Electronic Supplementary Material (ESI) for ChemComm.

Supporting Information

Catalyst-free Electrochemical Decarboxylative Cross-Coupling of *N*-Hydroxyphthalimide Esters and *N*-Heteroarenes towards C(sp^3)-C(sp^2) Bond Formation

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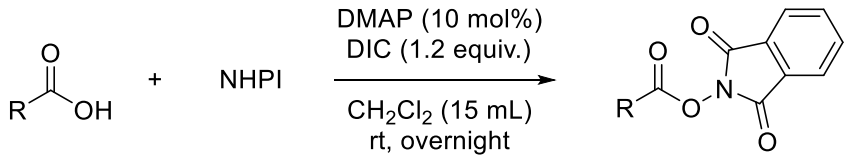
Content

General information

Unless otherwise noted, materials were obtained from commercial suppliers and used without further purification. DMA was purchased from Sinopharm. *p*-TsOH was purchased from Innochem, the other compounds, such as quinoline derivates, acid derivates, NHPI and DIC were purchased from Heowns. $^{n}Bu_4NBF_4$ was purchased from J&K. The NHP esters (1a-1l) were prepared according to literature report. Graphite felt was purchased from Hitechcarbon Co., Ltd. Thin layer chromatography (TLC) employed glass 0.25 mm silica gel plates. Flash chromatography columns were packed with 200-300 mesh silica gel. GC yields were recorded with a Shimadzu GC-2014. GC-MS was recorded by Shimadzu GCMS-QP2010 SE. All new compounds were characterized by ^{1}H NMR, ^{13}C NMR, ^{19}F NMR and HRMS. The known compounds were characterized by ^{1}H NMR, ^{13}C NMR and ^{19}F NMR. ^{1}H and ^{13}C NMR data were recorded with ADVANCE III 400 MHz with tetramethylsilane as an internal standard. All chemical shifts (δ) were reported in ppm and coupling constants (*J*) in Hz. All chemical shifts were reported relative to tetramethylsilane (0 ppm for ^{1}H), and $CDCl_3$ (77.16 ppm for ^{13}C) respectively. High resolution mass spectra (HRMS) were measured with Orbitrap Velos Pro，Thermo Scientific or Waters Micromass GCT Premier, accurate masses were reported for the molecular ion + proton ($[M+H]^+$) or molecular ion + Na^+ ($[M+Na]^+$).

Experimental section

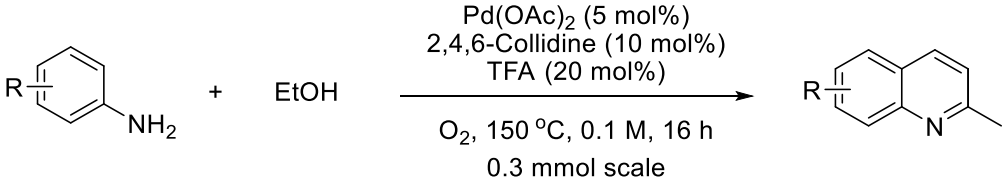
1) General procedure for synthesis of redox-active esters (1a-1l)[1]



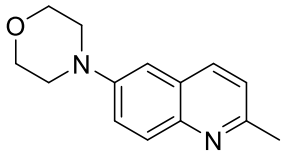
5 mmol 1.1 equiv.

General procedure: To a solution of the corresponding acid (5 mmol, 1.0 equiv.), 4-dimethylaminepyridine (61 mg, 0.5 mmol, 10 mol%) and *N*, *N*'-diisopropylcarbodiimide (756 mg, 0.6 mmol, 1.2 equiv.) in CH_2Cl_2 (15 mL) was stirred under air at room temperature for 5 min. Then, the NHPI (897 mg, 5.5 mmol, 1.1 equiv.) was added into the solution, and stirred overnight at room temperature. After reaction, the solution was concentrated in vacuo. The residue was purified by chromatography on silica gel, eluted with petroleum/ethyl acetate to afford the desired product. The compound **1a-1l** was previously reported.

2) General procedure for synthesis of quinlines (3c and 3e)[2]

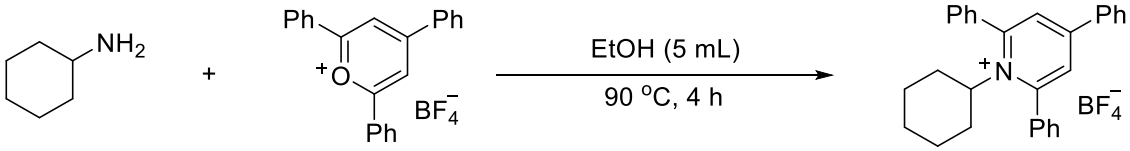


General procedure: Anilines 1 (0.3 mmol), Pd $(OAc)_2$ (5 mol%), 2,4,6-Collidine (10 mol%), and TFA (20 mol%) were added to a Schlenk tube charged with a magnetic stir bar in 3.0 mL of ethanol. The resulting suspension was stirred at 150 °C under O_2 for 16 h. After reaction, the solution was concentrated in vacuo. The residue was purified by chromatography on silica gel, eluting with petroleum/ethyl acetate to afford the desired product.



4-(2-methylquinolin-6-yl)morpholine (3e). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.93-7.90 (m, 2H), 7.45 (dd, *J* = 9.6, 2.8 Hz, 1H), 7.22 (d, *J* = 8.4 Hz, 1H), 7.01 (d, *J* = 2.8 Hz, 1H), 3.93 – 3.91 (m, 4H), 3.28 – 3.26 (m, 4H), 2.70 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 156.39, 148.84, 143.65, 135.19, 129.48, 127.49, 122.45, 122.14, 109.36, 67.02, 49.75, 25.20.

3) General procedure for synthesis of *N*-cyclohexylpyridinium salt (6)[3]



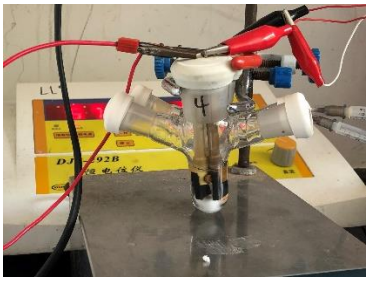
General procedure: A Schlenk tube equipped with a magnetic stirrer bar was charged with triphenylpyrylium tetrafluoroborate (5 mmol, 1.0 equiv.) and the cyclohexanamine (6 mmol, 1.2 equiv.). Ethanol (5 mL) was added to the reaction vessel and the tube was sealed. The reaction mixture was heated to 90 °C and after 4 h cooled to ambient temperature. The solid was collected by filtration and washed with ethanol and diethyl ether. After the operations required the solids were dried under reduced pressure to obtain the analytically pure pyridinium salts.

4) Procedures and analytical data of compounds for alkylated product

Graphical guide for the set-up: As experiment set-up, a piece of graphite felt (15 mm×10 mm×3 mm) was fixed on electrode for anode, and another piece of graphite felt (15 mm×10 mm×3 mm) was fixed on electrode for cathode. Rubber plugs, magneton, an undivided three-necked bottle and a dual display potentiostat (HJS-292B) (made in China) were used.

A) graphite felt anode and cathode

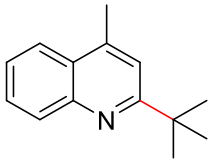
B) Assembly of electrochemical cell



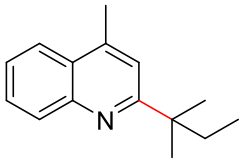
C) Current control electrolysis

General conditions: An oven-dried undivided three-necked bottle equipped with a stir bar. The bottle was equipped a graphite felt (15 mm×10 mm×3 mm) electrode as the anode and another graphite felt (15 mm×10 mm×3 mm) electrode as the cathode. The corresponding ester (0.4 mmol, if it was solid), the quinoline derivate (0.2 mmol, if it was solid) and $^{n}Bu_4NBF_4$ (82.3mg, 0.25 mmol, 0.05 M) was added into the undivided cell. And then the cell was charged with argon gas by glove box. *p*-TsOH (51.6mg, 0.3 mmol, 1.5 equiv.) was added in the glove box. After leaving glove box, the cell was charged with nitrogen. Finally, DMA (5 mL) were added. If any substrate was liquid, it would be added by using microsyringe before adding the solvent. The reaction mixture was stirred and electrolyzed at a constant current of 7.5 mA under room temperature for 2.5 h. The reaction was quenched with saturated sodium carbonate (aq.). The organic layer was extracted with EtOAc, dried with anhydrous Na_2SO_4, filtered, and concentrated under reduced pressure. The pure product was obtained by flash column chromatography on silica gel.

Analytical data of compounds:

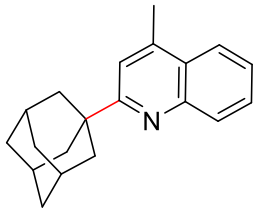


2-(tert-butyl)-4-methylquinoline (3aa). Prepared according to general condition, after work-up, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 50:1) to give **3aa** in 82% yield as a colorless oil**.** **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.06 (d, *J* = 8.4 1H), 7.93 (dd, *J* = 8.0, 0.8 Hz, 1H), 7.67-7.63 (m, 1H), 7.50-7.46 (m, 1H), 7.35 (d, *J* = 0.8 Hz, 1H), 2.68 (d, *J* = 0.8 Hz, 3H), 1.46 (s, 9H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 169.04, 147.38, 143.73, 130.04, 128.82, 126.65, 125.50, 123.51, 119.04, 38.04, 30.26, 19.12.

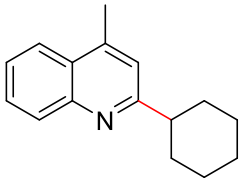


4-methyl-2-(tert-pentyl)quinoline (3ba) Prepared according to general condition, after work-up, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 50:1) to give **3ba** in 83% yield as a colorless oil**.** **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.06 (d, *J* = 8.4 Hz, 1H), 7.93 (dd, *J* = 8.4, 0.8 Hz, 1H), 7.67-7.63 (m, 1H), 7.50-7.46 (m, 1H), 7.29 (s, 1H), 2.67 (d, *J* = 0.4 Hz, 3H), 1.83

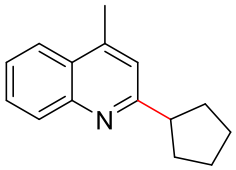
(q, *J* = 7.6 Hz, 2H), 1.42 (s, 6H), 0.73 (t, *J* = 7.6 Hz, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 168.17, 147.47, 143.47, 130.08, 128.73, 126.59, 125.46, 123.52, 119.52, 41.31, 35.97, 27.48, 19.12, 9.40.



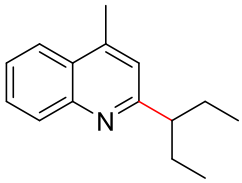
2-((1s,3s)-adamantan-1-yl)-4-methylquinoline (3ca). Prepared according to general condition, after work-up, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 30:1) to give **3ca** in 67% yield as a white solid**. ^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.06 (d, *J* = 8.4, 1H), 7.93 (dd, *J* = 7.2, 1.2 Hz, 1H), 7.67-7.63 (m, 1H), 7.50-7.46 (m, 1H), 7.32 (d, *J* = 0.8 Hz, 1H), 2.68 (m, *J* = 0.8 Hz, 3H), 2.15-2.10 (s, 9H), 1.82 (t, *J* = 2.8 Hz, 6H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 168.82, 147.60, 143.70, 130.03, 128.76, 126.82, 125.45, 123.56, 118.67, 41.91, 39.66, 37.01, 28.95, 19.15.



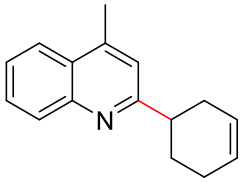
2-cyclohexyl-4-methylquinoline (3da). Prepared according to general condition, after work-up, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 30:1) to give **3da** in 91% yield as a colorless oil**. ^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.05 (d, *J* = 8.4 Hz, 1H), 7.93 (dd, *J* = 8.4, 0.8 Hz, 1H), 7.68-7.63 (m, 1H), 7.50-7.46 (m, 1H), 7.16 (s, 1H), 2.87 (tt, *J* = 12.0, 3.2 Hz, 1H), 2.67 (s, 3H), 2.01 (dd, *J* = 13.2, 1.6 Hz, 2H), 1.91 – 1.86 (dt, *J* = 12.8, 3.2 Hz 2H), 1.81 – 1.77 (m, 1H), 1.62 (qd, *J* = 12.4, 3.2 Hz, 2H), 1.46 (qt, *J* = 12.8, 3.2 Hz, 2H), 1.34 (tt, *J* = 12.4, 3.2 Hz 1H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 166.62, 147.70, 144.32, 129.57, 129.02, 127.12, 125.45, 123.66, 120.33, 47.74, 32.94, 26.67, 26.23, 18.96.



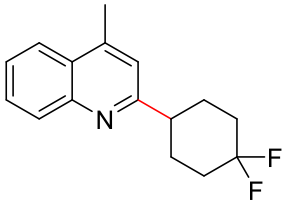
2-cyclopentyl-4-methylquinoline (3ea). Prepared according to general condition, after work-up, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 30:1) to give **3ea** in 63% yield as a colorless oil**. ^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.04 (d, *J* = 8.4 Hz, 1H), 7.89 – 7.87 (m, 1H), 7.65-7.61 (m, 1H), 7.47-7.43 (m, 1H), 7.14 (s, 1H), 3.36 – 3.28 (m, 1H), 2.61 (d, *J* = 7.2 Hz, 3H), 2.18 – 2.12 (m, 2H), 1.91 – 1.70 (m, 6H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 165.88, 147.52, 144.06, 129.46, 128.90, 126.95, 125.33, 123.53, 120.64, 48.84, 33.60, 26.06, 18.82.



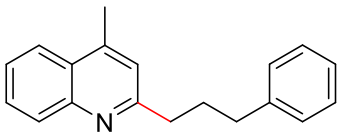
4-methyl-2-(pentan-3-yl)quinoline (3fa). Prepared according to general condition, after work-up, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 30:1) to give **3fa** in 66% yield as a colorless oil**. ^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.07 (dd, *J* = 8.4, 0.8 Hz, 1H), 7.95 (dd, *J* = 8.0, 0.8 Hz, 1H), 7.69-7.64 (m, 1H), 7.52-7.48 (m, 1H), 7.10 (d, *J* = 0.4 Hz, 1H), 2.77-2.68 (m, 4H), 1.82-1.74 (m, 4H), 0.83 (t, *J* = 7.6 Hz, 6H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 165.75, 147.74, 144.07, 129.66, 128.94, 127.16, 125.44, 123.70, 120.79, 52.34, 28.39, 19.01, 12.39.



2-(cyclohex-3-en-1-yl)-4-methylquinoline (3ga). Prepared according to general condition, after work-up, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 30:1) to give **3ga** in 72% yield as a colorless oil**. ^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.05 (d, *J* = 8.4 Hz, 1H), 7.95 (dd, *J* = 8.4, 0.8 Hz, 1H), 7.69-7.65 (m, 1H), 7.52-7.48 (m, 1H), 7.18 (s, 1H), 5.87 – 5.75 (m, 2H), 3.18 – 3.10 (m, 1H), 2.68 (s, 3H), 2.44-2.40 (m, 2H), 2.24– 2.21 (m, 2H), 2.09 – 2.05 (m, 1H), 1.97-1.87 (m, 1H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 166.04, 147.71, 144.51, 129.60, 129.12, 127.14, 127.02, 126.52, 125.58, 123.70, 120.50, 43.26, 31.49, 28.70, 25.78, 18.99.

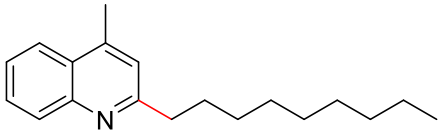


2-(4,4-difluorocyclohexyl)-4-methylquinoline (3ha). Prepared according to general condition, after work-up, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 5:1) to give **3ha** in 50% yield as a colorless oil**. ^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.03 (d, *J* = 8.4 Hz, 1H), 7.96 (dd, *J* = 7.2, 0.8 Hz, 1H), 7.71-7.67 (m, 1H), 7.54-7.50 (m, 1H), 7.17 (s, 1H), 2.97 (tt, *J* = 11.2, 3.6 Hz, 1H), 2.70 (d, *J* = 0.8 Hz, 3H), 2.30-2.22 (m, 2H), 2.11-1.84 (m, 6H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 164.00, 147.66, 144.91, 129.60, 129.35, 127.25, 125.89, 123.77, 123.77, 123.39 (dd, *J* = 243.2, 240.3 Hz), 119.89, 45.29, 33.87 (dd, *J* = 25.6, 22.8 Hz), 28.86 (d, *J* = 9.8 Hz), 19.02. **^{19}F NMR** (377 MHz, $CDCl_3$) δ -91.60 (d, *J* = 236.0 Hz), -101.54 (d, *J* = 236.4 Hz).

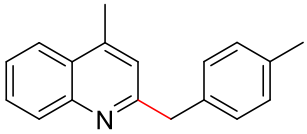


4-methyl-2-(3-phenylpropyl)quinoline (3ia) Prepared according to general condition, after work-up, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 15:1) to give **3ia** in 49% yield as a colorless oil. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.04 (d, *J* = 8.4 Hz, 1H), 7.94 (dd, *J* = 8.0, 0.8 Hz, 1H), 7.69-7.65 (m, 1H), 7.51-7.47 (m, 1H), 7.30-7.16 (m, 6H), 2.99-2.95 (m, 2H),

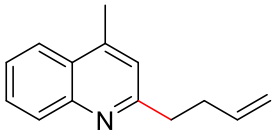
2.76-2.65 (m, 5H), 2.18 – 2.10 (m, 2H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 162.28, 147.80, 144.38, 142.26, 129.41, 129.18, 128.60, 128.42, 126.89, 125.89, 125.58, 123.71, 122.16, 38.86, 35.87, 31.77, 18.81.



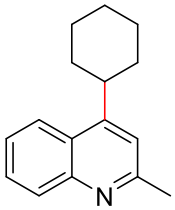
4-methyl-2-nonylquinoline (3ja). Prepared according to general condition, after work-up, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 30:1) to give **3ja** in 52% yield as a colorless oil. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.04 (d, *J* = 8.4 Hz, 1H), 7.94 (d, *J* = 8.0 Hz, 1H), 7.68-7.64 (m, 1H), 7.51-7.47 (m, 1H), 7.14 (s, 1H), 2.93-2.89 (m, 2H), 2.67 (s, 3H), 1.83-1.75 (m, 2H), 1.44-1.26 (m, 12H), 0.89-0.85 (m, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 162.93, 147.81, 144.23, 129.43, 129.10, 126.87, 125.47, 123.69, 122.18, 39.47, 32.01, 30.28, 29.76, 29.68, 29.65, 29.44, 22.81, 18.84, 14.26. **HR-MS (ESI)**: *m/z* calculated for $[C19H28N]^+$, $[M+H]^+$: 270.2216, measured: 270.2225



4-methyl-2-(4-methylbenzyl)quinoline (3ka). Prepared according to general condition, after work-up, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 5:1) to give **3ka** in 36% yield as a white solid. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.09 (d, *J* = 8.4 Hz, 1H), 7.92 (dd, *J* = 8.4, 0.8 Hz, 1H), 7.70-7.66 (m, 1H), 7.52-7.48 (m, 1H), 7.16 (dd, *J* = 38.0, 8.0 Hz, 2H), 7.05 (s, 1H), 4.25 (s, 2H), 2.59 (d, *J* = 0.4 Hz, 3H), 2.31 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 161.23, 147.67, 144.69, 136.38, 136.09, 129.57, 129.41, 129.25, 129.19, 126.97, 125.80, 123.73, 122.25, 45.20, 21.18, 18.84.

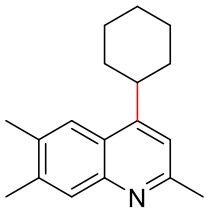


2-(but-3-en-1-yl)-4-methylquinoline (3la). Prepared according to general condition, after work-up, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 15:1) to give **3la** in 21% yield as a colorless oil. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.05 (d, *J* = 8.4 Hz, 1H), 7.96 (dd, *J* = 8.4, 0.8 Hz, 1H), 7.70-7.66 (m, 1H), 7.53-7.49 (m, 1H), 7.15 (s, 1H), 5.98-5.88 (m, 1H), 5.12-5.07 (m, 1H), 5.02-4.98 (m, 1H), 3.03 (dd, *J* = 9.6, 8 Hz, 2H), 2.68 (d, *J* = 0.8 Hz, 3H), 2.61-2.55 (m, 2H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 161.80, 147.75, 144.53, 137.91, 129.39, 129.26, 126.95, 125.68, 123.76, 122.26, 115.30, 38.54, 34.02, 18.89.

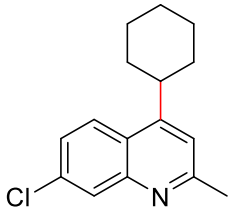


4-cyclohexyl-2-methylquinoline (3ab). Prepared according to general condition, after work-up, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 15:1) to give **3ab** in 90% yield as a colorless oil. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.03 (d, *J* = 8.8 Hz, 2H), 7.67-7.63 (m, 1H), 7.51-7.47 (m, 1H), 7.17 (s, 1H), 3.31-3.26 (m, 1H), 2.72 (s, 3H), 2.02-1.84 (m, 5H), 1.60-

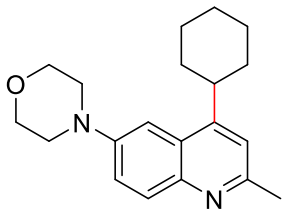
1.48 (m, 4H), 1.39-1.31 (m, 1H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 158.92, 153.43, 148.20, 129.59, 128.91, 125.38, 125.25, 122.96, 118.44, 38.88, 33.67, 27.05, 26.44, 25.67.



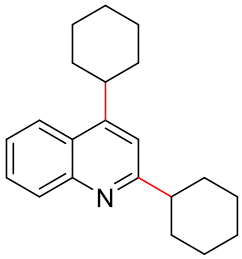
4-cyclohexyl-2,6,7-trimethylquinoline (3ac). Prepared according to general condition, after work-up, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 5:1) to give **3ac** in 89% yield as a white solid. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.79 (s, 1H), 7.73 (s, 1H), 7.08 (s, 1H), 3.28-3.22 (m, 1H), 2.68 (s, 3H), 2.45 (d, *J* = 6.0 Hz, 6H), 1.99-1.84 (m, 5H), 1.58 – 1.47 (m, 4H), 1.38-1.29 (m, 1H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 157.83, 152.62, 147.26, 138.90, 134.96, 129.04, 123.66, 122.30, 117.65, 38.77, 33.68, 27.08, 26.48, 25.52, 20.55, 20.38. **HR-MS (ESI)**: *m*/*z* calculated for $[C18H24N]^+$, $[M+H]^+$: 254.1903, measured: 254.1900.



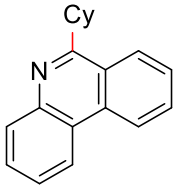
7-chloro-4-cyclohexyl-2-methylquinoline (3ad). Prepared according to general condition, after work-up, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 10:1) to give **3ad** in 90% yield as a colorless oil. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.01 (d, *J* = 2.0 Hz, 1H), 7.93 (d, *J* = 9.2 Hz, 1H), 7.41 (dd, *J* = 8.8, 2.0 Hz, 1H), 7.15 (s, 1H), 3.24-3.18 (m, 1H), 2.70 (s, 3H), 1.97-1.83 (m, 5H), 1.59-1.45 (m, 4H), 1.36-1.27 (m, 1H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 160.18, 153.44, 148.74, 134.60, 128.53, 126.19, 124.38, 123.66, 118.61, 38.93, 33.59, 26.93, 26.31, 25.62.



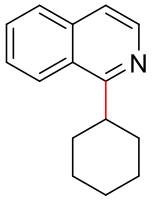
4-(4-cyclohexyl-2-methylquinolin-6-yl)morpholine (3ae). Prepared according to general condition, after work-up, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 2:1) to give a mixture of **3ae and 3e,** the NMR yield was 48% and **3ae** was a yellow solid. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.93 (d, *J* = 9.2 Hz, 1H), 7.42 (dd, *J* = 9.2, 2.8 Hz, 1H), 7.23 (d, *J* = 2.4 Hz, 1H), 7.11 (s, 1H), 3.94 (t, *J* = 4.4 Hz, 4H), 3.28 (t, *J* = 4.8 Hz, 4H), 3.20-3.16 (m, 1H), 2.67 (s, 3H), 2.02-1.84 (m, 5H), 1.63 – 1.47 (m, 4H), 1.39-1.32 (m, 1H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 156.27, 151.94, 148.65, 143.86, 130.36, 125.85, 121.51, 118.69, 105.27, 67.07, 49.94, 39.01, 33.45, 27.12, 26.47, 25.32. **HR-MS (ESI)**: *m*/*z* calculated for $[C20H27N2O]^+$, $[M+H]^+$: 311.2118, measured: 311.2109



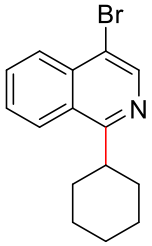
2,4-dicyclohexylquinoline (3af). Prepared according to general condition, but 4 equiv. of NHP ester (0.8 mmol) was used and the time was expanded to 5 hours. After work-up, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 30:1) to give **3af** in 64% yield as a white solid. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.07-8.02 (m, 2H), 7.66-6.62 (m, 1H), 7.49-7.45 (m, 1H), 7.20 (s, 1H), 3.32-3.27 (m, 1H), 2.88 (tt, *J* = 12.0, 3.2 Hz, 1H), 2.03-1.77 (m, 10H), 1.69-1.29 (m, 10H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 166.73, 153.45, 148.14, 129.98, 128.68, 125.74, 125.29, 122.90, 115.84, 47.97, 39.06, 33.73, 33.00, 27.07, 26.70, 26.45, 26.23.



6-cyclohexylphenanthridine (3ag). Prepared according to general condition, after work-up, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 50:1) to give **3ag** in 97% yield as a white solid. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.57 (d, *J* = 8.0 Hz, 1H), 8.47 (d, *J* = 8.0 Hz, 1H), 8.26 (d, *J* = 8.4 Hz, 1H), 8.13 (d, *J* = 7.6 Hz, 1H), 7.75-7.53 (m, 4H), 3.58 (tt, *J* = 11.6, 2.8 Hz, 1H), 2.08-1.81 (m, 7H), 1.60-1.36 (m, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 165.33, 143.93, 133.03, 129.99, 129.96, 128.44, 127.11, 126.18, 125.65, 124.76, 123.40, 122.61, 121.89, 42.05, 32.38, 26.97, 26.42.

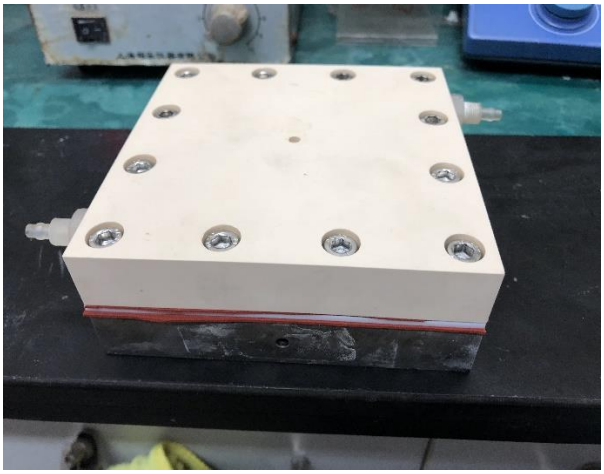


1-cyclohexylisoquinoline (3ah). Prepared according to general condition, after work-up, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 15:1) to give **3ah** in 35% yield as a colorless oil. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.48 (d, *J* = 5.6 Hz, 1H), 8.20 (d, *J* = 8.4 Hz, 1H), 7.77 (d, *J* = 8.0 Hz, 1H), 7.63-7.54 (m, 2H), 7.45 (d, *J* = 5.6 Hz, 1H), 3.55 (tt, *J* = 9.6, 3.2 Hz, 1H), 2.00-1.79 (m, 7H), 1.52 (qt, *J* = 12.4, 3.2 Hz, 2H), 1.40 (tt, *J* = 12.4, 3.2 Hz, 1H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 165.71, 141.95, 136.38, 129.56, 127.57, 126.84, 126.29, 124.74, 118.92, 41.55, 32.63, 26.93, 26.30.



4-bromo-1-cyclohexylisoquinoline (3ai). Prepared according to general condition, after work-up, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 10:1) to give **3ai** in 65% yield as a white solid. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.65 (s, 1H), 8.20 (dd, *J* = 13.2, 8.4 Hz, 2H), 7.78-7.74 (m, 1H), 7.66-7.62 (m, 1H), 3.51 (tt, *J* = 11.6, 2.8 Hz, 1H), 1.98-1.91 (m, 4H), 1.84- 1.74 (m, 3H), 1.52 (qt, *J* = 13.2, 3.6 Hz, 2H), 1.39 (tt, *J* = 12.4, 3.2 Hz, 1H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 165.44, 143.68, 134.96, 130.89, 127.83, 127.69, 126.94, 125.16, 117.63, 41.56, 32.63, 26.88, 26.26.

5) The gram scale reaction in continue-flow system



A The undivided electrolytic cell by using two pieces of carbon paper

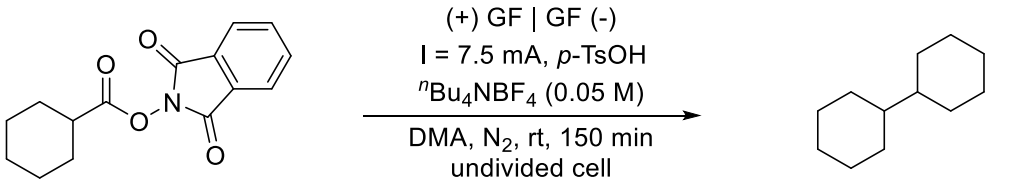
B The continuous-flow reactor

A 200 mL Schlenk tube equipped with a magnetic stirrer bar was charged with **1d** (4.10 g, 15 mmol, 2 equiv.) and ^{n}Bu$_4$NBF$_4$ (1.64 g, 5 mmol, 0.05M). And then the tube was charged with argon gas by glove box. *p*-TsOH (1.94 g, 11.25 mmol, 1.5 equiv.) was added in the glove box. After leaving glove box, the cell was charged with nitrogen. Finally, 2a (1.07 g, 7.5 mmol, 1 equiv.) and DMA (100 mL) were added. After stirring for 10 min, the pump was started and electrolyzed at a constant current of 10 mA under room temperature for 45 h. The reaction was quenched with saturated sodium carbonate (aq.). The organic layer was extracted with EtOAc, dried with anhydrous Na_2SO_4, filtered, and concentrated under reduced pressure. The pure product was obtained by flash column chromatography on silica gel to give 71% of isolated yield (1.2 g).

For more details of the continue-flow device please check our previous work[4].

6) Control experiments

A: Home-coupling product



1d

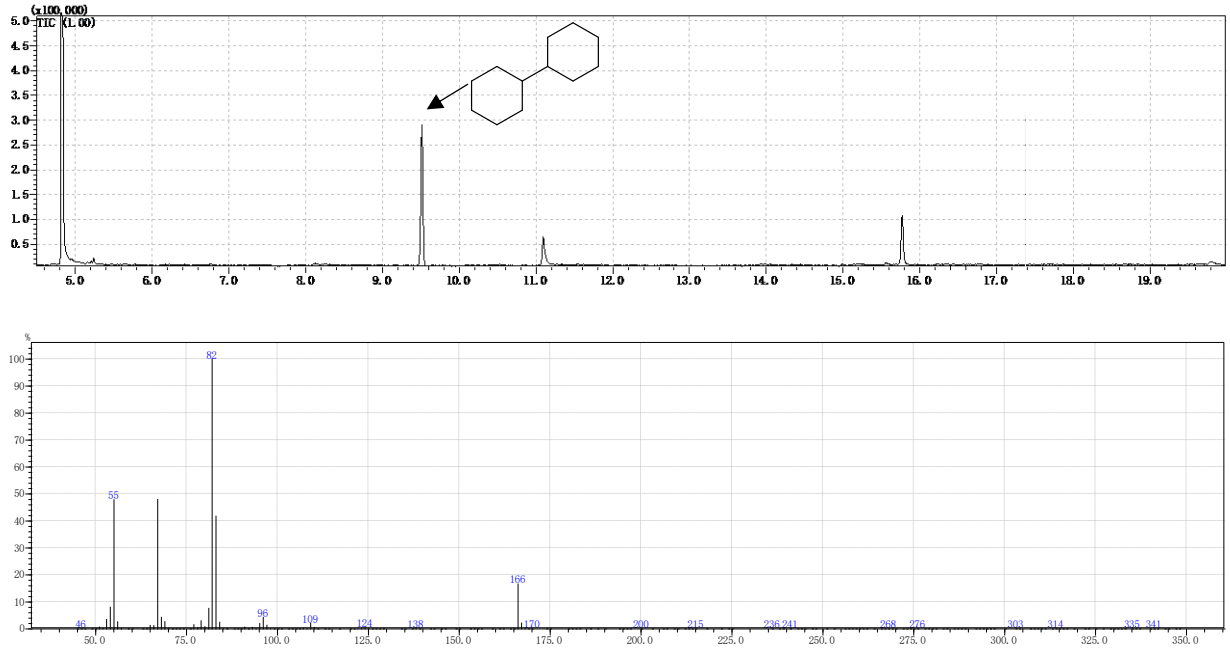
0.4 mmol

7, m/z = 166

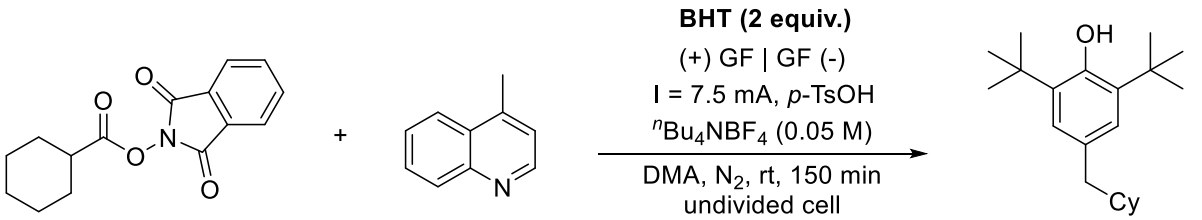
detected by GC-MS

An oven-dried undivided three-necked bottle equipped with a stir bar. The bottle was equipped a graphite felt (15 mm×10 mm×3 mm) electrode as the anode and another graphite felt (15 mm×10 mm×3 mm) electrode as the cathode. The **1d** (109.2 mg, 0.4 mmol), $^{n}Bu_4NBF_4$ (82.3mg, 0.25 mmol, 0.05 M) was added in to the undivided cell. And then the cell was charged with argon gas by glove box. *p*-TsOH (51.6mg, 0.3 mmol, 1.5 equiv.) was added in the glove box. After leaving glove box, the cell was charged with nitrogen. Finally, DMA (5 mL) were added. The reaction mixture was stirred and electrolyzed at a constant current of 7.5 mA under room temperature for 2.5 h. The reaction was quenched with saturated sodium carbonate (aq.). The organic layer was extracted with EtOAc (10 mL). Take a drop from the reaction solution and use the "plug" to filter it. Finally, dilute to 10 μL/ mL in a vial and do the GC-MS test.

GC-MS data

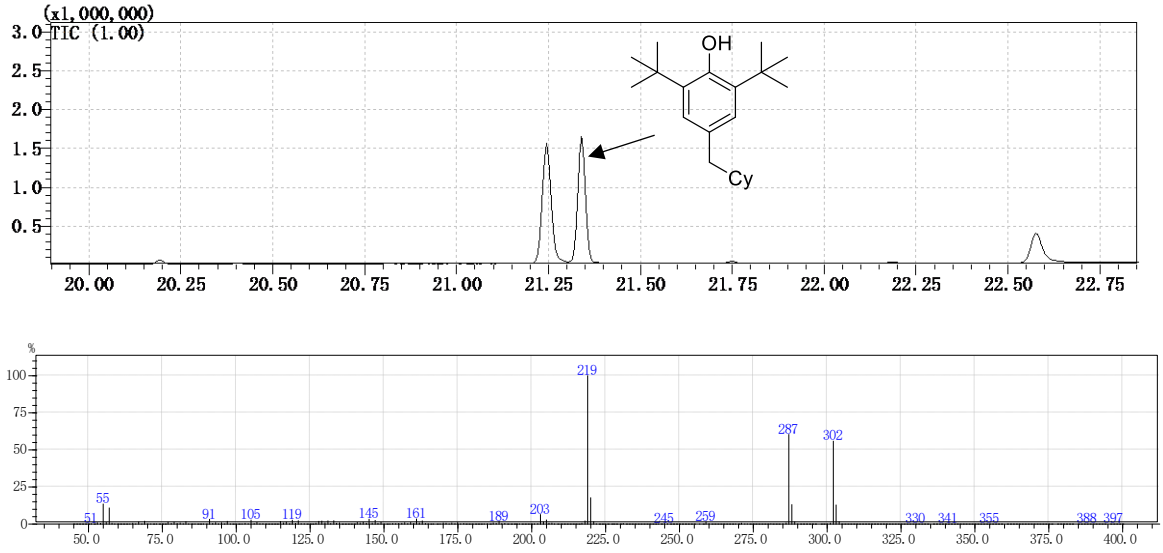


B: The radical trapping experiment

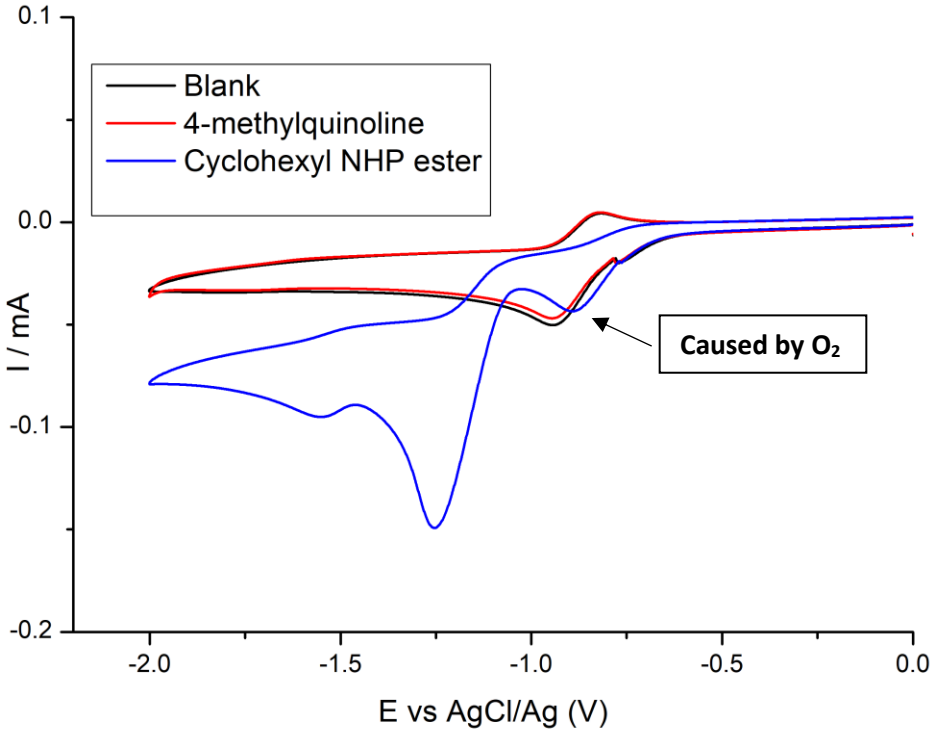


An oven-dried undivided three-necked bottle equipped with a stir bar. The bottle was equipped a graphite felt (15 mm×10 mm×3 mm) electrode as the anode and another graphite felt (15 mm×10 mm×3 mm) electrode as the cathode. The ester **1d** (109.2 mg, 0.4 mmol), BHT (butylated hydroxytoluene, 44.0 mg, 0.4 equiv.) and $^{n}Bu_4NBF_4$ (82.3mg, 0.25 mmol, 0.05 M) was added into the undivided cell. And then the cell was charged with argon gas by glove box. *p*-TsOH (51.6mg, 0.3 mmol, 1.5 equiv.) was added in the glove box. After leaving glove box, the cell was charged with nitrogen. Finally, the quinoline **2a** (24 μL, 0.2 mmol) and DMA (5 mL) were added. The reaction mixture was stirred and electrolyzed at a constant current of 7.5 mA under room temperature for 2.5 h. The reaction was quenched with saturated sodium carbonate (aq.). The organic layer was extracted with EtOAc (10 mL). Take a drop from the reaction solution and use the "plug" to filter it. Finally, dilute it to 10 μL/ mL in a vial and do the GC-MS test.

GC-MS data



7) Cyclic voltammetry (CV) tests



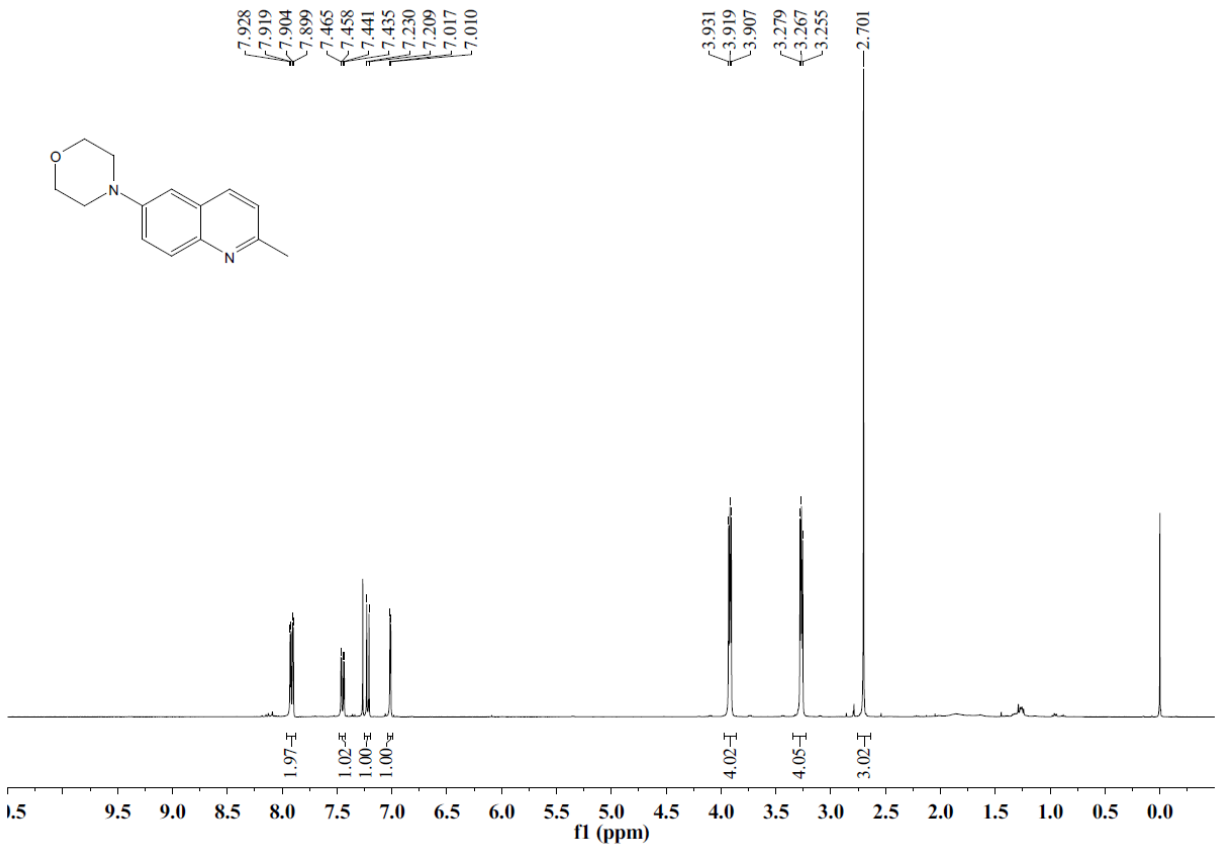
CV test conditions: Study of the reduction potential during the electrolysis. A cyclic voltammograms in DMA (10 mL) by using glassy carbon as the working electrode, Pt wire as the counter electrode and AgCl/Ag as the reference electrode. The scan rate was 100 mV/s.
black line: 0.05 M $^{n}Bu_4NBF_4$ in DMA (10 mA) under air; **red line**: 4-methylquinoline (**2a**, 0.1 mmol), 0.05 M $^{n}Bu_4NBF_4$ in DMA (10 mA) under air; **blue line**: Cyclohexyl NHP ester (**1d**, 0.1 mmol), 0.05 M $^{n}Bu_4NBF_4$ in DMA (10 mA) under air.

References

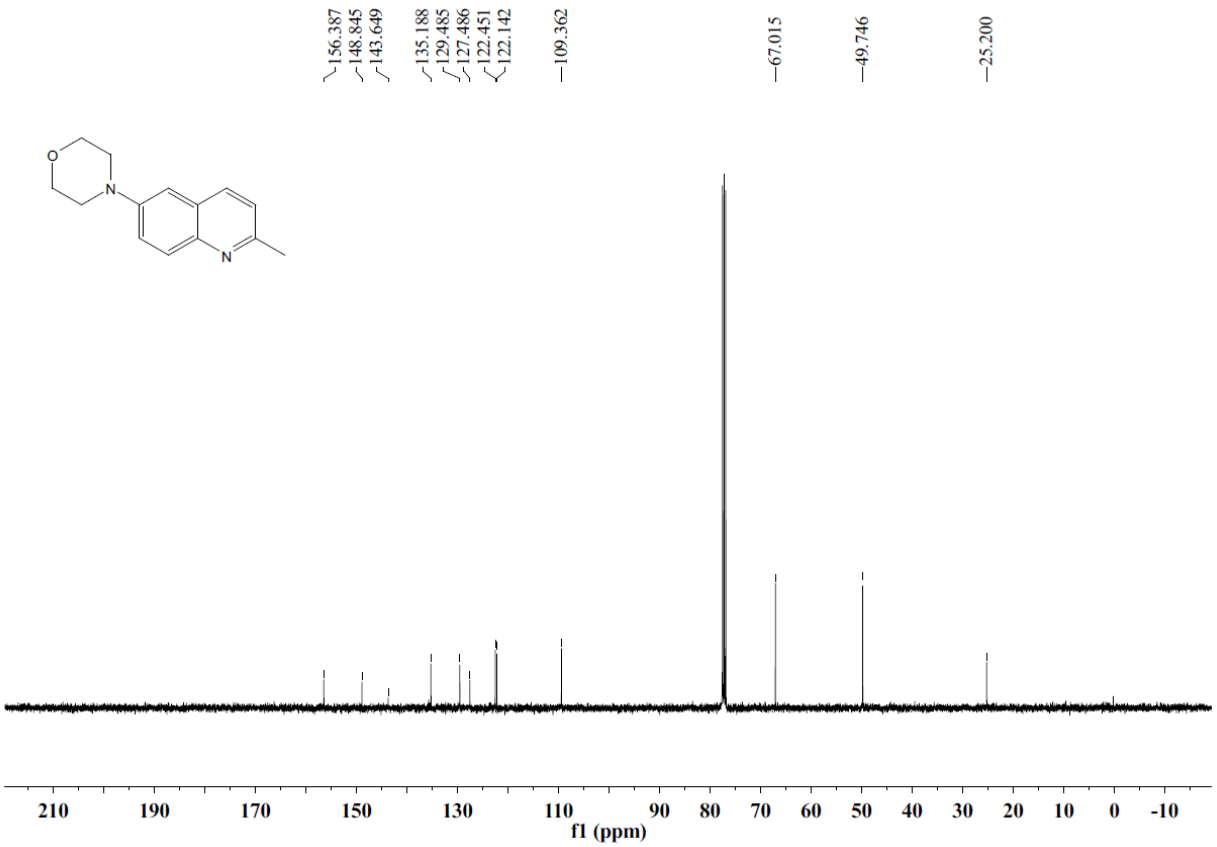
1. A. Tlahuext-Aca, R. Garza-Sanchez, and F. Glorius, *Angew. Chem. Int. Ed*., 2017, **56**, 3708-3711.
2. J. Li, J. Zhang, H. Yang, and G. Jiang, *J. Org. Chem*., 2017, **82**, 3284-3290.
3. F. Klauck, M. James, and F. Glorius, *Angew. Chem. Int. Ed.*, 2017, **56**, 12336-12339.
4. D. Wang, P. Wang, S. Wang, Y. Chen, H. Zhang and A. Lei, *Nature Comum*., 2019, **10**, 2796

NMR Spectra of Products

3e 1H NMR



3e 13C NMR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25.200
O
N
N
210
190
170
150
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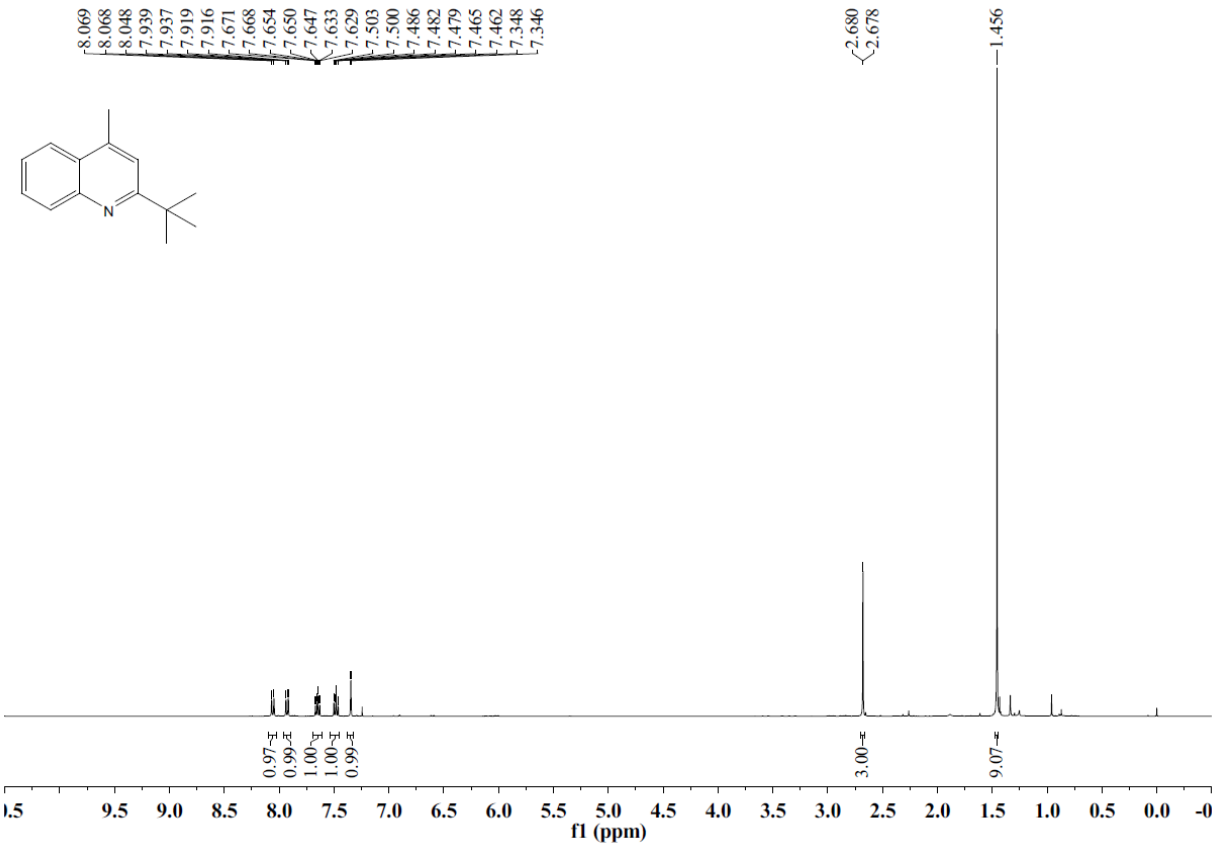
110
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

3aa 1H NMR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7.465
7.462
7.348
7.346
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3.00
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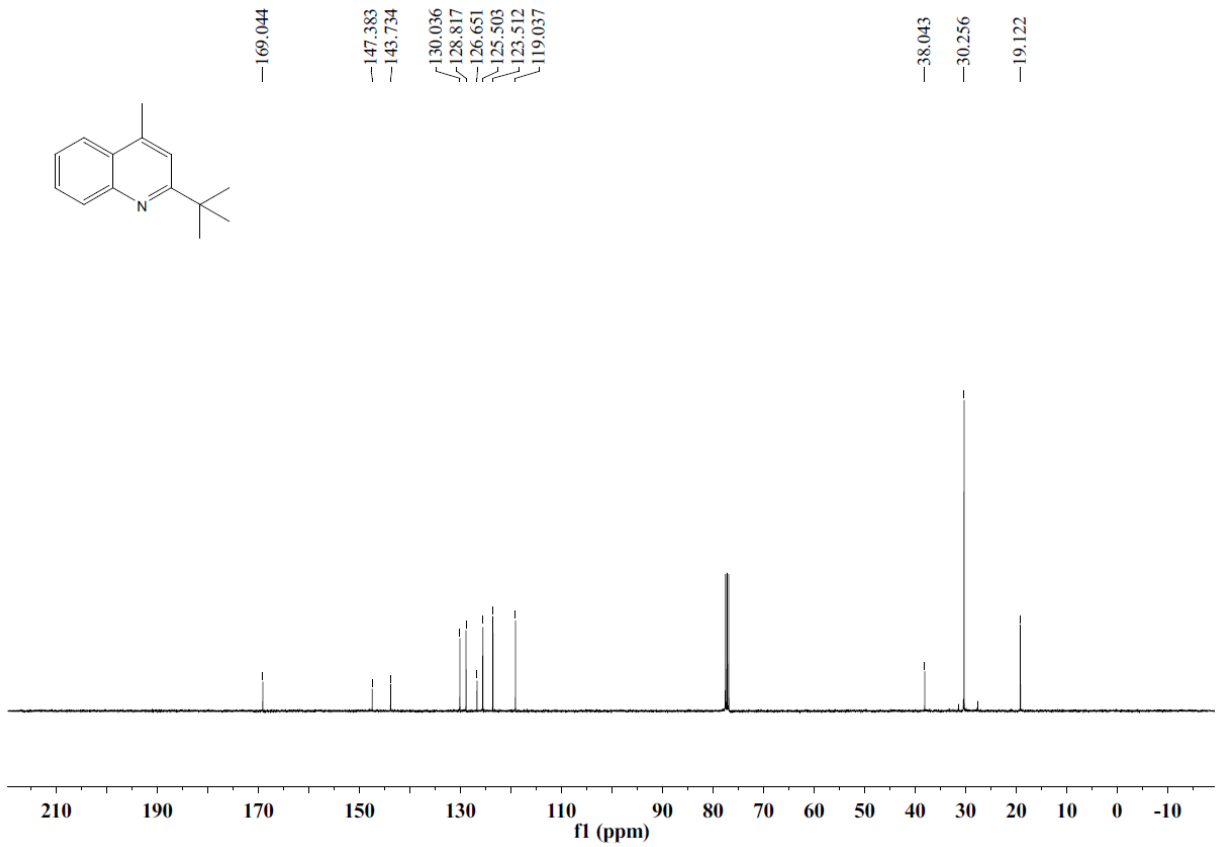
f1 (ppm)

3aa 13C NMR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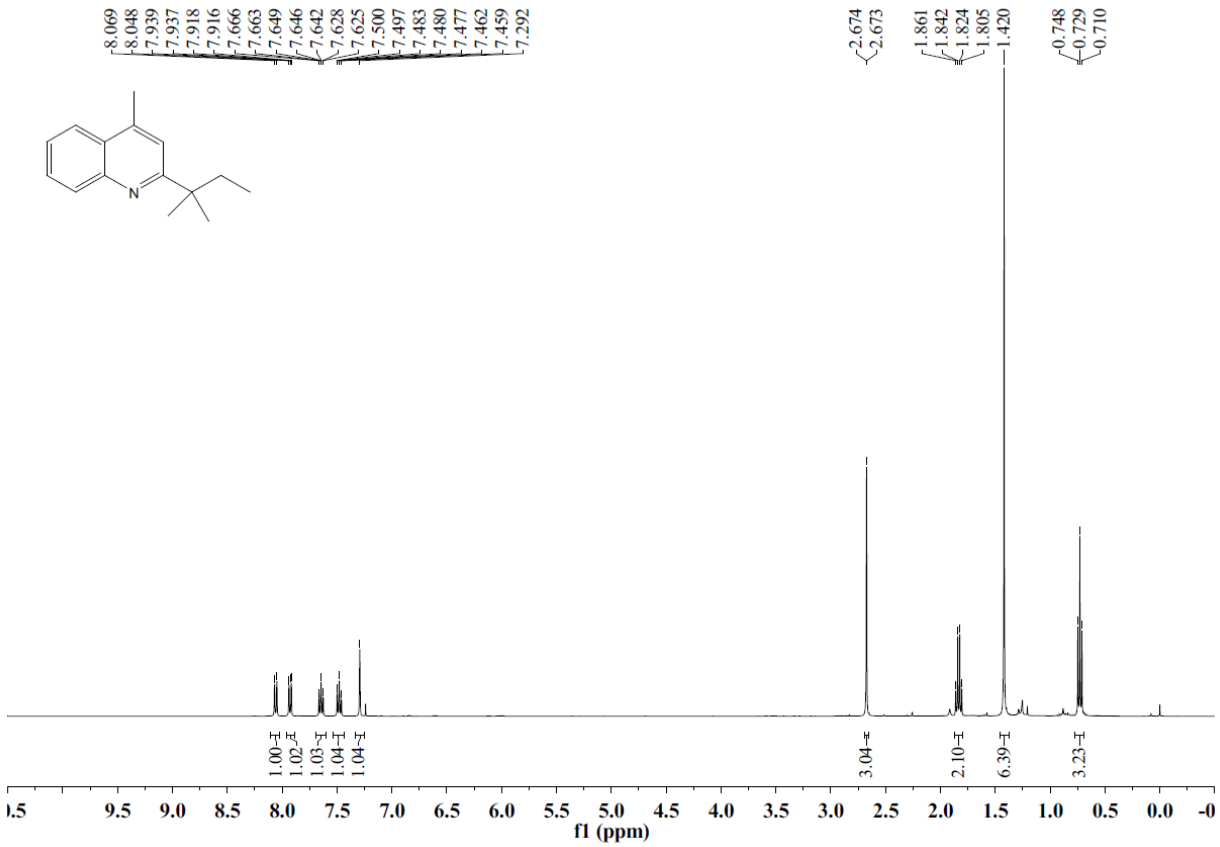
f1 (ppm)

3ba 1H NMR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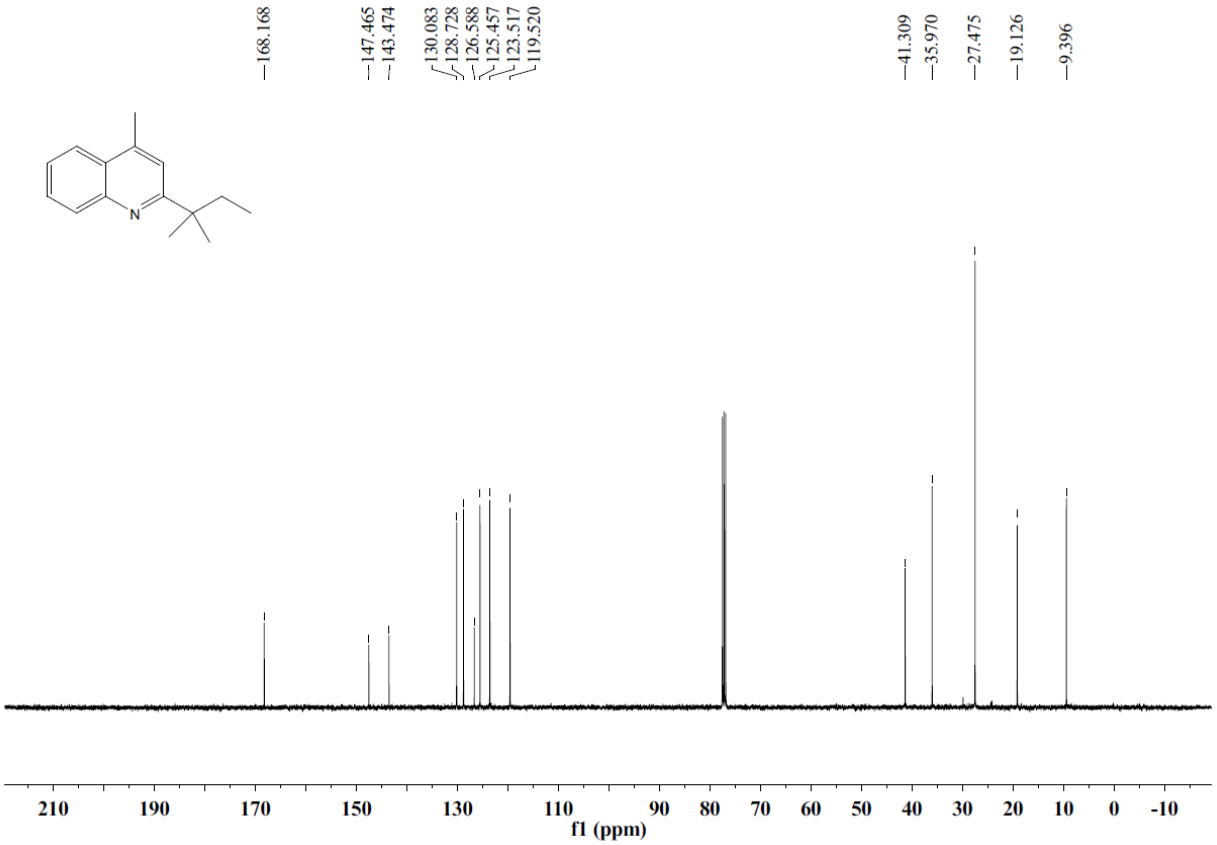
3ba 13C NMR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9.396
N
210
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80
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50
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10
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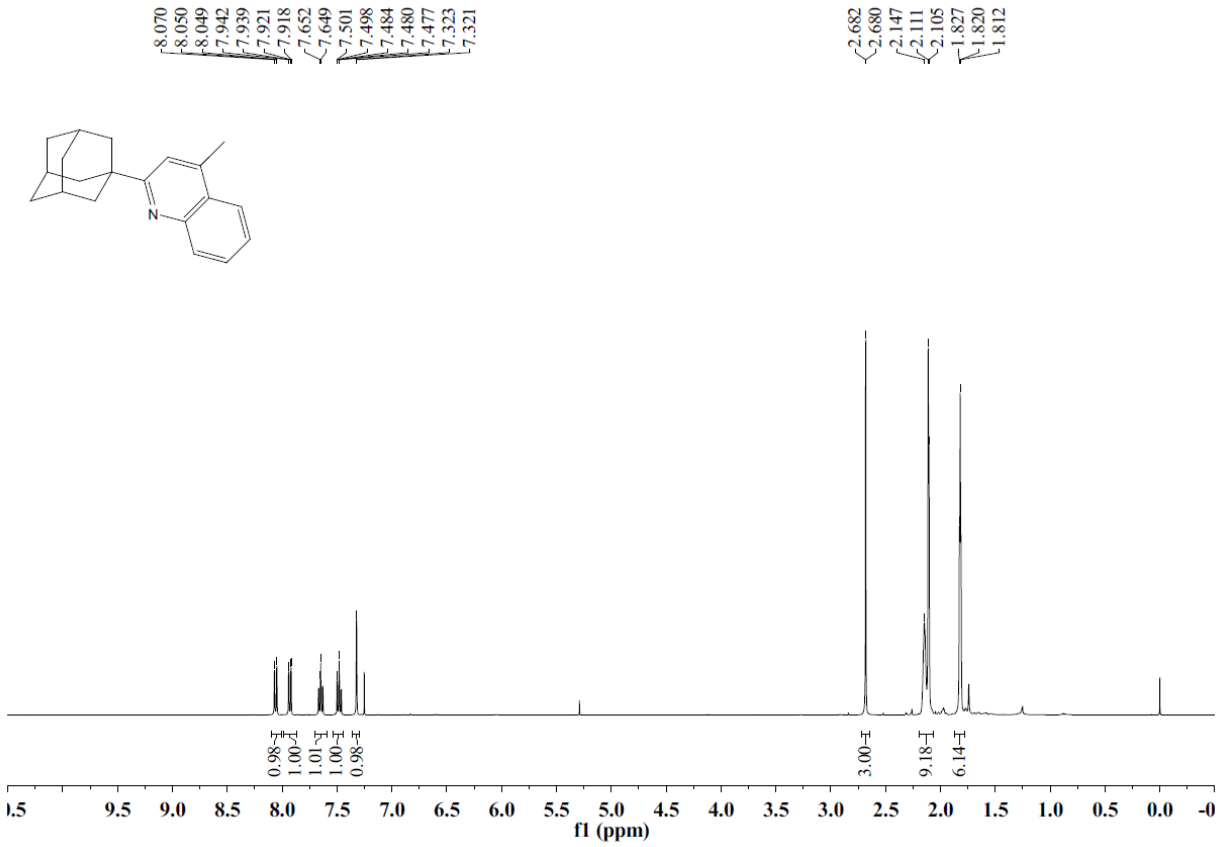
f1 (ppm)

3ca 1H NMR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7.477
7.323
7.321
2.682
2.680
2.147
2.111
2.105
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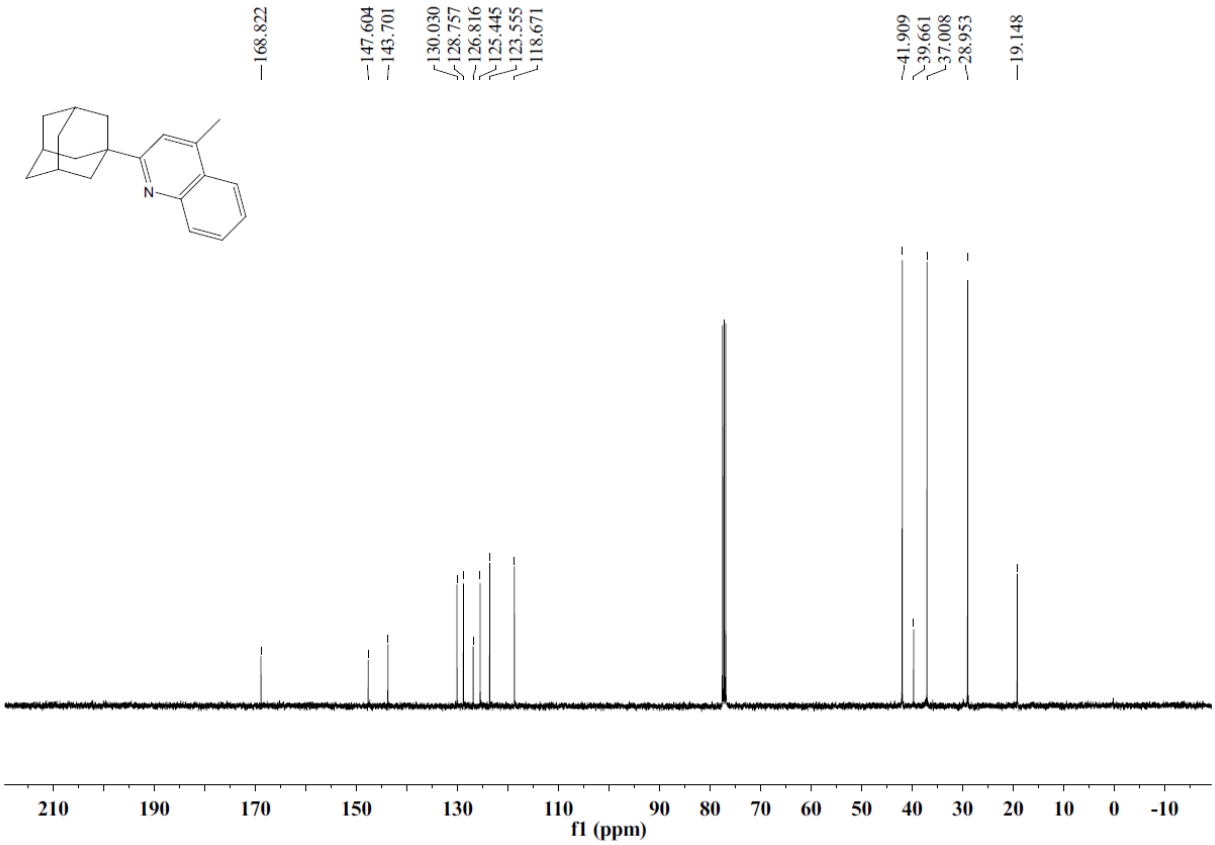
f1 (ppm)

3ca 13C NMR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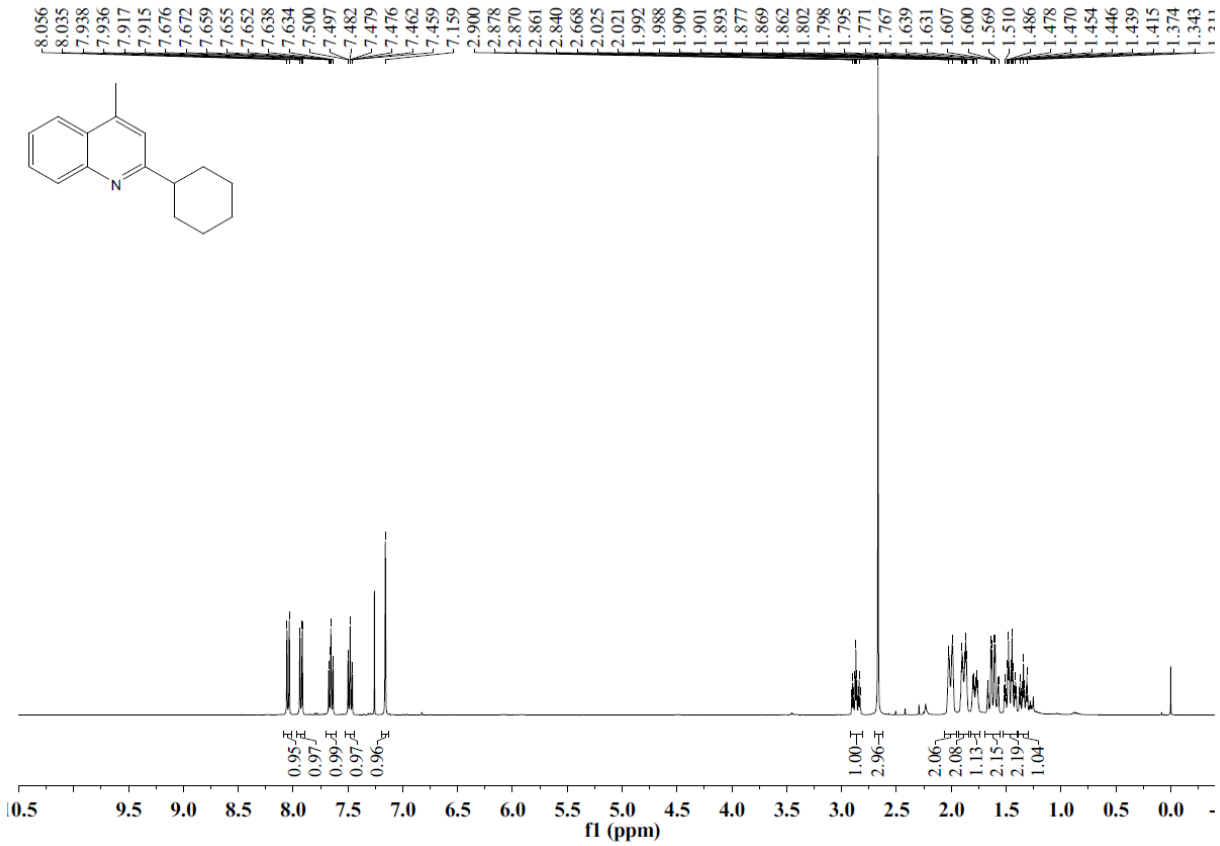
f1 (ppm)

3da 1H NMR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7.479
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7.462
7.459
7.159
2.900
2.878
2.870
2.861
2.840
2.668
2.025
2.021
1.992
1.988
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1.901
1.893
1.877
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1.862
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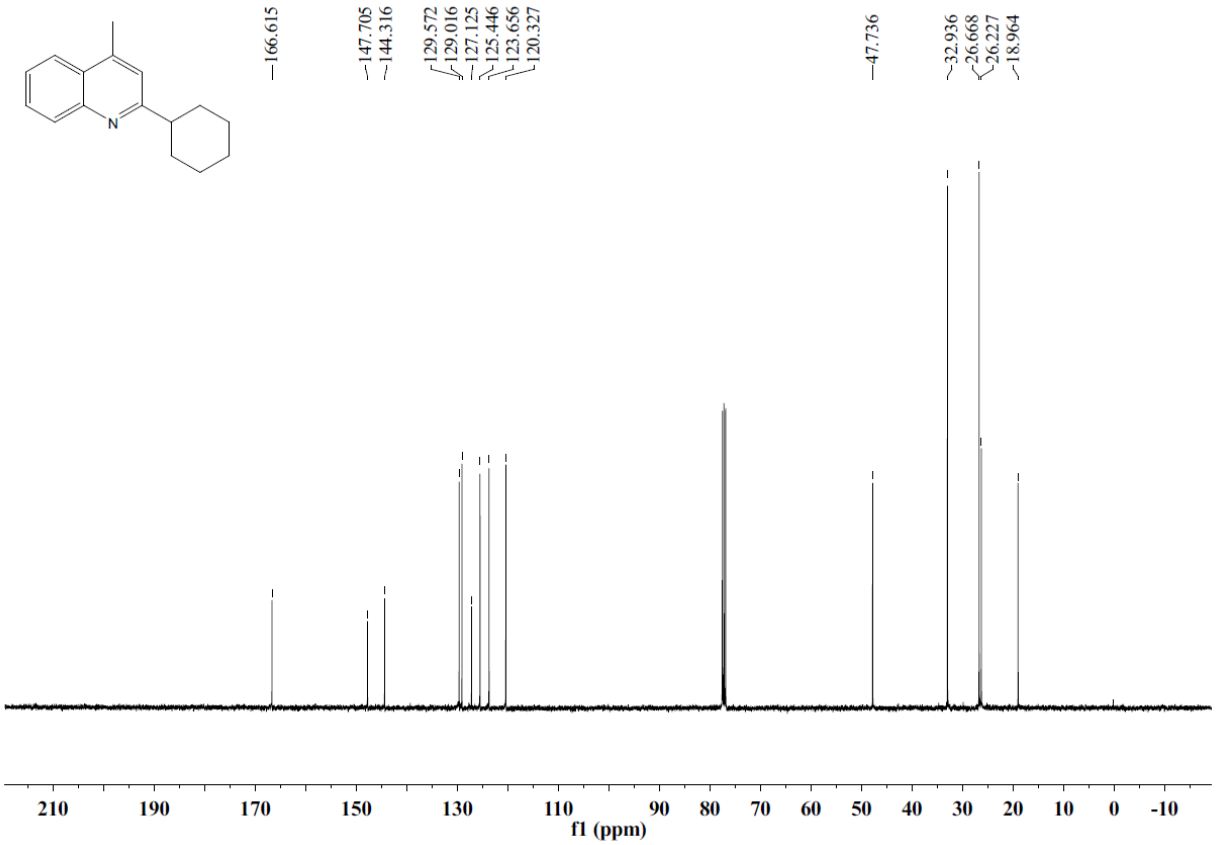
0.95
0.97
0.99
0.97
0.96
1.00
2.96
2.06
2.08
1.13
2.15
2.19
1.04
f1 (ppm)

3da 13C NMR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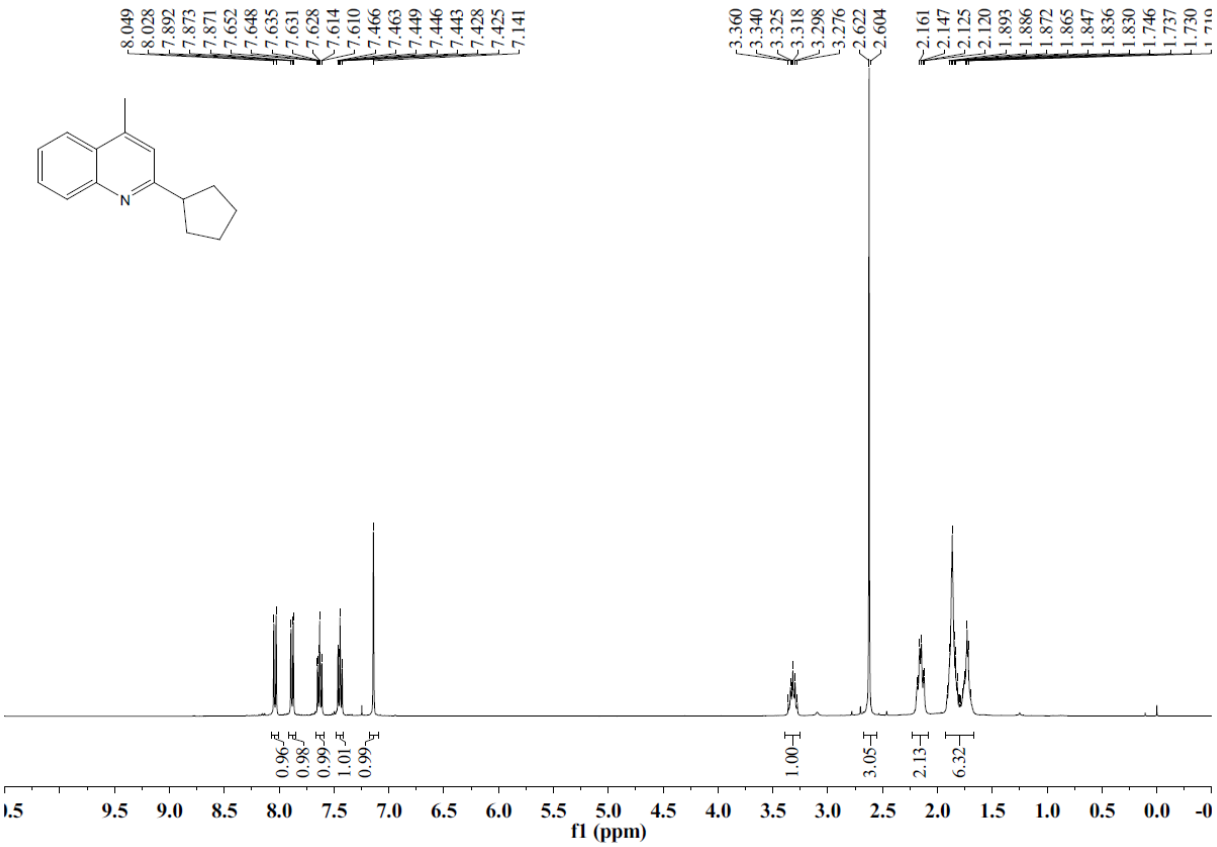
147.705
144.316
129.572
129.016
127.125
125.446
123.656
120.327
47.736
32.936
26.668
26.227
18.964
N
210
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

3ea 1H NMR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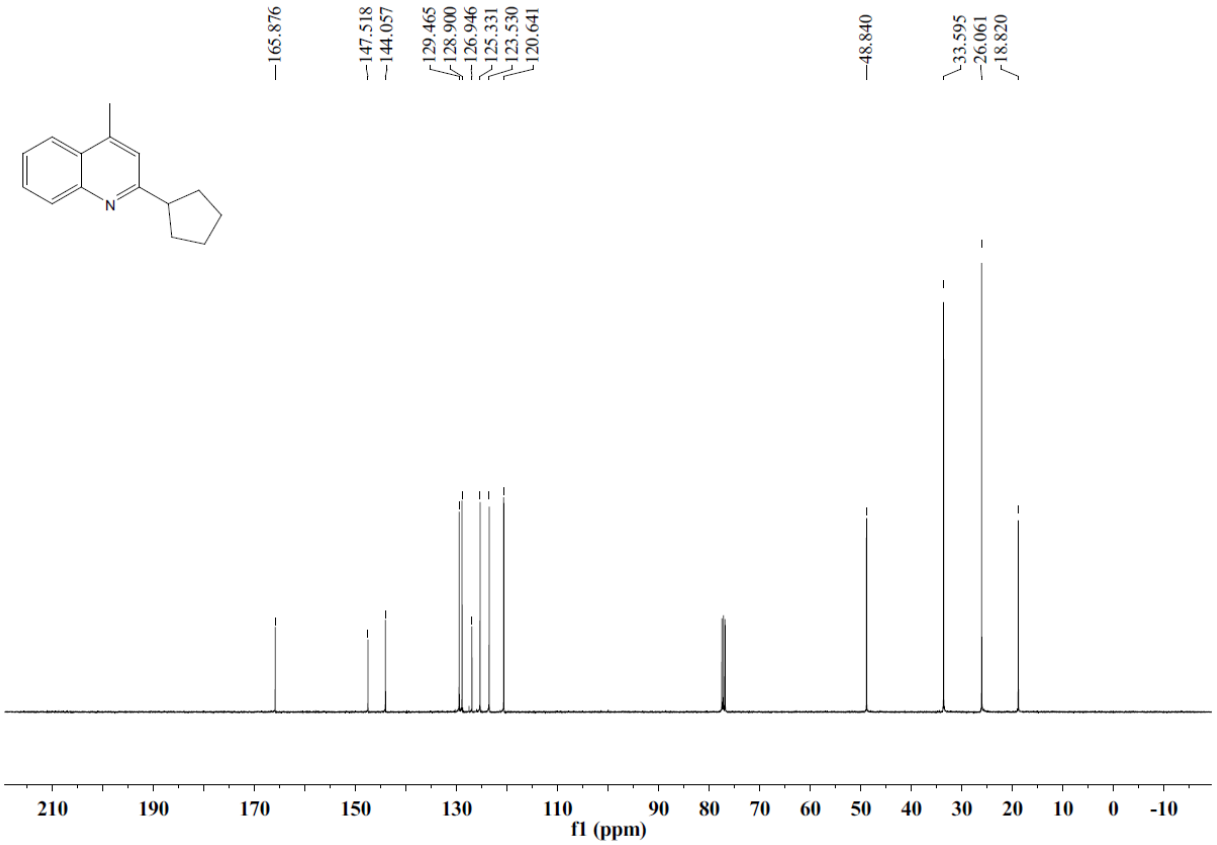
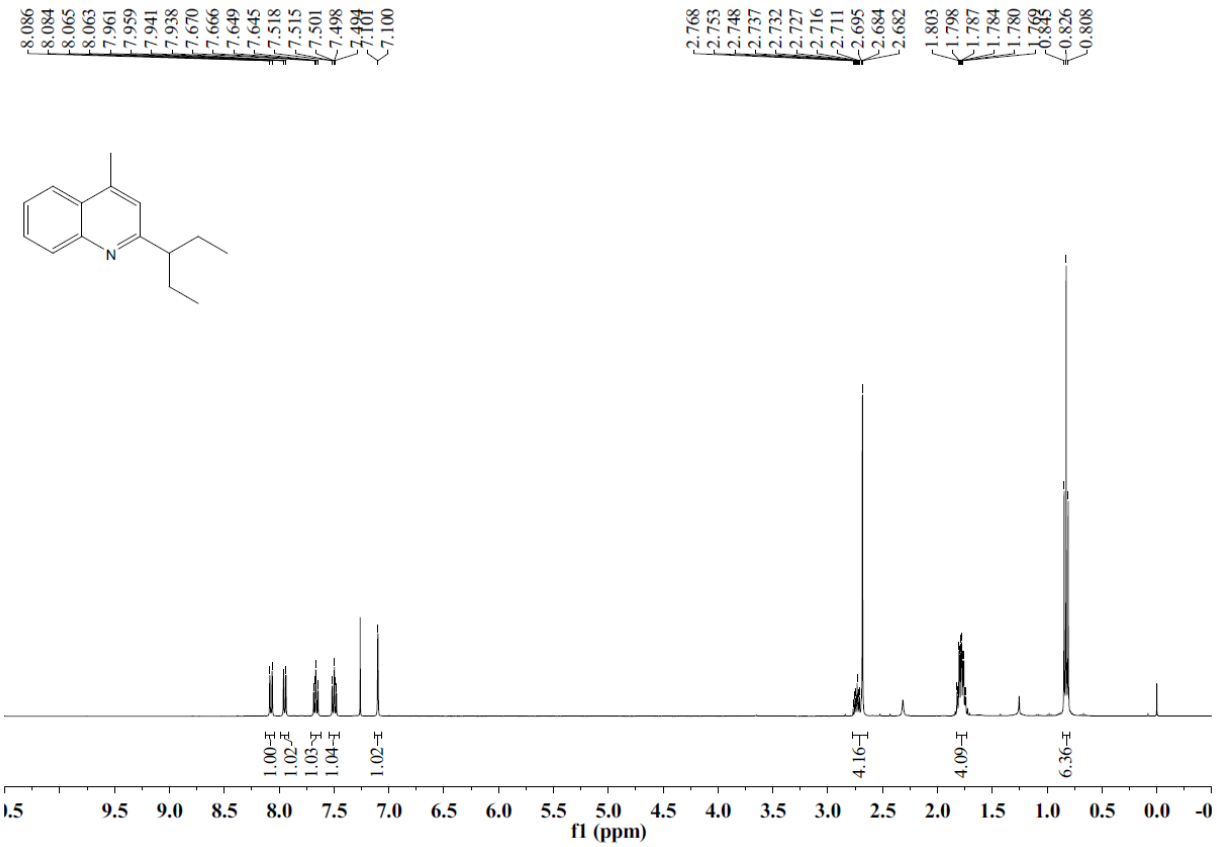
8.028
7.892
7.873
7.871
7.652
7.648
7.635
7.631
7.628
7.614
7.610
7.466
7.463
7.449
7.446
7.443
7.428
7.425
7.141
3.360
3.340
3.325
3.318
3.298
3.276
2.622
2.604
2.161
2.147
2.125
2.120
1.893
1.886
1.872
1.865
1.847
1.836
1.830
1.746
1.737
1.730
N
0.96
0.98
0.99
1.01
0.99
1.00
3.05
2.13
6.32
f1 (ppm)

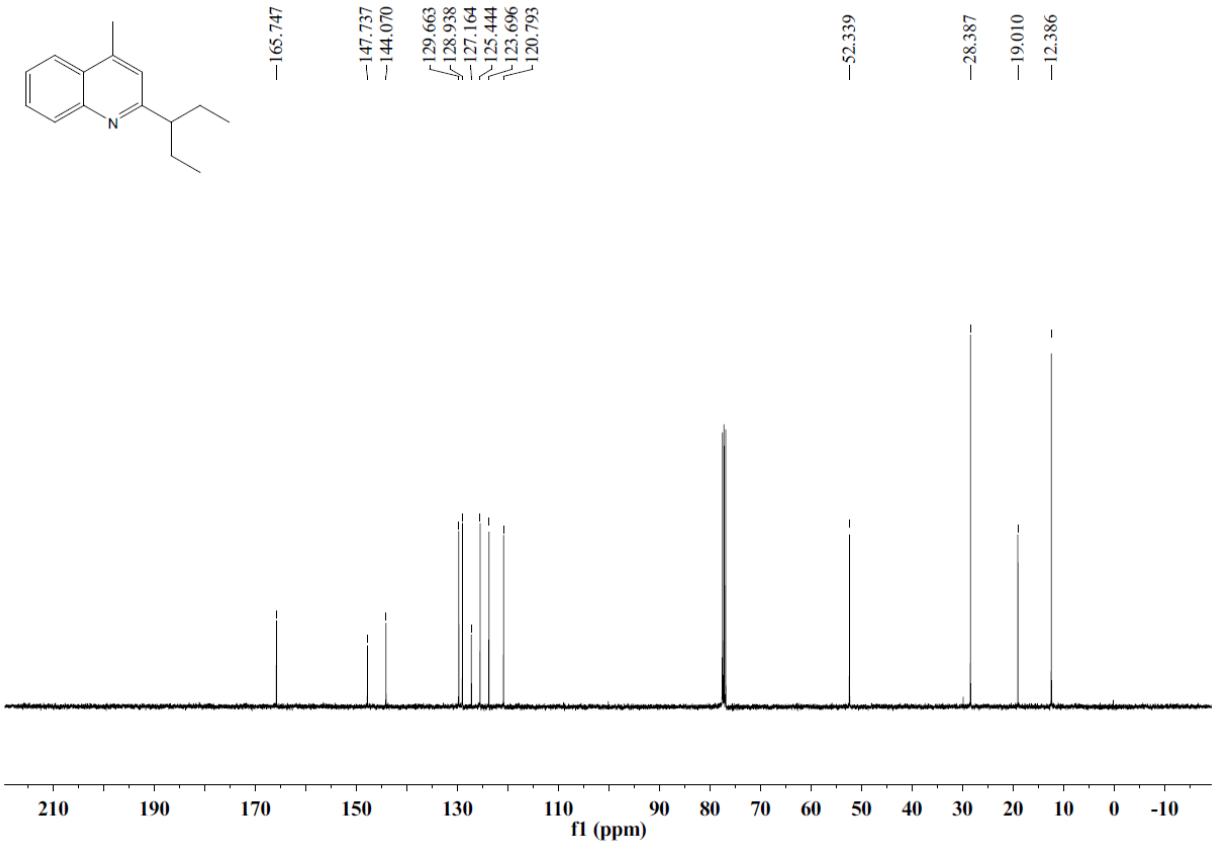
3ea 13C NMR


165.876
147.518
144.057
129.465
128.900
126.946
125.331
123.530
120.641
48.840
33.595
26.061
18.820
N
210
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

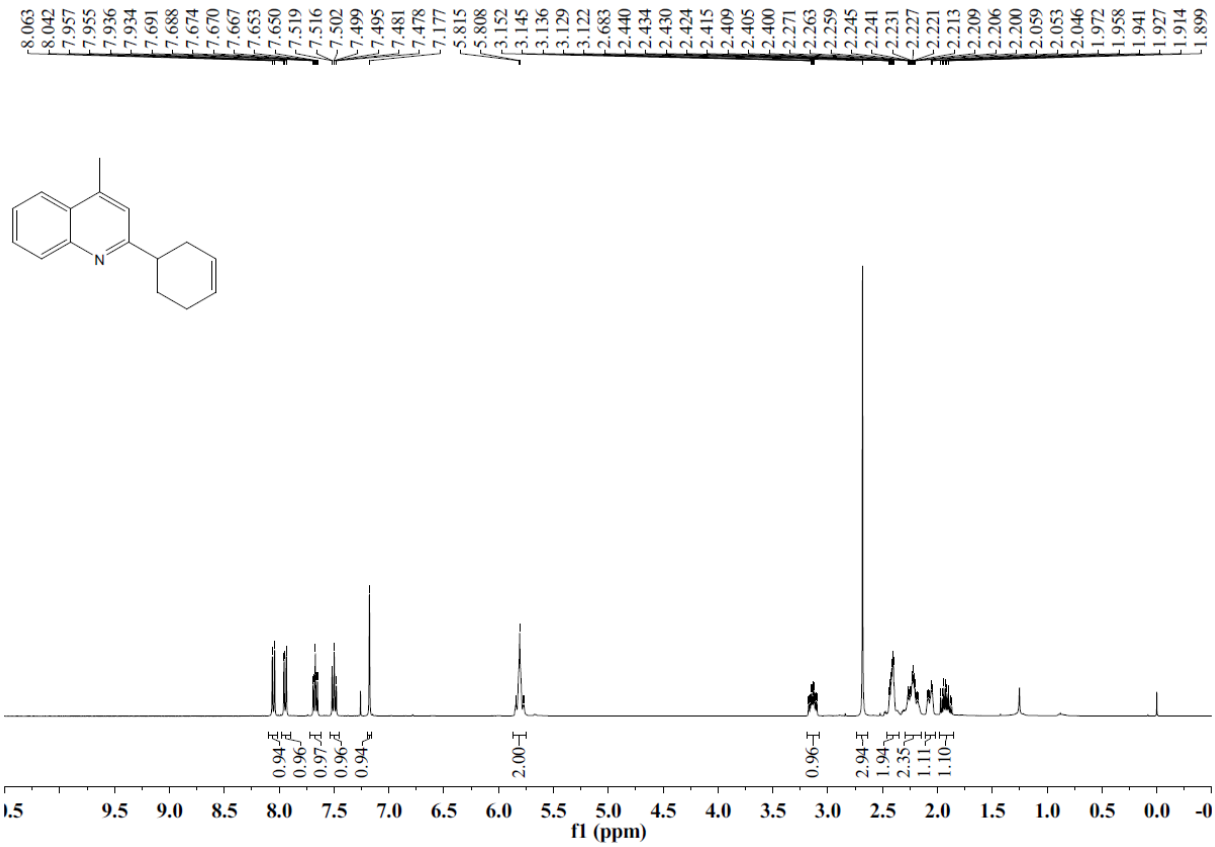
3fa 1H NMR


8.086
8.084
8.065
8.063
7.961
7.959
7.941
7.938
7.670
7.666
7.649
7.645
7.518
7.515
7.501
7.498
7.494
7.101
7.100
2.768
2.753
2.748
2.737
2.732
2.727
2.716
2.711
2.695
2.684
2.682
1.803
1.798
1.787
1.784
1.780
1.769
0.845
0.826
0.808
N
1.00
1.02
1.03
1.04
1.02
4.16
4.09
6.36
f1 (ppm)

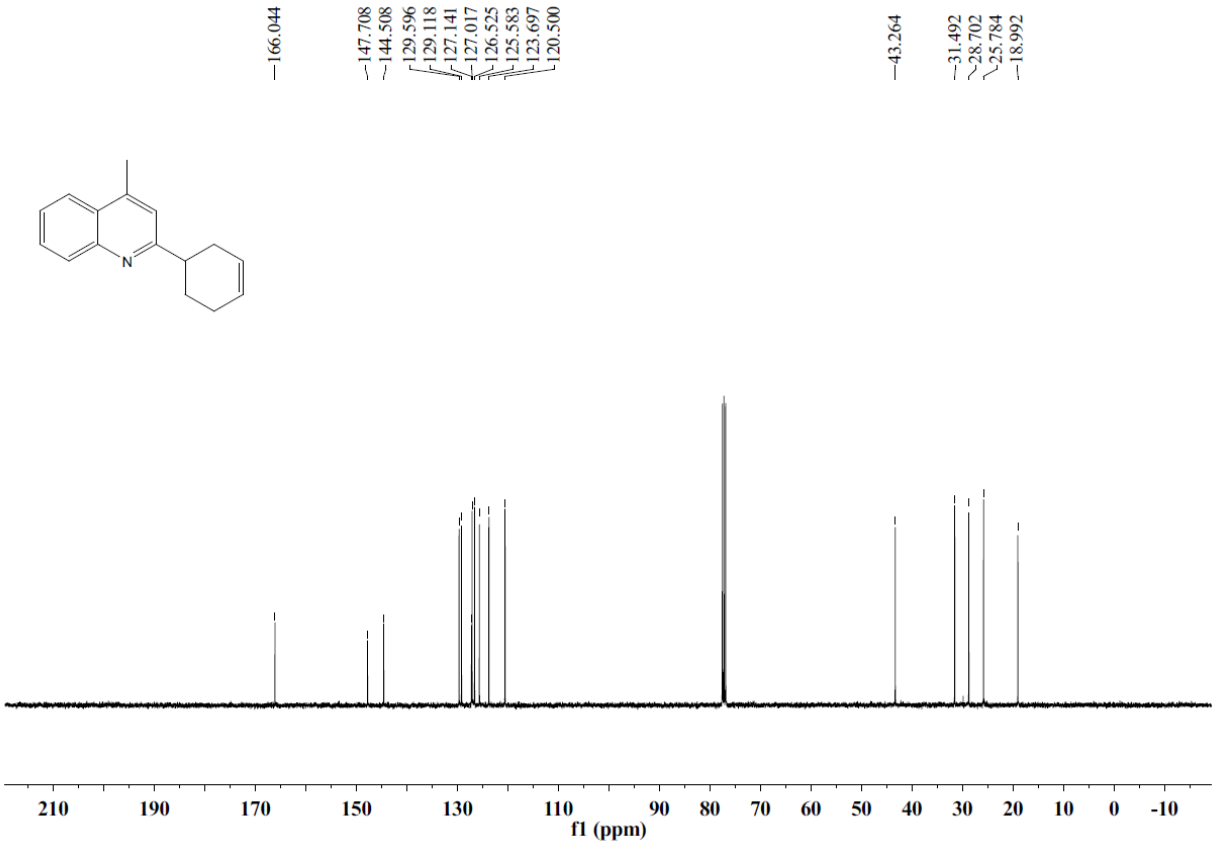
3fa 13C NMR


N
165.747
147.737
144.070
129.663
128.938
127.164
125.444
123.696
120.793
52.339
28.387
19.010
12.386
210
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

3ga 1H NMR


8.063
8.042
7.957
7.955
7.936
7.934
7.691
7.688
7.674
7.670
7.667
7.653
7.650
7.519
7.516
7.502
7.499
7.495
7.481
7.478
7.177
5.815
5.808
3.152
3.145
3.136
3.129
3.122
2.683
2.440
2.434
2.430
2.424
2.415
2.409
2.405
2.400
2.271
2.263
2.259
2.245
2.241
2.231
2.227
2.221
2.213
2.209
2.206
2.200
2.059
2.053
2.046
1.972
1.958
1.941
1.927
1.914
1.899
N
0.94
0.96
0.97
0.96
0.94
2.00
0.96
2.94
1.94
2.35
1.11
1.10
f1 (ppm)

3ga 13C NMR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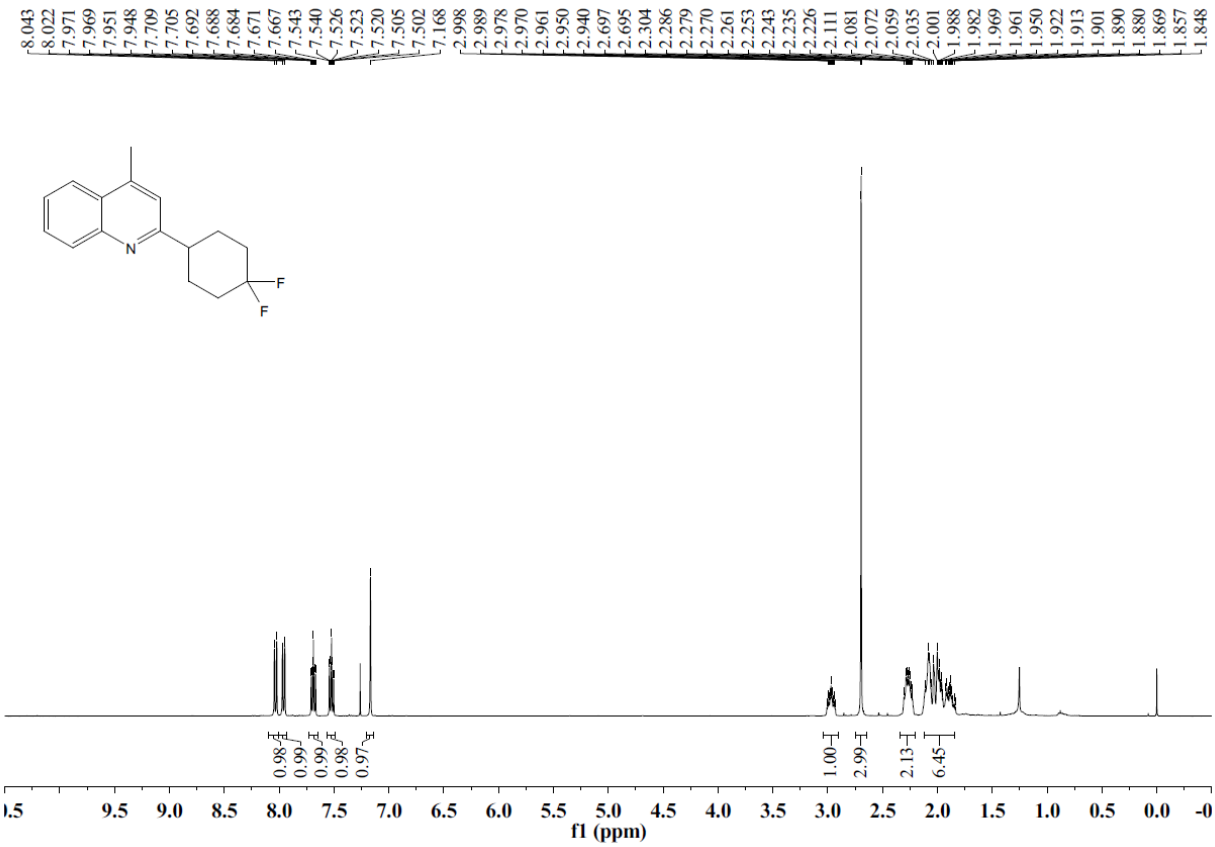
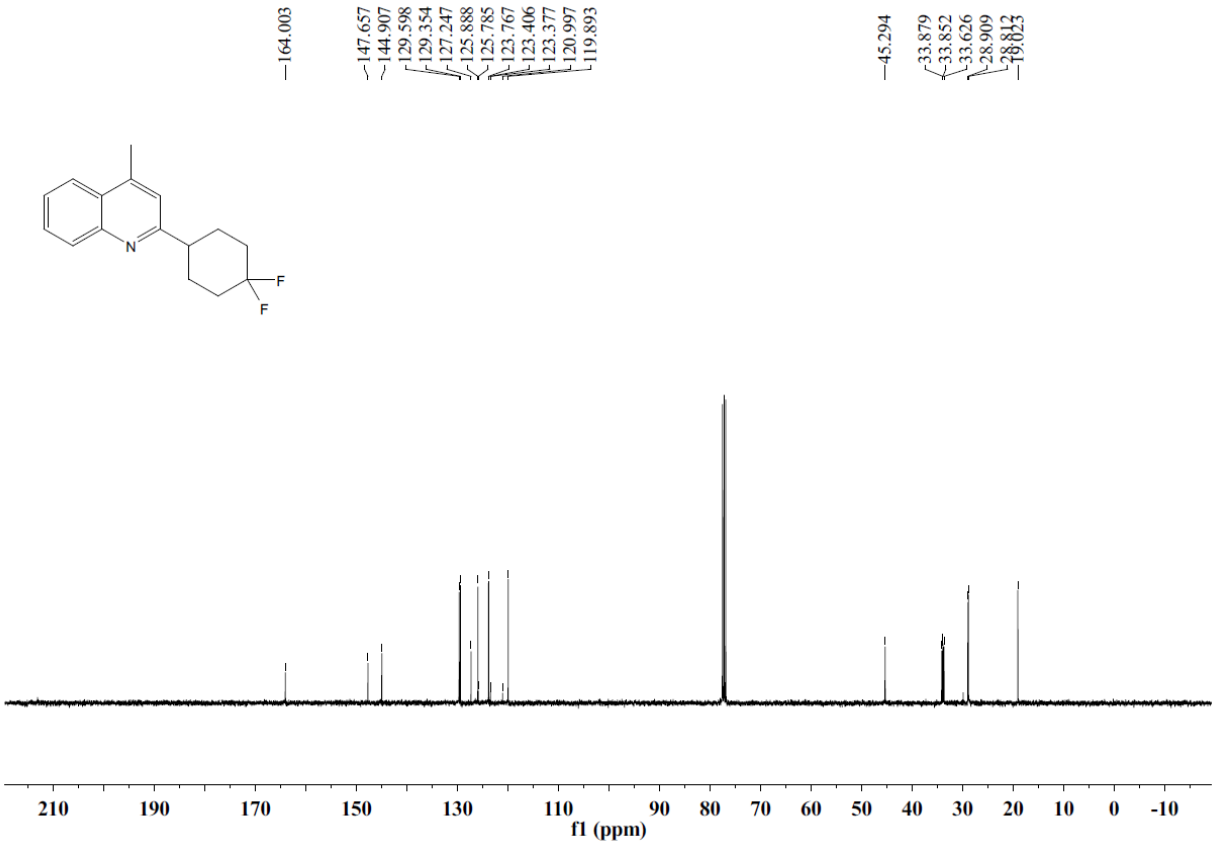
144.508
129.596
129.118
127.141
127.017
126.525
125.583
123.697
120.500
43.264
31.492
28.702
25.784
18.992
N
210
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

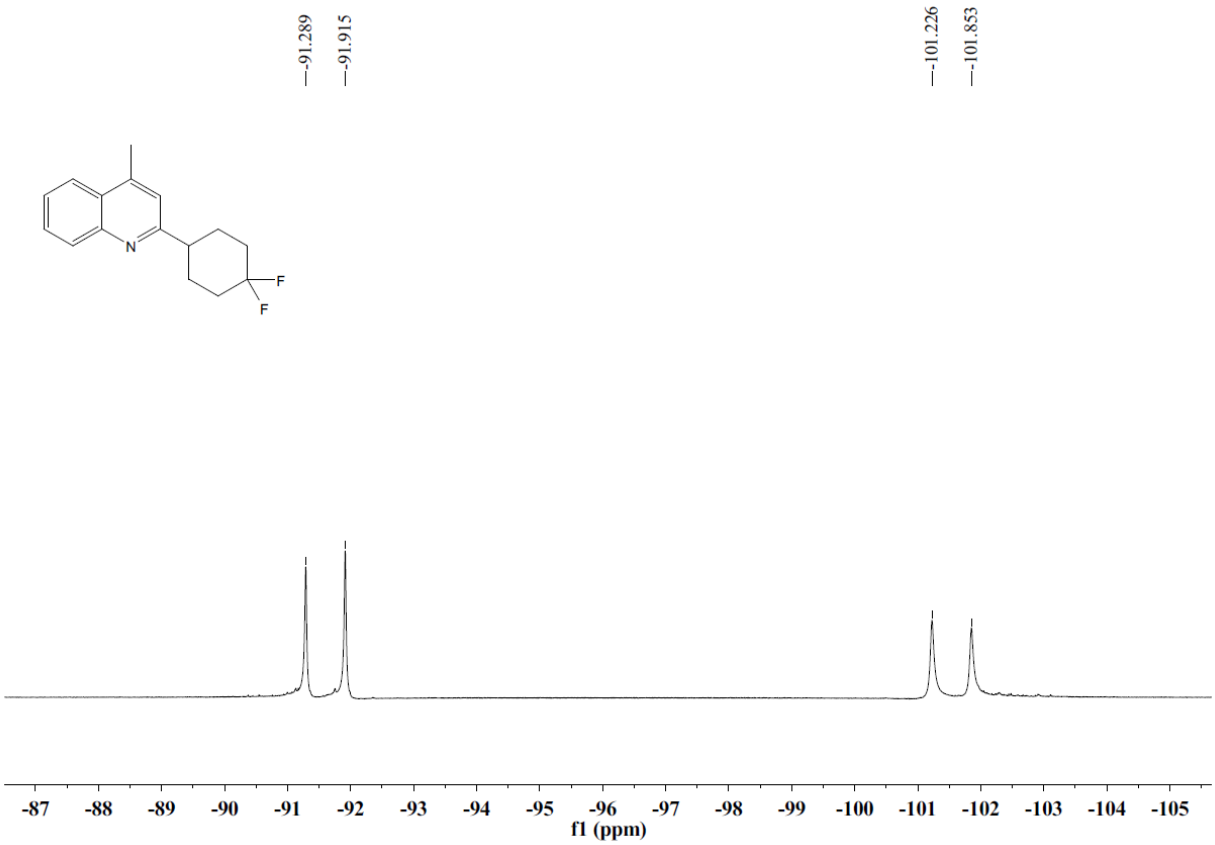
3ha 1H NMR


8.043
8.022
7.971
7.969
7.951
7.948
7.709
7.705
7.692
7.688
7.684
7.671
7.667
7.543
7.540
7.526
7.523
7.520
7.505
7.502
7.168
2.998
2.989
2.978
2.970
2.961
2.950
2.940
2.697
2.695
2.304
2.286
2.279
2.270
2.261
2.253
2.243
2.235
2.226
2.111
2.081
2.072
2.059
2.035
2.001
1.988
1.982
1.969
1.961
1.950
1.922
1.913
1.901
1.890
1.880
1.869
1.857
1.848
N
F
F
0.98
0.99
0.99
0.98
0.97
1.00
2.99
2.13
6.45
f1 (ppm)

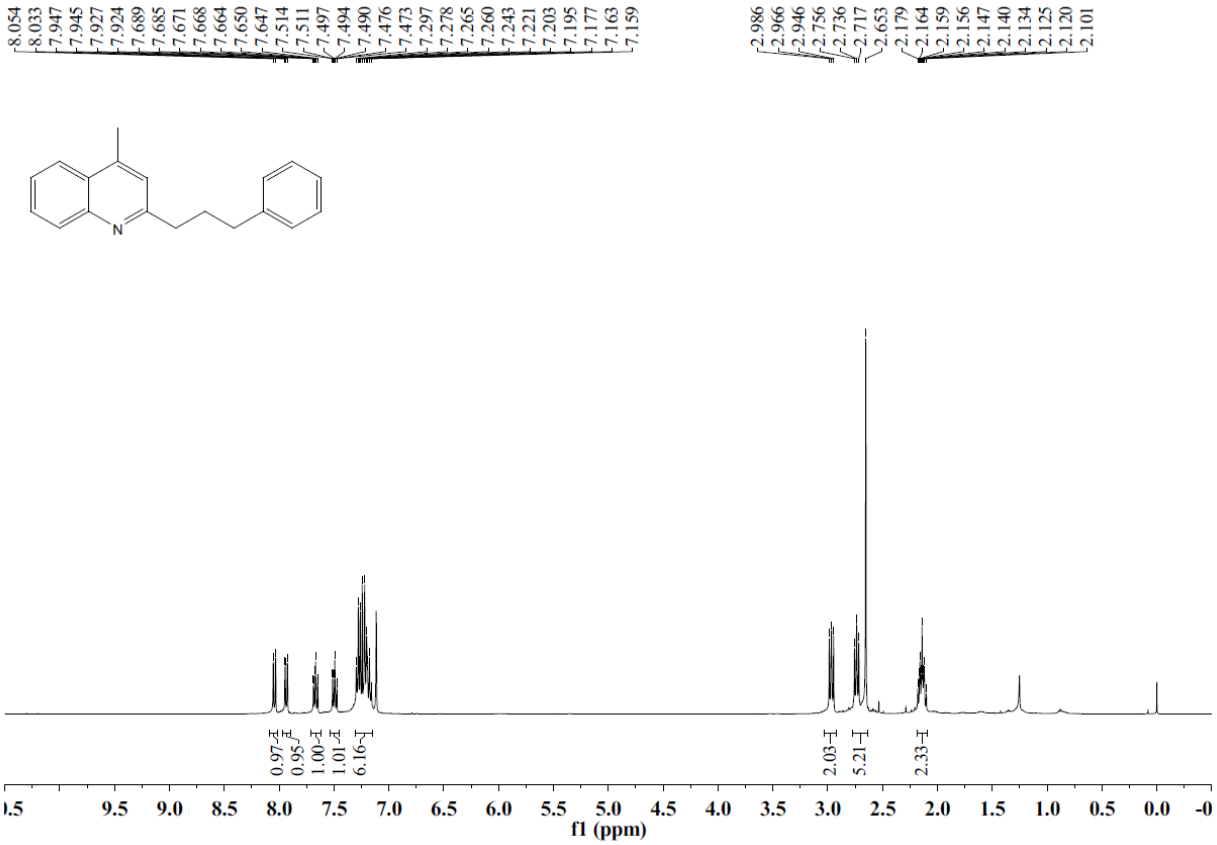
3ha 13C NMR


164.003
147.657
144.907
129.598
129.354
127.247
125.888
125.785
123.767
123.406
123.377
120.997
119.893
45.294
33.879
33.852
33.626
28.909
28.812
19.023
N
F
F
210
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

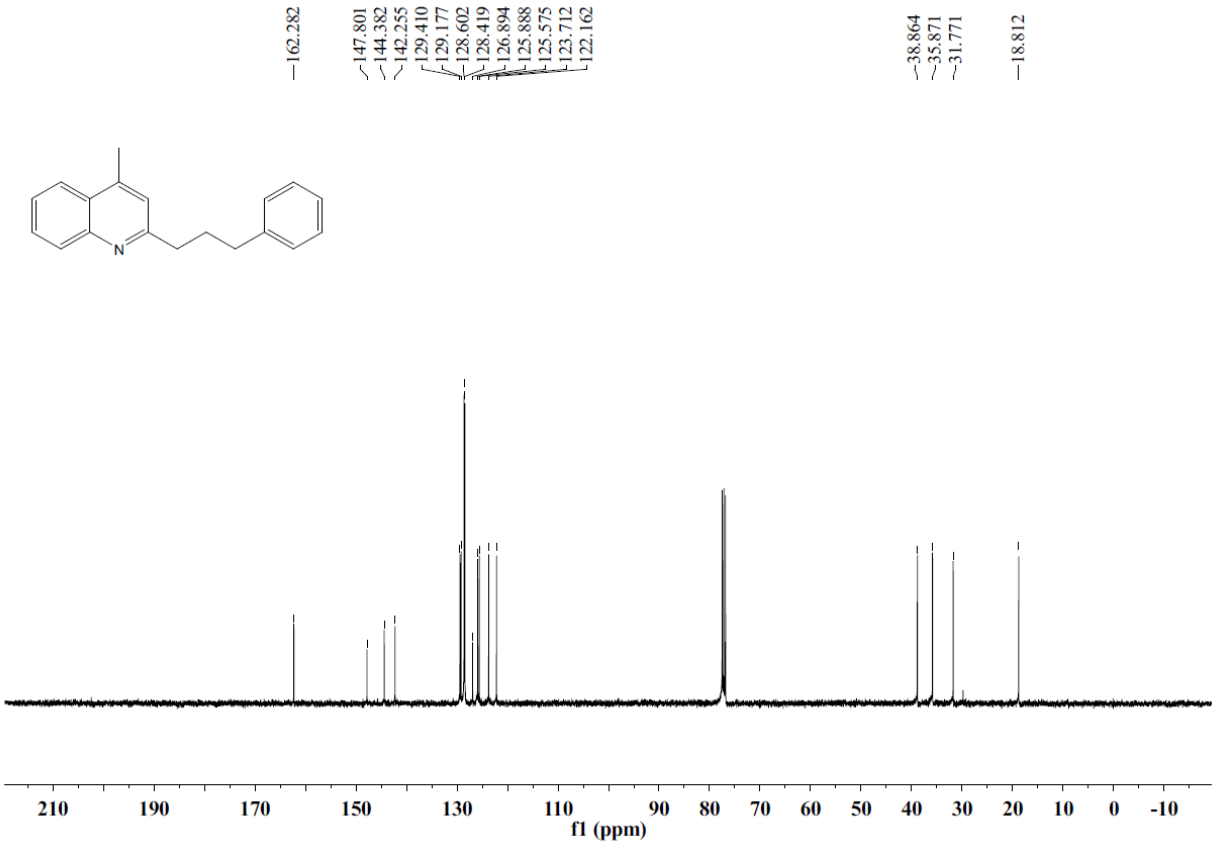
3ha 19F NMR


-91.289
-91.915
-101.226
-101.853
N
F
F
-87 -88 -89 -90 -91 -92 -93 -94 -95 -96 -97 -98 -99 -100 -101 -102 -103 -104 -105
f1 (ppm)

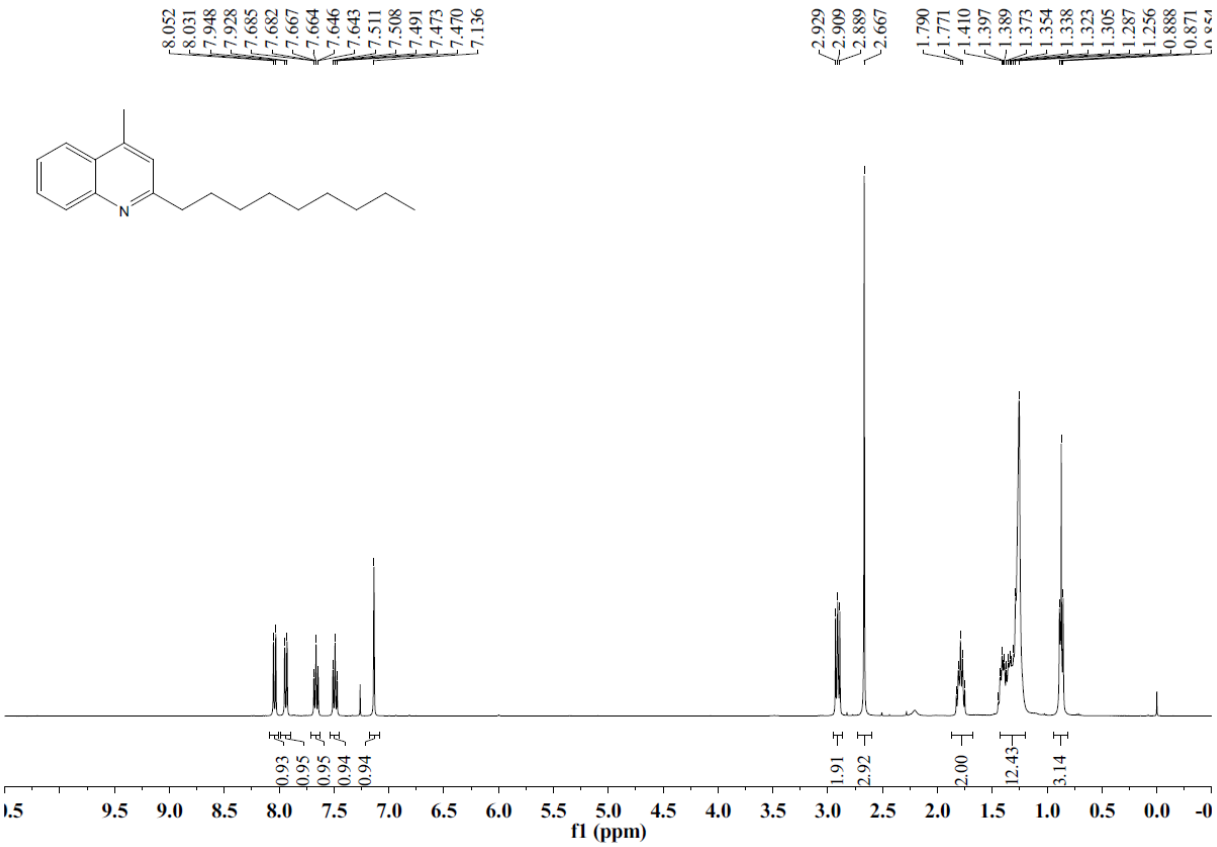
3ia 1H NMR


8.054
8.033
7.947
7.945
7.927
7.924
7.689
7.685
7.671
7.668
7.664
7.650
7.647
7.514
7.511
7.497
7.494
7.490
7.476
7.473
7.297
7.278
7.265
7.260
7.243
7.221
7.203
7.195
7.177
7.163
7.159
2.986
2.966
2.946
2.756
2.736
2.717
2.653
2.179
2.164
2.159
2.156
2.147
2.140
2.134
2.125
2.120
2.101
N
0.97
0.95
1.00
1.01
6.16
2.03
5.21
2.33
f1 (ppm)

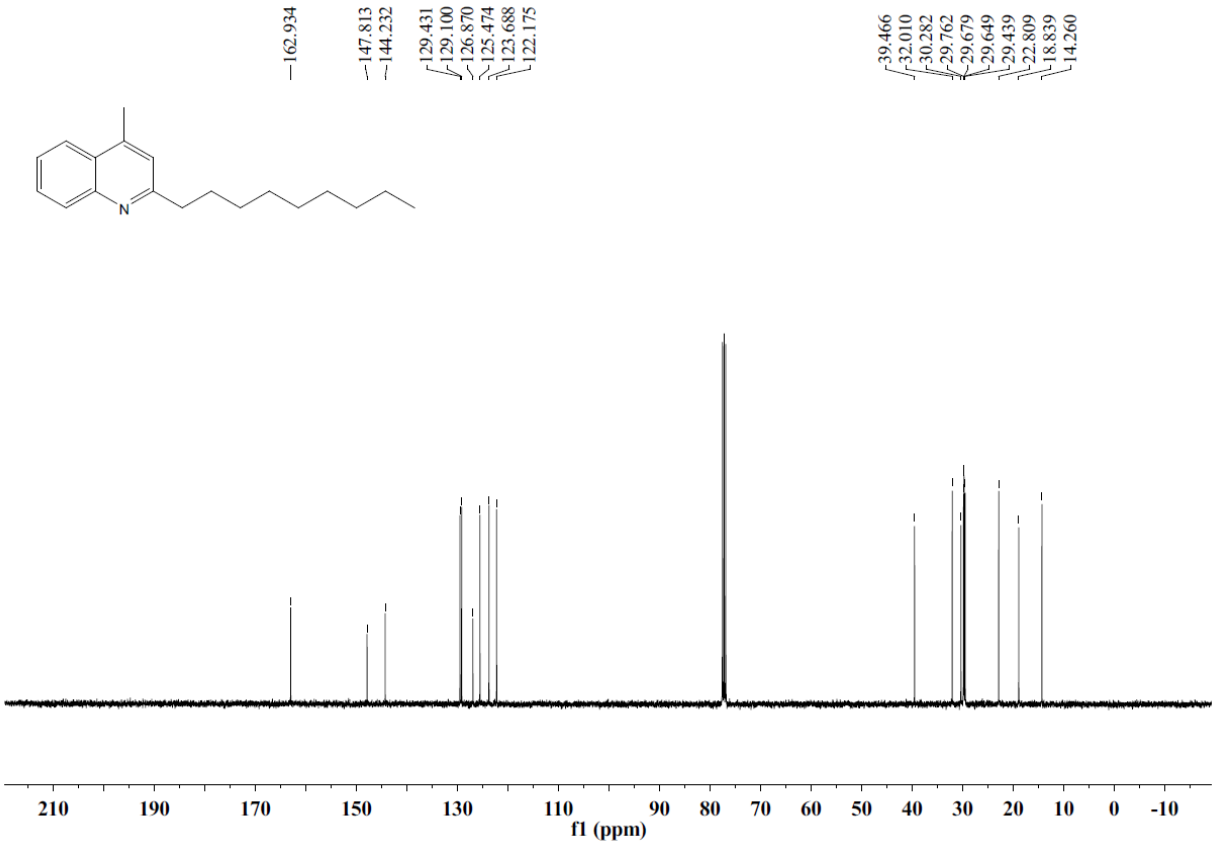
3ia 13C NMR


162.282
147.801
144.382
142.255
129.410
129.177
128.602
128.419
126.894
125.888
125.575
123.712
122.162
38.864
35.871
31.771
18.812
N
210
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

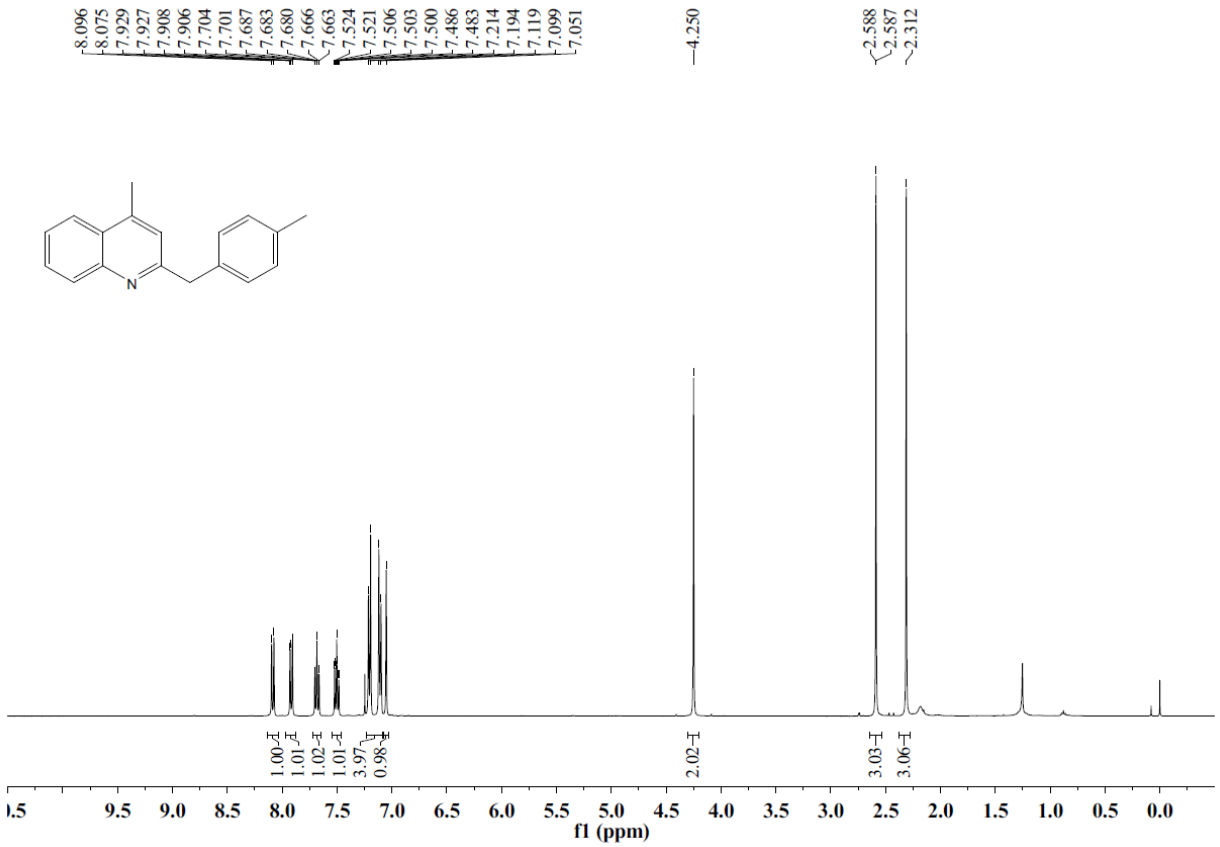
3ja 1H NMR


8.052
8.031
7.948
7.928
7.685
7.682
7.667
7.664
7.646
7.643
7.511
7.508
7.491
7.473
7.470
7.136
2.929
2.909
2.889
2.667
1.790
1.771
1.410
1.397
1.389
1.373
1.354
1.338
1.323
1.305
1.287
1.256
0.888
0.871
N
0.93
0.95
0.95
0.94
0.94
1.91
2.92
2.00
12.43
3.14
f1 (ppm)

3ja 13C NMR


162.934
147.813
144.232
129.431
129.100
126.870
125.474
123.688
122.175
39.466
32.010
30.282
29.762
29.679
29.649
29.439
22.809
18.839
14.260
N
210
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

3ka 1H NMR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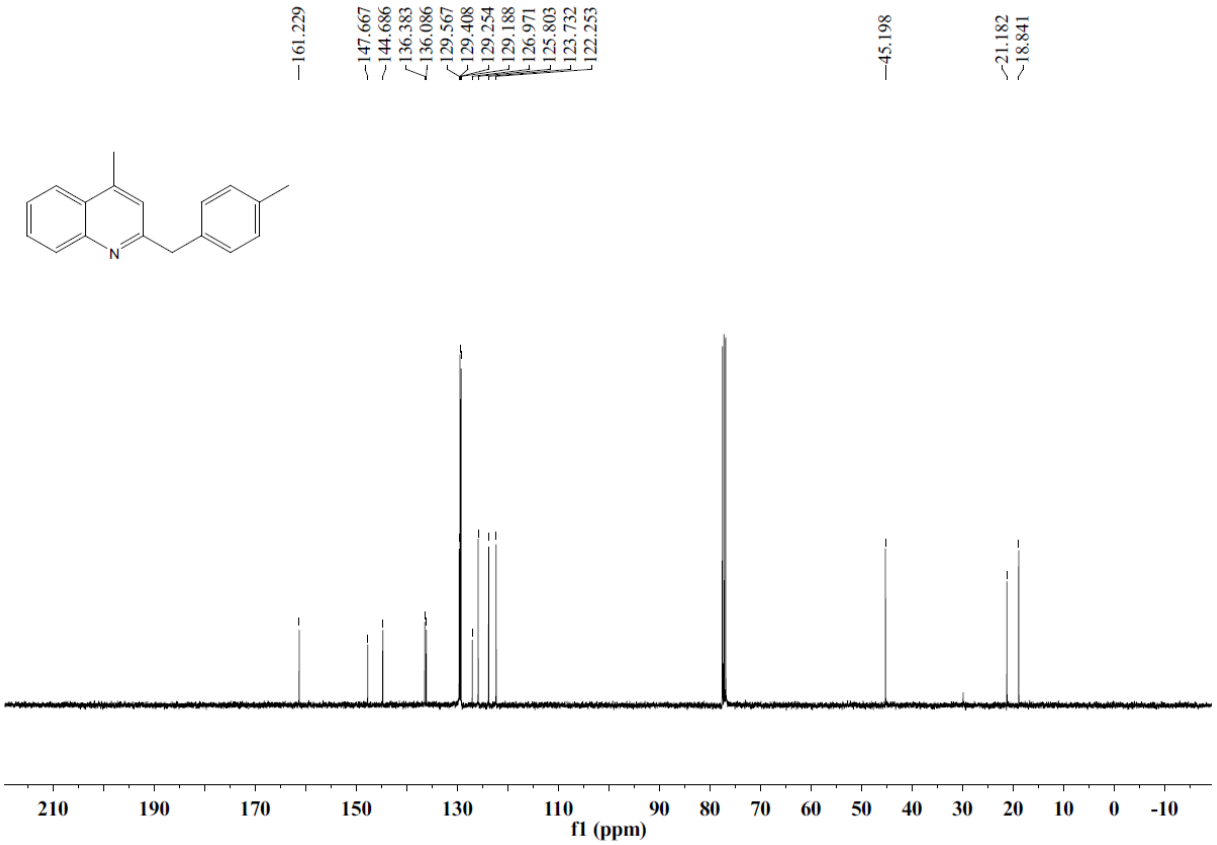
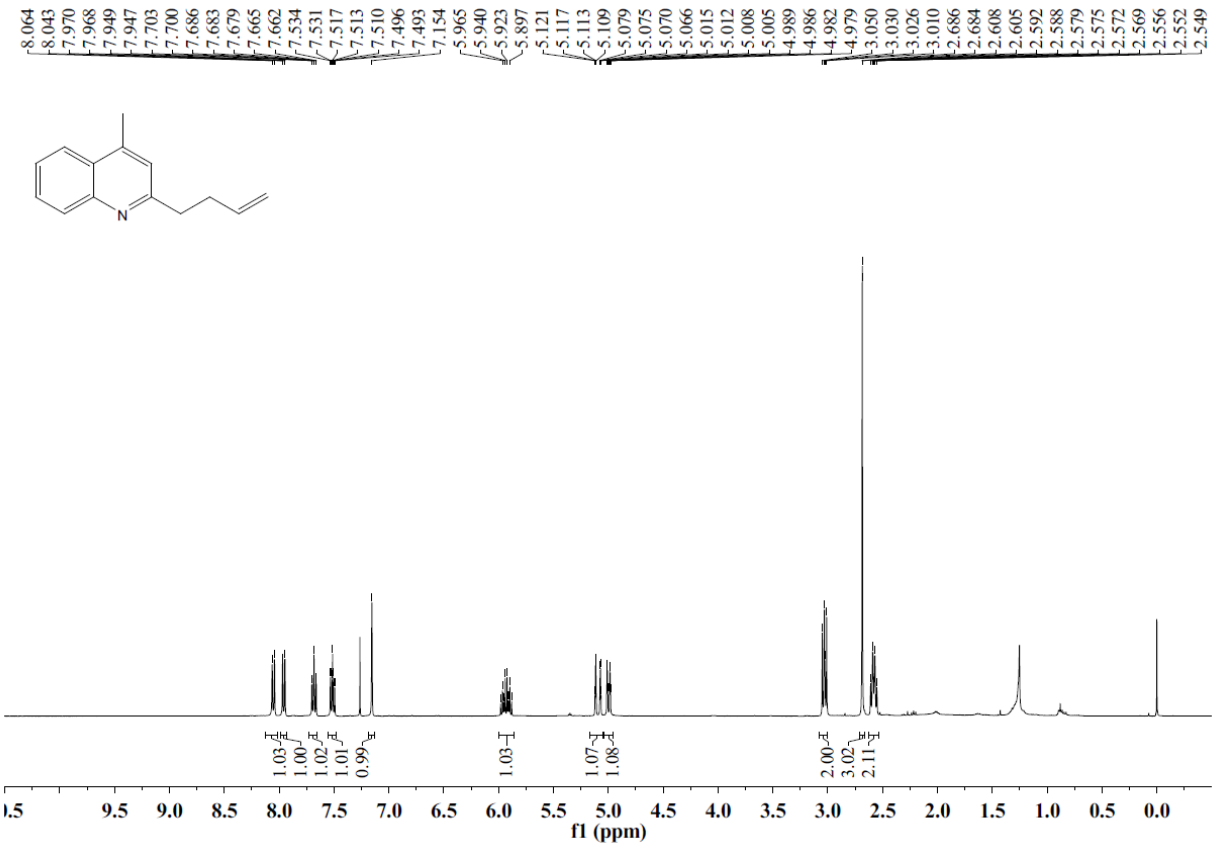
8.075
7.929
7.927
7.908
7.906
7.704
7.701
7.687
7.683
7.680
7.666
7.663
7.524
7.521
7.506
7.503
7.500
7.486
7.483
7.214
7.194
7.119
7.099
7.051
4.250
2.588
2.587
2.312
N
1.00
1.01
1.02
1.01
3.97
0.98
2.02
3.03
3.06
f1 (ppm)

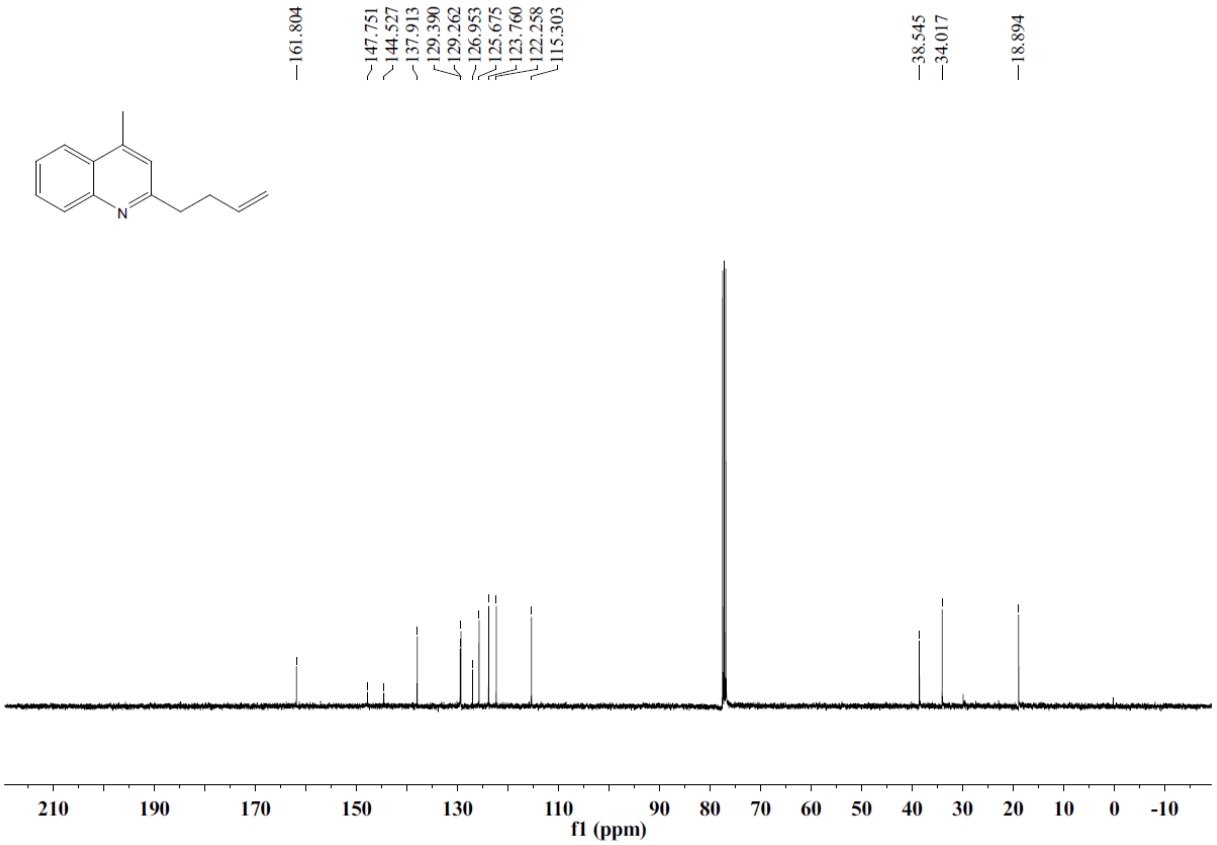
3ka 13C NMR


161.229
147.667
144.686
136.383
136.086
129.567
129.408
129.254
129.188
126.971
125.803
123.732
122.253
45.198
21.182
18.841
N
210
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

3la 1H NMR


8.064
8.043
7.970
7.968
7.949
7.947
7.703
7.700
7.686
7.683
7.679
7.665
7.662
7.534
7.531
7.517
7.513
7.510
7.496
7.493
7.154
5.965
5.940
5.923
5.897
5.121
5.117
5.113
5.109
5.079
5.075
5.070
5.066
5.015
5.012
5.008
5.005
4.989
4.986
4.982
4.979
3.050
3.030
3.026
3.010
2.686
2.684
2.608
2.605
2.592
2.588
2.579
2.575
2.572
2.569
2.556
2.552
2.549
N
1.03
1.00
1.02
1.01
0.99
1.03
1.07
1.08
2.00
3.02
2.11
f1 (ppm)

3la 13C NMR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144.527
137.913
129.390
129.262
126.953
125.675
123.760
122.258
115.303
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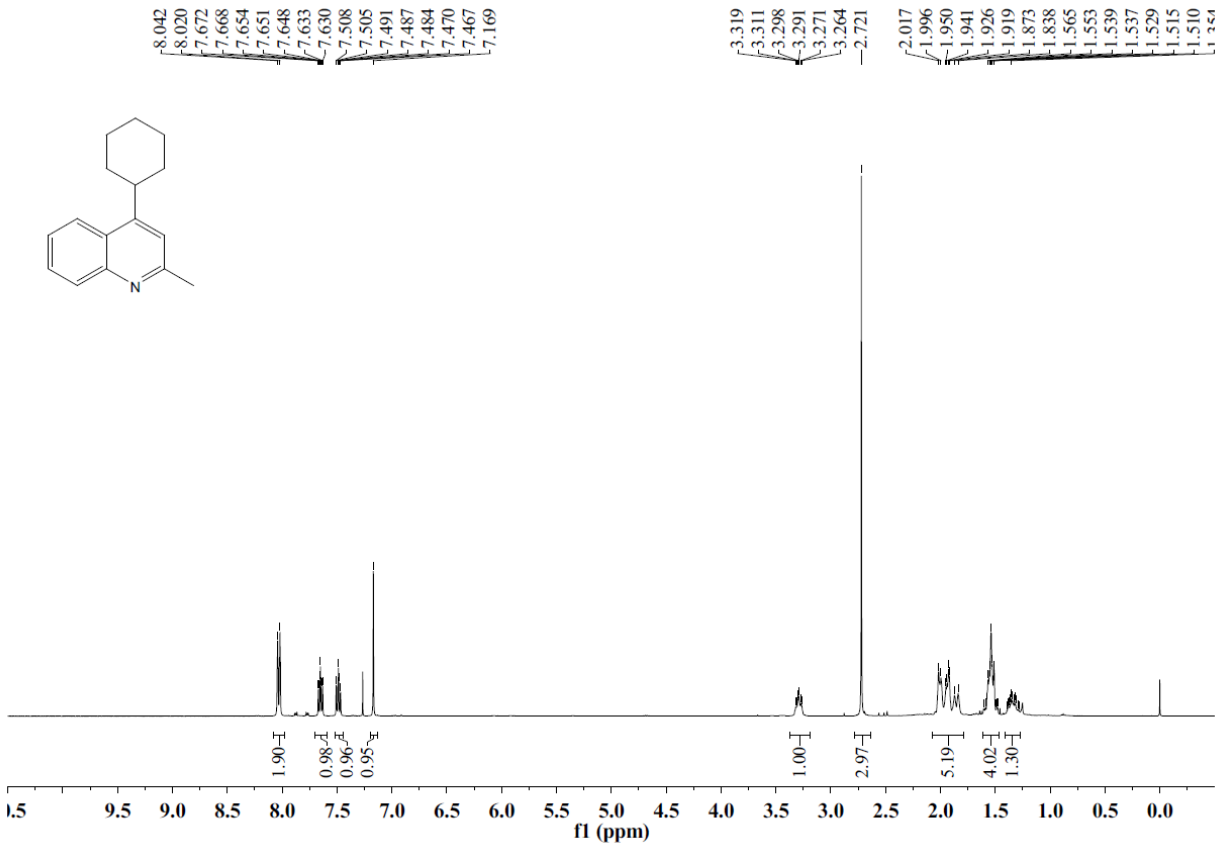
34.017
18.894
N
210
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

3ab 1H NMR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8.020
7.672
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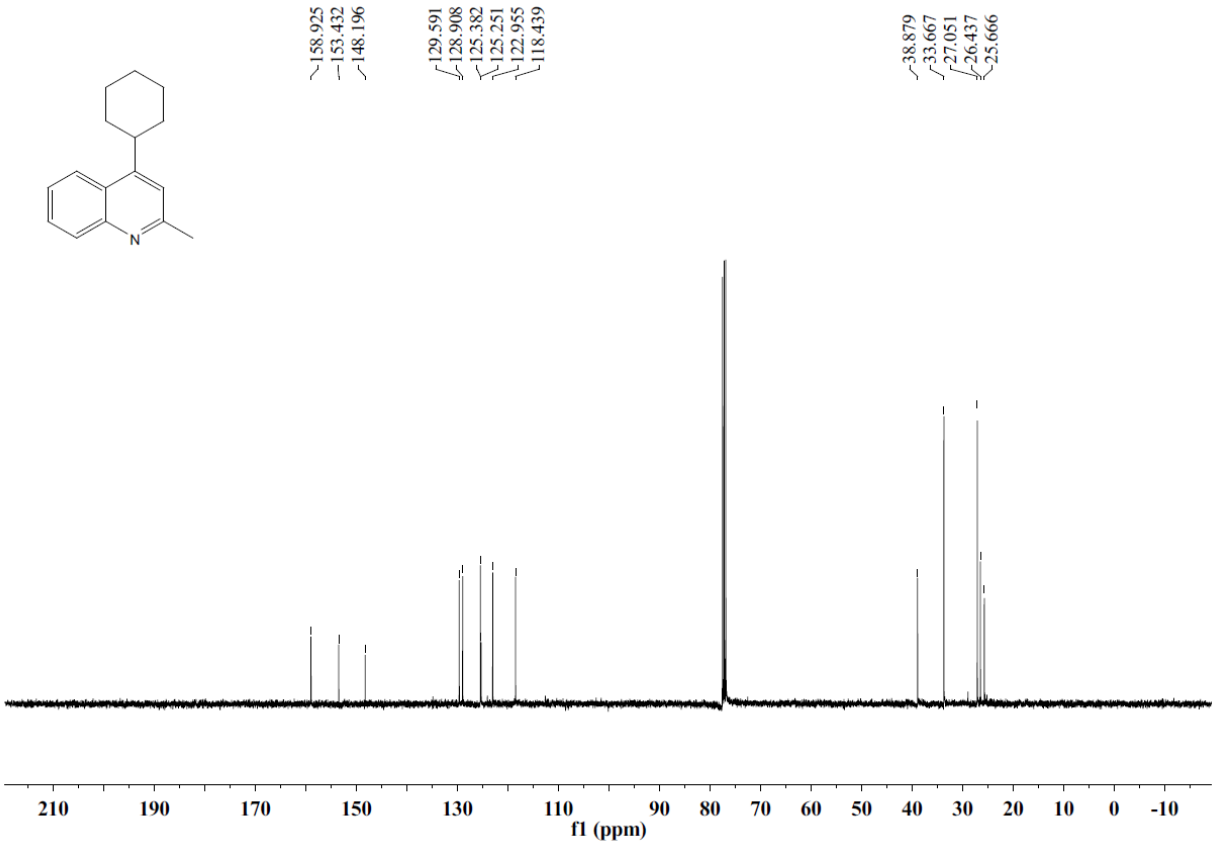
7.654
7.651
7.648
7.633
7.630
7.508
7.505
7.491
7.487
7.484
7.470
7.467
7.169
3.319
3.311
3.298
3.291
3.271
3.264
2.721
2.017
1.996
1.950
1.941
1.926
1.919
1.873
1.838
1.565
1.553
1.539
1.537
1.529
1.515
1.510
N
1.90
0.98
0.96
0.95
1.00
2.97
5.19
4.02
1.30
f1 (ppm)

3ab 13C NMR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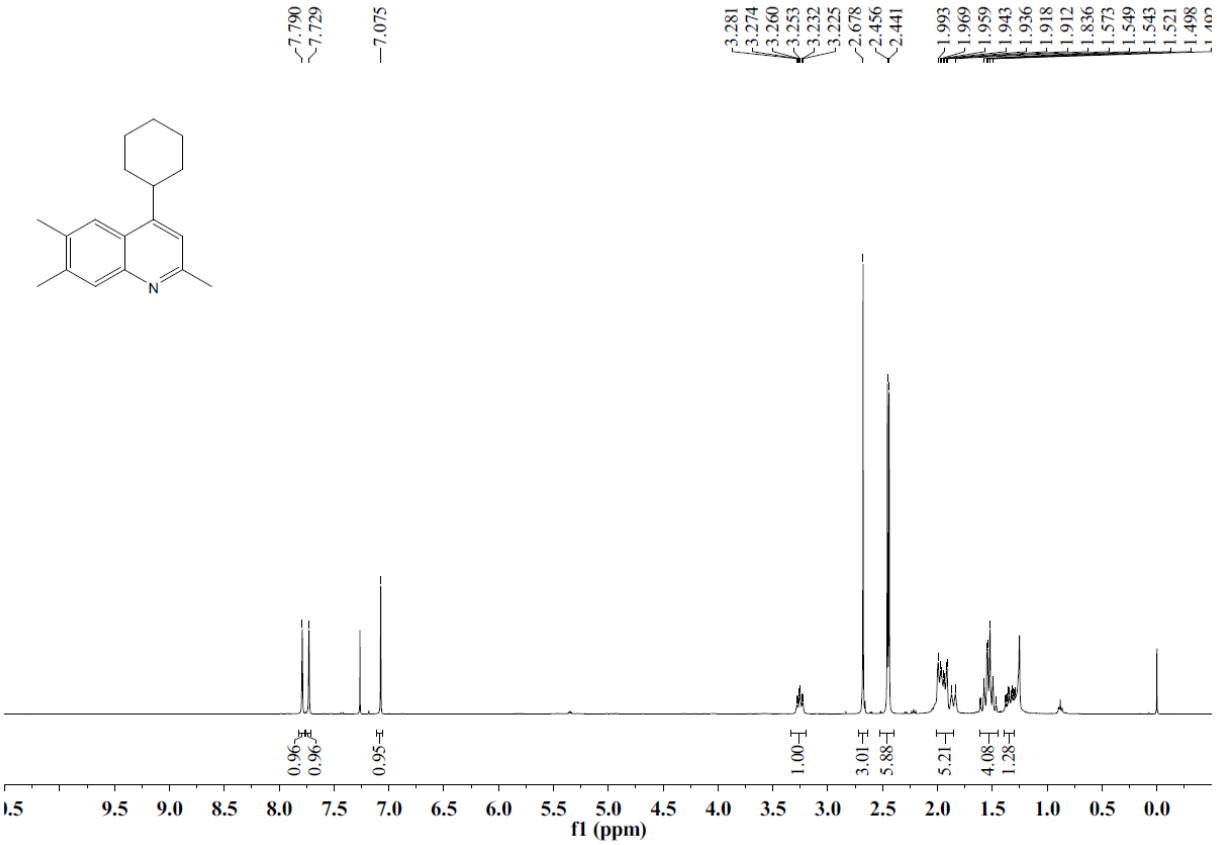
148.196
129.591
128.908
125.382
125.251
122.955
118.439
38.879
33.667
27.051
26.437
25.666
N
210
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

3ac 1H NMR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3.281
3.274
3.260
3.253
3.232
3.225
2.678
2.456
2.441
1.993
1.969
1.959
1.943
1.936
1.918
1.912
1.836
1.573
1.549
1.543
1.521
1.498
N
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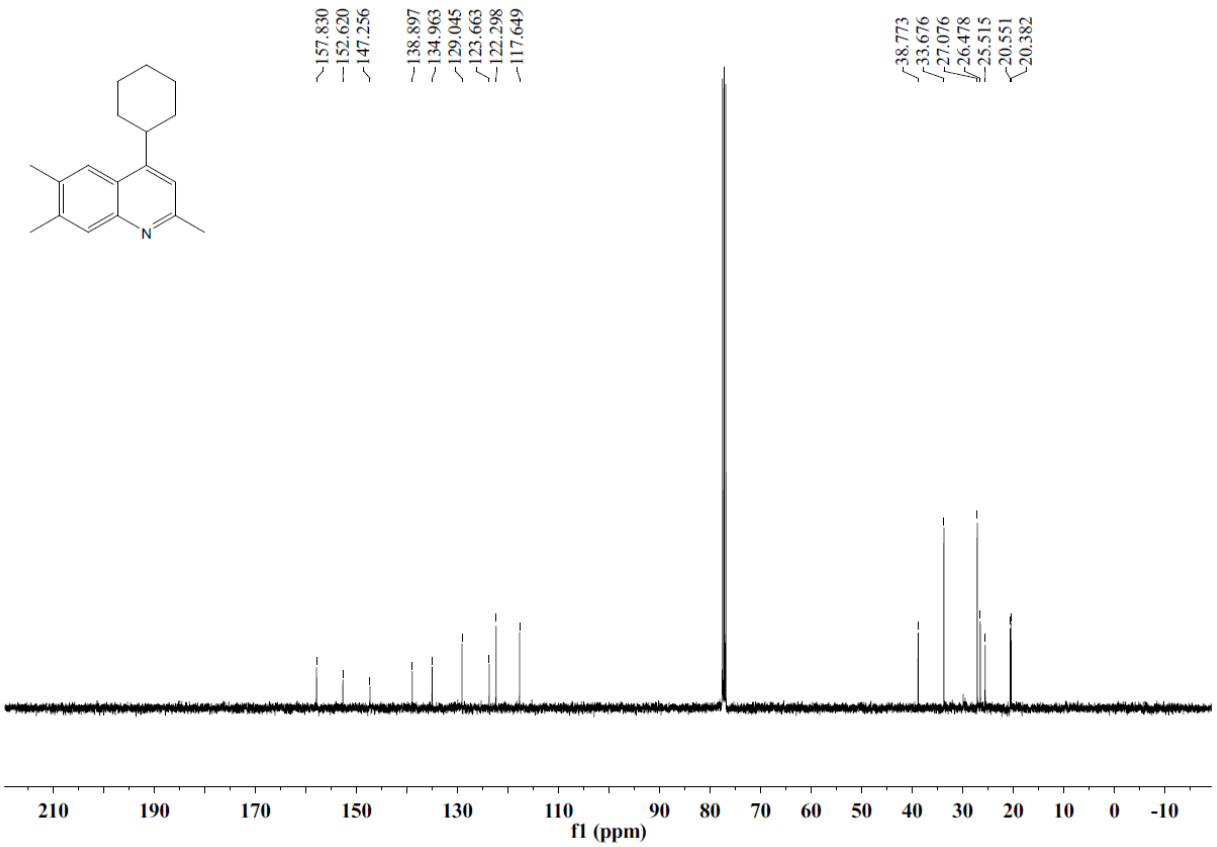
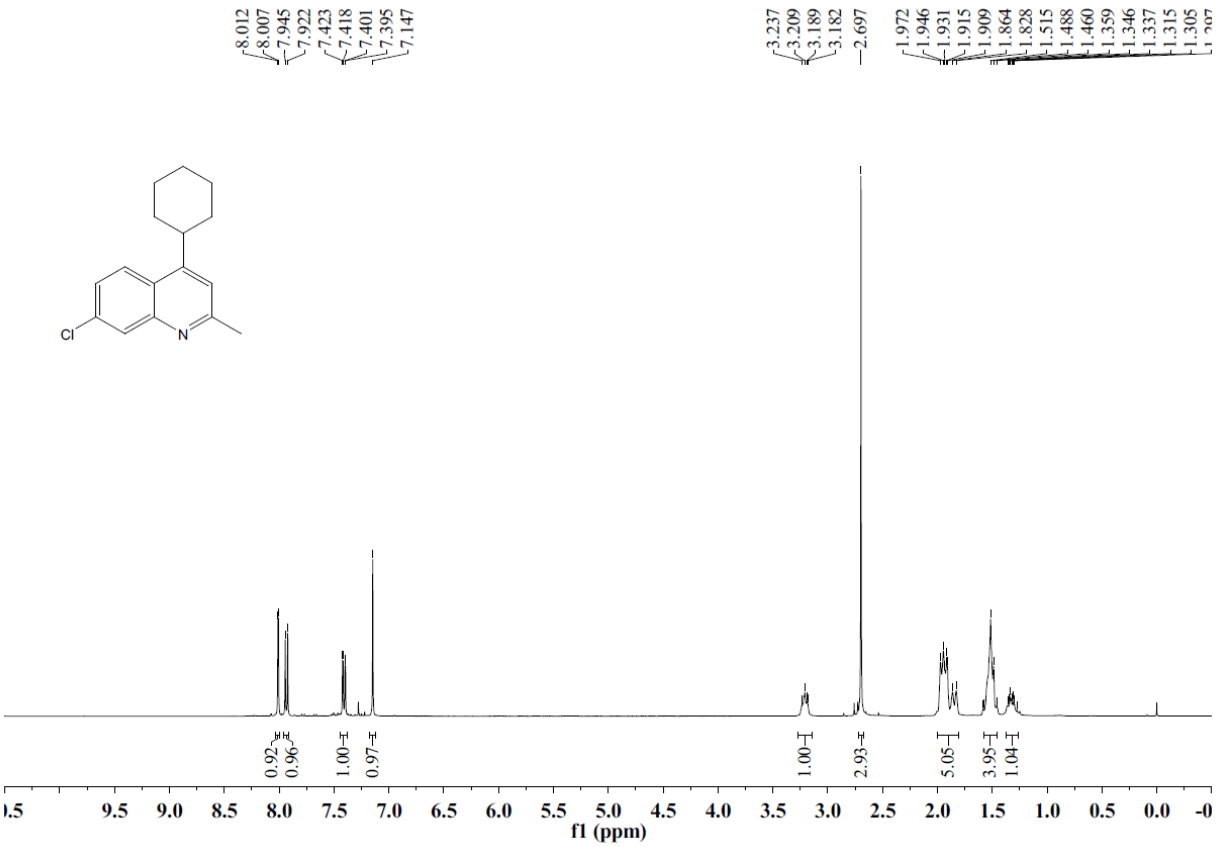
0.96
0.95
1.00
3.01
5.88
5.21
4.08
1.28
f1 (ppm)

3ac 13C NMR


157.830
152.620
147.256
138.897
134.963
129.045
123.663
122.298
117.649
38.773
33.676
27.076
26.478
25.515
20.551
20.382
N
210
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

3ad 1H NMR


8.012
8.007
7.945
7.922
7.423
7.418
7.401
7.395
7.147
3.237
3.209
3.189
3.182
2.697
1.972
1.946
1.931
1.915
1.909
1.864
1.828
1.515
1.488
1.460
1.359
1.346
1.337
1.315
1.305
Cl
N
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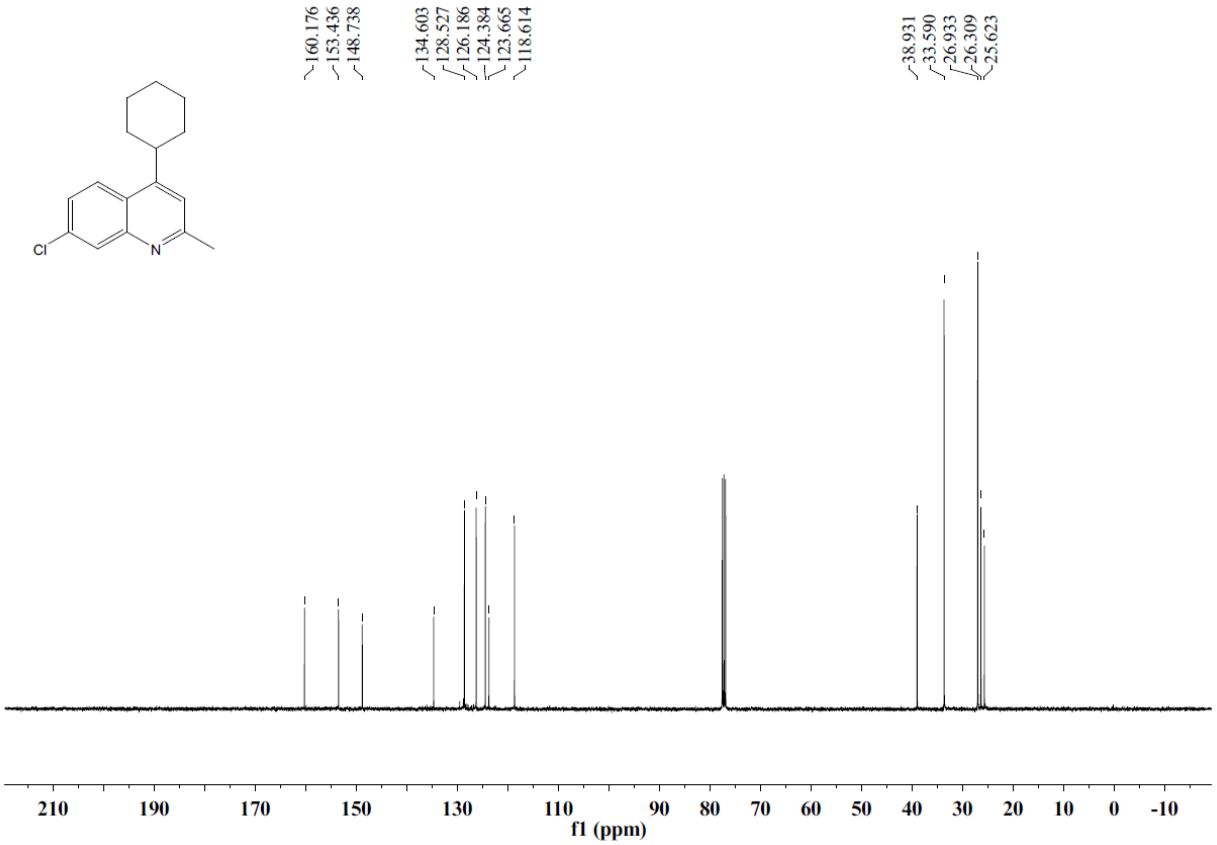
0.96
1.00
0.97
1.00
2.93
5.05
3.95
1.04
f1 (ppm)

3ad 13C NMR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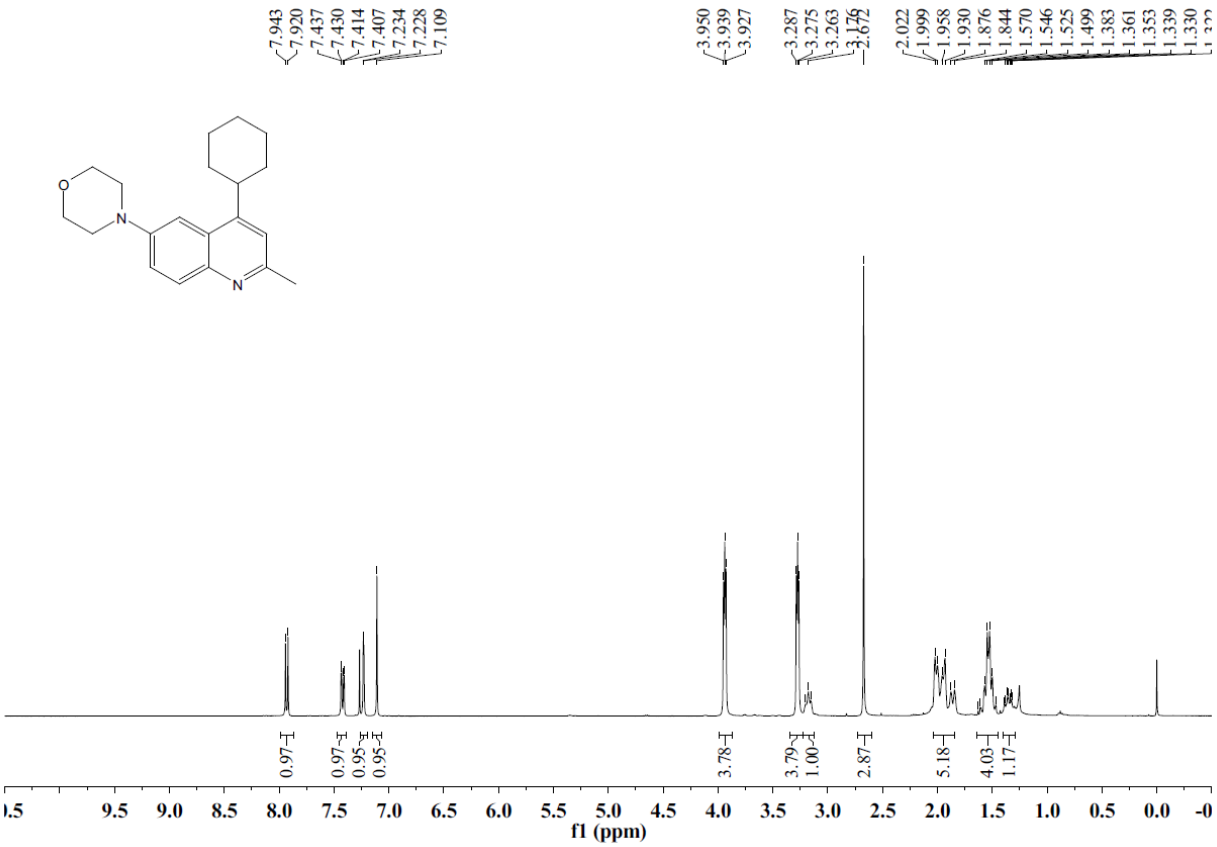
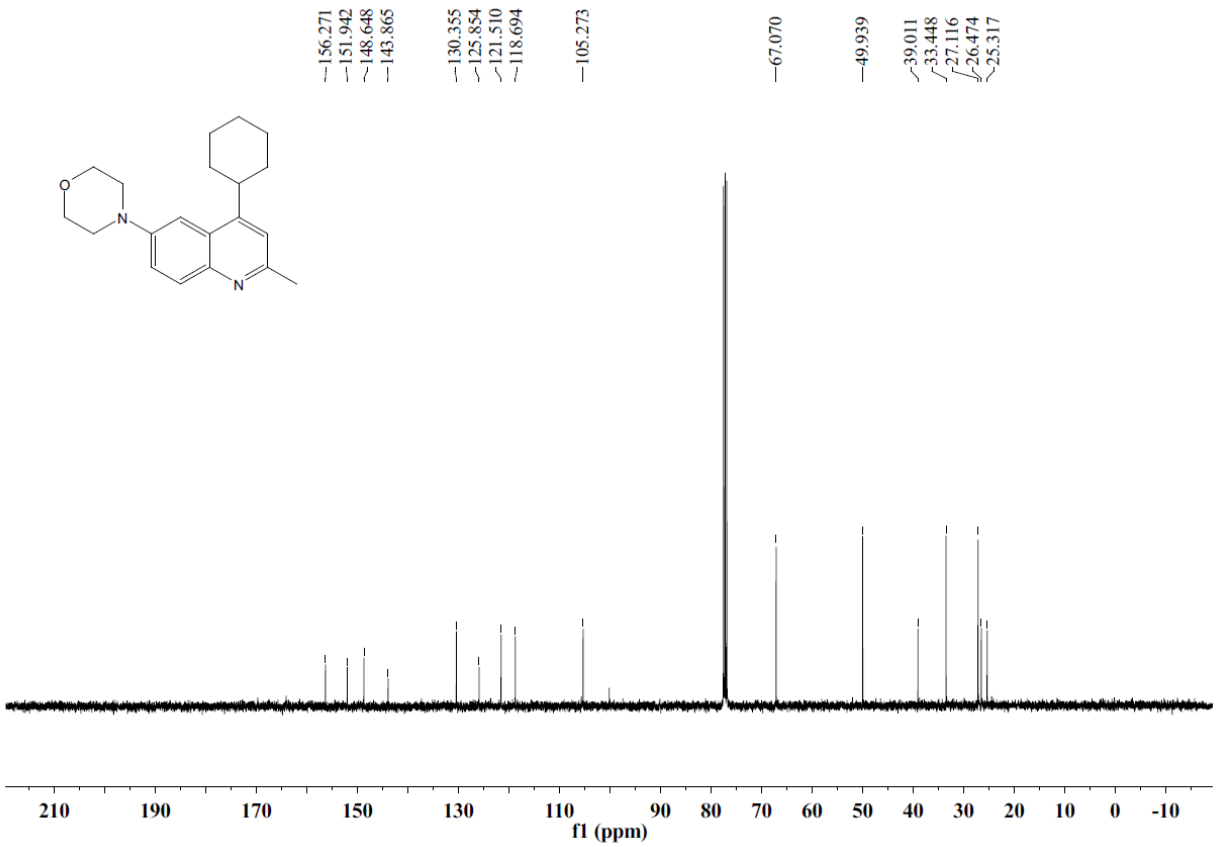
128.527
126.186
124.384
123.665
118.614
38.931
33.590
26.933
26.309
25.623
Cl
N
210
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

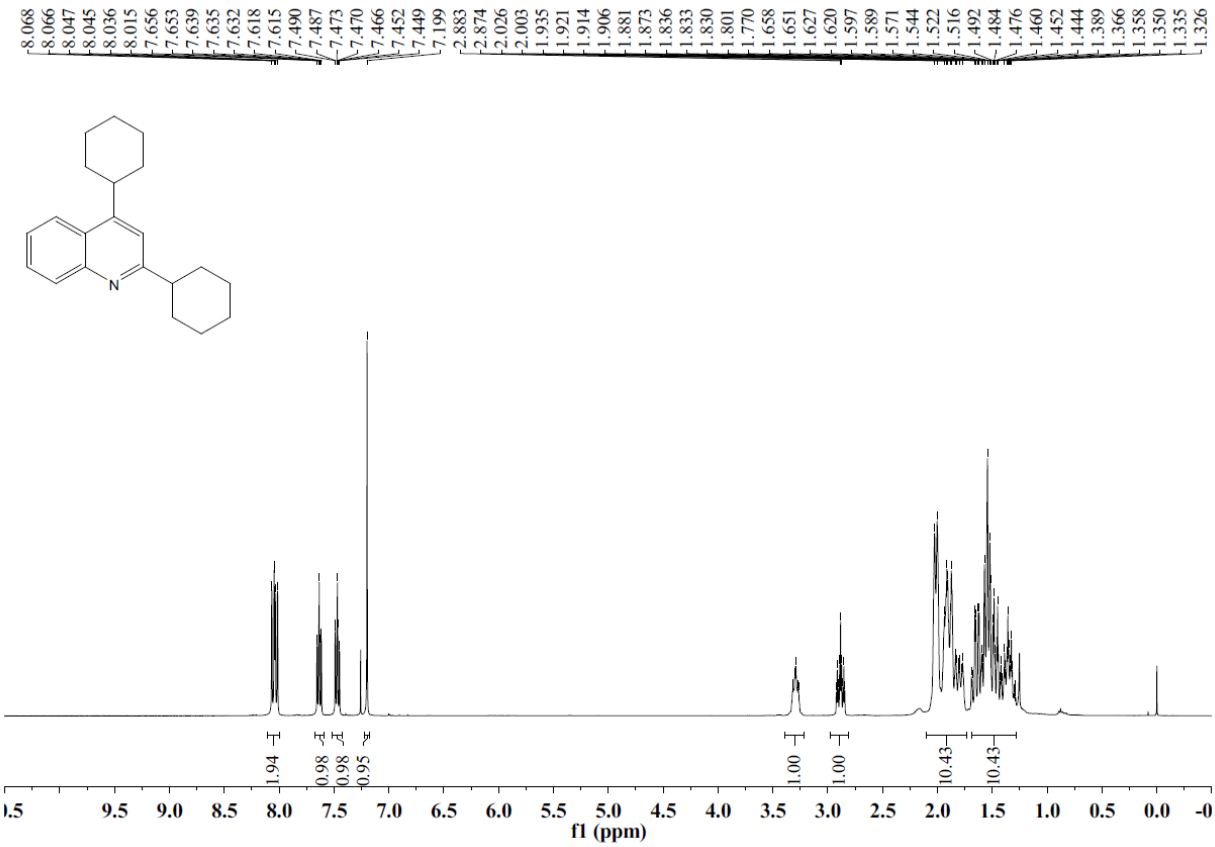
3ae 1H NMR


7.943
7.920
7.437
7.430
7.414
7.407
7.234
7.228
7.109
3.950
3.939
3.927
3.287
3.275
3.263
2.672
2.022
1.999
1.958
1.930
1.876
1.844
1.570
1.546
1.525
1.499
1.383
1.361
1.353
1.339
1.330
O
N
N
0.97
0.97
0.95
0.95
3.78
3.79
1.00
2.87
5.18
4.03
1.17
f1 (ppm)

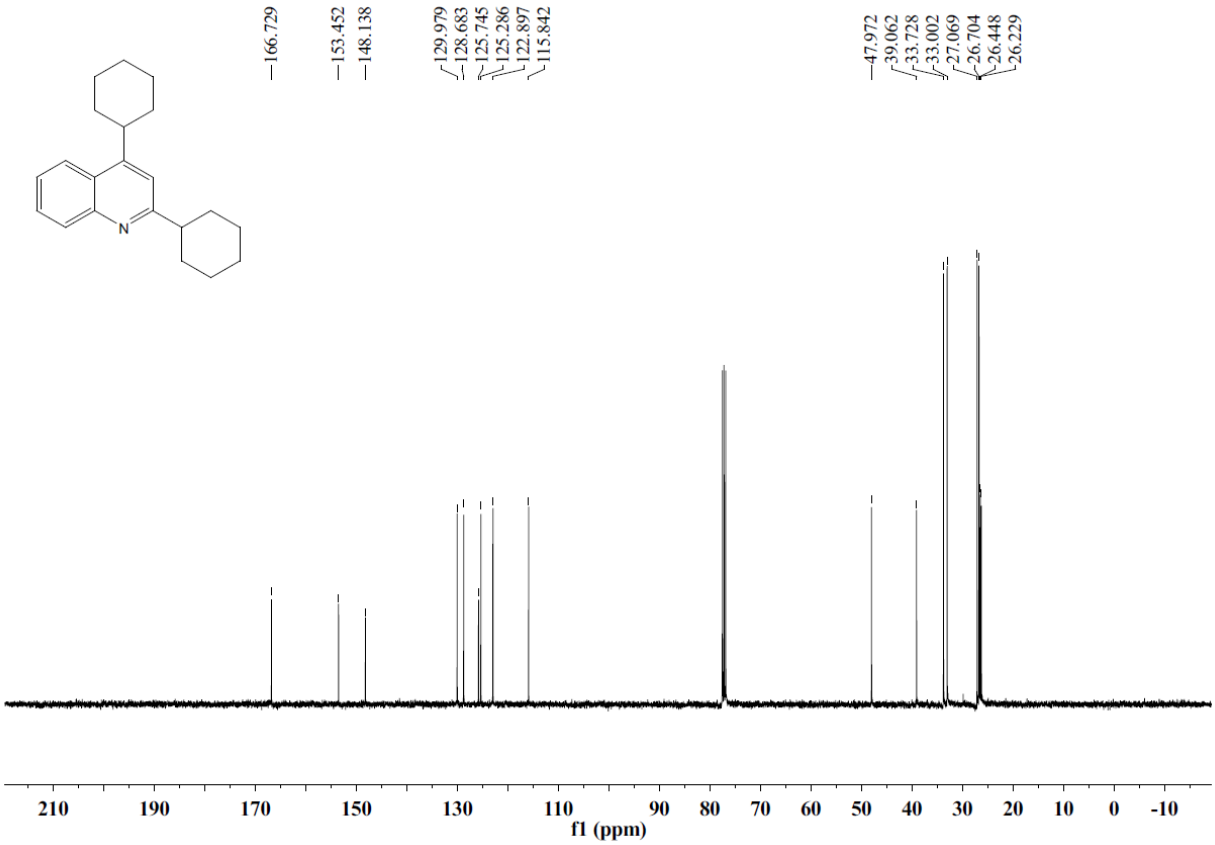
3ae 13C NMR


156.271
151.942
148.648
143.865
130.355
125.854
121.510
118.694
105.273
67.070
49.939
39.011
33.448
27.116
26.474
25.317
O
N
N
210
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

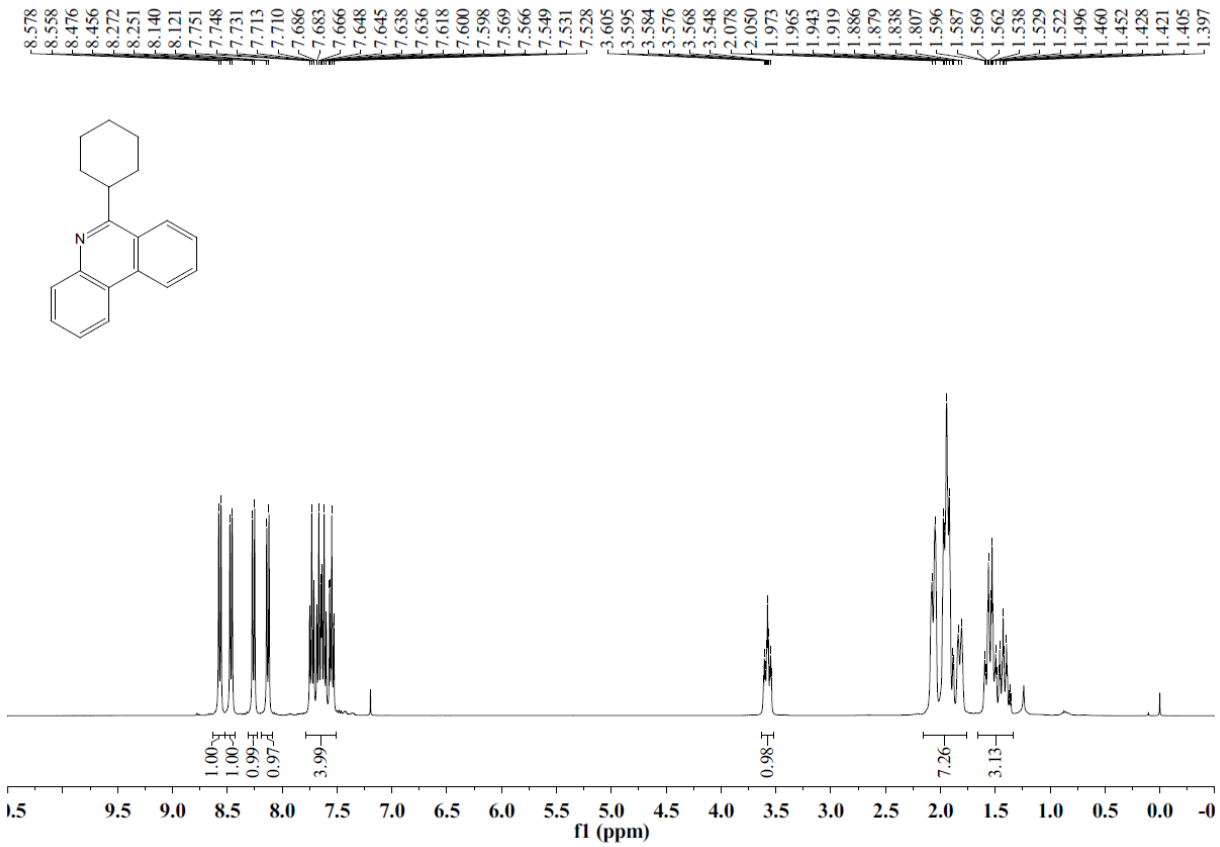
3af 1H NMR


8.068
8.066
8.047
8.045
8.036
8.015
7.656
7.653
7.639
7.635
7.632
7.618
7.615
7.490
7.487
7.473
7.470
7.466
7.452
7.449
7.199
2.883
2.874
2.026
2.003
1.935
1.921
1.914
1.906
1.881
1.873
1.836
1.833
1.830
1.801
1.770
1.658
1.651
1.627
1.620
1.597
1.589
1.571
1.544
1.522
1.516
1.492
1.484
1.476
1.460
1.452
1.444
1.389
1.366
1.358
1.350
1.335
1.326
N
1.94
0.98
0.98
0.95
1.00
1.00
10.43
10.43
f1 (ppm)

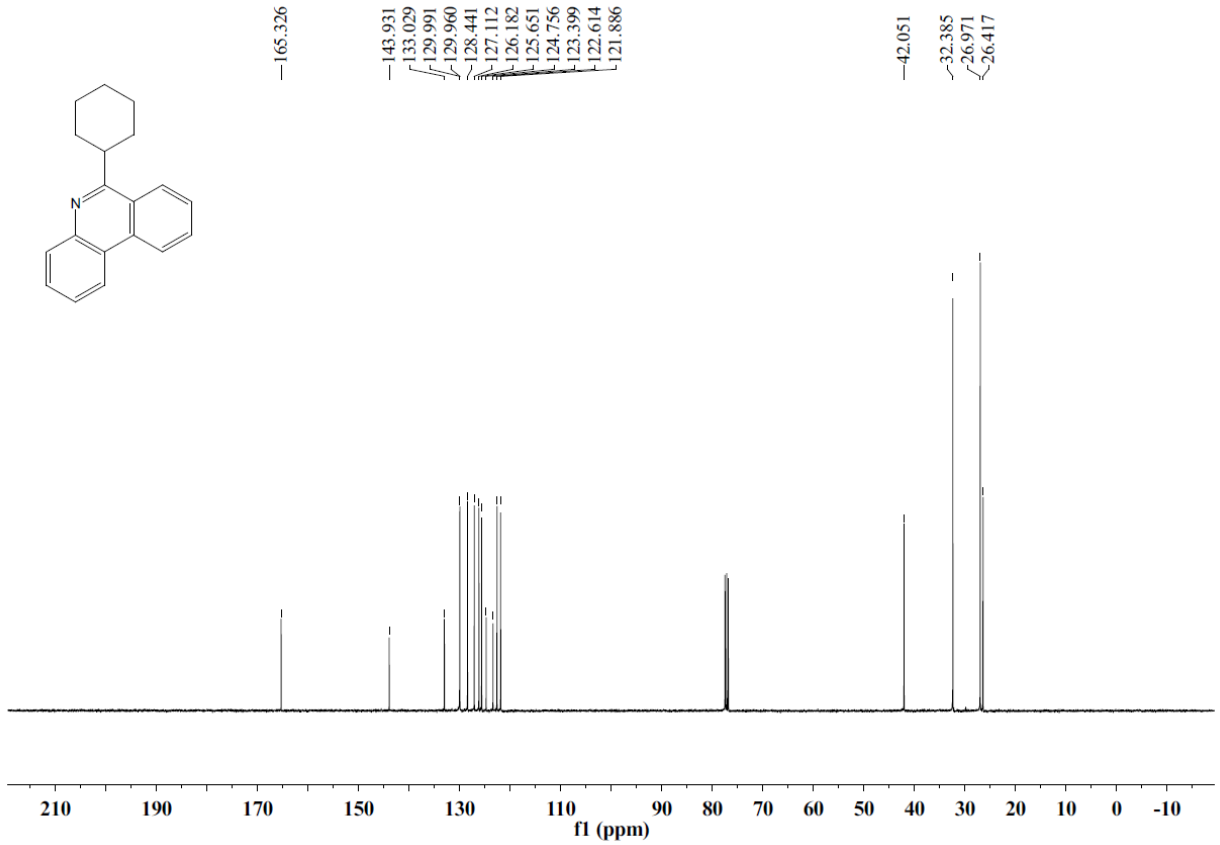
3af 13C NMR


166.729
153.452
148.138
129.979
128.683
125.745
125.286
122.897
115.842
47.972
39.062
33.728
33.002
27.069
26.704
26.448
26.229
N
210
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

3ag 1H NMR


8.578
8.558
8.476
8.456
8.272
8.251
8.140
8.121
7.751
7.748
7.731
7.713
7.710
7.686
7.683
7.666
7.648
7.645
7.638
7.636
7.618
7.600
7.598
7.569
7.566
7.549
7.531
7.528
3.605
3.595
3.584
3.576
3.568
3.548
2.078
2.050
1.973
1.965
1.943
1.919
1.886
1.879
1.838
1.807
1.596
1.587
1.569
1.562
1.538
1.529
1.522
1.496
1.460
1.452
1.428
1.421
1.405
1.397
N
1.00
1.00
0.99
0.97
3.99
0.98
7.26
3.13
f1 (ppm)

3ag 13C NMR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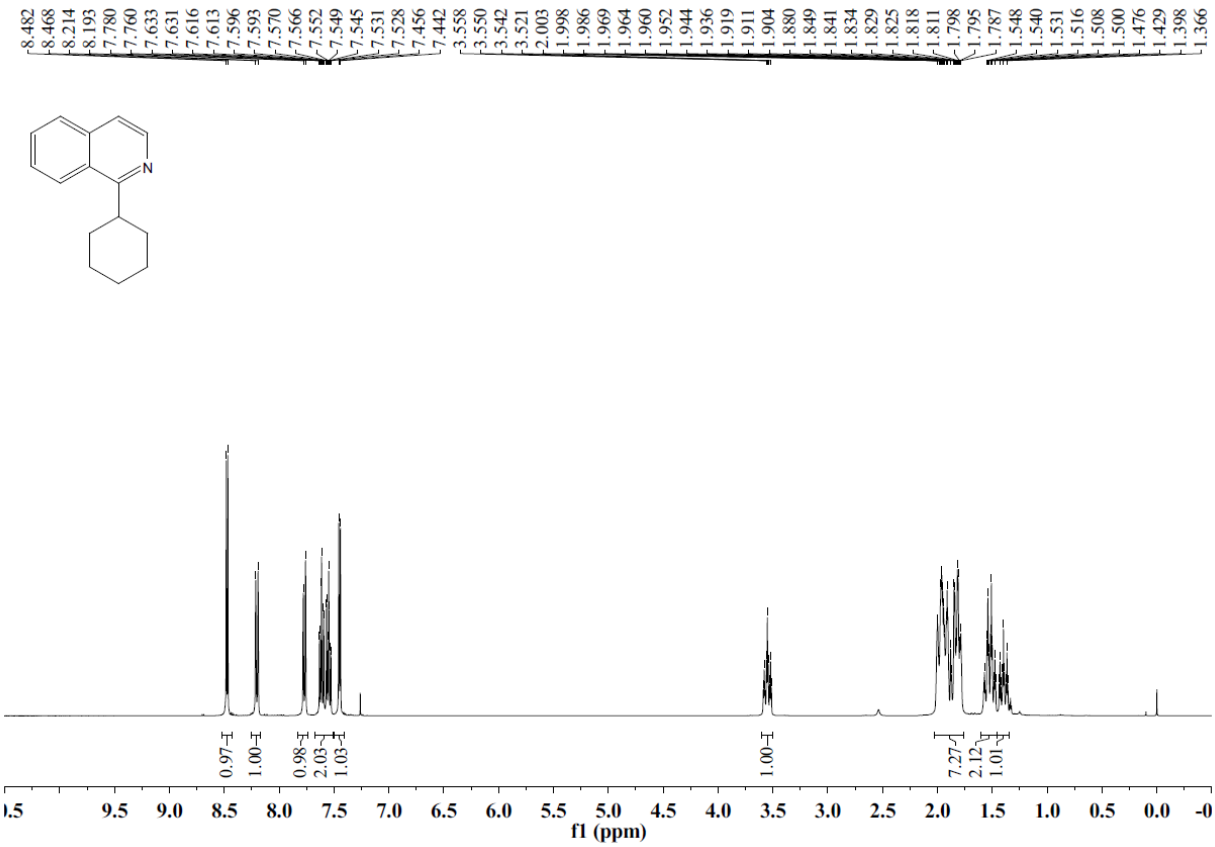
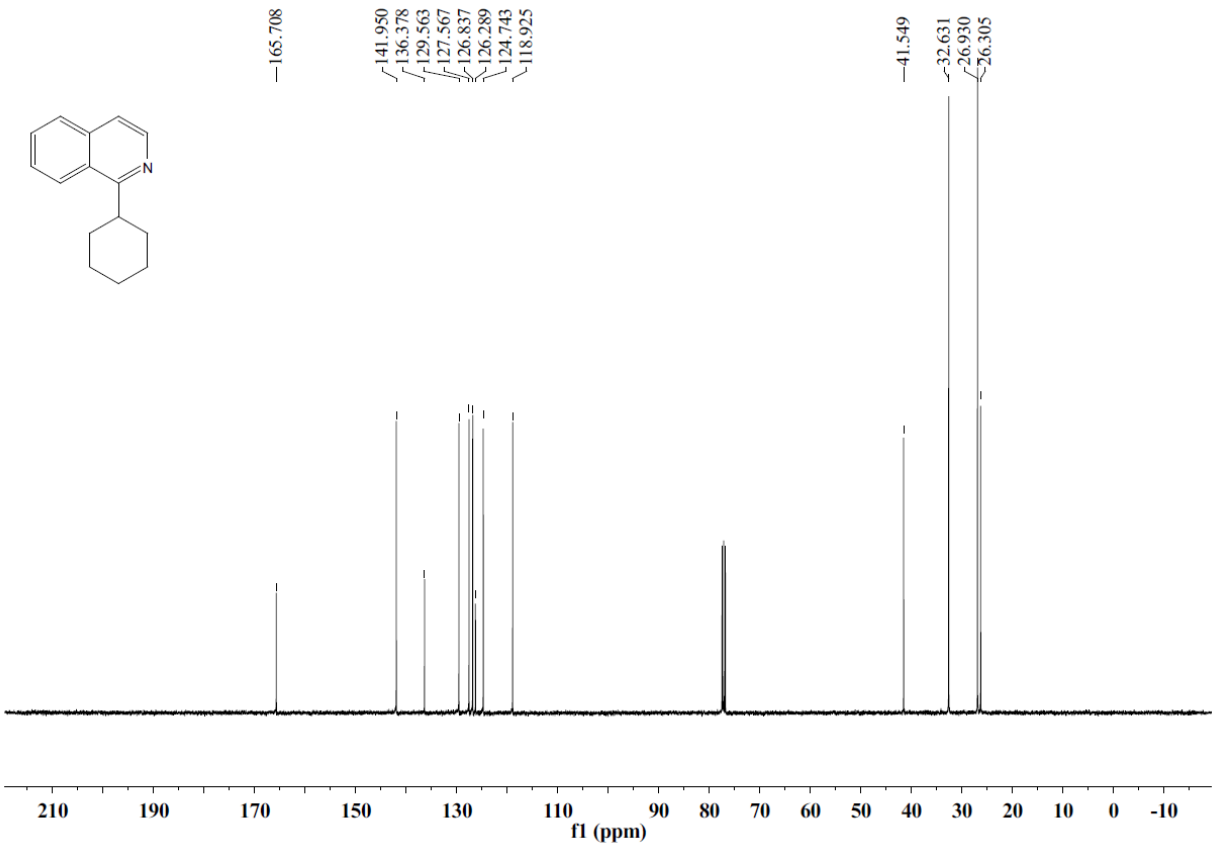
143.931
133.029
129.991
129.960
128.441
127.112
126.182
125.651
124.756
123.399
122.614
121.886
42.051
32.385
26.971
26.417
N
210
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

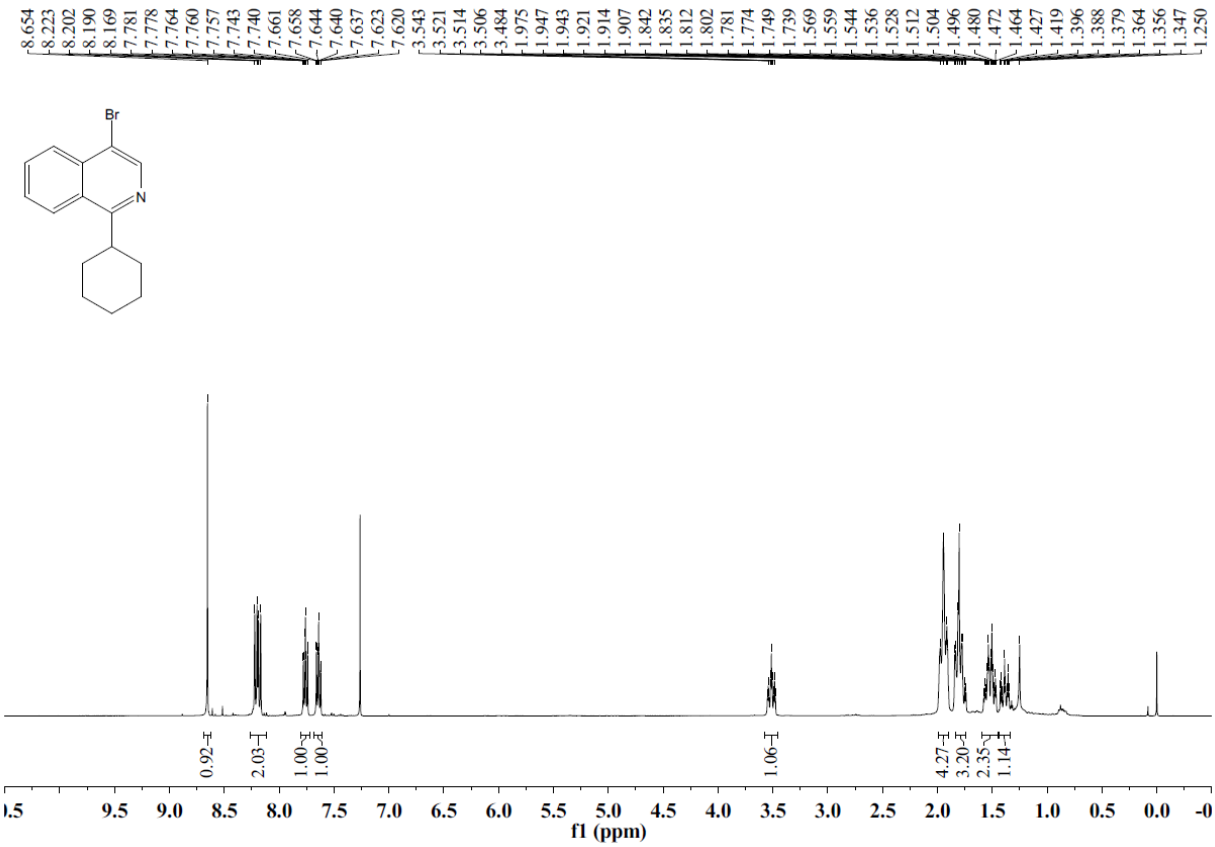
3ah 1H NMR


8.482
8.468
8.214
8.193
7.780
7.760
7.633
7.631
7.616
7.613
7.596
7.593
7.570
7.566
7.552
7.549
7.545
7.531
7.528
7.456
7.442
3.558
3.550
3.542
3.521
2.003
1.998
1.986
1.969
1.964
1.960
1.952
1.944
1.936
1.919
1.911
1.904
1.880
1.849
1.841
1.834
1.829
1.825
1.818
1.811
1.798
1.795
1.787
1.548
1.540
1.531
1.516
1.508
1.500
1.476
1.429
1.398
1.366
N
0.97
1.00
0.98
2.03
1.03
1.00
7.27
2.12
1.01
f1 (ppm)

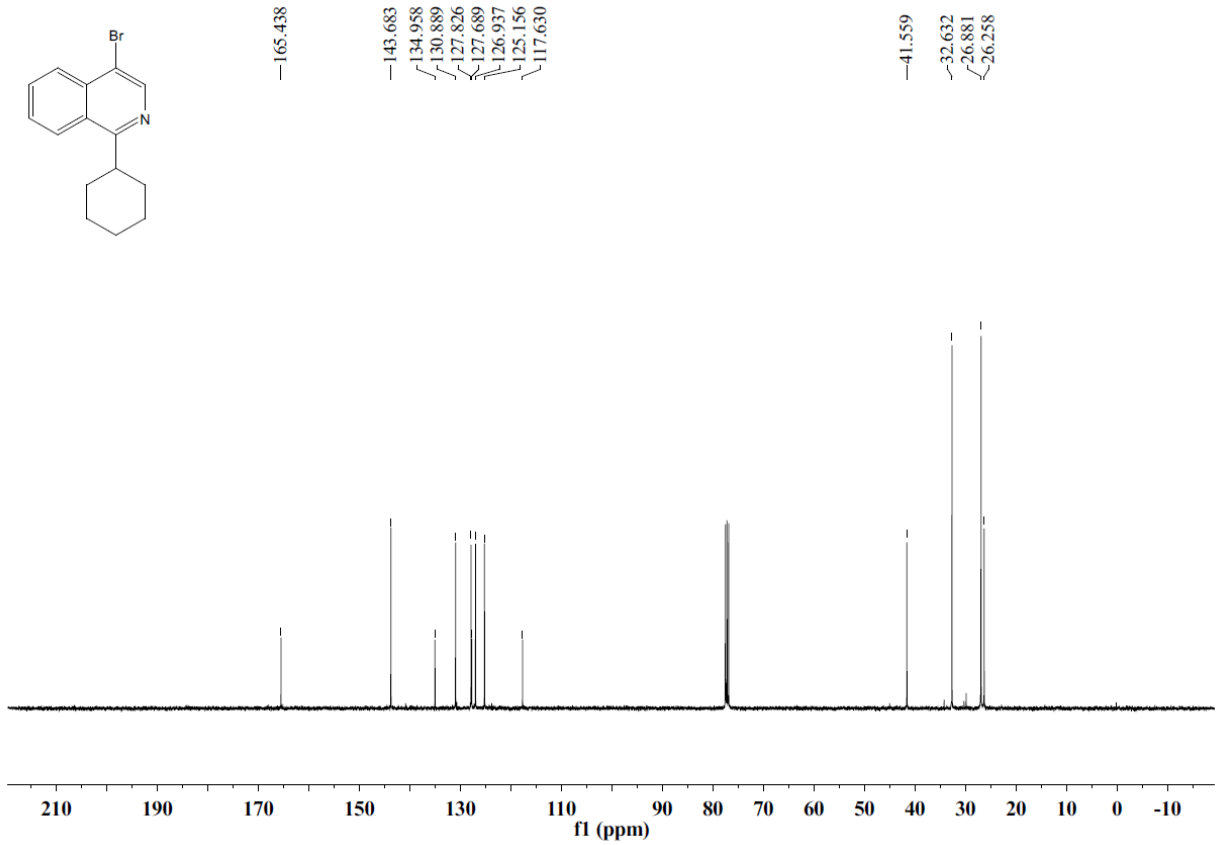
3ah 13C NMR


165.708
141.950
136.378
129.563
127.567
126.837
126.289
124.743
118.925
41.549
32.631
26.930
26.305
N
210
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

3ai 1H NMR


8.654
8.223
8.202
8.190
8.169
7.781
7.778
7.764
7.760
7.757
7.743
7.740
7.661
7.658
7.644
7.640
7.637
7.623
7.620
3.543
3.521
3.514
3.506
3.484
1.975
1.947
1.943
1.921
1.914
1.907
1.842
1.835
1.812
1.802
1.781
1.774
1.749
1.739
1.569
1.559
1.544
1.536
1.528
1.512
1.504
1.496
1.480
1.472
1.464
1.427
1.419
1.396
1.388
1.379
1.364
1.356
1.347
1.250
Br
N
0.92
2.03
1.00
1.00
1.06
4.27
3.20
2.35
1.14
f1 (ppm)

3ai 13C NMR


Br
N
165.438
143.683
134.958
130.889
127.826
127.689
126.937
125.156
117.630
41.559
32.632
26.881
26.258
210
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)