**Supporting Information for**

# Ni-Catalyzed C($sp^2$)−H alkylation of *N*-Quinolylbenzamide using alkylsilyl peroxides as structurally diverse alkyl sources

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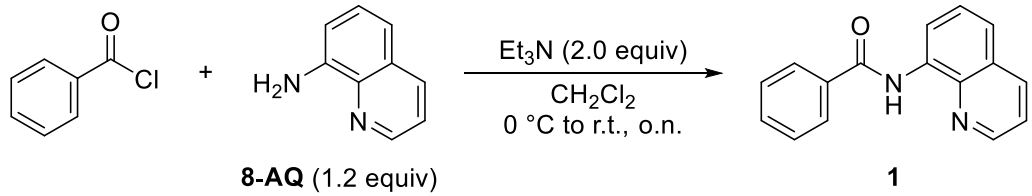
## 1. General Information

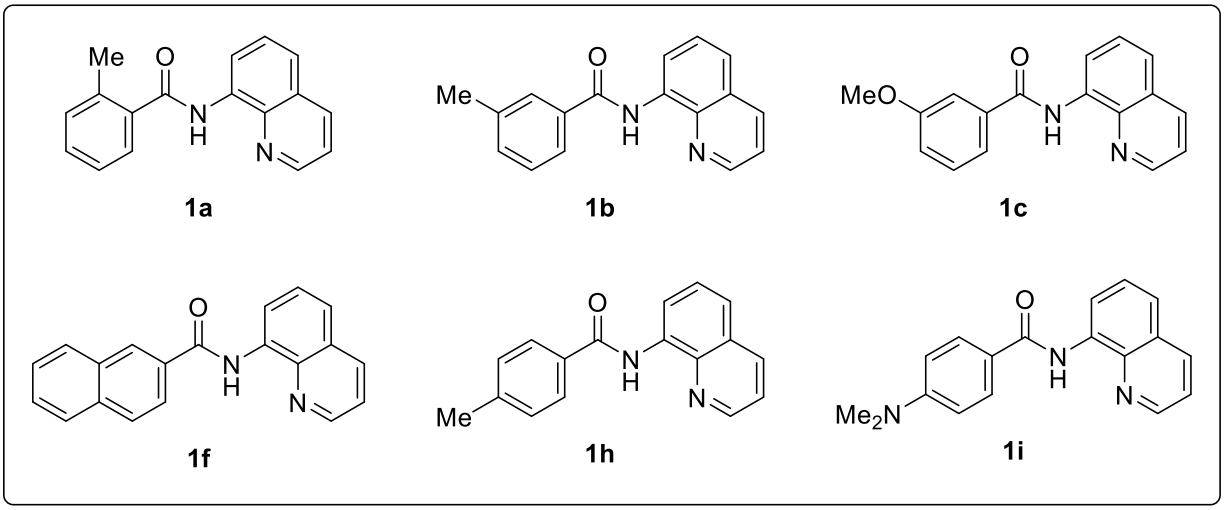
$^{1}H$ NMR spectra were measured on JEOL JNM-ECA500 (500 MHz) spectrometer. Data were reported as follows: chemical shifts in ppm from tetramethylsilane as an internal standard in $CDCl_3$, integration, multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet, dd = doublet-doublet, dt = doublet-triplet, ddd = doublet-doublet-doublet), coupling constants (Hz), and assignment. $^{13}C$ NMR spectra were measured on JEOL JNM-ECA500 (125 MHz) spectrometer with complete proton decoupling. Chemical shifts were reported in ppm from the residual solvent as an internal standard. High-resolution mass spectra (HRMS) were performed on Brucker micrOTOF. For thin layer chromatography (TLC) analysis throughout this work, Merck precoated TLC plates (Merck, TLC Silica gel 60 $F_{254}$) were used. The products were purified by flash column chromatography on silica gel (Kanto Chemical, Silica gel 60 N, spherical, neutral, 40-50 μm or FUJIFILM Wako, Wakosil®, 60, spherical, 64-210 μm) or preparative thin layer chromatography silica gel (PLC 60 F254. 0.5 mm). Commercially available reagents and solvents were purchased from CHEM-IMPEX INT'L INC., FUJIFILM Wako, Oakwood Chemical, Sigma-Aldrich and TCI, and used as received. DMF was used a Super Dehydrated DMF purchased from FUJIFILM Wako. Alkylsilyl peroxides (ASPs) were prepared according to the literate procedures.[1] All reactions were performed under $N_2$ atmosphere, and NMR yields were determined by $^{1}H$ NMR spectroscopy using 1,1,2,2-tetrachloroethane as an internal standard.

## 2. General Procedure for the Preparation of *N*-Quinolylbenzamide Substrates

All aromatic amides bearing an 8-aminoquinoline moiety were prepared by general procedures A or B.[2,3] Spectral data of **1a**–**1k** matched those previously reported in the literatures.[2–4]

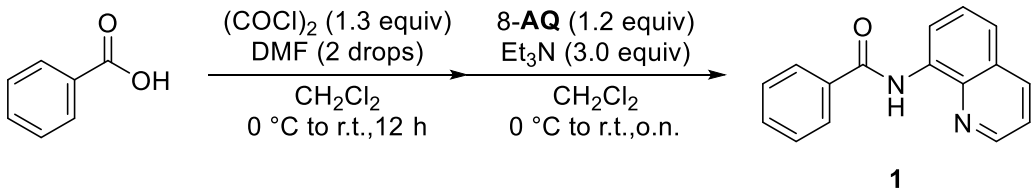
### General Procedure A



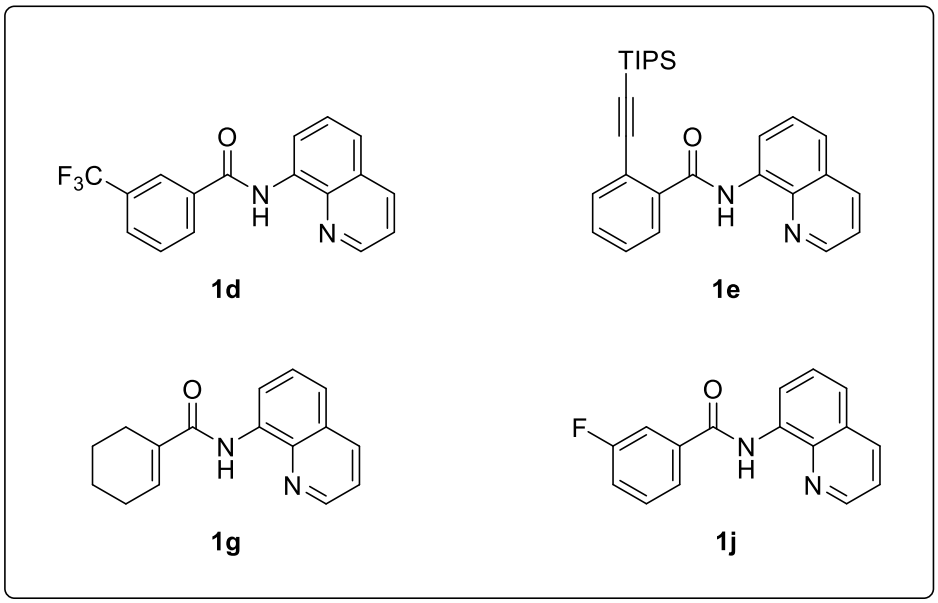




To an oven-dried side-arm flask were added 8-aminoquinoline (**8-AQ**, 1.2 equiv), $Et_3N$ (2.0 equiv) and dry $CH_2Cl_2$ (1.0 M), and the resulting solution was stirred at 0 ℃ for 10 minutes. To the reaction mixture was added a solution of acid chloride in $CH_2Cl_2$ dropwisely at 0 °C, and the solution was then warmed to room temperature. After being stirred overnight, the reaction mixture was quenched with sat. $NH_4Cl$ aq. and the organic layer was extracted with EtOAc three times. The combined organic layers were dried over $Na_2SO_4$ and concentrated in vacuo. The residue was purified by flash column chromatography on silica gel (hexane / EtOAc =5 / 1 –2 / 1) to afford desired aromatic amides **1**.

**General Procedure B**




**1**

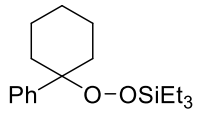



**1d** **1e** **1g** **1j**

To an oven-dried side-arm flask were added benzoic acid, DMF (2 drops) and dry $CH_2Cl_2$ (0.3 M) under $N_2$ atmosphere. Oxalyl chloride (1.3 equiv) was added dropwise at 0 °C. The reaction mixture was stirred at room temperature for 12 h. The resulting acid chloride was used immediately without further purification. To another oven-dried side-arm flask were added 8-aminoquinoline (**8-AQ**, 1.2 equiv), $Et_3N$ (3.0 equiv) and dry $CH_2Cl_2$ (1.0 M), and the resulting solution was stirred at 0 ℃ for 10 minutes. To the reaction mixture was added a solution of the acid chloride in $CH_2Cl_2$ dropwisely at 0 °C, and the solution was then warmed to room temperature. After being stirred overnight, the reaction mixture was quenched with sat. $NH_4Cl$ aq. and the organic layer was extracted with EtOAc three times. The combined organic layers were dried over $Na_2SO_4$ and concentrated *in vacuo*. The residue was purified by flash column chromatography on silica gel (hexane / EtOAc =5 / 1 –3 / 1) to afford desired aromatic amides **1**.

## 3. Characterization Data of Unreported Alkylsilyl Peroxides

**Triethyl((1-phenylcyclohexyl)peroxy)silane (2b)**



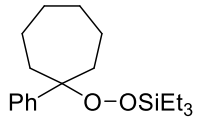

Colorless oil.

**$^1$H NMR** (500 MHz, $CDCl_3$) $\delta$ 7.46 (2H, d, $J$ = 7.4 Hz), 7.31 (2H, t, $J$ = 7.7 Hz), 7.23 (1H, t, $J$ = 7.4 Hz), 2.17-2.14 (2H, m), 1.80-1.67 (5H, m), 1.55-1.51 (2H, m), 1.31-1.26 (1H, m), 0.93 (9H, t, $J$ = 7.9 Hz), 0.65 (6H, q, $J$ = 7.9 Hz).

**$^{13}$C NMR** (125 MHz, $CDCl_3$) $\delta$ 146.0, 127.9, 126.8, 126.2, 83.9, 34.5, 25.8, 22.3, 6.9, 3.9.

**HRMS (ESI)** calculated for $C_{18}H_{30}O_2SiNa$: *m/z* 329.1907 ([M + Na]$^+$), found: *m/z* 329.1908 ([M + Na]$^+$).

**Triethyl((1-phenylcycloheptyl)peroxy)silane (2e)**



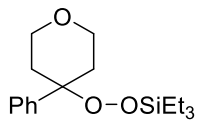

Colorless oil.

**$^1$H NMR** (500 MHz, $CDCl_3$) $\delta$ 7.47-7.44 (2H, m), 7.32-7.29 (2H, m), 7.23-7.20 (1H, m), 2.13 (2H, ddd, $J$ = 14.9, 9.0, 1.3 Hz), 2.02 (2H, ddd, $J$ = 14.9, 9.8, 1.3 Hz), 1.79-1.72 (2H, m), 1.69-1.62 (2H, m), 1.59-1.49 (4H, m), 0.95 (9H, t, $J$ = 7.9 Hz), 0.67 (6H, q, $J$ = 7.9 Hz).

**$^{13}$C NMR** (125 MHz, $CDCl_3$) $\delta$ 147.2, 127.9, 126.6, 126.1, 88.7, 38.2, 30.6, 23.2, 6.9, 3.9.

**HRMS (ESI)** calculated for $C_{19}H_{32}O_2SiNa$: *m/z* 343.2064 ([M + Na]$^+$), found: *m/z* 343.2068 ([M + Na]$^+$).

**Triethyl((4-phenyltetrahydro-2*H*-pyran-4-yl)peroxy)silane (2f)**



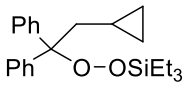

Colorless oil.

**$^1$H NMR** (500 MHz, $CDCl_3$) $\delta$ 7.44 (2H, d, $J$ = 7.7 Hz), 7.34 (2H, t, $J$ = 7.5 Hz), 7.28-7.26 (3H, m), 3.87-3.79 (4H, m), 2.18 (2H, m), 2.11-2.04 (2H, m), 0.90 (9H, t, $J$ = 7.9 Hz), 0.63 (6H, q, $J$ = 7.9 Hz).

**$^{13}$C NMR** (125 MHz, $CDCl_3$) $\delta$ 144.5, 128.1, 127.4, 126.0, 81.2, 64.1, 34.3, 6.8, 3.9.

**HRMS (ESI)** calculated for $C_{17}H_{28}O_3SiNa$: *m/z* 331.1700 ([M + Na]$^+$), found: *m/z* 331.1701 ([M + Na]$^+$).

**((2-Cyclopropyl-1,1-diphenylethyl)peroxy)triethylsilane (2h)**



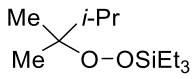

Colorless oil.

**$^1$H NMR** (500 MHz, $CDCl_3$) $\delta$ 7.32-7.30 (4H, m), 7.28-7.24 (4H, m), 7.23-7.20 (2H, m), 2.36 (2H, d, $J$ = 6.5 Hz), 1.30-1.26 (1H, m), 0.86 (9H, t, $J$ = 7.9 Hz), 0.56 (6H, q, $J$ = 7.9 Hz), 0.25-0.22 (2H, m), −0.11- −0.14 (2H, m).

**$^{13}$C NMR** (125 MHz, $CDCl_3$) $\delta$ 144.5, 127.9, 127.5, 126.9, 89.3, 41.4, 6.8, 6.1, 4.7, 3.9.

**HRMS (ESI)** calculated for $C_{23}H_{32}O_2SiNa$: *m/z* 391.2064 ([M + Na]$^+$), found: *m/z* 391.2064 ([M + Na]$^+$).

**((2,3-Dimethylbutan-2-yl)peroxy)triethylsilane (2i)**



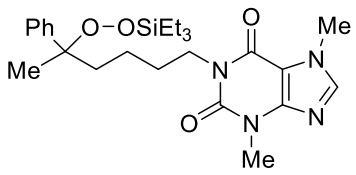

Colorless oil.

**$^1$H NMR** (500 MHz, $CDCl_3$) $\delta$ 1.96-1.90 (1H, m), 1.12 (6H, s), 0.98 (9H, t, $J$ = 7.9 Hz), 0.87 (6H, d, $J$ = 7.1 Hz), 0.66 (6H, q, $J$ = 7.9 Hz).

**$^{13}$C NMR** (125 MHz, $CDCl_3$) $\delta$ 85.0, 34.6, 21.3, 17.7, 7.0, 4.0.

**HRMS (ESI)** calculated for $C_{12}H_{28}O_2SiNa$: *m/z* 255.1751 ([M + Na]$^+$), found: *m/z* 255.1751 ([M + Na]$^+$).

**3,7-Dimethyl-1-(5-phenyl-5-((triethylsilyl)peroxy)hexyl)-3,7-dihydro-1*H*-purine-2,6-dione (2j)**



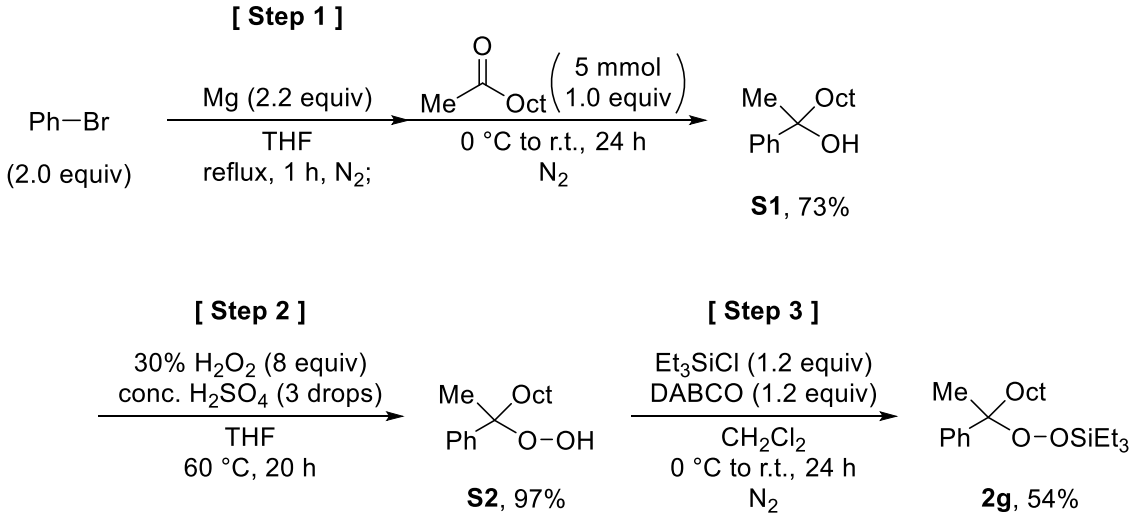

Colorless oil.

**$^1$H NMR** (500 MHz, $CDCl_3$) $\delta$ 7.48 (1H, s), 7.36 (2H, d, $J$ = 7.5 Hz), 7.30 (2H, t, $J$ = 7.7 Hz), 7.21 (1H, t, $J$ = 7.5 Hz), 3.97 (3H, s), 3.92 (2H, t, $J$ = 7.8 Hz), 3.55 (3H, s), 1.92-1.78 (2H, m), 1.61 (3H, s), 1.56 (2H, m), 1.31-1.22 (2H, m), 0.97 (9H, t, $J$ = 7.9 Hz), 0.68 (6H, q, $J$ = 7.9 Hz).

**$^{13}$C NMR** (125 MHz, $CDCl_3$) $\delta$ 155.3, 151.5, 148.8, 144.9, 141.5, 127.9, 126.7, 125.9, 107.7, 85.7, 41.3, 40.2, 33.6, 29.7, 28.3, 23.7, 21.4, 6.9, 3.9.

**HRMS (ESI)** calculated for $C_{25}H_{38}O_4N_4SiNa$: *m/z* 509.2555 ($[M + Na]^+$), found: *m/z* 509.2558 ($[M + Na]^+$).

## 4. Synthesis of Triethyl((2-phenyldecan-2-yl)peroxy)silane (2g)




**[ Step 1 ]**

To a suspension of flame-dried Mg turnings (0.27 g, 11 mmol, 2.2 equiv) in dry THF (13 mL) was added PhBr (1.1 mL, 10 mmol, 2.0 equiv) carefully under $N_2$ atmosphere. After being refluxed for 1 h, the obtained solution of PhMgBr was cooled down to 0 °C and then decane-2,3-dione (0.95 mL, 5 mmol, 1.0 equiv) was added dropwisely. After being stirred at room temperature for 24 h, the reaction mixture was quenched with sat. $NH_4Cl$ aq. at 0 °C and extracted with EtOAc three times. The combined organic layers were dried over $Na_2SO_4$ and concentrated *in vacuo*. The residue was purified by flash column chromatography on silica gel (hexane / EtOAc = 8 / 1) to afford **S1** as a colorless oil (0.91 g, 73%). Spectral data of **S1** matched those previously reported in the literature.[5]

**[ Step 2 ]**[6]

To a solution of **S1** (683 mg, 2.8 mmol, 1.0 equiv) in THF (3 mL) was added a mixture of 30% $H_2O_2$ aq. (2.5 mL) with a few drops of conc. $H_2SO_4$ slowly. After being stirred at 60 °C for 20 h, the reaction mixture was diluted with $H_2O$ and then extracted with $CH_2Cl_2$ three times. The combined organic layers were dried over $Na_2SO_4$ and concentrated *in vacuo*. The residue was purified by flash column chromatography on silica gel ($CH_2Cl_2$) to afford hydroperoxide **S2** as a colorless oil (686 mg, 94%). Spectral data of **S2** matched those previously reported in the literature.[6]

**[ Step 3 ]**

To a solution of **S2** (686 mg, 2.6 mmol, 1.0 equiv) and 1,4-diazabicyclo[2.2.2]octane (DABCO, 349 mg, 3.1 mmol, 1.3 equiv) in dry $CH_2Cl_2$ (10 mL) was added $Et_3SiCl$ (523 μL, 3.1 mmol, 1.3

equiv) dropwisely at 0 °C under $N_2$ atmosphere. After being stirred at room temperature for 24 h, the reaction mixture was diluted with $H_2O$ and then extracted with $CH_2Cl_2$ three times. The combined organic layers were dried over $Na_2SO_4$ and concentrated *in vacuo*. The residue was purified by flash column chromatography on silica gel (hexane / $CH_2Cl_2$= 20 / 1) to afford triethyl((2-phenyldecan-2-yl)peroxy)silane (**2g**) as a colorless oil (533 mg, 54%).

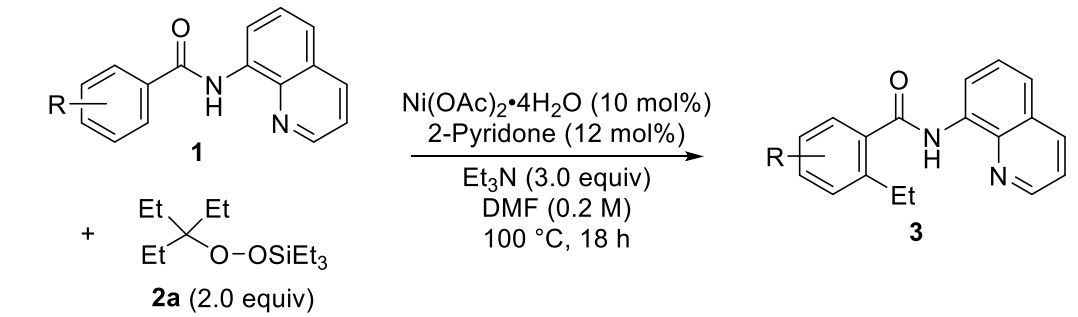
**$^1$H NMR** (500 MHz, $CDCl_3$) $\delta$ 7.39-7.37 (2H, m), 7.33-7.29 (2H, m), 7.24-7.22 (1H, m), 1.80-1.73 (2H, m), 1.60 (3H, s), 1.28-1.12 (12H, m), 0.98 (9H, t, $J$ = 8.0 Hz), 0.86 (3H, *t*, $J$ = 7.5 Hz), 0.68 (6H, q, $J$ = 7.5 Hz).

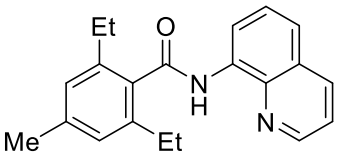
**$^{13}$C NMR** (125 MHz, $CDCl_3$) $\delta$ 145.3, 127.9, 126.7, 126.0, 85.9, 40.6, 32.0, 30.1, 29.6, 29.4, 24.0, 23.6, 22.8, 14.2, 6.9, 4.0.

**HRMS (ESI)** calculated for $C_{22}H_{40}O_2SiNa$: *m/z* 387.2690 ($[M + Na]^+$), found: *m/z* 387.2698 ($[M + Na]^+$).

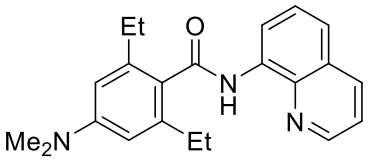
## 5. Optimization of Reaction Conditions

### 5-1. Ethylation Reactions of Benzamides 1h−1j Using 2.0 equiv of ASP 2a without LiBr

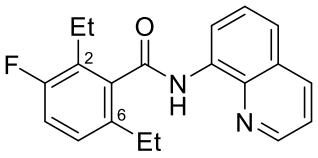



**3h** + **3h'**, 78%
di (**3h**) / mono (**3h'**)
= 44 / 34

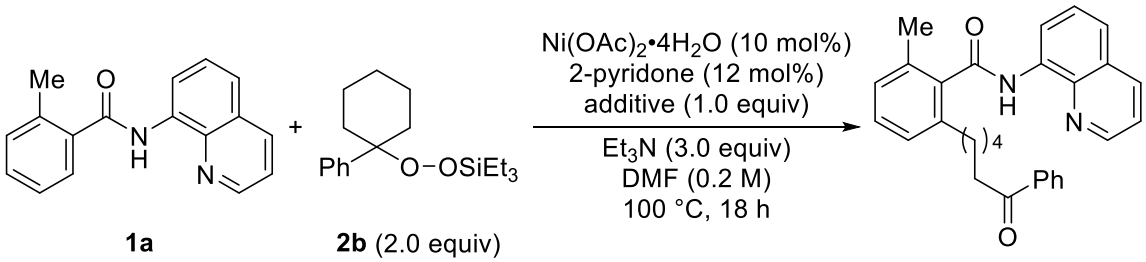



**3i** + **3i'**, 89%
di (**3i**) / mono (**3i'**)
= 57 / 32




**3j** + **3j'**, 79%
di (**3j**) / mono 6-Et (**3j'**)
= 40 / 39

## 5-2. Effect of Additives on the Reaction with Cyclic ASP 2b




**1a** **2b** (2.0 equiv) **3k**

| entry | additive | **1a** (%)[b] | **3k** (%)[b] |
|---|---|---|---|
| 1 | - | 67 | 8 |
| 2 | LiCl | 46 | 43 |
| 3 | LiBr | 0 | 94 (85[c]) |
| 4 | LiI | 84 | 22 |
| 5 | $LiBF_4$ | 75 | 13 |
| 6 | NaBr | trace | 85 |
| 7 | KBr | 53 | 22 |
| 8 | $Bu_4NBr$ | 52 | 37 |

[a]The reactions were performed on a 0.2 mmol scale in DMF (1.0 mL) under a $N_2$ atmosphere. [b]Yields were determined by $^1H$ NMR spectroscopy using 1,1,2,2-tetrachloroethane as an internal standard. [c]Isolated yield.

## 6. General Procedures for Ni-catalyzed AQ-directed C($sp^2$)−H Alkylation Reactions with ASPs

### General Procedure A

To the solution of benzamide **1** (0.2 mmol, 1.0 equiv), $Ni(OAc)_2•4H_2O$ (5.0 mg, 0.02 mmol, 10 mol%), and 2-pyridone (2.3 mg, 0.024 mmol, 12 mol%) in DMF (1.0 mL) were added ASP **2** (0.4 mmol, 2.0 equiv) and $Et_3N$ (84 μL, 0.6 mmol, 3.0 equiv) at room temperature under $N_2$ atmosphere. The reaction mixture was stirred at 100 °C for 18 h. After being cooled to room temperature, the reaction mixture was passed through a short silica gel / $Na_2SO_4$ plug eluting with EtOAc. The obtained solution was concentrated and the residue was purified by flash column chromatography on silica gel to afford desired coupling products.

### General Procedure B

To the solution of benzamide **1** (0.2 mmol, 1.0 equiv), $Ni(OAc)_2•4H_2O$ (5.0 mg, 0.02 mmol, 10 mol%), 2-pyridone (2.3 mg, 0.024 mmol, 12 mol%), and LiBr (17.4 mg, 0.2 mmol, 1.0 equiv) in DMF (1.0 mL) were added ASP **2** (0.4 mmol, 2.0 equiv) and $Et_3N$ (84 μL, 0.6 mmol, 3.0 equiv) at room temperature under $N_2$ atmosphere. The reaction mixture was stirred at 100 °C for 18 h. After being cooled to room temperature, the reaction mixture was passed through a short silica gel / $Na_2SO_4$ plug eluting with EtOAc. The obtained solution was concentrated and the residue was purified by flash column chromatography on silica gel to afford desired coupling products.

### General Procedure C

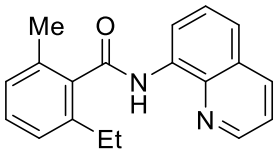
To the solution of benzamide **1** (0.2 mmol, 1.0 equiv), $Ni(OAc)_2•4H_2O$ (5.0 mg, 0.02 mmol, 10 mol%), 2-pyridone (2.3 mg, 0.024 mmol, 12 mol%), and LiBr (17.4 mg, 0.2 mmol, 1.0 equiv) in DMF (1.0 mL) were added ASP **2** (0.8 mmol, 4.0 equiv) and $Et_3N$ (84 μL, 0.6 mmol, 3.0 equiv) at room temperature under $N_2$ atmosphere. The reaction mixture was stirred at 100 °C for 18 h. After being cooled to room temperature, the reaction mixture was passed through a short silica gel / $Na_2SO_4$ plug eluting with EtOAc. The obtained solution was concentrated and the residue was purified by flash column chromatography on silica gel to afford desired coupling products.

### General Procedure D

To the solution of benzamide **1** (0.2 mmol, 1.0 equiv), $Ni(OAc)_2•4H_2O$ (5.0 mg, 0.02 mmol, 10 mol%), 2-pyridone (2.3 mg, 0.024 mmol, 12 mol%), and LiBr (17.4 mg, 0.2 mmol, 1.0 equiv) in DMF (1.0 mL) were added ASP **2** (0.4 mmol, 2.0 equiv) and $Et_3N$ (84 μL, 0.6 mmol, 3.0 equiv) at room temperature under $N_2$ atmosphere. After the reaction mixture was stirred at 100 °C for 9 h, an

additional ASP **2** (0.4 mmol, 2.0 equiv) was added and the mixture was further stirred at 100 °C for 9 h.After being cooled to room temperature, the reaction mixture was passed through a short silica gel / $Na_2SO_4$ plug eluting with EtOAc. The obtained solution was concentrated and the residue was purified by flash column chromatography on silica gel to afford desired coupling products.

**2-Ethyl-6-methyl-*N*-(quinolin-8-yl)benzamide (3a)**

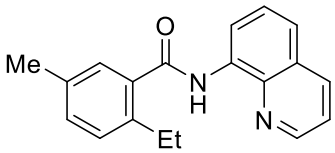



White solid, 46.7 mg, 80% yield (procedure A).

**$^1$H NMR** (500 MHz, $CDCl_3$) $\delta$ 9.93 (1H, s), 9.00 (1H, d, $J$ = 7.4 Hz), 8.74 (1H, dd, $J$ = 4.2, 1.5 Hz), 8.18 (1H, dd, $J$ = 8.2, 1.7 Hz), 7.63-7.56 (2H, m), 7.45 (1H, dd, $J$ = 8.3, 4.3 Hz), 7.30 (1H, t, $J$ = 7.7 Hz), 7.15 (2H, dd, $J$ = 21.7, 7.5 Hz), 2.76 (2H, q, $J$ = 7.6 Hz), 2.43 (3H, s), 1.27 (3H, t, $J$ = 7.5 Hz).

The spectral data of this compound are consistent with those previously reported in the literature.[2]

**2-Ethyl-5-methyl-*N*-(quinolin-8-yl)benzamide (3b)**

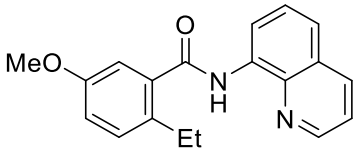



Colorless oil, 42.0 mg, 72% yield (procedure A).

**$^1$H NMR** (500 MHz, $CDCl_3$) $\delta$ 10.14 (1H, s), 8.95 (1H, d, $J$ = 7.7 Hz), 8.78 (1H, dd, $J$ = 4.1, 1.6 Hz), 8.18 (1H, dd, $J$ = 8.4, 1.6 Hz), 7.62-7.54 (2H, m), 7.47-7.44 (2H, m), 7.25 (2H, s), 2.90 (2H, q, $J$ = 7.6 Hz), 2.40 (3H, s), 1.28 (3H, t, $J$ = 7.5 Hz).

The spectral data of this compound are consistent with those previously reported in the literature.[7]

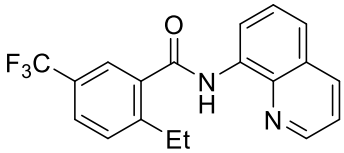
**2-Ethyl-5-methoxy-*N*-(quinolin-8-yl)benzamide (3c)**




White solid, 44.4 mg, 72% yield (procedure A).

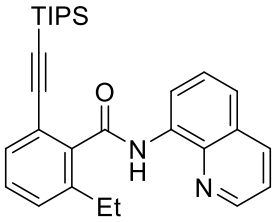
**$^1$H NMR** (500 MHz, $CDCl_3$) $\delta$ 10.17 (1H, s), 8.95 (1H, d, $J$ = 6.8 Hz), 8.77 (1H, dd, $J$ = 4.3, 2.0 Hz), 8.18 (1H, dd, $J$ = 8.2, 1.4 Hz), 7.60-7.54 (2H, m), 7.45 (1H, m), 7.27-7.26 (1H, m), 7.18 (1H, d, $J$ = 2.6 Hz), 6.99 (1H, dd, $J$ = 8.5, 2.6 Hz), 3.85 (3H, s), 2.87 (2H, q, $J$ = 7.8 Hz), 1.28 (3H, t, $J$ = 7.7 Hz).
The spectral data of this compound are consistent with those previously reported in the literature.[7]

**2-Ethyl-*N*-(quinolin-8-yl)-5-(trifluoromethyl)benzamide (3d)**



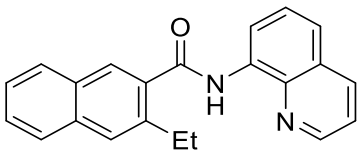

White solid, 50.4 mg, 73% yield (procedure A).
**$^1$H NMR** (500 MHz, $CDCl_3$) $\delta$ 10.18 (1H, s), 8.92 (1H, dd, $J$ = 6.8, 1.7 Hz), 8.79 (1H, dd, $J$ = 4.5, 1.5 Hz), 8.20 (1H, dd, $J$ = 8.4, 1.6 Hz), 7.87 (1H, s), 7.69 (1 H, d, $J$ = 6.8 Hz), 7.64-7.58 (2H, m), 7.48 (2H, q, $J$ = 4.2 Hz), 2.99 (2H, q, $J$ = 7.6 Hz), 1.33 (3H, t, $J$ = 7.5 Hz).
The spectral data of this compound are consistent with those previously reported in the literature.[8]

**2-Ethyl-*N*-(quinolin-8-yl)-6-((triisopropylsilyl)ethynyl)benzamide (3e)**




Colorless oil, 72.2 mg, 79% yield (procedure A).
**$^1$H NMR** (500 MHz, $CDCl_3$) $\delta$ 10.07 (1H, s), 9.00 (1H, dd, $J$ = 7.4, 1.4 Hz), 8.73 (1H, dd, $J$ = 4.1, 1.6 Hz), 8.16 (1H, dd, $J$ = 8.2, 1.7 Hz), 7.60-7.53 (2H, m), 7.44-7.41 (2H, m), 7.35-7.28 (2H, m), 2.79 (2H, q, $J$ = 7.6 Hz), 1.27 (3H, t, $J$ = 7.5 Hz ), 0.78-0.76 (21H, m).
The spectral data of this compound are consistent with those previously reported in the literature.[2]

**3-Ethyl-*N*-(quinolin-8-yl)-2-naphthamide (3f)**

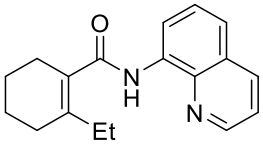



White solid, 46.4 mg, 71% yield (procedure A).

**$^1$H NMR** (500 MHz, $CDCl_3$) $\delta$ 10.32 (1H, s), 8.99 (1H, d, $J$ = 7.7 Hz), 8.77 (1H,m), 8.20 (1H, m), 8.16 (1H, s), 7.91 (1H, d, $J$ = 7.9 Hz), 7.85 (1H, d, $J$ = 7.9 Hz), 7.78 (1H, s), 7.63 (1H, t, $J$ = 7.9 Hz), 7.59-7.45 (4H, m), 3.12 (2H, q, $J$ = 7.6 Hz), 1.37 (3H, t, $J$ = 7.5 Hz).

The spectral data of this compound are consistent with those previously reported in the literature.[9]

**2-Ethyl-*N*-(quinolin-8-yl)cyclohex-1-ene-1-carboxamide (3g)**

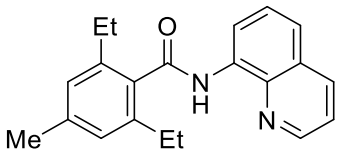



White foam, 36.7 mg, 75% yield (procedure B).

**$^1$H NMR** (500 MHz, $CDCl_3$) $\delta$ 9.84 (1H, s), 8.86 (1H, d, $J$ = 7.7 Hz), 8.81 (1H, dd, $J$ = 4.1, 1.6 Hz), 8.17 (1H, dd, $J$ = 8.4, 1.6 Hz), 7.57-7.50 (2H, m), 7.45 (1H, dd, $J$ = 8.3, 4.2 Hz), 2.43 (2H, s), 2.28 (2H, q, $J$ = 7.5 Hz), 2.17-2.14 (2H, m), 1.74-1.67 (4H, m), 1.12 (3H, t, $J$ = 7.5 Hz).

The spectral data of this compound are consistent with those previously reported in the literature.[9]

**2,6-Diethyl-4-methyl-*N*-(quinolin-8-yl)benzamide (3h)**



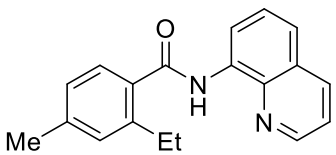

Colorless oil, 45.5 mg, 71% yield (procedure C).

**$^1$H NMR** (500 MHz, $CDCl_3$) $\delta$ 9.94 (1H, s), 8.99 (1H, d, $J$ = 7.4 Hz), 8.72 (1H, dd, $J$ = 3.8, 1.3 Hz), 8.17 (1H, dd, $J$ = 8.2, 1.4 Hz), 7.62-7.55 (2H, m), 7.44 (1H, dd, $J$ = 6.3, 4.2 Hz), 6.99 (2H, s), 2.86-2.25 (4H, q, $J$ = 7.5 Hz), 2.38 (3H, s), 1.27 (6H, t, $J$ = 7.5 Hz).

**$^{13}$C NMR** (125 MHz, $CDCl_3$) $\delta$ 169.3, 148.4, 140.9, 139.2, 138.6, 136.4, 134.7, 134.6, 128.1, 127.6, 127.0, 121.9, 121.8, 116.8, 26.6, 21.5, 16.1.

**HRMS (ESI)** calculated for $C_{21}H_{23}ON_2$: *m/z* 319.1805 ($[M + H]^+$), found: *m/z* 319.1806 ($[M + H]^+$).

**2-Ethyl-4-methyl-*N*-(quinolin-8-yl)benzamide (3h')**

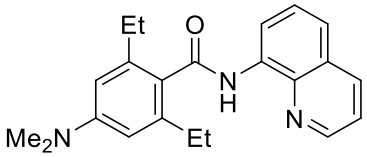



Colorless oil, 20.0 mg, 34% yield (procedure A).

**$^1$H NMR** (500 MHz, $CDCl_3$) $\delta$ 10.18 (1H, s), 8.94 (1H, d, $J$ = 7.1 Hz), 8.77 (1H, dd, $J$ = 4.1, 0.8 Hz), 8.18 (1H, dt, $J$ = 8.2, 1.3 Hz), 7.61-7.53 (3H, m), 7.45 (1H, m), 7.16-7.12 (2H, m), 2.93 (2H, q, $J$ = 7.6 Hz), 2.41 (3H, s), 1.30 (3H, t, $J$ = 7.7 Hz).

The spectral data of this compound are consistent with those previously reported in the literature.[8]

**4-(Dimethylamino)-2,6-diethyl-*N*-(quinolin-8-yl)benzamide (3i)**



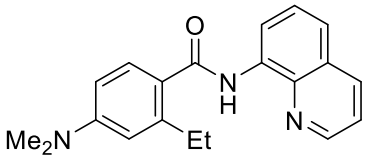

Yellow oil, 50.9 mg, 73% yield (procedure C).

**$^1$H NMR** (500 MHz, $CDCl_3$) $\delta$ 9.94 (1H, s), 9.00 (1H, d, $J$ = 7.4 Hz), 8.71 (1H, dd, $J$ = 4.3, 2.0 Hz), 8.16 (1H, dd, $J$ = 8.2, 1.7 Hz), 7.60 (1H, t, $J$ = 7.9 Hz), 7.55-7.53 (1H, m), 7.43 (1H, dd, $J$ = 8.5,4.2 Hz), 6.51 (2H, s), 3.01 (6H, s), 2.73 (4H, q, $J$ = 7.5Hz), 1.27 (6H, t, $J$ = 7.5 Hz).

**$^{13}$C NMR** (125 MHz, $CDCl_3$) $\delta$ 169.8, 151.2, 148.3, 142.3, 138.6, 136.4, 135.0, 128.1, 127.6, 126.3, 121.7, 121.6, 116.6, 110.2, 40.6, 27.3, 16.3.

**HRMS (ESI)** calculated for $C_{22}H_{26}ON_3$: *m/z* 348.2070 ($[M + H]^+$), found: *m/z* 348.2075 ($[M + H]^+$).

**4-(Dimethylamino)-2-ethyl-*N*-(quinolin-8-yl)benzamide (3i')**

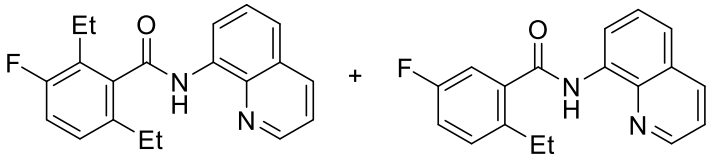



Yellow oil, 20.3 mg, 32% yield (procedure A).

**$^1$H NMR** (500 MHz, $CDCl_3$) $\delta$ 10.21 (1H, s), 8.92 (1H, d, $J$ = 7.7 Hz), 8.77 (1H, dd, $J$ = 4.0, 1.4 Hz), 8.17 (1H, dd, $J$ = 8.2, 1.4 Hz), 7.65 (1H, d, $J$ = 9.1 Hz), 7.58 (1H, t, $J$ = 7.9 Hz), 7.51 (1H, d, $J$ = 7.4 Hz), 7.44 (1H, dd, $J$ = 4.2 Hz), 6.64-6.62 (2H, m), 3.18-2.89 (8H, m), 1.33 (3H, t, $J$ = 7.5 Hz).

The spectral data of this compound are consistent with those previously reported in the literature.[9]

**2,6-Diethyl-3-fluoro-*N*-(quinolin-8-yl)benzamide (3j)** and **2-Ethyl-5-fluoro-*N*-(quinolin-8-yl)benzamide (3j')**



Colorless oil, 48.7 mg, 79% yield (**3j**: 40%, **3j'**: 39%, procedure A).

33.0 mg, 52% yield (**3j**: 44%, **3j'**: 8%, procedure C).

Each product was characterized by analyzing the $^1$H NMR of a mixture of products, **3j** / **3j'** = 1.0 / 0.96.

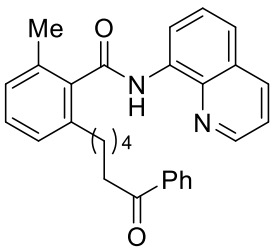
**$^1$H NMR** (500 MHz, $CDCl_3$) $\delta$ 10.16 (0.96H, s), 9.95 (1H, s), 8.97 (1H, dd, $J$ = 7.2, 1.6 Hz), 8.92 (0.96H, $J$ = 7.2, 1.6 Hz), 8.79 (0.96H, dd , $J$ = 4.5, 2.0 Hz), 8.74 (1H, dd , $J$ = 4.5, 2.0 Hz), 8.20 (1.96H, m), 7.64-7.57 (3.92H, m), 7.49-7.45 (1.92H, m), 7.36-7.28 (1.96H, m), 7.16-7.12 (1.96H, m), 7.07 (1H, t, $J$ = 9.5 Hz), 2.90 (1.92H, q, $J$ = 7.6 Hz), 2.71 (4H, q, $J$ = 7.6 Hz), 1.31-1.23 (8.76H, m).

**$^{13}$C NMR** (125 MHz, $CDCl_3$) $\delta$ 167.5, 167.1, 160.8 (d, $J$ = 247 Hz), 159.6 (d, $J$ = 245 Hz), 148.5 (Two peaks were overlapped.), 138.7 (d, $J$ = 3.6 Hz), 138.6, 138.5, 137.8 (d, $J$ = 6.0 Hz), 136.54 (Two peaks were overlapped.), 136.51, 136.4 (d, $J$ = 3.6 Hz), 134.6, 134.3, 131.5 (d, $J$ = 7.2 Hz), 128.1(Two peaks were overlapped.), 128.0, 127.8, 127.7, 127.5 (Two peaks were overlapped.), 122.3, 122.2, 121.9 (Two peaks were overlapped.), 117.3 (d, $J$ = 20 Hz), 116.9, 116.8, 116.2 (d, $J$ = 23 Hz), 114.3 (d, $J$ = 23 Hz), 26.1, 26.0, 20.9 (d, $J$ = 2.4 Hz), 16.3, 16.1, 15.5.

**HRMS (ESI) (3j)** calculated for $C_{20}H_{20}ON_2F$: *m/z* 323.1554 ($[M + H]^+$), found: *m/z* 323.1554 ($[M + H]^+$).

**HRMS (ESI) (3j')** calculated for $C_{18}H_{16}ON_2F$: *m/z* 295.1241 ($[M + H]^+$), found: *m/z* 295.1249 ($[M + H]^+$).

**2-Methyl-6-(6-oxo-6-phenylhexyl)-*N*-(quinolin-8-yl)benzamide (3k)**



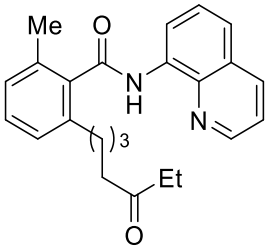

Yellow oil, 74.6 mg, 85% yield (procedure B).

**$^1$H NMR** (500 MHz, $CDCl_3$) $\delta$ 9.92 (1H, s), 8.97 (1H, dd, $J$ = 7.1, 1.7 Hz), 8.71 (1H, dd, $J$ = 4.1, 1.6 Hz), 8.16 (1H, dd, $J$ = 8.2, 1.7 Hz), 7.86 (2H, dd, $J$ = 8.3, 1.3 Hz), 7.60-7.51 (3H, m), 7.43-7.40 (3H, m), 7.30-7.26 (2H, m), 7.13 (2H, dd, $J$ = 10.1, 7.8 Hz), 2.83 (2H, t, $J$ = 7.4 Hz), 2.74 (2H, t, $J$ = 7.8 Hz), 2.43 (3H, s), 1.77-1.71 (2H, m), 1.69-1.63 (2H, m), 1.41-1.35 (2H, m).

**$^{13}$C NMR** (125 MHz, $CDCl_3$) $\delta$ 200.5, 169.0, 148.4, 139.4, 138.6, 137.9, 137.1, 136.5, 134.7, 134.5, 133.0, 129.2, 128.6, 128.4, 128.2, 128.0, 127.6, 127.0, 122.1, 121.8, 116.9, 38.5, 33.5, 31.5, 29.3, 24.2, 19.7.

**HRMS (ESI)** calculated for $C_{29}H_{29}O_2N_2$: *m/z* 437.2224 ($[M + H]^+$), found: *m/z* 437.2219 ($[M + H]^+$).

**2-Methyl-6-(5-oxoheptyl)-*N*-(quinolin-8-yl)benzamide (3l)**



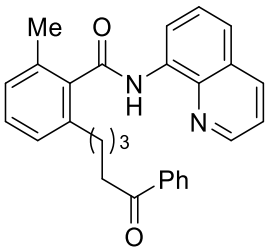

Yellow oil, 63.1 mg, 84% yield (procedure B).

**$^1$H NMR** (500 MHz, $CDCl_3$) $\delta$ 9.91 (1H, s), 8.98 (1H, dd, $J$ = 7.5, 1.6 Hz), 8.74 (1H, dd , $J$ = 4.3, 2.0 Hz), 8.19 (1H, dd, $J$ = 8.2, 1.7 Hz), 7.63-7.56 (2H, m), 7.45 (1H, dd, $J$ = 8.3, 4.2 Hz), 7.29-7.26 (1H, m), 7.13 (2H, t, $J$ = 6.7 Hz), 2.71 (2H, t, $J$ = 7.8 Hz), 2.42 (3H, s), 2.29 (2H, t, $J$ = 7.5 Hz), 2.25 (2H, q, $J$ = 7.4 Hz), 1.70-1.64 (2H, m), , 1.57-1.53 (2H, m), 0.92 (3H, t, $J$ = 7.4 Hz).

**$^{13}$C NMR** (125 MHz, $CDCl_3$) $\delta$ 211.6, 168.9, 148.4, 138.9, 138.6, 137.8, 136.4, 134.6, 134.4, 129.2, 128.1, 128.0, 127.5, 126.9, 122.1, 121.8, 116.8, 42.1, 35.8, 33.3, 31.3, 23.7, 19.6, 7.8.

**HRMS (ESI)** calculated for $C_{24}H_{26}O_2N_2Na$: *m/z* 397.1886 ($[M + Na]^+$), found: *m/z* 397.1885 ($[M + Na]^+$).

**2-Methyl-6-(5-oxo-5-phenylpentyl)-*N*-(quinolin-8-yl)benzamide (3m)**



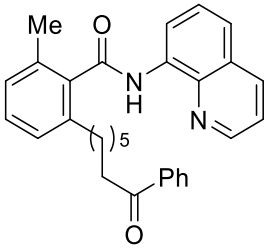

Yellow oil, 68.6 mg, 81% yield (procedure B).

**$^1$H NMR** (500 MHz, $CDCl_3$) $\delta$ 9.93 (1H, s), 8.99 (1H, dd, $J$ = 7.4, 1.4 Hz), 8.71 (1H, dd, $J$ = 4.3, 1.4 Hz), 8.17 (1H, dd, $J$ = 8.2, 1.7 Hz), 7.76-7.75 (2H, m), 7.63-7.56 (2H, m), 7.51-7.48 (1H, m), 7.42 (1H, dd, $J$ = 8.3, 4.2 Hz), 7.36 (2H, t, $J$ = 7.8 Hz), 7.30-7.27 (1H, m), 7.14 (2H, dd, $J$ = 16.9, 7.8 Hz), 2.85 (2H, t, $J$ = 7.2 Hz), 2.77 (2H, t, $J$ = 7.7 Hz), 2.43 (3H, s), 1.83-1.70 (4H, m).

**$^{13}$C NMR** (125 MHz, $CDCl_3$) $\delta$ 200.2, 169.0, 148.4, 139.0, 138.6, 137.9, 137.0, 136.4, 134.7, 134.5, 132.9, 129.2, 128.5, 128.1, 128.04, 128.01, 127.5, 126.9, 122.1, 121.8, 116.9, 38.3, 33.3, 31.3, 24.0, 19.6.

**HRMS (ESI)** calculated for $C_{28}H_{26}O_2N_2Na$: *m/z* 445.1886 ([M + Na]$^+$), found: *m/z* 445.1887 ([M + Na]$^+$).

**2-Methyl-6-(7-oxo-7-phenylheptyl)-*N*-(quinolin-8-yl)benzamide (3n)**



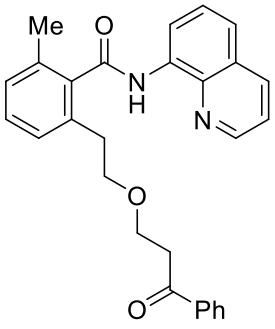

Yellow oil, 79.0 mg, 88% yield (procedure B).

**$^1$H NMR** (500 MHz, $CDCl_3$) $\delta$ 9.93 (1H, s), 8.99 (1H, dd, $J$ = 7.5, 1.3 Hz), 8.72 (1H, dd, $J$ = 4.1, 1.6 Hz), 8.14 (1H, dd, $J$ = 8.5, 1.4 Hz), 7.87 (2H, dd, $J$ = 8.4, 1.3 Hz), 7.60 (1H, t, $J$ = 7.9 Hz), 7.56-7.53 (2H, m), 7.45-7.40 (3H, m), 7.29-7.26 (1H, m), 7.13 (2H, dd, $J$ = 10.6, 7.8 Hz), 2.76 (2H, t, $J$ = 7.4 Hz) , 2.71 (2H, t, $J$ = 7.8 Hz), 2.43 (3H, s), 1.73-1.67 (2H, m), 1.59 (2H, m), 1.35-1.27 (4H, m).

**$^{13}$C NMR** (125 MHz, $CDCl_3$) $\delta$ 200.5, 169.1, 148.5, 139.5, 138.6, 137.9, 137.1, 136.4, 134.7, 134.6, 133.0, 129.2, 128.6, 128.16, 128.13, 127.9, 127.6, 126.9, 122.1, 121.8, 116.9, 38.6, 33.5, 31.7, 29.4, 29.2, 24.2, 19.7.

**HRMS (ESI)** calculated for $C_{30}H_{30}O_2N_2Na$: *m/z* 473.2199 ([M + Na]$^+$), found: *m/z* 473.2193 ([M + Na]$^+$).

**2-Methyl-6-(2-(3-oxo-3-phenylpropoxy)ethyl)-*N*-(quinolin-8-yl)benzamide (3o)**



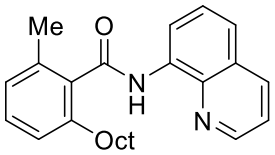

Yellow oil, 20.7 mg, 24% yield (procedure D).

**$^1$H NMR** (500 MHz, $CDCl_3$) $\delta$ 9.96 (1H, s), 8.98 (1H, dd, $J$ = 7.4, 1.0 Hz), 8.72 (1H, dd, $J$ = 4.1, 1.3 Hz), 8.16 (1H, dd, $J$ = 8.2, 1.4 Hz), 7.83 (2H, d, $J$ = 7.4 Hz), 7.62-7.51 (3H, m), 7.43-7.39 (3H, m), 7.28-7.25 (1H, m), 7.15 (2H, dd, $J$ = 16, 7.5 Hz), 3.80 (2H, t, $J$ = 6.5 Hz), 3.75 (2H, t, $J$ = 7.0 Hz), 3.11 (2H, *t*, $J$ = 6.5 Hz), 3.00 (2H, t, $J$ = 7.0 Hz), 2.42 (3H, s).

**$^{13}$C NMR** (125 MHz, $CDCl_3$) $\delta$ 198.6, 168.8, 148.4, 138.7, 138.4, 137.0, 136.5, 135.7, 134.7, 134.5, 133.2, 129.2, 128.6, 128.5, 128.20, 128.16, 127.63, 127.56, 122.2, 121.8, 117.0, 72.0, 66.3, 38.8, 33.9, 19.7.

**HRMS (ESI)** calculated for $C_{28}H_{26}O_3N_2Na$: *m/z* 461.1836 ($[M + Na]^+$), found: *m/z* 461.1831 ($[M + Na]^+$).

**2-Methyl-6-octyl-*N*-(quinolin-8-yl)benzamide (3p)**

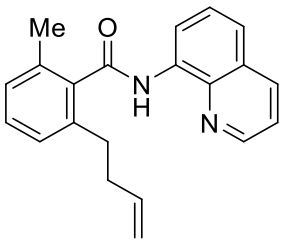



Colorless oil, 45.4 mg, 58% yield (procedure B).

**$^1$H NMR** (500 MHz, $CDCl_3$) $\delta$ 9.92 (1H, s), 8.99 (1H, d, $J$ = 7.7 Hz), 8.73 (1H, d, $J$ = 6.0 Hz), 8.18 (1H, d, $J$ = 8.2 Hz), 7.63-7.56 (2H, m), 7.46-7.42 (1H, m), 7.34 (1H, t, $J$ = 7.5 Hz), 7.15-7.11 (2H, m), 2.70 (2H, t, $J$ = 7.9 Hz), 2.43 (3H, s), 1.68-1.65 (2H, m), 1.25-1.21 (2H, m), 1.16-1.07 (8H, m), 0.78 (3H, t, $J$ = 7.2 Hz).

The spectral data of this compound are consistent with those previously reported in the literature.[3]

**2-(But-3-en-1-yl)-6-methyl-*N*-(quinolin-8-yl)benzamide (3q)**

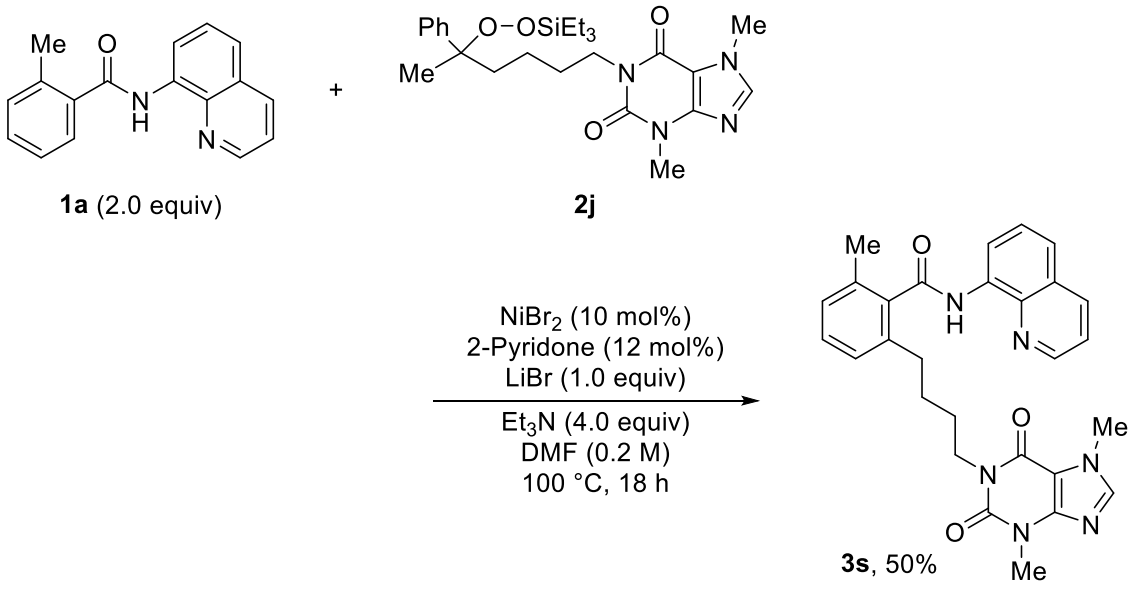



Colorless oil, 34.1 mg, 54% yield (procedure B).

**$^1$H NMR** (500 MHz, $CDCl_3$) $\delta$ 9.93 (1H, s), 8.99 (1H, d, $J$ = 7.7 Hz), 8.74-8.73 (1H, dd, $J$ = 4.0, 1.4 Hz), 8.19 (1H, dd, $J$ = 8.2, 1.1 Hz), 7.63-7.57 (2H, m), 7.45 (1H, dd, $J$ = 8.2, 4.2 Hz), 7.29 (1H, t, $J$ = 7.7 Hz), 7.16-7.13 (2H, m), 5.83-5.74 (1H, m), 4.94-4.86 (2H, m), 2.82 (2H,m), 2.44 (5H, m).

The spectral data of this compound are consistent with those previously reported in the literature.[3]

**7. Synthesis of 2-(4-(3,7-Dimethyl-2,6-dioxo-2,3,6,7-tetrahydro-1*H*-purin-1-yl)butyl)-6-methyl-*N*-(quinolin-8-yl)benzamide (3s)**




To the solution of ASP **2j** (97.3 mg,0.2 mmol, 1.0 equiv), benzamide **1a** (104 mg, 0.4 mmol, 2.0 equiv), $NiBr_2$ (4.4 mg, 0.02 mmol, 10 mol%), 2-pyridone (2.3 mg, 0.024 mmol, 12 mol%), and LiBr (17.4 mg, 0.2 mmol, 1.0 equiv) in DMF (1.0 mL) was added $Et_3N$ (84 μL, 0.6 mmol, 3.0 equiv) at room temperature under $N_2$ atmosphere. The reaction mixture was stirred at 100 °C for 18 h. After being cooled to room temperature, the reaction mixture was passed through a short silica gel / $Na_2SO_4$ plug eluting with EtOAc. The obtained solution was concentrated and the residue was purified by flash column chromatography on silica gel to afford desired coupling products **3s** as a colorless oil (49.5 mg, 50%).

**$^1$H NMR** (500 MHz, $CDCl_3$) $\delta$ 9.90 (1H, s), 8.95 (1H, d, $J$ = 7.4 Hz), 8.71 (1H, dd, $J$ = 4.3, 1.4 Hz), 8.17 (1H, d, $J$ = 8.2 Hz), 7.62-7.55 (2H, m), 7.45 (1H, s), 7.43 (1H, dd, $J$ = 8.3, 4.2 Hz), 7.29-7.26 (1H, m), 7.14 (2H, dd, $J$ = 27.5, 7.7 Hz), 3.97-3.94 (2H, m), 3.93 (3H, s), 3.50 (3H, s), 2.77 (2H, t, $J$ = 7.7 Hz), 2.41 (3H, s), 1.80-1.61 (4H, m).

**$^{13}$C NMR** (125 MHz, $CDCl_3$) $\delta$ 168.9, 155.3, 151.5, 148.8, 148.4, 141.4, 139.1, 138.7, 137.9, 136.4, 134.6, 134.5, 129.2, 128.1, 128.0, 127.6, 127.0, 122.0, 121.8, 117.0, 107.8, 41.3, 33.7, 33.2, 29.8, 29.0, 28.1, 19.7.

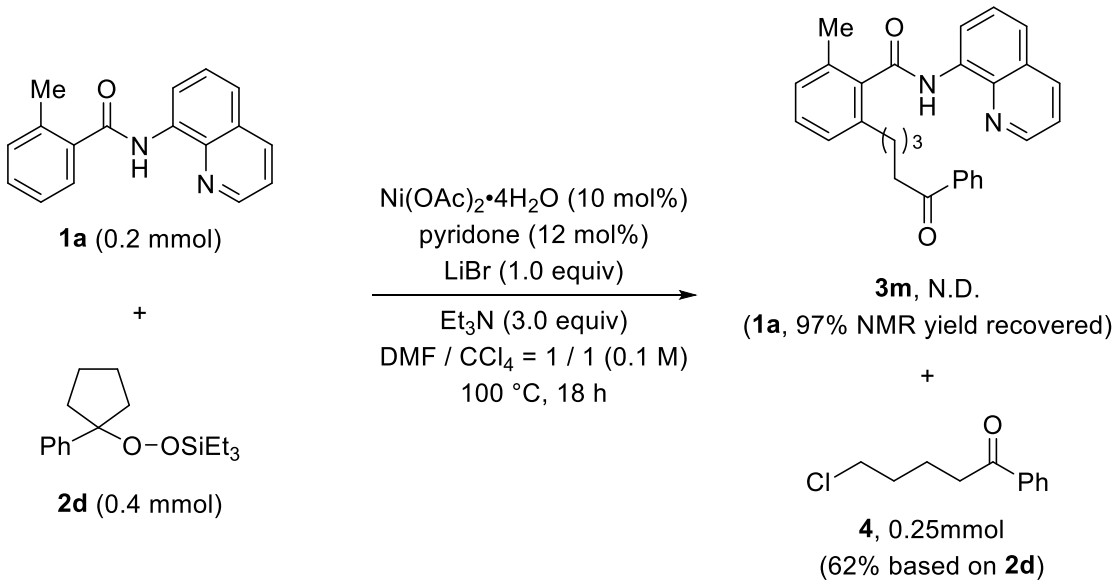
**HRMS (ESI)** calculated for $C_{28}H_{28}O_3N_6Na$: *m/z* 519.2115 ($[M + Na]^+$), found: *m/z* 519.2117 ($[M + Na]^+$).

## 8. Control Experiments

### 8-1. Competition Experiment (Scheme 3-a)

To a solution of benzamide **1c** (55.6 mg, 0.2 mmol, 1.0 equiv), **1d** (63.3 mg, 0.2 mmol, 1.0 equiv), $Ni(OAc)_2$•$4H_2O$ (5.0 mg, 0.02 mmol, 10 mol%), and 2-pyridone (2.3 mg, 0.024 mmol, 12 mol%) in DMF (1.0 mL) were added ASP **2a** (49.3 mg, 0.2 mmol, 1.0 equiv) and $Et_3N$ (84 μL, 0.6 mmol, 3.0 equiv) at room temperature under $N_2$ atmosphere. The reaction mixture was stirred at 100 °C for 18 h. After being cooled to room temperature, the reaction mixture was passed through a short silica gel / $Na_2SO_4$ plug eluting with EtOAc. The obtained solution was concentrated and the residue was purified by flash column chromatography on silica gel (hexane / EtOAc / MeOH = 200 / 15 / 1) to afford **3c** (2.5 mg, 4% isolated yield) and **3d** (44.2 mg, 64% isolated yield).

### 8-2. A Control Experiment using Tetrachloromethane ($CCl_4$) (Scheme 3-b)




When tetrachloromethane ($CCl_4$, 1.0 mL) was added to the reaction (0.2 mmol scale) using benzamide **1a** and ASP **2d**, the desired alkylated product (**3m**) was not detected and **1a** was recovered (97% NMR yield). Instead, 5-chloro-1-phenylpentan-1-one (**4**) was obtained in 62% isolated yield (based on **2d**) as a white solid (29.5 mg), which was purified by flash column chromatography on silica gel (hexane / EtOAc = 10 / 1). $^1H$ NMR spectrum data of **4** matched the one previously reported in the literature.[10]

## 9. References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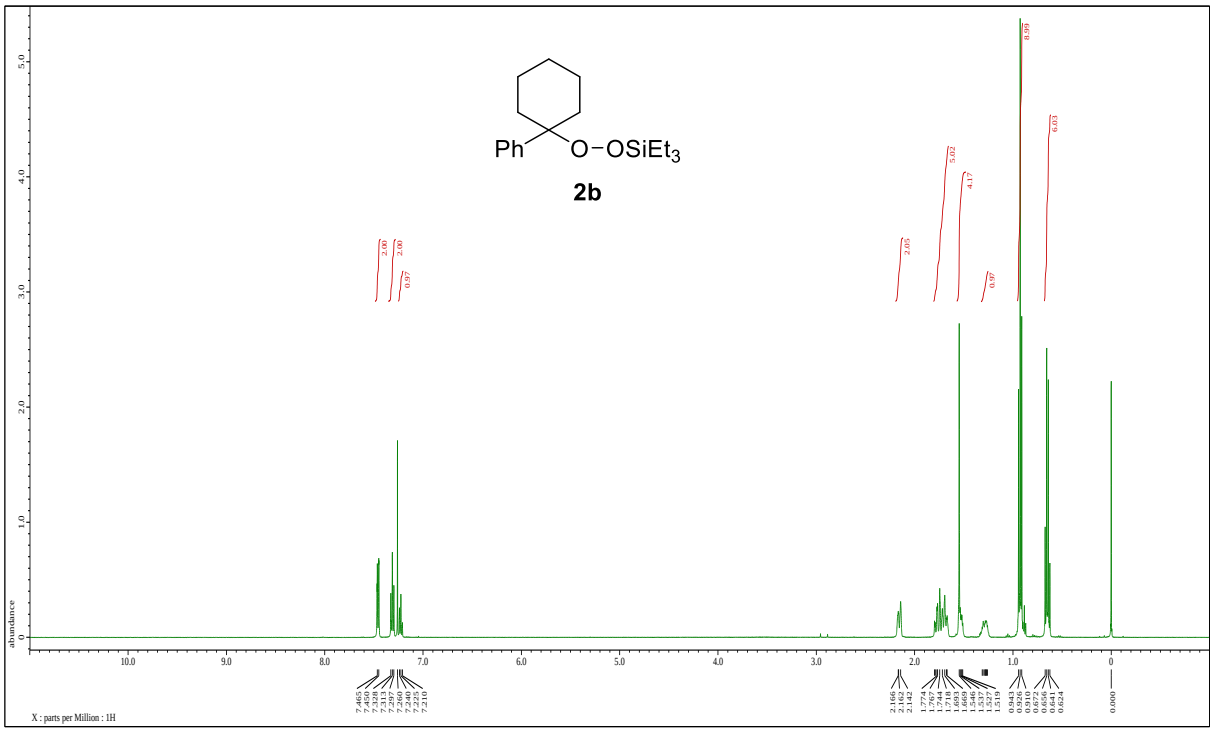
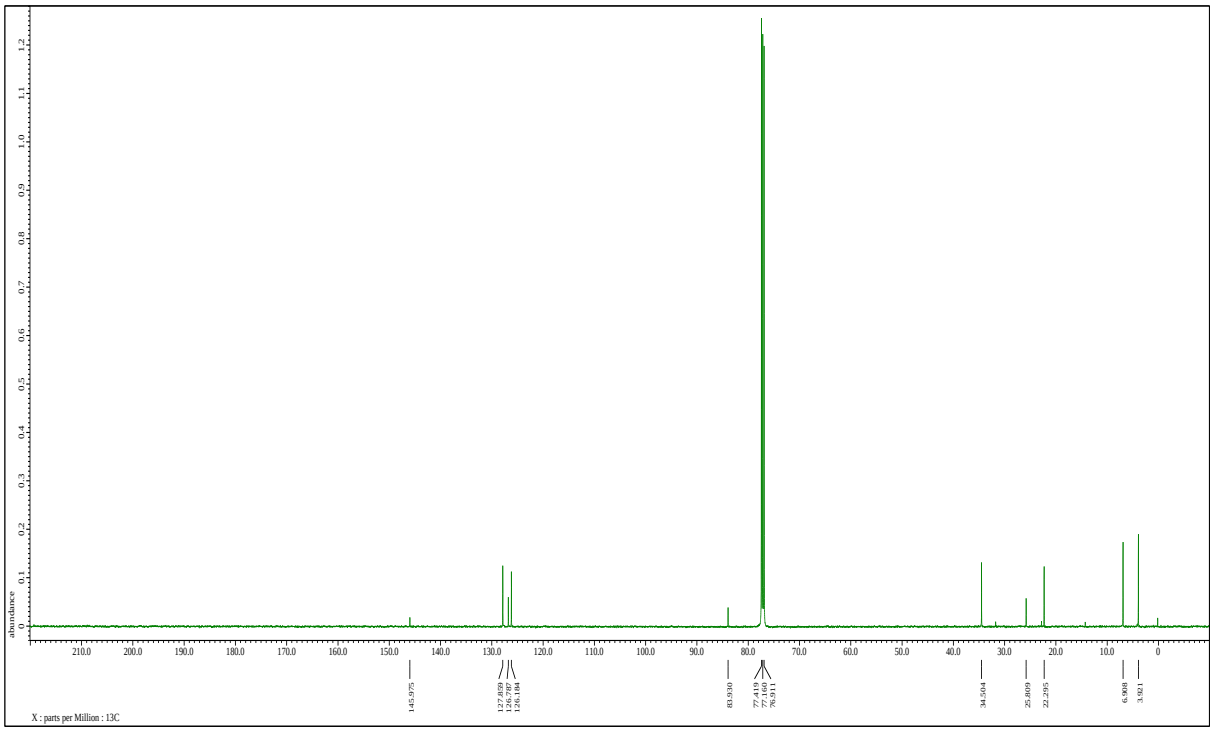
## 10. $^{1}$H NMR and $^{13}$C NMR Spectra

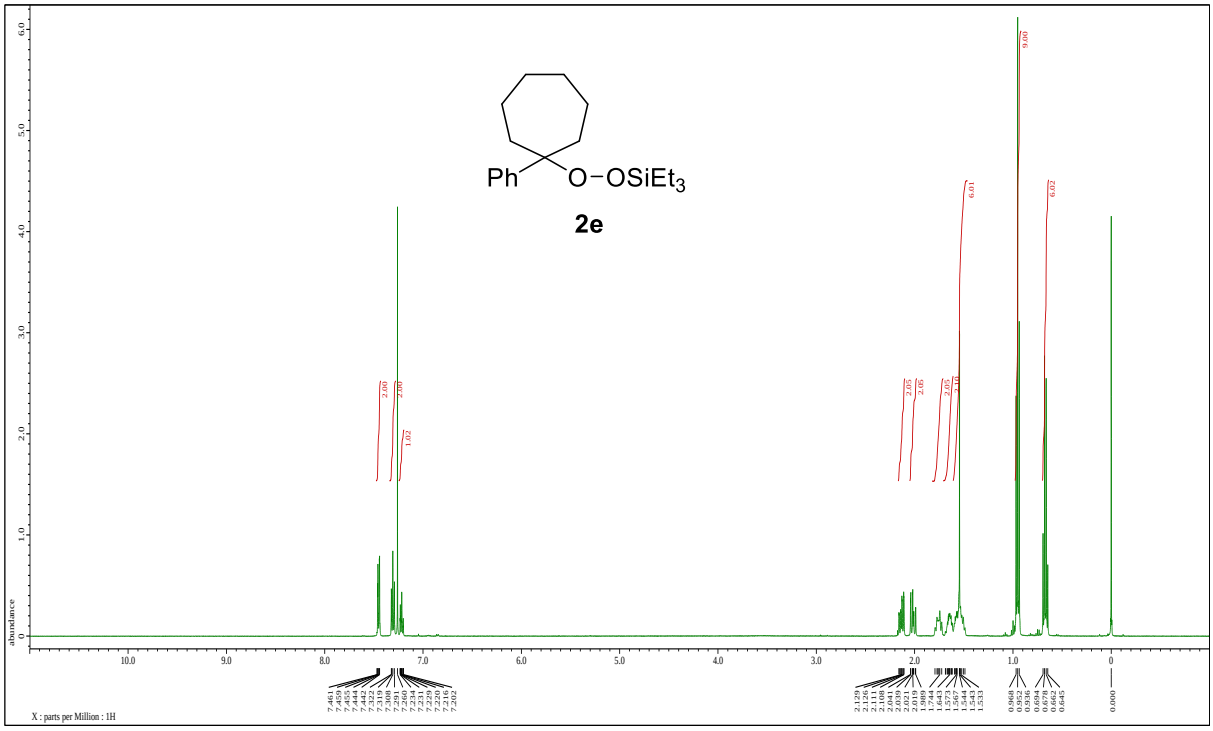
$^{1}$H NMR spectrum of **2b** (500 MHz, $CDCl_3$)



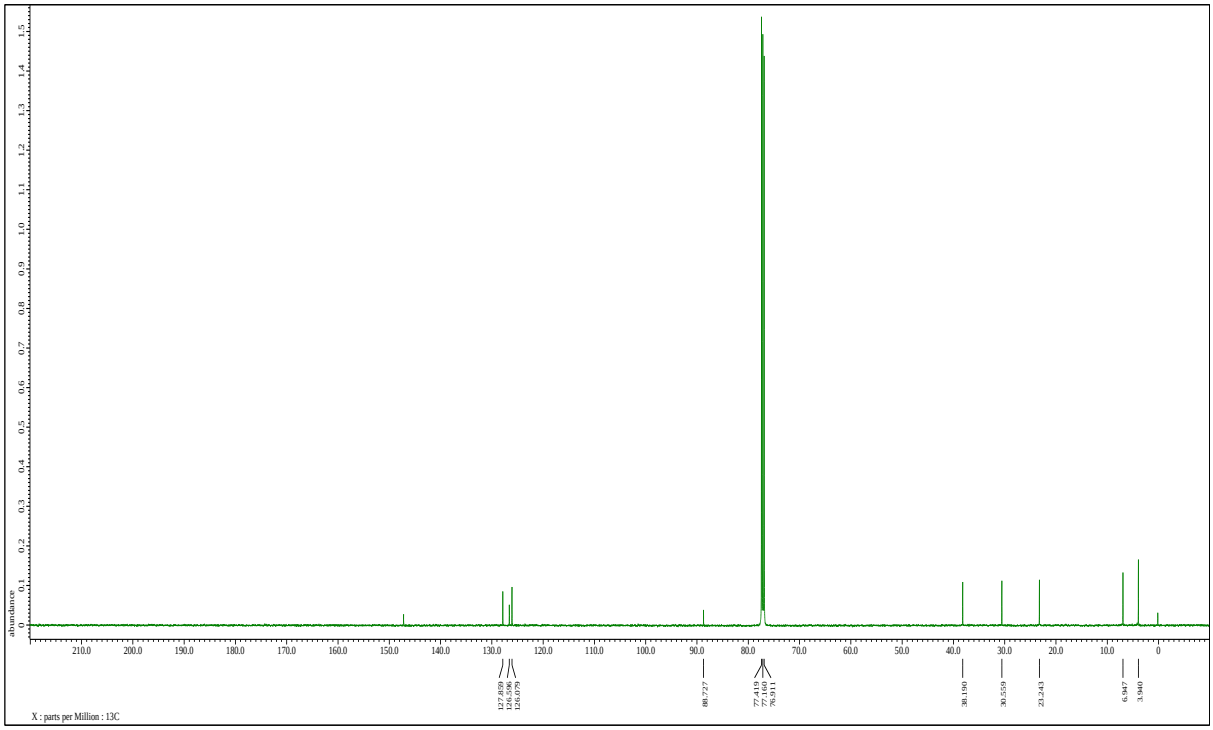

$^{13}$C NMR spectrum of **2b** (125 MHz, $CDCl_3$)



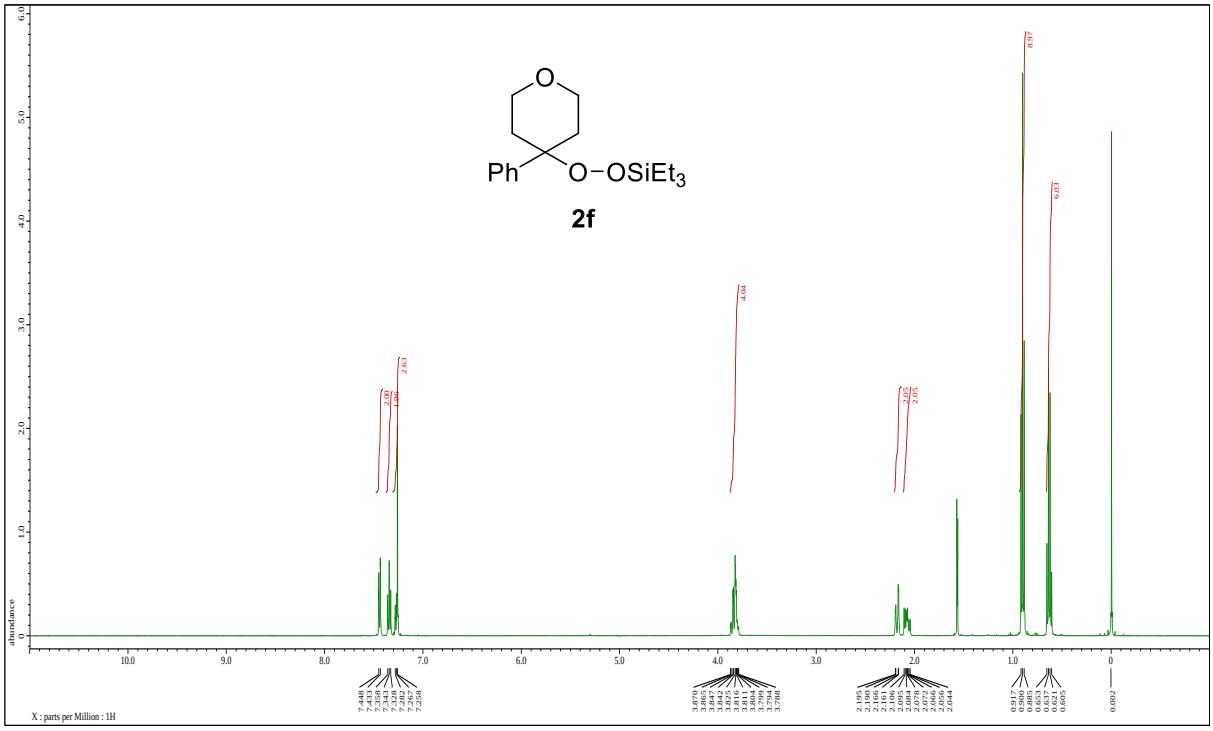
$^{1}$H NMR spectrum of **2e** (500 MHz, $CDCl_3$)




$^{13}$C NMR spectrum of **2e** (125 MHz, $CDCl_3$)



$^{1}$H NMR spectrum of **2f** (500 MHz, $CDCl_3$)

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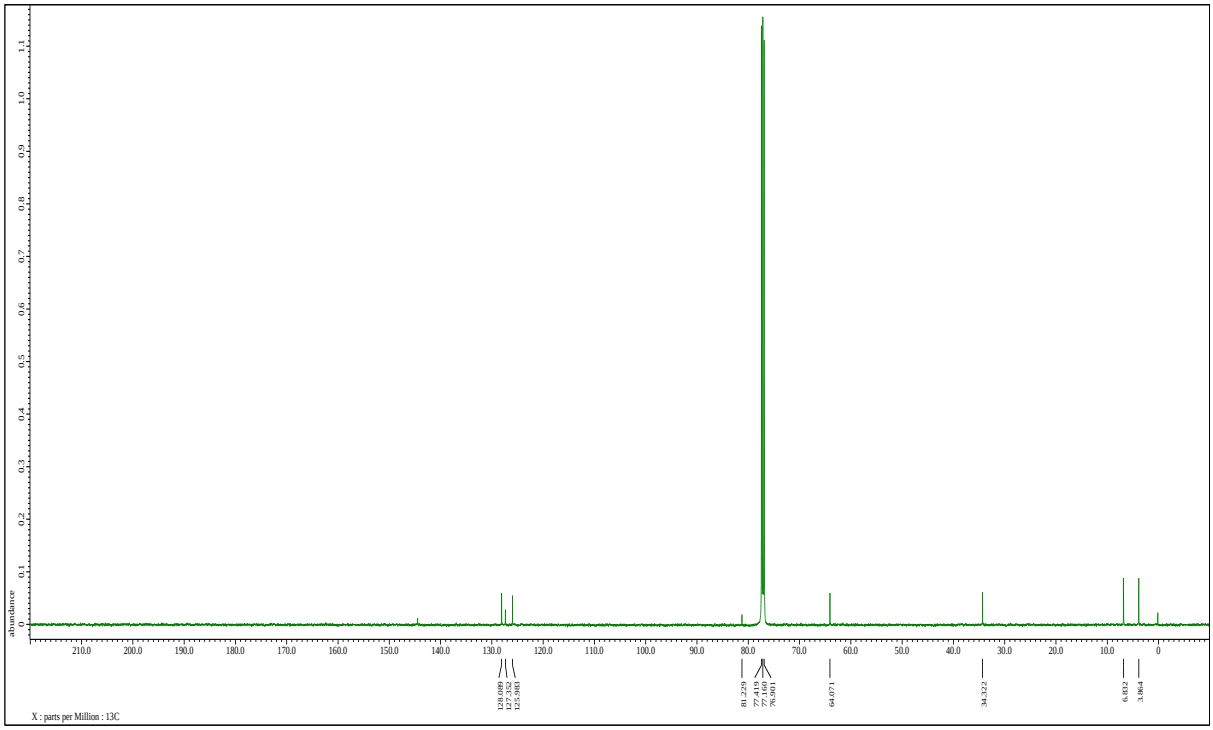
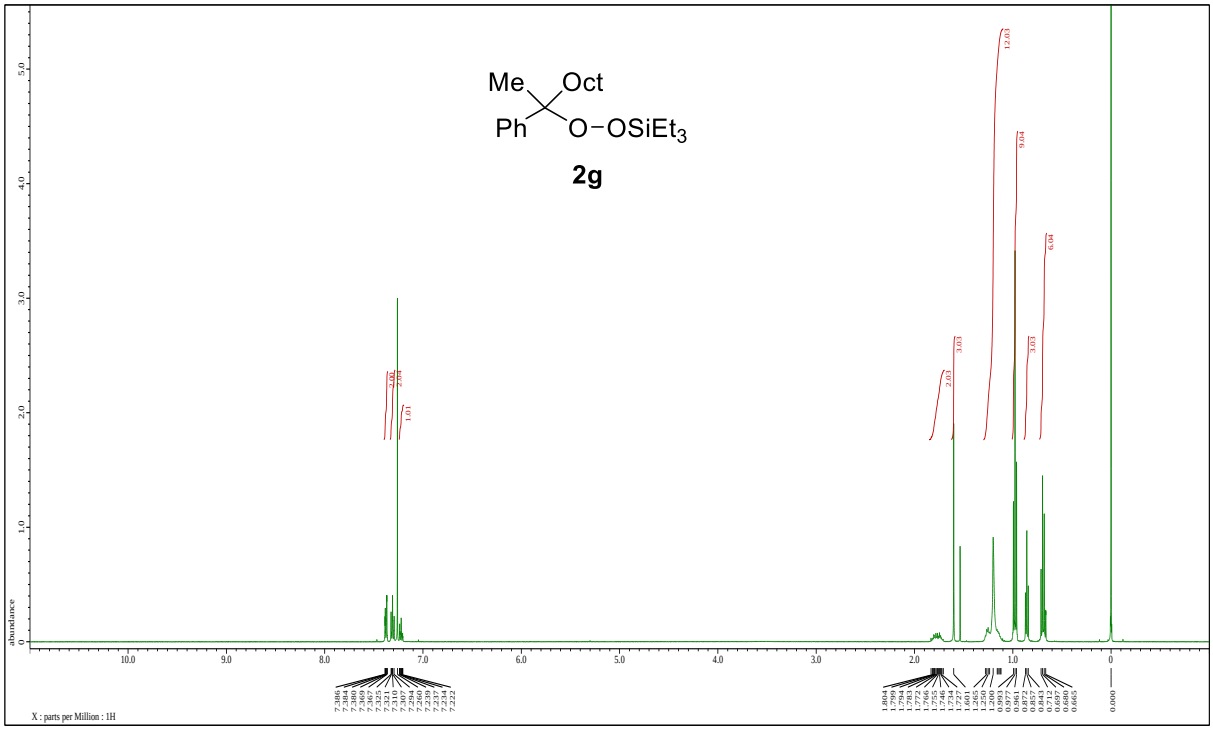
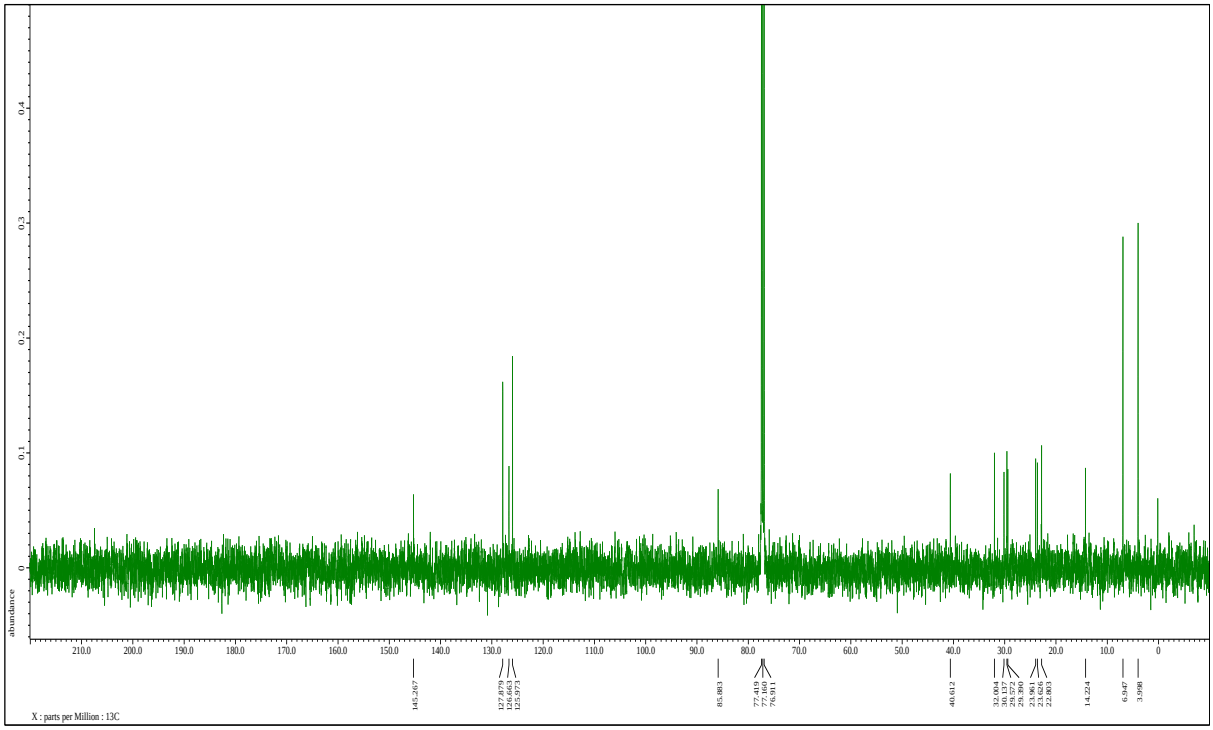


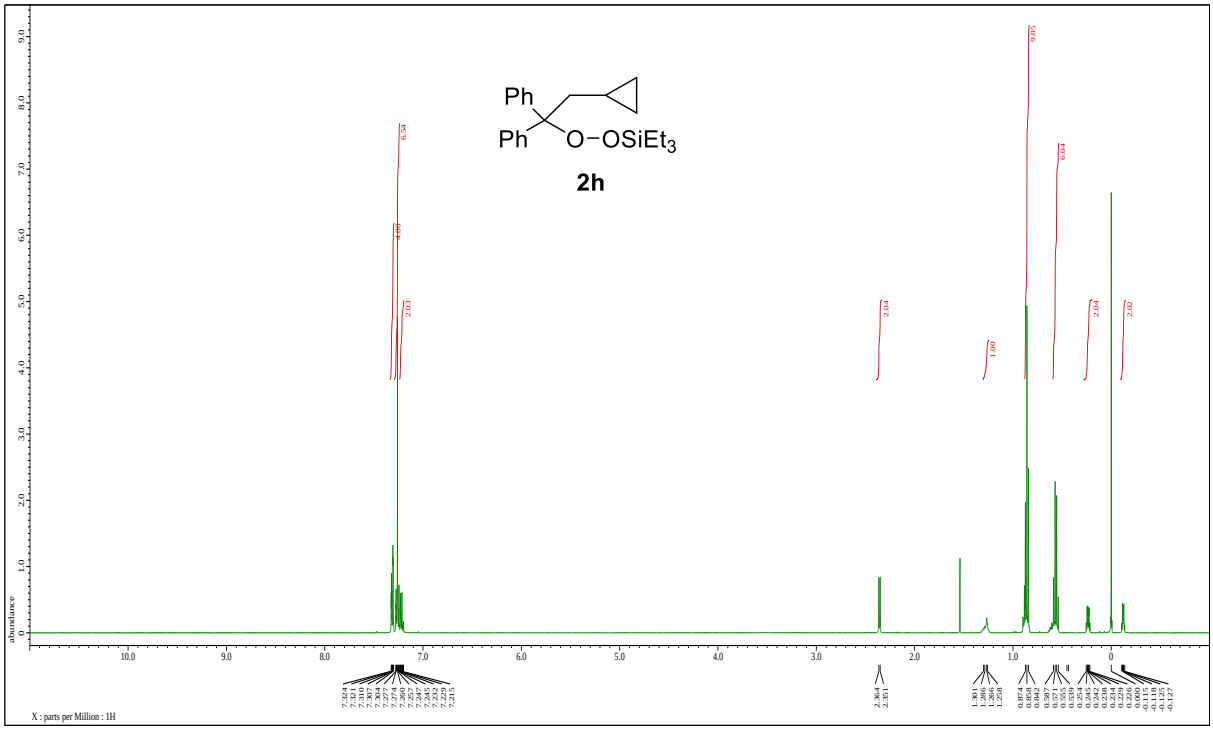
$^{1}$H NMR spectrum of **2g** (500 MHz, $CDCl_3$)




$^{13}$C NMR spectrum of **2g** (125 MHz, $CDCl_3$)



$^{1}$H NMR spectrum of **2h** (500 MHz, $CDCl_3$)

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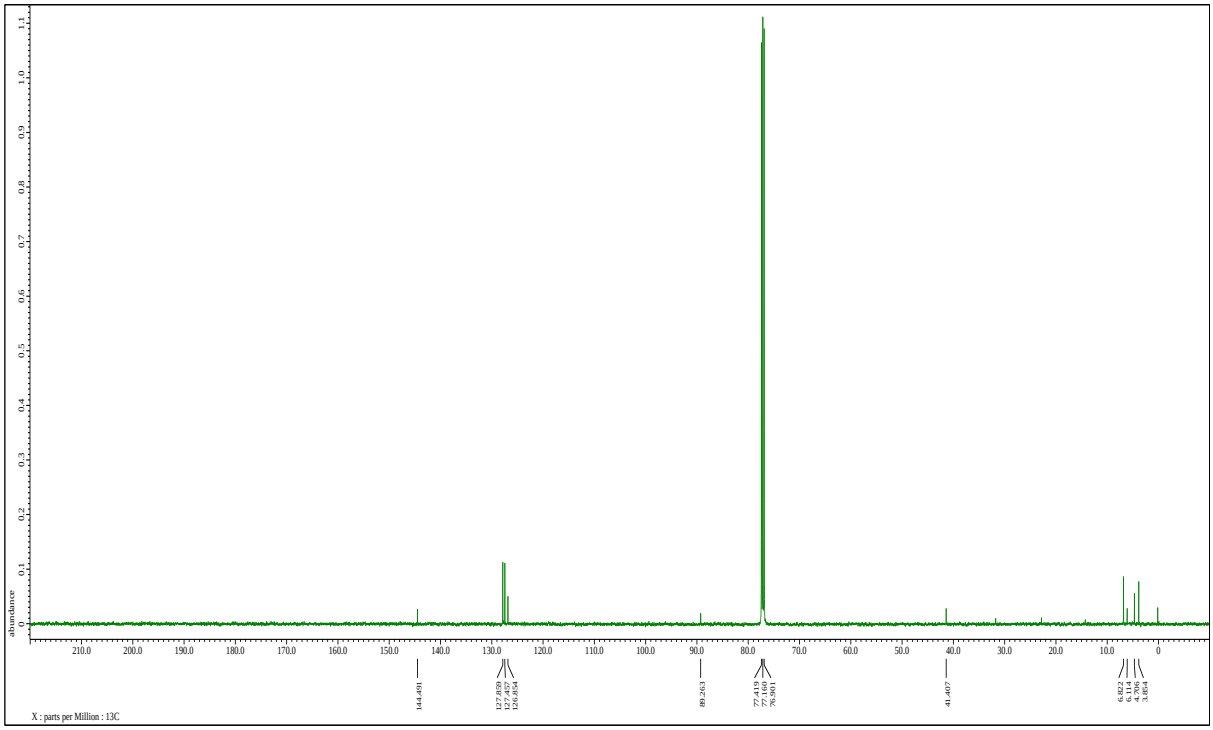
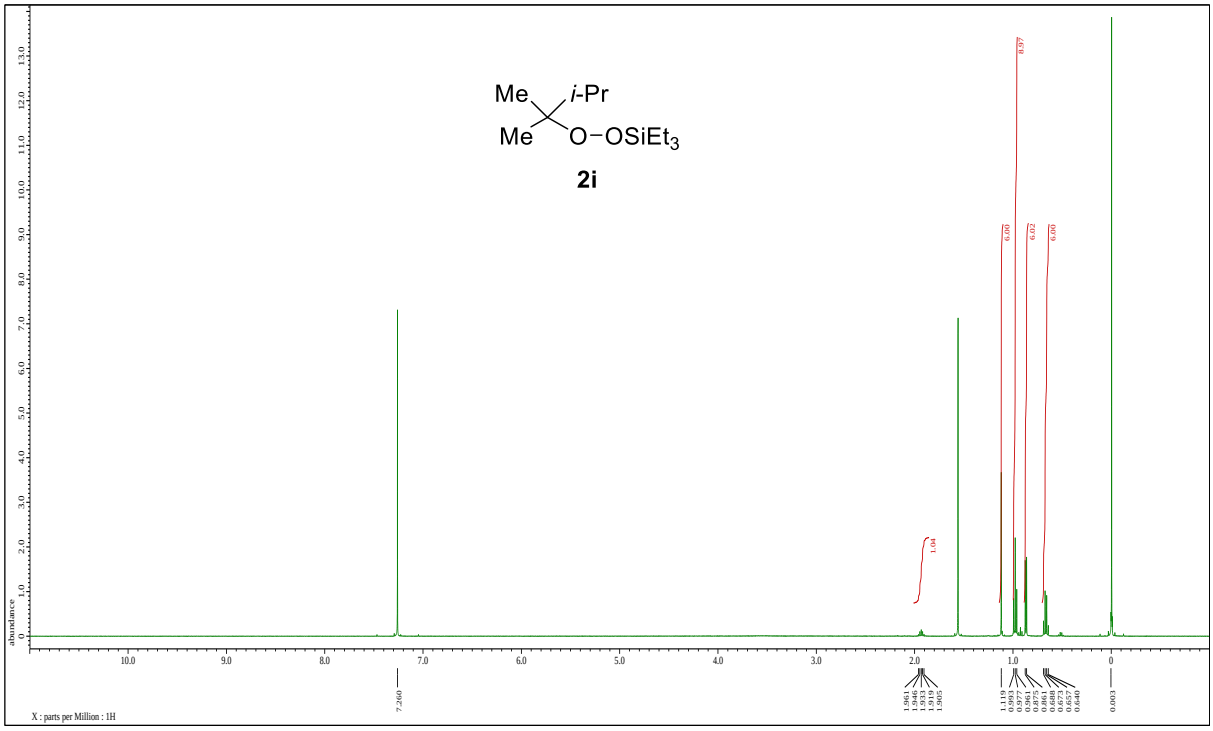
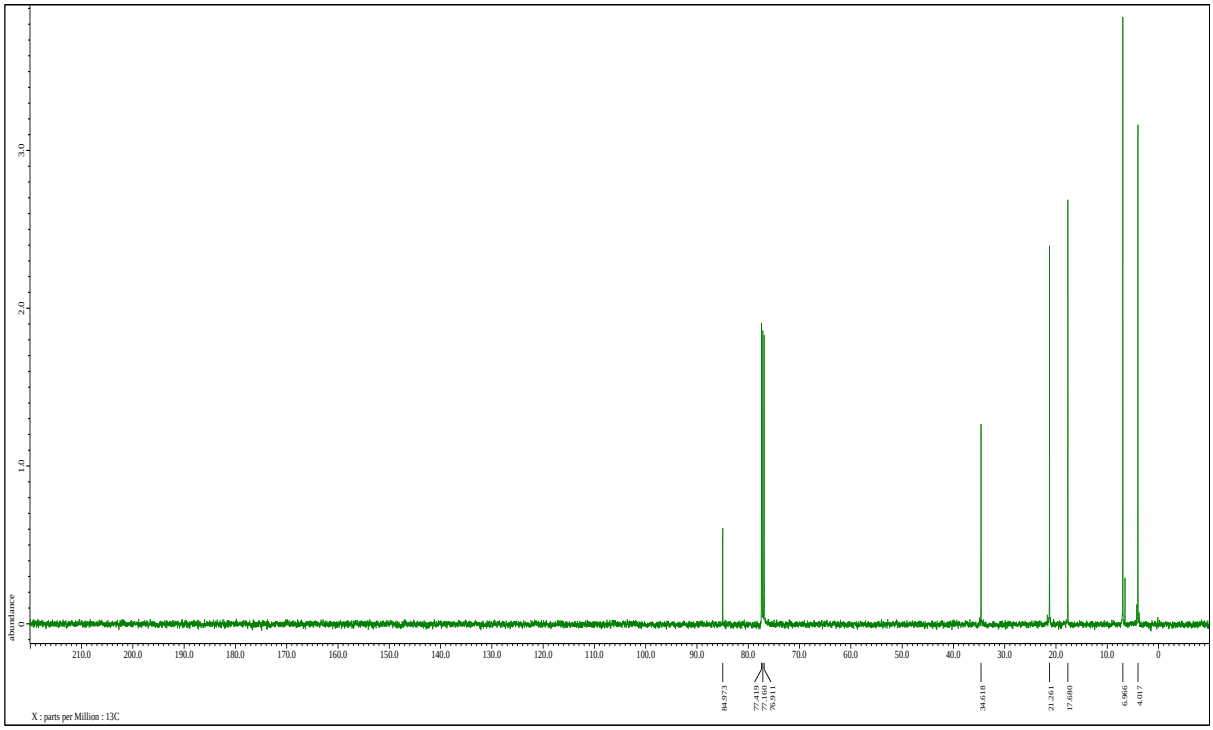


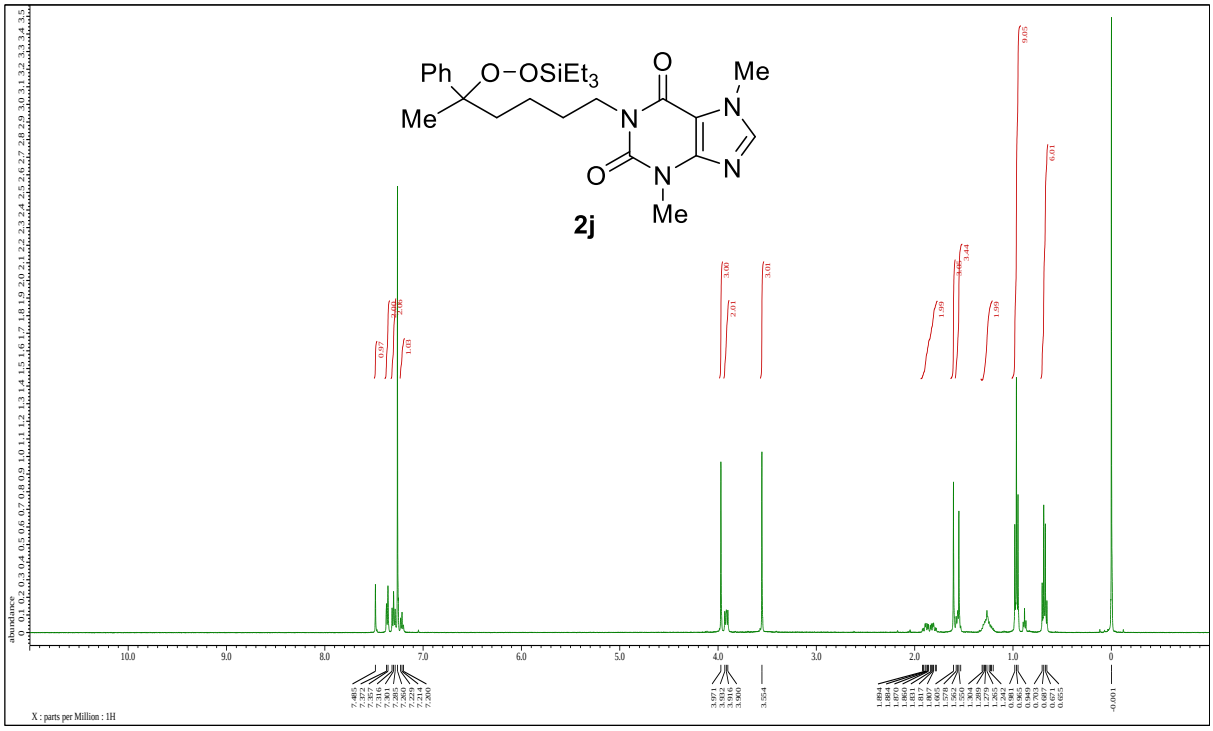
$^{1}$H NMR spectrum of **2i** (500 MHz, $CDCl_3$)




$^{13}$C NMR spectrum of **2i** (125 MHz, $CDCl_3$)



$^{1}$H NMR spectrum of **2j** (500 MHz, $CDCl_3$)

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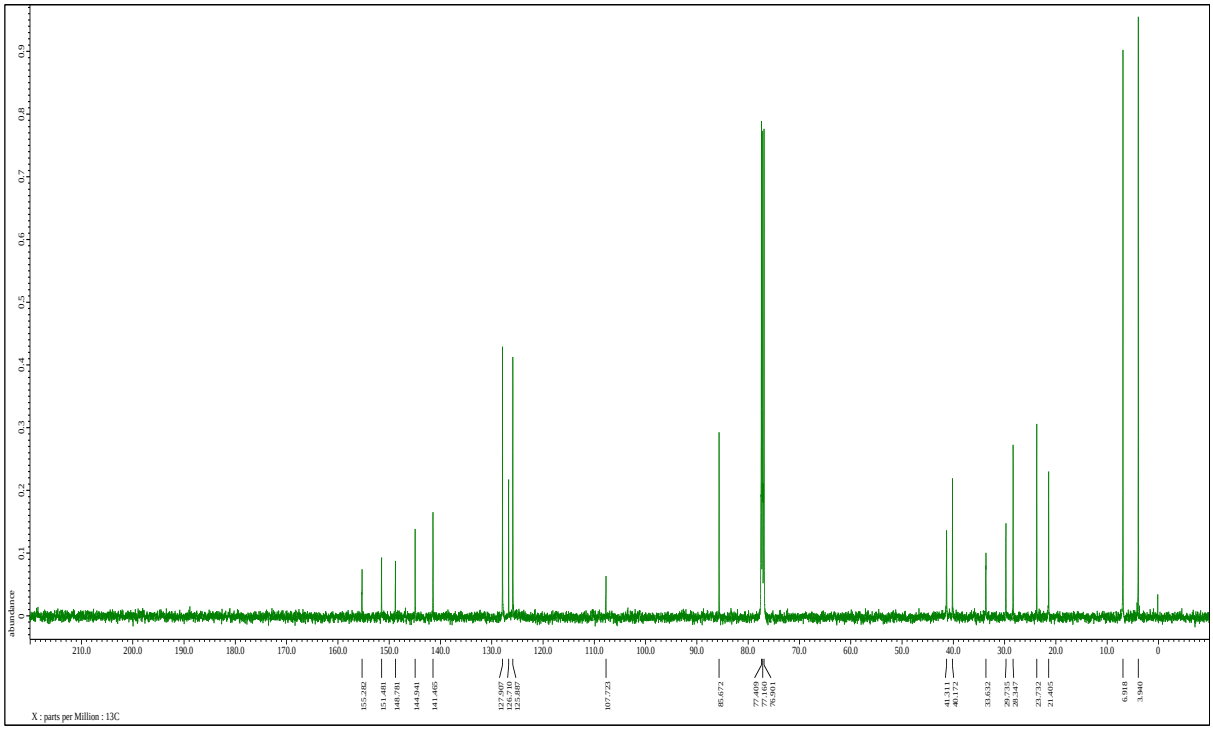
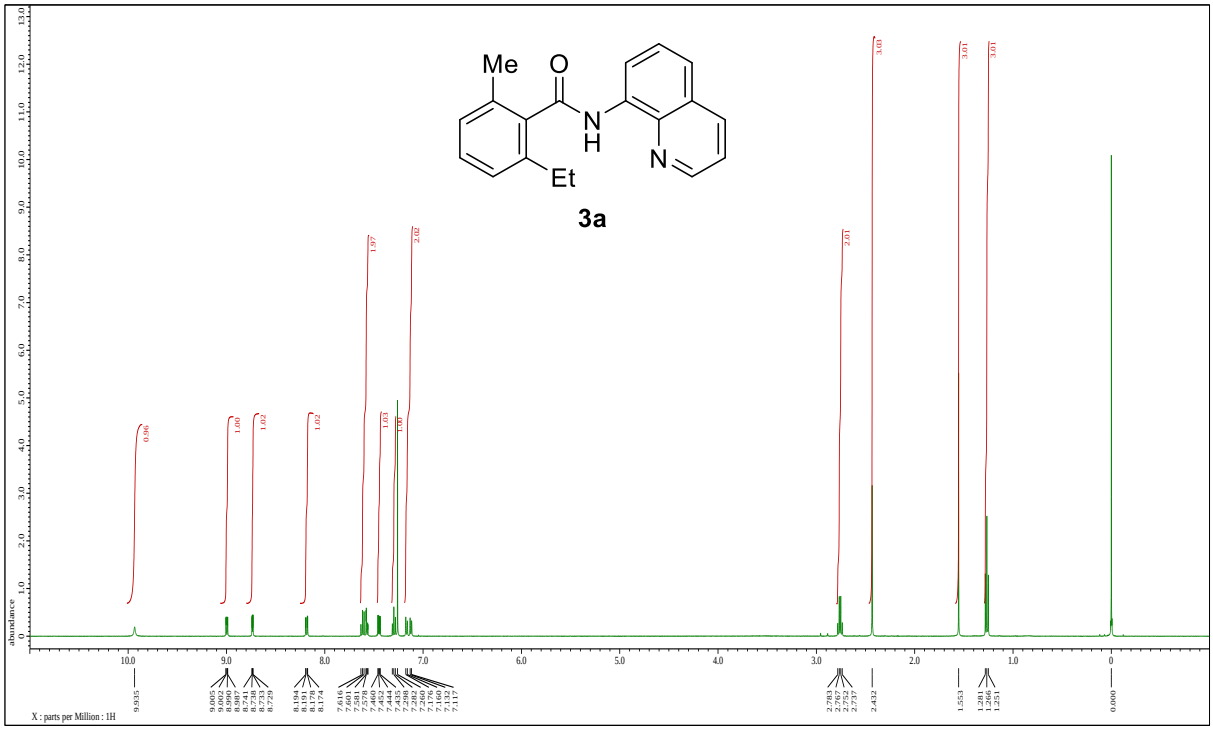
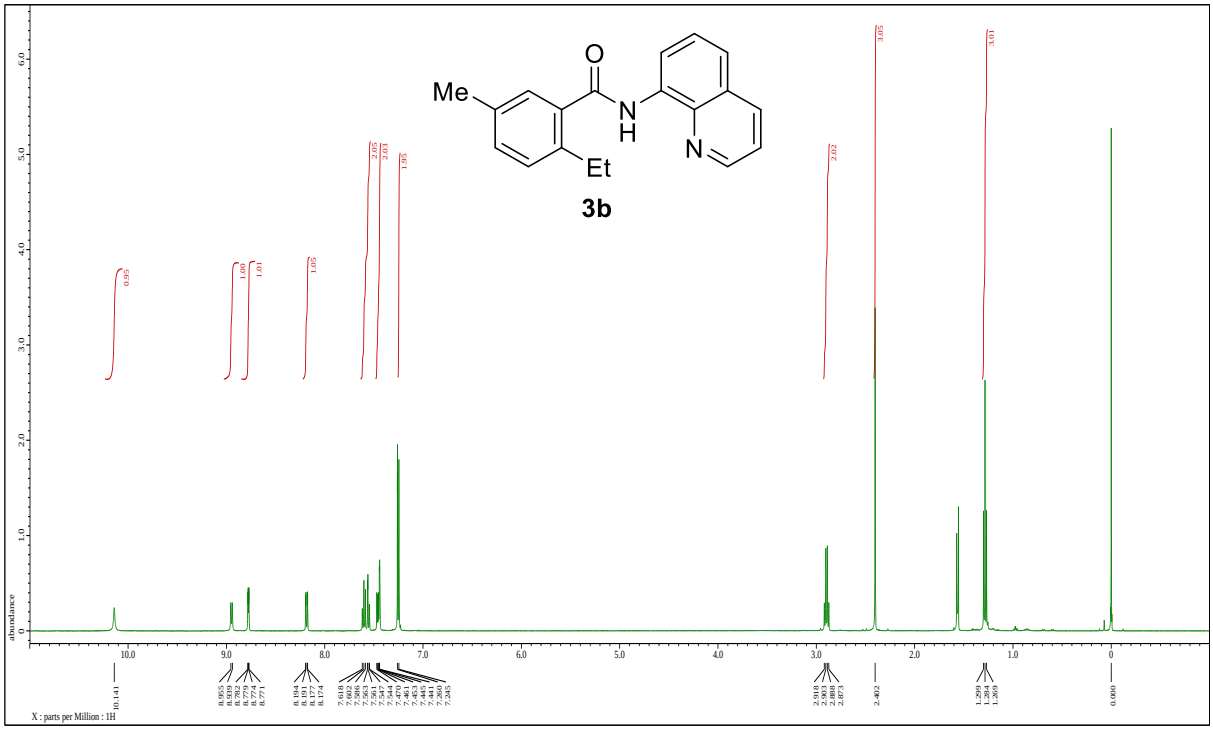


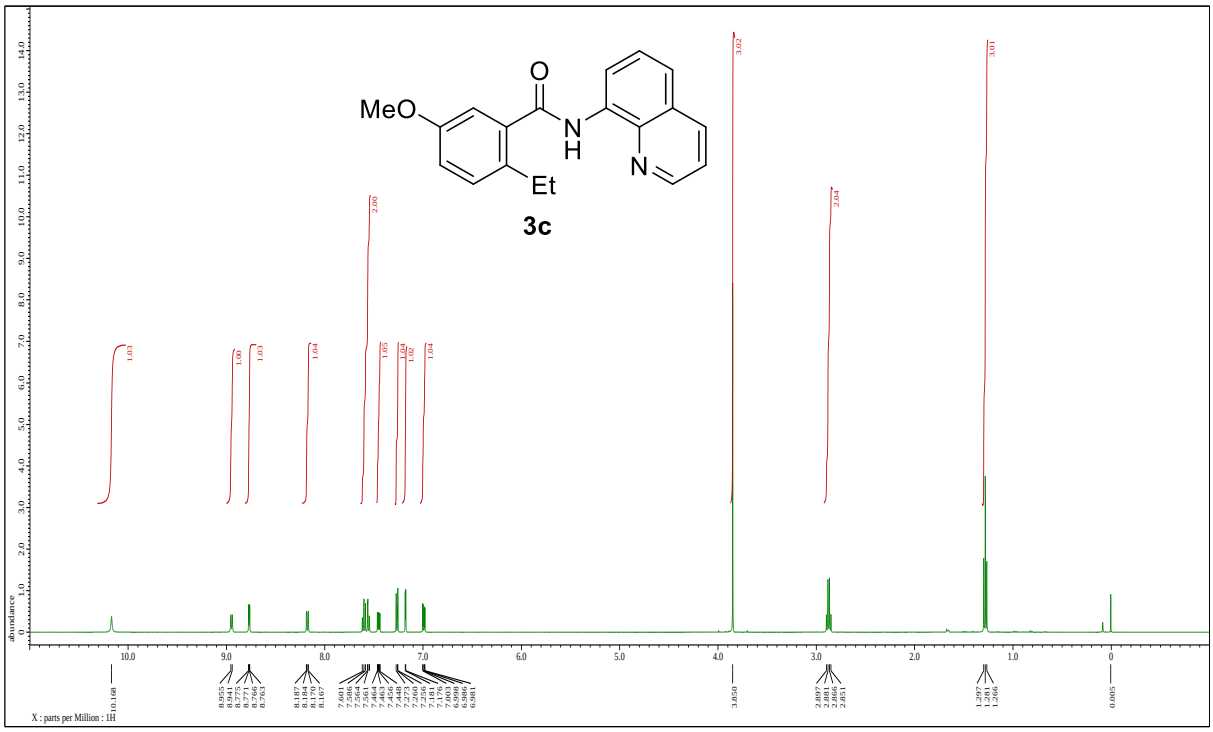
$^1$H NMR spectrum of **3a** (500 MHz, $CDCl_3$)



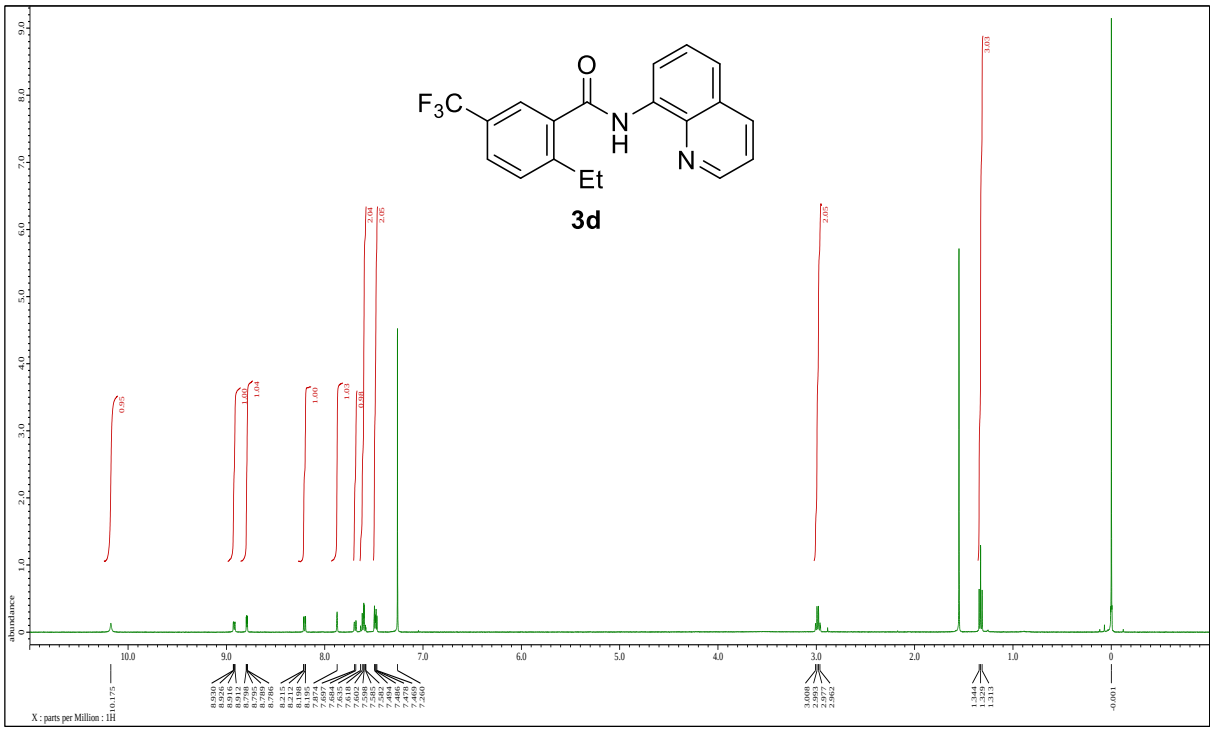

$^1$H NMR spectrum of **3b** (500 MHz, $CDCl_3$)



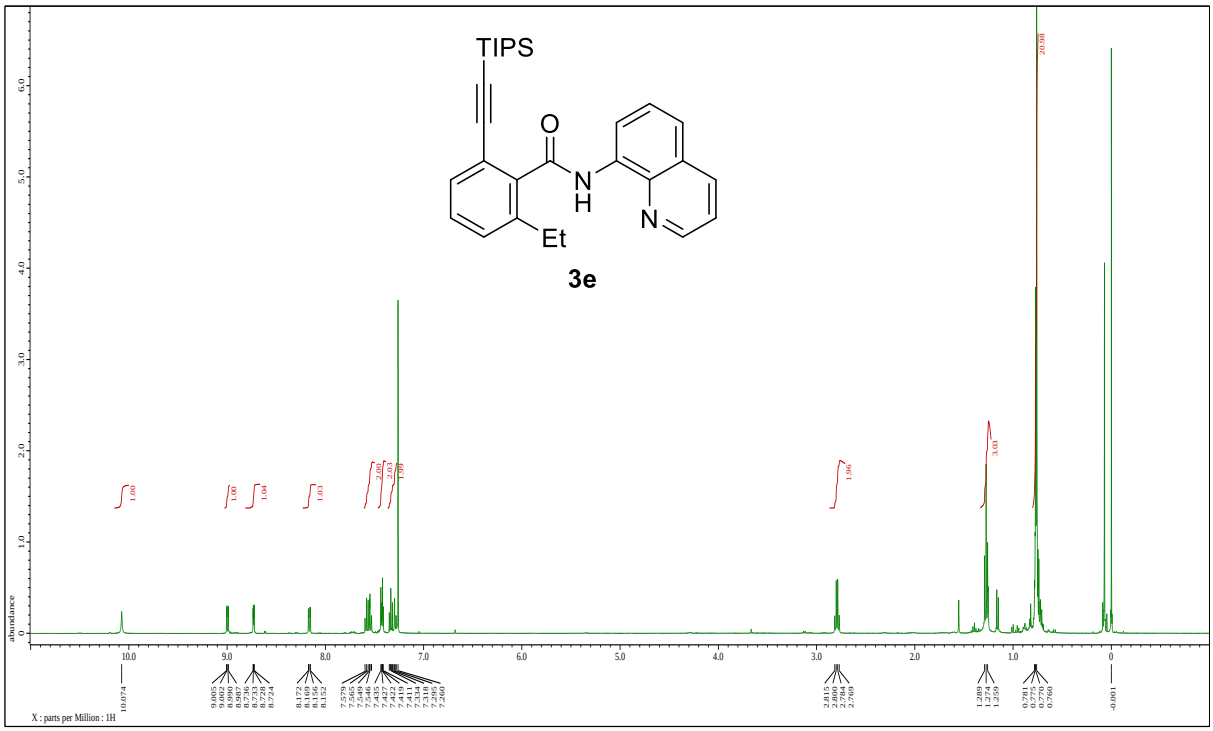
$^1$H NMR spectrum of **3c** (500 MHz, $CDCl_3$)



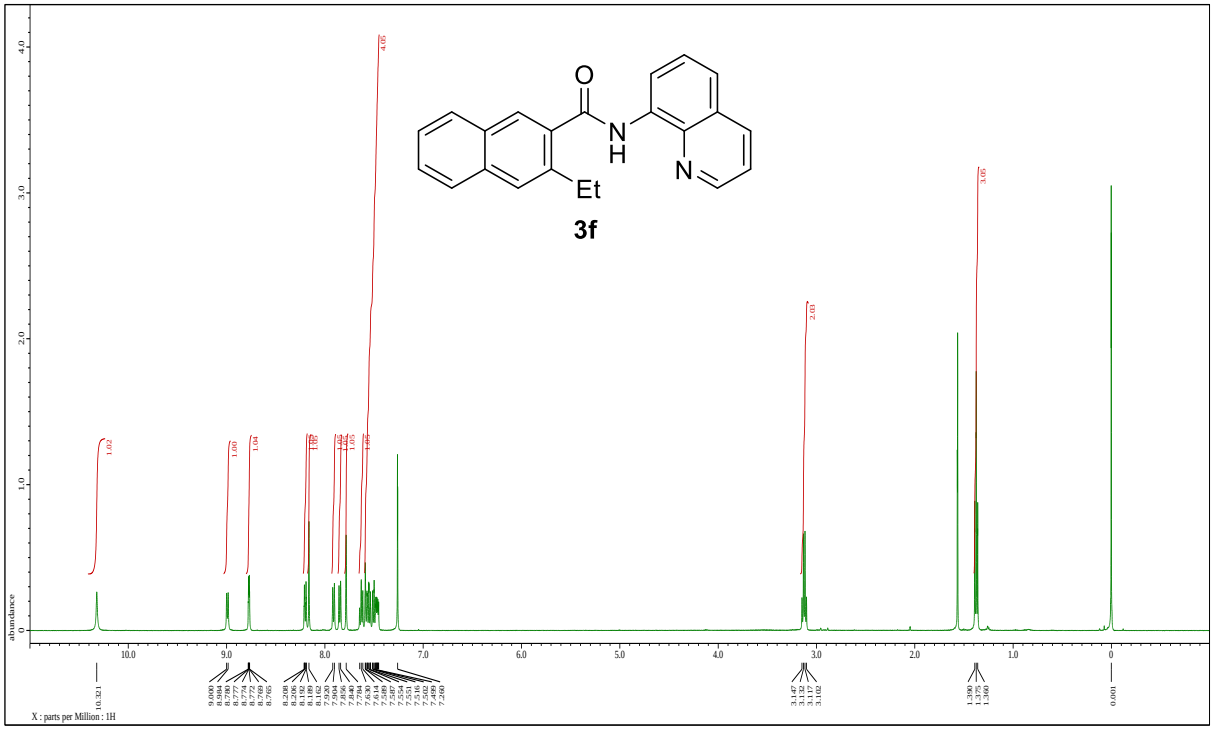

$^1$H NMR spectrum of **3d** (500 MHz, $CDCl_3$)



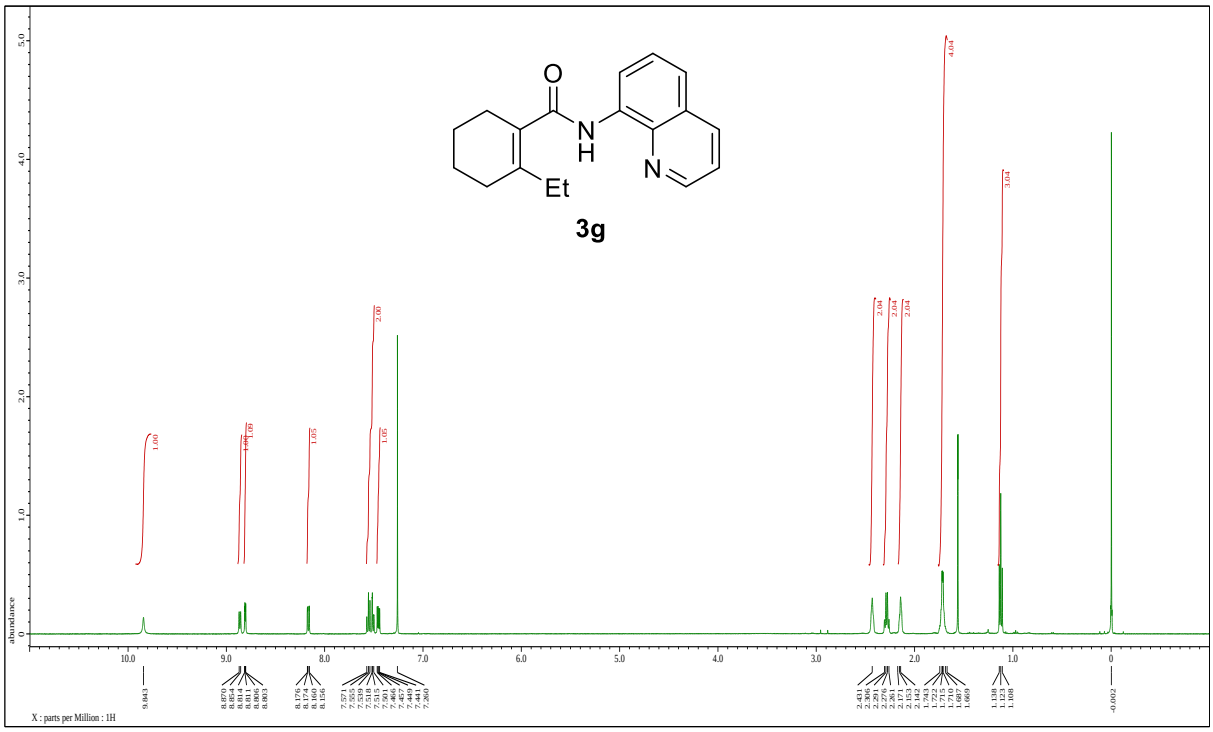
$^1$H NMR spectrum of **3e** (500 MHz, $CDCl_3$)



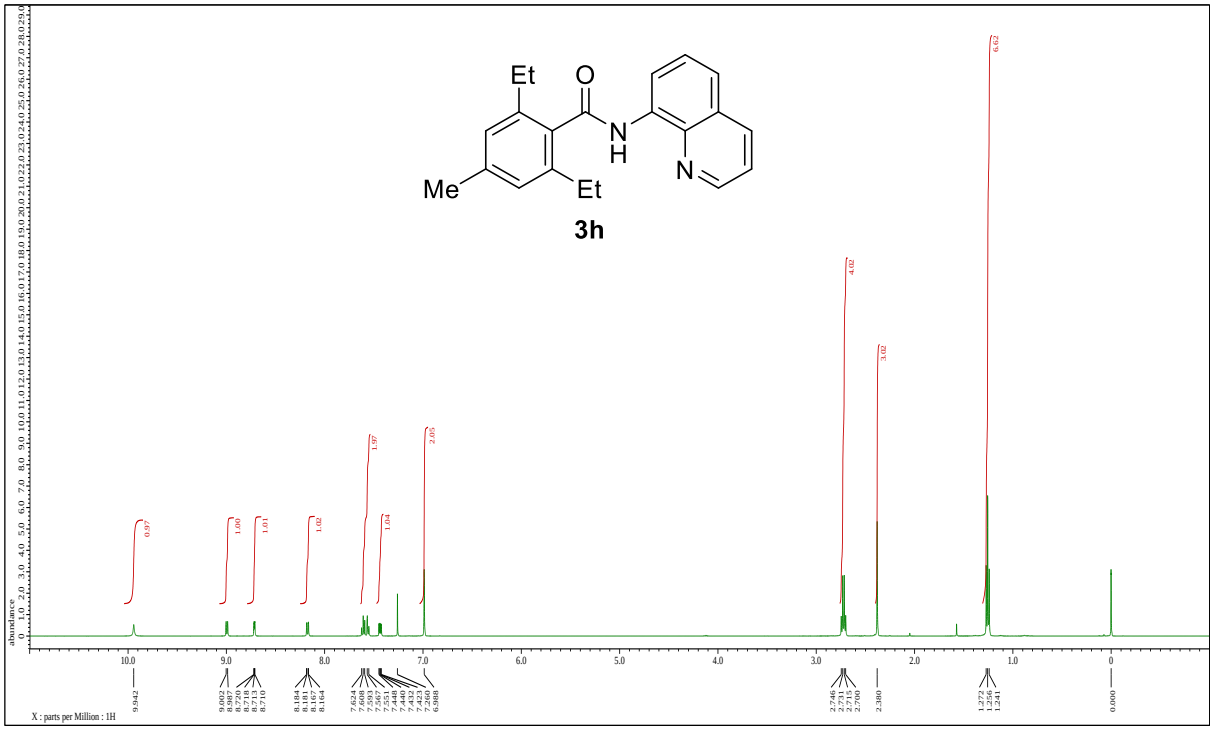

$^1$H NMR spectrum of **3f** (500 MHz, $CDCl_3$)



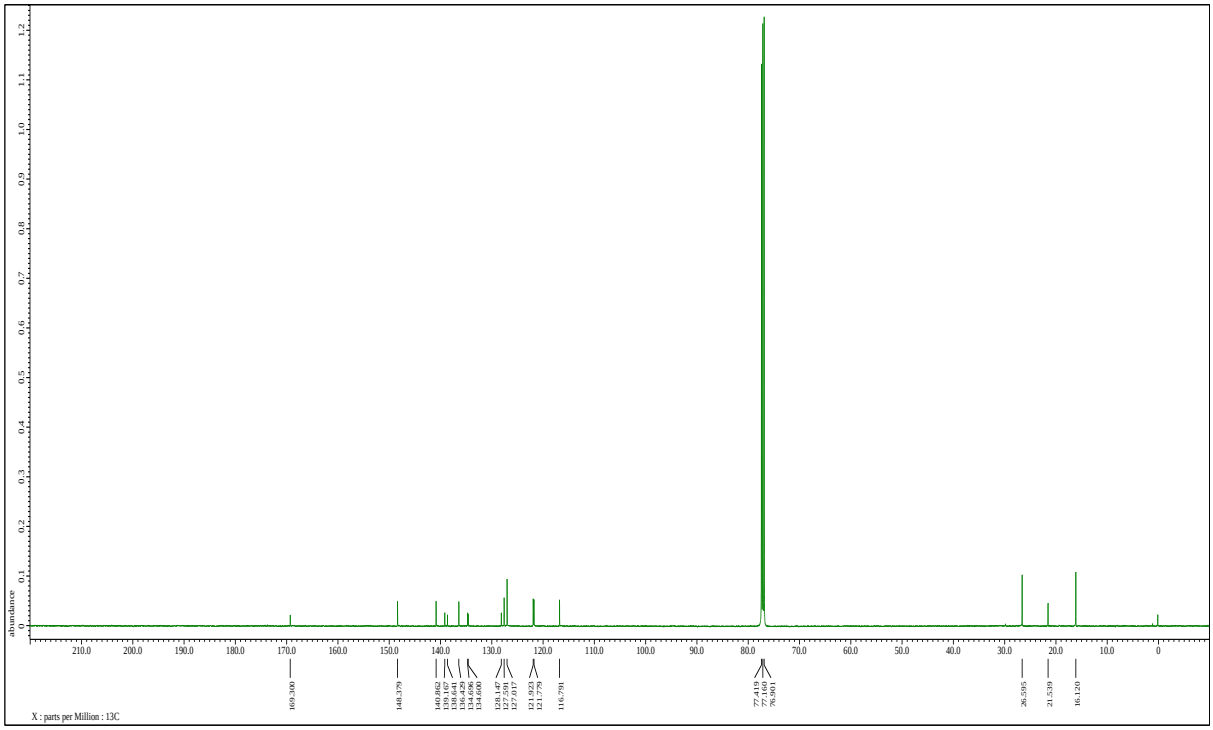
$^{1}$H NMR spectrum of **3g** (500 MHz, $CDCl_3$)



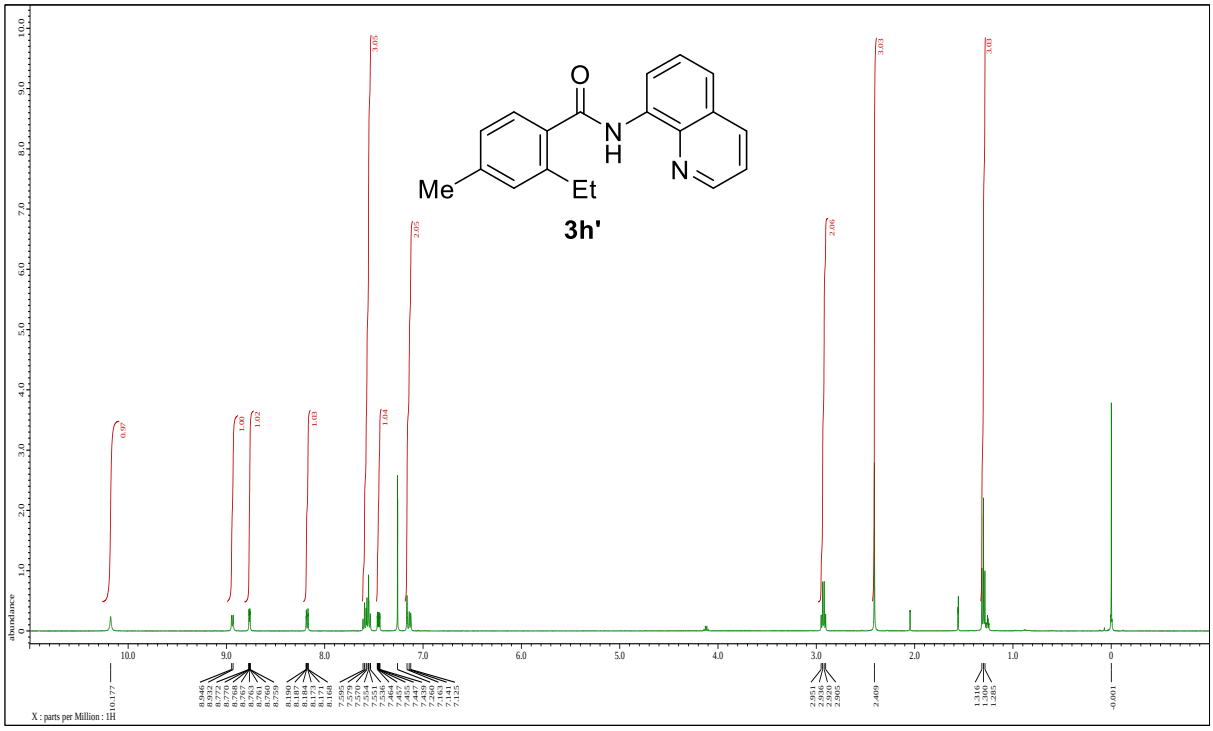
$^{1}$H NMR spectrum of **3h** (500 MHz, $CDCl_3$)



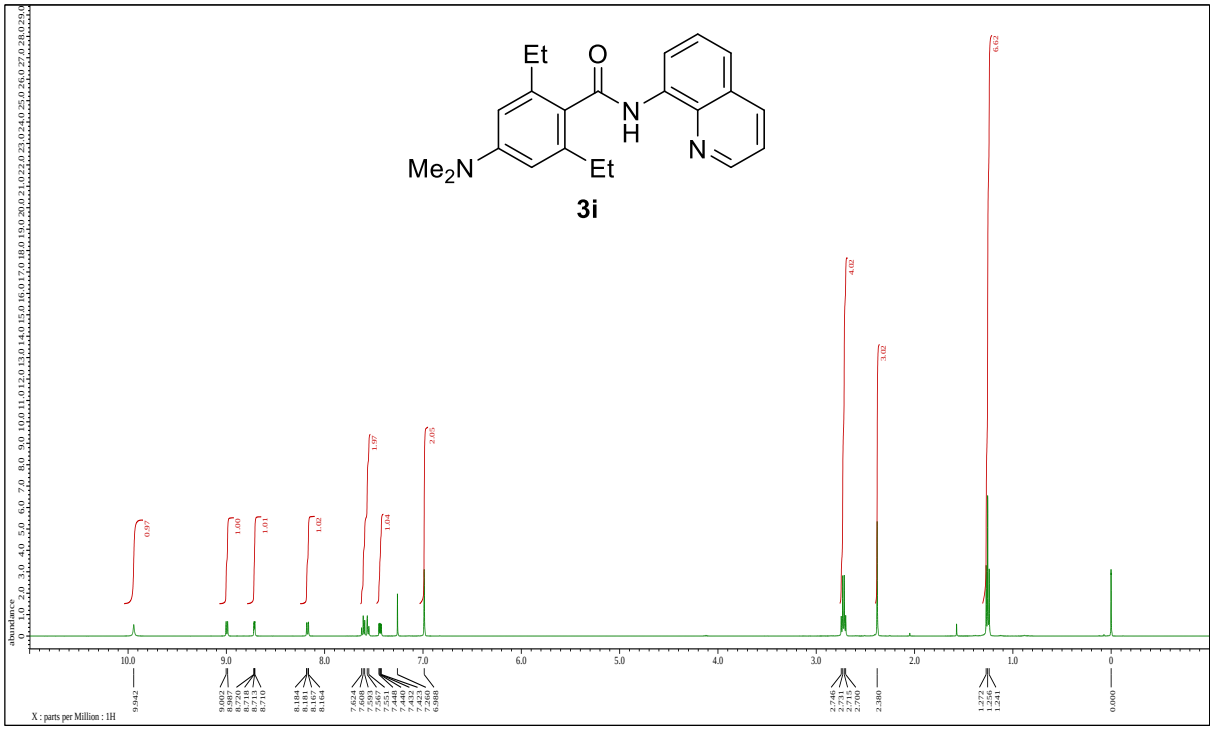

$^{13}$C NMR spectrum of **3h** (125 MHz, $CDCl_3$)



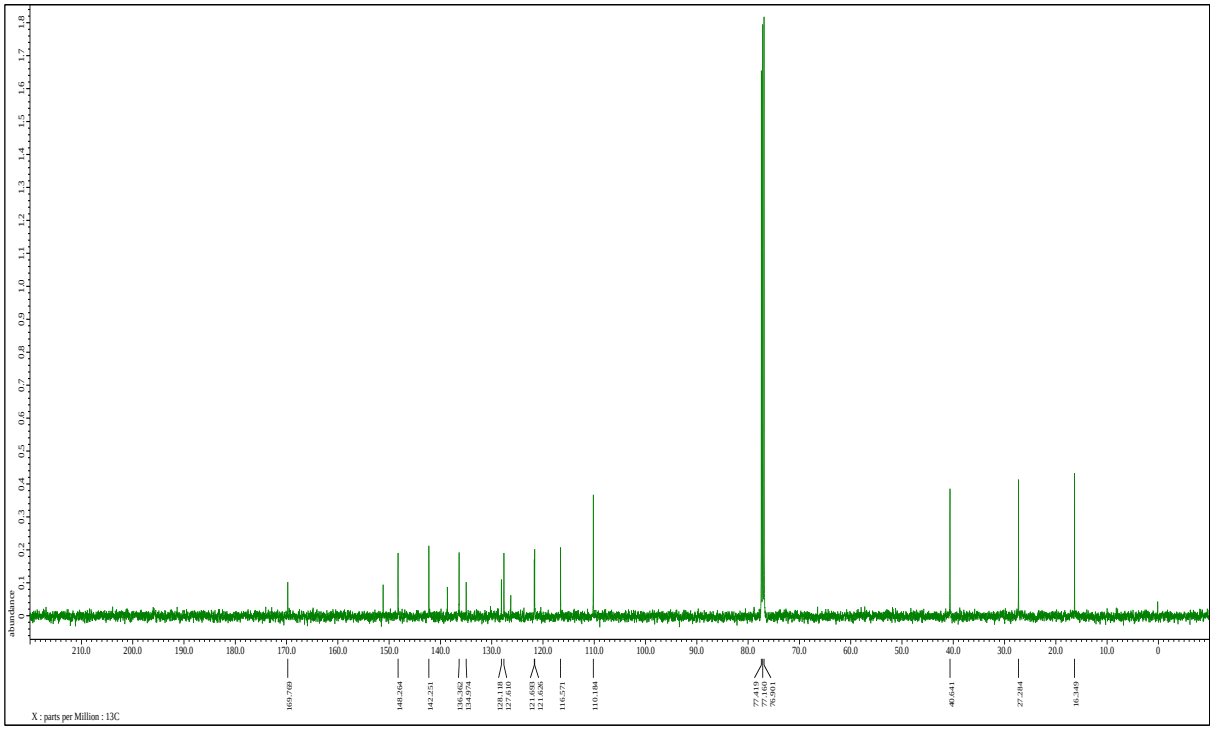
$^{1}$H NMR spectrum of **3h'** (500 MHz, $CDCl_3$)



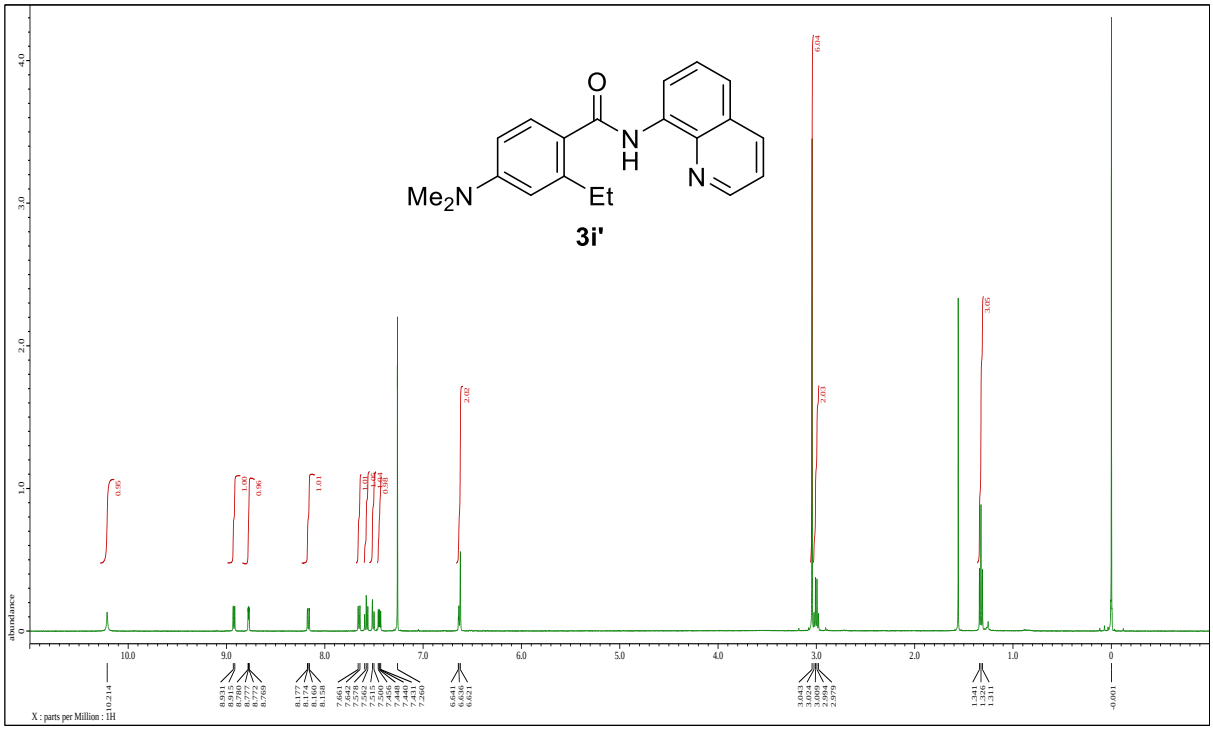
$^{1}$H NMR spectrum of **3i** (500 MHz, $CDCl_3$)



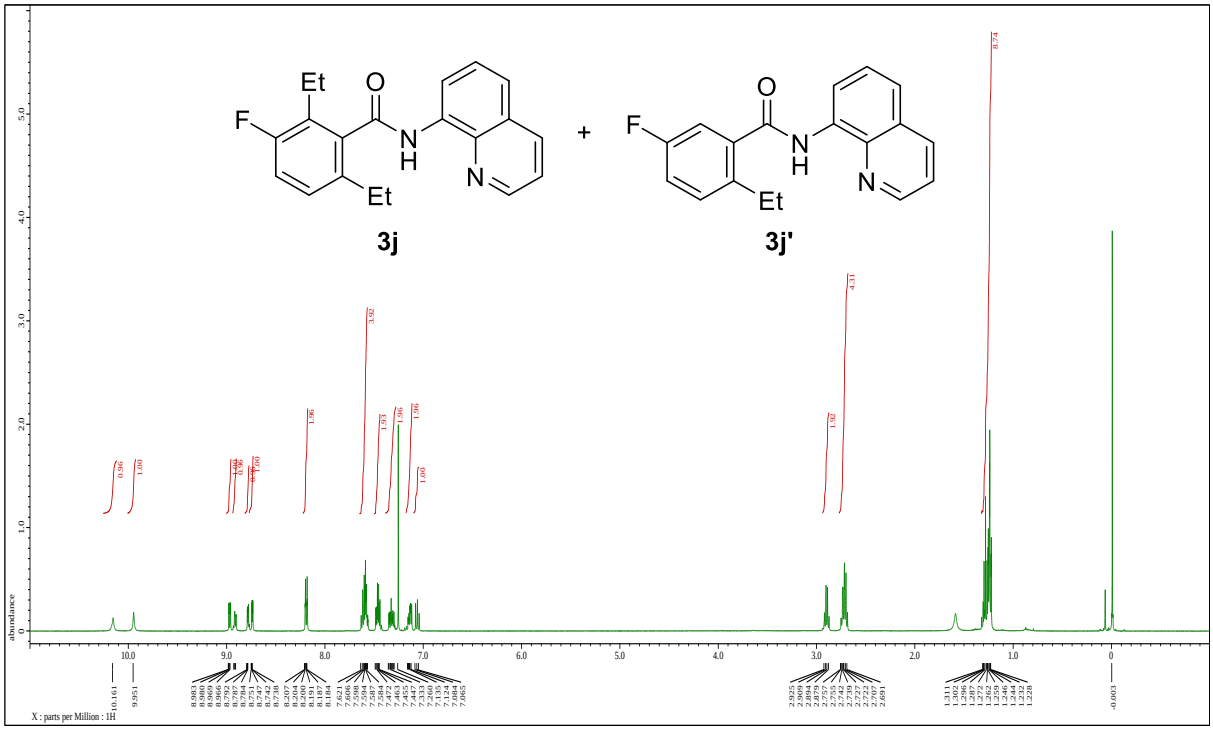

$^{13}$C NMR spectrum of **3i** (125 MHz, $CDCl_3$)



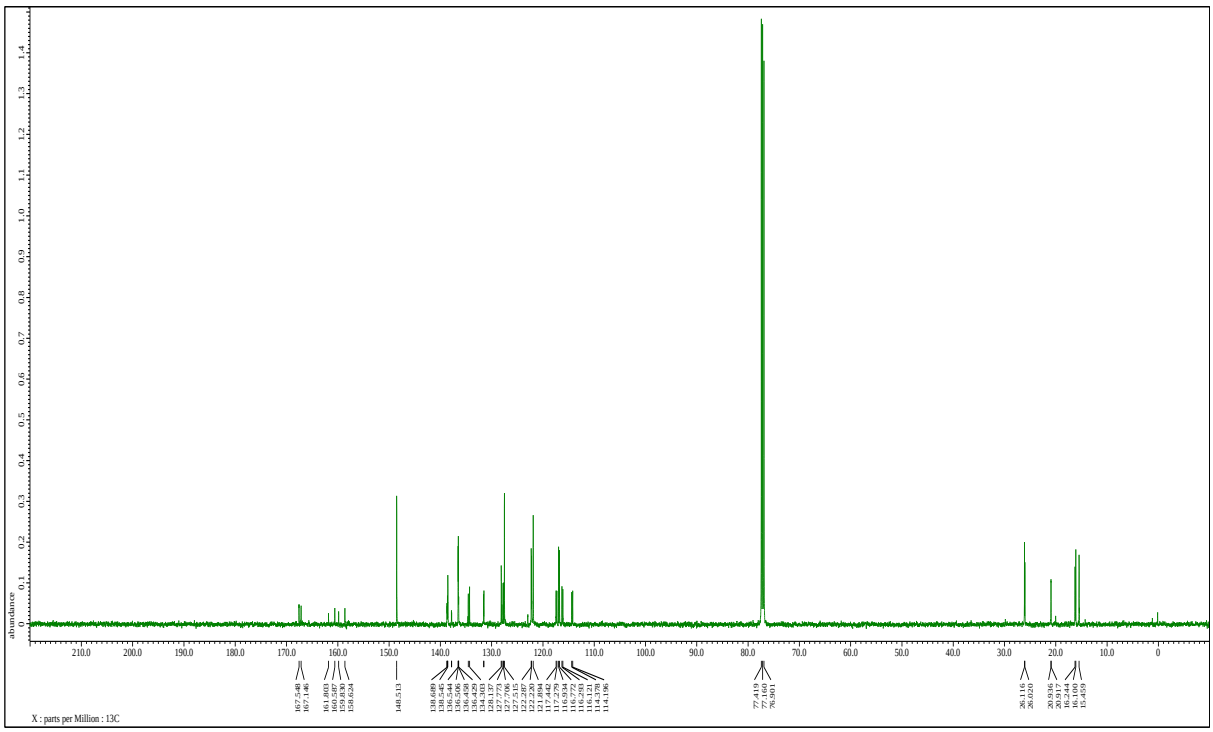
$^{1}$H NMR spectrum of **3i'** (500 MHz, $CDCl_3$)



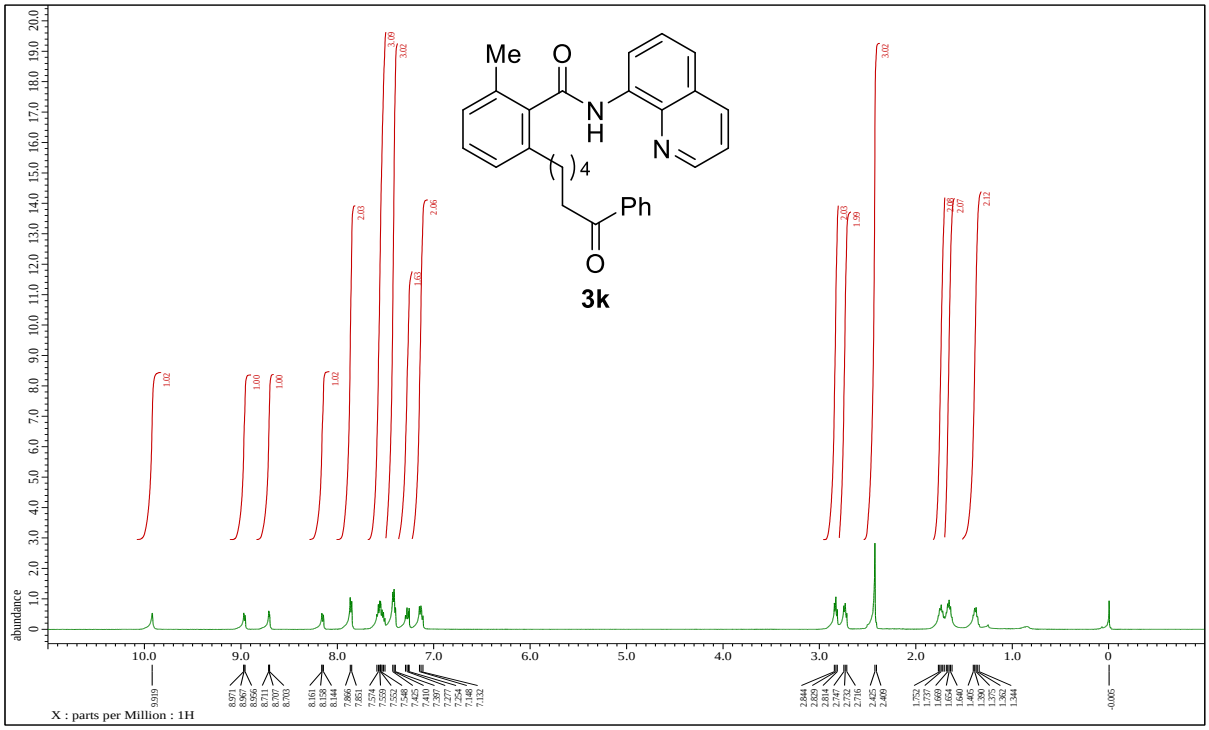
$^{1}$H NMR spectrum of **3j** and **3j'** (500 MHz, $CDCl_3$) (**3j** / **3j'** = 1.0 / 0.96)



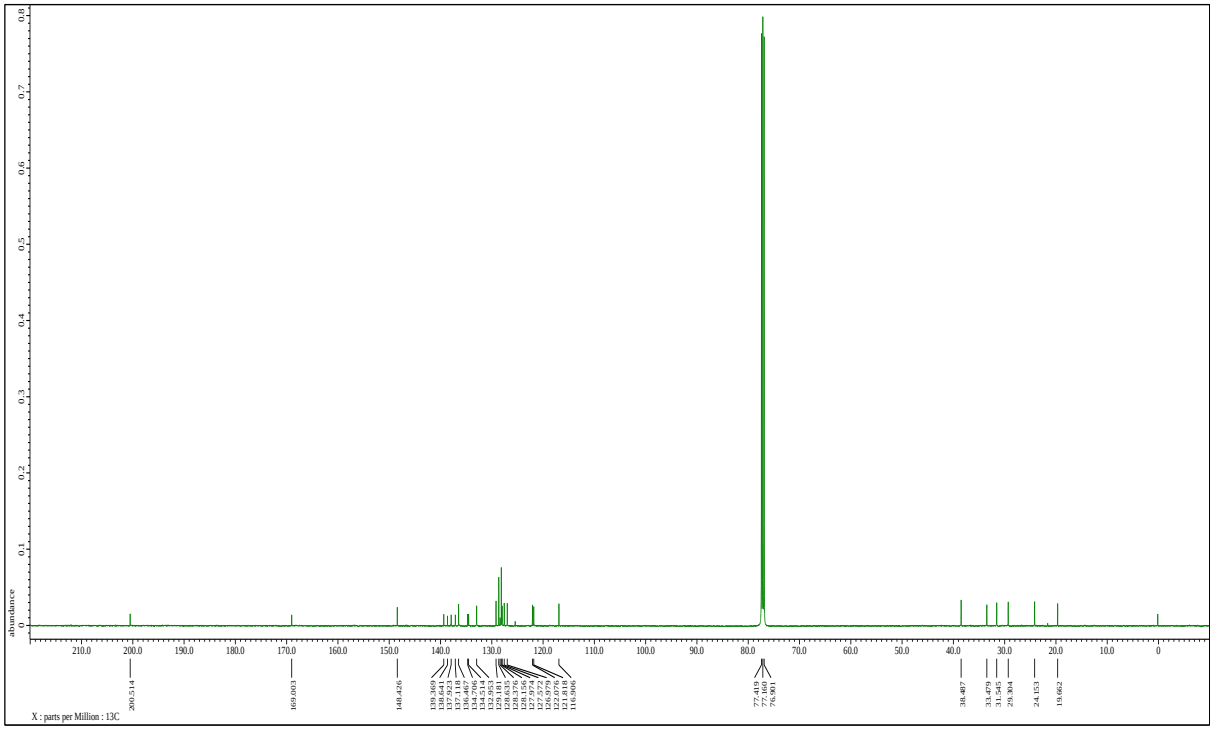

$^{13}$C NMR spectrum of **3j** and **3j'** (125 MHz, $CDCl_3$)



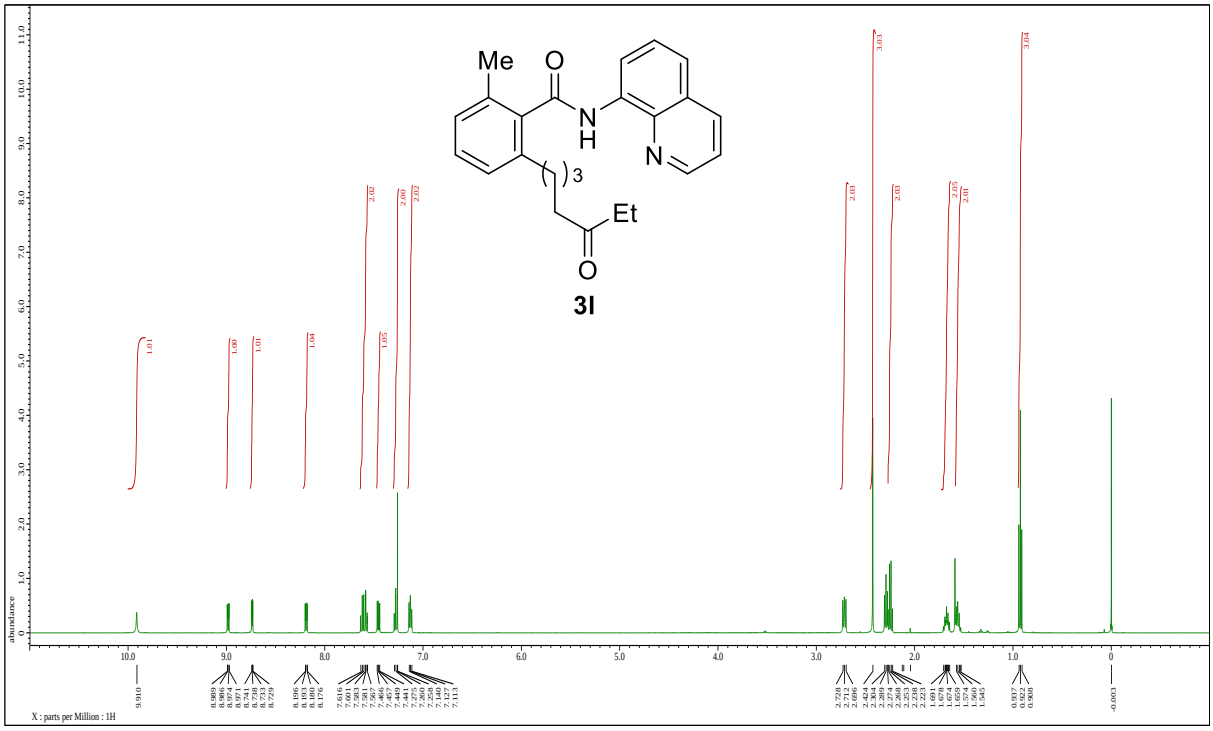
$^{1}$H NMR spectrum of **3k** (500 MHz, $CDCl_3$)



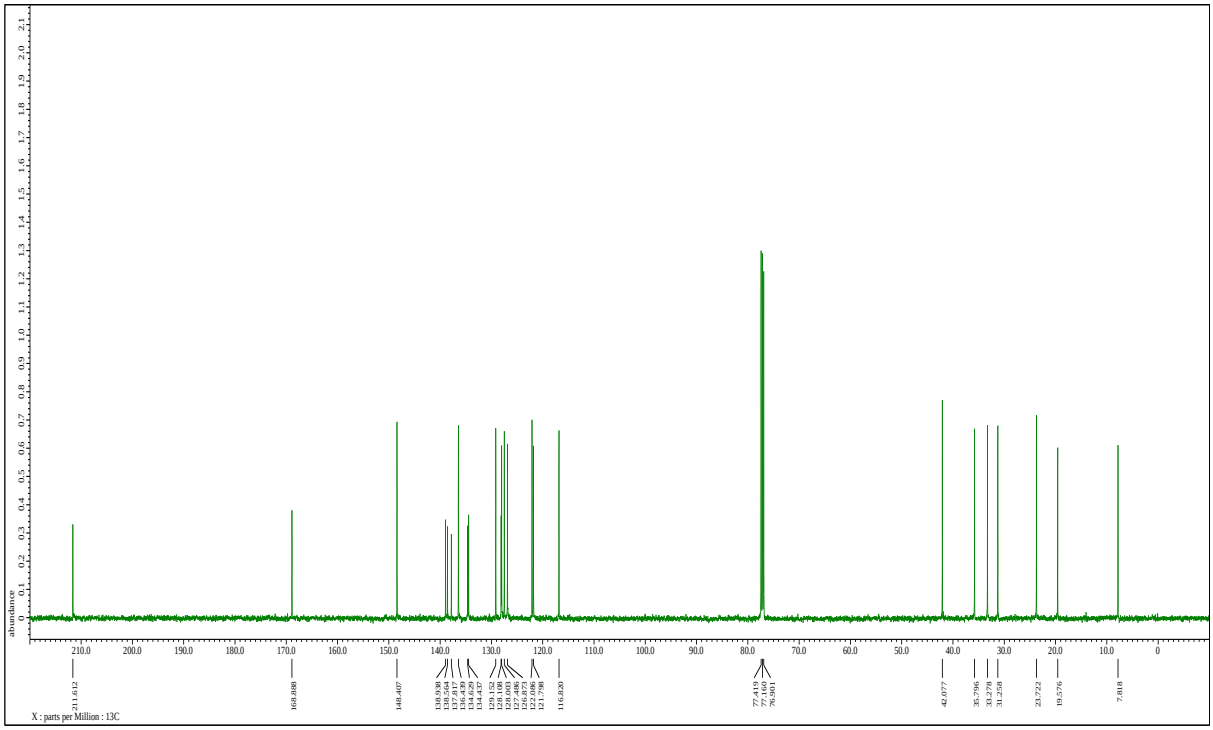

$^{13}$C NMR spectrum of **3k** (125 MHz, $CDCl_3$)



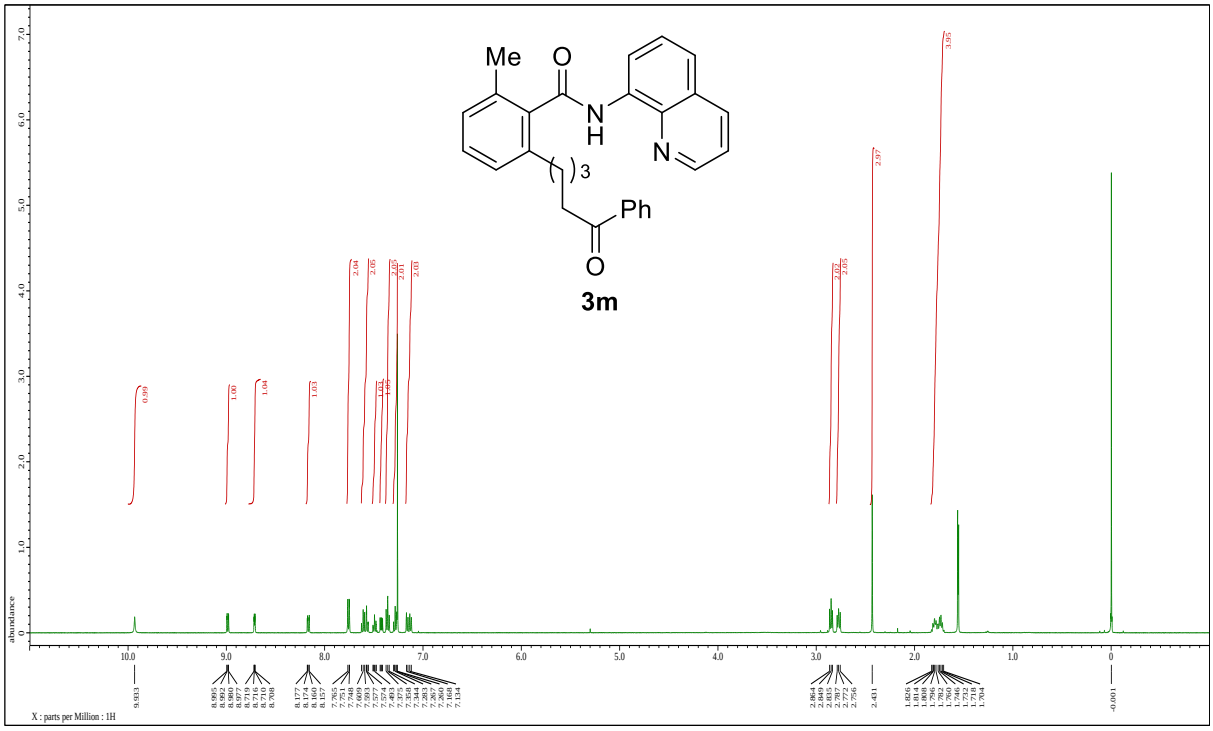
$^{1}$H NMR spectrum of **3l** (500 MHz, $CDCl_3$)



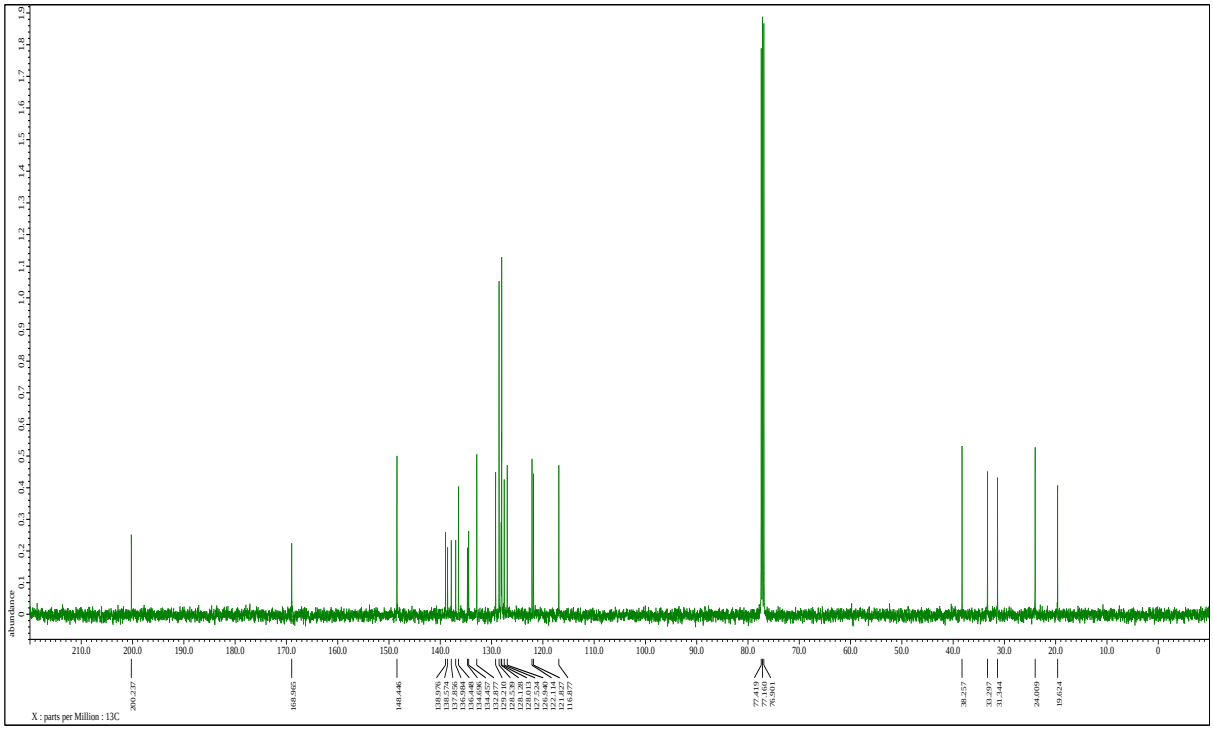

$^{13}$C NMR spectrum of **3l** (125 MHz, $CDCl_3$)



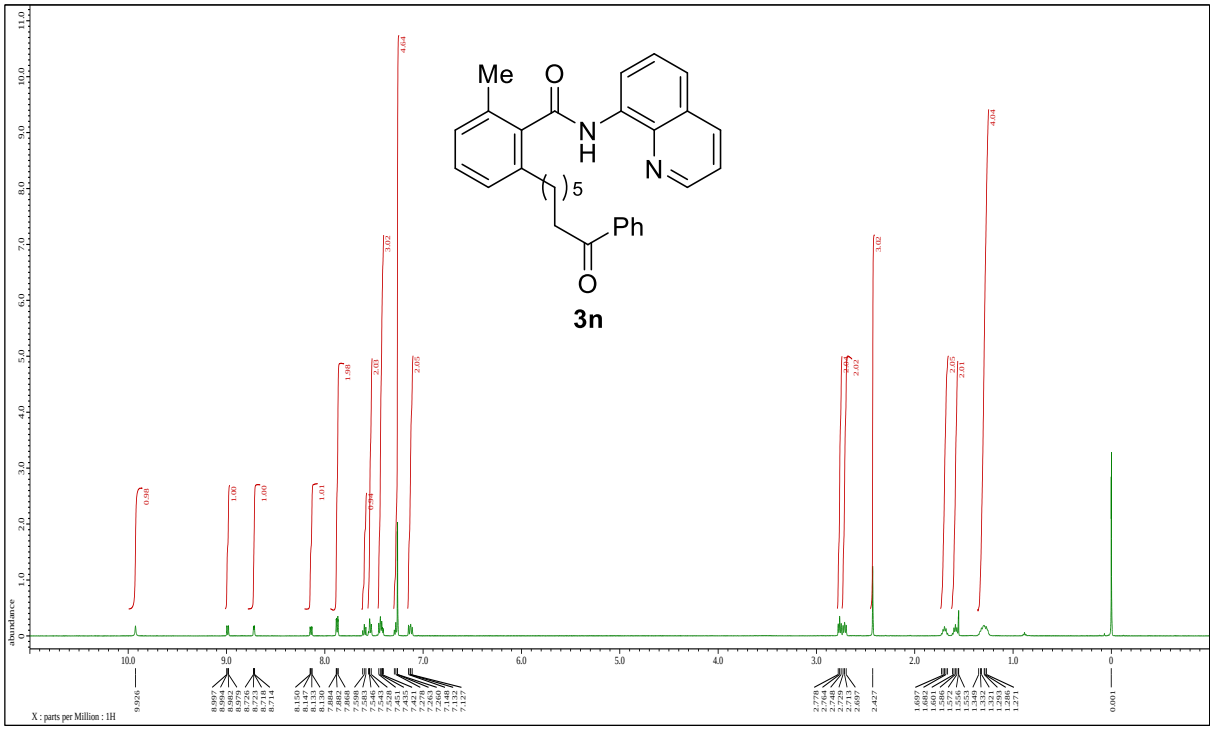
$^{1}$H NMR spectrum of **3m** (500 MHz, $CDCl_3$)



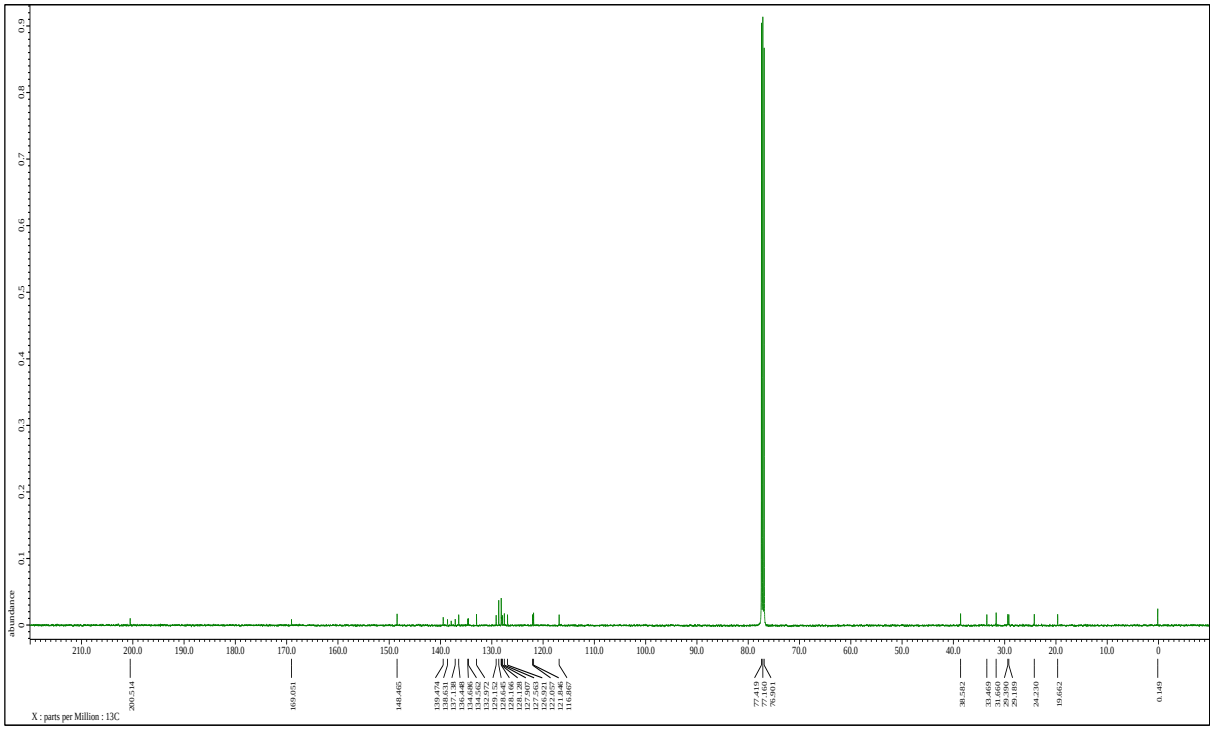

$^{13}$C NMR spectrum of **3m** (125 MHz, $CDCl_3$)



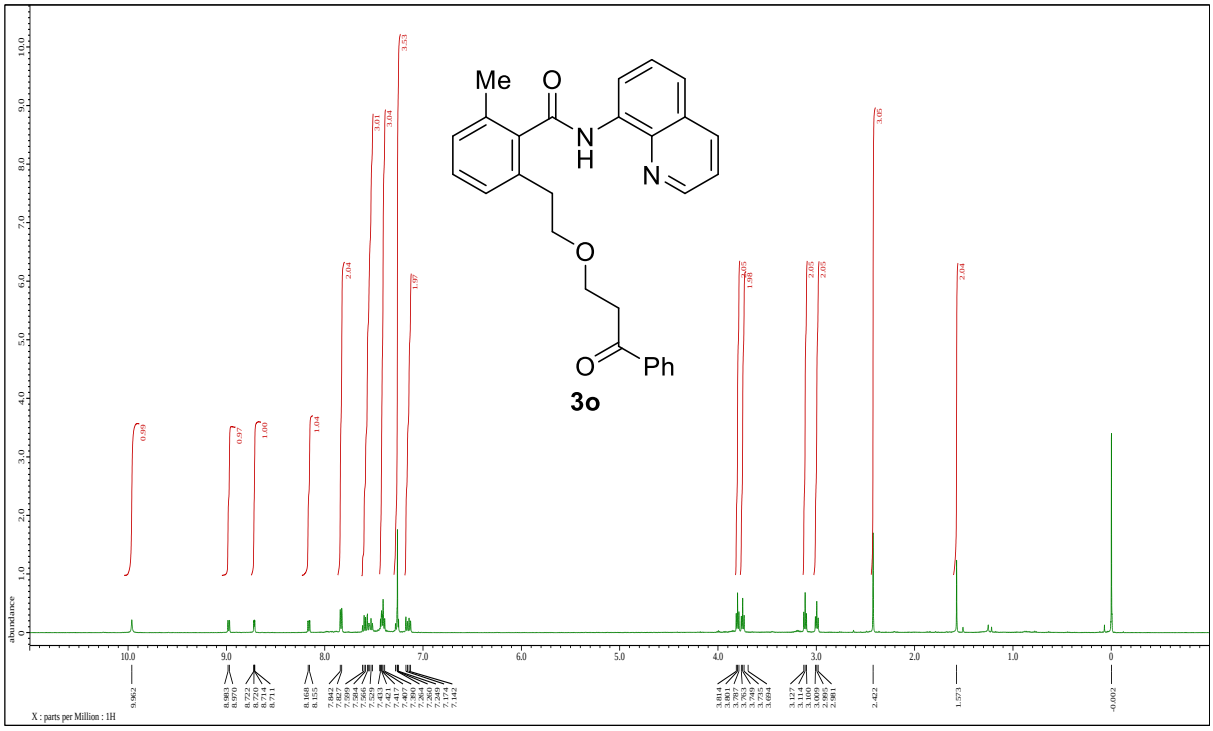
$^{1}$H NMR spectrum of **3n** (500 MHz, $CDCl_3$)



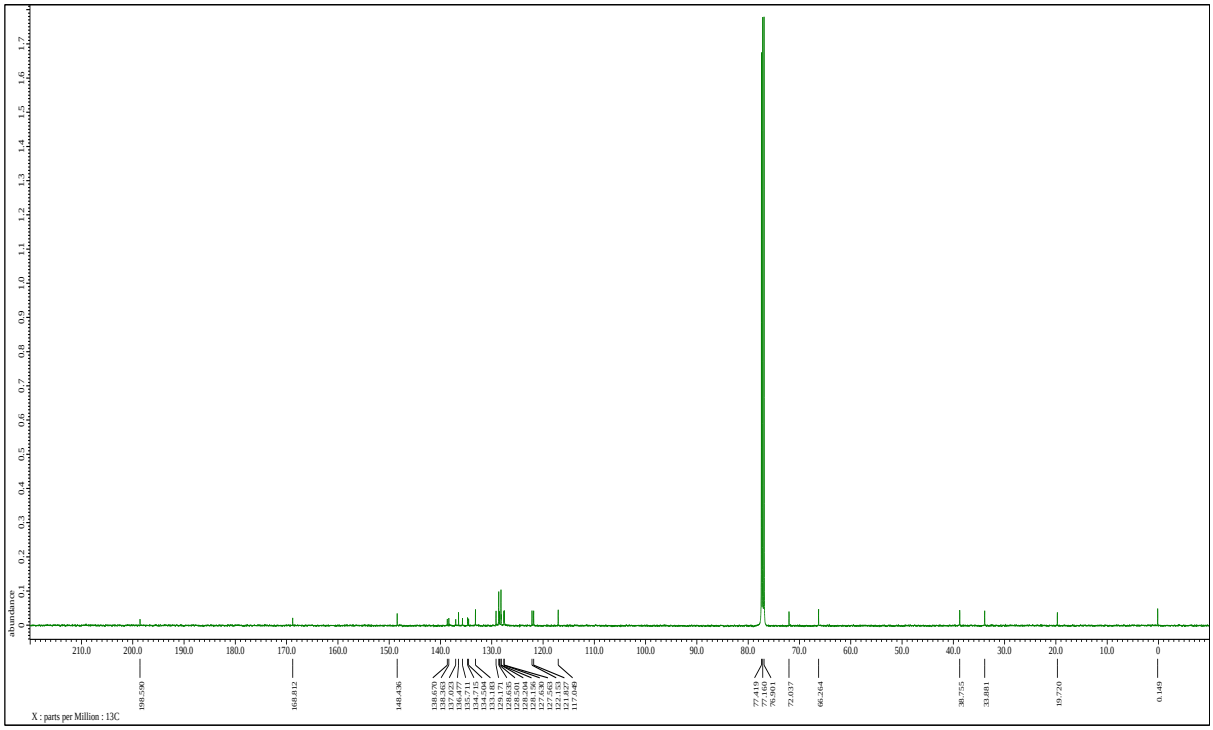

$^{13}$C NMR spectrum of **3n** (125 MHz, $CDCl_3$)



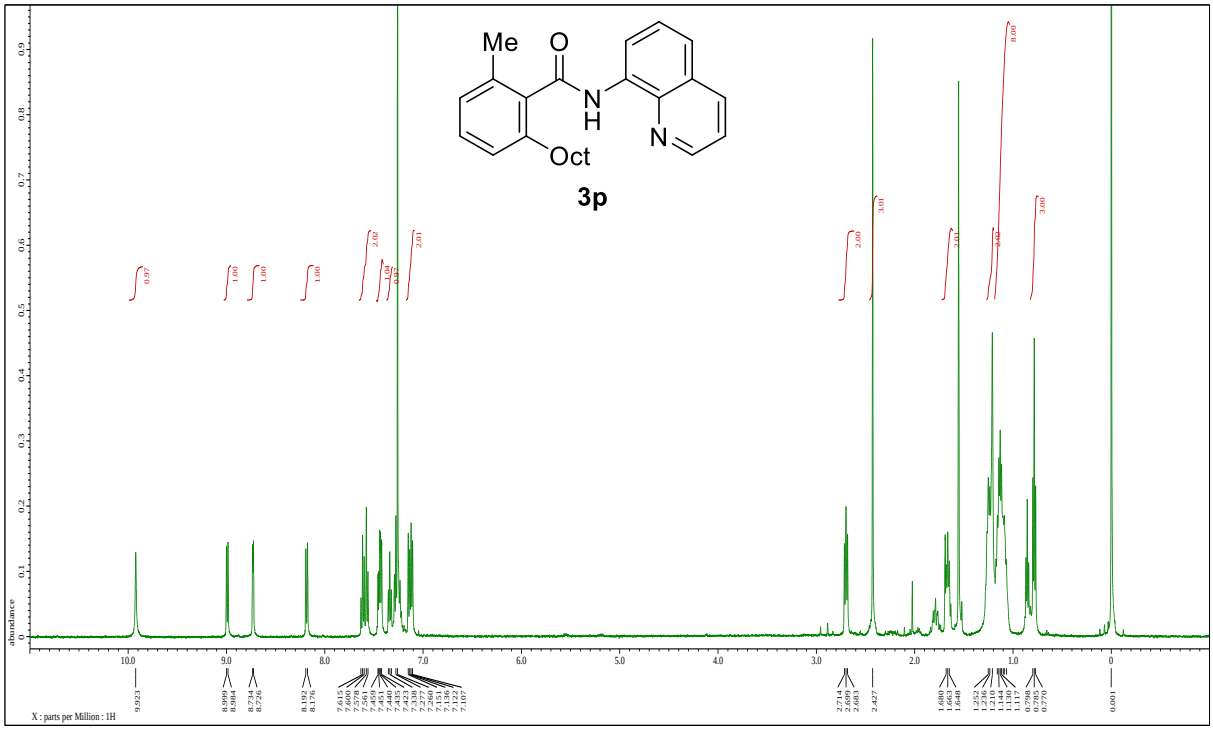
$^{1}$H NMR spectrum of **3o** (500 MHz, $CDCl_3$)



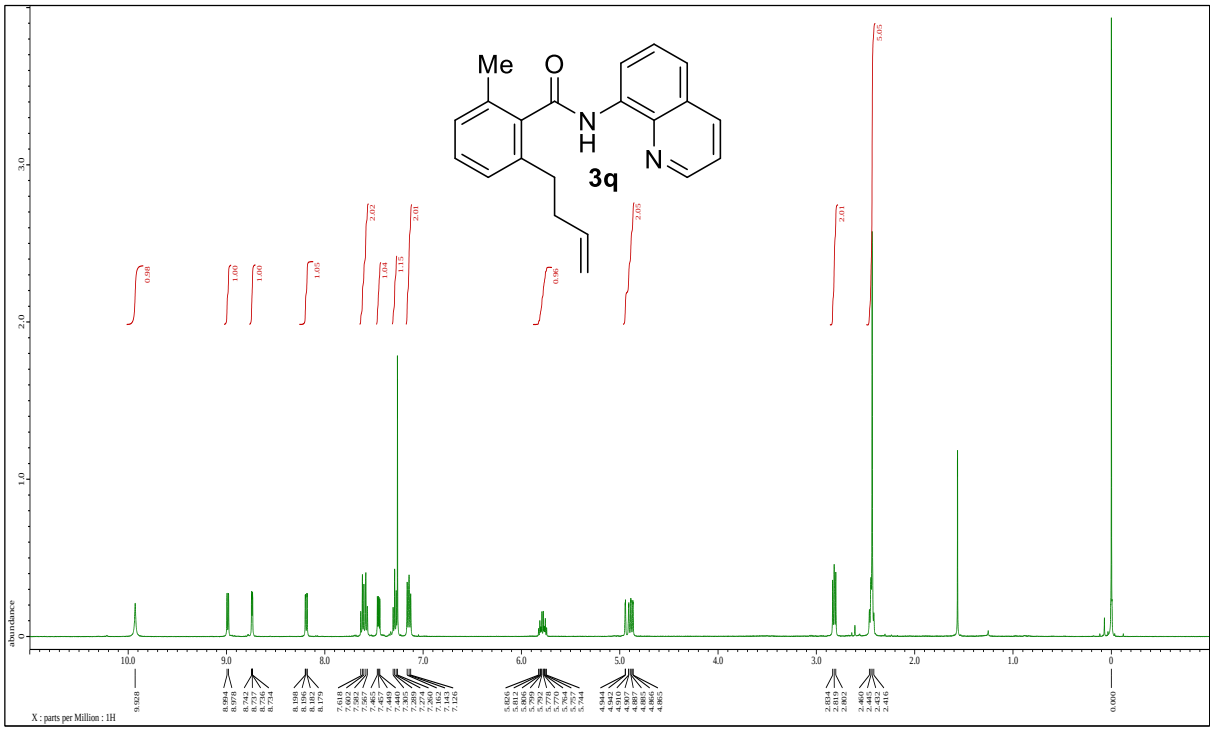

$^{13}$C NMR spectrum of **3o** (125 MHz, $CDCl_3$)



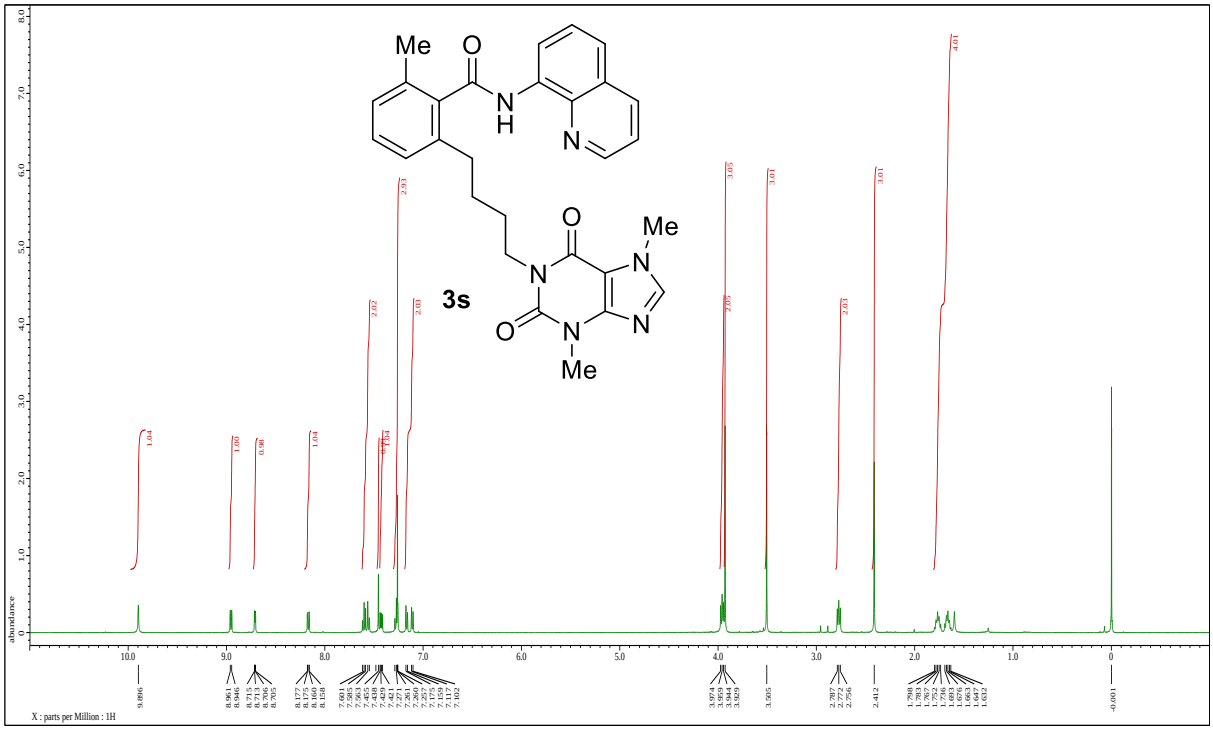
$^1$H NMR spectrum of **3p** (500 MHz, $CDCl_3$)




$^1$H NMR spectrum of **3q** (500 MHz, $CDCl_3$)



$^{1}$H NMR spectrum of **3s** (500 MHz, $CDCl_3$)




$^{13}$C NMR spectrum of **3s** (125 MHz, $CDCl_3$)