

Supporting Information

Synthesis of Enantioenriched α,α -Difluoro- β -Arylbutanoic Esters By Pd-Catalysed Asymmetric Hydrogenation

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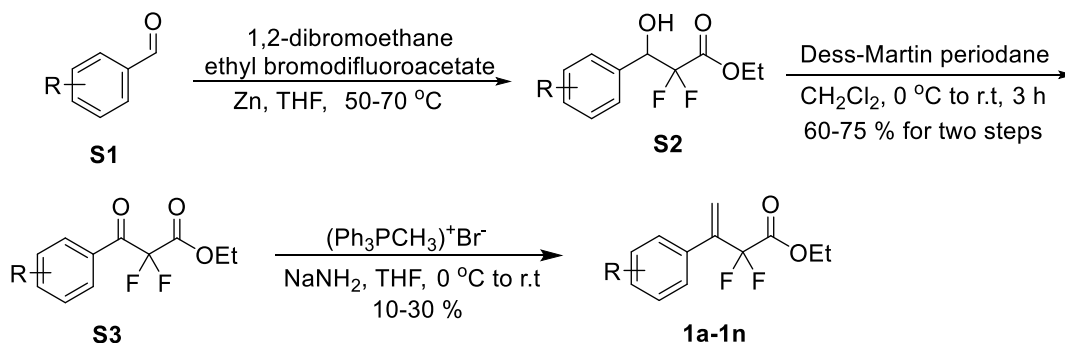
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1. General experimental details

All reactions and manipulations were performed in a nitrogen-filled glove box or under nitrogen using Schlenk techniques unless otherwise noted. Solvents were purified by standard procedure before use. Commercial reagents were used without further purification. The products were purified by column chromatography over silica gel (200-300 mesh). ^1H NMR spectra were recorded on a Bruker AV-500 (500 MHz) and Bruker AV-600 (600 MHz). ^{19}F NMR spectra were recorded on a Bruker AV-500 (470 MHz) and Bruker AV-600 (564 MHz). ^{13}C NMR spectra were recorded on a Bruker AV-500 (125 MHz) and Bruker AV-600 (150 MHz). ^1H NMR chemical shifts were referenced to tetramethylsilane signal (0 ppm), ^{13}C NMR chemical shifts were referenced to the solvent resonance (77.00 ppm, CDCl_3). Coupling constants are given in hertz. The following abbreviations are used: s, singlet; d, doublet; t, triplet; q, quadruplet; m, multiplet; dd, doublet of doublet; tt, triplet of triplet. High resolution mass spectra (HRMS) were recorded on Bruker microTof by using ESI method. Enantiomeric ratios were determined by chiral HPLC with hexane and $i\text{PrOH}$ as solvents. Infrared spectroscopy was recorded on Thermo Scientific Nicolet iS 10 FTIR spectrometer. Optical rotation was determined using CHCl_3 and as the solvent on INESA WZZ-3. The absolute configuration was determined by single crystal X-ray diffraction analysis on Rigaku XtaLAB PRO MM003-DS dual system at 293 K with a Cu micro-focus source.

2. General procedure for the synthesis of substrates and characterization data

Procedure A: Preparation of α,α -difluoro- β -arylbutenoic esters (**1a-1n**, **1p**, **1q**), amide (**1o**) and α,α -difluoro- β,γ -diphenylbutenoic esters (**1r**)



To an oven-dried 250 mL Schlenk tube was charged with Zn (98.4 mmol, 2 equiv.) in dry THF (100 mL). To activate the Zn, the initiator 1,2-dibromoethane (5.8 mmol, 0.1 equiv.) was added and the reaction mixture was heated to gentle reflux by heat gun (ca. 65 °C) and then cooled to r.t. This heating-cooling procedure for activating Zn was repeated three times. Subsequently, to this mixture, THF solution of **S1** (49 mmol, 1 equiv.) and ethyl bromodifluoroacetate (49 mmol, 1 equiv.) was added dropwise at 50 °C in oil bath. After completion of the reaction, the reaction was cooled to room temperature and filtered through Celite and 1N HCl(aq) was added until the residual Zn was dissolved. Then the organic layer was separated and the water phase was extracted with ethyl acetate for 3 times. The combined organic phase was evaporated under reduced pressure to provide the compound **S2** as a colorless oil,^[S1] which was pure enough and directly used for the next step.

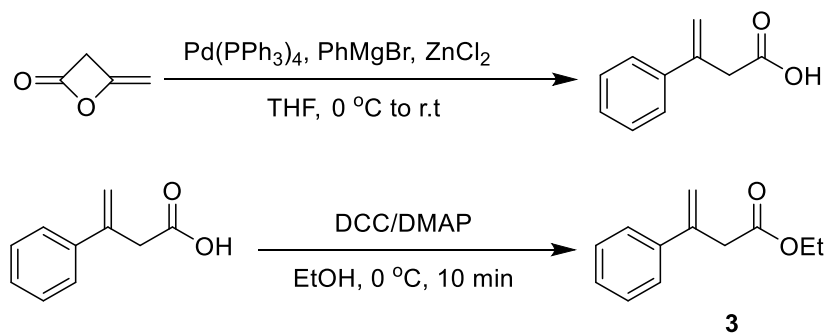
To an oven-dried flask was added the solution of **S2** (10 mmol, 1.0 equiv.) in CH_2Cl_2 (40 mL). Then the resulting solution was cooled to 0 °C with ice-bath and Dess-Martin periodinane (15 mmol, 1.5 equiv.) was added in portion. After stirring at room temperature for 3 hours, the mixture was filtered through Celite. NaHCO_3 and

Na₂SO₃ were added to the resulting filtrate until Dess-Martin periodinane was consumed. Then organic phase was separated and the aqueous layer was extracted with CH₂Cl₂ (3 × 10 mL). The combined organic phase was washed with brine (1 × 10 mL), dried over anhydrous Na₂SO₄ and concentrated under reduced pressure. Purification by column chromatography over silica gel (200-300 mesh, PE/EA = 30/1) afforded **S3** as oil.^[S2]

To an over-dried 100 mL Schlenk tube was added the solution of **S3** (5 mmol, 1 equiv) in dry THF (25 mL). Then the reaction mixture was cooled to 0 °C with ice-bath and added THF solution of “instant ylide”^[S3] (i.e. the Schlosser-Schaub salt-base mixtures, 1 equiv) dropwise with syringe. The temperature was then allowed to rise to 25 °C. After completion of the reaction, the reaction mixture was passed through a short silica bed and washed with THF. The solvent was evaporated under reduced pressure to give the crude product, which was purified by column chromatography using mixture of petroleum ether as an eluent to afford **1a-1n**^[S4a].

The preparation of **1o** followed procedure A by replacing ethyl difluorobromoacetate with 2-bromo-*N,N*-diethyl-2,2-difluoroacetamide. 2-Bromo-*N,N*-diethyl-2,2-difluoroacetamide was prepared from ethyl bromodifluoroacetate according to the experimental procedure reported in the literature (eluent: petroleum ether).^[S4b] The preparation of **1p** followed procedure A by replacing benzaldehyde with 2-thenaldehyde (eluent: petroleum ether). The preparation of **1q** followed procedure A by replacing benzaldehyde with 3-phenylpropanal (eluent: petroleum ether). The preparation of **1r** followed procedure A by replacing methyltriphenylphosphonium bromide with benzyltriphenylphosphonium bromide (eluent: EA/PE = 100/1).

Preparation of ethyl 3-phenylbut-3-enoate (**3**)

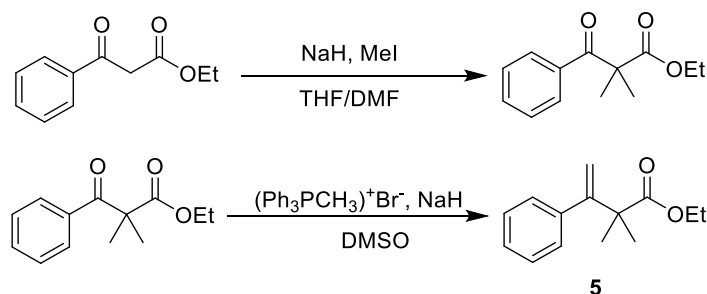


Synthesis of ethyl 3-phenylbut-3-enoate (**3**) was according to the reported literature.^[S6] Under the nitrogen atmosphere, diketene (12.5 mmol, 1 equiv) and Pd (PPh₃)₄ (0.38 mmol, 3 mol%) dissolving in dry THF 20 mL were added dropwise to a suspension of phenylzinc chloride, prepared by adding anhydrous ZnCl₂ (16.8 mmol, 1.3 equiv.) in THF (15 mL) to phenyl magnesium bromide with ice-water cooling and the resulting mixture was stirred for additional 3 h at 0 °C. The reaction mixture was poured into a cold HCl aq. (2 equiv.) and extracted with ethyl acetate. The separated organic layer was extracted with 3 equiv. NaOH aq. The alkaline extracts were acidified with 6 equiv. HCl aq. and then extracted with ethyl acetate (40 mL × 3). The ether extracts were combined, washed with brine and dried over anhydrous Na₂SO₄. After removing the solvent, the crude product can be purified by recrystallization in hexane to give 3-phenyl-3-butenoic acid.

An over-dried 100 mL Schlenk tube equipped with stirring bar was charged with 3-phenyl-3-butenoic acid (3.1 mmol, 1 equiv) and dry dichloromethane (30 mL). Afterward, the solution was cooled to 0 °C and EtOH (6.2 mmol, 2 equiv) solution of 4-dimethylaminopyridine (DMAP, 0.31 mmol, 0.1 equiv) was added. After ten minutes stirring at 10 °C, *N,N'*-dicyclohexylcarbodiimide (DCC, 4.7 mmol, 1.5 equiv) was added into the solution and the mixture was further stirred for 10 min at 0 °C. The progress of the reaction was monitored by TLC. After completion of the reaction, the reaction mixture was filtered through a short silica bed and eluting with ethyl acetate. The filtrate was evaporated under reduced pressure and the crude product was purified

by column chromatography using petroleum ether/ethyl acetate (PE/EA = 30/1) as an eluent to afford ethyl 3-phenylbut-3-enoate **3**.

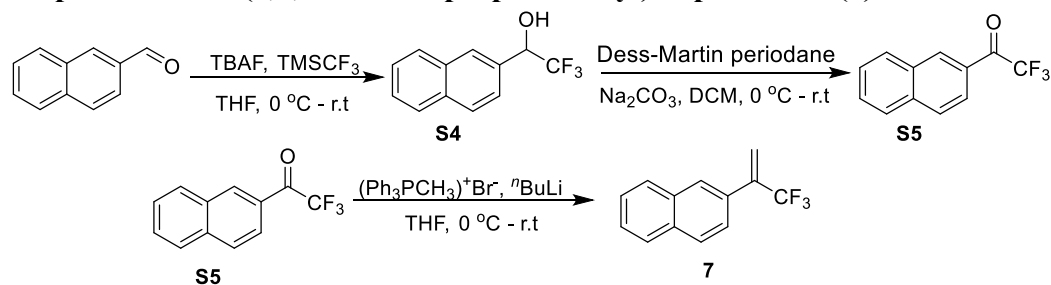
Preparation of 2,2-dimethyl-3-phenylbut-3-enoate (**5**)



Synthesis of ethyl 2,2-dimethyl-3-phenylbut-3-enoate (**5**) was according to the reported literature.^[S7] To a suspension of NaH (2.10 g, 52.5 mmol, 60% wt. dispersion in mineral oil) and ethyl benzoylacetate (9.98 g, 52 mmol) in THF (125 mL) and DMF (1.5 mL), MeI (8.99 g, 63 mmol) was added dropwise at 0 °C, and the reaction mixture was stirred for 2 h under reflux condition. The mixture was then cooled to 0 °C, and NaH (2.10 g, 52.5 mmol, 60% wt. dispersion in mineral oil) was added followed by MeI (8.93 g, 63 mmol). The mixture was refluxed for 16 h. The reaction was quenched by water (100 mL), and the mixture was extracted with diethyl ether, washed with water and brine, dried over Na₂SO₄, and concentrated to give the crude product ethyl 2,2-dimethyl-3-oxo-3-phenylpropanoate as a yellow liquid (11.08 g). The crude product was used in the next reaction without purification. To a suspension of NaH (0.93 g, 24 mmol, 60% wt. dispersion in oil) in DMSO (25 mL), a solution of methyltriphenylphosphonium bromide (8.24 g, 23 mmol) in DMSO (25 mL) was added, and the reaction mixture was stirred for 1 h at 70 °C. Then ethyl 2,2-dimethylbenzoylacetate (4.37 g, 20 mmol) was added, and the mixture was stirred for 20 h at 55 °C in oil bath. The reaction was quenched by water (85 mL), and the mixture was extracted with diethyl ether (3 × 20 mL). The collected organic layers were washed with water/DMSO (1/1, 50 mL) and brine, dried (Na₂SO₄), and

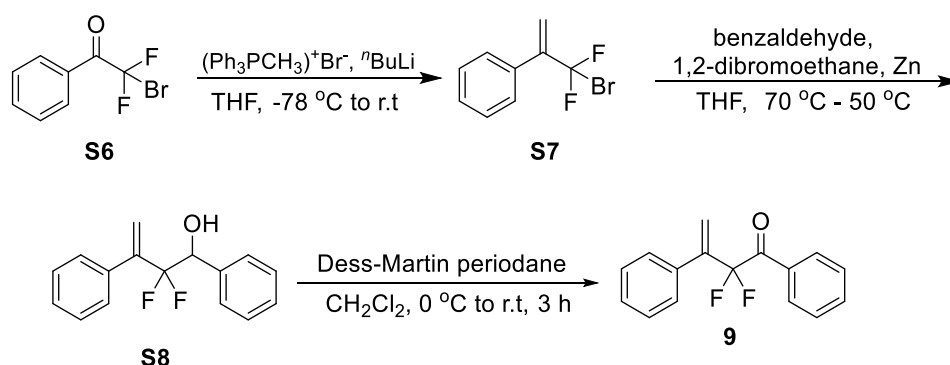
concentrated to give the crude product, which was purified by silica gel chromatography (petroleum ether/ethyl acetate = 95/5) to give 2,2-dimethyl-3-phenylbut-3-enoate **5** as a colorless oil.

Preparation of 2-(3,3,3-trifluoroprop-1-en-2-yl) naphthalene (**7**)



Synthesis of 2-(3,3,3-trifluoroprop-1-en-2-yl) naphthalene (**7**) was according to the reported literature.^[S8] An over-dried 100 mL Schlenk tube was charged with THF solution (20 mL) of 2-naphthaldehyde (20 mmol, 1 equiv) under N₂ atmosphere, TMSCF₃ (24 mmol, 1.2 equiv) was added and the mixture was stirred in an ice bath. After approximately 10 min, THF solution of TBAF (2.4 mmol, 0.12 equiv) was added dropwise via syringe. After 10 min, the ice bath was removed and the solution was stirred for approximately 6 h at room temperature. The progress of the reaction was monitored by TLC. After completion of the reaction, the reaction was quenched by water (20 mL), and the mixture was extracted with ethyl acetate (20 mL × 3). The organic phase was washed with brine and then dried over anhydrous Na₂SO₄. After filtration and evaporation under vacuum, the residue was subjected to silica gel column chromatography using petroleum ether/ethyl acetate (PE/EA = 95/5) as eluent to afford 2,2,2-trifluoro-1-(naphthalen-2-yl)ethan-1-ol (**S4**). The synthetic routes for **S4** → **S5** and **S5** → **7** are the same as routes of **S1** → **S2** and **S2** → **S3**, respectively.

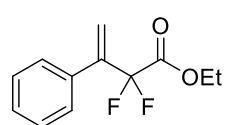
Preparation of 2,2-difluoro-1,3-diphenylbut-3-en-1-one (**9**)



To an over-dried 250-mL Schlenk tube was added THF (60 mL) solution of methyltriphenylphosphonium bromide (12.5 mmol, 1.3 equiv), then *n*BuLi (12 mmol, 1.2 equiv) was added dropwise to the mixture at -78 °C. After stirring at -78 °C for 0.5 h, 2-bromo-2,2-difluoro-1-phenylethan-1-one **S6** (10 mmol, 1 equiv) was added to the reaction mixture. Then stirring at room temperature for 2 h, the reaction was quenched with an aqueous HCl solution (2N, 30 mL). The mixture was extracted with diethyl ether three times. The combined organic phase was washed with brine and dried over Na₂SO₄. After the solvent was removed under reduced pressure, the residue was purified by silica gel column chromatography with hexane as an eluent to give **S7** (700 mg, 30%) as colorless oil.^[S5]

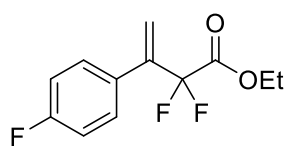
The synthetic routes for **S7** → **S8** and **S8** → **9** are the same as routes of **S1** → **S2** and **S2** → **S3**, respectively.

Ethyl 2,2-difluoro-3-phenylbut-3-enoate (**1a**)^[S4]



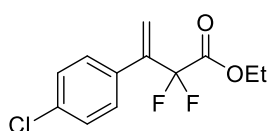
Colorless oil (4.0 g and 70% overall yield for **S1** → **S3**; 800 mg and 15% yield for **S3** → **1a**). ¹H NMR (600 MHz, CDCl₃) δ 7.40-7.38 (m, 2H), 7.35-7.33 (m, 3H), 5.90 (s, 1H), 5.72 (s, 1H), 4.22 (q, *J* = 7.2 Hz, 2H), 1.16 (t, *J* = 7.2 Hz, 3H). ¹⁹F NMR (564 MHz, CDCl₃) δ -102.4 (s). ¹³C NMR (150 MHz, CDCl₃) δ 163.6 (t, *J* = 33.8 Hz), 141.3 (t, *J* = 21.9 Hz), 134.8 (s), 128.7 (s), 128.4 (s), 127.7 (s), 120.1 (t, *J* = 8.6 Hz), 113.0 (t, *J* = 250.4 Hz), 62.9 (s), 13.7 (s).

Ethyl 2,2-difluoro-3-(4-fluorophenyl) but-3-enoate (**1b**)



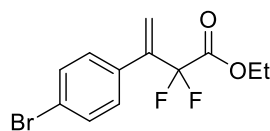
Colorless oil (4.6 g and 74% overall yield for **S1** → **S3**; 900 mg and 22% yield for **S3** → **1b**). ^1H NMR (500 MHz, CDCl_3): δ 7.40-7.36 (m, 2H), 7.04 (t, $J = 9.0$ Hz, 2H), 5.89 (s, 1H), 5.68 (s, 1H), 4.24 (q, $J = 7.0$ Hz, 2H), 1.19 (t, $J = 7.0$ Hz, 3H). ^{19}F NMR (470 MHz, CDCl_3): δ -102.7 (s, 2F), -112.9 (s, 1F). ^{13}C NMR (125 MHz, CDCl_3): δ 163.5 (t, $J = 33.6$ Hz), 163.0 (d, $J = 247.0$ Hz), 140.4 (t, $J = 22.4$ Hz), 130.9-130.8 (m), 129.8 (d, $J = 8.1$ Hz), 120.3 (t, $J = 8.8$ Hz), 115.4 (d, $J = 21.4$ Hz), 112.9 (t, $J = 250.6$ Hz), 63.0, 13.7. IR (ATR, cm^{-1}) max 1764.6, 1604.6, 1510.1, 1290.2, 1236.2, 1155.2, 1085.8, 1054.9, 1014.4, 941.1, 840.8, 777.2. HRMS (ESI) m/z : $[\text{M}+\text{Na}]^+$ calcd. for $\text{C}_{12}\text{H}_{11}\text{F}_3\text{NaO}_2$ $[\text{M}+\text{Na}]^+$ 267.0603, found 267.0603.

Ethyl 3-(4-chlorophenyl)-2,2-difluorobut-3-enoate (**1c**)



Green oil (4.5 g and 69% overall yield for **S1** → **S3**; 789 mg and 30% yield for **S3** → **1c**). ^1H NMR (500 MHz, CDCl_3): δ 7.36-7.31 (m, 4H), 5.91 (t, $J = 1.5$ Hz, 1H), 5.71 (t, $J = 1.5$ Hz, 1H), 4.24 (q, $J = 7.0$ Hz, 2H), 1.20 (t, $J = 7.5$ Hz, 3H). ^{19}F NMR (470 MHz, CDCl_3): δ -102.5. ^{13}C NMR (125 MHz, CDCl_3): δ 163.4 (t, $J = 33.6$ Hz), 140.3 (t, $J = 22.2$ Hz), 134.9, 133.2, 129.2, 128.6, 120.7 (t, $J = 8.4$ Hz), 112.8 (t, $J = 250.7$ Hz), 63.1, 13.8. IR (ATR, cm^{-1}) max 1764.6, 1490.8, 1288.3, 1155.2, 1091.6, 1054.9, 1014.4, 941.1, 835.1, 771.4. HRMS (ESI) m/z : $[\text{M}+\text{Na}]^+$ calcd. for $\text{C}_{12}\text{H}_{11}\text{ClF}_2\text{NaO}_2$ 283.0308, found 283.0305.

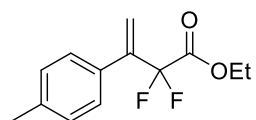
Ethyl 3-(4-bromophenyl)-2,2-difluorobut-3-enoate (**1d**)



Colorless oil (5.4 g and 70% overall yield for **S1** → **S3**; 780 mg and 22% yield for **S3** → **1d**). ^1H NMR (600 MHz, CDCl_3) δ 7.49-7.48 (m, 2H), 7.28-7.27 (m, 2H), 5.91 (s, 1H), 5.72 (s, 1H), 4.24 (q, $J = 7.2$ Hz, 2H), 1.20 (t, $J = 6.6$ Hz, 3H). ^{19}F NMR (470 MHz, CDCl_3): δ -102.5. ^{13}C NMR (150 MHz, CDCl_3) δ 163.4 (t, $J = 33.8$ Hz), 140.4 (t, $J = 22.5$ Hz), 133.7 (s), 131.6 (s), 129.4 (s), 123.1 (s), 120.7 (t, $J = 8.4$ Hz), 112.8 (t, $J = 250.5$ Hz), 63.1 (s), 13.8 (s). IR

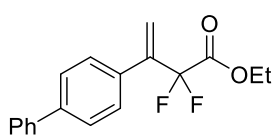
(ATR, cm^{-1}) max 1764.6, 1720.3, 1488.8, 1394.3, 1284.4, 1155.2, 1087.7, 1053.0, 1010.6, 941.1, 852.4, 831.2. HRMS (ESI) m/z : $[M+Na]^+$ calcd. for $C_{12}H_{11}^{79}BrF_2NaO_2$ and $C_{12}H_{11}^{81}BrF_2NaO_2$ 326.9803, 328.9782, found 326.9800, 328.9778.

Ethyl 2,2-difluoro-3-(*p*-tolyl)but-3-enoate (**1e**)



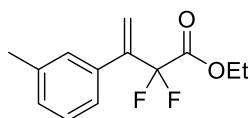
Colorless oil (4.0 g and 66% overall yield for **S1** \rightarrow **S3**; 380 mg and 39% yield for **S3** \rightarrow **1e**). 1H NMR (500 MHz, $CDCl_3$): δ 7.29 (d, $J = 8.0$ Hz, 2H), 7.15 (d, $J = 8.0$ Hz, 2H), 5.85 (s, 1H), 5.68 (s, 1H), 4.22 (q, $J = 7.0$ Hz, 2H), 2.34 (s, 3H), 1.18 (t, $J = 7.5$ Hz, 3H). ^{19}F NMR (470 MHz, $CDCl_3$): δ -102.4 (s, 2F). ^{13}C NMR (125 MHz, $CDCl_3$): δ 163.6 (t, $J = 33.8$ Hz), 141.1 (t, $J = 22.0$ Hz), 138.6, 131.8, 129.1, 127.6, 119.4 (t, $J = 8.5$ Hz), 113.1 (t, $J = 250.2$ Hz), 62.9, 21.1, 13.7. IR (ATR, cm^{-1}) max 1762.7, 1515.8, 1286.3, 1153.3, 1083.8, 1054.9, 935.3, 852.4, 823.5, 763.7. HRMS (ESI) m/z : $[M+Na]^+$ calcd. for $C_{13}H_{14}F_2NaO_2$ 263.0854, found 263.0852.

Ethyl 3-([1,1'-biphenyl]-4-yl)-2,2-difluorobut-3-enoate (**1f**)



White solid (5.5 g and 72% overall yield for **S1** \rightarrow **S3**; 600 mg and 20% yield for **S3** \rightarrow **1f**). 1H NMR (500 MHz, $CDCl_3$): δ 7.61-7.57 (m, 4H), 7.50-7.43 (m, 4H), 7.38-7.34 (m, 1H), 5.92 (t, $J = 1.5$ Hz, 1H), 5.78 (t, $J = 1.5$ Hz, 1H), 4.26 (q, $J = 7.0$ Hz, 2H), 1.20 (t, $J = 7.5$, 3H). ^{19}F NMR (470 MHz, $CDCl_3$): δ -102.3. ^{13}C NMR (125 MHz, $CDCl_3$): δ 163.6 (t, $J = 33.8$ Hz), 141.5, 140.9 (t, $J = 22.1$ Hz), 140.3, 133.6, 128.8, 128.1, 127.6, 127.1, 127.0, 120.0 (t, $J = 8.5$ Hz), 113.1 (t, $J = 250.5$ Hz), 63.0, 13.7. IR (ATR, cm^{-1}) max 1762.7, 1488.8, 1288.3, 1157.1, 1085.8, 1054.9, 844.7, 771.4, 740.6, 696.2. HRMS (ESI) m/z : $[M+Na]^+$ calcd. for $C_{18}H_{16}F_2NaO_2$ 325.1011, found 325.1009.

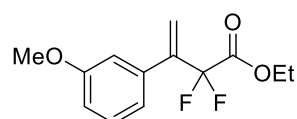
Ethyl 2,2-difluoro-3-(*m*-tolyl)but-3-enoate (**1g**)



Colorless oil (3.8 g and 62% overall yield for **S1** \rightarrow **S3**; 200 mg and 20% yield for **S3** \rightarrow **1g**). 1H NMR (500 MHz, $CDCl_3$): δ 7.26-7.14 (m, 4H), 5.87 (t, $J = 1.5$ Hz, 1H), 5.70 (s, 1H), 4.23 (q, $J = 7.5$ Hz, 2H), 2.35 (s, 3H), 1.18 (t, $J = 7.0$ Hz, 3H). ^{19}F NMR (470 MHz, $CDCl_3$): δ -102.3 (s, 2F). ^{13}C NMR (125 MHz, $CDCl_3$): δ 163.6 (t, $J = 33.8$ Hz), 141.4

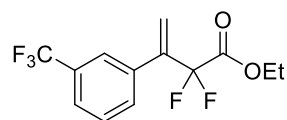
(t, $J = 22.0$ Hz), 138.0, 134.7, 129.4, 128.5, 128.3, 124.9, 119.9 (t, $J = 8.5$ Hz), 113.1 (t, $J = 250.4$ Hz), 62.9, 21.4, 13.7. IR (ATR, cm^{-1}) max 1762.7, 1290.2, 1145.6, 1083.8, 1054.9, 939.2, 844.7, 792.6. HRMS (ESI) m/z : $[\text{M}+\text{Na}]^+$ calcd. for $\text{C}_{13}\text{H}_{14}\text{F}_2\text{NaO}_2$ 263.0854, found 263.0855

Ethyl 2,2-difluoro-3-(3-methoxyphenyl)but-3-enoate (1h)



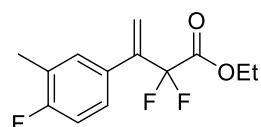
Colorless oil (3.9 g and 60% overall yield for **S1** \rightarrow **S3**; 1.2 g and 38% yield for **S3** \rightarrow **1h**). ^1H NMR (600 MHz, CDCl_3): δ 7.29-7.22 (m, 1H), 7.01-6.96 (m, 1H), 6.96-6.92 (m, 1H), 6.92-6.88 (m, 1H), 5.90 (t, $J = 1.8$ Hz, 1H), 5.73 (t, $J = 1.2$ Hz, 1H), 4.24 (q, $J = 7.2$ Hz, 2H), 3.81 (s, 3H), 1.19 (t, $J = 7.2$ Hz, 3H). ^{19}F NMR (470 MHz, CDCl_3): δ -102.2. ^{13}C NMR (150 MHz, CDCl_3): δ 163.5 (t, $J = 33.6$ Hz), 159.4, 141.1 (t, $J = 21.8$ Hz), 136.1, 129.4, 120.2, 120.2 (t, $J = 9.8$ Hz), 114.2, 113.4, 113.0 (t, $J = 250.2$ Hz), 63.0, 55.2, 13.7. IR (ATR, cm^{-1}) max 1762.7, 1577.6, 1488.8, 1286.3, 1240.0, 1145.6, 1081.9, 1039.5, 941.1, 786.8, 757.9. HRMS (ESI) m/z : $[\text{M}+\text{Na}]^+$ calcd. for $\text{C}_{13}\text{H}_{14}\text{F}_2\text{NaO}_3$ 279.0803, found 279.0804.

Ethyl 2,2-difluoro-3-(3-(trifluoromethyl)phenyl)but-3-enoate (1i)



Colorless oil (4.6 g and 62% overall yield for **S1** \rightarrow **S3**; 900 mg and 26% yield for **S3** \rightarrow **1i**). ^1H NMR (500 MHz, CDCl_3): δ 7.66 (s, 1H), 7.63-7.59 (m, 2H), 7.50-7.47 (m, 1H), 5.99 (t, $J = 1.5$ Hz, 1H), 5.77 (t, $J = 1.5$ Hz, 1H), 4.25 (q, $J = 7.0$ Hz, 2H), 1.19 (t, $J = 7.0$, 3H). ^{19}F NMR (470 MHz, CDCl_3): δ -102.6 (s, 2F), -62.8 (s, 3F). ^{13}C NMR (125 MHz, CDCl_3): δ 163.3 (t, $J = 33.6$ Hz), 140.4 (t, $J = 22.9$ Hz), 135.6, 131.2, 130.9 (q, $J = 32.1$ Hz), 129.0, 125.4 (q, $J = 3.8$ Hz), 124.8 (q, $J = 3.9$ Hz), 123.8 (q, $J = 270.5$ Hz), 121.7 (t, $J = 8.3$ Hz), 112.7 (t, $J = 250.9$ Hz), 63.2, 13.7. IR (ATR, cm^{-1}) max 1762.7, 1515.8, 1286.3, 1153.3, 1083.8, 1054.9, 935.3, 852.4, 823.5, 763.7. HRMS (ESI) m/z : $[\text{M} + \text{Na}]^+$ calcd. for $\text{C}_{13}\text{H}_{11}\text{F}_5\text{NaO}_2$ 317.0571, found 317.0570.

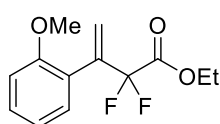
Ethyl 2,2-difluoro-3-(4-fluoro-3-methylphenyl)but-3-enoate (1j)



Colorless oil (5.1 g and 65% overall yield for **S1** \rightarrow **S3**; 900 mg and 26% yield for **S3** \rightarrow **1j**). ^1H NMR (500 MHz, CDCl_3):

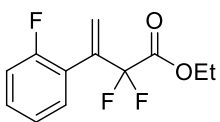
δ 7.24-7.13 (m, 2H), 6.96 (t, $J = 9.0$ Hz, 1H), 5.86 (t, $J = 1.5$ Hz, 1H), 5.66 (t, $J = 1.5$ Hz, 1H), 4.24 (q, $J = 7.0$ Hz, 2H), 2.27 (d, $J = 2.0$ Hz, 3H), 1.20 (t, $J = 7.0$ Hz, 3H). ^{19}F NMR (470 MHz, CDCl_3): δ -102.6, -117.2. ^{13}C NMR (125 MHz, CDCl_3): δ 163.5 (t, $J = 33.6$ Hz), 161.6 (d, $J = 245.5$ Hz), 140.5 (t, $J = 22.1$ Hz), 131.1 (d, $J = 5.4$ Hz), 130.6-130.5 (m), 127.0 (d, $J = 8.3$ Hz), 124.9 (d, $J = 17.5$ Hz), 120.0 (t, $J = 8.4$ Hz), 115.0 (d, $J = 22.5$ Hz), 113.0 (t, $J = 250.5$ Hz), 63.0, 14.5 (d, $J = 3.4$ Hz), 13.8. IR (ATR, cm^{-1}) max 1762.7, 1504.3, 1297.9, 1238.1, 1137.8, 1120.5, 1085.8, 1056.8, 941.1, 825.4. HRMS (ESI) m/z : $[\text{M} + \text{Na}]^+$ calcd. for $\text{C}_{13}\text{H}_{13}\text{F}_3\text{NaO}_2$ 281.0760, found 281.0759.

Ethyl 2,2-difluoro-3-(2-methoxyphenyl)but-3-enoate (1k)



Colorless oil (3.9 g and 60% overall yield for **S1** \rightarrow **S3**; 1.4 g and 44% yield for **S3** \rightarrow **1k**). ^1H NMR (500 MHz, CDCl_3): δ 7.32 (t, $J = 7.5$ Hz, 1H), 7.20 (d, $J = 7.5$ Hz, 1H), 6.94 (t, $J = 7.5$ Hz, 1H), 6.85 (d, $J = 8.0$ Hz, 1H), 5.97 (s, 1H), 5.65 (s, 1H), 4.30 (q, $J = 7.0$ Hz, 2H), 3.73 (s, 3H), 1.29 (t, $J = 7.5$ Hz, 3H). ^{19}F NMR (470 MHz, CDCl_3): δ -102.8. ^{13}C NMR (125 MHz, CDCl_3): δ 163.6 (t, $J = 34.8$ Hz), 156.4, 139.7 (t, $J = 24.9$ Hz), 130.7, 130.0, 125.0 (t, $J = 2.1$ Hz), 122.6 (t, $J = 8.0$ Hz), 120.7, 113.0 (t, $J = 249.6$ Hz), 110.6, 62.6, 55.1, 13.9. IR (ATR, cm^{-1}) max 1764.6, 1598.8, 1492.7, 1294.1, 1159.1, 1134.0, 1072.3, 1039.5, 937.3, 852.4, 752.1. HRMS (ESI) m/z : $[\text{M} + \text{Na}]^+$ calcd. for $\text{C}_{13}\text{H}_{14}\text{F}_2\text{NaO}_3$ 279.0803, found 279.0806.

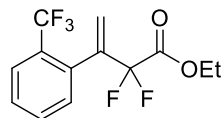
Ethyl 2,2-difluoro-3-(2-fluorophenyl)but-3-enoate (1l)



Green oil (4.5 g and 73% overall yield for **S1** \rightarrow **S3**; 160 mg and 10% yield for **S3** \rightarrow **1l**). ^1H NMR (500 MHz, CDCl_3): δ 7.36-7.29 (m, 2H), 7.15-7.06 (m, 2H), 6.10 (t, $J = 1.5$ Hz, 1H), 5.72 (s, 1H), 4.28 (q, $J = 7.0$ Hz, 2H), 1.24 (t, $J = 7.0$ Hz, 3H). ^{19}F NMR (470 MHz, CDCl_3): δ -103.6 (d, $J = 5.2$ Hz, 2F), -114.0 (t, $J = 5.2$ Hz, 1F). ^{13}C NMR (125 MHz, CDCl_3): δ 163.3 (t, $J = 33.9$ Hz), 159.9 (d, $J = 246.8$ Hz), 135.6 (t, $J = 24.4$ Hz), 131.0 (d, $J = 2.6$ Hz), 130.5 (d, $J = 8.1$ Hz), 124.0-123.8 (m), 122.8-122.6 (m), 115.8, 115.6, 112.5 (t, $J = 251.0$ Hz), 63.1, 13.7. IR (ATR, cm^{-1}) max 1766.6, 1492.7, 1452.2, 1297.9,

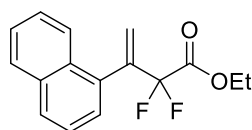
1259.3, 1081.9, 1051.1, 1012.5, 788.8, 759.8. HRMS (ESI) m/z: $[M + Na]^+$ calcd. for $C_{12}H_{11}F_3NaO_2$ $[M+Na]^+$: 267.0603, found 267.0603.

Ethyl 2,2-difluoro-3-(2-(trifluoromethyl) phenyl) but-3-enoate (1m)



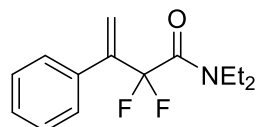
Colorless oil (4.8 g and 65% yield for **S1** → **S3**; 650 mg and 23% yield for **S3** → **1m**). 1H NMR (600 MHz, $CDCl_3$): δ 7.71 (d, $J = 7.8$ Hz, 1H), 7.54 (t, $J = 7.2$ Hz, 1H), 7.48 (t, $J = 7.8$ Hz, 1H), 7.38 (d, $J = 7.8$ Hz, 1H), 6.07 (t, $J = 1.5$ Hz, 1H), 5.60 (s, 1H), 4.28 (q, $J = 7.2$ Hz, 2H), 1.27 (t, $J = 7.2$ Hz, 3H). ^{19}F NMR (470 MHz, $CDCl_3$): δ -102.7 (s, 2F), -57.2 (s, 3F). ^{13}C NMR (150 MHz, $CDCl_3$): δ 163.4 (t, $J = 33.6$ Hz), 138.4 (t, $J = 24.8$ Hz), 133.1, 131.4, 131.2, 129.6 (q, $J = 29.7$ Hz), 128.7, 126.4 (q, $J = 4.8$ Hz), 124.3-124.2 (m), 122.8 (t, $J = 271.8$ Hz), 112.4 (t, $J = 251.3$ Hz), 63.1, 13.7. IR (ATR, cm^{-1}) max 1766.6, 1313.3, 1128.2, 1112.8, 1035.6, 952.7, 852.4, 769.5. HRMS (ESI) m/z: $[M+Na]^+$ calcd. for $C_{13}H_{11}F_5NaO_2$ 317.0571, found 317.0573.

Ethyl 2,2-difluoro-3-(naphthalen-1-yl)but-3-enoate (1n)



Colorless oil (4.2 g and 60% yield for **S1** → **S3**; 700 mg and 30% yield for **S3** → **1n**). 1H NMR (500 MHz, $CDCl_3$) δ 7.96-7.94 (m, 1H), 7.86-7.83 (m, 2H), 7.51-7.42 (m, 3H), 7.38 (d, $J = 7.0$ Hz, 1H), 6.28 (s, 1H), 5.66 (s, 1H), 4.11 (q, $J = 7.5$ Hz, 2H), 1.04 (t, $J = 7.5$ Hz, 3H); ^{19}F NMR (470 MHz, $CDCl_3$): δ -103.5; ^{13}C NMR (125 MHz, $CDCl_3$) δ 163.5 (t, $J = 33.8$ Hz), 139.3 (t, $J = 23.3$ Hz), 133.6, 132.3, 132.2, 129.0, 128.2, 127.3, 126.3, 125.9, 125.5, 124.8, 123.7 (t, $J = 7.6$ Hz), 113.0 (t, $J = 251.1$ Hz), 62.9, 13.5. IR (ATR, cm^{-1}) max 1762.7, 1288.3, 1105.1, 1056.8, 946.9, 804.2, 779.1. HRMS (ESI) m/z: $[M + Na]^+$ calcd. for $C_{16}H_{14}F_2NaO_2$ 299.0854, found 299.0854.

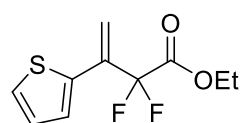
N,N-diethyl-2,2-difluoro-3-phenylbut-3-enamide (1o)



Colorless oil (3.1 g and 67% yield for **S1** → **S3**; 370 mg and 10% yield for **S3** → **1o**). 1H NMR (500 MHz, $CDCl_3$) δ 7.45-7.43 (m,

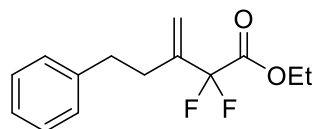
2H), 7.36-7.33 (m, 3H), 5.77 (t, $J = 1.5$ Hz, 1H), 5.69 (s, 1H), 3.38-3.31 (m, 4H), 1.15 (t, $J = 7.0$ Hz, 3H), 1.02 (t, $J = 7.0$ Hz, 3H). ^{19}F NMR (470 MHz, CDCl_3): δ -95.0. ^{13}C NMR (125 MHz, CDCl_3) δ 162.1 (t, $J = 29.1$ Hz), 143.0 (t, $J = 22.9$ Hz), 134.9, 128.6, 128.3, 127.8, 119.6 (t, $J = 8.1$ Hz), 115.2 (t, $J = 249.1$ Hz), 42.0 (t, $J = 3.6$ Hz), 41.1, 13.9, 11.8. HRMS (ESI) m/z : $[\text{M}+\text{Na}]^+$ calcd. for $\text{C}_{14}\text{H}_{17}\text{F}_2\text{NNaO}$ 276.1170, found 276.1171.

Ethyl 2,2-difluoro-3-(thiophen-2-yl)but-3-enoate (**1p**)



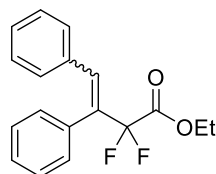
Colorless oil (4.0 g and 68% yield for **S1** \rightarrow **S3**; 700 mg and 59% yield for **S3** \rightarrow **1p**). ^1H NMR (500 MHz, CDCl_3): δ 7.26-7.24 (m, 1H), 7.18-7.16 (m, 1H), 6.99-6.97 (m, 1H), 5.82 (t, $J = 1.5$ Hz, 1H), 5.77 (s, 1H), 4.26 (q, $J = 7.0$ Hz, 2H), 1.22 (t, $J = 7.0$ Hz, 3H). ^{19}F NMR (470 MHz, CDCl_3): δ -103.9 (s, 2F). ^{13}C NMR (125 MHz, CDCl_3) δ 163.3 (t, $J = 33.8$ Hz), 136.4 (t, $J = 1.3$ Hz), 134.6 (t, $J = 23.5$ Hz), 127.7, 126.7 (t, $J = 1.8$ Hz), 125.9, 117.7 (t, $J = 8.5$ Hz), 112.4 (t, $J = 251.1$ Hz), 63.1, 13.7. HRMS (ESI) m/z : $[\text{M} + \text{Na}]^+$ calcd. for $\text{C}_{10}\text{H}_{10}\text{F}_2\text{NaO}_2\text{S}$ 255.0262, found 255.0264.

Ethyl 2,2-difluoro-3-methylene-5-phenylpentanoate (**1q**)



Colorless oil (4.6 g and 71% overall yield for **S1** \rightarrow **S3**; 400 mg and 40% yield for **S3** \rightarrow **1q**). ^1H NMR (600 MHz, CDCl_3) δ 7.33-7.28 (m, 2H), 7.24-7.18 (m, 3H), 5.60 (s, 1H), 5.32 (s, 1H), 4.33 (q, $J = 7.1$ Hz, 2H), 2.83 (t, $J = \text{Hz}$, 2H), 2.50 (t, $J = \text{Hz}$, 2H), 1.34 (t, $J = 7.1$ Hz, 3H). ^{13}C NMR (150 MHz, CDCl_3) δ 164.0 (t, $J = 34.5$ Hz), 141.0, 140.5 (t, $J = 21.0$ Hz), 128.6, 128.5, 126.3, 117.8 (t, $J = 9.0$ Hz), 114.0 (t, $J = 250.2$ Hz), 63.2, 34.1, 31.4, 14.1. ^{19}F NMR (470 MHz, CDCl_3) δ -106.1. HRMS (ESI) m/z : $[\text{M}+\text{Na}]^+$ calcd. for $\text{C}_{14}\text{H}_{16}\text{F}_2\text{NaO}_2$ 277.1011, found 277.1008.

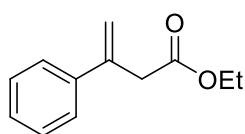
Ethyl 2,2-difluoro-3,4-diphenylbut-3-enoate (**1r**)



Colorless oil (330 mg and 25% yield for **S3** \rightarrow **1r**). The ratio of (*E*)- to (*Z*)-alkene is ca. 5:1 determined by ^1H NMR. ^1H NMR (600

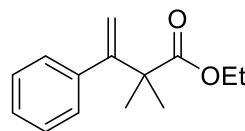
MHz, CDCl₃) δ 7.47 (d, $J = 6.6$ Hz, 1H for (*Z*)-alkene), 7.43-7.34 (m, overlapped peaks for (*E*)- and (*Z*)-alkene), 7.28-7.26 (m, overlapped peaks for (*E*)- and (*Z*)-alkene), 7.20-7.08 (m, overlapped peaks for (*E*)- and (*Z*)-alkene), 6.99 (d, $J = 7.2$ Hz, 1H for (*E*)-alkene), 4.22 (q, $J = 7.1$ Hz, 2H for (*E*)-alkene), 3.86 (q, $J = 7.1$ Hz, 2H for (*Z*)-alkene), 1.20 (t, $J = 7.1$ Hz, 3H for (*E*)-alkene), 1.03 (t, $J = 7.2$ Hz, 3H for (*Z*)-alkene). ¹³C NMR (150 MHz, CDCl₃) δ 163.76 (t, $J = 34.8$ Hz), 138.29 (t, $J = 6.1$ Hz), 134.79, 134.12, 132.88, 132.73, 132.52 (t, $J = 8.9$ Hz), 130.10, 130.03, 128.95 (t, $J = 2.7$ Hz), 128.85, 128.69, 128.62, 128.54, 128.31, 128.13 (t, $J = 10.3$ Hz), 113.63 (t, $J = 253.2$ Hz), 62.89, 62.78, 13.83, 13.47. ¹⁹F NMR (471 MHz, CDCl₃) δ -91.93 ((*E*)-alkene), -103.12 ((*Z*)-alkene). HRMS (ESI) m/z : [M + Na]⁺ calcd. for C₁₈H₁₆F₂NaO₂ 325.1011, found 325.1014.

Ethyl 3-phenylbut-3-enoate (3)^[S6]



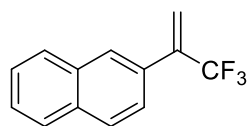
Colorless oil (500 mg and 25% yield for the first step; 350 mg and 59% yield for the second step). ¹H NMR (600 MHz, CDCl₃) δ 7.44-7.41 (m, 2H), 7.34-7.30 (m, 2H), 7.28-7.23 (m, 1H), 5.53 (s, 1H), 5.23 (s, 1H), 4.10 (q, $J = 7.2$ Hz, 2H), 3.51 (d, $J = 0.9$ Hz, 2H), 1.17 (t, $J = 7.2$ Hz, 3H).

Ethyl 2,2-dimethyl-3-phenylbut-3-enoate(5)^[S7]



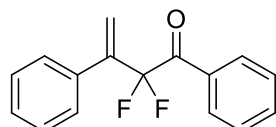
Colorless oil (4.4 g and 77% yield for the first step; 380 mg and 10% yield for the second step). ¹H NMR (600 MHz, CDCl₃) δ 7.29-7.22 (m, 3H), 7.17-7.15 (m, 2H), 5.32 (s, 1H), 5.15 (s, 1H), 4.11 (q, $J = 7.2$ Hz, 2H), 1.39 (s, 6H), 1.18 (t, $J = 7.2$ Hz, 3H). ¹³C NMR (150 MHz, CDCl₃) δ 176.5, 153.2, 141.8, 127.9, 127.8, 127.0, 114.4, 60.7, 47.5, 25.9, 14.0.

2-(3,3,3-trifluoroprop-1-en-2-yl) Naphthalene (7)^[S8]



Colorless oil (1.0 g and 90% yield for the synthesis of **S5**; 674 mg and 68% yield for **S5** → **7**). ¹H NMR (600 MHz, CDCl₃) δ 7.92 (s, 1H), 7.84-7.80 (m, 3H), 7.54 (d, *J* = 8.4 Hz, 1H), 7.50-7.47 (m, 2H), 6.02 (d, *J* = 0.6 Hz, 1H), 5.86 (d, *J* = 1.2 Hz, 1H). ¹⁹F NMR (564 MHz, CDCl₃) δ -64.4.

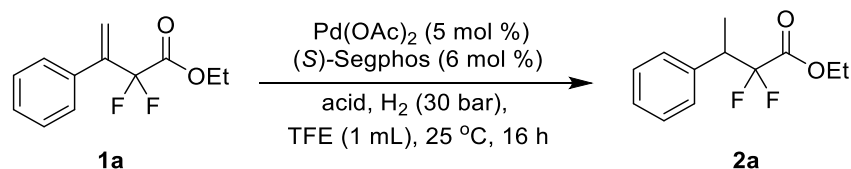
2,2-Difluoro-1,3-diphenylbut-3-en-1-one (**9**)^{[S5][S9]}



Green oil (700 mg and 30% yield for **S6** → **S8**; 470 mg and 70% yield for **S8** → **9**). ¹H NMR (600 MHz, CDCl₃) δ 8.00 (d, *J* = 7.8 Hz, 2H), 7.61-7.57 (m, 1H), 7.46-7.42 (m, 2H), 7.40-7.38 (m, 2H), 7.34-7.31 (m, 3H), 5.87 (t, *J* = 1.8 Hz, 1H), 5.76 (t, *J* = 1.2 Hz, 1H). ¹⁹F NMR (470 MHz, CDCl₃) δ -96.8. ¹³C NMR (125 MHz, CDCl₃) δ 188.5 (t, *J* = 30.0 Hz), 142.7 (t, *J* = 22.3 Hz), 134.9, 134.2, 132.2, 130.1 (t, *J* = 2.6 Hz), 128.7, 128.6, 128.4, 128.0, 120.9 (t, *J* = 8.4 Hz), 116.2 (t, *J* = 252.1 Hz).

3. Asymmetric hydrogenation of α,α -difluoro- β -arylbutenoic esters

Table S1. Screening of acid for Pd-catalyzed AH of **1a**^a

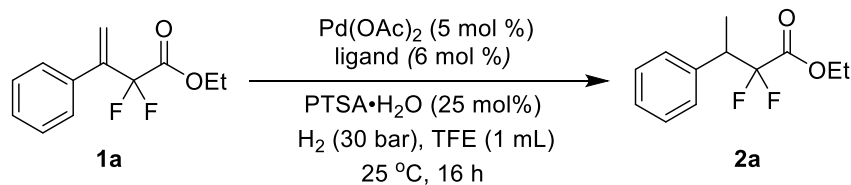


| Entry | Acid (x mol%) | Conv. (%) ^b | er (%) ^c |
|-------|--|------------------------|---------------------|
| 1 | CF ₃ SO ₃ H (25) | >99 | 90:10 |
| 2 | PTSA·H ₂ O (25) | >99 | 91:9 |
| 3 | PTSA·H ₂ O (10) | >99 | 89:11 |
| 4 | PTSA·H ₂ O (30) | >99 | 87:13 |
| 5 | CH ₃ COOH (25) | 66 | 86:14 |
| 6 | <i>L</i> -DTTA (25) | 90 | 87:13 |
| 7 | <i>L</i> -CSA (10) | >99 | 90:10 |
| 8 | <i>L</i> -CSA (20) | 16 | 88:12 |
| 9 | <i>L</i> -CSA (30) | 38 | 90:10 |
| 10 | <i>D</i> -CSA (10) | >99 | 90:10 |
| 11 | <i>D</i> -CSA (20) | 49 | 88:12 |
| 12 | <i>D</i> -CSA (30) | 45 | 89:11 |

^a Reaction conditions: **1a** (0.2 mmol), Pd (OAc)₂ (5 mol %), (*S*)-Segphos (6 mol%),

H₂ (30 bar), TFE (1 mL), 25 °C, 16 h; ^bDetermined by GC analysis using isooctane as internal standard; ^cDetermined by chiral HPLC analysis. *L*-DTTA = di-*p*-toluoyl-*L*-tartaric acid. *L*-CSA = (1*R*)-(-)-10-camphorsulfonic acid.

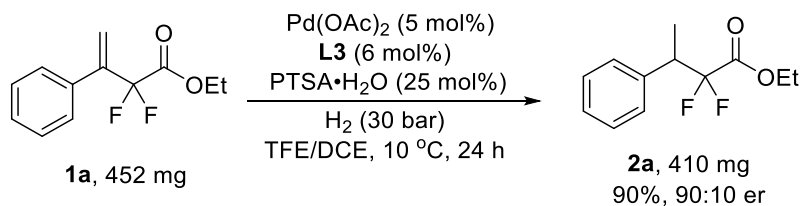
Table S2. Screening of ligand for Pd-catalyzed AH of 1a^a



| Entry | Ligand (6 mol%) | Conv. (%) | er (%) |
|-------|--|-----------|--------|
| 1 | (<i>R</i>)-H ₈ -BINAP | >99 | 89:11 |
| 2 | (<i>S,S</i>)-Me-Duphos | 6 | - |
| 3 | (<i>R</i>)-DM-Segphos | >99 | 83:17 |
| 4 | (<i>R</i>)-DTBM-Segphos | >99 | 50:50 |
| 5 | (<i>R</i>)-Tol-BINAP | >99 | 50:50 |
| 6 | (<i>R</i>)-Xyl-BINAP | >99 | 89:11 |
| 7 | (<i>R</i>)-Garphos | >99 | 15:85 |
| 8 | (<i>S</i>)-BIPHEP | >99 | 50:50 |
| 9 | (1 <i>R</i> ,1' <i>R</i> ,2 <i>S</i> ,2' <i>S</i>)-Duanphos | >99 | 42:58 |
| 10 | (<i>R,R</i>)-Ph-BPE | 9 | - |
| 11 | (<i>R,R</i>)- JoSPoPhos | >99 | 47:53 |

^a Reaction conditions: **1a** (0.2 mmol), Pd (OAc)₂ (5 mol %), ligand (6 mol%), H₂ (30 bar), TFE (1 mL), 25 °C, 16 h; ^bDetermined by GC analysis using isooctane as internal standard; ^cDetermined by chiral HPLC analysis.

3.1 General procedure for asymmetric hydrogenation: In a 4-mL tube, Pd(OAc)₂ (2.3 mg, 5 mol%), PTSA monohydrate (9.5 mg, 25 mol%) and (*S*)-difluorophos (8.2 mg, 6 mol%) was dissolved in TFE/DCE (0.5/0.5 mL) and the solution was stirred at room temperature for 0.5 h. Substrate **1** (0.2 mmol) was added to the above solution and then the tube was transferred into an autoclave. The autoclave was sealed and purged five times with hydrogen. The autoclave was charged with hydrogen to 30 bar and the reaction mixture was stirred at 10 °C for 24 h. After releasing the hydrogen and removing the solvent, the mixture was purified by silica gel column chromatography (PE/EA = 98/2) to give the desired product. The er values were determined by chiral HPLC. For Ni-catalyzed asymmetric hydrogenation, the autoclave was heated to 60 °C with the heating mantle.



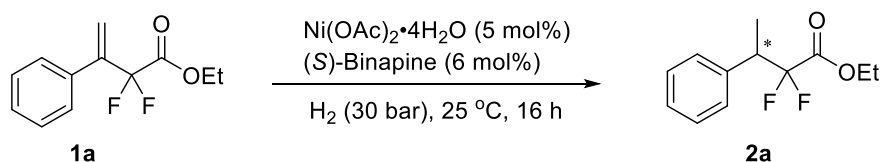
Scale-up experiments for asymmetric hydrogenation of **1a** (2 mmol): In a 30-mL tube, Pd(OAc)₂ (23 mg, 5 mol%), PTSA monohydrate (95 mg, 25 mol%) and (*S,S*)-Difluorophos (82 mg, 6 mol%) was dissolved in TFE/DCE (5/5 mL) and the solution was stirred at room temperature for 0.5 h. Substrate **1a** (452 mg, 2 mmol) was added to the above solution and then the tube was transferred into an autoclave. The autoclave was sealed and purged three times with hydrogen. The autoclave was charged with hydrogen to 30 bar and the reaction mixture was stirred at 10 °C for 24 h. After releasing the hydrogen and removing the solvent, the mixture was purified by silica gel column chromatography (PE/EA = 98/2) to give the desired product **2a** in 90% yield. The er ratio was determined as 90:10 by chiral HPLC analysis.

Table S3. Screening of ligand for Ni-catalyzed AH of 1a^a

| Entry | Ligand | Conv. (%) ^b | er (%) ^c |
|----------------|--------------------------|------------------------|---------------------|
| 1 | (<i>S,S</i>)-Me-Duphos | 20 | 33:67 |
| 2 | (<i>S,S</i>)-Et-Duphos | 3 | - |
| 3 | (<i>R,R</i>)-Quinoxp | >99 | 70:30 |
| 4 | (<i>R,R</i>)-Ph-BPE | 0 | - |
| 5 | (<i>S</i>)-Binapine | >99 | 12:88 |
| 6 | (<i>R</i>)-Segphos | 0 | - |
| 7 ^d | (<i>S</i>)-Binapine | >99 | 11:89 |

^aReaction conditions: **1a** (0.2 mmol), [Ni] (5.0 mol%), (*S*)-Binapine (6.0 mol%), H₂ (30 bar), solvent, 60 °C, 16 h. ^bDetermined by GC analysis using isooctane as internal standard. ^cEr was determined by HPLC analysis on a chiral stationary phase. ^dThe temperature was 25 °C.

Table S4. Screening of Solvent for Ni-Catalyzed AH of 1a^a

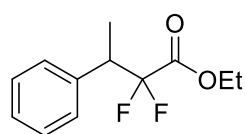


| Entry | Sovent | Conv. (%) ^b | er (%) ^c |
|----------------|-------------------|------------------------|---------------------|
| 1 | MeOH | 0 | - |
| 2 | TFE | >99 | 11:89 |
| 3 | Toluene | 0 | - |
| 4 | DCE | 0 | - |
| 5 | TFE/DCE (1:1) | >99 | 10:90 |
| 6 | TFE/Toluene (1:1) | >99 | 8:92 |
| 7 ^d | TFE/Toluene (1:1) | >99 | 8:92 |

^aReaction conditions: **1a** (0.2 mmol), [Ni] (5.0 mol%), (*S*)-Binapine (6.0 mol%), H₂ (30 bar), solvent, 25 °C, 16 h. ^bDetermined by GC analysis using isooctane as internal standard. ^cEr was determined by HPLC analysis on a chiral stationary phase. ^dThe temperature was 0 °C.

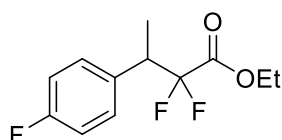
Ethyl 2,2-difluoro-3-phenylbutanoate (**2a**)

Purified by column chromatography (2% ethyl acetate in petroleum ether) to provide



a green oil (45.0 mg, 92% yield); 95:5 er, $[\alpha]_{\text{D}}^{25}$ -20 (*c* 0.1, CHCl₃); ¹H NMR (500 MHz, CDCl₃) δ 7.33-7.26 (m, 5H), 4.16 (q, *J* = 7.5 Hz, 2H), 3.56-3.44 (m, 1H), 1.46 (d, *J* = 7.0 Hz, 3H), 1.16 (t, *J* = 7.0 Hz, 3H). ¹⁹F NMR (470 MHz, CDCl₃): δ -108.7 (d, *J* = 251.5 Hz, 1F), -114.7 (d, *J* = 251.5 Hz, 1F). ¹³C NMR (125 MHz, CDCl₃): δ 164.0 (t, *J* = 32.5 Hz), 136.9 (d, *J* = 6.1 Hz), 128.8, 128.5, 127.9, 116.5 (dd, *J* = 254.6, 252.1 Hz), 62.5, 44.3 (dd, *J* = 23.1, 21.9 Hz), 13.7-13.6 (m, 2C). IR (ATR, cm⁻¹) max 1756.9, 1456.1, 1297.9, 1211.1, 1191.8, 1124.3, 1093.5, 1026.0, 777.2, 698.1. HRMS (ESI) *m/z*: [M + Na]⁺ calcd. for C₁₂H₁₄F₂NaO₂ 251.0854, found 251.0860. The enantiomeric ratio of **2a** was determined by chiral HPLC analysis on OJ-3. Conditions: hexane/isopropanol = 99/1, flow rate = 1.0 mL/min, UV-vis detection at λ = 208 nm, *t*_R = 8.6 min (major), 9.9 min (minor).

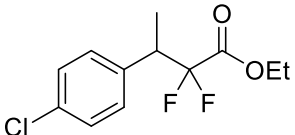
Ethyl 2,2-difluoro-3-(4-fluorophenyl)butanoate (**2b**)



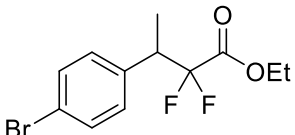
Purified by column chromatography (2% ethyl acetate in petroleum ether) to provide a colorless oil (48.0 mg, 99%

yield); 93:7 er, $[\alpha]_D^{25}$ -17.0 (*c* 0.1, CHCl₃); ¹H NMR (600 MHz, CDCl₃): δ 7.26-7.24 (m, 2H), 7.02-6.98 (m, 2H), 4.18 (q, *J* = 7.2 Hz, 2H), 3.55-3.45 (m, 1H), 1.43 (d, *J* = 7.2 Hz, 3H), 1.19 (t, *J* = 7.2 Hz, 3H). ¹⁹F NMR (564 MHz, CDCl₃): δ -109.2 (d, *J* = 252.1 Hz), -114.5, -114.6 (d, *J* = 252.7 Hz). ¹³C NMR (150 MHz, CDCl₃): δ 163.9 (t, *J* = 32.4 Hz), 162.4 (d, *J* = 245.3 Hz), 132.7-132.6 (m), 130.5 (d, *J* = 8.3 Hz), 116.4 (t, *J* = 253.2 Hz), 115.4 (d, *J* = 21.5 Hz), 62.6, 43.6 (t, *J* = 22.7 Hz), 13.9-13.8 (m), 13.8. IR (ATR, cm⁻¹) max 1756.9, 1606.5, 1512.0, 1301.8, 1228.5, 1120.5, 1103.1, 1029.8, 837.0. HRMS (ESI) *m/z*: [M+Na]⁺ calcd. for C₁₂H₁₃F₃NaO₂ 269.0760, found 269.0758. The enantiomeric ratio of **2b** was determined by chiral HPLC analysis on OJ-3. Conditions: hexane/isopropanol = 99/1, flow rate = 1.0 mL/min, UV-vis detection at λ = 263 nm, *t_R* = 6.7 min (major), 7.0 min (minor).

Ethyl 3-(4-chlorophenyl)-2,2-difluorobutanoate (**2c**)

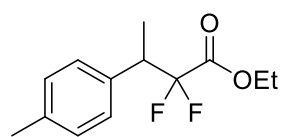
 Purified by column chromatography (2% ethyl acetate in petroleum ether) to provide a green oil (47.0 mg, 90% yield); 94:6 er, $[\alpha]_D^{25}$ -11.1 (*c* 0.2, CHCl₃); ¹H NMR (500 MHz, CDCl₃): δ 7.30 (d, *J* = 8.5 Hz, 2H), 7.21 (d, *J* = 8.0 Hz, 2H), 4.19 (q, *J* = 7.2 Hz, 2H), 3.55-3.44 (m, 1H), 1.43 (d, *J* = 7.0 Hz, 3H), 1.20 (t, *J* = 7.0 Hz, 3H). ¹⁹F NMR (564 MHz, CDCl₃): δ -109.30 (d, *J* = 254.4 Hz), -114.02 (d, *J* = 254.4 Hz). ¹³C NMR (125 MHz, CDCl₃): δ 163.8 (t, *J* = 32.4 Hz), 135.4 (d, *J* = 6.0 Hz), 133.9, 130.2, 128.7, 116.2 (dd, *J* = 254.1, 252.8 Hz), 62.7, 43.7 (t, *J* = 22.2 Hz), 13.8, 13.8-13.7 (m). IR (ATR, cm⁻¹) max 1758.8, 1494.6, 1458.0, 1373.1, 1301.8, 1213.1, 1093.5, 1031.8, 1014.4, 831.2, 798.4. HRMS (ESI) *m/z*: [M + Na]⁺ calcd. for C₁₂H₁₃³⁵ClF₂NaO₂ 285.0464, found 285.0465; calcd. for C₁₂H₁₃³⁷ClF₂NaO₂ 287.0435, found 287.0437. The enantiomeric ratio of **2c** was determined by chiral HPLC analysis on OJ-3. Conditions: hexane/isopropanol = 99/1, flow rate = 1.0 mL/min, UV-vis detection at λ = 221 nm, *t_R* = 6.9 min (major), 7.6 min (minor).

Ethyl 3-(4-bromophenyl)-2,2-difluorobutanoate (**2d**)

 Purified by column chromatography (2% ethyl acetate in petroleum ether) to provide a colorless oil (61.6 mg, 99%

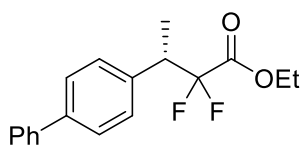
yield); 94:6 er, $[\alpha]_D^{25}$ -12.3 (*c* 0.2, CHCl₃); ¹H NMR (600 MHz, CDCl₃): δ 7.45 (d, *J* = 8.4 Hz, 2H), 7.16 (d, *J* = 8.4 Hz, 2H), 4.19 (q, *J* = 7.2 Hz, 2H), 3.52-3.43 (m, 1H), 1.43 (d, *J* = 7.2 Hz, 3H), 1.20 (t, *J* = 7.2 Hz, 3H). ¹⁹F NMR (564 MHz, CDCl₃): δ -109.4 (d, *J* = 253.2 Hz), -113.9 (d, *J* = 252.7 Hz). ¹³C NMR (150 MHz, CDCl₃): δ 163.8 (t, *J* = 32.4 Hz), 136.0 (d, *J* = 5.7 Hz), 131.7, 130.5, 122.0, 116.1 (t, *J* = 254.0 Hz), 62.7, 43.8 (t, *J* = 23.3 Hz), 13.8, 13.8-13.6 (m). IR (ATR, cm⁻¹) max 1770.4, 1756.9, 1490.8, 1301.8, 1259.3, 1105.1, 1074.2, 1029.8, 1010.6, 825.4, 796.5. HRMS (ESI) *m/z*: [M+Na]⁺ calcd. for C₁₂H₁₃³⁵BrF₂NaO₂ [M+Na]⁺ 328.9959, found 328.9956; calcd. for C₁₂H₁₃⁸¹BrF₂NaO₂ [M+Na]⁺ 330.9939, found 330.9936. The enantiomeric ratio of **2d** was determined by chiral HPLC analysis on OJ-3. Conditions: hexane/isopropanol = 99/1, flow rate = 1.0 mL/min, UV-vis detection at λ = 221 nm, *t_R* = 7.7 min (major), 8.6 min (minor).

Ethyl 2,2-difluoro-3-(*p*-tolyl)butanoate (**2e**)



Purified by column chromatography (2% ethyl acetate in petroleum ether) to provide a colorless oil (47.6 mg, 99% yield); 85:15 er, $[\alpha]_D^{25}$ -17.4 (*c* 0.2, CHCl₃); ¹H NMR (600 MHz, CDCl₃): δ 7.16 (d, *J* = 7.8 Hz, 2H), 7.12 (d, *J* = 7.8 Hz, 2H), 4.16 (q, *J* = 7.2 Hz, 2H), 3.51-3.41 (m, 1H), 2.32 (s, 1H), 1.43 (d, *J* = 7.2 Hz, 3H), 1.18 (t, *J* = 7.2 Hz, 3H). ¹⁹F NMR (564 MHz, CDCl₃): δ -108.8 (d, *J* = 251.5 Hz), -114.6 (d, *J* = 251.0 Hz). ¹³C NMR (150 MHz, CDCl₃): δ 164.1 (t, *J* = 32.7 Hz), 137.5, 133.8 (d, *J* = 5.9 Hz), 129.2, 128.7, 116.6 (t, *J* = 252.9 Hz), 62.5, 43.9 (t, *J* = 22.5 Hz), 21.0, 13.8-13.7 (m, 2C). IR (ATR, cm⁻¹) max 1770.4, 1515.8, 1456.1, 1373.1, 1296.0, 1211.1, 1108.9, 1049.1, 1016.3, 819.6, 723.2. HRMS (ESI) *m/z*: [M+Na]⁺ calcd. for C₁₃H₁₆F₂NaO₂ 265.1011, found 265.1013. The enantiomeric ratio of **2e** was determined by chiral HPLC analysis on OJ-3. Conditions: hexane/isopropanol = 99/1, flow rate = 1.0 mL/min, UV-vis detection at λ = 212 nm, *t_R* = 8.5 min (minor), 9.5 min (major).

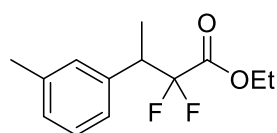
Ethyl (*S*)-3-([1,1'-biphenyl]-4-yl)-2,2-difluorobutanoate (**2f**)



Purified by column chromatography (2% ethyl acetate in petroleum ether) to provide a white solid (60.2 mg, 99%

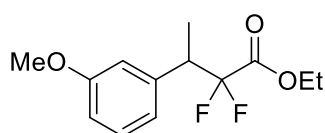
yield); 93:7 er, $[\alpha]_D^{25}$ -14.9 (c 0.3, CHCl_3); ^1H NMR (500 MHz, CDCl_3) δ 7.58-7.53 (m, 4H), 7.43 (t, $J = 7.5$ Hz, 2H), 7.37-7.32 (m, 3H), 4.18 (q, $J = 7.0$ Hz, 2H), 3.60-3.50 (m, 1H), 1.49 (d, $J = 7.5$ Hz, 3H), 1.17 (t, $J = 7.0$ Hz, 3H). ^{19}F NMR (470 MHz, CDCl_3) δ -108.8 (d, $J = 250.5$ Hz), -114.4 (d, $J = 250.5$ Hz). ^{13}C NMR (125 MHz, CDCl_3) δ 164.0 (t, $J = 32.6$ Hz), 140.8, 140.6, 135.9 (d, $J = 5.9$ Hz), 129.2, 128.8, 127.4, 127.2, 127.0, 116.5 (dd, $J = 254.3, 252.6$ Hz), 62.6, 44.0 (t, $J = 22.4$ Hz), 13.8-13.7 (m, 2C). IR (ATR, cm^{-1}) max 1747.3, 1481.2, 1291.2, 1107.8, 1030.7, 840.7, 704.3. HRMS (ESI) m/z : $[\text{M} + \text{Na}]^+$ calcd. for $\text{C}_{18}\text{H}_{18}\text{F}_2\text{NaO}_2$ 327.1167, found 327.1166. The enantiomeric ratio of **2f** was determined by chiral HPLC analysis on OD-3. Conditions: hexane/isopropanol = 99/1, flow rate = 1.0 mL/min, UV-vis detection at $\lambda = 251$ nm, $t_R = 5.8$ min (minor), 8.2 min (major).

Ethyl 2,2-difluoro-3-(*m*-tolyl)butanoate (**2g**)



Purified by column chromatography (2% ethyl acetate in petroleum ether) to provide a colorless oil (40.2 mg, 83% yield); 91:9 er, $[\alpha]_D^{25}$ -11.4 (c 0.1, CHCl_3); ^1H NMR (600 MHz, CDCl_3): δ 7.19 (t, $J = 7.8$ Hz, 1H), 7.08 (t, $J = 7.8$ Hz, 3H), 4.16 (q, $J = 7.2$ Hz, 2H), 3.50-3.41 (m, 1H), 2.33 (s, 3H), 1.44 (d, $J = 7.2$ Hz, 3H), 1.16 (t, $J = 7.2$ Hz, 3H). ^{19}F NMR (564 MHz, CDCl_3): δ -108.6 (d, $J = 250.4$ Hz), -114.6 (d, $J = 252.1$ Hz). ^{13}C NMR (150 MHz, CDCl_3): δ 164.0 (t, $J = 32.6$ Hz), 138.0, 136.8 (d, $J = 5.7$ Hz), 129.5, 128.6, 128.3, 125.8, 116.6 (dd, $J = 254.1, 252.3$ Hz), 62.5, 44.3 (t, $J = 22.4$ Hz), 21.3, 13.7-13.6 (m, 2C). IR (ATR, cm^{-1}) max 1756.9, 1608.4, 1459.9, 1373.1, 1297.9, 1203.4, 1118.5, 1033.7, 842.8, 790.7, 713.6. HRMS (ESI) m/z : $[\text{M} + \text{Na}]^+$ calcd. for $\text{C}_{13}\text{H}_{16}\text{F}_2\text{NaO}_2$ 265.1011, found 265.1009. The enantiomeric ratio of **2g** was determined by chiral HPLC analysis on OJ-3. Conditions: hexane/isopropanol = 99/1, flow rate = 1.0 mL/min, UV-vis detection at $\lambda = 264$ nm, $t_R = 6.6$ min (major), 8.2 min (minor).

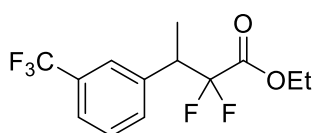
Ethyl 2,2-difluoro-3-(3-methoxyphenyl)butanoate (**2h**)



Purified by column chromatography (2% ethyl acetate in petroleum ether) to provide a colorless oil (50.1 mg, 97%

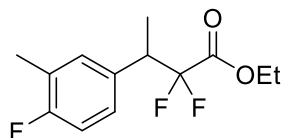
yield); 88:12 er, $[\alpha]_{\text{D}}^{25}$ -16.9 (c 0.3, CHCl_3); ^1H NMR (600 MHz, CDCl_3): δ 7.24-7.20 (m, 1H), 6.87-6.81 (m, 3H), 4.17 (q, $J = 7.2$ Hz, 2H), 3.79 (s, 3H), 3.52-3.43 (m, 1H), 1.44 (d, $J = 7.2$ Hz, 3H), 1.18 (t, $J = 7.2$ Hz, 3H). ^{19}F NMR (564 MHz, CDCl_3): δ -108.60 (d, $J = 252.1$ Hz), -114.37 (d, $J = 251.0$ Hz). ^{13}C NMR (150 MHz, CDCl_3): δ 164.0 (t, $J = 32.1$ Hz), 159.6, 138.4 (d, $J = 6.0$ Hz), 129.4, 121.2, 116.5 (dd, $J = 254.6$, 252.3 Hz), 114.7, 113.1, 62.6, 55.2, 44.3 (t, $J = 22.4$ Hz), 13.8, 13.7-13.6 (m). IR (ATR, cm^{-1}) max 1762.7, 1577.6, 1488.8, 1284.4, 1230.4, 1145.6, 1081.9, 1039.5, 786.8, 757.9. HRMS (ESI) m/z : $[\text{M}+\text{Na}]^+$ calcd. for $\text{C}_{13}\text{H}_{17}\text{F}_2\text{O}_3$ 259.1140, found 259.1137. The enantiomeric ratio of **2h** was determined by chiral HPLC analysis on OD-3. Conditions: hexane/isopropanol = 99/1, flow rate = 1.0 mL/min, UV-vis detection at $\lambda = 273$ nm, $t_{\text{R}} = 5.8$ min (major), 6.7 min (minor).

Ethyl 2,2-difluoro-3-(3-(trifluoromethyl)phenyl)butanoate (**2i**)



Purified by column chromatography (2% ethyl acetate in petroleum ether) to provide a colorless oil (56.2 mg, 95% yield); 91:9 er, $[\alpha]_{\text{D}}^{25}$ -31.7 (c 0.3, CHCl_3); ^1H NMR (500 MHz, CDCl_3): δ 7.57-7.44 (m, 4H), 4.19 (q, $J = 7.0$ Hz, 2H), 3.64-3.53 (m, 1H), 1.48 (d, $J = 7.5$ Hz, 3H), 1.18 (t, $J = 7.0$ Hz, 3H). ^{19}F NMR (470 MHz, CDCl_3): δ -62.7, -109.6 (d, $J = 253.8$ Hz), -113.7 (d, $J = 253.3$ Hz). ^{13}C NMR (125 MHz, CDCl_3): δ 163.6 (t, $J = 32.4$ Hz), 137.9 (d, $J = 5.6$ Hz), 132.2, 130.8 (q, $J = 32.0$ Hz), 129.0, 125.7 (q, $J = 3.8$ Hz), 124.8 (q, $J = 3.8$ Hz), 123.9 (q, $J = 270.4$ Hz), 116.1 (dd, $J = 254.0$, 253.3 Hz), 62.8, 44.1 (t, $J = 23.4$ Hz), 13.7, 13.7-13.6 (m). IR (ATR, cm^{-1}) max 1635.4, 1263.2, 1093.5, 1026.0, 808.3. HRMS (ESI) m/z : $[\text{M}+\text{Na}]^+$ calcd. for $\text{C}_{13}\text{H}_{13}\text{F}_5\text{NaO}_2$ 319.0728, found 319.0725. The enantiomeric ratio of **2i** was determined by chiral HPLC analysis on OJ-3. Conditions: hexane/isopropanol = 99/1, flow rate = 1.0 mL/min, UV-vis detection at $\lambda = 208$ nm, $t_{\text{R}} = 4.7$ min (major), 5.9 min (minor).

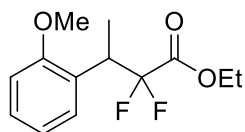
Ethyl 2,2-difluoro-3-(4-fluoro-3-methylphenyl)butanoate (**2j**)



Purified by column chromatography (2% ethyl acetate in petroleum ether) to provide a colorless oil (51.0 mg, 99%

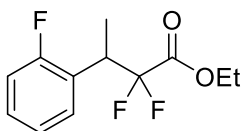
yield); 91:9 er, $[\alpha]_{\text{D}}^{25}$ -24.1 (c 0.4, CHCl_3); ^1H NMR (500 MHz, CDCl_3): δ 7.10-7.04 (m, 2H), 6.94 (t, $J = 9.0$ Hz, 1H), 4.19 (q, $J = 7.5$ Hz, 2H), 3.51-3.40 (m, 1H), 2.25 (s, 3H), 1.42 (d, $J = 7.0$ Hz, 3H), 1.19 (t, $J = 7.0$ Hz, 3H). ^{19}F NMR (470 MHz, CDCl_3): δ -109.1 (d, $J = 251.9$ Hz), -114.5 (d, $J = 251.9$ Hz), -118.8. ^{13}C NMR (125 MHz, CDCl_3): δ 164.0 (t, $J = 32.6$ Hz), 160.9 (d, $J = 243.6$ Hz), 132.4-132.2 (m), 131.9 (d, $J = 5.3$ Hz), 127.7 (d, $J = 8.1$ Hz), 124.8 (d, $J = 17.4$ Hz), 116.4 (t, $J = 252.9$ Hz), 115.0 (d, $J = 22.1$ Hz), 62.6, 43.6 (t, $J = 23.0$ Hz), 14.5 (d, $J = 3.5$ Hz), 13.9-13.8 (m, 2C). IR (ATR, cm^{-1}) max 1758.8, 1504.3, 1296.0, 1247.8, 1203.4, 1116.6, 1083.8, 1033.7, 821.6, 767.6. HRMS (ESI) m/z : $[\text{M}+\text{Na}]^+$ calcd. for $\text{C}_{13}\text{H}_{15}\text{F}_3\text{NaO}_2$ 283.0916, found 283.0918. The enantiomeric ratio of **2j** was determined by chiral HPLC analysis on OJ-3. Conditions: hexane/isopropanol = 99/1, flow rate = 0.5 mL/min, UV-vis detection at $\lambda = 265$ nm, $t_{\text{R}} = 11.5$ min (minor), 12.4 min (major).

Ethyl 2,2-difluoro-3-(2-methoxyphenyl)butanoate (**2k**)



Purified by column chromatography (2% ethyl acetate in petroleum ether) to provide a colorless oil (51.0 mg, 99% yield); 87:13 er, $[\alpha]_{\text{D}}^{25}$ 9.3 (c 0.2, CHCl_3). ^1H NMR (600 MHz, CDCl_3): δ 7.34 (d, $J = 7.8$ Hz, 1H), 7.25-7.22 (m, 1H), 6.94 (t, $J = 7.2$ Hz, 1H), 6.85 (d, $J = 8.4$ Hz, 1H), 4.22-4.12 (m, 3H), 3.81 (s, 3H), 1.38 (d, $J = 7.2$ Hz, 3H), 1.16 (t, $J = 7.2$ Hz, 3H). ^{19}F NMR (564 MHz, CDCl_3): δ -107.7 (d, $J = 249.3$ Hz), -113.5 (d, $J = 249.3$ Hz). ^{13}C NMR (150 MHz, CDCl_3): δ 164.2 (t, $J = 32.6$ Hz), 157.0, 128.8, 128.6, 125.8 (d, $J = 5.7$ Hz), 120.7, 116.7 (dd, $J = 253.4, 251.6$ Hz), 110.5, 62.3, 55.5, 35.3 (t, $J = 22.8$ Hz), 13.7, 13.7-13.5 (m). IR (ATR, cm^{-1}) max 1762.7, 1602.6, 1494.6, 1463.8, 1301.8, 1247.8, 1186.1, 1105.1, 1026.0, 798.4, 754.0. HRMS (ESI) m/z : $[\text{M} + \text{Na}]^+$ calcd. for $\text{C}_{13}\text{H}_{16}\text{F}_2\text{NaO}_3$ 281.0960, found 281.0963. The enantiomeric ratio of **2k** was determined by chiral HPLC analysis on OJ-3. Conditions: hexane/isopropanol = 99/1, flow rate = 1.0 mL/min, UV-vis detection at $\lambda = 273$ nm, $t_{\text{R}} = 7.3$ min (major), 7.7 min (minor).

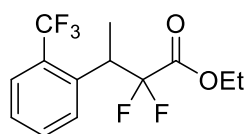
Ethyl 2,2-difluoro-3-(2-fluorophenyl)butanoate (**2l**)



Purified by column chromatography (2% ethyl acetate in

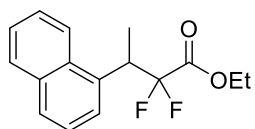
petroleum ether) to provide a green oil (47.1 mg, 95% yield); 97:3 er, $[\alpha]_{\text{D}}^{25}$ -9.2 (c 0.2, CHCl_3); ^1H NMR (600 MHz, CDCl_3) δ 7.39 (t, $J = 7.8$ Hz, 1H), 7.29-7.24 (m, 2H), 7.14 (t, $J = 7.8$ Hz, 1H), 7.05-7.02 (m, 1H), 4.21 (q, $J = 7.2$ Hz, 2H), 4.02-3.93 (m, 1H), 1.44 (d, $J = 7.2$ Hz, 3H), 1.21 (t, $J = 7.2$ Hz, 3H). ^{19}F NMR (564 MHz, CDCl_3) δ -109.1 (dd, $J = 252.7, 13.5$ Hz), -113.2 (dd, $J = 257.2, 18.0$ Hz), -117.4. ^{13}C NMR (150 MHz, CDCl_3) δ 163.7 (t, $J = 32.4$ Hz), 160.6 (d, $J = 245.6$ Hz), 129.6, 129.4 (d, $J = 8.1$ Hz), 124.3 (d, $J = 3.5$ Hz), 124.2-124.1 (m), 116.1 (t, $J = 252.6$ Hz), 115.4 (d, $J = 22.8$ Hz), 62.7, 35.9 (t, $J = 21.5$ Hz), 13.7, 13.4-13.2 (m). IR (ATR, cm^{-1}) max 1766.6, 1494.6, 1456.0, 1301.8, 1205.3, 1128.2, 1056.8, 1029.8, 756.0. HRMS (ESI) m/z : $[\text{M}+\text{Na}]^+$ calcd. for $\text{C}_{12}\text{H}_{13}\text{F}_3\text{NaO}_2$ 269.0760, found 269.0761. The enantiomeric ratio of **2l** was determined by chiral HPLC analysis on OJ-3. Conditions: hexane/isopropanol = 99/1, flow rate = 1.0 mL/min, UV-vis detection at $\lambda = 210$ nm, $t_{\text{R}} = 14.9$ min (major), 18.1 min (minor).

Ethyl 2,2-difluoro-3-(2-(trifluoromethyl)phenyl)butanoate (**2m**)



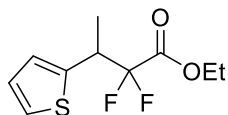
Purified by column chromatography (2% ethyl acetate in petroleum ether) to provide a colorless oil (56.2 mg, 95% yield); 92:8 er, $[\alpha]_{\text{D}}^{25}$ -8.9 (c 0.2, CHCl_3); ^1H NMR (600 MHz, CDCl_3) δ 7.66 (d, $J = 8.4$ Hz, 2H), 7.55 (t, $J = 7.8$ Hz, 1H), 7.39 (t, $J = 7.8$ Hz, 1H), 4.21-4.10 (m, 2H), 4.01-3.90 (m, 1H), 1.45 (d, $J = 7.2$ Hz, 3H), 1.14 (t, $J = 7.2$ Hz, 3H). ^{19}F NMR (470 MHz, CDCl_3) δ -58.6, -107.5 (d, $J = 255.7$ Hz), -110.76 (d, $J = 255.2$ Hz). ^{13}C NMR (150 MHz, CDCl_3) δ 163.5 (t, $J = 32.3$ Hz), 136.7 (d, $J = 5.4$ Hz), 132.2, 129.5-129.3 (m), 128.9 (q, $J = 29.3$ Hz), 127.6, 126.0 (q, $J = 5.7$ Hz), 124.2 (q, $J = 272.1$ Hz), 116.1 (t, $J = 252.8$ Hz), 62.8, 39.5 (t, $J = 23.6$ Hz), 15.6-15.3 (m), 13.6. IR (ATR, cm^{-1}) max 1768.5, 1456.1, 1311.4, 1161.0, 1122.4, 1081.9, 1031.8, 848.6, 769.5. HRMS (ESI) m/z : $[\text{M}+\text{Na}]^+$ calcd. for $\text{C}_{13}\text{H}_{13}\text{F}_5\text{NaO}_2$ 319.0728, found 319.0725. The enantiomeric ratio of **2m** was determined by chiral HPLC analysis on AD-3. Conditions: hexane/isopropanol = 99/1, flow rate = 0.5 mL/min, UV-vis detection at $\lambda = 208$ nm, $t_{\text{R}} = 7.7$ min (major), 8.0 min (minor).

Ethyl (S)-2,2-difluoro-3-(naphthalen-1-yl)butanoate (**2n**)



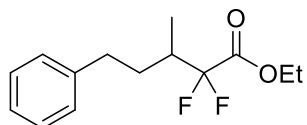
Purified by column chromatography (2% ethyl acetate in petroleum ether) to provide a green oil (51.8 mg, 92% yield); 85:15 er, $[\alpha]_D^{25}$ -24.1 (c 0.4, CHCl_3); ^1H NMR (500 MHz, CDCl_3) δ 8.09 (d, $J = 8.5$ Hz, 1H), 7.85 (d, $J = 8.0$ Hz, 1H), 7.79 (d, $J = 8.0$ Hz, 1H), 7.60 (d, $J = 7.0$ Hz, 1H), 7.57-7.52 (m, 1H), 7.51-7.43 (m, 2H), 4.54-4.43 (m, 1H), 4.05-3.93 (m, 2H), 1.58 (d, $J = 7.0$ Hz, 3H), 0.92 (t, $J = 7.0$ Hz, 3H). ^{19}F NMR (470 MHz, CDCl_3) δ -106.6 (d, $J = 251.0$ Hz), -113.3 (d, $J = 251.5$ Hz). ^{13}C NMR (125 MHz, CDCl_3) δ 164.0 (t, $J = 32.5$ Hz), 133.8, 133.4 (d, $J = 6.4$ Hz), 131.7, 129.0, 128.3, 126.3, 125.8, 125.6, 125.4, 122.8, 116.7 (dd, $J = 254.6, 251.5$ Hz), 62.5, 37.7, 14.6-14.5 (m), 13.4. IR (ATR, cm^{-1}) max 1768.5, 1288.3, 1199.6, 1120.5, 1076.1, 1035.6, 1000.9, 800.3, 779.1. HRMS (ESI) m/z : $[\text{M}+\text{Na}]^+$ calcd. for $\text{C}_{16}\text{H}_{16}\text{F}_2\text{NaO}_2$ 301.1011, found 301.1013. The enantiomeric ratio of **2n** was determined by chiral HPLC analysis on OJ-3. Conditions: hexane/isopropanol = 99/1, flow rate = 1.0 mL/min, UV-vis detection at $\lambda = 224$ nm, $t_R = 9.2$ min (major), 10.8 min (minor).

Ethyl 2,2-difluoro-3-(thiophen-2-yl) butanoate (2p)



Purified by column chromatography (2% ethyl acetate in Petroleum ether) to provide a colorless oil (44.3 mg, 95% yield); 53:47 er. ^1H NMR (500 MHz, CDCl_3): δ 7.24-7.23 (m, 1H), 6.97-6.94 (m, 2H), 4.22 (q, $J = 7.0$ Hz, 2H), 3.90-3.79 (m, 1H), 1.50 (d, $J = 7.5$ Hz, 3H), 1.23 (t, $J = 7.0$ Hz, 3H). ^{19}F NMR (470 MHz, CDCl_3): δ -109.3 (d, $J = 251.5$ Hz, 1F), -114.7 (d, $J = 251.5$ Hz, 1F). ^{13}C NMR (125 MHz, CDCl_3) δ 163.7 (t, $J = 32.5$ Hz), 138.9 (d, $J = 6.4$ Hz), 126.7, 126.7, 125.2, 115.7 (dd, $J = 254.5, 253.1$ Hz), 62.7, 39.8 (dd, $J = 24.9, 23.1$ Hz), 14.9-14.8 (dd, $J = 5.1, 3.0$ Hz), 13.8. HRMS (ESI) m/z : $[\text{M} + \text{Na}]^+$ calcd. for $\text{C}_{10}\text{H}_{12}\text{F}_2\text{NaO}_2\text{S}$ 257.0418, found 257.0416. The enantiomeric ratio of **2p** was determined by chiral HPLC analysis on OJ-3. Conditions: hexane/isopropanol = 99/1, flow rate = 1.0 mL/min, uv-vis detection at $\lambda = 232$ nm, $t_R = 8.6$ min (major), 9.1 min (minor).

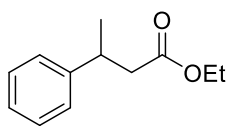
Ethyl 2,2-difluoro-3-methyl-5-phenylpentanoate (2q)



Purified by column chromatography (2% ethyl acetate in

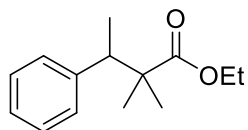
Petroleum ether) to provide a colorless oil (47.7 mg, 93% yield); 84:16 er, $[\alpha]_D^{25}$ -14.0 (*c* 0.3, CHCl₃); ¹H NMR (500 MHz, CDCl₃): δ 7.30-7.27 (m, 2H), 7.21-7.16 (m, 3H), 4.29 (q, *J* = 7.0 Hz, 2H), 2.81-2.75 (m, 1H), 2.60-2.56 (m, 1H), 2.26-2.21 (m, 1H), 1.94-1.90 (m, 1H), 1.60-1.54 (m, 1H), 1.31 (t, *J* = 7.0 Hz, 3H), 1.09 (d, *J* = 7.0 Hz, 3H). ¹⁹F NMR (470 MHz, CDCl₃): δ -112.4. ¹³C NMR (125 MHz, CDCl₃) δ 164.3 (t, *J* = 33.0 Hz), 141.2, 128.4, 128.3, 126.0, 117.8 (t, *J* = 251.1 Hz), 62.6, 37.2 (t, *J* = 21.9 Hz), 32.9, 30.6 (t, *J* = 3.4 Hz), 13.9, 12.0 (t, *J* = 4.6 Hz). HRMS (ESI) *m/z*: [M + Na]⁺ calcd. for C₁₄H₁₈F₂NaO₂ 279.1167, found 279.1160. The enantiomeric ratio of **2q** was determined by chiral HPLC analysis on OJ-3. Conditions: hexane/isopropanol = 99/1, flow rate = 1.0 mL/min, uv-vis detection at λ = 209nm, *t*_R = 8.8 min (major), 10.6 min (minor).

Ethyl 3-phenylbutanoate (**4**)^[S10]



Purified by column chromatography (2% ethyl acetate in petroleum ether) to provide a colorless oil (38.0 mg, 99% yield). ¹H NMR (600 MHz, CDCl₃) δ 7.29 (t, *J* = 7.8 Hz, 2H), 7.23-7.18 (m, 3H), 4.07 (q, *J* = 7.2 Hz, 2H), 3.31-3.24 (m, 1H), 2.62-2.51 (m, 2H), 1.30 (d, *J* = 7.2 Hz, 3H), 1.18 (q, *J* = 7.2 Hz, 3H). The enantiomeric ratio of **4** was determined by chiral HPLC analysis on OJ-3. Conditions: hexane/isopropanol = 99/1, flow rate = 1.0 mL/min, UV-vis detection at λ = 208 nm, *t*_R = 7.8min, 8.5 min.

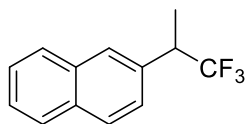
Ethyl 2,2-dimethyl-3-phenylbutanoate (**6**)



Purified by column chromatography (2% ethyl acetate in petroleum ether) to provide a colorless oil (39.0 mg, 89% yield). ¹H NMR (600 MHz, CDCl₃) δ 7.28-7.25 (m, 2H), 7.22-7.17 (m, 3H), 4.12-4.07 (m, 2H), 3.17 (q, *J* = 7.2 Hz, 1H), 1.26 (d, *J* = 7.2 Hz, 3H), 1.23 (t, *J* = 7.2 Hz, 3H), 1.11 (s, 3H), 1.05 (s, 3H). ¹³C NMR (125 MHz, CDCl₃) δ 177.7, 142.5, 129.1, 127.7, 126.5, 60.3, 46.4, 46.3, 23.9, 20.6, 15.9, 14.1. HRMS (ESI) *m/z*: [M +

$\text{Na}]^+$ calcd. for $\text{C}_{14}\text{H}_{20}\text{NaO}_2$ 243.1356, found 243.1353. The enantiomeric ratio of **6** was determined by chiral HPLC analysis on OJ-3. Conditions: hexane/isopropanol = 95/5, flow rate = 1.0 mL/min, UV-vis detection at $\lambda = 209$ nm, $t_{\text{R}} = 5.7$ min, 5.9 min.

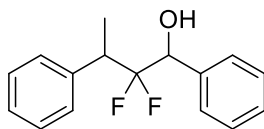
2-(1,1,1-trifluoropropan-2-yl)naphthalene (**8**)^[S11]



Purified by column chromatography (2% ethyl acetate in petroleum ether) to provide a colorless oil (44.6 mg, 99% yield).

^1H NMR (600 MHz, CDCl_3) δ 7.84-7.82 (m, 3H), 7.77 (s, 1H) 7.51-7.46 (m, 2H), 7.44 (d, $J = 8.4$ Hz, 1H), 3.64-3.55 (m, 1H), 1.60 (d, $J = 7.2$ Hz, 3H). ^{19}F NMR (470 MHz, CDCl_3) δ -71.2. The enantiomeric ratio of **2s** was determined by chiral HPLC analysis on OJ-3. Conditions: hexane/isopropanol = 99/1, flow rate = 1.0 mL/min, UV-vis detection at $\lambda = 209$ nm, $t_{\text{R}} = 7.9$ min, 8.3 min.

2,2-difluoro-1,3-diphenyl-1 λ^3 ,3 λ^3 -butan-1-ol (**10**)



Purified by column chromatography (2% ethyl acetate in petroleum ether) to provide a colorless oil (52.1 mg, 99% yield); dr: 1.5:1, 61:39 er; 65:35 er. ^1H NMR (500 MHz,

CDCl_3) δ 7.41-7.16 (m, 10H), 4.76-4.44 (m, 1H), 3.62-3.03 (m, 1H), 2.40-2.20 (m, 1H), 1.43-1.42 (m, 3H). ^{19}F NMR (470 MHz, CDCl_3) δ -115.2 (d, $J = 248.2$ Hz), -116.1 (d, $J = 248.2$ Hz), -116.7 (d, $J = 252.4$ Hz), -117.7 (d, $J = 251.9$ Hz). ^{13}C NMR (125 MHz, CDCl_3) δ 139.7 (d, $J = 7.7$ Hz), 139.1 (d, $J = 5.2$ Hz), 136.8, 136.4 (d, $J = 3.5$ Hz), 129.0, 129.0, 128.9, 128.8, 128.6, 128.4, 128.3, 128.2, 128.1, 127.9, 127.4, 127.3, 123.3 (t, $J = 249.4$ Hz), 122.9 (dd, $J = 253.1, 249.2$ Hz), 74.4 (t, $J = 26.0$ Hz), 73.2 (dd, $J = 32.7, 25.6$ Hz), 43.5 (t, $J = 23.2$ Hz), 43.0 (dd, $J = 24.9, 22.3$ Hz), 15.6 (t, $J = 4.6$ Hz), 14.3 (t, $J = 5.3$ Hz). IR (ATR, cm^{-1}) max 1454.1, 1186.0, 1058.8, 970.0, 738.6, 698.1. HRMS (ESI) m/z : $[\text{M}+\text{Na}]^+$ calcd. for $\text{C}_{16}\text{H}_{16}\text{F}_2\text{NaO}$ 285.1061, found 285.1060. The diastereomeric and enantiomeric ratios of **10** was determined by chiral HPLC analysis on OZ-3. Conditions: hexane/isopropanol = 98/2, flow rate = 1.0 mL/min, UV-vis detection at $\lambda = 208$ nm, $t_{\text{R}1} = 8.2$ min (minor), 14.2 min (major); $t_{\text{R}2} = 11.7$ min (major), 13.2 min (minor).

4. Determination of the absolute configuration of product **2f**

To determine the absolute configuration of **2f**, the single crystal of product **2f** was grown in 2-mL vial by liquid/liquid diffusion technique. Less-dense n-hexane (0.6 mL) was slowly dropped into the dichloromethane solution (0.2 mL) of **2f** at 25 °C, so that they formed distinct layers. Then, the vial was cooled down to 0 °C. n-Hexane gradually diffused into the dichloromethane solution, creating a solvent mixture with lower solubility for the compound **2f** than that of pure dichloromethane. The crystal was grown from the solution, which was suitable for X-ray diffraction analysis.

The structure in Figure S1 showed that the absolute configuration of **2f** is (*S*). [CCDC number: 1978406] contains the structure and supplementary crystallographic data for compound (*S*)-**2f**. These data can be obtained free of charge from the Cambridge Crystallographic Data Centre via www.ccdc.cam.ac.uk.

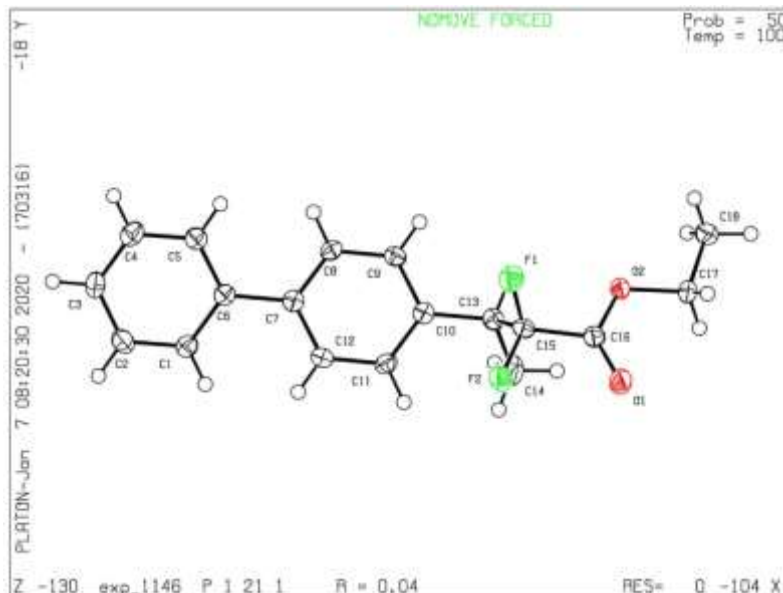


Figure S1 ORTEP diagram of (*S*)-**2f**

Table S5. Crystal data and structure refinement for exp_1146.

| | |
|---------------------|---|
| Identification code | exp_1146 |
| Empirical formula | C ₁₈ H ₁₈ F ₂ O ₂ |
| Formula weight | 304.32 |

| | |
|---|--|
| Temperature/K | 100.00(10) |
| Crystal system | monoclinic |
| Space group | P2 ₁ |
| a/Å | 8.2127(2) |
| b/Å | 7.21400(10) |
| c/Å | 13.1423(2) |
| α /° | 90 |
| β /° | 101.549(2) |
| γ /° | 90 |
| Volume/Å ³ | 762.87(2) |
| Z | 2 |
| ρ_{calc} /g/cm ³ | 1.325 |
| μ /mm ⁻¹ | 0.848 |
| F(000) | 320.0 |
| Crystal size/mm ³ | 0.25 × 0.14 × 0.12 |
| Radiation | CuK α (λ = 1.54184) |
| 2 Θ range for data collection/° | 6.864 to 134.08 |
| Index ranges | -9 ≤ h ≤ 9, -8 ≤ k ≤ 8, -15 ≤ l ≤ 15 |
| Reflections collected | 19742 |
| Independent reflections | 2708 [R_{int} = 0.0529, R_{sigma} = 0.0242] |
| Data/restraints/parameters | 2708/1/201 |
| Goodness-of-fit on F ² | 1.062 |
| Final R indexes [$I \geq 2\sigma(I)$] | R_1 = 0.0357, wR_2 = 0.0958 |
| Final R indexes [all data] | R_1 = 0.0360, wR_2 = 0.0960 |
| Largest diff. peak/hole / e Å ⁻³ | 0.31/-0.21 |
| Flack parameter | 0.07(6) |

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- S8 Brambilla, M.; Tredwell, M. Palladium-Catalyzed Suzuki-Miyaura Cross-Coupling of Secondary α -(Trifluoromethyl)benzyl Tosylates. *Angew. Chem. Int. Ed.* **2017**, *56*, 11981-11985.

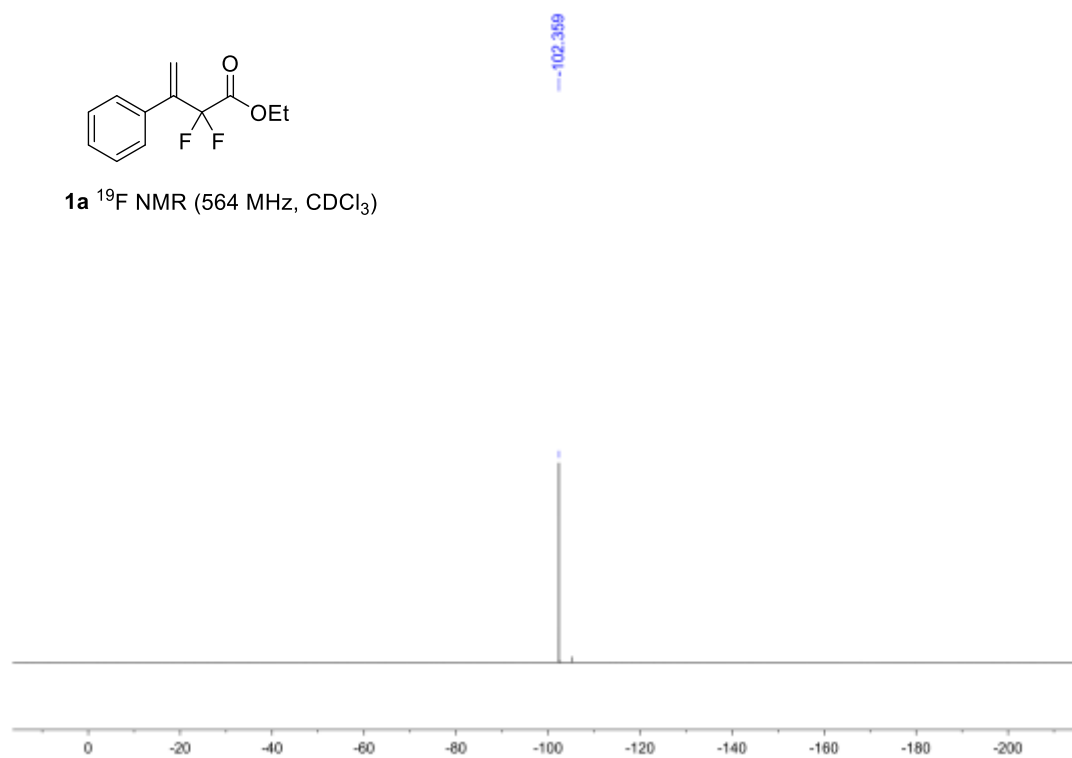
S9 Guo, Y.; Shreeve, J. M. Effect of fluorine on palladium-catalyzed cross-coupling reactions of aryl bromides with trifluoromethyl aryl ketones via difluoroenol silyl or monofluoroenol silyl ethers. *Chem. Commun.* **2007**, 3583-3585.

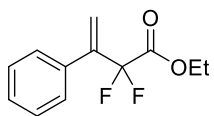
S10 Wen, J.; Jiang, J.; Zhang, X. M. Rhodium catalyzed asymmetric hydrogenation of α,β -unsaturated carbonyl compounds via a thiourea hydrogen bonding. *Org. Lett.* **2016**, *18*, 4451-4453.

S11 Qiao, Y.; Si, T.; Yang, M. H., Altman, R. A. Metal-Free Trifluoromethylation of Aromatic and Heteroaromatic Aldehydes and Ketones. *J. Org. Chem.* **2014**, *79*, 7122-7131.

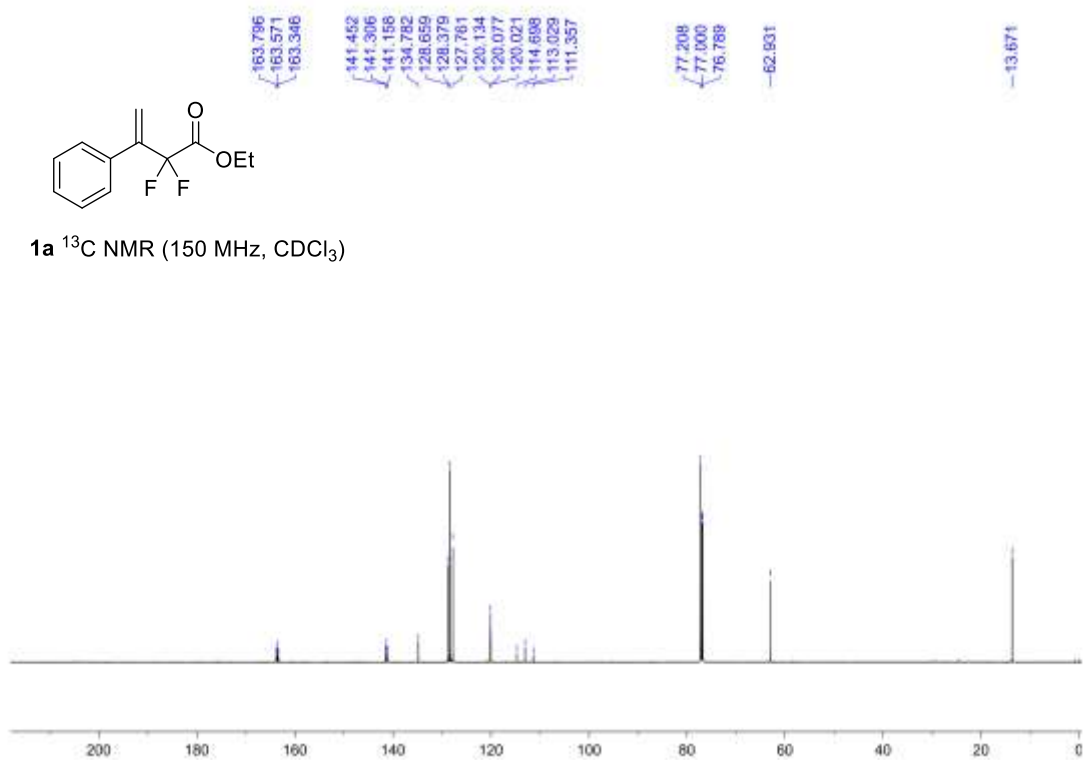
6. Copy of NMR spectra, HRMS reports of new compounds and

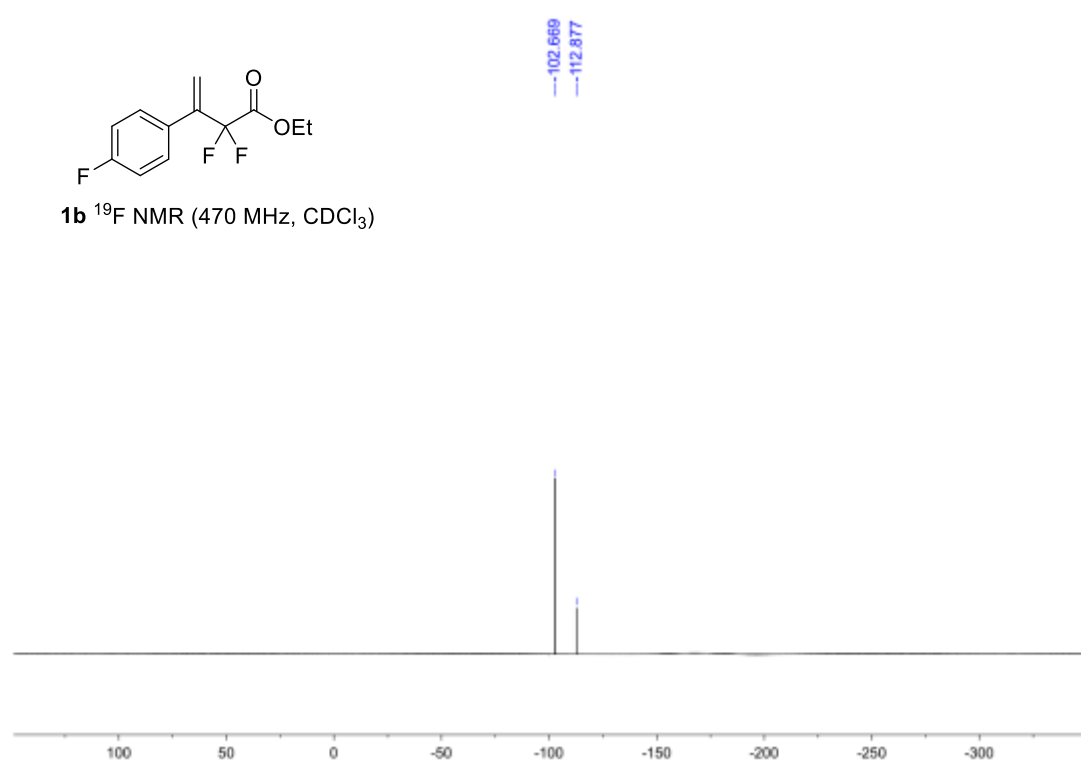
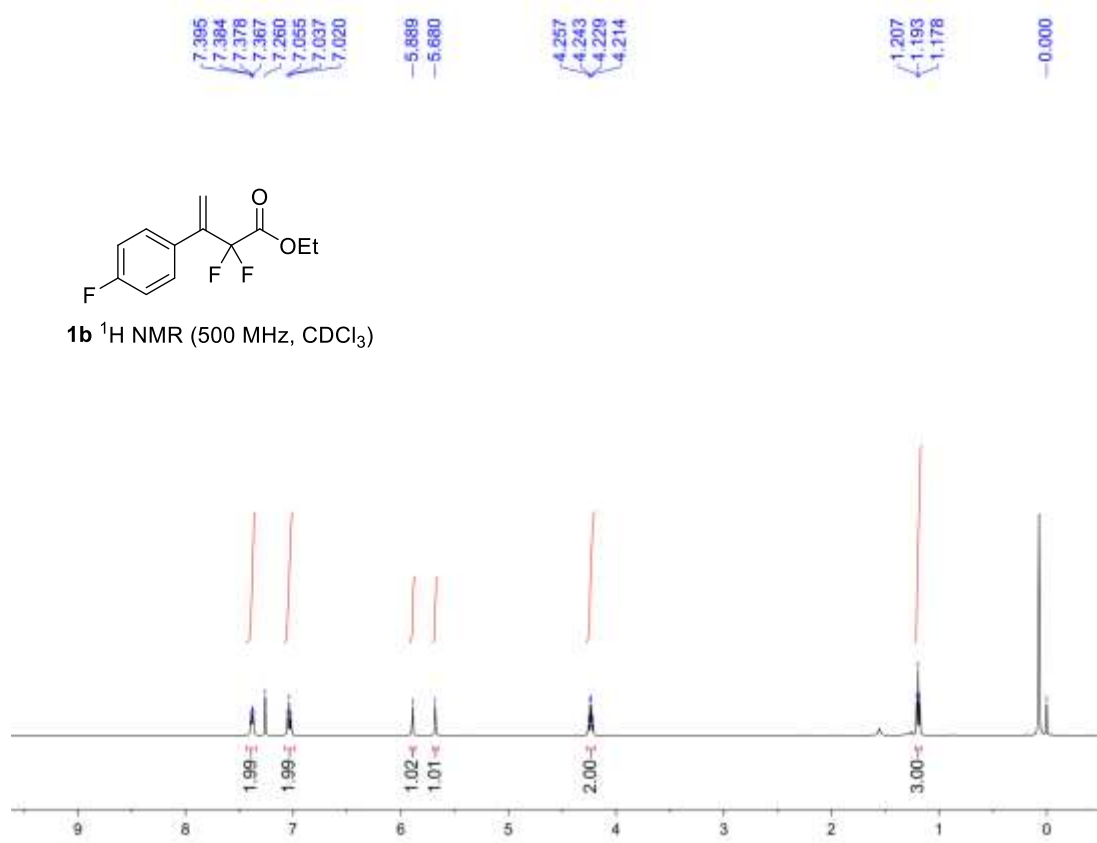
HPLC charts





1a ^{13}C NMR (150 MHz, CDCl_3)





163.981
163.731
163.462
162.192
162.015

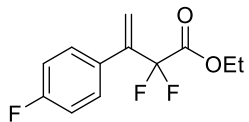
140.561
140.362
140.203

129.798
129.733
120.384
120.324
120.255
115.485
115.314
114.919
112.914
110.910

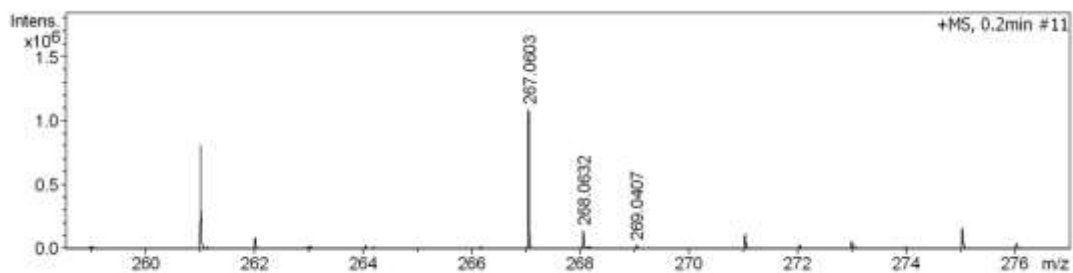
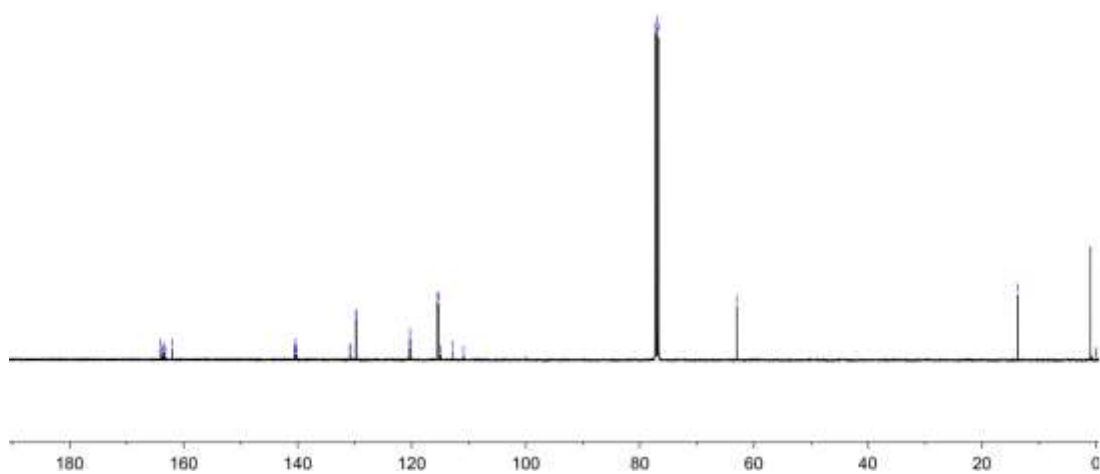
77.254
77.000
76.746

-63.029

-13.743

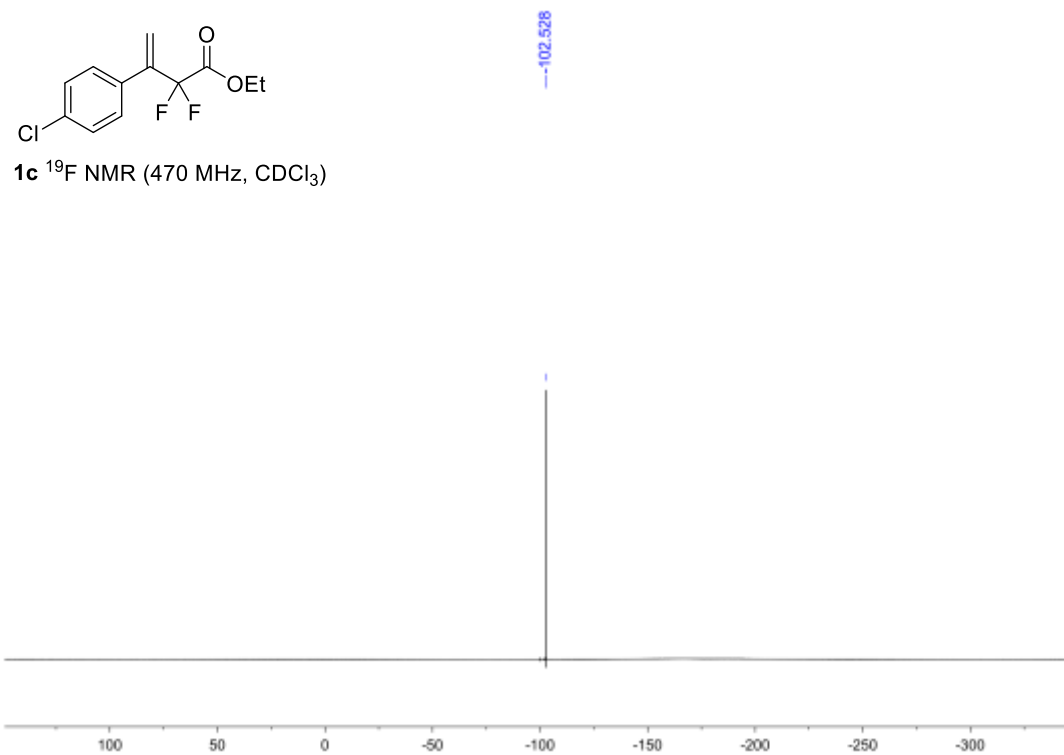
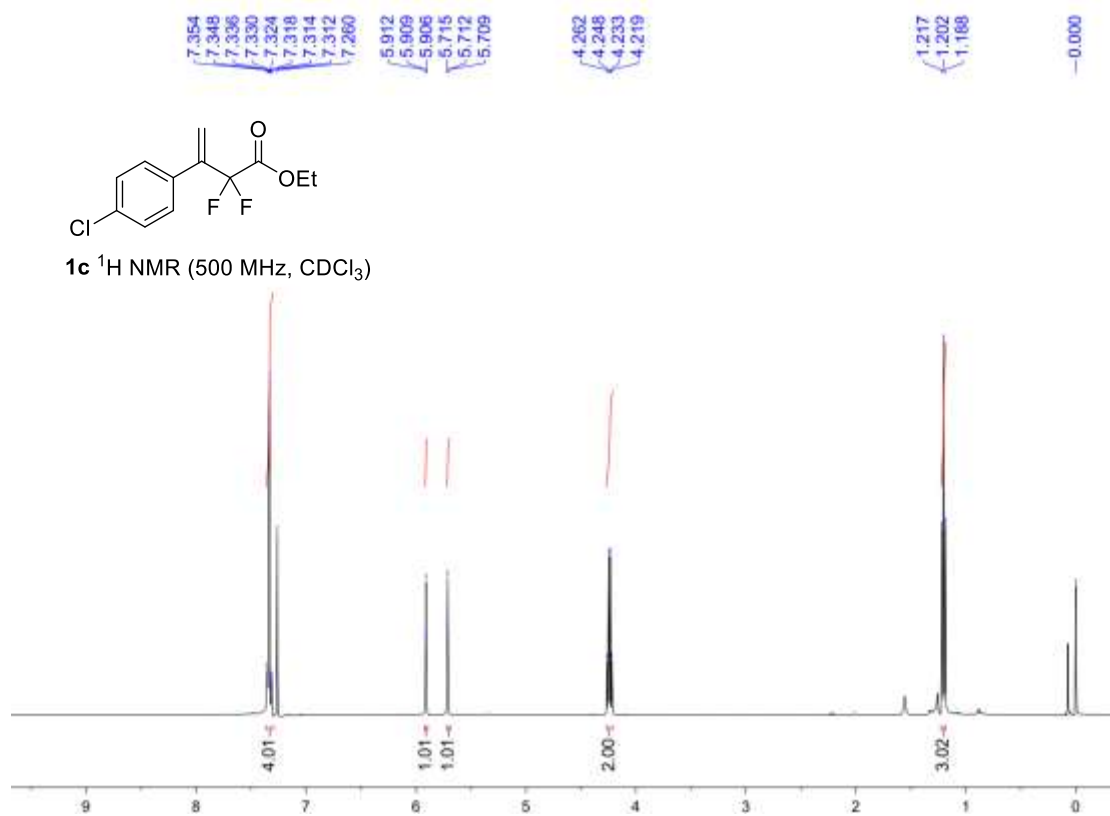


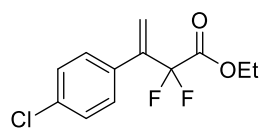
1b ^{13}C NMR (125 MHz, CDCl_3)



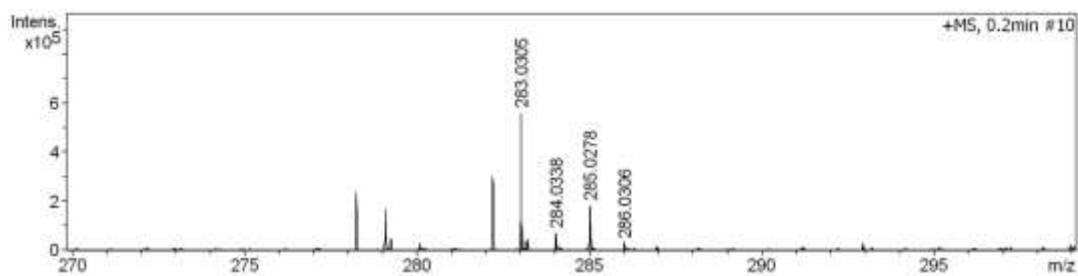
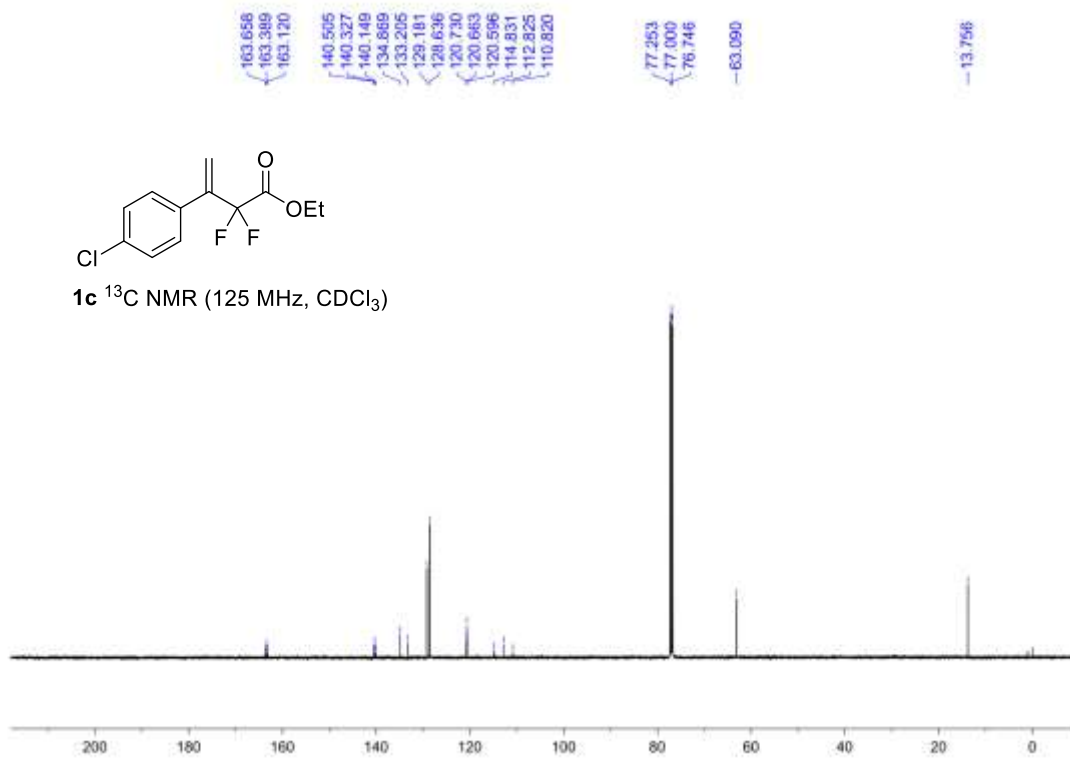
| # | m/z | Res. | S/N | I | I% | FWHM |
|---|----------|-------|--------|---------|-------|--------|
| 1 | 267.0603 | 20777 | 2411.4 | 1082240 | 100.0 | 0.0129 |
| 2 | 268.0632 | 15345 | 315.6 | 142588 | 13.2 | 0.0175 |
| 3 | 269.0407 | 12210 | 45.9 | 20860 | 1.9 | 0.0220 |

| Meas. m/z | # | Ion Formula | m/z | err [ppm] | mSigma | Score | rdb | e ⁻ Conf | N-Rule |
|-----------|---|---|----------|-----------|--------|-------|--------|---------------------|------------|
| 267.0603 | 1 | C ₁₂ H ₁₁ F ₃ NaO ₂ | 267.0603 | 0.2 | 7.0 | 1 | 100.00 | 5.5 | even ok |



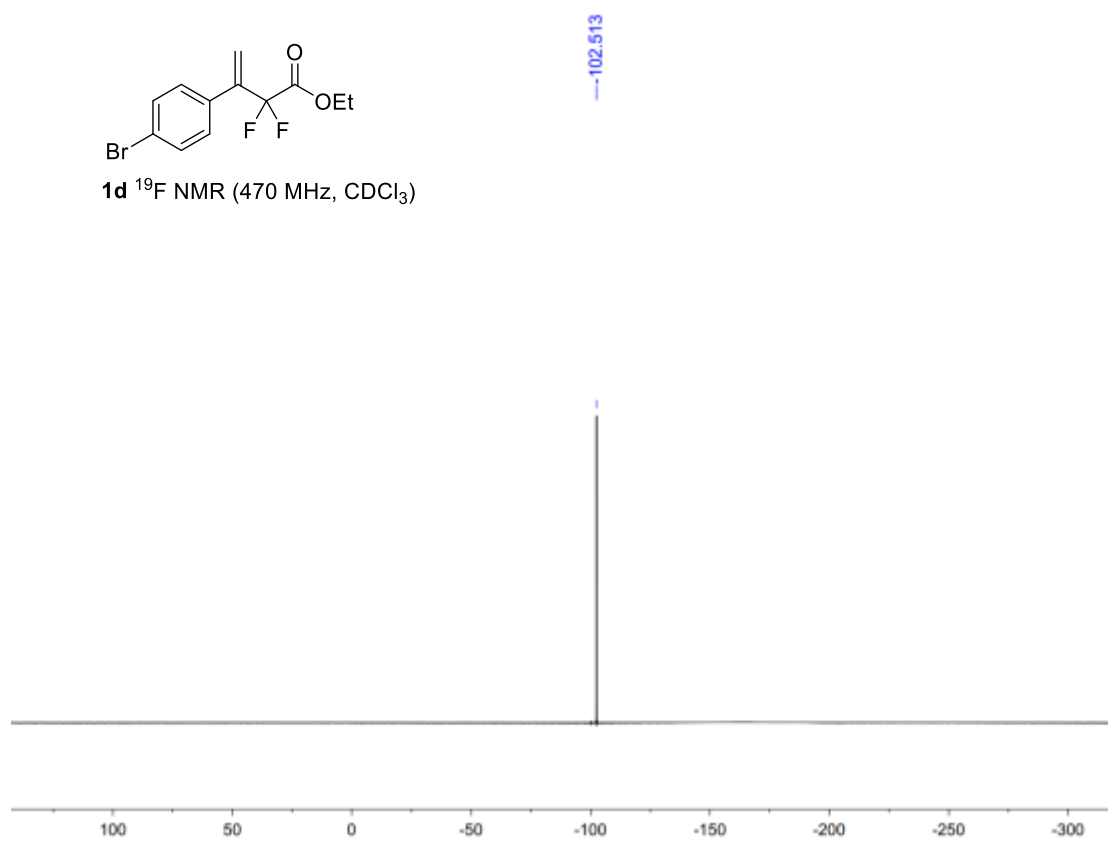
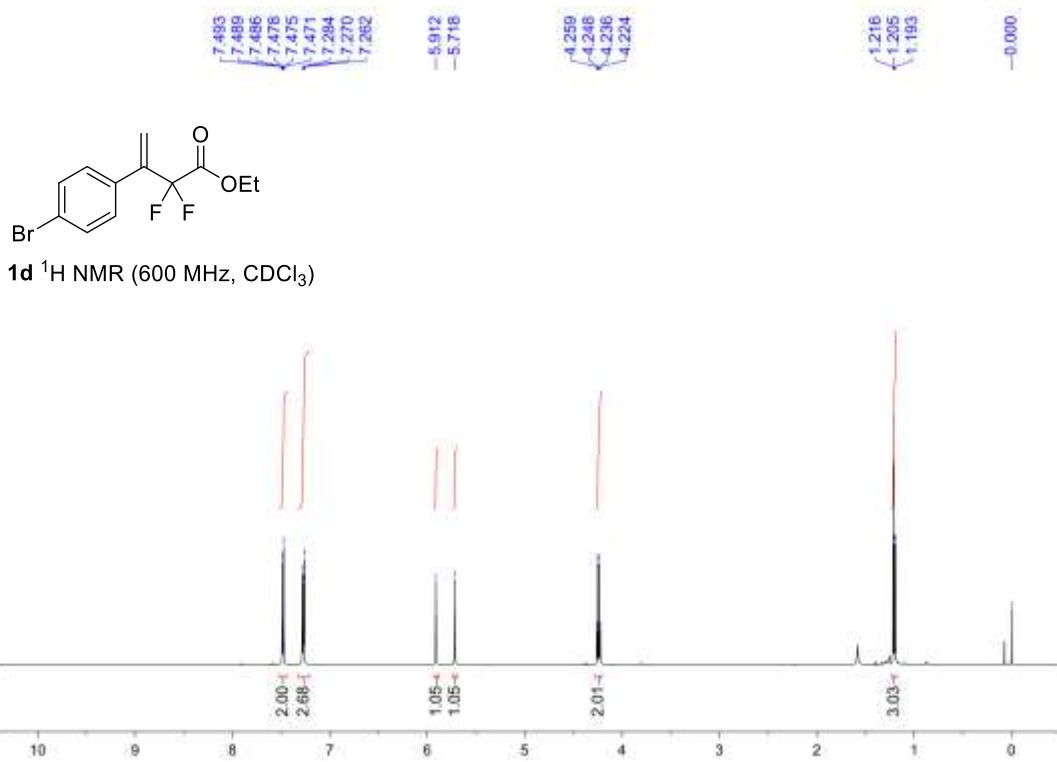


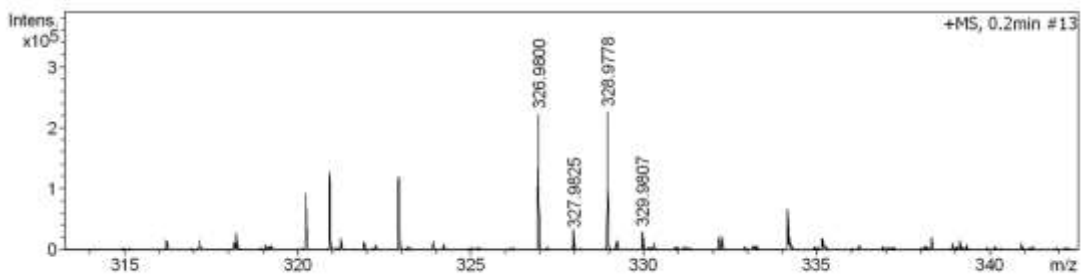
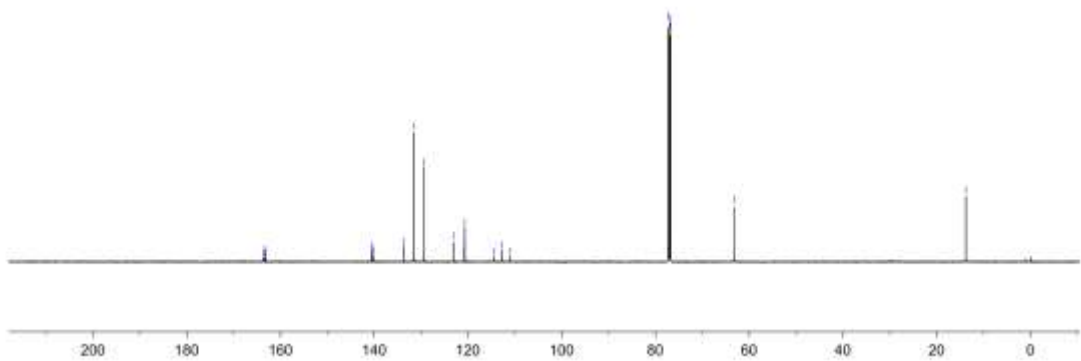
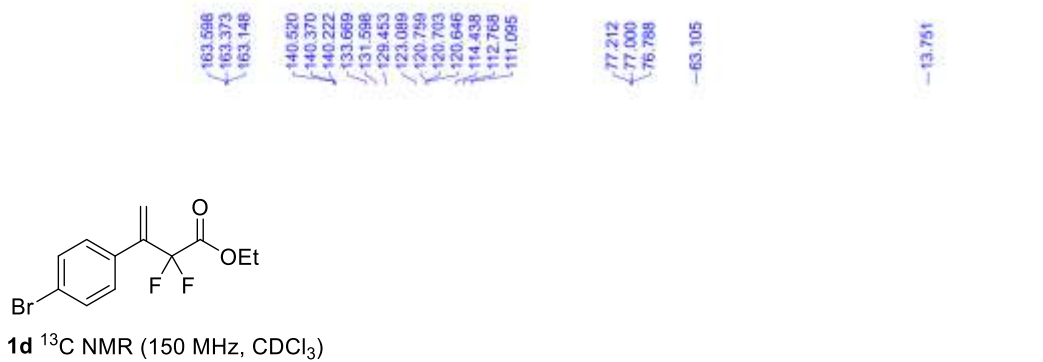
1c ^{13}C NMR (125 MHz, CDCl_3)



| # | m/z | Res. | S/N | I | I% | FWHM |
|---|----------|-------|--------|--------|-------|--------|
| 1 | 283.0305 | 18444 | 1095.6 | 556904 | 100.0 | 0.0153 |
| 2 | 284.0338 | 14344 | 137.9 | 70704 | 12.7 | 0.0198 |
| 3 | 285.0278 | 14939 | 354.2 | 182236 | 32.7 | 0.0191 |
| 4 | 286.0306 | 12648 | 48.4 | 25060 | 4.5 | 0.0226 |

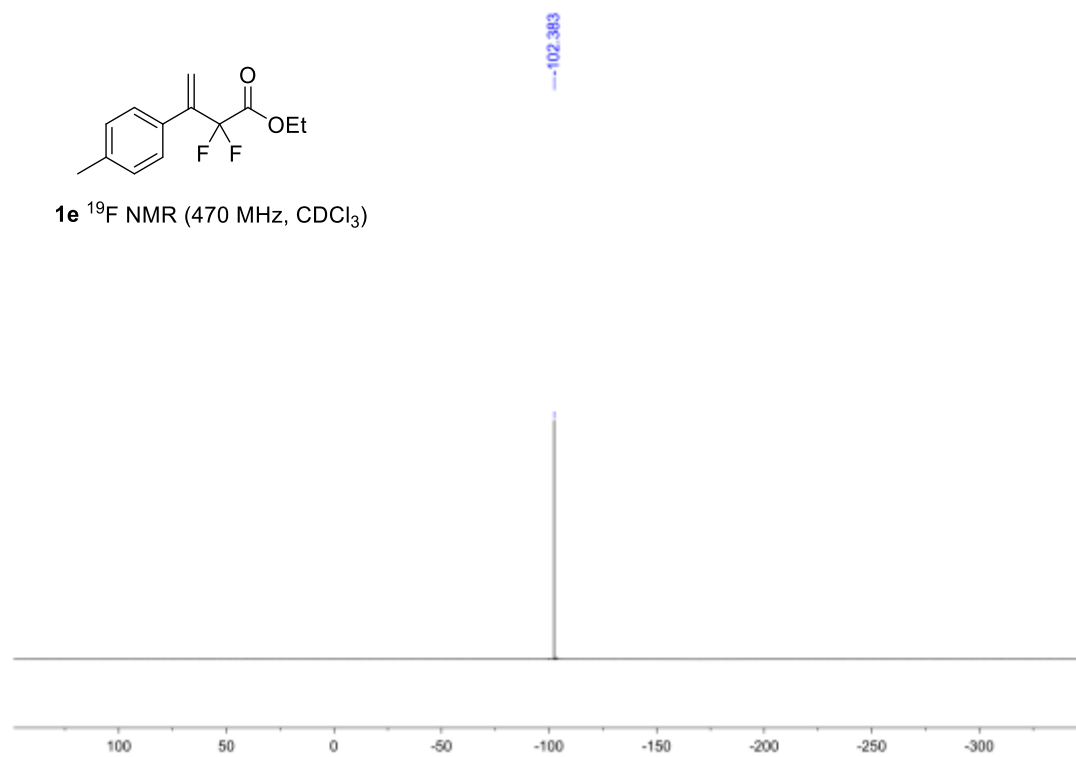
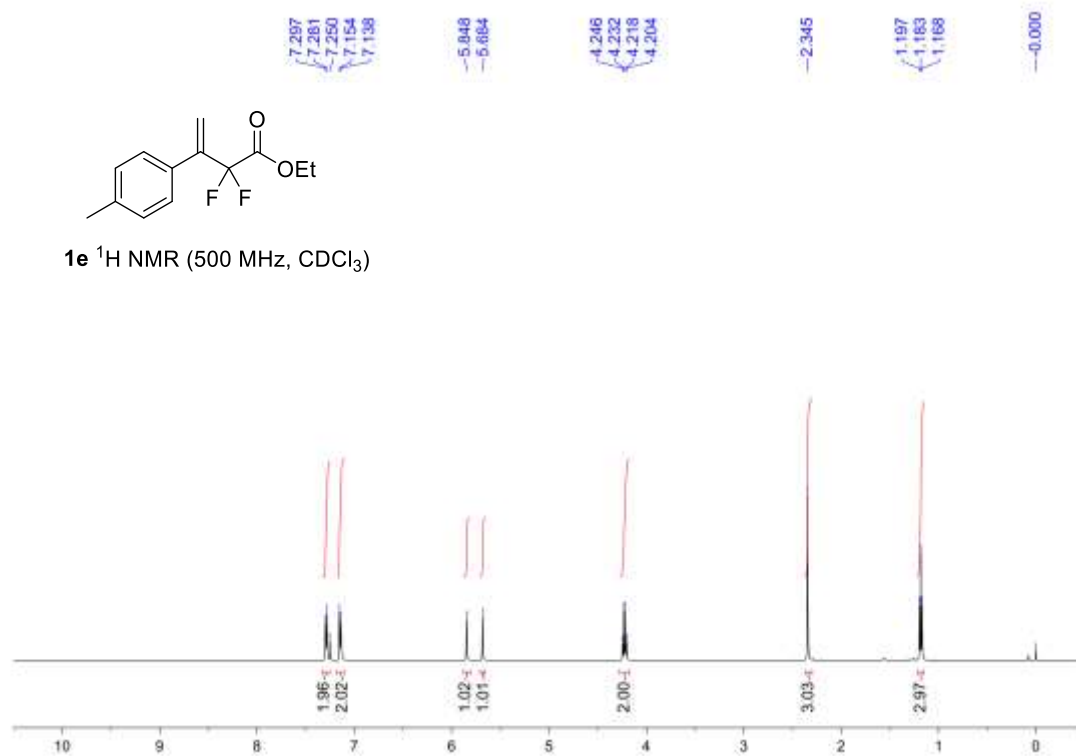
| Meas. m/z | # | Ion Formula | m/z | err [ppm] | mSigma | Score | rdB | e ⁻ Conf | N-Rule |
|-----------|---|--|----------|-----------|--------|-------|--------|---------------------|------------|
| 283.0305 | 1 | $\text{C}_{12}\text{H}_{11}\text{ClF}_2\text{NaO}_2$ | 283.0308 | 0.9 | 3.2 | 1 | 100.00 | 5.5 | even ok |

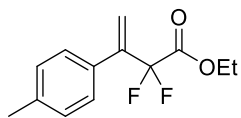




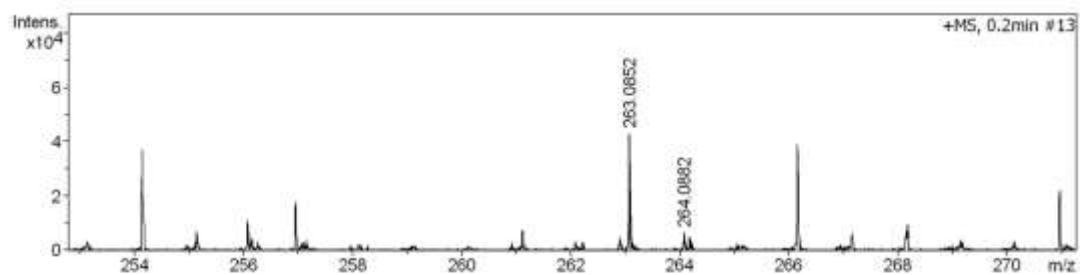
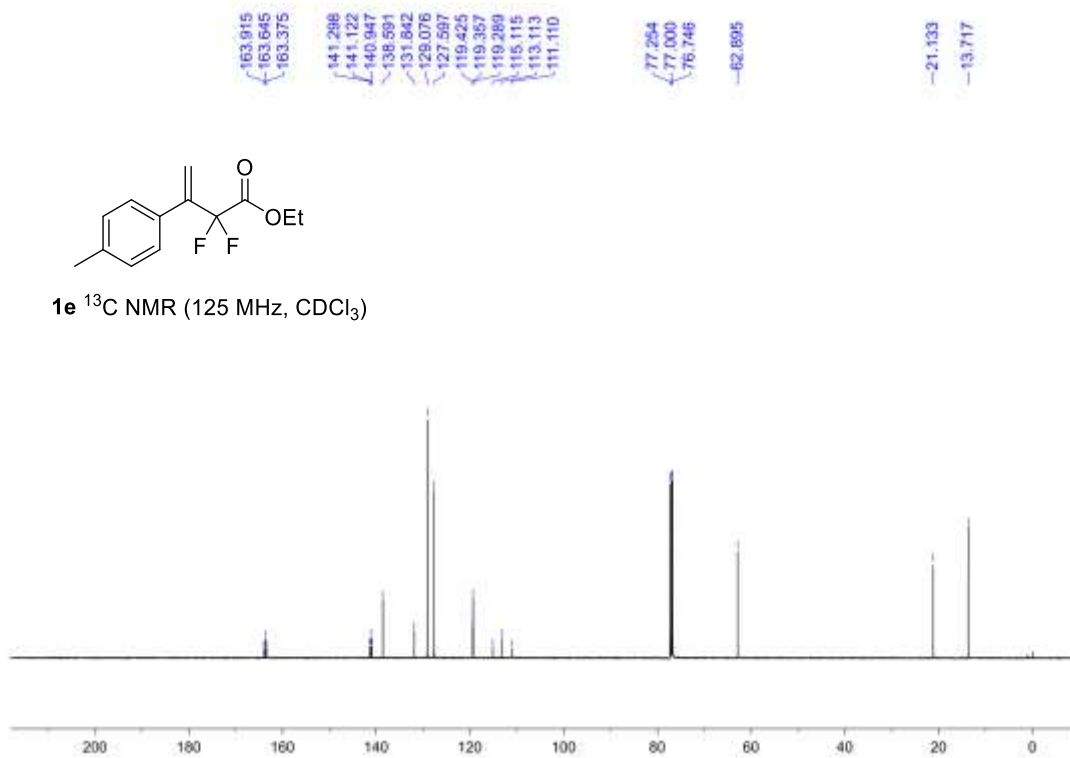
| # | m/z | Res. | S/N | I | I% | FWHM |
|---|----------|-------|-------|--------|-------|--------|
| 1 | 326.9800 | 14406 | 378.4 | 221784 | 98.6 | 0.0227 |
| 2 | 327.9825 | 13351 | 47.0 | 27856 | 12.3 | 0.0246 |
| 3 | 328.9778 | 15123 | 381.8 | 225004 | 100.0 | 0.0218 |
| 4 | 329.9807 | 13639 | 50.1 | 29592 | 13.2 | 0.0242 |

| Meas. m/z | # | Ion Formula | m/z | err [ppm] | mSigma | Score | rdb | e ⁻ Conf | N-Rule |
|-----------|---|---|----------|-----------|--------|-------|--------|---------------------|------------|
| 326.9800 | 1 | C ₁₂ H ₁₁ BrF ₂ NaO ₂ | 326.9803 | 0.8 | 11.5 | 1 | 100.00 | 5.5 | even ok |



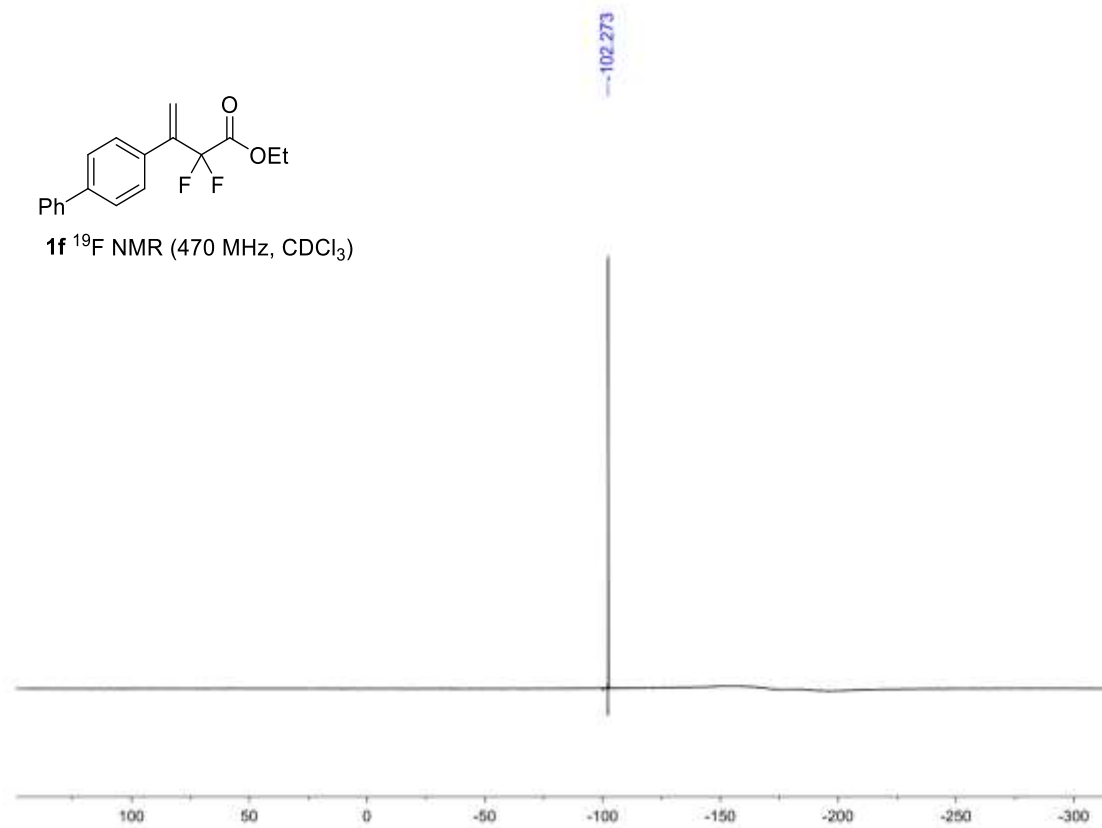
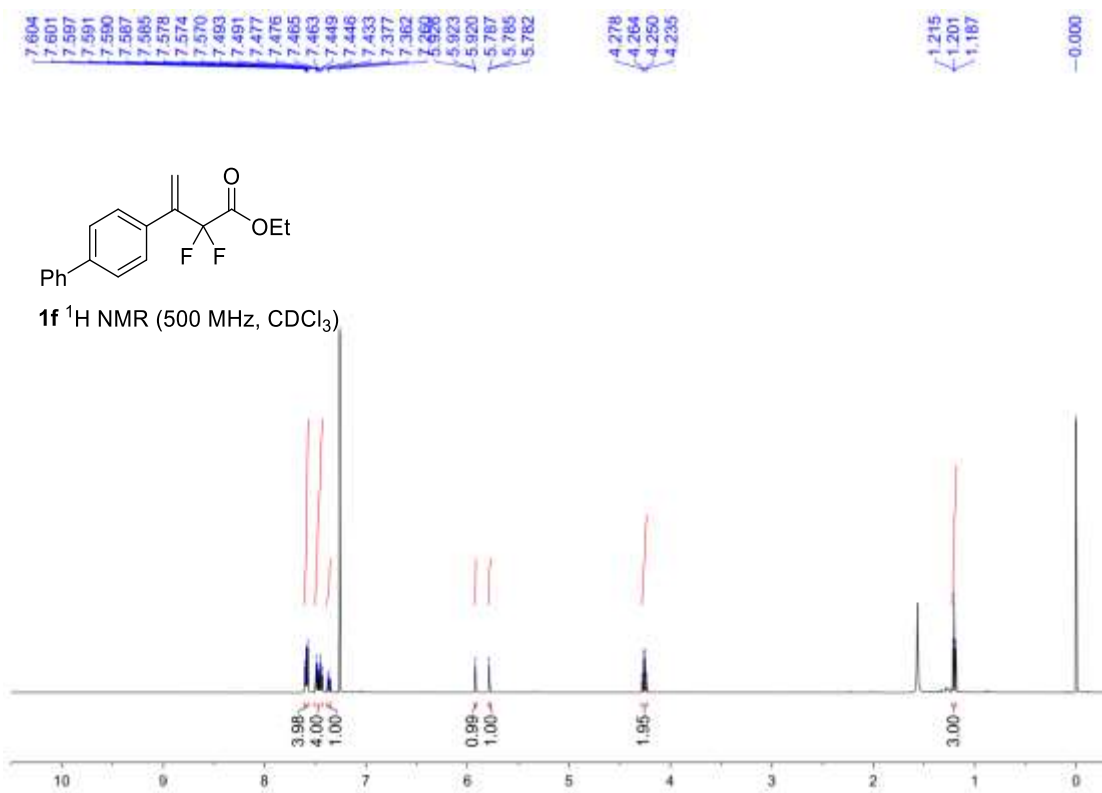


1e ^{13}C NMR (125 MHz, CDCl_3)

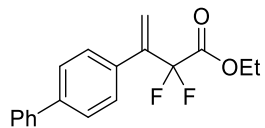


| # | m/z | Res. | S/N | I | I% | FWHM |
|---|----------|-------|------|-------|-------|--------|
| 1 | 263.0852 | 14732 | 87.0 | 42972 | 100.0 | 0.0179 |
| 2 | 264.0882 | 17408 | 13.1 | 6508 | 15.1 | 0.0152 |

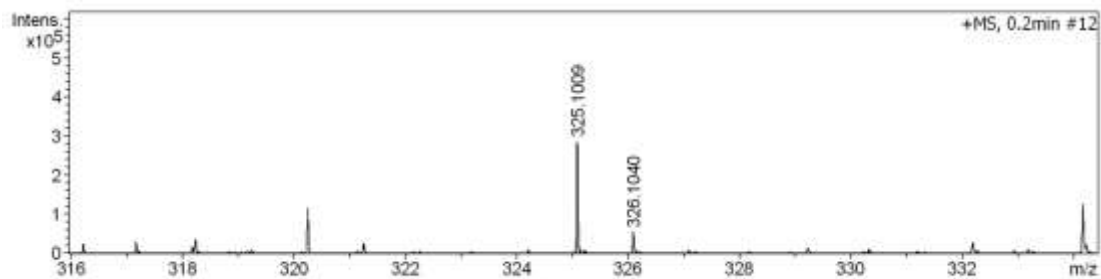
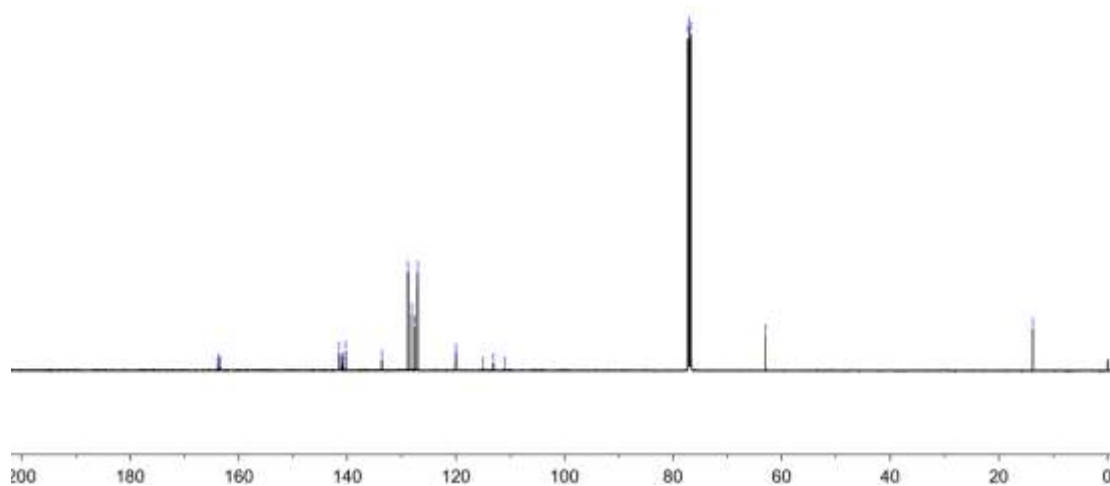
| Meas. m/z | # | Ion Formula | m/z | err [ppm] | mSigma | Score | rdb | e ⁻ Conf | N-Rule |
|-----------|---|---|----------|-----------|--------|--------|-----|---------------------|--------|
| 263.0852 | 1 | C ₁₃ H ₁₄ F ₂ NaO ₂ | 263.0854 | 0.9 | 9.2 | 100.00 | 5.5 | even | ok |



163.899
163.629
163.359
141.488
140.910
140.733
140.294
133.641
128.830
128.141
127.602
127.081
127.029
120.071
120.003
119.935
115.081
113.077
111.072
77.254
77.000
76.746
-63.022
-13.745

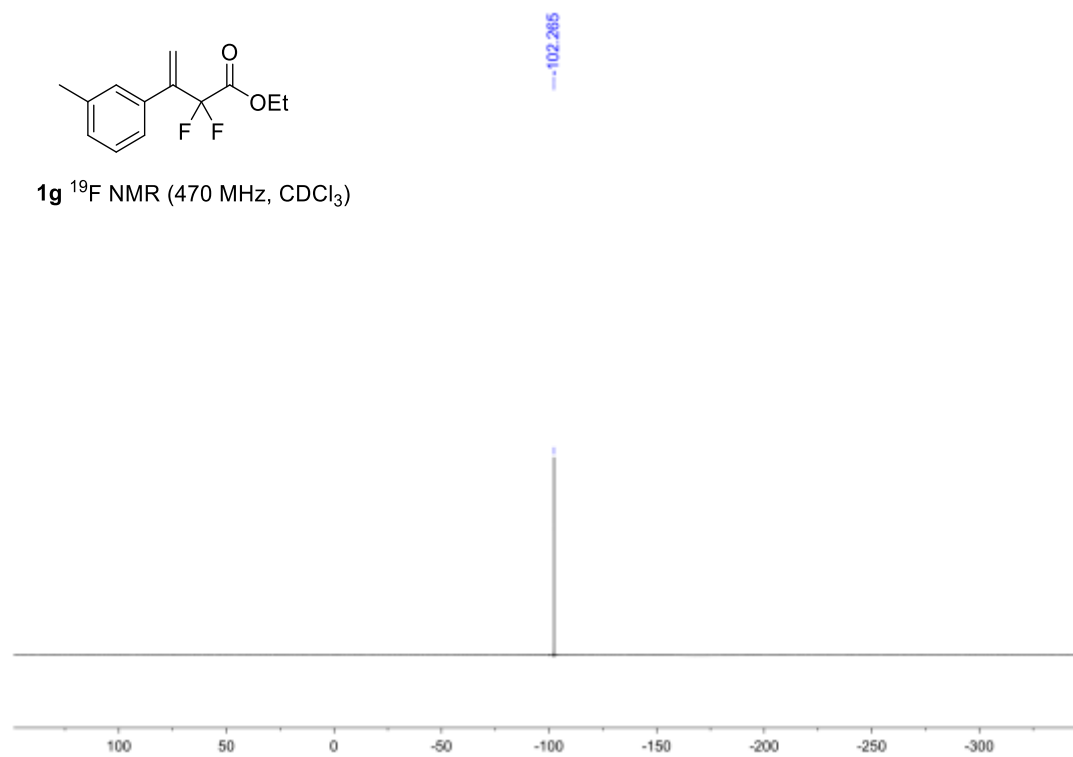
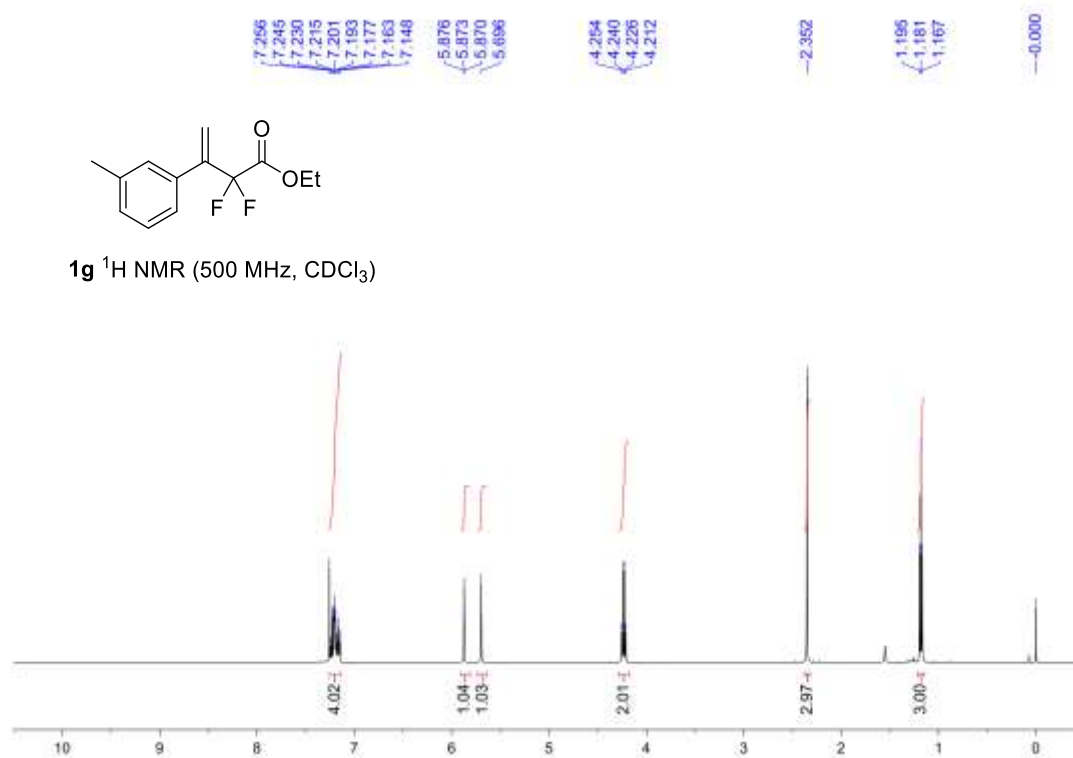


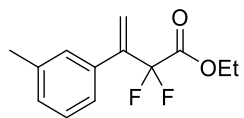
1f ^{13}C NMR (125 MHz, CDCl_3)



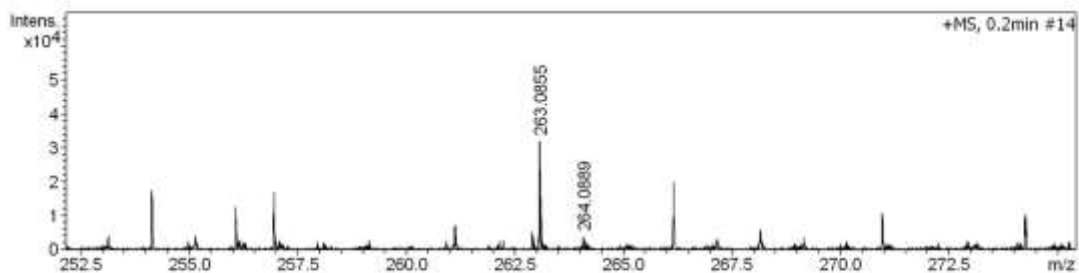
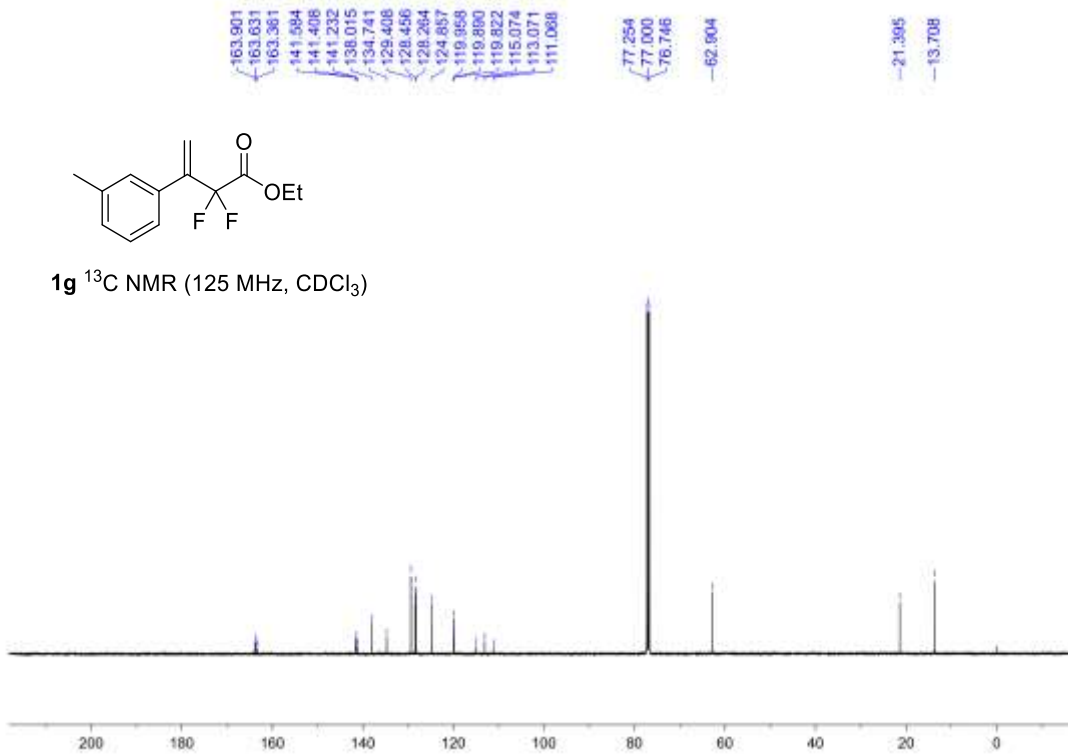
| # | m/z | Res. | S/N | I | I% | FWHM |
|---|----------|-------|-------|--------|-------|--------|
| 1 | 325.1009 | 15390 | 518.3 | 283376 | 100.0 | 0.0211 |
| 2 | 326.1040 | 12702 | 95.3 | 52264 | 18.4 | 0.0257 |
| 3 | 327.1061 | 11048 | 10.9 | 5984 | 2.1 | 0.0296 |

| Meas. m/z | # | Ion Formula | m/z | err [ppm] | mSigma | Score | rdb | e ⁻ Conf | N-Rule |
|-----------|---|--|----------|-----------|--------|--------|-----|---------------------|--------|
| 325.1009 | 1 | $\text{C}_{18}\text{H}_{16}\text{F}_2\text{NaO}_2$ | 325.1011 | 0.6 | 7.5 | 100.00 | 9.5 | even | ok |



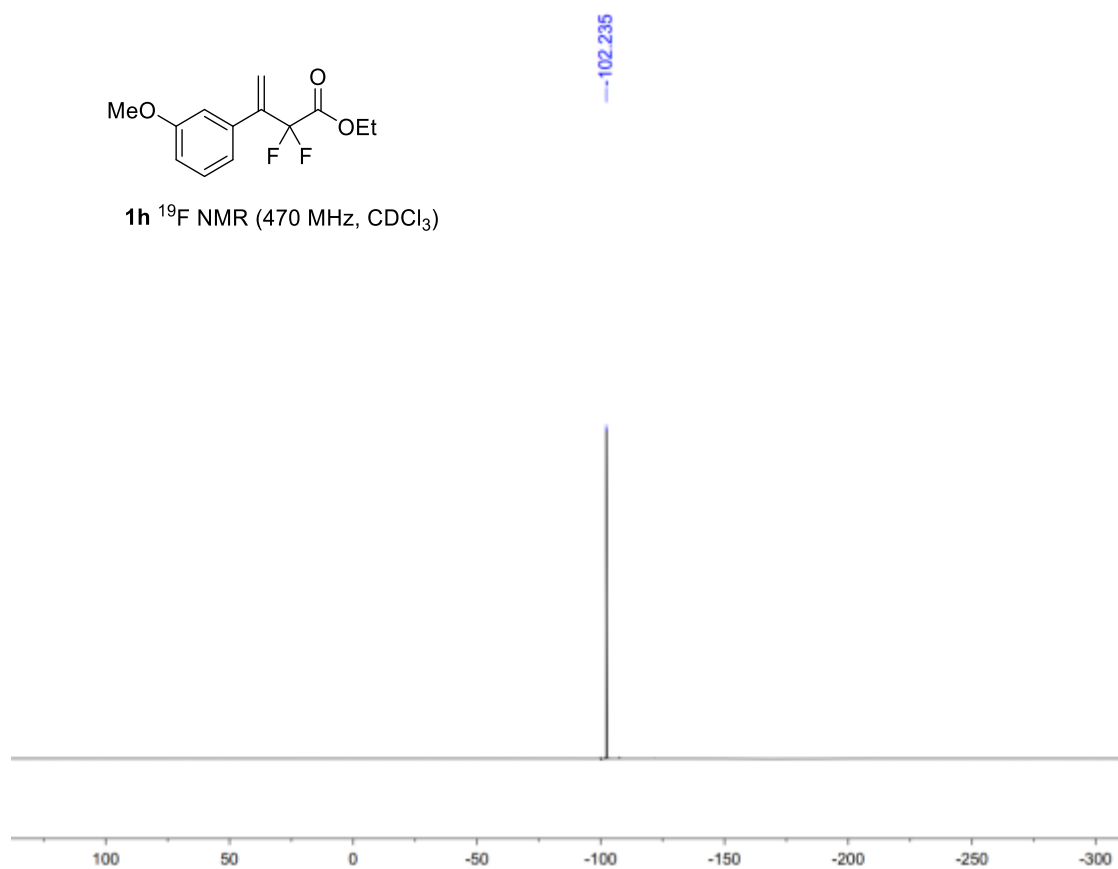
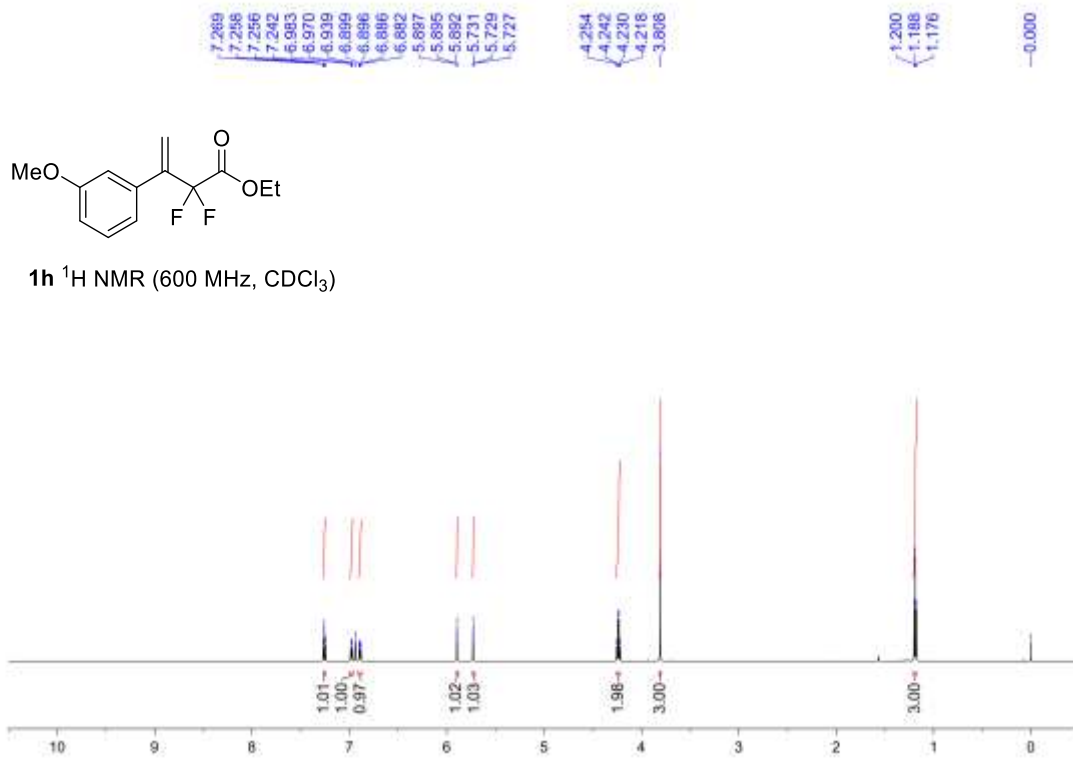


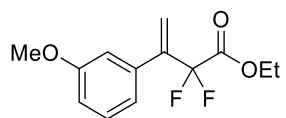
1g ¹³C NMR (125 MHz, CDCl₃)



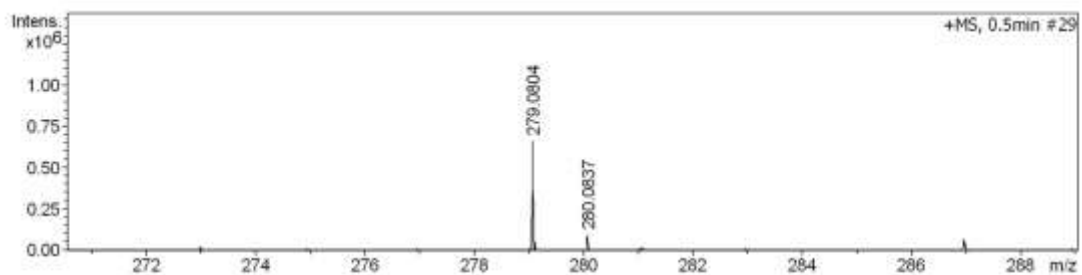
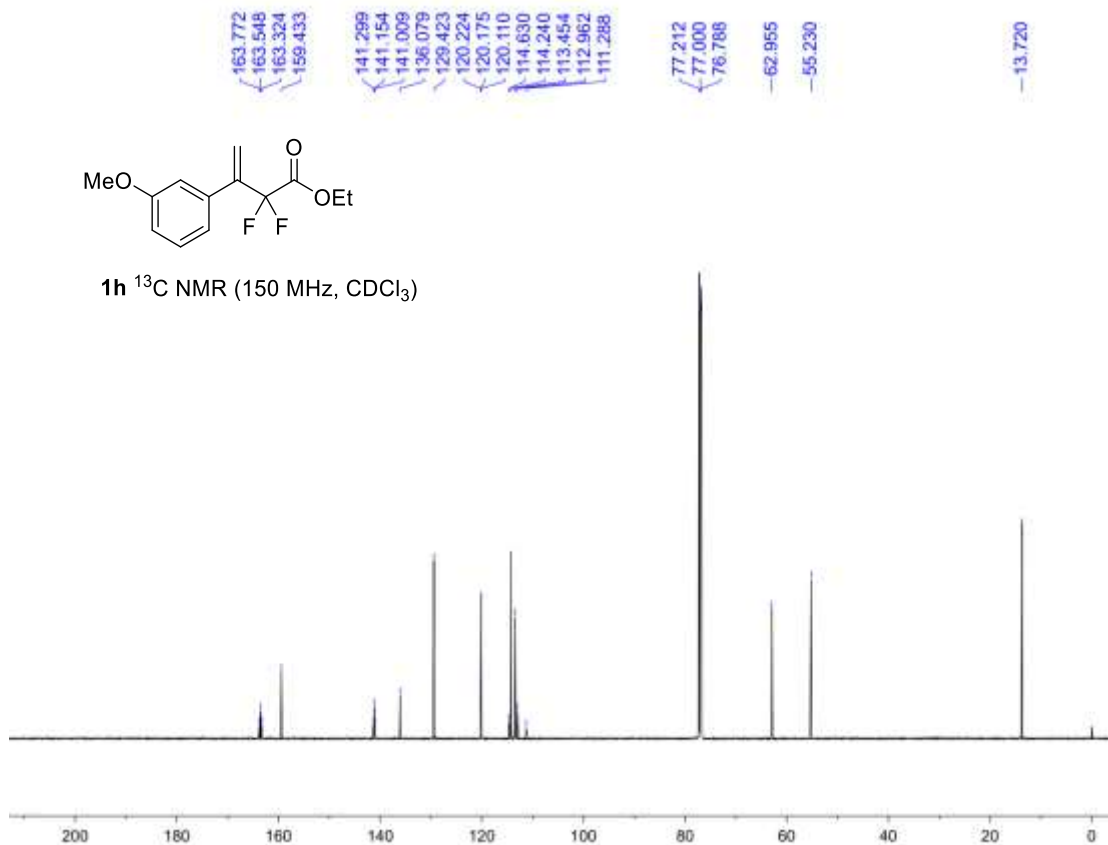
| # | m/z | Res. | S/N | I | I% | FWHM |
|---|----------|-------|------|-------|-------|--------|
| 1 | 263.0855 | 15701 | 65.8 | 32000 | 100.0 | 0.0168 |
| 2 | 264.0889 | 17760 | 7.9 | 3844 | 12.0 | 0.0149 |

| Meas. m/z | # | Ion Formula | m/z | err [ppm] | mSigma | Score | rdB | e ⁻ Conf | N-Rule |
|-----------|---|---|----------|-----------|--------|-------|--------|---------------------|------------|
| 263.0855 | 1 | C ₁₃ H ₁₄ F ₂ NaO ₂ | 263.0854 | -0.3 | 15.3 | 2 | 100.00 | 5.5 | even ok |



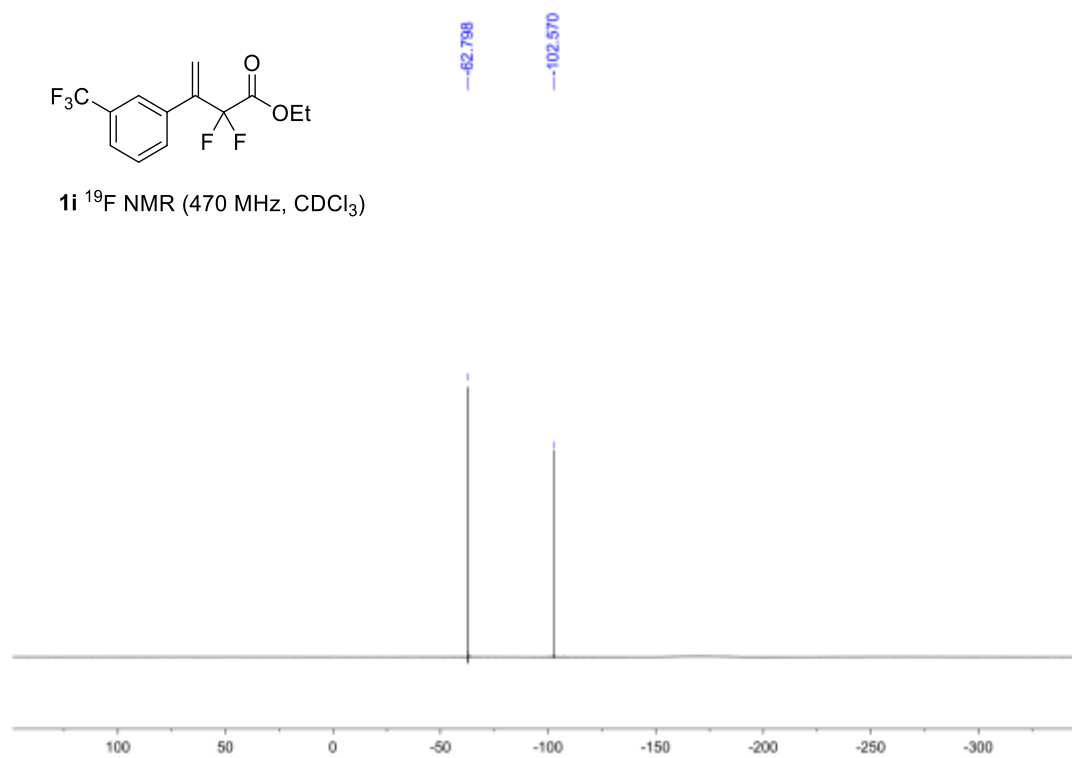
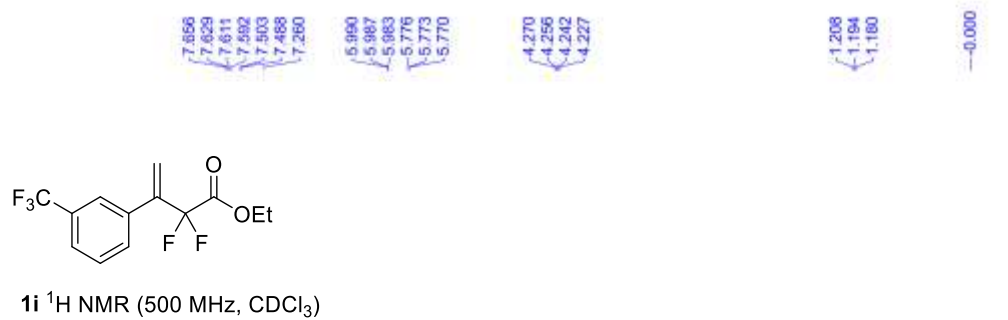


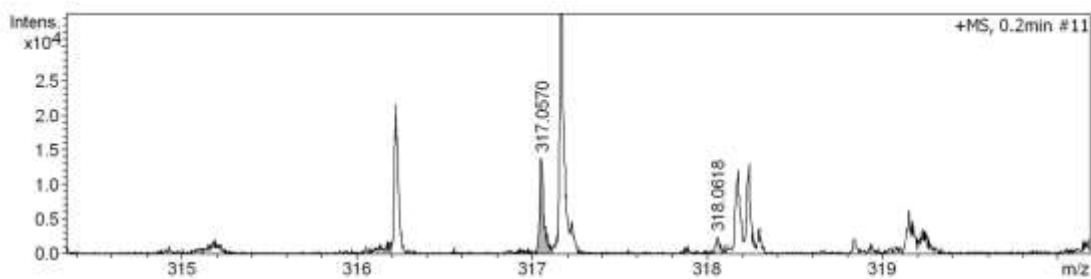
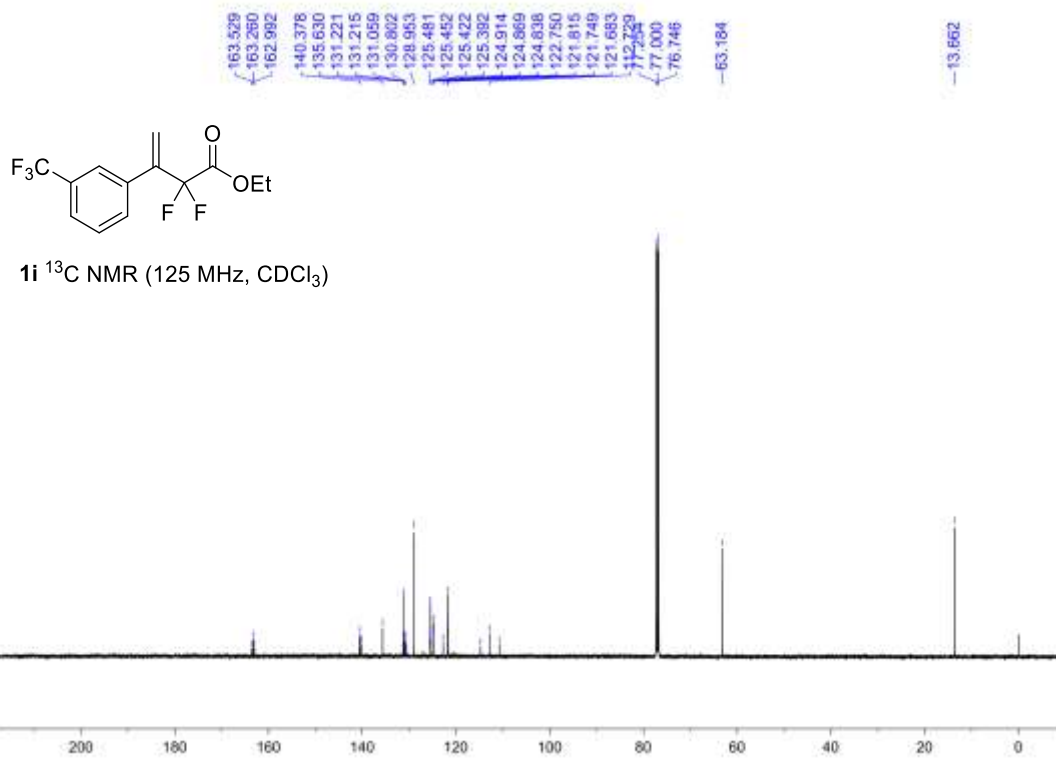
1h ¹³C NMR (150 MHz, CDCl₃)



| # | m/z | Res. | S/N | I | I% | FWHM |
|---|----------|-------|--------|--------|-------|--------|
| 1 | 279.0804 | 17831 | 1380.1 | 658904 | 100.0 | 0.0157 |
| 2 | 280.0837 | 14321 | 187.8 | 89820 | 13.6 | 0.0196 |
| 3 | 281.0852 | 11691 | 25.4 | 12176 | 1.8 | 0.0240 |

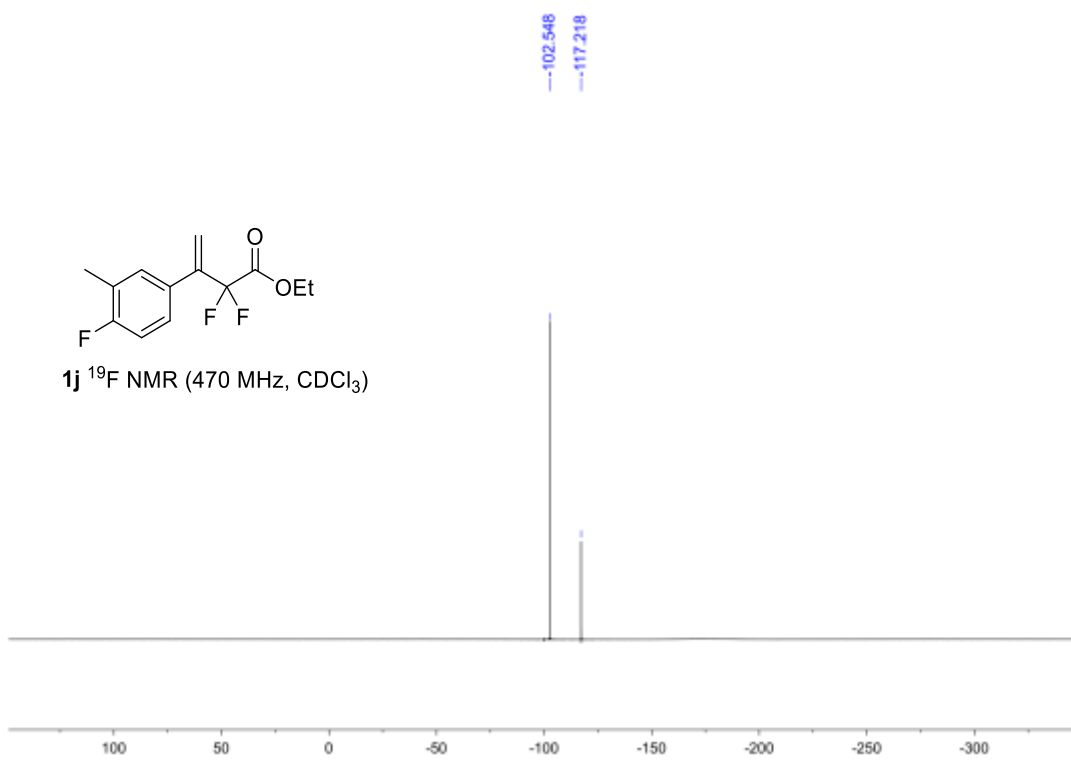
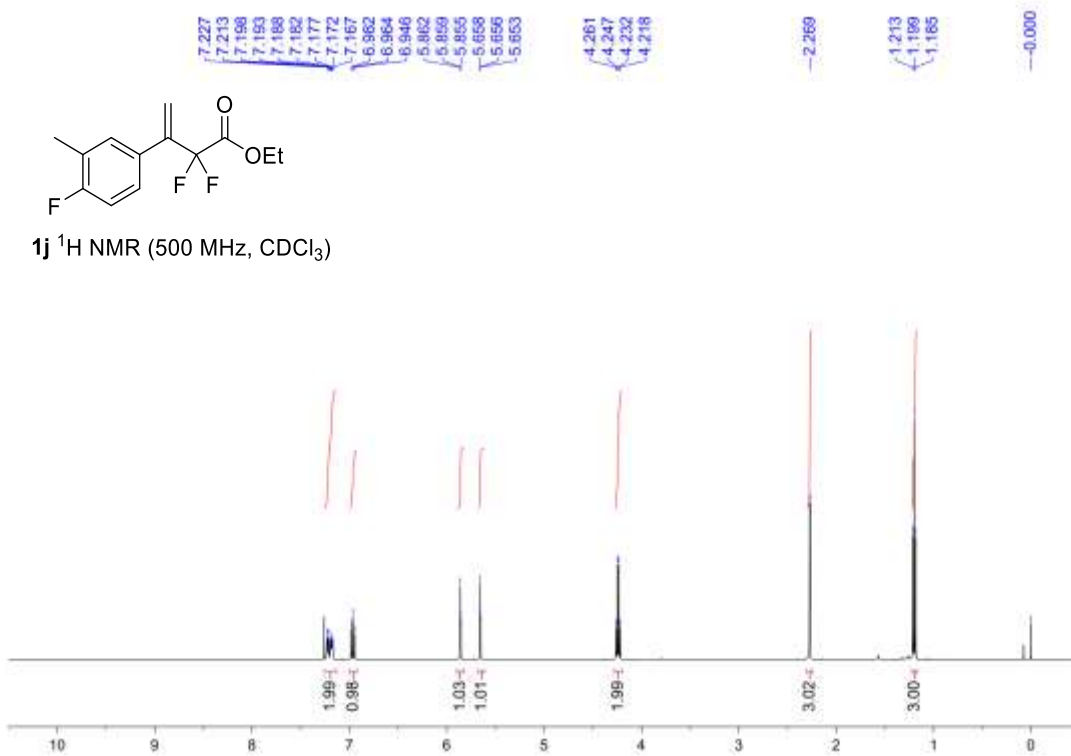
| Meas. m/z | # | Ion Formula | m/z | err [ppm] | mSigma | Score | rdb | e ⁻ Conf | N-Rule |
|-----------|---|---|----------|-----------|--------|-------|--------|---------------------|------------|
| 279.0804 | 1 | C ₁₃ H ₁₄ F ₂ NaO ₃ | 279.0803 | -0.3 | 4.4 | 1 | 100.00 | 5.5 | even ok |

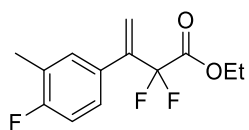




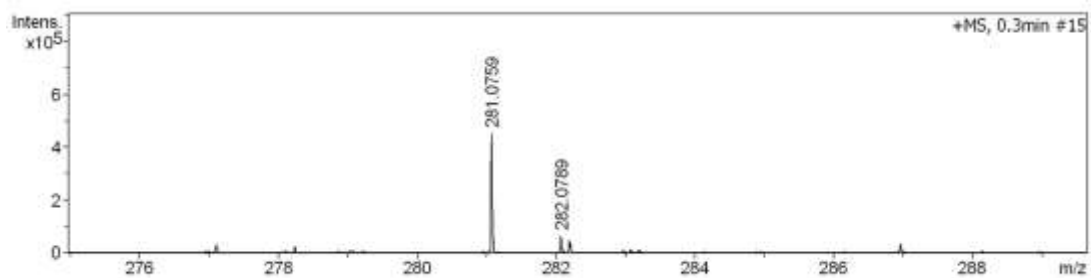
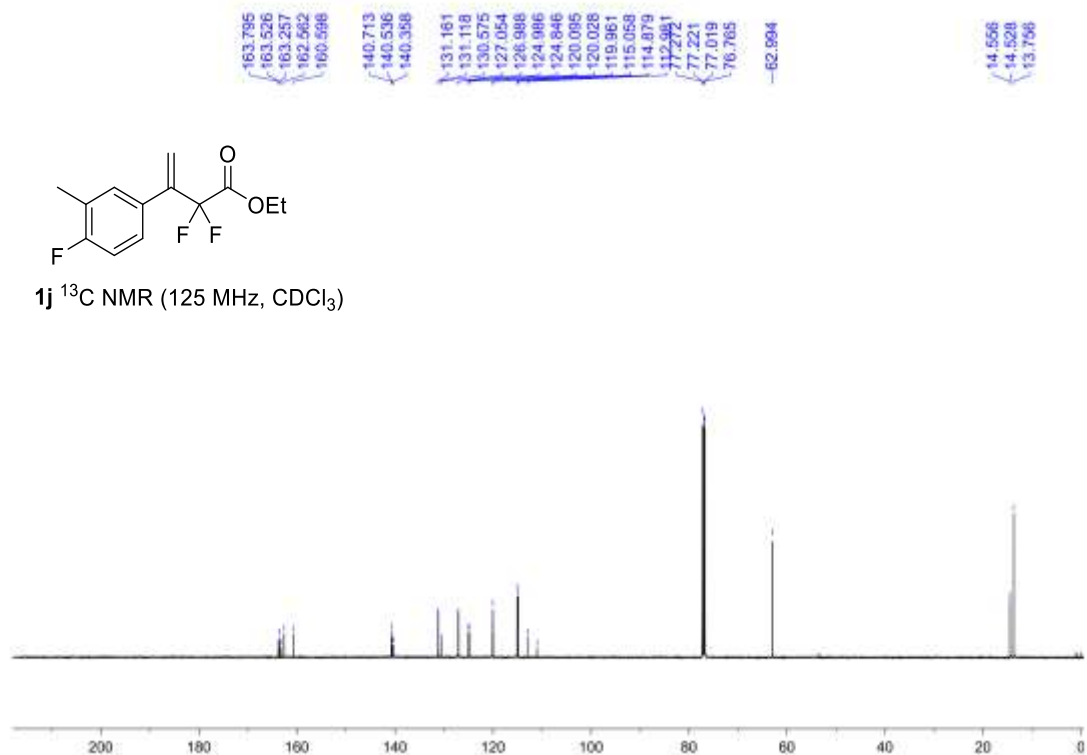
| # | m/z | Res. | S/N | I | I% | FWHM |
|---|----------|-------|------|-------|-------|--------|
| 1 | 317.0570 | 15102 | 25.6 | 13912 | 100.0 | 0.0210 |
| 2 | 318.0618 | 15536 | 4.6 | 2508 | 18.0 | 0.0205 |

| Meas. m/z | # | Ion Formula | m/z | err [ppm] | mSigma | Score | rdb | e ⁻ Conf | N-Rule |
|-----------|---|--|----------|-----------|--------|-------|-------|---------------------|------------|
| 317.0570 | 1 | $\text{C}_{13}\text{H}_{11}\text{F}_5\text{NaO}_2$ | 317.0571 | 0.5 | 23.1 | 4 | 96.23 | 5.5 | even ok |



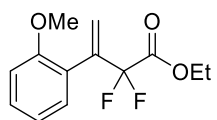


1j ^{13}C NMR (125 MHz, CDCl_3)

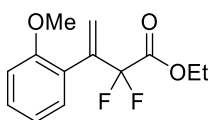
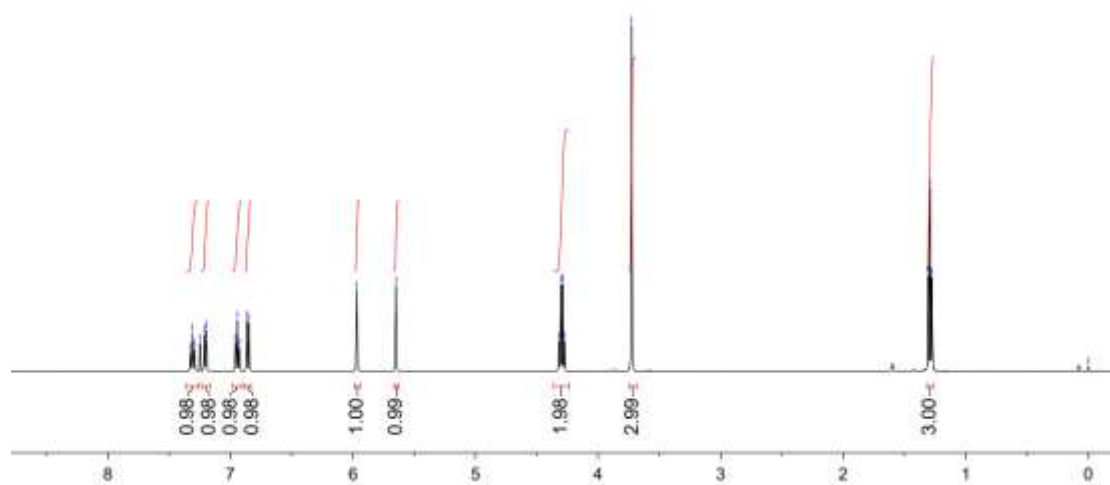


| # | m/z | Res. | S/N | I | I% | FWHM |
|---|----------|-------|-------|--------|-------|--------|
| 1 | 281.0759 | 16475 | 855.9 | 452472 | 100.0 | 0.0171 |
| 2 | 282.0789 | 13791 | 121.6 | 64596 | 14.3 | 0.0205 |
| 3 | 283.0820 | 11657 | 15.9 | 8456 | 1.9 | 0.0243 |

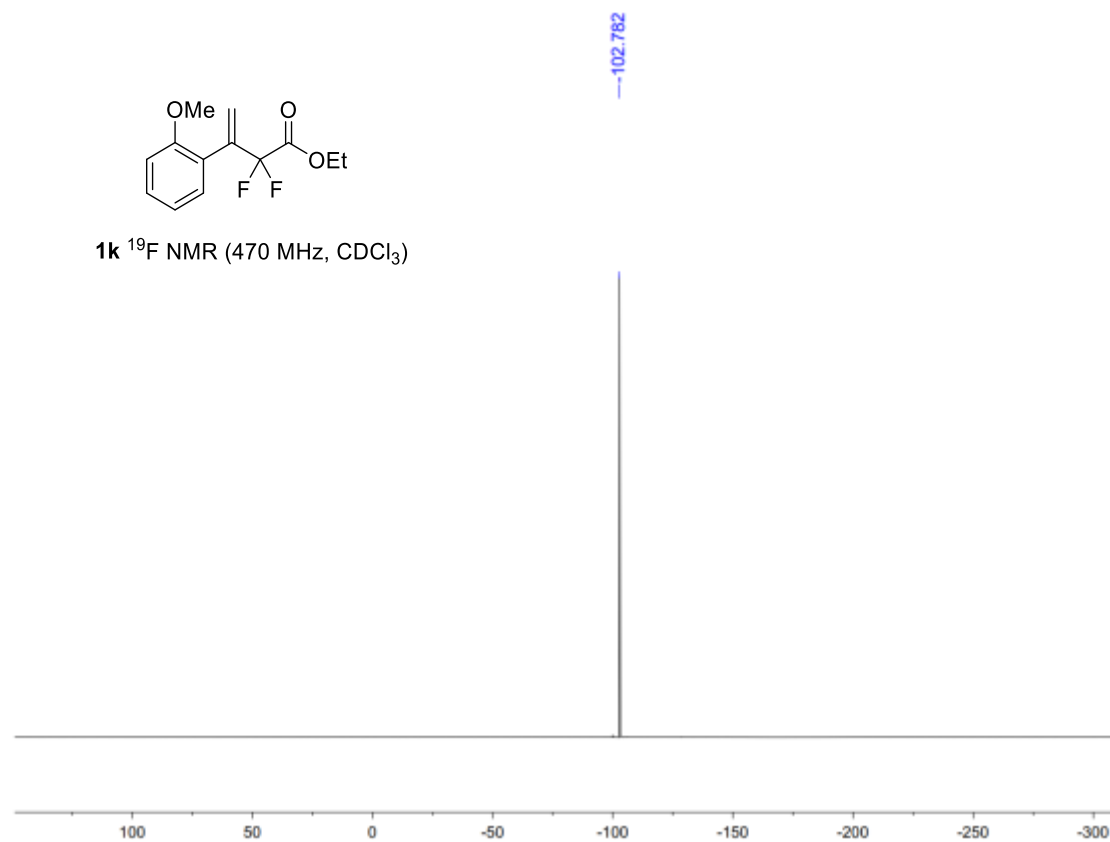
| Meas. m/z | # | Ion Formula | m/z | err [ppm] | mSigma | Score | rdb | e ⁻ Conf | N-Rule |
|-----------|---|--|----------|-----------|--------|-------|--------|---------------------|------------|
| 281.0759 | 1 | $\text{C}_{13}\text{H}_{13}\text{F}_3\text{NaO}_2$ | 281.0760 | 0.2 | 3.0 | 1 | 100.00 | 5.5 | even ok |



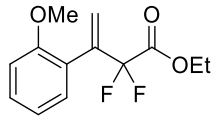
1k ^1H NMR (500 MHz, CDCl_3)



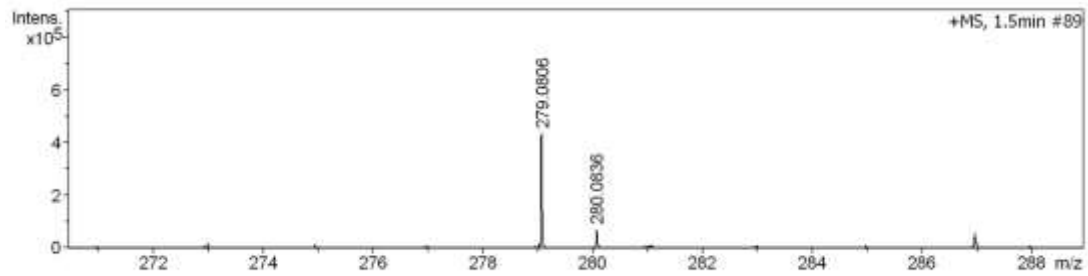
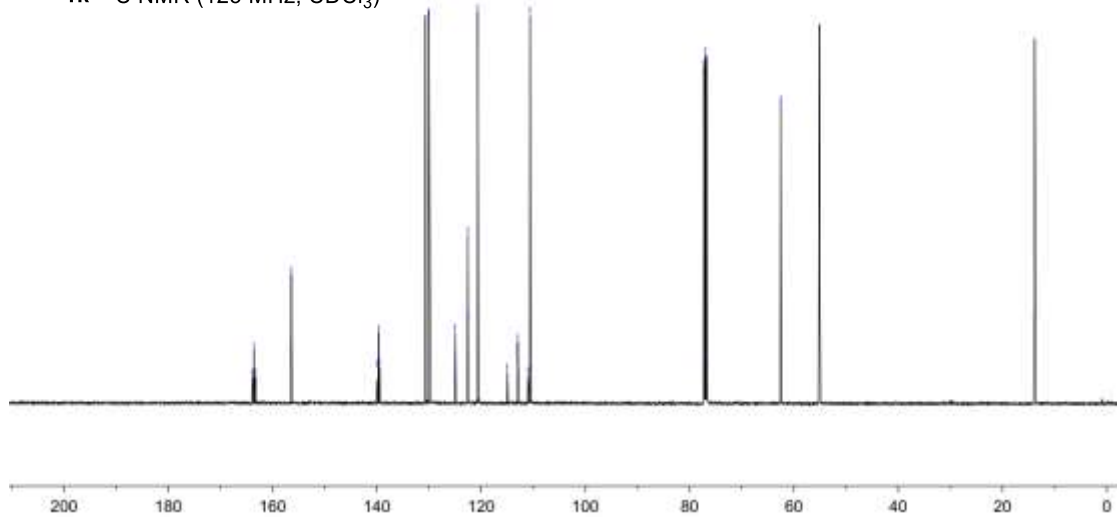
1k ^{19}F NMR (470 MHz, CDCl_3)



163.865
163.567
163.309
156.422
139.913
139.714
139.516
130.709
129.994
124.980
124.963
124.945
122.641
122.577
120.678
114.988
113.001
111.005
110.644
77.254
77.202
77.000
76.746
62.588
55.087
-13.856

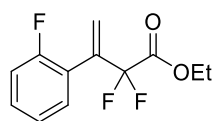


1k ^{13}C NMR (125 MHz, CDCl_3)

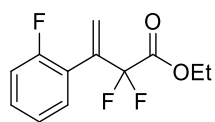
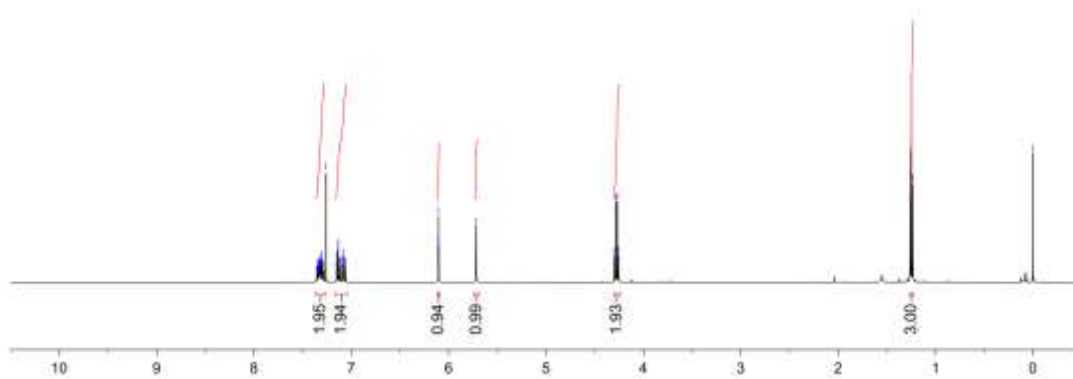


| # | m/z | Res. | S/N | I | I % | FWHM |
|---|----------|-------|-------|--------|-------|--------|
| 1 | 279.0806 | 16724 | 909.9 | 431260 | 100.0 | 0.0167 |
| 2 | 280.0836 | 14787 | 145.0 | 68816 | 16.0 | 0.0189 |
| 3 | 281.0869 | 11596 | 17.7 | 8424 | 2.0 | 0.0242 |

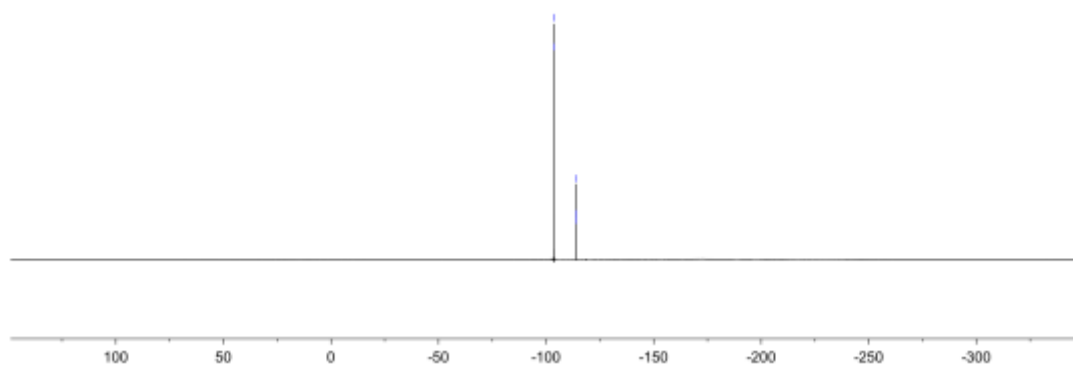
| Meas. m/z | # | Ion Formula | m/z | err [ppm] | mSigma | Score | rdb | e ⁻ Conf | N-Rule |
|-----------|---|--|----------|-----------|--------|-------|--------|---------------------|------------|
| 279.0806 | 1 | $\text{C}_{13}\text{H}_{14}\text{F}_2\text{NaO}_3$ | 279.0803 | -0.9 | 9.6 | 2 | 100.00 | 5.5 | even ok |



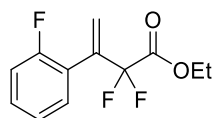
11 ¹H NMR (500 MHz, CDCl₃)



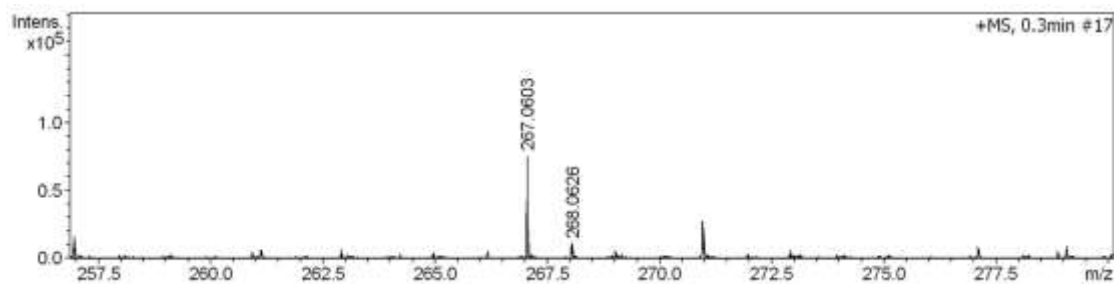
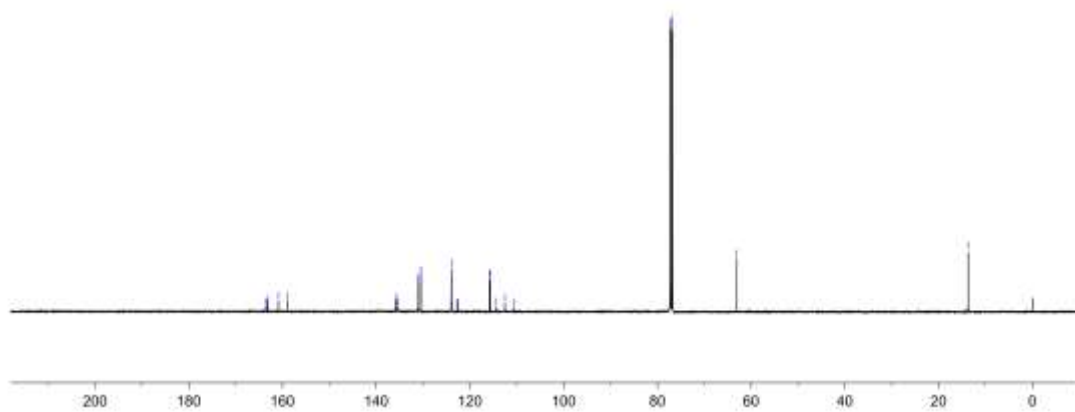
11 ¹⁹F NMR (470 MHz, CDCl₃)



163.575
163.303
163.032
160.841
158.867
135.646
135.651
135.457
131.017
130.986
130.508
130.443
124.024
124.004
123.950
123.921
123.896
123.878
115.801
115.623
114.541
112.534
77.000
76.745
-63.061
-13.710

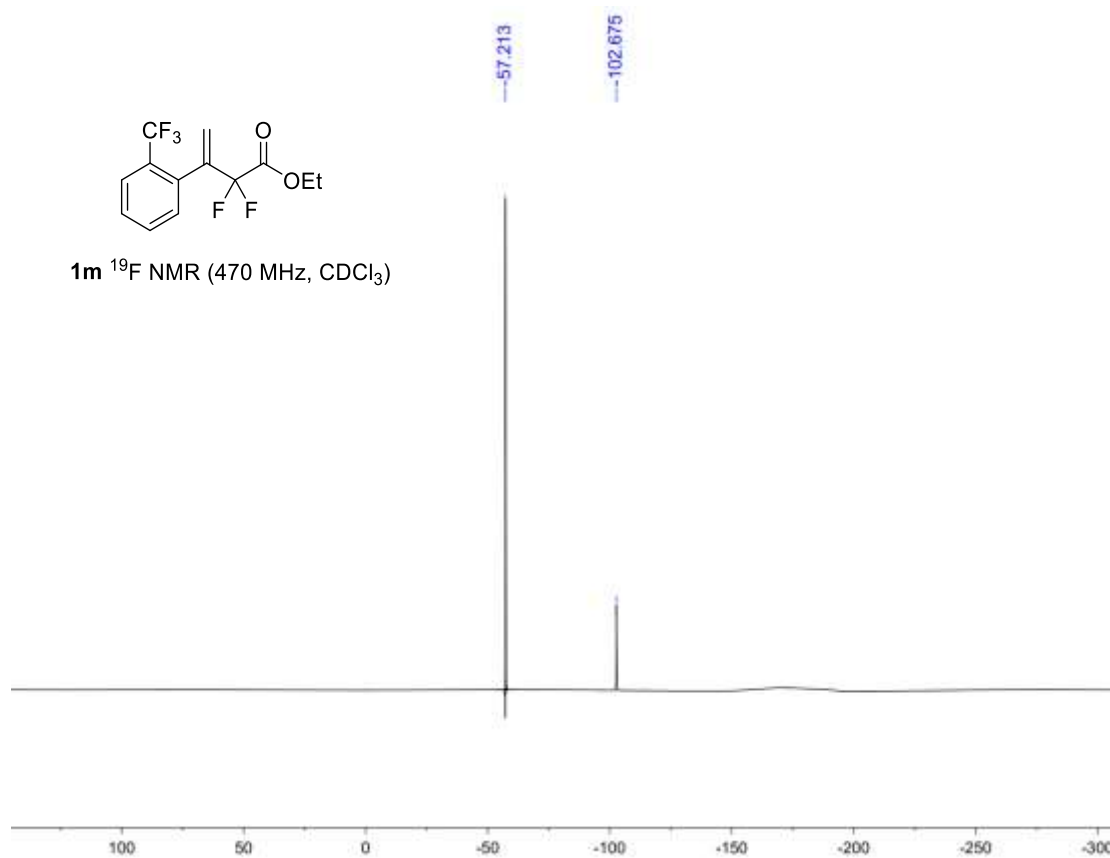
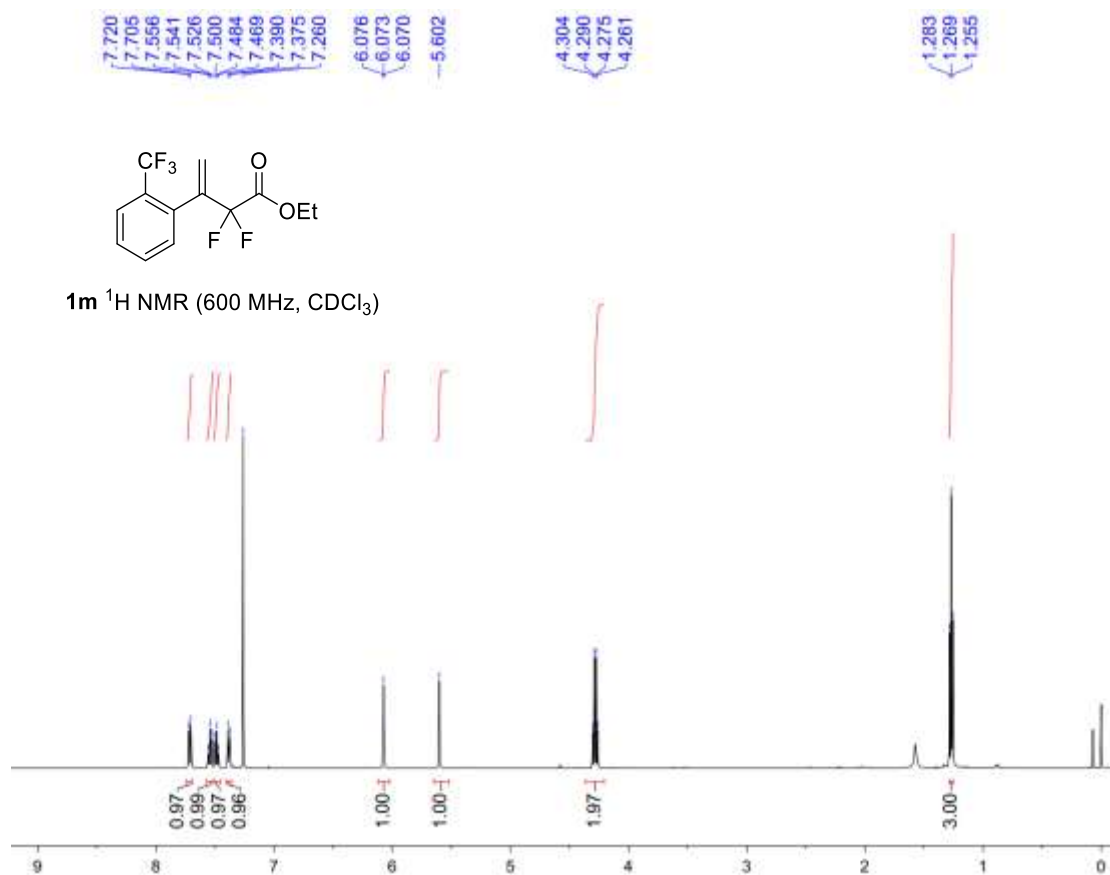


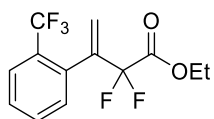
11 ^{13}C NMR (125 MHz, CDCl_3)



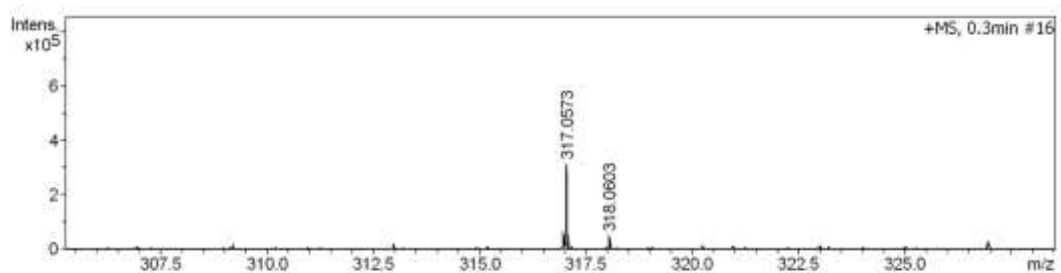
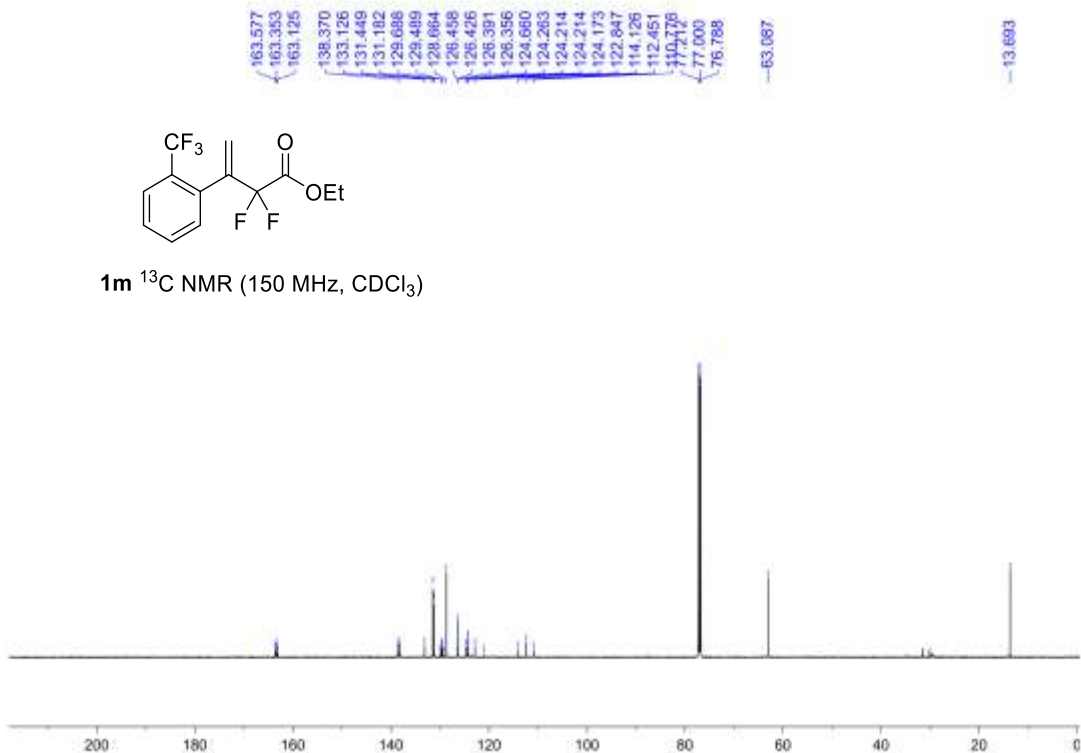
| # | m/z | Res. | S/N | I | I % | FWHM |
|---|----------|-------|-------|-------|-------|--------|
| 1 | 267.0603 | 13477 | 151.6 | 75312 | 100.0 | 0.0198 |
| 2 | 268.0626 | 12885 | 20.7 | 10316 | 13.7 | 0.0208 |

| Meas. m/z | # | Ion Formula | m/z | err [ppm] | mSigma | Score | rdb | e ⁻ Conf | N-Rule |
|-----------|---|--|----------|-----------|--------|-------|--------|---------------------|------------|
| 267.0603 | 1 | $\text{C}_{12}\text{H}_{11}\text{F}_3\text{NaO}_2$ | 267.0603 | 0.1 | 7.6 | 1 | 100.00 | 5.5 | even ok |





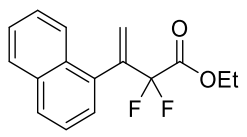
1m ^{13}C NMR (150 MHz, CDCl_3)



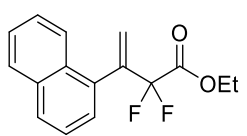
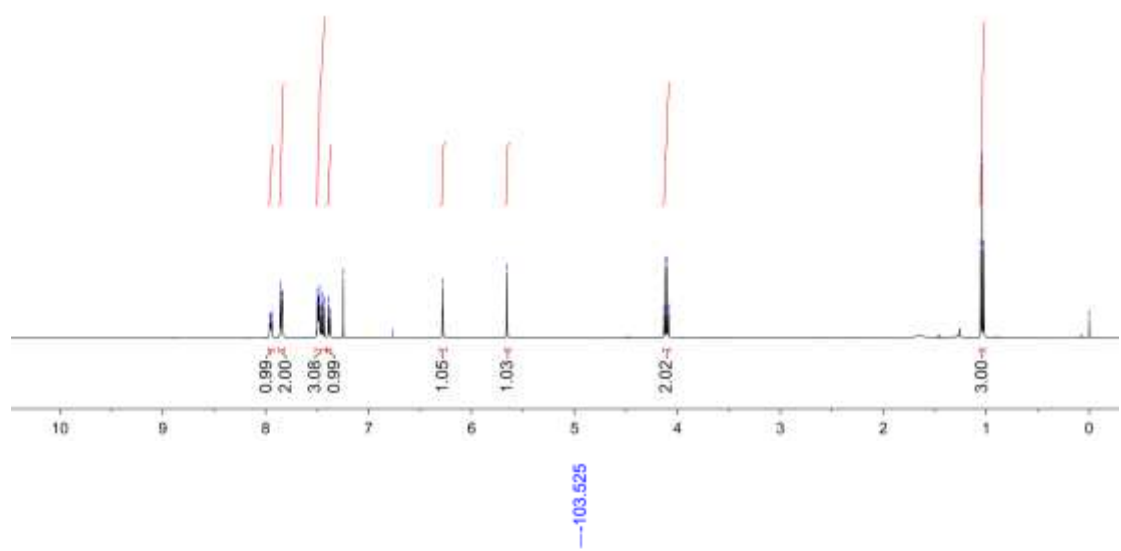
| # | m/z | Res. | S/N | I | I% | FWHM |
|---|----------|-------|-------|--------|-------|--------|
| 1 | 317.0573 | 15228 | 561.4 | 310620 | 100.0 | 0.0208 |
| 2 | 318.0603 | 13543 | 82.5 | 45744 | 14.7 | 0.0235 |

| Meas. m/z | # | Ion Formula | m/z | err [ppm] | mSigma | Score | rdb | e ⁻ Conf | N-Rule |
|-----------|---|--------------|----------|-----------|--------|--------|-----|---------------------|--------|
| 317.0573 | 1 | C13H11F5NaO2 | 317.0571 | -0.6 | 2.8 | 100.00 | 5.5 | even | ok |

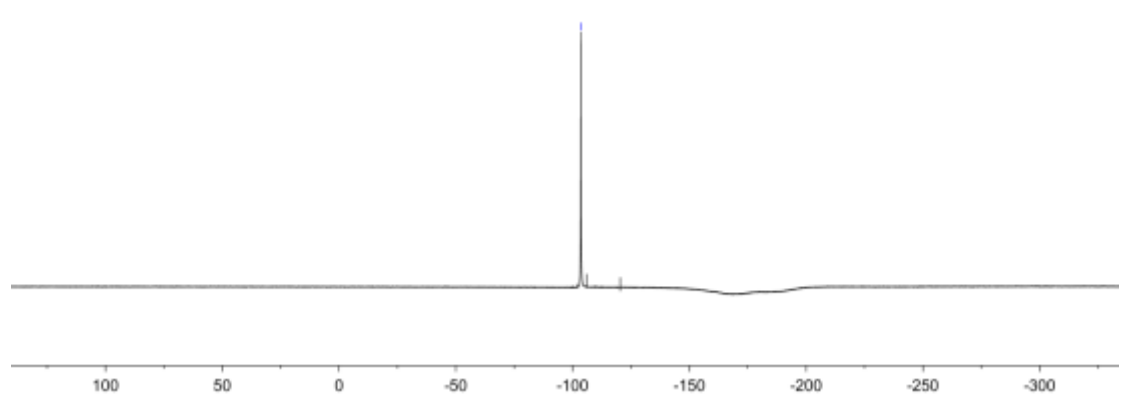
7.959
7.951
7.940
7.857
7.846
7.843
7.830
7.496
7.493
7.488
7.486
7.482
7.477
7.462
7.447
7.431
7.390
7.376
7.286
-6.280
-5.657
-4.129
-4.114
-4.100
-4.086
-1.053
-1.038
-1.024
-0.000

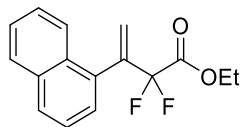


1n ¹HNMR (500 MHz, CDCl₃)

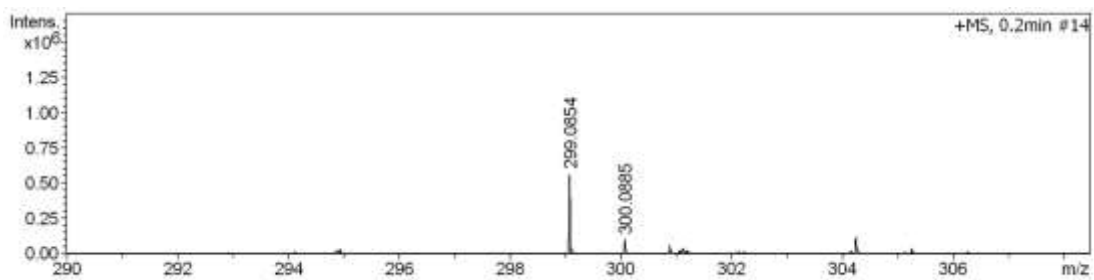
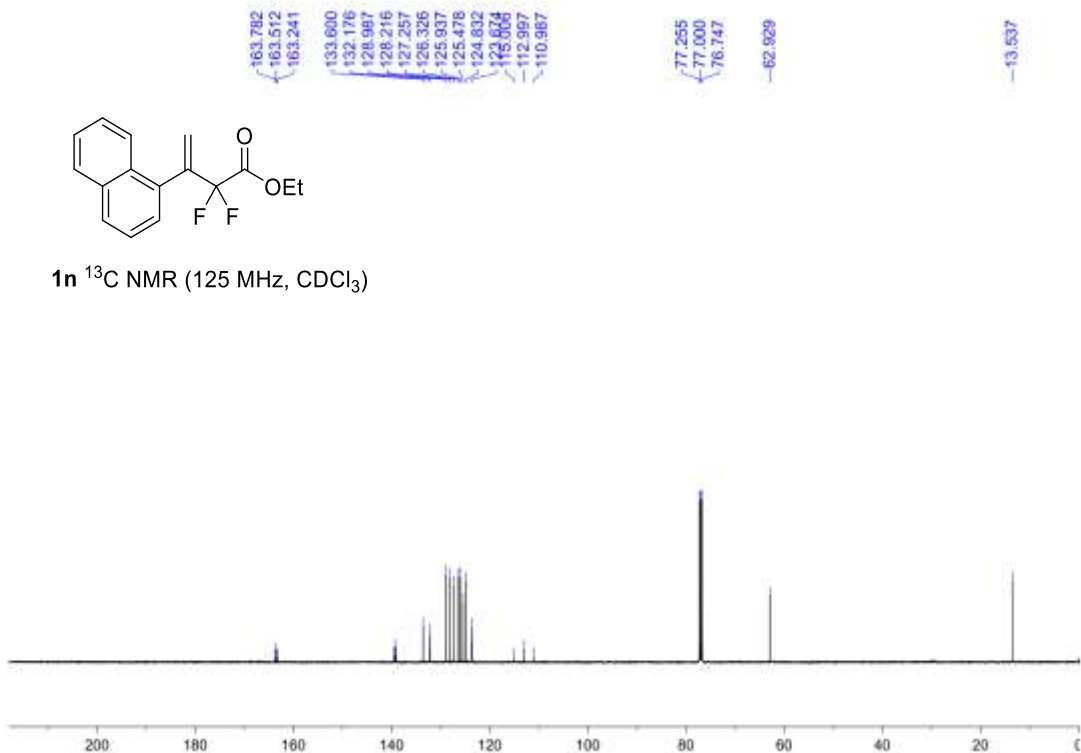


1n ¹⁹FNMR (470 MHz, CDCl₃)





1n ^{13}C NMR (125 MHz, CDCl_3)

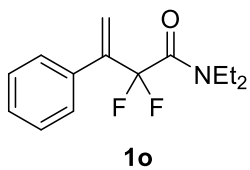
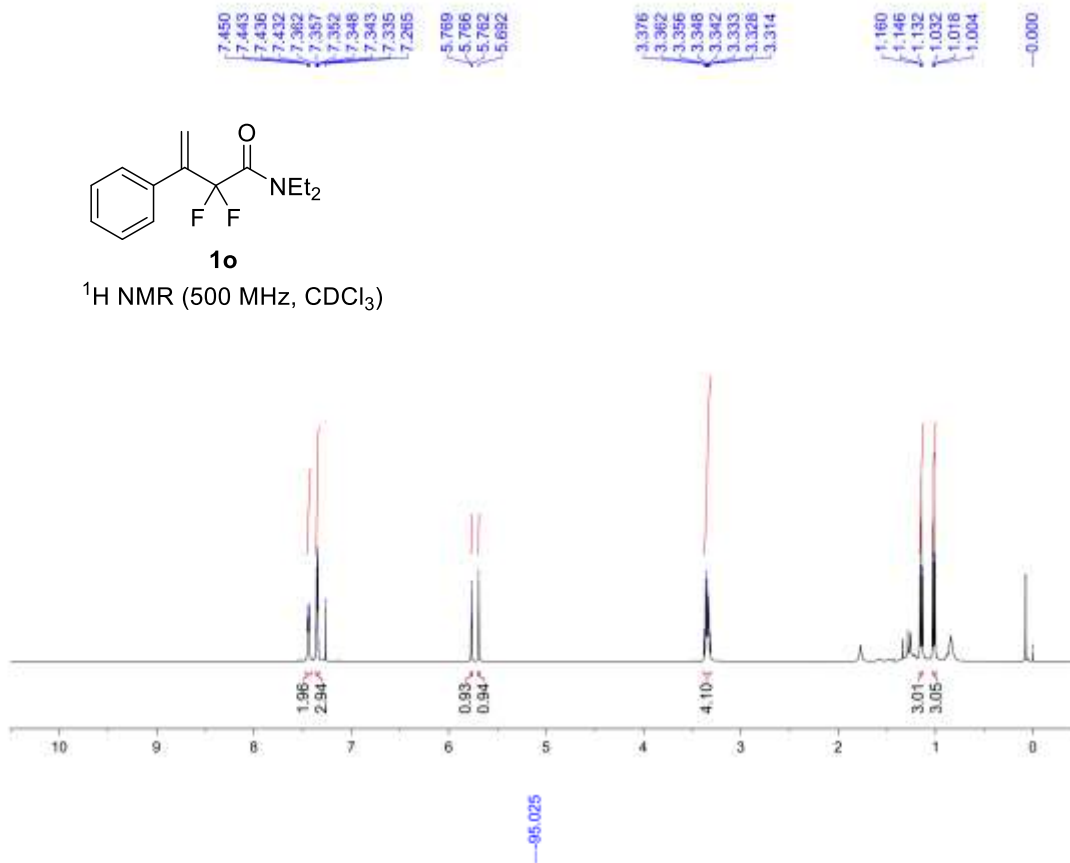


| # | m/z | Res. | S/N | I | I % | FWHM |
|---|----------|-------|--------|--------|-------|--------|
| 1 | 299.0854 | 17724 | 1116.1 | 563620 | 100.0 | 0.0169 |
| 2 | 300.0885 | 13963 | 190.5 | 96292 | 17.1 | 0.0215 |
| 3 | 301.0819 | 9432 | 28.4 | 14328 | 2.5 | 0.0319 |

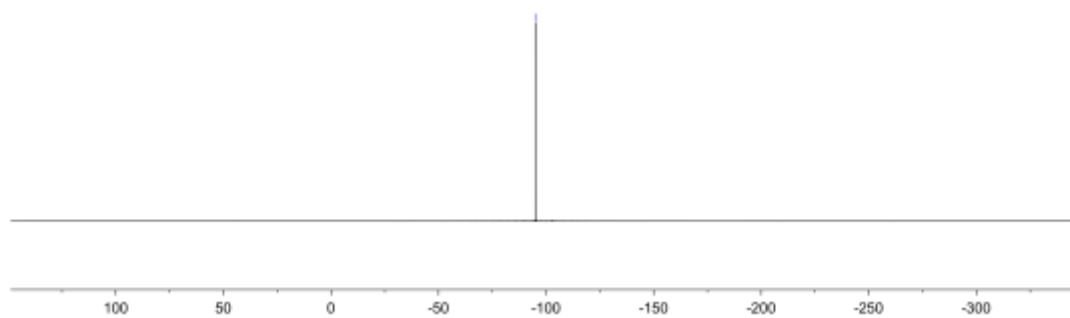
| Meas. m/z | # | Ion Formula | m/z | err [ppm] | mSigma | Score | rdb | e ⁻ Conf | N-Rule |
|-----------|---|--|----------|-----------|--------|-------|--------|---------------------|------------|
| 299.0854 | 1 | $\text{C}_{16}\text{H}_{14}\text{F}_2\text{NaO}_2$ | 299.0854 | -0.0 | 4.8 | 1 | 100.00 | 8.5 | even ok |

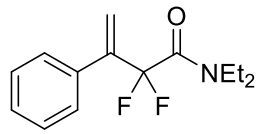


^1H NMR (500 MHz, CDCl_3)

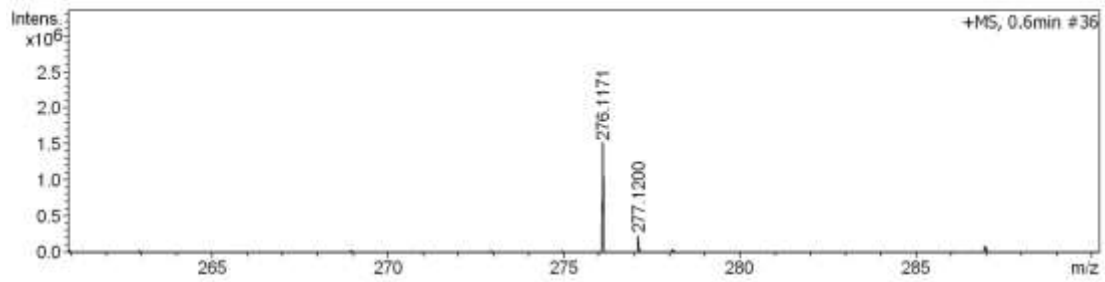
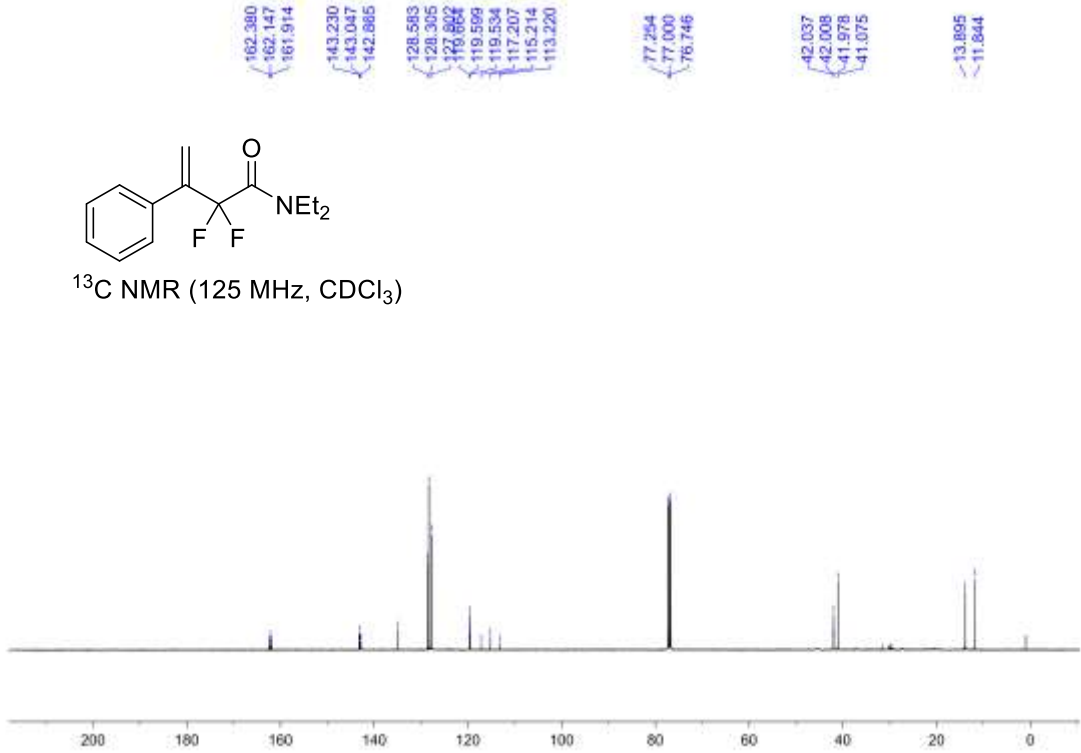


^{19}F NMR (470 MHz, CDCl_3)





^{13}C NMR (125 MHz, CDCl_3)



| # | m/z | Res. | S/N | I | I% | FWHM |
|---|----------|-------|--------|---------|-------|--------|
| 1 | 276.1171 | 17645 | 2113.3 | 1465144 | 100.0 | 0.0156 |
| 2 | 277.1200 | 10271 | 274.9 | 190820 | 13.0 | 0.0270 |
| 3 | 278.1222 | 10282 | 40.8 | 28392 | 1.9 | 0.0271 |

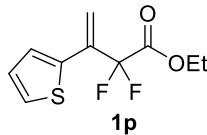
| Meas. m/z | # | Ion Formula | m/z | err [ppm] | mSigma | Score | rdb | e ⁻ Conf | N-Rule |
|-----------|---|---|----------|-----------|--------|-------|--------|---------------------|------------|
| 276.1171 | 1 | $\text{C}_{14}\text{H}_{17}\text{F}_2\text{NNaO}$ | 276.1170 | -0.2 | 16.0 | 2 | 100.00 | 5.5 | even ok |

7.254
7.252
7.244
7.173
7.170
7.166
7.165
7.163
6.991
6.984
6.981
6.974
5.823
5.820
5.816
5.768

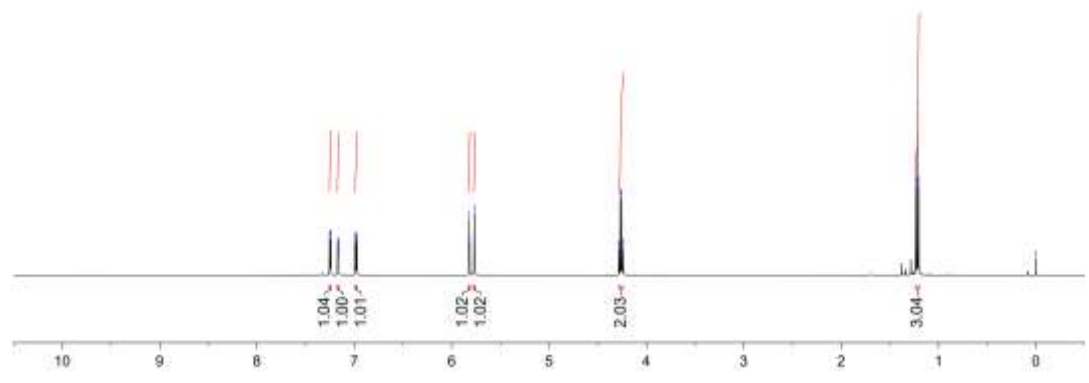
4.283
4.289
4.285
4.241

1.233
1.219
1.204

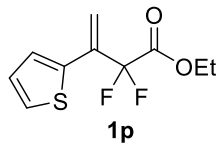
-0.000



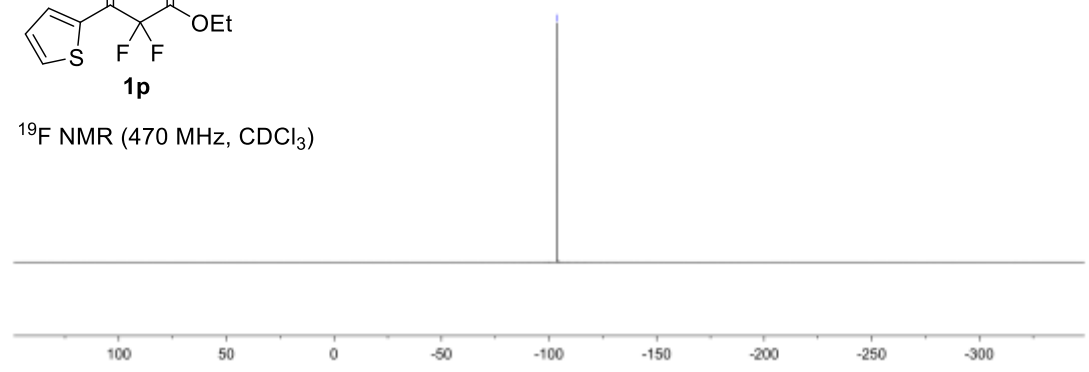
¹H NMR (500 MHz, CDCl₃)

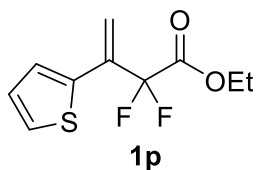


-103.907

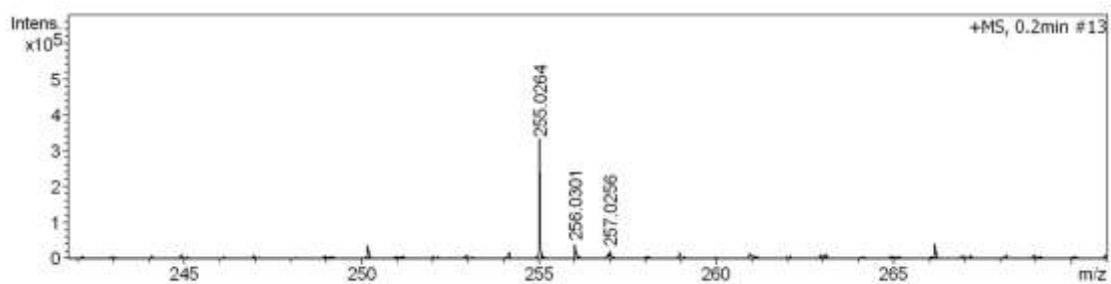
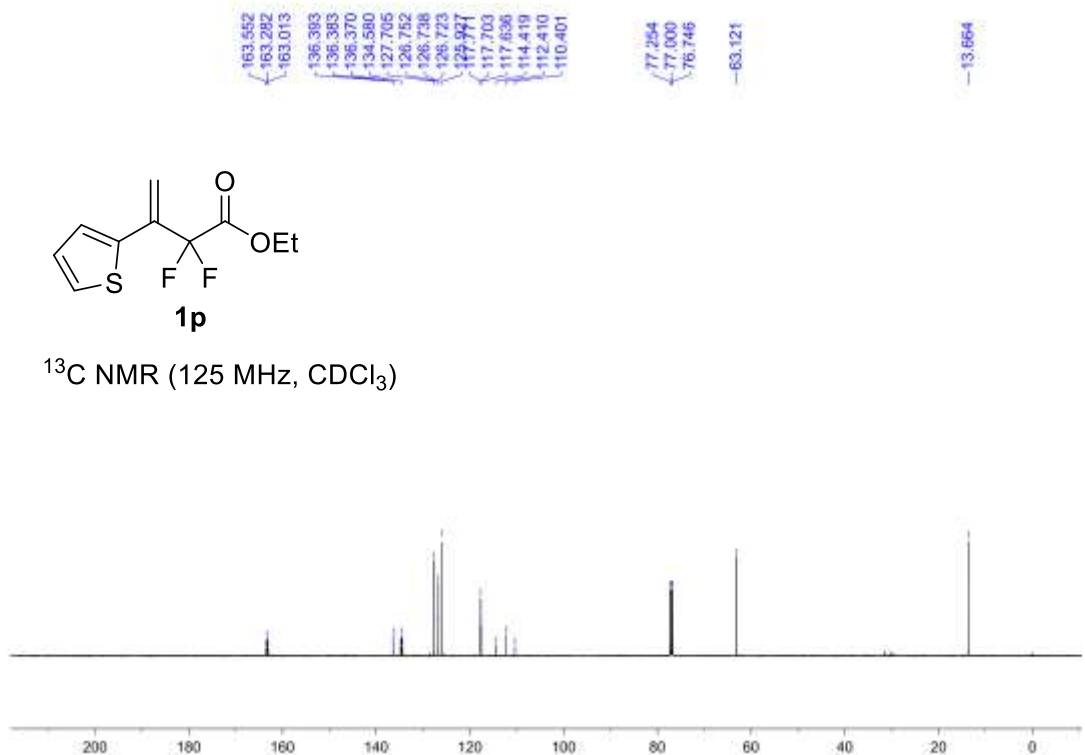


¹⁹F NMR (470 MHz, CDCl₃)



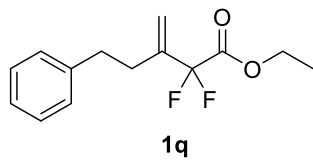


^{13}C NMR (125 MHz, CDCl_3)

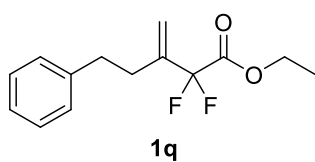
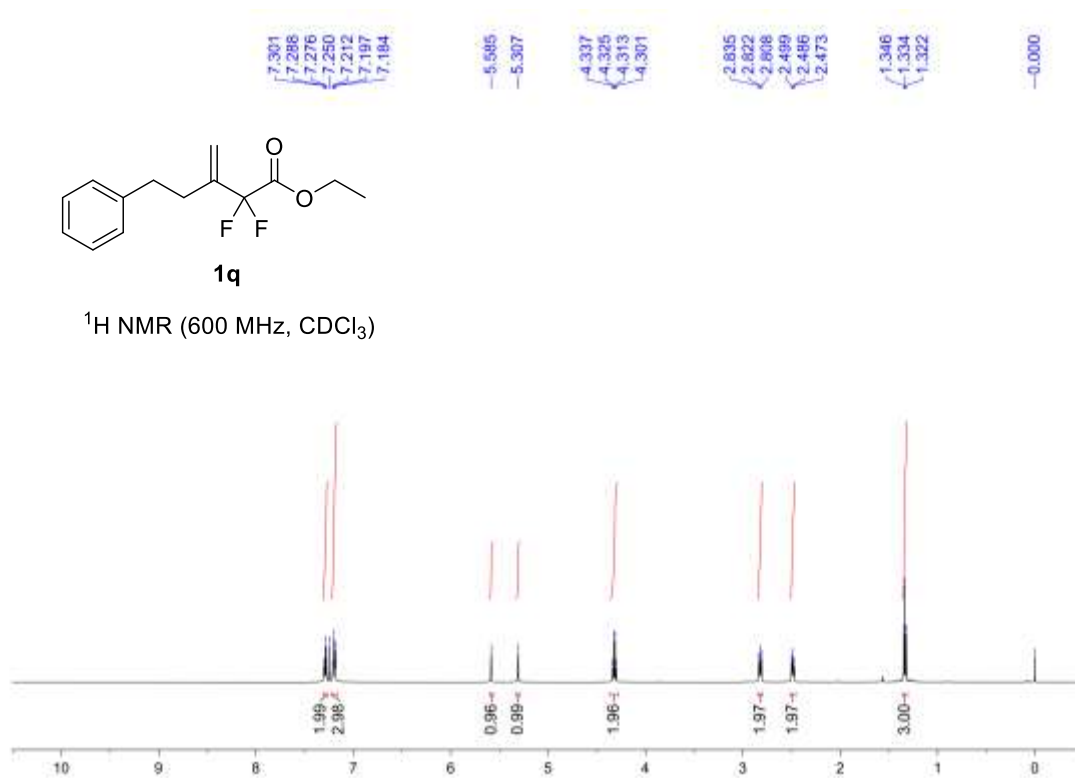


| # | m/z | Res. | S/N | I | I% | FWHM |
|---|----------|-------|-------|--------|-------|--------|
| 1 | 255.0264 | 14947 | 526.6 | 321632 | 100.0 | 0.0171 |
| 2 | 256.0301 | 12767 | 56.4 | 34584 | 10.8 | 0.0201 |
| 3 | 257.0256 | 7725 | 27.8 | 17120 | 5.3 | 0.0333 |

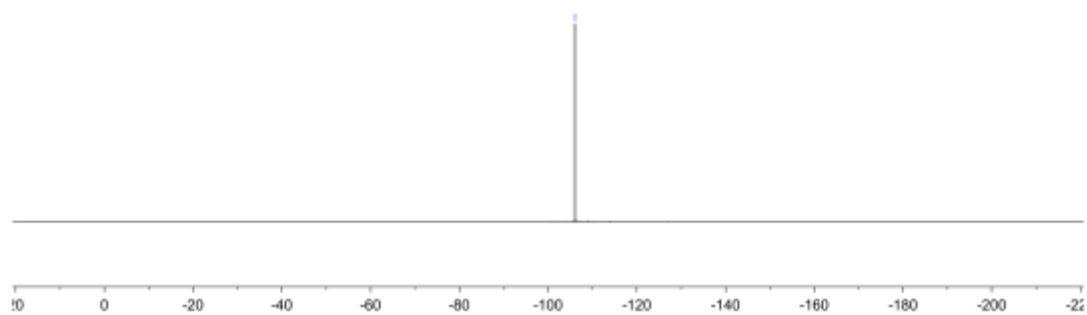
| Meas. m/z | # | Ion Formula | m/z | err [ppm] | mSigma | Score | rdb | e ⁻ Conf | N-Rule |
|-----------|---|---|----------|-----------|--------|--------|-----|---------------------|--------|
| 255.0264 | 1 | C ₁₀ H ₁₀ F ₂ NaO ₂ S | 255.0262 | -0.9 | 5.6 | 100.00 | 4.5 | even | ok |

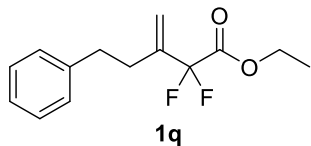


^1H NMR (600 MHz, CDCl_3)

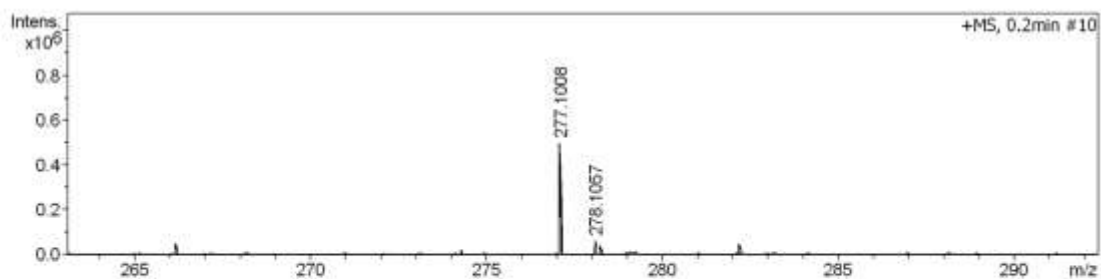
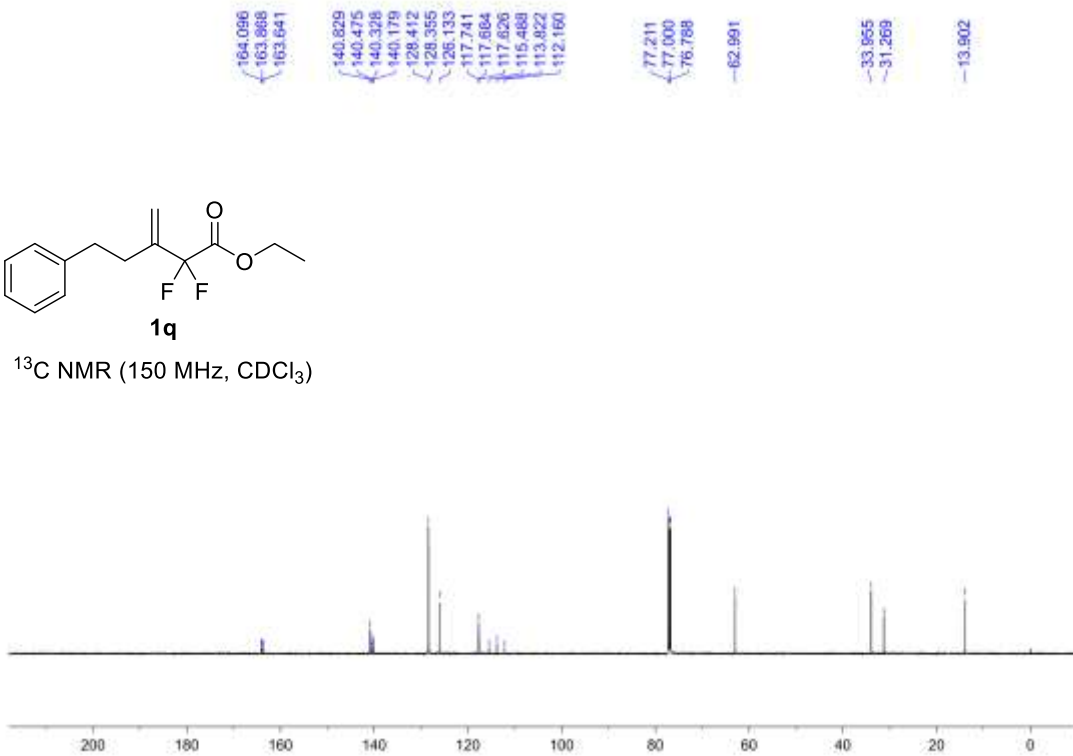


^{19}F NMR (470 MHz, CDCl_3)



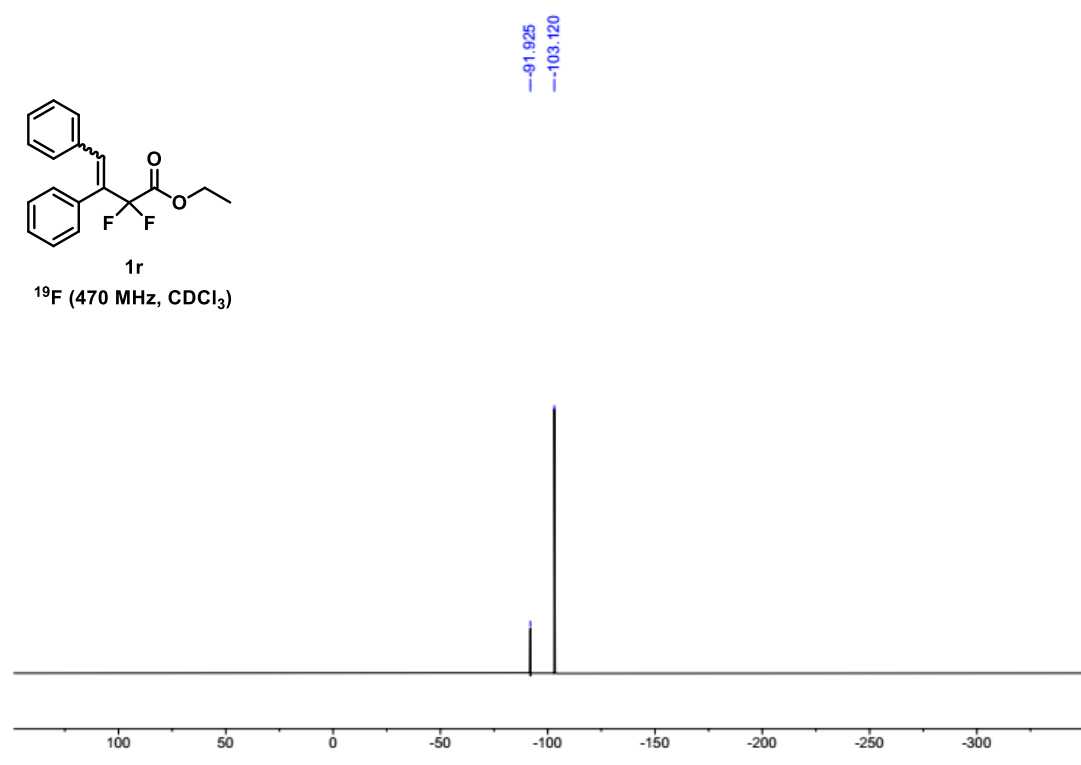
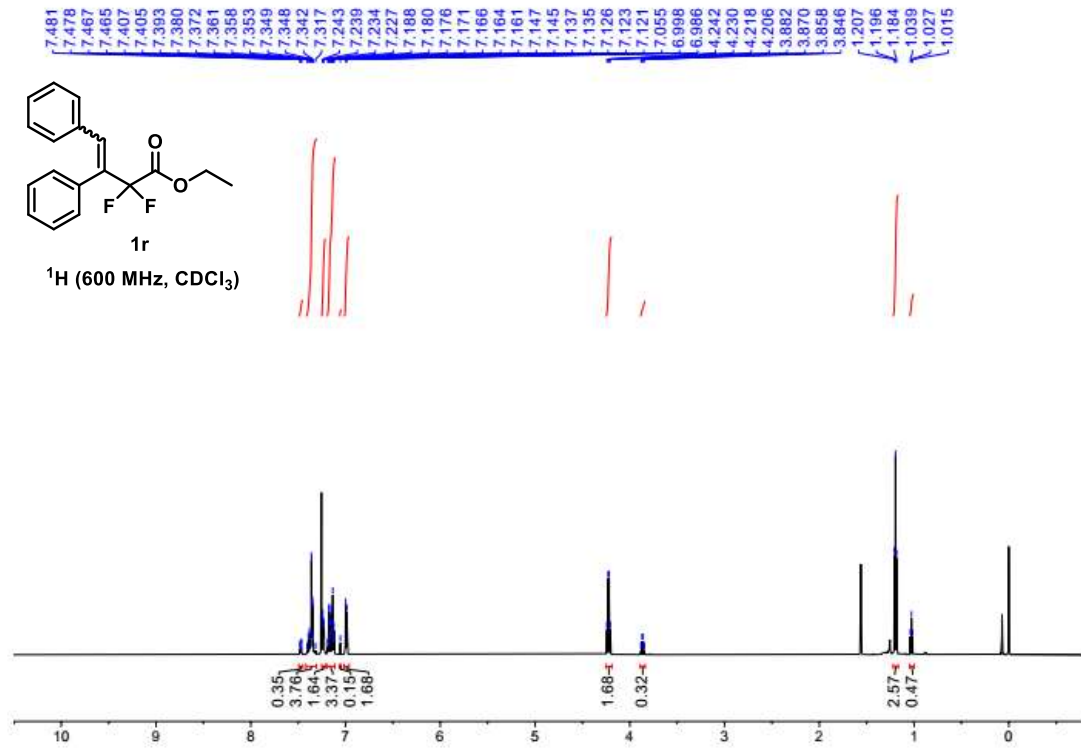


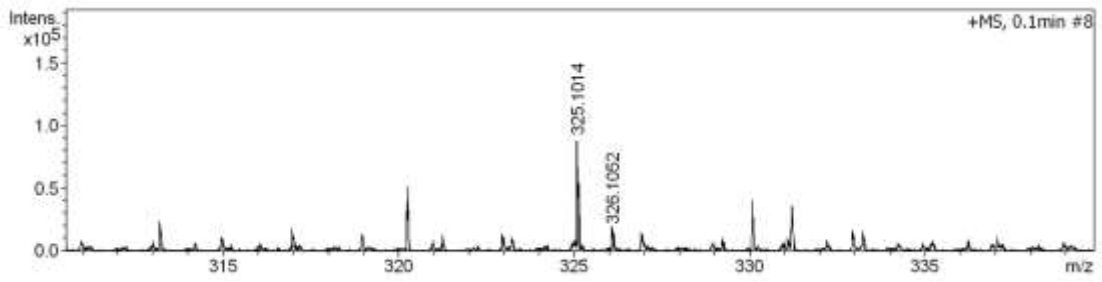
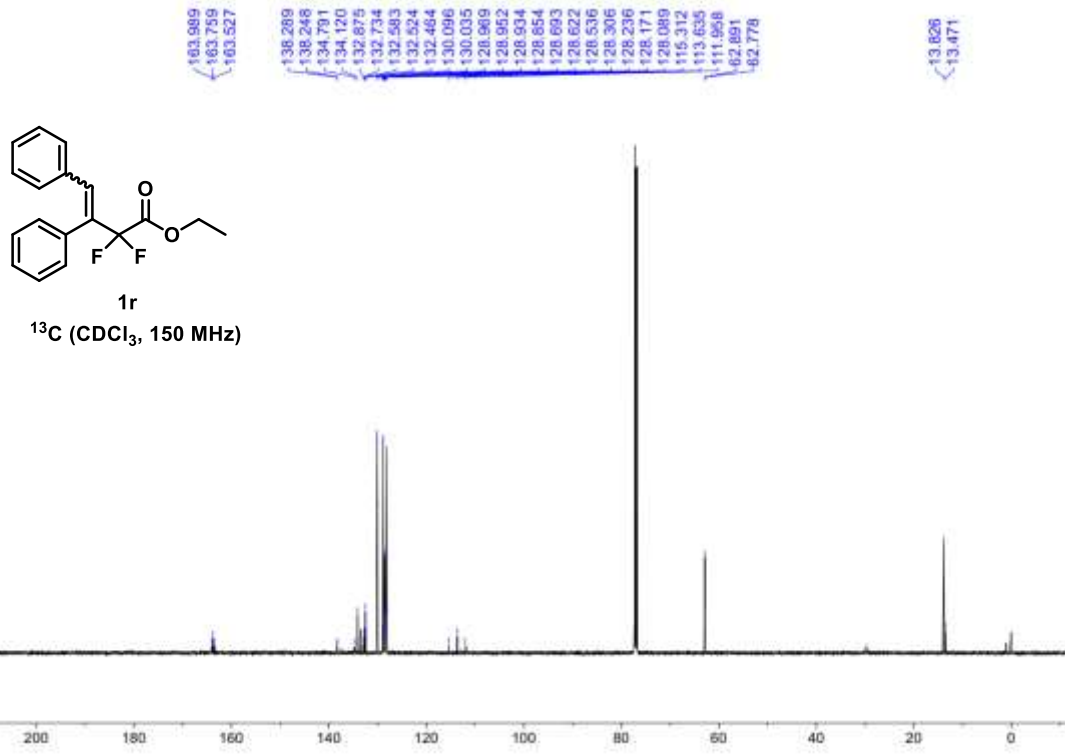
¹³C NMR (150 MHz, CDCl₃)



| # | m/z | Res. | S/N | I | I% | FWHM |
|---|----------|-------|-------|--------|-------|--------|
| 1 | 277.1008 | 22800 | 871.7 | 493036 | 100.0 | 0.0122 |
| 2 | 278.1057 | 10467 | 104.6 | 59496 | 12.1 | 0.0266 |
| 3 | 279.1069 | 8435 | 17.8 | 10140 | 2.1 | 0.0331 |

| Meas. m/z | # | Ion Formula | m/z | err [ppm] | mSigma | Score | rdb | e ⁻ Conf | N-Rule |
|-----------|---|---|----------|-----------|--------|-------|--------|---------------------|------------|
| 277.1008 | 1 | C ₁₄ H ₁₆ F ₂ NaO ₂ | 277.1011 | 1.0 | 19.5 | 3 | 100.00 | 5.5 | even ok |





| # | m/z | Res. | S/N | I | I% | FWHM |
|---|----------|-------|-------|-------|-------|--------|
| 1 | 325.1014 | 16543 | 115.4 | 87792 | 100.0 | 0.0197 |
| 2 | 326.1052 | 14209 | 22.7 | 17348 | 19.8 | 0.0230 |

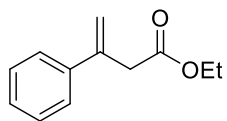
| Meas. m/z | # | Ion Formula | m/z | err [ppm] | mSigma | Score | rdb | e ⁻ Conf | N-Rule |
|-----------|---|---|----------|-----------|--------|-------|--------|---------------------|------------|
| 325.1014 | 1 | C ₁₈ H ₁₆ F ₂ NaO ₂ | 325.1011 | -1.1 | 6.5 | 1 | 100.00 | 9.5 | even ok |

7.436
7.433
7.430
7.421
7.416
7.332
7.329
7.320
7.317
7.309
7.307
7.278
7.276
7.274
7.267
7.264
7.260
7.263
7.251
7.250
7.241
5.534
-5.229

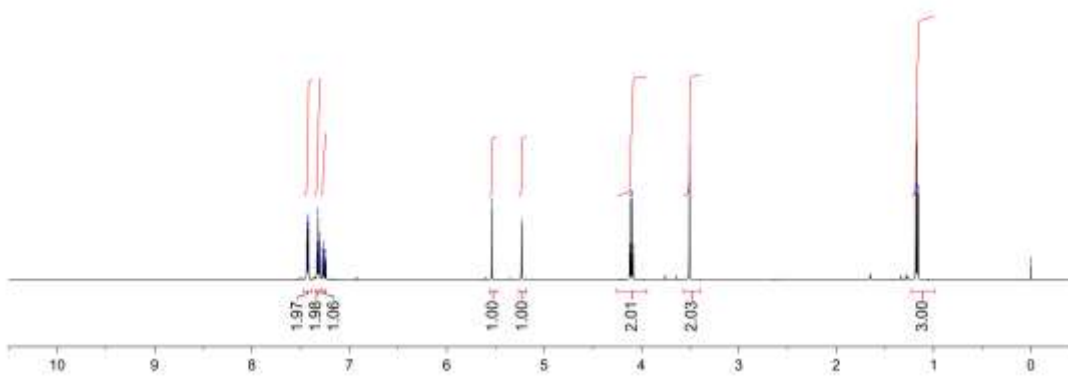
4.121
4.109
4.087
4.085
-3.507

1.182
1.170
1.159

-0.000



3 ¹H NMR (600MHz, CDCl₃)

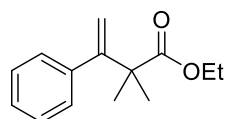


7.282
7.278
7.275
7.267
7.255
7.251
7.248
7.245
7.241
7.230
7.228
7.168
7.163
7.159
7.155
7.152
7.150
-5.318
-5.152

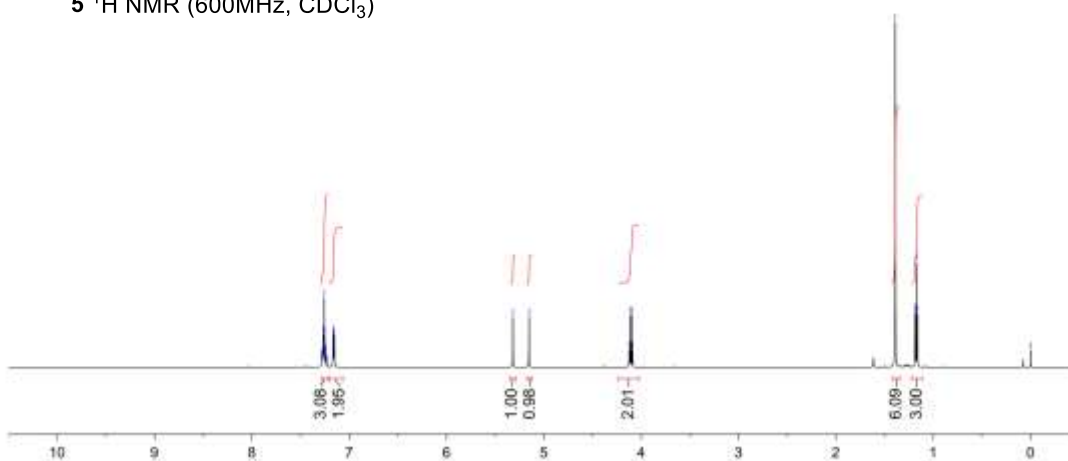
4.122
4.110
4.088
4.087

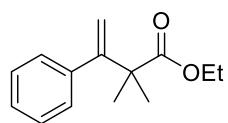
1.388
1.185
1.173
1.161

-0.000

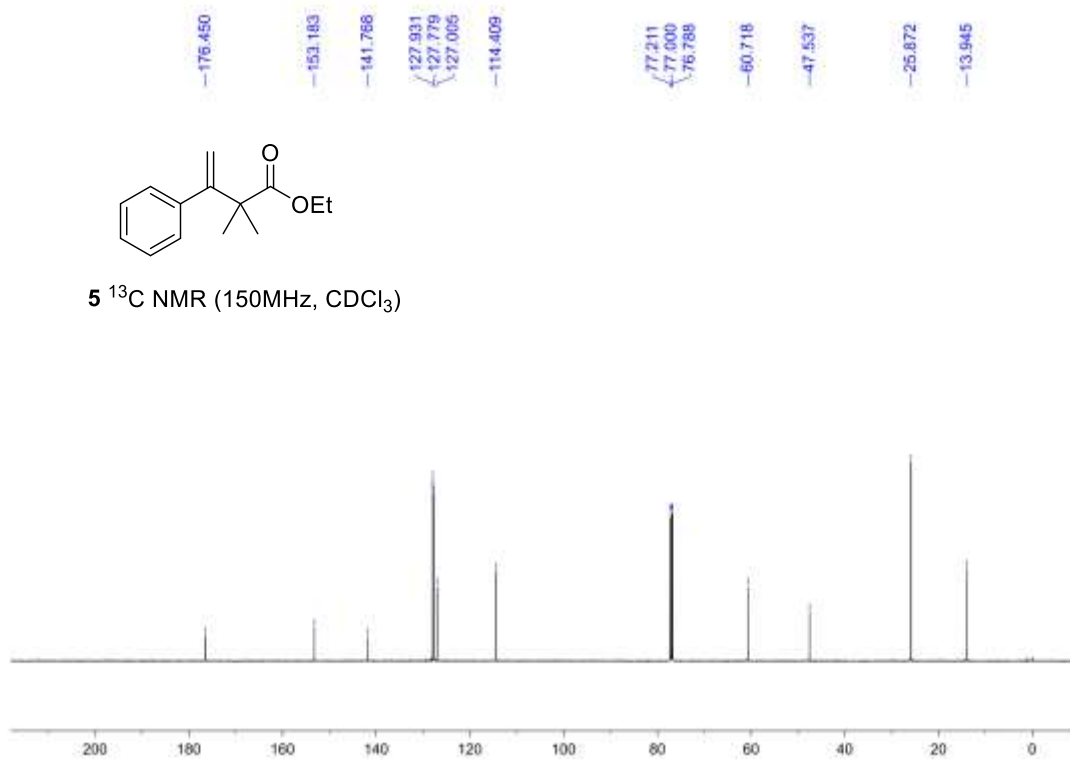


5 ¹H NMR (600MHz, CDCl₃)

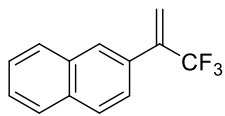




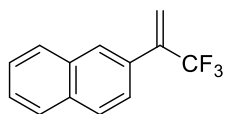
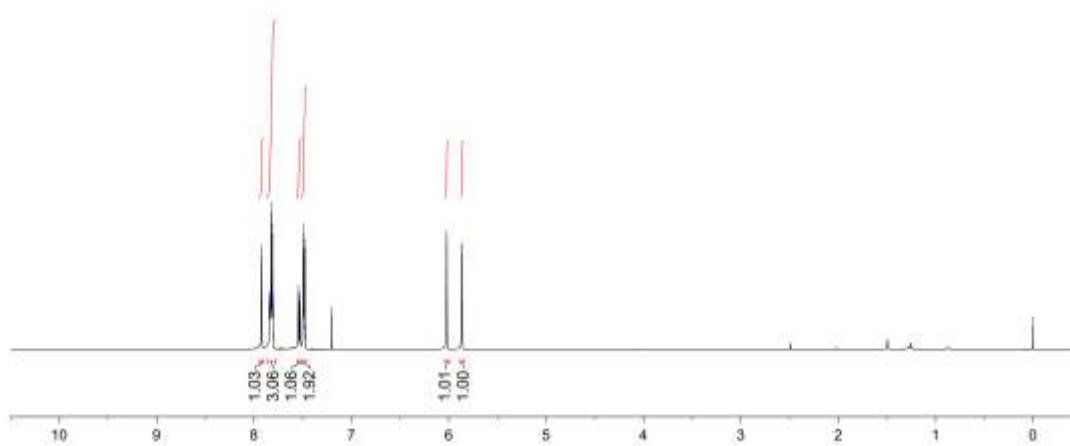
5 ^{13}C NMR (150MHz, CDCl_3)



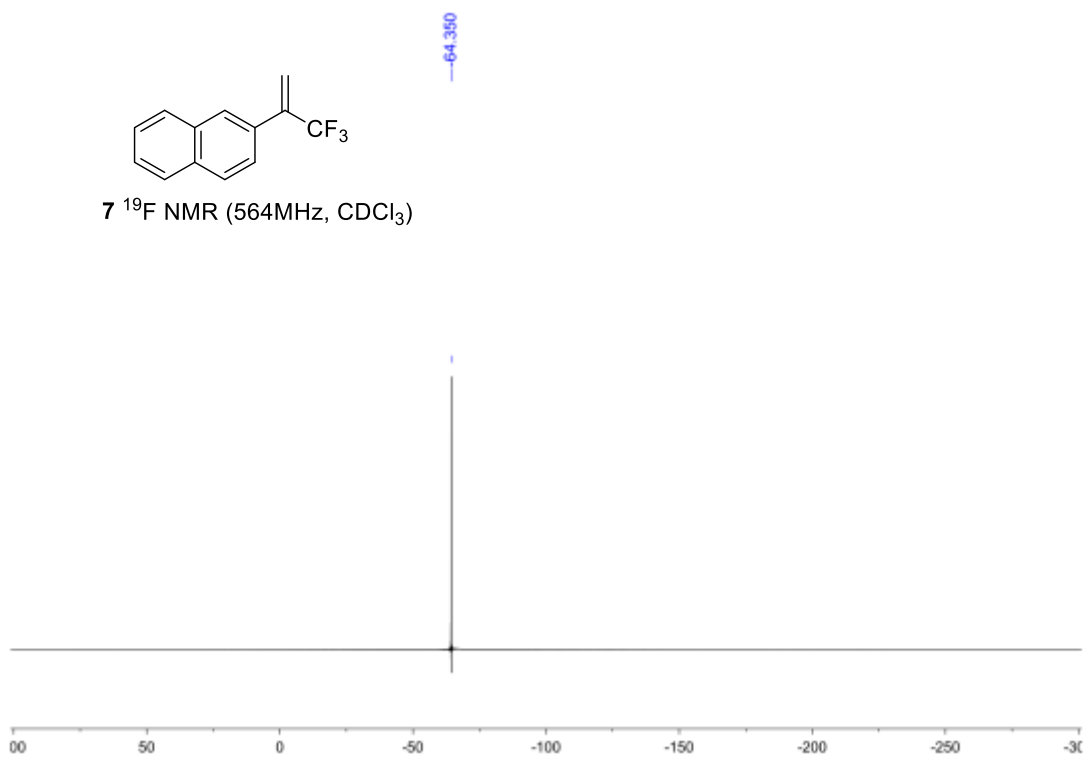
7.922
7.841
7.835
7.831
7.825
7.820
7.811
7.804
7.799
7.543
7.529
7.499
7.493
7.488
7.483
7.477
7.471
7.201
6.022
5.865
5.863
-0.000

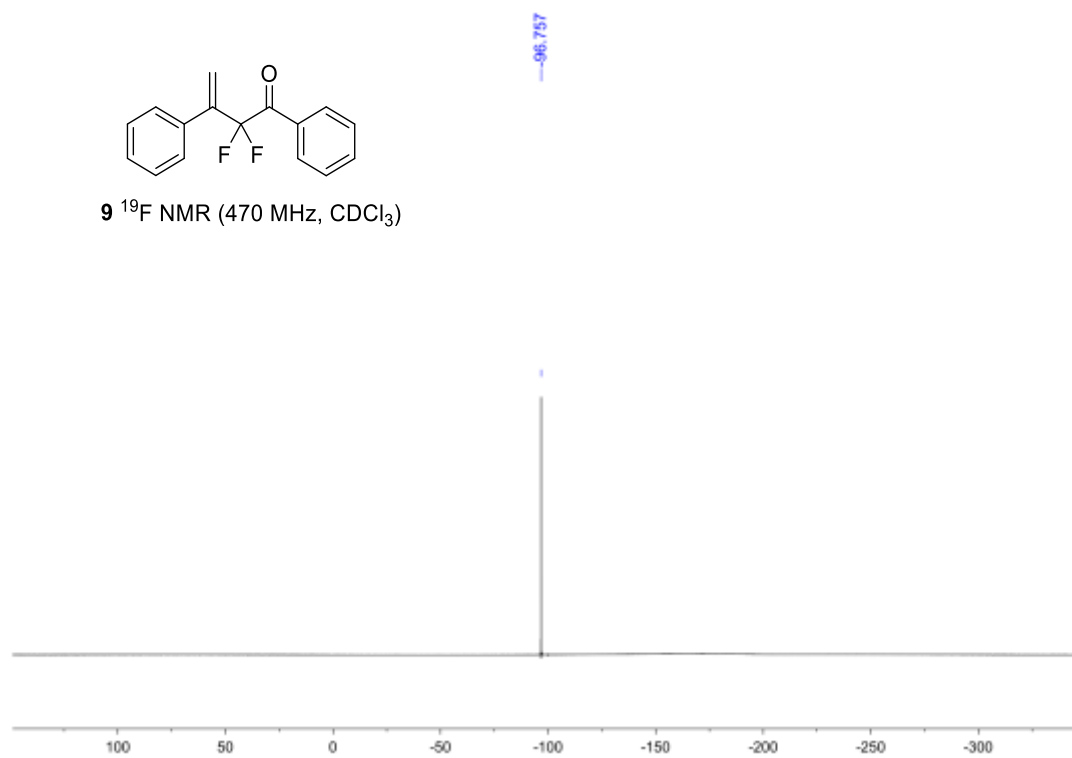
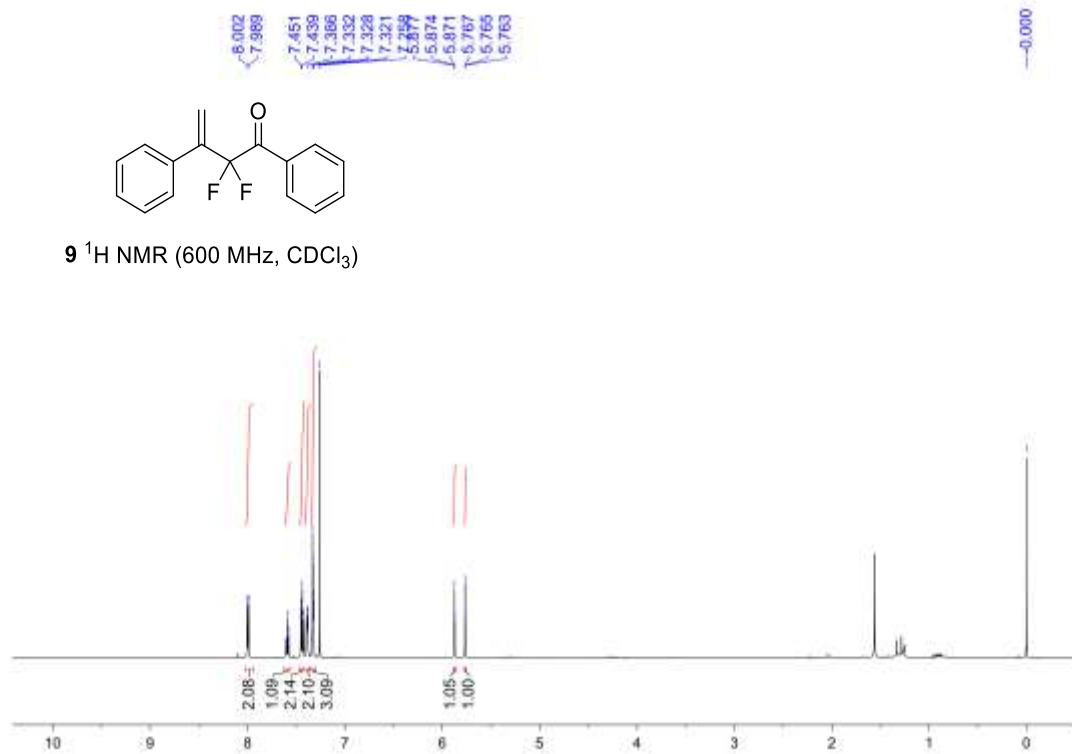


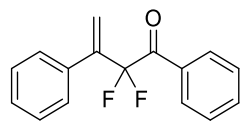
^1H NMR (600MHz, CDCl_3)



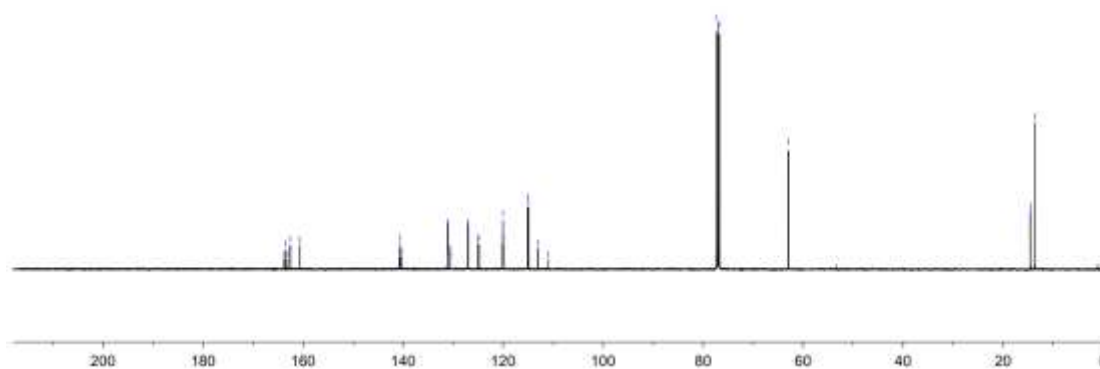
^{19}F NMR (564MHz, CDCl_3)







9 ^{13}C NMR (125 MHz, CDCl_3)

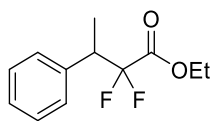


7.333
7.330
7.327
7.322
7.320
7.316
7.313
7.302
7.301
7.297
7.292
7.290
7.286
7.283
7.279
7.277
7.270
7.264
7.261
7.253

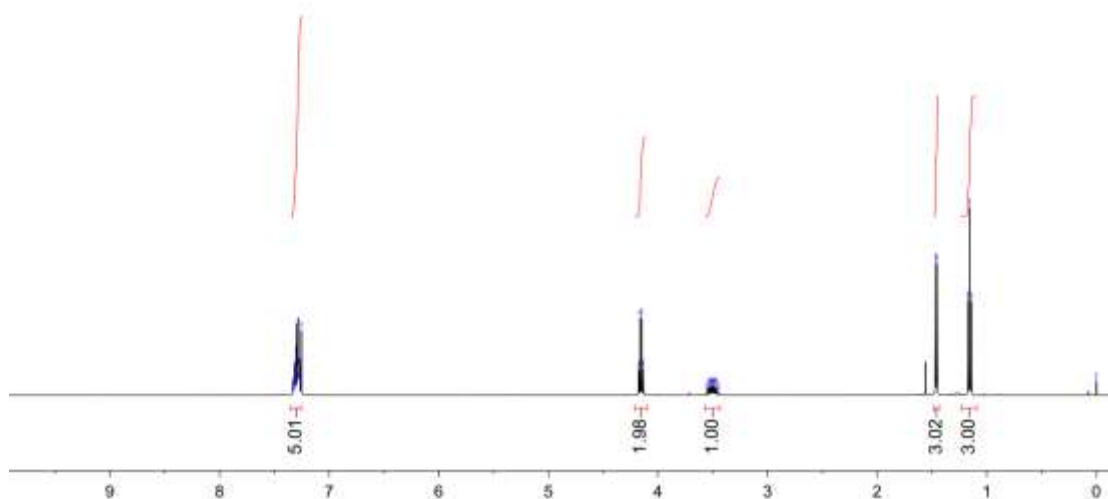
4.177
4.162
4.148
4.134
3.556
3.541
3.527
3.515
3.503
3.501
3.489
3.477
3.463
3.448

1.467
1.453
1.169
1.155
1.141

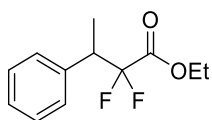
-0.000



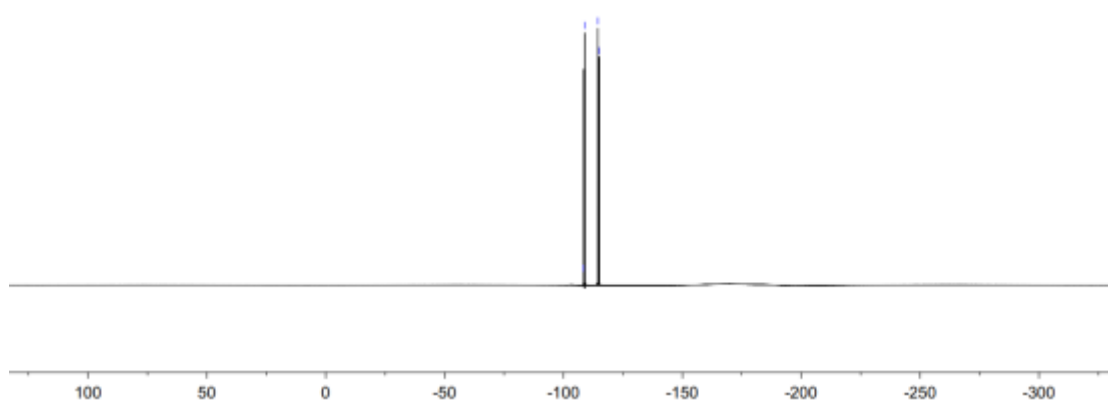
2a ^1H NMR (500 MHz, CDCl_3)

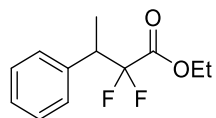


-108.470
-109.008
-114.475
-115.010

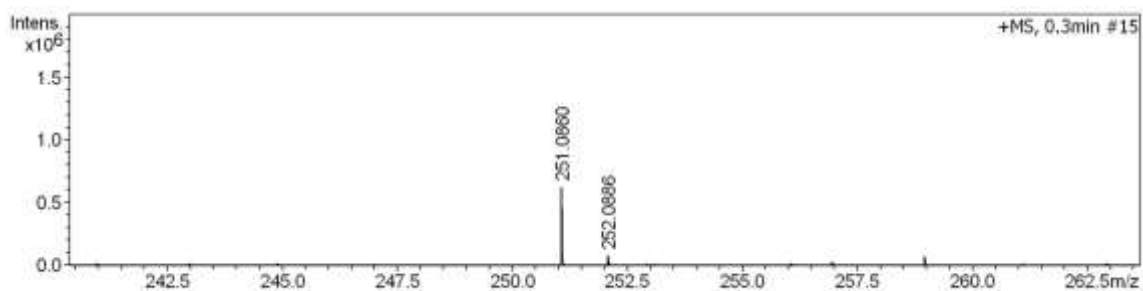
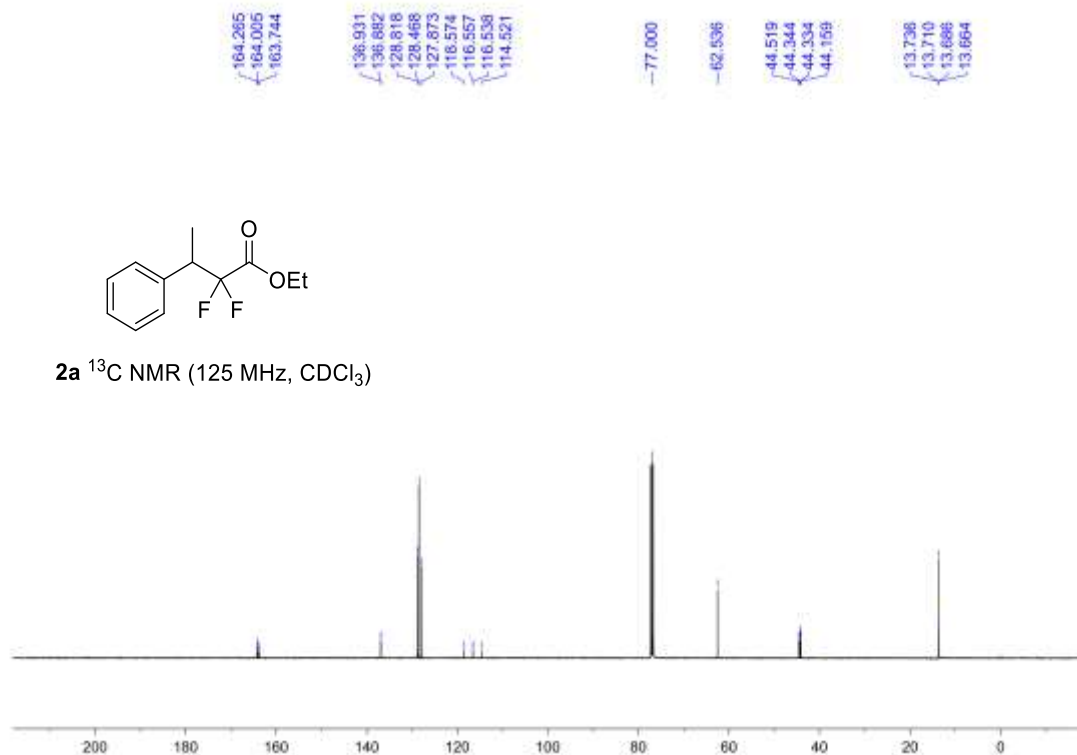


2a ^{19}F NMR (470 MHz, CDCl_3)





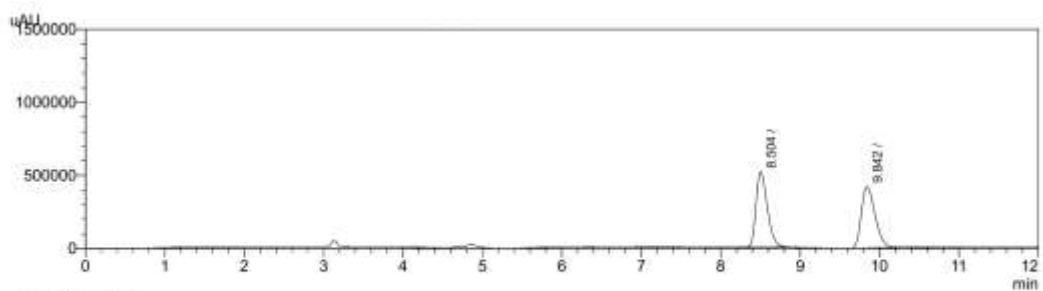
2a ^{13}C NMR (125 MHz, CDCl_3)



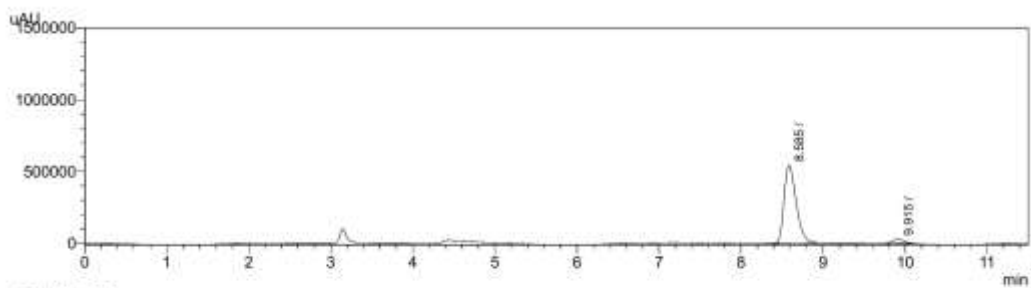
| # | m/z | Res. | S/N | I | I % | FWHM |
|---|----------|-------|--------|--------|-------|--------|
| 1 | 251.0860 | 17842 | 1328.3 | 627340 | 100.0 | 0.0141 |
| 2 | 252.0886 | 13146 | 165.4 | 78424 | 12.5 | 0.0192 |
| 3 | 253.0922 | 11850 | 17.6 | 8376 | 1.3 | 0.0214 |

| Meas. m/z | # | Ion Formula | m/z | err [ppm] | mSigma | Score | rdb | e ⁻ Conf | N-Rule |
|-----------|---|---|----------|-----------|--------|-------|--------|---------------------|--------|
| 251.0860 | 1 | C ₁₂ H ₁₄ F ₂ NaO ₂ | 251.0854 | -2.3 | 4.2 | 1 | 100.00 | 4.5 even | ok |

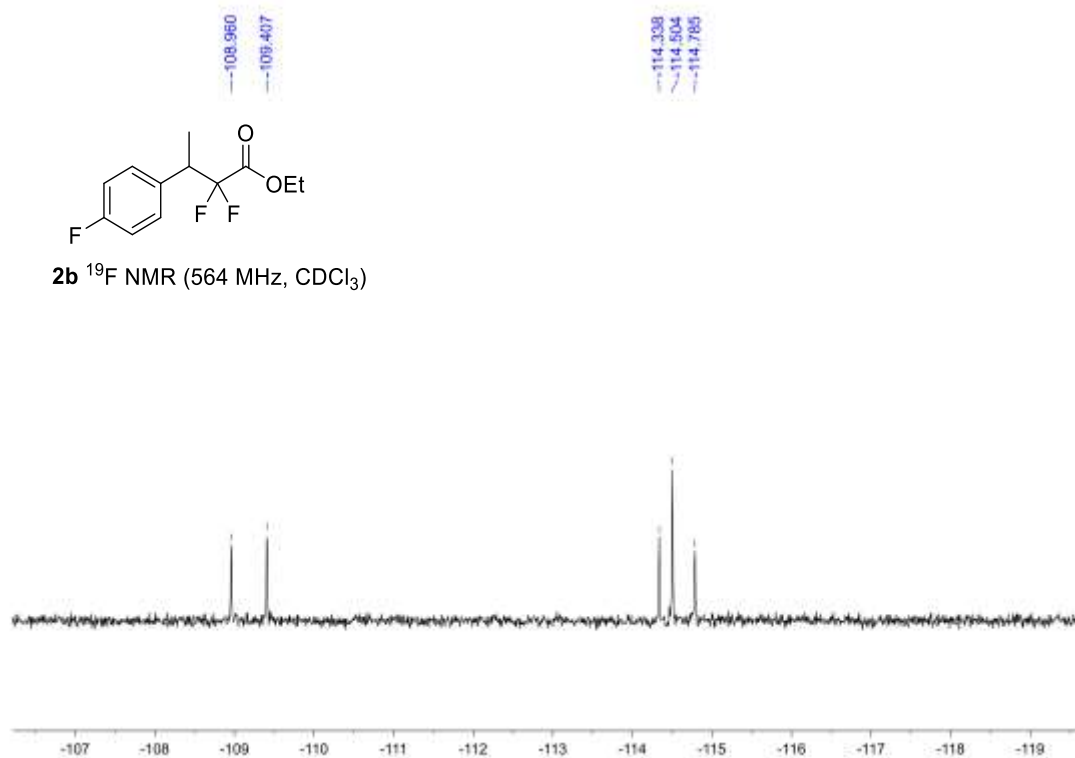
HPLC spectra of 2a

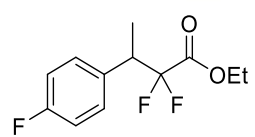


| PDA Ch1 208nm | | | | | | | | |
|---------------|-----------|----------|---------|--------|-------|------|-----|--|
| Peak# | Ret. Time | Area | Area% | Height | Conc. | Mark | ID# | |
| 1 | 8.804 | 5054276 | 50.122 | 513676 | 0.000 | M | | |
| 2 | 9.842 | 5029738 | 49.878 | 421817 | 0.000 | M | | |
| 总计 | | 10084014 | 100.000 | 935494 | | | | |

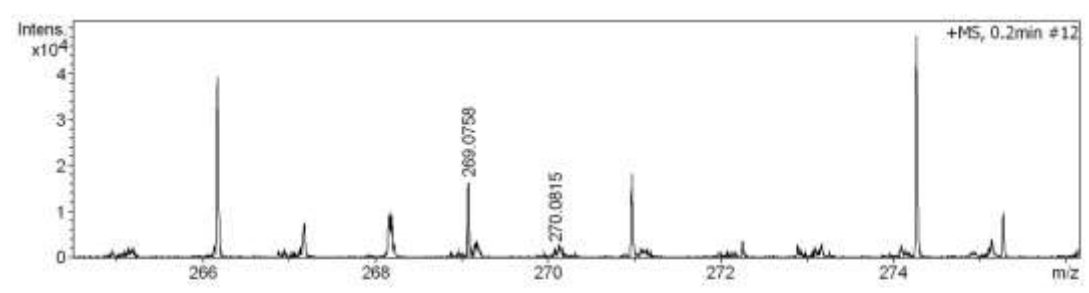
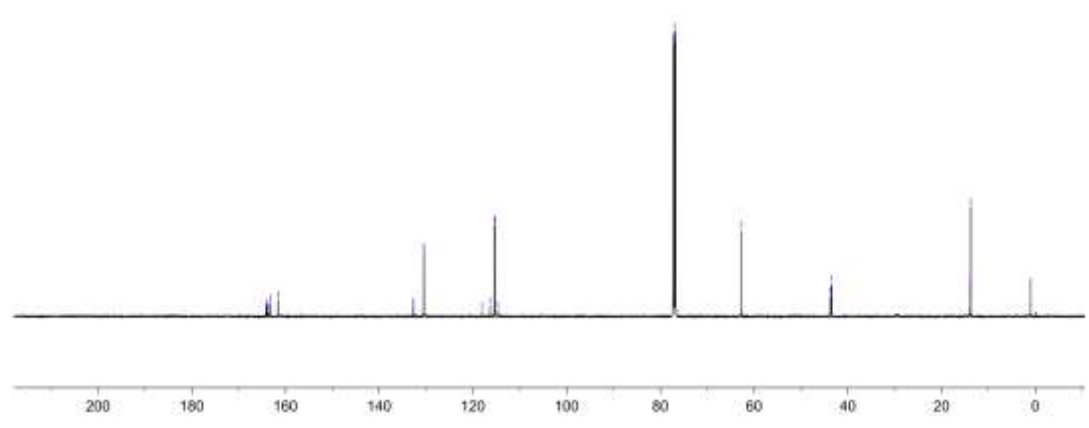


| PDA Ch1 208nm | | | | | | | | |
|---------------|-----------|---------|---------|--------|-------|------|-----|--|
| Peak# | Ret. Time | Area | Area% | Height | Conc. | Mark | ID# | |
| 1 | 8.585 | 5576310 | 94.867 | 543864 | 0.000 | M | | |
| 2 | 9.915 | 301695 | 5.133 | 29270 | 0.000 | M | | |
| 总计 | | 5878005 | 100.000 | 572834 | | | | |





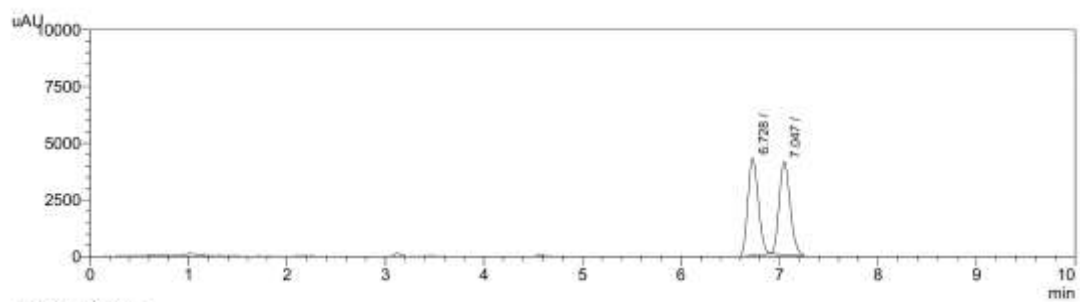
2b ^{13}C NMR (150 MHz, CDCl_3)



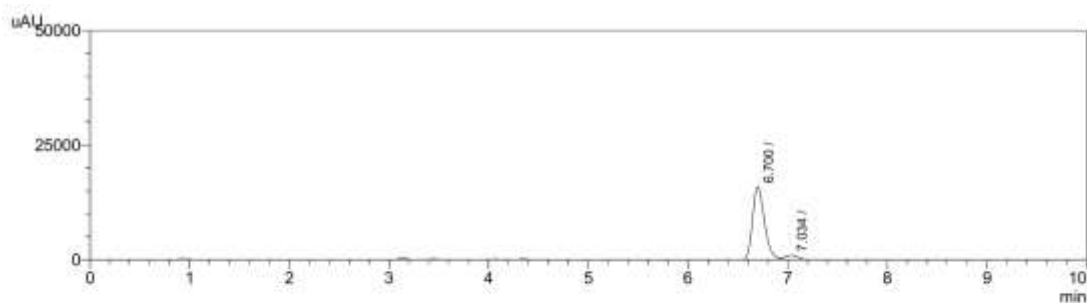
| # | m/z | Res. | S/N | I | I% | FWHM |
|---|----------|-------|------|-------|-------|--------|
| 1 | 269.0758 | 18307 | 30.8 | 16260 | 100.0 | 0.0147 |
| 2 | 270.0815 | 24402 | 3.9 | 2084 | 12.8 | 0.0111 |

| Meas. m/z | # | Ion Formula | m/z | err [ppm] | mSigma | Score | rdb | e ⁻ Conf | N-Rule |
|-----------|---|---|----------|-----------|--------|-------|-------|---------------------|------------|
| 269.0758 | 1 | C ₁₂ H ₁₃ F ₃ NaO ₂ | 269.0760 | 0.6 | 76.6 | 6 | 34.91 | 4.5 | even ok |

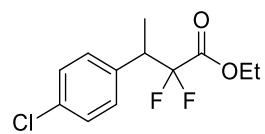
HPLC spectra of 2b



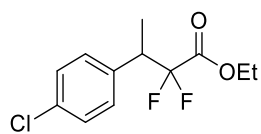
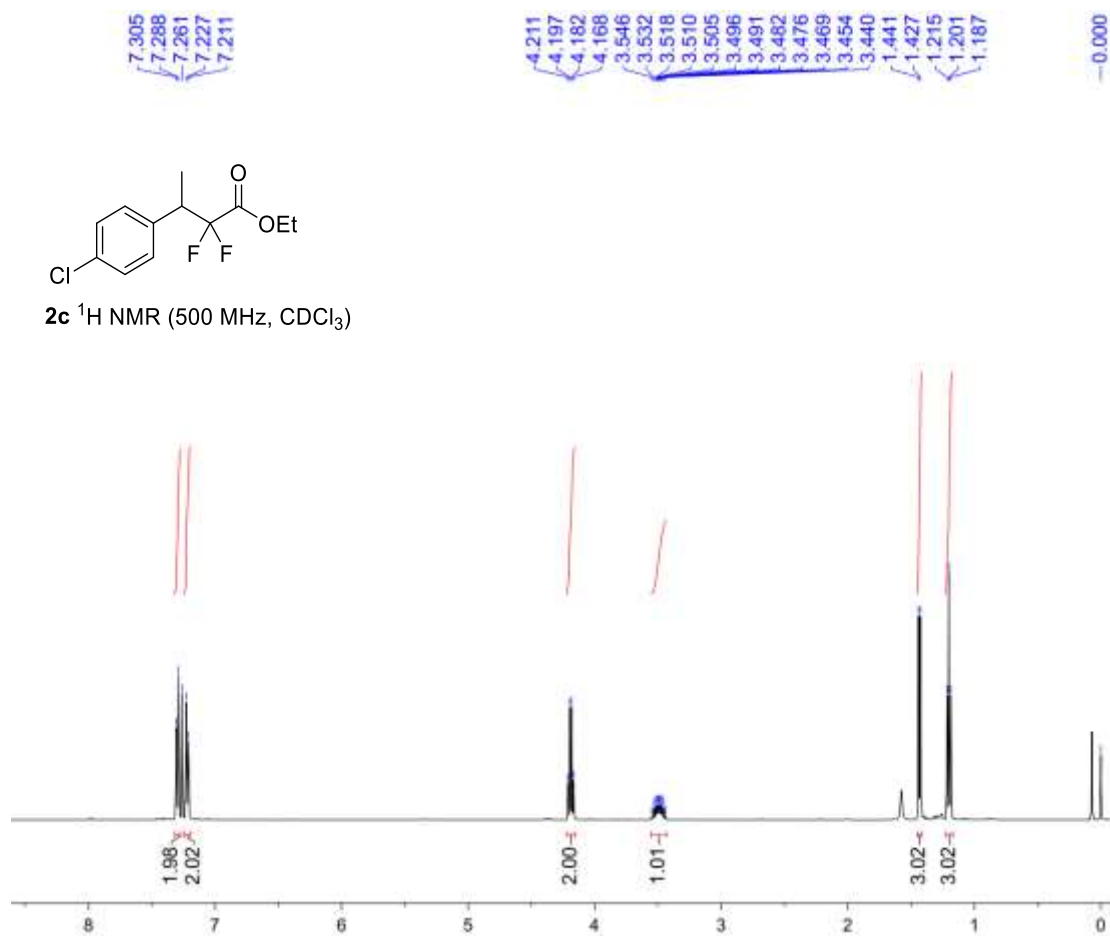
| PDA Ch1 263nm | | | | | | | |
|---------------|-----------|-------|---------|--------|-------|------|-----|
| Peak# | Ret. Time | Area | Area% | Height | Conc. | Mark | ID# |
| 1 | 6.728 | 31625 | 49.977 | 4293 | 0.000 | M | |
| 2 | 7.047 | 31654 | 50.023 | 4097 | 0.000 | M | |
| Σ | | 63280 | 100.000 | 8391 | | | |



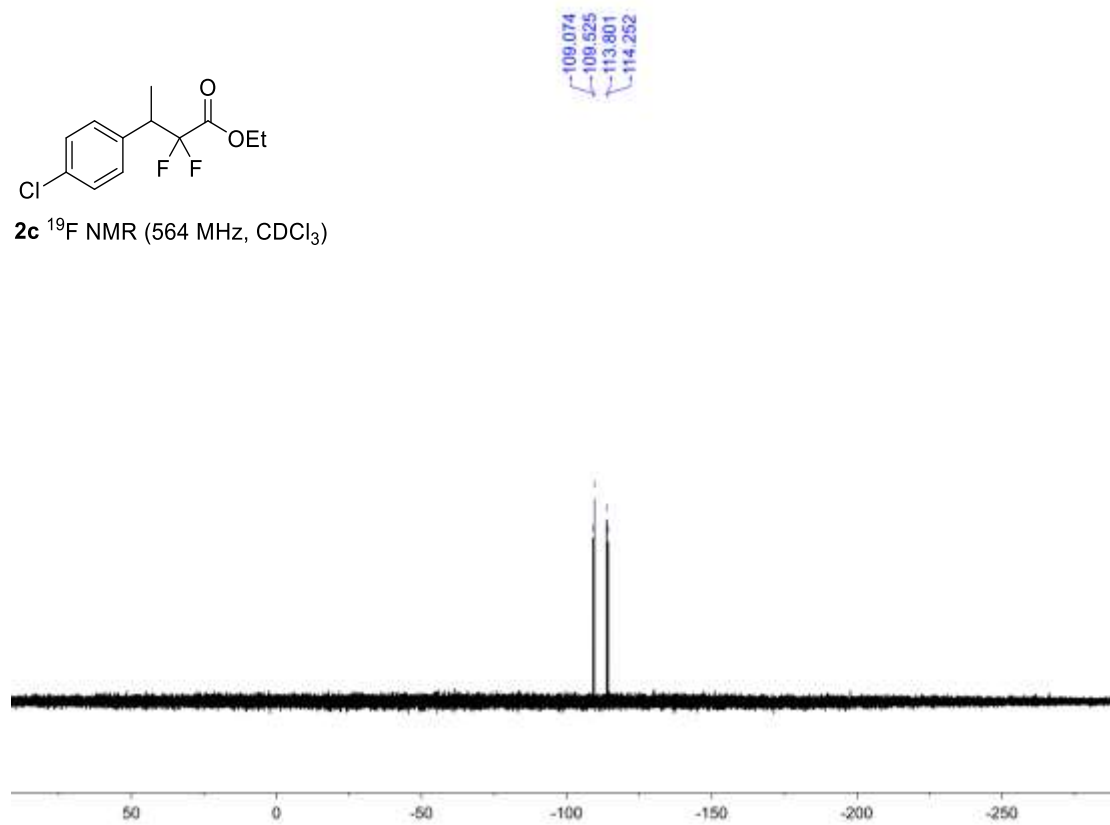
| PDA Ch1 263nm | | | | | | | |
|---------------|-----------|--------|---------|--------|-------|------|-----|
| Peak# | Ret. Time | Area | Area% | Height | Conc. | Mark | ID# |
| 1 | 6.700 | 133742 | 93.071 | 16014 | 0.000 | M | |
| 2 | 7.034 | 9956 | 6.929 | 1076 | 0.000 | V M | |
| Σ | | 143698 | 100.000 | 17090 | | | |

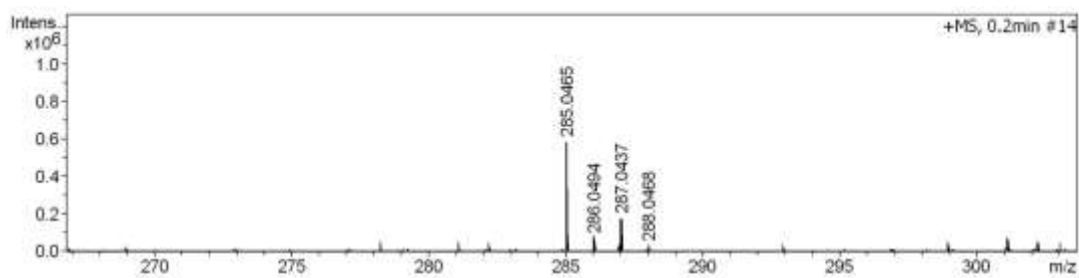
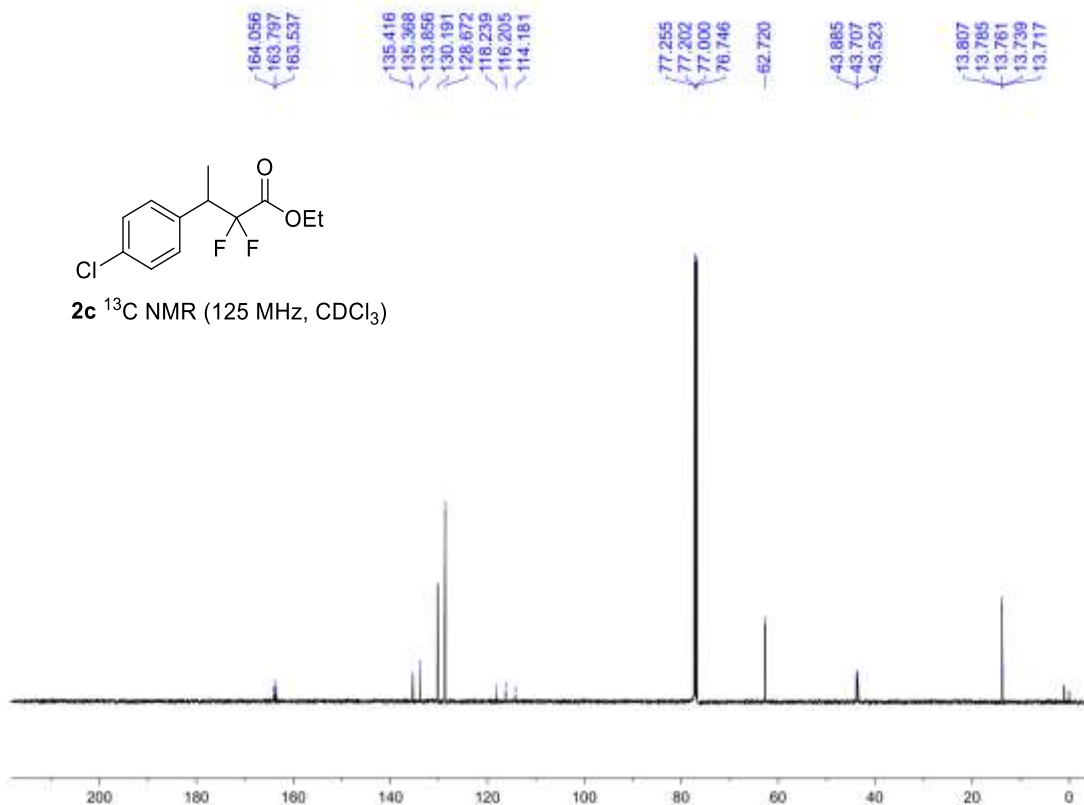


2c ¹H NMR (500 MHz, CDCl₃)



2c ¹⁹F NMR (564 MHz, CDCl₃)

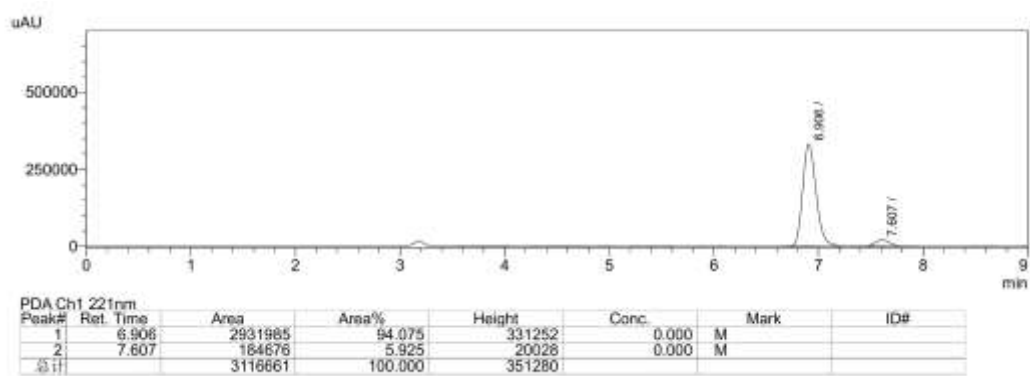
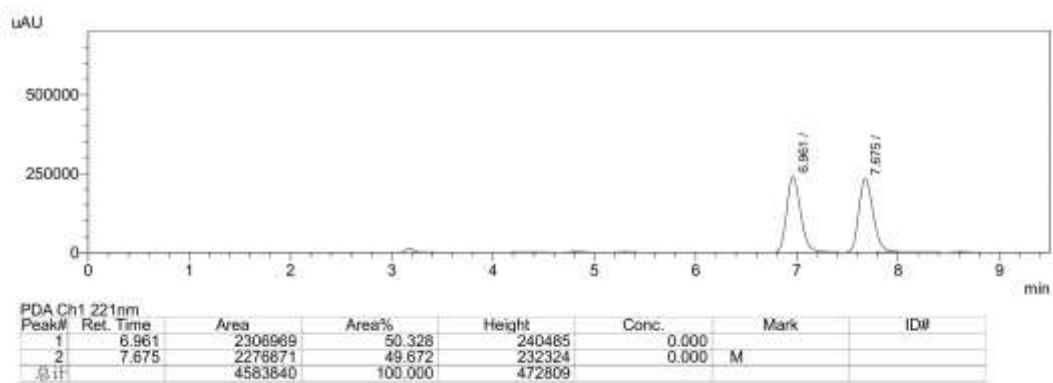


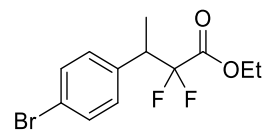


| # | m/z | Res. | S/N | I | I% | FWHM |
|---|----------|-------|--------|--------|-------|--------|
| 1 | 285.0465 | 18230 | 1085.4 | 579380 | 100.0 | 0.0156 |
| 2 | 286.0494 | 12942 | 125.2 | 67248 | 11.6 | 0.0221 |
| 3 | 287.0437 | 14343 | 322.8 | 174216 | 30.1 | 0.0200 |
| 4 | 288.0468 | 12247 | 45.2 | 24556 | 4.2 | 0.0235 |

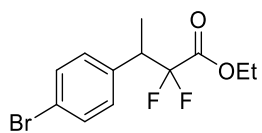
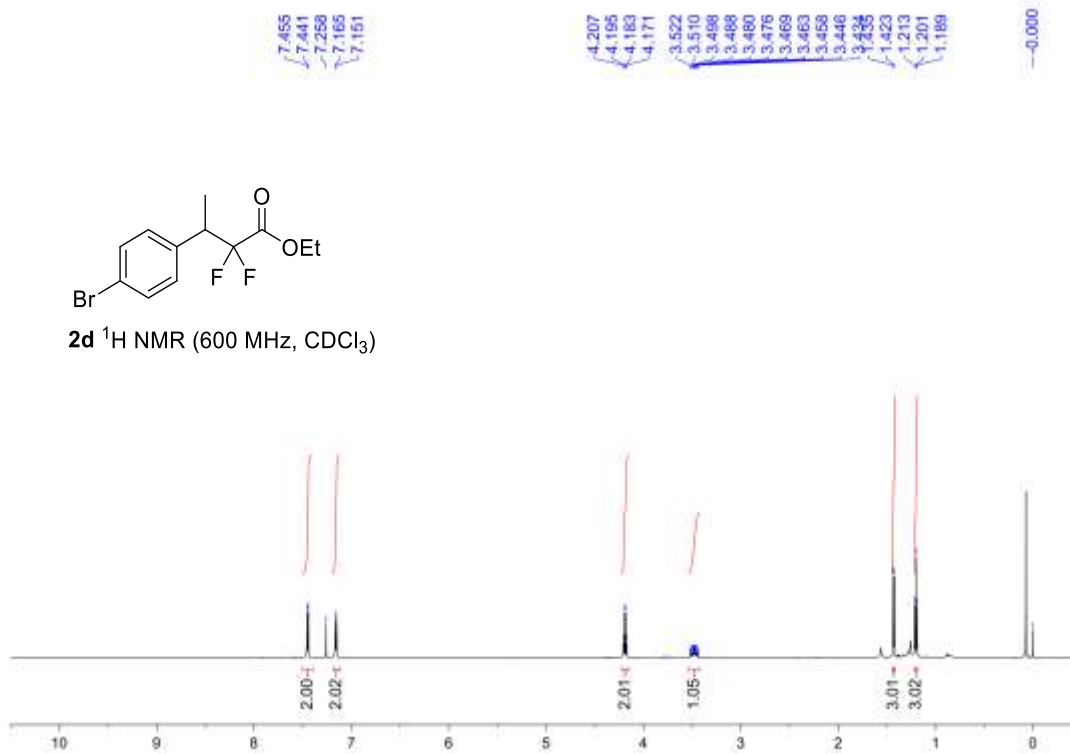
| Meas. m/z | # | Ion Formula | m/z | err [ppm] | mSigma | Score | rdb | e ⁻ Conf | N-Rule |
|-----------|---|--|----------|-----------|--------|-------|--------|---------------------|------------|
| 285.0465 | 1 | $\text{C}_{12}\text{H}_{13}\text{ClF}_2\text{NaO}_2$ | 285.0464 | -0.1 | 15.8 | 1 | 100.00 | 4.5 | even ok |

HPLC spectra of 2c

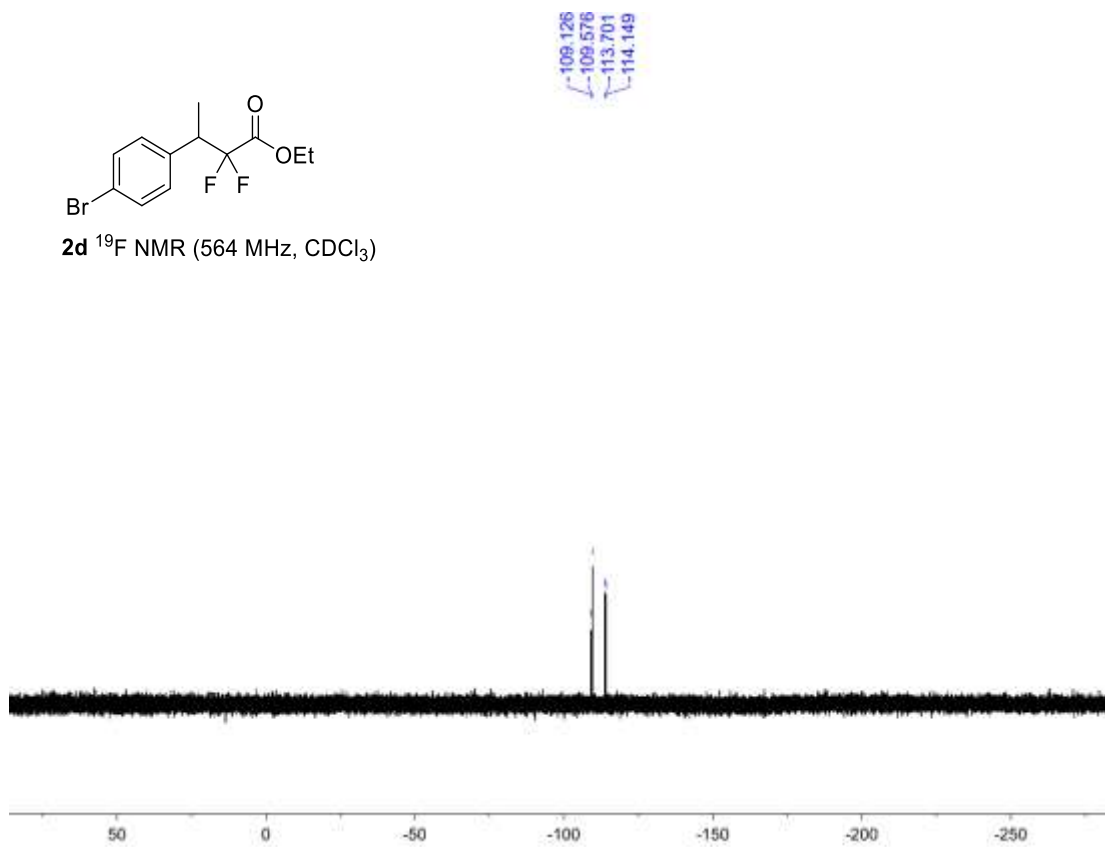


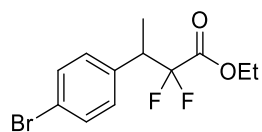


2d ^1H NMR (600 MHz, CDCl_3)

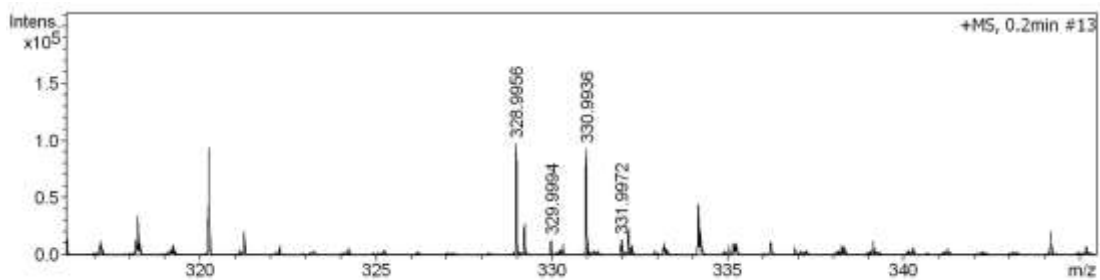
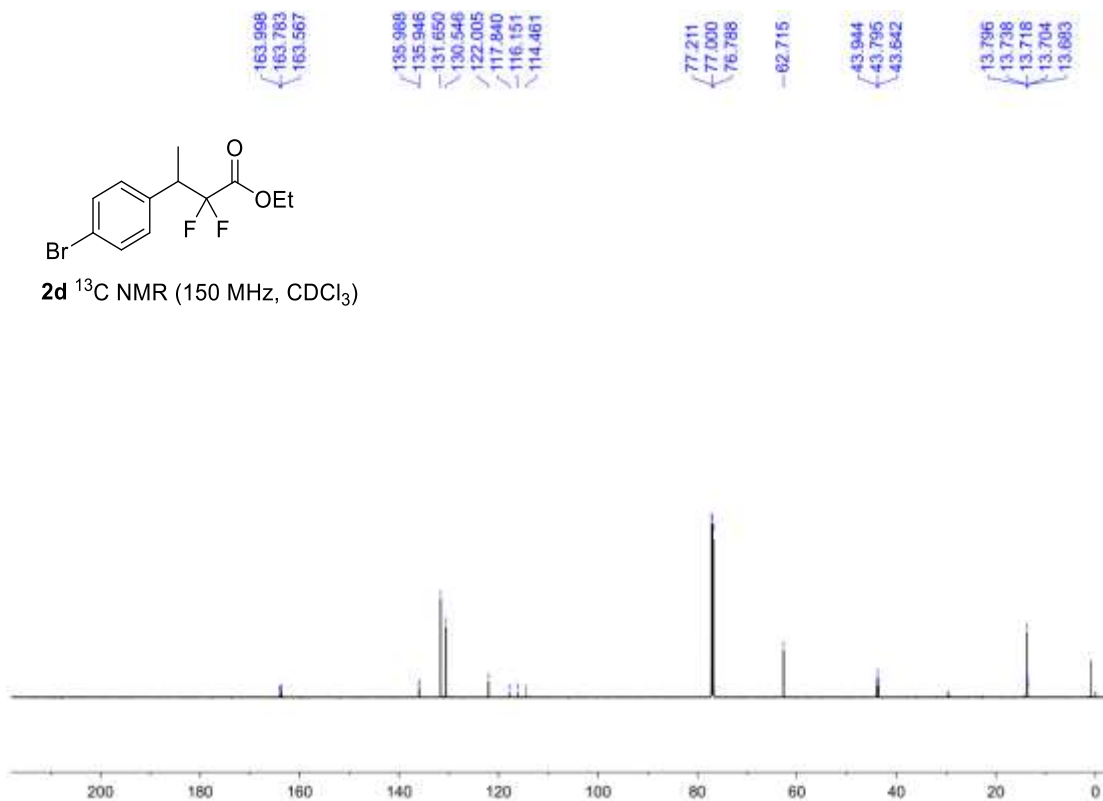


2d ^{19}F NMR (564 MHz, CDCl_3)





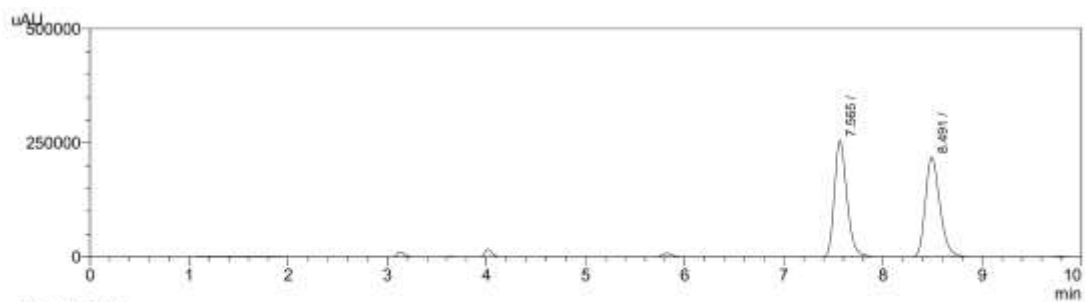
2d ^{13}C NMR (150 MHz, CDCl_3)



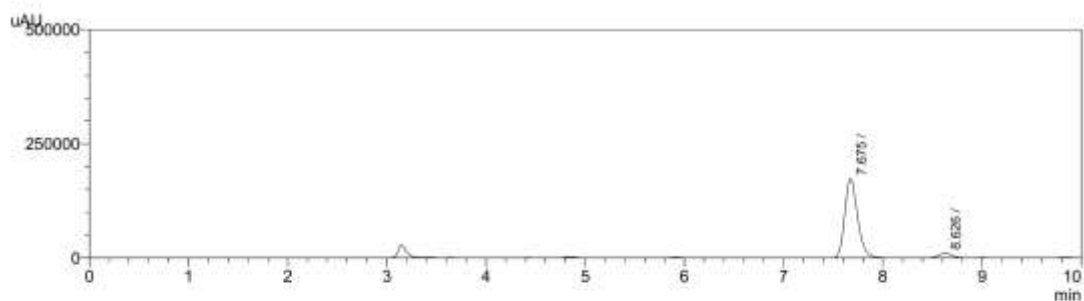
| # | m/z | Res. | S/N | I | I% | FWHM |
|---|----------|-------|-------|-------|-------|--------|
| 1 | 328.9956 | 14315 | 183.8 | 96876 | 100.0 | 0.0230 |
| 2 | 329.9994 | 9211 | 24.0 | 12660 | 13.1 | 0.0358 |
| 3 | 330.9936 | 14327 | 176.1 | 93120 | 96.1 | 0.0231 |
| 4 | 331.9972 | 12438 | 24.5 | 12972 | 13.4 | 0.0267 |

| Meas. m/z | # | Ion Formula | m/z | err [ppm] | mSigma | Score | rdb | e ⁻ Conf | N-Rule |
|-----------|---|--|----------|-----------|--------|-------|--------|---------------------|------------|
| 328.9956 | 1 | $\text{C}_{12}\text{H}_{13}\text{BrF}_2\text{NaO}_2$ | 328.9959 | 1.0 | 12.0 | 1 | 100.00 | 4.5 | even ok |

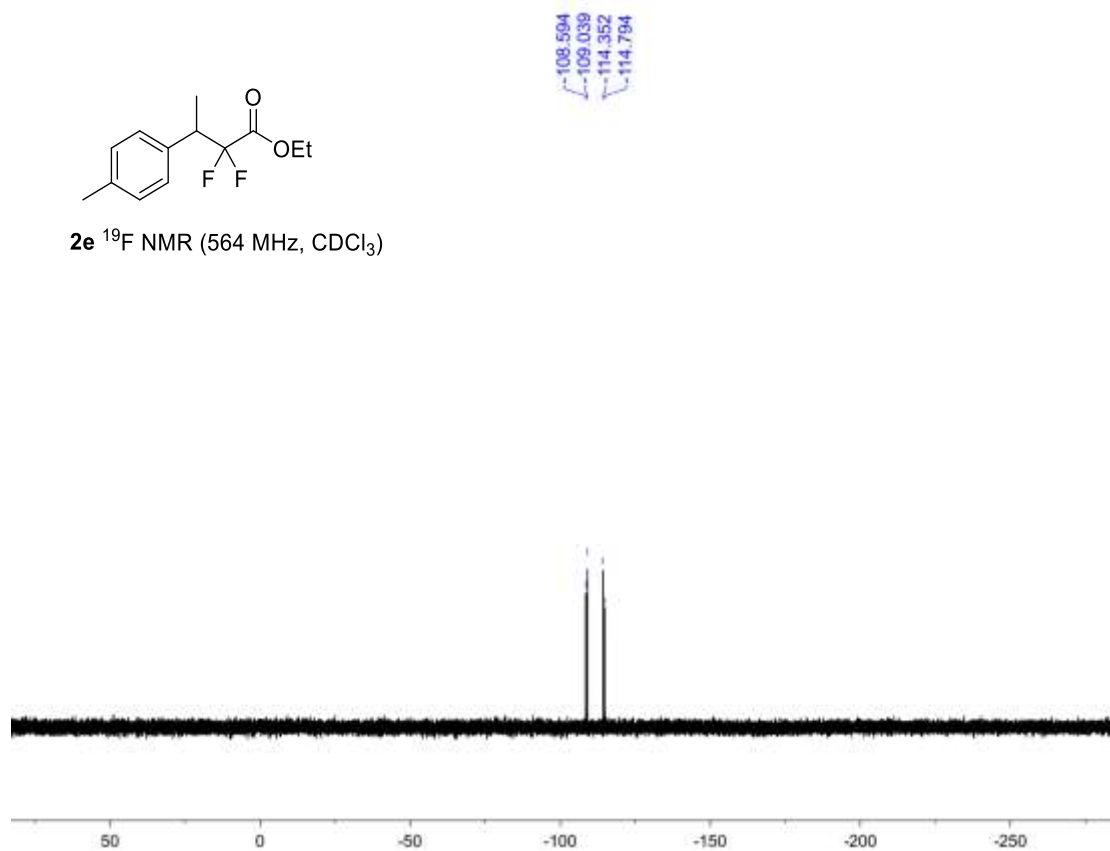
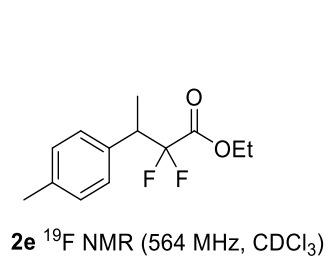
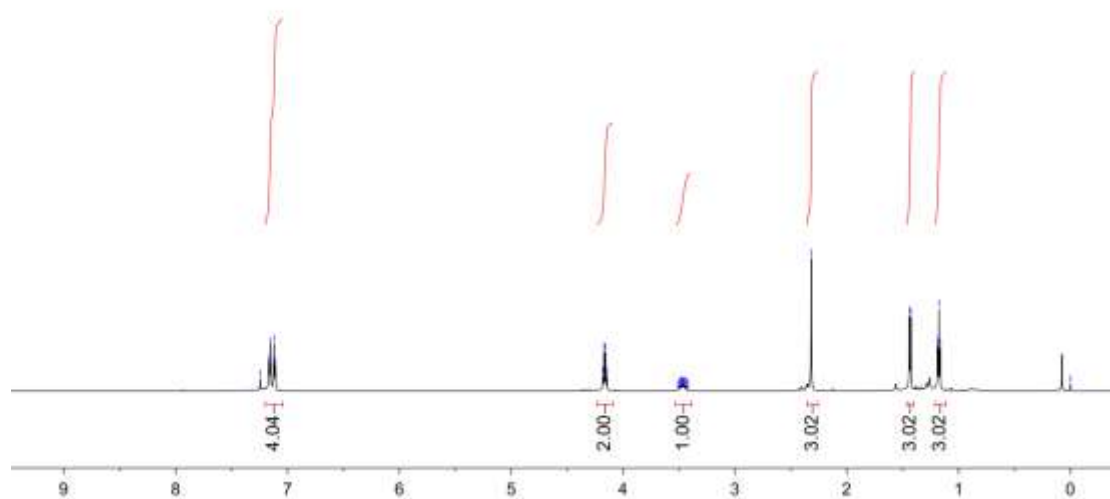
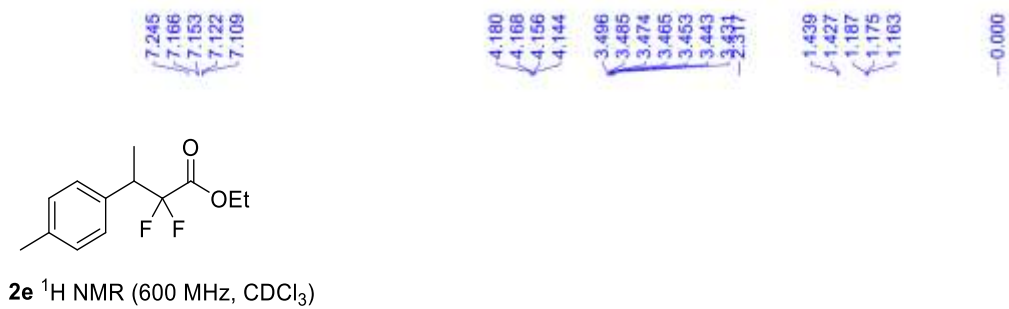
HPLC spectra of 2d



| Peak# | Ret. Time | Area | Area% | Height | Conc. | Mark | ID# |
|-------|-----------|---------|---------|--------|--------|------|-----|
| 1 | 7.565 | 2225958 | 50.001 | 255631 | 50.001 | M | |
| 2 | 8.491 | 2225864 | 49.999 | 218660 | 49.999 | M | |
| Σ | | 4451822 | 100.000 | 474290 | | | |



| Peak# | Ret. Time | Area | Area% | Height | Conc. | Mark | ID# |
|-------|-----------|---------|---------|--------|-------|------|-----|
| 1 | 7.675 | 1564917 | 94.149 | 173317 | 0.000 | M | |
| 2 | 8.626 | 97248 | 5.851 | 10112 | 0.000 | M | |
| Σ | | 1662165 | 100.000 | 183429 | | | |



164.275
164.059
163.841

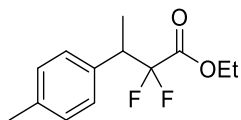
137.560
133.876
133.839
129.154
128.669
118.303
116.619
114.931

77.211
77.000
76.788

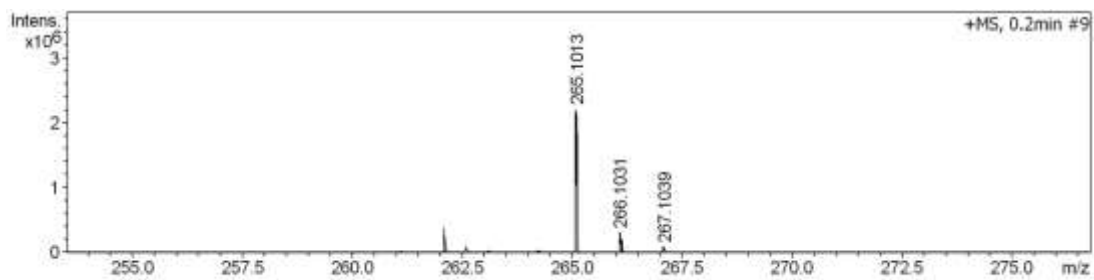
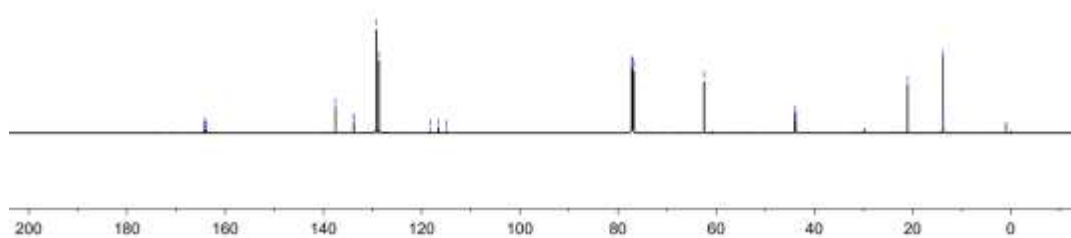
-62.477

44.061
43.914
43.764

21.002
13.746
13.718
13.703



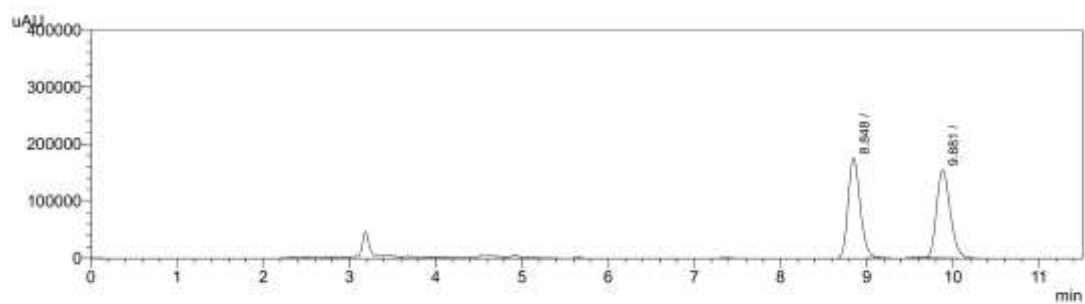
2e ^{13}C NMR (150 MHz, CDCl_3)



| # | m/z | Res. | S/N | I | I% | FWHM |
|---|----------|-------|--------|---------|-------|--------|
| 1 | 265.1013 | 12394 | 4521.5 | 2184808 | 100.0 | 0.0214 |
| 2 | 266.1031 | 21166 | 605.6 | 293828 | 13.4 | 0.0126 |
| 3 | 267.1039 | 8873 | 125.6 | 61072 | 2.8 | 0.0301 |

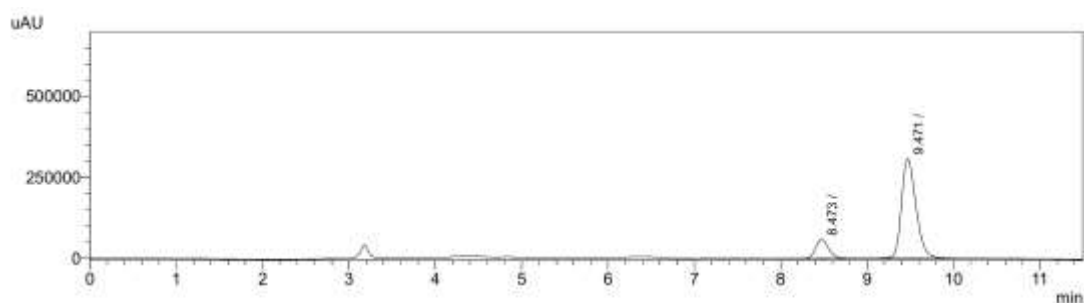
| Meas. m/z | # | Ion Formula | m/z | err [ppm] | mSigma | Score | rdb | e ⁻ Conf | N-Rule |
|-----------|---|---|----------|-----------|--------|--------|-----|---------------------|--------|
| 265.1013 | 1 | C ₁₃ H ₁₆ F ₂ NaO ₂ | 265.1011 | -0.8 | 9.7 | 100.00 | 4.5 | even | ok |

HPLC spectra of 2e



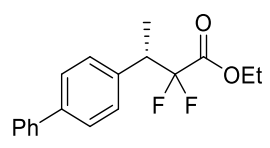
PDA Ch1 212nm

| Peak# | Ret. Time | Area | Area% | Height | Conc. | Mark | ID# |
|-------|-----------|---------|---------|--------|-------|------|-----|
| 1 | 8.848 | 1728387 | 50.068 | 176070 | 0.000 | M | |
| 2 | 9.881 | 1724719 | 49.932 | 155195 | 0.000 | M | |
| 总计 | | 3454106 | 100.000 | 331265 | | | |

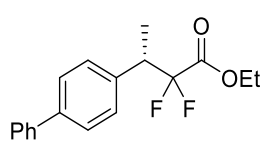
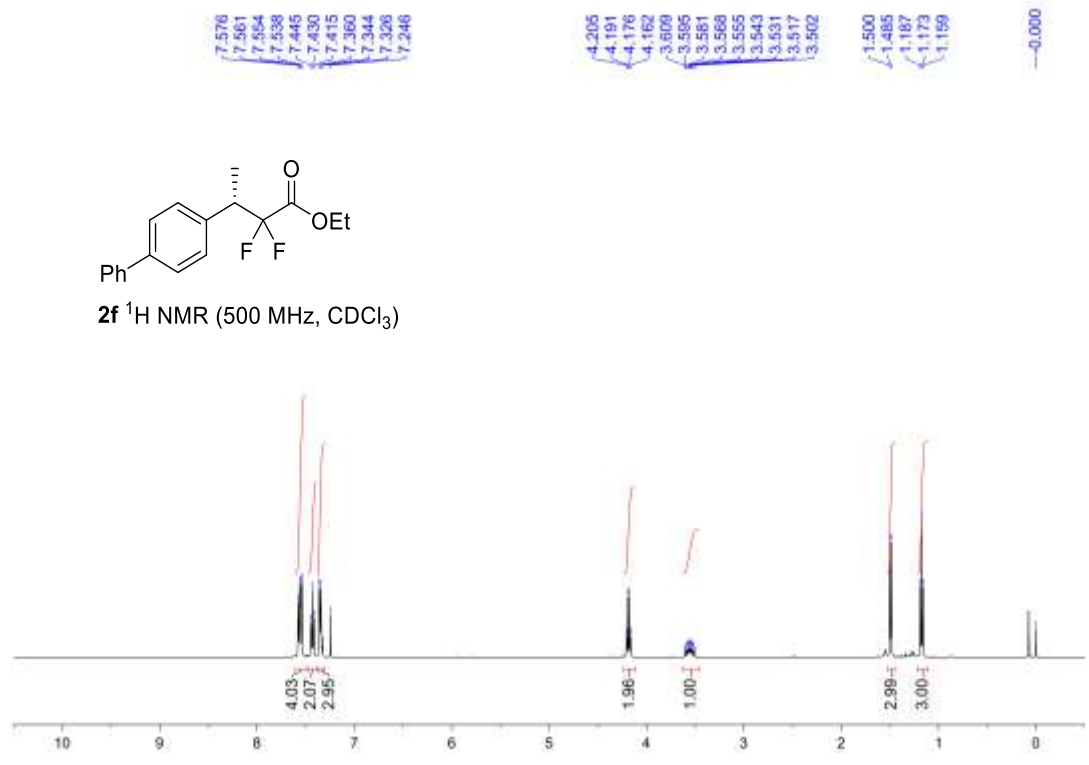


PDA Ch1 212nm

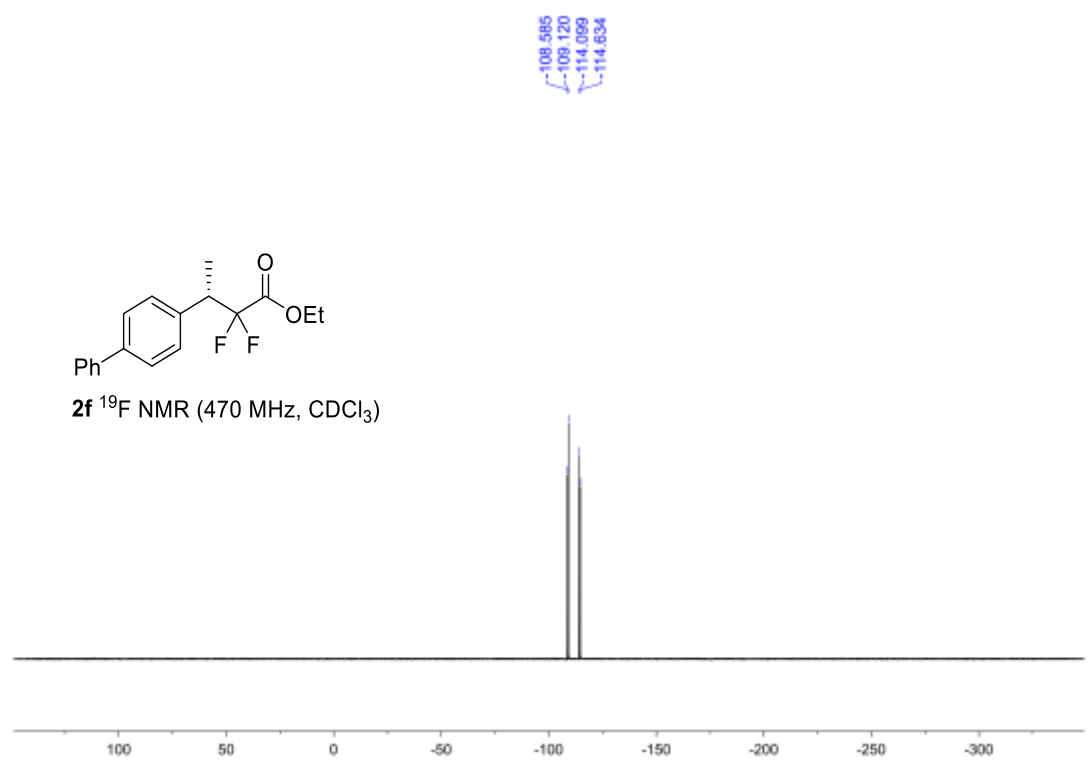
| Peak# | Ret. Time | Area | Area% | Height | Conc. | Mark | ID# |
|-------|-----------|---------|---------|--------|-------|------|-----|
| 1 | 8.473 | 599096 | 14.389 | 58278 | 0.000 | M | |
| 2 | 9.471 | 3564561 | 85.611 | 307846 | 0.000 | M | |
| 总计 | | 4163657 | 100.000 | 366124 | | | |

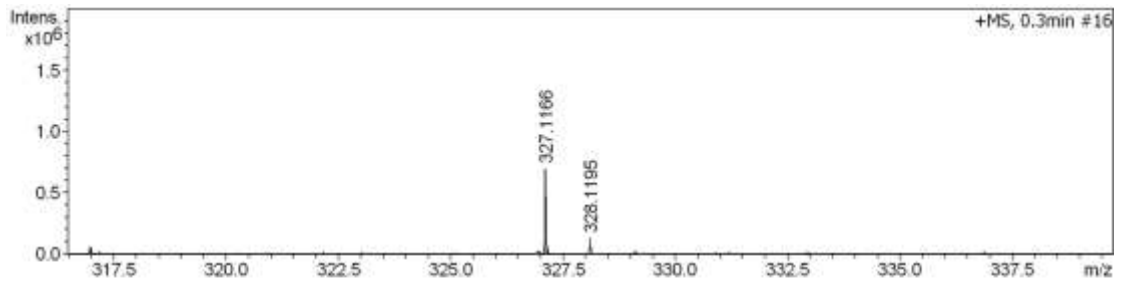
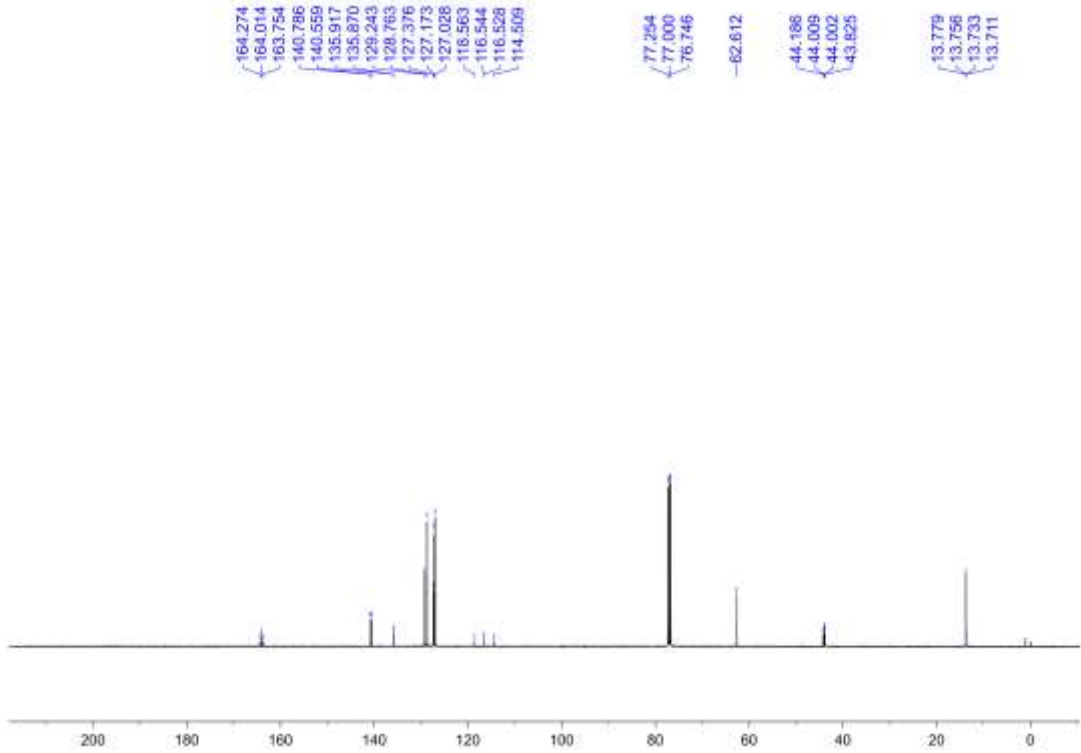


2f ^1H NMR (500 MHz, CDCl_3)



2f ^{19}F NMR (470 MHz, CDCl_3)

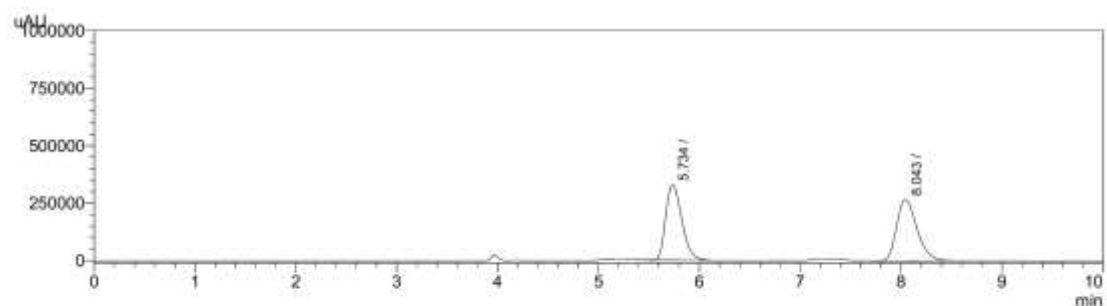




| # | m/z | Res. | S/N | I | I% | FWHM |
|---|----------|-------|--------|--------|-------|--------|
| 1 | 327.1166 | 18988 | 1277.5 | 696580 | 100.0 | 0.0172 |
| 2 | 328.1195 | 14590 | 236.6 | 129276 | 18.6 | 0.0225 |
| 3 | 329.1234 | 13348 | 29.8 | 16292 | 2.3 | 0.0247 |

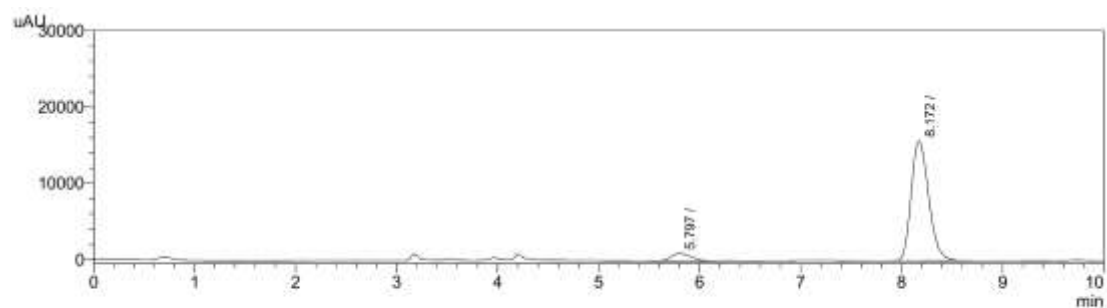
| Meas. m/z | # | Ion Formula | m/z | err [ppm] | mSigma | Score | rdb | e ⁻ Conf | N-Rule |
|-----------|---|---|----------|-----------|--------|--------|-----|---------------------|--------|
| 327.1166 | 1 | C ₁₈ H ₁₈ F ₂ NaO ₂ | 327.1167 | 0.2 | 6.9 | 100.00 | 8.5 | even | ok |

HPLC spectra of 2f



PDA Ch1 251nm

| Peak# | Ret. Time | Area | Area% | Height | Conc. | Mark | ID# |
|-------|-----------|---------|---------|--------|-------|------|-----|
| 1 | 5.734 | 3619381 | 49.520 | 326947 | 0.000 | M | |
| 2 | 8.043 | 3689587 | 50.480 | 265676 | 0.000 | M | |
| 总计 | | 7308968 | 100.000 | 592623 | | | |



PDA Ch1 251nm

| Peak# | Ret. Time | Area | Area% | Height | Conc. | Mark | ID# |
|-------|-----------|--------|---------|--------|-------|------|-----|
| 1 | 5.797 | 12734 | 6.337 | 953 | 0.000 | M | |
| 2 | 8.172 | 188224 | 93.663 | 15695 | 0.000 | M | |
| 总计 | | 200958 | 100.000 | 16649 | | | |

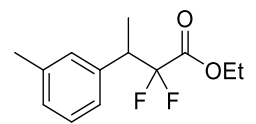
7.243
7.205
7.192
7.180
7.091
7.079
7.063

4.177
4.165
4.153
4.141

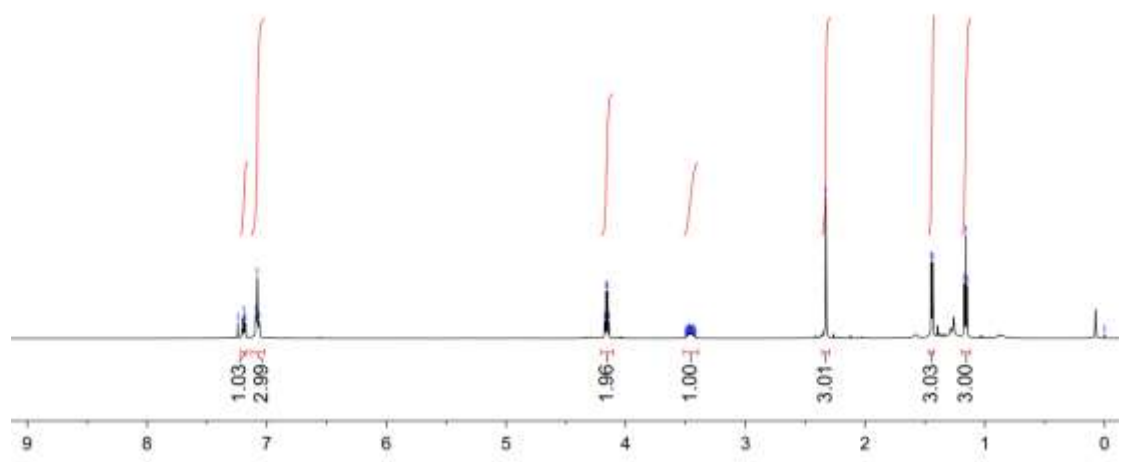
3.492
3.480
3.470
3.460
3.448
3.438
3.426

1.447
1.435
1.172
1.160
1.148

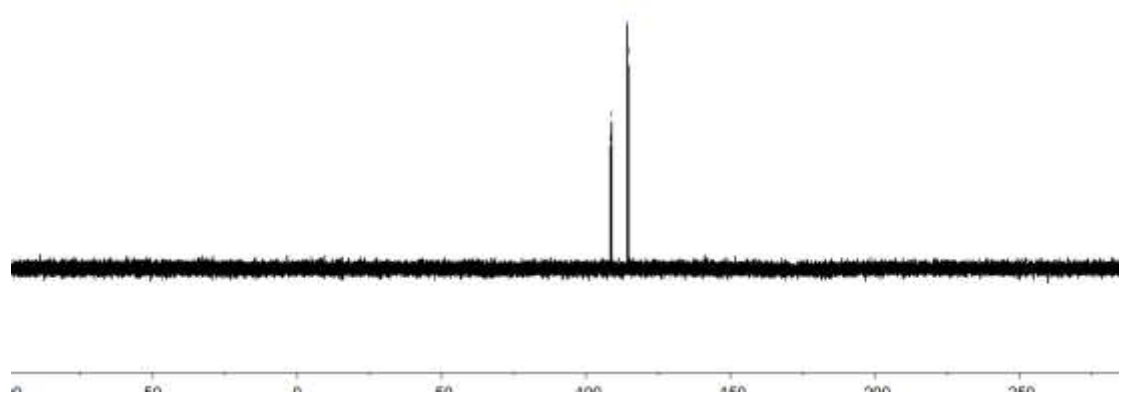
-0.000



2g ¹H NMR (600 MHz, CDCl₃)



108.386
108.833
114.309
114.757



164.250
164.043
163.826

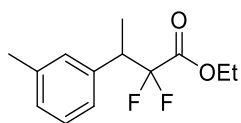
134.025
136.863
136.826
129.557
128.980
128.336
125.632
116.294
116.808
116.569
114.916

77.211
77.000
76.788

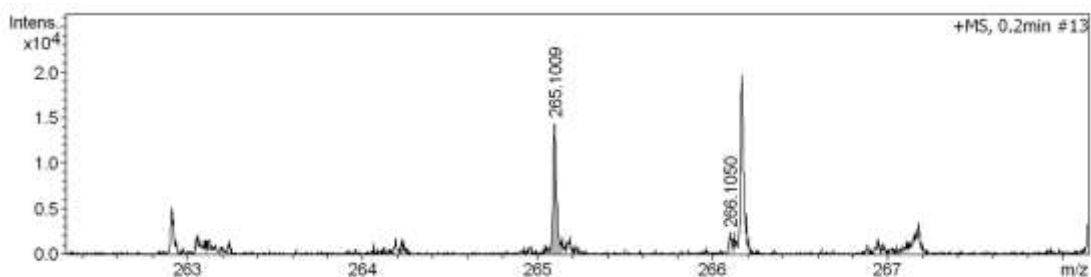
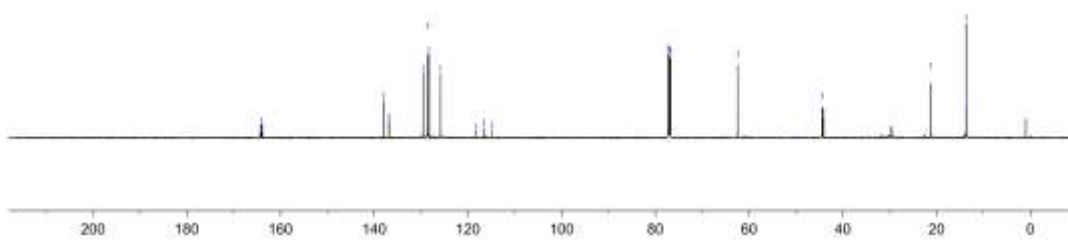
62.466

44.428
44.278
44.131

21.335
13.715
13.685
13.666



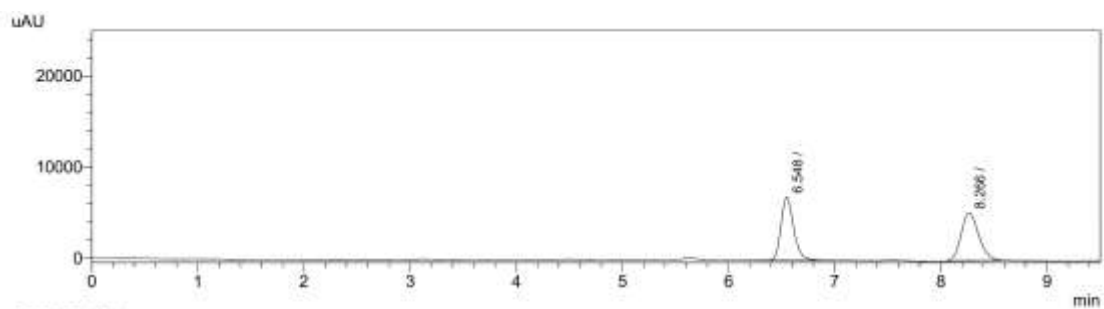
2g ^{13}C NMR (150 MHz, CDCl_3)



| # | m/z | Res. | S/N | I | I % | FWHM |
|---|----------|-------|------|-------|-------|--------|
| 1 | 265.1009 | 13516 | 28.6 | 14360 | 100.0 | 0.0196 |
| 2 | 266.1050 | 8869 | 4.7 | 2344 | 16.3 | 0.0300 |

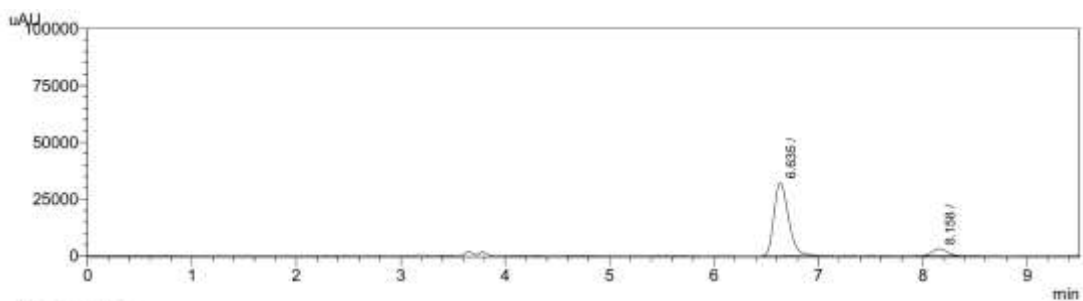
| Meas. m/z | # | Ion Formula | m/z | err [ppm] | mSigma | Score | rdb | e ⁻ Conf | N-Rule |
|-----------|---|---|----------|-----------|--------|-------|--------|---------------------|------------|
| 265.1009 | 1 | C ₁₃ H ₁₆ F ₂ NaO ₂ | 265.1011 | 0.7 | 14.0 | 2 | 100.00 | 4.5 | even ok |

HPLC spectra of 2g



PDA Ch1 264nm

| Peak# | Ret. Time | Area | Area% | Height | Conc. | Mark | ID# |
|-------|-----------|--------|---------|--------|-------|------|-----|
| 1 | 6.548 | 57229 | 48.566 | 6932 | 0.000 | M | |
| 2 | 8.266 | 60610 | 51.434 | 5278 | 0.000 | M | |
| Σ(1) | | 117839 | 100.000 | 12210 | | | |



PDA Ch1 264nm

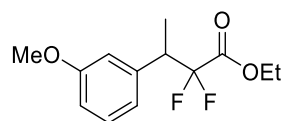
| Peak# | Ret. Time | Area | Area% | Height | Conc. | Mark | ID# |
|-------|-----------|--------|---------|--------|-------|------|-----|
| 1 | 6.635 | 311797 | 90.776 | 32398 | 0.000 | M | |
| 2 | 8.158 | 31681 | 9.224 | 3176 | 0.000 | M | |
| Σ(1) | | 343477 | 100.000 | 35573 | | | |

7.254
7.236
7.223
7.221
7.209
6.867
6.855
6.826
6.816
6.812

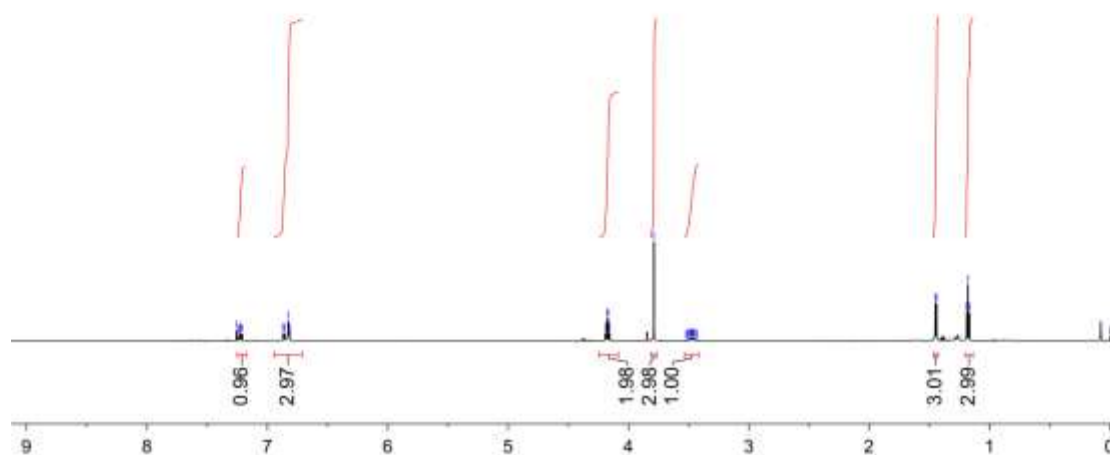
4.191
4.179
4.167
4.155
3.788
3.520
3.508
3.496
3.486
3.477
3.474
3.465
3.454
3.443
3.431

1.451
1.439
1.190
1.178
1.166

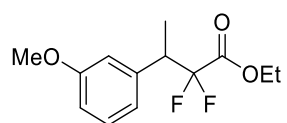
—0.000



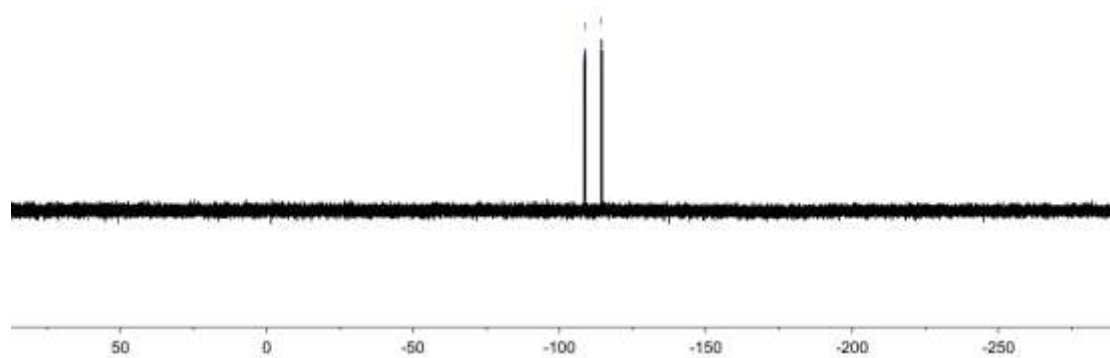
2h ^1H NMR (600 MHz, CDCl_3)

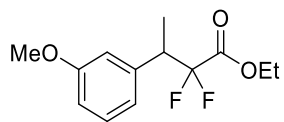


108.379
108.825
114.149
114.592

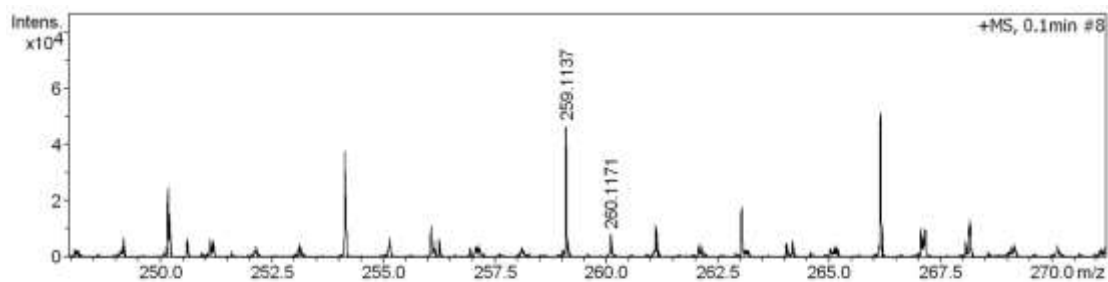
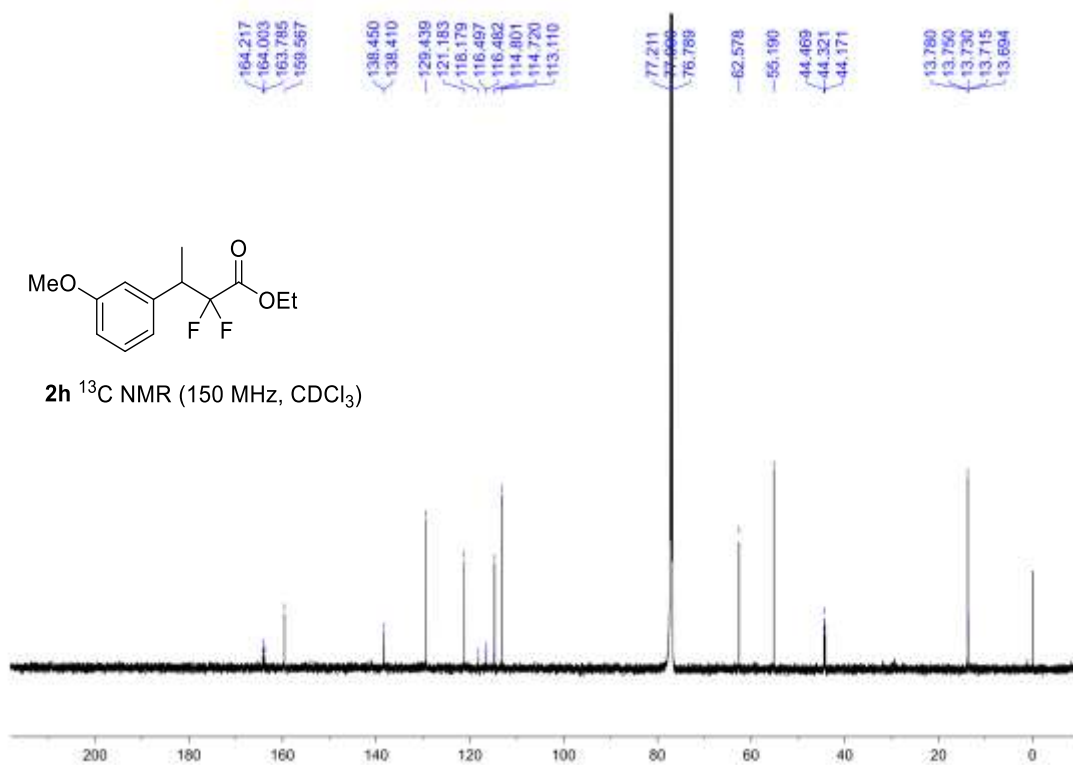


2h ^{19}F NMR (564 MHz, CDCl_3)





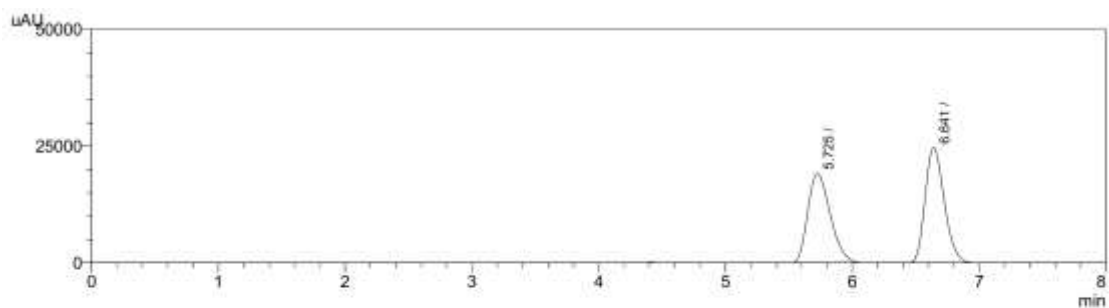
2h ^{13}C NMR (150 MHz, CDCl_3)



| # | m/z | Res. | S/N | I | I% | FWHM |
|---|----------|-------|-------|-------|-------|--------|
| 1 | 259.1137 | 13437 | 108.1 | 46416 | 100.0 | 0.0193 |
| 2 | 260.1171 | 10623 | 18.7 | 8044 | 17.3 | 0.0245 |

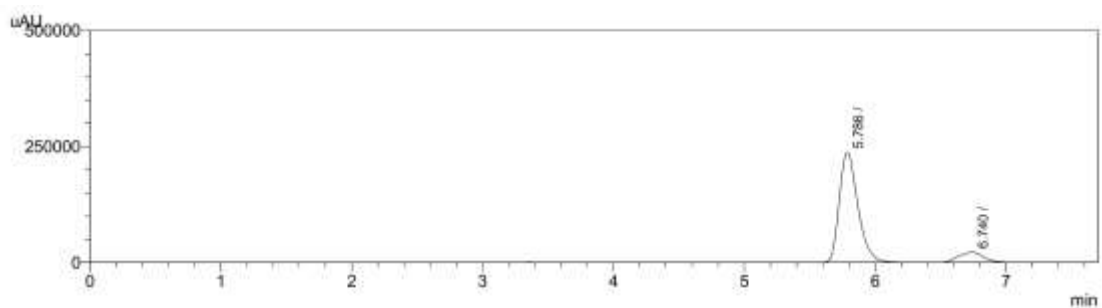
| Meas. m/z | # | Ion Formula | m/z | err [ppm] | mSigma | Score | rdb | e ⁻ Conf | N-Rule |
|-----------|---|---|----------|-----------|--------|-------|--------|---------------------|--------|
| 259.1137 | 1 | C ₁₃ H ₁₇ F ₂ O ₃ | 259.1140 | 1.5 | 19.4 | 2 | 100.00 | 4.5 even | ok |

HPLC spectra of hi



PDA Ch1 273nm

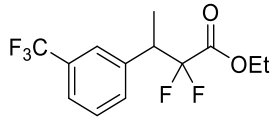
| Peak# | Ret. Time | Area | Area% | Height | Conc. | Mark | ID# |
|-------|-----------|--------|---------|--------|--------|------|-----|
| 1 | 5.725 | 240044 | 47.865 | 19283 | 47.865 | M | |
| 2 | 6.641 | 261458 | 52.135 | 24752 | 52.135 | M | |
| 总计 | | 501502 | 100.000 | 44036 | | | |



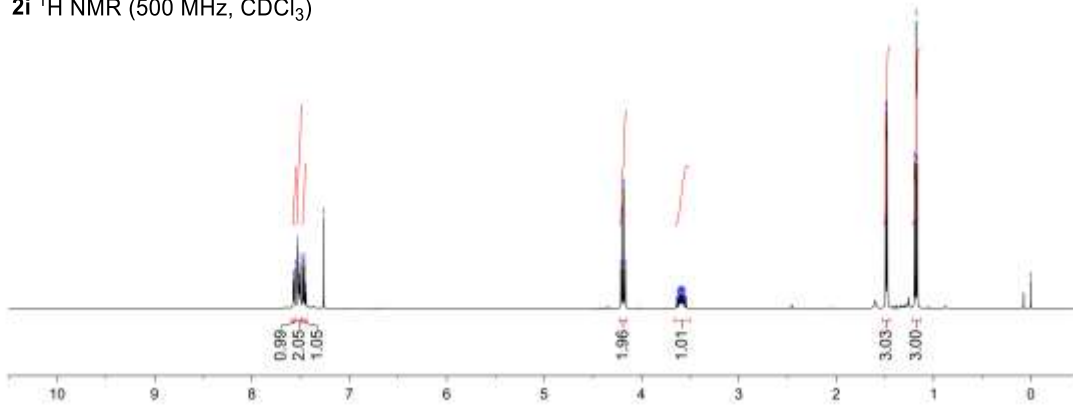
PDA Ch1 273nm

| Peak# | Ret. Time | Area | Area% | Height | Conc. | Mark | ID# |
|-------|-----------|---------|---------|--------|-------|------|-----|
| 1 | 5.786 | 2349224 | 88.527 | 237071 | 0.000 | | |
| 2 | 6.740 | 304464 | 11.473 | 22019 | 0.000 | V | |
| 总计 | | 2653688 | 100.000 | 259090 | | | |

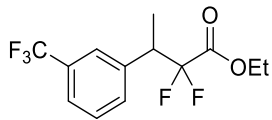
7.573, 7.568, 7.529, 7.515, 7.500, 7.476, 7.461, 7.445, 7.281, 4.209, 4.195, 4.181, 4.166, 3.629, 3.614, 3.608, 3.601, 3.593, 3.587, 3.579, 3.573, 3.566, 3.552, 3.537, 1.476, 1.195, 1.181, 1.166, -0.000



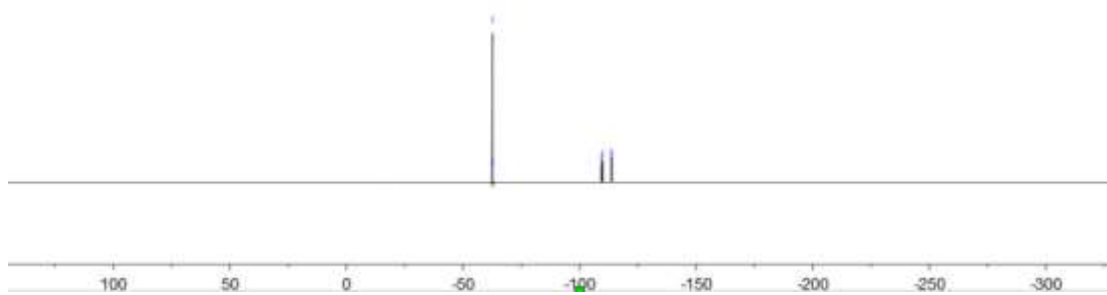
2i ¹H NMR (500 MHz, CDCl₃)



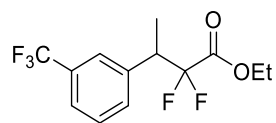
-62.896, -62.704, -62.714, -109.306, -109.846, -113.391, -113.931



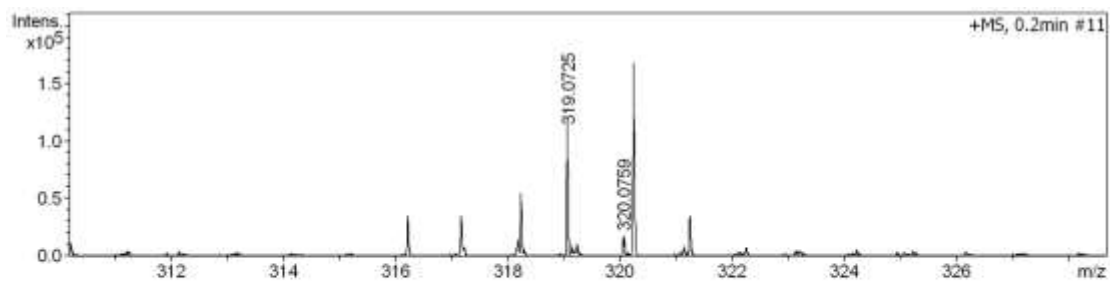
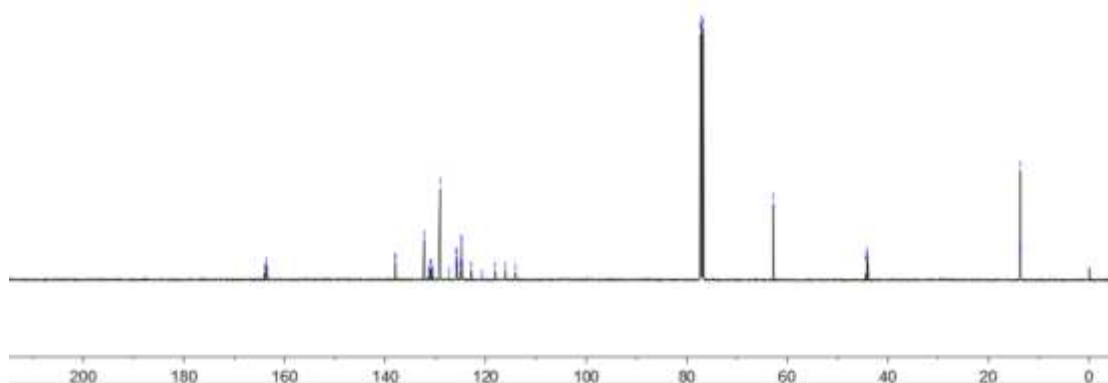
2i ¹⁹F NMR (470 MHz, CDCl₃)



163.911
163.851
163.392
137.966
137.920
132.218
130.998
130.741
129.048
125.805
125.777
125.747
125.719
125.016
124.855
124.824
124.795
124.765
122.852
116.117
116.092
77.259
77.000
76.747
-62.800
44.346
44.159
43.982
13.685
13.667
13.647
13.623



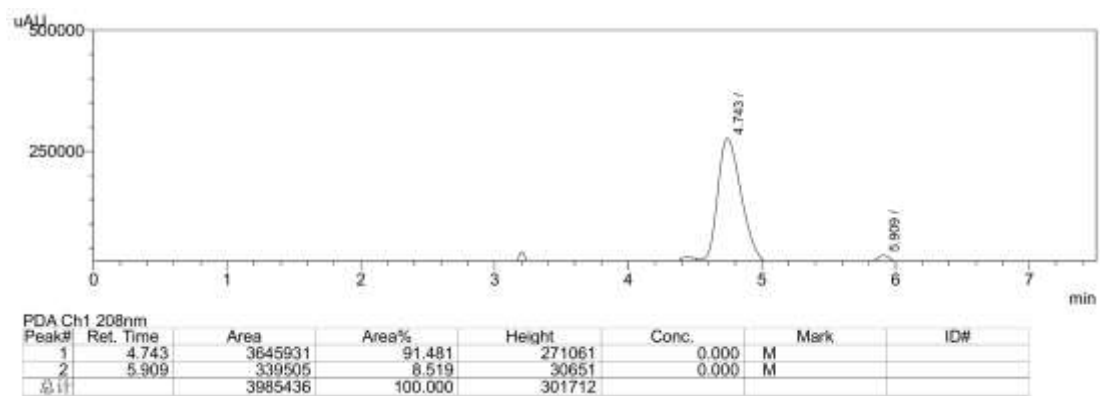
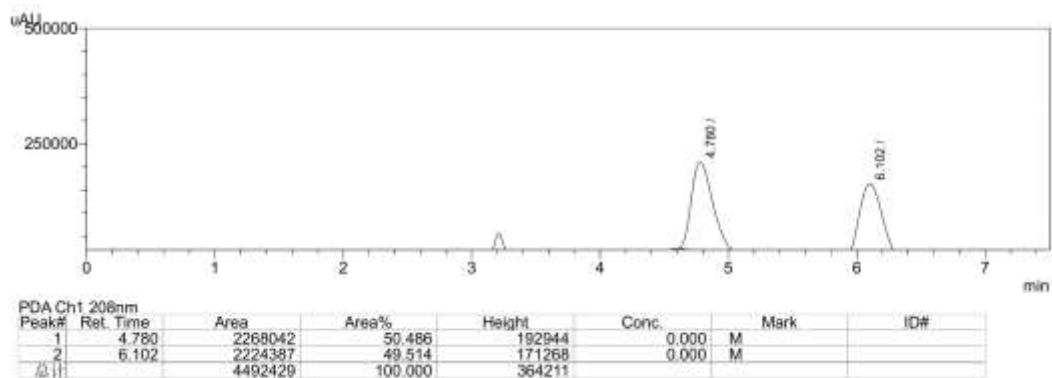
2i ^{13}C NMR (125 MHz, CDCl_3)

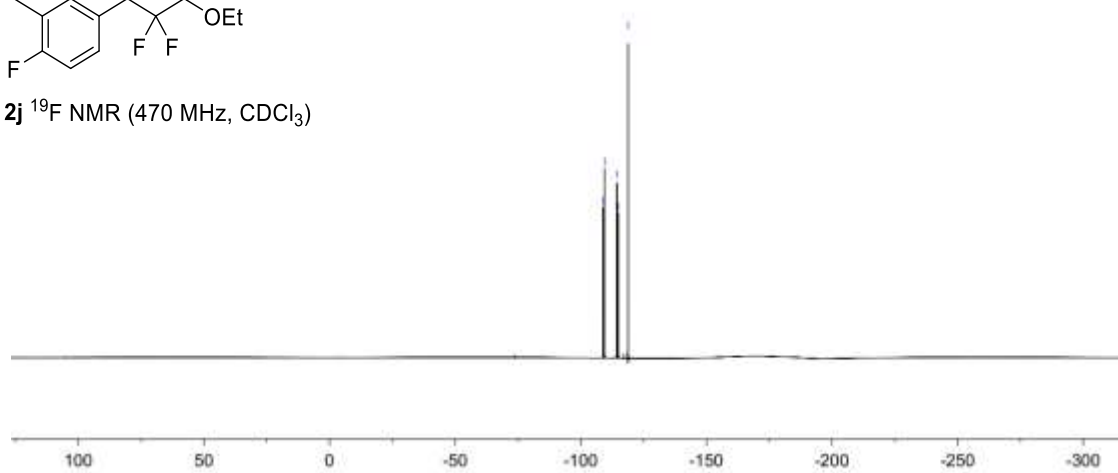
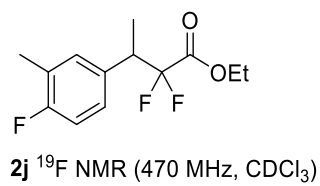
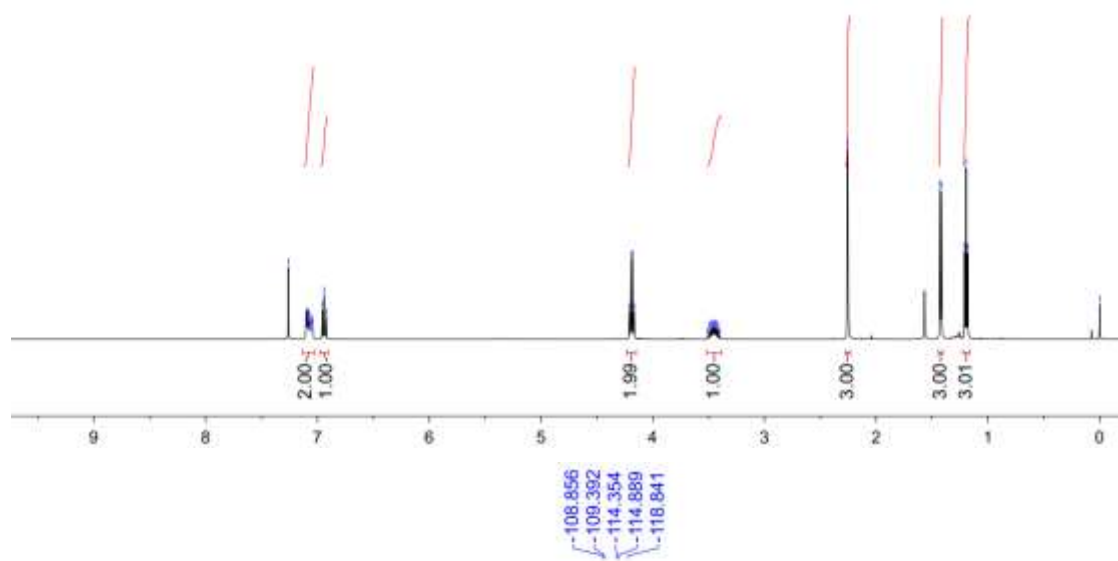


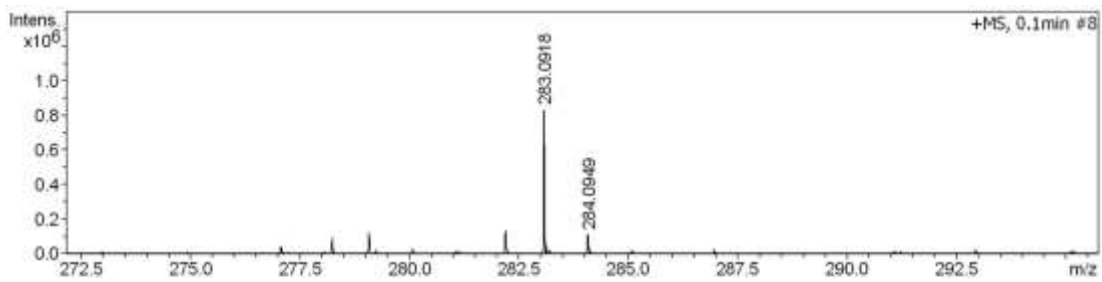
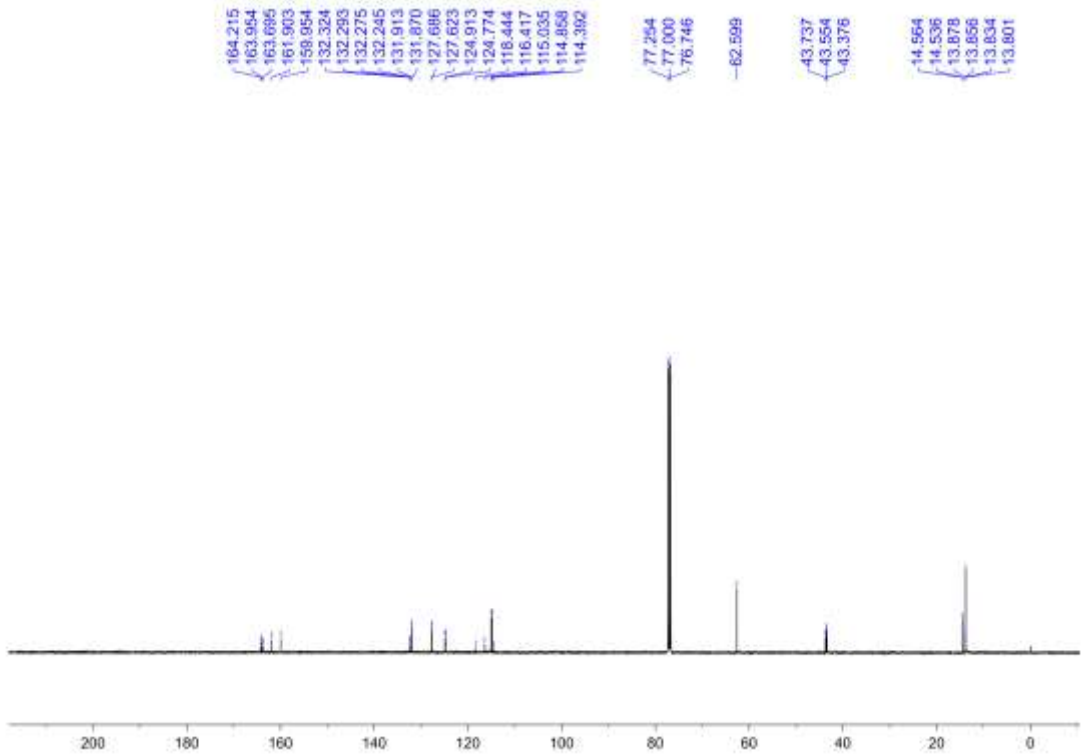
| # | m/z | Res. | S/N | I | I% | FWHM |
|---|----------|-------|-------|--------|-------|--------|
| 1 | 319.0725 | 12640 | 211.1 | 108932 | 100.0 | 0.0252 |
| 2 | 320.0759 | 13679 | 33.0 | 17028 | 15.6 | 0.0234 |
| 3 | 321.0819 | 9834 | 3.6 | 1888 | 1.7 | 0.0327 |

| Meas. m/z | # | Ion Formula | m/z | err [ppm] | mSigma | Score | rdb | e ⁻ Conf | N-Rule |
|-----------|---|--|----------|-----------|--------|-------|-----|---------------------|--------|
| 319.0725 | 1 | $\text{C}_{13}\text{H}_{13}\text{F}_5\text{NaO}_2$ | 319.0728 | 0.8 | 11.0 | 90.49 | 4.5 | even | ok |

HPLC spectra of 2i



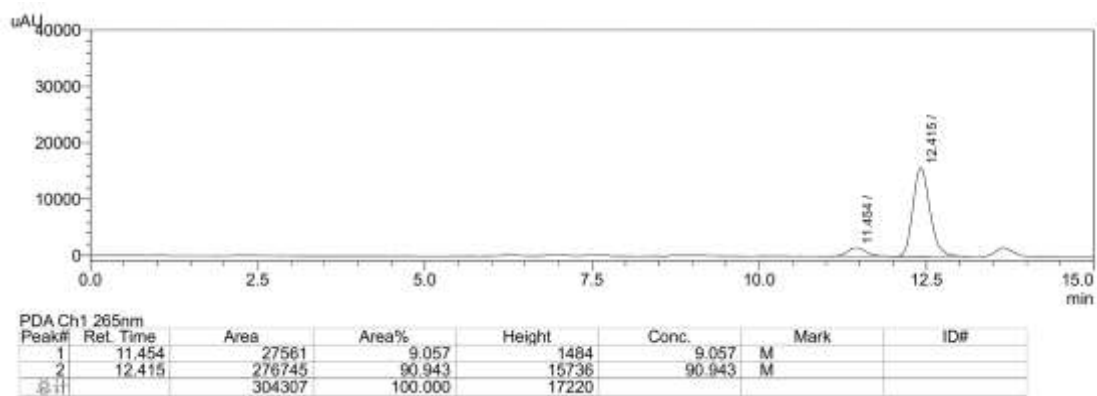
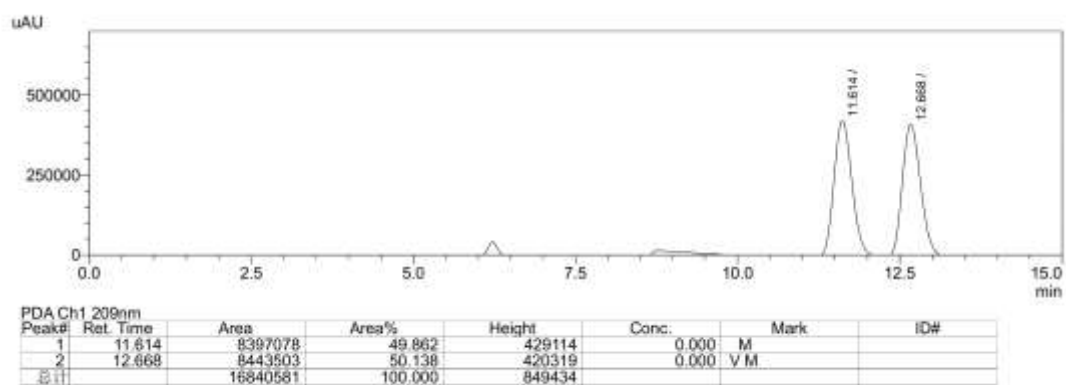


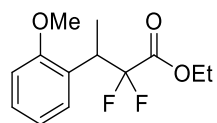


| # | m/z | Res. | S/N | I | I% | FWHM |
|---|----------|-------|--------|--------|-------|--------|
| 1 | 283.0918 | 20885 | 1655.7 | 828204 | 100.0 | 0.0136 |
| 2 | 284.0949 | 15120 | 215.7 | 108640 | 13.1 | 0.0188 |
| 3 | 285.0977 | 11935 | 23.9 | 12084 | 1.5 | 0.0239 |

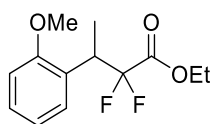
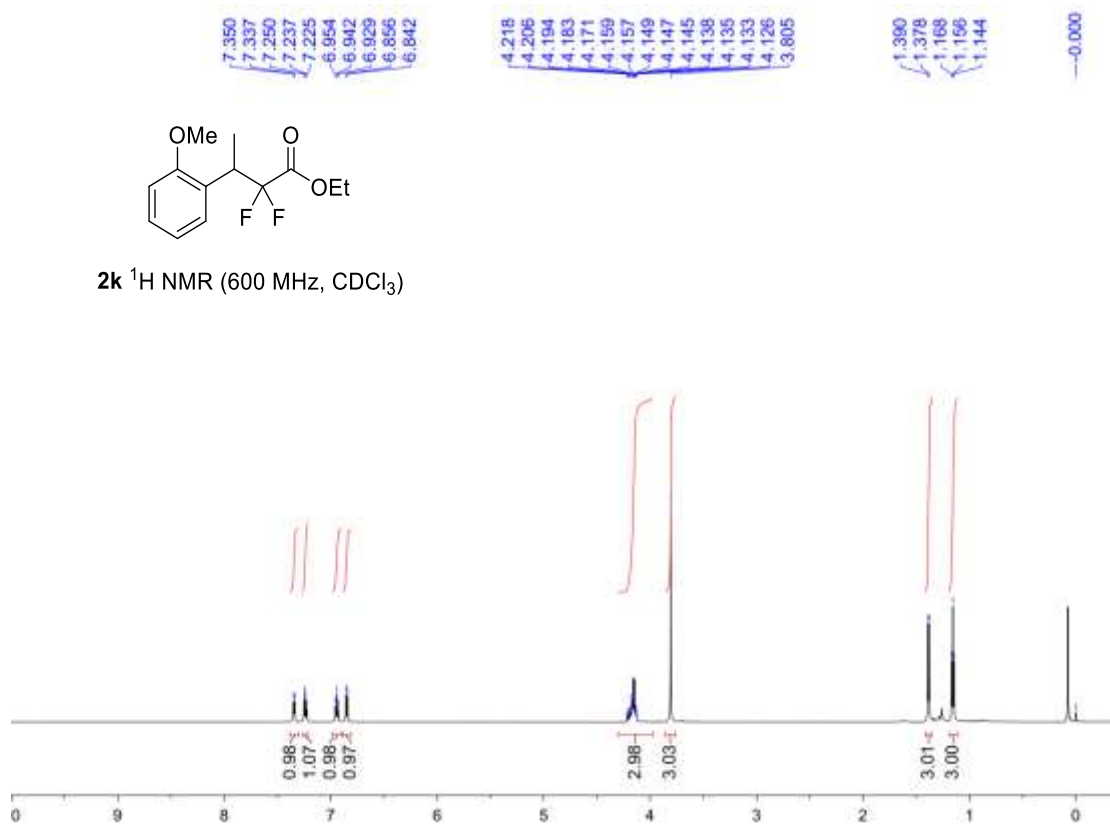
| Meas. m/z | # | Ion Formula | m/z | err [ppm] | mSigma | Score | rdb | e ⁻ Conf | N-Rule |
|-----------|---|---|----------|-----------|--------|-------|--------|---------------------|------------|
| 283.0918 | 1 | C ₁₃ H ₁₅ F ₃ NaO ₂ | 283.0916 | -0.7 | 6.9 | 1 | 100.00 | 4.5 | even ok |

HPLC spectra of 2j

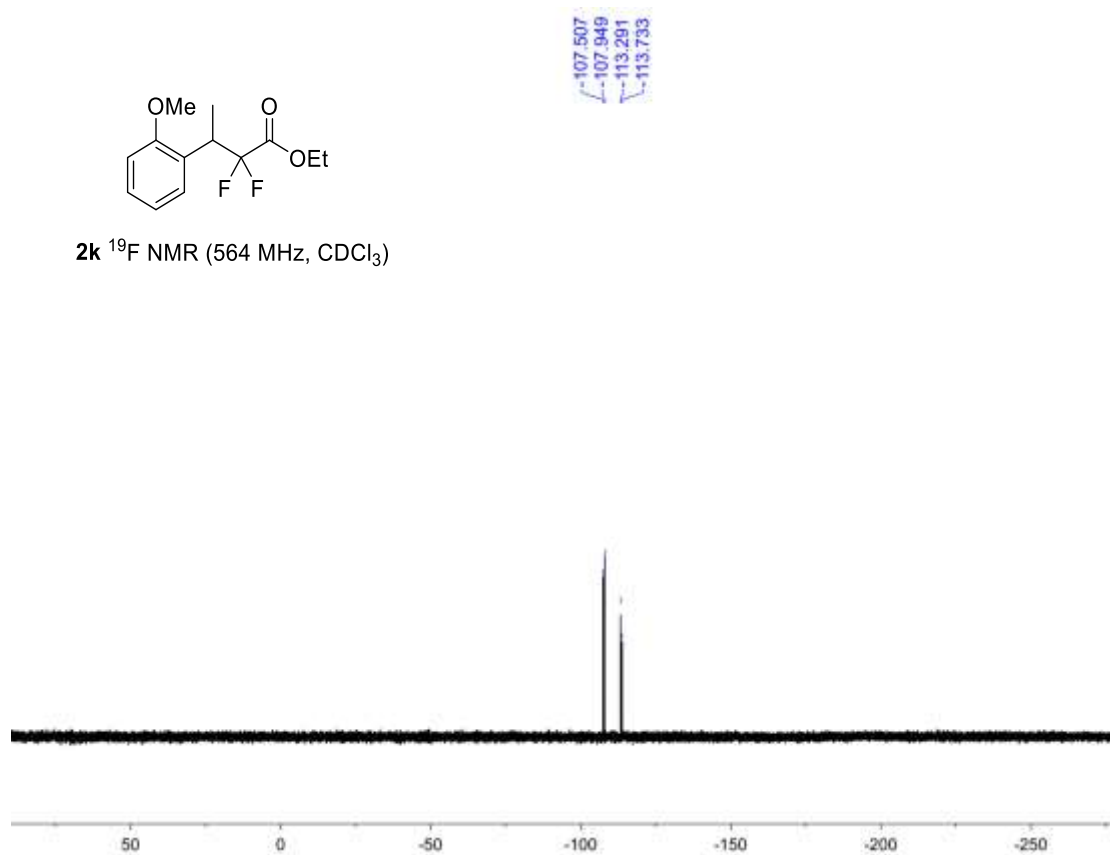




2k ^1H NMR (600 MHz, CDCl_3)



2k ^{19}F NMR (564 MHz, CDCl_3)



164.410
164.193
163.976
157.003

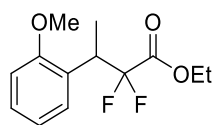
128.752
128.646
125.846
125.808
120.740
118.432
116.755
116.743
115.066
110.489

77.211
77.000
76.789

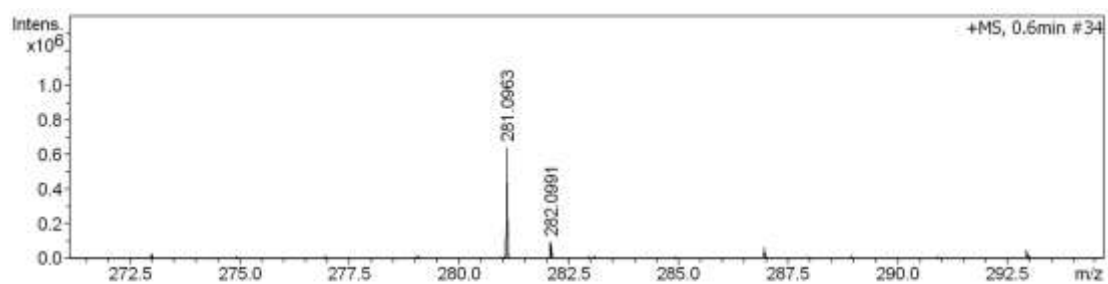
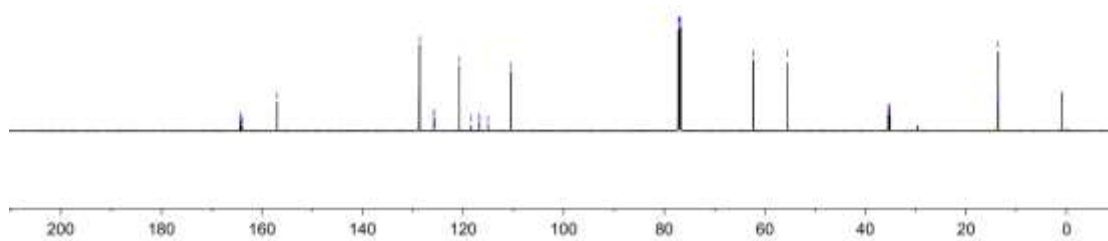
-62.337
-55.504

35.467
35.315
35.163

13.666
13.643
13.622
13.607
13.586



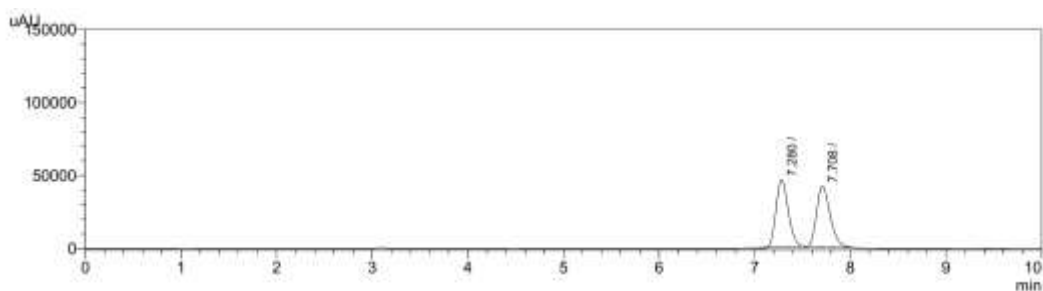
2k ¹³C NMR (150 MHz, CDCl₃)



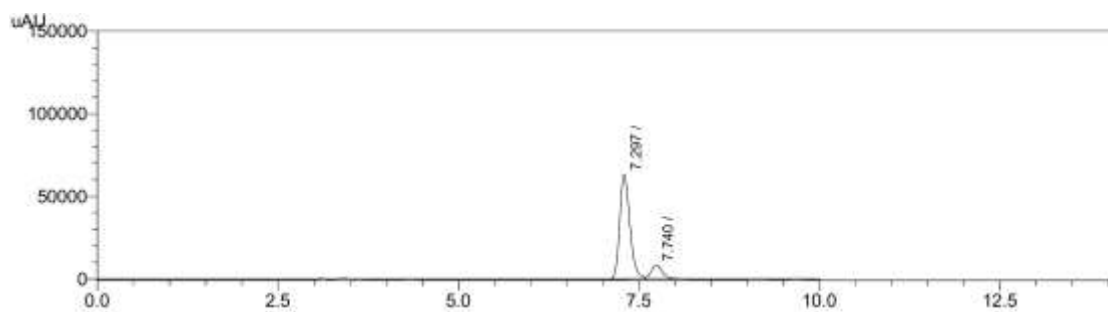
| # | m/z | Res. | S/N | I | I % | FWHM |
|---|----------|-------|--------|--------|-------|--------|
| 1 | 281.0963 | 17588 | 1332.9 | 640120 | 100.0 | 0.0160 |
| 2 | 282.0991 | 13868 | 195.4 | 93984 | 14.7 | 0.0203 |
| 3 | 283.1011 | 11746 | 21.4 | 10320 | 1.6 | 0.0241 |

| Meas. m/z | # | Ion Formula | m/z | err [ppm] | mSigma | Score | rdb | e ⁻ Conf | N-Rule |
|-----------|---|---|----------|-----------|--------|--------|-----|---------------------|--------|
| 281.0963 | 1 | C ₁₃ H ₁₆ F ₂ NaO ₃ | 281.0960 | -1.2 | 1.9 | 100.00 | 4.5 | even | ok |

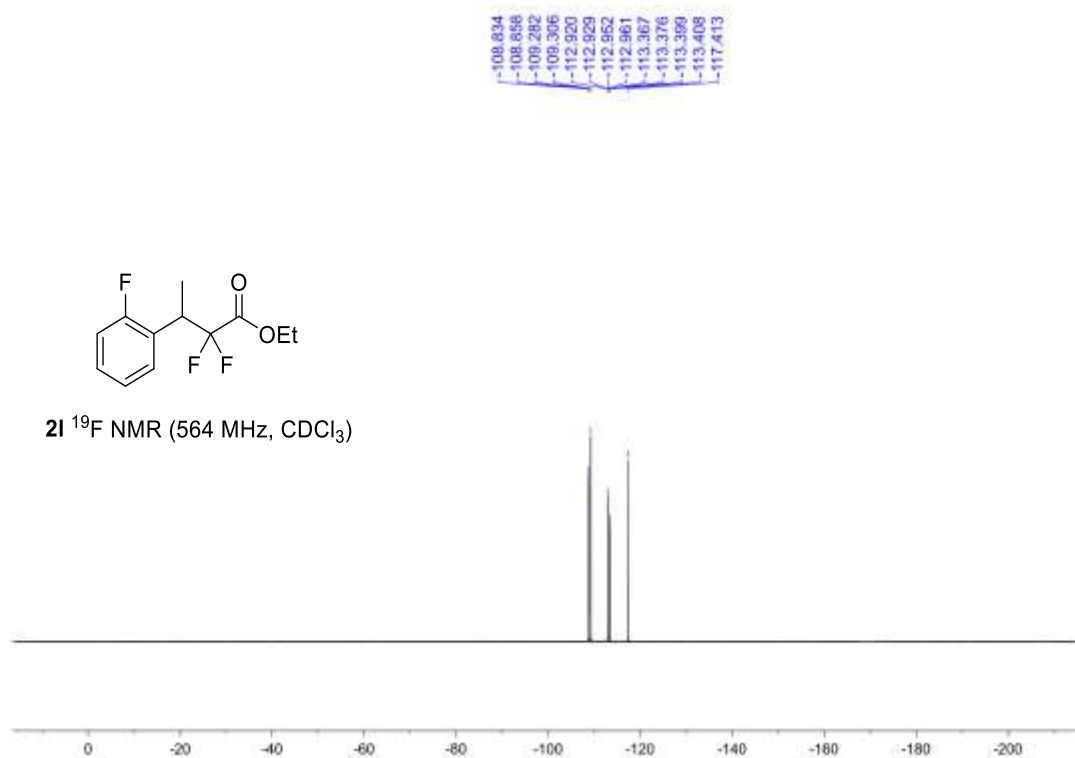
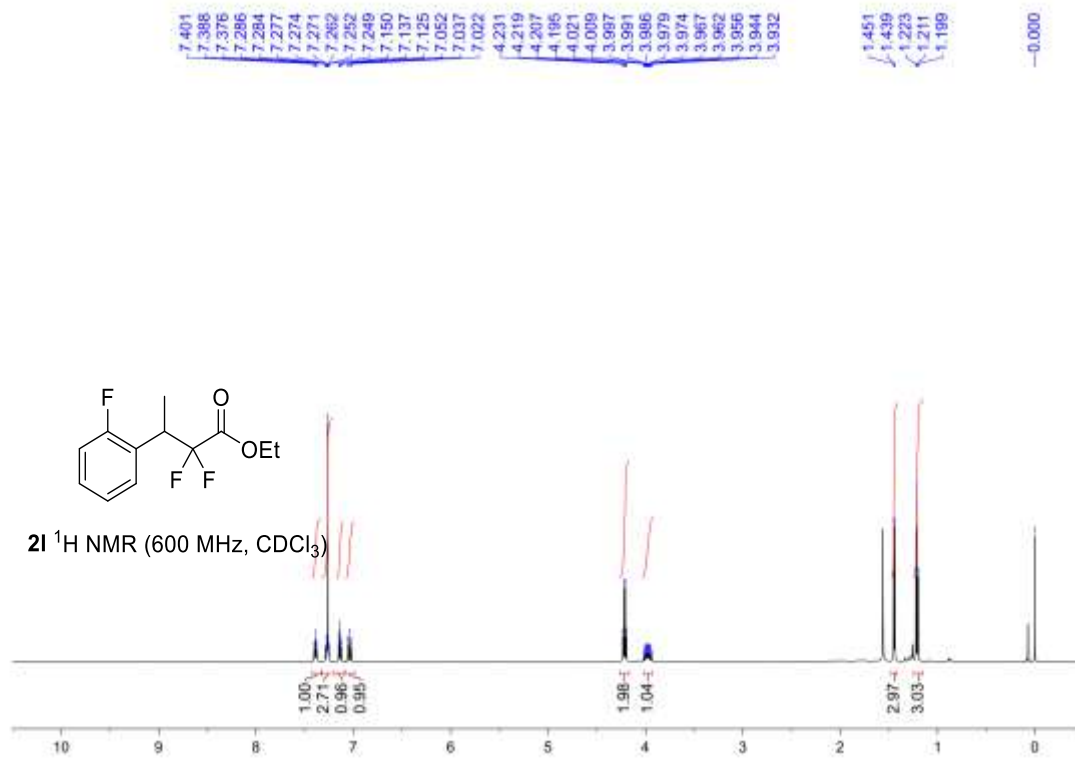
HPLC spectra of 2k

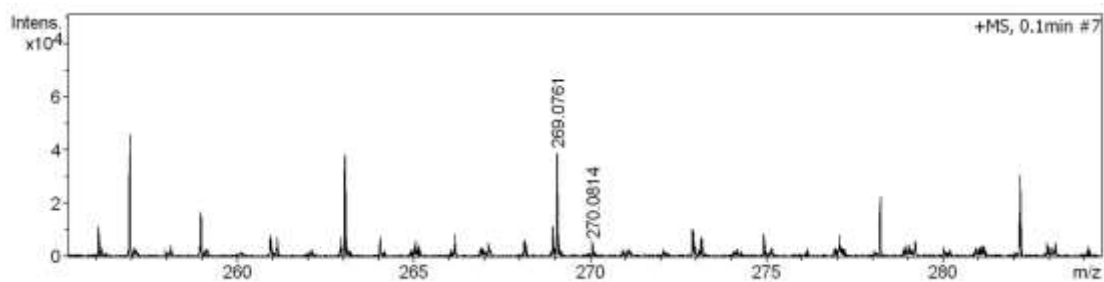
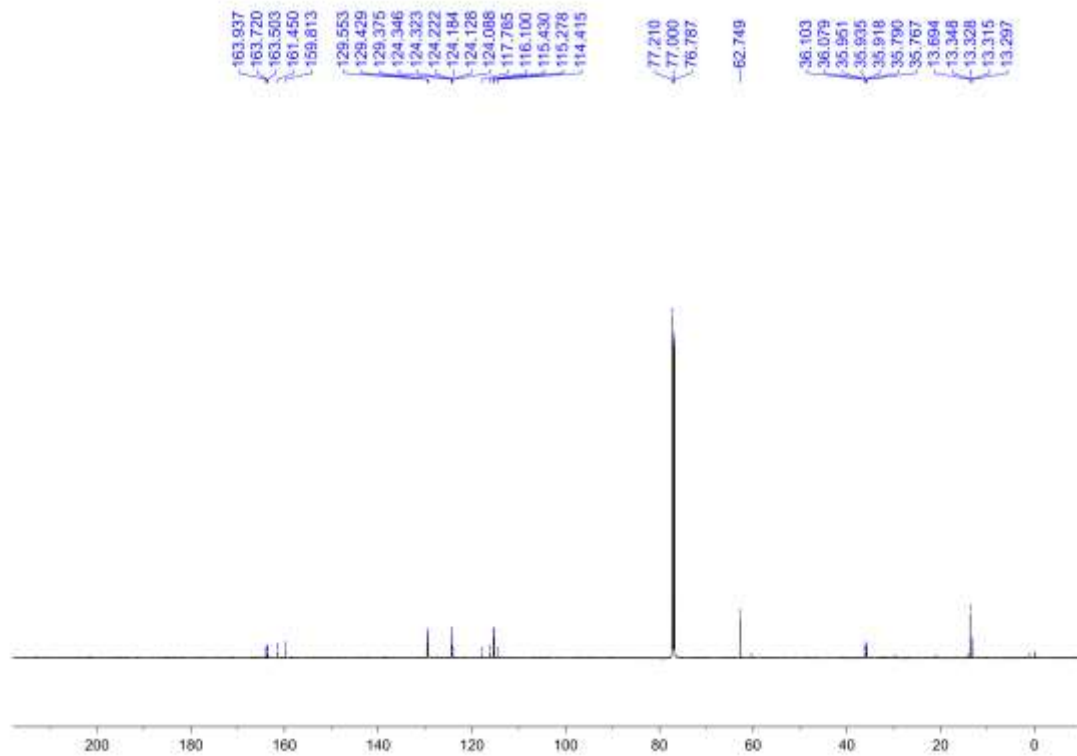


| Peak# | Ret. Time | Area | Area% | Height | Conc. | Mark | ID# |
|-------|-----------|--------|---------|--------|-------|------|-----|
| 1 | 7.280 | 405945 | 49.798 | 46055 | 0.000 | M | |
| 2 | 7.708 | 409243 | 50.202 | 41688 | 0.000 | M | |
| 总计 | | 815187 | 100.000 | 87744 | | | |



| Peak# | Ret. Time | Area | Area% | Height | Conc. | Mark | ID# |
|-------|-----------|--------|---------|--------|--------|------|-----|
| 1 | 7.297 | 615478 | 87.597 | 63309 | 87.597 | M | |
| 2 | 7.740 | 87143 | 12.403 | 8260 | 12.403 | V M | |
| 总计 | | 702621 | 100.000 | 71570 | | | |

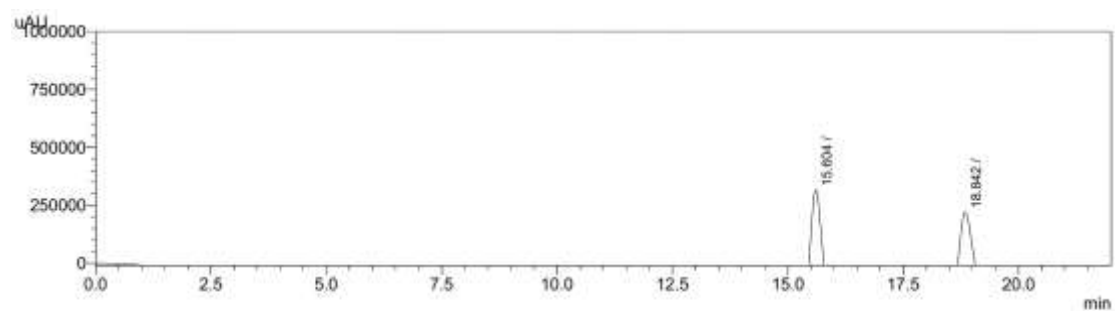




| # | m/z | Res. | S/N | I | I% | FWHM |
|---|----------|-------|------|-------|-------|--------|
| 1 | 269.0761 | 15507 | 83.3 | 38532 | 100.0 | 0.0174 |
| 2 | 270.0814 | 9136 | 9.9 | 4612 | 12.0 | 0.0296 |

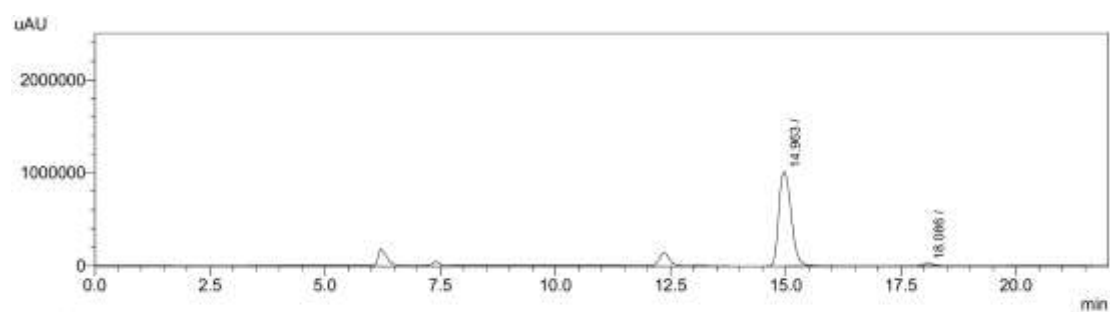
| Meas. m/z | # | Ion Formula | m/z | err [ppm] | mSigma | Score | rdb | e ⁻ Conf | N-Rule |
|-----------|---|---|----------|-----------|--------|-------|--------|---------------------|---------|
| 269.0761 | 1 | C ₁₂ H ₁₃ F ₃ NaO ₂ | 269.0760 | -0.2 | 23.8 | 1 | 100.00 | 4.5 | even ok |

HPLC spectra of 21



PDA Ch1 210nm

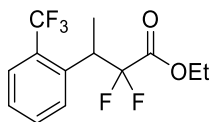
| Peak# | Ret. Time | Area | Area% | Height | Conc. | Mark | ID# |
|-------|-----------|----------|---------|--------|--------|------|-----|
| 1 | 15.604 | 7499299 | 50.042 | 457238 | 50.042 | M | |
| 2 | 18.842 | 7486632 | 49.958 | 364764 | 49.958 | M | |
| 总计 | | 14985931 | 100.000 | 822002 | | | |



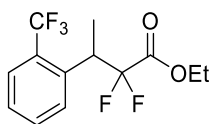
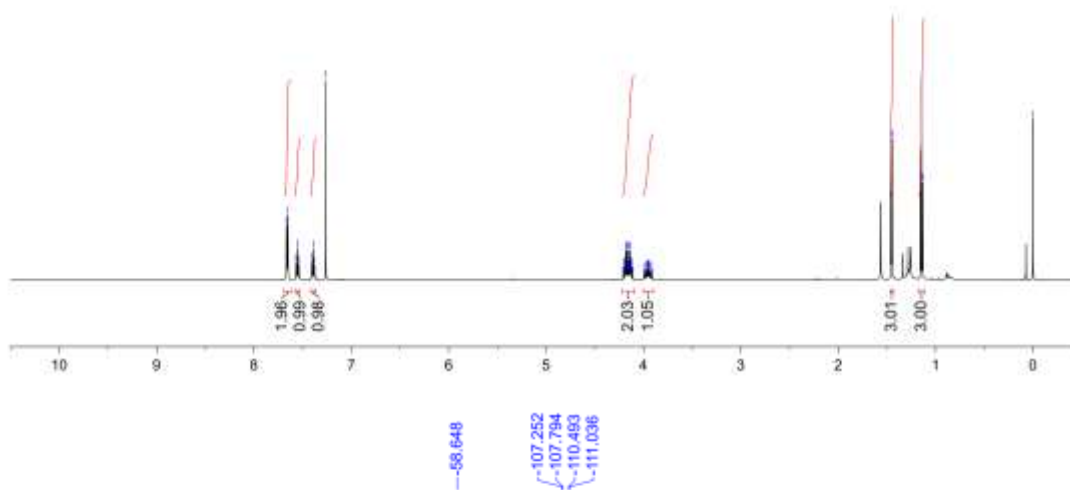
PDA Ch1 210nm

| Peak# | Ret. Time | Area | Area% | Height | Conc. | Mark | ID# |
|-------|-----------|----------|---------|---------|--------|------|-----|
| 1 | 14.963 | 18990752 | 97.604 | 1014628 | 97.604 | M | |
| 2 | 18.086 | 466113 | 2.396 | 25729 | 2.396 | M | |
| 总计 | | 19456865 | 100.000 | 1040357 | | | |

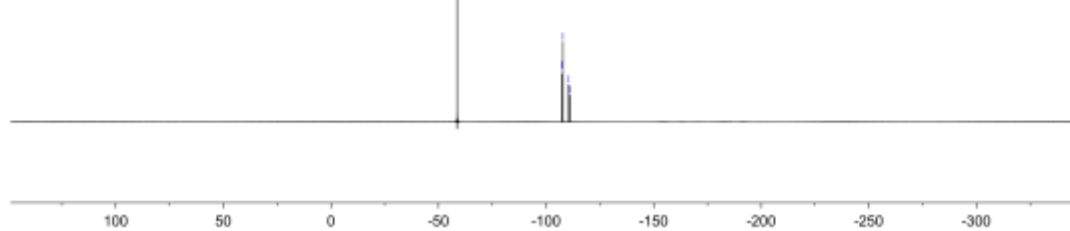
7.665
7.651
7.566
7.553
7.541
7.404
7.391
7.378
7.261
4.210
4.196
4.192
4.186
4.180
4.174
4.168
4.162
4.156
4.150
4.144
4.138
4.132
4.127
4.120
4.109
3.985
3.973
3.960
3.957
3.948
3.945
3.932
3.920
3.908
3.858
1.446
1.155
1.143
1.131
-0.000

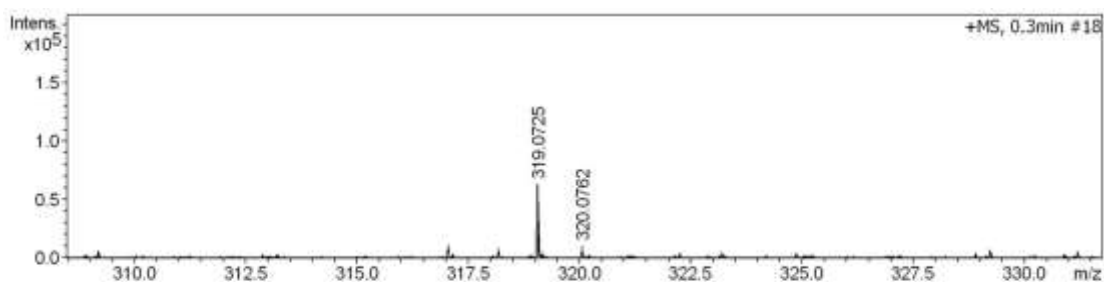
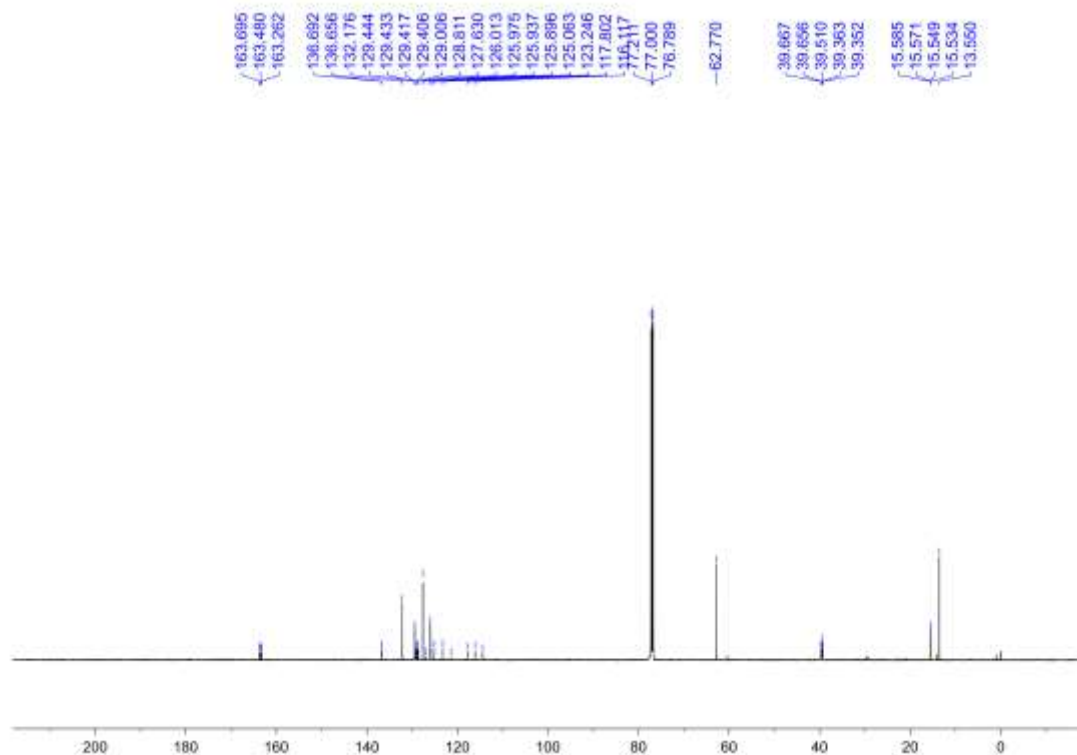


2m ^1H NMR (600 MHz, CDCl_3)



2m ^{19}F NMR (470 MHz, CDCl_3)

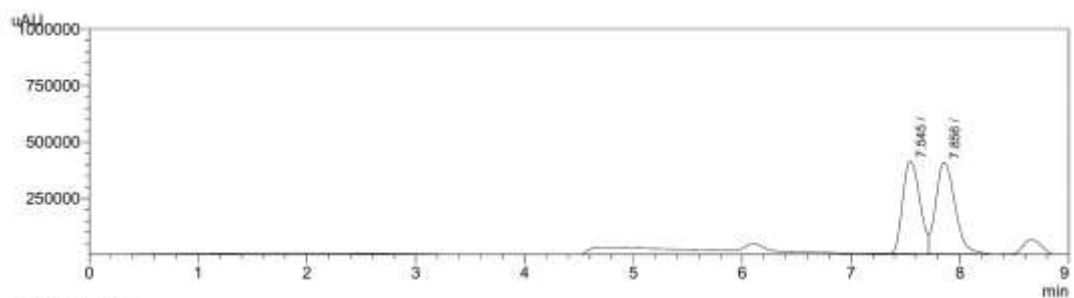




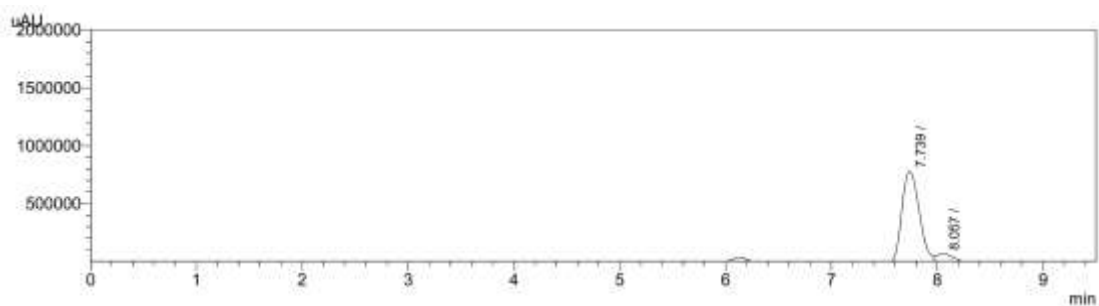
| # | m/z | Res. | S/N | I | I% | FWHM |
|---|----------|-------|-------|-------|-------|--------|
| 1 | 319.0725 | 14400 | 123.7 | 62776 | 100.0 | 0.0222 |
| 2 | 320.0762 | 14600 | 19.4 | 9852 | 15.7 | 0.0219 |

| Meas. m/z | # | Ion Formula | m/z | err [ppm] | mSigma | Score | rdb | e ⁻ Conf | N-Rule |
|-----------|---|---|----------|-----------|--------|-------|-------|---------------------|---------|
| 319.0725 | 1 | C ₁₃ H ₁₃ F ₅ NaO ₂ | 319.0728 | 1.0 | 8.5 | 1 | 90.19 | 4.5 | even ok |

HPLC spectra of 2m

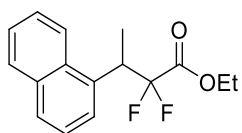


| Peak# | Ret. Time | Area | Area% | Height | Conc. | Mark | ID# |
|-------|-----------|---------|---------|--------|-------|------|-----|
| 1 | 7.545 | 4494989 | 47.496 | 410618 | 0.000 | M | |
| 2 | 7.856 | 4968863 | 52.504 | 404232 | 0.000 | V M | |
| Σ | | 9463852 | 100.000 | 814850 | | | |

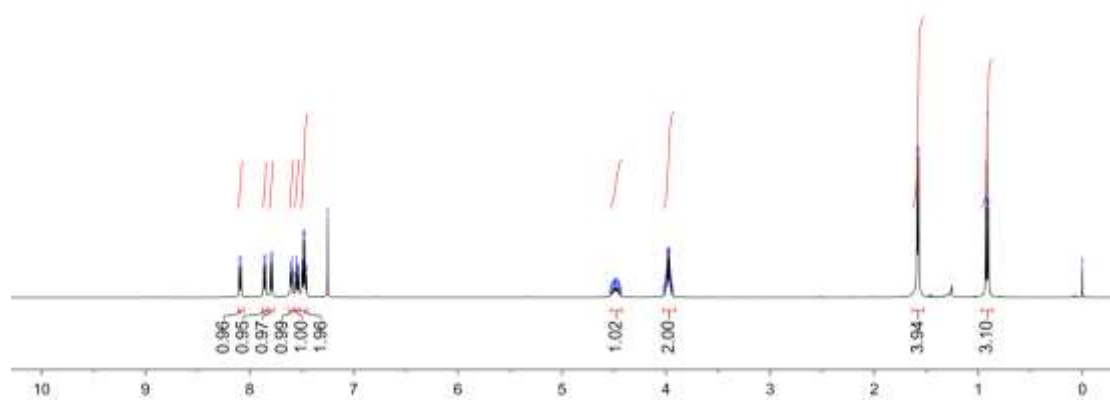


| Peak# | Ret. Time | Area | Area% | Height | Conc. | Mark | ID# |
|-------|-----------|---------|---------|--------|-------|------|-----|
| 1 | 7.739 | 8943350 | 91.810 | 785559 | 0.000 | M | |
| 2 | 8.057 | 797839 | 8.190 | 71825 | 0.000 | V M | |
| Σ | | 9741188 | 100.000 | 857384 | | | |

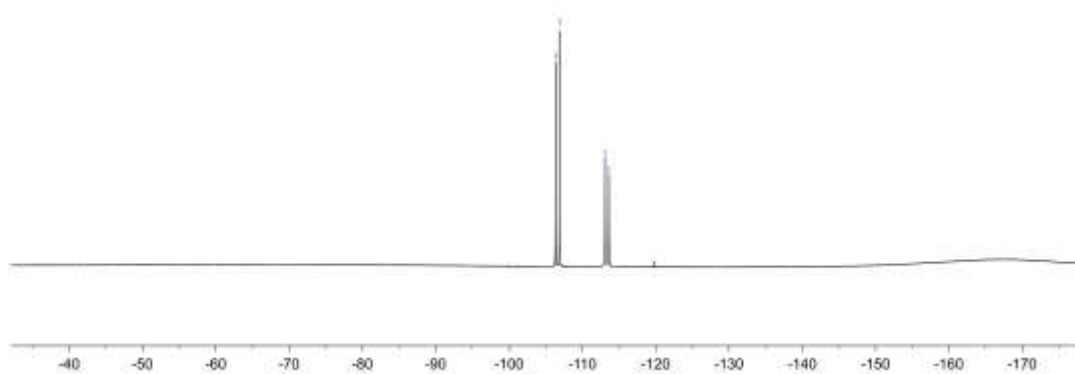
8.099
7.864
7.848
7.789
7.783
7.607
7.593
7.562
7.560
7.548
7.546
7.531
7.529
7.497
7.484
7.469
7.454
7.251
4.536
4.522
4.508
4.495
4.485
4.471
4.458
4.444
4.423
4.009
4.002
3.985
3.987
3.981
3.973
3.966
3.959
3.952
3.945
3.931
1.588
1.574
0.930
0.916
0.902
-0.000

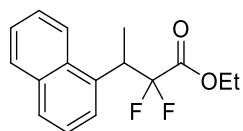


2n ^1H NMR (500 MHz, CDCl_3)

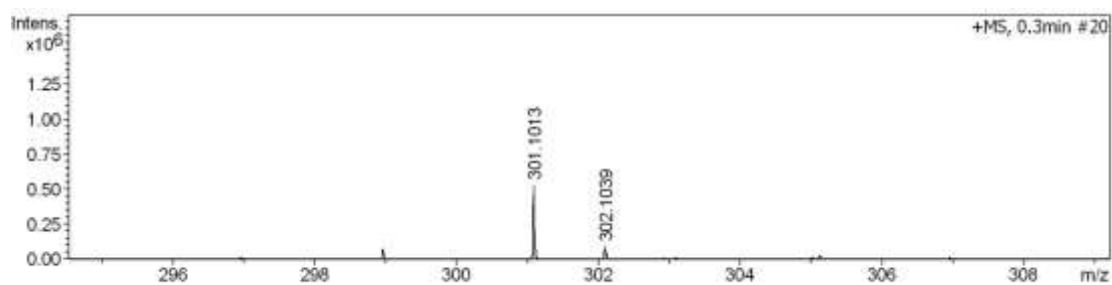
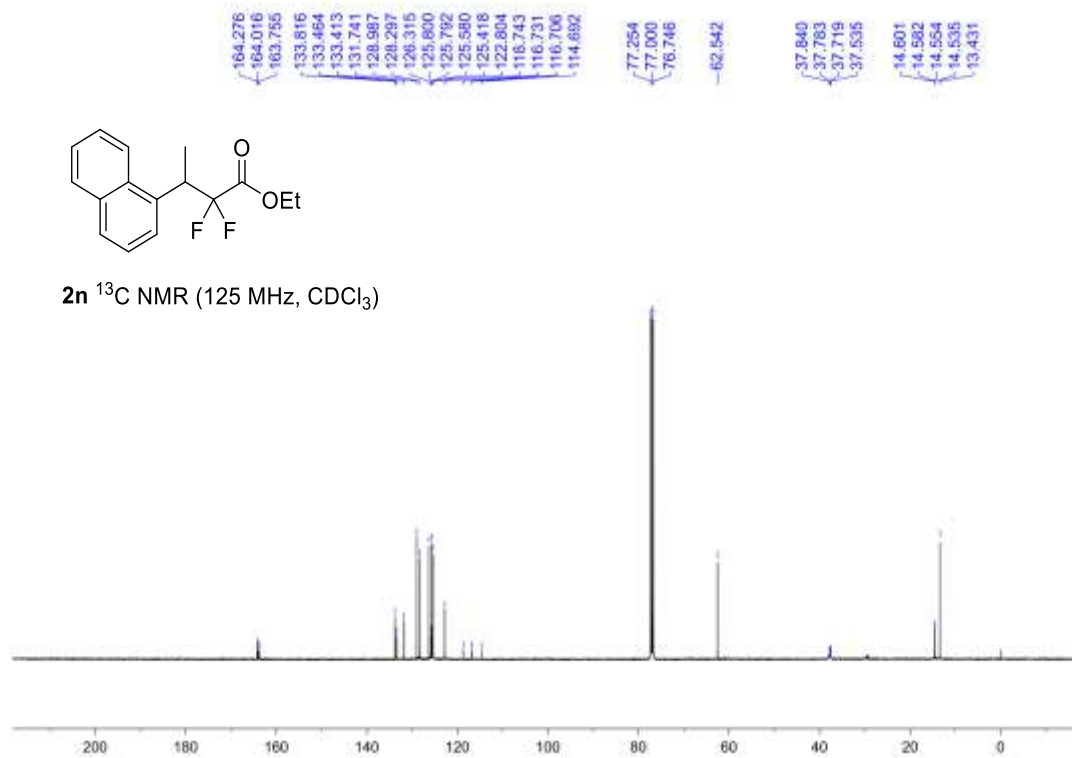


106.334
106.868
113.088
113.832





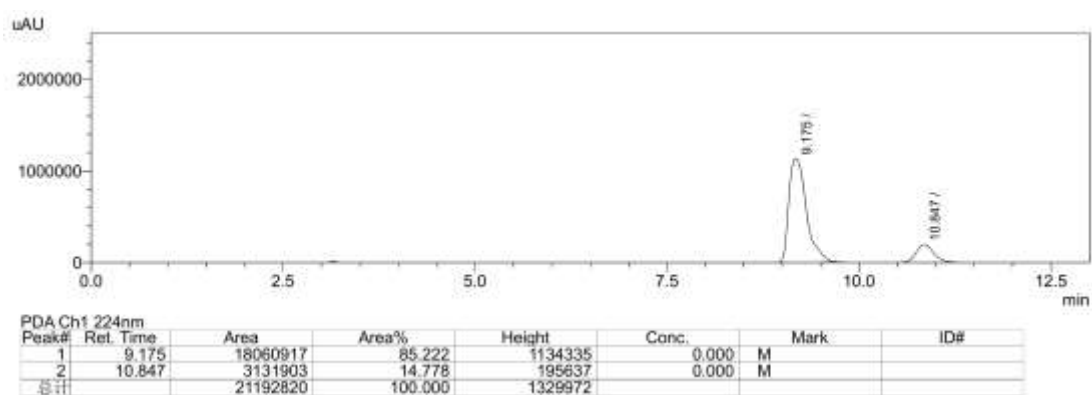
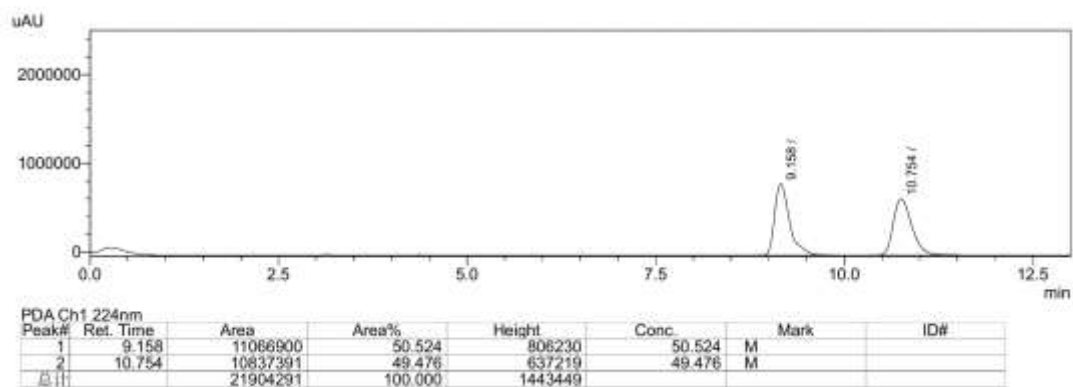
2n ¹³C NMR (125 MHz, CDCl₃)

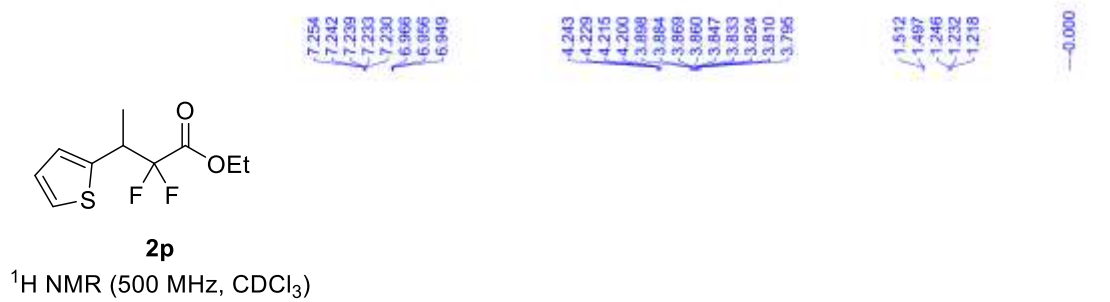


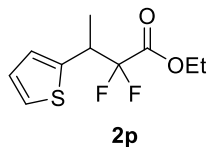
| # | m/z | Res. | S/N | I | I % | FWHM |
|---|----------|-------|--------|--------|-------|--------|
| 1 | 301.1013 | 17234 | 1058.7 | 528208 | 100.0 | 0.0175 |
| 2 | 302.1039 | 13587 | 178.3 | 89176 | 16.9 | 0.0222 |
| 3 | 303.1073 | 15487 | 21.2 | 10604 | 2.0 | 0.0196 |

| Meas. m/z | # | Ion Formula | m/z | err [ppm] | mSigma | Score | rdb | e ⁻ Conf | N-Rule |
|-----------|---|---|----------|-----------|--------|-------|--------|---------------------|------------|
| 301.1013 | 1 | C ₁₆ H ₁₆ F ₂ NaO ₂ | 301.1011 | -0.9 | 4.0 | 1 | 100.00 | 7.5 | even ok |

HPLC spectra of 2n







¹³C NMR (125 MHz, CDCl₃)

163.941
163.681
163.422

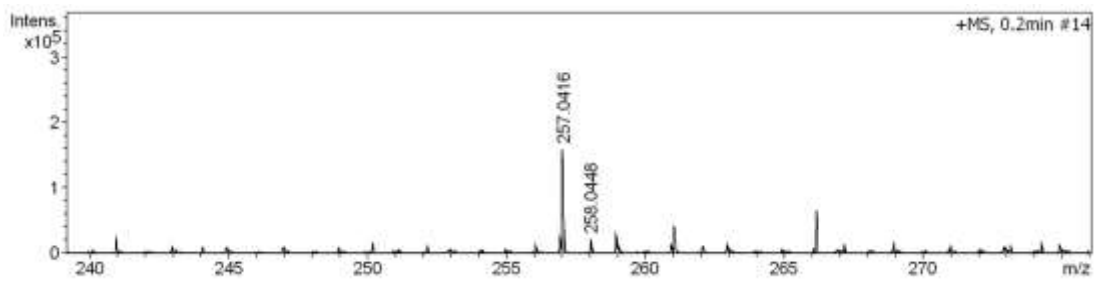
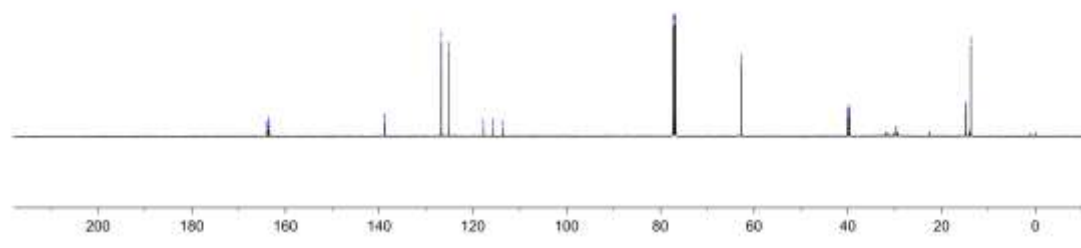
138.926
138.875
126.746
126.706
125.221
117.723
115.698
115.687
113.862

77.254
77.000
76.746

-62.723

40.028
39.843
39.628
39.644

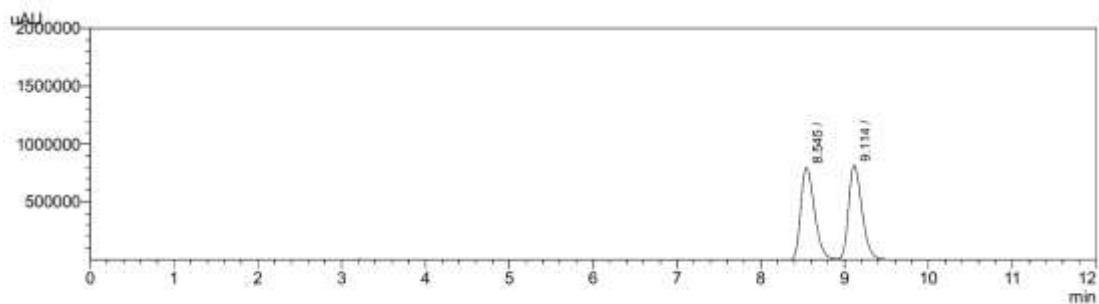
14.912
14.888
14.871
14.847
13.766



| # | m/z | Res. | S/N | I | I % | FWHM |
|---|----------|-------|-------|--------|-------|--------|
| 1 | 257.0416 | 13449 | 253.3 | 158724 | 100.0 | 0.0191 |
| 2 | 258.0448 | 11521 | 33.8 | 21268 | 13.4 | 0.0224 |

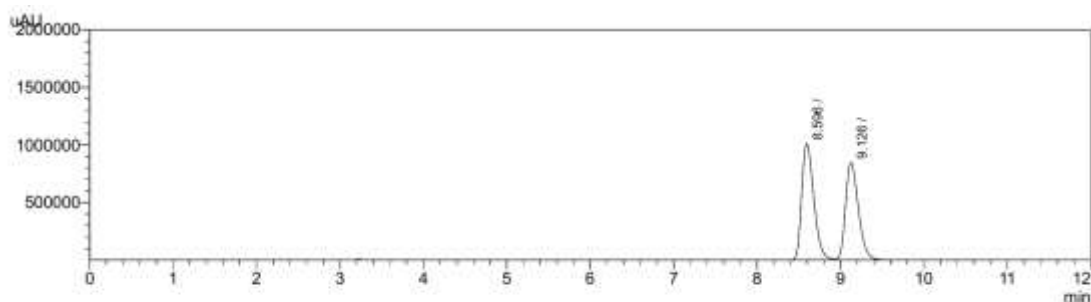
| Meas. m/z | # | Ion Formula | m/z | err [ppm] | mSigma | Score | rdb | e ⁻ Conf | N-Rule |
|-----------|---|---------------|----------|-----------|--------|-------|--------|---------------------|------------|
| 257.0416 | 1 | C10H12F2NaO2S | 257.0418 | 0.7 | 9.8 | 2 | 100.00 | 3.5 | even ok |

HPLC spectra of 2p



PDA Ch1 232nm

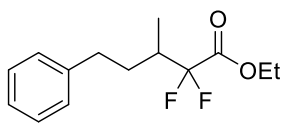
| Peak# | Ret. Time | Area | Area% | Height | Conc. | Mark | ID# |
|-------|-----------|----------|---------|---------|-------|------|-----|
| 1 | 8.545 | 9033463 | 50.070 | 797698 | 0.000 | M | |
| 2 | 9.114 | 9008161 | 49.930 | 812829 | 0.000 | V M | |
| 总计 | | 18041624 | 100.000 | 1610527 | | | |



PDA Ch1 232nm

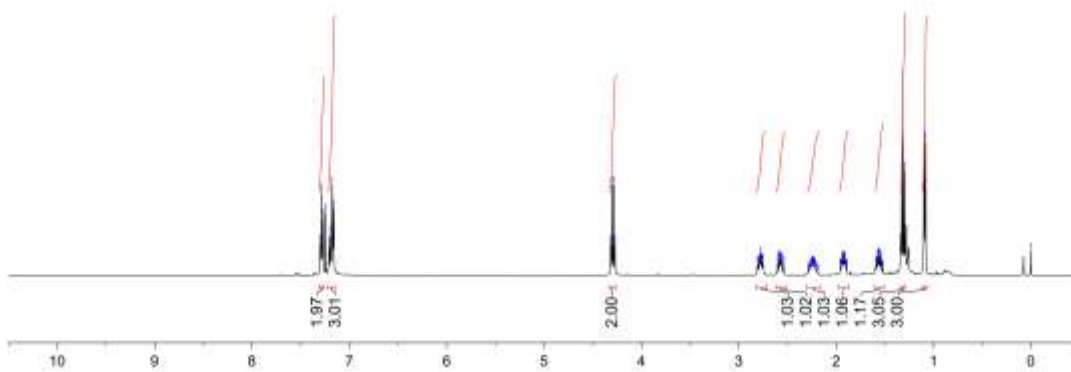
| Peak# | Ret. Time | Area | Area% | Height | Conc. | Mark | ID# |
|-------|-----------|----------|---------|---------|-------|------|-----|
| 1 | 8.596 | 10158151 | 52.935 | 1010628 | 0.000 | M | |
| 2 | 9.126 | 9029964 | 47.065 | 843972 | 0.000 | V M | |
| 总计 | | 19188114 | 100.000 | 1854600 | | | |

7.259
7.264
7.269
7.242
7.207
7.193
7.176
7.160
4.315
4.301
4.286
4.272
2.809
2.798
2.780
2.771
2.761
2.751
2.602
2.587
2.582
2.573
2.568
2.560
2.555
2.540
2.258
2.251
2.245
2.239
2.232
2.225
2.218
1.958
1.951
1.944
1.937
1.930
1.923
1.916
1.910
1.903
1.898
1.868
1.585
1.584
1.575
1.567
1.565
1.556
1.548
1.538
1.326
1.312
1.297
1.097
1.083
-0.000

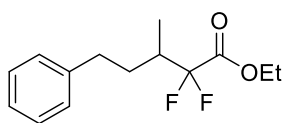


2q

$^1\text{H NMR}$ (500 MHz, CDCl_3)

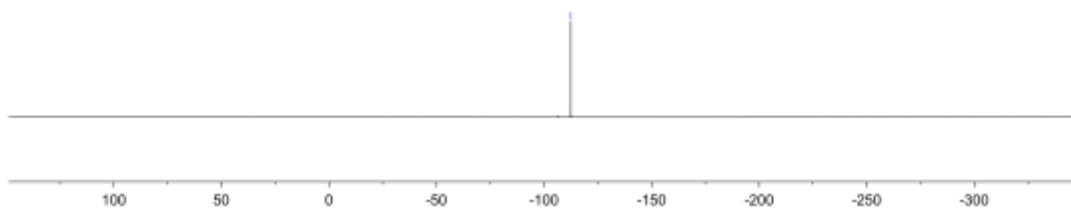


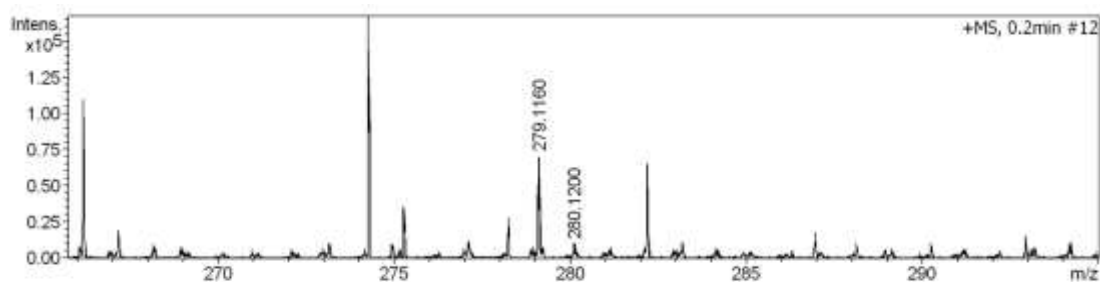
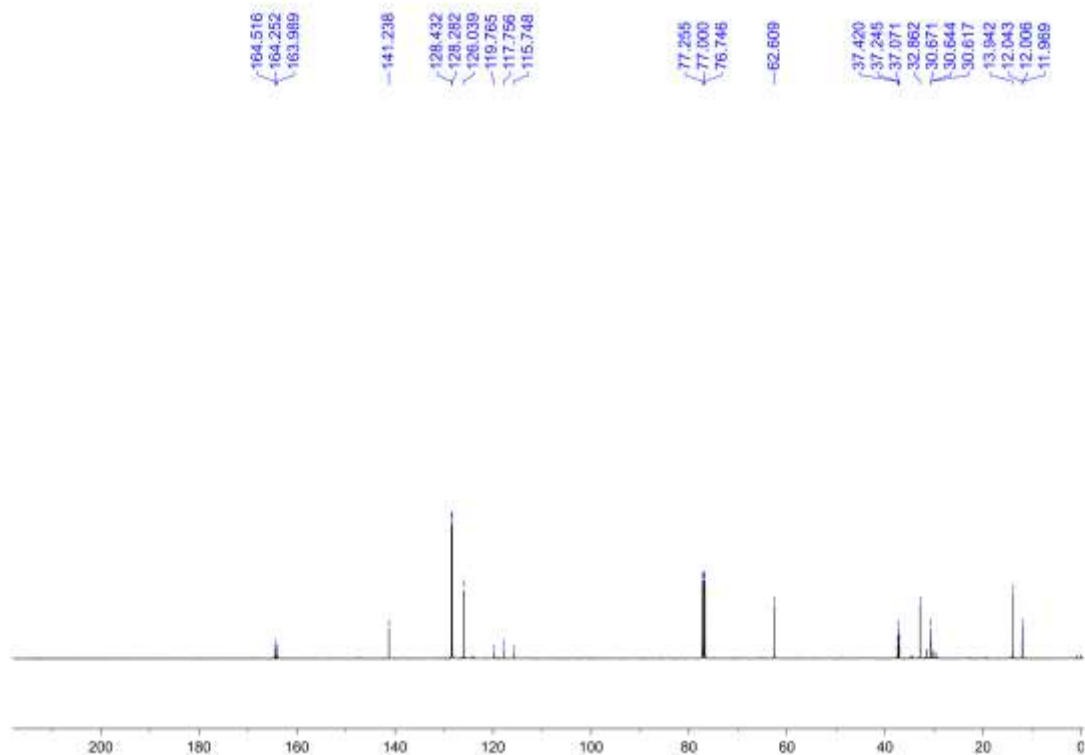
-112.438



2q

$^{19}\text{F NMR}$ (470MHz, CDCl_3)

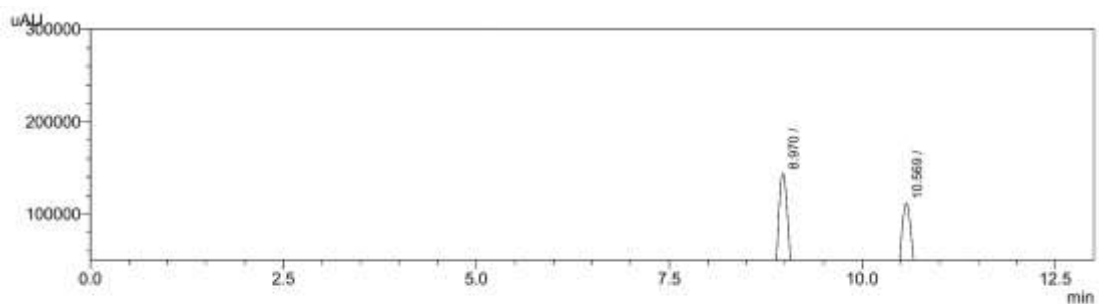




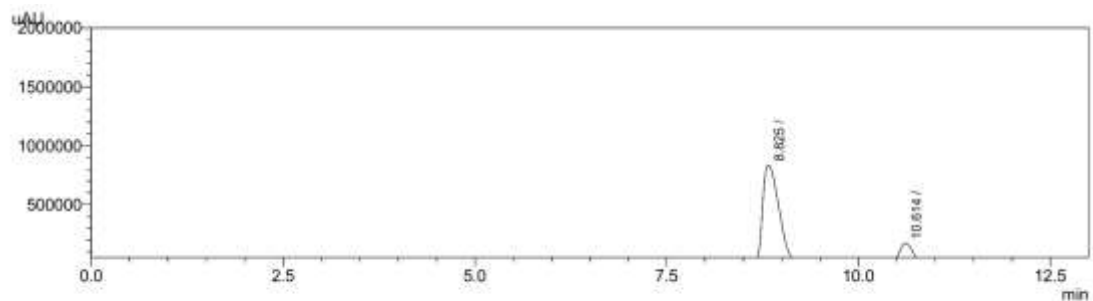
| # | m/z | Res. | S/N | I | I% | FWHM |
|---|----------|-------|-------|-------|-------|--------|
| 1 | 279.1160 | 15256 | 111.9 | 69784 | 100.0 | 0.0183 |
| 2 | 280.1200 | 10573 | 14.8 | 9248 | 13.3 | 0.0265 |

| Meas. m/z | # | Ion Formula | m/z | err [ppm] | mSigma | Score | rdb | e ⁻ Conf | N-Rule |
|-----------|---|---|----------|-----------|--------|-------|--------|---------------------|---------|
| 279.1160 | 1 | C ₁₄ H ₁₈ F ₂ NaO ₂ | 279.1167 | 2.5 | 24.4 | 2 | 100.00 | 4.5 | even ok |

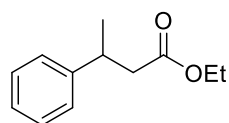
HPLC spectra of 2q



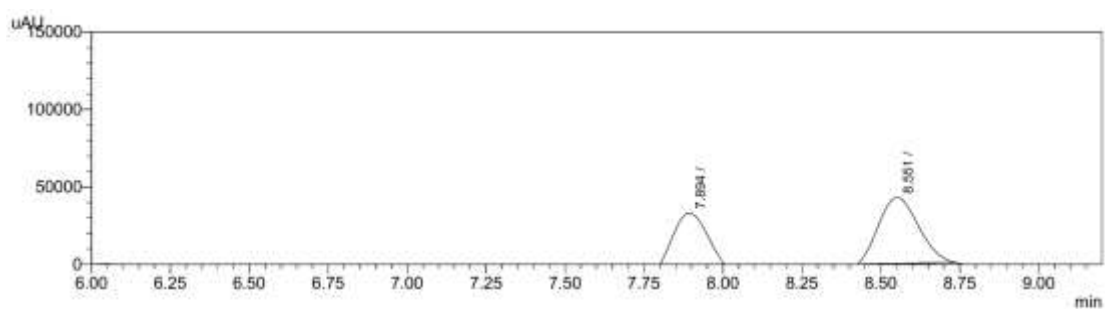
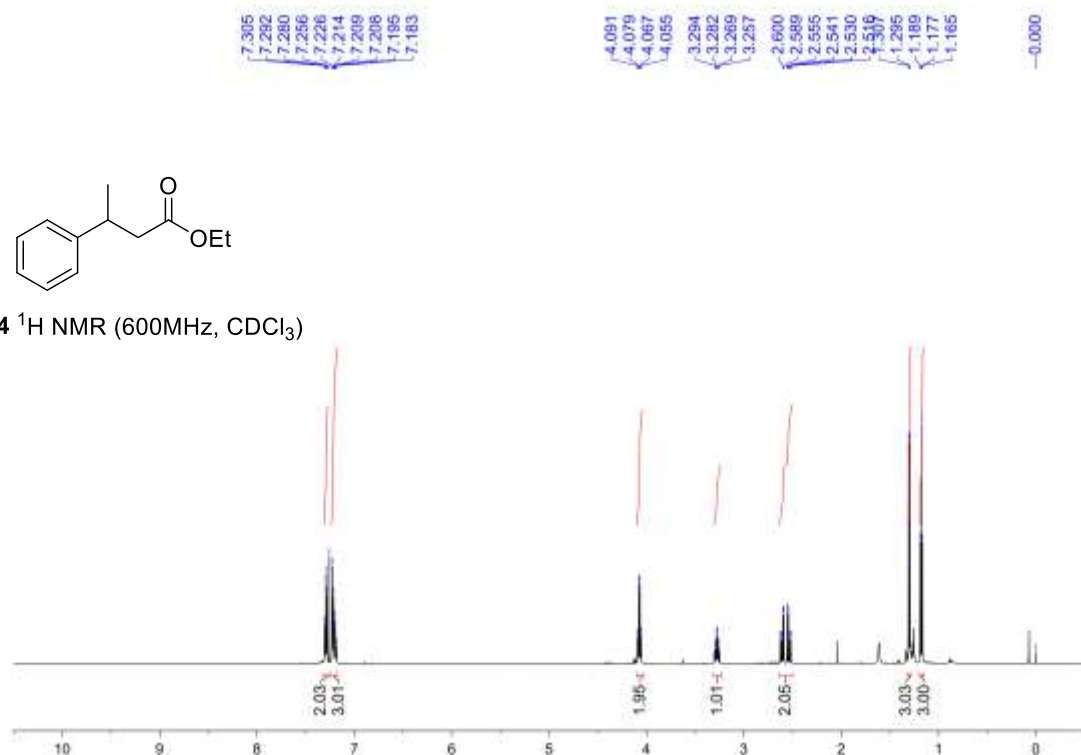
| Peak# | Ret. Time | Area | Area% | Height | Conc. | Mark | ID# |
|-------|-----------|---------|---------|--------|-------|------|-----|
| 1 | 8.970 | 1804443 | 49.980 | 167967 | 0.000 | M | |
| 2 | 10.569 | 1805895 | 50.020 | 142984 | 0.000 | M | |
| 总计 | | 3610338 | 100.000 | 310951 | | | |



| Peak# | Ret. Time | Area | Area% | Height | Conc. | Mark | ID# |
|-------|-----------|----------|---------|---------|-------|------|-----|
| 1 | 8.825 | 12742675 | 84.775 | 856058 | 0.000 | M | |
| 2 | 10.614 | 2288476 | 15.225 | 180680 | 0.000 | M | |
| 总计 | | 15031152 | 100.000 | 1036739 | | | |

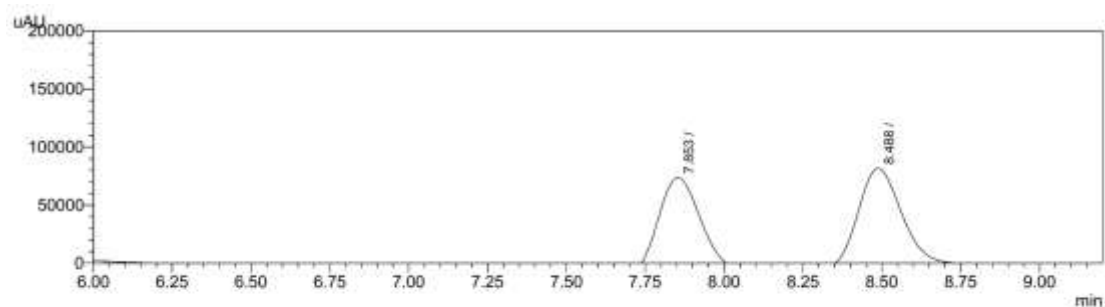


4 ¹H NMR (600MHz, CDCl₃)



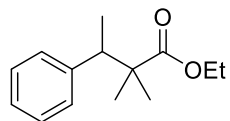
PDA Ch1 208nm

| Peak# | Ret. Time | Area | Area% | Height | Conc. | Mark | ID# |
|-------|-----------|--------|---------|--------|-------|------|-----|
| 1 | 7.894 | 379045 | 50.410 | 43182 | 0.000 | M | |
| 2 | 8.551 | 372874 | 49.590 | 42647 | 0.000 | M | |
| 总计 | | 751920 | 100.000 | 85829 | | | |

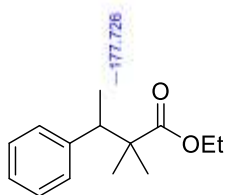
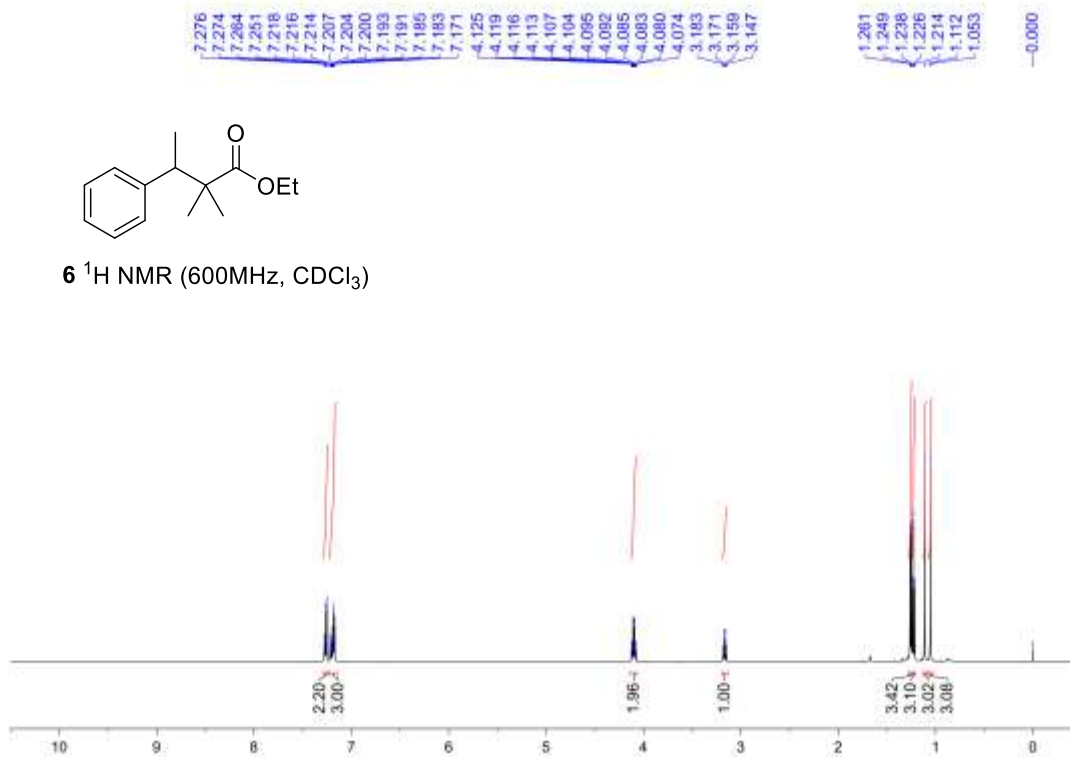


PDA Ch1 208nm

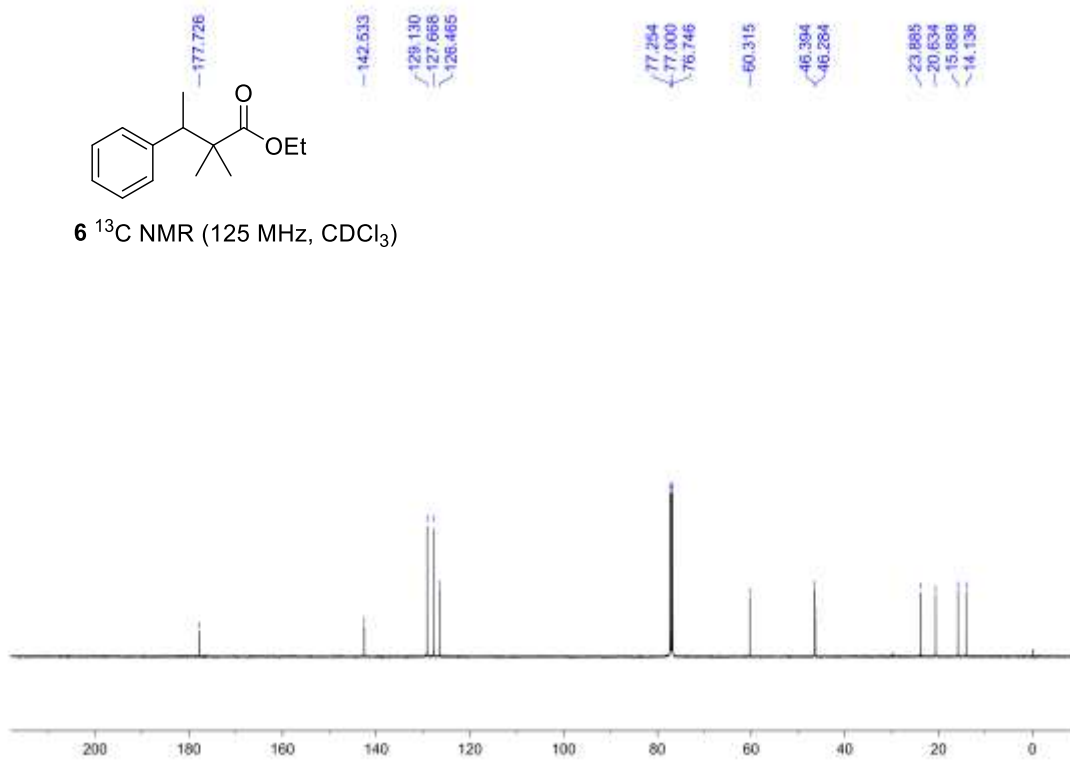
| Peak# | Ret. Time | Area | Area% | Height | Conc. | Mark | ID# |
|-------|-----------|---------|---------|--------|-------|------|-----|
| 1 | 7.853 | 791622 | 48.856 | 83189 | 0.000 | M | |
| 2 | 8.488 | 828700 | 51.144 | 85453 | 0.000 | M | |
| 总计 | | 1620323 | 100.000 | 168642 | | | |

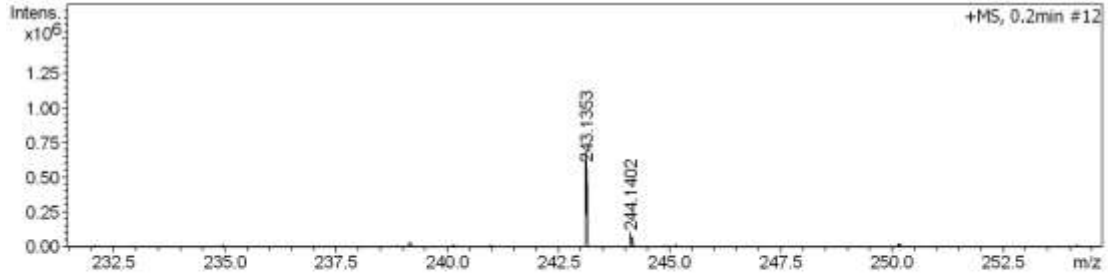


6 ^1H NMR (600MHz, CDCl_3)



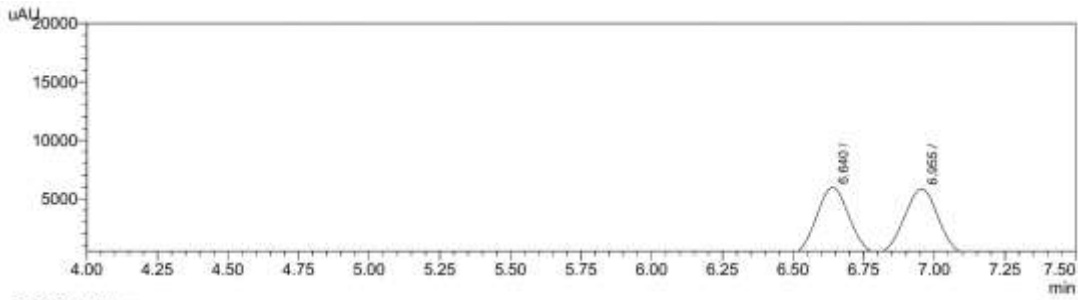
6 ^{13}C NMR (125 MHz, CDCl_3)



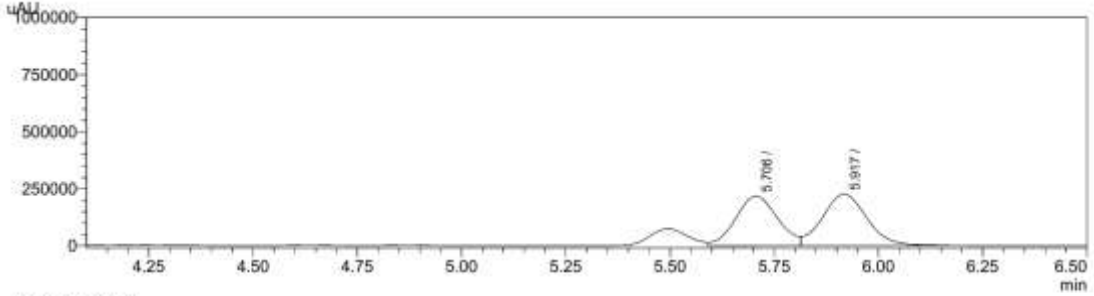


| # | m/z | Res. | S/N | I | I % | FWHM |
|---|----------|-------|--------|--------|-------|--------|
| 1 | 243.1353 | 18409 | 1181.7 | 569920 | 100.0 | 0.0132 |
| 2 | 244.1402 | 8793 | 159.7 | 77236 | 13.6 | 0.0278 |
| 3 | 245.1413 | 8096 | 19.9 | 9652 | 1.7 | 0.0303 |

| Meas. m/z | # | Ion Formula | m/z | err [ppm] | mSigma | Score | rdb | e ⁻ Conf | N-Rule |
|-----------|---|--|----------|-----------|--------|-------|--------|---------------------|--------|
| 243.1353 | 1 | C ₁₄ H ₂₀ NaO ₂ | 243.1356 | 1.1 | 11.0 | 1 | 100.00 | 4.5 even | ok |

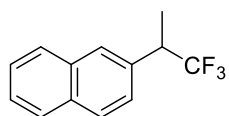


| Peak# | Ret. Time | Area | Area% | Height | Conc. | Mark | ID# |
|-------|-----------|--------|---------|--------|-------|------|-----|
| 1 | 6.640 | 51596 | 49.162 | 6010 | 0.000 | | |
| 2 | 6.955 | 53355 | 50.838 | 5917 | 0.000 | V | |
| Σ | | 104951 | 100.000 | 11927 | | | |

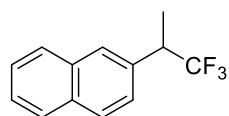
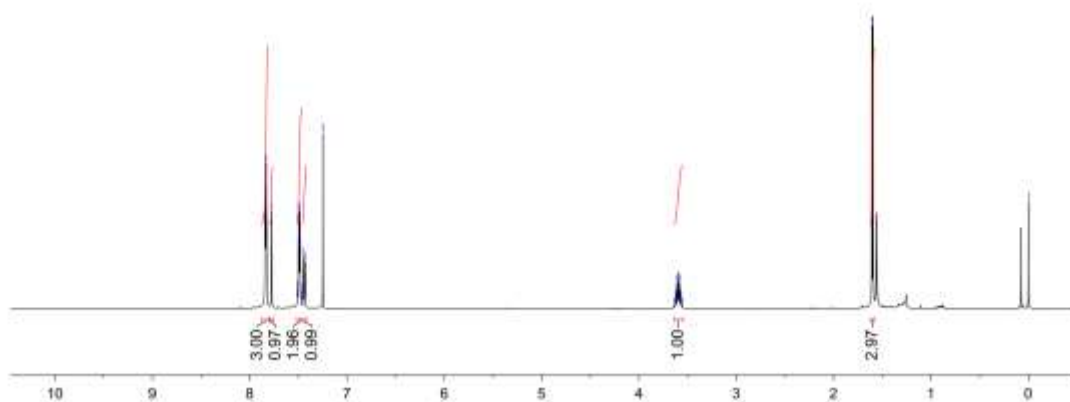


| Peak# | Ret. Time | Area | Area% | Height | Conc. | Mark | ID# |
|-------|-----------|---------|---------|--------|-------|------|-----|
| 1 | 5.706 | 1519043 | 47.727 | 217428 | 0.000 | M | |
| 2 | 5.917 | 1663722 | 52.273 | 226272 | 0.000 | V M | |
| Σ | | 3182765 | 100.000 | 443700 | | | |

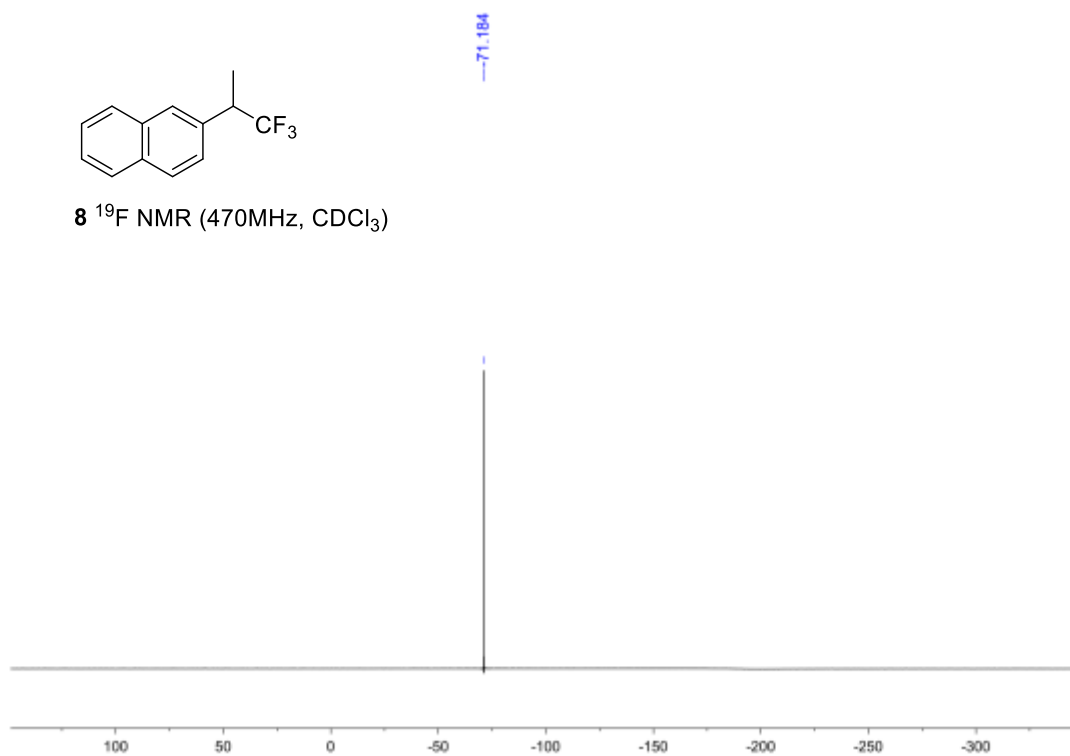
7.842 7.833 7.829 7.775 7.509 7.506 7.498 7.485 7.488 7.452 7.480 7.471 7.468 7.444 7.430 7.248 3.637 3.624 3.622 3.609 3.597 3.595 3.582 3.570 3.567 3.555 1.607 1.595 -0.000

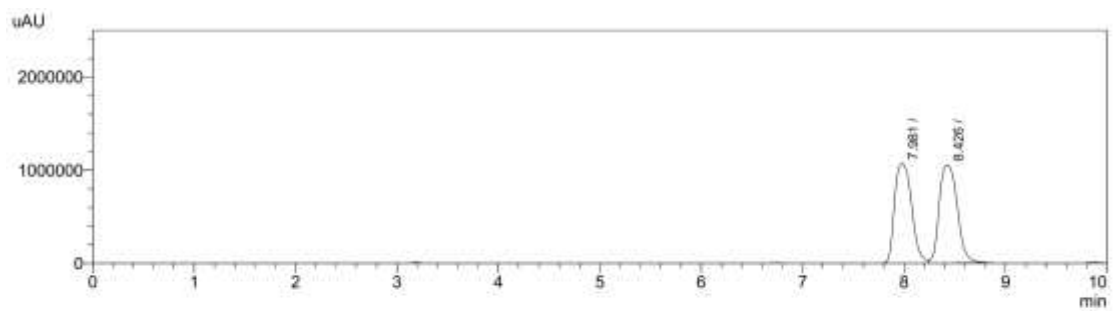


8 ^1H NMR (600MHz, CDCl_3)



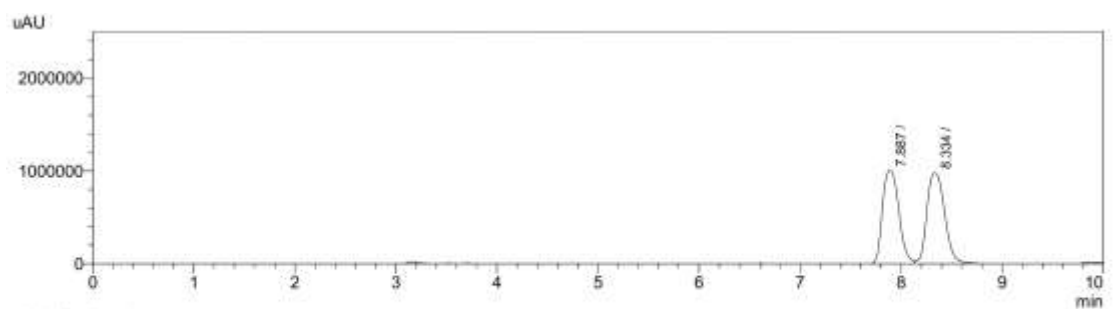
8 ^{19}F NMR (470MHz, CDCl_3)





PDA Ch1 223nm

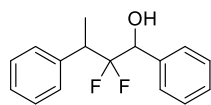
| Peak# | Ret. Time | Area | Area% | Height | Conc. | Mark | ID# |
|-------|-----------|----------|---------|---------|-------|------|-----|
| 1 | 7.981 | 12494848 | 49.119 | 1070358 | 0.000 | M | |
| 2 | 8.426 | 12943235 | 50.881 | 1052407 | 0.000 | V M | |
| 总计 | | 25438082 | 100.000 | 2122765 | | | |



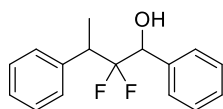
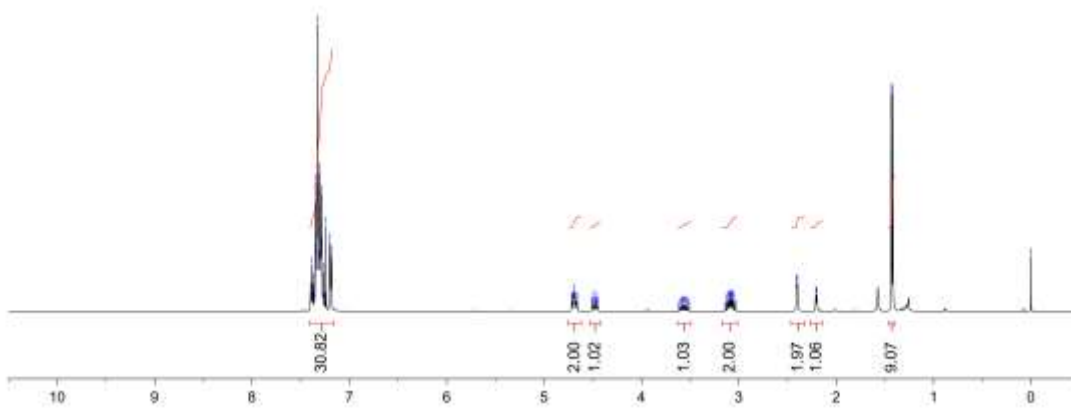
PDA Ch1 223nm

| Peak# | Ret. Time | Area | Area% | Height | Conc. | Mark | ID# |
|-------|-----------|----------|---------|---------|-------|------|-----|
| 1 | 7.887 | 11308869 | 48.540 | 1007168 | 0.000 | M | |
| 2 | 8.334 | 11989091 | 51.460 | 960411 | 0.000 | V M | |
| 总计 | | 23297960 | 100.000 | 1967579 | | | |

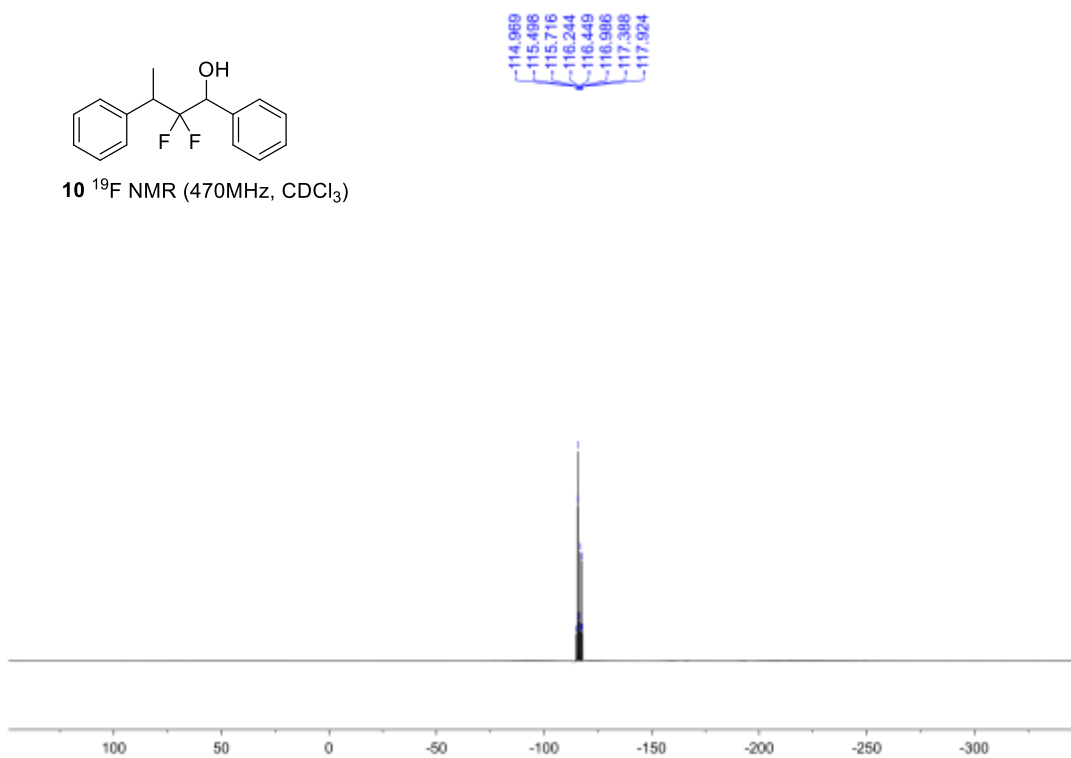
7.397
7.361
7.365
7.361
7.351
7.345
7.340
7.327
7.317
7.314
7.304
7.300
7.289
7.264
7.261
7.278
7.273
7.267
7.259
7.255
7.252
7.239
7.198
7.184
4.717
4.709
4.695
4.688
4.668
4.660
4.607
4.497
4.487
4.470
4.460
4.449
-3.588
-3.585
-3.570
-3.556
-3.541
-3.538
-3.523
-3.125
-3.111
-3.098
-3.088
-3.064
-3.074
-3.061
-3.047
-2.406
-2.398
-2.210
-2.199
-1.433
-1.419
-0.000



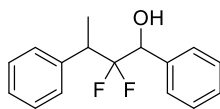
10 ^1H NMR (500MHz, CDCl_3)



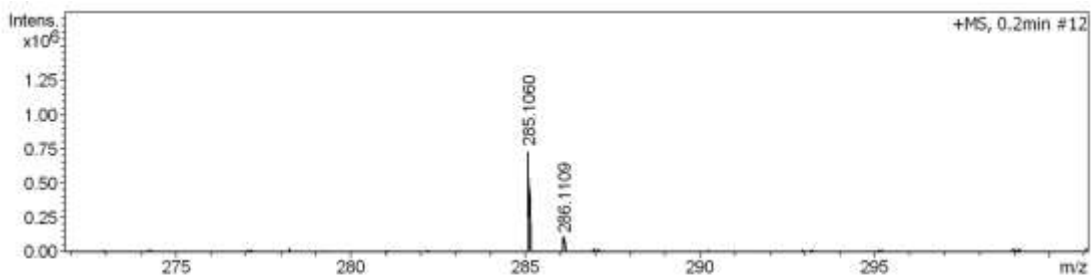
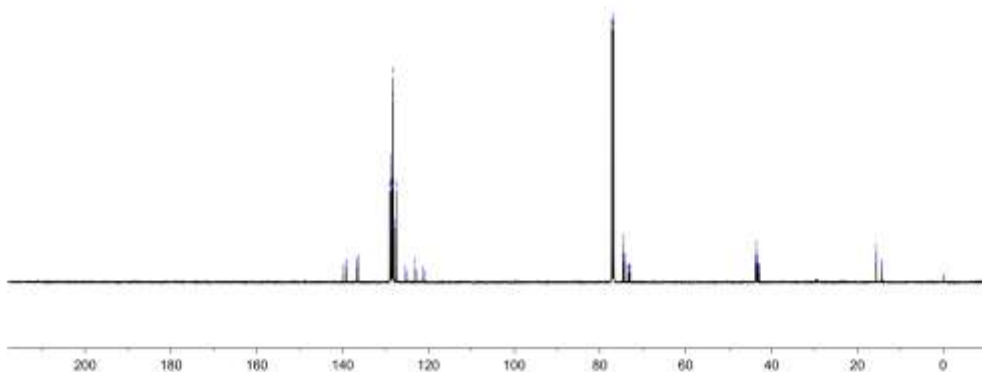
10 ^{19}F NMR (470MHz, CDCl_3)



138.771
138.710
138.158
138.117
136.790
136.434
136.406
128.976
128.885
128.816
128.429
128.585
128.305
128.287
128.142
127.888
127.423
127.370
125.315
124.859
123.320
122.877
122.847
121.324
120.866
77.263
77.000
76.745
74.650
74.444
74.236
73.424
73.220
73.164
72.960
43.714
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42.847
15.600
15.557
15.520
14.380
14.338
14.304

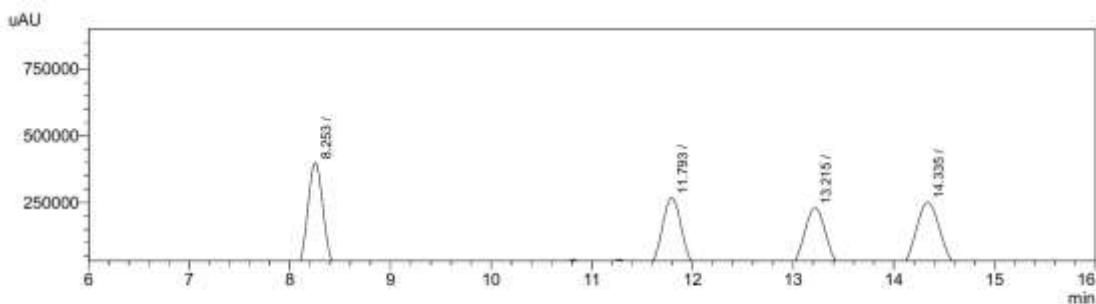


10 ¹³C NMR (125MHz, CDCl₃)

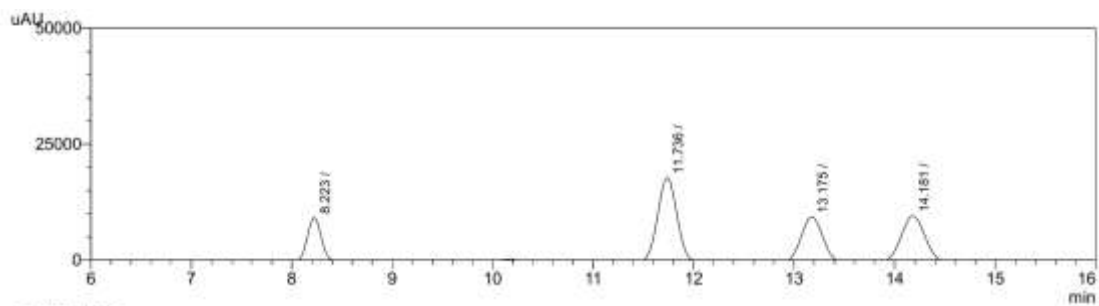


| # | m/z | Res. | S/N | I | I % | FWHM |
|---|----------|-------|--------|--------|-------|--------|
| 1 | 285.1060 | 23969 | 1224.8 | 728492 | 100.0 | 0.0119 |
| 2 | 286.1109 | 10251 | 159.8 | 95496 | 13.1 | 0.0279 |
| 3 | 287.1130 | 11456 | 21.5 | 12908 | 1.8 | 0.0251 |

| Meas. m/z | # | Ion Formula | m/z | err [ppm] | mSigma | Score | rdb | e ⁻ Conf | N-Rule |
|-----------|---|--|----------|-----------|--------|-------|--------|---------------------|---------|
| 285.1060 | 1 | C ₁₆ H ₁₆ F ₂ NaO | 285.1061 | 0.6 | 25.5 | 5 | 100.00 | 7.5 | even ok |



| Peak# | Ret. Time | Area | Area% | Height | Conc. | Mark | ID# |
|-------|-----------|----------|---------|---------|-------|------|-----|
| 1 | 8.253 | 4323059 | 27.022 | 402248 | 0.000 | M | |
| 2 | 11.793 | 3575330 | 22.348 | 266413 | 0.000 | M | |
| 3 | 13.215 | 3667461 | 22.924 | 234195 | 0.000 | M | |
| 4 | 14.335 | 4432498 | 27.706 | 254431 | 0.000 | M | |
| Σ fit | | 15998348 | 100.000 | 1157288 | | | |



PDA Ch1 208nm

| Peak# | Ret. Time | Area | Area% | Height | Conc. | Mark | ID# |
|-------|-----------|--------|---------|--------|-------|------|-----|
| 1 | 8.223 | 92457 | 13.930 | 9536 | 0.000 | M | |
| 2 | 11.736 | 247700 | 37.319 | 18327 | 0.000 | M | |
| 3 | 13.175 | 152075 | 22.912 | 9967 | 0.000 | M | |
| 4 | 14.181 | 171507 | 25.839 | 10095 | 0.000 | M | |
| Sum | | 663738 | 100.000 | 47925 | | | |