Supporting Information

Oxidation of the Inert sp^3 C-H Bonds of Tetrahydroisoquinolines through C-H Activation Relay (CHAR): Construction of Functionalized Isoquinolin-1-ones

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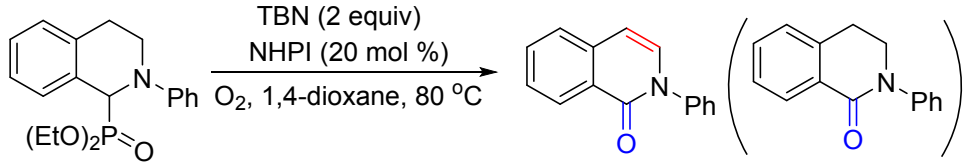
General:

TBN were purchased from commercial source and used without further purification. Flash chromatography was carried out with silica gel (200-300 mesh). Analytical TLC was performed with silica gel GF254 plates, and the products were visualized by UV detection. ^{1}H NMR and ^{13}C NMR (400 MHz, 600MHz and 100 MHz, 150MHz respectively) spectra were recorded in $CDCl_3$. Chemical shifts (δ) are reported in ppm using TMS as internal standard and spin-spin coupling constants (J) are given in Hz. The high resolution mass spectra (HRMS) were measured on an electrospray ionization (ESI) apparatus using time of flight (TOF) mass spectrometry.

General Experimental Procedure

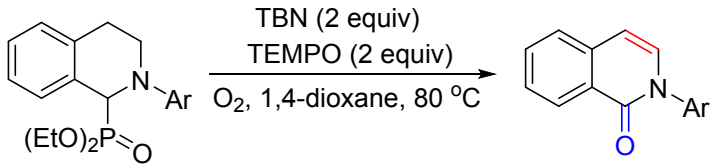
1. TBN/O_2/NHPI initiated synthesis of isoquinolin-1-ones (P1)



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

A solution of **1a** (1 mmol) and NHPI (20 mol %) in 1,4-dioxane (16 mL) was mixed fully, then TBN (2 mmol) was added dropwise under O_2 atmosphere. The reaction solution was stirred under 80 °C (oil bath). After completion monitored by TLC (by UV visualization), the solvent was removed under reduced pressure. The products were separated by silica gel column chromatography eluted with petroleum ether/ethyl acetate (v/v 6:1) to afford the product **2a** in 71% yield (69% for 0.5 mmol scale).

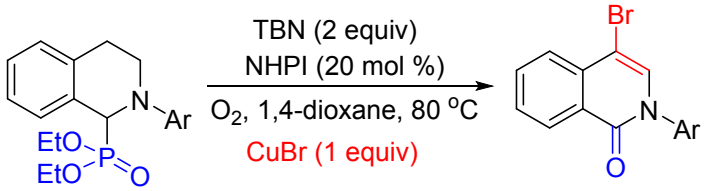
2. TBN/O_2/TEMPO initiated synthesis of isoquinolin-1-ones (P2)



1 **2**

A solution of **1** (0.5 mmol) and TEMPO (1 mmol) in 1,4-dioxane (8 mL) was mixed fully, then TBN (1 mmol) was added dropwise under O_2 atmosphere. The reaction solution was stirred under 80 °C (oil bath). After completion monitored by TLC (by UV visualization), the solvent was removed under reduced pressure. The products were separated by silica gel column chromatography eluted with petroleum ether/ethyl acetate (v/v 6:1) to afford the product.

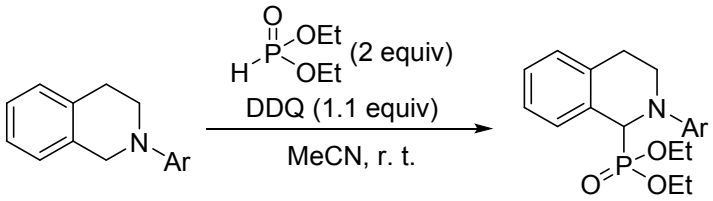
3. TBN initiated synthesis of 4-bromoisoquinolin-1-ones (P3)



A solution of **1** (0.5 mmol), CuBr (0.5 mmol), NHPI (20 mol %) in 1,4-dioxane (8 mL) was

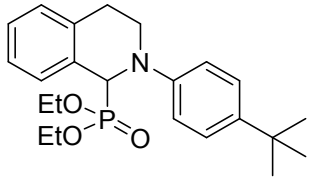
mixed fully, then TBN (1 mmol) was added dropwise under O_2 atmosphere. The reaction solution was stirred under 80 °C (oil bath). After completion monitored by TLC (by UV visualization), the solvent was removed under reduced pressure. The products were separated by silica gel column chromatography eluted with petroleum ether/ethyl acetate (v/v 6:1) to afford the product.

Synthesis of the starting material [1]



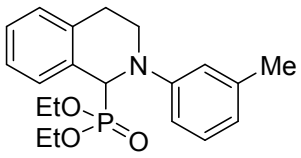
A solution of N-aryltetraisoquinoline (1 mmol) and DDQ (1.1 mmol) in MeCN (10 mL) was mixed fully, then dialkyl phosphonate (2 mmol) was added dropwise at room temperature. After stirred overnight, the reaction mixture was diluted with CH_2Cl_2, and then concentrated under vacuum. The products were separated by silica gel column chromatography eluted with petroleum ether/ ethyl acetate (v/v 3:1) to afford the product.

For compounds **1a,**[2] **1b**,[3] **1d-1e,**[3] **1f-1g**,[2] **1i,**[4] **1j,**[5] **1k,**[2] **1l**,[5] **1p,**[6] **1q-1t**,[2] all these THIQs were known compounds, and the compounds spectra data are in agreement with the reports.



Diethyl (2-(4-(tert-butyl)phenyl)-1,2,3,4-tetrahydroisoquinolin-1-yl)phosphonate (1c)

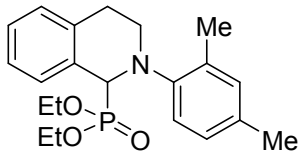
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.41 – 7.31 (m, 1H), 7.25 (d, J = 8.8 Hz, 2H), 7.21 – 7.06 (m, 3H), 6.92 (d, J = 8.9 Hz, 2H), 5.13 (d, J = 20.4 Hz, 1H), 4.18 – 3.84 (m, 5H), 3.66 – 3.55 (m, 1H), 3.00 (d, J = 3.8 Hz, 2H), 1.27 (s, 9H), 1.24 (t, J = 7.1 Hz, 3H), 1.14 (t, J = 7.1 Hz, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 147.2 (C-P, $^2J_{C\text{-}P}$ = 6.6 Hz), 141.3, 136.4 (C-P, $^3J_{C\text{-}P}$ = 5.7 Hz), 130.7, 128.8 (C-P, $^4J_{C\text{-}P}$ = 2.6 Hz), 128.1 (C-P, $^3J_{C\text{-}P}$ = 4.5 Hz), 127.3 (C-P, $^3J_{C\text{-}P}$ = 3.4 Hz), 125.9, 125.7 (C-P, $^4J_{C\text{-}P}$ = 2.9 Hz), 114.7, 63.3 (C-P, $^2J_{C\text{-}P}$ = 7.1 Hz), 62.26 (C-P, $^2J_{C\text{-}P}$ = 7.7 Hz), 59.12 (C-P, $^1J_{C\text{-}P}$ = 159.3 Hz), 43.5, 33.8, 31.5, 26.6, 16.5 (C-P, $^3J_{C\text{-}P}$ = 5.6 Hz), 16.36 (C-P, $^3J_{C\text{-}P}$ = 5.9 Hz); HRMS (ESI) m/z: $[M + Na]^+$ Calcd for $C_{23}H_{32}NO_3PNa$, 424.2012; Found, 424.2001.



Diethyl (2-(m-tolyl)-1,2,3,4-tetrahydroisoquinolin-1-yl)phosphonate (1h)

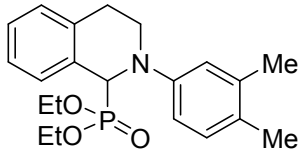
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.39 (dd, J = 5.3, 3.5 Hz, 1H), 7.24 – 7.07 (m, 4H), 6.81 (d, J = 8.3 Hz, 2H), 6.64 (d, J = 7.4 Hz, 1H), 5.20 (d, J = 20.2 Hz, 1H), 4.20 – 3.85 (m, 5H), 3.73 – 3.55 (m, 1H), 3.19 – 2.93 (m, 2H), 2.33 (s, 3H), 1.27 (t, J = 7.1 Hz, 3H), 1.16 (t, J = 7.1 Hz, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 149.5 (C-P, $^2J_{C\text{-}P}$ = 6.0 Hz), 138.8, 136.5 (C-P, $^3J_{C\text{-}P}$ = 5.6 Hz), 130.6, 129.0, 128.8 (C-P, $^4J_{C\text{-}P}$ = 2.6 Hz), 128.1 (C-P, $^3J_{C\text{-}P}$ = 4.6 Hz), 127.4 (C-P, $^3J_{C\text{-}P}$ = 3.5 Hz), 125.8 (C-P, $^4J_{C\text{-}P}$ = 2.9 Hz), 119.4, 115.5, 112.0, 63.3 (C-P, $^2J_{C\text{-}P}$ = 7.2 Hz), 62.3 (C-P, $^2J_{C\text{-}P}$ = 7.7 Hz), 58.9 (C-P, $^1J_{C\text{-}P}$ = 159.2 Hz), 43.4,

26.7, 21.9, 16.5 (C-P, $^{3}J_{C\text{-}P}$ = 5.5 Hz), 16.4 (C-P, $^{3}J_{C\text{-}P}$ = 5.9 Hz); HRMS (ESI) m/z: $[M + Na]^+$ Calcd for $C_{20}H_{26}NO_3PNa$, 382.1543; Found, 382.1532.



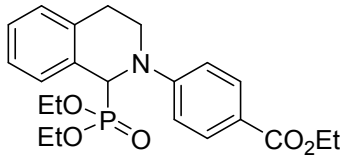
Diethyl (2-(2,4-dimethylphenyl)-1,2,3,4-tetrahydroisoquinolin-1-yl)phosphonate (1m)

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.57 – 7.43 (m, 1H), 7.29 – 7.17 (m, 2H), 7.17 – 7.05 (m, 1H), 7.00 (s, 1H), 6.78 (d, *J* = 8.1 Hz, 1H), 6.67 (d, *J* = 8.1 Hz, 1H), 4.71 (d, *J* = 25.1 Hz, 1H), 4.18 – 3.84 (m, 5H), 3.22 – 3.07 (m, 1H), 2.85 – 2.69 (m, 1H), 2.59 (dd, *J* = 16.3, 2.5 Hz, 1H), 2.35 (s, 3H), 2.24 (s, 3H), 1.24 (t, *J* = 7.1 Hz, 3H), 1.16 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 147.9 (C-P, $^{2}J_{C\text{-}P}$ = 12.4 Hz), 136.7 (C-P, $^{3}J_{C\text{-}P}$ = 6.3 Hz), 133.2, 133.0, 131.8, 130.6, 129.3 (C-P, $^{4}J_{C\text{-}P}$ = 2.4 Hz), 128.1 (C-P, $^{3}J_{C\text{-}P}$ = 3.8 Hz), 127.0 (C-P, $^{3}J_{C\text{-}P}$ = 3.6 Hz), 126.9, 125.8 (C-P, $^{4}J_{C\text{-}P}$ = 3.2 Hz), 122.4, 62.9 (C-P, $^{2}J_{C\text{-}P}$ = 7.3 Hz), 62.0 (C-P, $^{2}J_{C\text{-}P}$ = 7.2 Hz), 59.9 (C-P, $^{1}J_{C\text{-}P}$ = 157.5 Hz), 45.6, 24.8, 20.7, 17.9, 16.5 (C-P, $^{3}J_{C\text{-}P}$ = 5.8 Hz), 16.4 (C-P, $^{3}J_{C\text{-}P}$ = 6.0 Hz); HRMS (ESI) m/z: $[M + Na]^+$ Calcd for $C_{21}H_{28}NO_3PNa$, 396.1699; Found, 396.1690.



Diethyl (2-(3,4-dimethylphenyl)-1,2,3,4-tetrahydroisoquinolin-1-yl)phosphonate (1n)

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.42 (dd, *J* = 5.4, 3.5 Hz, 1H), 7.29 – 7.10 (m, 3H), 7.02 (d, *J* = 8.4 Hz, 1H), 6.83 (d, *J* = 2.4 Hz, 1H), 6.76 (dd, *J* = 8.2, 2.6 Hz, 1H), 5.17 (d, *J* = 21.0 Hz, 1H), 4.27 – 3.88 (m, 5H), 3.77 – 3.57 (m, 1H), 3.00 (t, *J* = 7.2 Hz, 2H), 2.26 (s, 3H), 2.19 (s, 3H), 1.29 (t, *J* = 7.1 Hz, 3H), 1.19 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 147.8 (C-P, $^{2}J_{C\text{-}P}$ = 7.2 Hz), 137.1, 136.5 (C-P, $^{3}J_{C\text{-}P}$ = 5.8 Hz), 130.6 (C-P, $^{4}J_{C\text{-}P}$ = 1.1 Hz), 130.2, 128.8 (C-P, $^{4}J_{C\text{-}P}$ = 2.6 Hz), 128.1 (C-P, $^{3}J_{C\text{-}P}$ = 4.4 Hz), 127.3 (C-P, $^{3}J_{C\text{-}P}$ = 3.5 Hz), 126.8, 125.8 (C-P, $^{4}J_{C\text{-}P}$ = 2.9 Hz), 116.9, 112.8, 63.4 (C-P, $^{2}J_{C\text{-}P}$ = 7.2 Hz), 62.3 (C-P, $^{2}J_{C\text{-}P}$ = 7.6 Hz), 59.1 (C-P, $^{1}J_{C\text{-}P}$ = 159.6 Hz), 43.7, 26.4, 20.3, 18.7, 16.5 (C-P, $^{3}J_{C\text{-}P}$ = 5.5 Hz), 16.41 (C-P, $^{3}J_{C\text{-}P}$ = 5.9 Hz); HRMS (ESI) m/z: $[M + Na]^+$ Calcd for $C_{21}H_{28}NO_3PNa$, 396.1699; Found, 396.1694.

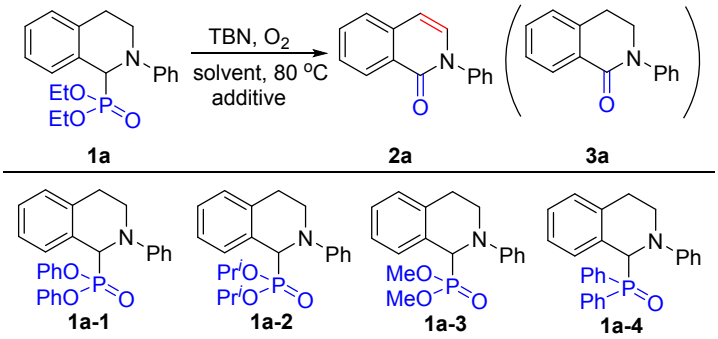


Ethyl 4-(1-(diethoxyphosphoryl)-3,4-dihydroisoquinolin-2(1H)-yl)benzoate (1o)

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.92 (d, *J* = 9.1 Hz, 2H), 7.35 (d, *J* = 7.2 Hz, 1H), 7.29 – 7.12 (m, 3H), 6.93 (d, *J* = 9.0 Hz, 2H), 5.27 (d, *J* = 18.2 Hz, 1H), 4.31 (q, *J* = 7.1 Hz, 2H), 4.13 – 3.88 (m, 4H), 3.88 – 3.75 (m, 1H), 3.75 – 3.53 (m, 1H), 3.44 – 3.20 (m, 1H), 3.13 – 2.89 (m, 1H), 1.35 (t, *J* = 7.1 Hz, 3H), 1.21 (t, *J* = 7.1 Hz, 3H), 1.10 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 166.7, 152.1 (C-P, $^{4}J_{C\text{-}P}$ = 3.0 Hz), 136.2 (C-P, $^{2}J_{C\text{-}P}$ = 5.3 Hz), 131.1, 130.4, 128.5 (C-P, $^{4}J_{C\text{-}P}$ = 2.7 Hz), 128.1 (C-P, $^{3}J_{C\text{-}P}$ = 5.0 Hz), 127.8 (C-P, $^{3}J_{C\text{-}P}$ = 3.4 Hz), 126.1 (C-P, $^{4}J_{C\text{-}P}$ = 2.8 Hz), 119.2, 112.4, 63.2 (C-P, $^{2}J_{C\text{-}P}$ = 7.3 Hz), 62.6 (C-P, $^{2}J_{C\text{-}P}$ = 7.7 Hz), 60.3, 58.0 (C-P, $^{1}J_{C\text{-}P}$ = 159.1 Hz), 43.4, 27.4, 16.4 (C-P, $^{3}J_{C\text{-}P}$ = 5.5 Hz), 16.4 (C-P, $^{3}J_{C\text{-}P}$ = 5.9 Hz), 14.4; HRMS (ESI) m/z: $[M + Na]^+$ Calcd for $C_{26}H_{28}NO_5PNa$, 440.1597; Found, 440.1586.

Optimization of reaction conditions

1. The synthesis of isoquinolin-1-ones.



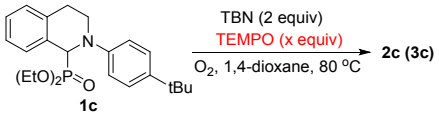
entry	TBN (equiv)	additive (mol %)	solvent	yield (%) [a]
1	2	none	1,4-dioxane	51 (**3a**, 15) [b]
2	2.5	none	1,4-dioxane	50 (**3a**, 18) [b]
3	2	none	THF	45 (**3a**,18) [b]
4	2	none	toluene	37 (**3a**, 20) [b]
5	2	none	anisole	trace
6	2	TEMPO (10)	1,4-dioxane	52 (**3a**, 12) [b]
7	2	NHPI (10)	1,4-dioxane	64 (**3a**, 8) [b]
8	**2**	**NHPI (20)**	**1,4-dioxane**	**78 (3a, 9) [b, c]**
9	2	NHPI (30)	1,4-dioxane	74 (**3a**, 8) [b]
10	2	NHPI (20)	1,4-dioxane	55 (**3a**, 10) [b, d]
11	2	NHPI (20)	1,4-dioxane	58 (**3a**, 8) [b, e]
12	2	NHPI (20)	1,4-dioxane	61 (**3a**, 12) [b, f]
13	2	NHPI (20)	1,4-dioxane	39 (**3a**, 15) [b, g]
14	none	none	1,4-dioxane	N. R. [h]
15	none	none	1,4-dioxane	0 (**3a**, trace) [i]

[a] Yields were determined by crude ^{1}H NMR using 1,3,5-trimethoxylbenzene as an internal standard; [b] The ^{1}H NMR yield of **3a** is given in the parentheses; [c] The isolated yield of **2a** is 69%; [d] **1a-1** instead of **1a** was employed as the starting material; [e] **1a-2** instead of **1a** was employed as the starting material; f **1a-3** instead of **1a** was employed as the starting material; g **1a-4** instead of **1a** was employed as the starting material; [h] TBHP (1 equiv)/CuBr (10 mol %) were employed as the initiator; [i] CAN (ceric ammonium nitrate, 2 equiv) was employed as the oxidant.

Using TBN (*tert*-butylnitrite)/O_2 as the catalyst system, an isoquinolin-1-one **2a** was detected in 51% yield through the designed HAT process (entry 1). However, in the presence of dioxygen, the oxidative Wittig reaction of α-aminophosphates were inevitable, giving the corresponding amide **3a** in 15% yield. Increasing the amount of TBN did not reinforce the reaction efficiency as well as the selectivity (entry 2). Then, several solvents were screened (entries 3-5), and the results remained unsatisfactory. To further accelerate the HAT, the model reaction was conducted in the presence of TEMPO (2,2,6,6-tetramethyl-1-piperidinyloxy),

however, comparable result was obtained (entry 6). When catalytic amount NHPI (*N*-hydroxyl phthalimide) was added to the reaction solution, the desired product was provided in higher yield (entry 7). Further optimization showed that 20 mol % NHPI gave the best result, and the expected product was afforded in 78% ^{1}H NMR and 69% isolated yields, respectively (entry 8). Other phosphates were also tested, and ethyl phosphate still gave the best yield (entries 10-13). Using other initiators, the reaction efficiency was not increased (entries 14-15).

2. Evaluation of the effect of TEMPO



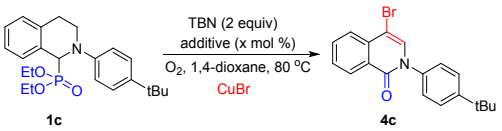
1c

Entry	TEMPO (x equiv)	Yield (%) [a]
1	0	56 (**3c**, 18) [b]
2	1	58 (**3c**, 13) [b]
3	2	66 (**3c**, 7) [b]
4	4	75
5	6	75

[a] Isolated yields; [b] The yield of **3a** is given in the parentheses.

We accidentally found that the addition of stoichiometric amount of TEMPO can efficiently promote the reaction outcome (catalytic amount TEMPO is not beneficial to the reaction). Therefore, using **1c** as the model substrate, the effect of TEMPO was studied. When the amount of TEMPO was increased to 2 equivalent, the selectivity was obviously improved (entries 2-3). Further increasing the amount of TEMPO could totally inhibited the formation of **3c**, albeit it would cause large amount of waste (entries 4-5). Therefore, some representative examples were tested in the presence of 2 equivalent of TEMPO, and in the most cases, the reaction efficiency as well as the selectivity was improved.

3. The synthesis of 4-bromoisoquinolin-1-ones.



1c **4c**

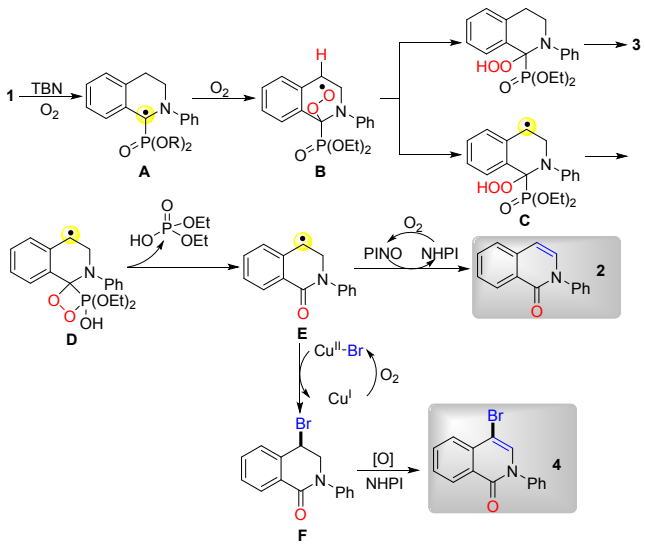
Entry	Cu (equiv)	NHPI (mol %)	TEMPO (mol %)	Yield (%) [a]
1	CuBr (1)	none	none	42
2	CuBr (1)	none	10	54
3	CuBr (1)	none	20	50
4	CuBr (2)	none	20	32
5	**CuBr (1)**	**20**	**none**	**60**
6	CuBr (1)	40	none	47
7	$CuBr_2$ (1)	none	none	40
8	$CuBr_2$ (1)	20	none	40
9	none	20	none	N. D. [b]
10	none	20	none	trace [c]
11	none	20	none	trace [d]

[a] Yields were determined by crude ^{1}H NMR using 1,3,5-trimethoxylbenzene as an internal

standard; [b] In the presence of CBr_4 (1 equiv); [c] In the presence of NBS (1 equiv); [d] In the presence of Br_2 (1 equiv).

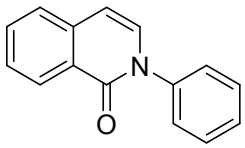
The model reaction were performed in the presence of 1 equivalent of CuBr (entry 1), and as our design, the 4-bromodihydroisoquinolin-1-one was obtained in 42% yield. With this promising result, NHPI and TEMPO as the additives were tested, respectively (entries 2-6). The results shown that 20 mol % of NHPI is sufficient to give the best product outcome, and the desired product was isolated in 60% yield (entry 5). Although Cu(II) species can efficiently initiate halogen atom-transfer reaction, their oxidability might cause undesired side-reactions, and in the presence of $CuBr_2$, the reaction efficiency was reduced (entry 7-8). It is worth noting that CuBr might accelerate the formation of the desired product and no direct oxidative Wittig product **3c** was detected. In the presence of one equivalent of CBr_4, only products **2c** and **3c** were detected (entry 9). When one equivalent of NBS or Br_2 was employed as the bromine atom donors, the desired reaction was disturbed and the product **4c** was obtained in trace amount (entries 10-11).

Proposed mechanism



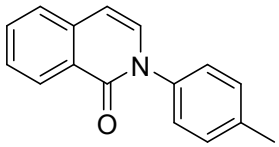
In the presence of TBN/O_2, a radical intermediate **A** is generated, followed by dioxygen trapping, giving a peroxide radical **B**, which might undergo the direct oxidative Wittig reaction to provide the side-product **3**. After the intramolecular HAT, a carbon-centered radical **C** is formed and meanwhile, the peroxide cyclizes with the phosphate, forming a four-membered ring **D**. After elimination of the diethyl phosphate, a radical **E** is provided through Wittig reaction. In the presence of NHPI/O_2, the H-abstraction between PINO radical and intermediate **E** accelerates the formation of the desired product **2**. It is worth noting that the formation of 3,4-double bond and the Wittig process might proceed simultaneously. When copper bromide exists in the reaction solution, the copper-catalyzed atom transfer will afford the 4-brominated intermediate **F**, which undergoes further oxidation to give the 4-bromodihydroisoquinolin-1-one **4**.

Analytical data for compounds



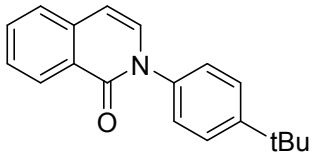
2-Phenylisoquinolin-1(2H)-one (2a)

A mixture of **2a** and **3a** [7] was obtained as a light yellow solid. **P1**: 86mg (**2a**: 69%; **3a**: 9%). **P2**: 88mg (**2a**: 75%; **3a**: 4%). Elution: petroleum ether/ethyl acetate = 6:1 (v : v); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.47 (d, *J* = 8.0 Hz, 1H), 7.67 – 7.61 (m, 1H), 7.55 – 7.45 (m, 4H), 7.44 – 7.36 (m, 3H), 7.15 (d, *J* = 7.4 Hz, 1H), 6.54 (d, *J* = 7.4 Hz, 1H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 162.0, 141.4, 137.1, 132.6, 132.2, 129.3, 128.2, 128.1, 127.1, 126.8, 126.5, 126.0, 106.2; HRMS (ESI) m/z: $[M + Na]^+$ Calcd for $C_{15}H_{11}NONa$, 244.0733; Found, 244.0730.



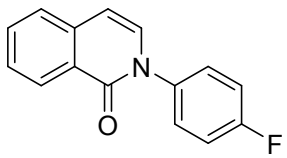
2-(p-Tolyl)isoquinolin-1(2H)-one (2b)

A mixture of **2b** and **3b** [7] was obtained as a light yellow solid. **P1**: 94mg (**2b**: 63%; **3b**: 17%). Elution: petroleum ether/ethyl acetate = 8:1 (v : v); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.47 (d, *J* = 8.0 Hz, 1H), 7.68 – 7.61 (m, 1H), 7.57 – 7.46 (m, 2H), 7.32 – 7.25 (m, 4H), 7.15 (d, *J* = 7.4 Hz, 1H), 6.53 (d, *J* = 7.4 Hz, 1H), 2.40 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 162.0, 141.4, 137.1, 132.6, 132.2, 129.3, 128.2, 128.1, 127.1, 126.8, 126.5, 126.0, 106.2; HRMS (ESI) m/z: $[M + Na]^+$ Calcd for $C_{16}H_{13}NONa$, 258.0889; Found, 258.0889.



2-(4-(*tert*-Butyl)phenyl)isoquinolin-1(2H)-one (2c)

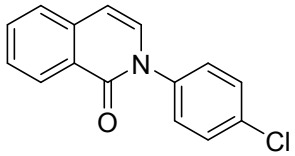
A mixture of **2c** and **3c** [8] was obtained as a yellow oil. **P1**: 103mg (**2c**: 56%; **3c**: 18%). **P2**: 101mg (**2c**: 66%; **3c**: 7%). Elution: petroleum ether/ethyl acetate = 8:1 (v : v); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.47 (d, *J* = 8.0 Hz, 1H), 7.68 – 7.60 (m, 1H), 7.55 – 7.47 (m, 4H), 7.35 (d, *J* = 8.5 Hz, 2H), 7.17 (d, *J* = 7.4 Hz, 1H), 6.54 (d, *J* = 7.4 Hz, 1H), 1.35 (s, 9H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 162.1, 150.1, 138.7, 137.1, 132.5, 132.3, 128.3, 127.0, 126.6, 126.2, 126.2, 125.9, 106.1, 34.7, 31.3; HRMS (ESI) m/z: $[M + Na]^+$ Calcd for $C_{19}H_{19}NONa$, 300.1359; Found, 300.1359.



2-(4-Fluorophenyl)isoquinolin-1(2H)-one (2d)

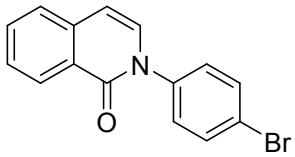
A mixture of **2d** and **3d** [7] was obtained as a light yellow solid. **P1**: 90mg (**2d**: 66%; **3d**: 9%). Elution: petroleum ether/ethyl acetate = 6:1 (v : v); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.44 (d, *J* = 8.0 Hz, 1H), 7.66 (t, *J* = 7.2 Hz, 1H), 7.51 (dd, *J* = 17.5, 7.9 Hz, 2H), 7.39 (dd, *J* = 8.6, 4.8 Hz, 2H), 7.15 (m, 3H), 6.55 (d,

J = 7.4 Hz, 1H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 163.2, 162.1, 160.7, 137.0, 132.7, 132.0, 128.7, 128.6, 128.2, 127.3, 126.4, 126.0, 116.3, 116.1, 106.4; HRMS (ESI) m/z: $[M + Na]^+$ Calcd for $C_{15}H_{10}FNONa$, 262.0639; Found, 262.0636.



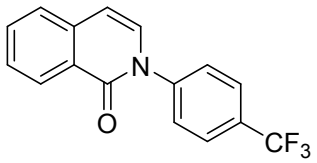
2-(4-Chlorophenyl)isoquinolin-1(2H)-one (2e)

A mixture of **2e** and **3e** [7] was obtained as a light yellow solid. **P1**: 106mg (**2e**: 68%; **3e**: 15%). Elution: petroleum ether/ethyl acetate = 7:1 (v : v); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.44 (d, J = 8.0 Hz, 1H), 7.65 (t, J = 7.5 Hz, 1H), 7.51 (m, 2H), 7.44 (d, J = 8.4 Hz, 2H), 7.36 (d, J = 8.5 Hz, 2H), 7.11 (d, J = 7.4 Hz, 1H), 6.55 (d, J = 7.4 Hz, 1H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 161.9, 139.8, 137.0, 133.9, 132.7, 131.6, 129.4, 128.3, 128.2, 127.3, 126.4, 126.0, 106.6; HRMS (ESI) m/z: $[M + Na]^+$ Calcd for $C_{15}H_{10}ClNONa$, 278.0343; Found, 278.0339.



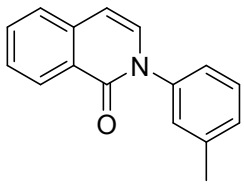
2-(4-Bromophenyl)isoquinolin-1(2H)-one (2f)

A mixture of **2f** and **3f** [7] was obtained as a yellow solid. **P1**: 69mg (**2f**: 33%; **3f**: 13%). **P2**: 126mg (**2f**: 79%; **3f**: 5%). Elution: petroleum ether/ethyl acetate = 5:1 (v : v); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.43 (d, J = 8.0 Hz, 1H), 7.66 (t, J = 7.5 Hz, 1H), 7.59 (d, J = 8.6 Hz, 2H), 7.51 (m, 2H), 7.30 (d, J = 8.6 Hz, 2H), 7.11 (d, J = 7.4 Hz, 1H), 6.55 (d, J = 7.4 Hz, 1H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 161.8, 140.3, 137.0, 132.8, 132.4, 131.6, 128.5, 128.2, 127.3, 126.4, 126.1, 121.9, 106.6; HRMS (ESI) m/z: $[M + Na]^+$ Calcd for $C_{15}H_{10}BrNONa$, 321.9838; Found, 321.9837.



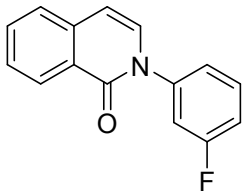
2-(4-(Trifluoromethyl)phenyl)isoquinolin-1(2H)-one (2g)

A mixture of **2g** and **3g** [7] was obtained as a light yellow solid. **P1**: 75mg (**2g**: 44%; **3g**: 8%). **P2**: 129mg (**2g**: 83%; **3g**: 6%). Elution: petroleum ether/ethyl acetate = 5:1 (v : v); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.45 (d, J = 8.0 Hz, 1H), 7.75 (d, J = 8.3 Hz, 2H), 7.71 – 7.65 (m, 1H), 7.62 – 7.48 (m, 4H), 7.15 (d, J = 7.4 Hz, 1H), 6.59 (d, J = 7.4 Hz, 1H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 161.8, 144.2, 136.9, 134.2, 132.9, 131.2, 128.3, 127.5, 127.3, 126.4 (two ^{13}C), 126.1, 123.4, 106.9; HRMS (ESI) m/z: $[M + Na]^+$ Calcd for $C_{16}H_{10}F_3NONa$, 312.0607; Found, 312.0620.



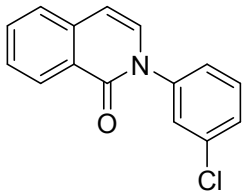
2-(m-Tolyl)isoquinolin-1(2H)-one (2h)

A mixture of **2h** and **3h** [9] was obtained as a light yellow oil. **P1**: 77mg (**2h**: 52%; **3h**: 13%). Elution: petroleum ether/ethyl acetate = 10:1 (v : v); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.47 (d, J = 8.0 Hz, 1H), 7.69 – 7.62 (m, 1H), 7.57 – 7.48 (m, 2H), 7.38 (t, J = 7.7 Hz, 1H), 7.22 (m, 3H), 7.16 (d, J = 7.4 Hz, 1H), 6.55 (d, J = 7.4 Hz, 1H), 2.41 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 162.0, 141.3, 139.3, 137.1, 132.5, 132.3, 129.1, 128.9, 128.3, 127.5, 127.1, 126.2, 125.9, 123.8, 106.0, 21.3; HRMS (ESI) m/z: $[M + Na]^+$ Calcd for $C_{16}H_{13}NONa$, 258.0889; Found, 258.0899.



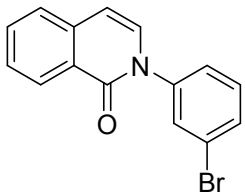
2-(3-Fluorophenyl)isoquinolin-1(2H)-one (2i)

A mixture of **2i** and **3i** [7] was obtained as a light yellow solid. **P1**: 70mg (**2i**: 49%; **3i**: 9%). Elution: petroleum ether/ethyl acetate = 6:1 (v : v); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.45 (d, J = 8.0 Hz, 1H), 7.69 – 7.63 (m, 1H), 7.56 – 7.41 (m, 3H), 7.24 – 7.18 (m, 2H), 7.16 – 7.07 (m, 2H), 6.56 (d, J = 7.4 Hz, 1H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 162.7 (d, J_{CF} = 247.8 Hz), 142.6 (d, J_{CF} = 9.8 Hz), 137.0, 132.8, 131.6, 130.5, 130.4, 128.2, 127.3, 126.0, 122.6 (d, J_{CF} = 3.3 Hz), 115.2 (d, J_{CF} = 21.0 Hz), 114.7 (d, J_{CF} = 23.7 Hz), 106.6; HRMS (ESI) m/z: $[M + Na]^+$ Calcd for $C_{15}H_{10}FNONa$, 262.0639; Found, 262.0635.



2-(3-Chlorophenyl)isoquinolin-1(2H)-one (2j)

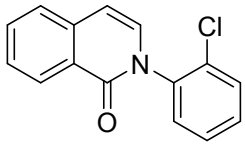
A mixture of **2j** and **3j** [7] was obtained as a light yellow solid. **P1**: 78mg (**2j**: 49%; **3j**: 12%). Elution: petroleum ether/ethyl acetate = 6:1 (v : v); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.45 (dd, J = 8.0, 0.5 Hz, 1H), 7.70 – 7.63 (m, 1H), 7.52 (m, 2H), 7.46 (dd, J = 2.6, 1.2 Hz, 1H), 7.43 – 7.38 (m, 2H), 7.34 (dd, J = 7.5, 1.9 Hz, 1H), 7.13 (d, J = 7.4 Hz, 1H), 6.56 (d, J = 7.4 Hz, 1H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 161.8, 142.3, 137.0, 134.7, 132.8, 131.5, 130.2, 128.3, 128.3, 127.4, 127.3, 126.1, 125.2, 106.6; HRMS (ESI) m/z: $[M + Na]^+$ Calcd for $C_{15}H_{10}ClNONa$, 278.0343; Found, 278.0340.



2-(3-Bromophenyl)isoquinolin-1(2H)-one (2k)

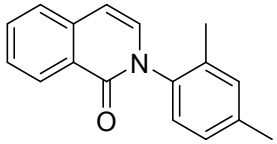
A mixture of **2k** and **3k** was obtained as a light yellow solid. **P1**: 77mg (**2k**: 41%; **3k**: 10%). **P2**: 127mg (**2k**: 81%; **3k**: 4%). Elution: petroleum ether/ethyl acetate = 5:1 (v : v); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.45 (d, J = 8.0 Hz, 1H), 7.70 – 7.65 (m, 1H), 7.61 (d, J = 1.9 Hz, 1H), 7.56 – 7.49 (m, 3H), 7.38 (dd, J = 6.0, 4.4 Hz, 2H), 7.13 (d, J = 7.4 Hz, 1H), 6.57 (d, J = 7.4 Hz, 1H); ^{13}C NMR (101 MHz, $CDCl_3$) δ

161.8, 142.4, 136.9, 132.8, 131.5, 131.3, 130.5, 130.1, 128.3, 127.4, 126.4, 126.0, 125.7, 122.6, 106.6; HRMS (ESI) m/z: $[M + Na]^+$ Calcd for $C_{15}H_{10}BrNONa$, 321.9838; Found, 321.9847.



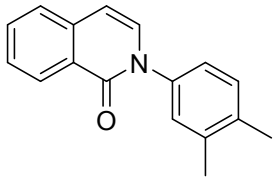
2-(2-Chlorophenyl)isoquinolin-1(2H)-one (2l)

A mixture of **2l** and **3l** [7] was obtained as a light yellow oil. **P1**: 106mg (**2l**: 28%; **3l**: 55%). **P2**: 121mg (**2l**: 61%; **3l**: 33%). Elution: petroleum ether/ethyl acetate = 5:1 (v : v); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.46 (d, *J* = 8.0 Hz, 1H), 7.70 – 7.63 (m, 1H), 7.55 (dd, *J* = 4.5, 3.5 Hz, 2H), 7.51 – 7.43 (m, 2H), 7.39 (d, *J* = 2.8 Hz, 2H), 6.98 (d, *J* = 7.4 Hz, 1H), 6.57 (d, *J* = 7.4 Hz, 1H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 164.0, 140.4, 138.8, 132.8, 132.2, 131.8, 130.5, 130.1, 129.6, 128.9, 128.3, 127.9, 127.2, 126.1, 106.3; HRMS (ESI) m/z: $[M + Na]^+$ Calcd for $C_{15}H_{10}ClNONa$, 278.0343; Found, 278.0348.



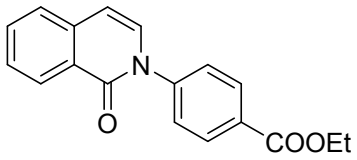
2-(2,4-Dimethylphenyl)isoquinolin-1(2H)-one (2m)

A mixture of **2m** and **3m** was obtained as a yellow oil. **P1**: 47mg (**2m**: 38%). **P2**: 71mg (**2m**: 53%; **3m**: 4%). Elution: petroleum ether/ethyl acetate = 10:1 (v : v); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.47 (d, *J* = 8.0 Hz, 1H), 7.66 (t, *J* = 7.5 Hz, 1H), 7.58 – 7.46 (m, 2H), 7.13 (d, *J* = 17.5 Hz, 3H), 7.00 (d, *J* = 7.4 Hz, 1H), 6.54 (d, *J* = 7.3 Hz, 1H), 2.37 (s, 3H), 2.13 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 161.8, 138.7, 138.0, 137.3, 135.0, 132.4, 132.4, 131.7, 128.2, 127.7, 127.3, 127.0, 126.6, 126.0, 106.0, 21.1, 17.6; HRMS (ESI) m/z: $[M + Na]^+$ Calcd for $C_{17}H_{15}NONa$, 272.1046; Found, 272.1046.



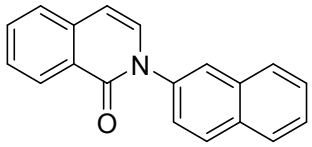
2-(3,4-Dimethylphenyl)isoquinolin-1(2H)-one (2n)

A mixture of **2n** and **3n** was obtained as a yellow oil. **P1**: 76mg (**2n**: 37%; **3n**: 24%). **P2**: 62mg (**2n**: 46%; **3n**: 4%). Elution: petroleum ether/ethyl acetate = 10:1 (v : v); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.47 (d, *J* = 8.0 Hz, 1H), 7.68 – 7.62 (m, 1H), 7.57 – 7.47 (m, 2H), 7.25 (s, 1H), 7.20 (d, *J* = 1.8 Hz, 1H), 7.14 (m, 2H), 6.53 (d, *J* = 7.4 Hz, 1H), 2.31 (s, 6H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 162.2, 139.1, 137.7, 137.1, 136.7, 132.5, 132.4, 130.4, 128.3, 127.8, 127.0, 126.6, 125.9, 124.0, 105.9, 19.8, 19.5; HRMS (ESI) m/z: $[M + Na]^+$ Calcd for $C_{17}H_{15}NONa$, 272.1046; Found, 272.1049.



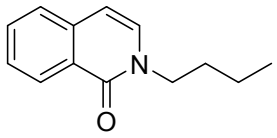
Ethyl 4-(1-oxoisoquinolin-2(1H)-yl)benzoate (2o)

A mixture of **2o** and **3o** was obtained as a light yellow solid. **P1**: 120mg (**2o**: 58%; **3o**: 24%). Elution: petroleum ether/ethyl acetate = 5:1 (v : v); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.41 (d, *J* = 7.6 Hz, 1H), 8.16 – 8.10 (m, 2H), 7.67 – 7.61 (m, 1H), 7.53 – 7.44 (m, 4H), 7.13 (d, *J* = 7.4 Hz, 1H), 6.56 (d, *J* = 7.5 Hz, 1H), 4.36 (q, *J* = 7.1 Hz, 2H), 1.37 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 165.7, 161.8, 145.0, 136.9, 132.8, 131.3, 130.6, 129.9, 128.2, 127.4, 126.7, 126.3, 126.1, 106.9, 61.3, 14.3; HRMS (ESI) m/z: $[M + Na]^+$ Calcd for $C_{18}H_{15}NO_3Na$, 316.0944; Found, 316.0942.



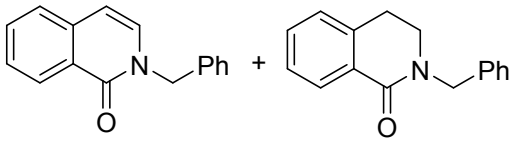
2-(Naphthalen-2-yl)isoquinolin-1(2H)-one (2p)

A mixture of **2p** and **3p** [7] was obtained as a light yellow solid. **P1**: 109mg (**2p**: 57%; **3p**: 23%). **P2**: 116mg (**2p**: 73%; **3p**: 12%). Elution: petroleum ether/ethyl acetate = 5:1 (v : v); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.50 (d, *J* = 8.0 Hz, 1H), 7.95 (d, *J* = 8.7 Hz, 1H), 7.92 – 7.84 (m, 3H), 7.71 – 7.66 (m, 1H), 7.60 – 7.50 (m, 5H), 7.28 (d, *J* = 7.4 Hz, 1H), 6.60 (d, *J* = 7.4 Hz, 1H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 162.2, 139.1, 137.1, 133.5, 132.6, 132.3, 129.0, 128.3, 128.0, 127.8, 127.2, 126.7, 126.7, 126.6, 126.0, 125.1, 125.0, 106.4 (one ^{13}C signal lost for overlap); HRMS (ESI) m/z: $[M + Na]^+$ Calcd for $C_{19}H_{13}NONa$, 294.0889; Found, 294.0887.



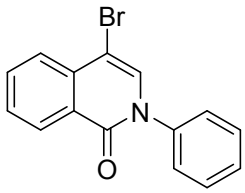
2-Butylisoquinolin-1(2H)-one (2s)

A mixture of **2s** and **3s** [10] was obtained as a colorless oil. **P2**: 56mg (**2s**: 52%; **3s**: 4%). Elution: petroleum ether/ethyl acetate = 8:1 (v : v); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.40 (d, *J* = 8.1 Hz, 1H), 7.66 – 7.52 (m, 1H), 7.52 – 7.36 (m, 2H), 7.02 (d, *J* = 7.3 Hz, 1H), 6.44 (d, *J* = 7.3 Hz, 1H), 4.03 – 3.88 (m, 2H), 1.78 – 1.68 (m, 2H), 1.43 – 1.30 (m, 2H), 0.92 (t, *J* = 7.4 Hz, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 162.0, 137.0, 134.4, 131.9, 131.7, 127.8, 126.6, 125.8, 105.8, 49.1, 31.4, 20.0, 13.7; HRMS (ESI) m/z: $[M + Na]^+$ Calcd for $C_{13}H_{15}NONa$, 224.1046; Found, 224.1040.



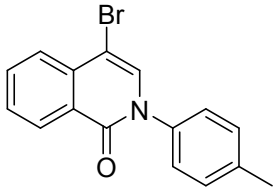
2-Benzylisoquinolin-1(2H)-one (2t) and 2-benzyl-3,4-dihydroisoquinolin-1(2H)-one (3t)

A mixture of **2t** and **3t** [11] was obtained as a yellow oil. **P2**: 90mg (**2t**: 38%; **3p**: 38%). Elution: petroleum ether/ethyl acetate = 8:1 (v : v); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.45 (d, *J* = 8.1 Hz, 1H), 8.14 (d, *J* = 7.6 Hz, 1H), 7.61 (dd, *J* = 7.9, 7.2 Hz, 1H), 7.55 – 7.43 (m, 2H), 7.40 (t, *J* = 7.4 Hz, 1H), 7.43 – 7.21 (m, 11H), 7.14 (d, *J* = 7.3 Hz, 1H), 7.07 (d, *J* = 7.4 Hz, 1H), 6.46 (d, *J* = 7.4 Hz, 1H), 5.21 (s, 2H), 4.78 (s, 2H), 3.47 (t, *J* = 6.6 Hz, 2H), 2.91 (t, *J* = 6.6 Hz, 2H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 164.5, 162.2, 138.0, 137.4, 137.0, 136.9, 132.2, 131.7, 131.3, 129.4, 128.8, 128.6, 128.4, 128.0, 127.9, 127.8, 127.4, 127.0, 126.9, 126.9, 126.3, 125.9, 106.4, 51.7, 50.4, 45.3, 28.1; HRMS (ESI) m/z: $[M + Na]^+$ Calcd for $C_{16}H_{13}NONa$ (**2t**), 258.0889; Found, 258.0883; Calcd for $C_{16}H_{15}NONa$ (**3t**), 260.1046; Found, 260.1039.



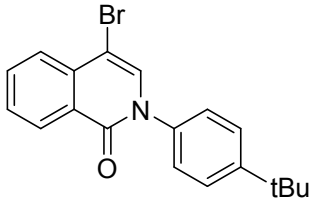
4-Bromo-2-phenylisoquinolin-1(2H)-one (4a)

Follow **P3** and the title compound **4a** was obtained as a light yellow solid (m.p.: 89-93 °C), 72mg (48%). Elution: petroleum ether/ethyl acetate = 6:1 (v : v); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.47 (d, *J* = 8.0 Hz, 1H), 7.84 (d, *J* = 7.9 Hz, 1H), 7.79 – 7.72 (m, 1H), 7.59 – 7.54 (m, 1H), 7.52 – 7.46 (m, 3H), 7.44 – 7.39 (m, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 161.1, 140.5, 135.5, 133.3, 132.6, 129.4, 128.7 (two ^{13}C), 128.1, 126.7, 125.9, 100.2 (one ^{13}C signal lost for overlap); HRMS (ESI) m/z: $[M + Na]^+$ Calcd for $C_{15}H_{10}BrNONa$, 321.9838; Found, 321.9845.



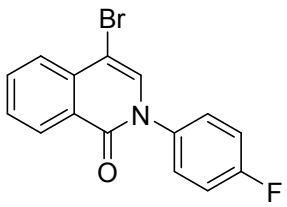
4-Bromo-2-(p-tolyl)isoquinolin-1(2H)-one (4b)

Follow **P3** and the title compound **4b** was obtained as a light yellow solid (m.p.: 95-100 °C), 63mg (40%). Elution: petroleum ether/ethyl acetate = 10:1 (v : v); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.48 (d, *J* = 8.0 Hz, 1H), 7.84 (d, *J* = 8.1 Hz, 1H), 7.76 (t, *J* = 7.4 Hz, 1H), 7.57 (t, *J* = 7.5 Hz, 1H), 7.47 (s, 1H), 7.29 (s, 4H), 2.41 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 161.2, 138.5, 138.0, 135.5, 133.2, 132.8, 130.0, 128.7, 128.1, 126.7, 126.4, 125.89, 100.0, 21.2; HRMS (ESI) m/z: $[M + Na]^+$ Calcd for $C_{16}H_{12}BrNONa$, 335.9995; Found, 335.9994.



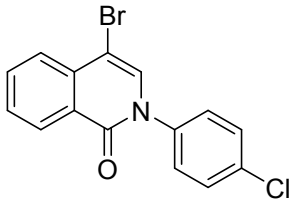
4-Bromo-2-(4-(tert-butyl)phenyl)isoquinolin-1(2H)-one (4c)

Follow **P3** and the title compound **4c** was obtained as a light yellow solid (m.p.: 157-160 °C), 107mg (60%). Elution: petroleum ether/ethyl acetate = 8:1 (v : v); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.47 (d, *J* = 7.7 Hz, 1H), 7.81 (d, *J* = 7.9 Hz, 1H), 7.73 (t, *J* = 7.1 Hz, 1H), 7.58 – 7.45 (m, 4H), 7.34 (d, *J* = 8.5 Hz, 2H), 1.35 (s, 9H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 161.1, 151.4, 137.9, 135.5, 133.2, 132.8, 128.7, 128.0, 126.7, 126.4, 126.2, 125.9, 100.1, 34.7, 31.3; HRMS (ESI) m/z: $[M + Na]^+$ Calcd for $C_{19}H_{18}BrNONa$, 378.0464; Found, 378.0470.



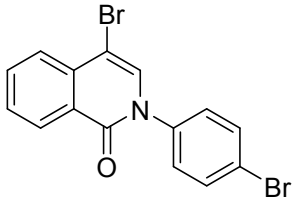
4-Bromo-2-(4-fluorophenyl)isoquinolin-1(2H)-one (4d)

Follow **P3** and the title compound **4d** was obtained as a white solid (m.p.: 141-147 °C), 82mg (52%). Elution: petroleum ether/ethyl acetate = 6:1 (v : v); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.44 (d, J = 8.0 Hz, 1H), 7.82 (d, J = 8.0 Hz, 1H), 7.76 (m, 1H), 7.56 (t, J = 7.5 Hz, 1H), 7.44 – 7.37 (m, 3H), 7.16 (m, 2H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 162.1 (C-F, $^1J_{CF}$ = 248.7 Hz), 161.1, 136.4 (C-F, $^4J_{CF}$ = 3.2 Hz), 135.4, 133.4, 132.37 (C-F, $^3J_{CF}$ = 8.6 Hz), 128.6 (two ^{13}C), 128.2 (C-F, $^4J_{CF}$ = 3.9 Hz), 126.5, 126.0, 116.4 (C-F, $^2J_{CF}$ = 23.1 Hz), 100.4; HRMS (ESI) m/z: $[M + Na]^+$ Calcd for $C_{15}H_{11}NONa$, 339.9744; Found, 339.9740.



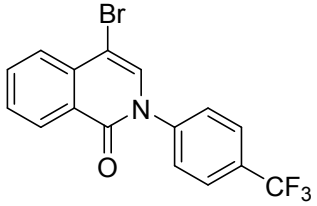
4-Bromo-2-(4-chlorophenyl)isoquinolin-1(2H)-one (4e)

Follow **P3** and the title compound **4e** was obtained as a light yellow solid (m.p.: 164-170 °C), 120mg (72%). Elution: petroleum ether/ethyl acetate = 6:1 (v : v); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.48 (dd, J = 8.0, 0.8 Hz, 1H), 7.88 (d, J = 8.1 Hz, 1H), 7.84 – 7.77 (m, 1H), 7.65 – 7.58 (m, 1H), 7.53 – 7.43 (m, 3H), 7.43 – 7.36 (m, 2H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 161.0, 138.8, 135.4, 134.3, 133.5, 132.1, 129.6, 128.7, 128.3, 128.1, 126.5, 126.0, 100.7; HRMS (ESI) m/z: $[M + Na]^+$ Calcd for $C_{15}H_9BrClNONa$, 355.9448; Found, 355.9449.



4-Bromo-2-(4-bromophenyl)isoquinolin-1(2H)-one (4f)

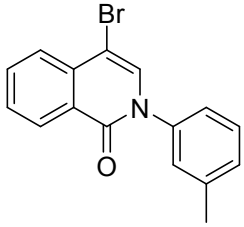
Follow **P3** and the title compound **4f** was obtained as a light yellow solid (m.p.: 184-187 °C), 145mg (77%). Elution: petroleum ether/ethyl acetate = 6:1 (v : v); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.44 (d, J = 8.0 Hz, 1H), 7.84 (d, J = 8.0 Hz, 1H), 7.77 (t, J = 7.5 Hz, 1H), 7.59 (dd, J = 19.2, 7.9 Hz, 3H), 7.42 (s, 1H), 7.31 (d, J = 8.4 Hz, 2H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 160.9, 139.3, 135.4, 133.5, 132.6, 132.0, 128.7, 128.4, 128.3, 126.5, 126.0, 122.3, 100.7; HRMS (ESI) m/z: $[M + Na]^+$ Calcd for $C_{15}H_9Br_2NONa$, 399.8943; Found, 399.8946.



4-Bromo-2-(4-(trifluoromethyl)phenyl)isoquinolin-1(2H)-one (4g)

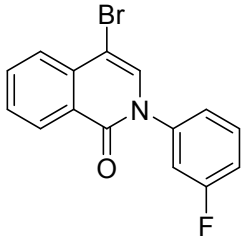
Follow **P3** and the title compound **4g** was obtained as a light yellow solid (m.p.: 132-140 °C), 121mg (66%). Elution: petroleum ether/ethyl acetate = 6:1 (v : v); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.46 (d, J =

8.0 Hz, 1H), 7.85 (d, J = 8.0 Hz, 1H), 7.78 (dd, J = 10.6, 8.4 Hz, 3H), 7.60 (dd, J = 7.9, 4.7 Hz, 3H), 7.46 (s, 1H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 160.8, 143.2, 135.4, 133.7, 131.6, 130.5 (C-F, $^2J_{C\text{-}F}$ = 32.8 Hz), 128.7, 128.5, 127.2, 126.6 (C-F, $^3J_{C\text{-}F}$ = 3.7 Hz), 126.5, 126.3 (C-F, $^1J_{C\text{-}F}$ = 272.4 Hz), 126.1, 101.1; HRMS (ESI) m/z: $[M + Na]^+$ Calcd for $C_{16}H_9BrF_3NONa$, 389.9712; Found, 389.9711.



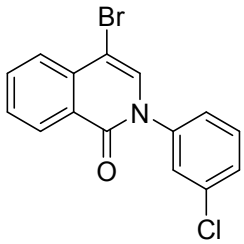
4-Bromo-2-(m-tolyl)isoquinolin-1(2H)-one (4h)

Follow **P3** and the title compound **4h** was obtained as a light yellow solid (m.p.: 88-95 °C), 78mg (50%). Elution: petroleum ether/ethyl acetate = 8:1 (v : v); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.59 – 8.41 (m, 1H), 7.91 – 7.84 (m, 1H), 7.84 – 7.70 (m, 1H), 7.59 (t, J = 7.6 Hz, 1H), 7.49 (s, 1H), 7.40 (t, J = 7.9 Hz, 1H), 7.32 – 7.15 (m, 3H), 2.43 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 161.1, 140.4, 139.5, 135.5, 133.3, 132.8, 132.7, 129.3, 128.7, 128.1, 127.4, 126.7, 125.9, 123.7, 100.1, 21.4; HRMS (ESI) m/z: $[M + Na]^+$ Calcd for $C_{16}H_{12}BrNONa$, 335.9995; Found, 335.9999.



4-Bromo-2-(3-fluorophenyl)isoquinolin-1(2H)-one (4i)

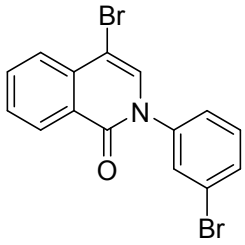
Follow **P3** and the title compound **4i** was obtained as a light yellow solid (m.p.: 89-97 °C), 97mg (61%). Elution: petroleum ether/ethyl acetate = 6:1 (v : v); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.48 (dd, J = 8.0, 0.7 Hz, 1H), 7.86 (d, J = 8.1 Hz, 1H), 7.79 (t, J = 7.6 Hz, 1H), 7.60 (t, J = 8.1 Hz, 1H), 7.54 – 7.42 (m, 2H), 7.22 (dd, J = 11.5, 4.3 Hz, 2H), 7.15 (td, J = 8.4, 2.4 Hz, 1H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 162.7 (C-F, $^1J_{CF}$ = 248.5 Hz), 160.8, 141.6 (C-F, $^3J_{CF}$ = 9.9 Hz), 135.4, 133.5, 132.0, 130.6 (C-F, $^3J_{CF}$ = 9.0 Hz), 128.7, 128.3, 126.5, 126.0, 122.5 (C-F, $^4J_{CF}$ = 3.3 Hz), 115.6 (C-F, $^2J_{CF}$ = 20.9 Hz), 114.6 (C-F, $^2J_{CF}$ = 23.9 Hz), 100.7; HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_{15}H_{10}BrFNO$, 317.9924; Found, 317.9928.



4-Bromo-2-(3-chlorophenyl)isoquinolin-1(2H)-one (4j)

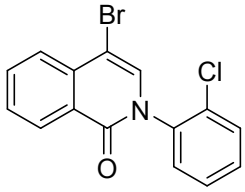
Follow **P3** and the title compound **4j** was obtained as a light yellow solid (m.p.: 91-93 °C), 87mg (52%). Elution: petroleum ether/ethyl acetate = 6:1 (v : v); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.48 (d, J = 8.0 Hz, 1H), 7.87 (d, J = 8.1 Hz, 1H), 7.81 (t, J = 7.6 Hz, 1H), 7.61 (t, J = 7.6 Hz, 1H), 7.50 – 7.39 (m, 4H), 7.35

(dt, J = 7.3, 1.9 Hz, 1H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 160.9, 141.3, 135., 134.9, 133.5, 131.9, 130.4, 128.7 (two ^{13}C), 128.3, 127.2, 126.5, 126.0, 125.1, 100.7; HRMS (ESI) m/z: $[M + Na]^+$ Calcd for $C_{15}H_9BrClNONa$, 355.9448; Found, 355.9455.



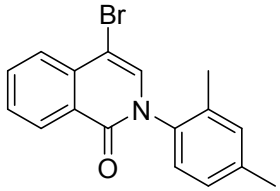
4-Bromo-2-(3-bromophenyl)isoquinolin-1(2H)-one (4k)

Follow **P3** and the title compound **4k** was obtained as a light yellow solid (m.p.: 107-112 °C), 104mg (55%). Elution: petroleum ether/ethyl acetate = 6:1 (v : v); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.44 (d, J = 8.0 Hz, 1H), 7.82 (d, J = 8.1 Hz, 1H), 7.76 (t, J = 7.6 Hz, 1H), 7.61 – 7.52 (m, 3H), 7.42 (s, 1H), 7.36 (d, J = 7.0 Hz, 2H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 160.8, 141.4, 135.4, 133.5, 131.9, 131.6, 130.6, 129.9, 128.7, 128.3, 126.5, 126.0, 125.6, 122.7, 100.7; HRMS (ESI) m/z: $[M + Na]^+$ Calcd for $C_{15}H_9Br_2NONa$, 399.8943; Found, 399.8939.



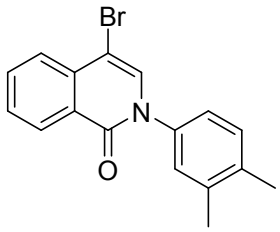
4-Bromo-2-(2-chlorophenyl)isoquinolin-1(2H)-one (4l)

Follow **P3** and the title compound **4l** was obtained as a light yellow oil, 100mg (60%). Elution: petroleum ether/ethyl acetate = 6:1 (v : v); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.49 (dd, J = 8.0, 0.7 Hz, 1H), 7.90 (d, J = 7.7 Hz, 1H), 7.85 – 7.78 (m, 1H), 7.65 – 7.55 (m, 2H), 7.47 – 7.40 (m, 3H), 7.32 (s, 1H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 160.8, 137.8, 135.7, 134.5, 133.6, 132.1, 130.6, 130.5, 129.5, 128.7, 128.2, 128.0, 126.5, 126.1, 100.3; HRMS (ESI) m/z: $[M + H]^+$ Calcd for $C_{15}H_{10}BrClNO$, 333.9629; Found, 333.9637.



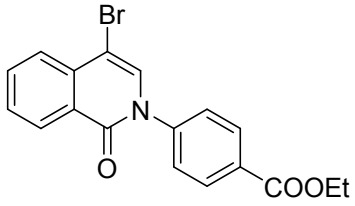
4-Bromo-2-(2,4-dimethylphenyl)isoquinolin-1(2H)-one (4m)

Follow **P3** and the title compound **4m** was obtained as a light yellow solid (m.p.: 101-103 °C), 67mg (41%). Elution: petroleum ether/ethyl acetate = 8:1 (v : v); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.46 (d, J = 8.0 Hz, 1H), 7.85 (d, J = 7.8 Hz, 1H), 7.75 (t, J = 7.6 Hz, 1H), 7.55 (t, J = 7.6 Hz, 1H), 7.31 (s, 1H), 7.11 (d, J = 18.4 Hz, 3H), 2.35 (s, 3H), 2.12 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 160.9, 139.1, 137.1, 135.7, 134.9, 133.2, 132.9, 131.8, 128.7, 128.0, 127.8, 127.1, 126.7, 125.9, 99.8, 21.1, 17.6; HRMS (ESI) m/z: $[M + Na]^+$ Calcd for $C_{17}H_{14}BrNONa$, 350.0151; Found, 350.0157.



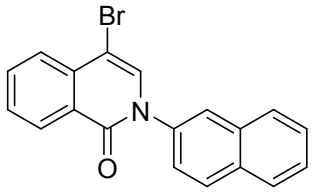
4-Bromo-2-(3,4-dimethylphenyl)isoquinolin-1(2H)-one (4n)

Follow **P3** and the title compound **4n** was obtained as a light yellow solid (m.p.: 91-97 °C), 74mg (45%). Elution: petroleum ether/ethyl acetate = 6:1 (v : v); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.50 – 8.45 (m, 1H), 7.84 (d, *J* = 8.0 Hz, 1H), 7.79 – 7.73 (m, 1H), 7.60 – 7.53 (m, 1H), 7.46 (s, 1H), 7.26 – 7.22 (m, 1H), 7.18 (d, *J* = 1.9 Hz, 1H), 7.12 (dd, *J* = 8.0, 2.2 Hz, 1H), 2.30 (s, 6H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 161.2, 138.2, 137.9, 137.2, 135.5, 133.2, 132.9, 130.5, 128.7, 128.0, 127.6, 126.7, 125.9, 123.8, 99.9, 19.9, 19.5; HRMS (ESI) m/z: $[M + Na]^+$ Calcd for $C_{17}H_{14}BrNONa$, 350.0151; Found, 350.0153.



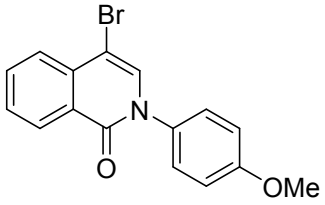
Ethyl 4-(4-bromo-1-oxoisoquinolin-2(1H)-yl)benzoate (4o)

Follow **P3** and the title compound **4o** was obtained as a light yellow solid (m.p.: 103-106 °C), 26mg (14%). Elution: petroleum ether/ethyl acetate = 8:1 (v : v); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.47 (dd, *J* = 8.0, 0.7 Hz, 1H), 8.20 – 8.15 (m, 2H), 7.89 – 7.83 (m, 1H), 7.82 – 7.76 (m, 1H), 7.62 – 7.57 (m, 1H), 7.55 – 7.50 (m, 2H), 7.47 (s, 1H), 4.40 (q, *J* = 7.1 Hz, 2H), 1.41 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 165.6, 160.9, 144.0, 135.4, 133.6, 131.7, 130.7, 130.4, 128.7, 128.4, 126.6 (two ^{13}C), 126.1, 100.9, 61.3, 14.3; HRMS (ESI) m/z: $[M + Na]^+$ Calcd for $C_{18}H_{14}BrNO_3Na$, 394.0049; Found, 394.0049.



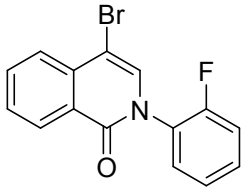
4-Bromo-2-(naphthalen-2-yl)isoquinolin-1(2H)-one (4p)

Follow **P3** and the title compound **4p** was obtained as a light yellow solid (m.p.: 194-198 °C), 61mg (35%). Elution: petroleum ether/ethyl acetate = 10:1 (v : v); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.52 (dd, *J* = 8.0, 0.7 Hz, 1H), 7.95 (d, *J* = 8.7 Hz, 1H), 7.88 (m, 4H), 7.83 – 7.76 (m, 1H), 7.62 – 7.51 (m, 5H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 161.3, 138.1, 135.5, 133.4, 133.4, 132.8, 132.7, 129.3, 128.7, 128.2, 128.1, 127.8, 126.9, 126.8, 126.7, 126.0, 125.2, 124.7, 100.4; HRMS (ESI) m/z: $[M + Na]^+$ Calcd for $C_{19}H_{12}BrNONa$, 371.9995; Found, 371.9994.



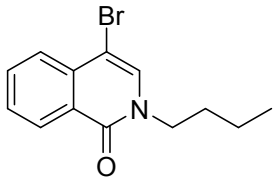
4-Bromo-2-(4-methoxyphenyl)isoquinolin-1(2H)-one (4q)

Follow **P3** and the title compound **4q** was obtained as a white solid (m.p.: 105-109 °C), 46mg (28%). Elution: petroleum ether/ethyl acetate = 6:1 (v : v); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.47 (d, J = 8.0 Hz, 1H), 7.85 (d, J = 8.1 Hz, 1H), 7.77 (t, J = 7.6 Hz, 1H), 7.57 (t, J = 7.5 Hz, 1H), 7.47 (s, 1H), 7.33 (d, J = 8.7 Hz, 2H), 7.00 (d, J = 8.8 Hz, 2H), 3.84 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 161.0, 159.0, 135.2, 133.0, 132.9, 132.6, 128.3, 127.7, 127.5, 126.3, 125.6, 114.3, 99.6, 55.2; HRMS (ESI) m/z: $[M + Na]^+$ Calcd for $C_{16}H_{12}BrNO_2Na$, 351.9949; Found, 351.9942.



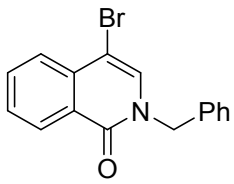
4-Bromo-2-(2-fluorophenyl)isoquinolin-1(2H)-one (4r)

Follow **P3** and the title compound **4r** was obtained as a light yellow solid (m.p.: 152-154 °C), 76mg (48%). Elution: petroleum ether/ethyl acetate = 6:1 (v : v); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.47 (d, J = 8.0 Hz, 1H), 7.87 (d, J = 8.1 Hz, 1H), 7.82 – 7.75 (m, 1H), 7.59 (t, J = 7.6 Hz, 1H), 7.47 – 7.37 (m, 3H), 7.30 – 7.23 (m, 2H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 160.7, 157.4 (C-F, $^{1}J_{CF}$ = 252.6 Hz), 135.6, 133.5, 132.3, 130.7 (C-F, $^{3}J_{CF}$ = 7.9 Hz), 129.0, 128.7, 128.3, 127.9 (C-F, $^{2}J_{CF}$ = 13.0 Hz), 126.4, 126.1, 124.9 (C-F, $^{4}J_{CF}$ = 3.9 Hz), 116.9 (C-F, $^{2}J_{CF}$ = 19.6 Hz), 100.5; HRMS (ESI) m/z: $[M + Na]^+$ Calcd for $C_{15}H_9BrFNONa$, 339.9744; Found, 339.9744.



4-Bromo-2-butylisoquinolin-1(2H)-one (4s)

Follow **P3** and the title compound **4s** was obtained as colorless oil, 31mg (22%). Elution: petroleum ether/ethyl acetate = 6:1 (v : v); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.45 – 8.38 (m, 1H), 7.79 (d, J = 8.1 Hz, 1H), 7.76 – 7.67 (m, 1H), 7.57 – 7.49 (m, 1H), 7.33 (s, 1H), 4.06 – 3.90 (m, 2H), 1.89 – 1.66 (m, 2H), 1.51 – 1.28 (m, 2H), 0.95 (t, J = 7.4 Hz, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 161.2, 135.4, 132.8, 132.2, 128.2, 127.7, 125.7, 110.0, 99.6, 49.2, 31.4, 19.9, 13.7; HRMS (ESI) m/z: $[M + Na]^+$ Calcd for $C_{13}H_{14}BrFNONa$, 302.0151; Found, 302.0145.



2-Benzyl-4-bromoisoquinolin-1(2H)-one (4t)

Follow **P3** and the title compound **4t** was obtained as yellow oil, 50mg (32%). Elution: petroleum ether/ethyl acetate = 6:1 (v : v); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.48 (d, *J* = 8.0 Hz, 1H), 7.81 (d, *J* = 7.7 Hz, 1H), 7.79 – 7.70 (m, 1H), 7.62 – 7.53 (m, 1H), 7.42 – 7.27 (m, 6H), 5.20 (s, 2H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 161.4, 136.2, 135.4, 133.0, 131.8, 128.9, 128.5, 128.1, 128.1, 127.9, 126.5, 125.9, 100.2, 51.7; HRMS (ESI) m/z: $[M + Na]^+$ Calcd for $C_{16}H_{12}BrNONa$, 335.9995; Found, 335.9987.

References

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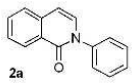
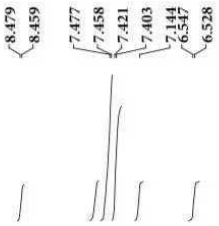
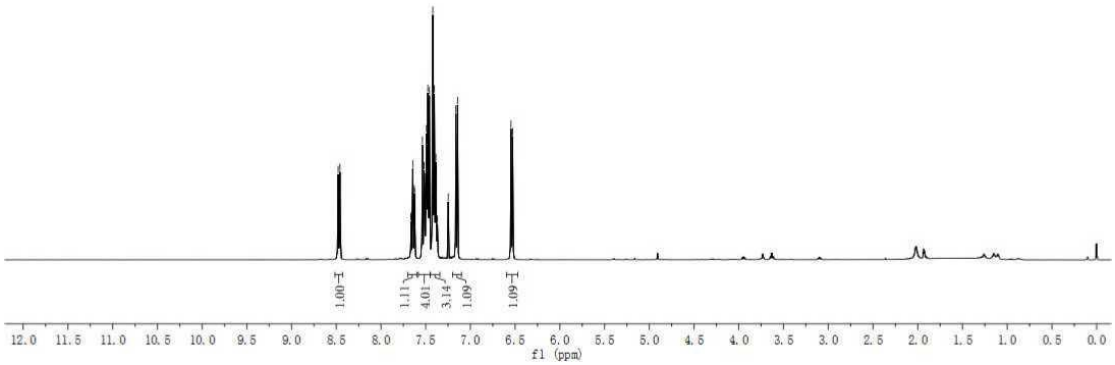
^{1}H and ^{13}C spectra

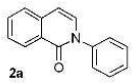


2a

400 MHz, $CDCl_3$







2a

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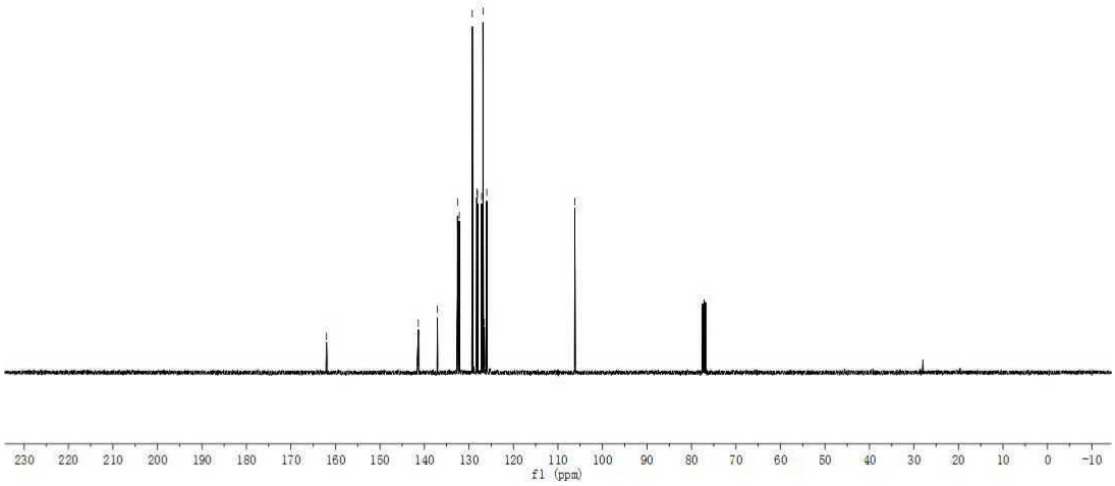

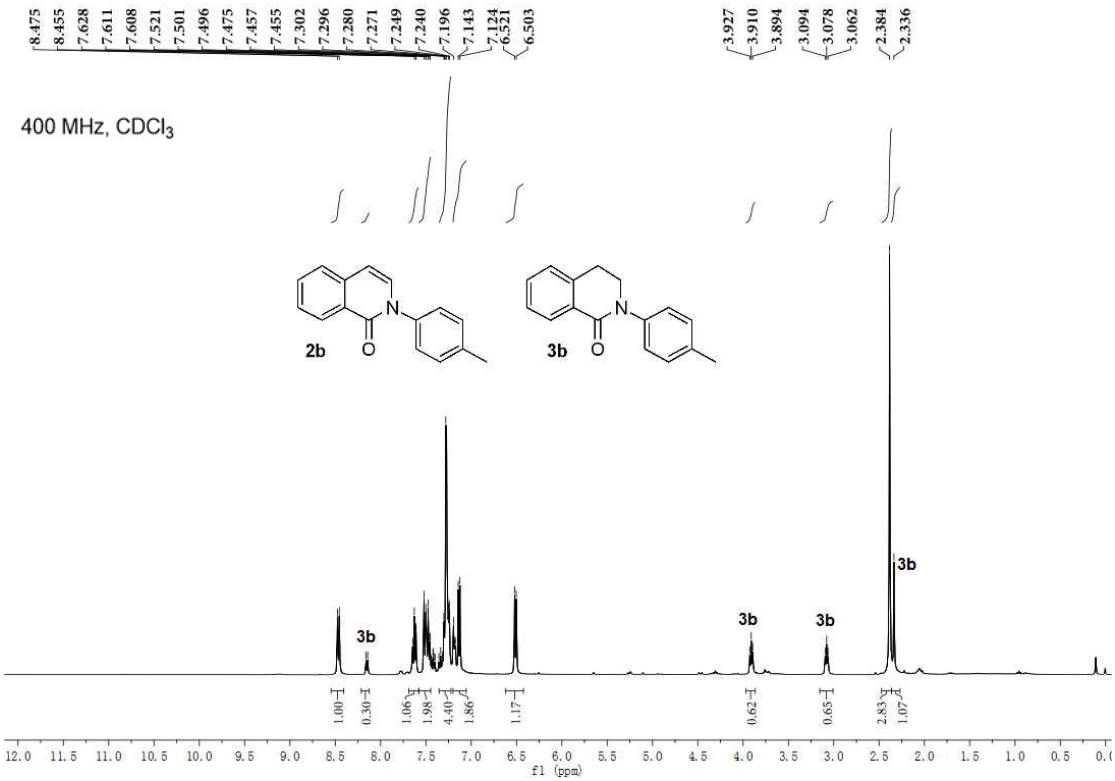
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7.296
7.280
7.271
7.249
7.240
7.196
7.143
7.124
6.521
6.503
3.927
3.910
3.894
3.094
3.078
3.062
2.384
2.336
400 MHz, CDCl3
2b
3b
3b
3b
3b
3b
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1.86
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0.65
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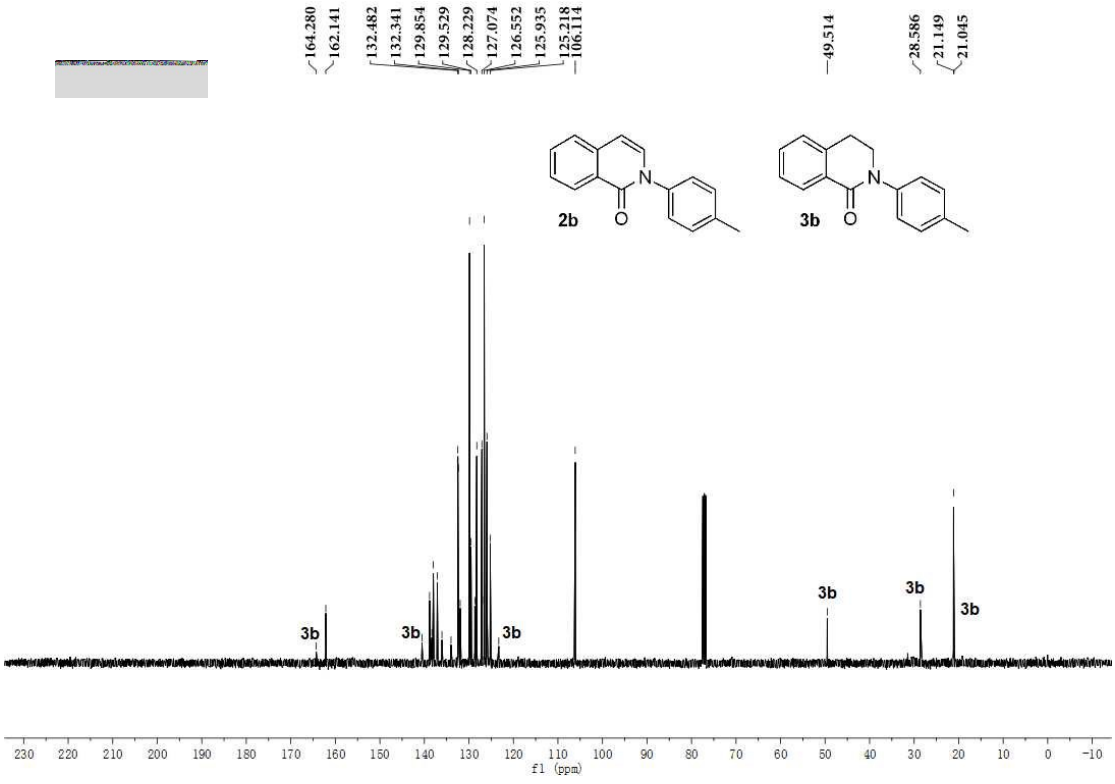
f1 (ppm)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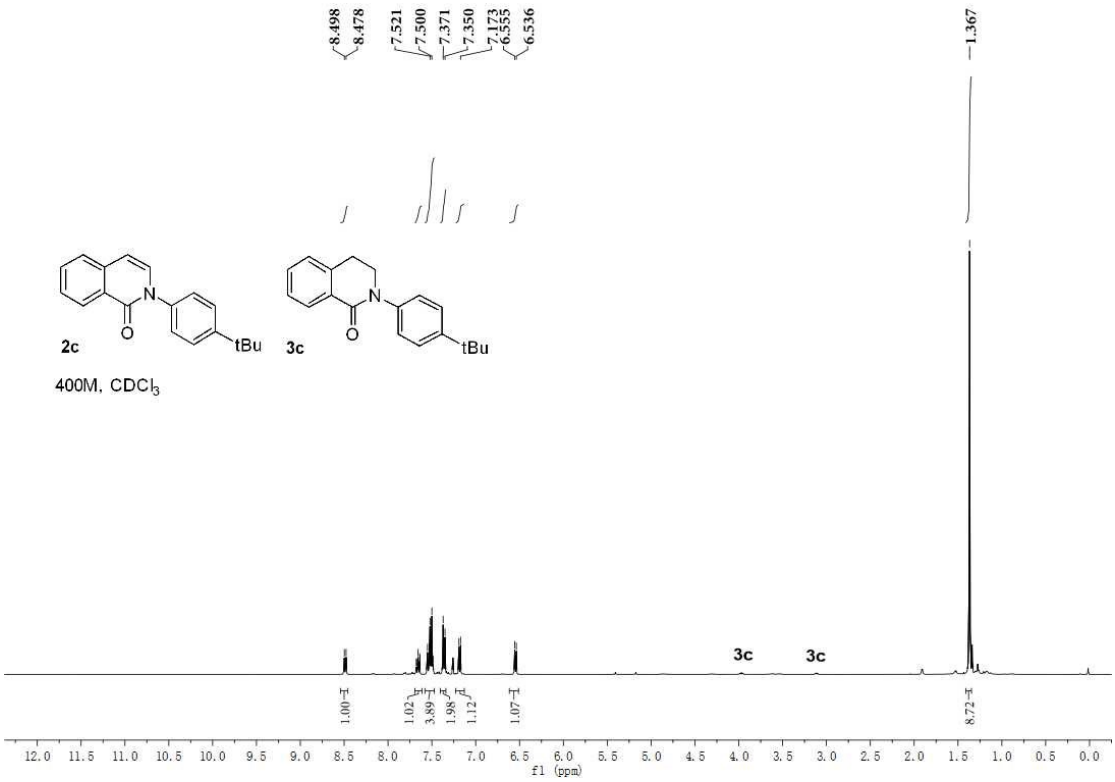
21.045
2b
3b
3b
3b
3b
3b
3b
f1 (ppm)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3c
tBu
400M, CDCl3
3c
3c
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1.12
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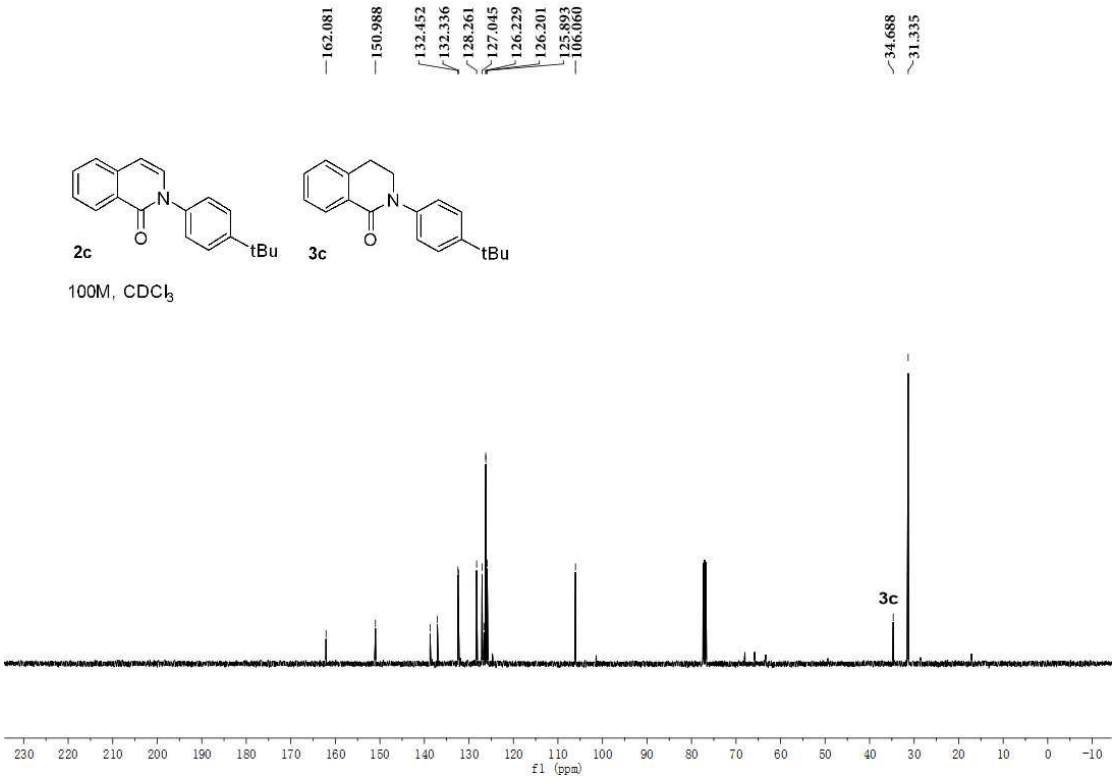
8.72
f1 (ppm)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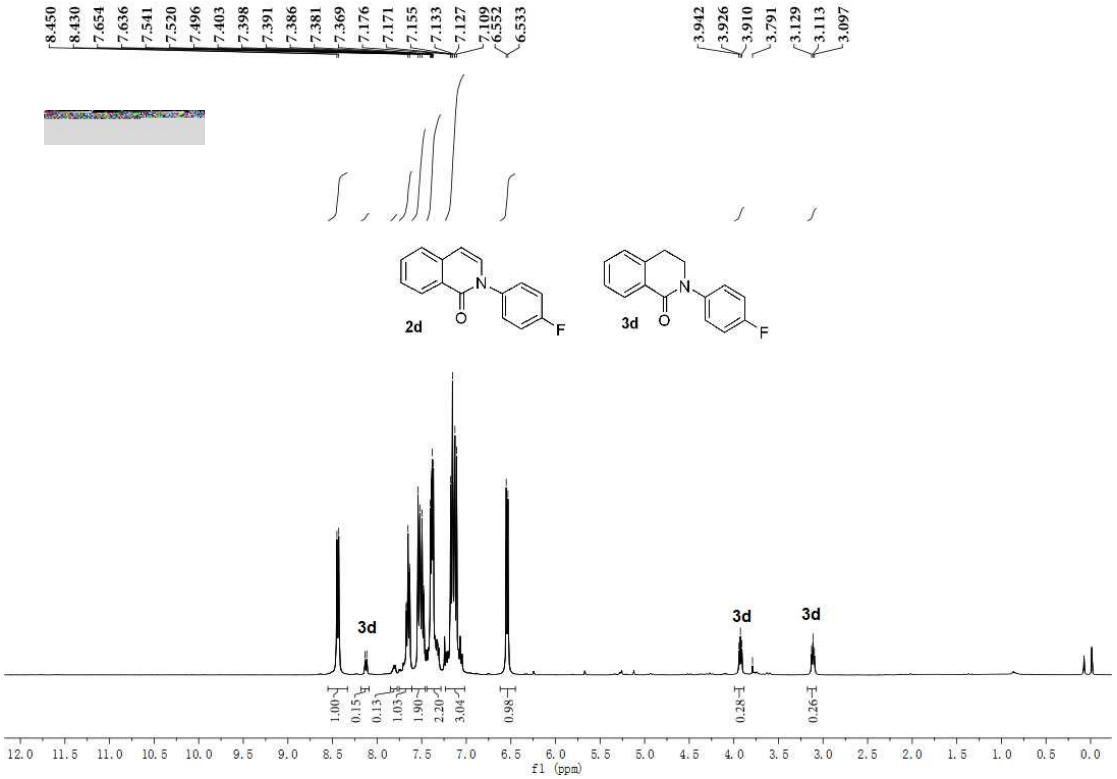
3c
tBu
100M, CDCl3
3c
f1 (ppm)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7.176
7.171
7.155
7.133
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6.552
6.533
3.942
3.926
3.910
3.791
3.129
3.113
3.097
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3d
3d
3d
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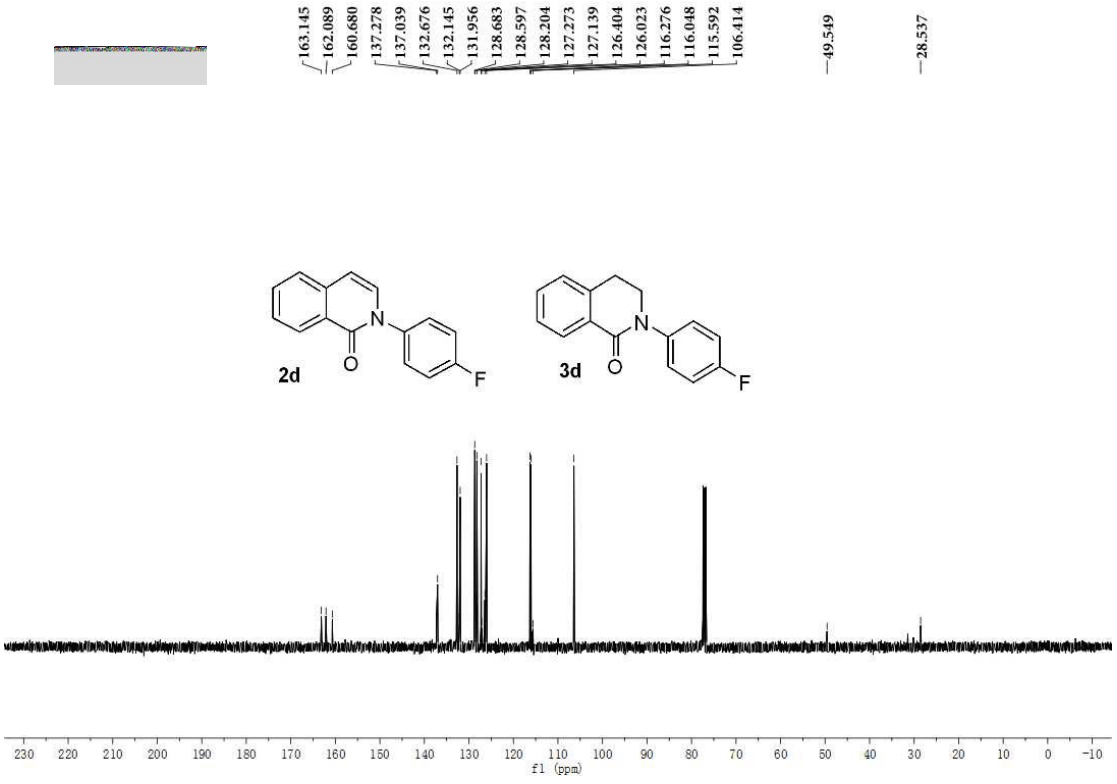
0.26
f1 (ppm)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49.549
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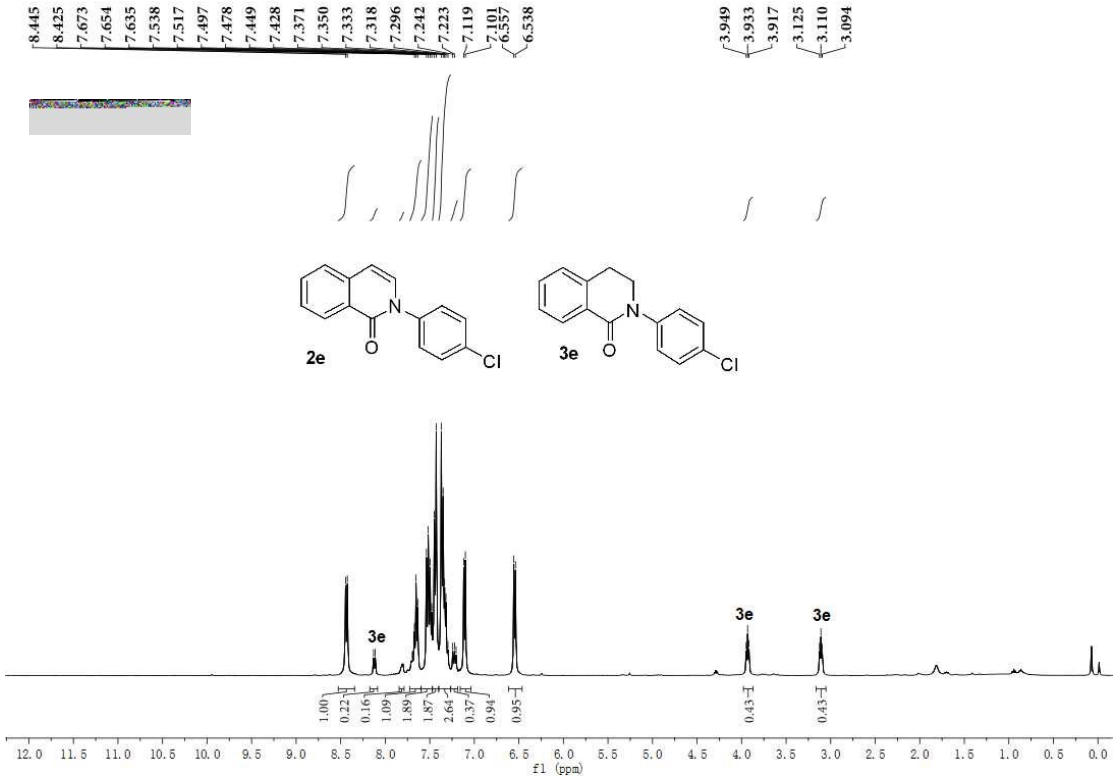
2d
3d
f1 (ppm)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7.296
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3.125
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2e
3e
Cl
3e
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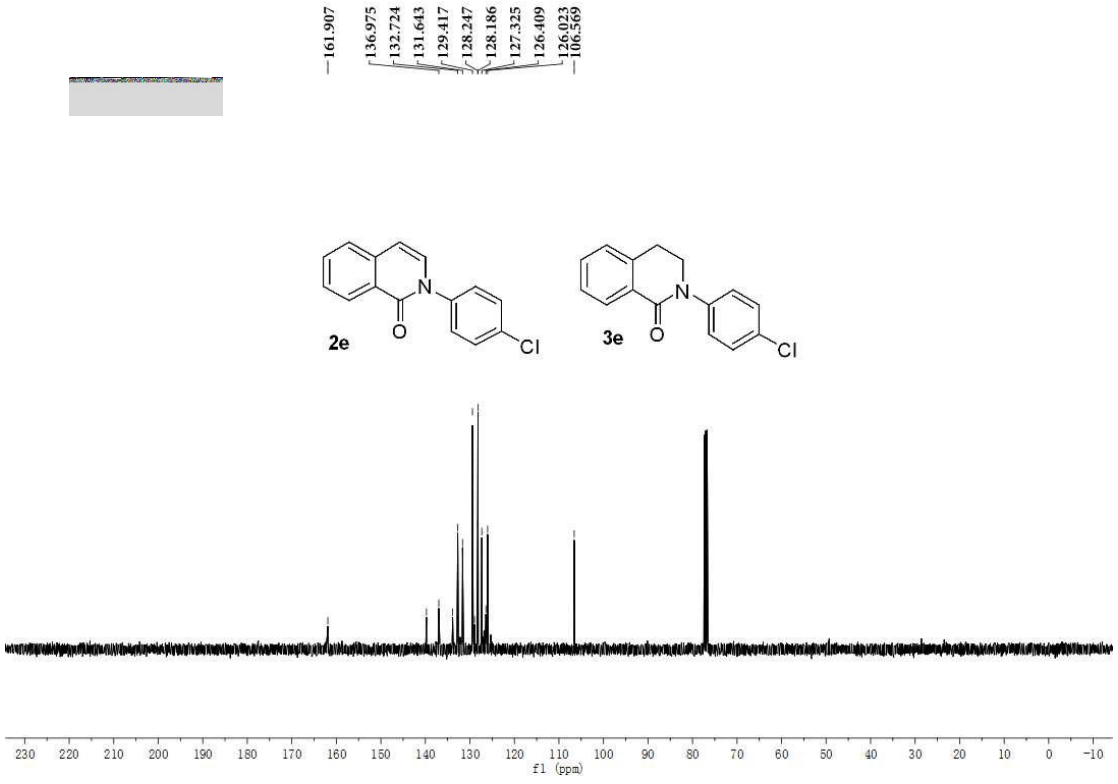
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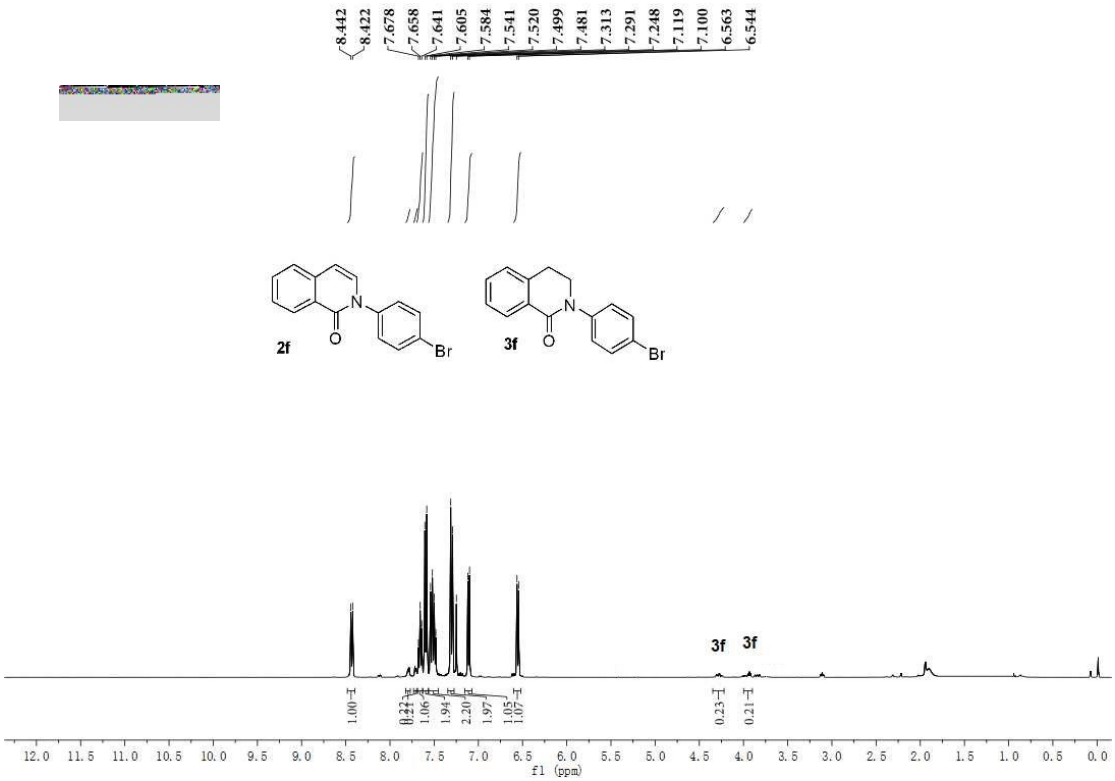
3e
Cl
f1 (ppm)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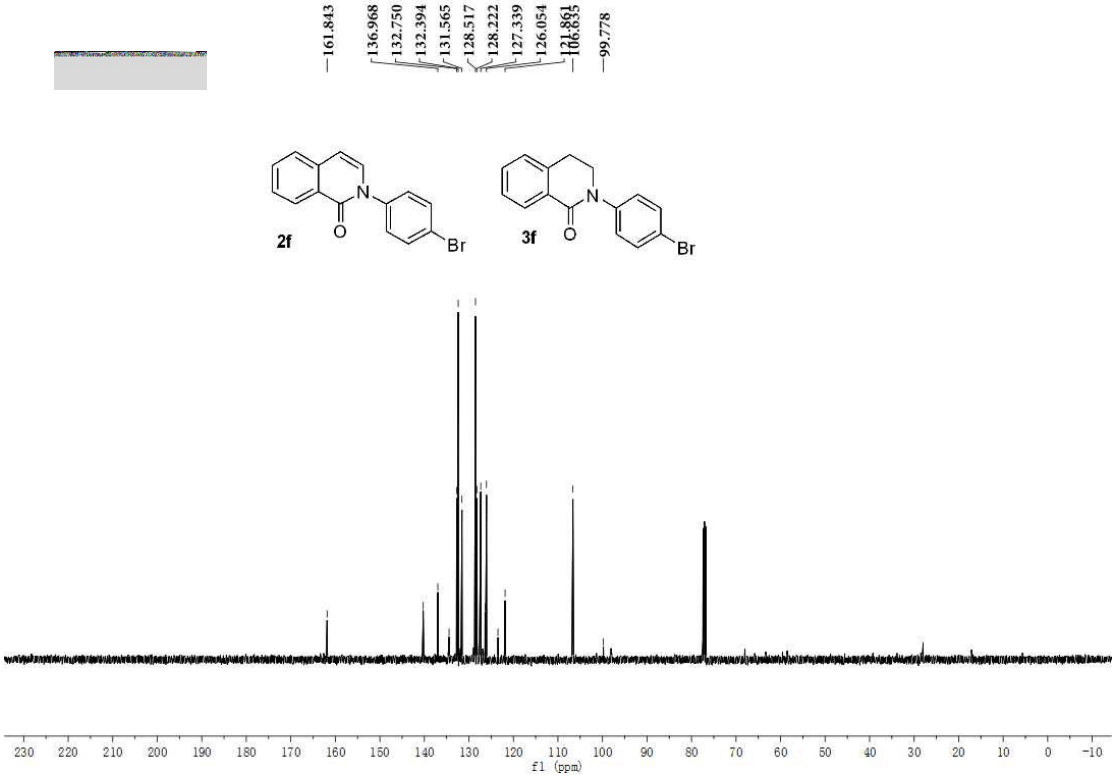
f1 (ppm)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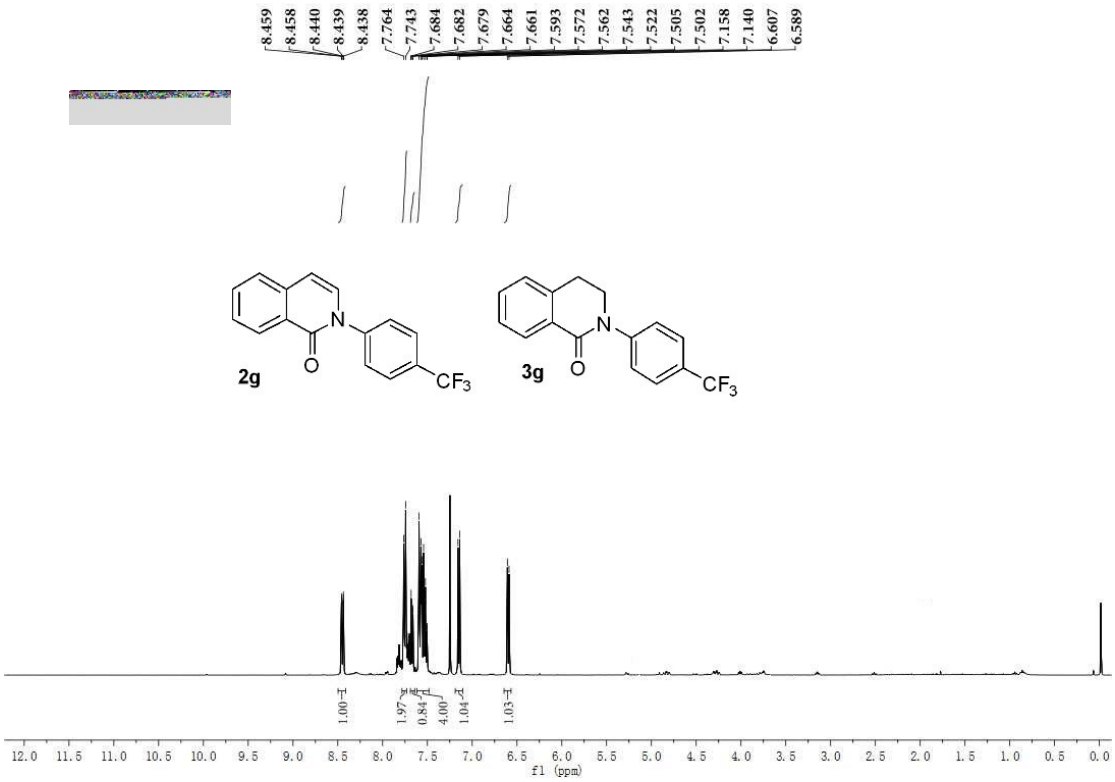
3f
Br
f1 (ppm)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3g
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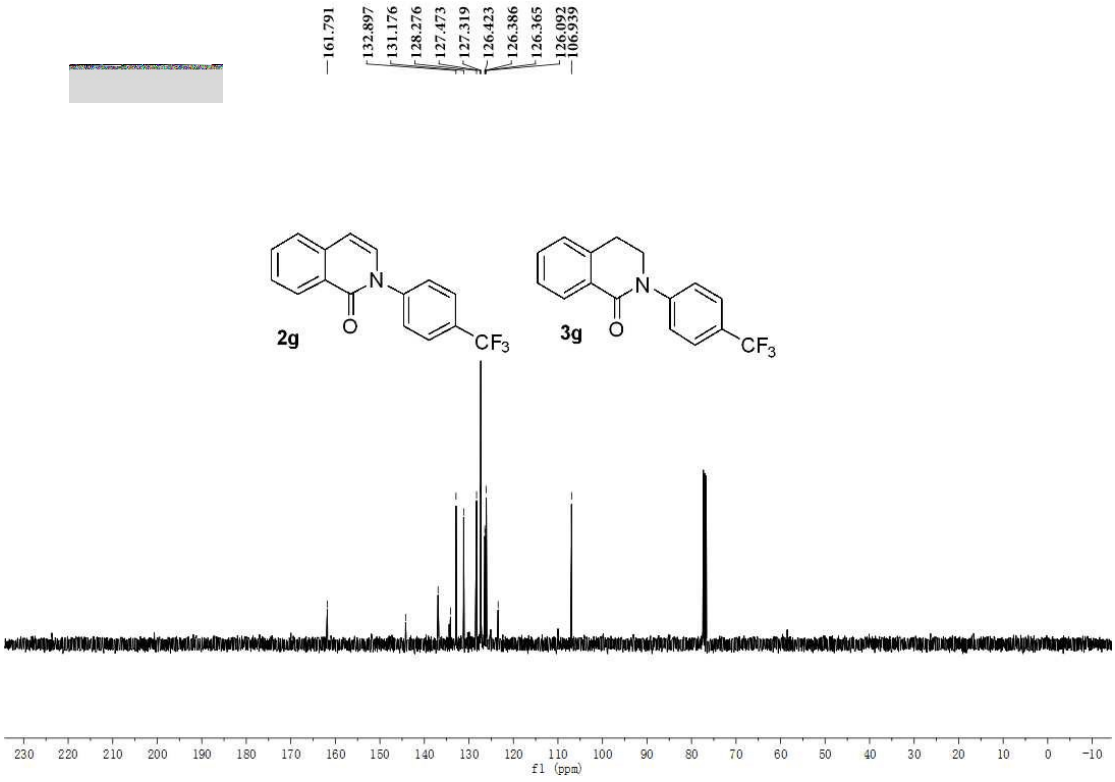
1.03
f1 (ppm)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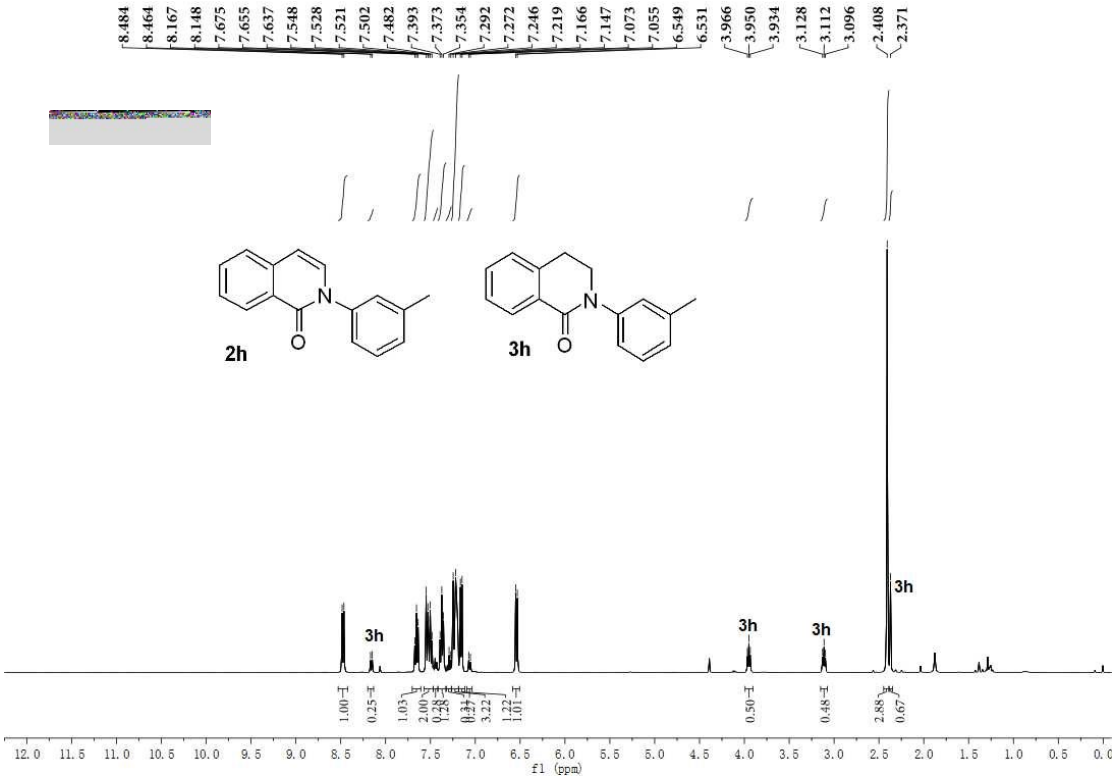
2g
3g
CF3
f1 (ppm)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7.292
7.272
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7.147
7.073
7.055
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6.531
3.966
3.950
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2h
3h
3h
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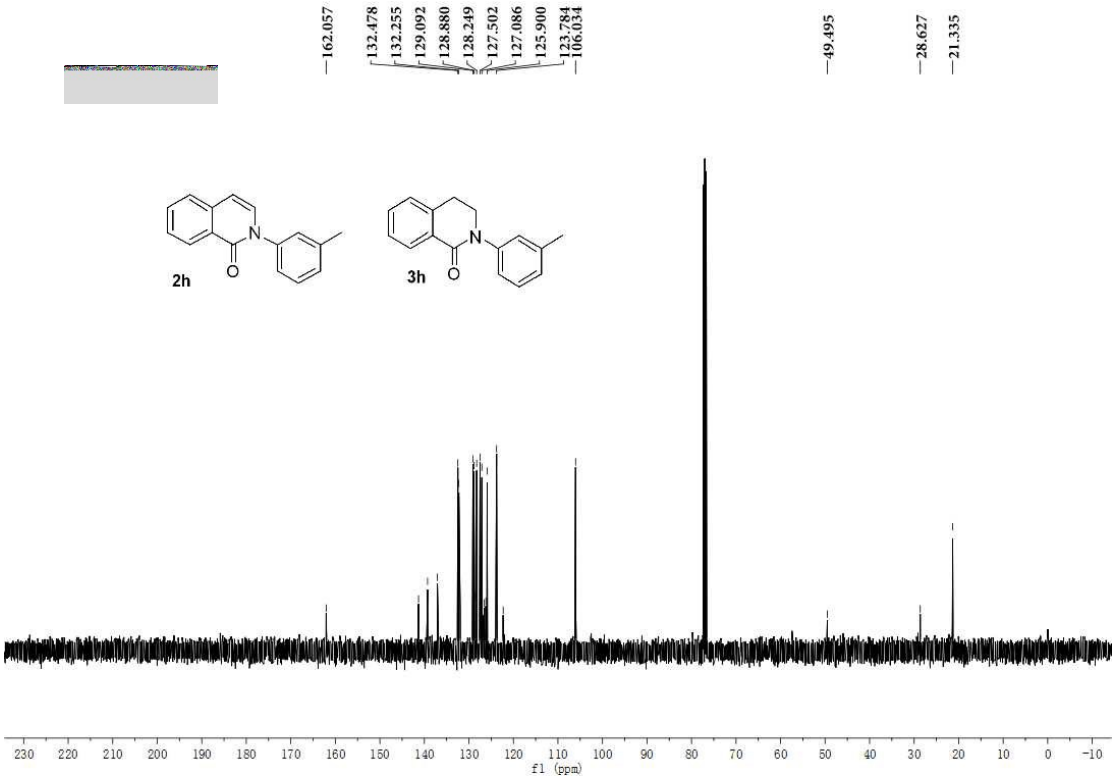
3h
3h
f1 (ppm)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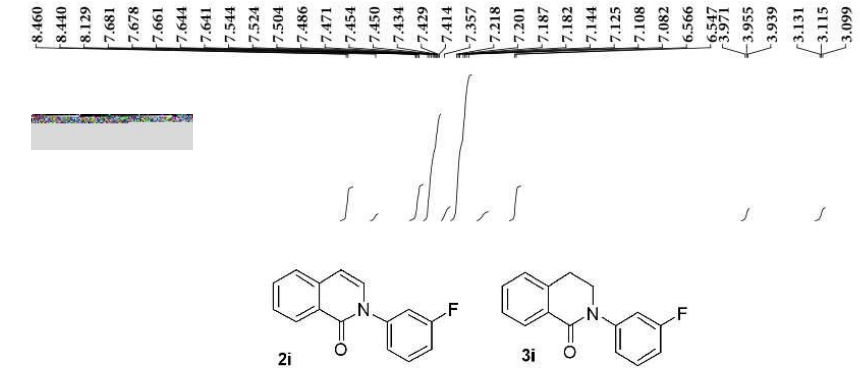
3h
f1 (ppm)

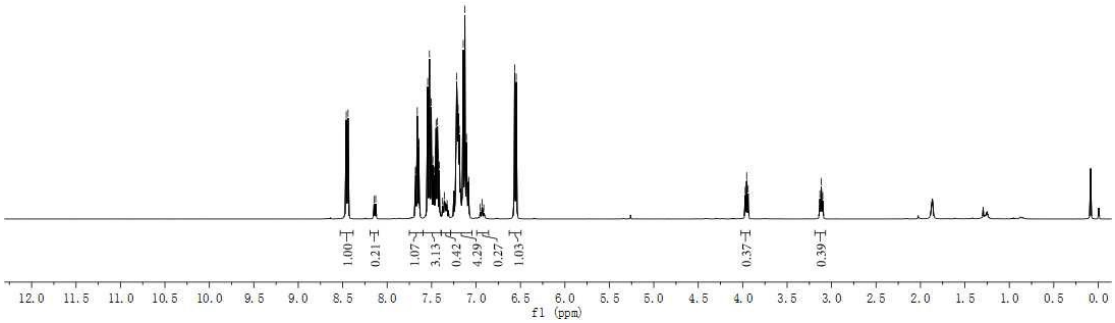

8.460
8.440
8.129
7.681
7.678
7.661
7.644
7.641
7.544
7.524
7.504
7.486
7.471
7.454
7.450
7.434
7.429
7.414
7.357
7.218
7.201
7.187
7.182
7.144
7.125
7.108
7.082
6.566
6.547
3.971
3.955
3.939
3.131
3.115
3.099

N
F
O

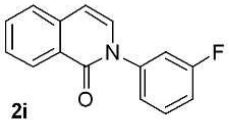
2i

N
F
O

3i


1.00
0.21
1.07
3.13
0.42
4.29
0.27
1.03
0.37
0.39
12.0 11.5 11.0 10.5 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
f1 (ppm)

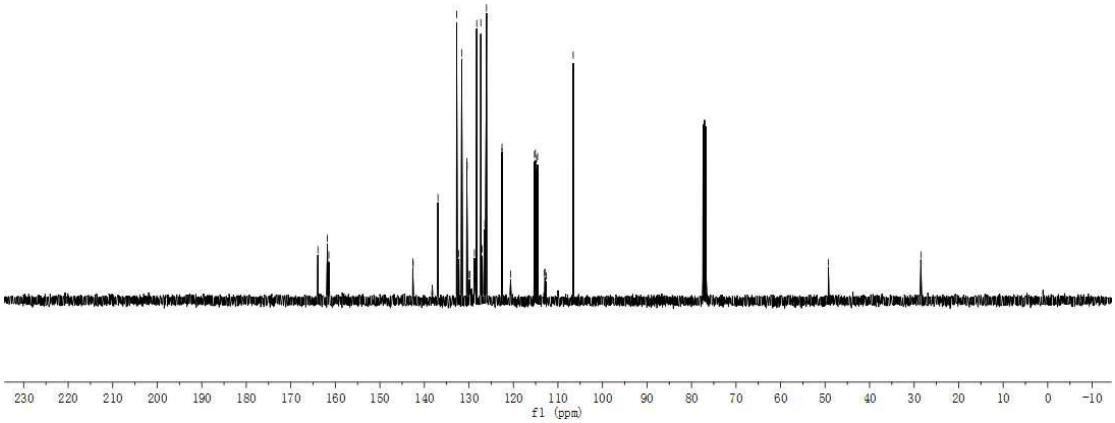

163.914
161.783
161.448
136.945
132.754
131.612
130.471
130.381
128.759
128.243
127.323
127.007
126.425
126.045
122.590
122.557
115.274
115.065
114.806
114.570
106.575
49.255
28.487

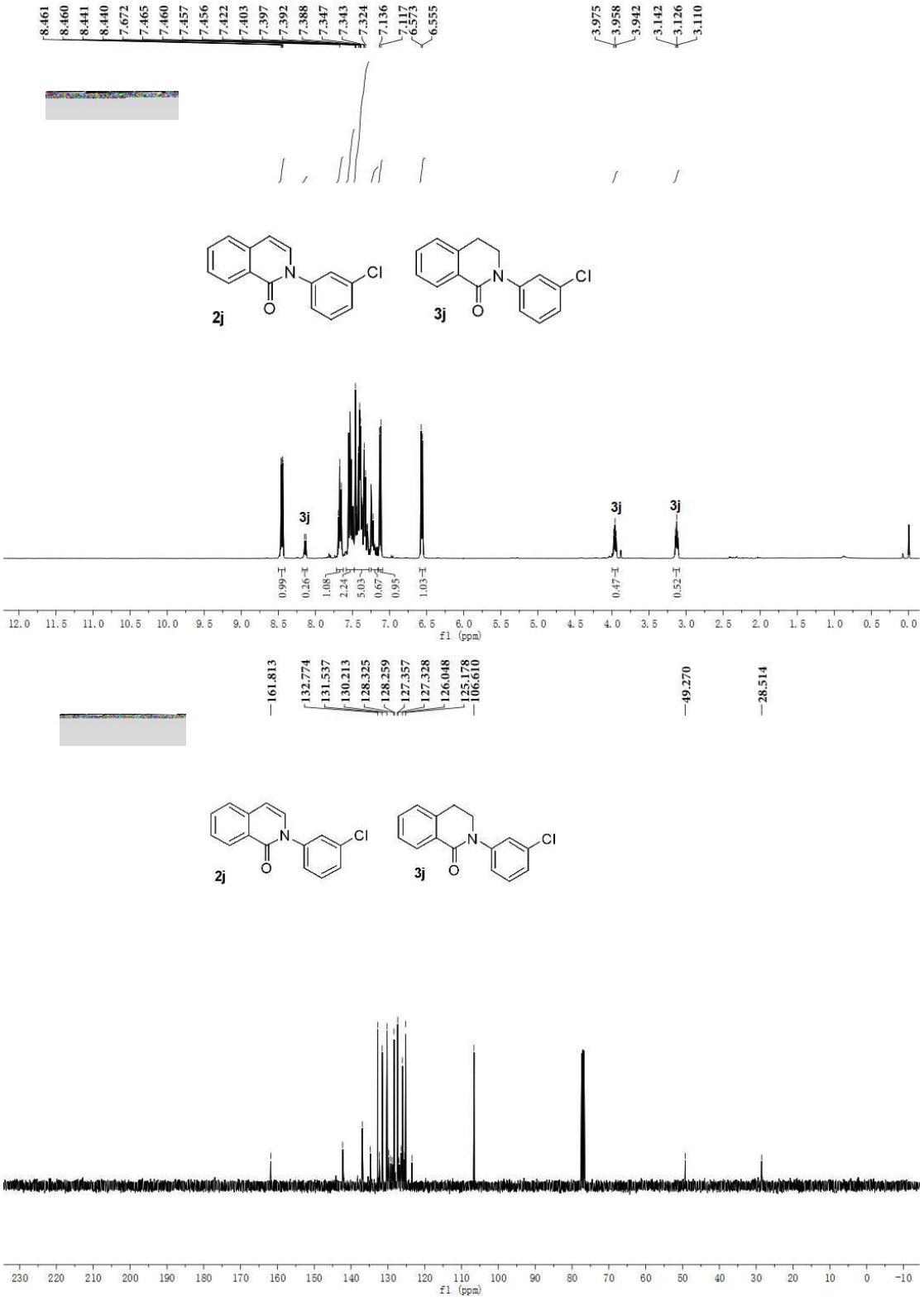

N
F
O

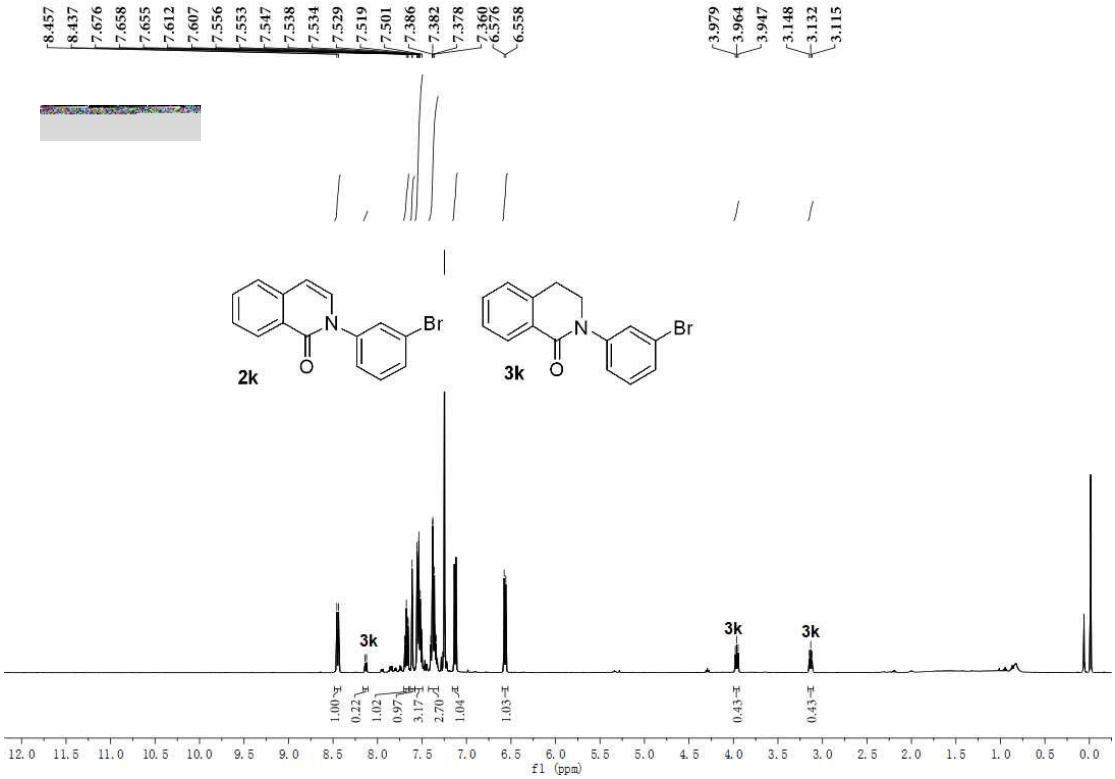
2i

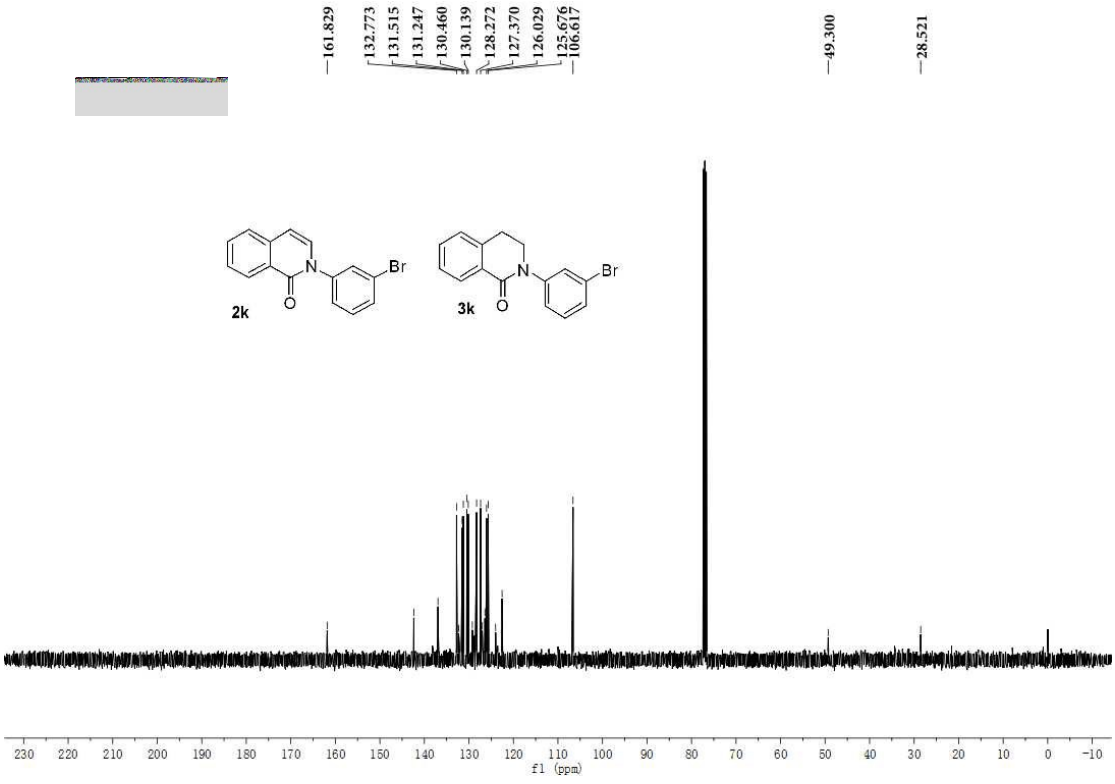

N
F
O

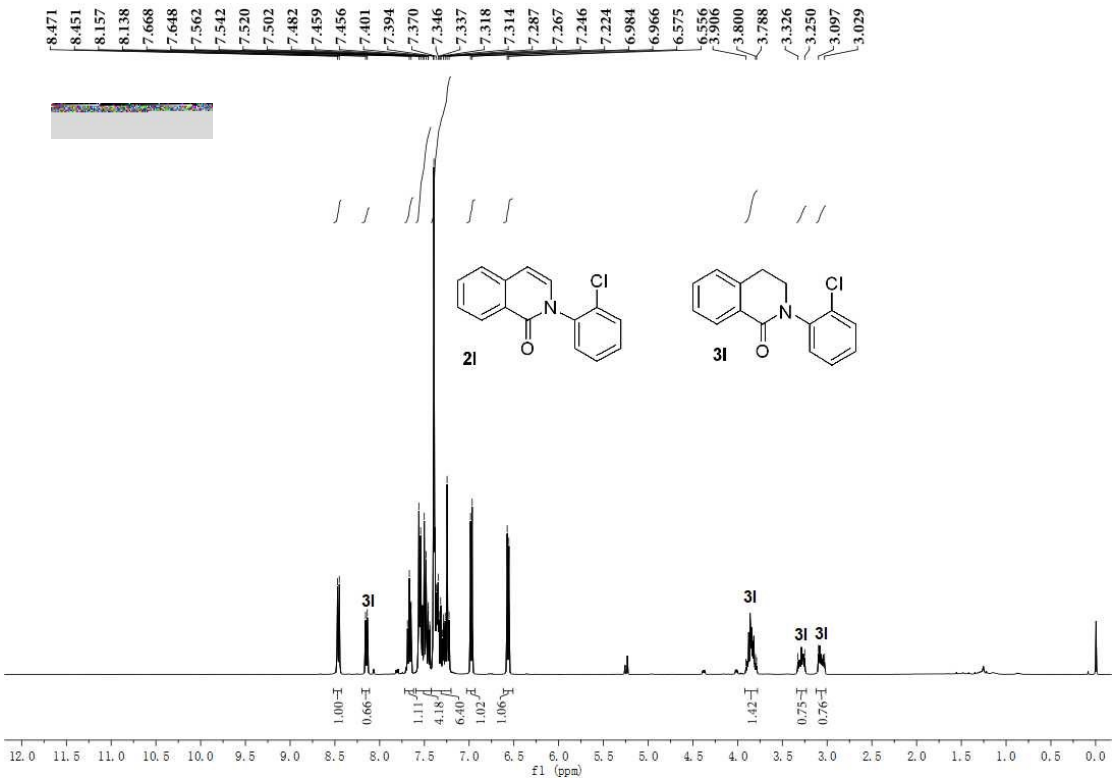
3i

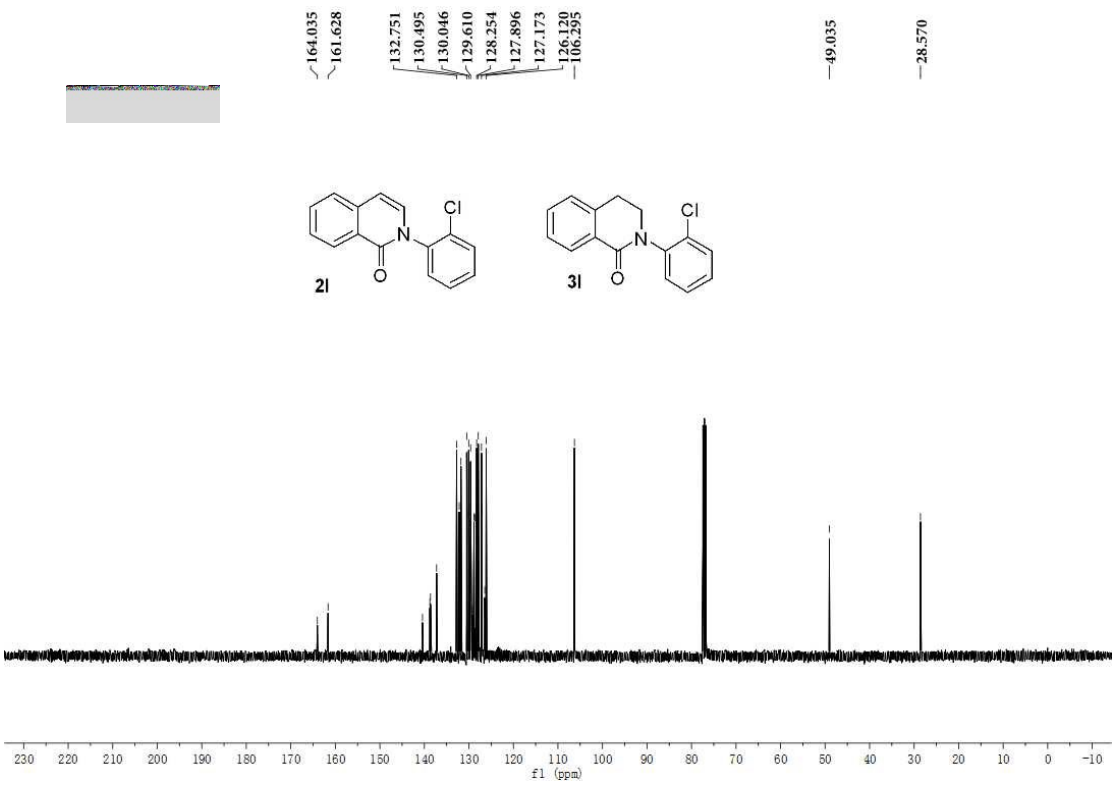

230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

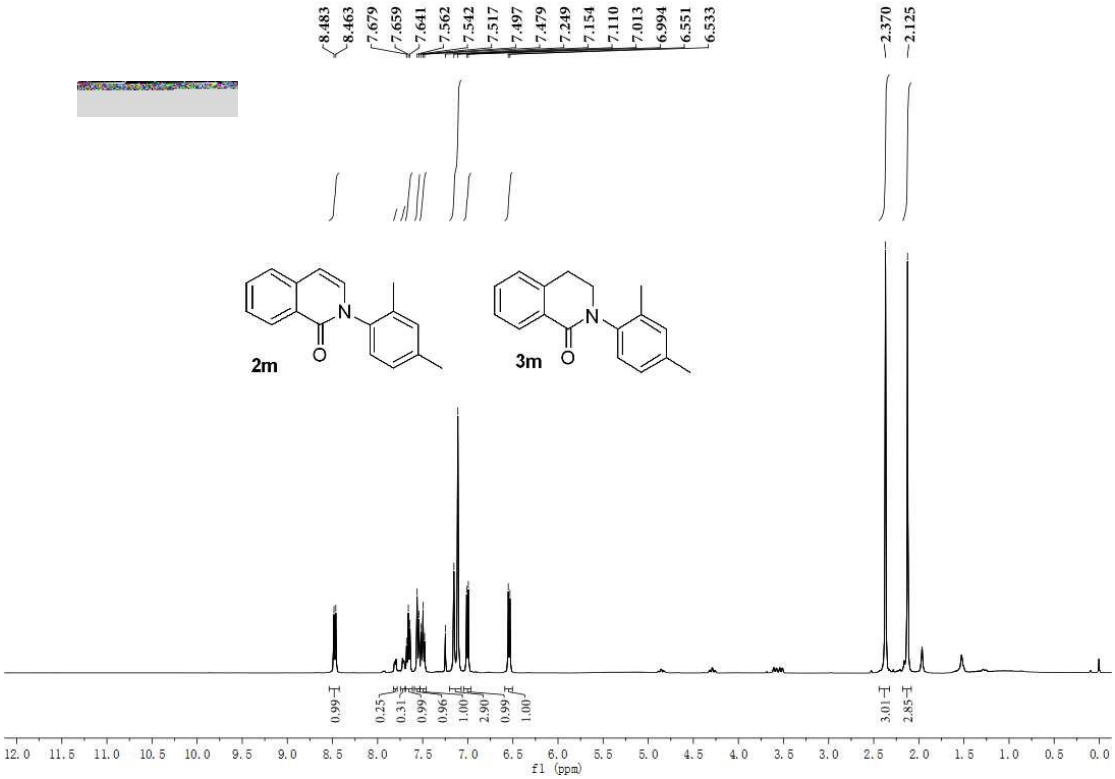

8.461
8.460
8.441
8.440
7.672
7.465
7.460
7.457
7.456
7.422
7.403
7.397
7.392
7.388
7.347
7.343
7.324
7.136
7.117
6.573
6.555
3.975
3.958
3.942
3.142
3.126
3.110
Cl
O
N
2j
3j
3j
3j
0.99
0.26
1.08
2.24
5.03
0.67
0.95
1.03
0.47
0.52
f1 (ppm)
161.813
132.774
131.537
130.213
128.325
128.259
127.357
127.328
126.048
125.178
106.610
49.270
28.514

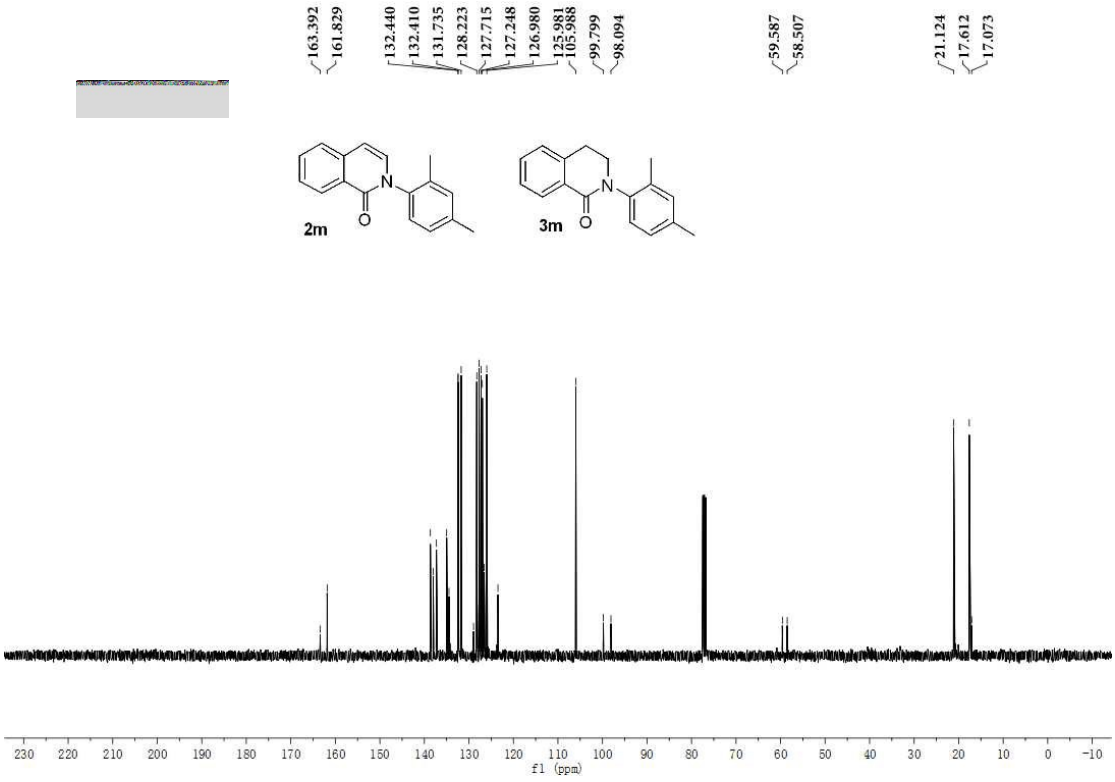

8.457
8.437
7.676
7.658
7.655
7.612
7.607
7.556
7.553
7.547
7.538
7.534
7.529
7.519
7.501
7.386
7.382
7.378
7.360
6.576
6.558
3.979
3.964
3.947
3.148
3.132
3.115
2k
3k
Br
N
O
3k
3k
3k
1.00
0.22
1.02
0.97
3.17
2.70
1.04
1.03
0.43
0.43
f1 (ppm)

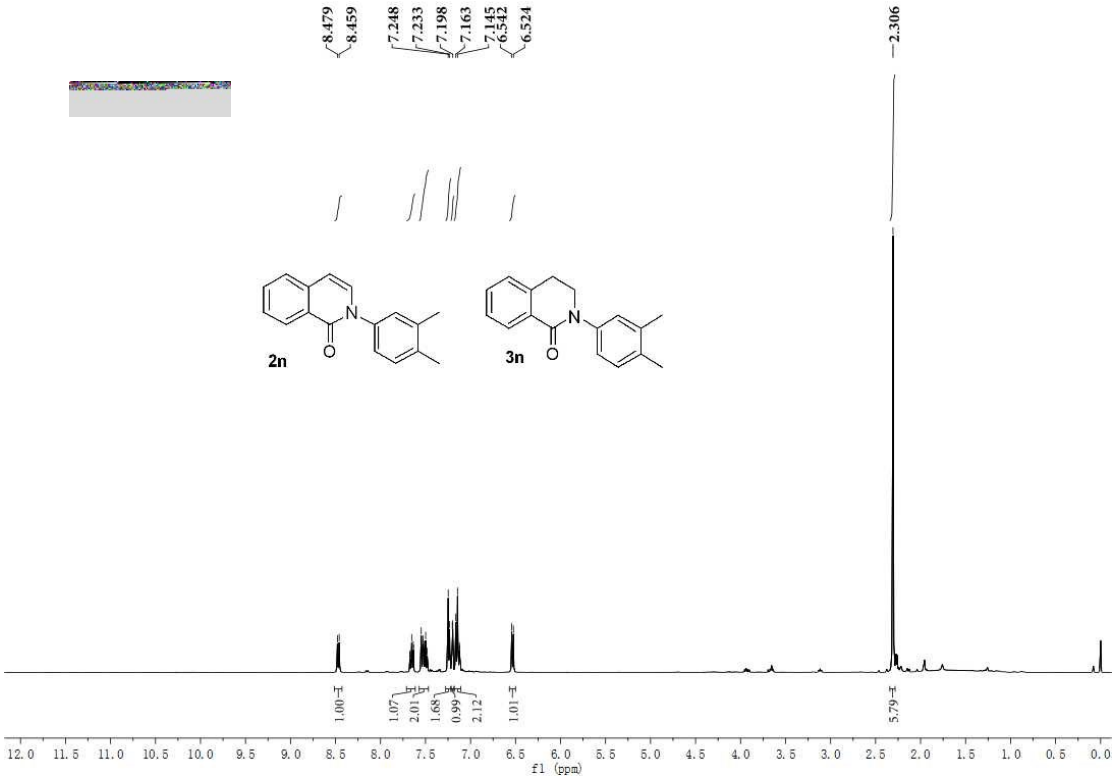

161.839
132.773
131.515
131.247
130.460
130.139
128.272
127.370
126.029
125.676
106.617
49.300
28.521
2k
3k
Br
N
O
f1 (ppm)

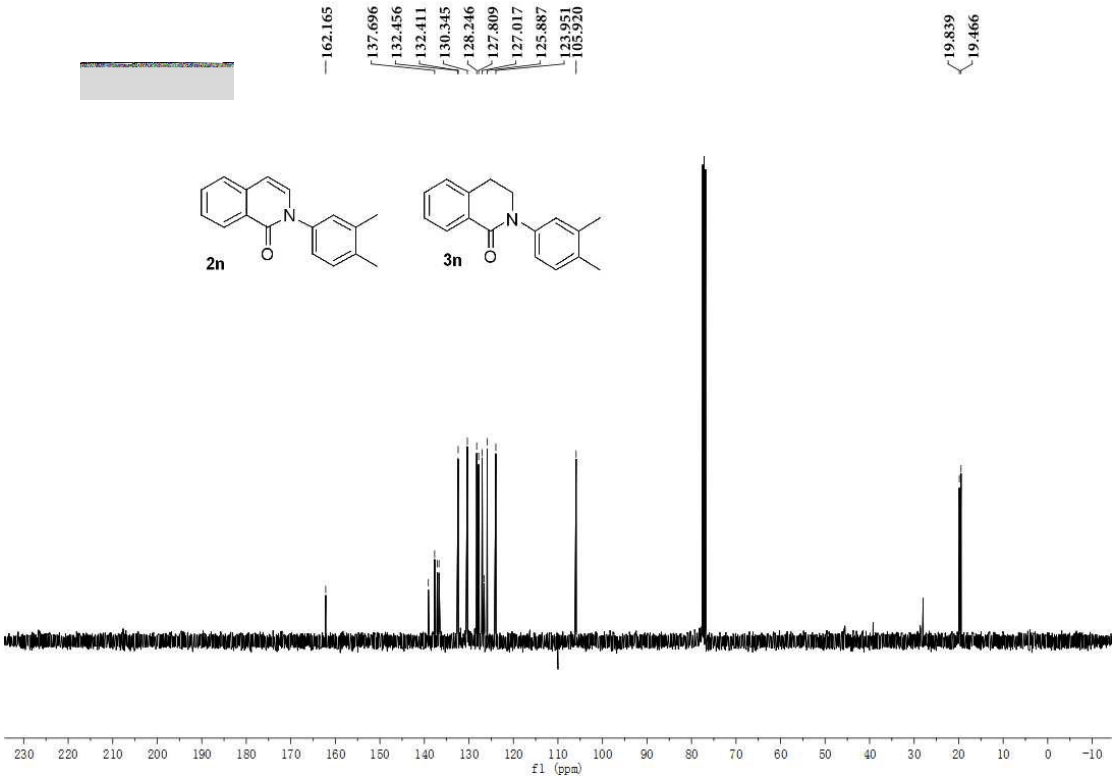

8.471
8.451
8.157
8.138
7.668
7.648
7.562
7.542
7.520
7.502
7.482
7.459
7.456
7.401
7.394
7.370
7.346
7.337
7.318
7.314
7.287
7.267
7.246
7.224
6.984
6.966
6.575
6.556
3.906
3.800
3.788
3.326
3.250
3.097
3.029
2l
3l
3l
3l
3l
3l
1.00
0.66
1.11
4.18
6.40
1.02
1.06
1.42
0.75
0.76
f1 (ppm)

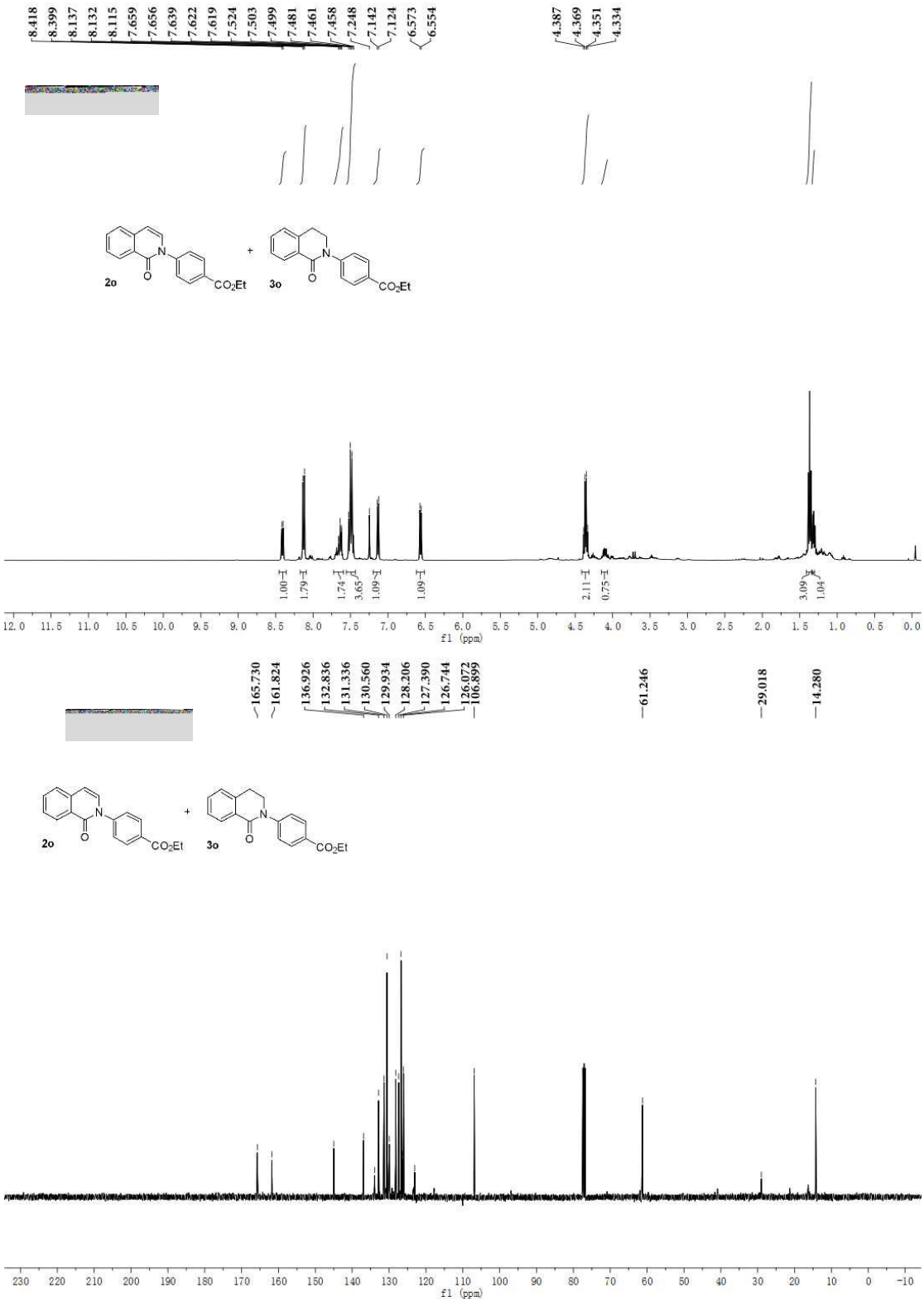

164.035
161.628
132.751
130.495
130.046
129.610
128.254
127.896
127.173
126.120
106.295
49.035
28.570
2l
3l
f1 (ppm)

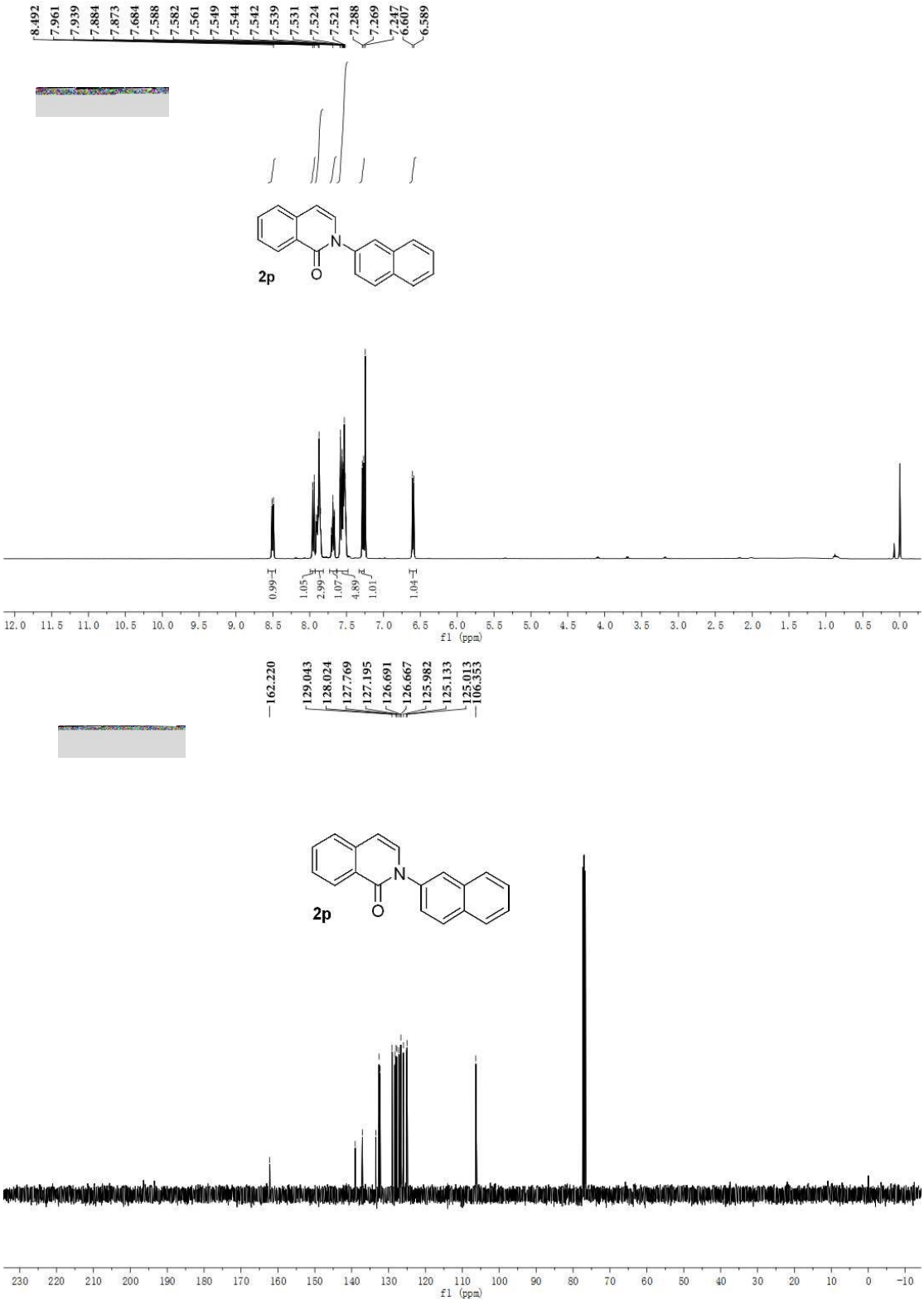

8.483
8.463
7.679
7.659
7.641
7.562
7.542
7.517
7.497
7.479
7.249
7.154
7.110
7.013
6.994
6.551
6.533
2.370
2.125
2m
3m
0.99
0.25
0.31
0.99
0.96
1.00
2.90
0.99
1.00
3.01
2.85
f1 (ppm)

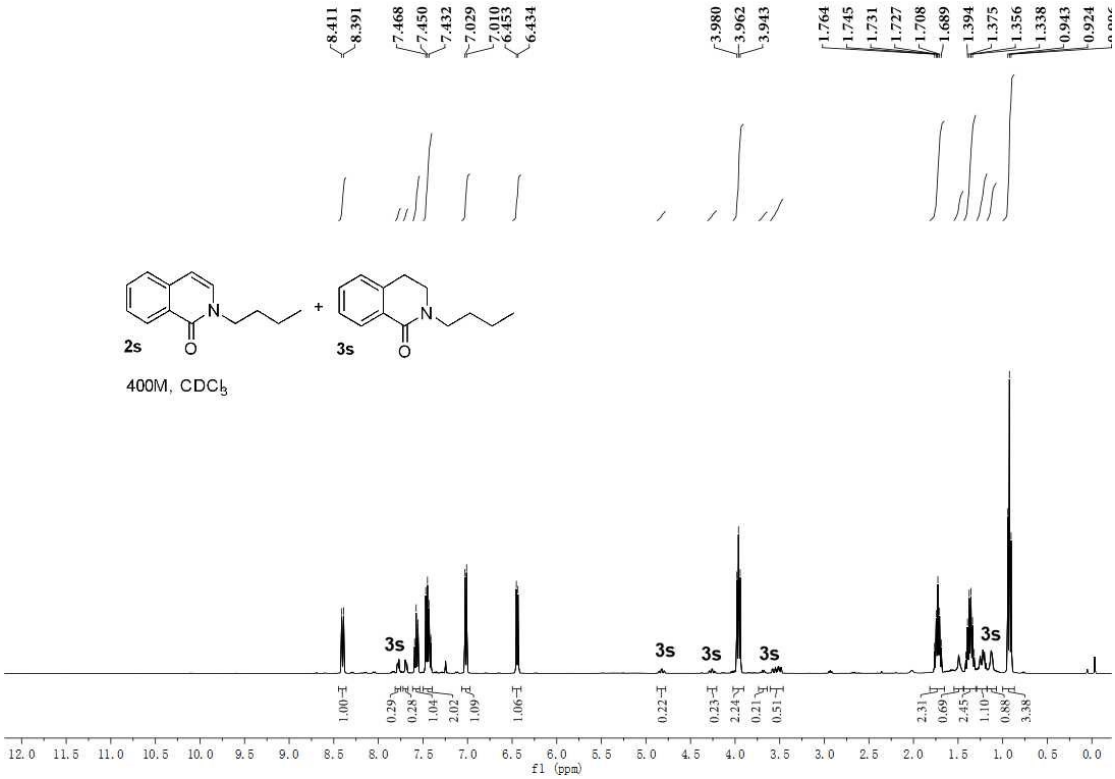

163.392
161.829
132.440
132.410
131.735
128.223
127.715
127.248
126.980
125.981
105.988
99.799
98.094
59.587
58.507
21.124
17.612
17.073
2m
3m
f1 (ppm)

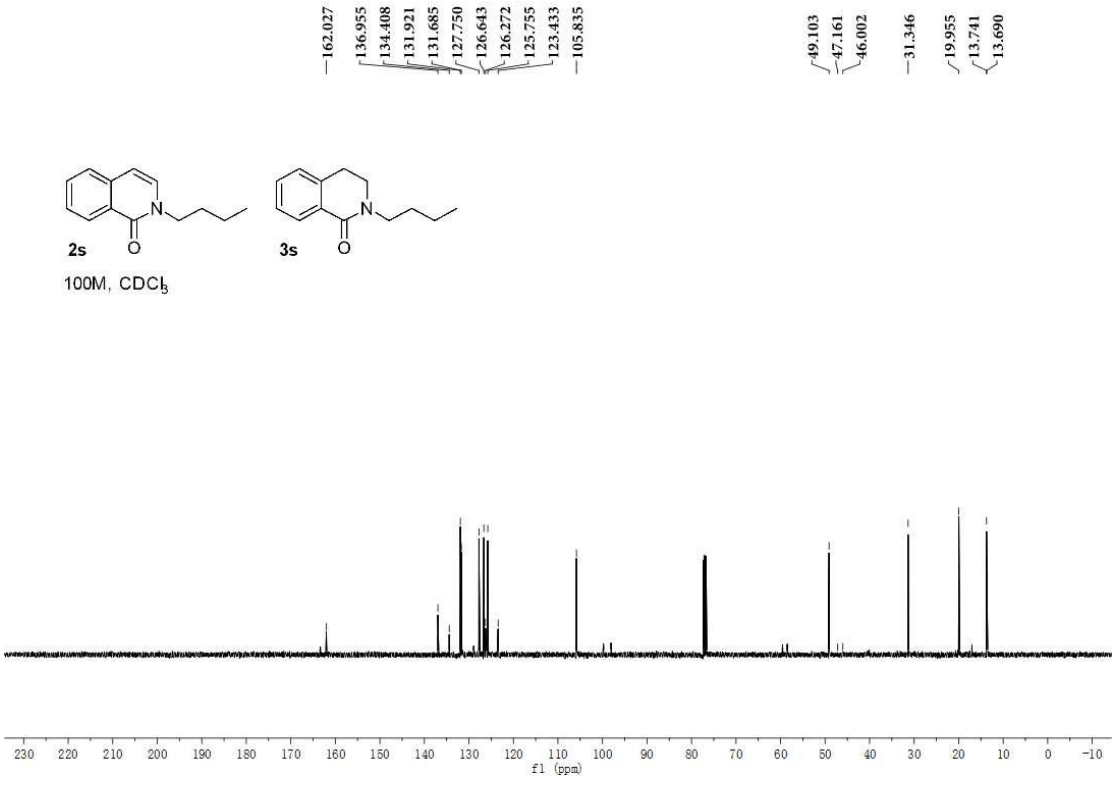

8.479
8.459
7.248
7.233
7.198
7.163
7.145
6.542
6.524
2.306
2n
3n
1.00
1.07
2.01
1.68
0.99
2.12
1.01
5.79
f1 (ppm)

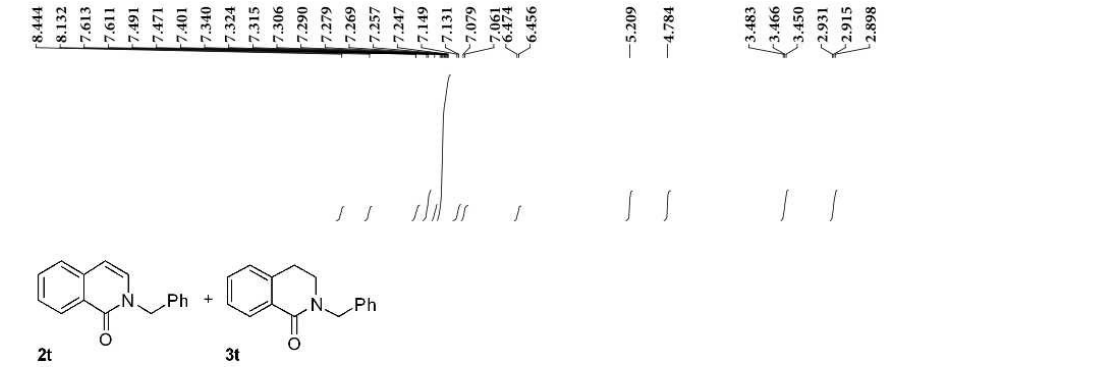

162.165
137.696
132.456
132.411
130.345
128.246
127.809
127.017
125.887
123.951
105.920
19.839
19.466
2n
3n
f1 (ppm)


8.418
8.399
8.137
8.132
8.115
7.659
7.656
7.639
7.622
7.619
7.524
7.503
7.499
7.481
7.461
7.458
7.248
7.142
7.124
6.573
6.554
4.387
4.369
4.351
4.334
2o
3o
CO2Et
1.00
1.79
1.74
3.65
1.09
1.09
2.11
0.75
3.09
1.04
f1 (ppm)
165.730
161.824
136.926
132.836
131.336
130.560
129.934
128.206
127.390
126.744
126.072
106.899
61.246
29.018
14.280


8.492
7.961
7.939
7.884
7.873
7.684
7.588
7.582
7.561
7.549
7.544
7.542
7.539
7.531
7.524
7.521
7.288
7.269
7.247
6.607
6.589
2p
0.99
1.05
2.99
1.07
4.89
1.01
1.04
f1 (ppm)
162.220
129.043
128.024
127.769
127.195
126.691
126.667
125.982
125.133
125.013
106.353
2p
f1 (ppm)

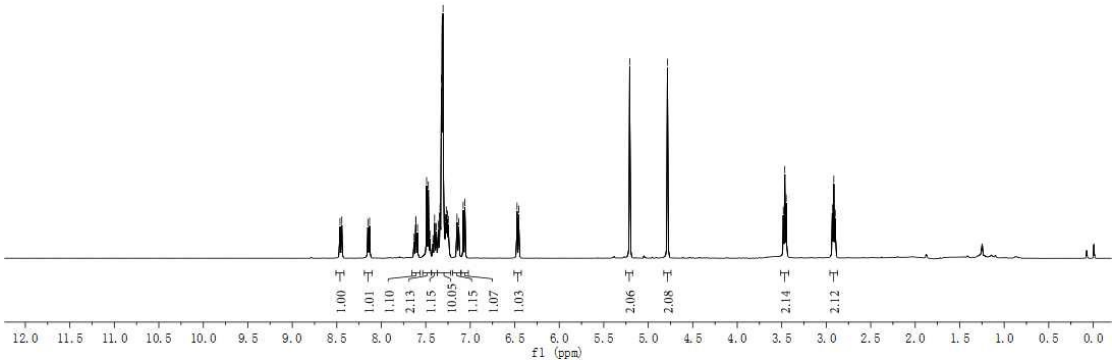

8.411
8.391
7.468
7.450
7.432
7.029
7.010
6.453
6.434
3.980
3.962
3.943
1.764
1.745
1.731
1.727
1.708
1.689
1.394
1.375
1.356
1.338
0.943
0.924
2s
3s
400M, CDCl3
3s
3s
3s
3s
1.00
0.29
0.28
1.04
2.02
1.09
1.06
0.22
0.23
2.24
0.21
0.51
2.31
0.69
2.45
1.10
0.88
3.38
f1 (ppm)

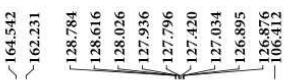

162.027
136.955
134.408
131.921
131.685
127.750
126.643
126.272
125.755
123.433
105.835
49.103
47.161
46.002
31.346
19.955
13.741
13.690
2s
3s
100M, CDCl3
f1 (ppm)

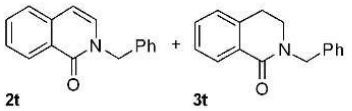


2t **3t**

400M, $CDCl_3$

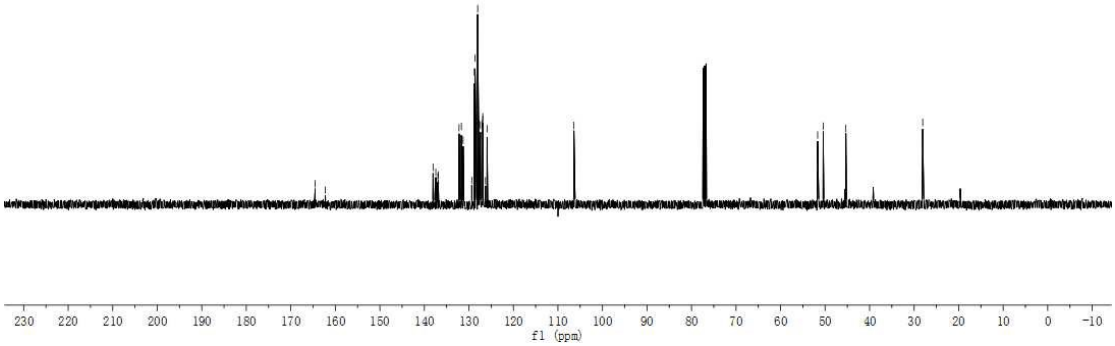


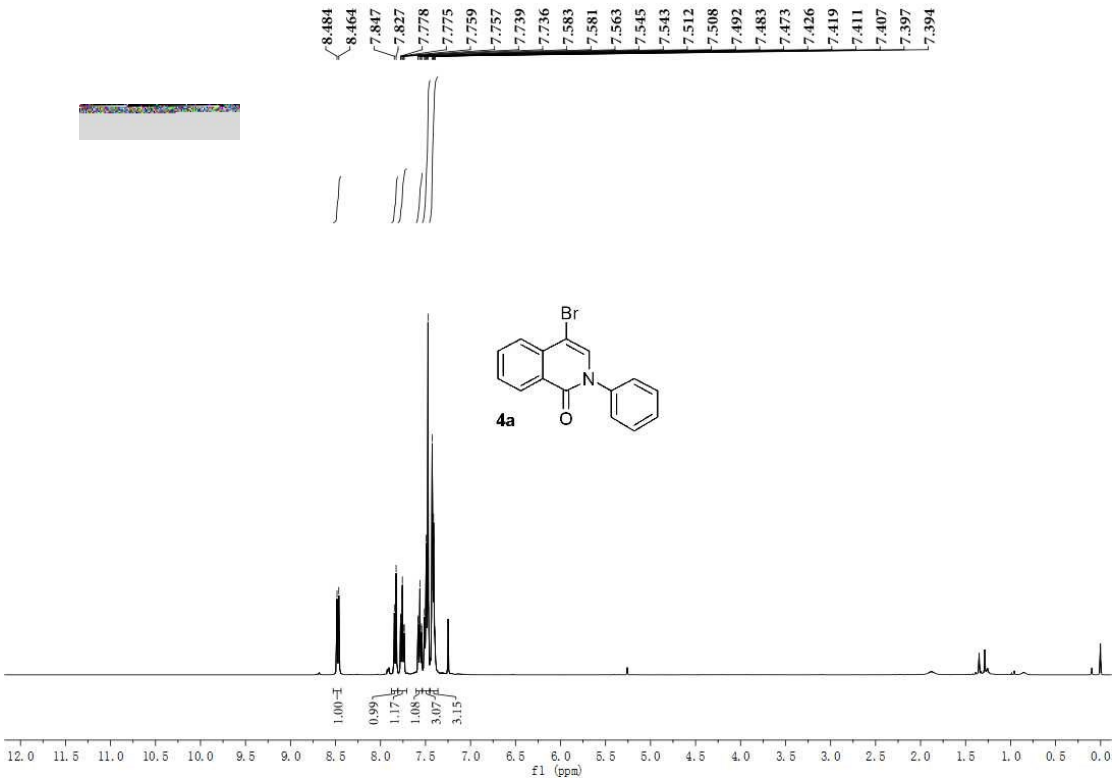


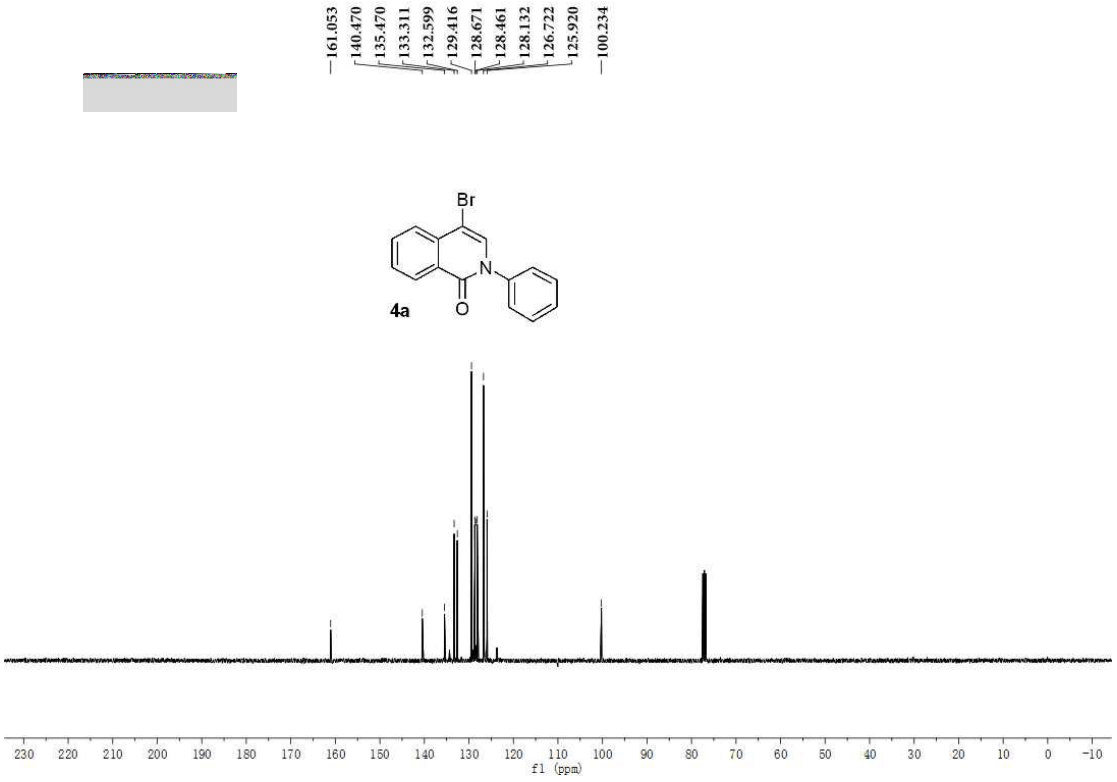


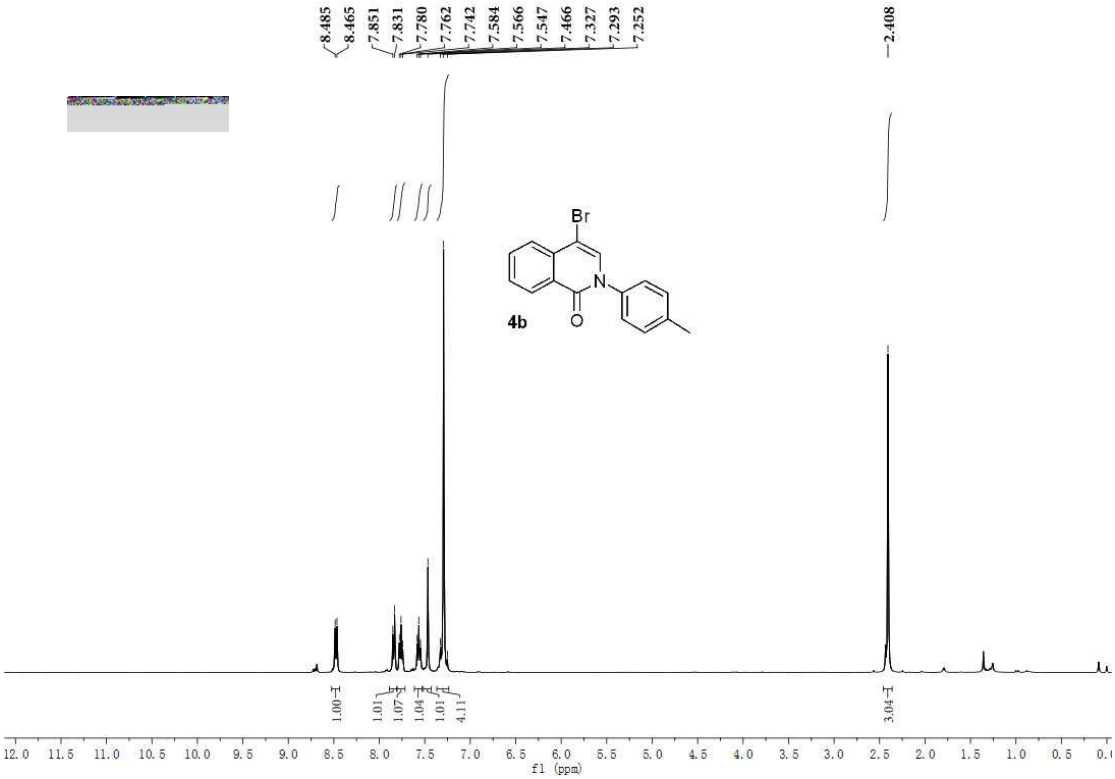
2t **3t**

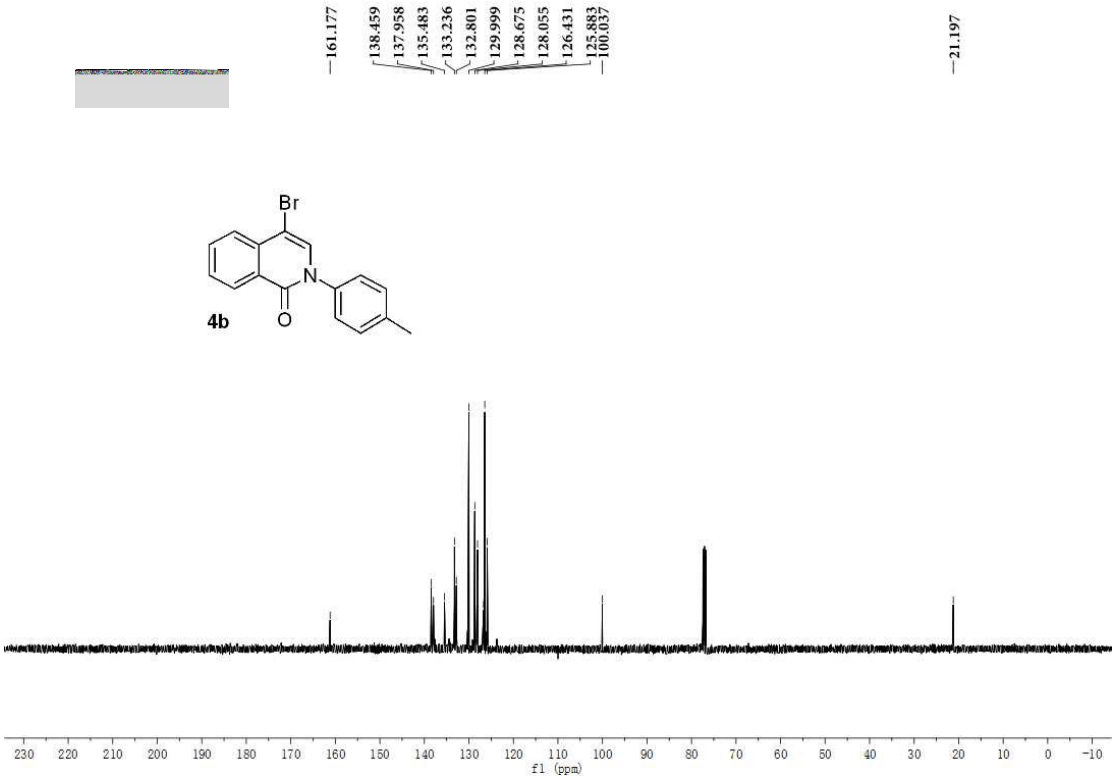
400M, $CDCl_3$

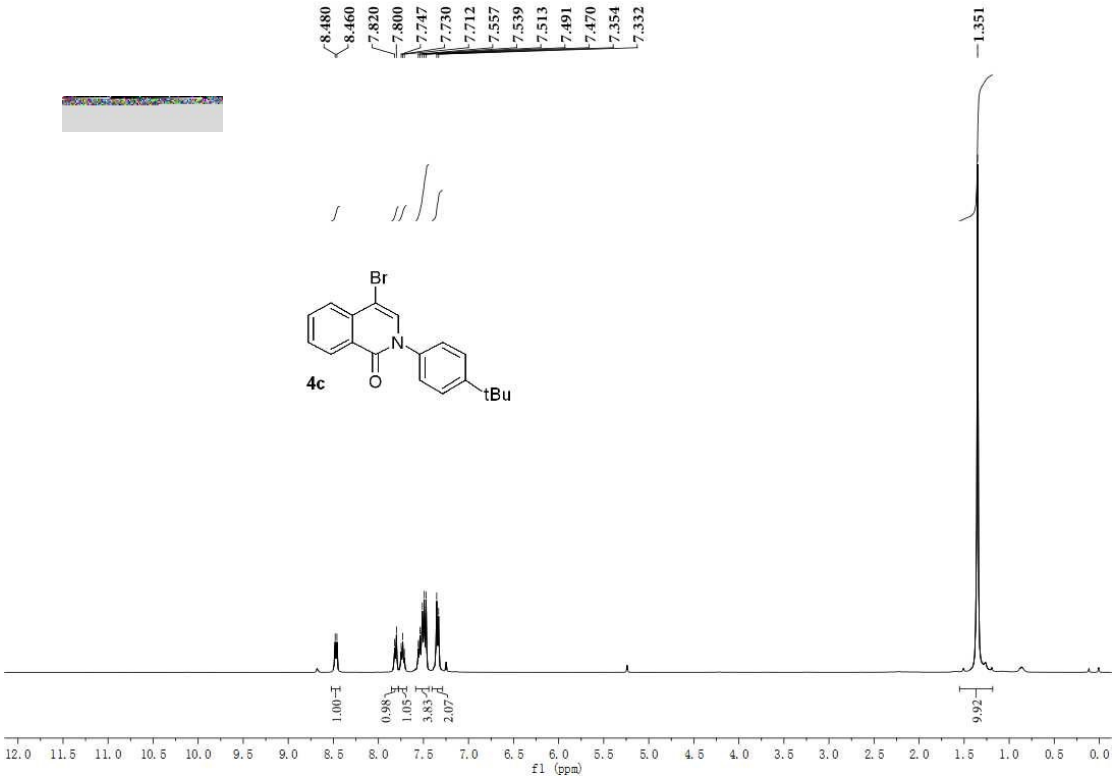



8.484
8.464
7.847
7.827
7.778
7.775
7.759
7.757
7.739
7.736
7.583
7.581
7.563
7.545
7.543
7.512
7.508
7.492
7.483
7.473
7.426
7.419
7.411
7.407
7.397
7.394
Br
N
O
4a
1.00
0.99
1.17
1.08
3.07
3.15
12.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)


161.053
140.470
135.470
133.311
132.599
129.416
128.671
128.461
128.132
126.722
125.920
100.234
Br
N
O
4a
230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


8.485
8.465
7.851
7.831
7.780
7.762
7.742
7.584
7.566
7.547
7.466
7.327
7.293
7.252
2.408
Br
N
O
4b
1.00
1.01
1.07
1.04
1.01
4.11
3.04
f1 (ppm)


161.177
138.459
137.958
135.483
133.236
132.801
129.999
128.675
128.055
126.431
125.883
100.037
21.197
Br
N
O
4b
f1 (ppm)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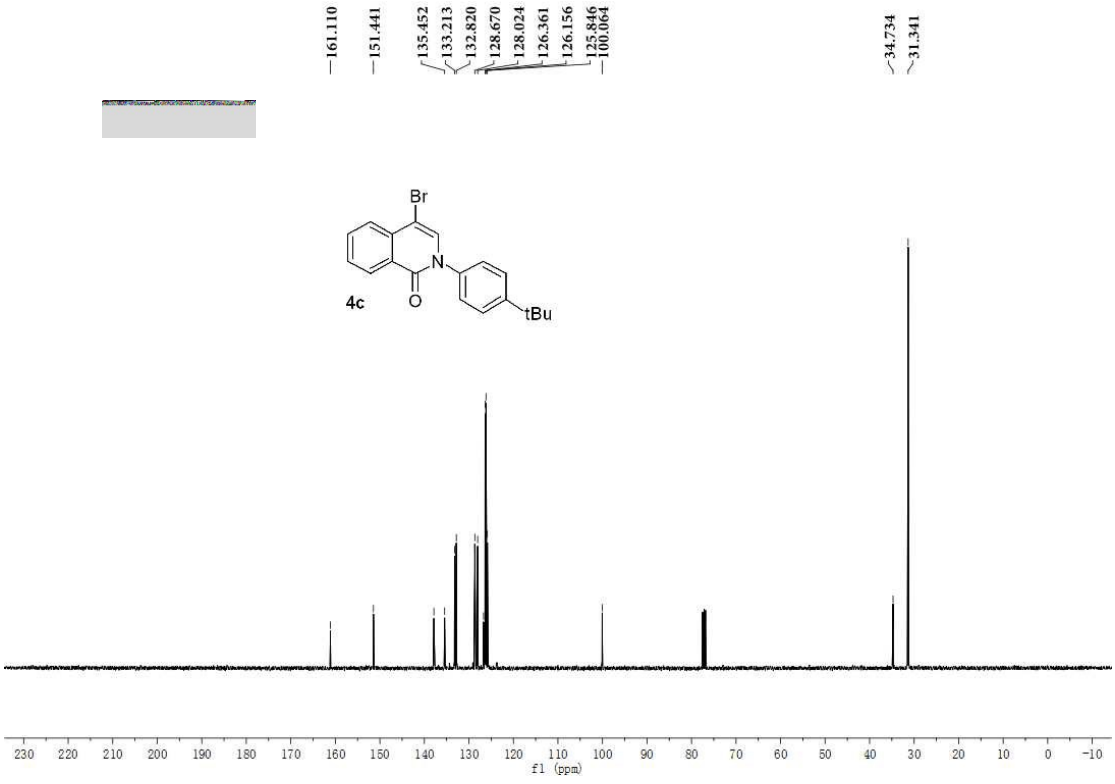
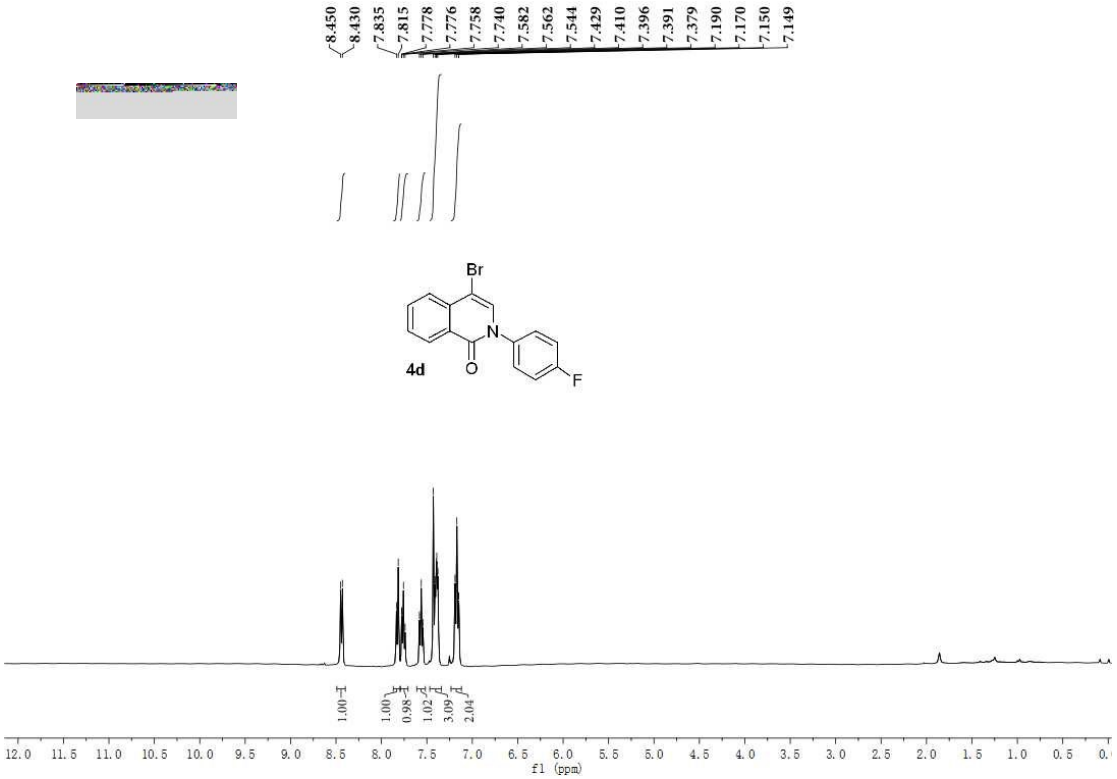
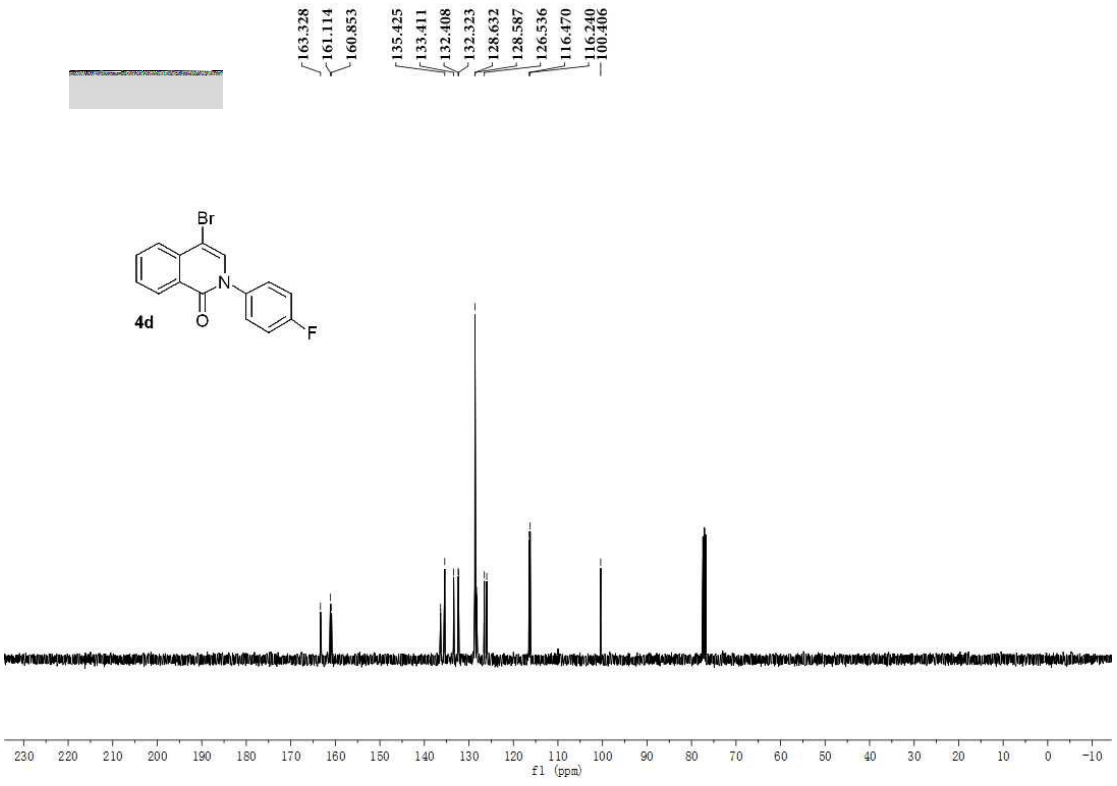
7.800
7.747
7.730
7.712
7.557
7.539
7.513
7.491
7.470
7.354
7.332
1.351
Br
N
O
4c
tBu
1.00
0.98
1.05
3.83
2.07
9.92
f1 (ppm)


161.110
151.441
135.452
133.213
132.820
128.670
128.024
126.361
126.156
125.846
100.064
34.734
31.341
Br
N
O
4c
tBu
f1 (ppm)


8.450
8.430
7.835
7.815
7.778
7.776
7.758
7.740
7.582
7.562
7.544
7.429
7.410
7.396
7.391
7.379
7.190
7.170
7.150
7.149
Br
N
O
F
4d
1.00
1.00
0.98
1.02
3.09
2.04
f1 (ppm)


163.328
161.114
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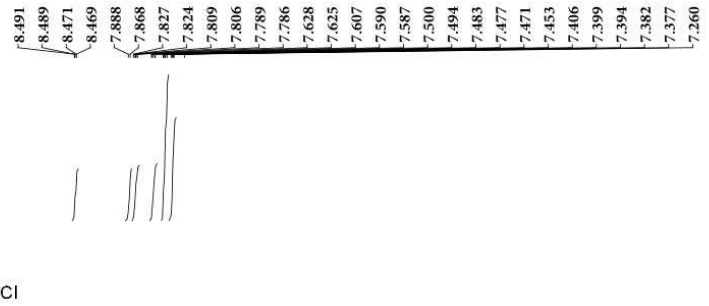
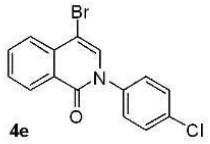
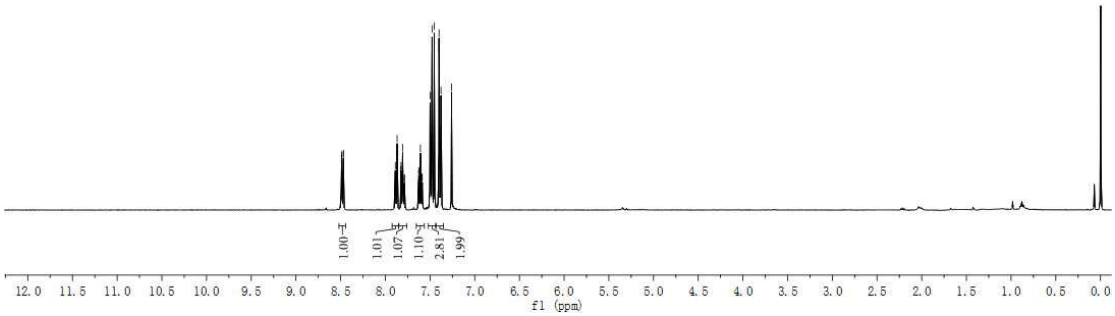
135.425
133.411
132.408
132.323
128.632
128.587
126.536
116.470
116.240
100.406
Br
N
O
F
4d
f1 (ppm)

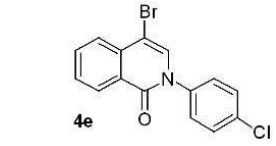




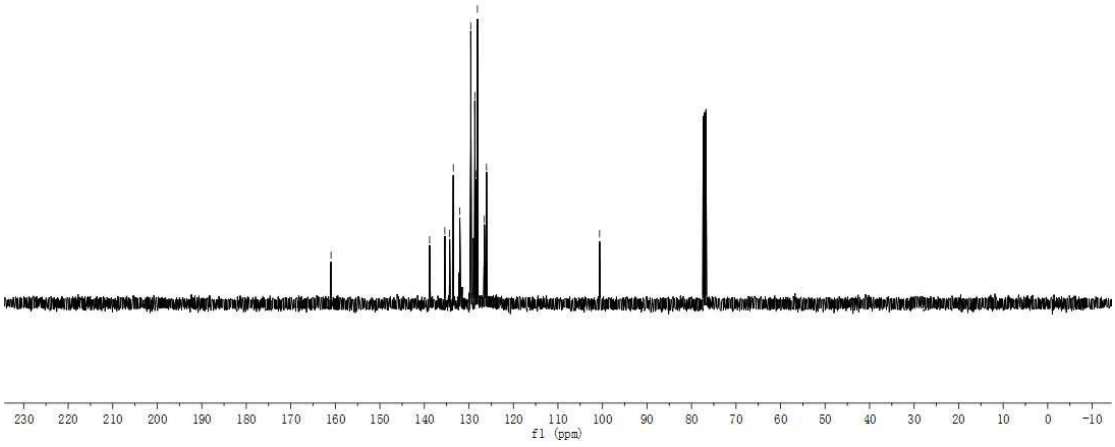
4e

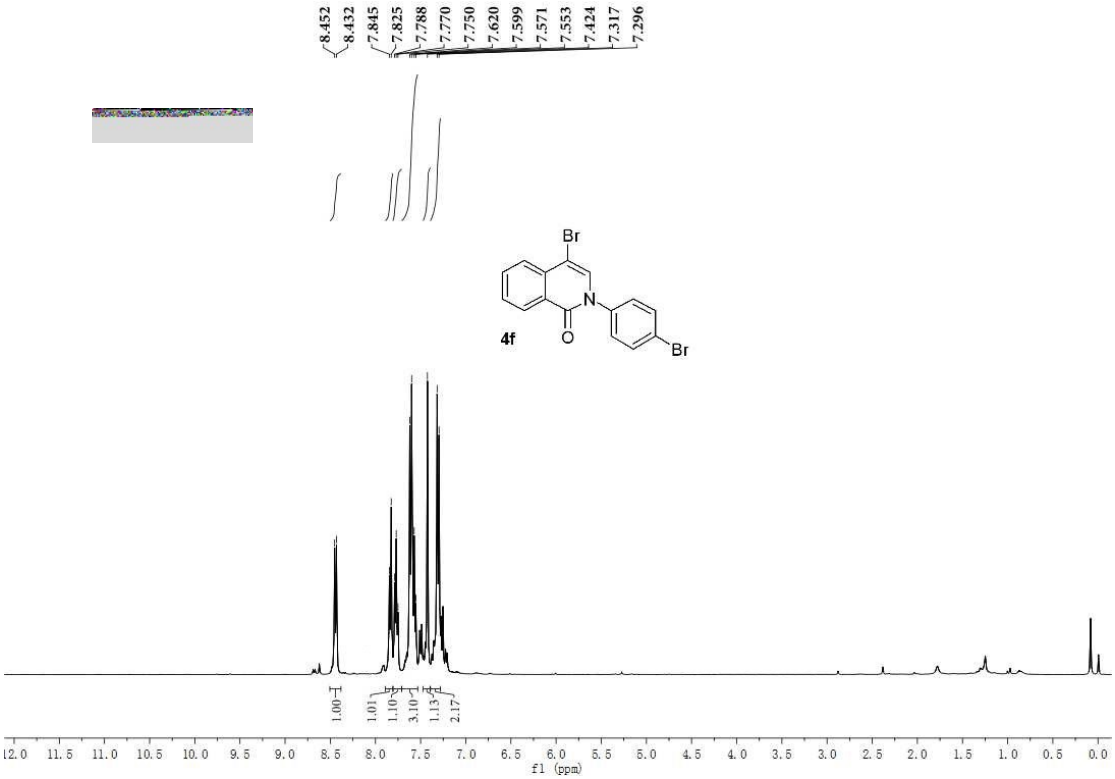
400M, $CDCl_3$





4e

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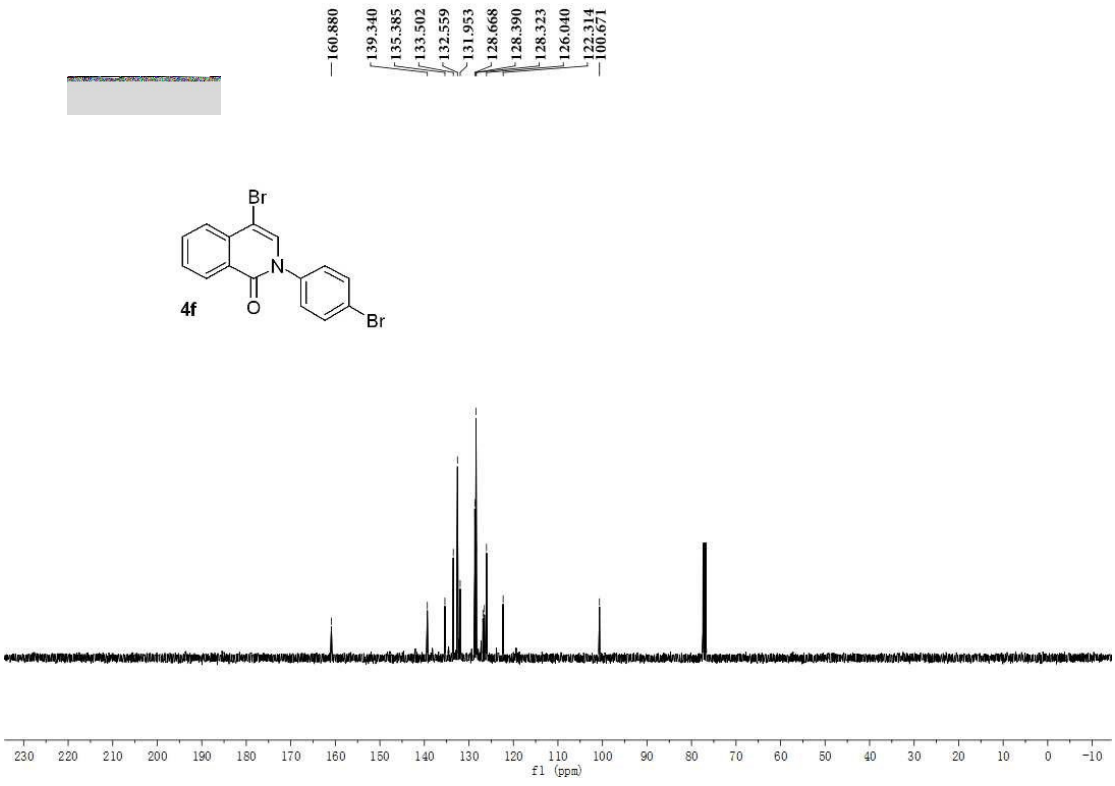
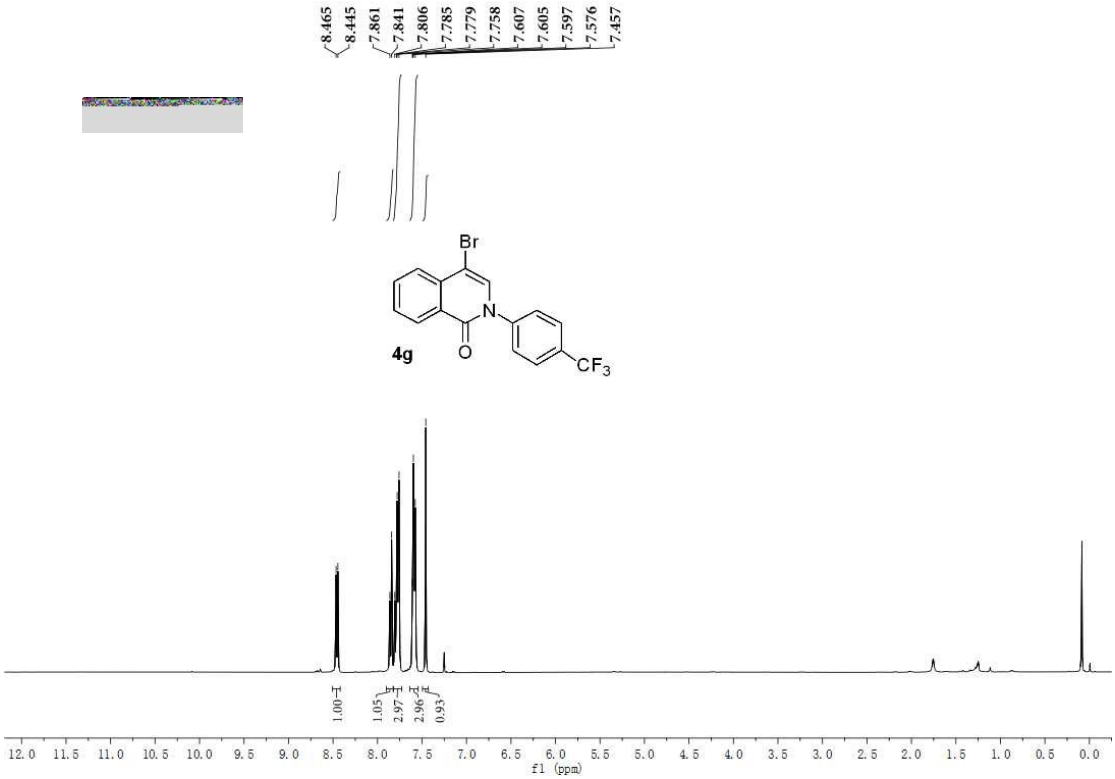
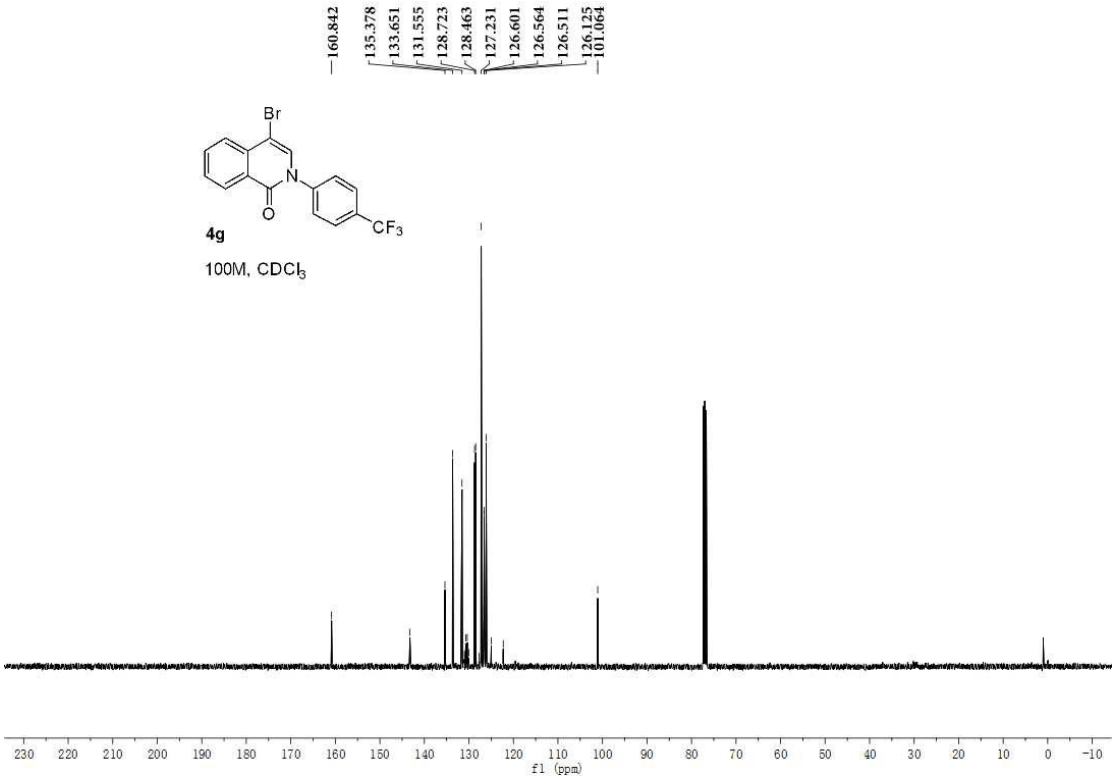
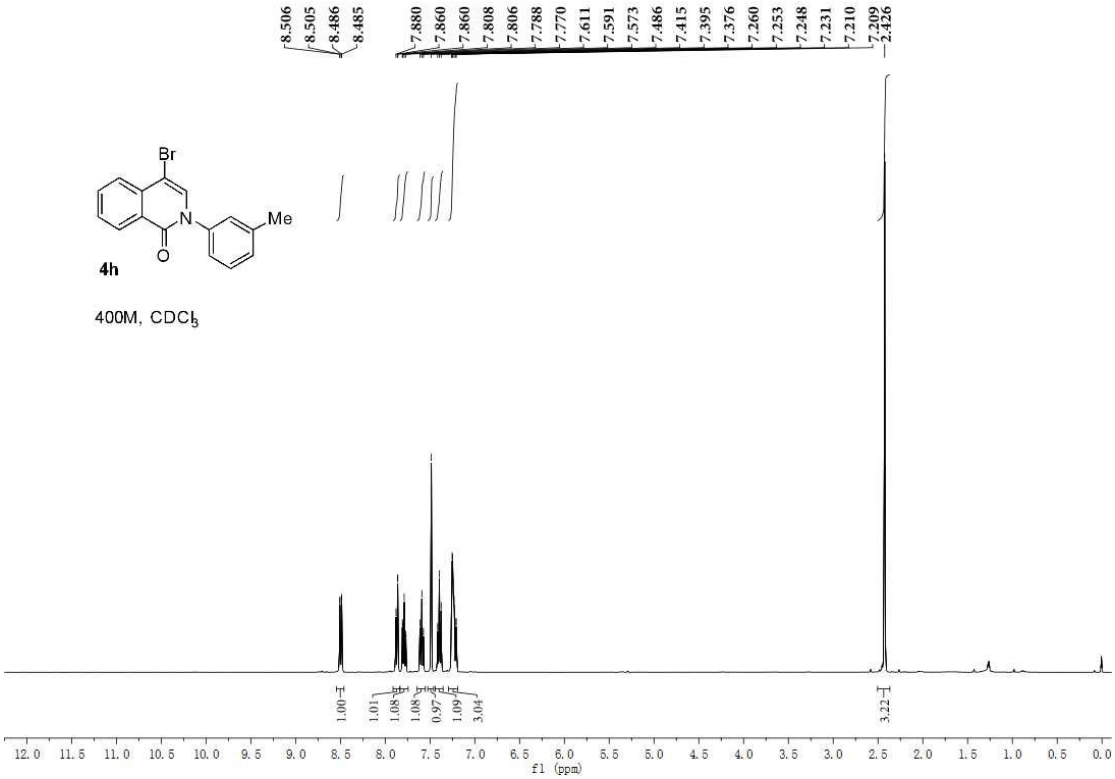
8.432
7.845
7.825
7.788
7.770
7.750
7.620
7.599
7.571
7.553
7.424
7.317
7.296
Br
N
O
Br
4f
1.00
1.01
1.10
3.10
1.13
2.17
f1 (ppm)


160.880
139.340
135.385
133.502
132.559
131.953
128.668
128.390
128.323
126.040
122.314
100.671
Br
N
O
Br
4f
f1 (ppm)


8.465
8.445
7.861
7.841
7.806
7.785
7.779
7.758
7.607
7.605
7.597
7.576
7.457
Br
N
O
4g
CF3
1.00
1.05
2.97
2.96
0.93
f1 (ppm)


160.842
135.378
133.651
131.555
128.723
128.463
127.231
126.601
126.564
126.511
126.125
101.064
Br
N
O
4g
CF3
100M, CDCl3
f1 (ppm)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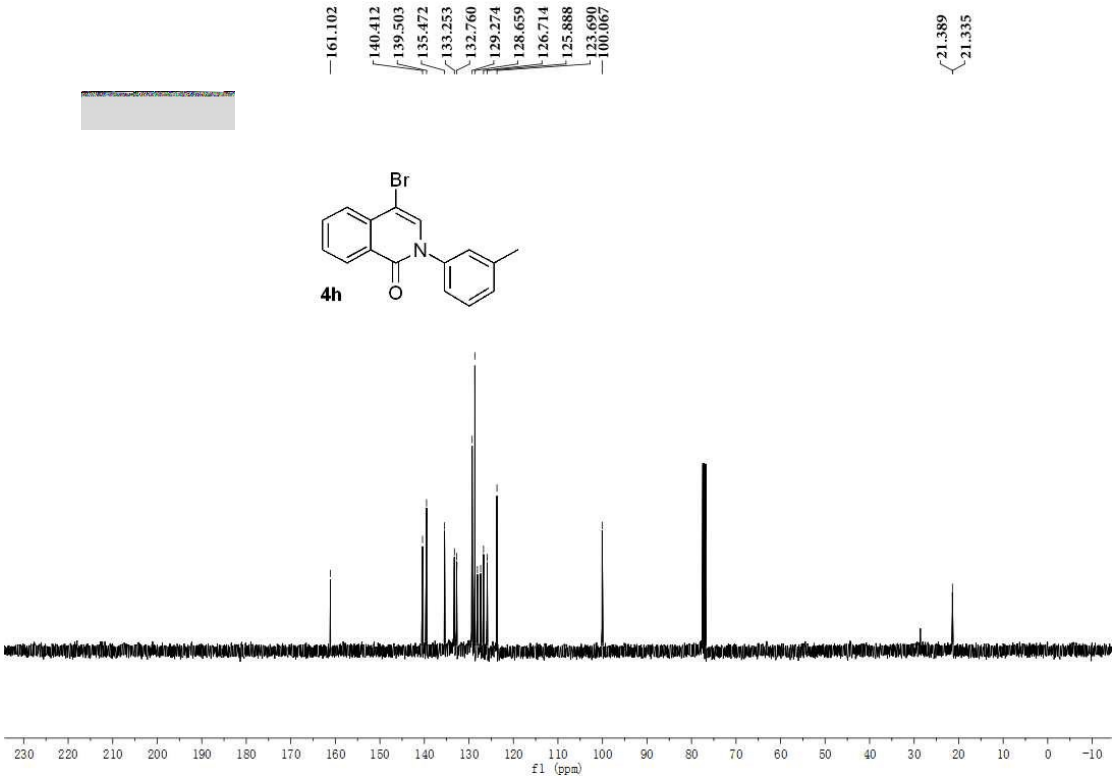
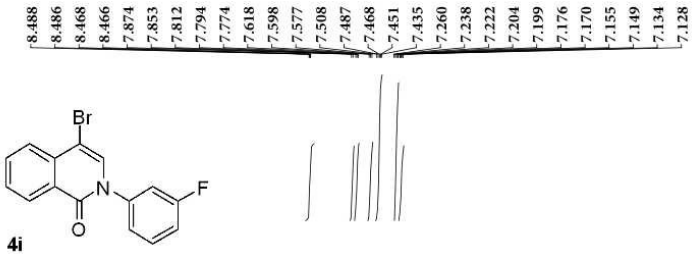
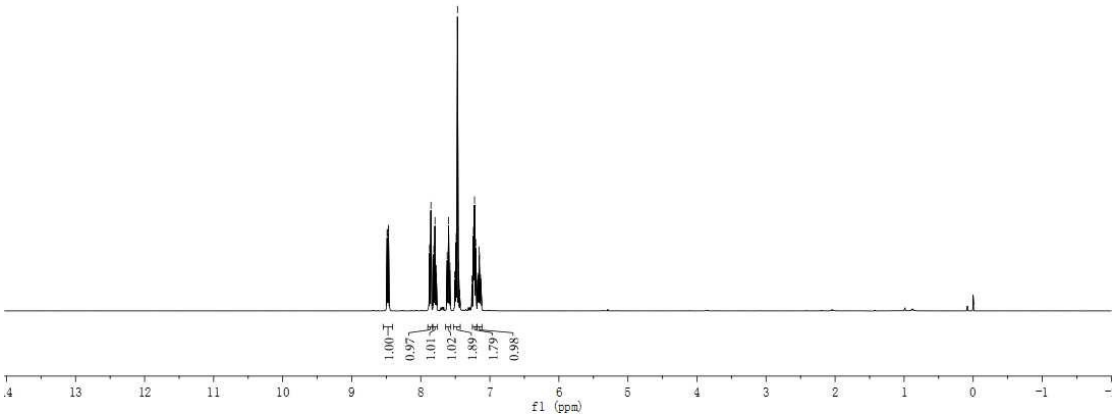
8.505
8.486
8.485
7.880
7.860
7.860
7.808
7.806
7.788
7.770
7.611
7.591
7.573
7.486
7.415
7.395
7.376
7.260
7.253
7.248
7.231
7.210
7.209
2.426
Br
N
Me
O
4h
400M, CDCl3
1.00
1.01
1.08
1.08
0.97
1.09
3.04
3.22
12.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

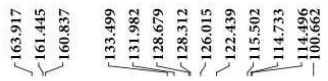

161.102
140.412
139.503
135.472
133.253
132.760
129.274
128.659
126.714
125.888
123.690
100.067
21.389
21.335
Br
N
O
4h
230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

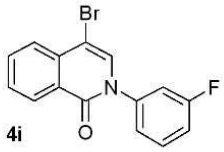


4i

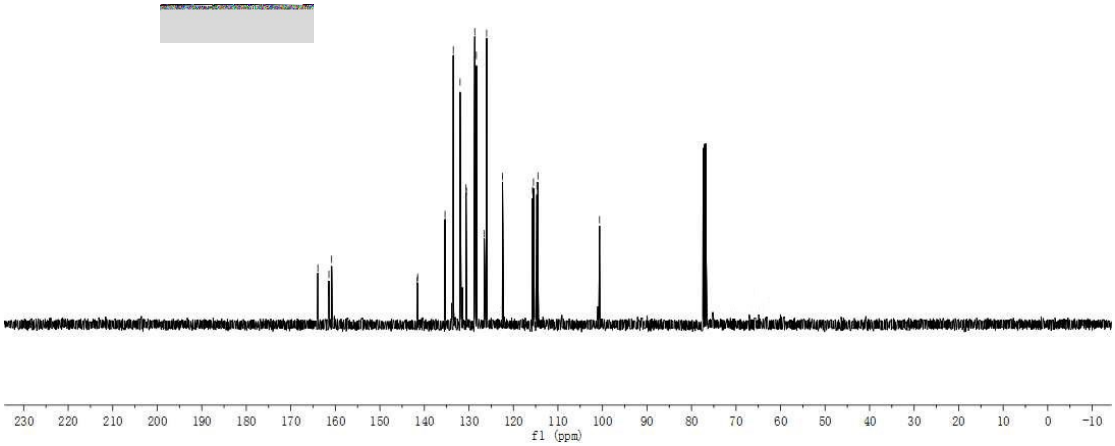
400M, $CDCl_3$

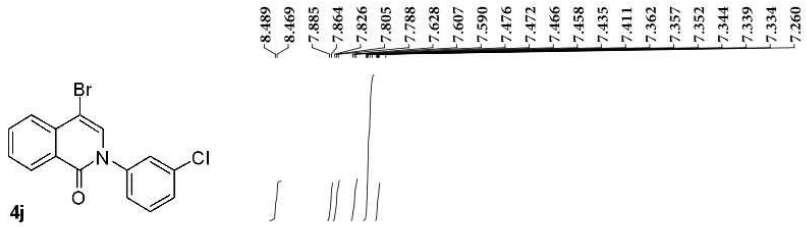






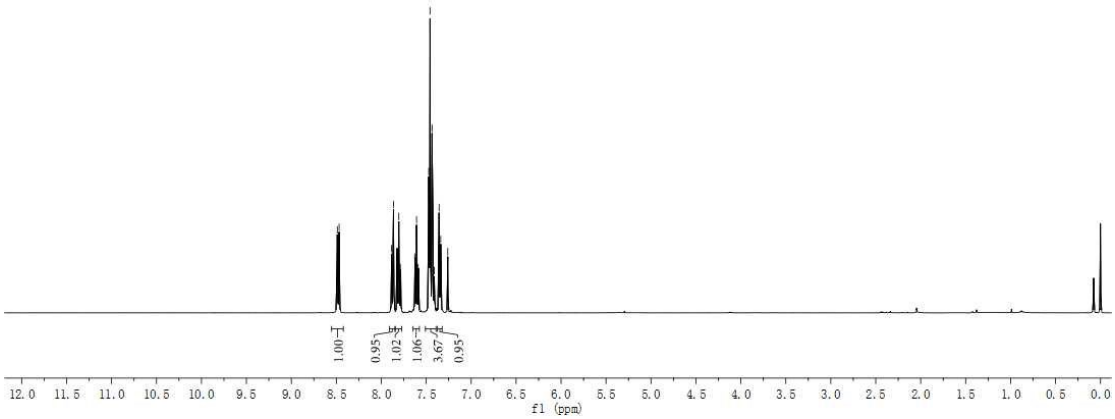
4i

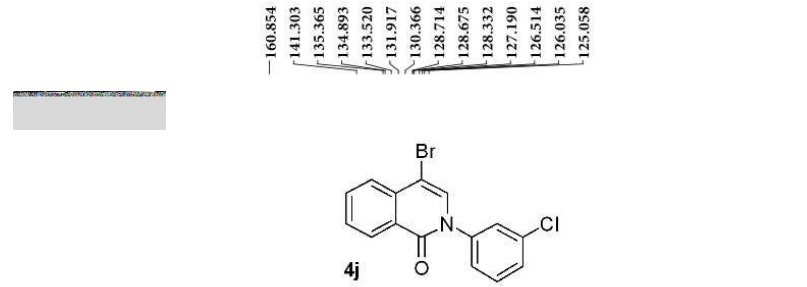




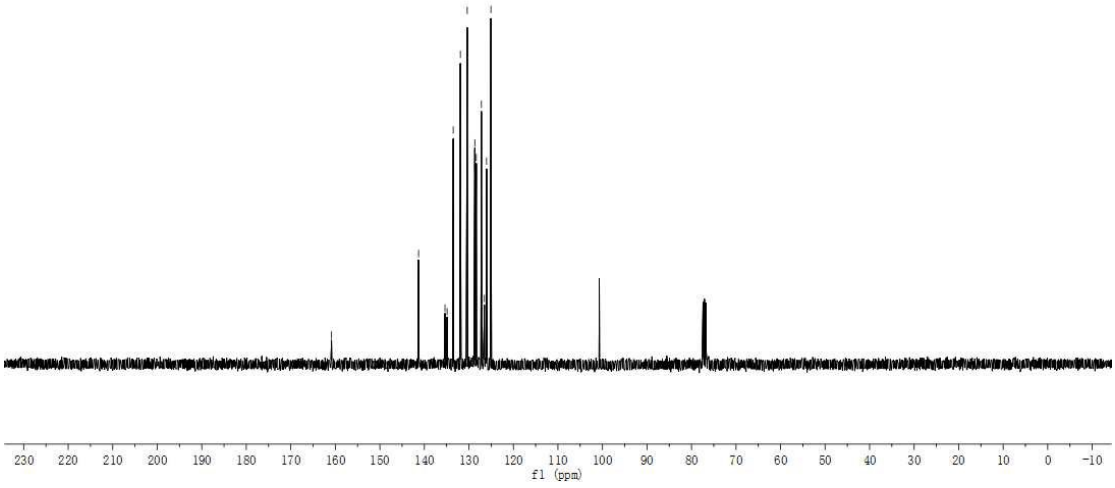
4j

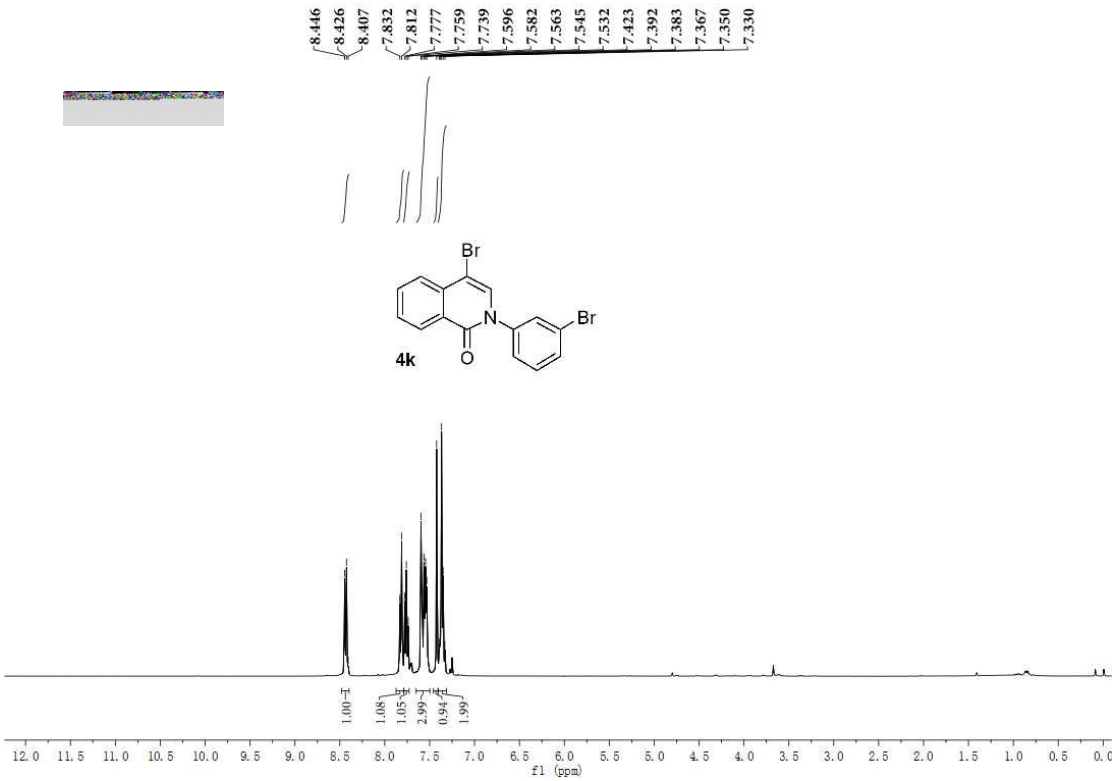
400M, $CDCl_3$





4j

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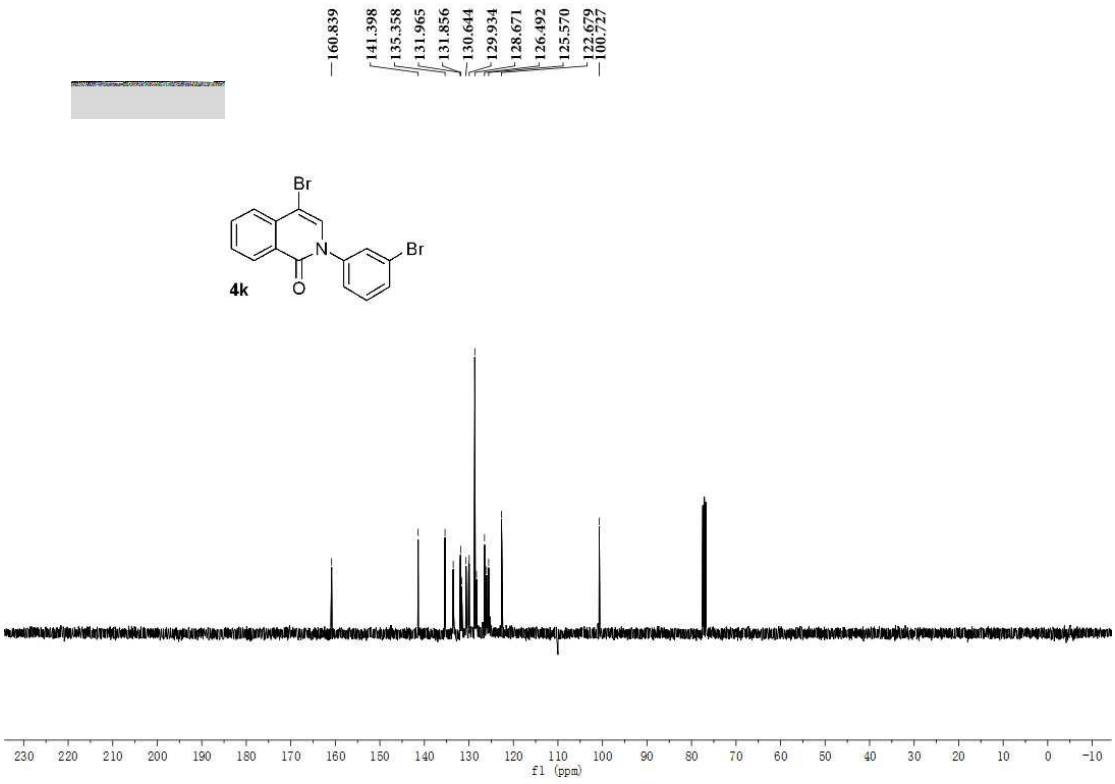
8.426
8.407
7.832
7.812
7.777
7.759
7.739
7.596
7.582
7.563
7.545
7.532
7.423
7.392
7.383
7.367
7.350
7.330
Br
N
Br
O
4k
1.00
1.08
1.05
2.99
0.94
1.99
f1 (ppm)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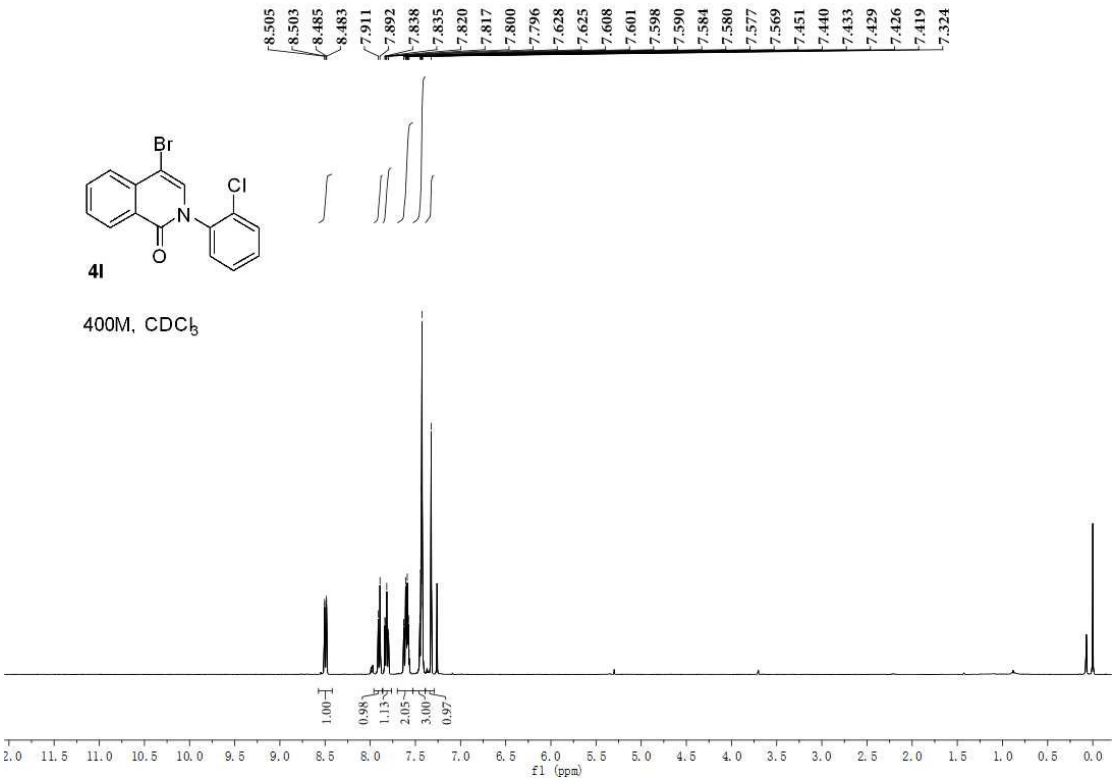
141.398
135.358
131.965
131.856
130.644
129.934
128.671
126.492
125.570
122.679
100.727
Br
N
Br
O
4k
f1 (ppm)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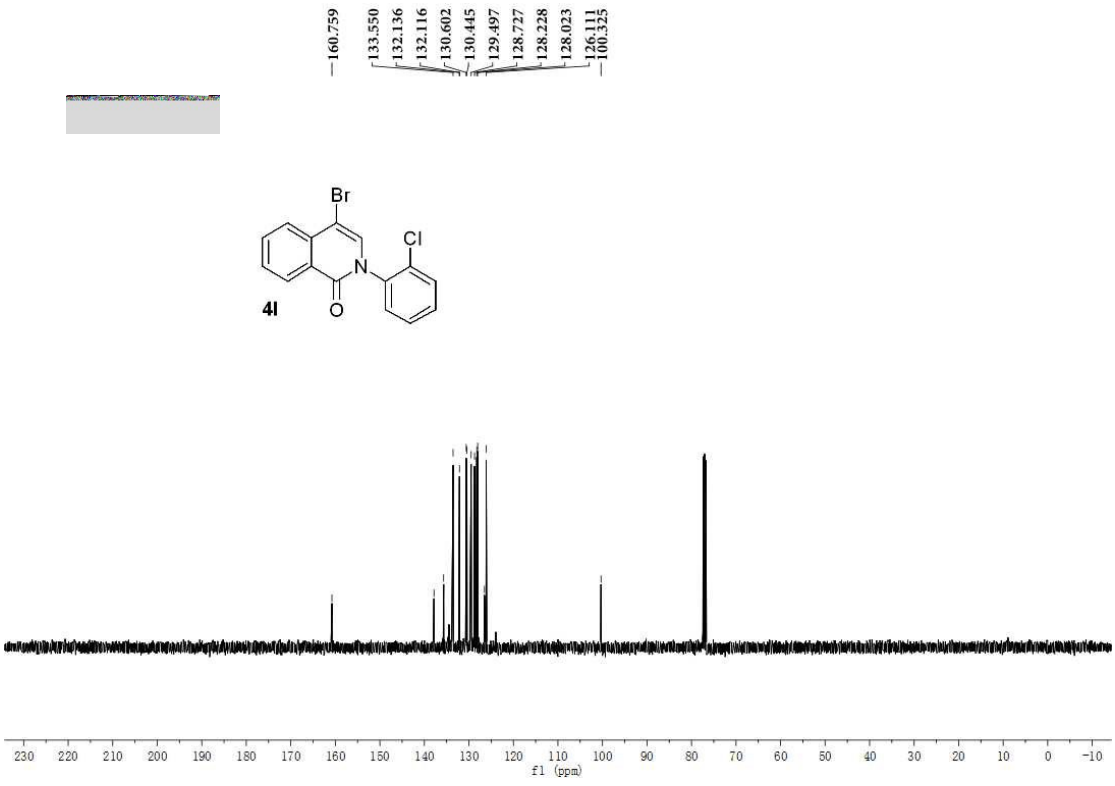
8.503
8.485
8.483
7.911
7.892
7.838
7.835
7.820
7.817
7.800
7.796
7.628
7.625
7.608
7.601
7.598
7.590
7.584
7.580
7.577
7.569
7.451
7.440
7.433
7.429
7.426
7.419
7.324
Br
Cl
N
O
4l
400M, CDCl3
1.00
0.98
1.13
2.05
3.00
0.97
f1 (ppm)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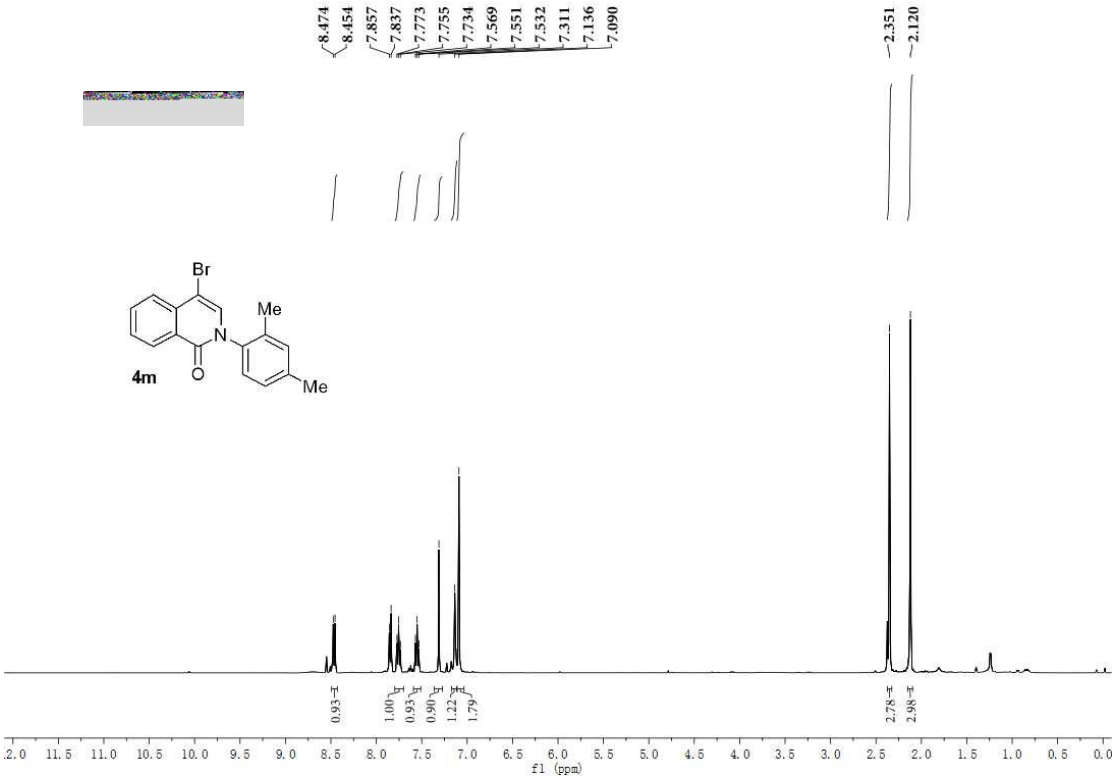
133.550
132.136
132.116
130.602
130.445
129.497
128.727
128.228
128.023
126.111
100.325
Br
Cl
N
O
4l
f1 (ppm)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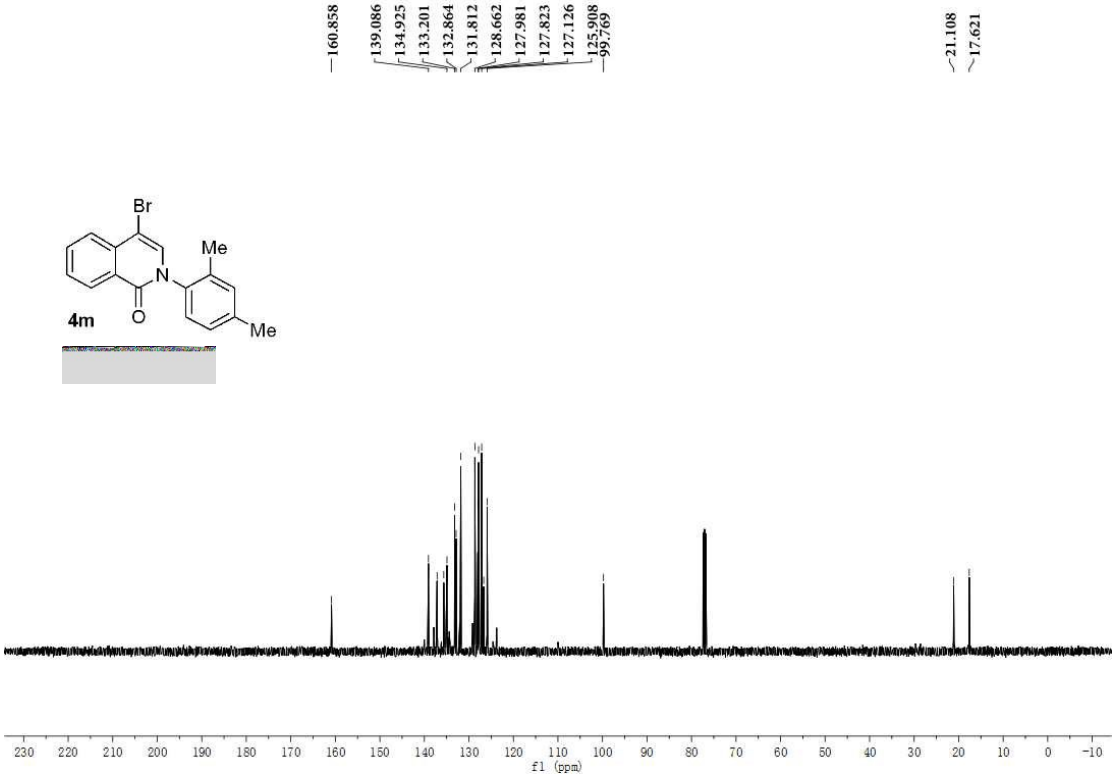
8.454
7.857
7.837
7.773
7.755
7.734
7.569
7.551
7.532
7.311
7.136
7.090
2.351
2.120
Br
Me
N
O
Me
4m
0.93
1.00
0.93
0.90
1.22
1.79
2.78
2.98
f1 (ppm)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132.864
131.812
128.662
127.981
127.823
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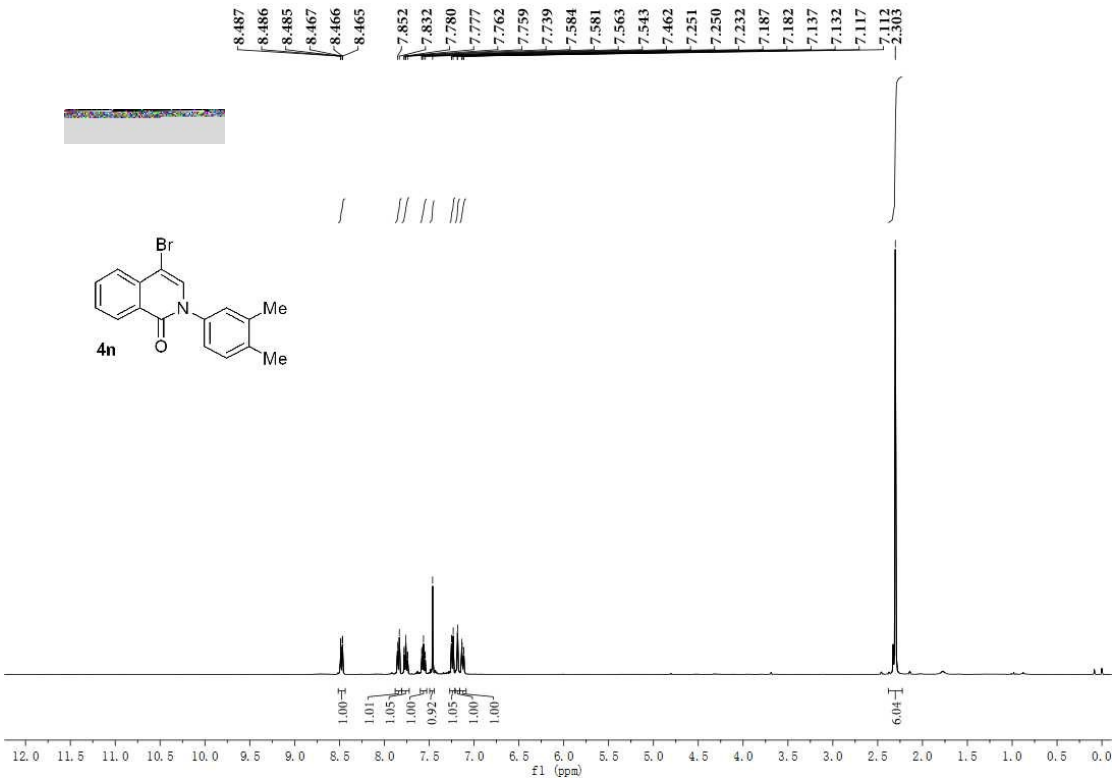
125.908
99.769
21.108
17.621
Br
Me
N
O
Me
4m
f1 (ppm)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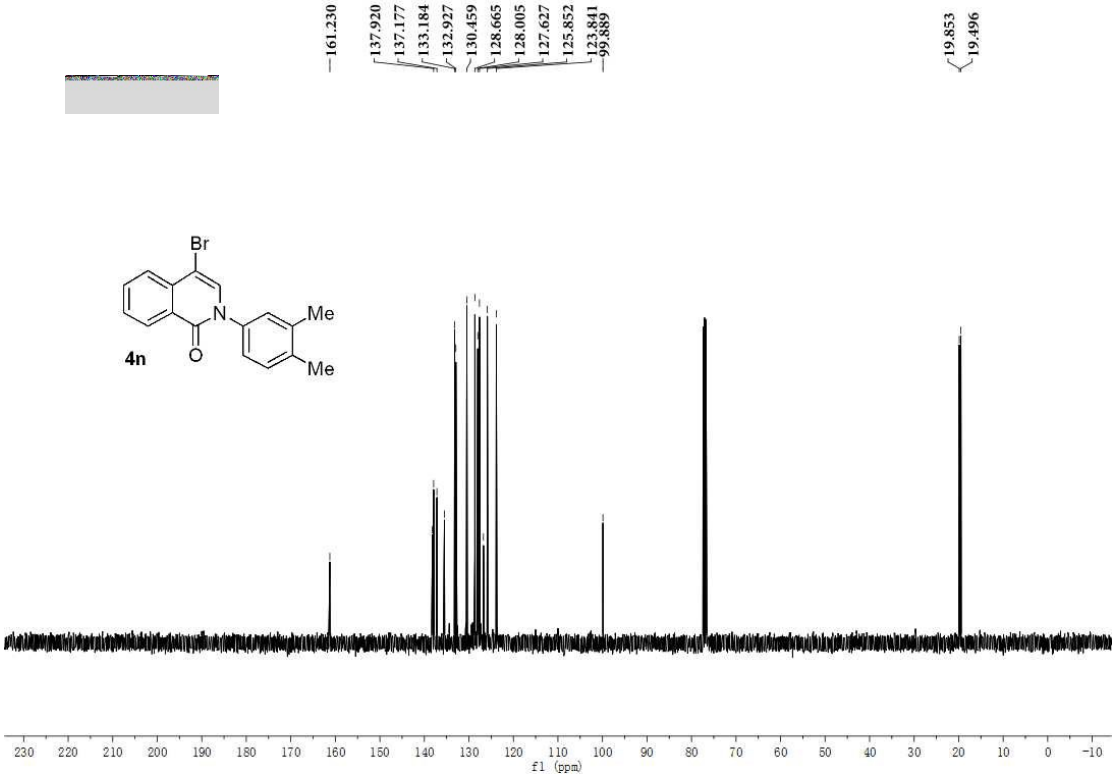
8.486
8.485
8.467
8.466
8.465
7.852
7.832
7.780
7.777
7.762
7.759
7.739
7.584
7.581
7.563
7.543
7.462
7.251
7.250
7.232
7.187
7.182
7.137
7.132
7.117
7.113
2.303
Br
N
O
Me
Me
4n
1.00
1.01
1.05
1.00
0.92
1.05
1.00
1.00
6.04
f1 (ppm)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137.177
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132.927
130.459
128.665
128.005
127.627
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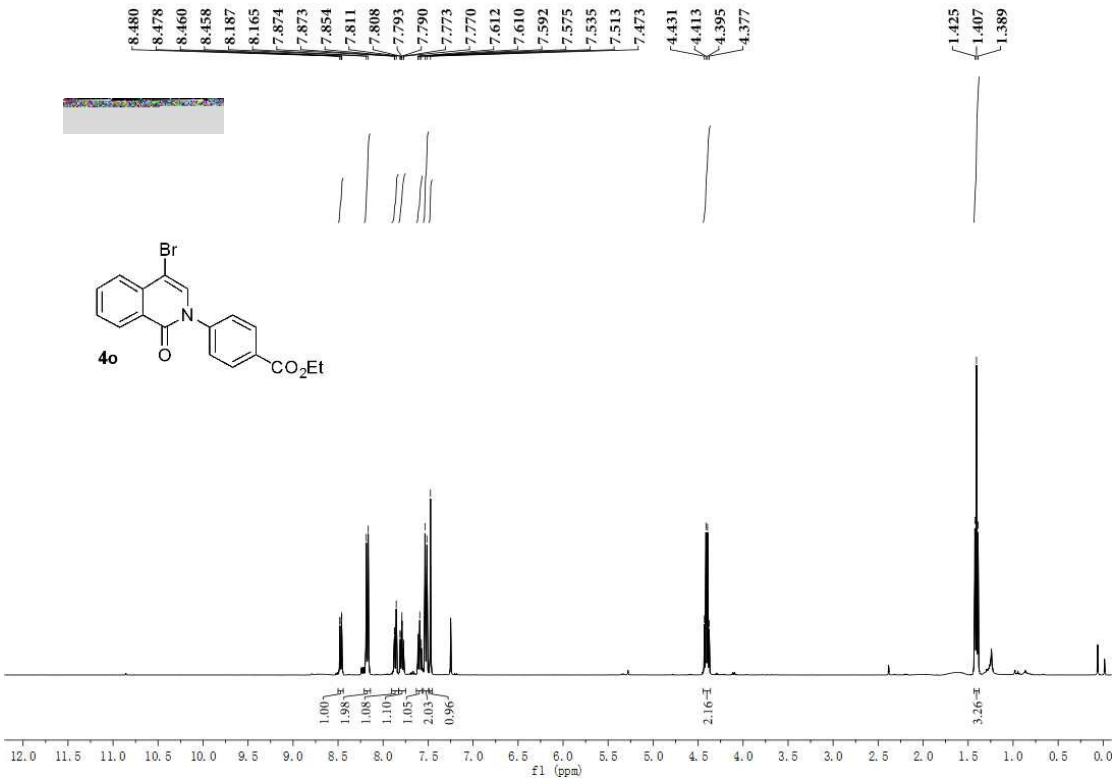
123.841
99.889
19.853
19.496
Br
N
O
Me
Me
4n
f1 (ppm)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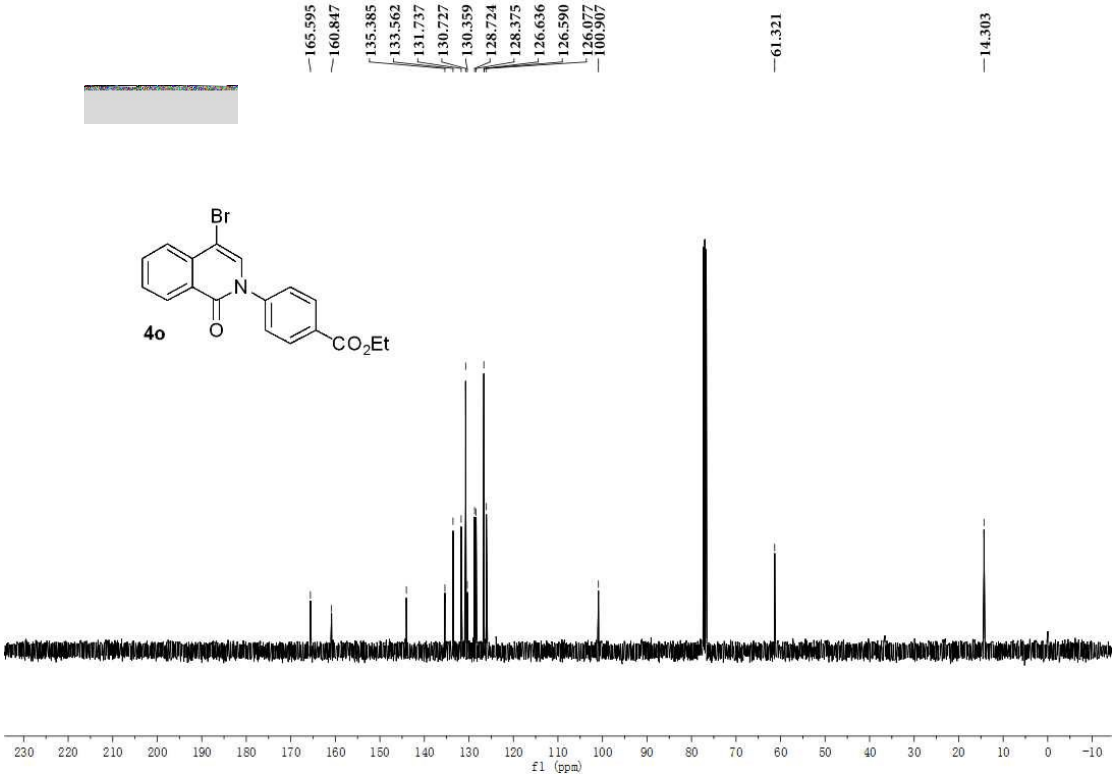
7.873
7.854
7.811
7.808
7.793
7.790
7.773
7.770
7.612
7.610
7.592
7.575
7.535
7.513
7.473
4.431
4.413
4.395
4.377
1.425
1.407
1.389
Br
N
O
CO2Et
4o
1.00
1.98
1.08
1.10
1.05
2.03
0.96
2.16
3.26
f1 (ppm)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133.562
131.737
130.727
130.359
128.724
128.375
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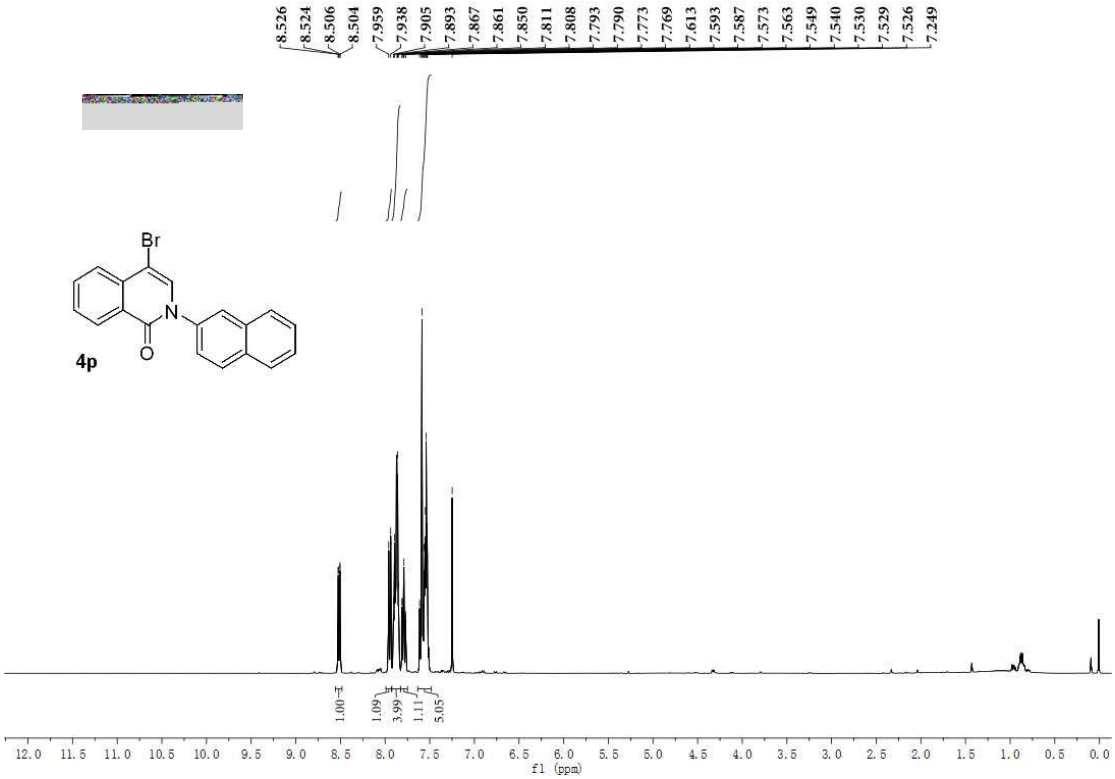
126.590
126.077
100.907
61.321
14.303
Br
N
O
CO2Et
4o
f1 (ppm)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8.506
8.504
7.959
7.938
7.905
7.893
7.867
7.861
7.850
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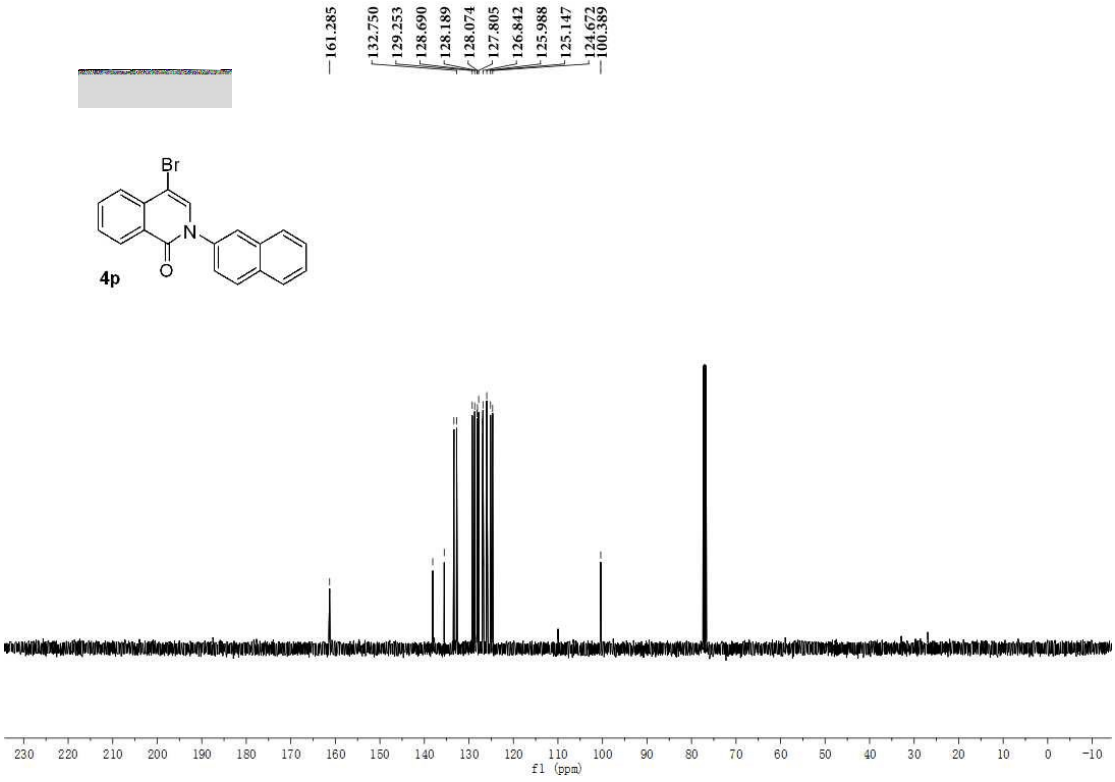
7.808
7.793
7.790
7.773
7.769
7.613
7.593
7.587
7.573
7.563
7.549
7.540
7.530
7.529
7.526
7.249
Br
N
O
4p
1.00
1.09
3.99
1.11
5.05
f1 (ppm)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129.253
128.690
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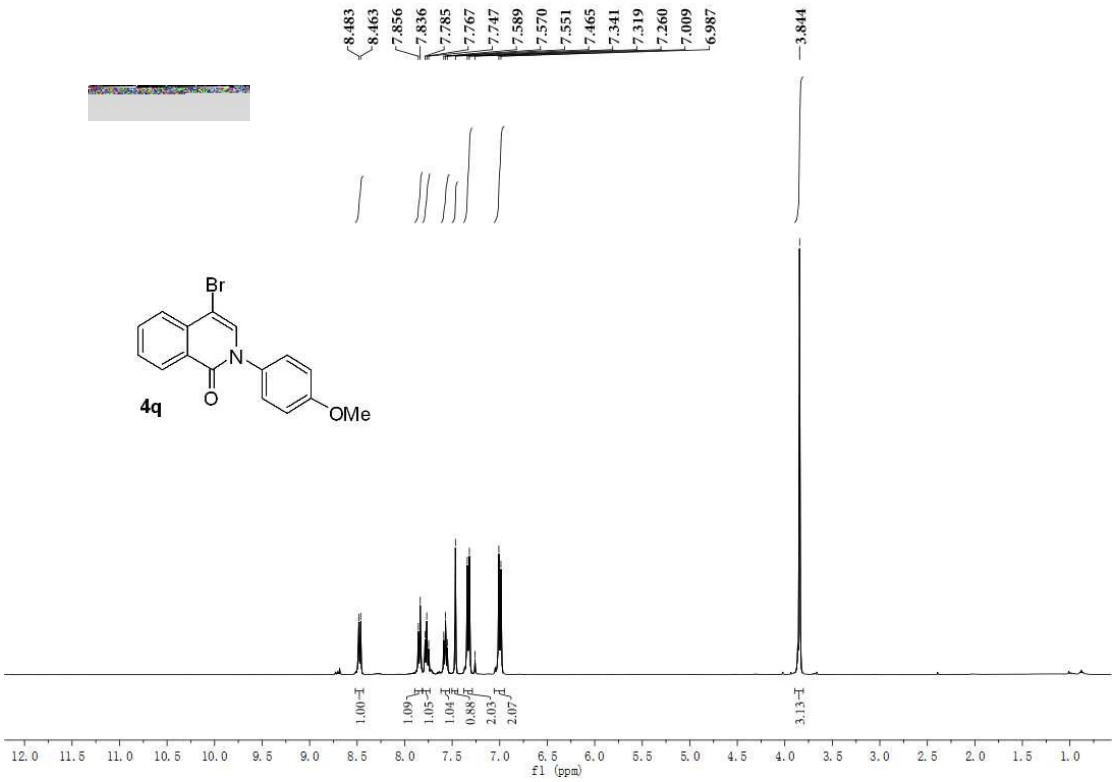
127.805
126.842
125.988
125.147
124.672
100.389
Br
N
O
4p
f1 (ppm)


8.483
8.463
7.856
7.836
7.785
7.767
7.747
7.589
7.570
7.551
7.465
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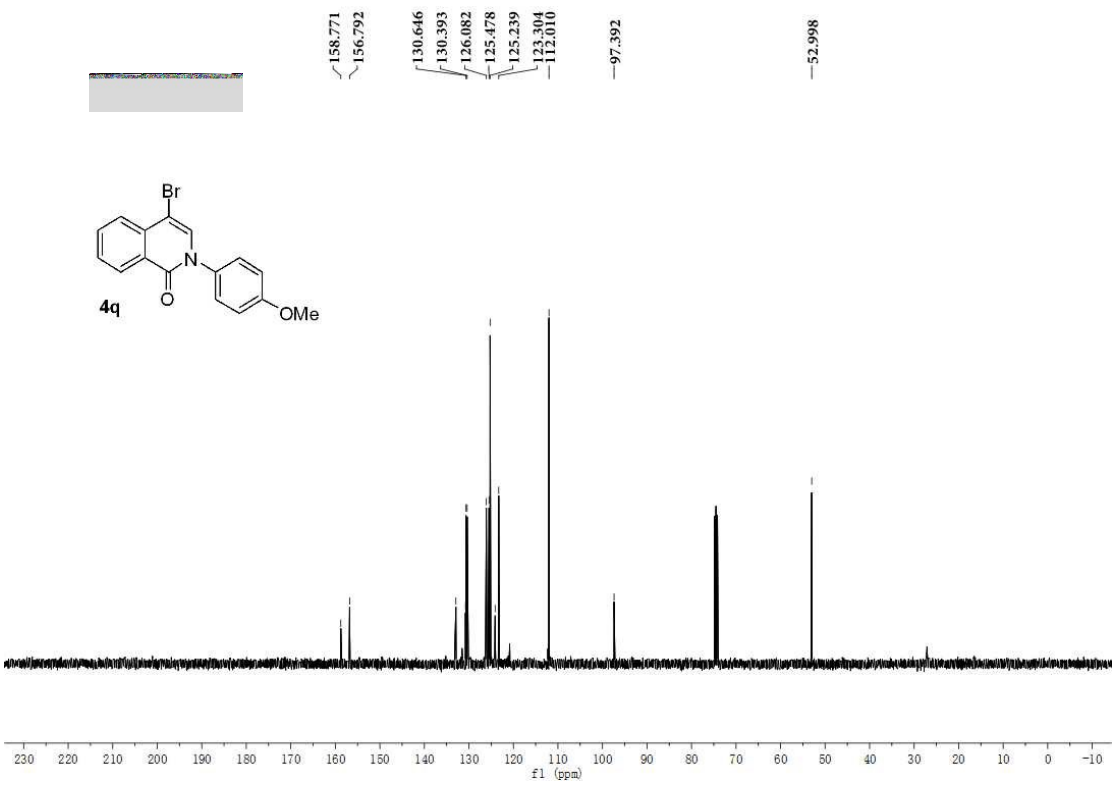
7.319
7.260
7.009
6.987
3.844
Br
N
O
OMe
4q
1.00
1.09
1.05
1.04
0.88
2.03
2.07
3.13
f1 (ppm)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130.393
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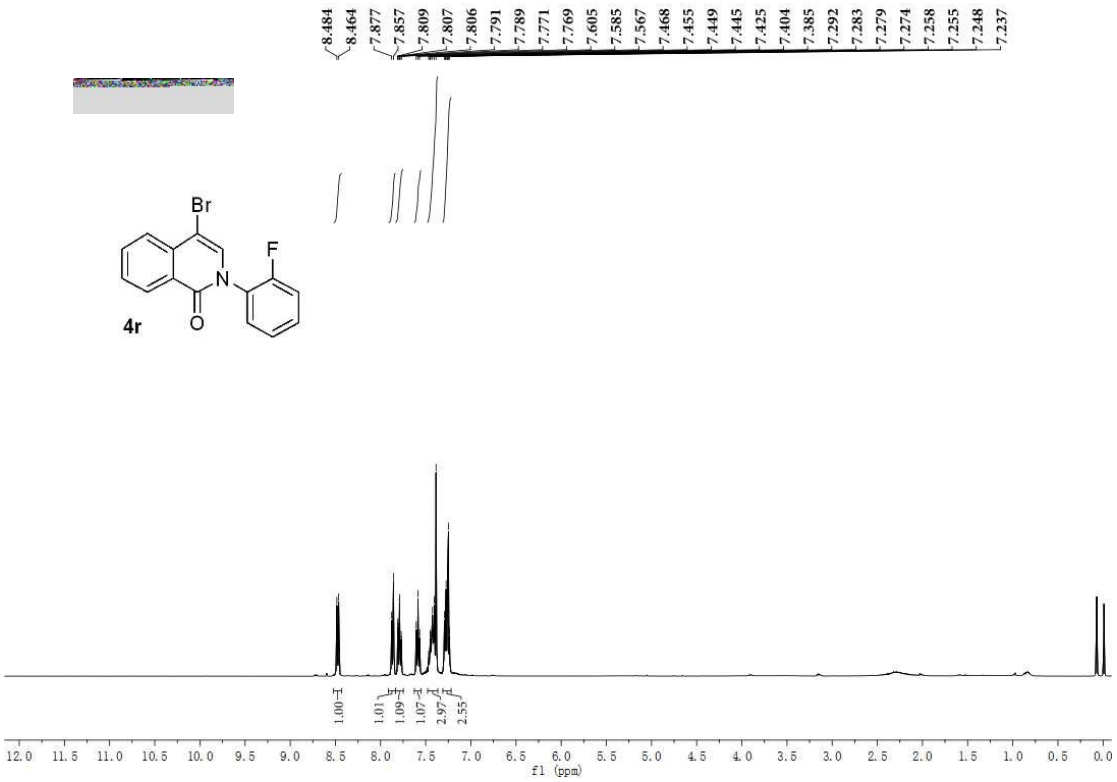
125.239
123.304
112.010
97.392
52.998
Br
N
O
OMe
4q
f1 (ppm)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8.464
7.877
7.857
7.809
7.807
7.806
7.791
7.789
7.771
7.769
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7.585
7.567
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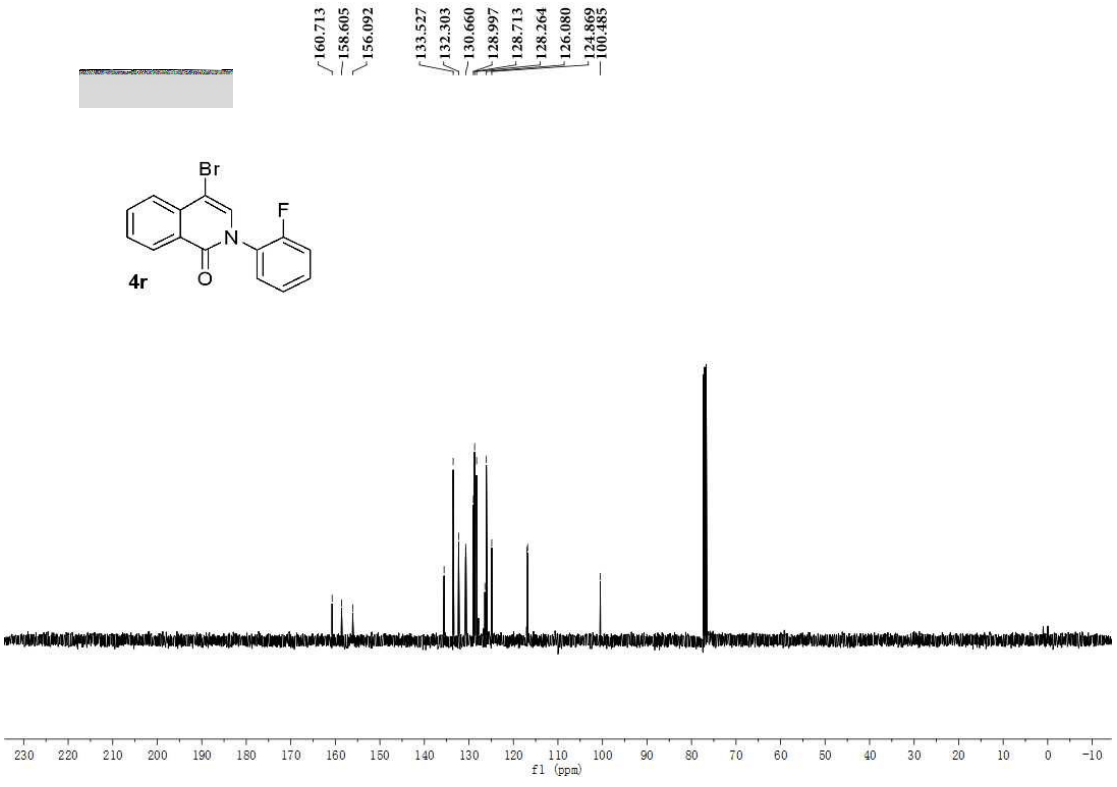
7.455
7.449
7.445
7.425
7.404
7.385
7.292
7.283
7.279
7.274
7.258
7.255
7.248
7.237
Br
F
N
O
4r
1.00
1.01
1.09
1.07
2.97
2.55
f1 (ppm)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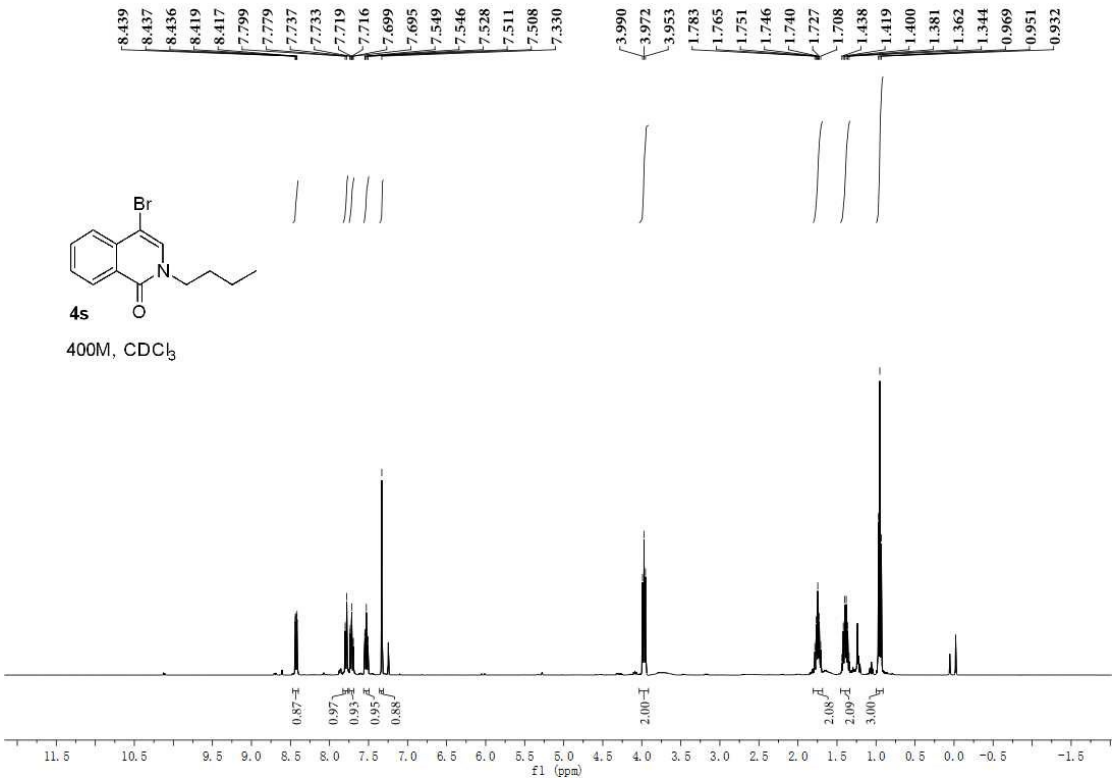
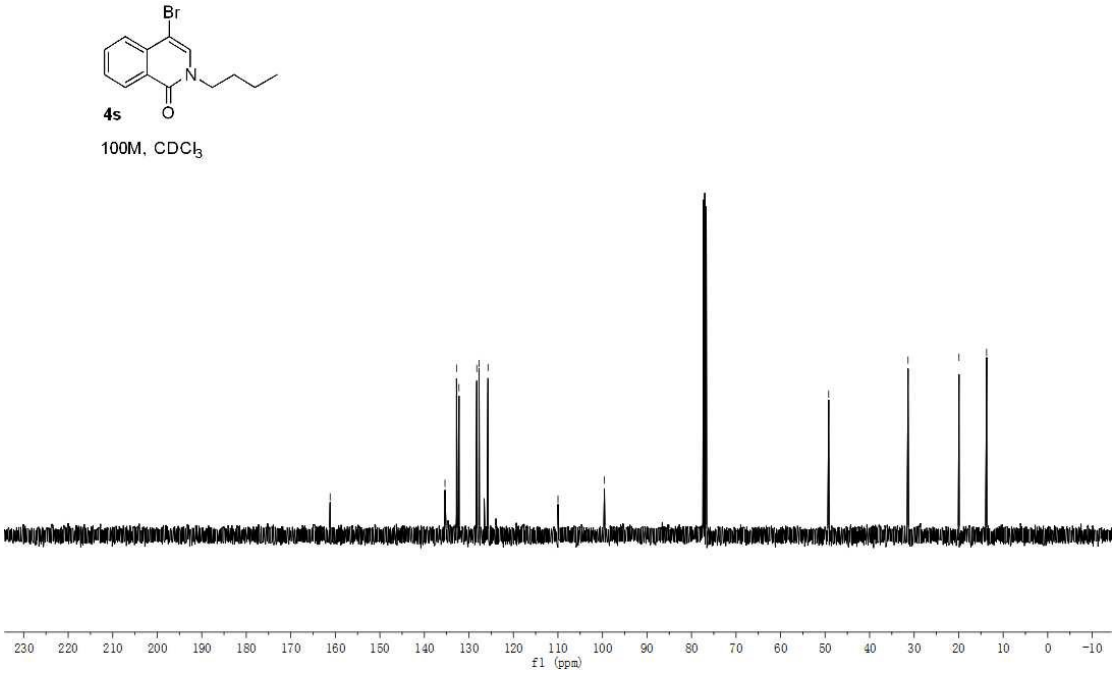
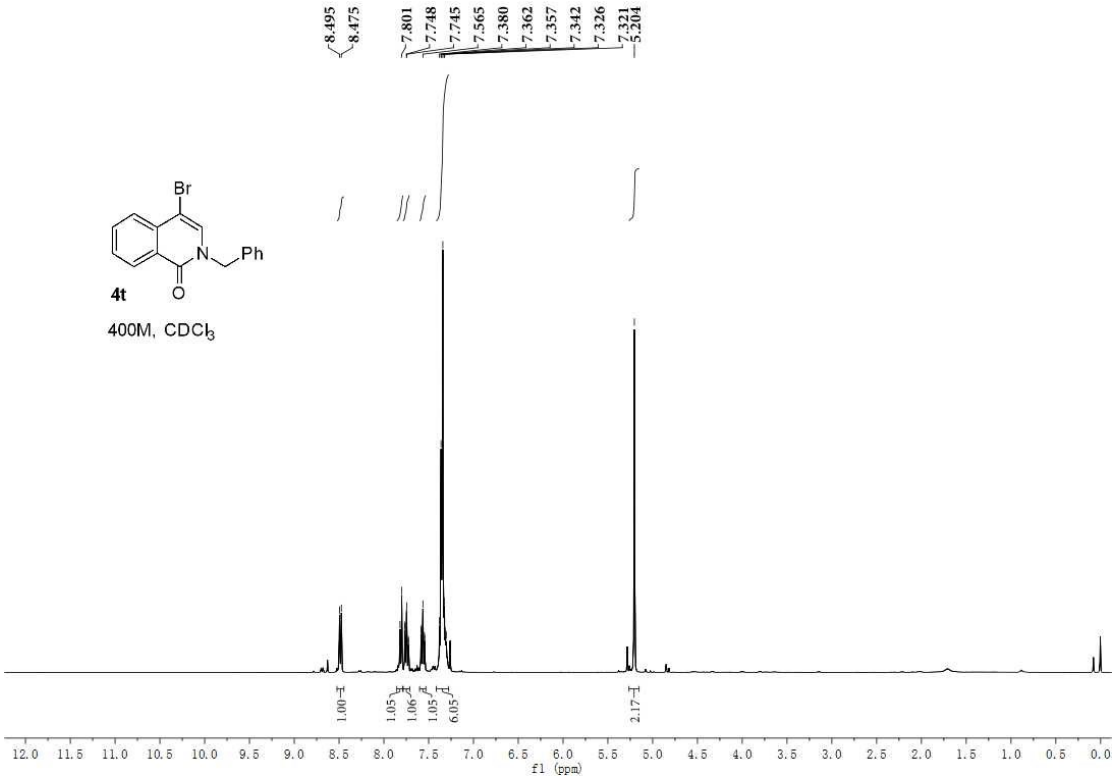
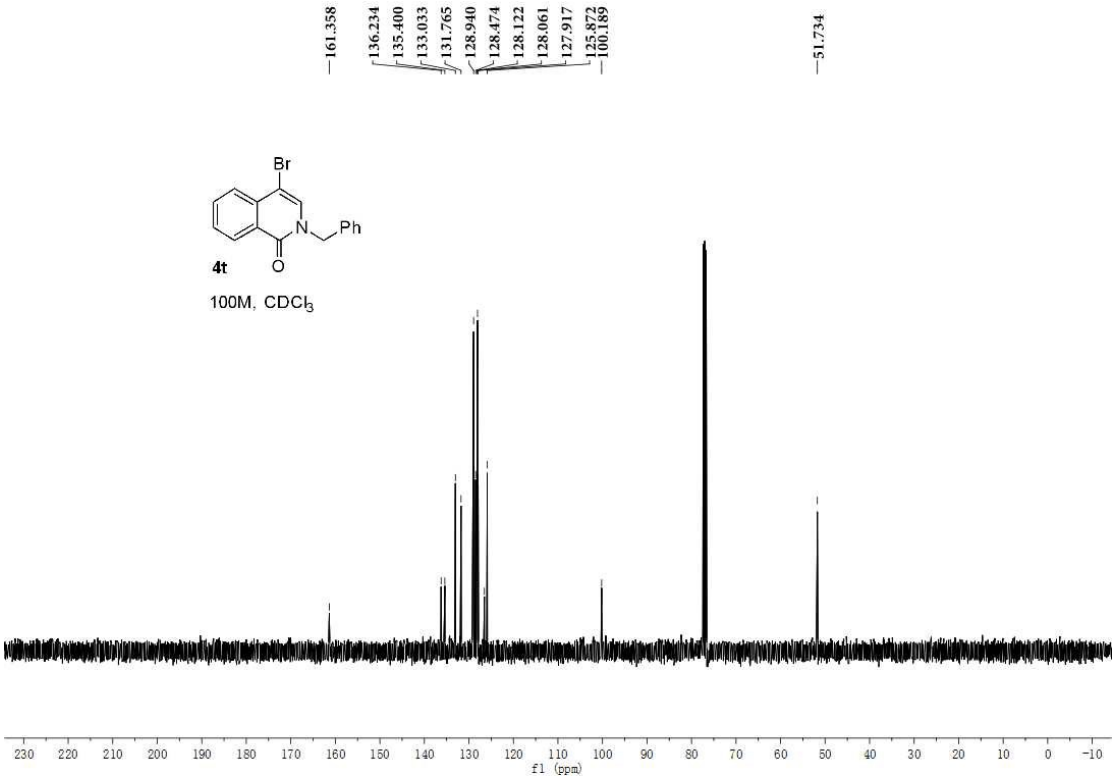
158.605
156.092
133.527
132.303
130.660
128.997
128.713
128.264
126.080
124.869
100.485
Br
F
N
O
4r
f1 (ppm)


8.439
8.437
8.436
8.419
8.417
7.799
7.779
7.737
7.733
7.719
7.716
7.699
7.695
7.549
7.546
7.528
7.511
7.508
7.330
3.990
3.972
3.953
1.783
1.765
1.751
1.746
1.740
1.727
1.708
1.438
1.419
1.400
1.381
1.362
1.344
0.969
0.951
0.932
Br
N
O
4s
400M, CDCl3
0.87
0.97
0.93
0.95
0.88
2.00
2.08
2.09
3.00
f1 (ppm)


161.161
135.369
132.780
132.230
128.225
127.704
125.702
109.985
99.568
49.194
31.366
19.927
13.716
Br
N
O
4s
100M, CDCl3
f1 (ppm)


8.495
8.475
7.801
7.748
7.745
7.565
7.380
7.362
7.357
7.342
7.326
7.321
5.204
Br
N
Ph
O
4t
400M, CDCl3
1.00
1.05
1.06
1.05
6.05
2.17
f1 (ppm)


161.358
136.234
135.400
133.033
131.765
128.940
128.474
128.122
128.061
127.917
125.872
100.189
51.734
Br
N
Ph
O
4t
100M, CDCl3
f1 (ppm)