.478
77.160
76.843
55.730
27.588
21.251
O
N
O
3za
100 MHz, CDCl3
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10 -20
f1 (ppm)

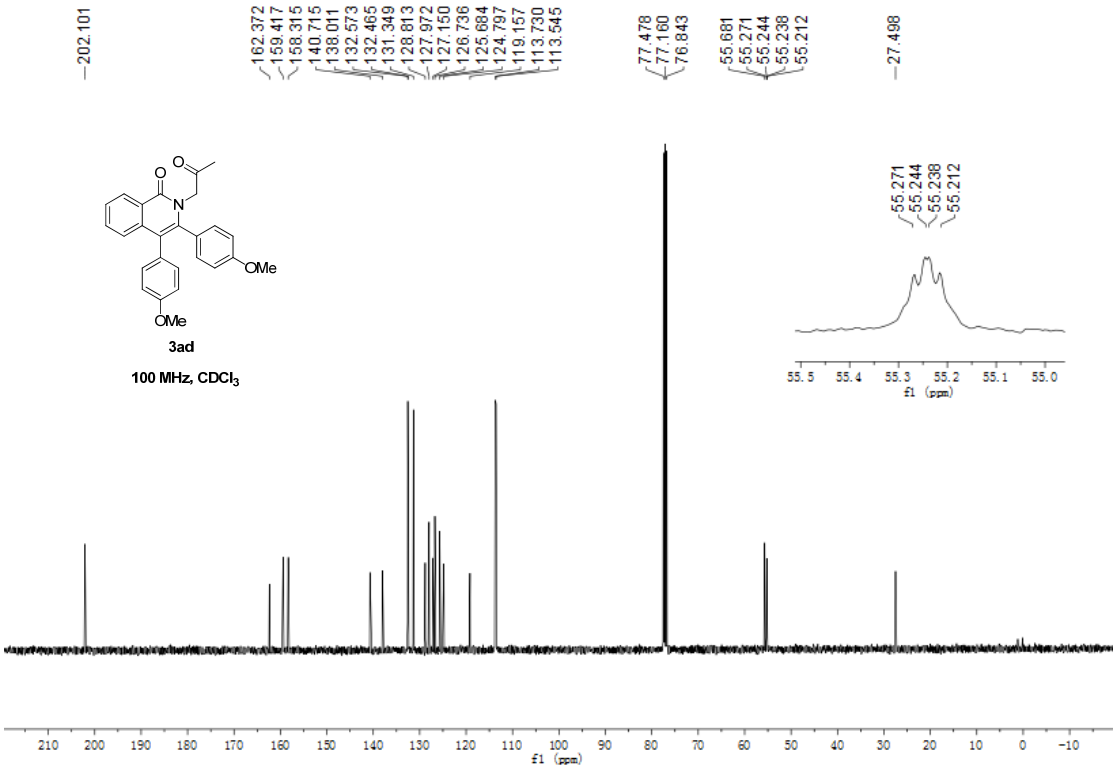

8.493
8.477
7.545
7.526
7.507
7.489
7.485
7.471
7.454
7.260
7.178
7.160
7.011
6.990
6.985
6.976
6.963
6.955
4.605
2.269
2.261
2.066
O
N
O
Me
Me
3ab
400 MHz, CDCl3
1.00
2.20
1.04
8.66
2.08
6.04
2.97
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0
f1 (ppm)

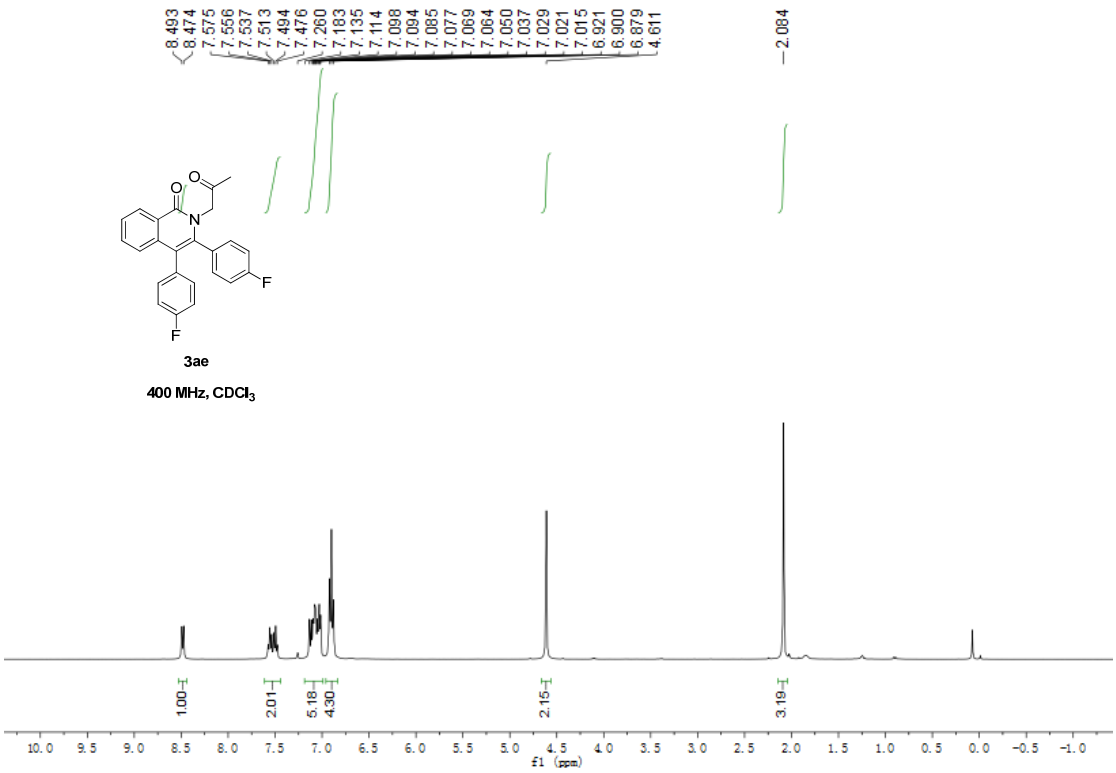

202.024
162.357
140.688
138.393
137.885
136.407
133.428
132.435
131.833
131.367
129.908
129.033
128.784
127.938
126.714
125.712
124.756
119.194
77.478
77.160
76.843
55.687
27.440
21.400
21.381
21.302
21.285
Me
Me
3ab
100 MHz, CDCl3
f1 (ppm)

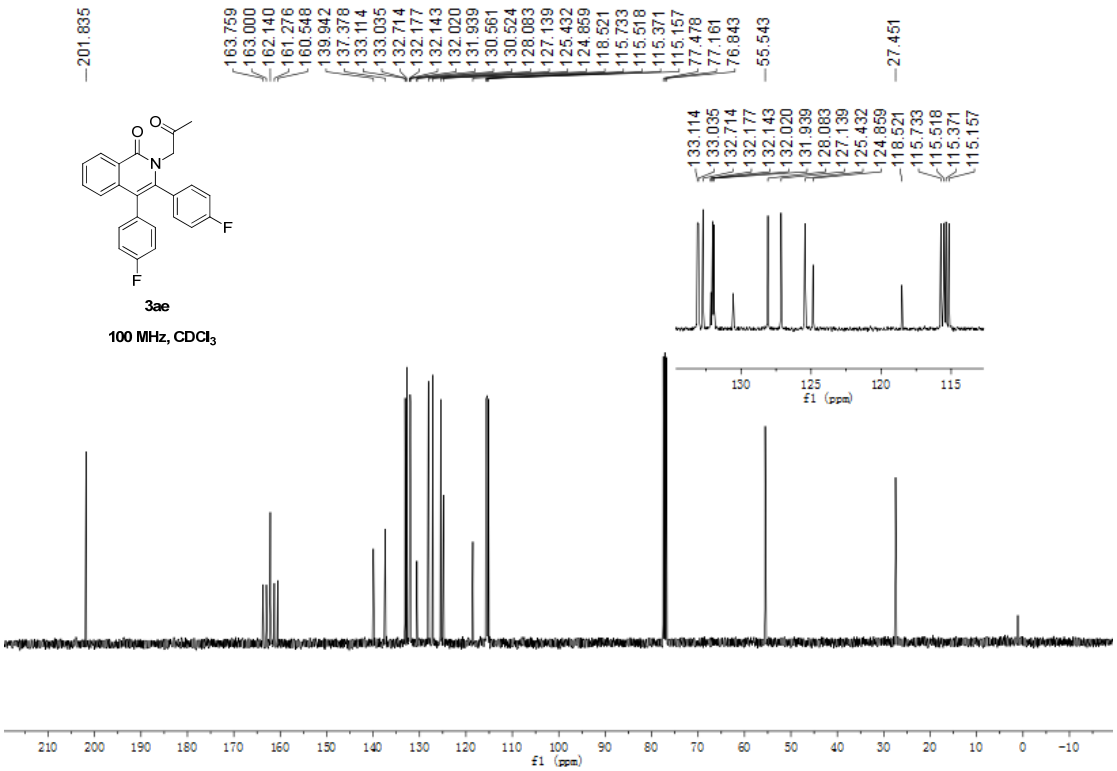

8.520
8.500
7.572
7.568
7.554
7.550
7.534
7.530
7.505
7.502
7.485
7.482
7.468
7.465
7.280
7.260
7.038
7.018
7.002
6.988
6.968
4.676
2.867
2.861
2.850
2.843
2.833
2.826
2.815
2.809
2.798
2.792
2.781
2.774
2.763
2.757
2.085
1.183
1.165
1.147
1.00
2.08
0.63
7.98
2.01
2.15
3.05
12.27
3ac
400 MHz, CDCl3
f1 (ppm)

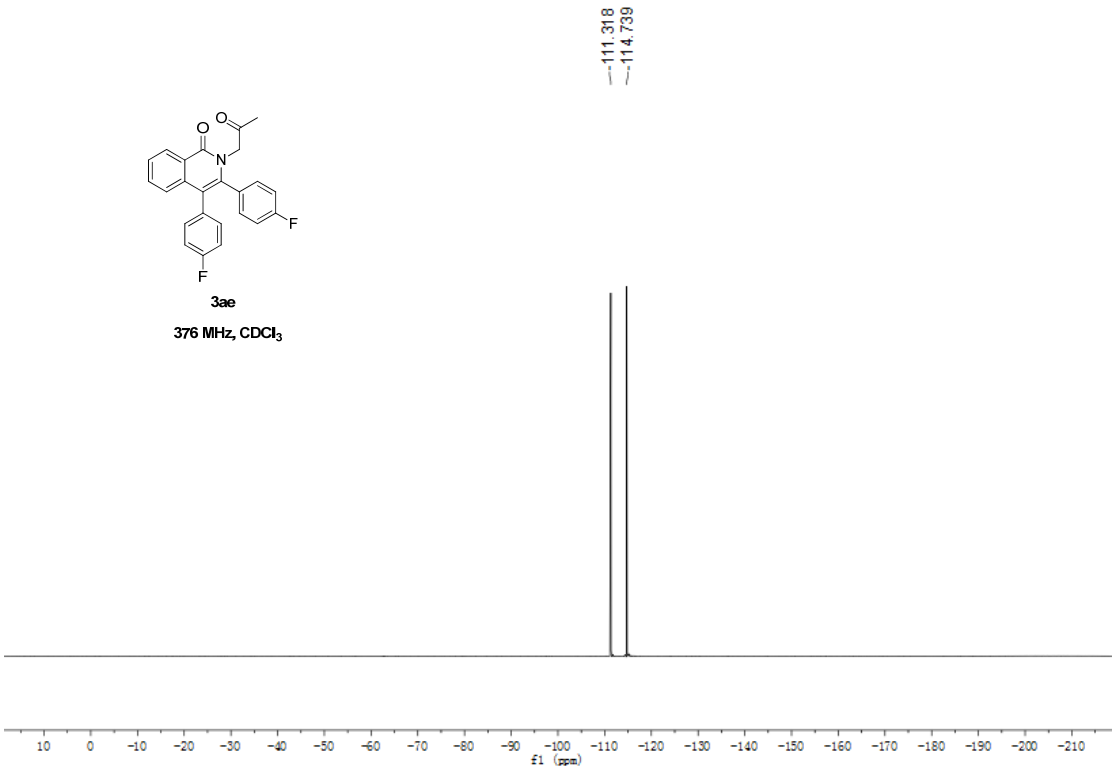

202.102
162.329
149.244
147.294
140.903
137.767
133.724
132.408
132.102
131.420
130.102
127.921
126.659
126.131
125.848
125.758
124.729
119.393
77.478
77.160
76.842
55.735
33.874
33.797
27.491
23.977
23.840
3ac
100 MHz, CDCl3
f1 (ppm)

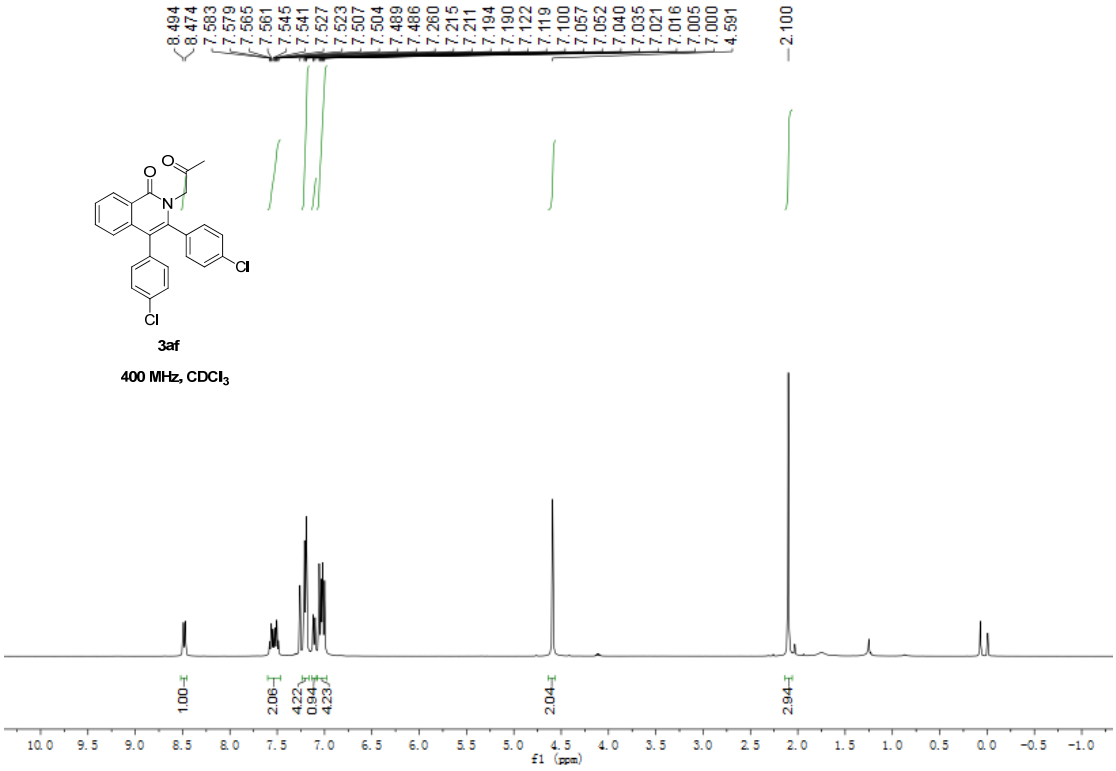

8.491
8.471
7.555
7.551
7.537
7.534
7.531
7.517
7.513
7.490
7.487
7.470
7.467
7.452
7.449
7.260
7.246
7.196
7.174
7.023
7.015
7.010
7.000
6.994
6.983
6.978
6.971
6.758
6.751
6.746
6.734
6.729
6.725
6.720
6.708
6.703
4.625
3.750
3.739
2.077
OMe
OMe
3ad
400 MHz, CDCl3
1.00
2.10
0.86
4.15
4.08
2.14
6.20
2.94
f1 (ppm)

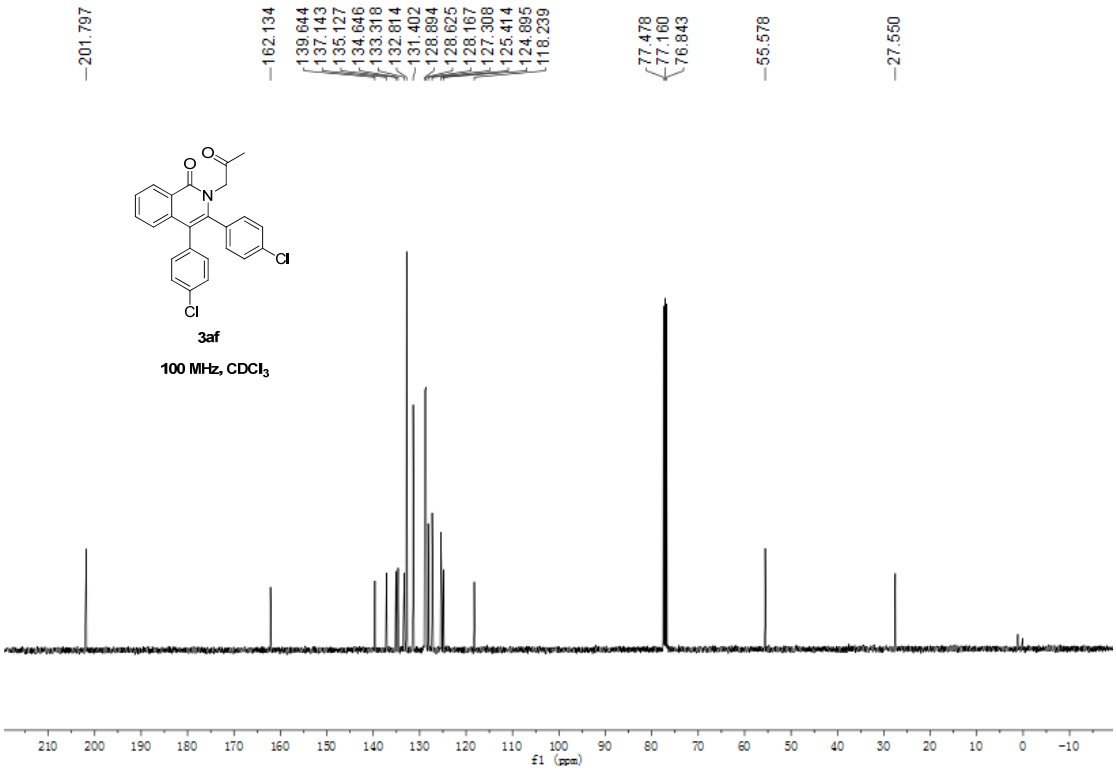

202.101
162.372
159.417
158.315
140.715
138.011
132.573
132.465
131.349
128.813
127.972
127.150
126.736
125.684
124.797
119.157
113.730
113.545
77.478
77.160
76.843
55.681
55.271
55.244
55.238
55.212
27.498
OMe
OMe
3ad
100 MHz, CDCl3
f1 (ppm)

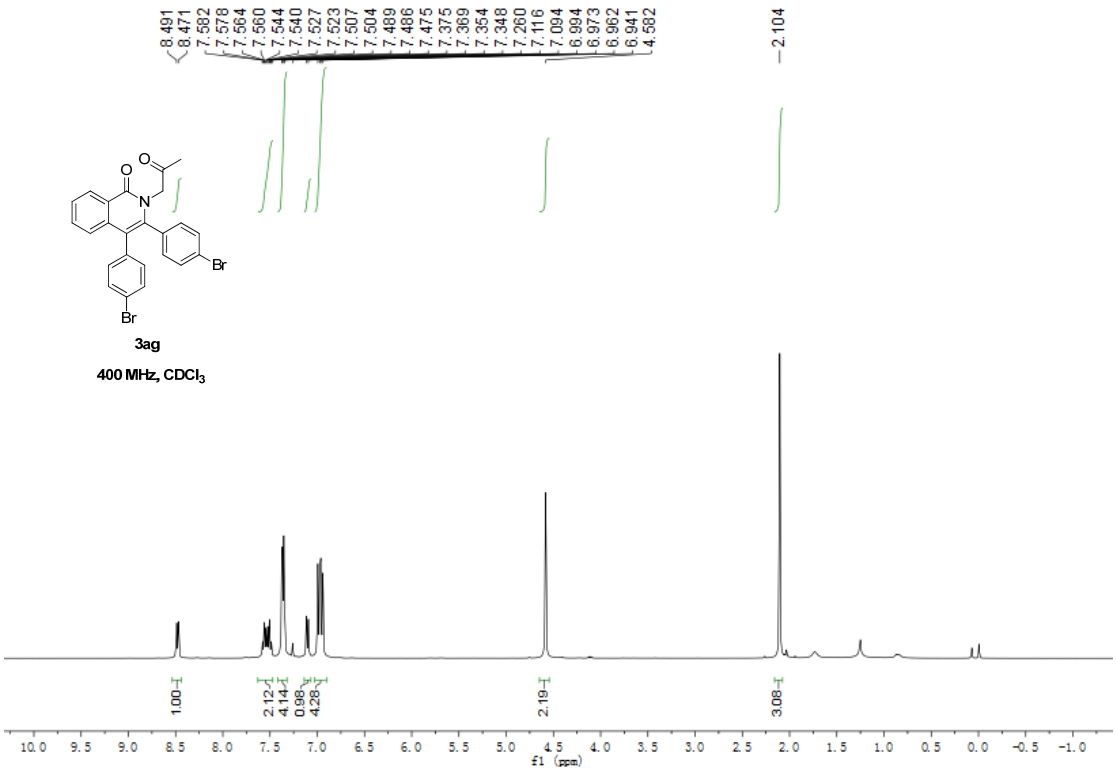

8.493
8.474
7.575
7.556
7.537
7.513
7.494
7.476
7.260
7.183
7.135
7.114
7.098
7.094
7.085
7.077
7.069
7.064
7.050
7.037
7.029
7.021
7.015
6.921
6.900
6.879
4.611
2.084
F
F
3ae
400 MHz, CDCl3
1.00
2.01
5.18
4.30
2.15
3.19
f1 (ppm)


201.835
163.759
163.000
162.140
161.276
160.548
139.942
137.378
133.114
133.035
132.714
132.177
132.143
132.020
131.939
130.561
130.524
128.083
127.139
125.432
124.859
118.521
115.733
115.518
115.371
115.157
77.478
77.161
76.843
55.543
27.451
O
N
F
F
3ae
100 MHz, CDCl3
f1 (ppm)


111.318
114.739
O
N
F
F
3ae
376 MHz, CDCl3
f1 (ppm)

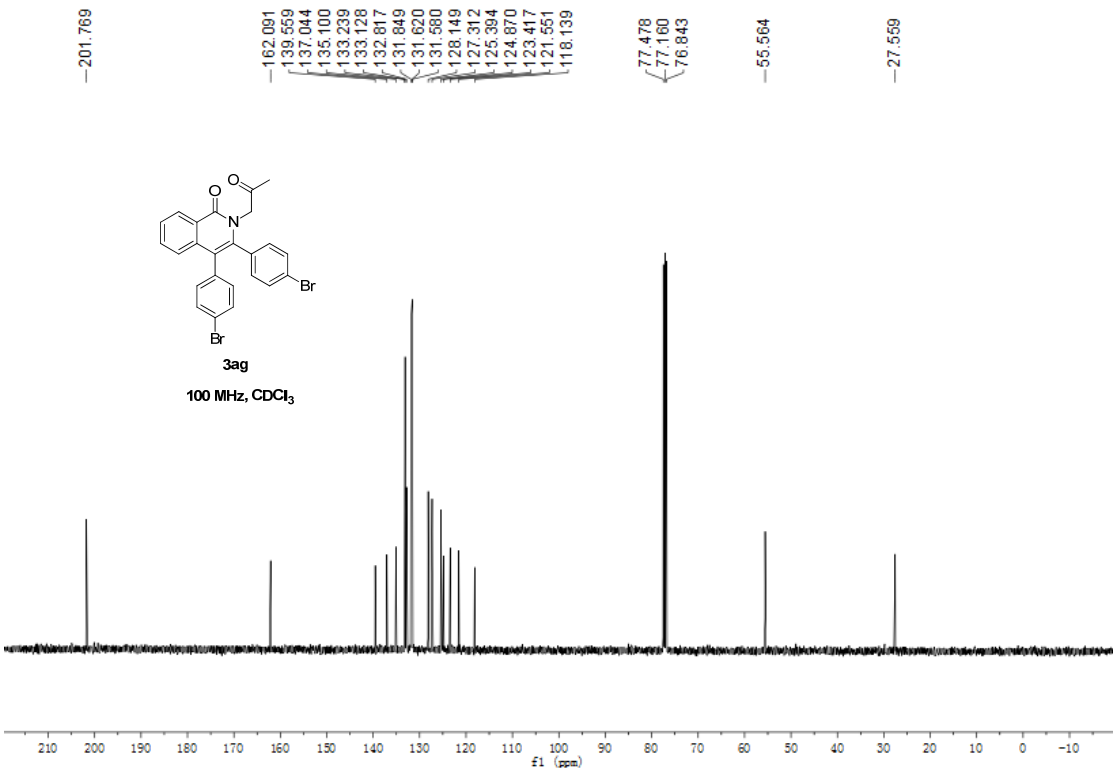

8.494
8.474
7.583
7.579
7.565
7.561
7.545
7.541
7.527
7.523
7.507
7.504
7.489
7.486
7.260
7.215
7.211
7.194
7.190
7.122
7.119
7.100
7.057
7.052
7.040
7.035
7.021
7.016
7.005
7.000
4.591
2.100
O
O
N
Cl
Cl
3af
400 MHz, CDCl3
1.00
2.06
4.22
0.94
4.23
2.04
2.94
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0
f1 (ppm)


201.797
162.134
139.644
137.143
135.127
134.646
133.318
132.814
131.402
128.894
128.625
128.167
127.308
125.414
124.895
118.239
77.478
77.160
76.843
55.578
27.550
O
O
N
Cl
Cl
3af
100 MHz, CDCl3
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)



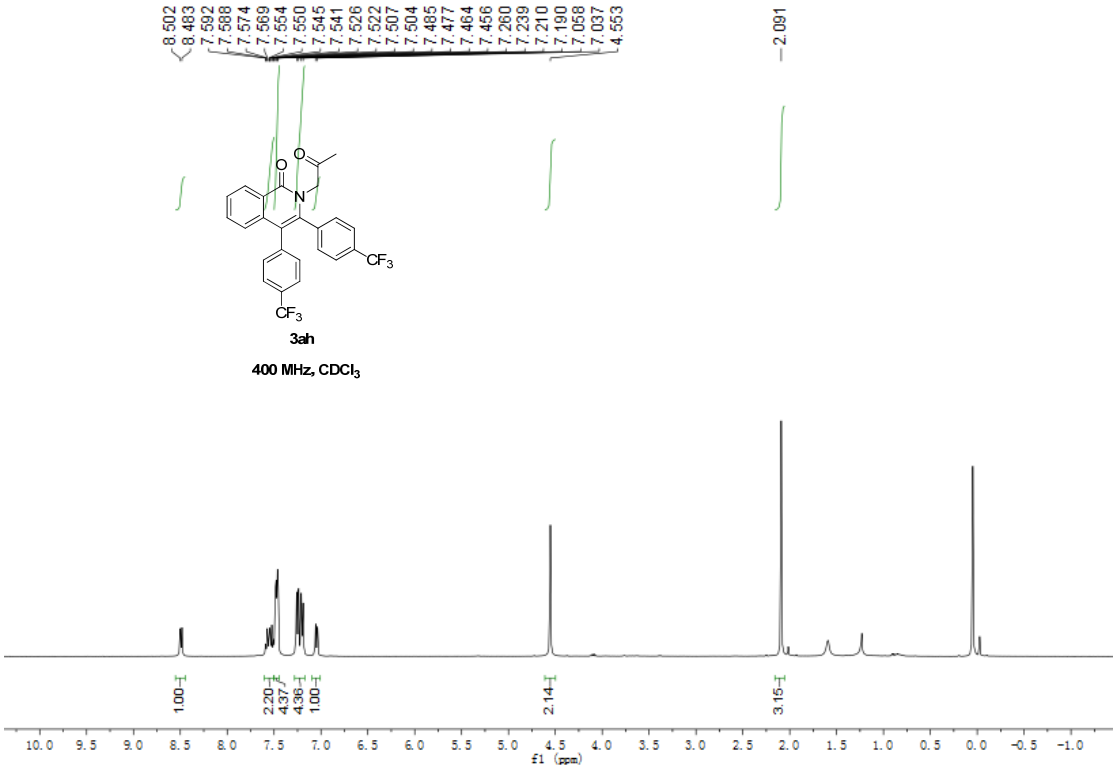
3ag

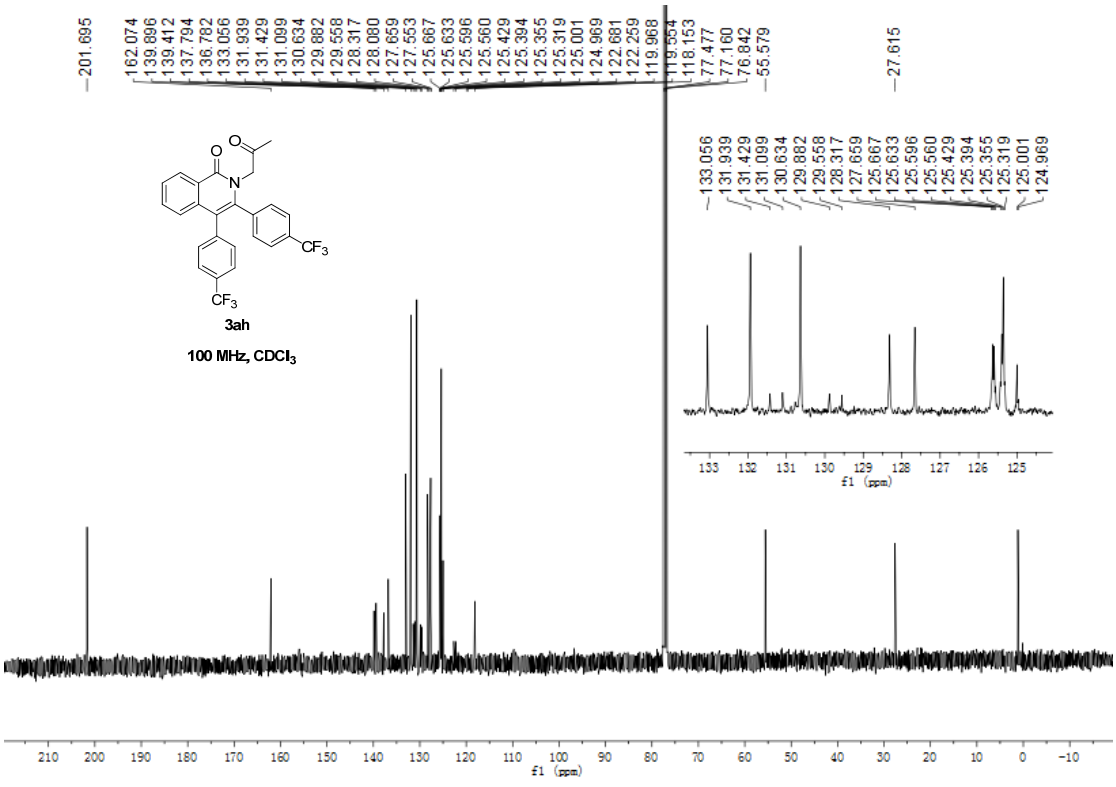
400 MHz, $CDCl_3$

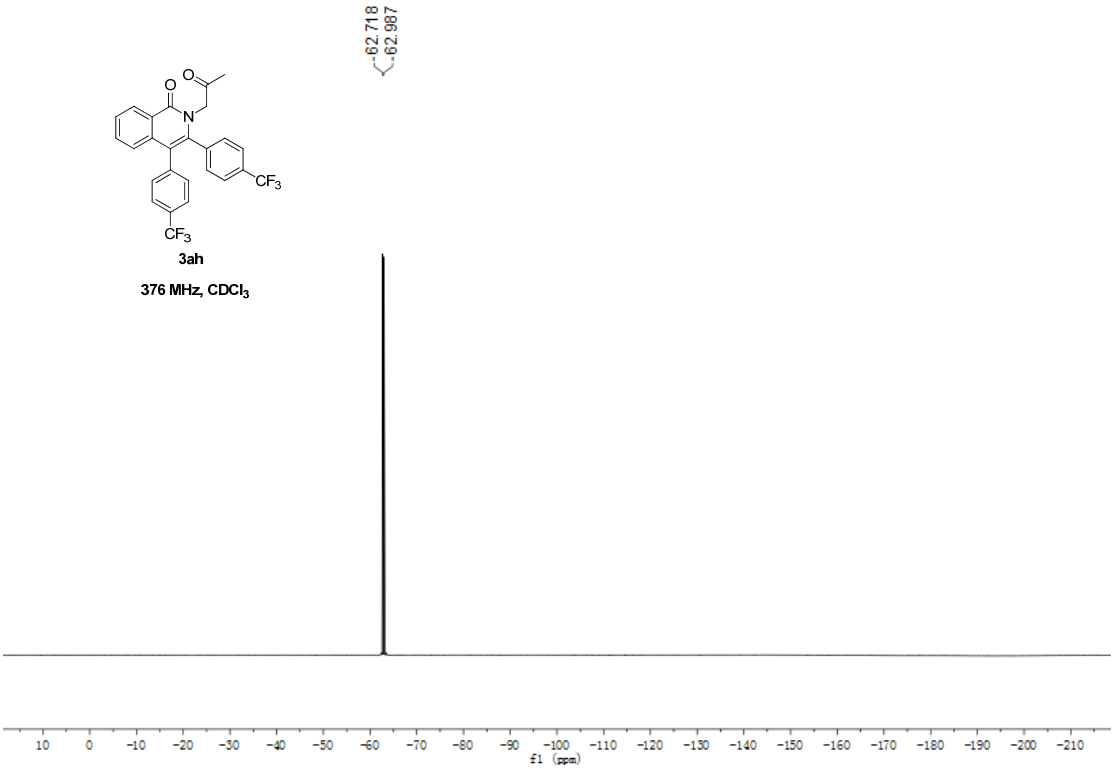


3ag

100 MHz, $CDCl_3$

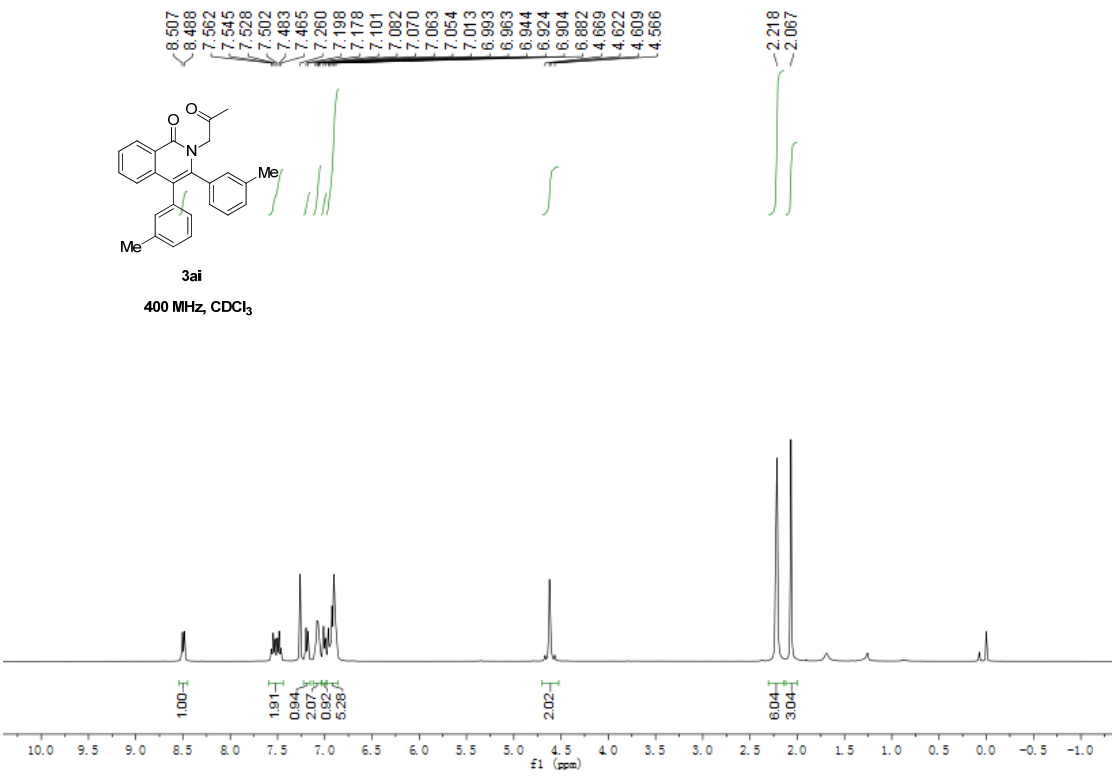

8.502
8.483
7.592
7.588
7.574
7.569
7.554
7.550
7.545
7.541
7.526
7.522
7.507
7.504
7.485
7.477
7.464
7.456
7.260
7.239
7.210
7.190
7.058
7.037
4.553
2.091
O
O
N
CF3
CF3
3ah
400 MHz, CDCl3
1.00
2.20
4.37
4.36
1.00
2.14
3.15
f1 (ppm)


201.695
162.074
139.896
139.412
137.794
136.782
133.056
131.939
131.429
131.099
130.634
129.882
129.558
128.317
128.080
127.659
127.553
125.667
125.633
125.596
125.560
125.429
125.394
125.355
125.319
125.001
124.969
122.681
122.259
119.968
119.554
118.153
77.477
77.160
76.842
55.579
27.615
O
O
N
CF3
CF3
3ah
100 MHz, CDCl3
f1 (ppm)



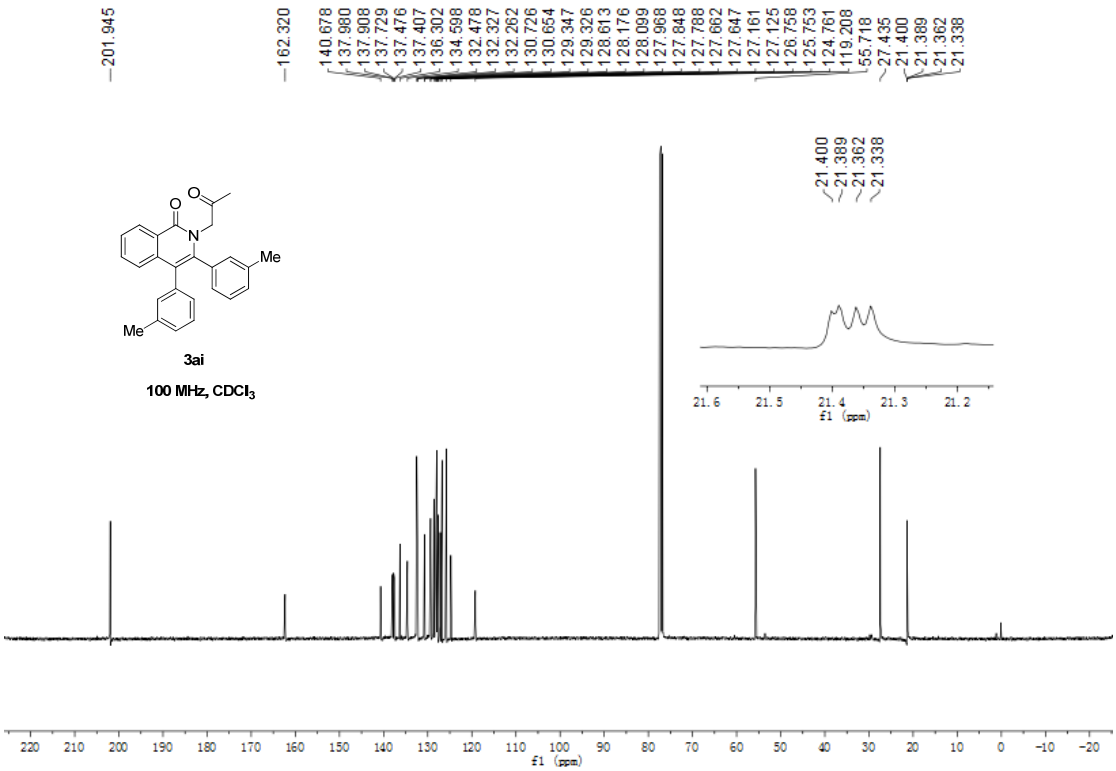
3ah

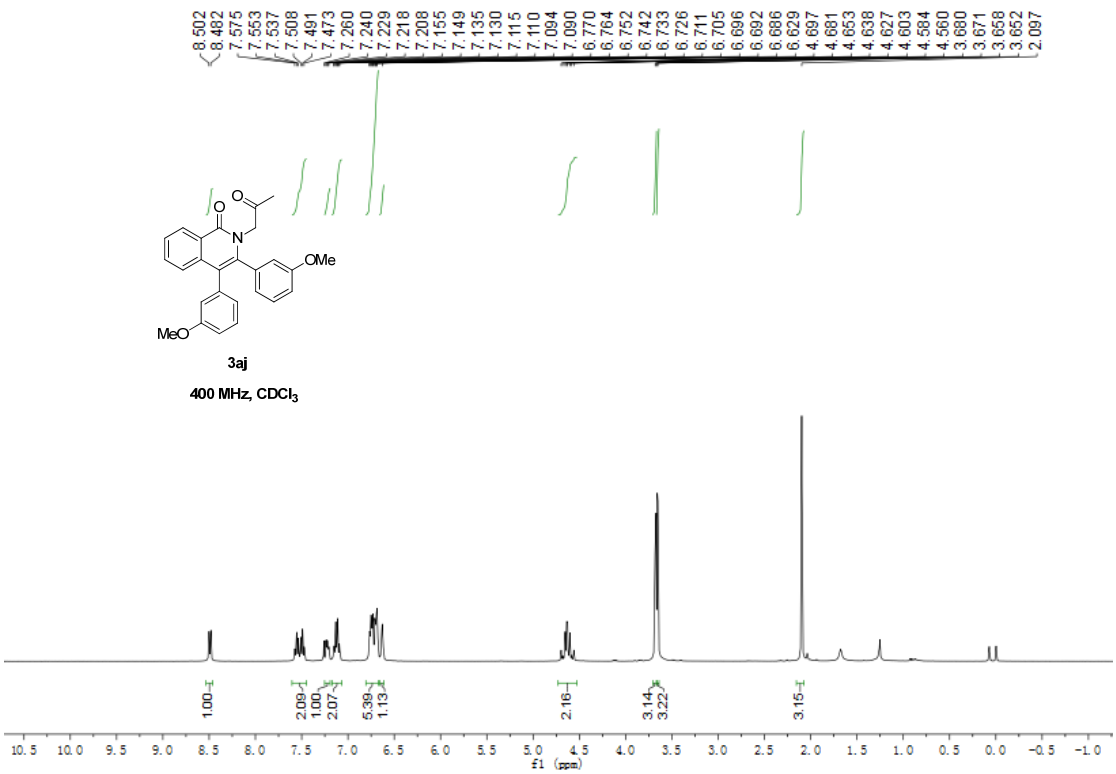
376 MHz, $CDCl_3$

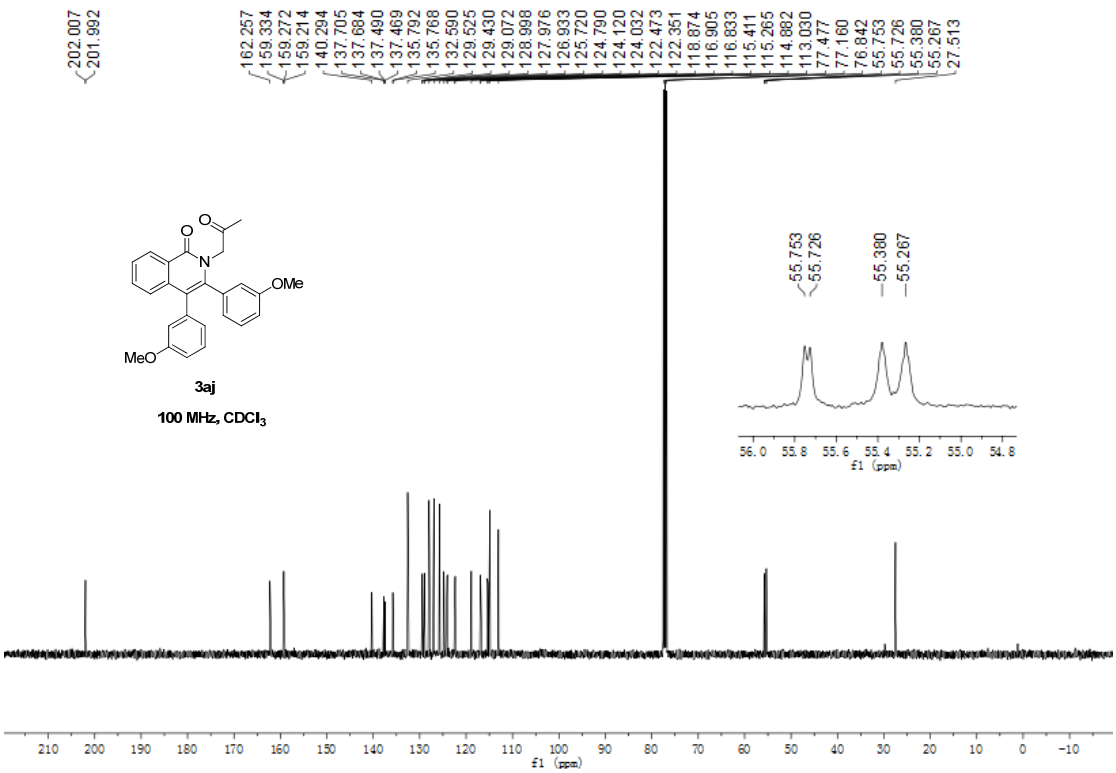


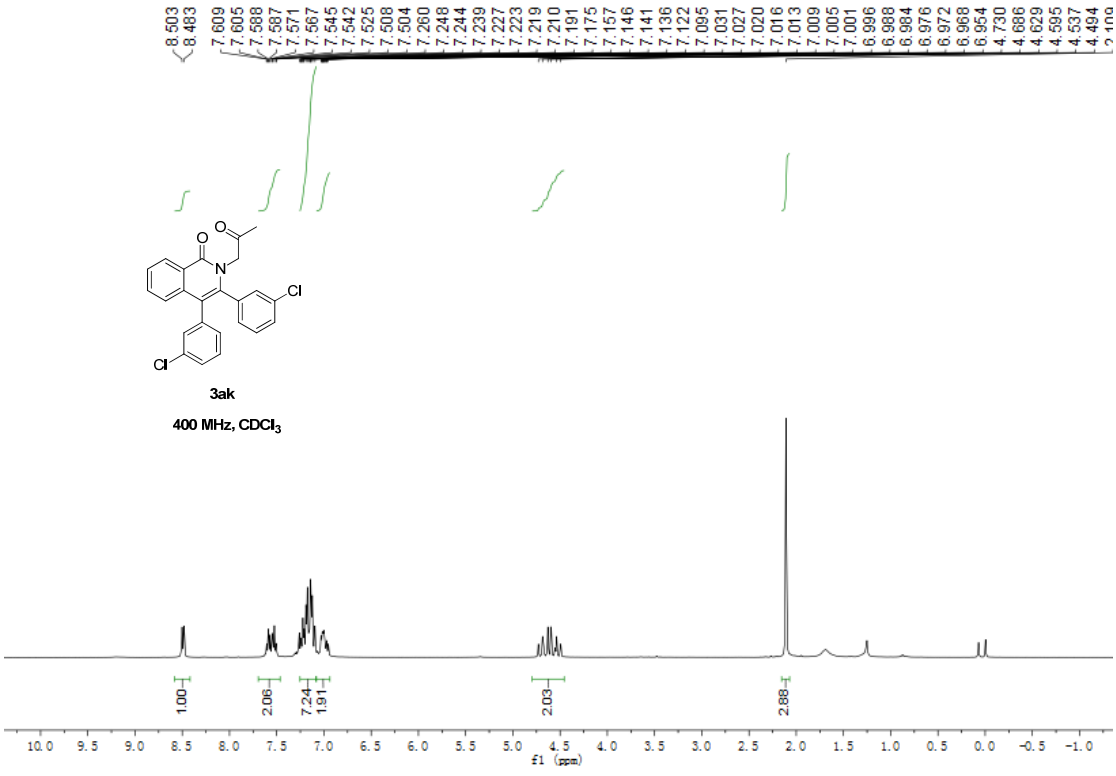
3ai

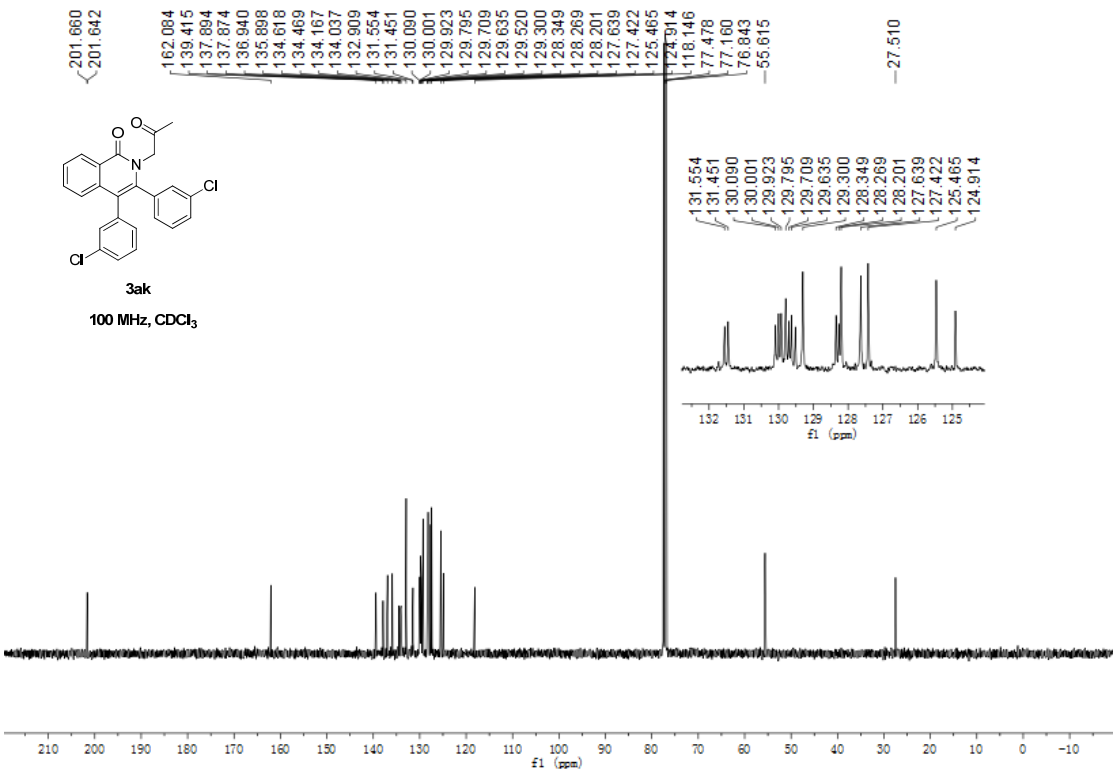
400 MHz, $CDCl_3$

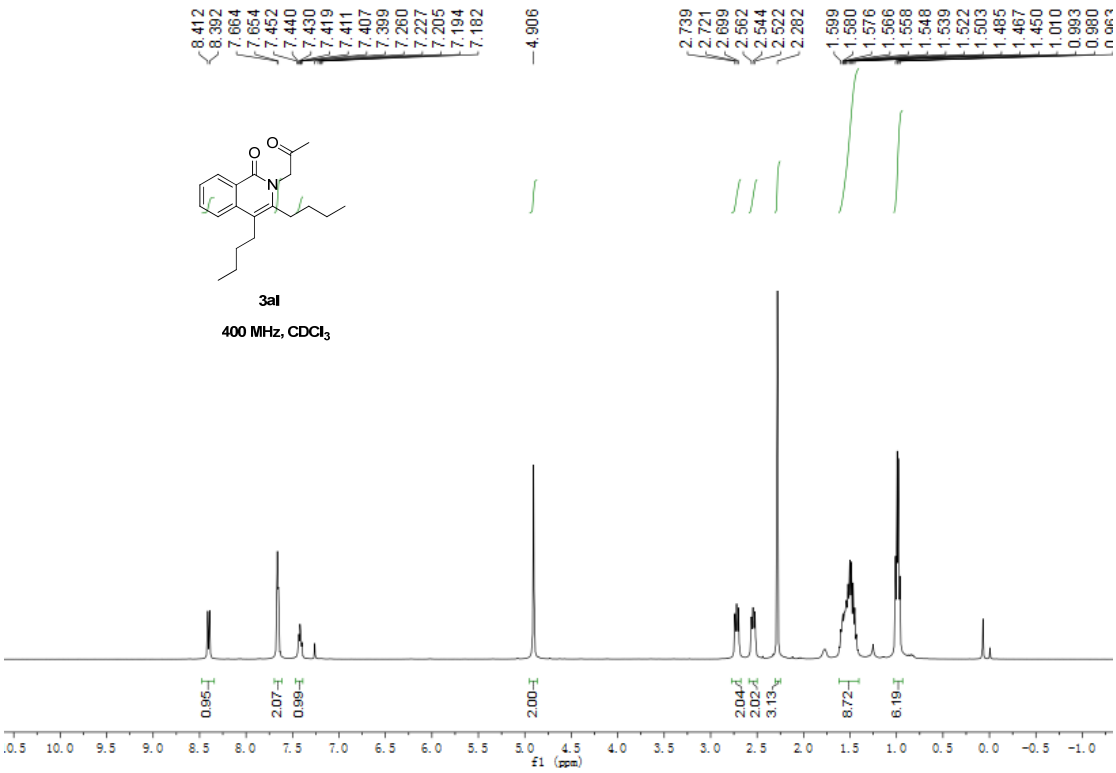

201.945
162.320
140.678
137.980
137.908
137.729
137.476
137.407
136.302
134.598
132.478
132.327
132.262
130.726
130.654
129.347
129.326
128.613
128.176
128.099
127.968
127.848
127.788
127.662
127.647
127.161
127.125
126.758
125.753
124.761
119.208
55.718
27.435
21.400
21.389
21.362
21.338
Me
Me
3ai
100 MHz, CDCl3
f1 (ppm)

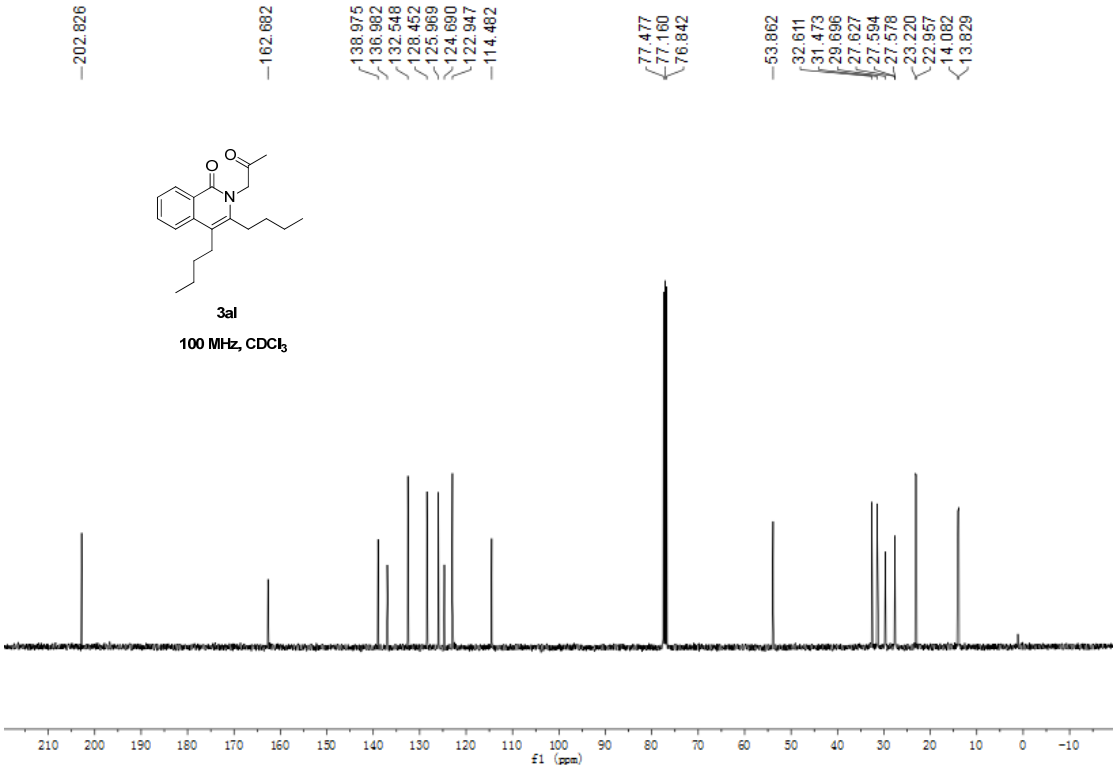

8.502
8.482
7.575
7.553
7.537
7.508
7.491
7.473
7.260
7.240
7.229
7.218
7.208
7.155
7.149
7.135
7.130
7.115
7.110
7.094
7.090
6.770
6.764
6.752
6.742
6.733
6.726
6.711
6.705
6.696
6.692
6.686
6.629
4.697
4.681
4.653
4.638
4.627
4.603
4.584
4.560
3.680
3.671
3.658
3.652
2.097
OMe
MeO
3aj
400 MHz, CDCl3
1.00
2.09
1.00
2.07
5.39
1.13
2.16
3.14
3.22
3.15
f1 (ppm)

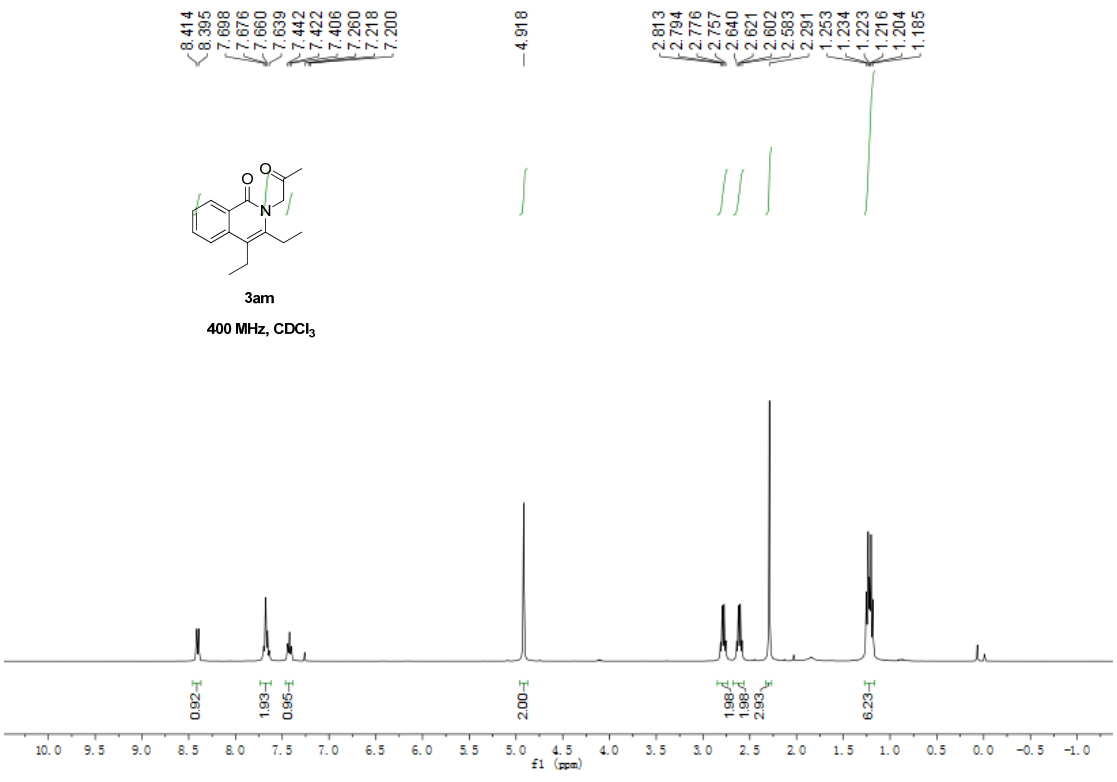

202.007
201.992
162.257
159.334
159.272
159.214
140.294
137.705
137.684
137.490
137.469
135.792
135.768
132.590
129.525
129.430
129.072
128.998
127.976
126.933
125.720
124.790
124.120
124.032
122.473
122.351
118.874
116.905
116.833
115.411
115.265
114.882
113.030
77.477
77.160
76.842
55.753
55.726
55.380
55.267
27.513
OMe
MeO
3aj
100 MHz, CDCl3
55.753
55.726
55.380
55.267
f1 (ppm)
f1 (ppm)

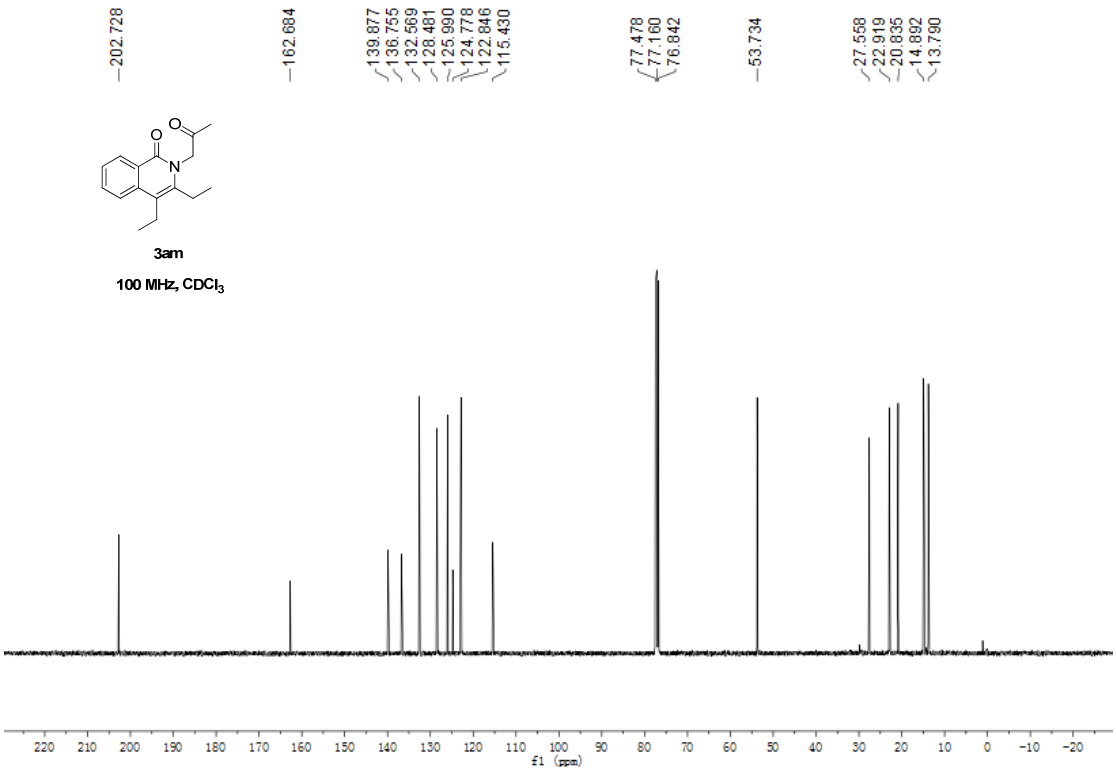

8.503
8.483
7.609
7.605
7.588
7.587
7.571
7.567
7.545
7.542
7.525
7.508
7.504
7.260
7.248
7.244
7.239
7.227
7.223
7.219
7.210
7.191
7.175
7.157
7.146
7.141
7.136
7.122
7.095
7.031
7.027
7.020
7.016
7.013
7.009
7.005
7.001
6.996
6.988
6.984
6.976
6.972
6.968
6.954
4.730
4.686
4.629
4.595
4.537
4.494
Cl
Cl
3ak
400 MHz, CDCl3
1.00
2.06
7.24
1.91
2.03
2.88
f1 (ppm)

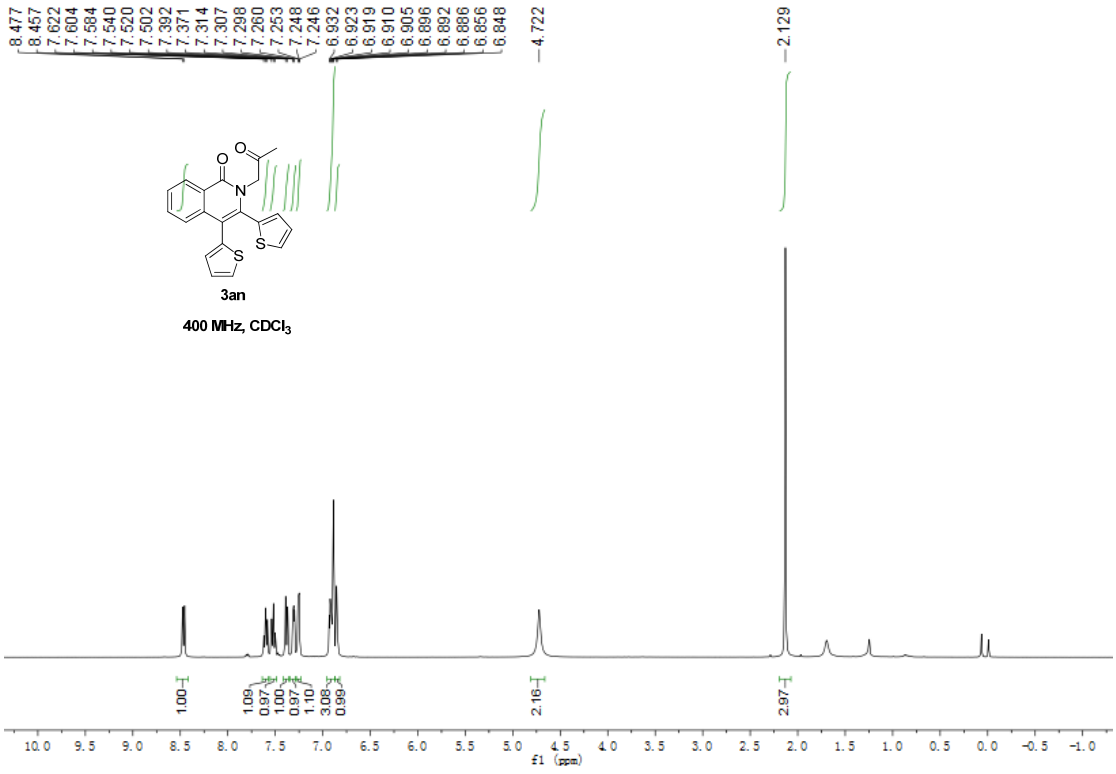

201.660
201.642
162.084
139.415
137.894
137.874
136.940
135.898
134.618
134.469
134.167
134.037
132.909
131.554
131.451
130.090
130.001
129.923
129.795
129.709
129.635
129.520
129.300
128.349
128.269
128.201
127.639
127.422
125.465
124.914
118.146
77.478
77.160
76.843
55.615
27.510
Cl
Cl
3ak
100 MHz, CDCl3
f1 (ppm)

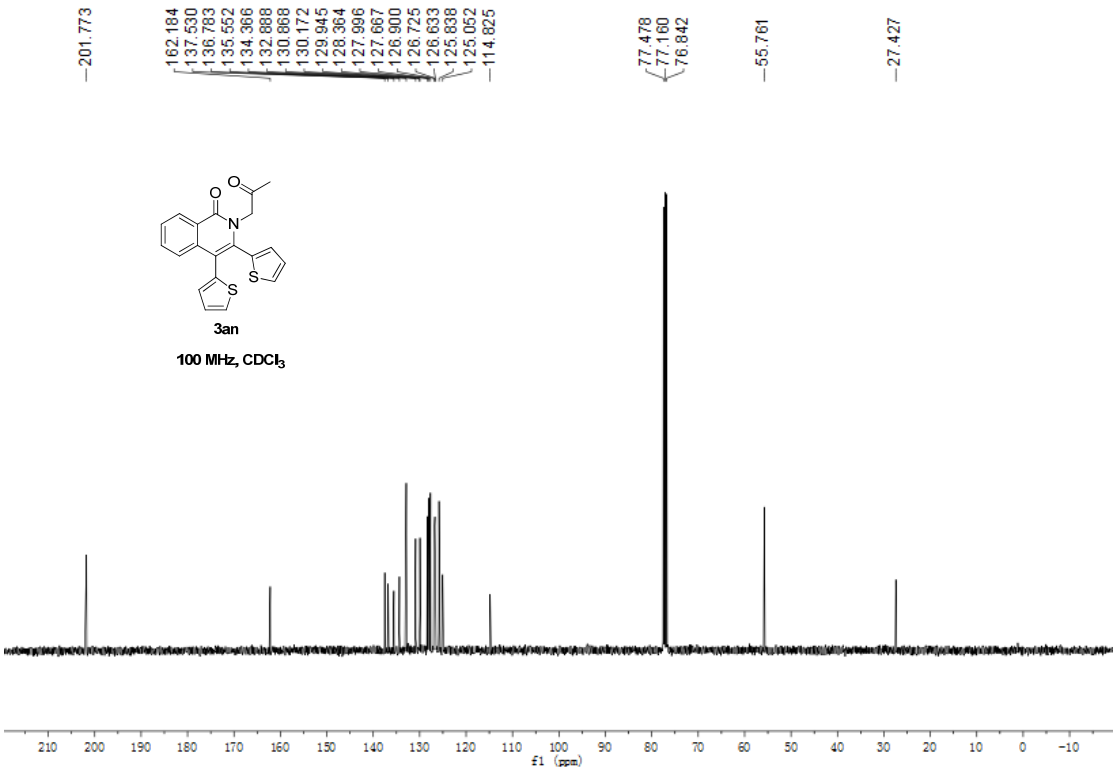

8.412
8.392
7.664
7.654
7.452
7.440
7.430
7.419
7.411
7.407
7.399
7.260
7.227
7.205
7.194
7.182
4.906
2.739
2.721
2.699
2.562
2.544
2.522
2.282
1.599
1.580
1.576
1.566
1.558
1.548
1.539
1.522
1.503
1.485
1.467
1.450
1.010
0.993
0.980
0.95
2.07
0.99
2.00
2.04
2.02
3.13
8.72
6.19
3al
400 MHz, CDCl3
f1 (ppm)

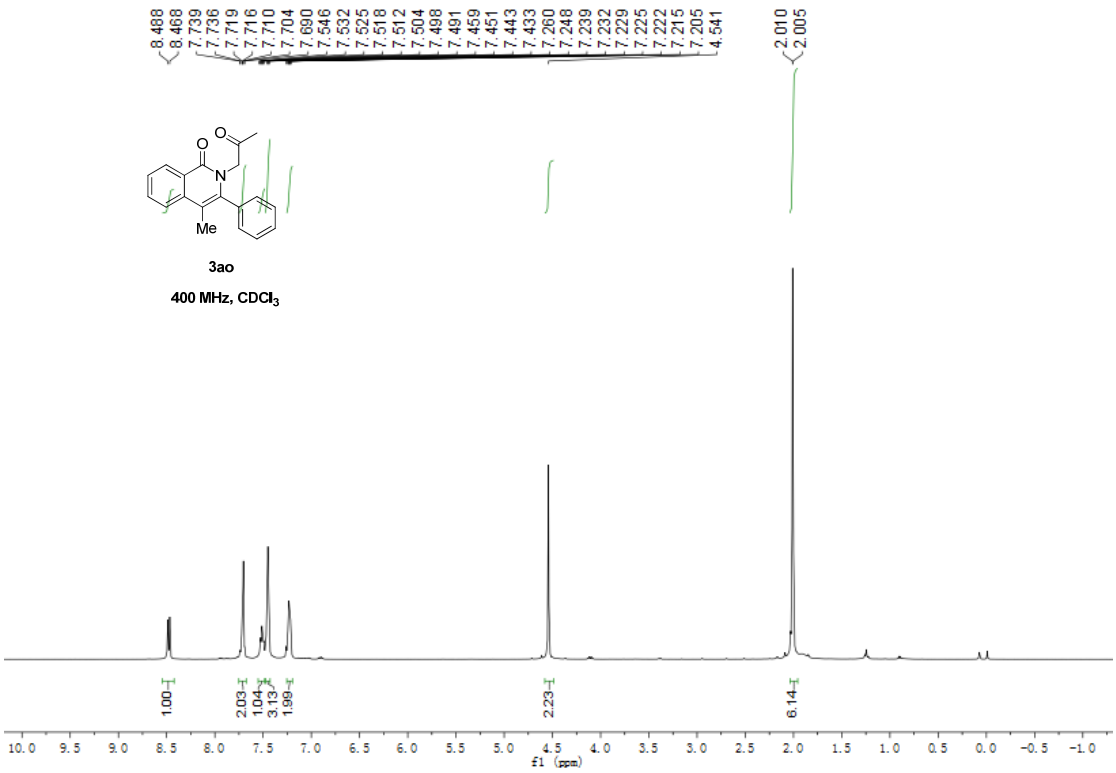

202.826
162.682
138.975
136.982
132.548
128.452
125.969
124.690
122.947
114.482
77.477
77.160
76.842
53.862
32.611
31.473
29.696
27.627
27.594
27.578
23.220
22.957
14.082
13.829
O
O
N
3al
100 MHz, CDCl3
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

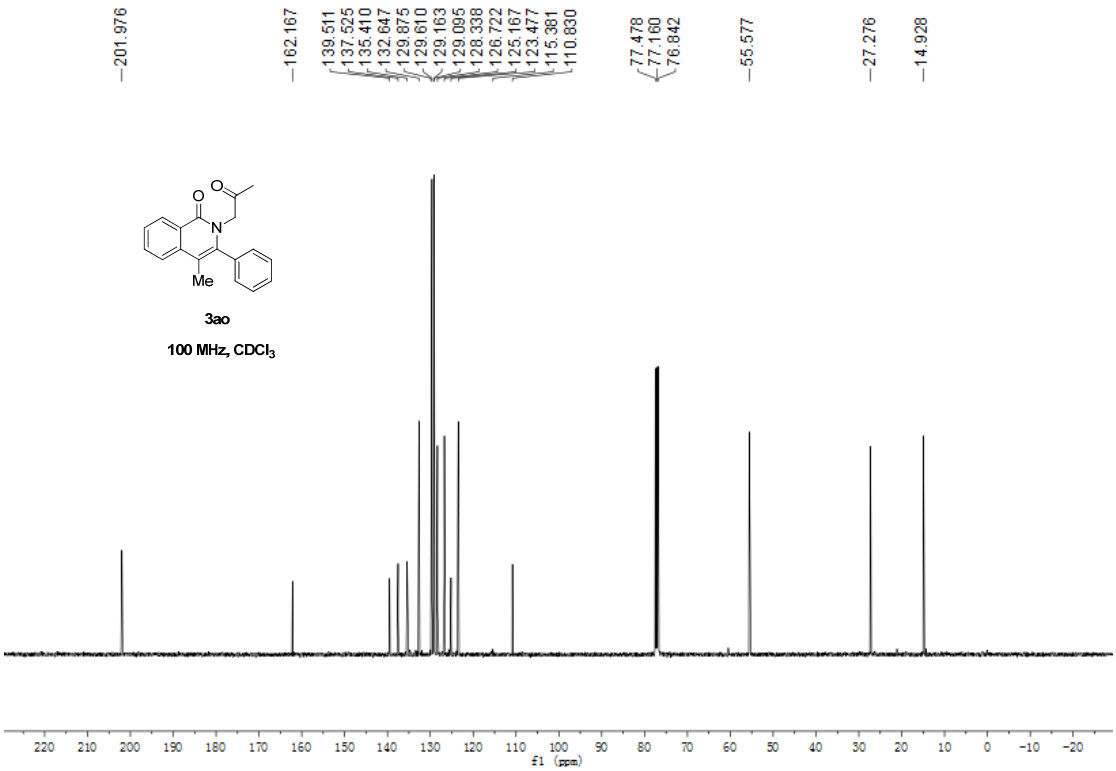

8.414
8.395
7.698
7.676
7.660
7.639
7.442
7.422
7.406
7.260
7.218
7.200
4.918
2.813
2.794
2.776
2.757
2.640
2.621
2.602
2.583
2.291
1.253
1.234
1.223
1.216
1.204
1.185
O
O
N
3am
400 MHz, CDCl3
0.92
1.93
0.95
2.00
1.98
1.98
2.93
6.23
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0
f1 (ppm)


202.728
162.684
139.877
136.755
132.569
128.481
125.990
124.778
122.846
115.430
77.478
77.160
76.842
53.734
27.558
22.919
20.835
14.892
13.790
3am
100 MHz, CDCl3
f1 (ppm)


8.477
8.457
7.622
7.604
7.584
7.540
7.520
7.502
7.392
7.371
7.314
7.307
7.298
7.260
7.253
7.248
7.246
6.932
6.923
6.919
6.910
6.905
6.896
6.892
6.886
6.856
6.848
4.722
2.129
3an
400 MHz, CDCl3
1.00
1.09
0.97
1.00
0.97
1.10
3.08
0.99
2.16
2.97
f1 (ppm)

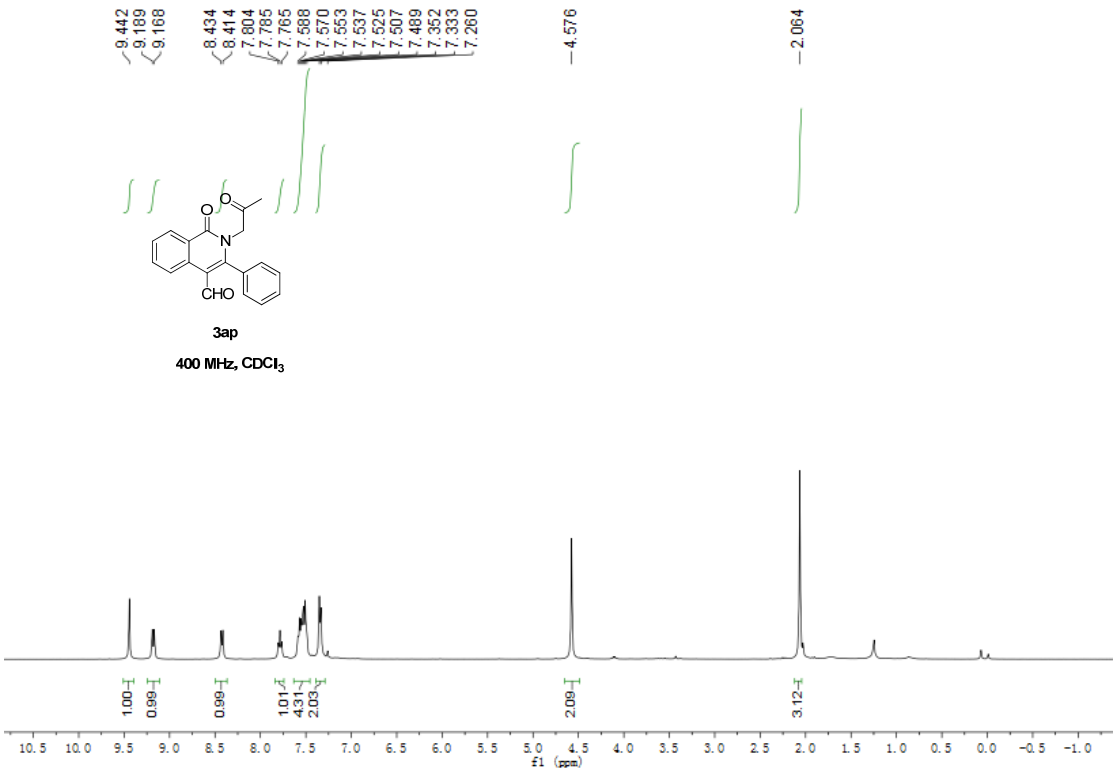

201.773
162.184
137.530
136.783
135.552
134.366
132.888
130.868
130.172
129.945
128.364
127.996
127.667
126.900
126.725
126.633
125.838
125.052
114.825
77.478
77.160
76.842
55.761
27.427
3an
100 MHz, CDCl3
f1 (ppm)


8.488
8.468
7.739
7.736
7.719
7.716
7.710
7.704
7.690
7.546
7.532
7.525
7.518
7.512
7.504
7.498
7.491
7.459
7.451
7.443
7.433
7.260
7.248
7.239
7.232
7.229
7.225
7.222
7.215
7.205
4.541
2.010
2.005
Me
3ao
400 MHz, CDCl3
1.00
2.03
1.04
3.13
1.99
2.23
6.14
f1 (ppm)



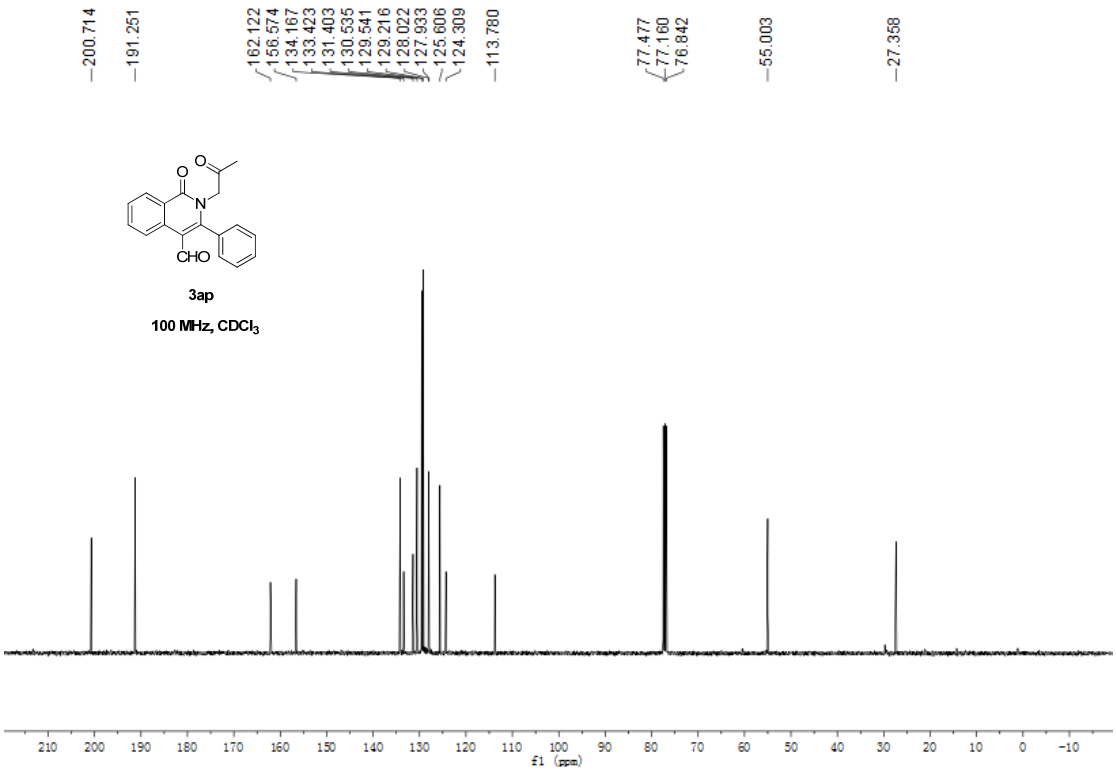
3ao

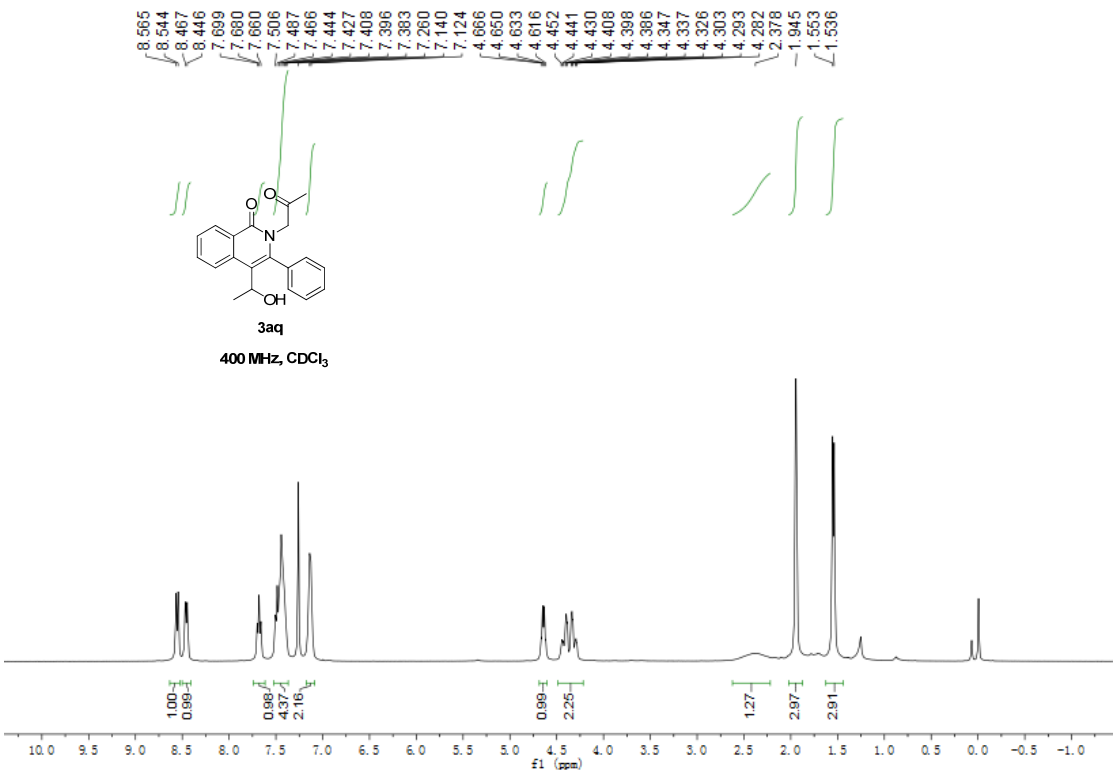
100 MHz, $CDCl_3$

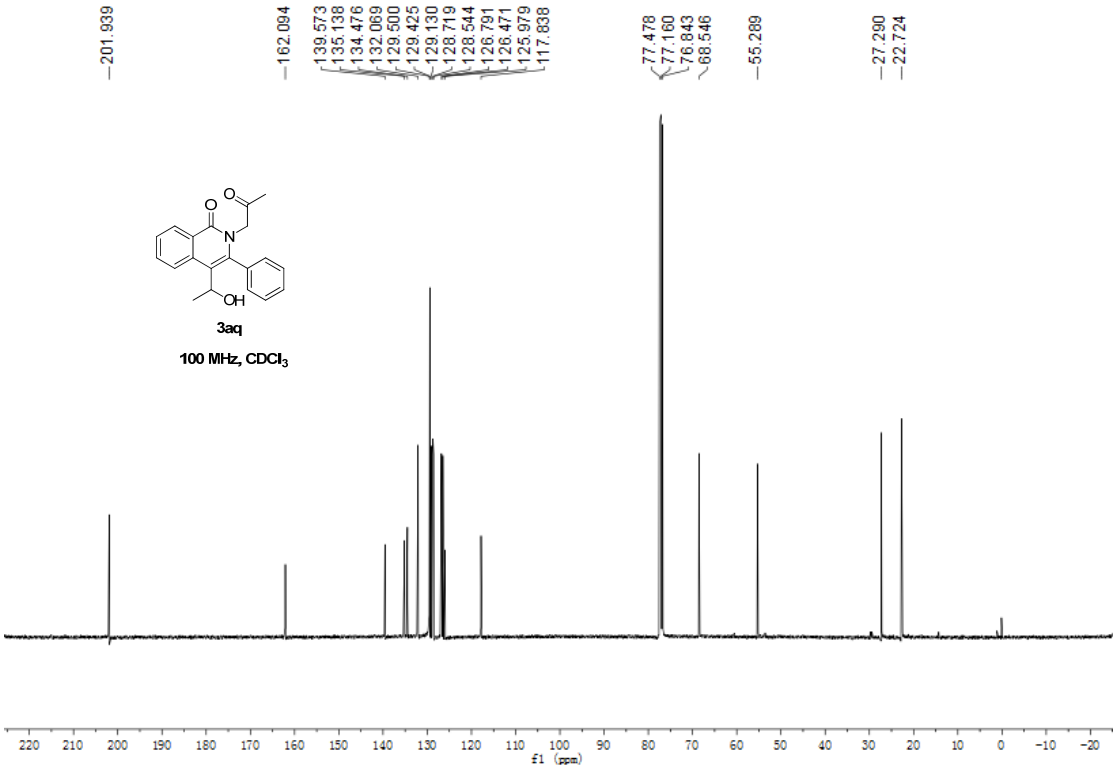


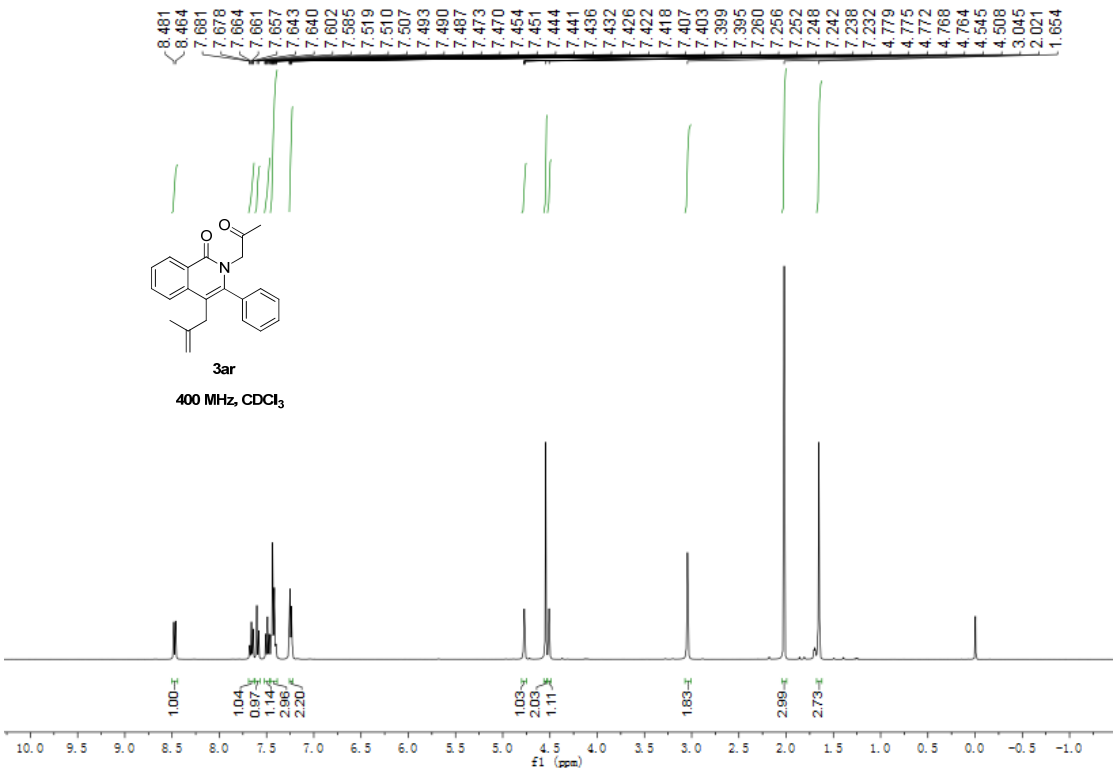
3ap

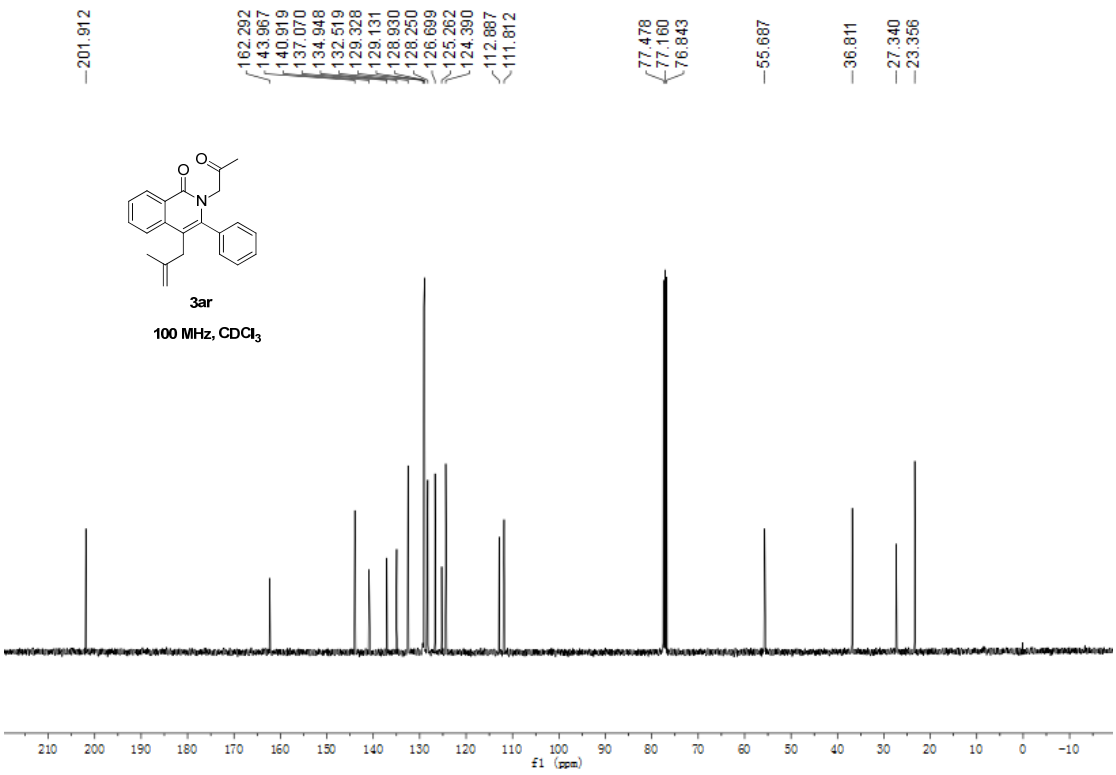
400 MHz, $CDCl_3$

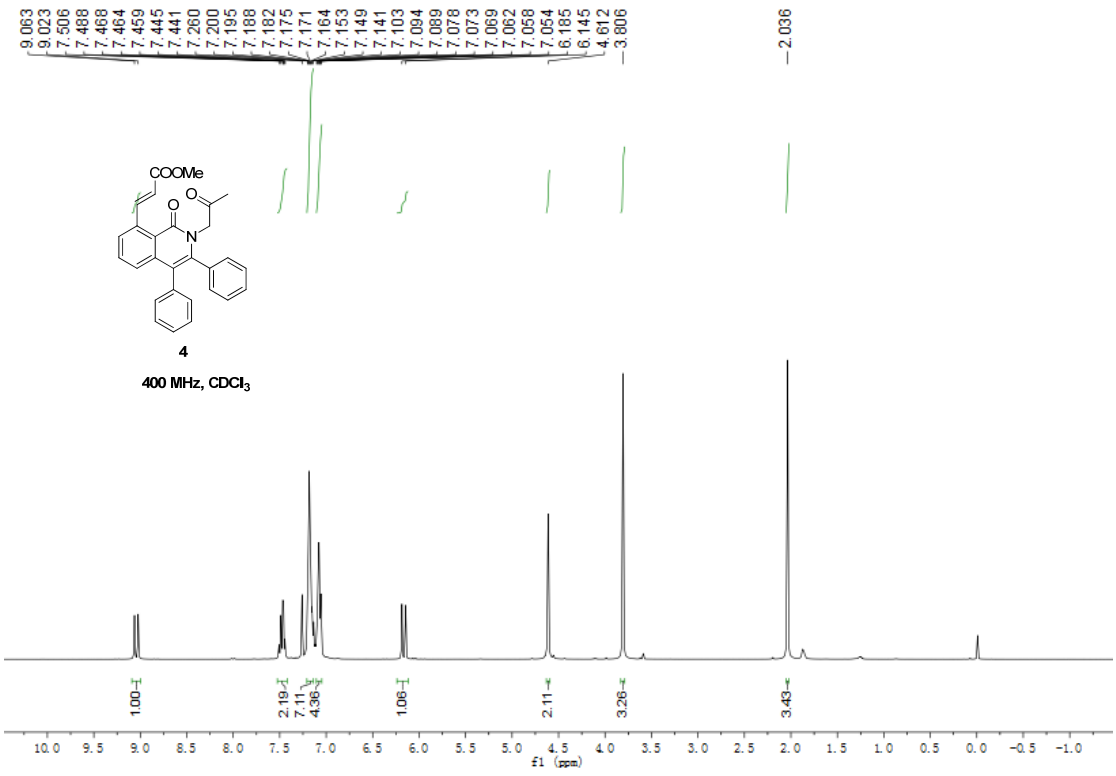

200.714
191.251
162.122
156.574
134.167
133.423
131.403
130.535
129.541
129.216
128.022
127.933
125.606
124.309
113.780
77.477
77.160
76.842
55.003
27.358
O
O
N
CHO
3ap
100 MHz, CDCl3
f1 (ppm)

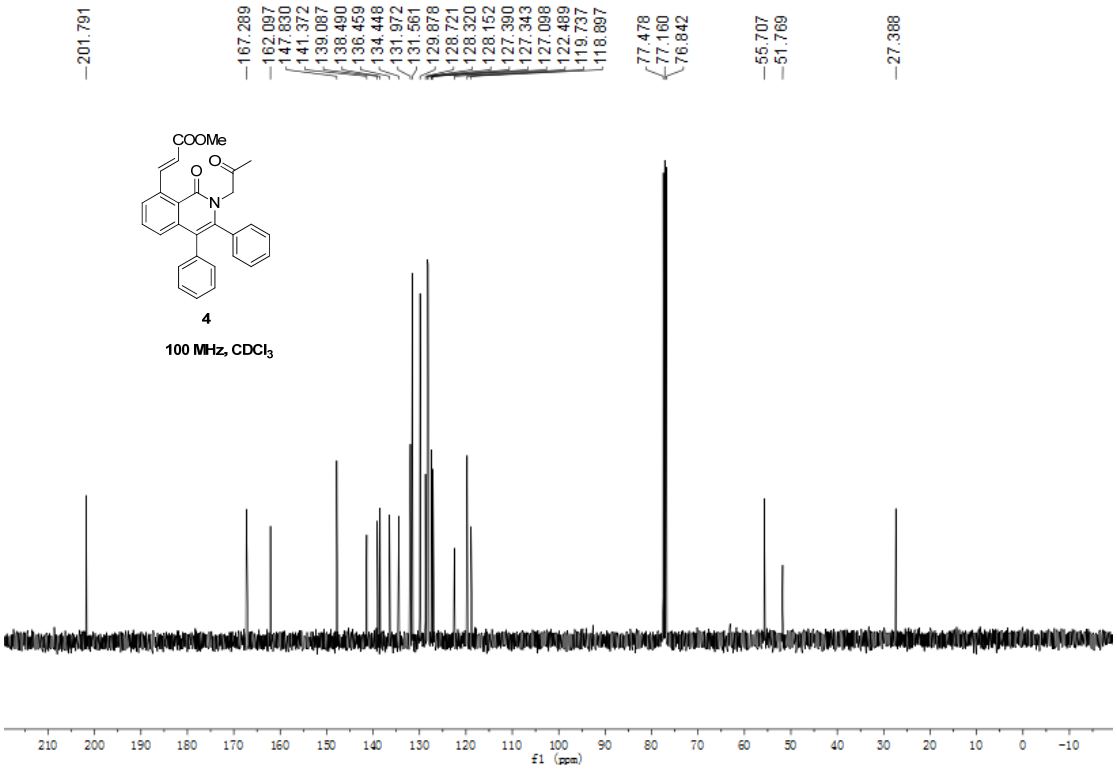

8.565
8.544
8.467
8.446
7.699
7.680
7.660
7.506
7.487
7.466
7.444
7.427
7.408
7.396
7.383
7.260
7.140
7.124
4.666
4.650
4.633
4.616
4.452
4.441
4.430
4.408
4.398
4.386
4.347
4.337
4.326
4.303
4.293
4.282
2.378
1.945
1.553
1.536
O
O
N
OH
3aq
400 MHz, CDCl3
1.00
0.99
0.98
4.37
2.16
0.99
2.25
1.27
2.97
2.91
f1 (ppm)

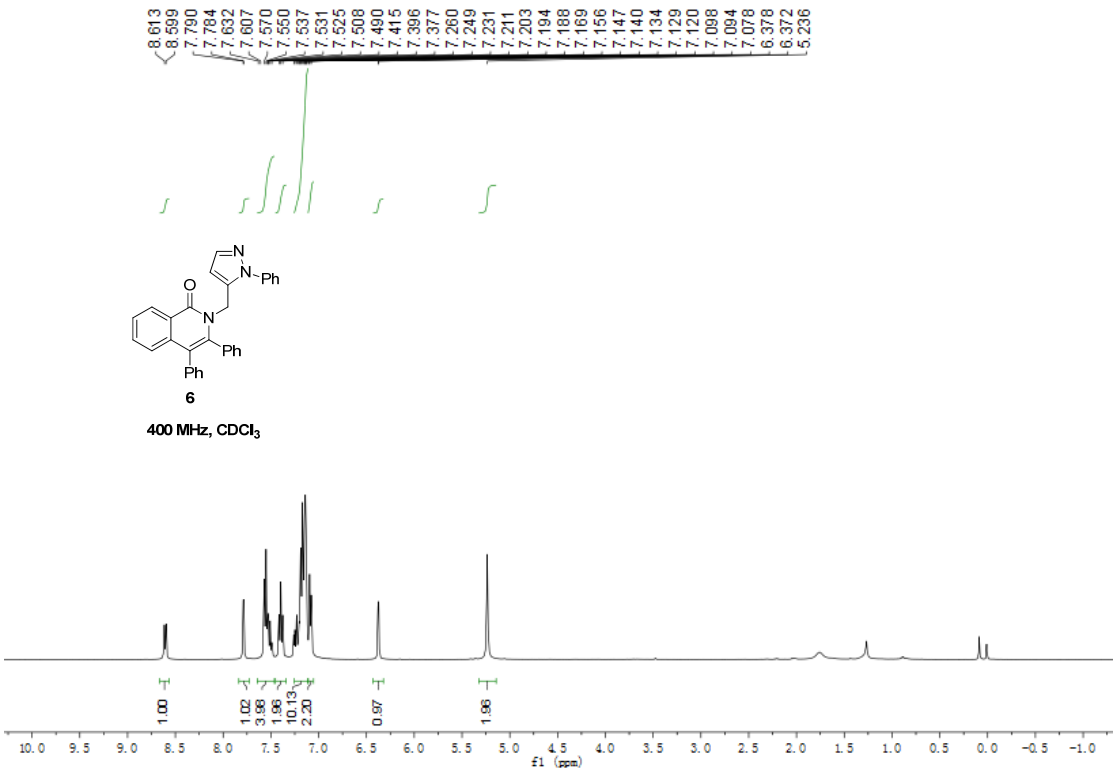

201.939
162.094
139.573
135.138
134.476
132.069
129.500
129.425
129.130
128.719
128.544
126.791
126.471
125.979
117.838
77.478
77.160
76.843
68.546
55.289
27.290
22.724
O
O
N
OH
3aq
100 MHz, CDCl3
f1 (ppm)

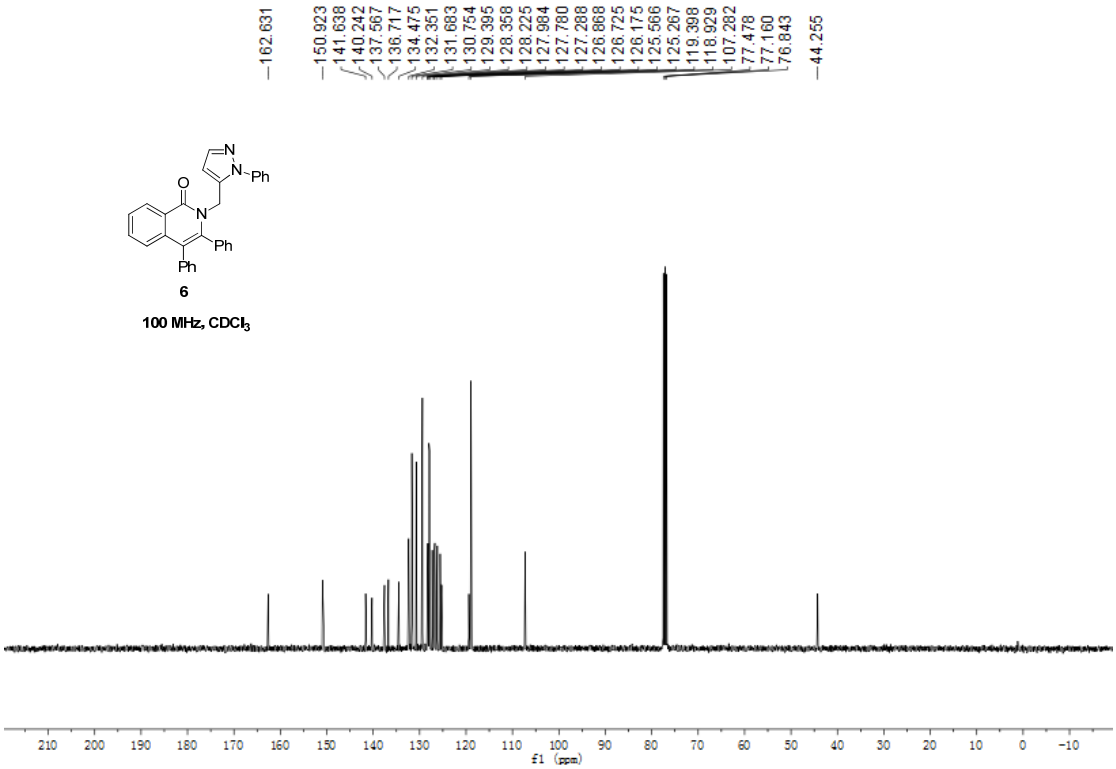

8.481
8.464
7.681
7.678
7.664
7.661
7.657
7.643
7.640
7.602
7.585
7.519
7.510
7.507
7.493
7.490
7.487
7.473
7.470
7.454
7.451
7.444
7.441
7.436
7.432
7.426
7.422
7.418
7.407
7.403
7.399
7.395
7.260
7.256
7.252
7.248
7.242
7.238
7.232
4.779
4.775
4.772
4.768
4.764
4.545
4.508
3.045
2.021
1.654
O
O
N
3ar
400 MHz, CDCl3
1.00
1.04
0.97
1.14
2.96
2.20
1.03
2.03
1.11
1.83
2.99
2.73
f1 (ppm)

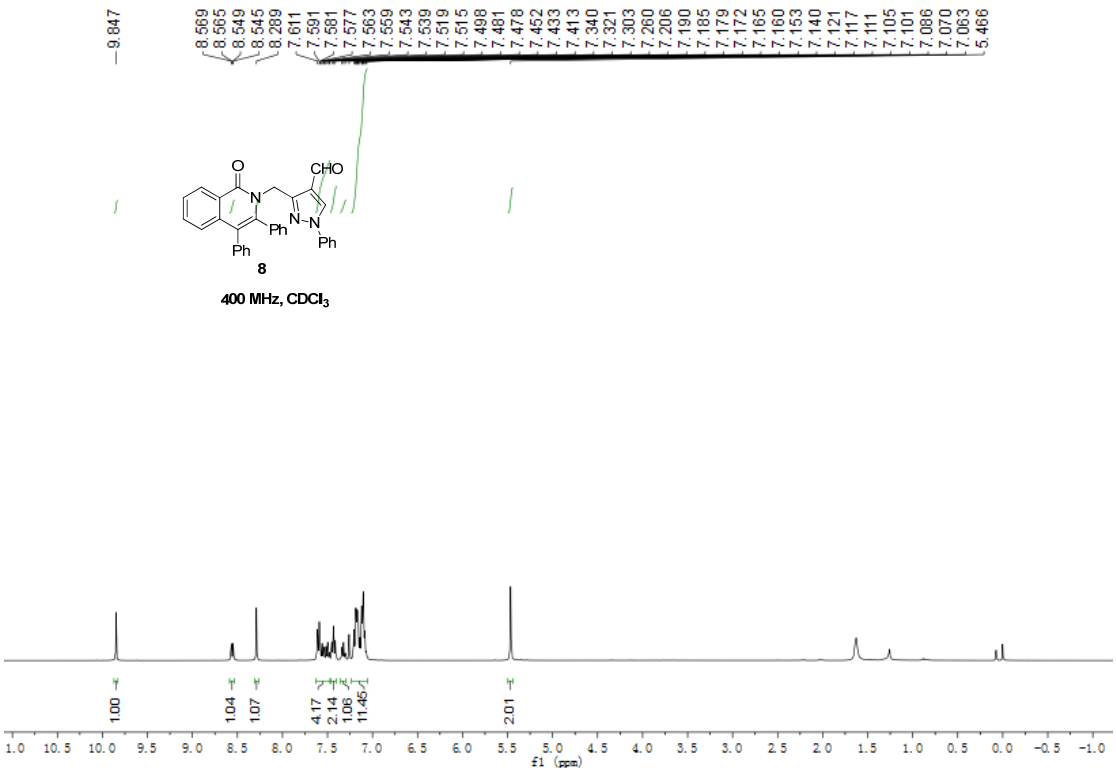

201.912
162.292
143.967
140.919
137.070
134.948
132.519
129.328
129.131
128.930
128.250
126.699
125.262
124.390
112.887
111.812
77.478
77.160
76.843
55.687
36.811
27.340
23.356
3ar
100 MHz, CDCl3
f1 (ppm)

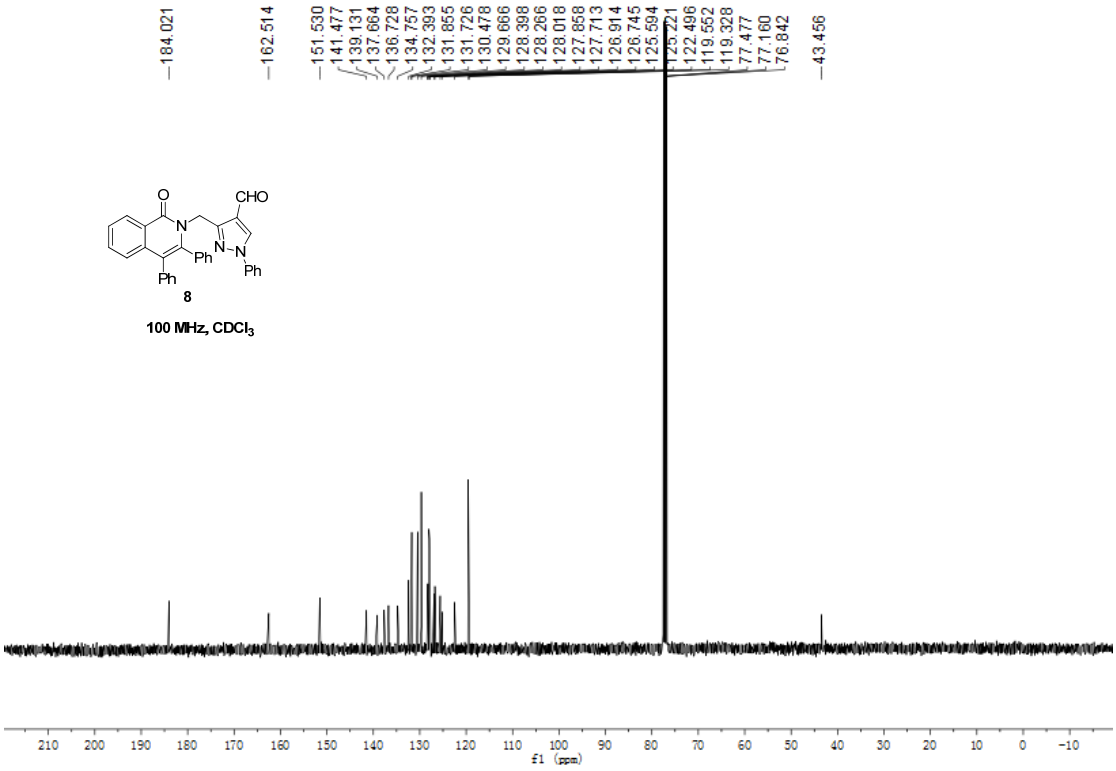

9.063
9.023
7.506
7.488
7.468
7.464
7.459
7.445
7.441
7.260
7.200
7.195
7.188
7.182
7.175
7.171
7.164
7.153
7.149
7.141
7.103
7.094
7.089
7.078
7.073
7.069
7.062
7.058
7.054
6.185
6.145
4.612
3.806
2.036
COOMe
4
400 MHz, CDCl3
1.00
2.19
7.11
4.36
1.06
2.11
3.26
3.43
f1 (ppm)


201.791
167.289
162.097
147.830
141.372
139.087
138.490
136.459
134.448
131.972
131.561
129.878
128.721
128.320
128.152
127.390
127.343
127.098
122.489
119.737
118.897
77.478
77.160
76.842
55.707
51.769
27.388
COOMe
O
O
N
4
100 MHz, CDCl3
f1 (ppm)


8.613
8.599
7.790
7.784
7.632
7.607
7.570
7.550
7.537
7.531
7.525
7.508
7.490
7.415
7.396
7.377
7.260
7.249
7.231
7.211
7.203
7.194
7.188
7.169
7.156
7.147
7.140
7.134
7.129
7.120
7.098
7.094
7.078
6.378
6.372
5.236
N
N
Ph
O
N
Ph
Ph
6
400 MHz, CDCl3
1.00
1.02
3.98
1.96
10.13
2.20
0.97
1.96
f1 (ppm)


162.631
150.923
141.638
140.242
137.567
136.717
134.475
132.351
131.683
130.754
129.395
128.358
128.225
127.984
127.780
127.288
126.868
126.725
126.175
125.566
125.267
119.398
118.929
107.282
77.478
77.160
76.843
44.255
N
N
Ph
O
N
Ph
Ph
6
100 MHz, CDCl3
f1 (ppm)


9.847
8.569
8.565
8.549
8.545
8.289
7.611
7.591
7.581
7.577
7.563
7.559
7.543
7.539
7.519
7.515
7.498
7.481
7.478
7.452
7.433
7.413
7.340
7.321
7.303
7.260
7.206
7.190
7.185
7.179
7.172
7.165
7.160
7.153
7.140
7.121
7.117
7.111
7.105
7.101
7.086
7.070
7.063
5.466
O
CHO
N
N
N
Ph
Ph
Ph
8
400 MHz, CDCl3
1.00
1.04
1.07
4.17
2.14
1.06
11.45
2.01
f1 (ppm)


184.021
162.514
151.530
141.477
139.131
137.664
136.728
134.757
132.393
131.855
131.726
130.478
129.666
128.398
128.266
128.018
127.858
127.713
126.914
126.745
125.594
125.221
122.496
119.552
119.328
77.477
77.160
76.842
43.456
O
N
CHO
Ph
N
N
Ph
Ph
8
100 MHz, CDCl3
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
f1 (ppm)