Ni-Catalyzed Intramolecular Cyclization of B-H Adducts of 2-Cyanoaniline towards 2,3-Dihydroquinolin-4(1H)-ones

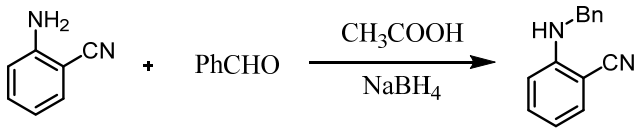
Contents

1. General Information

All commercial reagents were purchased from TCI, Leyan, Energy Chemical and used as received. Solvents used in catalytic reactions were dried and distilled in appropriate method. Solvent employed for column chromatography were purchased in technical grade quality without distillation before use.

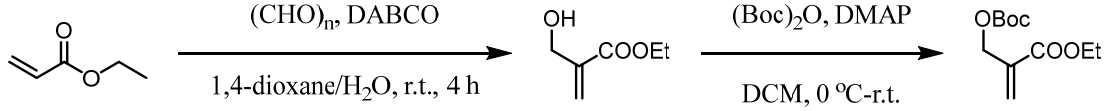
All reactions were generally performed in dried glassware filled with dry argon. TLC plates were stained using potassium permanganate. Chromatographic purification of products (column chromatography) was performed on the glass column filled in (300–400 Mesh) silica gel. Concentration of reaction product solutions and chromatography fractions under reduced pressure was performed by rotary evaporation at 30-40 °C at the appropriate pressure and then at rt, ca. 0.1 mmHg (vacuum pump) unless otherwise indicated. For reactions that require heating, oil bath is used as the heat source. NMR spectra were obtained on a Bruker 600 spectrometer, operating at 600 MHz or 400MHZfor ^{1}H NMR, 151 MHz or 101MHz for ^{13}C NMR, 565 MHz for ^{19}F NMR. ^{1}H and ^{13}C positive chemical shifts (δ) are downfield from tetramethylsilane and are given in parts per million (ppm). Chemical shifts were reported in ppm relative to the central line of $CHCl_3$ (δ 7.26) for ^{1}H NMR, for ^{13}C NMR, the residual $CDCl_3$ (δ 77.16) were used as the internal standards. Coupling constants *(J)* are given in Hertz (Hz). The following abbreviations are used for spin multiplicity: s = singlet, d = doublet, dd = doublet of doublet, dt = doublet of triplet, ddd = doublet of doublet of doublet, t = triplet, m = multiplet and brs = broad singlet. Electrospray ionization high-resolution mass spectra (ESI-HRMS) and atmospheric pressure chemical ionization high-resolution mass spectra (APCI-HRMS) were recorded on a Bruke P-SIMS-Gly FT-ICR mass spectrometer. Enantiomeric excess was determined by HPLC analysis on Chiralpak column (Daicel Chemical Industries, LTD).

2. Preparation of Benzyl-protected aminobenzonitrile



Benzyl-protected aminobenzonitrile was prepared according to related literatures.[1] Anthranilonitrile (1.0 equiv.) was dissolved in AcOH. Benzaldehyde (1.28 equiv.) was added and the reaction stirred at rt for 30 min. The reaction flask was immersed in ice and $NaBH_4$ (1.04 equiv.) was added in portions. A vigorous exothermic reaction followed on each addition. On cooling a thick precipitate formed. After addition of water, the product was filtered off and dried to white powder.

3. Preparation of 2-substituted ethyl acrylate compounds

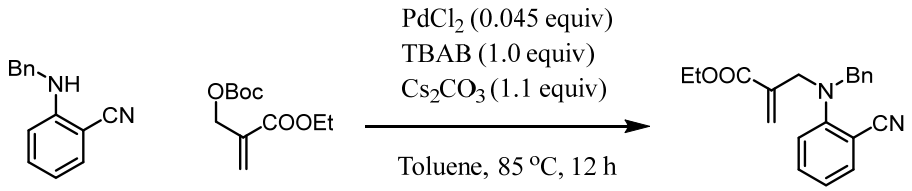


2-substituted ethyl acrylate compounds were prepared according to related literatures.[2][3] At room temperature, paraformaldehyde (3.0 equiv.), ethyl acrylate (1.0 equiv.), and DABCO (1.0 equiv.) were dissolved in 1,4-dioxane/water (V:V=1:1) and stirred for 4 h. Then 1,4-dioxane was evaporated under pressure reduction, and each of ether and water were added. The aqueous layer was extracted with ether for 3 times, and the organic layer was washed with saturated sodium chloride. Anhydrous magnesium sulfate dry, filtration, pressurized evaporation, silica gel column chromatography purification (petroleum ether/ethyl acetate = 1:1) to obtain colorless oily liquid, which was used in the next reaction step.

The above product (1.0 equiv) and Boc_2O (1.1 equiv) were dissolved in DCM. The solution was cooled to 0 °C. 4-dimethylaminopyridine (0.1 equiv) was slowly added to the reaction solution at 0 °C. The mixture was allowed to stir for 12 hours at room

temperature. At the end of the reaction, the reaction solution was diluted with dichloromethane, and the organic layer was washed sequentially with 4 mol/L HCl solution, saturated $NaHCO_3$ and brine. The organic layers were combined, dried with anhydrous Na_2SO_4, filtered through diatomaceous earth and concentrated under vacuum. The mixture was purified by silica gel column chromatography (petroleum ether: ethyl acetate = 5:1) to give a light-yellow liquid.

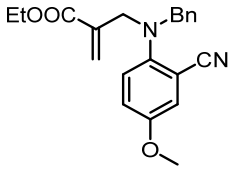
4. Preparation of alkenyl-nitrile compounds



1a

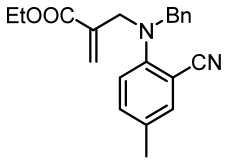
Alkenyl-nitrile compounds were prepared according to related literatures.[4] Benzyl protected aminobenzonitrile (1.0 equiv), 2-substituted ethyl acrylate compounds (3.0 equiv), palladium chloride (0.045 equiv), tetrabutylammonium bromide (1 equiv), and cesium carbonate (1.1 equiv) were heated and reacted in toluene at 85 °C for 10 h. At the end of the reaction, the reaction mixture was dissolved with methyl tertiary butyl ether, and the extracts were washed with water and saturated saline to wash the extract three times, dried with anhydrous Na_2SO_4, filtered through diatomaceous earth and finally concentrated under vacuum. The extract was purified by silica gel column chromatography (petroleum ether: ethyl acetate = 5:1) to give a pale-yellow viscous liquid **1a** (90% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.60 – 7.52 (m, 1H), 7.39 – 7.33 (m, 1H), 7.32 – 7.27 (m, 3H), 7.26 – 7.24 (m, 2H), 6.97 – 6.86 (m, 2H), 6.31 (s, 1H), 5.76 (s, 1H), 4.54 (s, 2H), 4.21 (s, 2H), 4.14 (q, *J* = 7.2 Hz, 2H), 1.23 (t, *J* = 7.2 Hz, 3H).

Ethyl 2-((benzyl(2-cyano-4-methoxyphenyl)amino)methyl)acrylate (1b)



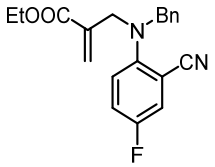
The synthetic method is according to the literature report.[4] Pale yellow oil **1b** (57% yield) was isolated by column chromatography (5/1 petroleum ether/ethyl acetate). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.30 – 7.28 (m, 3H), 7.27 – 7.24 (m, 2H), 7.06 – 7.04 (m, 1H), 6.97 – 6.93 (m, 2H), 6.27 (s, 1H), 5.82 (s, 1H), 4.34 (s, 2H), 4.14 (q, *J* = 7.2 Hz, 2H), 4.02 (s, 2H), 3.76 (s, 3H), 1.24 (t, *J* = 7.2 Hz, 3H).

Ethyl 2-((benzyl(2-cyano-4-methylphenyl)amino)methyl)acrylate (1c)



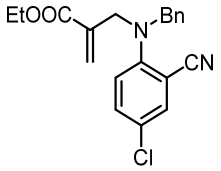
The synthetic method is according to the literature report.[4] Pale yellow oil **1c** (69% yield) was isolated by column chromatography (5/1 petroleum ether/ethyl acetate). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.38 – 7.33 (m, 1H), 7.30 – 7.24 (m, 5H), 7.29 – 7.24 (m, 1H), 6.85 (d, *J* = 8.4 Hz, 1H), 6.29 (s, 1H), 5.78 (s, 1H), 4.46 (s, 2H), 4.15 (q, *J* = 7.2 Hz, 2H), 4.12 (s, 2H), 2.26 (s, 3H), 1.23 (t, *J* = 7.2 Hz, 3H).

Ethyl 2-((benzyl(2-cyano-4-fluorophenyl)amino)methyl)acrylate (1d)



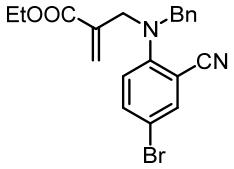
The synthetic method is according to the literature report.[4] Pale yellow oil **1d** (95% yield) was isolated by column chromatography (5/1 petroleum ether/ethyl acetate).。 **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.49 – 7.28 (m, 6H), 7.25 – 7.08 (m, 1H), 6.96 – 6.90 (m, 1H), 6.31 (s, 1H), 5.79 (s, 1H), 4.42 (s, 2H), 4.14 (q, *J* = 7.2 Hz, 2H), 4.10 (s, 2H), 1.24 (t, *J* = 7.2 Hz, 3H).

Ethyl 2-((benzyl(4-chloro-2-cyanophenyl)amino)methyl)acrylate (1e)



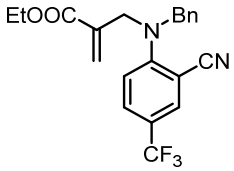
The synthetic method is according to the literature report.[4] Pale yellow oil **1e** (75% yield) was isolated by column chromatography (5/1 petroleum ether/ethyl acetate). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.53 – 7.46 (m, 1H), 7.35 – 7.27 (m, 3H), 7.26 – 7.22 (m, 3H), 6.87 – 6.81 (m, 1H), 6.32 (s, 1H), 5.74 (s, 1H), 4.52 (s, 2H), 4.20 (s, 2H), 4.15 (q, *J* = 7.2 Hz 2H), 1.24 (t, *J* = 7.6 Hz, 3H).

Ethyl 2-((benzyl(4-bromo-2-cyanophenyl)amino)methyl)acrylate (1f)



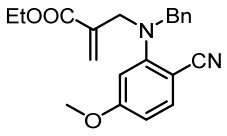
The synthetic method is according to the literature report.[4] Pale yellow oil **1f** (80% yield) was isolated by column chromatography (5/1 petroleum ether/ethyl acetate). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.63 (d, *J* = 2.4 Hz, 1H), 7.45 – 7.40 (m, 1H), 7.35 – 7.29 (m, 2H), 7.27 – 7.22 (m, 3H), 6.78 (d, *J* = 9.0 Hz, 1H), 6.32 (s, 1H), 5.73 (s, 1H), 4.54 (s, 2H), 4.22 (s, 2H), 4.16 (q, *J* = 7.2 Hz, 2H), 1.24 (t, *J* = 7.2 Hz, 3H).

Ethyl 2-((benzyl(2-cyano-4-(trifluoromethyl)phenyl)amino)methyl)acrylate (1g)



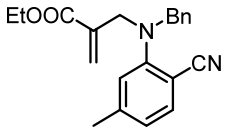
The synthetic method is according to the literature report.[4] Pale yellow oil **1g** (86% yield) was isolated by column chromatography (5/1 petroleum ether/ethyl acetate). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.77 (m, 1H), 7.56 – 7.50 (m, 1H), 7.43 – 7.28 (m, 3H), 7.27 – 7.20 (m, 2H), 6.89 (d, *J* = 9.0 Hz, 1H), 6.38 (s, 1H), 5.69 (s, 1H), 4.71 (s, 2H), 4.41 (s, 2H), 4.18 (q, *J* = 7.2 Hz, 2H), 1.25 (t, *J* = 7.2 Hz, 3H).

Ethyl 2-((benzyl(2-cyano-5-methoxyphenyl)amino)methyl)acrylate (1h)



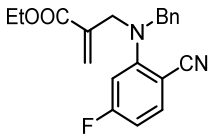
The synthetic method is according to the literature report.[4] Pale yellow oil **1h** (73% yield) was isolated by column chromatography (5/1 petroleum ether/ethyl acetate). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.47 (d, *J* = 8.6 Hz, 1H), 7.35 – 7.26 (m, 5H), 6.49 – 6.44 (m, 1H), 6.38 (d, *J* = 2.4 Hz, 1H), 6.31 (s, 1H), 5.77 (s, 1H), 4.54 (s, 2H), 4.20 (s, 2H), 4.16 (q, *J* = 7.2 Hz, 2H), 3.74 (s, 3H), 1.24 (t, *J* = 7.2 Hz, 3H).

Ethyl 2-((benzyl(2-cyano-5-methylphenyl)amino)methyl)acrylate (1i)



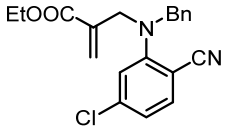
The synthetic method is according to the literature report.[4] Pale yellow oil **1i** (73% yield) was isolated by column chromatography (5/1 petroleum ether/ethyl acetate). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.42 (d, *J* = 7.6 Hz, 1H), 7.35 – 7.30 (m, 1H), 7.30 – 7.28 (m, 5H), 7.06 (t, *J* = 7.6 Hz, 1H), 6.25 (s, 1H), 5.67 (s, 1H), 4.34 (s, 2H), 4.13 (q, *J* = 7.2 Hz, 2H), 4.01 (s, 2H), 2.17 (s, 3H), 1.17 (t, *J* = 7.2 Hz, 3H).

Ethyl 2-((benzyl(2-cyano-5-fluorophenyl)amino)methyl)acrylate (1j)



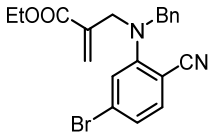
The synthetic method is according to the literature report.[4] Pale yellow oil **1j** (86% yield) was isolated by column chromatography (5/1 petroleum ether/ethyl acetate). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.56 – 7.48 (m, 1H), 7.36 – 7.30 (m, 2H), 7.29 – 7.22 (m, 3H), 6.64 – 6.52 (m, 2H), 6.35 (s, 1H), 5.72 (s, 1H), 4.60 (s, 2H), 4.27 (s, 2H), 4.17 (q, *J* = 7.2 Hz, 2H), 1.25 (t, *J* = 7.2 Hz, 3H).

Ethyl 2-((benzyl(5-chloro-2-cyanophenyl)amino)methyl)acrylate (1k)



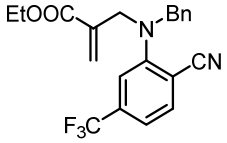
The synthetic method is according to the literature report.[4] Pale yellow solid **1k** (80% yield) was isolated by column chromatography (5/1 petroleum ether/ethyl acetate). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.45 (d, *J* = 8.4 Hz, 1H), 7.37 – 7.30 (m, 2H), 7.29 – 7.25 (m, 4H), 6.89 – 6.87 (m, 1H), 6.33 (s, 1H), 5.71 (s, 1H), 4.58 (s, 2H), 4.24 (s, 2H), 4.17 (q, *J* = 7.2 Hz, 2H), 1.24 (t, *J* = 7.2 Hz, 3H).

Ethyl 2-((benzyl(5-bromo-2-cyanophenyl)amino)methyl)acrylate (1l)



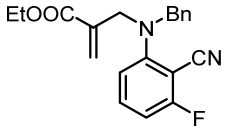
The synthetic method is according to the literature report.[4] Pale yellow oil **1l** (92% yield) was isolated by column chromatography (5/1 petroleum ether/ethyl acetate). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.40 – 7.36 (m, 1H), 7.36 – 7.30 (m, 2H), 7.30 – 7.24 (m, 3H), 7.06 – 7.01 (m, 2H), 6.34 (s, 1H), 5.71 (s, 1H), 4.57 (s, 2H), 4.23 (s, 2H), 4.16 (q, *J* = 7.2 Hz, 2H), 1.24 (t, *J* = 7.2 Hz, 3H).

Ethyl 2-((benzyl(2-cyano-5-(trifluoromethyl)phenyl)amino)methyl)acrylate (1m)



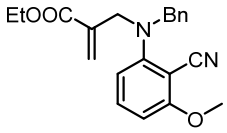
The synthetic method is according to the literature report.[4] Pale yellow oil **1m** (92% yield) was isolated by column chromatography (5/1 petroleum ether/ethyl acetate). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.65 (d, *J* = 8.4 Hz, 1H), 7.37 – 7.31 (m, 2H), 7.28 – 7.24 (m, 3H), 7.26 – 7.08 (m, 2H), 6.34 (s, 1H), 5.71 (s, 1H), 4.61 (s, 2H), 4.30 (s, 2H), 4.15 (q, *J* =7.2 Hz, 2H), 1.22 (t, *J* = 7.2 Hz, 3H).

Ethyl 2-((benzyl(2-cyano-3-fluorophenyl)amino)methyl)acrylate (1n)



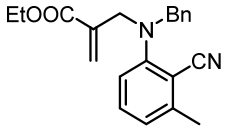
The synthetic method is according to the literature report.[4] Pale yellow oil **1n** (76% yield) was isolated by column chromatography (5/1 petroleum ether/ethyl acetate). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.36 – 7.30 (m, 2H), 7.31 – 7.20 (m, 4H), 6.68 – 6.59 (m, 2H), 6.35 (s, 1H), 5.73 (s, 1H), 4.61 (s, 2H), 4.29 (s, 2H), 4.16 (q, *J* = 7.2 Hz, 2H), 1.24 (t, *J* = 7.2 Hz, 3H).

Ethyl 2-((benzyl(2-cyano-3-methoxyphenyl)amino)methyl)acrylate (1na)



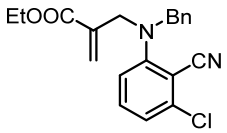
The synthetic method is according to the literature report.[4] Pale yellow oil **1na** (75% yield) was isolated by column chromatography (5/1 petroleum ether/ethyl acetate). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.34 – 7.27 (m, 3H), 7.27 – 7.24 (m, 3H), 6.53 – 6.44 (m, 2H), 6.30 (s, 1H), 5.77 (s, 1H), 4.53 (s, 2H), 4.17 (s, 2H), 4.13 (q, *J* = 7.2 Hz, 2H), 3.90 (s, 3H), 1.23 (t, *J* = 7.2 Hz, 3H).

Ethyl 2-((benzyl(2-cyano-3-methylphenyl)amino)methyl)acrylate (1nb)



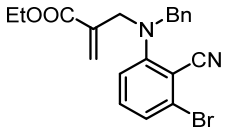
The synthetic method is according to the literature report.[4] Pale yellow oil **1nb** (67% yield) was isolated by column chromatography (5/1 petroleum ether/ethyl acetate). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.32 – 7.27 (m, 4H), 7.25 – 7.21 (m, 2H), 6.85 (d, *J* = 7.4 Hz, 1H), 6.79 (d, *J* = 8.4 Hz, 1H), 6.29 (s, 1H), 5.79 (s, 1H), 4.46 (s, 2H), 4.16 – 4.10 (m, 4H), 2.51 (s, 3H), 1.22 (t, *J* = 7.2 Hz, 3H).

Ethyl 2-((benzyl(3-chloro-2-cyanophenyl)amino)methyl)acrylate (1nc)



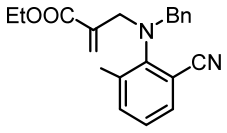
The synthetic method is according to the literature report.[4] Pale yellow oil **1nc** (75% yield) was isolated by column chromatography (5/1 petroleum ether/ethyl acetate). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.35 – 7.28 (m, 2H), 7.28 – 7.24 (m, 4H), 7.01 (d, *J* = 8.0 Hz, 1H), 6.83 (d, *J* = 8.6 Hz, 1H), 6.32 (s, 1H), 5.76 (s, 1H), 4.53 (s, 2H), 4.20 (s, 2H), 4.14 (q, *J* = 7.2 Hz, 2H), 1.23 (t, *J* = 7.2 Hz, 3H).

Ethyl 2-((benzyl(3-bromo-2-cyanophenyl)amino)methyl)acrylate (1nd)



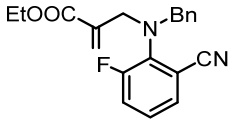
The synthetic method is according to the literature report.[4] Pale yellow oil **1nd** (75% yield) was isolated by column chromatography (5/1 petroleum ether/ethyl acetate). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.40 – 7.36 (m, 1H), 7.36 – 7.30 (m, 2H), 7.30 – 7.24 (m, 3H), 7.06 – 7.01 (m, 2H), 6.34 (s, 1H), 5.71 (s, 1H), 4.57 (s, 2H), 4.23 (s, 2H), 4.16 (q, *J* = 7.2 Hz, 2H), 1.24 (t, *J* = 7.2 Hz, 3H).

Ethyl 2-((benzyl(2-cyano-6-methylphenyl)amino)methyl)acrylate (1o)



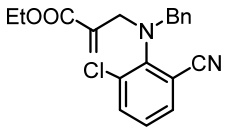
The synthetic method is according to the literature report.[4] Pale yellow oil **1o** (60% yield) was isolated by column chromatography (5/1 petroleum ether/ethyl acetate). **^{1}H NMR** (400 MHz, $cdcl_3$) δ 7.41 (d, *J* = 7.8 Hz, 1H), 7.36 – 7.31 (m, 1H), 7.31 – 7.22 (m, 5H), 7.06 (t, *J* = 7.6 Hz, 1H), 6.25 (s, 1H), 5.67 (s, 1H), 4.34 (s, 2H), 4.13 (q, *J* = 7.2 Hz, 2H), 4.02 (s, 2H), 2.17 (s, 3H), 1.18 (t, *J* = 7.2 Hz, 3H).

Ethyl 2-((benzyl(2-cyano-6-fluorophenyl)amino)methyl)acrylate (1p)



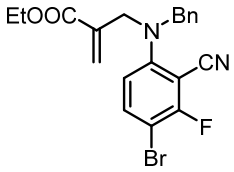
The synthetic method is according to the literature report.[4] Pale yellow oil **1p** (71% yield) was isolated by column chromatography (5/1 petroleum ether/ethyl acetate). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.46 – 7.28 (m, 5H), 7.29 – 7.24 (m, 1H), 7.23 – 7.27 (m, 1H), 7.21 – 7.04 (m, 1H), 6.26 (s, 1H), 5.68 (s, 1H), 4.40 (s, 2H), 4.15 (q, *J* = 7.2 Hz, 2H), 4.07 (s, 2H), 1.20 (t, *J* = 7.2 Hz, 3H).

Ethyl 2-((benzyl(2-chloro-6-cyanophenyl)amino)methyl)acrylate (1q)



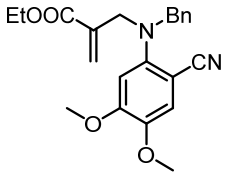
The synthetic method is according to the literature report.[4] Pale yellow oil **1q** (60% yield) was isolated by column chromatography (5/1 petroleum ether/ethyl acetate). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.55 (d, *J* = 8.0 Hz, 1H), 7.46 (d, *J* = 7.8 Hz, 1H), 7.37 – 7.33 (m, 2H), 7.33 – 7.21 (m, 3H), 7.08 (t, *J* = 7.8 Hz, 1H), 6.27 (s, 1H), 5.63 (s, 1H), 4.44 (s, 2H), 4.14 (q, *J* = 7.2 Hz, 2H), 4.09 (s, 2H), 1.16 (t, *J* = 7.2 Hz, 3H).

Ethyl 2-((benzyl(4-bromo-2-cyano-3-fluorophenyl)amino)methyl)acrylate (1r)



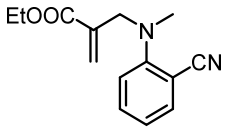
The synthetic method is according to the literature report.[4] Pale yellow oil **1r** (52% yield) was isolated by column chromatography (5/1 petroleum ether/ethyl acetate). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.47 – 7.41 (m, 1H), 7.37 – 7.27 (m, 3H), 7.25 – 7.28 (m, 2H), 6.55 (d, *J* = 9.2 Hz, 1H), 6.36 (s, 1H), 5.71 (s, 1H), 4.61 (s, 2H), 4.30 (s, 2H), 4.17 (q, *J* = 7.2 Hz, 2H), 1.26 (t, *J* = 7.2 Hz, 3H).

Ethyl 2-((benzyl(2-cyano-4,5-dimethoxyphenyl)amino)methyl)acrylate (1s)



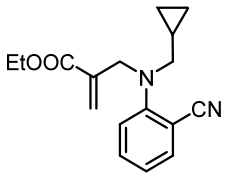
The synthetic method is according to the literature report.[4] Pale yellow oil **1s** (83% yield) was isolated by column chromatography (5/1 petroleum ether/ethyl acetate). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.31 – 7.29 (m, 3H), 7.27 – 7.21 (m, 2H), 6.95 (s, 1H), 6.47 (s, 1H), 6.29 (s, 1H), 5.86 (s, 1H), 4.40 (s, 2H), 4.15 (q, *J* = 7.2 Hz, 2H), 4.07 (s, 2H), 3.83 (s, 3H), 3.77 (s, 3H), 1.24 (t, *J* = 7.2 Hz, 3H).

Ethyl 2-(((2-cyanophenyl)(methyl)amino)methyl)acrylate (1t)



The synthetic method is according to the literature report.[4] Pale yellow oil **1t** (75% yield) was isolated by column chromatography (5/1 petroleum ether/ethyl acetate). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.51 (d, *J* = 7.8 Hz, 1H), 7.38 (t, *J* = 8.0 Hz, 1H), 6.92 – 6.81 (m, 2H), 6.37 (s, 1H), 5.76 (s, 1H), 4.24 (s, 2H), 4.20 (q, *J* = 7.2 Hz, 2H), 3.05 (s, 3H), 1.27 (t, *J* = 7.2 Hz, 3H).

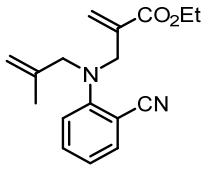
Ethyl 2-(((2-cyanophenyl)(cyclopropylmethyl)amino)methyl)acrylate (1u)



The synthetic method is according to the literature report.[4] Pale yellow oil **1u** (81% yield) was isolated by column chromatography (5/1 petroleum ether/ethyl acetate). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.52 (d, *J* = 7.6 Hz, 1H), 7.39 (t, *J* = 8.8 Hz, 1H), 6.98 (d, *J* = 8.4 Hz, 1H), 6.89 (t, *J* = 7.6 Hz, 1H), 6.29 (s, 1H), 5.76 (s, 1H), 4.30 (s, 2H), 4.20

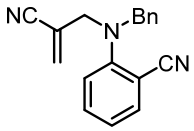
(q, *J* = 7.2 Hz, 2H), 3.26 (d, *J* = 6.6 Hz, 2H), 1.28 (t, *J* = 7.2 Hz, 3H), 1.10 – 0.97 (m, 1H), 0.55 – 0.45 (m, 2H), 0.15 – 0.07 (m, 2H).

Ethyl 2-(((2-cyanophenyl)(2-methylallyl)amino)methyl)acrylate (1v)



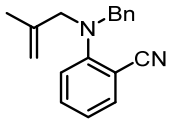
The synthetic method is according to the literature report.[4] Pale yellow oil **1v** (79% yield) was isolated by column chromatography (5/1 petroleum ether/ethyl acetate). **^{1}H NMR** (600 MHz, $CDCl_3$) δ 7.51 – 7.49 (m, 1H), 7.38 – 7.34 (m, 1H), 6.86 – 6.83 (m, 2H), 6.32 (s, 2H), 5.90 (t, *J* = 4.9 Hz, 1H), 5.70 (s, 1H), 4.19 (q, *J* = 7.1 Hz, 4H), 1.75 (s, 3H), 1.27 (t, *J* = 7.1 Hz, 3H).

2-(benzyl(2-cyanoallyl)amino)benzonitrile (1w)



The synthetic method is according to the literature report.[4] White solid **1w** (51% yield) was isolated by column chromatography (5/1 petroleum ether/ethyl acetate). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.61 (d, *J* = 7.6 Hz, 1H), 7.46 (t, *J* = 7.2 Hz, 1H), 7.37 – 7.25 (m, 5H), 7.20 – 7.02 (m, 2H), 6.02 (s, 1H), 5.92 (s, 1H), 4.53 (s, 2H), 4.09 (s, 2H).

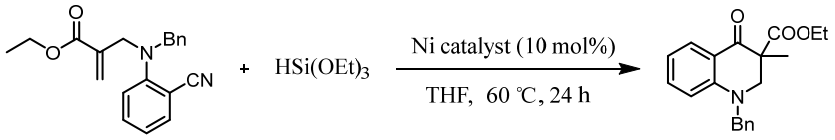
2-(benzyl(2-methylallyl)amino)benzonitrile (1x)



The synthetic method is according to the literature report.[4] Pale yellow oil **1x** (70% yield) was isolated by column chromatography (5/1 petroleum ether/ethyl acetate). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.57 – 7.51 (m, 1H), 7.39 – 7.29 (m, 2H), 7.29 – 7.24 (m, 3H), 6.93 – 6.85 (m, 2H), 4.93 (s, 1H), 4.89 (s, 1H), 4.54 (s, 2H), 3.86 (s, 2H), 1.74 (s, 3H).

5.Optimization to Reaction Conditions

Table S1. Effect of Ni catalyst [a]

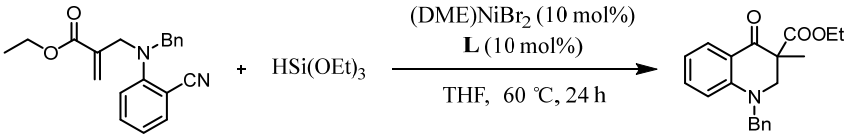


1a **2** **3a**

Entry	Solvent	yield of **3a**(%)[b]
1	$Ni(COD)_2$	37
2	$Ni(PPH_3)_4$	32
3	$C_{10}H_{12}O_2NiC_8H_{12}$-1,5-cyclo	38
4	$(DME)NiBr_2$	22
5	$Ni(acac)_2$	19
6	$NiCl_2$	9
7	$NiBr_2$	13
8	$Ni(OTf)_2$	10
9	$(DME)NiCl_2$	11
10	$Ni(BF_4)_2 \cdot 6H_2O$	19
11	$NiCl_2 \cdot 6H_2O$	9
12	$NiNO_2 \cdot 6H_2O$	20

[a] Reactions performed with 0.2 mmol of **1a**, 0.4 mmol of **2** (2.0 eq.), Ni catalyst (10 mol%), THF (0.2 M, 1 mL). [b] Yield was determined by ^{1}H NMR with nitromethane as internal standard.

Table S2. Effects of bipyridine ligands [a]

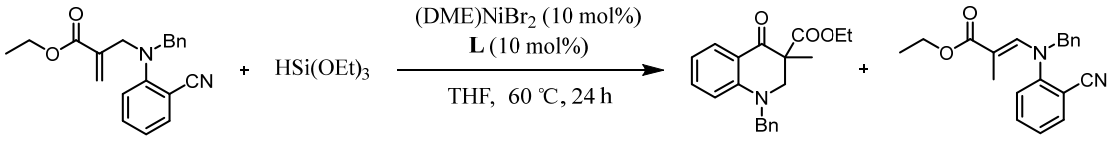


1a **2** **3a**

Entry	**L**	yield of **3a**(%)[b]
1	**L1**	31
2	**L2**	10
3	**L3**	8
4	**L4**	11
5	**L5**	12
6	**L6**	14

[a] Reactions performed with 0.2 mmol of **1a**, 0.4 mmol of **2** (2.0 eq.), $(DME)NiBr_2$ (10 mol%), **L** (10 mol%), THF (0.2 M, 1 mL). [b] Yield was determined by ^{1}H NMR with nitromethane as internal standard.

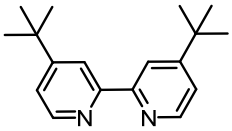
Table S3. Effects of ferrocene-based ligands [a]



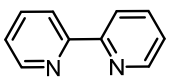
1a **2** **3a** **3a'**

Entry	**L**	yield of **3a**(%)[b]
1	**L7**	31
2	**L8**	15
3	**L9**	trace
4	**L10**	17
5	**L11**	trace
6	**L12**	trace
7	**L13**	31
8	**L14**	trace
9	**L15**	9
10	**L16**	trace
11	**L17**	trace
12	**L18**	trace

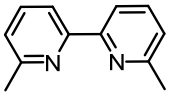
[a] Reactions performed with 0.2 mmol of **1a**, 0.4 mmol of **2** (2.0 eq.), (DME)$NiBr_2$ (10 mol%), **L** (10 mol%), THF (0.2 M, 1 mL). [b] Yield was determined by ^1H NMR with nitromethane as internal standard.



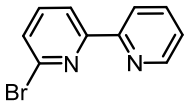
L1



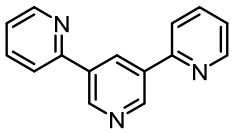
L2



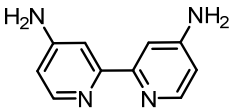
L3



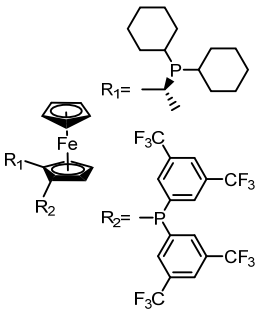
L4



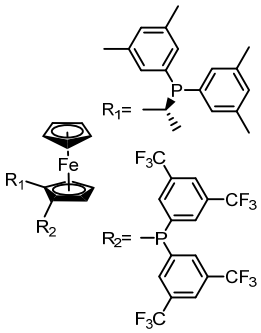
L5



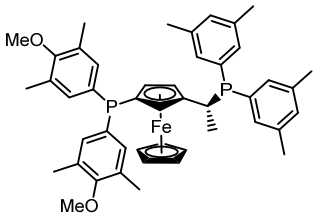
L6



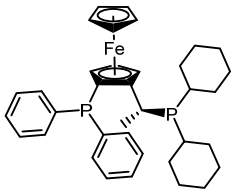
L7[a]
31% yield



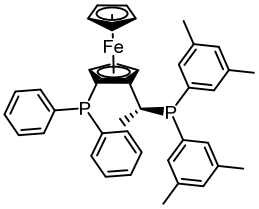
L8[a]
15% yield



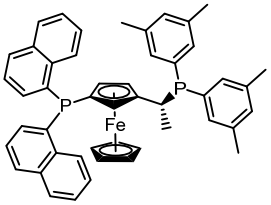
L9[a]
trace



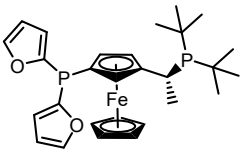
L10[a]
17% yield



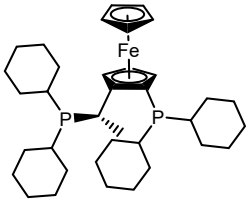
L11[a]
trace



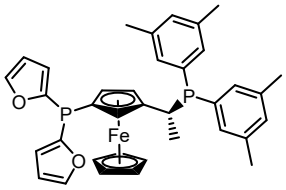
L12[a]
trace



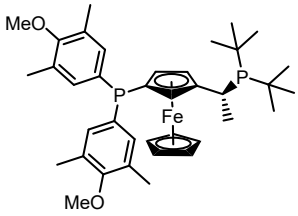
L13[a]
31% yield



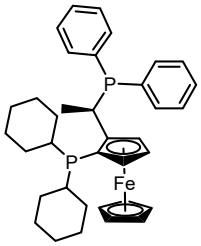
L14[a]
trace



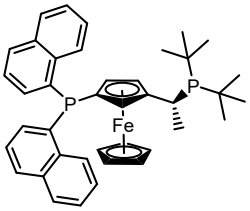
L15[a]
9% yield



L16[a]
trace

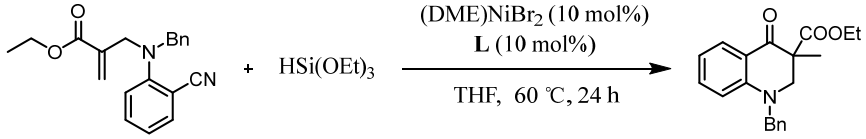


L17[a]
trace



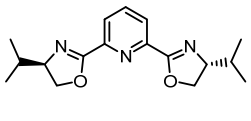
L18[a]
trace

Table S4. Effects of N and P ligands [a]

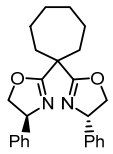


1a **2** **3a**

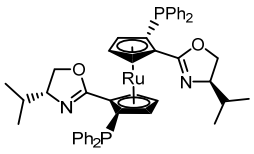
Entry	L	yield of **3a**(%)[b]
1	**L19**	11
2	**L20**	12
3	**L21**	17
4	**L22**	6
5	**L23**	22
6	**L24**	5
7	**L25**	trace
8	**L26**	25
9	**L27**	trace
10	**L28**	trace
11	**L29**	trace
12	**L30**	trace



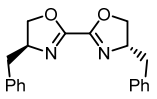
L19[a]
11% yield



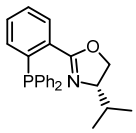
L20[a]
12% yield
-



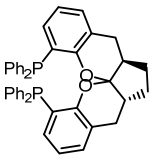
L21[a]
17% yield
-



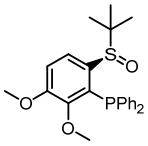
L22[a]
6% yield
13% *ee*



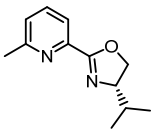
L23[a]
22% yield
14% *ee*



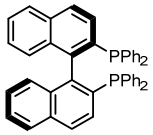
L24[a]
5% yield
-



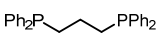
L25[a]
trace



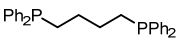
L26[a]
25% yield
-



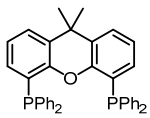
L27[a]
trace



L28[a]
trace



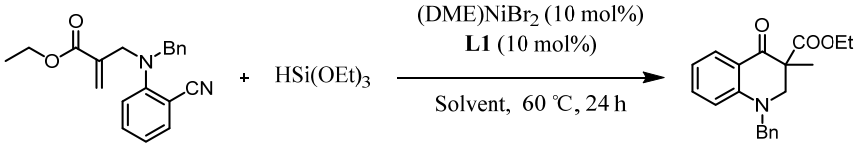
L29[a]
trace



L30[a]
trace

[a] Reactions performed with 0.2 mmol of **1a**, 0.4 mmol of **2** (2.0 eq.), (DME)$NiBr_2$ (10 mol%), **L** (10 mol%), THF (0.2 M, 1 mL). [b] Yield was determined by ^1H NMR with nitromethane as internal standard.

Table S5. Effect of solvents [a]

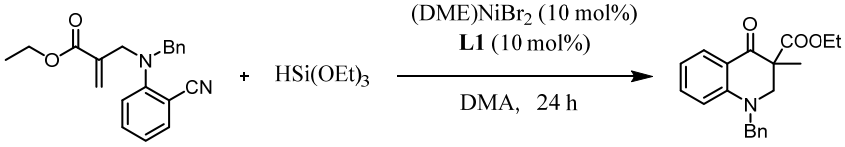


1a **2** **3a**

Entry	Solvent	yield of **3a**(%)[b]
1	toluene	N.R.
2	DMA	36
3	DMF	12
4	MTBE	N.R.
5	CF_3CH_2OH	N.D.
6	DMI	N.R.
7	NMP	N.R.
8	DMPU	N.R.
9	1,4-dioxine	N.R.
10	DME	N.R.
11	THF	31

[a] Reactions performed with 0.2 mmol of **1a**, 0.4 mmol of **2** (2.0 eq.), (DME)$NiBr_2$ (10 mol%), **L1** (10 mol%), solvent (0.2 M, 1 mL). [b] Yield was determined by ^1H NMR with nitromethane as internal standard.

Table S6. Effect of temperature [a]

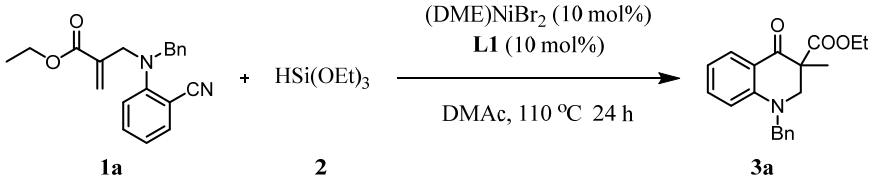


1a **2** **3a**

Entry	Temp (°C)	yield of **3a**(%)[b]
1	60	31
2	70	33
3	80	32
4	90	32
5	100	40
6	110	44
7	120	43

[a] Reactions performed with 0.2 mmol of **1a**, 0.4 mmol of **2** (2.0 eq.), (DME)$NiBr_2$ (10 mol%), **L1** (10 mol%), DMAc (0.2 M, 1 mL). [b] Yield was determined by ^1H NMR with nitromethane as internal standard.

Table S7. Effect of H-Si equivalent [a]

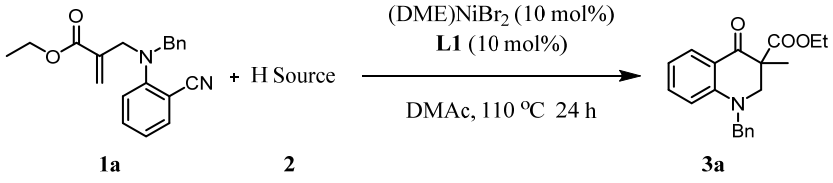


1a **2** **3a**

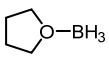
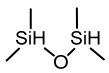
Entry	**2** (equiv)	yield of **3a**(%)[b]
1	2.0	46
2	3.0	70
3	4.0	78
4	5.0	68

[a] Reactions performed with 0.2 mmol of **1a**, **2** (x eq.), (DME)$NiBr_2$ (10 mol%), **L1** (10 mol%), DMAc (0.2 M, 1 mL). [b] Yield was determined by ^1H NMR with nitromethane as internal standard.

Table S8. Effects of source H[a]



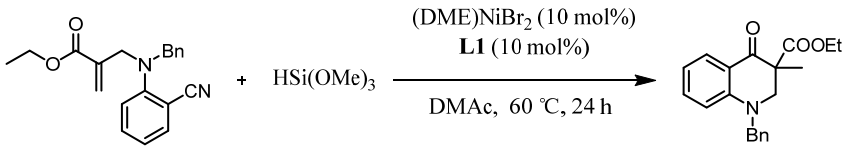
1a **2** **3a**

Entry	H Source	yield of **3a** (%)[b]
1	$HSi(OEt)_3$	78
2	$HSiCH_3(OEt)_2$	90
3	$HSi(OMe)_3$	95
4	$HSi(CH_3)_2Cl$	N.R.
5	$ZrH(Cp)_2$	N.R.
6		N.R.
7		N.R.
8		N.R.
9		N.R.

[a] Reactions performed with 0.2 mmol of **1a**, 0.8 mmol of **2** (4.0 eq.), (DME)$NiBr_2$ (10 mol%), **L1**

(10 mol%), DMAc (0.2 M, 1 mL). [b] Yield was determined by ^{1}H NMR with nitromethane as internal standard.

Table S8. Effects of other conditions[a]

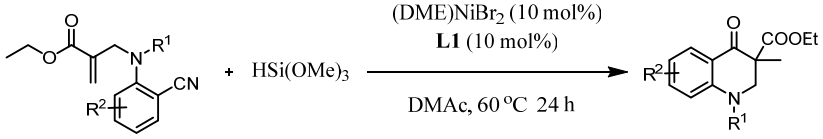


1a **2** **3a**

Entry	Temp (°C)	**2** (equiv)	yield of **3a**(%)[b]
1	110	4.0	95
2	110	3.0	95
3	110	2.0	68
4	100	3.0	95
5	90	3.0	95
6	80	3.0	95
7	70	3.0	95
8	60	2.0	59
9	60	3.0	95
10	60	4.0	56
11	50	3.0	63

[a] Reactions performed with 0.2 mmol of **1a**, of **2** (x eq.), (DME)NiBr$_2$ (10 mol%), **L1** (10 mol%), DMAc (0.2 M, 1 mL). [b] Yield was determined by ^{1}H NMR with nitromethane as internal standard.

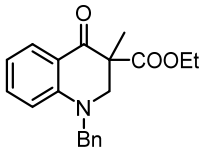
6. General Procedure for Synthesis of 2,3-dihydro-4(1*H*)-quinolinones



1 **2** **3**

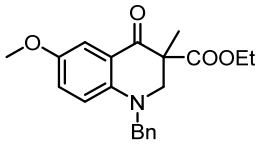
In the glove box, to a flame-dried tube was added (DME)NiBr$_2$ (6.17 mg, 10 mol%), **L1** (5.37 mg, 10 mol%) and DMAc (1 mL). After stirred for 15 min, to the solution was added alkenyl-nitrile **1** (64.08 mg, 0.2 mmol) and HSi(OMe)$_3$ **2** (80.55 mg, 0.6 mmol). The tube was removed from the glove box and heated to 60 °C in an oil bath for 12 hours. The reaction was monitored by TLC. After the reaction is completed, add 10 mL of water and extract with ethyl acetate. Combine the organic phase, dry with anhydrous Na_2SO_4, filter with 100-200 mesh silica gel, and finally concentrate under vacuum. Purify the mixture (petroleum ether: ethyl acetate = 5:1) using silica gel column chromatography to obtain the target product **3**.

Ethyl 1-benzyl-3-methyl-4-oxo-1,2,3,4-tetrahydroquinoline-3-carboxylate (3a)



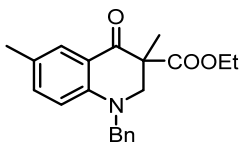
A yellowish green liquid **3a** (54.3 mg, 85% yield) was isolated by column chromatography (5/1 petroleum ether/ethyl acetate). **^{1}H NMR** (600 MHz, $CDCl_3$) δ 7.99 – 7.95 (m, 1H), 7.36 – 7.27 (m, 4H), 7.25 (d, *J* = 7.4 Hz, 2H), 6.76 (t, *J* = 7.6 Hz, 1H), 6.69 (d, *J* = 8.4 Hz, 1H), 4.63 (d, *J* = 16.6 Hz, 1H), 4.55 (d, *J* = 16.6 Hz, 1H), 4.19 – 4.08 (m, 2H), 3.93 (d, *J* = 12.6 Hz, 1H), 3.46 (d, J = 12.6 Hz, 1H), 1.43 (s, 3H), 1.14 (t, J = 7.2 Hz,3H). **^{13}C NMR** (151 MHz, CDCl3) δ 191.73, 171.97, 150.83, 137.09, 135.43, 128.97, 128.82, 127.47, 126.80, 118.70, 117.48, 113.38, 61.59, 58.52, 55.42, 53.23, 17.61, 13.96. **HRMS** (ESI) m/z: Calcd for $C_{20}H_{21}NaNO_3^+$ $[M + Na]^+$: 364.1414; found: 364.1415.

Ethyl 1-benzyl-6-methoxy-3-methyl-4-oxo-1,2,3,4-tetrahydroquinoline-3-carboxylate (3b)



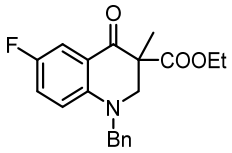
A yellowish green liquid **3b** (55.8 mg, 79% yield) was isolated by column chromatography (5/1 petroleum ether/ethyl acetate). **^{1}H NMR** (600 MHz, $CDCl_3$) δ 7.46 (d, *J* = 3.2 Hz, 1H), 7.33 (t, *J* = 7.6 Hz, 2H), 7.28 – 7.23 (m, 3H), 7.00 – 6.95 (m, 1H), 6.65 (d, *J* = 9.2 Hz, 1H), 4.57 (d, *J* = 16.6 Hz, 1H), 4.51 (d, *J* = 16.6 Hz, 1H), 4.21 – 4.10 (m, 2H), 3.88 (d, *J* = 12.6 Hz, 1H), 3.79 (s, 3H), 3.41 (d, *J* = 12.6 Hz, 1H), 1.44 (s, 3H), 1.15 (t, *J* = 7.2 Hz, 3H). **^{13}C NMR** (151 MHz, $CDCl_3$) δ 191.71, 172.12, 151.72, 146.28, 137.38, 128.79, 127.42, 126.82, 125.13, 118.73, 115.17, 109.46, 61.57, 59.08, 55.71, 53.53, 17.62, 14.00. **HRMS** (ESI) m/z: Calcd for $C_{21}H_{23}NaNO_4^+$ $[M + Na]^+$: 376.1519; found: 376.1529.

Ethyl 1-benzyl-6-fluoro-3-methyl-4-oxo-1,2,3,4-tetrahydroquinoline-3-carboxylate (3c)



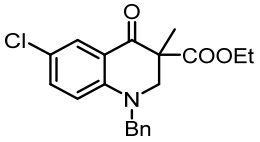
A yellowish green liquid **3c** (40.5 mg, 60% yield) was isolated by column chromatography (5/1 petroleum ether/ethyl acetate). **^{1}H NMR** (600 MHz, $CDCl_3$) δ 7.78 (d, *J* = 1.2 Hz, 1H), 7.33 (t, *J* = 7.4 Hz, 2H), 7.29 – 7.23 (m, 3H), 7.24 (dd, *J* = 8.6, 2.0 Hz, 1H), 6.61 (d, *J* = 8.6 Hz, 1H), 4.60 (d, *J* = 16.6 Hz, 1H), 4.52 (d, *J* = 16.6 Hz, 1H), 4.20 – 4.09 (m, 2H), 3.89 (d, *J* = 12.6 Hz, 1H), 3.42 (d, *J* = 12.6 Hz, 1H), 2.24 (s, 3H), 1.43 (s, 3H), 1.15 (t, *J* = 7.2 Hz, 3H). **^{13}C NMR** (151 MHz, $CDCl_3$) δ 191.91, 172.10, 149.04, 137.32, 136.64, 128.77, 128.54, 127.39, 126.77, 118.52, 113.48, 61.55, 58.71, 55.45, 53.40, 20.12, 17.64, 13.99. **HRMS** (ESI) m/z: Calcd for $C_{21}H_{23}NaNO_3^+$ $[M + Na]^+$: 360.1570; found: 360.1562.

Ethyl
1-benzyl-6-fluoro-3-methyl-4-oxo-1,2,3,4-tetrahydroquinoline-3-carboxylate (3d)



A yellowish green liquid **3d** (44.4 mg, 65% yield) was isolated by column chromatography (5/1 petroleum ether/ethyl acetate). **^{1}H NMR** (600 MHz, $CDCl_3$) δ 7.67 – 7.62 (m, 1H), 7.34 (t, *J* = 7.6 Hz, 2H), 7.29 (t, *J* = 7.2 Hz, 1H), 7.23 (d, *J* = 7.6 Hz, 2H), 7.08 – 7.03 (m, 1H), 6.65 – 6.61 (m, 1H), 4.59 (d, *J* = 16.6 Hz, 1H), 4.52 (d, *J* = 16.6 Hz, 1H), 4.20 – 4.09 (m, 2H), 3.90 (d, *J* = 12.6 Hz, 1H), 3.46 (d, *J* = 12.6 Hz, 1H), 1.43 (s, 3H), 1.14 (t, *J* = 7.2 Hz, 3H). **^{13}C NMR** (151 MHz, $CDCl_3$) δ 191.08, 171.81, 156.21, 147.65, 136.90, 128.88, 127.56, 126.71, 123.19, 123.03, 114.97, 113.79, 113.64, 61.70, 58.99, 55.83, 53.40, 17.45, 13.95. **^{19}F NMR** (565 MHz, $CDCl_3$) δ -127.24. **HRMS** (ESI) m/z: Calcd for $C_{20}H_{21}FNO_3^+$ $[M + H]^+$: 342.1500; found: 342.1495.

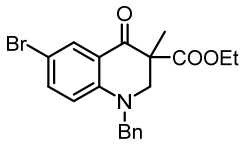
ethyl
1-benzyl-6-chloro-3-methyl-4-oxo-1,2,3,4-tetrahydroquinoline-3-carboxylate（3e）



A yellowish green liquid **3e**（48.2 mg, 71%）was isolated by column chromatography (5/1 petroleum ether/ethyl acetate). ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.84 (d, *J* = 2.4 Hz, 1H), 7.26 (t, *J* = 7.5 Hz, 2H), 7.21 (t, *J* = 7.2 Hz, 1H), 7.18 – 7.12 (m, 3H), 6.56 (d, *J*

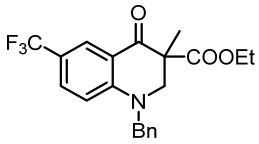
= 9.0 Hz, 1H), 4.54 (d, *J* = 16.6 Hz, 1H), 4.46 (d, *J* = 16.6 Hz, 1H), 4.12 – 4.01 (m, 2H), 3.83 (d, *J* = 12.8 Hz, 1H), 3.39 (d, *J* = 12.8 Hz, 1H), 1.35 (s, 3H), 1.07 (t, *J* = 7.1 Hz, 3H). ^{13}C NMR (151 MHz, $CDCl_3$) δ 190.63, 171.66, 149.25, 136.57, 135.18, 128.92, 128.07, 127.64, 126.70, 123.00, 119.49, 115.06, 61.76, 58.56, 55.55, 53.16, 17.49, 13.96. HRMS (ESI) m/z: Calcd for C20H20ClNaNO3 $[M + H]^+$: 358.1204; found: 358.1210.

Ethyl 1-benzyl-6-bromo-3-methyl-4-oxo-1,2,3,4-tetrahydroquinoline-3-carboxylate (3f)



A yellowish green liquid **3f** (51.5 mg, 64% yield) was isolated by column chromatography (5/1 petroleum ether/ethyl acetate). **^{1}H NMR** (600 MHz, CDCl3) δ 8.05 (d, J = 2.5 Hz, 1H), 7.37 – 7.31 (m, 3H), 7.28 (t, J = 7.2 Hz, 1H), 7.21 (d, J = 7.2 Hz, 2H), 6.58 (d, J = 9.0 Hz, 1H), 4.62 (d, J = 16.6 Hz, 1H), 4.53 (d, J = 16.6 Hz, 1H), 4.19 – 4.09 (m, 2H), 3.91 (d, J = 12.8 Hz, 1H), 3.46 (d, J = 12.8 Hz, 1H), 1.42 (s, 3H), 1.14 (t, J = 7.2 Hz, 3H). **^{13}C NMR** (151 MHz, CDCl3) δ 190.48, 171.63, 149.58, 137.86, 136.49, 131.14, 128.92, 127.65, 126.69, 119.97, 115.40, 109.98, 61.77, 58.49, 55.50, 53.09, 17.50, 13.97. **HRMS** (ESI) m/z: Calcd for $C_{20}H_{20}BrNaNO_3^+$ $[M + Na]^+$: 424.0519; found: 424.0522.

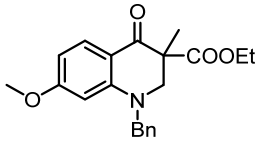
Ethyl 1-benzyl-3-methyl-4-oxo-6-(trifluoromethyl)-1,2,3,4-tetrahydroquinoline-3-carboxylate (3g)



A yellowish green liquid **3g** (18.8 mg, 24% yield) was isolated by column chromatography (5/1 petroleum ether/ethyl acetate). **^{1}H NMR** (600 MHz, $CDCl_3$) δ 8.23 (s, 1H), 7.50 (d, *J* = 7.4 Hz, 1H), 7.35 (t, *J* = 7.6 Hz, 2H), 7.30 (t, *J* = 7.2 Hz, 1H), 7.22 (d, *J* = 7.6 Hz, 2H), 6.77 (d, *J* = 8.8 Hz, 1H), 4.71 (d, *J* = 16.6 Hz, 1H), 4.60 (d, *J* = 16.6 Hz, 1H), 4.18 – 4.10 (m, 2H), 3.97 (d, *J* = 13.0 Hz, 1H), 3.53 (d, *J* = 13.0 Hz, 1H), 1.44 (s, 3H), 1.14 (t, *J* = 7.2 Hz, 3H). **^{13}C NMR** (151 MHz, $CDCl_3$) δ 190.58, 171.42, 152.29, 136.04, 131.60, 129.02, 127.81, 126.66, 117.82, 113.67, 61.87, 58.18,

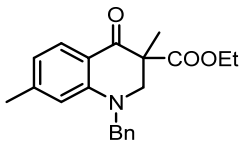
55.47, 52.92, 17.48, 13.93. **^{19}F NMR** (565 MHz, $CDCl_3$) δ -61.81 . **HRMS** (ESI) m/z: Calcd for $C_{21}H_{20}F_3NaNO_3^+$ $[M + Na]^+$: 414.1287; found: 414.1279.

Ethyl 1-benzyl-7-methoxy-3-methyl-4-oxo-1,2,3,4-tetrahydroquinoline-3-carboxylate (3h)



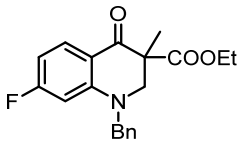
A yellowish green liquid **3h** (36.8 mg, 52% yield) was isolated by column chromatography (5/1 petroleum ether/ethyl acetate). **^{1}H NMR** (600 MHz, $CDCl_3$) δ 7.94 (d, *J* = 8.8 Hz, 1H), 7.34 (t, *J* = 7.4 Hz, 2H), 7.30 – 7.24 (m, 3H), 6.37 – 6.33 (m, 1H), 6.10 (d, *J* = 2.2 Hz, 1H), 4.61 (d, *J* = 16.6 Hz, 1H), 4.52 (d, *J* = 16.6 Hz, 1H), 4.19 – 4.09 (m, 2H), 3.93 (d, *J* = 12.6 Hz, 1H), 3.70 (s, 3H), 3.45 (d, *J* = 12.6 Hz, 1H), 1.42 (s, 3H), 1.16 (t, *J* = 7.2 Hz, 3H). **^{13}C NMR** (151 MHz, $CDCl_3$) δ 190.27, 172.11, 15.58, 152.64, 137.08, 131.26, 128.84, 127.49, 126.86, 113.12, 105.27, 97.24, 61.53, 58.76, 55.64, 55.25, 53.07, 17.76, 14.01. **HRMS** (ESI) m/z: Calcd for $C_{21}H_{23}NaNO_4^+$ $[M + Na]^+$: 367.2519; found: 367.2529.

Ethyl 1-benzyl-3,7-dimethyl-4-oxo-1,2,3,4-tetrahydroquinoline-3-carboxylate (3i)



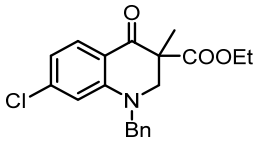
A yellowish green liquid **3i** (49.3 mg, 73% yield) was isolated by column chromatography (5/1 petroleum ether/ethyl acetate). **^{1}H NMR** (600 MHz, $CDCl_3$) δ 7.87 (d, *J* = 8.2 Hz, 1H), 7.34 (t, *J* = 7.6 Hz, 2H), 7.28 (t, *J* = 7.2 Hz, 1H), 7.25 (d, *J* = 7.8 Hz, 2H), 6.59 (d, *J* = 8.2 Hz, 1H), 6.51 (s, 1H), 4.63 (d, *J* = 16.6 Hz, 1H), 4.54 (d, *J* = 16.6 Hz, 1H), 4.18 – 4.08 (m, 2H), 3.89 (d, *J* = 12.6 Hz, 1H), 3.41 (d, *J* = 12.6 Hz, 1H), 2.25 (s, 3H), 1.41 (s, 3H), 1.14 (t, *J* = 7.2 Hz, 3H). **^{13}C NMR** (151 MHz, $CDCl_3$) δ 191.31, 172.05, 150.97, 146.55, 137.28, 129.04, 128.80, 127.43, 126.88, 119.09, 116.58, 113.31, 61.53, 58.32, 55.19, 53.14, 22.40, 17.67, 13.99. **HRMS** (ESI) m/z: Calcd for $C_{21}H_{24}NO_3^+$ $[M + H]^+$: 338.1751; found: 338.1731.

Ethyl 1-benzyl-7-fluoro-3-methyl-4-oxo-1,2,3,4-tetrahydroquinoline-3-carboxylate (3j)



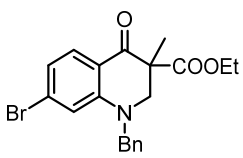
A yellowish green liquid **3j** (36.9 mg, 54% yield) was isolated by column chromatography (5/1 petroleum ether/ethyl acetate). **^{1}H NMR** (600 MHz, $CDCl_3$) δ 7.98 (t, *J* = 7.8 Hz, 1H), 7.35 (t, *J* = 7.6 Hz, 2H), 7.30 (t, *J* = 7.2 Hz, 1H), 7.23 (d, *J* = 7.6 Hz, 2H), 6.46 (t, *J* = 8.4 Hz, 1H), 6.35 (d, *J* = 11.8 Hz, 1H), 4.59 (d, *J* = 16.6 Hz, 1H), 4.51 (d, *J* = 16.6 Hz, 1H), 4.20 – 4.08 (m, 2H), 3.93 (d, *J* = 12.8 Hz, 1H), 3.48 (d, *J* = 12.8 Hz, 1H), 1.42 (s, 3H), 1.14 (t, *J* = 7.2 Hz, 3H). **^{13}C NMR** (151 MHz, $CDCl_3$) δ 190.32, 171.74, 168.65, 166.97, 152.71, 136.30, 131.91, 128.33, 127.70, 126.79, 115.55, 105.69, 99.73, 61.70, 58.44, 55.56, 52.99, 17.57, 13.96. **^{19}F NMR** (565 MHz, $CDCl_3$) δ -101.58 . **HRMS** (ESI) m/z: Calcd for $C_{20}H_{21}FNO_3^+$ $[M + H]^+$: 342.1500; found: 342.1495.

Ethyl
1-benzyl-7-chloro-3-methyl-4-oxo-1,2,3,4-tetrahydroquinoline-3-carboxylate (3k)



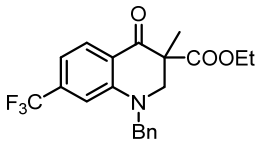
A yellowish green liquid **3k** (46.5 mg, 65% yield) was isolated by column chromatography (5/1 petroleum ether/ethyl acetate). **^{1}H NMR** (600 MHz, $CDCl_3$) δ 7.89 (d, *J* = 8.4 Hz, 1H), 7.35 (t, *J* = 7.4 Hz, 2H), 7.30 (t, *J* = 7.4 Hz, 1H), 7.23 (d, *J* = 7.6 Hz, 2H), 6.72 (d, *J* = 8.8 Hz, 2H), 4.61 (d, *J* = 16.6 Hz, 1H), 4.52 (d, *J* = 16.6 Hz, 1H), 4.18 – 4.07 (m, 2H), 3.90 (d, *J* = 12.8 Hz, 1H), 3.45 (d, *J* = 12.8 Hz, 1H), 1.41 (s, 3H), 1.14 (t, *J* = 7.2 Hz, 3H). **^{13}C NMR** (151 MHz, $CDCl_3$) δ 190.71, 171.64, 151.33, 141.90, 136.27, 130.45, 128.96, 127.73, 126.84, 118.08, 117.20, 112.98, 61.74, 58.18, 55.32, 53.00, 17.52, 13.96. **HRMS** (ESI) m/z: Calcd for $C_{20}H_{20}ClNaNO_3^+$ $[M + Na]^+$: 380.1024; found: 380.1027.

Ethyl
1-benzyl-7-bromo-3-methyl-4-oxo-1,2,3,4-tetrahydroquinoline-3-carboxylate (3l)



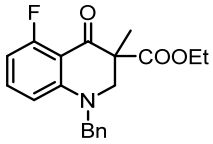
A yellowish green liquid **3l** (34.6 mg, 43% yield) was isolated by column chromatography (5/1 petroleum ether/ethyl acetate). **^{1}H NMR** (600 MHz, $CDCl_3$) δ 7.81 (d, *J* = 8.4 Hz, 1H), 7.36 (t, *J* = 7.4 Hz, 2H), 7.30 (t, *J* = 7.4 Hz, 1H), 7.23 (d, *J* = 7.2 Hz, 2H), 6.91 – 6.87 (m, 2H), 4.61 (d, *J* = 16.6 Hz, 1H), 4.52 (d, *J* = 16.6 Hz, 1H), 4.18 – 4.09 (m, 2H), 3.89 (d, *J* = 12.8 Hz, 1H), 3.44 (d, *J* = 12.8 Hz, 1H), 1.41 (s, 3H), 1.14 (t, *J* = 7.2 Hz, 3H). **^{13}C NMR** (151 MHz, $CDCl_3$) δ 190.90, 171.61, 151.30, 136.22, 130.87, 130.42, 128.97, 127.75, 126.86, 120.93, 117.51, 115.99, 61.76, 58.08, 55.26, 52.99, 17.51, 13.96. **HRMS** (ESI) m/z: Calcd for $C_{20}H_{20}BrNaNO_3^+$ $[M + Na]^+$: 424.0519; found: 424.0522.

Ethyl 1-benzyl-3-methyl-4-oxo-7-(trifluoromethyl)-1,2,3,4-tetrahydroquinoline-3-carboxylate (3m)



A yellowish green liquid **3m** (41.5 mg, 53% yield) was isolated by column chromatography (5/1 petroleum ether/ethyl acetate). **^{1}H NMR** (600 MHz, $CDCl_3$) δ 7.98 (d, *J* = 8.0 Hz, 1H), 7.28 (t, *J* = 7.4 Hz, 2H), 7.23 (t, *J* = 7.4 Hz, 1H), 7.26 (d, *J* = 7.6 Hz, 2H), 6.89 (d, *J* = 8.6 Hz, 2H), 4.59 (d, *J* = 16.4 Hz, 1H), 4.50 (d, *J* = 16.4 Hz, 1H), 4.11 – 4.00 (m, 2H), 3.86 (d, *J* = 12.8 Hz, 1H), 3.40 (d, *J* = 12.8 Hz, 1H), 1.35 (s, 3H), 1.05 (t, *J* = 7.2 Hz, 3H). **^{13}C NMR** (151 MHz, $CDCl_3$) δ 189.95, 170.42, 149.41, 135.45, 135.24, 135.06, 128.81, 127.95, 126.81, 125.89, 123.45, 121.63, 119.58, 112.55, 109.24, 60.78, 57.06, 54.32, 52.01, 16.34, 12.86. **^{19}F NMR** (565 MHz, $CDCl_3$) δ -63.79. **HRMS** (ESI) m/z: Calcd for $C_{21}H_{20}F_3NaNO_3^+$ $[M + Na]^+$: 414.1287; found: 414.1279.

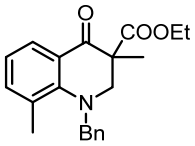
Ethyl 1-benzyl-5-fluoro-3-methyl-4-oxo-1,2,3,4-tetrahydroquinoline-3-carboxylate (3n)



A yellowish green liquid **3n** (34.1 mg, 51% yield) was isolated by column chromatography (5/1 petroleum ether/ethyl acetate). **^{1}H NMR** (600 MHz, $CDCl_3$) δ

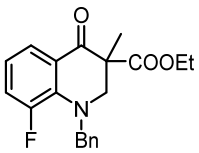
7.34 (t, *J* = 7.6 Hz, 2H), 7.28 (t, *J* = 7.2 Hz, 1H), 7.24 – 7.28 (m, 3H), 6.44 (d, *J* = 8.8 Hz, 1H), 6.42 – 6.38 (m, 1H), 4.66 (d, *J* = 16.8 Hz, 1H), 4.55 (d, *J* = 16.8 Hz, 1H), 4.22 – 4.07 (m, 2H), 3.93 (d, *J* = 12.6 Hz, 1H), 3.50 (d, *J* = 12.6 Hz, 1H), 1.41 (s, 3H), 1.13 (t, *J* = 7.2 Hz, 3H). **^{13}C NMR** (151 MHz, $CDCl_3$) δ 189.24, 171.74, 164.35, 162.61, 151.86, 136.62, 135.62, 128.89, 127.57, 126.61, 108.85, 108.26, 104.69, 61.66, 58.10, 56.07, 53.43, 17.39, 13.94. **^{19}F NMR** (565 MHz, $CDCl_3$) δ -111.14 . **HRMS** (ESI) m/z: Calcd for $C_{20}H_{21}FNO_3^+$ $[M + H]^+$: 342.1500; found: 342.1495.

Ethyl 1-benzyl-3,8-dimethyl-4-oxo-1,2,3,4-tetrahydroquinoline-3-carboxylate (3o)



A yellowish green liquid **3o** (45.2 mg, 67% yield) was isolated by column chromatography (5/1 petroleum ether/ethyl acetate). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.92 (d, *J* = 8.6 Hz, 1H), 7.47 – 7.37 (m, 4H), 7.35 – 7.25 (m, 2H), 6.90 (t, *J* = 7.6 Hz, 1H), 4.54 (s, 2H), 4.23 – 4.10 (m, 2H), 3.83 (d, *J* = 14.2 Hz, 1H), 3.34 (d, *J* = 14.2 Hz, 1H), 2.27 (s, 3H), 1.41 (s, 3H), 1.18 (t, *J* = 7.2 Hz, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 193.45, 172.88, 152.07, 138.26, 128.76, 128.44, 127.32, 126.79, 126.62, 123.43, 120.52, 61.64, 57.23, 55.95, 51.82, 19.98, 18.88, 13.97. **HRMS** (ESI) m/z: Calcd for $C_{21}H_{24}NO_3^+$ $[M + H]^+$: 338.1751; found: 338.1769.

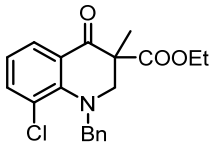
Ethyl 1-benzyl-8-fluoro-3-methyl-4-oxo-1,2,3,4-tetrahydroquinoline-3-carboxylate (3p)



A yellowish green liquid **3p** (49.8 mg, 73% yield) was isolated by column chromatography (5/1 petroleum ether/ethyl acetate). **^{1}H NMR** (600 MHz, $CDCl_3$) δ 7.71 (d, *J* = 7.8 Hz, 1H), 7.28 (t, *J* = 7.6 Hz, 2H), 7.24 – 7.29 (m, 3H), 7.09 – 7.04 (m, 1H), 6.67 – 6.62 (m, 1H), 4.83 (d, *J* = 16.6 Hz, 1H), 4.60 (d, *J* = 16.6 Hz, 1H), 4.12 – 4.00 (m, 2H), 3.71 (d, *J* = 13.4 Hz, 1H), 3.27 (d, *J* = 13.4 Hz, 1H), 1.31 (s, 3H), 1.08 (t, *J* = 7.2 Hz, 3H). **^{13}C NMR** (151 MHz, $CDCl_3$) δ 191.07, 171.68, 152.50, 150.89, 140.01, 138.03, 128.65, 127.42, 127.23, 124.81, 121.98, 117.51, 61.70, 57.69, 52.46,

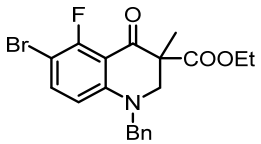
17.51, 13.97. **^{19}F NMR** (565 MHz, $CDCl_3$) δ -126.14. **HRMS** (ESI) m/z: Calcd for $C_{20}H_{21}FNO_3^+$ $[M + H]^+$: 342.1500; found: 342.1495.

Ethyl 1-benzyl-8-chloro-3-methyl-4-oxo-1,2,3,4-tetrahydroquinoline-3-carboxylate (3q)



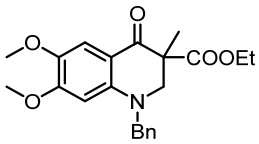
A yellowish green liquid **3q** (27.9 mg, 39% yield) was isolated by column chromatography (5/1 petroleum ether/ethyl acetate). **^{1}H NMR** (600 MHz, $CDCl_3$) δ 7.97 (d, *J* = 7.8 Hz, 1H), 7.53 – 7.46 (m, 3H), 7.40 (t, *J* = 7.6 Hz, 2H), 7.32 (t, *J* = 7.4 Hz, 1H), 6.90 (t, *J* = 7.8 Hz, 1H), 4.94 (d, *J* = 16.6 Hz, 1H), 4.62 (d, *J* = 16.6 Hz, 1H), 4.24 – 4.15 (m, 2H), 3.77 (d, *J* = 14.2 Hz, 1H), 3.33 (d, *J* = 14.2 Hz, 1H), 1.39 (s, 3H), 1.20 (t, *J* = 7.2 Hz, 3H). **^{13}C NMR** (151 MHz, $CDCl_3$) δ 192.43, 172.48, 149.12, 137.85, 137.22, 128.53, 127.67, 127.47, 124.78, 124.36, 120.79, 61.85, 56.61, 55.58, 51.73, 18.45, 13.98. **HRMS** (ESI) m/z: Calcd for $C_{20}H_{20}ClNaNO_3^+$ $[M + Na]^+$: 380.1024; found: 380.1067.

Ethyl 1-benzyl-6-bromo-5-fluoro-3-methyl-4-oxo-1,2,3,4-tetrahydroquinoline-3-carboxylate (3r)



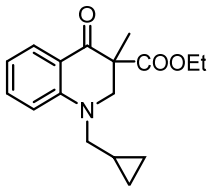
A yellowish green liquid **3r** (29.4 mg, 35% yield) was isolated by column chromatography (5/1 petroleum ether/ethyl acetate). **^{1}H NMR** (600 MHz, $CDCl_3$) δ 7.38 – 7.32 (m, 3H), 7.29 (t, *J* = 7.2 Hz, 1H), 7.29 (d, *J* = 7.6 Hz, 2H), 6.37 (d, *J* = 9.2 Hz, 1H), 4.65 (d, *J* = 16.8 Hz, 1H), 4.55 (d, *J* = 16.8 Hz, 1H), 4.20 – 4.09 (m, 2H), 3.93 (d, *J* = 13.0 Hz, 1H), 3.51 (d, *J* = 13.0 Hz, 1H), 1.41 (s, 3H), 1.15 (t, *J* = 7.2 Hz, 3H). **^{13}C NMR** (151 MHz, $CDCl_3$) δ 188.33, 171.48, 160.02, 158.27, 150.85, 138.28, 136.10, 128.99, 127.74, 126.51, 110.10, 109.06, 96.57, 61.85, 58.07, 56.04, 53.30, 17.35, 13.96. **^{19}F NMR** (565 MHz, $CDCl_3$) δ -104.59. **HRMS** (ESI) m/z: Calcd for $C_{20}H_{20}BrFNO_3^+$ $[M + H]^+$: 420.0606; found: 420.0600.

Ethyl 1-benzyl-6,7-dimethoxy-3-methyl-4-oxo-1,2,3,4-tetrahydroquinoline-3-carboxylate (3s)



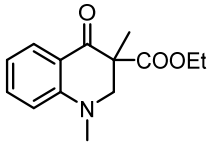
A yellowish green liquid **3s** (30.7 mg, 40% yield) was isolated by column chromatography (5/1 petroleum ether/ethyl acetate). **^{1}H NMR** (600 MHz, $CDCl_3$) δ 7.43 (s, 1H), 7.37 – 7.32 (m, 2H), 7.30 – 7.26 (m, 3H), 6.11 (s, 1H), 4.59 (d, *J* = 16.4 Hz, 1H), 4.52 (d, *J* = 16.4 Hz, 1H), 4.29 – 4.00 (m, 2H), 3.93 (d, *J* = 12.4 Hz, 1H), 3.85 (s, 3H), 3.70 (s, 3H), 3.45 (d, *J* = 12.4 Hz, 1H), 1.44 (s, 3H), 1.18 (t, *J* = 7.2 Hz, 3H). **^{13}C NMR** (151 MHz, CDCl3) δ 190.06, 172.28, 155.89, 147.92, 142.18, 137.44, 128.88, 127.55, 126.81, 111.22, 109.39, 96.31, 61.53, 59.54, 56.12, 55.81, 53.19, 17.85, 14.04. **HRMS** (ESI) m/z: Calcd for $C_{22}H_{25}NaNO_5^+$ $[M + Na]^+$: 406.1625; found: 406.1617.

Ethyl 1-(cyclopropylmethyl)-3-methyl-4-oxo-1,2,3,4-tetrahydroquinoline-3-carb oxylate (3t)



A yellowish green liquid **3t** (36.8 mg, 64% yield) was isolated by column chromatography (5/1 petroleum ether/ethyl acetate). **^{1}H NMR** (600 MHz, $CDCl_3$) δ 7.95 (d, *J* = 6.6 Hz, 1H), 7.37 (t, *J* = 7.8 Hz, 1H), 6.81 (d, *J* = 8.6 Hz, 1H), 6.73 (t, *J* = 7.2 Hz, 1H), 4.19 – 4.07 (m, 2H), 3.92 (d, *J* = 12.6 Hz, 1H), 3.48 – 3.40 (m, 2H), 3.11 (dd, *J* = 14.8, 7.2 Hz, 1H), 1.10 – 1.02 (m, 1H), 0.62 – 0.54 (m, 2H), 0.33 – 0.21 (m, 2H). **^{13}C NMR** (151 MHz, $CDCl_3$) δ 191.95, 172.11, 150.68, 135.27, 129.07, 118.60, 116.89, 112.81, 61.44, 58.07, 55.34, 53.17, 17.50, 13.97, 8.21, 3.99, 3.14. **HRMS** (ESI) m/z: Calcd for $C_{17}H_{21}NaNO_3^+$ $[M + Na]^+$: 310.1414; found: 310.1421.

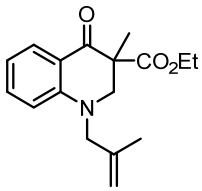
Ethyl 1,3-dimethyl-4-oxo-1,2,3,4-tetrahydroquinoline-3-carboxylate (3u)



A yellowish green liquid **3u** (29.7 mg, 60% yield) was isolated by column chromatography (5/1 petroleum ether/ethyl acetate). **^{1}H NMR** (600 MHz, $CDCl_3$) δ

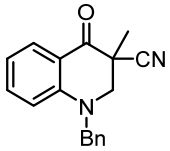
7.95 (d, *J* = 7.8 Hz, 1H), 7.41 (t, *J* = 6.8 Hz, 1H), 6.77 (t, *J* = 7.0 Hz, 1H), 6.69 (d, *J* = 8.4 Hz, 1H), 4.14 (q, *J* = 7.2 Hz, 2H), 3.82 (d, *J* = 12.4 Hz, 1H), 3.31 (d, *J* = 12.4 Hz, 1H), 3.01 (s, 3H), 1.43 (s, 3H), 1.14 (t, *J* = 7.2 Hz, 3H). **^{13}C NMR** (151 MHz, $CDCl_3$) δ 191.94, 172.00, 151.58, 135.40, 128.81, 118.76, 117.39, 112.91, 61.49, 60.24, 53.48, 39.05, 17.50, 13.98. **HRMS** (ESI) m/z: Calcd for $C_{14}H_{18}NO_3^+$ $[M + H]^+$: 248.1281; found: 248.1277.

Ethyl 3-methyl-1-(2-methylallyl)-4-oxo-1,2,3,4-tetrahydroquinoline-3-carboxylate **(3v)**



A yellowish green liquid **3v** (31.6 mg, 55% yield) was isolated by column chromatography (5/1 petroleum ether/ethyl acetate). **^{1}H NMR** (400 MHz, cdcl3) δ 7.92 (d, *J* = 7.8 Hz, 1H), 7.32 (t, *J* = 7.7 Hz, 1H), 6.72 (t, *J* = 7.4 Hz, 1H), 6.64 (d, *J* = 8.5 Hz, 1H), 4.90 (s, 1H), 4.81 (s, 1H), 4.11 (qd, *J* = 6.9, 3.2 Hz, 2H), 3.84 (d, *J* = 8.6 Hz, 3H), 3.38 (d, *J* = 12.7 Hz, 1H), 1.74 (s, 3H), 1.42 (s, 3H), 1.13 (t, *J* = 7.1 Hz, 3H). **^{13}C NMR** (101 MHz, cdcl3) δ 191.67, 171.93, 150.74, 139.81, 135.19, 128.72, 118.39, 117.11, 113.29, 111.84, 61.45, 58.32, 57.71, 53.03, 20.09, 17.57, 13.92. **HRMS** (ESI) m/z: Calcd for $C_{17}H_{21}NNaO_3^+$ $[M + Na]^+$: 310.1414; found: 310.1429.

1-benzyl-3-methyl-4-oxo-1,2,3,4-tetrahydroquinoline-3-carbonitrile (3w)



A yellowish green liquid **3w** (43.1 mg, 78% yield) was isolated by column chromatography (5/1 petroleum ether/ethyl acetate). **^{1}H NMR** (600 MHz, $CDCl_3$) δ 8.00 – 7.95 (m, 1H), 7.43 – 7.39 (m, 1H), 7.39 – 7.36 (m, 2H), 7.32 (d, *J* = 7.4 Hz, 3H), 6.87 – 6.80 (m, 2H), 4.66 (q, *J* = 16.4 Hz, 2H), 3.78 (d, *J* = 12.6 Hz, 1H), 3.50 (d, *J* = 12.6 Hz, 1H), 1.58 (s, 3H). **^{13}C NMR** (151 MHz, $CDCl_3$) δ 189.95, 170.42, 149.41, 135.45, 135.24, 135.06, 128.81, 127.95, 126.81, 125.89, 123.45, 121.63, 119.58, 112.55, 109.24, 60.78, 57.06, 54.32, 52.01, 16.34, 12.86. **HRMS** (ESI) m/z: Calcd for $C_{18}H_{16}NaN_2O^+$ $[M + Na]^+$: 299.1155; found: 299.1142.

7. References

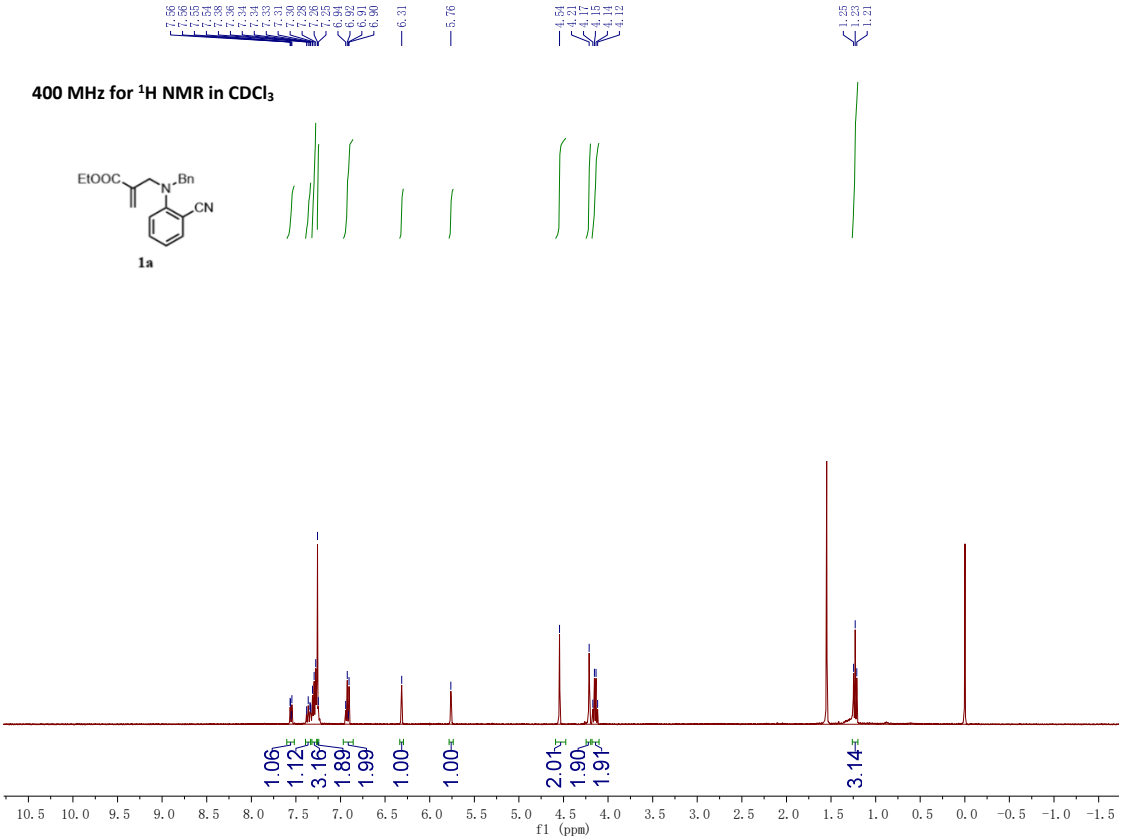
[1] Wiklund, P.; Bergman, J. Ring Forming Reactions of Imines of 2-Aminobenzaldehyde and Related Compounds. *Org. Biomol. Chem. ,* **2003**, *1,* 367–372.

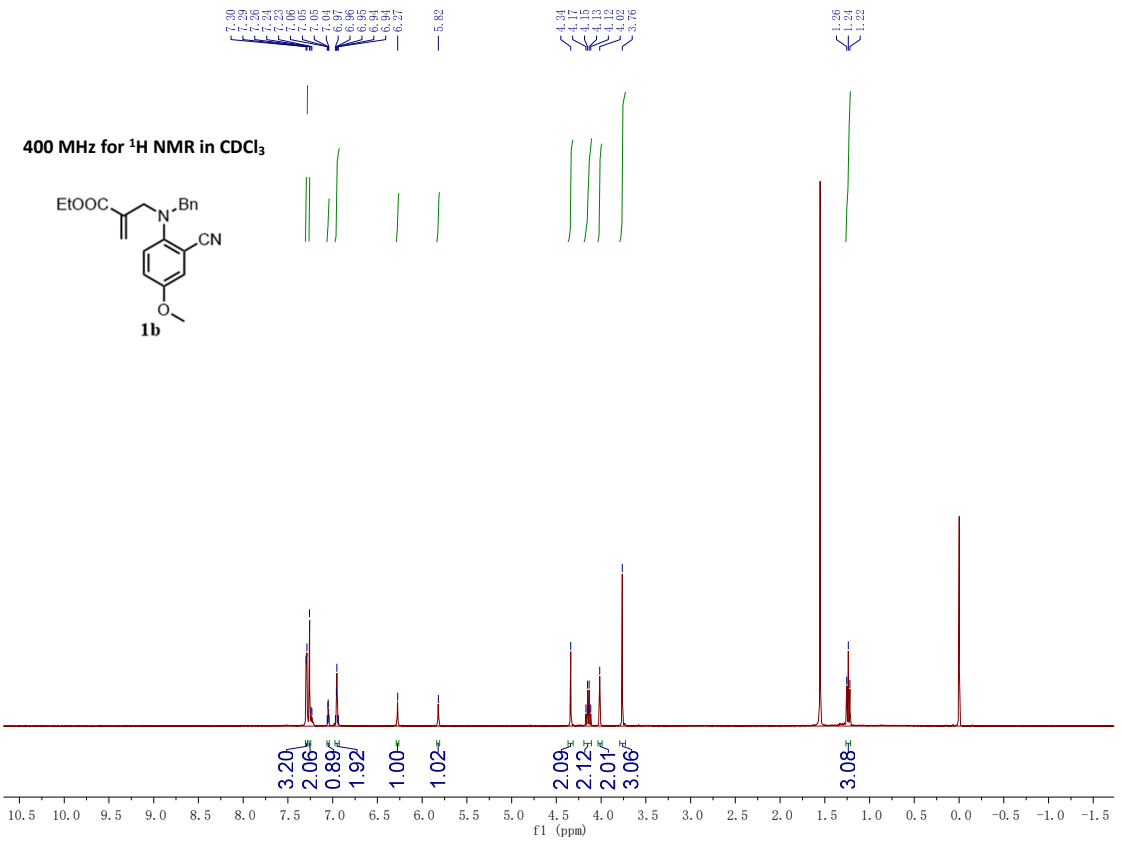
[2] Wang W.; Lu X.-H.; Dong X.-C.; Zhao W.-L. Synthesis of Azaspiro[3.4]octanes via [3+2] Cycloaddition. *Chin. J. Org. Chem.* **2015**, *35* (1), 137.

[3] He, J.-N.; Zheng, N.; Li, M.; Zheng, Y.-B.; Song, W.-Z. Cu-Catalyzed Four-Component Polymerization of Alkynes, Sulfonyl Azides, Nucleophiles and Electrophiles. *Polym. Chem.* **2021**, *12* (30), 4347–4358.

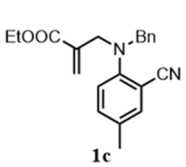
[4] Adak, L.; Chattopadhyay, K.; Ranu, B. C. Palladium Nanoparticle-Catalyzed C−N Bond Formation. A Highly Regio- and Stereoselective Allylic Amination by Allyl Acetates. *J. Org. Chem.* **2009**, *74* (10), 3982–3985.

8. NMR Spectral Data

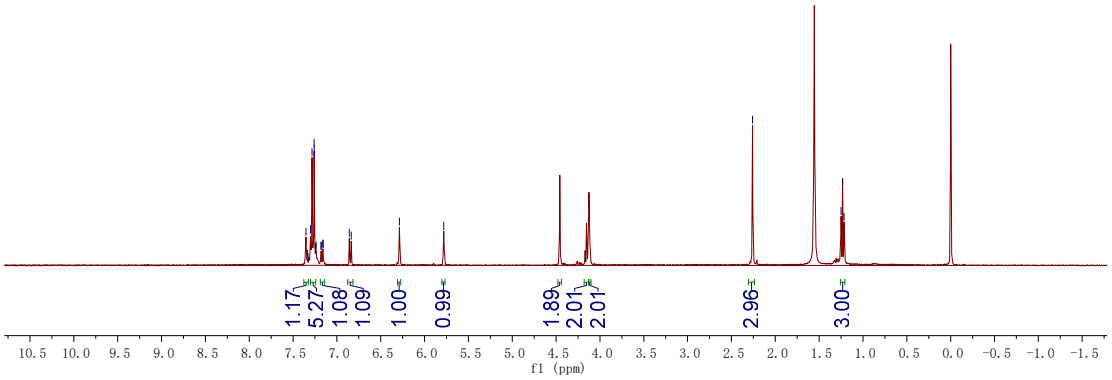




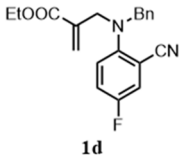
400 MHz for ^{1}H NMR in $CDCl_3$



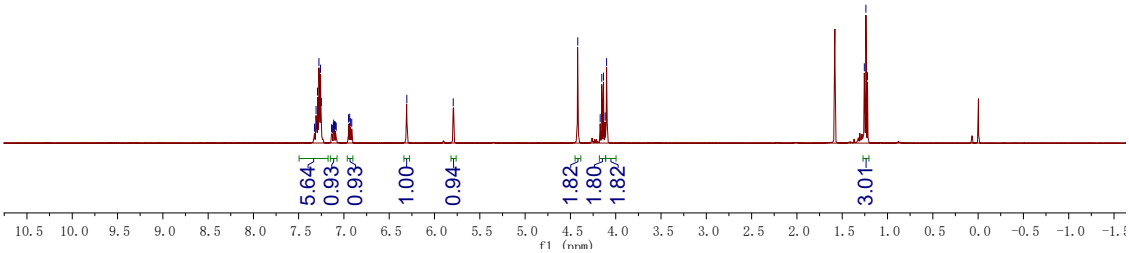
1c

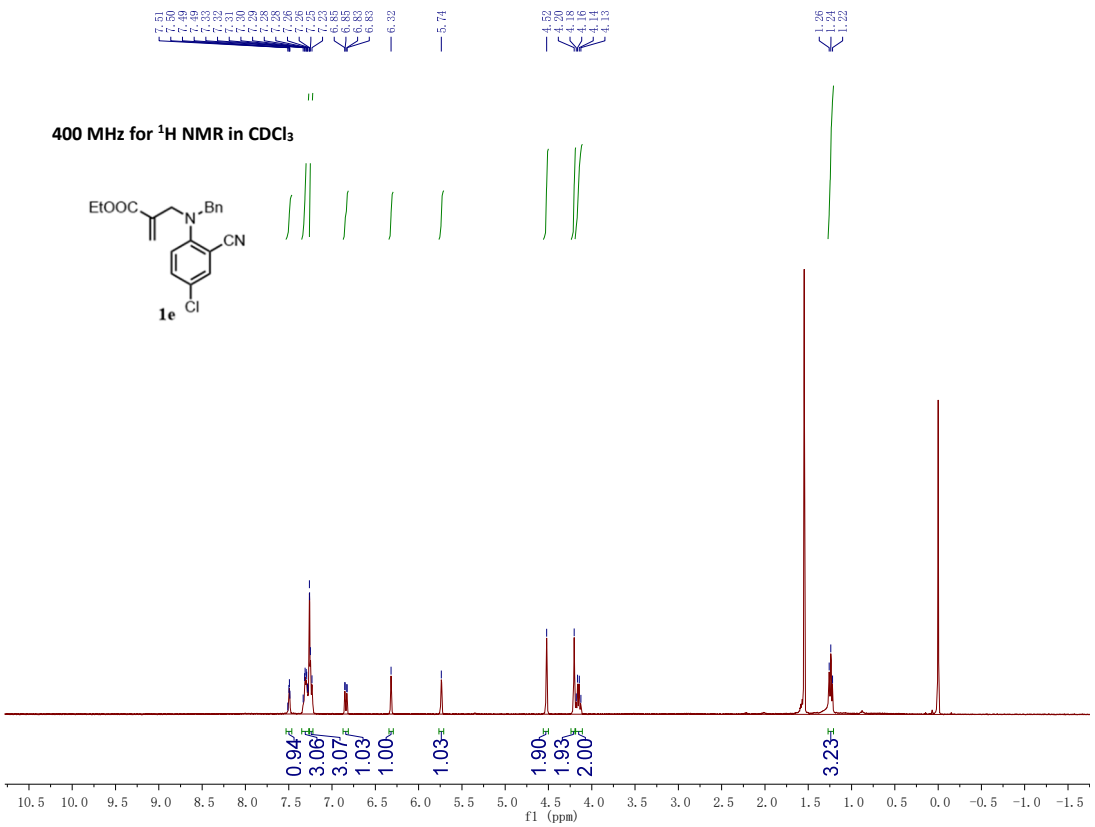


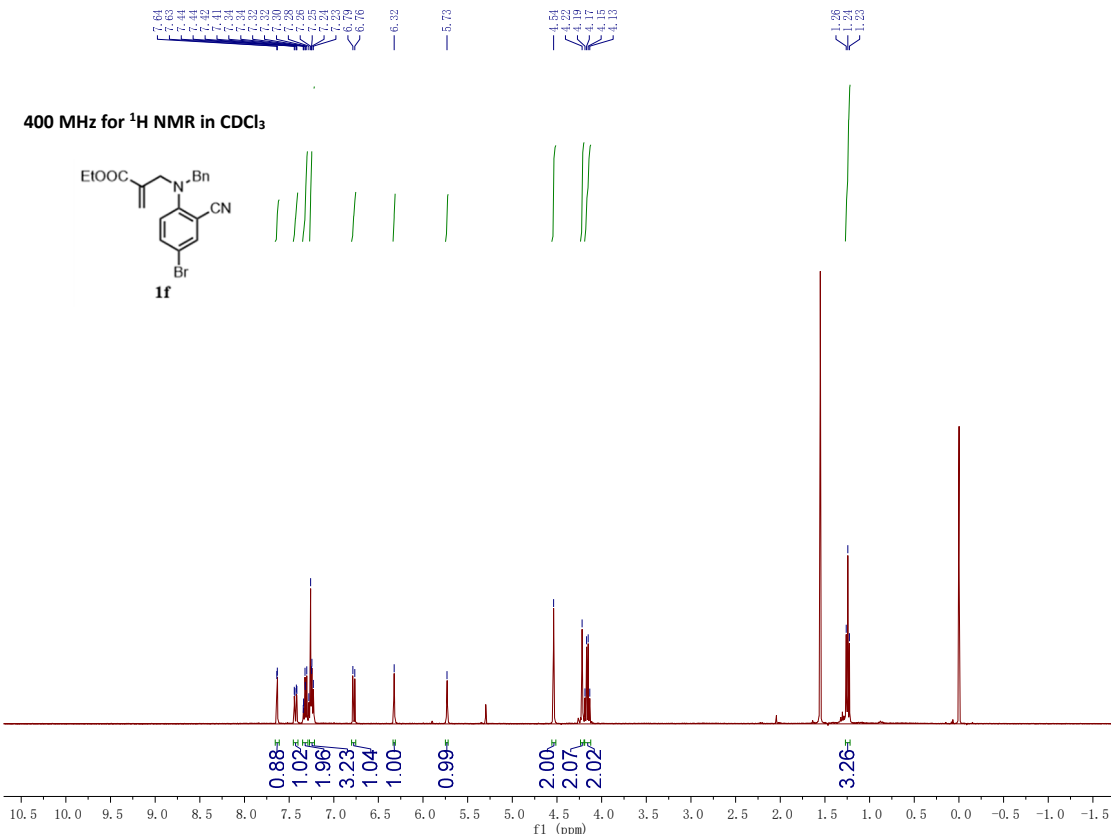
400 MHz for ^{1}H NMR in $CDCl_3$

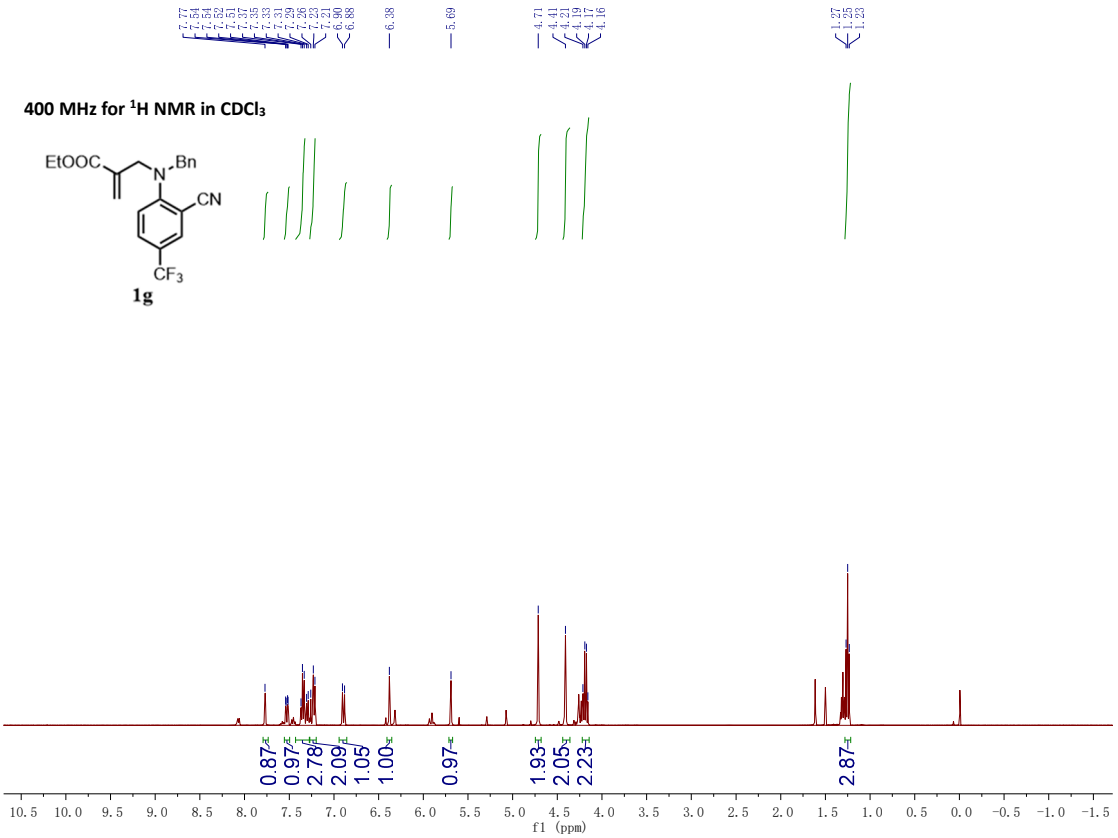


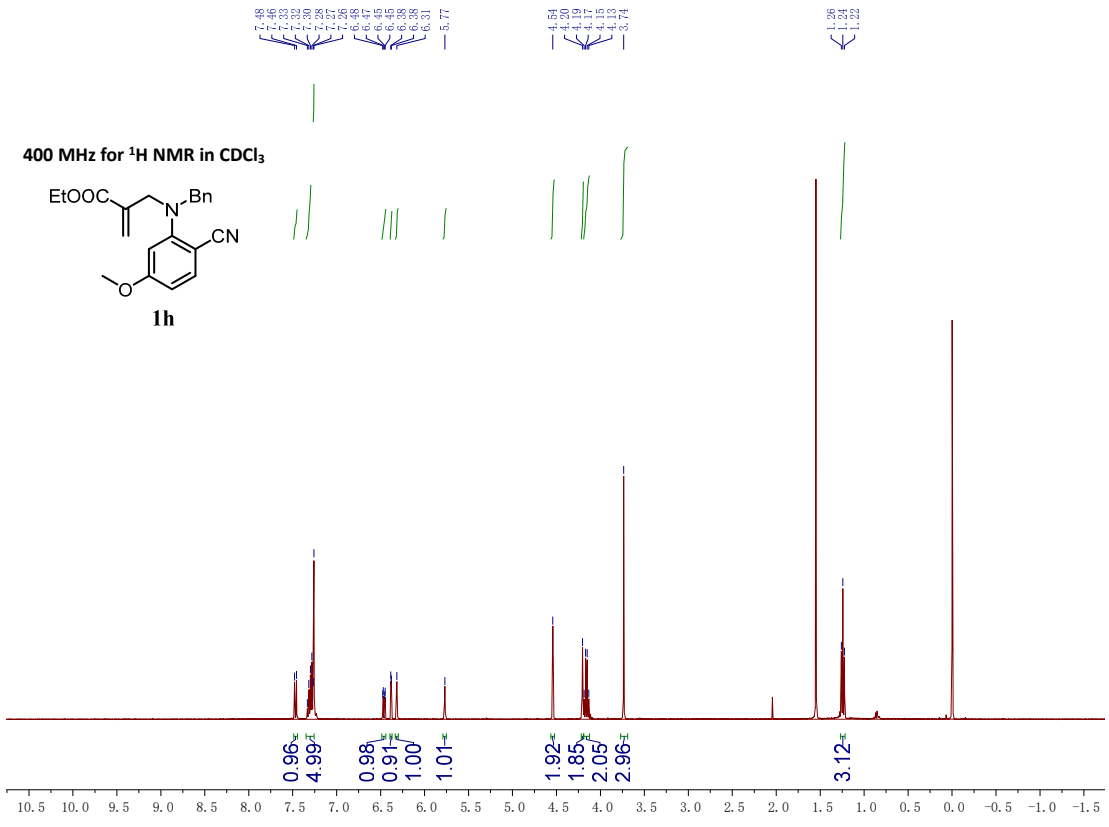
1d



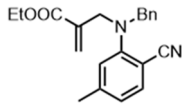

400 MHz for ^{1}H NMR in CDCl$_3$
EtOOC
N
Bn
CN
Cl
1e
f1 (ppm)


400 MHz for ^{1}H NMR in CDCl$_3$
EtOOC
N
Bn
CN
Br
1f
f1 (ppm)


400 MHz for ^{1}H NMR in CDCl$_3$
EtOOC
N
Bn
CN
CF$_3$
1g
0.87
0.97
2.78
2.09
1.05
1.00
0.97
1.93
2.05
2.23
2.87
f1 (ppm)


400 MHz for ^{1}H NMR in CDCl$_3$
EtOOC
N
Bn
CN
O
1h
0.96
4.99
0.98
0.91
1.00
1.01
1.92
1.85
2.05
2.96
3.12

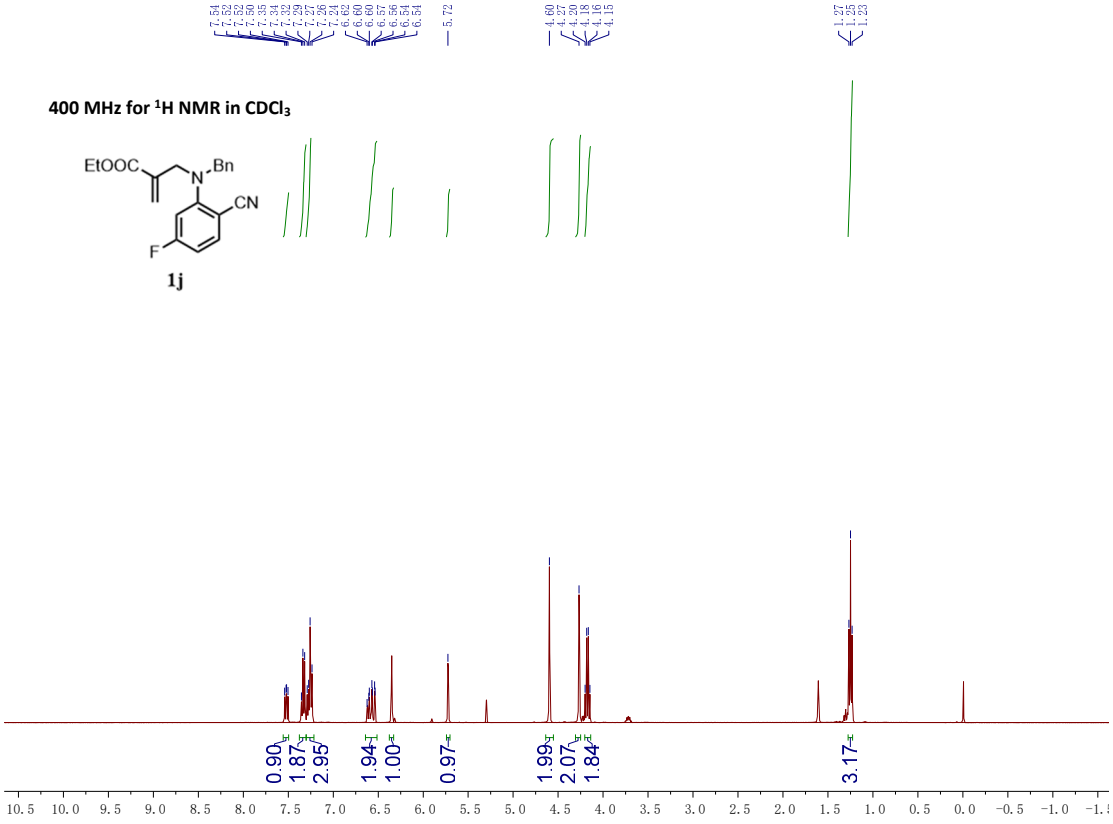
400 MHz for ^{1}H NMR in $CDCl_3$



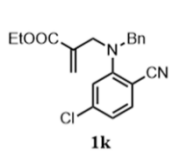
1i

400 MHz for ^{1}H NMR in $CDCl_3$

1j

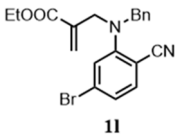


400 MHz for ^{1}H NMR in $CDCl_3$

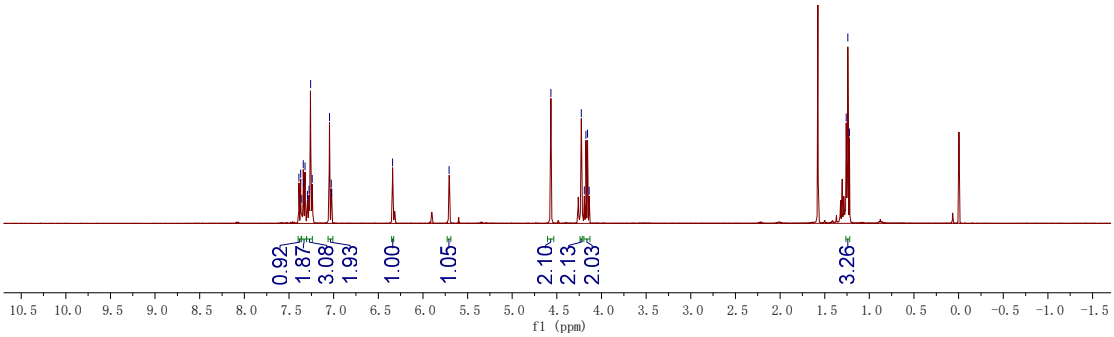


1k

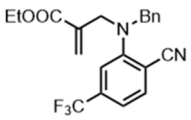
400 MHz for ^{1}H NMR in $CDCl_3$



1l

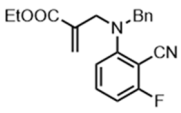


400 MHz for ^{1}H NMR in $CDCl_3$

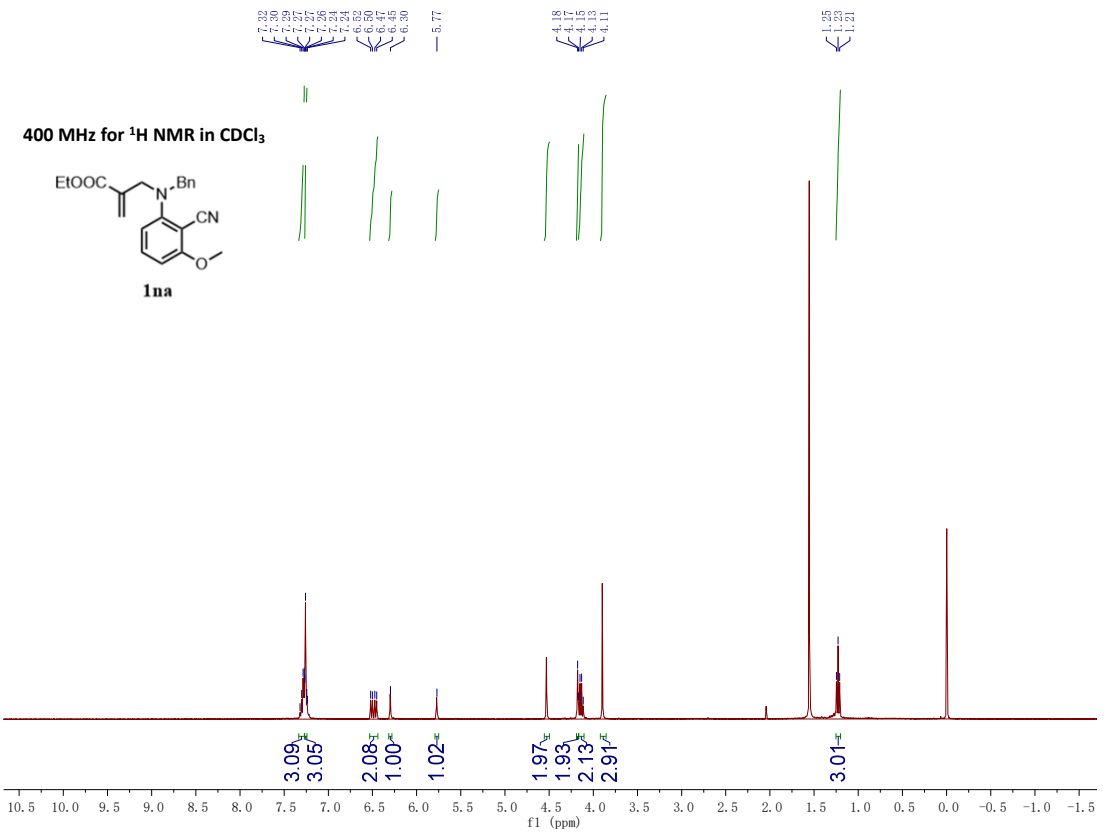


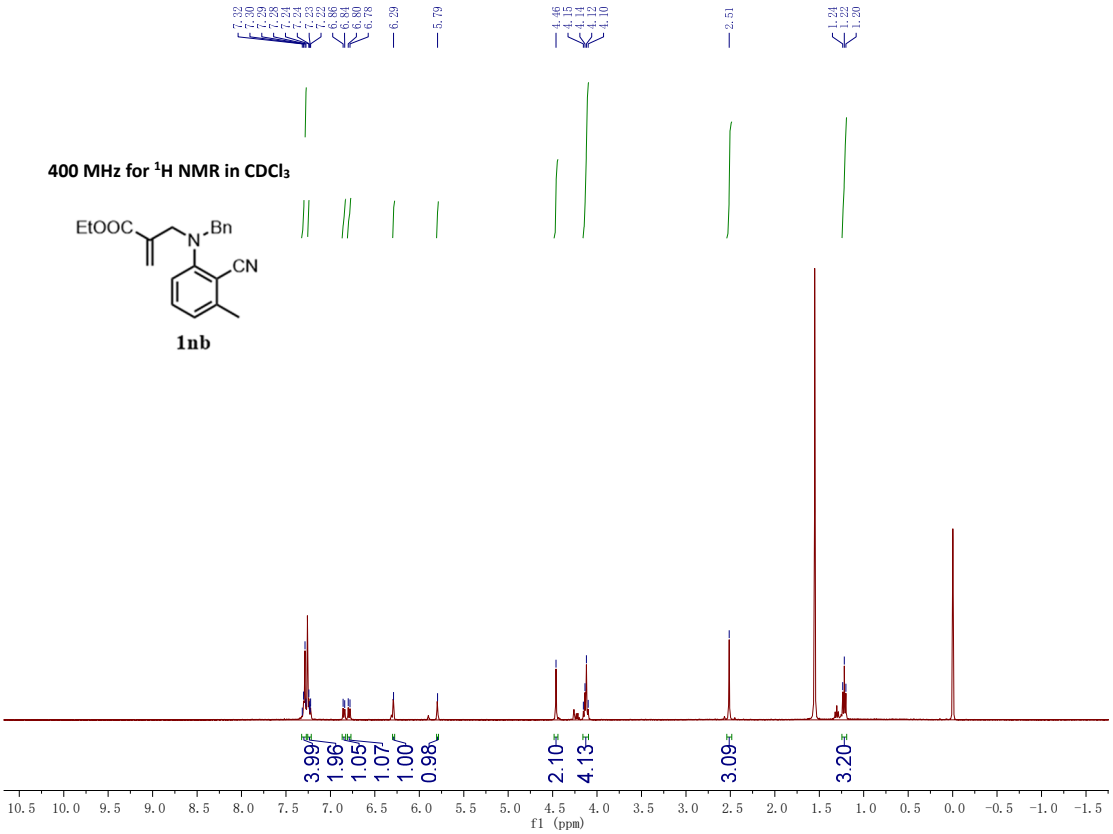
1m

400 MHz for ^{1}H NMR in $CDCl_3$

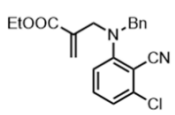


1n


400 MHz for ^{1}H NMR in CDCl$_3$
EtOOC
N
Bn
CN
O
1na
7.32
7.30
7.29
7.27
7.26
7.24
6.52
6.50
6.47
6.45
6.30
5.77
4.18
4.17
4.15
4.13
4.11
1.25
1.23
1.21
3.09
3.05
2.08
1.00
1.02
1.97
1.93
2.13
2.91
3.01
f1 (ppm)

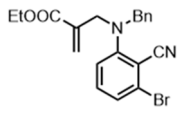

400 MHz for ^{1}H NMR in CDCl$_3$
EtOOC
N
Bn
CN
1nb
7.32
7.30
7.29
7.28
7.24
7.23
6.86
6.84
6.80
6.78
6.29
5.79
4.46
4.15
4.14
4.12
4.10
2.51
1.24
1.22
1.20
3.99
1.96
1.05
1.07
1.00
0.98
2.10
4.13
3.09
3.20
f1 (ppm)

400 MHz for ^{1}H NMR in $CDCl_3$



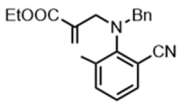
1nc

400 MHz for ^{1}H NMR in $CDCl_3$



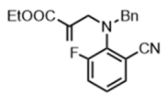
1nd

400 MHz for ^{1}H NMR in $CDCl_3$

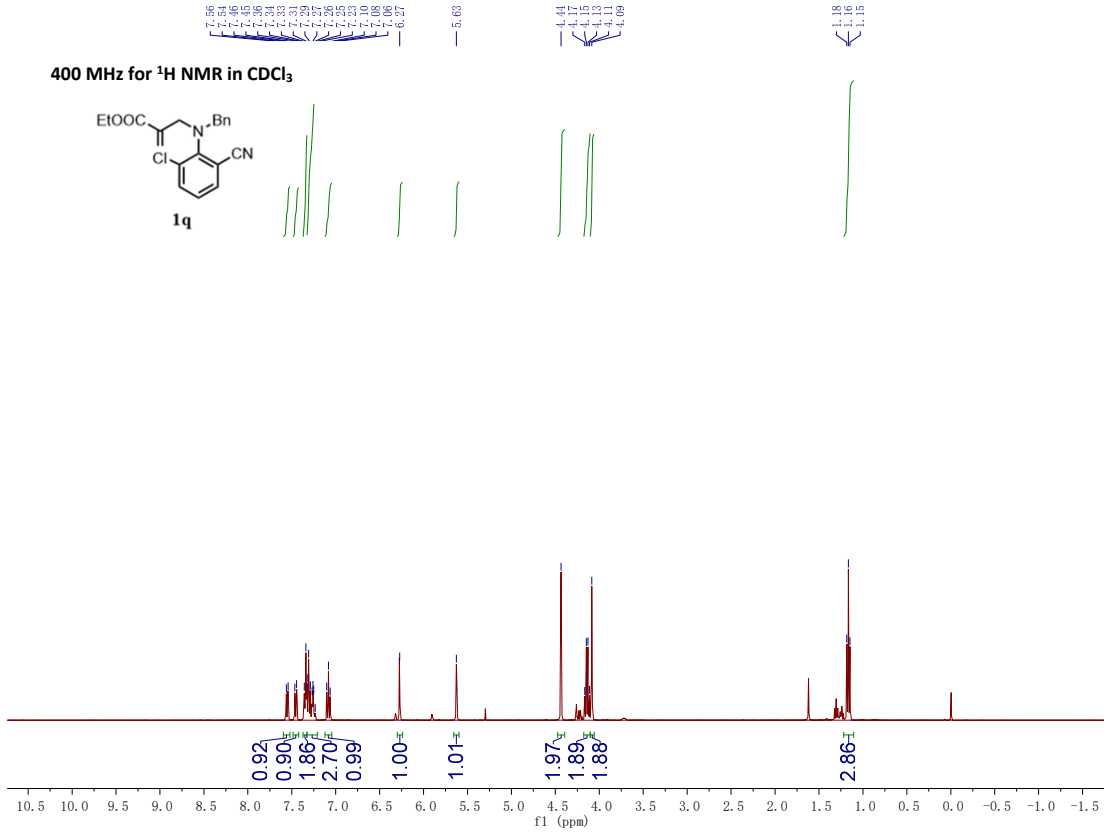


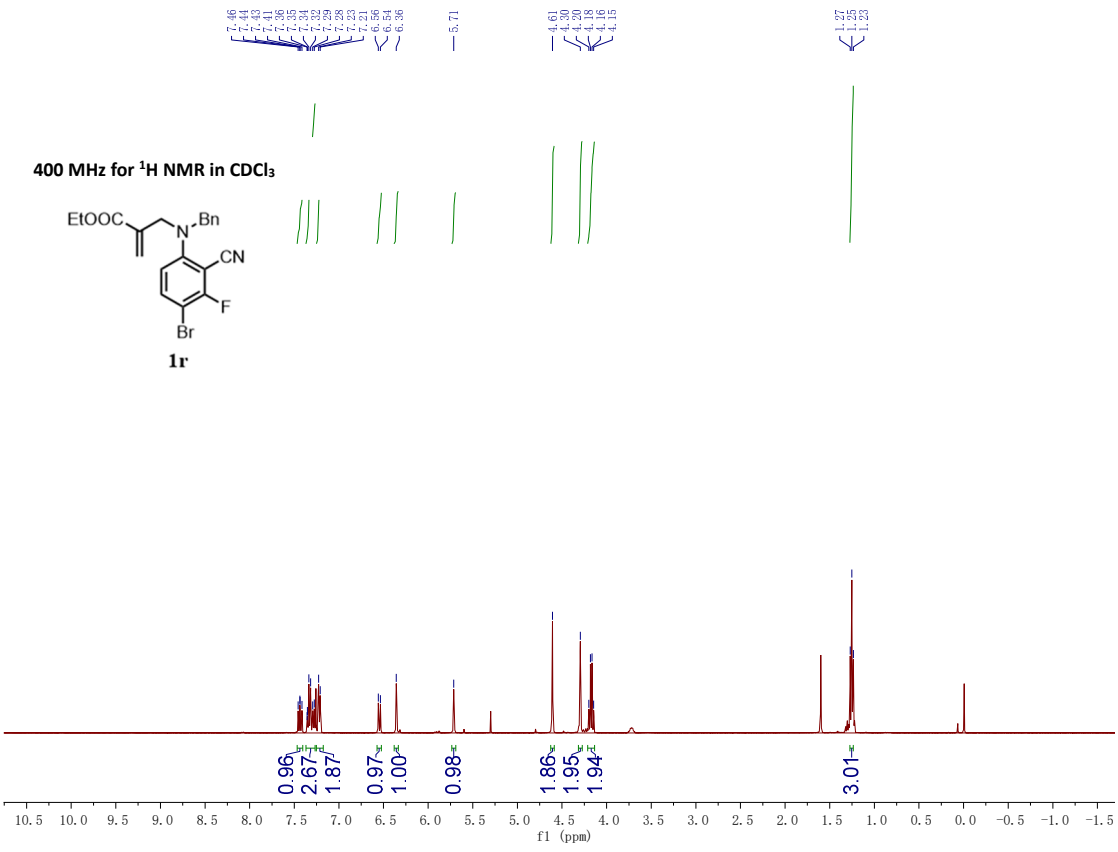
1o

400 MHz for ^{1}H NMR in $CDCl_3$

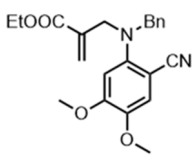


1p


400 MHz for ^{1}H NMR in CDCl$_3$
EtOOC
N
Bn
Cl
CN
1q
0.92
0.90
1.86
2.70
0.99
1.00
1.01
1.97
1.89
1.88
2.86
f1 (ppm)

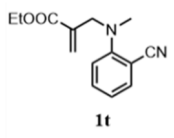

400 MHz for ^{1}H NMR in CDCl$_3$
EtOOC
N
Bn
CN
F
Br
1r
0.96
2.67
1.87
0.97
1.00
0.98
1.86
1.95
1.94
3.01
f1 (ppm)

400 MHz for ^{1}H NMR in $CDCl_3$



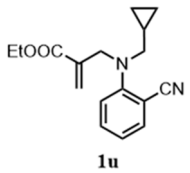
1s

400 MHz for ^{1}H NMR in $CDCl_3$



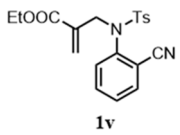
1t

400 MHz for ^{1}H NMR in $CDCl_3$

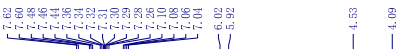


1u

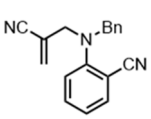
400 MHz for ^{1}H NMR in $CDCl_3$



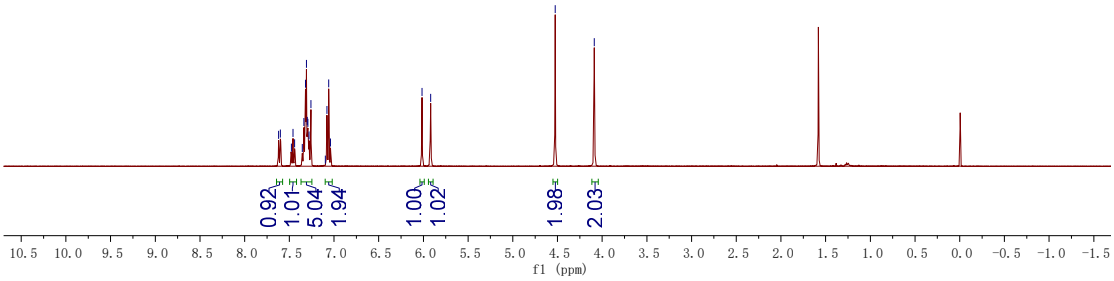
1v



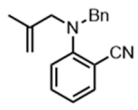
400 MHz for ^{1}H NMR in $CDCl_3$



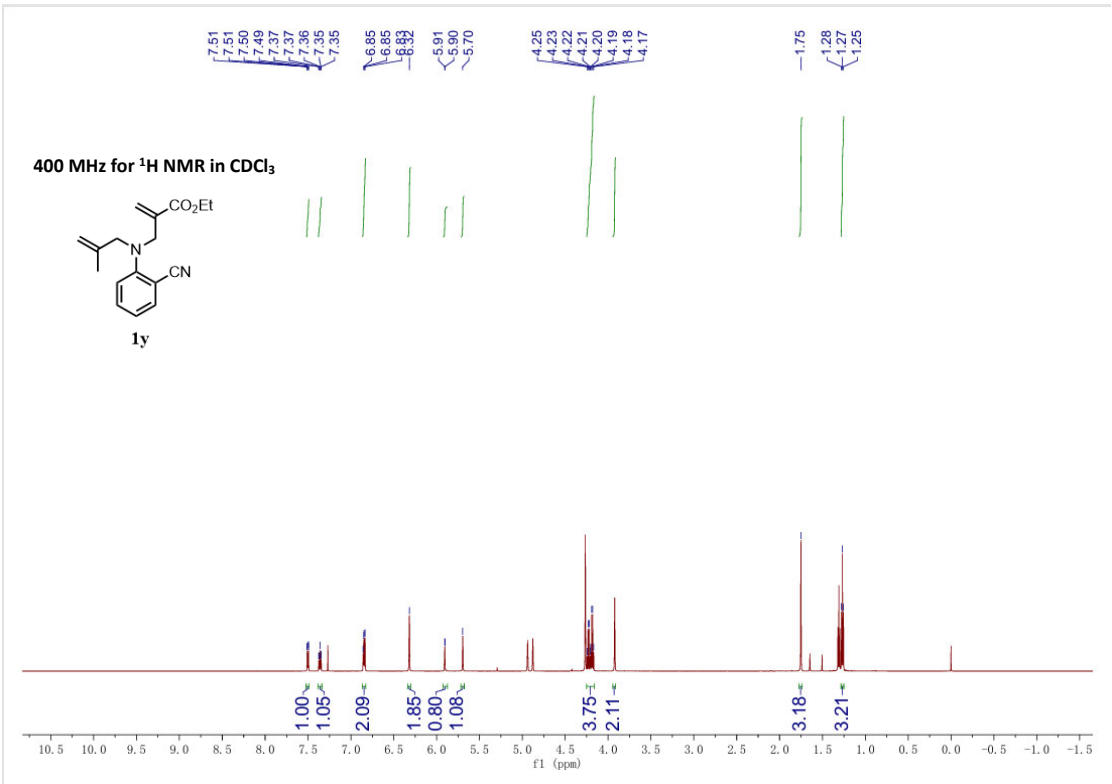
1w

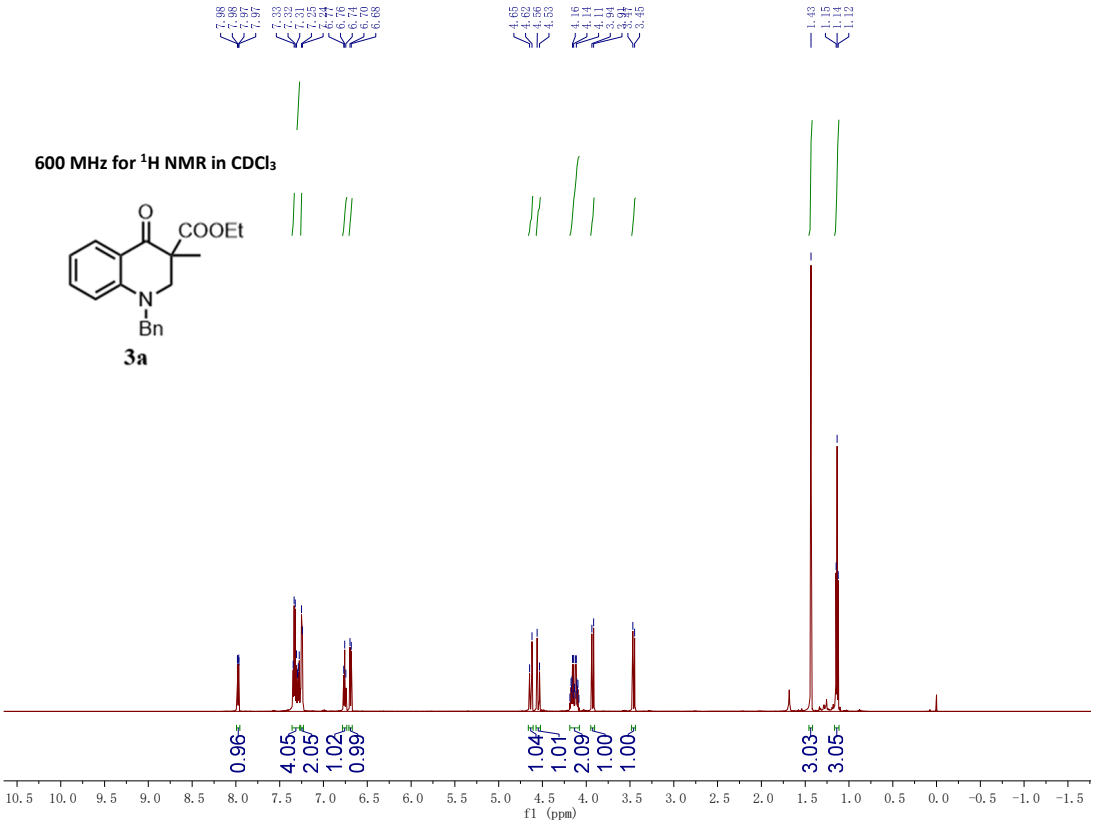


400 MHz for ^{1}H NMR in $CDCl_3$

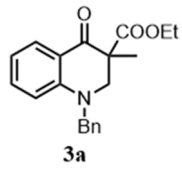


1x

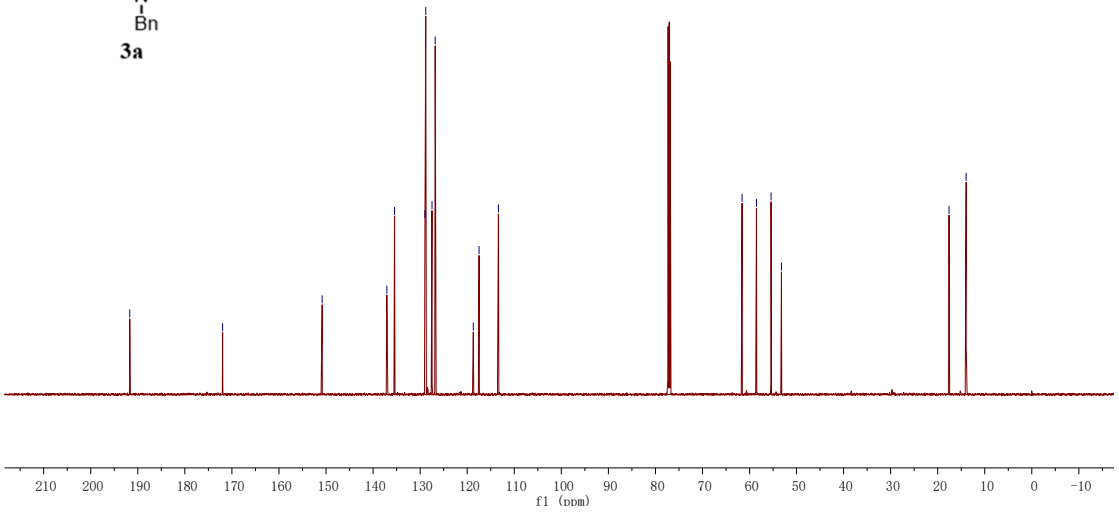

400 MHz for ^{1}H NMR in $CDCl_3$
CO_2Et
N
CN
1y
7.51 7.51 7.50 7.49 7.37 7.37 7.36 7.35 7.35
6.85 6.85 6.83 6.32
5.91 5.90 5.70
4.25 4.23 4.22 4.21 4.20 4.19 4.18 4.17
1.75
1.28 1.27 1.25
1.00 1.05 2.09 1.85 0.80 1.08 3.75 2.11 3.18 3.21
f1 (ppm)


600 MHz for ^{1}H NMR in $CDCl_3$
O
COOEt
N
Bn
3a
7.98 7.98 7.97 7.97
7.33 7.32 7.31 7.25 6.74 6.76 6.74 6.70 6.68
4.65 4.62 4.56 4.53
4.16 4.14 4.11 3.94 3.45
1.43 1.15 1.14 1.12
0.96 4.05 2.05 1.02 0.99 1.04 1.01 2.09 1.00 1.00 3.03 3.05
f1 (ppm)

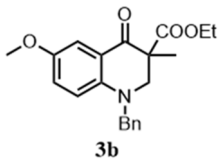
151 MHz for ^{13}C NMR in $CDCl_3$



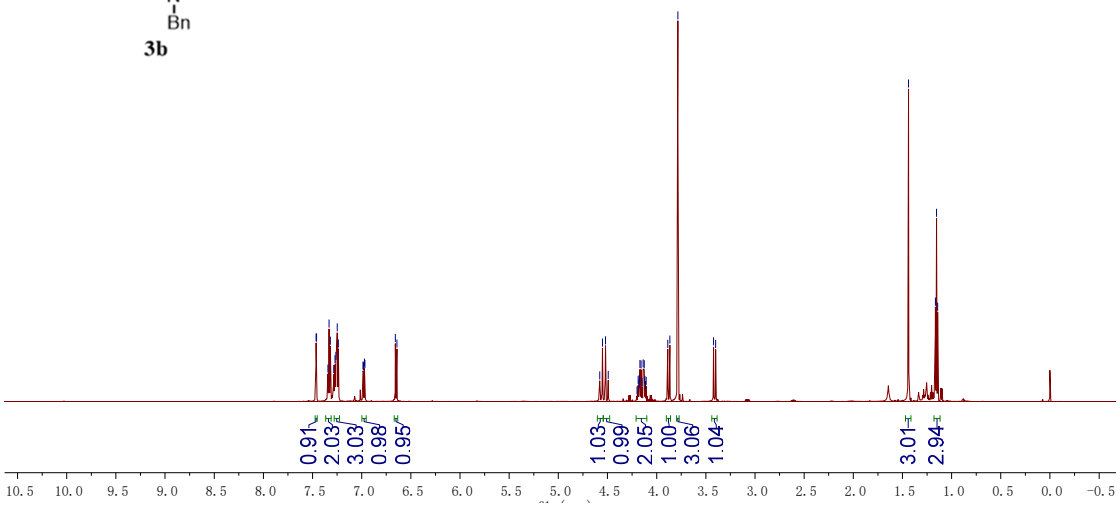
3a

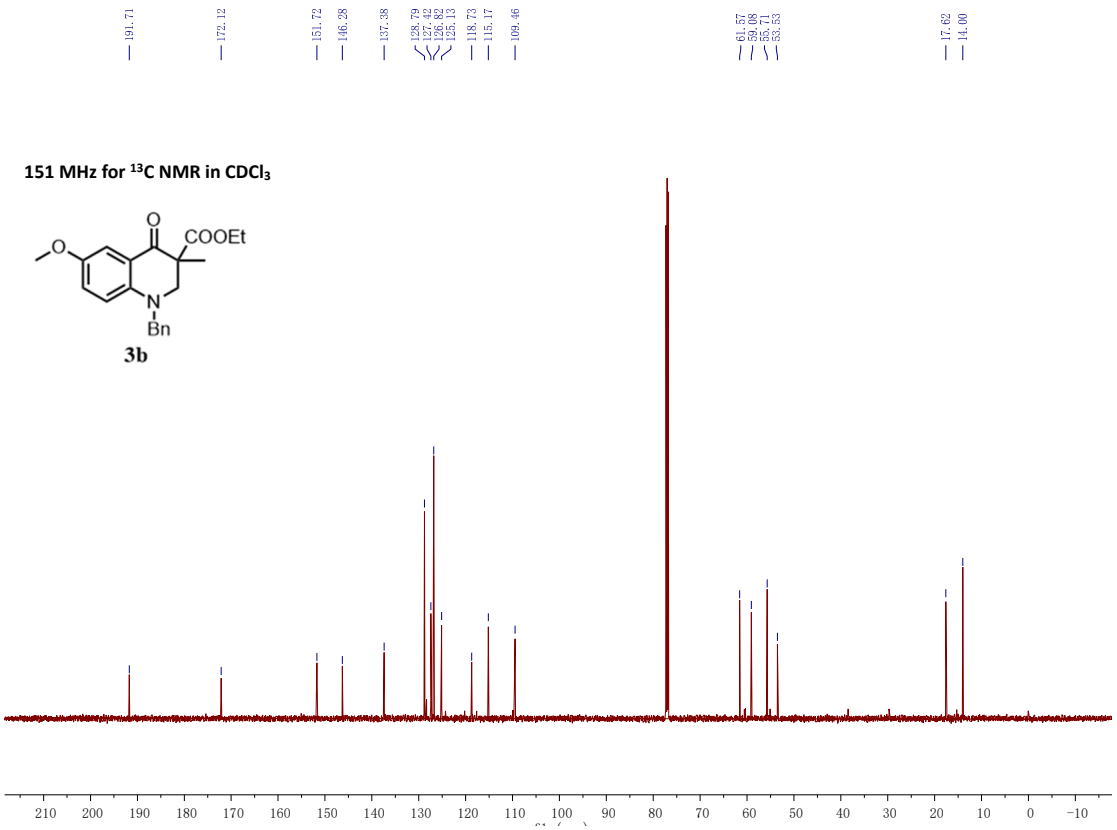


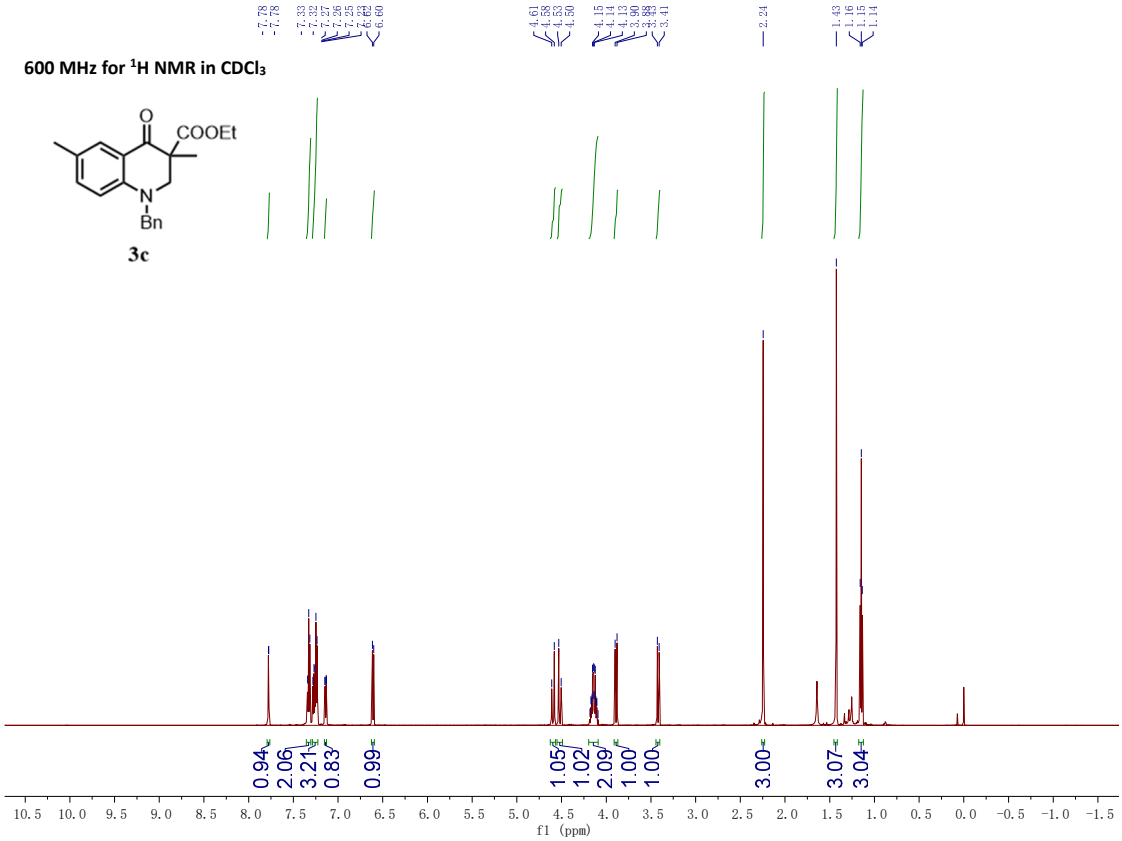
600 MHz for ^{1}H NMR in $CDCl_3$

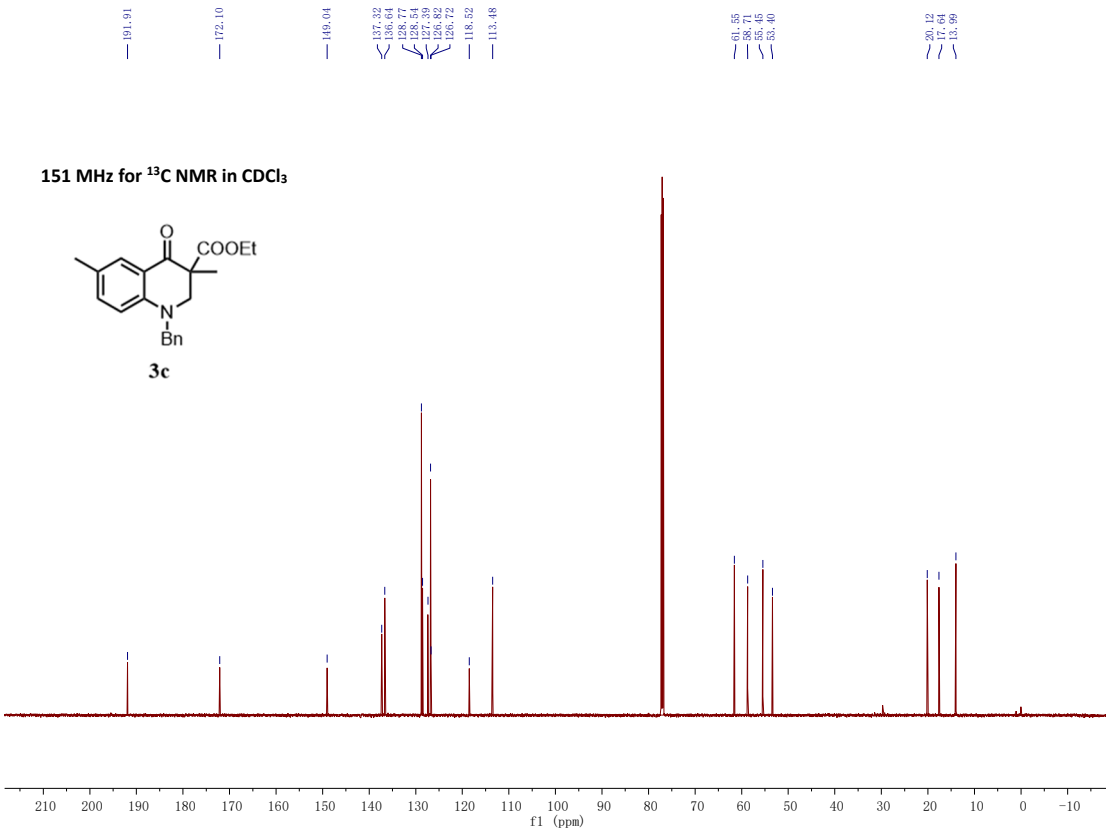


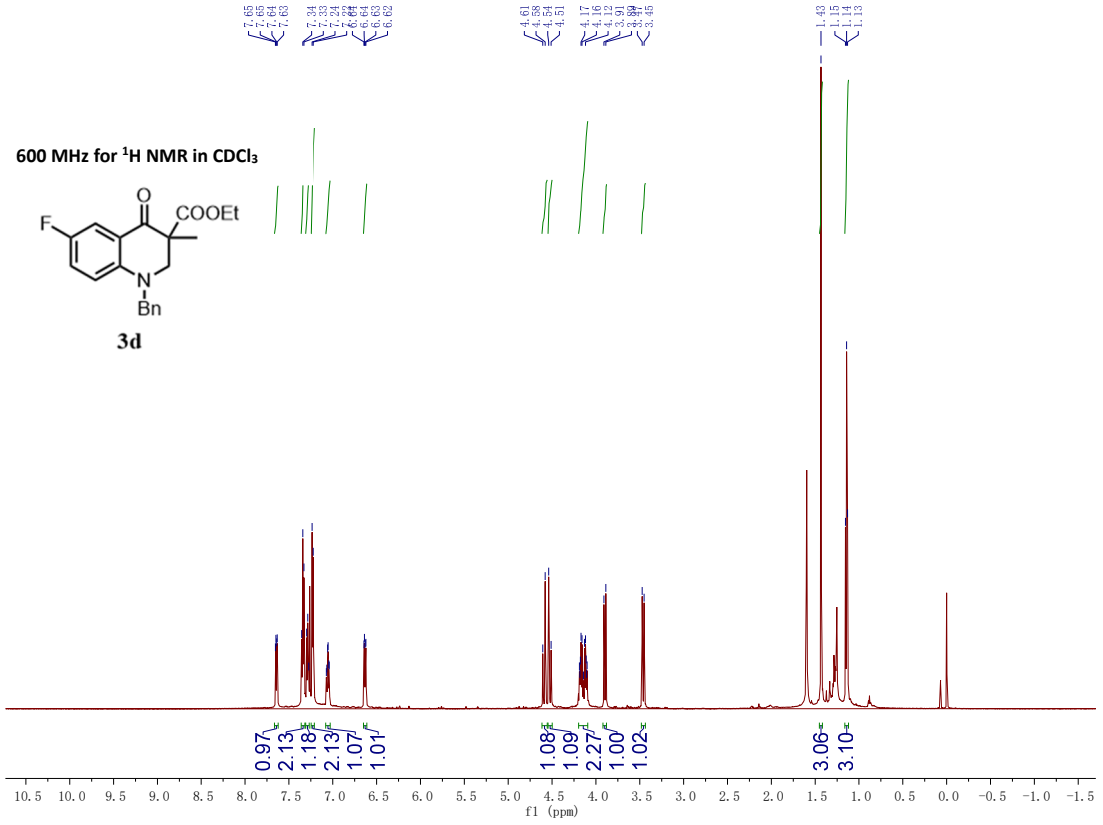
3b

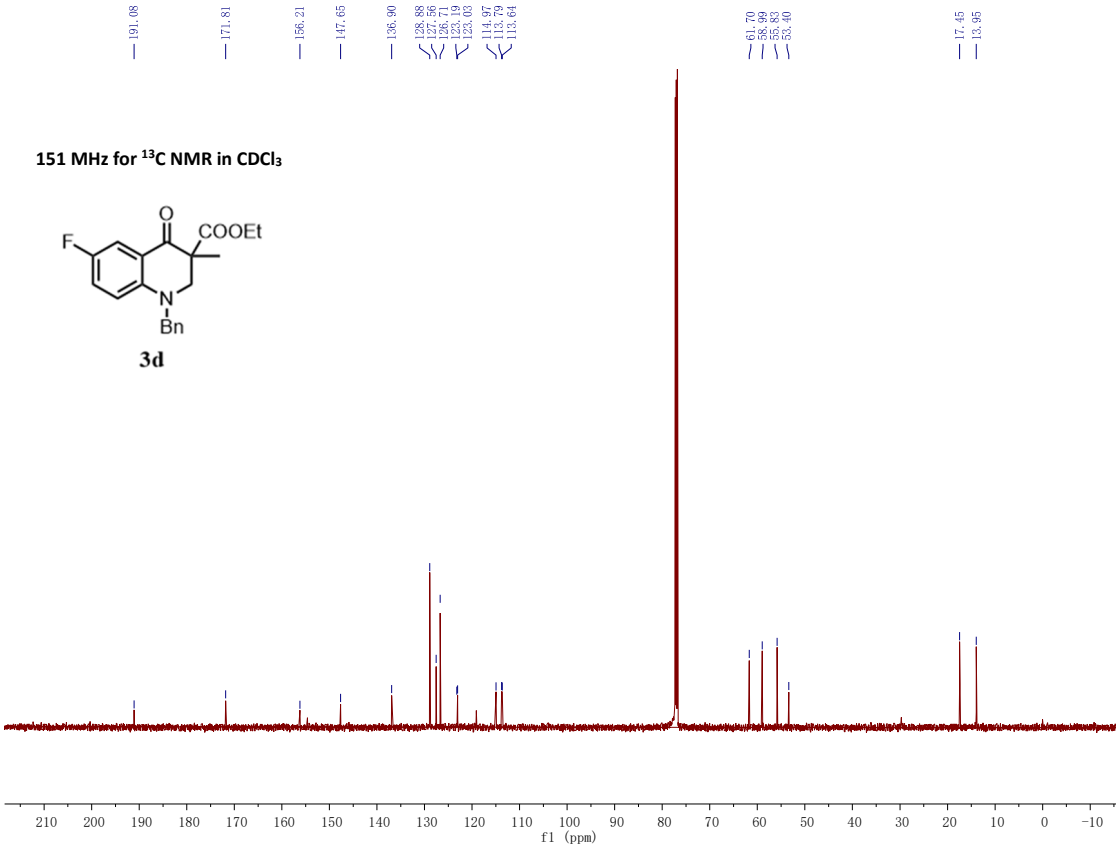



191.71
172.12
151.72
146.28
137.38
128.79
127.42
126.82
125.13
118.73
115.17
109.46
61.57
59.08
55.71
53.53
17.62
14.00
151 MHz for 13C NMR in CDCl3
COOEt
O
N
Bn
3b
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10


7.78
7.78
7.33
7.32
7.27
7.26
7.25
6.82
6.80
4.61
4.58
4.53
4.50
4.15
4.14
4.13
3.90
3.88
3.41
2.24
1.43
1.16
1.15
1.14
600 MHz for 1H NMR in CDCl3
COOEt
O
N
Bn
3c
0.94
2.06
3.21
0.83
0.99
1.05
1.02
2.09
1.00
1.00
3.00
3.07
3.04
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 −0.5 −1.0 −1.5
f1 (ppm)


191.91
172.10
149.04
137.32
136.64
128.77
128.54
127.39
126.82
126.72
118.52
113.48
61.55
58.71
55.45
53.40
20.12
17.64
13.99
151 MHz for 13C NMR in CDCl3
O
COOEt
N
Bn
3c
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10
f1 (ppm)

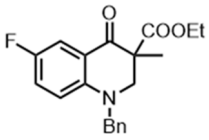

7.65
7.64
7.63
7.34
7.33
7.24
6.64
6.63
6.62
4.61
4.58
4.54
4.51
4.17
4.16
4.12
3.91
3.45
1.43
1.15
1.14
1.13
600 MHz for 1H NMR in CDCl3
O
COOEt
F
N
Bn
3d
0.97
2.13
1.18
2.13
1.07
1.01
1.08
1.09
2.27
1.00
1.02
3.06
3.10
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 −0.5 −1.0 −1.5
f1 (ppm)



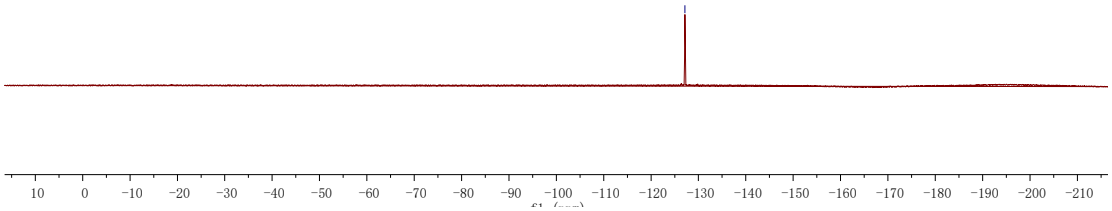
151 MHz for ^{13}C NMR in $CDCl_3$

3d

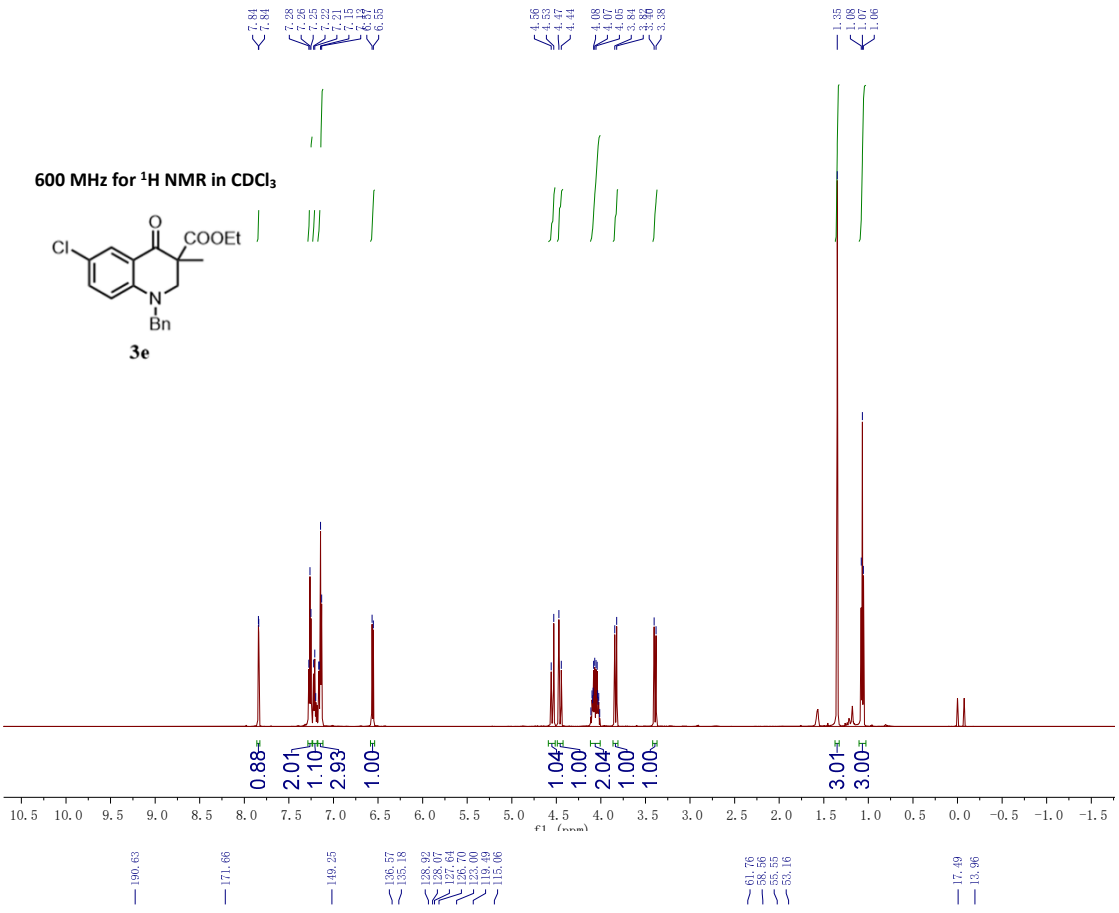
565 MHz for ^{19}F NMR in $CDCl_3$



3d

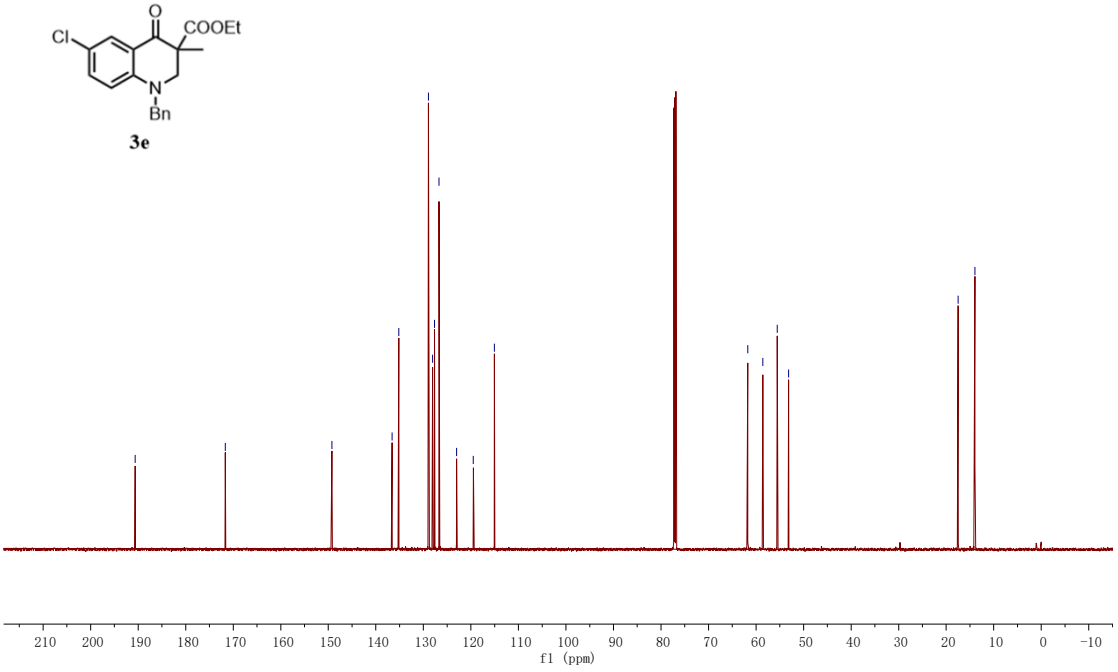


600 MHz for ^{1}H NMR in $CDCl_3$



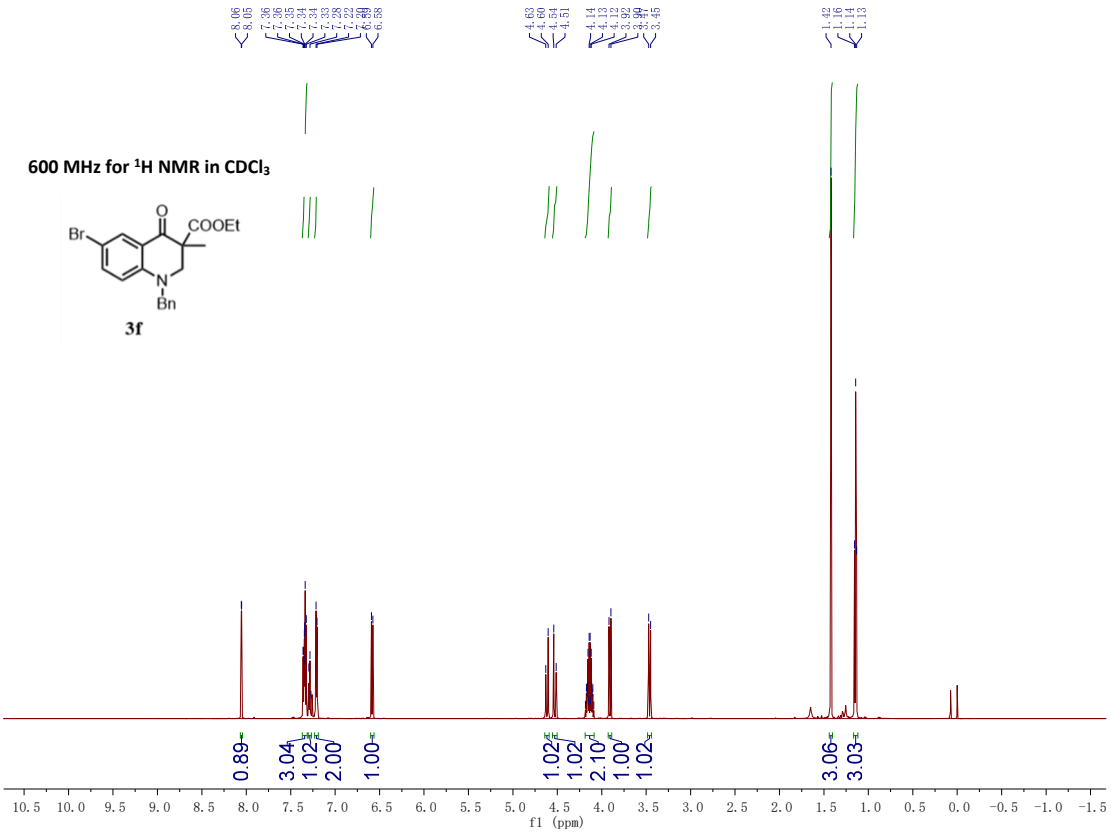
3e

151 MHz for ^{13}C NMR in $CDCl_3$



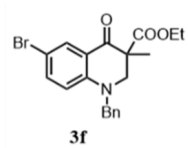
3e

600 MHz for ^{1}H NMR in $CDCl_3$



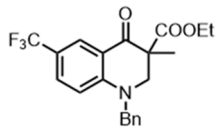
3f

151 MHz for ^{13}C NMR in $CDCl_3$



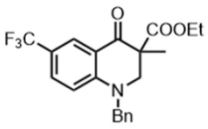
3f

600 MHz for ^{1}H NMR in $CDCl_3$

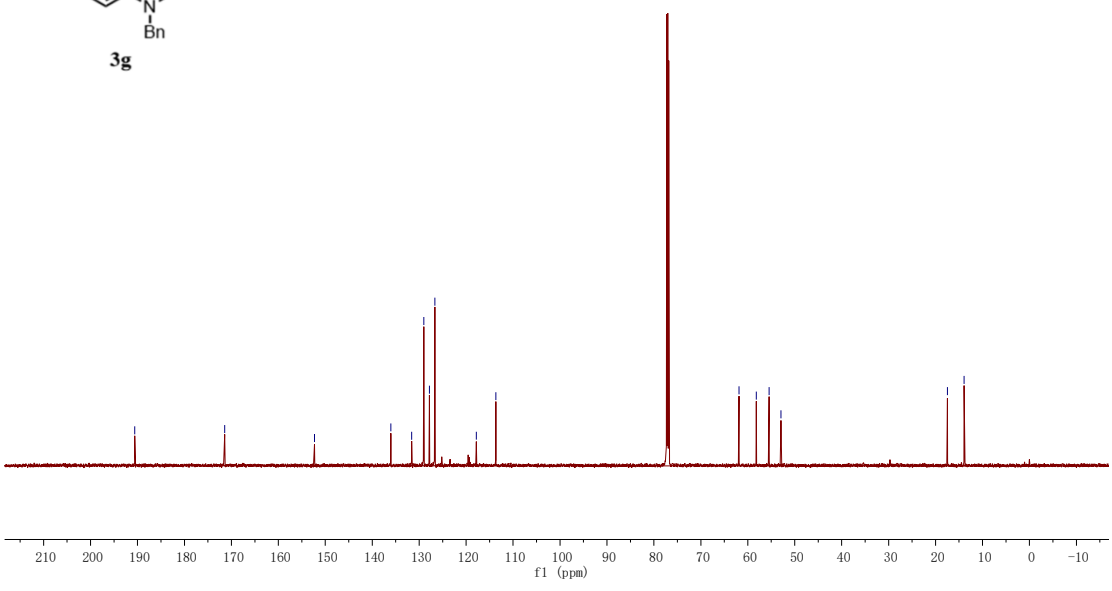


3g

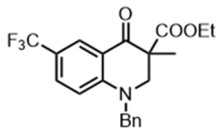
151 MHz for ^{13}C NMR in $CDCl_3$



3g

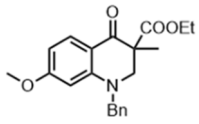


565 MHz for ^{19}F NMR in $CDCl_3$



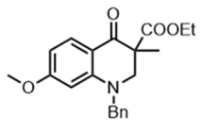
3g

600 MHz for ^{1}H NMR in $CDCl_3$

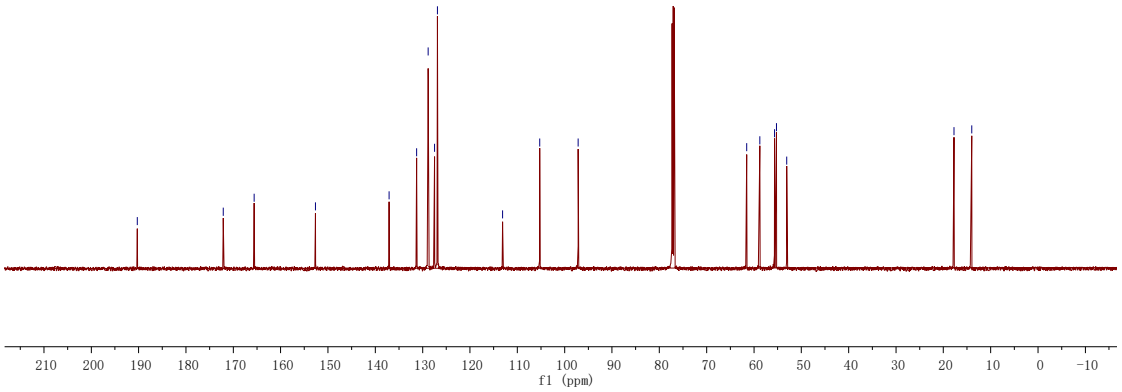


3h

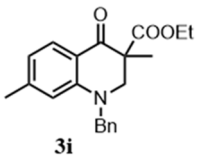
151 MHz for ^{13}C NMR in $CDCl_3$



3h

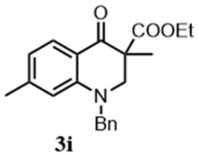


600 MHz for ^{1}H NMR in $CDCl_3$

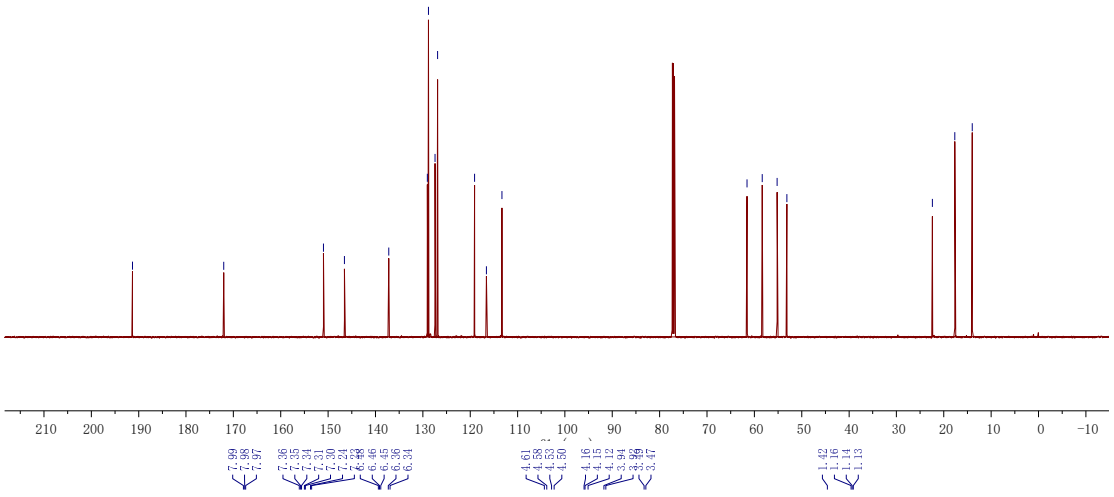


3i

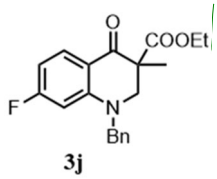
151 MHz for ^{13}C NMR in $CDCl_3$



3i



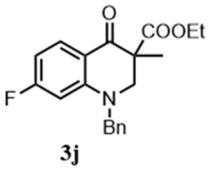
600 MHz for ^{1}H NMR in $CDCl_3$



3j

190.32
171.74
168.65
166.97
152.71
136.30
131.91
128.95
127.71
126.79
115.55
105.69
99.73
61.70
58.44
55.56
52.99
17.57
13.96

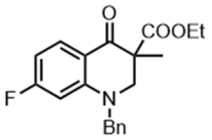
151 MHz for ^{13}C NMR in $CDCl_3$



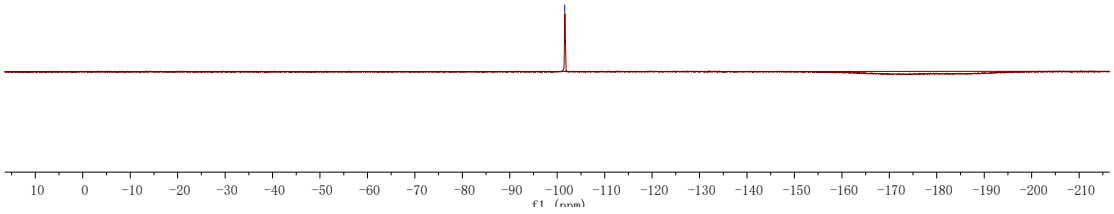
3j

−101.58

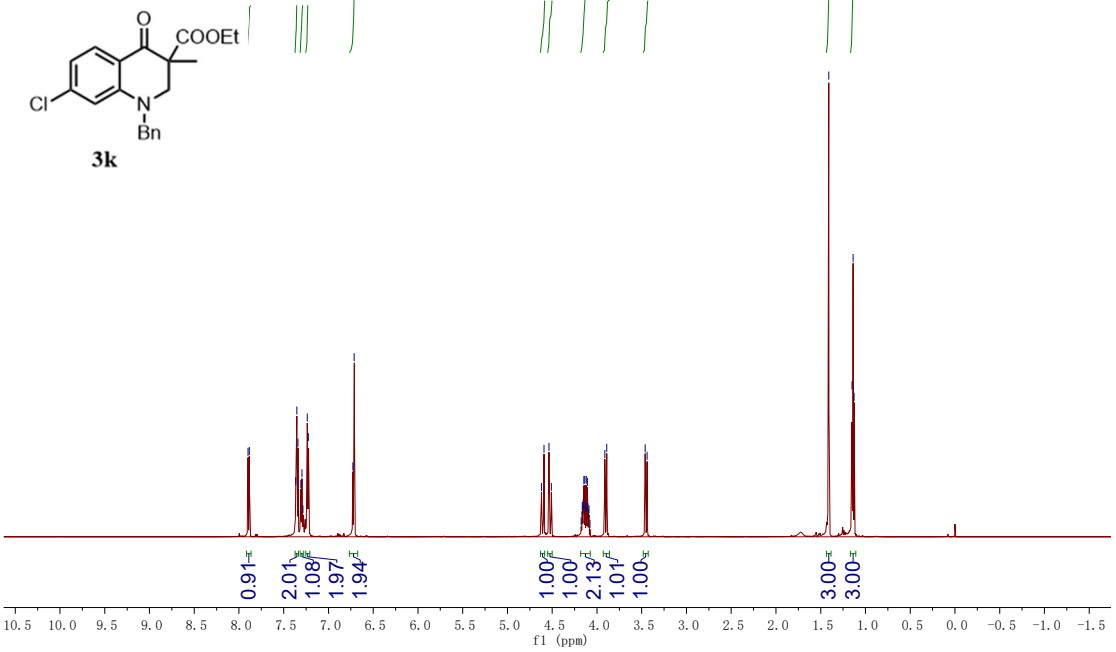
565 MHz for ^{19}F NMR in $CDCl_3$



3j

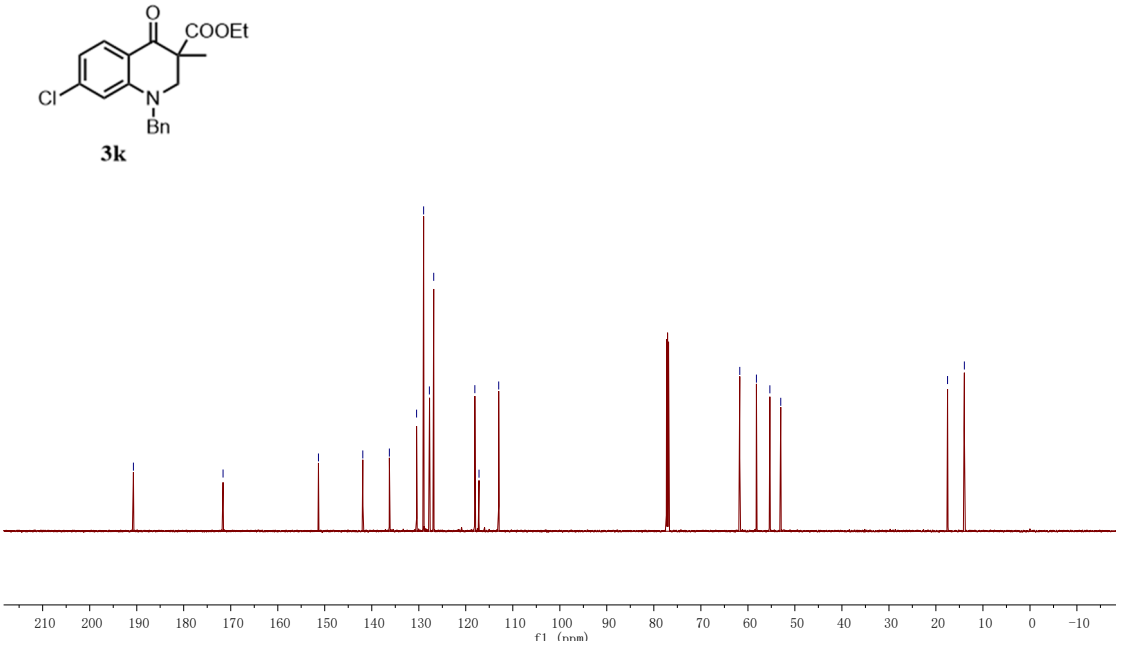


600 MHz for ^{1}H NMR in $CDCl_3$



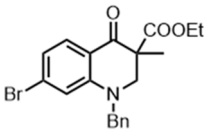
3k

151 MHz for ^{13}C NMR in $CDCl_3$



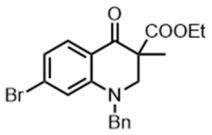
3k

600 MHz for ^{1}H NMR in $CDCl_3$



3l

151 MHz for ^{13}C NMR in $CDCl_3$



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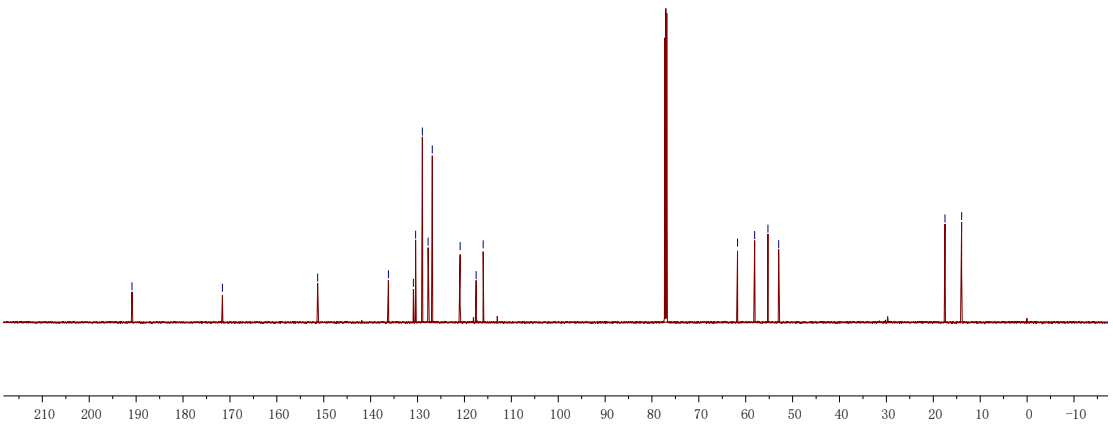
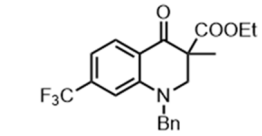
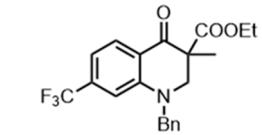


600 MHz for ^{1}H NMR in $CDCl_3$

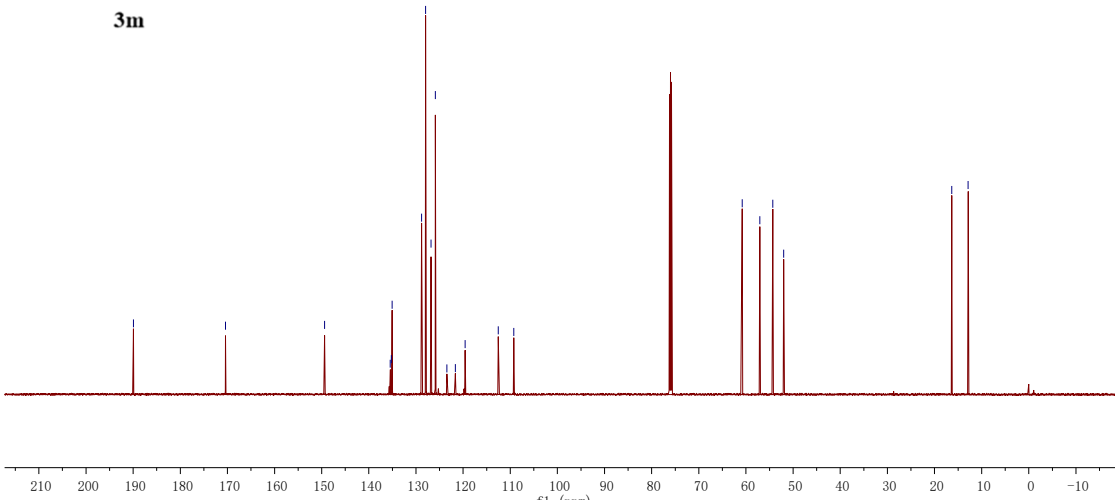


3m

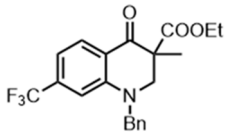
151 MHz for ^{13}C NMR in $CDCl_3$



3m

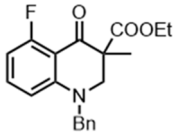


565 MHz for ^{19}F NMR in $CDCl_3$



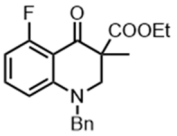
3m

600 MHz for ^{1}H NMR in $CDCl_3$

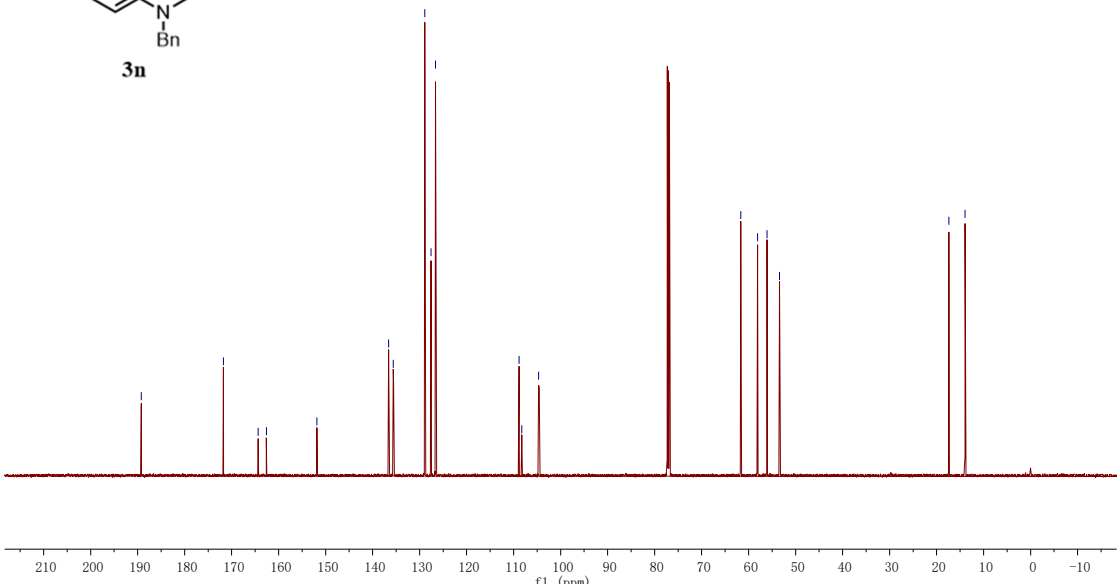


3n

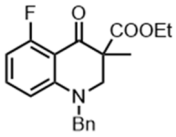
151 MHz for ^{13}C NMR in $CDCl_3$



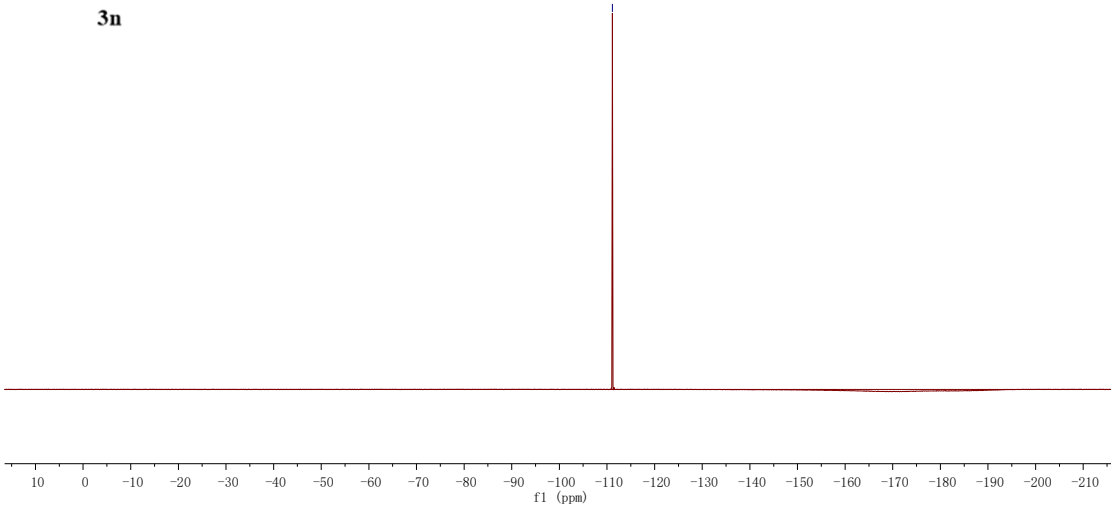
3n

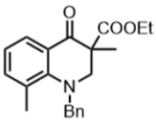


565 MHz for ^{19}F NMR in $CDCl_3$



3n

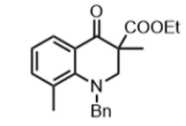




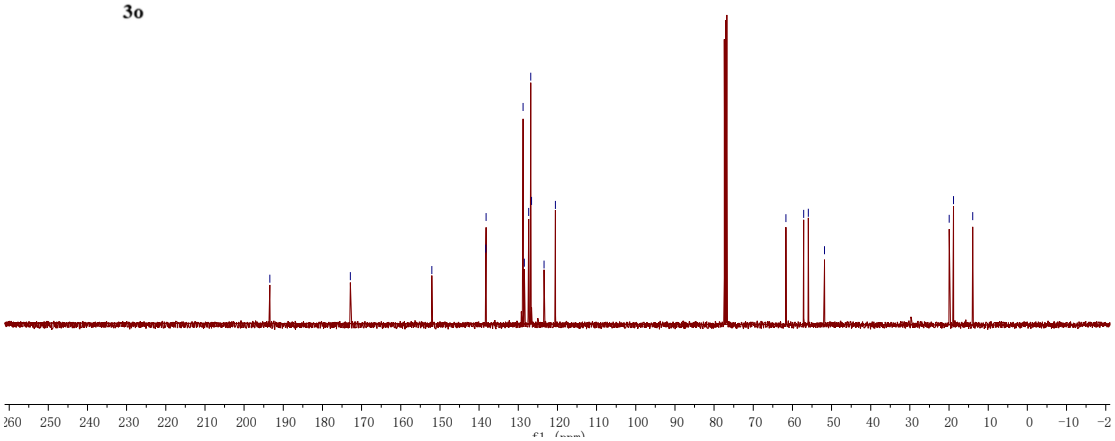
3o

400 MHz for ^{1}H NMR in $CDCl_3$

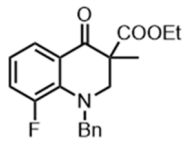
101 MHz for ^{13}C NMR in $CDCl_3$



3o

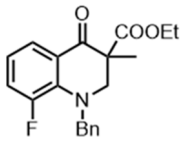


600 MHz for ^{1}H NMR in $CDCl_3$

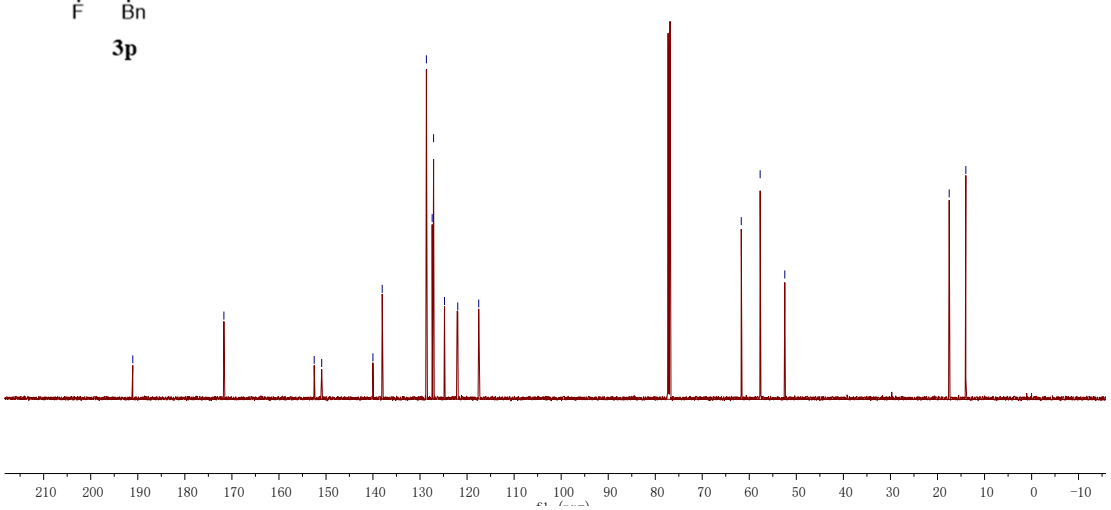


3p

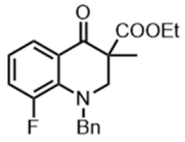
151 MHz for ^{13}C NMR in $CDCl_3$



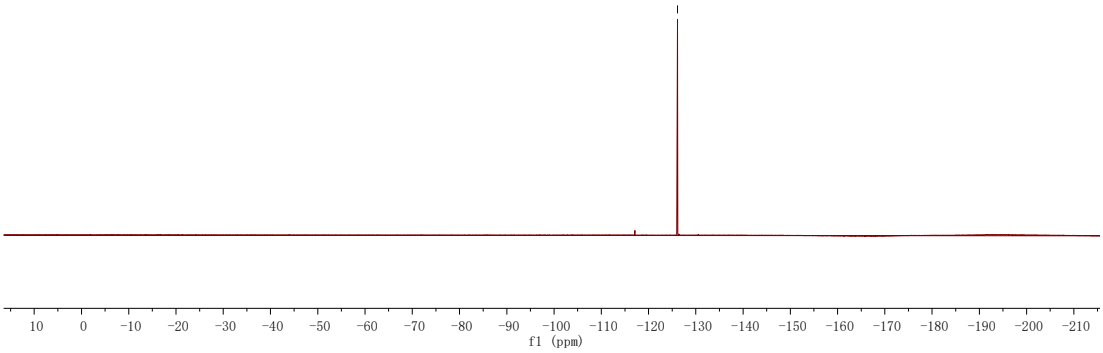
3p



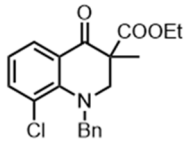
565 MHz for ^{19}F NMR in $CDCl_3$



3p

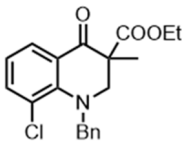


600 MHz for ^{1}H NMR in $CDCl_3$



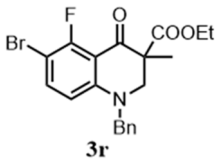
3q

151 MHz for ^{13}C NMR in $CDCl_3$



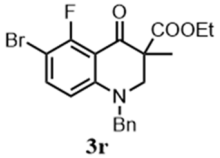
3q

600 MHz for ^{1}H NMR in $CDCl_3$



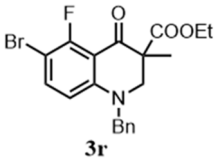
3r

151 MHz for ^{13}C NMR in $CDCl_3$

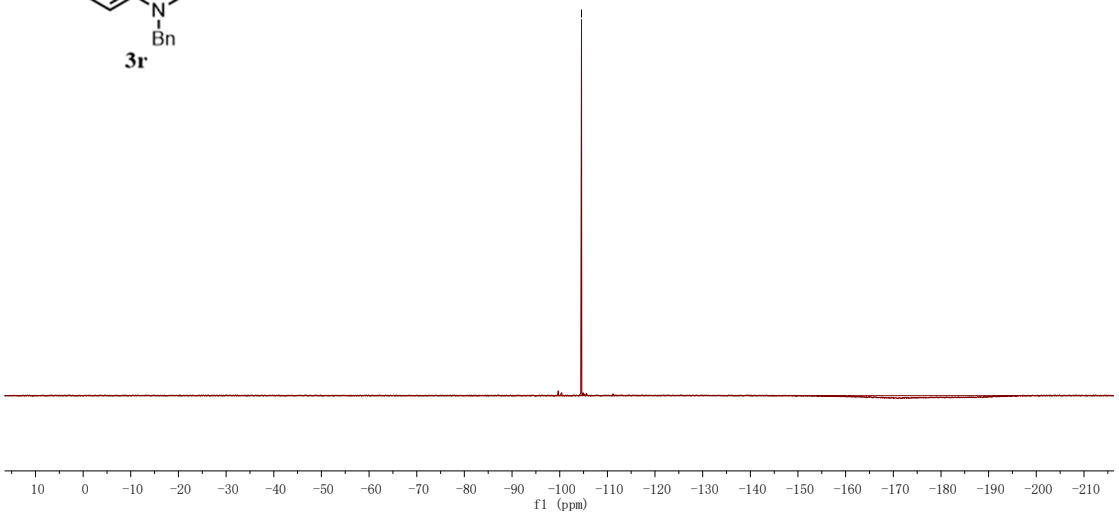


3r

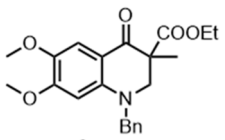
565 MHz for ^{19}F NMR in $CDCl_3$



3r

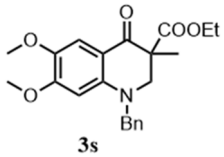


600 MHz for ^{1}H NMR in $CDCl_3$



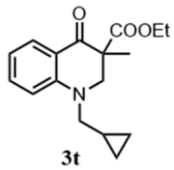
3s

151 MHz for ^{13}C NMR in $CDCl_3$



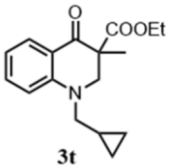
3s

600 MHz for ^{1}H NMR in $CDCl_3$



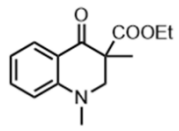
3t

151 MHz for ^{13}C NMR in $CDCl_3$

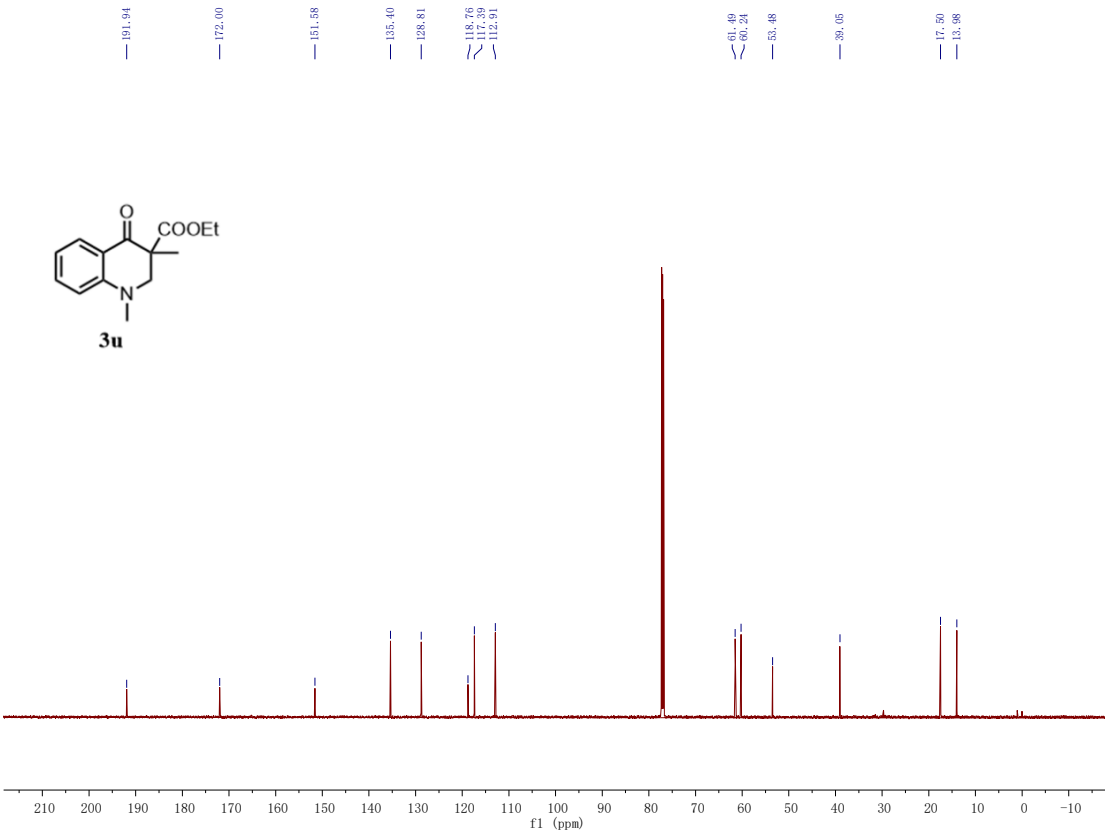


3t

600 MHz for ^{1}H NMR in $CDCl_3$

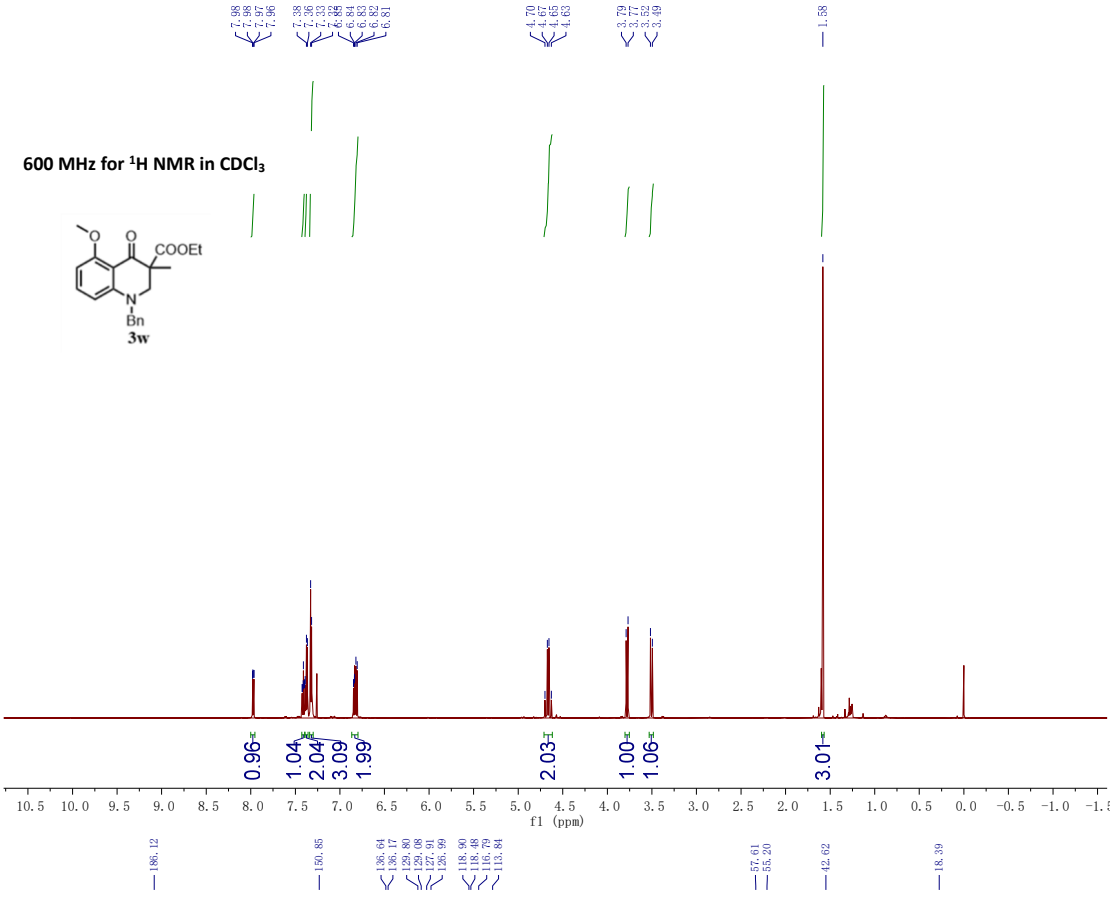


3u

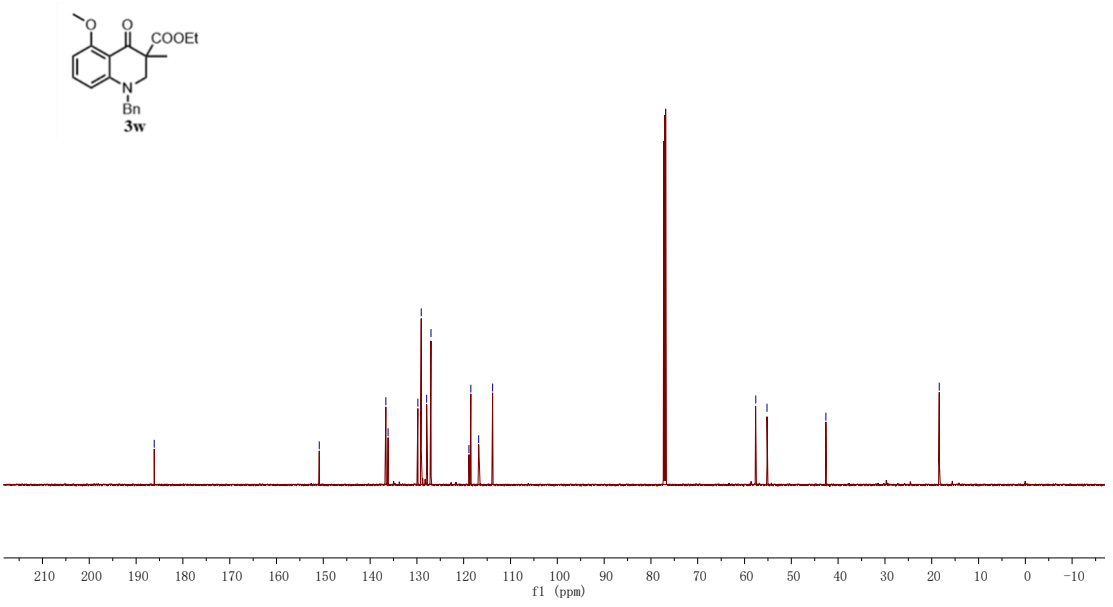


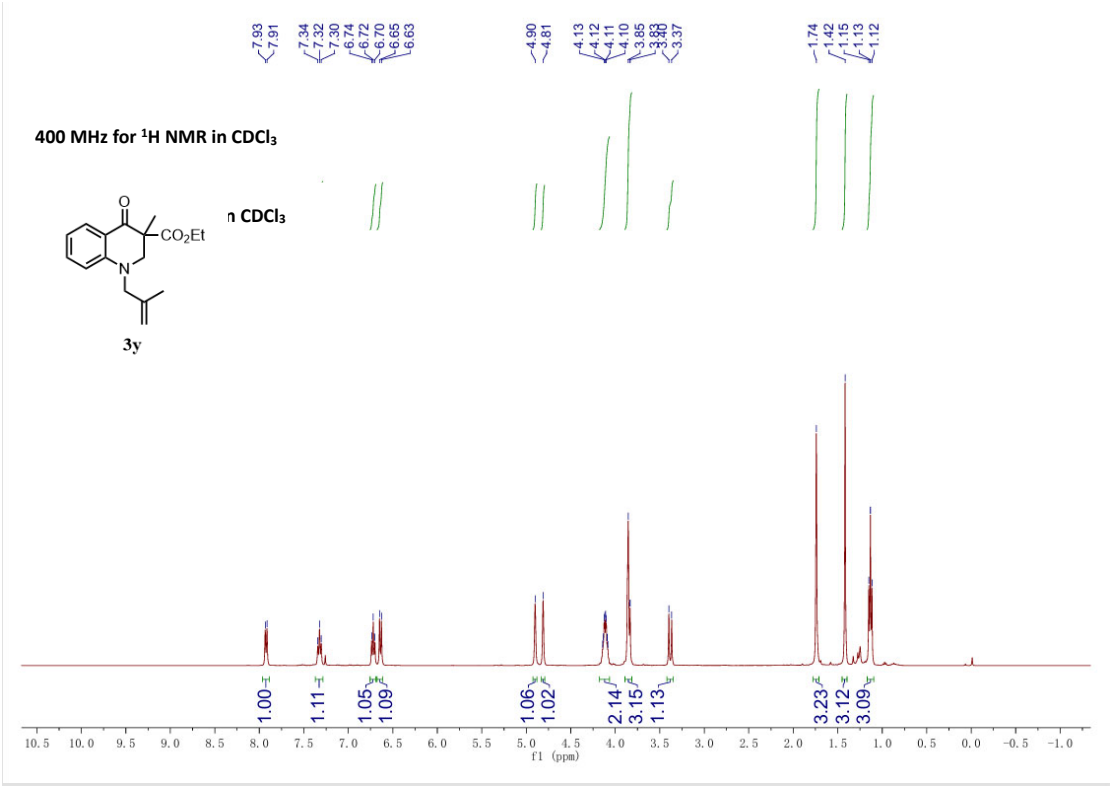
3u

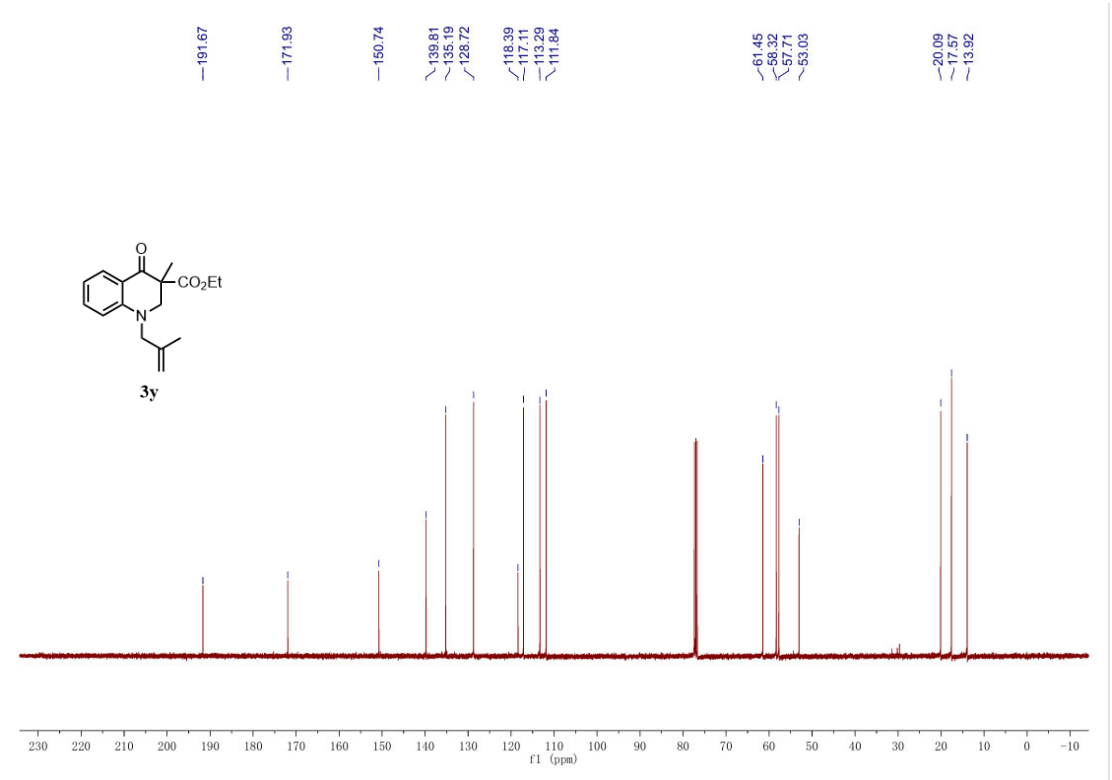
600 MHz for ^{1}H NMR in $CDCl_3$



151 MHz for ^{13}C NMR in $CDCl_3$

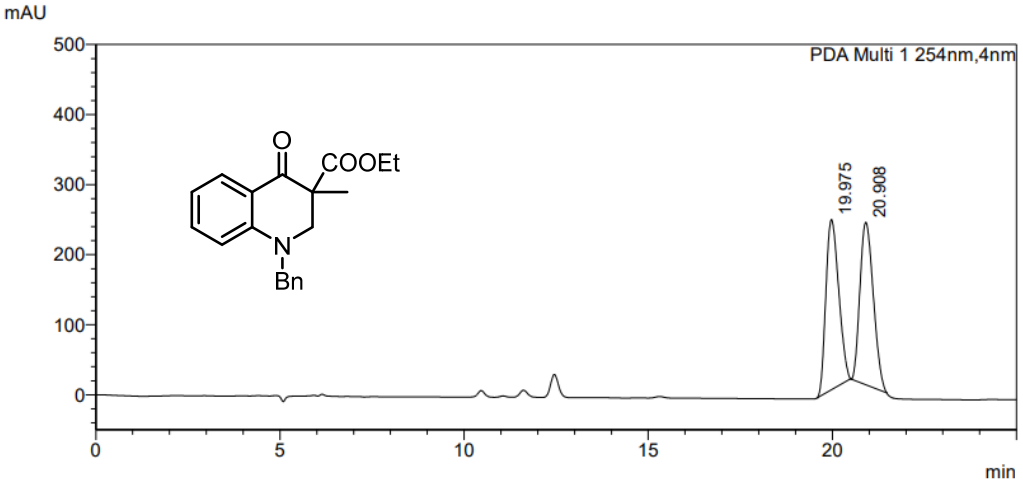



400 MHz for ^{1}H NMR in CDCl$_3$
n CDCl$_3$
3y
7.93
7.91
7.34
7.32
7.30
6.74
6.72
6.70
6.65
6.63
4.90
4.81
4.13
4.12
4.11
4.10
3.85
3.83
3.40
3.37
1.74
1.42
1.15
1.13
1.12
1.00
1.11
1.05
1.09
1.06
1.02
2.14
3.15
1.13
3.23
3.12
3.09
f1 (ppm)


3y
191.67
171.93
150.74
139.81
135.19
128.72
118.39
117.11
113.29
111.84
61.45
58.32
57.71
53.03
20.09
17.57
13.92
f1 (ppm)

9. HPLC Spectral Data of 3a

<Chromatogram>

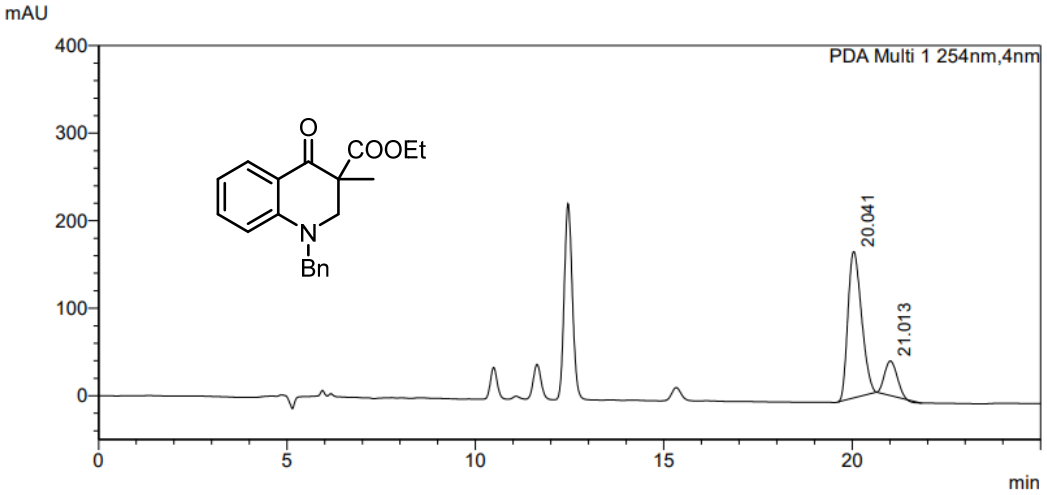


<Peak Table>

PDA Ch1 254nm

Peak#	Ret. Time	S/N	Noise	Area	Height	Area%
1	19.975	136.52	1778.84	5876846	242842	49.988
2	20.908	130.34	1778.84	5879706	231861	50.012
Total				11756552	474703	100.000

<Chromatogram>



<Peak Table>

PDA Ch1 254nm

Peak#	Ret. Time	S/N	Noise	Area	Height	Area%
1	20.041	20.32	8225.37	4194072	167120	82.473
2	21.013	4.78	8225.37	891335	39352	17.527
Total				5085407	206472	100.000