Supporting information

Visible-Light Promoted Oxidative Cyclization of Cinnamic Acid Derivatives using Xanthone as the Photocatalyst

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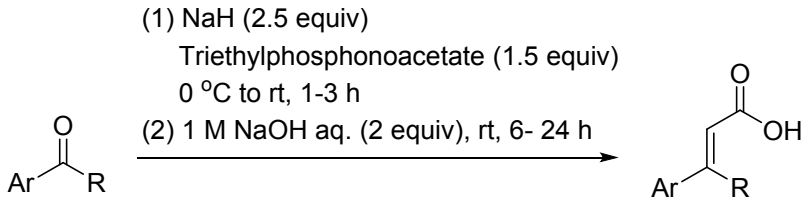
1. General

Commercial reagents and solvents were obtained from the commercial providers and used without further purification. The products were purified using a commercial flash chromatography system or a regular glass column. TLC was developed on silica gel 60 F254 glass plates. ^{1}H NMR (400 MHz or 500MHz) and ^{13}C NMR (101 MHz or 126MHz) spectra were recorded on a Bruker NMR apparatus. The chemical shifts are reported in δ (ppm) values (^{1}H and ^{13}C NMR relative to $CHCl_3$, δ 7.26 ppm for ^{1}H NMR and δ 77.0 ppm for ^{13}C NMR). Or alternatively, ^{1}H NMR chemical shifts were referenced to tetramethylsilane signal (0 ppm). Multiplicities are recorded by s (singlet), d (doublet), t (triplet), q (quartet), p (pentet), h (hextet), m (multiplet) and br (broad). Coupling constants (*J*), are reported in Hertz (Hz). GC analyses were performed using a Shimadzu GC-2010 ultra gas chromatography–mass spectrometry instrument equipped with a Shimadzu AOC-20s autosampler.

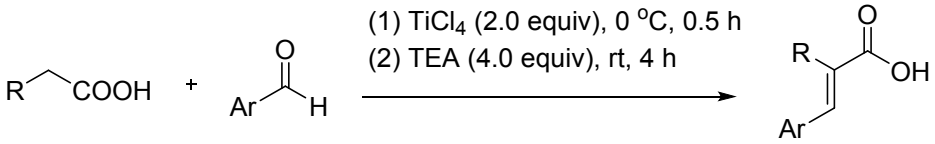
2. Preparation of starting materials - cinnamic acid derivatives



General procedure A.[1] To a mixture solution of NaH (2.5 equiv, 60% dispersion in mineral) in dry THF, triethylphosphonoacetate (1.5 equiv) was added dropwise before cooled the reaction mixture in an ice bath. After 30 min, the corresponding aldehyde or ketone (1.0 equiv) was added to the reaction mixture before agitated for 1-3 hours at room temperature. After the reaction was completed, the reaction mixture was quenched with AcOH and water. THF was evaporated under reduced pressure, and the residue was extracted with dichloromethane. The organic layer was dried by solvent-switch with ethyl acetate. The crude product was purified by the column chromatography on silica gel using petroleum ether and ethyl acetate (v/v, 10:1) as eluent yielding compound **1**.

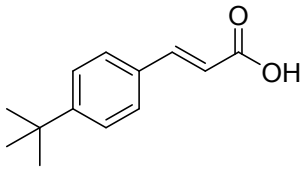
Dissolve compound **1** in ethanol and 1M NaOH aq. (2.0 equiv), stir the solution for 6 to 24 h at room temperature. After the reaction was completed, adjust the pH of the reaction mixture with

2M HCl aq. to 1-2, then filter the mixture and wash the wet cake with water. Compound **2** was obtained after dry in vacuum at 45 to 50 degrees centigrade. If necessary, purified compound **2** with the column chromatography on silica gel using petroleum ether and ethyl acetate as eluent.

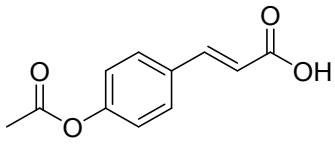


General procedure B.[2] To a stirred solution of benzaldehyde (1.5 equiv), the corresponding acids (1.0 equiv) in dry THF was added $TiCl_4$ (2.0 equiv) in an ice bath. The mixture was vigorously stirred for 0.5 h, followed by adding dropwise Et_3N (4.0 equiv). After being kept for an additional 4 h at room temperature, the reaction was quenched by adding water dropwise in an ice bath, and the obtained mixture was extracted with CH_2Cl_2. The organic layer was concentrated to dryness under reduced pressure. The obtained residue was purified by flash chromatography using petroleum ether and ethyl acetate as eluent (v/v, 5:1) as the eluent to give the target product **2**.

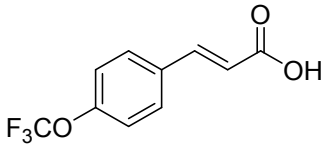
Compounds **1a, 1b, 1c, 1d, 1e, 1i, 1k, 1l, 1m, 1o, 1p, 1q, 1s, 1t, 1ae, 1an, 1ao** are commercially available, used as obtained.



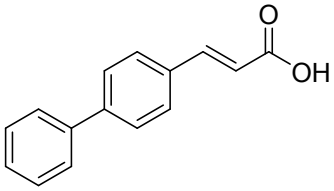
(E)-3-(4-(tert-butyl)phenyl)acrylic acid (**1f**).[3] Prepared according to General Procedure A, white solid, 78% yield, >99% of (E) isomer. ^{1}H NMR (400 MHz, *d6*-DMSO): δ 12.38 (s, 1H), 7.60 (d, *J* = 8.0 Hz, 2H), 7.56 (d, *J* = 16.2 Hz, 1H), 7.42 (d, *J* = 8.0 Hz, 2H), 6.47 (d, *J* = 16.0 Hz, 1H), 1.27 (s, 9H). ^{13}C NMR (101 MHz, *d6*-DMSO): δ 167.71, 153.11, 143.83, 131.52, 128.05, 125.73, 118.30, 34.59, 30.92.



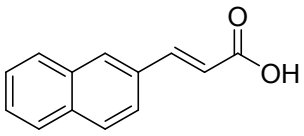
(E)-3-(4-acetoxyphenyl)acrylic acid (**1g**).[4] Prepared according to General Procedure A, white solid, 63% yield, >99% of (E) isomer. ^{1}H NMR (400 MHz, *d6*-DMSO): δ 7.74 (d, *J* = 7.2 Hz, 2H), 7.59 (d, *J* = 16.2 Hz, 1H), 7.17 (d, *J* = 7.2 Hz, 2H), 6.51 (d, *J* = 16.2 Hz, 1H), 2.28 (s, 3H). ^{13}C NMR (101 MHz, *d6*-DMSO): δ 169.07, 167.57, 151.82, 142.99, 131.93, 129.46, 122.38, 119.29, 20.89.



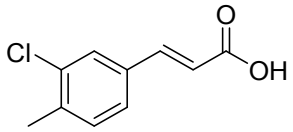
(E)-3-(4-(trifluoromethoxy) phenyl) acrylic acid (**1h**).[5] Prepared according to General Procedure A, white solid, 79% yield, >99% of (E) isomer. ^{1}H NMR (600 MHz, *d6*-DMSO): δ 12.53 (s, 1H), 7.83 (d, *J* = 8.7 Hz, 2H), 7.61 (d, *J* = 16.0 Hz, 1H), 7.38 (d, *J* = 8.2 Hz, 2H), 6.57 (d, *J* = 16.1 Hz, 1H). ^{19}F NMR (565 MHz, *d6*-DMSO): δ -56.81. ^{13}C NMR (151 MHz, *d6*-DMSO): δ 167.38, 149.31, 142.16, 133.61, 130.15, 121.25, 120.57, 120.00 (q, *J* = 257.2 Hz).



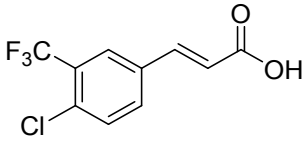
(E)-3-([1,1'-biphenyl]-4-yl)acrylic acid (**1j**).[6] Prepared according to General Procedure A, white solid, 75% yield, >99% of (E) isomer.^{1}H NMR (400 MHz, *d6*-DMSO): δ 7.79-7.70 (m, 6H), 7.64 (d, *J* = 15.9 Hz, 1H), 7.47 (t, *J* = 7.2 Hz, 2H), 7.39 (t, *J* = 7.5 Hz, 1H), 6.59 (d, *J* = 15.9 Hz, 1H). ^{13}C NMR (101 MHz, *d6*-DMSO): δ 167.71, 143.31, 141.68, 139.26, 133.43, 129.05, 128.87, 127.95, 127.09, 126.71, 119.38.



(E)-3-(naphthalen-2-yl)acrylic acid (**1r**).[7] Prepared according to General Procedure A, white solid, 73% yield, >99% of (E) isomer. ^{1}H NMR (600 MHz, *d6*-DMSO): δ 12.50 (s, 1H), 8.15 (s, 1H), 7.92-7.85 (m, 4H), 7.77 (d, *J* = 15.9 Hz, 1H), 7.54 (d, *J* = 3.6 Hz, 2H), 6.68 (d, *J* = 16.0 Hz, 1H). ^{13}C NMR (151 MHz, *d6*-DMSO): δ 167.68, 143.95, 133.72, 132.92, 131.89, 129.68, 128.53, 128.47, 127.69, 127.25, 126.74, 123.95, 119.61.

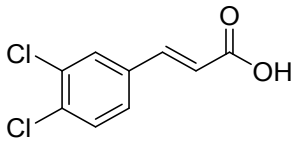


(E)-3-(3-chloro-4-methylphenyl) acrylic acid (**1u**). Prepared according to General Procedure A, white solid, 71% yield, >99% of (E) isomer. ^{1}H NMR (400 MHz, *d6*-DMSO): δ 12.45 (s, 1H), 7.77 (s, 1H), 7.58-7.51 (m, 2H), 7.38 (d, *J* = 7.8 Hz, 1H), 6.56 (d, *J* = 16.1 Hz, 1H), 2.34 (s, 3H). ^{13}C NMR (101 MHz, *d6*-DMSO): δ 167.47, 142.36, 137.54, 134.03, 133.87, 131.62, 128.37, 126.72, 119.92, 19.58.

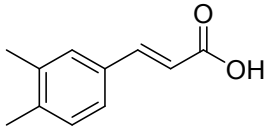


(E)-3-(4-chloro-3-(trifluoromethyl)phenyl)acrylic acid (**1v**).[8] Prepared according to General Procedure A, white solid, 73% yield, >99% of (E) isomer. 1H NMR (600 MHz, d6-DMSO): δ

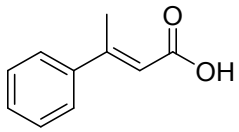
12.58 (s, 1H), 8.13 (s, 1H), 8.01 (d, J = 8.1 Hz, 1H), 7.72 (d, J = 8.3 Hz, 1H), 7.65 (d, J = 16.1 Hz, 1H), 6.70 (d, J = 16.1 Hz, 1H). 19F NMR (565 MHz, d6-DMSO): δ -61.40. 13C NMR (151 MHz, d6-DMSO): δ 167.63, 141.48, 134.55, 133.39, 132.53, 132.26, 128.08 (q, J = 5.2 Hz), 127.66 (q, J = 31.2 Hz), 123.09 (q, J = 273.7 Hz), 122.52.



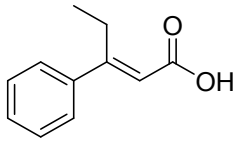
(E)-3-(3,4-dichlorophenyl)acrylic acid (**1w**).[7] Prepared according to General Procedure A, white solid, 83% yield, >99% of (E) isomer. ^{1}H NMR (600 MHz, *d6*-DMSO): δ 12.54 (s, 1H), 8.01 (d, *J* = 1.9 Hz, 1H), 7.69 (dd, *J* = 8.4, 1.9 Hz, 1H), 7.64 (d, *J* = 8.4 Hz, 1H), 7.56 (d, *J* = 16.0 Hz, 1H), 6.64 (d, *J* = 16.0 Hz, 1H). ^{13}C NMR (151 MHz, *d6*-DMSO): δ 167.23, 141.22, 135.13, 132.38, 131.73, 130.92, 129.96, 128.10, 121.58.



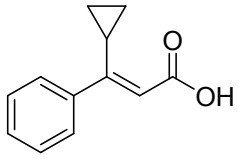
(E)-3-(3,4-dimethylphenyl)acrylic acid (**1x**).[9] Prepared according to General Procedure A, white solid, 81% yield, >99% of (E) isomer. ^{1}H NMR (400 MHz, *d6*-DMSO): δ 12.33 (s, 1H), 7.51 (d, *J* = 15.9 Hz, 1H), 7.45 (s, 1H), 7.38 (d, *J* = 7.6 Hz, 1H), 7.16 (d, *J* = 7.6 Hz, 1H), 6.44 (d, *J* = 15.9 Hz, 1H), 2.22 (s, 6H). ^{13}C NMR (101 MHz, *d6*-DMSO): δ 167.78, 144.15, 139.03, 136.86, 131.83, 130.01, 129.14, 125.88, 117.87, 19.39, 19.28.



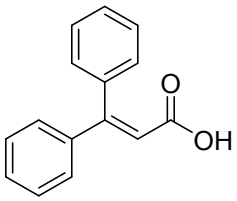
(E)-3-phenylbut-2-enoic acid (**1y**).[1] Prepared according to General Procedure A, white solid, 66% yield, >99% of (E) isomer. ^{1}H NMR (400 MHz, *d6*-DMSO): δ 12.21 (s, 1H), 7.51-7.49 (m, 2H), 7.39-7.33 (m, 3H), 6.05 (s, 1H), 2.46 (s, 3H). ^{13}C NMR (101 MHz, *d6*-DMSO): δ 167.60, 153.83, 141.49, 129.13, 128.66, 126.22, 117.57, 17.29.



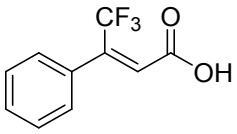
(E)-3-phenylpent-2-enoic acid (**1z**).[1] Prepared according to General Procedure A, white solid, 63% yield, >99% of (E) isomer. ^{1}H NMR (400 MHz, *d6*-DMSO): δ 12.25 (s, 1H), 7.51-7.49 (m, 2H), 7.43-7.38 (m, 3H), 5.96 (s, 1H), 3.05 (q, J = 7.7 Hz, 2H), 0.95 (q, J = 7.4 Hz, 3H). ^{13}C NMR (101 MHz, *d6*-DMSO): δ 167.22, 160.14, 140.28, 129.02, 128.74, 126.59, 117.30, 23.11, 13.55.



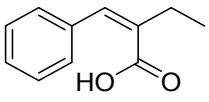
(E)-3-cyclopropyl-3-phenylacrylic acid (**1aa**).[1] Prepared according to General Procedure A, white solid, 33% yield, >99% of (E) isomer. ^{1}H NMR (400 MHz, *d6*-DMSO): δ 12.22 (s, 1H), 7.33 (s, 3H), 7.16 (d, J = 6.9 Hz, 2H), 5.64 (s, 1H), 3.14-3.07 (m, 1H), 0.85-0.83 (m, 2H), 0.34 (m, 2H). ^{13}C NMR (101 MHz, *d6*-DMSO): δ 167.54, 161.68, 138.35, 127.96, 127.87, 127.80, 119.25, 13.00, 6.51.



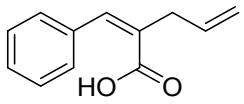
3,3-Diphenylacrylic acid (**1ac**).[10] Prepared according to General Procedure A, white solid, 67% yield. ^{1}H NMR (400 MHz, $CDCl_3$): δ 11.52 (s, 1H), 7.37-7.20 (m, 10H), 6.31 (s, 1H). ^{13}C NMR (151 MHz, $CDCl_3$): δ 171.15, 158.99, 140.81, 138.36, 129.70, 129.23, 128.50, 128.42, 128.37, 127.89, 116.43.



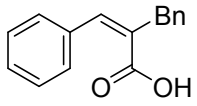
(Z)-4,4,4-trifluoro-3-phenylbut-2-enoic acid (**1ad**).[11] Prepared according to General Procedure A, white solid, 72% yield, >99% of (Z) isomer. ^{1}H NMR (400 MHz, *d6*-DMSO): δ 13.14 (s, 1H), 7.45-7.43 (m, 3H), 7.32-7.30 (m, 2H), 6.84 (d, J = 1.0 Hz, 1H). ^{19}F NMR (377 MHz, *d6*-DMSO): δ -65.71. ^{13}C NMR (101 MHz, *d6*-DMSO): δ 165.46, 137.44 (q, J = 30.4 Hz), 130.81, 129.42, 128.67, 128.50, 127.65 (q, J = 5.4 Hz), 122.95 (q, J = 274.1 Hz).



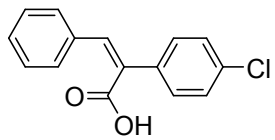
(Z)-2-benzylidenebutanoic acid (**1af**). Prepared according to General Procedure B, white solid, 78% yield, >99% of (Z) isomer. ^{1}H NMR (600 MHz, *d6*-DMSO): δ 12.51 (s, 1H), 7.55 (s, 1H), 7.46-7.39 (m, 4H), 7.38-7.34 (m, 1H), 2.44 (q, J = 7.4 Hz, 2H), 1.10 (t, J = 7.4 Hz, 3H). ^{13}C NMR (151 MHz, *d6*-DMSO): δ 168.93, 137.34, 135.33, 134.99, 129.03, 128.63, 128.42, 20.35, 13.64.



(Z)-2-benzylidenepent-4-enoic acid (**1ag**). Prepared according to General Procedure B, white solid, 71% yield, >99% of (Z) isomer. ^{1}H NMR (600 MHz, *d6*-DMSO): δ 12.57 (s, 1H), 7.72 (s, 1H), 7.42 (q, *J* = 7.9 Hz, 4H), 7.36 (t, *J* = 6.7 Hz, 1H), 5.97-5.96 (m, 1H), 5.05-5.03 (m, 2H), 3.19 (d, *J* = 5.4 Hz, 2H). ^{13}C NMR (151 MHz, *d6*-DMSO): δ 168.76, 139.10, 135.79, 135.05, 130.53, 129.12, 128.71, 128.57, 115.43, 31.19.

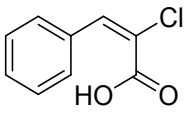


(Z)-2-benzyl-3-phenylacrylic acid (**1ai**). Prepared according to General Procedure B, white solid, 65% yield, >99% of (Z) isomer. ^{1}H NMR (600 MHz, $CDCl_3$): δ 12.3 (b, 1H), 8.05 (s, 1H), 7.40-7.39 (m, 2H), 7.37-7.34 (m, 3H), 7.30 (t, *J* = 7.6 Hz, 2H), 7.23-7.20 (m, 3H), 3.96 (s, 2H). ^{13}C NMR (101 MHz, $CDCl_3$): δ 173.48, 143.15, 139.06, 135.00, 129.77, 129.38, 129.15, 128.63, 128.59, 127.88, 126.20, 32.82.

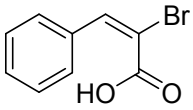


(Z)-2-(4-chlorophenyl)-3-phenylacrylic acid (**1aj**).[12] Prepared according to General Procedure B, white solid, 65% yield, >99% of (Z) isomer. ^{1}H NMR (400 MHz, *d6*-DMSO): δ 12.86 (s, 1H), 7.80 (s, 1H), 7.43 (d, *J* = 7.7 Hz, 2H), 7.24-7.19 (m, 5H), 7.08 (d, *J* = 6.9 Hz, 2H). ^{13}C NMR (101

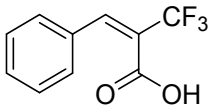
MHz, *d6*-DMSO): δ 168.03, 139.61, 135.19, 134.21, 132.36, 132.13, 131.58, 130.18, 129.20, 128.58, 128.43.



(E)-2-chloro-3-phenylacrylic acid (**1ak**).[13] Prepared according to General Procedure B, white solid, 85% yield, >99% of (Z) isomer. ^{1}H NMR (600 MHz, *d6*-DMSO): δ 12.54 (s, 1H), 8.01 (d, *J* = 1.9 Hz, 1H), 7.72-7.60 (m, 2H), 7.56 (d, *J* = 16.0 Hz, 1H), 6.64 (d, *J* = 16.0 Hz, 1H). ^{13}C NMR (151 MHz, *d6*-DMSO): δ 167.23, 141.22, 135.13, 132.38, 131.73, 130.92, 129.96, 128.10, 121.58.



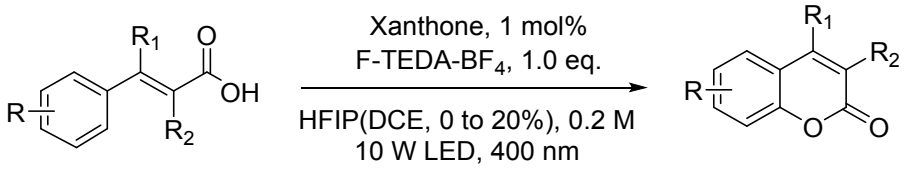
(E)-2- Bromo-3-phenylacrylic acid (**1al**).[13] Prepared according to General Procedure B, white solid, 73% yield, >99% of (Z) isomer. ^{1}H NMR (600 MHz, *d6*-DMSO): δ 13.63 (s, 1H), 8.24 (s, 1H), 7.89 (dd, *J* = 7.3, 2.1 Hz, 2H), 7.49-7.44 (m, 3H). ^{13}C NMR (151 MHz, *d6*-DMSO): δ 164.02, 140.02, 133.50, 130.19, 130.02, 128.52, 114.34.



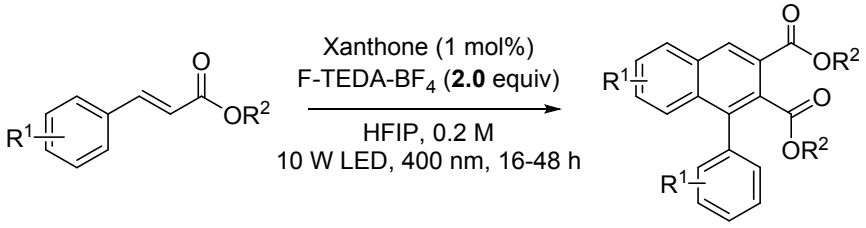
(E)-3-phenyl-2-(trifluoromethyl)acrylic acid (**1am**).[2] Prepared according to General Procedure B, white solid, 71% yield, >99% of (Z) isomer.. ^{1}H NMR (400 MHz, *d6*-DMSO): δ 13.78 (s, 1H), 8.18 (s, 1H), 7.43 (s, 5H). ^{19}F NMR (377 MHz, *d6*-DMSO): δ -56.99. ^{13}C NMR (101 MHz, *d6*-

DMSO): δ 163.98, 148.07, 148.04, 132.61, 130.09, 129.12, 129.10, 128.39, 122.32 (q, J = 30.8 Hz), 122.22 (q, J = 272.2 Hz).

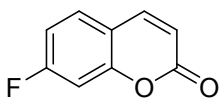
3. Oxidative cyclization of cinnamic acid derivatives



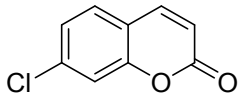
General procedure C. The specified α, β-unsaturated carbonyl compound (0.2 mmol, 1 equiv), F-TEDA-BF_4, photocatalyst Xanthone (1 mol %), and 1 mL HFIP (and DCE, 0 to 20%) were charged in the tube, then the mixture was agitated under blue LED irradiation (400 nm, 10 W) at room temperature. The reaction was monitored by GC-MS. After the reaction was completed, HFIP was removed under reduced pressure. The crude product was purified by flash chromatography using petroleum ether and ethyl acetate as eluent (v/v, 10:1).



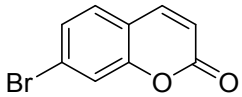
General procedure D. The specified cinnamic acid esters (0.2 mmol, 1 equiv), F-TEDA-BF_4 (2.0 equiv), photocatalyst Xanthone (1 mol %) and 1 mL HFIP were charged in the tube, then the mixture was agitated under blue LED irradiation (400 nm, 10 W) at room temperature. The reaction was monitored by GC-MS. After the reaction was completed, HFIP was removed under reduced pressure. The crude product was purified by flash chromatography using petroleum ether and ethyl acetate as eluent (v/v, 10:1).



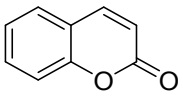
7-Fluoro-2H-chromen-2-one (**3a**).[14] Prepared according to General Procedure C, white solid, 72% yield. ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.68 (d, *J* = 9.5 Hz, 1H), 7.47 (m, 1H), 7.03-6.99 (m, 2H), 6.36 (d, *J* = 9.5 Hz, 1H). ^{19}F NMR (377 MHz, $CDCl_3$): δ -105.11 (dd, *J* = 14.7, 8.5 Hz). ^{13}C NMR (101 MHz, $CDCl_3$): δ 164.32 (d, *J* = 252.2 Hz), 160.07, 155.08 (d, *J* = 13.0 Hz), 142.81, 129.38 (d, *J* = 10.4 Hz), 115.43 (d, *J* = 2.9 Hz), 115.21 (d, *J* = 3.2 Hz), 112.40 (d, *J* = 22.6 Hz), 104.27 (d, *J* = 25.5 Hz).



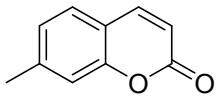
7-Chloro-2H-chromen-2-one (**3b**).[15] Prepared according to General Procedure C, white solid, 73% yield. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.71 (d, *J* = 9.6 Hz, 1H), 7.45 (d, *J* = 7.2 Hz, 1H), 7.32-7.26 (m, 2H), 6.43 (d, *J* = 9.6 Hz, 1H). ^{13}C NMR (101 MHz, $CDCl_3$): δ 159.82, 154.22, 142.59, 137.67, 128.60, 124.93, 117.32, 117.07, 116.49.



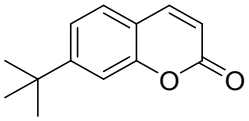
7-Bromo-2H-chromen-2-one (**3c**).[1] Prepared according to General Procedure C, white solid, 71yield. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.67 (d, *J* = 9.6 Hz, 1H), 7.46 (d, *J* = 1.4 Hz, 1H), 7.40-7.32 (m, 2H), 6.42 (d, *J* = 9.6 Hz, 1H). ^{13}C NMR (101 MHz, $CDCl_3$): δ 159.74, 154.16, 142.66, 128.73, 127.77, 125.67, 120.03, 117.65, 116.75.



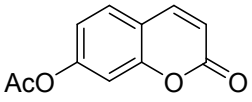
2H-chromen-2-one (**3d**).[1] Prepared according to General Procedure C, white solid, 75% yield. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.73 (d, *J* = 9.6 Hz, 1H), 7.55-7.48 (m, 2H), 7.32-7.26 (m, 2H), 6.43 (d, *J* = 9.6 Hz, 1H). ^{13}C NMR (101 MHz, $CDCl_3$): δ 160.60, 153.86, 143.35, 131.68, 127.77, 124.29, 118.68, 116.65, 116.47.



7-Methyl-2H-chromen-2-one (**3e**).[1] Prepared according to General Procedure C, white solid, 62% yield. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.67 (d, *J* = 9.6 Hz, 1H), 7.36 (d, *J* = 7.7 Hz, 1H), 7.12 (s, 1H), 7.09 (d, *J* = 7.7 Hz, 1H), 6.35 (d, *J* = 9.6 Hz, 1H), 2.44 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$): δ 161.04, 154.13, 143.33, 143.06, 127.48, 125.55, 117.00, 116.43, 115.40, 21.71.

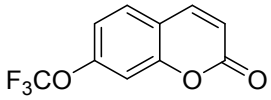


7-(Tert-butyl)-2H-chromen-2-one (**3f**).[16] Prepared according to General Procedure C, white solid, 58% yield. ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.67 (d, *J* = 9.4 Hz, 1H), 7.41 (d, *J* = 7.8 Hz, 1H), 7.33-7.31 (m, 2H), 6.36 (d, *J* = 9.4 Hz, 1H), 1.34 (s, 9H). ^{13}C NMR (151 MHz, $CDCl_3$): δ 161.13, 156.33, 154.08, 143.14, 127.27, 121.91, 116.35, 115.68, 113.67, 31.02.

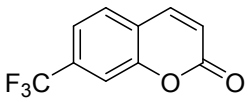


2-Oxo-2H-chromen-7-yl acetate (**3g**)[17]: Prepared according to General Procedure C, white solid, 69% yield. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.67 (d, *J* = 9.2 Hz, 1H), 7.46 (d, *J* = 7.2 Hz, 1H), 7.06

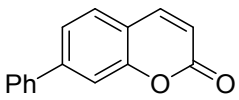
(s, 1H), 7.01 (d, J = 7.2 Hz, 1H), 6.34 (d, J = 9.2 Hz, 1H), 2.30 (s, 3H). ^{13}C NMR (151 MHz, $CDCl_3$): δ 168.61, 160.21, 154.46, 152.98, 142.82, 128.51, 118.29, 116.52, 115.85, 110.24, 20.98.



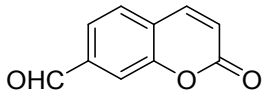
7-(Trifluoromethoxy)-2H-chromen-2-one (**3h**). Prepared according to General Procedure C, white solid, 73% yield. ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.71 (d, J = 9.4 Hz, 1H), 7.52 (d, J = 8.5 Hz, 1H), 7.16 (s, 1H), 7.13 (d, J = 8.5 Hz, 1H), 6.41 (d, J = 9.4 Hz, 1H). ^{19}F NMR (565 MHz, $CDCl_3$): δ -57.85. ^{13}C NMR (151 MHz, $CDCl_3$): δ 159.77, 154.62, 151.19, 142.45, 129.12, 120.12 (q, J = 259.1 Hz), 117.21, 116.74, 116.62, 109.11. HRMS (EI): calculated for $C_{10}H_5F_3O_3$: 230.0191; found: 230.0190.



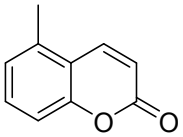
7-(Trifluoromethyl)-2H-chromen-2-one (**3i**).[18] Prepared according to General Procedure C, white solid, 56% yield. ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.76 (d, J = 9.6 Hz, 1H), 7.63 (d, J = 8.1 Hz, 1H) , 7.56 (s, 1H), 7.52 (d, J = 8.1 Hz, 1H), 6.54 (d, J = 9.6 Hz, 1H). ^{19}F NMR (565 MHz, $CDCl_3$): δ -62.93. ^{13}C NMR (151 MHz, $CDCl_3$): δ 159.51, 153.62, 142.18, 133.39 (q, J = 33.5 Hz), 128.59, 123.09 (q, J = 272.1 Hz), 121.30, 120.97 (q, J = 3.6 Hz), 118.91, 114.25 (q, J = 3.8 Hz).



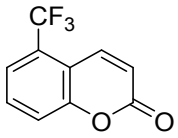
7-Phenyl-2H-chromen-2-one (**3j**).[19] Prepared according to General Procedure C, white solid, 58% yield. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.73 (d, J = 9.3 Hz, 1H), 7.62 (d, J = 7.2 Hz, 2H), 7.54-7.40 (m, 6H), 6.43 (d, J = 9.3 Hz, 1H). ^{13}C NMR (101 MHz, $CDCl_3$): δ 160.85, 154.41, 144.98, 143.09, 139.08, 129.05, 128.50, 128.11, 127.18, 123.29, 117.73, 116.25, 114.99.



2-Oxo-2H-chromene-7-carbaldehyde (**3k**).[20] Prepared according to General Procedure C, white solid, 44% yield. ^{1}H NMR (400 MHz, $CDCl_3$): δ 10.08 (s, 1H), 7.81-7.76 (m, 3H), 7.66 (d, J = 7.8 Hz, 1H), 6.57 (d, J = 9.6 Hz, 1H). ^{13}C NMR (101 MHz, $CDCl_3$): δ 190.58, 159.77, 154.16, 142.34, 138.31, 128.73, 124.51, 123.29, 119.45, 118.15.

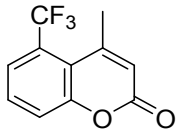


5-Methyl-2H-chromen-2-one (**3l**).[21] Prepared according to General Procedure C, white solid, 58% yield. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.68 (d, J = 9.6 Hz, 1H), 7.35-7.26 (m, 2H), 7.14 (t, J = 7.3 Hz, 1H), 6.38 (d, J = 9.6 Hz, 1H), 2.41 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$): δ 160.84, 152.19, 143.70, 133.00, 126.07, 125.47, 123.85, 118.39, 116.06, 15.20.

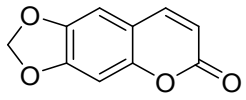


5-(Trifluoromethyl)-2H-chromen-2-one (**3m**). Prepared according to General Procedure C, white solid, 63% yield. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.01 (d, J = 9.7 Hz, 1H), 7.60-7.52 (m, 3H), 6.56

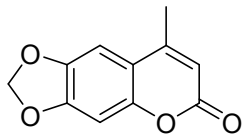
(d, J = 9.6 Hz, 1H). ^{19}F NMR (565 MHz, $CDCl_3$): δ -58.67. ^{13}C NMR (151 MHz, $CDCl_3$): δ 158.97, 154.78, 138.79 (d, J = 2.2 Hz), 131.07, 127.29 (q, J = 33.5 Hz), 123.25 (q, J = 273.5 Hz), 121.94 (q, J = 3.8 Hz), 121.09, 118.46, 115.77. HRMS (EI): calculated for $C_{10}H_5F_3O_2$: 214.0242; found: 214.0245.



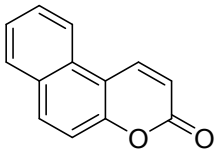
4-Methyl-5-(trifluoromethyl)-2H-chromen-2-one (**3n**). Prepared according to General Procedure C, white solid, 71% yield. ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.81 (d, J = 8.0 Hz, 2H), 7.38 (t, J = 7.8 Hz, 1H), 6.36 (s, 1H), 2.47 (s, 3H). ^{19}F NMR (565 MHz, $CDCl_3$): δ -61.72. ^{13}C NMR (151 MHz, $CDCl_3$): δ 158.55, 151.64, 150.79, 128.92 (q, J = 4.9 Hz), 128.50, 123.47, 122.48 (q, J = 273.3 Hz), 120.85, 118.62 (q, J = 31.7 Hz), 115.87, 18.87. HRMS (EI): calculated for $C_{11}H_7F_3O_2$: 228.0398; found: 228.0397.



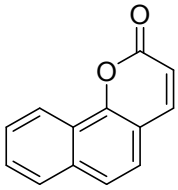
6H-[1,3]dioxolo[4,5-g]chromen-6-one (**3o**).[22] Prepared according to General Procedure C, white solid, 46% yield. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.58 (d, J = 9.5 Hz, 1H), 6.83 (s, 2H), 6.28 (d, J = 9.5 Hz, 1H), 6.07 (s, 2H). ^{13}C NMR (101 MHz, $CDCl_3$): δ 161.20, 151.25, 144.88, 143.46, 113.37, 112.66, 105.00, 102.33, 98.38.



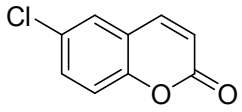
8-Methyl-6H-[1,3]dioxolo[4,5-g]chromen-6-one (**3p**).[22] Prepared according to General Procedure C, white solid, 48% yield. ^{1}H NMR (600 MHz, $CDCl_3$): δ 6.94 (s, 1H), 6.80 (s, 1H), 6.15 (s, 1H), 6.06 (s, 2H), 2.35 (s, 3H). ^{13}C NMR (151 MHz, $CDCl_3$): δ 161.20, 152.40, 150.91, 150.49, 144.86, 113.77, 112.16, 102.27, 102.05, 98.29, 19.10.



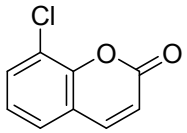
3H-benzo[f]chromen-3-one (**3q**).[15] Prepared according to General Procedure C, white solid, 44% yield. ^{1}H NMR (600 MHz, $CDCl_3$): δ 8.49 (d, *J* = 9.4 Hz, 1H), 8.22 (d, *J* = 7.7 Hz, 1H), 7.98 (d, *J* = 7.7 Hz, 1H), 7.91 (d, *J* = 7.7 Hz, 1H), 7.69-7.57 (m, 2H), 7.46 (d, *J* = 8.0 Hz, 1H), 6.58 (d, *J* = 9.4 Hz, 1H). ^{13}C NMR (151 MHz, $CDCl_3$): δ 160.90, 153.82, 139.09, 133.09, 130.22, 128.97, 128.95, 128.25, 126.02, 121.31, 117.03, 115.61, 112.93.



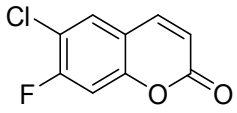
2H-benzo[g]chromen-2-one (**3r**).[15] Prepared according to General Procedure C, white solid, 67% yield. ^{1}H NMR (600 MHz, $CDCl_3$): δ 8.51 (dt, *J* = 6.9, 2.2 Hz, 1H), 7.85 (d, *J* = 6.9 Hz, 1H), 7.80 (d, *J* = 9.2 Hz, 1H), 7.66 (d, *J* = 8.6 Hz, 1H), 7.62 (dt, *J* = 6.8, 2.6 Hz, 2H), 7.43(d, *J* = 8.4 Hz, 1H), 6.50 (d, *J* = 9.4 Hz, 1H). ^{13}C NMR (151 MHz, $CDCl_3$): δ 160.89, 151.22, 144.14, 134.75, 128.65, 127.73, 127.12, 124.38, 123.50, 122.97, 122.22, 115.85, 114.18.



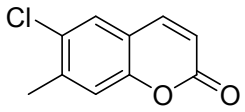
6-Chloro-2H-chromen-2-one (**3s**).[15] Prepared according to General Procedure C, white solid, 56% yield. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.68 (d, *J* = 9.6 Hz, 1H), 7.48-7.47 (m, 2H), 7.28-7.26 (m, 1H), 6.49 (d, *J* = 9.6 Hz, 1H). ^{13}C NMR (101 MHz, $CDCl_3$): δ 159.89, 152.31, 142.13, 131.62, 129.55, 127.03, 119.72, 118.17, 117.72.



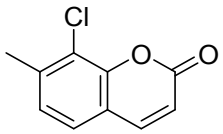
8-Chloro-2H-chromen-2-one (**3s'**).[15] Prepared according to General Procedure C, white solid, 13% yield. **3s / 3s'** = 1 / 0.18 in GCMS. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.70 (d, *J* = 9.6 Hz, 1H), 7.60 (d, *J* = 7.8 Hz, 1H), 7.40 (d, *J* = 7.8 Hz, 1H), 7.23 (t, *J* = 7.9 Hz, 1H), 6.47 (d, *J* = 9.6 Hz, 1H). ^{13}C NMR (101 MHz, $CDCl_3$): δ 159.51, 149.72, 143.08, 132.24, 126.33, 124.62, 121.77, 120.07, 117.35.



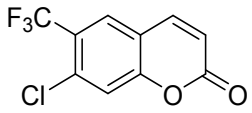
6-Chloro-7-fluoro-2H-chromen-2-one (**3t**). Prepared according to General Procedure C, white solid, 61% yield. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.63 (d, *J* = 9.6 Hz, 1H), 7.55 (d, *J* = 7.5 Hz, 1H), 7.14 (d, *J* = 8.9 Hz, 1H), 6.42 (d, *J* = 9.6 Hz, 1H). ^{19}F NMR (377 MHz, $CDCl_3$) δ -106.77 (t, *J* = 8.5 Hz). ^{13}C NMR (101 MHz, $CDCl_3$) δ 159.49, 159.47 (d, *J* = 256.7 Hz), 153.31 (d, *J* = 11.4 Hz), 141.76 (d, *J* = 1.3 Hz), 128.92 (d, *J* = 1.3 Hz), 117.68 (d, *J* = 19.1 Hz), 116.63 (d, *J* = 3.1 Hz), 116.08 (d, *J* = 3.4 Hz), 105.71 (d, *J* = 15.2 Hz). HRMS (EI): calculated for $C_9H_4ClFO_2$: 197.9884; found: 197.9888.



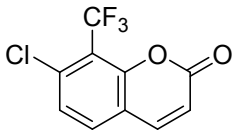
6-Chloro-7-methyl-2H-chromen-2-one (**3u**).[18] Prepared according to General Procedure C, white solid, 47% yield. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.61 (d, *J* = 9.6 Hz, 1H), 7.45 (s, 1H), 7.19 (s, 1H), 6.39 (d, *J* = 9.6 Hz, 1H), 2.44 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$): δ 160.36, 152.31, 142.14, 140.69, 130.09, 127.23, 118.79, 117.75, 116.70, 20.63.



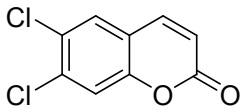
8-Chloro-7-methyl-2H-chromen-2-one (**3u'**). Prepared according to General Procedure C, white solid, 19% yield. **3u / 3u'** = 1 / 0.44 (determined by GC-MS). ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.68 (d, *J* = 9.5 Hz, 1H), 7.30 (d, *J* = 7.8 Hz, 1H), 7.18 (d, *J* = 7.8 Hz, 1H), 6.41 (d, *J* = 9.5 Hz, 1H), 2.50 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$): δ 159.92, 149.84, 143.19, 141.01, 126.17, 125.24, 121.60, 117.79, 115.93, 20.53. HRMS (EI): calculated for $C_{10}H_7ClO_2$: 194.0135; found: 194.0142.



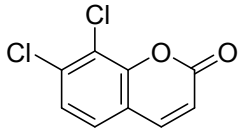
7-Chloro-6-(trifluoromethyl)-2H-chromen-2-one (**3v**). Prepared according to General Procedure C, white solid, 46% yield. ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.83 (s, 1H), 7.72 (d, *J* = 9.6 Hz, 1H), 7.48 (s, 1H), 6.51 (d, *J* = 9.6 Hz, 1H). ^{19}F NMR (565 MHz, $CDCl_3$): δ -62.15. ^{13}C NMR (151 MHz, $CDCl_3$): δ 158.81, 155.75, 141.89, 135.52, 127.18 (q, *J* = 5.0 Hz), 124.91 (q, *J* = 32.3 Hz), 122.19 (q, *J* = 272.4 Hz), 119.99, 119.48, 118.01, 117.02.



7-Chloro-8-(trifluoromethyl)-2H-chromen-2-one (**3v'**). Prepared according to General Procedure C, white solid, 19% yield. **3v / 3v'** = 1 / 0.41 in GCMS. ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.71 (d, *J* = 9.6 Hz, 1H), 7.57 (d, *J* = 8.3 Hz, 1H), 7.41 (d, *J* = 8.3 Hz, 1H), 6.49 (d, *J* = 9.6 Hz, 1H). ^{19}F NMR (565 MHz, $CDCl_3$): δ -55.43. ^{13}C NMR (151 MHz, $CDCl_3$): δ 158.00, 152.64, 142.37, 136.78, 131.30, 127.44, 122.03 (q, *J* = 276.7 Hz), 118.25, 117.15, 116.92 (q, *J* = 31.6 Hz). HRMS (EI): calculated for $C_{10}H_4ClF_3O_2$: 247.9852; found: 247.9858.

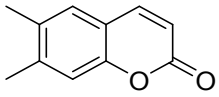


6,7-Dichloro-2H-chromen-2-one (**3w**).[18] Prepared according to General Procedure C, white solid, 49% yield. 1H NMR (600 MHz, CDCl3) δ 7.62 (d, J = 9.6 Hz, 1H), 7.57 (s, 1H), 7.44 (s, 1H), 6.45 (d, J = 9.6 Hz, 1H). ^{13}C NMR (151 MHz, $CDCl_3$): δ 159.28, 152.30, 141.54, 135.89, 128.45, 128.39, 118.80, 118.39, 117.75.

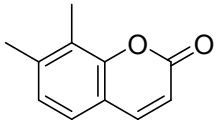


7, 8-Dichloro-2H-chromen-2-one (**3w'**). Prepared according to General Procedure C, white solid, 21% yield. **3w / 3w'** = 1 / 0.45 in GCMS. ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.68 (d, *J* = 9.6 Hz, 1H), 7.39 (d, *J* = 8.4 Hz, 1H), 7.34 (d, *J* = 8.4 Hz, 1H), 6.46 (d, *J* = 9.6 Hz, 1H). ^{13}C NMR (151 MHz,

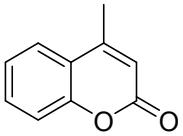
$CDCl_3$): δ 158.98, 150.77, 142.58, 136.71, 125.91, 125.65, 121.17, 118.28, 116.95. HRMS (EI): calculated for $C_9H_4Cl_2O_2$: 213.9588; found: 213.9593.



6,7-Dimethyl-2H-chromen-2-one (**3x**).[18] Prepared according to General Procedure C, white solid, 33% yield. ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.63 (d, *J* = 9.4 Hz, 1H), 7.21 (s, 1H), 7.11 (s, 1H), 6.33 (d, *J* = 9.4 Hz, 1H), 2.34 (s, 3H), 2.29(s, 3H). ^{13}C NMR (151 MHz, $CDCl_3$): δ 161.35, 152.45, 143.31, 141.90, 133.13, 127.87, 117.38, 116.58, 115.41, 20.31, 19.14.

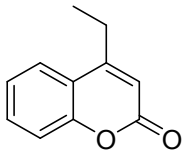


7, 8-Dimethyl-2H-chromen-2-one (**3x'**). Prepared according to General Procedure C, white solid, 18% yield. **3x / 3x'** = 1 / 0.53 in GCMS. ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.67 (d, *J* = 9.4 Hz, 1H), 7.22 (d, *J* = 7.9 Hz, 1H), 7.09 (d, *J* = 7.9 Hz, 1H), 6.35 (d, *J* = 9.4 Hz, 1H), 2.39 (s, 3H), 2.37 (s, 3H). ^{13}C NMR (151 MHz, $CDCl_3$): δ 161.45, 152.24, 143.97, 141.67, 125.86, 124.66, 116.62, 114.95, 20.41, 11.36. HRMS (EI): calculated for $C_{11}H_{10}O_2$: 285.9491; found: 285.9485.

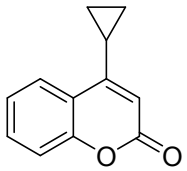


4-Methyl-2H-chromen-2-one (**3y**).[1] Prepared according to General Procedure C, white solid, 68% yield. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.59 (d, *J* = 9.6 Hz, 1H), 7.50 (t, *J* = 7.6 Hz, 1H), 7.29 (d, *J*

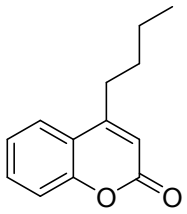
= 7.2 Hz, 2H), 6.26 (s, 1H), 2.42 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$): δ 160.57, 153.29, 152.27, 131.58, 124.44, 124.07, 119.76, 116.81, 114.86, 18.45.



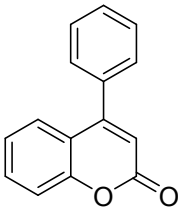
4-Ethyl-2H-chromen-2-one (**3z**).[1] Prepared according to General Procedure C, white solid, 67% yield. ^{1}H NMR (400 MHz, CDCl3): δ 7.64 (d, *J* = 9.6 Hz, 1H), 7.50 (dt, *J* = 7.7, 1.2 Hz, 1H), 7.32-7.26 (m, 2H), 6.28 (s, 1H), 2.84-2.78 (q, *J* = 7.2 Hz, 2H), 1.32 (t, *J* = 7.4 Hz, 3H). ^{13}C NMR (151 MHz, $CDCl_3$): δ 161.02, 157.27, 153.48, 131.45, 124.07, 124.01, 119.18, 117.11, 112.88, 24.50, 11.93.



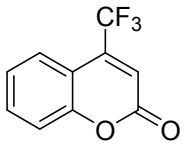
4-Cyclopropyl-2H-chromen-2-one (**3aa**).[1] Prepared according to General Procedure C, white solid, 62% yield from **1aa** or **1aa'** in similar reaction proceed. ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.92 (d, *J* = 7.8 Hz, 1H), 7.53 (t, *J* = 7.8 Hz, 1H), 7.33-7.30 (m, 2H), 6.05 (s, 1H), 2.13-2.08 (m, 1H), 1.19-1.13 (m, 2H), 0.85-0.83 (m, 2H). ^{13}C NMR (151 MHz, $CDCl_3$): δ 161.36, 157.61, 153.35, 131.58, 124.61, 124.09, 120.14, 117.03, 110.29, 11.93, 7.99.



4-Butyl-2H-chromen-2-one (**3ab**).[23] Prepared according to General Procedure C, white solid, 63% yield. ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.61 (d, *J* = 7.7 Hz, 1H), 7.48 (t, *J* = 8.1 Hz, 1H), 7.30-7.25 (m, 2H), 6.24 (s, 1H), 2.74 (t, *J* = 7.6 Hz, 2H), 1.68-1.63 (m, 2H), 1.47-1.41 (m, 2H), 0.95 (t, *J* = 7.3 Hz, 2H). ^{13}C NMR (151 MHz, $CDCl_3$): δ 160.89, 156.21, 153.63, 131.46, 124.22, 124.04, 119.21, 117.16, 113.74, 31.32, 30.08, 22.43, 13.71.

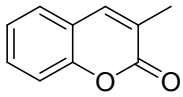


4-Phenyl-2H-chromen-2-one (**3ac**).[22] Prepared according to General Procedure C, white solid, 58% yield. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.57-7.39 (m, 8H), 7.23 (t, *J* = 7.7 Hz, 1H), 6.37 (s, 1H). ^{13}C NMR (101 MHz, $CDCl_3$): δ 160.69, 155.61, 154.11, 135.12, 131.87, 129.64, 128.82, 128.38, 126.95, 124.12, 118.90, 117.25, 115.11.

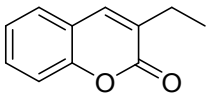


4-(Trifluoromethyl)-2H-chromen-2-one (**3ad**). Prepared according to General Procedure C, white solid, 88% yield. ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.73 (d, *J* = 8.4 Hz, 1H), 7.62 (t, *J* = 7.9 Hz, 1H), 7.40 (d, *J* = 8.4 Hz, 1H), 7.36 (t, *J* = 7.9 Hz, 1H), 6.78 (s, 1H). ^{19}F NMR (565 MHz, $CDCl_3$): δ -

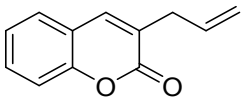
64.72 (s, 3F). ^{13}C NMR (151 MHz, $CDCl_3$): δ 158.76, 154.21, 141.43 (q, J = 32.9 Hz), 133.03, 125.26 (q, J = 2.3 Hz), 125.03, 121.34 (q, J = 275.4 Hz), 117.59, 116.01(q, J = 5.7 Hz), 113.49.



3-Methyl-2H-chromen-2-one (**3ae**).[24] Prepared according to General Procedure C, white solid, 68% yield. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.51 (s, 1H), 7.45-7.41 (m, 2H), 7.30-7.23 (m, 2H), 2.21 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$): δ 162.07, 153.10, 139.12, 130.32, 126.85, 125.65, 124.15, 119.45, 116.27, 17.03.

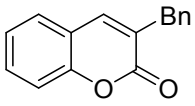


3-Ethyl-2H-chromen-2-one (**3af**).[24] Prepared according to General Procedure C, white solid, 68% yield. ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.46 (s, 1H), 7.43 (t, J = 8.9 Hz, 2H), 7.28 (d, J = 8.2 Hz, 1H), 7.23 (t, J = 7.5 Hz, 1H), 2.58 (q, J = 7.4 Hz, 2H), 1.24 (t, J = 7.4 Hz, 3H). ^{13}C NMR (151 MHz, $CDCl_3$): δ 161.74, 152.90, 137.43, 131.16, 130.36, 127.07, 124.15, 119.51, 116.27, 23.78, 12.18.

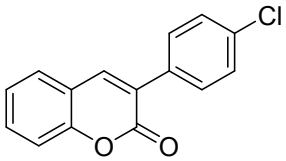


3-Allyl-2H-chromen-2-one (**3ag**).[25] Prepared according to General Procedure C, white solid, 41% yield. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.51 (s, 1H), 7.47 (dd, J = 15.8, 8.1 Hz, 2H), 7.32 (d, J = 8.2 Hz, 1H), 7.26 (t, J = 7.1 Hz, 1H), 5.98 (dt, J = 16.8, 7.0 Hz, 1H), 5.25 (d, J = 5.2 Hz, 1H), 5.21 (s,

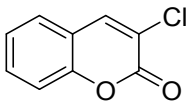
1H), 3.33 (d, J = 6.5 Hz, 2H). ^{13}C NMR (151 MHz, $CDCl_3$): δ 161.54, 153.04, 138.88, 133.72, 130.69, 127.94, 127.23, 124.26, 119.38, 118.15, 116.38, 34.48.



3-Benzyl-2H-chromen-2-one (**3ai**).[26] Prepared according to General Procedure C, white solid, 65% yield. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.44 (t, J = 7.5 Hz, 1H), 7.36-7.26 (m, 8H), 7.20 (t, J = 7.5 Hz, 1H), 3.88 (s, 2H). ^{13}C NMR (101 MHz, $CDCl_3$): δ 161.61, 152.99, 139.20, 137.58, 130.72, 129.33, 128.71, 127.32, 126.78, 124.21, 119.34, 116.34, 36.49.

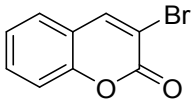


3-(4-Chlorophenyl)-2H-chromen-2-one (**3aj**).[27] Prepared according to General Procedure C, white solid, 63% yield. ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.81 (s, 1H), 7.66 (d, J = 8.3 Hz, 2H), 7.55-7.53 (m, 2H), 7.41 (d, J = 8.3 Hz, 2H), 7.36 (d, J = 8.4 Hz, 1H), 7.32 (d, J = 7.5 Hz, 1H). ^{13}C NMR (151 MHz, $CDCl_3$): δ 160.31, 153.46, 139.92, 134.85, 133.01, 131.64, 129.79, 128.63, 127.95, 127.04, 124.59, 119.41, 116.45.

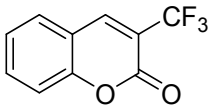


3-Chloro-2H-chromen-2-one (**3ak**).[28] Prepared according to General Procedure C, white solid, 73% yield. ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.89 (s, 1H), 7.56 (t, J = 7.8 Hz, 1H), 7.48 (d, J = 7.7

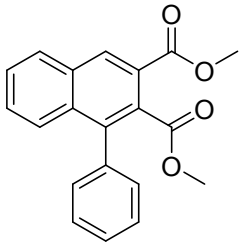
Hz, 1H), 7.34 (m, 2H). ^{13}C NMR (151 MHz, $CDCl_3$): δ 157.22, 152.54, 140.05, 131.84, 127.23, 125.01, 122.17, 118.69, 116.64.



3-Bromo-2H-chromen-2-one (**3al**).[28] Prepared according to General Procedure C, white solid, 72% yield. ^{1}H NMR (600 MHz, $CDCl_3$): δ 8.08 (s, 1H), 7.54 (t, *J* = 7.8 Hz, 1H), 7.45 (d, *J* = 7.5 Hz, 1H), 7.29 (t, *J* = 7.7 Hz, 2H). ^{13}C NMR (151 MHz, $CDCl_3$): δ 156.96, 153.01, 144.36, 132.01, 127.09, 124.92, 119.17, 116.64, 111.65.

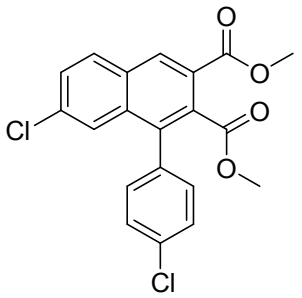


3-(Trifluoromethyl)-2H-chromen-2-one (**3am**).[29] Prepared according to General Procedure C, white solid, 91% yield. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.17 (s, 1H), 7.69-7.62 (m, 2H), 7.39-7.35 (m, 2H). ^{19}F NMR (377 MHz, $CDCl_3$): δ -66.17 (s, 3F). ^{13}C NMR (101 MHz, $CDCl_3$): δ 155.87, 154.50, 143.43 (q, *J* = 4.9 Hz), 134.43, 129.51, 125.27, 121.30 (q, *J* = 272.6 Hz), 117.45 (q, *J* = 33.2 Hz), 116.83, 116.67.

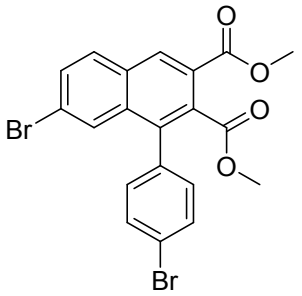


Dimethyl 1-phenylnaphthalene-2,3-dicarboxylate (**5a**).[30] Prepared according to General Procedure D, white solid, 64% yield. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.61 (s, 1H), 7.98 (d, *J* = 7.7

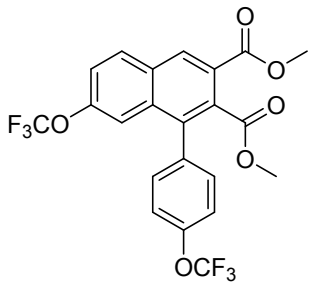
MHz), 7.58-7.56 (m, 2H), 7.52-7.45 (m, 4H), 7.37-7.35 (m, 2H), 3.96 (s, 3H), 3.60 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$): δ 169.15, 166.16, 138.58, 136.52, 133.99, 132.27, 131.35, 131.04, 130.10, 129.22, 128.90, 127.91, 127.39, 126.85, 124.32, 52.47, 51.99.



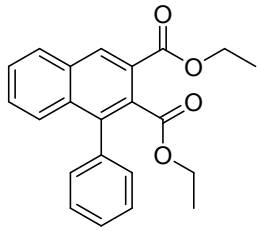
Dimethyl 7-chloro-1-(4-chlorophenyl)naphthalene-2,3-dicarboxylate (**5b**). Prepared according to General Procedure D, white solid, 55% yield. ^{1}H NMR (600 MHz, $CDCl_3$): δ 8.58 (s, 1H), 7.92 (d, *J* = 8.5 Hz, 1H), 7.52 (d, *J* = 8.5 Hz, 1H), 7.46 (s, 3H), 7.30 – 7.24 (m, 2H), 3.95 (s, 3H), 3.63 (s, 3H). ^{13}C NMR (151 MHz, $CDCl_3$): δ 168.69, 165.72, 136.50, 135.58, 134.56, 134.52, 134.18, 132.30, 131.48, 131.45, 130.90, 130.53, 128.68, 128.54, 125.49, 124.61, 52.71, 52.33.



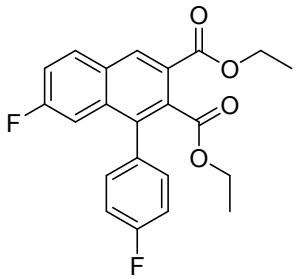
Dimethyl 7-bromo-1-(4-bromophenyl)naphthalene-2,3-dicarboxylate (**5c**). Prepared according to General Procedure D, white solid, 53% yield. ^{1}H NMR (600 MHz, $CDCl_3$): δ 8.58 (s, 1H), 7.85 (d, *J* = 8.6 Hz, 1H), 7.67 (d, *J* = 8.6 Hz, 1H), 7.66 – 7.58 (m, 3H), 7.21 (d, *J* = 8.0 Hz, 2H), 3.96 (s, 3H), 3.63 (s, 3H). ^{13}C NMR (151 MHz, $CDCl_3$): δ 168.66, 165.73, 136.43, 134.80, 134.64, 132.35, 132.23, 131.79, 131.57, 131.51, 131.25, 130.89, 130.75, 130.09, 128.77, 124.75, 124.15, 122.80, 52.74, 52.37.



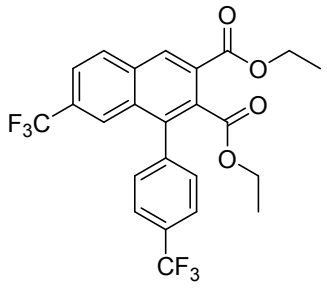
Dimethyl 7-(trifluoromethoxy)-1-(4-(trifluoromethoxy)phenyl)naphthalene-2,3-dicarboxylate (**5d**). Prepared according to General Procedure D, white solid, 44% yield. 1H NMR (399 MHz, $CDCl_3$): δ 8.65 (s, 1H), 8.06 (d, J = 9.0 Hz, 1H), 7.51 – 7.46 (m, 1H), 7.40 – 7.33 (m, 4H), 7.30 (s, 1H), 3.97 (s, 3H), 3.61 (s, 3H). 19F NMR (376 MHz, $CDCl_3$): δ -57.74 (s, 3F), -57.86 (s, 3F). ^{13}C NMR (100 MHz, $CDCl_3$): δ 168.6, 165.7, 149.4, 149.4, 137.0, 134.6, 134.3, 132.7, 131.7, 131.5, 130.6, 125.0, 121.8, 121.6, 121.5, 120.6, 119.2, 119.1, 117.0, 52.8, 52.3.



Diethyl 1-phenylnaphthalene-2,3-dicarboxylate (**5e**). Prepared according to General Procedure D, white solid, 40% yield. ^{1}H NMR (399 MHz, $CDCl_3$): δ 8.60 (s, 1H), 7.99 (d, J = 7.9 Hz, 1H), 7.63 – 7.42 (m, 6H), 7.36 (d, J = 5.4 Hz, 2H), 4.42 (q, J = 7.0 Hz, 2H), 4.05 (q, J = 7.0 Hz, 2H), 1.42 (t, J = 7.1 Hz, 3H), 0.98 (t, J = 7.1 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 168.7, 165.9, 138.5, 136.7, 134.0, 132.3, 131.3, 131.2, 130.3, 129.2, 128.8, 127.9, 127.4, 126.9, 124.9, 61.5, 61.1, 14.2, 13.6.



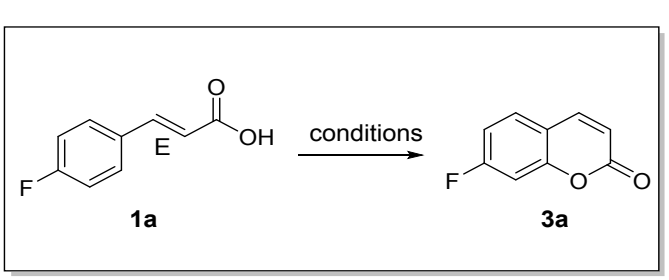
Diethyl 7-fluoro-1-(4-fluorophenyl)naphthalene-2,3-dicarboxylate (**5f**). Prepared according to General Procedure D, white solid, 56% yield. ^{1}H NMR (500 MHz, $CDCl_3$): δ 8.61 (s, 1H), 8.00 (dd, *J* = 9.0, 5.7 Hz, 1H), 7.38 – 7.30 (m, 3H), 7.20 – 7.15 (m, 2H), 7.11 (dd, *J* = 10.6, 2.2 Hz, 1H), 4.42 (q, *J* = 7.1 Hz, 2H), 4.09 (q, *J* = 7.2 Hz, 2H), 1.41 (t, *J* = 7.1 Hz, 3H), 1.03 (t, *J* = 7.2 Hz, 3H). ^{19}F NMR (376 MHz, $CDCl_3$): δ -108.02 – -108.12 (m, 1F), -113.40 – -113.50 (m, 1F). ^{13}C NMR (100 MHz, $CDCl_3$): δ 168.4, 165.5, 162.7 (d, *J* = 247.5 Hz), 162.5 (d, *J* = 250.3 Hz), 136.8, 136.7, 135.6, 135.5, 132.5, 132.1, 132.0, 131.4, 129.3, 124.3, 24.3, 118.0 (d, *J* = 25.6 Hz), 115.2 (d, *J* = 21.5 Hz), 110.4 (d, *J* = 22.5 Hz), 61.6, 61.3, 14.2, 13.7.

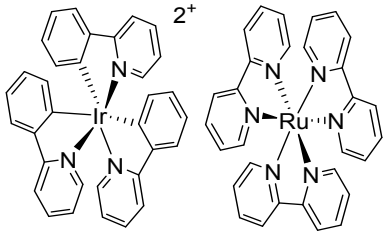


Diethyl 7-(trifluoromethyl)-1-(4-(trifluoromethyl)phenyl)naphthalene-2,3-dicarboxylate (**5g**). Prepared according to General Procedure D, white solid, 14% yield. ^{1}H NMR (500 MHz, $CDCl_3$): δ 8.68 (s, 1H), 8.16 (d, *J* = 8.6 Hz, 1H), 7.82 – 7.73 (m, 4H), 7.50 (d, *J* = 8.0 Hz, 2H), 4.44 (q, *J* = 7.1 Hz, 2H), 4.07 (q, *J* = 7.1 Hz, 2H), 1.43 (t, *J* = 7.2 Hz, 3H), 0.98 (t, *J* = 7.1 Hz, 3H). ^{19}F NMR (376 MHz, $CDCl_3$): δ -62.73 (s, 3F), -62.76 (s, 3F). ^{13}C NMR (100 MHz, $CDCl_3$): δ 167.8, 165.2, 139.5, 137.9, 133.6, 132.8, 132.6, 131.5, 131.4, 131.0, 130.8, 130.6, 130.4, 127.2, 125.3, 124.0, 123.9, 123.4, 77.3, 62.0, 61.5, 14.2, 13.5.

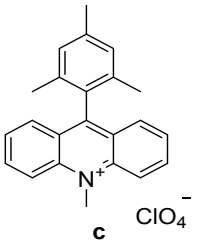
4. Additional information for optimization of conditions

Table S1. Screening solvents and photocatalysts of cyclization of **3a** with **1a**.[a]

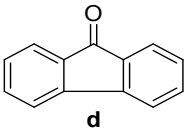




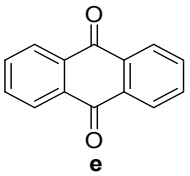
a *fac*-Ir[(ppy)$_3$] **b** [Ru(bpy)$_3$]Cl$_2$



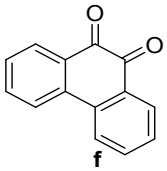
c Acridinium dye



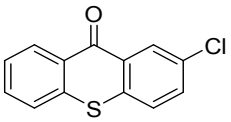
d 9*H*-fluoren-9-one



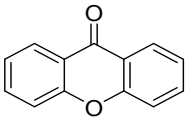
e Anthracene-9,10-dione



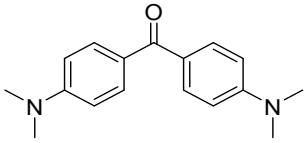
f Phenanthrenequinone



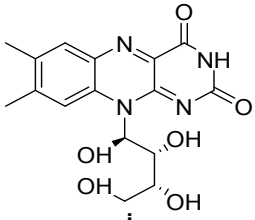
g 2-Chlorothioxanthen-9-one



h Xanthone



i 4,4'-Bis(diethylamino)benzophenone



j (-)-riboflavin

Entry	Photocatalyst	Solvent	F-TEDA-BF$_4$	Yield(%)[b]
1	**a,** 1 mol%	HFIP, 0.2 M	1.5 equiv	20h, 2%[c]
2	**b,** 1 mol%	HFIP, 0.2 M	1.5 equiv	20h, 3%[c]
3	**c,** 1 mol%	HFIP, 0.2 M	1.5 equiv	20h, 57%[c]
4	**d,** 5 mol%	HFIP, 0.2 M	1.5 equiv	20h, 0%[d]
5	**e,** 5 mol%	HFIP, 0.2 M	1.5 equiv	20h, 30%[c]
6	**f,** 5 mol%	HFIP, 0.2 M	1.5 equiv	20h, 5%[c]
7	**g,** 5 mol%	HFIP, 0.2 M	1.5 equiv	20h, 68%
8	**h,** 5 mol%	HFIP, 0.2 M	1.5 equiv	20h, **70%** 75% on 1 mmol scale
9	**i,** 5 mol%	HFIP, 0.2 M	1.5 equiv	20h, 14%[c]
10	**j,** 5 mol%	HFIP, 0.2 M	1.5 equiv	20h, 4%[c]
11	**h,** 5 mol%	HFIP/DCE(1/1), 0.2 M	1.5 equiv	40h, 65%
12	**h,** 5 mol%	HFIP/H_2O(1/1), 0.2 M	1.5 equiv	20h, 34%[d]
13	**h,** 5 mol%	HFIP/MeCN(1/1), 0.2 M	1.5 equiv	20h, 0%[c]

14	**h,** 5 mol%	MeOH/ACN(1/1), 0.2 M	1.5 equiv	20h, 0%[e]
15	**h,** 5 mol%	DMF, 0.2 M	1.5 equiv	20h, 0%[d]
16	**h,** 5 mol%	Dioxane, 0.2 M	1.5 equiv	20h, 0%[d]
17	**h,** 5 mol%	DCM, 0.2 M	1.5 equiv	44h, 54%[c]
18	**h,** 5 mol%	THF, 0.2 M	1.5 equiv	44h, 0%[c]
19	**h,** 5 mol%	ACN, 0.2 M	1.5 equiv	20h, 0%
20	**a,** 5 mol%	ACN, 0.2 M	1.5 equiv	20h, 0%
21	**j,** 5 mol%	ACN, 0.2 M	1.5 equiv	20h, 13%
22	**h,** 5 mol%	HFIP, 0.2 M	1.0 equiv	16h, 72%
23	**h,** 5 mol%	HFIP, 0.2 M	0.5 equiv	16h, 32%
24	**h,** 5 mol%	HFIP, 0.2 M	0.2 equiv	6h, 19% **24h**, 26%
25	**h,** 5 mol%	HFIP	-	24h, 9%
26	**h,** 5 mol%	HFIP, **0.1 M**	1.0 equiv	16h, 69%
27	**h**, 1 mol%	HFIP	1.0 equiv	16h, 72%
28	**h**, 1 mol%	HFIP/DCE(9/1), 0.2 M	1.0 equiv	16h, 71%
29	-	HFIP	1.5 equiv	24h, 0%[c] Addition of **1** mol% **h**, 1h, 19%[c]
30	**h**, 1 mol%, no light	HFIP	1.5 equiv	24 h, 0%[c]
31	**h,** 1 mol% 520 nm LEDs	HFIP	1.5 equiv	24 h, 0%[c]
32	**h,** 1 mol% 460 nm LEDs	HFIP	1.5 equiv	24h, 15%[c]
33	**h,** 1 mol% 365 nm LEDs	HFIP	1.5 equiv	61%

[a] Reaction conditions: **1a** (0.2 mmol, 1.0 equiv), catalyst, solvent, and F-TEDA-BF_4 as indicated, rt, 400 nm 10W LEDs, feeding operation in the glove box. [b] Yield of isolated product. [c] Conversion in GCMS. [d] Full conversion but a low isolated product. [e] All were esterification by-products.

Table S2. Screening of oxidants.[a]

Entry	Solvent	Oxidant	Yield(%)[b]
1	ACN, 0.2 M	$K_2S_2O_8$, 1.5 equiv	20h, 0%[c]
2	HFIP, 0.2 M	$K_2S_2O_8$, 1.5 equiv	40 h, 40%
3	/	30% H_2O_2 aq., 2.0 equiv	40 h, 15%[c]
4	HFIP, 0.2 M	F-TEDA-PF_6	20 h, 56%
5	ACN, 0.2 M	*m*-CPBA	40 h, 0%[c]
6	HFIP, 0.2 M	O_2	60 h, 54%
7	ACN, 0.2 M	O_2	60 h, 0%[c]

[a] Reaction conditions: **1a** (0.2 mmol, 1.0 equiv), **h** (1 mol%), solvent and oxidants as indicated, rt, 400 nm 10W LEDs. [b] Yield of isolated product. [c] Conversion in GCMS.

Table S3. E to Z Isomerization of (E)-3-(4-fluorophenyl) acrylic acid.[a]

Entry	Photocatalyst	Additives	Solvent	Z/E Ratio[b]
1	**a,** 1 mol%	/	HFIP, 0.2 M	24:76
2	**a,** 1 mol%	/	ACN, 0.2 M	65:34
3	**h,** 5 mol%	/	HFIP, 0.2 M	2:98
4	**h,** 1 mol%	/	HFIP, 0.2 M	1:99
5	**h,** 1 mol%	/	ACN, 0.2 M	2:98
6	**h,** 1 mol%	/	DCM, 0.2 M	39:61
7	**h,** 1 mol%	/	THF, 0.2 M	10:90
8	**h,** 1 mol%	/	HFIP/DCE(9/1), 0.2 M	5:95
9	/	F-TEDA-BF_4/1.0equiv	HFIP/DCE(9/1), 0.2 M	6:94
10	**j,** 5 mol%	/	HFIP, 0.2 M	1:99
11	**j,** 5 mol%	/	ACN, 0.2 M	22:78

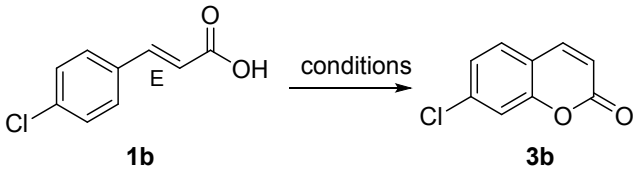
[a] Reaction conditions: **1a** (0.2 mmol, 1.0 equiv), photocatalysts and solvents indicated, rt, 16 h, 400 nm 10W LEDs. [b] Z/E Ratio was detected by GC-MS.

Table S4. Kinetic study of cyclization of **3a** with **1a**.[a]

Entry	Operations	Z/E Ratio[b]	Conversion[c]
1	Charge **2a**, F-TEDA-BF_4 (1.0 equiv), **h** (1 mol%) and HFIP/DCE (9/1, 0.2 M) into viral one portion	0h, 0:100	/
		1h, 0.05:1	19%
		2h, 0.22:1	40%
		4h, 0.40:1	72%
		8h, 0:0	100%

Reaction conditions: **1a** (1.0 equiv), F-TEDA-BF_4 (1.0 equiv), **h** (1 mol %), and HFIP/DCE (9/1, 0.2 M), rt, 400 nm, 10W. [b] Z/E ratio of remained **1a** was detected by GC-MS. [c] Conversion in GC-MS.

Table S5. Screen feeding sequence of cyclization of **3b** with **1b**.[a]

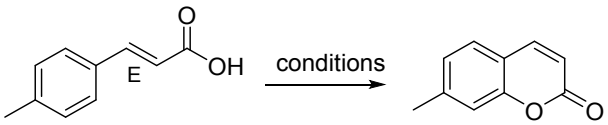


1b **3b**

Entry	Conditions	Yield(%)[b]
1	Addition of **1b**, F-TEDA-BF_4 (1.0 equiv), **h** (1 mol%) and HFIP/DCE (1/1, 0.2 M) in one portion	20 h, 73%
2	Addition of **1b**, F-TEDA-BF_4 (1.0 equiv), **h** (1 mol%) and HFIP (0.2 M) in one portion	20 h, 71%
3	Addition of **1b** (0.2 mmol), **h** (5 mol%) and HFIP (0.2 M) in one portion, agitated for 10 h at 10W 400 nm UV light, then add 1.0 equiv F-TEDA-BF_4	16 h, 74%

[a] Reaction conditions as indicated. [b] Yield of isolated product.

Table S6. Verify the influence of DCE on the cyclization of **3e** with **1e**.[a]



1e **3e**

Entry	Photocatalyst	Solvent	F-TEDA-BF_4	Yield(%)[b]	Esterification by-product
1	**h,** 5 mol%	HFIP, 0.2 M	1.0 equiv	24h, 100%	64%[c]
2	**h,** 5 mol%	HFIP, **0.1 M**	1.0 equiv	24h, 100%	22%[c]
3	**h,** 1 mol%	HFIP/DCE (9/1) 0.2 M	1.0 equiv	24h, 100%	6%[c]
4	**h,** 5 mol%	HFIP/DCE (1/1) 0.2 M	1.0 equiv	40h, 60%	Trace

Reaction conditions: **1e** (1.0 equiv), F-TEDA-BF_4 (1.0 equiv), **h** (1 mol%), rt, 400 nm 10W LEDs and solvent as indicated. [b] Conversion in GC-MS. [c] Percentage of HFIP esterification by-product determined by GC-MS.

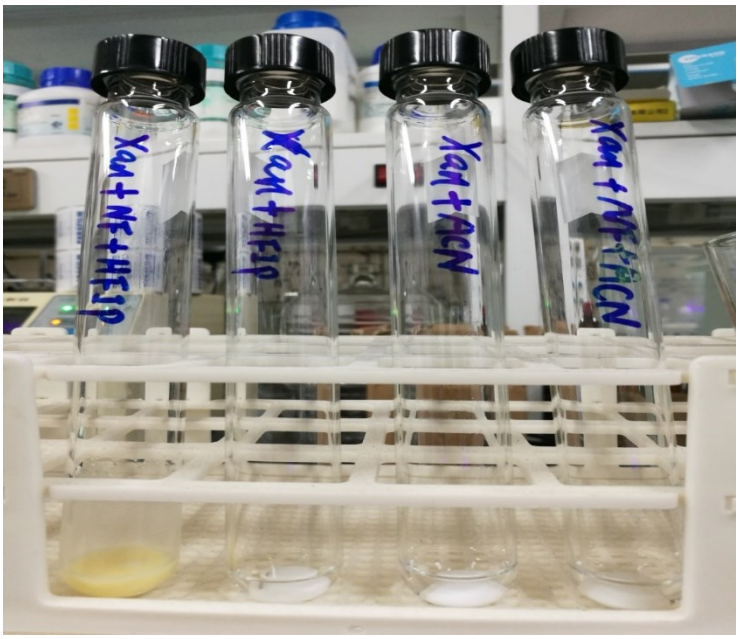


Figure S1. Color change of four vials (Xanthone/F-TEDA-BF_4/HFIP, Xanthone/HFIP, Xanthone/ACN and Xanthone/F-TEDA-BF_4/ACN subsequently) .

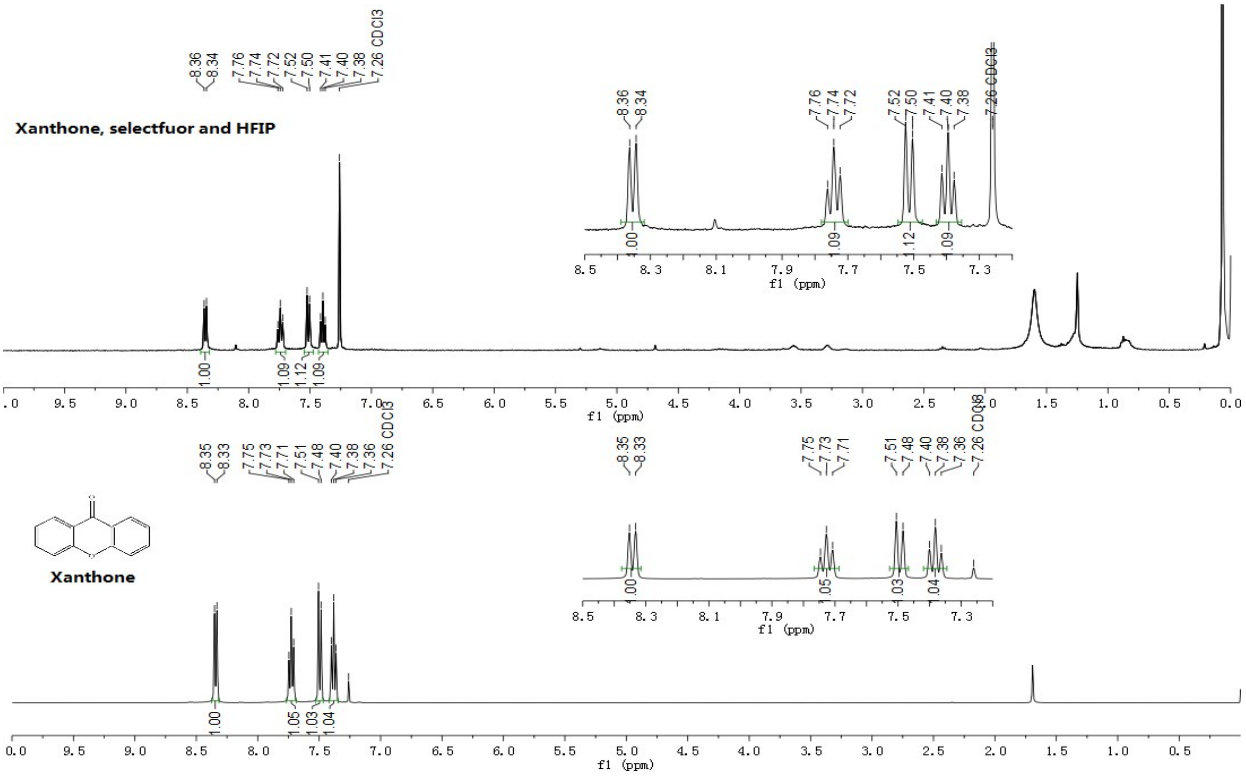
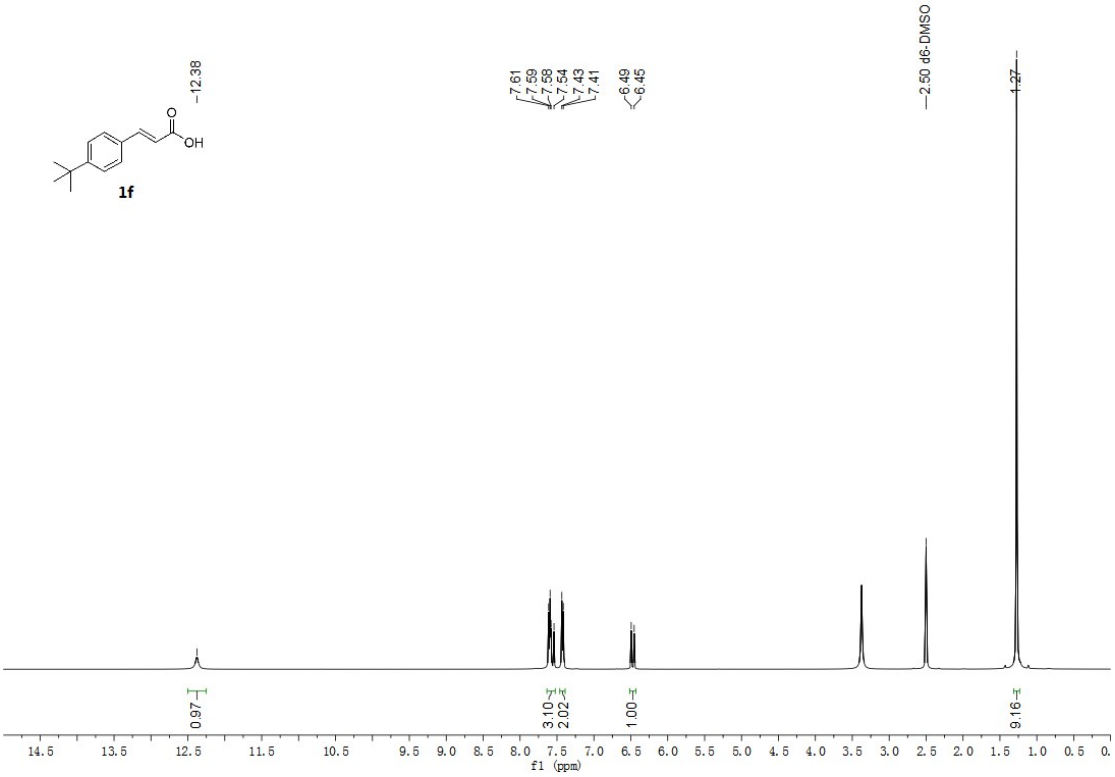
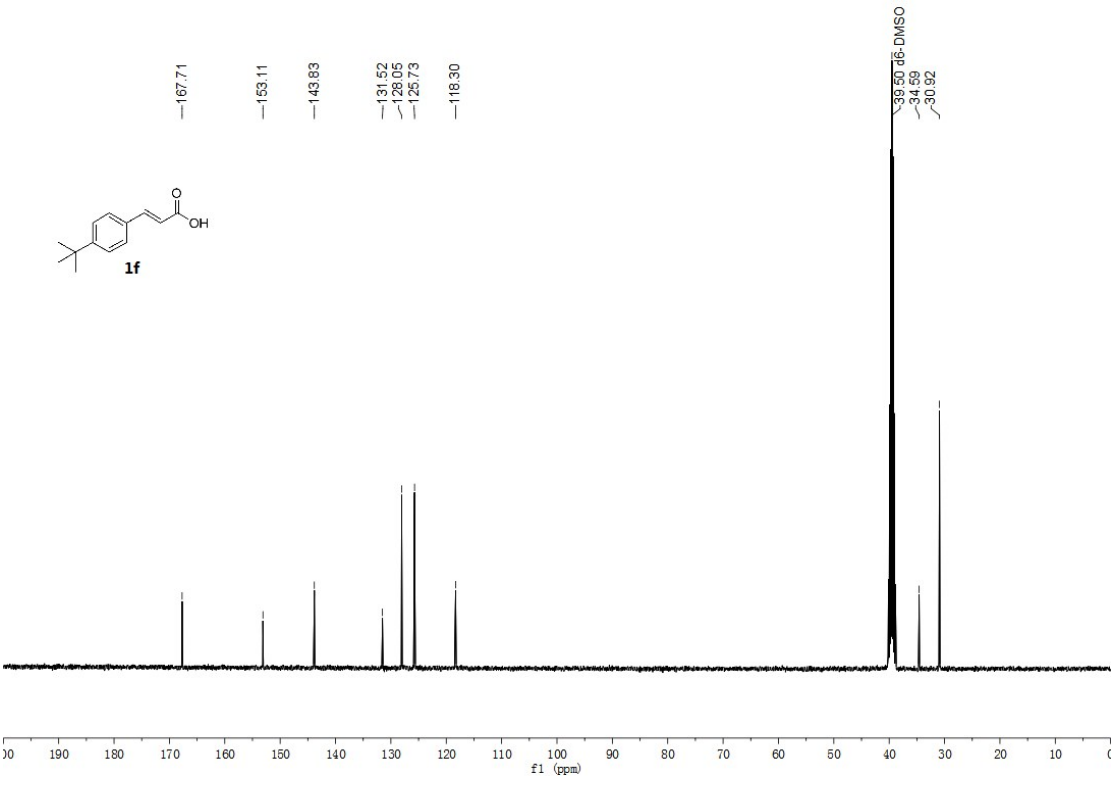
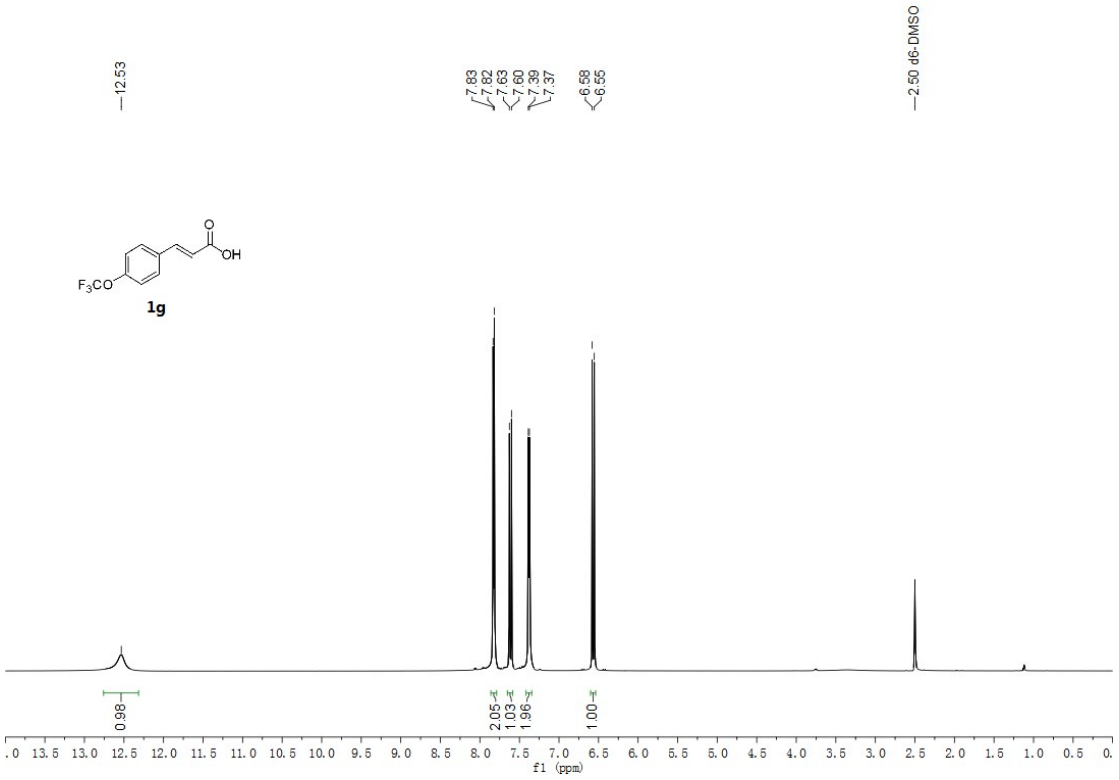


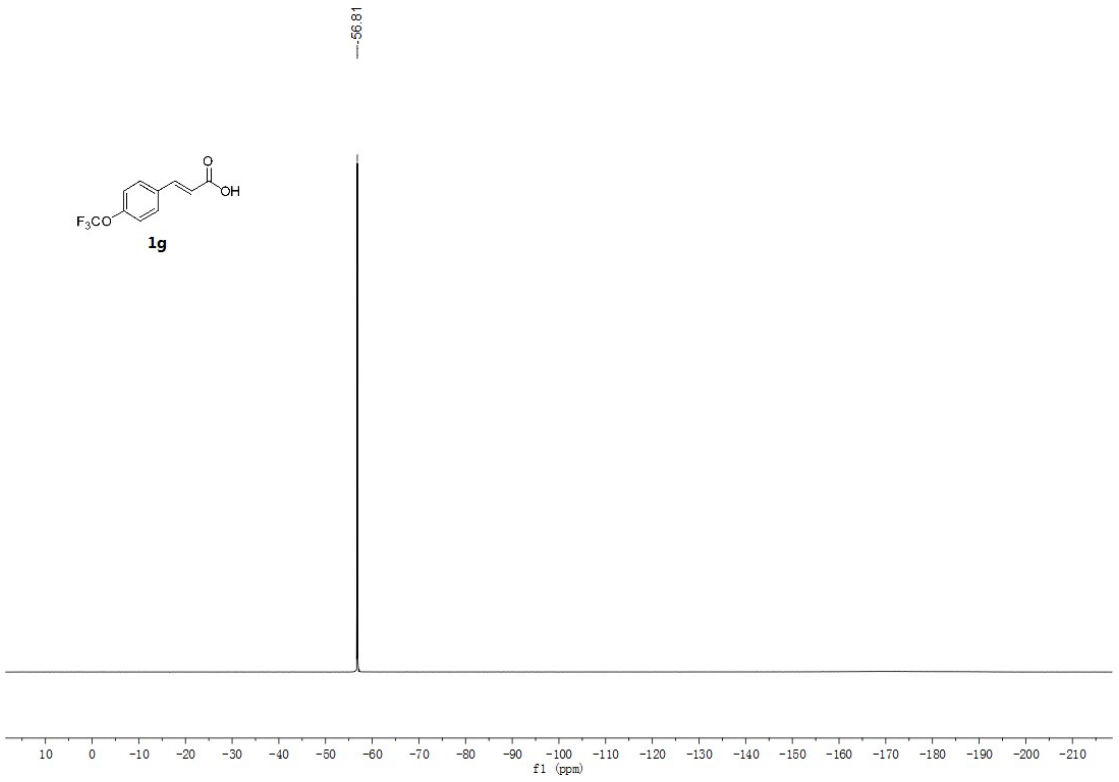
Figure S2. ^{1}H NMR spectrum of the crude mixture and pure xanthone.

5. Copies of NMR spectra






12.53
7.83
7.82
7.63
7.60
7.39
7.37
6.58
6.55
2.50 d6-DMSO
O
OH
F3CO
1g
0.98
2.05
1.03
1.96
1.00
f1 (ppm)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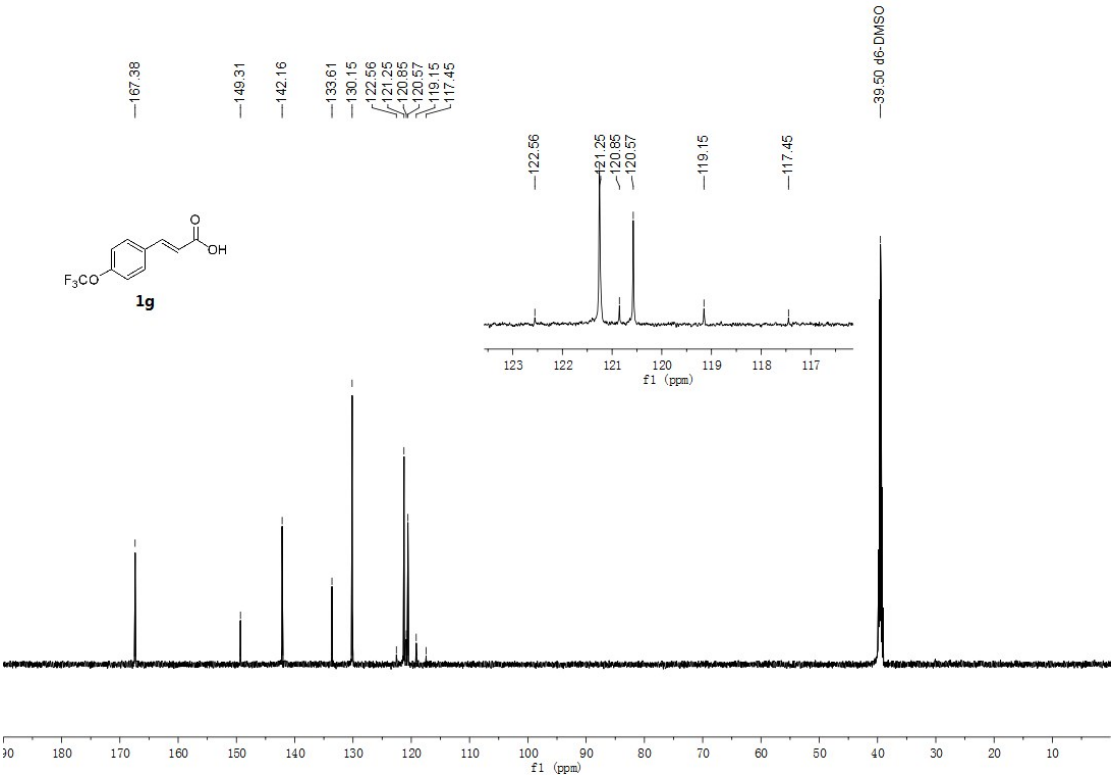
O
OH
F3CO
1g
f1 (ppm)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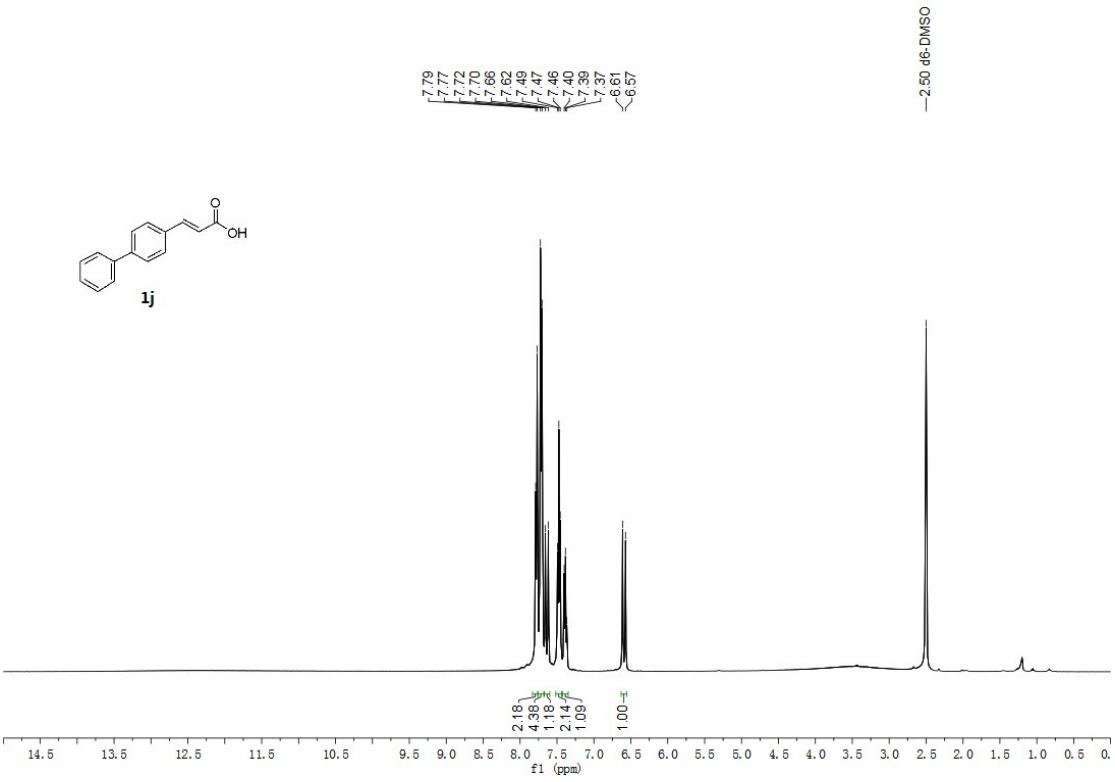
149.31
142.16
133.61
130.15
122.56
121.25
120.85
120.57
119.15
117.45
39.50 d6-DMSO
F3CO
OH
1g
f1 (ppm)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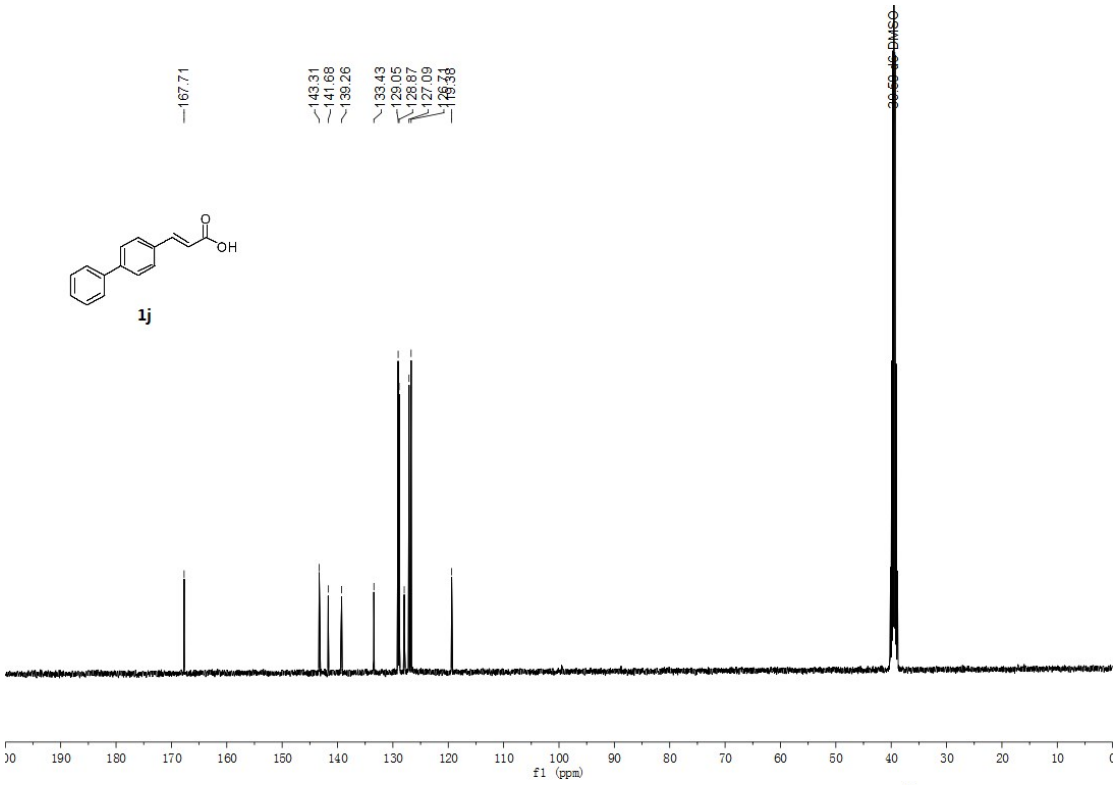
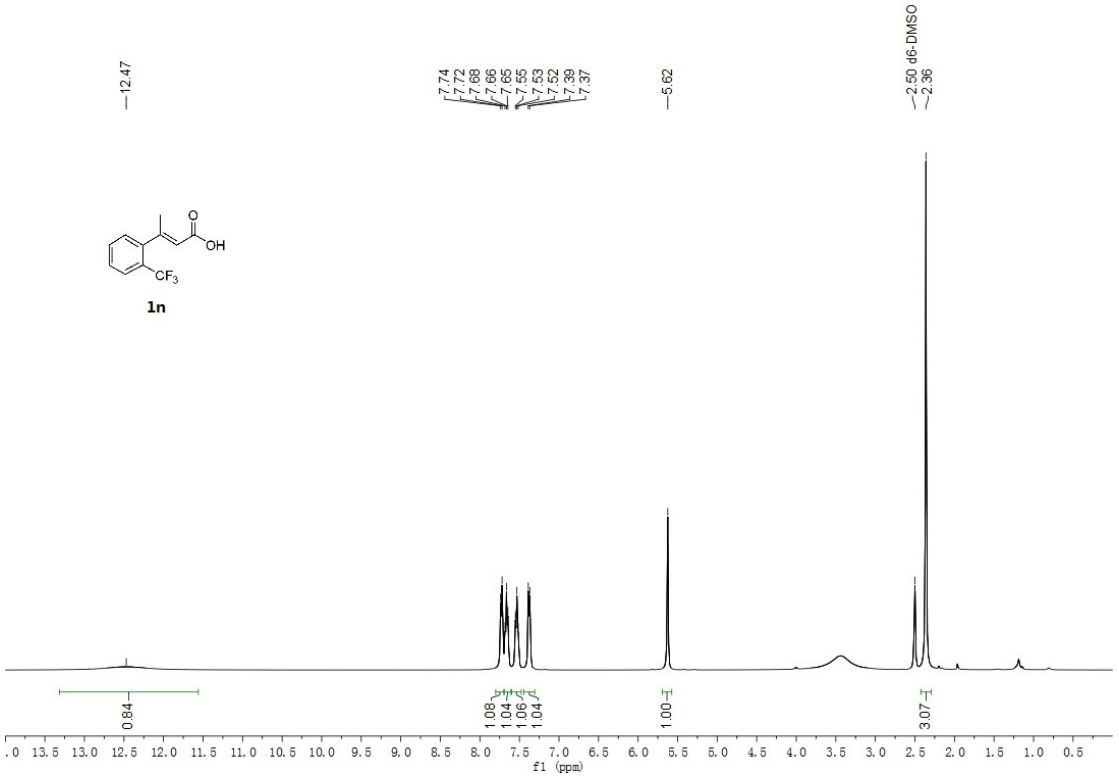
7.77
7.72
7.70
7.66
7.62
7.49
7.47
7.46
7.40
7.39
7.37
6.61
6.57
2.50 d6-DMSO
OH
1j
2.18
4.38
1.18
2.14
1.09
1.00
f1 (ppm)


167.71
143.31
141.68
139.26
133.43
129.05
128.87
127.09
126.74
126.38
39.52 d6-DMSO
O
OH
1j
f1 (ppm)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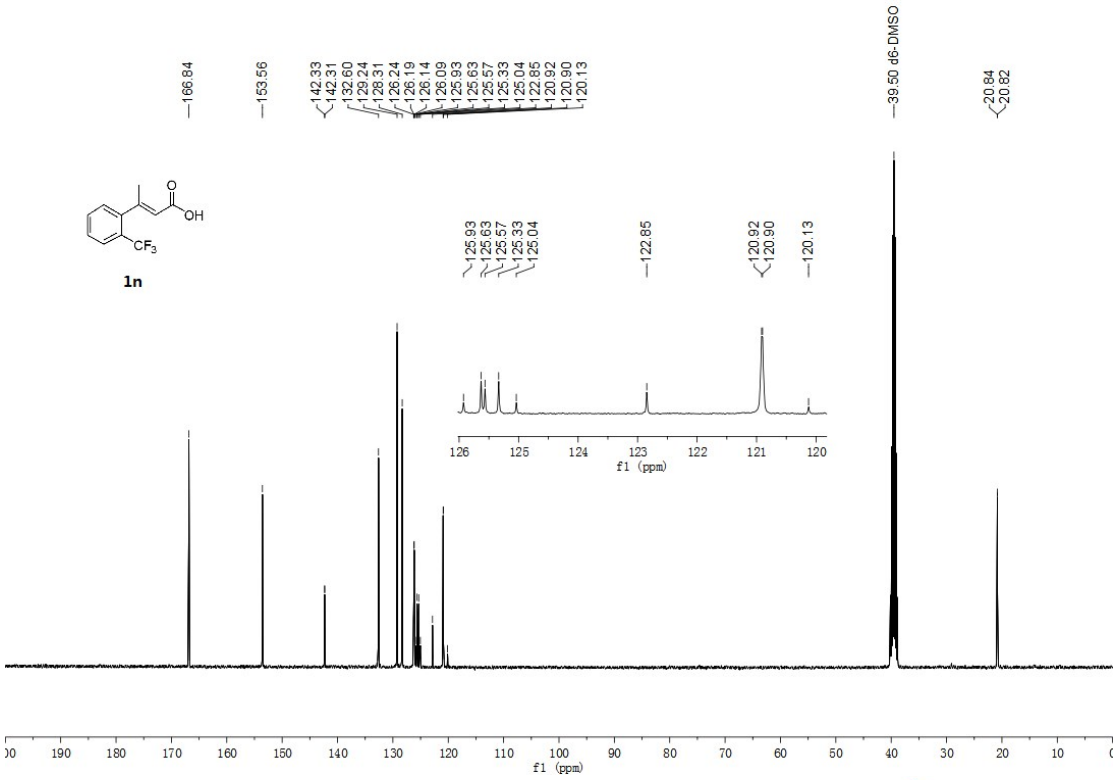
7.74
7.72
7.68
7.66
7.65
7.55
7.53
7.52
7.39
7.37
5.62
2.50 d6-DMSO
2.36
O
OH
CF3
1n
0.84
1.08
1.04
1.06
1.04
1.00
3.07
f1 (ppm)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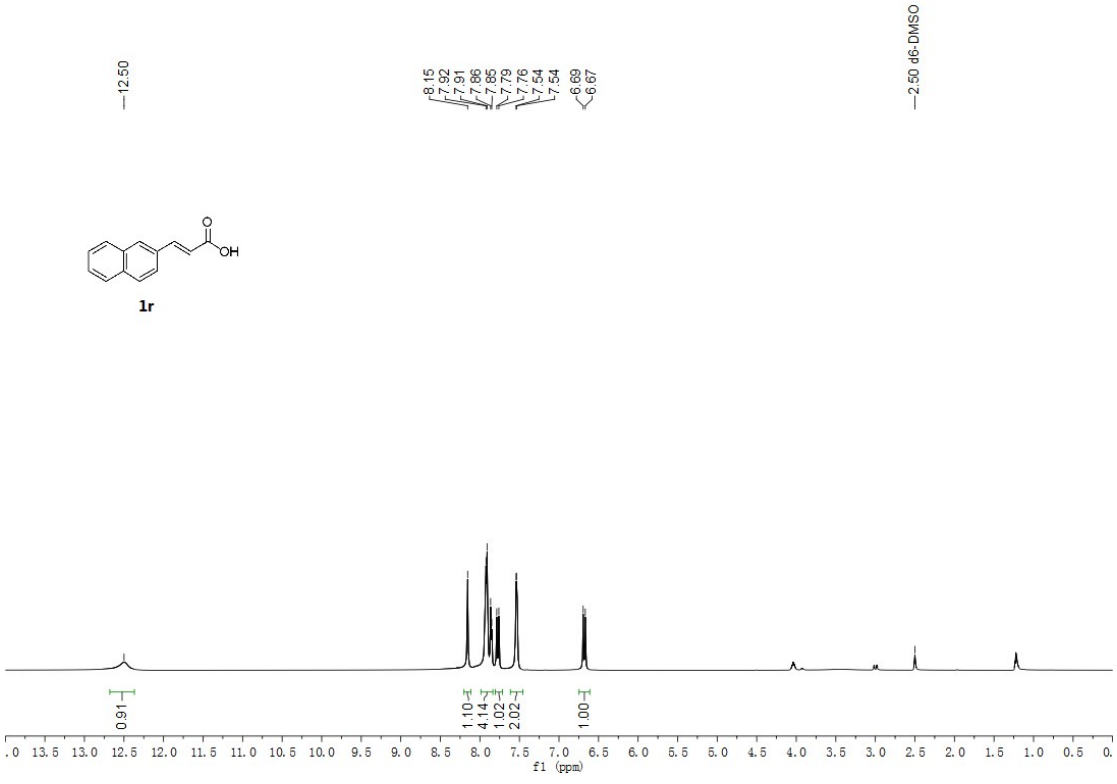
142.31
132.60
129.24
128.31
126.24
126.19
126.14
126.09
125.93
125.63
125.57
125.33
125.04
122.85
120.92
120.90
120.13
39.50 d6-DMSO
20.84
20.82
O
OH
CF3
1n
f1 (ppm)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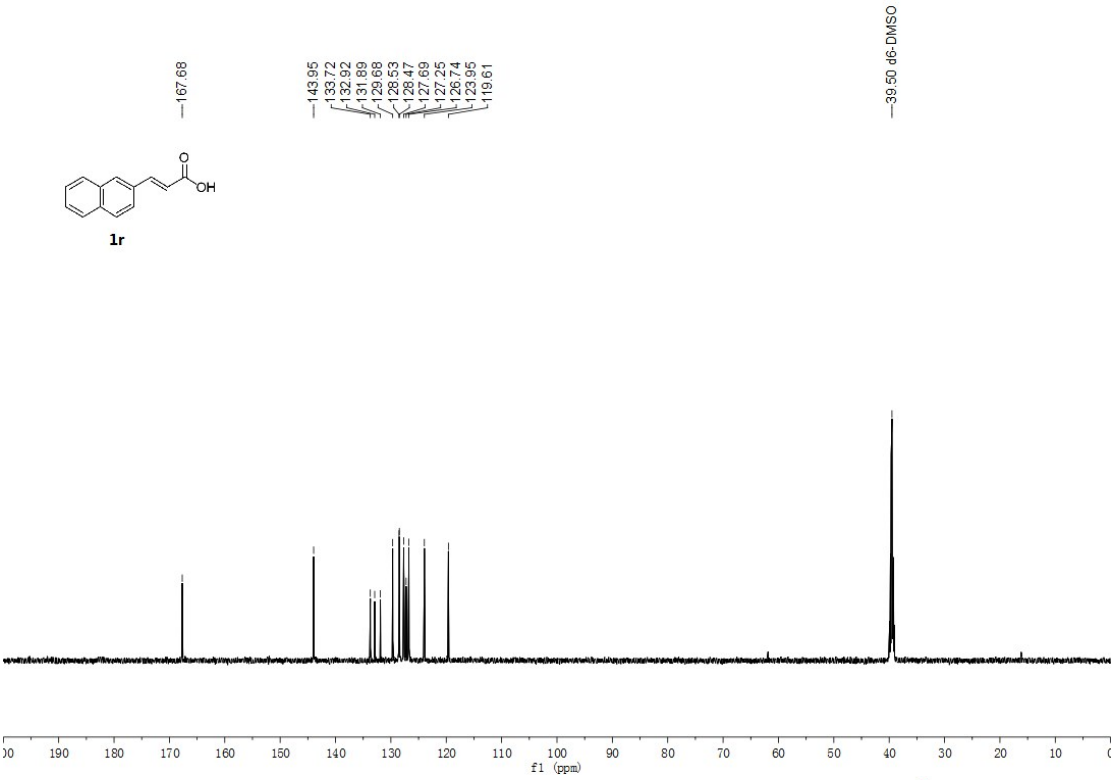
8.15
7.92
7.91
7.86
7.85
7.79
7.76
7.54
7.54
6.69
6.67
2.50 d6-DMSO
O
OH
1r
0.91
1.10
4.14
1.02
2.02
1.00
f1 (ppm)


167.68
143.95
133.72
132.92
131.89
129.68
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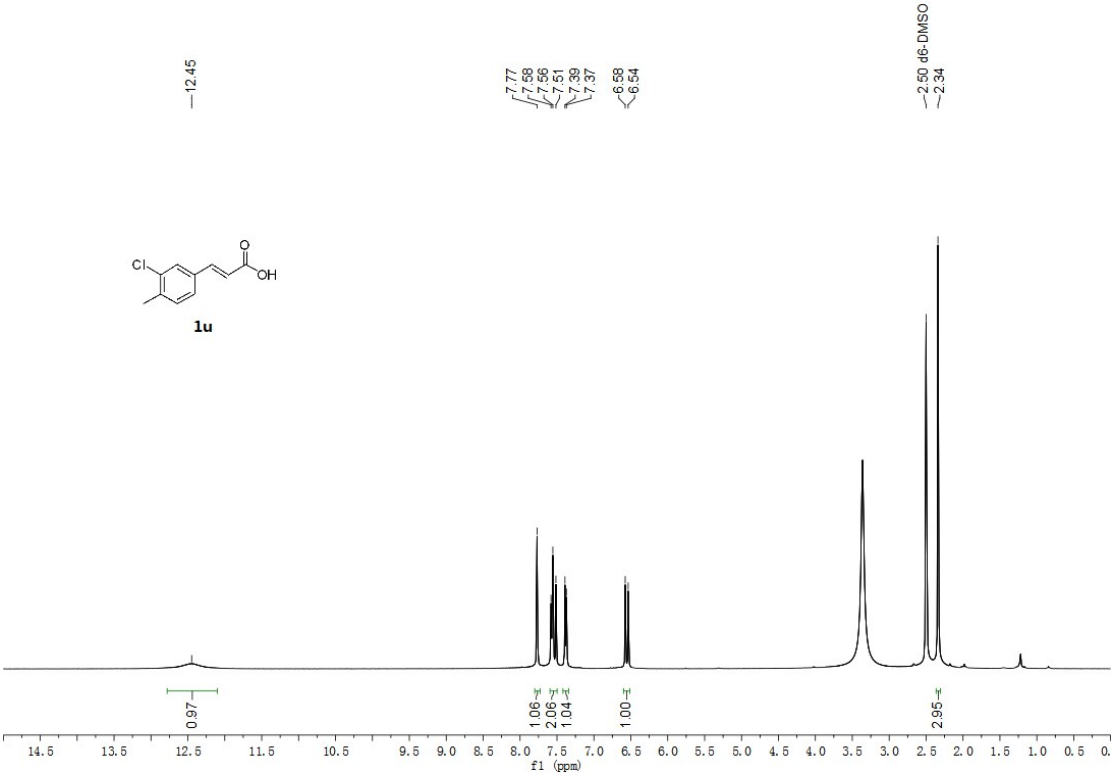
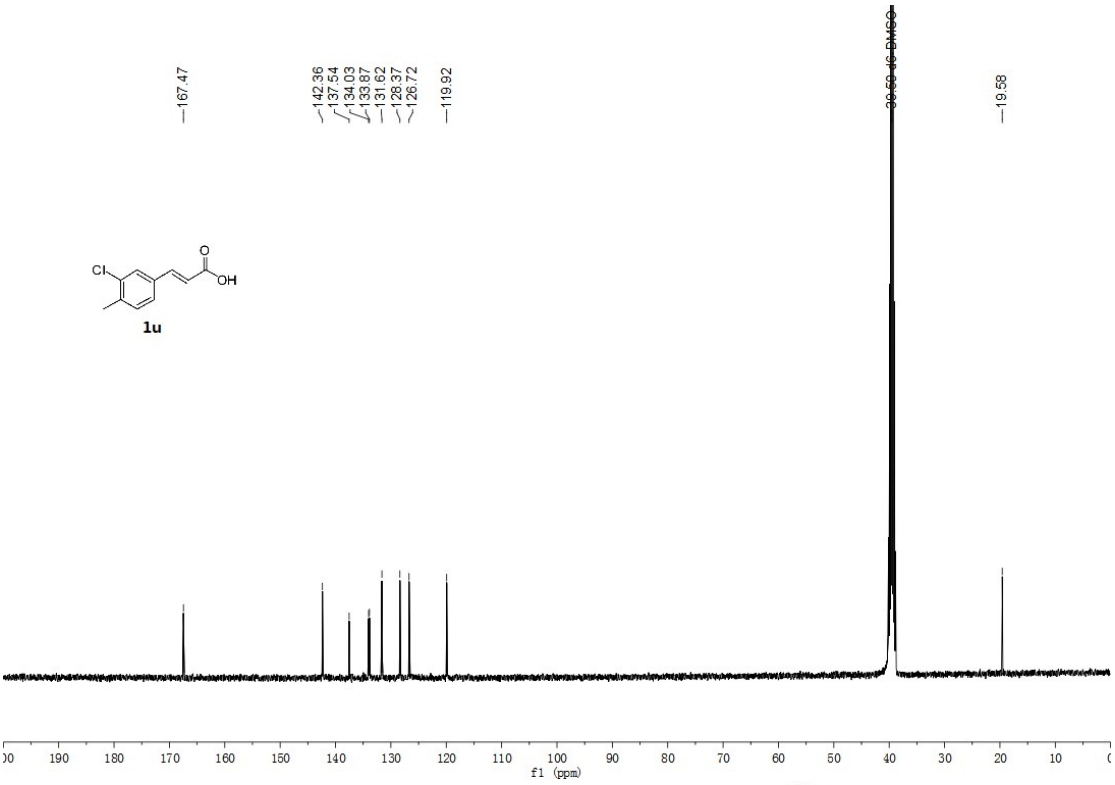
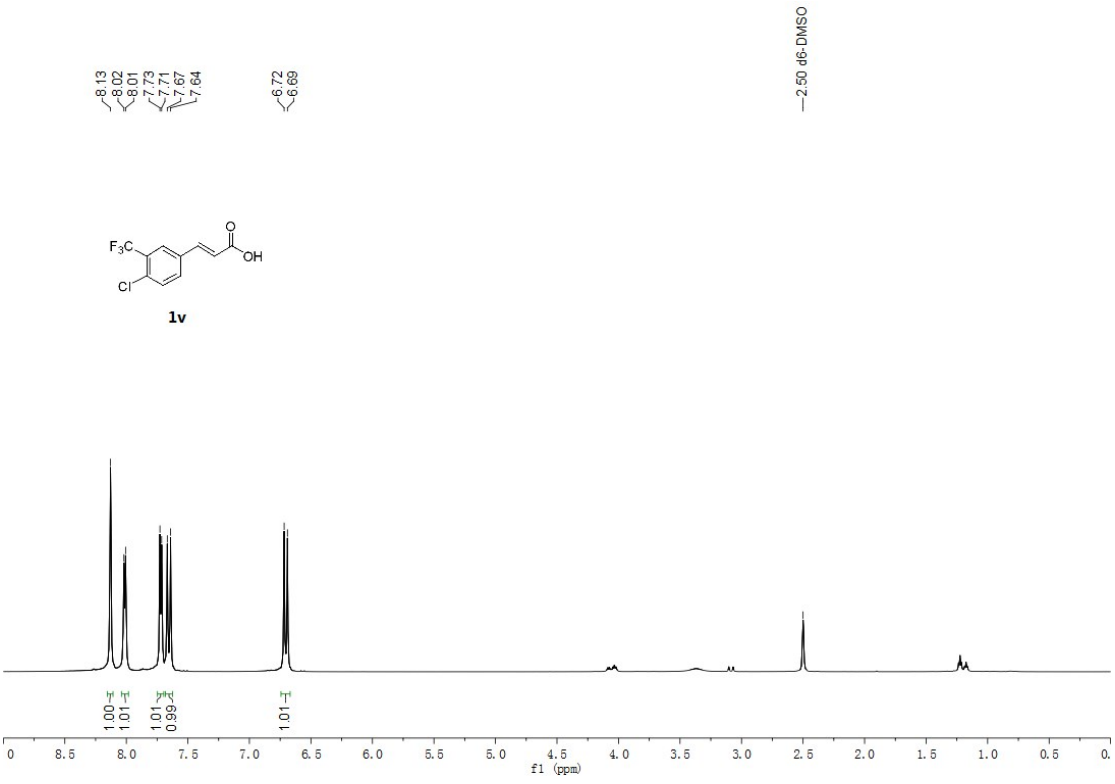
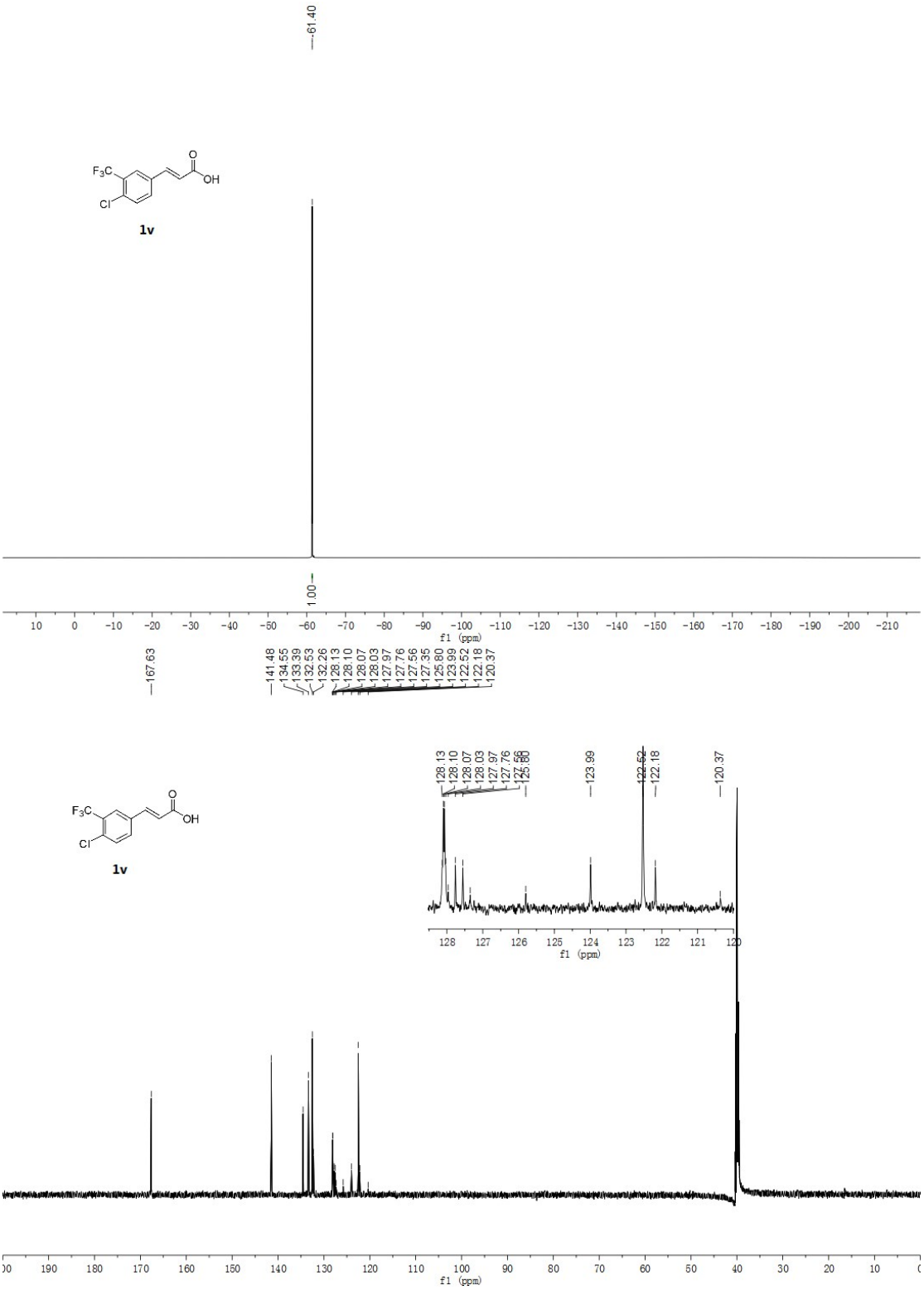
128.47
127.69
127.25
126.74
123.95
119.61
39.50 d6-DMSO
O
OH
1r
f1 (ppm)


12.45
7.77
7.58
7.56
7.51
7.39
7.37
6.58
6.54
2.50 d6-DMSO
2.34
Cl
O
OH
1u
0.97
1.06
2.06
1.04
1.00
2.95
f1 (ppm)


167.47
142.36
137.54
134.03
133.87
131.62
128.37
126.72
119.92
39.52 d6-DMSO
19.58
Cl
O
OH
1u
f1 (ppm)


8.13
8.02
8.01
7.73
7.71
7.67
7.64
6.72
6.69
2.50 d6-DMSO
F3C
Cl
O
OH
1v
1.00
1.01
1.01
0.99
1.01
f1 (ppm)


-61.40
1v
1.00
f1 (ppm)
167.63
141.48
134.55
133.39
132.53
132.26
128.13
128.10
128.07
128.03
127.97
127.76
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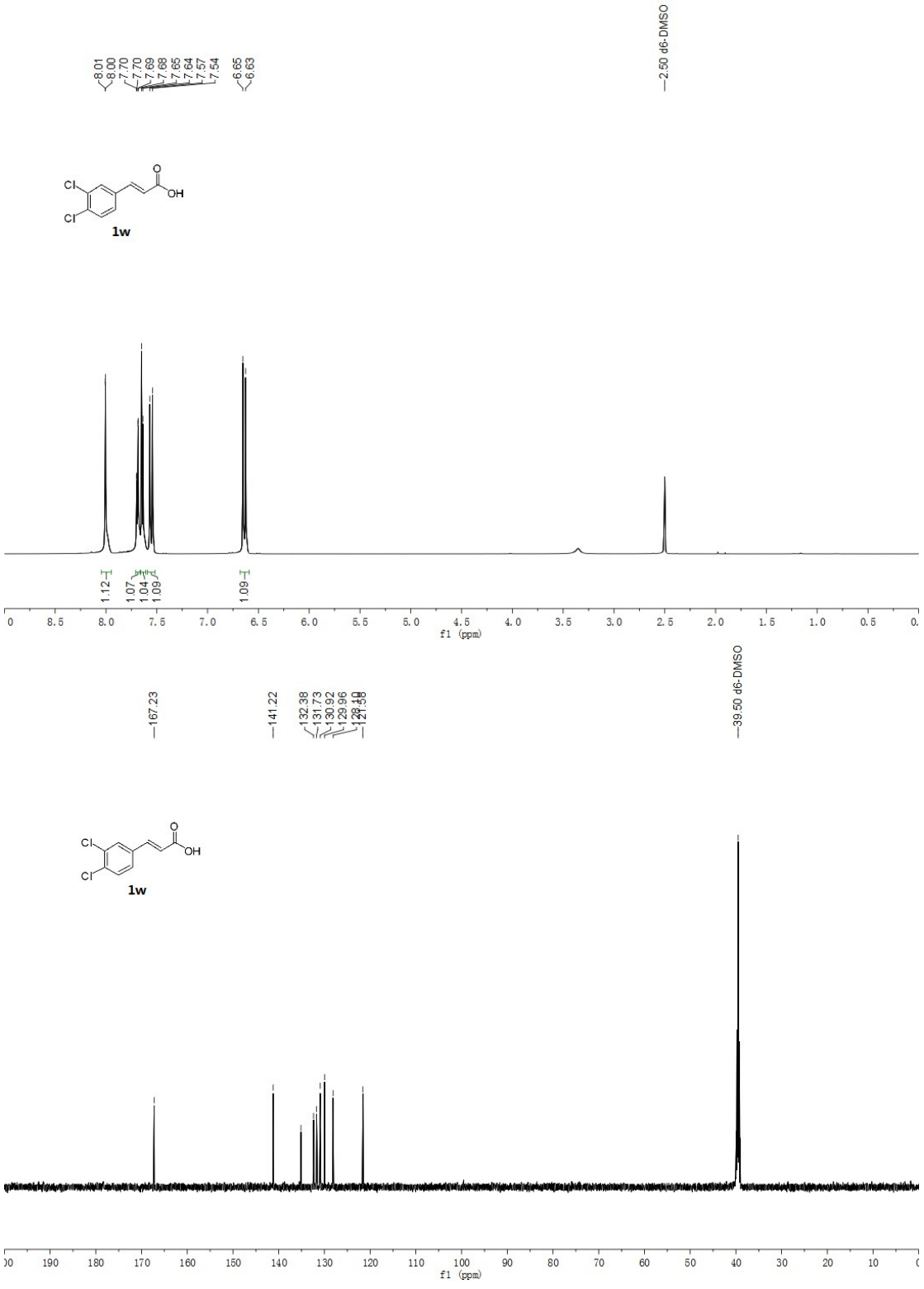
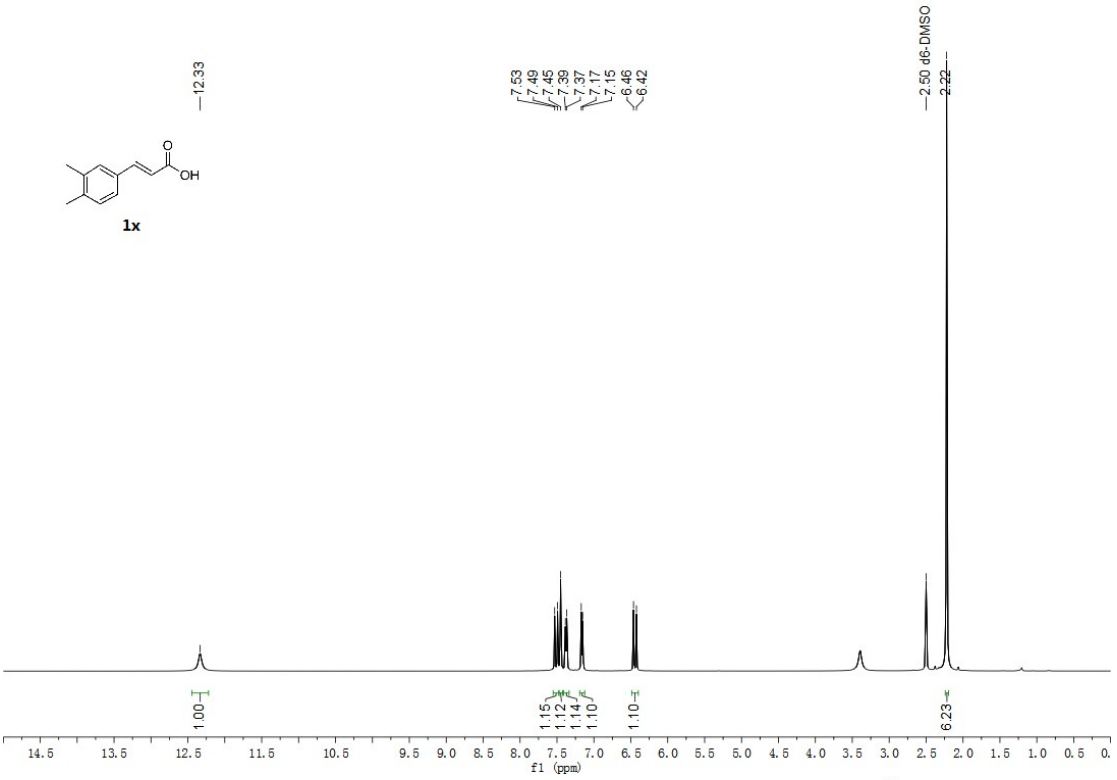
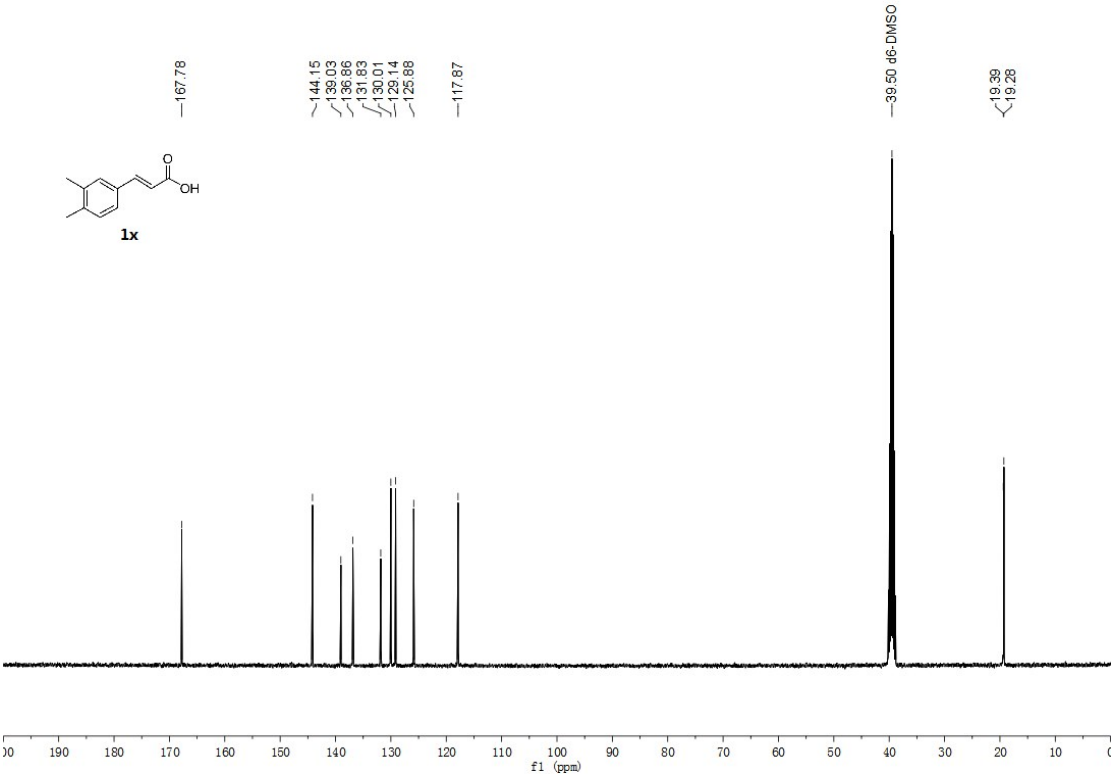
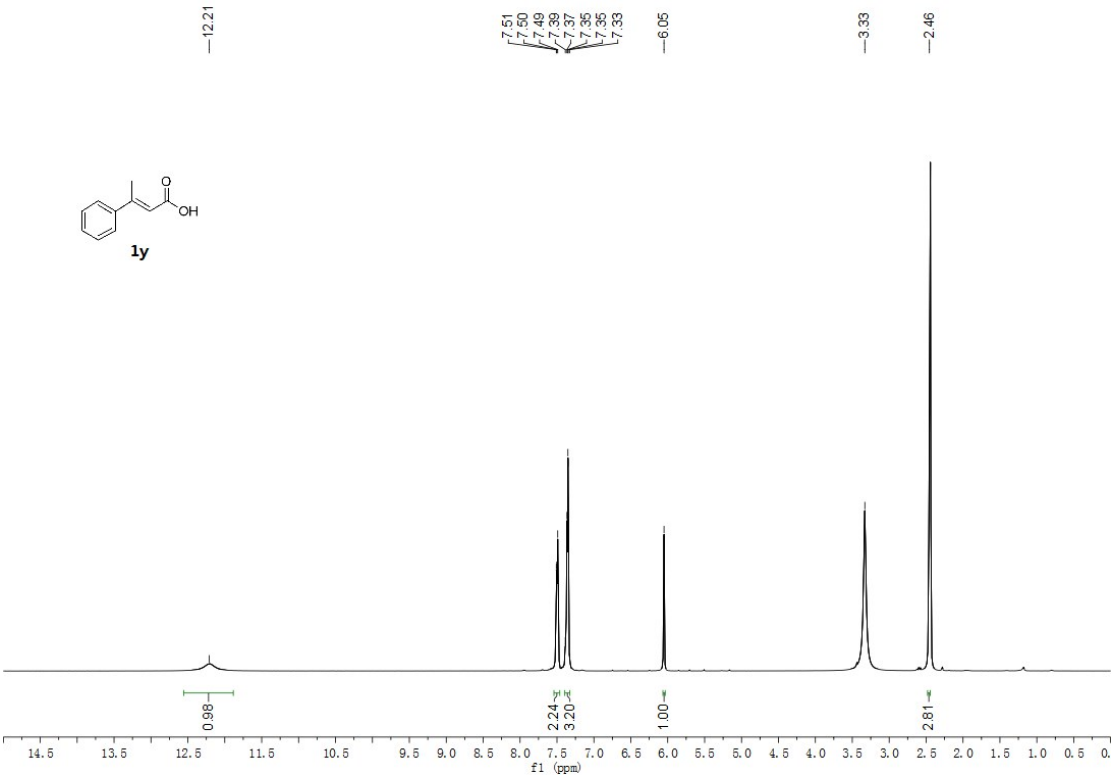
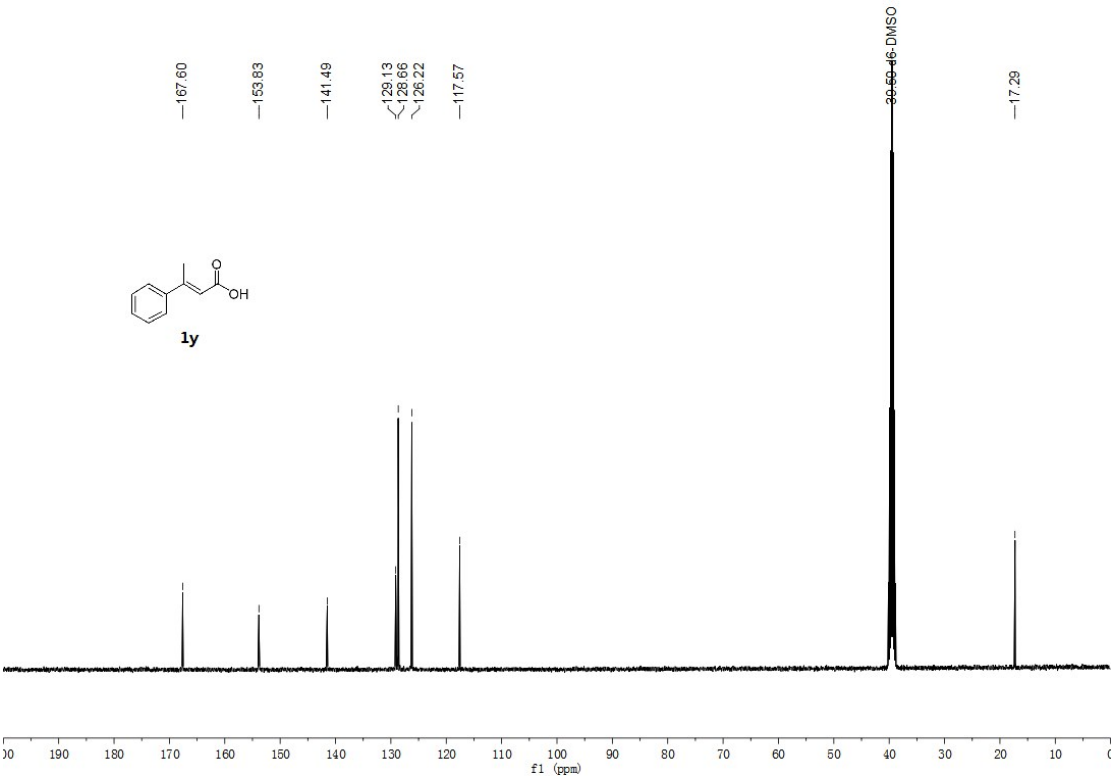
127.35
125.80
123.99
122.52
122.18
120.37
1v
f1 (ppm)
f1 (ppm)

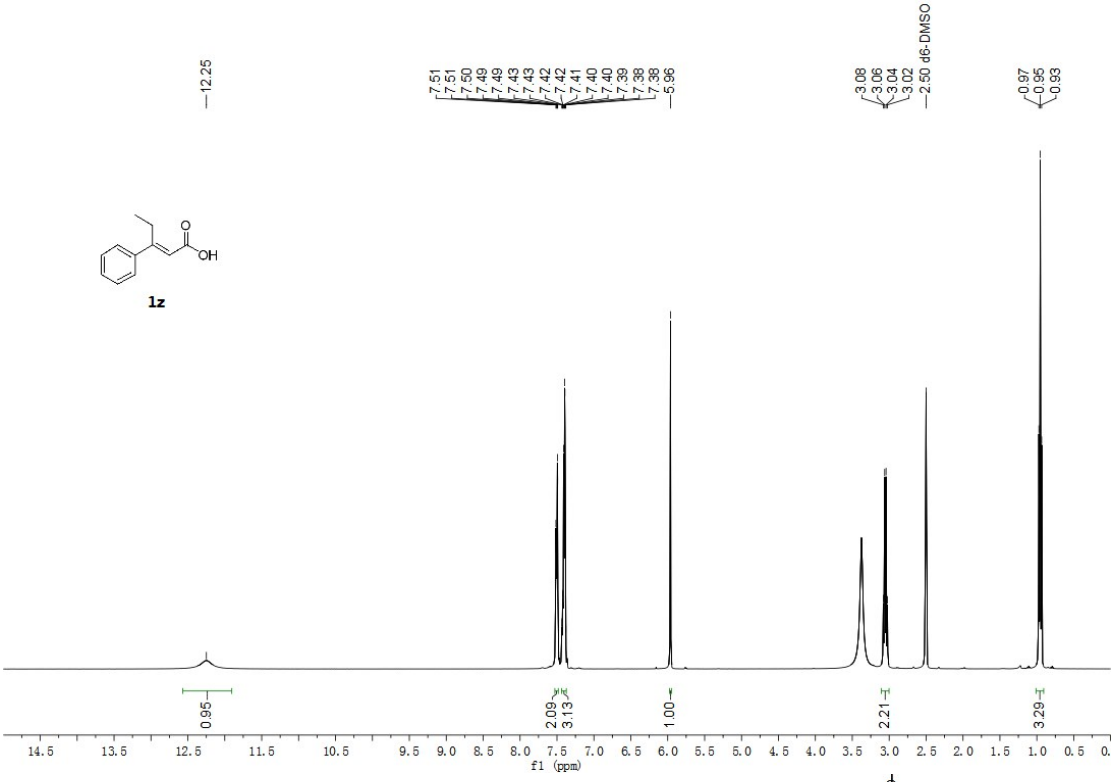

8.01
8.00
7.70
7.70
7.69
7.68
7.65
7.64
7.57
7.54
6.65
6.63
2.50 d6-DMSO
Cl
Cl
O
OH
1w
1.12
1.07
1.04
1.09
1.09
f1 (ppm)
167.23
141.22
132.38
131.73
130.92
129.96
39.50 d6-DMSO
Cl
Cl
O
OH
1w
f1 (ppm)

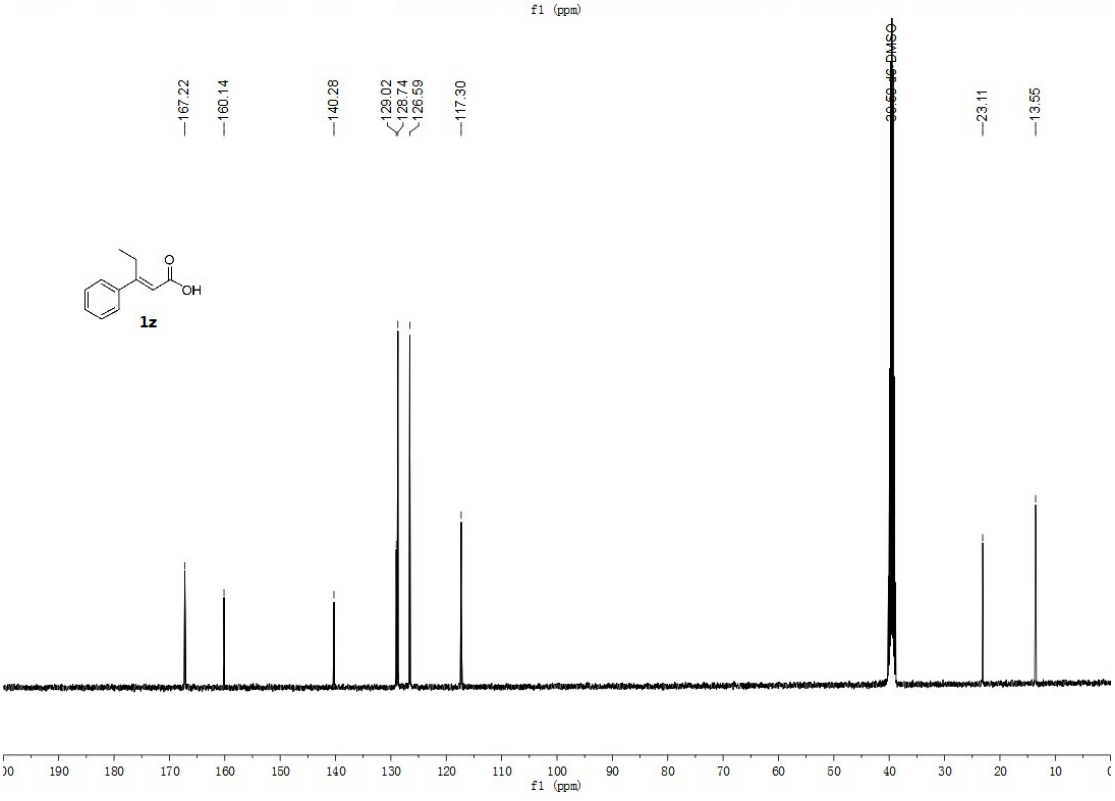

12.33
7.53
7.49
7.45
7.39
7.37
7.17
7.15
6.46
6.42
2.50 d6-DMSO
2.22
OH
1x
1.00
1.15
1.12
1.14
1.10
1.10
6.23
f1 (ppm)

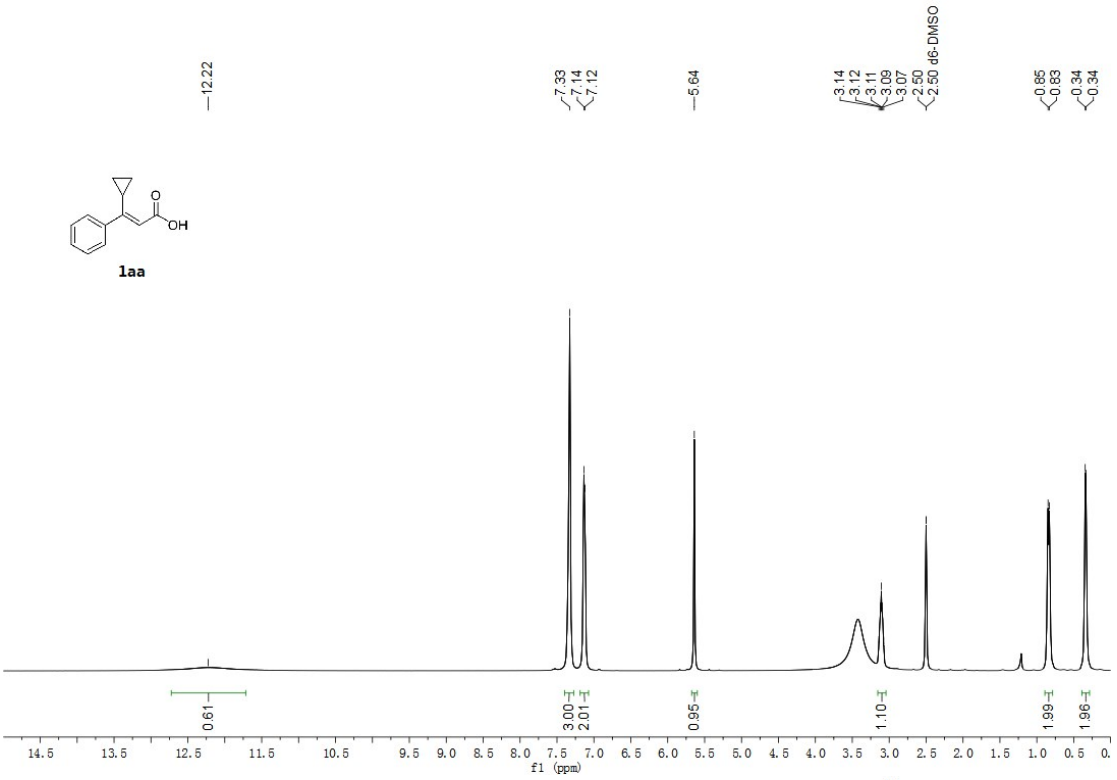

167.78
144.15
139.03
136.86
131.83
130.01
129.14
125.88
117.87
39.50 d6-DMSO
19.39
19.28
OH
1x
f1 (ppm)

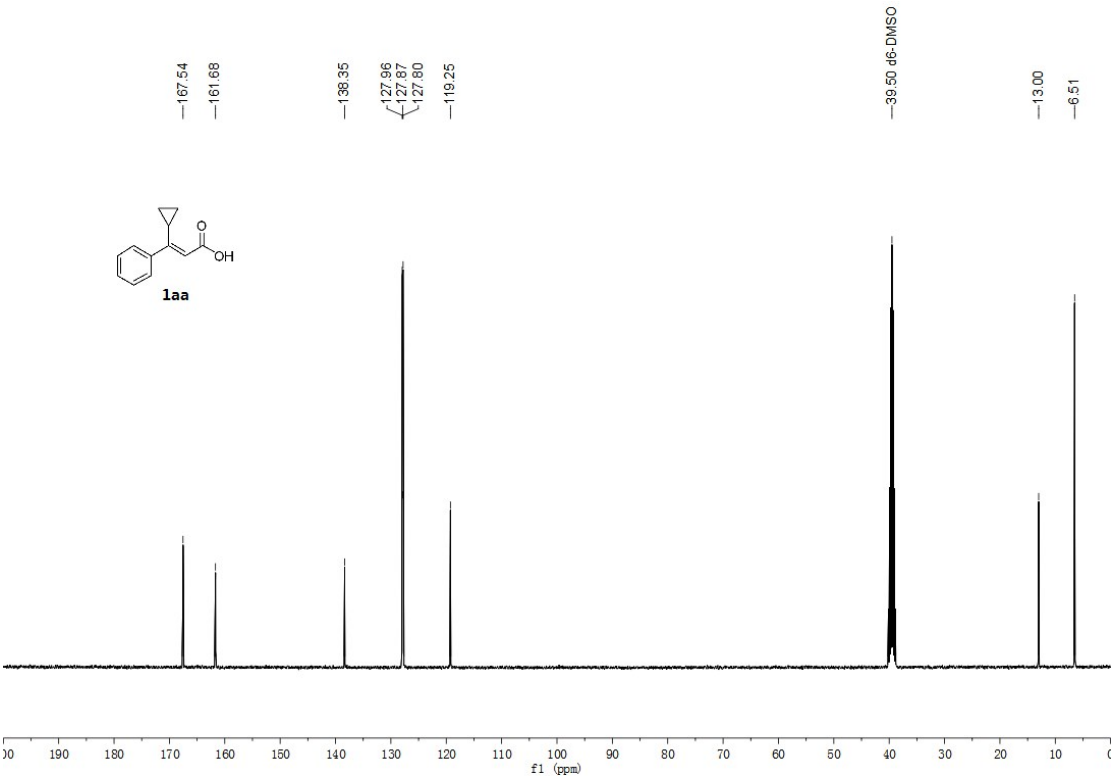

12.21
7.51
7.50
7.49
7.39
7.37
7.35
7.35
7.33
6.05
3.33
2.46
1y
0.98
2.24
3.20
1.00
2.81
f1 (ppm)

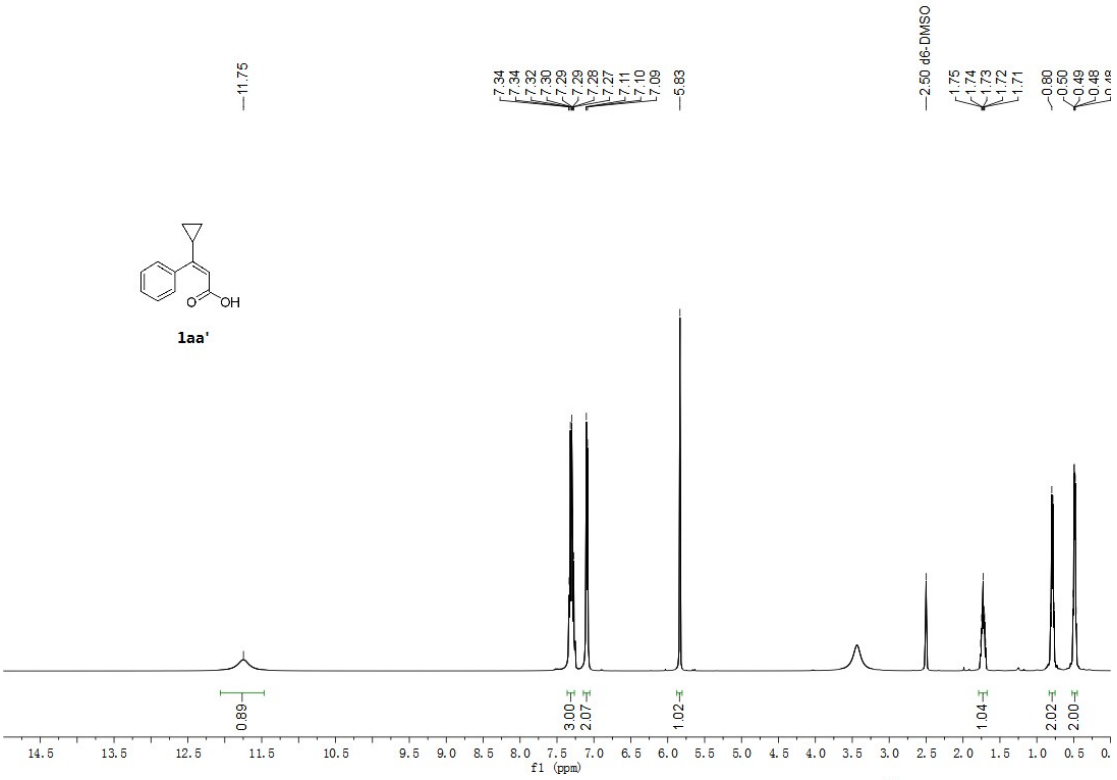

167.60
153.83
141.49
129.13
128.66
126.22
117.57
39.50 d6-DMSO
17.29
1y
f1 (ppm)


12.25
7.51
7.51
7.50
7.49
7.49
7.43
7.43
7.42
7.42
7.41
7.40
7.40
7.39
7.38
7.38
5.96
3.08
3.06
3.04
3.02
2.50 d6-DMSO
0.97
0.95
0.93
OH
1z
0.95
2.09
3.13
1.00
2.21
3.29
f1 (ppm)


167.22
160.14
140.28
129.02
128.74
126.59
117.30
39.52 d6-DMSO
23.11
13.55
OH
1z
f1 (ppm)


12.22
7.33
7.14
7.12
5.64
3.14
3.12
3.11
3.09
3.07
2.50
2.50 d6-DMSO
0.85
0.83
0.34
0.34
OH
1aa
0.61
3.00
2.01
0.95
1.10
1.99
1.96
f1 (ppm)


167.54
161.68
138.35
127.96
127.87
127.80
119.25
39.50 d6-DMSO
13.00
6.51
OH
1aa
f1 (ppm)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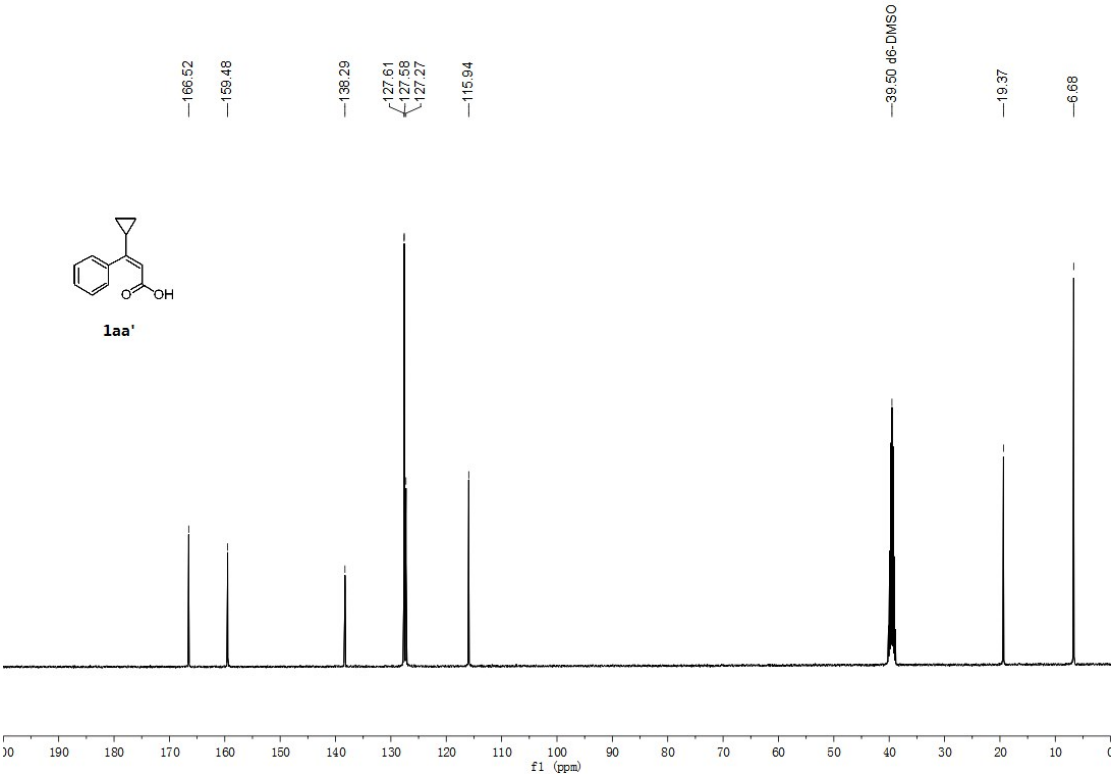
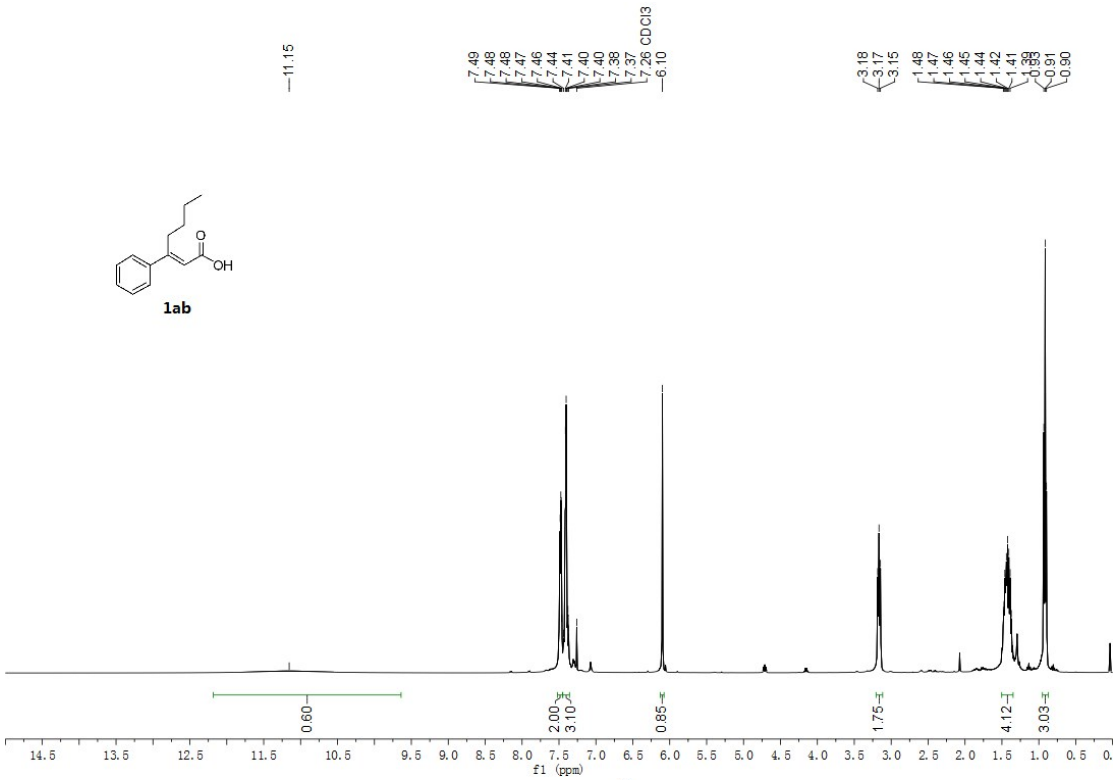
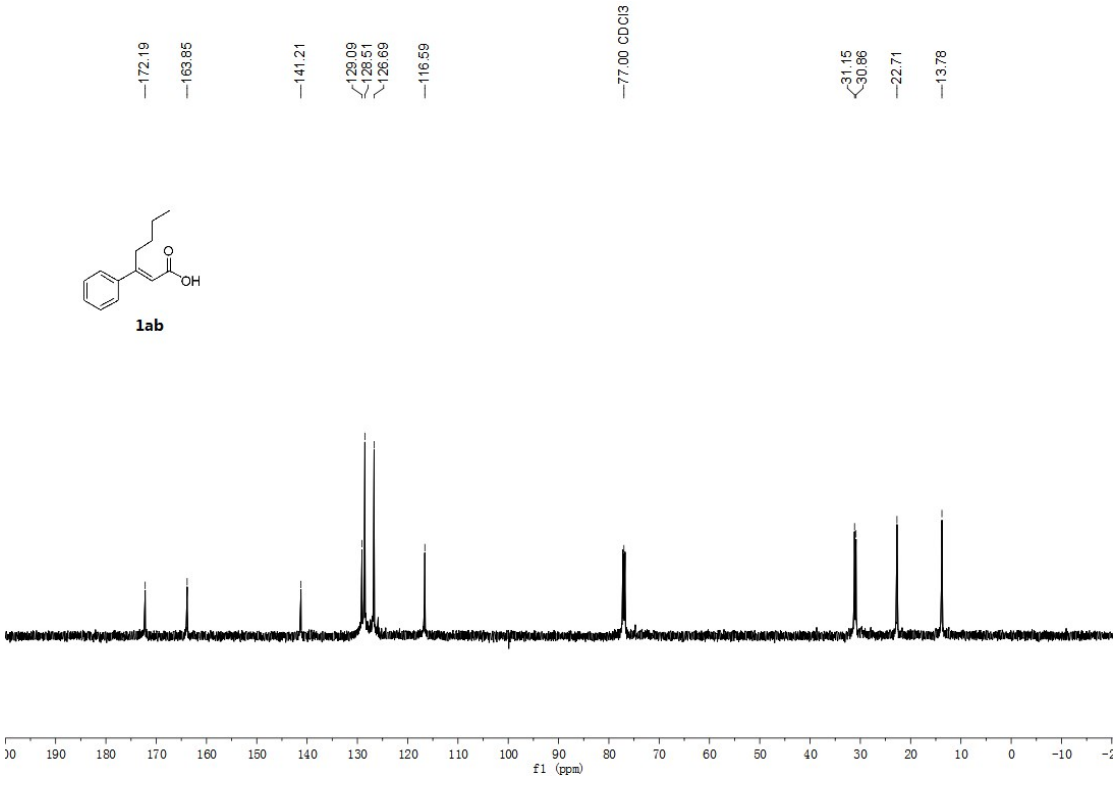
7.34
7.34
7.32
7.30
7.29
7.29
7.28
7.27
7.11
7.10
7.09
5.83
2.50 d6-DMSO
1.75
1.74
1.73
1.72
1.71
0.80
0.50
0.49
0.48
OH
1aa'
0.89
3.00
2.07
1.02
1.04
2.02
2.00
f1 (ppm)


166.52
159.48
138.29
127.61
127.58
127.27
115.94
39.50 d6-DMSO
19.37
6.68
OH
1aa'
f1 (ppm)


11.15
7.49
7.48
7.48
7.47
7.46
7.44
7.41
7.40
7.40
7.38
7.37
7.26 CDCl3
6.10
3.18
3.17
3.15
1.48
1.47
1.46
1.45
1.44
1.42
1.41
1.39
0.93
0.91
0.90
O
OH
1ab
0.60
2.00
3.10
0.85
1.75
4.12
3.03
f1 (ppm)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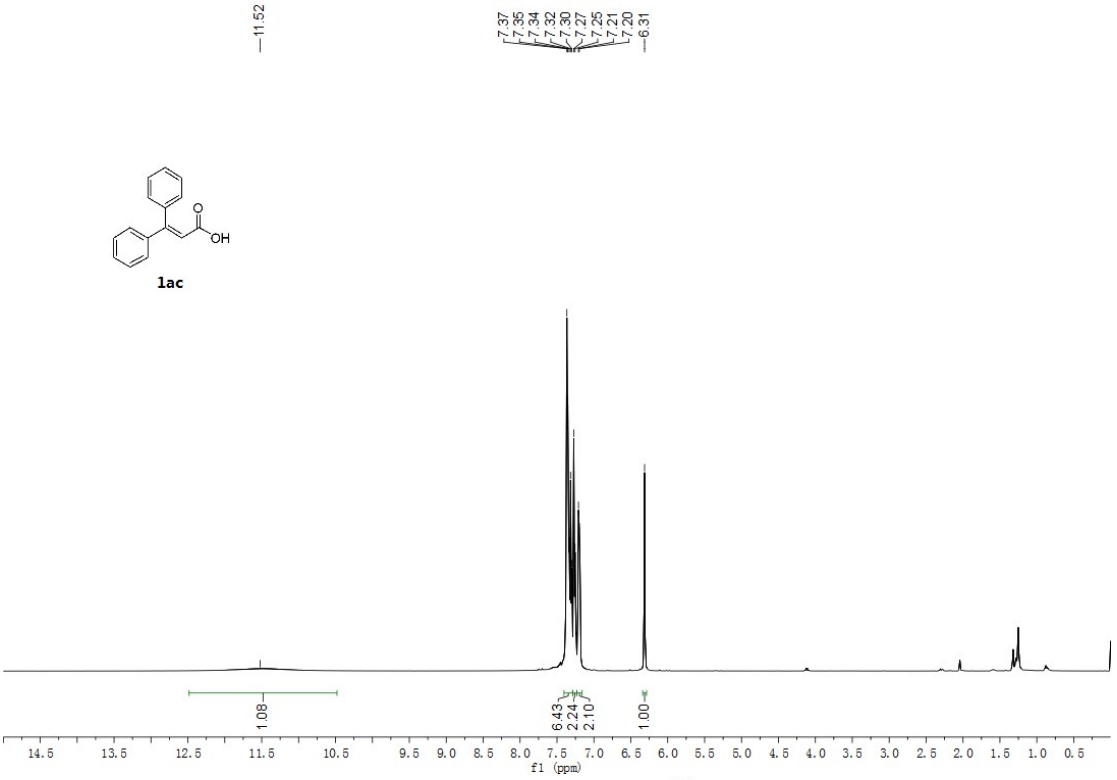
141.21
129.09
128.51
126.69
116.59
77.00 CDCl3
31.15
30.86
22.71
13.78
O
OH
1ab
f1 (ppm)


11.52
7.37
7.35
7.34
7.32
7.30
7.27
7.25
7.21
7.20
6.31
OH
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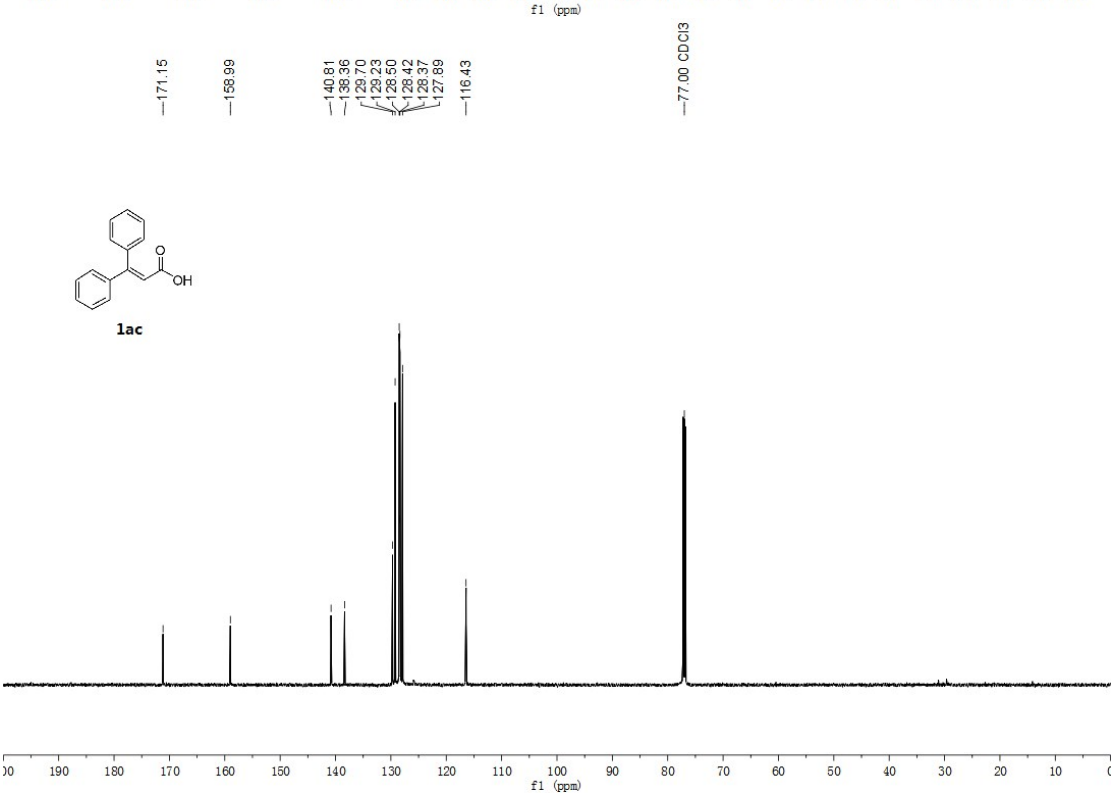
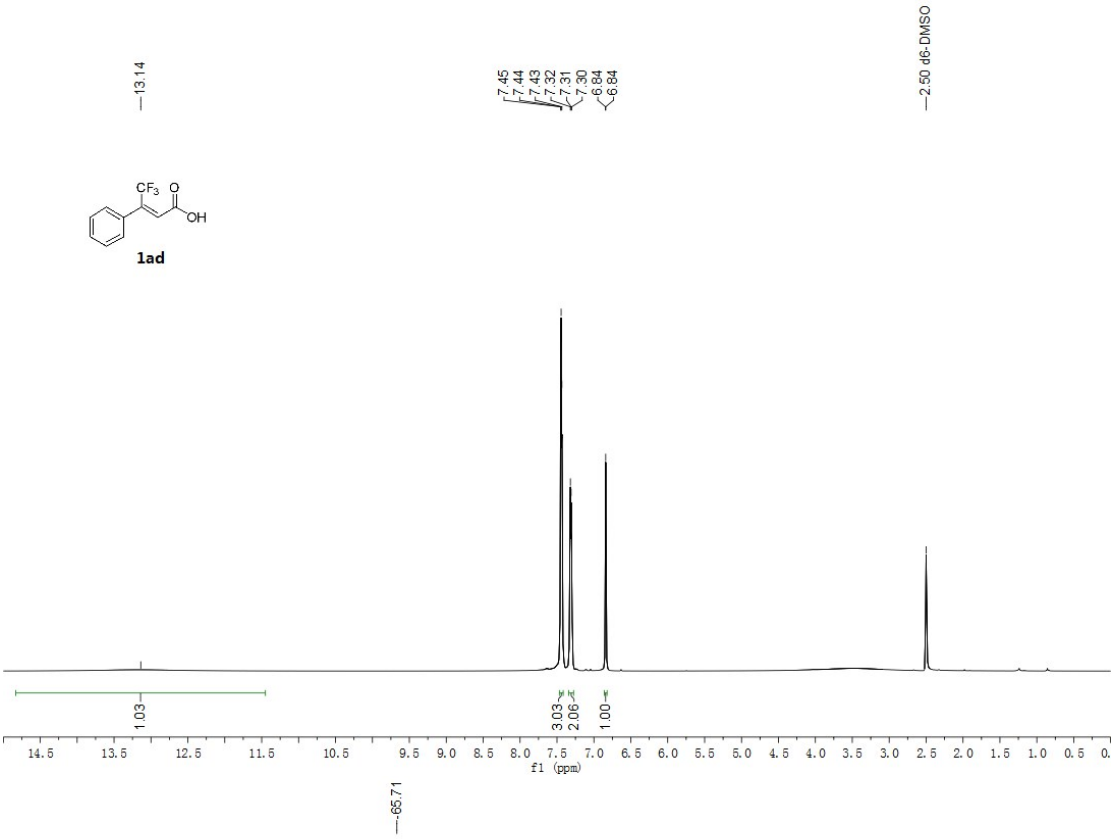
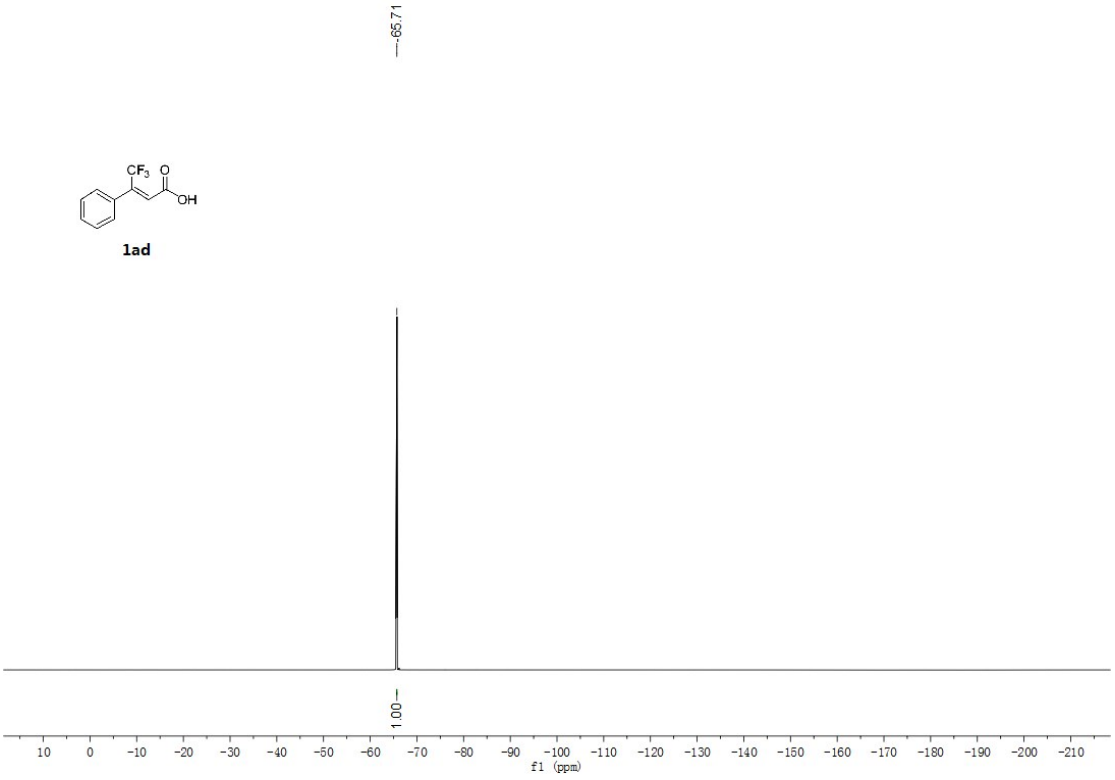
1.08
6.43
2.24
2.10
1.00
f1 (ppm)


171.15
158.99
140.81
138.36
129.70
129.23
128.50
128.42
128.37
127.89
116.43
77.00 CDCl3
OH
1ac
f1 (ppm)


13.14
7.45
7.44
7.43
7.32
7.31
7.30
6.84
6.84
2.50 d6-DMSO
CF3
O
OH
1ad
1.03
3.03
2.06
1.00
f1 (ppm)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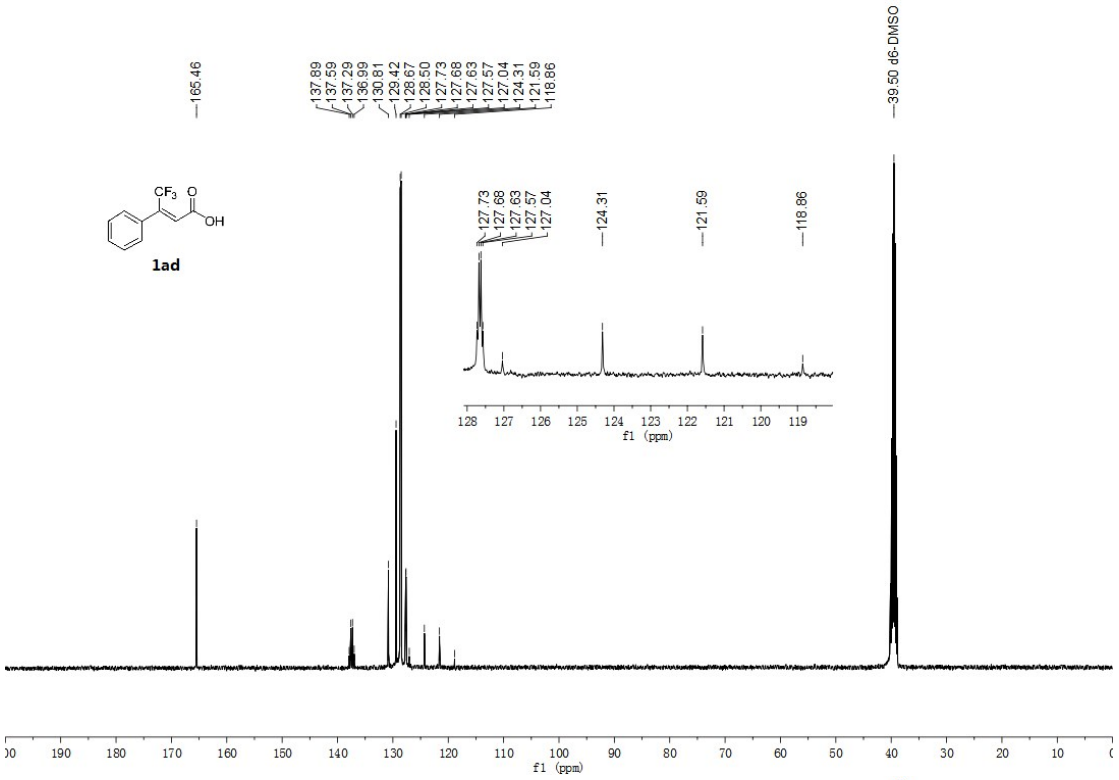
CF3
O
OH
1ad
1.00
f1 (ppm)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130.81
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128.67
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127.73
127.68
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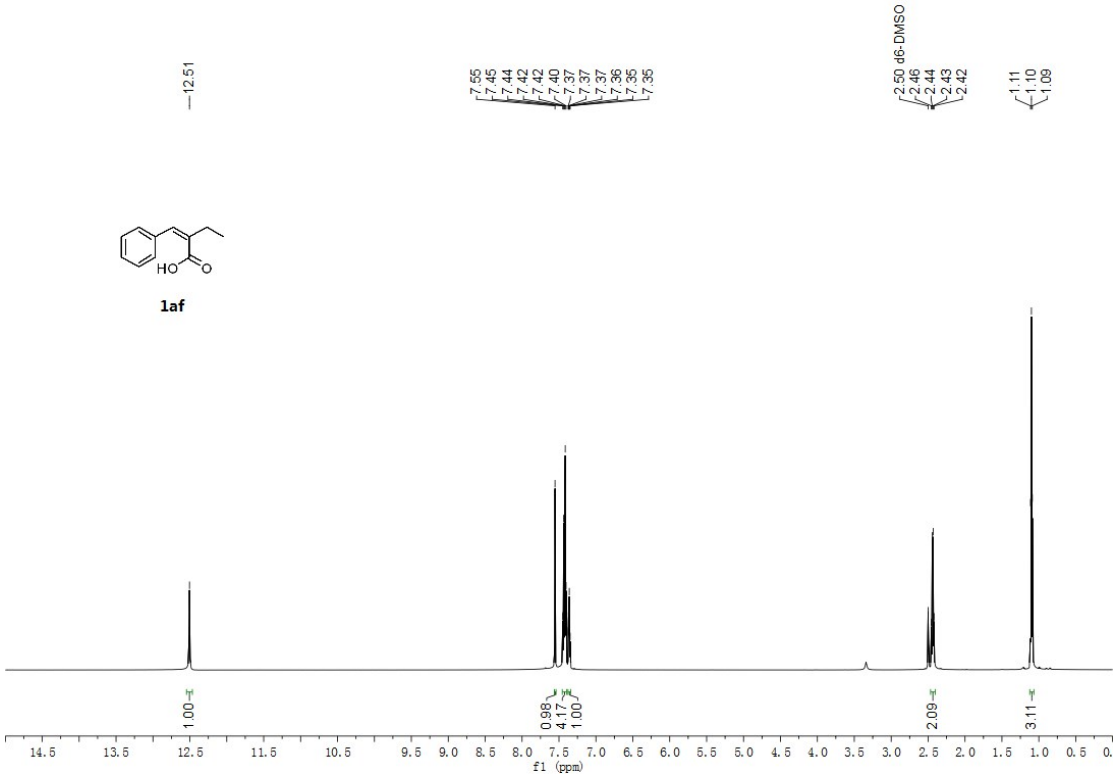
127.57
127.04
124.31
121.59
118.86
39.50 d6-DMSO
CF3
O
OH
1ad
f1 (ppm)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7.55
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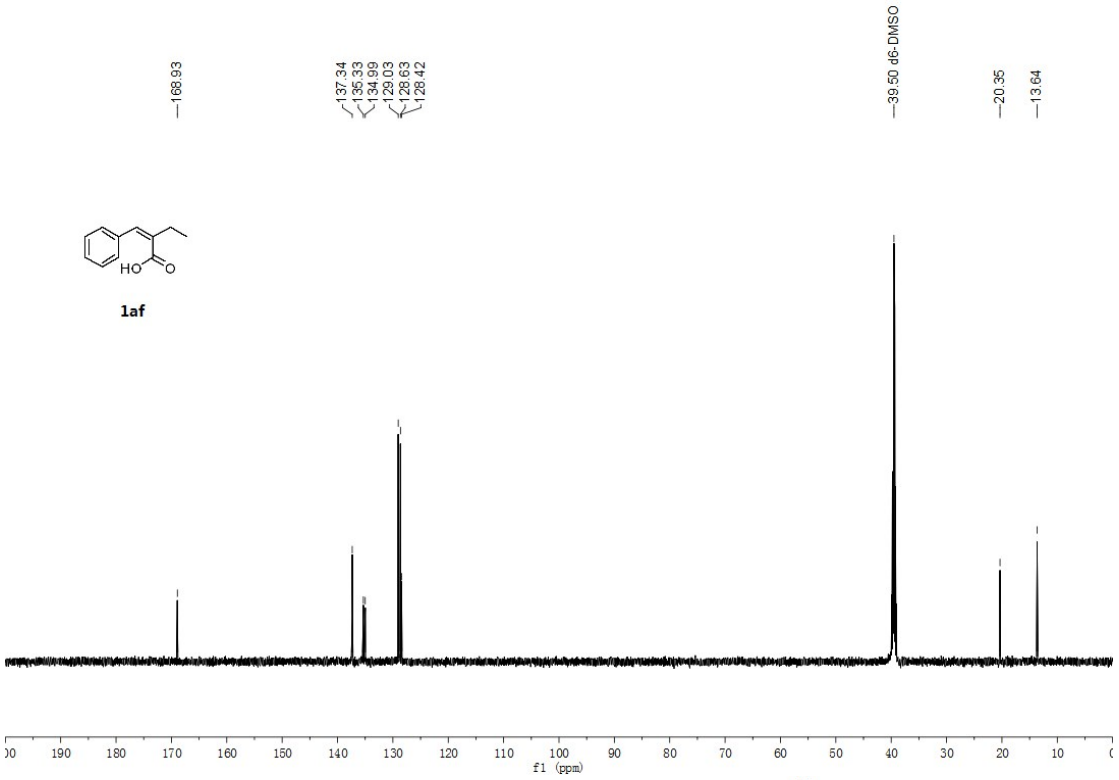
7.44
7.42
7.42
7.40
7.37
7.37
7.37
7.36
7.35
7.35
2.50 d6-DMSO
2.46
2.44
2.43
2.42
1.11
1.10
1.09
HO
O
1af
1.00
0.98
4.17
1.00
2.09
3.11
f1 (ppm)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137.34
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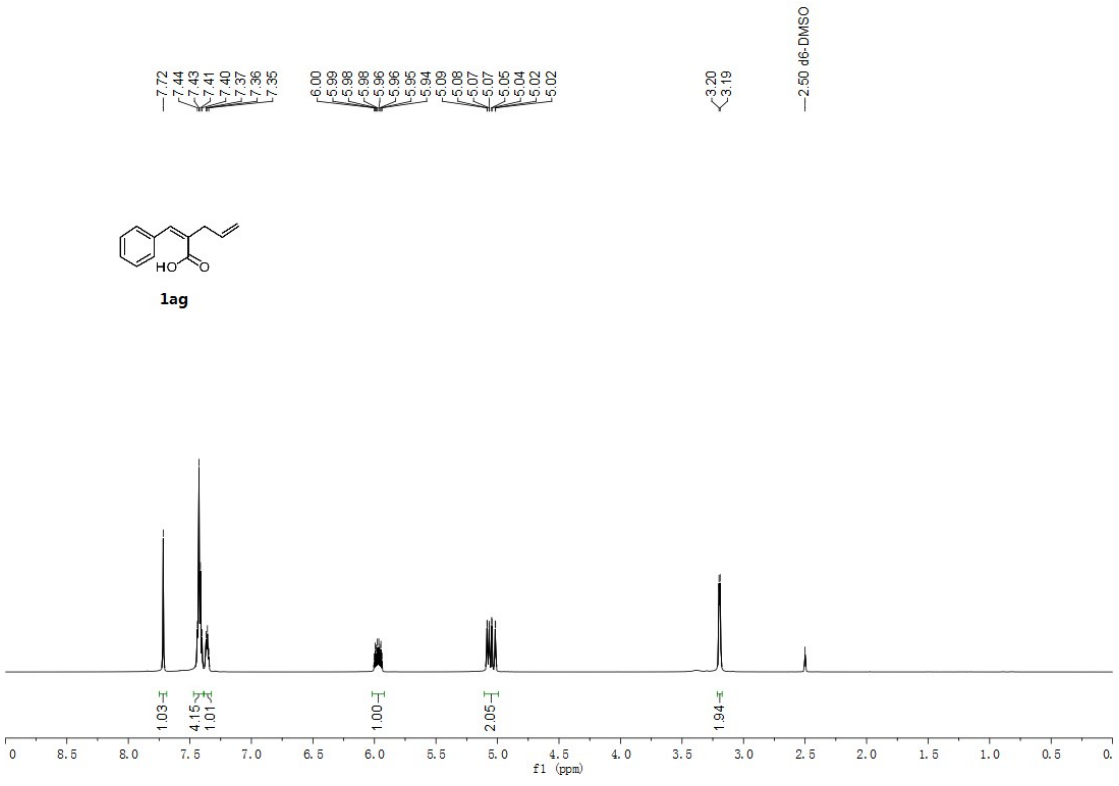
134.99
129.03
128.63
128.42
39.50 d6-DMSO
20.35
13.64
HO
O
f1 (ppm)

1af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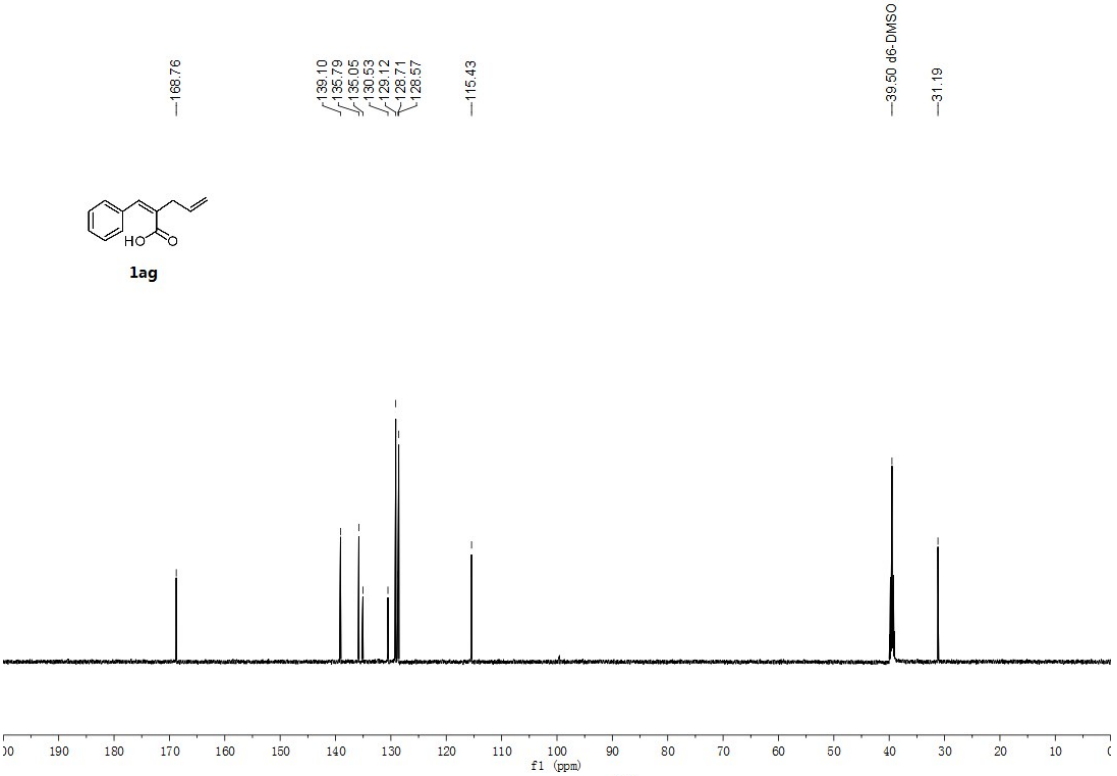
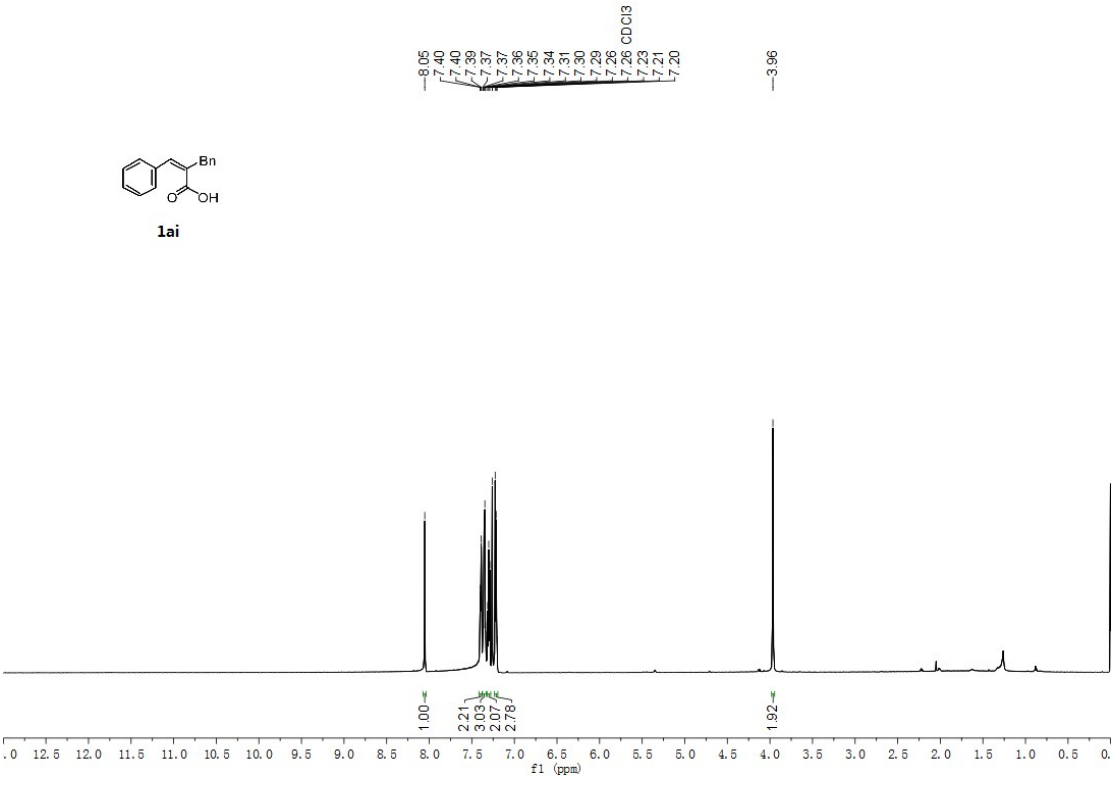
7.40
7.37
7.36
7.35
6.00
5.99
5.98
5.98
5.96
5.96
5.95
5.94
5.09
5.08
5.07
5.07
5.05
5.04
5.02
5.02
3.20
3.19
2.50 d6-DMSO
HO
O
1.03
4.15
1.01
1.00
2.05
1.94
f1 (ppm)

1ag


168.76
139.10
135.79
135.05
130.53
129.12
128.71
128.57
115.43
39.50 d6-DMSO
31.19
HO
O
f1 (ppm)

1ag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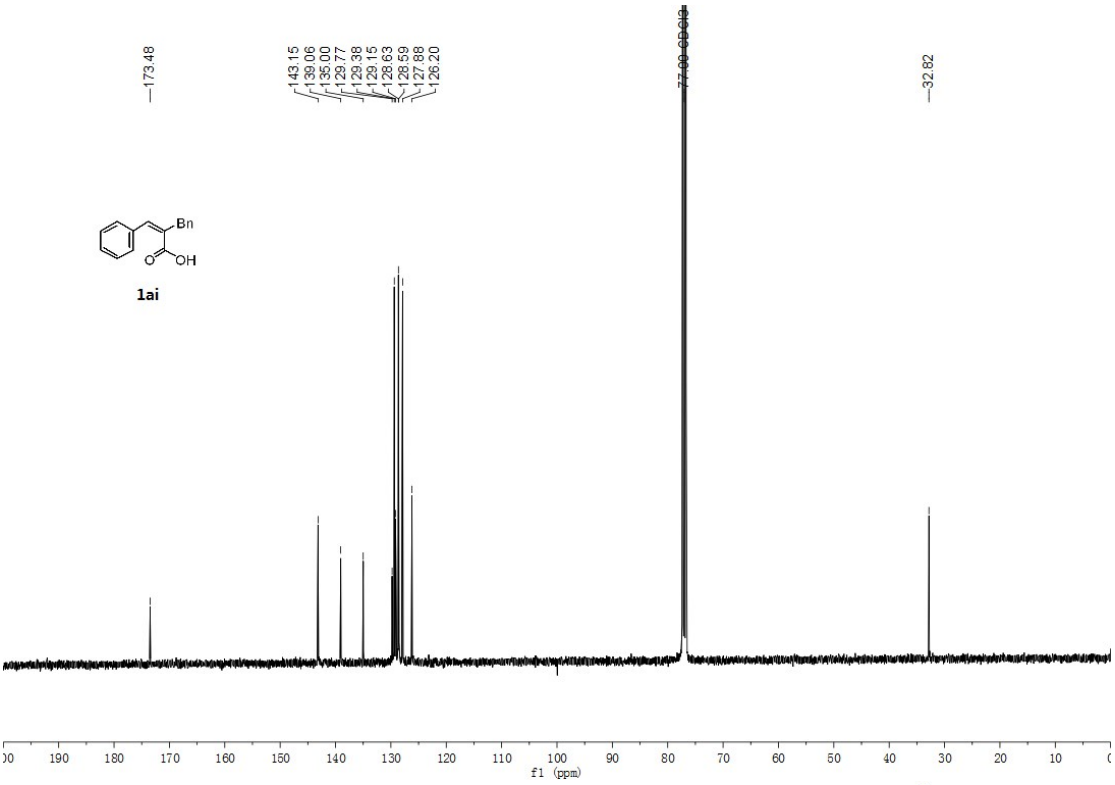
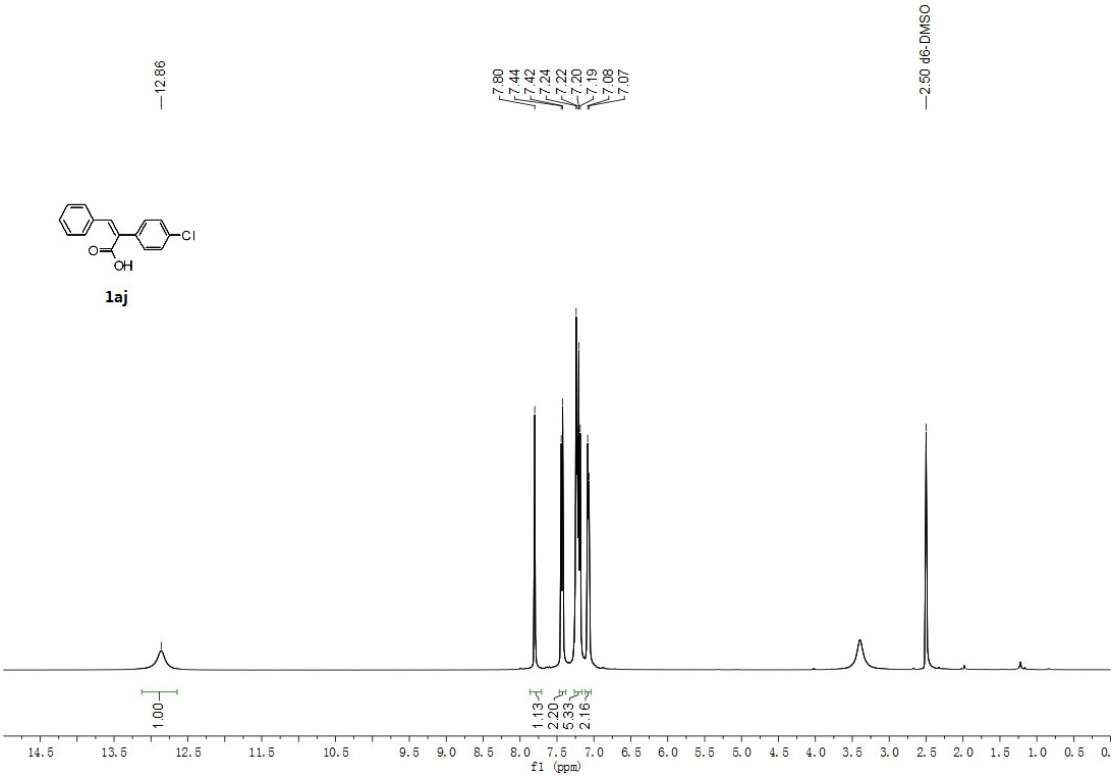
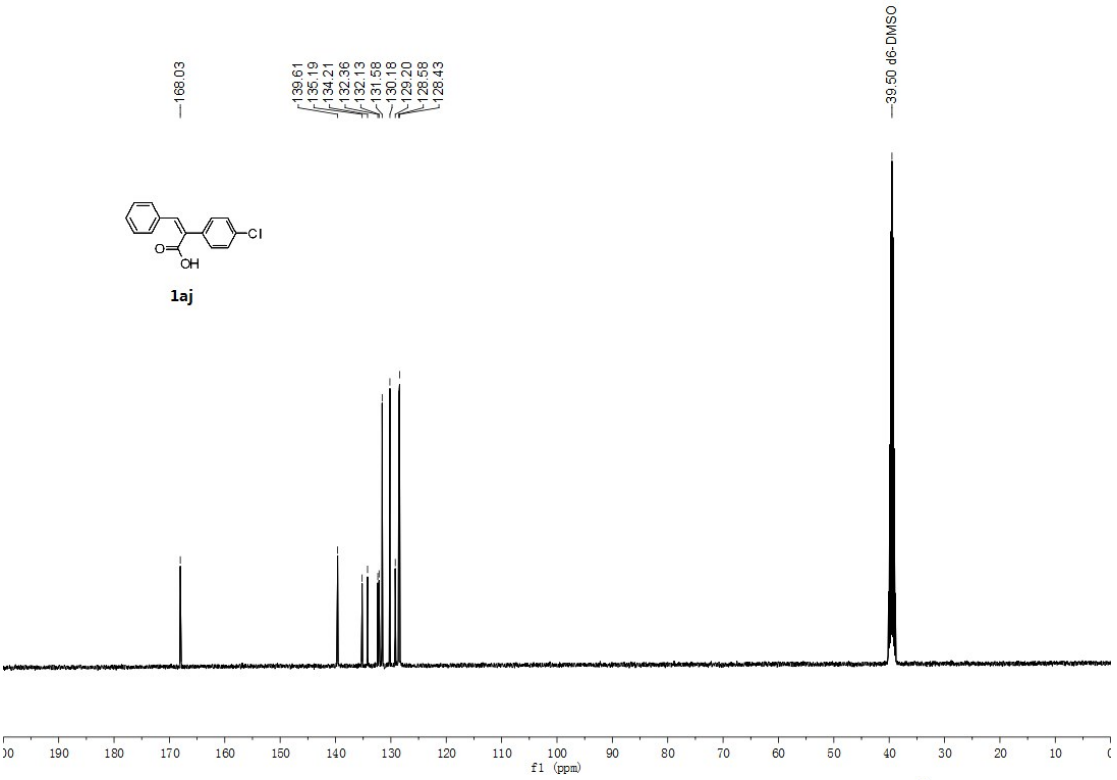
7.39
7.37
7.37
7.36
7.35
7.34
7.31
7.30
7.29
7.26
CDCl3
7.26
7.23
7.21
7.20
3.96
Bn
O
OH
1.00
2.21
3.03
2.07
2.78
1.92
f1 (ppm)

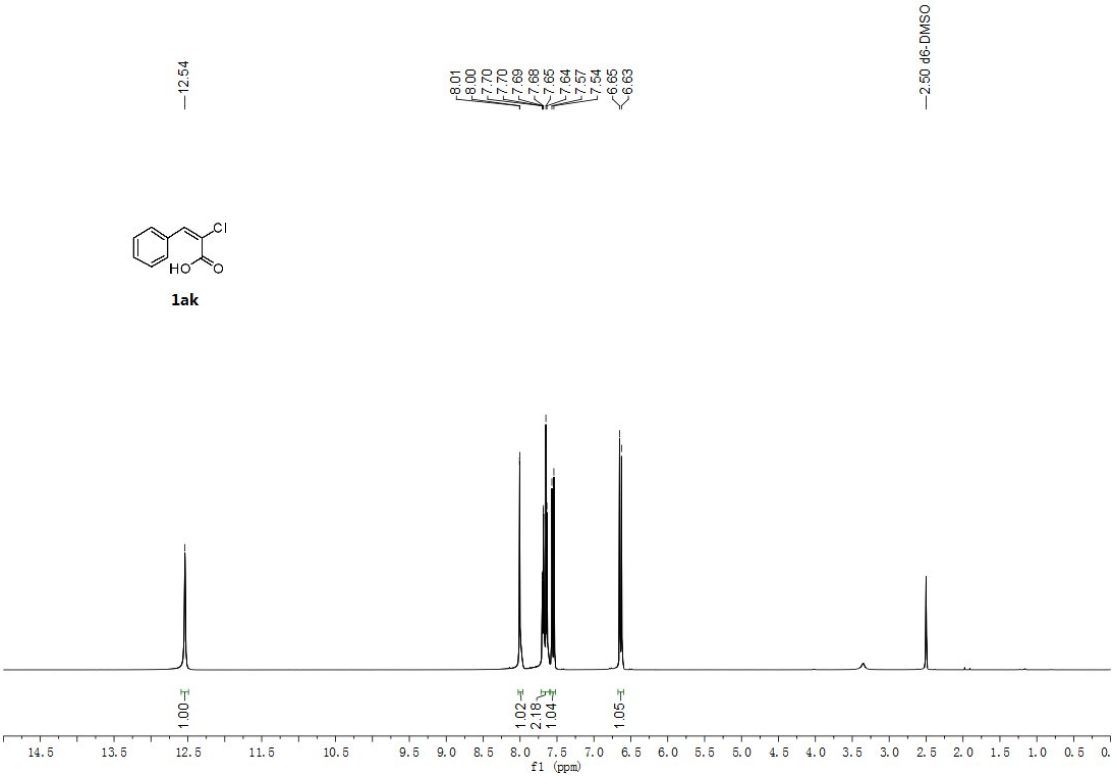
1ai


173.48
143.15
139.06
135.00
129.77
129.38
129.15
128.63
128.59
127.88
126.20
77.00
32.82
Bn
OH
1ai
f1 (ppm)

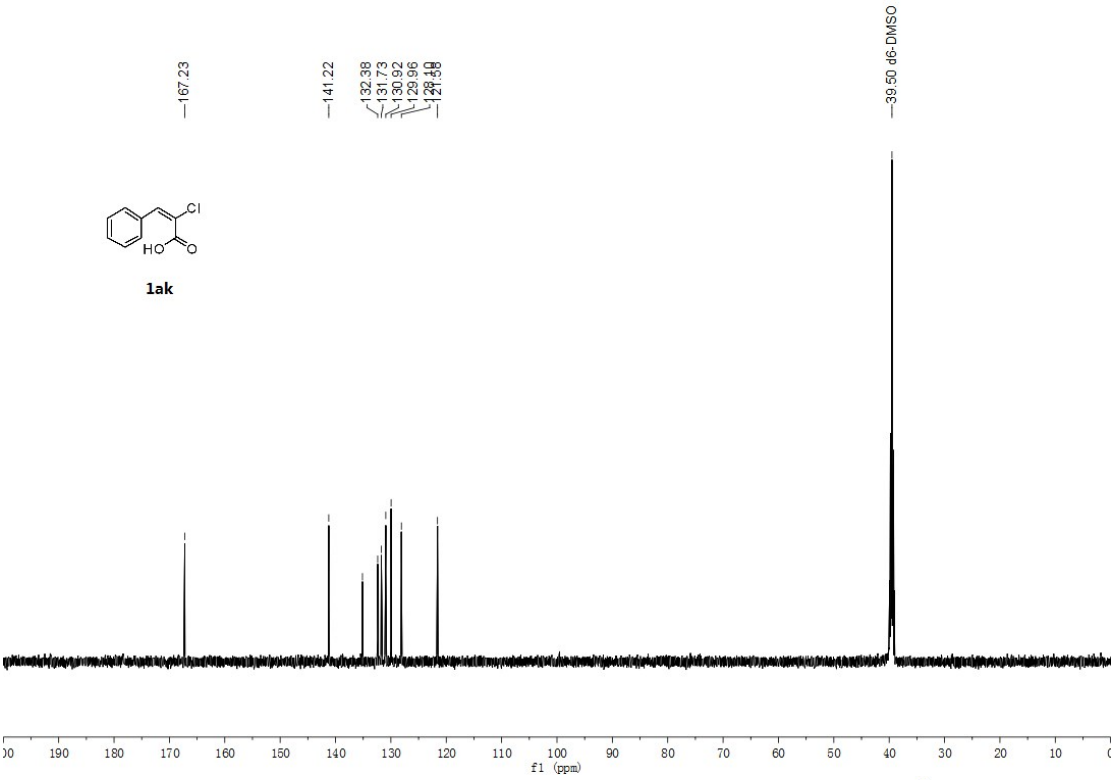

12.86
7.80
7.44
7.42
7.24
7.22
7.20
7.19
7.08
7.07
2.50 d6-DMSO
Cl
OH
1aj
1.00
1.13
2.20
5.33
2.16
f1 (ppm)

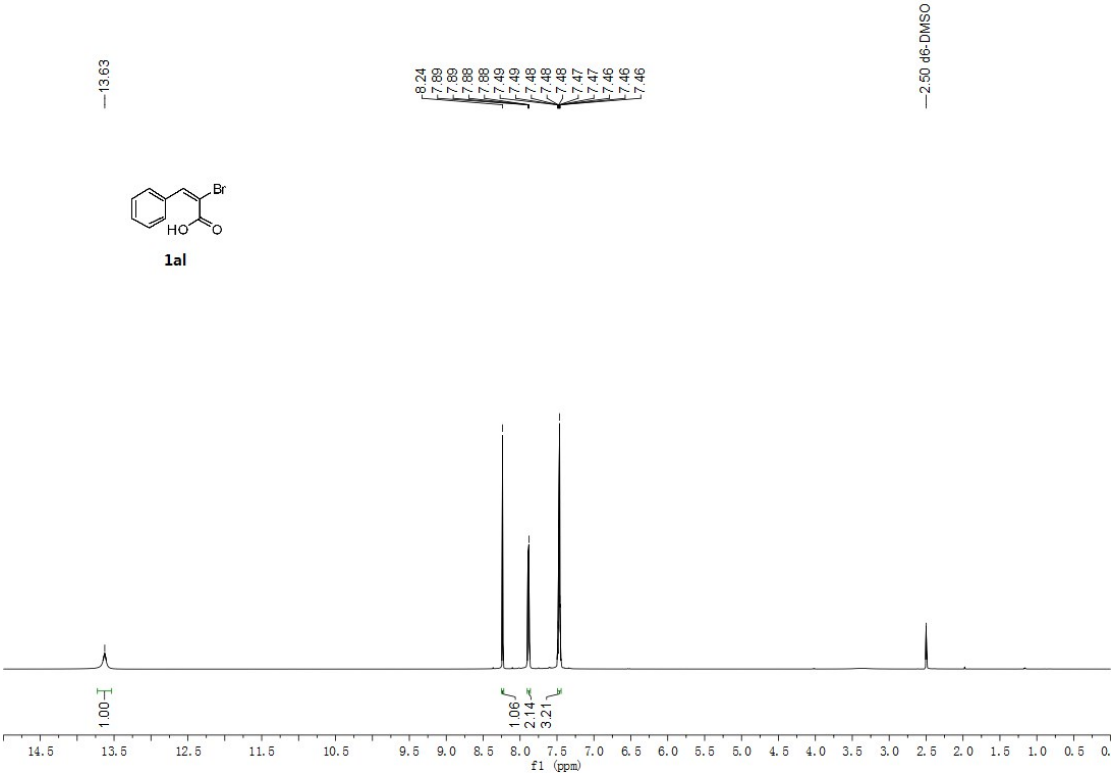

168.03
139.61
135.19
134.21
132.36
132.13
131.58
130.18
129.20
128.58
128.43
39.50 d6-DMSO
Cl
O
OH
f1 (ppm)

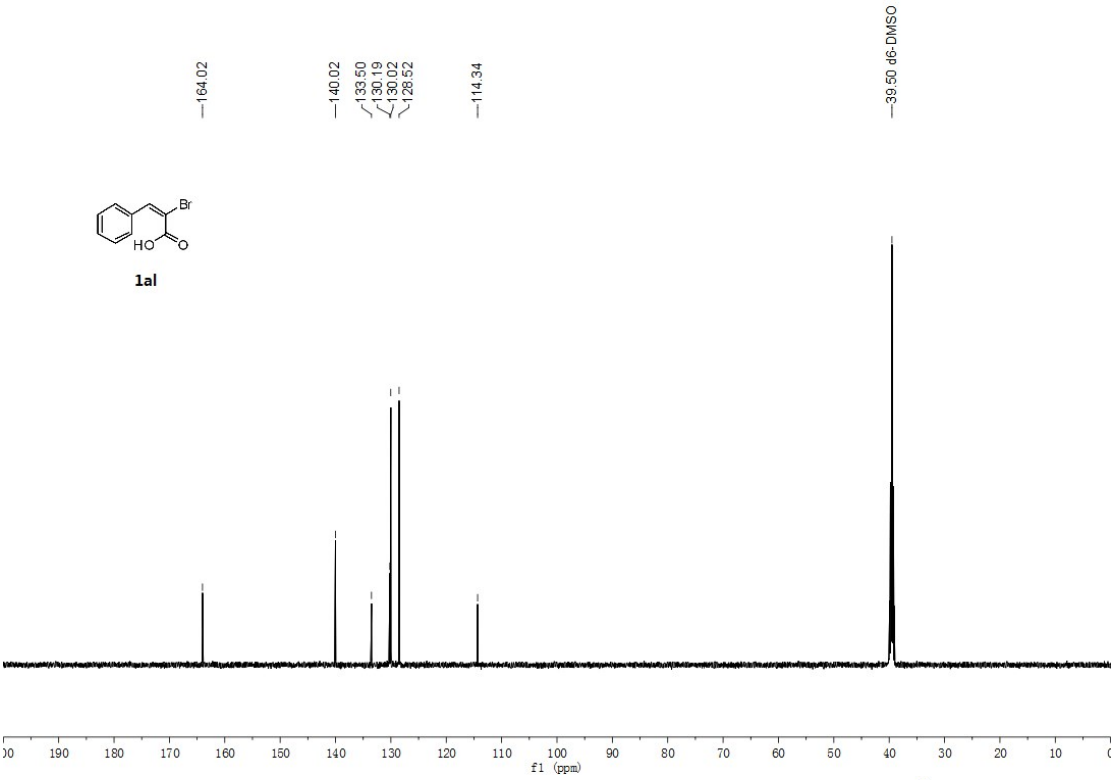
1aj

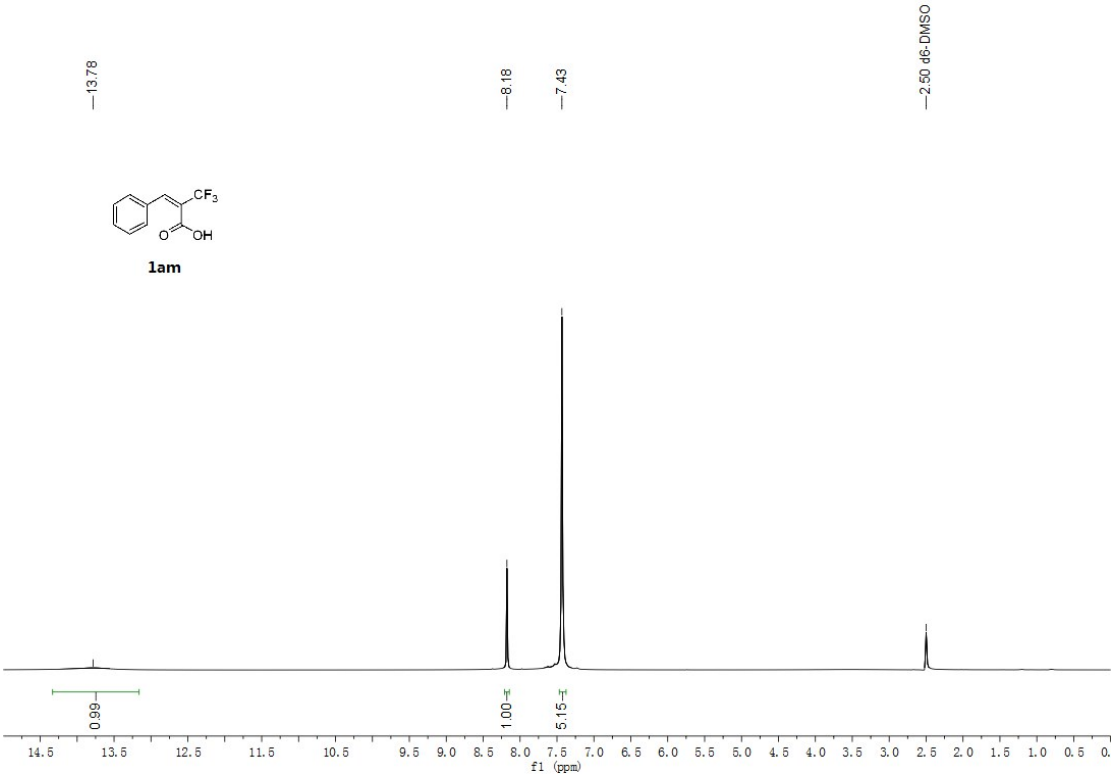

12.54
8.01
8.00
7.70
7.70
7.70
7.69
7.68
7.65
7.64
7.57
7.54
6.65
6.63
2.50 d6-DMSO
Cl
HO
O
1.00
1.02
2.18
1.04
1.05
f1 (ppm)

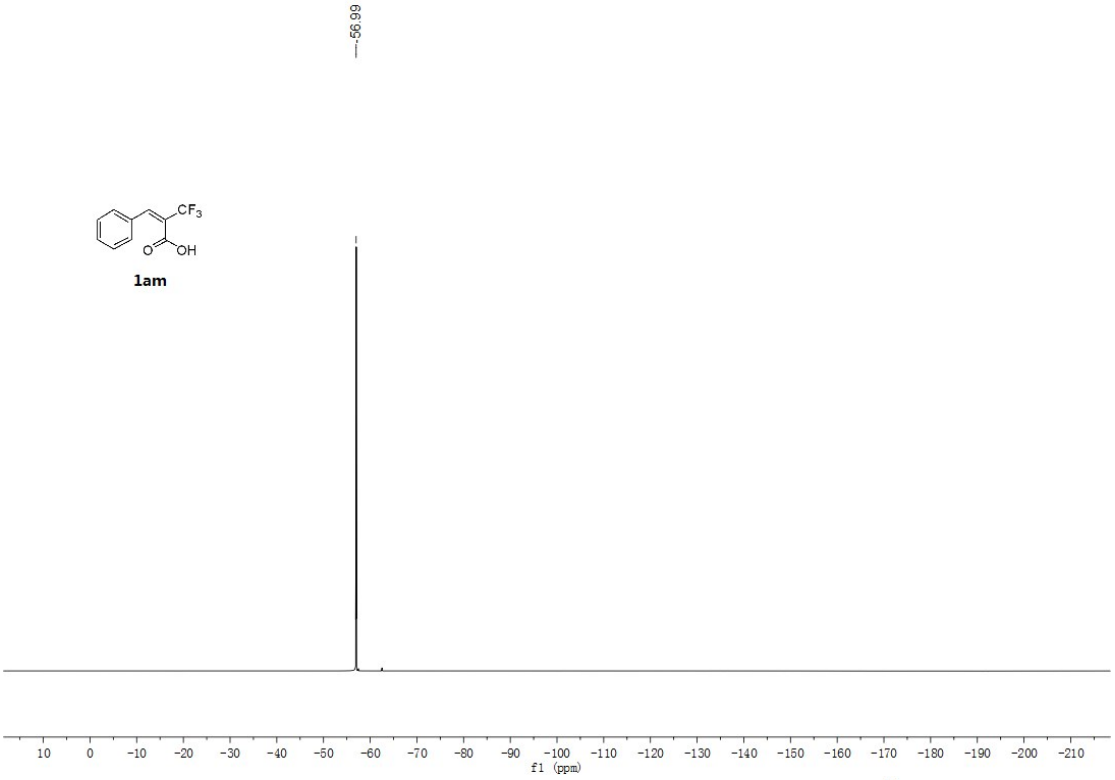
1ak

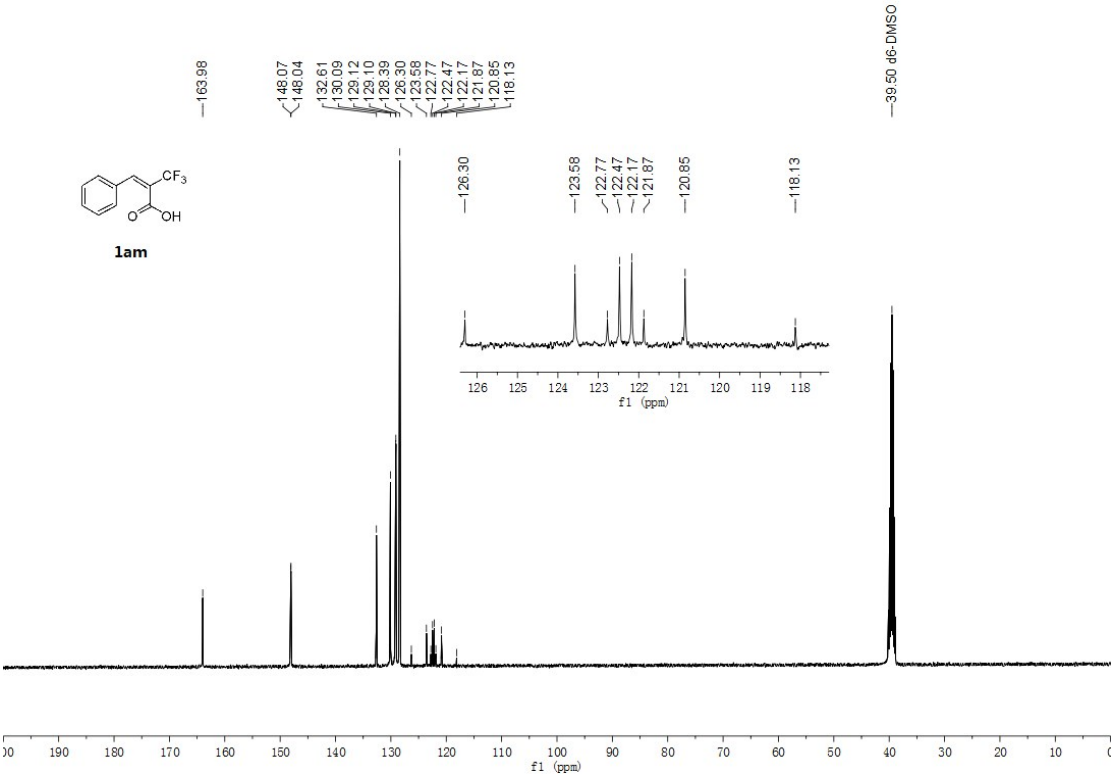

167.23
141.22
132.38
131.73
130.92
129.96
39.50 d6-DMSO
Cl
HO
O
1ak
f1 (ppm)

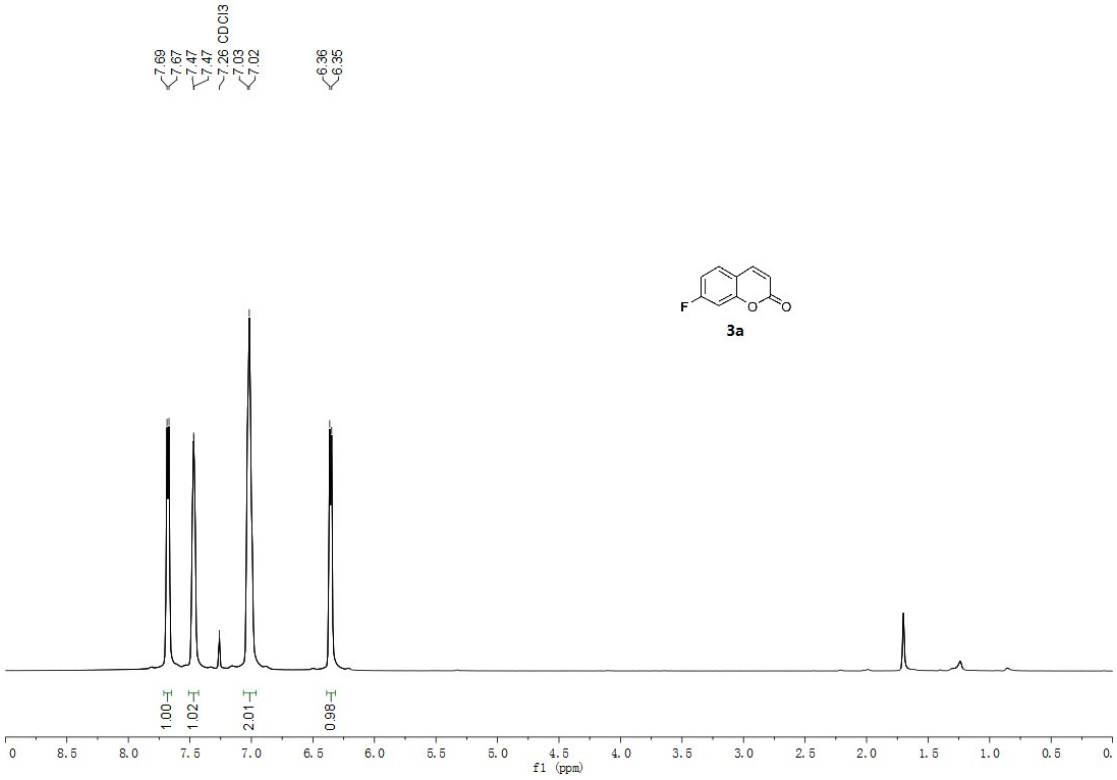

13.63
8.24
7.89
7.88
7.49
7.48
7.47
7.46
2.50 d6-DMSO
Br
HO
O
1al
1.00
1.06
2.14
3.21
f1 (ppm)

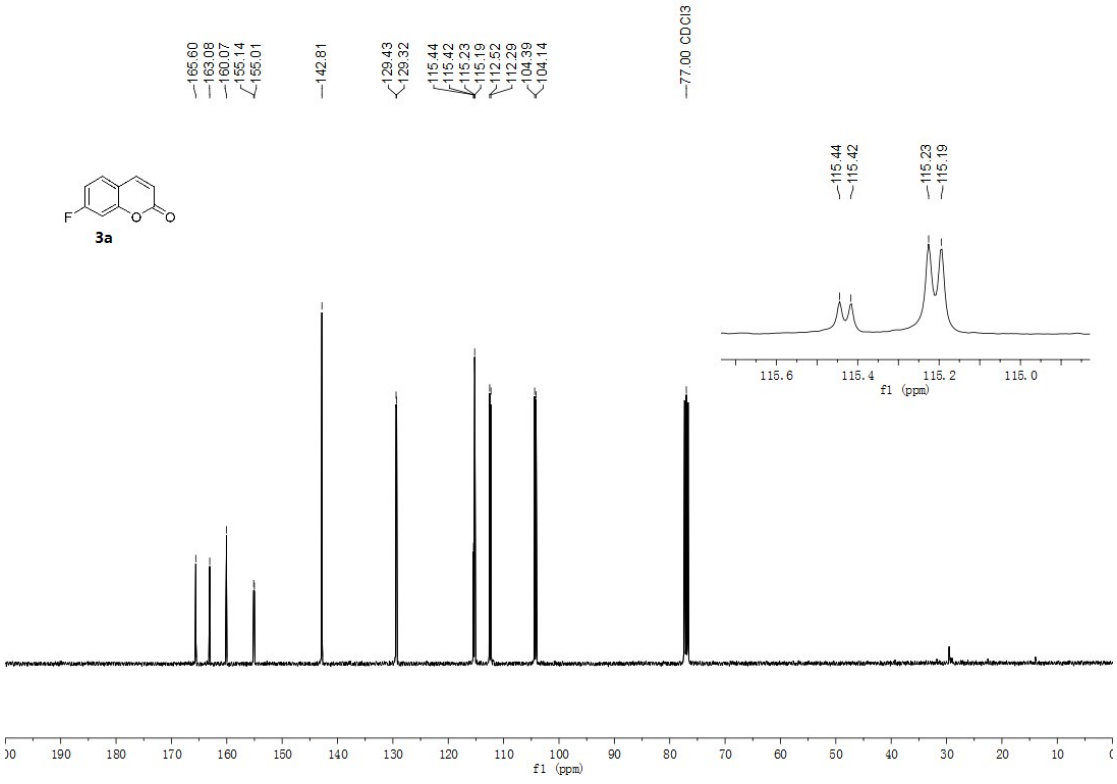

164.02
140.02
133.50
130.19
130.02
128.52
114.34
39.50 d6-DMSO
Br
HO
O
1al
f1 (ppm)

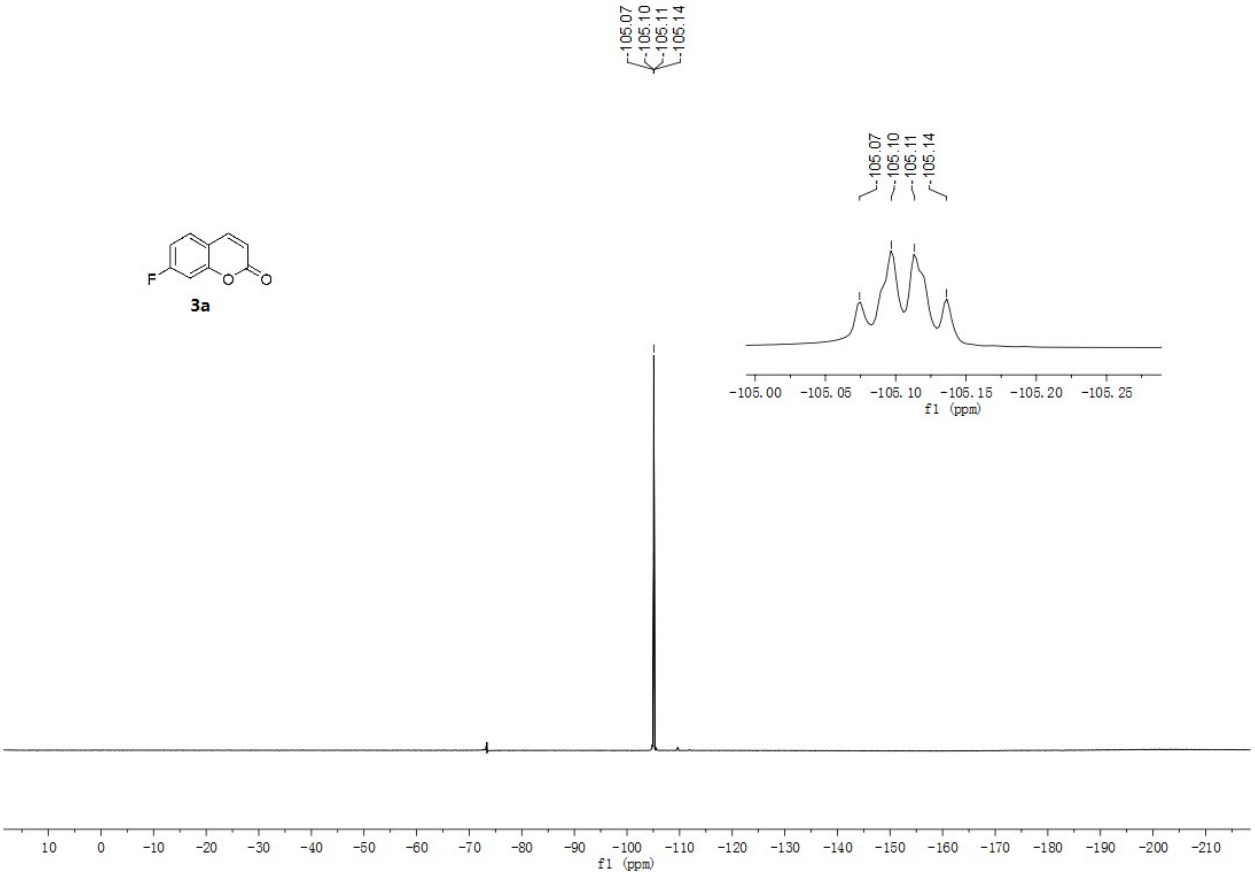

13.78
8.18
7.43
2.50 d6-DMSO
CF3
O
OH
1am
0.99
1.00
5.15
f1 (ppm)

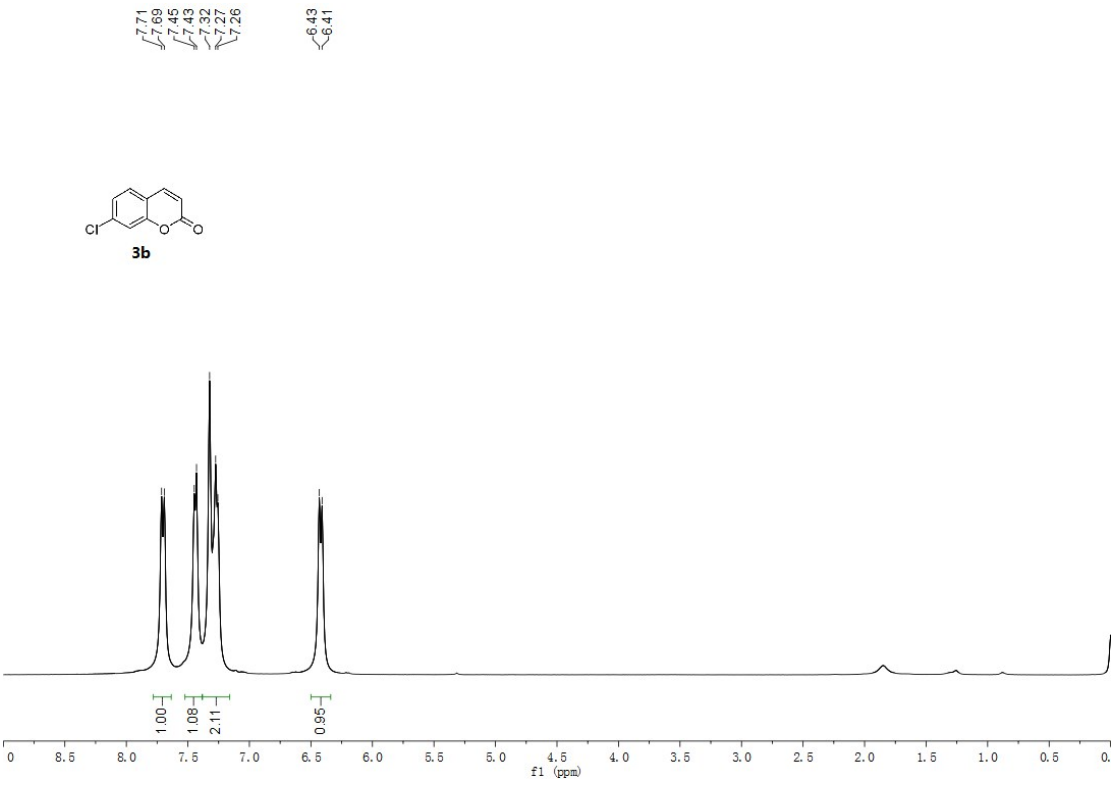

-56.99
CF3
OH
1am
f1 (ppm)

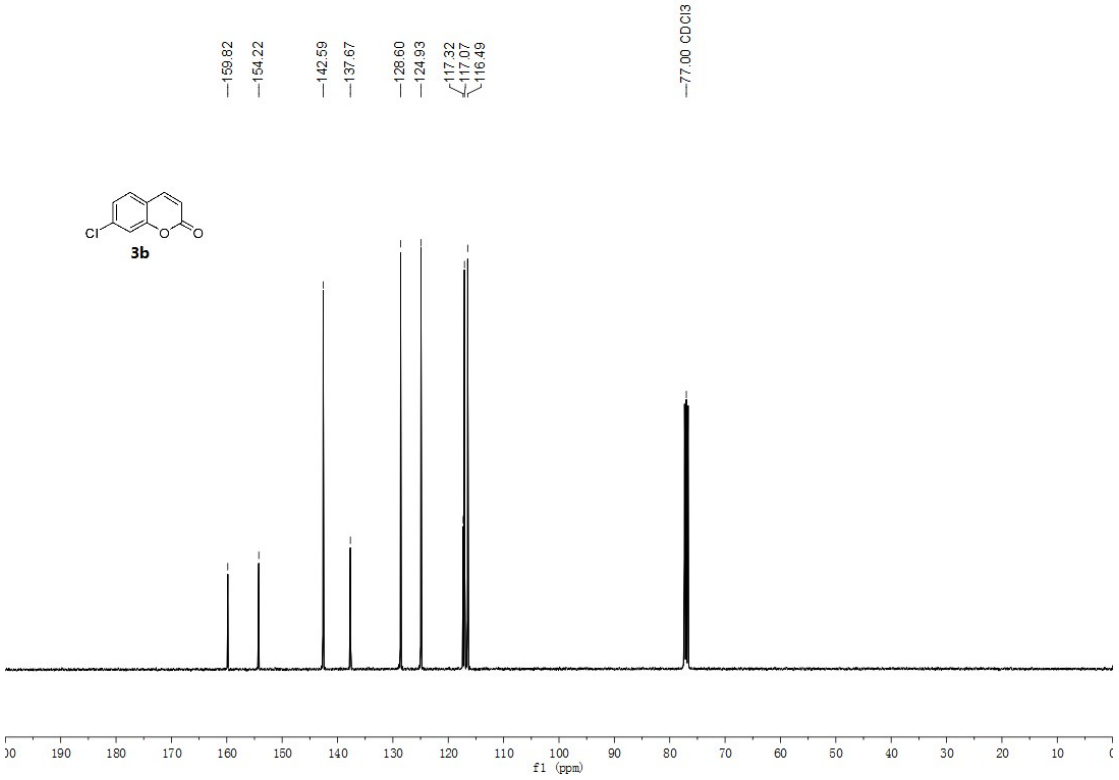

163.98
148.07
148.04
132.61
130.09
129.12
129.10
128.39
126.30
123.58
122.77
122.47
122.17
121.87
120.85
118.13
39.50 d6-DMSO
CF3
OH
1am
f1 (ppm)

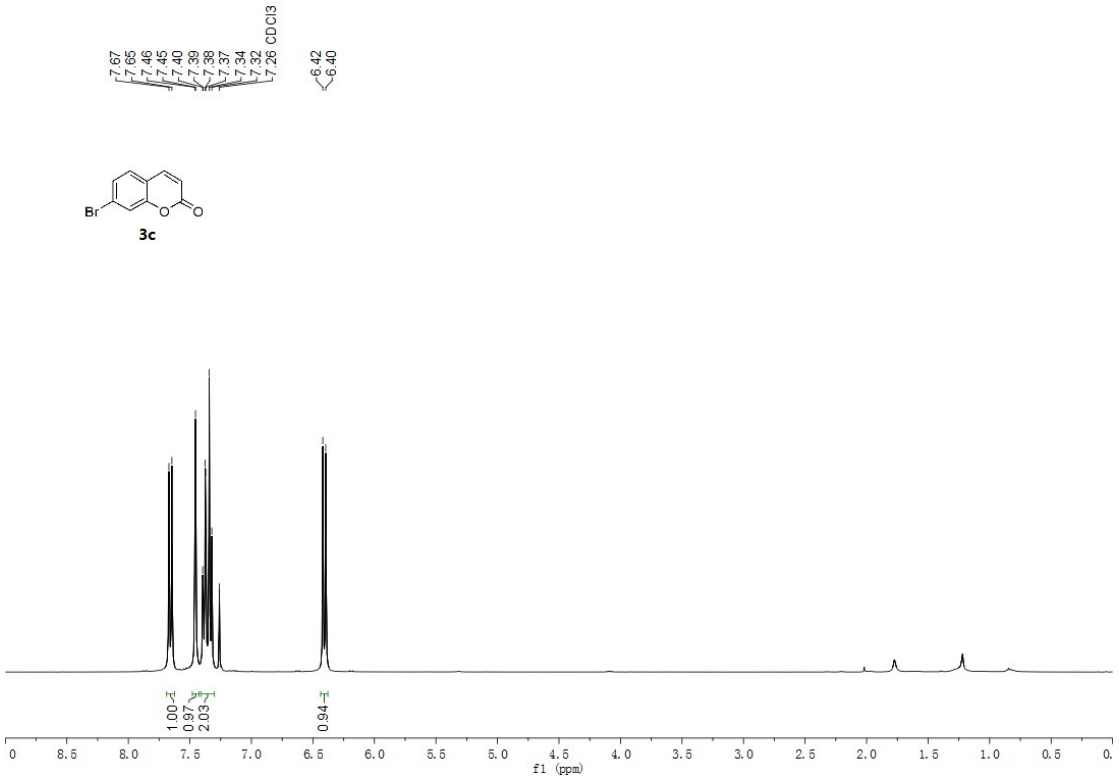

7.69
7.67
7.47
7.47
7.26 CDCl3
7.03
7.02
6.36
6.35
F
O
O
3a
1.00
1.02
2.01
0.98
f1 (ppm)

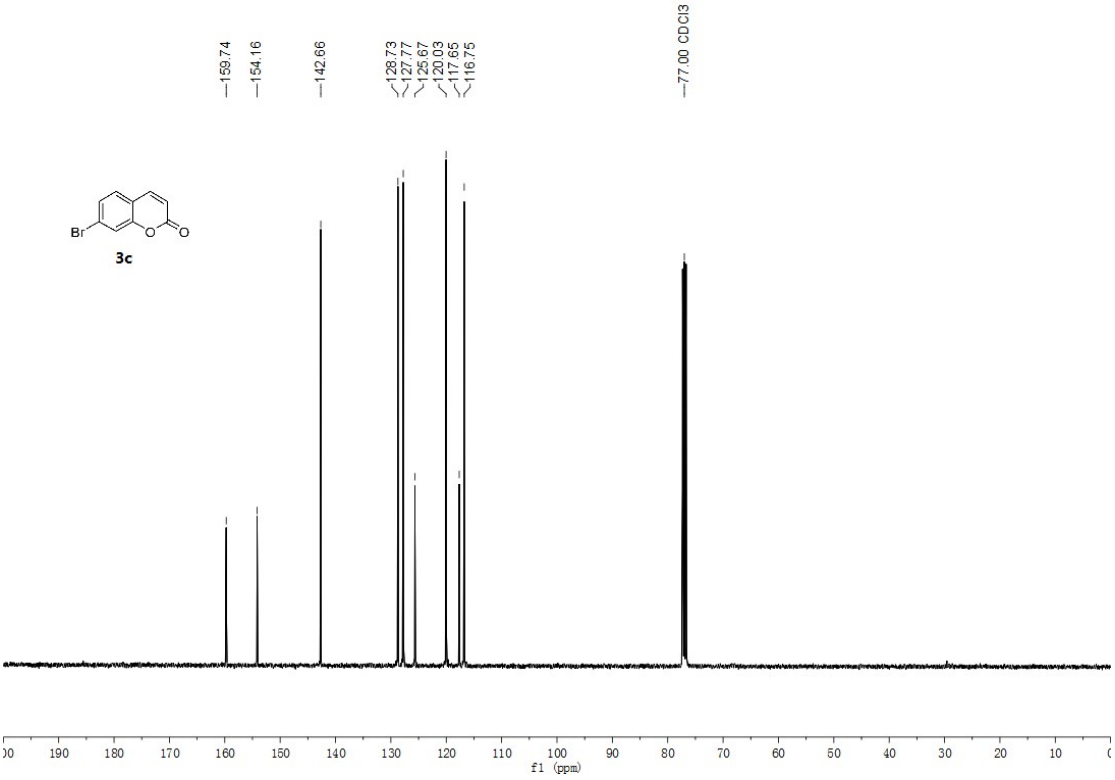

165.60
163.08
160.07
155.14
155.01
142.81
129.43
129.32
115.44
115.42
115.23
115.19
112.52
112.29
104.39
104.14
77.00 CDCl3
F
O
O
3a
115.44
115.42
115.23
115.19
115.6
115.4
115.2
115.0
f1 (ppm)
f1 (ppm)

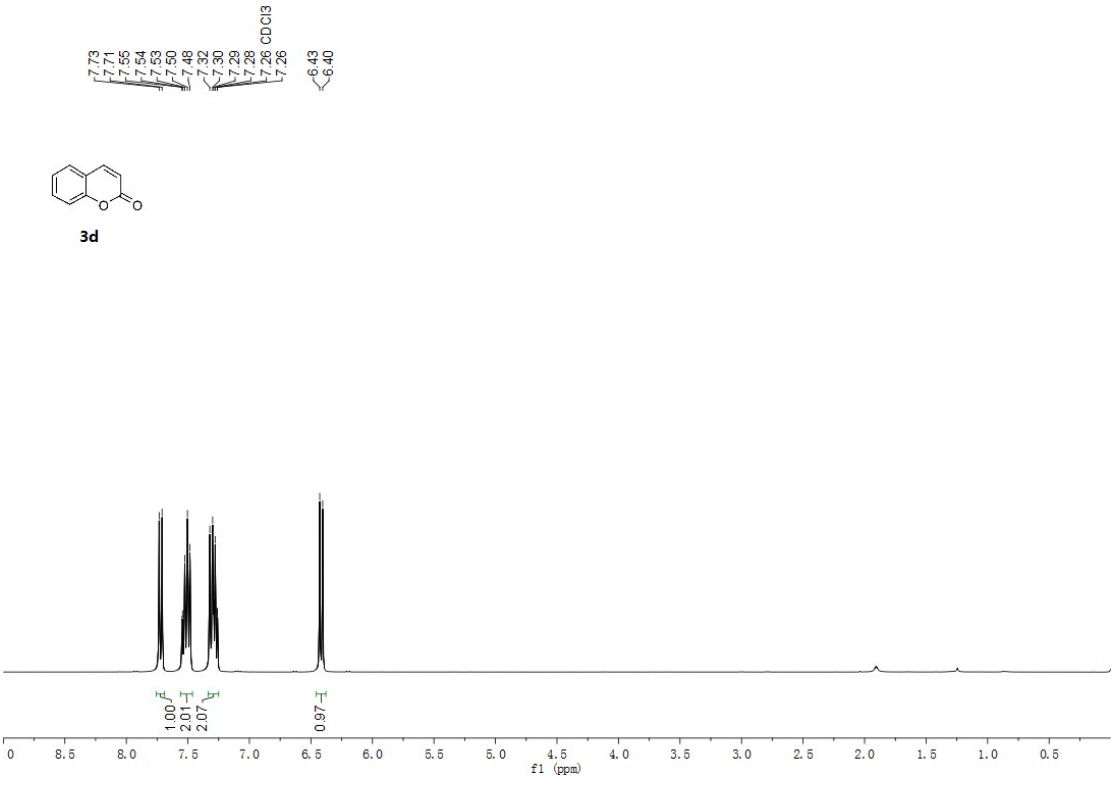

-105.07
-105.10
-105.11
-105.14
F
O
O
3a
-105.00 -105.05 -105.10 -105.15 -105.20 -105.25
f1 (ppm)
10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210
f1 (ppm)

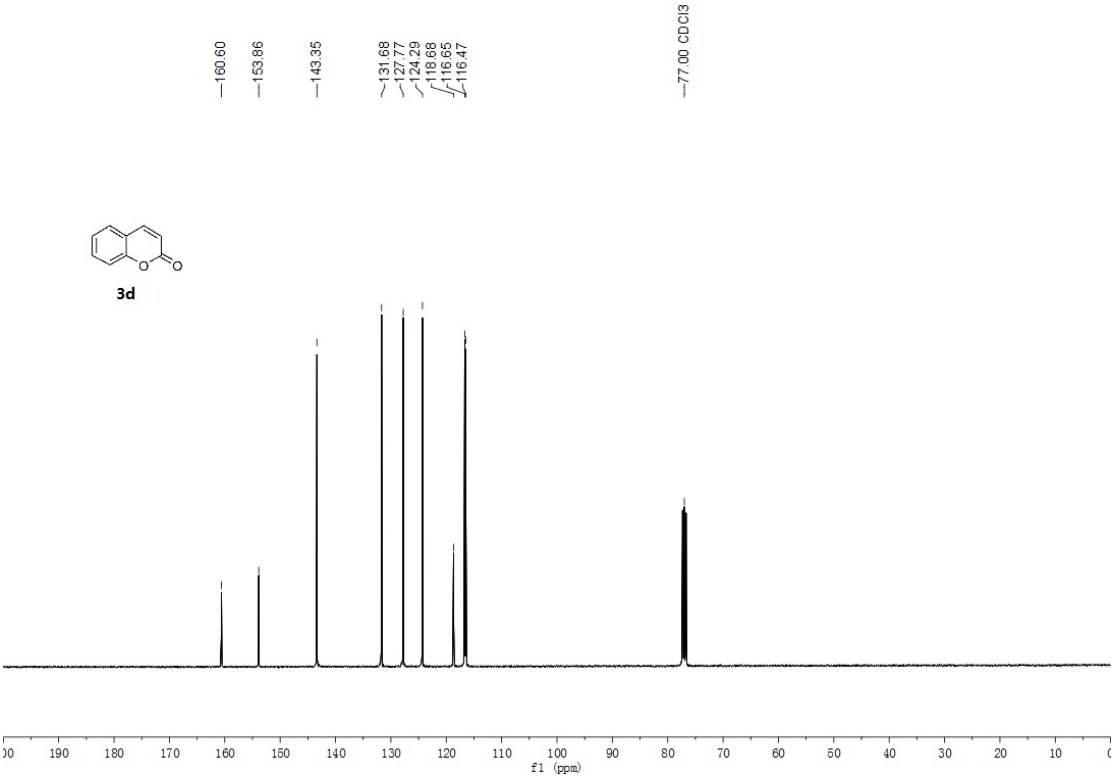

7.71
7.69
7.45
7.43
7.32
7.27
7.26
6.43
6.41
Cl
O
O
3b
1.00
1.08
2.11
0.95
0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.
f1 (ppm)

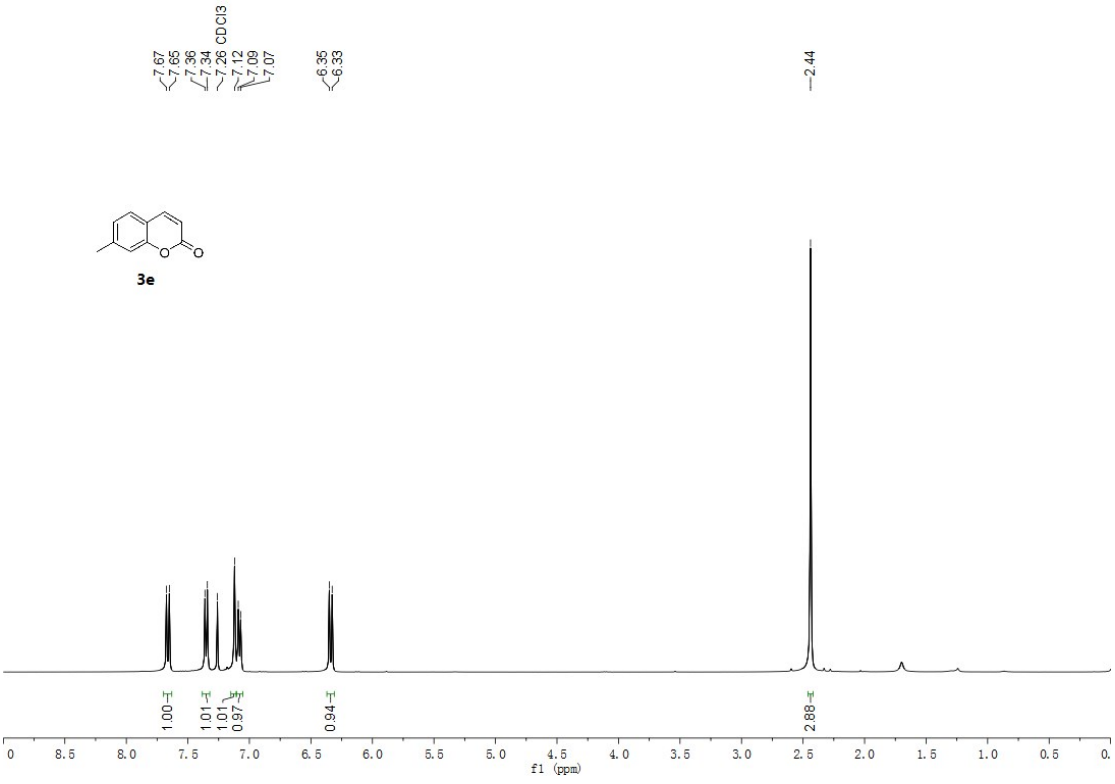

159.82
154.22
142.59
137.67
128.60
124.93
117.32
117.07
116.49
77.00 CDCl3
Cl
O
O
3b
f1 (ppm)

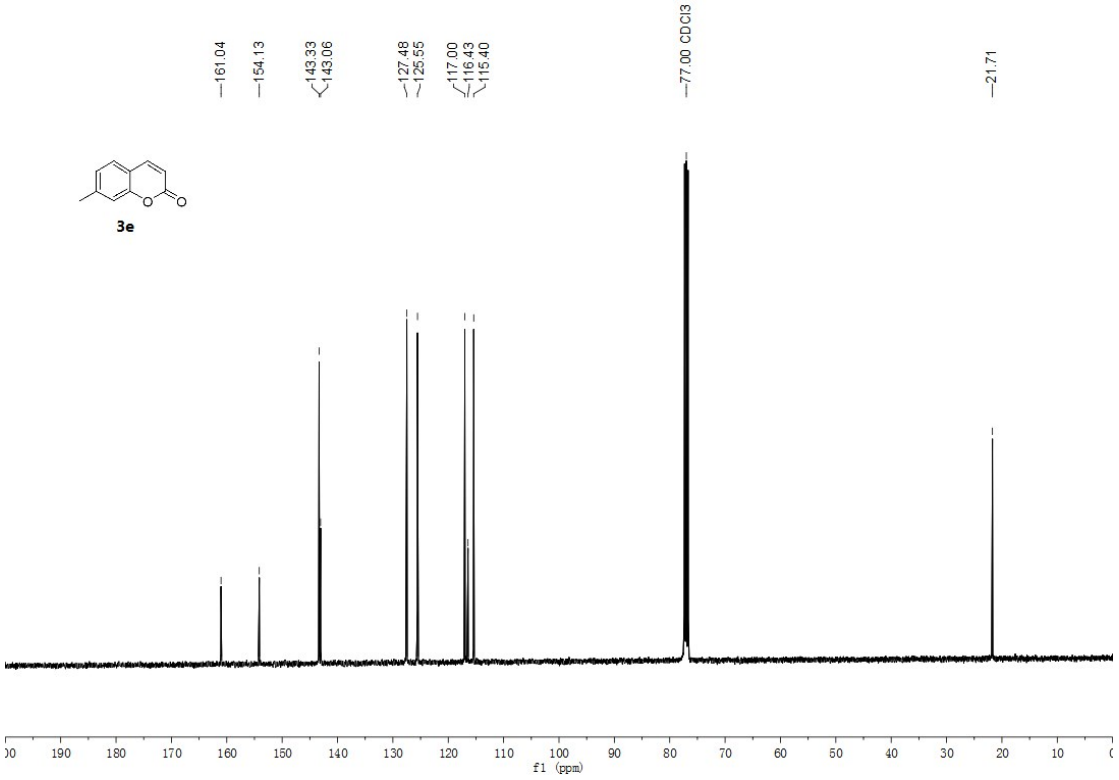

7.67
7.65
7.46
7.45
7.40
7.39
7.38
7.37
7.34
7.32
7.26 CDCl3
6.42
6.40
Br
O
O
3c
1.00
0.97
2.03
0.94
f1 (ppm)

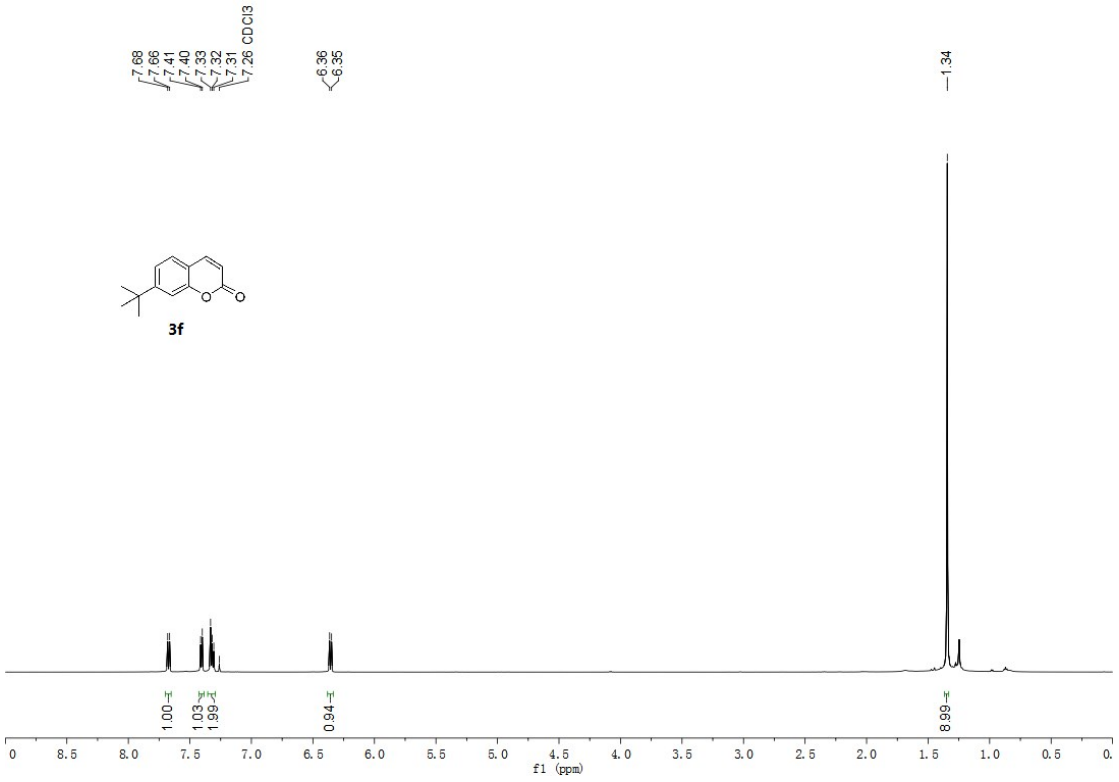

159.74
154.16
142.66
128.73
127.77
125.67
120.03
117.65
116.75
77.00 CDCl3
Br
O
O
3c
f1 (ppm)

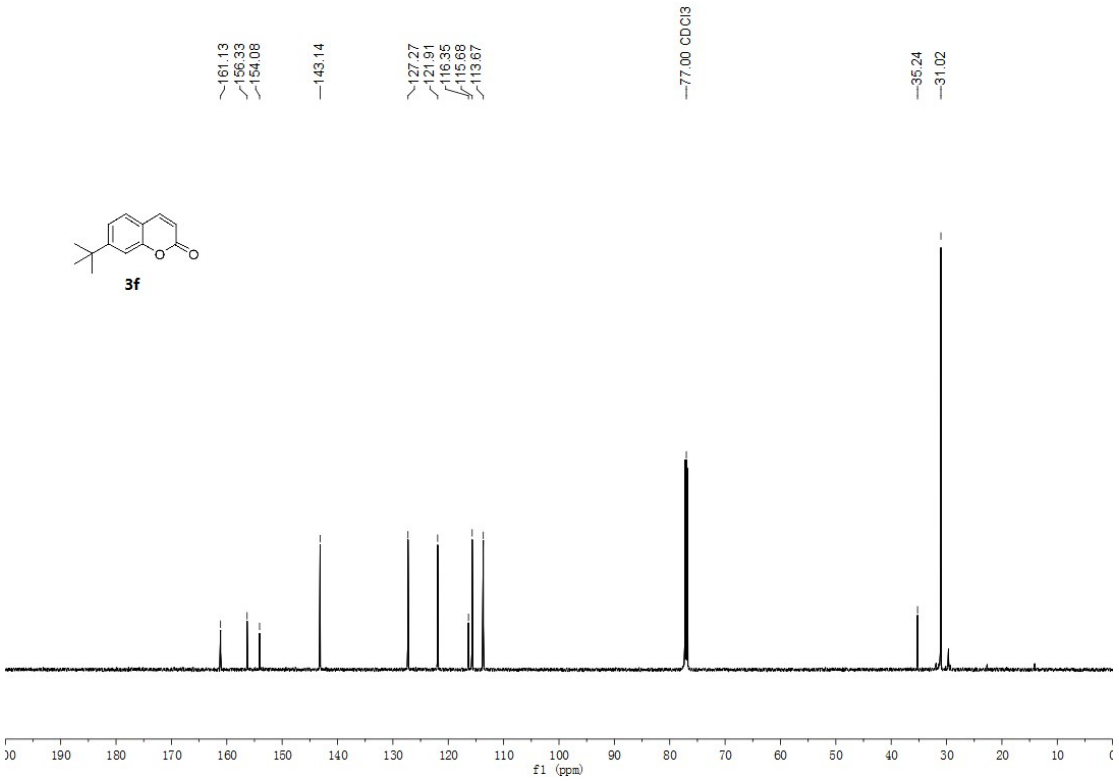

7.73
7.71
7.55
7.54
7.53
7.50
7.48
7.32
7.30
7.29
7.28
7.26 CDCl3
7.26
6.43
6.40
O
O
3d
1.00
2.01
2.07
0.97
f1 (ppm)

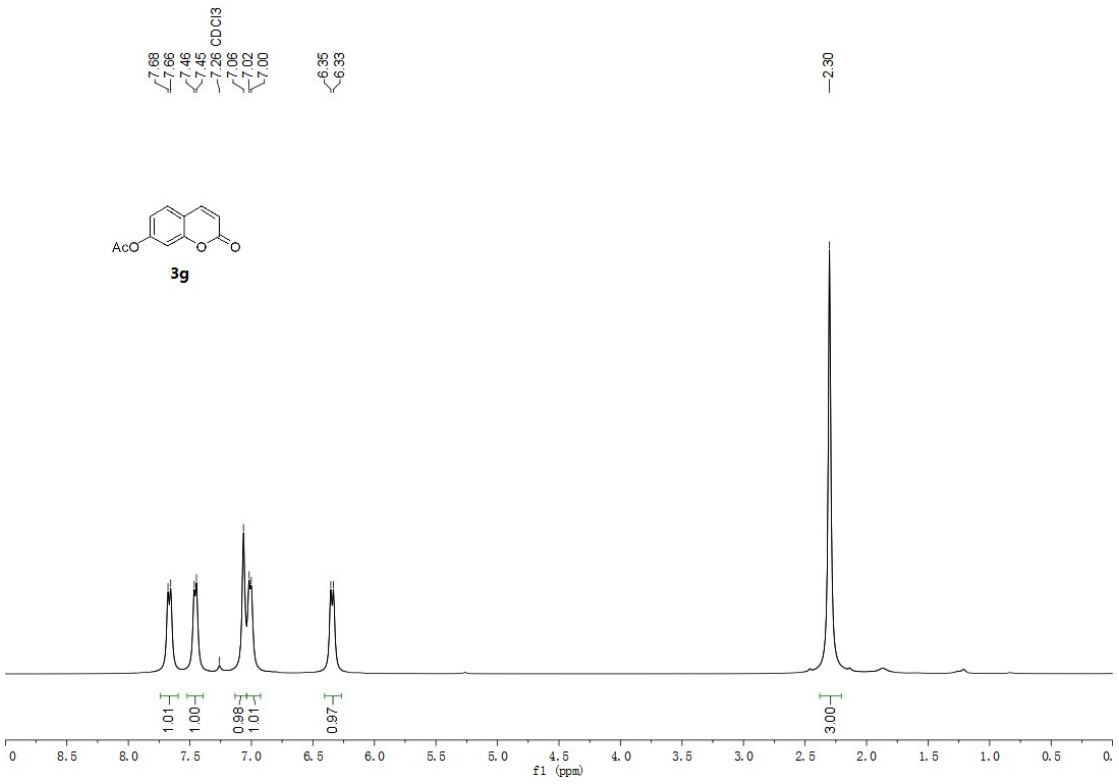

160.60
153.86
143.35
131.68
127.77
124.29
118.68
116.65
116.47
77.00 CDCl3
3d
f1 (ppm)

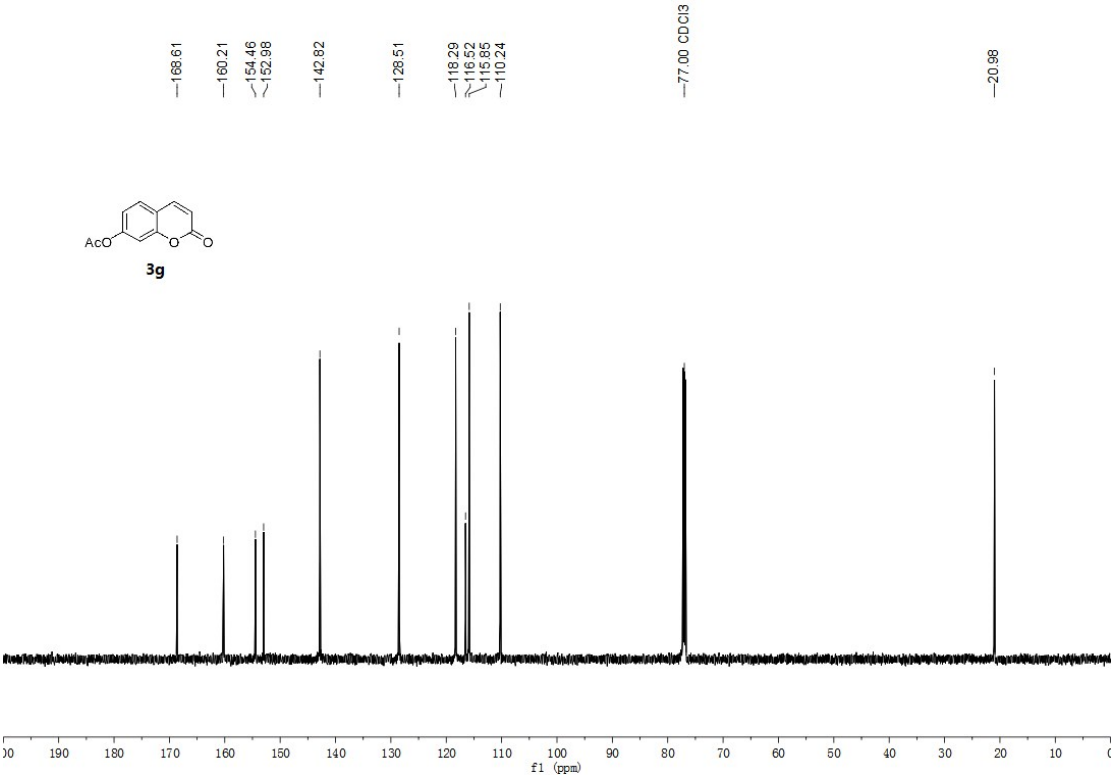

7.67
7.65
7.36
7.34
7.26 CDCl3
7.12
7.09
7.07
6.35
6.33
2.44
3e
1.00
1.01
1.01
0.97
0.94
2.88
f1 (ppm)

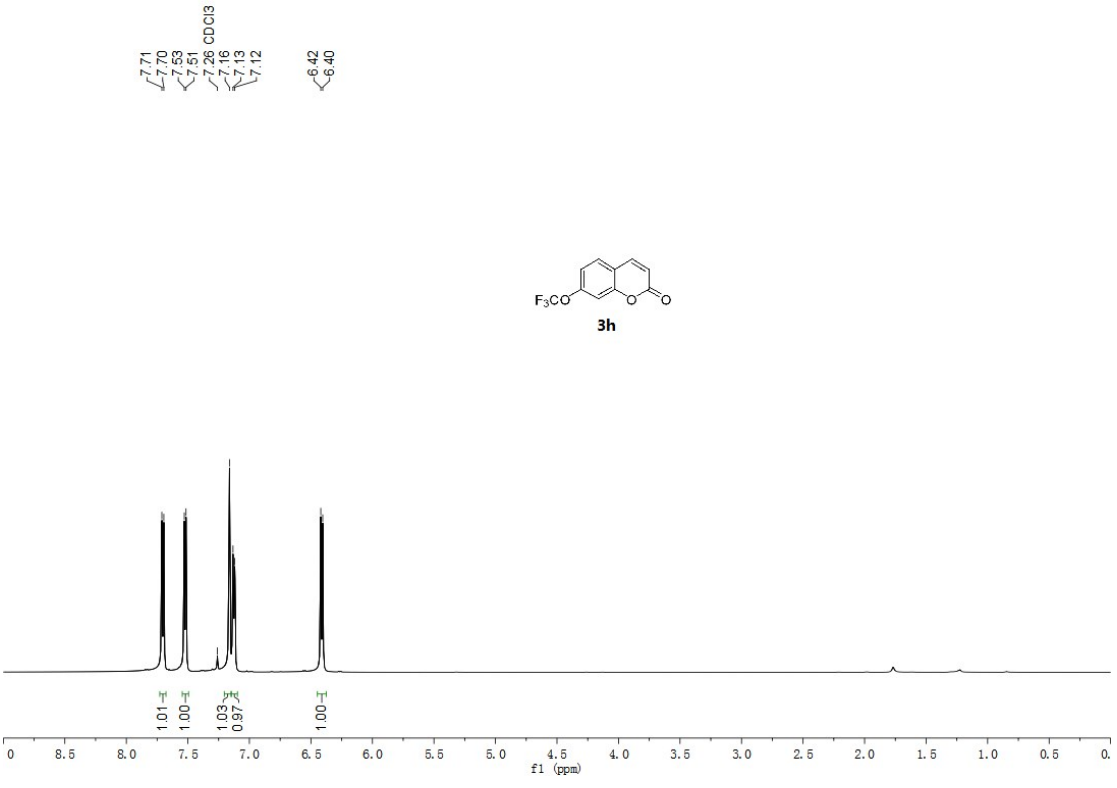

161.04
154.13
143.33
143.06
127.48
125.55
117.00
116.43
115.40
77.00 CDCl3
21.71
3e
f1 (ppm)

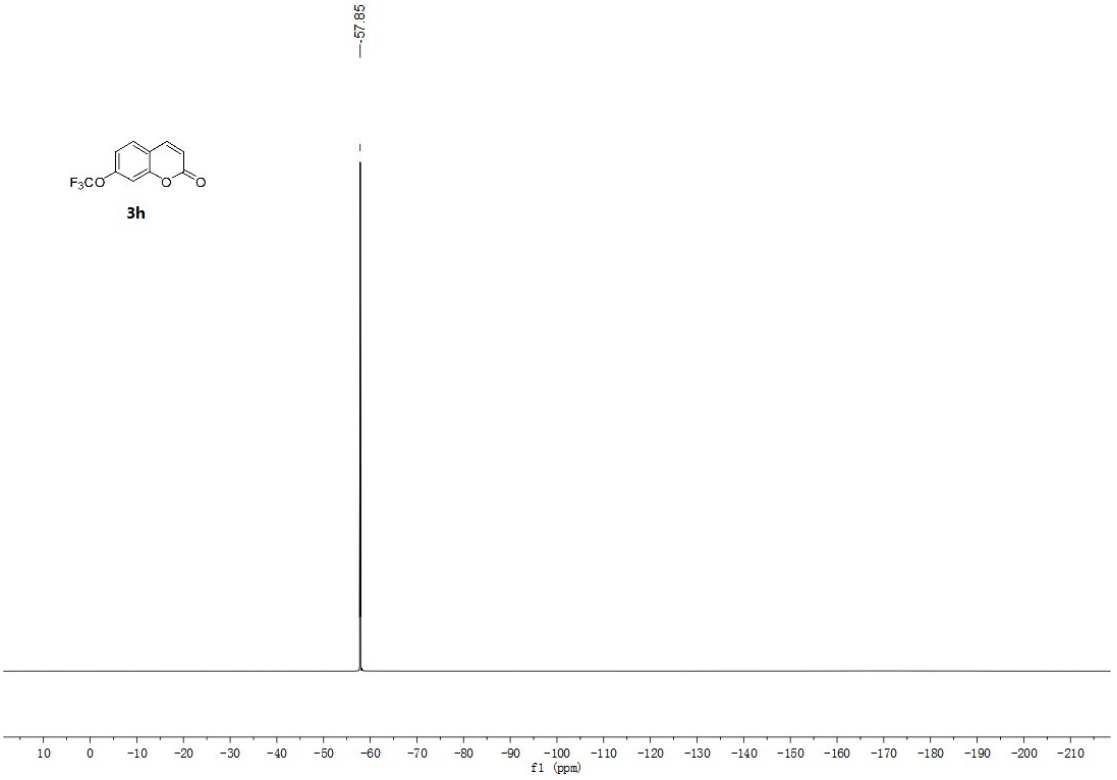

7.68
7.66
7.41
7.40
7.33
7.32
7.31
7.26 CDCl3
6.36
6.35
1.34
3f
1.00
1.03
1.99
0.94
8.99
f1 (ppm)

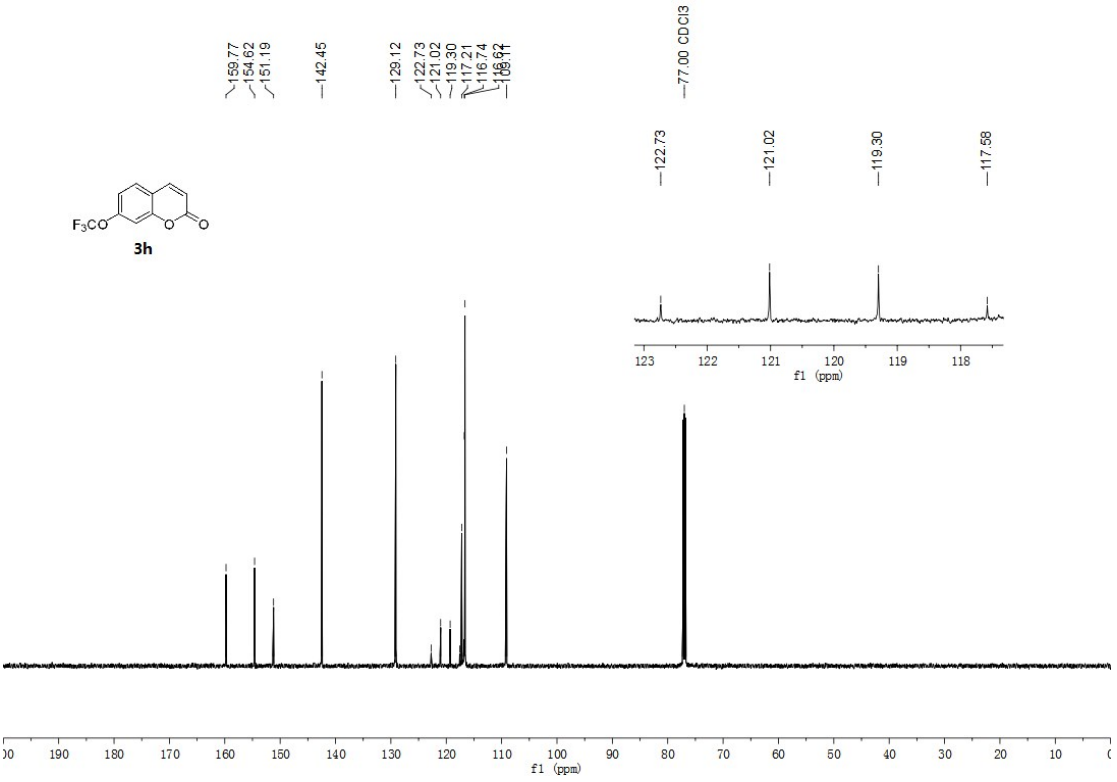

161.13
156.33
154.08
143.14
127.27
121.91
116.35
115.68
113.67
77.00 CDCl3
35.24
31.02
3f
f1 (ppm)

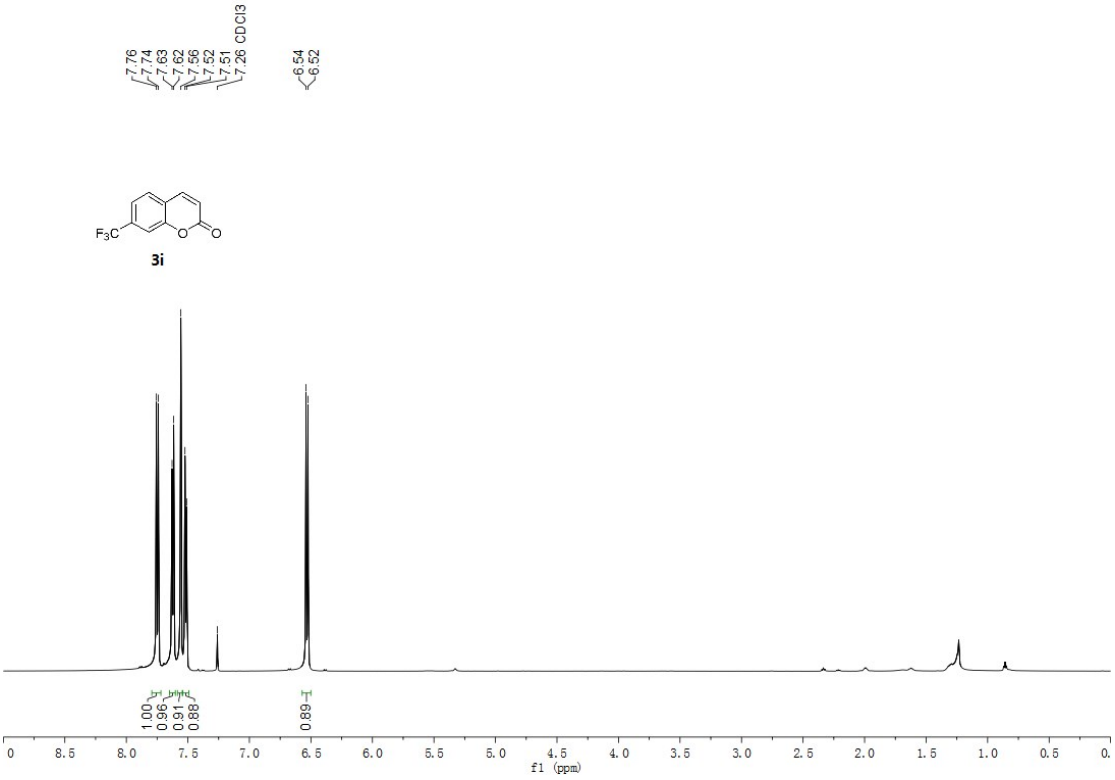

7.68
7.66
7.46
7.45
7.26 CDCl3
7.06
7.02
7.00
6.35
6.33
2.30
AcO
3g
1.01
1.00
0.98
1.01
0.97
3.00
f1 (ppm)

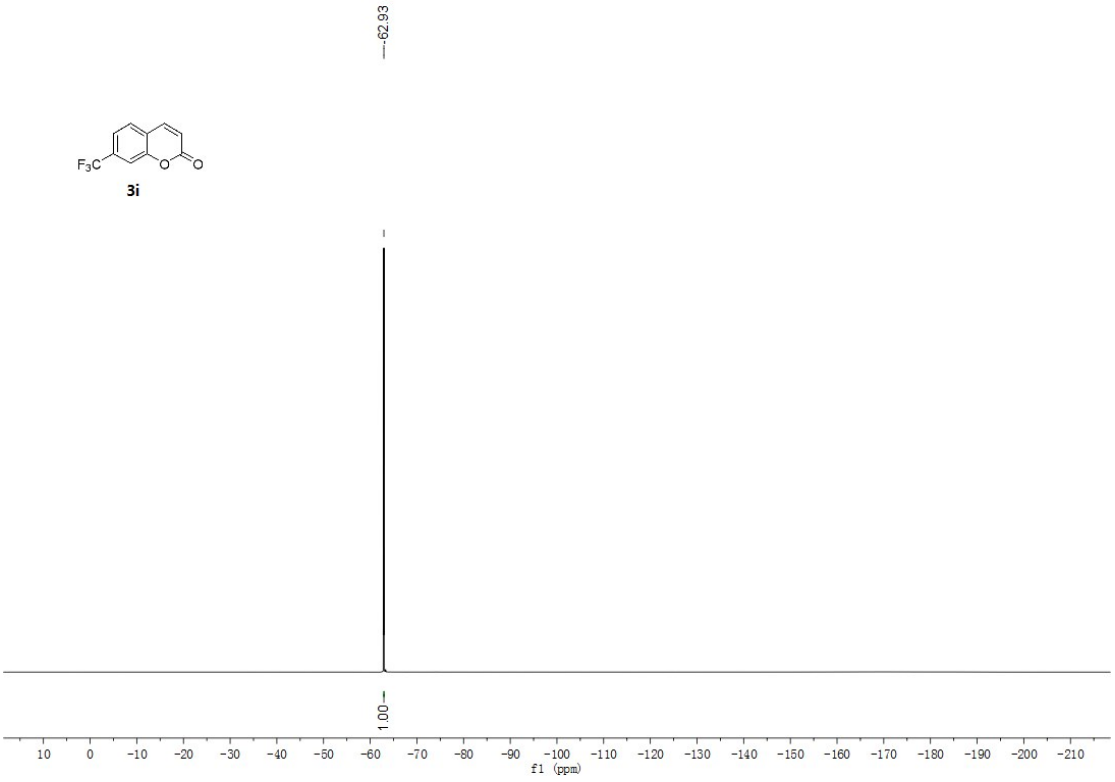

168.61
160.21
154.46
152.98
142.82
128.51
118.29
116.52
115.85
110.24
77.00 CDCl3
20.98
AcO
O
O
3g
f1 (ppm)

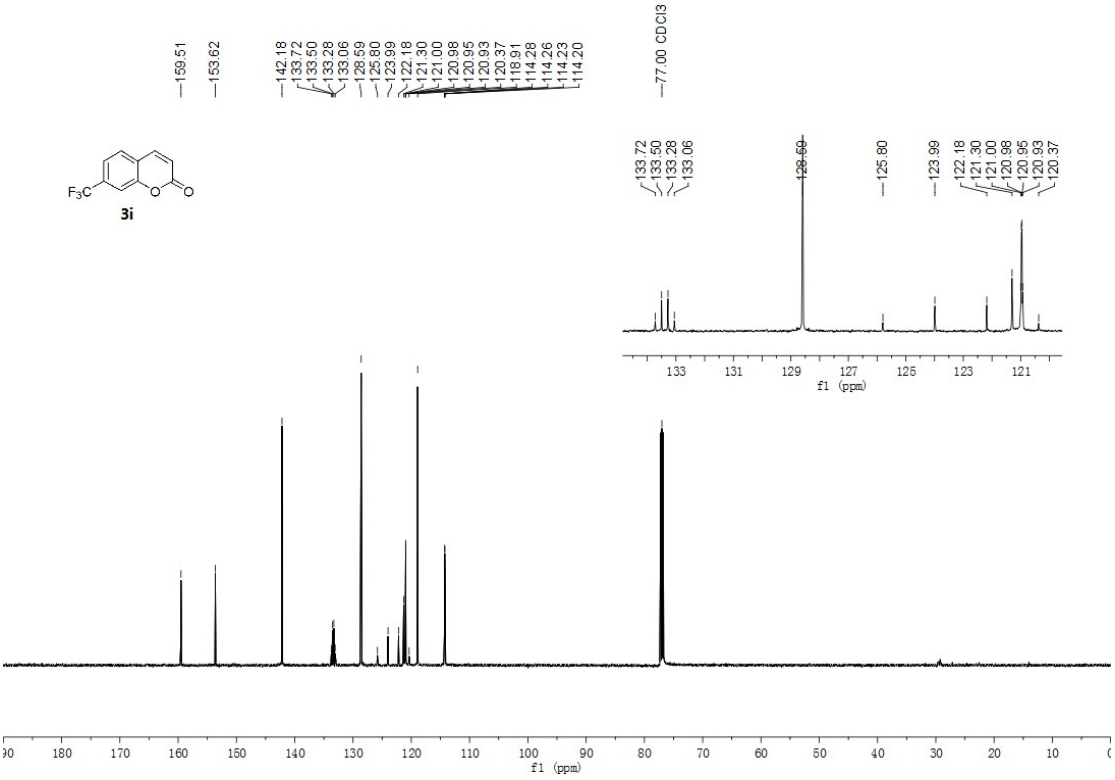

7.71
7.70
7.53
7.51
7.26 CDCl3
7.16
7.13
7.12
6.42
6.40
F3CO
O
O
3h
1.01
1.00
1.03
0.97
1.00
f1 (ppm)


-57.85
F3CO
O
O
3h
10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210
f1 (ppm)


159.77
154.62
151.19
142.45
129.12
122.73
121.02
119.30
117.21
116.74
77.00 CDCl3
122.73
121.02
119.30
117.58
F3CO
O
O
3h
123 122 121 120 119 118
f1 (ppm)
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10
f1 (ppm)


7.76
7.74
7.63
7.62
7.56
7.52
7.51
7.26 CDCl3
6.54
6.52
F3C
O
O
3i
1.00
0.96
0.91
0.88
0.89
f1 (ppm)


-62.93
F3C
O
O
3i
1.00
f1 (ppm)


159.51
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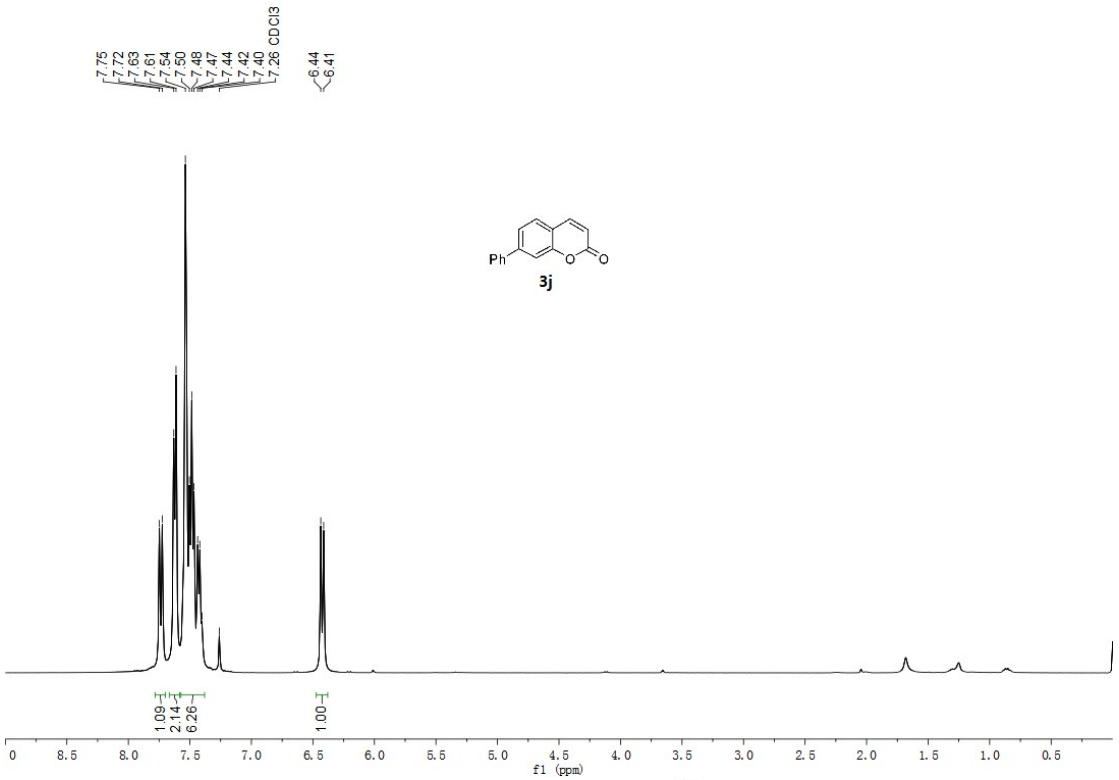
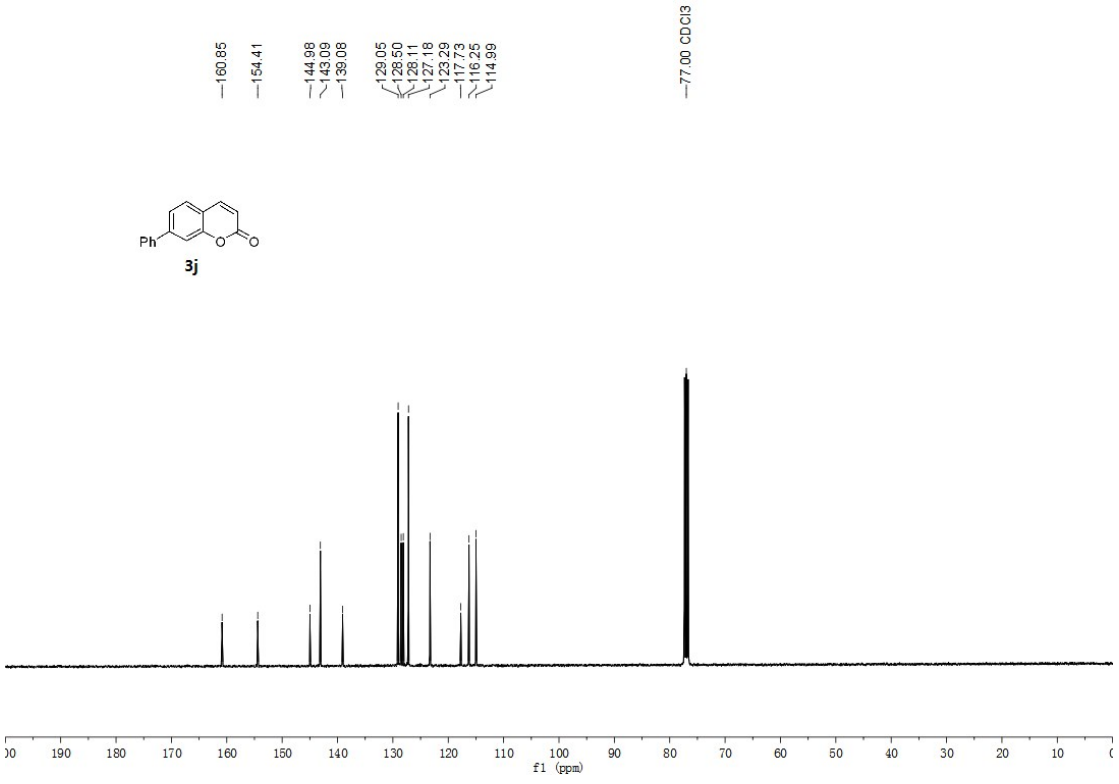
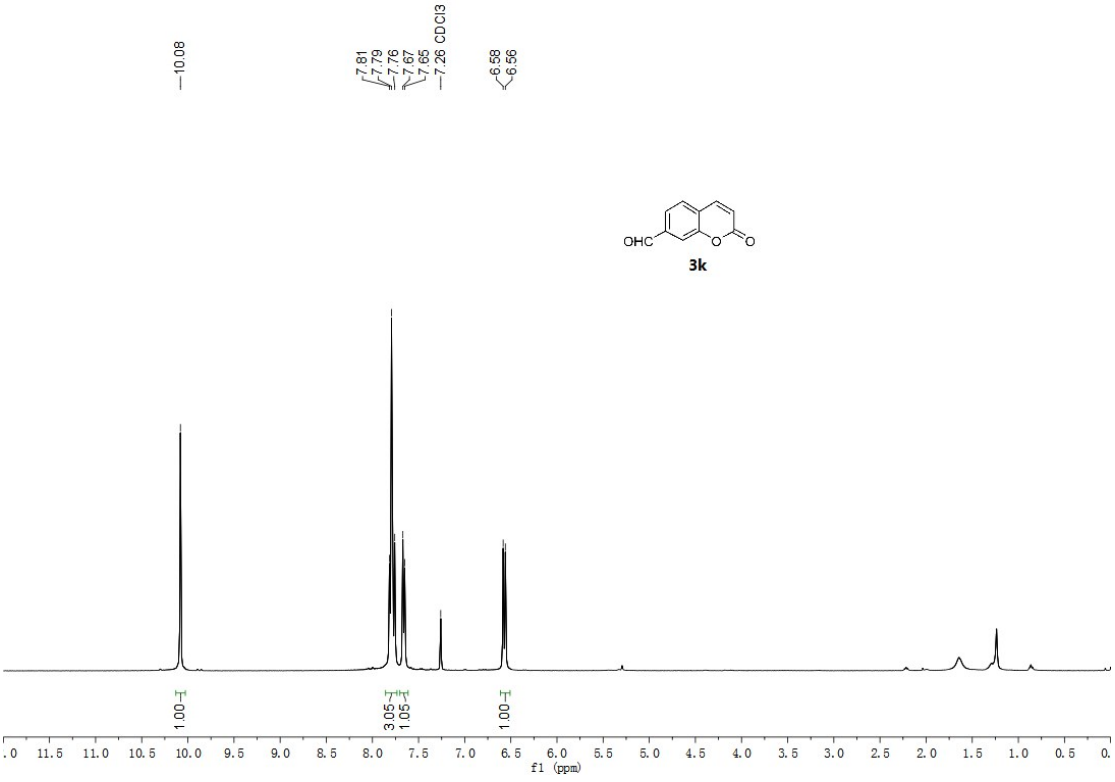
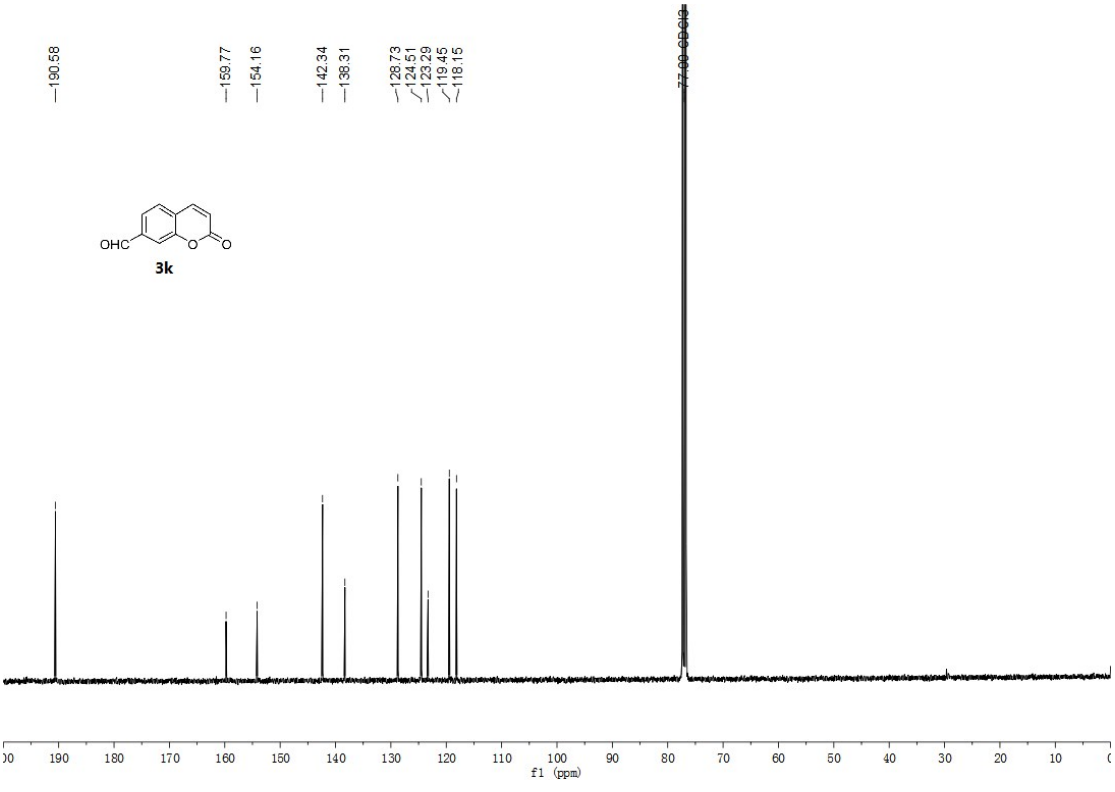
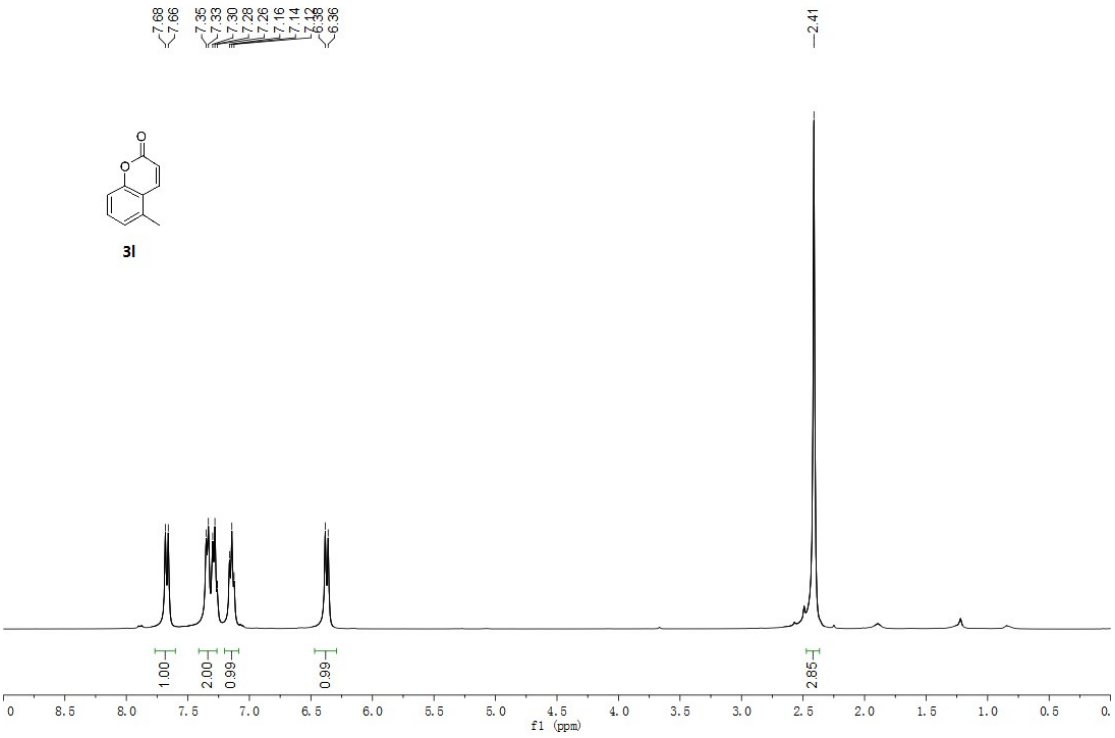
133.50
133.28
133.06
128.59
125.80
123.99
122.18
121.30
121.00
120.98
120.95
120.93
120.37
118.91
114.28
114.26
114.23
114.20
77.00 CDCl3
F3C
O
O
3i
133.72
133.50
133.28
133.06
128.60
125.80
123.99
122.18
121.30
121.00
120.98
120.95
120.93
120.37
f1 (ppm)
f1 (ppm)

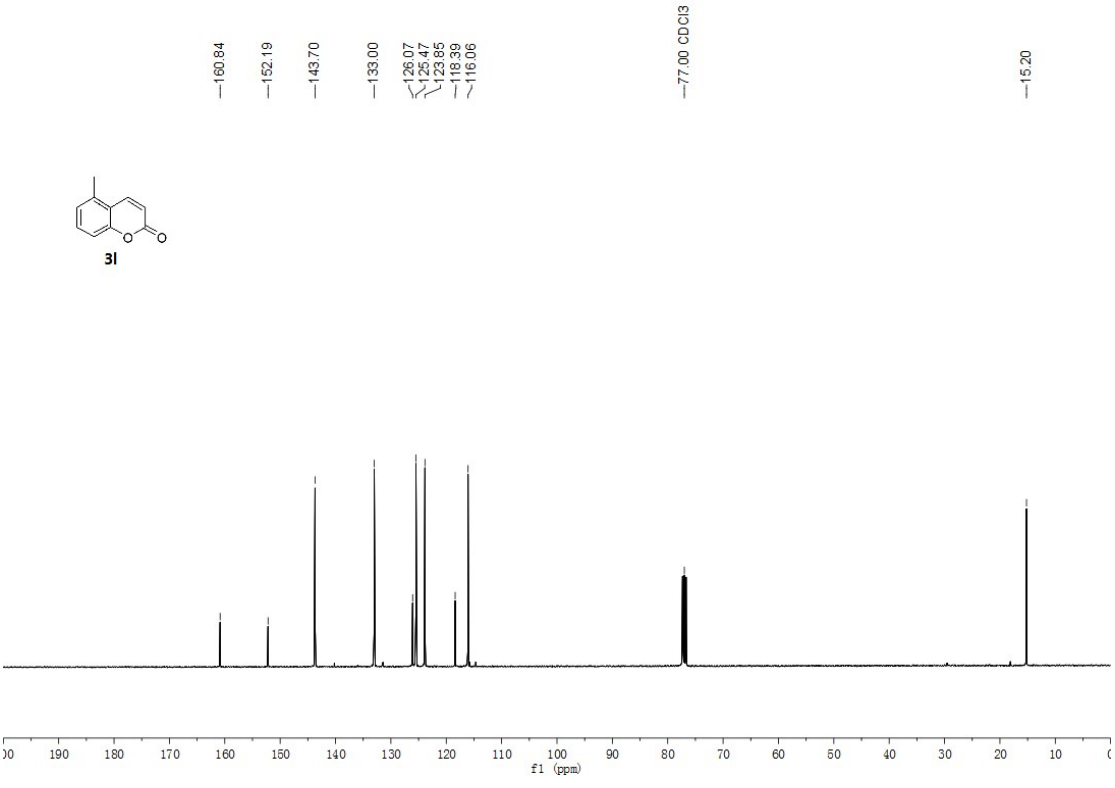

7.75
7.72
7.63
7.61
7.54
7.50
7.48
7.47
7.44
7.42
7.40
7.26 CDCl3
6.44
6.41
Ph
O
O
3j
1.09
2.14
6.26
1.00
f1 (ppm)

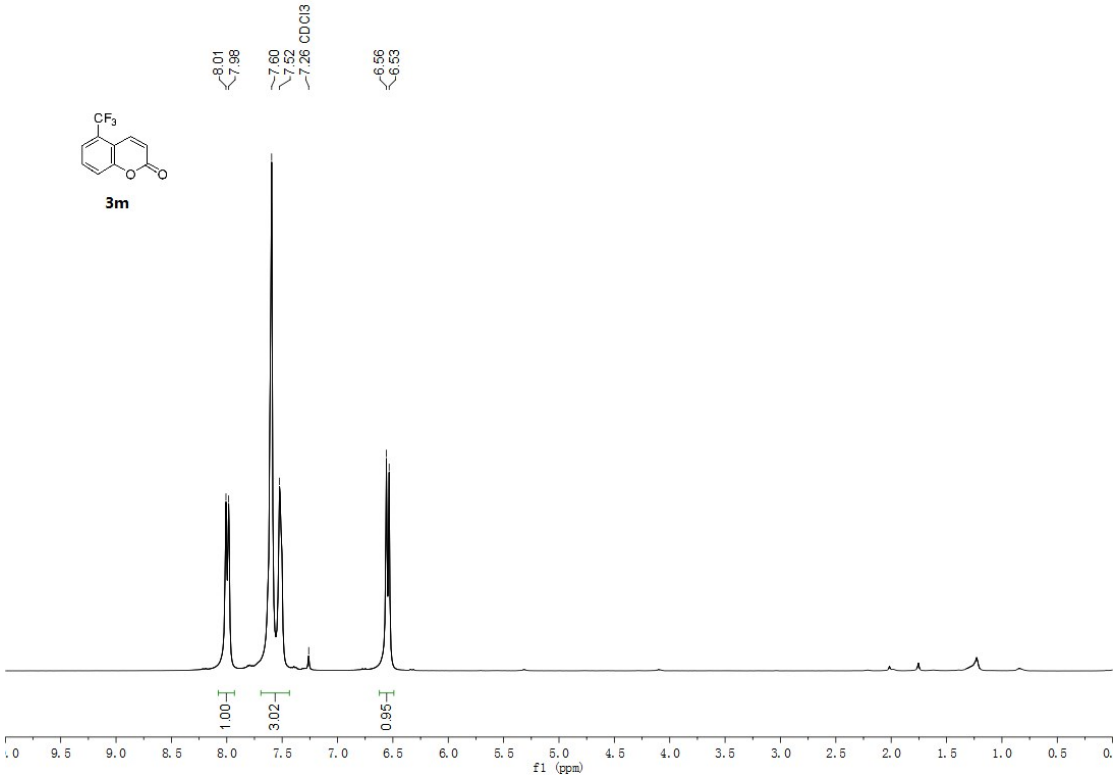

160.85
154.41
144.98
143.09
139.08
129.05
128.50
128.11
127.18
123.29
117.73
116.25
114.99
77.00 CDCl3
Ph
O
O
3j
f1 (ppm)

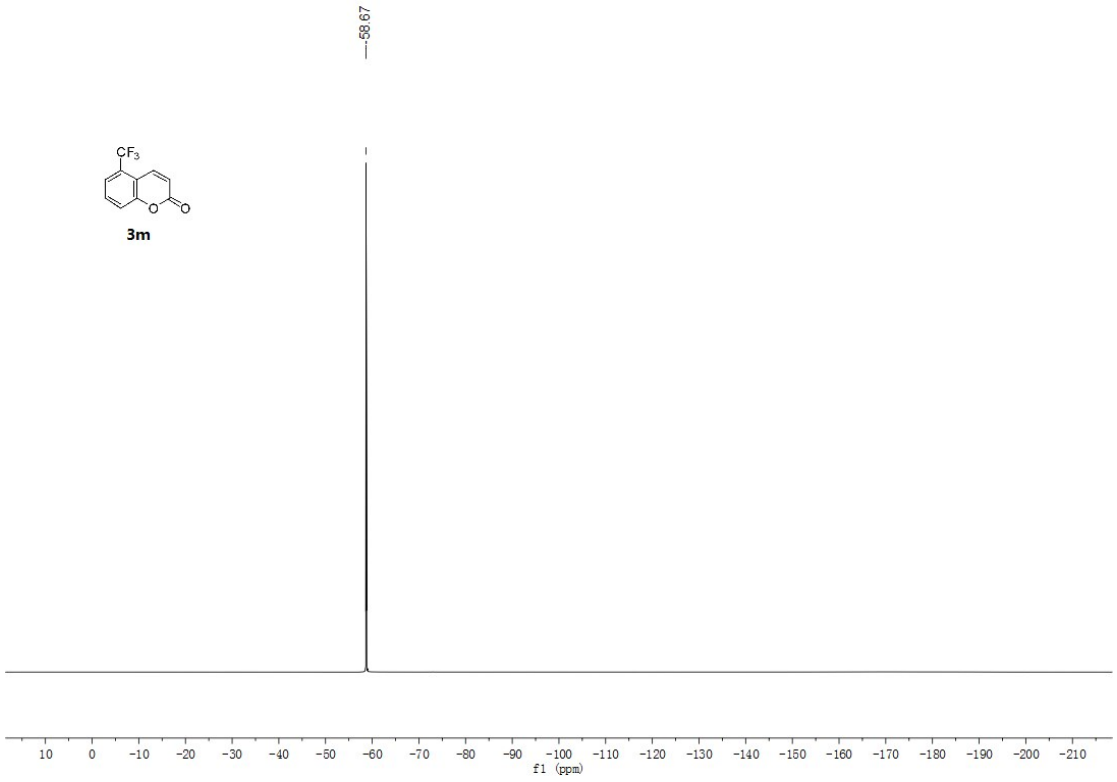

10.08
7.81
7.79
7.76
7.67
7.65
7.26 CDCl3
6.58
6.56
OHC
O
O
3k
1.00
3.05
1.05
1.00
f1 (ppm)

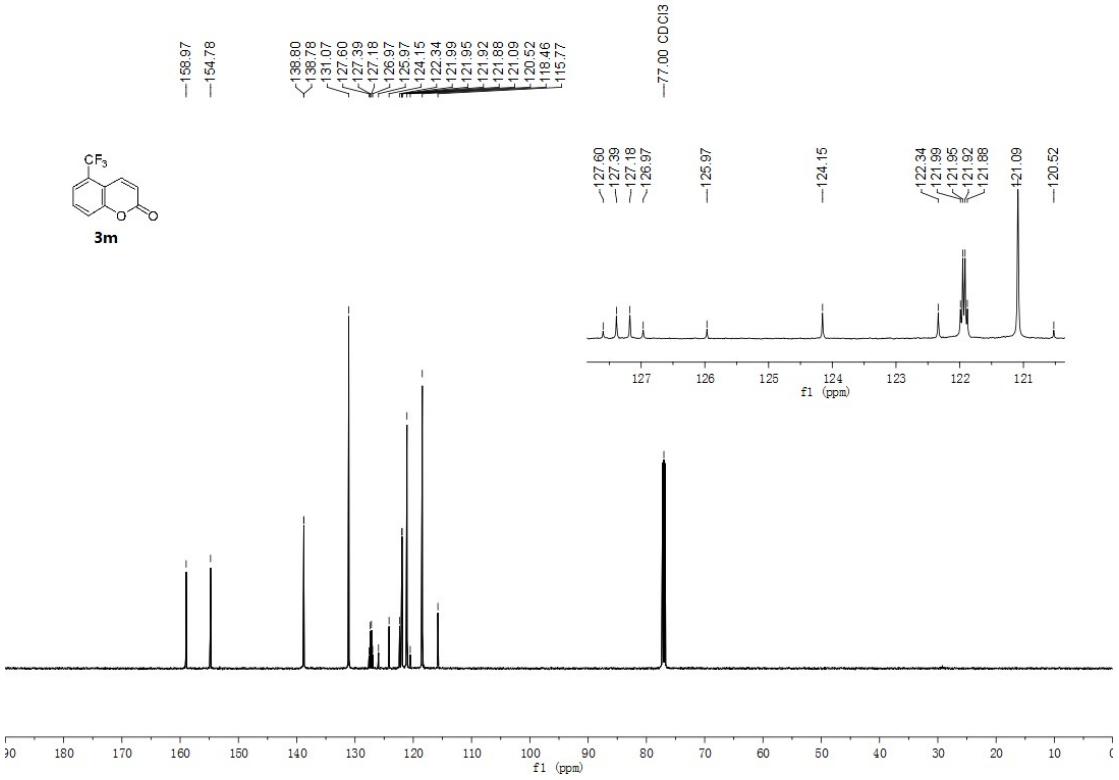

190.58
159.77
154.16
142.34
138.31
128.73
124.51
123.29
119.45
118.15
77.00
OHC
O
O
3k
f1 (ppm)

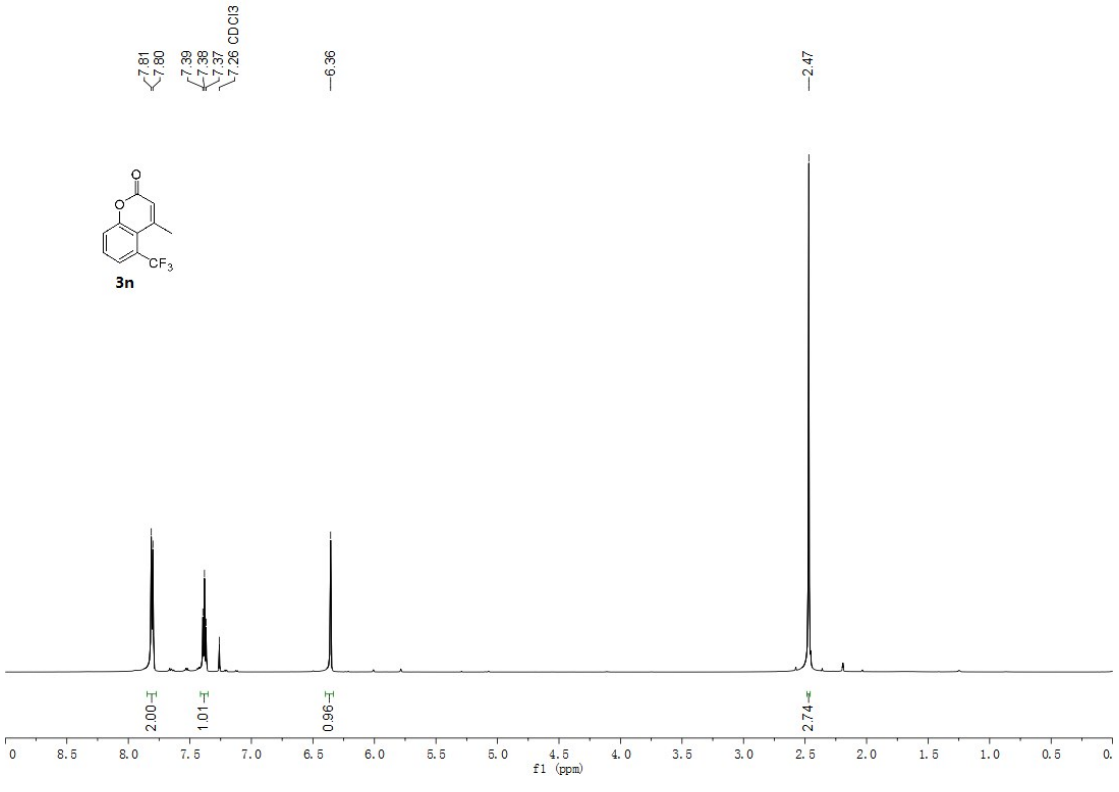

7.68
7.66
7.35
7.33
7.30
7.28
7.26
7.16
7.14
7.12
6.38
6.36
2.41
3l
1.00
2.00
0.99
0.99
2.85
f1 (ppm)

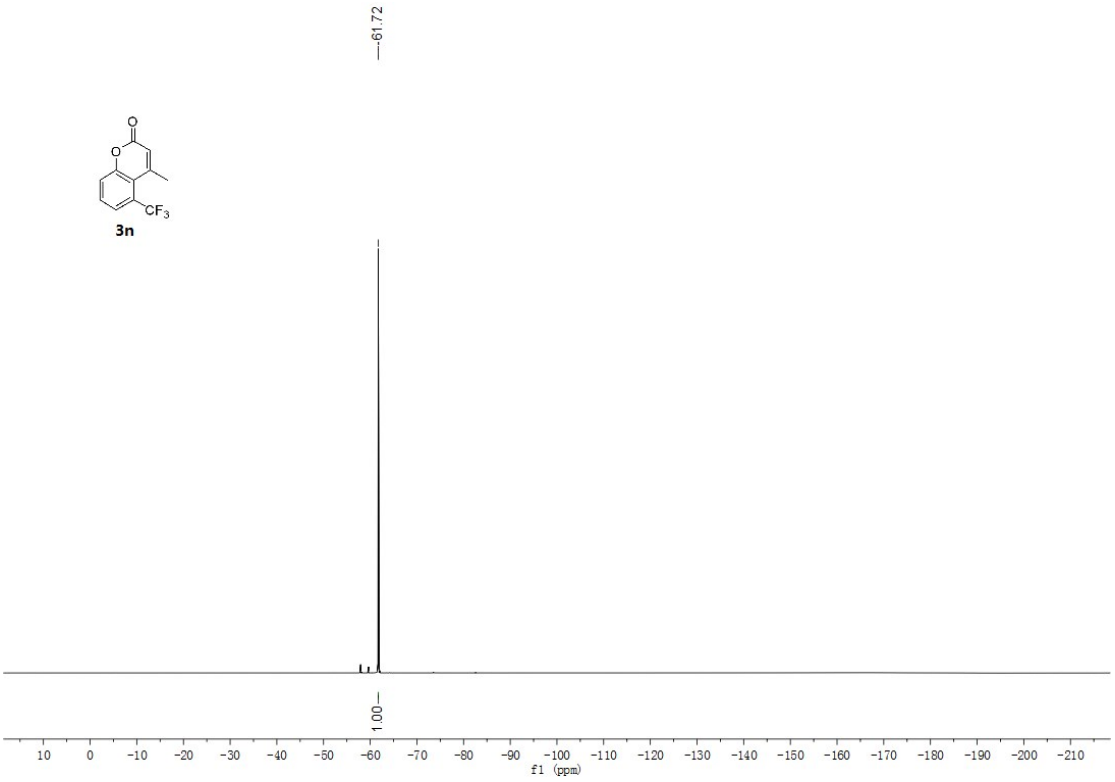

160.84
152.19
143.70
133.00
126.07
125.47
123.85
118.39
116.06
77.00 CDCl3
15.20
3l
f1 (ppm)

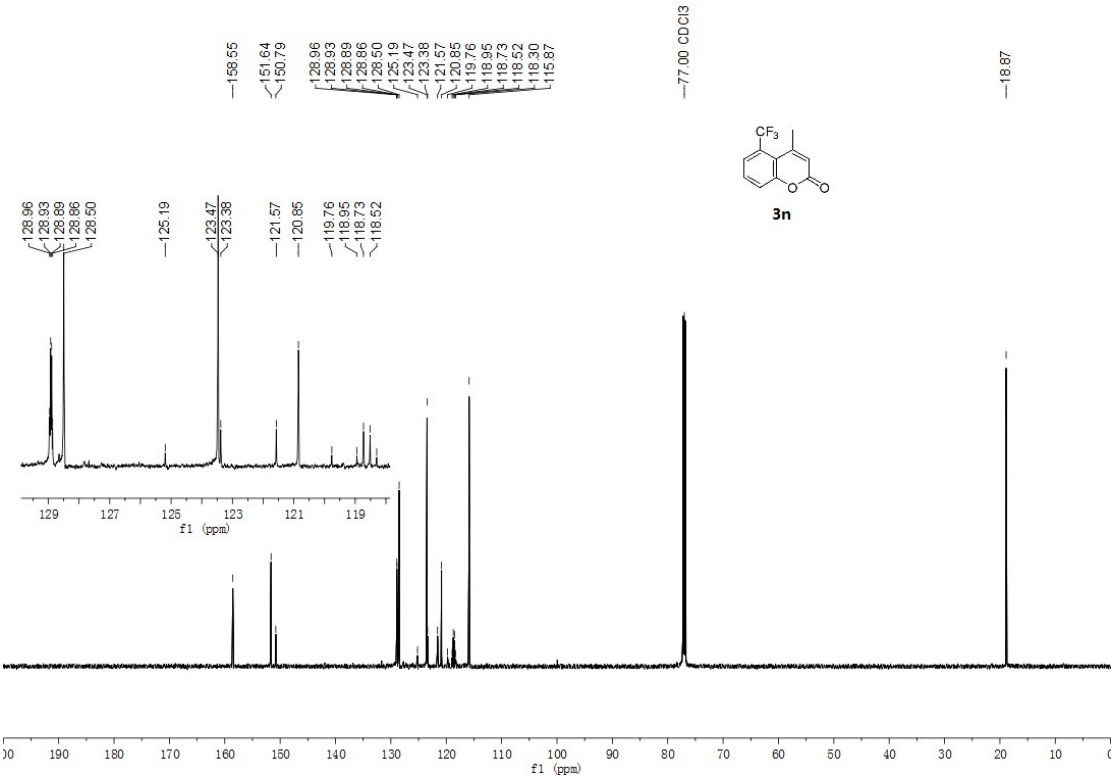

8.01
7.98
7.60
7.52
7.26 CDCl3
6.56
6.53
CF3
O
O
3m
1.00
3.02
0.95
f1 (ppm)

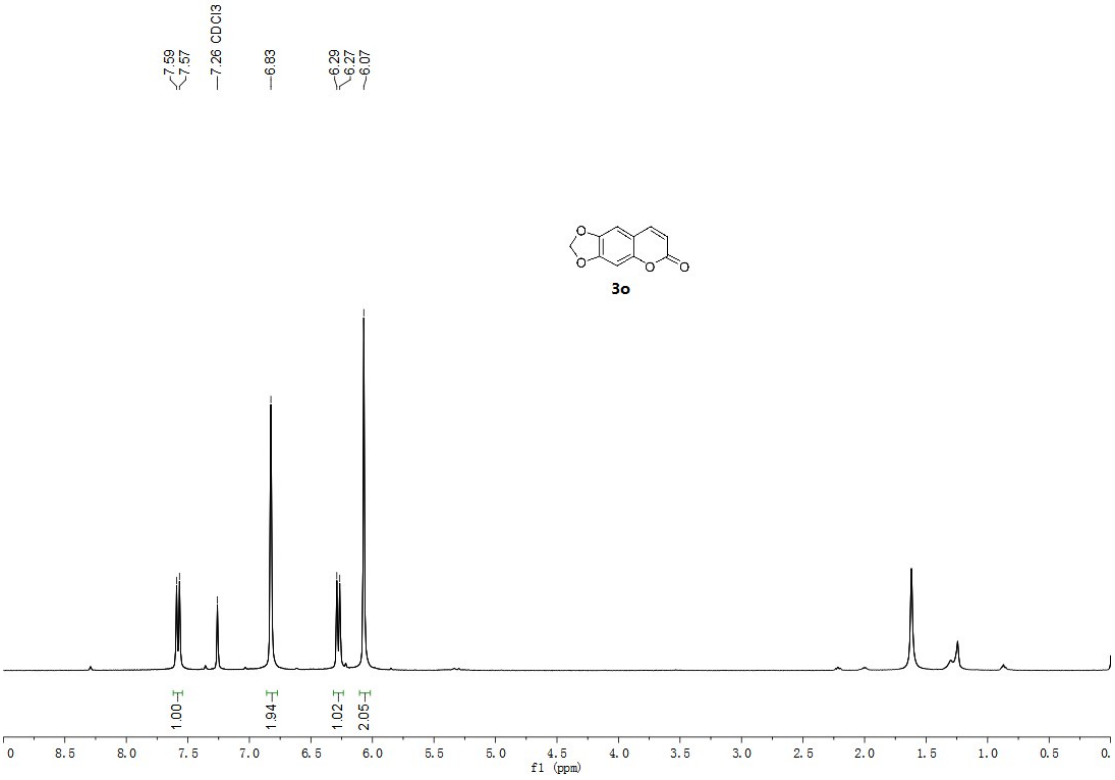

-58.67
CF3
O
O
3m
f1 (ppm)

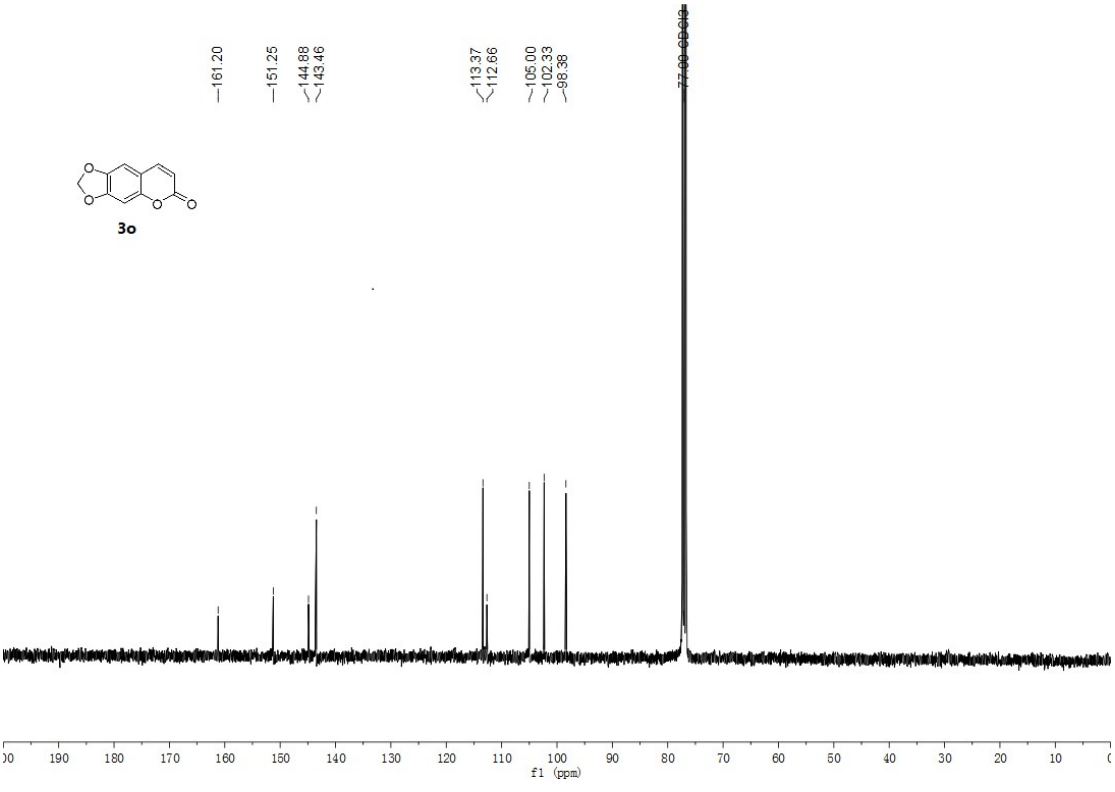

158.97
154.78
138.80
138.78
131.07
127.60
127.39
127.18
126.97
125.97
124.15
122.34
121.99
121.95
121.92
121.88
121.09
120.52
118.46
115.77
77.00 CDCl3
CF3
O
O
3m
127.60
127.39
127.18
126.97
125.97
124.15
122.34
121.99
121.95
121.92
121.88
121.09
120.52
f1 (ppm)

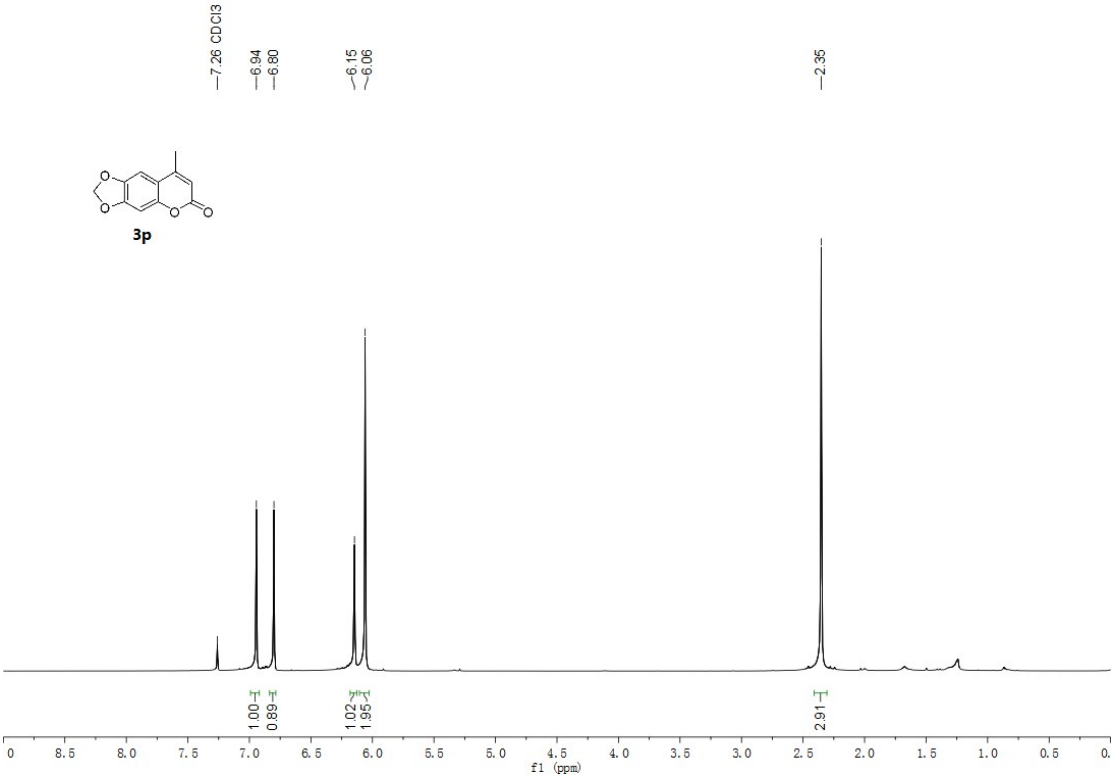

7.81
7.80
7.39
7.38
7.37
7.26 CDCl3
6.36
2.47
O
O
CF3
3n
2.00
1.01
0.96
2.74
f1 (ppm)

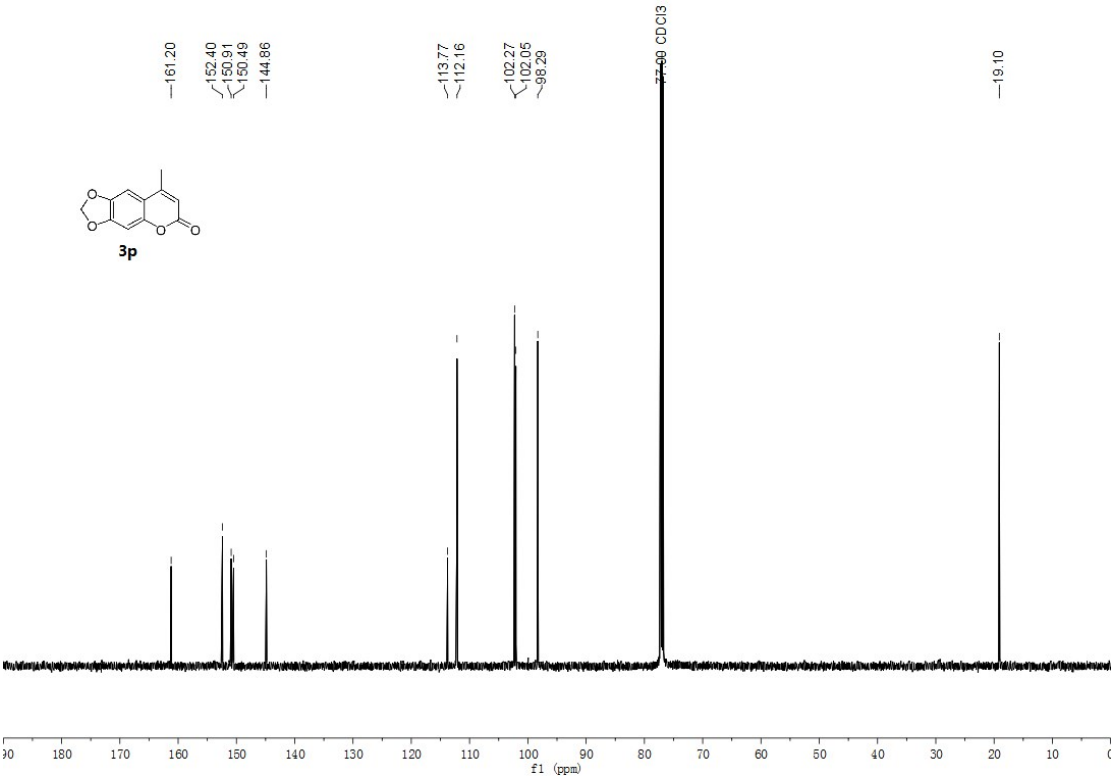

-61.72
3n
1.00
f1 (ppm)

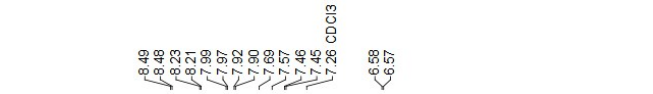

158.55
151.64
150.79
128.96
128.93
128.89
128.86
128.50
125.19
123.47
123.38
121.57
120.85
119.76
118.95
118.73
118.52
118.30
115.87
77.00 CDCl3
18.87
3n
f1 (ppm)

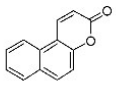

7.59
7.57
7.26 CDCl3
6.83
6.29
6.27
6.07
3o
1.00
1.94
1.02
2.05
f1 (ppm)


161.20
151.25
144.88
143.46
113.37
112.66
105.00
102.33
98.38
77.00
3o
f1 (ppm)

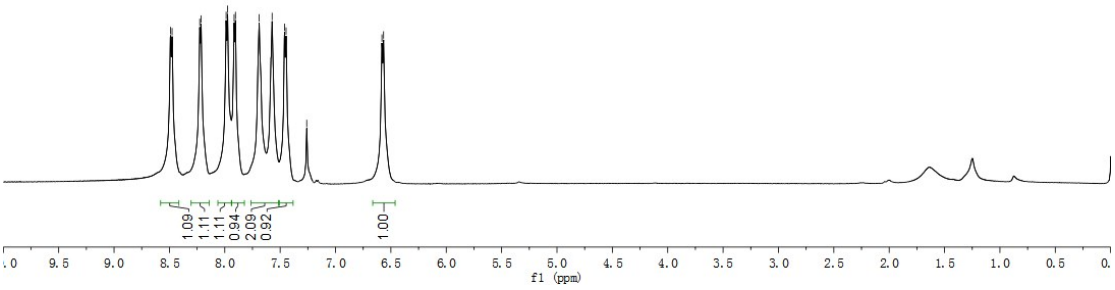

7.26 CDCl3
6.94
6.80
6.15
6.06
2.35
3p
1.00
0.89
1.02
1.95
2.91
f1 (ppm)

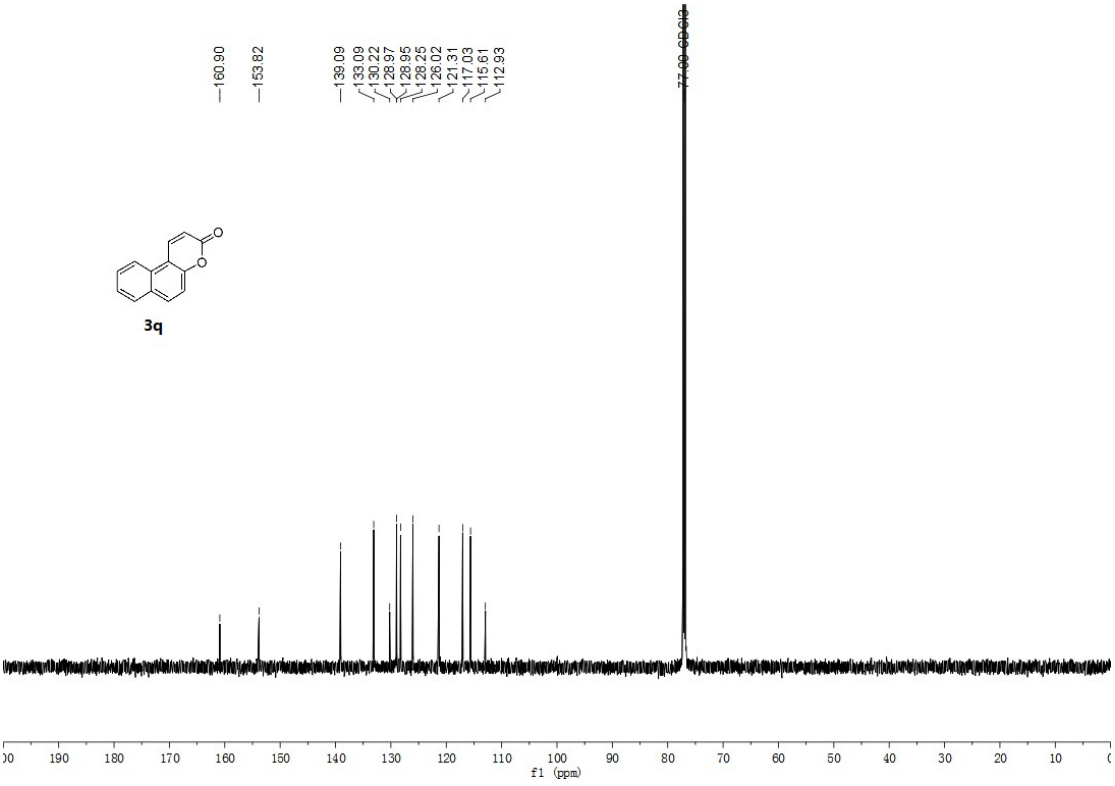

161.20
152.40
150.91
150.49
144.86
113.77
112.16
102.27
102.05
98.29
77.00 CDCl3
19.10
3p
f1 (ppm)


8.49
8.48
8.23
8.21
7.99
7.97
7.92
7.90
7.69
7.57
7.46
7.45
7.26 CDCl3
6.58
6.57

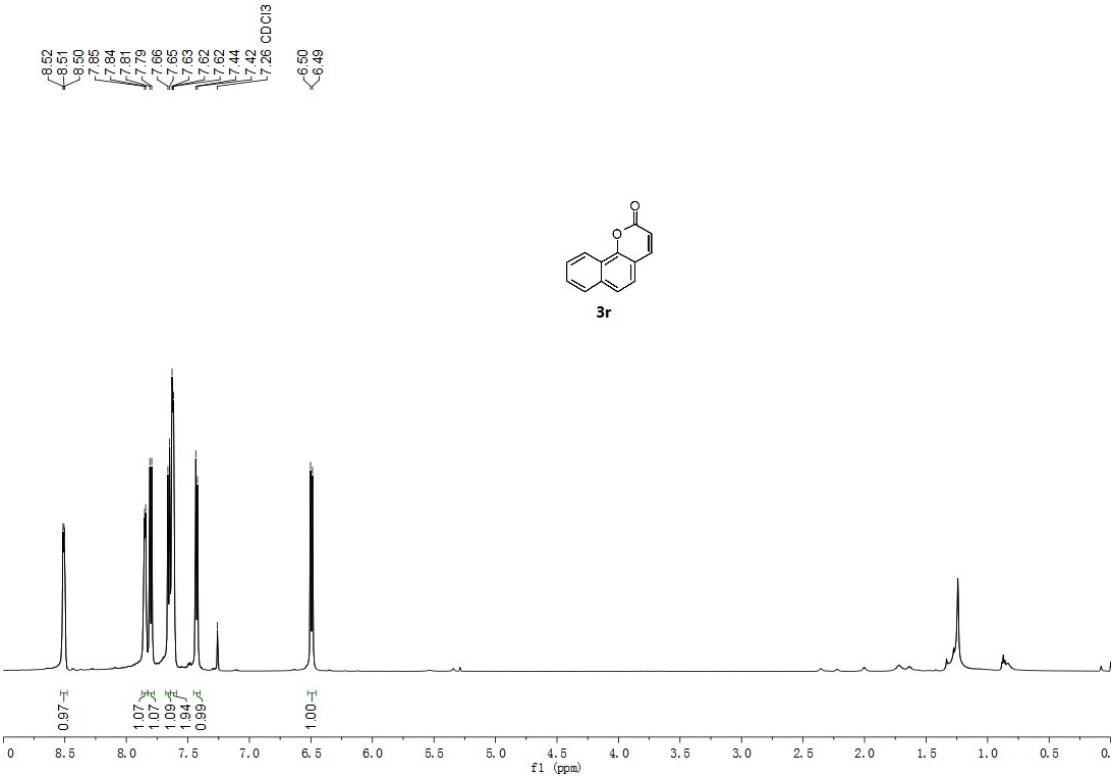


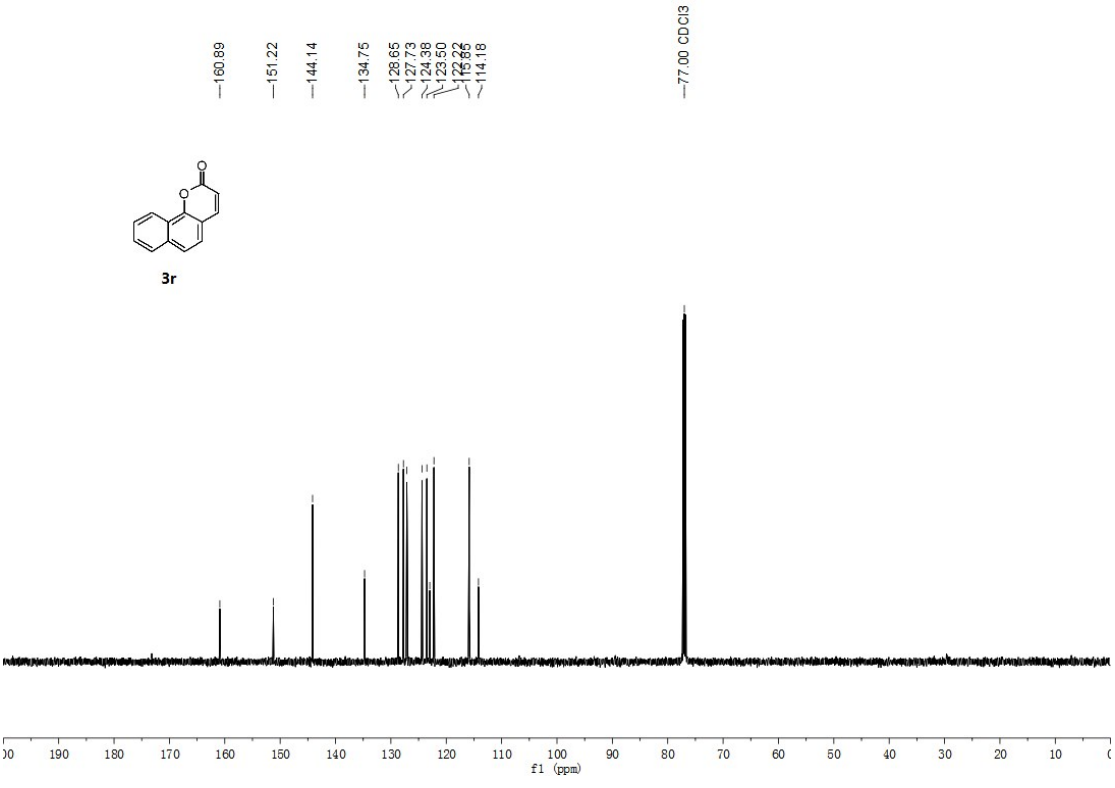
3q


1.09
1.11
1.11
0.94
2.09
0.92
1.00
f1 (ppm)


160.90
153.82
139.09
133.09
130.22
128.97
128.95
128.25
126.02
121.31
117.03
115.61
112.93
77.00
f1 (ppm)

3q


8.52
8.51
8.50
7.85
7.84
7.81
7.79
7.66
7.65
7.63
7.62
7.62
7.44
7.42
7.26 CDCl3
6.50
6.49
3r
0.97
1.07
1.07
1.09
1.94
0.99
1.00
f1 (ppm)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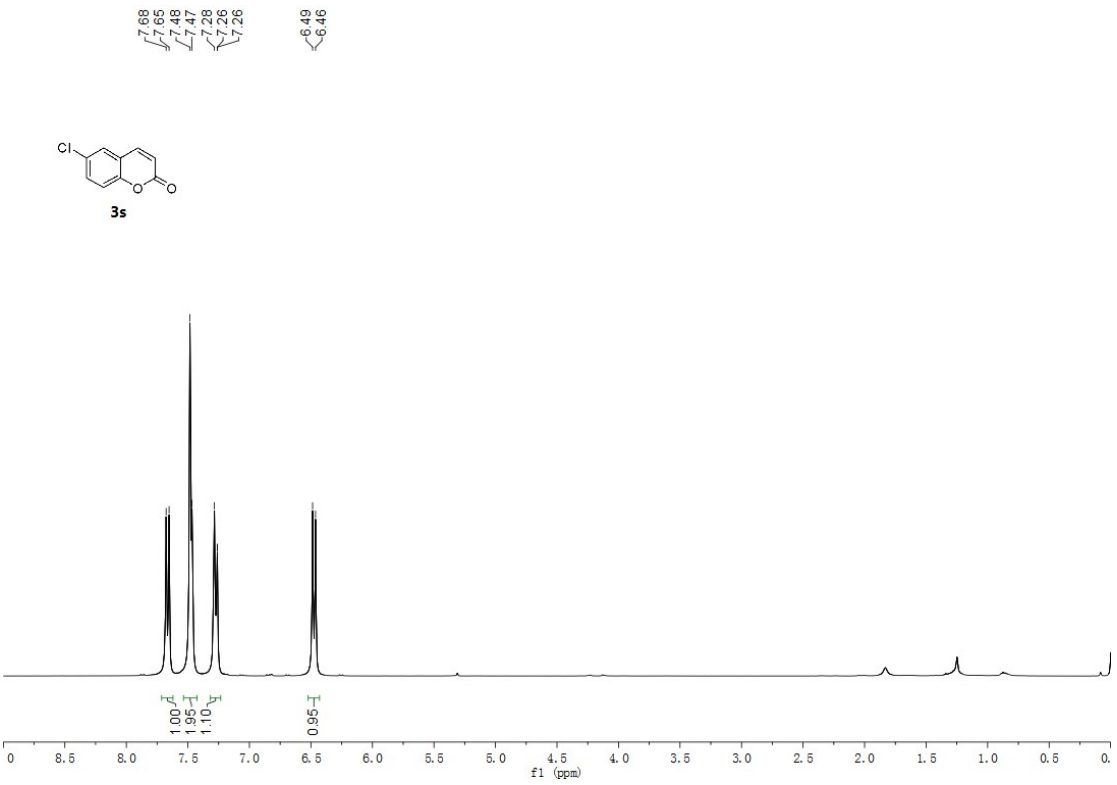
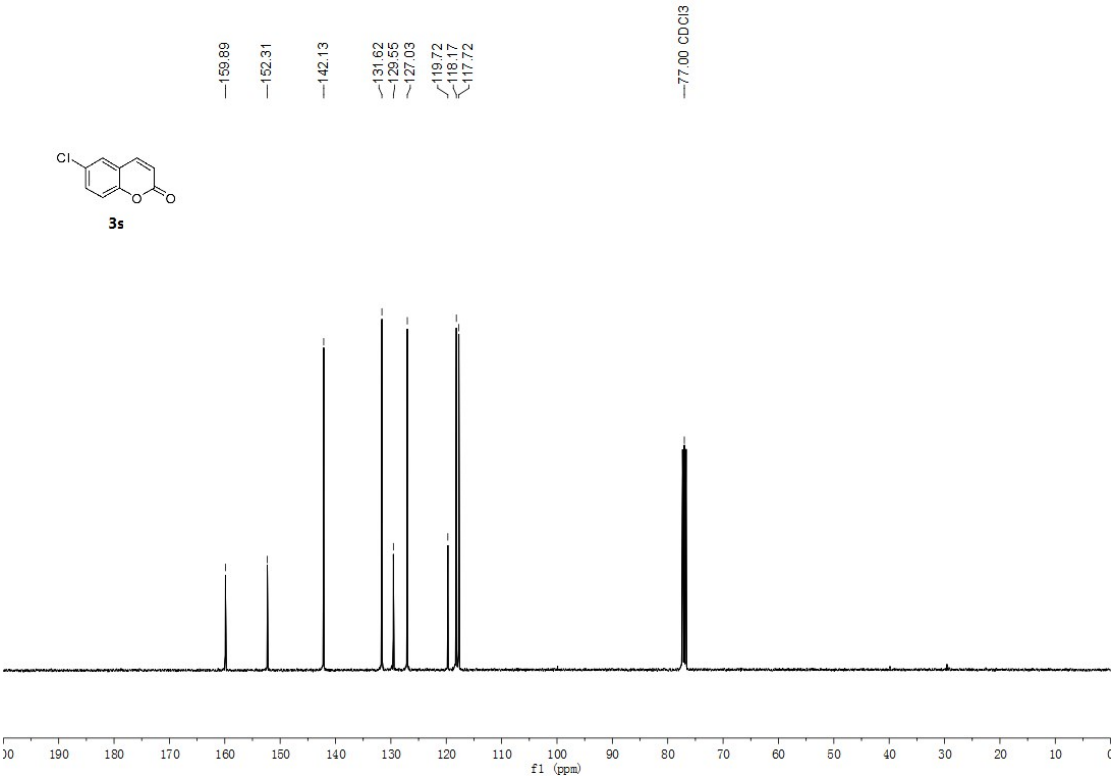
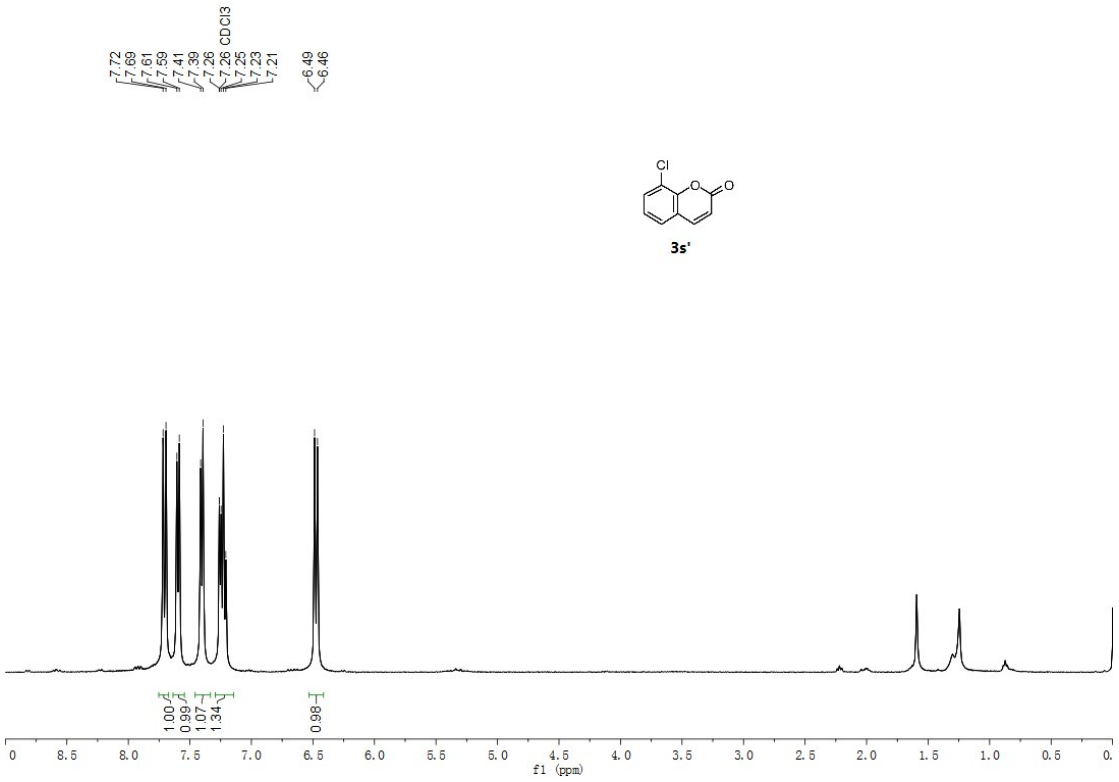
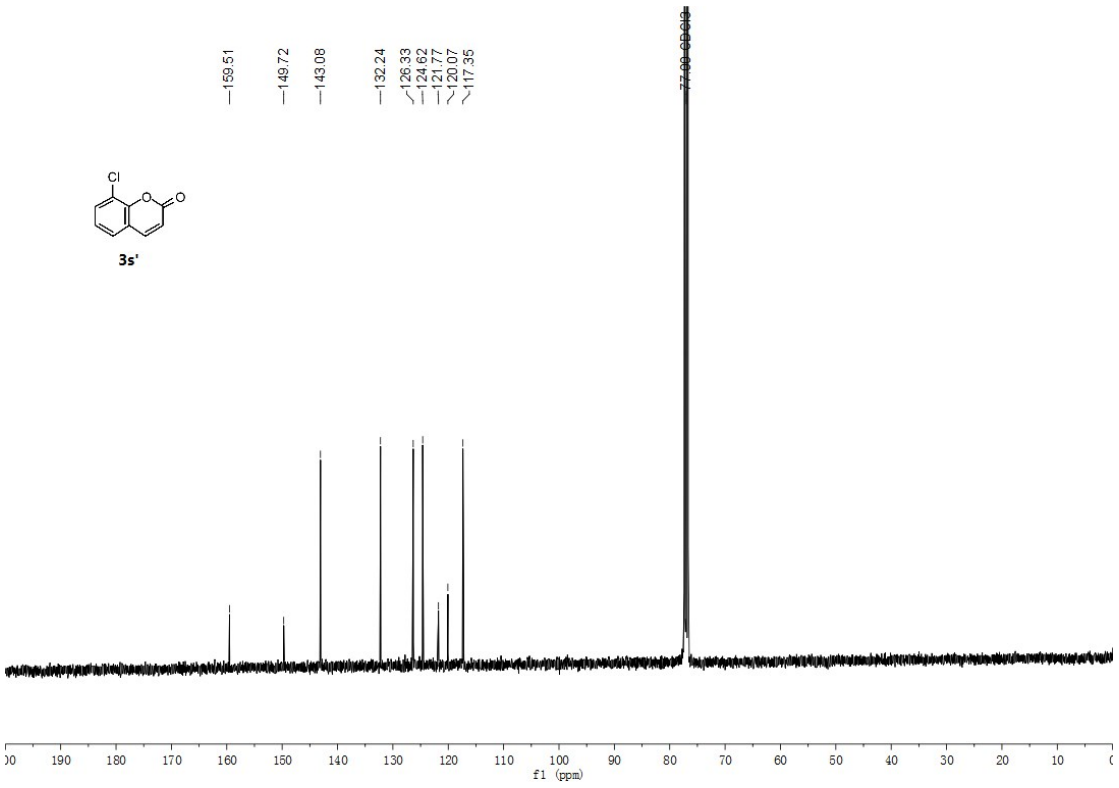
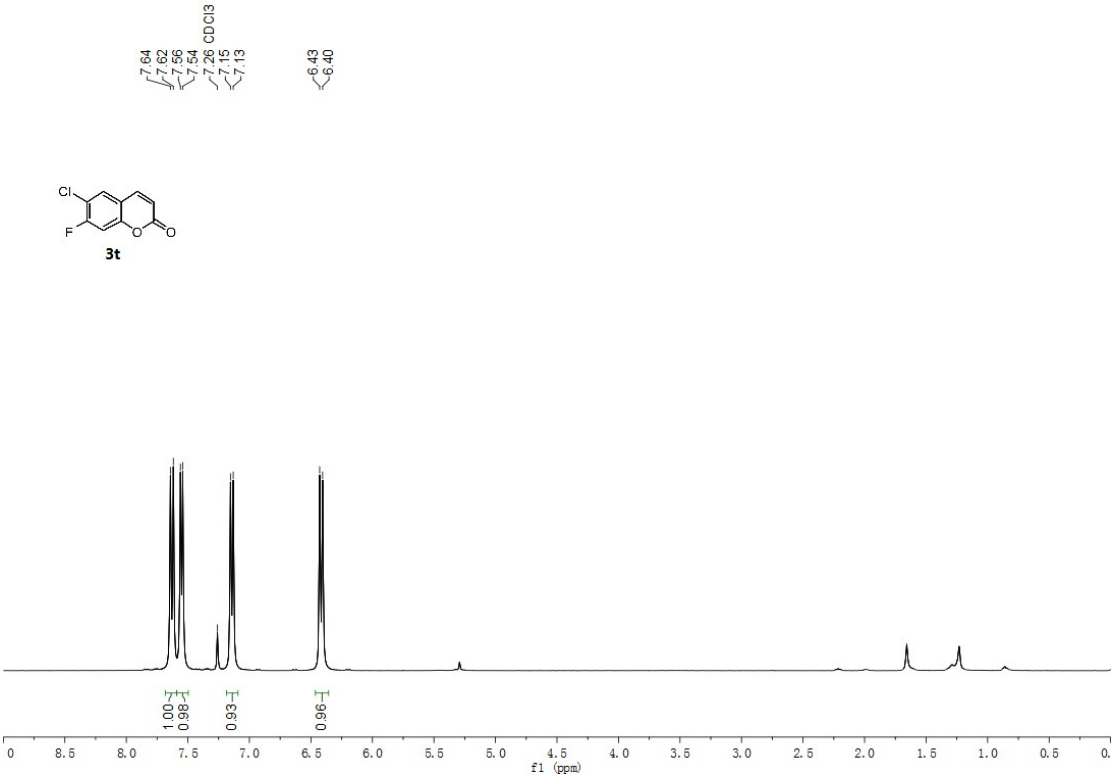
151.22
144.14
134.75
128.65
127.73
124.38
123.50
77.00 CDCl3
3r
f1 (ppm)

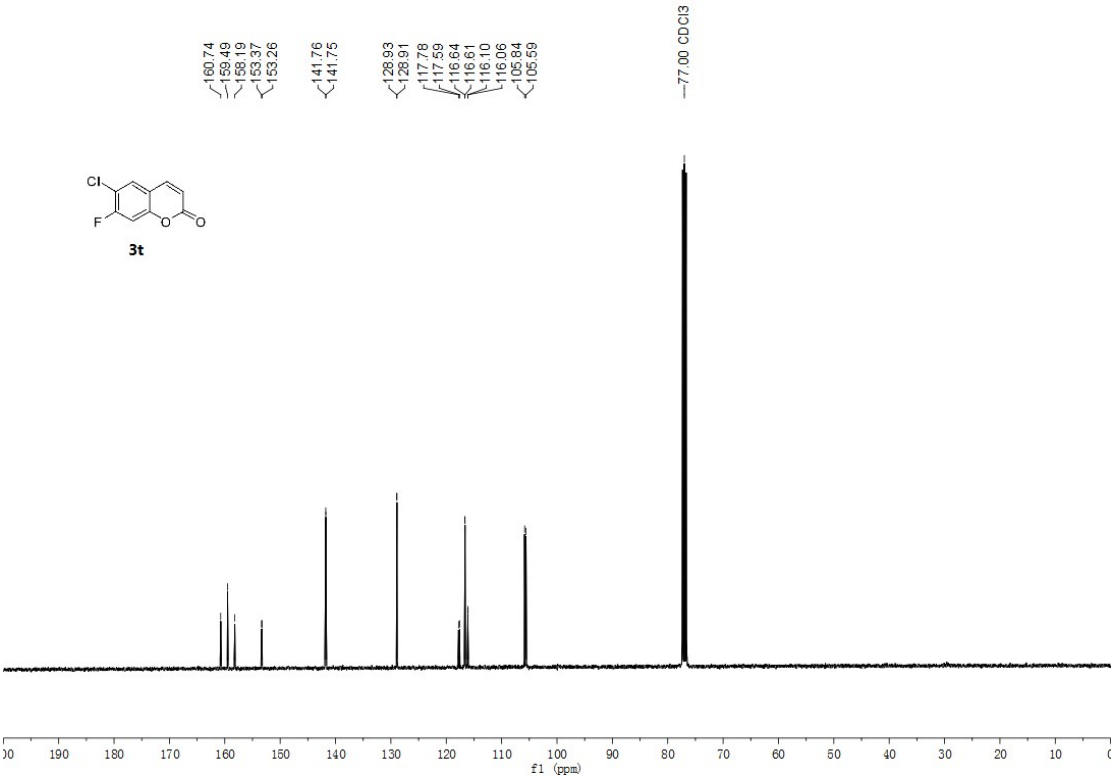

7.68
7.65
7.48
7.47
7.28
7.26
7.26
6.49
6.46
Cl
O
O
3s
1.00
1.95
1.10
0.95
f1 (ppm)

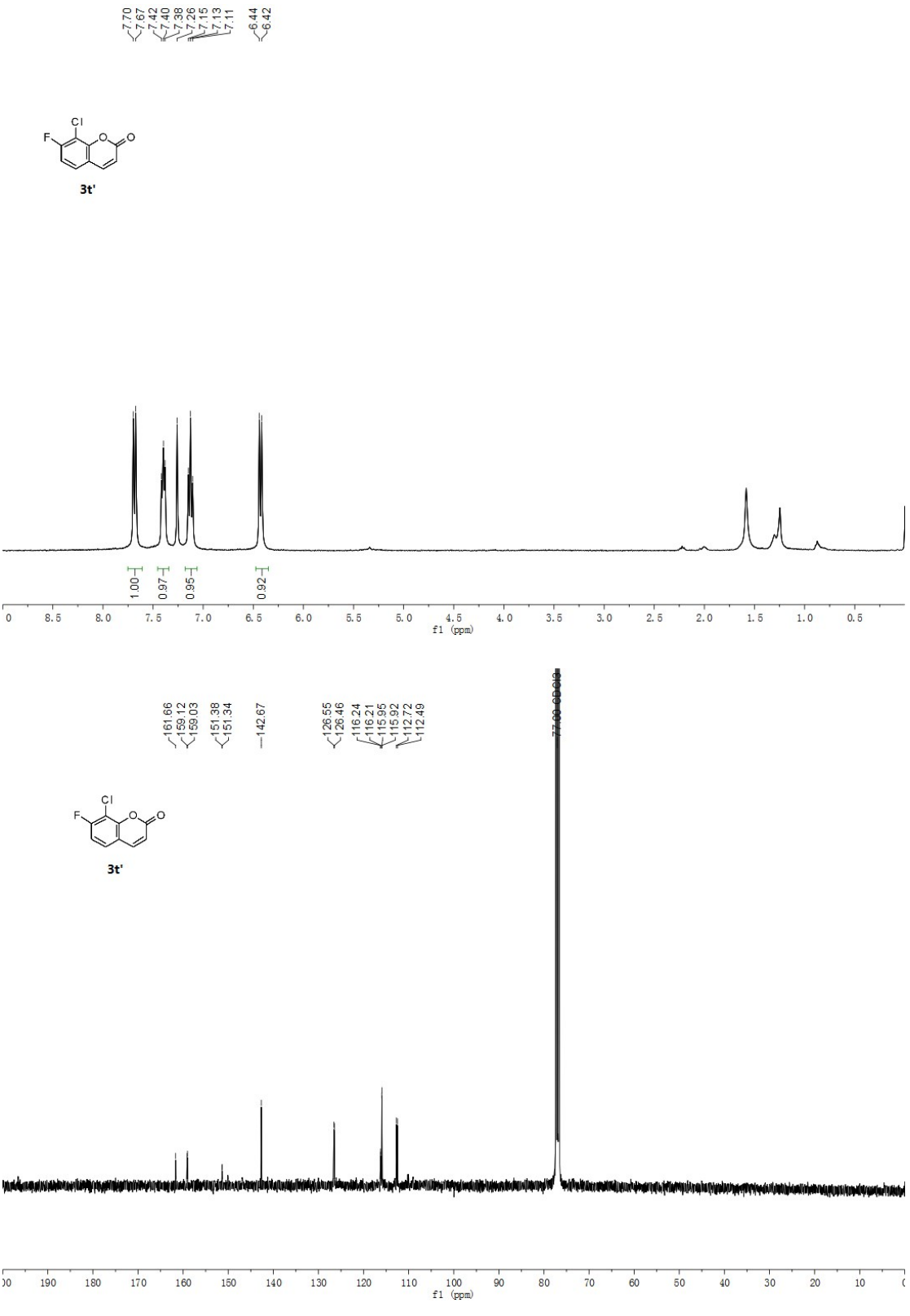

159.89
152.31
142.13
131.62
129.55
127.03
119.72
118.17
117.72
77.00 CDCl3
Cl
O
O
3s
f1 (ppm)

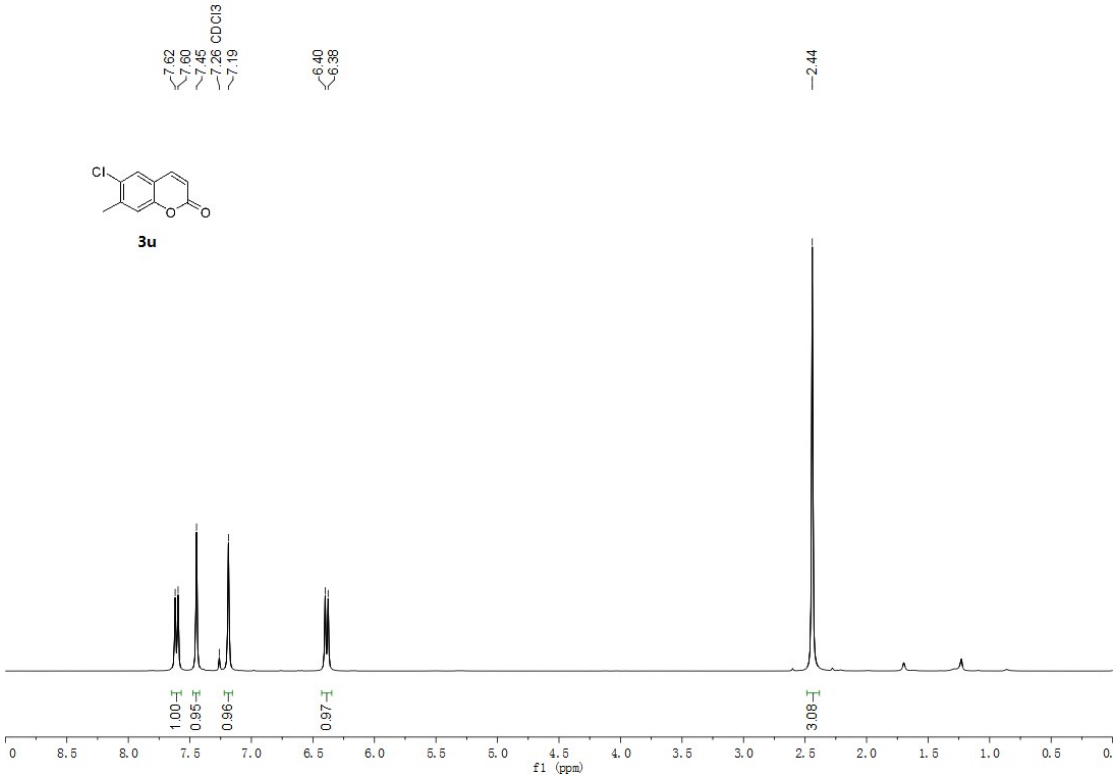

7.72
7.69
7.61
7.59
7.41
7.39
7.26
7.26 CDCl3
7.25
7.23
7.21
6.49
6.46
Cl
O
O
3s'
1.00
0.99
1.07
1.34
0.98
f1 (ppm)

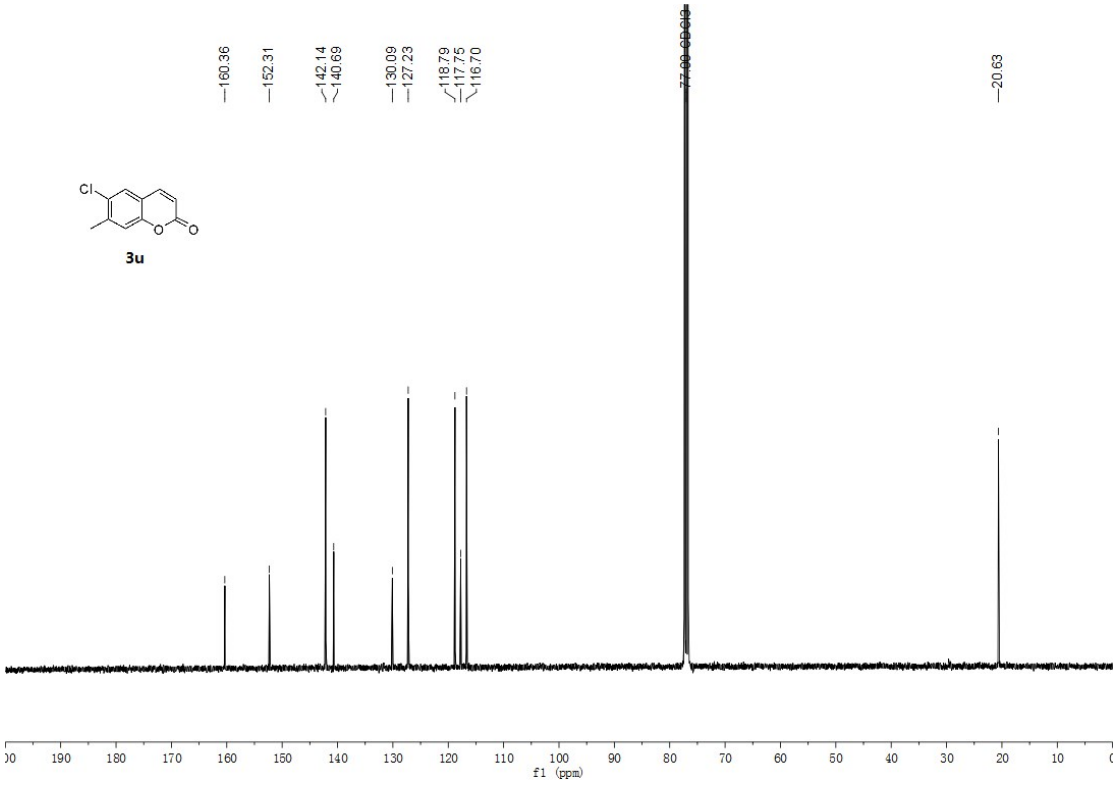

159.51
149.72
143.08
132.24
126.33
124.62
121.77
120.07
117.35
77.00
Cl
O
O
3s'
f1 (ppm)

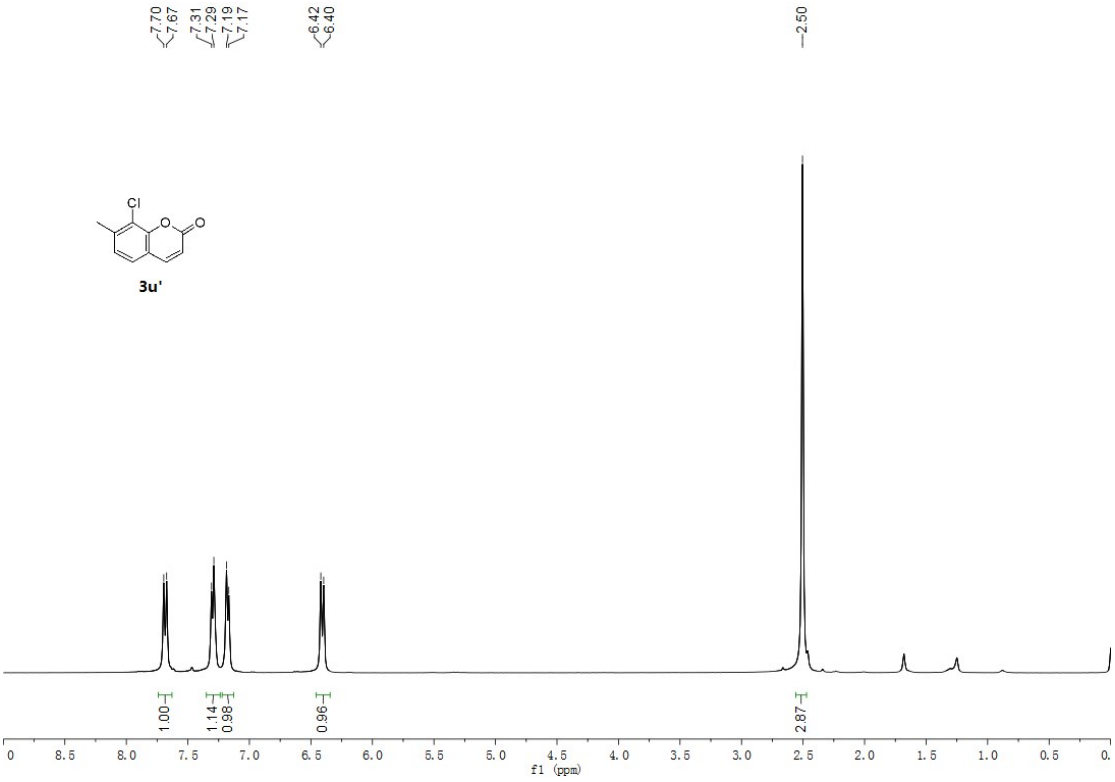

7.64
7.62
7.56
7.54
7.26 CDCl3
7.15
7.13
6.43
6.40
Cl
F
O
O
3t
1.00
0.98
0.93
0.96
f1 (ppm)

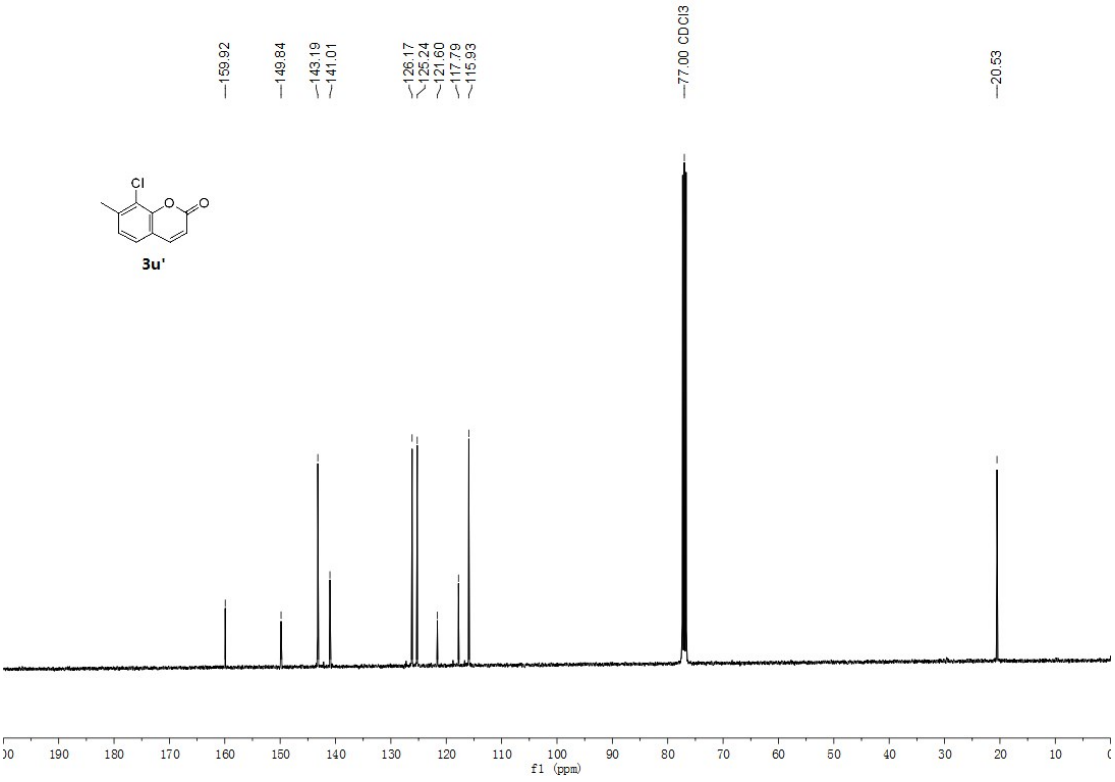

160.74
159.49
158.19
153.37
153.26
141.76
141.75
128.93
128.91
117.78
117.59
116.64
116.61
116.10
116.06
105.84
105.59
77.00 CDCl3
Cl
F
O
O
3t
f1 (ppm)

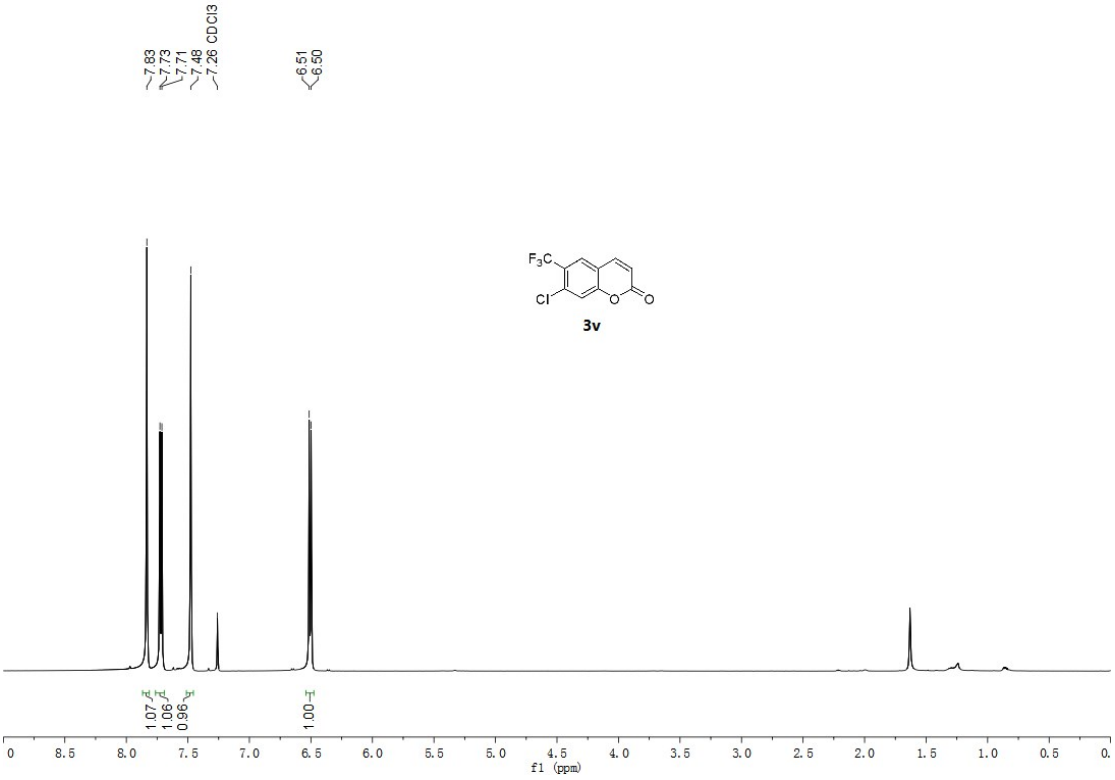

7.70
7.67
7.42
7.40
7.38
7.26
7.15
7.13
7.11
6.44
6.42
Cl
F
O
O
3t'
1.00
0.97
0.95
0.92
f1 (ppm)
161.66
159.12
159.03
151.38
151.34
142.67
126.55
126.46
116.24
116.21
115.95
115.92
112.72
112.49
77.00
Cl
F
O
O
3t'
f1 (ppm)

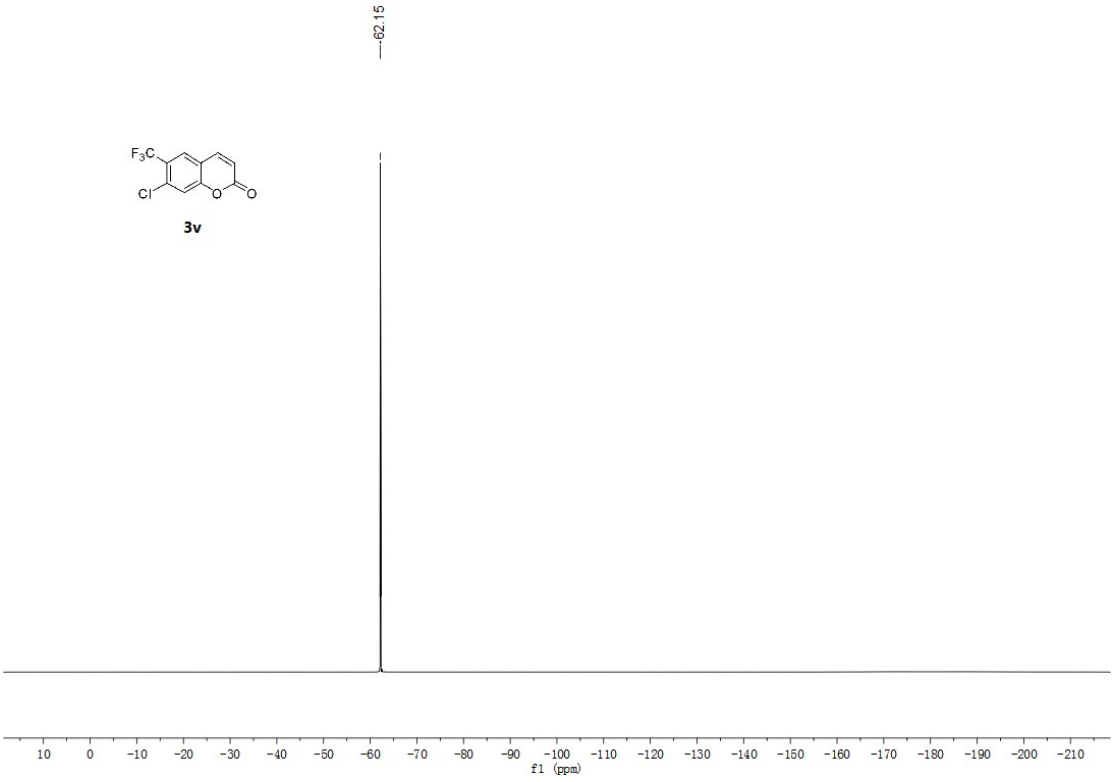

7.62
7.60
7.45
7.26 CDCl3
7.19
6.40
6.38
2.44
Cl
O
O
3u
1.00
0.95
0.96
0.97
3.08
f1 (ppm)

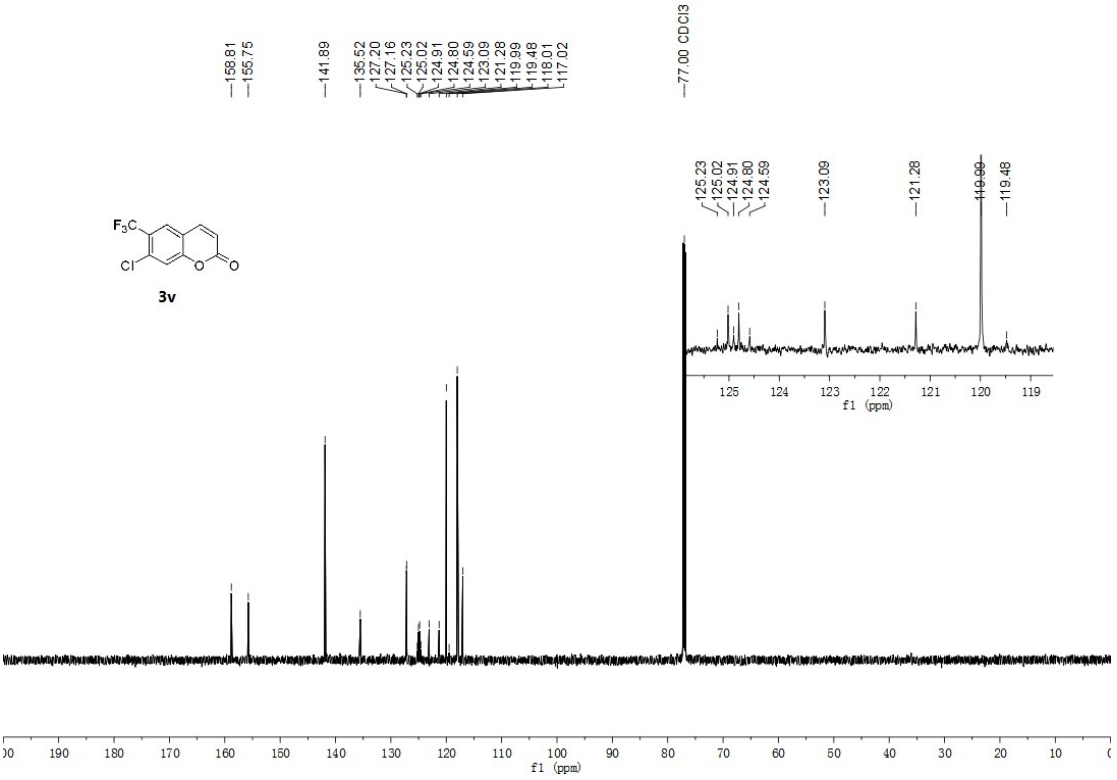

160.36
152.31
142.14
140.69
130.09
127.23
118.79
117.75
116.70
77.00
20.63
Cl
O
O
3u
f1 (ppm)

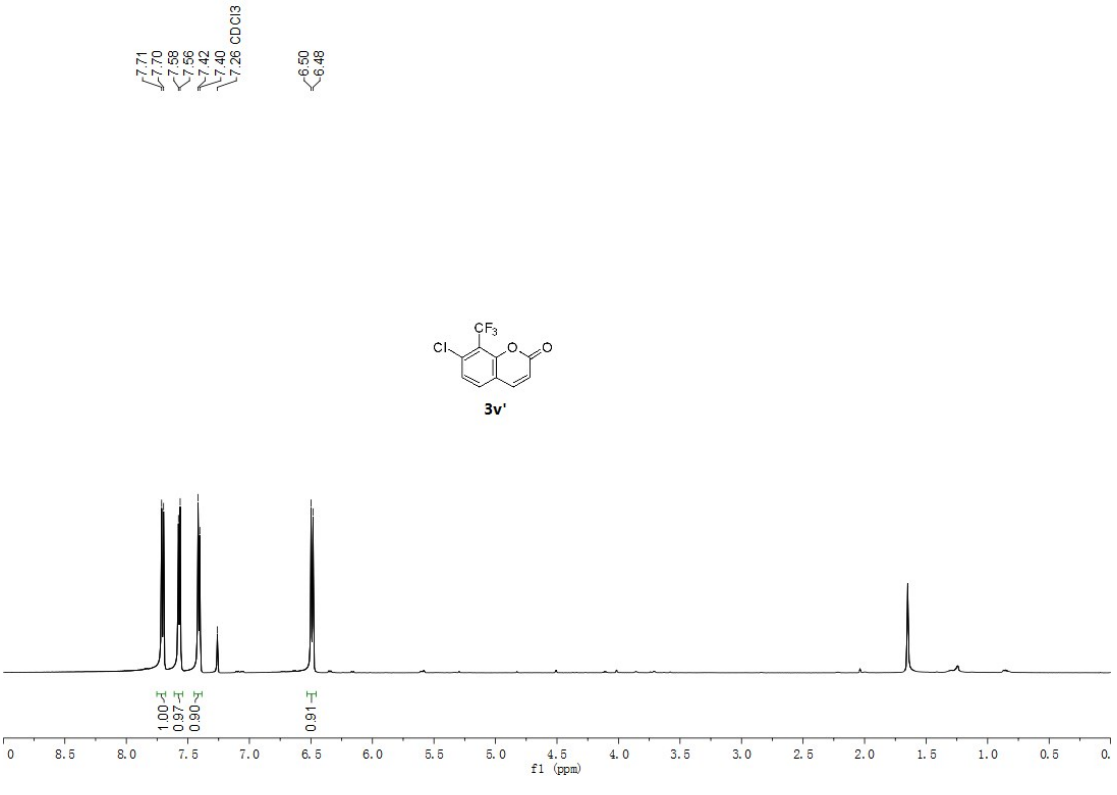

7.70
7.67
7.31
7.29
7.19
7.17
6.42
6.40
2.50
Cl
O
O
3u'
1.00
1.14
0.98
0.96
2.87
f1 (ppm)

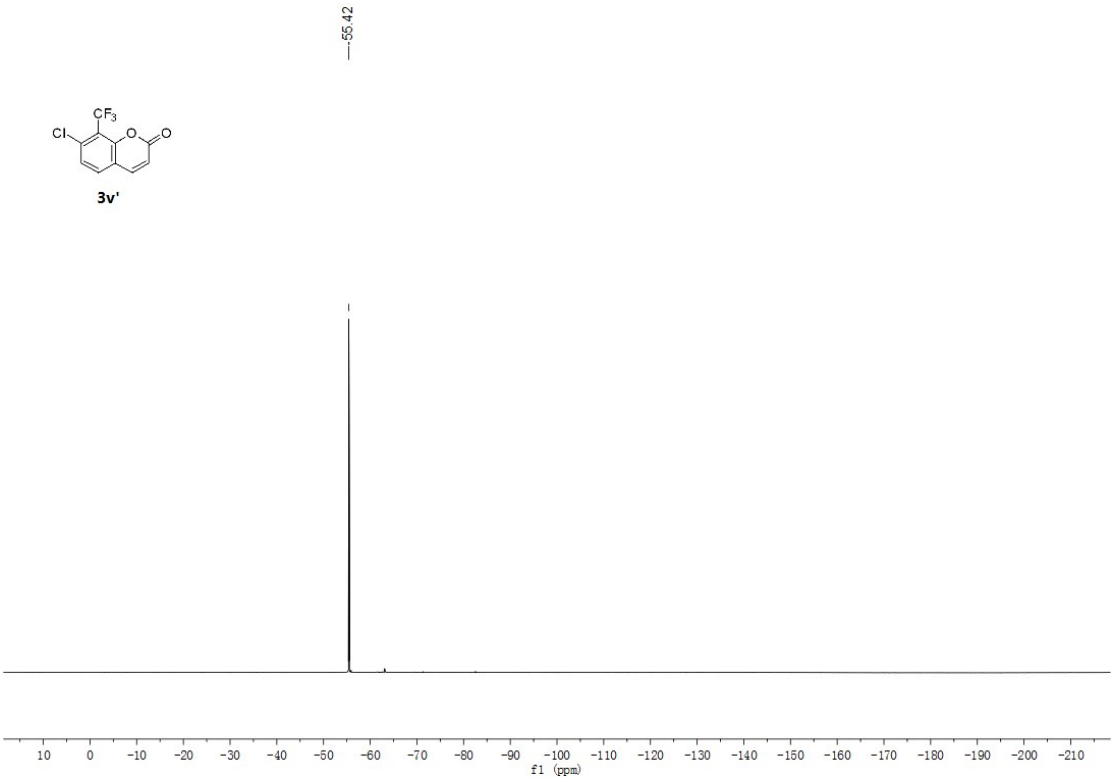

159.92
149.84
143.19
141.01
126.17
125.24
121.60
117.79
115.93
77.00 CDCl3
20.53
Cl
O
O
3u'
f1 (ppm)

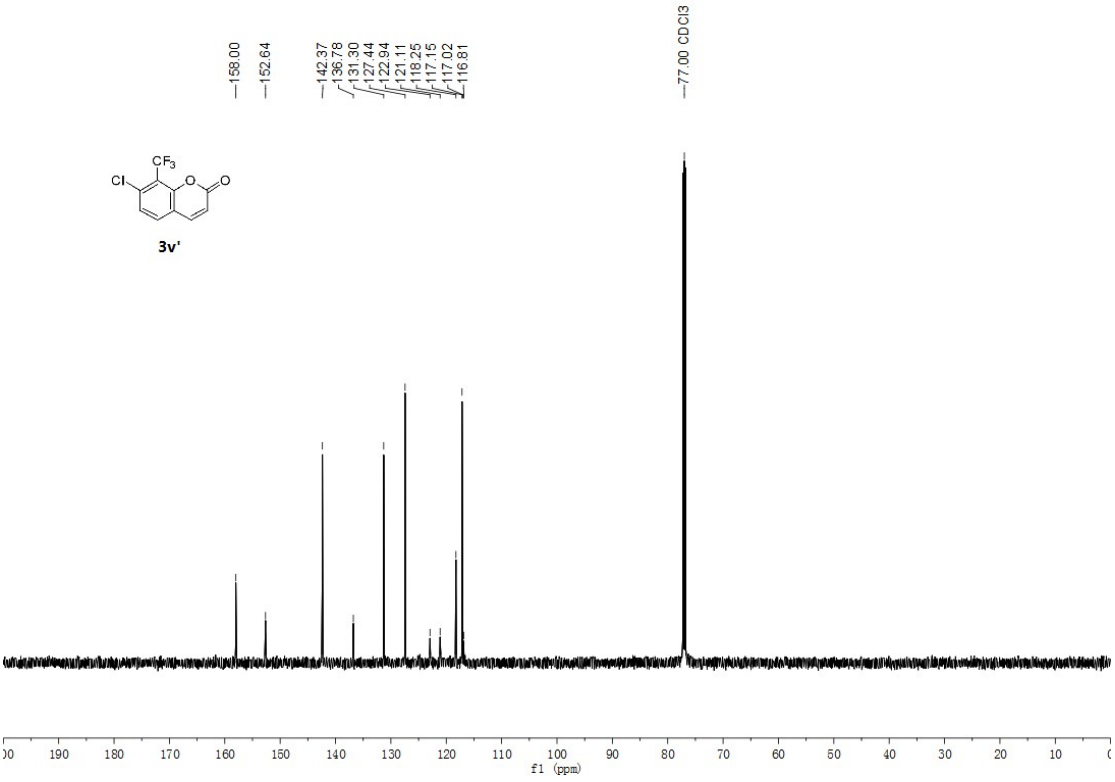

7.83
7.73
7.71
7.48
7.26 CDCl3
6.51
6.50
F3C
Cl
O
O
3v
1.07
1.06
0.96
1.00
f1 (ppm)

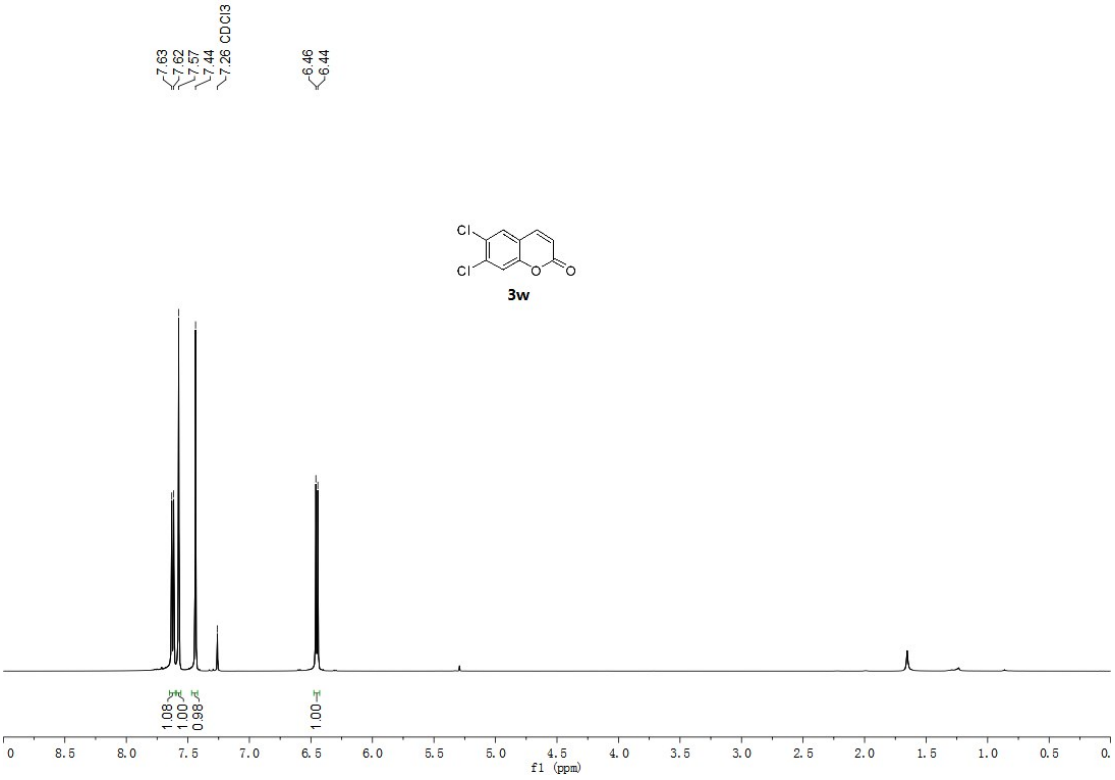

-62.15
F3C
Cl
O
O
3v
f1 (ppm)

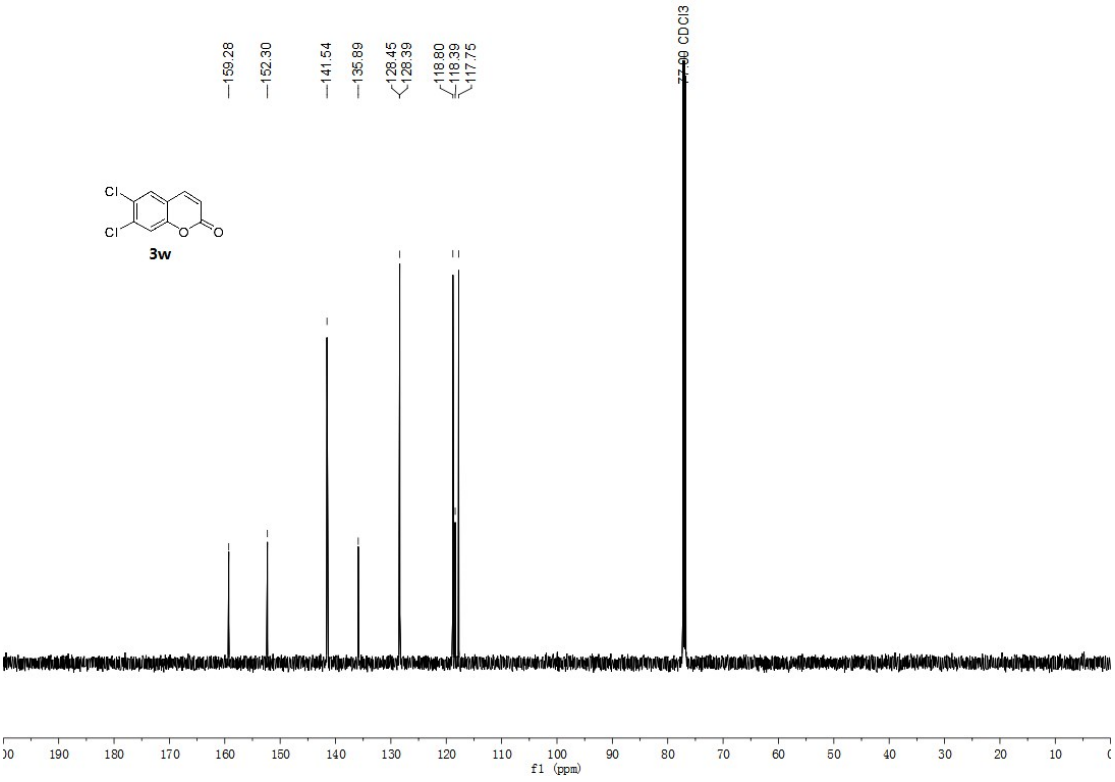

158.81
155.75
141.89
135.52
127.20
127.16
125.23
125.02
124.91
124.80
124.59
123.09
121.28
119.99
119.48
118.01
117.02
77.00 CDCl3
F3C
Cl
O
O
3v
125.23
125.02
124.91
124.80
124.59
123.09
121.28
119.99
119.48
f1 (ppm)
f1 (ppm)

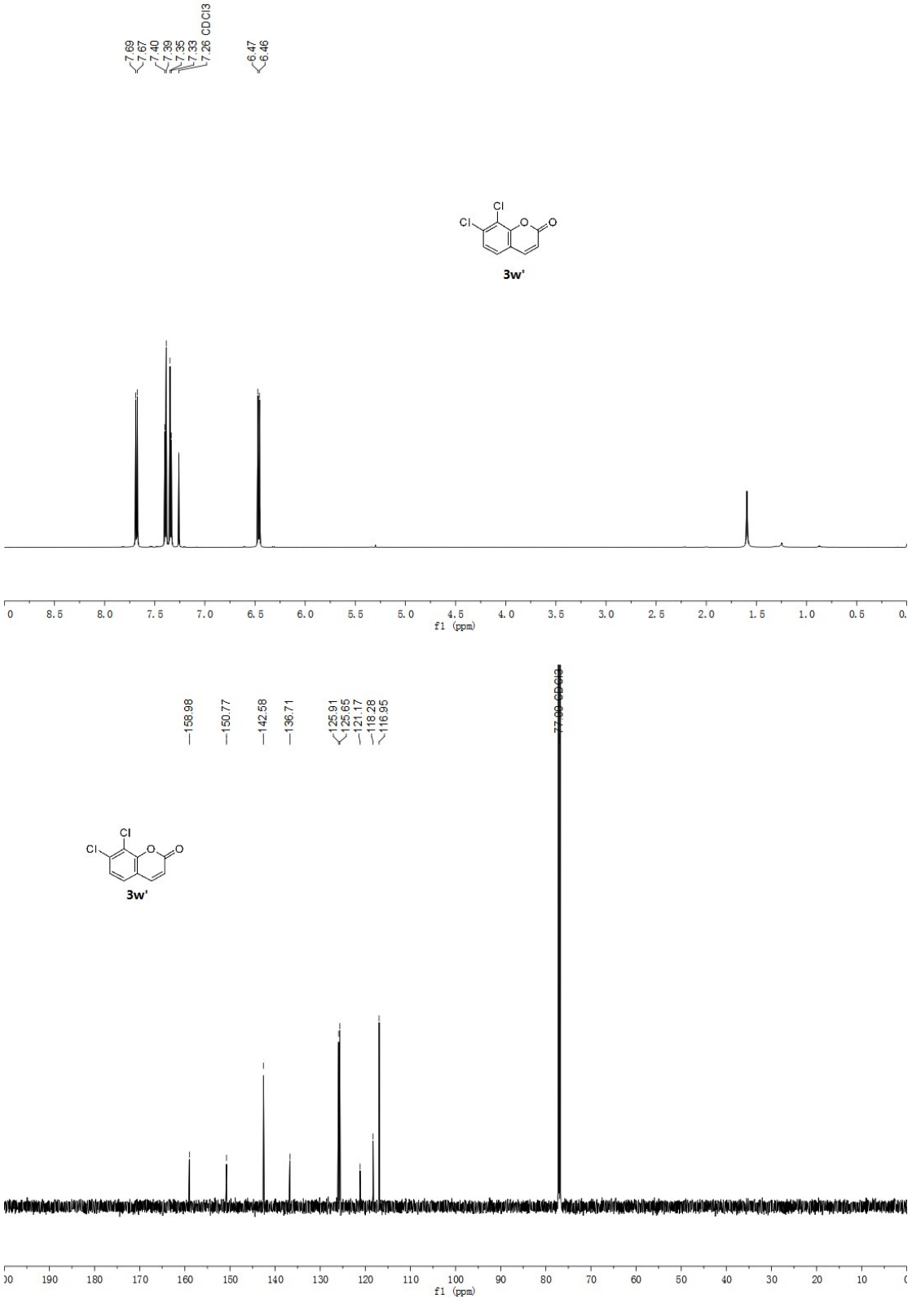

7.71
7.70
7.58
7.56
7.42
7.40
7.26 CDCl3
6.50
6.48
CF3
Cl
O
O
3v'
1.00
0.97
0.90
0.91
f1 (ppm)

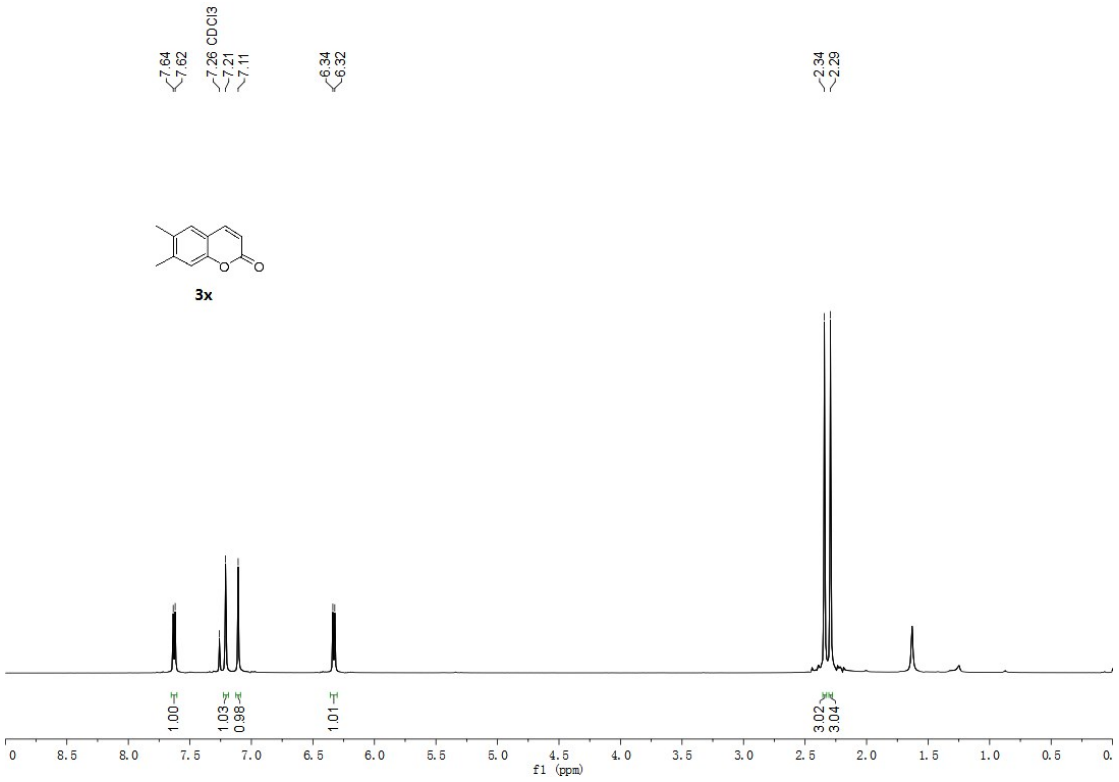

-55.42
Cl
CF3
O
O
3v'
10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210
f1 (ppm)

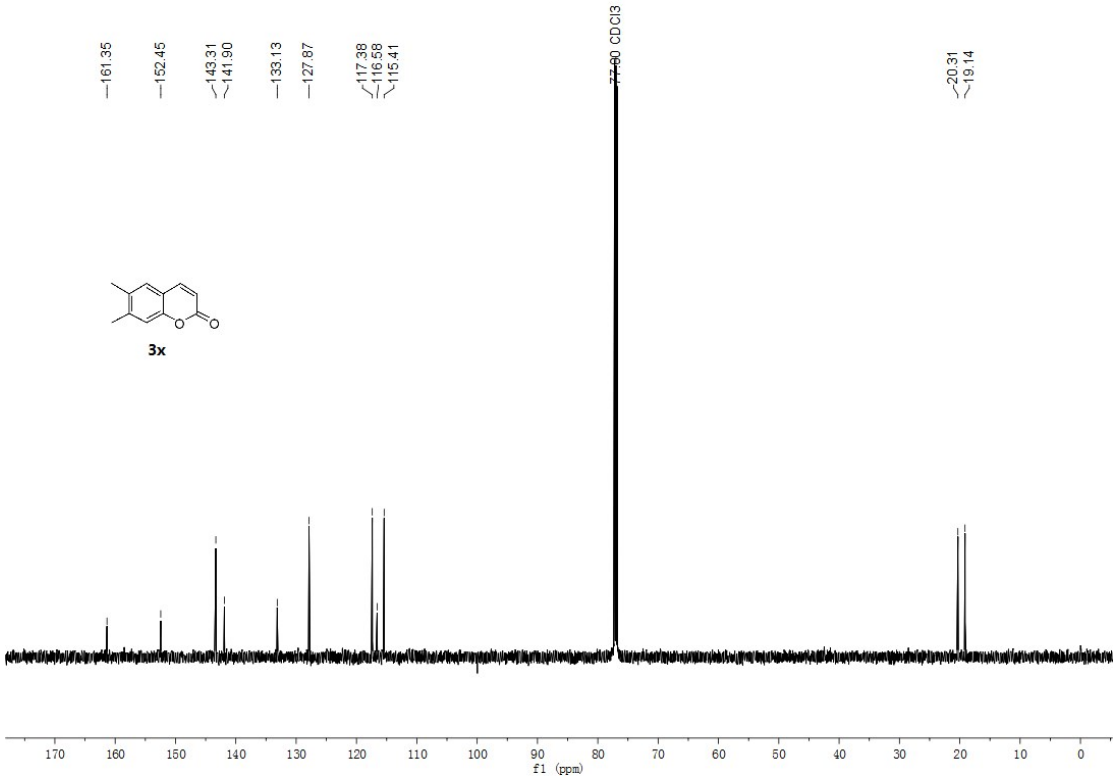

158.00
152.64
142.37
136.78
131.30
127.44
122.94
121.11
118.25
117.15
117.02
116.81
77.00 CDCl3
Cl
CF3
O
O
3v'
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10
f1 (ppm)

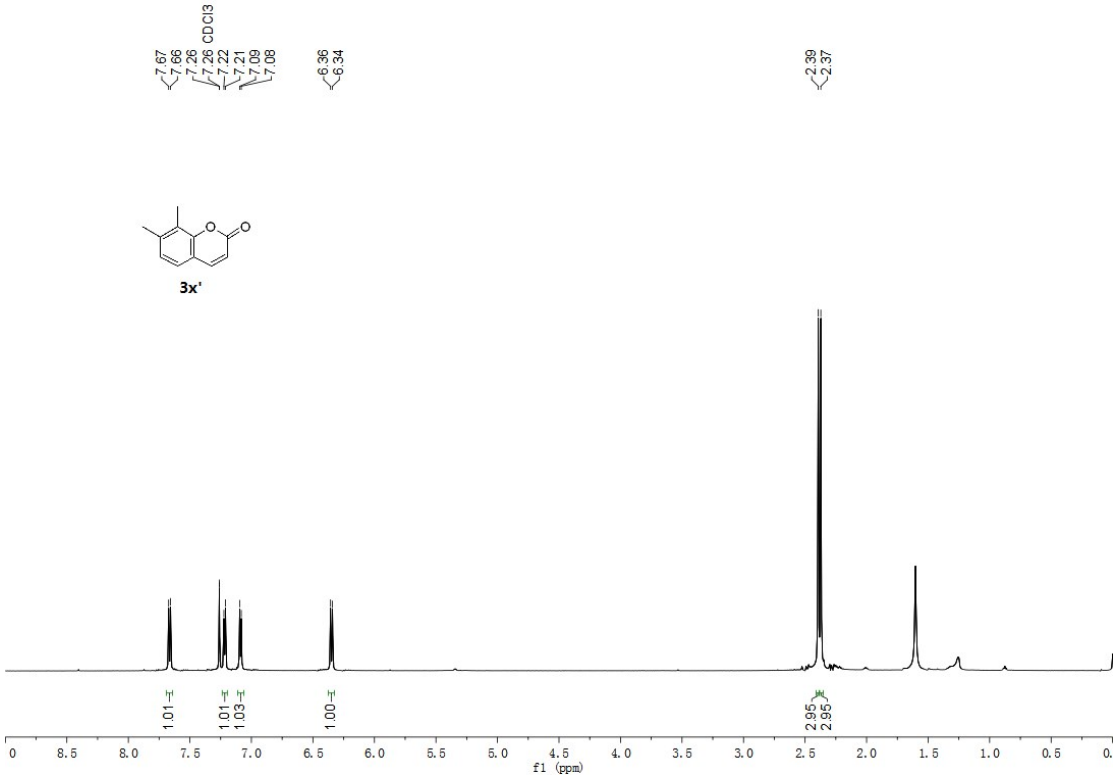

7.63
7.62
7.57
7.44
7.26 CDCl3
6.46
6.44
Cl
Cl
O
O
3w
1.08
1.00
0.98
1.00
f1 (ppm)

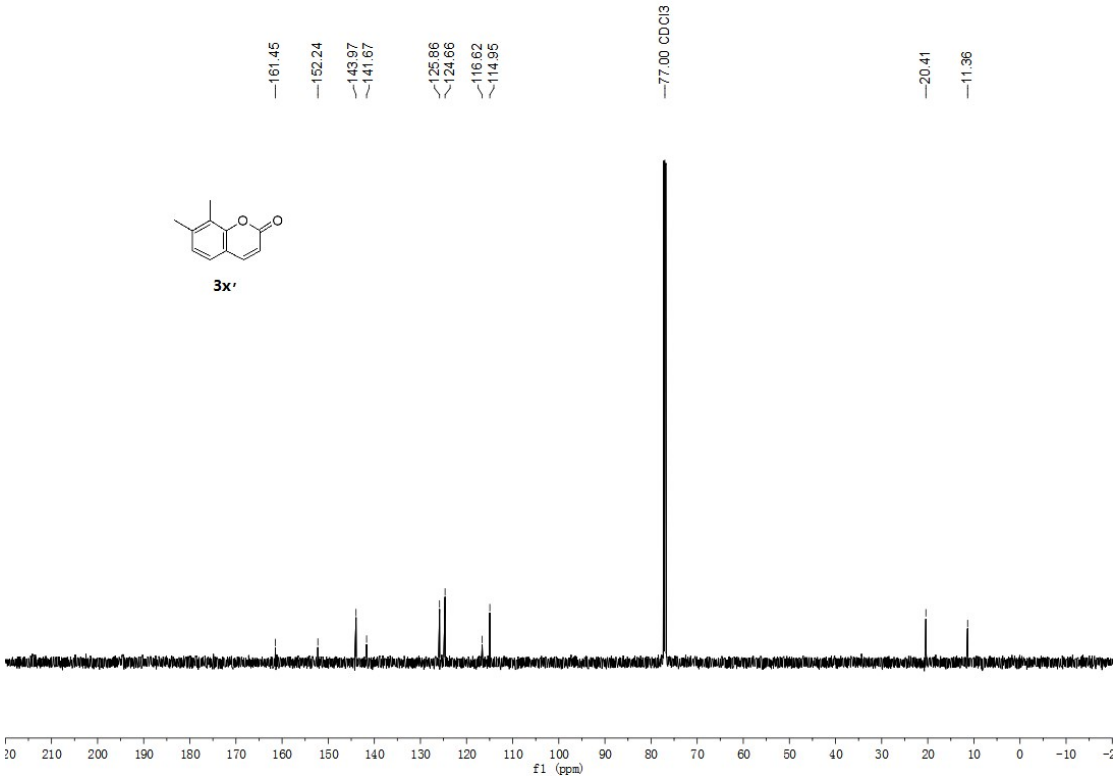

159.28
152.30
141.54
135.89
128.45
128.39
118.80
118.39
117.75
77.00 CDCl3
Cl
Cl
O
O
3w
f1 (ppm)

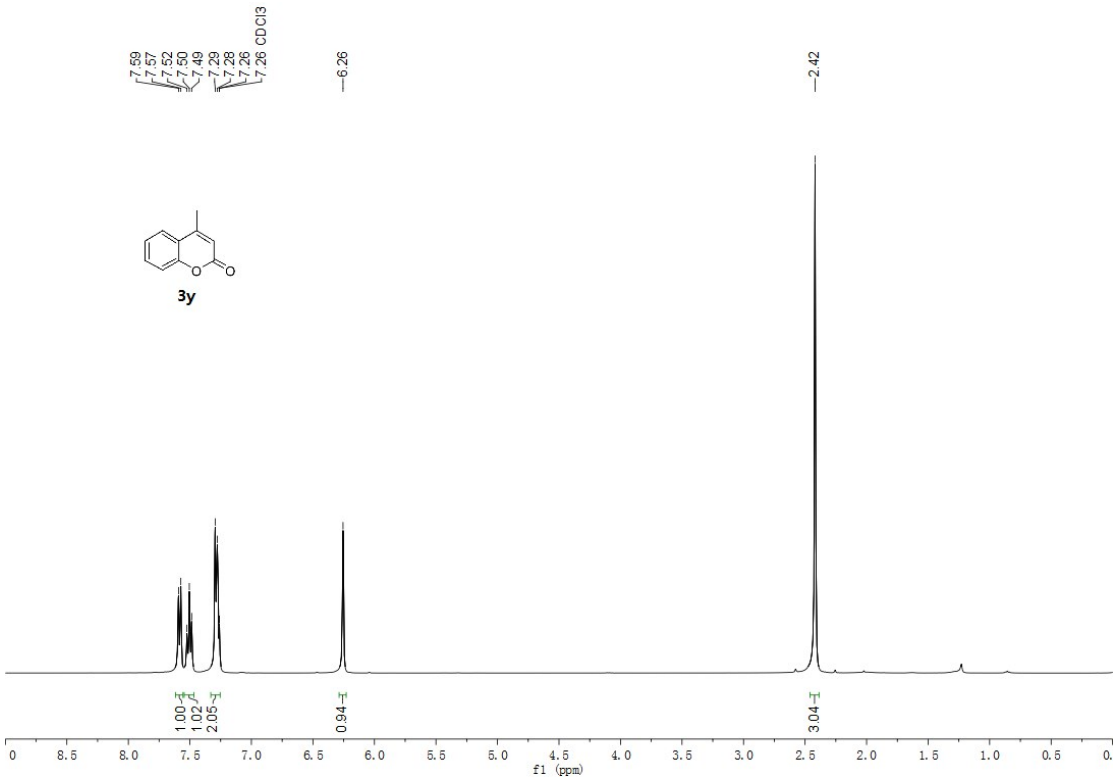

7.69
7.67
7.40
7.39
7.35
7.33
7.26 CDCl3
6.47
6.46
Cl
Cl
O
O
3w'
f1 (ppm)
158.98
150.77
142.58
136.71
125.91
125.65
121.17
118.28
116.95
77.00
Cl
Cl
O
O
3w'
f1 (ppm)

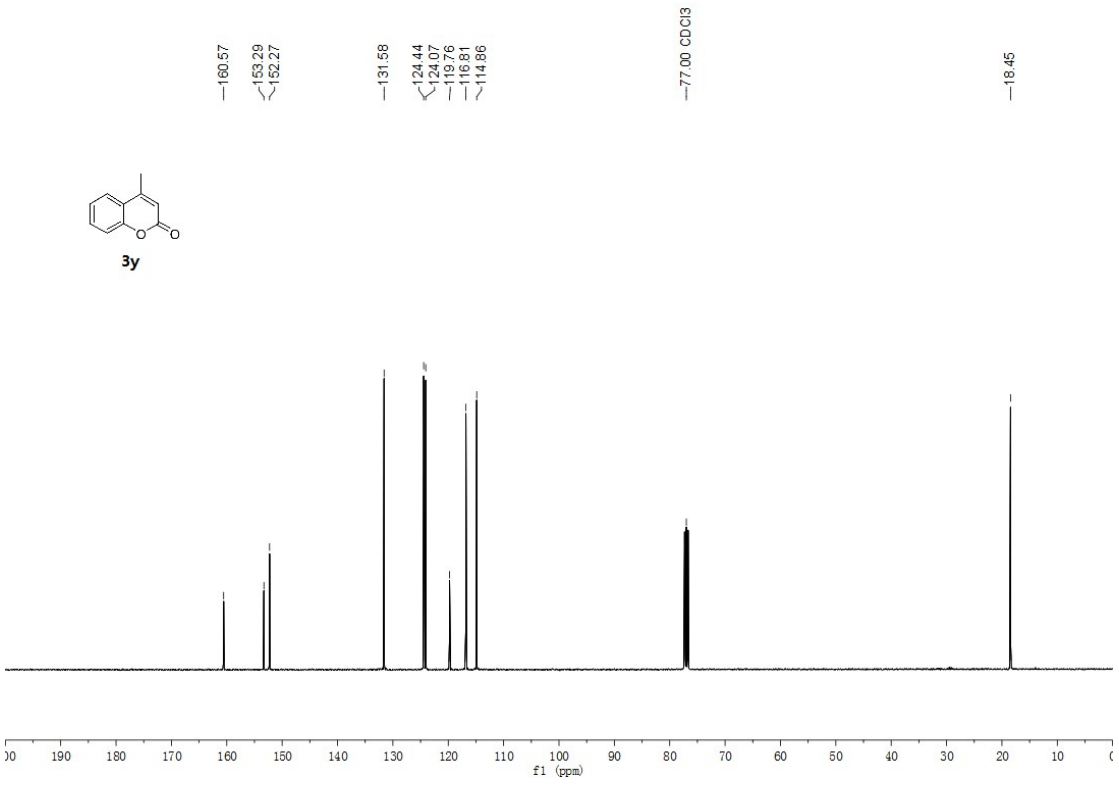

7.64
7.62
7.26 CDCl3
7.21
7.11
6.34
6.32
2.34
2.29
3x
1.00
1.03
0.98
1.01
3.02
3.04
f1 (ppm)

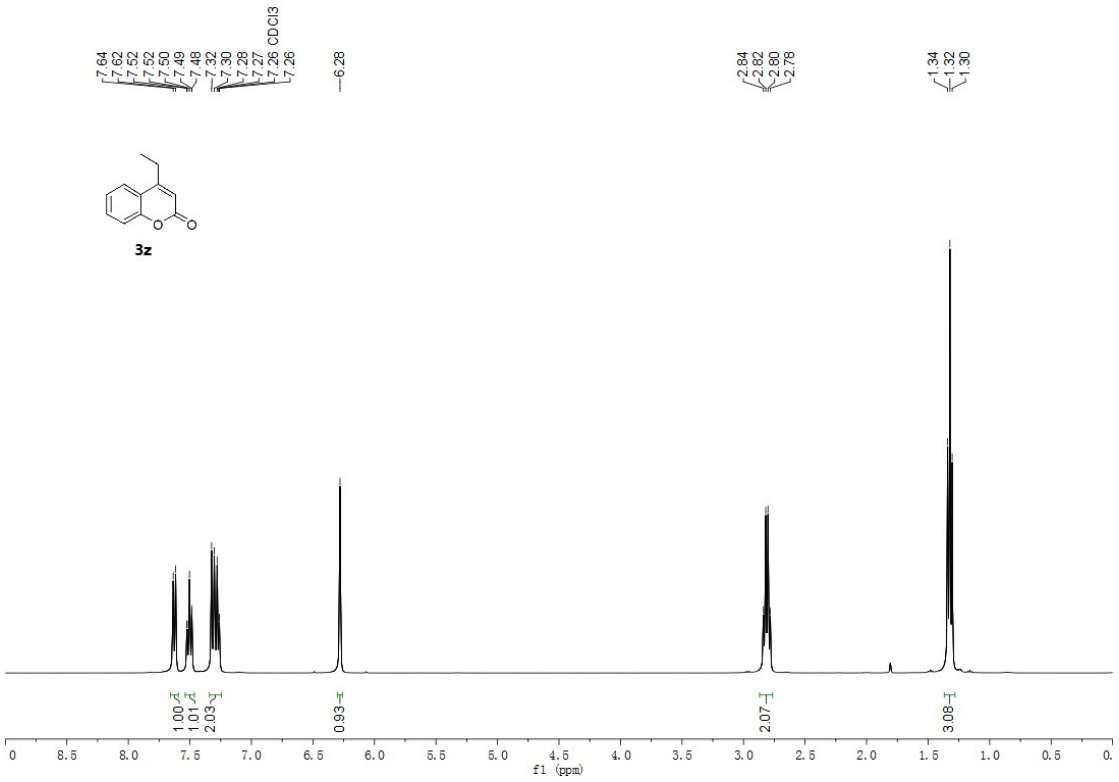

161.35
152.45
143.31
141.90
133.13
127.87
117.38
116.58
115.41
77.00 CDCl3
20.31
19.14
3x
f1 (ppm)

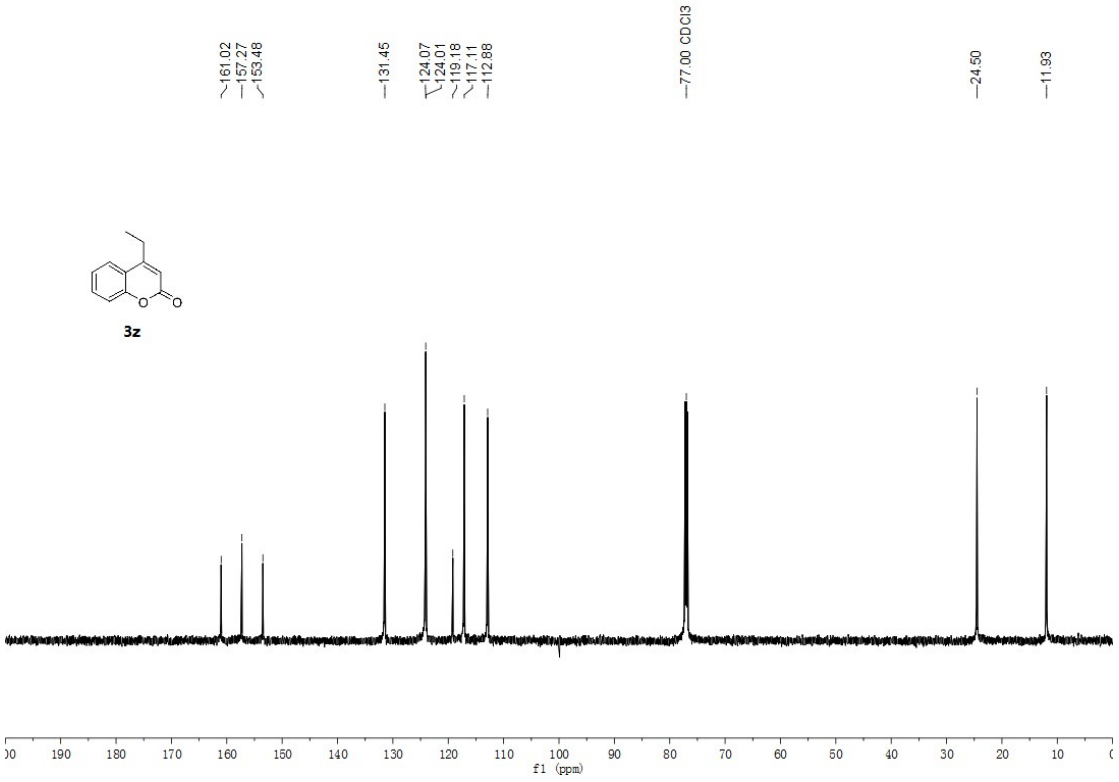

7.67
7.66
7.26
7.26 CDCl3
7.22
7.21
7.09
7.08
6.36
6.34
2.39
2.37
3x'
1.01
1.01
1.03
1.00
2.95
2.95
f1 (ppm)

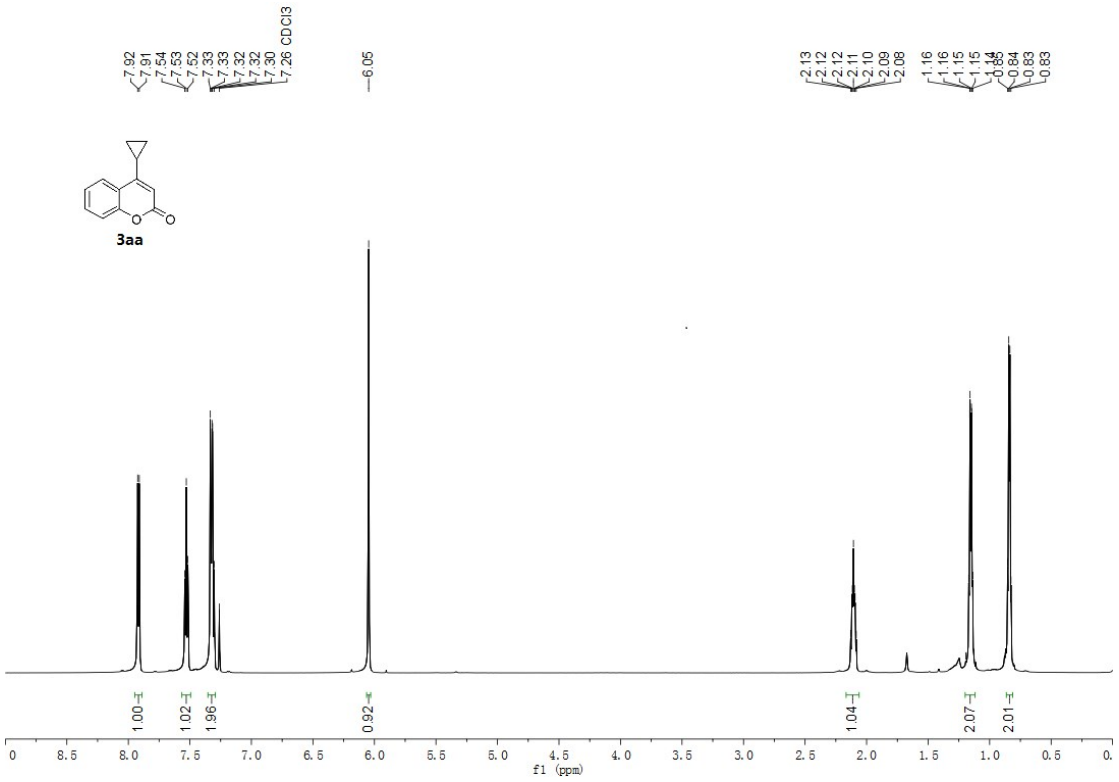

161.45
152.24
143.97
141.67
125.86
124.66
116.62
114.95
77.00 CDCl3
20.41
11.36
3x'
f1 (ppm)

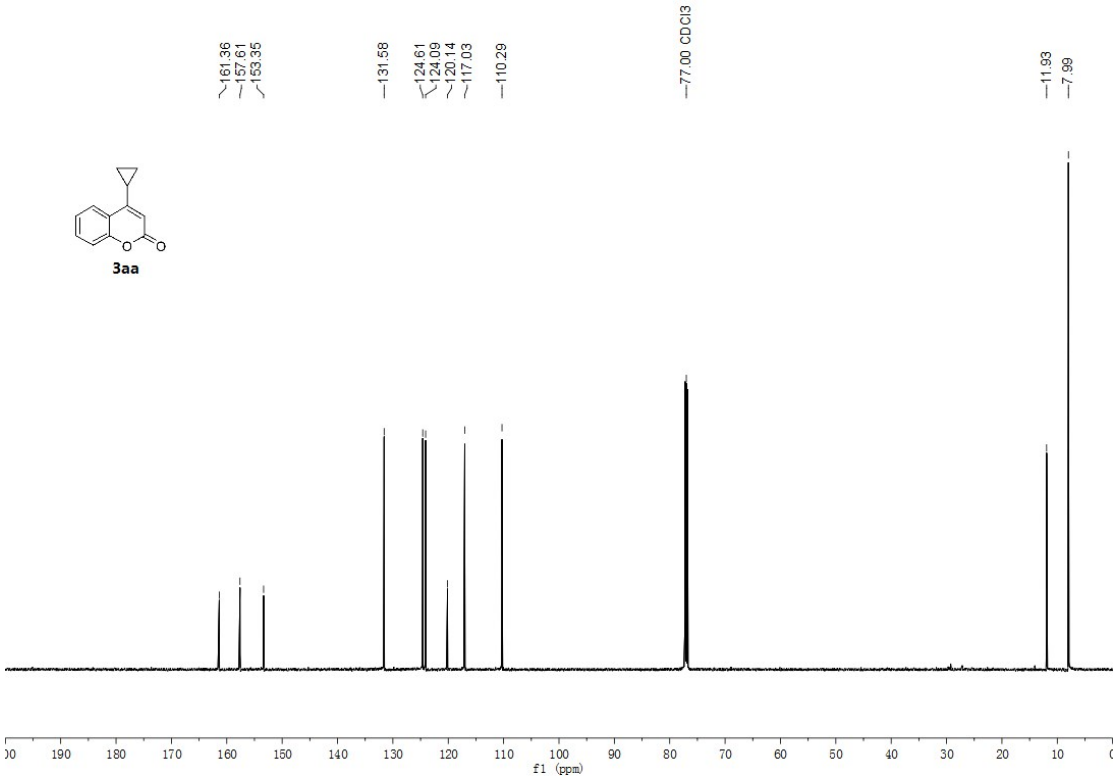

7.59
7.57
7.52
7.50
7.49
7.29
7.28
7.26
7.26 CDCl3
6.26
2.42
3y
1.00
1.02
2.05
0.94
3.04
f1 (ppm)

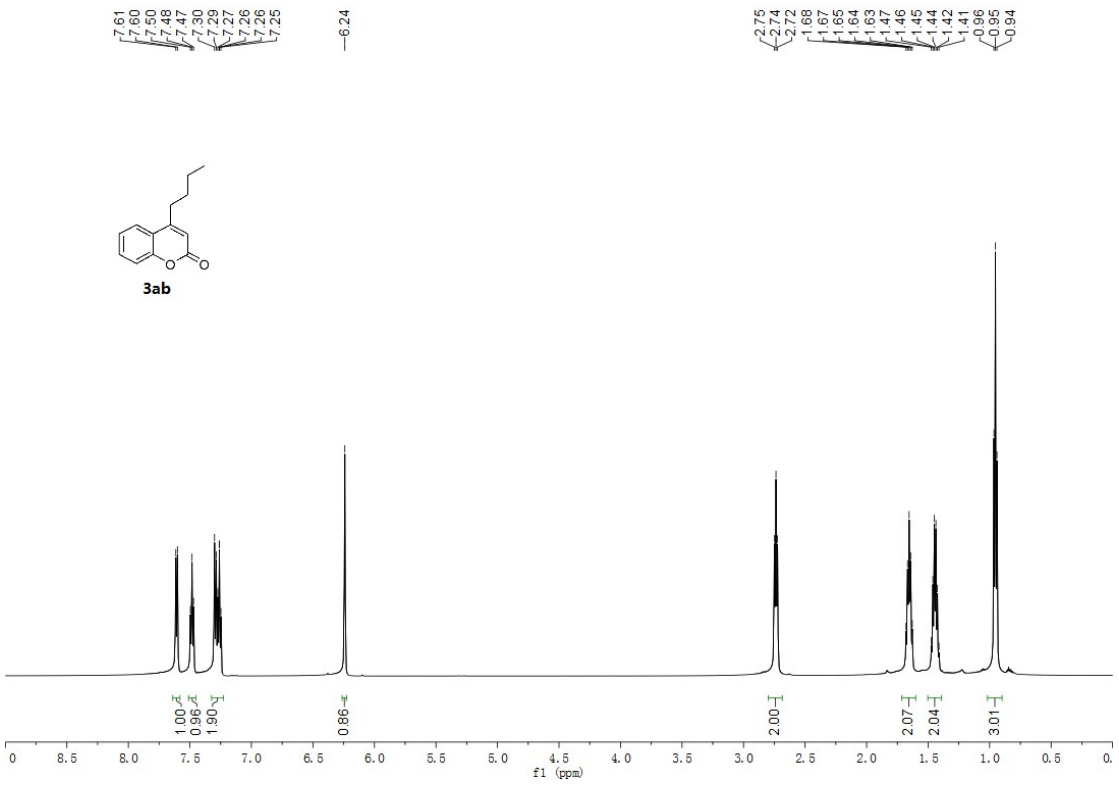

160.57
153.29
152.27
131.58
124.44
124.07
119.76
116.81
114.86
77.00 CDCl3
18.45
3y
f1 (ppm)

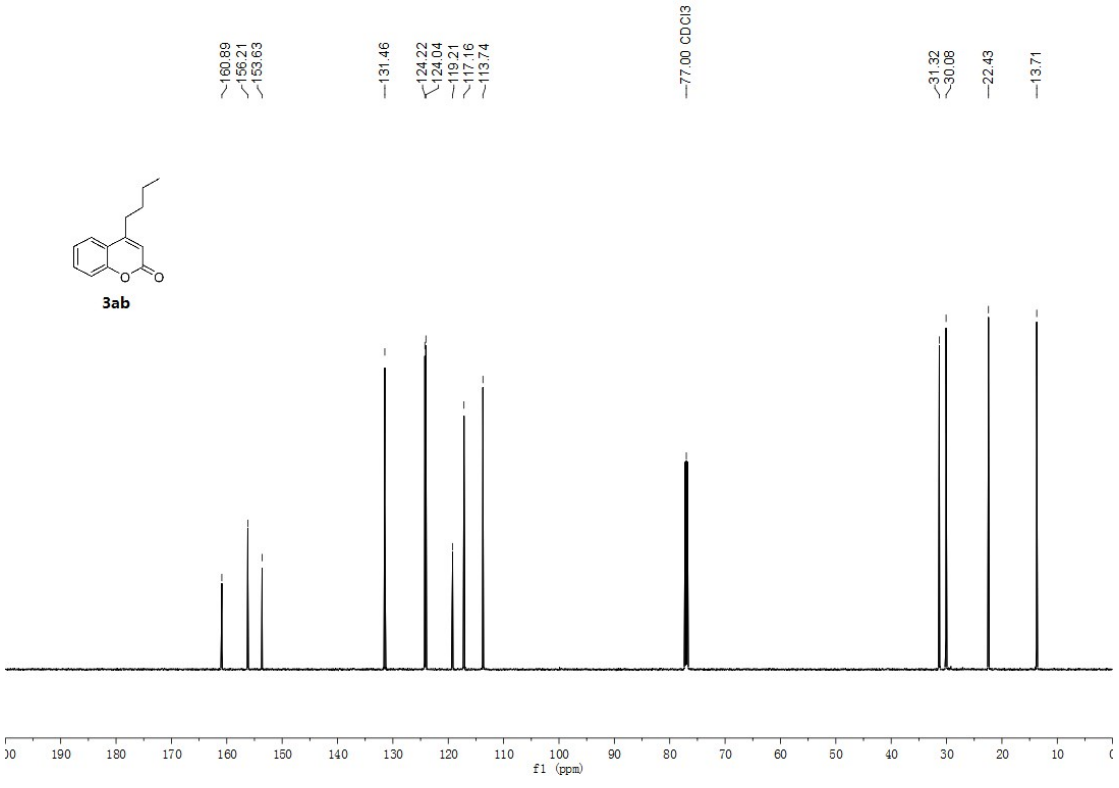

7.64
7.62
7.52
7.52
7.50
7.49
7.48
7.32
7.30
7.28
7.27
7.26 CDCl3
7.26
6.28
2.84
2.82
2.80
2.78
1.34
1.32
1.30
3z
1.00
1.01
2.03
0.93
2.07
3.08
f1 (ppm)

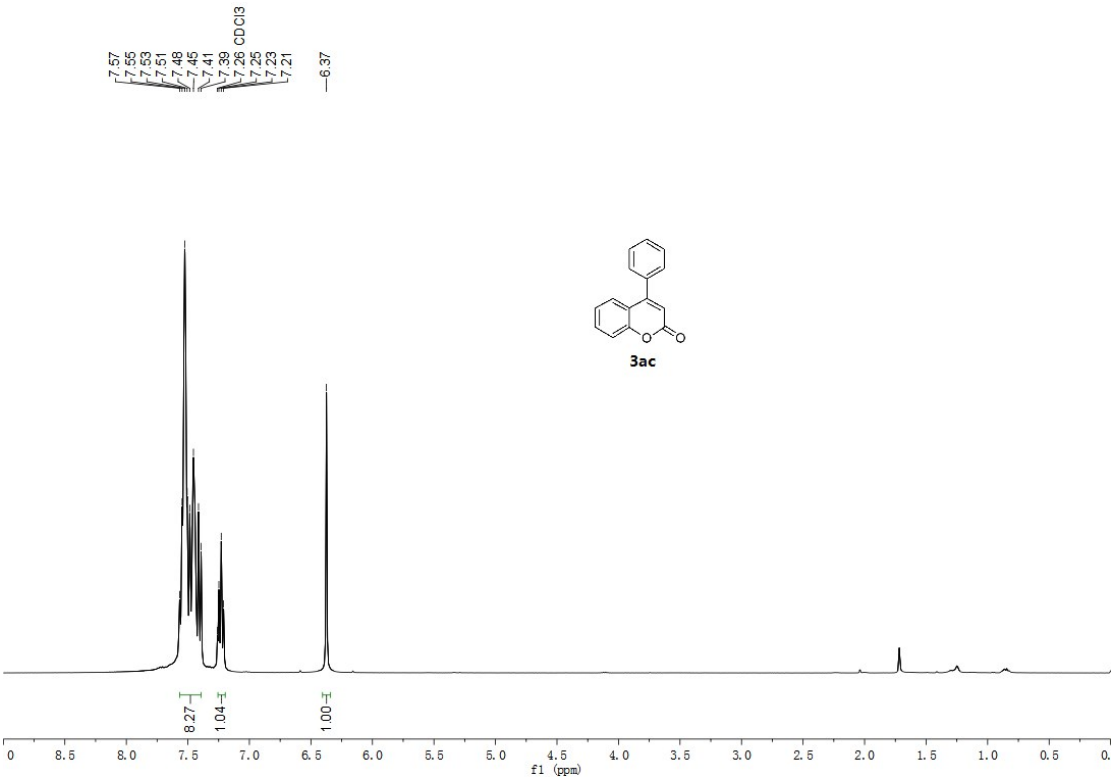

161.02
157.27
153.48
131.45
124.07
124.01
119.18
117.11
112.88
77.00 CDCl3
24.50
11.93
3z
f1 (ppm)

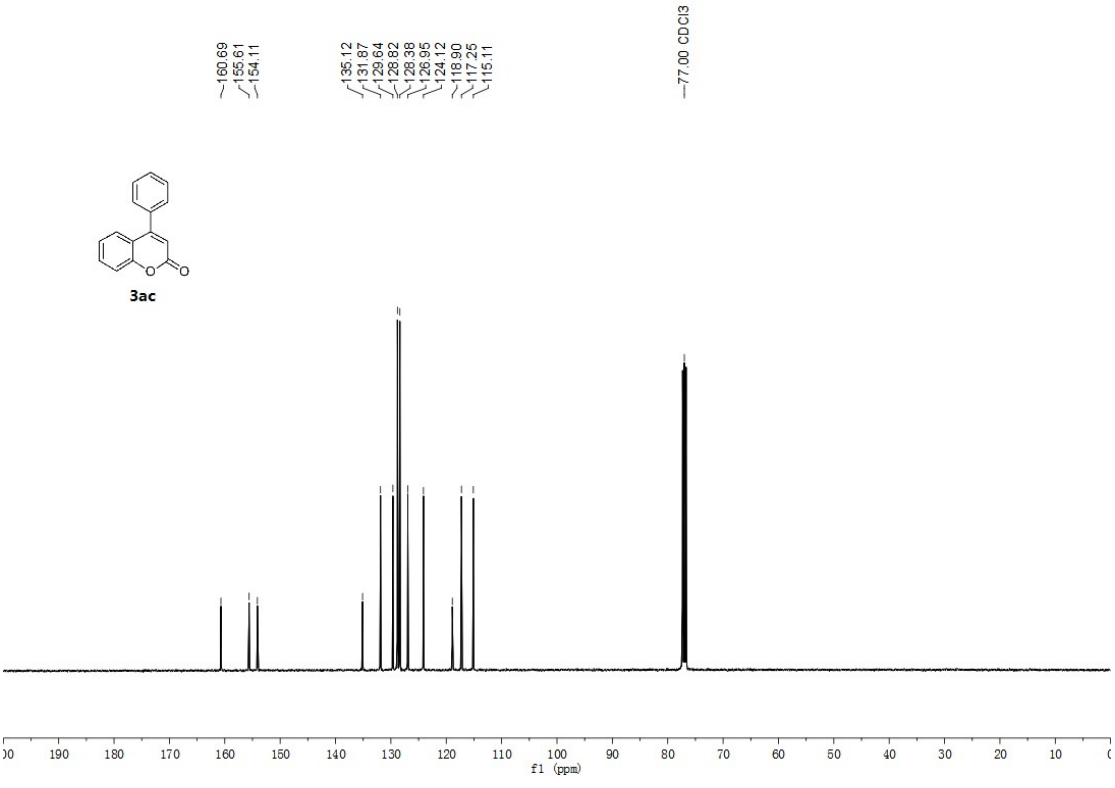

7.92
7.91
7.54
7.53
7.52
7.33
7.33
7.32
7.32
7.30
7.26 CDCl3
6.05
2.13
2.12
2.12
2.11
2.10
2.09
2.08
1.16
1.16
1.15
1.15
0.84
0.84
0.83
0.83
3aa
1.00
1.02
1.96
0.92
1.04
2.07
2.01
f1 (ppm)

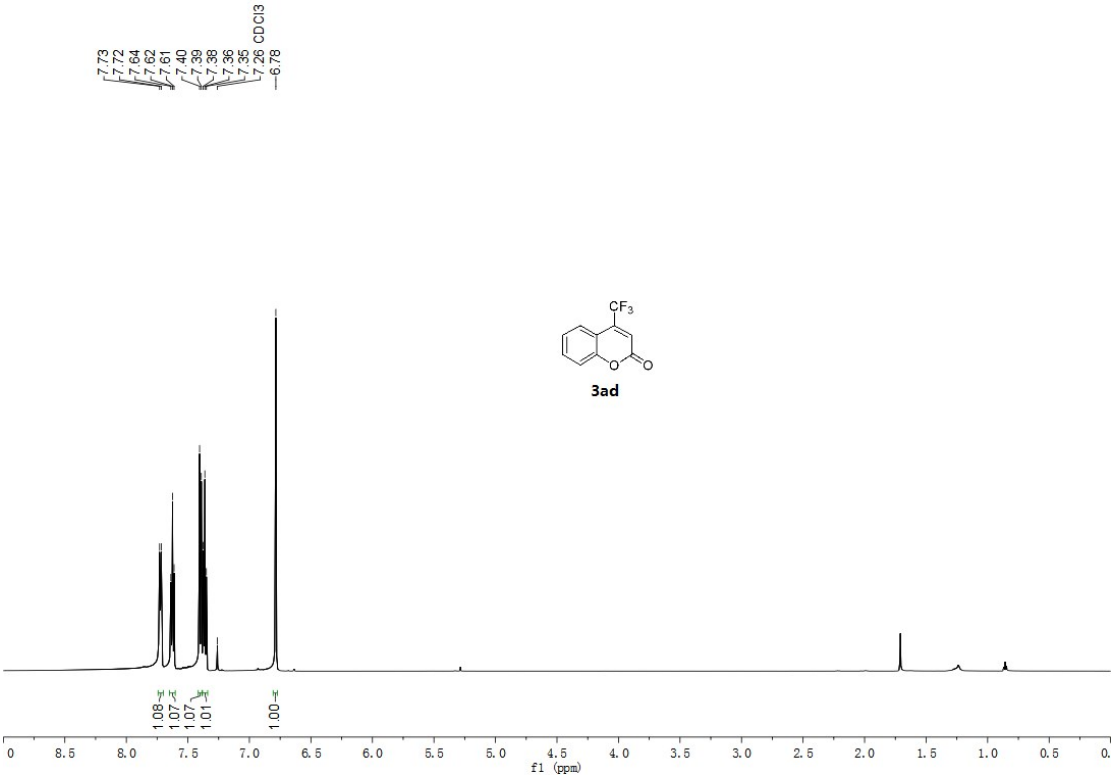

161.36
157.61
153.35
131.58
124.61
124.09
120.14
117.03
110.29
77.00 CDCl3
11.93
7.99
3aa
f1 (ppm)

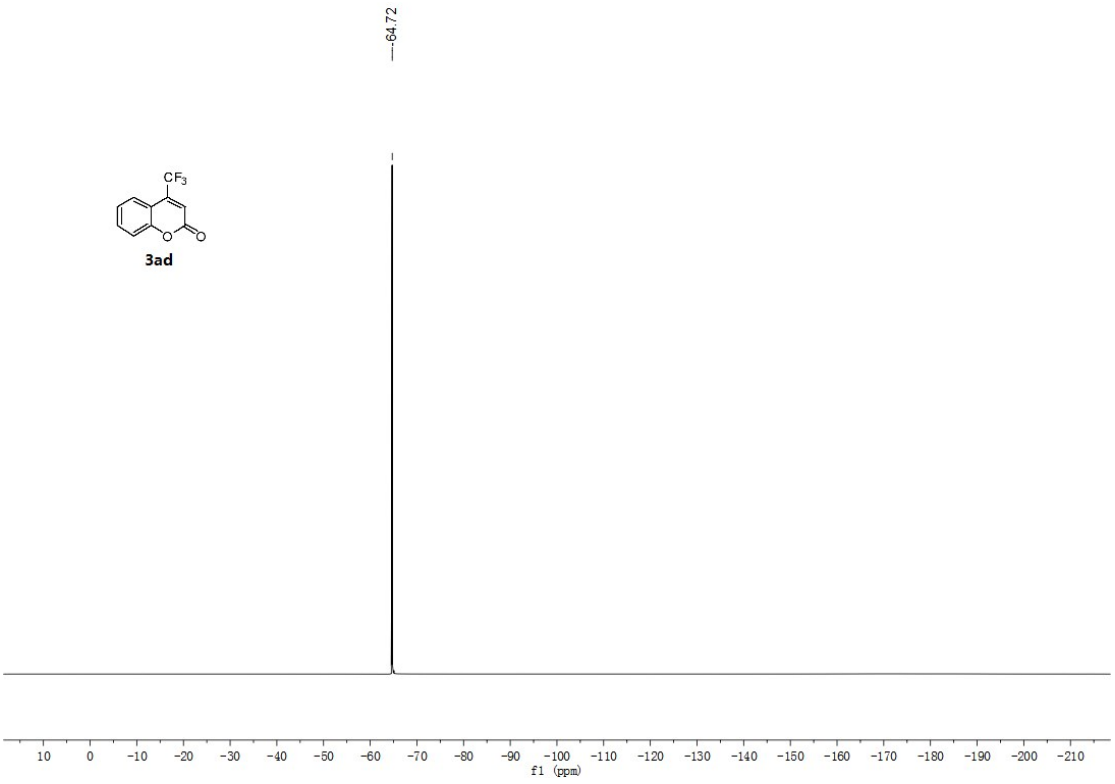

7.61
7.60
7.50
7.48
7.47
7.30
7.29
7.27
7.26
7.26
7.25
6.24
2.75
2.74
2.72
1.68
1.67
1.65
1.64
1.63
1.47
1.46
1.45
1.44
1.42
1.41
0.96
0.95
0.94
3ab
1.00
0.96
1.90
0.86
2.00
2.07
2.04
3.01
f1 (ppm)

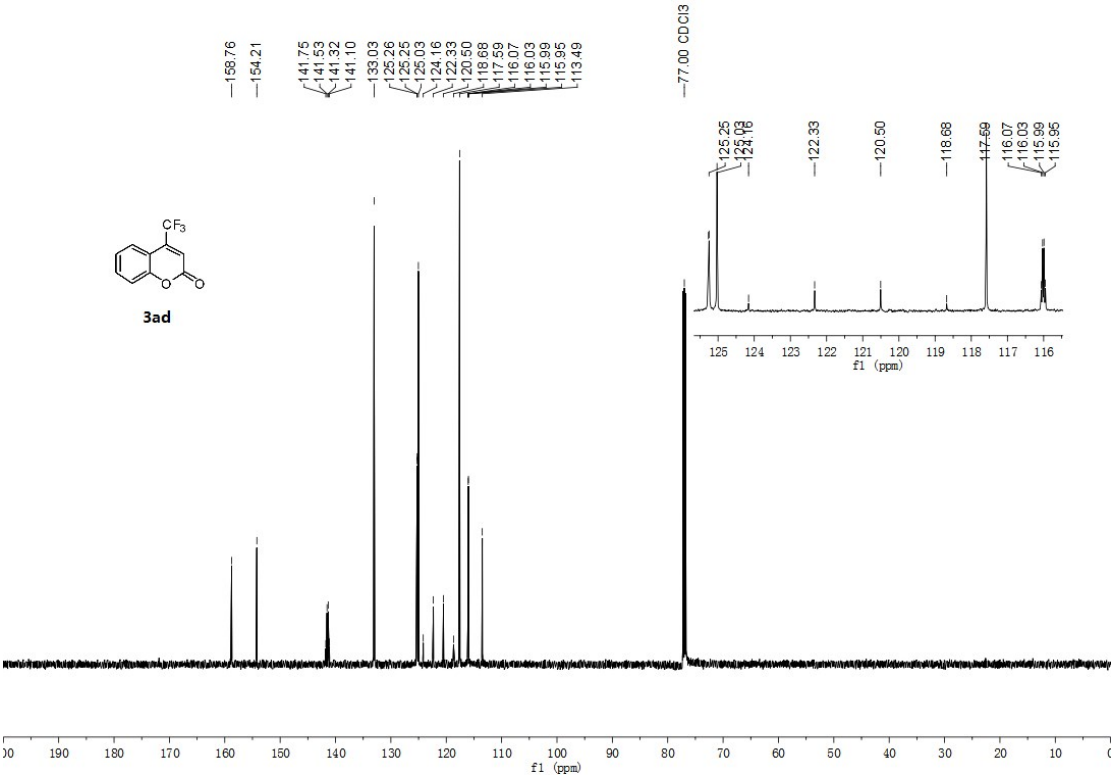

160.89
156.21
153.63
131.46
124.22
124.04
119.21
117.16
113.74
77.00 CDCl3
31.32
30.08
22.43
13.71
3ab
f1 (ppm)

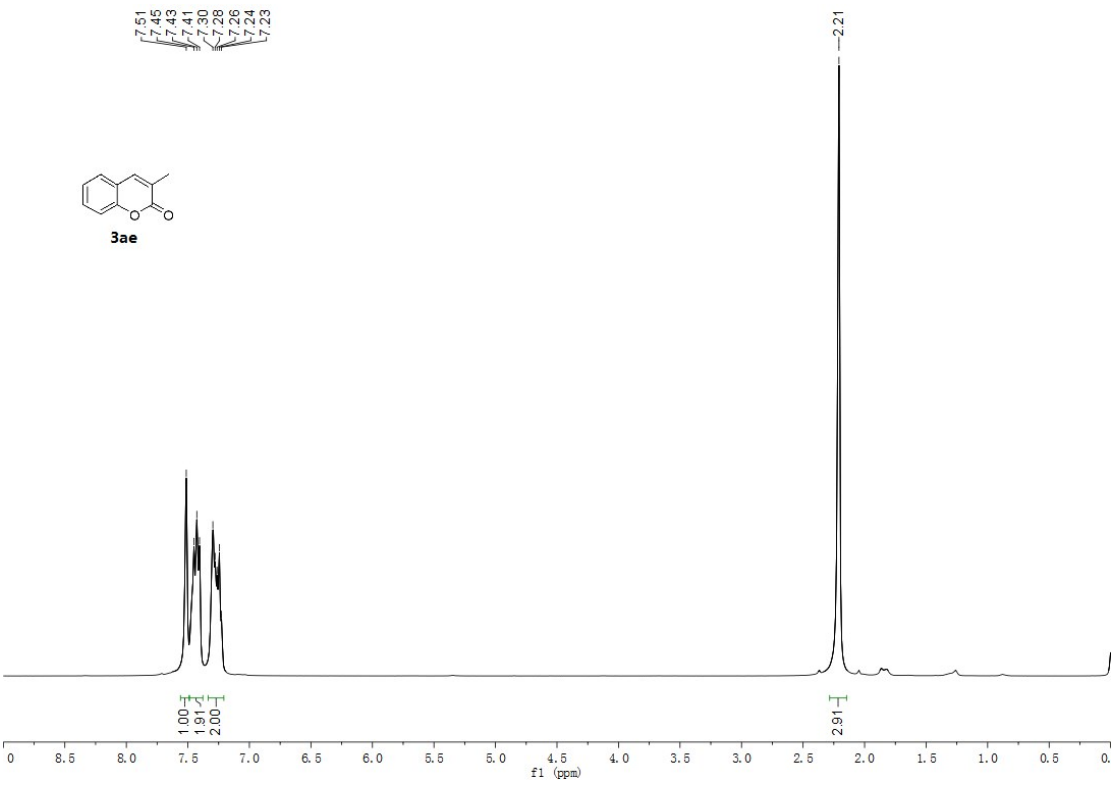

7.57
7.55
7.53
7.51
7.48
7.45
7.41
7.39
7.26 CDCl3
7.25
7.23
7.21
6.37
3ac
8.27
1.04
1.00
f1 (ppm)

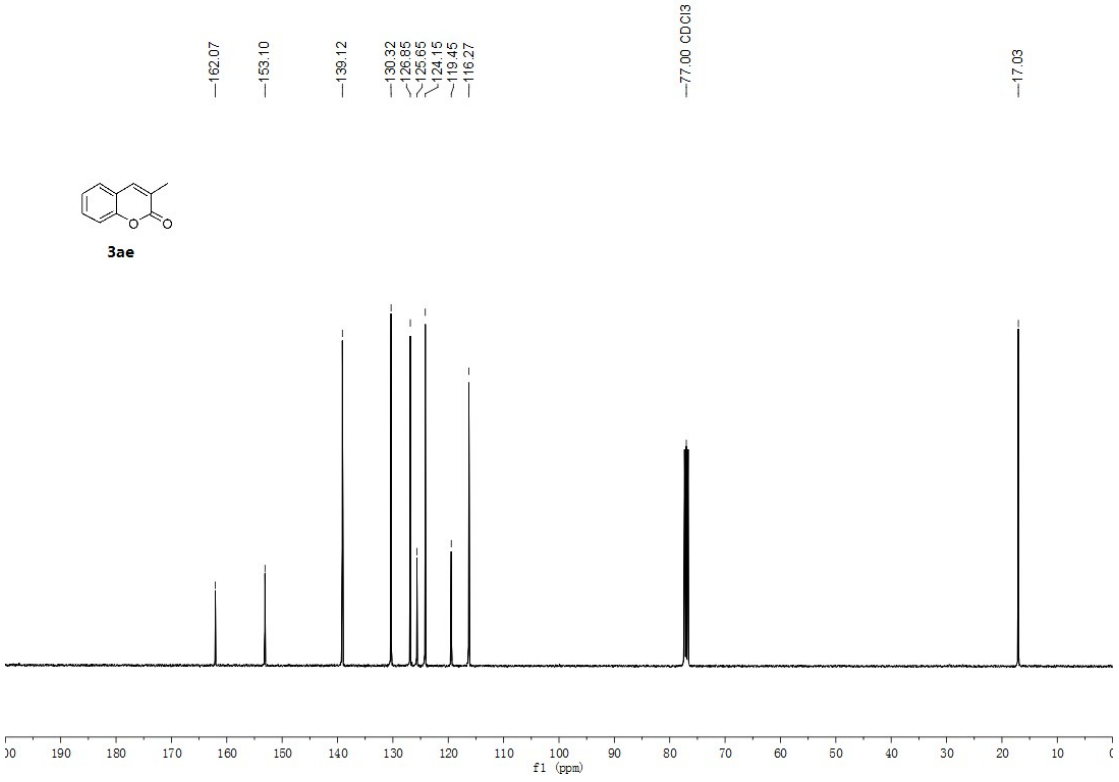

160.69
155.61
154.11
135.12
131.87
129.64
128.82
128.38
126.95
124.12
118.90
117.25
115.11
77.00 CDCl3
3ac
f1 (ppm)

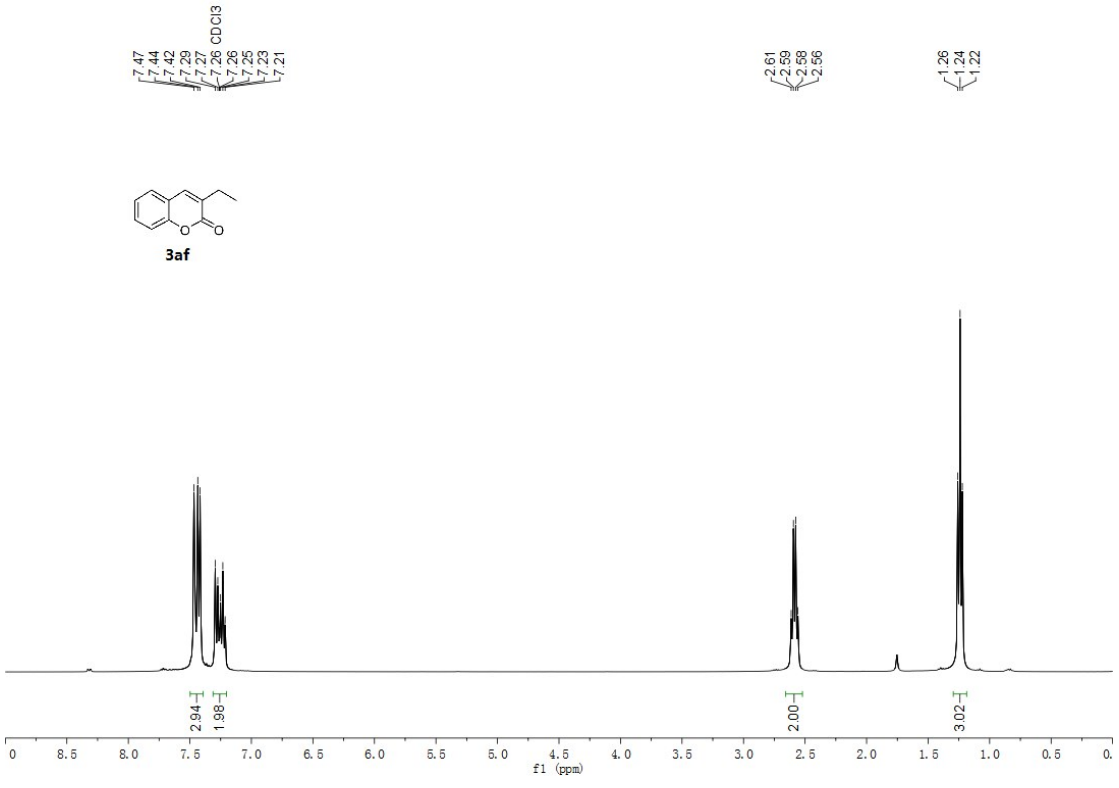

7.73
7.72
7.64
7.62
7.61
7.40
7.39
7.38
7.36
7.35
7.26 CDCl3
6.78
CF3
O
O
3ad
1.08
1.07
1.07
1.01
1.00
0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
f1 (ppm)

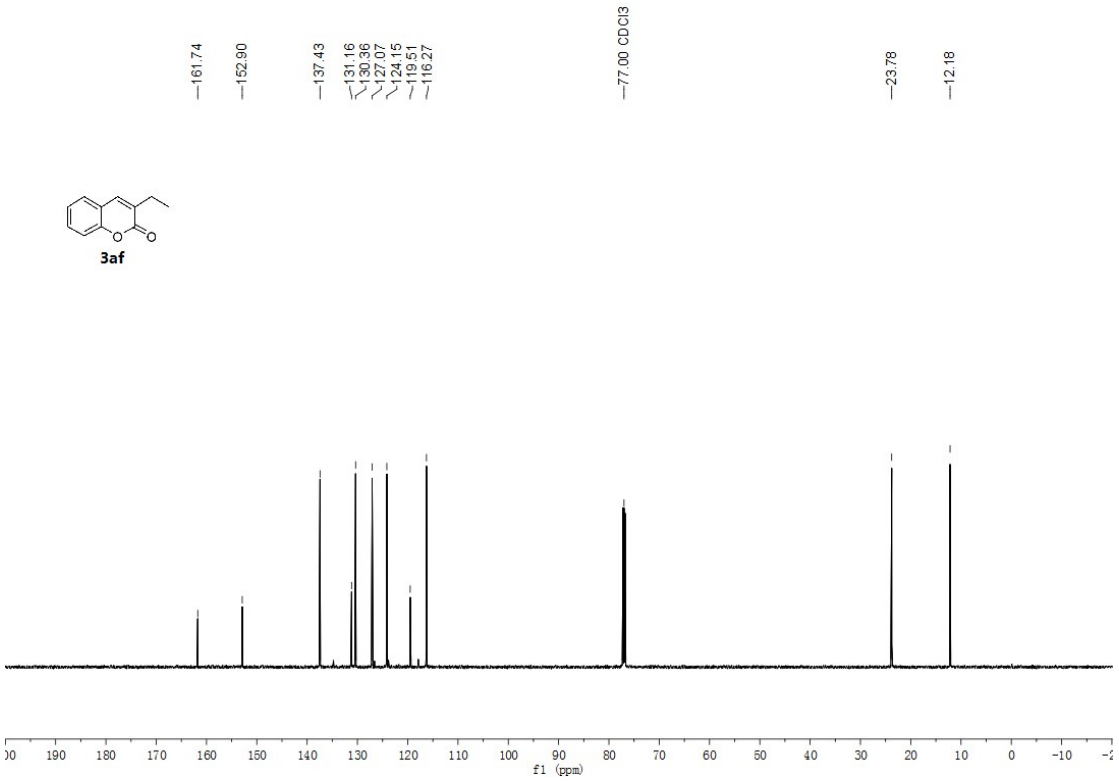

-64.72
CF3
O
O
3ad
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200
-210
f1 (ppm)

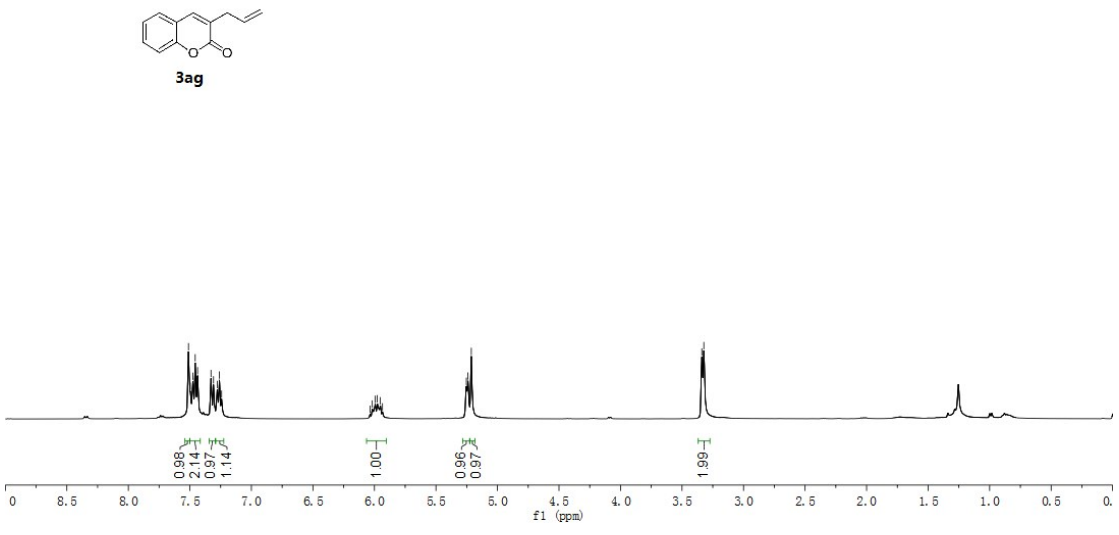

158.76
154.21
141.75
141.53
141.32
141.10
133.03
125.26
125.25
125.03
124.16
122.33
120.50
118.68
117.59
116.07
116.03
115.99
115.95
113.49
77.00 CDCl3
CF3
O
O
3ad
f1 (ppm)

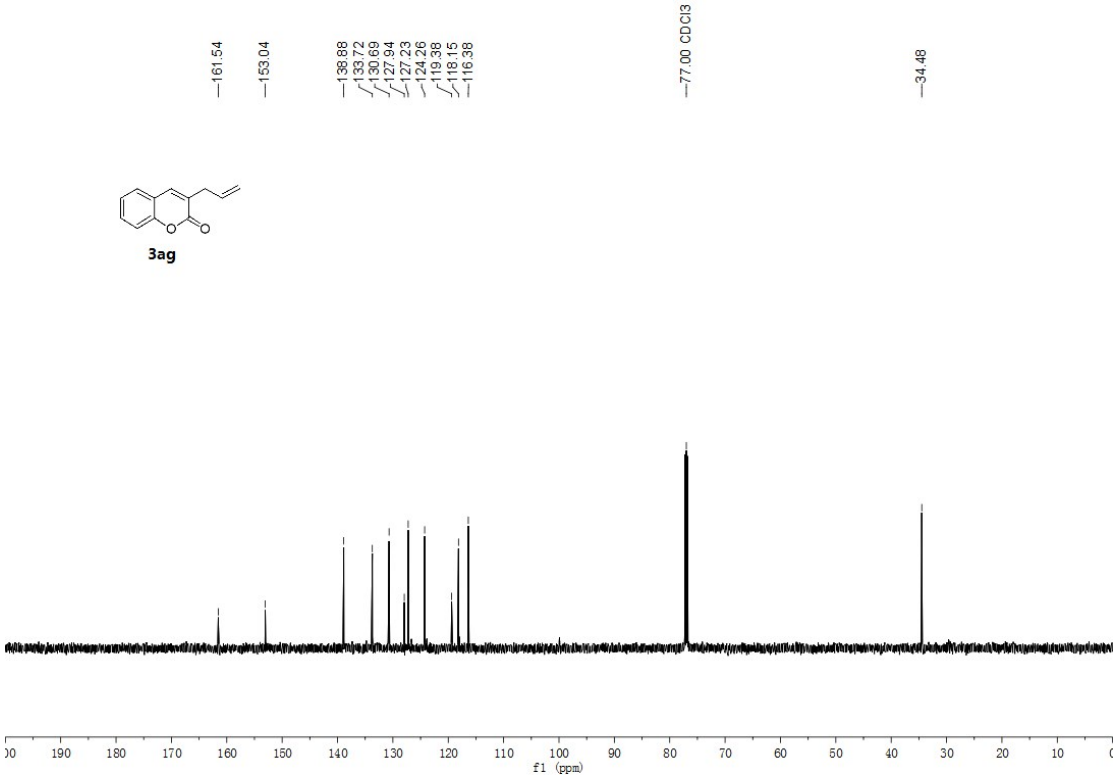

7.51
7.45
7.43
7.41
7.30
7.28
7.26
7.24
7.23
2.21
O
O
3ae
1.00
1.91
2.00
2.91
f1 (ppm)

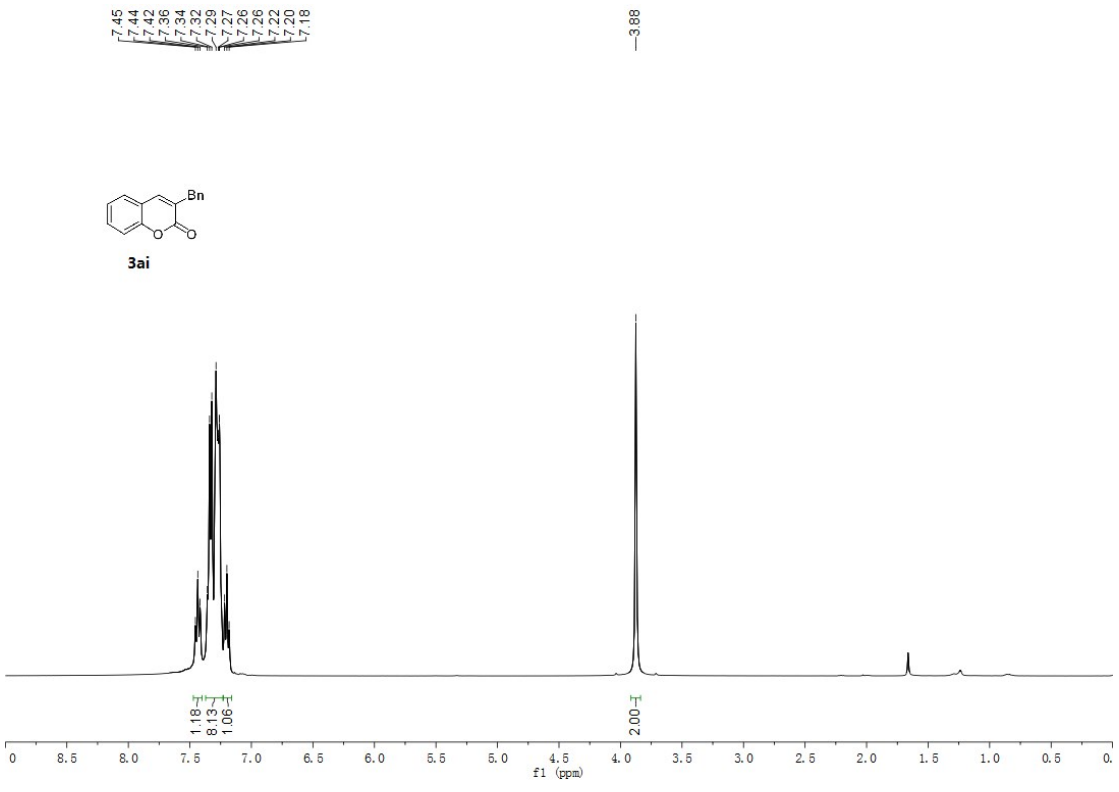

162.07
153.10
139.12
130.32
126.85
125.65
124.15
119.45
116.27
77.00 CDCl3
17.03
3ae
f1 (ppm)

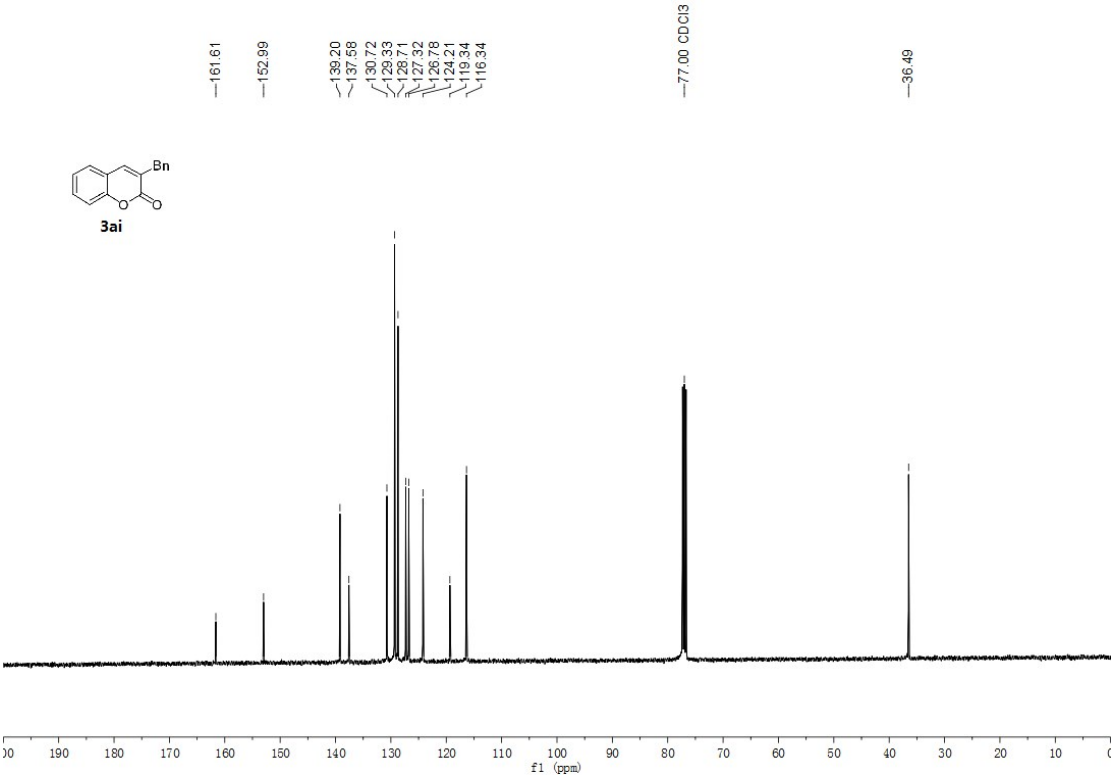

7.47
7.44
7.42
7.29
7.27
7.26 CDCl3
7.26
7.25
7.23
7.21
2.61
2.59
2.58
2.56
1.26
1.24
1.22
3af
2.94
1.98
2.00
3.02
f1 (ppm)

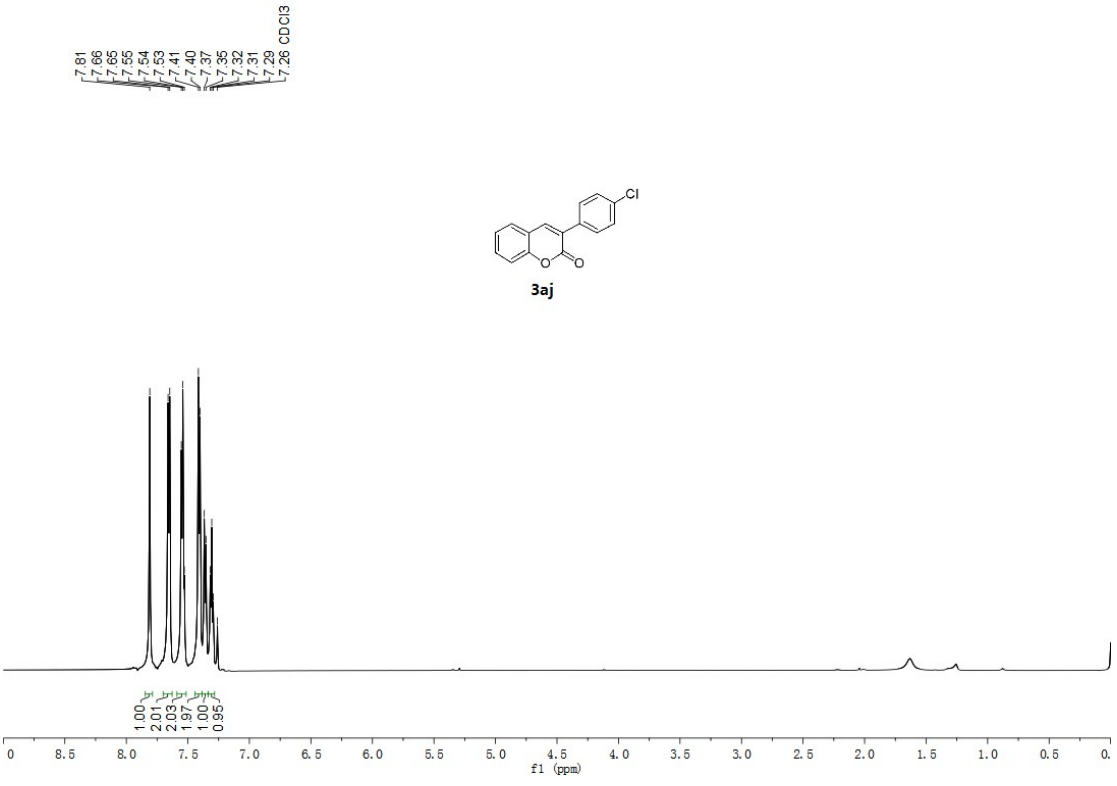

161.74
152.90
137.43
131.16
130.36
127.07
124.15
119.51
116.27
77.00 CDCl3
23.78
12.18
3af
f1 (ppm)
7.51
7.50
7.48
7.46
7.44
7.33
7.31
7.28
7.26
7.24
6.04
6.02
5.99
5.98
5.95
5.93
5.25
5.24
5.21
3.34
3.32

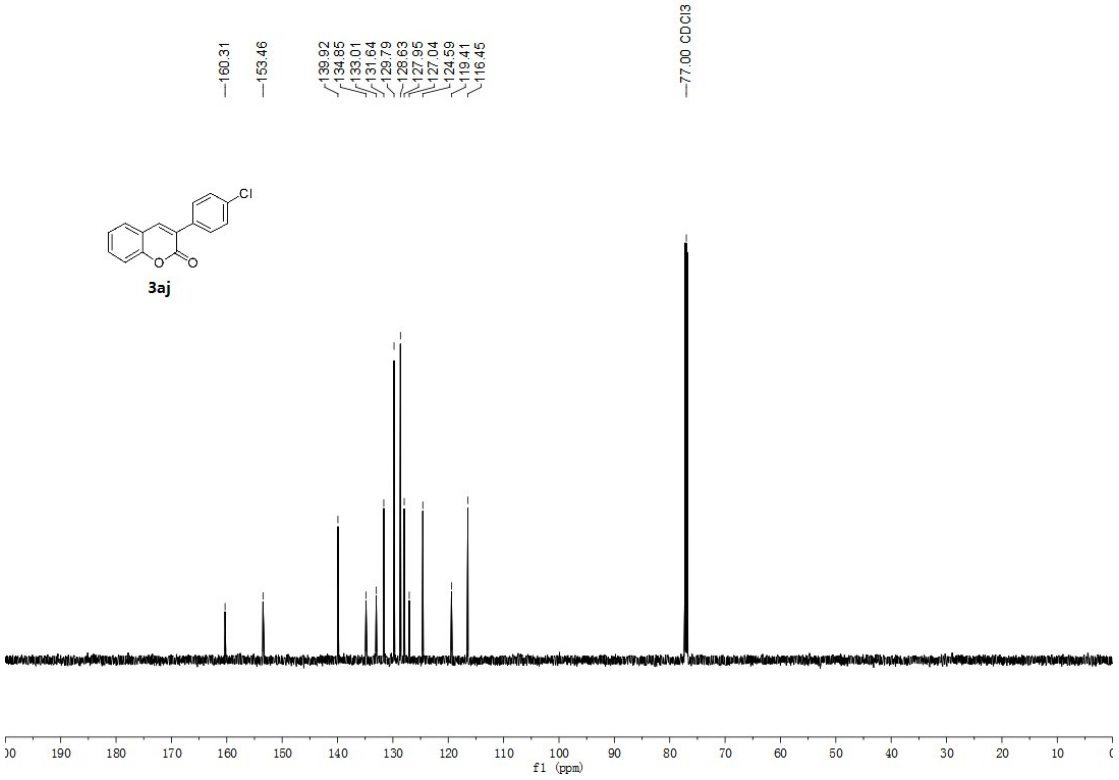

3ag
0.98
2.14
0.97
1.14
1.00
0.96
0.97
1.99
f1 (ppm)

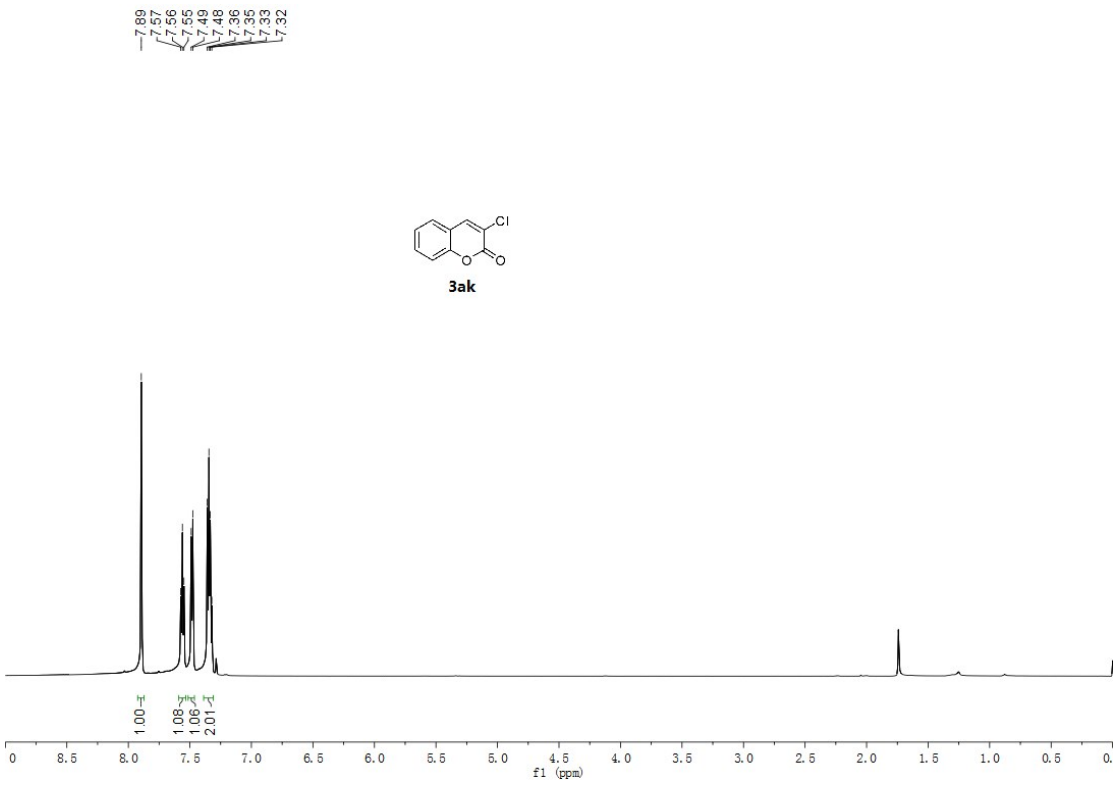

161.54
153.04
138.88
133.72
130.69
127.94
127.23
124.26
119.38
118.15
116.38
77.00 CDCl3
34.48
3ag
f1 (ppm)


7.45
7.44
7.42
7.36
7.34
7.32
7.29
7.27
7.26
7.26
7.22
7.20
7.18
3.88
Bn
3ai
1.18
8.13
1.06
2.00
f1 (ppm)


161.61
152.99
139.20
137.58
130.72
129.33
128.71
127.32
126.78
124.21
119.34
116.34
77.00 CDCl3
36.49
Bn
O
O
3ai
f1 (ppm)


7.81
7.66
7.65
7.55
7.54
7.53
7.41
7.40
7.37
7.35
7.32
7.31
7.29
7.26 CDCl3
Cl
O
O
3aj
1.00
2.01
2.03
1.97
1.00
0.95
f1 (ppm)


160.31
153.46
139.92
134.85
133.01
131.64
129.79
128.63
127.95
127.04
124.59
119.41
116.45
77.00 CDCl3
Cl
O
O
3aj
f1 (ppm)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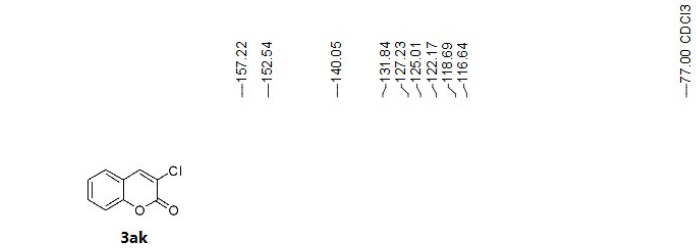
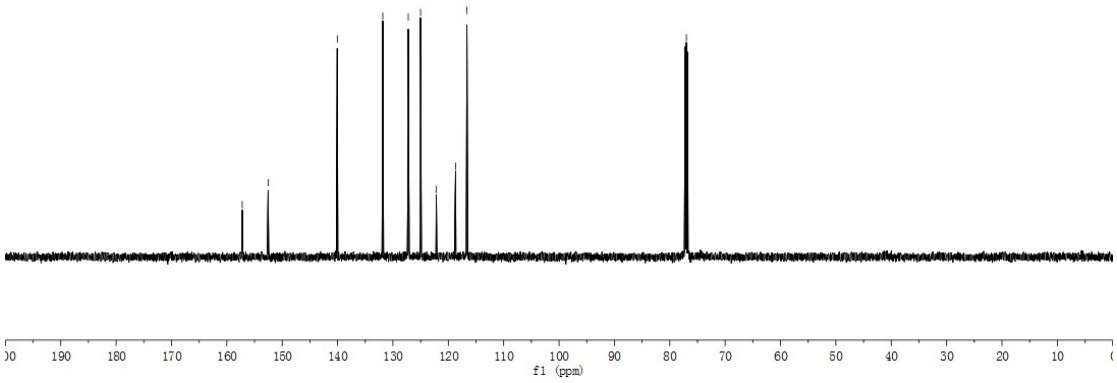
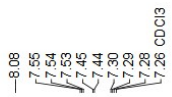
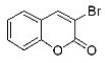
7.57
7.56
7.55
7.49
7.48
7.36
7.35
7.33
7.32
Cl
O
O
3ak
1.00
1.08
1.06
2.01
f1 (ppm)


157.22
152.54
140.05
131.84
127.23
125.01
122.17
118.69
116.64
77.00 CDCl3
Cl
O
O

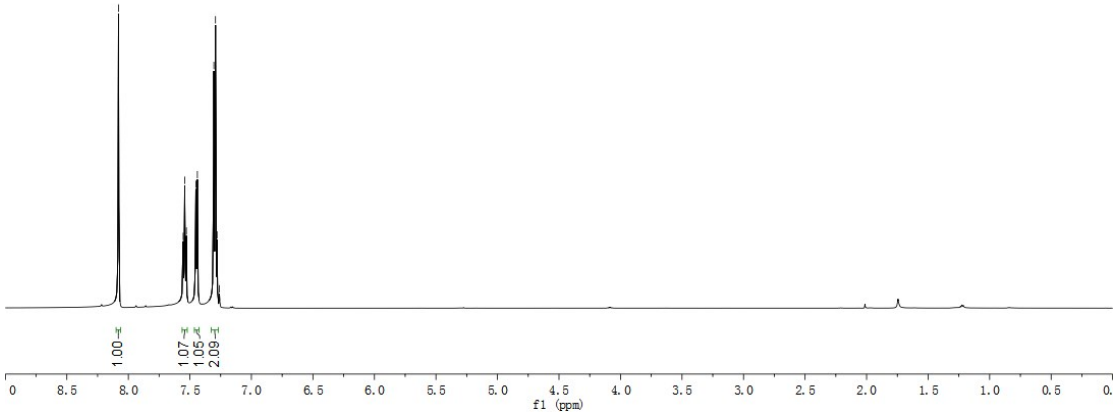
3ak

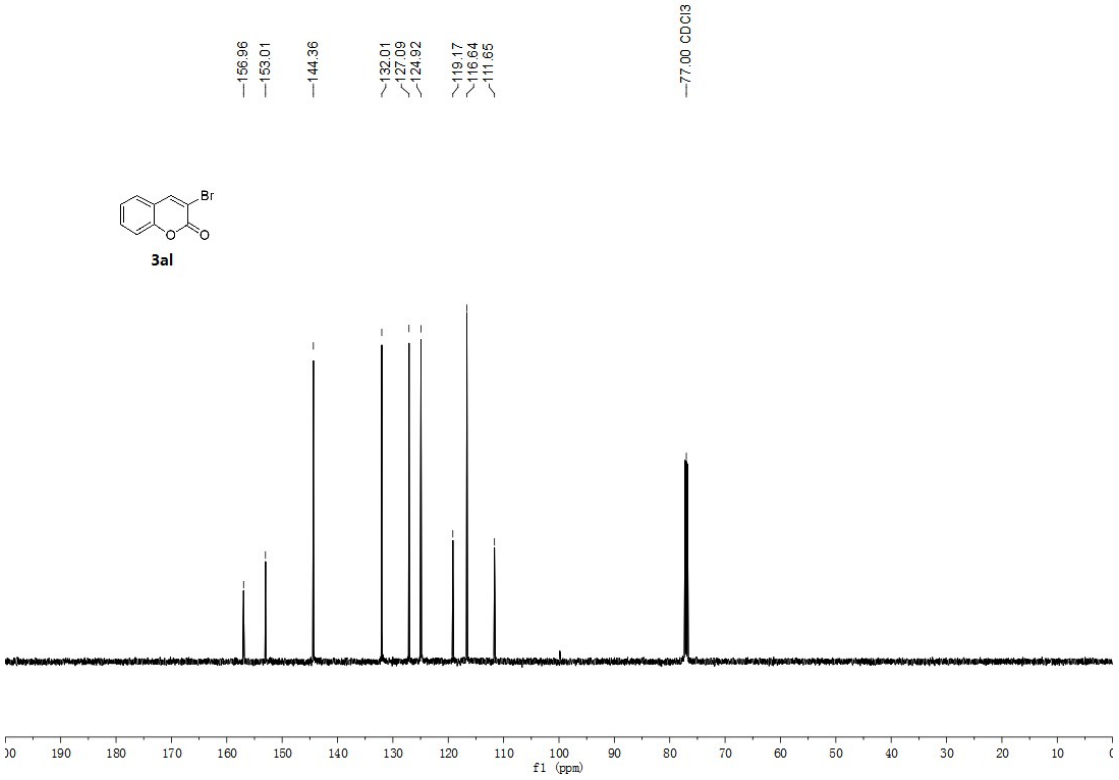

f1 (ppm)

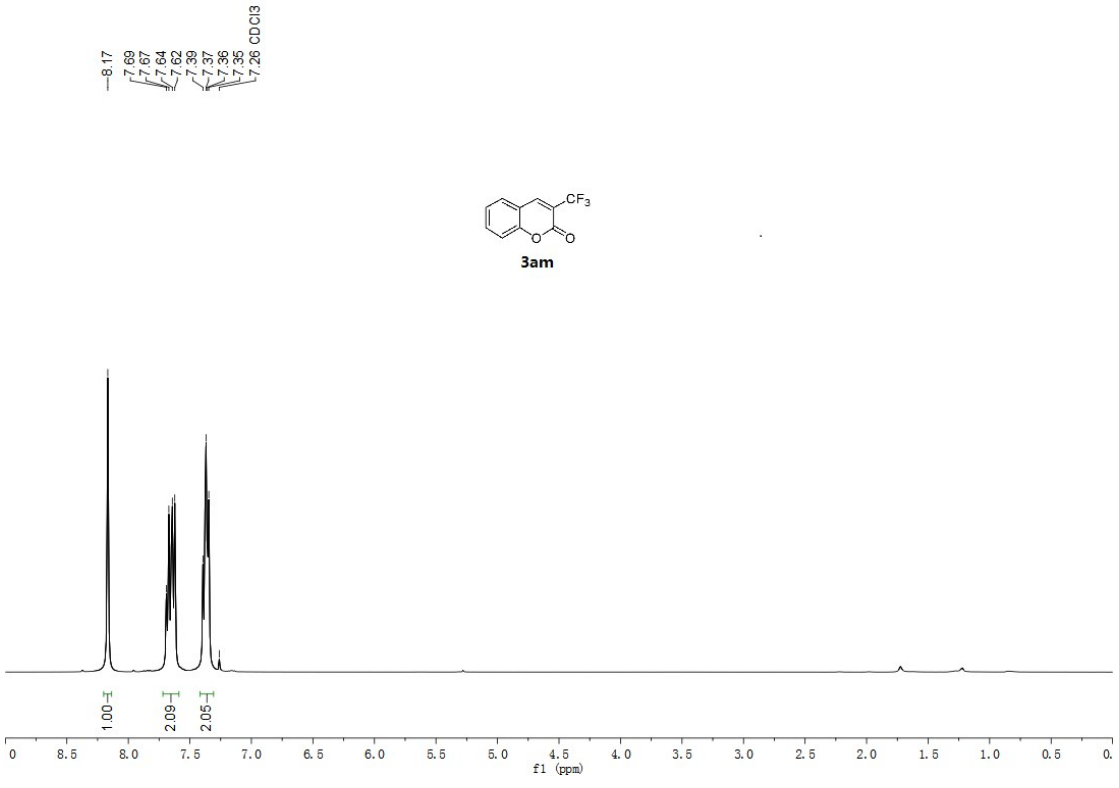

8.08
7.55
7.54
7.53
7.45
7.44
7.30
7.29
7.28
7.26 CDCl3

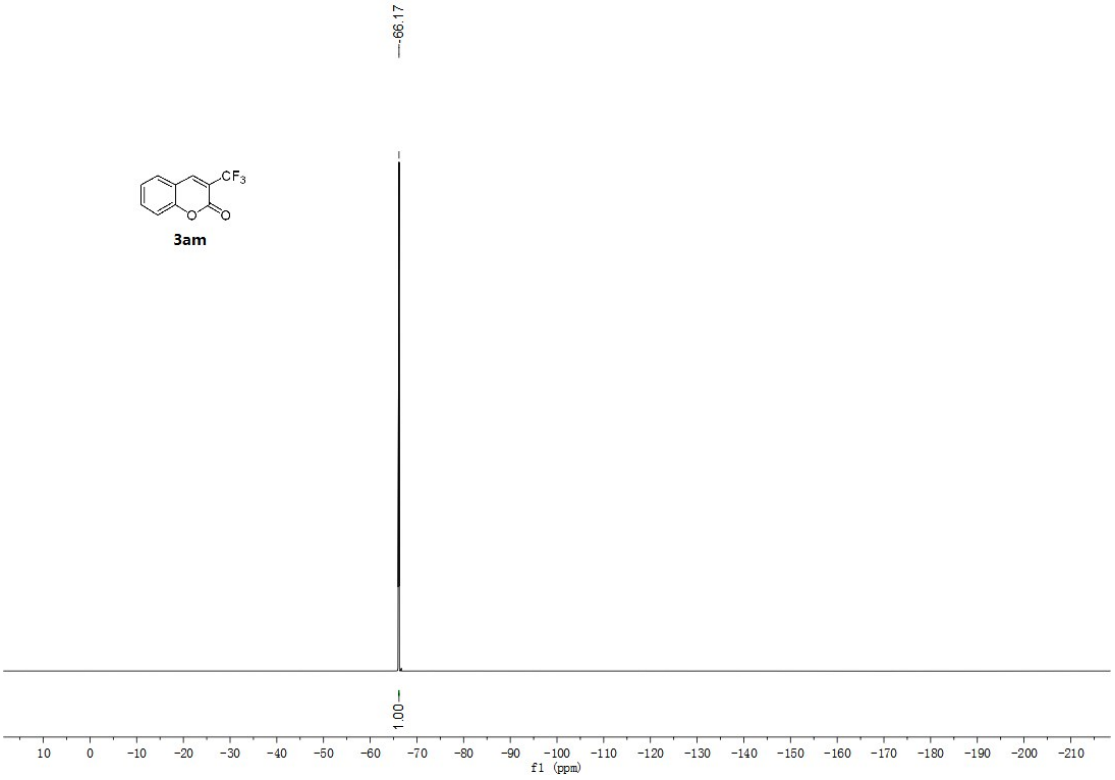

Br
O
O

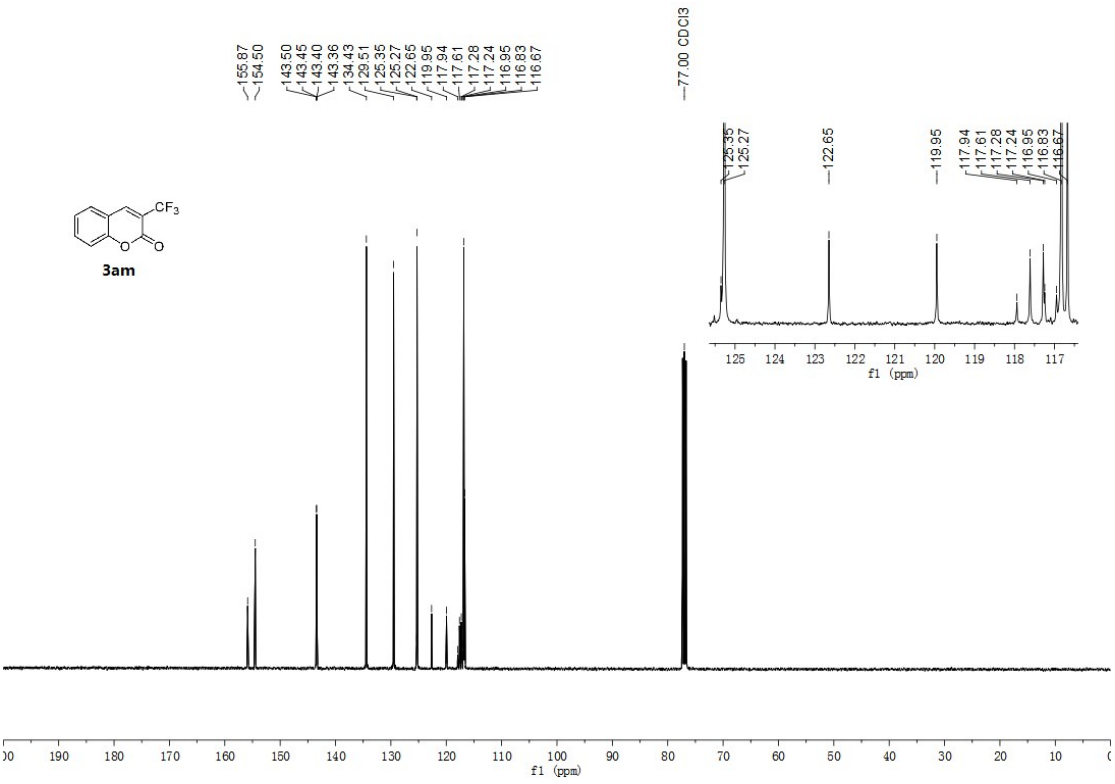
3al


1.00
1.07
1.05
2.09
f1 (ppm)


156.96
153.01
144.36
132.01
127.09
124.92
119.17
116.64
111.65
77.00 CDCl3
Br
O
O
3al
f1 (ppm)


8.17
7.69
7.67
7.64
7.62
7.39
7.37
7.36
7.35
7.26 CDCl3
CF3
O
O
3am
1.00
2.09
2.05
f1 (ppm)


-66.17
3am
1.00
f1 (ppm)


155.87
154.50
143.50
143.45
143.40
143.36
134.43
129.51
125.35
125.27
122.65
119.95
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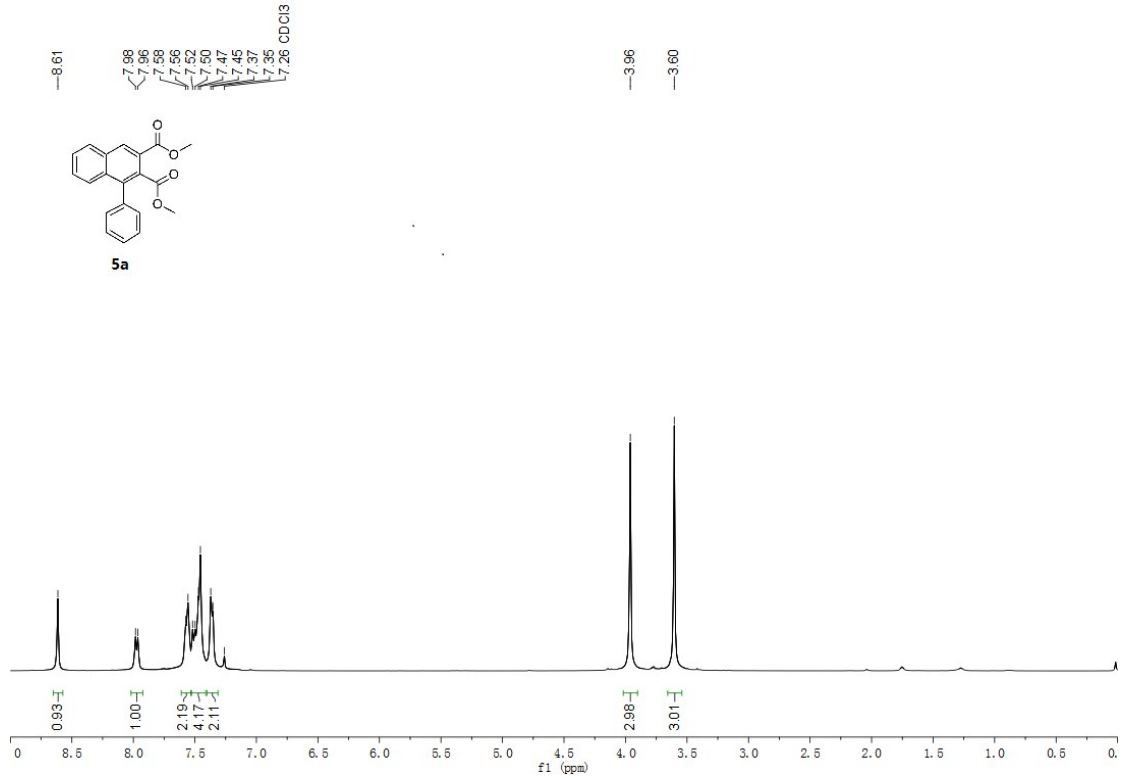
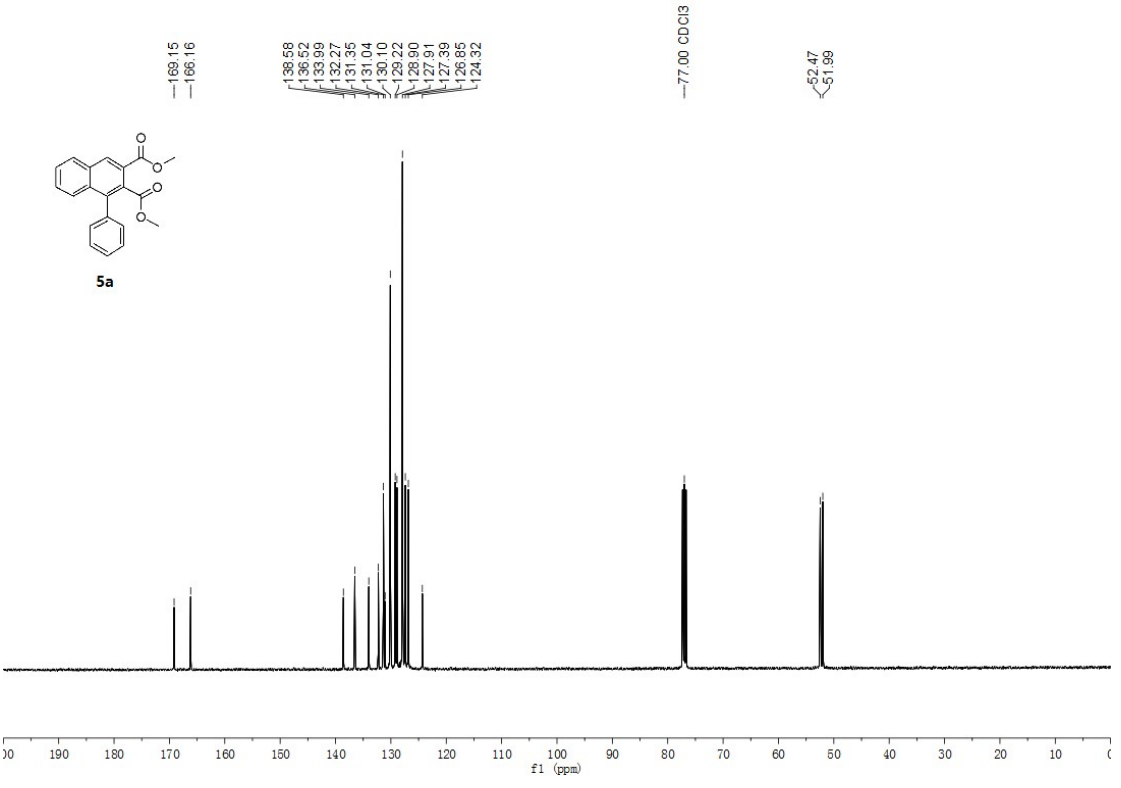
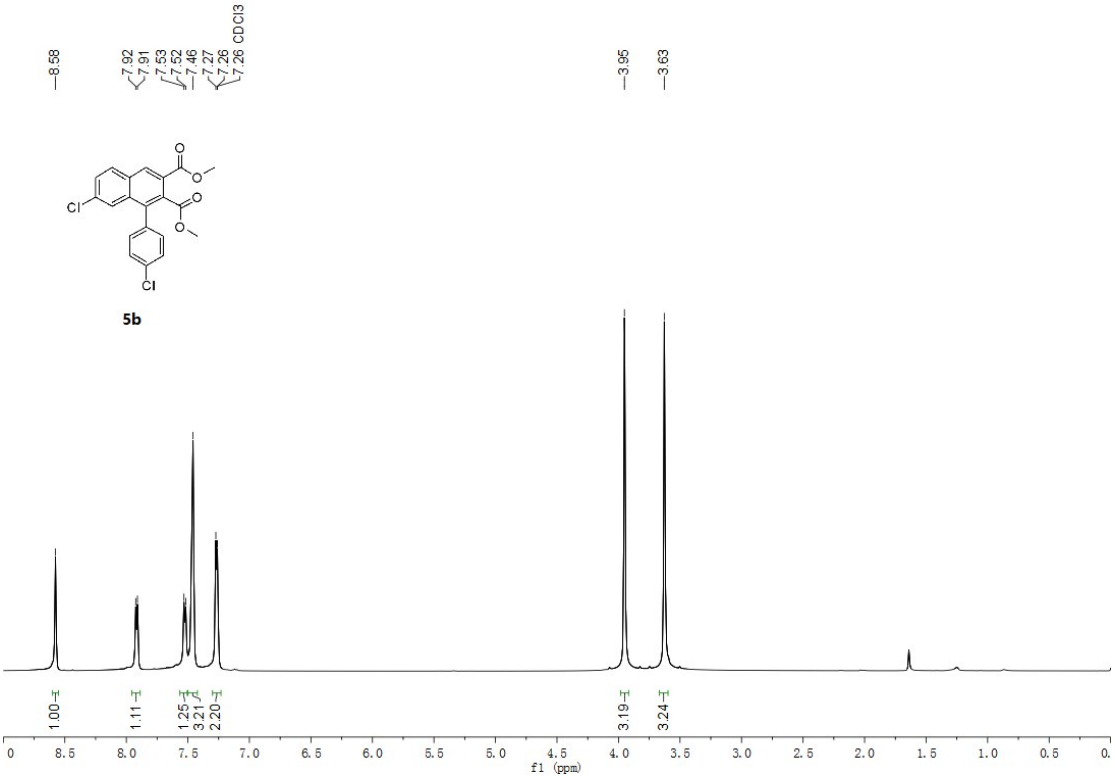
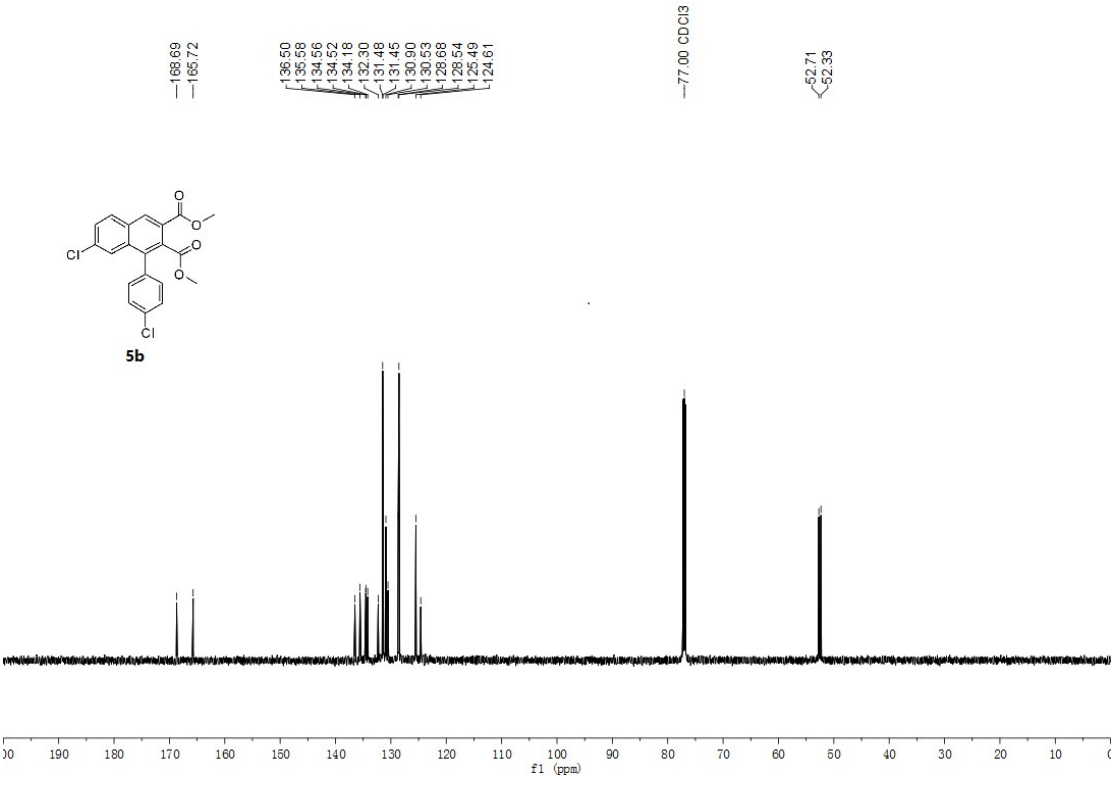
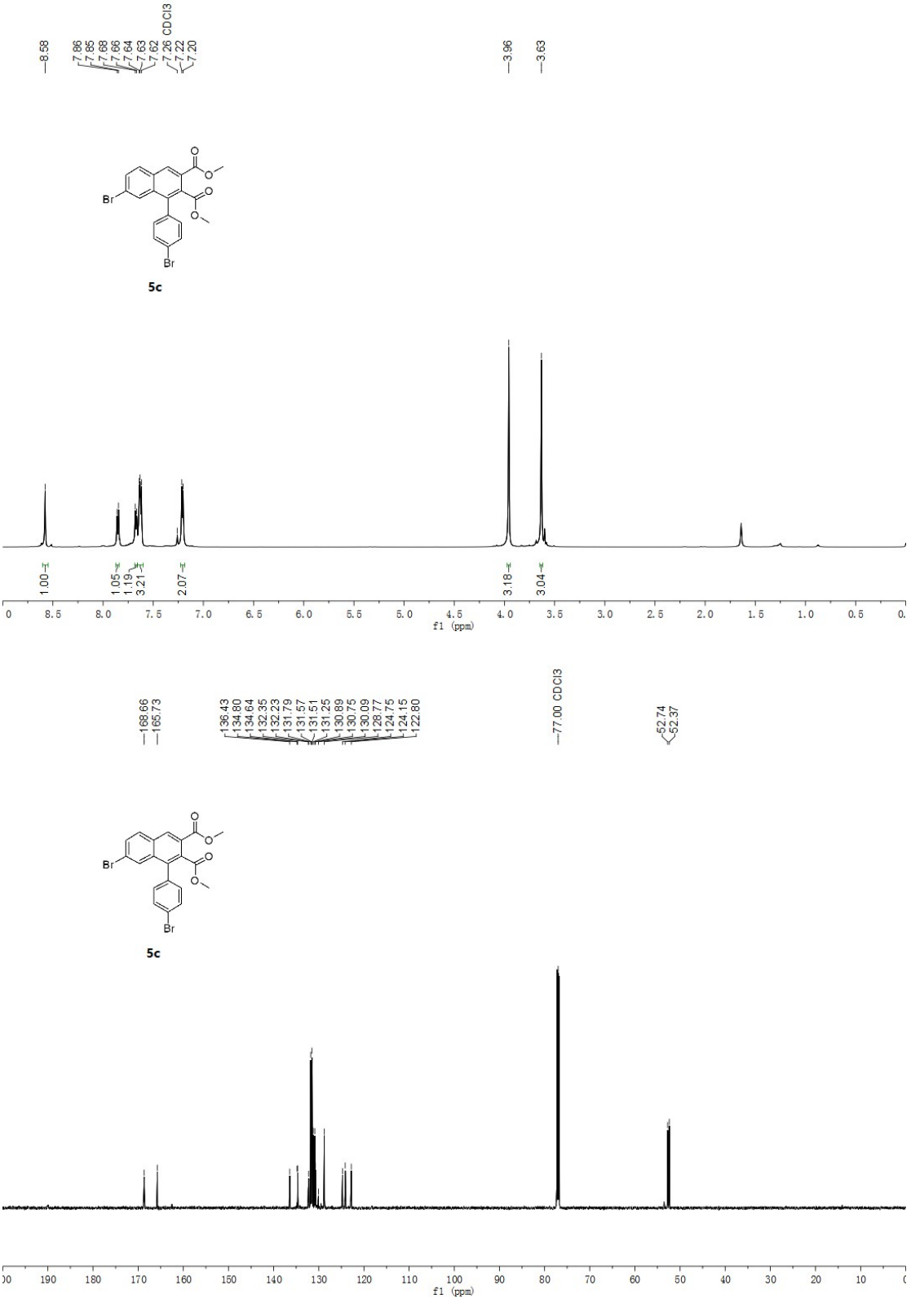
116.83
116.67
77.00 CDCl3
3am
f1 (ppm)

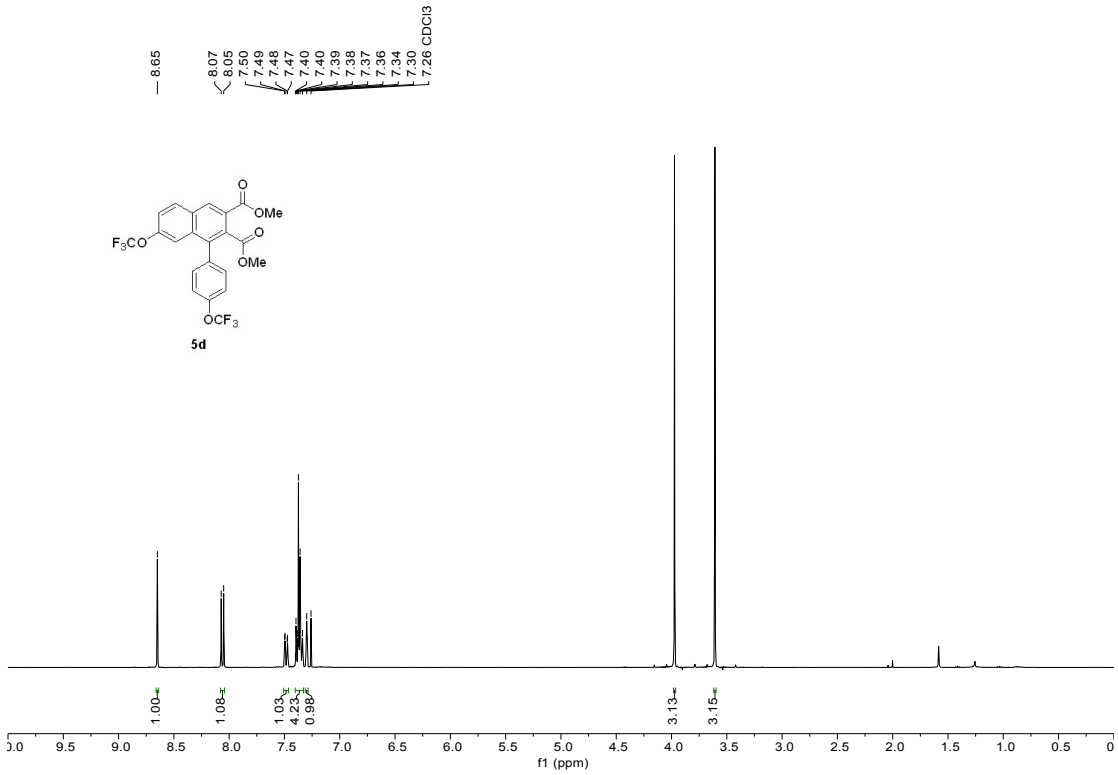

8.61
7.98
7.96
7.58
7.56
7.52
7.50
7.47
7.45
7.37
7.35
7.26 CDCl3
3.96
3.60
5a
0.93
1.00
2.19
4.17
2.11
2.98
3.01
f1 (ppm)

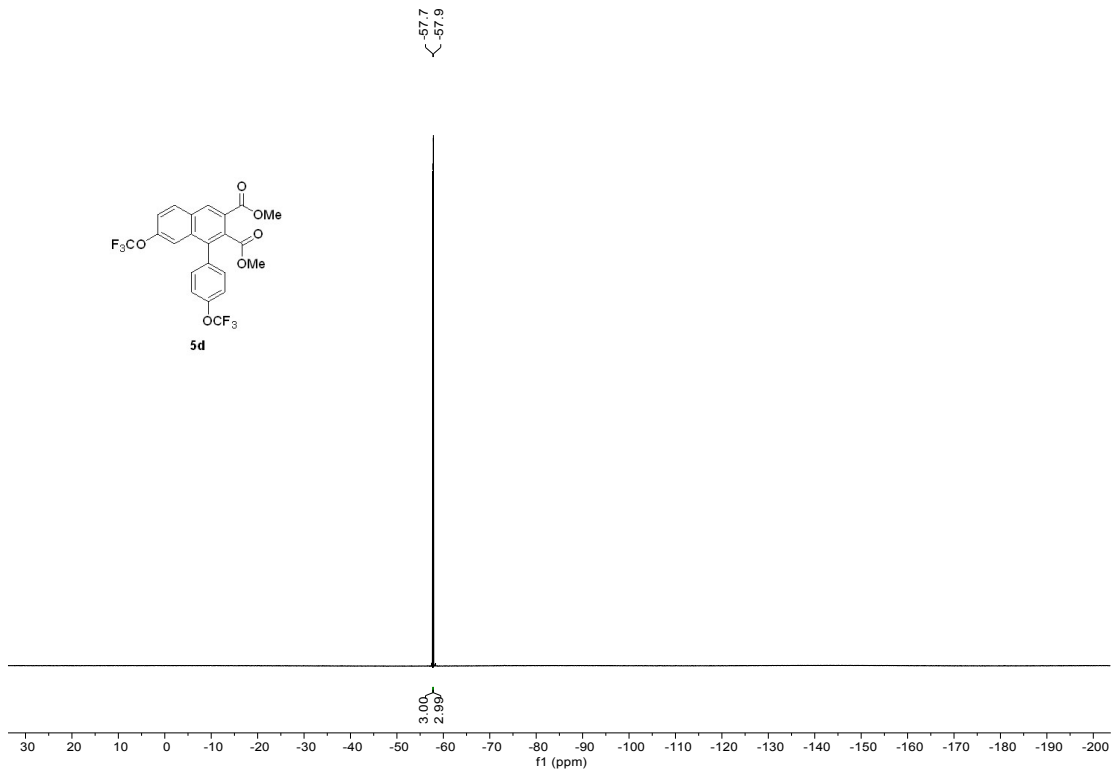

169.15
166.16
138.58
136.52
133.99
132.27
131.35
131.04
130.10
129.22
128.90
127.91
127.39
126.85
124.32
77.00 CDCl3
52.47
51.99
5a
f1 (ppm)

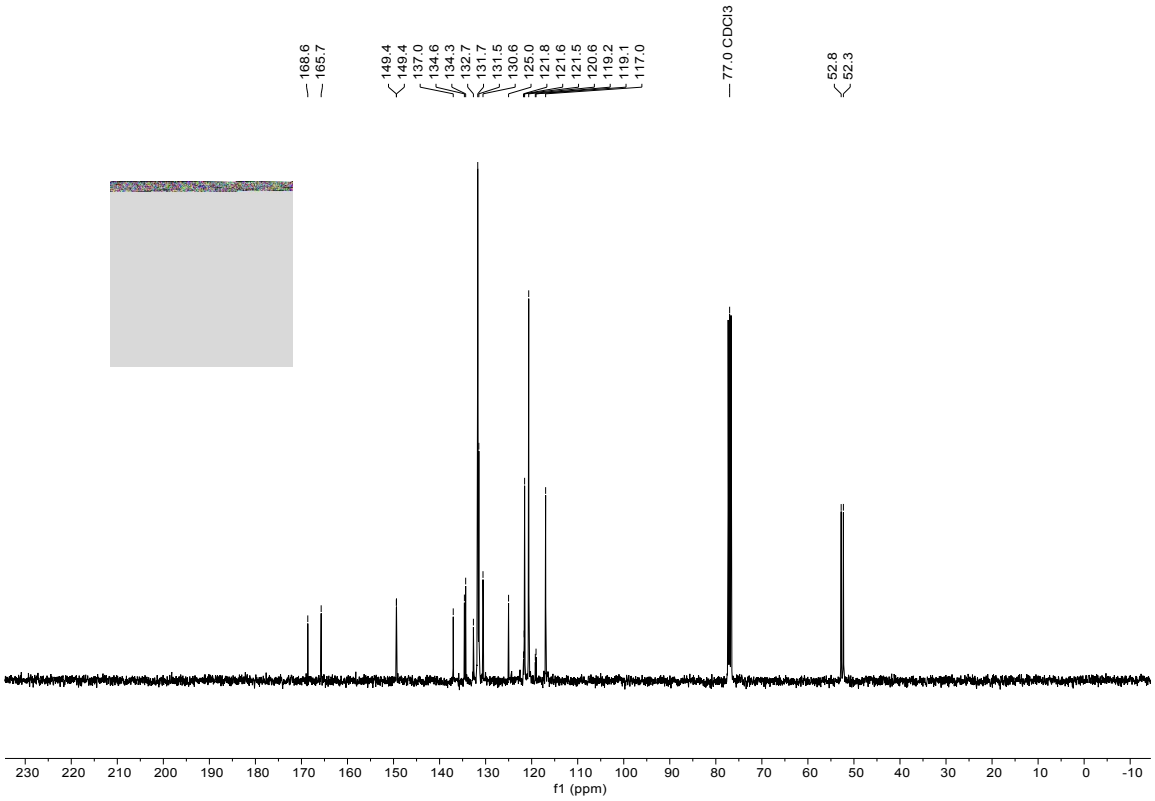

8.58
7.92
7.91
7.53
7.52
7.46
7.27
7.26
7.26 CDCl3
3.95
3.63
Cl
O
O
O
O
Cl
5b
1.00
1.11
1.25
3.21
2.20
3.19
3.24
f1 (ppm)

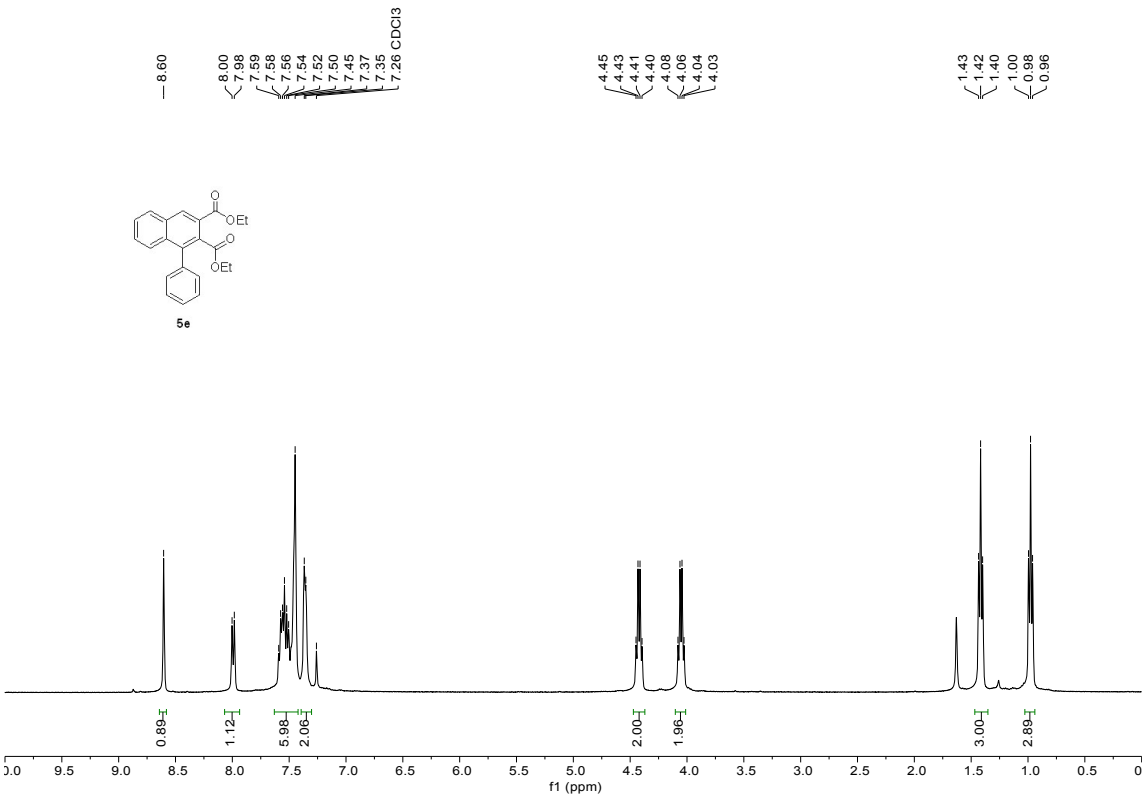

168.69
165.72
136.50
135.58
134.56
134.52
134.18
132.30
131.48
131.45
130.90
130.53
128.88
128.54
125.49
124.61
77.00 CDCl3
52.71
52.33
Cl
O
O
O
O
Cl
5b
f1 (ppm)

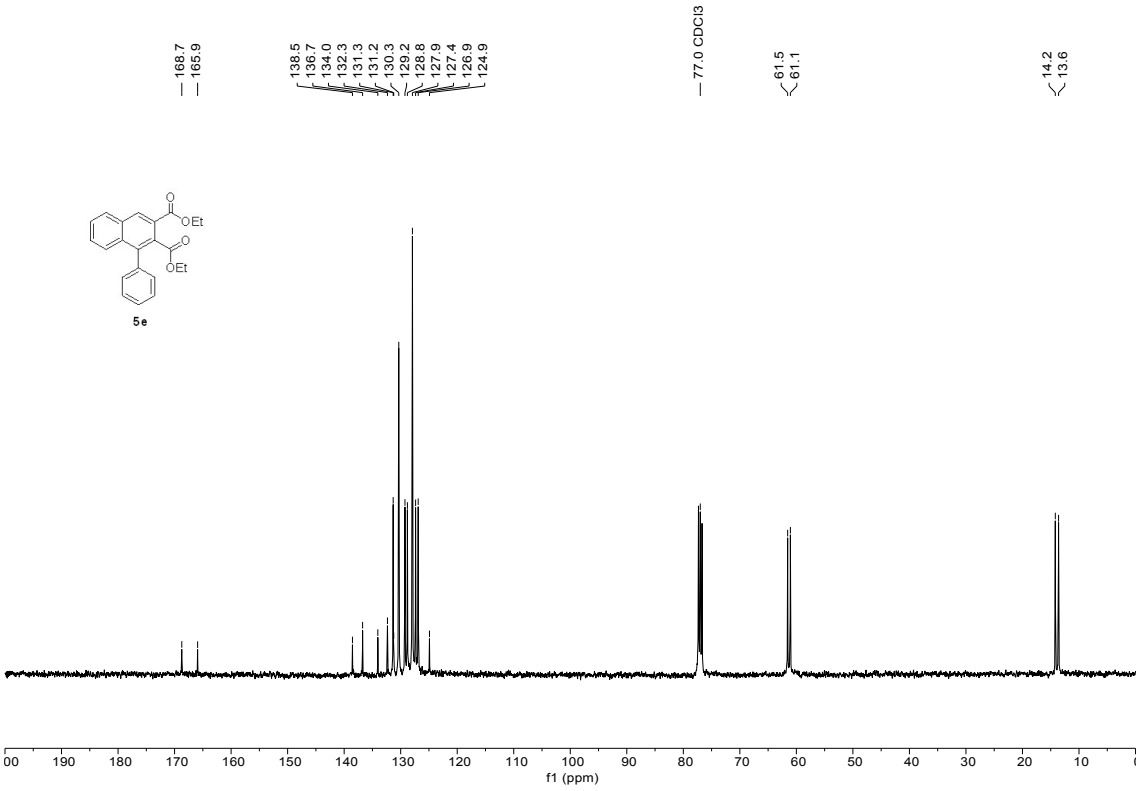

8.58
7.86
7.85
7.68
7.66
7.64
7.63
7.62
7.26 CDCl3
7.22
7.20
3.96
3.63
Br
Br
5c
1.00
1.05
1.19
3.21
2.07
3.18
3.04
f1 (ppm)
168.66
165.73
136.43
134.80
134.64
132.35
132.23
131.79
131.57
131.51
131.25
130.89
130.75
130.09
128.77
124.75
124.15
122.80
77.00 CDCl3
52.74
52.37
Br
Br
5c
f1 (ppm)

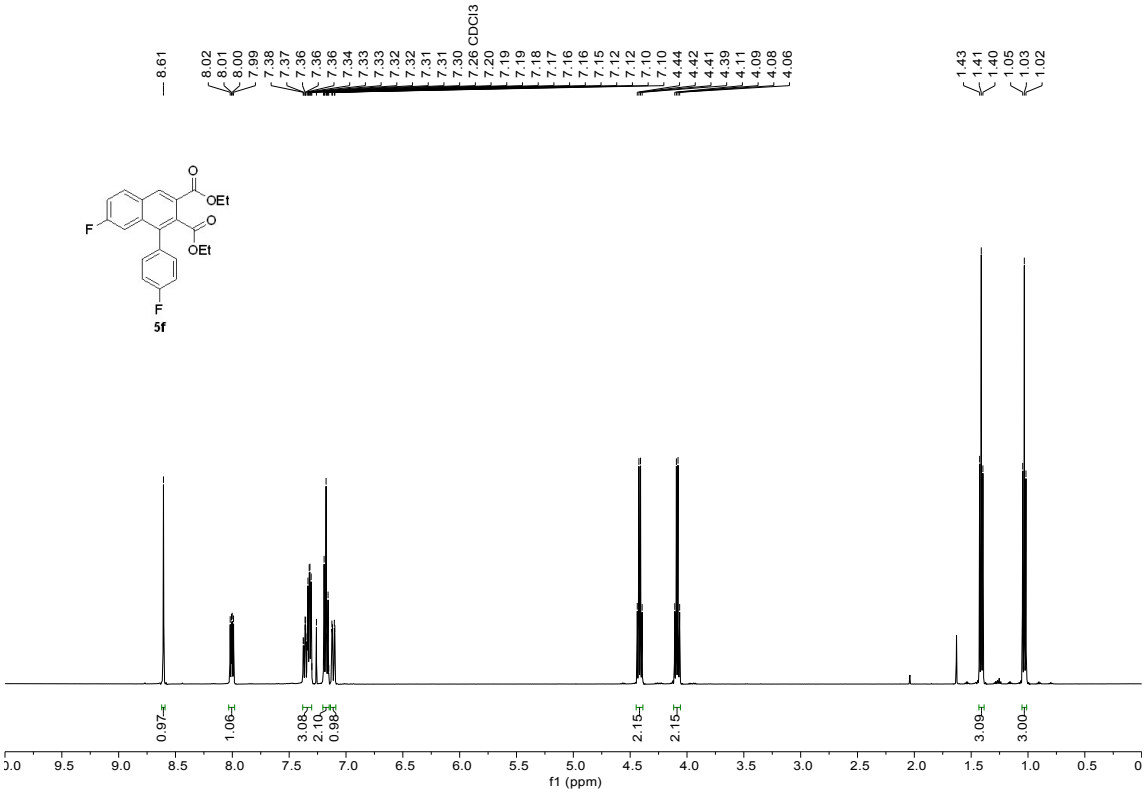

8.65
8.07
8.05
7.50
7.49
7.48
7.47
7.40
7.40
7.39
7.38
7.37
7.36
7.34
7.30
7.26 CDCl3
OMe
O
F3CO
O
OMe
OCF3
5d
1.00
1.08
1.03
4.23
0.98
3.13
3.15
f1 (ppm)

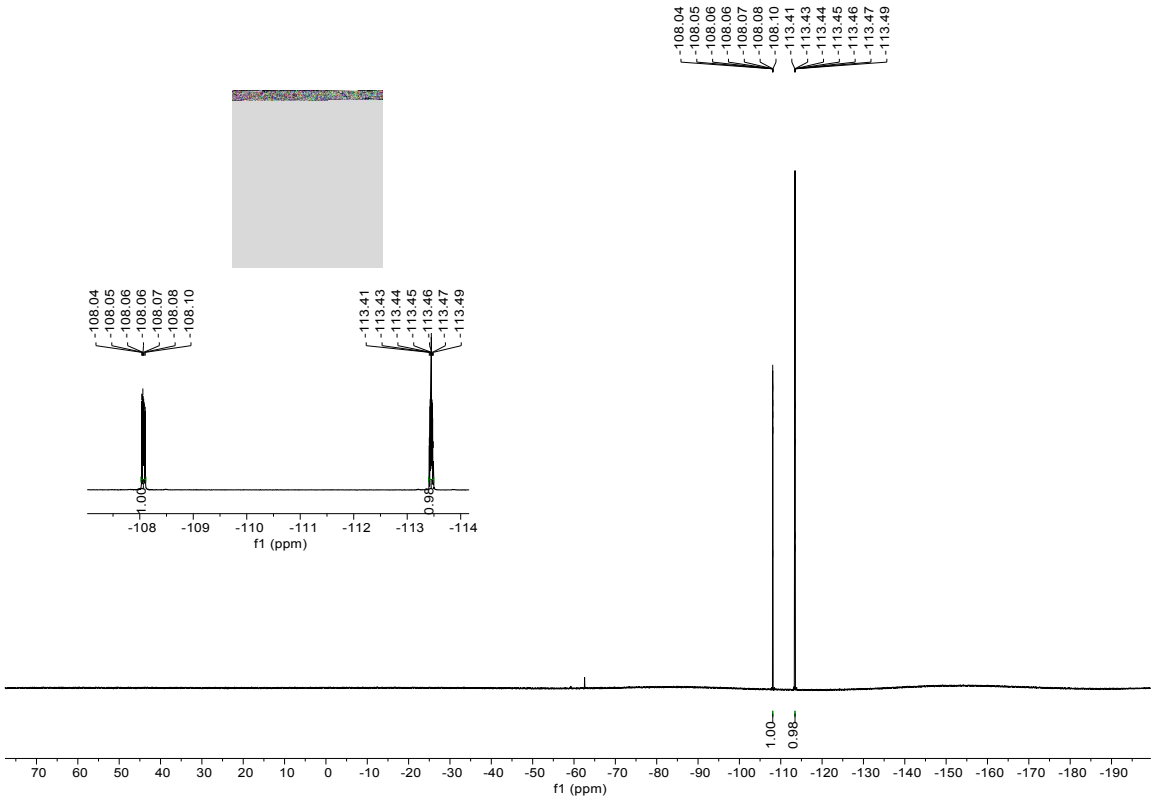

-57.7
-57.9
OMe
O
F3CO
O
OMe
OCF3
5d
3.00
2.99
f1 (ppm)

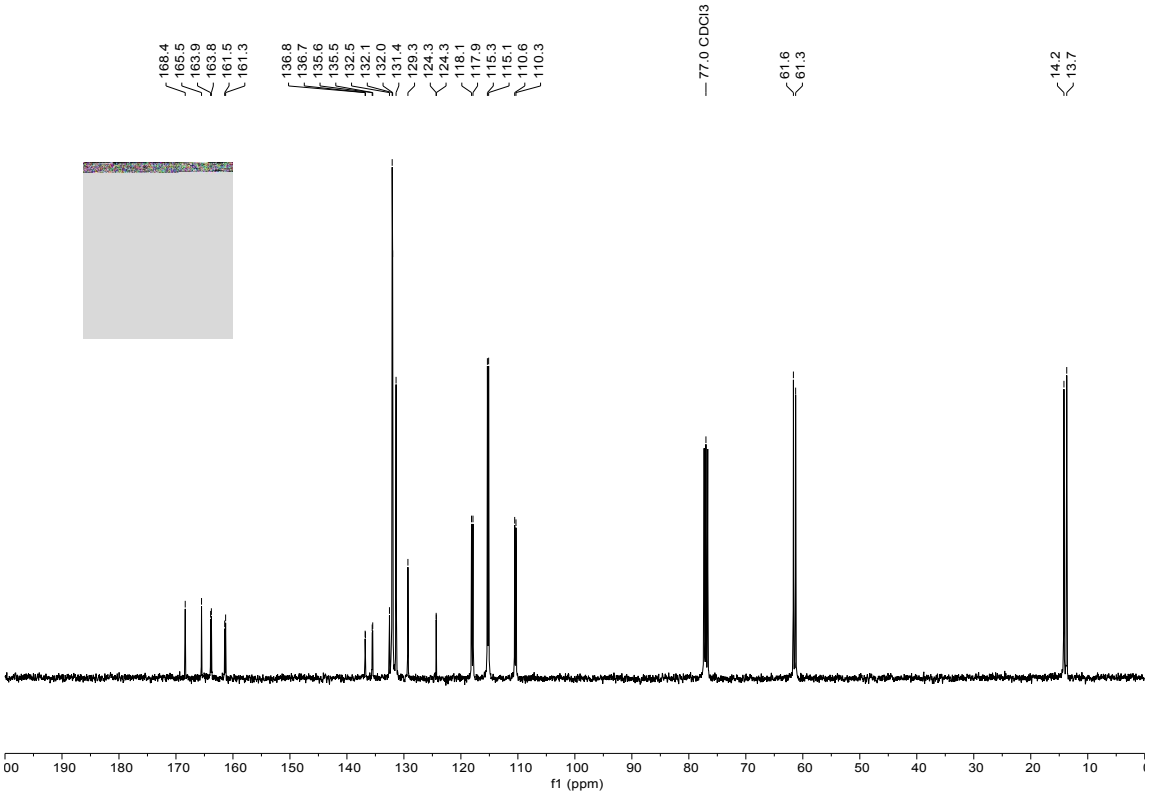

168.6
165.7
149.4
149.4
137.0
134.6
134.3
132.7
131.7
131.5
130.6
125.0
121.8
121.6
121.5
120.6
119.2
119.1
117.0
77.0 CDCl3
52.8
52.3
f1 (ppm)

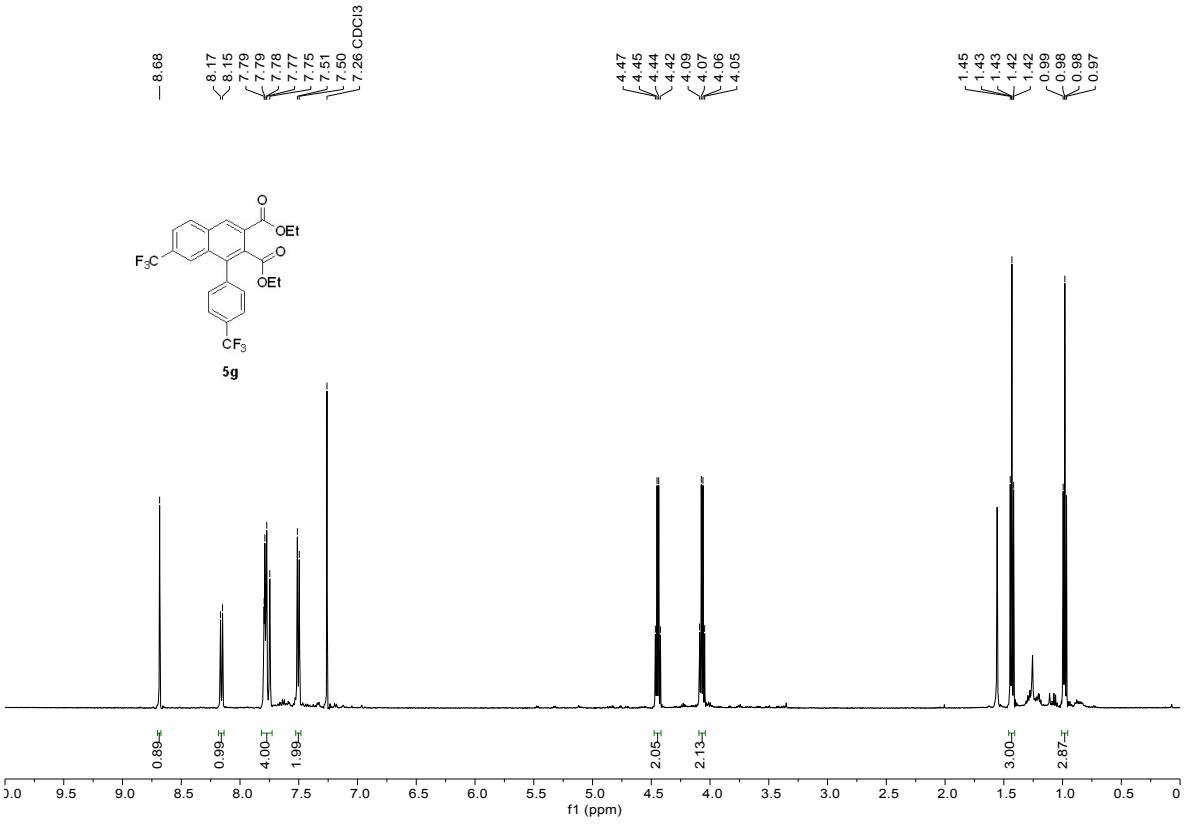

8.60
8.00
7.98
7.59
7.58
7.56
7.54
7.52
7.50
7.45
7.37
7.35
7.26 CDCl3
4.45
4.43
4.41
4.40
4.08
4.06
4.04
4.03
1.43
1.42
1.40
1.00
0.98
0.96
OEt
OEt
5e
0.89
1.12
5.98
2.06
2.00
1.96
3.00
2.89
f1 (ppm)

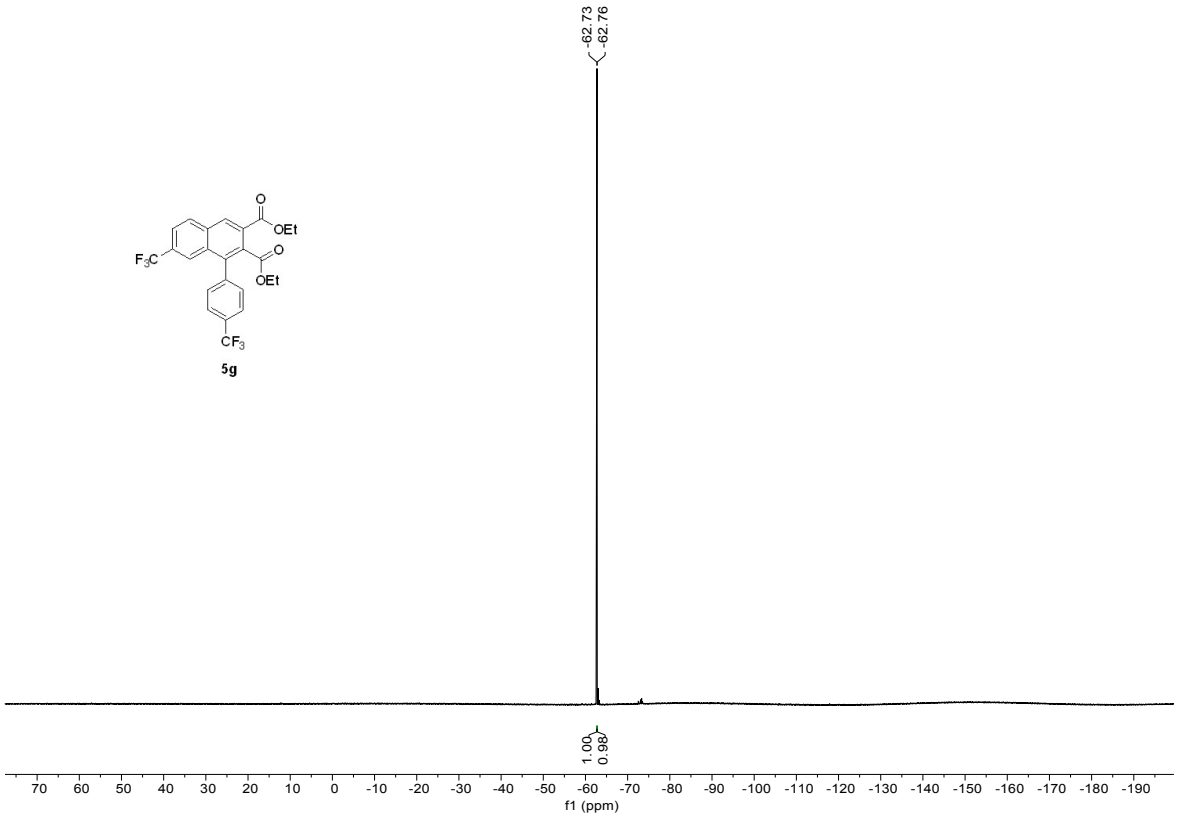

168.7
165.9
138.5
136.7
134.0
132.3
131.3
131.2
130.3
129.2
128.8
127.9
127.4
126.9
124.9
77.0 CDCl3
61.5
61.1
14.2
13.6
OEt
O
OEt
5e
f1 (ppm)

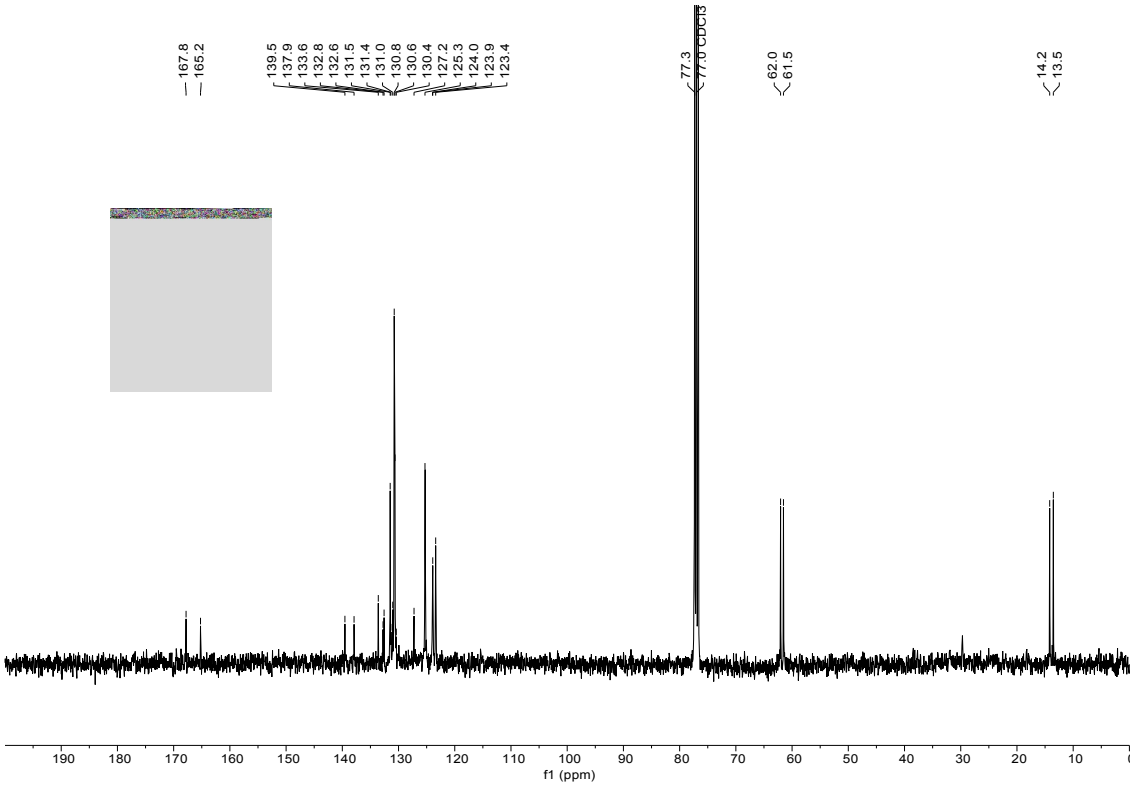

8.61
8.02
8.01
8.00
7.99
7.38
7.37
7.36
7.36
7.36
7.34
7.33
7.33
7.32
7.32
7.31
7.31
7.30
7.26 CDCl3
7.20
7.19
7.19
7.18
7.17
7.16
7.16
7.15
7.12
7.12
7.10
7.10
4.44
4.42
4.41
4.39
4.11
4.09
4.08
4.06
1.43
1.41
1.40
1.05
1.03
1.02
OEt
O
OEt
F
F
5f
0.97
1.06
3.08
2.10
0.98
2.15
2.15
3.09
3.00
f1 (ppm)


-108.04
-108.05
-108.06
-108.06
-108.07
-108.08
-108.10
-113.41
-113.43
-113.44
-113.45
-113.46
-113.47
-113.49
1.00
0.98
f1 (ppm)


168.4
165.5
163.9
163.8
161.5
161.3
136.8
136.7
135.6
135.5
132.5
132.1
132.0
131.4
129.3
124.3
124.3
118.1
117.9
115.3
115.1
110.6
110.3
77.0 CDCl3
61.6
61.3
14.2
13.7
f1 (ppm)


8.68
8.17
8.15
7.79
7.79
7.78
7.77
7.75
7.51
7.50
7.26 CDCl3
4.47
4.45
4.44
4.42
4.09
4.07
4.06
4.05
1.45
1.43
1.43
1.42
1.42
0.99
0.98
0.98
0.97
OEt
O
OEt
F3C
CF3
5g
0.89
0.99
4.00
1.99
2.05
2.13
3.00
2.87
f1 (ppm)


-62.73
-62.76
OEt
O
OEt
F3C
CF3
5g
1.00
0.98
f1 (ppm)


167.8
165.2
139.5
137.9
133.6
132.8
132.6
131.5
131.4
131.0
130.8
130.6
130.4
127.2
125.3
124.0
123.9
123.4
77.3
77.0 CDCl3
62.0
61.5
14.2
13.5
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
f1 (ppm)

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