Supporting Information

Palladium-catalyzed carbomonofluoromethylation of unactivated alkenes: a rapid access to γ-monoflurомethyl carboxylic acid derivatives

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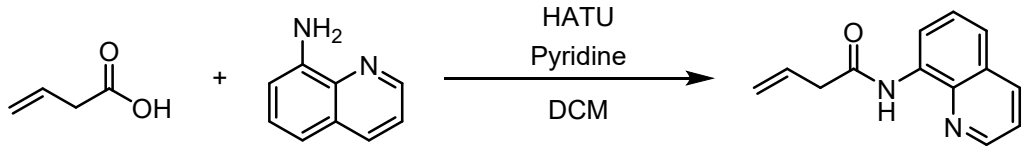
1. General information

Unless otherwise stated, all reagents were purchased from commercial suppliers and used without further purification. All reactions were carried out at air atmosphere using reaction tubes and were monitored through thin layer chromatography (TLC) on silica gel-precoated glass plates. Reactions were monitored by thin layer chromatography (TLC) using UV light or $KMnO_4$ to visualize the course of reaction. Flash column chromatography was performed using Yantai Yinlong flash silica gel (200-300 mesh). Melting points were recorded on an Electrothermal digital melting point apparatus. ^1H, ^{13}C and ^{19}F NMR spectra were recorded on Bruker 400 MHz spectrometer in $CDCl_3$ with tetramethylsilane (TMS) as internal standard. The chemical shifts are expressed in ppm and coupling constants are given in Hz. Data for ^1H NMR are recorded as follows: chemical shift (δ, ppm), multiplicity (s = singlet; d = doublet; t = triplet; q = quarter; p = pentet; m = multiplet; br = broad), coupling constant (Hz), integration. Data for ^{13}C NMR are reported in terms of chemical shift (δ, ppm). Data for ^{19}F NMR are reported in terms of chemical shift (δ, ppm). Data for HRMS were obtained by using BRUKER micrOTOF-Q III instrument with ESI source or EI source. The crystal was measured by using Agilent or Bruker instrument. IR spectra were recorded on a BRUKER VERTEX 70 spectrophotometer and are reported in terms of frequency of absorption (cm^{-1}).

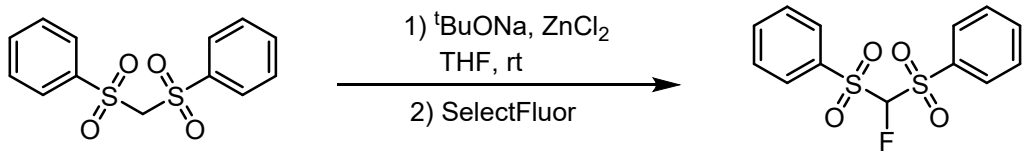
2. Alkene substrate synthesis[1]



1a

Crude acid (~7.2 mmol) was charged into a 100 mL flask containing 15 mL DCM. 8-Aminoquinoline (720 mg, 5 mmol), pyridine (0.8 mL, 10 mmol) and HATU (2.47 g, 6.5 mmol) were added sequentially, the reaction was stirred at ambient temperature for 16 h. The deep brown solution was diluted with 100 mL EtOAc, washed with sat. $NaHCO_3$ (40 mL ×2) and brine (40 mL × 1), and then purified by column chromatography (1:30 EA/PE) to afford **1a** as yellow oil (90%).

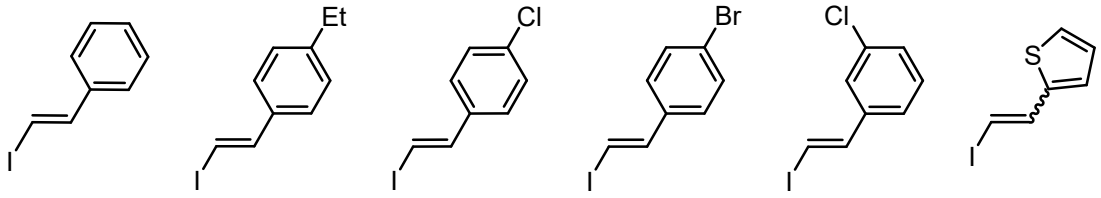
3. FBSM synthesis[2]



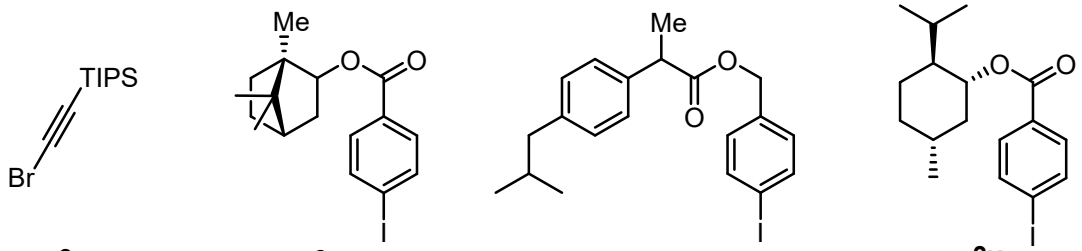
2a

^{t}BuONa (360.4 mg, 3.75 mmol) and anhydrous $ZnCl_2$ (511.1 mg, 3.75 mmol) were dissolved in 12 mL THF. Five minutes later, bis(phenylsulfonyl)methane (444.0 mg, 1.5 mmol) was added into the mixture under N_2 atomosphere. The reaction was stirred for half an hour. Then SelectFluor (1.0628g, 3.0 mmol) was added into the mixture in a flash. The reaction was allowed at room temperature for 2 h and quenched by 2M HCl until it became clear. After extraction with EtOAc, the organic layer was dried over anhydrous Na_2SO_4, filtered and removed under vacuum. The crude product was purified by flash column chromatography on silica gel with 1:10 (EA:PE) to provide white solid **2a** (377.0 mg) in 80% yield.

4. Iodides synthesis

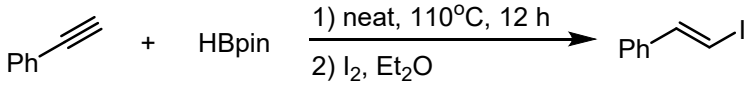


3p **3q** **3r** **3s** **3t** **3u**



3v **3w** **3x** **3y**

Iodides **3p-y** were prepared according to literature procedures. Styrenyl iodides **3p-t** were prepared according **Procedure A**.[3] **3u** was prepared according **Procedure B**.[4] **3v** was prepared according **Procedure C**.[5] **3w** was prepared according **Procedure D**.[6] **3x-y** were prepared according **Procedure E.** [7]



Procedure A: step-1) A 20 mL test tube was charged with phenylacetylene (0.11 mL, 1.0 mmol) and pinacolborane (0.29 mL, 2.0 mmol) under an argon atmosphere at room temperature, and the reaction mixture was heated to 110 °C and stirred for 6 h. After this (TLC analysis), the reaction mixture was cooled to room temperature, and the unreacted substrates were quenched by the addition of 1 mL of water. The crude mixture was extracted with ethyl acetate and the combined organic layers were dried over $MgSO_4$. The solvents were evaporated under reduced pressure, and the residue mixture was subjected to column chromatography using silica gel.

Procedure A: step-2) The vinyl boronate ester (1.1 g, 5 mmol) was dissolved in 5 mL Et_2O in 50 mL round bottom flask, then 5 mL aqueous solution of NaOH (3 M) was added dropwisely at 0 °C. Subsequently, a solution of I_2 (1.5 g, 6 mmol) in 10 mL Et_2O was added slowly and stirred for 30 mins before quenching with a saturated solution of sodium thiosulfate. The organic solution was separated, and the aqueous solution was washed with Et_2O. The combined organic layers were dried with $MgSO_4$, the solvent was evaporated and the crude product was isolated on silica gel using flash chromatography (PE as eluent).

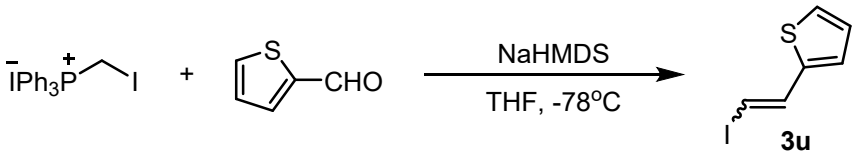
3p[3c] was prepared following **Procedure A** to give a light yellow oil. (1.73 g, 75%).

3q was prepared following **Procedure A** to give a green solid. (2.06 g, 80%).

3r[3b] was prepared following **Procedure A** to give a white solid. (2.12 g, 80%).

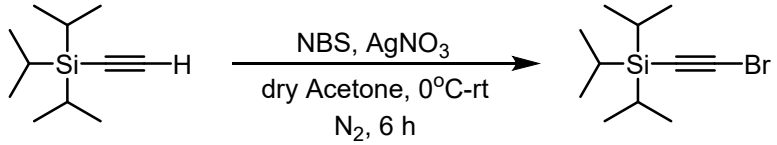
3s[3b] was prepared following **Procedure A** to give a white solid. (2.41 g, 78%).

3t was prepared following **Procedure A** to give a brown oil. (1.98 g, 75%).



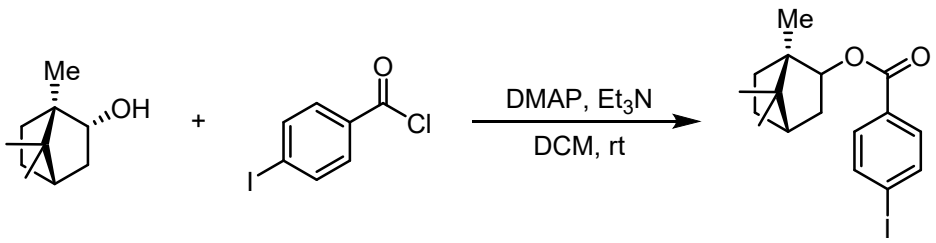
Procedure B: To a flame dried 250 mL round bottom flask equipped with a stir bar was added 5.67 g of iodomethylenetriphenylphosphonium iodide. The flask was then placed under vacuum for five minutes then purged with nitrogen. 35 mL of THF was added and the suspension was cooled to -20 °C. 11.4 mL of NaHMDS (1 M) was added

drop wise along the flask wall and after the addition was complete the solution was allowed to stir at -20 °C for 5 minutes. The flask was then cooled to -78 °C and a 0.84 mL of thiophene-2-carboxaldehyde in 15 mL of THF was added along the wall of the flask. The reaction was allowed to stir for 10 minutes and then quenched with saturated aqueous ammonium chloride. Diethyl ether was added to the mixture and the layers were separated with a separatory funnel. The aqueous layer was washed twice with diethyl ether and the combined organic layers were dried with magnesium sulphate and concentrated. The crude product was column with 1:10 (EA:PE) to give 0.90 g of product **3u**. 42 % (1:1 mixture of E and Z).



3v

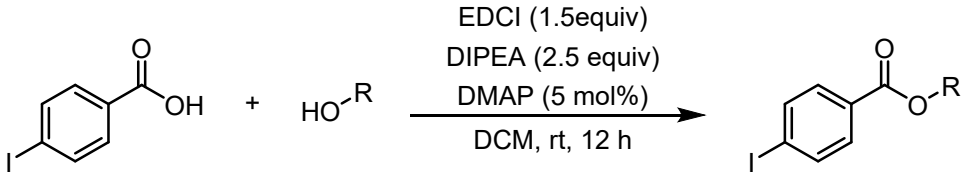
Procedure C: To solution of (triisopropylsilyl)acetylene (1 equiv., 2.74 mmol) in acetone (40 ml) was added *N*-bromosuccinimide (1.2 equiv., 3.28 mmol) and $AgNO_3$ (0.1 equiv., 0.27 mmol) at 0 °C, the mixture was stirred under N_2 for 6 hours at room temperature. This was then quenched with water and the organic layer was extracted thrice with pentane. Removal of the solvent under vacuum gave the crude product, which was purified by silica gel chromatography to give the product. A purification by flash chromatography in n-pentane:diethyl ether = 10 : 1 to give **3v** (19 mmol, 3.35 g, 54% yield) as a pale yellow liquid.



3w

Procedure D: A flame-dried Schlenk-flask equipped with a magnetic stir bar, was charged with L (-)- borneol (1.543 g, 10 mmol), 4-iodobenzoyl chloride (3.198 g, 12 mmol), 4-DMAP (1.222 g, 100 mmol), sealed with a septum, and degassed by alternating vacuum evacuation and nitrogen backfilling (three times) before DCM (25 mL) was added. Then Et_3N (2.024 g, 20 mmol) was added under positive pressure. The

reaction mixture was stirred at room temperature for 4 h. After the reaction was complete, the reaction mixture was diluted with Et_2O (30 mL) and filtrated through a small pad of silica gel. The solvent was removed under reduced pressure with the aid of a rotary evaporator and the crude residue was purified by a silica gel column chromatography (1:50 = EA:PE) to give the product as a white solid in 70% yield.



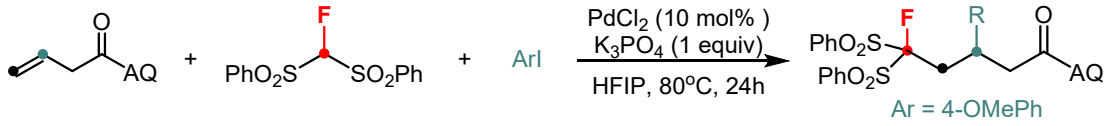
Procedure E: EDCI (2.87 g, 15 mmol) was added to a suspension of 4-iodobenzoic acid (10 mmol), R-OH (15 mmol), DIPEA (4.1 mL, 25 mmol) and DCM (50 mL) at room temperature. After addition, the resulting mixture was stirred at room temperature overnight. Water was added to the reaction followed by addition of DCM. The combined organic layers were washed with aq. NaCl, and dried over anhydrous Na_2SO_4. Removal of the solvent under vacuum gave the crude product, which was purified by silica gel chromatography to give the product.

3x[3b] was prepared following **Procedure E** to give a white solid. (0.68 g, 80% yield).

3y[3a] was prepared following **Procedure E** to give a white solid (3.29 g, 85% yield).

5. Selected conditions for reaction optimization

5.1 Evaluation of reaction substrate

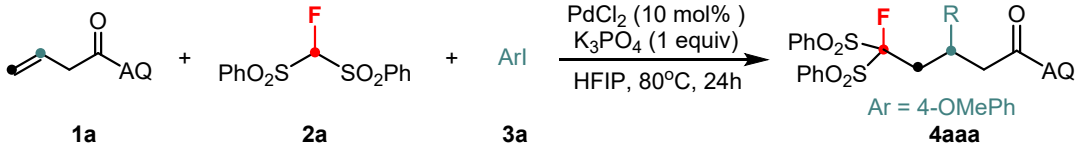


1a **2a** **3a** **4aaa**

Entry	Cat.	Base	Solvent	T(°C)	R (1:2:3)	4aaa (%)[b]
1	$PdCl_2$	K_3PO_4	HFIP	80	1:1.2:4	60(52[c])
2	$PdCl_2$	K_3PO_4	HFIP	80	1:1.5:4	51
3	$PdCl_2$	K_3PO_4	HFIP	80	1.2:1:4	53
4	$PdCl_2$	K_3PO_4	HFIP	80	1:1.2:3	27
5	$PdCl_2$	K_3PO_4	HFIP	80	1:1.2:6	58

[a]Reaction conditions: **1a** (0.1 mmol), **2a** (X mmol), **3a** (X mmol), $PdCl_2$ (10 mol%), HFIP (0.2 mL), K_3PO_4 (0.1 mmol) in air condition for 12 h. [b]The yields were determined by LC analysis using diphenyl as an internal standard. [c]Isolated yield.

5.2 Reaction concentration

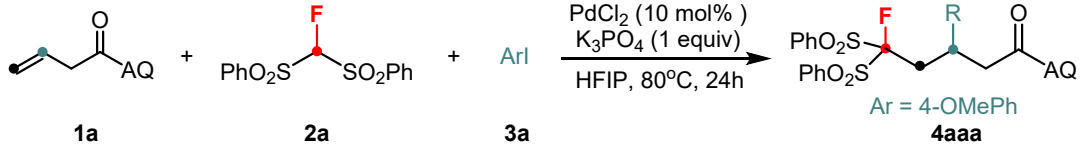


1a **2a** **3a** **4aaa**

Entry	Cat.	Base	Solvent(ML)	T(°C)	R (1:2:3)	4aaa (%)[b]
1	$PdCl_2$	K_3PO_4	0.2	80	1:1.2:4	60(52[c])
2	$PdCl_2$	K_3PO_4	0.5	80	1:1.2:4	54
3	$PdCl_2$	K_3PO_4	1	80	1:1.2:4	17

[a]Reaction conditions: **1a** (0.1 mmol), **2a** (0.12 mmol), **3a** (0.4 mmol), $PdCl_2$ (10 mol%), HFIP (X mL), K_3PO_4 (0.1 mmol) in air condition for 12 h. [b]The yields were determined by LC analysis using diphenyl as an internal standard. [c]Isolated yield.

5.3 Reaction times



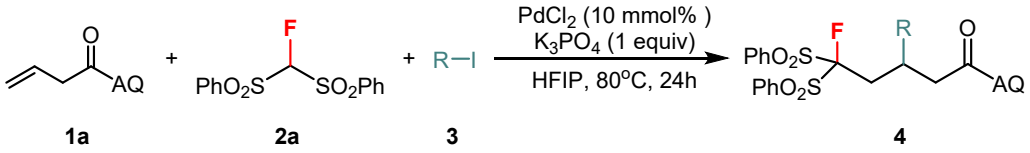
1a **2a** **3a** **4aaa**

Entry	Cat.	Base	Solvent(ML)	T(°C)	R (1:2:3)	Time (h)	4aaa (%)[b]
1	$PdCl_2$	K_3PO_4	0.2	80	1:1.2:4	12	60(52[c])
2	$PdCl_2$	K_3PO_4	0.2	80	1:1.2:4	16	68
3	$PdCl_2$	K_3PO_4	0.2	80	1:1.2:4	24	75(68 [c])

[a]Reaction conditions: **1a** (0.1 mmol), **2a** (0.12 mmol), **3a** (0.4 mmol), $PdCl_2$ (10 mol%),

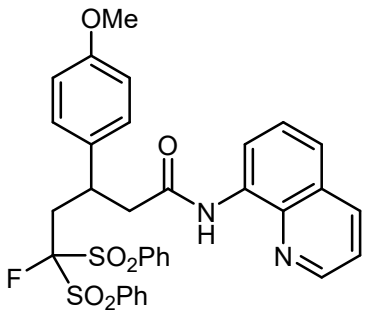
HFIP (0.2 mL), K_3PO_4 (0.1 mmol) in air condition for X h. [b]The yields were determined by LC analysis using diphenyl as an internal standard. [c]Isolated yield.

6. General procedure for dicarbofunctionalization of alkenes



1a **2a** **3** **4**

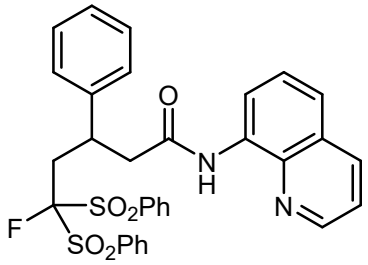
General Procedure: To a 8-mL scintillation vial equipped with a Teflon-coated magnetic stir bar were added the **1a** (0.1 mmol), **2a** (0.12 mmol), **3** (0.4 mmol), $PdCl_2$ (10 mol %), K_3PO_4 (0.1 mmol), and HFIP (0.2 mL). The vial was sealed with a screw-top septum cap and placed in a heating block that was preheated to 80 °C. After a time period of 24 h, the reaction vial was allowed cooled to room temperature, and the reaction mixture was filtered through a short plug of silica gel. The solvent was removed in vacuo to leave a brown residue, which was purified by silica gel chromatography to give pure product.



4aaa

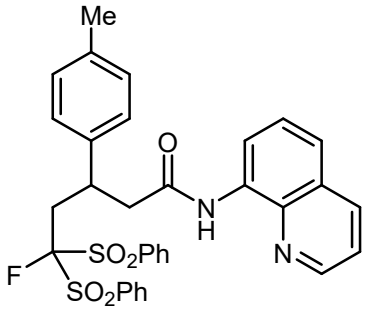
5-fluoro-3-(4-methoxyphenyl)-5,5-bis(phenylsulfonyl)-N-(quinolin-8-yl)pentanamide (4aaa): The title compound was prepared from **1a** (21.2 mg, 0.1 mmol), **2a** (38mg, 0.12 mmol), and 4-iodoanisole **3a** (93.6 mg, 0.4 mmol) according to the general procedure. Purification using silica gel chromatography (1:3 = EA:PE) gave the product as an white solid (43mg, 68% yield). **M.p.** = 82.4 - 84.5 °C; **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 9.51 (s, 1H), 8.73 (dd, *J* = 4.1, 1.7 Hz, 1H), 8.61 (dd, *J* = 5.8, 3.2 Hz, 1H), 8.10 (dd, *J* = 8.3, 1.7 Hz, 1H), 8.00 (d, *J* = 7.8 Hz, 2H), 7.84 (d, *J* = 7.8 Hz, 2H), 7.71 (q, *J* = 7.1 Hz, 2H), 7.60-7.38 (m, 7H), 6.92 (d, *J* = 8.3 Hz, 2H), 6.67 (d, *J* = 8.3 Hz, 2H), 3.68 (s, 3H), 3.61 - 3.50 (m, 1H), 3.07 (td, *J* = 16.5, 6.9 Hz, 1H), 2.96 - 2.83 (m, 2H), 2.69 (dd, *J* = 14.9, 9.5 Hz, 1H); **^{13}C NMR** (101 MHz, Chloroform-*d*) δ 168.7, 158.3, 148.0, 138.2, 136.3, 135.4, 135.2, 135.0, 134.7, 134.6, 134.3, 131.1, 130.9, 129.2, 129.1, 128.1, 127.8, 127.3, 121.6, 121.4, 116.4, 115.4 (d, *J*

= 269.1 Hz), 113.9, 55.1, 45.5, 36.6 (d, *J* = 5.2 Hz), 34.8 (d, *J* = 16.7 Hz); **^{19}F NMR** (376 MHz, Chloroform-*d*) δ -147.50, (s, 1F); **FT-IR** (ATR): 3338, 1677, 1514, 1324, 1164, 1146, 680, 561 cm^{-1}; **HRMS** (ESI$^+$, m/z): calcd for $C_{33}H_{30}FN_2O_6S_2^+$ [M+H]$^+$: 633.1529, found: 633.1530.



4aab

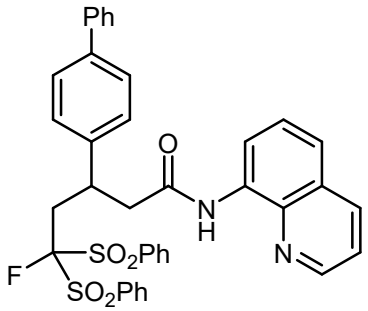
5-fluoro-3-phenyl-5,5-bis(phenylsulfonyl)-N-(quinolin-8-yl)pentanamide (4aab): The title compound was prepared from **1a** (21.2 mg, 0.1 mmol), **2a** (38mg, 0.12 mmol), and Iodobenzene **3b** (81.6 mg, 0.4 mmol) according to the general procedure. Purification using silica gel chromatography (1:3 = EA:PE) gave the product as an white solid (32mg, 53% yield). **M.p.** = 83.2 - 84.8 °C; **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 9.53 (s, 1H), 8.73 (d, *J* = 2.4 Hz, 1H), 8.62 (dd, *J* = 6.0, 3.2 Hz, 1H), 8.09 (d, *J* = 8.0 Hz, 1H), 8.00 (d, *J* = 7.8 Hz, 2H), 7.82 (d, *J* = 7.8 Hz, 2H), 7.70 (q, *J* = 7.4 Hz, 2H), 7.59 - 7.37 (m, 7H), 7.18 - 7.01 (m, 3H), 7.01 (d, *J* = 7.3 Hz, 2H), 3.72 - 3.56 (m, 1H), 3.13 (td, *J* = 16.8, 6.8 Hz, 1H), 3.00 - 2.88 (m, 2H), 2.74 (dd, *J* = 15.0, 9.2 Hz, 1H); **^{13}C NMR** (101 MHz, Chloroform-*d*) δ 168.6, 148.0, 142.7, 138.1, 136.3, 135.4, 135.3, 135.0, 134.6, 134.2, 131.1, 130.9, 129.2, 129.1, 128.6, 127.8, 127.3, 127.1, 126.8, 121.6, 121.5, 116.4, 115.4 (d, *J* = 269.2 Hz), 45.3, 37.3 (d, *J* = 5.2 Hz), 34.6 (d, *J* = 16.6 Hz); **^{19}F NMR** (376 MHz, Chloroform-*d*) δ -147.11, (s, 1F); **FT-IR** (ATR)**:** 3350, 1678, 1524, 1324, 1165, 1147, 749, 564, 535 cm^{-1}; **HRMS** (ESI$^+$, m/z): calcd for $C_{33}H_{27}FN_2O_5S_2Na^+$ [M+Na]$^+$: 625.1238, found: 625.1222.



4aac

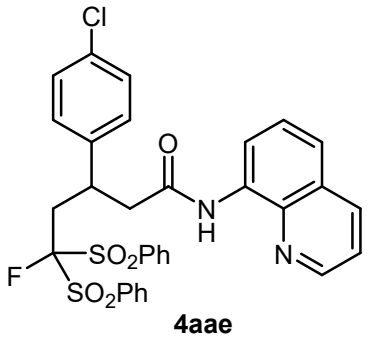
5-fluoro-5,5-bis(phenylsulfonyl)-N-(quinolin-8-yl)-3-(p-tolyl)pentanamide (4aac): The title compound was prepared from **1a** (21.2 mg, 0.1 mmol), **2a** (38mg, 0.12 mmol), and 4-Iodotoluene **3c** (87.2 mg, 0.4 mmol) according to the general procedure. Purification using silica gel chromatography (1:3 = EA:PE) gave the

product as an white solid (45mg, 73% yield). **M.p.** = 86.4 - 88.2 °C; **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 9.53 (s, 1H), 8.72 (d, *J* = 3.8 Hz, 1H), 8.62 (dd, *J* = 6.3, 2.8 Hz, 1H), 8.08 (d, *J* = 8.2 Hz, 1H), 8.00 (d, *J* = 7.9 Hz, 2H), 7.83 (d, *J* = 7.9 Hz, 2H), 7.65 - 7.74 (m, 2H), 7.58 - 7.36 (m, 7H), 6.92 (q, *J* = 7.6 Hz, 4H), 3.62-3.55 (m, 1H), 3.10 (td, *J* = 16.4, 6.8 Hz, 1H), 2.96 - 2.87 (m, 2H), 2.72 (dd, *J* = 14.8, 9.2 Hz, 1H), 2.20 (s, 3H); **^{13}C NMR** (101 MHz, Chloroform-*d*) δ 168.7, 148.0, 139.6, 138.2, 136.3, 135.4, 135.2, 135.0, 134.6, 134.3, 131.1, 130.9, 129.3, 129.2, 129.1, 127.8, 127.3, 126.9, 121.6, 121.4, 116.4, 115.4 (d, *J* = 269.3 Hz), 45.37, 36.94 (d, *J* = 5.1 Hz), 34.7 (d, *J* = 16.5 Hz), 21.0; **^{19}F NMR** (376 MHz, Chloroform-*d*) δ -147.31, (s, 1F); **FT-IR** (ATR)**:** 3338, 1678, 1524, 1343, 1164, 681, 560 cm^{-1}; **HRMS** (ESI$^+$, m/z): calcd for $C_{33}H_{30}FN_2O_5S_2^+$ $[M+H]^+$: 617.1575, found: 617.1578.



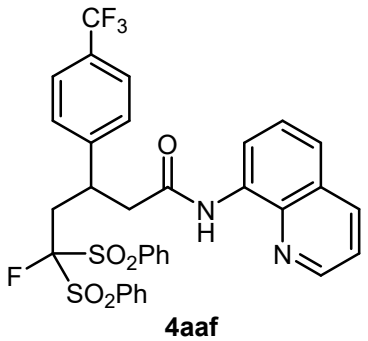
4aad

3-([1,1'-biphenyl]-4-yl)-5-fluoro-5,5-bis(phenylsulfonyl)-N-(quinolin-8-yl)pentanamide (4aad): The title compound was prepared from **1a** (21.2 mg, 0.1 mmol), **2a** (38mg, 0.12 mmol), and 4-Iodobiphenyl **3d**(112 mg, 0.4 mmol) according to the general procedure. Purification using silica gel chromatography (1:3 = EA:PE) gave the product as an white solid (34mg, 50% yield). **M.p.** = 91.2 - 92.7 °C; **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 9.56 (s, 1H), 8.71 (dd, *J* = 4.2, 1.7 Hz, 1H), 8.63 (dd, *J* = 6.4, 2.6 Hz, 1H), 8.10 (dd, *J* = 8.3, 1.7 Hz, 1H), 8.02 (dt, *J* = 8.6, 1.2 Hz, 2H), 7.84 (dt, *J* = 8.5, 1.3 Hz, 2H), 7.75-7.66 (m, 2H), 7.57 (t, *J* = 7.9 Hz, 2H), 7.52-7.44 (m, 6H), 7.41-7.35 (m, 5H), 7.33-7.28 (m, 1H), 7.11-7.06 (m, 2H), 3.72-3.64 (m, 1H), 3.22-3.10 (m, 1H), 3.02-2.91 (m, 2H), 2.79 (dd, *J* = 15.0, 9.3 Hz, 1H); **^{13}C NMR** (101 MHz, Chloroform-*d*) δ 168.6, 148.1, 141.9, 140.6, 139.5, 138.1, 136.3, 135.5, 135.3, 135.0, 134.5, 134.2, 131.1, 130.9, 129.2, 129.2, 128.8, 127.8, 127.6, 127.3, 126.9, 121.6, 121.6, 116.5, 115.5 (d, *J* = 269.3 Hz), 45.3, 37.1 (d, *J* = 5.3 Hz), 34.8 (d, *J* = 16.4 Hz); **^{19}F NMR** (376 MHz, Chloroform-*d*) δ -147.10, (s, 1F); **FT-IR** (ATR): 3339, 1679, 1522, 1484, 1325, 1150, 683, 560 cm^{-1}; **HRMS** (ESI$^+$, m/z): calcd for $C_{38}H_{32}FN_2O_5S_2^+$ $[M+H]^+$: 679.1732, found: 679.1737.



4aae

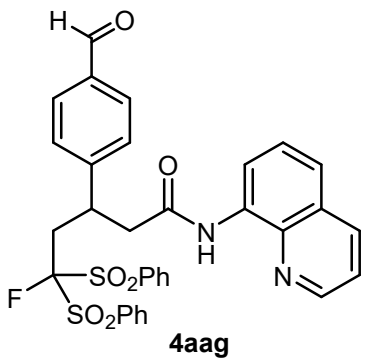
3-(4-chlorophenyl)-5-fluoro-5,5-bis(phenylsulfonyl)-N-(quinolin-8-yl)pentanamide (4aae): The title compound was prepared from **1a** (21.2 mg, 0.1 mmol), **2a** (38mg, 0.12 mmol), and 1-Chloro-4-iodobenzene **3e** (95.4 mg, 0.4 mmol) according to the general procedure. Purification using silica gel chromatography (1:3 = EA:PE) gave the product as an white solid (24.2mg, 38% yield). **M.p.** = 82.3 - 83.9 °C; **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 9.54 (s, 1H), 8.74 (dd, *J* = 4.2, 1.7 Hz, 1H), 8.61 (dd, *J* = 5.6, 3.4 Hz, 1H), 8.10 (dd, *J* = 8.3, 1.7 Hz, 1H), 8.01 (dt, *J* = 8.5, 1.2 Hz, 2H), 7.81 (dt, *J* = 8.5, 1.3 Hz, 2H), 7.75 - 7.67 (m, 2H), 7.58 - 7.37 (m, 7H), 7.09 - 7.03 (m, 2H), 6.98 - 6.90 (m, 2H), 3.68 - 3.61 (m, 1H), 3.19 - 3.09 (m, 1H), 2.95 - 2.81 (m, 2H), 2.74 (dd, *J* = 15.1, 9.2 Hz, 1H); **^{13}C NMR (101 MHz, Chloroform-*d*)** δ 168.3, 148.2, 141.3, 138.1, 136.3, 135.5, 135.3, 134.9, 134.3, 134.1, 132.4, 131.1, 130.8, 129.2, 129.2, 128.7, 128.6, 127.8, 127.2, 121.7, 116.5, 115.3 (d, *J* = 269 Hz), 45.2, 36.8 (d, *J* = 15.4 Hz), 34.6 (d, *J* = 16.6 Hz); **^{19}F NMR** (376 MHz, Chloroform-*d*) δ -147.10, (s, 1F); **FT-IR** (ATR): 3339, 1681, 1522, 1325, 1150, 683, 561 cm^{-1}; **HRMS** (ESI$^+$, m/z): calcd for $C_{32}H_{27}ClFN_2O_5S_2^+$ $[M+H]^+$: 637.1029, found: 637.1038.



4aaf

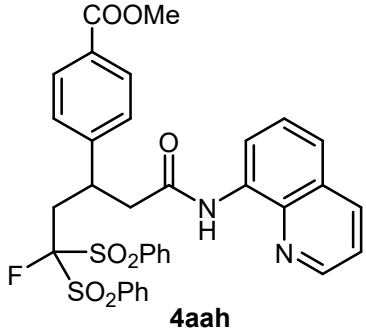
5-fluoro-5,5-bis(phenylsulfonyl)-N-(quinolin-8-yl)-3-(4-(trifluoromethyl)phenyl)pentanamide (4aaf): The title compound was prepared from **1a** (21.2 mg, 0.1 mmol), **2a** (38mg, 0.12 mmol), and 4-Iodobenzotrifluoride **3f** (109 mg, 0.4 mmol) according to the general procedure. Purification using silica gel chromatography (1:3 = EA:PE) gave the product as an white solid (23mg, 35% yield). **M.p.** = 130.2 - 132.1 °C; **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 9.54 (s, 1H), 8.72 (d, *J* = 4.4 Hz, 1H), 8.60 (p, *J* = 4.5 Hz, 1H), 8.14 – 8.08 (m, 1H), 8.00 (d, *J* = 7.9 Hz, 2H), 7.78 (d, *J* = 7.9 Hz, 2H), 7.73-7.66 (m, 2H), 7.56 (t, *J* = 7.7 Hz, 2H), 7.49 - 7.35 (m, 7H), 7.14 (d, *J* = 8.0 Hz, 2H), 3.83-3.77 (m, 1H), 3.22 - 3.10 (m, 1H), 3.02 - 2.89 (m,

2H), 2.82-2.76 (m, *J* = 15.1, 9.2 Hz, 1H); **^{13}C NMR** (101 MHz, Chloroform-*d*) δ 168.0, 148.1, 146.8, 138.1, 136.4, 135.5, 135.4, 134.8, 134.2, 134.0, 131.1, 130.8, 130.8, 129.2, 129.2,129.0 (q, *J* = 32.0 Hz), 128.8, 127.9, 127.6, 127.3, 125.5 (q, *J* = 3.6 Hz),125.4, 121.7, 121.6, 116.6, 115.1 (d, *J* = 268.9 Hz), 45.0, 37.2 (d, *J* = 5.3 Hz), 34.5 (d, *J* = 16.4 Hz); **^{19}F NMR** (376 MHz, Chloroform-*d*) δ -62.47 (s, 1F), -146.85 (s, 1F); **FT-IR** (ATR): 3311, 2919, 1677, 1524, 1323, 1151, 748, 680, 560, 522 cm^{-1}; **HRMS** (ESI$^+$, m/z): calcd for $C_{33}H_{27}F_4N_2O_5S_2^+$ $[M+H]^+$: 671.1293, found: 671.1293.



4aag

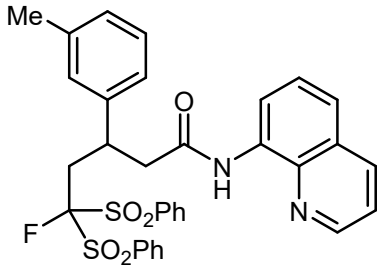
5-fluoro-3-(4-formylphenyl)-5,5-bis(phenylsulfonyl)-N-(quinolin-8-yl)pentanamide (4aag): The title compound was prepared from **1a** (21.2 mg, 0.1 mmol), **2a** (38mg, 0.12 mmol), and 4-Iodobenzaldehyde **3g** (92.8 mg, 0.4 mmol) according to the general procedure. Purification using silica gel chromatography (1:3 = EA:PE) gave the product as an white solid (23mg, 21% yield). **M.p.** = 81.1 - 82.1 °C; **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 9.86 (s, 1H), 9.55 (s, 1H), 8.71 (d, *J* = 4.2 Hz, 1H), 8.59 (t, *J* = 4.5 Hz, 1H), 8.11 (d, *J* = 8.2 Hz, 1H), 7.98 (d, *J* = 7.7 Hz, 2H), 7.79 (d, *J* = 7.7 Hz, 2H), 7.73 - 7.64 (m, 4H), 7.57 - 7.40 (m, 7H), 7.20 (d, *J* = 7.7 Hz, 2H), 3.84 - 3.79 (m, 1H), 3.21 - 3.11 (m, 1H), 3.00 - 2.92 (m, 2H), 2.82 - 2.76 (m, 1H); **^{13}C NMR** (101 MHz, Chloroform-*d*) δ 191.8, 168.0, 149.8, 148.0, 138.0, 136.5, 135.5, 134.4, 135.1, 134.9, 134.3, 133.9, 131.1, 130.9, 130.0, 129.2, 129.2, 128.0, 127.9, 127.3, 121.7, 121.6, 116.7, 115.1 (d, *J* = 268.8 Hz), 45.0, 37.5 (d, *J* = 5.2 Hz), 34.3 (d, *J* = 16.5 Hz); **^{19}F NMR** (376 MHz, Chloroform-*d*) δ -146.73, (s, 1F); **FT-IR** (ATR): 3339, 1679, 1523, 1325, 1151, 683, 562 cm^{-1}; **HRMS** (ESI$^+$, m/z): calcd for $C_{33}H_{29}FN_2O_6S_2^+$ $[M+H]^+$: 631.1367, found: 631.1371.



4aah

methyl 4-(1-fluoro-5-oxo-1,1-bis(phenylsulfonyl)-5-(quinolin-8-ylamino)pentan-3-yl)benzoate (4aah):

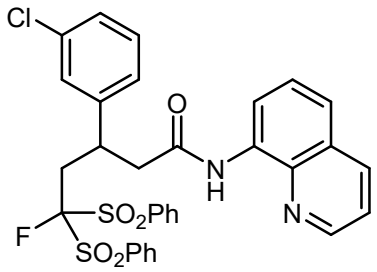
The title compound was prepared from **1a** (21.2 mg, 0.1 mmol), **2a** (38mg, 0.12 mmol), and Methyl 4-iodobenzoate **3h** (105 mg, 0.4 mmol) according to the general procedure. Purification using silica gel chromatography (1:3 = EA:PE) gave the product as an white solid (28mg, 42% yield). **M.p.** = 78.1 - 79.7 °C; **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 9.53 (s, 1H), 8.70 (d, *J* = 4.3 Hz, 1H), 8.59 (p, *J* = 4.5 Hz, 1H), 8.13 - 8.06 (m, 1H), 7.99 (d, *J* = 7.8 Hz, 2H), 7.79 (dd, *J* = 7.9, 2.6 Hz, 4H), 7.69 (q, *J* = 7.5 Hz, 2H), 7.58 - 7.37 (m, 7H), 7.08 (d, *J* = 7.9 Hz, 2H), 3.83 (s, 3H), 3.78 - 3.72 (m, 1H), 3.21 - 3.11 (m, 1H), 2.89 - 2.98 (m, 2H), 2.79 - 2.73 (m, 1H); **^{13}C NMR** (101 MHz, Chloroform-*d*) δ 168.1, 166.8, 148.1, 148.0, 138.0, 136.4, 135.5, 135.4, 134.9, 134.3, 134.0, 131.1, 130.8, 129.9, 129.2, 129.2, 128.7, 127.8, 127.3, 127.2, 121.6, 121.6, 116.6, 115.2 (d, *J* = 269 Hz), 52.0, 45.1, 37.4 (d, *J* = 5.1 Hz), 34.4 (d, *J* = 16.8 Hz); **^{19}F NMR** (376 MHz, Chloroform-*d*) δ -146.79, (s, 1F); **FT-IR** (ATR): 3339, 3115, 1682, 1522, 1325, 1150, 1078, 682, 561 cm^{-1}; **HRMS** (ESI$^+$, m/z): calcd for $C_{34}H_{30}FN_2O_7S_2^+$ $[M+H]^+$: 661.1473, found: 661.1478.



4aai

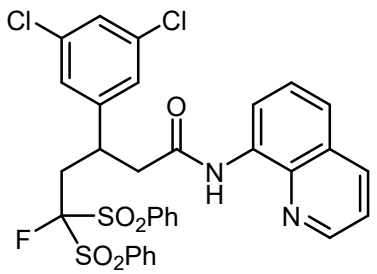
5-fluoro-5,5-bis(phenylsulfonyl)-N-(quinolin-8-yl)-3-(m-tolyl)pentanamide (4aai): The title compound was prepared from **1a** (21.2 mg, 0.1 mmol), **2a** (38mg, 0.12 mmol), and 3-Iodotoluene **3i** (87.2 mg, 0.4 mmol) according to the general procedure. Purification using silica gel chromatography (1:3 = EA:PE) gave the product as an white solid (43.2mg, 70% yield). **M.p.** = 69.9 - 70.8 °C; **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 9.52 (s, 1H), 8.71 (dd, *J* = 4.4, 2 Hz, 1H), 8.62 (dd, *J* = 6.4, 2.4 Hz, 1H), 8.07 (dd, *J* = 8.3, 1.7 Hz, 1H), 8.01 (d, *J* = 7.9 Hz, 2H), 7.83 (d, *J* = 8.1 Hz, 2H), 7.69 (q, *J* = 7.5 Hz, 2H), 7.57 - 7.36 (m, 7H), 7.02 (t, *J* = 8 Hz, 1H), 6.88 (d, *J* = 7.5 Hz, 1H), 6.81 (d, *J* = 6.6 Hz, 2H), 3.63 - 3.56 (m, 1H), 3.13 (td, *J* = 16.4, 6.8 Hz, 1H), 2.98 - 2.86 (m, 2H), 2.74 (dd, *J* = 15.0, 9.2 Hz, 1H), 2.19 (s, 3H); **^{13}C NMR** (101 MHz, Chloroform-*d*) δ 168.7, 148.0, 142.6, 138.1, 138.0, 136.3, 135.4, 135.3, 135.0, 134.6, 134.2, 131.1, 130.9, 129.2, 129.1, 128.5, 127.8, 127,8, 127.7, 127.2, 124.1, 121.6, 121.5, 116.5, 115.4 (d, *J* = 269.1 Hz), 45.3, 37.2 (d, *J* = 5.1 Hz), 34.7 (d, *J* = 16.7 Hz), 21.4; **^{19}F NMR** (376 MHz,

Chloroform-*d*) δ -147.29, (s, 1F); **FT-IR** (ATR): 3342, 1683, 1523, 1328, 1151, 684, 560 cm^{-1}; **HRMS** (ESI^+, m/z): calcd for $C_{33}H_{30}FN_2O_5S_2^+$ $[M+H]^+$: 617.1575, found: 617.1573.



4aaj

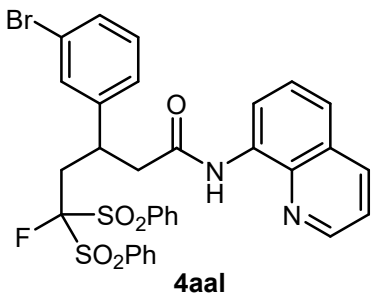
3-(3-chlorophenyl)-5-fluoro-5,5-bis(phenylsulfonyl)-N-(quinolin-8-yl)pentanamide (4aa*J*): The title compound was prepared from **1a** (21.2 mg, 0.1 mmol), **2a** (38mg, 0.12 mmol), and 1-Chloro-3-iodobenzene **3*J*** (95.4 mg, 0.4 mmol) according to the general procedure. Purification using silica gel chromatography (1:3 = EA:PE) gave the product as an white solid (25mg, 39% yield). **M.p.** = 75.1 - 76.9 °C; **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 9.54 (s, 1H), 8.75 (td, *J* = 4.1, 1.7 Hz, 1H), 8.65 - 8.56 (m, 1H), 8.12 (dt, *J* = 8.3, 1.5 Hz, 1H), 8.04 - 7.94 (m, 2H), 7.85 - 7.76 (m, 2H), 7.75 - 7.68 (m, 2H), 7.62 - 7.39 (m, 7H), 7.14 - 7.02 (m, 2H), 6.97 - 6.87 (m, 2H), 3.69 - 3.61 (m, 1H), 3.18 - 3.05 (m, 1H), 2.96 - 2.79 (m, 2H), 2.77 - 2.69 (m, 1H); **^{13}C NMR** (101 MHz, Chloroform-*d*) δ 168.2, 148.0, 144.8, 138.0, 136.5, 135.5, 134.9, 134.2, 134.2, 134.0, 131.1, 130.8, 129.8, 129.2, 129.1, 127.9, 127.3, 127.3, 127.1, 125.6, 121.6, 116.7, 115.0 (d, *J* = 269 Hz), 45.0, 37.1 (d, *J* = 5.5 Hz), 34.6 (d, *J* = 16.8 Hz); **^{19}F NMR** (376 MHz, Chloroform-*d*) δ -147.16, (s, 1F); **FT-IR** (ATR): 3340, 1683, 1523, 1328, 1151,684, 559 cm^{-1}; **HRMS** (ESI^+, m/z): calcd for $C_{32}H_{27}ClFN_2O_5S_2^+$ $[M+H]^+$: 637.1029, found: 637.1033.



4aak

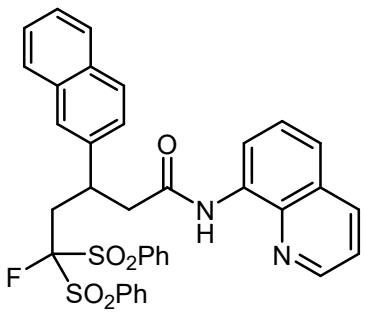
3-(3,5-dichlorophenyl)-5-fluoro-5,5-bis(phenylsulfonyl)-N-(quinolin-8-yl)pentanamide (4aak): The title compound was prepared from **1a** (21.2 mg, 0.1 mmol), **2a** (38mg, 0.12 mmol), and 3,5-Dichloroiodobenzene **3k** (109.16 mg, 0.4 mmol) according to the general procedure. Purification using silica gel chromatography (1:3 = EA:PE) gave the product as an white solid (23mg,

35% yield). **M.p.** = 140.1 - 141.5 °C; **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 9.58 (s, 1H), 8.77 (d, *J* = 4.2 Hz, 1H), 8.66 - 8.57 (m, 1H), 8.14 (d, *J* = 8.1 Hz, 1H), 8.02 (d, *J* = 7.8 Hz, 2H), 7.82 - 7.71 (m, 4H), 7.60 - 7.43 (m, 7H), 7.07 (s, 1H), 6.86 (s, 2H), 3.63 (s, 1H), 3.23 - 3.06 (m, 1H), 2.92 (dd, *J* = 15.2, 4.9 Hz, 1H), 2.85 - 2.70 (m, 2H); **^{13}C NMR** (101 MHz, Chloroform-*d*) δ 167.8, 148.1, 146.1, 138.1, 136.4, 135.6, 135.6, 134.9, 134.8, 134.0, 133.9, 131.2, 130.8, 129.3, 129.2, 127.9, 127.3, 127.2, 125.9, 121.7, 121.7, 116.7, 114.8 (d, *J* = 269 Hz), 44.7, 36.9 (d, *J* = 11 Hz), 34.5 (d, *J* =16.6 Hz); **^{19}F NMR** (376 MHz, Chloroform-*d*) δ -147.13, (s, 1F); **FT-IR** (ATR): 3334, 1682, 1522, 1325, 1150,683, 560 cm^{-1}; **HRMS** (ESI$^+$, m/z): calcd for $C_{32}H_{26}Cl_2FN_2O_5S_2^+$ $[M+H]^+$: 671.0639, found: 671.0645.



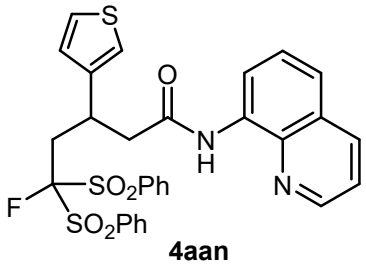
4aal

3-(3-bromophenyl)-5-fluoro-5,5-bis(phenylsulfonyl)-N-(quinolin-8-yl)pentanamide (4aal): The title compound was prepared from **1a** (21.2 mg, 0.1 mmol), **2a** (38mg, 0.12 mmol), and 1-Bromo-3-iodobenzene **3l** (113.2 mg, 0.4 mmol) according to the general procedure. Purification using silica gel chromatography (1:3 = EA:PE) gave the product as an white solid (17mg, 25% yield). **M.p.** = 84.1 - 85.2 °C; **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 9.52 (s, 1H), 8.72 (d, *J* = 4.3 Hz, 1H), 8.64 - 8.56 (m, 1H), 8.09 (d, *J* = 8.3 Hz, 1H), 7.99 (d, *J* = 7.9 Hz, 2H), 7.79 (d, *J* = 7.8 Hz, 2H), 7.69 (q, *J* = 7.2 Hz, 2H), 7.59 - 7.36 (m, 7H), 7.08 (d, *J* = 8 Hz, 2H), 6.95 (d, *J* = 8 Hz, 2H),3.70 - 3.63 (m, 1H), 3.16 - 3.06 (m, 1H), 2.93 - 2.85 (m, 2H), 2.77 - 2.69 (m, 1H); **^{13}C NMR** (101 MHz, Chloroform-*d*) δ 168.2, 148.1, 141.2, 138.1, 136.3, 135.5, 135.3, 134.9, 134.4, 134.1, 132.5, 131.1, 130.8, 129.9, 129.2, 121.2, 128.7, 128.6, 127.8, 127.2, 121.6, 116.5, 115.2 (d, *J* = 269 Hz), 45.2, 36.8 (d, *J* = 5.4 Hz), 34.6 (d, *J* = 16.6 Hz); **^{19}F NMR** (376 MHz, Chloroform-*d*) δ -147.1, (s, 1F); **FT-IR** (ATR): 3341, 1683, 1523, 1326, 1151, 683, 562 cm^{-1}; **HRMS** (ESI$^+$, m/z): calcd for $C_{32}H_{27}ClFN_2O_5S_2^+$ $[M+H]^+$: 681.0523, found: 681.0531.



4aam

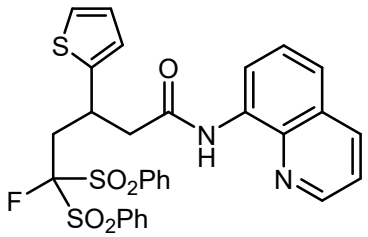
5-fluoro-3-(naphthalen-2-yl)-5,5-bis(phenylsulfonyl)-N-(quinolin-8-yl)pentanamide (4aam): The title compound was prepared from **1a** (21.2 mg, 0.1 mmol), **2a** (38mg, 0.12 mmol), and 2-iodonaphthalene **3m** (101.6 mg, 0.4 mmol) according to the general procedure. Purification using silica gel chromatography (1:3 = EA:PE) gave the product as an white solid (39.2mg, 60% yield). **M.p.** = 87.9 - 89.8 °C; **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 9.53 (s, 1H), 8.60 (dd, *J* = 6.8, 2.2 Hz, 1H), 8.55 (dd, *J* = 4.3, 1.7 Hz, 1H), 8.03 (dq, *J* = 8.4, 1.6 Hz, 3H), 7.78 (dt, *J* = 8.5, 1.3 Hz, 2H), 7.74 - 7.69 (m, 2H), 7.66 - 7.60 (m, 2H), 7.56 (q, *J* = 8.0 Hz, 3H), 7.43 - 7.37 (m, 7H), 7.33 (dd, *J* = 8.3, 4.2 Hz, 1H), 7.18 (dd, *J* = 8.6, 1.8 Hz, 1H), 3.86 - 3.79 (m, 1H), 3.29 - 3.19 (m, 1H), 3.08 - 2.98 (m, 2H), 2.88 (dd, *J* = 15.0, 9.3 Hz, 1H); **^{13}C NMR** (101 MHz, Chloroform-*d*) δ 168.6, 148.0, 140.1, 138.1, 136.2, 135.5, 135.2, 135.0, 134.4, 134.2, 133.4, 132.5, 131.1, 130.8, 129.1, 129.1, 128.4, 127.8, 127.8, 127.6, 127.2, 126.0, 126.0, 125.7, 125.4, 121.5, 121.5, 116.5, 115.40 (d, *J* = 269.4Hz), 45.4, 37.5 (d, *J* = 5.3 Hz), 34.8 (d, *J* = 16.5 Hz); **^{19}F NMR** (376 MHz, Chloroform-*d*) δ -147.10, (s, 1F); **FT-IR** (ATR): 3338, 1680, 1521, 1484, 1324, 1149, 1078, 682, 560 cm^{-1}; **HRMS** (ESI$^+$, m/z): calcd for $C_{36}H_{30}FN_2O_5S_2^+$ $[M+H]^+$: 653.1575, found: 653.1581.



4aan

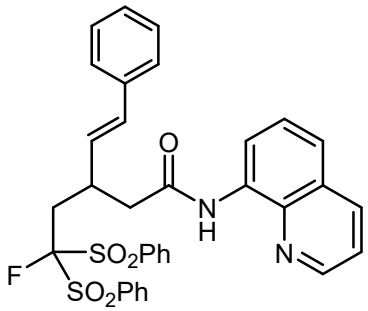
5-fluoro-5,5-bis(phenylsulfonyl)-N-(quinolin-8-yl)-3-(thiophen-3-yl)pentanamide (4aan): The title compound was prepared from **1a** (21.2 mg, 0.1 mmol), **2a** (38mg, 0.12 mmol), and 3-iodothiophene **3n** (84 mg, 0.4 mmol) according to the general procedure. Purification using silica gel chromatography (1:3 = EA:PE) gave the product as an white solid (48.70mg, 80% yield). **M.p.** = 142.6 - 143.5 °C; **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 9.58 (s, 1H), 8.77 (dd, *J* = 4.1, 1.7 Hz, 1H), 8.66 (dd, *J* = 6.3, 2.7 Hz, 1H), 8.13 (dd, *J* = 8.3, 1.7 Hz, 1H), 8.00 (d, *J* = 7.9 Hz, 2H), 7.89 (d, *J* = 7.9 Hz, 2H),

7.72 (t, *J* = 7.5 Hz, 2H), 7.60 - 7.41 (m, 7H), 7.13 (dd, *J* = 5.0, 2.9 Hz, 1H), 6.85 (dd, *J* = 13.5, 4.0 Hz, 2H), 3.86 - 3.80 (m, 1H), 3.12 (td, *J* = 16.5, 6.8 Hz, 1H), 3.01 - 2.90 (m, 2H), 2.75 (dd, *J* = 15.0, 9.1 Hz, 1H); **^{13}C NMR** (101 MHz, Chloroform-*d*) δ 168.7, 148.0, 143.2, 138.2, 136.4, 135.4, 135.3, 134.9, 134.6, 134.2, 131.1, 130.9, 129.2, 129.1, 127.9, 127.3, 126.3, 125.8, 121.6, 121.5, 121.0, 116.5, 115.3 (d, *J* = 269.1 Hz), 45.0, 34.7 (d, *J* = 16.5 Hz), 32.7 (d, *J* = 5.3 Hz); **^{19}F NMR** (376 MHz, Chloroform-*d*) δ -147.61, (s, 1F); **FT-IR** (ATR): 3337, 1679, 1526, 1325, 1165, 682, 571 cm^{-1}; **HRMS** (ESI$^+$, m/z): calcd for $C_{30}H_{26}FN_2O_5S_3^+$ $[M+H]^+$: 609.0983, found: 609.0985.



4aao

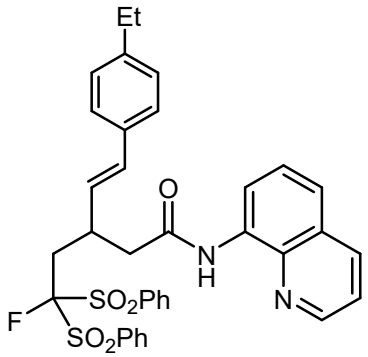
5-fluoro-5,5-bis(phenylsulfonyl)-N-(quinolin-8-yl)-3-(thiophen-2-yl)pentanamide (4aao): The title compound was prepared from **1a** (21.2 mg, 0.1 mmol), **2a** (38mg, 0.12 mmol), and 2-iodothiophene **3o** (84 mg, 0.4 mmol) according to the general procedure. Purification using silica gel chromatography (1:3 = EA:PE) gave the product as an white solid (56mg, 92% yield). **M.p.** = 160.5 - 162.3 ^{o}C; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 9.62 (s, 1H), 8.75 (dd, *J* = 4.2, 1.7 Hz, 1H), 8.65 (dd, *J* = 6.1, 2.9 Hz, 1H), 8.11 (dd, *J* = 8.3, 1.7 Hz, 1H), 7.99 (d, *J* = 7.9 Hz, 2H), 7.88 (d, *J* = 7.9 Hz, 2H), 7.75 - 7.66 (m, 2H), 7.59 - 7.38 (m, 7H), 7.02 (d, *J* = 5.0 Hz, 1H), 6.78 - 6.67 (m, 2H), 4.06 - 3.99 (m, 1H), 3.16 (td, *J* = 16.4, 7.0 Hz, 1H), 3.03 - 2.94 (m, 2H), 2.80 (dd, *J* = 15.1, 9.1 Hz, 1H); **^{13}C NMR** (101 MHz, Chloroform-*d*) δ 168.3, 148.1, 146.1, 138.1, 136.4, 135.4, 135.4, 134.9, 134.5, 134.2, 131.1, 130.9, 129.3, 129.1, 127.9, 127.3, 126.7, 124.6, 123.8, 121.6, 121.5, 116.6, 115.1 (d, *J* = 269.2 Hz), 45.9, 35.9 (d, *J* = 16.5Hz), 32.9 (d, *J* = 5.4Hz); **^{19}F NMR** (376 MHz, Chloroform-*d*) δ -147.84, (s, 1F); **FT-IR** (ATR): 3346, 1675, 1528, 1325, 1166, 738, 682, 567 cm^{-1}; **HRMS** (ESI$^+$, m/z): calcd for $C_{30}H_{26}FN_2O_5S_3^+$ $[M+H]^+$: 609.0983, found: 609.0989.



4aap

(E)-3-(2-fluoro-2,2-bis(phenylsulfonyl)ethyl)-5-phenyl-N-(quinolin-8-yl)pent-4-enamide (4aap): The title compound was prepared from **1a** (21.2 mg, 0.1

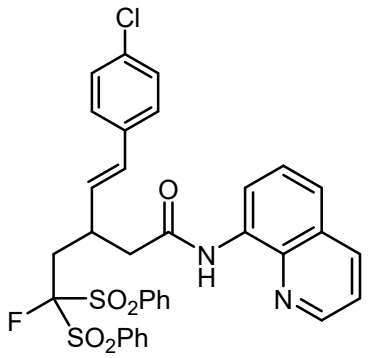
mmol), **2a** (38mg, 0.12 mmol), and (E)-(2-iodovinyl)benzene **3p** (92 mg, 0.4 mmol) according to the general procedure. Purification using silica gel chromatography (1:5 = EA:PE) gave the product as an white solid (50mg, 80% yield). **M.p.** = 70.6 - 71.7 °C; **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 9.72 (s, 1H), 8.71 (dd, *J* = 4.2, 1.7 Hz, 1H), 8.68 (dd, *J* = 6.6, 2.4 Hz, 1H), 8.13 (dd, *J* = 8.3, 1.7 Hz, 1H), 8.00 - 7.91 (m, 4H), 7.66 (q, *J* = 7.4 Hz, 2H), 7.54 - 7.47 (m, 6H), 7.42 (dd, *J* = 8.3, 4.2 Hz, 1H), 7.25 - 7.15 (m, 5H), 6.29 (d, *J* = 15.8 Hz, 1H), 6.00 (dd, *J* = 15.8, 8.5 Hz, 1H), 3.27 - 3.20 (m, 1H), 2.96 - 2.75 (m, 3H), 2.67 - 2.61 (m, 1H); **^{13}C NMR** (101 MHz, Chloroform-*d*) δ 168.7, 148.2, 138.3, 136.9, 136.3, 135.3, 135.3, 134.9, 134.7, 134.3, 131.3, 131.0, 130.8, 129.1, 128.4, 127.9, 127.4, 127.3, 126.4, 121.6, 121.6, 116.5, 115.6 (d, *J* = 269.2 Hz), 43.8, 35.2 (d, *J* = 4.9 Hz), 33.7 (d, *J* = 16.6 Hz); **^{19}F NMR** (376 MHz, Chloroform-*d*) δ -146.76 (s, 1F); **FT-IR** (ATR): 3342, 1682, 1523, 1326, 1151, 750, 683, 561 cm^{-1}; **HRMS** (ESI$^+$, m/z): calcd for $C_{34}H_{30}FN_2O_5S_2^+$ $[M+H]^+$: 629.1575, found: 629.1580.



4aaq

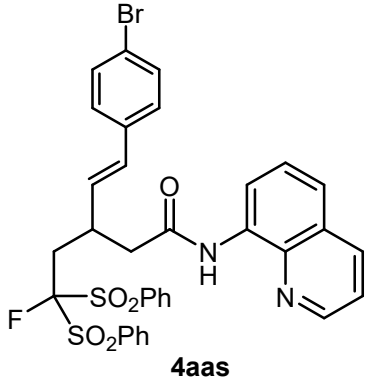
(E)-5-(4-ethylphenyl)-3-(2-fluoro-2,2-bis(phenylsulfonyl)ethyl)-N-(quinolin-8-yl)pent-4-enamide (4aaq): The title compound was prepared from **1a** (21.2 mg, 0.1 mmol), **2a** (38mg, 0.12 mmol), and (E)-1-ethyl-4-(2-iodovinyl)benzene **3q** (103 mg, 0.4 mmol) according to the general procedure. Purification using silica gel chromatography (1:5 = EA:PE) gave the product as an white solid (57mg, 86% yield). **M.p.** = 64.7 - 65.1 °C; **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 9.73 (s, 1H), 8.73 - 8.66 (m, 2H), 8.10 (dd, *J* = 8.3, 1.7 Hz, 1H), 8.02 - 7.91 (m, 4H), 7.64 (td, *J* = 7.4, 5.2 Hz, 2H), 7.55 - 7.44 (m, 6H), 7.39 (dd, *J* = 8.3, 4.2 Hz, 1H), 7.16 - 7.04 (m, 4H), 6.27 (d, *J* = 15.8 Hz, 1H), 5.96 (dd, *J* = 15.8, 8.5 Hz, 1H), 3.28 - 3.23 (m, 1H), 2.98 - 2.75 (m, 3H), 2.66 - 2.56 (m, 3H), 1.19 (t, *J* = 7.6 Hz, 3H); **^{13}C NMR** (101 MHz, Chloroform-*d*) δ 168.9, 148.2, 143.6, 138.2, 136.4, 135.4, 135.4, 134.9, 134.7, 134.4, 136.3, 131.2, 131.0, 129.8, 129.2, 127.9, 127.3,

126.4, 121.7, 121.6, 116.6, 115.6 (d, J = 269.0 Hz), 43.9, 35.3 (d, J = 5 Hz), 33.8 (d, J = 16.7 Hz), 28.6, 15.7; **^{19}F NMR** (376 MHz, Chloroform-*d*) δ -146.64, (s, 1F); **FT-IR** (ATR): 3340, 1682, 1522, 1325, 1150, 682, 559 cm^{-1}; **HRMS** (ESI$^+$, m/z): calcd for $C_{36}H_{34}FN_2O_5S_2^+$ $[M+H]^+$: 657.1888, found: 657.1897.



4aar

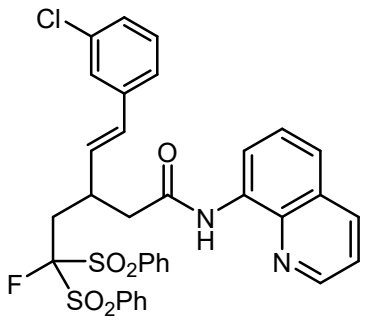
(E)-5-(4-chlorophenyl)-3-(2-fluoro-2,2-bis(phenylsulfonyl)ethyl)-N-(quinolin-8-yl)pent-4-enamide (4aar): The title compound was prepared from **1a** (21.2 mg, 0.1 mmol), **2a** (38mg, 0.12 mmol), and (E)-1-chloro-4-(2-iodovinyl)benzene **3r** (106 mg, 0.4 mmol) according to the general procedure. Purification using silica gel chromatography (1:5 = EA:PE) gave the product as an white solid (53mg, 80% yield). **M.p.** = 68.5 - 70.1 °C; **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 9.71 (s, 1H), 8.68 (dd, J = 6.6, 3.8 Hz, 2H), 8.08 (d, J = 7.9 Hz, 1H), 7.94 (dd, J = 18.3, 7.5 Hz, 4H), 7.61 (td, J = 7.2, 4.0 Hz, 2H), 7.53 - 7.35 (m, 7H), 7.19 - 7.06 (m, 4H), 6.26 (dd, J = 15.8, 4.0 Hz, 1H), 6.00 (dd, J = 15.8, 8.3 Hz, 1H), 3.32 - 3.27 (m, 1H), 3.00 - 2.72 (m, 3H), 2.68 - 2.61 (m, 1H); **^{13}C NMR** (101 MHz, Chloroform-*d*) δ 168.7, 148.2, 138.2, 136.4, 135.4, 135.4, 134.8, 134.7, 134.2, 132.9, 131.6, 131.0, 130.1, 129.2, 129.1, 128.5, 127.9, 127.6, 127.3, 121.7, 116.6, 115.6 (d, J = 268.8 Hz), 43.6, 35.2 (d, J = 5.0 Hz), 33.7 (d, J = 16.4 Hz); **^{19}F NMR** (376 MHz, Chloroform-*d*) δ -146.58, (s, 1F); **FT-IR** (ATR): 3336, 1682, 1522, 1326, 1151, 683, 561 cm^{-1}; **HRMS** (ESI$^+$, m/z): calcd for $C_{34}H_{29}ClFN_2O_5S_2^+$ $[M+H]^+$: 663.1185, found: 663.1190.



4aas

(E)-5-(4-bromophenyl)-3-(2-fluoro-2,2-bis(phenylsulfonyl)ethyl)-N-(quinolin-8-yl)pent-4-enamide (4aas): The title compound was prepared from **1a** (21.2 mg, 0.1 mmol), **2a** (38mg, 0.12 mmol), and (E)-1-bromo-4-(2-iodovinyl)benzene **3s** (124 mg, 0.4 mmol) according to the general procedure. Purification using

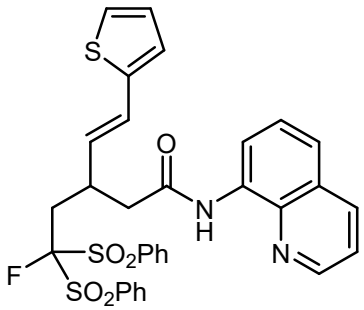
silica gel chromatography (1:5 = EA:PE) gave the product as an white solid (58mg, 82% yield). **M.p.** = 175.1 - 176.6 °C; **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 9.63 (s, 1H), 8.64 (dd, *J* = 4.3, 1.7 Hz, 1H), 8.58 (dd, *J* = 6.1, 2.9 Hz, 1H), 8.07 (dd, *J* = 8.3, 1.7 Hz, 1H), 7.90 - 7.81 (m, 4H), 7.62 - 7.55 (m, 2H), 7.48 - 7.34 (m, 7H), 7.28 - 7.22 (m, 2H), 6.99 - 6.93 (m, 2H), 6.16 (d, *J* = 15.8 Hz, 1H), 5.98 - 5.88 (m, 1H), 3.20 - 3.16 (m, 1H), 2.86 - 2.64 (m, 3H), 2.56 (dd, *J* = 14.9, 8.1 Hz, 1H); **^{13}C NMR** (101 MHz, Chloroform-*d*) δ 168.7, 148.2, 138.2, 136.4, 135.9, 135.4, 135.4, 134.8, 134.7, 134.2, 131.8, 131.4, 131.0, 130.1, 129.2, 129.1, 127.9, 127.9, 127.3, 121.7, 121.1, 116.6, 115.6 (d, *J* = 268.7 Hz), 43.6, 35.3 (d, *J* = 5.2 Hz), 33.7 (d, *J* = 16.5 Hz); **^{19}F NMR** (376 MHz, Chloroform-*d*) δ -146.67, (s, 1F); **FT-IR** (ATR): 3351, 1696, 1522, 1330, 1150, 684, 563 cm^{-1}; **HRMS** (ESI$^+$, m/z): calcd for $C_{34}H_{30}BrFN_2O_5S_2^+$ $[M+H]^+$: 707.0680, found: 707.0682.



4aat

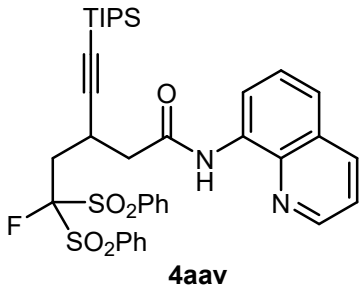
(E)-5-(3-chlorophenyl)-3-(2-fluoro-2,2-bis(phenylsulfonyl)ethyl)-N-(quinolin-8-yl)pent-4-enamide (4aat): The title compound was prepared from **1a** (21.2 mg, 0.1 mmol), **2a** (38mg, 0.12 mmol), and (E)-1-chloro-3-(2-iodovinyl)benzene **3t** (106 mg, 0.4 mmol) according to the general procedure. Purification using silica gel chromatography (1:5 = EA:PE) gave the product as an white solid (57mg, 85% yield). **M.p.** = 68.2 - 69.1 °C; **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 9.60 (s, 1H), 8.58 (dd, *J* = 14.0, 5.1 Hz, 2H), 8.00 (d, *J* = 8.1 Hz, 1H), 7.84 (dd, *J* = 25.6, 7.7 Hz, 4H), 7.53 (dd, *J* = 7.9, 4.3 Hz, 2H), 7.43 - 7.28 (m, 7H), 7.01 (d, *J* = 3.3 Hz, 3H), 6.91 (t, *J* = 4.9 Hz, 1H), 6.13 (d, *J* = 15.8 Hz, 1H), 5.85 (dd, *J* = 15.8, 8.5 Hz, 1H), 3.21 - 3.12 (m, 1H), 2.88 - 2.62 (m, 3H), 2.57 - 2.51 (m, 1H); **^{13}C NMR** (101 MHz, Chloroform-*d*) δ 168.6, 148.2, 138.7, 138.2, 136.4, 135.4, 135.4, 134.9, 134.2, 134.2, 132.4, 131.0, 131.0, 130.0, 129.6, 129.2, 127.9, 127.3, 126.1, 124.8, 121.7, 116.6, 115.5 (d, *J* = 268.8 Hz), 43.7, 35.3 (d, *J* = 5.1 Hz), 33.7 (d, *J* = 16.7 Hz); **^{19}F NMR** (376 MHz, Chloroform-*d*) δ -146.77, (s, 1F); **FT-IR** (ATR): 3334, 1682, 1522, 1326, 1150, 683,

560 cm^{-1}; **HRMS** (ESI^+, m/z): calcd for $C_{34}H_{29}ClFN_2O_5S_2^+$ $[M+H]^+$: 663.1185, found: 663.1191.



4aau

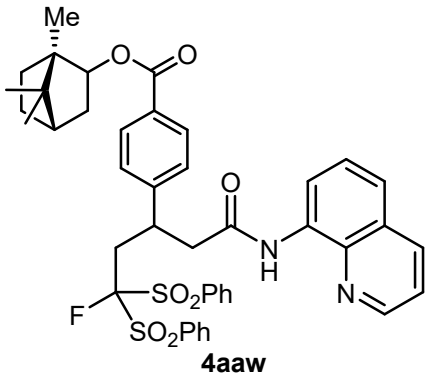
(E)-3-(2-fluoro-2,2-bis(phenylsulfonyl)ethyl)-N-(quinolin-8-yl)-5-(thiophen-2-yl)pent-4-enamide (4aau): The title compound was prepared from **1a** (21.2 mg, 0.1 mmol), **2a** (38mg, 0.12 mmol), and 2-(2-iodoethyl)thiophene **3u** (96 mg, 0.4 mmol) according to the general procedure. Purification using silica gel chromatography (1:5 = EA:PE) gave the product as an white solid (55 mg, 86% yield). **M.p.** = 68.1 - 69.4 °C; **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 9.71 (s, 1H), 8.73 - 8.66 (m, 2H), 8.11 (dd, *J* = 8.3, 1.7 Hz, 1H), 8.00 - 7.90 (m, 4H), 7.69 - 7.61 (m, 2H), 7.53 - 7.39 (m, 7H), 7.06 (d, *J* = 5.1 Hz, 1H), 6.86 (dd, *J* = 5.1, 3.5 Hz, 1H), 6.78 (d, *J* = 3.5 Hz, 1H), 6.40 (d, *J* = 15.7 Hz, 1H), 5.83 (dd, *J* = 15.7, 8.6 Hz, 1H), 3.30 - 3.19 (m, 1H), 2.96 - 2.85 (m, 1H), 2.84 - 2.70 (m, 2H), 2.66 - 2.60 (m, 1H); **^{13}C NMR** (101 MHz, Chloroform-*d*) δ 168.6, 148.2, 141.9, 138.2, 136.3, 135.4, 134.9, 134.6, 134.3, 131.0, 131.0, 130.3, 129.1, 127.9, 127.3, 127.2, 125.5, 124.6, 124.0, 121.7, 121.6, 116.6, 115.5 (d, *J* = 268.8 Hz), 43.6, 35.1 (d, *J* = 5.2 Hz), 33.7 (d, *J* = 16.4 Hz); **^{19}F NMR** (376 MHz, Chloroform-*d*) δ -146.68, (s, 1F); **FT-IR** (ATR): 3341, 2961, 1682, 1522, 1326, 1151, 683, 561 cm^{-1}; **HRMS** (ESI^+, m/z): calcd for $C_{32}H_{28}FN_2O_5S_3^+$ $[M+H]^+$: 635.1139, found: 635.1145.



4aav

3-(2-fluoro-2,2-bis(phenylsulfonyl)ethyl)-N-(quinolin-8-yl)-5-(triisopropylsilyl)pent-4-ynamide (4aav): The title compound was prepared from **1a** (21.2 mg, 0.1 mmol), **2a** (38mg, 0.12 mmol), and (bromoethynyl)triisopropylsilane **3v** (105 mg, 0.4 mmol) according to the general procedure. Purification using silica gel chromatography (1:5 = EA:PE) gave the product as an white solid (57mg, 80% yield). **M.p.** = 101.6 - 102.7 °C; **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 9.78 (s,

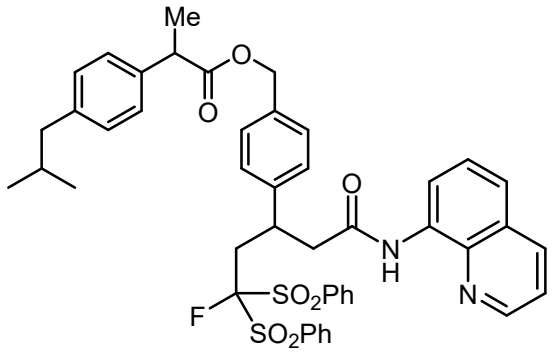
1H), 8.77 - 8.70 (m, 2H), 8.11 (dd, *J* = 8.3, 1.7 Hz, 1H), 7.95 (dd, *J* = 22.1, 8.0 Hz, 4H), 7.68 (td, *J* = 7.5, 3.7 Hz, 2H), 7.55 - 7.40 (m, 7H), 3.50 - 3.43 (m, 1H), 3.05 - 2.75 (m, 3H), 2.66 - 2.60 (m, 1H), 0.83 (d, *J* = 5.1 Hz, 21H); **^{13}C NMR** (101 MHz, Chloroform-*d*) δ 168.0, 148.1, 138.3, 136.3, 135.7, 135.5, 134.9, 134.6, 134.3, 131.0, 130.9, 130.1, 129.5,129.3, 129.1, 127.8, 127.3, 121.6, 121.6, 116.6, 114.9 (d, *J* = 270.2 Hz), 107.7, 83.4, 44.2, 34.4 (d, *J* = 16.4 Hz), 25.4 (d, *J* = 5.7 Hz), 18.4, 11.0; **^{19}F NMR** (376 MHz, Chloroform-*d*) δ -147.81 (s, 1F); **FT-IR** (ATR): 3339, 2750, 1683, 1523, 1326, 1150, 682, 562 cm^{-1}; **HRMS** (ESI$^+$, m/z): calcd for $C_{37}H_{44}FN_2O_5S_2Si^+$ $[M+H]^+$: 707.2439, found: 707.2449.



4aaw

(1S,4S)-1,7,7-trimethylbicyclo[2.2.1]heptan-2-yl 4-(1-fluoro-5-oxo-1,1-bis(phenylsulfonyl)-5-(quinolin-8-ylamino)pentan-3-yl)benzoate (4aaw): The title compound was prepared from **1a** (21.2 mg, 0.1 mmol), **2a** (38mg, 0.12 mmol), and (1S,4S)-1,7,7-trimethylbicyclo[2.2.1]heptan-2-yl 4-iodobenzoate **3w** (154 mg, 0.4 mmol) according to the general procedure. Purification using silica gel chromatography (1:5 = EA:PE) gave the product as an white solid (23mg, 30% yield). **M.p.** = 82.6 - 84.5 ^{o}C; **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 9.56 (s, 1H), 8.73 (dd, *J* = 4.3, 1.7 Hz, 1H), 8.59 (p, *J* = 4.5 Hz, 1H), 8.11 (dd, *J* = 8.3, 1.7 Hz, 1H), 8.00 (d, *J* = 7.9 Hz, 2H), 7.81 (t, *J* = 8.0 Hz, 4H), 7.74 - 7.66 (m, 2H), 7.56 (t, *J* = 7.9 Hz, 2H), 7.51 - 7.44 (m, 4H), 7.41 (dd, *J* = 8.3, 4.3 Hz, 1H), 7.09 (dd, *J* = 8.3, 1.7 Hz, 2H), 5.05 (ddt, *J* = 10.0, 4.0, 2.1 Hz, 1H), 3.80 - 3.73 (m, 1H), 3.21 - 3.10 (m, 1H), 2.99 - 2.91 (m, 2H), 2.78 (dd, *J* = 15.0, 9.2 Hz, 1H), 2.47 - 2.39 (m, 1H), 2.11 - 2.04 (m, 1H), 1.86 - 1.68 (m, 2H), 1.38 (tt, *J* = 14.9, 3.2 Hz, 1H), 1.29 (dd, *J* = 8.7, 3.7 Hz, 1H), 1.08 - 1.02 (m, 1H), 0.94 (s, 3H), 0.91 - 0.86 (m, 6H); **^{13}C NMR** (101 MHz, Chloroform-*d*) δ 168.2, 166.5, 148.0, 147.8, 137.9, 136.6, 135.5, 135.3, 134.9, 134.3, 133.9, 131.1, 130.9, 129.8, 129.4, 129.2, 129.1, 129.0, 127.9, 127.3, 127.2, 121.7, 121.6, 116. 9, 115.2 (d, *J* = 269.3 Hz), 80.4, 80.4

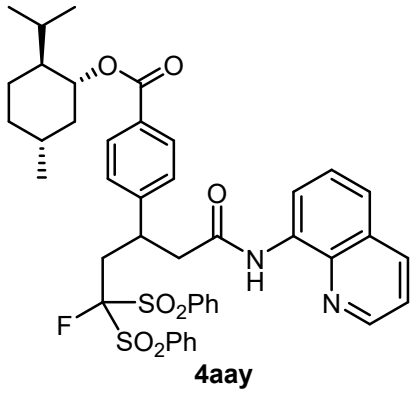
(isomers), 49.1, 49.1 (isomers), 47.9, 45.1, 45.0 (isomers), 37.4 (d, J = 5.2 Hz), 37.0, 36.9 (isomers), 34.4 (d, J = 16.6 Hz), 29.7, 28.1, 27.4, 19.7, 18.9, 13.6; **^{19}F NMR** (376 MHz, Chloroform-*d*) δ -146.89 (s, 1F), -146.90 (s, 1F) (isomers); **FT-IR** (ATR): 3337, 2923, 1705, 1522, 1271, 1151, 1078, 683, 561 cm^{-1}; **HRMS** (ESI$^+$, m/z): calcd for $C_{43}H_{44}FN_2O_7S_2^+$ $[M+H]^+$: 783.2568, found: 783.2579.



4aax

4-(1-fluoro-5-oxo-1,1-bis(phenylsulfonyl)-5-(quinolin-8-ylamino)pentan-3-yl)benzyl 2-(4-isobutylphenyl)propanoate (4aax): The title compound was prepared from **1a** (21.2 mg, 0.1 mmol), **2a** (38mg, 0.12 mmol), and 4-iodobenzyl 2-(4-isobutylphenyl)propanoate **3x** (169 mg, 0.4 mmol) according to the general procedure. Purification using silica gel chromatography (1:5 = EA:PE) gave the product as an white solid (22mg, 27% yield). **M.p.** = 146.1 - 147.5 ^{o}C; **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 9.53 (s, 1H), 8.79 - 8.69 (m, 1H), 8.61 (dd, J = 5.6, 3.5 Hz, 1H), 8.11 (dd, J = 8.2, 1.7 Hz, 1H), 8.06 - 7.93 (m, 2H), 7.79 (dt, J = 8.4, 1.3 Hz, 2H), 7.74 - 7.61 (m, 2H), 7.59 - 7.53 (m, 2H), 7.49 - 7.38 (m, 5H), 7.17 (d, J = 8.0 Hz, 2H), 7.10 - 7.05 (m, 2H), 7.03 - 6.93 (m, 4H), 5.06 - 4.90 (m, 2H), 3.76 - 3.61 (m, 2H), 3.10 (td, J = 16.7, 6.6 Hz, 1H), 2.95 - 2.81 (m, 2H), 2.73 (dd, J = 15.1, 9.3 Hz, 1H), 2.43 (d, J = 7.2 Hz, 2H), 1.89 - 1.79 (m, 1H), 1.47 (d, J = 7.1 Hz, 3H), 0.89 (d, J = 6.6 Hz, 6H); **^{13}C NMR** (101 MHz, Chloroform-*d*) δ 174.5, 168.5, 148.1, 142.6, 140.6, 138.2, 137.6, 136.3, 135.4, 135.3, 134.9, 134.5, 134.5, 134.5 (isomers), 134.2, 131.1, 130.8, 129.4, 129.2, 129.1, 128.0, 128.0, 127.8, 127.3, 127.2, 127.2, 121.6, 121.5, 116.5, 115. 5 (d, J = 268.9 Hz), 66.0, 65.9 (isomers), 45.1, 45.1, 45.0, 37.0 (d, J = 5.2 Hz), 37.0 (d, J = 3.8 Hz) (isomers), 34.6 (d, J = 15.6 Hz), 30.2, 22.4, 18.5; **^{19}F NMR** (376 MHz, Chloroform-

d) δ -147.08 (s, 1F), -147.10 (s, 1F) (isomers); **FT-IR** (ATR): 3338, 1682, 1522, 1325, 1150, 683, 561 cm^{-1}; **HRMS** (ESI^+, m/z): calcd for $C_{46}H_{46}FN_2O_7S_2^+$ $[M+H]^+$: 821.2725, found: 821.2732.

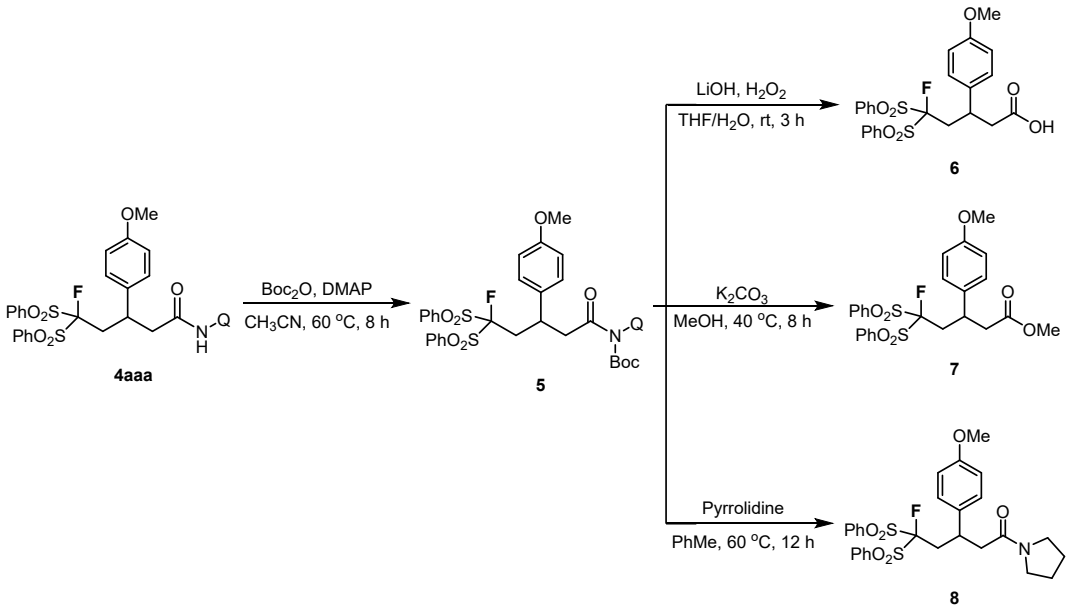


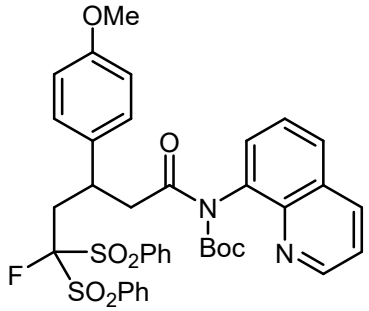
4aay

(1R,2S,5R)-2-isopropyl-5-methylcyclohexyl 4-(1-fluoro-5-oxo-1,1-bis(phenylsulfonyl)-5-(quinolin-8-ylamino)pentan-3-yl)benzoate (4aay): The title compound was prepared from **1a** (21.2 mg, 0.1 mmol), **2a** (38mg, 0.12 mmol), and (1R,2S,5R)-2-isopropyl-5-methylcyclohexyl 4-iodobenzoate **3y** (155 mg, 0.4 mmol) according to the general procedure. Purification using silica gel chromatography (1:5 = EA:PE) gave the product as an white solid (33mg, 41% yield). **M.p.** = 95.5 - 96.7 °C; **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 9.53 (s, 1H), 8.71 (dd, *J* = 4.3, 1.7 Hz, 1H), 8.60 (p, *J* = 4.6 Hz, 1H), 8.10 (dd, *J* = 8.3, 1.7 Hz, 1H), 8.02 - 7.98 (m, 2H), 7.80 (dt, *J* = 8.4, 2.9 Hz, 4H), 7.74 - 7.66 (m, 2H), 7.56 (t, *J* = 7.8 Hz, 2H), 7.51 - 7.43 (m, 4H), 7.40 (dd, *J* = 8.3, 4.2 Hz, 1H), 7.08 (dd, *J* = 10.6, 8.2 Hz, 2H), 4.87 (tdd, *J* = 10.9, 4.4, 1.7 Hz, 1H), 3.77 - 3.71 (m, 1H), 3.24 - 3.07 (m, 1H), 2.98 - 2.88 (m, 2H), 2.81 - 2.74 (m, 1H), 2.12 - 2.02 (m, 1H), 1.94 - 1.88 (m, 1H), 1.71 (dt, *J* = 12.3, 3.0 Hz, 2H), 1.51 (tq, *J* = 11.2, 3.1 Hz, 2H), 1.16 - 0.99 (m, 2H), 0.92 - 0.87 (m, 7H), 0.76 (dd, *J* = 7.0, 3.5 Hz, 3H); **^{13}C NMR** (101 MHz, Chloroform-*d*) δ 168.1, 165.8, 148.1, 147.8, 147.7 (isomers), 138.1, 136.3, 135.5, 135.3, 134.9, 134.9, 134.3, 134.0, 131.1, 130.8, 129.9, 129.4, 129.4, 129.2, 129.2, 129.1, 127.8, 127.3, 127.2, 127.2, 121.6, 116.5, 115.1 (d, *J* = 269.5 Hz), 113.8, 74.7, 47.2, 47.2 (isomers), 45.1, 41.0, 37.4 (d, *J* = 5.2 Hz), 34.5 (d, *J* = 16.9 Hz), 34.3, 31.4, 26.4, 23.6, 22.1, 20.8, 16.5, 16.5 (isomers); **^{19}F NMR** (376 MHz, Chloroform-*d*) δ -146.85 (s, 1F), -146.88 (s, 1F) (isomers); **FT-IR** (ATR): 3339, 1682, 1522, 1325, 1151,

683, 561 cm^{-1}; **HRMS** (ESI^+, m/z): calcd for $C_{43}H_{46}FN_2O_7S_2^+$ $[M+H]^+$: 785.2725, found: 785.2740.

7.General procedure for removal of 8-Aminoquinoline directing group

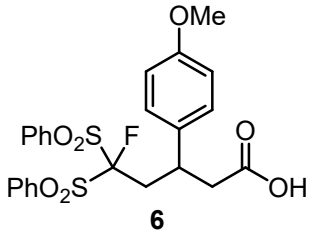




5

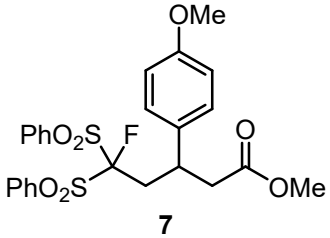
A solution of compound **4aaa** (64 mg, 0.1 mmol), Boc_2O (44 mg, 0.2 mmol) and DMAP (12.2 mg, 0.01 mmol) in CH_3CN (1 mL) was stirred at 60 °C for 6 h. Purification using silica gel chromatography (2:1 hexane:EtOAc) to provide the Boc-protecting amide as yellow solide. (108 mg, 94% yield). **M.p.** = 130.6 - 132.8 °C; **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 8.83 (dd, *J* = 4.2, 1.6 Hz, 1H), 8.11 (dd, *J* = 8.3, 1.6 Hz, 1H), 7.99 (d, *J* = 7.8 Hz, 2H), 7.84 - 7.72 (m, 3H), 7.67 (td, *J* = 7.8, 3.1 Hz, 2H), 7.56 - 7.41 (m, 5H), 7.35 (dd, *J* = 8.3, 4.2 Hz, 1H), 7.19 (d, *J* = 7.2 Hz, 1H), 6.91 (d, *J* = 8.3 Hz, 2H), 6.70 (d, *J* = 8.3 Hz, 2H), 3.76 (s, 3H), 3.73 - 3.67 (m, 1H), 3.49 (dd, *J* = 16.5, 8.2 Hz, 1H), 3.34 (dd, *J* = 16.4, 6.0 Hz, 1H), 3.21 - 3.11 (m, 1H), 2.96 - 2.87 (m, 1H), 1.23 (s, 9H); **^{13}C NMR** (101 MHz, Chloroform-*d*) δ 173.7, 158.1, 152.8, 150.3, 144.0, 136.7,

136.0, 135.4, 135.3, 135.2, 135.2, 134.5, 131.1, 130.8, 129.1, 129.1, 129.0, 128.8, 128.3, 128.0, 126.1, 121.5, 115.9 (d, J = 270.2 Hz), 113.7, 82.6, 55.2, 45.6, 36.5 (d, J = 4.5 Hz), 34.5 (d, J = 16.5 Hz), 27.6; **^{19}F NMR** (376 MHz, Chloroform-*d*) δ -147.04 (s, 1F); **FT-IR (ATR):** 2952, 1730, 1513, 1333, 1297, 1248, 1151, 685, 553 cm^{-1}; **HRMS (ESI$^+$, m/z):** calcd for $C_{37}H_{44}FN_2O_5S_2Si^+$ $[M+H]^+$: 733.2048, found: 733.2061.



6

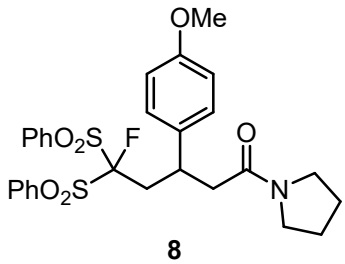
5-fluoro-3-(4-methoxyphenyl)-5,5-bis(phenylsulfonyl)pentanoic acid (6): To a solution of **5** (73.2 mg, 0.1 mmol) in THF/H_2O (1 mL, 4:1) was added LiOH (30 mg, 0.12 mmol) and 30% H_2O_2 (1.0 mmol) at 0 ^{o}C. Ater the reaction was stirred at room temperature for 3 h, Na_2SO_3 (252 mg, 2 mmol) was added. The reaction mixture was diluted with EtOAc (4 mL), acidified with 0.5 M aqueous HCl, and extracted with EtOAc. The organic layer was dried over anhydrous Na_2SO_4 and concentrated under reduced pressure. The resulting residue was purified by chromatography on silica gel eluting with EtOAc/hexanes (1/5) to provide the acid product **6** as a white solid (33 m g, 65%). **M.p.** = 123.6 - 125.4 ^{o}C; **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 7.93 (dt, J = 8.5, 1.2 Hz, 2H), 7.81 (dt, J = 8.5, 1.2 Hz, 2H), 7.75 - 7.67 (m, 2H), 7.58 - 7.48 (m, 4H), 6.87 - 6.81 (m, 2H), 6.72 - 6.67 (m, 2H), 3.75 (s, 3H), 3.49 - 3.42 (m, 1H), 2.94 - 2.72 (m, 2H), 2.66 (dd, J = 15.9, 5.0 Hz, 1H), 2.48 (dd, J = 16.0, 9.4 Hz, 1H); **^{13}C NMR** (101 MHz, Chloroform-*d*) δ 176.4, 158.4, 135.4, 135.3, 134.9, 134.6, 134.3, 131.0, 130.9, 129.2, 129.1, 128.0, 115.3 (d, J = 269.5 Hz), 113.9, 55.2, 41.3, 35.9 (d, J = 4.6 Hz), 34.8 (d, J = 16.6 Hz); **^{19}F NMR** (376 MHz, Chloroform-*d*) δ -147.51 (s, 1F); **FT-IR** (ATR): 2920, 1716, 1338, 1247, 1147, 684, 552 cm^{-1}; **HRMS** (ESI$^+$, m/z): calcd for $C_{24}H_{23}FO_7S_2Na^+$ $[M+Na]^+$: 529.0761, found: 529.0773.



7

methyl 5-fluoro-3-(4-methoxyphenyl)-5,5-bis(phenylsulfonyl)pentanoate (7): To a solution of **5**

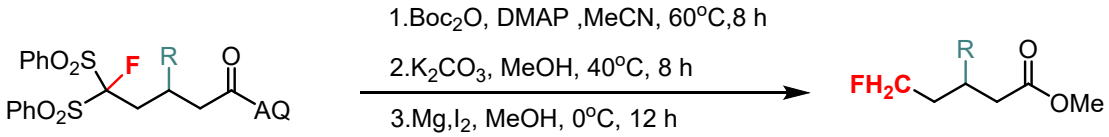
(73.2 mg, 0.1 mmol) in MeOH (1 mL) was added K_2CO_3 (13.8 mg, 0.1 mmol) in one portion at 40 °C under N_2 atmosphere for 8 h. The reaction mixture was diluted with CH_2Cl_2 (2 mL). Purification using silica gel chromatography (5:1 hexane:EtOAc) to provide the product **7** as white solid. (40 mg, 77% yield). **M.p.** = 106.9 - 108.2 °C; **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 7.93 (d, *J* = 7.8 Hz, 2H), 7.79 - 7.65 (m, 4H), 7.50 (dt, *J* = 31.7, 7.7 Hz, 4H), 6.81 (d, *J* = 8.2 Hz, 2H), 6.66 (d, *J* = 8.2 Hz, 2H), 3.71 (s, 3H), 3.48 (s, 4H), 2.99 - 2.89 (m, 1H), 2.82 - 2.73 (m, 1H), 2.62 (dd, *J* = 15.4, 5.4 Hz, 1H), 2.48 - 2.42 (m, 1H); **^{13}C NMR** (101 MHz, Chloroform-*d*) δ 171.4, 158.3, 135.5, 135.3, 135.0, 134.5, 134.4, 131.0, 130.8, 129.2, 129.2, 127.9, 115.4 (d, *J* = 269.1 Hz),113.9, 55.2, 51.5, 41.8, 36.5 (d, *J* = 5.0 Hz), 34.8 (d, *J* = 16.6 Hz); **^{19}F NMR** (376 MHz, Chloroform-*d*) δ -147.53 (s, 1F); **FT-IR** (ATR): 2953, 1731, 1513, 1334, 1256, 1150,758, 684, 526 cm^{-1}; **HRMS** (ESI$^+$, m/z): calcd for $C_{25}H_{25}FO_7S_2Na^+$ $[M+Na]^+$: 543.0918, found: 543.0922.



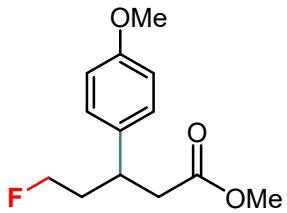
8

5-fluoro-3-(4-methoxyphenyl)-5,5-bis(phenylsulfonyl)-1-(pyrrolidin-1-yl)pentan-1-one (8): To a solution of **5** (73.2 mg, 0.1 mmol) in Toluene (1 mL, 4:1) was added Pyrrolidine (11 mg, 0.15 mmol) in one portion at 40 °C under N_2 atmosphere for 8 h . Purification using silica gel chromatography (5:1 hexane:EtOAc) to provide the product **8** as white solide. (32 mg, 57% yield). **M.p.** = 59.2 - 60.6 °C; **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 7.95 (d, *J* = 7.8 Hz, 2H), 7.77 - 7.63 (m, 4H), 7.53 (t, *J* = 7.7 Hz, 2H), 7.44 (t, *J* = 7.7 Hz, 2H), 6.77 (d, *J* = 8.3 Hz, 2H), 6.61 (d, *J* = 8.2 Hz, 2H), 3.68 (s, 3H), 3.42 - 3.03 (m, 6H), 2.83 - 2.74 (m, 1H), 2.48 - 2.37 (m, 2H), 1.77 - 1.60 (m, 4H); **^{13}C NMR** (101 MHz, Chloroform-*d*) δ 168.8, 158.1, 135.3, 135.3, 135.2, 135.2, 134.6, 131.2, 130.8, 129.2, 129.0, 128.1, 115.5 (d, *J* = 269.6 Hz), 113.6, 55.2, 46.6, 45.5, 42.7, 36.0 (d, *J* = 5.7 Hz), 34.1 (d, *J* = 16.3 Hz), 26.0, 24.3; **^{19}F NMR** (376 MHz, Chloroform-*d*) δ -147.61 (s, 1F); **FT-IR** (ATR): 2955, 1732, 1513, 1334, 1248, 1149, 684, 560 cm^{-1}; **HRMS** (ESI$^+$, m/z): calcd for $C_{28}H_{31}FNO_6S_2^+$ $[M+H]^+$: 560.1571, found: 560.1562.

8. General procedure for synthesis of α-monofluoromethyl compounds

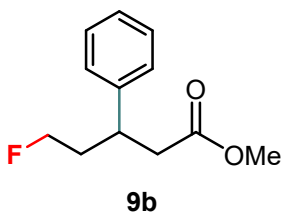


To a solution of **7** (0.1 mmol) in absolute **MeOH** (3 mL) or **CH_3OD** (3 mL) was added activated Mg (146 mg, 60 equivs) and I_2 (2 mg) in one portion at 0 °C under N_2 atmosphere. The reaction was stirred at 0 °C until full consumption of **7** monitored by TLC. After adding saturated NH_4Cl (3 mL), the reaction mixture was extracted with EtOAc (10 mL × 3). The combined organic layers were dried over Na_2SO_4, and concentrated under reduced pressure. Purification using silica gel chromatography (100:1 hexane:EtOAc) to provide the desired **CH_2F-** or **CD_2F**-containing products **9** or **9a-D**.



9a

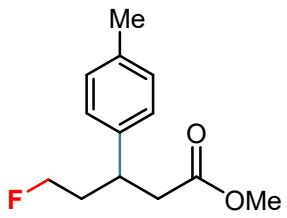
Product **9a** was obtained as a yellow oil. **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 7.15 - 7.08 (m, 2H), 6.89 - 6.81 (m, 2H), 4.43 - 4.13 (m, 2H), 3.79 (s, 3H), 3.59 (s, 3H), 3.31 - 3.26 (m, 1H), 2.69 - 2.57 (m, 2H), 2.23 - 2.04 (m, 1H), 1.95 - 1.79 (m, 1H); **^{13}C NMR** (101 MHz, Chloroform-*d*) δ 172.4, 158.4, 134.5, 128.4, 114.0, 81.8 (d, J = 163.8 Hz), 55.2, 51.6, 41.4, 37.4 (d, J = 5.0 Hz), 36.6 (d, J = 19.6 Hz); **^{19}F NMR** (376 MHz, Chloroform-*d*) δ -220.15 (s, 1F); **FT-IR** (ATR): 2921, 1734, 1512, 1246, 1160, 1024, 829 cm^{-1}; **HRMS** (ESI^+, m/z): calcd for $C_{13}H_{17}FO_3Na^+$ $[M+Na]^+$: 263.1054, found: 263.1049.



9b

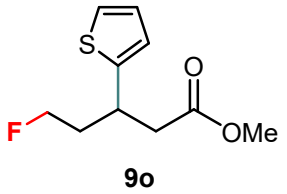
Product **9b** was obtained as a yellow oil. **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 7.26 - 7.20 (m, 2H), 7.17 - 7.11 (m, 3H), 4.35 - 4.06 (m, 2H), 3.51 (s, 3H), 3.29 - 3.22 (m, 1H), 2.60 (dd, J = 7.6, 4.0 Hz, 2H), 2.15 - 2.00 (m, 1H), 1.92 - 1.76 (m, 1H); **^{13}C NMR** (101 MHz, Chloroform-*d*) δ 172.4, 142.6, 128.7, 127.4, 126.9, 81.8 (d, J = 163.8

Hz), 51.6, 41.2, 38.2 (d, J = 5.1 Hz), 36.5 (d, J = 19.6 Hz); **^{19}F NMR** (376 MHz, Chloroform-*d*) δ -220.04 (s, 1F); **FT-IR** (ATR): 2955, 1436, 1160, 1020, 762, 700 cm^{-1}; **HRMS** (ESI$^+$, m/z): calcd for $C_{12}H_{15}FO_2Na^+$ [M+Na]$^+$: 233.0948, found: 233.0953.



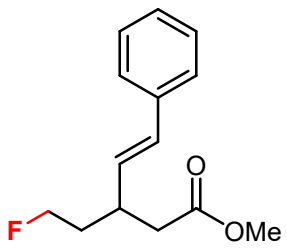
9c

Product **9c** was obtained as a yellow oil. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.14 - 7.07 (m, 4H), 4.44 - 4.15 (m, 2H), 3.60 (s, 3H), 3.33 - 3.26 (m, 1H), 2.72 - 2.60 (m, 2H), 2.32 (s, 3H), 2.20 - 2.07 (m, 1H), 1.98 - 1.82 (m, 1H); **^{13}C NMR** (101 MHz, Chloroform-*d*) δ 172.4, 139.5, 136.4, 129.4, 127.3, 81.9 (d, J = 163.7 Hz), 51.6, 41.3, 37.8 (d, J = 5.2 Hz), 36.6 (d, J = 19.5 Hz), 21.0; **^{19}F NMR** (376 MHz, Chloroform-*d*) δ -220.00 (s, 1F); **FT-IR** (ATR): 2954, 1735, 1435, 1160, 1018, 814 cm^{-1}; **HRMS** (ESI$^+$, m/z): calcd for $C_{13}H_{17}FO_2Na^+$ [M+Na]$^+$: 247.1105, found: 247.1106.



9o

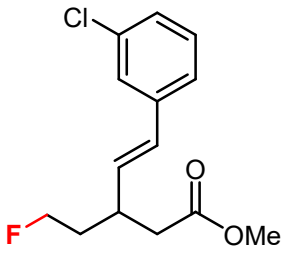
Product **9o** was obtained as a yellow oil. **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 7.28 (dd, J = 5.0, 2.9 Hz, 1H), 7.03 (dd, J = 3.0, 1.3 Hz, 1H), 6.95 (dd, J = 5.0, 1.3 Hz, 1H), 4.48 - 4.19 (m, 2H), 3.62 (s, 3H), 3.53 - 3.46 (m, 1H), 2.72 - 2.59 (m, 2H), 2.24 - 2.06 (m, 1H), 2.02 - 1.83 (m, 1H); **^{13}C NMR** (101 MHz, Chloroform-*d*) δ 172.3, 143.3, 126.4, 126.1, 121.0, 81.8 (d, J = 163.8 Hz), 51.6, 41.0, 36.3 (d, J = 19.6 Hz), 33.6 (d, J = 5.1 Hz); **^{19}F NMR** (376 MHz, Chloroform-*d*) δ -220.06 (s, 1F); **FT-IR** (ATR): 2920, 1734, 1435, 1163, 1011, 781 cm^{-1}; **HRMS** (ESI$^+$, m/z): calcd for $C_{10}H_{13}FO_2Na^+$ [M+Na]$^+$: 239.0512, found: 239.0502.



9p

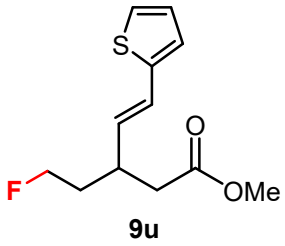
Product **9p** was obtained as a yellow oil. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.36 - 7.27 (m, 4H), 7.24 - 7.19 (m, 1H), 6.47 (d, J = 15.8 Hz, 1H), 6.01 (dd, J = 15.8, 8.9 Hz, 1H), 4.61 - 4.37 (m, 2H), 3.65 (s, 3H), 2.98 - 2.87 (m, 1H), 2.55 - 2.41 (m,

2H), 2.04 -1.91 (m, 1H), 1.83 - 1.68 (m, 1H); **^{13}C NMR** (101 MHz, Chloroform-*d*) δ 172.4, 137.0, 131.6, 131.0, 128.6, 127.5, 126.3, 81.9 (d, *J* = 163.9 Hz), 51.6, 40.1, 36.2 (d, *J* = 4.7 Hz), 35.2 (d, *J* = 19.5 Hz); **^{19}F NMR** (376 MHz, Chloroform-*d*) δ -219.52 (s, 1F); **FT-IR** (ATR): 2922, 1736, 1264, 732, 701 cm^{-1}; **HRMS** (ESI$^+$, m/z): calcd for $C_{14}H_{17}FO_2Na^+$ [M+Na]$^+$: 259.1105, found: 259.1100.



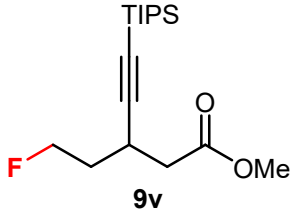
9t

Product **9t** was obtained as a yellow oil. **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 7.34 (t, *J* = 1.8 Hz, 1H), 7.23 - 7.17 (m, 3H), 6.41 (d, *J* = 15.8 Hz, 1H), 6.04 (dd, *J* = 15.8, 8.9 Hz, 1H), 4.61 - 4.37 (m, 2H), 3.66 (s, 3H), 2.99 - 2.87 (m, 1H), 2.54 - 2.44 (m, 2H), 2.04 - 1.91 (m, 1H), 1.85 - 1.69 (m, 1H); **^{13}C NMR** (101 MHz, Chloroform-*d*) δ 172.2, 138.9, 134.5, 132.7, 130.30, 129.8, 127.4, 126.1, 124.6, 82.7 (d, *J* = 164.2 Hz), 51.6, 39.8, 36.2 (d, *J* = 4.5 Hz), 35.1 (d, *J* = 19.6 Hz); **^{19}F NMR** (376 MHz, Chloroform-*d*) δ -219.57 (s, 1F); **FT-IR** (ATR): 2953, 1734, 1160, 966, 777, 684 cm^{-1}; **HRMS** (ESI$^+$, m/z): calcd for $C_{14}H_{16}ClFO_2Na^+$ [M+Na]$^+$: 293.0715, found: 293.0703.



9u

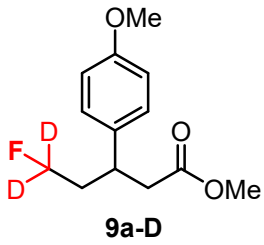
Product **9u** was obtained as a yellow oil. **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 7.12 (dt, *J* = 5.0, 1.0 Hz, 1H), 6.96 - 6.86 (m, 2H), 6.60 (dd, *J* = 15.6, 0.8 Hz, 1H), 5.85 (dd, *J* = 15.7, 8.9 Hz, 1H), 4.58 - 4.50 (m, 1H), 4.46 - 4.38 (m, 1H), 3.66 (s, 3H), 2.95 - 2.83 (m, 1H), 2.53 - 2.42 (m, 2H), 2.03 - 1.90 (m, 1H), 1.80 - 1.67 (m, 1H); **^{13}C NMR** (101 MHz, Chloroform-*d*) δ 172.3, 142.1, 130.7, 127.3, 125.4, 124.8, 123.9, 81.8 (d, *J* = 164.0 Hz), 51.6, 39.9, 36.1 (d, *J* = 4.8 Hz), 35.1 (d, *J* = 19.5 Hz); **^{19}F NMR** (376 MHz, Chloroform-*d*) δ -219.69 (s, 1F); **FT-IR** (ATR): 2920, 2851, 1736, 1260, 1018, 800 cm^{-1}; **HRMS** (ESI$^+$, m/z): calcd for $C_{14}H_{16}ClFO_2Na^+$ [M+Na]$^+$: 265.0669, found: 265.0674.



9v

Product **9v** was obtained as a yellow oil. **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 4.75 - 4.65 (m, 1H), 4.60 - 4.46 (m, 1H), 3.68

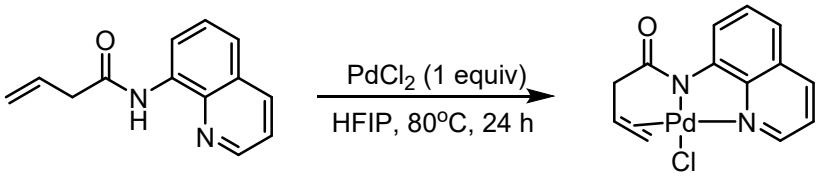
(s, 3H), 3.1 - 3.09 (m, 1H), 2.63 - 2.48 (m, 2H), 2.04 - 1.91 (m, 1H), 1.87 - 1.71 (m, 1H), 1.08 - 0.98 (m, 21H); **^{13}C NMR** (101 MHz, Chloroform-*d*) δ 171.5, 108.4, 83.0, 81.8 (d, *J* = 164.1 Hz), 51.7, 40.1, 35.1 (d, *J* = 19.8 Hz), 26.0 (d, *J* = 5.1 Hz), 18.5, 11.1; **^{19}F NMR** (376 MHz, Chloroform-*d*) δ -220.30 (s, 1F); **FT-IR** (ATR): 2924, 2864, 1741, 1462, 1250, 1185, 1080, 9655, 799, 697 cm^{-1}; **HRMS** (ESI$^+$, m/z): calcd for $C_{17}H_{31}FO_2SiNa^+$ $[M+Na]^+$: 337.1970, found: 337.1954.



9a-D

Product **9a-D** was obtained as a colorless oil. **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 7.15 - 7.08 (m, 2H), 6.88 - 6.81 (m, 2H), 3.79 (s, 3H), 3.59 (s, 3H), 3.40 - 3.24 (m, 1H), 2.72 - 2.52 (m, 2H), 2.15 - 2.06 (m, 1H), 1.95 - 1.78 (m, 1H); **^{13}C NMR** (101 MHz, Chloroform-*d*) δ 172.4, 158.4, 134.5, 128.4, 114.0, 55.2, 51.6, 41.4, 37.3 (d, *J* = 5.3 Hz), 36.4 (d, *J* = 19.5 Hz); **^{19}F NMR** (376 MHz, Chloroform-*d*) δ -221.39 - 221.47(m, 1F); **FT-IR** (ATR): 2922, 2851, 1736, 1514, 1250, 1179, 732 cm^{-1}; **HRMS** (ESI$^+$, m/z): calcd for $C_{13}H_{15}D_2FO_3Na^+$ $[M+Na]^+$: 265.1179, found:265.1182.

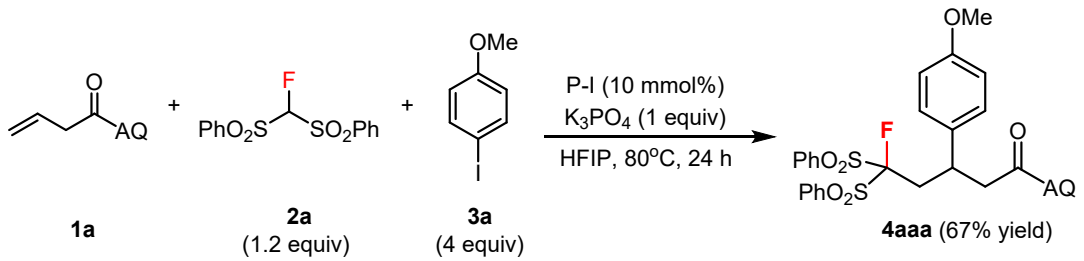
9.Mechanism Experiment



1a **Pd-I**, 50% yield

To a 8-mL scintillation vial equipped with a Teflon-coated magnetic stir bar was added

$PdCl_2$ (18.0 mg, 0.1 mmol, 1.0 equiv), **1a** (21.2 mg, 0.1 mmol, 1.0 equiv), and HFIP (0.2 mL). The vial was sealed with a solid screw cap and stirred at 80°C. After 24 h, the dark brown precipitate was filtered and washed with 2.0 mL of DCE. Purification using silica gel chromatography (3:1 hexane:EtOAc) to provide the desired products **Pd-I** as brown solid (15.8 mg, 50% yield). **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 9.17 (dd, *J* = 5.2, 1.5 Hz, 1H), 8.76 (dd, *J* = 7.9, 1.2 Hz, 1H), 8.37 (dd, *J* = 8.3, 1.5 Hz, 1H), 7.56 - 7.50 (m, 2H), 7.43 (dd, *J* = 8.1, 1.2 Hz, 1H), 6.15 (dddd, *J* = 15.6, 8.4, 7.0, 4.1 Hz, 1H), 5.86 (dq, *J* = 8.4, 1.5 Hz, 1H), 5.37 (dt, *J* = 15.6, 1.3 Hz, 1H), 3.64 (ddd, *J* = 17.5, 7.0, 1.8 Hz, 1H), 3.25 (ddt, *J* = 17.5, 4.1, 1.3 Hz, 1H); **^{13}C NMR** (101 MHz, Chloroform-*d*) δ 178.9, 148.2, 146.9, 146.0, 140.3, 130.2, 129.8, 122.9, 120.9, 120.8, 98.1, 92.9, 40.4.

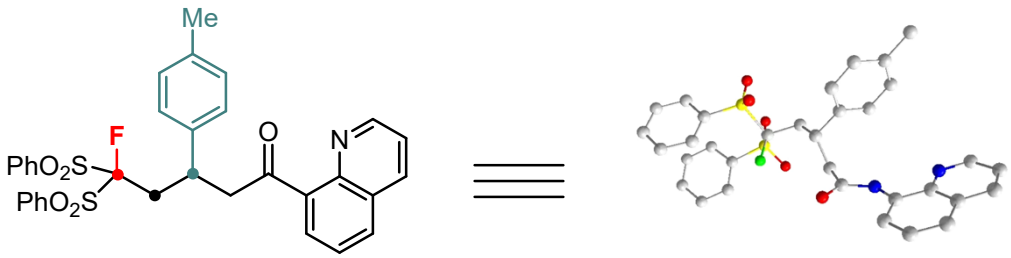


1a **2a** (1.2 equiv) **3a** (4 equiv) **4aaa** (67% yield)

To a 8-mL scintillation vial equipped with a Teflon-coated magnetic stir bar were added the **1a** (0.1 mmol), **2a** (0.12 mmol), **3a** (0.4 mmol), **Pd-I** (10 mol %), K_3PO_4 (0.1 mmol), and HFIP (0.2 mL). The vial was sealed with a screw-top septum cap and placed in a heating block that was preheated to 80 °C. After a time period of 24 h, the reaction vial was allowed cooled to room temperature, and the reaction mixture was filtered through a short plug of silica gel. Purification using silica gel chromatography (5:1 hexane:EtOAc) to provide the desired products **4aaa** as white solid (42.5 mg, 67% yield).

10. X-Ray Crystallography

Crystal of **4aac** was prepared in a mixture solvent system (dichloromethane and hexane)，the solution was evaporated at room temperature for about one week, sing crystals were formed.



4aac **CCDC: 2303278**

The thermal ellipsoid was drawn at the 50% probability level.

```
Bond precision:   C-C = 0.0044 A          Wavelength=0.71073

Cell:          a=8.3017(4)        b=13.9812(7)     c=14.6108(7)
               alpha=112.009(2)   beta=98.334(2)   gamma=104.508(2)
Temperature:   296 K

                Calculated                Reported
Volume          1467.25(13)               1467.25(13)
Space group     P -1                      P -1
Hall group      -P 1                      -P 1
Moiety formula  C33 H29 F N2 O5 S2        C33 H29 F N2 O5 S2
Sum formula     C33 H29 F N2 O5 S2        C33 H29 F N2 O5 S2
Mr              616.70                    616.70
Dx,g cm-3       1.396                     1.396
Z               2                         2
Mu (mm-1)       0.234                     0.234
F000            644.0                     644.0
F000'           644.80
h,k,lmax        10,18,19                  10,18,19
Nref            6914                      6846
Tmin,Tmax       0.869,0.954               0.626,0.746
Tmin'           0.869

Correction method= # Reported T Limits: Tmin=0.626 Tmax=0.746
AbsCorr = NONE

Data completeness= 0.990          Theta(max)= 27.765

R(reflections)= 0.0563( 4494)                wR2(reflections)=
                                             0.1529( 6846)
S = 1.014                 Npar= 389
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11. References

1 C.-D. Wang, G.-L Xiao, T. Guo, Y.-L. Ding, X.-*J*. Wu and T-P. Loh, *J. Am. Chem. Soc*., 2018, **140**, 9332-9336.

2 F.-Z. *J*iang, Y.-C. Zhao and *J*.-B. Hu, *Org. Chem. Front.*, 2014, **1**, 625-629.

3 a) A. Kumar. *J*aladi, H. S. Choi and D. K. An, *New J. Chem.*, 2020, **44**, 13626-

13632; b) *J.* Szyling, A. Franczyk, P. Pawluć, B. Marciniec and *J.* Walkowiak, *Org. Biomol. Chem.,* 2017, **15**, 3207-3215; c) Y.-G. Zhao and V. Snieckus, *Org.Lett*., 2014, **16**, 3-5.

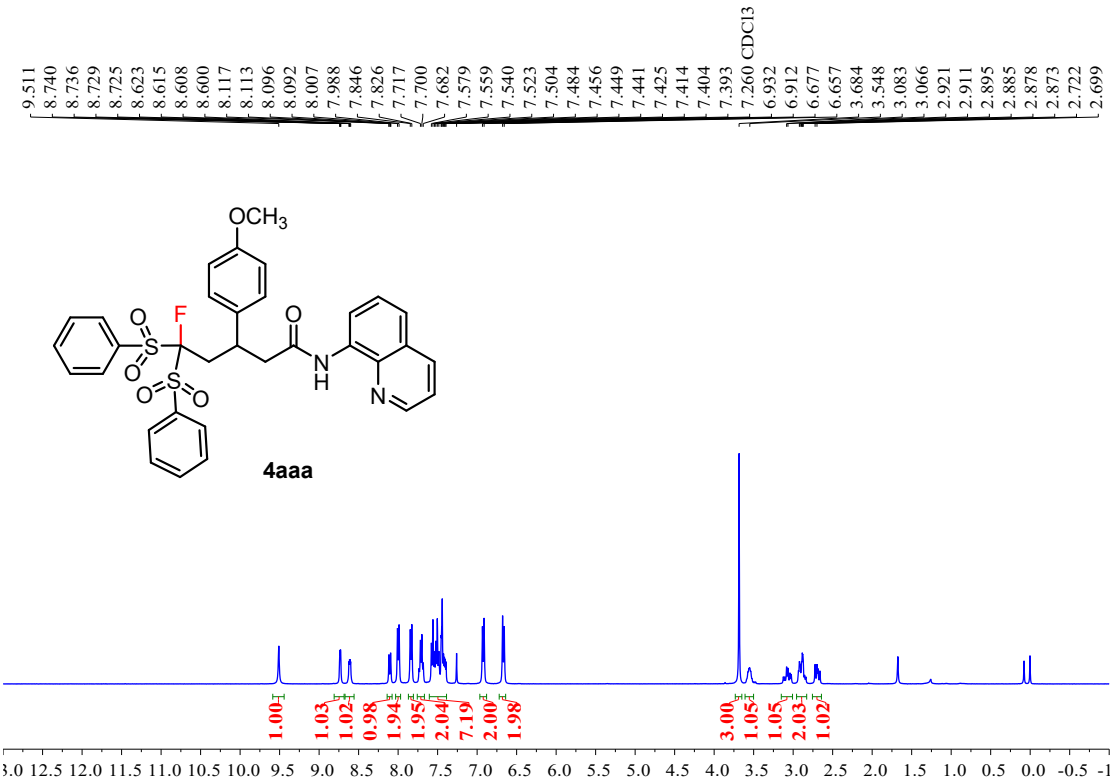
4 L. L. W. Cheung and A. K. Yudin, *Org. Lett.,* 2009, **11**, 1281-1284.

5 *J.* Skotnitzki, V. Morozova and P. Knochel, *Org. Lett.,* 2018, **20**, 2365-2368.

6 X.-Y. Wang, W.-Y. Tong, B. Huang, S. Cao, Y.-L. Li, *J.*-C. *J*iao, H. Huang, Q. Yi, S.-L Qu and X. Wang, *J. Am. Chem. Soc.,* 2022, **144**, 4952-4965.

7 a) Y.-Q. Han, X. Yang, K.-X. Kong, Y.-T. Deng, L.-S. Wu, Y. Ding and B.-F. Shi, *Angew. Chem. Int. Ed.,* 2020, **59**, 20455-20458; b) Y.-Y. Che, Y. Yue, L.-Z. Lin, B.-B. Pei, X.-Z. Deng and C. Feng, *Angew. Chem. Int. Ed*., 2020, **59**, 16414-16419.

12. ^{1}H and ^{13}C NMR s pectra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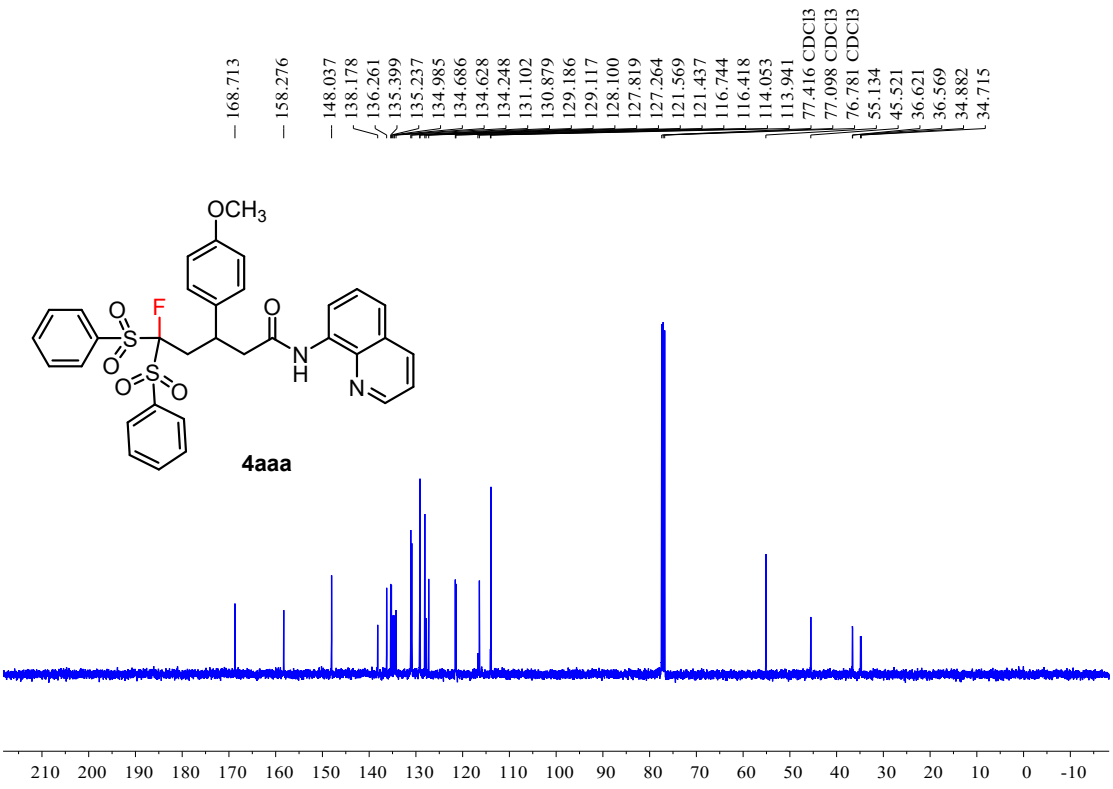
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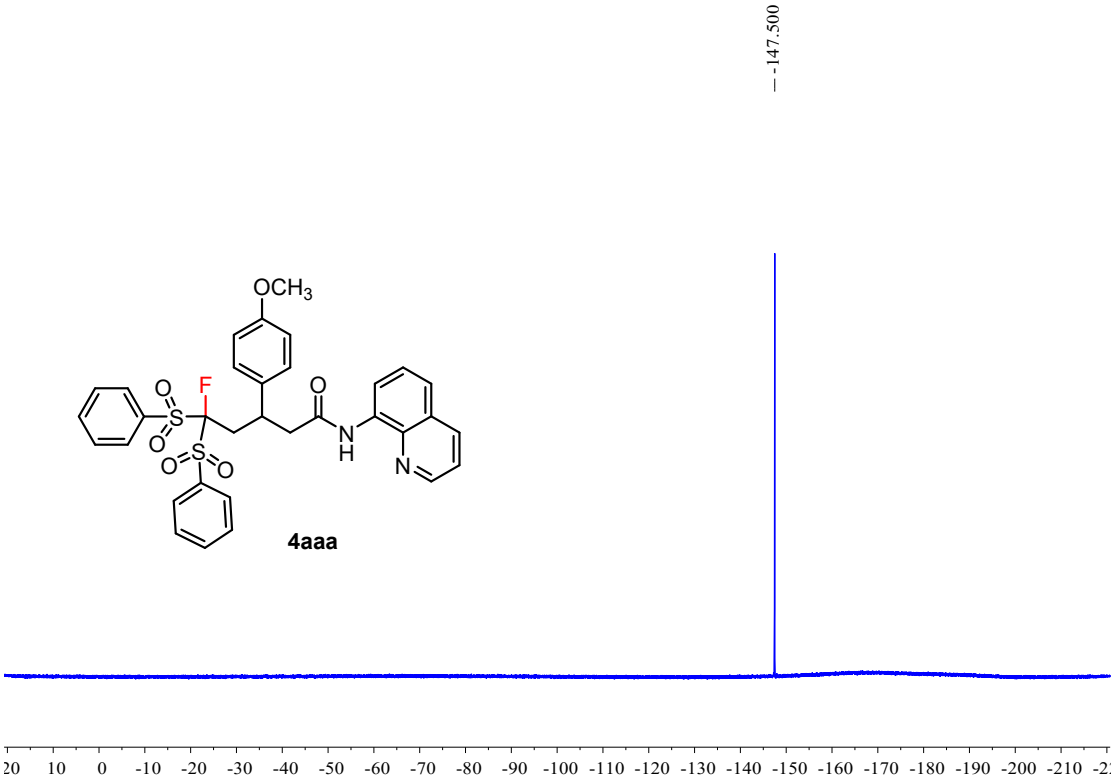
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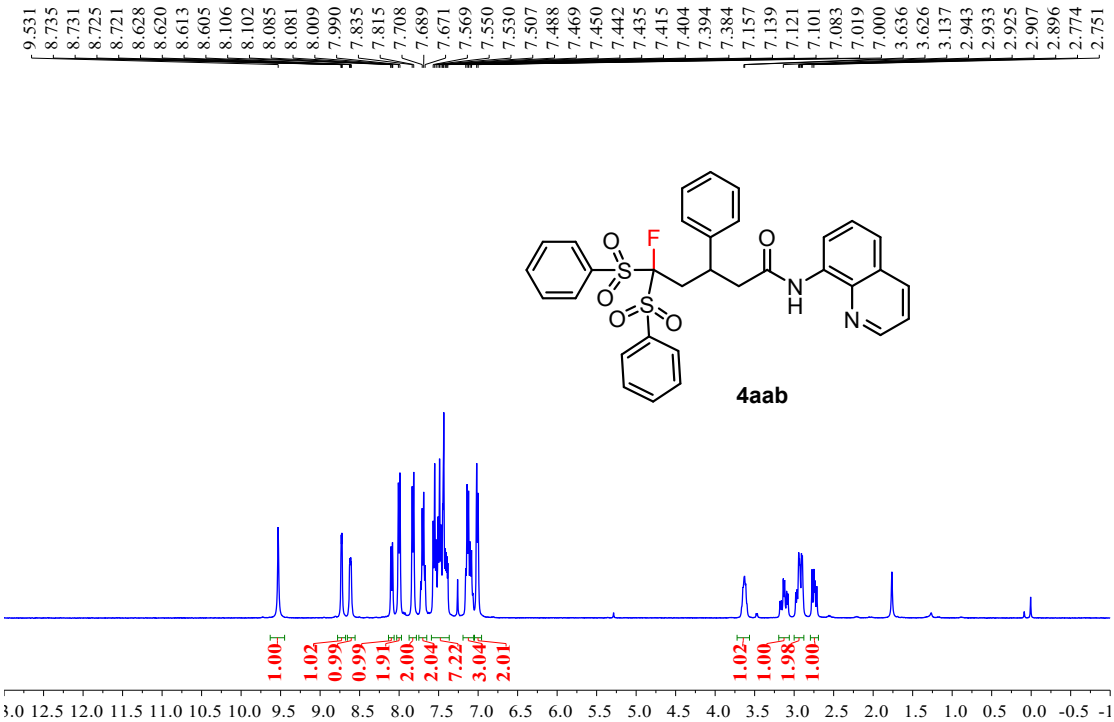
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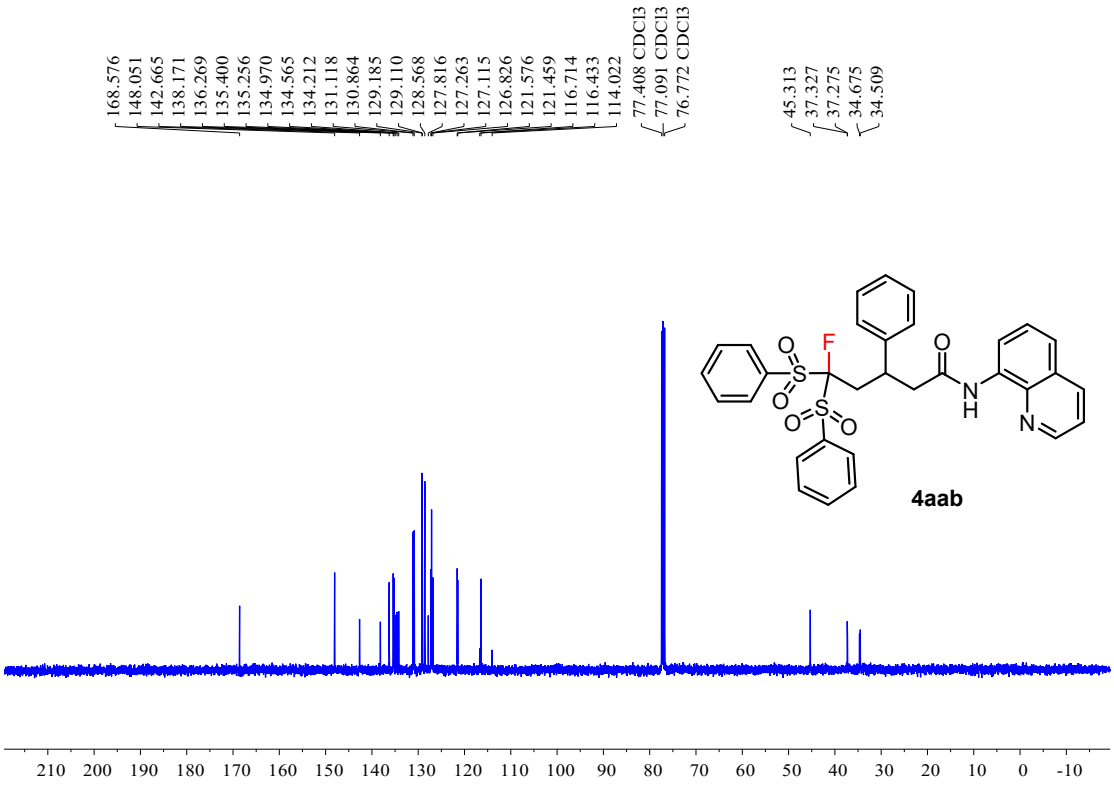
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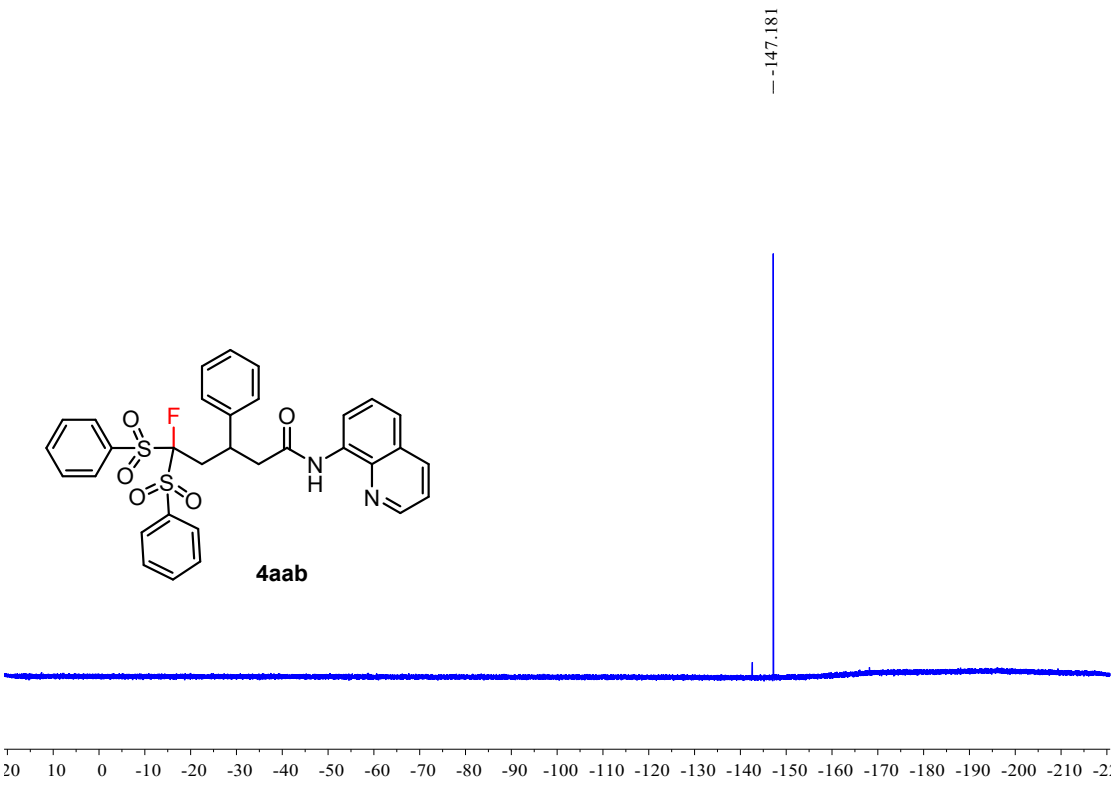
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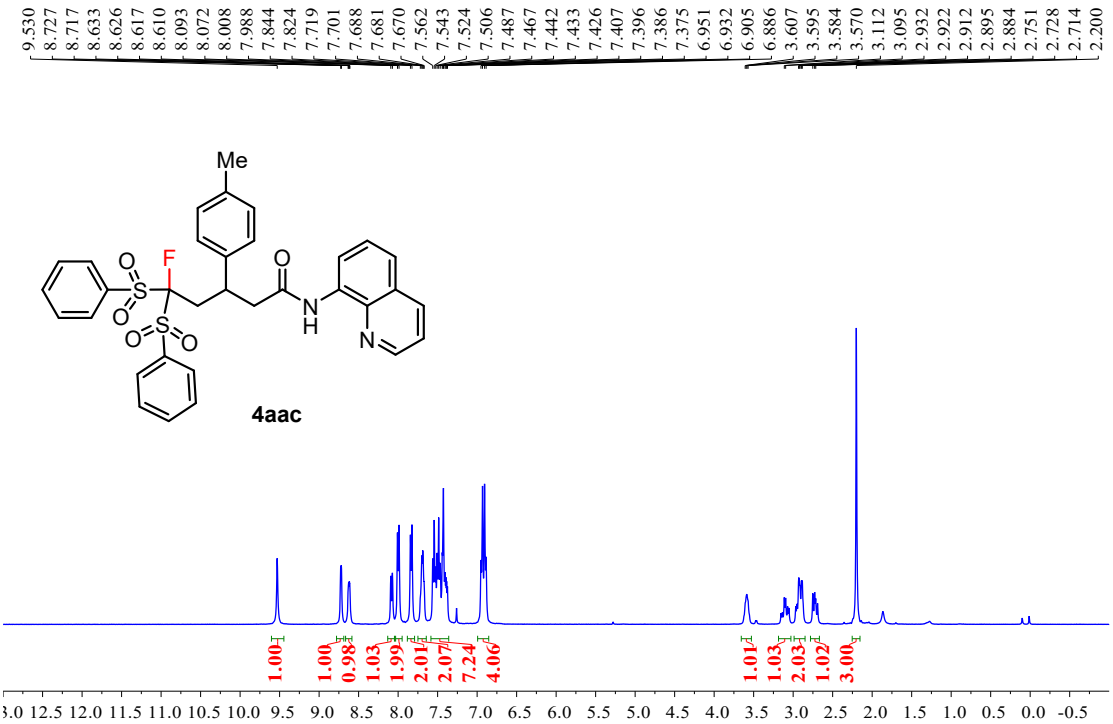
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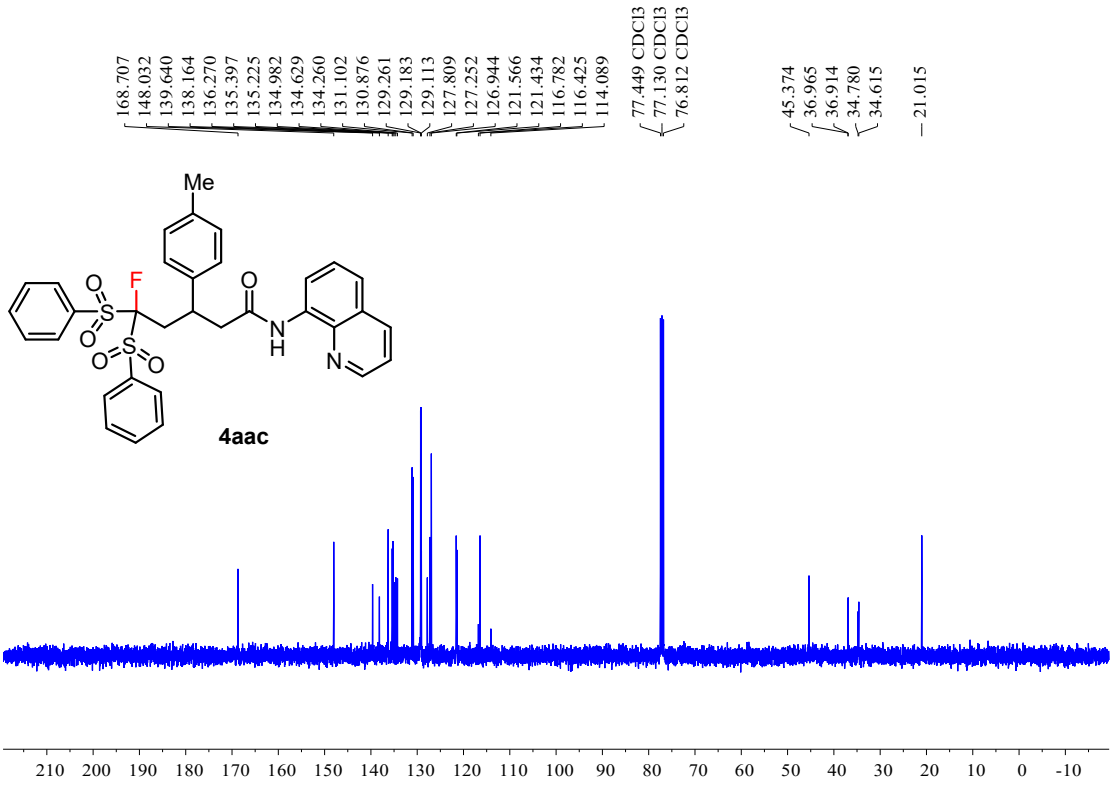
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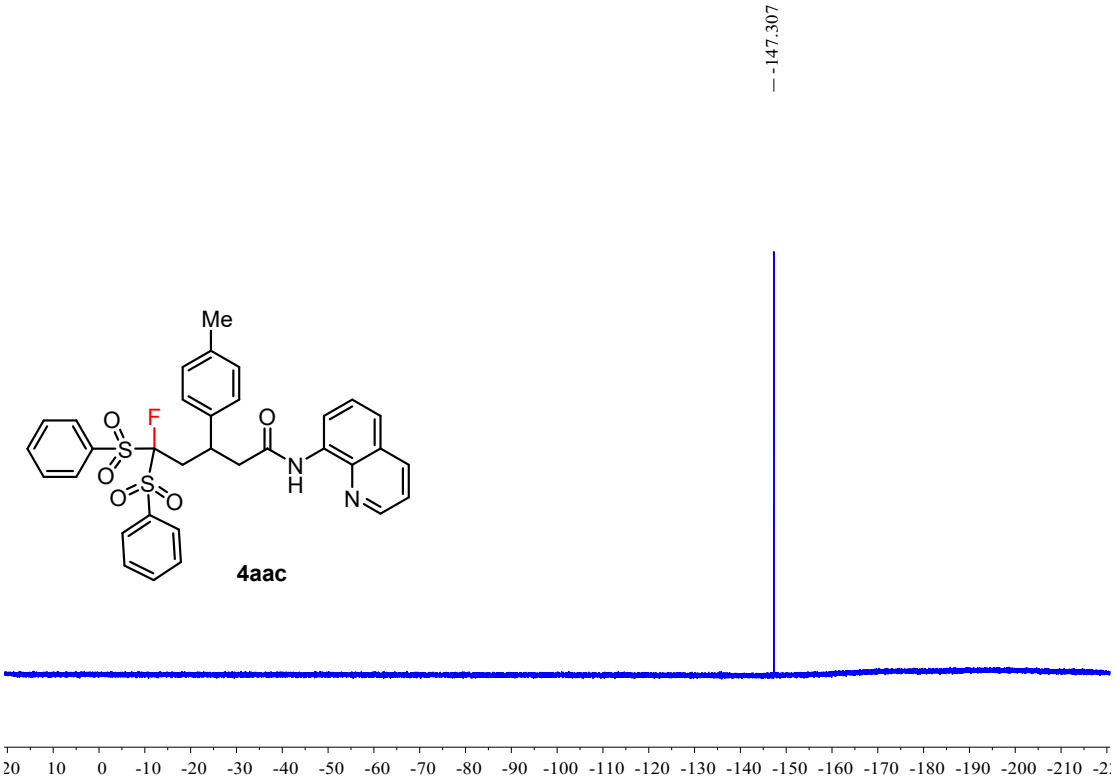
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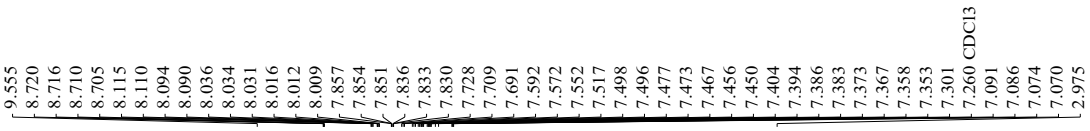
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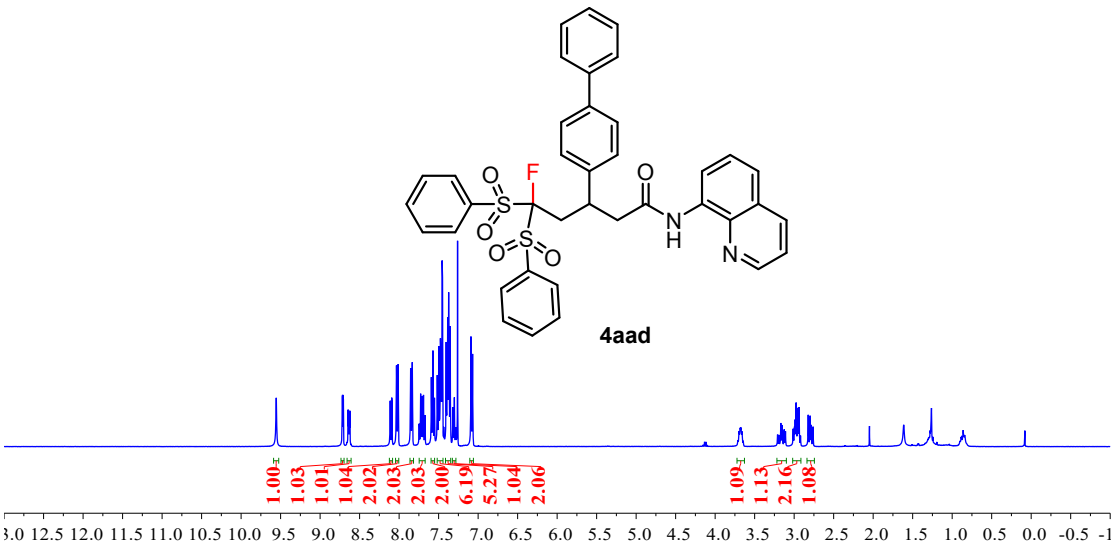
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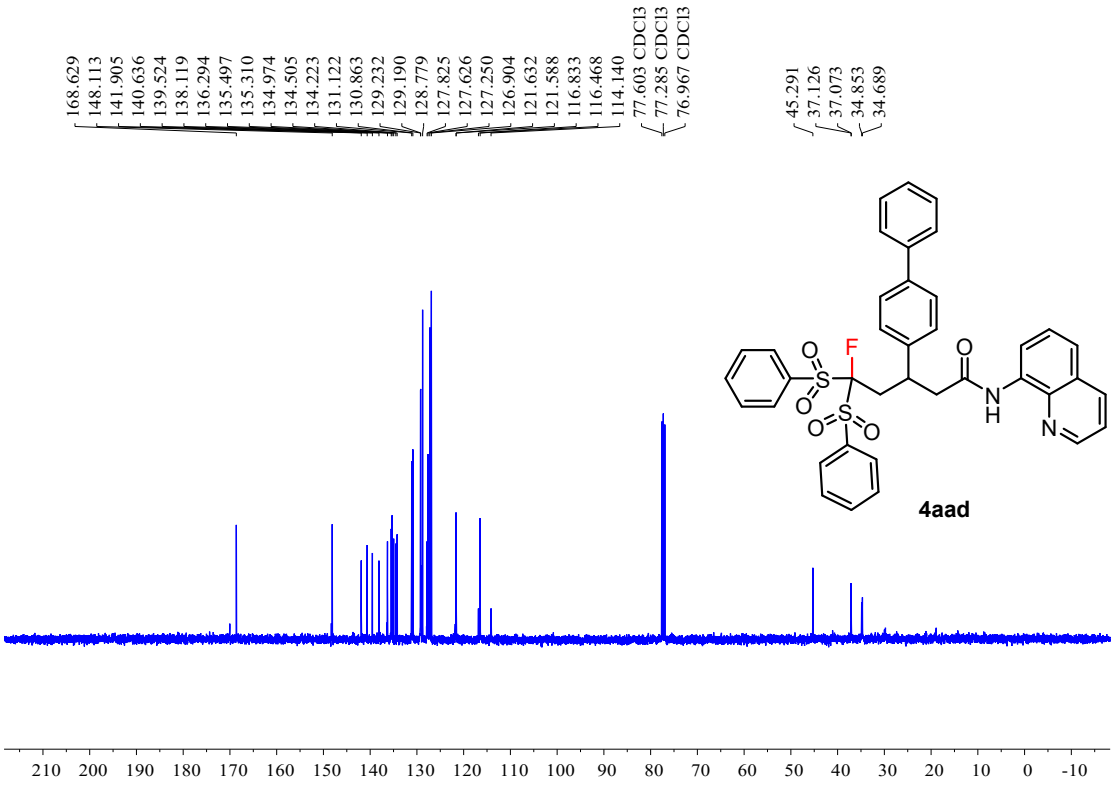
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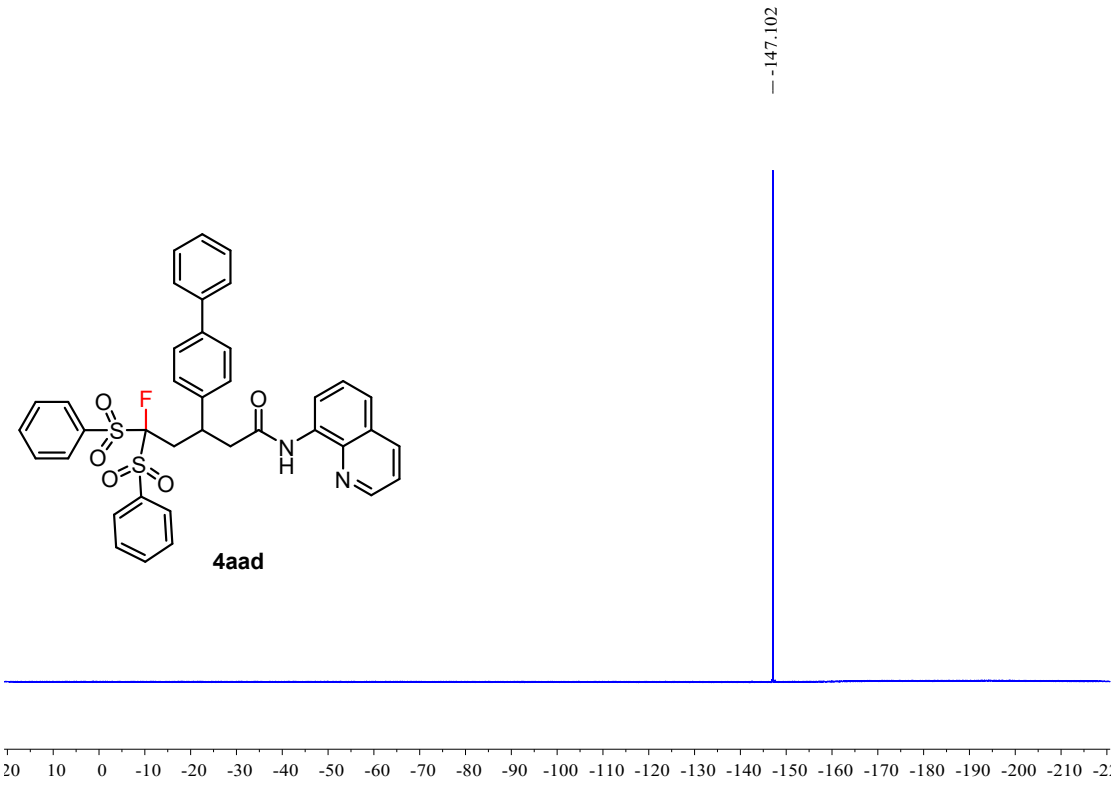
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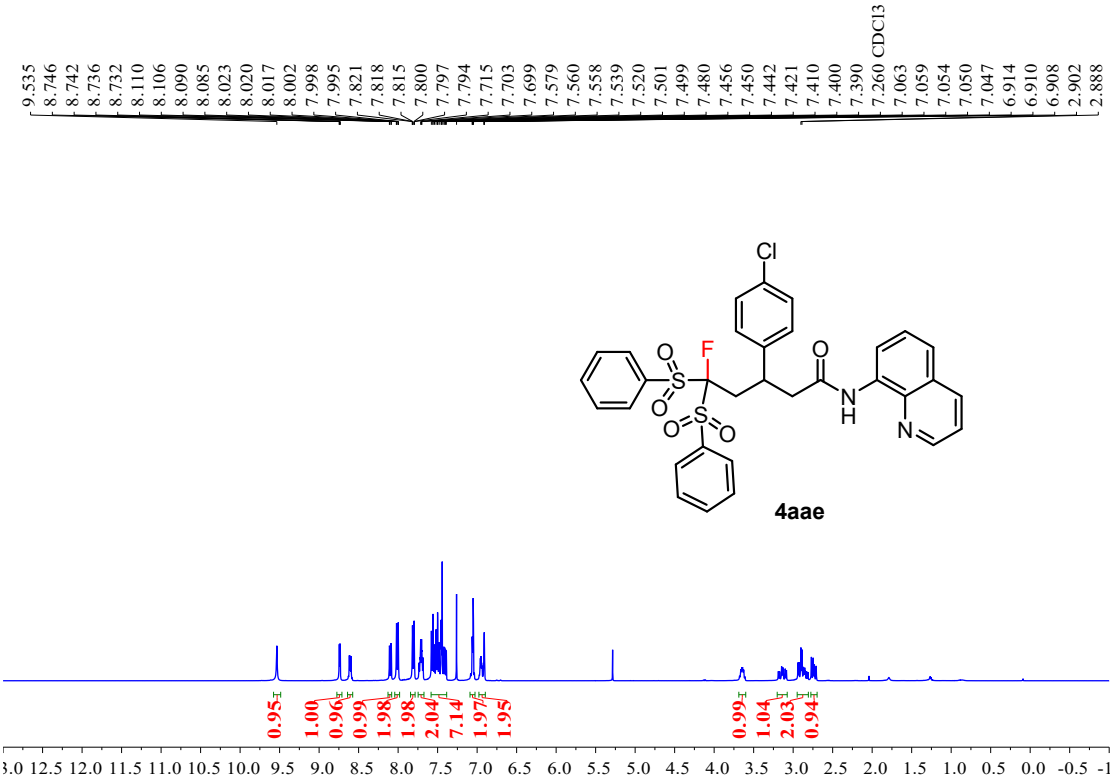
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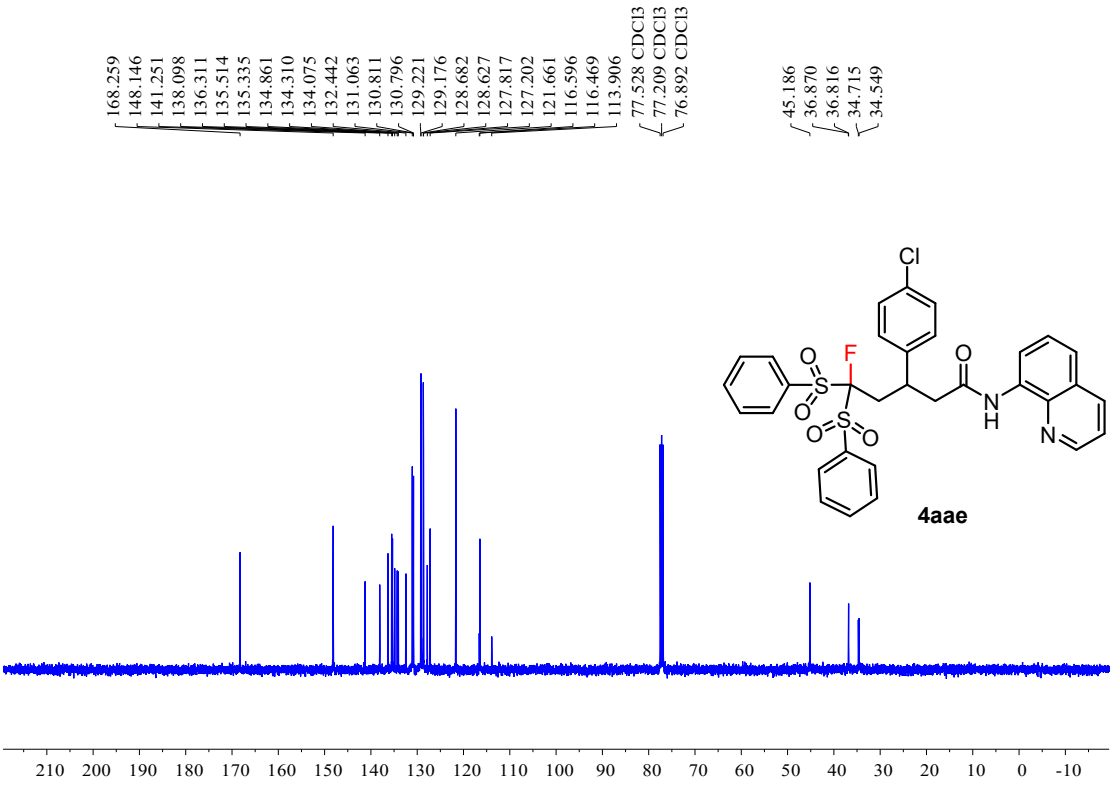
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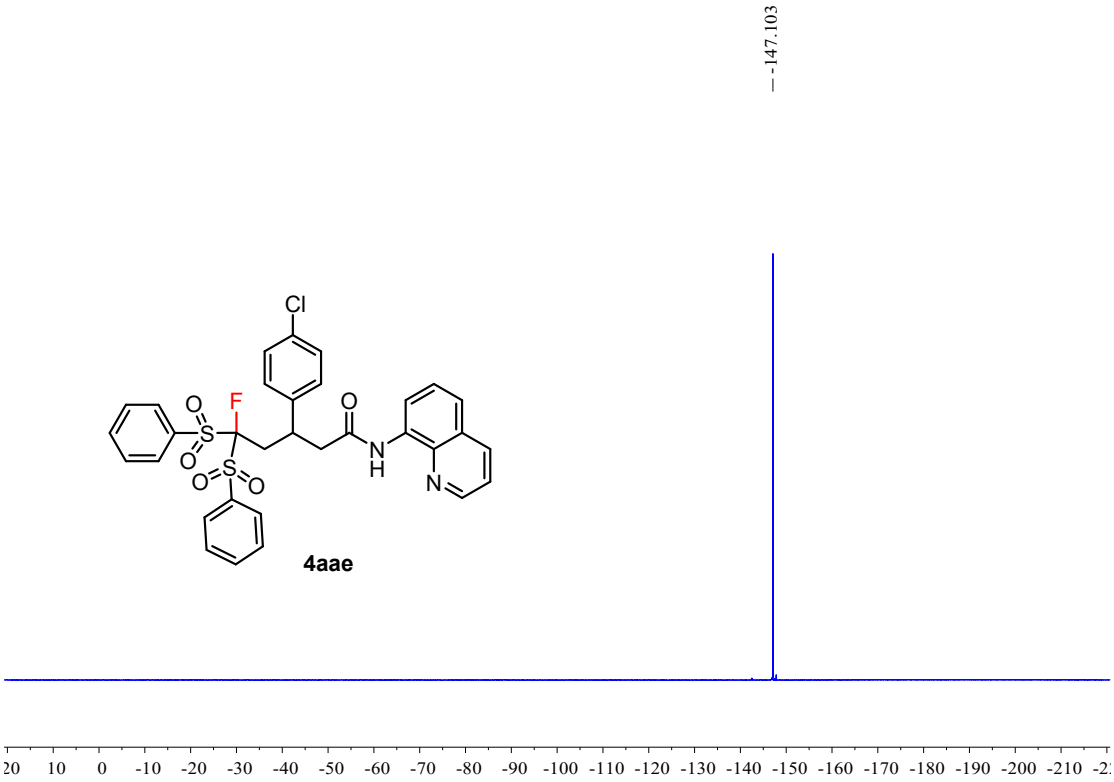
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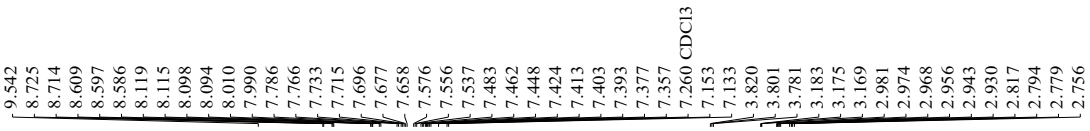
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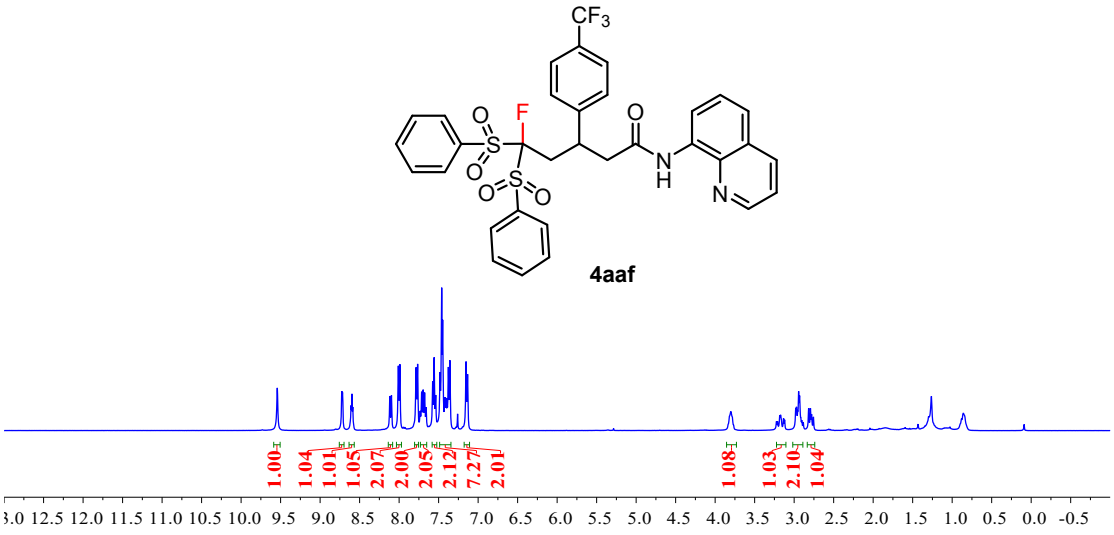
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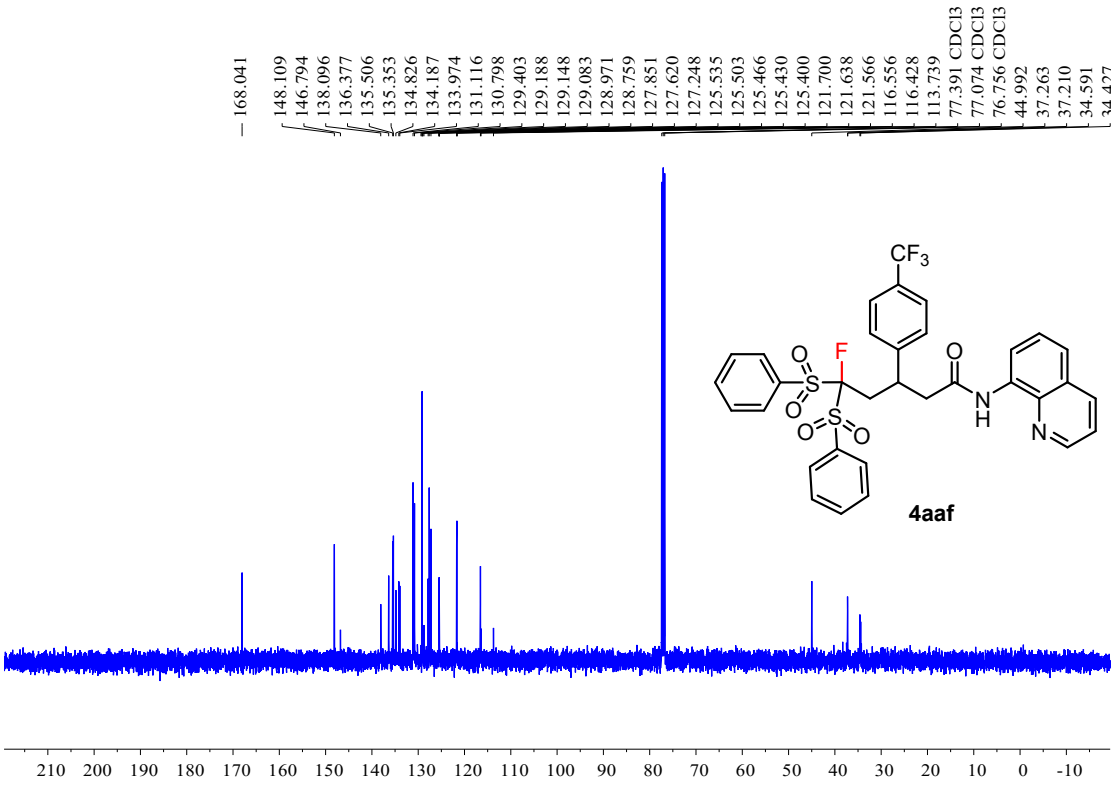
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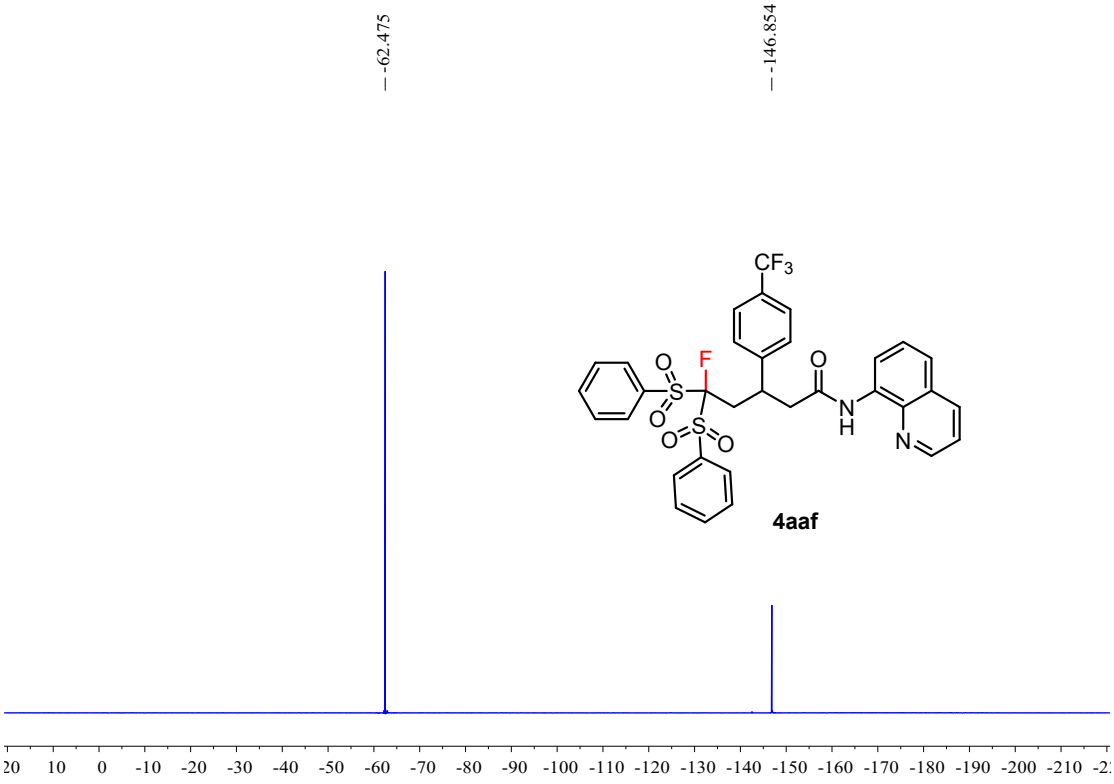
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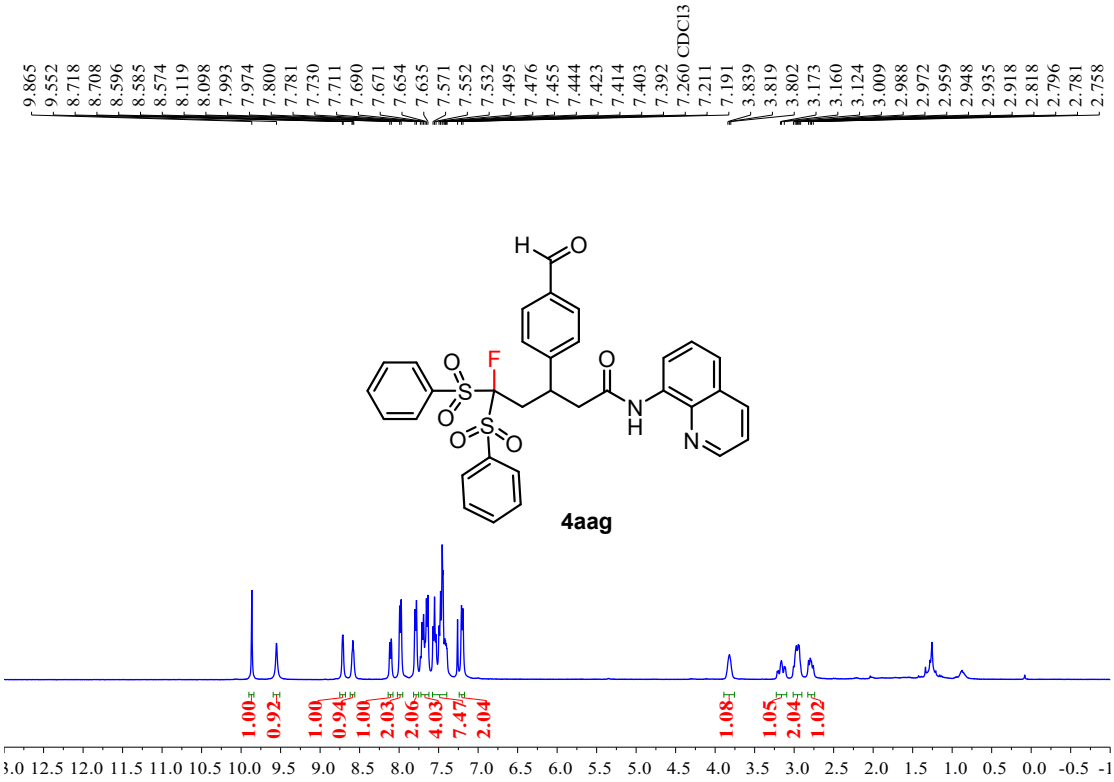
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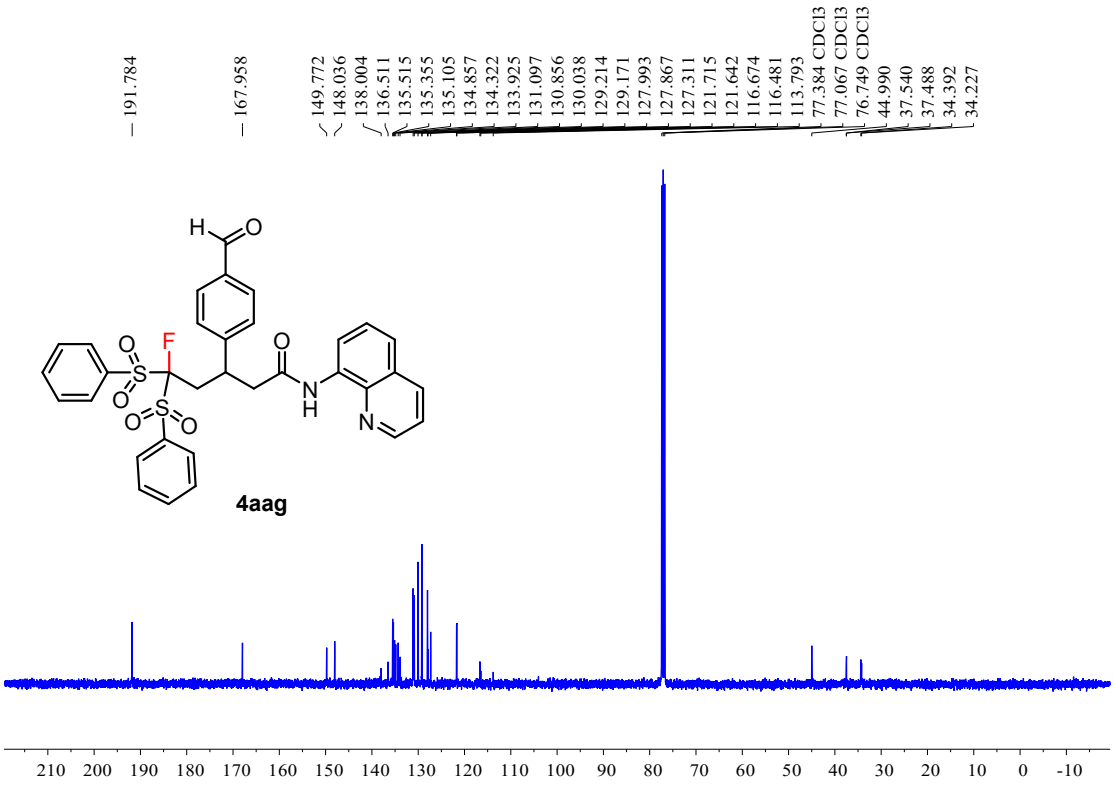
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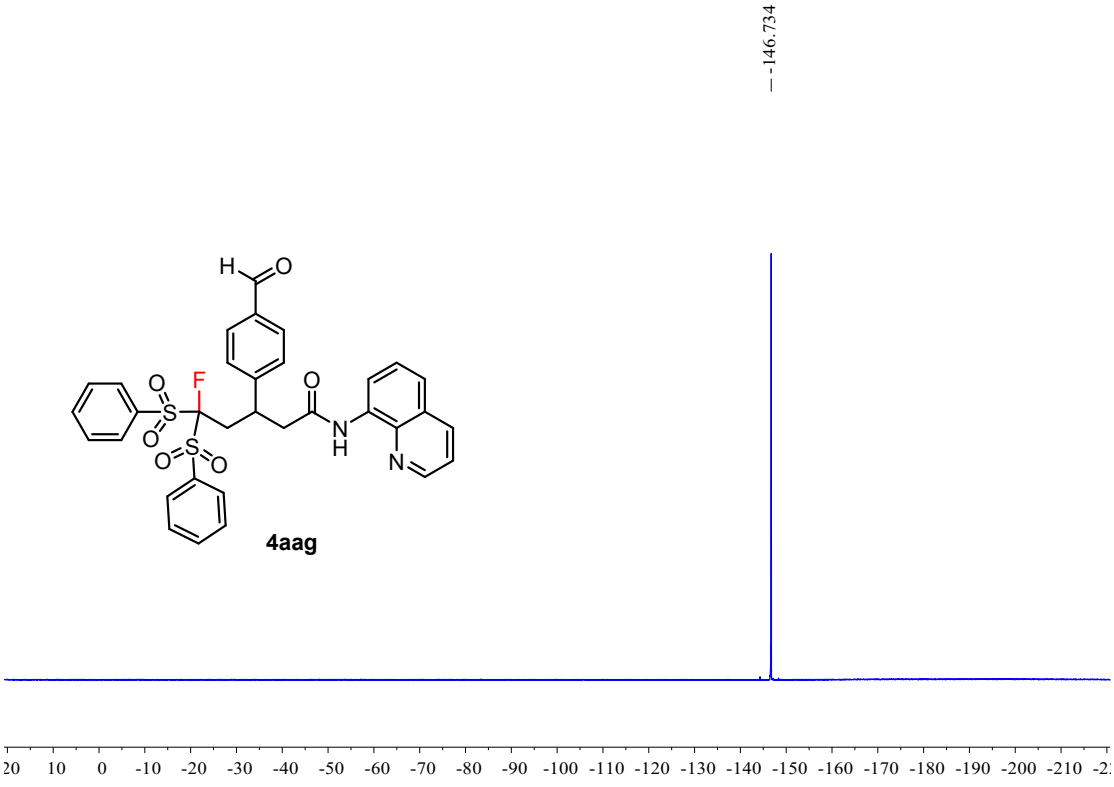
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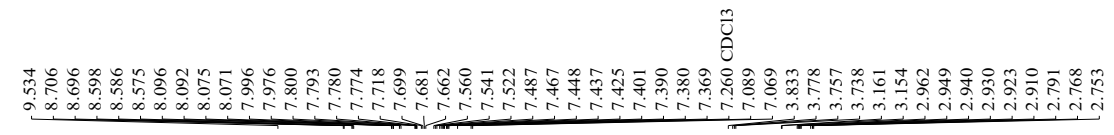
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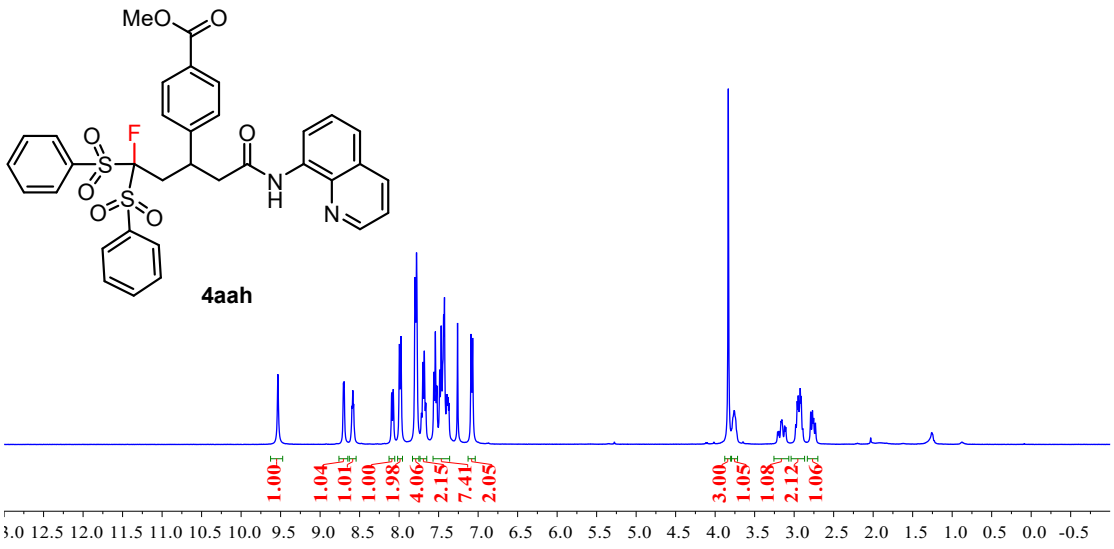
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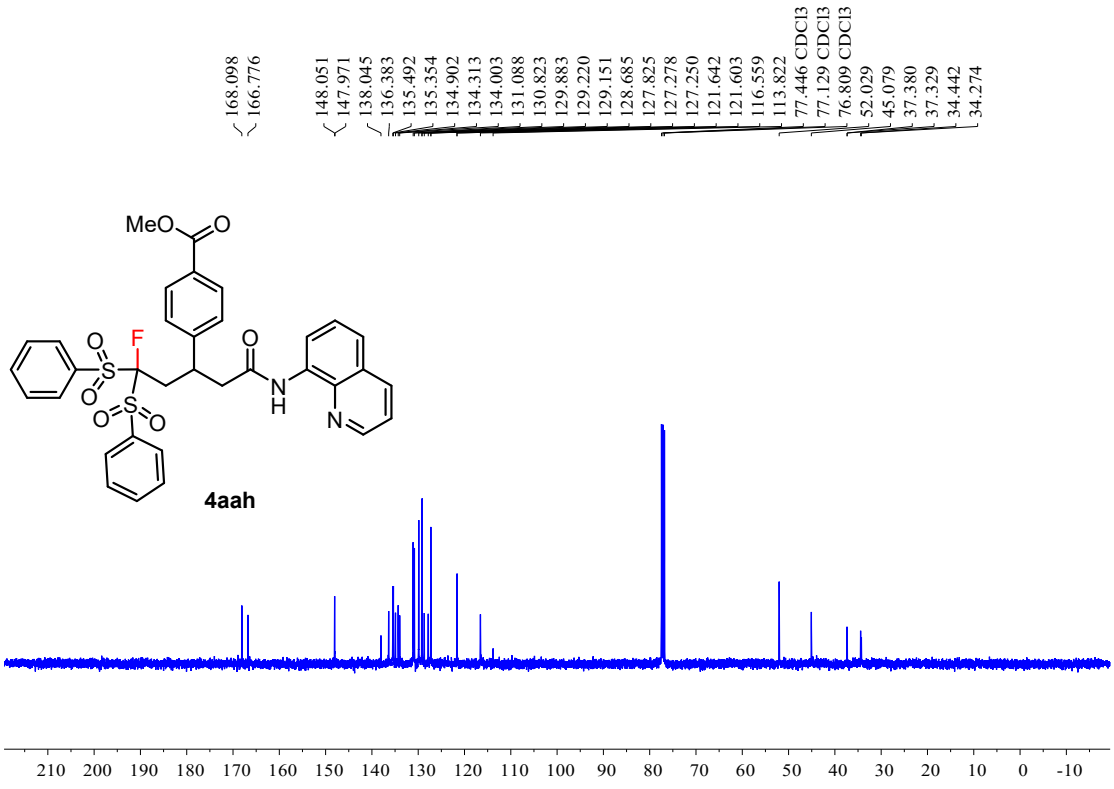
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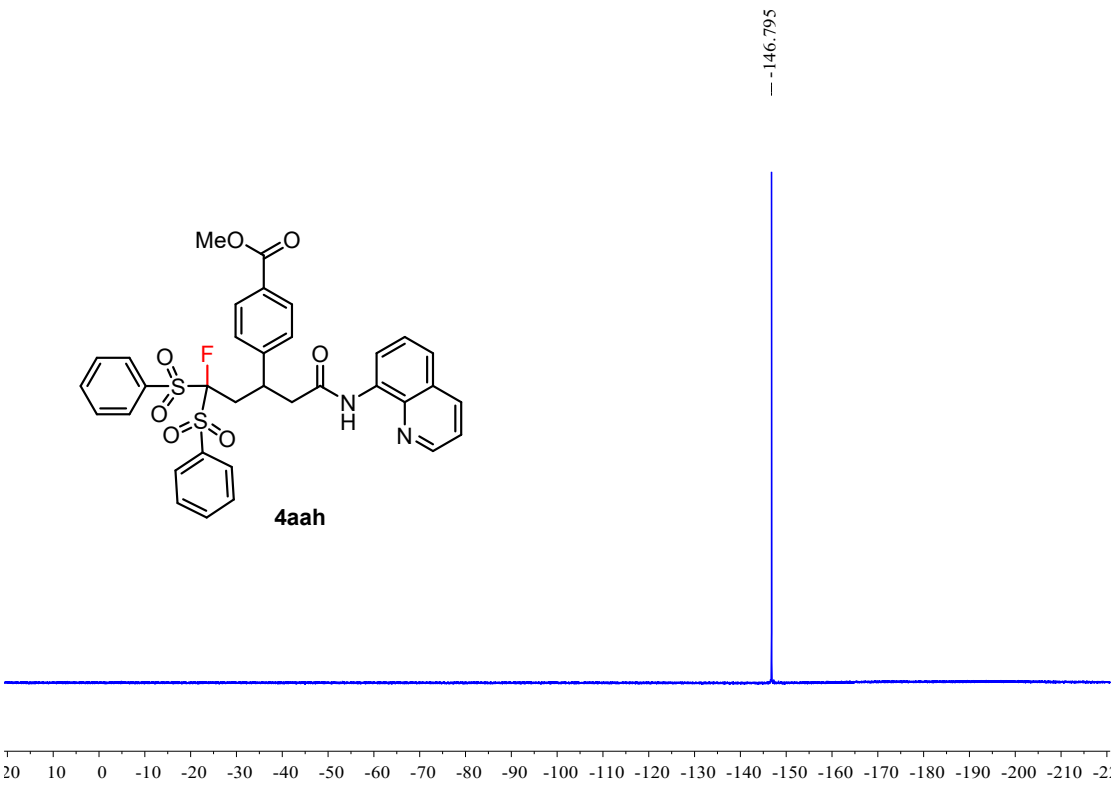
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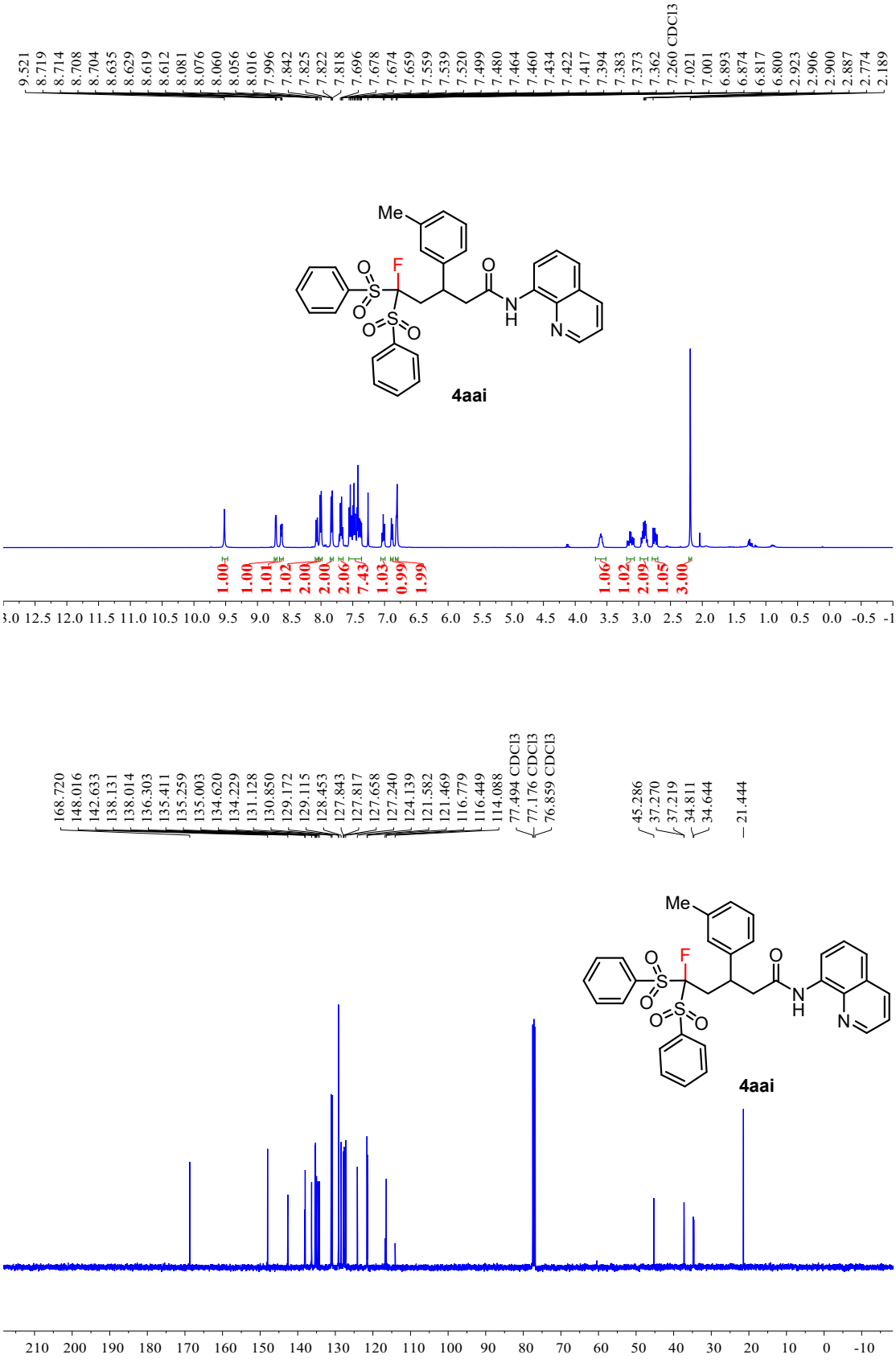
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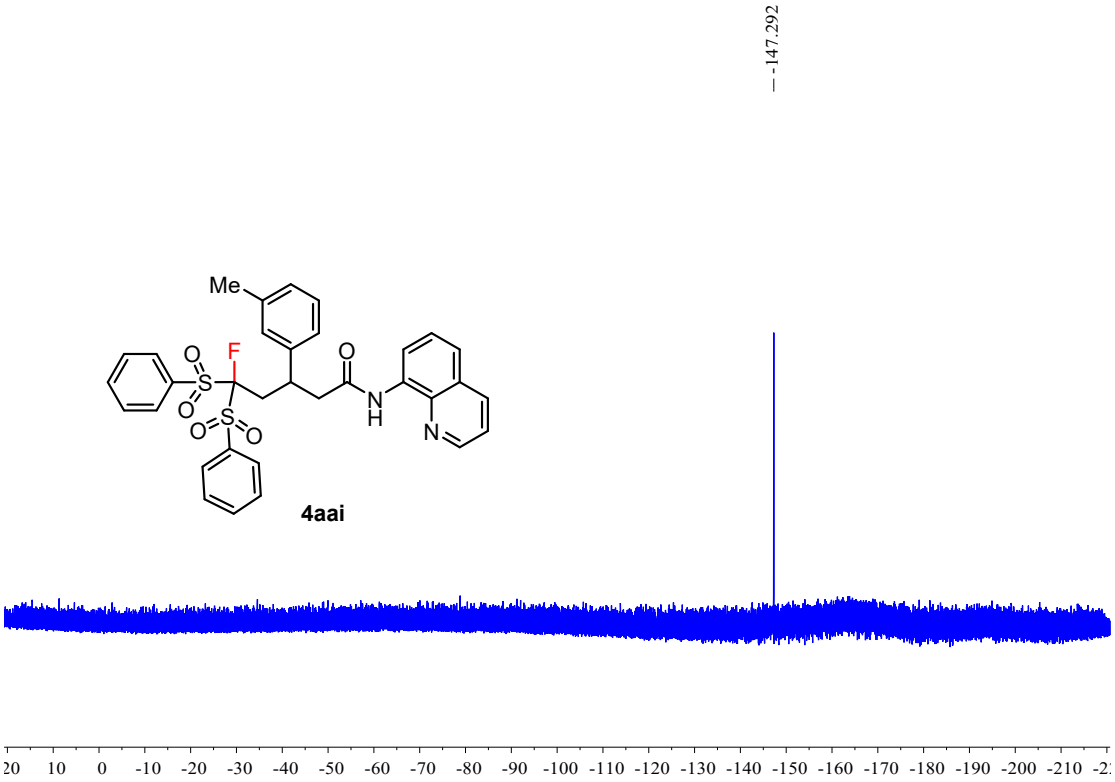
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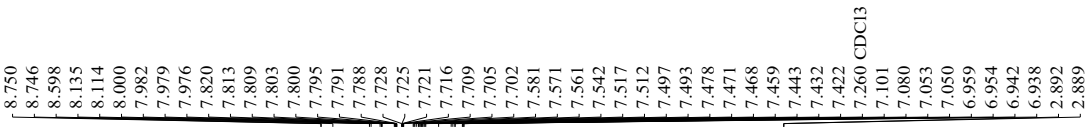
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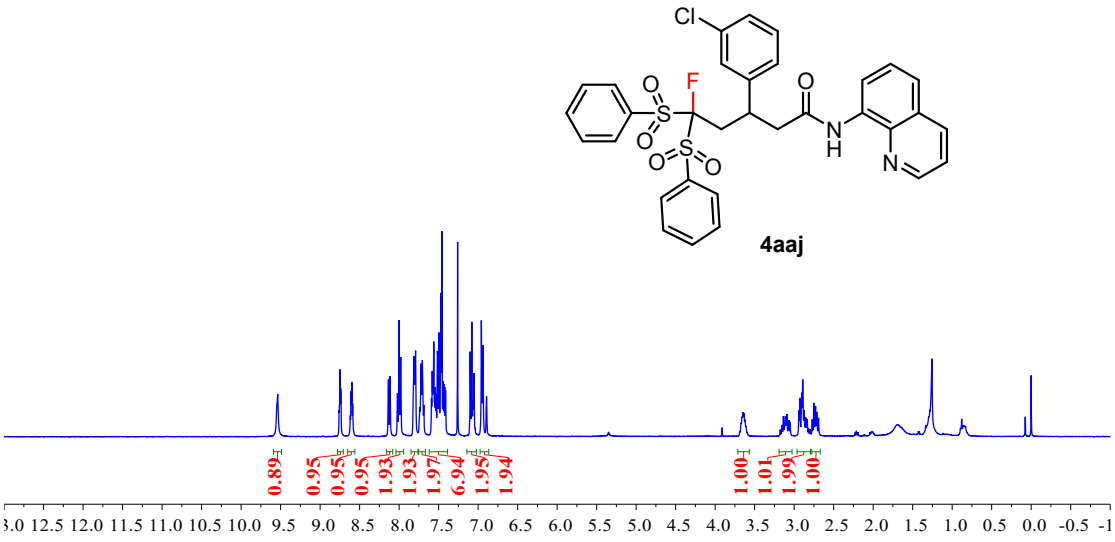
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1.99
1.00
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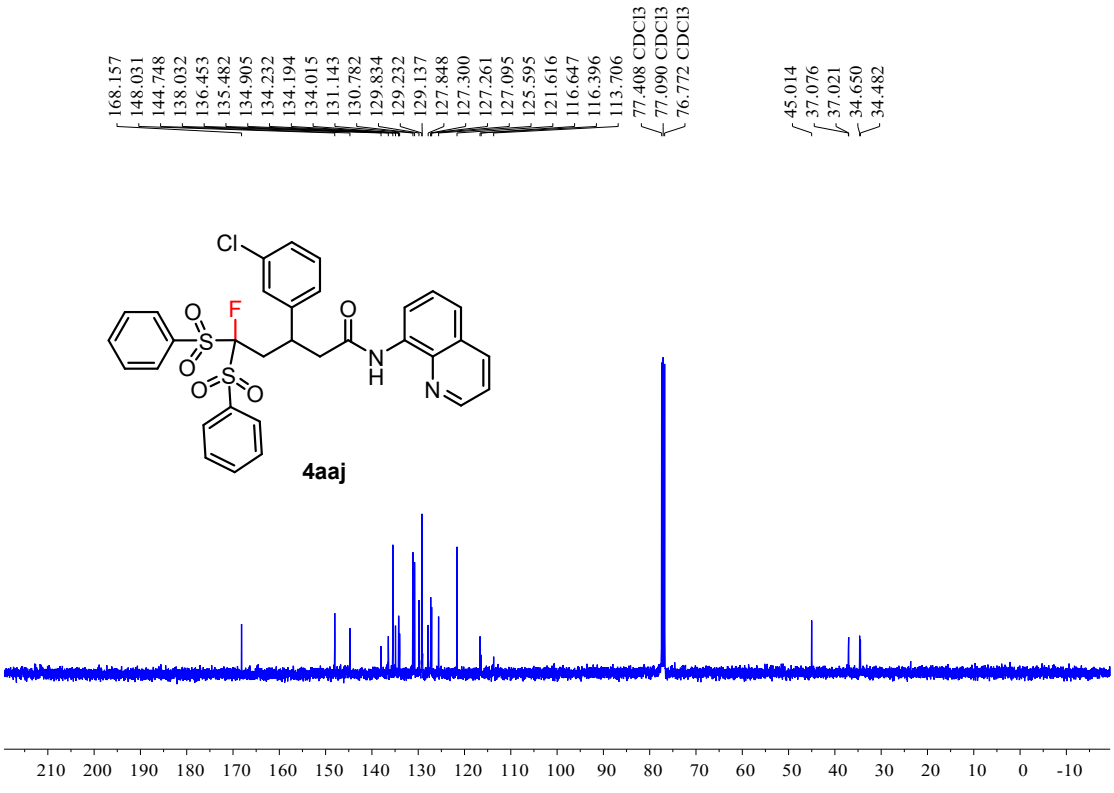
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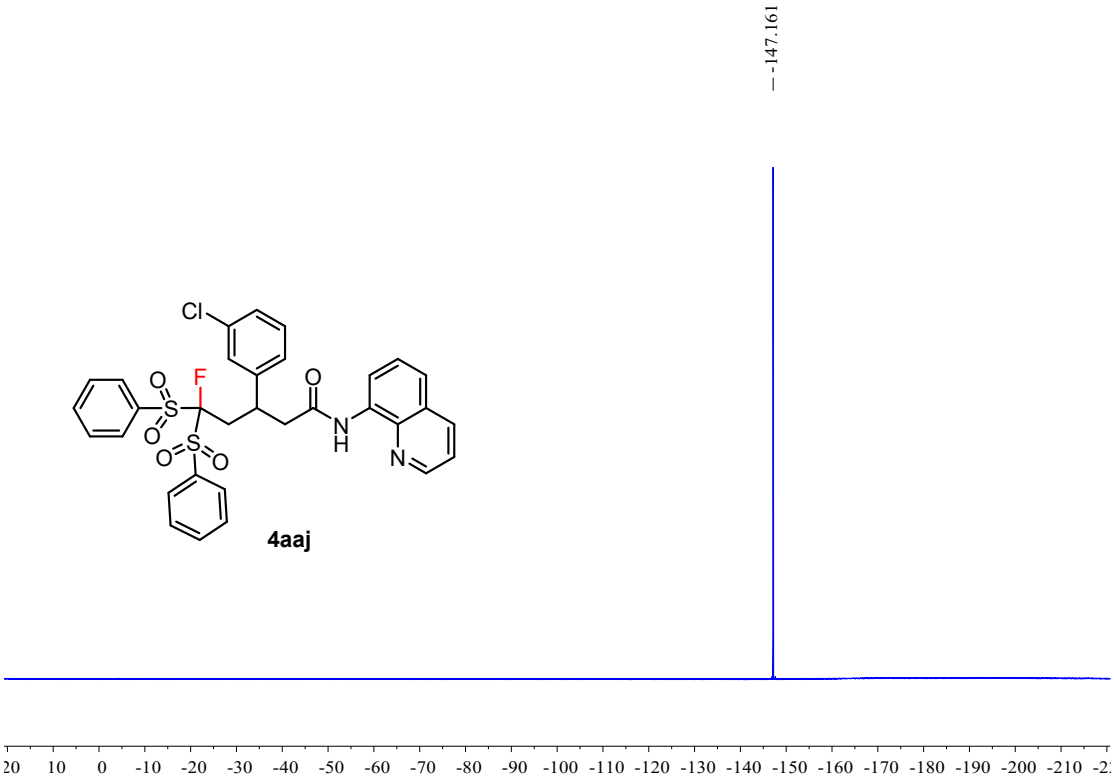
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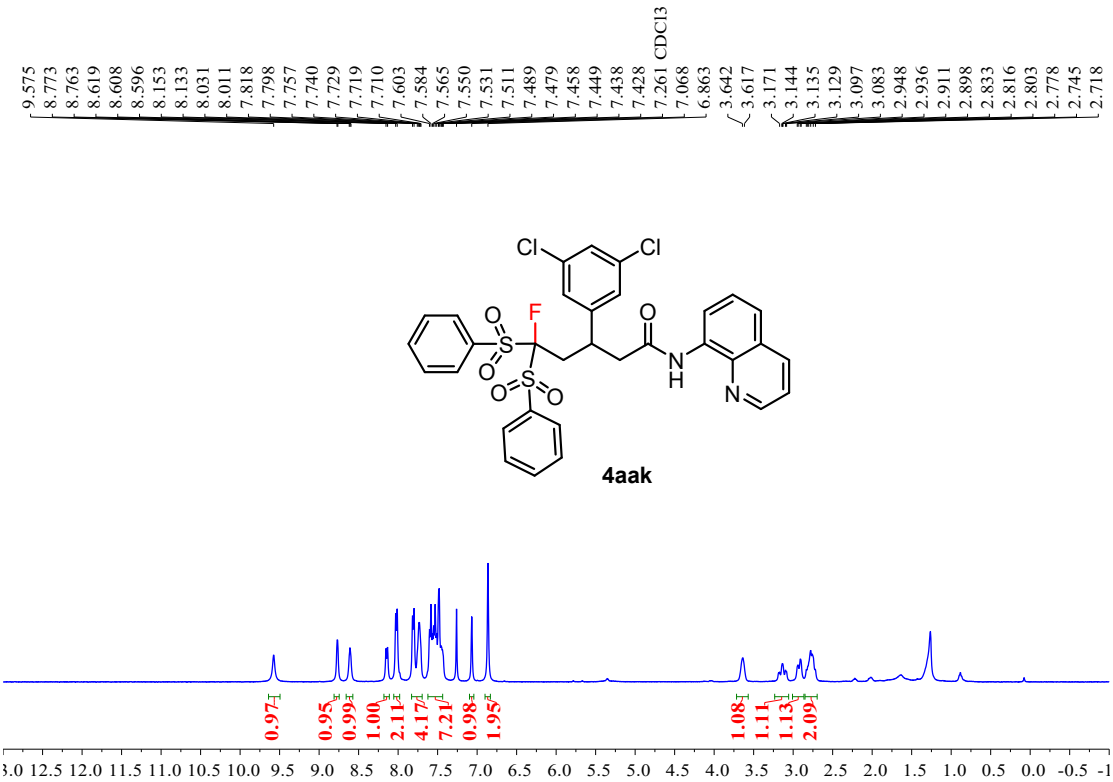
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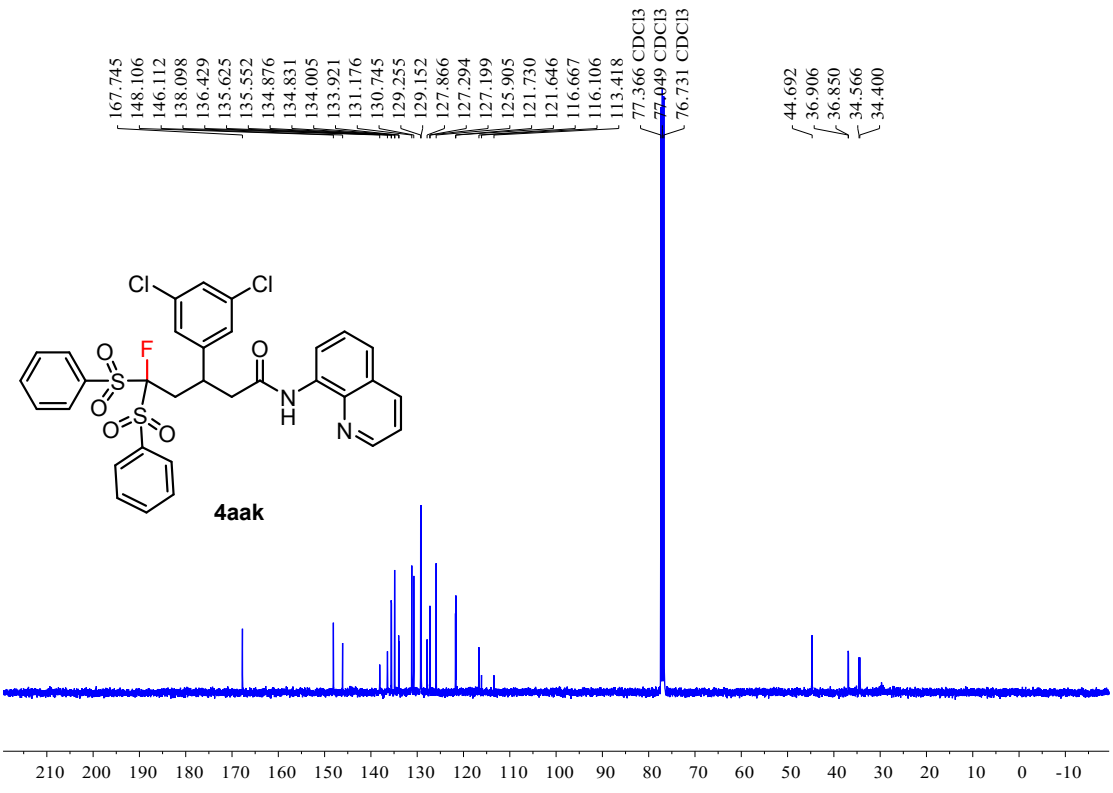
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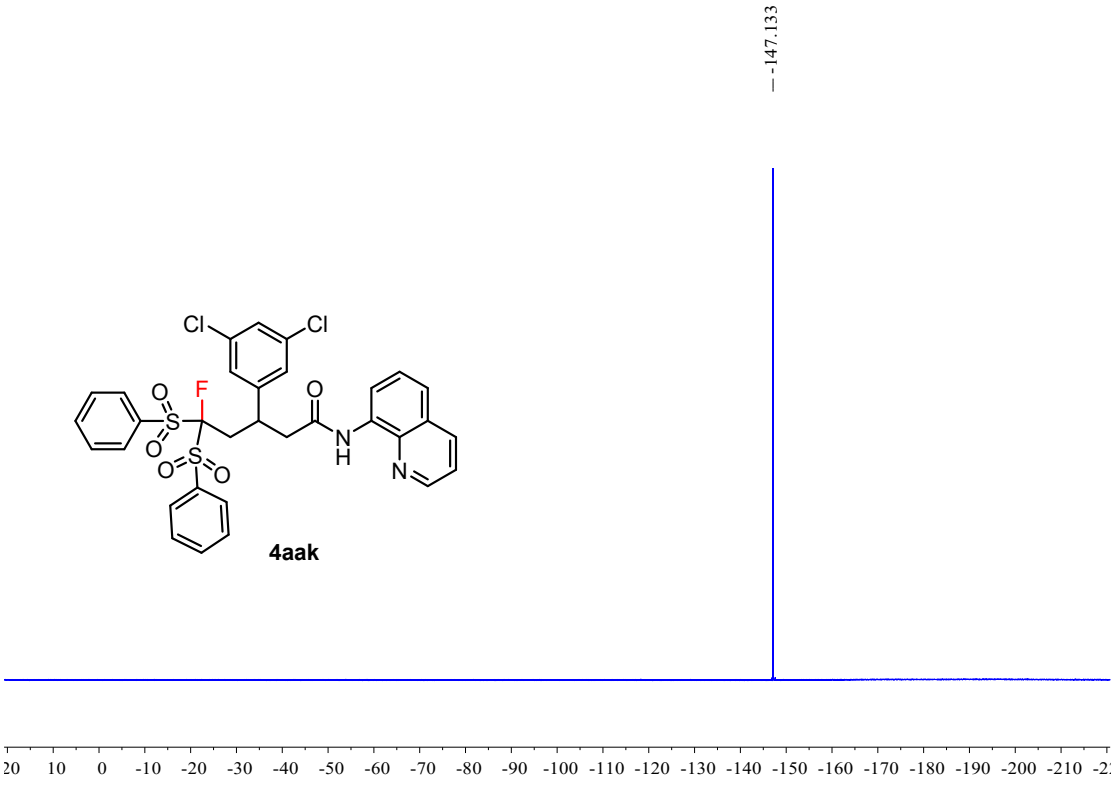
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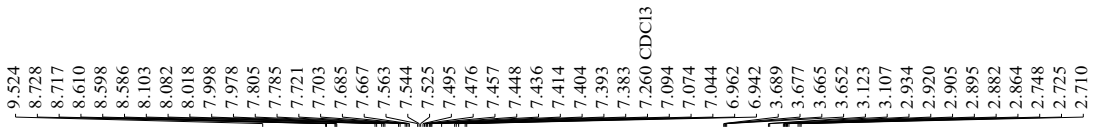
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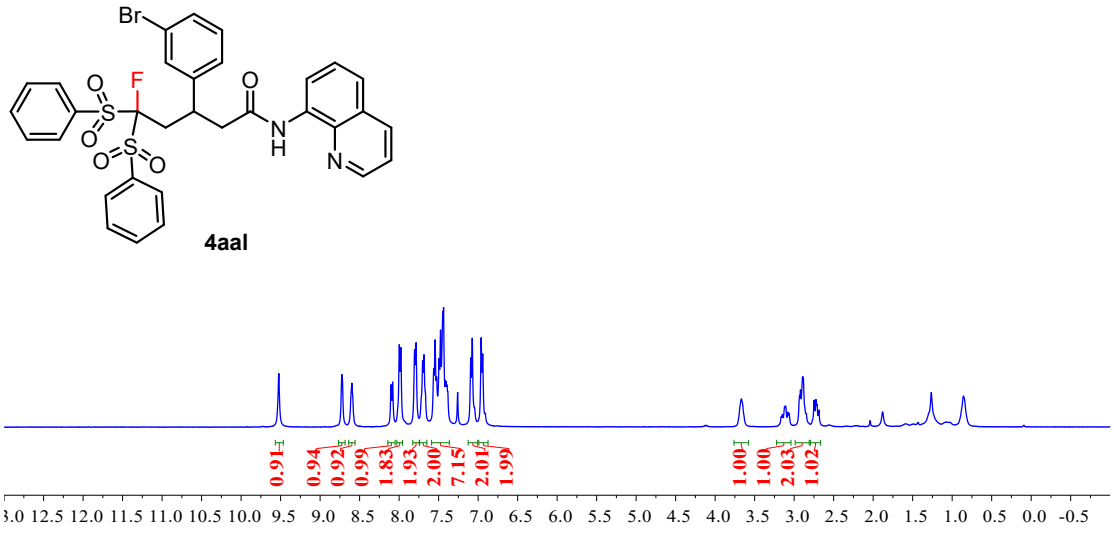
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1.00
2.03
1.02
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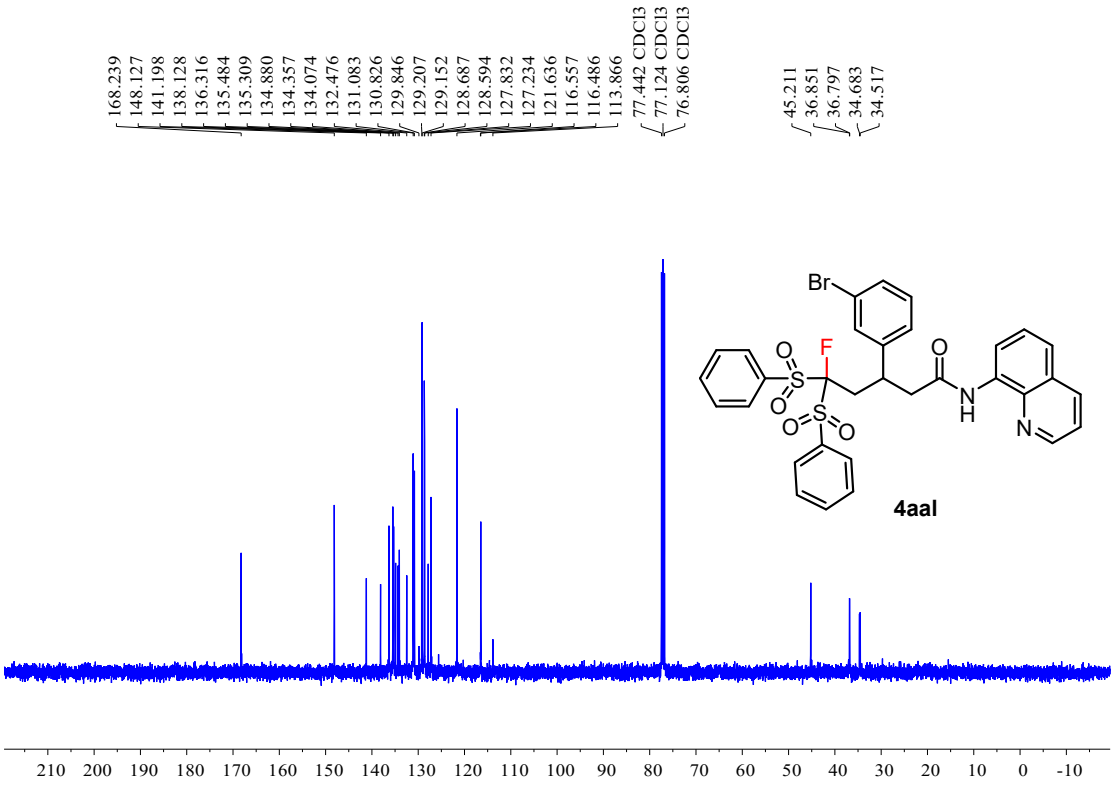
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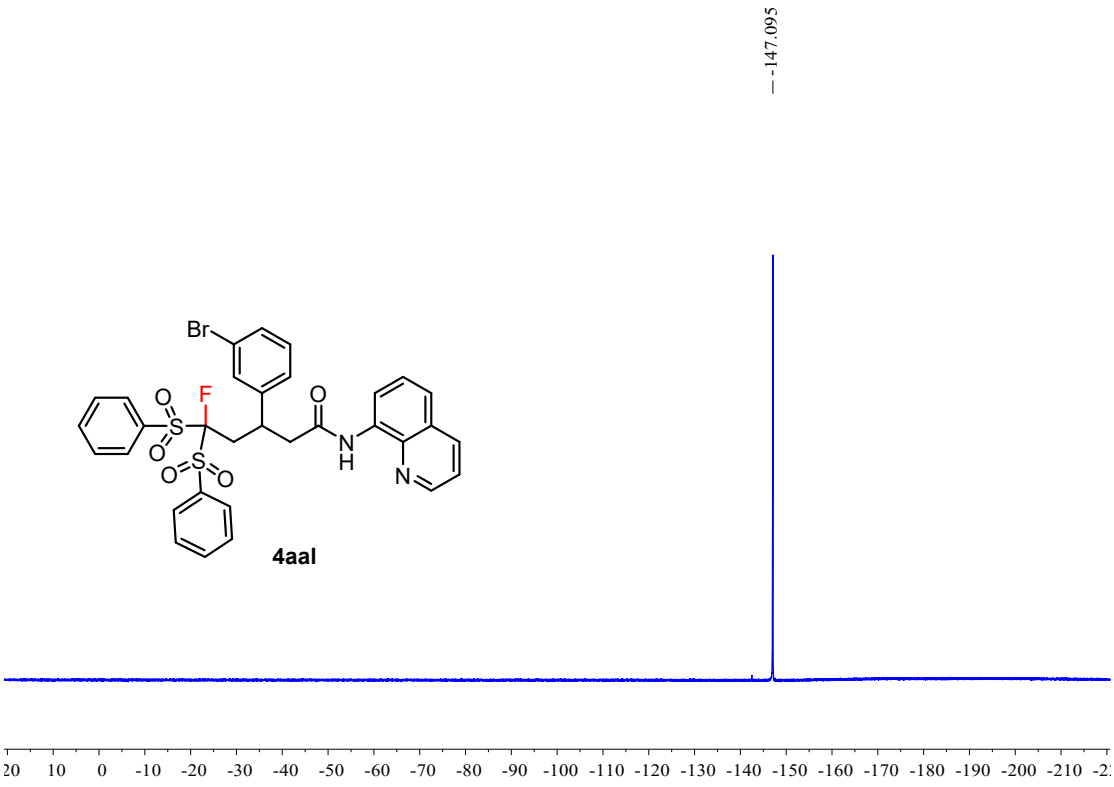
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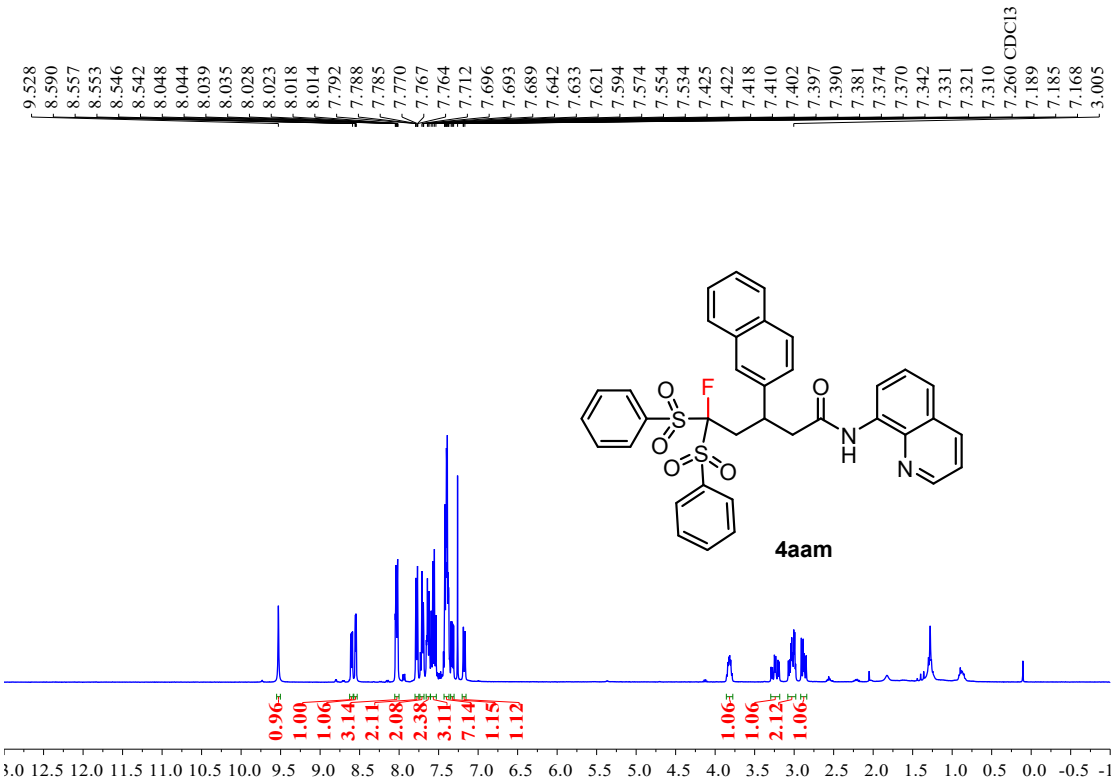
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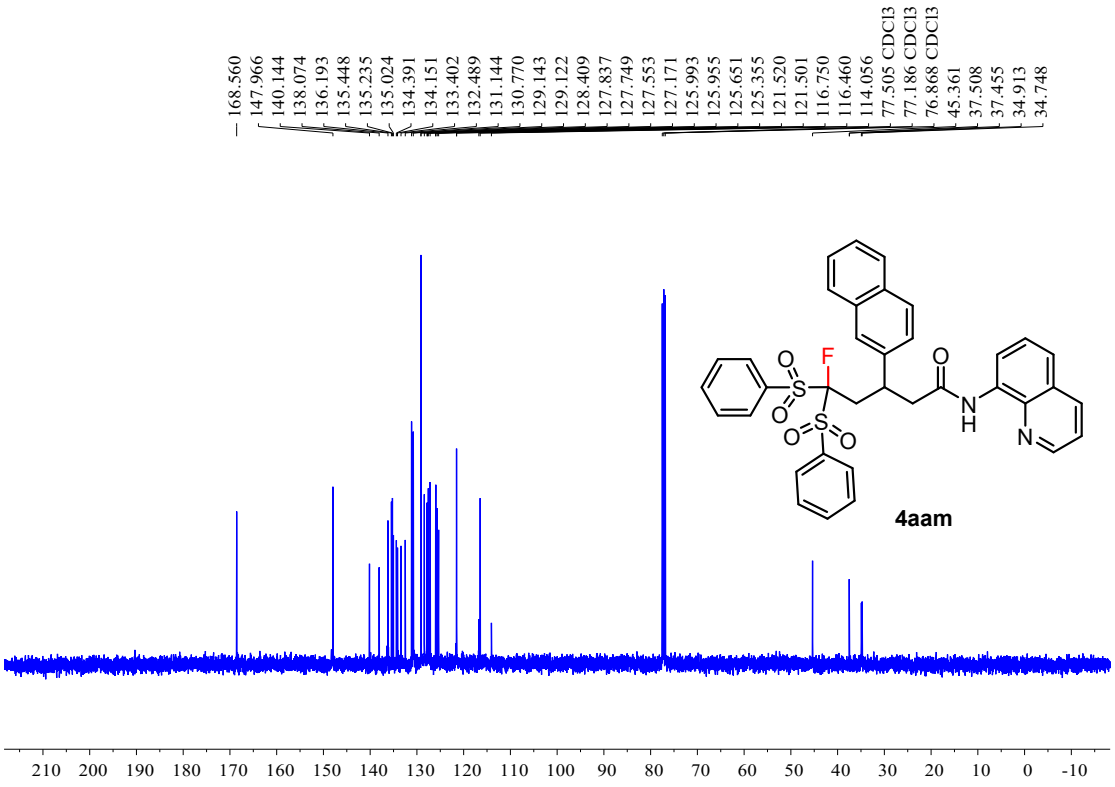
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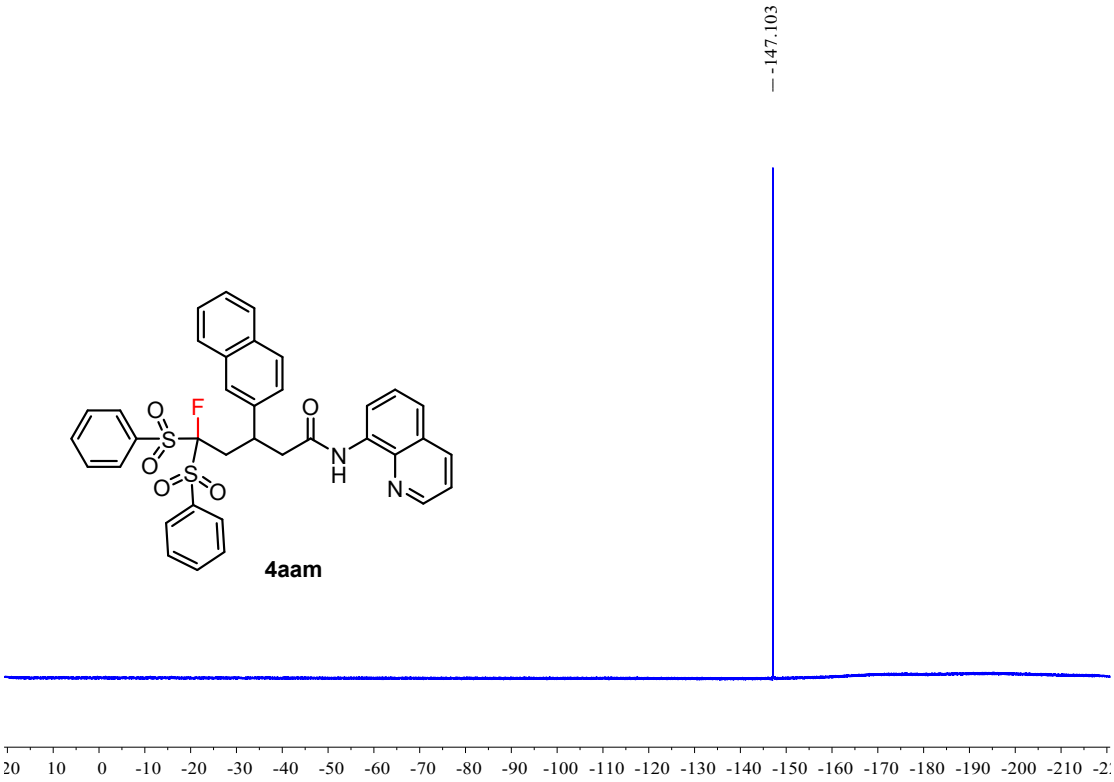
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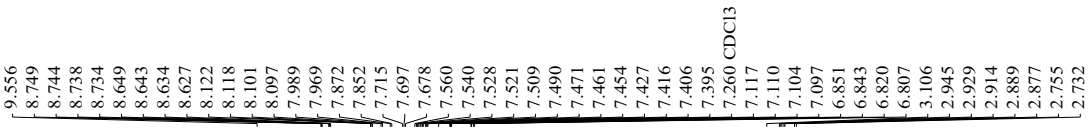
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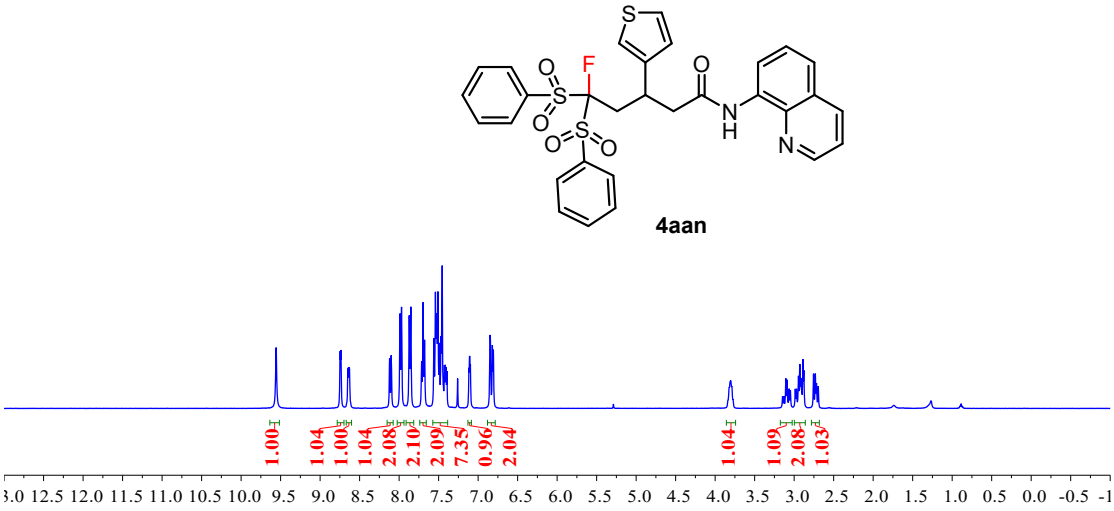
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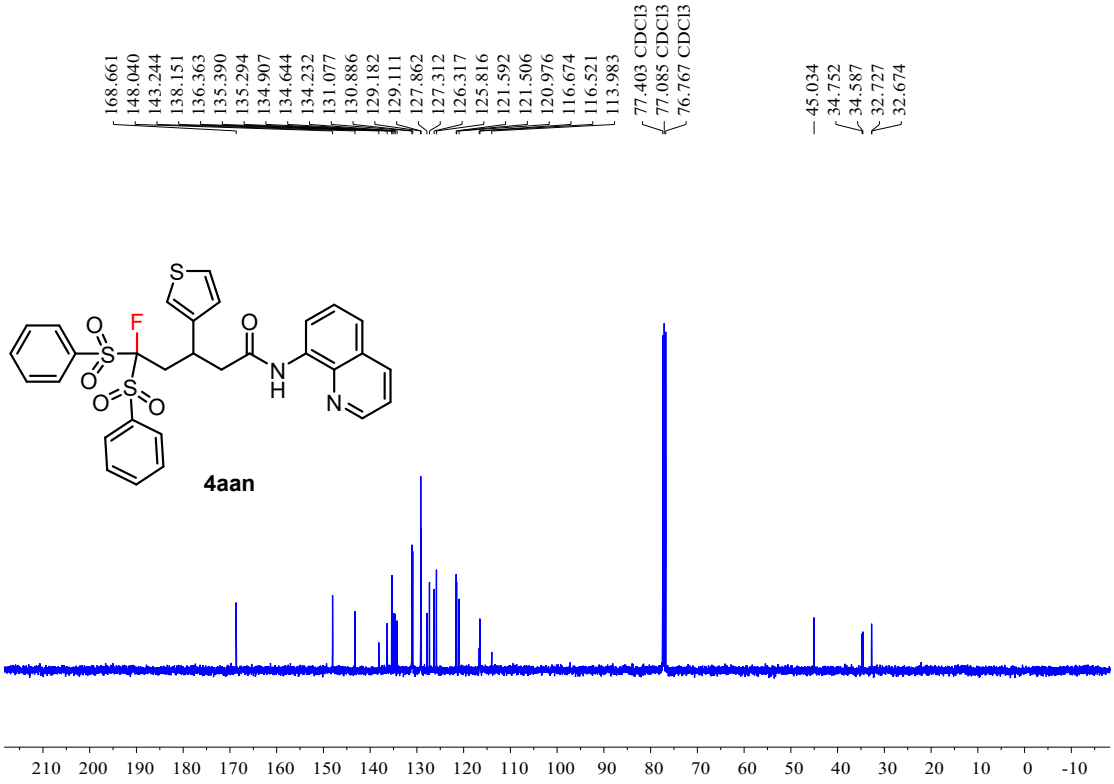
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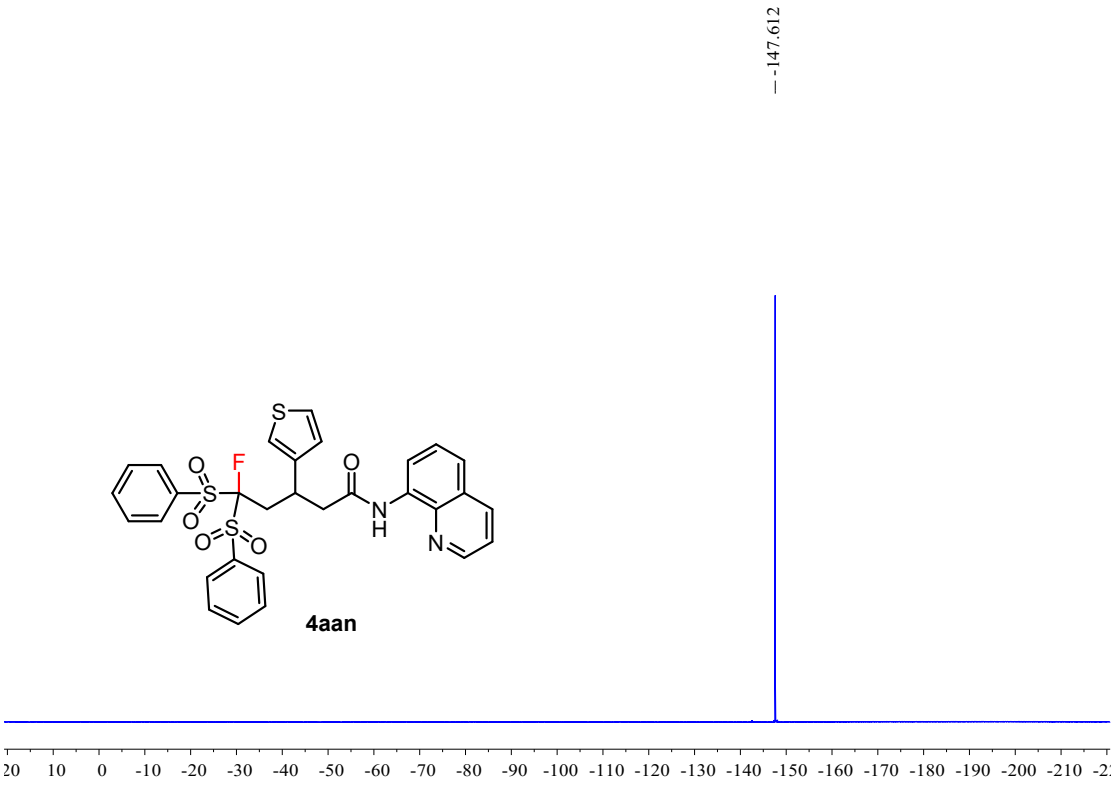
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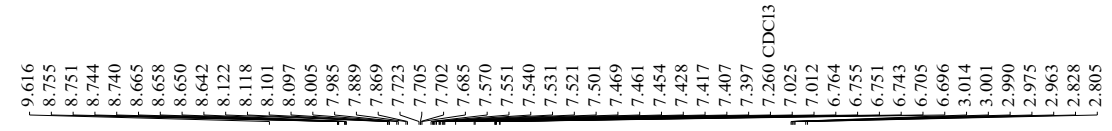
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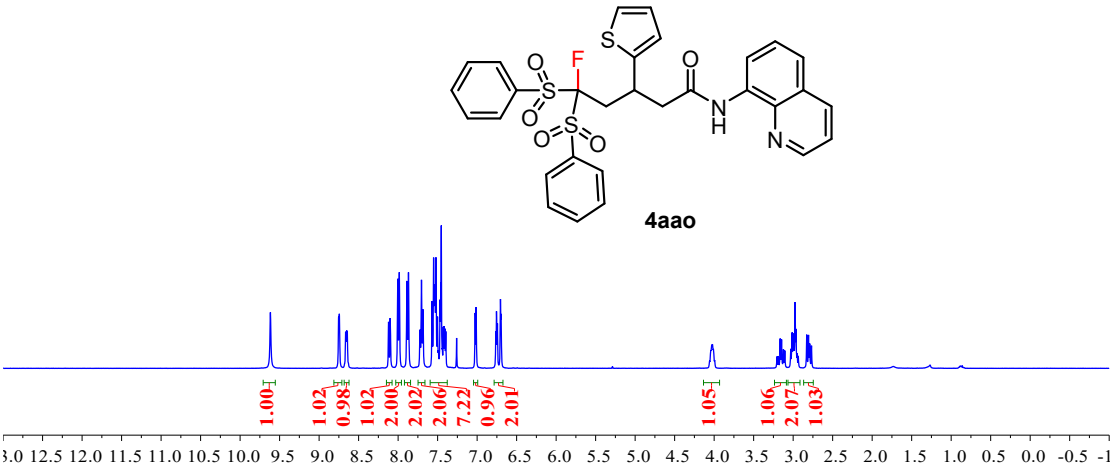
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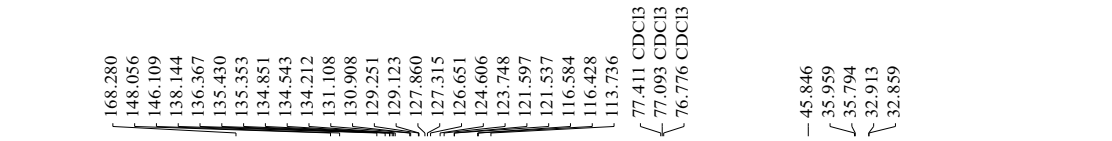
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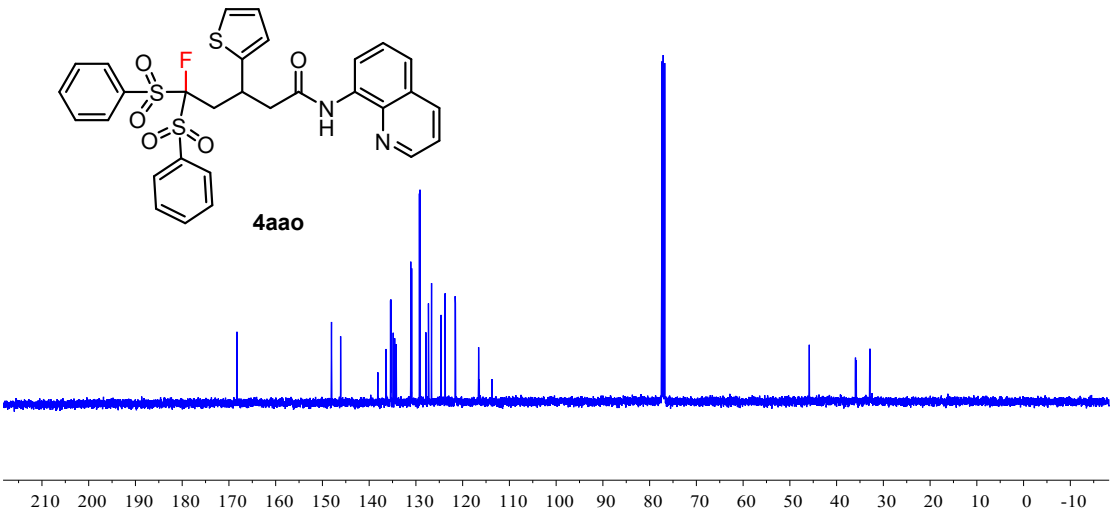
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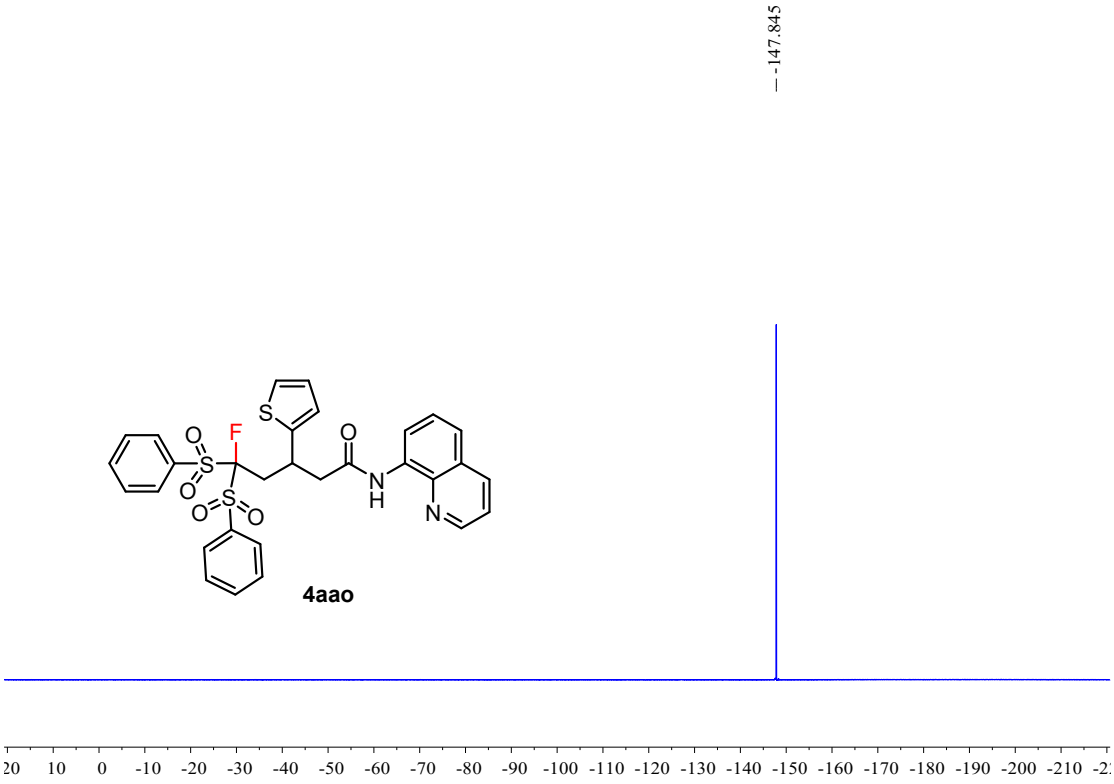
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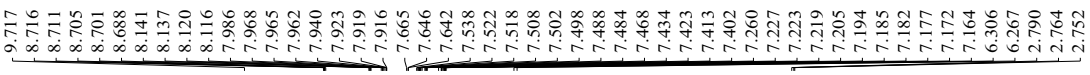
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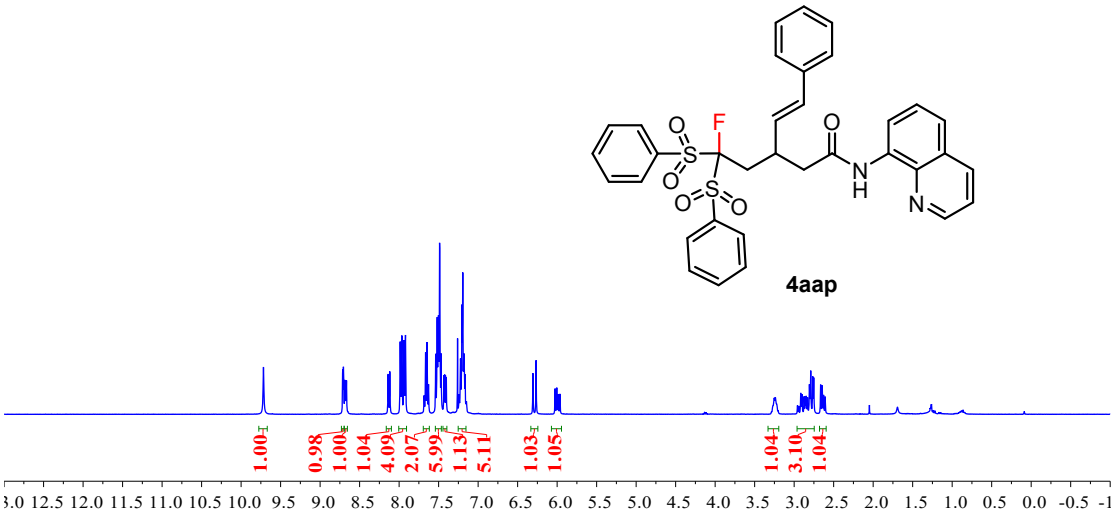
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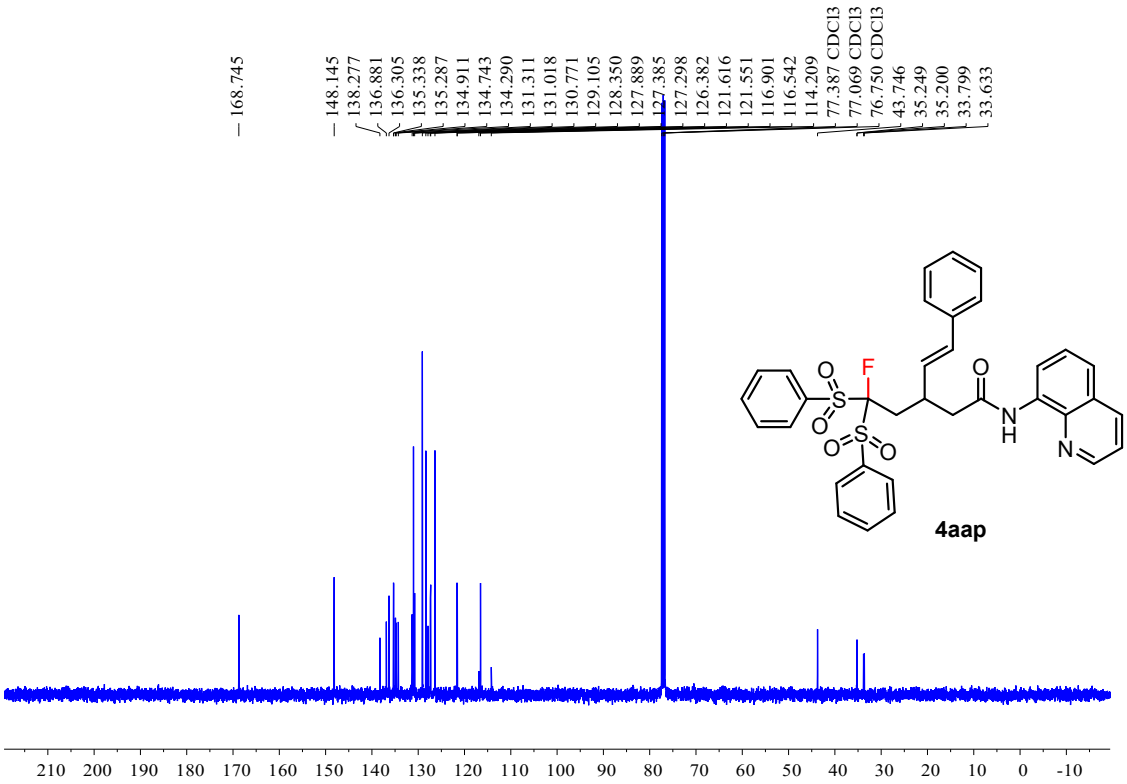
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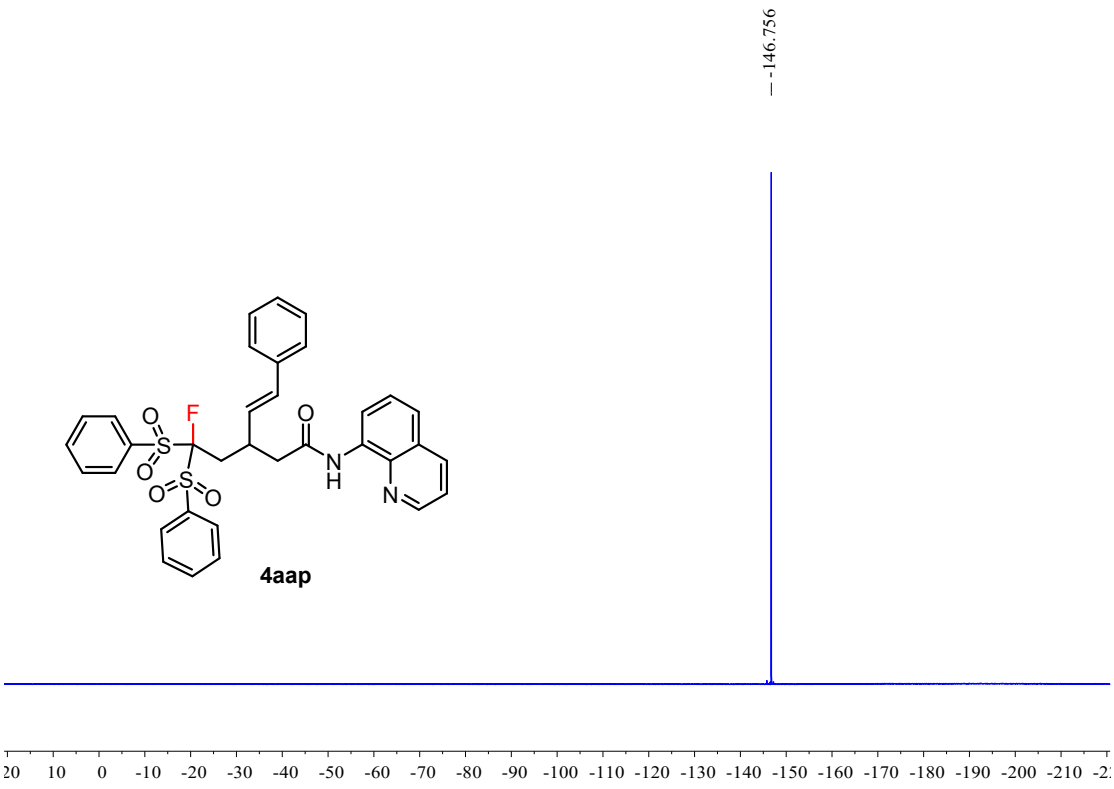
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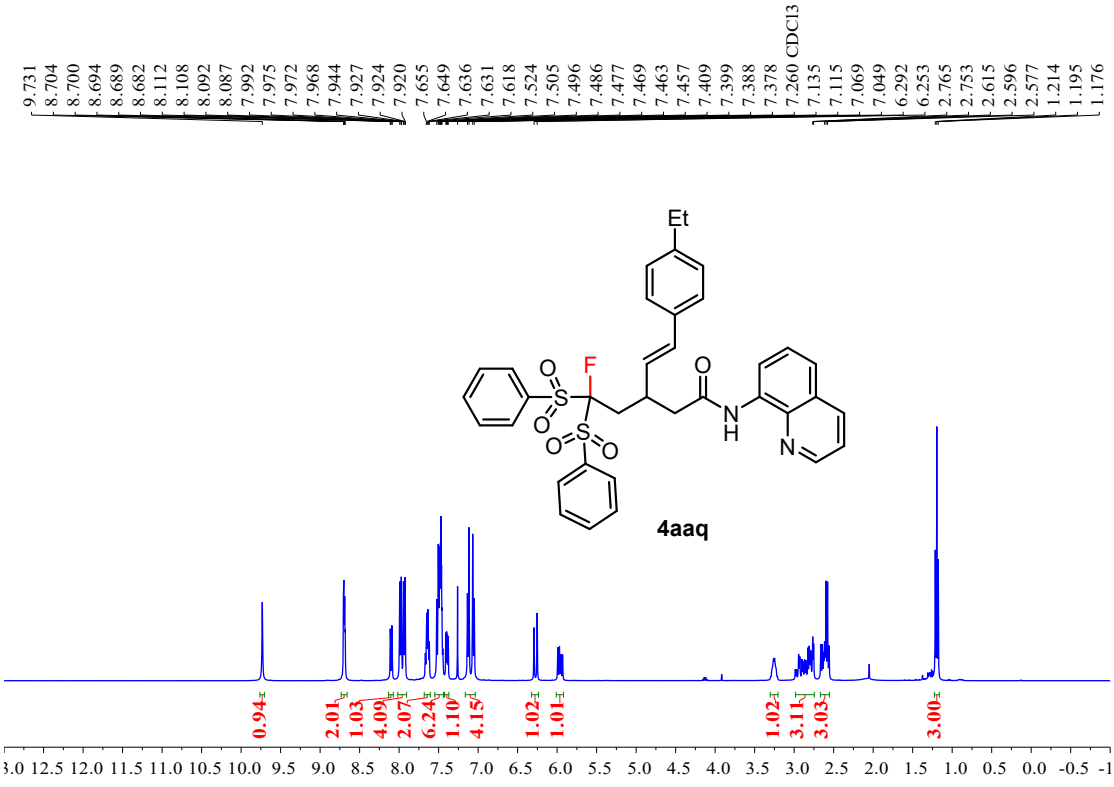
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2.07
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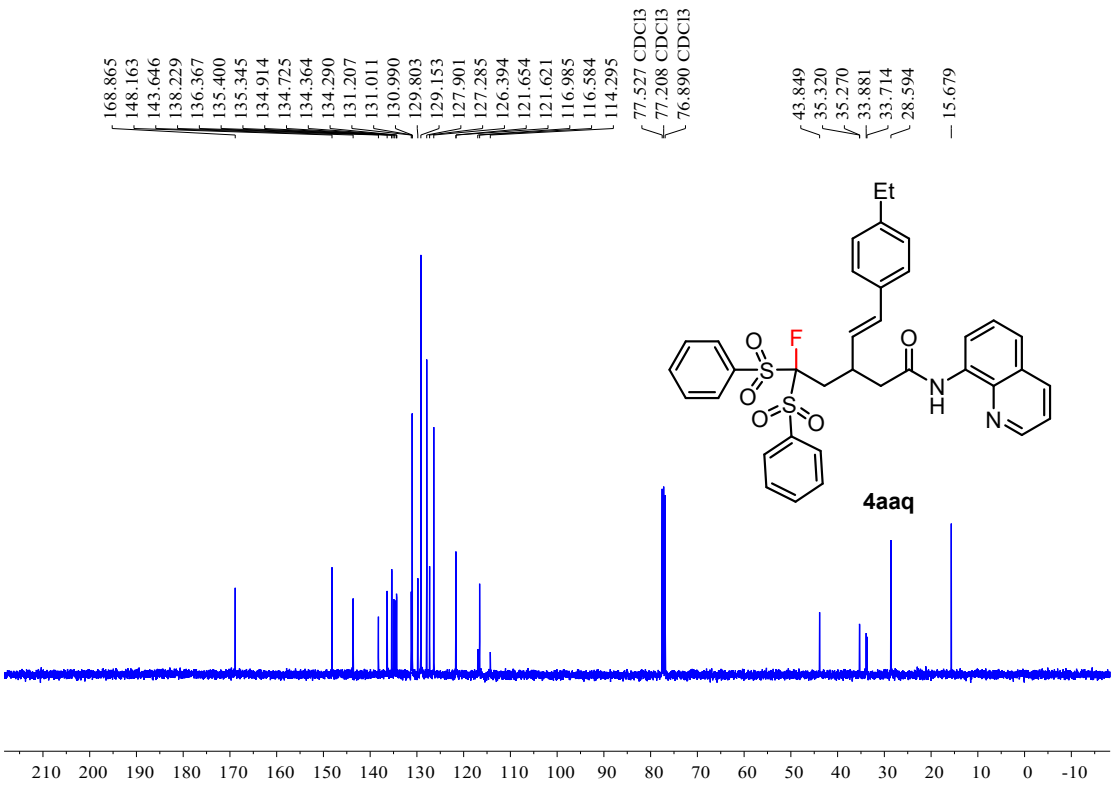
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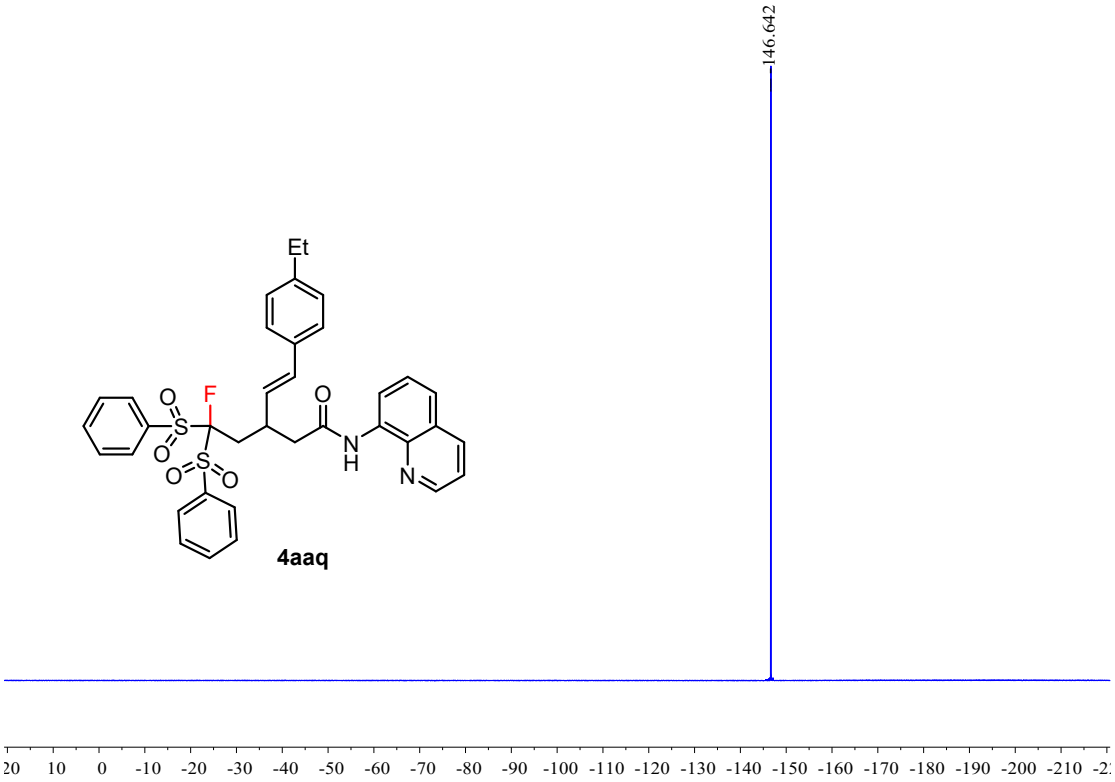
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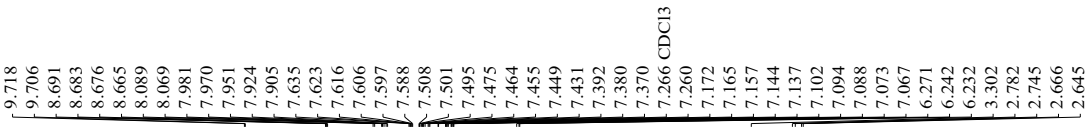
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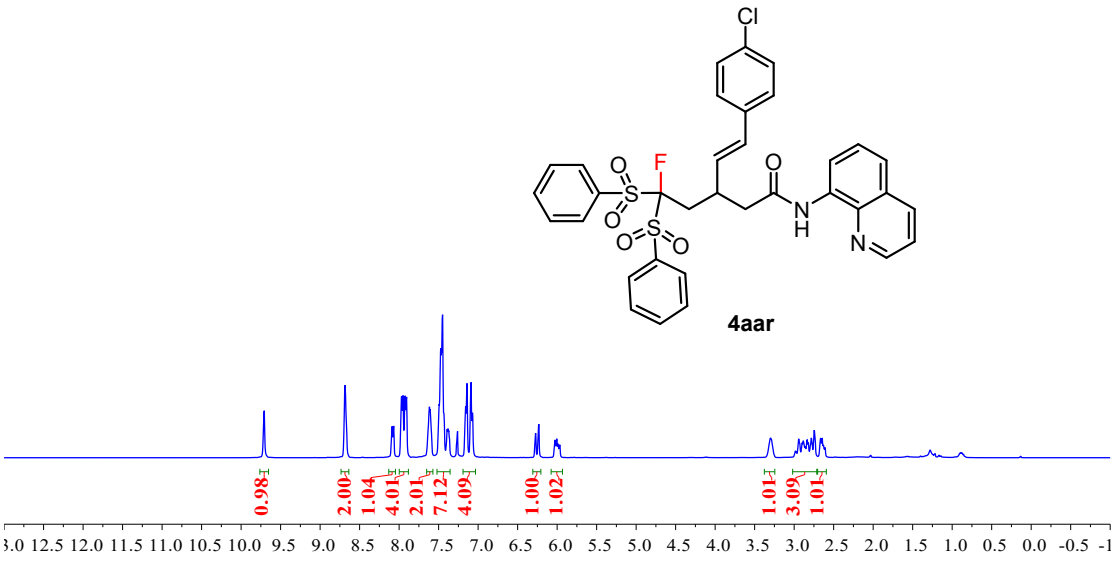
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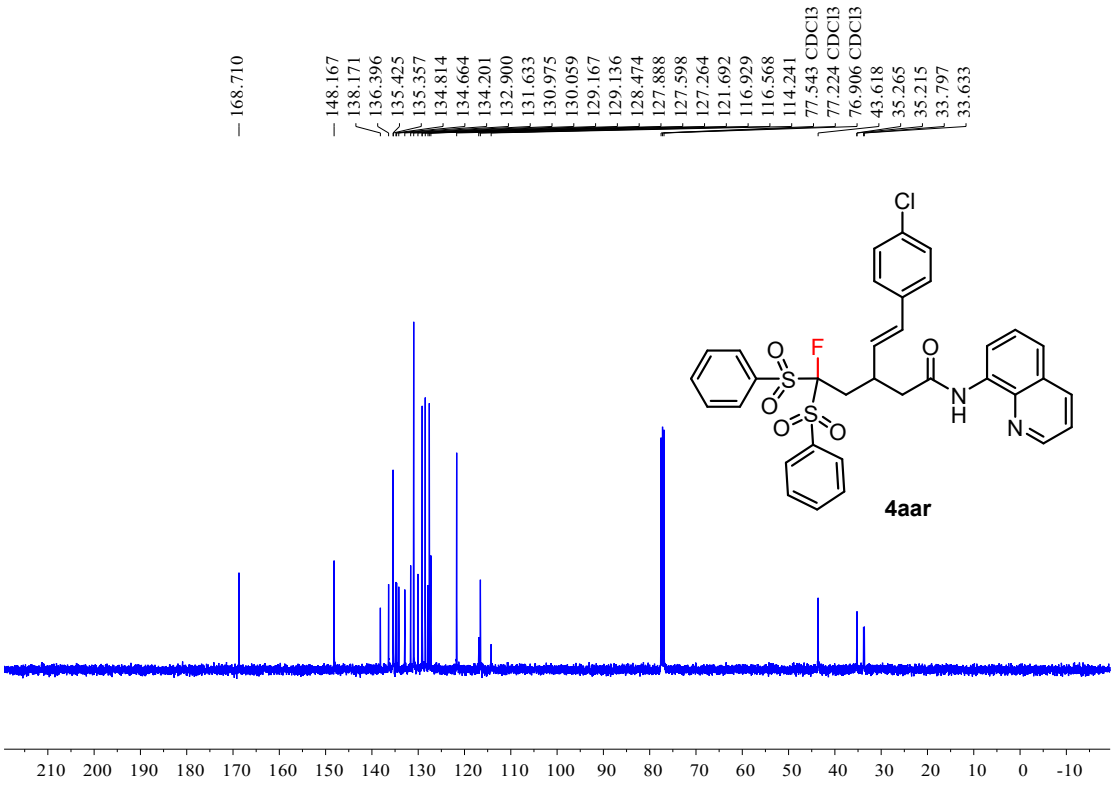
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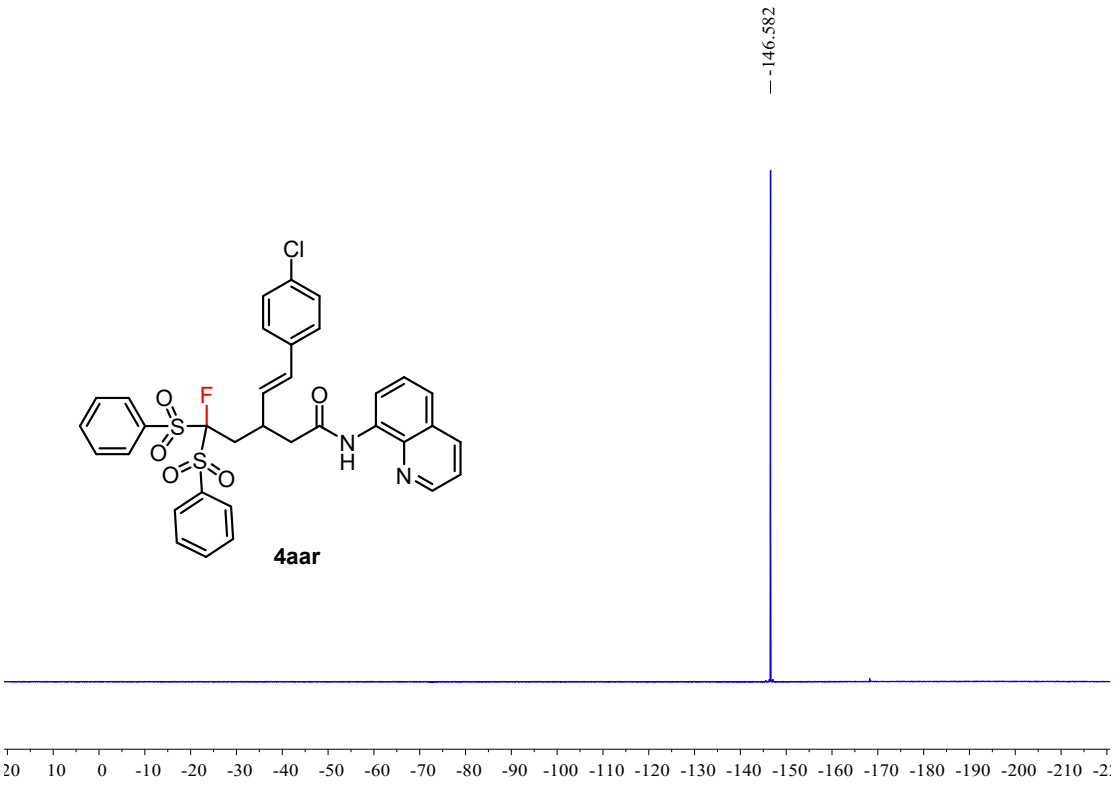
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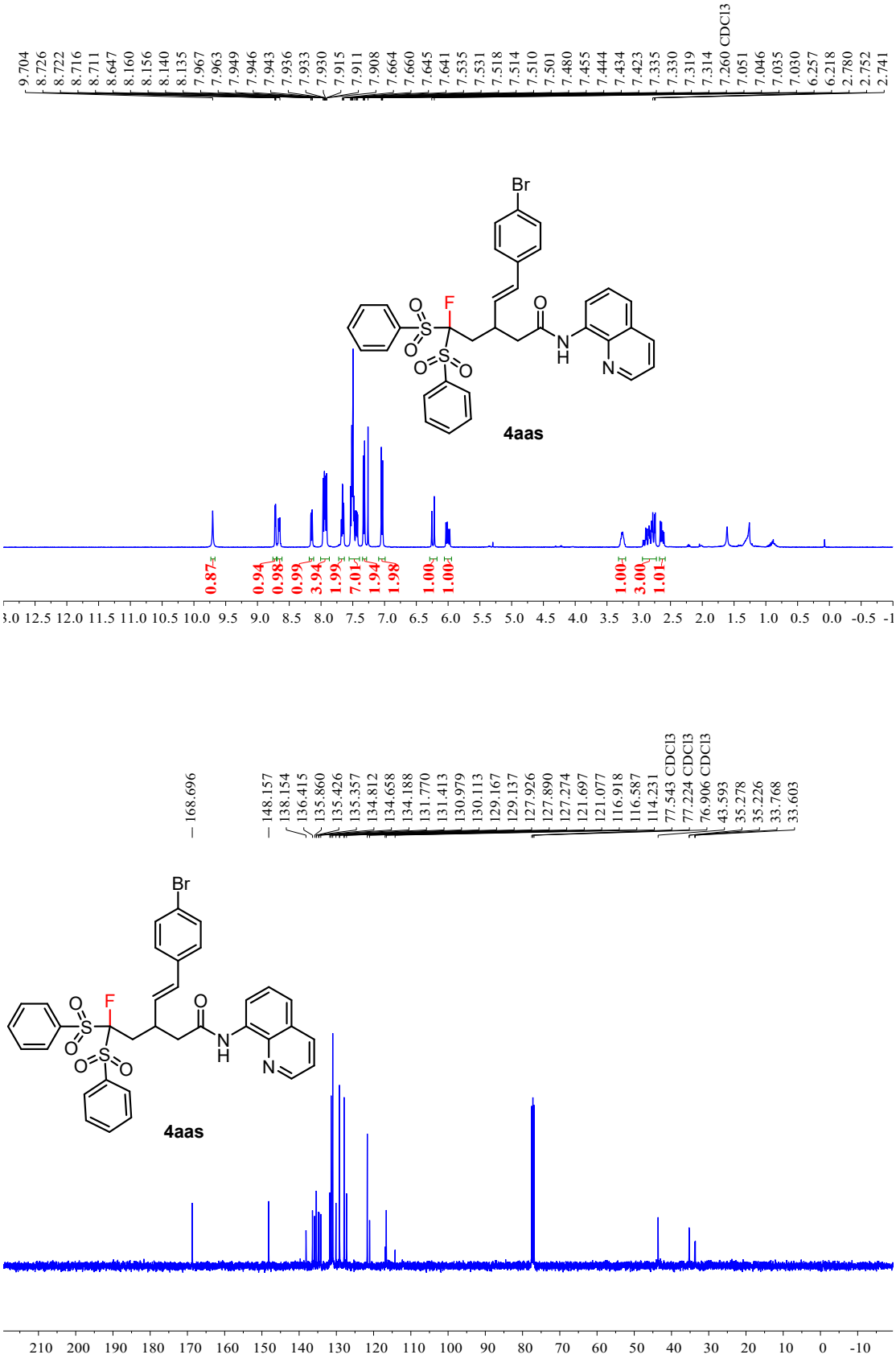
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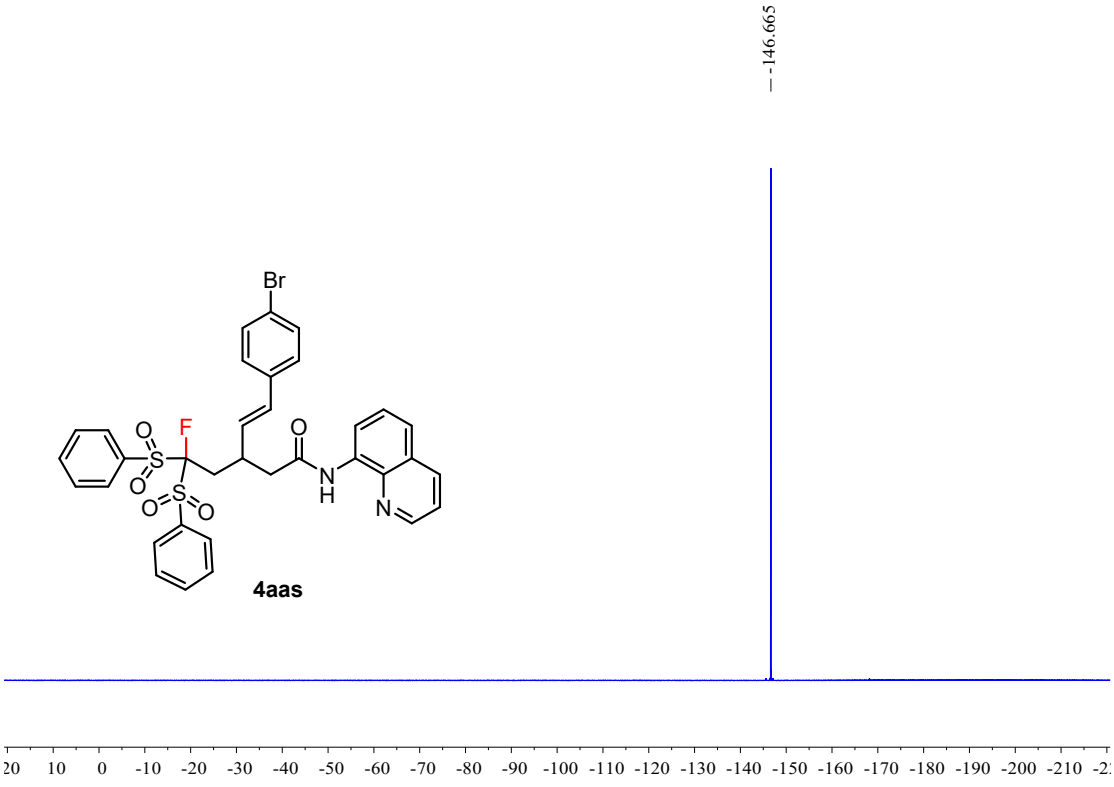
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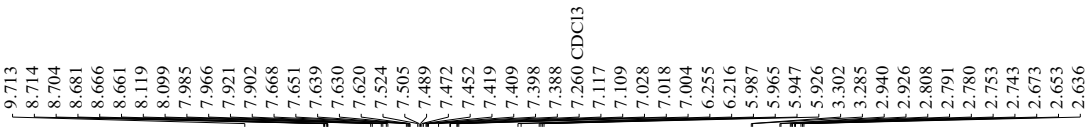
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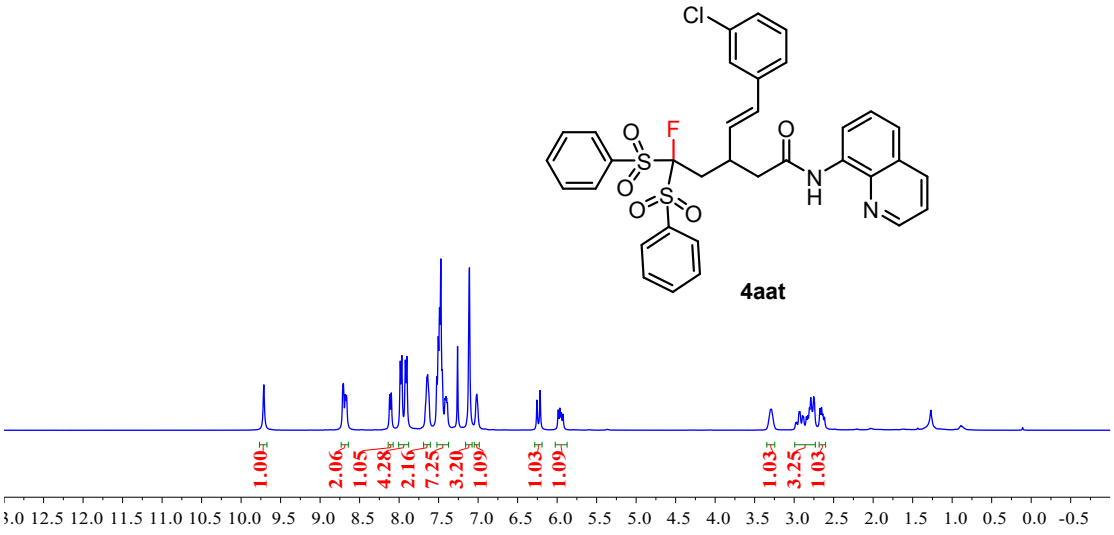
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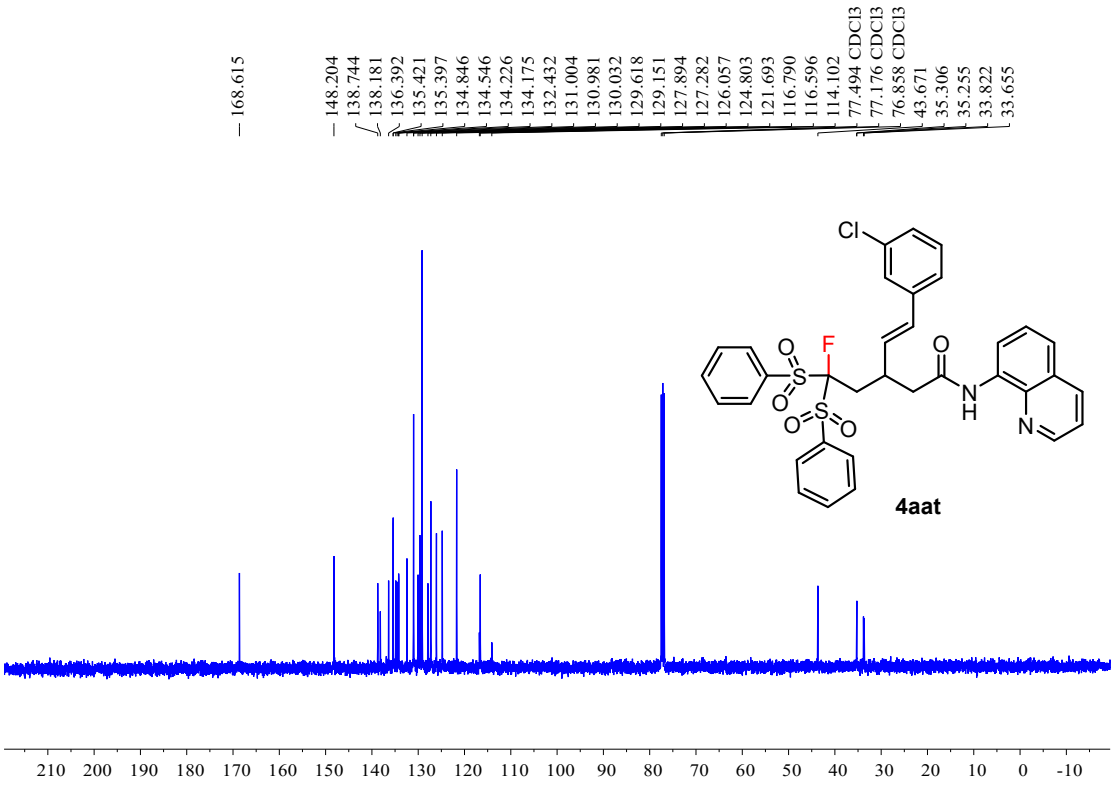
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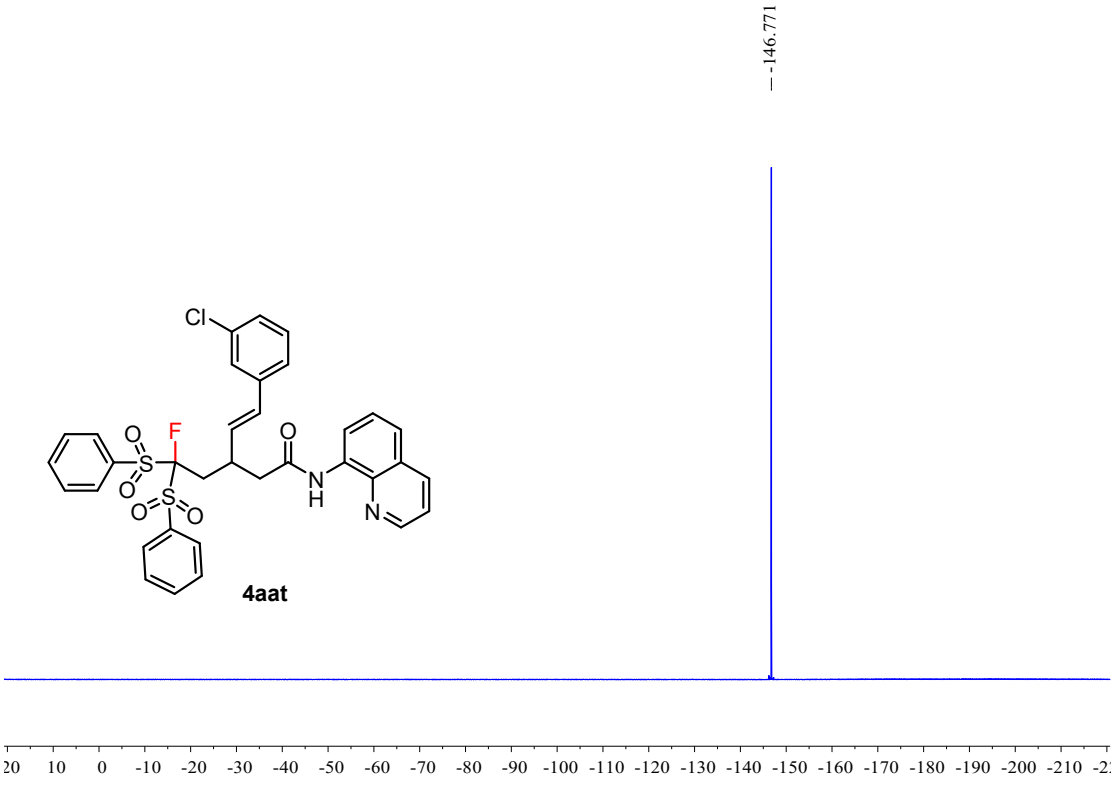
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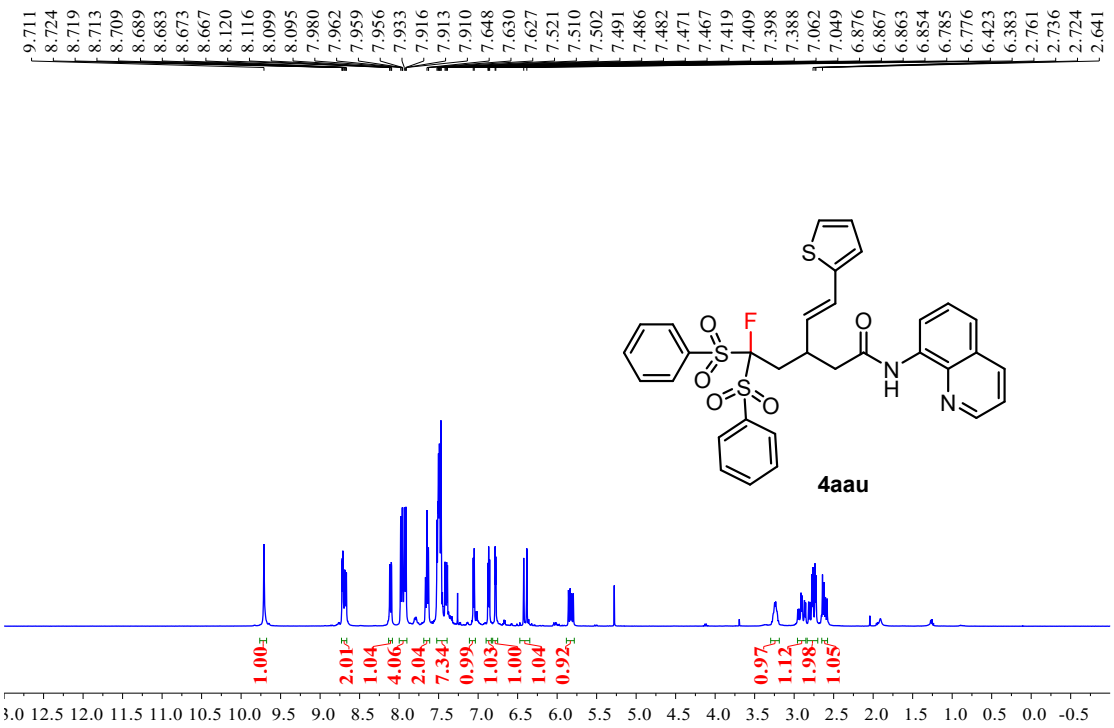
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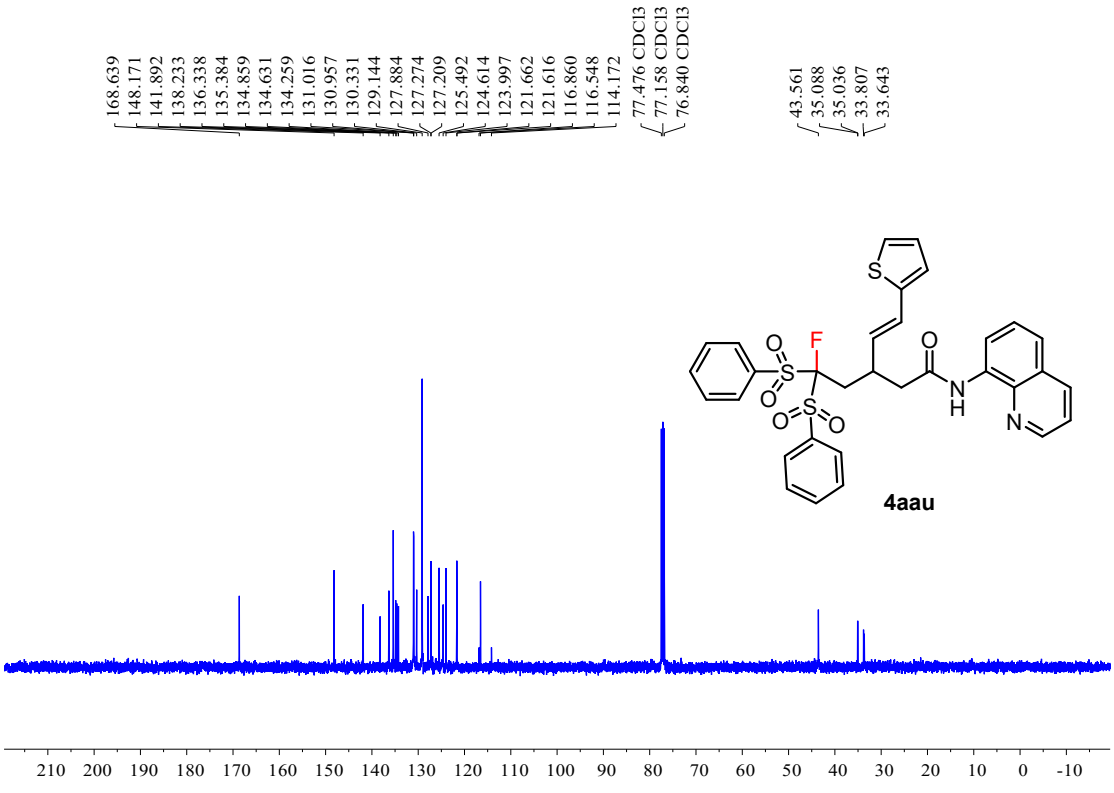
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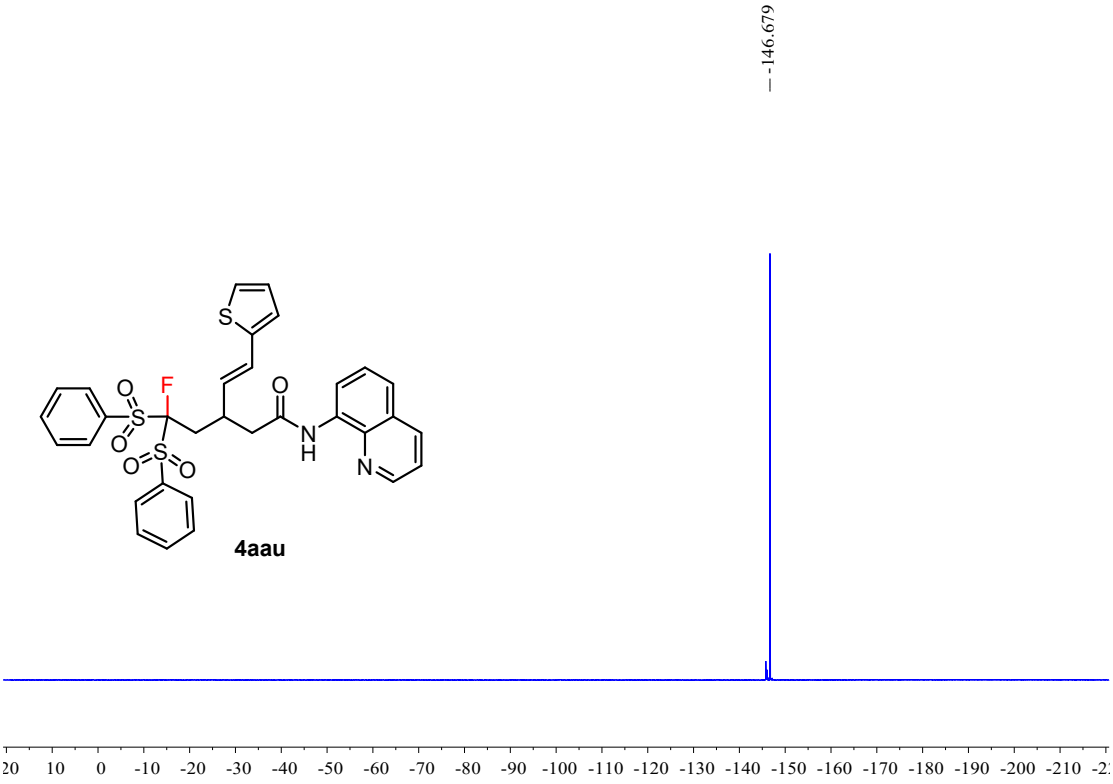
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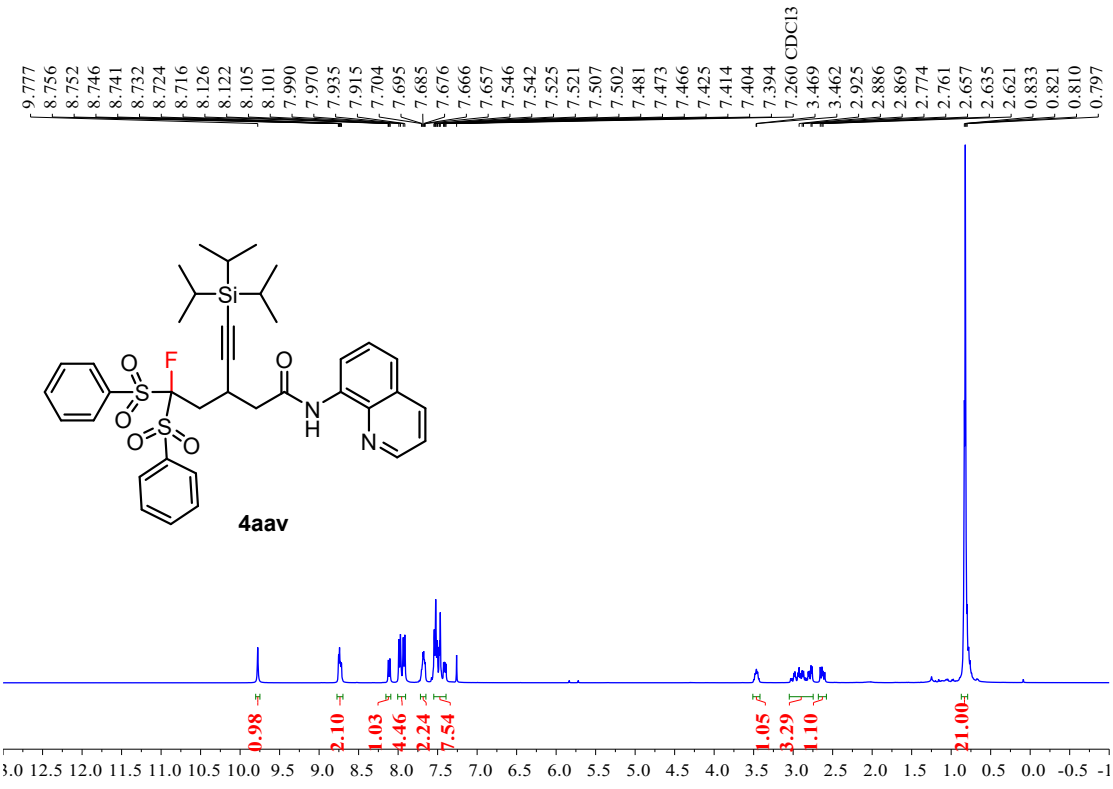
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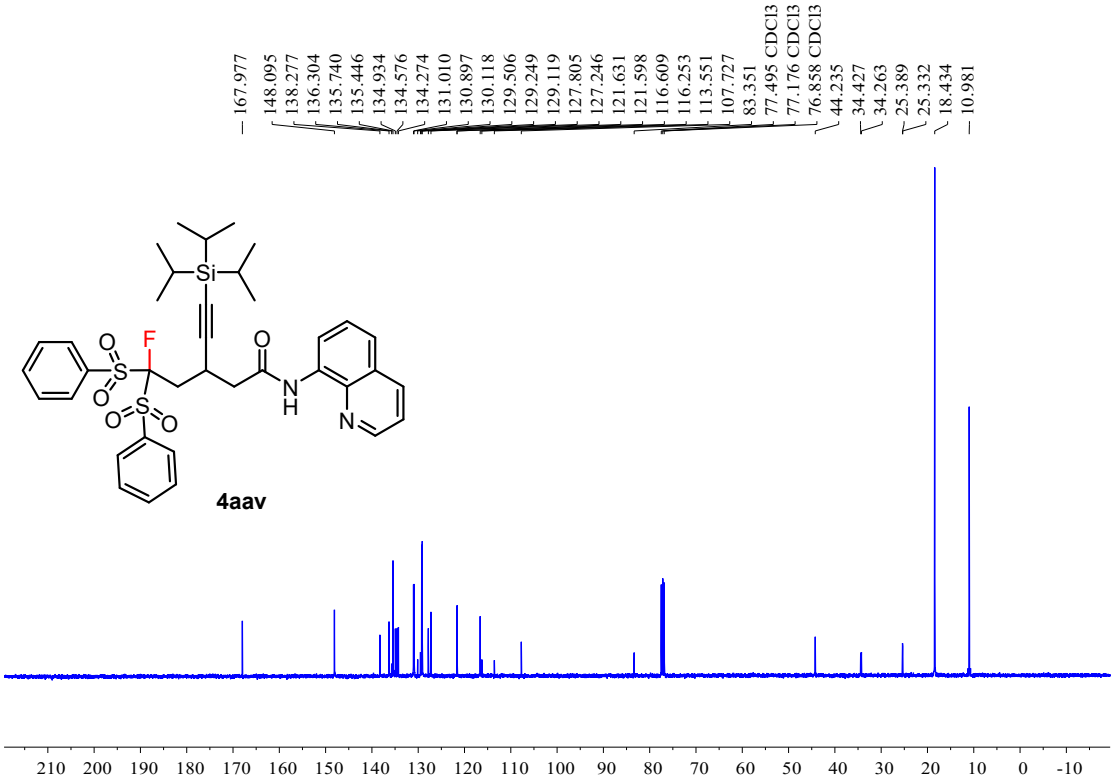
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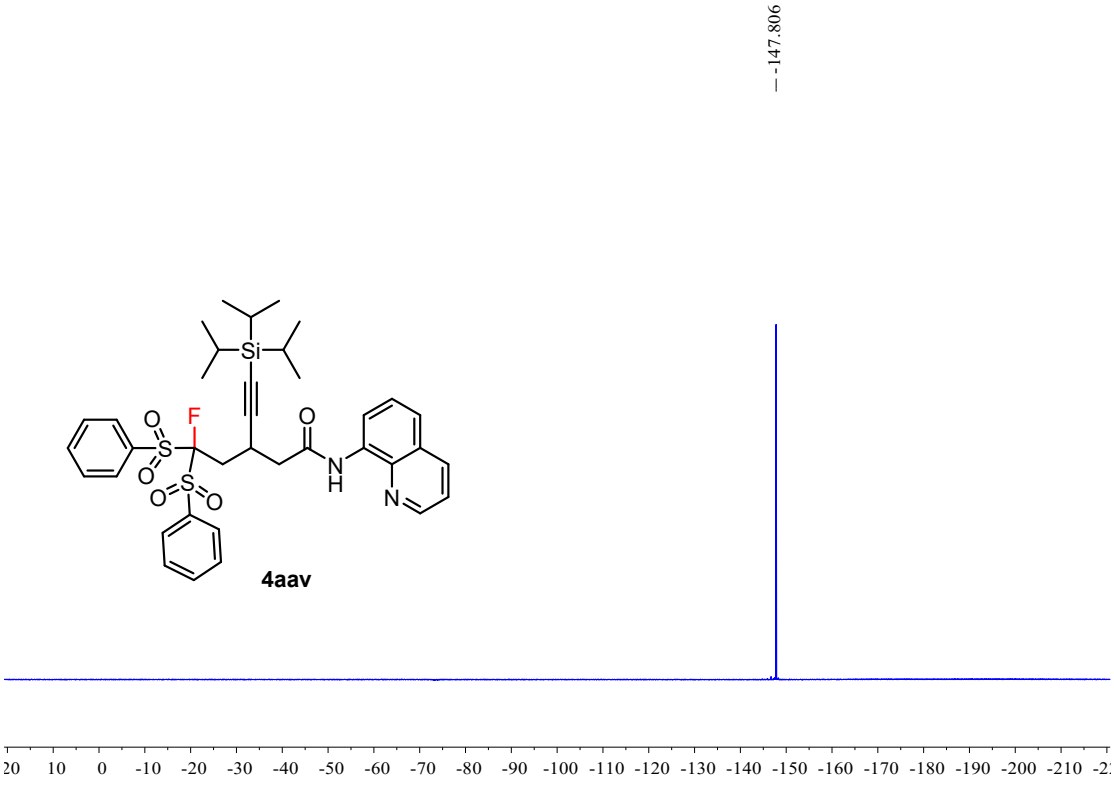
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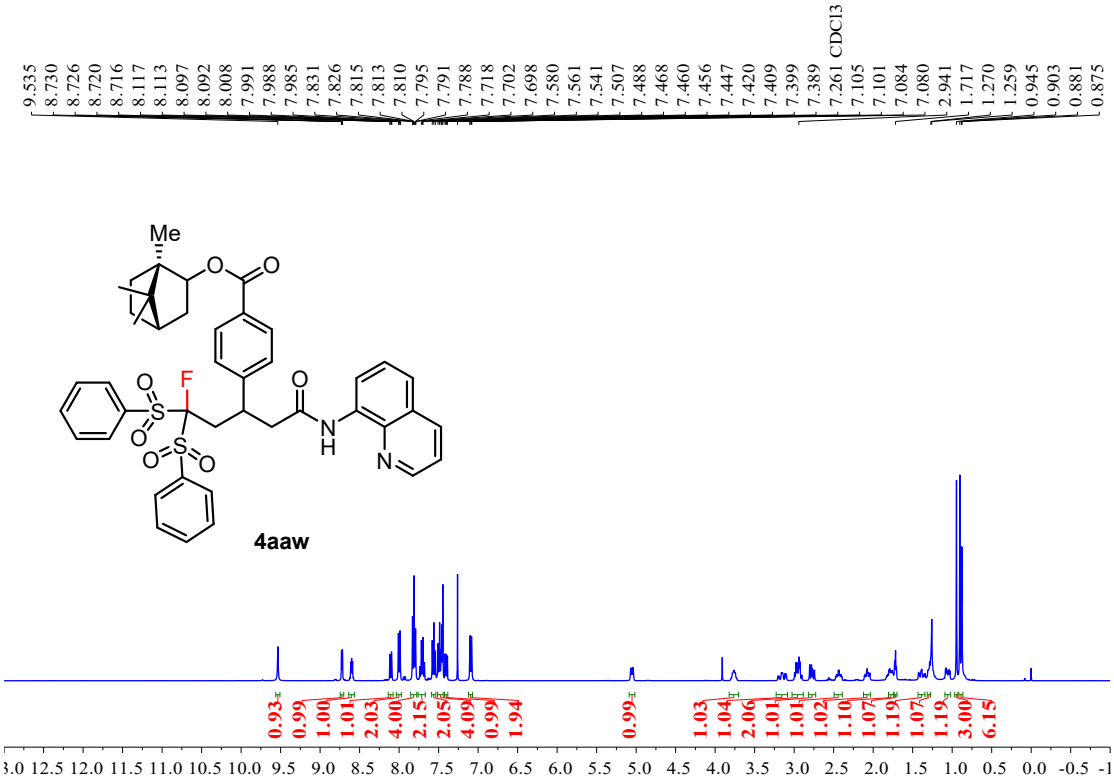
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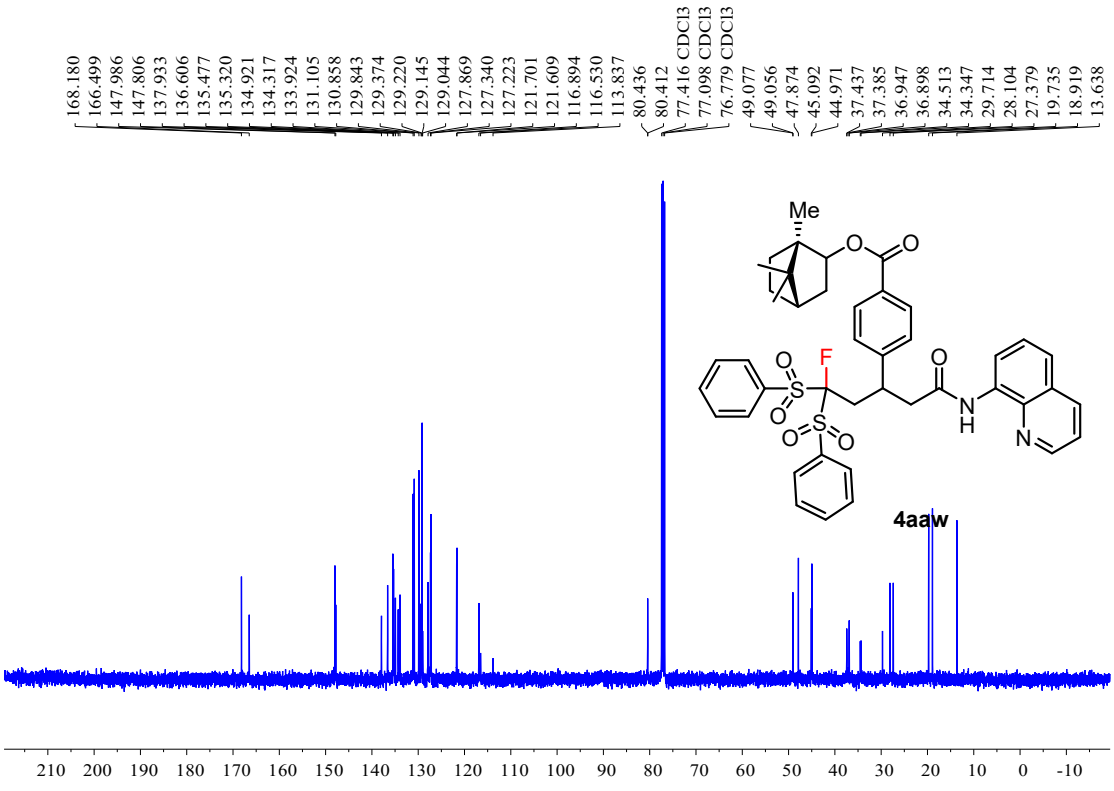
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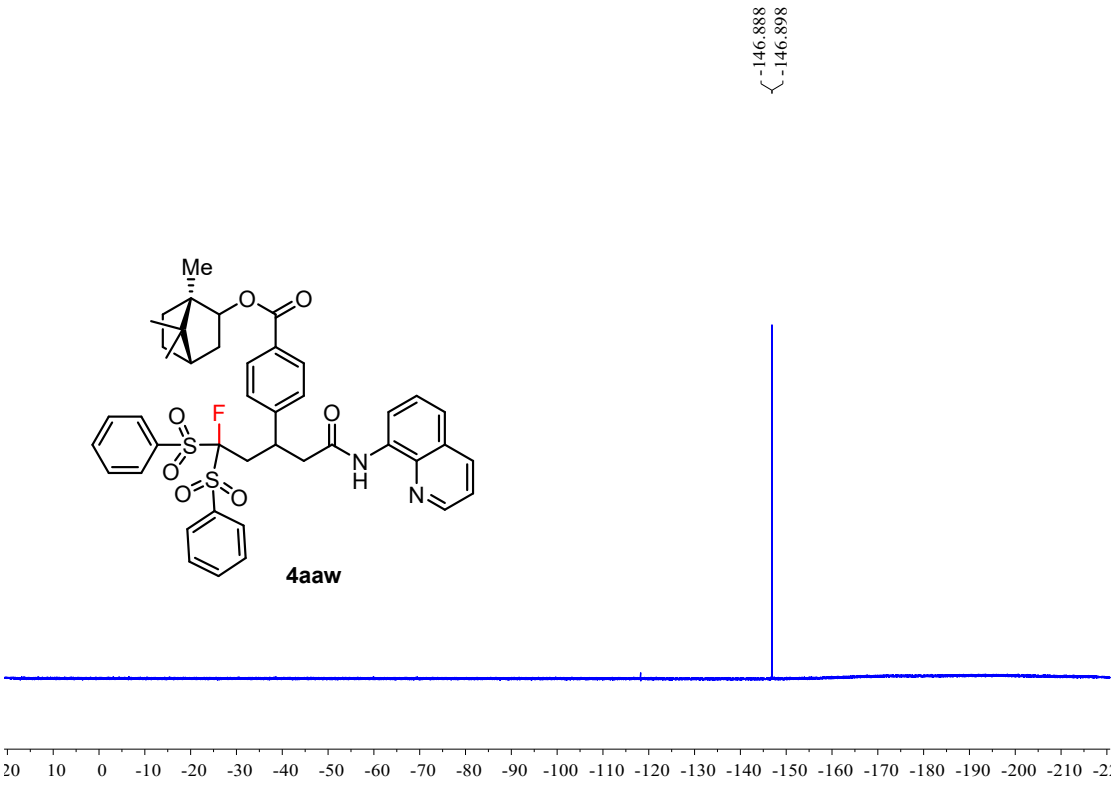
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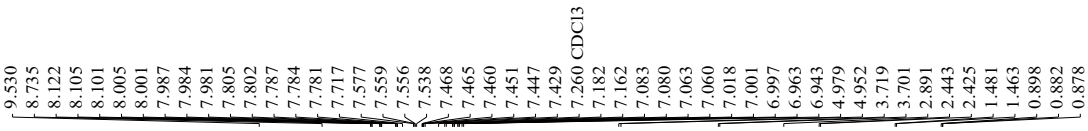
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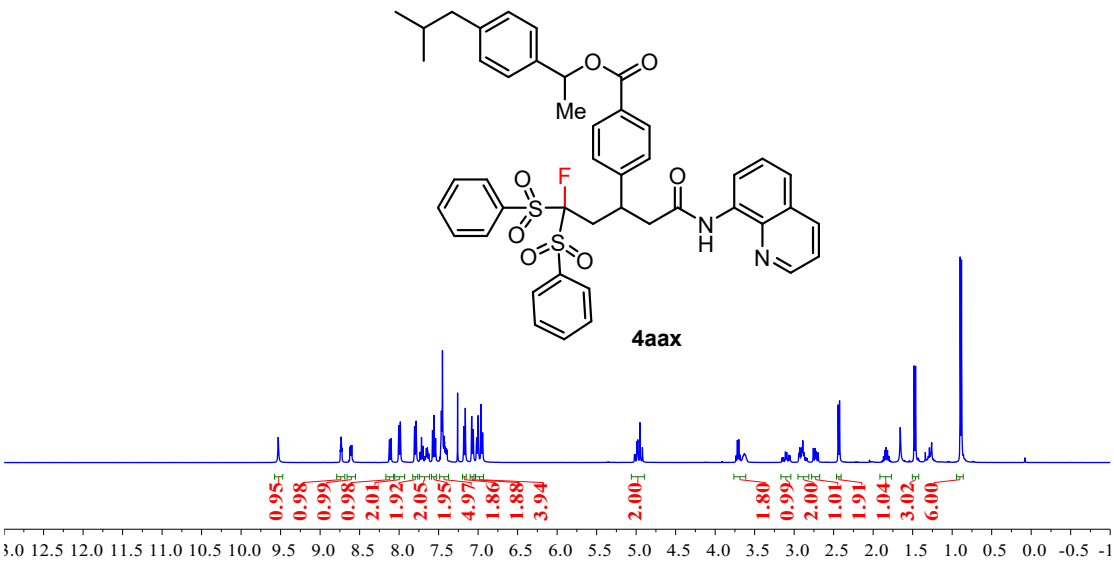
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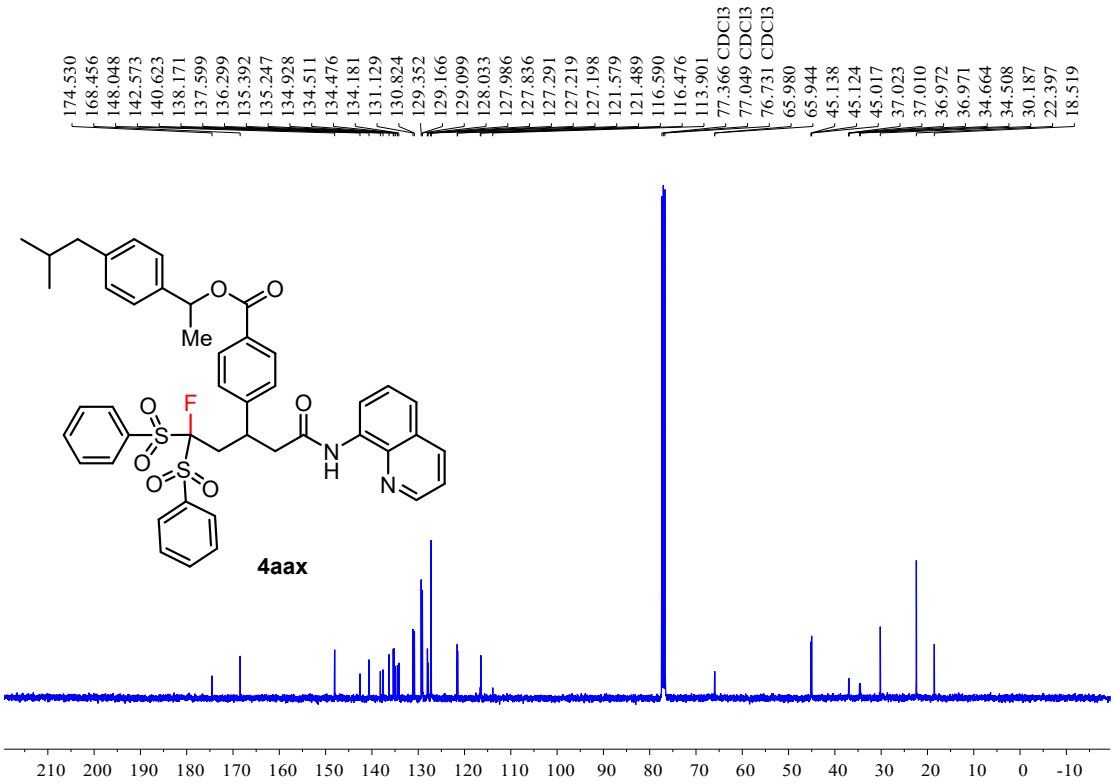
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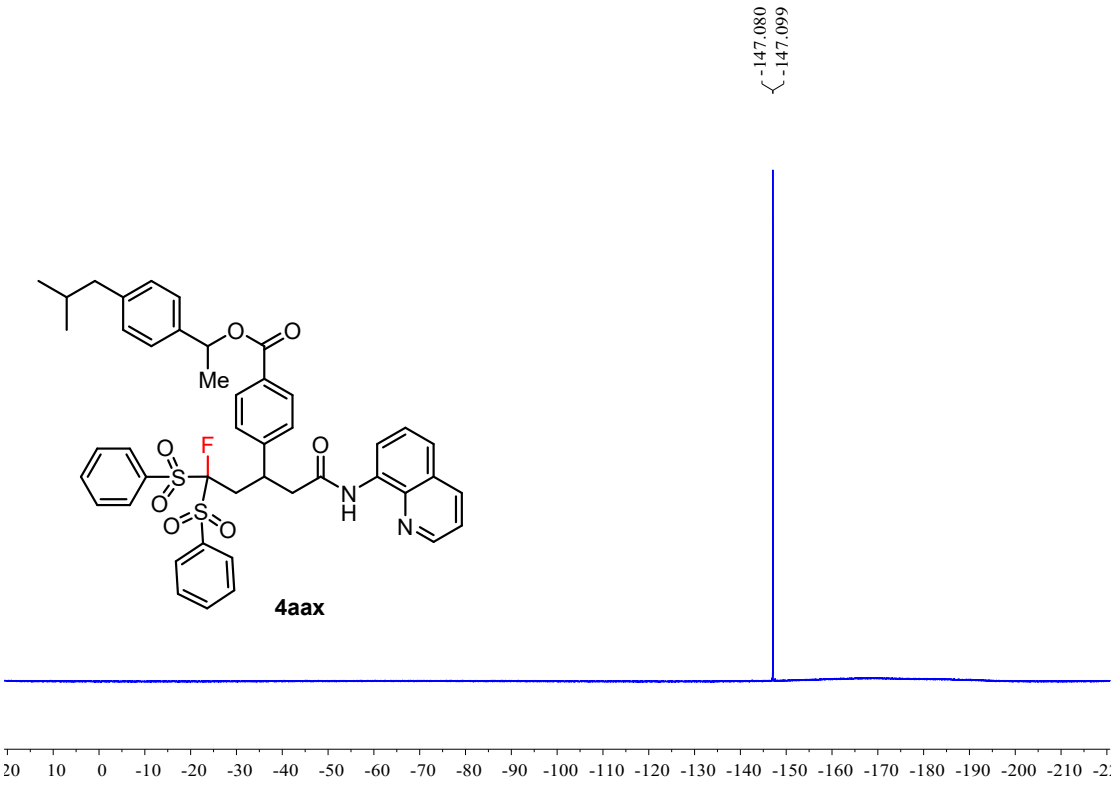
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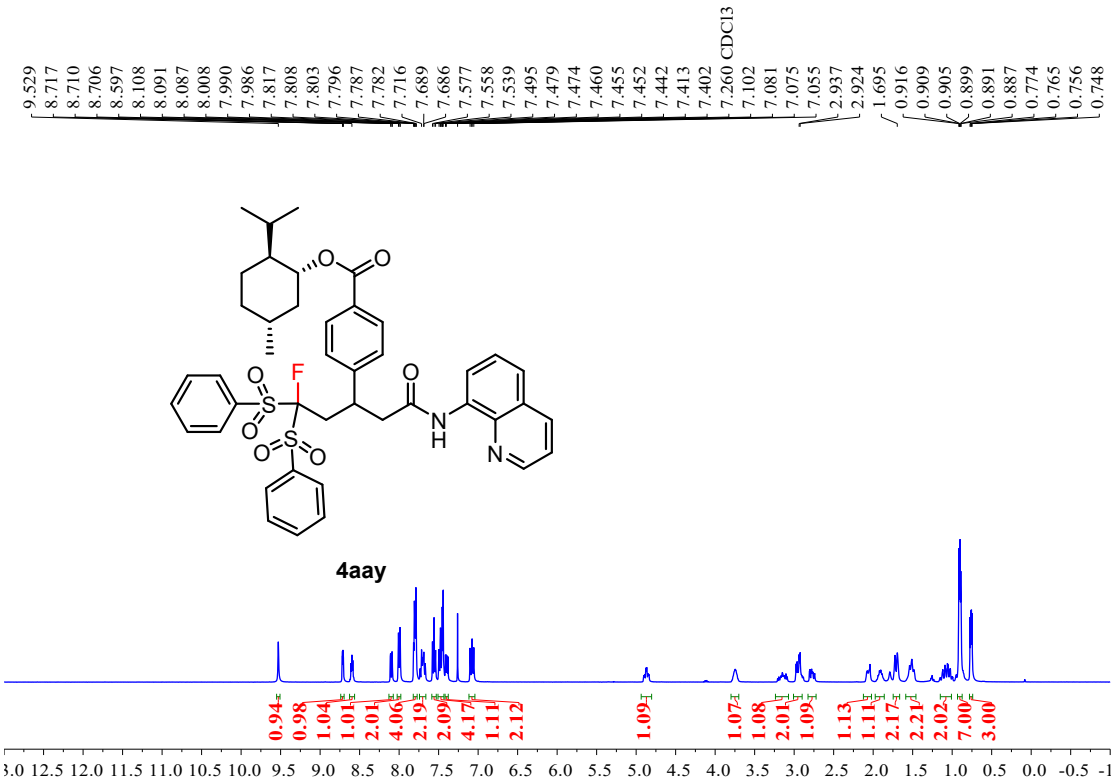
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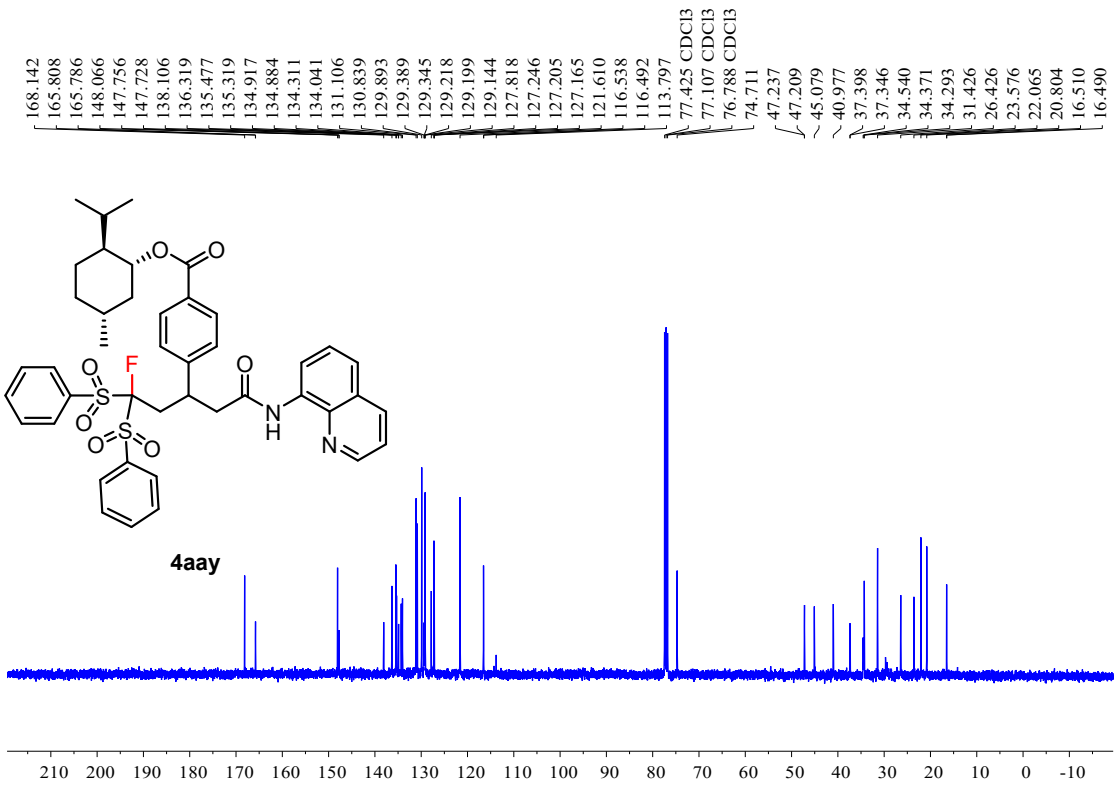
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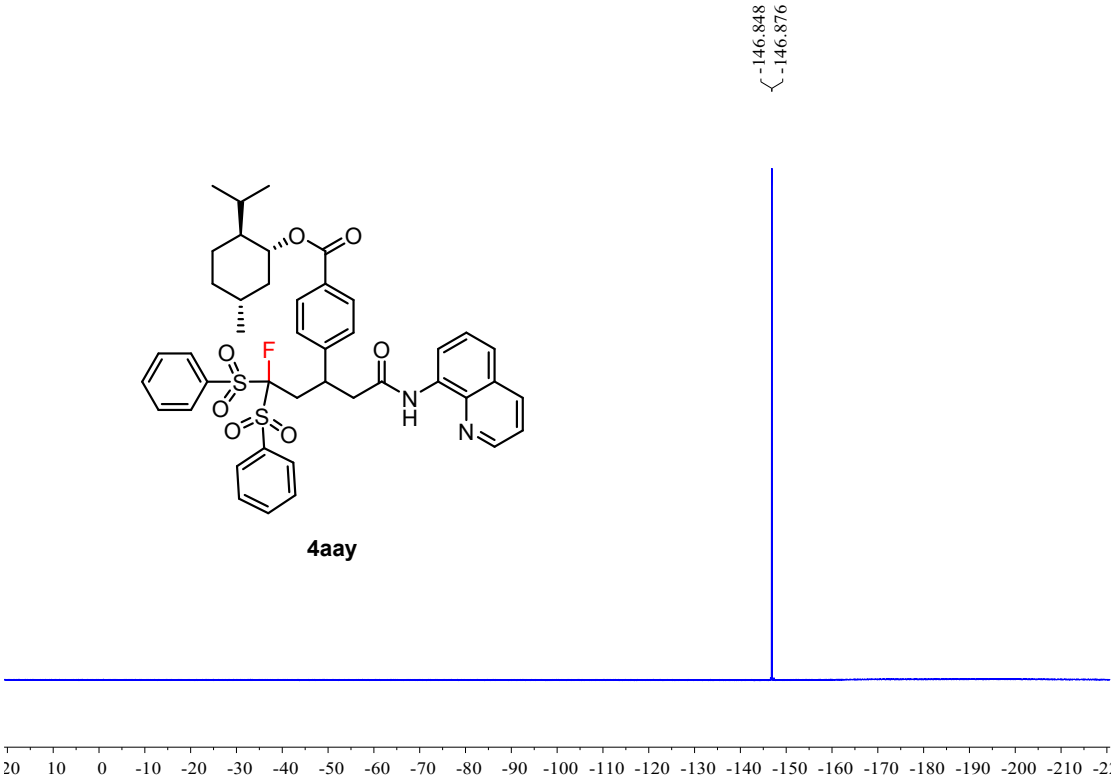
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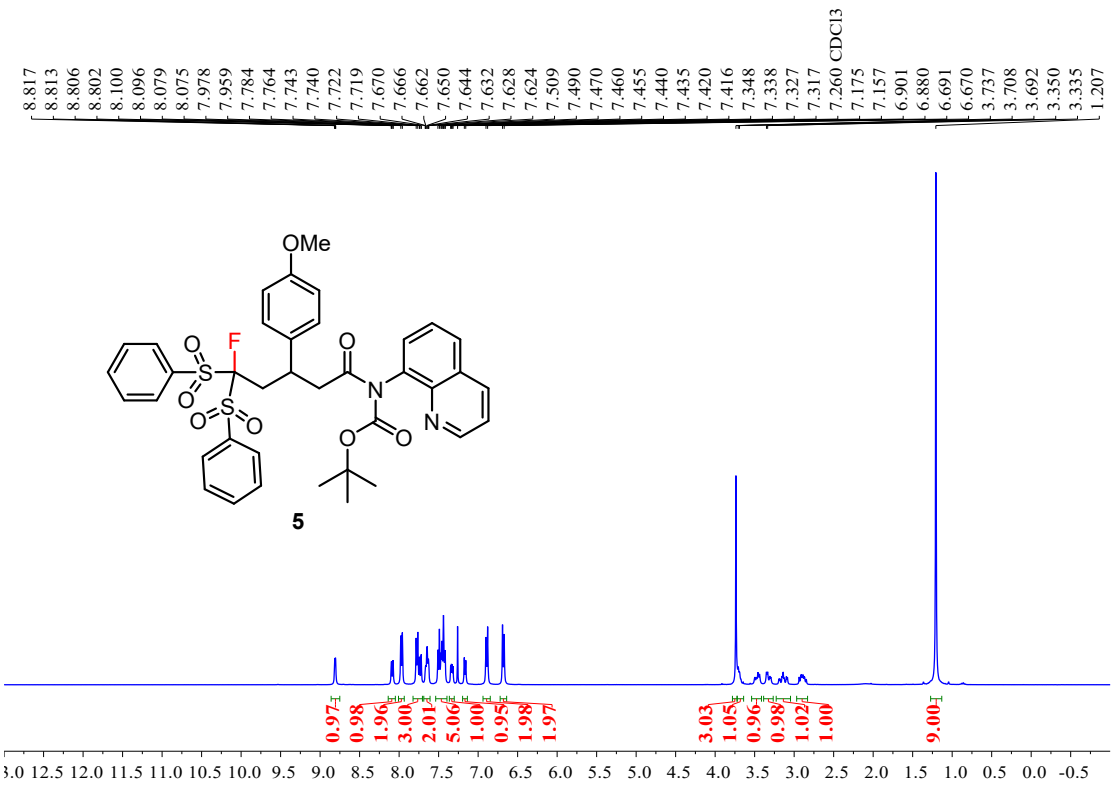
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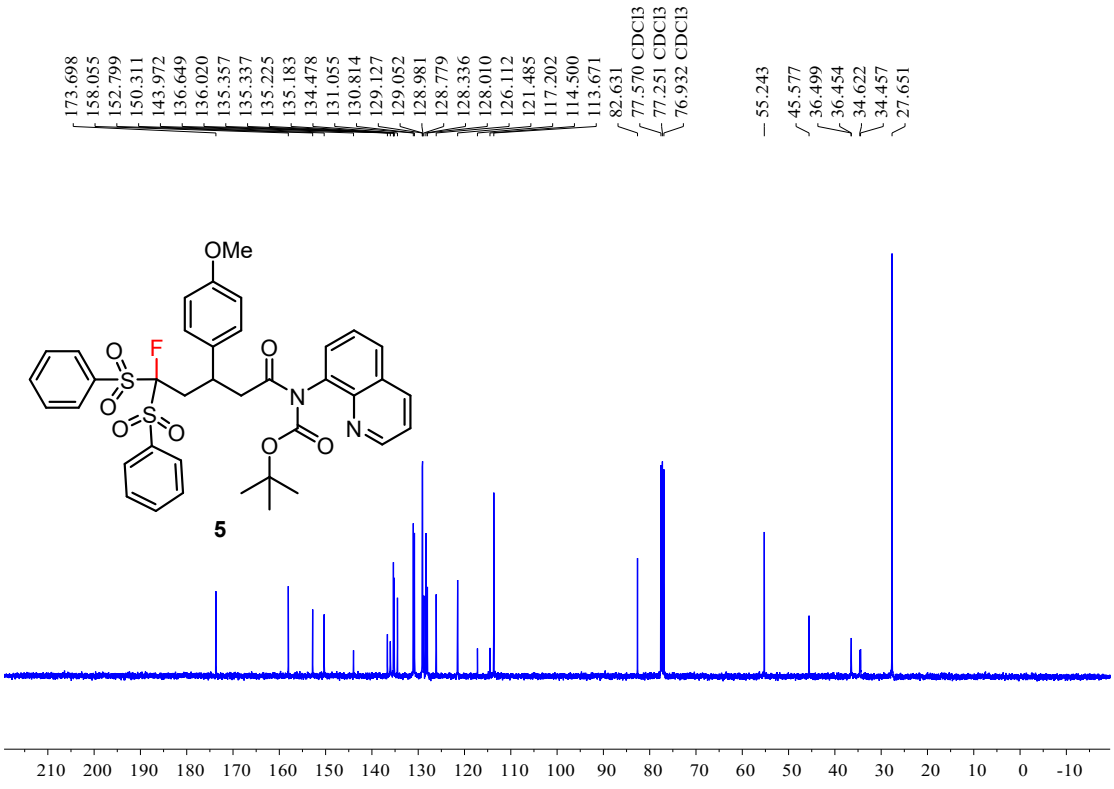
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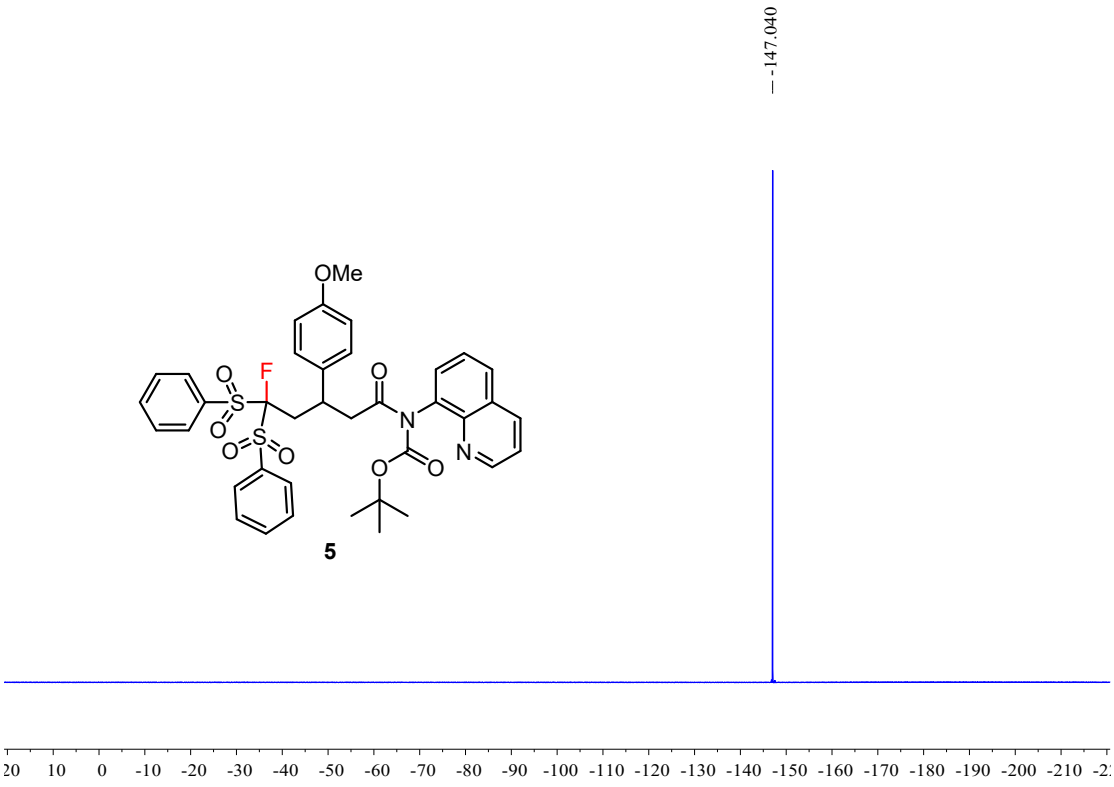
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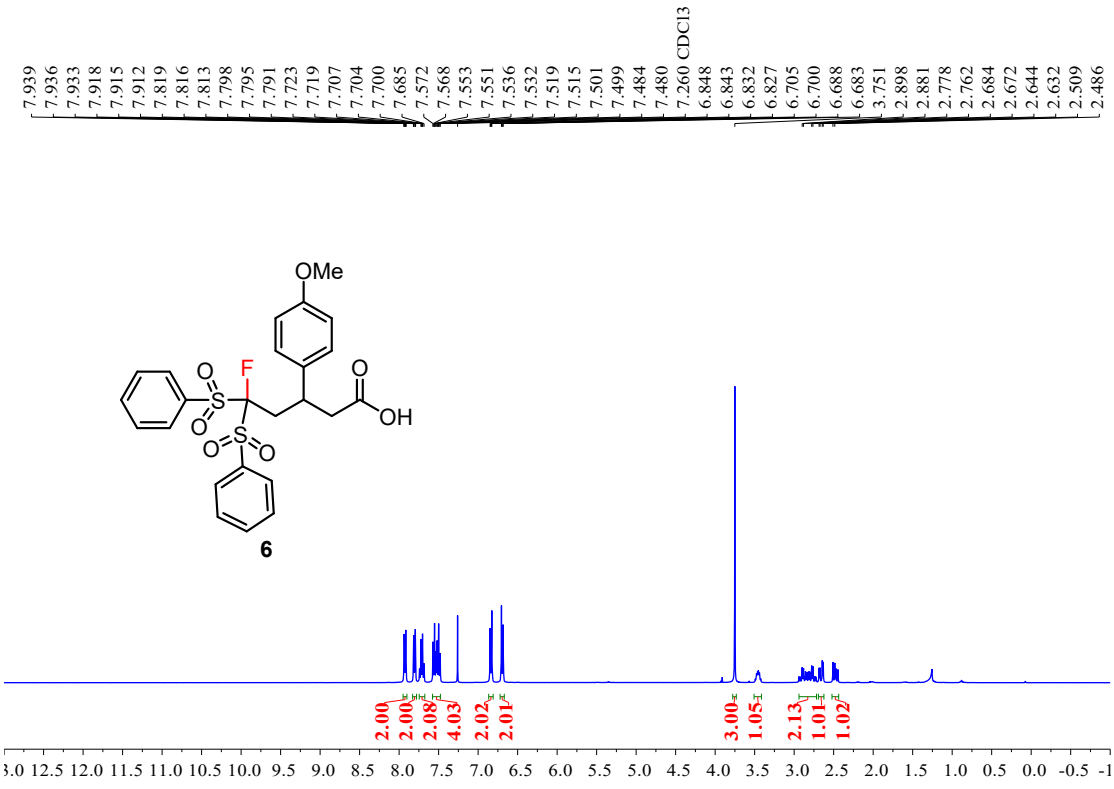
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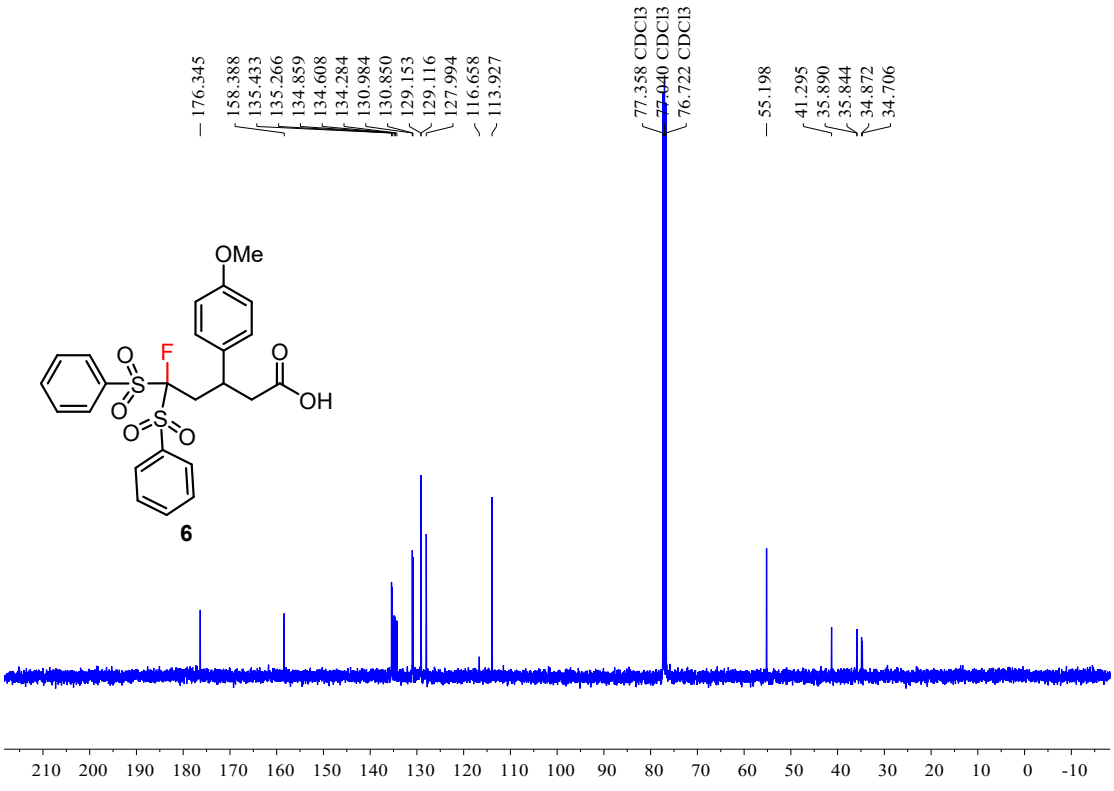
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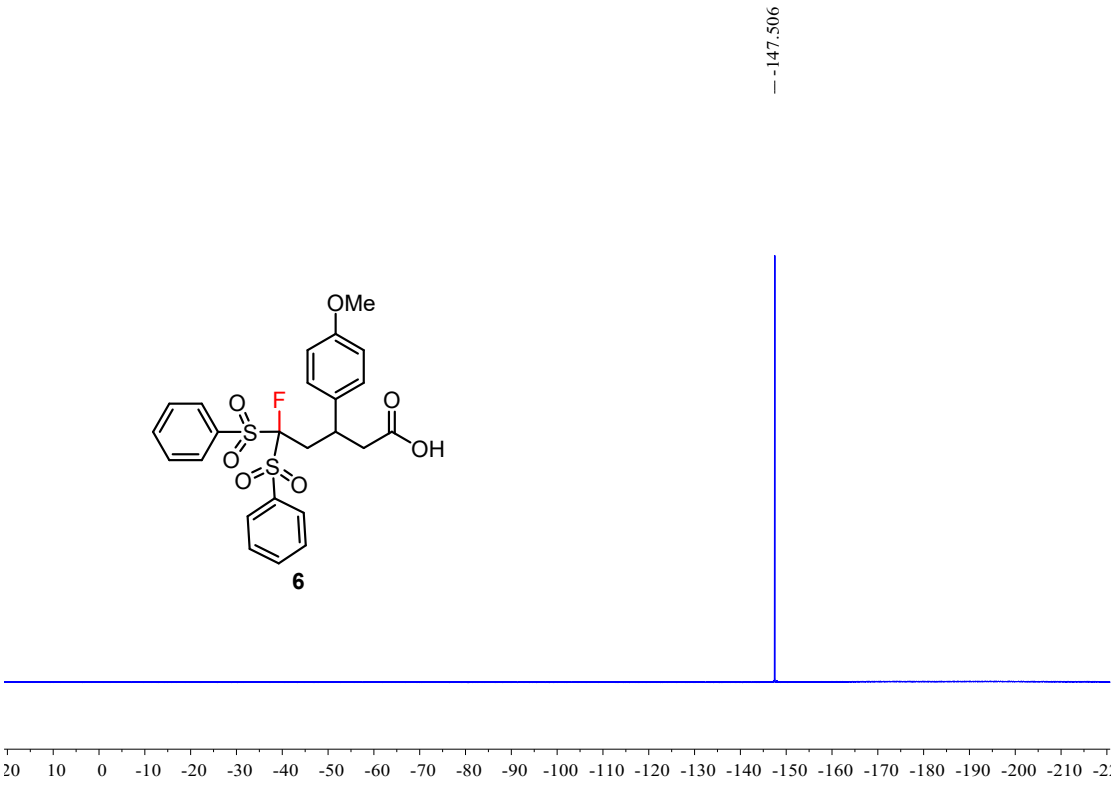
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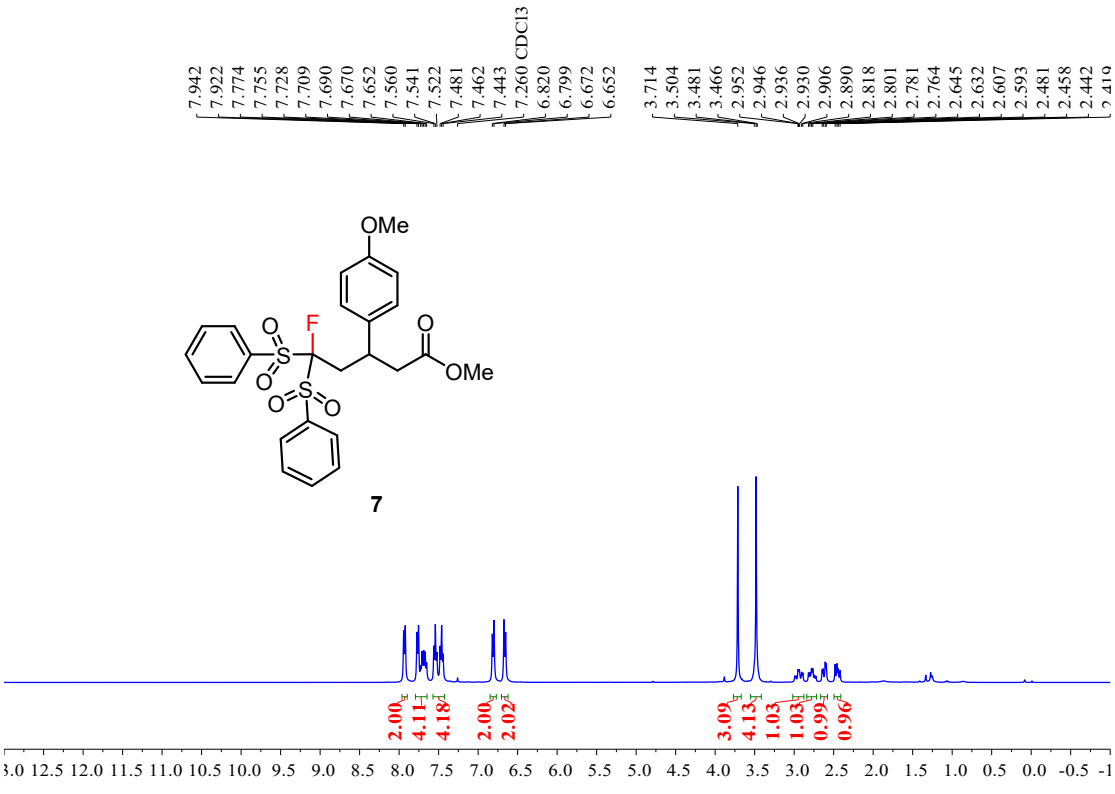
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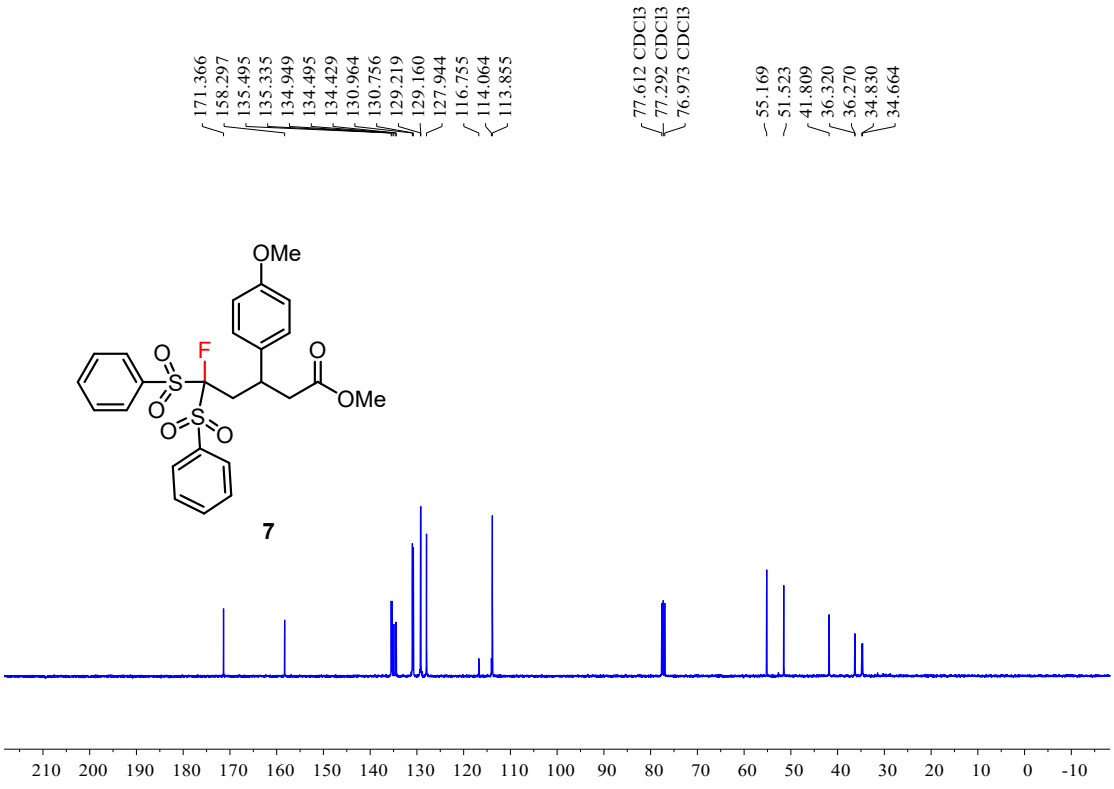
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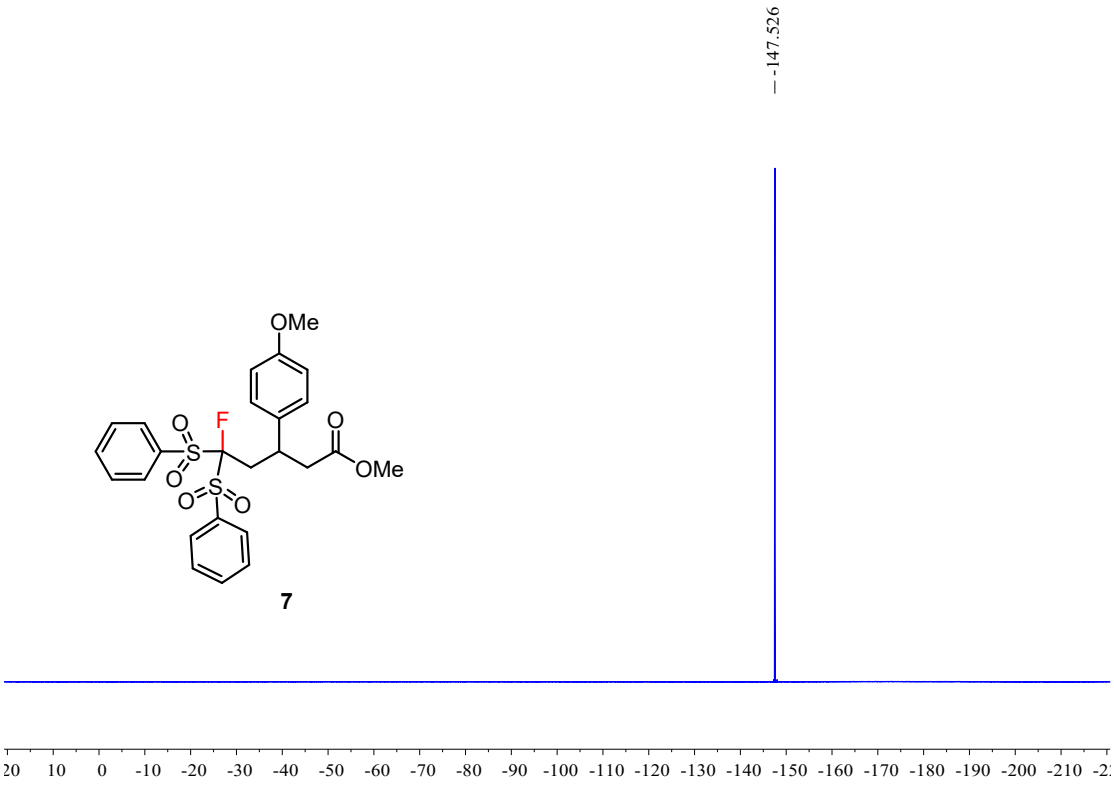
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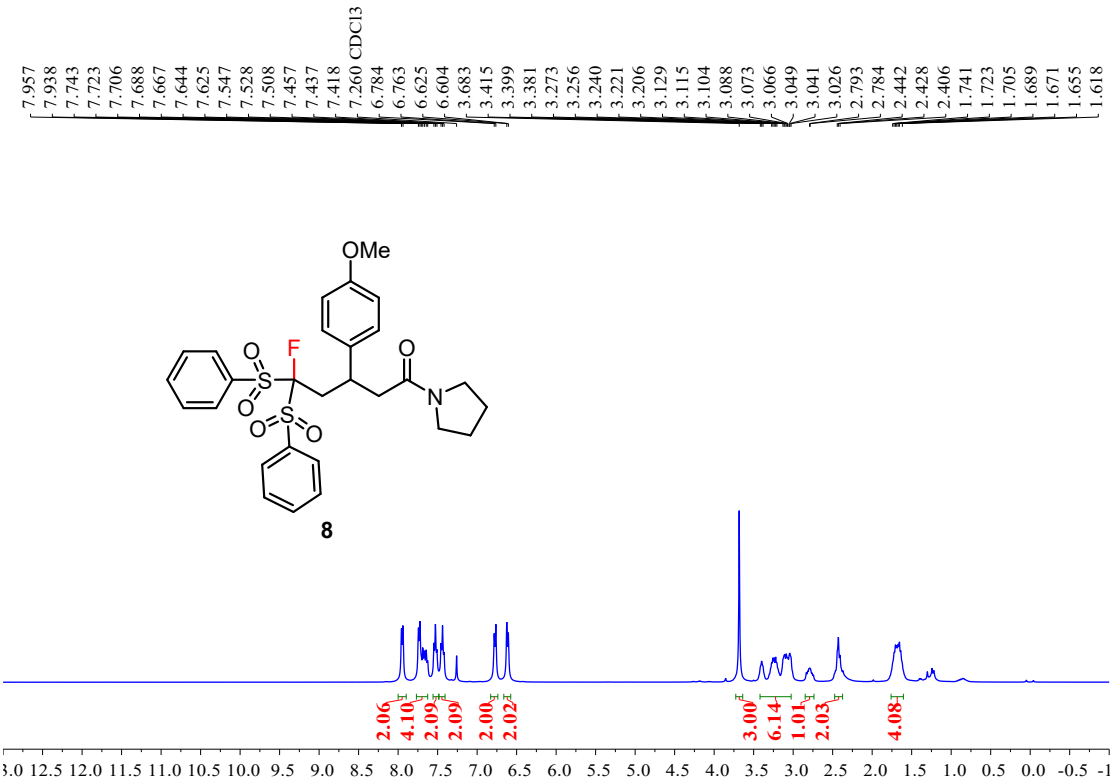
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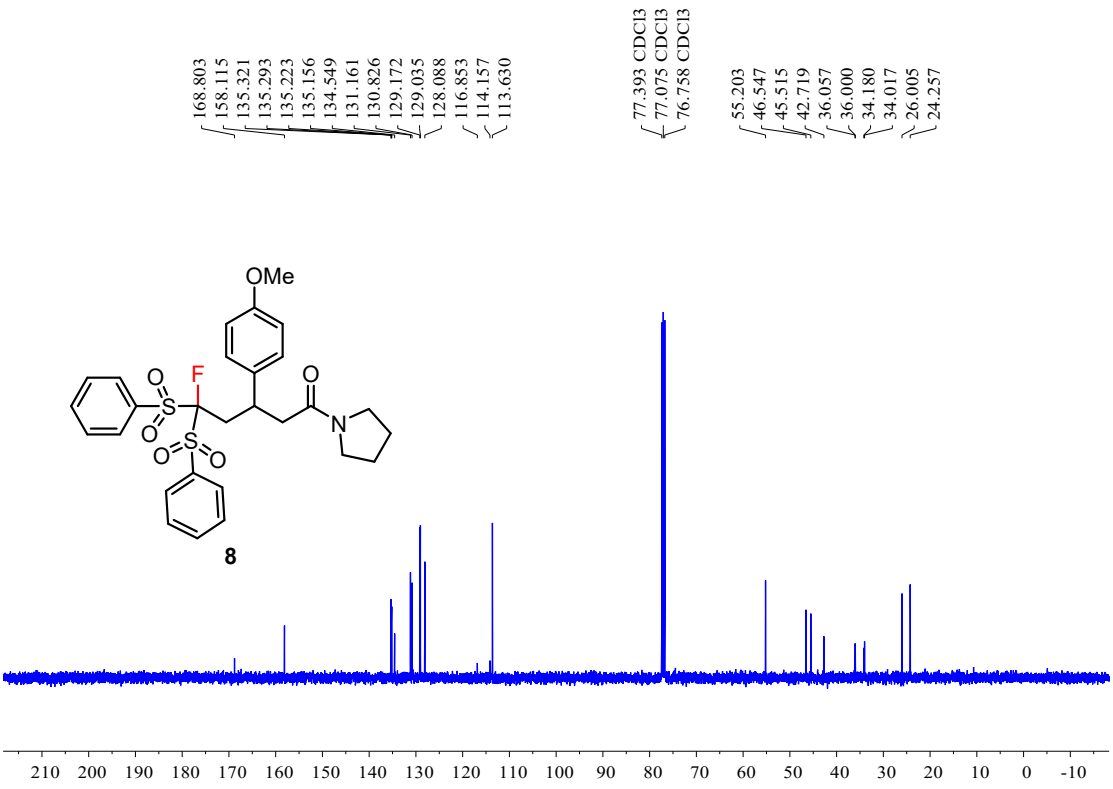
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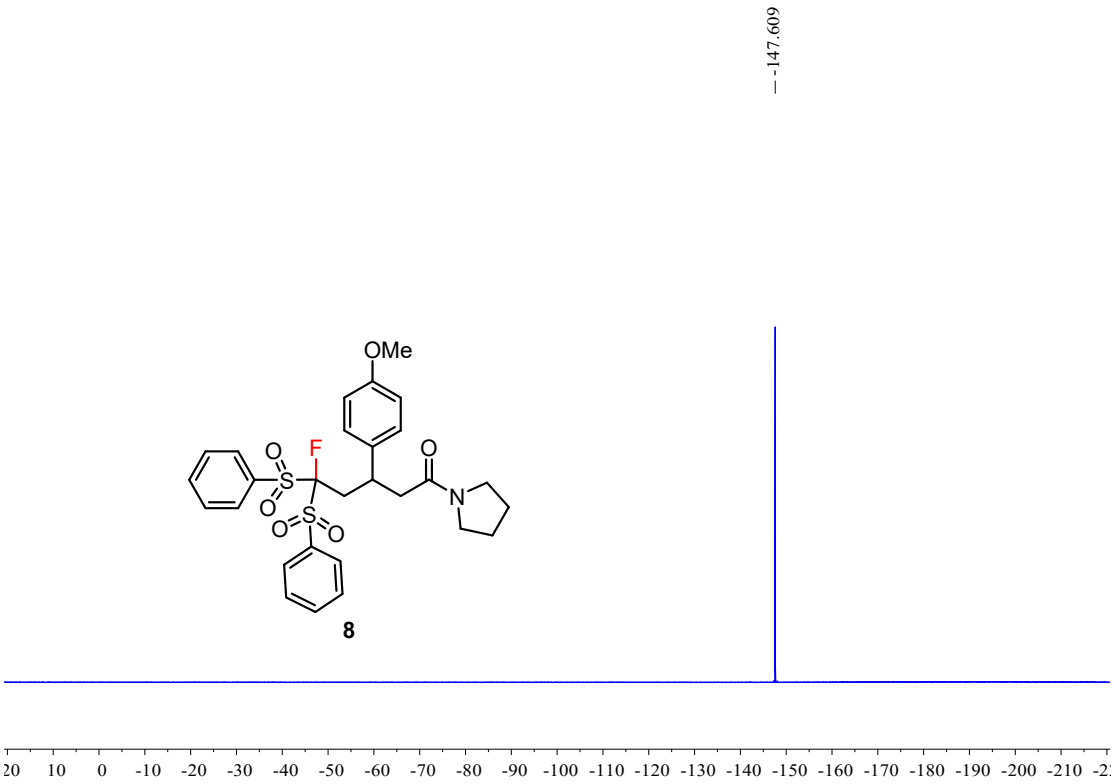
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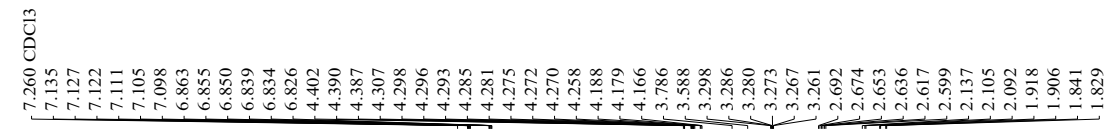
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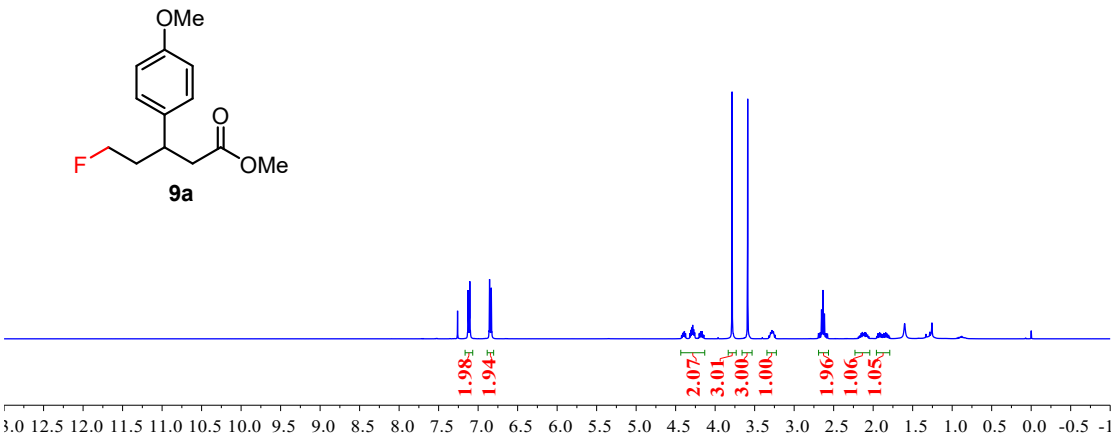
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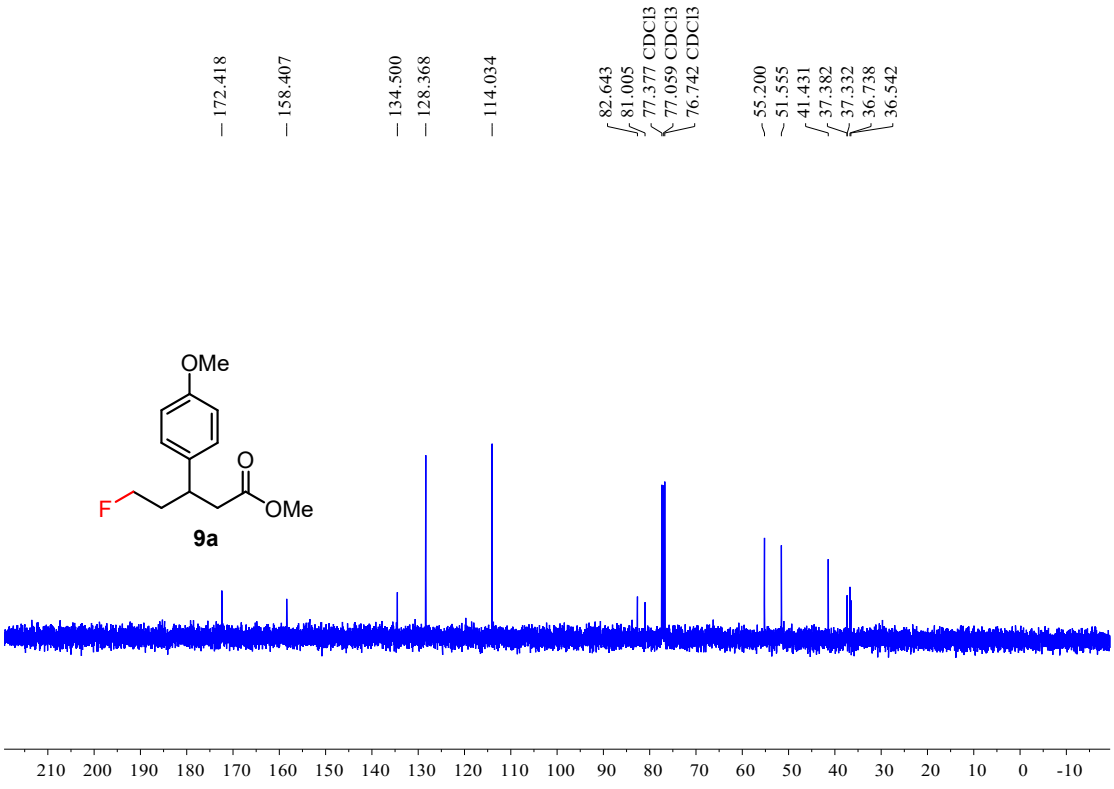
1.05
3.0 12.5 12.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5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37.382
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36.542
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O
F
OMe
9a
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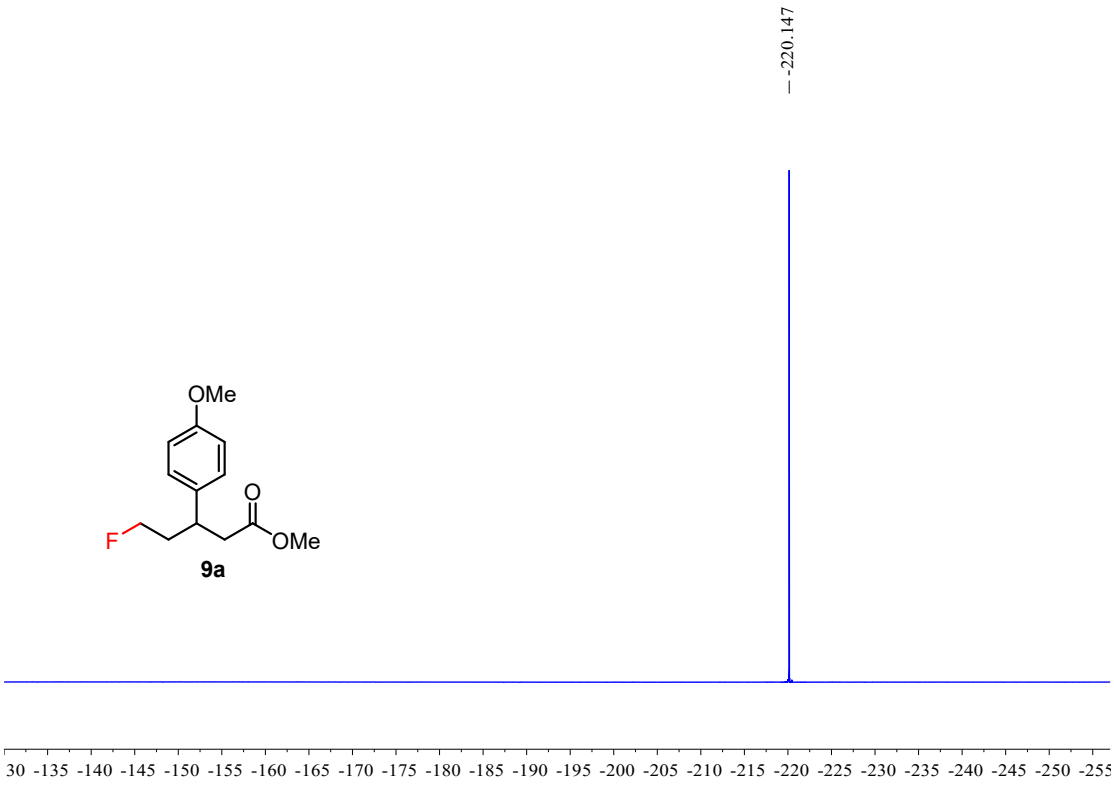
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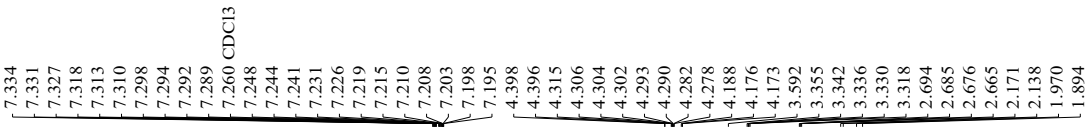
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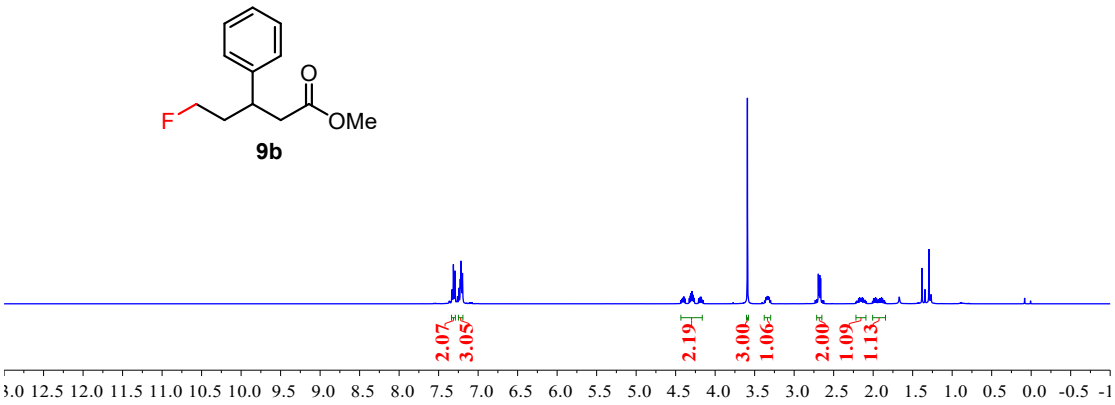
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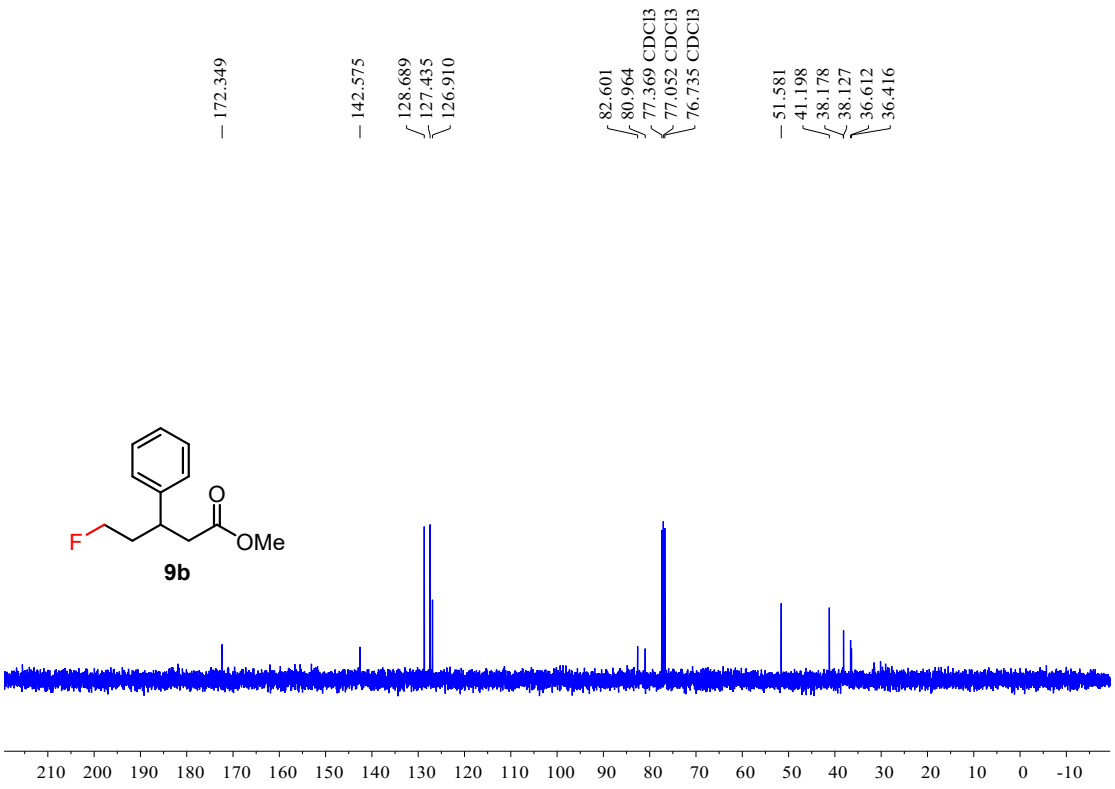
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O
OMe
9b
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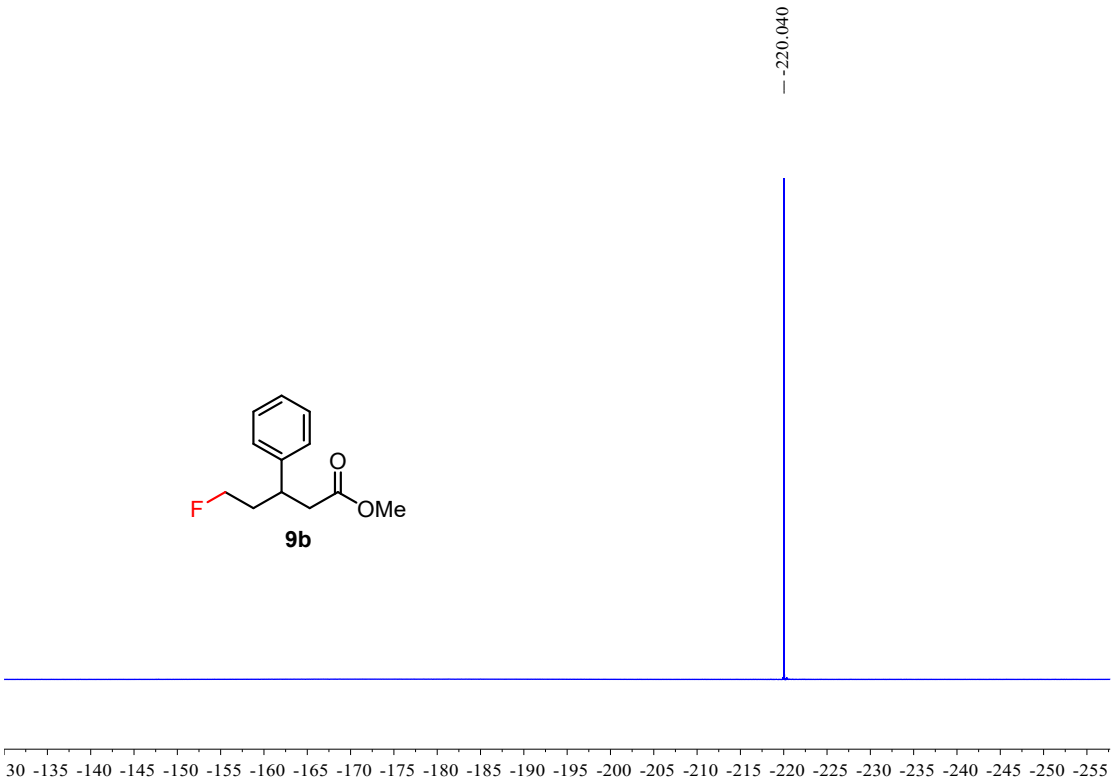
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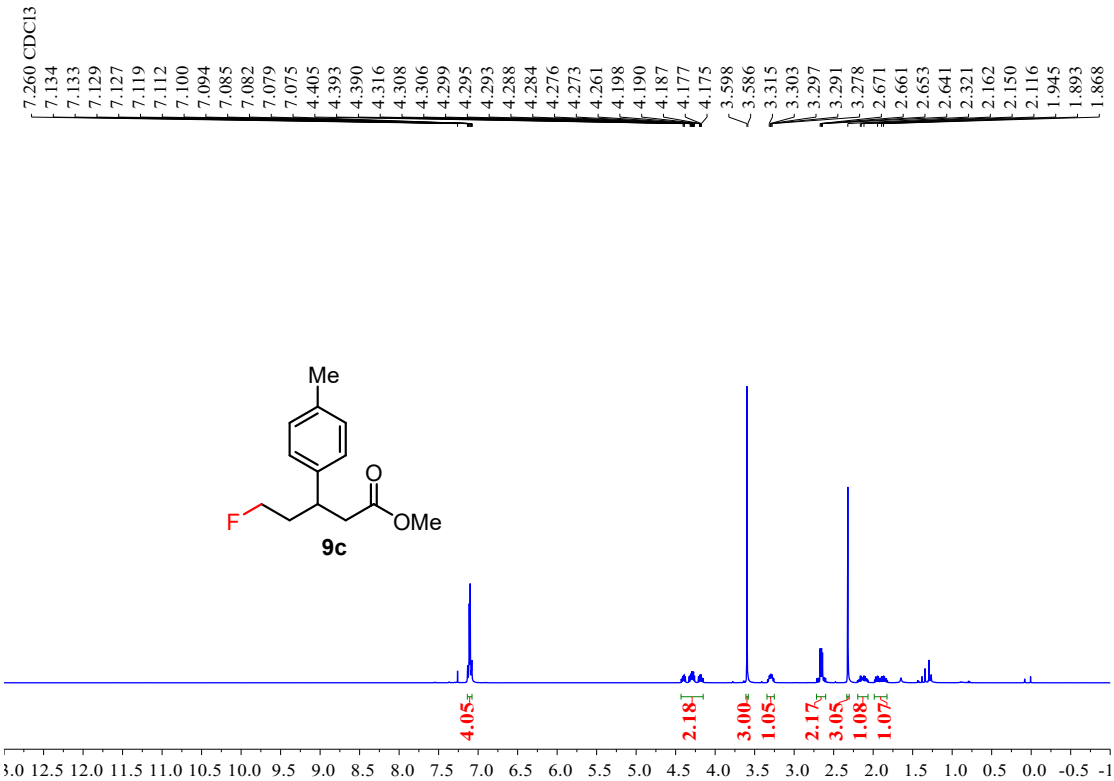
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7.075
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4.308
4.306
4.299
4.295
4.293
4.288
4.284
4.276
4.273
4.261
4.198
4.190
4.187
4.177
4.175
3.598
3.586
3.315
3.303
3.297
3.291
3.278
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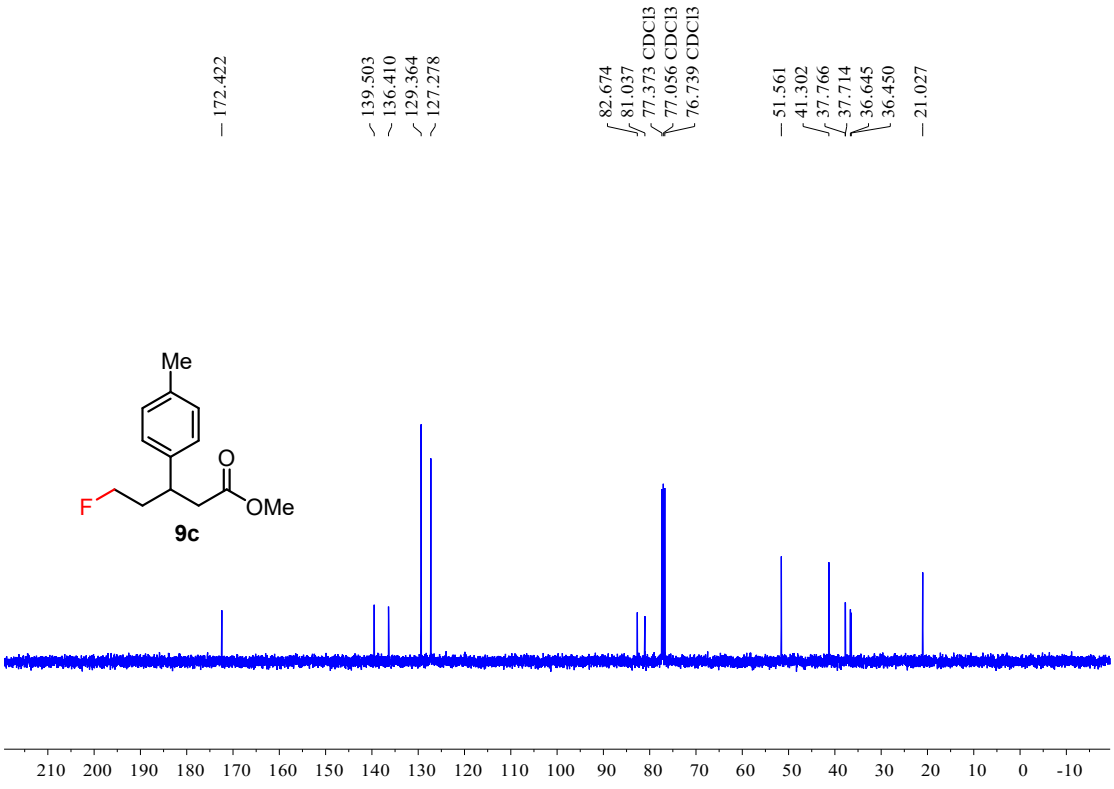
2.661
2.653
2.641
2.321
2.162
2.150
2.116
1.945
1.893
1.868
Me
F
O
OMe
9c
4.05
2.18
3.00
1.05
2.17
3.05
1.08
1.07
3.0 12.5 12.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1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37.766
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Me
O
F
OMe
9c
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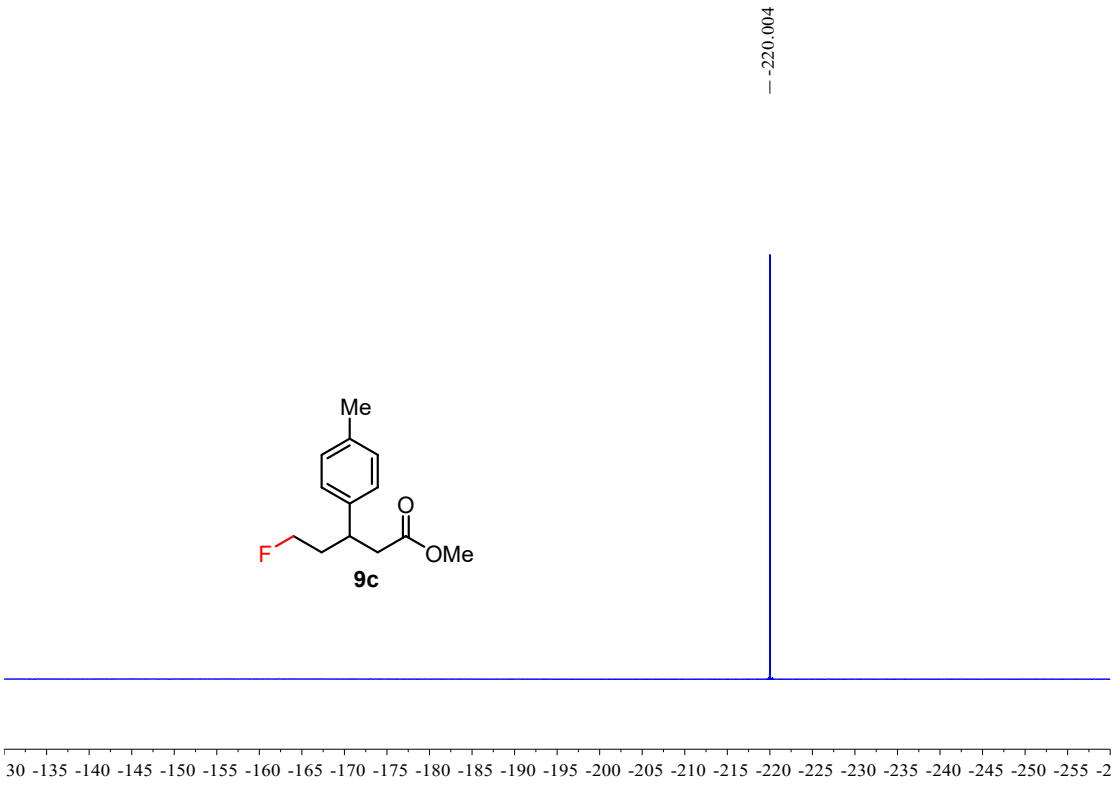
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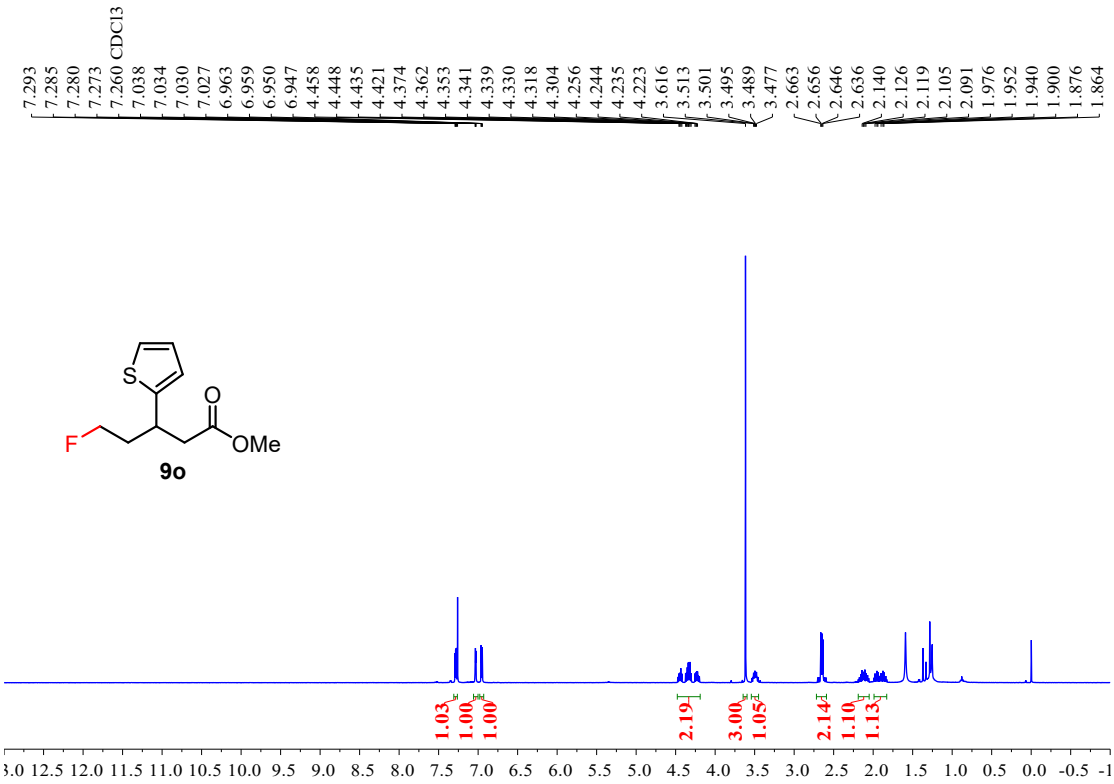
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2.119
2.105
2.091
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1.952
1.940
1.900
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O
F
OMe
9o
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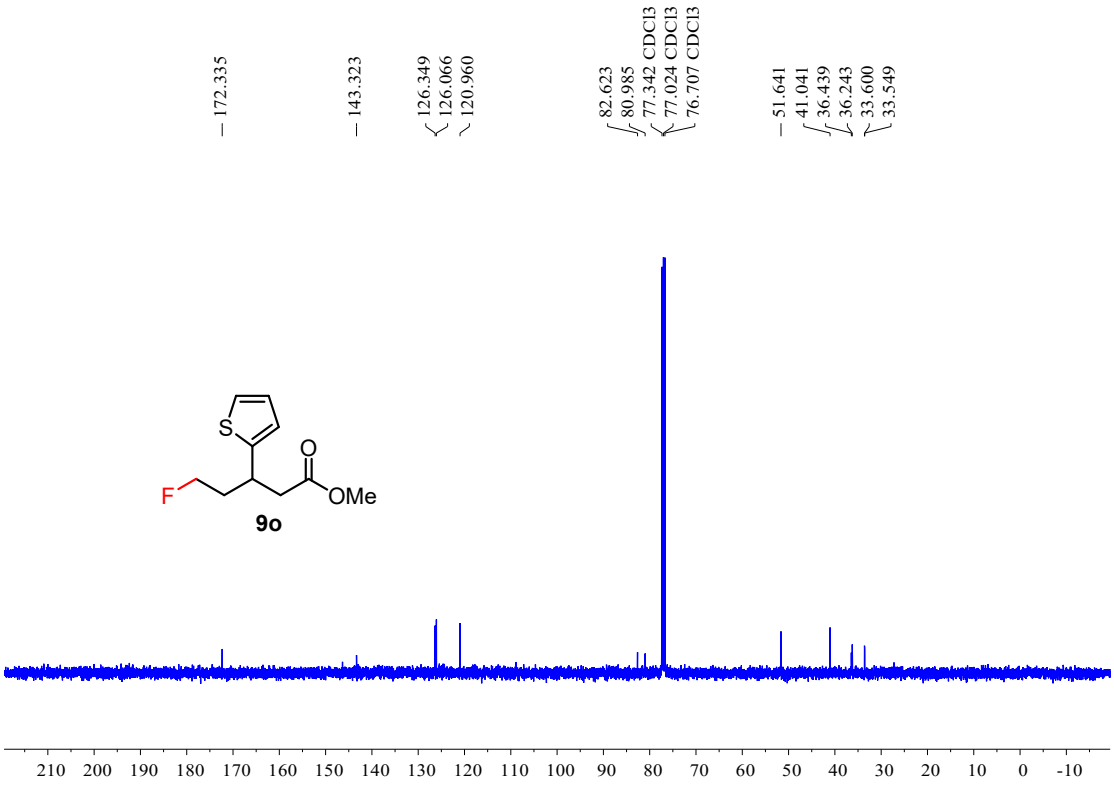
1.00
1.00
2.19
3.00
1.05
2.14
1.10
1.13
3.0 12.5 12.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1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41.041
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33.549
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O
F
OMe
9o
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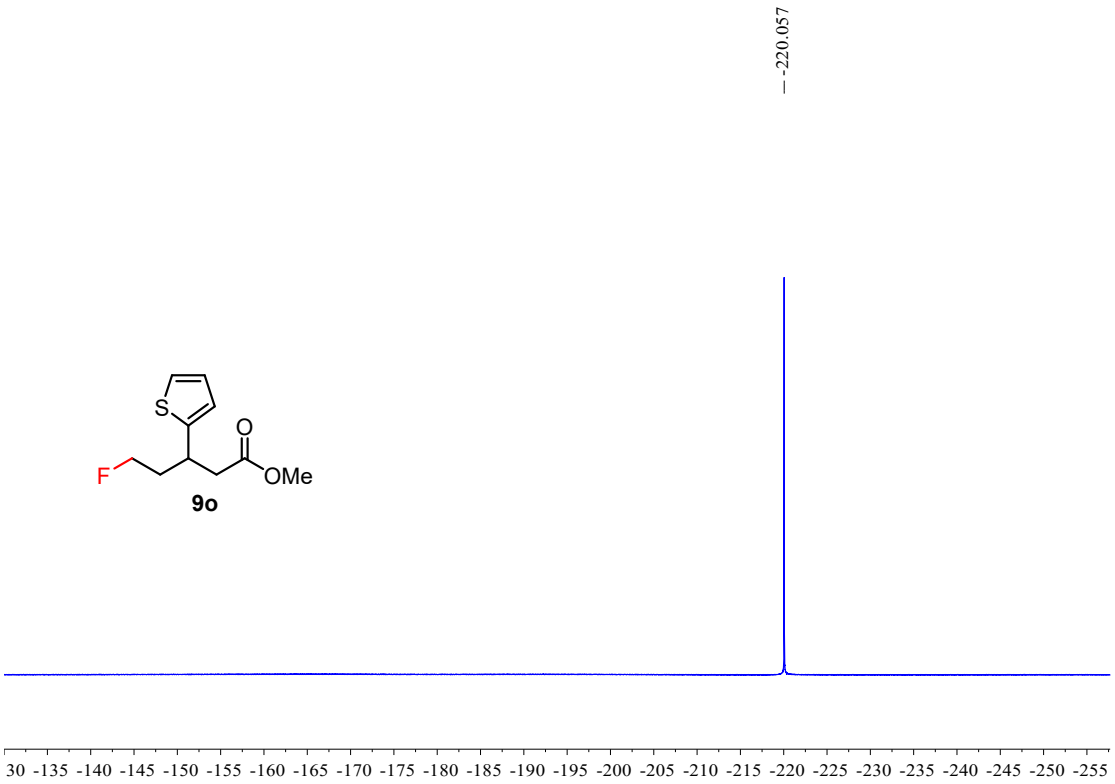
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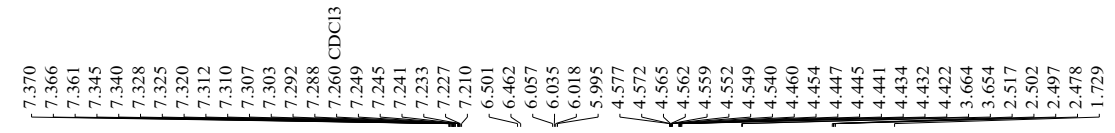
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7.288
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7.241
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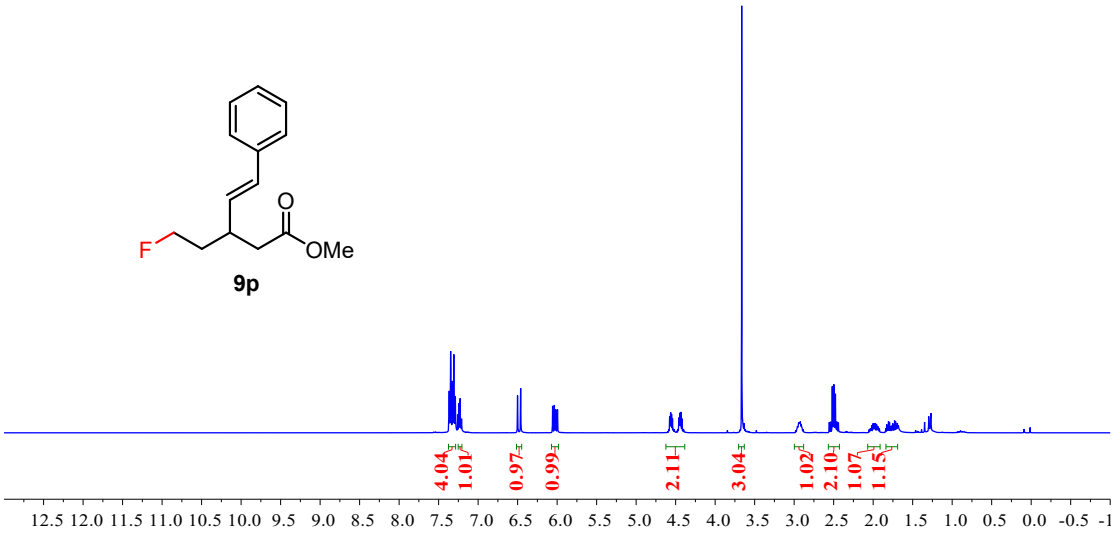
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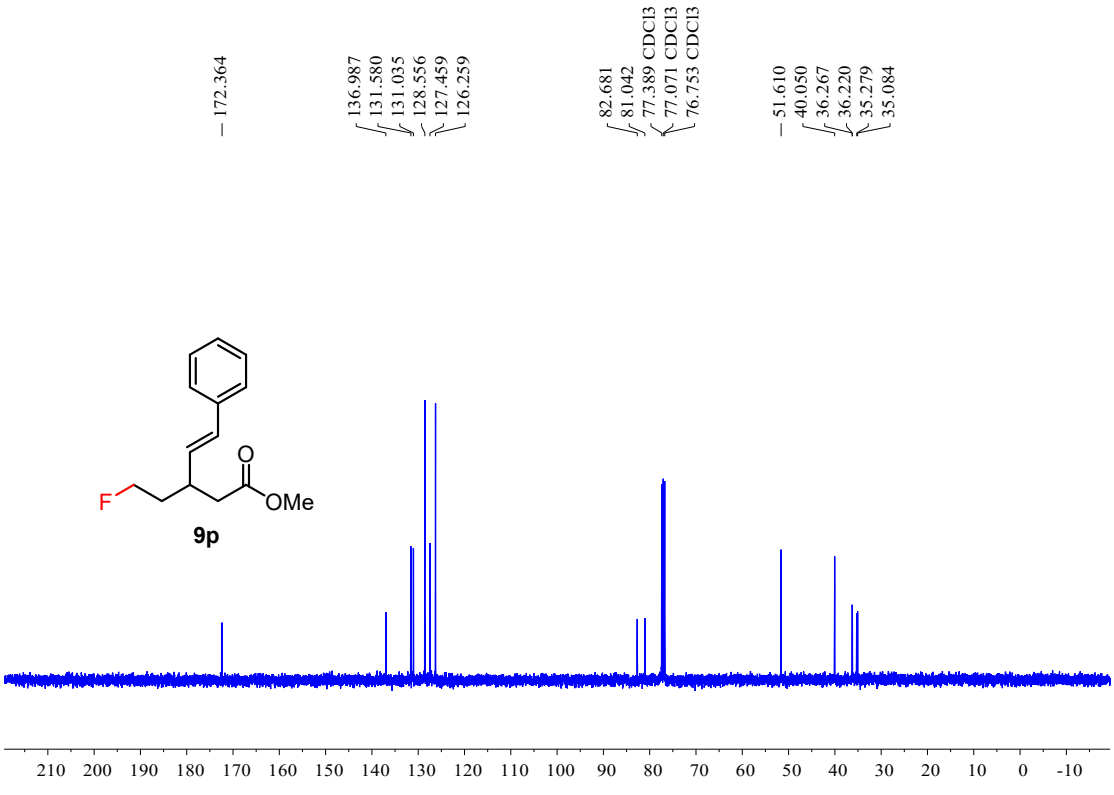
1.02
2.10
1.07
1.15
12.5 12.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1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O
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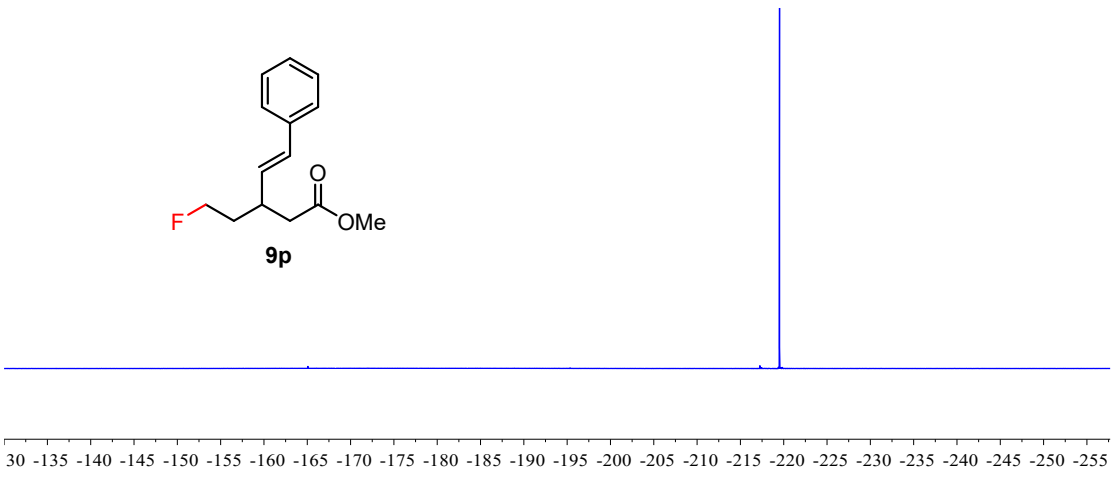
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OMe
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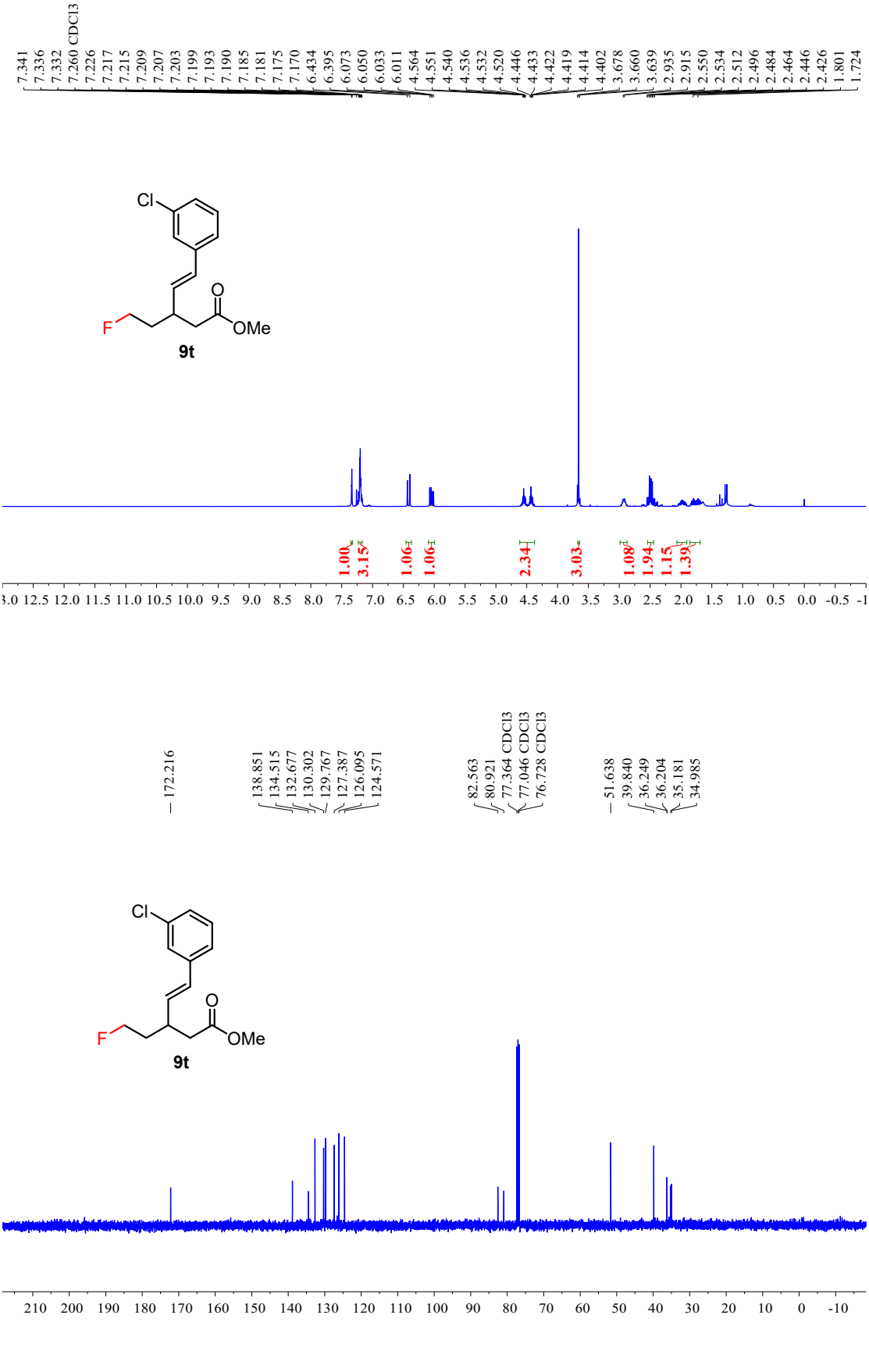
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Cl
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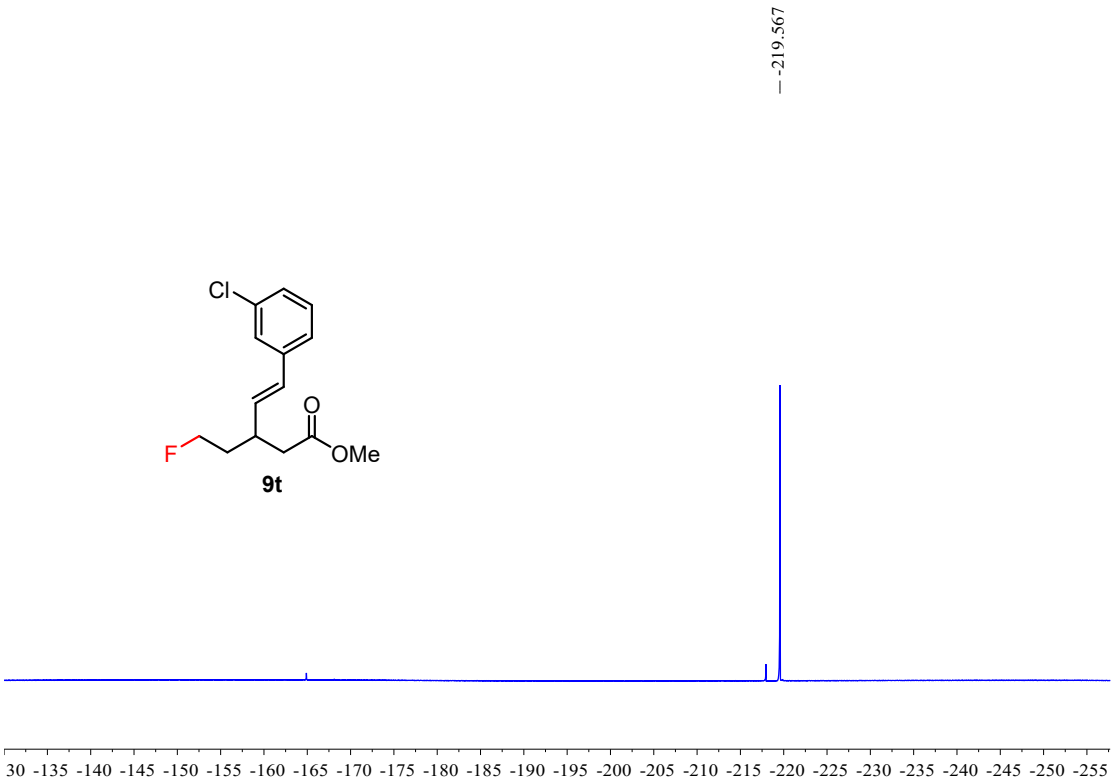
F
OMe
9t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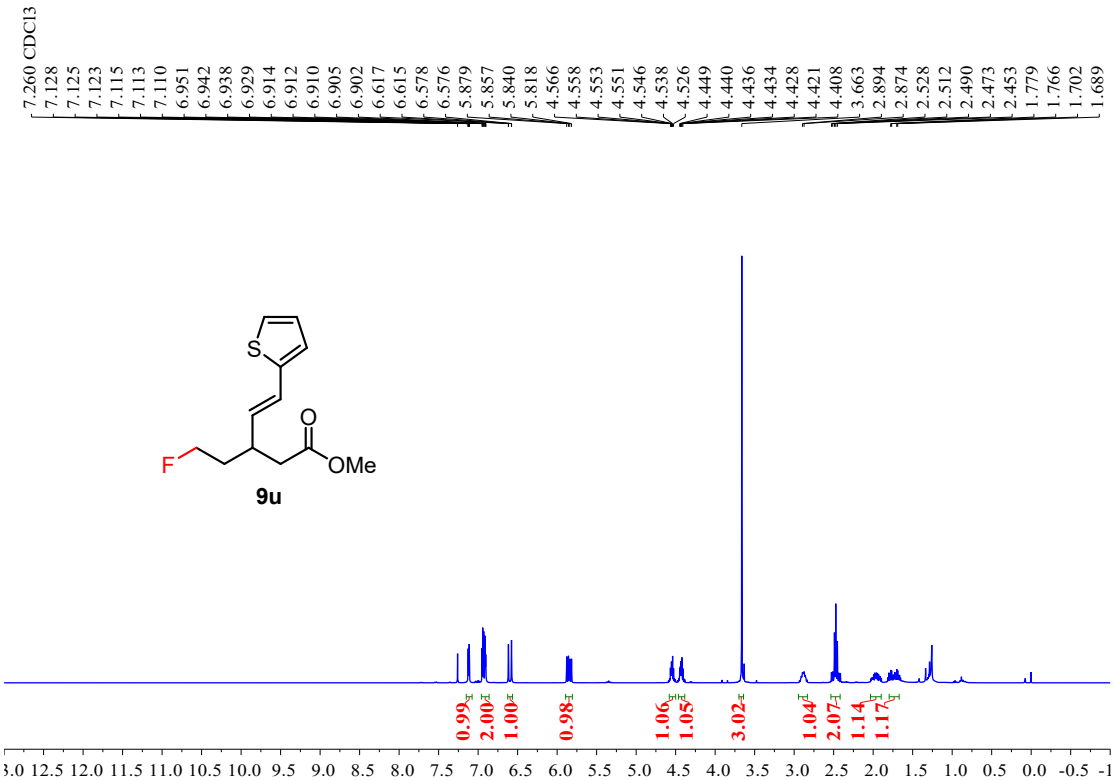
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S
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OMe
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1.00
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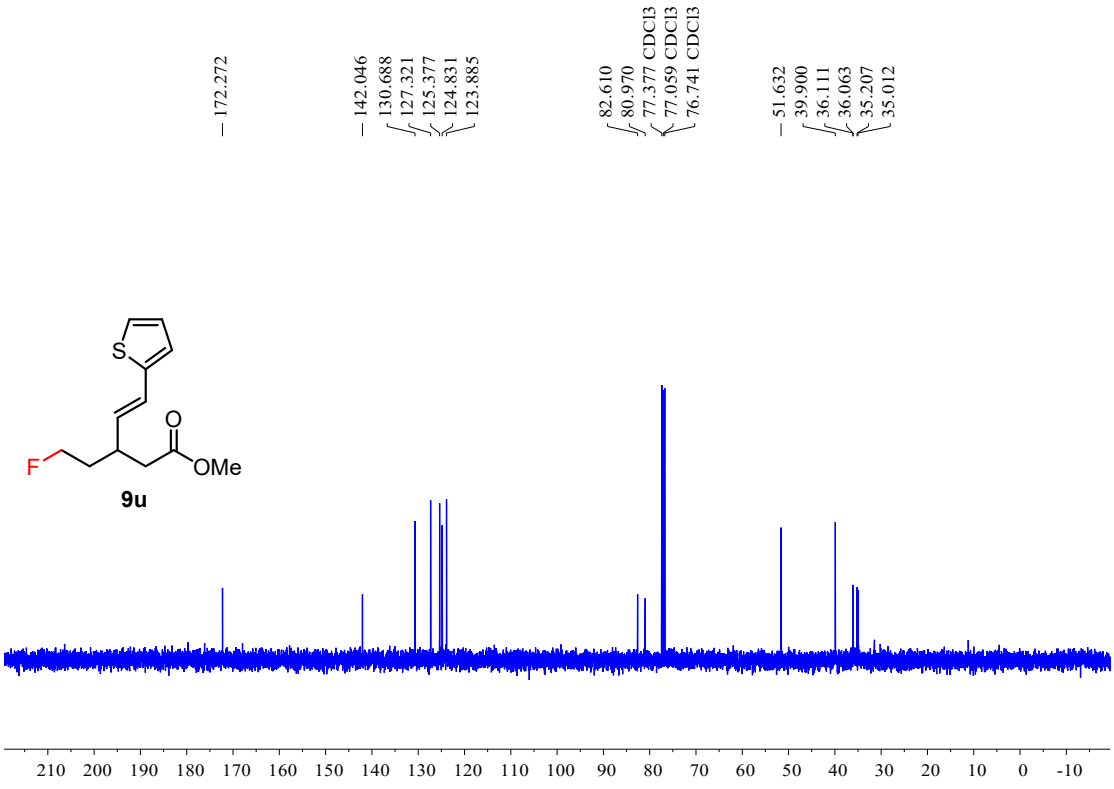
3.02
1.04
2.07
1.14
1.17
3.0 12.5 12.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1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76.741 CDCl3
51.632
39.900
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35.012
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F
OMe
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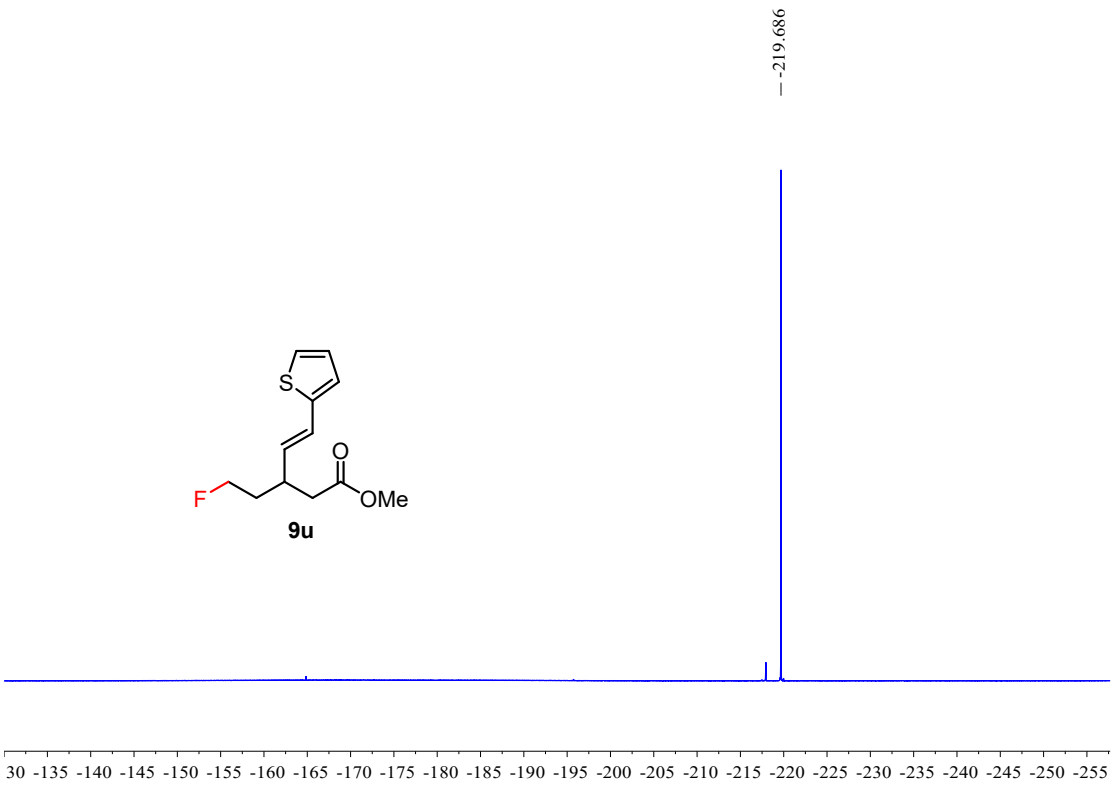
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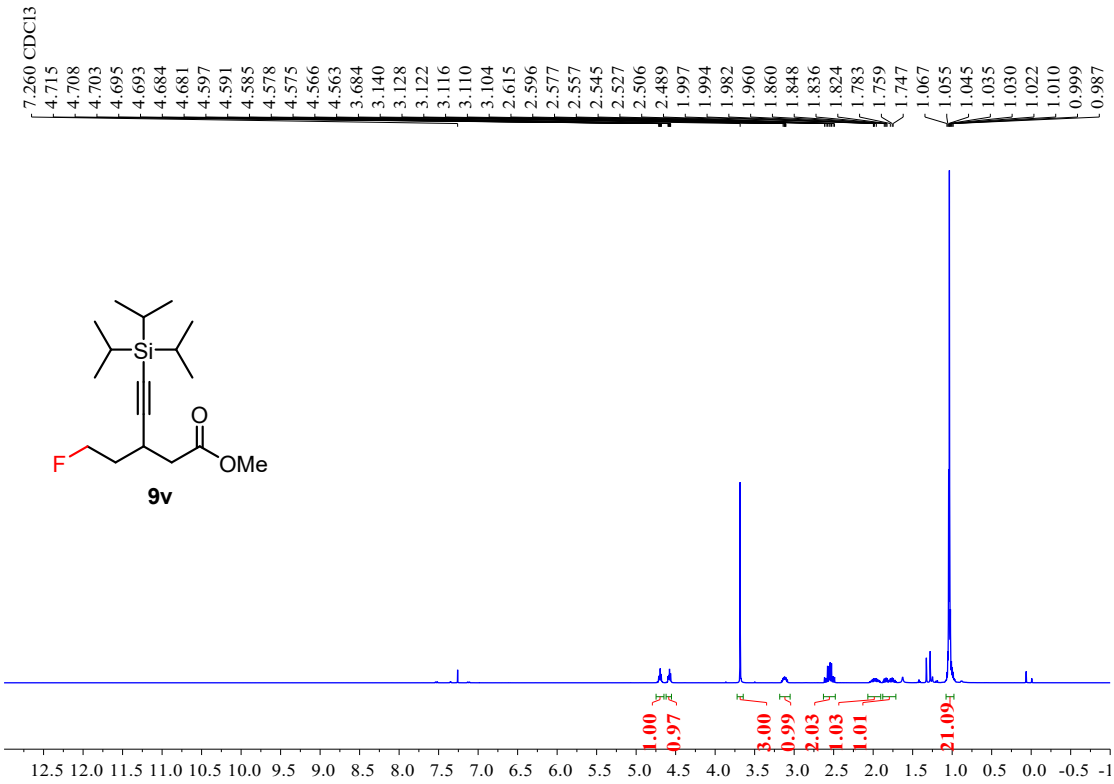
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OMe
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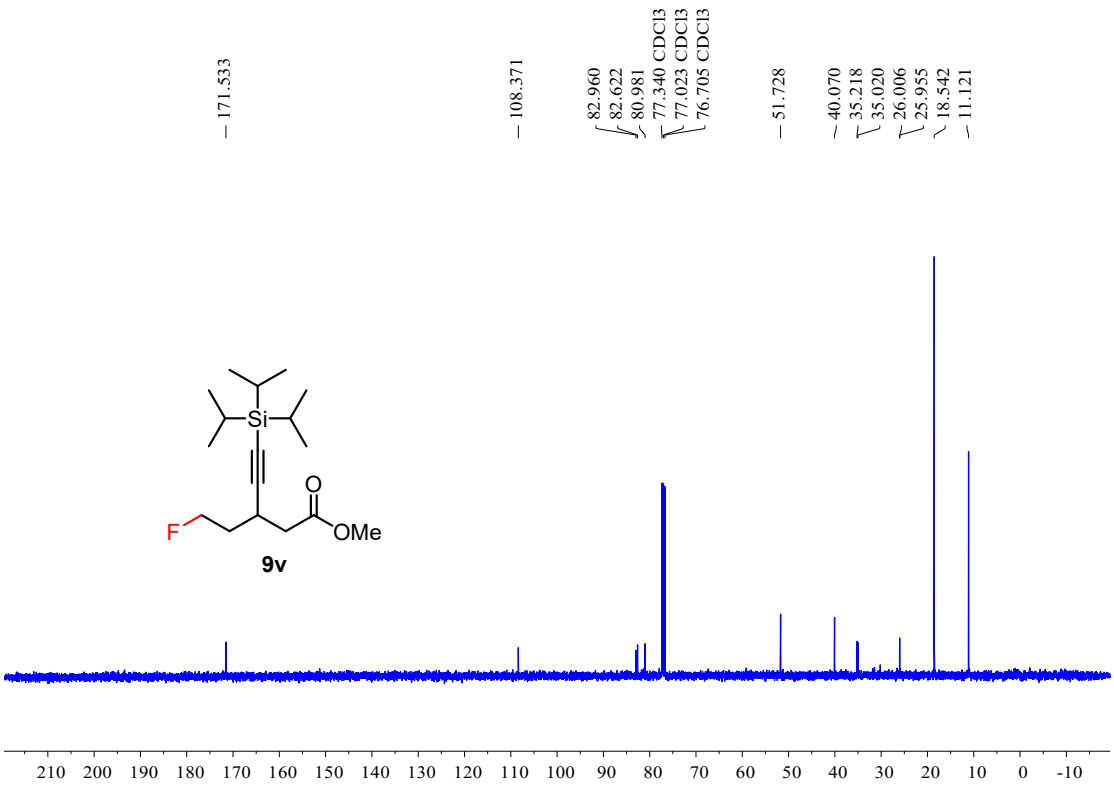
3.00
0.99
2.03
1.03
1.01
21.09
12.5 12.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1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OMe
F
9v
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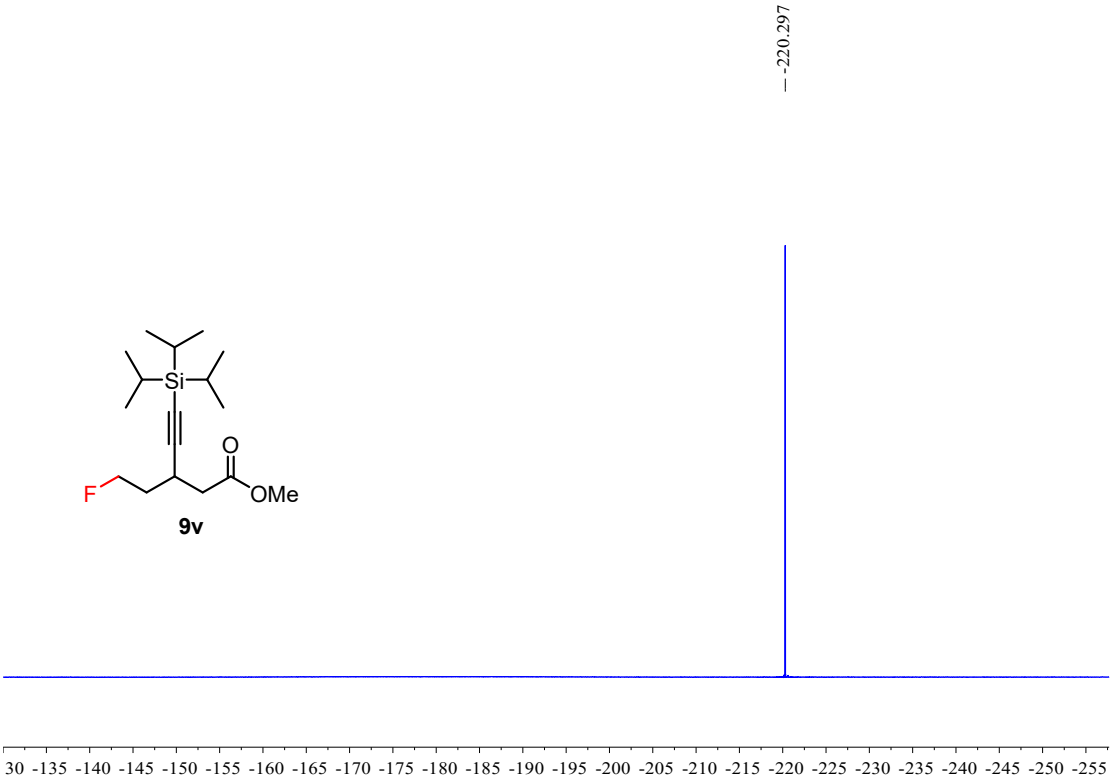
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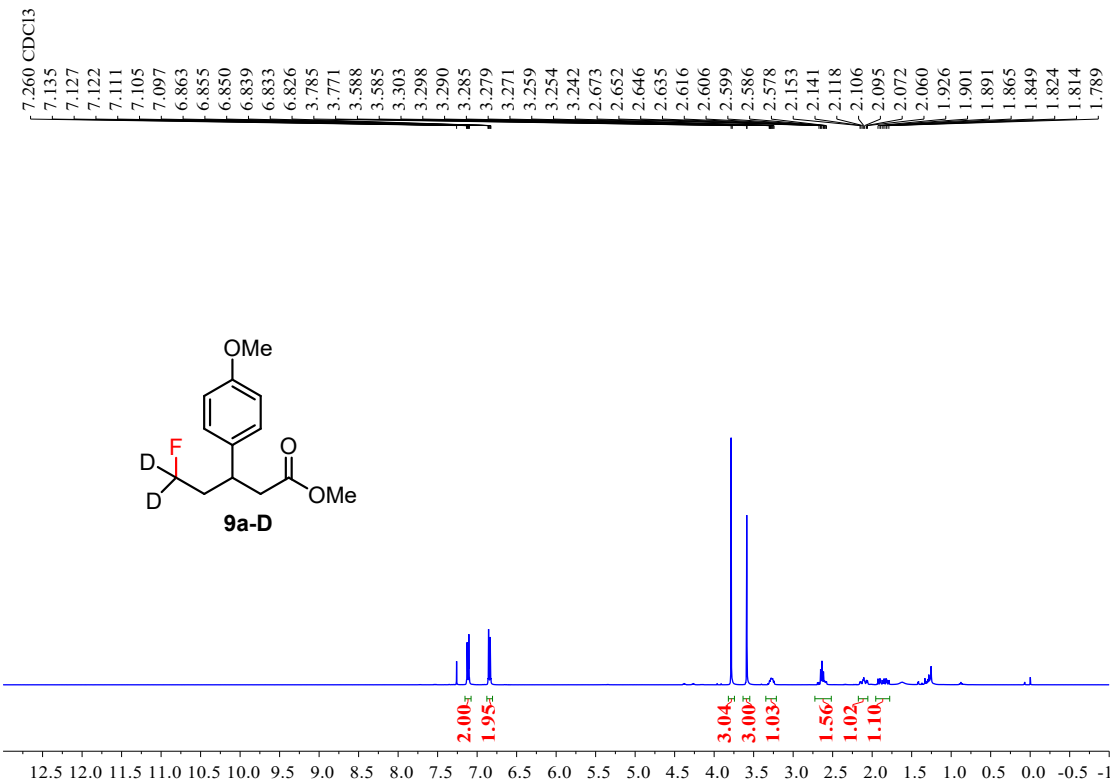
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F
D
D
O
OMe
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3.00
1.03
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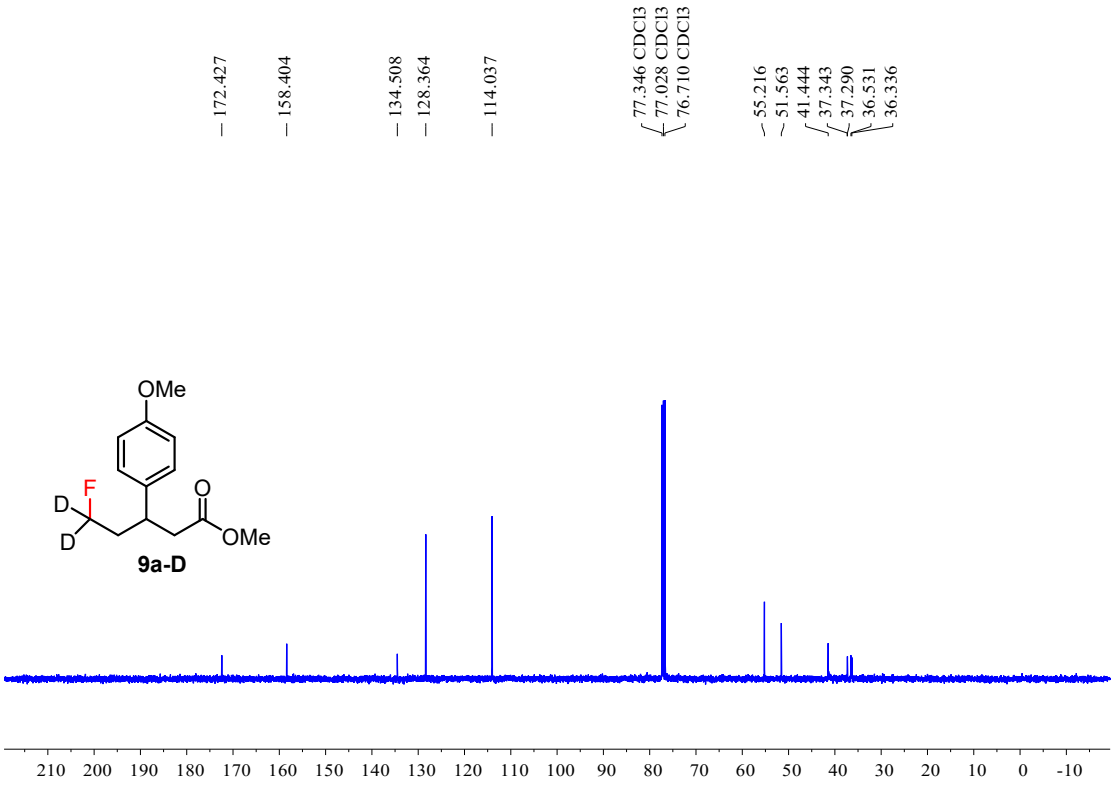
1.02
1.10
12.5 12.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1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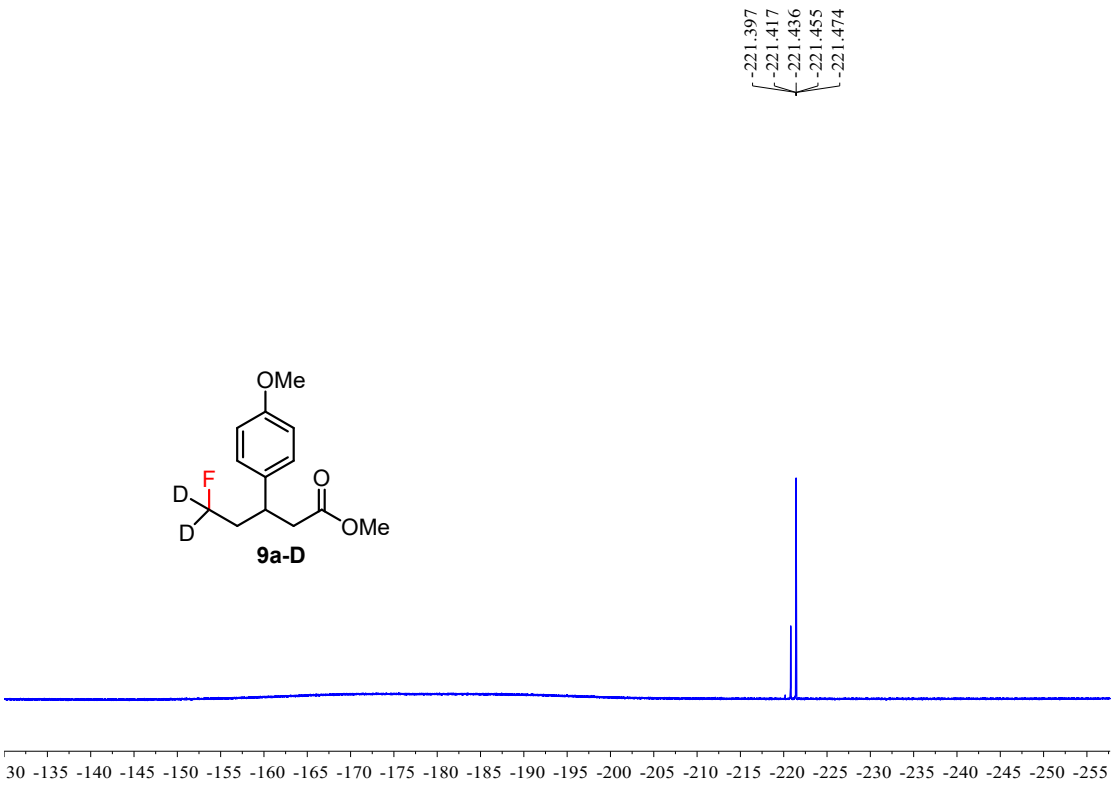
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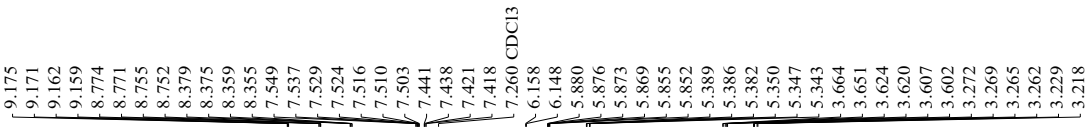
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7.503
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7.438
7.421
7.418
7.260 CDCl3
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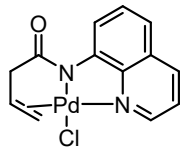
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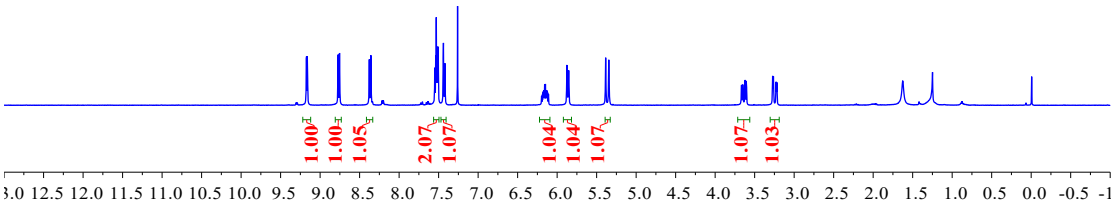
N
Cl

Pd-I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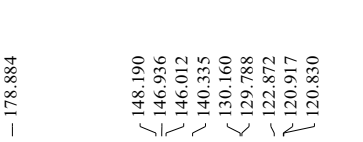
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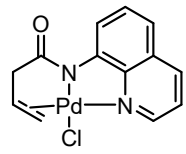
O
N
Pd
N
Cl

Pd-I

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