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Supplementary information

Facile access to fused 2D/3D rings via intermolecular cascade dearomative [2 + 2] cycloaddition/rearrangement reactions of quinolines with alkenes

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Supplementary Information for

Facile Access to Fused 2D/3D Rings via Intermolecular Cascade Dearomative [2+2] Cycloaddition/Rearrangements of Quinolines with Alkenes

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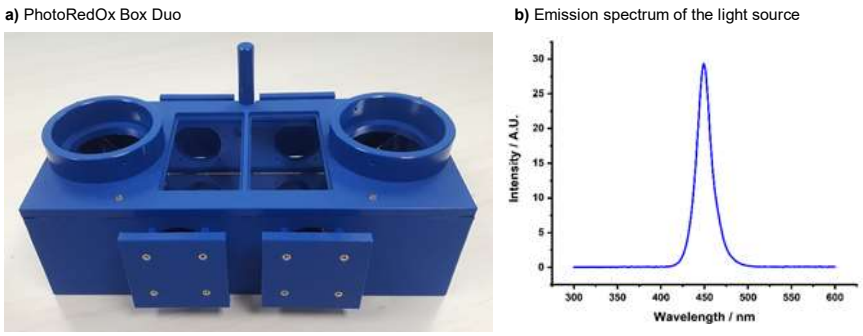
General remarks

Unless otherwise noted, all reactions were carried out under an atmosphere of argon in flame-dried glassware. Reaction temperatures are referred to the ones of the heating/cooling media (heating block, cryogenic bath), unless otherwise stated. Dry solvents were either purchased from ACROS Organics (H_2O < 50 ppm), stored under activated molecular sieves, withdrawn under positive argon pressure or purified using a custom-made SPS purification system (activated alumina columns) and transferred under argon.

Solvents for flash column chromatography (*n*-pentane, EtOAc, CH_2Cl_2) were purchased of technical grade and purified by atmospheric pressure distillation or purchased of reagent grade (MeOH, acetone, Et_2O) and used without additional purification. Reagents were purchased from Sigma-Aldrich, ACROS Organics, TCI, Combiblocks, Fluorochem, Merck and used without additional purification, unless otherwise stated.

Photochemical set-up

Photochemical reactions were performed in a Hepatochem EvoluChem™ PhotoRedOx Box Duo device and irradiated with two EvoluChem™ P303-30-1 LEDs (30 W, λ_{max} = 450 nm). The reaction temperature was measured not to exceed room temperature more than 9 °C, using this setup.



Supplementary Figure 1. Photoreaction setup. a) Image showing the Hepatochem EvoluChem™ PhotoRedOx Box Duo (without light sources and vial holders). Courtesy of Hepatochem. b) Measured emission spectrum of the EvoluChem™ P303-30-1 LEDs light.

Purification techniques

Flash chromatography was performed on Merck silica gel (40-63 mesh) under a slight positive pressure, according to the procedure by Still and co-workers. Thin layer chromatography (TLC) as carried out on Merck silica gel $60F_{254}$ pre-coated aluminum sheets and were visualized using UV light (254 nm) and stained with basic aqueous potassium permanganate (2 g $KMnO_4$, 10 g K_2CO_3, 0.3 g of NaOH in 200 ml of deionized water) or alcoholic solution of phosphomolybdic acid (10 g of PMA in 100 ml of absolute EtOH) dips.

Analytical techniques

NMR-spectra were recorded on a Bruker DPX 300, Avance II 300, Avance II 400 MHz, NEO 400 MHz, Agilent DD2 500 or DD2 600 spectrometers. Chemicals shifts (δ) are quoted in ppm downfield of tetramethylsilane (0.00 ppm). The residual solvent signals were used as references for ^{1}H and ^{13}C NMR spectra ($CDCl_3$: δ_H = 7.26 ppm, δ_C = 77.16 ppm; DMSO-d_6: δ_H = 2.50 ppm, δ_C = 39.52 ppm; CD_3OD: δ_H = 4.87 ppm, δ_C = 49.00 ppm; acetone-d_6: δ_H = 2.05 ppm, δ_C = 206.26 ppm). ^{19}F NMR spectra were calibrated using absolute referencing to the ^{1}H NMR spectrum, as suggested by IUPAC.[1] Coupling constants (*J*) are quoted in Hz and rounded to the nearest 0.1 Hz. The multiplicity abbreviations used (or combinations thereof) are: s = singlet, d = doublet, t = triplet, q = quartet, hept = heptet, m = multiplet.

High-resolution mass spectra (HRMS) were obtained by the MS service of the Organisch-Chemisches Institut, Westfälische Wilhelms - Universität Münster, using electrospray ionisation (ESI) on a Bruker Daltonics, MicroToF spectrometeror Thermo-Fisher Scientific Orbitrap LTQ XL spectrometer.

Absorption spectra were recorded on a JASCO V-730 two-beam UV/Vis spectrometer using the following parameter set: spectral bandwith 1.0 nm, response time 0.06 s, data interval 0.5 nm, baseline correction. All samples were measured in *Hellma* fluorescence QS quartz cuvettes (chamber volume 1.4 mL, dimension: 46 mm x 12.5 mm x 12.5 mm) fitted with a PTFE stopper.

Sensitivity Screening

The sensitivity assessment was performed according to Glorius and co-workers.[2] The following reactions were set-up in order to assess the influence of different reaction parameters:

Supplementary Table 1. Entries for condition-based sensitivity screening.

Entry		Note
1	Standard	
2	Standard jacketed	Jacketed, still water
3	Low concentration (-10%)	
4	High concentration (-10%)	
5	High intensity (ca. 16x)	d = 0.5 cm
6	Low intensity (ca. 1/16)	d = 8.8 cm
7	High temperature	Wrapped with aluminium foil
8	High H_2O (10^4 ppm)	5 µl of H_2O added
9	Medium O_2	Only argon filling the vessel
10	High O_2	5 ml of air injected in solution
11	Low temperature	Jacketed, water flowing
12	Large scale (30x)	Isolated yield

Step 1. Preparation of the stock solution (for 12 reactions)

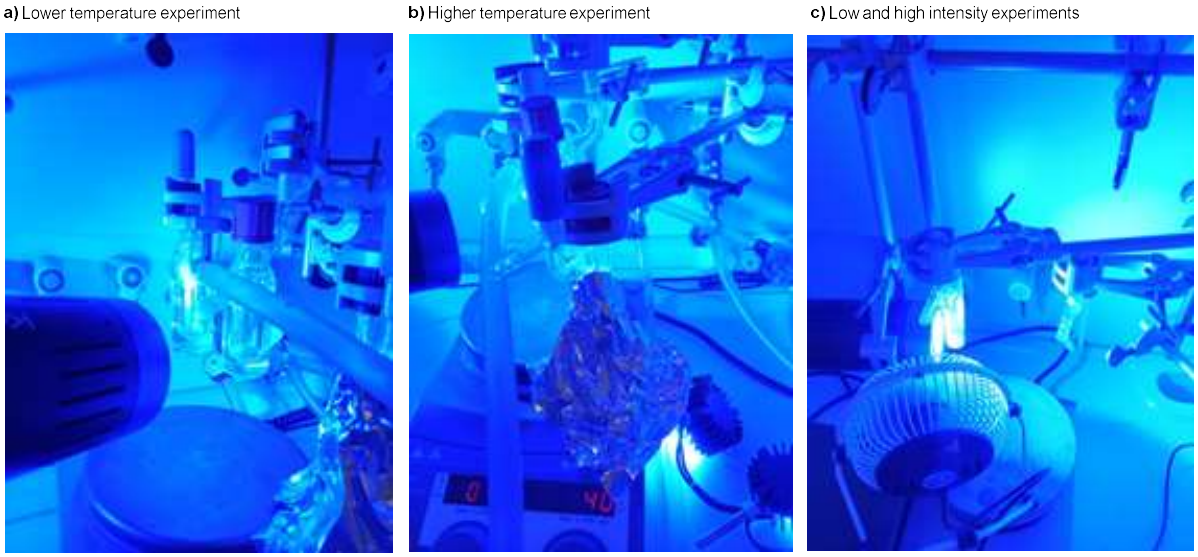
In an oven-dried round-bottom flask equipped with a PTFE-coated stirring bar, 6-chloroquinoline (196.3 mg, 0.10 mmol for each reaction), Ir-F (26.9 mg, 2 mol% for each reaction) were dissolved in HFIP (4.8 ml) and 2-bromopropene (213 µl, 0.20 mmol for each reaction) was added and the yellow clear solution was thoroughly stirred.

Step 2. Preparation of the reactions (except large scale reaction)

In an oven-dried Schlenk tube equipped with a PTFE-coated stirring bar (one for each reaction), 400 µl of stock solution were added under air, followed by the appropriate amount of HFIP (50 µl for all the reactions except #3 – 100 µl and #4 – none added) and HCl 4M in 1,4-dioxane (50 µl, 0.20 mmol for each reaction). In case further addition of substances or treatments to be performed

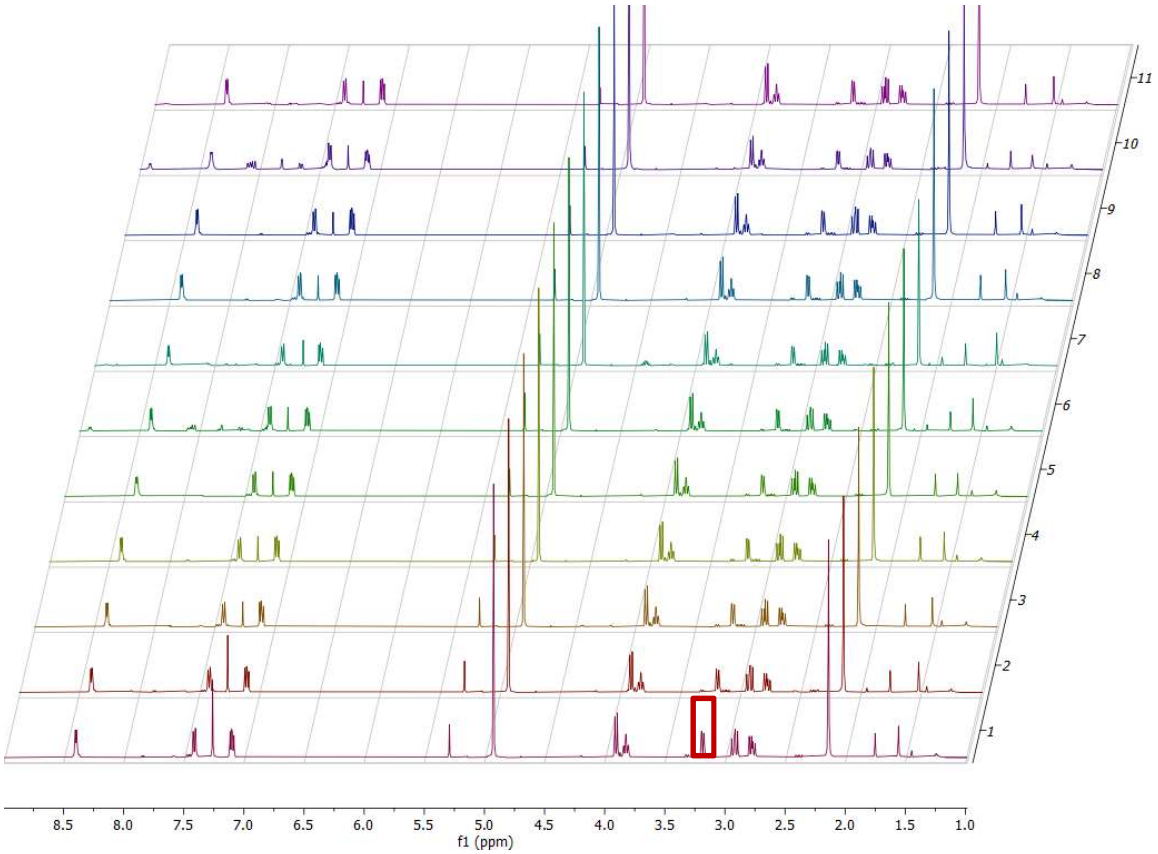
these were carried out at this stage. The reactions, except the ones at higher oxygen concentrations, were degassed by freezing the solutions with liquid nitrogen, followed by vacuum-argon exchange (five times).

For reactions #1, 3, 4, 8-11, the standard photobox set-up was used for irradiation, while #2, 5-7, 11 were irradiated as shown in **Supplementary Figure 2**.



Supplementary Figure 2. Photoreaction setup for sensitivity screening. a) Lower temperature experiment. The jacketed Schlenk tubes were filled either with still water or flowing water from the cooling system and irradiated with a Kessil light H150 blue (34W 455 nm). b) Higher temperature experiment. The reaction was wrapped with aluminium foil to reduce the extent of heat dissipation. c) Low and high intensity experiments. The Schlenk tubes were placed either at 0.5 or 8.8 cm away from the light source and irradiated with a Kessil light H150 blue (34W 455 nm). A cooling fan was installed to provide increased heat dissipation.

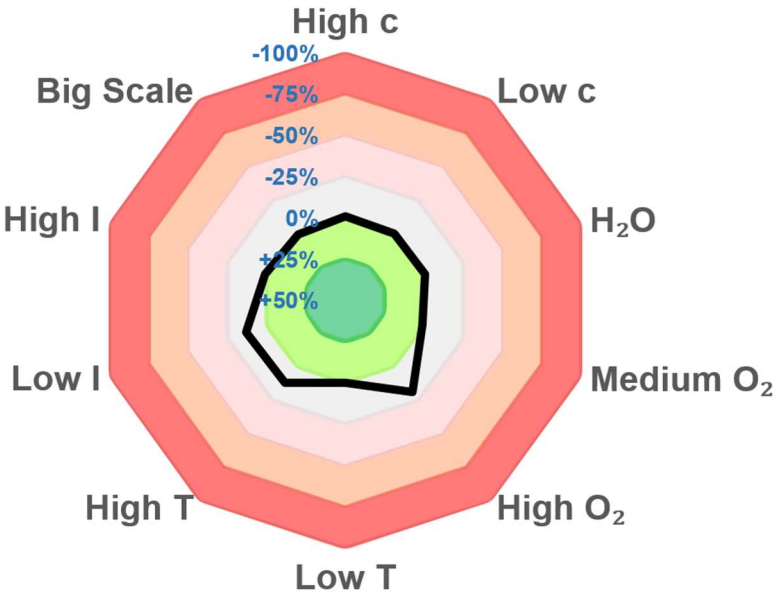
After 24 hours of irradiation, the reactions were transferred to a separating funnel with CH_2Cl_2 (10 ml), neutralized with saturated $NaHCO_3$ (5 ml) and the layers were separated. The aqueous layer was extracted twice with CH_2Cl_2 (5 ml), then the combined extracts were dried over $MgSO_4$ and the solvent was removed *in vacuo*. The residue was dissolved in $CDCl_3$ and analysed by ^1H NMR, using dibromomethane as internal standard (d_1 = 30 s). The resonance at 2.93 ppm was chosen as it minimizes overlap with by-products (**Supplementary Figure 3**).



Supplementary Figure 3. Overlay of ^{1}H NMR spectra (400 MHz, $CDCl_3$) of the crude reactions, with d_1 = 30 seconds.

Supplementary Table 2. Results for condition-based sensitivity screening

Entry		Yield %	Deviation %
1	Standard	78	--
2	Standard jacketed	77	--
3	Low concentration (-10%)	78	0
4	High concentration (-10%)	77	-1
5	High intensity (ca. 16x)	77	-1
6	Low intensity (ca. 1/16)	65	-13
7	High temperature	66	-12
8	High H_2O (10^4 ppm)	77	-1
9	Medium O_2	79	+1
10	High O_2	59	-19
11	Low temperature	77	0
12	Large scale (6 mmol, isolated yields)	73	+1



Supplemmentary Figure 4. Radar diagram showing the sensitivity assessment results.

Comment on the results. As detailed in **Supplementary Table 2** and **Supplemmentary Figure 4**, the reaction proved compatible with moderate positive and negative concentration variations, wet solvent, scaling up, high light intensity and reduced temperature, as well as less effective degassing

(sparging instead of freeze-pump-thaw). We observed a moderate reduction of the yield in the case of low irradiation intensity (-13%), as well as with increased temperatures (-12%) and under aerobic conditions (-19%).

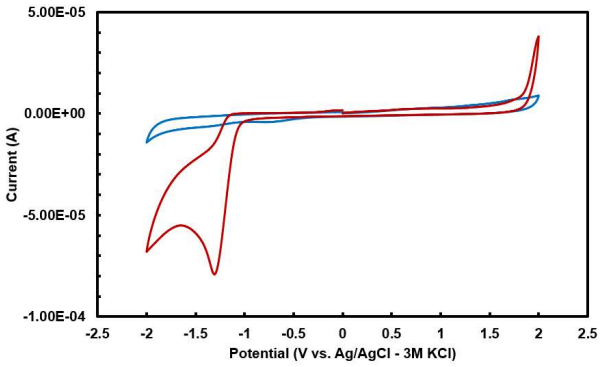
Mechanistic investigation

Ruling-out of single-electron transfer pathways

In order to exclude the possibility of single-electron oxidation or reduction of the quinoline substrate, cyclovoltammetry experiments were carried in order to assess the redox potentials.

Preparation of **1a·HCl.** In a round-bottom flask equipped with a PTFE-coated stirring bar, **1a** (1.0 equiv.) was dissolved in CH_2Cl_2 (0.2 M), then HCl 4 M in 1,4-dioxane (2.0 equiv.) was added under vigorous stirring. The reaction was stirred at room temperature for 2 hours, then the volatiles were removed *in vacuo* and the corresponding white solid was dried under high vacuum.

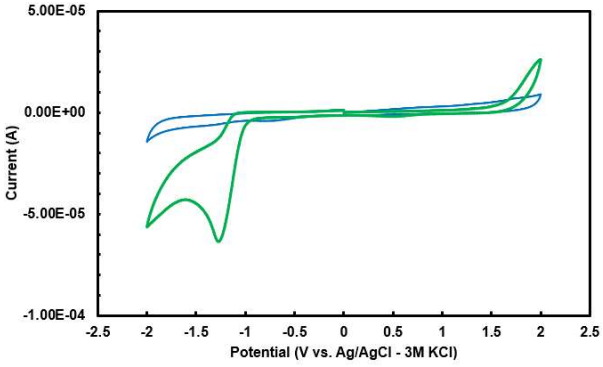
Measurement of the redox potential of **1a** and **1a·HCl** in HFIP. a standard three-electrode cell configuration was used to collect cyclic voltammograms (CVs) at room temperature with a CHI600e electrochemical workstation (CHI Instruments, Austin, Texas, USA). A 3 mm glassy carbon disc electrode, a Ag/AgCl (3 M KCl) electrode, and a platinum wire were used as the working electrode, reference electrode, and counter electrode, respectively. The scan rate was set to 100 mV/s. The electrolyte solution contains 0.1 M tetrabutylammonium hexafluorophosphate ($TBAPF_6$) and 5 mM **1a** or **1a·HCl** in HFIP, which was preliminarily degassed by freeze-pump-thaw. For comparison with reported redox potentials of the photosensitizers, the reference electrode potential was converted to the saturated calomel electrode (SCE) scale. Argon gas protection was applied during the test to avoid the interference of atmospheric oxygen. A sharp reduction peak with a half peak potential of -1.18 V and -1.12 vs. Ag/AgCl were observed in the cathodic reduction scan (**Supplementary Figures 5** and **6**) for 1a and 1a·HCl, respectively. This peak was not observed in blank electrolyte solution, thus is attributed to the reduction of the analyte. The analytes itself are free of oxidation at least at 1.80 V vs. Ag/AgCl, as no oxidation process was observed below this potential in the anodic oxidation scan. The current wave beyond 1.80 V vs. Ag/AgCl is either due to the oxidation of the analyte or the solvent.



Supplementary Figure 5. Cyclovoltammogram of **1a** (5 mM) in 0.1 M $TBAPF_6$ HFIP solution (0.1 M).

E_{red} (1a) = -1.18 V vs Ag/AgCl

E_{red} (1a·HCl) = -1.12 V vs Ag/AgCl



Supplementary Figure 6. Cyclovoltammogram of **1a·HCl** (5 mM) in 0.1 M $TBAPF_6$ HFIP solution (0.1 M).

E_{red} (1a) = -1.22 V vs SCE

E_{red} (1a·HCl) = -1.16 V vs SCE

Comment on the results. Given the redox potentials of the employed photocatalyst Ir-F ($E_{1/2}^{PC+/PC*}$ = -0.89 V vs SCE; $E_{1/2}^{PC*/PC-}$ = +1.21 V vs SCE) in comparison with **1a** and **1a·HCl**, neither a reductive nor an oxidative quenching towards **1a** or **1a·HCl** appears possible, therefore ruling-out the operativity of a single-electron transfer pathway (see **Supplementary Figures 5** and **6**).

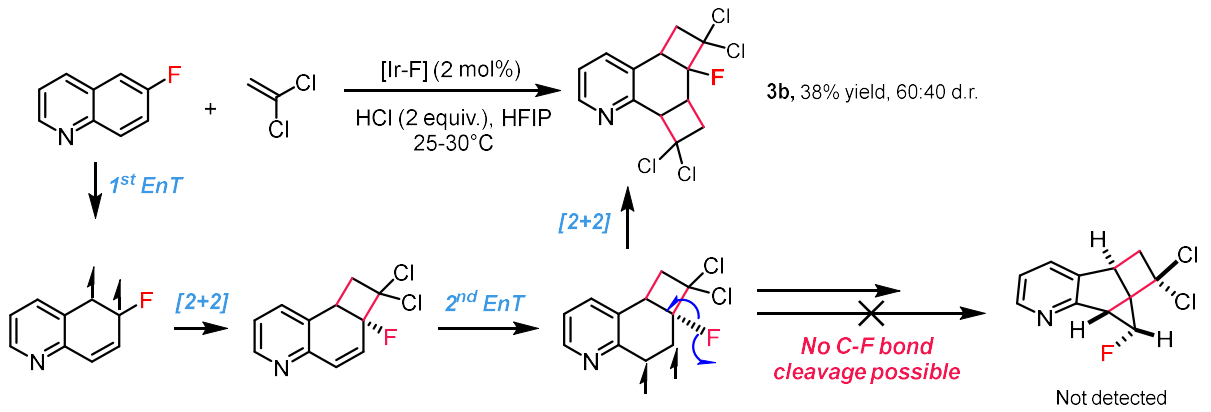
Evidence of a cascade energy transfer

Experimental set-up. A dried 5 mL Schlenk tube was charged with the 6-fluoroquinoline (29.4 mmol, 0.2 mmol, 1.0 equiv.), 1,1-dichloroethene (80 µl 1.0 mmol, 5.0 equiv.), HCl (4 M in 1,4-dioxane, 100 µl, 0.4 mmol, 2.0 equiv.) and [Ir(*d*F(CF_3)ppy$_2$)(dtbbpy)][PF_6] (4.4 mg, 0.004 mmol, 2 mol%) in 1,1,1,3,3,3-hexafluoro-2-propanol (1 ml). The reaction mixture was degassed via freeze-pump-thaw for two cycles. After the mixture was thoroughly degassed and filled with argon, the Schlenk tube was sealed tightly and stirred under irradiation with 30 W blue LEDs (λ_{max} = 450 nm) for 24 hours. The reaction was subsequently quenched by saturated aqueous $NaHCO_3$ and extracted with CH_2Cl_2 (10 mL × 3). The organic phases were combined and concentrated under reduced pressure. ^{1}H NMR analysis of this crude reaction mixture gave the d.r. values. Finally, the product was obtained by flash chromatography on silica gel (*n*-pentane/EtOAc = 8/1), affording **3b** (25.9 mg, 0.076 mmol, 38%) as a mixture (60:40) of diastereoisomers.

^{1}H NMR (400 MHz, $CDCl_3$, mixture of two diastereomers) δ 8.65 (dd, *J* = 5.0, 1.6 Hz, 1H, major), 8.54 (dd, *J* = 4.9, 1.6 Hz, 1H, minor), 7.48 (dt, *J* = 7.8, 1.3 Hz, 1H, major), 7.36 (ddd, *J* = 7.8, 1.7, 0.8 Hz, 1H, minor), 7.29-7.26 (m, 1H, major), 7.19 (ddd, *J* = 7.8, 4.9, 0.9 Hz, 1H, minor), 4.60 (dp, *J* = 9.1, 1.5 Hz, 1H, major), 3.99 (d, *J* = 12.9 Hz, 1H, minor), 3.90-3.79 (m, 1H, mixture of major and minor), 3.68 (tdd, *J* = 9.2, 8.0, 1.3 Hz, 1H, major), 3.59 (ddd, *J* = 13.2, 10.3, 1.8 Hz, 1H, major), 3.34-3.23 (m, 1H, mixture of major and minor), 3.23 – 3.16 (m, 1H, minor), 3.07 (dd, *J* = 11.4, 6.7 Hz, 1H, minor), 2.98 (ddd, *J* = 14.0, 8.1, 1.3 Hz, 1H, major), 2.84-2.66 (m, 1H, mixture of major and minor), 2.44 (ddd, *J* = 13.0, 9.8, 0.8 Hz, 1H, minor).

^{13}C NMR (151 MHz, $CDCl_3$, mixture of two diastereomers) {^{1}H, ^{19}F} δ 146.64, 142.85, 136.89, 132.48, 125.83, 124.51, 98.07, 94.81, 83.41, 83.18, 82.68, 55.82, 49.48, 45.59, 45.07, 40.81, 37.94, 37.89, 37.02, 29.76.

HRMS (ESI, *m/z*) calcd for $C_{13}H_{10}NCl_4FNa^+$ $[M+Na]^+$: 363.9414, found: 363.9414.



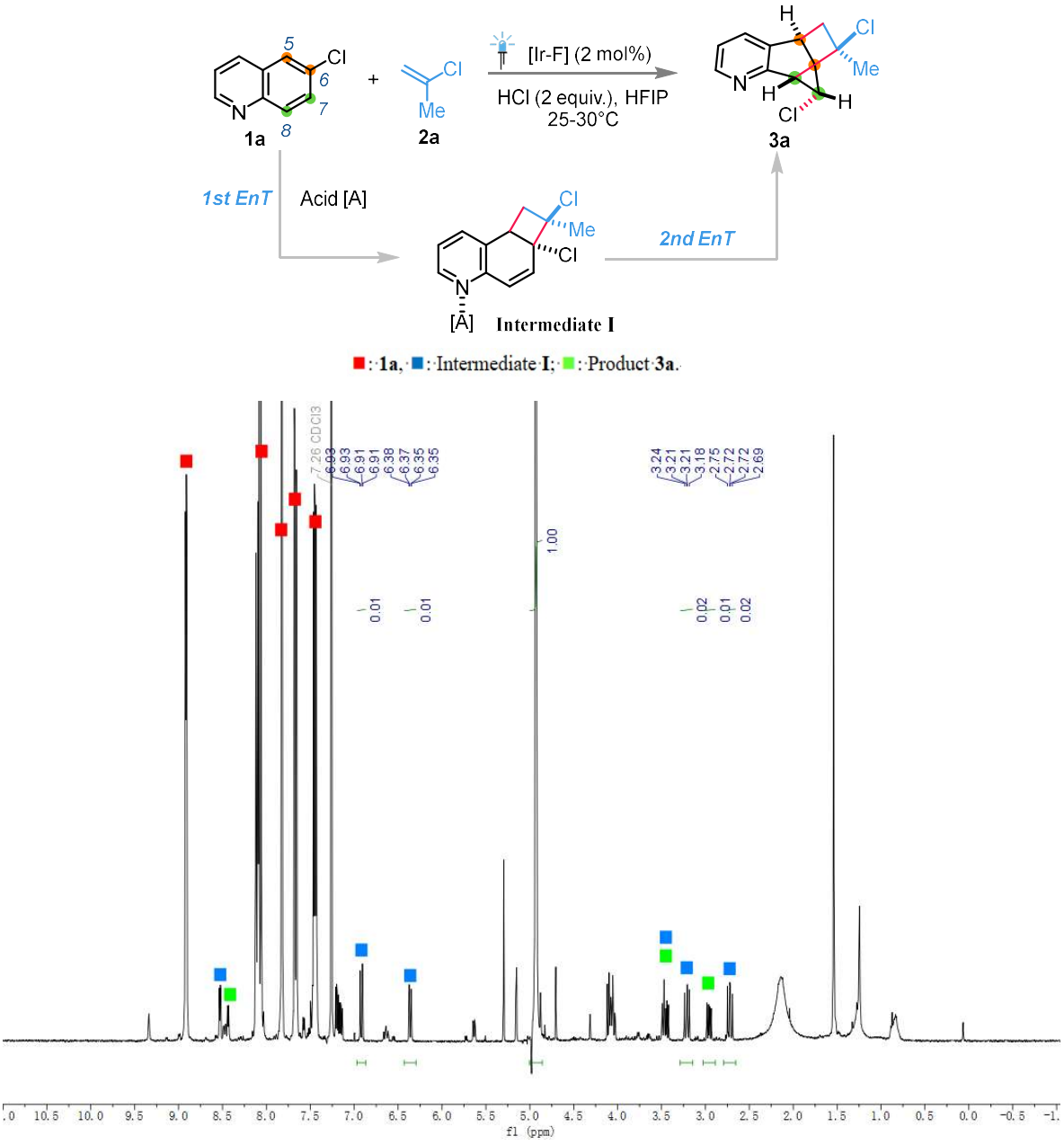
Supplementary Figure 7. 6-Fluoroquinoline led to a twofold [2+2] cycloadditions product which is an evidence for cascade energy transfer process.

Comment on the results. The twofold [2+2] cycloaddition, which arises from the impossibility of C–F bond cleavage upon the second photoexcitation process, suggests the operability of the cascade energy transfer mechanism (**Supplementary Figure 7**).

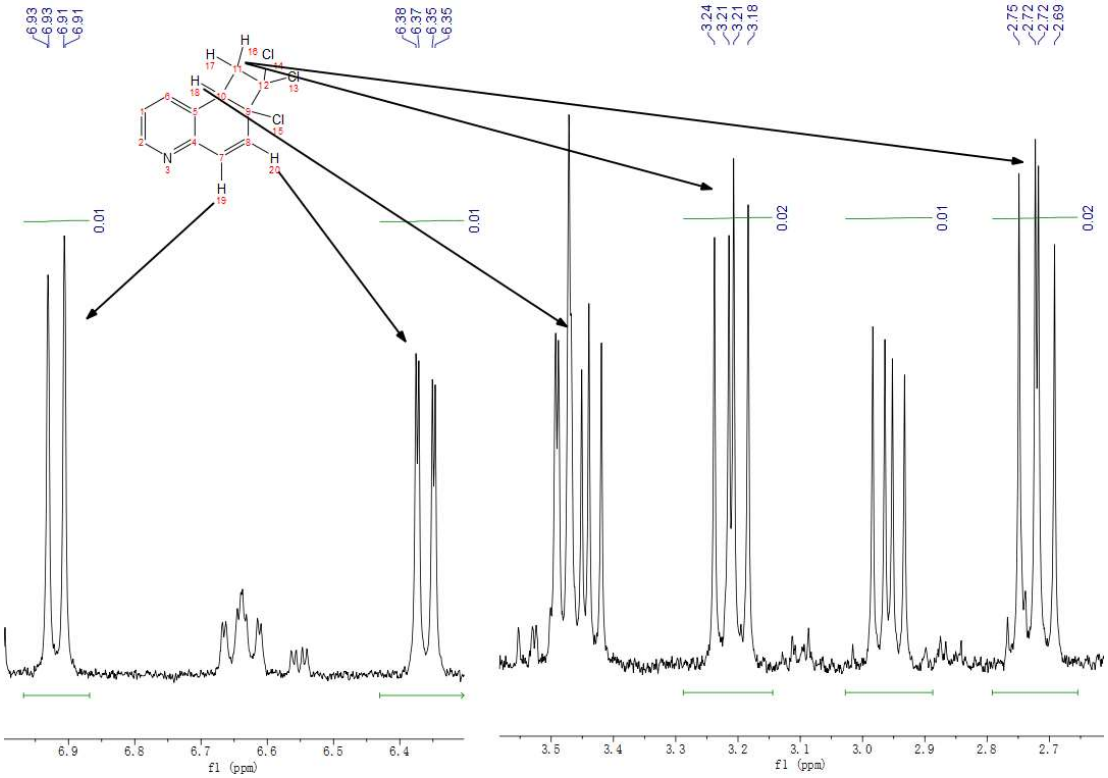
Detection of the reaction intermediate I

Experimental procedure. In a scintillation vial equipped with a PTFE-coated stirring bar and a PTFE septum, **1a** (8.2 mg, 0.05 mmol, 1.00 equiv.) and Ir-F (1.1 mg, 0.001 mmol, 2 mol%) were charged, then the vessel was evacuated and back-filled with argon (three times). HFIP (0.25 ml) was

added, then 1,1-dichloroethene (20 µl, 0.25 mmol, 5.0 equiv.) and HCl 4 M in 1,4-dioxane (25 µl, 0.1 mmol, 2.00 equiv.) were added and the reaction was irradiated at 450 nm with a single blue LED. After 30 minutes, the irradiation was interrupted and the reaction was diluted with CH_2Cl_2 (5 ml) and washed with saturated aqueous $NaHCO_3$ (5 ml). The aqueous layer was extracted twice with CH_2Cl_2 (5 ml each time), then the combined organic extracts were concentrated *in vacuo*. The crude was analyzed by ^1H NMR, using dibromomethane as internal standard.



Supplementary Figure 8. ^1H NMR (400 MHz, $CDCl_3$) spectrum of the reaction after 30 minutes. CH_2Br_2 used as internal standard.



Supplementary Figure 9. Close-up of the ^{1}H NMR (400 MHz, $CDCl_3$) spectrum of the reaction after 30 minutes, with regards of the olefin protons and the cyclobutane ring system.

Comment on the results. By means of ^{1}H NMR analysis on the reaction mixture before reaction completion allowed to monitor the presence of the intermediate **I** (after neutralization), which shows typical ^{1}H NMR signals (**Supplementary Figures 8** and **9**). In addition, the ratio of product/intermediate increases overtime, further corroborating the proposed intermediacy of such [2+2]-cycloaddition species in the catalytic manifold (see **Supplementary Table 3**).

Initial-rate kinetic analysis of the reaction

In order to achieve more controllable irradiation conditions, a single-LED set-up was used in combination with scintillation vials equipped with PTFE septa. The distance between the light source and the flat bottom of the vial was measured to be 4 cm.

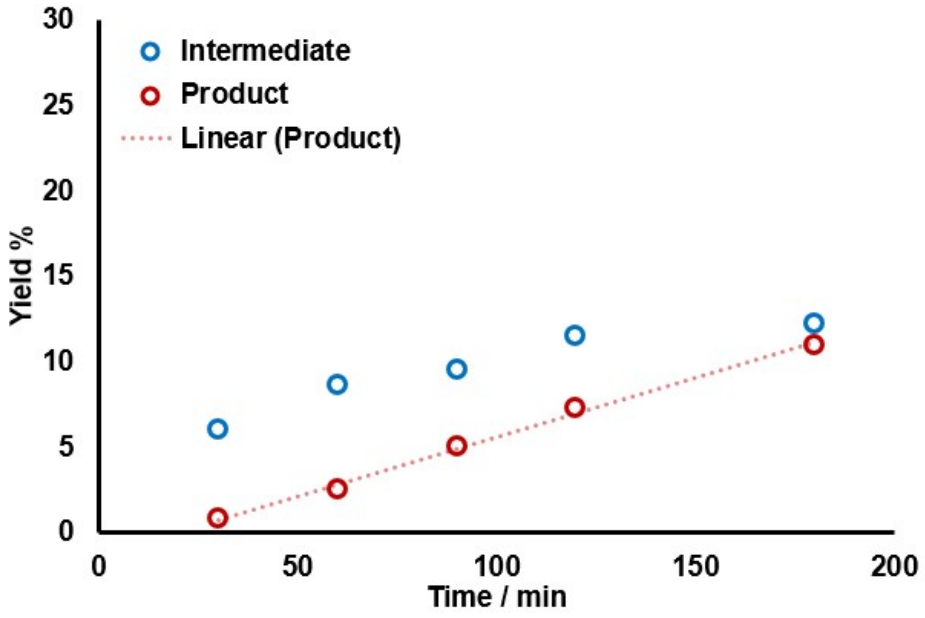
Set-up procedure. In an oven-dried Schlenk tube equipped with a PTFE-coated stirring bar, 6-chloroquinoline (0.05 mmol for each reaction) and Ir-F (2 mol% for each reaction) were weighted under air, then the vessel was evacuated and back-filled with argon (three times). HFIP (250 µl) for each reaction, followed by HCl 4 M in 1,4-dioxane (0.1 mmol for each reaction) were consecutively added, then the solution was stirred for 30 seconds and degassed by freeze-pump-thaw (three times).

Individual aliquots were transferred to argon filled scintillation vials equipped with a PTFE-coated stirring bars, then 1,1-dichloroethene (20 µl for each reaction) was added through the septum and the reactions were irradiated with the custom setup for the indicated amount of time. Upon completion of the irradiation, the reaction was partitioned between CH_2Cl_2/saturated $NaHCO_3$ (1:1, 10 ml), then the aqueous layer was extracted twice with CH_2Cl_2 (5 ml each time) and the combined organic layers were removed in vacuo. The residue was dissolved in $CDCl_3$ and analyzed by ^1H NMR, using dibromomethane as internal standard.

Supplementary Table 3. Experimental data for the initial rate kinetic measurement.

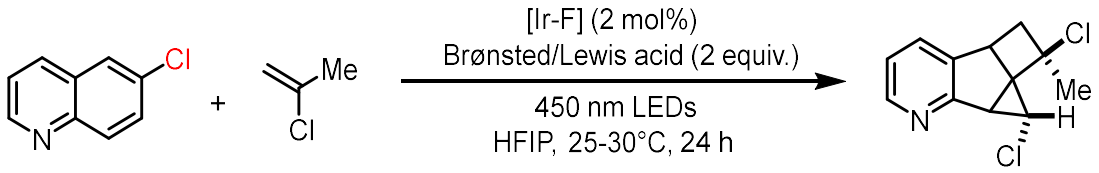
Time / min	Integral STD / A.U.	Integral Int I / A.U.	Integral 3a / A.U.	Yield Int I (%)	Yield 3a (%)	Ratio 3a/Int I
30	150042943	2237946.6	293848.56	6.0	0.8	1:7.5
60	131171420	2829765.8	812021.54	8.6	2.5	1:3.44
90	111314892	2645769.3	1393971.4	9.5	5.0	1:1.9
120	138428547	3970594.2	2525472.9	11.5	7.3	1:1.57
180	137021683	4176383.7	3749370.7	12.2	10.9	1.12:1

Slope	0.069±0.003
Intercept	1.4±0.4
R^2	0.996



Supplementary Figure 10. Initial-rate kinetic profile of the reaction.

Use of different Brønsted/Lewis acids



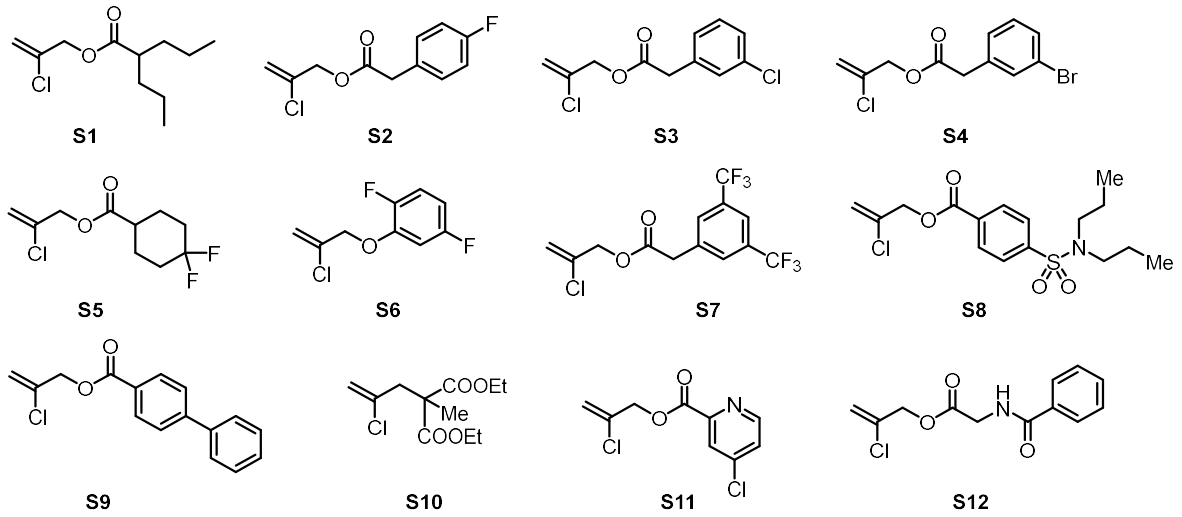
In an oven-dried Schlenk tube equipped with a PTFE-coated stirring bar, 6-chloroquinoline (0.05 mmol for each reaction) and Ir-F (2 mol% for each reaction) were weighted under air, then the vessel was evacuated and back-filled with argon (three times). HFIP (250 µl for each reaction) and 2-chloropropene (0.1 mmol for each reaction) were consecutively added, then the solution was stirred for 30 seconds and degassed by freeze-pump-thaw (three times). Individual aliquots were transferred to argon filled oven-dried Schlenk tube equipped with a PTFE-coated stirring bar, then the appropriate Brønsted/Lewis acid (0.1 mmol for each reaction) was added and the reactions were irradiated 24 hours at 450 nm with the standard setup. Upon completion of the irradiation, the reaction was partitioned between CH_2Cl_2/saturated $NaHCO_3$ (1:1, 10 ml), then the aqueous layer was extracted twice with CH_2Cl_2 (5 ml each time) and the combined organic layers were removed in vacuo. The residue was dissolved in $CDCl_3$ and analyzed by ^1H NMR, using dibromomethane as internal standard.

Supplementary Table 4. Yields upon addition of acid additives.

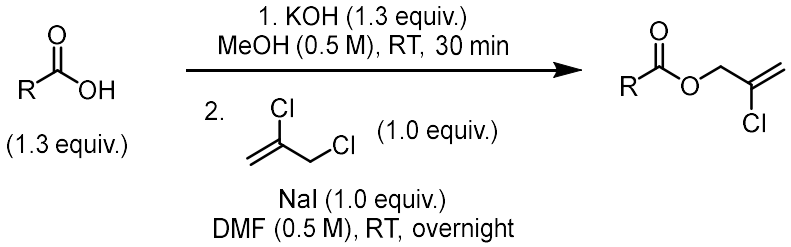
Acid additive	Yield %
HBr 33% *w/w* in AcOH (2 equiv.)	70
HBr 48% *w/w* in H_2O (2 equiv.)	66
BF_3·OEt (2 equiv.)	8
$AlCl_3$ (2 equiv.)	<5
$TiCl_4$ (2 equiv.)	62

Comment on the results. Pleasingly, we observed that HBr afforded significant levels of reactivity, as well as $TiCl_4$. In the former case, we believe that the HFIP/$TiCl_4$ mixture can generate HCl *in situ* (see, for instance [3]), this being the active species in the quinoline activation. On the other hand, $AlCl_3$ and BF_3·OEt failed at providing substantial drive for the process (**Supplementary Table 4**).

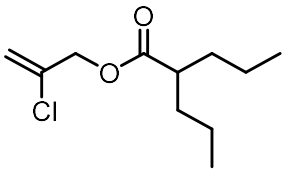
Synthesis of Starting Materials



General procedure for the synthesis of alkenes (GP1)



In an oven-dried round-bottom flask equipped with a PTFE-coated stirring bar, powdered KOH (1.30 equiv.) was dissolved in MeOH (0.5 M), then the appropriate carboxylic acid (1.30 equiv.) was added in one portion and the reaction was stirred for 30 minutes at room temperature. The volatiles were removed *in vacuo* to afford the crude carboxylate, which was suspended in dry DMF (0.5 M). After addition of NaI (1.00 equiv.), 2,3-dichloroprop-1-ene (1.00 equiv.) was added in one portion and the reaction was stirred at room temperature overnight, then diluted with water (50 ml) and extracted twice with EtOAc (50 ml each time). The combined organic layers were washed once with water (50 ml) and twice with brine (50 ml each time), then were dried over $MgSO_4$ and the solvent was removed *in vacuo*. The crude residue was purified by flash column chromatography on silica using the eluent system indicated in the individual entries, affording analytically pure **S1-S5**, **S7-S9**, **S11-12**.

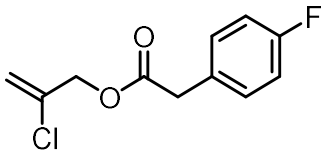


2-Chloroallyl 2-propylpentanoate (S1). Compound **S1** was synthesized according to **GP1**, purified by flash column chromatography (*n*-pentane/EtOAc = 50/1) to afford a colourless liquid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 5.46 (p, *J* = 1.3 Hz, 1H), 5.41 – 5.38 (m, 1H), 4.65 (s, 2H), 2.44 (ttd, *J* = 8.9, 5.2, 1.1 Hz, 1H), 1.68 – 1.56 (m, 2H), 1.50 – 1.39 (m, 2H), 1.37 – 1.24 (m, 4H), 0.90 (t, *J* = 7.3 Hz, 6H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 175.8, 136.4, 115.0, 65.8, 45.3, 34.7, 20.7, 14.1.

No molecular ion could be obtained under the available experimental conditions.



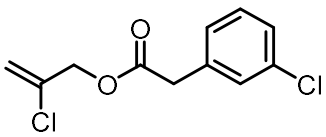
2-Chloroallyl 2-(4-fluorophenyl)acetate (S2). Compound **S2** was synthesized according to **GP1**, purified by flash column chromatography (*n*-pentane/EtOAc = 40/1) to afford a colourless liquid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.30 – 7.23 (m, 2H), 7.06 – 6.99 (m, 2H), 5.39 – 5.36 (m, 2H), 4.67 (t, *J* = 1.0 Hz, 2H), 3.67 (s, 2H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 170.7, 162.2 (d, *J* = 245.7 Hz), 135.7, 131.0 (d, *J* = 8.1 Hz), 129.3 (d, *J* = 3.4 Hz), 115.7 (d, *J* = 21.5 Hz), 115.2, 66.5, 40.4.

^{19}F{^{1}H} NMR (377 MHz, $CDCl_3$) δ -115.37.

HRMS (ESI, *m*/*z*) calcd for $C_{11}H_{10}O_2{}^{35}ClFNa$ $[M+Na]^+$: 251.0246, found: 251.0246.

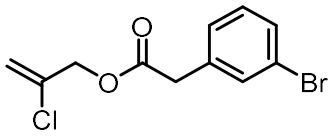


2-Chloroallyl 2-(3-chlorophenyl)acetate (S3). Compound **S3** was synthesized according to **GP1**, purified by flash column chromatography (*n*-pentane/EtOAc = 40/1) to afford a colourless liquid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.33 – 7.30 (m, 1H), 7.29 – 7.24 (m, 2H), 7.22 – 7.16 (m, 1H), 5.40 – 5.38 (m, 2H), 4.68 (t, *J* = 1.0 Hz, 2H), 3.67 (s, 2H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 170.1, 135.7, 135.4, 134.5, 130.0, 129.6, 127.7, 115.3, 66.5, 40.8. *One aromatic signal missing, likely due to overlap.*

HRMS (ESI, *m*/*z*) calcd for $C_{11}H_{10}O_2{}^{35}Cl_2Na$ $[M+Na]^+$: 266.9950, found: 266.9951.

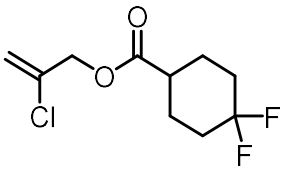


2-Chloroallyl 2-(3-bromophenyl)acetate (S4). Compound **S4** was synthesized according to **GP1**, purified by flash column chromatography (*n*-pentane/EtOAc = 40/1) to afford a colourless liquid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.48 – 7.46 (m, 1H), 7.42 (dt, *J* = 7.1, 1.9 Hz, 1H), 7.25 – 7.18 (m, 2H), 5.41 – 5.38 (m, 2H), 4.68 (t, *J* = 1.0 Hz, 2H), 3.66 (s, 2H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 170.1, 135.7, 132.5, 130.6, 130.3, 128.1, 122.7, 115.4, 66.6, 40.7.

HRMS (ESI, *m*/*z*) calcd for $C_{11}H_{10}O_2{}^{35}Cl^{79}BrNa$ $[M+Na]^+$: 310.9445, found: 310.9446.



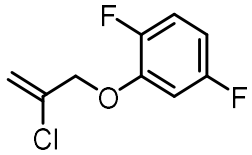
2-Chloroallyl 4,4-difluorocyclohexane-1-carboxylate (S5). Compound **S5** was synthesized according to **GP1**, purified by flash column chromatography (*n*-pentane/EtOAc = 20/1) to afford a colourless liquid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 5.47 – 5.44 (m, 1H), 5.43 – 5.40 (m, 1H), 4.68 (s, 2H), 2.54 – 2.44 (m, 1H), 2.18 – 1.96 (m, 4H), 1.95 – 1.69 (m, 4H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 173.4, 136.0, 122.7 (t, *J* = 241.1 Hz), 115.5, 66.3, 40.5, 32.6 (t, *J* = 24.6 Hz), 25.1 (d, *J* = 10.3 Hz).

^{19}F NMR (377 MHz, $CDCl_3$) δ -94.51 (d, *J* = 237.4 Hz), -99.63 (d, *J* = 237.7 Hz).

HRMS (ESI, *m*/*z*) calcd for $C_{10}H_{13}O_2{}^{35}ClF_2Na$ $[M+Na]^+$: 261.0464, found: 261.0463.



2-((2-Chloroallyl)oxy)-1,4-difluorobenzene (S6).

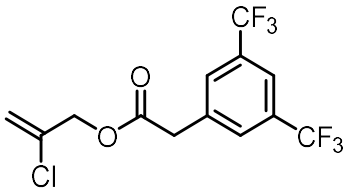
In an oven-dried Schlenk tube equipped with a PTFE-coated stirring bar, 2,5-difluorophenol (520 mg, 4.00 mmol, 1.00 equiv.), K_2CO_3 (663 mg, 4.80 mmol, 1.20 equiv.) were suspended in acetone (8 ml), then 2,3-dichloroprop-1-ene (369 µl, 4.00 mmol, 1.00 equiv.) was added and the reaction was heated at reflux overnight. Upon cooling at room temperature, the suspension was filtered over a short pad of silica (1 cm), rinsing thoroughly with CH_2Cl_2. The organic filtrate was dried *in vacuo*, then the residue was purified by flash column chromatography on silica (*n*-pentane/EtOAc = 50/1), affording **S6** (482 mg, 2.36 mmol, 59%) as a colourless oil.

^{1}H NMR (599 MHz, $CDCl_3$) δ 7.04 (ddd, *J* = 10.6, 9.0, 5.2 Hz, 1H), 6.71 (ddd, *J* = 9.6, 6.7, 3.0 Hz, 1H), 6.65 (ddt, *J* = 9.0, 7.7, 3.1 Hz, 1H), 5.60 (q, *J* = 1.6 Hz, 1H), 5.48 (dt, *J* = 2.1, 1.1 Hz, 1H), 4.63 (t, *J* = 1.3 Hz, 2H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 159.0 (dd, *J* = 242.9, 2.5 Hz), 149.0 (dd, *J* = 241.9, 3.5 Hz), 146.5 (dd, *J* = 12.8, 10.4 Hz), 135.5, 116.8 (dd, *J* = 20.8, 10.0 Hz), 114.7, 108.2 (dd, *J* = 23.7, 7.0 Hz), 104.2 (dd, *J* = 27.4, 1.8 Hz), 71.7 (d, *J* = 1.1 Hz).

^{19}F NMR (564 MHz, $CDCl_3$) δ -116.42 – -116.51 (m), -139.19 (dddd, *J* = 14.6, 10.3, 6.7, 3.4 Hz).

The compound does not ionize under the available conditions.



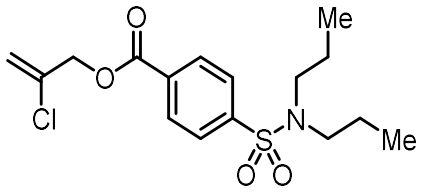
2-Chloroallyl 2-(3,5-bis(trifluoromethyl)phenyl)acetate (S7). Compound **S7** was synthesized according to **GP1**, purified by flash column chromatography (*n*-pentane/EtOAc = 20/1) to afford a colourless liquid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.82 (s, 1H), 7.78 (s, 2H), 5.46 – 5.41 (m, 2H), 4.72 (s, 2H), 3.84 (s, 2H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 169.3, 135.9, 135.5, 132.1 (q, *J* = 33.3 Hz), 130.0 – 129.8 (m), 123.3 (q, *J* = 272.7 Hz), 121.7 – 121.5 (m), 116.1, 67.1, 40.6.

^{19}F NMR (377 MHz, $CDCl_3$) δ -62.91.

HRMS (ESI, *m*/*z*) calcd for $C_{13}H_9O_2{}^{35}ClF_6Na$ $[M+Na]^+$: 369.0088, found: 369.0089.

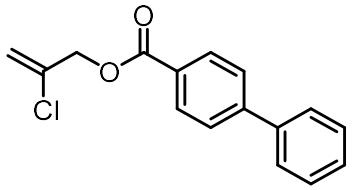


2-Chloroallyl 4-(*N*,*N*-dipropylsulfamoyl)benzoate (S8). Compound **S8** was synthesized according to **GP1**, purified by flash column chromatography (*n*-pentane/EtOAc = 12/1) to afford a colourless sticky gum.

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.20 – 8.14 (m, 2H), 7.90 – 7.84 (m, 2H), 5.56 (q, *J* = 1.4 Hz, 1H), 5.47 (q, *J* = 1.9 Hz, 1H), 4.92 – 4.89 (m, 2H), 3.11 – 3.03 (m, 4H), 1.59 – 1.47 (m, 4H), 0.87 – 0.81 (m, 6H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 164.4, 144.7, 135.6, 132.8, 130.5, 127.2, 115.9, 67.0, 50.0, 22.0, 11.2.

HRMS (ESI, *m*/*z*) calcd for $C_{16}H_{22}NO_4{}^{35}ClSNa^+$ $[M+Na]^+$: 382.0850, found: 382.0848.

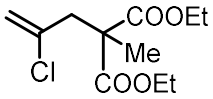


2-Chloroallyl [1,1'-biphenyl]-4-carboxylate (S9). Compound **S9** was synthesized according to **GP1**, purified by flash column chromatography (*n*-pentane/EtOAc = 35/1) to afford a white waxy solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.18 – 8.14 (m, 2H), 7.72 – 7.67 (m, 2H), 7.66 – 7.61 (m, 2H), 7.51 – 7.45 (m, 2H), 7.41 (tt, *J* = 7.2, 1.3 Hz, 1H), 5.59 (q, *J* = 1.3 Hz, 1H), 5.50 – 5.46 (m, 1H), 4.95 – 4.91 (m, 2H).

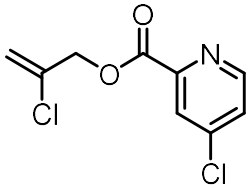
^{13}C NMR (101 MHz, $CDCl_3$) δ 165.7, 146.2, 140.0, 136.1, 130.5, 129.1, 128.4, 128.3, 127.4, 127.3, 115.1, 66.5.

HRMS (ESI, *m*/*z*) calcd for $C_{16}H_{13}O_2{}^{35}ClNa$ $[M+Na]^+$: 295.0496, found: 295.0498.



Diethyl 2-(2-chloroallyl)-2-methylmalonate (S10). In an oven-dried Schlenk tube equipped with a PTFE-coated stirring bar, 2-methyldiethylmalonate (794 µl, 4.60 mmol, 1.15 equiv.) was dissolved in dry MeCN (13 ml), then the solution was cooled to 0°C and NaH 60% in mineral oil (200 mg, 5.00 mmol, 1.25 equiv.) was added in one portion and the mixture was stirred at room temperature for 30 minutes. 2,3-dichloroprop-1-ene (369 µl, 4.00 mmol, 1.00 equiv.) was added dropwise and the reaction was stirred at room temperature for 20 hours, then quenched by carefully adding saturated aqueous NH_4Cl. The suspension was partitioned between EtOAc/H_2O (1:1, 70 ml), then the aqueous layer was extracted twice with EtOAc (30 ml each time) and the combined organic layers were dried over $MgSO_4$ and the solvent was removed *in vacuo*. The crude residue was purified by flash column chromatography on silica (*n*-pentane/EtOAc = 20/1), affording **S10** (905 mg, 3.64 mmol, 91%) as a colourless oil.

^{1}H NMR (400 MHz, $CDCl_3$) δ 5.30 (d, J = 1.3 Hz, 1H), 5.21 (q, J = 0.9 Hz, 1H), 4.19 (q, J = 7.1 Hz, 4H), 3.03 (d, J = 0.8 Hz, 2H), 1.47 (s, 3H), 1.26 (t, J = 7.1 Hz, 6H). The experimental data are in agreement with the literature report.[4]

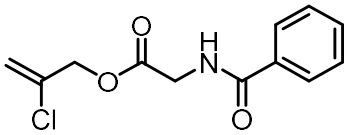


2-Chloroallyl 4-chloropicolinate (S11). Compound **S11** was synthesized according to **GP1**, purified by flash column chromatography (*n*-pentane/EtOAc = 4/1) to afford a yellow thick oil.

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.67 (d, J = 5.2 Hz, 1H), 8.14 (d, J = 2.1 Hz, 1H), 7.51 (dd, J = 5.2, 2.0 Hz, 1H), 5.59 – 5.56 (m, 1H), 5.49 – 5.46 (m, 1H), 4.98 (s, 2H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 163.4, 151.0, 148.9, 145.6, 135.3, 127.5, 126.0, 116.0, 67.5.

HRMS (ESI, *m*/*z*) calcd for $C_9H_7O_2{}^{35}Cl_2Na$ $[M+Na]^+$: 253.9746, found: 253.9744.

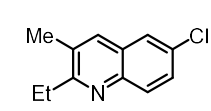


2-Chloroallyl benzoylglycinate (S12). Compound **S12** was synthesized according to **GP1**, purified by flash column chromatography (*n*-pentane/EtOAc = 3/2) to afford a white waxy solid.

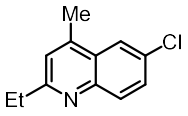
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.84 – 7.77 (m, 2H), 7.52 (tt, *J* = 7.4, 1.2 Hz, 1H), 7.47 – 7.40 (m, 2H), 6.77 (t, *J* = 5.4 Hz, 1H), 5.52 – 5.50 (m, 1H), 5.45 – 5.43 (m, 1H), 4.76 (s, 2H), 4.31 (d, *J* = 5.3 Hz, 2H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 169.5, 167.7, 135.2, 133.6, 132.0, 128.8, 127.2, 115.9, 66.9, 41.8.

HRMS (ESI, *m*/*z*) calcd for $C_{12}H_{12}NO_3{}^{35}ClNa$ $[M+Na]^+$: 276.0398, found: 276.0396.



S13



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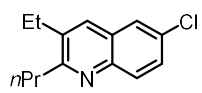

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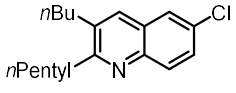
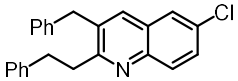
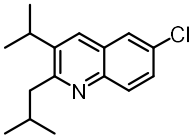


S16



S17



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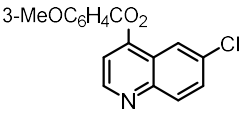

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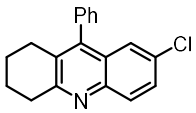
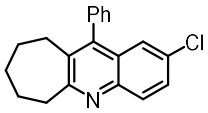
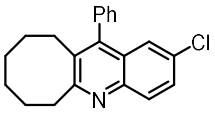


S20



S21



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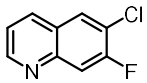

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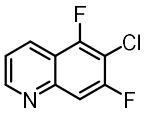
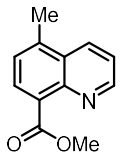
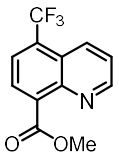


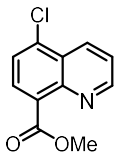
S24



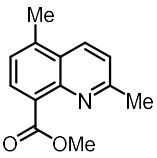
S25



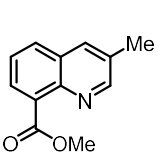
S26



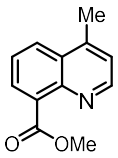
S27



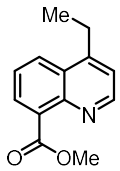
S28



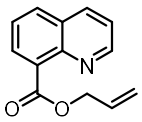
S29



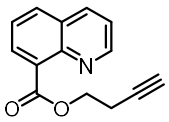
S30



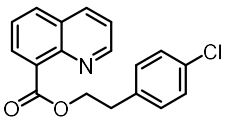
S31



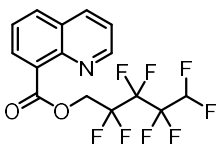
S32



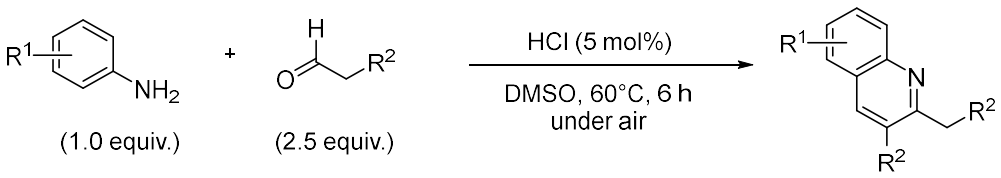
S33



S34

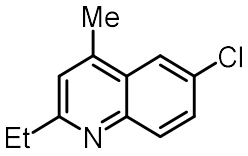


S35



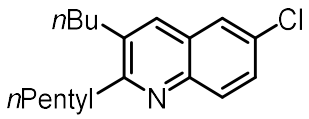
General procedure 2 for the synthesis of quinolines (GP2)

To a mixture of aniline (1.0 equiv.) and the corresponding aldehyde (2.50 equiv.) in DMSO (2 mL) was added HCl (4 M in dioxane) (5 mol%). After stirring for 6 h at 60 °C, the reaction mixture was poured into aqueous $NaHCO_3$ (10 mL) and water (20 mL). The solution was extracted with EtOAc (10 mL × 3) and the combined organic layers were dried over $MgSO_4$ and the solvent was removed *in vacuo*. The crude residue was purified by flash column chromatography (*n*-pentane/EtOAc mixtures) to afford the desired quinolines **S13**, **S15-18**, **S20-22**. The analytical data of **S13**[5], **S15**[6], **S17**[7], **S20**[8], **S21**[9] and **S22**[10] are consistent with the previous reports.



6-chloro-2-ethyl-4-methylquinoline (S14). In an oven-dried Schlenk tube equipped with a PTFE-coated stirring bar, 4-cloroaniline (255 mg, 2.00 mmol, 1.00 equiv.), 1-nitropropane (8 ml), $FeCl_3$ (65 mg, 0.40 mmol, 20 mol%) and propanal (722 µl, 10.0 mmol, 5.00 equiv.) were charged, then the reaction was heated at 90 °C overnight. The reaction was cooled at room temperature, then partitioned between EtOAc/H_2O (1:1, 60 ml), the layers were separated and the aqueous layer was extracted twice with EtOAc (20 ml each time). The combined organic extracts were dried over $MgSO_4$, then the solvent was removed in vacuo and residual 1-nitropropane was removed under high vacuum. The crude residue was purified by flash column chromatography on silica (pentane/EtOAc = 50/1 to 40/1), affording the desired quinoline (134 mg, 0.65 mmol, 33%) as a yellow-orange waxy solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.00 (br d, J = 8.9 Hz, 1H), 7.78 (br s, 1H), 7.69 (d, J = 2.4 Hz, 1H), 7.56 (dd, J = 8.9, 2.3 Hz, 1H), 3.01 (q, J = 7.6 Hz, 2H), 2.49 (s, 3H), 1.38 (t, J = 7.5 Hz, 3H). The experimental data are in agreement with the literature reports.[11]

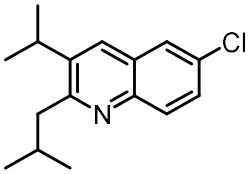


3-Butyl-6-chloro-2-pentylquinoline (S16). Compound **S16** was synthesized according to **GP2**.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.94 (d, *J* = 8.9 Hz, 1H), 7.74 (s, 1H), 7.68 (d, *J* = 2.4 Hz, 1H), 7.53 (dd, *J* = 8.9, 2.3 Hz, 1H), 2.96 – 2.92 (m, 2H), 2.79 – 2.75 (m, 2H), 1.82 – 1.74 (m, 2H), 1.70 – 1.62 (m, 2H), 1.50 – 1.34 (m, 6H), 0.99 (t, *J* = 7.3 Hz, 3H), 0.92 (t, *J* = 7.0 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 162.8, 144.8, 135.3, 133.9, 131.2, 130.1, 129.3, 127.9, 125.6, 35.9, 32.6, 32.2, 32.1, 29.3, 22.7, 22.7, 14.2, 14.0.

HRMS (ESI, *m*/*z*) calcd for $C_{18}H_{25}NCl^+$ $[M+H]^+$: 290.1670, found: 290.1670.

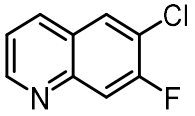


6-Chloro-2-isobutyl-3-isopropylquinoline (S18). Compound **S18** was synthesized according to **GP2**.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.94 (d, *J* = 9.0 Hz, 1H), 7.85 (s, 1H), 7.72 (d, *J* = 2.3 Hz, 1H), 7.53 (dd, *J* = 9.0, 2.3 Hz, 1H), 3.36 – 3.26 (m, 1H), 2.90 (d, *J* = 7.3 Hz, 2H), 2.31 – 2.19 (m, 1H), 1.32 (d, *J* = 6.9 Hz, 6H), 0.99 (d, *J* = 6.7 Hz, 6H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 161.2, 144.6, 141.9, 131.2, 130.8, 130.2, 129.3, 128.0, 125.8, 44.16, 29.4, 28.9, 23.9, 22.7.

HRMS (ESI, *m*/*z*) calcd for $C_{16}H_{21}NCl^+$ $[M+H]^+$: 262.1357, found: 262.1356.



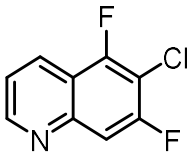
6-Chloro-7-fluoroquinoline (S23). Compound **S23** was synthesized according to **GP2**.

^{1}H NMR (599 MHz, $CDCl_3$) δ 9.00 – 8.86 (m, 1H), 8.25 – 8.07 (m, 1H), 7.91 (d, *J* = 7.8 Hz, 1H), 7.86 (d, *J* = 9.8 Hz, 1H), 7.43 (dd, *J* = 8.3, 4.3 Hz, 1H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 158.3 (d, *J* = 253.4 Hz), 151.4, 147.4 (d, *J* = 11.5 Hz), 135.4, 128.9 (d, *J* = 1.4 Hz), 125.7, 122.6 (d, *J* = 21.1 Hz), 121.4 (d, *J* = 2.7 Hz), 114.5 (d, *J* = 20.5 Hz).

^{19}F NMR (376 MHz, $CDCl_3$) δ -111.6 (br).

HRMS (ESI, *m*/*z*) calcd for $C_9H_6NClF^+$ $[M+H]^+$: 182.0167, found: 182.0166.



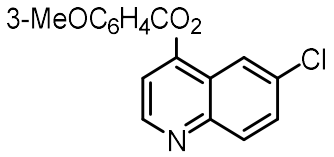
6-Chloro-5,7-difluoroquinoline (S24). In a Schlenk tube equipped with a PTFE-coated stirring bar, 4-chloro-3,5-difluoroaniline (500 mg, 3.06 mmol, 1.00 equiv.), I_2 (38 mg, 0.15 mmol, 5 mol%) and H_2SO_4 96% (1 ml), were charged, then glycerol (340 µl, 4.59 mmol, 1.50 equiv.) was added and the reaction was heated at 140 °C for 4 hours. The reaction was cooled to room temperature, poured in iced water (150 ml) and brought to pH 12 using NaOH pallets, then the aqueous layer was extracted three times with Et_2O (70 ml each time). The combined organic extracts were dried over $MgSO_4$, then the solvent was removed *in vacuo* and the residue was purified by flash column chromatography on silica (*n*-pentane/EtOAc = 5/1), affording **S24** as light yellow crystalline solid (242 mg, 1.21 mmol, 40%).

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.95 (d, *J* = 4.4 Hz, 1H), 8.36 (d, *J* = 8.6 Hz, 1H), 7.68 (d, *J* = 9.7 Hz, 1H), 7.47 (dd, *J* = 8.5, 4.3 Hz, 1H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 158.2 (dd, *J* = 252.7, 4.3 Hz), 154.3 (dd, *J* = 258.3, 5.2 Hz), 152.5, 146.3 (dd, *J* = 13.2, 4.1 Hz), 129.1 (dd, *J* = 4.0, 2.3 Hz), 121.4 (t, *J* = 2.9 Hz), 116.5 (dd, *J* = 15.8, 1.6 Hz), 110.2 (dd, *J* = 21.0, 4.7 Hz), 108.8 (dd, *J* = 24.3, 19.8 Hz).

^{19}F NMR (376 MHz, $CDCl_3$) δ -111.41 (br), -120.63 (d, *J* = 3.2 Hz).

HRMS (ESI, *m*/*z*) calcd for $C_9H_4N^{35}ClF_2^+$ $[M+H]^+$: 198.9995, found: 198.9996.



6-Chloroquinolin-4-yl 3-methoxybenzoate (S19). In an oven-dried Schlenk tube equipped with a PTFE-coated stirring bar, In an oven-dried Schlenk tube equipped with a PTFE-coated stirring bar, the appropriate 6-chloro-quinol-4-ol (359 mg, 2.00 mmol, 1.00 equiv.) and *N*-Me-morpholine (1.20 equiv.) were dissolved in dry DMA (0.4 M), then 3-methoxybenzoyl chloride (309 µl, 2.20 mmol,

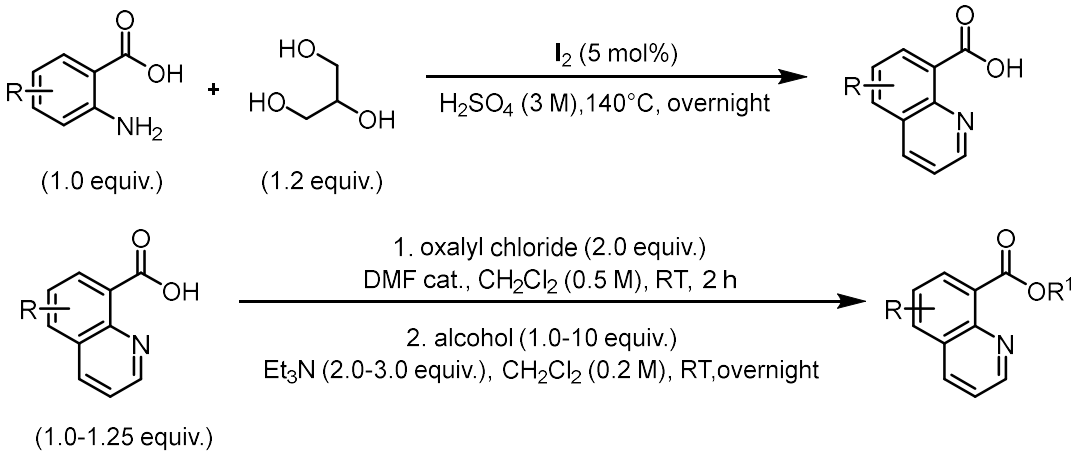
1.10 equiv.) was added dropwise under stirring and the reaction was left overnight at room temperature. The reaction was carefully quenched with distilled water (approx. 5 ml/mmol) and vigorously stirred for 10 minutes, then neutralized with saturated $NaHCO_3$ partitioned between CH_2Cl_2:H_2O (1:1). The aqueous layer was extracted twice with CH_2Cl_2 (approx. 5 ml/mmol), then the combined organic layers were washed three times with deionized water (approx. 5 ml/mmol each time), dried over $MgSO_4$ and the solvent was removed *in vacuo*. The crude residue was purified by flash column chromatography (CH_2Cl_2/EtOAc = 100/0 to 7/1), affording **S19** as a white solid (552 mg, 1.76 mmol, 88%).

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.93 (d, *J* = 5.0 Hz, 1H), 8.09 (d, *J* = 9.0 Hz, 1H), 7.97 (d, *J* = 2.4 Hz, 1H), 7.89 (dt, *J* = 7.7, 1.3 Hz, 1H), 7.76 (t, *J* = 1.8 Hz, 1H), 7.67 (dd, *J* = 9.0, 2.4 Hz, 1H), 7.48 (t, *J* = 8.0 Hz, 1H), 7.44 (d, *J* = 4.9 Hz, 1H), 7.24 (dd, *J* = 8.4, 2.7 Hz, 1H), 3.89 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 163.7, 160.0, 153.5, 151.1, 148.5, 133.2, 131.4, 131.2, 130.1, 129.7, 123.3, 122.8, 121.0, 120.4, 115.0, 113.9, 55.7.

HRMS (ESI, *m*/*z*) calcd for $C_{17}H_{12}NO_3{}^{35}ClNa$ $[M+Na]^+$: 336.0409, found: 336.0398.

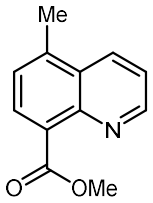
General procedure 3 for the synthesis of 8-carboxylate quinolines



Step 1. In a round-bottom flask equipped with a PTFE-coated stirring bar, the appropriate anthranilic acid (1.00 equiv.), iodine (5 mol %) and sulfuric acid 96% (3 M) were charged, the under vigorous stirring glycerol (1.20 equiv.) was carefully added (*Warning: the reaction could be very exothermic*), then the reaction was heated at 140 °C overnight. The reaction was cooled to room temperature, diluted with deionized water (approx. 5 ml/mmol), then cooled to 0 °C and carefully quenched until neutrality with solid NaOH. The dark slurry was brought to room temperature, then CH_2Cl_2 (approx. 5 ml/mmol) was added and the biphasic mixture was filtered

twice over Celite® to remove the carbonized byproducts (*if residual amounts of carbonized byproducts remain, separation between layers can become challenging*), rinsing thoroughly with water and CH_2Cl_2. The biphasic mixture was transferred to a separating funnel and the layers were separated, then the aqueous layer was extracted twice with CH_2Cl_2 (approx. 5 ml/mmol each time). The combined extracts were dried over $MgSO_4$, then the solvent was removed *in vacuo*. The residue was either judged to be pure enough for the next step or was purified by re-crystallization from boiling ethanol, as specified in the individual entries.

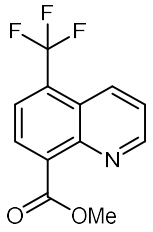
Step 2. In an oven-dried round bottom flask equipped with a PTFE-coated stirring bar, the appropriate carboxylic acid (1.00-1.25 equiv.) was suspended/dissolved in dry CH_2Cl_2 (0.5 M), then one drop of DMF was added. Oxalyl chloride (2.00 equiv.) was added dropwise (*WARNING: Strong evolution of HCl and CO, perform the reaction in a well-ventilated fume hood*) and the reaction was stirred at room temperature until gas evolution ceased (usually within two hours). The volatiles were removed *in vacuo*, then the residue was re-dissolved in dry CH_2Cl_2 (0.20 M) and the appropriate alcohol (1.00-10.0 equiv.), followed by Et_3N (2.00-3.00 equiv.) were added. The reaction was stirred at room temperature for 2 hours. The reaction was quenched with water (approx. 5 ml/mmol) and stirred for 10 minutes, then the layers were separated and the aqueous layer was extracted twice with CH_2Cl_2 (approx. 5 ml/mmol each time), then the combined organic layers were dried over $MgSO_4$ and the solvent was removed *in vacuo*. The residue was purified by flash column chromatography on silica.



Methyl 5-methylquinoline-8-carboxylate (S25). Compound **S25** was synthesized according to **GP3**, purified by flash column chromatography (*n*-pentane/acetone = 5/1) to afford a red thick oil.
^{1}H NMR (400 MHz, $CDCl_3$) δ 9.04 (dd, *J* = 4.2, 1.6 Hz, 1H), 8.33 (d, *J* = 8.5 Hz, 1H), 7.93 (d, *J* = 7.4 Hz, 1H), 7.46 (dd, *J* = 8.5, 4.2 Hz, 1H), 7.37 (d, *J* = 7.3 Hz, 1H), 4.03 (s, 3H), 2.70 (s, 3H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 168.4, 151.1, 145.9, 139.0, 132.6, 130.5, 129.8, 127.8, 126.2, 121.2,

52.6, 19.1.

HRMS (ESI, *m*/*z*) calcd for $C_{12}H_{11}NO_2Na$ $[M+Na]^+$: 224.0682, found: 224.0677.



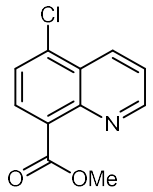
Methyl 5-(trifluoromethyl)quinoline-8-carboxylate (S26). Compound **S26** was synthesized according to **GP3**, purified by flash column chromatography (*n*-pentane/acetone = 6/1) to afford a red thick oil.

^{1}H NMR (400 MHz, $CDCl_3$) δ 9.09 (d, *J* = 4.1 Hz, 1H), 8.51 (d, *J* = 8.9 Hz, 1H), 7.98 – 7.90 (m, 3H), 7.58 (dd, *J* = 8.8, 4.2 Hz, 1H), 4.07 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 167.8, 151.9, 145.6, 136.9, 132.7 (q, *J* = 2.6 Hz), 128.8 (q, *J* = 30.8 Hz), 127.8, 124.7, 124.4 (q, *J* = 5.7 Hz), 123.7 (q, *J* = 274.0 Hz), 122.9, 53.1.

^{19}F{^{1}H} NMR (377 MHz, $CDCl_3$) δ -59.45

HRMS (ESI, *m*/*z*) calcd for $C_{12}H_8NO_2F_3Na$ $[M+Na]^+$: 278.0399, found: 278.0397.

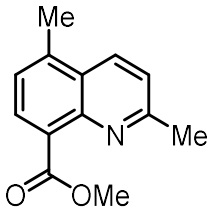


Methyl 5-chloroquinoline-8-carboxylate (S27). Compound **S27** was synthesized according to **GP3**, purified by flash column chromatography (*n*-pentane/acetone = 11/2) to afford a red thick gum.

^{1}H NMR (400 MHz, $CDCl_3$) δ 9.10 (d, *J* = 4.2 Hz, 1H), 8.62 (d, *J* = 8.6 Hz, 1H), 7.96 (d, *J* = 7.9 Hz, 1H), 7.66 (d, *J* = 7.9 Hz, 1H), 7.57 (dd, *J* = 8.5, 3.9 Hz, 1H), 4.05 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 167.7, 152.1, 146.3, 135.0, 133.2, 130.9, 130.3, 126.6, 125.9, 122.5, 52.9.

HRMS (ESI, *m*/*z*) calcd for $C_{11}H_8NO_2{}^{35}ClNa$ $[M+Na]^+$: 244.0136, found: 244.0133.

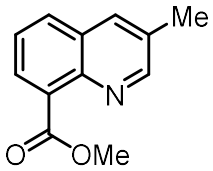


Methyl 2,5-dimethylquinoline-8-carboxylate (S28). Compound **S28** was synthesized according to **GP3**, purified by flash column chromatography (*n*-pentane/acetone = 13/2 to 6/1) to afford a red low melting solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.19 (d, *J* = 8.7 Hz, 1H), 7.87 (d, *J* = 7.3 Hz, 1H), 7.34 – 7.28 (m, 2H), 4.02 (s, 3H), 2.76 (s, 3H), 2.67 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 168.8, 159.8, 145.6, 138.5, 132.5, 130.1, 129.4, 126.0, 125.3, 122.1, 52.4, 25.9, 19.1.

HRMS (ESI, *m*/*z*) calcd for $C_{13}H_{13}NO_2Na$ $[M+Na]^+$: 238.0839, found: 238.0835.

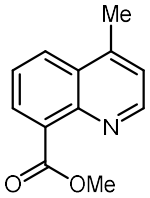


Methyl 3-methylquinoline-8-carboxylate (S29). Compound **S29** was synthesized according to **GP3**, purified by flash column chromatography (*n*-pentane/acetone = 6/1 to 11/2) to afford an orange low-melting solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.89 (d, *J* = 2.3 Hz, 1H), 7.96 (dd, *J* = 7.1, 1.5 Hz, 1H), 7.92 (dd, *J* = 2.3, 1.1 Hz, 1H), 7.86 (dd, *J* = 8.3, 1.5 Hz, 1H), 7.52 (dd, *J* = 8.2, 7.1 Hz, 1H), 4.04 (s, 3H), 2.51 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 168.5, 153.7, 143.9, 134.9, 131.4, 131.3, 130.9, 129.7, 128.5, 125.7, 52.7, 18.8.

HRMS (ESI, *m*/*z*) calcd for $C_{12}H_{11}NO_2Na$ $[M+Na]^+$: 224.0682, found: 224.0677.

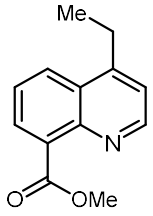


Methyl 4-methylquinoline-8-carboxylate (S30). Compound **S30** was synthesized according to **GP3**, purified by flash column chromatography (*n*-pentane/acetone = 5/1) to afford an orange thick oil.

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.88 (d, *J* = 4.4 Hz, 1H), 8.12 (dd, *J* = 8.4, 1.4 Hz, 1H), 7.97 (dd, *J* = 7.1, 1.5 Hz, 1H), 7.56 (dd, *J* = 8.4, 7.1 Hz, 1H), 7.29 – 7.24 (m, 1H), 4.04 (s, 3H), 2.70 (d, *J* = 1.0 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 168.8, 151.3, 145.4, 144.5, 132.5, 129.8, 128.6, 127.2, 125.4, 122.5, 52.8, 19.0.

HRMS (ESI, *m*/*z*) calcd for $C_{12}H_{11}NO_2Na$ $[M+Na]^+$: 224.0682, found: 224.0680.

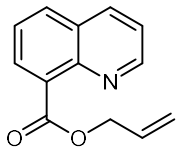


Methyl 4-ethylquinoline-8-carboxylate (S31). Compound **S31** was synthesized according to **GP3**, purified by flash column chromatography (*n*-pentane/acetone = 5/1) to afford an orange thick oil.

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.93 (d, *J* = 4.4 Hz, 1H), 8.18 (dd, *J* = 8.5, 1.4 Hz, 1H), 7.96 (dd, *J* = 7.1, 1.5 Hz, 1H), 7.57 (dd, *J* = 8.5, 7.1 Hz, 1H), 7.30 (d, *J* = 4.4 Hz, 1H), 4.05 (s, 3H), 3.13 (qd, *J* = 7.5, 0.8 Hz, 2H), 1.39 (t, *J* = 7.5 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 168.9, 151.5, 150.1, 145.6, 132.8, 129.6, 127.8, 126.8, 125.4, 120.4, 52.8, 25.3, 14.2.

HRMS (ESI, *m*/*z*) calcd for $C_{13}H_{13}NO_2Na$ $[M+Na]^+$: 238.0839, found: 238.0832.



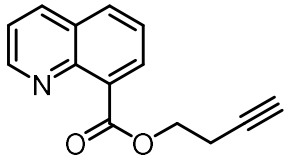
Allyl quinoline-8-carboxylate (S32). Compound **S32** was synthesized according to **GP3**, purified by flash column chromatography (*n*-pentane/acetone = 8/1) to afford an orange thick oil.

^{1}H NMR (400 MHz, $CDCl_3$) δ 9.05 (dd, *J* = 4.2, 1.8 Hz, 1H), 8.17 (dd, *J* = 8.3, 1.8 Hz, 1H), 8.05 (dd, *J* = 7.2, 1.5 Hz, 1H), 7.93 (dd, *J* = 8.2, 1.5 Hz, 1H), 7.55 (dd, *J* = 8.2, 7.2 Hz, 1H), 7.44 (dd, *J* =

8.3, 4.2 Hz, 1H), 6.09 (ddt, *J* = 17.2, 10.5, 5.7 Hz, 1H), 5.49 (dq, *J* = 17.2, 1.6 Hz, 1H), 5.30 (dq, *J* = 10.4, 1.4 Hz, 1H), 4.97 (dt, *J* = 5.7, 1.4 Hz, 2H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 167.4, 151.6, 145.7, 136.3, 132.3, 131.6, 131.5, 130.5, 128.5, 125.7, 121.7, 118.6, 66.2.

HRMS (ESI, *m*/*z*) calcd for $C_{13}H_{11}NO_2Na$ $[M+Na]^+$: 236.0682, found: 236.0677.

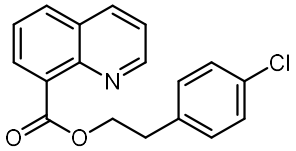


But-3-yn-1-yl quinoline-8-carboxylate (S33). Compound **S33** was synthesized according to **GP3**.

^{1}H NMR (400 MHz, $CDCl_3$) δ 9.06 (dt, *J* = 4.2, 1.6 Hz, 1H), 8.18 (dt, *J* = 8.3, 1.7 Hz, 1H), 8.08 (dt, *J* = 7.1, 1.4 Hz, 1H), 7.95 (dt, *J* = 8.2, 1.5 Hz, 1H), 7.57 (ddd, *J* = 8.4, 7.1, 1.3 Hz, 1H), 7.45 (ddd, *J* = 8.3, 4.2, 1.4 Hz, 1H), 4.58 (td, *J* = 6.9, 0.9 Hz, 2H), 2.74 (tdd, *J* = 6.9, 2.7, 0.9 Hz, 2H), 2.05 (t, *J* = 2.7 Hz, 1H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 167.2, 151.6, 145.6, 136.4, 131.6, 131.2, 130.7, 128.5, 125.7, 121.7, 80.2, 70.1, 63.0, 19.2.

HRMS (ESI, *m*/*z*) calcd for $C_{14}H_{11}NO_2Na^+$ $[M+Na]^+$: 248.0682, found: 248.0676.

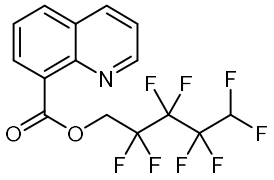


4-Chlorophenethyl quinoline-8-carboxylate (S34). Compound **S34** was synthesized according to **GP3**, purified by flash column chromatography (*n*-pentane/acetone = 4/1) to afford an orange thick oil.

^{1}H NMR (400 MHz, $CDCl_3$) δ 9.05 (dd, *J* = 4.2, 1.8 Hz, 1H), 8.18 (dd, *J* = 8.3, 1.8 Hz, 1H), 7.97 – 7.90 (m, 2H), 7.55 (dd, *J* = 8.1, 7.2 Hz, 1H), 7.46 (dd, *J* = 8.3, 4.2 Hz, 1H), 7.31 – 7.23 (m, 4H), 4.66 (t, *J* = 6.9 Hz, 2H), 3.11 (t, *J* = 6.9 Hz, 2H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 167.6, 151.6, 145.7, 136.6, 136.4, 132.5, 131.6, 131.5, 130.6, 130.5, 128.7, 128.6, 125.7, 121.8, 65.7, 34.7.

HRMS (ESI, *m*/*z*) calcd for $C_{18}H_{14}NO_2{}^{35}ClNa$ $[M+Na]^+$: 334.0611, found: 334.0605.



2,2,3,3,4,4,5,5-Octafluoropentyl quinoline-8-carboxylate (S35). Compound **S35** was synthesized according to **GP3**, purified by flash column chromatography (*n*-pentane/acetone = 6/1) to afford an orange thick oil.

^{1}H NMR (599 MHz, $CDCl_3$) δ 9.07 (dd, *J* = 4.2, 1.8 Hz, 1H), 8.21 (dd, *J* = 8.3, 1.8 Hz, 1H), 8.14 (dd, *J* = 7.2, 1.5 Hz, 1H), 8.01 (dd, *J* = 8.2, 1.5 Hz, 1H), 7.60 (dd, *J* = 8.2, 7.2 Hz, 1H), 7.49 (dd, *J* = 8.3, 4.2 Hz, 1H), 6.10 (tt, *J* = 51.9, 5.2 Hz, 1H), 4.95 (t, *J* = 13.8 Hz, 2H).

^{1}H{^{19}F} NMR (599 MHz, $CDCl_3$) δ 9.07 (dd, *J* = 4.2, 1.8 Hz, 1H), 8.21 (dd, *J* = 8.3, 1.8 Hz, 1H), 8.14 (dd, *J* = 7.2, 1.5 Hz, 1H), 8.01 (dd, *J* = 8.2, 1.5 Hz, 1H), 7.60 (dd, *J* = 8.2, 7.2 Hz, 1H), 7.49 (dd, *J* = 8.3, 4.2 Hz, 1H), 6.10 (s. 1H), 4.95 (s, 2H).

^{13}C{^{1}H, ^{19}F} NMR (151 MHz, $CDCl_3$) δ 165.3, 152.0, 145.9, 136.5, 132.8, 131.6, 129.1, 128.7, 125.7, 122.0, 114.9, 111.0, 110.3, 107.8, 60.3.

^{19}F NMR (564 MHz, $CDCl_3$) δ -119.29 – -119.43 (m), -125.24 (t, *J* = 8.7 Hz), -129.99 (dq, *J* = 11.4, 5.8 Hz), -137.21 (dddt, *J* = 51.9, 8.6, 5.4, 2.8 Hz).

^{19}F{^{1}H} NMR (564 MHz, $CDCl_3$) δ -119.32 – -119.40 (m), -125.24 (td, *J* = 8.5, 2.5 Hz), -129.94 – -130.04 (m), -137.21 (tp, *J* = 8.7, 3.2 Hz).

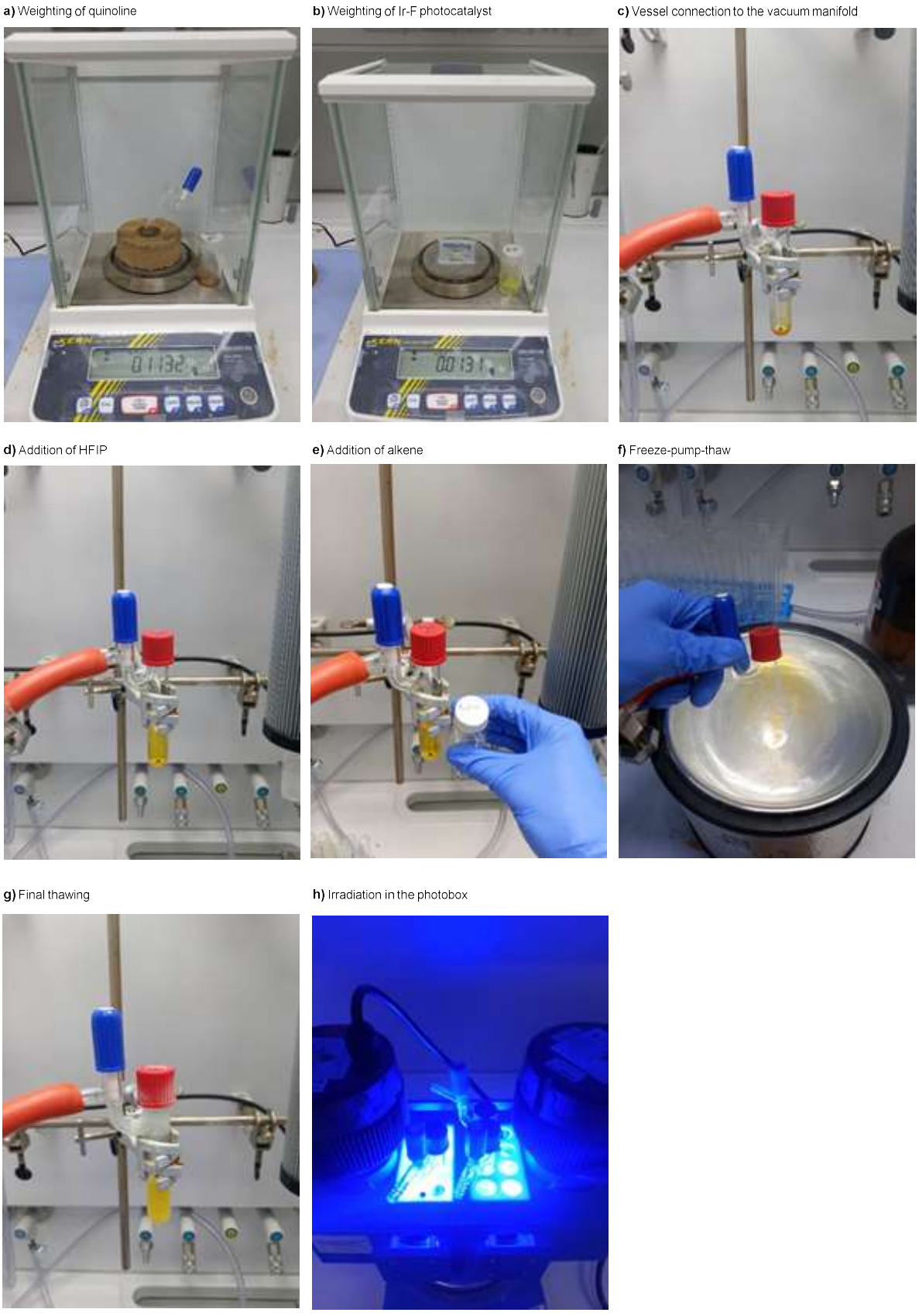
HRMS (ESI, *m*/*z*) calcd for $C_{15}H_9NO_2F_8Na$ $[M+Na]^+$: 410.0403, found: 410.0396.

General Experimental Procedure and Graphical Step-by-Step Reaction Set-up

General Procedure

A dried 5 mL Schlenk tube was charged with the quinoline, the alkene (2 or 5 equivalent), HCl (2 equivalent, 4 M in 1,4-dioxane, as indicated) and [Ir(*d*F(CF_3)ppy$_2$)(dtbbpy)][PF_6] (2 mol%) in 1,1,1,3,3,3-hexafluoro-2-propanol (HFIP, 0.2 M). The reaction mixture was degassed via freeze-pump-thaw for two cycles. After the mixture was thoroughly degassed and filled with argon, the Schlenk tube was sealed tightly and stirred under irradiation with 30 W blue LEDs (λ_{max} = 450 nm) for the indicated time (monitored by TLC, 14 to 48 hours). Ambient temperature around the Schlenk tube was kept at ~30 °C due to the heating effect of blue LEDs. Afterwards, the reaction was quenched by saturated aqueous $NaHCO_3$ and extracted with CH_2Cl_2 (10 mL × 3) in case HCl used. The organic phases were combined and concentrated under reduced pressure. ^{1}H NMR analysis of this crude reaction mixture gave the d.r. values. Finally, the product was obtained by flash chromatography on silica gel (*n*-pentane/EtOAc, *n*-pentane/Et_2O or CH_2Cl_2/MeOH as eluent).

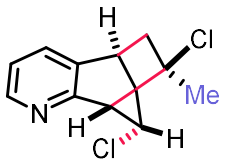
Graphical Step-by-Step Reaction Set-up



Supplementary Figure 11. Graphical reaction setup. a) The appropriate quinoline was weighted

under air. b) The appropriate amount of [Ir-F] photocatalyst was weighted under air. c) The reaction components were charged in a Schlenk tube, which was connected to the argon-vacuum hose. d) HFIP was added under air. e) The appropriate alkene, followed by further additives (*e.g.* HCl) if necessary, was added under air. f) The solution was frozen using liquid nitrogen, followed by vacuum-argon exchange (five times). g) The solution was brought to room temperature under argon, and repeated the freeze-pump-thaw one more time. Then the vessel was tightly sealed. h) The reaction was irradiated using the standard set-up.

Characterization Data of Fused Rings Products



3, 78% yield, 92:8 d.r.

According to the general procedure, a mixture of 6-chloroquinoline (32.7 mg, 0.20 mmol, 1.0 equiv.), 2-chloroprop-1-ene (34.0 μL, 0.40 mmol, 2.0 equiv.), HCl (100 μL, 0.4 mmol, 4 M in 1,4-dioxane) and Ir-F (4.4 mg, 2 mol%, 0.004 mmol) in HFIP (1 mL, 0.2 M) was stirred under argon atmosphere for 14 hours under irradiation with blue LEDs to afford **3** as a white solid (37.5 mg, 78% yield, >95:5 d.r.). The ^{1}H NMR analysis of the crude reaction mixture gave 92:8 d.r.

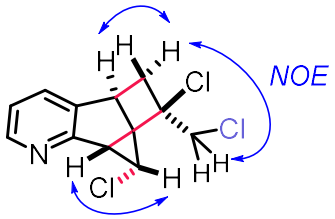
Purification conditions: *n*-pentane/EtOAc = 10:1 to 4:1.

R_f = 0.50 in *n*-pentane/EtOAc (6:1).

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.39 (dd, *J* = 5.0, 1.6 Hz, 1H), 7.42 (dd, *J* = 7.7, 1.6 Hz, 1H), 7.09 (dd, *J* = 7.6, 5.0 Hz, 1H), 3.88 (dd, *J* = 8.0, 0.6 Hz, 1H), 3.71 (td, *J* = 8.0, 2.0 Hz, 1H), 3.25 (dd, *J* = 8.0, 2.1 Hz, 1H), 2.84 (dd, *J* = 11.7, 8.1 Hz, 1H), 2.59 (ddd, *J* = 11.8, 7.8, 0.8 Hz, 1H), 1.94 (s, 2H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 161.9, 148.5, 141.9, 131.8, 122.0, 66.6, 48.9, 46.3, 39.4, 38.2, 38.07, 28.8.

HRMS (ESI, *m*/*z*) calcd for $C_{12}H_{11}NCl_2Na^+$ $[M+Na]^+$: 262.0160, found: 262.0160.



5, 84% yield, 92:8 d.r.

According to the general procedure, a mixture of 6-chloroquinoline (32.7 mg, 0.20 mmol, 1.0 equiv.), 2,3-dichloroprop-1-ene (92.0 μL, 1.00 mmol, 5.0 equiv.), HCl (100 μL, 0.4 mmol, 4 M in 1,4-dioxane) and Ir-F (4.4 mg, 2 mol%, 0.004 mmol) in HFIP (1 mL, 0.2 M) was stirred under argon atmosphere for 14 hours under irradiation with blue LEDs to afford **5** as a white solid (46.0 mg, 84% yield, >95:5 d.r.). The ^{1}H NMR analysis of the crude reaction mixture gave 92:8 d.r.

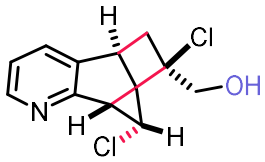
Purification conditions: *n*-pentane/EtOAc = 10:1 to 4:1.

R_f = 0.50 in *n*-pentane/EtOAc (6:1).

^{1}H NMR (599 MHz, $CDCl_3$) δ 8.42 (dd, *J* = 5.1, 1.6 Hz, 1H), 7.52 – 7.40 (m, 1H), 7.12 (dd, *J* = 7.7, 5.0 Hz, 1H), 4.04 (s, 2H), 4.01 (dd, *J* = 8.1, 0.7 Hz, 1H), 3.84 – 3.70 (m, 1H), 3.27 (dd, *J* = 8.1, 2.0 Hz, 1H), 3.08 (dd, *J* = 12.4, 8.4 Hz, 1H), 2.62 (dd, *J* = 12.4, 7.7 Hz, 1H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 161.3, 148.7, 141.7, 132.0, 122.2, 69.2, 50.6, 46.7, 42.7, 39.8, 38.1, 37.9.

HRMS (ESI, *m*/*z*) calcd for $C_{12}H_{10}NCl_3Na^+$ $[M+Na]^+$: 297.9742, found: 297.9742.



6, 80% yield, >95:5 d.r.

According to the general procedure, a mixture of 6-chloroquinoline (32.7 mg, 0.20 mmol, 1.0 equiv.), 2-chloroprop-2-en-1-ol (80.0 μL, 1.00 mmol, 5.0 equiv.), HCl (100 μL, 0.4 mmol, 4 M in 1,4-dioxane) and Ir-F (4.4 mg, 2 mol%, 0.004 mmol) in HFIP (1 mL, 0.2 M) was stirred under argon atmosphere for 14 hours under irradiation with blue LEDs to afford **6** as a white solid (41.1 mg, 80% yield, >95:5 d.r.). The ^{1}H NMR analysis of the crude reaction mixture gave >95:5 d.r.

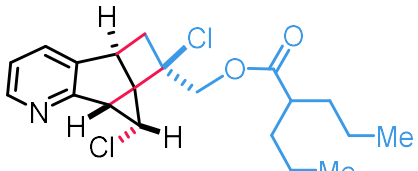
Purification conditions: *n*-pentane/EtOAc = 2:1 to 1:1.

R_f = 0.30 in *n*-pentane/EtOAc (1:1).

^{1}H NMR (599 MHz, CD_3OD) δ 8.32 (dd, *J* = 5.1, 1.5 Hz, 1H), 7.73 – 7.56 (m, 1H), 7.25 (dd, *J* = 7.7, 5.0 Hz, 1H), 4.15 (dd, *J* = 7.9, 0.7 Hz, 1H), 4.08 – 3.92 (m, 2H), 3.79 (td, *J* = 8.0, 2.0 Hz, 1H), 3.14 (dd, *J* = 7.9, 2.0 Hz, 1H), 3.06 (dd, *J* = 12.1, 8.4 Hz, 1H), 2.42 (dd, *J* = 12.1, 7.6 Hz, 1H).

^{13}C NMR (151 MHz, CD_3OD) δ 162.6, 148.4, 144.7, 134.0, 123.7, 71.7, 68.2, 47.6, 42.6, 41.0, 38.9, 37.5.

HRMS (ESI, *m*/*z*) calcd for $C_{12}H_{12}Cl_2NO^+$ $[M+H]^+$: 256.0290, found: 256.0290.



7, 78% yield, >95:5 d.r.

According to the general procedure, a mixture of 6-chloroquinoline (32.7 mg, 0.20 mmol), 2-chloroallyl 2-propylpentanoate (87.5 mg, 0.40 mmol, 2.00 equiv.), HCl 4M in 1,4-dioxane (100 µl, 0.40 mmol, 2.0 equiv.) and Ir-F (4.4 mg, 2 mol%, 0.004 mmol) in HFIP (1 mL, 0.2 M) was stirred under argon atmosphere for 14 hours under irradiation with blue LEDs to afford **7** as a light yellow gum (60.0 mg, 0.157 mmol, 78% yield, >95:5 d.r.).

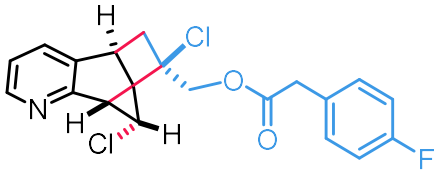
Purification conditions: *n*-pentane/EtOAc = 5:1.

R_f = 0.60 in *n*-pentane/EtOAc (4:1).

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.41 (dd, *J* = 5.0, 1.6 Hz, 1H), 7.43 (dd, *J* = 7.7, 1.6 Hz, 1H), 7.11 (dd, *J* = 7.7, 5.0 Hz, 1H), 4.55 (d, *J* = 11.8 Hz, 1H), 4.46 (d, *J* = 11.8 Hz, 1H), 3.91 (d, *J* = 8.0 Hz, 1H), 3.73 (td, *J* = 7.9, 2.0 Hz, 1H), 3.25 (dd, *J* = 8.0, 2.0 Hz, 1H), 2.56 (dd, *J* = 12.2, 7.7 Hz, 1H), 2.48 (tt, *J* = 8.9, 5.3 Hz, 1H), 1.71 – 1.60 (m, 2H), 1.53 – 1.43 (m, 2H), 1.40 – 1.28 (m, 4H), 0.91 (apt td, *J* = 7.3, 1.9 Hz, 6H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 176.1, 161.6, 148.7, 141.8, 131.9, 122.2, 68.2, 67.0, 46.2, 45.5, 42.1, 39.8, 38.1, 37.4, 34.7, 20.8, 14.1.

HRMS (ESI, *m/z*) calcd for $C_{20}H_{26}NO_2{}^{35}Cl_2^+$ $[M+H]^+$: 382.1335, found: 382.1335.



8, 96% yield, >95:5 d.r.

According to the general procedure, a mixture of 6-chloroquinoline (32.7 mg, 0.20 mmol), 2-chloroallyl 3-fluorobenzoate (91.5 mg, 0.40 mmol, 2.00 equiv.), HCl 4M in 1,4-dioxane (100 µl, 0.40 mmol, 2.0 equiv.) and Ir-F (4.4 mg, 2 mol%, 0.004 mmol) in HFIP (1 mL, 0.2 M) was stirred under argon atmosphere for 14 hours under irradiation with blue LEDs to afford **8** as a light yellow gum (75.6 mg, 0.193 mmol, 96% yield, >95:5 d.r.).

Purification conditions: *n*-pentane/EtOAc = 13:4.

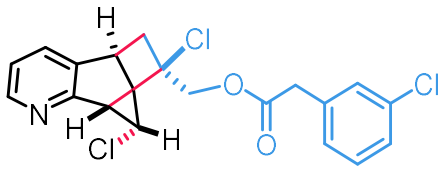
R_f = 0.35 in *n*-pentane/EtOAc (4:1).

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.40 (dd, *J* = 5.0, 1.6 Hz, 1H), 7.38 (dd, *J* = 7.7, 1.5 Hz, 1H), 7.32 – 7.27 (m, 2H), 7.10 (dd, *J* = 7.7, 5.0 Hz, 1H), 7.06 – 6.99 (m, 2H), 4.63 (d, *J* = 11.7 Hz, 1H), 4.46 (d, *J* = 11.7 Hz, 1H), 3.72 (s, 2H), 3.71 (d, *J* = 8.0 Hz, 1H), 3.50 (td, *J* = 8.0, 2.0 Hz, 1H), 3.20 (dd, *J* = 8.0, 2.0 Hz, 1H), 2.89 (dd, *J* = 12.3, 8.4 Hz, 1H), 2.52 (dd, *J* = 12.3, 7.7 Hz, 1H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 170.8 (d, *J* = 1.4 Hz), 162.2 (d, *J* = 245.7 Hz), 161.5, 148.7, 141.7, 131.9, 131.2 (d, *J* = 8.1 Hz), 129.3 (d, *J* = 3.4 Hz), 122.2, 115.7 (d, *J* = 21.4 Hz), 68.3, 67.0, 45.9, 42.1, 40.5, 39.7, 38.1, 37.5.

^{19}F NMR (377 MHz, $CDCl_3$) δ -115.13.

HRMS (ESI, *m*/*z*) calcd for $C_{20}H_{17}NO_2{}^{35}Cl_2F^+$ $[M+H]^+$: 392.0615, found: 392.0614.



According to the general procedure, a mixture of 6-chloroquinoline (32.7 mg, 0.20 mmol), 2-chloroallyl 3-chlorobenzoate (98.0 mg, 0.40 mmol, 2.00 equiv.), HCl 4M in 1,4-dioxane (100 µl, 0.40 mmol, 2.0 equiv.) and Ir-F (4.4 mg, 2 mol%, 0.004 mmol) in HFIP (1 mL, 0.2 M) was stirred under argon atmosphere for 14 hours under irradiation with blue LEDs to afford **9** as a faint yellow gum (77.6 mg, 0.190 mmol, 95% yield, >95:5 d.r.).

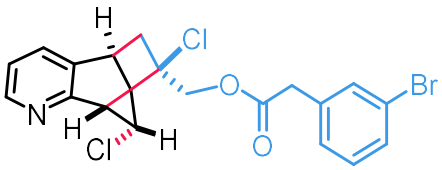
Purification conditions: *n*-pentane/EtOAc = 4:1 to 7:2.

R_f = 0.25 in *n*-pentane/EtOAc (5:1).

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.38 (dd, *J* = 5.0, 1.6 Hz, 1H), 7.37 (dd, *J* = 7.7, 1.6 Hz, 1H), 7.34 – 7.31 (m, 1H), 7.27 – 7.16 (m, 3H), 7.08 (dd, *J* = 7.6, 5.0 Hz, 1H), 4.62 (d, *J* = 11.7 Hz, 1H), 4.45 (d, *J* = 11.7 Hz, 1H), 3.71 (s, 2H), 3.66 (d, *J* = 8.0 Hz, 1H), 3.49 (td, *J* = 8.0, 2.0 Hz, 1H), 3.18 (dd, *J* = 8.0, 2.0 Hz, 1H), 2.88 (dd, *J* = 12.3, 8.3 Hz, 1H), 2.51 (dd, *J* = 12.3, 7.7 Hz, 1H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 170.2, 161.4, 148.7, 141.7, 135.4, 134.5, 131.9, 130.0, 129.7, 127.8, 127.7, 122.2, 68.4, 67.0, 45.9, 42.0, 41.0, 39.6, 38.1, 37.5.

HRMS (ESI, *m*/*z*) calcd for $C_{20}H_{17}NO_2{}^{35}Cl_3^+$ $[M+H]^+$: 408.0319, found: 408.0318.



According to the general procedure, a mixture of 6-chloroquinoline (32.7 mg, 0.20 mmol), 2-chloroallyl 3-bromobenzoate (115.8 mg, 0.40 mmol, 2.00 equiv.), HCl 4M in 1,4-dioxane (100 µl, 0.40 mmol, 2.0 equiv.) and Ir-F (4.4 mg, 2 mol%, 0.004 mmol) in HFIP (1 mL, 0.2 M) was stirred under argon atmosphere for 14 hours under irradiation with blue LEDs to afford **10** as a light yellow gum (83.7 mg, 0.185 mmol, 92% yield, >95:5 d.r.).

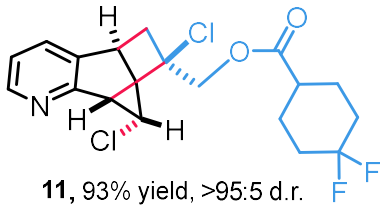
Purification conditions: *n*-pentane/EtOAc = 7:2.

R_f = 0.40 in *n*-pentane/EtOAc (4:1).

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.40 (dd, *J* = 5.1, 1.6 Hz, 1H), 7.50 (t, *J* = 1.9 Hz, 1H), 7.42 (dt, *J* = 7.8, 1.4 Hz, 1H), 7.39 (dd, *J* = 7.7, 1.6 Hz, 1H), 7.27 – 7.24 (m, 1H), 7.20 (t, *J* = 7.7 Hz, 1H), 7.10 (dd, *J* = 7.6, 4.9 Hz, 1H), 4.63 (d, *J* = 11.7 Hz, 1H), 4.46 (d, *J* = 11.7 Hz, 1H), 3.72 (s, 2H), 3.67 (d, *J* = 8.1 Hz, 1H), 3.50 (td, *J* = 8.0, 2.0 Hz, 1H), 3.19 (dd, *J* = 8.0, 2.0 Hz, 1H), 2.89 (dd, *J* = 12.3, 8.3 Hz, 1H), 2.53 (dd, *J* = 12.3, 7.7 Hz, 1H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 170.2, 161.5, 148.7, 141.7, 135.7, 132.7, 131.9, 130.6, 130.3, 128.3, 122.7, 122.2, 68.4, 67.0, 45.9, 42.1, 40.9, 39.6, 38.1, 37.6.

HRMS (ESI, *m/z*) calcd for $C_{20}H_{17}NO_2{}^{35}Cl_2{}^{79}Br^+$ $[M+H]^+$: 451.9814, found: 451.9815.



According to the general procedure, a mixture of 6-chloroquinoline (32.7 mg, 0.20 mmol), 2-chloroallyl 4,4-difluorocyclohexane-1-carboxylate (95.5 mg, 0.40 mmol, 2.00 equiv.), HCl 4M in 1,4-dioxane (100 µl, 0.40 mmol, 2.0 equiv.) and Ir-F (4.4 mg, 2 mol%, 0.004 mmol) in HFIP (1 mL, 0.2 M) was stirred under argon atmosphere for 14 hours under irradiation with blue LEDs to afford **11** as a faint yellow gum (74.6 mg, 0.186 mmol, 93% yield, >95:5 d.r.).

Purification conditions: *n*-pentane/EtOAc = 4:1 to 7:2.

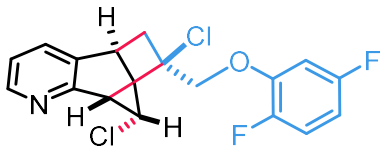
R_f = 0.40 in *n*-pentane/EtOAc (4:1).

$^1H\{^{19}F\}$ NMR (599 MHz, $CDCl_3$) δ 8.41 (dd, *J* = 4.9, 1.6 Hz, 1H), 7.44 (dd, *J* = 7.8, 1.5 Hz, 1H), 7.11 (dd, *J* = 7.6, 4.9 Hz, 1H), 4.65 (d, *J* = 11.8 Hz, 1H), 4.45 (d, *J* = 11.8 Hz, 1H), 3.88 (dd, *J* = 8.0, 0.6 Hz, 1H), 3.71 (td, *J* = 8.0, 2.0 Hz, 1H), 3.26 (dd, *J* = 8.0, 2.0 Hz, 1H), 2.99 (dd, *J* = 12.3, 8.3 Hz, 1H), 2.58 (dd, *J* = 12.4, 7.8 Hz, 1H), 2.55 – 2.51 (m, 1H), 2.15 – 2.09 (m, 2H), 2.09 – 2.03 (m, 2H), 1.95 – 1.88 (m, 2H), 1.83 – 1.77 (m, 2H).

$^{13}C\{^1H, ^{19}F\}$ NMR (151 MHz, $CDCl_3$) δ 173.7, 161.4, 148.8, 141.7, 131.9, 122.6 (br), 122.2, 68.3, 67.1, 46.0, 42.2, 40.6, 39.8, 38.2, 37.5, 32.62, 32.61, 25.2.

^{19}F NMR (564 MHz, $CDCl_3$) δ -94.38 (d, *J* = 237.8 Hz), -99.74 (d, *J* = 238.5 Hz).

HRMS (ESI, *m/z*) calcd for $C_{19}H_{20}NO_2{}^{35}Cl_2F_2^+$ $[M+H]^+$: 402.0834, found: 402.0835.



12, 75% yield, >95:5 d.r.

According to the general procedure, a mixture of 6-chloroquinoline (32.7 mg, 0.20 mmol), 2-((2-chloroallyl)oxy)-1,4-difluorobenzene (205 mg, 1.0 mmol, 5.00 equiv.), HCl 4M in 1,4-dioxane (100 µl, 0.40 mmol, 2.0 equiv.) and Ir-F (4.4 mg, 2 mol%, 0.004 mmol) in HFIP (1 mL, 0.2 M) was stirred under argon atmosphere for 14 hours under irradiation with blue LEDs to afford **12** as a colorless gum (55.2 mg, 75% yield, >95:5 d.r.).

Purification conditions: *n*-pentane/EtOAc = 25:6 to 9:2.

R_f = 0.37 in *n*-pentane/EtOAc (5:1).

^1H NMR (599 MHz, $CDCl_3$) δ 8.42 (dd, *J* = 5.0, 1.6 Hz, 1H), 7.46 (dd, *J* = 7.6, 1.5 Hz, 1H), 7.12 (dd, *J* = 7.6, 5.0 Hz, 1H), 7.06 (ddd, *J* = 10.5, 9.0, 5.2 Hz, 1H), 6.80 (ddd, *J* = 9.5, 6.6, 3.0 Hz, 1H), 6.69 – 6.64 (m, 1H), 4.41 (s, 2H), 3.97 (dd, *J* = 8.0, 0.7 Hz, 1H), 3.88 (td, *J* = 8.0, 2.0 Hz, 1H), 3.30 (dd, *J* = 8.0, 2.0 Hz, 1H), 3.15 (dd, *J* = 12.3, 8.4 Hz, 1H), 2.64 (dd, *J* = 12.3, 7.7 Hz, 1H).

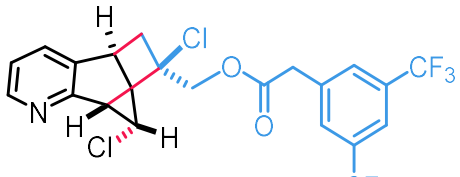
$^1H\{^{19}F\}$ NMR (599 MHz, $CDCl_3$) δ 8.42 (dd, *J* = 5.0, 1.6 Hz, 1H), 7.51 – 7.40 (m, 1H), 7.12 (dd, *J* = 7.7, 4.9 Hz, 1H), 7.06 (d, *J* = 9.0 Hz, 1H), 6.80 (d, *J* = 3.0 Hz, 1H), 6.66 (dd, *J* = 9.0, 3.0 Hz, 1H), 4.41 (s, 2H), 3.97 (d, *J* = 8.0 Hz, 1H), 3.88 (td, *J* = 8.1, 2.0 Hz, 1H), 3.30 (dd, *J* = 8.0, 2.0 Hz, 1H), 3.15 (dd, *J* = 12.3, 8.4 Hz, 1H), 2.64 (dd, *J* = 12.3, 7.7 Hz, 1H).

$^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) δ 161.6, 158.7 (dd, *J* = 243.0, 2.6 Hz), 149.3 (dd, J = 242.4, 3.3 Hz), 148.7, 147.0 (dd, *J* = 12.8, 10.5 Hz), 142.1, 132.0, 122.2, 116.8 (dd, *J* = 20.6, 10.0 Hz), 108.2 (dd, *J* = 23.7, 6.9 Hz), 104.0 (dd, *J* = 27.2, 1.7 Hz), 74.2, 67.4, 46.2, 42.1, 39.9, 38.2, 37.7.

$^{13}C\{^{1}H, ^{19}F\}$ NMR (151 MHz, $CDCl_3$) δ 161.6, 158.7, 149.4, 148.7, 147.0, 142.1, 132.0, 122.2, 116.8, 108.2, 104.0, 74.3, 67.4, 46.2, 42.1, 40.0, 38.2, 37.7.

^{19}F NMR (377 MHz, $CDCl_3$) δ -116.31 (d, *J* = 15.2 Hz), -139.03 (d, *J* = 15.2 Hz).

HRMS (ESI, *m/z*) calcd for $C_{18}H_{14}NO^{35}Cl_2F_2^+$ $[M+H]^+$: 368.0415, found: 368.0415.



13, >99% yield, >95:5 d.r.

According to the general procedure, a mixture of 6-chloroquinoline (32.7 mg, 0.20 mmol), 2-chloroallyl 3,5-bis(trifluoromethyl)benzoate (138.7 mg, 0.40 mmol, 2.00 equiv.), HCl 4M in 1,4-dioxane (100 µl, 0.40 mmol, 2.0 equiv.) and Ir-F (4.4 mg, 2 mol%, 0.004 mmol) in HFIP (1 mL, 0.2 M) was stirred under argon atmosphere for 14 hours under irradiation with blue LEDs to afford **13** as a light yellow gum (103.0 mg, 0.200 mmol, >99% yield, >95:5 d.r.).

Purification conditions: *n*-pentane/EtOAc = 4:1.

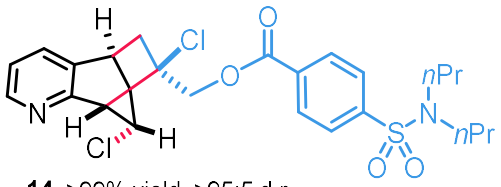
R_f = 0.45 in *n*-pentane/EtOAc (4:1).

^{1}H NMR (599 MHz, $CDCl_3$) δ 8.40 (dd, *J* = 5.0, 1.6 Hz, 1H), 7.82 (s, 1H), 7.81 (s, 2H), 7.39 (dd, *J* = 7.8, 1.5 Hz, 1H), 7.10 (dd, *J* = 7.6, 5.0 Hz, 1H), 4.71 (d, *J* = 11.8 Hz, 1H), 4.47 (d, *J* = 11.7 Hz, 1H), 3.93 – 3.87 (m, 2H), 3.72 (d, *J* = 8.0 Hz, 1H), 3.55 (td, *J* = 8.0, 2.0 Hz, 1H), 3.22 (dd, *J* = 8.0, 2.0 Hz, 1H), 2.93 (dd, *J* = 12.4, 8.3 Hz, 1H), 2.55 (dd, *J* = 12.4, 7.7 Hz, 1H).

$^{13}C\{^{1}H, ^{19}F\}$ NMR (151 MHz, $CDCl_3$) δ 169.3, 161.3, 148.8, 141.6, 135.9, 132.1, 131.9, 130.0, 123.3, 122.2, 121.6, 68.8, 66.9, 45.8, 42.1, 40.7, 39.7, 38.0, 37.6.

^{19}F NMR (564 MHz, $CDCl_3$) δ -62.92.

HRMS (ESI, *m/z*) calcd for $C_{22}H_{16}NO_2{}^{35}Cl_2F_6^+$ $[M+H]^+$: 510.0457, found: 510.0456.



14, >99% yield, >95:5 d.r.

According to the general procedure, a mixture of 6-chloroquinoline (32.7 mg, 0.20 mmol), 2-chloroallyl 4-(*N*,*N*-dipropylsulfamoyl)benzoate (143.9 mg, 0.40 mmol, 2.00 equiv.), HCl 4M in 1,4-dioxane (100 µl, 0.40 mmol, 2.0 equiv.) and Ir-F (4.4 mg, 2 mol%, 0.004 mmol) in HFIP (1 mL, 0.2 M) was stirred under argon atmosphere for 14 hours under irradiation with blue LEDs to afford **14** as a light yellow gum (104.6 mg, 0.200 mmol, >99% yield, >95:5 d.r.).

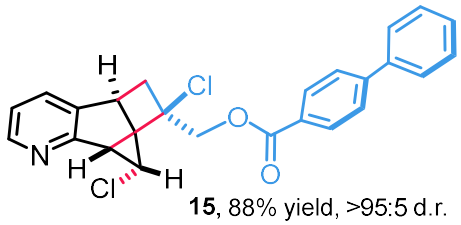
Purification conditions: *n*-pentane/EtOAc = 5:3.

R_f = 0.55 in *n*-pentane/EtOAc (17:10).

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.40 (dd, *J* = 5.0, 1.6 Hz, 1H), 8.22 (d, *J* = 8.5 Hz, 2H), 7.90 (d, *J* = 8.5 Hz, 2H), 7.43 (dd, *J* = 7.7, 1.6 Hz, 1H), 7.11 (dd, *J* = 7.6, 5.0 Hz, 1H), 4.81 (apt dd, *J* = 20.3, 11.8 Hz, 2H), 3.93 (d, *J* = 8.0 Hz, 1H), 3.75 (td, *J* = 7.9, 2.0 Hz, 1H), 3.29 (dd, *J* = 8.0, 2.0 Hz, 1H), 3.14 – 3.02 (m, 5H), 2.63 (dd, *J* = 12.4, 7.7 Hz, 1H), 1.58 – 1.48 (m, 4H), 0.84 (t, *J* = 7.4 Hz, 6H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 164.7, 161.3, 148.8, 144.8, 141.6, 132.7, 132.0, 130.5, 127.3, 122.2, 68.8, 67.1, 50.0, 46.0, 42.2, 39.8, 38.2, 37.6, 22.0, 11.2.

HRMS (ESI, *m*/*z*) calcd for $C_{25}H_{28}N_2O_4S^{35}Cl_2Na^+$ $[M+Na]^+$: 545.1039, found: 545.1037.



15, 88% yield, >95:5 d.r.

According to the general procedure, a mixture of 6-chloroquinoline (32.7 mg, 0.20 mmol), 2-chloroallyl [1,1'-biphenyl]-4-carboxylate (109.1 mg, 0.40 mmol, 2.00 equiv.), HCl 4M in 1,4-dioxane (100 µl, 0.40 mmol, 2.0 equiv.) and Ir-F (4.4 mg, 2 mol%, 0.004 mmol) in HFIP (1 mL, 0.2 M) was stirred under argon atmosphere for 14 hours under irradiation with blue LEDs to afford **15** as a faint yellow gum (77.0 mg, 0.176 mmol, 88% yield, >95:5 d.r.).

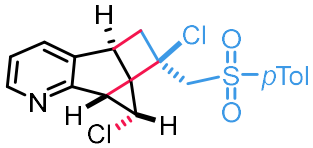
Purification conditions: *n*-pentane/EtOAc = 4:1.

R_f = 0.25 in *n*-pentane/EtOAc (5:1).

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.43 (dd, *J* = 5.0, 1.6 Hz, 1H), 8.23 – 8.18 (m, 2H), 7.73 – 7.69 (m, 2H), 7.66 – 7.61 (m, 2H), 7.50 – 7.43 (m, 3H), 7.40 (tt, *J* = 7.3, 1.2 Hz, 1H), 7.12 (dd, *J* = 7.6, 5.0 Hz, 1H), 4.83 (s, 2H), 3.99 (d, *J* = 8.0 Hz, 1H), 3.81 (td, *J* = 8.0, 2.0 Hz, 1H), 3.33 (dd, *J* = 8.0, 2.0 Hz, 1H), 3.12 (dd, *J* = 12.3, 8.3 Hz, 1H), 2.66 (dd, *J* = 12.3, 7.7 Hz, 1H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 166.0, 161.5, 148.7, 146.3, 141.9, 139.9, 132.0, 130.5, 129.1, 128.4, 128.2, 127.4, 122.2, 68.3, 67.4, 46.1, 42.3, 39.9, 38.3, 37.7. *One aromatic signal missing due to overlap.*

HRMS (ESI, *m/z*) calcd for $C_{25}H_{20}NO_2{}^{35}Cl_2^+$ $[M+H]^+$: 436.0866, found: 436.0865.



16, 58% yield, >95:5 d.r.

According to the general procedure, a mixture of 6-chloroquinoline (32.7 mg, 0.20 mmol), 1-((2-chloroallyl)sulfonyl)-4-methylbenzene (231 mg, 1.00 mmol, 5.00 equiv.), HCl 4M in 1,4-dioxane (100 µl, 0.40 mmol, 2.0 equiv.) and Ir-F (4.4 mg, 2 mol%, 0.004 mmol) in HFIP (1 mL, 0.2 M) was stirred under argon atmosphere for 48 hours under irradiation with blue LEDs to afford **16** as a light yellow foam (45.6 mg, 0.116 mmol, 58% yield, >95:5 d.r.).

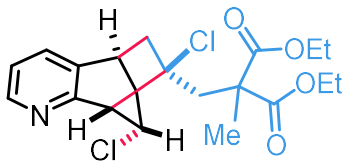
Purification conditions: *n*-pentane/acetone = 9:2 to 4:1.

R_f = 0.55 in CH_2Cl_2/EtOAc (4:1).

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.40 (dd, *J* = 5.0, 1.6 Hz, 1H), 7.85 (d, *J* = 8.3 Hz, 2H), 7.44 (dd, *J* = 7.7, 1.6 Hz, 1H), 7.39 – 7.34 (m, 2H), 7.11 (dd, *J* = 7.7, 5.0 Hz, 1H), 4.05 (d, *J* = 8.2 Hz, 1H), 3.98 (d, *J* = 14.9 Hz, 1H), 3.88 (dd, *J* = 14.9, 1.0 Hz, 1H), 3.86 – 3.80 (m, 1H), 3.47 (dd, *J* = 12.5, 8.3 Hz, 1H), 3.32 (dd, *J* = 8.1, 2.0 Hz, 1H), 2.61 (ddd, *J* = 12.5, 8.0, 1.0 Hz, 1H), 2.45 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 161.3, 148.7, 145.3, 141.5, 137.6, 132.0, 130.1, 128.4, 122.3, 64.24, 64.22, 48.2, 44.4, 39.1, 38.8, 38.4, 21.8.

HRMS (ESI, *m/z*) calcd for $C_{19}H_{17}NO_2{}^{35}Cl_2SNa^+$ $[M+Na]^+$: 416.0249, found: 416.0249.



17, 91% yield, >95:5 d.r.

According to the general procedure, a mixture of 6-chloroquinoline (32.7 mg, 0.20 mmol), diethyl 2-(2-chloroallyl)-2-methylmalonate (99.5 mg, 0.40 mmol, 2.00 equiv.), HCl 4M in 1,4-dioxane (100 µl, 0.40 mmol, 2.0 equiv.) and Ir-F (4.4 mg, 2 mol%, 0.004 mmol) in HFIP (1 mL, 0.2 M) was stirred under argon atmosphere for 14 hours under irradiation with blue LEDs to afford **17** as a faint yellow gum (, >95:5 d.r.).

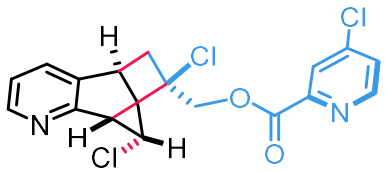
Purification conditions: *n*-pentane/EtOAc = 4:1 to 7:2.

R_f = 0.42 in *n*-pentane/EtOAc (4:1).

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.37 (dd, *J* = 5.0, 1.6 Hz, 1H), 7.39 (dd, *J* = 7.6, 1.5 Hz, 1H), 7.07 (dd, *J* = 7.6, 5.0 Hz, 1H), 4.19 (apt qt, *J* = 7.1, 3.2 Hz, 4H), 3.92 (dd, *J* = 8.1, 0.6 Hz, 1H), 3.76 (td, *J* = 8.1, 2.0 Hz, 1H), 3.25 (dd, *J* = 8.1, 2.0 Hz, 1H), 3.09 – 3.02 (m, 2H), 2.89 (dd, *J* = 15.5, 1.2 Hz, 1H), 2.49 (ddd, *J* = 12.0, 7.9, 1.2 Hz, 1H), 1.57 (s, 3H), 1.25 (t, *J* = 7.1 Hz, 6H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 171.9, 171.8, 161.7, 148.5, 141.8, 131.7, 122.1, 68.6 – 68.5 (m), 62.0, 61.8, 53.4, 49.0, 46.2, 44.0, 39.4, 38.6, 38.4, 20.8, 14.0.

HRMS (ESI, *m*/*z*) calcd for $C_{20}H_{23}NO_4{}^{35}Cl_2Na^+$ $[M+Na]^+$: 434.0896, found: 434.0896.



18, 94% yield, >95:5 d.r.

According to the general procedure, a mixture of 6-chloroquinoline (32.7 mg, 0.20 mmol), 2-chloroallyl 4-chloropicolinate (92.8 mg, 0.40 mmol, 2.00 equiv.), HCl 4M in 1,4-dioxane (100 µl, 0.40 mmol, 2.0 equiv.) and Ir-F (4.4 mg, 2 mol%, 0.004 mmol) in HFIP (1 mL, 0.2 M) was stirred under argon atmosphere for 14 hours under irradiation with blue LEDs to afford **18** as a light yellow gum (74.7 mg, 0.189 mmol, 94% yield, >95:5 d.r.).

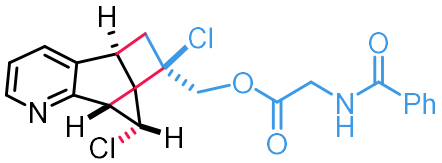
Purification conditions: *n*-pentane/EtOAc = 3:2 to 6:5.

R_f = 0.30 in *n*-pentane/EtOAc (9:5).

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.68 (dd, *J* = 5.2, 0.6 Hz, 1H), 8.39 (dd, *J* = 5.0, 1.6 Hz, 1H), 8.16 (dd, *J* = 2.0, 0.6 Hz, 1H), 7.50 (dd, *J* = 5.2, 2.0 Hz, 1H), 7.42 (dd, *J* = 7.7, 1.6 Hz, 1H), 7.09 (dd, *J* = 7.7, 5.0 Hz, 1H), 4.97 (d, *J* = 11.6 Hz, 1H), 4.76 (d, *J* = 11.6 Hz, 1H), 3.97 (dd, *J* = 8.0, 0.6 Hz, 1H), 3.78 (td, *J* = 8.0, 2.0 Hz, 1H), 3.29 (dd, *J* = 8.0, 2.0 Hz, 1H), 3.14 (dd, *J* = 12.3, 8.3 Hz, 1H), 2.63 (dd, *J* = 12.3, 7.7 Hz, 1H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 163.7, 161.4, 151.1, 148.9, 148.7, 145.5, 141.8, 131.9, 127.5, 126.0, 122.1, 69.1, 67.1, 45.9, 42.4, 39.8, 38.3, 37.7.

HRMS (ESI, *m/z*) calcd for $C_{18}H_{13}N_2O_2{}^{35}Cl_3Na^+$ $[M+Na]^+$: 416.9935, found: 416.9934.



19, 86% yield, >95:5 d.r.

According to the general procedure, a mixture of 6-chloroquinoline (32.7 mg, 0.20 mmol), 2-chloroallyl benzoylglycinate (101.5 mg, 0.40 mmol, 2.00 equiv.), HCl 4M in 1,4-dioxane (100 µl, 0.40 mmol, 2.0 equiv.) and Ir-F (4.4 mg, 2 mol%, 0.004 mmol) in HFIP (1 mL, 0.2 M) was stirred under argon atmosphere for 14 hours under irradiation with blue LEDs to afford **19** as a white foam (71.8 mg, 0.172 mmol, 86% yield, >95:5 d.r.).

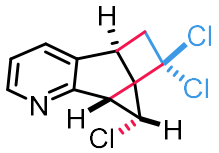
Purification conditions: *n*-pentane/EtOAc = 1:1.

R_f = 0.40 in CH_2Cl_2/EtOAc (2:1).

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.39 (dd, *J* = 5.0, 1.6 Hz, 1H), 7.86 – 7.79 (m, 2H), 7.50 (tt, *J* = 7.4, 1.2 Hz, 1H), 7.45 – 7.37 (m, 3H), 7.09 (dd, *J* = 7.7, 5.0 Hz, 1H), 7.05 (t, *J* = 5.3 Hz, 1H), 4.74 (d, *J* = 11.6 Hz, 1H), 4.51 (d, *J* = 11.6 Hz, 1H), 4.35 (dd, *J* = 5.4, 1.4 Hz, 2H), 3.89 (d, *J* = 8.1 Hz, 1H), 3.70 (td, *J* = 8.0, 2.0 Hz, 1H), 3.23 (dd, *J* = 8.0, 2.0 Hz, 1H), 3.01 (dd, *J* = 12.4, 8.3 Hz, 1H), 2.56 (dd, *J* = 12.4, 7.7 Hz, 1H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 169.7, 167.8, 161.3, 148.7, 141.7, 133.6, 132.0, 128.7, 127.2, 122.2, 68.6, 66.9, 45.8, 42.2, 41.9, 39.8, 38.2, 37.6. *One aromatic signal missing due to overlap.*

HRMS (ESI, *m/z*) calcd for $C_{21}H_{18}N_2O_3{}^{35}Cl_2SNa^+$ $[M+Na]^+$: 439.0587, found: 439.0585.



20, 72% yield, >95:5 d.r.

According to the general procedure, a mixture of 6-chloroquinoline (32.7 mg, 0.20 mmol), 1,1-dichloethene (80 μL, 1.0 mmol), HCl (50 μL, 0.2 mmol, 4 M in 1,4-dioxane) and Ir-F (4.4 mg, 2 mol%, 0.004 mmol) in HFIP (1 mL, 0.2 M) was stirred under argon atmosphere for 14 hours under irradiation with blue LEDs to afford **20** as a colorless gum (37.4 mg, 72% yield, >95:5 d.r.). The ^{1}H NMR analysis of the crude reaction mixture gave >95:5 d.r.

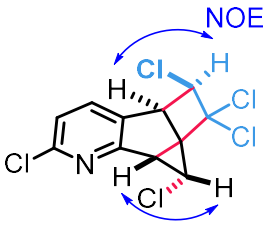
Purification conditions: *n*-pentane/EtOAc = 9:1 to 6:1.

R_f = 0.35 in *n*-pentane/EtOAc (9:1).

^{1}H NMR (599 MHz, $CDCl_3$) δ 8.43 (dd, *J* = 4.9, 1.6 Hz, 1H), 7.47 (dd, *J* = 7.7, 1.6 Hz, 1H), 7.14 (dd, *J* = 7.7, 5.0 Hz, 1H), 4.10 (d, *J* = 8.3 Hz, 1H), 4.06 (t, *J* = 7.9 Hz, 1H), 3.47 (dd, *J* = 8.2, 2.0 Hz, 1H), 3.43 (dd, *J* = 12.7, 8.1 Hz, 1H), 2.95 (dd, *J* = 12.7, 7.9 Hz, 1H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 160.8, 149.1, 140.5, 132.3, 122.5, 84.1, 52.9, 52.8, 41.5, 39.6, 39.1.

HRMS (ESI, *m*/*z*) calcd for $C_{11}H_8N^{35}Cl_3Na^+$ $[M+Na]^+$: 259.9795, found: 259.9794.



21, 88% yield, 94:6 d.r.

According to the general procedure, a mixture of 6-chloroquinoline (32.7 mg, 0.20 mmol), trichloroethylene (90 μL, 1.0 mmol), HCl (100 μL, 0.4 mmol, 4 M in 1,4-dioxane) and Ir-F (4.4 mg, 2 mol%, 0.004 mmol) in HFIP (1 mL, 0.2 M) was stirred under argon atmosphere for 14 hours under irradiation with blue LEDs to afford **21** as a white solid (58.0 mg, 88% yield, 94:6 d.r.).

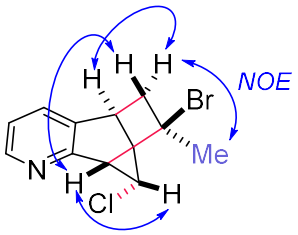
Purification conditions: *n*-pentane/Et_2O= 20:1 to 10:1.

R_f = 0.60 in *n*-pentane/Et_2O (10:1).

^{1}H NMR (599 MHz, $CDCl_3$) δ 7.45 (dd, *J* = 8.1, 0.6 Hz, 1H), 7.25 (d, *J* = 8.1 Hz, 1H), 5.10 (d, *J* = 6.9 Hz, 1H), 4.50 (ddd, *J* = 6.9, 1.7, 1.0 Hz, 1H), 4.08 (d, *J* = 8.2 Hz, 1H), 3.42 (dd, *J* = 8.2, 2.1 Hz, 1H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 162.5, 151.7, 136.0, 134.9, 123.2, 86.9, 69.6, 52.0, 45.8, 41.8, 38.0.

HRMS (ESI, *m*/*z*) calcd for $C_{19}H_{16}NO_2FNa^+$ [M+Na]$^+$: 332.1057, found: 332.1056.



22, 71% yield, 91:9 d.r.

According to the general procedure, a mixture of 6-chloroquinoline (32.7 mg, 0.20 mmol), 2-bromoprop-1-ene (88 μL, 1.0 mmol), HCl (100 μL, 0.2 mmol, 4 M in 1,4-dioxane) and Ir-F (4.4 mg, 2 mol%, 0.004 mmol) in HFIP (1 mL, 0.2 M) was stirred under argon atmosphere for 14 hours under irradiation with blue LEDs to afford **22** as a colorless gum (40.5 mg, 71% yield, 91:9 d.r.). The ^{1}H NMR analysis of the crude reaction mixture gave 91:9 d.r.

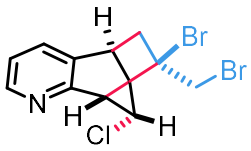
Purification conditions: *n*-pentane/EtOAc = 9:1 to 6:1.

R_f = 0.40 in *n*-pentane/EtOAc (5:1).

^{1}H NMR (599 MHz, $CDCl_3$) δ 8.40 (ddd, *J* = 5.0, 1.6, 0.5 Hz, 1H), 7.41 (ddd, *J* = 7.6, 1.5, 0.7 Hz, 1H), 7.10 (dd, *J* = 7.6, 5.0 Hz, 1H), 3.90 (dd, *J* = 8.1, 0.6 Hz, 1H), 3.87 – 3.73 (m, 1H), 3.19 (dd, *J* = 8.0, 2.0 Hz, 1H), 2.92 (dd, *J* = 11.8, 8.1 Hz, 1H), 2.77 (ddd, *J* = 11.8, 7.7, 0.7 Hz, 1H), 2.14 (d, *J* = 0.7 Hz, 3H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 161.8, 148.5, 141.8, 131.8, 122.1, 60.1, 49.9, 47.3, 40.7, 40.6, 38.0, 30.7.

HRMS (ESI, *m*/*z*) calcd for $C_{12}H_{11}NBrCl^+$ [M+H]$^+$: 285.9814, found: 285.9813.



23, 70% yield, 92:8 d.r.

According to the general procedure, a mixture of 6-chloroquinoline (65.4 mg, 0.40 mmol), 2,3-dibromoprop-1-ene (78 μL, 0.8 mmol), HCl (200 μL, 0.2 mmol, 4 M in 1,4-dioxane) and Ir-F (8.8 mg, 2 mol%, 0.008 mmol) in HFIP (2 mL, 0.2 M) was stirred under argon atmosphere for 14 hours under irradiation with blue LEDs to afford **23** as a colorless gum (101.0 mg, 70% yield, 92:8

d.r.). The ^{1}H NMR analysis of the crude reaction mixture gave 92:8 d.r.

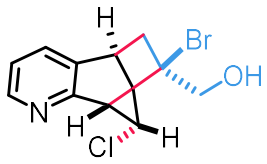
Purification conditions: *n*-pentane/EtOAc = 9:1 to 6:1.

R_f = 0.40 in *n*-pentane/EtOAc (5:1).

^{1}H NMR (599 MHz, $CDCl_3$) δ 8.42 (ddd, *J* = 5.0, 1.6, 0.5 Hz, 1H), 7.44 (ddt, *J* = 7.7, 1.4, 0.6 Hz, 1H), 7.13 (dd, *J* = 7.7, 5.0 Hz, 1H), 4.05 – 4.03 (m, 3H), 3.96 – 3.93 (m, 1H), 3.23 – 3.18 (m, 2H), 2.85 (dd, *J* = 12.6, 7.6 Hz, 1H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 161.3, 148.7, 141.7, 132.09 122.3, 62.6, 47.9, 44.5, 41.5, 41.2, 39.7, 38.4.

HRMS (ESI, *m*/*z*) calcd for $C_{12}H_{11}NBr_2Cl^+$ $[M+H]^+$: 363.8920, found: 363.8920.



24, 55% yield, >95:5 d.r.

According to the general procedure, a mixture of 6-chloroquinoline (32.7 mg, 0.20 mmol), 2-bromoprop-2-en-1-ol (33 μL, 0.4 mmol), HCl (100 μL, 0.4 mmol, 4 M in 1,4-dioxane) and Ir-F (4.4 mg, 2 mol%, 0.004 mmol) in HFIP (1 mL, 0.2 M) was stirred under argon atmosphere for 14 hours under irradiation with blue LEDs to afford **24** as a white solid (35.2 mg, 55% yield, >95:5 d.r.). The ^{1}H NMR analysis of the crude reaction mixture gave >95:5 d.r.

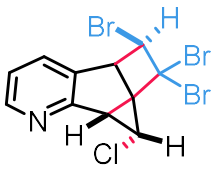
Purification conditions: *n*-pentane/EtOAc = 3:1 to 1:1.

R_f = 0.40 in *n*-pentane/EtOAc (1:1).

^{1}H NMR (300 MHz, CD_3OD) δ 8.32 (dd, *J* = 5.1, 1.5 Hz, 1H), 7.62 (ddd, *J* = 7.7, 1.5, 0.7 Hz, 1H), 7.25 (dd, *J* = 7.7, 5.1 Hz, 1H), 4.17 (dd, *J* = 7.9, 0.7 Hz, 1H), 4.04 (d, *J* = 1.8 Hz, 2H), 3.95 – 3.83 (m, 1H), 3.14 (dd, *J* = 12.2, 8.4 Hz, 1H), 3.08 (dd, *J* = 7.9, 2.0 Hz, 1H), 2.61 (dd, *J* = 12.2, 7.5 Hz, 1H).

^{13}C NMR (151 MHz, CD_3OD) δ 162.5, 148.5, 144.7, 134.0, 123.7, 69.1, 66.6, 48.2, 43.5, 42.5, 40.0, 38.9.

HRMS (ESI, *m*/*z*) calcd for $C_{12}H_{12}NOBr\,Cl^+$ $[M+H]^+$: 301.9763, found: 301.9762.



25, 39% yield, 88:12 d.r.

According to the general procedure, a mixture of 6-chloroquinoline (32.7 mg, 0.20 mmol), 1,1,2-tribromoethene (33 μL, 0.4 mmol), HCl (100 μL, 0.4 mmol, 4 M in 1,4-dioxane) and Ir-F (4.4 mg, 2 mol%, 0.004 mmol) in HFIP (1 mL, 0.2 M) was stirred under argon atmosphere for 14 hours under irradiation with blue LEDs to afford **25** as a white solid (35.2 mg, 55% yield, 90:10 d.r.). The ^{1}H NMR analysis of the crude reaction mixture gave 88:12 d.r.

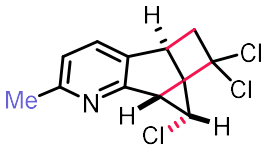
Purification conditions: *n*-pentane/EtOAc = 3:1 to 1:1.

R_f = 0.40 in *n*-pentane/EtOAc (1:1).

^{1}H NMR (599 MHz, $CDCl_3$) δ 8.48 (ddd, *J* = 4.9, 1.5, 0.5 Hz, 1H), 7.63 – 7.40 (m, 1H), 7.20 (dd, *J* = 7.7, 5.0 Hz, 1H), 5.48 (d, *J* = 6.9 Hz, 1H), 4.67 – 4.54 (m, 1H), 4.03 (dd, *J* = 8.2, 0.6 Hz, 1H), 3.47 (dd, *J* = 8.2, 1.9 Hz, 1H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 162.1, 149.6, 137.5, 133.7, 122.5, 63.2, 61.7, 53.4, 46.8, 45.1, 39.7.

HRMS (ESI, *m*/*z*) calcd for $C_{11}H_8NBr_3Cl^+$ $[M+H]^+$: 429.7847, found: 429.7847.



26, 74% yield, >95:5 d.r.

According to the general procedure, a mixture of 6-chloro-2-methylquinoline (35.5 mg, 0.20 mmol), 1,1-dichloroethylene (81 μL, 1.0 mmol), HCl (100 μL, 0.4 mmol, 4 M in 1,4-dioxane) and Ir-F (4.4 mg, 2 mol%, 0.004 mmol) in HFIP (1 mL, 0.2 M) was stirred under argon atmosphere for 14 hours under irradiation with blue LEDs to afford **26** as a white solid (40.6 mg, 74% yield, >95:5 d.r.).

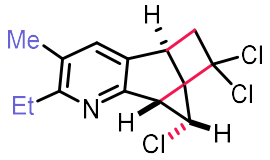
Purification conditions: *n*-pentane/Et_2O = 20:1 to 10:1.

R_f = 0.60 in *n*-pentane/Et_2O (10:1).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.36 (d, *J* = 7.8 Hz, 1H), 7.00 (d, *J* = 7.8 Hz, 1H), 4.08 (dd, *J* = 8.2, 0.6 Hz, 1H), 4.02 (td, *J* = 7.9, 2.0 Hz, 1H), 3.52 – 3.33 (m, 2H), 2.91 (dd, *J* = 12.6, 7.7 Hz, 1H), 2.54 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 160.1, 158.1, 137.4, 132.4, 122.0, 84.2, 53.1, 53.0, 41.5, 39.3, 39.2, 24.3.

HRMS (ESI, *m/z*) calcd for $C_{12}H_{11}NCl_3^+$ $[M+Na]^+$: 273.99516, found: 273.99519.



27, 77% yield, >95:5 d.r.

According to the general procedure, a mixture of 6-chloro-2-ethyl-3-methylquinoline (40.2 mg, 0.20 mmol), 1,1-dichloroethylene (81 μL, 1.0 mmol), HCl (100 μL, 0.4 mmol, 4 M in 1,4-dioxane) and Ir-F (4.4 mg, 2 mol%, 0.004 mmol) in HFIP (1 mL, 0.2 M) was stirred under argon atmosphere for 14 hours under irradiation with blue LEDs to afford **27** as a white solid (46.4 mg, 77% yield, >95:5 d.r.). The ^{1}H NMR analysis of the crude reaction mixture gave >95:5 d.r.

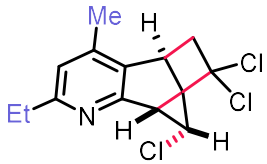
Purification conditions: *n*-pentane/Et_2O= 20:1 to 10:1.

R_f= 0.60 in *n*-pentane/Et_2O (10:1).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.21 (s, 1H), 4.29 – 4.03 (m, 1H), 4.00 (td, *J* = 7.9, 2.0 Hz, 1H), 3.49 – 3.21 (m, 2H), 2.92 (dd, *J* = 12.6, 7.7 Hz, 1H), 2.79 (q, *J* = 7.6 Hz, 2H), 2.28 (s, 3H), 1.27 (t, *J* = 7.6 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 161.3, 157.4, 137.9, 134.0, 129.7, 84.4, 53.1, 53.0, 41.4, 39.4, 39.3, 28.7, 18.9, 13.0.

HRMS (ESI, *m/z*) calcd for $C_{14}H_{15}N_1Cl_3^+$ $[M+H]^+$: 302.02646, found: 302.02645.



28, 73% yield, >95:5 d.r.

According to the general procedure, a mixture of 6-chloro-2-ethyl-4-methylquinoline (41.1 mg, 0.20 mmol), 1,1-dichloethene (80 μL, 1.0 mmol), HCl (100 μL, 0.4 mmol, 4 M in 1,4-dioxane) and Ir-F (4.4 mg, 2 mol%, 0.004 mmol) in HFIP (1 mL, 0.2 M) was stirred under argon atmosphere for 14 hours under irradiation with blue LEDs to afford **28** as a white waxy solid (44.2 mg, 73%

yield, >95:5 d.r.). The ^{1}H NMR analysis of the crude reaction mixture gave >95:5 d.r.

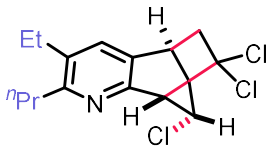
Purification conditions: *n*-pentane/EtOAc = 35:1 to 25:1.

R_f = 0.30 in *n*-pentane/EtOAc (35:1).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.20 (s, 1H), 4.05 (d, *J* = 8.0 Hz, 1H), 3.99 (td, *J* = 7.8, 2.0 Hz, 1H), 3.42 (dd, *J* = 8.0, 1.8 Hz, 1H), 3.40 (dd, *J* = 12.8, 8.0 Hz, 1H), 2.91 (dd, *J* = 12.6, 7.8 Hz, 1H), 2.78 (q, *J* = 7.5 Hz, 2H), 2.27 (s, 3H), 1.27 (t, *J* = 7.6 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 161.4, 157.4, 137.9, 134.0, 129.6, 84.4, 53.10, 53.05, 41.5, 39.5, 39.4, 28.8, 18.9, 13.0.

HRMS (ESI, *m*/*z*) calcd for $C_{14}H_{15}N^{35}Cl_3^+$ $[M+H]^+$: 302.0265, found: 302.0266.



29, 95% yield, >95:5 d.r.

According to the general procedure, a mixture of 6-chloro-3-ethyl-2-propylquinoline (46.7 mg, 0.20 mmol), 1,1-dichloroethylene (81 μL, 1.0 mmol), HCl (100 μL, 0.4 mmol, 4 M in 1,4-dioxane) and Ir-F (4.4 mg, 2 mol%, 0.004 mmol) in HFIP (1 mL, 0.2 M) was stirred under argon atmosphere for 14 hours under irradiation with blue LEDs to afford **29** as a white solid (63.0 mg, 95% yield, >95:5 d.r.). The ^{1}H NMR analysis of the crude reaction mixture gave >95:5 d.r.

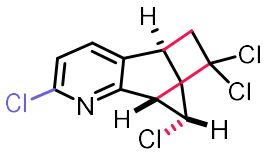
Purification conditions: *n*-pentane/Et_2O= 20:1 to 10:1.

R_f = 0.60 in *n*-pentane/Et_2O (15:1).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.23 (s, 1H), 4.05 (d, *J* = 8.1 Hz, 1H), 4.00 (td, *J* = 7.9, 2.0 Hz, 1H), 3.46 – 3.36 (m, 2H), 2.93 (dd, *J* = 12.6, 7.7 Hz, 1H), 2.74 (t, *J* = 7.9 Hz, 2H), 2.62 (q, *J* = 7.5 Hz, 2H), 1.83 – 1.64 (m, 2H), 1.20 (t, *J* = 7.5 Hz, 3H), 1.00 (t, *J* = 7.4 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 159.8, 157.2, 138.0, 135.6, 132.1, 84.4, 53.1, 53.0, 41.4, 39.5, 39.4, 37.1, 25.2, 23.1, 14.8, 14.4.

HRMS (ESI, *m*/*z*) calcd for $C_{16}H_{19}N_1Cl_3^+$ $[M+H]^+$: 330.05776, found: 330.05781.



30, 77% yield, >95:5 d.r.

According to the general procedure, a mixture of 2,6-dichloroquinoline (39.6 mg, 0.20 mmol), 1,1-dichloroethylene (81 μL, 1.0 mmol), HCl (100 μL, 0.4 mmol, 4 M in 1,4-dioxane) and Ir-F (4.4 mg, 2 mol%, 0.004 mmol) in HFIP (1 mL, 0.2 M) was stirred under argon atmosphere for 14 hours under irradiation with blue LEDs to afford **30** as a white solid (45.6 mg, 77% yield, >95:5 d.r.). The ^{1}H NMR analysis of the crude reaction mixture gave >95:5 d.r.

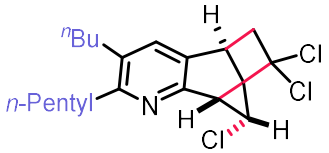
Purification conditions: *n*-pentane/Et_2O = 20:1 to 10:1.

R_f = 0.60 in *n*-pentane/Et_2O (10:1).

^{1}H NMR (599 MHz, $CDCl_3$) δ 7.44 (dt, *J* = 8.1, 0.6 Hz, 1H), 7.22 – 7.07 (m, 1H), 4.09 (dd, *J* = 8.2, 0.7 Hz, 1H), 4.04 (tdt, *J* = 8.0, 2.2, 0.7 Hz, 1H), 3.54 – 3.34 (m, 2H), 2.95 (dd, *J* = 12.7, 7.8 Hz, 1H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 161.3, 150.9, 139.3, 134.6, 123.0, 83.7, 53.4, 52.9, 41.1, 38.9, 38.8.

HRMS (ESI, *m*/*z*) calcd for $C_{11}H_7NCl_4Na^+$ $[M+Na]^+$: 317.9195, found: 317.9194.



31, 92% yield, >95:5 d.r.

According to the general procedure, a mixture of 3-butyl-6-chloro-2-pentylquinoline (58.0 mg, 0.20 mmol), 1,1-dichloroethylene (81 μL, 1.0 mmol), HCl (100 μL, 0.4 mmol, 4 M in 1,4-dioxane) and Ir-F (4.4 mg, 2 mol%, 0.004 mmol) in HFIP (1 mL, 0.2 M) was stirred under argon atmosphere for 14 hours under irradiation with blue LEDs to afford **31** as a white solid (71.0 mg, 92% yield, >95:5 d.r.). The ^{1}H NMR analysis of the crude reaction mixture gave >95:5 d.r.

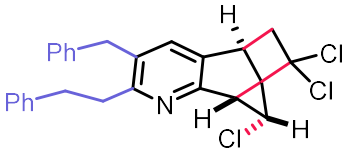
Purification conditions: *n*-pentane/Et_2O= 20:1 to 10:1.

R_f = 0.60 in *n*-pentane/Et_2O (15:1).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.21 (s, 1H), 4.05 (dd, *J* = 8.1, 0.6 Hz, 1H), 3.99 (td, *J* = 7.9, 2.0 Hz, 1H), 3.55 – 3.34 (m, 2H), 2.93 (dd, *J* = 12.6, 7.7 Hz, 1H), 2.75 (t, *J* = 8.1 Hz, 1H), 2.63 – 2.48 (m, 2H), 1.74 – 1.62 (m, 2H), 1.57 – 1.49 (m, 2H), 1.43 – 1.33 (m, 6H), 0.96 – 0.89 (m, 6H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 160.1, 157.3, 137.8, 134.4, 132.9, 84.4, 53.1, 53.0, 41.4, 39.5, 39.4, 35.2, 33.0, 32.2, 32.1, 29.7, 22.8, 22.7, 14.2, 14.0.

HRMS (ESI, *m/z*) calcd for $C_{20}H_{27}N_1Cl_3^+$ [M+ H]$^+$: 386.12036, found: 386.12035.



32, 83% yield, >95:5 d.r.

According to the general procedure, a mixture of 3-benzyl-6-chloro-2-phenethylquinoline (71.6 mg, 0.20 mmol), 1,1-dichloroethylene (81 μL, 1.0 mmol), HCl (100 μL, 0.4 mmol, 4 M in 1,4-dioxane) and Ir-F (4.4 mg, 2 mol%, 0.004 mmol) in HFIP (1 mL, 0.2 M) was stirred under argon atmosphere for 14 hours under irradiation with blue LEDs to afford **32** as a white solid (75.7 mg, 83% yield, >95:5 d.r.). The ^{1}H NMR analysis of the crude reaction mixture gave >95:5 d.r.

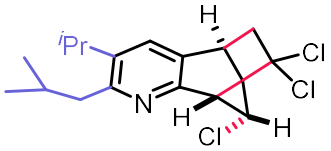
Purification conditions: *n*-pentane/Et_2O = 20:1 to 10:1.

R_f = 0.60 in *n*-pentane/Et_2O (15:1).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.33 – 7.24 (m, 5H), 7.21 – 7.18 (m, 1H), 7.13 – 7.11 (m, 3H), 7.04 – 7.03 (m, 2H), 4.11 (d, *J* = 8.1 Hz, 1H), 4.00 (td, *J* = 7.8, 2.0 Hz, 1H), 3.92 – 3.75 (m, 2H), 3.49 (dd, *J* = 8.1, 2.0 Hz, 1H), 3.41 (dd, *J* = 12.7, 8.0 Hz, 1H), 3.10 – 2.88 (m, 5H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 159.3, 158.2, 141.8, 139.3, 138.3, 133.8, 133.0, 128.9, 128.8, 128.6, 128.4, 126.6, 126.0, 84.3, 53.2, 53.1, 41.4, 39.4, 38.3, 37.2, 35.6.

HRMS (ESI, *m/z*) calcd for $C_{26}H_{23}N_1Cl_3^+$ [M+ H]$^+$: 456.08649, found: 456.08611.



33, 95% yield, >95:5 d.r.

According to the general procedure, a mixture of 6-chloro-2-isobutyl-3-isopropylquinoline (52.2 mg, 0.20 mmol), 1,1-dichloroethylene (81 μL, 1.0 mmol), HCl (100 μL, 0.4 mmol, 4 M in 1,4-dioxane) and Ir-F (4.4 mg, 2 mol%, 0.004 mmol) in HFIP (1 mL, 0.2 M) was stirred under argon atmosphere for 14 hours under irradiation with blue LEDs to afford **33** as a colorless gum (68.2 mg, 95% yield, >95:5 d.r.). The ^{1}H NMR analysis of the crude reaction mixture gave >95:5 d.r.

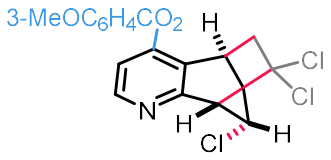
Purification conditions: *n*-pentane/Et_2O = 20:1 to 10:1.

R_f = 0.60 in *n*-pentane/Et_2O (15:1).

^1H NMR (400 MHz, $CDCl_3$) δ 7.32 (s, 1H), 4.05 (dd, *J* = 8.1, 0.6 Hz, 1H), 4.00 (td, *J* = 7.9, 2.0 Hz, 1H), 3.44 – 3.39 (m, 2H), 3.15 (p, *J* = 6.8 Hz, 1H), 2.96 (dd, *J* = 12.6, 7.7 Hz, 1H), 2.75 – 2.64 (m, 2H), 2.15 – 2.04 (m, 1H), 1.19 (t, *J* = 6.7 Hz, 6H), 0.94 (dd, *J* = 12.8, 6.6 Hz, 6H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 158.2, 156.9, 140.8, 138.1, 129.2, 84.4, 53.0, 43.6, 41.4, 39.5, 29.6, 28.7, 24.0, 23.6, 22.7, 22.5.

HRMS (ESI, *m/z*) calcd for $C_{18}H_{22}NCl_3Na^+$ $[M+Na]^+$: 380.0710, found: 380.0710.



34, 72% yield, >95:5 d.r.

According to the general procedure, a mixture of 6-chloroquinolin-4-yl 3-methoxybenzoate (62.7 mg, 0.20 mmol), 1,1-dichloethene (80 μL, 1.0 mmol), HCl (50 μL, 0.2 mmol, 4 M in 1,4-dioxane) and Ir-F (4.4 mg, 2 mol%, 0.004 mmol) in HFIP (1 mL, 0.2 M) was stirred under argon atmosphere for 14 hours under irradiation with blue LEDs to afford **34** as a white waxy solid (58.9 mg, 72% yield, >95:5 d.r.). The ^1H NMR analysis of the crude reaction mixture gave >95:5 d.r.

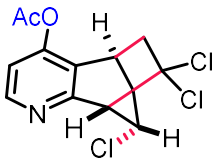
Purification conditions: *n*-pentane/EtOAc = 6:1 to 5:1.

R_f = 0.35 in *n*-pentane/EtOAc (6:1).

^1H NMR (400 MHz, $CDCl_3$) δ 8.49 (d, *J* = 5.5 Hz, 1H), 7.75 (dt, *J* = 7.6, 1.2 Hz, 1H), 7.64 (dd, *J* = 2.7, 1.6 Hz, 1H), 7.44 (t, *J* = 8.0 Hz, 1H), 7.22 (ddd, *J* = 8.4, 2.7, 1.0 Hz, 1H), 7.10 (d, *J* = 5.6 Hz, 1H), 4.10 (d, *J* = 8.3 Hz, 1H), 4.05 (td, *J* = 7.9, 2.1 Hz, 1H), 3.89 (s, 3H), 3.56 (dd, *J* = 8.2, 2.1 Hz, 1H), 3.36 (dd, *J* = 13.0, 8.0 Hz, 1H), 3.11 (dd, *J* = 13.0, 7.9 Hz, 1H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 163.5, 163.2, 160.0, 154.3, 151.2, 132.7, 130.0, 129.5, 122.8, 121.0, 116.2, 114.9, 83.9, 55.7, 52.9, 52.3, 41.8, 38.9, 37.9.

HRMS (ESI, *m/z*) calcd for $C_{19}H_{15}NO_3Cl_3^+$ $[M+H]^+$: 410.0112, found: 410.0112.



35, 47% yield, >95:5 d.r.

According to the general procedure, a mixture of 6-chloroquinolin-4-yl acetate (44.3 mg, 0.20 mmol), 1,1-dichloethene (80 μL, 1.0 mmol), HCl (100 μL, 0.2 mmol, 4 M in 1,4-dioxane) and Ir-F (4.4 mg, 2 mol%, 0.004 mmol) in HFIP (1 mL, 0.2 M) was stirred under argon atmosphere for 14 hours under irradiation with blue LEDs to afford **35** as a white waxy solid (29.7 mg, 47% yield, >95:5 d.r.). The ^{1}H NMR analysis of the crude reaction mixture gave >95:5 d.r.

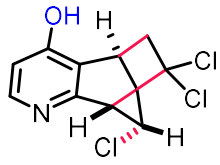
Purification conditions: *n*-pentane/EtOAc = 6:1 to 5:1.

R_f = 0.40 in *n*-pentane/EtOAc (6:1).

^{1}H NMR (599 MHz, $CDCl_3$) δ 8.54 – 8.27 (m, 1H), 6.98 (d, *J* = 5.5 Hz, 1H), 4.09 (dd, *J* = 8.2, 0.7 Hz, 1H), 4.01 (td, *J* = 7.9, 2.1 Hz, 1H), 3.52 (dd, *J* = 8.2, 2.0 Hz, 1H), 3.38 (dd, *J* = 13.0, 8.0 Hz, 1H), 3.04 (dd, *J* = 13.0, 7.9 Hz, 1H), 2.32 (s, 3H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 167.4, 163.4, 153.9, 151.0, 132.4, 116.0, 83.8, 52.8, 52.3, 41.7, 38.8, 37.9, 21.0.

HRMS (ESI, *m*/*z*) calcd for $C_{11}H_9Cl_3NO^+$ $[M+2H^+–OAc]^+$: 275.9744, found: 275.9742.



36, 98% yield, >95:5 d.r.

According to the general procedure, a mixture of 6-chloroquinolin-4-ol (35.9 mg, 0.20 mmol), 1,1-dichloethene (80 μL, 1.0 mmol), HCl (100 μL, 0.2 mmol, 4 M in 1,4-dioxane) and Ir-F (4.4 mg, 2 mol%, 0.004 mmol) in HFIP (1 mL, 0.2 M) was stirred under argon atmosphere for 24 hours under irradiation with blue LEDs to afford **36** as a pale yellow oil (54.1 mg, 98% yield, >95:5 d.r.). The ^{1}H NMR analysis of the crude reaction mixture gave >95:5 d.r.

Purification conditions: *n*-pentane/EtOAc = 4:1 to 1:1.

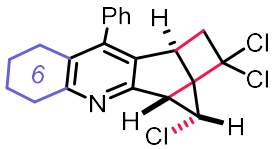
R_f = 0.40 in *n*-pentane/EtOAc (2:1).

^{1}H NMR (599 MHz, $CDCl_3$) δ 7.67 (d, *J* = 6.9 Hz, 1H), 6.52 (d, *J* = 6.8 Hz, 1H), 4.10 (td, *J* = 7.8,

2.5 Hz, 1H), 4.02 (dd, *J* = 8.0, 0.7 Hz, 1H), 3.42 (dd, *J* = 12.9, 7.9 Hz, 1H), 3.35 (dd, *J* = 7.9, 2.5 Hz, 1H), 2.97 (dd, *J* = 12.8, 7.7 Hz, 1H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 174.5, 152.2, 139.9, 132.5, 116.3, 83.5, 53.3, 53.2, 39.1, 38.5, 38.0.

HRMS (ESI, *m*/*z*) calcd for $C_{11}H_8NOCl_3Na^+$ $[M+Na]^+$: 297.9562, found: 297.9562.



37, 86% yield, >95:5 d.r.

According to the general procedure, a mixture of 7-chloro-9-phenyl-1,2,3,4-tetrahydroacridine (58.8 mg, 0.20 mmol), 1,1-dichloroethylene (81 μL, 1.0 mmol), HCl (100 μL, 0.4 mmol, 4 M in 1,4-dioxane) and Ir-F (4.4 mg, 2 mol%, 0.004 mmol) in HFIP (1 mL, 0.2 M) was stirred under argon atmosphere for 14 hours under irradiation with blue LEDs to afford **37** as a colorless gum (67.3 mg, 86% yield, >95:5 d.r.). The ^{1}H NMR analysis of the crude reaction mixture gave >95:5 d.r.

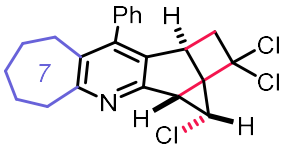
Purification conditions: *n*-pentane/Et_2O= 20:1 to 10:1.

R_f= 0.50 in *n*-pentane/Et_2O (15:1).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.56 – 7.39 (m, 3H), 7.24 – 6.98 (m, 2H), 4.08 (d, *J* = 8.0 Hz, 1H), 3.73 (td, *J* = 7.9, 2.0 Hz, 1H), 3.48 (dd, *J* = 8.1, 2.0 Hz, 1H), 3.17 (dd, *J* = 12.5, 8.0 Hz, 1H), 3.05 – 2.95 (m, 3H), 2.61 – 2.52 (m, 1H), 2.40 (dt, *J* = 17.2, 5.9 Hz, 1H), 1.92 – 1.61 (m, 4H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 157.5, 157.0, 146.8, 137.1, 137.1, 129.0, 128.8, 128.1, 127.9, 84.2, 53.6, 52.7, 41.8, 39.4, 39.1, 33.2, 27.3, 22.9, 22.8.

HRMS (ESI, *m*/*z*) calcd for $C_{21}H_{18}NCl_3Na^+$ $[M+Na]^+$: 412.0397, found: 412.0397.



38, 99% yield, >95:5 d.r.

According to the general procedure, a mixture of 2-chloro-11-phenyl-7,8,9,10-tetrahydro-6H-cyclohepta[*b*]quinoline (61.6 mg, 0.20 mmol), 1,1-dichloroethylene (81 μL, 1.0 mmol), HCl (100 μL, 0.4 mmol, 4 M in 1,4-dioxane) and Ir-F (4.4

mg, 2 mol%, 0.004 mmol) in HFIP (1 mL, 0.2 M) was stirred under argon atmosphere for 14 hours under irradiation with blue LEDs to afford **38** as a pale yellow solid (80.1 mg, 99% yield, >95:5 d.r.). The ^{1}H NMR analysis of the crude reaction mixture gave >95:5 d.r.

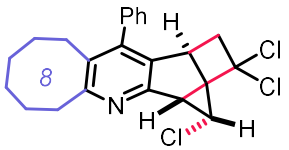
Purification conditions: *n*-pentane/Et_2O = 20:1 to 10:1.

R_f = 0.50 in *n*-pentane/Et_2O (15:1).

^{1}H NMR (599 MHz, $CDCl_3$) δ 7.46 – 7.38 (m, 3H), 7.12 (d, *J* = 7.5 Hz, 1H), 7.01 (d, *J* = 7.2 Hz, 1H), 4.04 (dd, *J* = 8.1, 0.7 Hz, 1H), 3.67 (td, *J* = 7.9, 2.1 Hz, 1H), 3.46 (dd, *J* = 8.1, 2.1 Hz, 1H), 3.13 – 3.10 (m, 3H), 2.96 (dd, *J* = 12.6, 7.9 Hz, 1H), 2.63 – 2.55 (m, 2H), 1.88 – 1.69 (m, 4H), 1.61 – 1.55 (m, 1H), 1.52 – 1.46 (m, 1H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 164.0, 155.9, 146.2, 137.7, 137.5, 134.8, 128.7, 128.6, 128.4, 128.0, 84.3, 53.6, 52.7, 41.9, 39.5, 39.4, 39.3, 32.3, 29.7, 27.6, 26.4.

HRMS (ESI, *m*/*z*) calcd for $C_{22}H_{20}NCl_3Na^+$ $[M+Na]^+$: 426.0553, found: 426.0553.



39, 90% yield, >95:5 d.r.

According to the general procedure, a mixture of 2-chloro-12-phenyl-6,7,8,9,10,11-hexahydrocycloocta[*b*]quinoline (64.4 mg, 0.20 mmol), 1,1-dichloroethylene (81 μL, 1.0 mmol), HCl (100 μL, 0.4 mmol, 4 M in 1,4-dioxane) and Ir-F (4.4 mg, 2 mol%, 0.004 mmol) in HFIP (1 mL, 0.2 M) was stirred under argon atmosphere for 14 hours under irradiation with blue LEDs to afford **39** as a pale yellow solid (75.2 mg, 90% yield, >95:5 d.r.). The ^{1}H NMR analysis of the crude reaction mixture gave >95:5 d.r.

Purification conditions: *n*-pentane/Et_2O = 20:1 to 10:1.

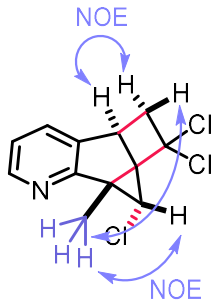
R_f = 0.50 in *n*-pentane/Et_2O (15:1).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.40 (m, 3H), 7.15 – 7.02 (m, 2H), 4.04 (d, *J* = 8.0 Hz, 1H), 3.62 (td, *J* = 7.9, 2.1 Hz, 1H), 3.46 (dd, *J* = 8.0, 2.1 Hz, 1H), 3.07 (dd, *J* = 12.6, 8.0 Hz, 1H), 3.01 (t, *J* = 6.2 Hz, 2H), 2.92 (dd, *J* = 12.5, 7.9 Hz, 1H), 2.69 – 2.54 (m, 2H), 1.92 – 1.75 (m, 2H), 1.44 – 1.29 (m, 6H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 161.8, 156.8, 146.8, 137.8, 137.7, 132.3, 128.7, 128.5, 127.9, 84.3,

53.3, 52.7, 41.8, 39.3, 39.2, 35.7, 31.1, 30.9, 27.3, 26.6, 25.8.

HRMS (ESI, *m*/*z*) calcd for $C_{23}H_{23}NCl_3^+$ $[M+H]^+$: 420.0864, found: 420.0860.



40, 70% yield, >95:5 d.r.

According to the general procedure, a mixture of 6-chloro-8-methylquinoline (35.5 mg, 0.20 mmol), 1,1-dichloethene (80 μL, 1.0 mmol), HCl (100 μL, 0.2 mmol, 4 M in 1,4-dioxane) and Ir-F (4.4 mg, 2 mol%, 0.004 mmol) in HFIP (1 mL, 0.2 M) was stirred under argon atmosphere for 14 hours under irradiation with blue LEDs to afford **40** as a pale yellow solid (38.4 mg, 70% yield, >95:5 d.r.). The ^{1}H NMR analysis of the crude reaction mixture gave >95:5 d.r.

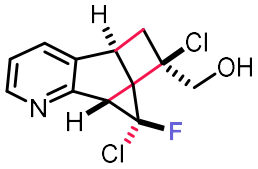
Purification conditions: *n*-pentane/EtOAc = 10:1 to 5:1.

R_f = 0.50 in *n*-pentane/EtOAc (5:1).

^{1}H NMR (599 MHz, $CDCl_3$) δ 8.47 (dd, *J* = 4.9, 1.6 Hz, 1H), 7.49 (ddd, *J* = 7.6, 1.5, 0.8 Hz, 1H), 7.15 (dd, *J* = 7.6, 4.9 Hz, 1H), 4.01 (t, *J* = 8.1 Hz, 1H), 3.94 (s, 1H), 3.44 (dd, *J* = 12.4, 8.0 Hz, 1H), 2.92 (dd, *J* = 12.4, 8.3 Hz, 1H), 1.93 (s, 3H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 163.3, 148.9, 139.1, 132.1, 122.5, 84.7, 54.9, 53.0, 49.2, 44.3, 39.4, 15.3.

HRMS (ESI, *m*/*z*) calcd for $C_{12}H_{11}NCl_3^+$ $[M+H]^+$: 273.9951, found: 273.9951.



41, 75% yield, 91:9 d.r.

According to the general procedure, a mixture of 6-chloro-7-fluoroquinoline (36.3 mg, 0.20 mmol), 2-chloroprop-2-en-1-ol (48 μL, 0.6 mmol), HCl (100 μL, 0.2 mmol, 4 M in 1,4-dioxane) and Ir-F (4.4 mg, 2 mol%, 0.004 mmol) in HFIP (1 mL, 0.2 M) was stirred under argon atmosphere for 24

hours under irradiation with blue LEDs to afford **41** as a pale yellow solid (41.4 mg, 75% yield, 91:9 d.r.). The ^{1}H NMR analysis of the crude reaction mixture gave 91:9 d.r.

Purification conditions: *n*-pentane/EtOAc = 4:1 to 1:1.

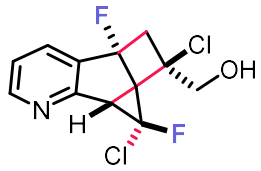
R_f= 0.50 in *n*-pentane/EtOAc (1:1).

^{1}H NMR (599 MHz, CD_3OD) δ 8.36 (dd, *J* = 5.0, 1.5 Hz, 1H), 7.74 – 7.62 (m, 1H), 7.29 (dd, *J* = 7.7, 5.0 Hz, 1H), 4.05 (d, *J* = 11.7 Hz, 1H), 3.94 (d, *J* = 11.7 Hz, 1H), 3.84 (td, *J* = 8.0, 7.5, 1.8 Hz, 1H), 3.50 (dd, *J* = 15.9, 1.8 Hz, 1H), 3.15 (dd, *J* = 12.2, 8.6 Hz, 1H), 2.44 (dd, *J* = 12.2, 7.5 Hz, 1H).

^{13}C NMR (151 MHz, CD_3OD) δ 161.7, 149.0, 143.7 (d, *J* = 5.8 Hz), 134.9 (d, *J* = 2.2 Hz), 124.3, 95.1 (d, *J* = 288.5 Hz), 70.5 (d, *J* = 2.0 Hz), 67.8, 50.0 (d, *J* = 10.2 Hz), 43.4 (d, *J* = 13.7 Hz), 43.0 (d, *J* = 2.3 Hz), 42.68.

^{19}F NMR (564 MHz, CD_3OD) δ -136.70 (m).

HRMS (ESI, *m*/*z*) calcd for $C_9H_6NClF^+$ $[M+H]^+$: 182.0167, found: 182.0166.



42, 57% yield, 95:5 d.r.

According to the general procedure, a mixture of 6-chloro-5,7-difluoroquinoline (40.0 mg, 0.20 mmol), xx (32 µl, 0.40 mmol, 2.00 equiv.), and Ir-F (4.4 mg, 2 mol%, 0.004 mmol) in HFIP (1 mL, 0.2 M) was stirred under argon atmosphere for 48 hours under irradiation with blue LEDs to afford **42** as a white solid (33.4 mg, 0.114 mmol, 57% yield, >95:5 d.r.). The ^{1}H NMR analysis of the crude reaction mixture gave 95:5 d.r. *Note. The compound is only sparingly soluble in $CDCl_3$. Traces of the solvent can be detected even after prolonged drying under high vacuum.*

Purification conditions: *n*-pentane/EtOAc = 2:1.

R_f= 0.40 in *n*-pentane/EtOAc (2:1).

^{1}H NMR (599 MHz, CD_3OD) δ 8.54 (ddd, *J* = 5.0, 1.5, 0.9 Hz, 1H), 7.82 (dt, *J* = 7.7, 1.4 Hz, 1H), 7.44 (dd, *J* = 7.8, 5.0 Hz, 1H), 4.24 (d, *J* = 12.4 Hz, 1H), 4.11 (dt, *J* = 12.3, 1.2 Hz, 1H), 3.65 (dd, *J* = 15.3, 7.2 Hz, 1H), 3.41 (dd, *J* = 17.5, 14.3 Hz, 1H), 3.01 (ddd, *J* = 20.6, 14.4, 1.4 Hz, 1H).

^{1}H{^{19}F} NMR (599 MHz, CD_3OD) δ 8.54 (dd, *J* = 5.0, 1.6 Hz, 1H), 7.82 (dd, *J* = 7.8, 1.5 Hz, 1H),

7.44 (dd, *J* = 7.8, 5.0 Hz, 1H), 4.24 (d, *J* = 12.3 Hz, 1H), 4.11 (dd, *J* = 12.3, 1.4 Hz, 1H), 3.65 (s, 1H), 3.41 (d, *J* = 14.4 Hz, 1H), 3.03 – 2.98 (m, 1H).

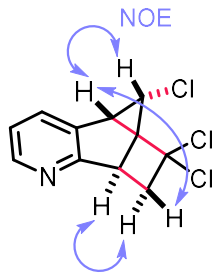
$^{13}C\{^{1}H\}$ NMR (151 MHz, CD_3OD) δ 159.8 (d, *J* = 4.4 Hz), 151.8 (d, *J* = 2.1 Hz), 139.1 (dd, *J* = 24.8, 5.7 Hz), 134.7 (d, *J* = 2.0 Hz), 125.2 (d, *J* = 1.4 Hz), 103.9 (dd, *J* = 224.2, 2.3 Hz), 96.1 (d, *J* = 289.4 Hz), 70.6 (d, *J* = 1.5 Hz), 68.2, 49.8 (d, *J* = 29.4 Hz), 47.7 (dd, *J* = 21.4, 12.0 Hz), 44.1 (d, *J* = 13.3 Hz).

$^{13}C\{^{1}H, ^{19}F\}$ NMR (151 MHz, CD_3OD) δ 159.8, 151.8, 139.1, 134.7, 125.2, 103.9, 96.1, 70.6, 68.2, 49.8, 47.7, 44.1.

^{19}F NMR (564 MHz, CD_3OD) δ -131.28 (dd, *J* = 15.3, 4.3 Hz), -170.78 (ddd, *J* = 20.3, 17.5, 7.2 Hz).

$^{19}F\{^{1}H\}$ NMR (564 MHz, CD_3OD) δ -131.28 (dd, *J* = 4.3, 1.3 Hz), -170.78 (d, *J* = 1.2 Hz).

HRMS (ESI, *m/z*) calcd for $C_{12}H_{10}NO^{35}Cl_2F_2^+$ $[M+H]^+$: 292.0102, found: 292.0101; calcd for $C_{12}H_9NO^{35}Cl_2F_2Na^+$ $[M+Na]^+$: 313.9922, found: 313.9921.



43, 87% yield, >95:5 d.r.

According to the general procedure, a mixture of 7-chloroquinoline (32.7 mg, 0.20 mmol), 1,1-dichloethene (80 μL, 1.0 mmol), HCl (100 μL, 0.2 mmol, 4 M in 1,4-dioxane) and Ir-F (4.4 mg, 2 mol%, 0.004 mmol) in HFIP (1 mL, 0.2 M) was stirred under argon atmosphere for 14 hours under irradiation with blue LEDs to afford **43** as a pale yellow solid (45.0 mg, 87% yield, >95:5 d.r.). The ^{1}H NMR analysis of the crude reaction mixture gave >95:5 d.r.

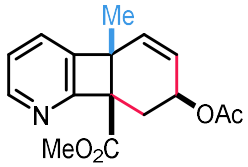
Purification conditions: *n*-pentane/EtOAc = 10:1 to 5:1.

R_f = 0.50 in *n*-pentane/EtOAc (5:1).

^{1}H NMR (599 MHz, $CDCl_3$) δ 8.41 (dd, *J* = 5.0, 1.6 Hz, 1H), 7.68 (dd, *J* = 7.7, 1.6 Hz, 1H), 7.14 (dd, *J* = 7.7, 5.0 Hz, 1H), 4.09 (td, *J* = 8.0, 2.0 Hz, 1H), 4.02 (dd, *J* = 7.8, 0.6 Hz, 1H), 3.48 (dd, *J* = 12.9, 8.4 Hz, 1H), 3.27 (dd, *J* = 7.8, 2.0 Hz, 1H), 3.04 (dd, *J* = 12.9, 7.7 Hz, 1H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 167.8, 149.0, 134.5, 134.2, 122.1, 84.2, 51.9, 51.5, 42.8, 39.3, 37.9.

HRMS (ESI, *m*/*z*) calcd for $C_{11}H_9NCl_3^+$ $[M+H]^+$: 261.9766, found: 261.9765.



4, 97% yield, >95:5 d.r.

According to the general procedure, a mixture of methyl 5-methylquinoline-8-carboxylate (40.2 mg, 0.20 mmol), vinyl acetate (93 μL, 1.0 mmol), and Ir-F (4.4 mg, 2 mol%, 0.004 mmol) in HFIP (1 mL, 0.2 M) was stirred under argon atmosphere for 48 hours under irradiation with blue LEDs to afford **4** as a light yellow gum (55.9 mg, 0.195 mmol, 97%, >95:5 d.r.).

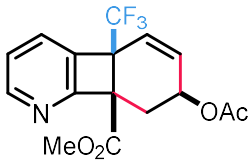
Purification conditions: *n*-pentane/EtOAc = 1:1.

R_f = 0.25 in *n*-pentane/EtOAc (3:2).

^{1}H NMR (599 MHz, $CDCl_3$) δ 8.45 (dd, *J* = 5.2, 1.5 Hz, 1H), 7.24 (dd, *J* = 7.4, 1.5 Hz, 1H), 7.12 (dd, *J* = 7.4, 5.3 Hz, 1H), 5.92 (dd, *J* = 10.5, 2.6 Hz, 1H), 5.74 (dt, *J* = 10.5, 1.2 Hz, 1H), 4.70 – 4.65 (m, 1H), 3.68 (s, 3H), 2.76 (dd, *J* = 13.0, 5.6 Hz, 1H), 2.31 (dd, *J* = 12.9, 11.6 Hz, 1H), 2.02 (s, 3H), 1.44 (s, 3H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 172.5, 170.3, 160.3, 150.4, 144.5, 133.5, 130.8, 127.9, 124.9, 67.0, 63.1, 52.4, 49.6, 33.3, 21.5, 21.2.

HRMS (ESI, *m*/*z*) calcd for $C_{16}H_{17}NO_4Na^+$ $[M+Na]^+$: 310.1050, found: 310.1052.



44, 75% yield, >95:5 d.r.

According to the general procedure, a mixture of methyl 5-(trifluoromethyl)quinoline-8-carboxylate (51.0 mg, 0.20 mmol), vinyl acetate (93 μL, 1.0 mmol), and Ir-F (4.4 mg, 2 mol%, 0.004 mmol) in HFIP (1 mL, 0.2 M) was stirred under argon atmosphere for 48 hours under irradiation with blue LEDs to afford **44** as a light yellow gum (51.2 mg, 0.150 mmol, 75%, >95:5 d.r.).

Purification conditions: *n*-pentane/EtOAc = 11:9.

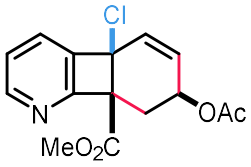
R_f = 0.30 in *n*-pentane/EtOAc (3:2).

^{1}H NMR (599 MHz, $CDCl_3$) δ 8.60 (dd, *J* = 5.2, 1.5 Hz, 1H), 7.38 (dd, *J* = 7.5, 1.5 Hz, 1H), 7.25 (dd, *J* = 7.7, 5.4 Hz, 1H), 6.22 (dd, *J* = 10.7, 2.6 Hz, 1H), 6.03 (d, *J* = 10.7 Hz, 1H), 4.69 – 4.64 (m, 1H), 3.75 (s, 3H), 2.84 (dd, *J* = 13.0, 5.5 Hz, 1H), 2.32 (dd, *J* = 13.0, 11.7 Hz, 1H), 2.04 (s, 3H).

^{13}C{^{1}H, ^{19}F} NMR (151 MHz, $CDCl_3$) δ 170.2, 170.1, 160.4, 152.5, 136.3, 134.5, 129.3, 125.8, 125.1, 124.0, 66.1, 62.1, 56.4, 53.3, 34.3, 21.1.

^{19}F NMR (564 MHz, $CDCl_3$) δ -71.35.

HRMS (ESI, *m/z*) calcd for $C_{16}H_{14}NO_4F_3Na^+$ $[M+Na]^+$: 364.0767, found: 364.0761.



45, 60% yield, >95:5

According to the general procedure, a mixture of methyl 5-chloroquinoline-8-carboxylate (44.3 mg, 0.20 mmol), vinyl acetate (93 μL, 1.0 mmol), and Ir-F (4.4 mg, 2 mol%, 0.004 mmol) in HFIP (1 mL, 0.2 M) was stirred under argon atmosphere for 48 hours under irradiation with blue LEDs to afford **45** as a white low melting white solid (37.0 mg, 60%, >95:5 d.r.).

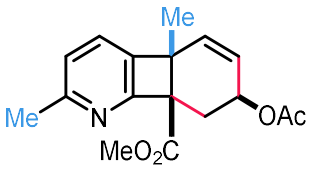
Purification conditions: *n*-pentane/EtOAc = 3:2.

R_f = 0.35 in *n*-pentane/EtOAc (3:2).

^{1}H NMR (599 MHz, $CDCl_3$) δ 8.59 (dd, *J* = 5.2, 1.4 Hz, 1H), 7.46 (dd, *J* = 7.6, 1.5 Hz, 1H), 7.27 (dd, *J* = 7.5, 5.3 Hz, 1H), 6.24 (dd, *J* = 10.6, 2.6 Hz, 1H), 5.79 (dt, *J* = 10.6, 1.5 Hz, 1H), 4.71 – 4.66 (m, 1H), 3.73 (s, 3H), 2.80 (ddd, *J* = 13.3, 5.9, 1.4 Hz, 1H), 2.50 (dd, *J* = 13.4, 11.8 Hz, 1H), 2.05 (s, 3H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 170.5, 170.2, 158.6, 153.1, 141.6, 131.5, 131.3, 128.7, 125.9, 68.1, 66.0, 64.7, 52.9, 31.8, 21.1.

HRMS (ESI, *m/z*) calcd for $C_{15}H_{14}NO_4{}^{35}ClNa^+$ $[M+Na]^+$: 330.0504, found: 330.0501.



46, 68% yield, >95:5 d.r.

According to the general procedure, a mixture of methyl 2,5-dimethylquinoline-8-carboxylate (43.1 mg, 0.20 mmol), vinyl acetate (93 μL, 1.0 mmol), and Ir-F (4.4 mg, 2 mol%, 0.004 mmol) in HFIP (1 mL, 0.2 M) was stirred under argon atmosphere for 48 hours under irradiation with blue LEDs to afford **46** as a light yellow waxy solid (40.7 mg, 0.135 mmol, 68%, >95:5 d.r.).

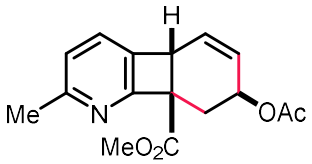
Purification conditions: *n*-pentane/EtOAc = 11:9.

R_f = 0.30 in *n*-pentane/EtOAc (3:2).

^{1}H NMR (599 MHz, $CDCl_3$) δ 7.13 (d, *J* = 7.7 Hz, 1H), 6.99 (dd, *J* = 7.6, 0.6 Hz, 1H), 5.91 (dd, *J* = 10.5, 2.6 Hz, 1H), 5.71 (dt, *J* = 10.4, 1.5 Hz, 1H), 4.72 – 4.68 (m, 1H), 3.68 (s, 3H), 2.74 (ddd, *J* = 12.9, 5.6, 1.2 Hz, 1H), 2.55 (s, 3H), 2.31 (dd, *J* = 12.9, 11.7 Hz, 1H), 2.02 (s, 3H), 1.41 (s, 3H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 172.7, 170.4, 159.5, 159.3, 141.4, 133.8, 130.6, 128.1, 124.5, 67.2, 62.9, 52.3, 49.0, 33.3, 24.8, 21.5, 21.2.

HRMS (ESI, *m*/*z*) calcd for $C_{17}H_{19}NO_4Na^+$ $[M+Na]^+$: 324.1206, found: 324.1205.



47, 62% yield, >95:5 d.r.

According to the general procedure, a mixture of methyl 2-methylquinoline-8-carboxylate (40.2 mg, 0.20 mmol), vinyl acetate (93 μL, 1.0 mmol), and Ir-F (4.4 mg, 2 mol%, 0.004 mmol) in HFIP (1 mL, 0.2 M) was stirred under argon atmosphere for 48 hours under irradiation with blue LEDs to afford **47** as a colourless gum (35.9 mg, 62%, >95:5 d.r.).

Purification conditions: *n*-pentane/EtOAc = 3:2.

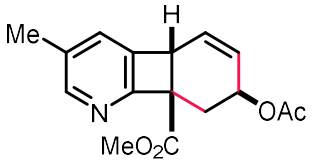
R_f = 0.35 in *n*-pentane/EtOAc (3:2).

^{1}H NMR (599 MHz, $CDCl_3$) δ 7.19 (d, *J* = 7.5 Hz, 1H), 7.01 (d, *J* = 7.6 Hz, 1H), 6.17 (ddd, *J* = 10.3, 5.6, 2.3 Hz, 1H), 5.84 (ddd, *J* = 10.4, 2.0, 1.1 Hz, 1H), 4.91 – 4.86 (m, 1H), 4.19 (d, *J* = 5.6 Hz, 1H), 3.72 (s, 3H), 2.76 (dd, *J* = 13.2, 5.1 Hz, 1H), 2.53 (s, 3H), 2.25 (dd, *J* = 13.2, 10.3 Hz, 1H),

2.02 (s, 3H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 172.6, 170.4, 161.1, 159.3, 137.8, 131.1, 129.7, 128.3, 124.7, 66.9, 58.1, 52.8, 43.6, 33.0, 24.8, 21.2.

HRMS (ESI, *m*/*z*) calcd for $C_{16}H_{17}NO_4Na^+$ $[M+Na]^+$: 310.0150, found: 310.0149.



48, 58% yield, 94:6 d.r.

According to the general procedure, a mixture of methyl 3-methylquinoline-8-carboxylate (40.2 mg, 0.20 mmol), vinyl acetate (93 μL, 1.0 mmol), and Ir-F (4.4 mg, 2 mol%, 0.004 mmol) in HFIP (1 mL, 0.2 M) was stirred under argon atmosphere for 48 hours under irradiation with blue LEDs to afford **48** as a colourless gum (33.4 mg, 0.116 mmol, 58% yield, 94:6 d.r.), which contains approximately 4% of inseparable remaining starting material.

Purification conditions: *n*-pentane/EtOAc = 11:9.

R_f = 0.35 in *n*-pentane/EtOAc (3:2).

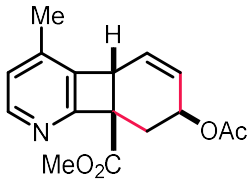
^{1}H NMR (599 MHz, $CDCl_3$, major isomer) δ 8.25 – 8.23 (m, 1H), 7.15 – 7.13 (m, 1H), 6.17 (ddd, *J* = 10.3, 5.6, 2.3 Hz, 1H), 5.85 (ddt, *J* = 10.3, 2.0, 0.9 Hz, 1H), 4.90 – 4.84 (m, 1H), 4.23 (d, *J* = 5.6 Hz, 1H), 3.72 (s, 3H), 2.76 (dd, *J* = 13.0, 5.1 Hz, 1H), 2.30 (s, 3H), 2.23 (dd, *J* = 13.1, 10.3 Hz, 1H), 2.02 (s, 3H).

^{1}H NMR (599 MHz, $CDCl_3$, minor isomer – diagnostic peaks) δ 8.18 – 8.17 (m, 1H), 7.30 (d, *J* = 2.0 Hz, 1H), 6.69 (dd, *J* = 7.8, 6.1 Hz, 1H), 6.50 (dd, *J* = 7.7, 1.6 Hz, 1H), 5.50 (dd, *J* = 8.6, 2.3 Hz, 1H), 3.93 (s, 3H), 1.87 (s, 3H).

^{13}C NMR (151 MHz, $CDCl_3$, major isomer) δ 172.7, 170.3, 158.9, 150.5, 140.3, 135.0, 131.3, 130.2, 128.0, 66.8, 57.8, 52.8, 43.7, 33.1, 21.2, 19.5.

^{13}C NMR (151 MHz, $CDCl_3$, minor isomer – diagnostic peaks) δ 146.3, 138.2, 132.4, 131.1, 71.1, 52.6, 38.7, 37.0, 18.4.

HRMS (ESI, *m*/*z*) calcd for $C_{17}H_{19}NO_4Na^+$ $[M+Na]^+$: 324.1206, found: 324.1205.



49, 82% yield, 89:11 d.r.

According to the general procedure, a mixture of methyl 4-methylquinoline-8-carboxylate (40.2 mg, 0.20 mmol), vinyl acetate (93 μL, 1.0 mmol), and Ir-F (4.4 mg, 2 mol%, 0.004 mmol) in HFIP (1 mL, 0.2 M) was stirred under argon atmosphere for 48 hours under irradiation with blue LEDs to afford **49** as a light yellow gum (47.2 mg, 0.164 mmol, 82%, 89:11 d.r.).

Purification conditions: *n*-pentane/EtOAc = 1:1.

R_f = 0.30 in *n*-pentane/EtOAc (1:1).

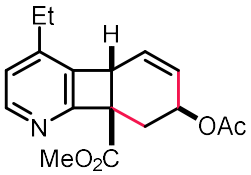
^{1}H NMR (599 MHz, $CDCl_3$, major isomer) δ 8.26 (d, *J* = 5.4 Hz, 1H), 6.93 (d, *J* = 5.4 Hz, 1H, *overlaps with minor isomer*), 6.20 (ddd, *J* = 10.4, 5.6, 2.3 Hz, 1H), 5.85 (ddt, *J* = 10.3, 2.0, 0.9 Hz, 1H), 4.88 – 4.83 (m, 1H), 4.24 (d, *J* = 5.6 Hz, 1H), 3.72 (s, 3H), 2.77 (dd, *J* = 13.2, 5.1 Hz, 1H), 2.23 (dd, *J* = 13.1, 10.3 Hz, 1H), 2.19 (s, 3H), 2.02 (s, 3H).

^{1}H NMR (599 MHz, $CDCl_3$, minor isomer – diagnostic peaks) δ 8.20 (d, *J* = 5.1 Hz, 1H), 6.68 (dd, *J* = 7.7, 6.2 Hz, 1H), 6.51 (dd, *J* = 7.7, 1.6 Hz, 1H), 5.51 (dd, *J* = 8.6, 2.3 Hz, 1H), 4.20 – 4.16 (m, 1H), 3.92 (s, 3H), 2.36 (s, 3H), 2.40 – 2.34 (m, 1H), 1.86 (s, 3H).

^{13}C NMR (151 MHz, $CDCl_3$, major isomer) δ 172.6, 170.3, 161.3, 150.1, 141.4, 140.1, 131.4, 127.4, 126.4, 66.8, 57.8, 52.8, 43.5, 33.0, 21.15, 16.9.

^{13}C NMR (151 MHz, $CDCl_3$, minor isomer) δ 171.2, 170.8, 158.8, 145.5, 139.8, 138.1, 134.1, 132.5, 123.0, 70.9, 59.3, 52.6, 36.5, 34.8, 21.17, 18.0.

HRMS (ESI, *m*/*z*) calcd for $C_{16}H_{17}NO_4Na^+$ $[M+Na]^+$: 310.1050, found: 310.1047.



50, 70% yield, 90:10 d.r.

According to the general procedure, a mixture of methyl 4-ethylquinoline-8-carboxylate (43.1 mg, 0.20 mmol), vinyl acetate (93 μL, 1.0 mmol), and Ir-F (4.4 mg, 2 mol%, 0.004 mmol) in HFIP (1 mL, 0.2 M) was stirred under argon atmosphere for 48 hours under irradiation with blue LEDs to

afford **xx** as a light yellow gum (42.3 mg, 0.140 mmol, 70%, 90:10 d.r.).

Purification conditions: *n*-pentane/EtOAc = 10:9.

R_f = 0.35 in *n*-pentane/EtOAc (1:1).

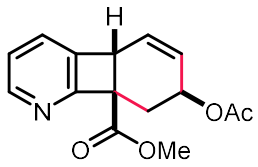
^{1}H NMR (599 MHz, $CDCl_3$, major isomer) δ 8.29 (d, *J* = 5.5 Hz, 1H), 6.95 (d, *J* = 5.4 Hz, 1H, *overlaps with minor isomer*), 6.21 (ddd, *J* = 10.4, 5.6, 2.4 Hz, 1H), 5.85 (d, *J* = 10.4 Hz, 1H), 4.90 – 4.85 (m, 1H), 4.26 (d, *J* = 5.6 Hz, 1H), 3.72 (s, 3H), 2.79 (dd, *J* = 13.2, 5.2 Hz, 1H), 2.61 – 2.50 (m, 2H, *overlaps with minor isomer*), 2.22 (dd, *J* = 13.1, 10.4 Hz, 1H), 2.02 (s, 3H), 1.23 (t, *J* = 7.6 Hz, 3H).

^{1}H NMR (599 MHz, $CDCl_3$, minor isomer – diagnostic peaks) δ 8.24 (d, *J* = 5.2 Hz, 1H), 6.69 (dd, *J* = 7.7, 6.2 Hz, 1H), 6.53 (dd, *J* = 7.7, 1.6 Hz, 1H), 5.52 (dd, *J* = 8.6, 2.3 Hz, 1H), 4.20 (dd, *J* = 6.2, 1.7 Hz, 0H), 3.92 (s, 3H), 2.74 – 2.68 (m, 2H), 2.39 (ddd, *J* = 13.0, 8.6, 2.7 Hz, 1H), 1.87 (s, 3H), 1.22 (t, *J* = 7.6 Hz, 3H).

^{13}C NMR (151 MHz, $CDCl_3$, major isomer) δ 172.6, 170.3, 161.4, 150.2, 147.2, 139.3, 131.4, 127.8, 124.8, 66.9, 57.9, 52.8, 43.7, 33.2, 24.8, 21.17, 13.2.

^{13}C NMR (151 MHz, $CDCl_3$, minor isomer) δ 171.3, 170.9, 158.9, 145.9, 145.7, 138.1, 133.6, 132.7, 121.2, 71.0, 59.3, 52.6, 36.7, 34.5, 25.1, 21.19, 14.8.

HRMS (ESI, *m/z*) calcd for $C_{17}H_{19}NO_4Na^+$ $[M+Na]^+$: 324.1206, found: 324.1205.



51, 62% yield, >95:5 d.r.

According to the general procedure, a mixture of methyl quinoline-8-carboxylate (37.4 mg, 0.20 mmol), vinyl acetate (93 µL, 1.0 mmol), and Ir-F (4.4 mg, 2 mol%, 0.004 mmol) in HFIP (1 mL, 0.2 M) was stirred under argon atmosphere for 48 hours under irradiation with blue LEDs to afford **51** as a light yellow gum (33.5 mg, 62%, >95:5 d.r.).

Purification conditions: *n*-pentane/EtOAc = 3:2.

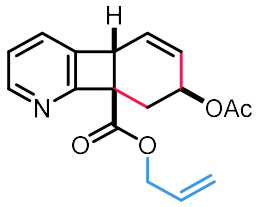
R_f = 0.35 in *n*-pentane/EtOAc (3:2).

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.44 – 8.38 (m, 1H), 7.31 (d, *J* = 7.4 Hz, 1H), 7.14 (dd, *J* = 7.4, 5.2 Hz, 1H), 6.19 (ddd, *J* = 10.3, 5.6, 2.2 Hz, 1H), 5.87 (ddd, *J* = 10.4, 2.3, 0.9 Hz, 1H), 4.90 – 4.84 (m,

1H), 4.28 (d, *J* = 5.6 Hz, 1H), 3.73 (s, 3H), 2.77 (dd, *J* = 13.2, 5.1 Hz, 1H), 2.26 (dd, *J* = 13.2, 10.2 Hz, 1H), 2.02 (s, 3H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 172.4, 170.3, 162.1, 150.1, 141.0, 131.3, 129.6, 128.0, 125.2, 66.7, 58.4, 52.9, 44.1, 33.1, 21.2.

HRMS (ESI, *m*/*z*) calcd for $C_{15}H_{15}NO_4Na^+$ $[M+Na]^+$: 296.2772, found: 296.2773.



52, 66% yield, >95:5 d.r.

According to the general procedure, a mixture of allyl quinoline-8-carboxylate (42.6 mg, 0.20 mmol), vinyl acetate (93 μL, 1.0 mmol), and Ir-F (4.4 mg, 2 mol%, 0.004 mmol) in HFIP (1 mL, 0.2 M) was stirred under argon atmosphere for 48 hours under irradiation with blue LEDs to afford **52** as a colorless gum (39.4 mg, 66%, >95:5 d.r.).

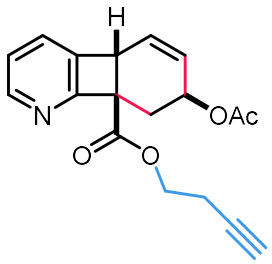
Purification conditions: *n*-pentane/acetone = 7:1.

R_f = 0.35 in *n*-pentane/acetone (7:1).

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.42 (ddd, *J* = 5.3, 1.5, 0.8 Hz, 1H), 7.34 (ddd, *J* = 7.4, 1.4, 0.8 Hz, 1H), 7.16 (dd, *J* = 7.4, 5.3 Hz, 1H), 6.20 (ddd, *J* = 10.3, 5.6, 2.3 Hz, 1H), 5.92 – 5.83 (m, 2H), 5.24 (dq, *J* = 17.2, 1.6 Hz, 1H), 5.19 (dq, *J* = 10.5, 1.3 Hz, 1H), 4.92 – 4.87 (m, 1H), 4.68 – 4.60 (m, 2H), 4.31 (dt, *J* = 5.5, 1.0 Hz, 1H), 2.80 (dd, *J* = 13.2, 5.0 Hz, 1H), 2.30 (dd, *J* = 13.2, 10.1 Hz, 1H), 2.03 (s, 3H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 171.5, 170.4, 162.0, 149.9, 141.1, 131.8, 131.3, 129.8, 128.0, 125.2, 118.4, 66.7, 66.1, 58.4, 44.2, 32.9, 21.2.

HRMS (ESI, *m*/*z*) calcd for $C_{17}H_{17}NO_4Na^+$ $[M+Na]^+$: 322.3152, found: 322.3150.



53, 59% yield, 93:7 d.r.

According to the general procedure, a mixture of but-3-yn-1-yl quinoline-8-carboxylate (45.0 mg, 0.20 mmol), vinyl acetate (93 μL, 1.0 mmol), and Ir-F (4.4 mg, 2 mol%, 0.004 mmol) in HFIP (1 mL, 0.2 M) was stirred under argon atmosphere for 48 hours under irradiation with blue LEDs to afford **53** as a pale yellow gum (36.6mg, 59% yield, 93:7 d.r.).

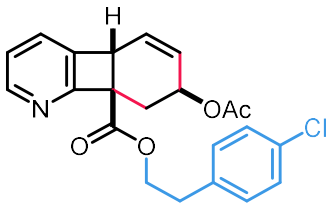
Purification conditions: *n*-pentane/acetone = 7:1.

R_f = 0.35 in *n*-pentane/acetone (7:1).

^{1}H NMR (599 MHz, $CDCl_3$) δ 8.40 (ddt, *J* = 5.3, 1.4, 0.7 Hz, 1H), 7.32 (dddd, *J* = 7.4, 1.4, 0.4 Hz, 1H), 7.14 (ddd, *J* = 7.4, 5.3, 0.5 Hz, 1H), 6.19 (dddd, *J* = 10.3, 5.6, 2.3, 0.5 Hz, 1H), 5.87 (ddq, *J* = 10.3, 2.3, 0.8 Hz, 1H), 4.91 – 4.87 (m, 1H), 4.31 (dd, *J* = 5.5, 1.3 Hz, 1H), 4.24 (m, 2H), 2.77 (dddd, *J* = 13.3, 5.0, 1.0, 0.5 Hz, 1H), 2.55 – 2.46 (m, 2H), 2.29 (dd, *J* = 13.3, 10.1 Hz, 1H), 2.03 (s, 3H), 1.94 (m, 1H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 171.6, 170.3, 162.0, 150.0, 141.0, 131.2, 129.6, 127.9, 125.1, 79.6, 70.1, 66.6, 63.0, 58.3, 44.1, 32.8, 21.1, 18.9.

HRMS (ESI, *m*/*z*) calcd for $C_{18}H_{17}NO_4Na^+$ $[M+Na]^+$: 334.1049, found: 334.1045.



54, 70% yield, >95:5 d.r.

According to the general procedure, a mixture of 4-chlorophenethyl quinoline-8-carboxylate (62.4 mg, 0.20 mmol), vinyl acetate (93 μL, 1.0 mmol), and Ir-F (4.4 mg, 2 mol%, 0.004 mmol) in HFIP (1 mL, 0.2 M) was stirred under argon atmosphere for 48 hours under irradiation with blue LEDs to afford **54** as a faint yellow gum (55.7 mg, 70% yield, >95:5 d.r.).

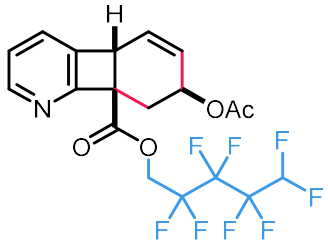
Purification conditions: *n*-pentane/EtOAc = 3:2.

R_f = 0.40 in *n*-pentane/EtOAc (3:2).

^{1}H NMR (599 MHz, $CDCl_3$) δ 8.42 (ddd, *J* = 5.3, 1.5, 0.8 Hz, 1H), 7.30 (ddd, *J* = 7.4, 1.5, 0.8 Hz, 1H), 7.19 – 7.14 (m, 3H), 7.00 – 6.97 (m, 2H), 6.16 (ddd, *J* = 10.3, 5.6, 2.3 Hz, 1H), 5.85 (ddt, *J* = 10.3, 2.0, 0.9 Hz, 1H), 4.89 – 4.84 (m, 1H), 4.35 – 4.25 (m, 2H), 4.13 (d, *J* = 5.7 Hz, 1H), 2.90 – 2.82 (m, 2H), 2.74 (dd, *J* = 13.2, 5.2 Hz, 1H), 2.19 (dd, *J* = 13.2, 10.3 Hz, 1H), 2.02 (s, 3H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 171.8, 170.3, 162.0, 150.1, 141.1, 136.1, 132.4, 131.3, 130.4, 129.5, 128.6, 127.8, 125.1, 66.7, 65.6, 58.4, 44.2, 34.4, 32.8, 21.2.

HRMS (ESI, *m/z*) calcd for $C_{22}H_{20}NO_4{}^{35}ClNa^+$ $[M+Na]^+$: 420.0984, found: 420.0971.



55, 53% yield, >95:5 d.r.

According to the general procedure, a mixture of 2,2,3,3,4,4,5,5-octafluoropentyl quinoline-8-carboxylate (77.4 mg, 0.20 mmol), vinyl acetate (93 μL, 1.0 mmol), and Ir-F (4.4 mg, 2 mol%, 0.004 mmol) in HFIP (1 mL, 0.2 M) was stirred under argon atmosphere for 48 hours under irradiation with blue LEDs to afford **55** as a light yellow gum (49.9 mg, 53%, >95:5 d.r.).

Purification conditions: *n*-pentane/EtOAc = 8:3 to 7:3.

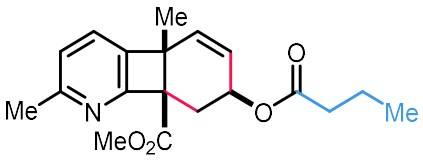
R_f = 0.40 in *n*-pentane/EtOAc (7:3).

^{1}H{^{19}F} NMR (599 MHz, $CDCl_3$) δ 8.42 (d, *J* = 5.1 Hz, 1H), 7.35 (ddd, *J* = 7.4, 1.4, 0.8 Hz, 1H), 7.18 (dd, *J* = 7.4, 5.3 Hz, 1H), 6.20 (ddd, *J* = 10.3, 5.5, 2.2 Hz, 1H), 6.02 (s, 1H), 5.91 (ddt, *J* = 10.3, 2.5, 0.9 Hz, 1H), 4.94 – 4.89 (m, 1H), 4.67 – 4.61 (m, 2H), 4.30 (dt, *J* = 5.5, 1.0 Hz, 1H), 2.76 (dd, *J* = 13.4, 4.9 Hz, 1H), 2.33 (dd, *J* = 13.3, 9.9 Hz, 1H), 2.03 (s, 3H).

^{13}C{^{1}H, ^{19}F} NMR (151 MHz, $CDCl_3$) δ 170.6, 170.4, 161.2, 150.3, 140.9, 131.3, 129.8, 127.7, 125.5, 114.5, 110.8, 110.1, 107.7, 66.3, 60.2, 58.1, 44.2, 32.5, 21.1.

^{19}F{^{1}H} NMR (564 MHz, $CDCl_3$) δ -119.62 (td, *J* = 10.9, 3.0 Hz), -125.45 (dtd, *J* = 8.0, 5.6, 2.6 Hz), -129.95 – -130.13 (m), -137.26 (ddt, *J* = 11.8, 5.4, 2.6 Hz).

HRMS (ESI, *m/z*) calcd for $C_{19}H_{15}NO_4F_8Na^+$ $[M+Na]^+$: 496.0766, found: 496.0770.



56, 84% yield, >95:5 d.r.

According to the general procedure, a mixture of methyl 2,5-dimethylquinoline-8-carboxylate (40.2 mg, 0.20 mmol), vinyl butyrate (127 µL, 1.0 mmol), and Ir-F (4.4 mg, 2 mol%, 0.004 mmol) in HFIP (1 mL, 0.2 M) was stirred under argon atmosphere for 48 hours under irradiation with blue LEDs to afford **56** as a light yellow gum (52.7 mg, 0.16 mmol, 84% yield, >95:5 d.r.).

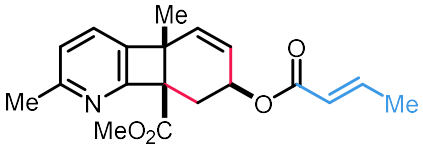
Purification conditions: *n*-pentane/EtOAc = 3:2.

R_f = 0. 50 in *n*-pentane/EtOAc (3:2).

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.45 (dd, *J* = 5.2, 1.5 Hz, 1H), 7.24 (dd, *J* = 7.5, 1.5 Hz, 1H), 7.13 (dd, *J* = 7.4, 5.2 Hz, 1H), 5.92 (dd, *J* = 10.5, 2.6 Hz, 1H), 5.73 (dt, *J* = 10.5, 1.4 Hz, 1H), 4.73 – 4.66 (m, 1H), 3.68 (s, 3H), 2.76 (ddd, *J* = 13.0, 5.6, 1.3 Hz, 1H), 2.31 (dd, *J* = 12.9, 11.7 Hz, 1H), 2.25 (t, *J* = 7.4 Hz, 2H), 1.60 (h, *J* = 7.4 Hz, 2H), 1.44 (s, 3H), 0.90 (t, *J* = 7.4 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 172.9, 172.5, 160.3, 150.4, 144.5, 133.3, 131.0, 127.9, 124.9, 66.7, 63.1, 52.4, 49.6, 36.3, 33.4, 21.5, 18.5, 13.7.

HRMS (ESI, *m/z*) calcd for $C_{18}H_{21}NO_4Na^+$ $[M+Na]^+$: 338.1363, found: 38.1357.



57, 85% yield, >95:5 d.r.

According to the general procedure, a mixture of methyl 2,5-dimethylquinoline-8-carboxylate (40.2 mg, 0.20 mmol), vinyl crotonate (119 µL, 1.0 mmol), and Ir-F (4.4 mg, 2 mol%, 0.004 mmol) in HFIP (1 mL, 0.2 M) was stirred under argon atmosphere for 48 hours under irradiation with blue LEDs to afford **57** as a light yellow gum (53.2 mg, 0.170 mmol, 85% yield, >95:5 d.r.).

Purification conditions: *n*-pentane/EtOAc = 3:2.

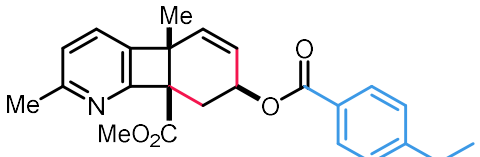
R_f = 0.45 in *n*-pentane/EtOAc (3:2).

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.46 (dd, *J* = 5.2, 1.5 Hz, 1H), 7.27 – 7.23 (m, 1H), 7.13 (dd, *J* = 7.5, 5.2 Hz, 1H), 6.95 (dq, *J* = 15.5, 6.9 Hz, 1H), 5.93 (dd, *J* = 10.4, 2.6 Hz, 1H), 5.84 – 5.74 (m, 2H),

4.78 – 4.71 (m, 1H), 3.69 (s, 3H), 2.79 (ddd, *J* = 13.0, 5.6, 1.2 Hz, 1H), 2.35 (dd, *J* = 12.9, 11.6 Hz, 1H), 1.85 (dd, *J* = 7.0, 1.7 Hz, 3H), 1.45 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 172.6, 165.7, 160.3, 150.4, 145.3, 144.5, 133.3, 131.0, 127.9, 124.9, 122.6, 66.7, 63.2, 52.4, 49.6, 33.4, 21.5, 18.1.

HRMS (ESI, *m/z*) calcd for $C_{18}H_{19}NO_4Na^+$ $[M+Na]^+$: 336.1206, found: 336.1201.



58, 81% yield, 92:8 d.r.

According to the general procedure, a mixture of methyl 2,5-dimethylquinoline-8-carboxylate (40.2 mg, 0.20 mmol), vinyl 4-(tert-butyl)benzoate (204 µL, 1.0 mmol), and Ir-F (4.4 mg, 2 mol%, 0.004 mmol) in HFIP (1 mL, 0.2 M) was stirred under argon atmosphere for 48 hours under irradiation with blue LEDs to afford **58** as a light yellow gum (65.5 mg, 0.162 mmol, 81% yield, 92:8 d.r.).

Purification conditions: *n*-pentane/EtOAc = 2:1.

R_f = 0.60 in *n*-pentane/EtOAc (3:2).

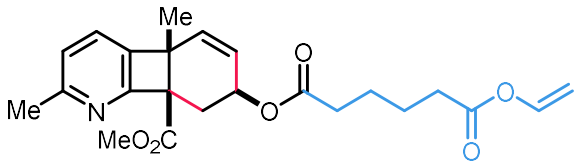
^{1}H NMR (599 MHz, $CDCl_3$, *major isomer*) δ 8.50 (dd, *J* = 5.3, 1.5 Hz, 1H), 7.96 – 7.93 (m, 2H), 7.45 – 7.42 (m, 2H), 7.29 (dd, *J* = 7.4, 1.5 Hz, 1H), 7.17 (dd, *J* = 7.4, 5.3 Hz, 1H), 5.99 (dd, *J* = 10.5, 2.6 Hz, 1H), 5.88 (dt, *J* = 10.4, 1.4 Hz, 1H), 4.98 – 4.93 (m, 1H), 3.72 (s, 3H), 2.91 (ddd, *J* = 12.8, 5.5, 1.2 Hz, 1H), 2.51 (dd, *J* = 12.9, 11.6 Hz, 1H), 1.49 (s, 3H), 1.32 (s, 9H).

^{13}C NMR (151 MHz, $CDCl_3$, *major isomer*) δ 172.6, 165.9, 160.33, 156.9, 150.4, 144.6, 133.5, 131.0, 129.6, 128.0, 127.4, 125.4, 124.97, 67.3, 63.2, 52.42, 49.7, 35.18, 33.5, 31.21, 21.6.

^{1}H NMR (599 MHz, $CDCl_3$, *minor isomer – diagnostic signals*) δ 8.02 – 8.00 (m, 2H), 7.54 – 7.51 (m, 2H), 7.32 – 7.30 (m, 1H), 7.10 (dd, *J* = 7.4, 5.3 Hz, 1H), 6.17 – 6.11 (m, 2H), 5.66 (q, *J* = 4.5 Hz, 1H), 3.73 (s, 3H), 2.75 (dd, *J* = 14.8, 4.4 Hz, 1H), 2.70 (dd, *J* = 14.8, 4.4 Hz, 1H), 1.33 (s, 9H).

^{13}C NMR (151 MHz, $CDCl_3$, *minor isomer*) δ 172.8, 166.0, 162.5, 156.5, 150.0, 136.5, 130.0, 127.9, 127.2, 126.4, 125.3, 125.01, 124.2, 66.1, 62.6, 52.39, 49.5, 35.15, 33.0, 31.24, 22.1.

HRMS (ESI, *m/z*) calcd for $C_{25}H_{27}NO_4Na^+$ $[M+Na]^+$: 428.1832, found: 428.1828.



59, 78% yield, >95:5 d.r.

According to the general procedure, a mixture of methyl 2,5-dimethylquinoline-8-carboxylate (40.2 mg, 0.20 mmol), divinyl adipate (198 mg, 1.0 mmol), and Ir-F (4.4 mg, 2 mol%, 0.004 mmol) in HFIP (1 mL, 0.2 M) was stirred under argon atmosphere for 48 hours under irradiation with blue LEDs to afford **59** as a light yellow gum (62.3 mg, 0.156 mmol, 78% yield, >95:5 d.r.).

Purification conditions: *n*-pentane/EtOAc = 1:1.

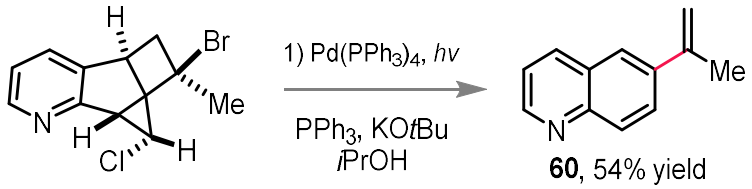
R_f = 0.30 in *n*-pentane/EtOAc (3:2).

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.40 (dd, *J* = 5.3, 1.5 Hz, 1H), 7.23 – 7.16 (m, 2H), 7.08 (dd, *J* = 7.4, 5.2 Hz, 1H), 5.88 (dd, *J* = 10.5, 2.6 Hz, 1H), 5.68 (dt, *J* = 10.4, 1.5 Hz, 1H), 4.80 (dd, *J* = 13.9, 1.6 Hz, 1H), 4.67 – 4.60 (m, 1H), 4.49 (dd, *J* = 6.4, 1.6 Hz, 1H), 3.64 (s, 3H), 2.71 (ddd, *J* = 12.9, 5.6, 1.3 Hz, 1H), 2.37 – 2.30 (m, 2H), 2.30 – 2.21 (m, 3H), 1.66 – 1.54 (m, 4H), 1.39 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 172.49, 172.45, 170.4, 160.2, 150.4, 144.5, 141.2, 133.5, 130.8, 127.9, 124.9, 97.7, 67.0, 63.1, 52.4, 49.6, 34.0, 33.6, 33.4, 24.3, 24.0, 21.5.

HRMS (ESI, *m*/*z*) calcd for $C_{22}H_{25}NO_6Na^+$ $[M+Na]^+$: 422.1574, found: 422.1569.

Synthetic Application



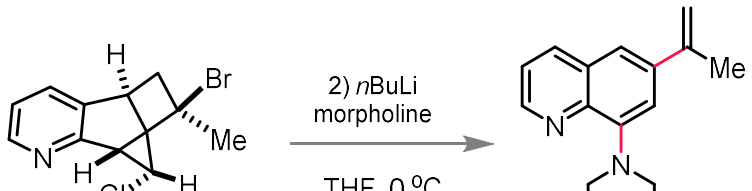
60, 54% yield

To a solution of substrate **22** (56.9 mg, 0.20 mmol, 1.00 equiv.), $Pd(PPh_3)_4$ (11.1 mg, 0.001 mmol, 5 mol%) and PPh_3 (5.2 mg, 0.002 mmol, 10 mol%) in *i*PrOH (2 mL) was added *t*BuOK (44.9 mg, 0.4 mmol) in one portion. The reaction mixture was stirred at room temperature for 14 hours under the irradiation of 30 W blue LEDs until the substrate **22** fully consumed (check by TLC). Then the reaction was quenched by the addition of water (1 ml) and the layers were separated. The aqueous layer was extracted twice with CH_2Cl_2 (5 ml each time), and the combined organic layers were dried *in vacuo*. The residue was purified by flash column chromatography on silica (pentane/EtOAc = 10/1), affording **60** (18.3 mg, 54% yield) as a colourless oil.

^{1}H NMR (599 MHz, $CDCl_3$) δ 8.88 (s, 1H), 8.30 – 8.12 (m, 1H), 8.09 – 8.00 (m, 1H), 7.91 (dd, J = 8.8, 2.1 Hz, 1H), 7.81 (d, J = 2.1 Hz, 1H), 7.39 (dd, J = 8.3, 4.2 Hz, 1H), 5.56 (p, J = 0.8 Hz, 1H), 5.25 (p, J = 1.4 Hz, 1H), 2.27 (dd, J = 1.5, 0.8 Hz, 3H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 150.2, 147.9, 142.4, 139.3, 136.4, 129.2, 128.3, 127.7, 124.0, 121.4, 114.1, 21.9.

HRMS (ESI, *m*/*z*) calcd for $C_{12}H_{11}NNa^+$ $[M+Na]^+$: 192.0783, found: 192.0782.



61, 60% yield

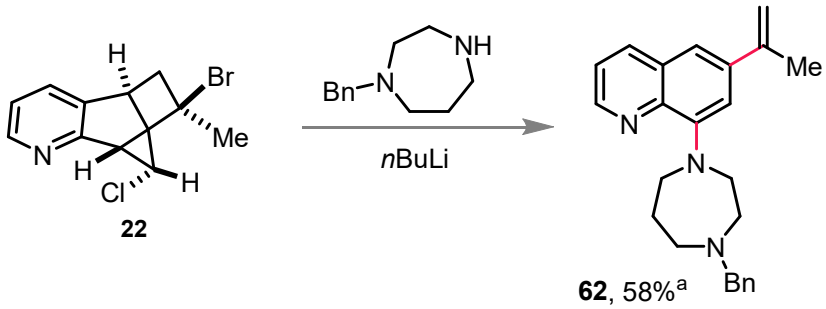
To a solution of morpholine (34.8 μL, 0.40 mmol, 2.00 equiv.) in THF (1 mL) was added *n*BuLi (0.40 mmol, 0.25 mL, 1.6 M in *n*-hexane) dropwise at 0 °C. The resulted mixture was stirred for 30 min under this temperature. Compound **22** (56.9 mg, 0.20 mmol, 1.00 equiv.) in THF (1 mL) was added to the mixture and then stirred for another 5 hours. Then the reaction was quenched by the addition of water (1 ml) and was extracted twice with CH_2Cl_2 (5 ml each time). The combined

organic layers were dried *in vacuo* and the residue was purified by flash column chromatography on silica (pentane/EtOAc = 10/1), affording **61** (30.7 mg, 60% yield) as a pale yellow oil.

^{1}H NMR (599 MHz, $CDCl_3$) δ 8.84 (dd, *J* = 4.2, 1.8 Hz, 1H), 8.11 (dd, *J* = 8.2, 1.8 Hz, 1H), 7.46 (d, *J* = 1.9 Hz, 1H), 7.37 (dd, *J* = 8.2, 4.2 Hz, 1H), 7.31 (s, 1H), 5.52 (t, *J* = 1.0 Hz, 1H), 5.23 (p, *J* = 1.5 Hz, 1H), 4.13 – 4.01 (m, 4H), 3.44 (t, *J* = 4.6 Hz, 4H), 2.26 (dd, *J* = 1.5, 0.7 Hz, 3H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 148.7, 148.0, 142.9, 142.2, 139.2, 136.9, 129.4, 121.1, 118.5, 114.0, 113.7, 67.1, 52.5, 21.8.

HRMS (ESI, *m/z*) calcd for $C_{16}H_{19}N_2O^+$ $[M+H]^+$: 255.1491, found: 255.1490.



Synthesis of 1-benzyl-1,4-diazepane.

Step 1. In an oven-dried round-bottom flask equipped with a PTFE-coated stirring bar, diazepane (2.11 ml, 20.0 mmol, 4.00 equiv.) was dissolved in dry CH_2Cl_2 (33 ml), then the solution was cooled at 0 °C and Boc_2O (1.15 ml, 5.00 mmol, 1.00 equiv.) in dry CH_2Cl_2 (14 ml) was added dropwise over 5 minutes, then the reaction was gently warmed to room temperature. After stirring for 4 hours, then reaction was quenched with water (50 ml), then the mixture was brought to pH 12 using saturated aqueous $NaHCO_3$. The layers were separated, the aqueous layer was extracted twice with CH_2Cl_2 (15 ml each time), the combined organic layers were washed once with brine, then were dried over $MgSO_4$ and the solvent was removed *in vacuo*, affording the crude Boc-protected azepane (955 mg, 4.77 mmol) as a light yellow oil.

Step 2. In a round-bottom flask equipped with a PTFE-coated stirring bar, the intermediate Boc-protected azepane (955 mg, 4.77 mmol, 1.00 equiv.) was dissolved in DMF (10 ml) with K_2CO_3 (1.32 g, 9.54 mmol, 2.00 equiv.) and vigorously stirred. Benzyl bromide (736 µl, 6.20 mmol, 1.30 equiv.) was added dropwise, then the reaction was stirred at room temperature for 22 hours, filtered over a short pad of Celite®, rinsing with CH_2Cl_2, then most DMF was removed *in vacuo*. The residue was partitioned between AcOEt/H_2O (1/1, 40 ml), then the aqueous layer was extracted

twice with EtOAc (15 ml each time). The combined organic layers were washed twice with water (30 ml each time), then once with brine (30 ml), dried over $MgSO_4$ and the volatiles were removed *in vacuo*. The residue was purified by flash column chromatography on silica (pentane/EtOAc = 5/2), affording *tert*-butyl 4-benzyl-1,4-diazepane-1-carboxylate (702 mg, 2.42 mmol, 51%) as a colourless thick oil.

Step 3. In a round-bottom flask equipped with a PTFE-coated stirring bar, *tert*-butyl 4-benzyl-1,4-diazepane-1-carboxylate (702 mg, 2.42 mmol, 1.00 equiv.) was dissolved in MeOH (3 ml), then cooled to 0 °C and HCl 4 M in 1,4-dioxane (1.8 ml, 7.25 mmol, 3.00 equiv.) was added dropwise, then the reaction was warmed to room temperature and stirred overnight. The solvent was removed *in vacuo*, affording 1-benzyl-1,4-diazepane bis-hydrochloride as a foamy white solid (636 mg, 2.42 mmol, quantitative yield). ^{1}H NMR (400 MHz, CD_3OD) δ 7.65 – 7.59 (m, 2H), 7.55 – 7.46 (m, 3H), 4.49 (s, 2H), 3.84 – 3.71 (m, 4H), 3.54 – 3.36 (m, 3H), 2.32 (p, *J* = 5.7 Hz, 2H). The experimental data are consistent with the literature report.[12]

The bis-hydrochloride salt was freebased by partitioning between CH_2Cl_2 and saturated $NaHCO_3$. The organic layer was dried over $MgSO_4$ and the solvent was removed *in vacuo*, affording the freebase amine as a colourless gum.

Formal cross-electrophilic coupling towards a CXCR7 chemokine antagonist.

In a flame-dried Schlenk tube equipped with a PTFE-coated stirring bar, 1-benzyl-1,4-diazepane (38.1 mg, 0.20 mmol, 2.00 equiv.) in dry THF (1 mL) was cooled to 0 °C, then *n*BuLi (1.6 M in hexanes, 125 µl, 0.200 mmol, 2.00 equiv.) was added dropwise at 0 °C. The resulted mixture was stirred for 30 min under this temperature, then compound **22** (28.4 mg, 0.10 mmol, 1.00 equiv.) in THF (1 mL) was added to the mixture and then stirred for another 5 hours. The reaction was quenched by the addition of two drops of water, then dried *in vacuo* and the residue was purified by flash column chromatography on silica (CH_2Cl_2/MeOH = 16/1 → 13/1), affording **62** (20.7 mg, 58% yield, containing approx. 15% of an inseparable isomer) as a yellow gum.

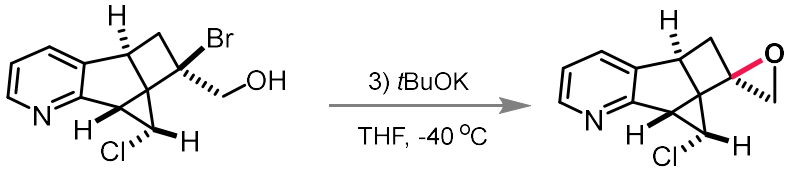
R_f = 0.50 in CH_2Cl_2/MeOH (12:1).

^{1}H NMR (599 MHz, $CDCl_3$) δ 8.72 (dd, *J* = 4.1, 1.8 Hz, 1H), 8.07 (dd, *J* = 8.3, 1.8 Hz, 1H), 7.63 (d, *J* = 7.2 Hz, 2H), 7.42 (t, *J* = 7.3 Hz, 2H), 7.39 (d, *J* = 7.3 Hz, 1H), 7.36 – 7.33 (m, 2H), 7.20 (d, *J* = 2.0 Hz, 1H), 5.47 (s, 1H), 5.20 (t, *J* = 1.3 Hz, 1H), 4.23 – 4.01 (br, 2H), 3.90 (t, *J* = 4.6 Hz, 2H), 3.66 –

3.43 (br, 3H), 3.36 – 3.14 (br, 2H), 2.92 – 2.74 (br, 1H), 2.23 (s, 3H). *The diazepane ring protons show broadening due to conformation flexibility.*

^{13}C NMR (151 MHz, $CDCl_3$) δ 150.3, 148.9, 147.3, 143.2, 142.1, 139.4, 136.9, 135.4, 130.9, 129.8, 129.1, 121.3, 116.8, 113.8, 112.7, 62.7, 61.9, 57.7, 55.2, 53.0 – 52.0 (br m), 50.8 – 49.8 (br m), 22.0. *Signal broadening was observed due to conformation flexibility of the diazepane fragment and unambiguous assignment can be performed by 2D NMR techniques.*

HRMS (ESI, *m*/*z*) calcd for $C_{24}H_{28}N_3^+$ $[M+H]^+$: 358.2278, found: 358.2277.



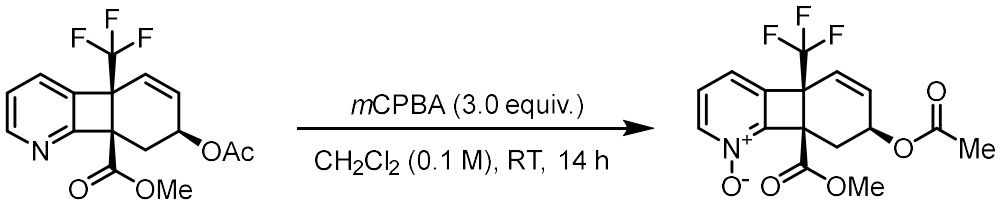
63, 82% yield
>95:5 d.r.

To a solution of **24** (500 mg, 1.66 mmol, 1.00 equiv.) in THF (10 mL) was added *t*BuOK (374 mg, 3.33 mmol) portionwise at –40 °C. The resulted mixture was stirred for 4 hours under this temperature. Then the reaction was quenched by the addition of water (10 ml) and was extracted twice with CH_2Cl_2 (20 ml each time). The combined organic layers were dried *in vacuo* and the residue was purified by flash column chromatography on silica (pentane/EtOAc = 10/1), affording **63** (299.0 mg, 82% yield) as a pale yellow solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.41 (dd, *J* = 4.9, 1.6 Hz, 1H), 7.53 (dt, *J* = 7.7, 1.1 Hz, 1H), 7.13 (dd, *J* = 7.6, 5.0 Hz, 1H), 4.13 (ddd, *J* = 9.2, 7.1, 2.0 Hz, 1H), 3.80 (d, *J* = 7.8 Hz, 1H), 3.08 (dd, *J* = 7.9, 2.1 Hz, 1H), 2.83 – 2.71 (m, 3H), 2.62 (d, *J* = 4.0 Hz, 1H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 161.1, 148.6, 142.3, 132.3, 122.0, 65.3, 48.2, 42.2, 40.6, 39.0, 38.7, 37.4.

HRMS (ESI, *m*/*z*) calcd for $C_{12}H_{11}N_1O_1Cl^+$ $[M+H]^+$: 220.0523, found: 220.0520.



44 **64**

In a flat-bottom vial equipped with a PTFE-coated stirring bar, substrate **44** (46.7 mg, 0.137 mmol, 1.00 equiv.) was dissolved in CH_2Cl_2 (1.3 ml) under air, then *m*CPBA 70% (101 mg, 0.41 mmol, 3.00 equiv.) was added portionwise and the reaction was stirred at room temperature for 14 hours, then the reaction was directly loaded on silica and purified by flash column chromatography over silica gel (CH_2Cl_2/MeOH/AcOH = 100/2/0.3 to 100/4/0.3), affording **64** (42.8 mg, 0.120 mmol, 87%) as a white foam.

Note. Acidification of the silica column and eluent allows improved separation of the excess reagent and byproduct.

R_f = 0.45 in CH_2Cl_2/MeOH (95:5).

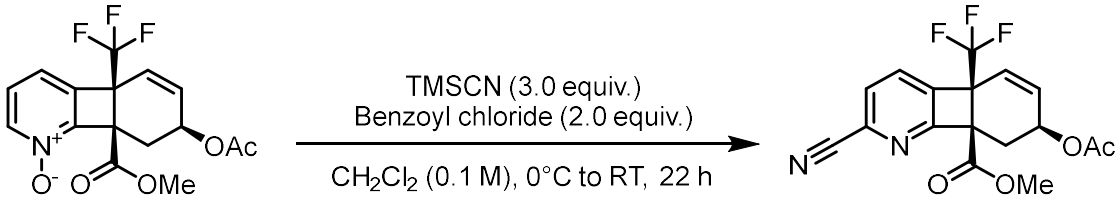
$^1H\{^{19}F\}$ NMR (599 MHz, $CDCl_3$) δ 8.12 (d, *J* = 6.7 Hz, 1H), 7.28 (t, *J* = 7.1 Hz, 1H), 6.98 (d, *J* = 7.4 Hz, 1H), 6.13 (dd, *J* = 10.7, 2.2 Hz, 1H), 6.10 (dt, *J* = 10.7, 1.3 Hz, 1H), 4.77 (ddt, *J* = 11.9, 5.6, 1.8 Hz, 1H), 3.78 (s, 3H), 3.04 (ddd, *J* = 13.4, 5.7, 1.1 Hz, 1H), 2.35 (dd, *J* = 13.3, 11.9 Hz, 1H), 2.05 (s, 3H).

$^{13}C\{^1H, ^{19}F\}$ NMR (151 MHz, $CDCl_3$) δ 170.1, 168.4, 143.8, 141.4, 139.7, 135.8, 128.4, 124.4, 122.2, 118.5, 66.1, 59.2, 56.0, 53.7, 31.5, 21.0.

^{13}C NMR (151 MHz, $CDCl_3$) δ 170.1, 168.4, 143.8, 141.4, 139.7 (q, *J* = 2.6 Hz), 135.8, 128.4, 124.4 (q, *J* = 280.8 Hz), 122.2, 118.5, 66.1, 59.2, 56.0 (q, *J* = 30.7 Hz), 53.7, 31.5, 21.0.

$^{19}F\{^1H\}$ NMR (564 MHz, $CDCl_3$) δ -71.4.

HRMS (ESI, *m*/*z*) calcd for $C_{16}H_{14}NO_5F_3Na^+$ $[M+Na]^+$: 380.0716, found: 380.0713.



64 **65**

In an oven-dried Schlenk tube equipped with a PTFE-coated stirring bar, substrate **64** (42 mg, 0.118 mmol, 1.00 equiv.) was dissolved in dry CH_2Cl_2 (1.1 ml) under argon, then the solution was cooled to 0°C and TMSCN (44 µl, 0.354 mmol, 3.00 equiv.) was added, followed by the dropwise addition of benzoyl chloride (28 µl, 0.236 mmol, 2.00 equiv.). The reaction was warmed at room temperature and stirred for 22 hours, then quenched by the addition of water (1 ml) and the layers were separated. The aqueous layer was extracted twice with CH_2Cl_2 (5 ml each time), then the combined layers were dried *in vacuo*. The residue was purified by flash column chromatography on

silica (pentane/EtOAc = 4/1), affording **65** (35.3 mg, 0.096 mmol, 82%) as a colourless gum.

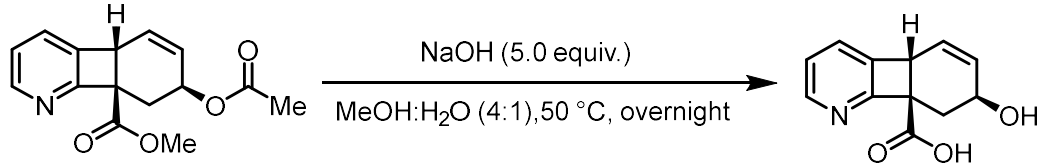
^{1}H NMR (599 MHz, $CDCl_3$) δ 7.69 (d, *J* = 7.7 Hz, 1H), 7.55 (d, *J* = 7.6 Hz, 1H), 6.21 (dd, *J* = 10.7, 2.6 Hz, 1H), 6.10 (d, *J* = 10.7 Hz, 1H), 4.67 (dddd, *J* = 11.7, 5.6, 2.6, 1.6 Hz, 1H), 3.77 (s, 3H), 2.86 (dd, *J* = 13.2, 5.6 Hz, 1H), 2.36 (dd, *J* = 13.2, 11.8 Hz, 1H), 2.07 (s, 3H).

^{13}C{^{1}H, ^{19}F} NMR (151 MHz, $CDCl_3$) δ 170.1, 169.0, 162.2, 139.9, 136.0, 135.7, 131.0, 130.4, 124.5, 122.9, 116.9, 65.6, 62.7, 56.7, 53.6, 33.8, 21.0.

^{13}C{^{1}H} NMR (151 MHz, $CDCl_3$) δ 170.1, 169.0, 162.2, 139.9, 136.0, 135.7, 131.0, 130.4, 124.5 (q, *J* = 280.8 Hz), 122.9 (q, *J* = 2.9 Hz), 116.9, 65.6, 62.7, 56.7 (q, *J* = 30.7 Hz), 53.6, 33.8, 21.0.

^{19}F{^{1}H} NMR (564 MHz, $CDCl_3$) δ -71.06.

HRMS (ESI, *m*/*z*) calcd for $C_{17}H_{13}N_2O_4F_3Na^+$ $[M+Na]^+$: 389.0720, found: 389.0715.



51 **66**

In a flat-bottom scintillation vial equipped with a PTFE-coated stirring bar, **51** (98.7 mg, 0.361 mmol, 1.00 equiv.) and NaOH (72.4 mg, 1.81 mmol, 5.00 equiv.) were dissolved in MeOH:H_2O 4:1 (3.5 ml), then stirred at 50°C overnight. After cooling to room temperature, the reaction was diluted with water (20 ml), then washed once with Et_2O (20 ml). The aqueous layer was neutralized with acetic acid, then the aqueous layer was washed twice with EtOAc (15 ml each time), then the water was removed *in vacuo*. The residue was purified by flash column chromatography on silica (CH_2Cl_2/MeOH/HCO_2H = 9/1/0.005), affording **66** (61.2 mg, 0.281 mmol, 78%) as a white solid.

^{1}H NMR (400 MHz, DMSO-*d*$_6$) δ 8.34 (d, *J* = 5.2 Hz, 1H), 7.43 (d, *J* = 7.3 Hz, 1H), 7.20 (dd, *J* = 7.4, 5.2 Hz, 1H), 6.07 (ddd, *J* = 10.2, 6.0, 2.6 Hz, 1H), 5.85 (d, *J* = 10.2 Hz, 1H), 4.09 (d, *J* = 6.0 Hz, 1H), 3.52 – 3.43 (m, 1H), 2.57 (dd, *J* = 12.9, 5.1 Hz, 1H), 1.78 (dd, *J* = 12.9, 11.0 Hz, 1H).

^{13}C NMR (101 MHz, DMSO-*d*$_6$) δ 173.6, 162.9, 149.1, 141.1, 136.8, 129.3, 125.6, 124.8, 62.7, 59.1, 43.8, 37.1.

HRMS (ESI, *m*/*z*) calcd for $C_{12}H_{10}NO_3^-$ $[M-H]^-$: 216.0666, found: 216.0665.

DFT Calculations

Computational Methods

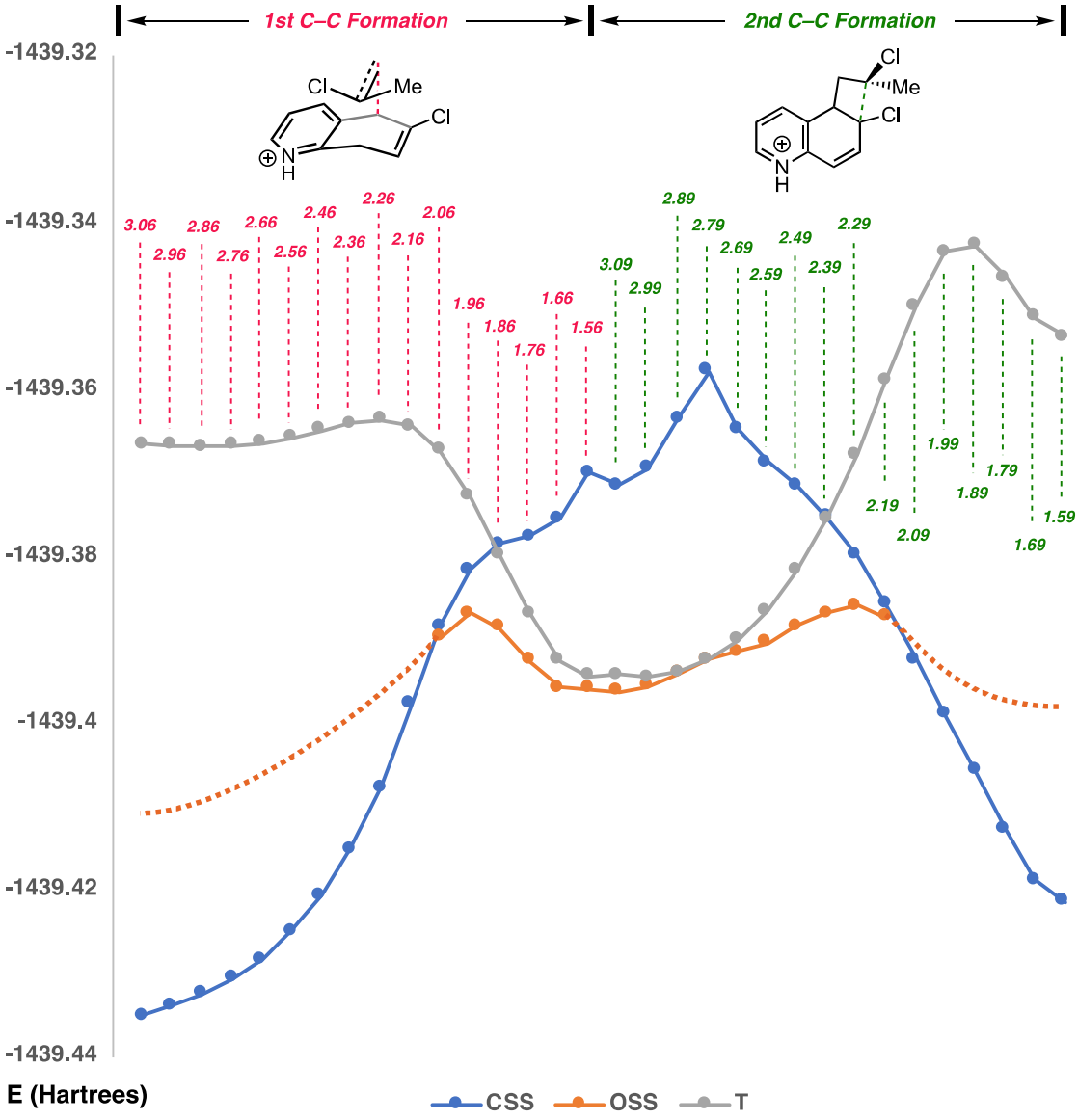
All calculations were performed with Gaussian 16.[13] Molecular geometries were optimized using the ωB97X-D[14] functional, using the def2-SVP basis set for all atoms. Frequency calculations were performed at the same level of theory as that used for geometry optimization in order to characterize the stationary points as either minima (zero imaginary frequencies) or saddle points (one imaginary frequency) on the potential energy surface. Thermal contributions to free energies were calculated from the vibrational frequencies using the quasi-rigid rotor-harmonic oscillator (RRHO) approach by Grimme.[15] Intrinsic Reaction Coordinate (IRC) calculations were performed to confirm the saddle points as real transition states connecting the expected reactants and products. Single point energies were calculated with the ωB97X-D functional using the def2-TZVPP basis set for all atoms. For modeling reactions conducted in solvent, solvation effects were incorporated using the SMD[16] model in geometry optimization, frequency analysis and single-point energy calculations. Implicit HFIP solvent was modeled using the parameters "solvent = generic, eps = 16.7, epsinf = 1.625".[17] Molecular visualizations were created using CYLview.[18] Conformational searches were performed with the MMFF force field as implemented in Spartan '18[19] to ensure that the lowest-energy conformers are presented in the manuscript. Minimum energy crossing points (MECPs) between triplet and closed-shell singlet surfaces were located using the EasyMECP[20] python wrapper around the original MECP Fortran routine from Harvey.[21]

Potential Energy Surfaces

For the formal [2+2] cycloaddition between 6-chloroquinoline and 2-chloropropene, we calculated the shape of the potential energy surfaces in three spin states: the triplet (T), the open-shell singlet (OSS), and the closed-shell singlet (CSS). For the first C–C formation event, constrained geometries optimizations were performed in the triplet state, and single-point energies were obtained based on these geometries in all three spin states. For the second C–C formation event, constrained optimizations were performed in the open-shell singlet state, and single-point energies were obtained based on these geometries in all three spin states. The keyword guess=mix was used

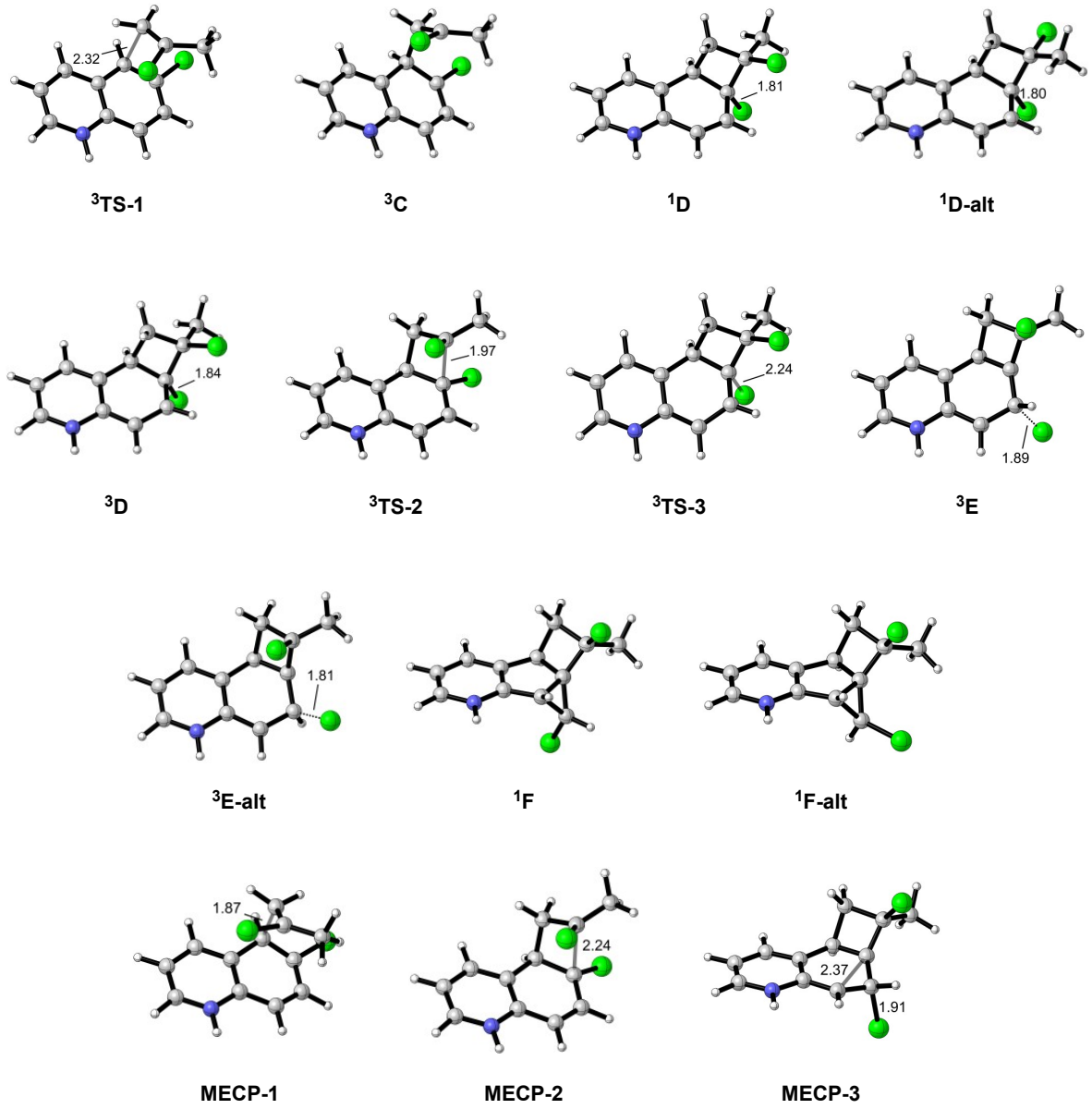
to break the α/β symmetry in open-shell singlet calculations, and the wavefunctions obtained were checked for their stability using the stable=opt keyword.

The three potential energy surfaces are plotted in **Supplementary Figure 12** with the horizontal axis corresponding to the forming C–C bond lengths.



Supplementary Figure 12. Calculated potential energy surfaces for the reaction between 6-chloroquinoline and 2-chloropropene at the ωB97X-D/def2-TZVPP, SMD(HFIP)//ωB97X-D/def2-SVP, SMD(HFIP) level of theory. Forming C–C bond lengths (Å) corresponding to each point of the horizontal axis are denoted in italic text. Dashed orange line indicates portions of the OSS surface that are not computationally accessible due to being higher in energy than the CSS.

Calculated Structures



Supplementary Figure 13. Calculated structures of intermediates, TSs and MECPs. Interatomic distances are in ångströms.

Calculated Energies

Supplementary Table 5. Calculated energies in Hartrees. ΔG = thermal corrections to free energies calculated at the ωB97X-D/def2-SVP, SMD (HFIP) level of theory and corrected using the quasi-rigid rotor-harmonic oscillator (RRHO) approach by Grimme.[13] E = single-point electronic energies calculated at the ωB97X-D/def2-TZVPP, SMD (HFIP). G = overall free energies calculated as the sum of ΔG and E. For MECPs, only electronic energies can be calculated, and free energies are therefore not provided.

Structure	ΔG [ωB97X-D/def2-SVP, SMD (HFIP)]	E [ωB97X-D/6-def2-TZVPP, SMD (HFIP)]	G (ΔG+E)	Imaginary Frequency (cm^{-1})
^{1}A	0.108105	-862.016087	-861.907982	-
^{3}A	0.101778	-861.918801	-861.817023	-
B	0.043340	-577.535518	-577.492178	-
^{3}C	0.170773	-1439.494721	-1439.323948	-
^{1}D	0.178940	-1439.557599	-1439.378659	-
^{1}D-alt	0.178423	-1439.554822	-1439.376399	-
^{3}D	0.172341	-1439.462000	-1439.289659	-
^{3}E	0.171914	-1439.471922	-1439.300008	-
^{3}E-alt	0.173004	-1439.464876	-1439.291872	-
^{1}F	0.177539	-1439.530215	-1439.352676	-
^{1}F-alt	0.177996	-1439.527717	-1439.349721	-
^{3}F	0.169250	-1439.405549	-1439.236299	-
MECP-1	-	-1439.400698	-	-
MECP-2	-	-1439.396847	-	-
MECP-3	-	-1439.466613	-	-
^{3}TS-1	0.166868	-1439.456885	-1439.290017	-362.29
^{3}TS-2	0.171134	-1439.441032	-1439.269898	-844.94
^{3}TS-3	0.172422	-1439.453363	-1439.280941	-312.36

8.5 Cartesian Coordinates of Calculated Structures

^{1}A

C	3.25486100	0.20875000	0.00013600
C	0.94316400	0.75926400	0.00003800
C	0.60510000	-0.61622300	-0.00000900
C	1.65507100	-1.56949400	0.00004500
C	2.97111200	-1.16049500	0.00011000
H	0.22253900	2.80925200	0.00013600
H	4.27044100	0.60641600	0.00016000
C	-0.05745700	1.75413800	0.00004500
C	-0.76518400	-0.98437900	-0.00011800
H	1.40522400	-2.63288300	-0.00002000
H	3.79390300	-1.87490600	0.00014800
C	-1.72238600	-0.00045900	-0.00013000
C	-1.37694800	1.37421300	0.00000300
H	-1.03536800	-2.04125200	-0.00013800
H	-2.16483300	2.12930300	0.00007300
N	2.26960000	1.09512500	0.00010300
H	2.51068300	2.08889800	0.00007200
Cl	-3.40786900	-0.43191700	-0.00010900

^{3}A

C	3.29121200	0.20437700	0.00012700
C	0.94796500	0.75813800	0.00006000
C	0.62381000	-0.63870200	0.00001100
C	1.67249900	-1.58284600	0.00001700
C	3.01936300	-1.12804100	0.00007800
H	0.20693700	2.80100700	0.00007600
H	4.28949800	0.63810800	0.00017700
C	-0.07891300	1.74693800	0.00003900
C	-0.73940700	-0.97873300	-0.00006700
H	1.44184700	-2.64854500	-0.00002300
H	3.84437500	-1.84114300	0.00008300
C	-1.77017800	0.06073000	-0.00005100
C	-1.44647900	1.38815100	-0.00001200
H	-1.04052900	-2.02722400	-0.00015500
H	-2.21323300	2.16287800	-0.00001800
N	2.23870800	1.11492200	0.00011200

H	2.46820100	2.10880400	0.00013600
Cl	-3.39925300	-0.46931800	-0.00013300

B

C	-0.94204400	1.37210400	-0.00001200
H	-0.30201900	2.25684000	-0.00010100
C	-0.44582300	0.13668600	0.00015100
Cl	1.30520800	-0.09043300	-0.00001500
H	-2.02602200	1.51376000	-0.00010200
C	-1.21638000	-1.14308200	-0.00002600
H	-0.96928600	-1.74632500	-0.88763800
H	-0.97042600	-1.74587600	0.88819600
H	-2.29530300	-0.93528000	-0.00078000

^{3}C

C	3.55198900	-0.64244500	-0.16252300
C	1.24892100	-0.94427700	-0.69510800
C	0.89141800	-0.62943200	0.63188500
C	1.90352800	-0.36132900	1.54670900
C	3.24616100	-0.36461700	1.15404000
H	0.59327400	-1.53302300	-2.68976000
H	4.56628500	-0.65686900	-0.56109400
C	0.27679400	-1.30806400	-1.67026700
C	-0.56566400	-0.52742000	1.02146500
H	1.64349300	-0.13285300	2.58309600
H	4.04583000	-0.14706400	1.86109500
C	-1.46555100	-1.14073800	-0.01164700
C	-1.06483900	-1.44610400	-1.28952100
H	-0.70420800	-1.06062600	1.97705300
H	-1.79145600	-1.81346100	-2.01615200
N	2.56569100	-0.92575300	-1.02533000
H	2.81719700	-1.14525400	-1.99100500
Cl	-3.11401000	-1.38204100	0.45418600
C	-0.97303900	1.86352800	0.10906100
C	-0.97277300	0.96256800	1.29670500
H	-0.30168300	1.35043500	2.07897800
H	-1.98923700	0.95097700	1.71929800
Cl	0.56328100	2.50988900	-0.40835100
C	-2.11362600	2.06298800	-0.82225300
H	-2.24596200	3.12872400	-1.07518200
H	-1.96776600	1.52165500	-1.77577900

H	-3.04311300	1.69626000	-0.36371100

^{1}D

C	-4.13634600	0.36116800	-0.12829900
C	-1.82572600	0.73084100	0.27805700
C	-1.51190700	-0.51218700	-0.28173300
C	-2.54940600	-1.31581800	-0.74729900
C	-3.87407600	-0.87726000	-0.67696800
H	-1.10997500	2.59256100	1.19122100
H	-5.13511600	0.78620700	-0.03118400
C	-0.80438800	1.60597400	0.83628100
C	-0.07165200	-0.89797200	-0.39023600
H	-2.32028500	-2.29460500	-1.17496900
H	-4.69638300	-1.49047000	-1.04457200
C	0.93243100	-0.15878800	0.52106600
C	0.46680300	1.19787300	0.95199800
H	0.03664100	-1.98591000	-0.29525300
H	1.21362200	1.84966300	1.41058400
N	-3.11819300	1.10943600	0.32692000
H	-3.33645700	2.01790500	0.74259400
Cl	1.45315600	-1.01955500	2.02544900
C	1.94193400	-0.16467800	-0.66959600
C	0.73580000	-0.37172900	-1.60696400
H	0.33406700	0.57849900	-1.98251300
H	0.88726900	-1.07301400	-2.43748700
Cl	2.83831100	1.38954400	-0.91082000
C	2.93686500	-1.30586600	-0.67823900
H	3.46239400	-1.32236100	-1.64378600
H	3.67318700	-1.19433900	0.12977000
H	2.42146300	-2.26936400	-0.54995000

^{1}D-alt

C	-4.18843200	-0.09584200	-0.09384200
C	-1.94906300	0.67793600	-0.26443200
C	-1.46922500	-0.57295200	0.13905100
C	-2.38852000	-1.57568800	0.43901800
C	-3.76039400	-1.34138500	0.31755500
H	-1.49421300	2.71788500	-0.93142800
H	-5.23560300	0.18042000	-0.21536400
C	-1.05599300	1.79171400	-0.55301600
C	0.00959900	-0.78297700	0.17780900

H	-2.02796400	-2.55337100	0.76654700
H	-4.49173100	-2.11759100	0.54049600
C	0.90634100	0.46900100	0.24609600
C	0.26091700	1.69852200	-0.32019900
H	0.27678100	-1.49953000	0.96456800
H	0.91118100	2.55746100	-0.50319900
N	-3.28122100	0.85722000	-0.36272500
H	-3.62223600	1.77638400	-0.65360100
Cl	1.53858000	0.94569800	1.86698000
C	1.89913000	-0.21581200	-0.75758200
C	0.72987200	-1.14455300	-1.14849100
H	0.20119000	-0.74973400	-2.02827800
H	0.96907200	-2.20311600	-1.30535800
Cl	3.15795200	-1.16747900	0.13246200
C	2.57453900	0.62114800	-1.81776100
H	3.26384000	1.34757100	-1.36330900
H	3.14185400	-0.02748700	-2.50021700
H	1.82270700	1.16617000	-2.40751700

^{3}D

C	4.16929500	-0.08713500	-0.32762100
C	1.87026700	-0.76123400	-0.32040500
C	1.49621100	0.56446800	0.12024400
C	2.48459300	1.51085900	0.32717600
C	3.83319800	1.19776200	0.09973100
H	1.27624500	-2.75336200	-0.80806800
H	5.19879700	-0.39542800	-0.51560500
C	0.95110000	-1.75532100	-0.50449700
C	0.05405000	0.87297600	0.33932900
H	2.20899100	2.50943600	0.67285600
H	4.62383700	1.93091200	0.25486500
C	-0.93692400	-0.30869700	0.41327700
C	-0.48495900	-1.50109100	-0.31875500
H	-0.05171600	1.53052700	1.21218400
H	-1.21365200	-2.21924500	-0.69406000
N	3.23010700	-1.00094600	-0.51947200
H	3.50776100	-1.93394800	-0.82713200
Cl	-1.36889000	-0.84710500	2.11764300
C	-1.98516300	0.59000000	-0.31455200
C	-0.79987300	1.42138800	-0.84152200
H	-0.43289100	1.05245400	-1.80820900
H	-0.94945700	2.50798100	-0.87717700

Cl	-2.96393400	-0.24526700	-1.58554400
C	-2.92525700	1.36446200	0.58649700
H	-3.47850000	2.10114800	-0.01287700
H	-3.63988500	0.69126200	1.07924000
H	-2.36148900	1.90459200	1.36119400

^{3}E

C	3.95440100	-0.20362500	0.48684400
C	1.68523500	0.53466600	0.35367600
C	1.38918400	-0.54463400	-0.52294200
C	2.40140800	-1.43878000	-0.85517900
C	3.69394100	-1.27736200	-0.35091100
H	1.06783800	2.30891300	1.42904600
H	4.93447700	-0.00004500	0.91921500
C	0.74017200	1.48187200	0.79463500
C	-0.00332500	-0.64714400	-1.07649100
H	2.17818400	-2.27263800	-1.52460700
H	4.49700900	-1.96801300	-0.60596300
C	-0.99326800	0.17334900	-0.31934200
C	-0.69701100	1.38234100	0.43797600
H	0.02507600	-0.43171100	-2.16033500
H	-1.34421800	1.51220400	1.31560500
N	2.97509900	0.64422900	0.80304300
H	3.19528200	1.42302500	1.42740600
Cl	-1.08876600	2.89571600	-0.61630500
C	-1.98157400	-0.93873100	-0.17748300
C	-0.89151200	-1.88969400	-0.75273000
H	-0.45042300	-2.54234800	0.01005900
H	-1.21105900	-2.48279600	-1.61923000
Cl	-2.38733600	-1.27594500	1.58019600
C	-3.27312900	-0.82977300	-0.96585500
H	-3.83988900	-1.77035900	-0.90396400
H	-3.89369400	-0.00608400	-0.58532600
H	-3.03767000	-0.63078400	-2.02254600

^{3}E-alt

C	3.73002900	0.59928700	0.58972800
C	1.47014800	0.86383700	-0.14197100
C	1.46506800	-0.48143500	-0.60261500
C	2.61419000	-1.24868100	-0.44750800
C	3.75791500	-0.71551800	0.15235100

H	0.47450700	2.77373900	0.09267000
H	4.57571500	1.09368600	1.06812900
C	0.37339500	1.73982200	-0.24671100
C	0.21329700	-1.02632800	-1.24467400
H	2.61637200	-2.28272200	-0.79964400
H	4.66382600	-1.30693400	0.28148300
C	-0.98223400	-0.17308200	-0.92880900
C	-0.90349100	1.30700400	-0.89611700
H	0.41088200	-1.21414400	-2.31423800
H	-0.91216200	1.70268300	-1.92934000
N	2.62417700	1.32801900	0.43301600
H	2.63232300	2.29437200	0.76589600
Cl	-2.32838800	2.07715000	-0.09310600
C	-1.59792100	-1.19745200	-0.02556200
C	-0.50885900	-2.19095500	-0.50614400
H	0.05822500	-2.69659800	0.28480200
H	-0.91738900	-2.93358600	-1.20440000
Cl	-1.26915400	-0.73596100	1.74527500
C	-3.05699400	-1.56643700	-0.16083800
H	-3.29605600	-2.42476200	0.48393300
H	-3.70129000	-0.71935800	0.11175900
H	-3.26323700	-1.84309000	-1.20581400

^{1}F

C	-3.56166600	-0.86792900	-0.75148200
C	-1.31747900	-0.17917700	-0.63860100
C	-1.24689100	-0.53631500	0.71031700
C	-2.37701200	-1.04497600	1.33663900
C	-3.54702600	-1.21642200	0.58460300
H	-4.43327200	-0.97667300	-1.39621300
C	-0.04379000	0.34725100	-1.17395000
C	0.13974100	-0.25663200	1.21621700
H	-2.35574100	-1.32033200	2.39286700
H	-4.45022300	-1.62691300	1.03575600
C	0.88059900	0.36665500	0.03190200
N	-2.45285400	-0.35511300	-1.32222200
H	-2.48656700	-0.08870500	-2.30895400
H	0.27586500	0.05529700	-2.17738000
C	0.53057300	1.64091100	-0.61871800
H	1.27284500	2.11536900	-1.26473100
Cl	-0.46988100	2.83132500	0.22414000
C	2.12149600	-0.46518600	0.31805900

C	1.22425700	-1.37522200	1.20306600
H	1.64846700	-1.65669600	2.17536500
Cl	2.83280700	-1.28091000	-1.13507400
H	0.14552700	0.34263200	2.13709300
H	0.88731400	-2.27045700	0.66533900
C	3.20853100	0.27903300	1.06548500
H	3.98329500	-0.41911500	1.41347900
H	3.67254400	1.04211200	0.42433000
H	2.77220100	0.78027200	1.94325400

^{1}F-alt

C	3.85469700	0.62016400	0.68406700
C	1.53687100	0.53703500	0.30005400
C	1.68744400	-0.57521500	-0.53482300
C	2.96019400	-1.07859600	-0.76781700
C	4.05564700	-0.46756800	-0.14190900
H	4.65732800	1.14107500	1.20514500
C	0.12420200	0.94038300	0.47453000
C	0.33424400	-1.01014600	-1.02758500
H	3.10964900	-1.94287900	-1.41798900
H	5.06896500	-0.84010200	-0.29130100
C	-0.64356700	0.00472900	-0.43165300
N	2.60651100	1.09320900	0.87755700
H	2.47727000	1.90434400	1.48660900
H	-0.23850000	1.22964800	1.46417100
C	-0.63728300	1.44835000	-0.74404200
H	-0.09003500	1.80611400	-1.62018900
Cl	-2.08708500	2.40514600	-0.42864400
C	-1.62619100	-1.09568500	-0.06145400
C	-0.46253400	-2.10826200	-0.26209000
H	-0.71830100	-3.01216500	-0.82970300
Cl	-2.26932000	-1.01184300	1.62957200
H	0.29186400	-1.12362800	-2.11910300
H	0.01589300	-2.38126900	0.68704000
C	-2.77913500	-1.25389400	-1.03296200
H	-3.32816400	-2.18378000	-0.82638700
H	-3.47034700	-0.40282700	-0.96121700
H	-2.38983800	-1.30091200	-2.06165600

^{3}F

C	-3.56453500	-0.90058900	-0.76437400

C	-1.31074000	-0.14064300	-0.67795400
C	-1.24836100	-0.48134200	0.70617000
C	-2.43253700	-1.02029600	1.39839300
C	-3.53836300	-1.21363400	0.62024700
H	-4.43050600	-1.04325400	-1.40643900
C	-0.03122000	0.35825100	-1.17644600
C	0.11094300	-0.21698800	1.20950900
H	-2.39931800	-1.24953300	2.46189600
H	-4.45598700	-1.62393800	1.04706100
C	0.88775900	0.37536200	0.03709200
N	-2.40921500	-0.33802000	-1.39027100
H	-2.44470500	-0.08105100	-2.37398500
H	0.28240400	0.10338500	-2.19169000
C	0.57825000	1.65575500	-0.60164300
H	1.32257700	2.10445800	-1.26392200
Cl	-0.40528100	2.86768000	0.21442900
C	2.10013500	-0.50076000	0.32329700
C	1.17852700	-1.38331600	1.20304700
H	1.57423000	-1.65517300	2.18908700
Cl	2.78502400	-1.33351100	-1.12658100
H	0.12916800	0.35001700	2.15191900
H	0.81294000	-2.27252900	0.67592600
C	3.20295900	0.21340100	1.07760600
H	3.95443700	-0.50757200	1.42926900
H	3.69034600	0.96195400	0.43706800
H	2.77639200	0.72728800	1.95265000

MECP-3

C	3.87116500	-0.44621000	0.59926300
C	1.60557600	0.31609900	0.55311200
C	1.35201200	-0.55425300	-0.54160300
C	2.38885900	-1.31244200	-1.06659700
C	3.66312300	-1.27131900	-0.49025600
H	4.82781500	-0.35992900	1.11494500
C	0.63455600	1.16935300	1.11434100
C	-0.05663200	-0.65084800	-1.02754400
H	2.19413000	-1.96693600	-1.91908200
H	4.48261000	-1.87973100	-0.87136100
C	-1.00811600	0.22707500	-0.30620200
N	2.87009200	0.30447900	1.07437900
H	3.06509300	0.91788000	1.86742400
H	0.86309800	1.70585400	2.03841100

C	-0.65608900	1.41247500	0.45230900
H	-1.43464800	1.73864000	1.14965800
Cl	-0.50465800	2.87391700	-0.76369700
C	-2.07461900	-0.81647700	-0.19588200
C	-0.97138600	-1.84295000	-0.57796200
H	-1.23971400	-2.56087100	-1.36328900
Cl	-2.71341000	-0.98438500	1.49717700
H	-0.08804400	-0.52716700	-2.12544200
H	-0.56495200	-2.35954600	0.29916100
C	-3.23679800	-0.71162600	-1.16884700
H	-3.84369300	-1.62731400	-1.11608900
H	-3.86646900	0.15792200	-0.93584600
H	-2.84862500	-0.60547300	-2.19308600

^{3}TS-1

C	-3.67284700	-0.18129800	0.19570900
C	-1.38659500	-0.56188800	0.82389400
C	-1.05910400	-0.84297900	-0.53472800
C	-2.07514700	-0.78604600	-1.50062700
C	-3.39151800	-0.44442800	-1.11641600
H	-0.68174600	-0.38250600	2.86530600
H	-4.65871800	0.08529700	0.57370300
C	-0.39716700	-0.61338300	1.83687900
C	0.31477700	-1.11628500	-0.84324800
H	-1.84132400	-1.00612500	-2.54350400
H	-4.19068100	-0.38904500	-1.85620100
C	1.26830300	-1.26540900	0.24283900
C	0.92959500	-0.98359800	1.54206700
H	0.55696700	-1.54030600	-1.81859600
H	1.66579200	-1.05626200	2.34293400
N	-2.67006500	-0.25732000	1.12744600
H	-2.90000100	-0.07122200	2.10219500
Cl	2.86247000	-1.78160000	-0.16334900
C	1.27512600	1.70970600	-0.50500500
C	1.02937800	0.95076000	-1.61730600
H	0.08091800	1.03053000	-2.15177000
H	1.88679600	0.53862400	-2.15462800
Cl	-0.07218800	2.48786800	0.26210800
C	2.59087300	1.91199800	0.15620900
H	2.85873500	2.98116000	0.14413500
H	2.55259000	1.59571900	1.21067600
H	3.37228200	1.34591100	-0.36686500

^{3}TS-2

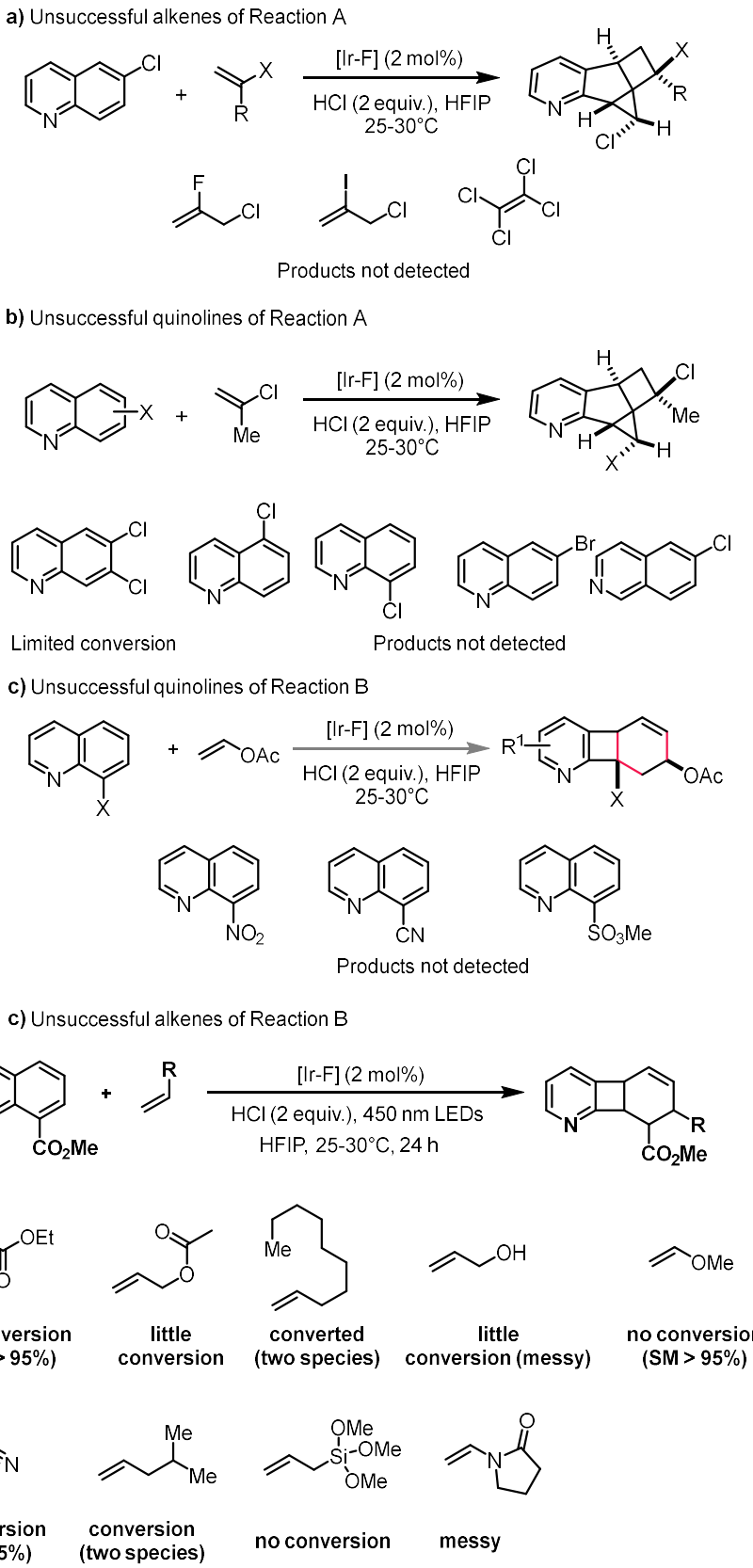
C	3.87674200	-0.00215100	-0.09329700
C	1.63778700	-0.64997200	-0.64810100
C	1.21083900	-0.26658800	0.66957500
C	2.14428300	0.25549300	1.55170700
C	3.49025800	0.38774400	1.18248000
H	1.13405600	-1.43048700	-2.57738300
H	4.90373500	0.07346900	-0.45268200
C	0.76090200	-1.13476100	-1.59439700
C	-0.21982700	-0.44583500	1.08556900
H	1.82625100	0.56027100	2.55155200
H	4.23425700	0.78477500	1.87191200
C	-1.14598900	-0.85843600	-0.06421700
C	-0.65344600	-1.28558900	-1.29759700
H	-0.25548700	-1.18029500	1.90609100
H	-1.31432800	-1.72707800	-2.04277000
N	2.98319600	-0.49249300	-0.94661400
H	3.29511500	-0.75793600	-1.88124100
Cl	-2.62446200	-1.68475400	0.47969500
C	-1.61385900	1.04726600	0.09046700
C	-0.94958800	0.87685500	1.43806700
H	-0.30593100	1.70788000	1.75463800
H	-1.71243500	0.70209100	2.20808600
Cl	-0.62395600	1.95459600	-1.06756900
C	-3.06577800	1.36596400	-0.05979300
H	-3.41366400	1.15349000	-1.08139000
H	-3.66553500	0.79408100	0.65843700
H	-3.21923100	2.43994900	0.14213700

^{3}TS-3

C	4.15665800	-0.14625500	0.29524900
C	1.86897800	0.45272700	0.63777300
C	1.48008600	-0.46963000	-0.38443800
C	2.46074900	-1.21914500	-1.02324500
C	3.80798200	-1.07144800	-0.68198100
H	1.29271400	1.94333600	2.08919600
H	5.18660800	0.03731200	0.60314800
C	0.95113500	1.21836600	1.34860800
C	0.04296000	-0.53212700	-0.78961600
H	2.17214900	-1.91922100	-1.81008100

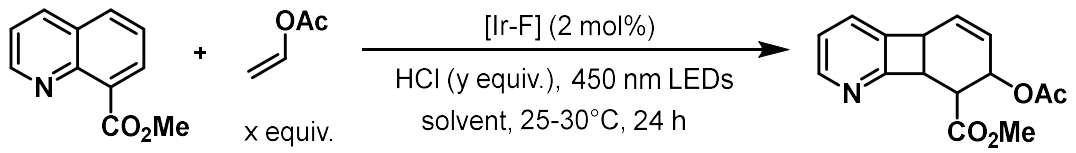
H	4.58882600	-1.64979900	-1.17461800
C	-0.90683500	0.33169600	0.00828800
C	-0.48458900	0.96127000	1.16907400
H	-0.04187200	-0.34842700	-1.87050300
H	-1.18929100	1.24979800	1.95084500
N	3.21516200	0.56804900	0.90544500
H	3.50075500	1.23542000	1.62463200
Cl	-1.24178300	2.25672000	-1.09131900
C	-2.02501600	-0.69367200	-0.12806300
C	-0.88631600	-1.72091100	-0.38934800
H	-0.55119300	-2.20421100	0.53677700
H	-1.09005200	-2.46518000	-1.16978700
Cl	-2.97251500	-0.95923800	1.38632200
C	-2.98016500	-0.52181800	-1.29205700
H	-3.59221000	-1.42830200	-1.39997200
H	-3.63392700	0.34539800	-1.12982900
H	-2.41934000	-0.36397400	-2.22444200

Limitation of the Methods



Supplementary Figure 14. Substrates which did not lead to detectable products or showed limited reactivity.

For the reaction type B, attempts were performed in order to reduce the excess of the alkene partner, generally obtaining lower yields, as summarized below:



vinyl acetate	HCl	solvent	yield%
1.5 equiv.	20 mol%	HFIP (0.2 M)	20
1.5 equiv.	1.0 equiv.	HFIP (0.2 M)	<5
1.5 equiv.	20 mol%	CH_2Cl_2 (0.2 M)	<5

Supplementary Figure 15. Attempts to lower the amount of required enol-esters for reaction B.

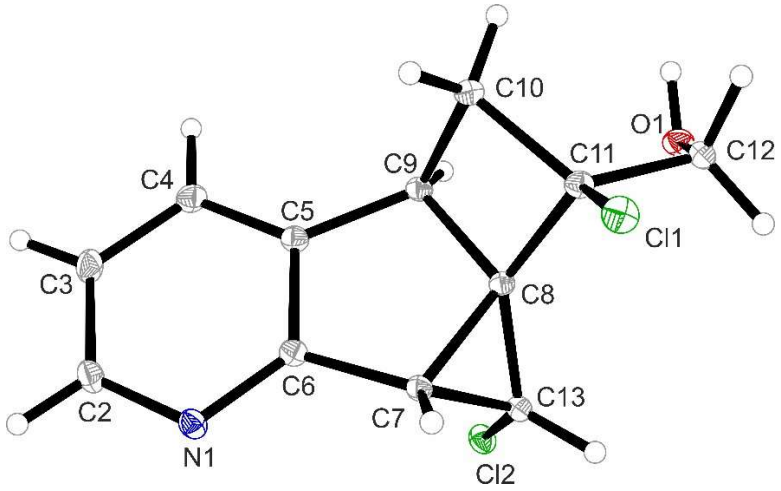
When the equivalents of vinyl acetate were lowered, little conversion was observed with sub-stoichiometric amounts of HCl, while absence of conversion occurred upon stoichiometric addition. This might be primarily imputed to the unavoidable reaction of the acid with vinyl acetate.

X-ray Analysis

X-Ray diffraction: Data sets for compounds **30**, **26**, **29**, **66**, **6** and **41** were collected with a Bruker D8 Venture PHOTON III diffractometer. Programs used: data collection: APEX3 V2019.1-0[22] (Bruker AXS Inc., **2019**); cell refinement: SAINT V8.40A (Bruker AXS Inc., **2019**); data reduction: SAINT V8.40A (Bruker AXS Inc., **2019**); absorption correction, SADABS V2016/2 (Bruker AXS Inc., **2019**); structure solution SHELXT-2015[23] (Sheldrick, G. M. *Acta Cryst.*, **2015**, *A71*, 3-8); structure refinement SHELXL-2015[24] (Sheldrick, G. M. *Acta Cryst.*, **2015**, *C71 (1)*, 3-8) and graphics, XP[25] (Version 5.1, Bruker AXS Inc., Madison, Wisconsin, USA, **1998**). R-values are given for observed reflections, and wR2 values are given for all reflections.

X-ray crystal structure analysis of **6**: A colourless plate-like specimen of $C_{12}H_{11}Cl_2NO$, approximate dimensions 0.046 mm x 0.062 mm x 0.159 mm, was used for the X-ray crystallographic analysis. The X-ray intensity data were measured on a Bruker D8 Venture Photon III Diffractometer system equipped with a micro focus tube MoK_α (MoK_α, λ = 0.71073 Å) and a MX mirror monochromator. A total of 924 frames were collected. The total exposure time was 7.70 hours. The frames were integrated with the Bruker SAINT software package using a narrow-frame algorithm. The integration of the data using a triclinic unit cell yielded a total of 18691 reflections to a maximum θ angle of 26.76° (0.79 Å resolution), of which 2493 were independent (average redundancy 7.497, completeness = 99.8%, R_{int} = 5.59%, R_{sig} = 2.99%) and 2167 (86.92%) were greater than $2\sigma(F^2)$. The final cell constants of a = 8.1542(7) Å, b = 8.2166(7) Å, c = 9.4579(8) Å, α = 97.803(3)°, β = 107.499(3)°, γ = 99.212(3)°, volume = 585.06(9) $Å^3$, are based upon the refinement of the XYZ-centroids of 7290 reflections above 20 σ(I) with 4.604° < 2θ < 53.42°. Data were corrected for absorption effects using the multi-scan method (SADABS). The ratio of minimum to maximum apparent transmission was 0.868. The calculated minimum and maximum transmission coefficients (based on crystal size) are 0.9200 and 0.9760. The structure was solved and refined using the Bruker SHELXTL Software Package, using the space group P-1, with Z = 2 for the formula unit, $C_{12}H_{11}Cl_2NO$. The final anisotropic full-matrix least-squares refinement on F^2 with 146 variables converged at R_1 = 3.05%, for the observed data and wR^2 = 7.18% for all data. The goodness-of-fit was 1.072. The largest peak in the final difference electron density synthesis was 0.357 $e^-/Å^3$ and the largest hole was -0.212 $e^-/Å^3$ with an RMS deviation of 0.052 $e^-/Å^3$. On the basis of the final

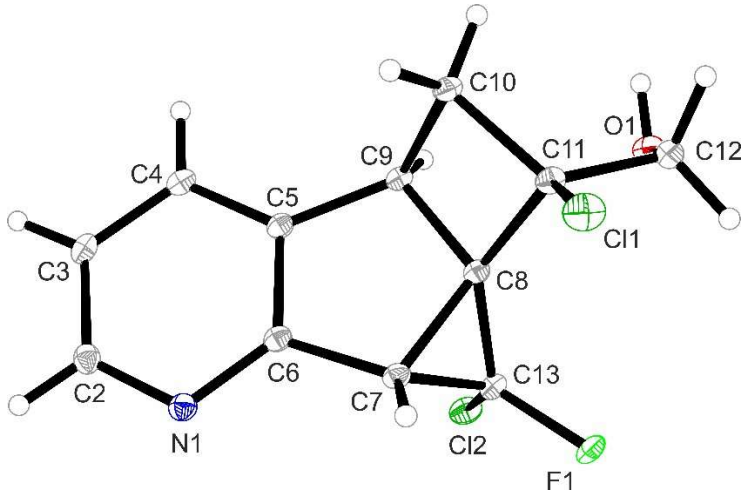
model, the calculated density was 1.454 g/cm^3 and F(000), 264 e$^-$. CCDC Nr.: 2088365.



Supplementary Figure 16. Crystal structure of compound **6**. Thermal ellipsoids are shown at 30% probability.

X-ray crystal structure analysis of **41**: A colorless prism-like specimen of $C_{12}H_{10}Cl_2FNO$, approximate dimensions 0.058 mm x 0.084 mm x 0.130 mm, was used for the X-ray crystallographic analysis. The X-ray intensity data were measured on a Bruker D8 Venture Photon III Diffractometer system equipped with a micro focus tube MoK_α (MoK_α, λ = 0.71073 Å) and a MX mirror monochromator. A total of 537 frames were collected. The total exposure time was 4.47 hours. The frames were integrated with the Bruker SAINT software package using a narrow-frame algorithm. The integration of the data using a monoclinic unit cell yielded a total of 23976 reflections to a maximum θ angle of 26.74° (0.79 Å resolution), of which 2459 were independent (average redundancy 9.750, completeness = 99.6%, R_{int} = 4.15%, R_{sig} = 1.84%) and 2211 (89.91%) were greater than $2\sigma(F^2)$. The final cell constants of a = 10.9603(2) Å, b = 7.9484(2) Å, c = 13.6654(2) Å, β = 101.3960(10)°, volume = 1167.02(4) Å^3, are based upon the refinement of the XYZ-centroids of 8754 reflections above 20 σ(I) with 5.96° < 2θ < 53.45°. Data were corrected for absorption effects using the multi-scan method (SADABS). The ratio of minimum to maximum apparent transmission was 0.957. The calculated minimum and maximum transmission coefficients (based on crystal size) are 0.9320 and 0.9690. The structure was solved and refined using the Bruker SHELXTL Software Package, using the space group $P2_1/c$, with Z = 4 for the formula unit, $C_{12}H_{10}Cl_2FNO$. The final anisotropic full-matrix least-squares refinement on F^2 with 158 variables converged at R_1 = 2.53%, for the observed data and wR^2 = 6.34% for all data. The goodness-of-fit

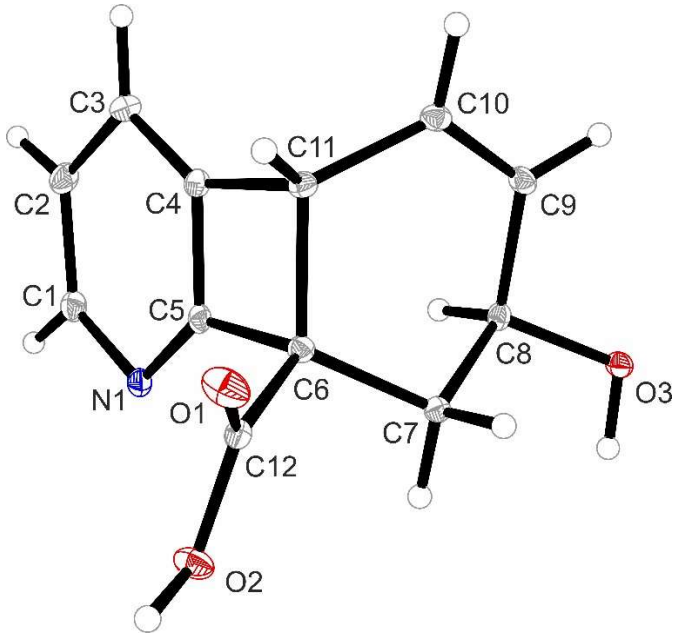
was 1.057. The largest peak in the final difference electron density synthesis was 0.330 $e^-/Å^3$ and the largest hole was -0.194 $e^-/Å^3$ with an RMS deviation of 0.045 $e^-/Å^3$. On the basis of the final model, the calculated density was 1.560 g/cm^3 and F(000), 560 e^-. The hydrogen at O1 atom was refined freely. CCDC Nr.: 2088370.



Supplementary Figure 17. Crystal structure of compound **41**. Thermal ellipsoids are shown at 30% probability.

X-ray crystal structure analysis of **66**: A colorless plate-like specimen of $C_{12}H_{11}NO_3$, approximate dimensions 0.041 mm x 0.100 mm x 0.178 mm, was used for the X-ray crystallographic analysis. The X-ray intensity data were measured on a Bruker D8 Venture Photon III Diffractometer system equipped with a micro focus tube CuK_α (CuK_α, λ = 1.54178 Å) and a MX mirror monochromator. A total of 1209 frames were collected. The total exposure time was 6.03 hours. The frames were integrated with the Bruker SAINT software package using a wide-frame algorithm. The integration of the data using an orthorhombic unit cell yielded a total of 16198 reflections to a maximum θ angle of 68.23° (0.83 Å resolution), of which 1790 were independent (average redundancy 9.049, completeness = 99.0%, R_{int} = 5.54%, R_{sig} = 2.99%) and 1539 (85.98%) were greater than $2\sigma(F^2)$. The final cell constants of a = 11.8624(4) Å, b = 7.8733(2) Å, c = 21.1293(6) Å, volume = 1973.40(10) $Å^3$, are based upon the refinement of the XYZ-centroids of 7323 reflections above 20 σ(I) with 8.369° < 2θ < 136.3°. Data were corrected for absorption effects using the Multi-Scan method (SADABS). The ratio of minimum to maximum apparent transmission was 0.822. The calculated minimum and maximum transmission coefficients (based on crystal size) are 0.8590 and 0.9650. The structure was solved and refined using the Bruker SHELXTL Software Package, using

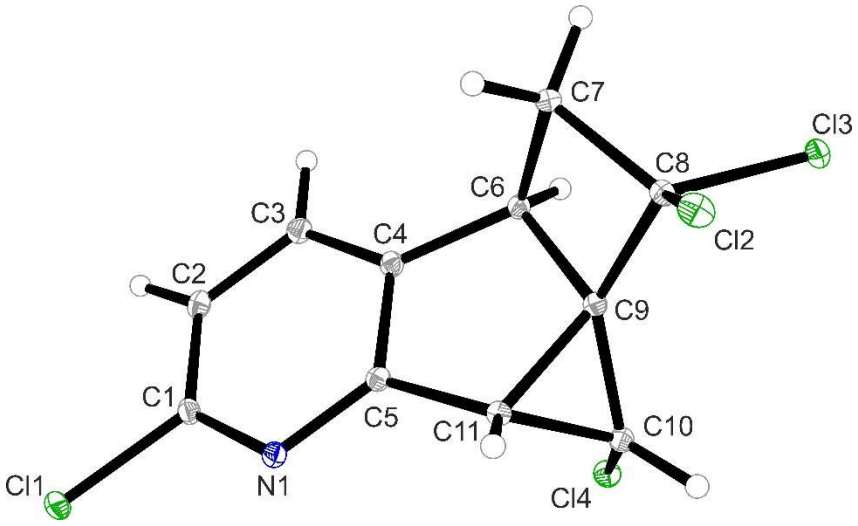
the space group Pbca, with Z = 8 for the formula unit, $C_{12}H_{11}NO_3$. The final anisotropic full-matrix least-squares refinement on F^2 with 153 variables converged at R_1 = 3.53%, for the observed data and wR^2 = 8.88% for all data. The goodness-of-fit was 1.054. The largest peak in the final difference electron density synthesis was 0.285 $e^-/Å^3$ and the largest hole was -0.213 $e^-/Å^3$ with an RMS deviation of 0.043 $e^-/Å^3$. On the basis of the final model, the calculated density was 1.462 g/cm^3 and F(000), 912 e^-. The hydrogen at O2 and O3 atoms were refined freely. CCDC Nr.: 2088371.



Supplementary Figure 18. Crystal structure of compound **66**. Thermal ellipsoids are shown at 30% probability.

X-ray crystal structure analysis of **30**: A colorless plate-like specimen of $C_{11}H_7Cl_4N$, approximate dimensions 0.068 mm x 0.215 mm x 0.357 mm, was used for the X-ray crystallographic analysis. The X-ray intensity data were measured on a Bruker D8 Venture PHOTON III Diffractometer system equipped with a micro focus tube Mo Ims (MoK_α, λ = 0.71073 Å) and a MX mirror monochromator. A total of 508 frames were collected. The total exposure time was 2.12 hours. The frames were integrated with the Bruker SAINT software package using a narrow-frame algorithm. The integration of the data using a triclinic unit cell yielded a total of 18842 reflections to a maximum θ angle of 26.74° (0.79 Å resolution), of which 4954 were independent (average redundancy 3.803, completeness = 98.4%, R_{int} = 2.75%, R_{sig} = 2.43%) and 4692 (94.71%) were

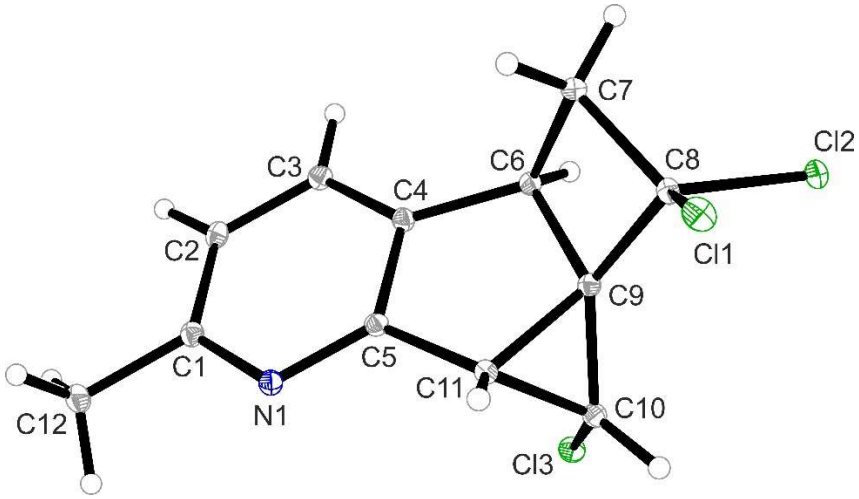
greater than 2σ(F2). The final cell constants of a = 9.2279(2) Å, b = 11.0020(2) Å, c = 13.0685(2) Å, α = 104.5330(10)°, β = 93.4840(10)°, γ = 111.1750(10)°, volume = 1180.65(4) $Å^3$, are based upon the refinement of the XYZ-centroids of 9995 reflections above 20 σ(I) with 4.467° < 2θ < 53.47°. Data were corrected for absorption effects using the Multi-Scan method (SADABS). The ratio of minimum to maximum apparent transmission was 0.898. The calculated minimum and maximum transmission coefficients (based on crystal size) are 0.7230 and 0.9370. The structure was solved and refined using the Bruker SHELXTL Software Package, using the space group P-1, with Z = 4 for the formula unit, $C_{11}H_7Cl_4N$. The final anisotropic full-matrix least-squares refinement on F^2 with 289 variables converged at R_1 = 2.15%, for the observed data and wR^2 = 5.45% for all data. The goodness-of-fit was 1.050. The largest peak in the final difference electron density synthesis was 0.402 $e^-/Å^3$ and the largest hole was -0.233 $e^-/Å^3$ with an RMS deviation of 0.048 $e^-/Å^3$. On the basis of the final model, the calculated density was 1.659 g/cm^3 and F(000), 592 e^-. CCDC Nr.: 2088369.



Supplementary Figure 19. Crystal structure of compound **30**. Thermal ellipsoids are shown at 30% probability. Only one molecule (molecule A) of two found in the asymmetric unit is shown.

X-ray crystal structure analysis of **26**: A colorless prism-like specimen of $C_{12}H_{10}Cl_3N$, approximate dimensions 0.091 mm x 0.152 mm x 0.298 mm, was used for the X-ray crystallographic analysis. The X-ray intensity data were measured on a Bruker D8 Venture PHOTON III Diffractometer system equipped with a micro focus tube Mo Ims ($MoK_α$, λ = 0.71073 Å) and a MX mirror

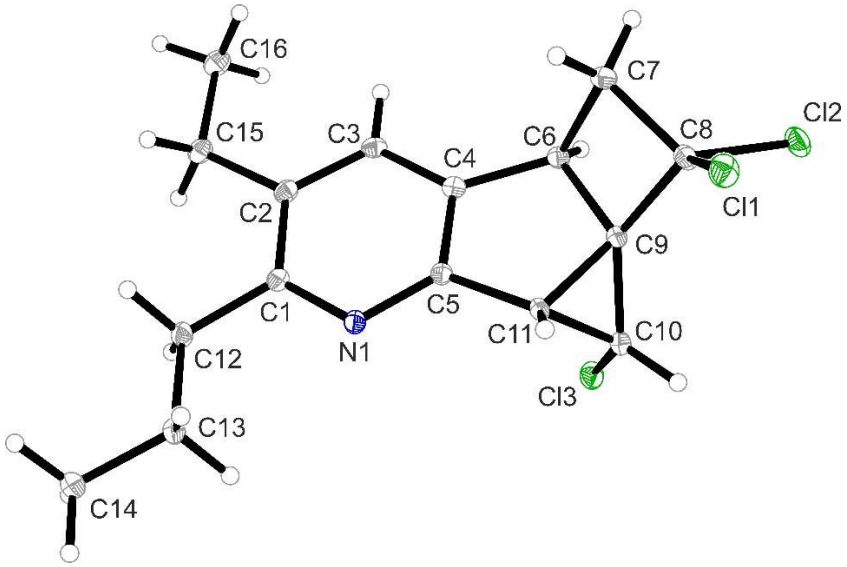
monochromator. A total of 510 frames were collected. The total exposure time was 3.54 hours. The frames were integrated with the Bruker SAINT software package using a narrow-frame algorithm. The integration of the data using a triclinic unit cell yielded a total of 25115 reflections to a maximum θ angle of 27.50° (0.77 Å resolution), of which 5429 were independent (average redundancy 4.626, completeness = 98.8%, R_{int} = 3.30%, R_{sig} = 2.47%) and 5070 (93.39%) were greater than $2\sigma(F^2)$. The final cell constants of a = 9.3016(2) Å, b = 10.9291(2) Å, c = 13.1956(3) Å, α = 104.2540(10)°, β = 93.7080(10)°, γ = 111.1590(10)°, volume = 1194.87(4) $Å^3$, are based upon the refinement of the XYZ-centroids of 9898 reflections above 20 σ(I) with 4.479° < 2θ < 54.98°. Data were corrected for absorption effects using the Multi-Scan method (SADABS). The ratio of minimum to maximum apparent transmission was 0.949. The calculated minimum and maximum transmission coefficients (based on crystal size) are 0.8110 and 0.9360. The structure was solved and refined using the Bruker SHELXTL Software Package, using the space group P-1, with Z = 4 for the formula unit, $C_{12}H_{10}Cl_3N$. The final anisotropic full-matrix least-squares refinement on F^2 with 291 variables converged at R_1 = 2.38%, for the observed data and wR^2 = 6.01% for all data. The goodness-of-fit was 1.039. The largest peak in the final difference electron density synthesis was 0.393 $e^-/Å^3$ and the largest hole was -0.241 $e^-/Å^3$ with an RMS deviation of 0.049 $e^-/Å^3$. On the basis of the final model, the calculated density was 1.526 g/cm^3 and F(000), 560 e^-. CCDC Nr.: 2088367.



Supplementary Figure 20. Crystal structure of compound **26**. Thermal ellipsoids are shown at 30% probability. Only one molecule (molecule A) of two found in the asymmetric unit is shown.

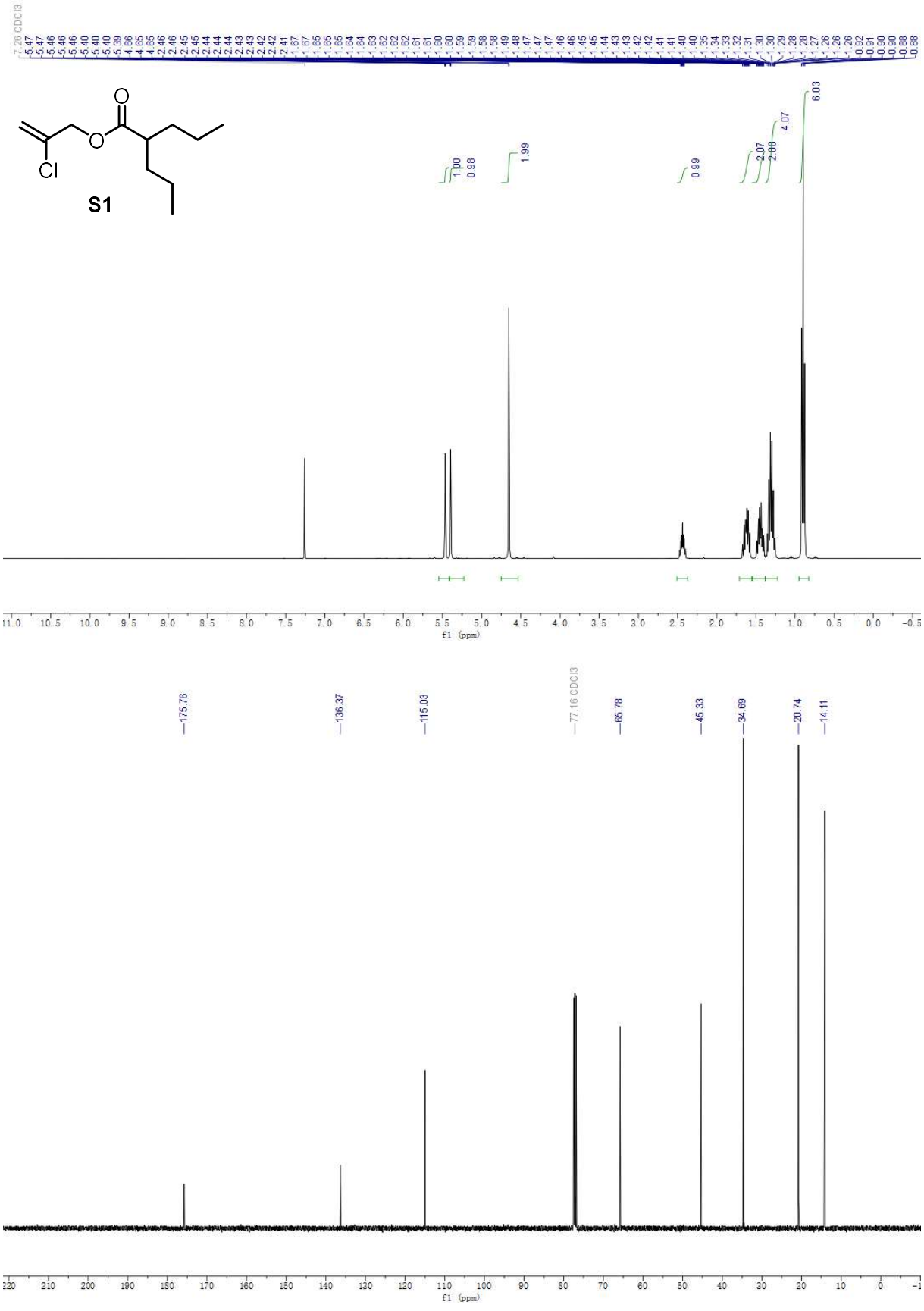
X-ray crystal structure analysis of **29**: A colorless prism-like specimen of $C_{16}H_{18}Cl_3N$, approximate

dimensions 0.061 mm x 0.101 mm x 0.183 mm, was used for the X-ray crystallographic analysis. The X-ray intensity data were measured on a Bruker D8 Venture PHOTON III Diffractometer system equipped with a micro focus tube Mo Ims (MoK_α, λ = 0.71073 Å) and a MX mirror monochromator. A total of 510 frames were collected. The total exposure time was 3.54 hours. The frames were integrated with the Bruker SAINT software package using a narrow-frame algorithm. The integration of the data using a monoclinic unit cell yielded a total of 32975 reflections to a maximum θ angle of 27.48° (0.77 Å resolution), of which 3625 were independent (average redundancy 9.097, completeness = 99.8%, R_{int} = 7.48%, R_{sig} = 3.43%) and 3095 (85.38%) were greater than 2σ(F2). The final cell constants of a = 10.7010(2) Å, b = 10.7590(2) Å, c = 14.3255(3) Å, β = 106.1770(10)°, volume = 1584.02(5) $Å^3$, are based upon the refinement of the XYZ-centroids of 7039 reflections above 20 σ(I) with 4.806° < 2θ < 54.93°. Data were corrected for absorption effects using the Multi-Scan method (SADABS). The ratio of minimum to maximum apparent transmission was 0.951. The calculated minimum and maximum transmission coefficients (based on crystal size) are 0.9030 and 0.9660. The structure was solved and refined using the Bruker SHELXTL Software Package, using the space group $P2_1/c$, with Z = 4 for the formula unit, $C_{16}H_{18}Cl_3N$. The final anisotropic full-matrix least-squares refinement on F^2 with 183 variables converged at R_1 = 3.18%, for the observed data and wR^2 = 7.86% for all data. The goodness-of-fit was 1.044. The largest peak in the final difference electron density synthesis was 0.354 $e^-/Å^3$ and the largest hole was -0.226 $e^-/Å^3$ with an RMS deviation of 0.052 $e^-/Å^3$. On the basis of the final model, the calculated density was 1.387 g/cm^3 and F(000), 688 e^-. CCDC Nr.: 2088368.



Supplementary Figure 21. Crystal structure of compound **29**. Thermal ellipsoids are shown at 30% probability.

NMR Spectra


S1
Cl
O
O
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1.00
0.98
1.99
0.99
2.07
2.08
4.07
6.03
f1 (ppm)
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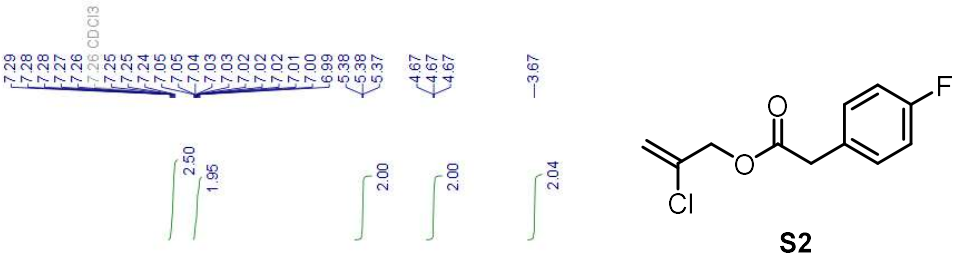
136.37
115.03
77.16 CDCl3
65.78
45.33
34.69
20.74
14.11
f1 (ppm)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7.27
7.26
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7.25
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7.24
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7.05
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7.03
7.03
7.02
7.02
7.02
7.01
7.00
6.99
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5.38
5.37
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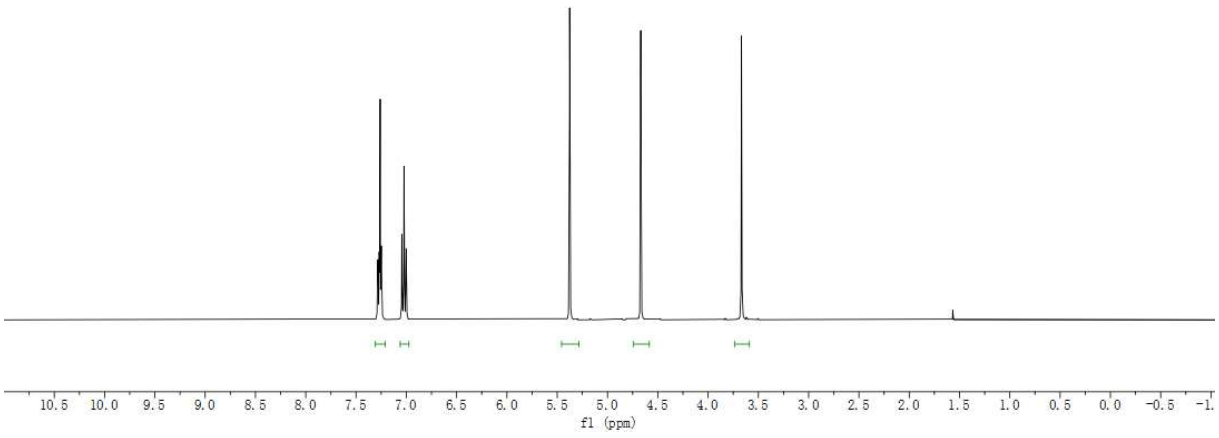
2.00
2.04
F
O
O
Cl

S2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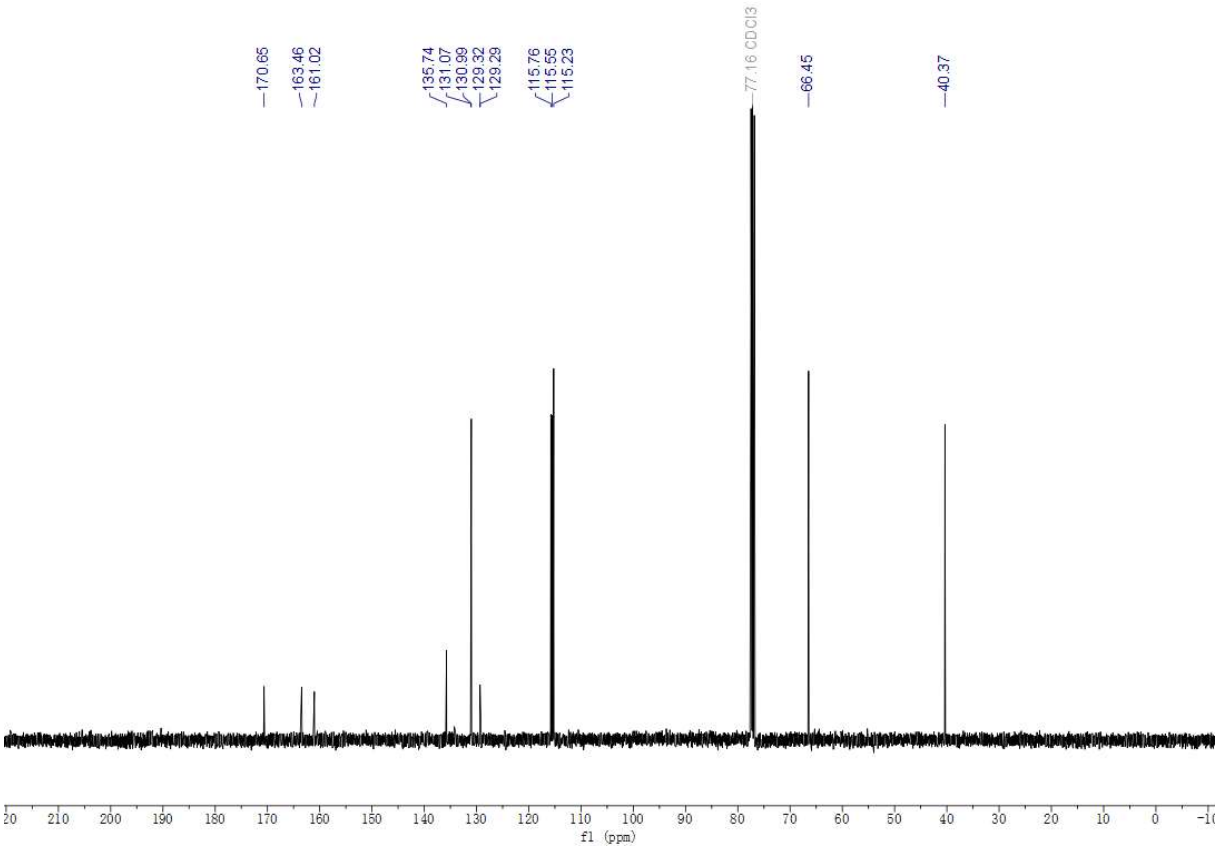
f1 (ppm)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130.99
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129.29
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115.55
115.23
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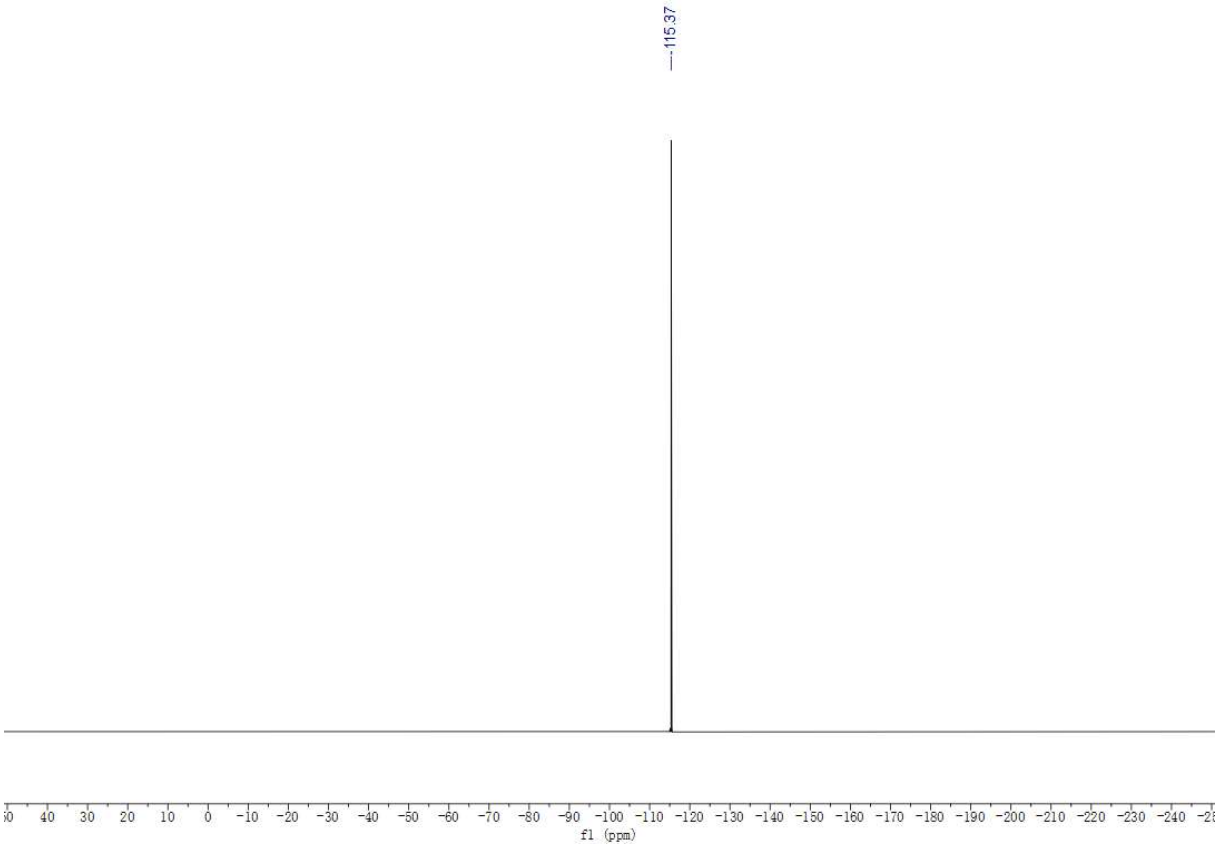
f1 (ppm)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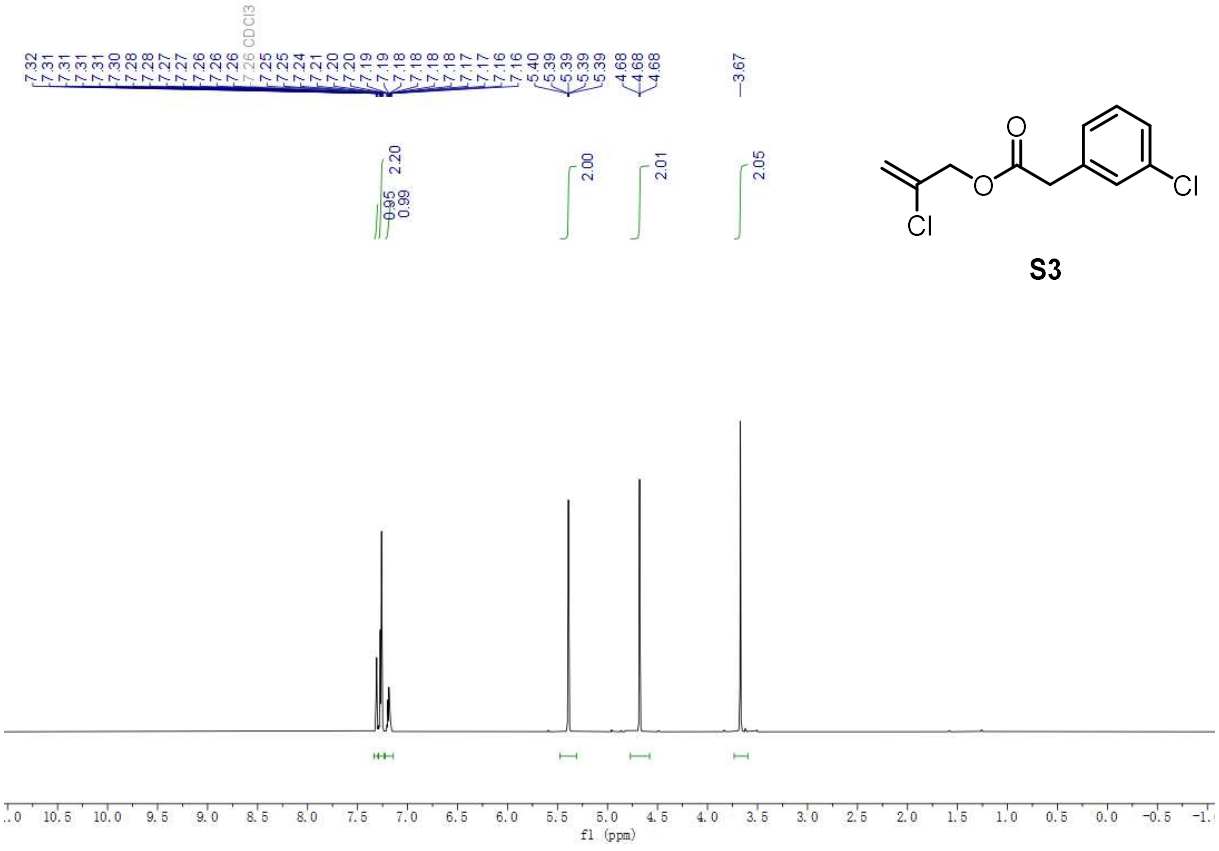
f1 (ppm)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7.31
7.31
7.31
7.30
7.28
7.28
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7.27
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7.26
7.26 CDCl3
7.25
7.25
7.24
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7.20
7.19
7.19
7.18
7.18
7.18
7.18
7.17
7.17
7.16
7.16
5.40
5.39
5.39
5.39
5.39
4.68
4.68
4.68
3.67
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0.95
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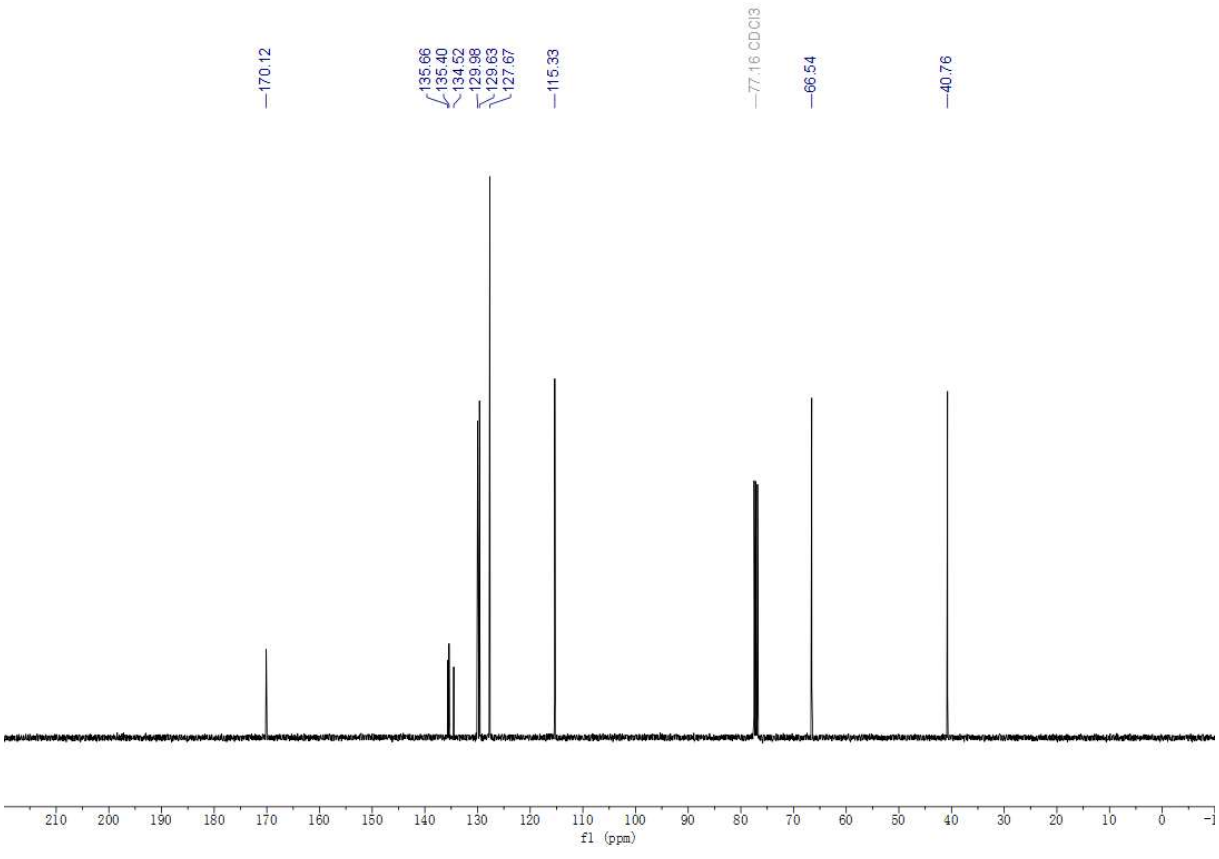
2.00
2.01
2.05
Cl
O
O
Cl
S3
f1 (ppm)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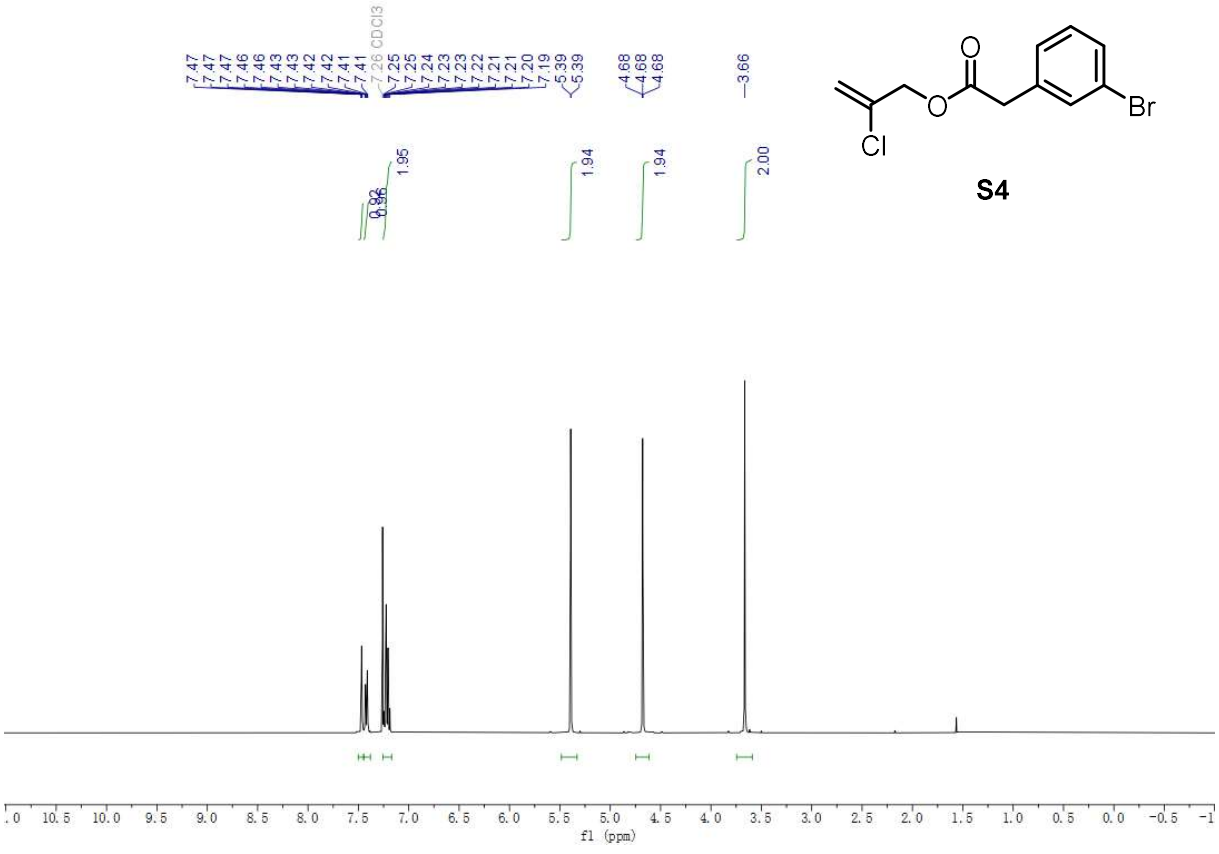
66.54
40.76
f1 (ppm)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7.43
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7.41
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7.25
7.24
7.23
7.23
7.22
7.21
7.21
7.20
7.19
5.39
5.39
4.68
4.68
4.68
3.66
1.95
1.94
1.94
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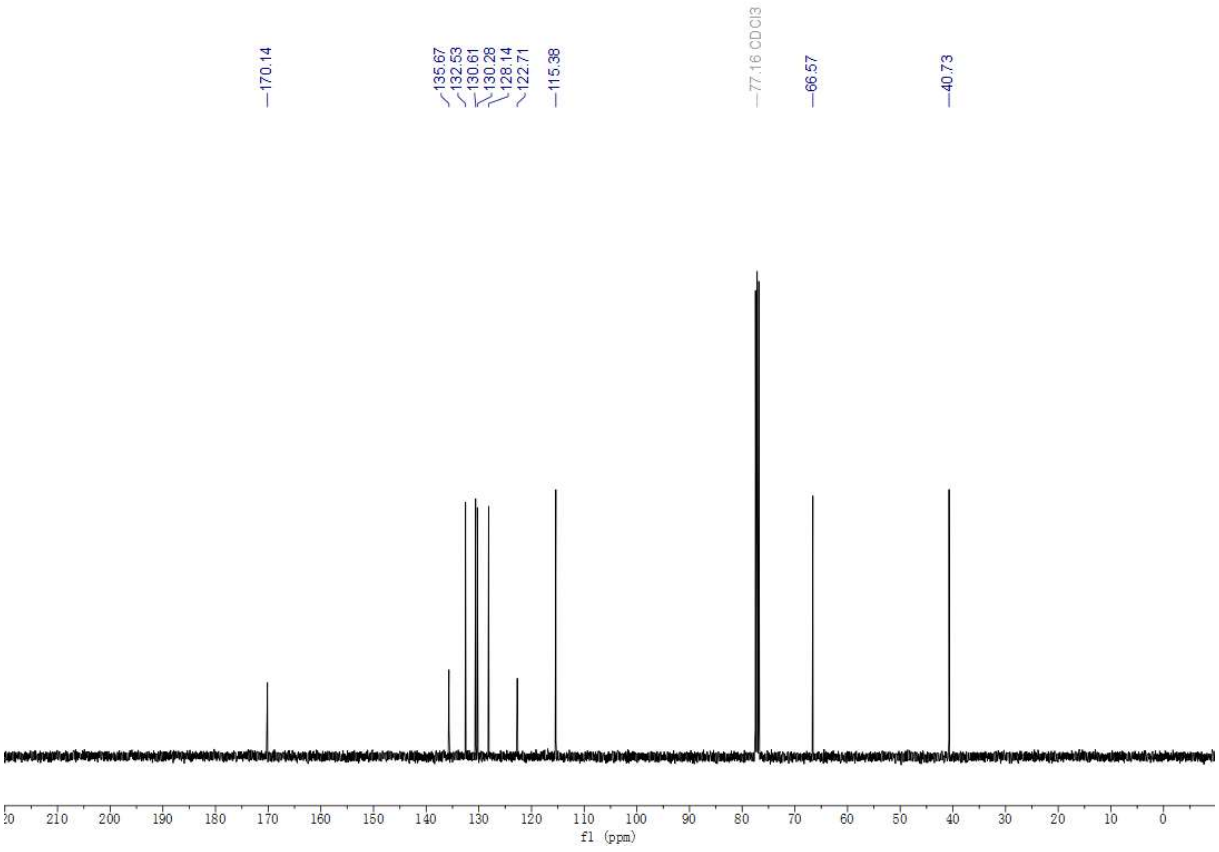
O
O
Cl
Br
S4
f1 (ppm)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128.14
122.71
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77.16 CDCl3
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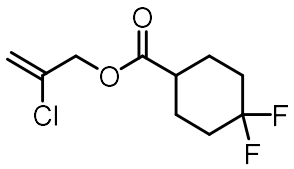
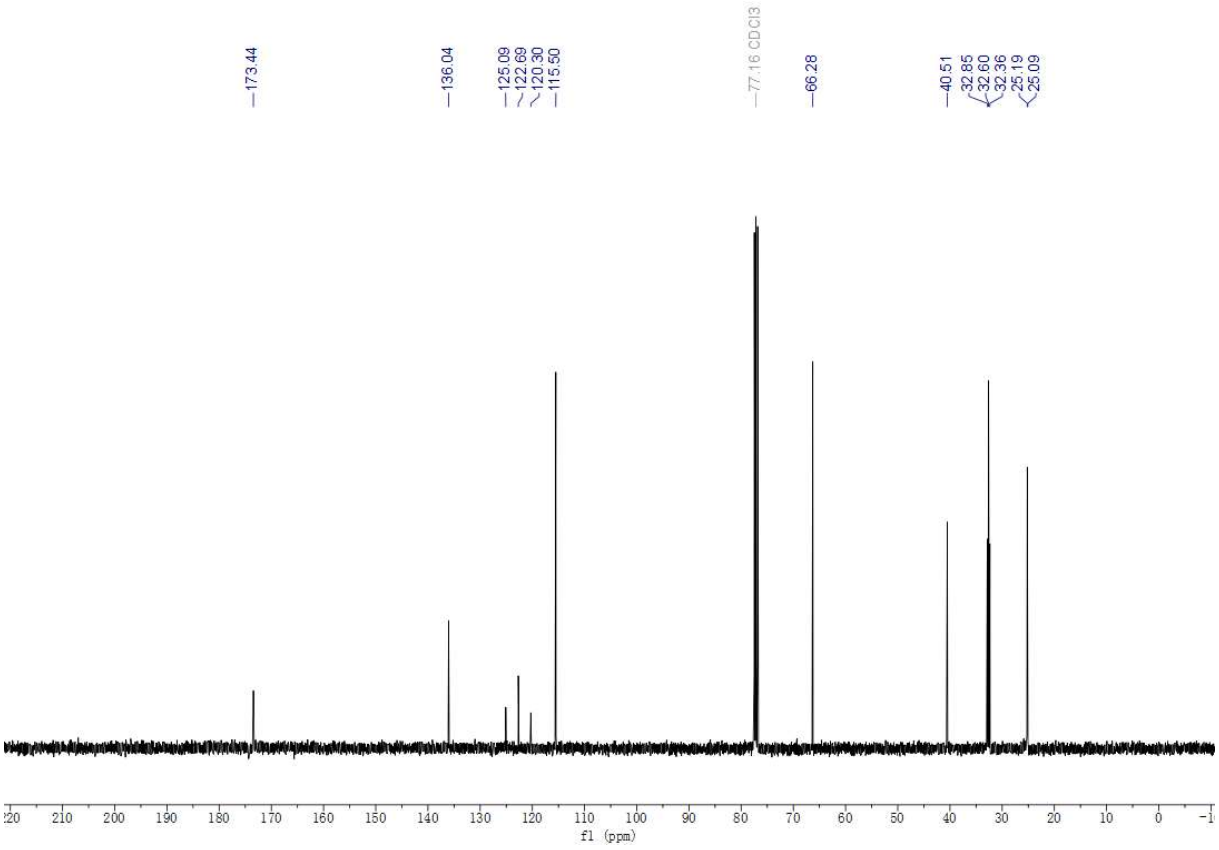
40.73
f1 (ppm)


O
O
Cl
F
F

S5

7.26 CDCl3
1.94
0.97
4.00
3.99
f1 (ppm)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122.69
120.30
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40.51
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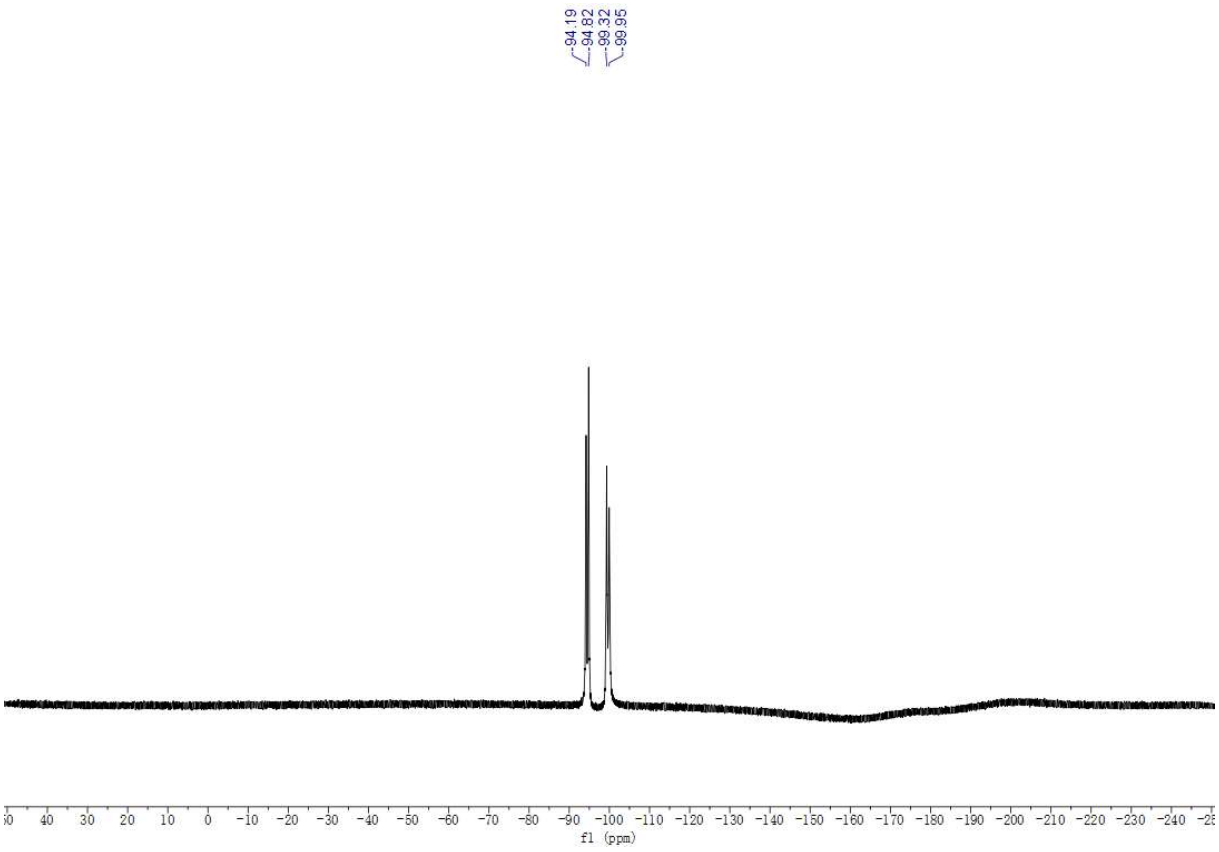
32.60
32.36
25.19
25.09
f1 (ppm)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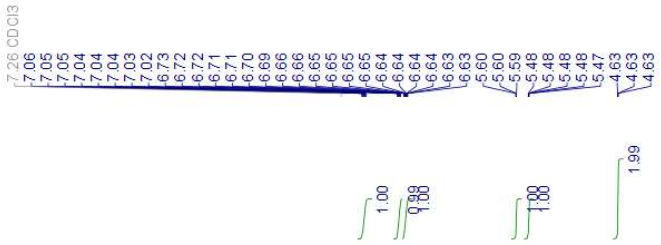
-94.82
-99.32
-99.95
40 30 20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210 -220 -230 -240
f1 (ppm)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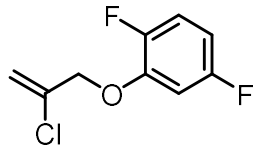
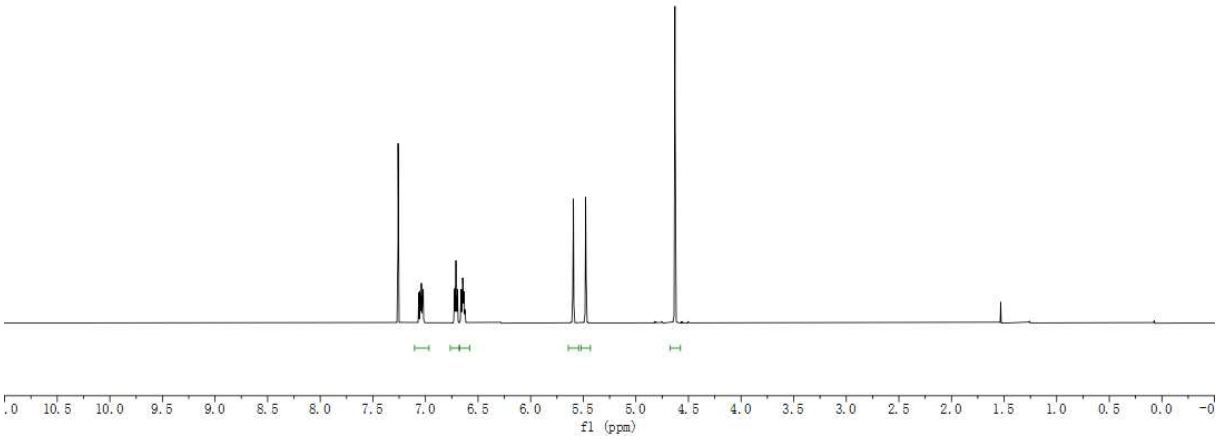
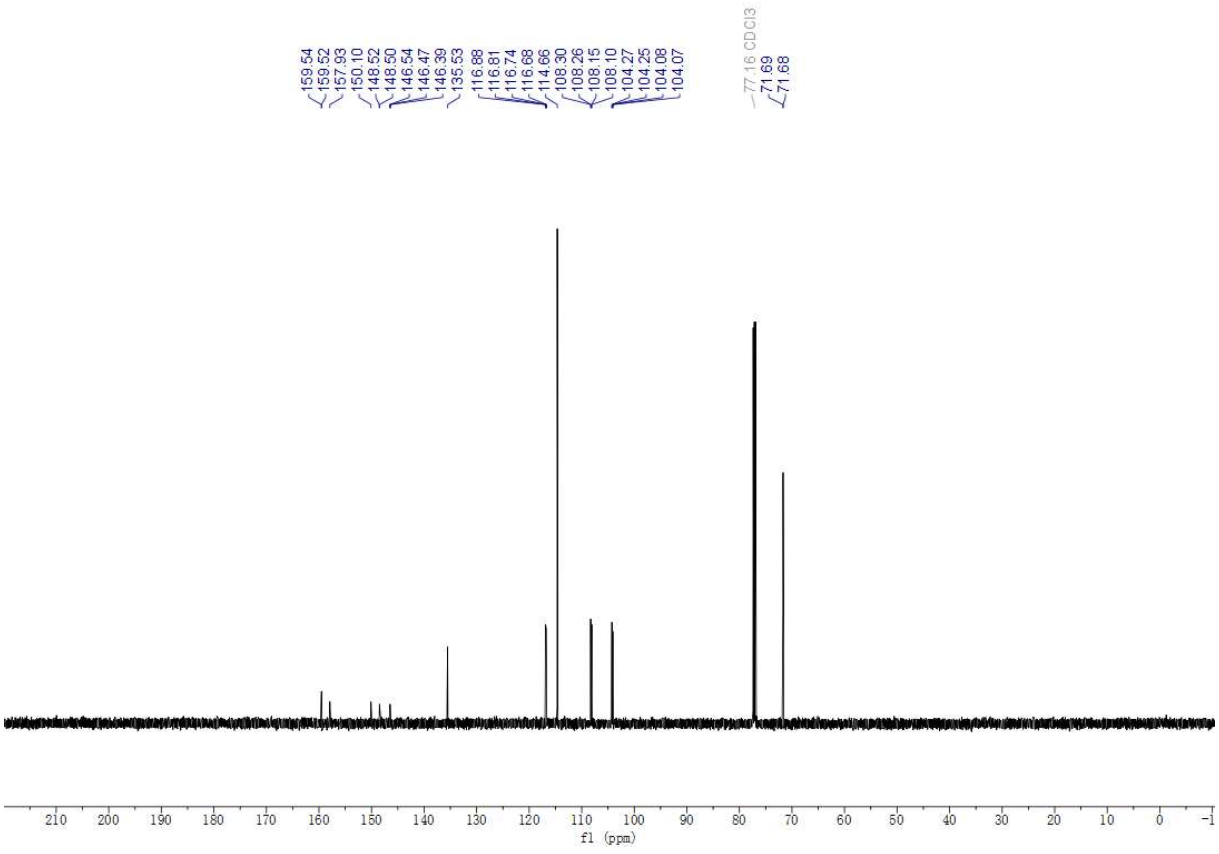
7.06
7.05
7.04
6.73
6.72
6.71
6.70
6.69
6.66
6.65
6.64
6.63
5.60
5.59
5.48
5.47
4.63
1.00
1.99


F
O
F
Cl

S6


f1 (ppm)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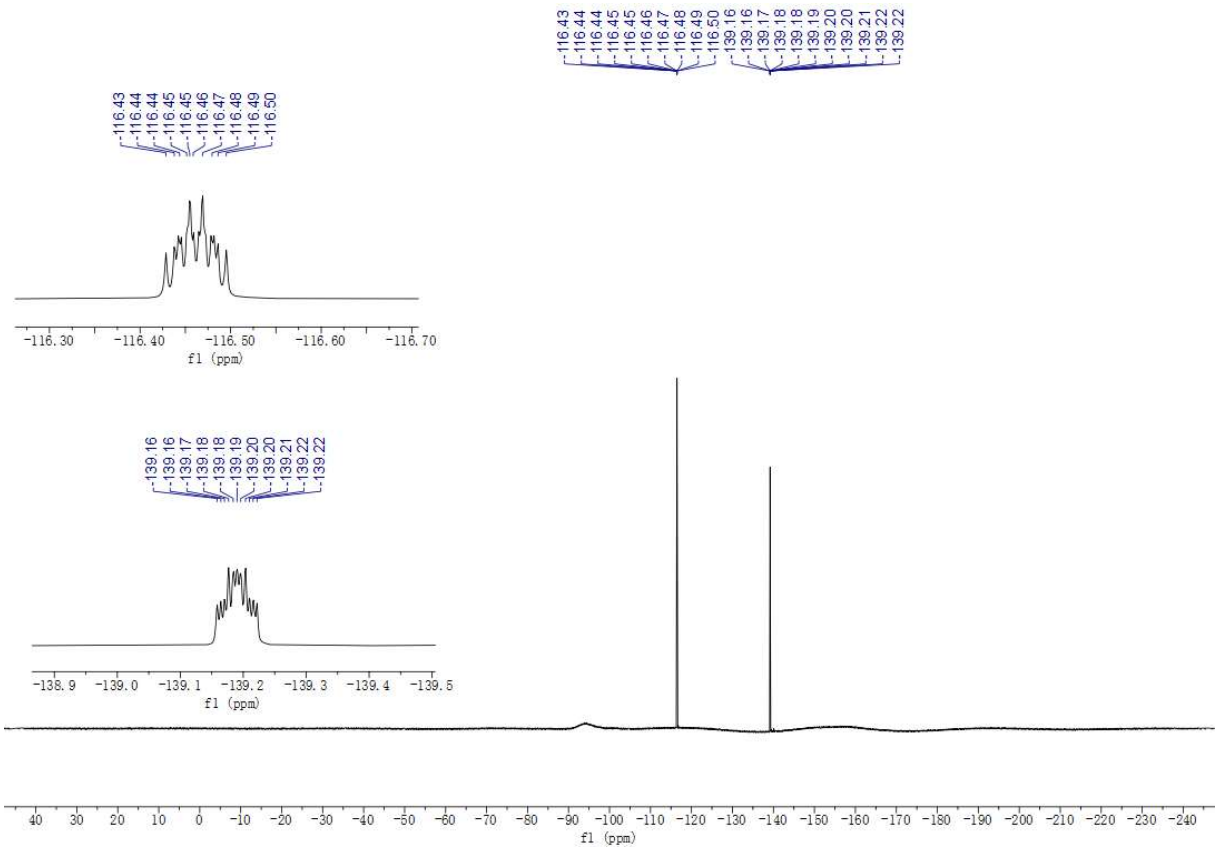
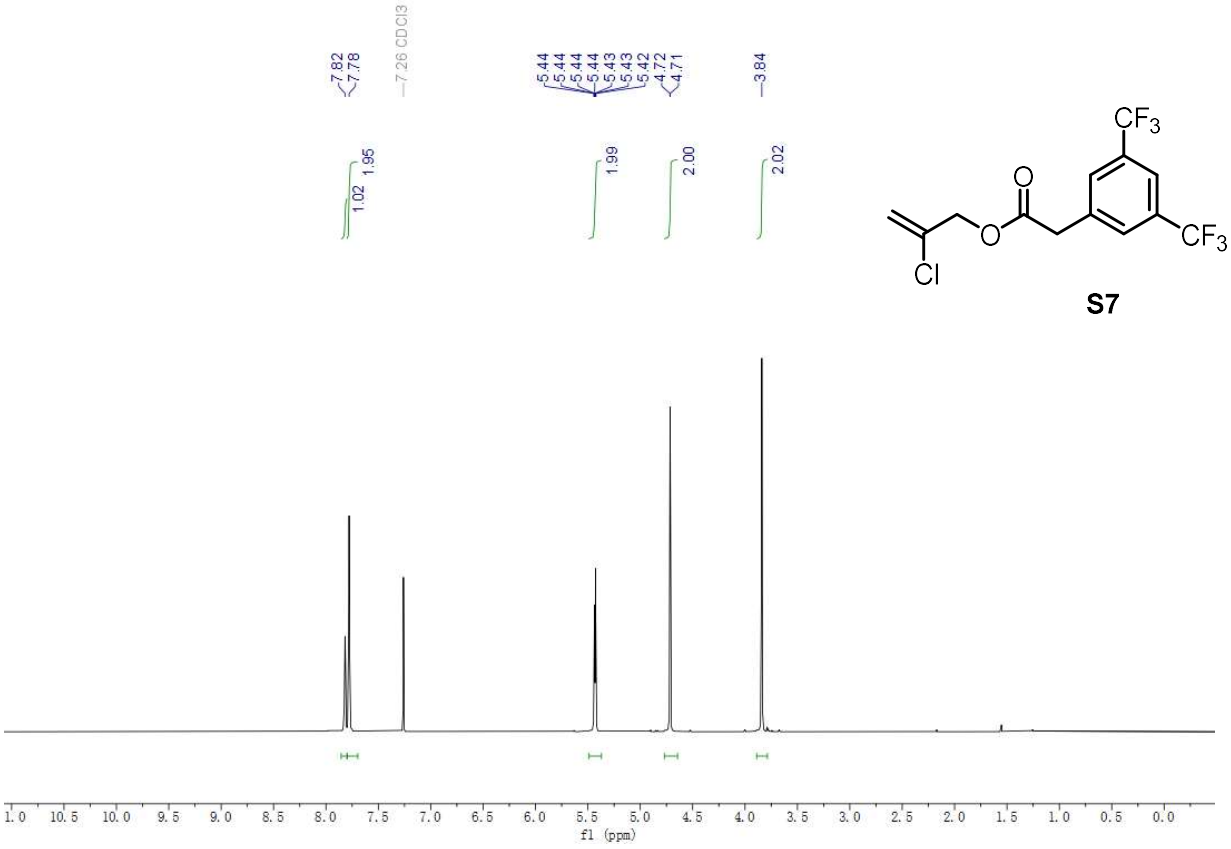
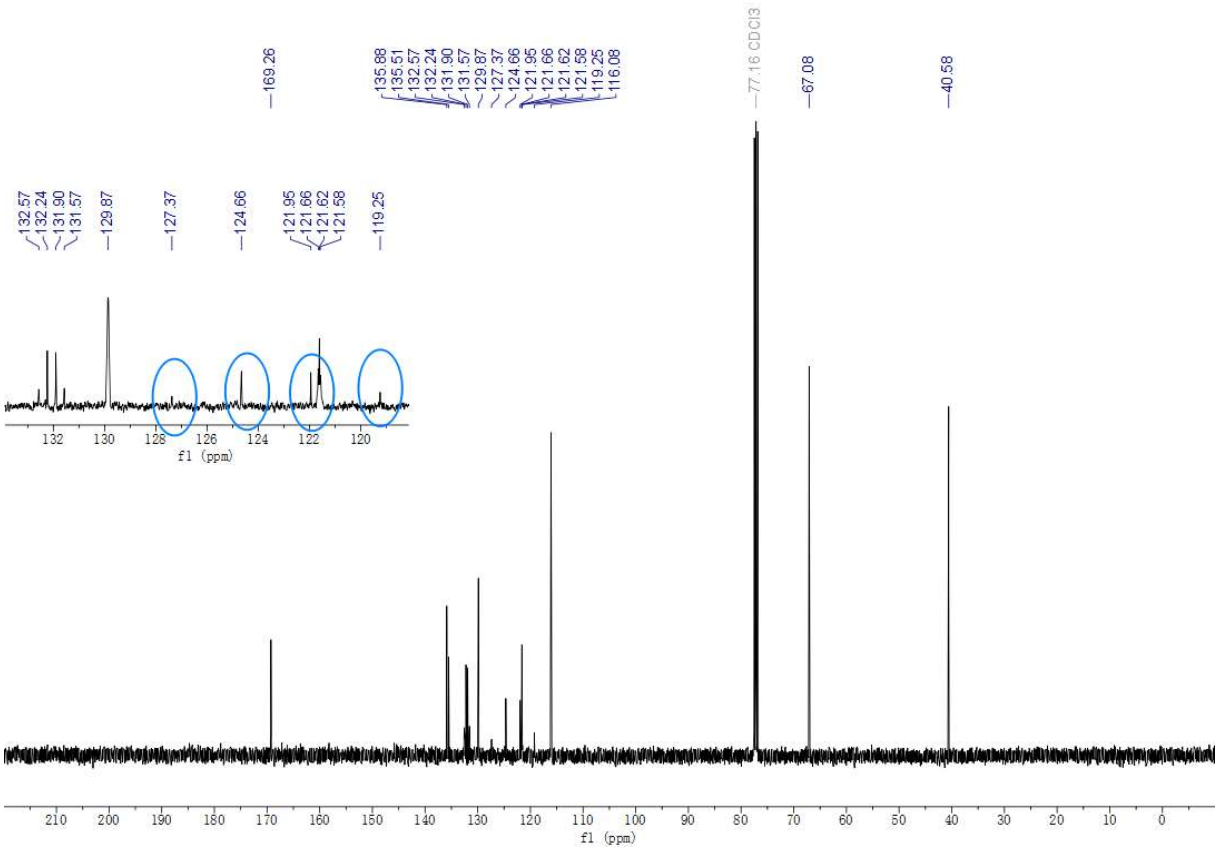
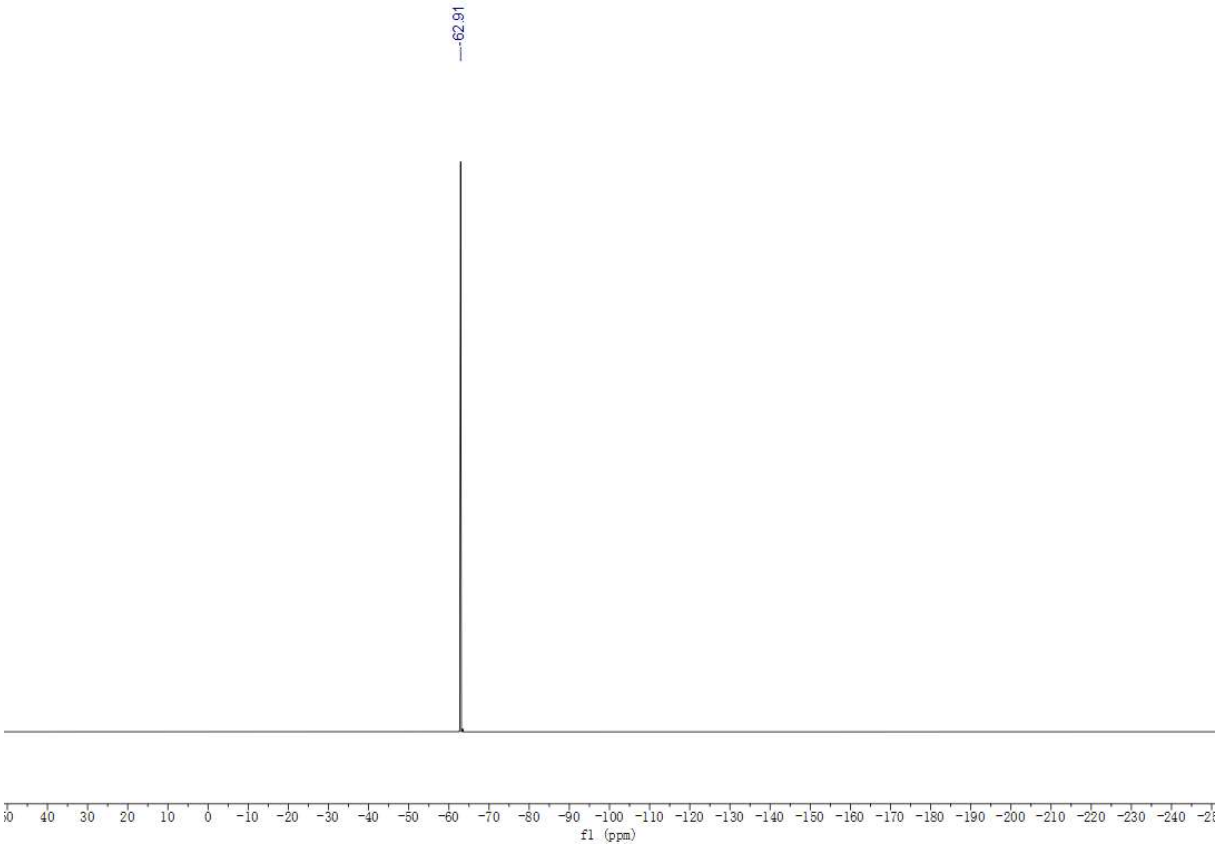
159.52
157.93
150.10
148.52
148.50
146.54
146.47
146.39
135.53
116.88
116.81
116.74
116.68
114.66
108.30
108.26
108.15
108.10
104.27
104.25
104.08
104.07
77.16 CDCl3
71.69
71.68
f1 (ppm)

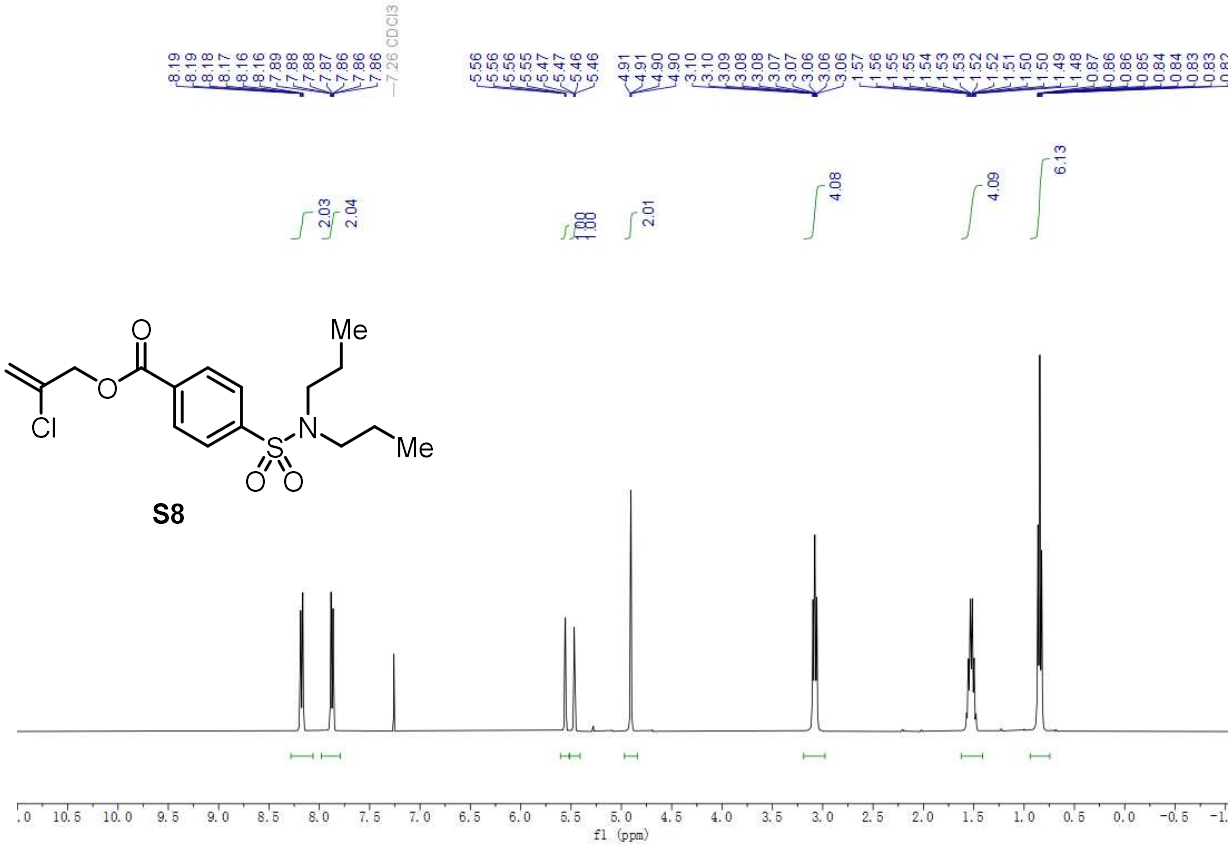

-116.43
-116.44
-116.44
-116.45
-116.45
-116.46
-116.47
-116.48
-116.49
-116.50
-116.30
-116.40
-116.50
-116.60
-116.70
f1 (ppm)
-139.16
-139.16
-139.17
-139.18
-139.18
-139.19
-139.20
-139.20
-139.21
-139.22
-139.22
-138.9
-139.0
-139.1
-139.2
-139.3
-139.4
-139.5
f1 (ppm)
40 30 20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210 -220 -230 -240
f1 (ppm)

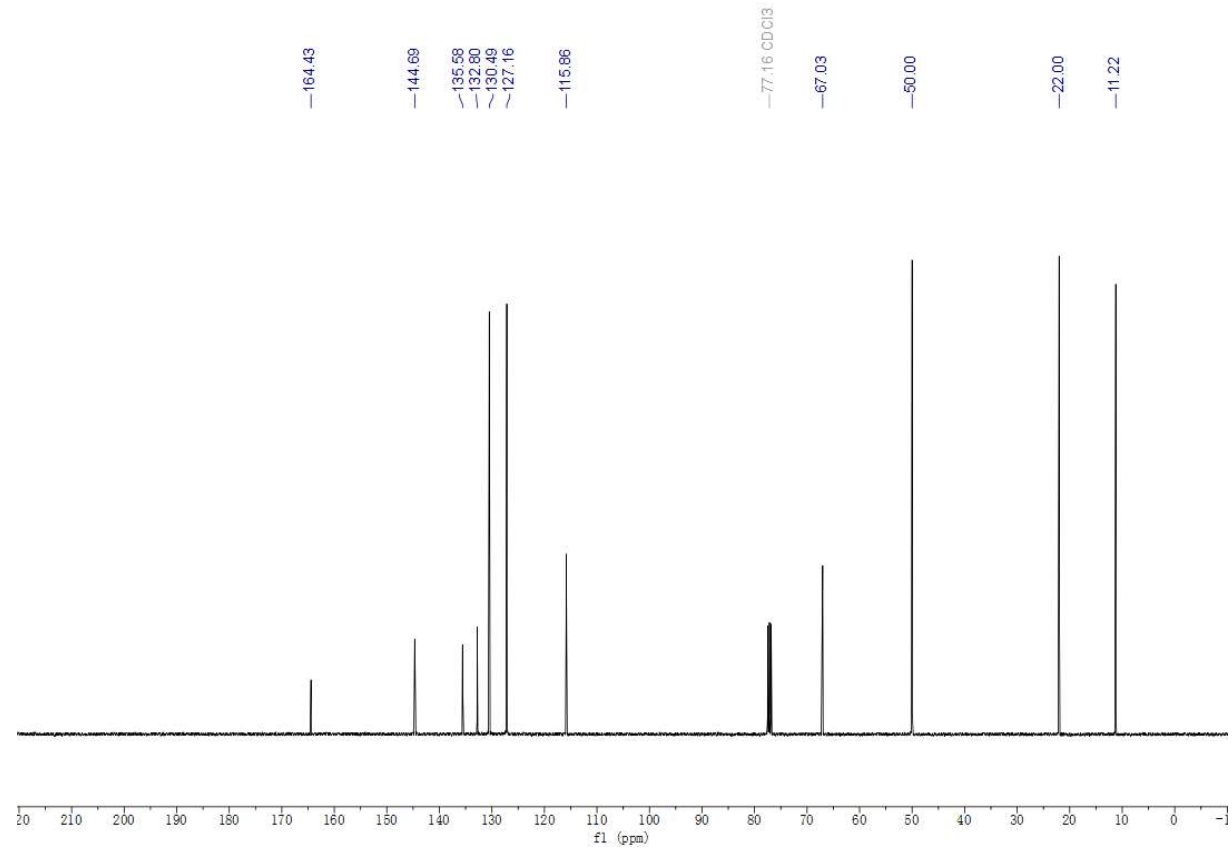

7.82
7.78
7.26 CDCl3
5.44
5.44
5.44
5.44
5.43
5.43
5.42
4.72
4.71
3.84
1.02
1.95
1.99
2.00
2.02
CF3
CF3
O
O
Cl
f1 (ppm)

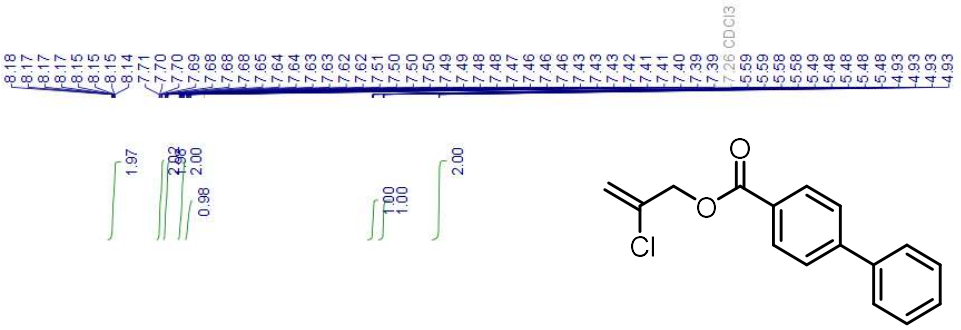
S7


169.26
135.88
135.51
132.57
132.24
131.90
131.57
129.87
127.37
124.66
121.95
121.66
121.62
121.58
119.25
116.08
77.16 CDCl3
67.08
40.58
f1 (ppm)

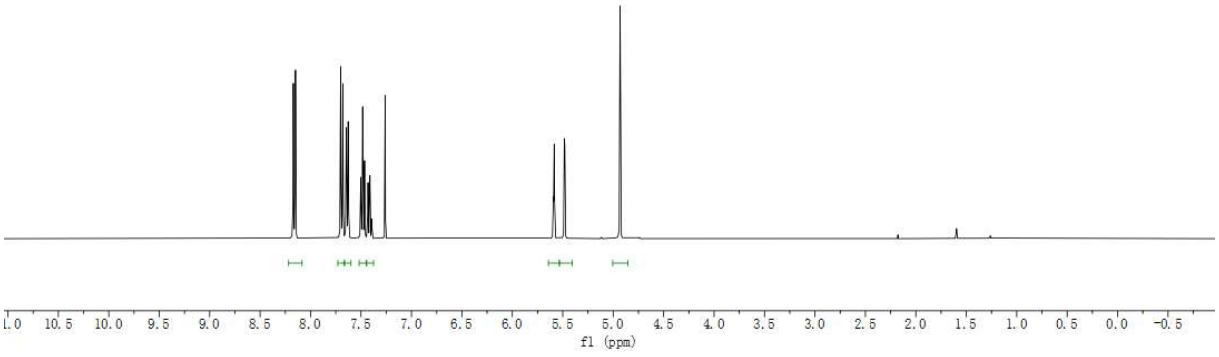

-62.91
40 30 20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210 -220 -230 -240
f1 (ppm)

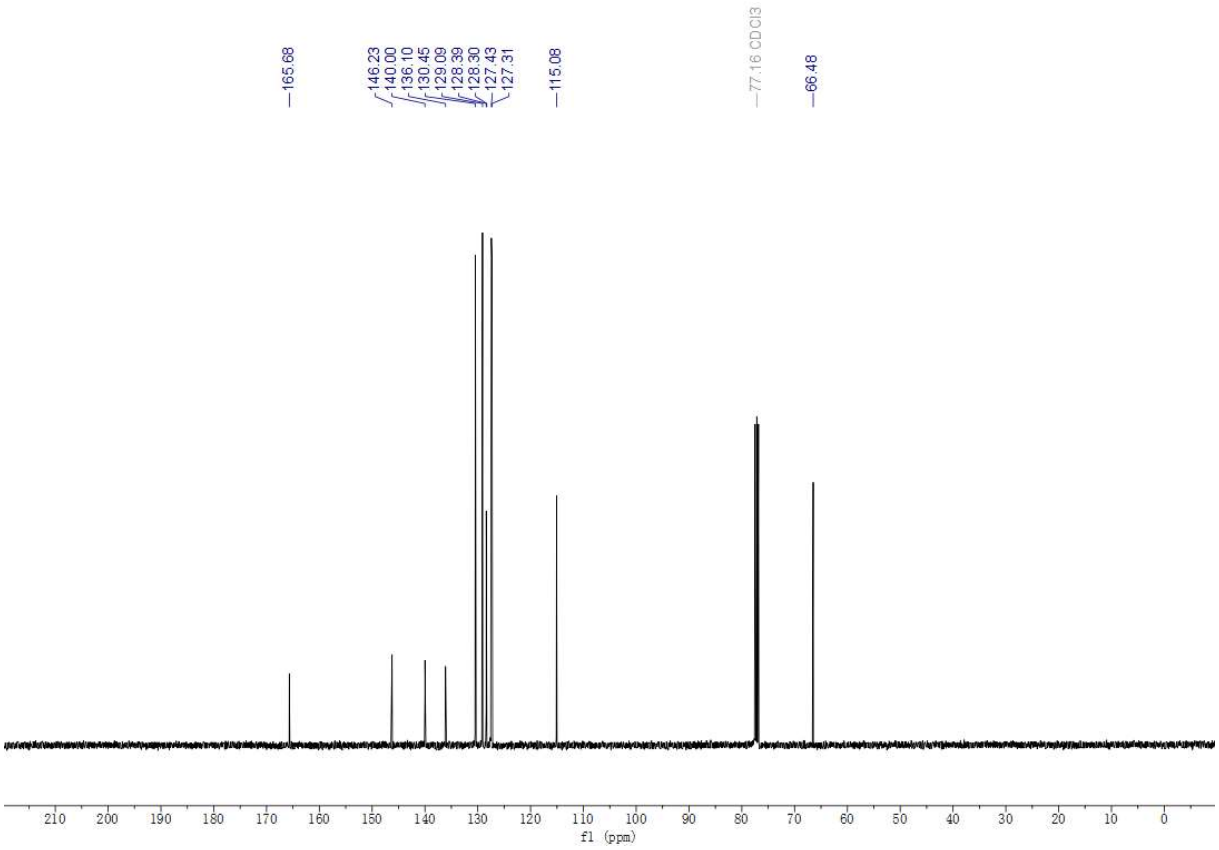

8.19
8.19
8.18
8.17
8.16
8.16
7.89
7.88
7.88
7.87
7.86
7.86
7.86
7.26 CDCl3
5.56
5.56
5.56
5.55
5.47
5.47
5.46
5.46
4.91
4.91
4.90
4.90
3.10
3.09
3.09
3.08
3.08
3.07
3.07
3.06
3.06
3.06
1.57
1.56
1.55
1.55
1.54
1.53
1.53
1.52
1.52
1.51
1.50
1.50
1.49
1.48
0.87
0.86
0.86
0.85
0.84
0.84
0.83
0.83
2.03
2.04
1.00
1.00
2.01
4.08
4.09
6.13
O
Me
O
Cl
N
Me
S
O
O
S8
f1 (ppm)

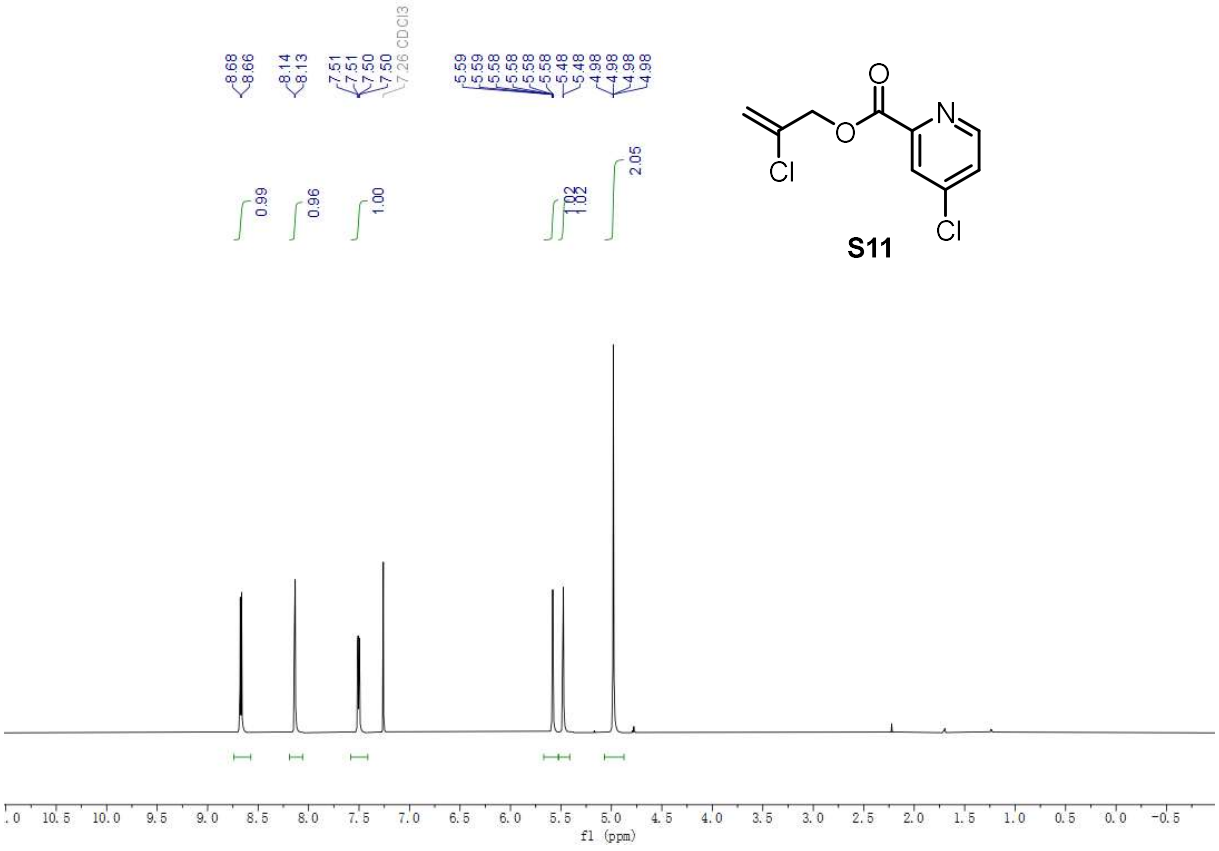

164.43
144.69
135.58
132.80
130.49
127.16
115.86
77.16 CDCl3
67.03
50.00
22.00
11.22
f1 (ppm)

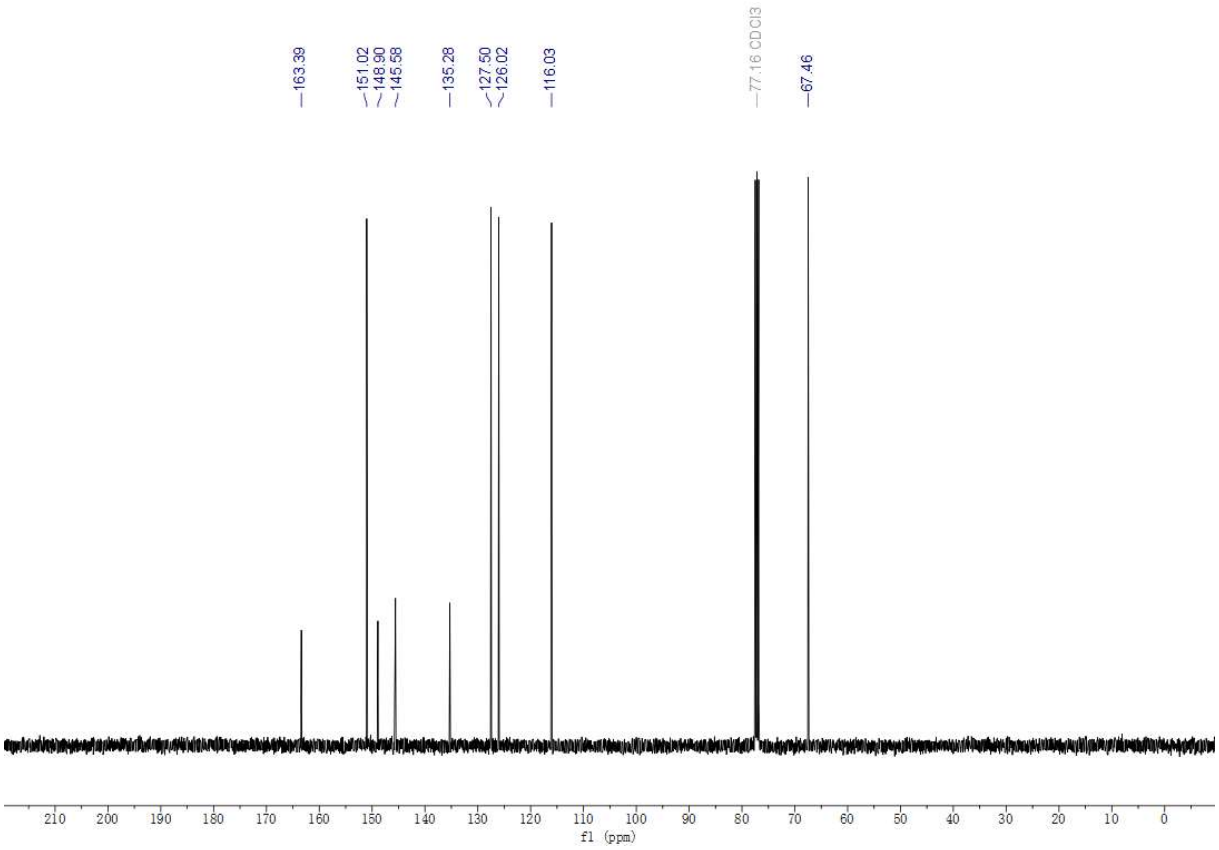

8.18
8.17
8.17
8.17
8.15
8.15
8.15
8.14
7.71
7.70
7.70
7.69
7.68
7.68
7.68
7.65
7.64
7.64
7.63
7.63
7.62
7.62
7.51
7.50
7.50
7.50
7.49
7.49
7.48
7.48
7.47
7.46
7.46
7.46
7.43
7.43
7.42
7.41
7.40
7.39
7.26 CDCl3
5.59
5.59
5.58
5.58
5.49
5.48
5.48
5.48
5.48
4.93
4.93
4.93
1.97
2.02
2.00
0.98
1.00
1.00
2.00
O
O
Cl

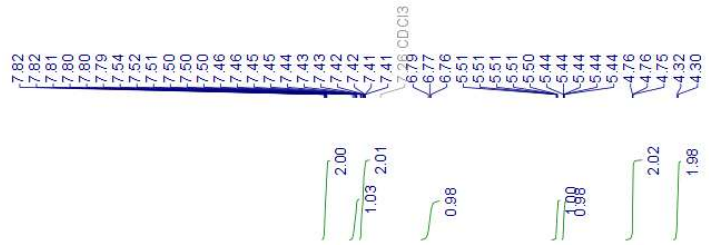
S9

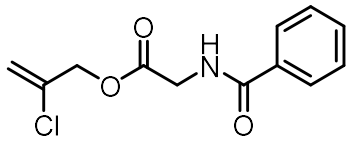

f1 (ppm)


165.68
146.23
140.00
136.10
130.45
129.09
128.39
128.30
127.43
127.31
115.08
77.16 CDCl3
66.48
f1 (ppm)

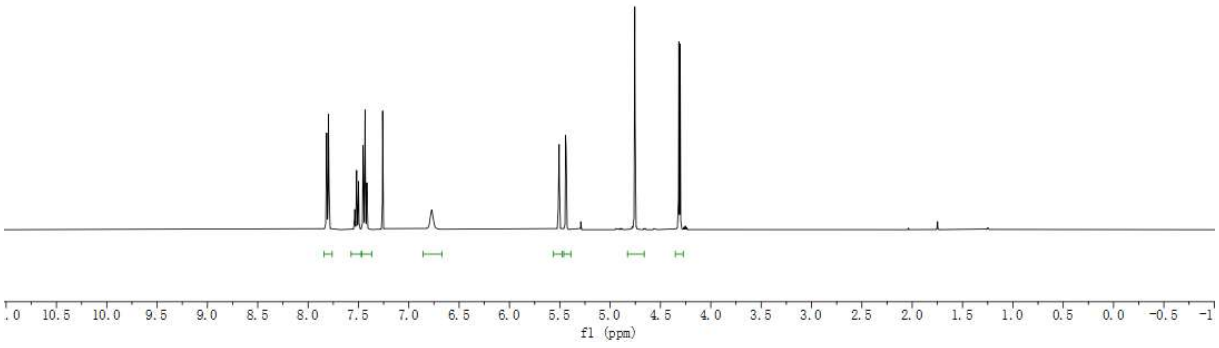

8.68
8.66
8.14
8.13
7.51
7.51
7.50
7.50
7.26 CDCl3
5.59
5.59
5.58
5.58
5.58
5.58
5.48
5.48
4.98
4.98
4.98
4.98
0.99
0.96
1.00
1.02
1.02
2.05
O
N
O
Cl
Cl
S11
f1 (ppm)

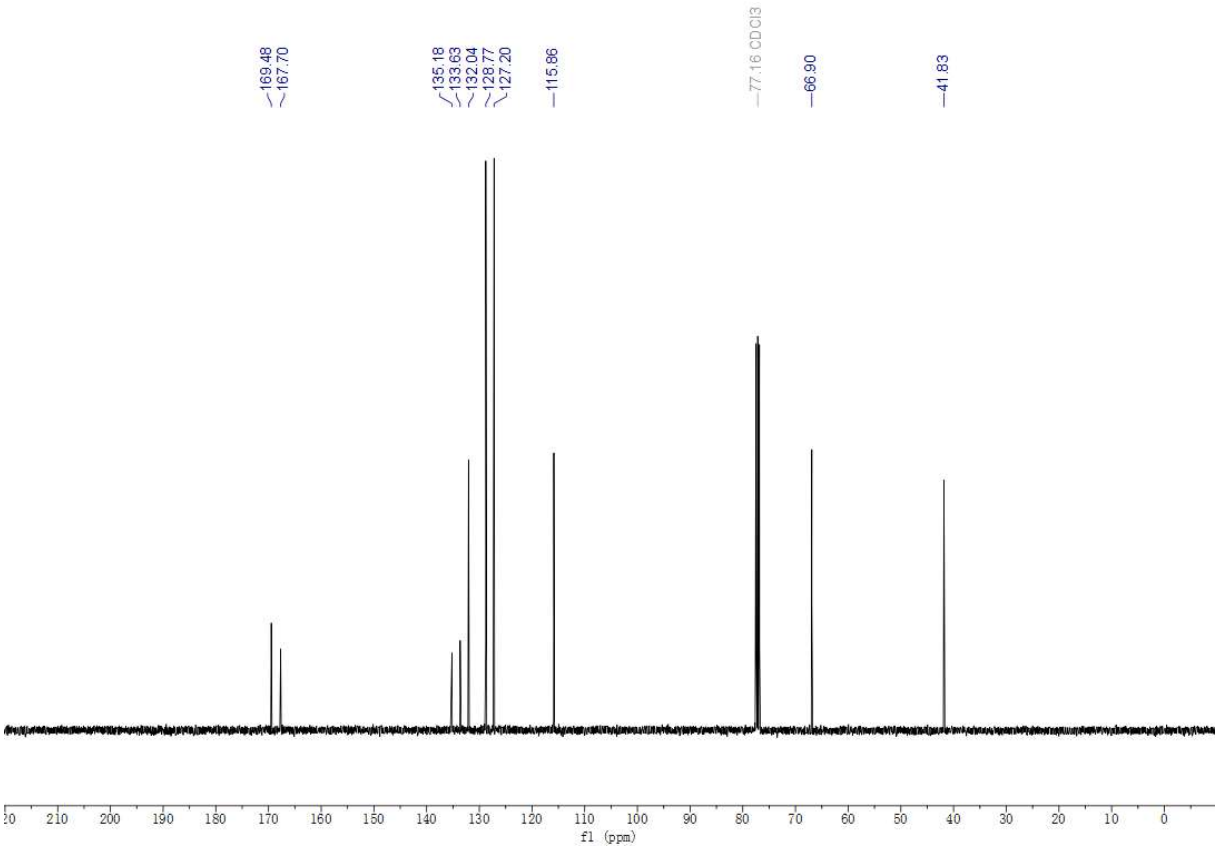

163.39
151.02
148.90
145.58
135.28
127.50
126.02
116.03
77.16 CDCl3
67.46
f1 (ppm)

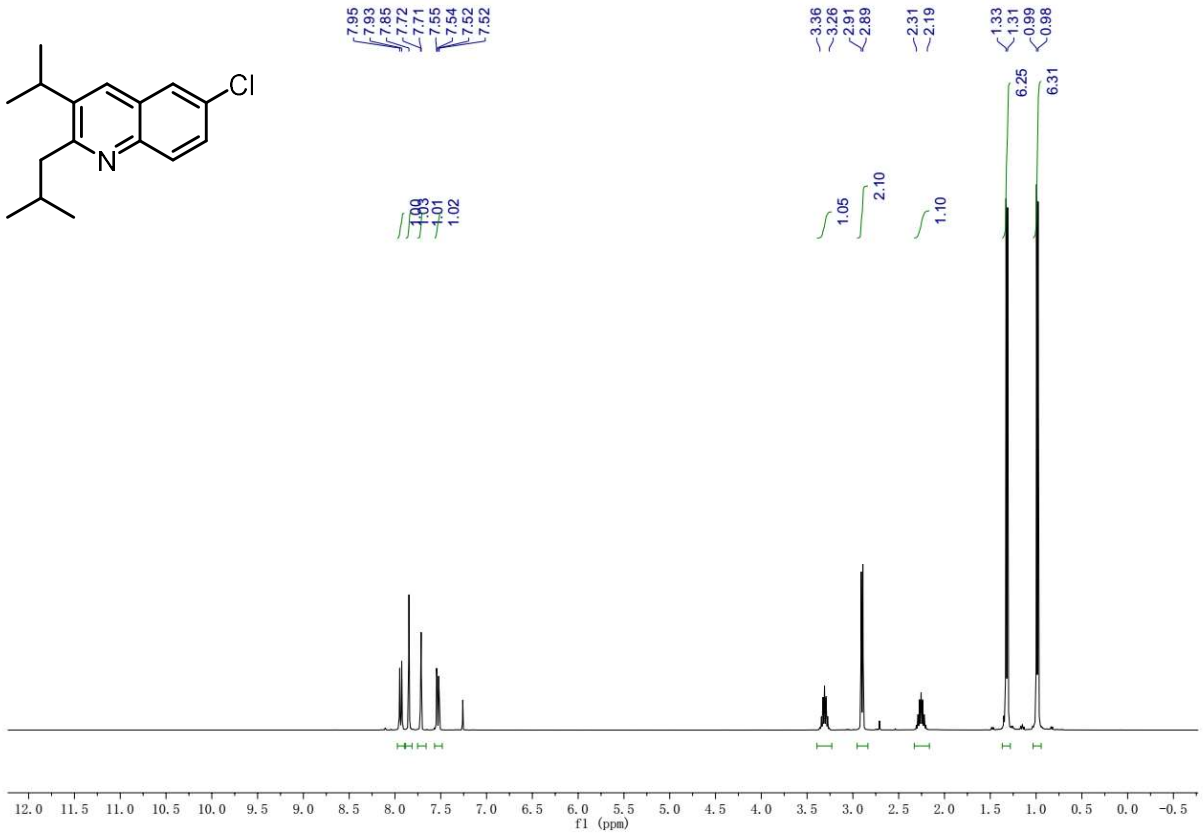

7.82
7.82
7.81
7.80
7.80
7.79
7.54
7.52
7.51
7.50
7.50
7.50
7.46
7.46
7.45
7.45
7.44
7.43
7.43
7.42
7.42
7.41
7.41
7.26 CDCl3
6.79
6.77
6.76
5.51
5.51
5.51
5.51
5.50
5.44
5.44
5.44
5.44
5.44
4.76
4.76
4.75
4.32
4.30
2.00
2.01
1.03
0.98
0.98
0.98
2.02
1.98

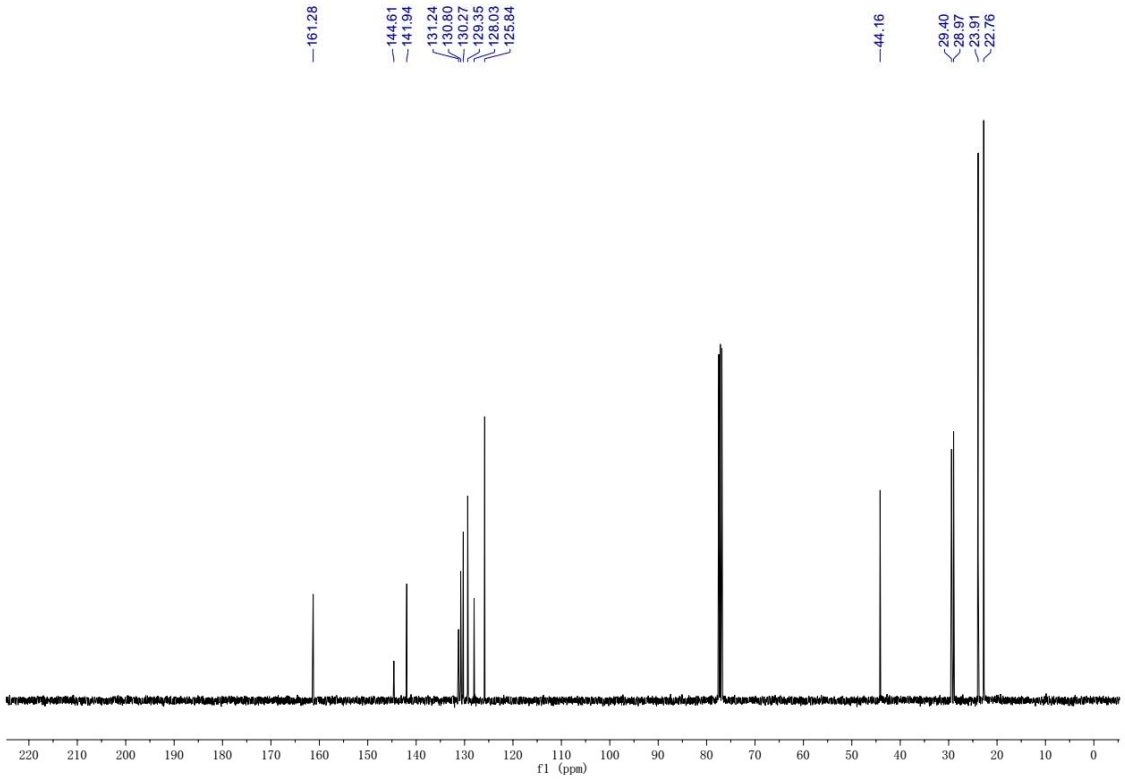

O
H
N
O
O
Cl

S12


f1 (ppm)


169.48
167.70
135.18
133.63
132.04
128.77
127.20
115.86
77.16 CDCl3
66.90
41.83
f1 (ppm)


Cl
N
7.95
7.93
7.85
7.72
7.71
7.55
7.54
7.52
7.52
3.36
3.26
2.91
2.89
2.31
2.19
1.33
1.31
0.99
0.98
6.25
6.31
1.00
1.03
1.01
1.02
1.05
2.10
1.10
f1 (ppm)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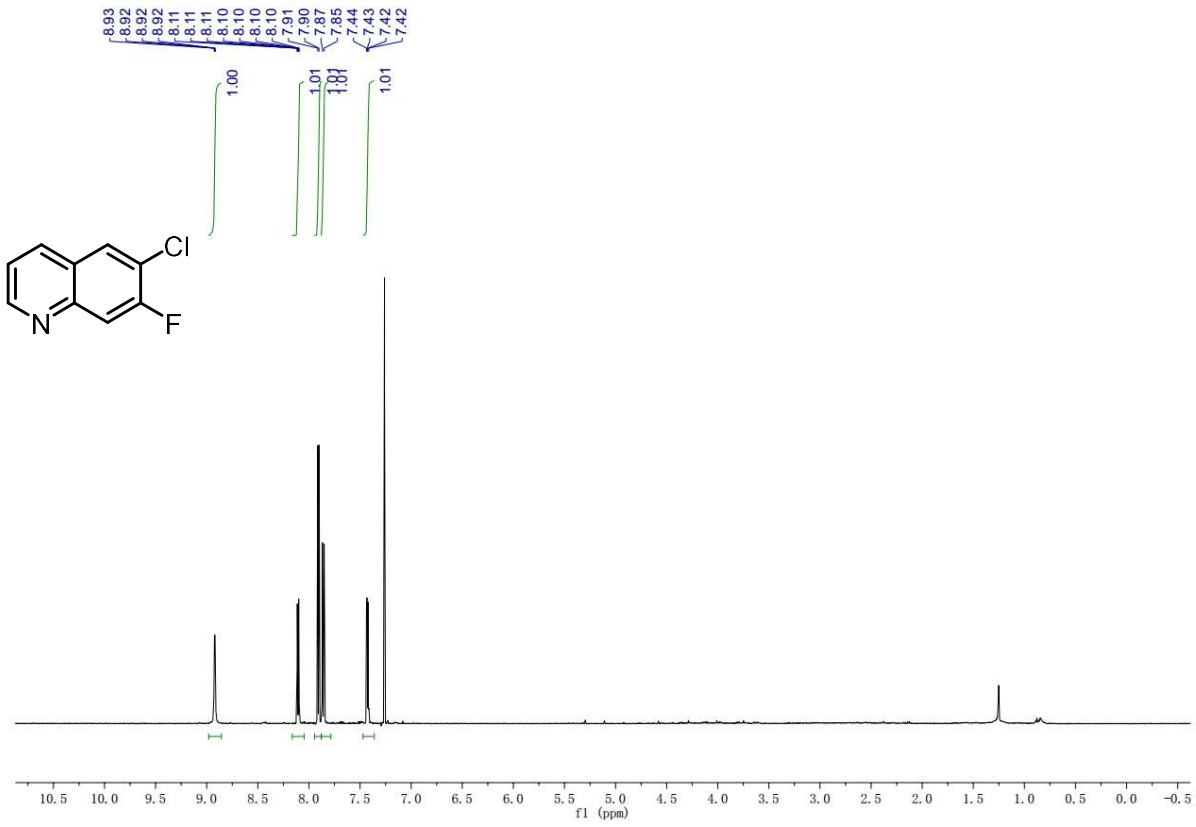
144.61
141.94
131.24
130.80
130.27
129.35
128.03
125.84
44.16
29.40
28.97
23.91
22.76
f1 (ppm)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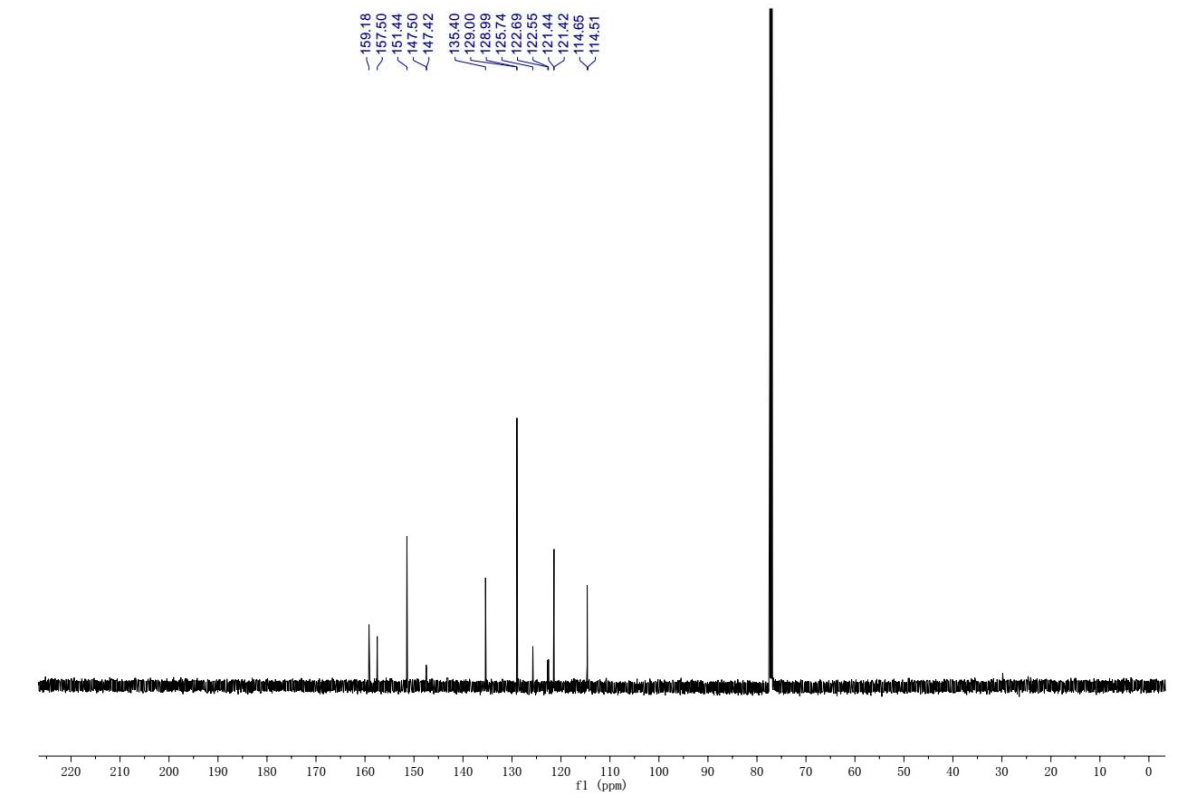
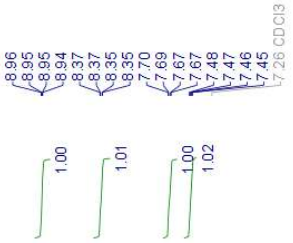
8.92
8.92
8.92
8.11
8.11
8.11
8.10
8.10
8.10
8.10
7.91
7.90
7.87
7.85
7.44
7.43
7.42
7.42
1.00
1.01
1.01
1.01
1.01
Cl
N
F
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)


159.18
157.50
151.44
147.50
147.42
135.40
129.00
128.99
125.74
122.69
122.55
121.44
121.42
114.65
114.51
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)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8.95
8.95
8.94
8.37
8.37
8.35
8.35
7.70
7.69
7.67
7.67
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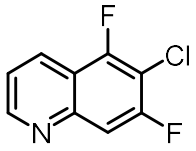
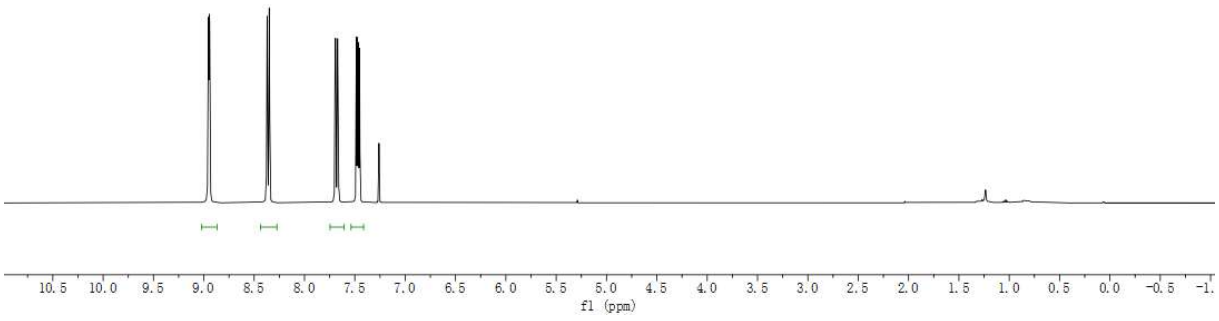
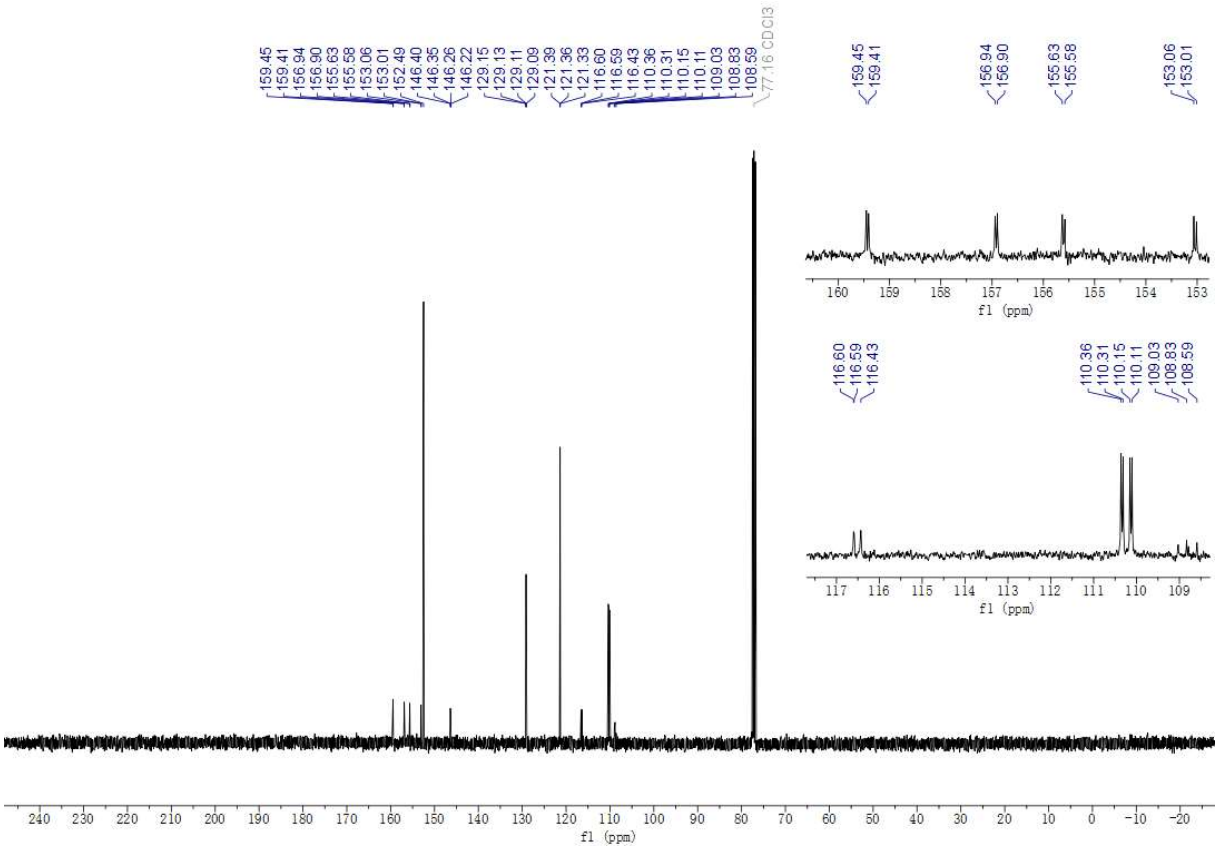
7.45
7.26 CDCl3
1.00
1.01
1.00
1.02


F
Cl
N
F

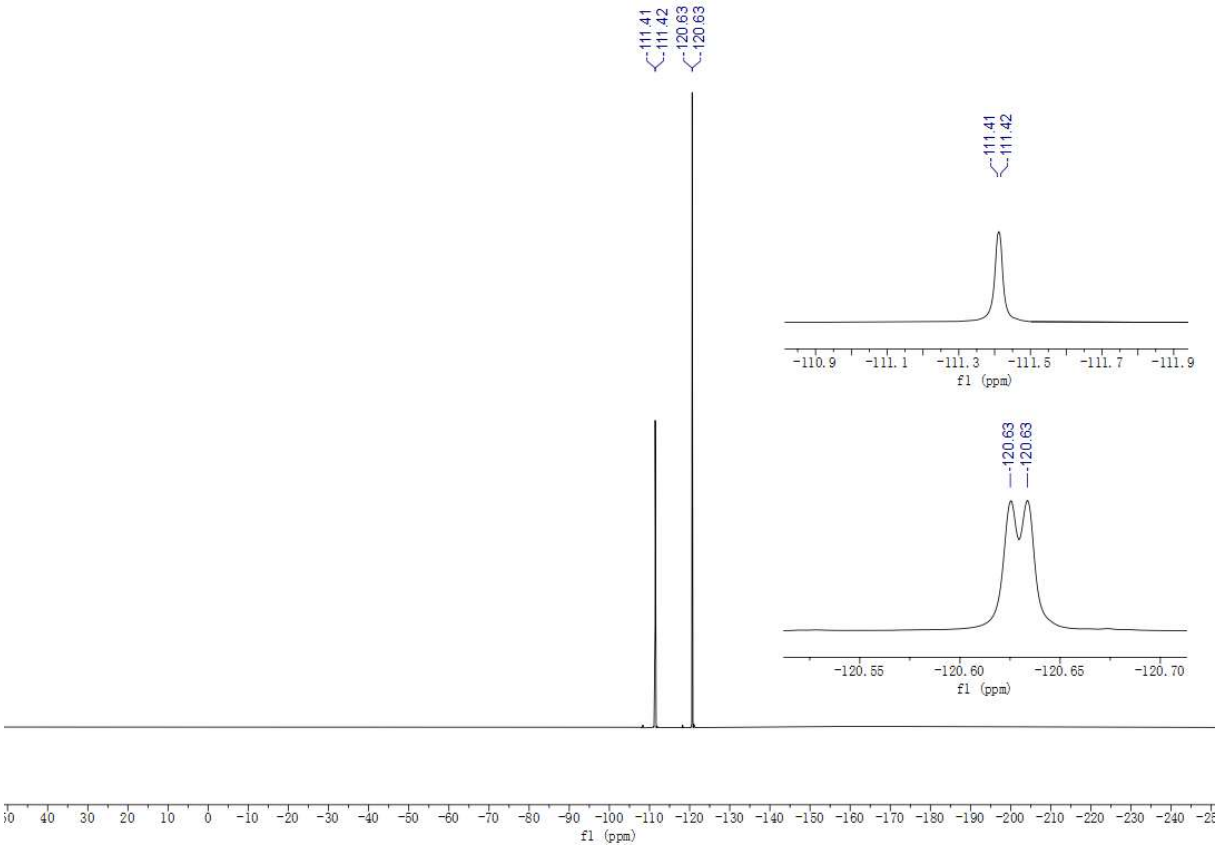
S24


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.
f1 (ppm)


159.45
159.41
156.94
156.90
155.63
155.58
153.06
153.01
152.49
146.40
146.35
146.26
146.22
129.15
129.13
129.11
129.09
121.39
121.36
121.33
116.60
116.59
116.43
110.36
110.31
110.15
110.11
109.03
108.83
108.59
77.16 CDCl3
240 230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10 -20
f1 (ppm)

159.45
159.41
156.94
156.90
155.63
155.58
153.06
153.01
160 159 158 157 156 155 154 153
f1 (ppm)

116.60
116.59
116.43
110.36
110.31
110.15
110.11
109.03
108.83
108.59
117 116 115 114 113 112 111 110 109
f1 (ppm)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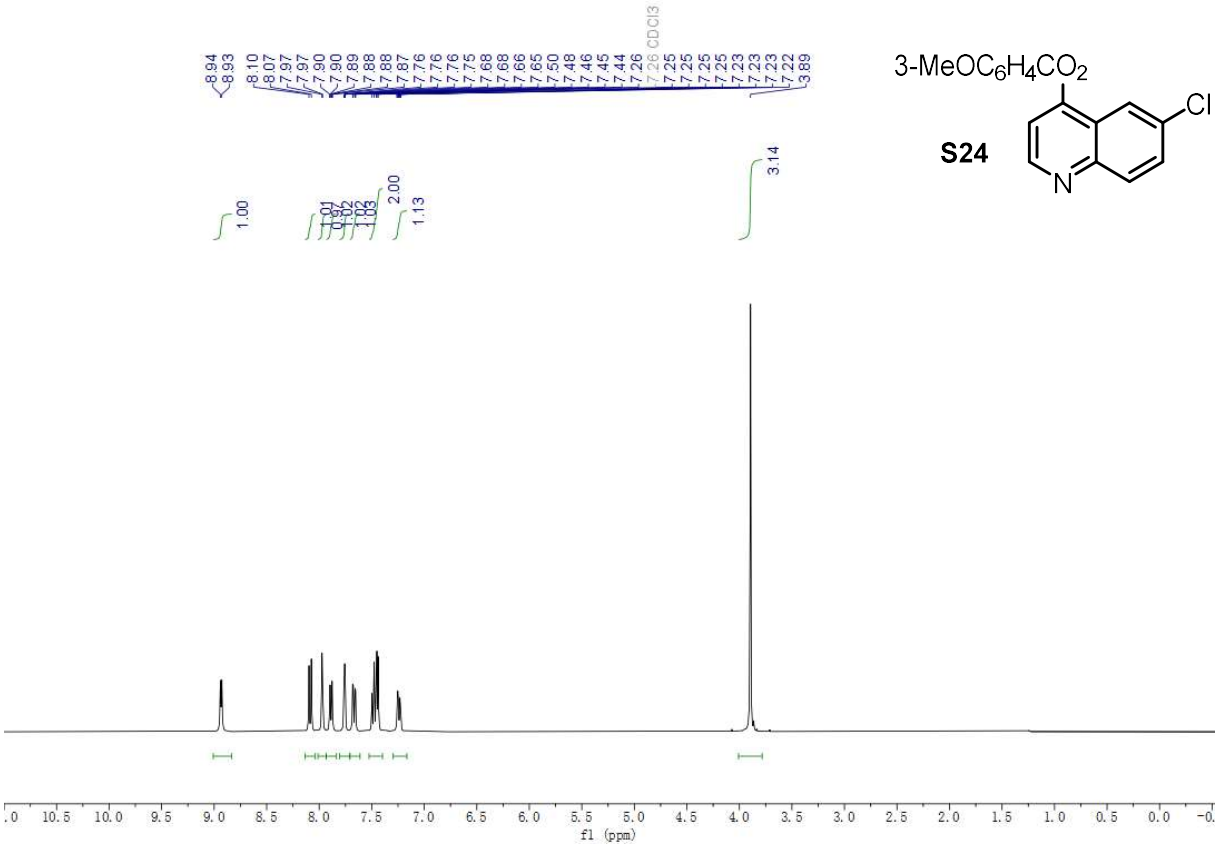
-111.42
-120.63
-120.63
-111.41
-111.42
-110.9
-111.1
-111.3
-111.5
-111.7
-111.9
f1 (ppm)
-120.63
-120.63
-120.55
-120.60
-120.65
-120.70
f1 (ppm)
f1 (ppm)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8.10
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7.97
7.90
7.90
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7.89
7.88
7.88
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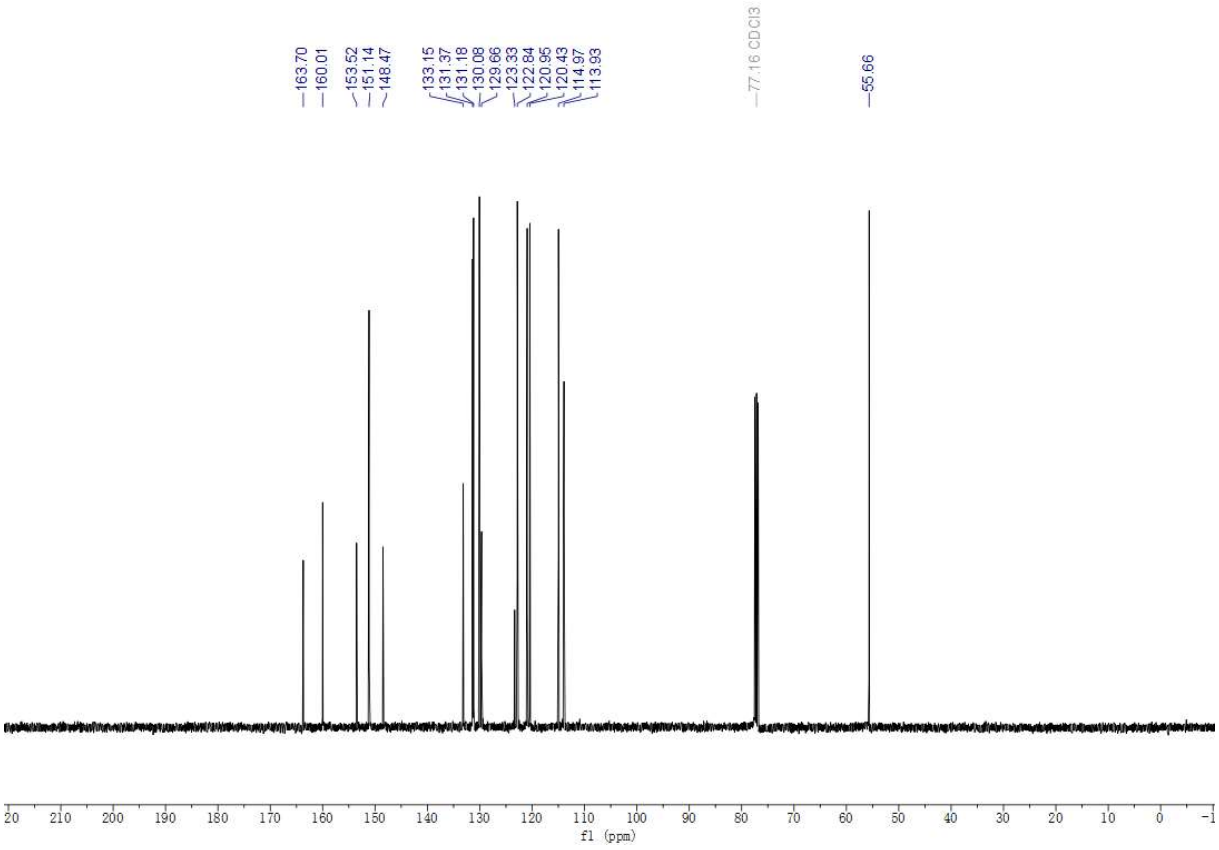
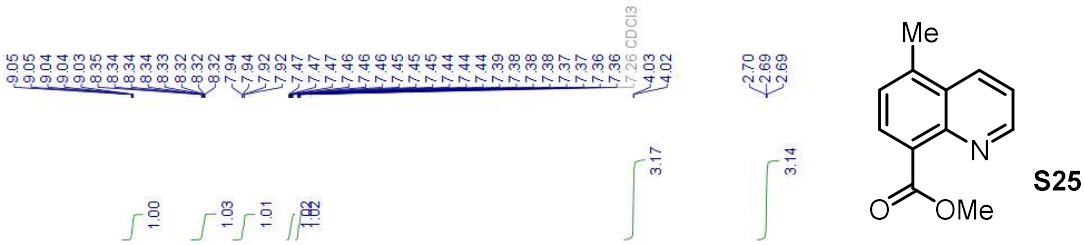
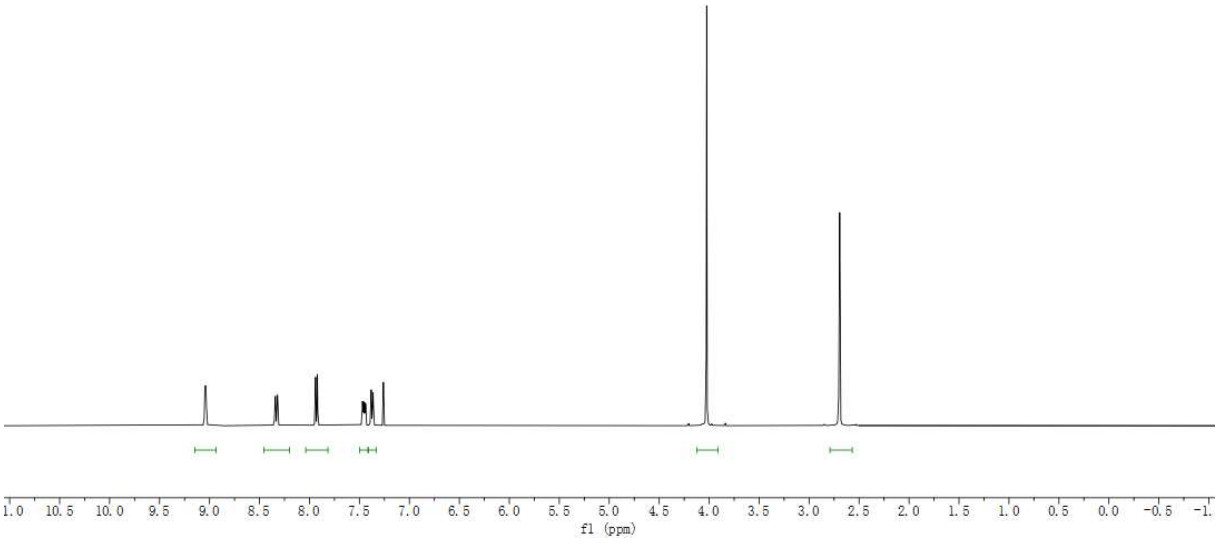
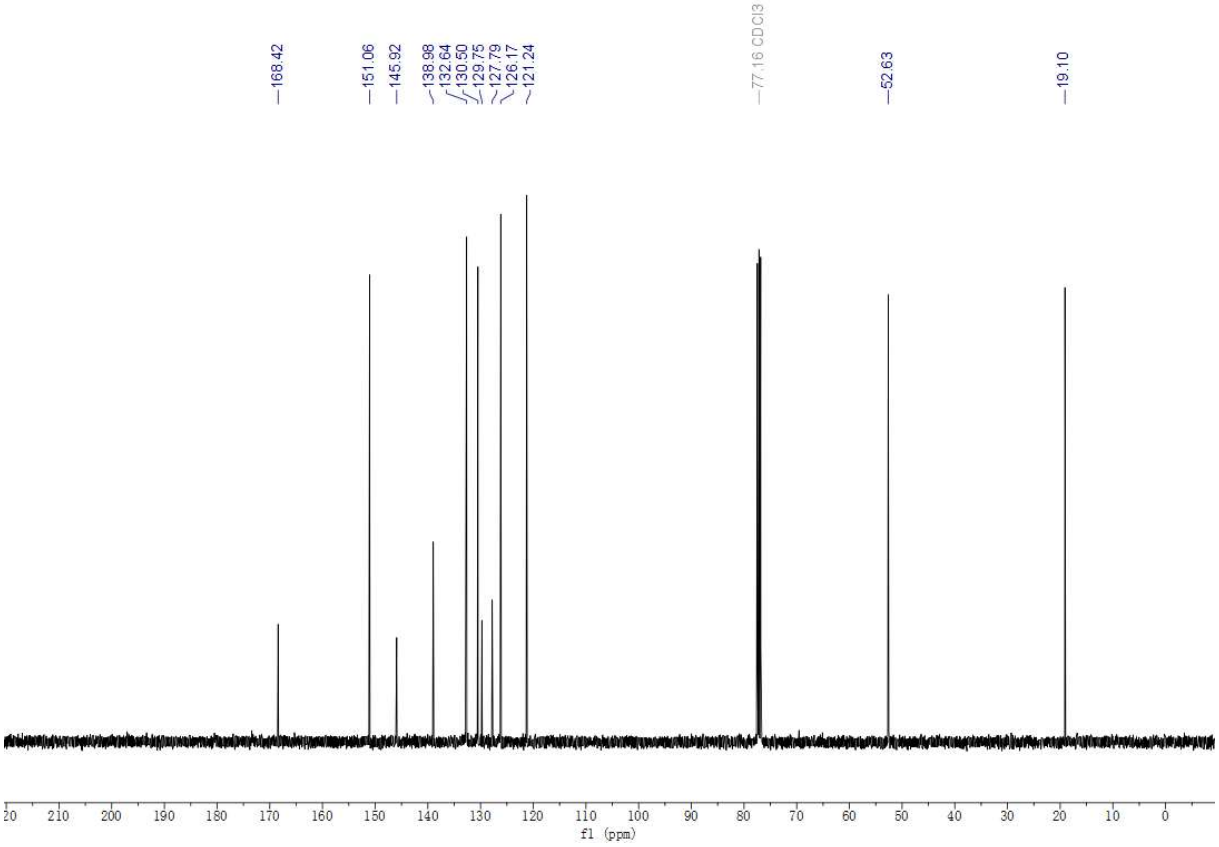
7.87
7.76
7.76
7.76
7.75
7.68
7.68
7.66
7.65
7.50
7.48
7.46
7.45
7.44
7.26 CDCl3
7.25
7.25
7.25
7.25
7.23
7.23
7.23
7.22
3.89
1.00
1.01
0.97
0.92
1.03
1.03
2.00
1.13
3.14
3-MeOC6H4CO2
Cl
S24
N
f1 (ppm)

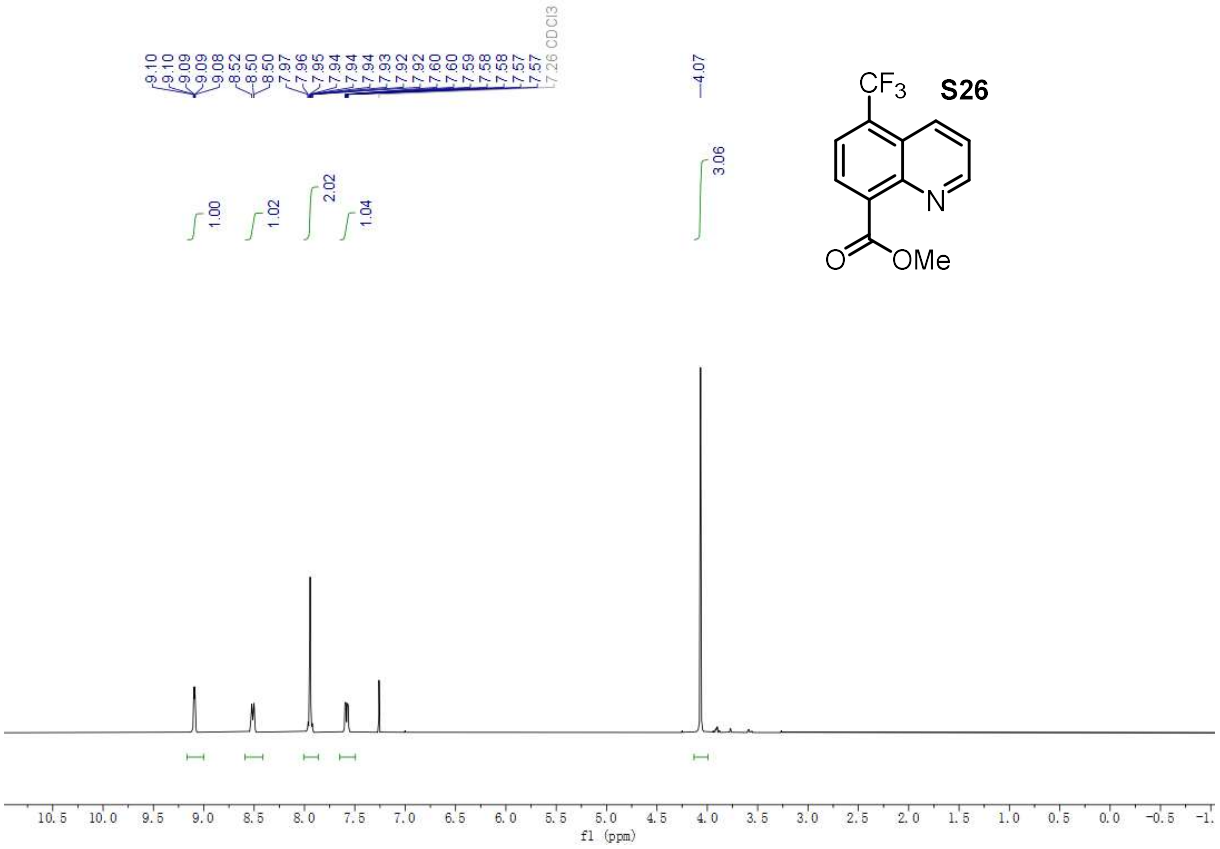

163.70
160.01
153.52
151.14
148.47
133.15
131.37
131.18
130.08
129.66
123.33
122.84
120.95
120.43
114.97
113.93
77.16 CDCl3
55.66
f1 (ppm)

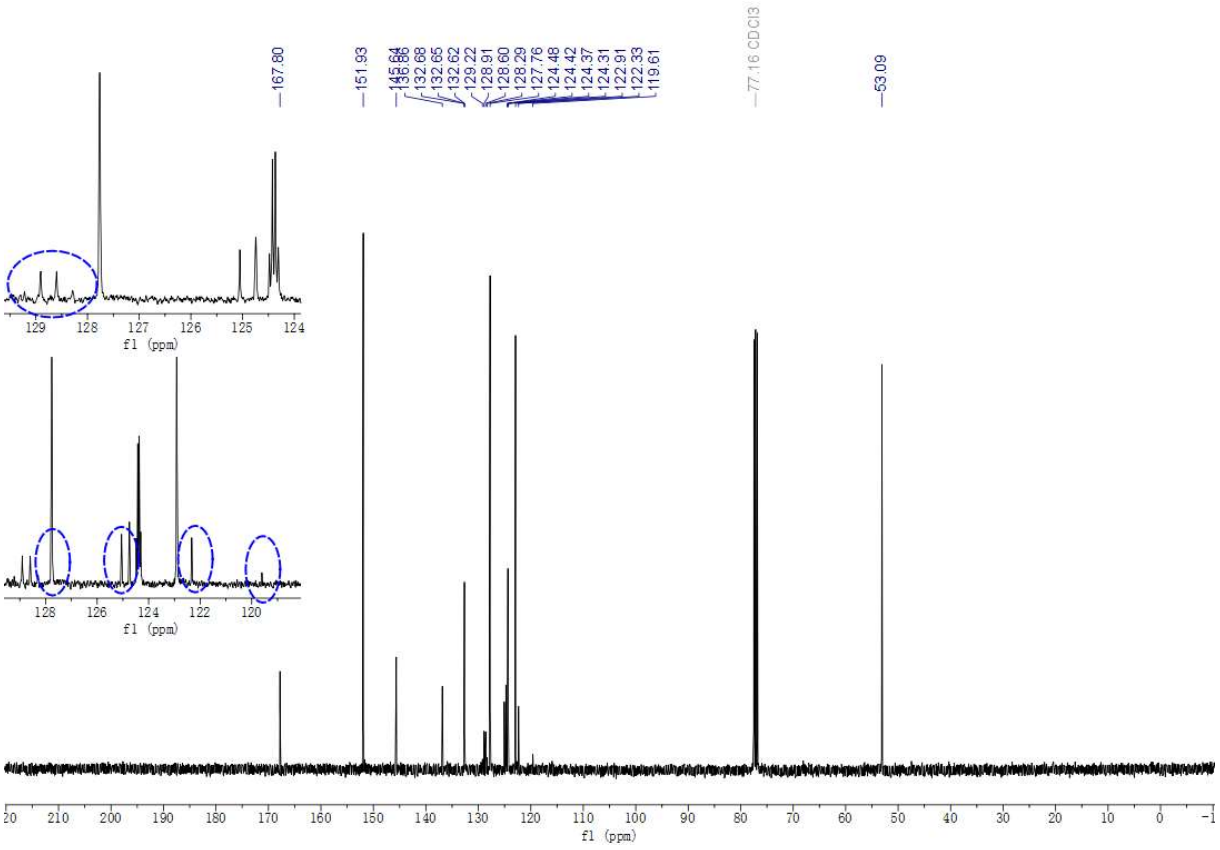

9.05
9.04
8.35
8.34
8.33
8.32
7.94
7.92
7.47
7.46
7.45
7.44
7.39
7.38
7.37
7.36
7.26 CDCl3
4.03
4.02
2.70
2.69
1.00
1.03
1.01
3.17
3.14
Me
N
O
OMe

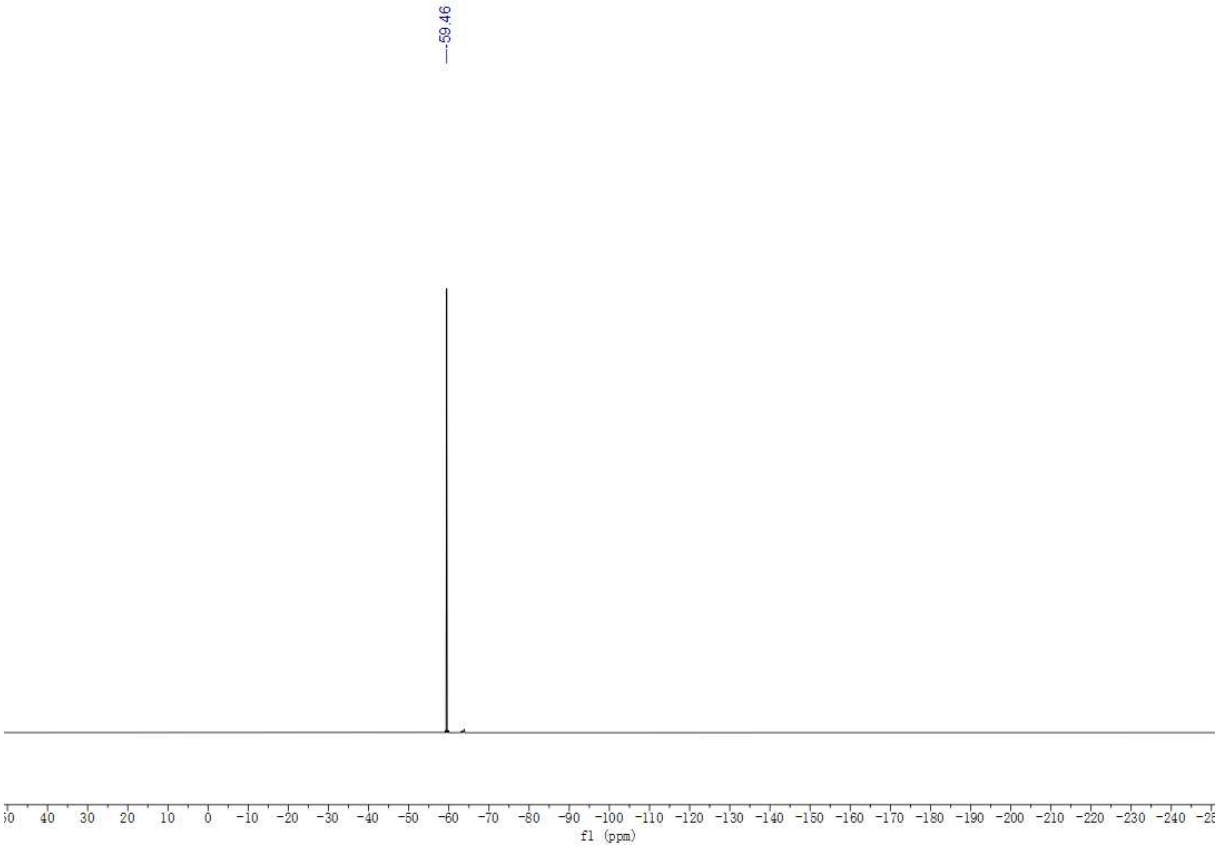
S25

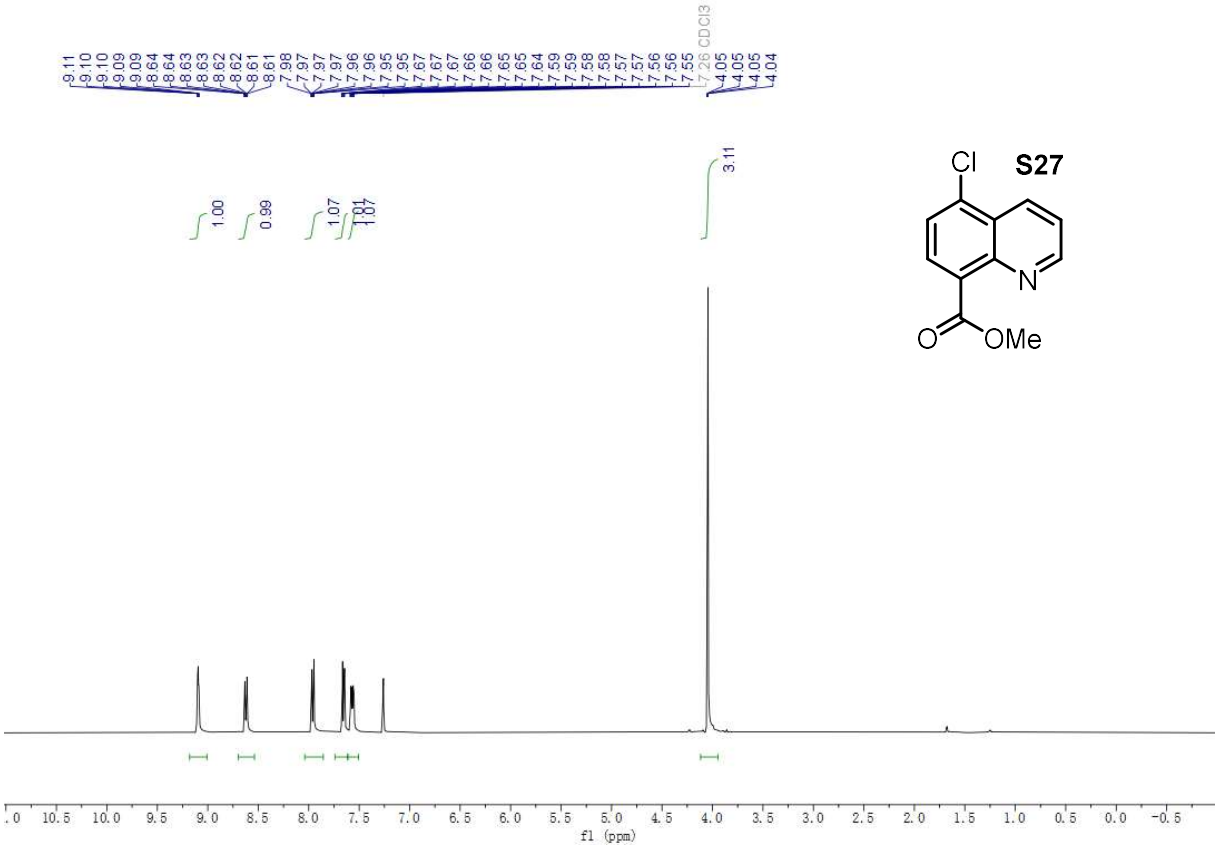

f1 (ppm)

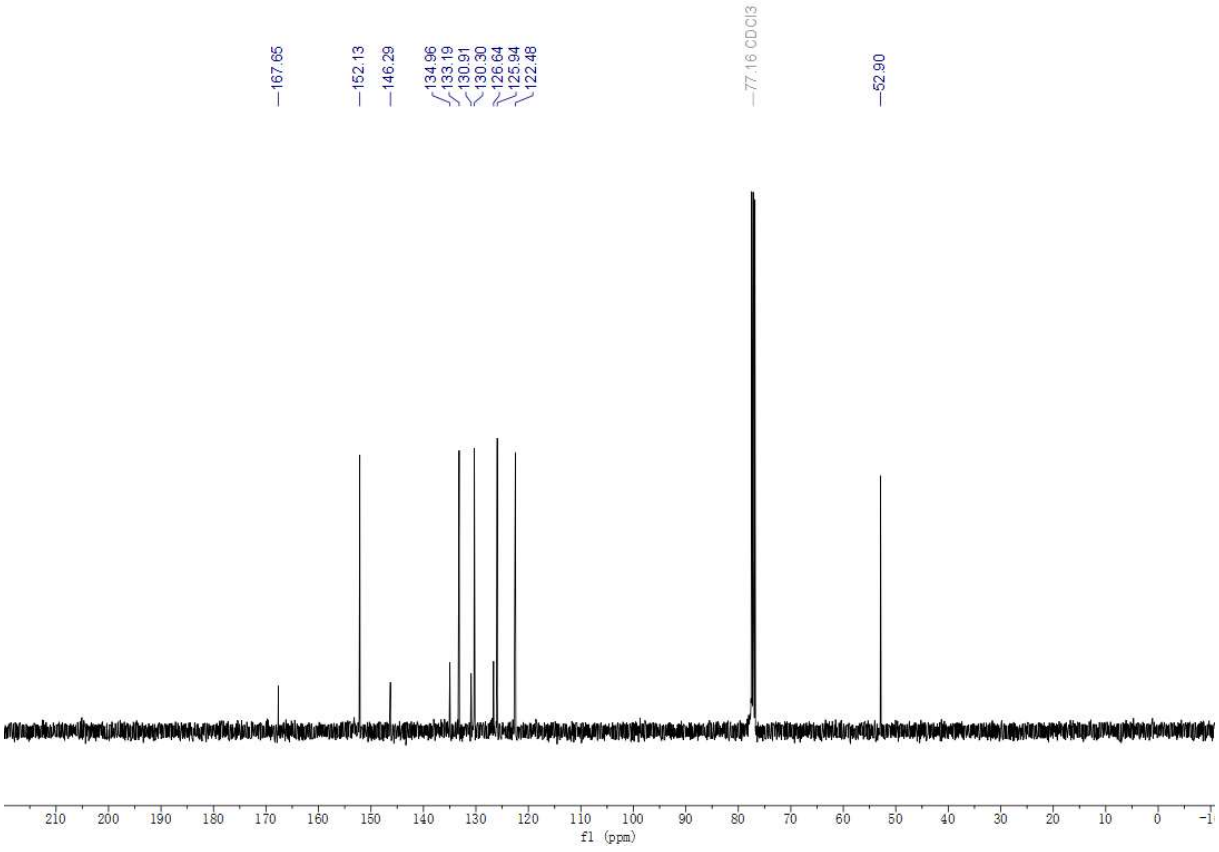

168.42
151.06
145.92
138.98
132.64
130.50
129.75
127.79
126.17
121.24
77.16 CDCl3
52.63
19.10
f1 (ppm)

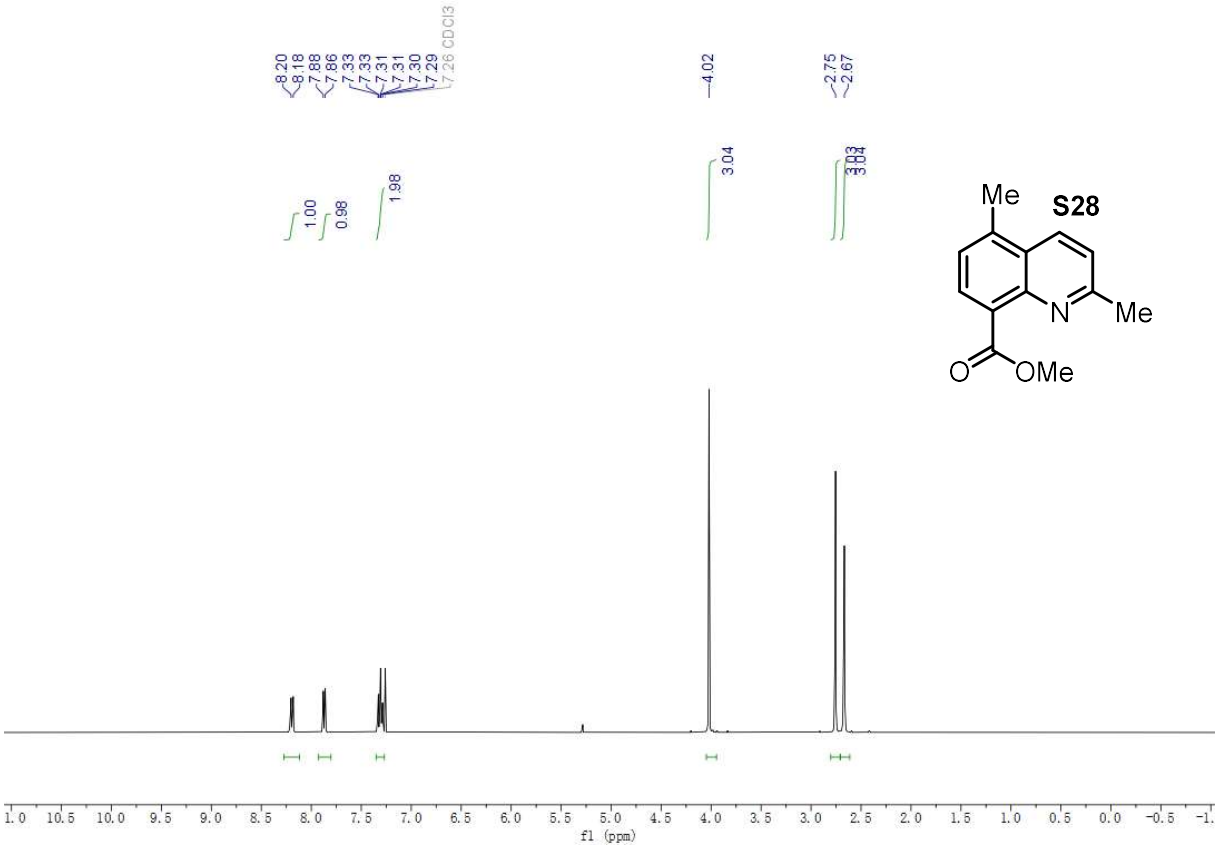

9.10
9.10
9.09
9.09
9.08
8.52
8.50
8.50
7.97
7.96
7.95
7.94
7.94
7.94
7.93
7.92
7.92
7.60
7.60
7.59
7.58
7.58
7.57
7.57
7.26 CDCl3
4.07
3.06
1.00
1.02
2.02
1.04
CF3
S26
N
O
OMe
f1 (ppm)

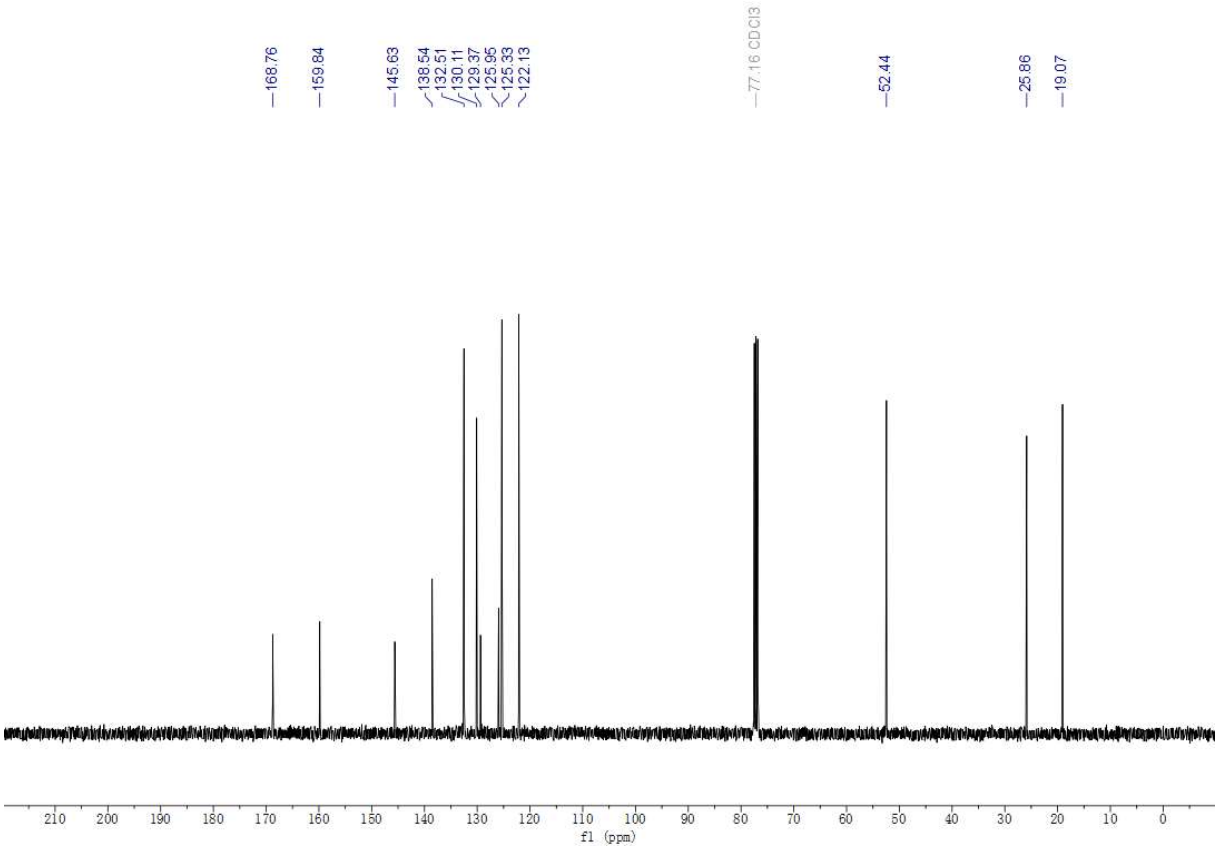

167.80
151.93
145.64
136.86
132.68
132.65
132.62
129.22
128.91
128.60
128.29
127.76
124.48
124.42
124.37
124.31
122.91
122.33
119.61
77.16 CDCl3
53.09
f1 (ppm)
f1 (ppm)
f1 (ppm)

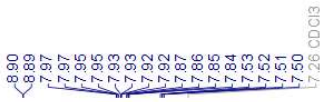

-59.46
40 30 20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210 -220 -230 -240
f1 (ppm)

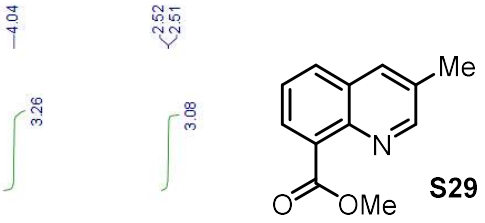

9.11
9.10
9.10
9.09
9.09
8.64
8.64
8.63
8.63
8.62
8.62
8.61
8.61
7.98
7.97
7.97
7.97
7.96
7.96
7.95
7.95
7.67
7.67
7.67
7.66
7.66
7.65
7.65
7.64
7.59
7.59
7.58
7.58
7.57
7.57
7.56
7.56
7.55
7.26 CDCl3
4.05
4.05
4.05
4.04
1.00
0.99
1.07
1.84
1.07
3.11
Cl
S27
N
O
OMe
f1 (ppm)


167.65
152.13
146.29
134.96
133.19
130.91
130.30
126.64
125.94
122.48
77.16 CDCl3
52.90
f1 (ppm)

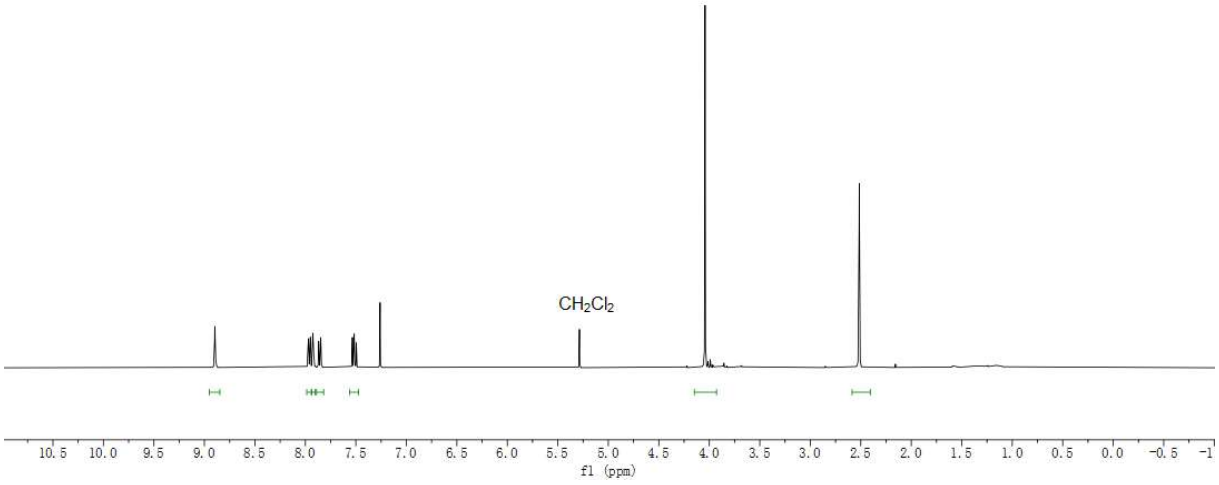

8.20
8.18
7.88
7.86
7.33
7.31
7.31
7.30
7.29
7.26 CDCl3
4.02
2.75
2.67
3.04
1.00
0.98
1.98
Me
S28
N
Me
O
OMe
f1 (ppm)

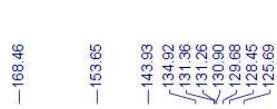

168.76
159.84
145.63
138.54
132.51
130.11
129.37
125.95
125.33
122.13
77.16 CDCl3
52.44
25.86
19.07
f1 (ppm)


8.90
8.89
7.97
7.97
7.95
7.95
7.93
7.93
7.92
7.92
7.87
7.86
7.85
7.84
7.53
7.52
7.51
7.50
7.26 CDCl3

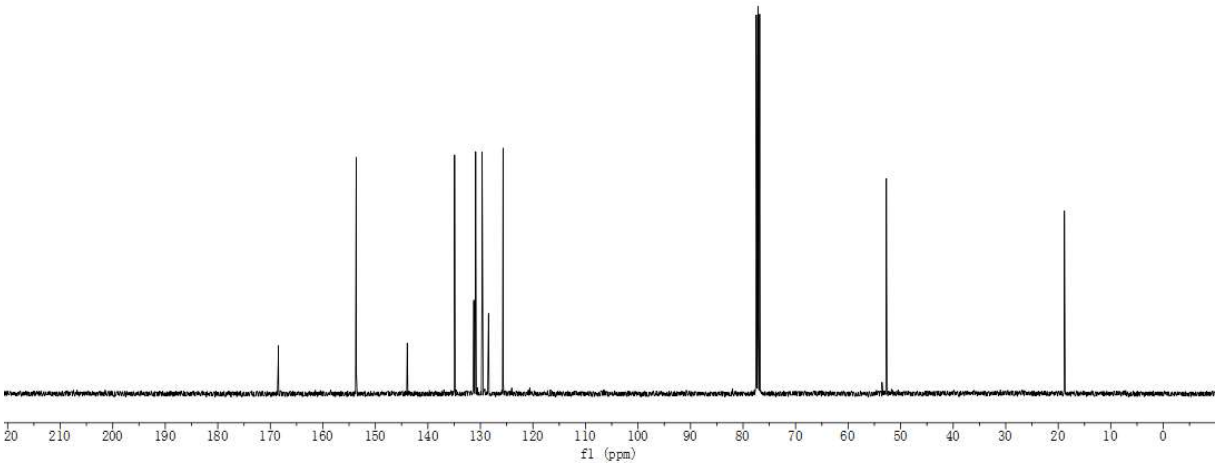

4.04
2.52
2.51
1.00
1.04
3.26
3.08
Me
N
O
OMe

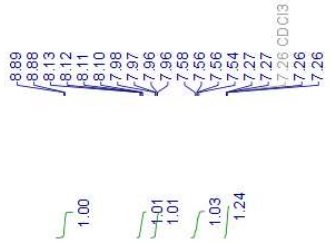
S29

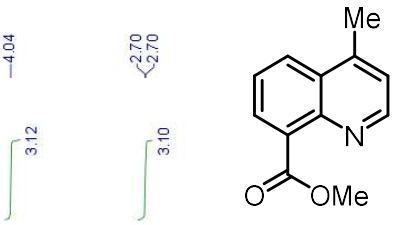

CH2Cl2
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1
f1 (ppm)


168.46
153.65
143.93
134.92
131.36
131.26
130.90
129.68
128.45
125.69


77.16 CDCl3
52.72
18.82

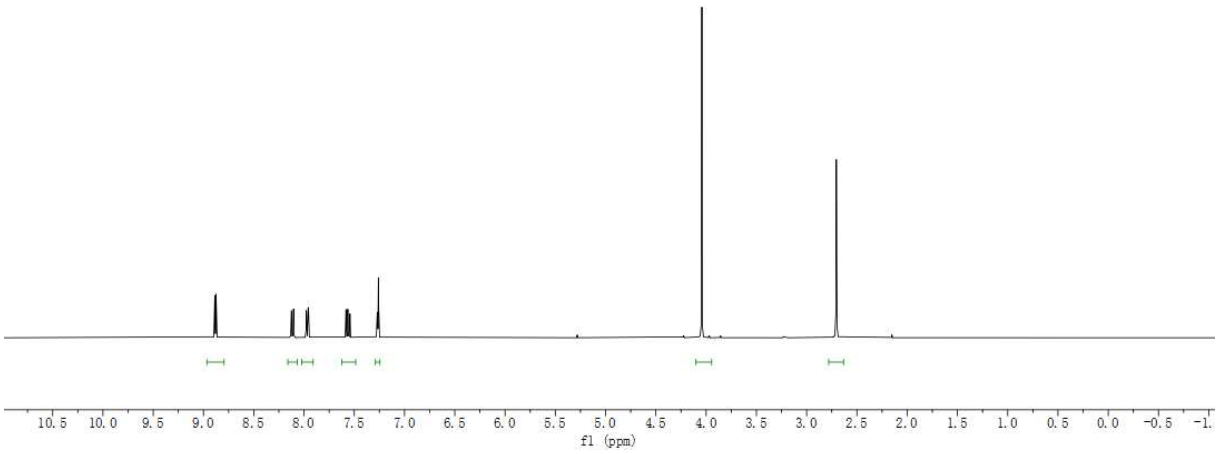

20 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)


8.89
8.88
8.13
8.12
8.11
8.10
7.98
7.97
7.96
7.96
7.58
7.56
7.56
7.54
7.27
7.26 CDCl3
7.26
7.26
1.00
1.01
1.01
1.03
1.24


4.04
3.12
2.70
2.70
3.10

Me
N
O
OMe

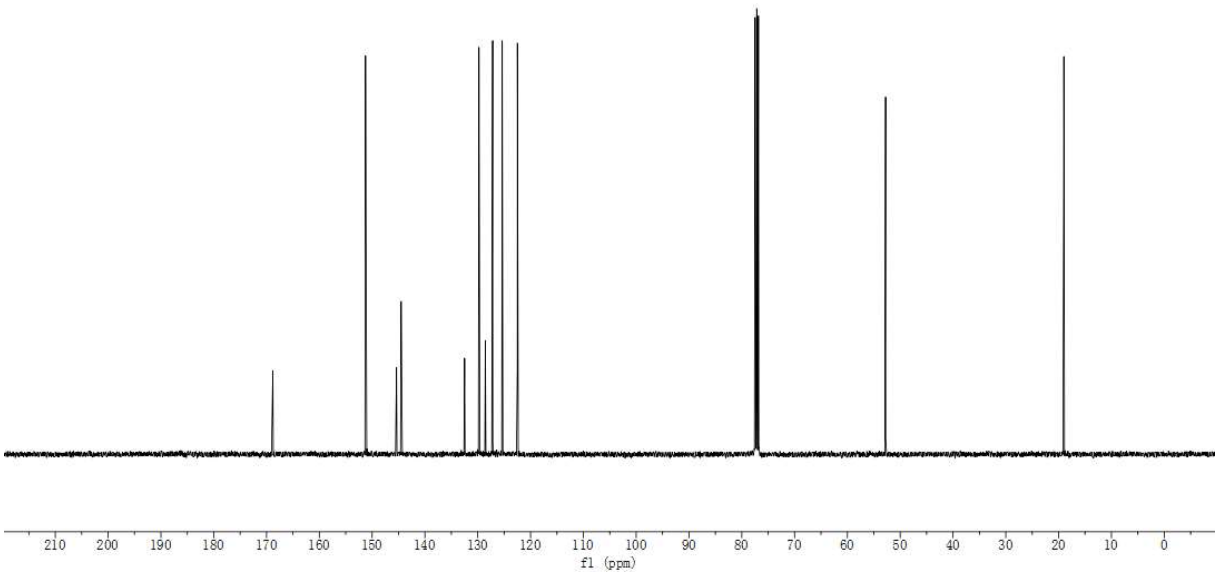
S30

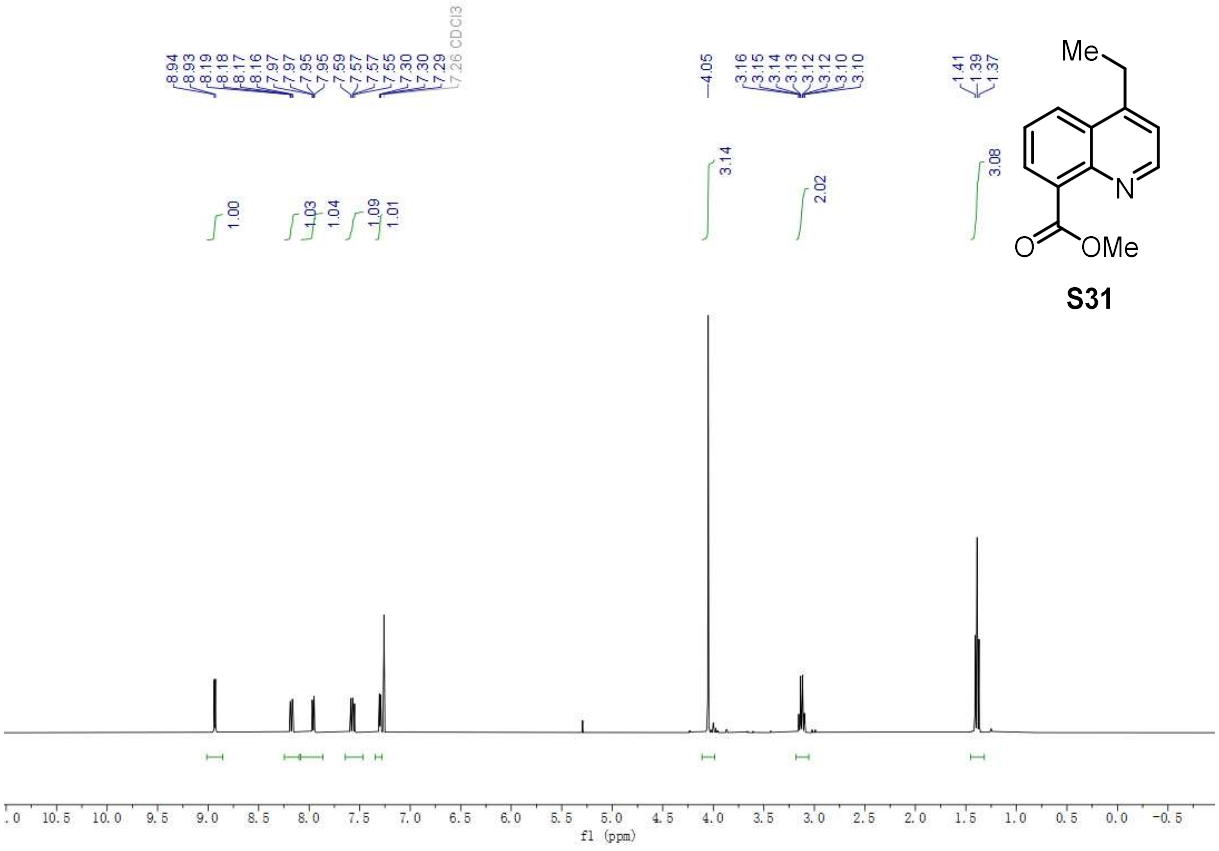

10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.
f1 (ppm)


168.80
151.25
145.38
144.51
132.48
129.77
128.56
127.17
125.36
122.49

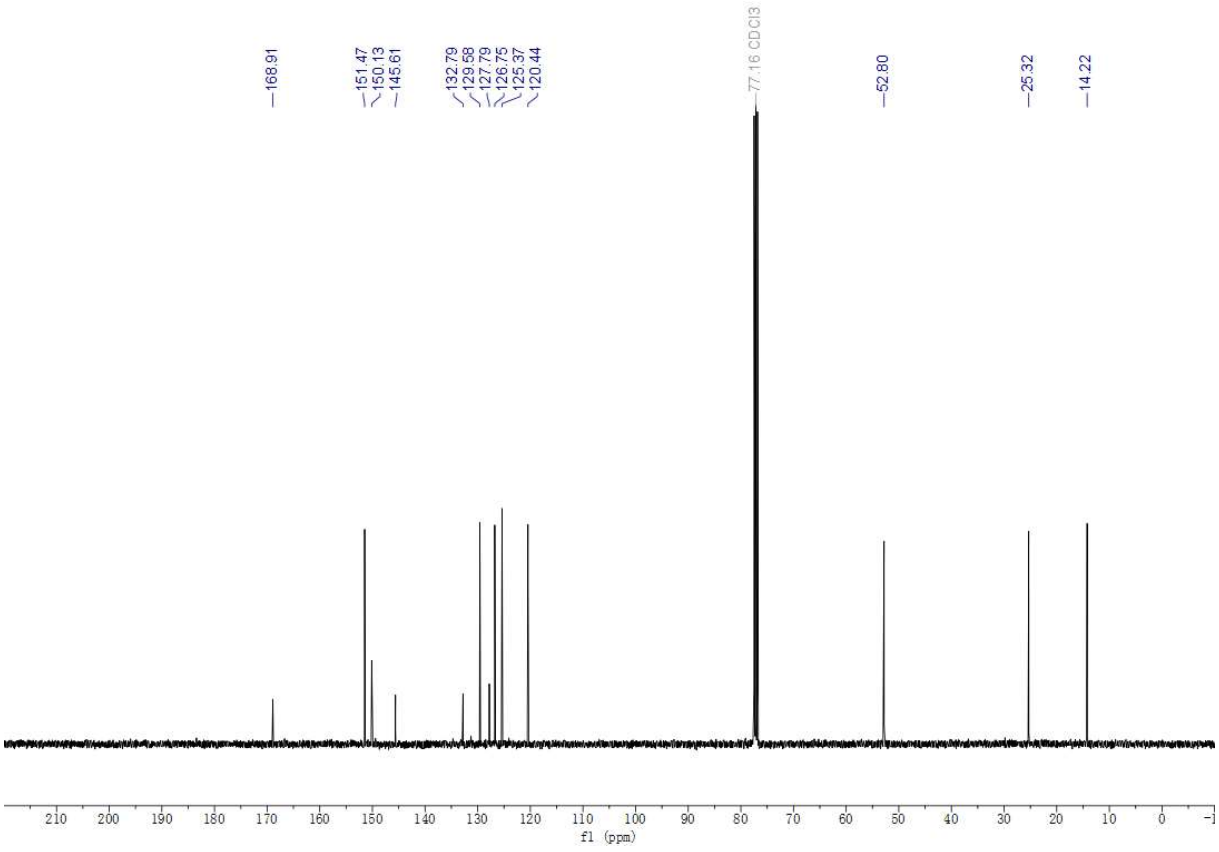

77.16 CDCl3

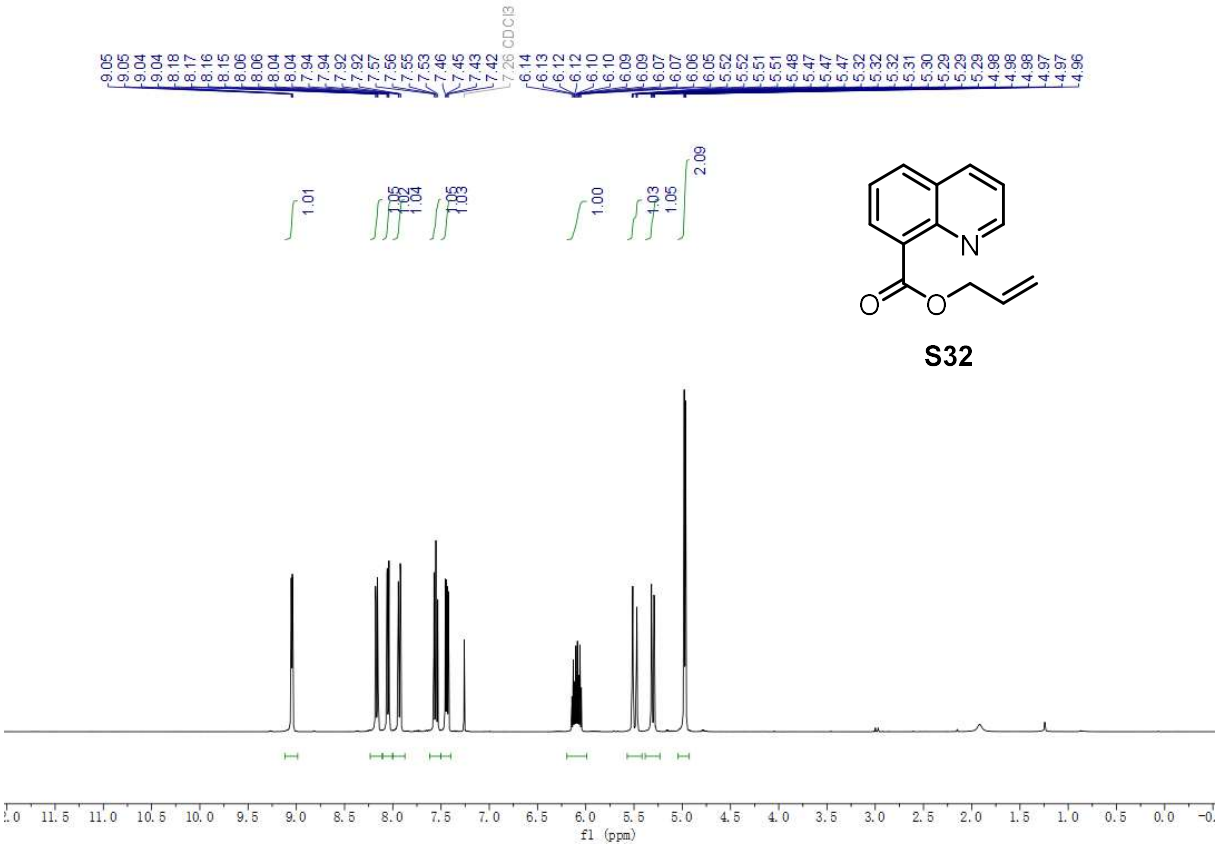

52.76
19.01


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

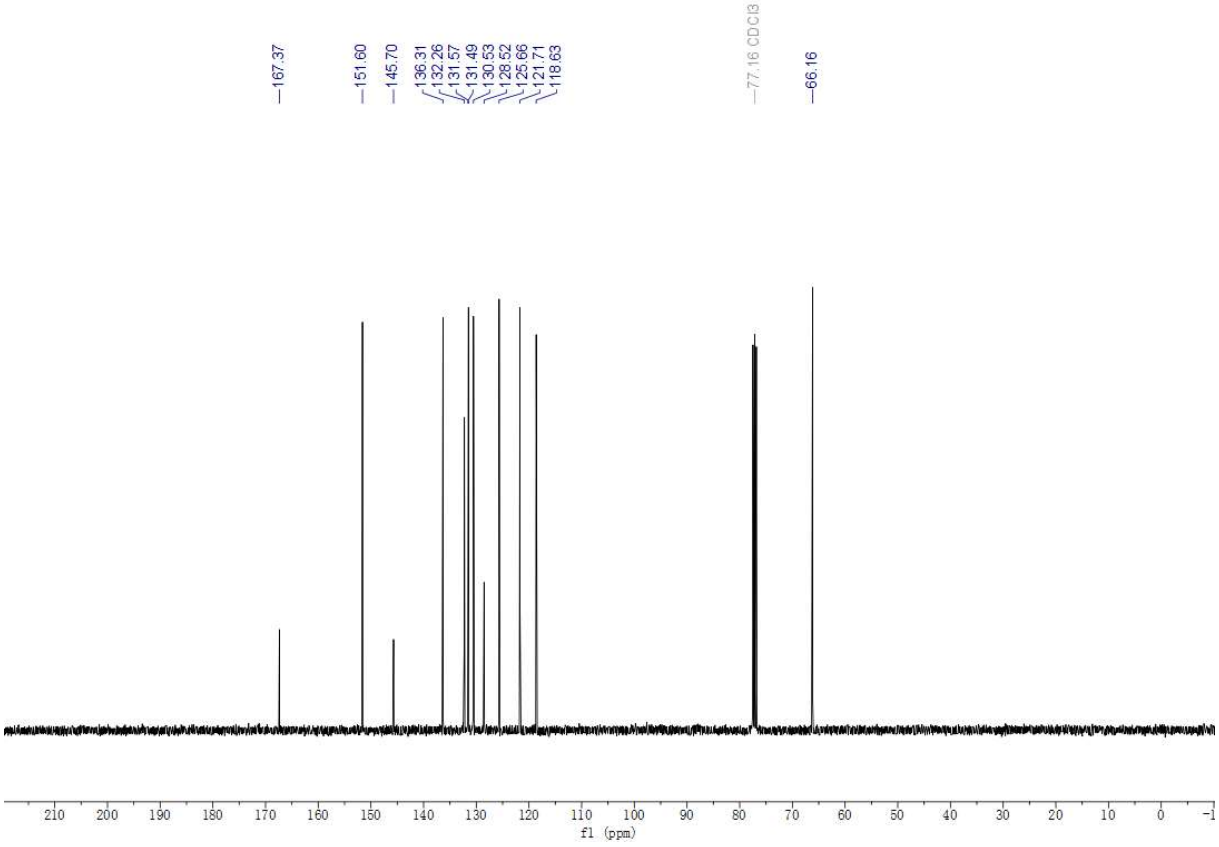

8.94
8.93
8.19
8.18
8.17
8.16
7.97
7.97
7.95
7.95
7.59
7.57
7.57
7.55
7.30
7.30
7.29
7.26 CDCl3
4.05
3.16
3.15
3.14
3.13
3.12
3.12
3.10
3.10
1.41
1.39
1.37
1.00
1.03
1.04
1.09
1.01
3.14
2.02
3.08
Me
N
O
OMe
f1 (ppm)

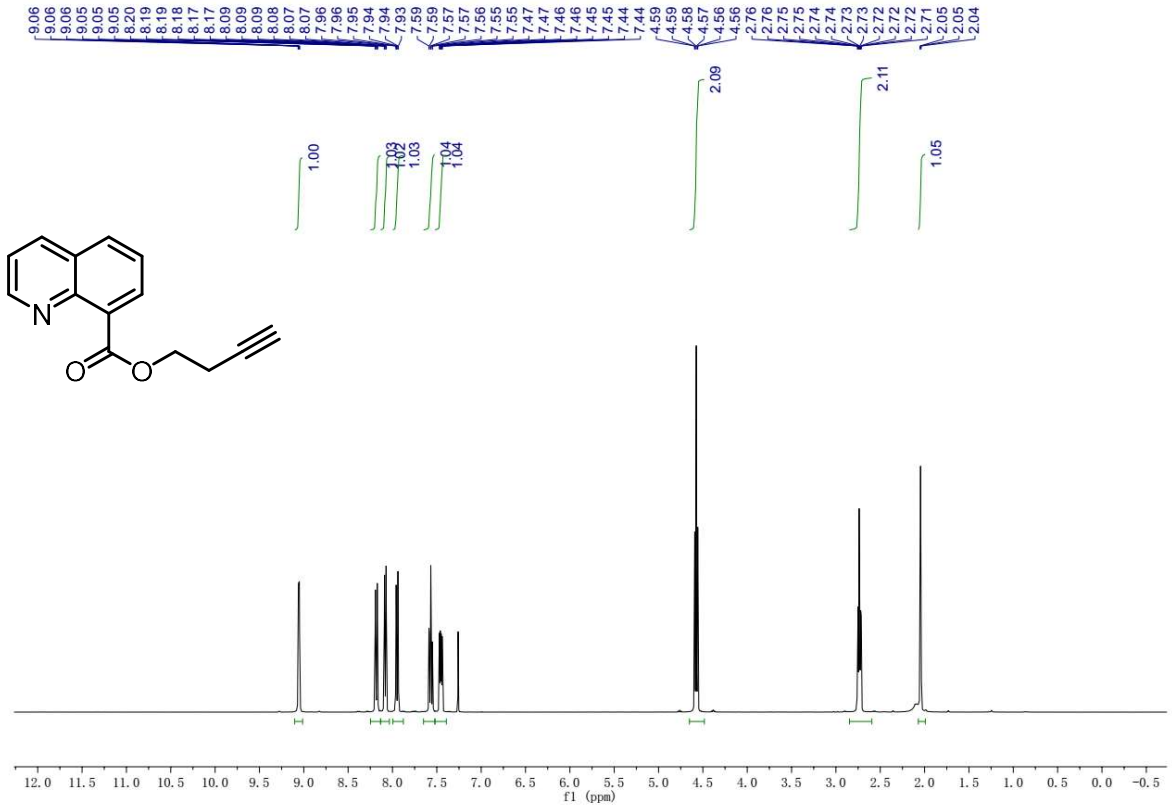
S31

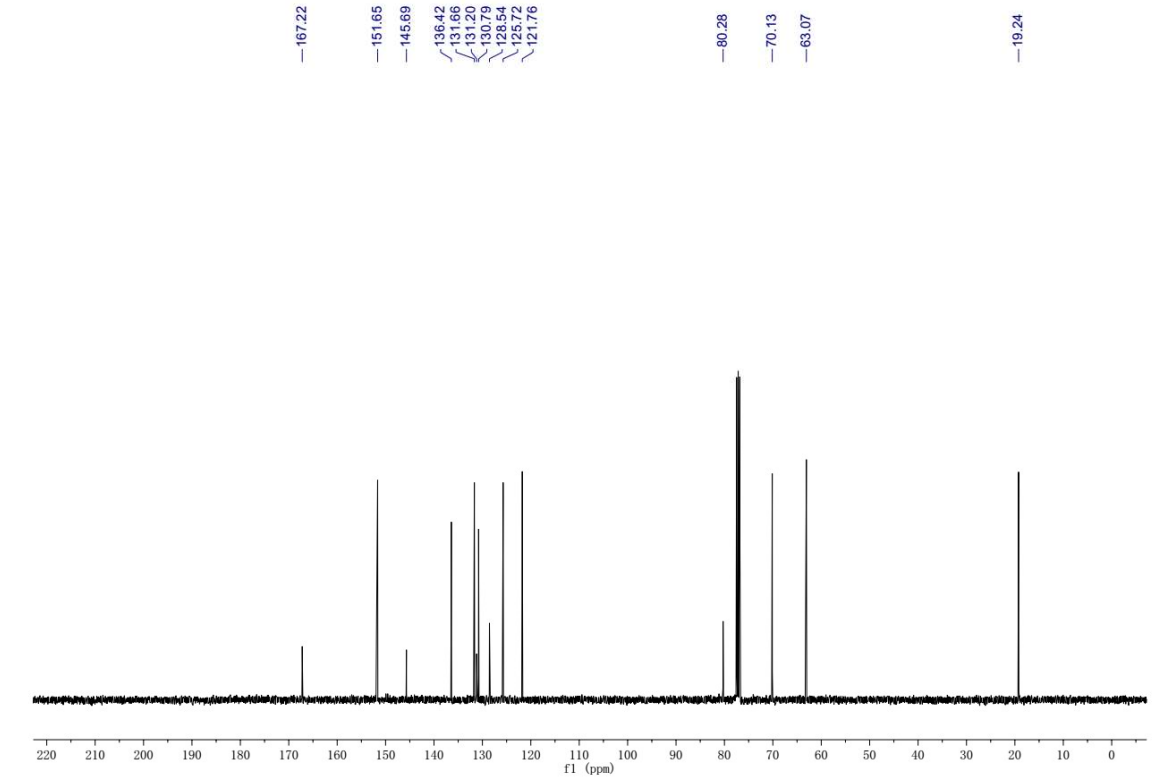

168.91
151.47
150.13
145.61
132.79
129.58
127.79
126.75
125.37
120.44
77.16 CDCl3
52.80
25.32
14.22
f1 (ppm)

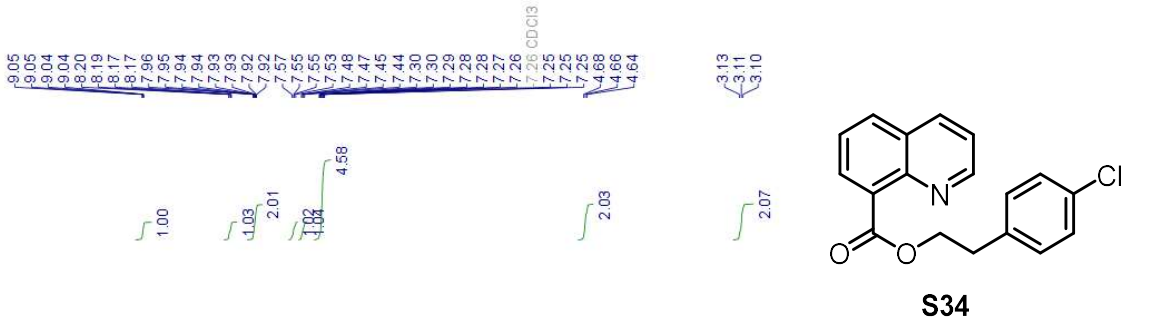


S32

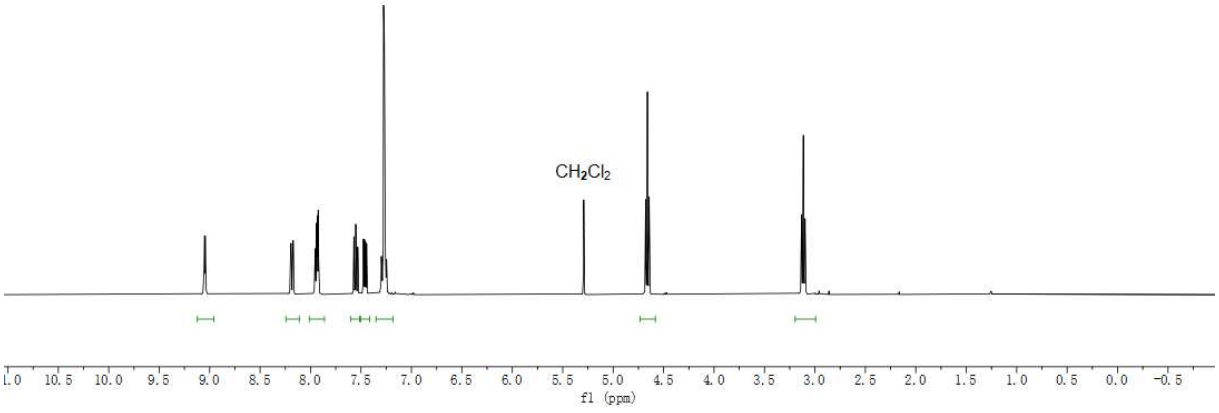


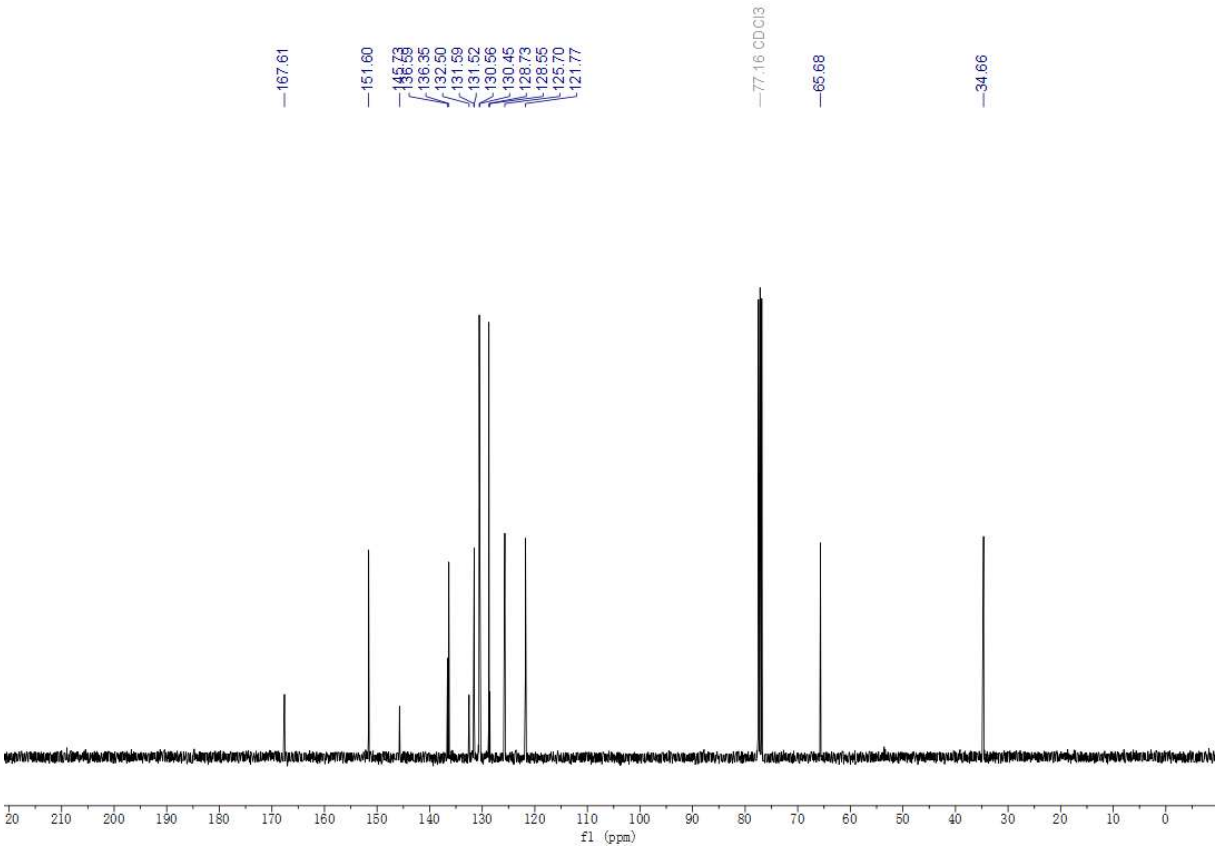


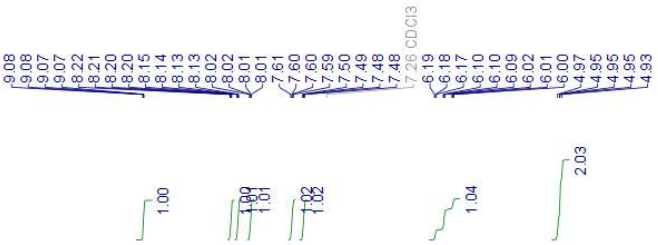


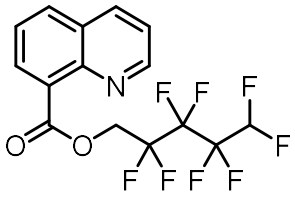

9.05
9.05
9.04
9.04
8.20
8.19
8.17
8.17
7.96
7.95
7.94
7.94
7.93
7.93
7.92
7.92
7.57
7.55
7.55
7.53
7.48
7.47
7.45
7.44
7.30
7.29
7.28
7.28
7.27
7.26
7.25 CDCl3
7.25
7.25
4.68
4.66
4.64
3.13
3.11
3.10
1.00
1.03
2.01
4.58
2.03
2.07
N
Cl
O
O

S34

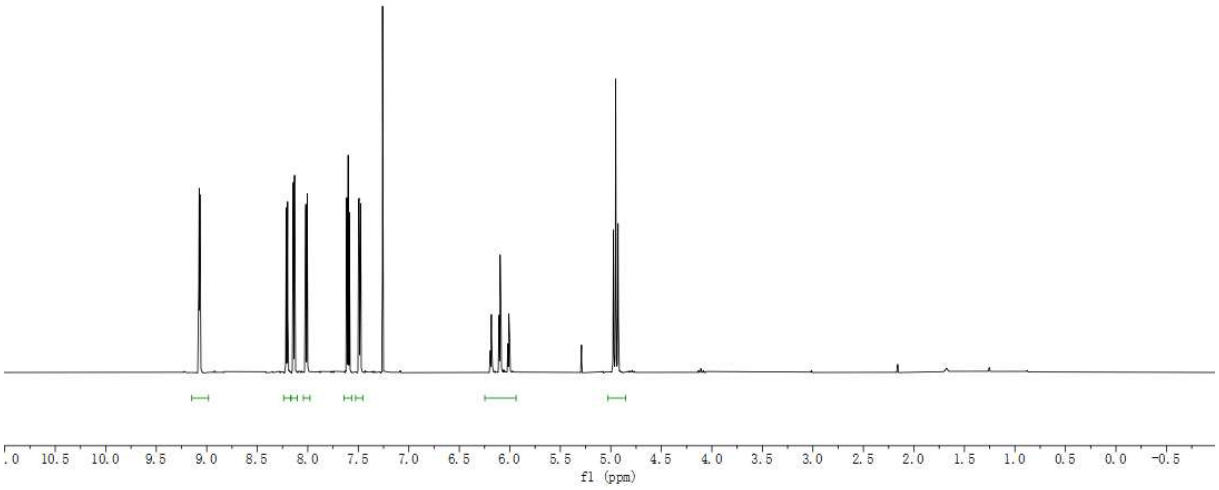

CH2Cl2
f1 (ppm)

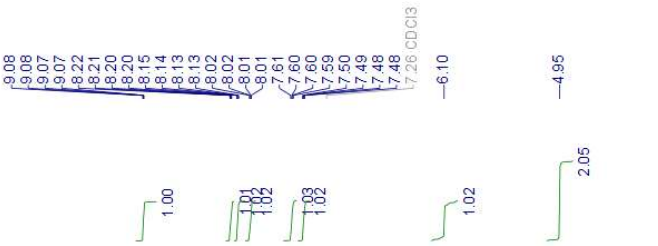

167.61
151.60
145.73
136.58
136.35
132.50
131.59
131.52
130.56
130.45
128.73
128.55
125.70
121.77
77.16 CDCl3
65.68
34.66
f1 (ppm)


9.08
9.08
9.07
9.07
8.22
8.21
8.20
8.20
8.15
8.14
8.13
8.13
8.02
8.02
8.01
8.01
7.61
7.60
7.60
7.59
7.50
7.49
7.48
7.48
7.26 CDCl3
6.19
6.18
6.17
6.10
6.10
6.09
6.02
6.01
6.00
4.97
4.95
4.95
4.93
1.00
1.09
1.01
1.01
1.02
1.02
1.04
2.03


N
F
F
F
F
O
O
F
F
F
F

S35


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
f1 (ppm)


9.08
9.08
9.07
9.07
8.22
8.21
8.20
8.20
8.15
8.14
8.13
8.13
8.02
8.02
8.01
8.01
7.61
7.60
7.60
7.59
7.50
7.49
7.48
7.48
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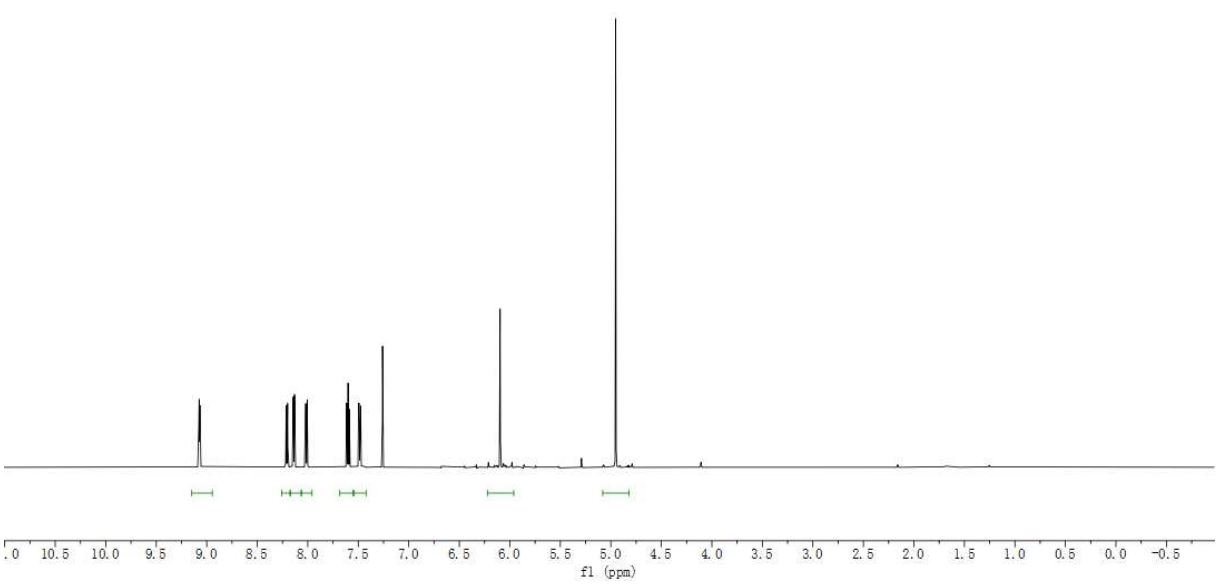
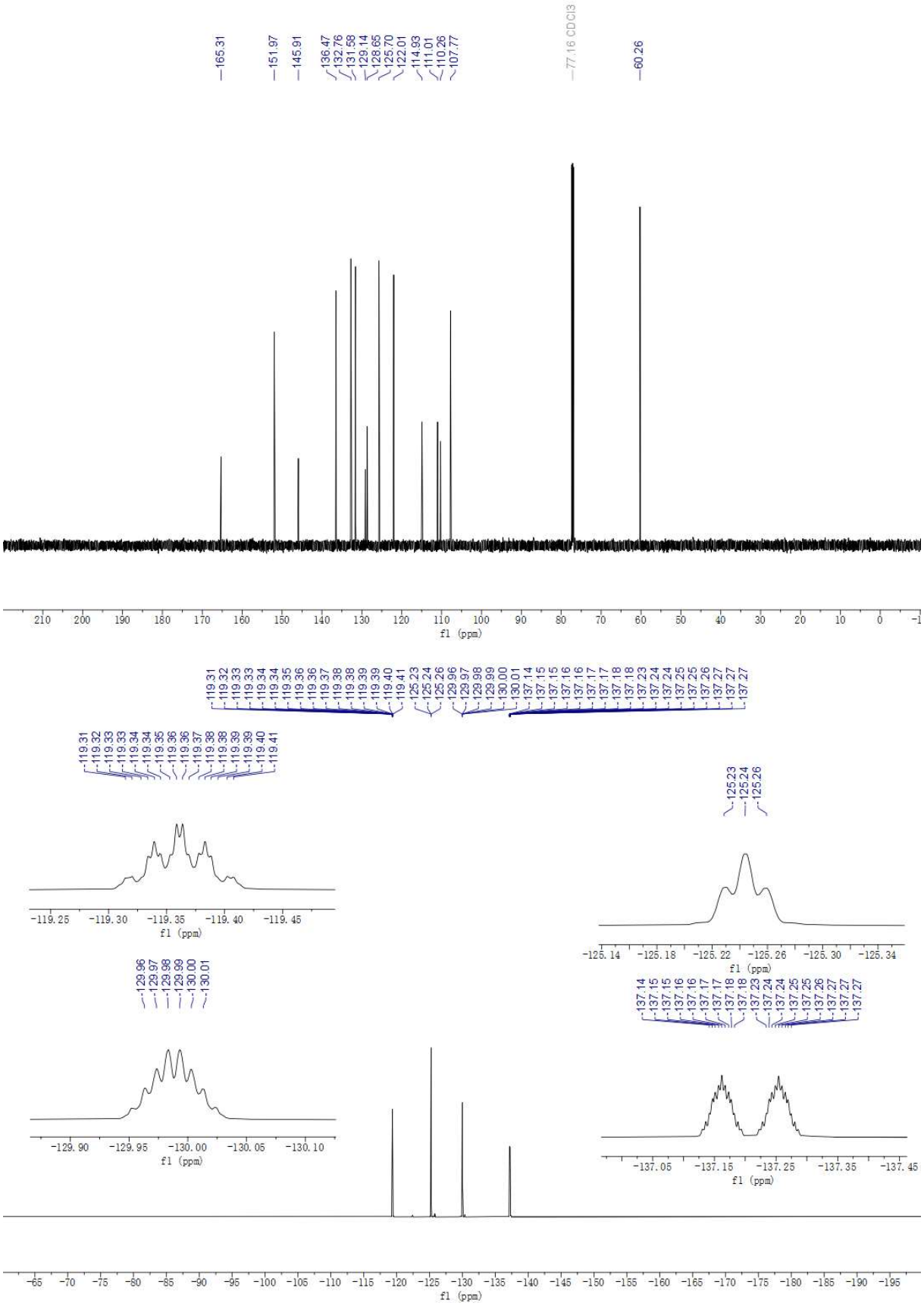
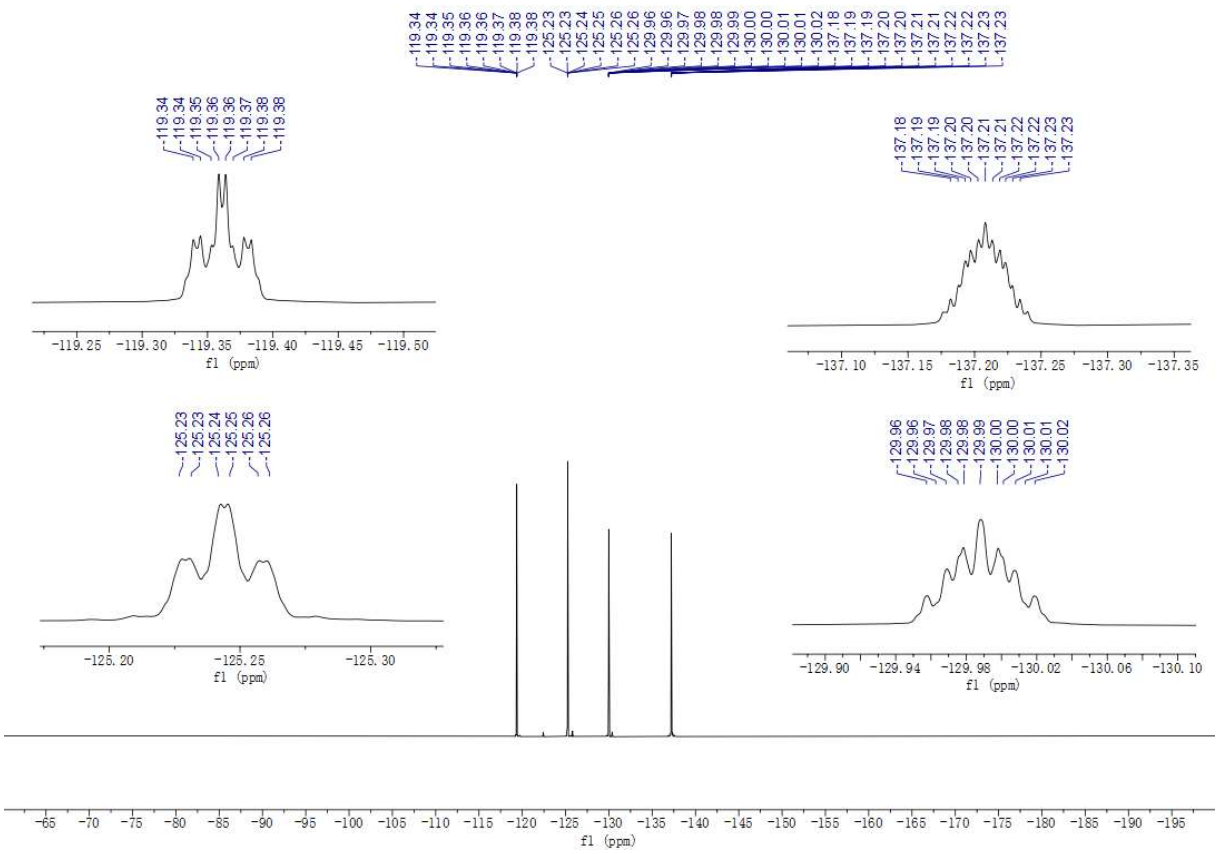
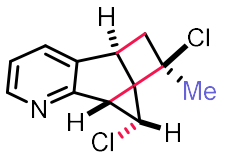
1.02
1.02
1.03
1.02
1.02
2.05

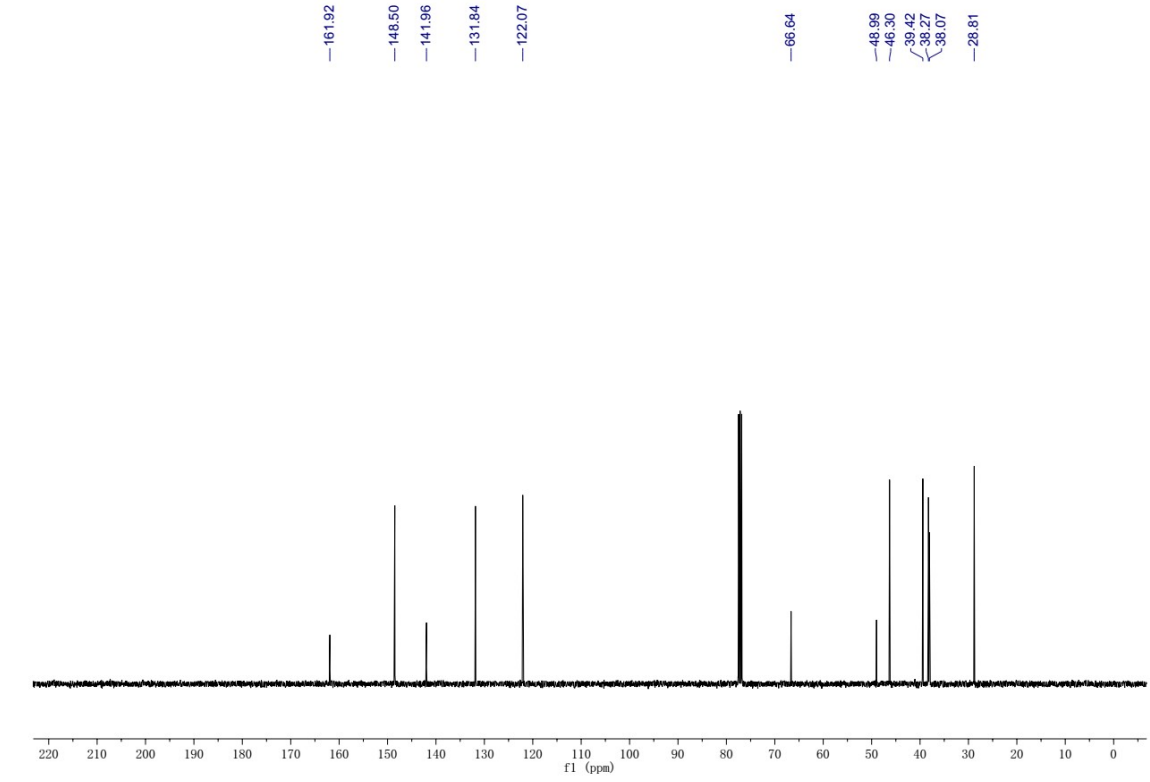

10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

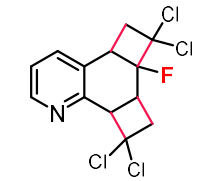

165.31
151.97
145.91
136.47
132.76
131.58
129.14
128.65
125.70
122.01
114.93
111.01
110.26
107.77
77.16 CDCl3
60.26
f1 (ppm)


119.34
119.34
119.35
119.36
119.36
119.37
119.38
119.38
125.23
125.23
125.24
125.25
125.26
125.26
129.96
129.97
129.98
129.98
129.99
130.00
130.00
130.01
130.01
130.02
137.18
137.19
137.19
137.20
137.20
137.21
137.21
137.22
137.22
137.23
137.23
-119.25 -119.30 -119.35 -119.40 -119.45 -119.50
f1 (ppm)
-137.10 -137.15 -137.20 -137.25 -137.30 -137.35
f1 (ppm)
-125.20 -125.25 -125.30
f1 (ppm)
-129.90 -129.94 -129.98 -130.02 -130.06 -130.10
f1 (ppm)
-65 -70 -75 -80 -85 -90 -95 -100 -105 -110 -115 -120 -125 -130 -135 -140 -145 -150 -155 -160 -165 -170 -175 -180 -185 -190 -195
f1 (ppm)

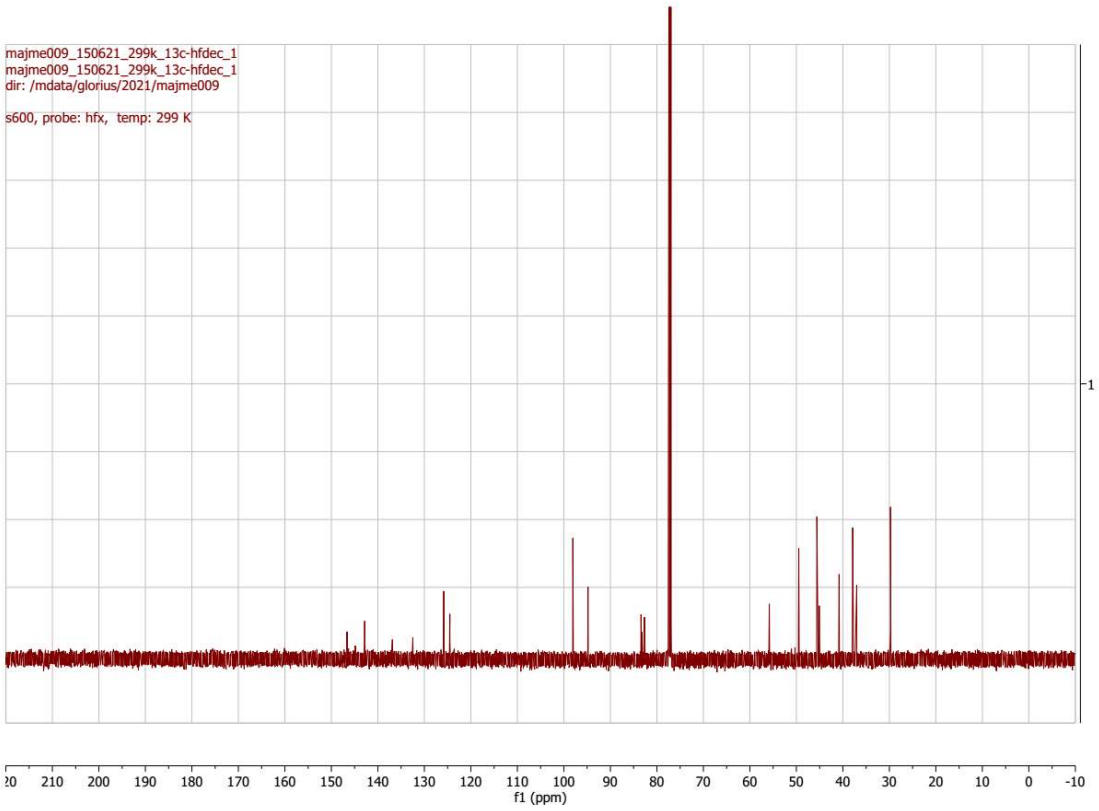


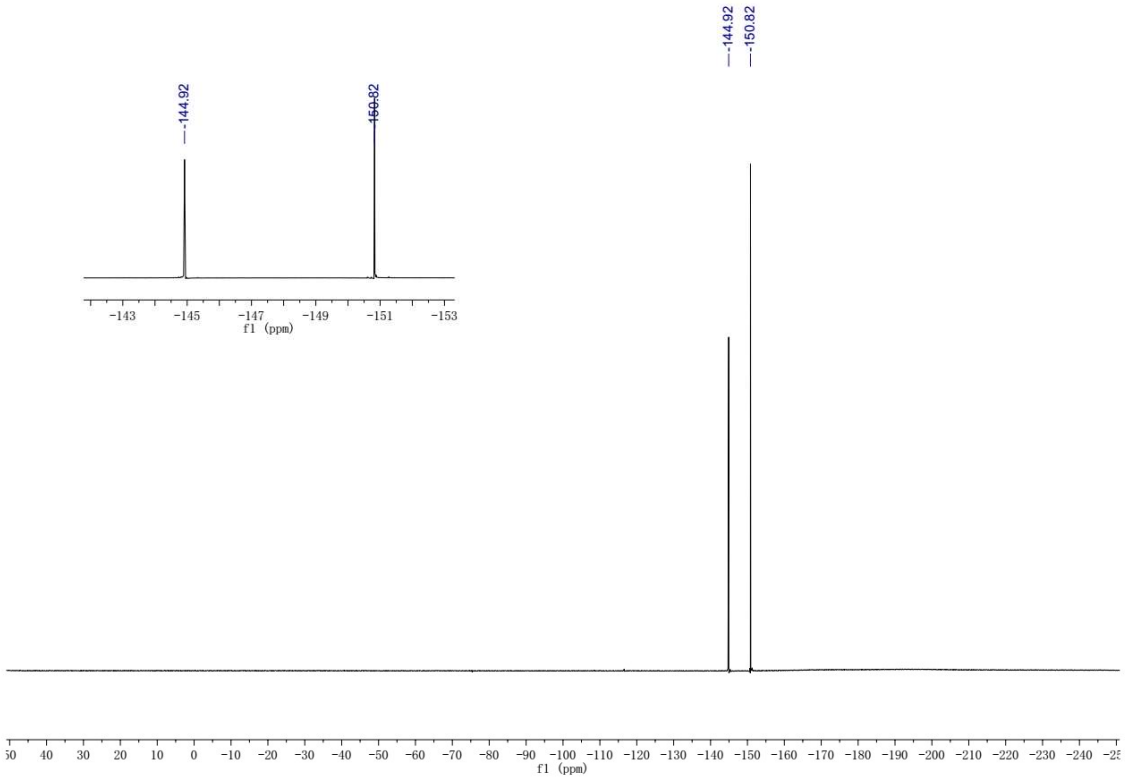
3a, 78% yield, 92:8 d.r.

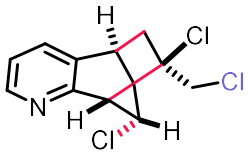




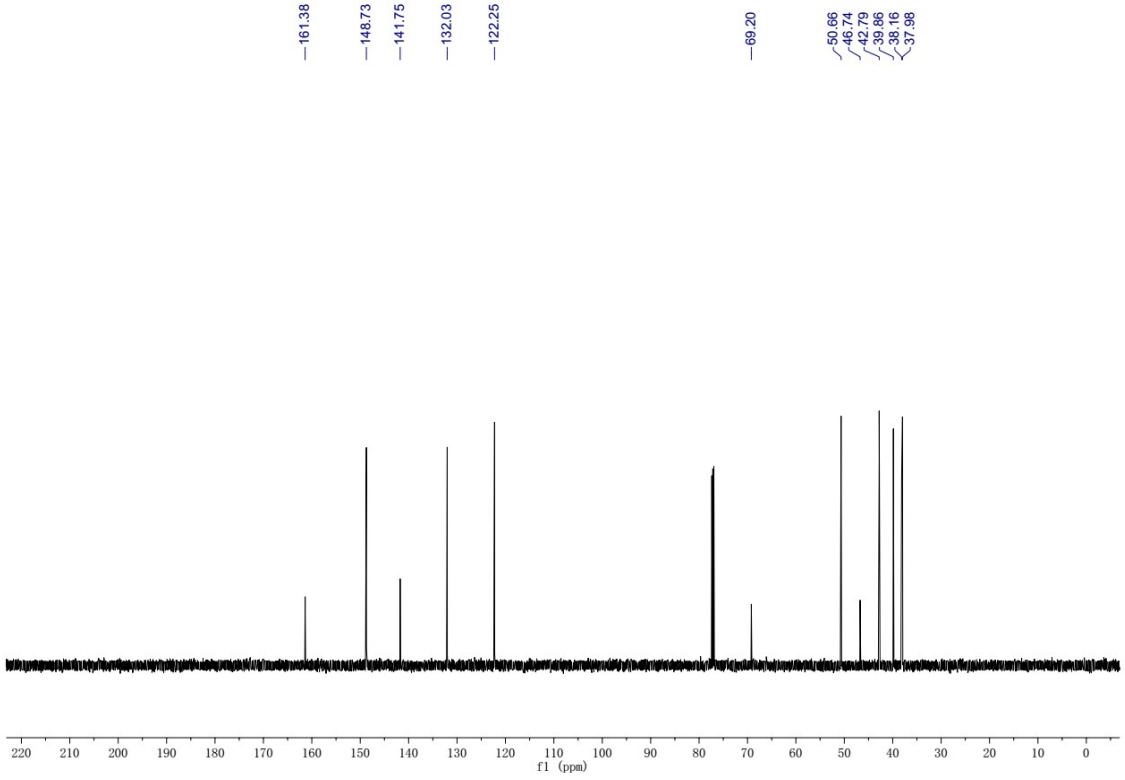
3b, 38% yield, 60:40 d.r.

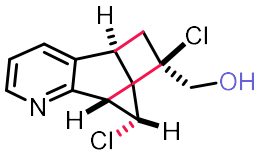



-144.92
-150.82
-144.92
-150.82
-143
-145
-147
-149
-151
-153
f1 (ppm)
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200
-210
-220
-230
-240
f1 (ppm)

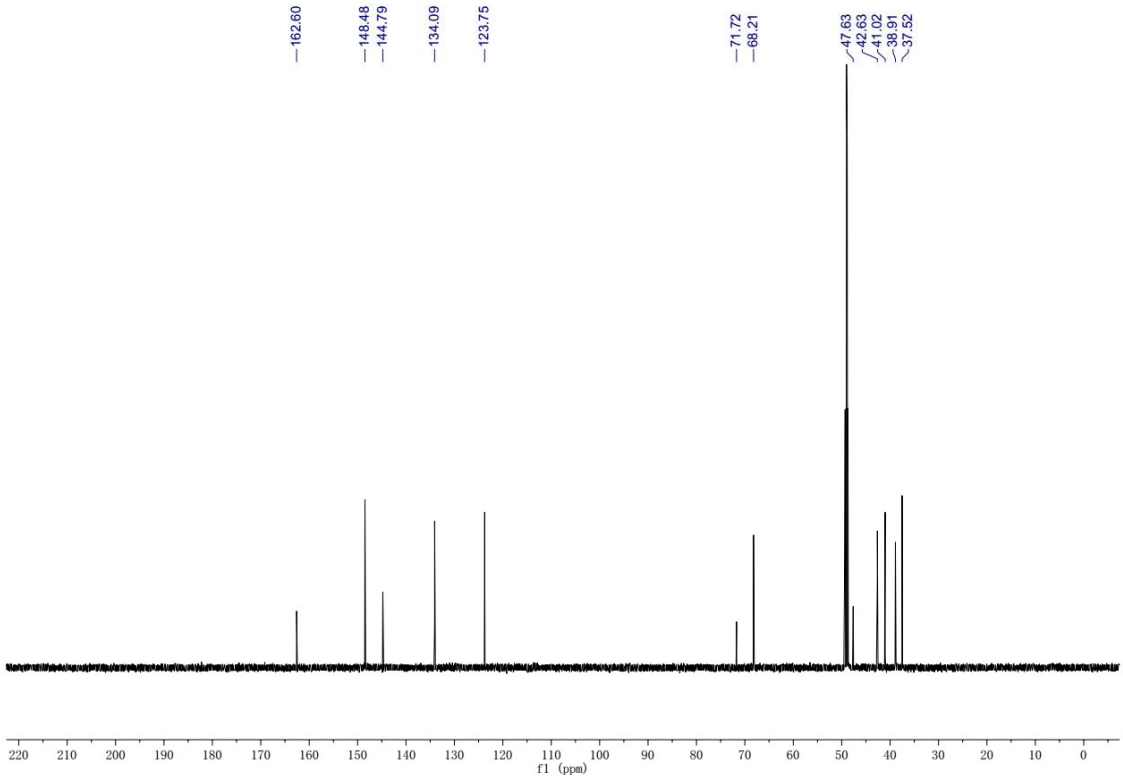


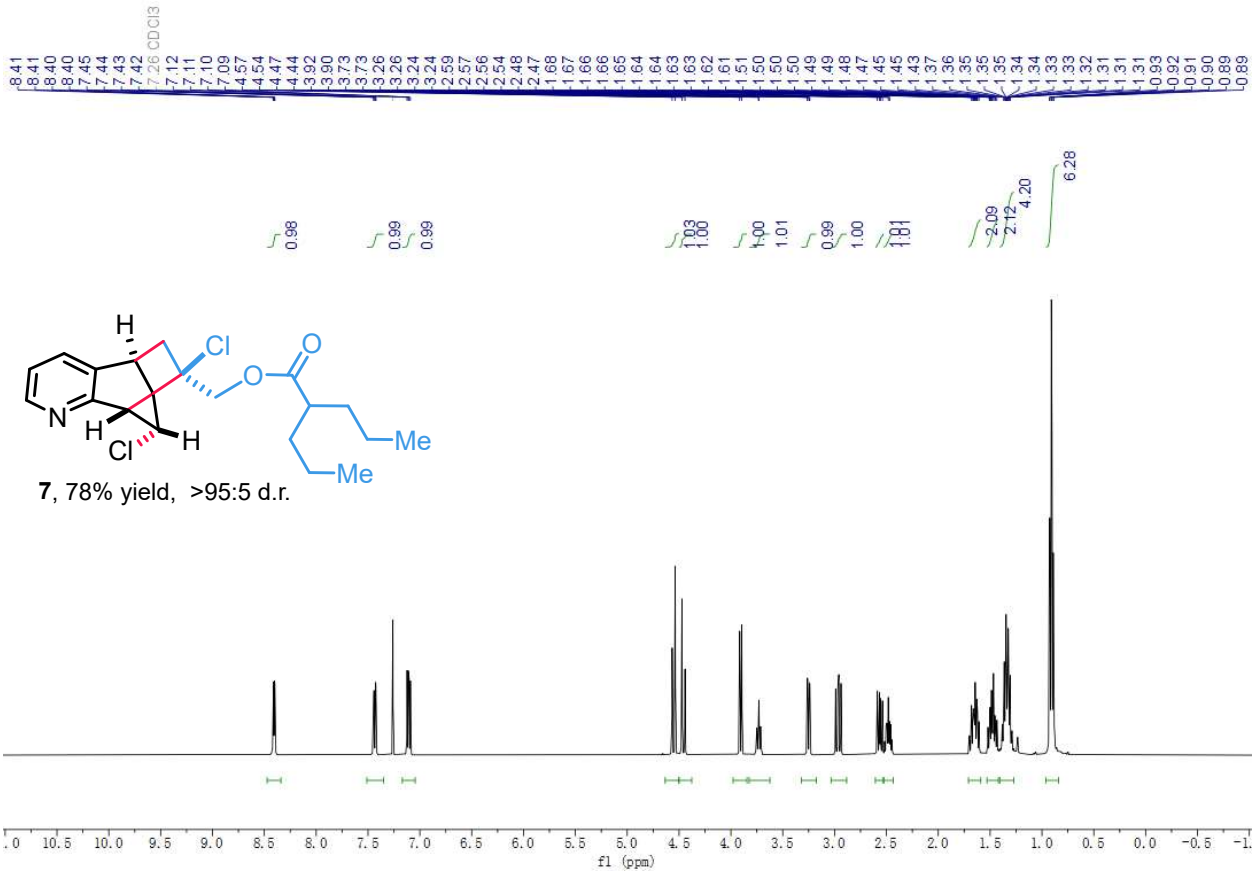
5, 84% yield, 92:8 d.r.



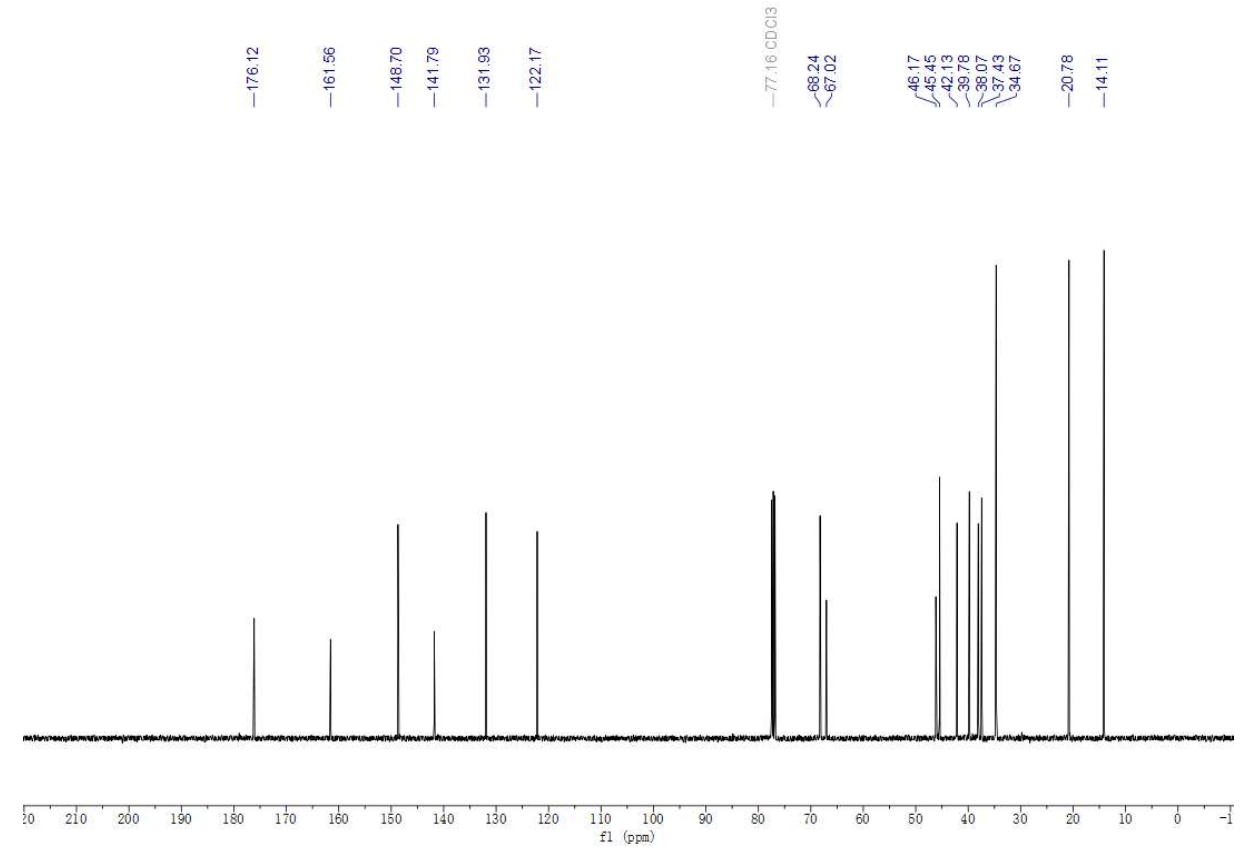


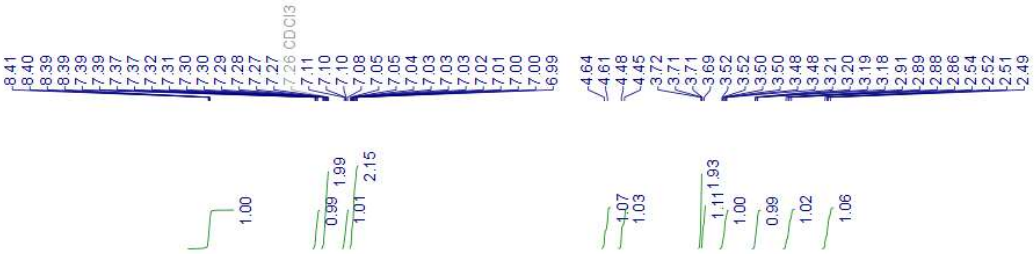
6, 80% yield, >95:5 d.r.

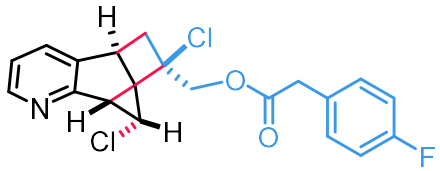




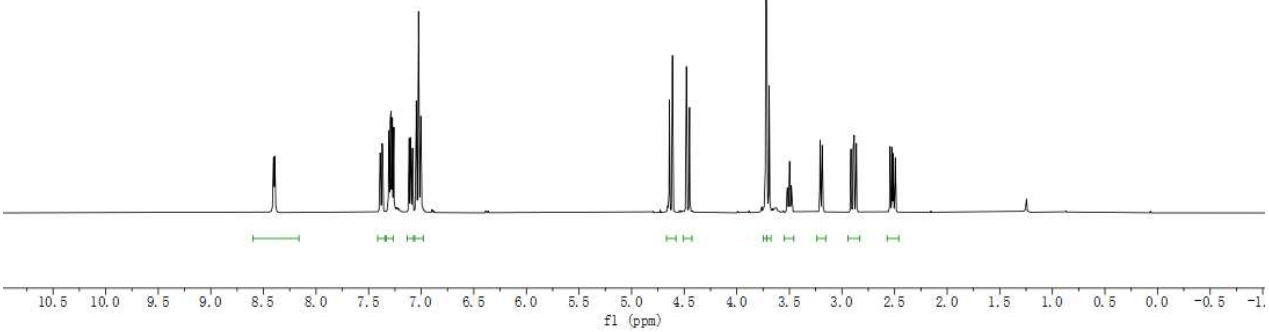
7, 78% yield, >95:5 d.r.

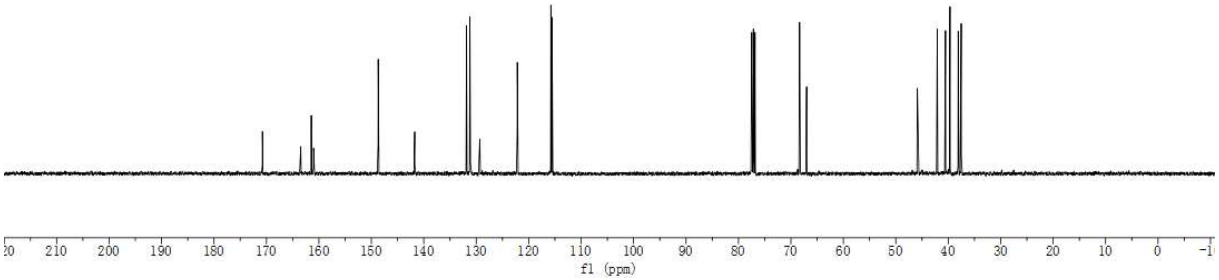


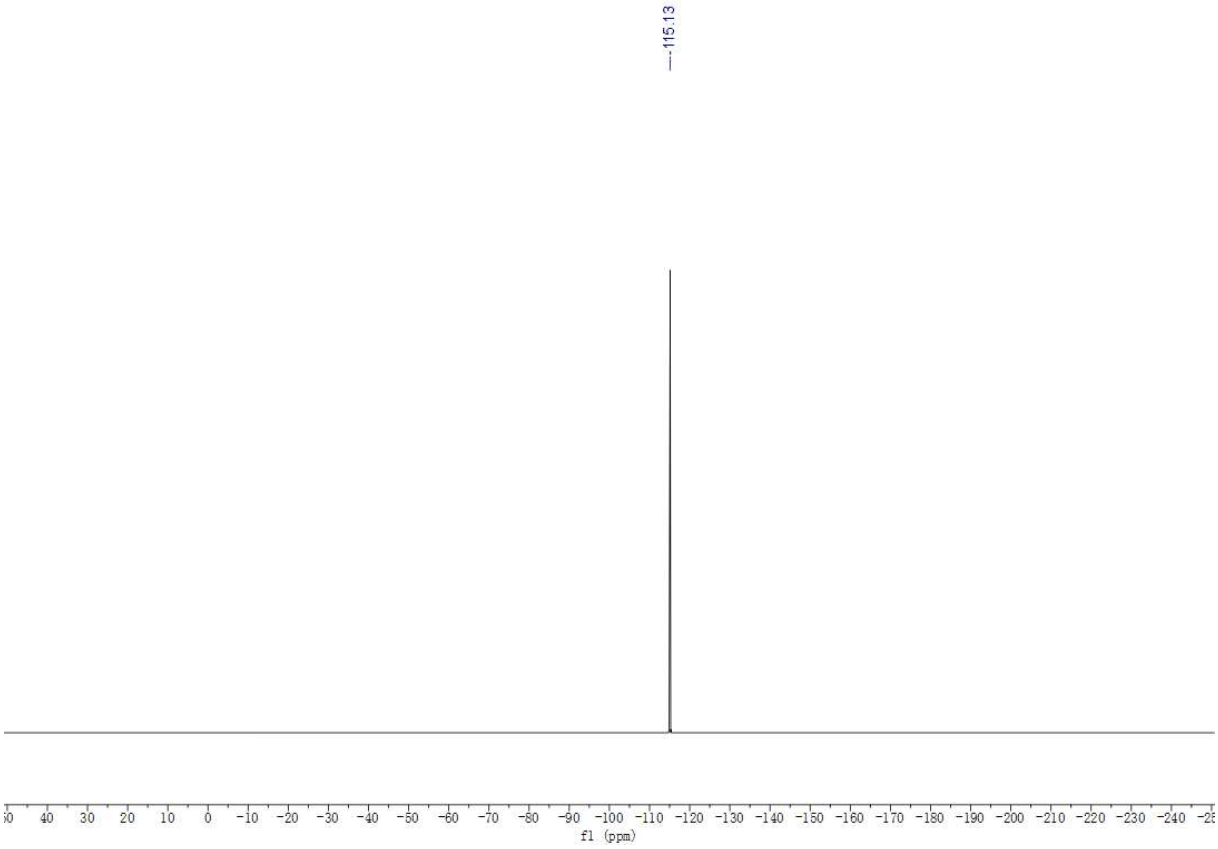


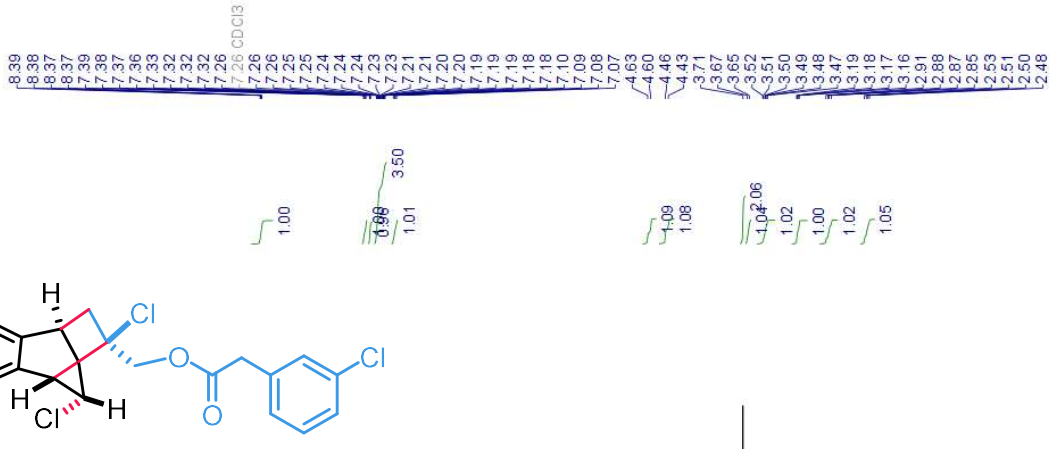


8, 96% yield, >95:5 d.r.

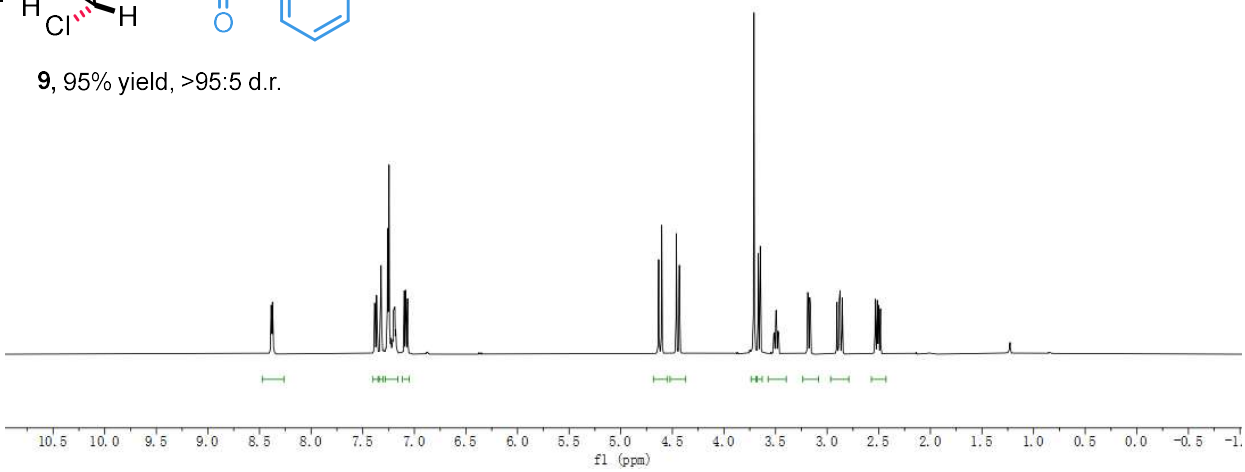


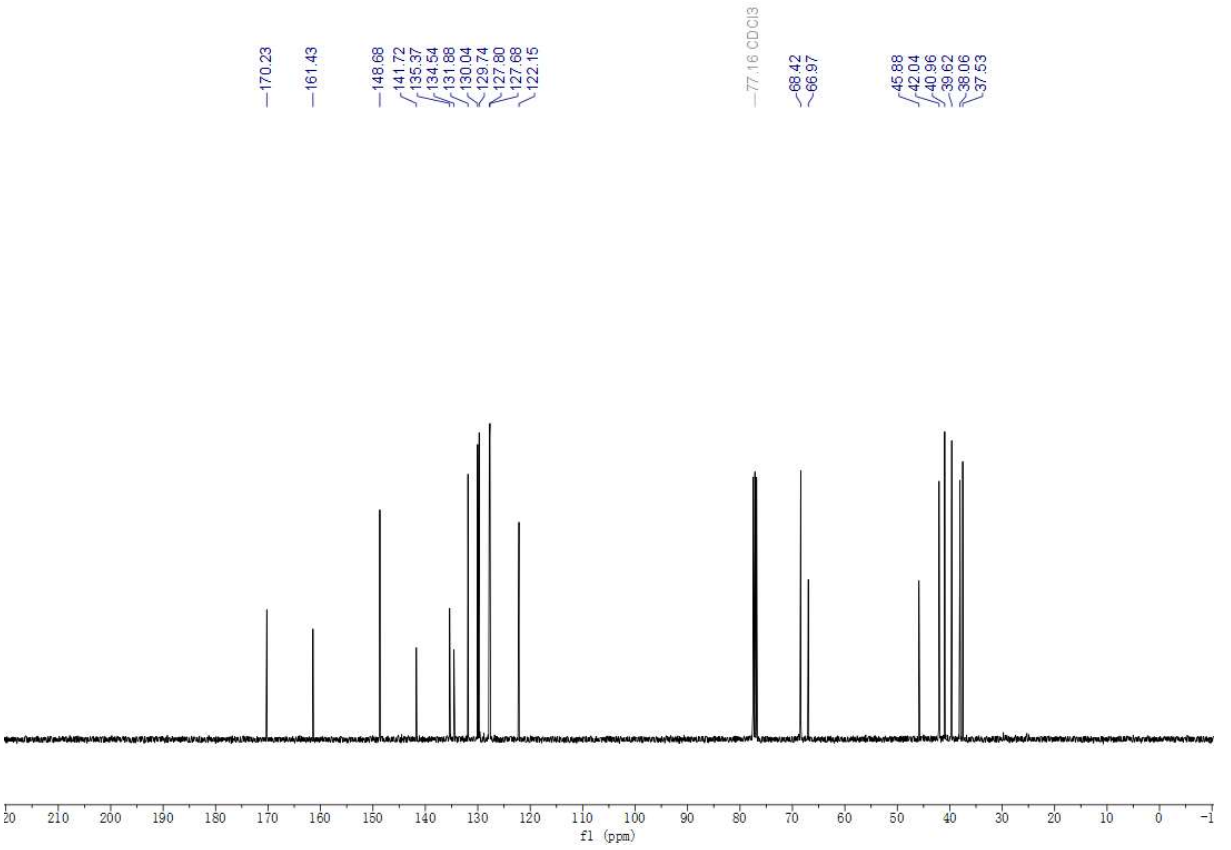


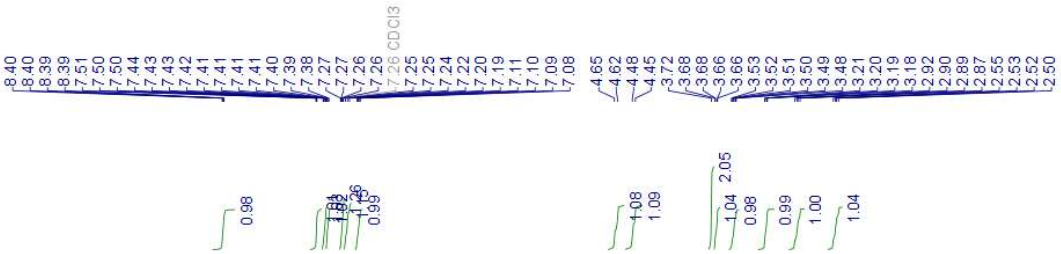

-115.13
40 30 20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210 -220 -230 -240
f1 (ppm)

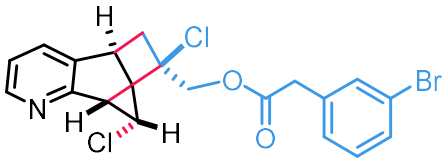


9, 95% yield, >95:5 d.r.

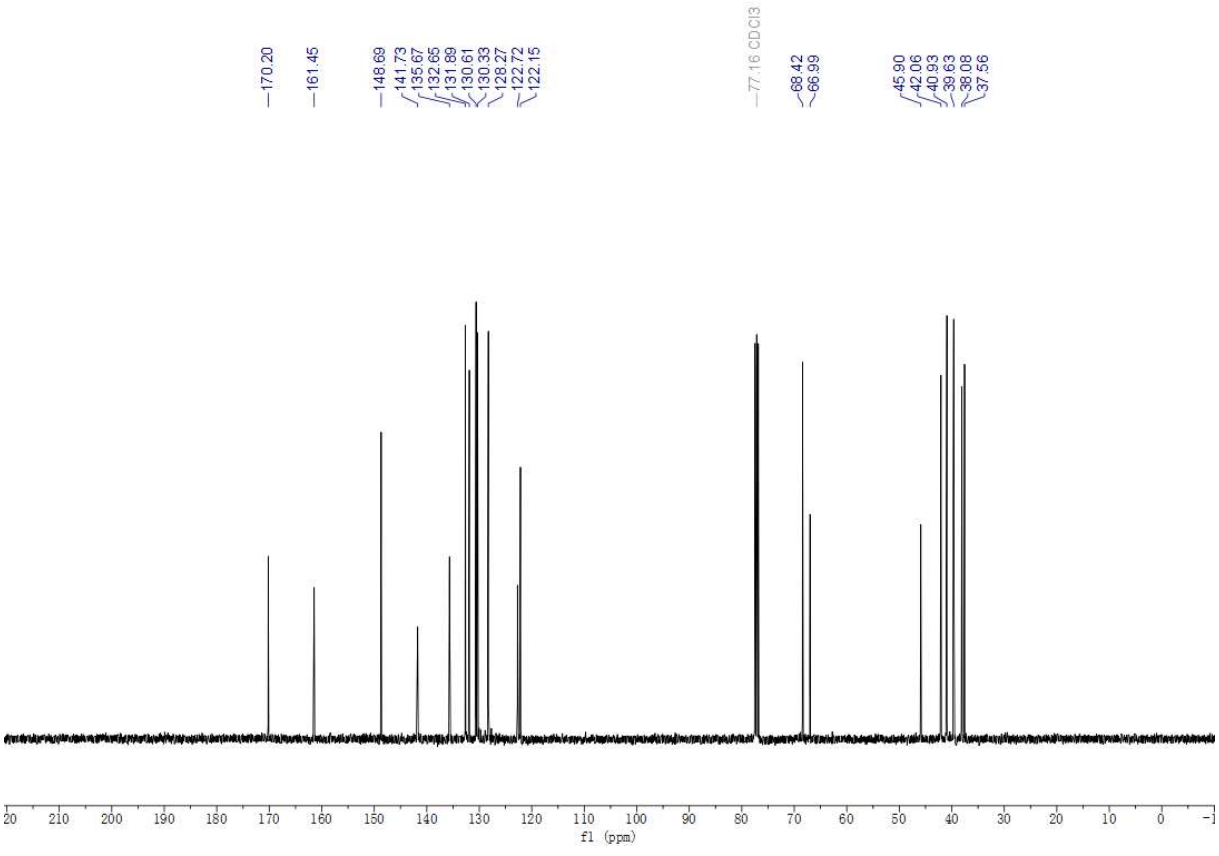


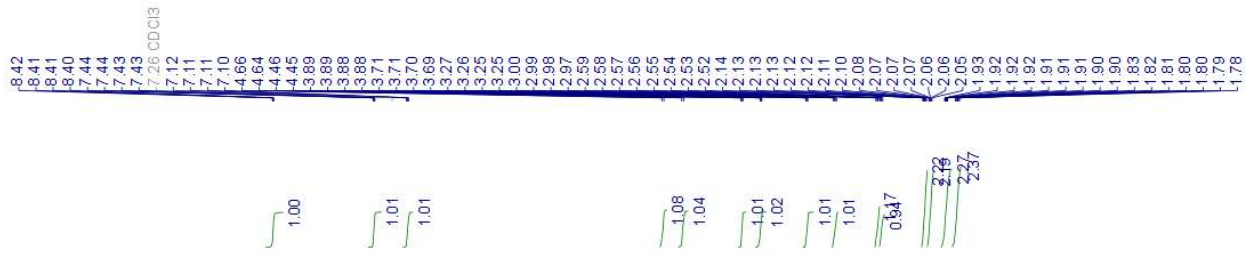


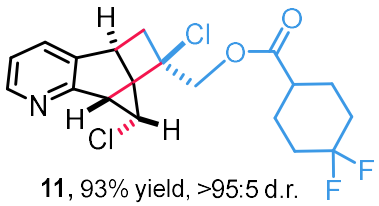




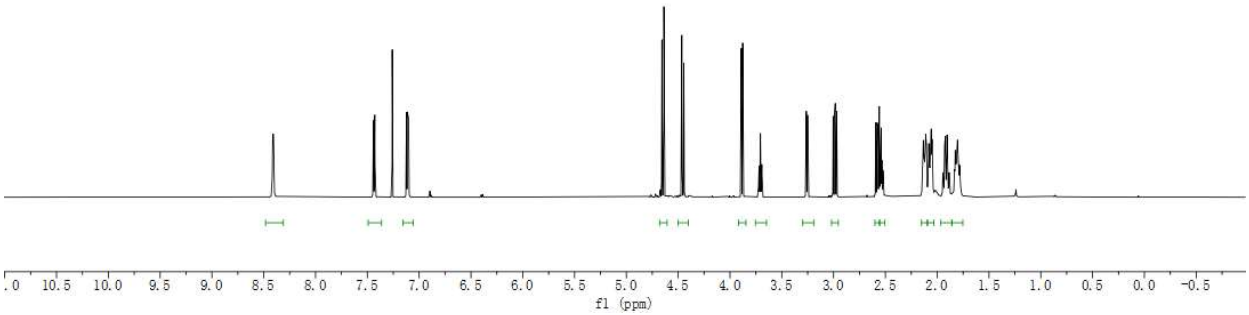
10, 92% yield, >95:5 d.r.

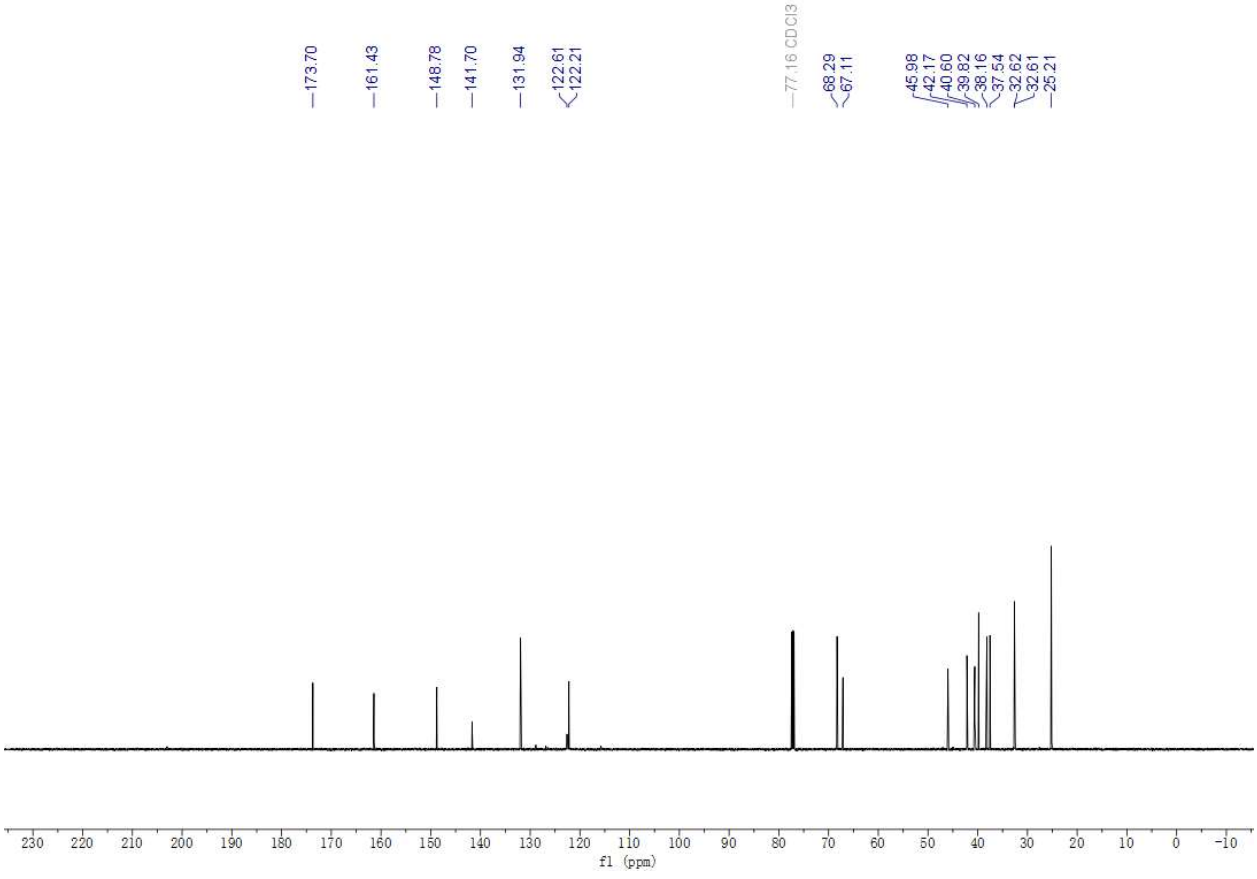


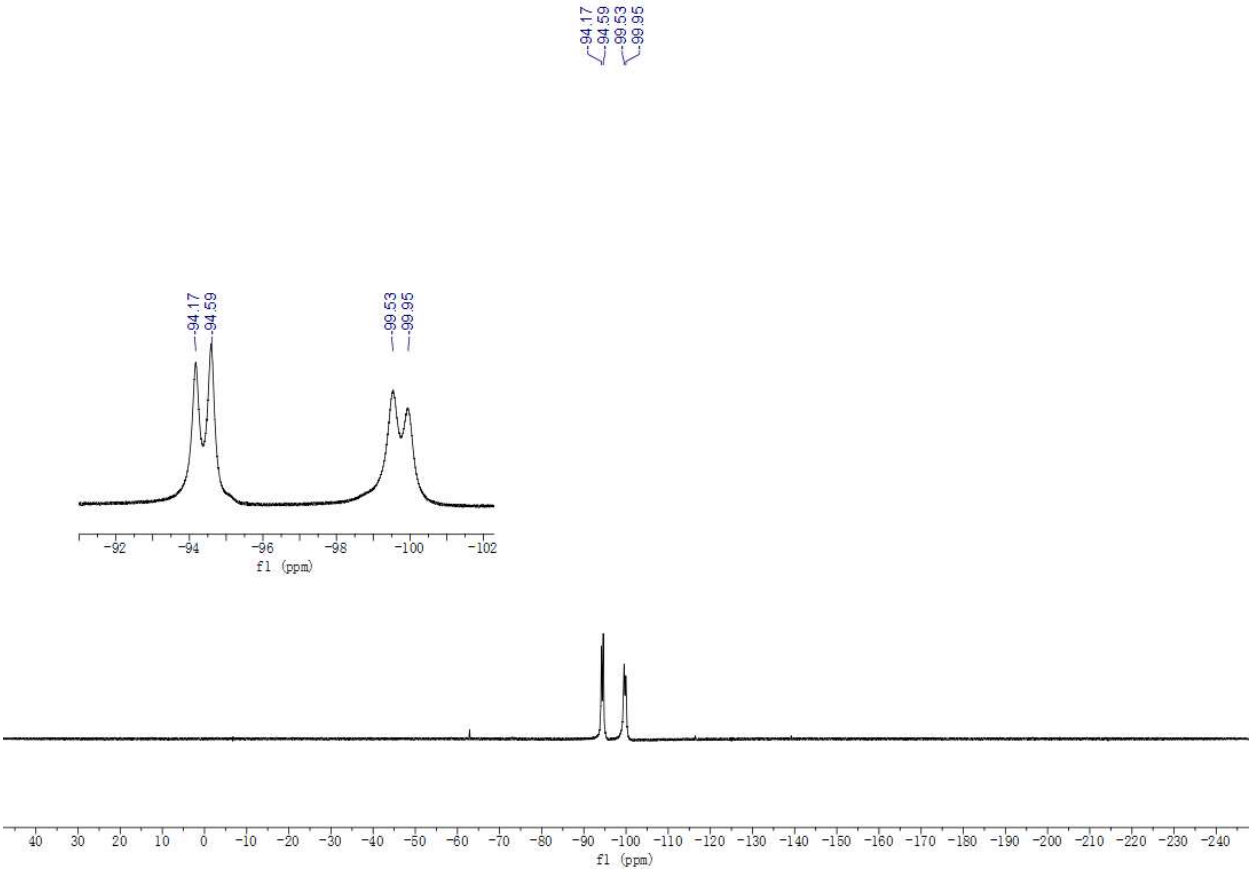


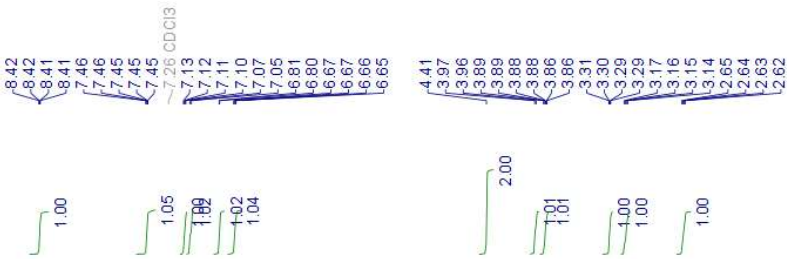


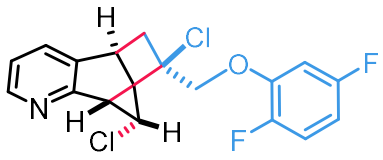
11, 93% yield, >95:5 d.r.



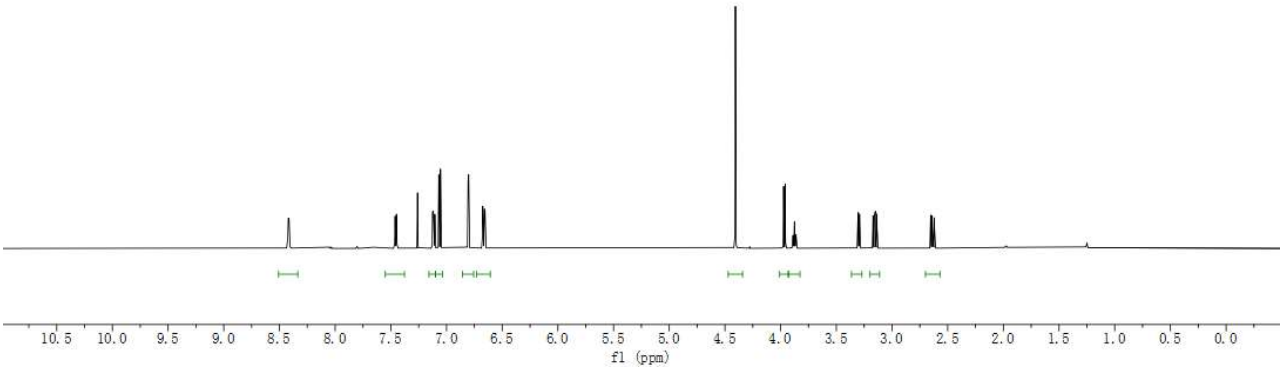


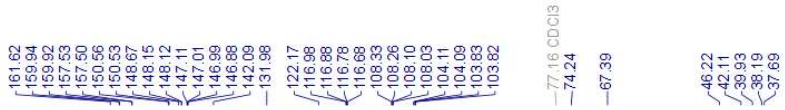

-94.17
-94.59
-99.53
-99.95
-92
-94
-96
-98
-100
-102
f1 (ppm)
40 30 20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210 -220 -230 -240
f1 (ppm)

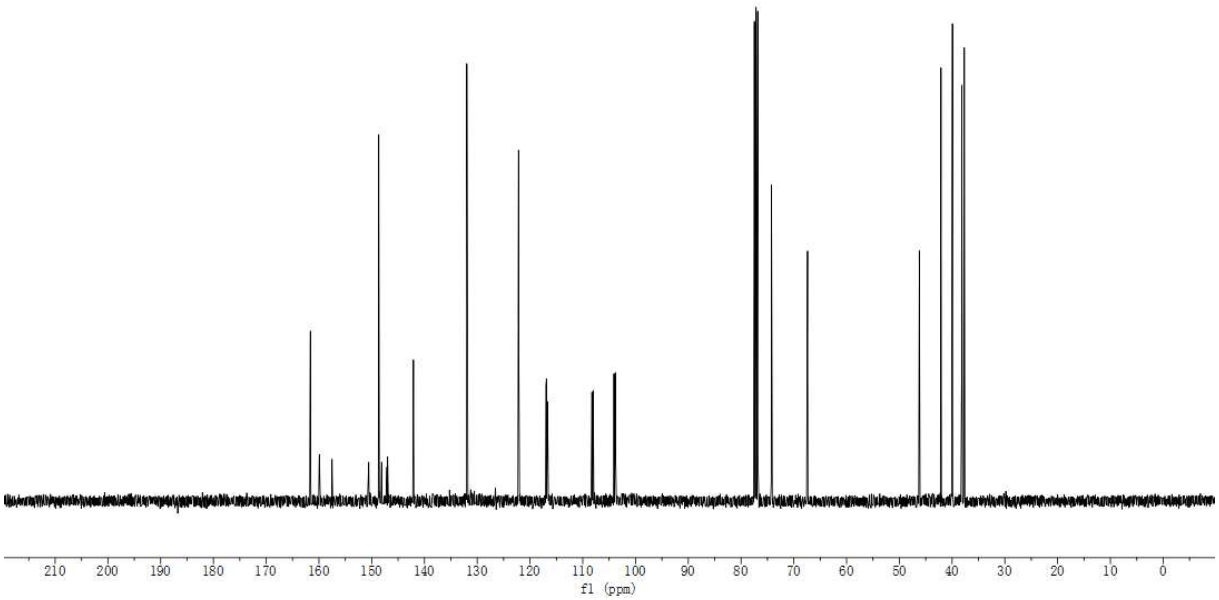


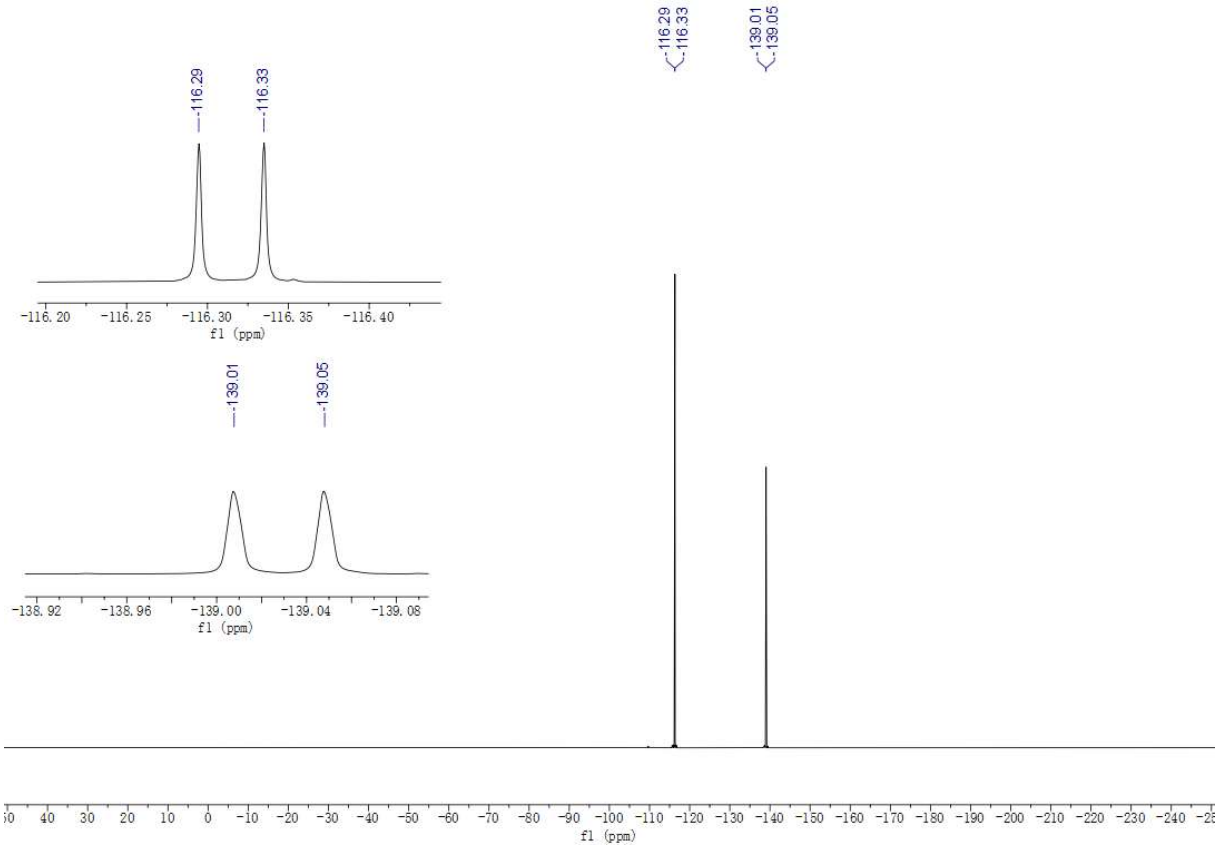


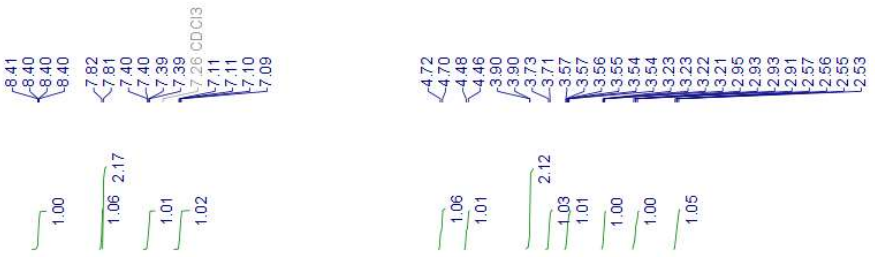
12, 75% yield, >95:5 d.r.

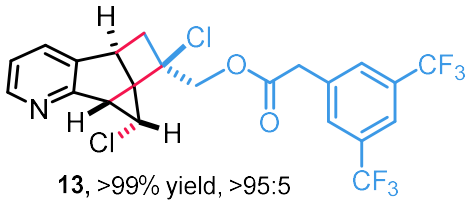




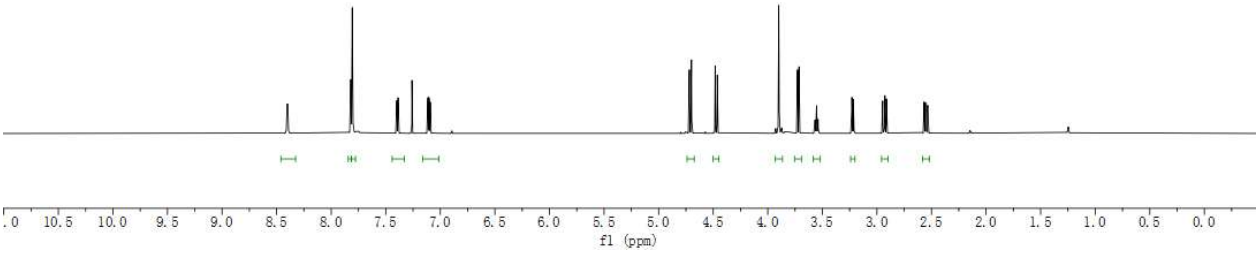


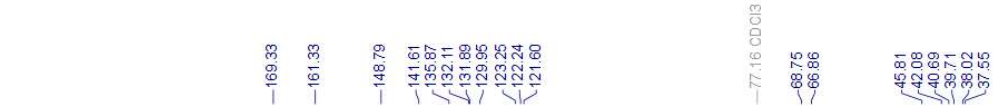

-116.29
-116.33
-116.20
-116.25
-116.30
-116.35
-116.40
f1 (ppm)
-139.01
-139.05
-138.92
-138.96
-139.00
-139.04
-139.08
f1 (ppm)
-116.29
-116.33
-139.01
-139.05
f1 (ppm)

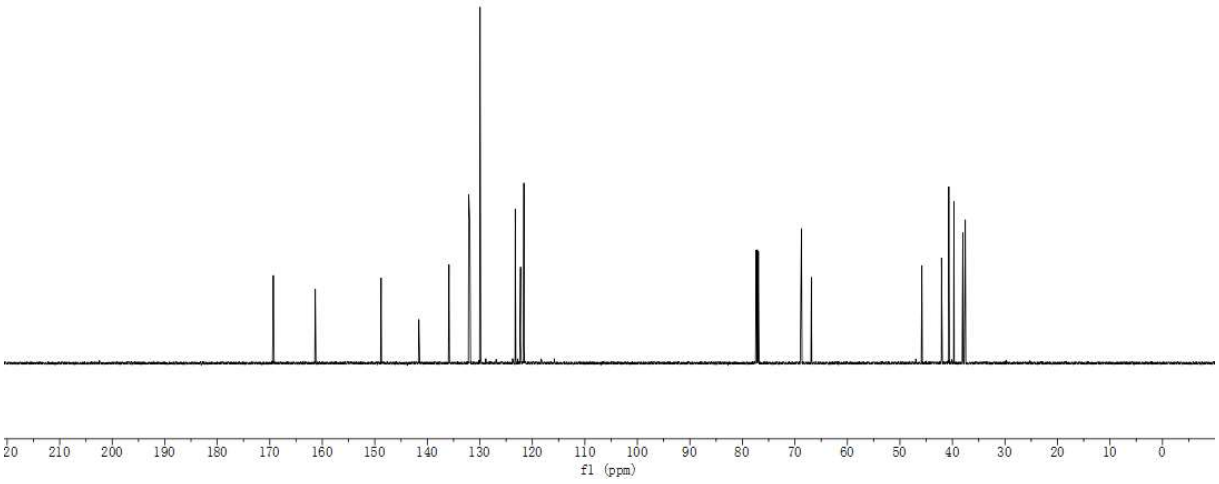


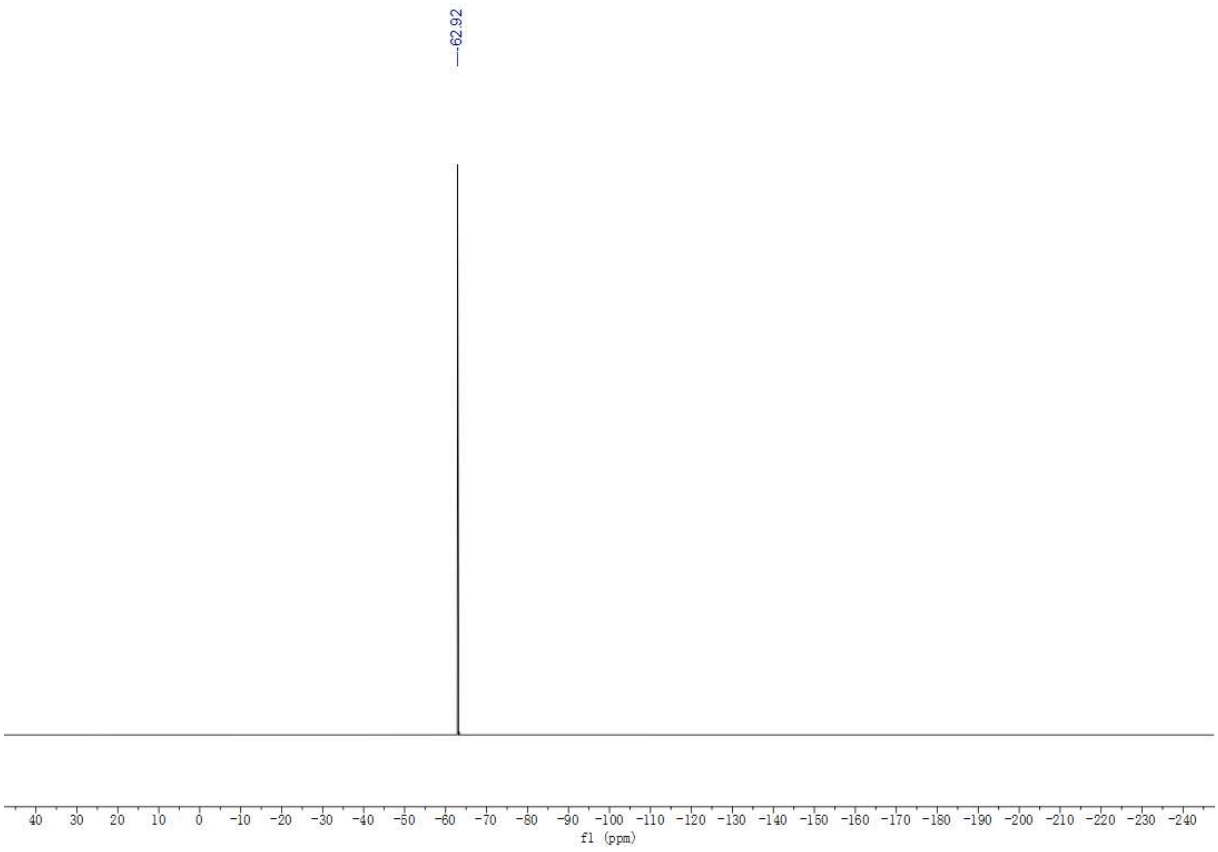


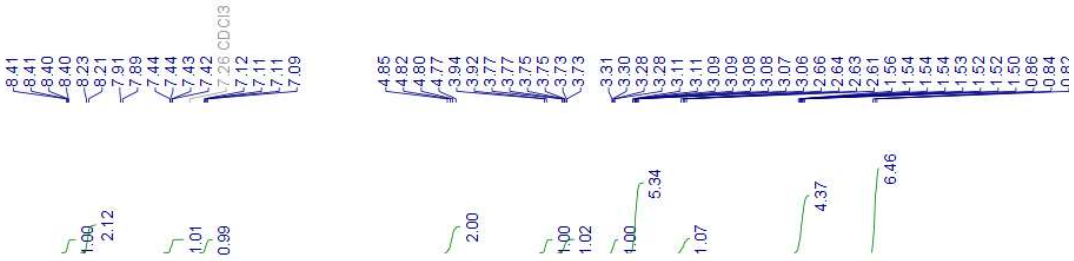
13, >99% yield, >95:5

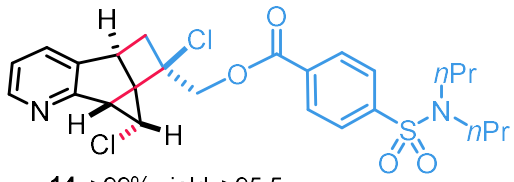




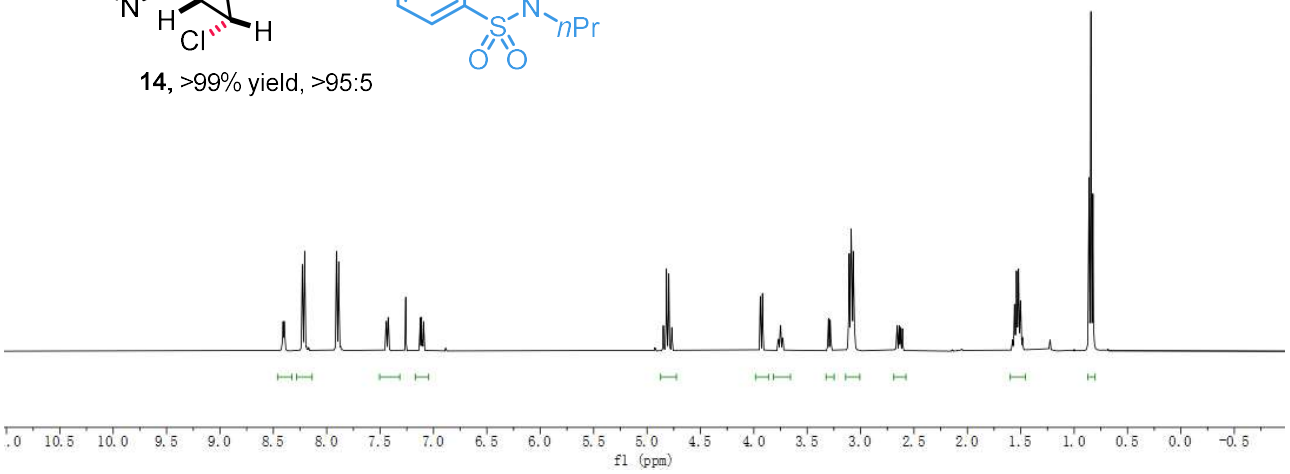


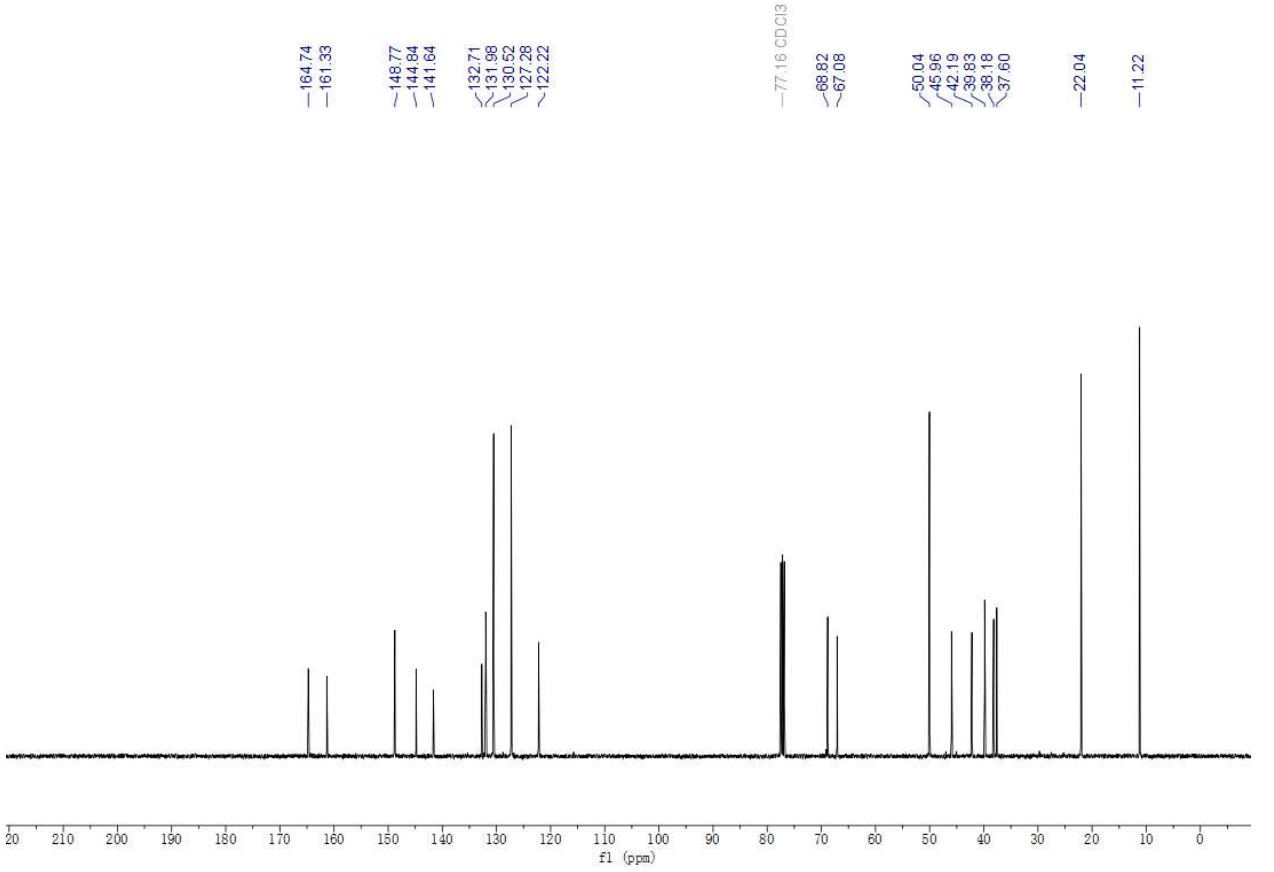

-62.92
40 30 20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210 -220 -230 -240
f1 (ppm)

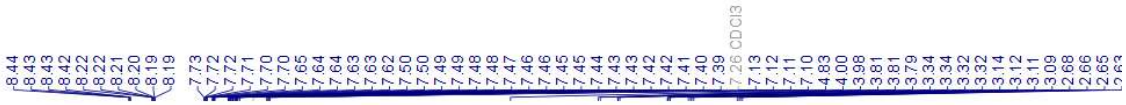


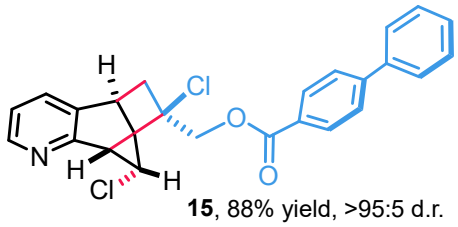


14, >99% yield, >95:5

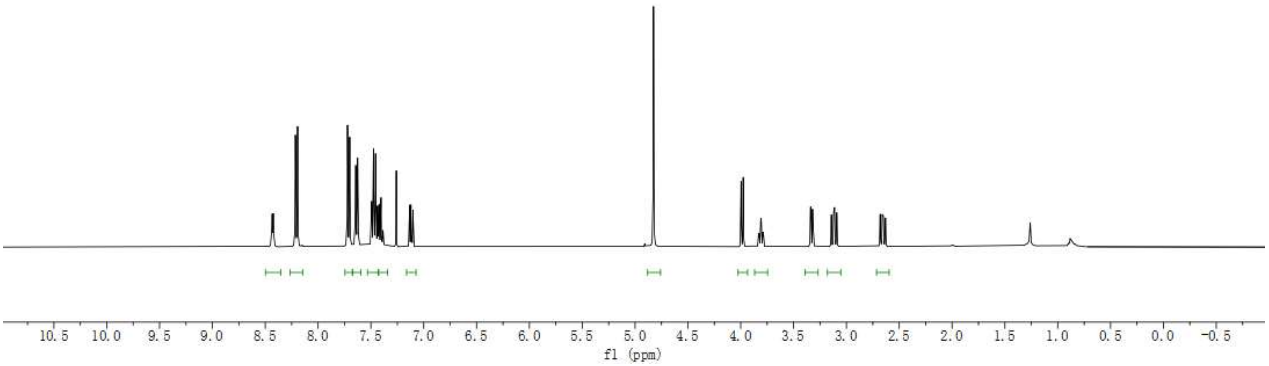


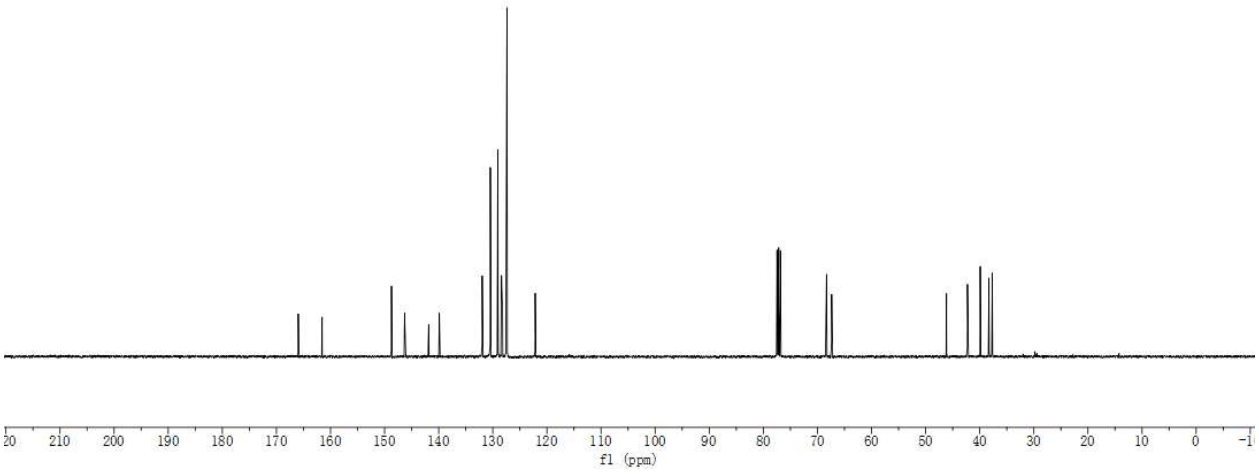


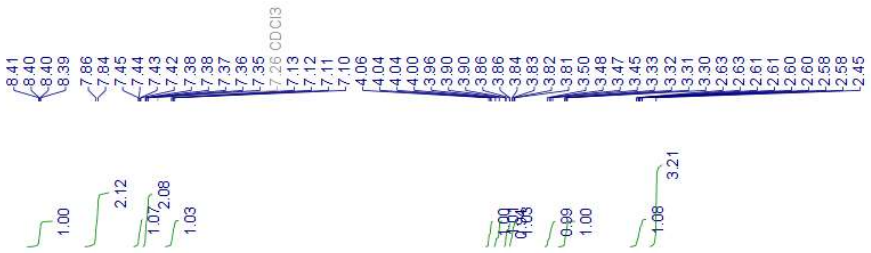


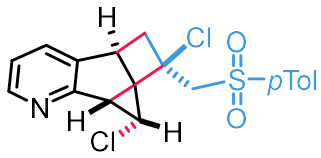


15, 88% yield, >95:5 d.r.

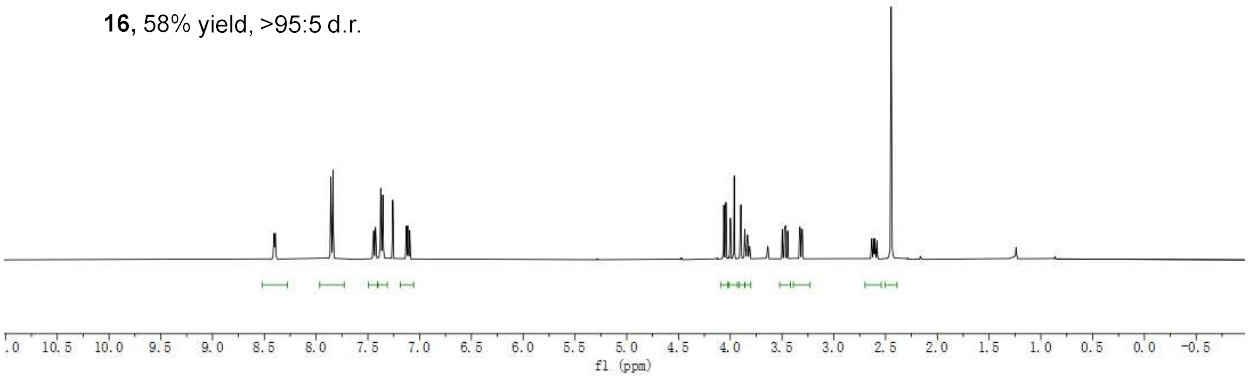


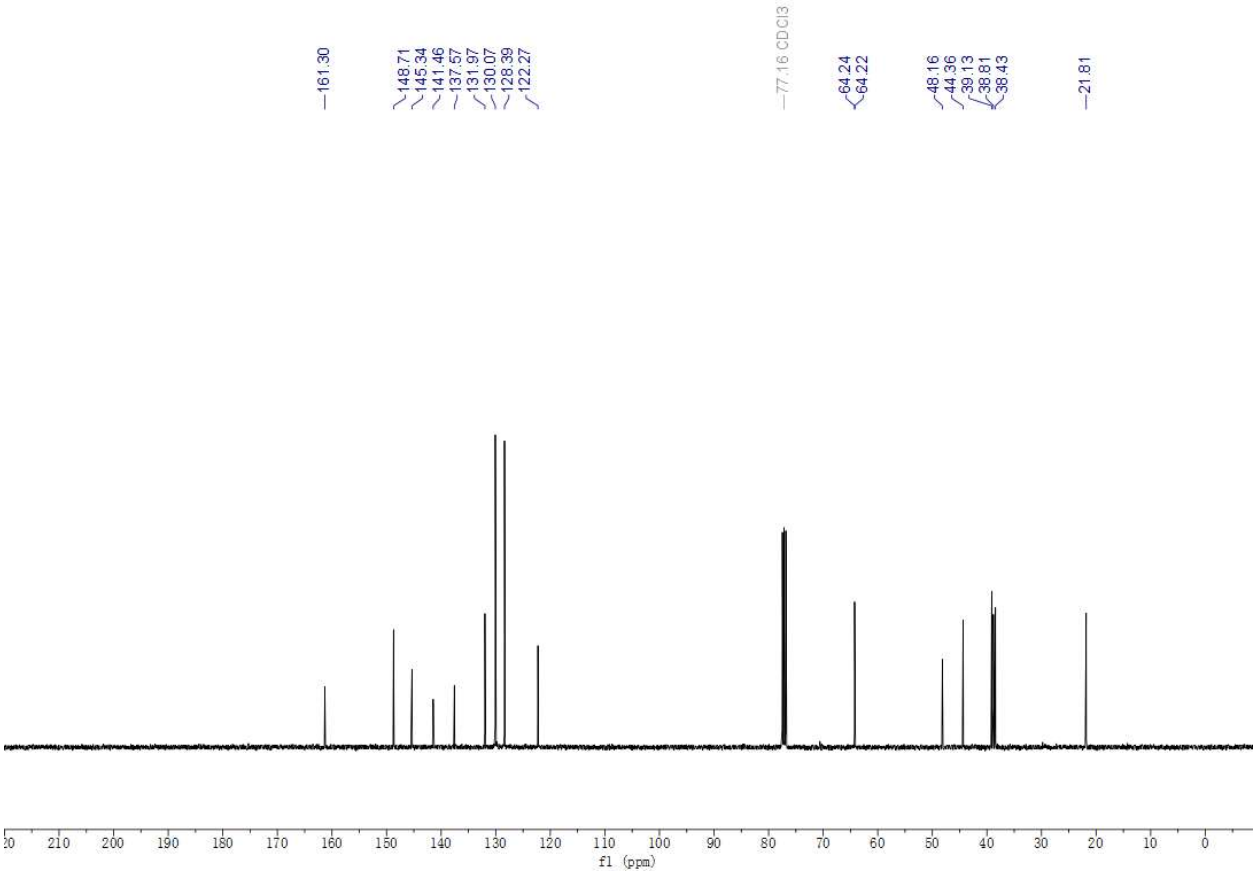


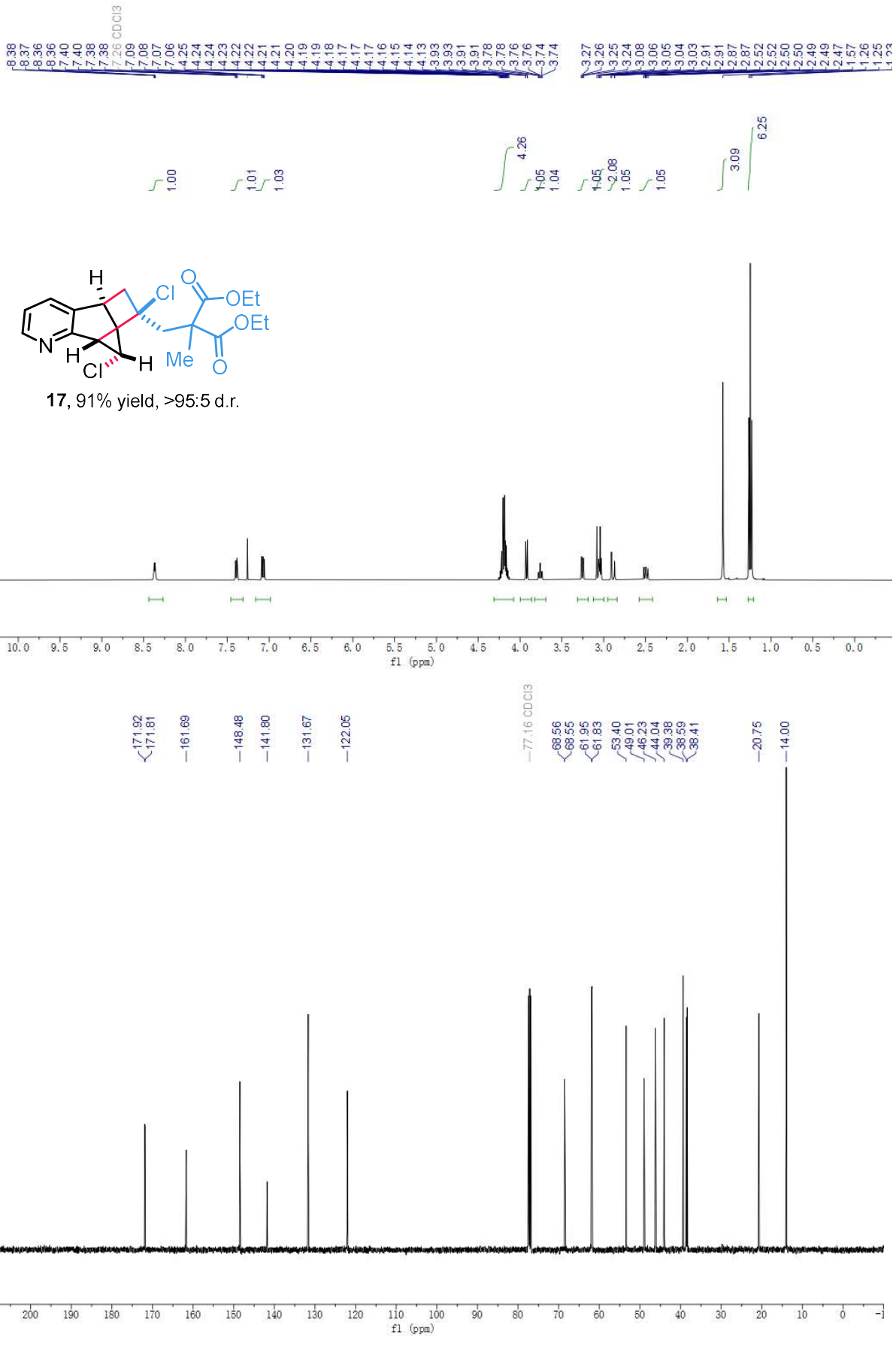




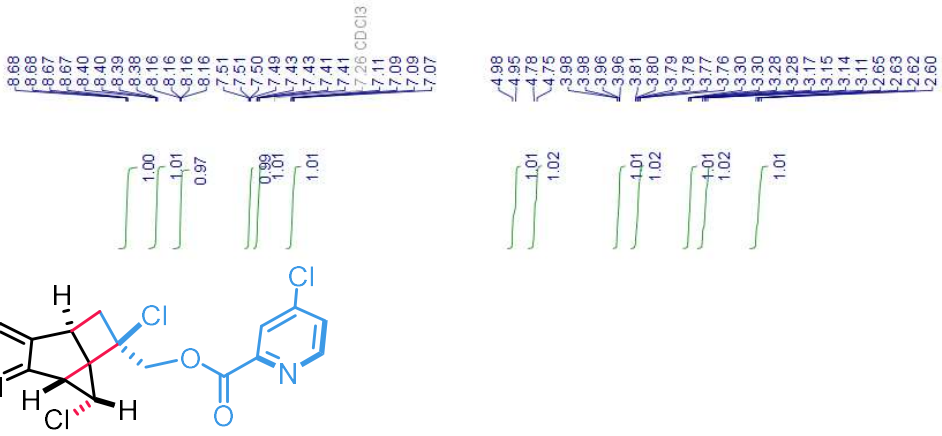
16, 58% yield, >95:5 d.r.



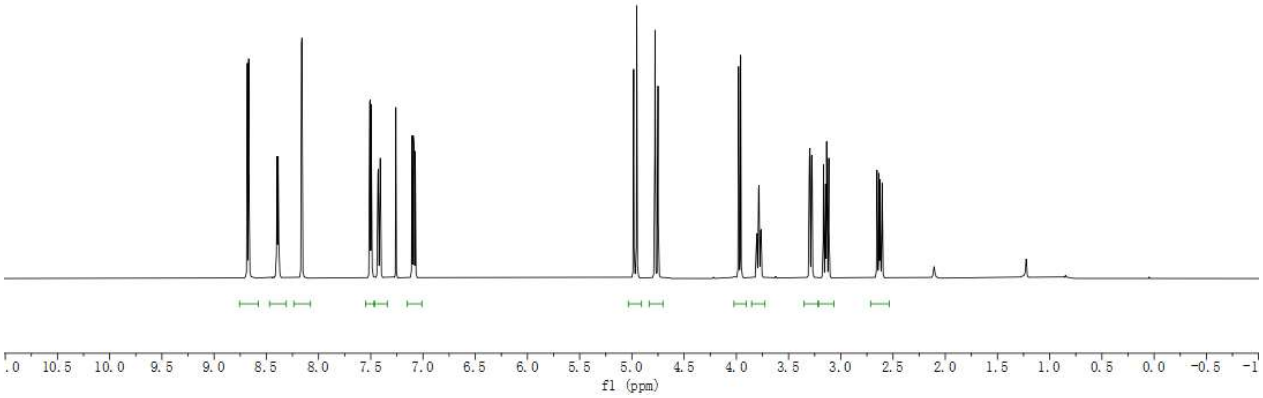


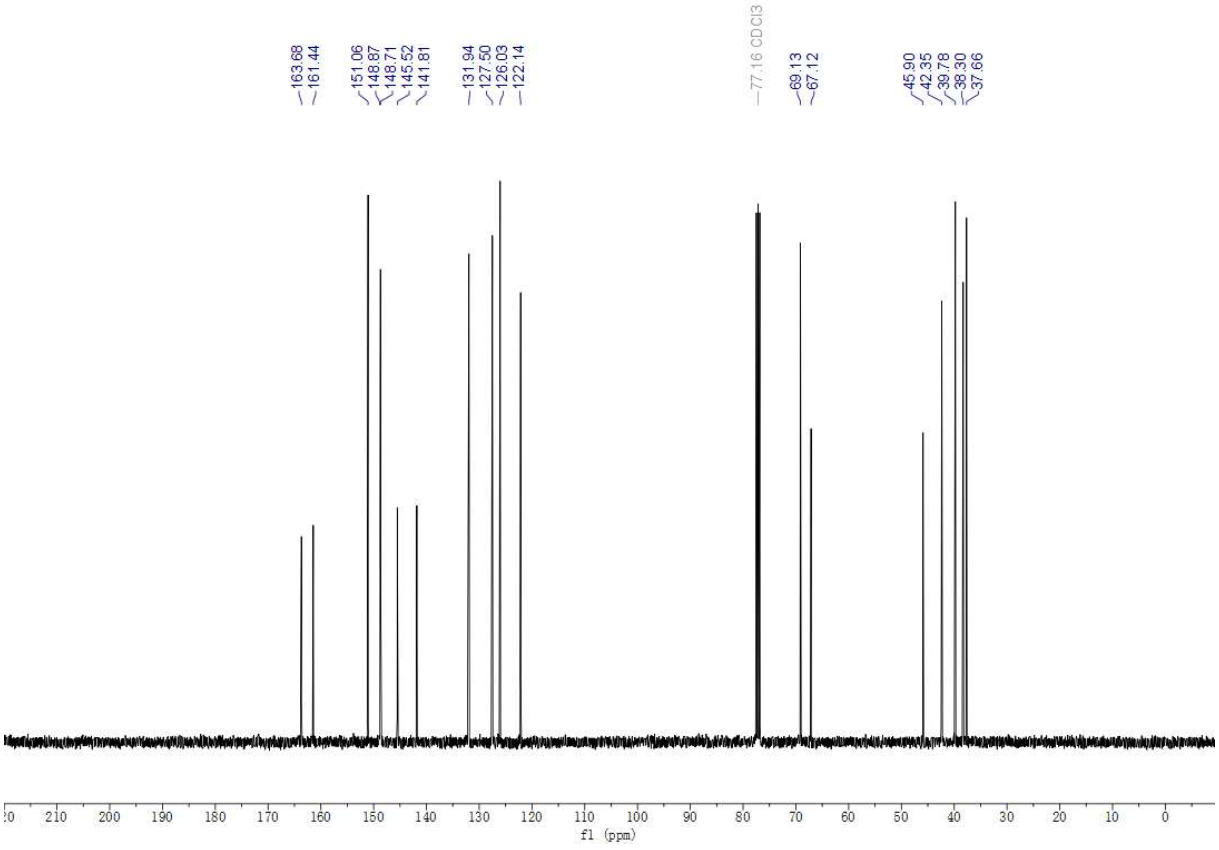


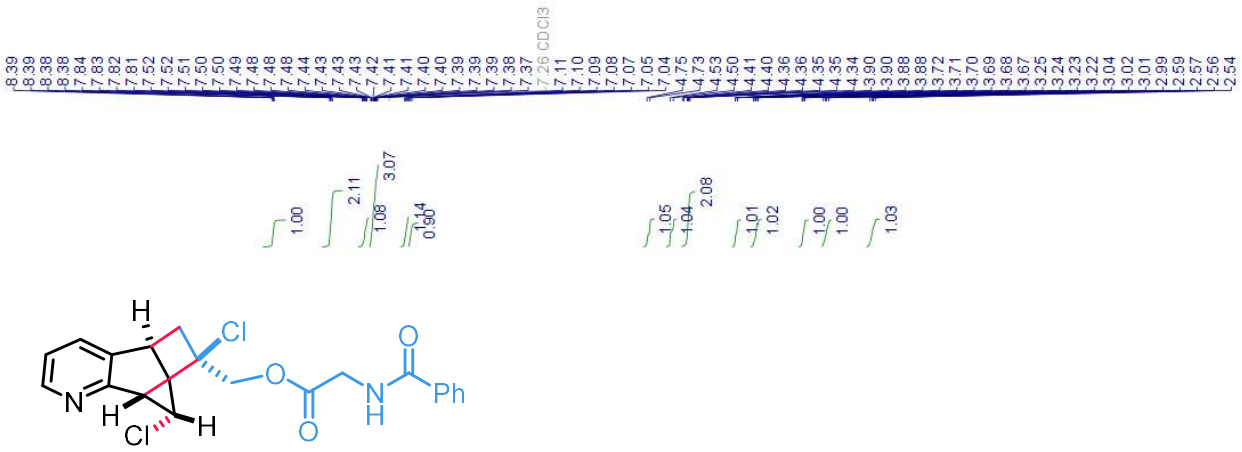
17, 91% yield, >95:5 d.r.



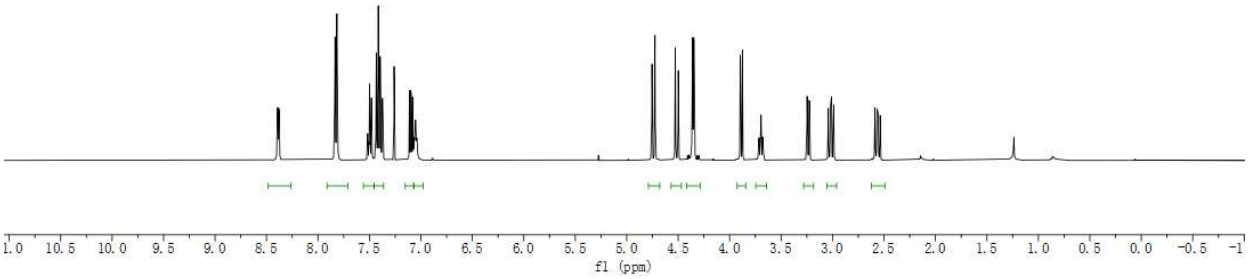
18, 94% yield, >95:5 d.r.

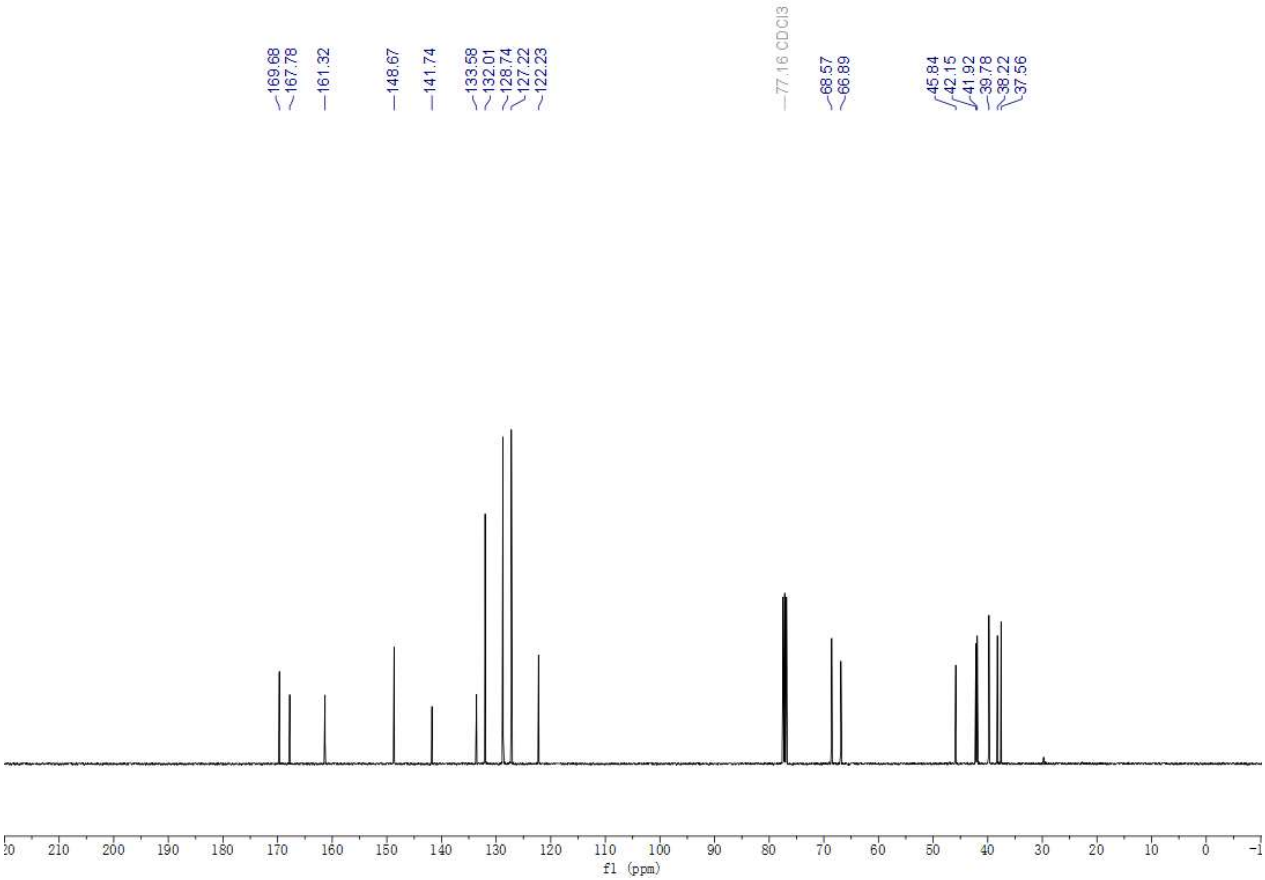


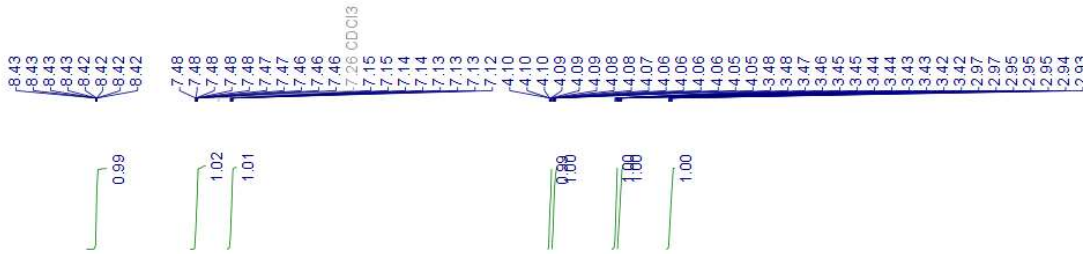


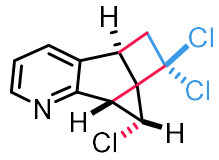


19, 86% yield, >95:5 d.r.

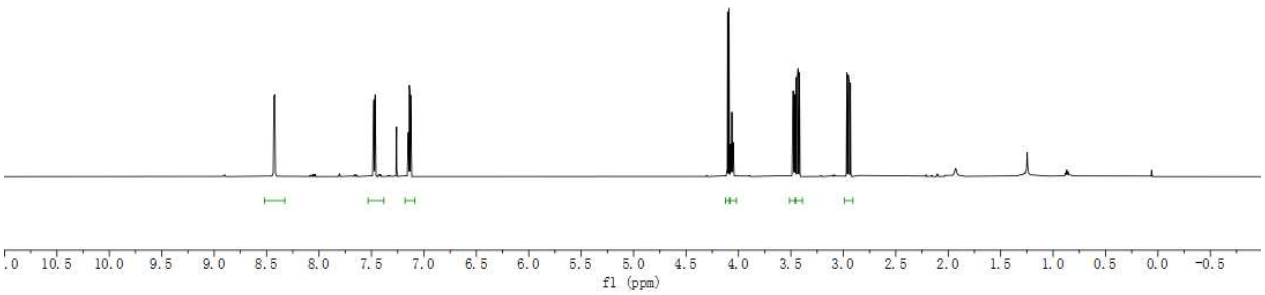


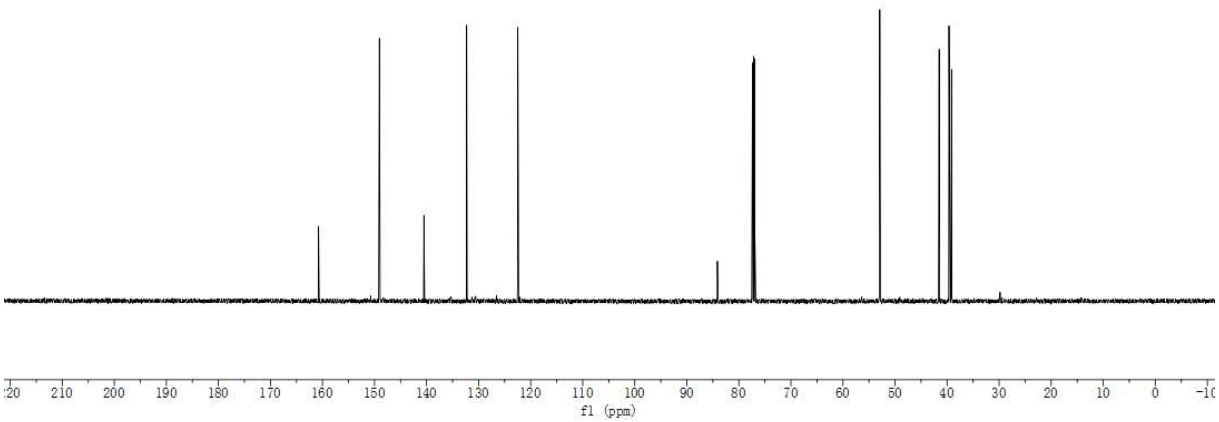


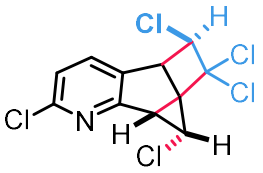




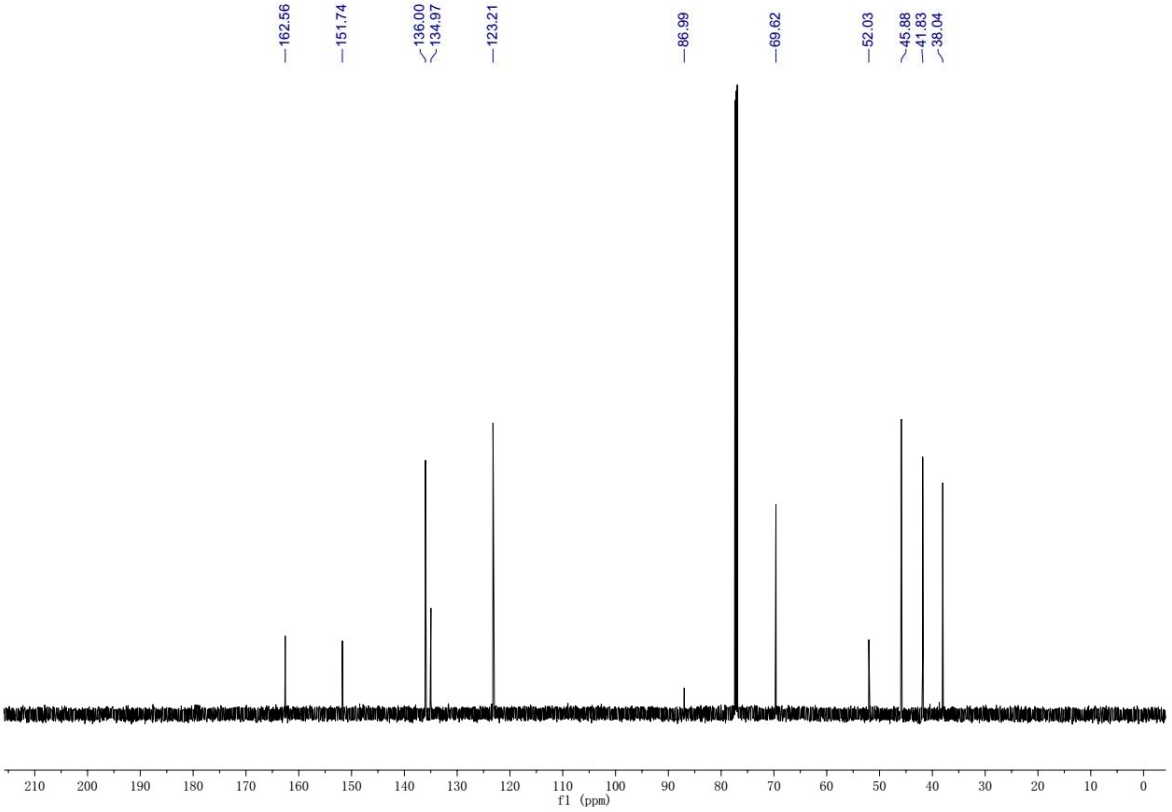
20, 72% yield, >95:5 d.r.

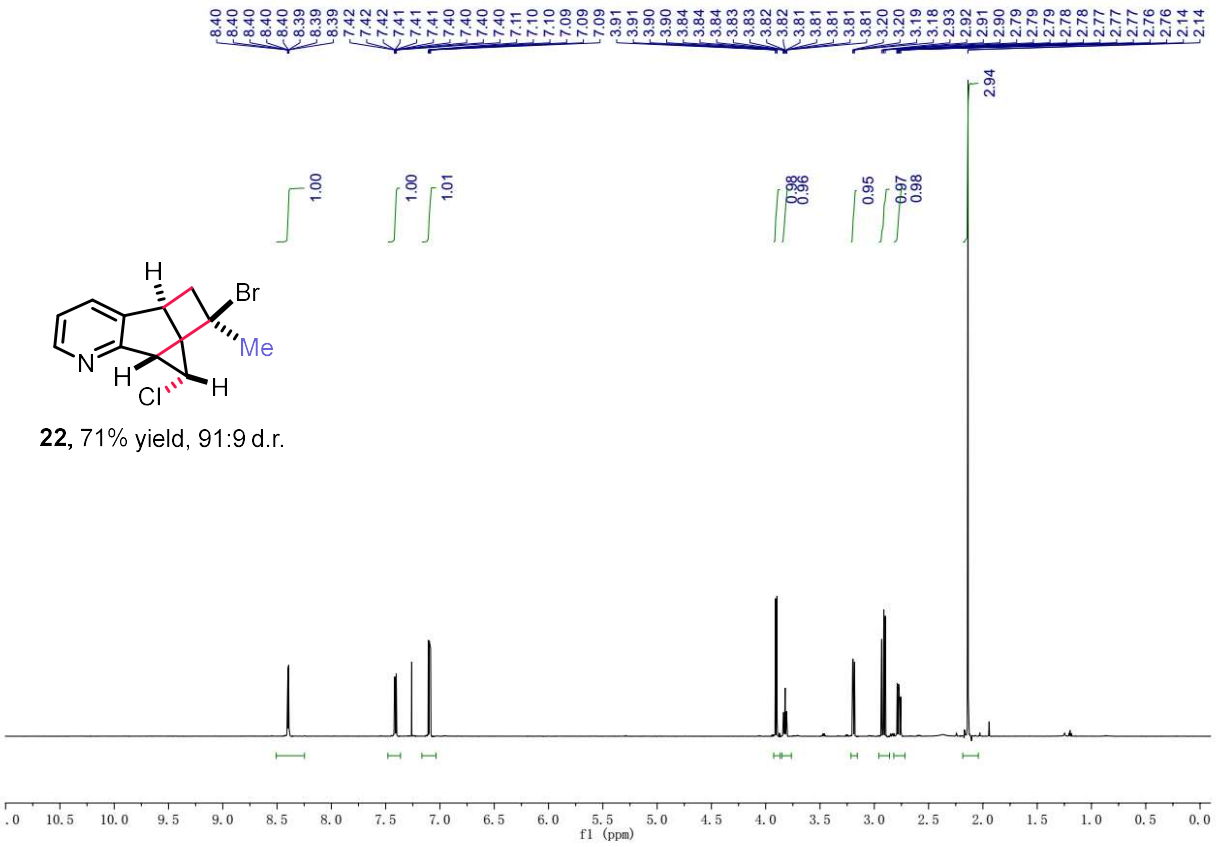




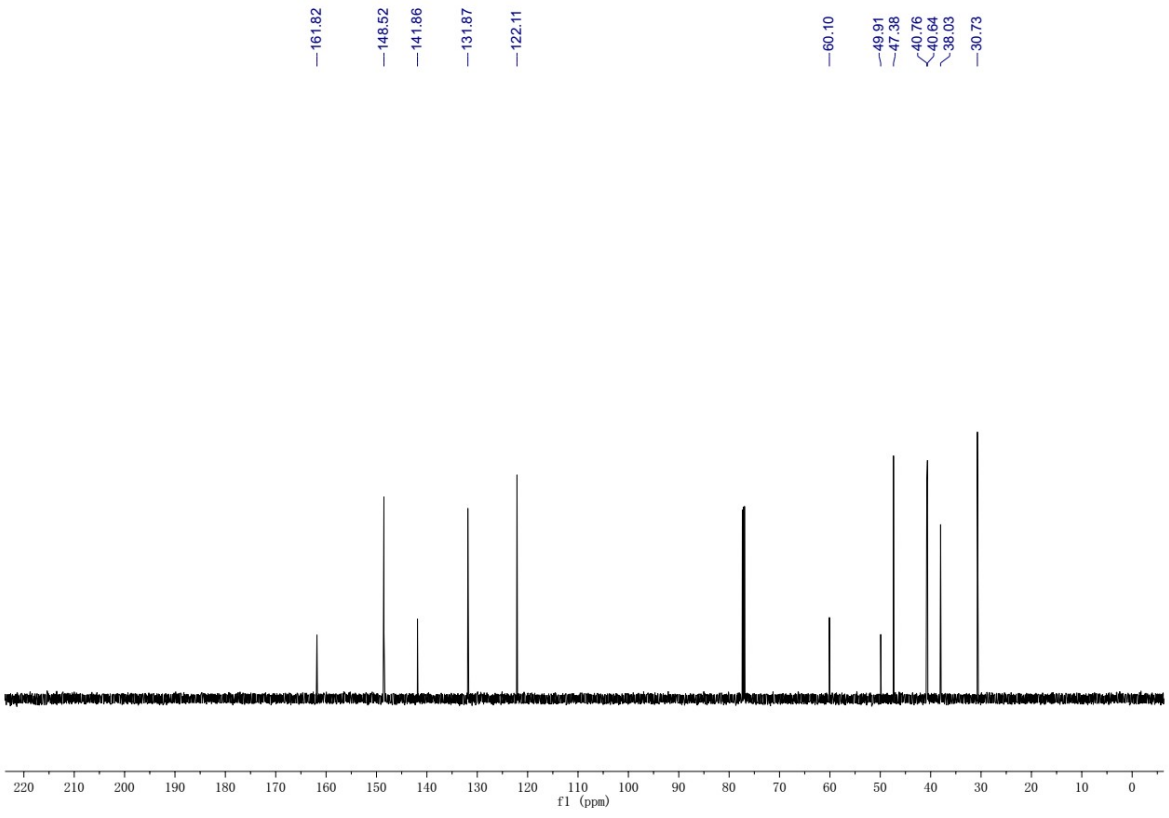


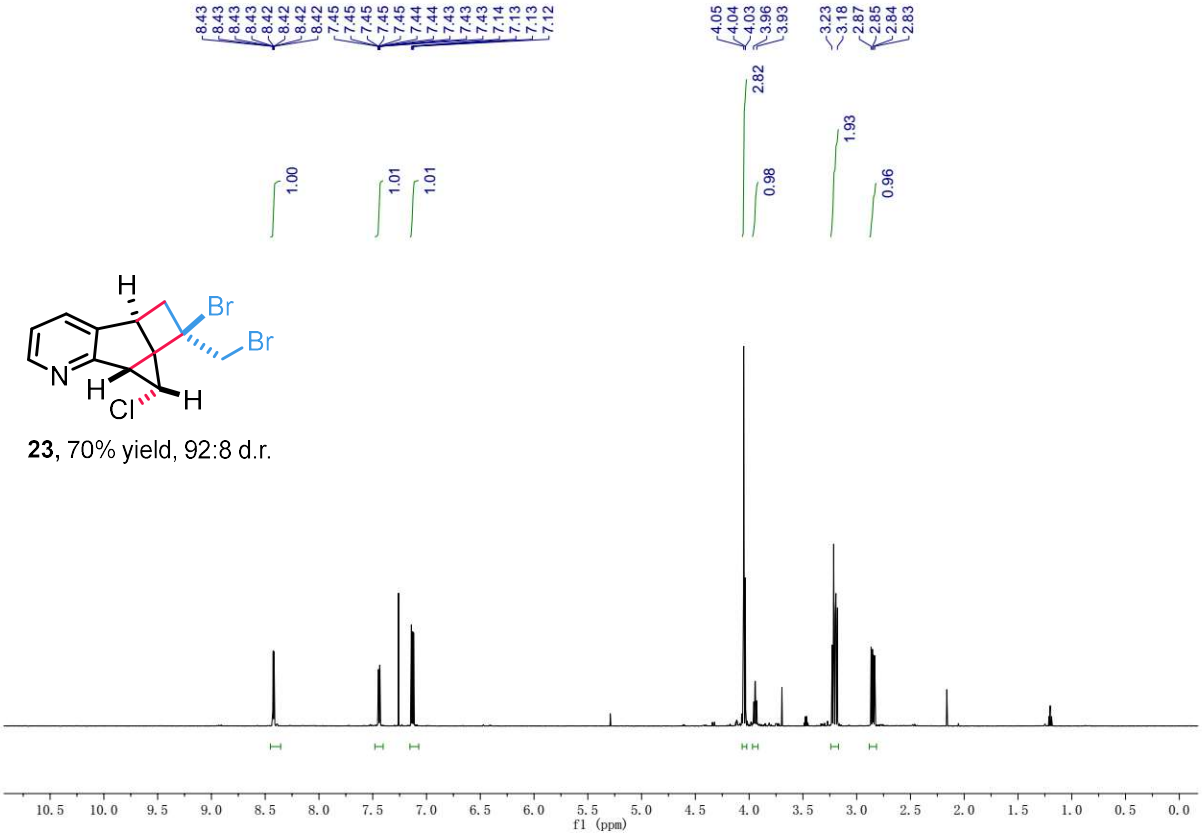
21, 88% yield, 94:6 d.r.



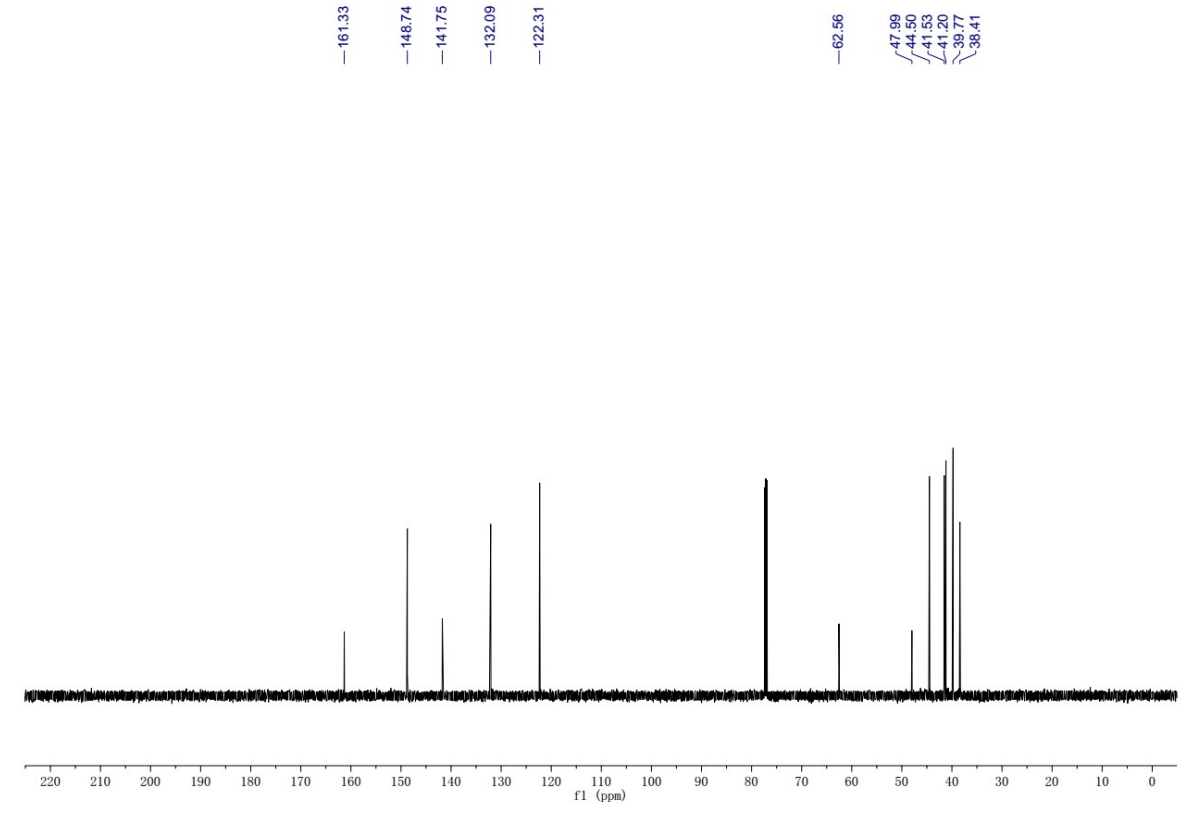


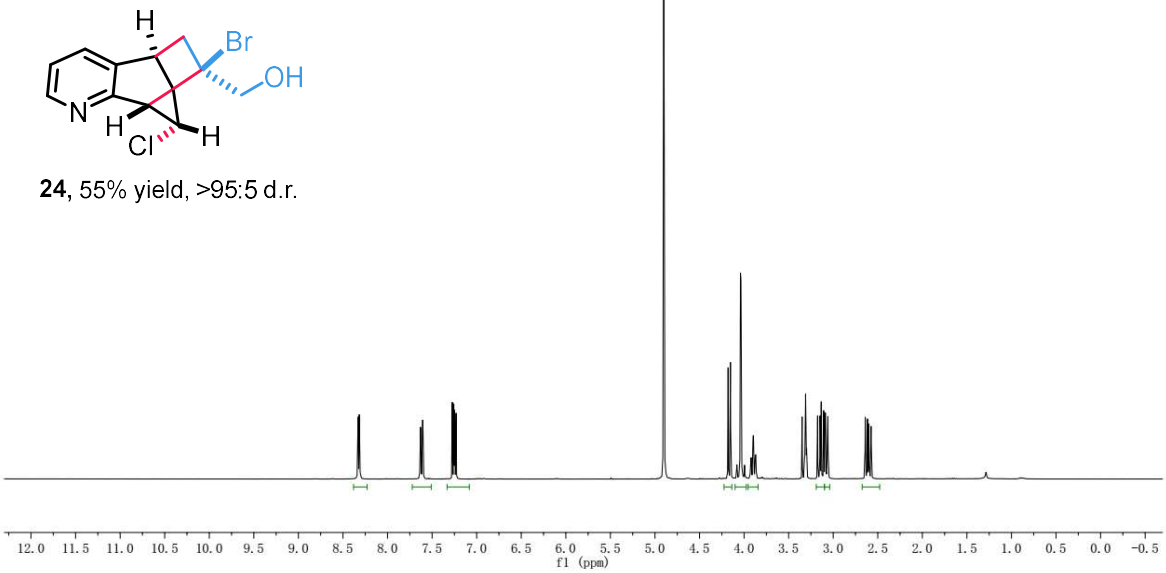
22, 71% yield, 91:9 d.r.



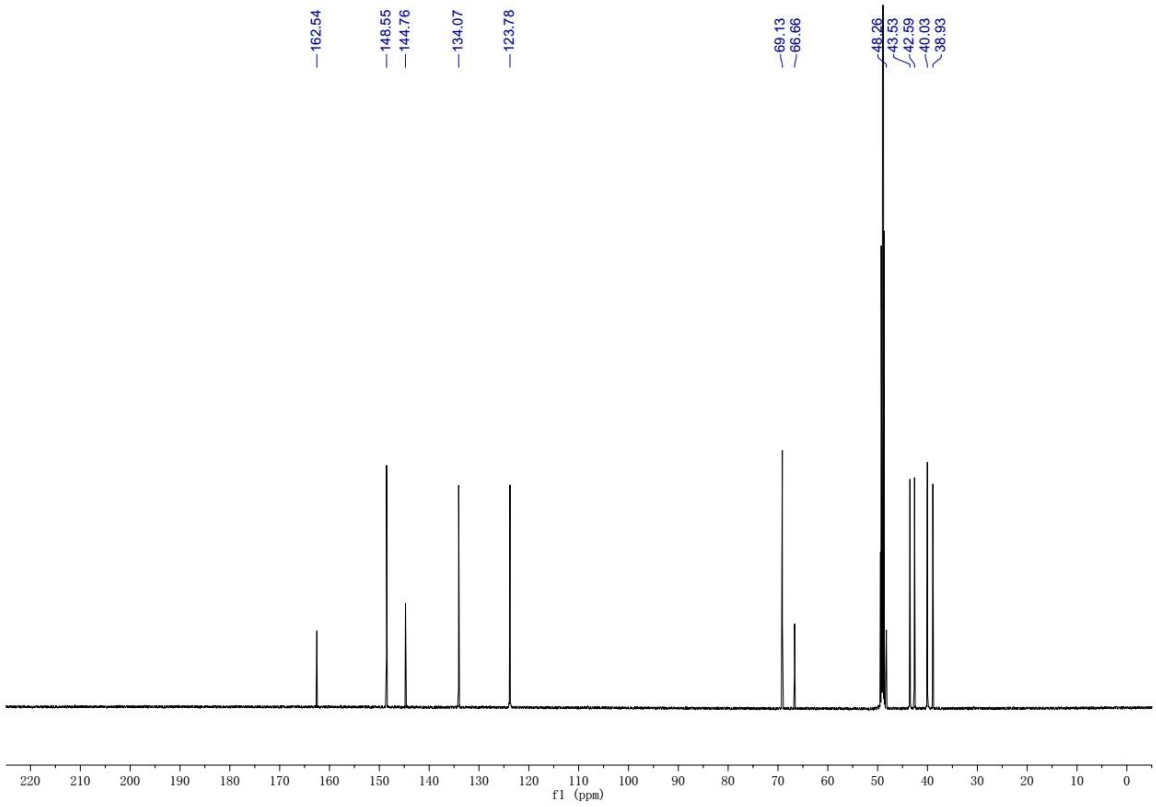


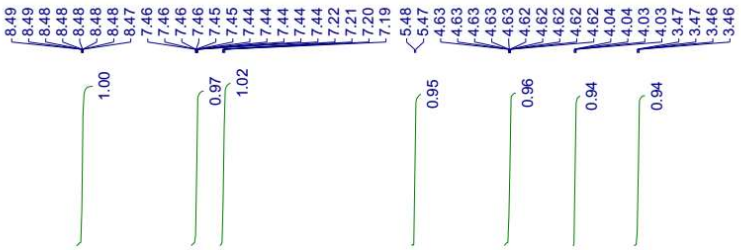
23, 70% yield, 92:8 d.r.

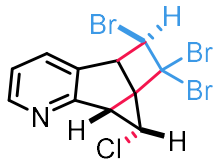




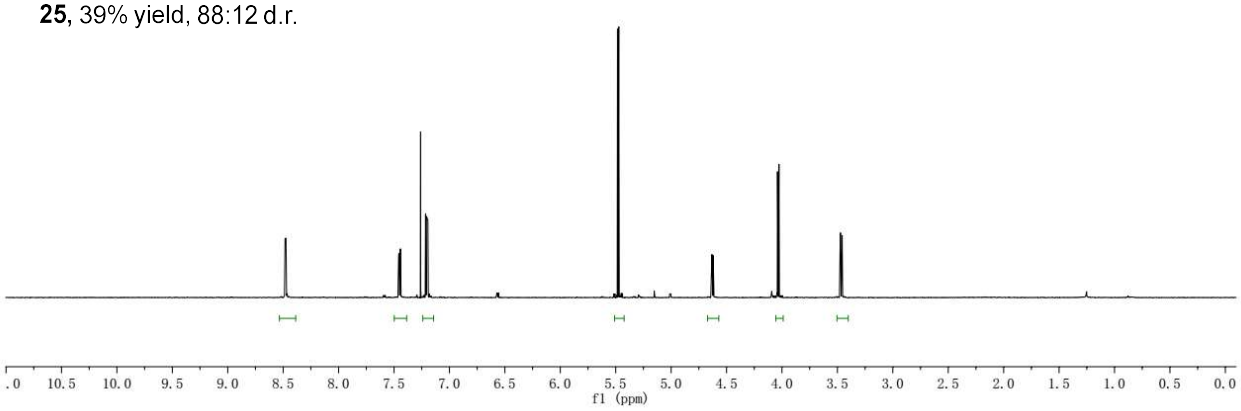
24, 55% yield, >95:5 d.r.

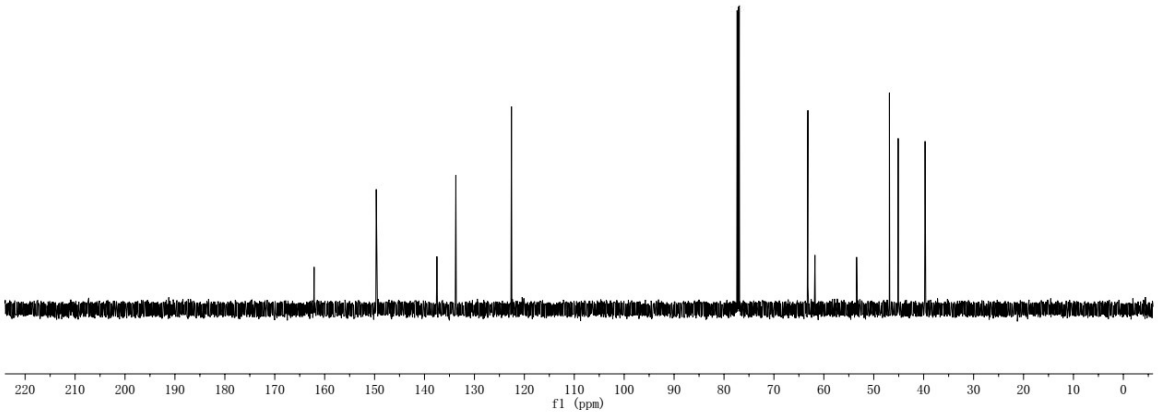


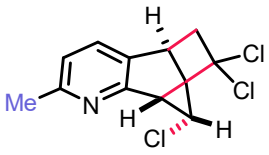




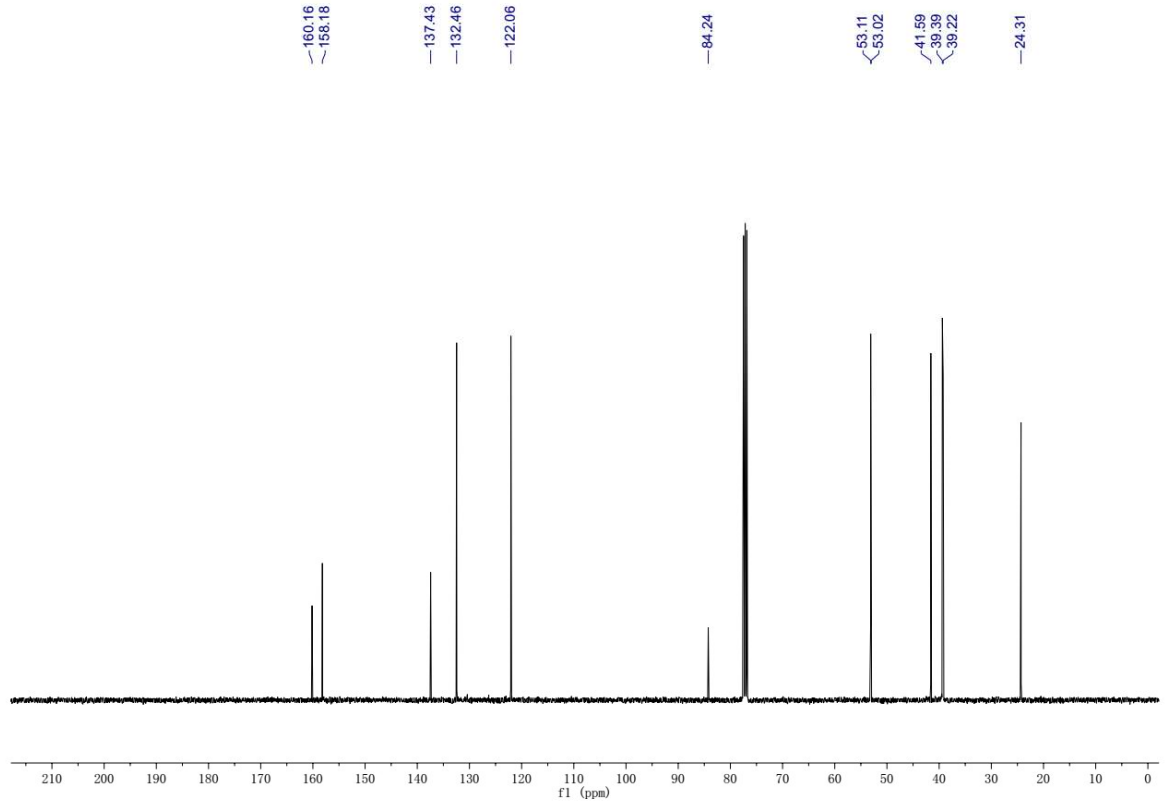
25, 39% yield, 88:12 d.r.

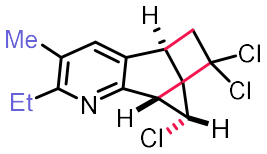




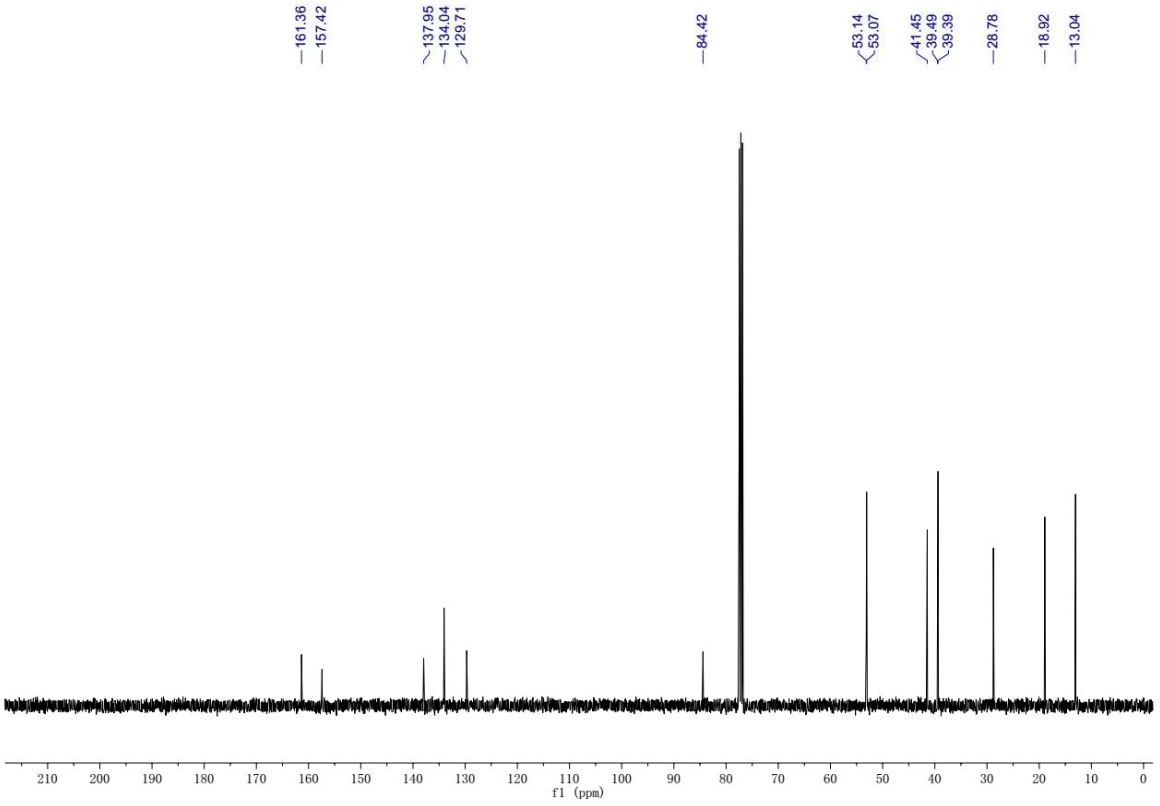


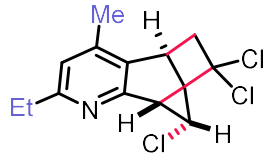
26, 74% yield, >95:5 d.r.



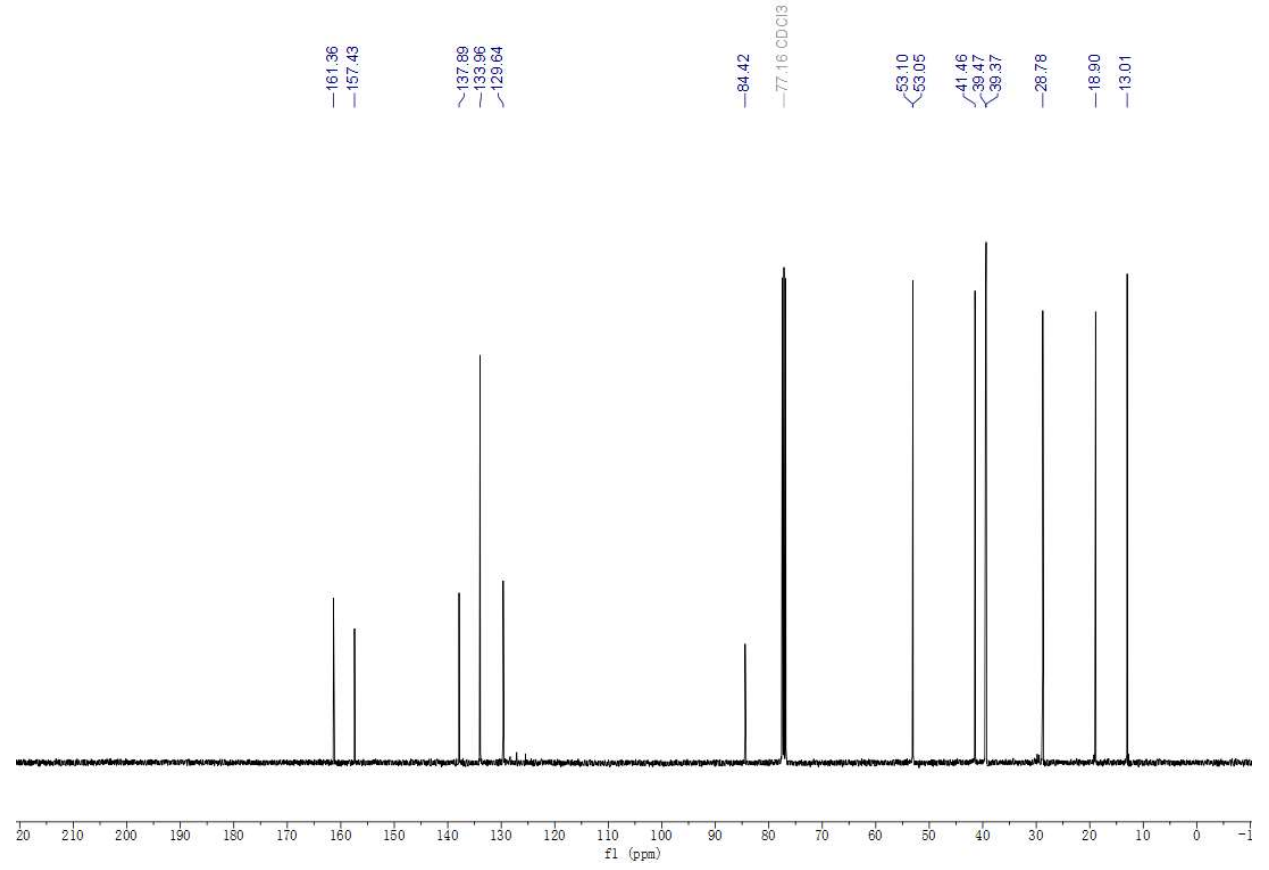


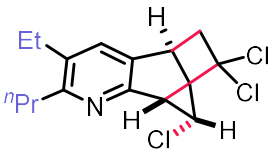
27, 77% yield, >95:5 d.r.



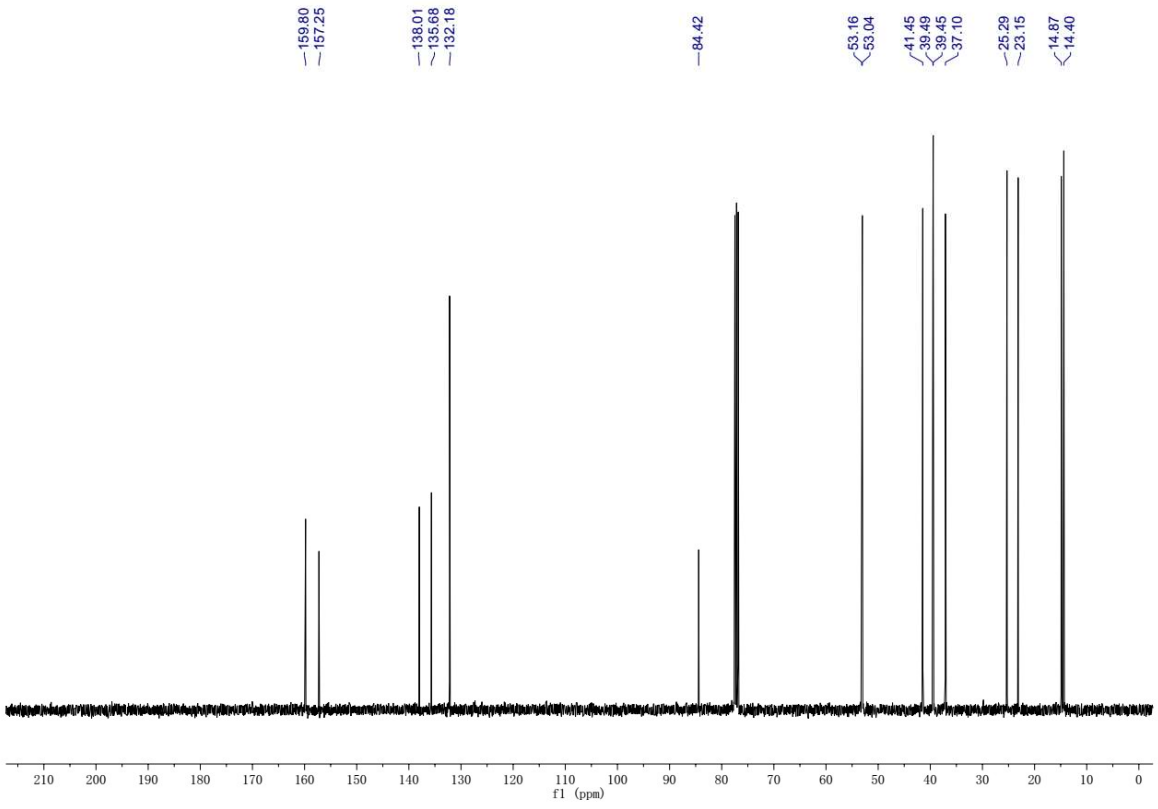


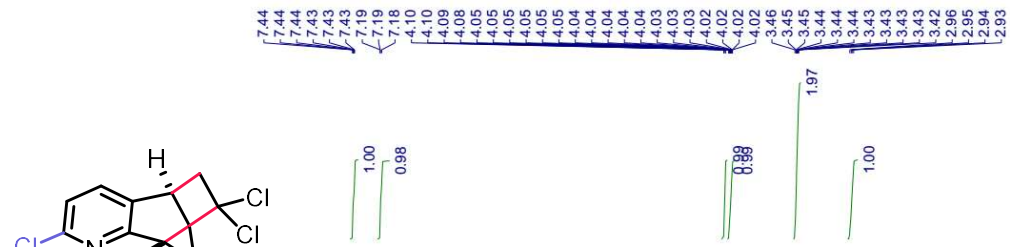
28, 73% yield, >95:5 d.r.



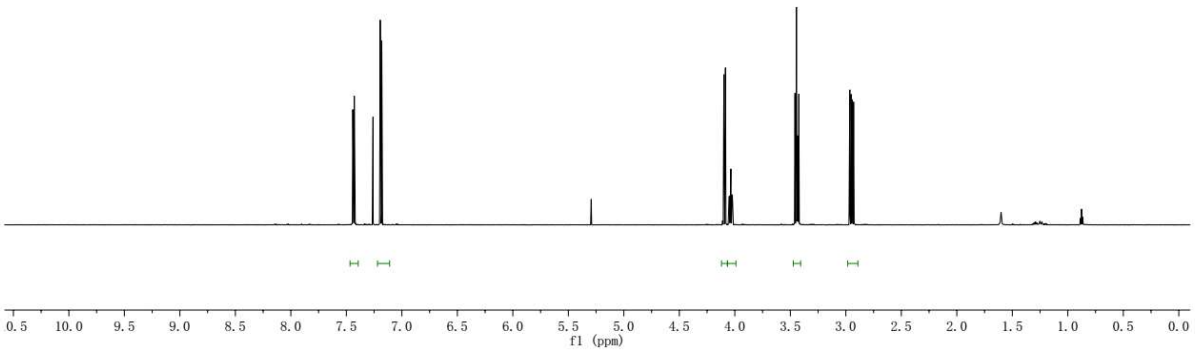


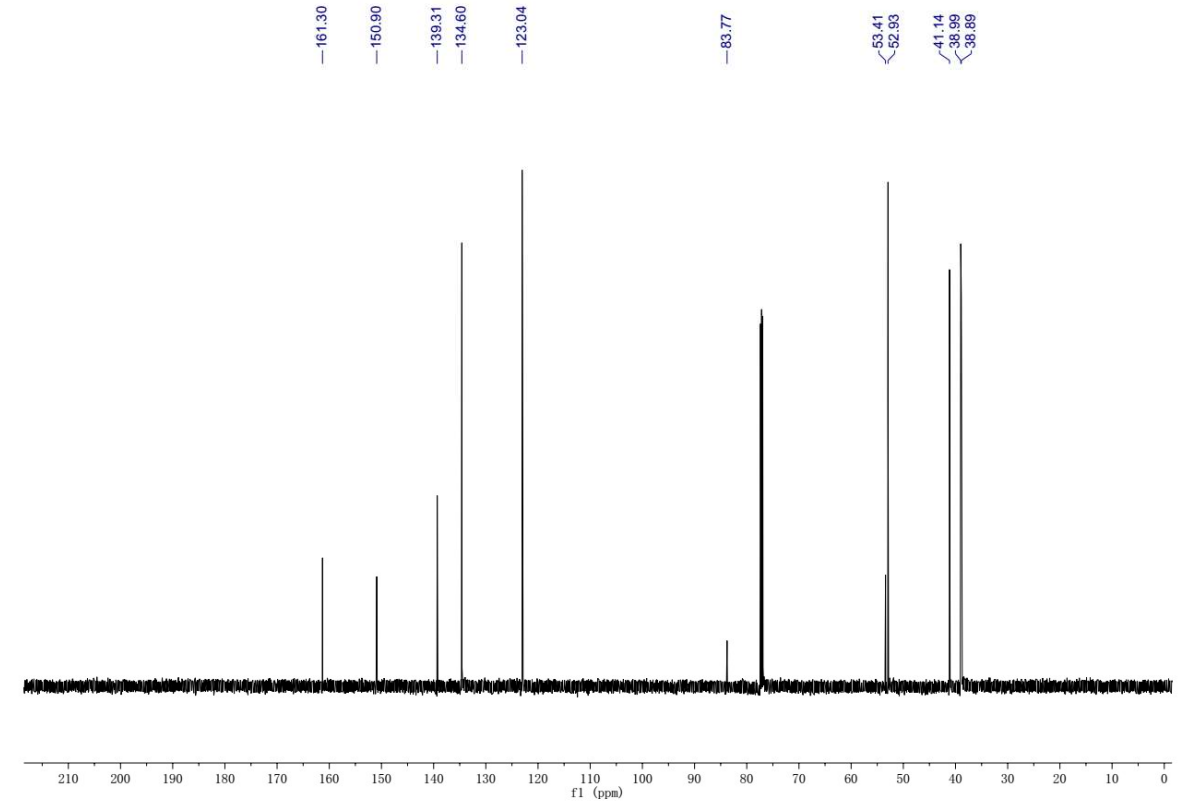
29, 95% yield, >95:5 d.r.

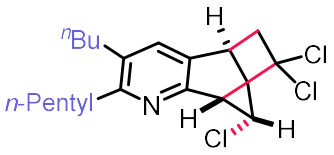




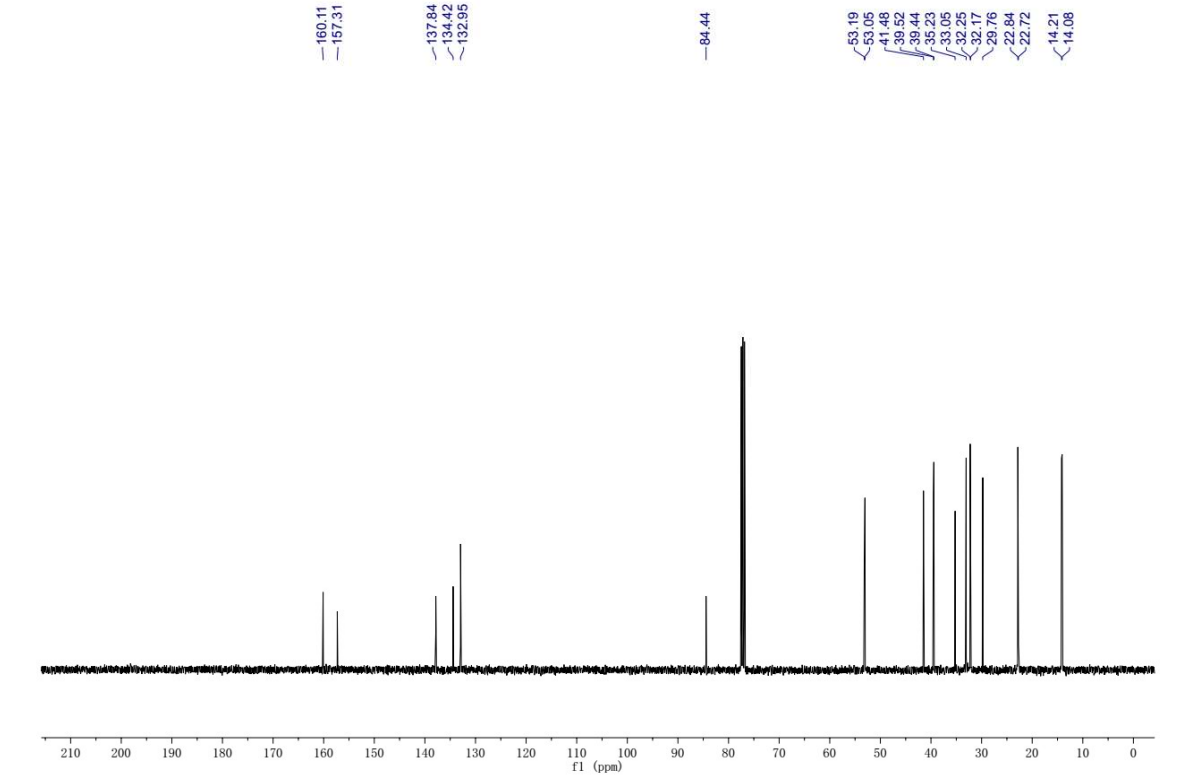
30, 77% yield, >95:5 d.r.

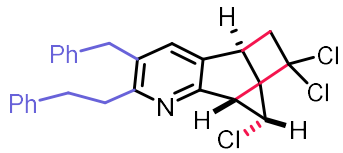




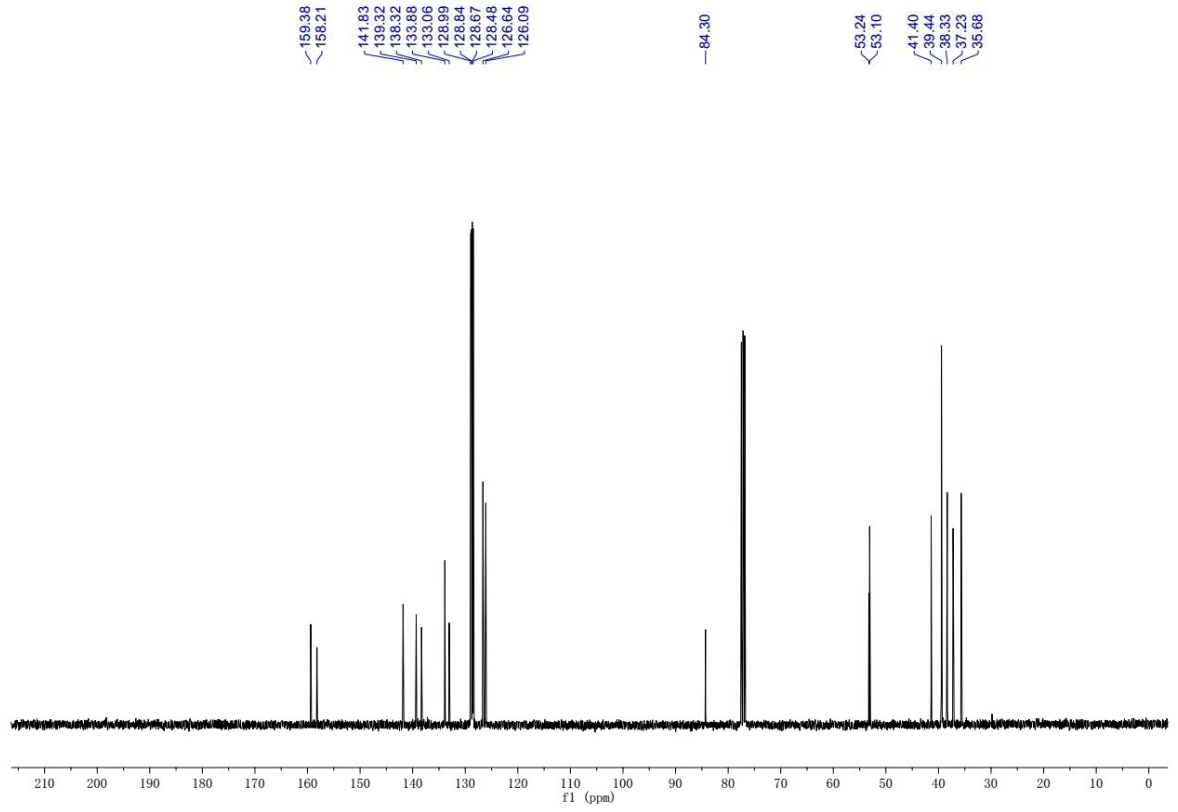


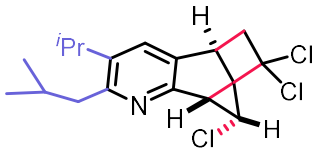
31, 92% yield, >95:5 d.r.



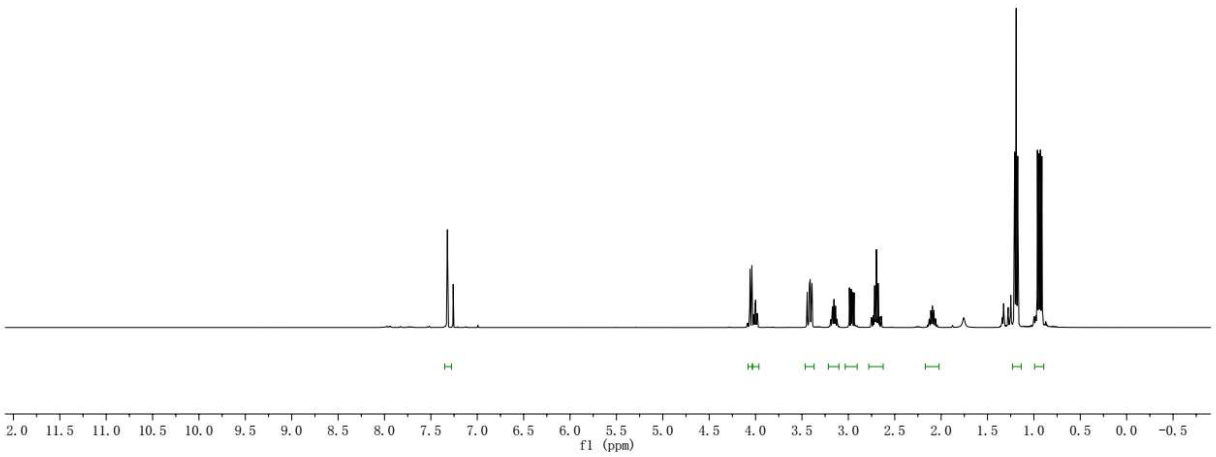


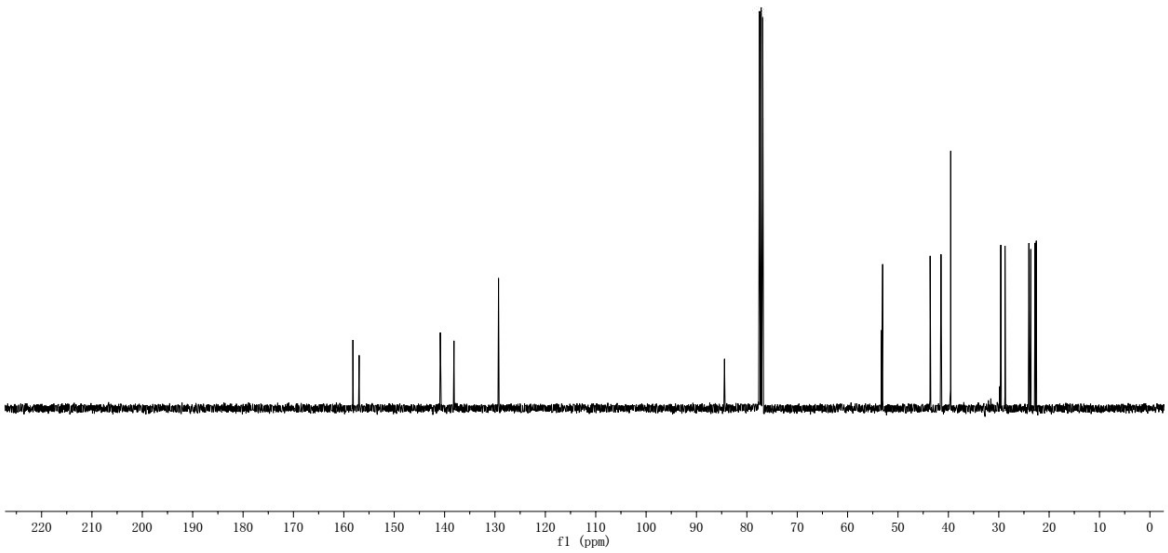
32, 83% yield, >95:5 d.r.

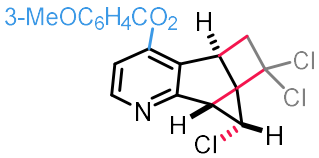




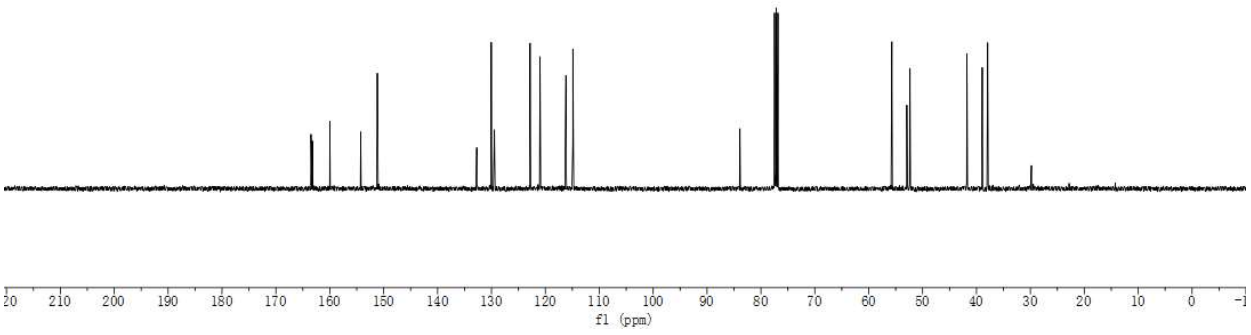
33, 95% yield, >95:5 d.r.

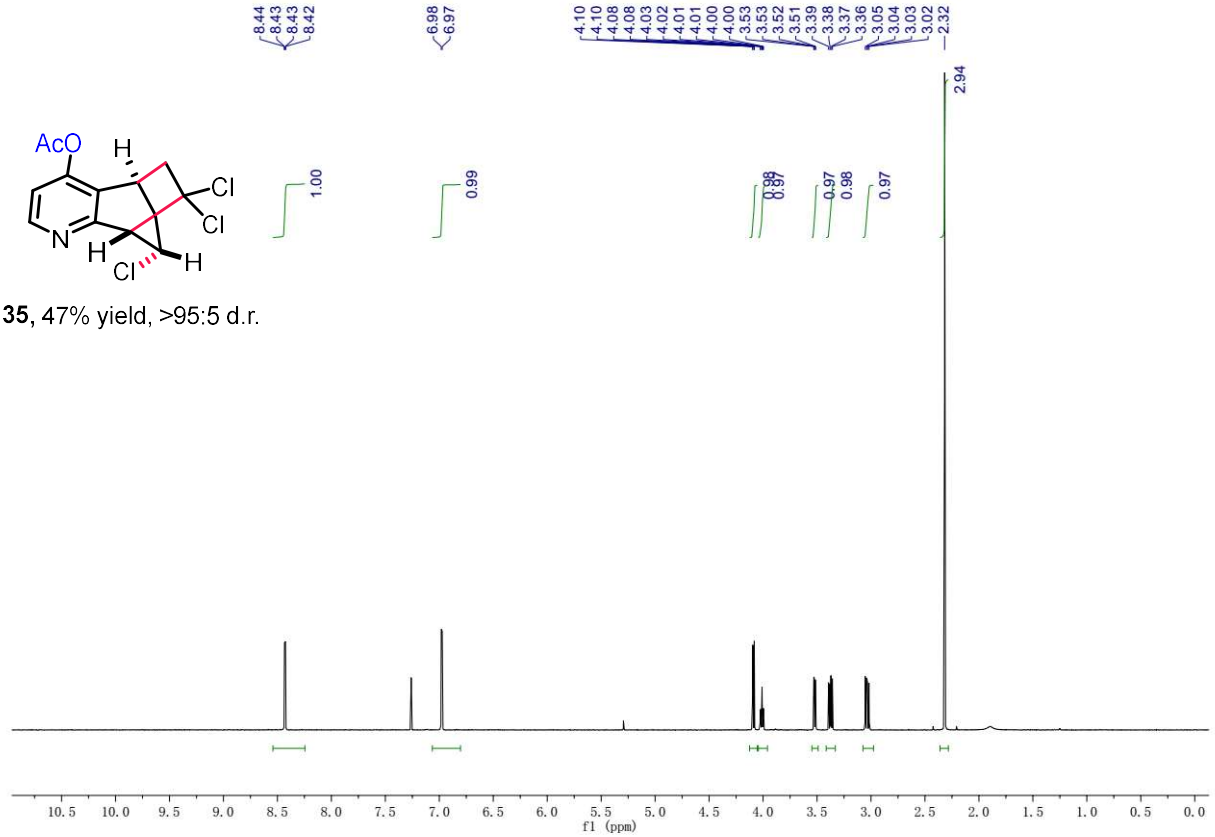




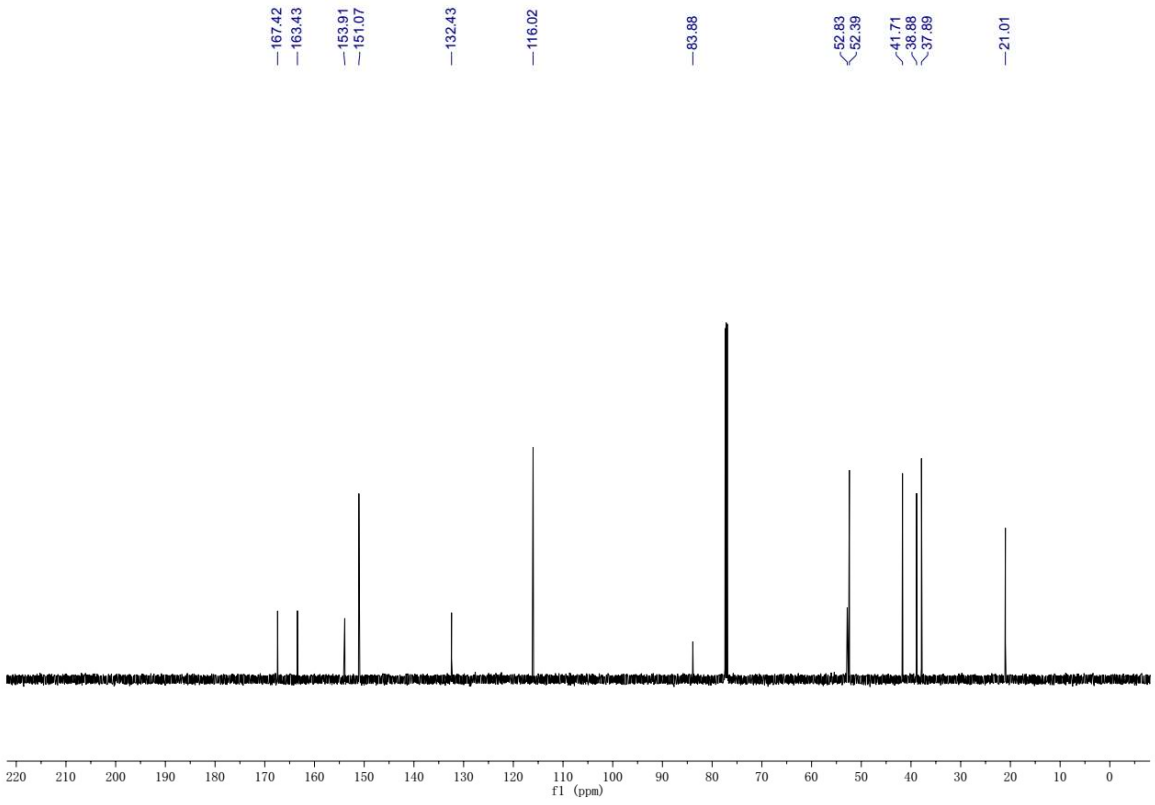


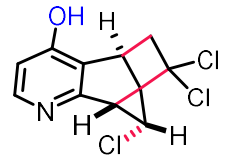
34, 72% yield, >95:5 d.r.

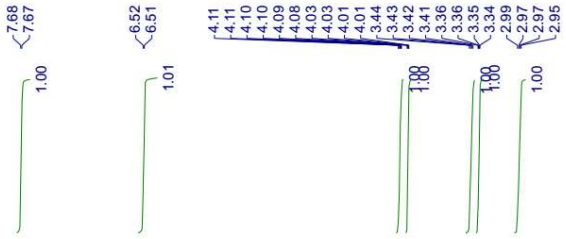




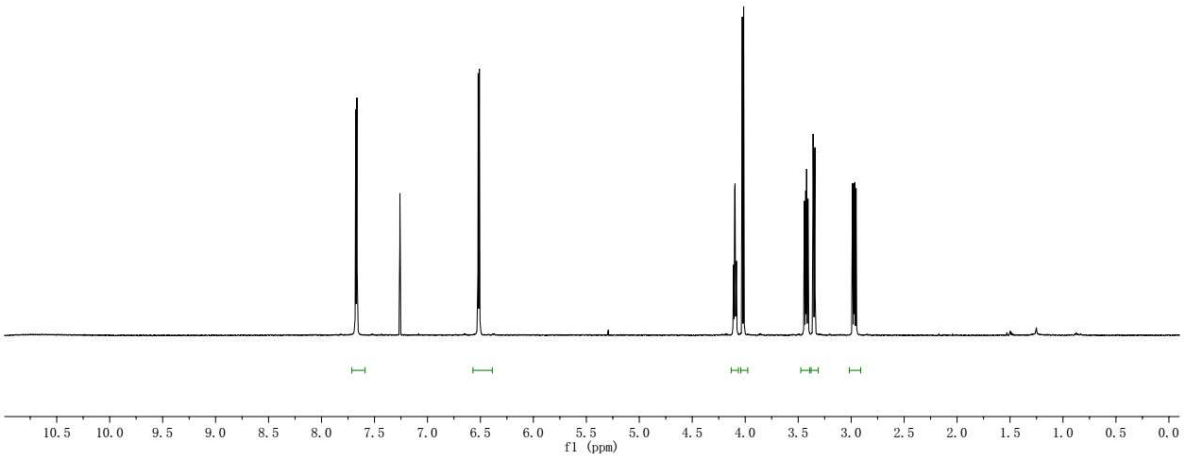
35, 47% yield, >95:5 d.r.

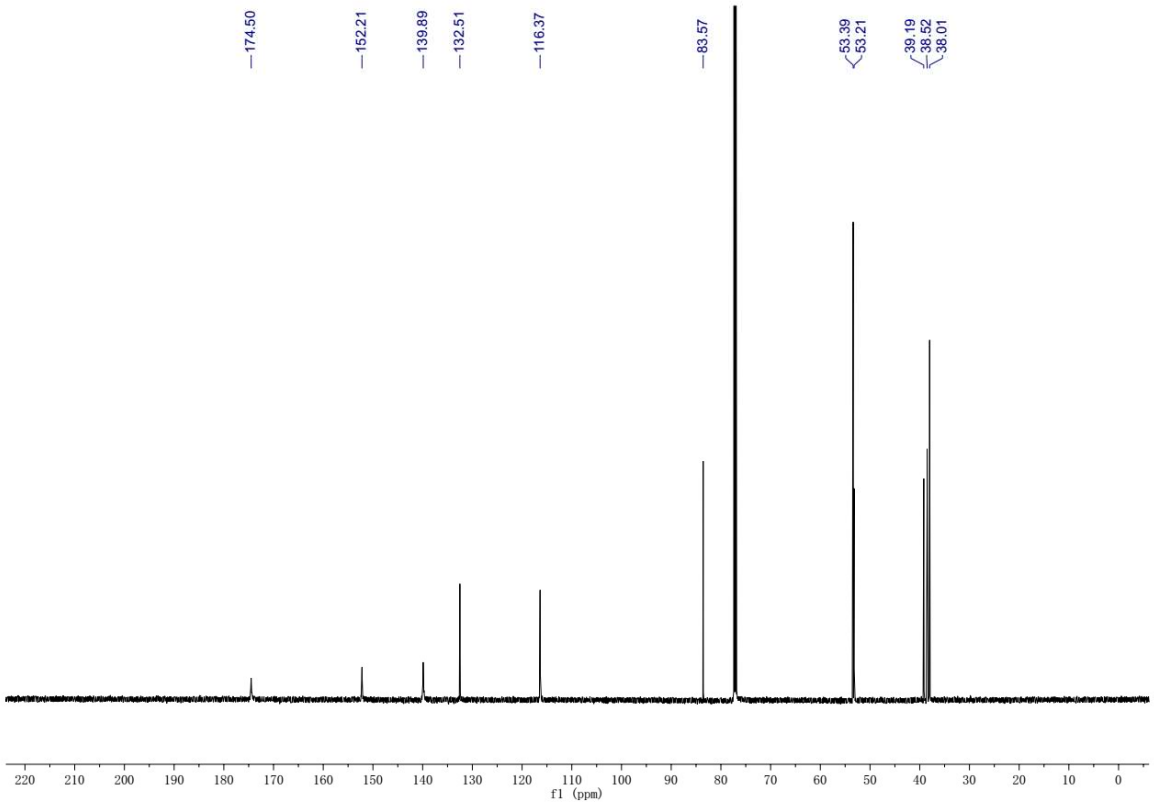


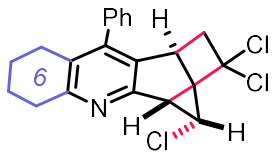




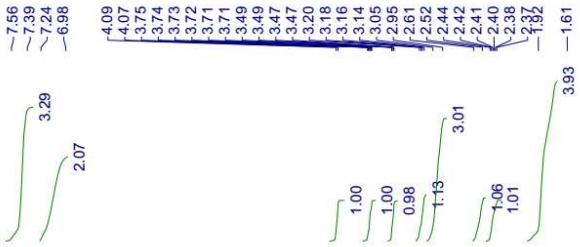
36, 98% yield, >95:5 d.r.

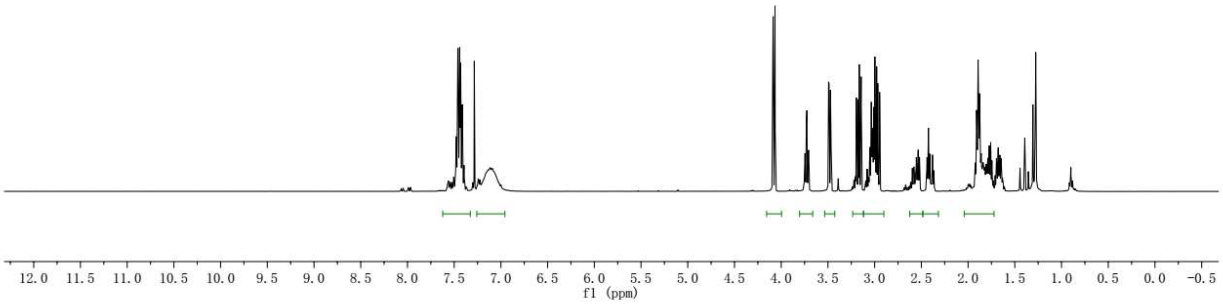


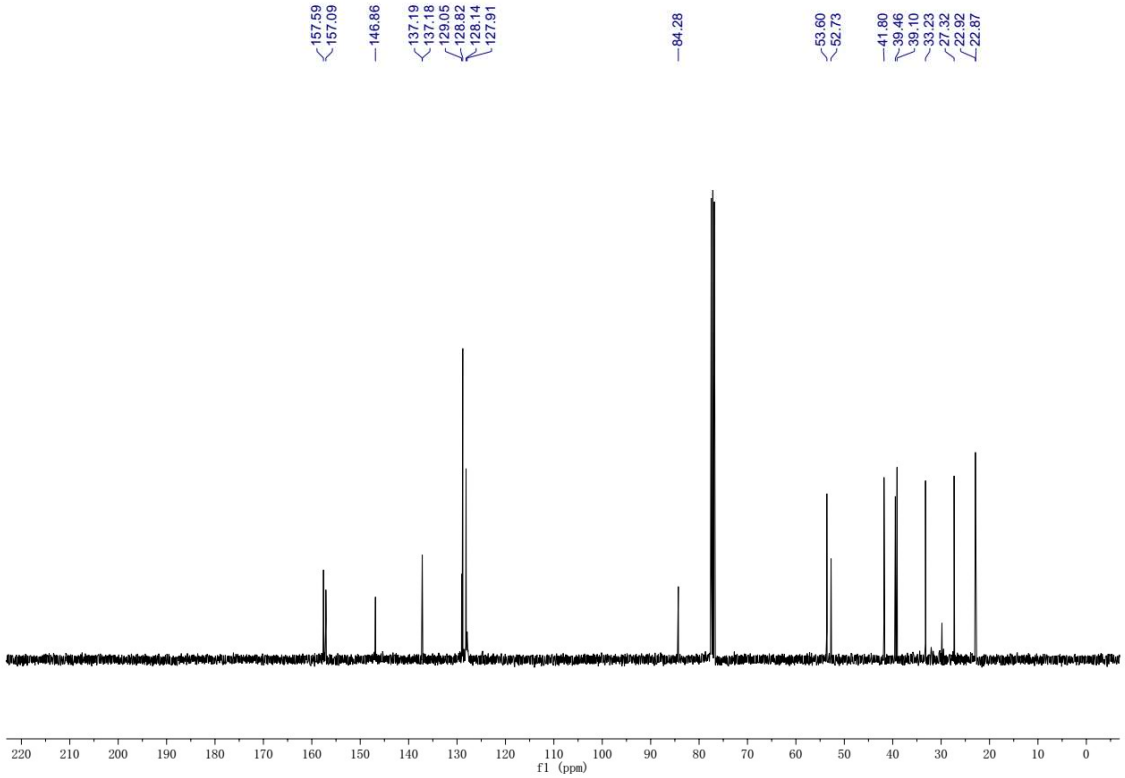


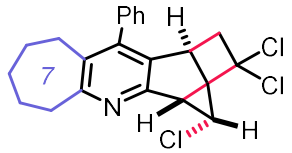


37, 86% yield, >95:5 d.r.

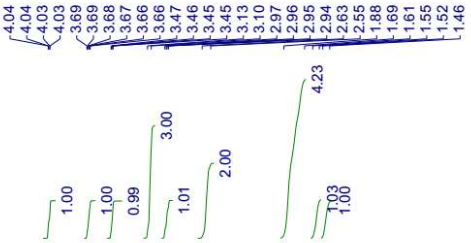


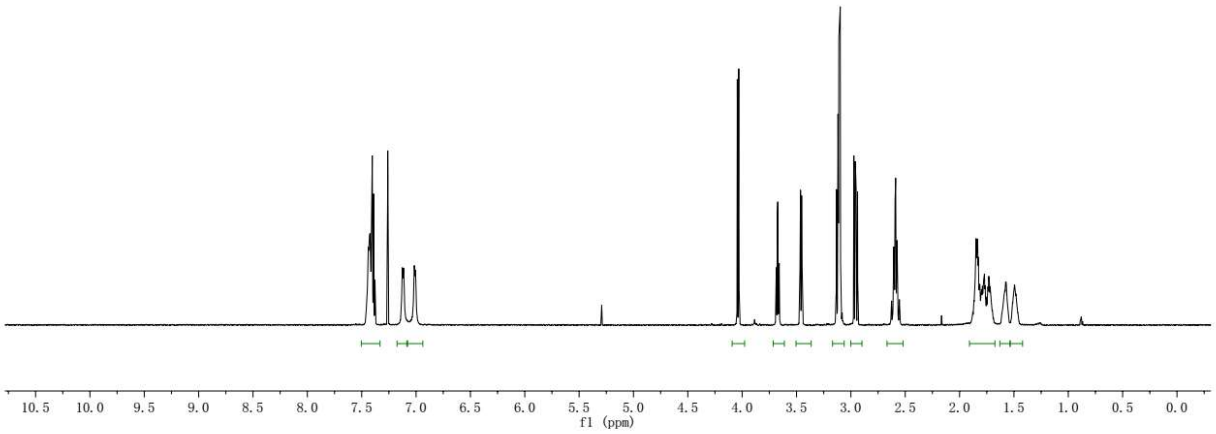


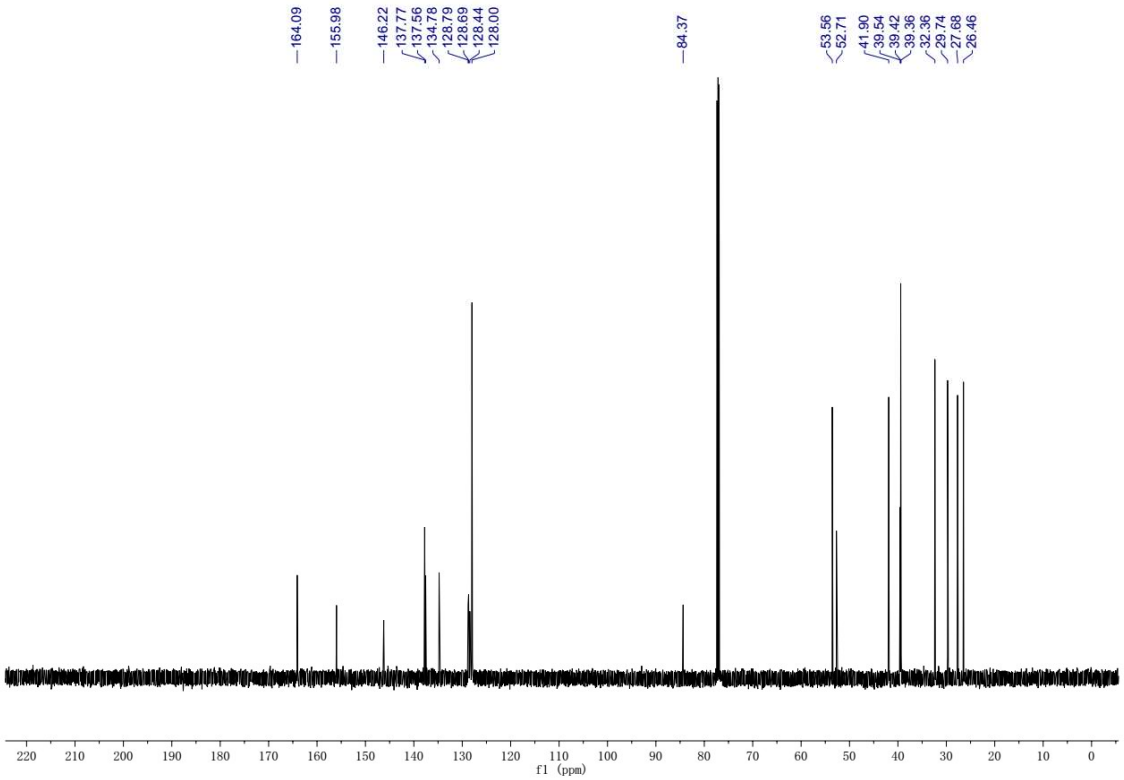


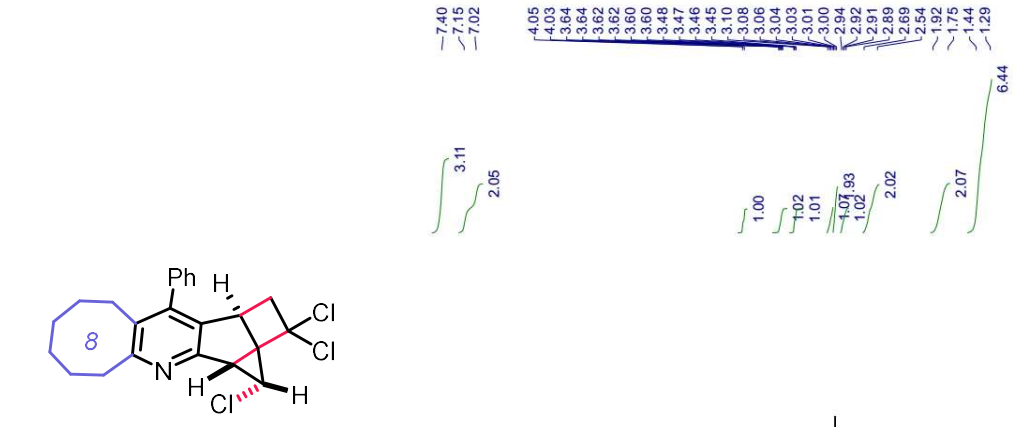


38, 99% yield, >95:5 d.r.

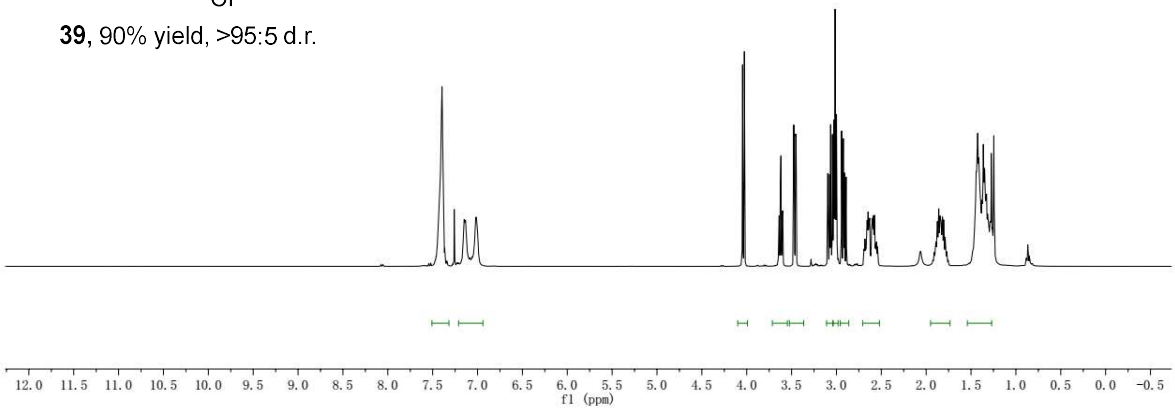


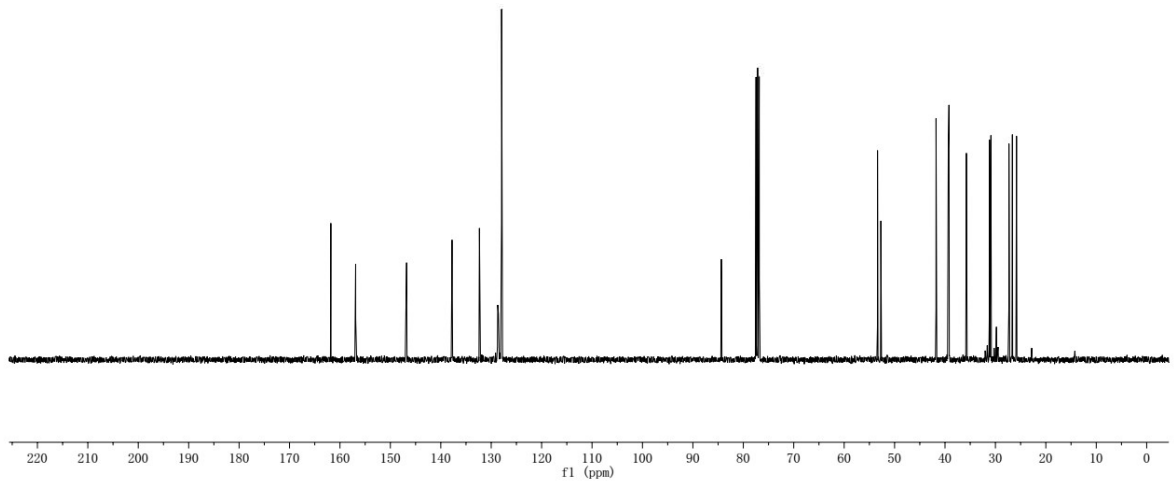


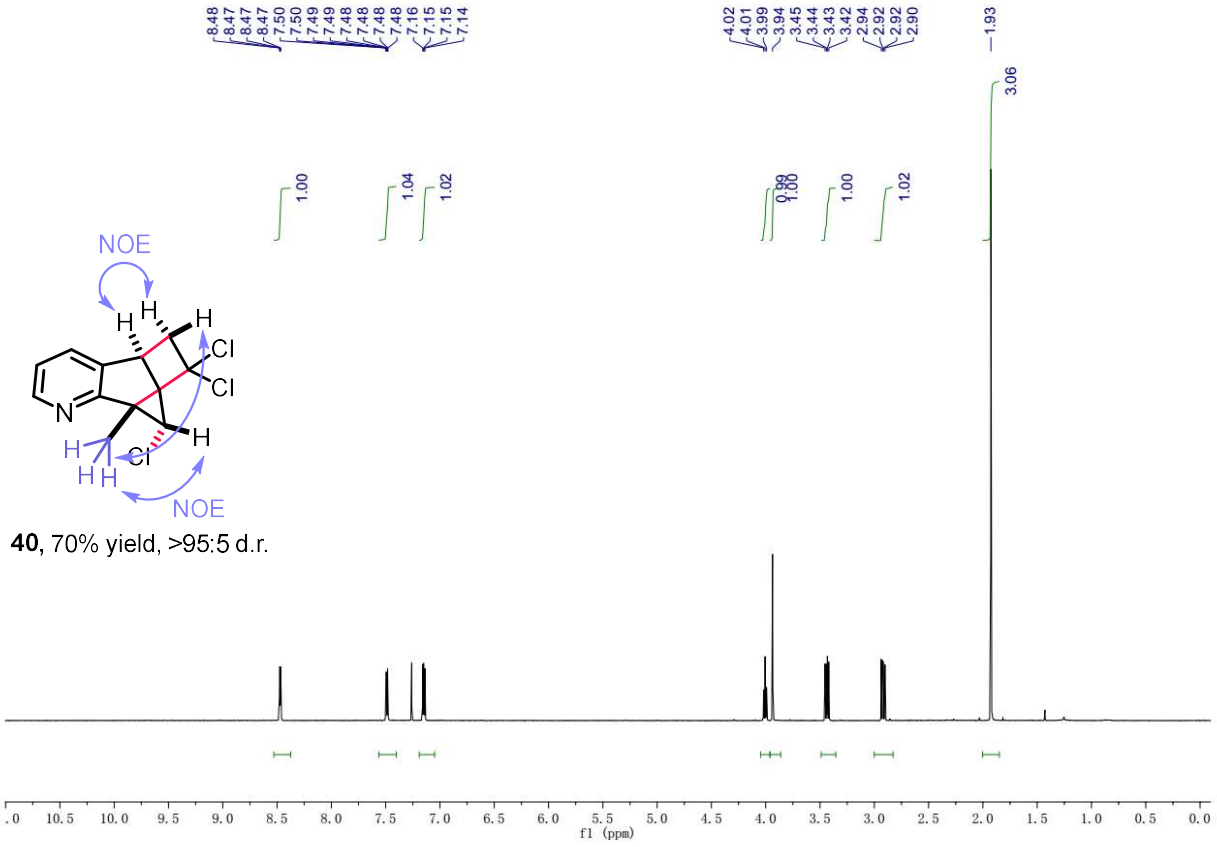




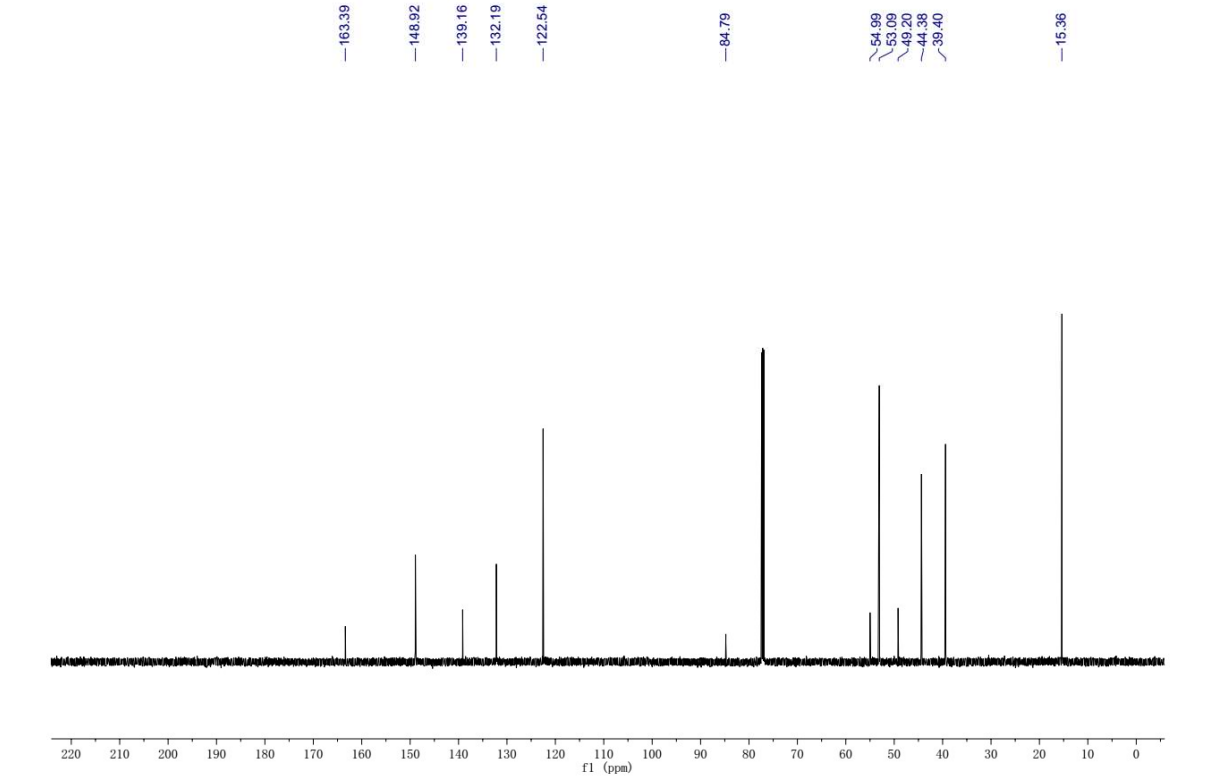
39, 90% yield, >95:5 d.r.

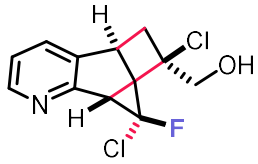




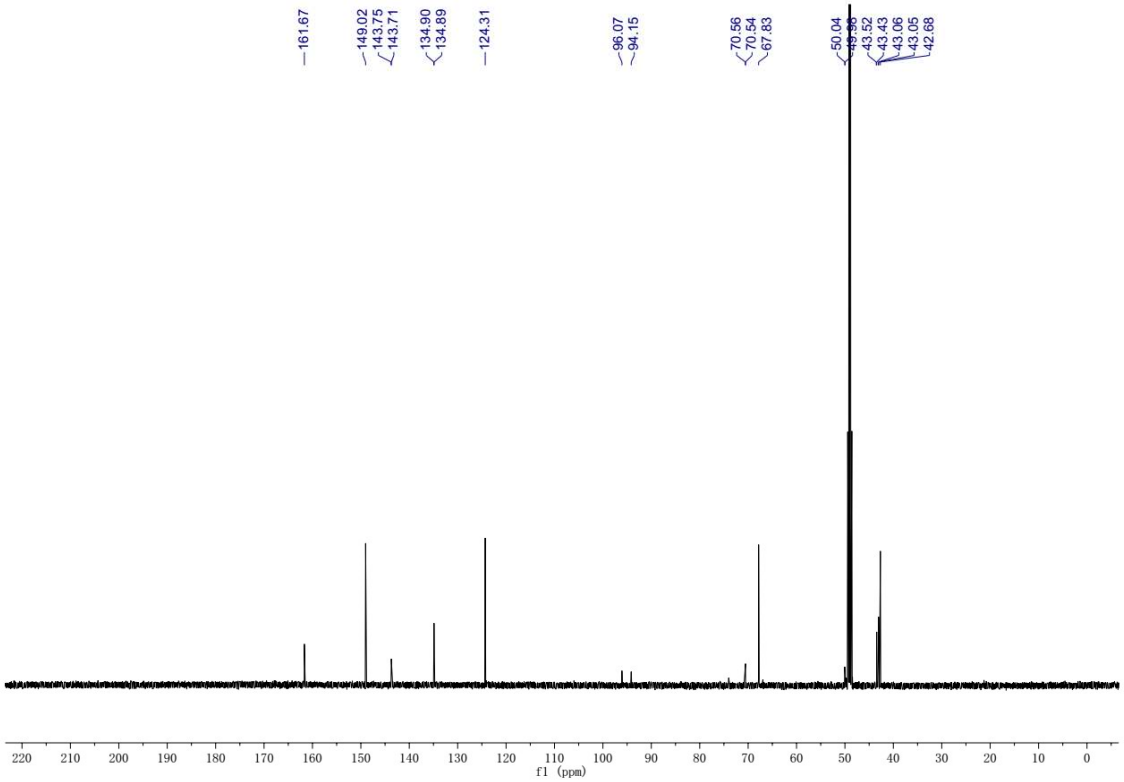


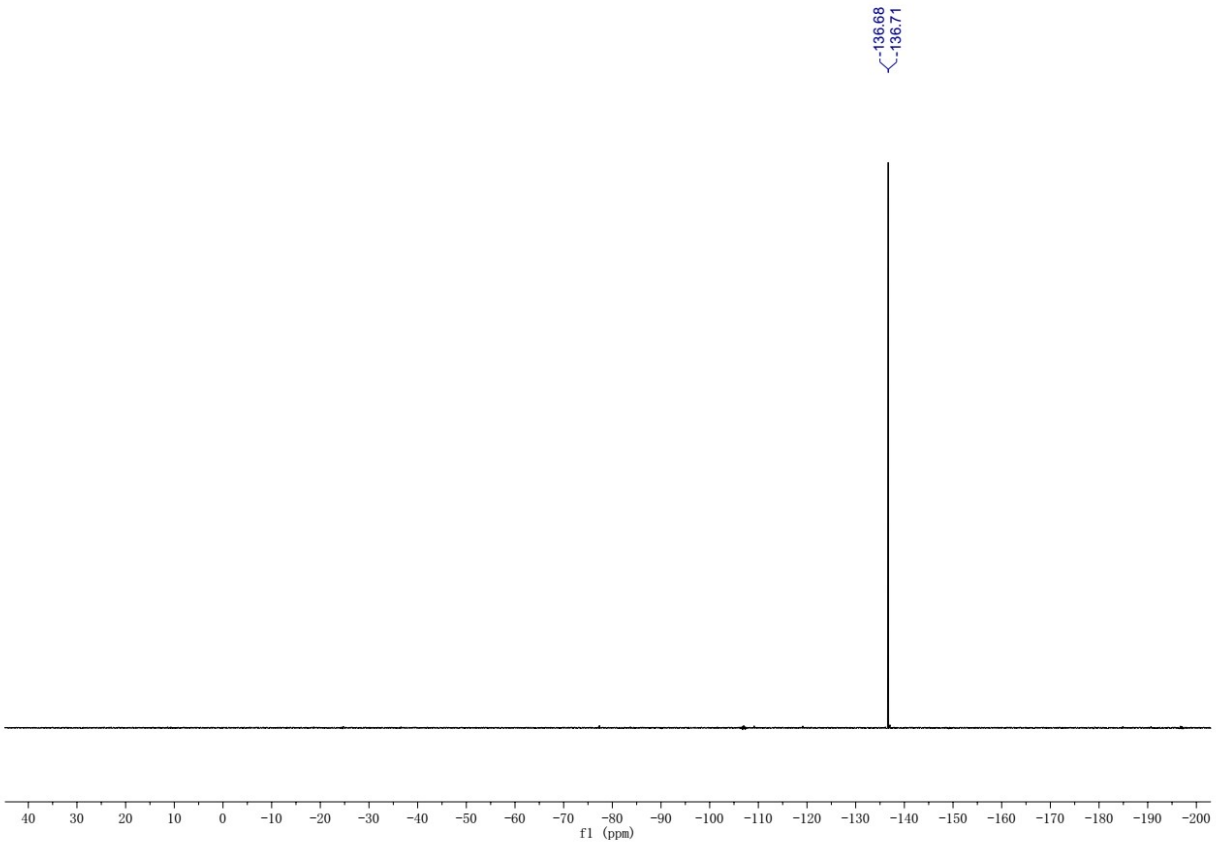
40, 70% yield, >95:5 d.r.

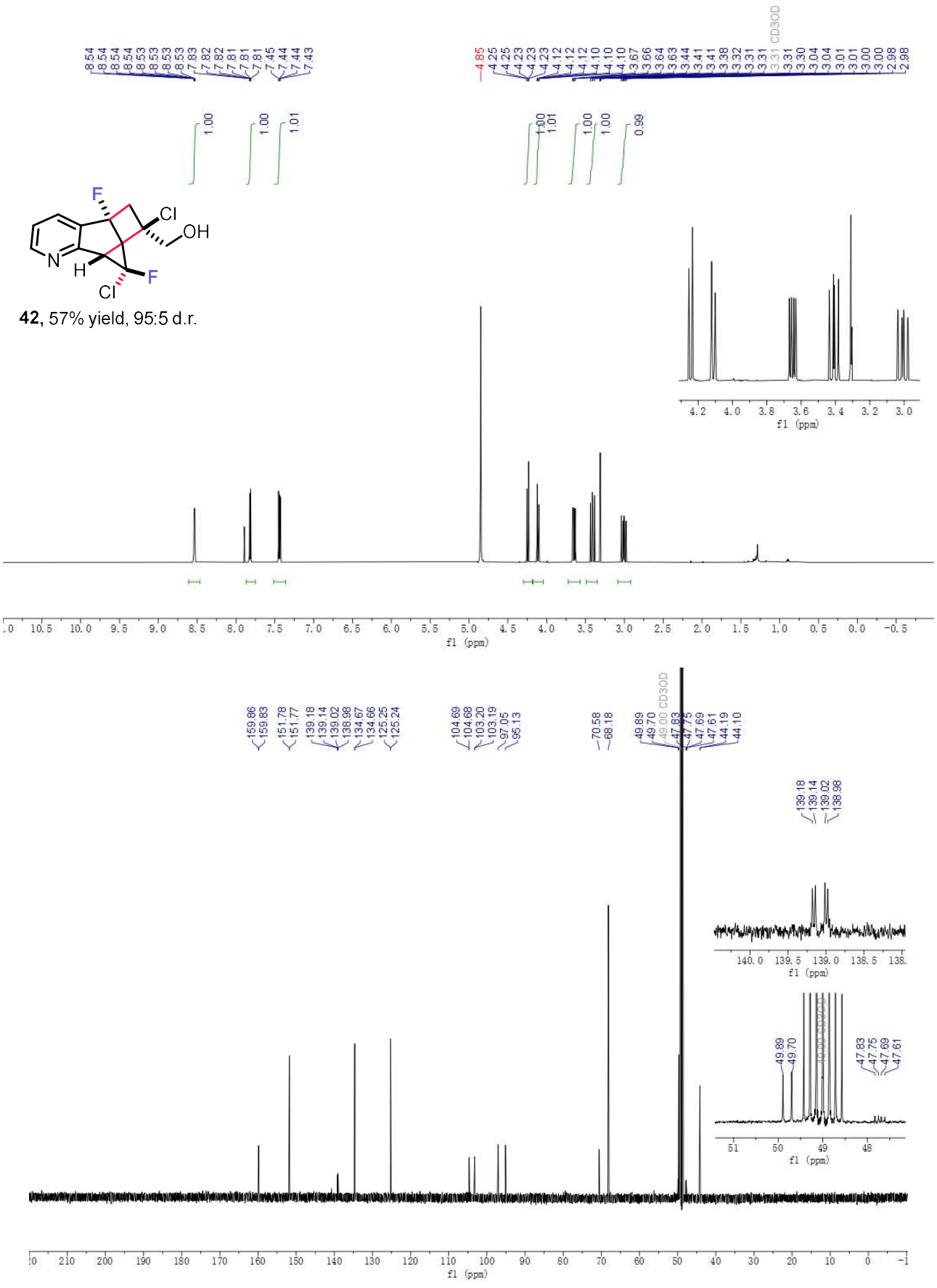




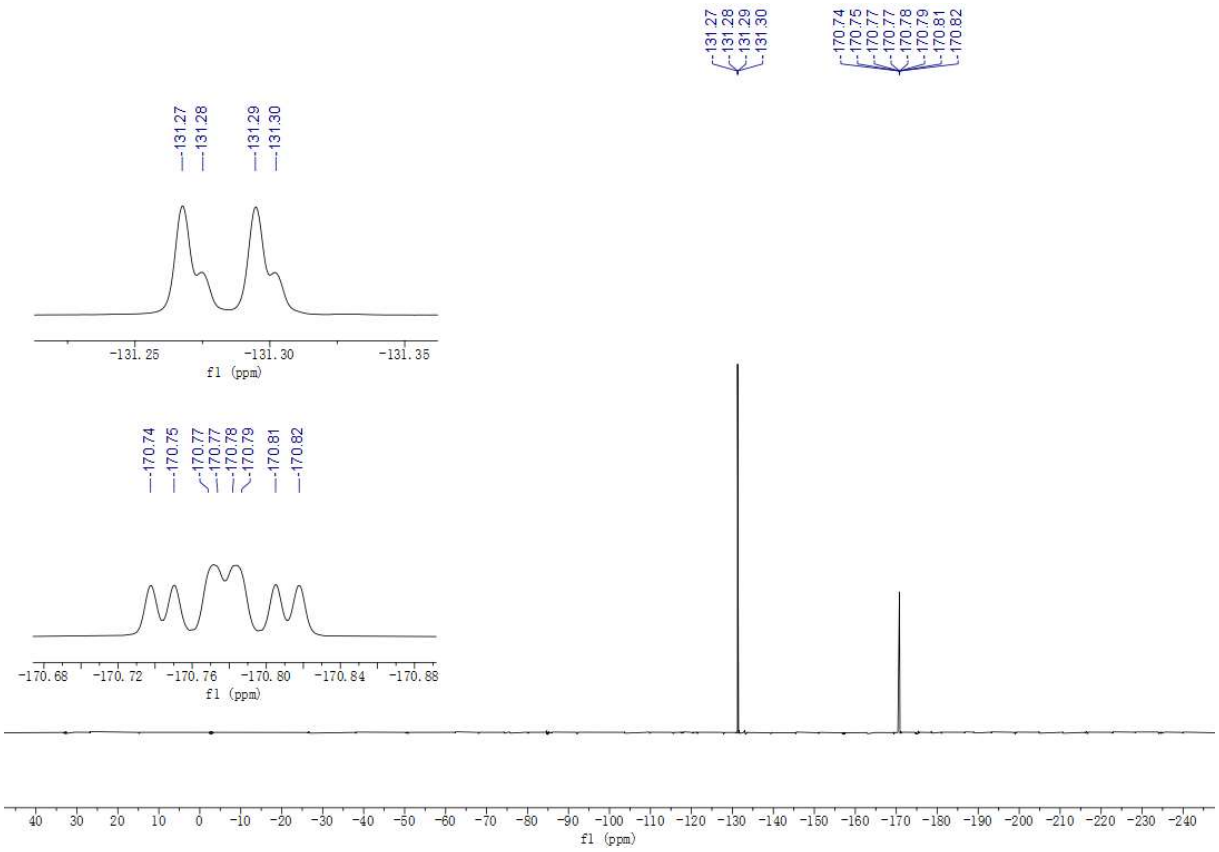
41, 75% yield, 91:9 d.r.

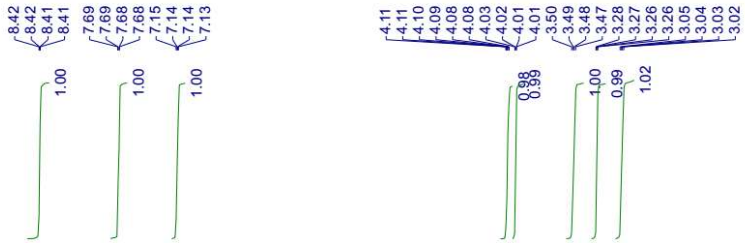


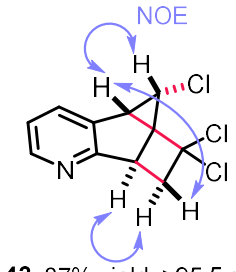

-136.68
-136.71
40 30 20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200
f1 (ppm)



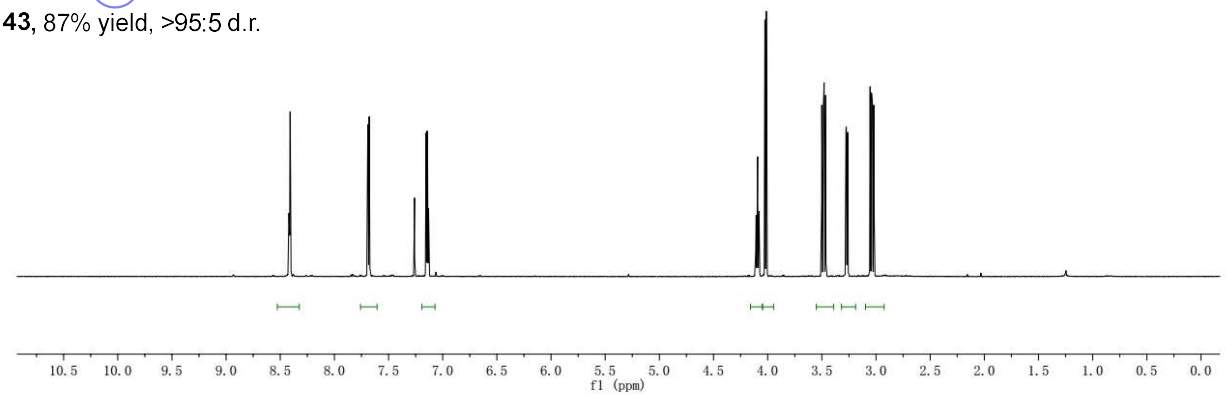
42, 57% yield, 95:5 d.r.

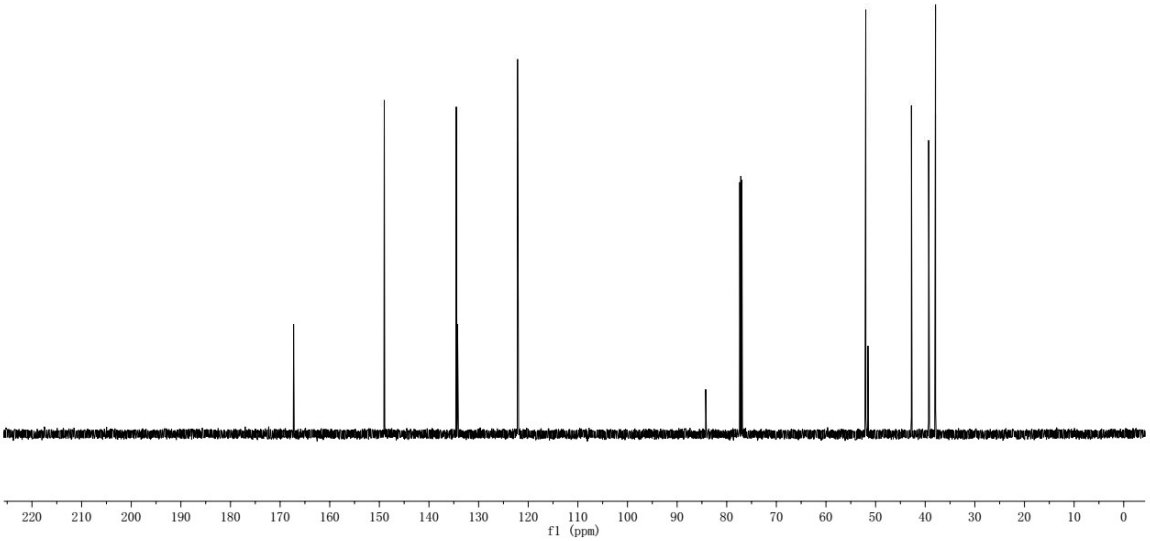

131.27
131.28
131.29
131.30
170.74
170.75
170.77
170.77
170.78
170.79
170.81
170.82
-131.25
-131.30
-131.35
f1 (ppm)
-170.68
-170.72
-170.76
-170.80
-170.84
-170.88
f1 (ppm)
40 30 20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210 -220 -230 -240
f1 (ppm)

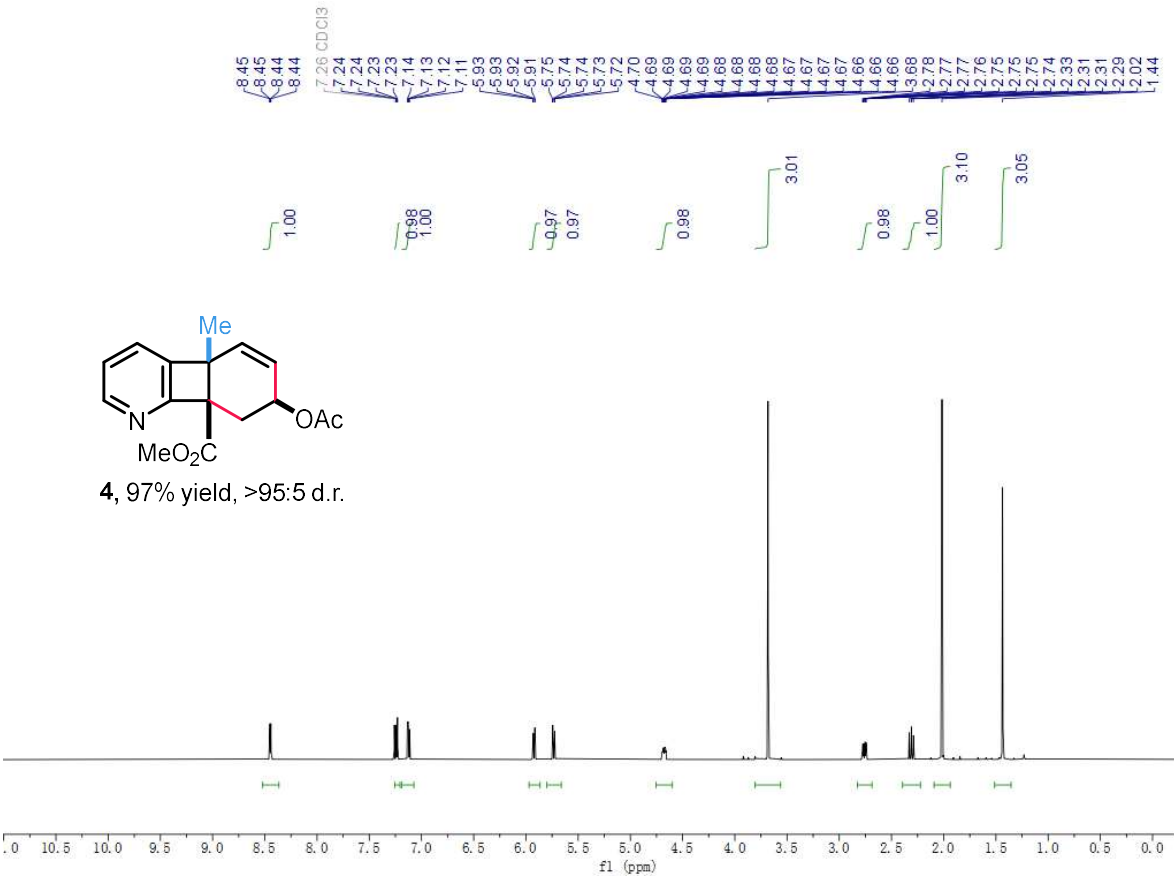




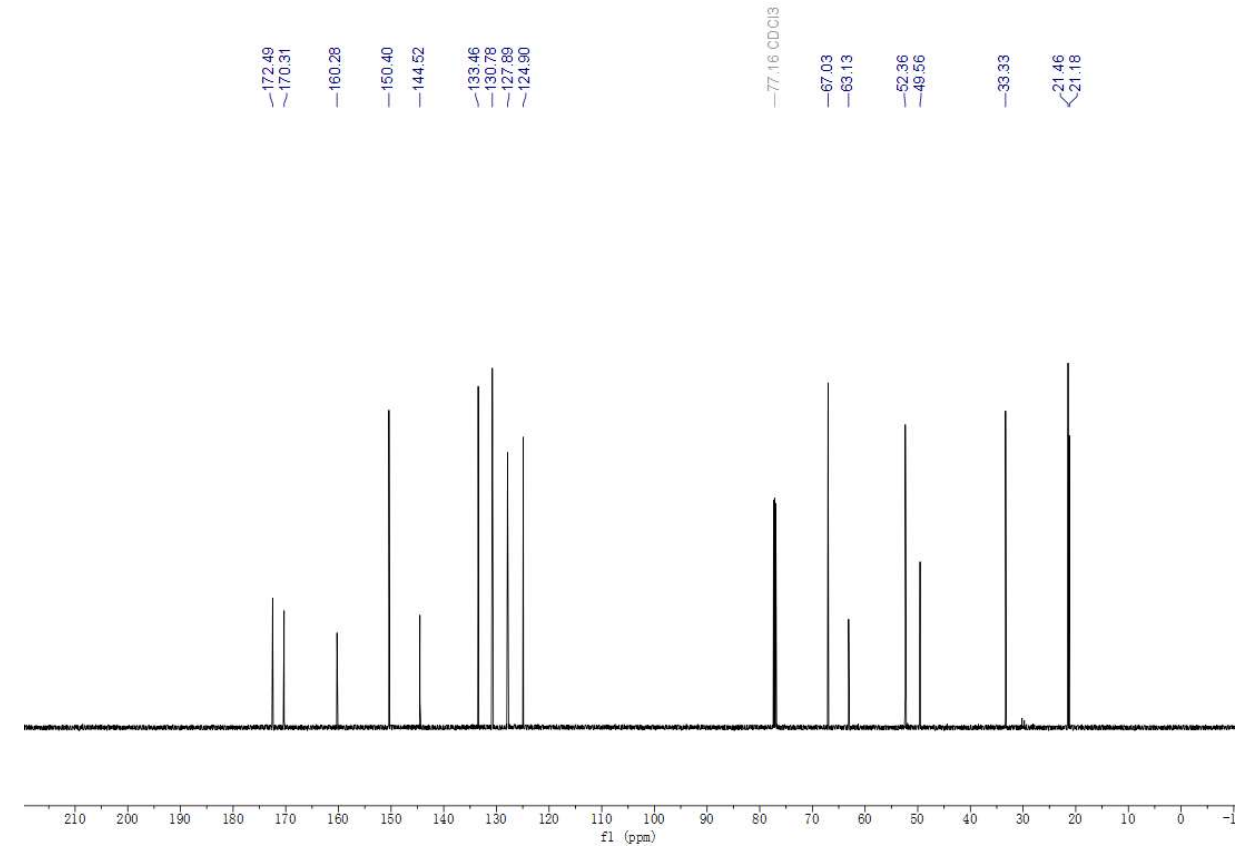
43, 87% yield, >95:5 d.r.

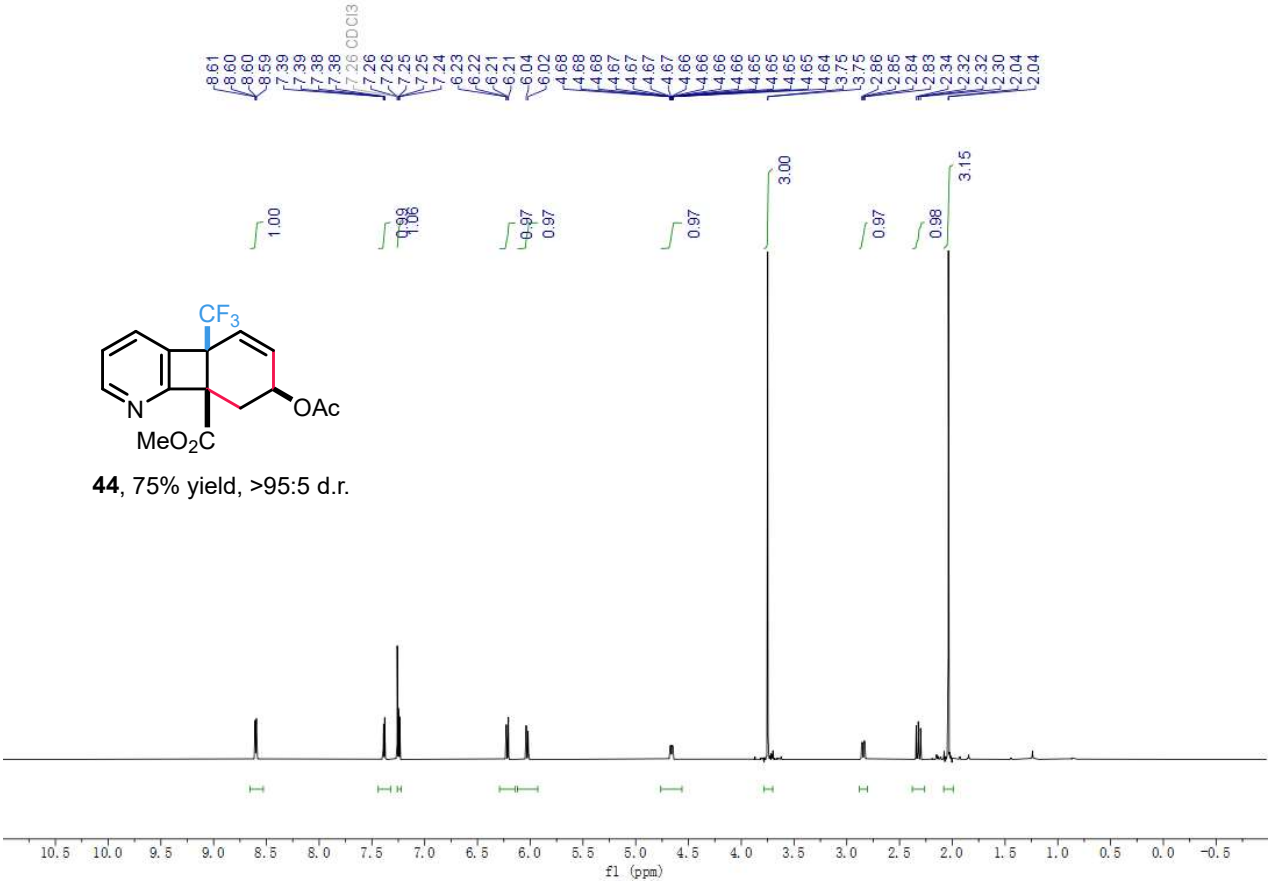




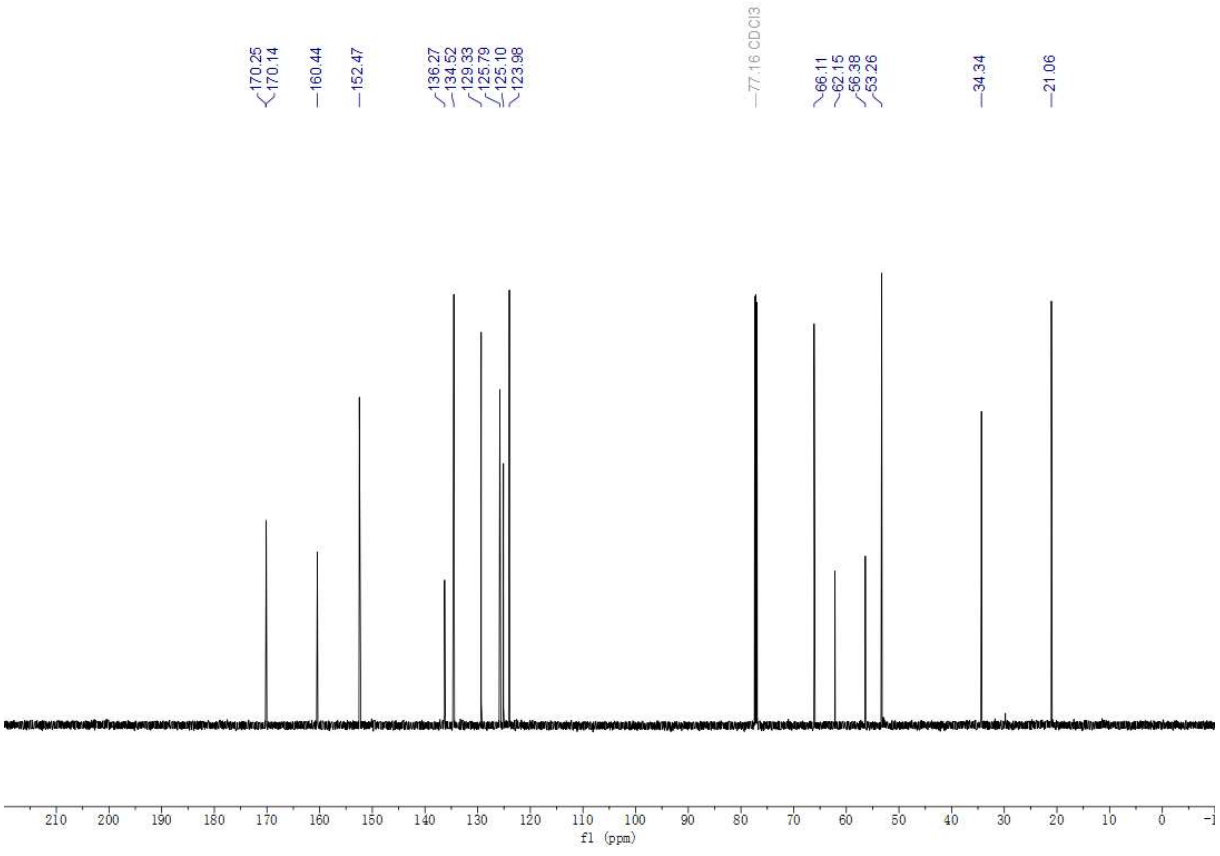


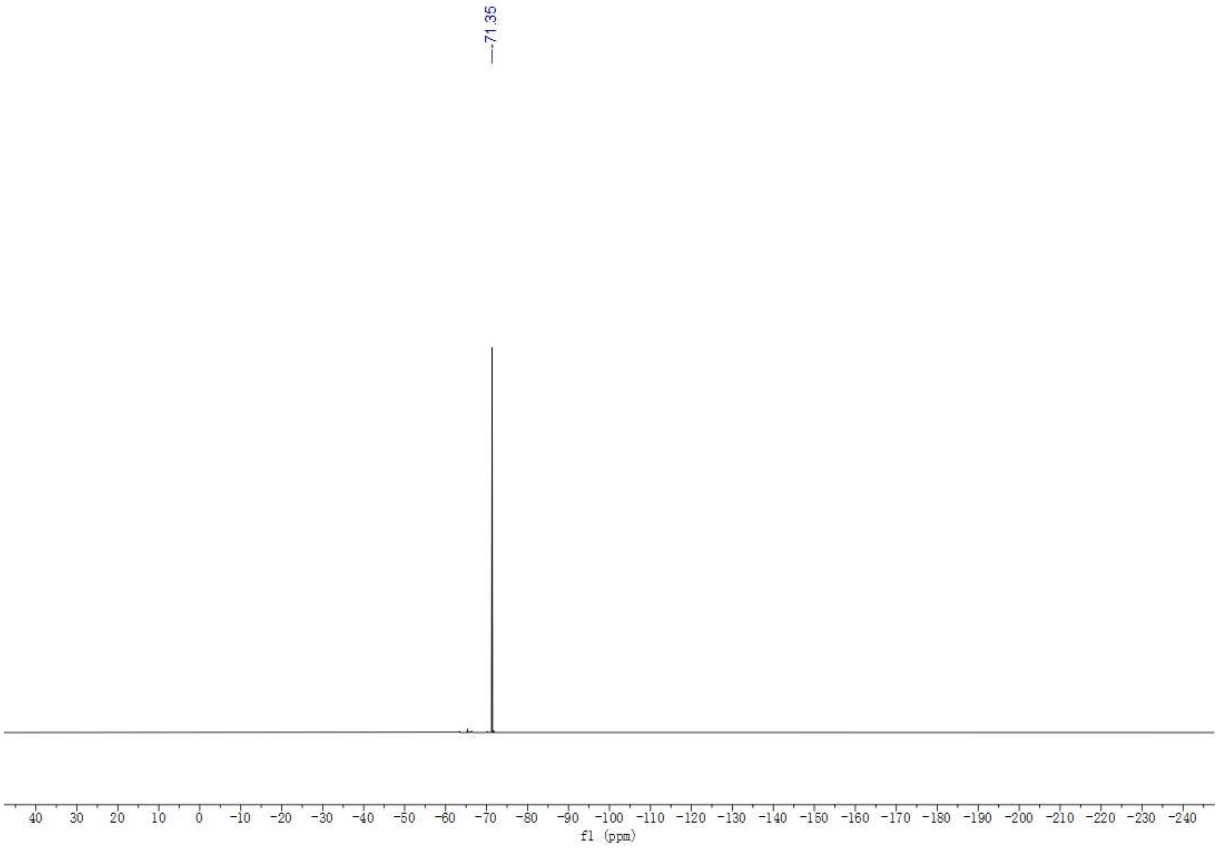
4, 97% yield, >95:5 d.r.

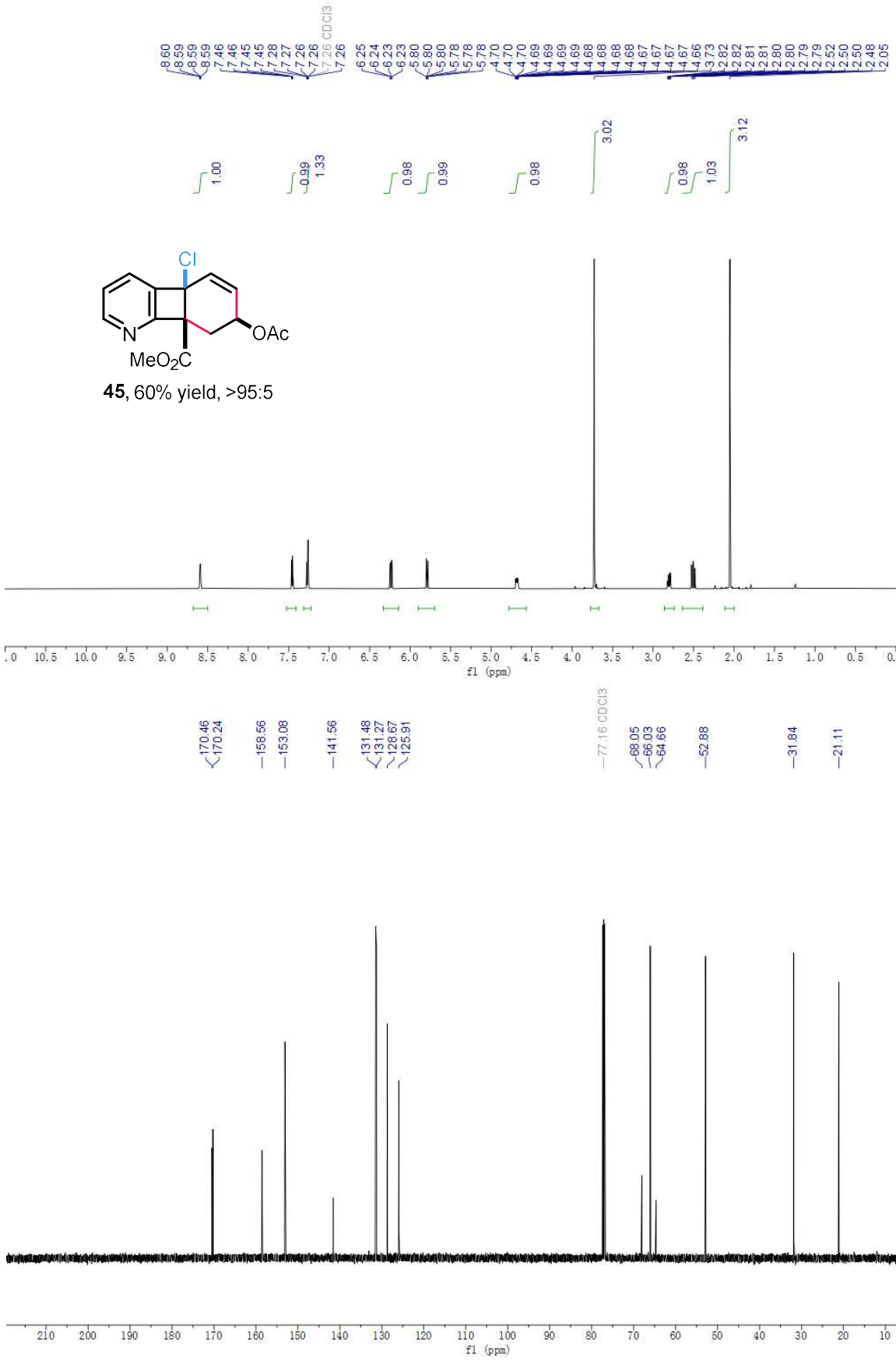


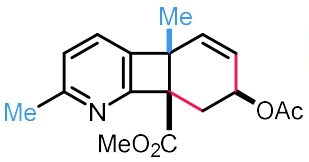


44, 75% yield, >95:5 d.r.

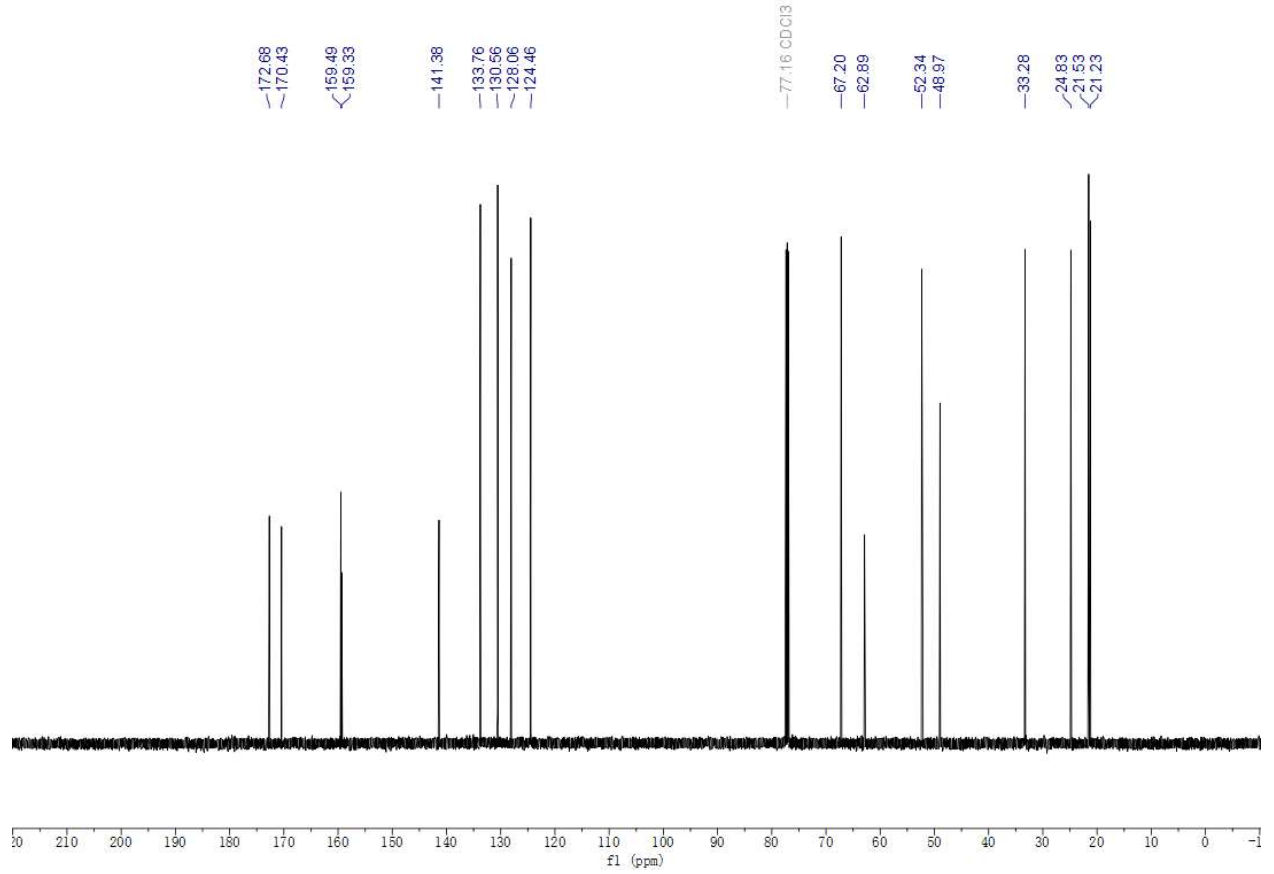


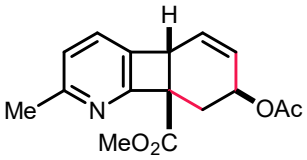

-71.35
40 30 20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210 -220 -230 -240
f1 (ppm)


Cl
N
OAc
MeO2C
45, 60% yield, >95:5
f1 (ppm)
f1 (ppm)

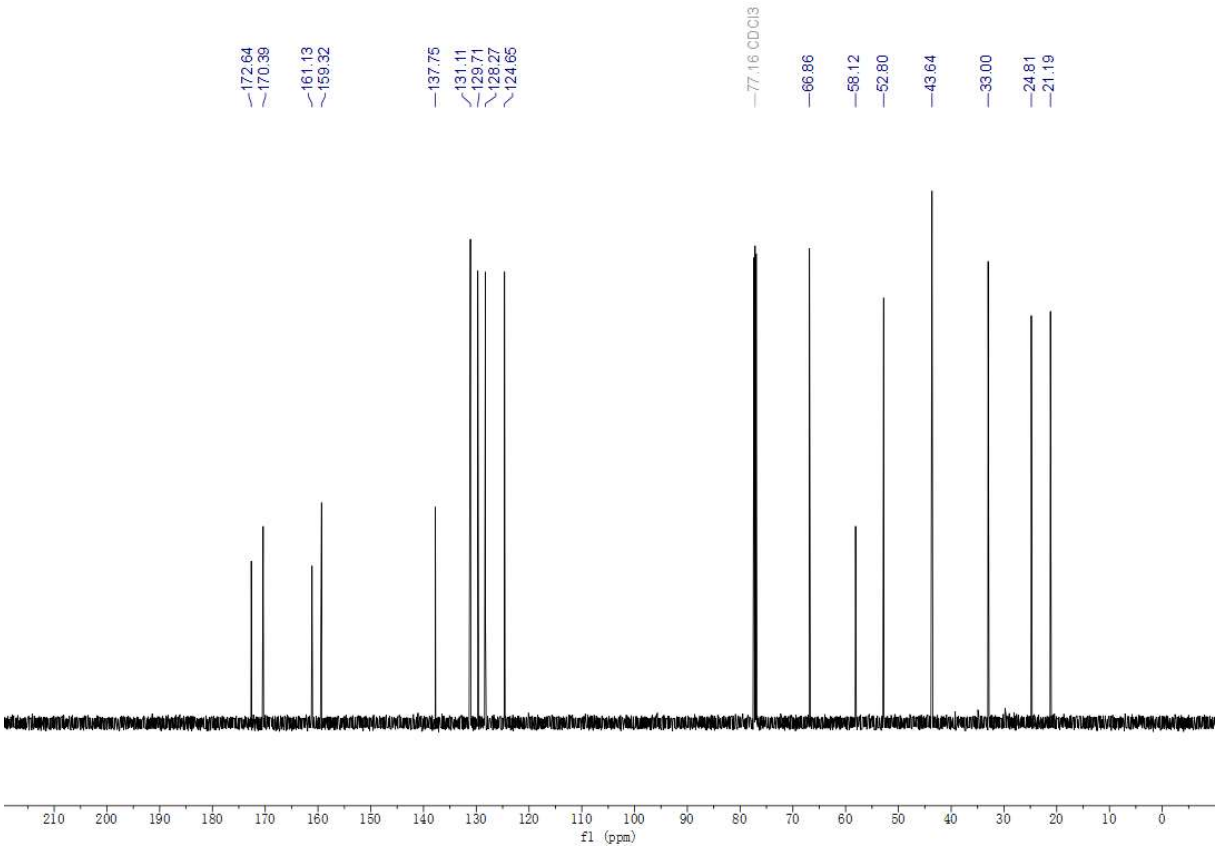


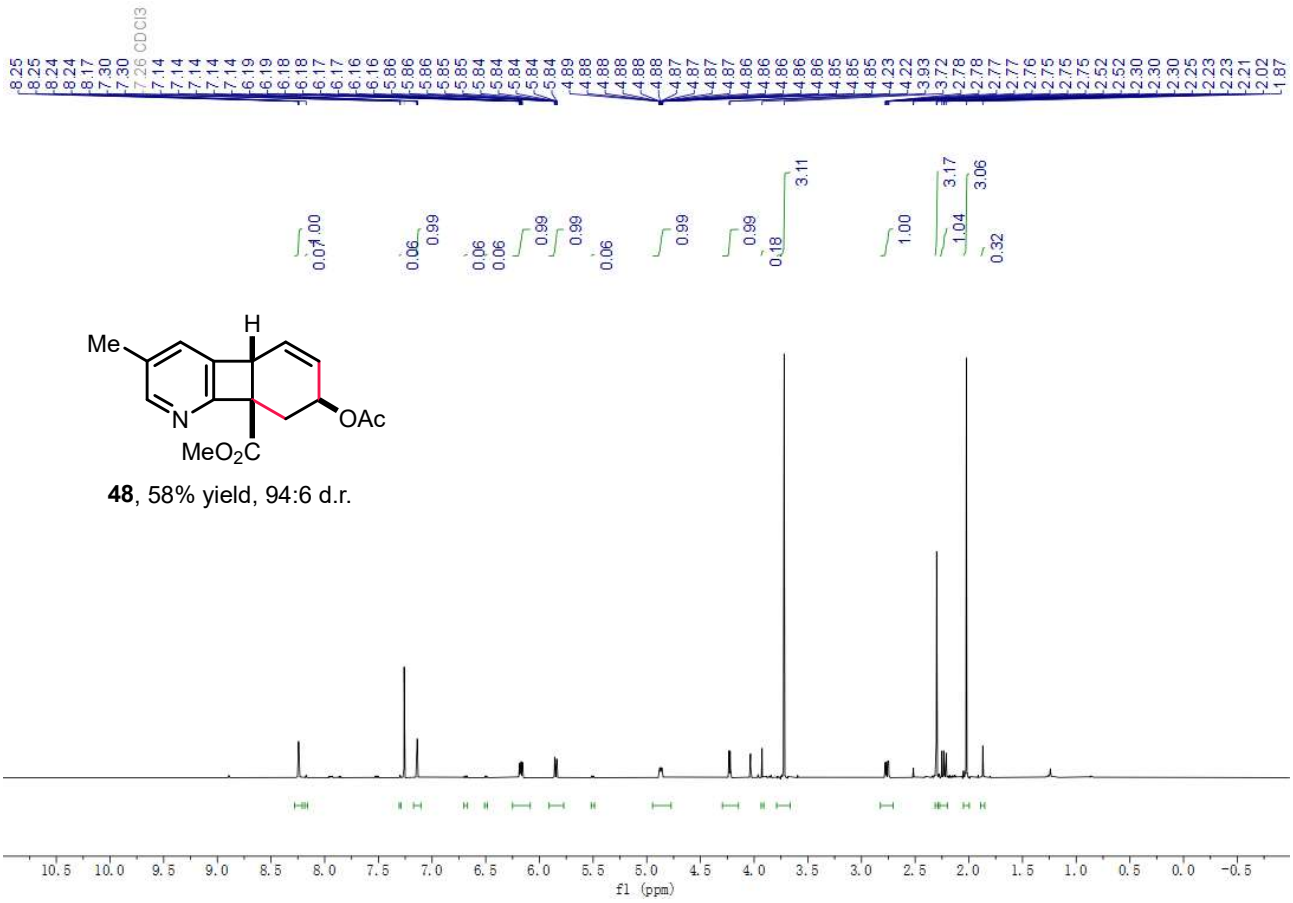
46, 68% yield, >95:5 d.r.



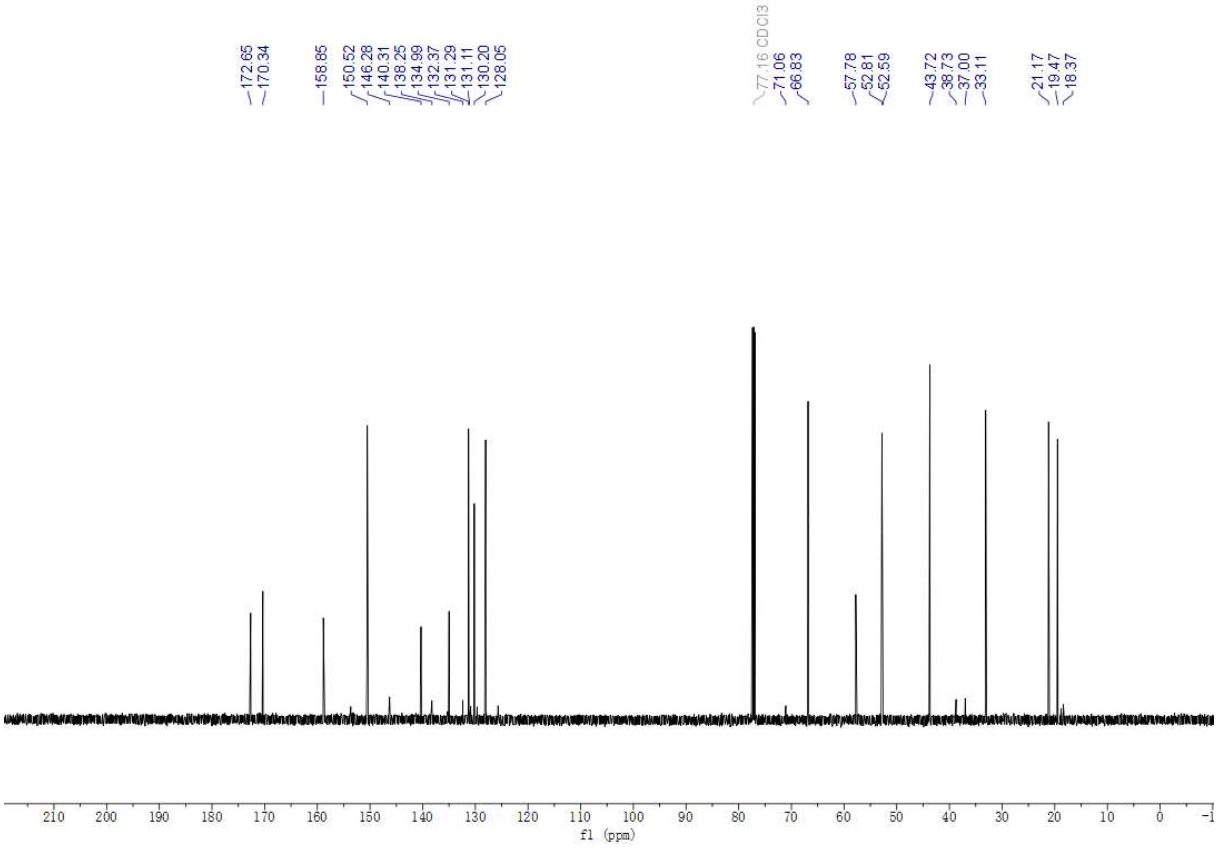


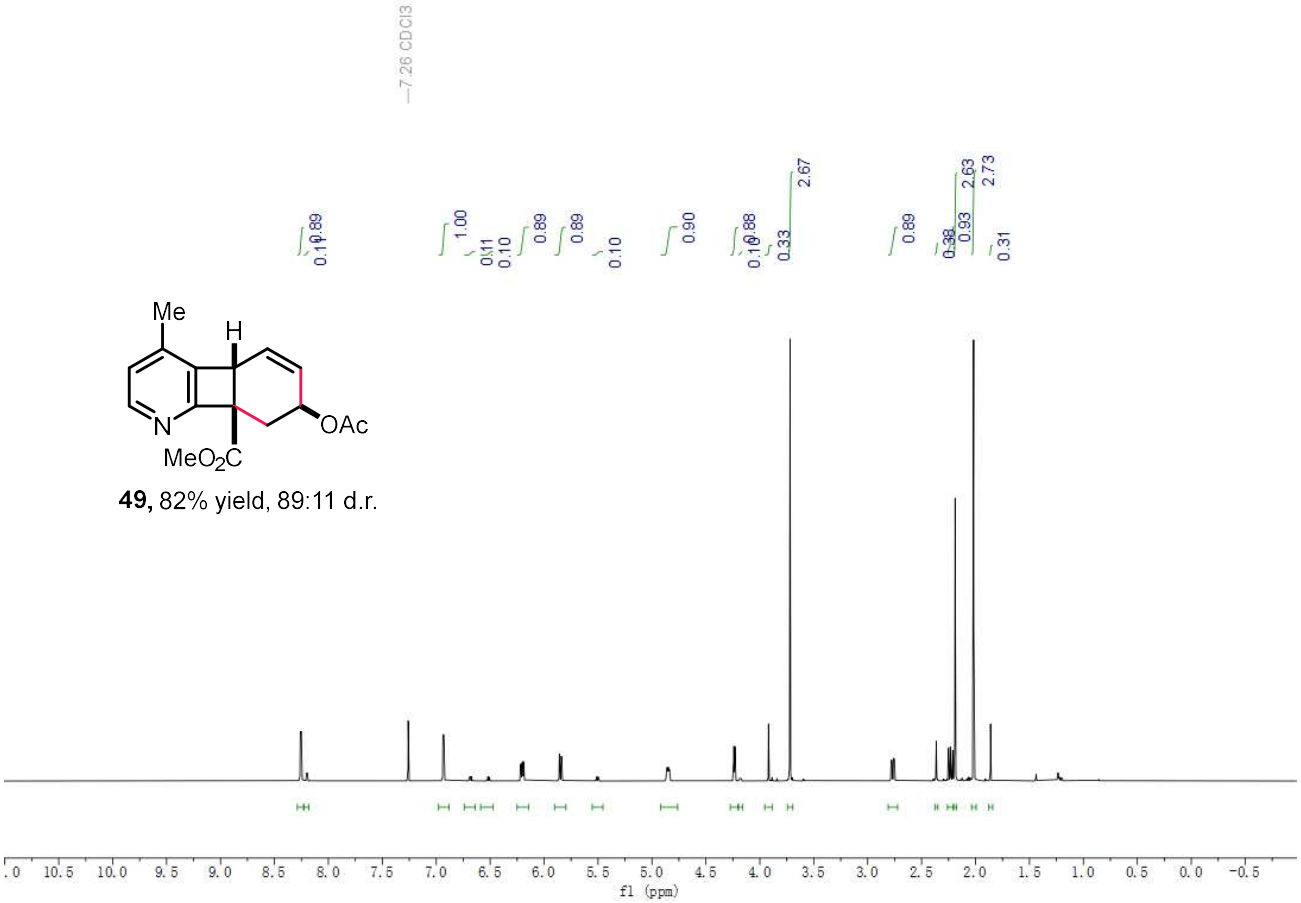
47, 62% yield, >95:5 d.r.



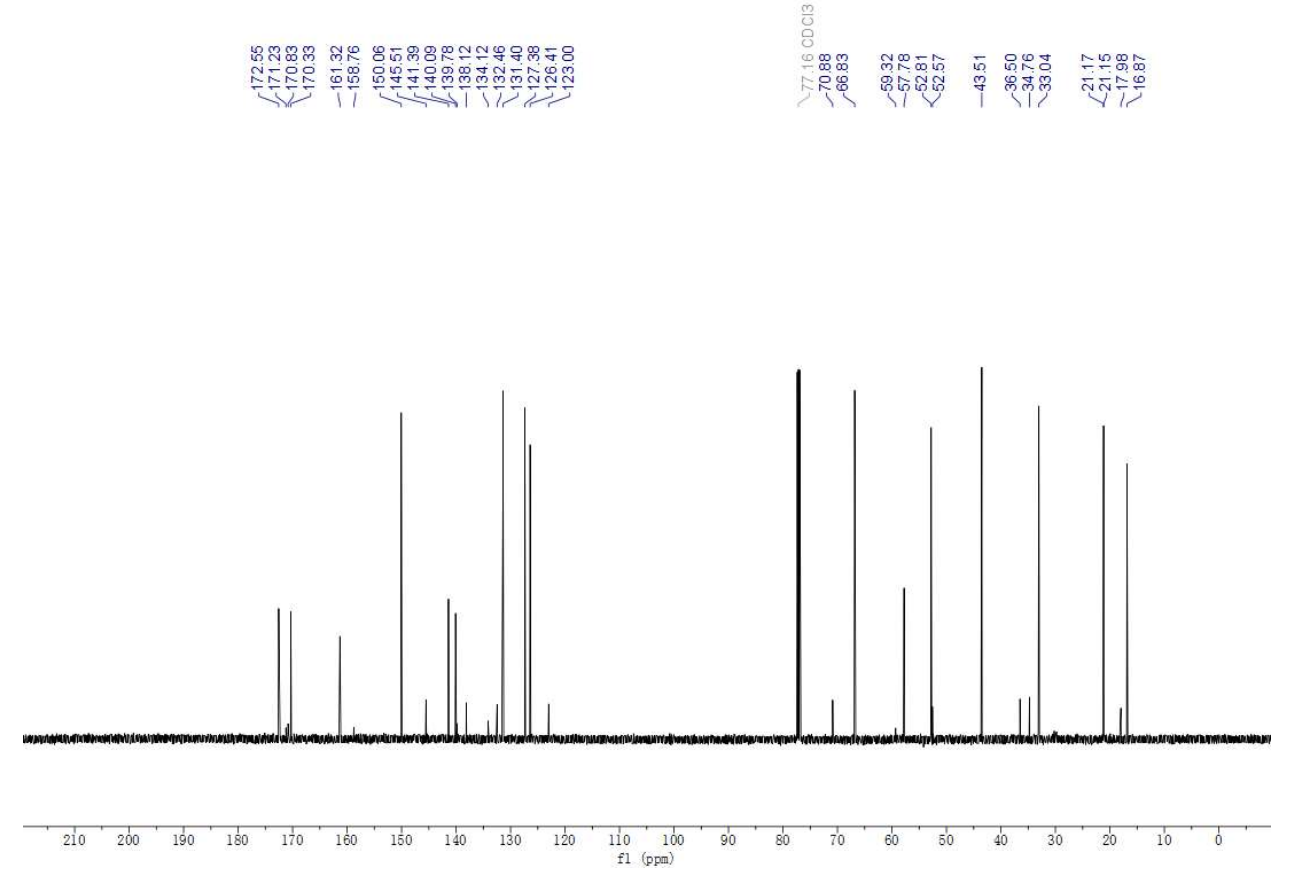


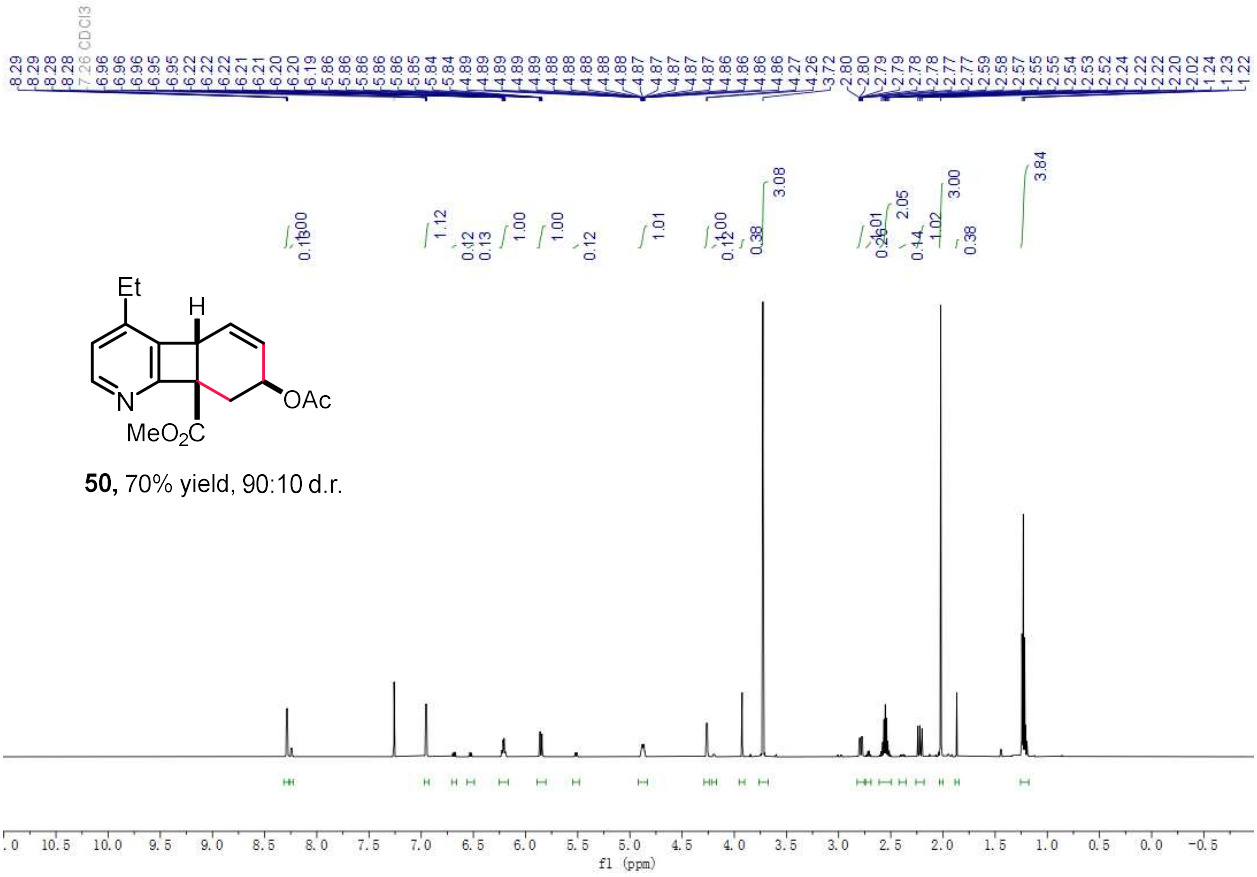
48, 58% yield, 94:6 d.r.



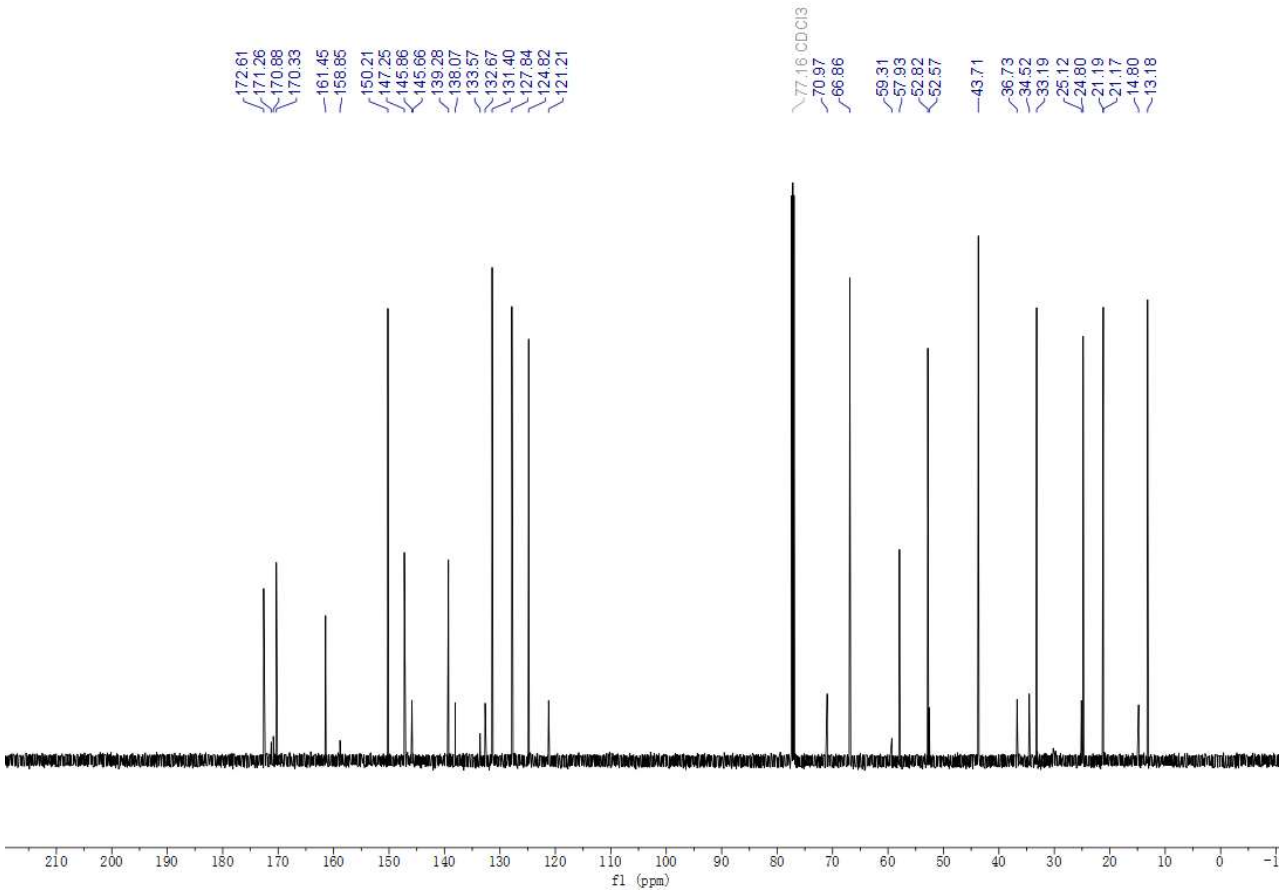


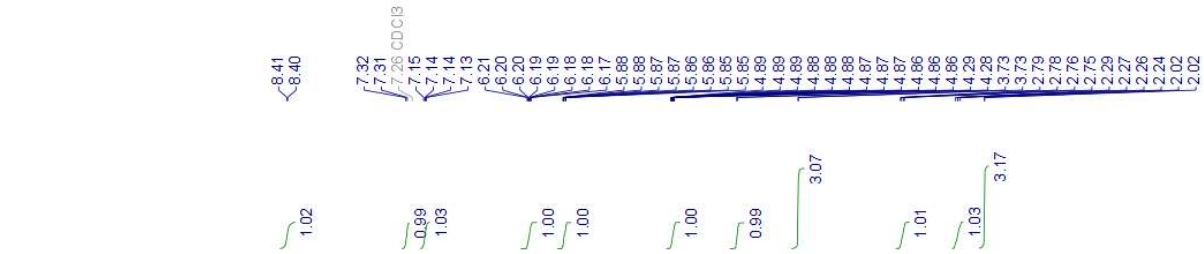
49, 82% yield, 89:11 d.r.

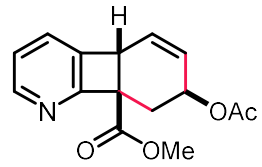




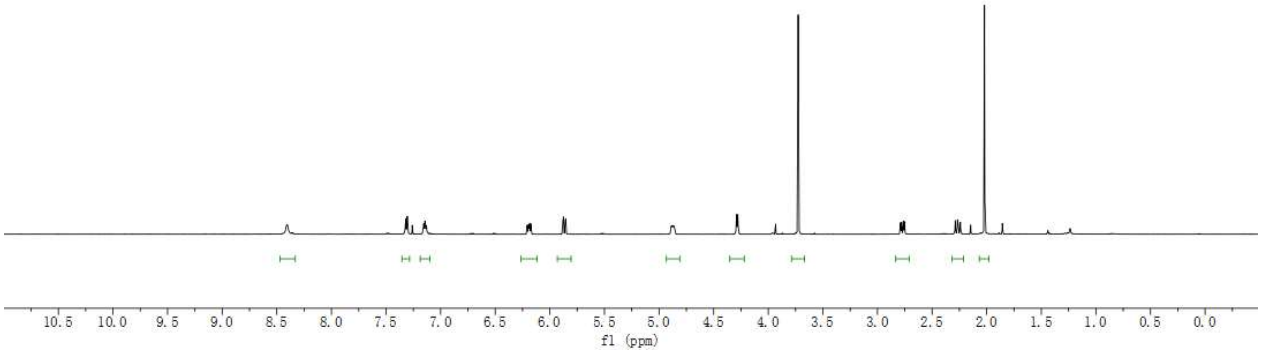
50, 70% yield, 90:10 d.r.

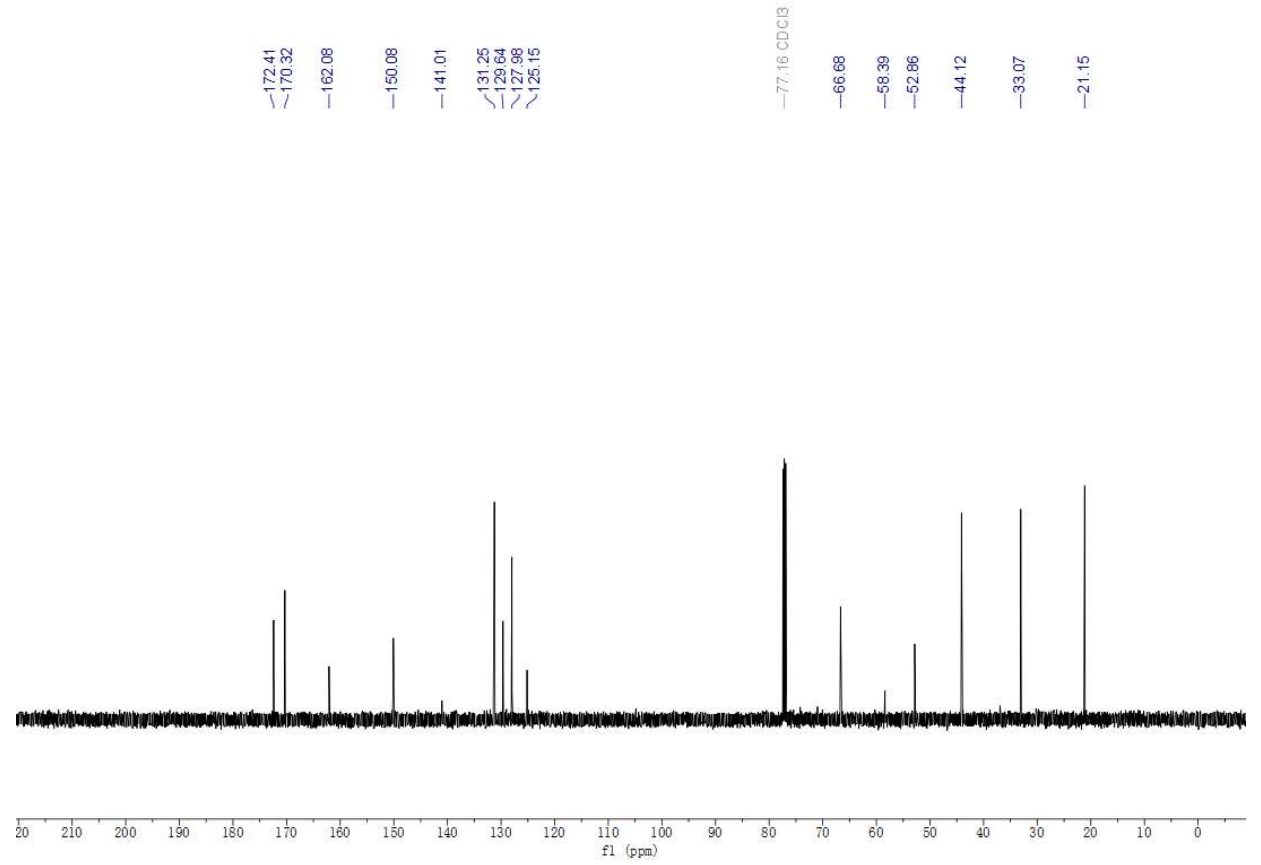


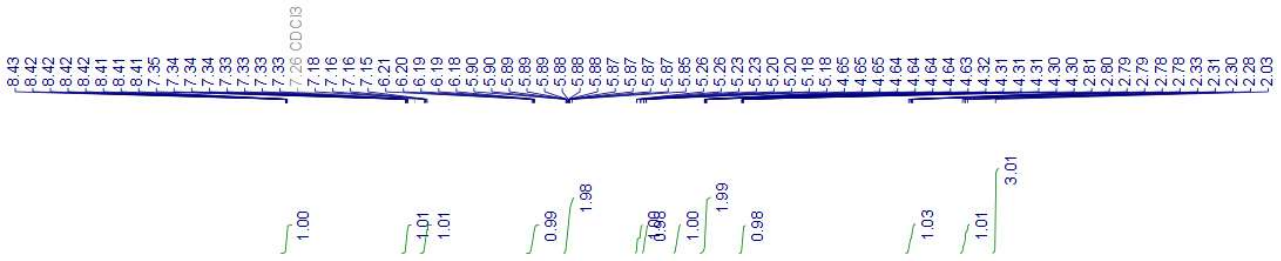


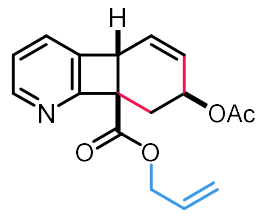


51, 62% yield, >95:5 d.r.

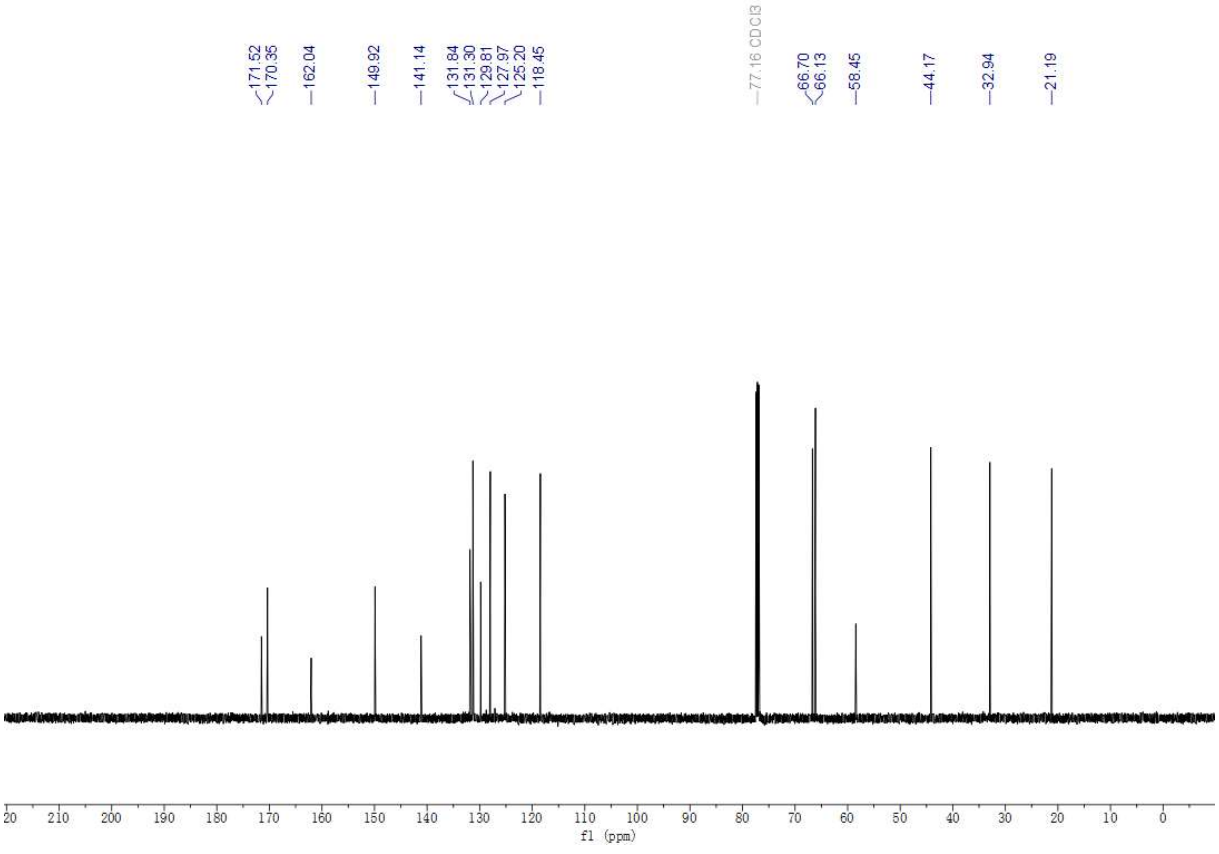


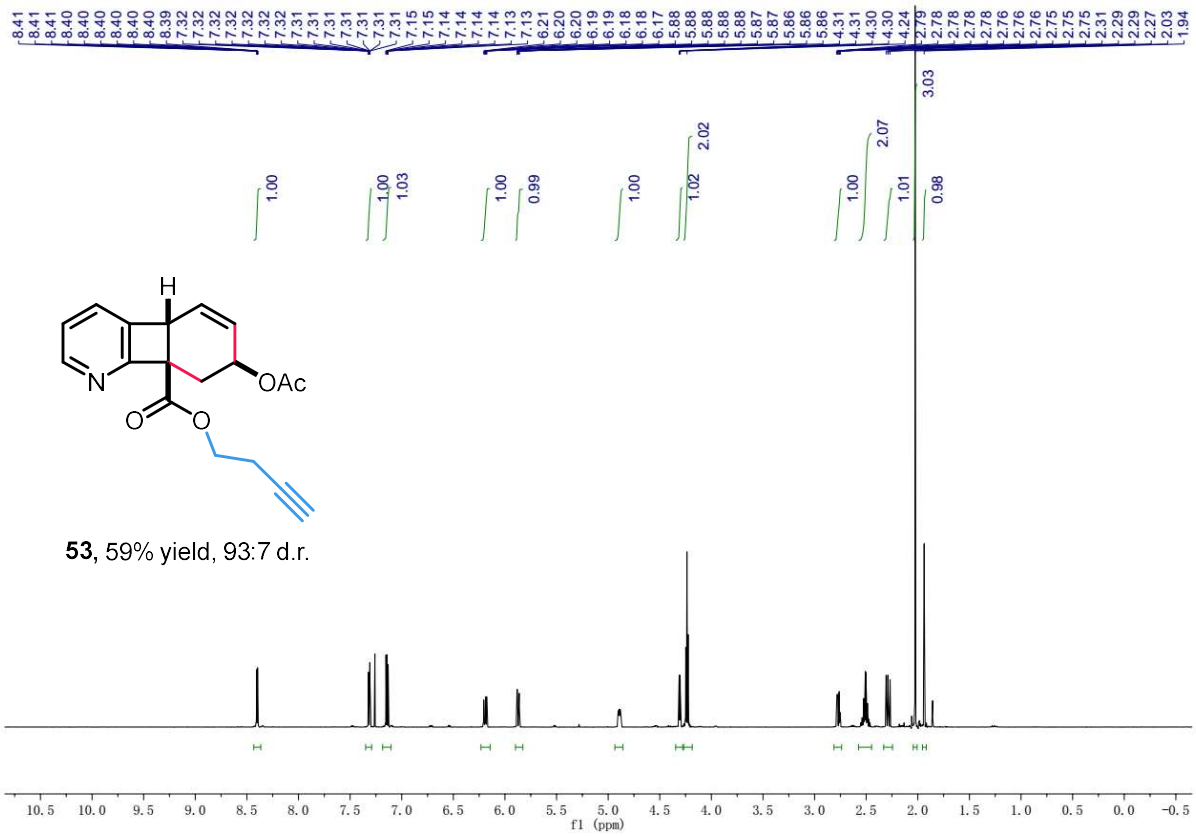




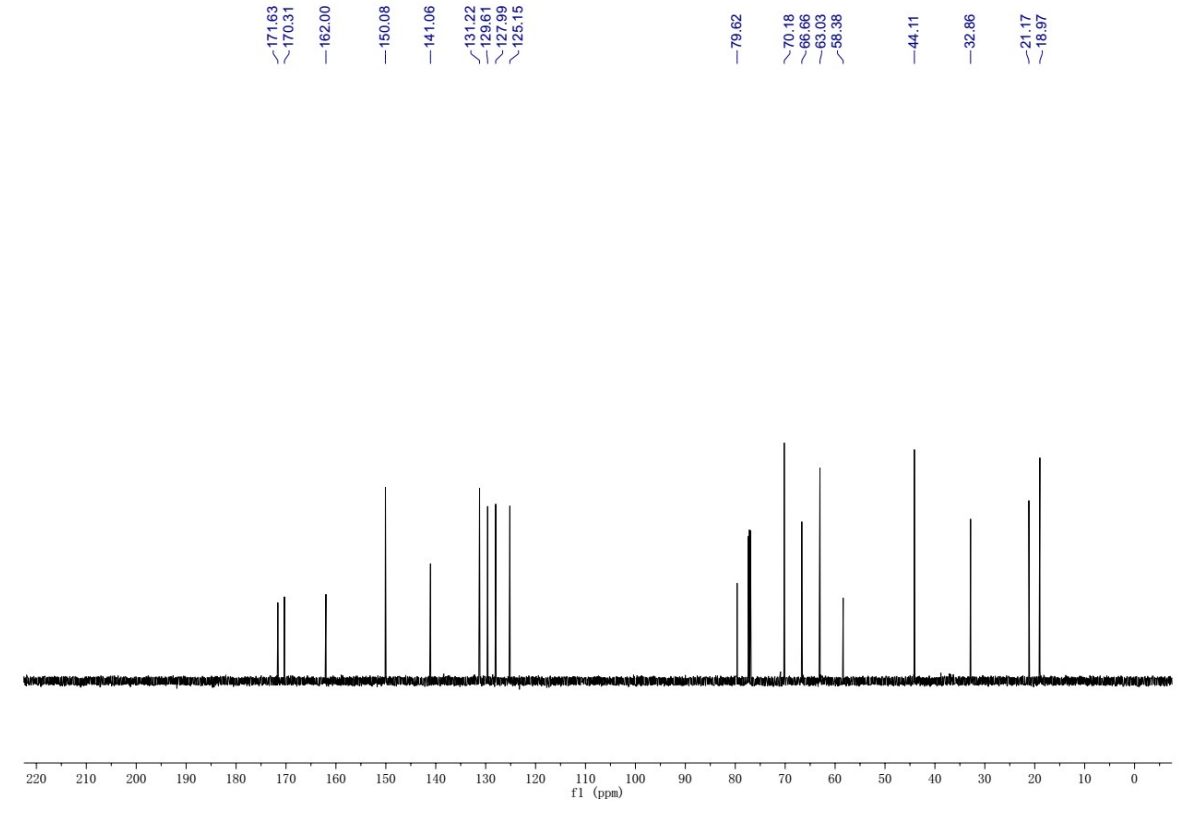


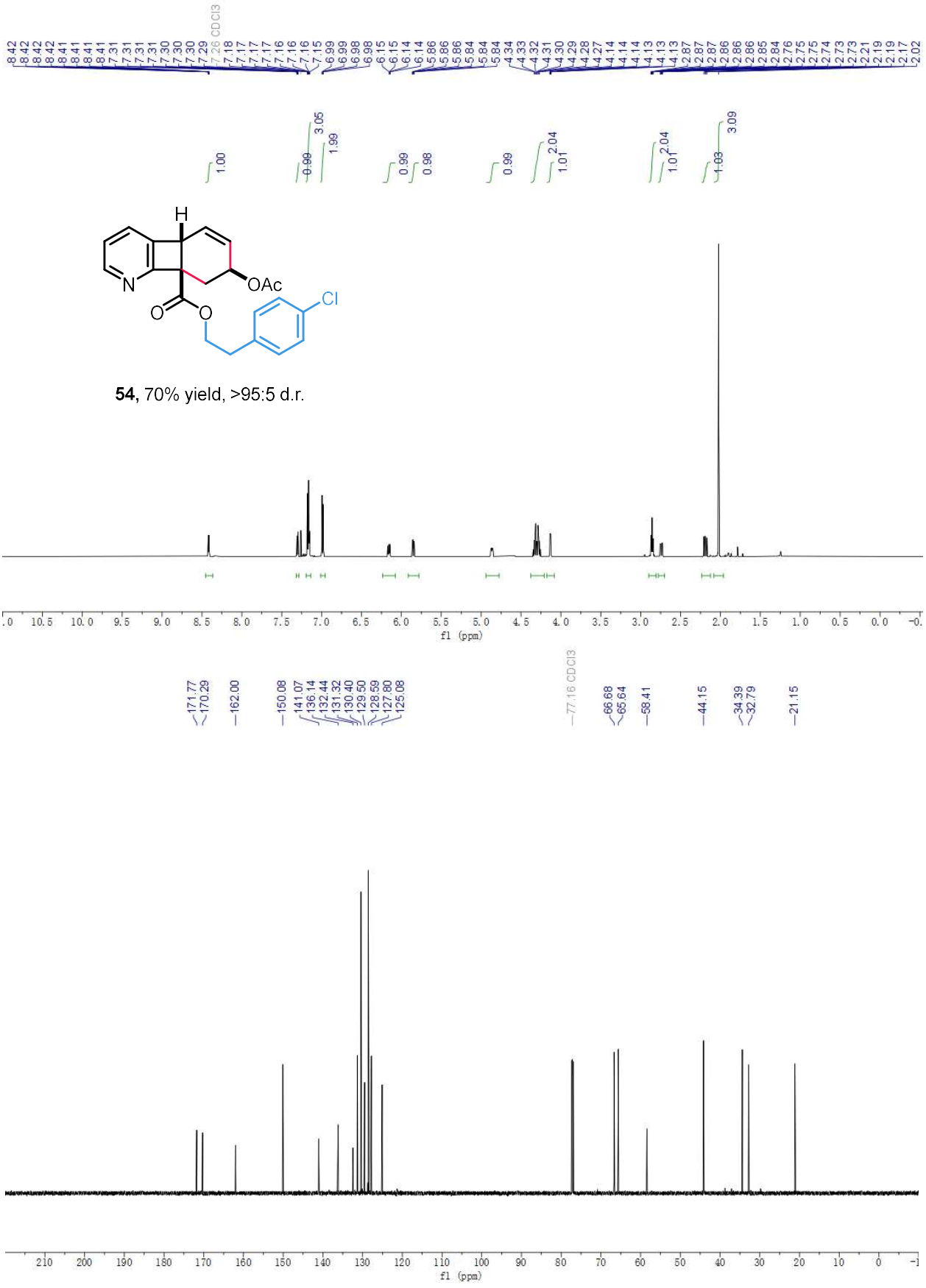
52, 66% yield, >95:5 d.r.



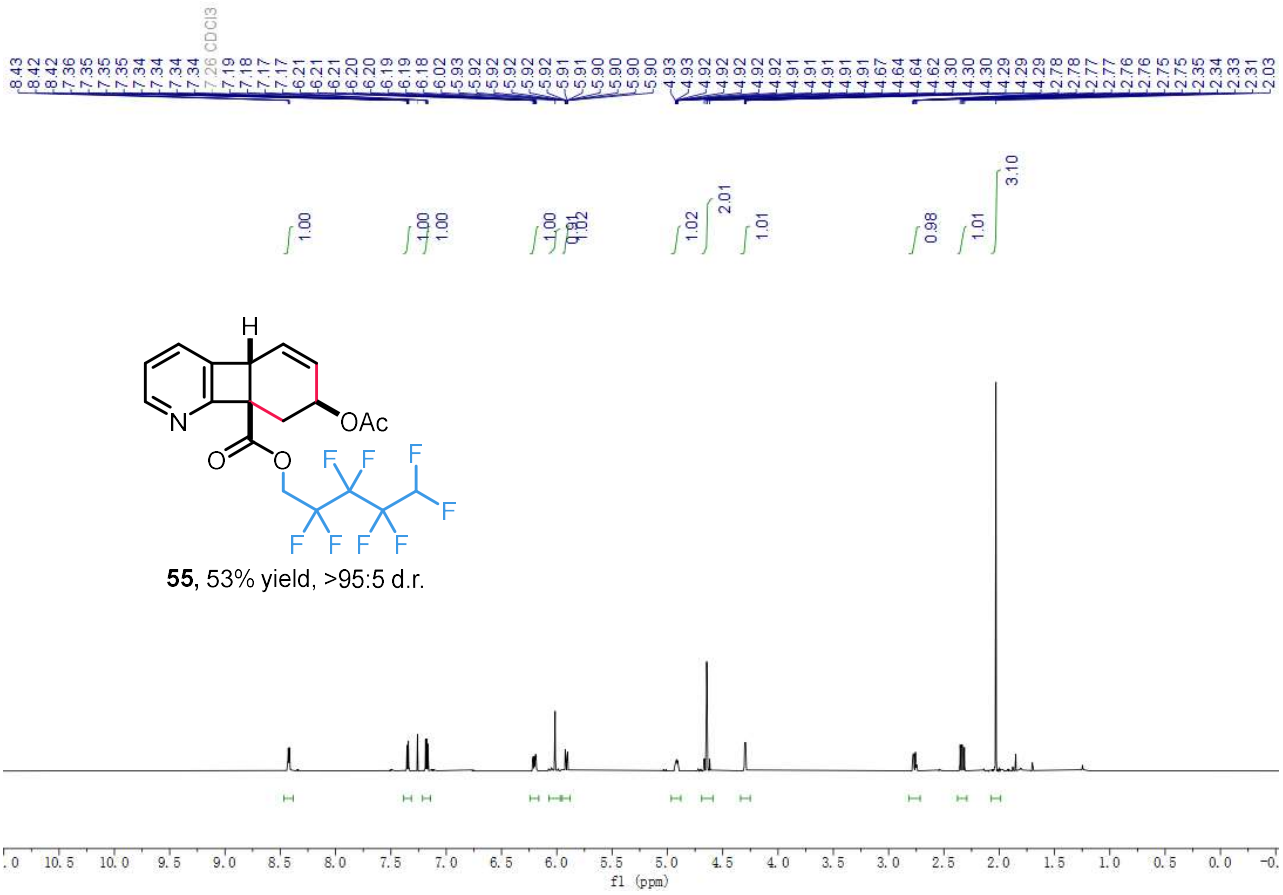


53, 59% yield, 93:7 d.r.

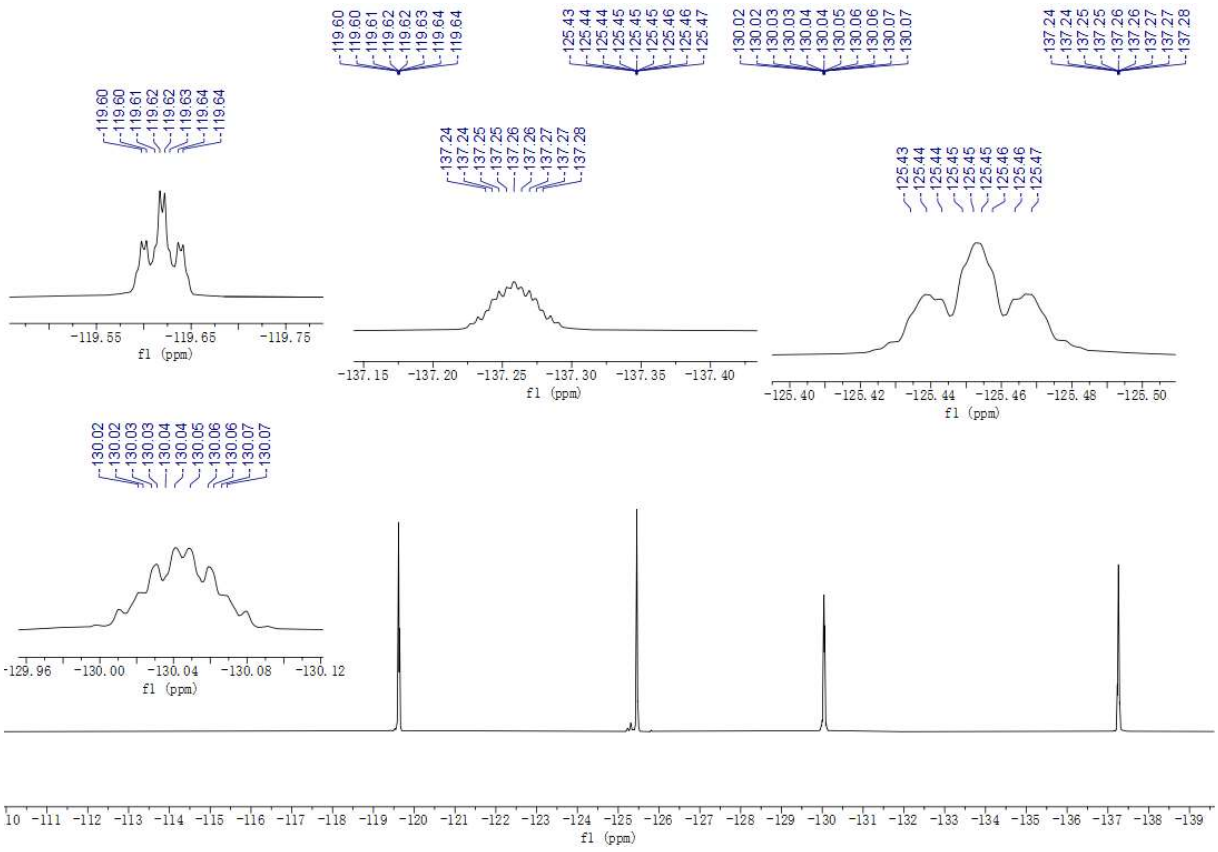


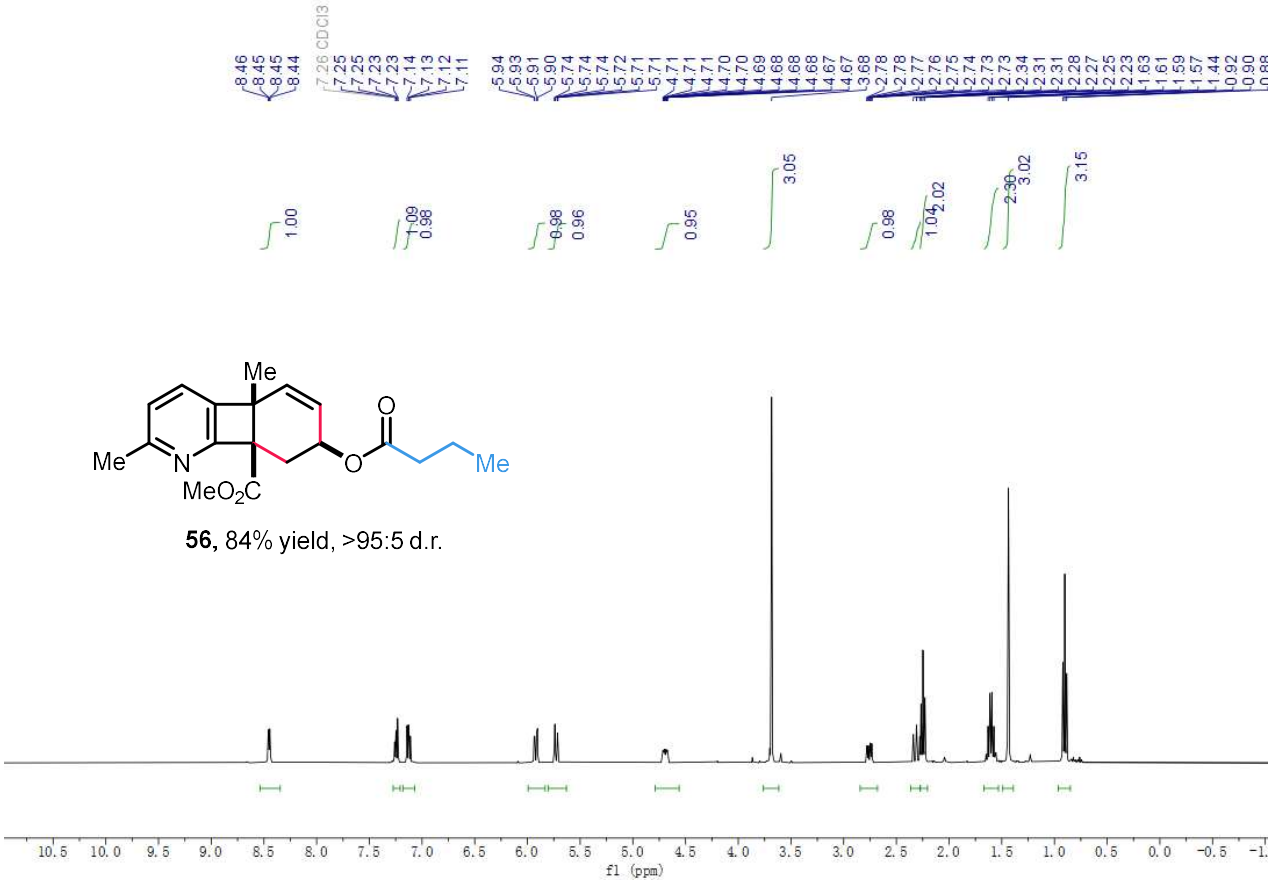


54, 70% yield, >95:5 d.r.

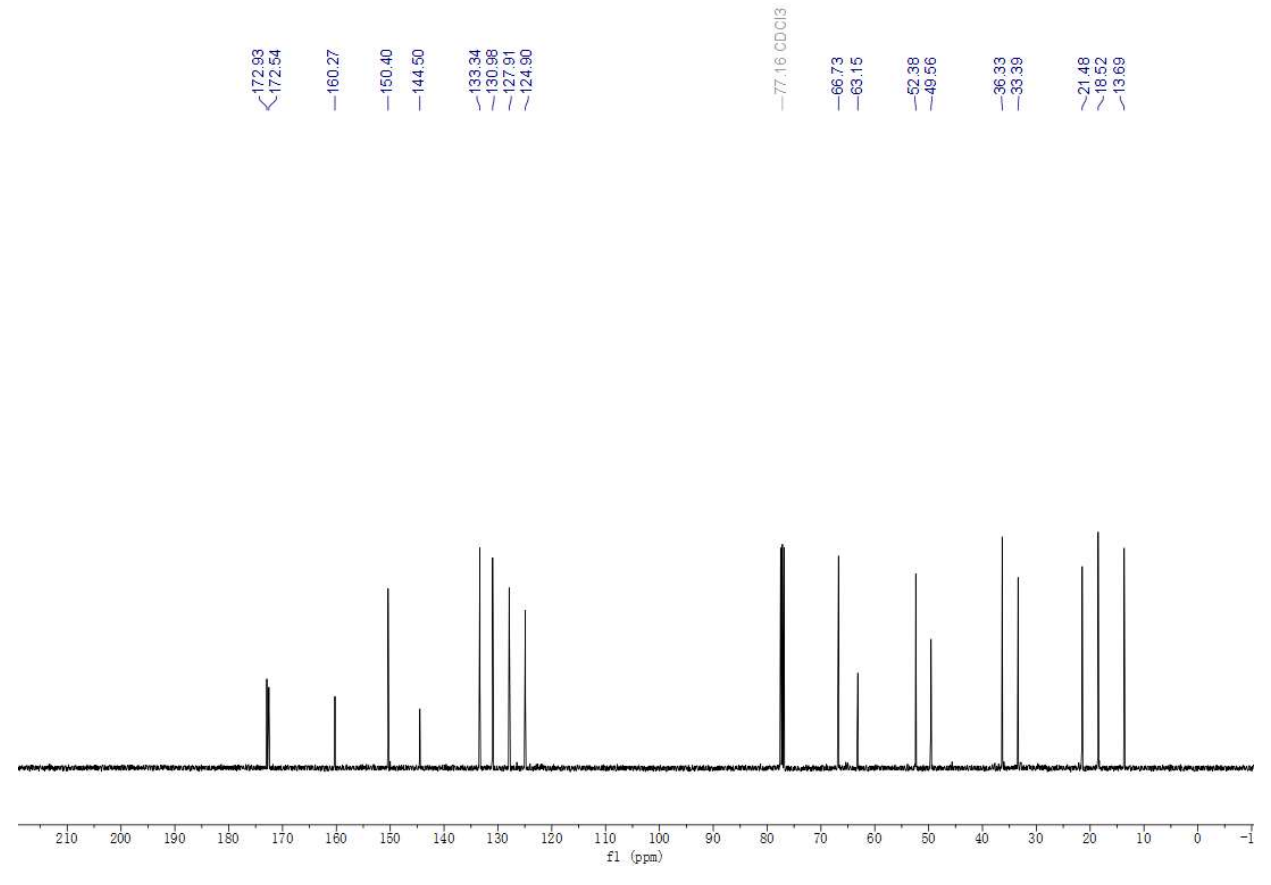


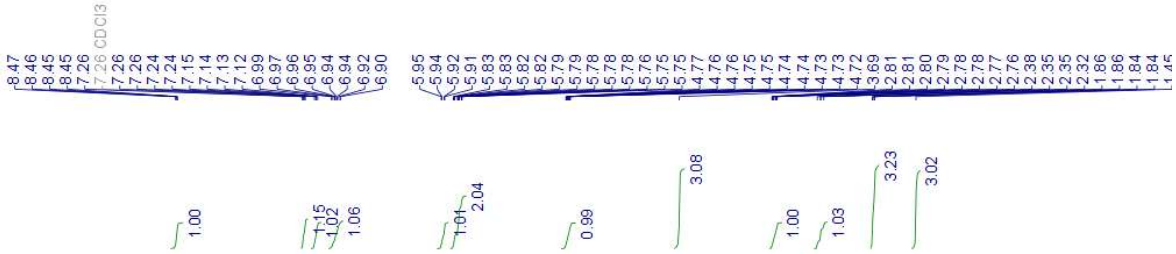
55, 53% yield, >95:5 d.r.

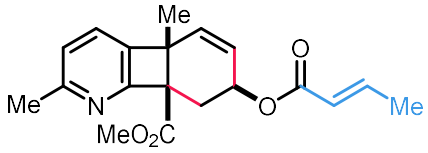

119.60
119.60
119.61
119.62
119.62
119.63
119.64
119.64
-119.55
-119.65
-119.75
f1 (ppm)
137.24
137.24
137.25
137.25
137.26
137.26
137.27
137.27
137.28
-137.15
-137.20
-137.25
-137.30
-137.35
-137.40
f1 (ppm)
125.43
125.44
125.44
125.45
125.45
125.45
125.46
125.46
125.47
-125.40
-125.42
-125.44
-125.46
-125.48
-125.50
f1 (ppm)
130.02
130.02
130.03
130.03
130.04
130.04
130.05
130.06
130.06
130.07
130.07
-129.96
-130.00
-130.04
-130.08
-130.12
f1 (ppm)
10 -111 -112 -113 -114 -115 -116 -117 -118 -119 -120 -121 -122 -123 -124 -125 -126 -127 -128 -129 -130 -131 -132 -133 -134 -135 -136 -137 -138 -139
f1 (ppm)



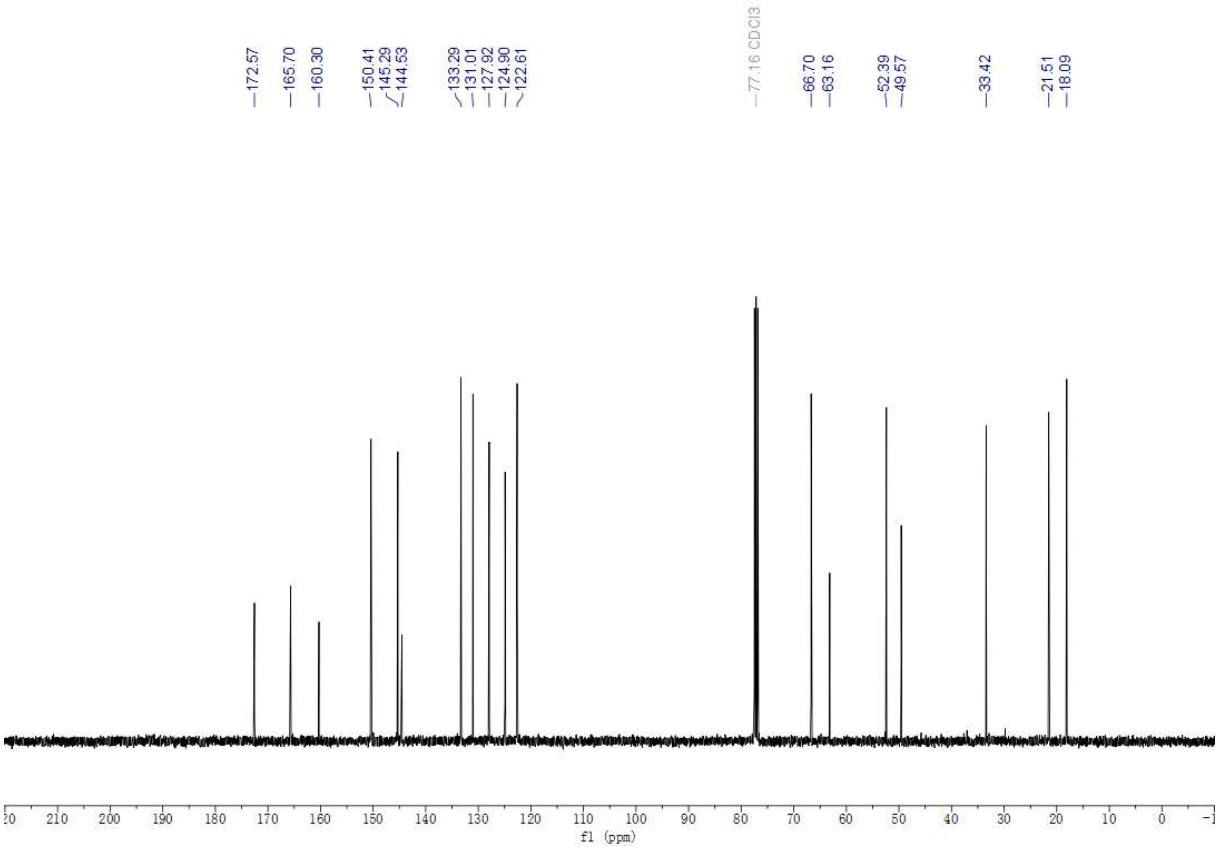
56, 84% yield, >95:5 d.r.

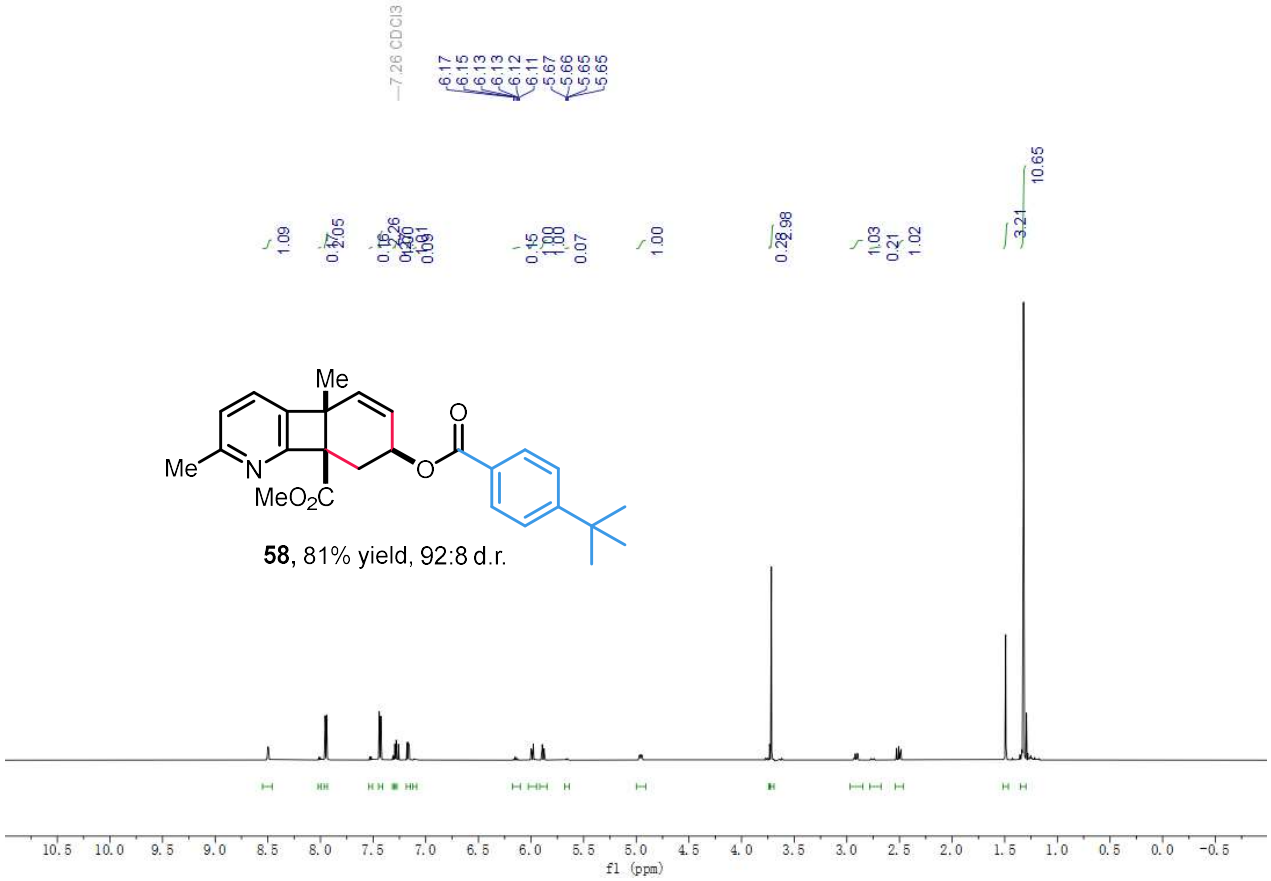




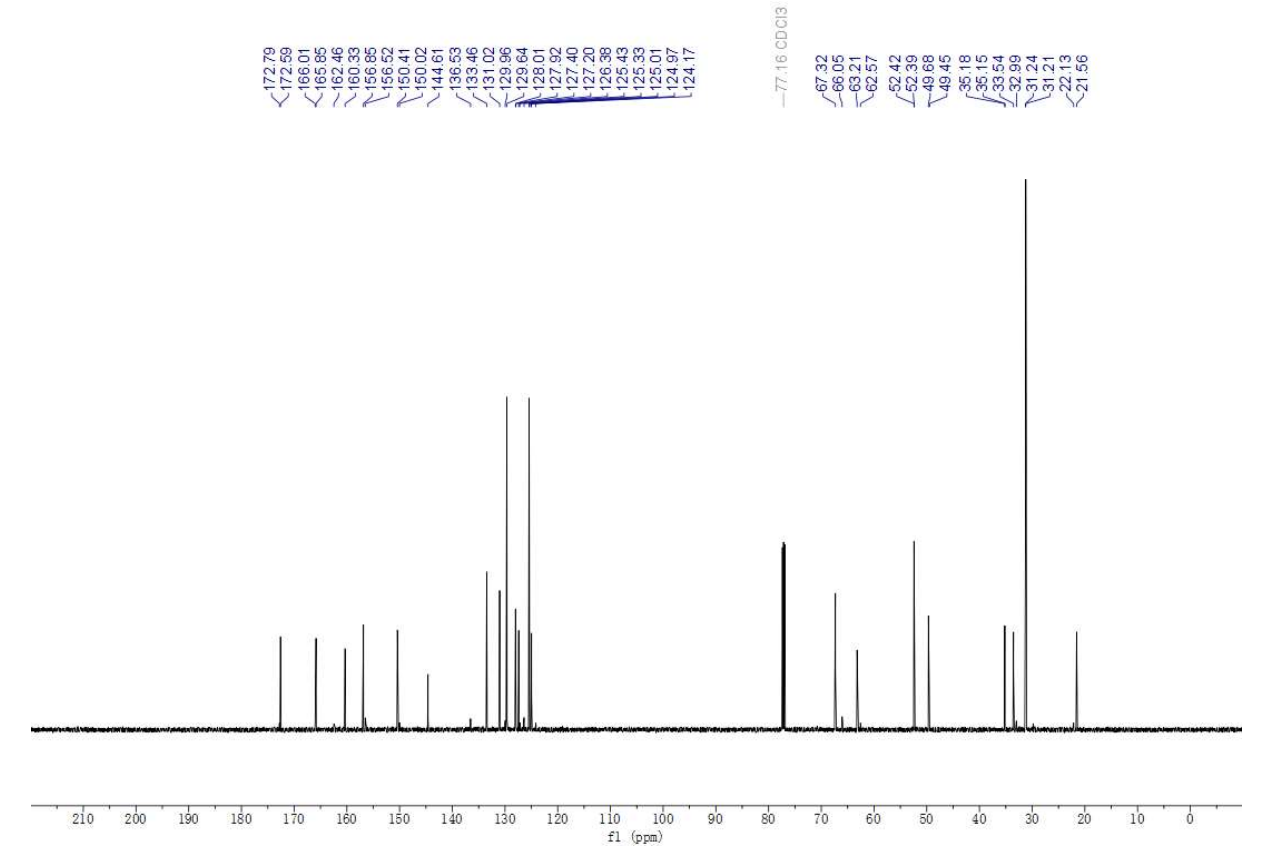


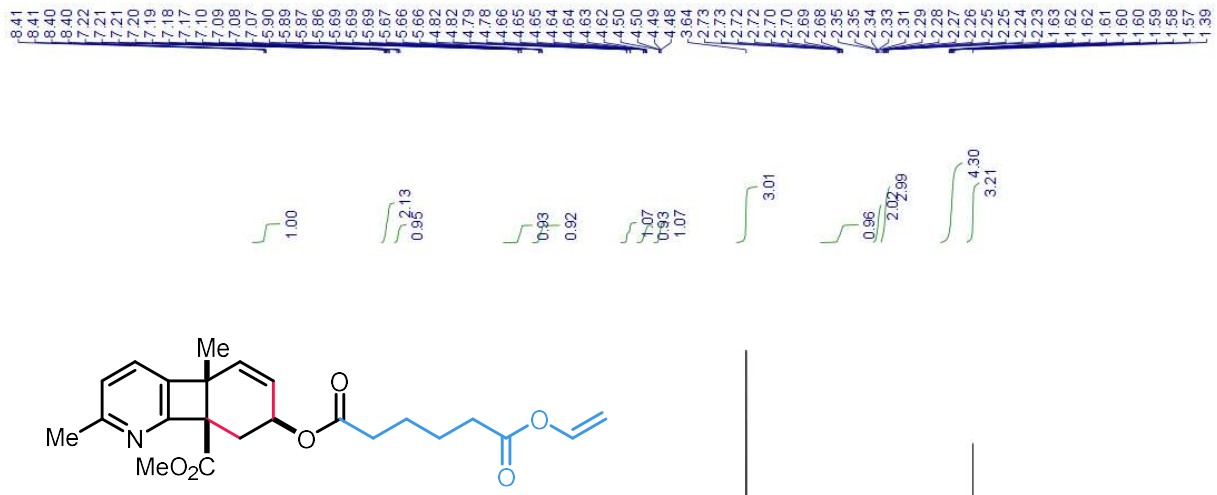
57, 85% yield, >95:5 d.r.



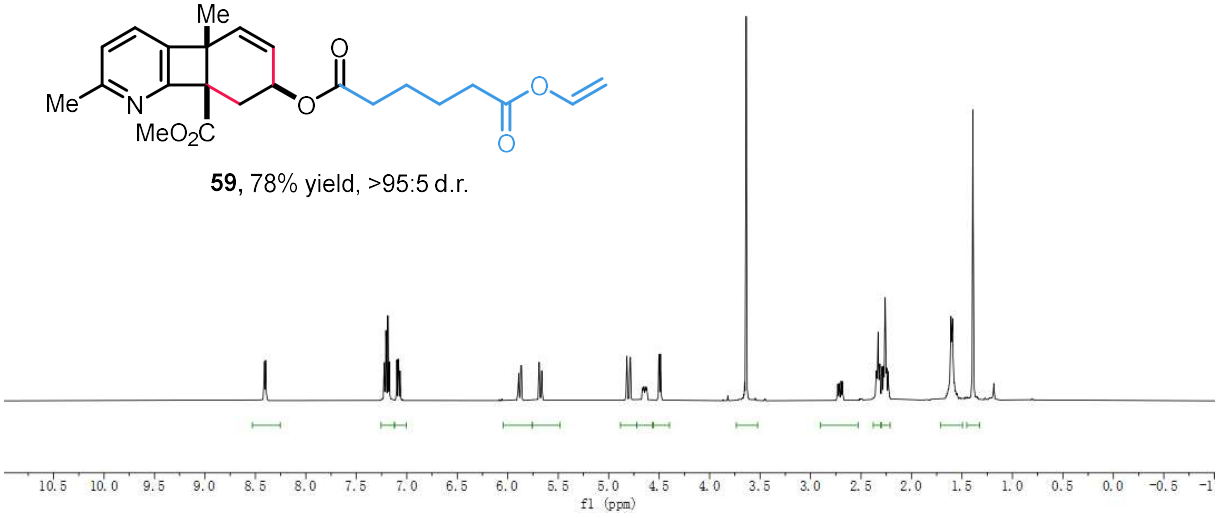


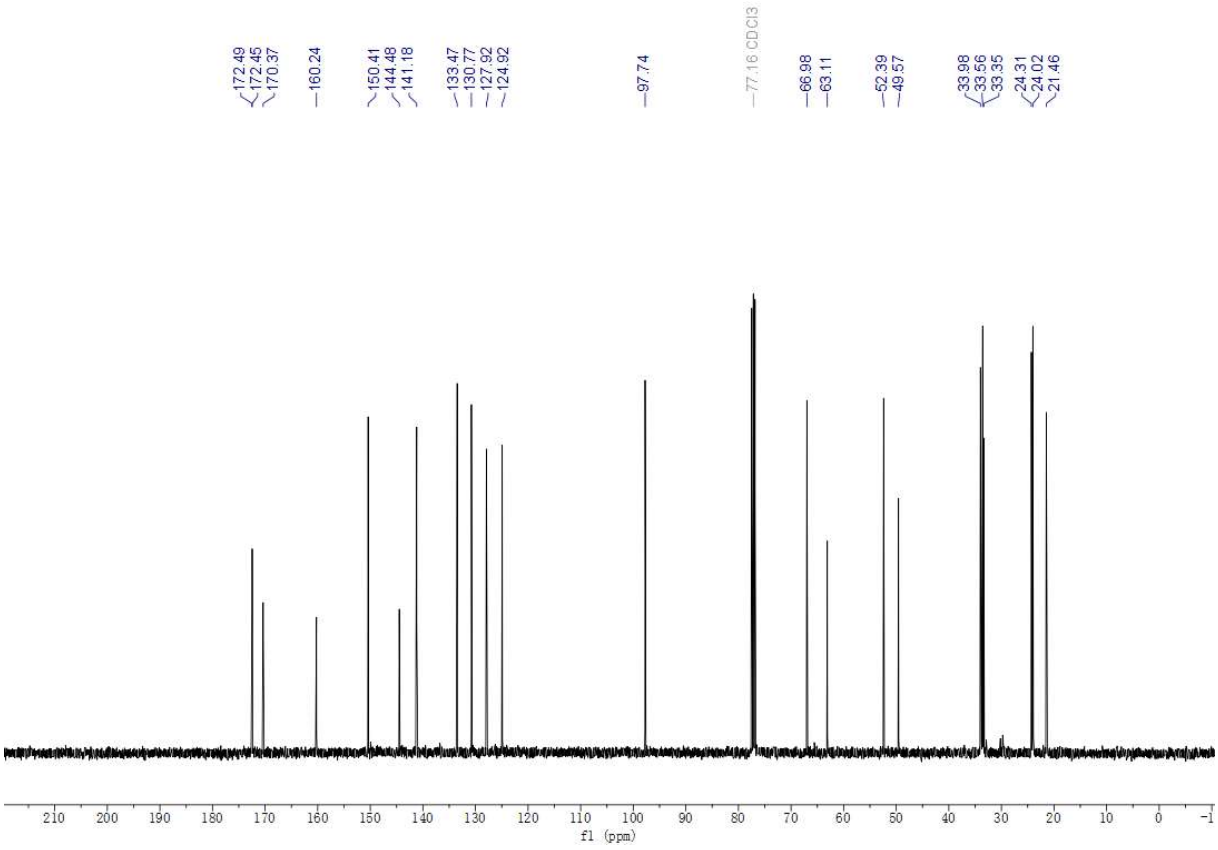
58, 81% yield, 92:8 d.r.

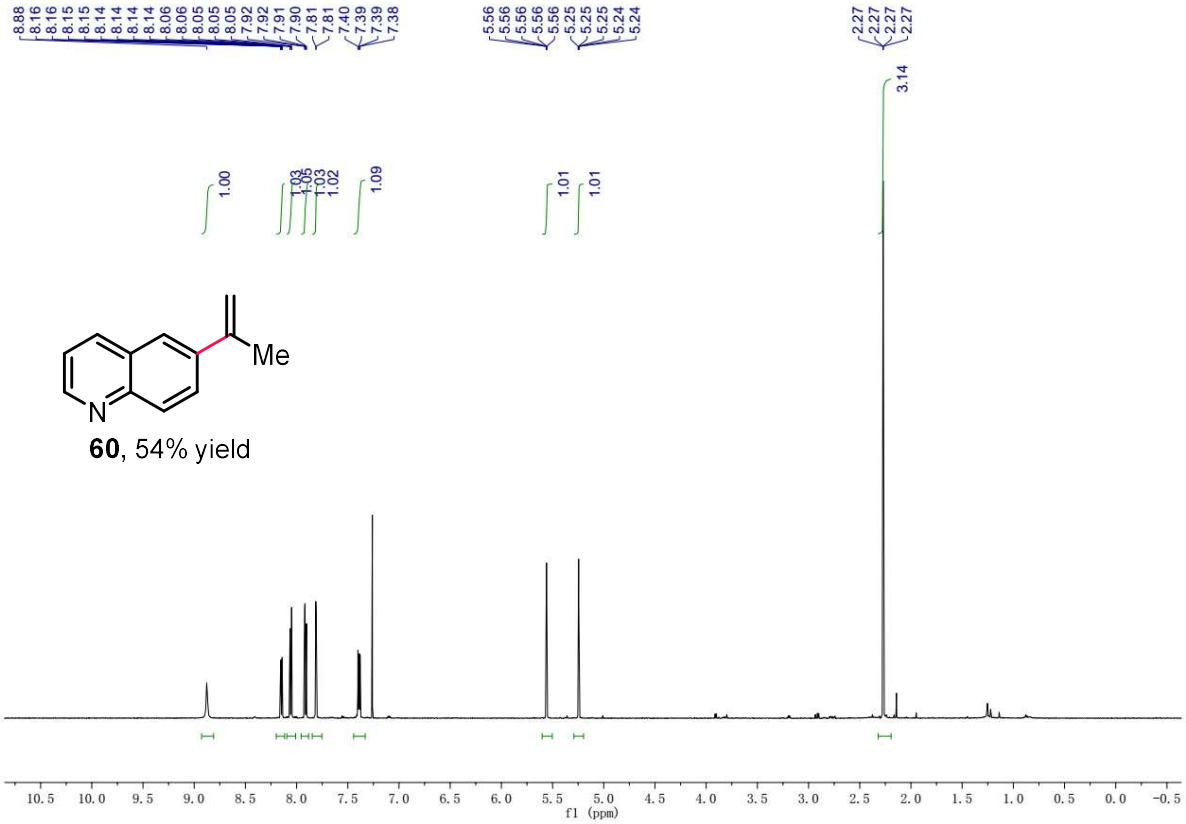




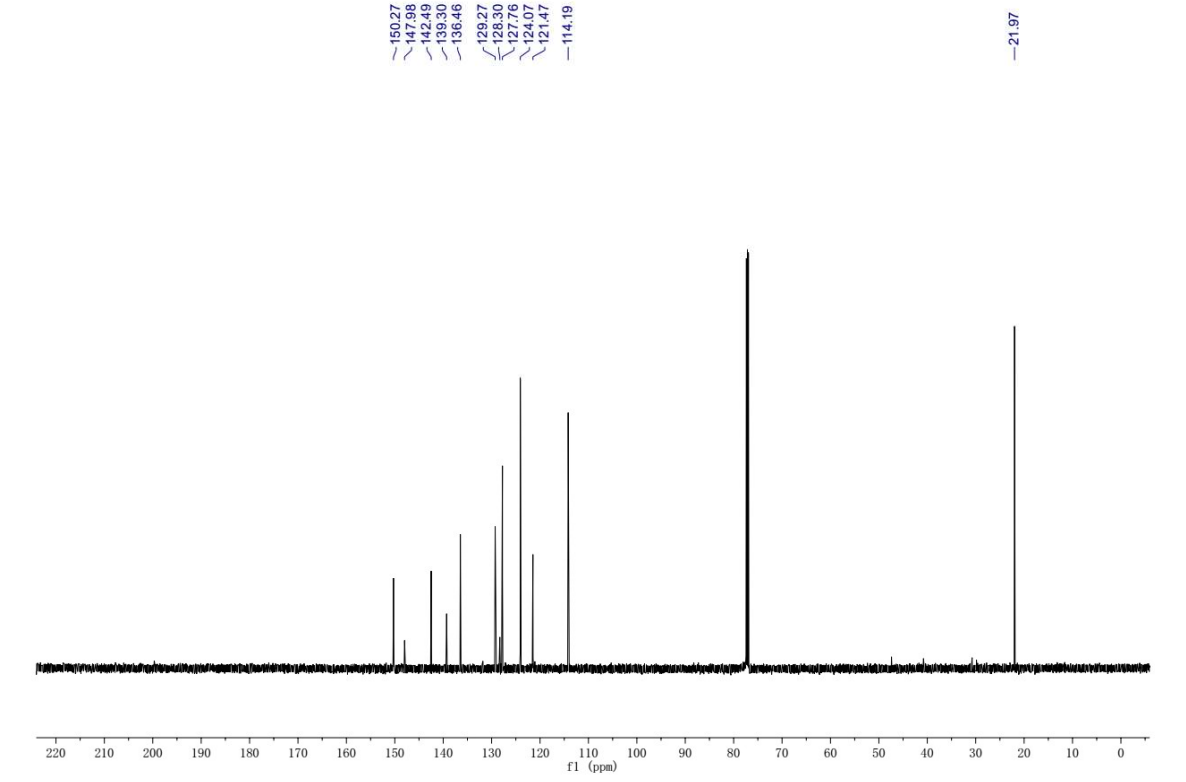
59, 78% yield, >95:5 d.r.

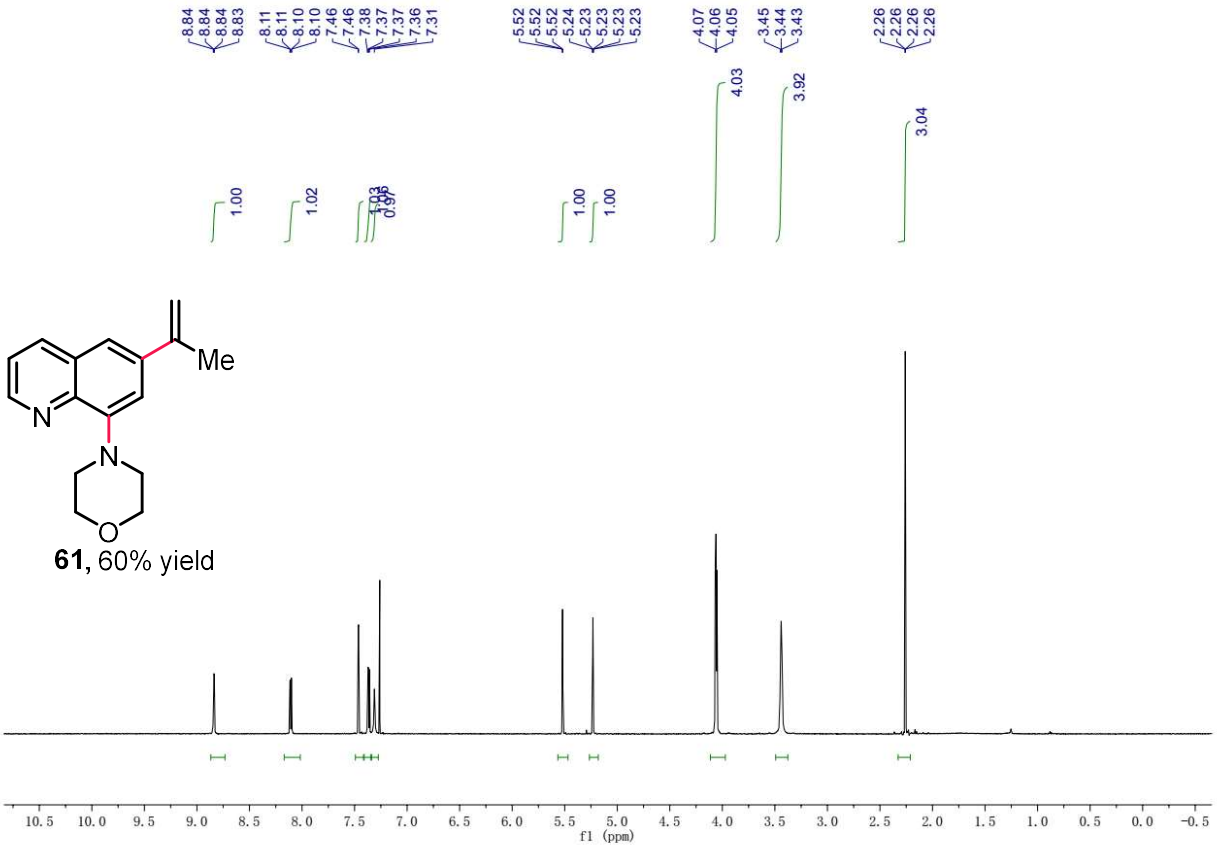


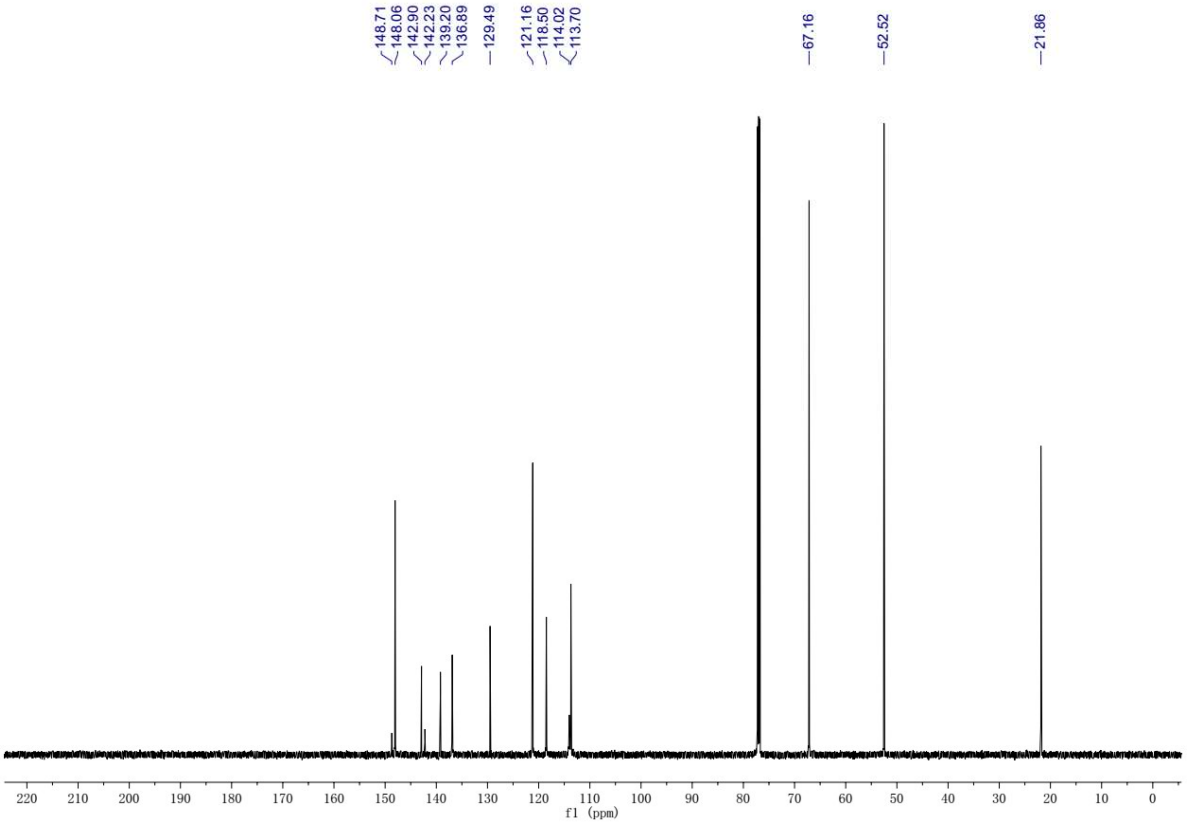


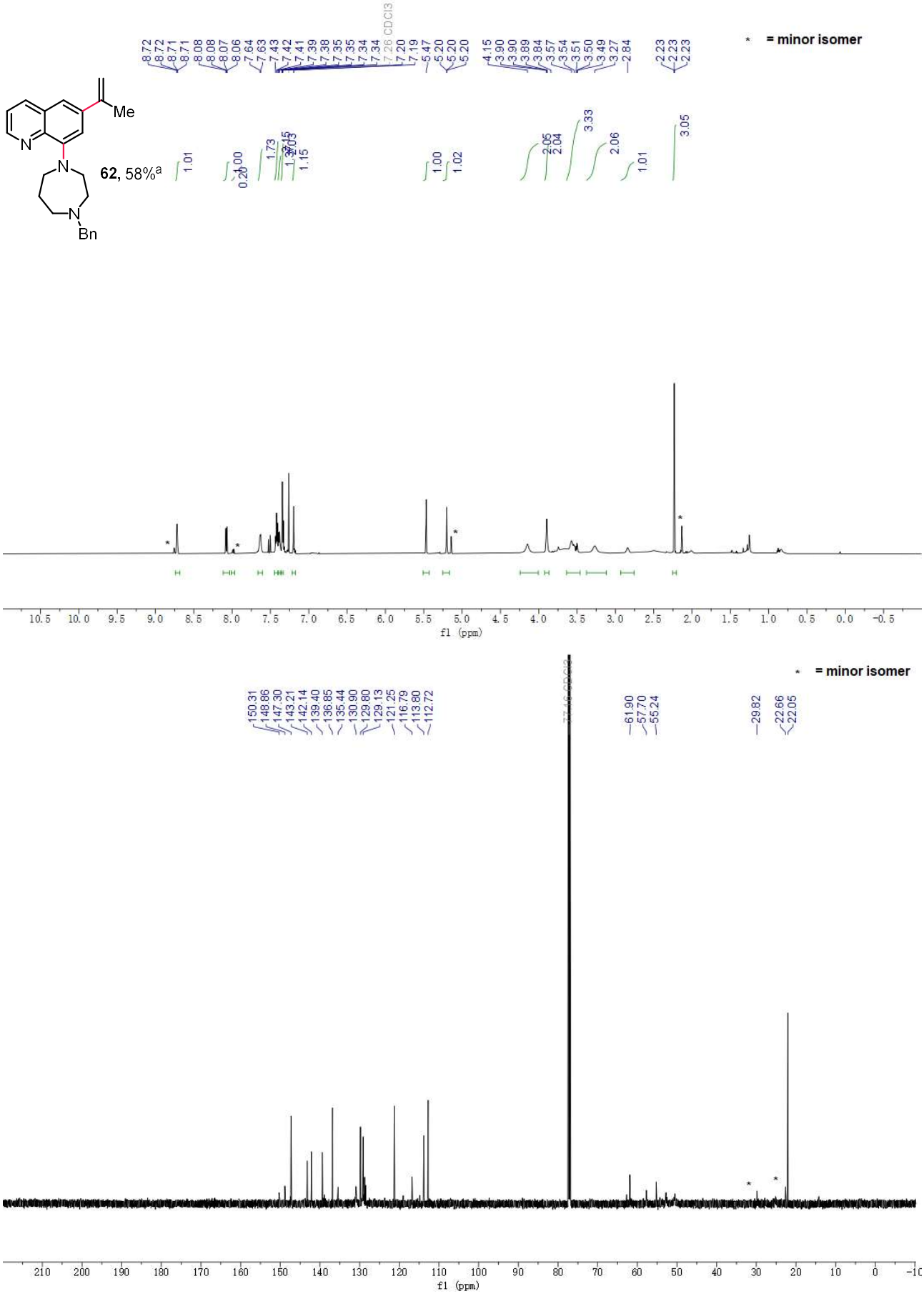

8.88
8.16
8.16
8.15
8.15
8.14
8.14
8.14
8.14
8.06
8.06
8.05
8.05
8.05
7.92
7.92
7.91
7.90
7.81
7.81
7.40
7.39
7.39
7.38
5.56
5.56
5.56
5.56
5.56
5.25
5.25
5.25
5.24
5.24
2.27
2.27
2.27
2.27
2.27
3.14
1.00
1.03
1.05
1.03
1.02
1.09
1.01
1.01
Me
N
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

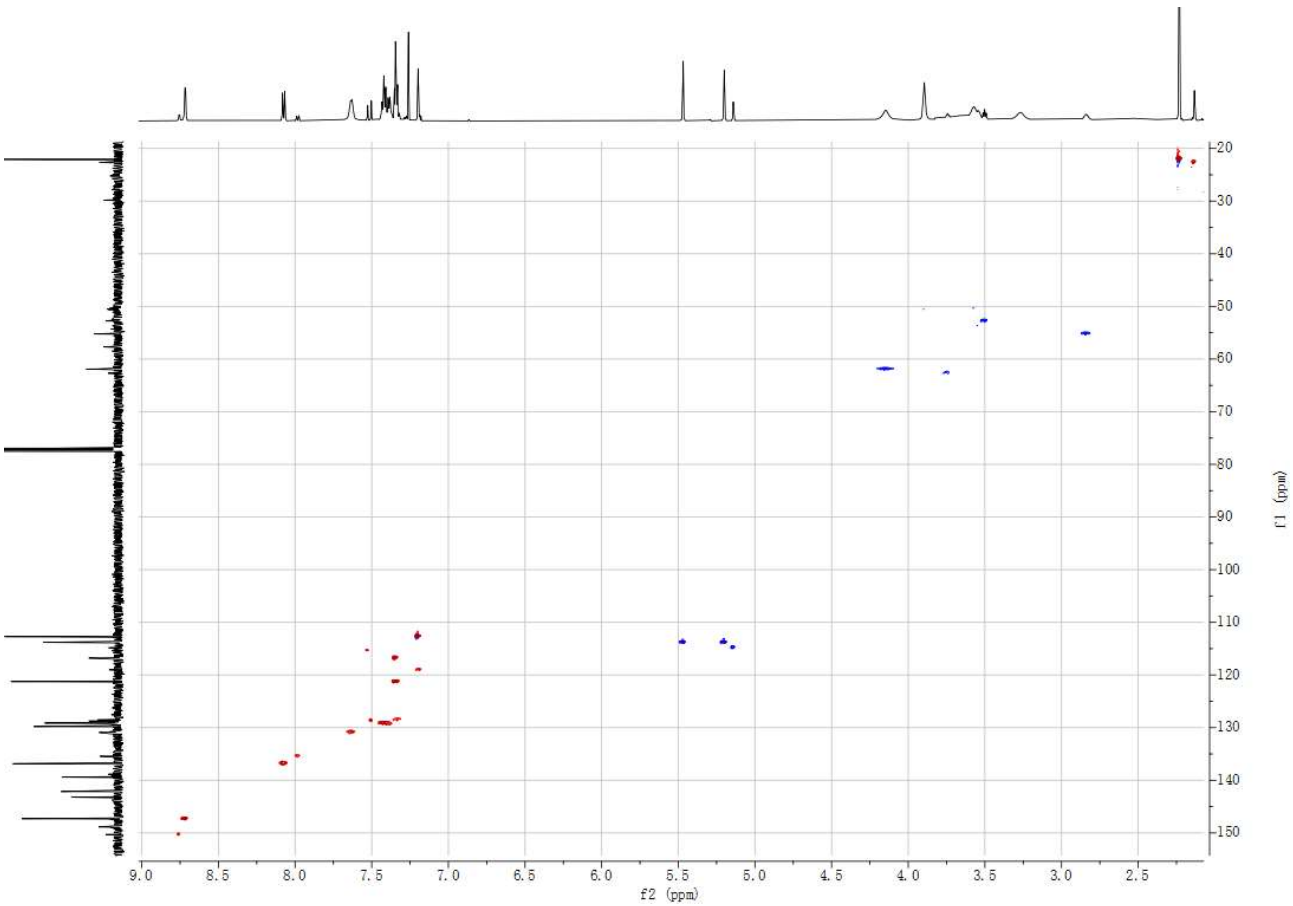
60, 54% yield

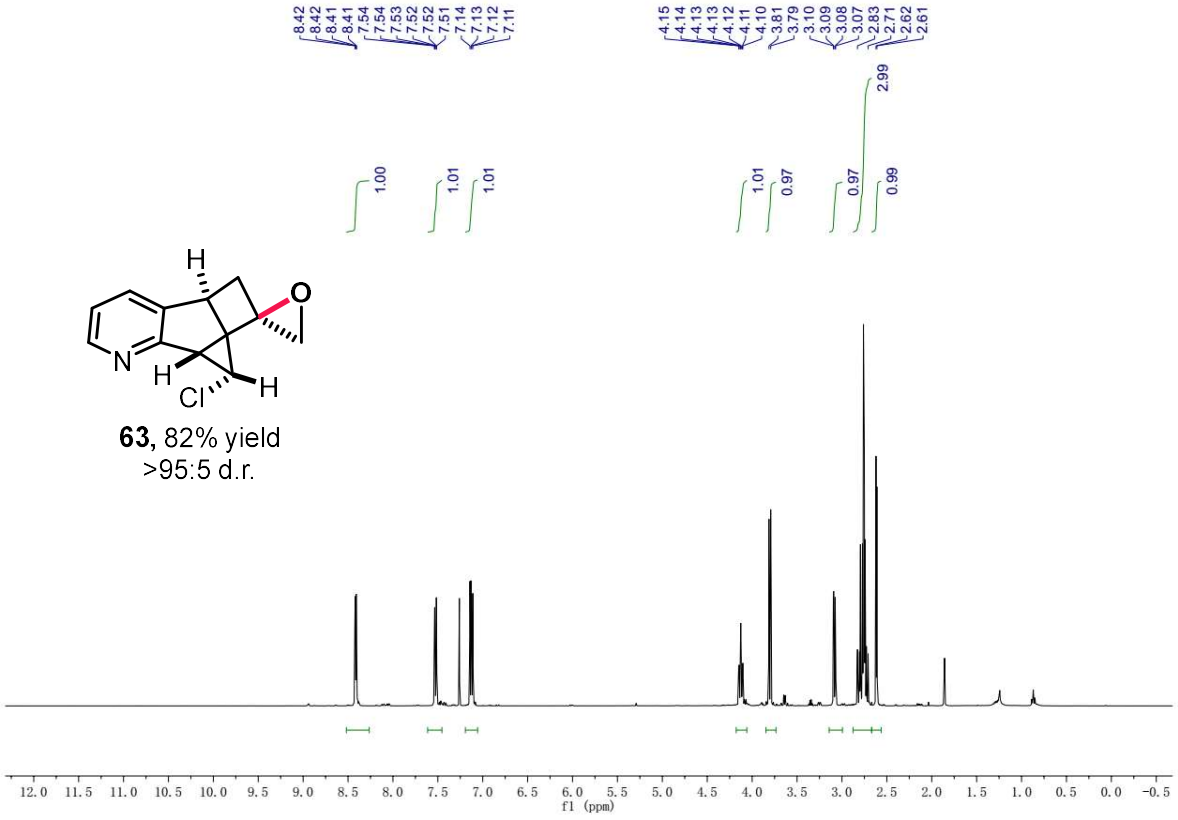

150.27
147.98
142.49
139.30
136.46
129.27
128.30
127.76
124.07
121.47
114.19
21.97
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


8.84
8.84
8.84
8.83
8.11
8.11
8.10
8.10
7.46
7.46
7.38
7.37
7.37
7.36
7.31
5.52
5.52
5.52
5.24
5.23
5.23
5.23
5.23
4.07
4.06
4.05
3.45
3.44
3.43
2.26
2.26
2.26
2.26
4.03
3.92
3.04
1.00
1.02
1.00
1.00
Me
N
N
O
61, 60% yield
f1 (ppm)

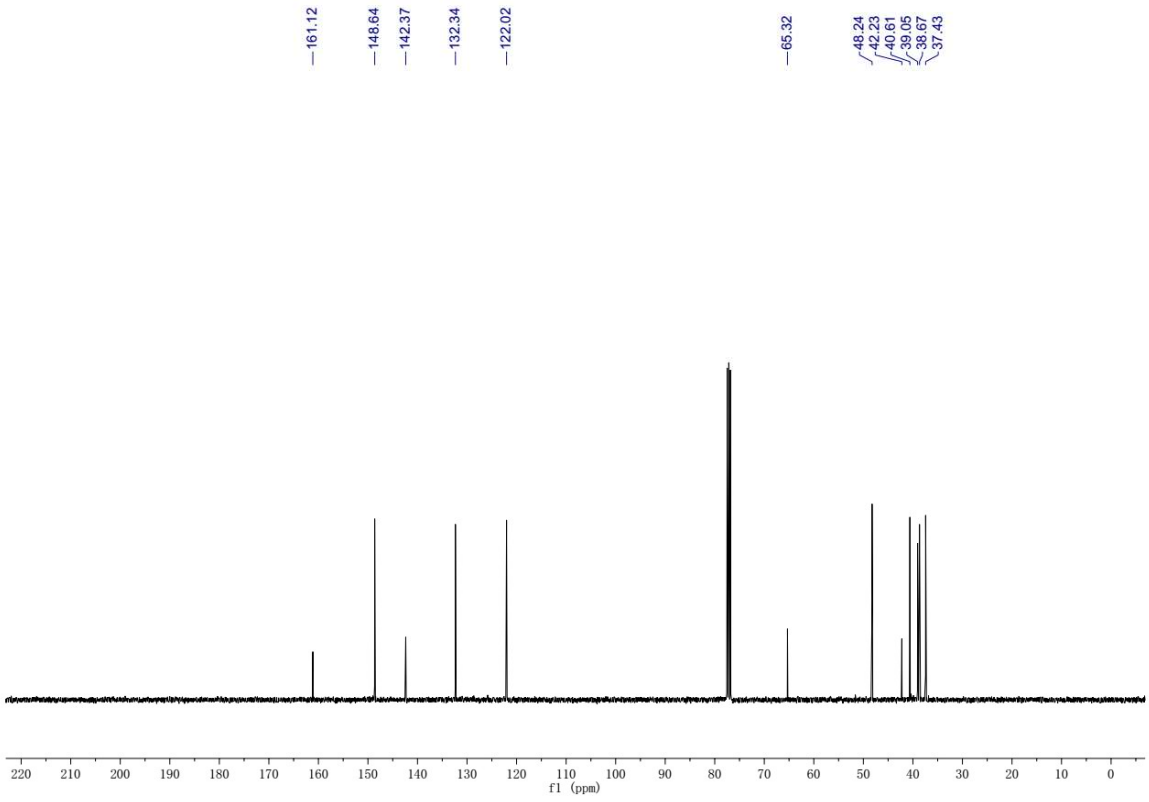

148.71
148.06
142.90
142.23
139.20
136.89
129.49
121.16
118.50
114.02
113.70
67.16
52.52
21.86
f1 (ppm)

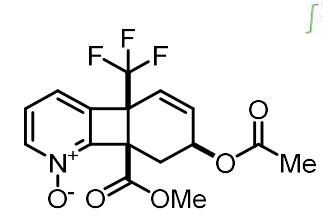

* = minor isomer
Me
N
N
N
Bn
62, 58%a
f1 (ppm)
* = minor isomer
f1 (ppm)


f2 (ppm)
f1 (ppm)



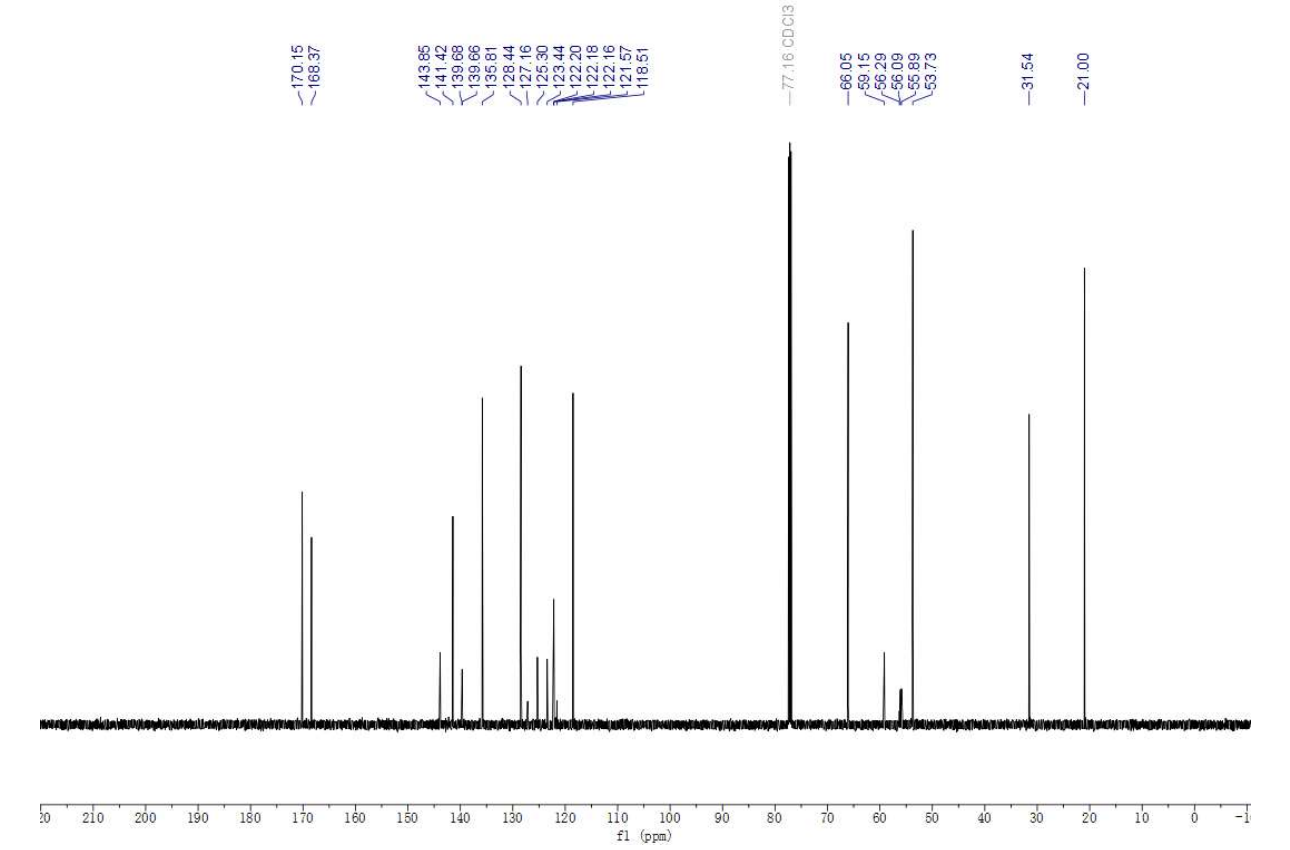
63, 82% yield
>95:5 d.r.

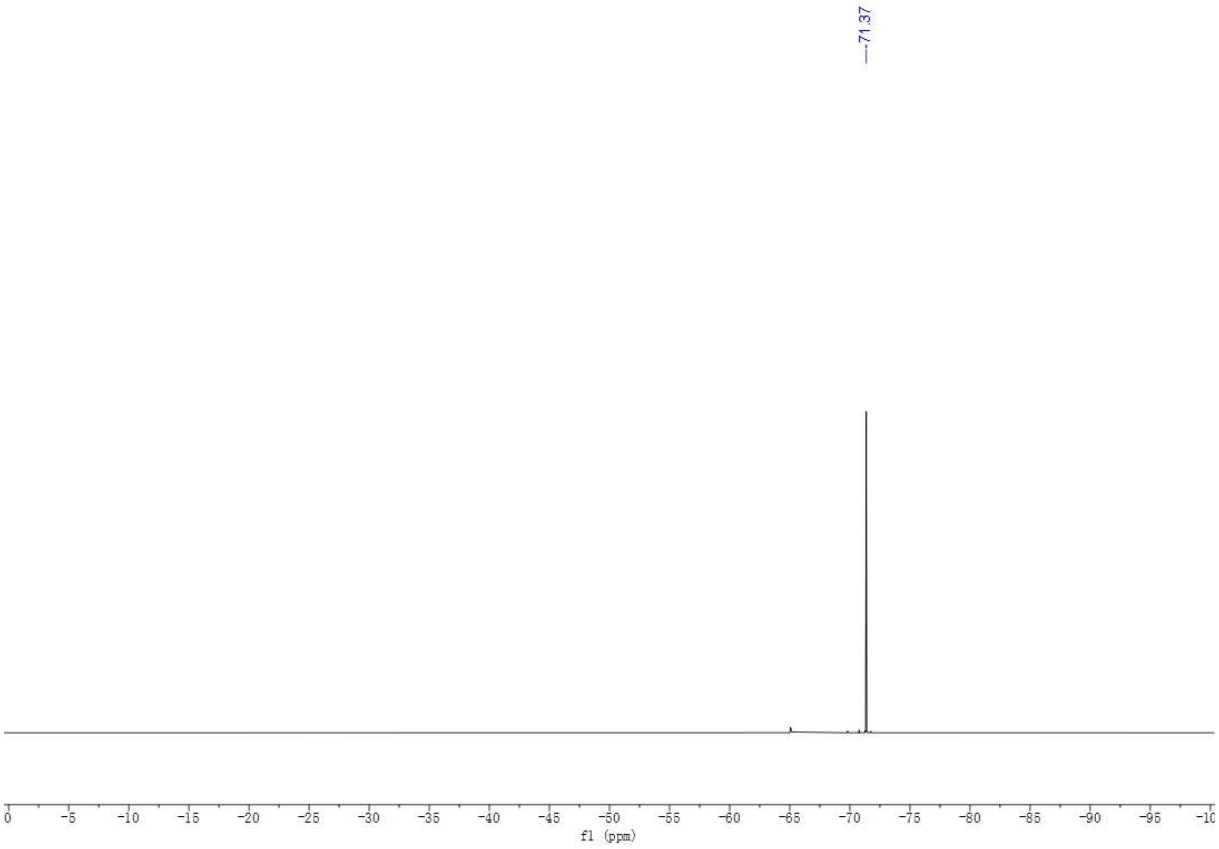


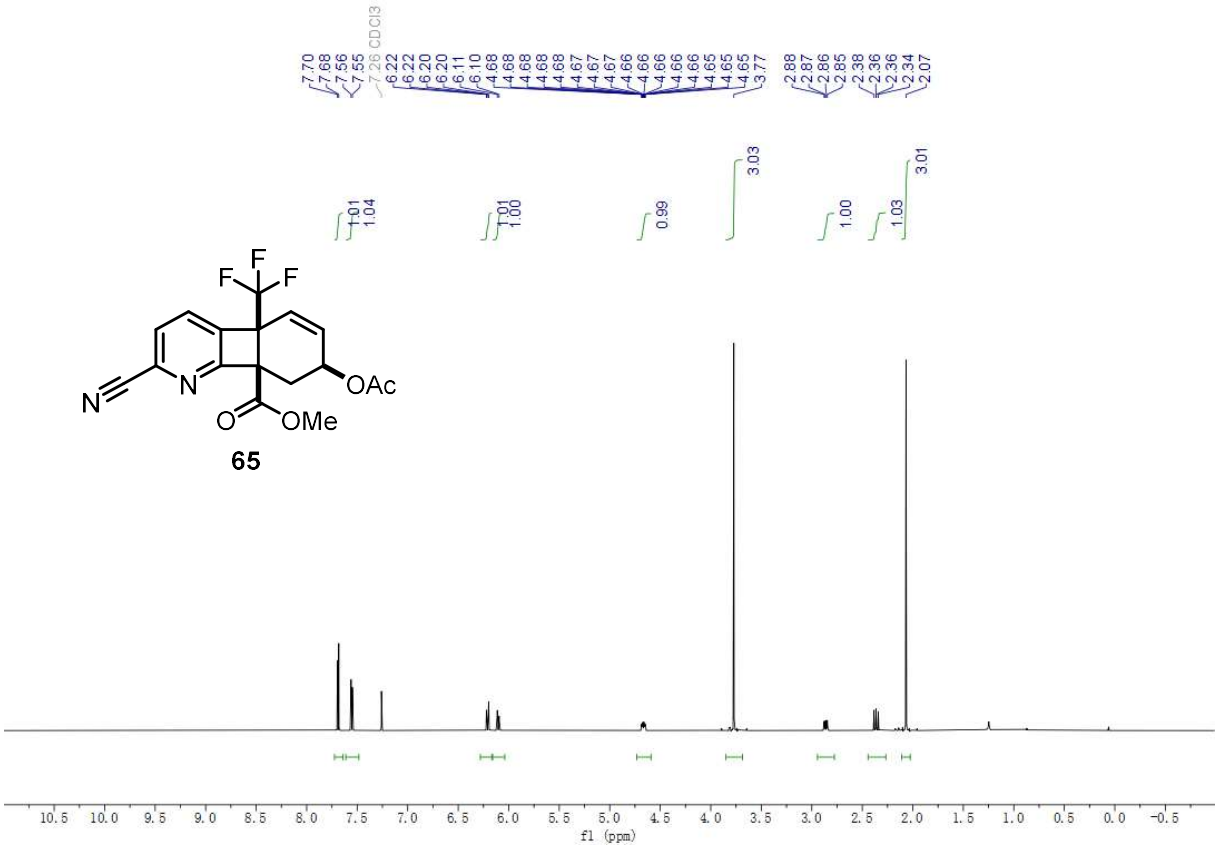


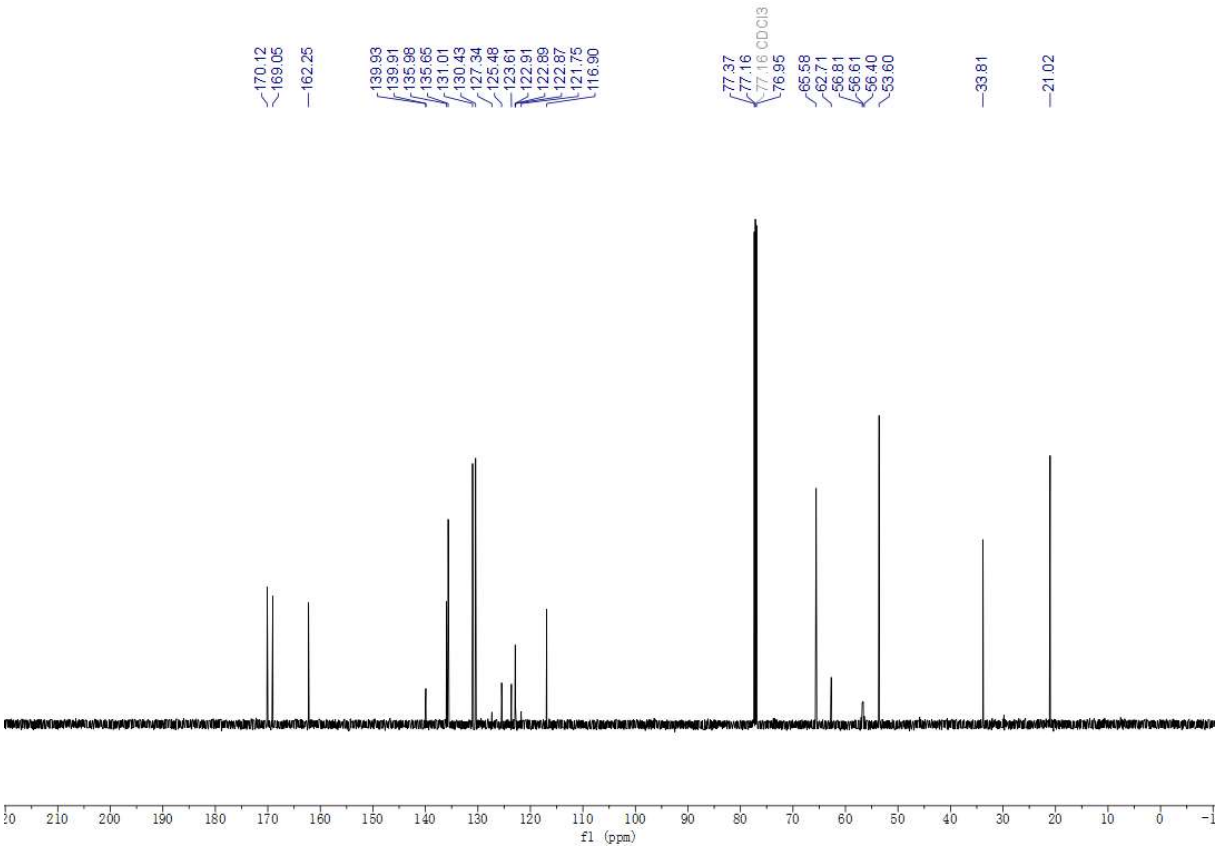
64

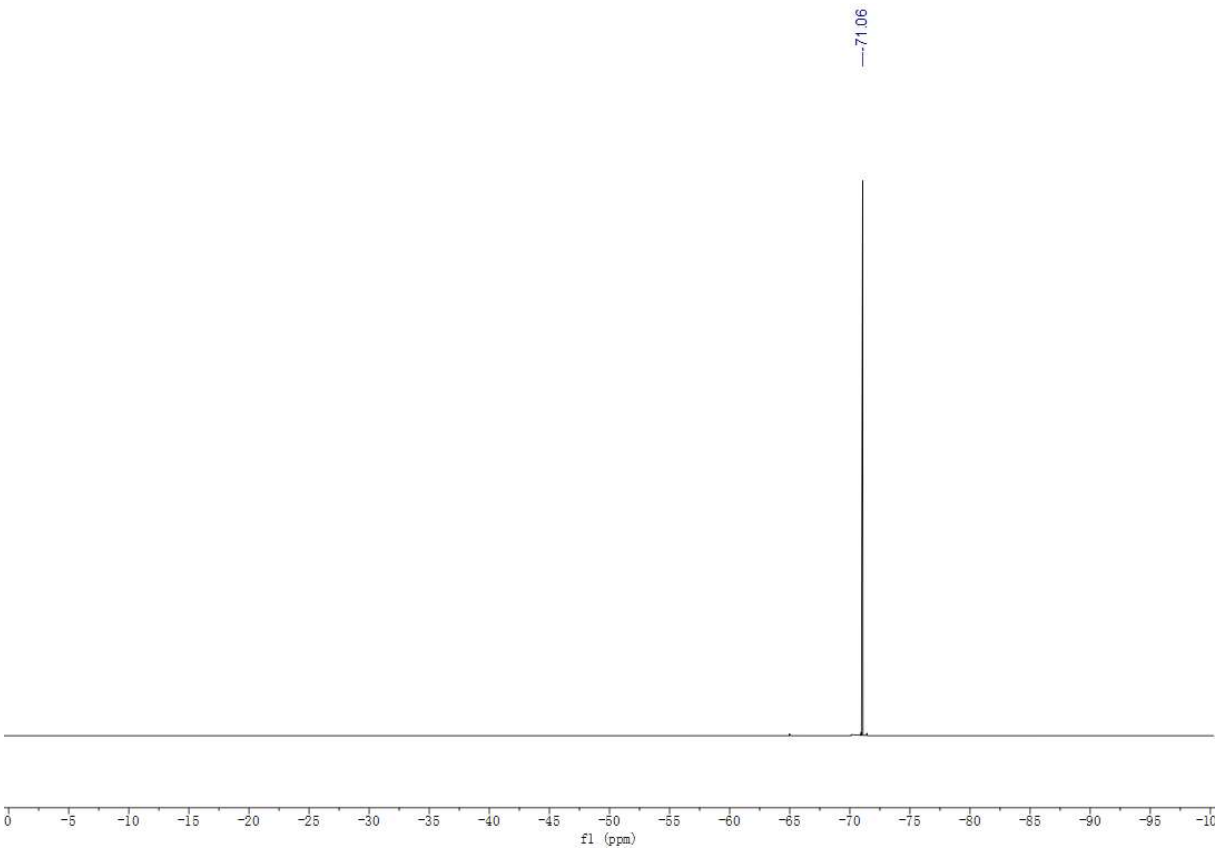
8.12
8.11
7.29
7.28
7.27
7.26 CDCl3
6.99
6.97
6.14
6.14
6.12
6.12
6.11
6.11
6.10
6.09
6.09
6.09
4.78
4.78
4.78
4.77
4.77
4.77
4.76
4.76
4.76
4.76
4.75
4.75
4.75
3.78
3.05
3.05
3.04
3.04
3.03
3.03
3.02
3.02
2.37
2.35
2.35
2.33
2.05
1.02
1.01
1.01
1.00
3.05
1.00
1.02
3.07
f1 (ppm)

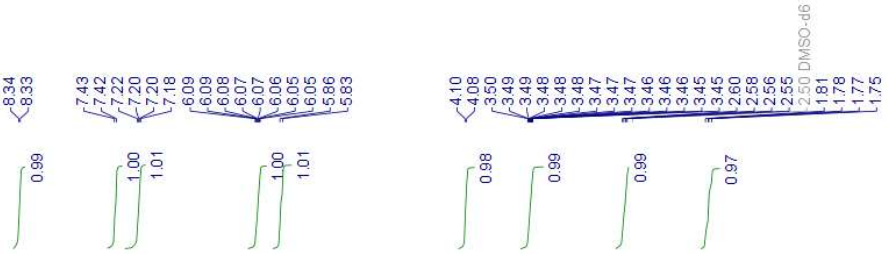

170.15
168.37
143.85
141.42
139.68
139.66
135.81
128.44
127.16
125.30
123.44
122.20
122.18
122.16
121.57
118.51
77.16 CDCl3
66.05
59.15
56.29
56.09
55.89
53.73
31.54
21.00
f1 (ppm)

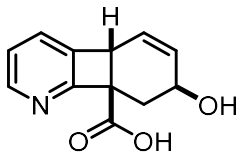

-71.37
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
-95
-10
f1 (ppm)


7.70
7.68
7.56
7.55
7.26 CDCl3
6.22
6.20
6.11
6.10
4.68
4.67
4.66
4.65
3.77
2.88
2.87
2.86
2.85
2.38
2.36
2.34
2.07
1.01
1.04
1.01
1.00
0.99
3.03
1.00
1.03
3.01
F
F
F
N
N
OAc
O
OMe
65
f1 (ppm)

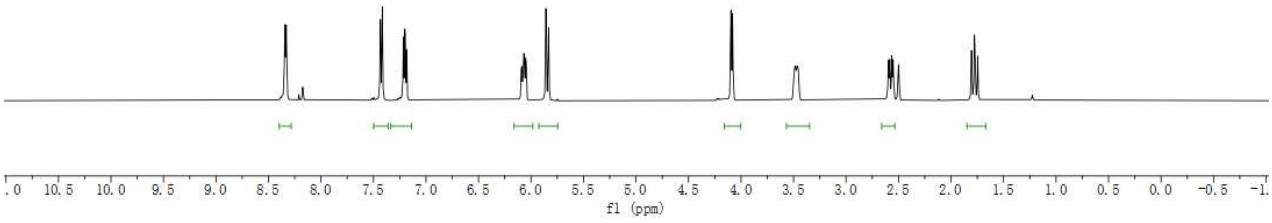

170.12
169.05
162.25
139.93
139.91
135.98
135.65
131.01
130.43
127.34
125.48
123.61
122.91
122.89
122.87
121.75
116.90
77.37
77.16
77.16 CDCl3
76.95
65.58
62.71
56.81
56.61
56.40
53.60
33.81
21.02
f1 (ppm)

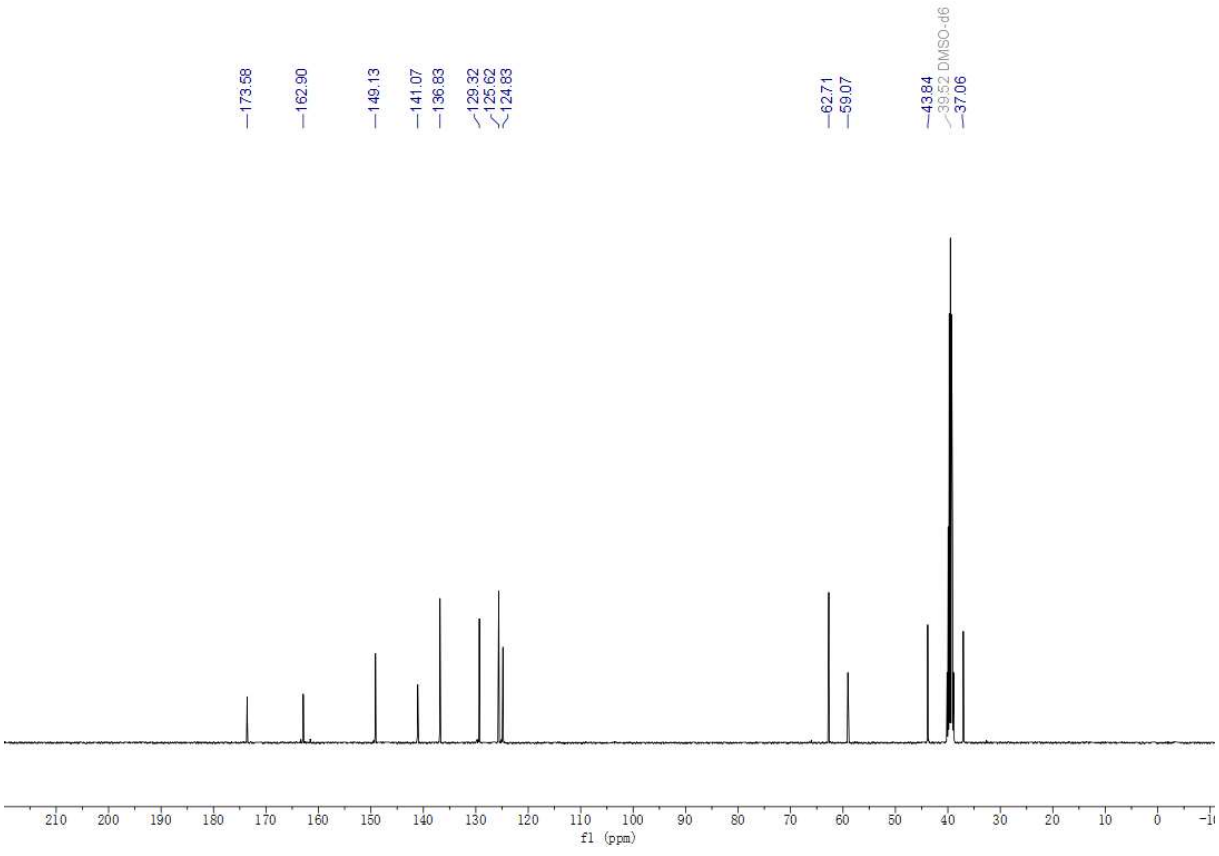

-71.06
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
-95
-10
f1 (ppm)


8.34
8.33
7.43
7.42
7.22
7.20
7.20
7.18
6.09
6.09
6.08
6.07
6.07
6.06
6.05
6.05
5.86
5.83
4.10
4.08
3.50
3.49
3.49
3.48
3.48
3.48
3.47
3.47
3.47
3.46
3.46
3.46
3.45
3.45
2.60
2.58
2.56
2.55
2.50 DMSO-d6
1.81
1.78
1.77
1.75
0.99
1.00
1.01
1.00
1.01
0.98
0.99
0.99
0.97


H
N
OH
O
OH

66


f1 (ppm)


173.58
162.90
149.13
141.07
136.83
129.32
125.62
124.83
62.71
59.07
43.84
39.52 DMSO-d6
37.06
f1 (ppm)

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