Supporting Information

Palladium-Catalyzed Cross-Coupling of Unactivated Alkylzinc Reagents with 2-Bromo-3,3,3-Trifluoropropene and Its Application in the Synthesis of Fluorinated Amino Acids

Yue-Guang Lou, [a] An-Jun Wang, [a] Liang Zhao, [a] Lin-Feng He, [a] Xiao-Fei Li, [a] Chun-Yang He,*, [a] Xingang Zhang*, [b]

[a] *Generic Drug Research Center of Guizhou Province, School of Pharmacy, Zunyi Medical University, Zunyi, Guizhou, 563003, P. R. China.*

[b] *Key Laboratory of Organofluorine Chemistry, Shanghai Institute of Organic Chemistry, Chinese Academy of Sciences, 345 Lingling Lu, Shanghai, 200032, P. R. China.*

E-mail: xgzhang@mail.sioc.ac.cn; hechy2002@163.com

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General Information: ^{1}H NMR and ^{13}C NMR spectra were recorded on an Agilent MR 400 and Agilent MR 500 spectrometer. ^{19}F NMR was recorded on an Agilent MR 400 spectrometer ($CFCl_3$ as an external standard and low field is positive). Chemical shifts (δ) are reported in ppm, and coupling constants (*J*) are in Hertz (Hz). The following abbreviations were used to explain the multiplicities: s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet, br = broad. NMR yield was determined by ^{19}FNMR using fluorobenzene as an internal standard before working up the reaction.

Materials: All reagents were used as received from commercial sources unless otherwise specified. Alkyl bromides were used as received from commercial sources without further purification. Zinc dust was activated by washing with 3% (v/v) HCl aqueous solution for 1 min and dried in vacuum. DMA was distilled under reduced pressure from CaH_2. THF, toluene, diethyl ether and 1, 4-dioxane were distilled from sodium immediately before use.

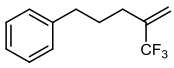
Optimization of Palladium Catalyzed Cross-Coupling of Alkylzinc Reagent 4a With 2-Bromo-3, 3, 3-trifluoropropane 2: To a 25 mL of Schlenk tube were added [Pd]-catalyst (2.5 mol%), P-ligand (2.5 - 5 mol%). The mixture was evacuated and backfilled with argon for three times, then alkylzinc reagent **4a** (0.2 mmol, 1.0 equiv), 2-bromo-3, 3, 3-trifluoropropane **2** (0.4 mmol, 2.0 equiv) and solvent (2.0 mL) were added subsequently. The Schlenk tube was screw capped and put into a preheated oil bath (80-110 ^{o}C). After stirring for 8 h, the reaction mixture was cooled to room temperature and fluorobenzene (3.0 equiv) was added. The yield was determined by ^{19}F NMR. The resulting mixture was filtered and concentrated, and the residue was purified with silica gel chromatography (petroleum) to give product **5a**.

Preparation of Alkylzinc Reagents[1]: A 25 mL of Schlenk tube was charged with zinc powder (295.0 mg, 4.5 mmol) and heated to 80 ^{o}C under vacuum for 30 min. After the tube was back-filled with argon and cooled to room temperature, iodine (38.0 mg, 0.15 mmol) and DMA (3.0 mL) were added. The resulting mixture was stirred until the brown color disappeared, then alkylbromide (3.0 mmol) was added. The reaction mixture was heated to 80 ℃. After stirring for 10 h at 80 ℃, the mixture was cooled to room temperature. The gray solution was filtered and the filtrate was stored under argon in a Schlenk tube, the solution of the alkylzinc reagent was titrated with I_2 according to

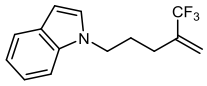
Knochel's method. This alkylzinc solution can be stored at room temperature under argon for several weeks without deterioration.

Preparation of Secondary Alkylzinc Reagents[2]: An oven-dried 250 mL round-bottom flask equipped with a magnetic stir bar and a rubber septum was charged with LiCl (8.5 g, 200.0 mmol). The vessel was heated with a heat gun for 10 min under high vacuum and backfilled with argon after cooling to room temperature. Zinc dust (13.1 g, 200.0 mmol) was added. The vessel was again heated with a heat gun for 10 min under high vacuum and backfilled with argon after cooling to room temperature. THF (100 mL) and 1, 2-dibromoethane (431 μL, 5.0 mmol) were added via syringe and the reaction mixture was heated at 60 °C until bubbling occurred. After cooling to room temperature, trimethylsilyl chloride (126 μL, 1.0 mmol) and a solution of iodine (127.0 mg, 0.5 mmol) in THF (1.0 mL) were added via syringe. The reaction mixture was heated at 60 °C for 20 min and then cooled to room temperature. Alkyl halide (100.0 mmol) was added and the reaction was stirred at 50 °C for 18 h. The reaction mixture was allowed to stand at room temperature for 1 h and the supernatant solution was carefully transferred to a dry vessel via cannula. The concentration of the organozinc solution was determined by iodometric titration using Knochel's procedure.

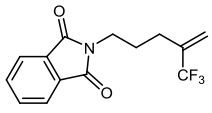
General Procedure for the Palladium Catalyzed Cross-Coupling of Alkylzinc Reagents 4 With 2-Bromo-3, 3, 3-trifluoropropane 2: To a 25 mL of Schlenk tube was added Cphos-Pd-G3 (4.0 mg, 2.5 mol%). The tube was evacuated and backfilled with argon for three times, then alkylzinc reagent **4** (0.3 mmol, 1.0 equiv), 2-bromo-3, 3, 3-trifluoropropane **2** (0.6 mmol, 2.0 equiv) and THF (2.0 mL) were added. The Schlenk tube was screw capped and put into a preheated oil bath (90 ^{o}C). After stirring for 8 h, the reaction mixture was cooled to room temperature. The reaction mixture was diluted with EtOAc (50 mL) and filtered with a pad of cellite. The filtrate was washed with water (15.0 mL). The organic layer was dried over Na_2SO_4, filtered and concentrated. The residue was purified with silica gel chromatography to give the pure product.



(4-(Trifluoromethyl)pent-4-en-1-yl)benzene (**5a**). The compound **5a** was obtained in 71% yield (45.6 mg) as a colorless oil after flash column chromatography (petroleum ether). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.32 (t, *J* = 7.0 Hz, 2H), 7.25 – 7.19 (m, 3H), 5.70 (s, 1H), 5.34 (s, 1H), 2.69 (t, *J* = 7.6 Hz, 2H), 2.27 (t, *J* = 7.8 Hz, 2H), 1.93 – 1.83 (m, 2H). ^{19}F NMR (376 MHz, $CDCl_3$) δ -68.6 (s, 3F). ^{13}C NMR (101 MHz, $CDCl_3$) δ 142.2, 138.8 (q, *J* = 29.3 Hz), 129.00, 128.97, 126.6, 124.4 (q, *J* = 274.7 Hz), 118.2 (q, *J* = 5.7 Hz), 35.8, 29.7, 29.6. MS (EI): m/z (%) 214 (M^+), 104, 91 (100), 77, 65, 45. HRMS (EI): Calculated for $C_{12}H_{13}F_3$: 214.0969; Found: 214.0975.

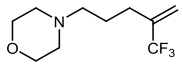


1-(4-(Trifluoromethyl)pent-4-en-1-yl)-1*H*-indole (**5b**). The compound **5b** was obtained in 76% yield (57.7 mg) as a yellow oil after flash column chromatography (hexane/EtOAc = 5/1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.71 (d, *J* = 7.9 Hz, 1H), 7.38 (d, *J* = 8.2 Hz, 1H), 7.28 (t, *J* = 7.1 Hz, 1H), 7.21 – 7.15 (m, 1H), 7.13 (d, *J* = 3.2 Hz, 1H), 6.58 – 6.56 (m, 1H), 5.75 (s, 1H), 5.33 (m, 1H), 4.20 (t, *J* = 7.0 Hz, 2H), 2.28 (t, *J* = 7.8 Hz, 2H), 2.16 – 2.09 (m, 2H). ^{19}F NMR (376 MHz, $CDCl_3$) δ -68.6 (s, 3F). ^{13}C NMR (101 MHz, $CDCl_3$) δ 137.8 (q, *J* = 29.3 Hz), 136.4, 129.2, 128.2, 124.2 (q, *J* = 274.7 Hz), 122.1, 121.6, 120.0, 118.9 (q, *J* = 5.7 Hz), 109.8, 101.9, 46.0, 28.4, 27.4. MS (EI): m/z (%) 253 (M^+), 184, 130 (100), 105, 89, 77. HRMS (EI): Calculated for $C_{14}H_{14}NF_3$: 253.1078; Found: 253.1088.

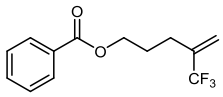


2-(4-(Trifluoromethyl)pent-4-en-1-yl)isoindoline-1,3-dione (**5c**). The compound **5c** was obtained in 76% yield (64.5 mg) as a yellow oil after flash column chromatography (hexane/EtOAc = 10/1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.87 – 7.80 (m, 2H), 7.74 – 7.68 (m, 2H), 5.69 (d, *J* = 1.1 Hz, 1H), 5.39 (d, *J* = 1.1 Hz, 1H), 3.72 (t, *J* = 7.2 Hz, 2H), 2.25 (t, *J* = 7.8 Hz, 2H), 1.96 – 1.86 (m, 2H). ^{19}F NMR (376 MHz, $CDCl_3$) δ -68.6 (s, 3F). ^{13}C NMR (101 MHz, $CDCl_3$) δ 167.9, 136.8 (q, *J* = 29.3 Hz), 133.6, 131.6, 123.2 (q, *J* = 274.7 Hz), 122.8, 117.7 (q, *J* = 5.7 Hz), 36.8, 26.2, 25.9. MS (EI): m/z (%) 283 (M^+), 160, 136, 122, 105 (100), 77, 51. HRMS (EI): Calculated for $C_{14}H_{12}NO_2F_3$:

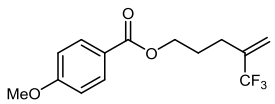
283.0820; Found: 283.0825.



4-(4-(Trifluoromethyl)pent-4-en-1-yl)morpholine (**5d**). The compound **5d** was obtained in 64% yield (43.0 mg) as a yellow oil after flash column chromatography (hexane/EtOAc = 1/2). ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.65 (s, 1H), 5.31 (s, 1H), 3.70 (t, *J* = 4.0 Hz, 4H), 2.43 (br, 4H), 2.36 (t, *J* = 7.6 Hz, 2H), 2.22 (t, *J* = 7.8 Hz, 2H), 1.75 – 1.63 (m, 2H). ^{19}F NMR (376 MHz, $CDCl_3$) δ -68.6 (s, 3F). ^{13}C NMR (101 MHz, $CDCl_3$) δ 138.7 (q, *J* = 29.3 Hz), 124.3 (q, *J* = 274.7 Hz), 118.4 (q, *J* = 5.7 Hz), 67.4, 58.5, 54.2, 27.8, 24.9. MS (ESI): m/z (%) 224.1 [M+H$^+$], (100), 188.1. HRMS (ESI): Calculated for $C_{10}H_{17}ONF_3$: 224.1257 [M+H$^+$]; Found: 224.1255.

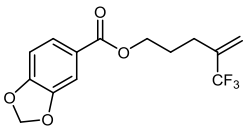


4-(Trifluoromethyl)pent-4-en-1-yl benzoate (**5e**). The compound **5e** was obtained in 91% yield (70.5 mg) as a colorless oil after flash column chromatography (hexane/EtOAc = 10/1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.05 (d, *J* = 8.0 Hz, 2H), 7.56 (t, *J* = 7.2 Hz, 1H), 7.44 (t, *J* = 7.6 Hz, 2H), 5.73 (s, 1H), 5.38 (s, 1H), 4.37 (t, *J* = 6.4 Hz, 2H), 2.39 (t, *J* = 7.6 Hz, 2H), 2.06 – 1.96 (m, 2H). ^{19}F NMR (376 MHz, $CDCl_3$) δ -68.6 (s, 3F). ^{13}C NMR (101 MHz, $CDCl_3$) δ 167.0, 138.0 (q, *J* = 29.3 Hz), 133.5, 130.7, 130.1, 128.9, 124.2 (q, *J* = 274.7 Hz), 118.9 (q, *J* = 5.7 Hz), 64.3, 27.2, 26.6. MS (EI): m/z (%) 258 (M$^+$), 136, 122, 105 (100). HRMS (EI): Calculated for $C_{13}H_{13}O_2F_3$: 258.0868; Found: 258.0860.

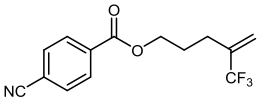


4-(Trifluoromethyl)pent-4-en-1-yl 4-methoxybenzoate (**5f**). The compound **5f** was obtained in 84% yield (72.6 mg) as a colorless oil after flash column chromatography (hexane/EtOAc = 10/1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.99 (d, *J* = 6.4 Hz, 2H), 6.92 (d, *J* = 6.4 Hz, 2H), 5.72 (s, 1H), 5.38 (s, 1H), 4.33 (t, *J* = 6.4 Hz, 2H), 3.86 (s, 3H), 2.38 (t, *J* = 7.8 Hz, 2H), 2.04 – 1.95 (m, 2H). ^{19}F NMR (376 MHz, $CDCl_3$) δ -68.6 (s, 3F). ^{13}C NMR (101 MHz, $CDCl_3$) δ 166.8, 164.0, 138.0 (q, *J* = 29.3

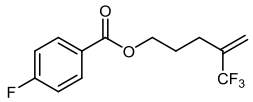
Hz), 132.1, 124.3 (q, J = 274.7 Hz), 123.1, 118.9 (q, J = 5.7 Hz), 114.2, 64.0, 56.0, 27.2, 26.7. MS (EI): m/z (%) 288 (M^+), 152, 135 (100). HRMS (EI): Calculated for $C_{14}H_{15}O_3F_3$: 288.0973; Found: 288.0968.



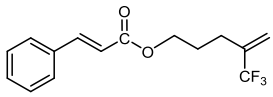
4-(Trifluoromethyl)pent-4-en-1-yl benzo[*d*][1,3]dioxole-5-carboxylate (**5g**). The compound **5g** was obtained in 71% yield (68.2 mg) as a colorless oil after flash column chromatography (hexane/EtOAc = 10/1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.65 (d, J = 8.0 Hz, 1H), 7.46 (s, 1H), 6.84 (d, J = 8.0 Hz, 1H), 6.04 (s, 2H), 5.72 (s, 1H), 5.38 (s, 1H), 4.32 (t, J = 6.4 Hz, 2H), 2.37 (t, J = 7.6 Hz, 2H), 2.02 - 1.93 (m, 2H). ^{19}F NMR (376 MHz, $CDCl_3$) δ -68.6 (s, 3F). ^{13}C NMR (101 MHz, $CDCl_3$) δ 166.4, 152.2, 148.3, 137.9 (q, J = 29.3 Hz), 125.8, 124.6, 124.2 (q, J = 274.7 Hz), 118.9 (q, J = 5.7 Hz), 110.0, 108.5, 102.4, 64.3, 27.2, 26.7. MS (EI): m/z (%) 302 (M^+), 166 (100), 149, 137, 109, 91, 65. HRMS (EI): Calculated for $C_{14}H_{13}O_4F_3$: 302.0766; Found: 302.0770.



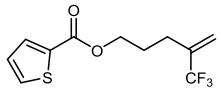
4-(Trifluoromethyl)pent-4-en-1-yl 4-cyanobenzoate (**5h**). The compound **5h** was obtained in 78% yield (66.2 mg) as a colorless oil after flash column chromatography (hexane/EtOAc = 10/1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.13 (d, J = 8.4 Hz, 2H), 7.75 (d, J = 8.0 Hz, 2H), 5.73 (s, 1H), 5.38 (s, 1H), 4.40 (t, J = 6.4 Hz, 2H), 2.38 (t, J = 7.6 Hz, 2H), 2.07 – 1.97 (m, 2H). ^{19}F NMR (376 MHz, $CDCl_3$) δ -68.5 (s, 3F). ^{13}C NMR (101 MHz, $CDCl_3$) δ 165.4, 137.8 (q, J = 29.3 Hz), 134.4, 132.8, 130.6, 124.2 (q, J = 274.7 Hz), 119.1 (q, J = 5.7 Hz), 118.5, 117.0, 65.2, 27.1, 26.6. MS (EI): m/z (%) 283 (M^+), 136, 130 (100), 102. HRMS (EI): Calculated for $C_{14}H_{12}NO_2F_3$: 283.0820; Found: 283.0824.



4-(Trifluoromethyl)pent-4-en-1-yl 4-fluorobenzoate (**5i**). The compound **5i** was obtained in 90% yield (74.5 mg) as a colorless oil after flash column chromatography (hexane/EtOAc = 10/1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.08 – 8.02 (m, 2H), 7.11 (t, *J* = 8.4 Hz, 2H), 5.72 (s, 1H), 5.38 (s, 1H), 4.35 (t, *J* = 6.6 Hz, 2H), 2.38 (t, *J* = 7.8 Hz, 2H), 2.05 – 1.96 (m, 2H). ^{19}F NMR (376 MHz, $CDCl_3$) δ -68.5 (s, 3F), -105.3 – -105.7 (m, 1F). ^{13}C NMR (101 MHz, $CDCl_3$) δ 166.3 (d, *J* = 254.0 Hz), 166.1, 137.9 (q, *J* = 29.3 Hz), 132.7 (d, *J* = 9.1 Hz), 126.9 (d, *J* = 3.0 Hz), 124.2 (q, *J* = 274.7 Hz), 119.0 (q, *J* = 5.7 Hz), 116.1 (d, *J* = 22.2 Hz), 64.5, 27.2, 26.7. MS (EI): m/z (%) 276 (M^+), 141, 136, 123 (100). HRMS (EI): Calculated for $C_{13}H_{12}O_2F_4$: 276.0773; Found: 276.0779.

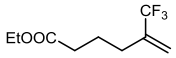


4-(Trifluoromethyl)pent-4-en-1-yl cinnamate (**5j**). The compound **5j** was obtained in 83% yield (70.7 mg) as a colorless oil after flash column chromatography (hexane/EtOAc = 10/1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.70 (d, *J* = 16.0 Hz, 1H), 7.58 – 7.49 (m, 2H), 7.43 – 7.35 (m, 3H), 6.45 (d, *J* = 16.0 Hz, 1H), 5.72 (s, 1H),5.37 (s, 1H), 4.25 (t, *J* = 6.2 Hz, 2H), 2.35 (t, *J* = 7.6 Hz, 2H), 2.00 – 1.90 (m, 2H). ^{19}F NMR (376 MHz, $CDCl_3$) δ -68.6 (s, 3F). ^{13}C NMR (101 MHz, $CDCl_3$) δ 167.4, 145.5, 138.0 (q, *J* = 29.3 Hz), 134.8, 130.9, 129.4, 128.6, 124.2 (q, *J* = 274.7 Hz), 118.8 (q, *J* = 5.7 Hz), 118.3, 63.9, 27.1, 26.6. MS (EI): m/z (%) 284 (M^+), 148, 131 (100), 103. HRMS (EI): Calculated for $C_{15}H_{15}O_2F_3$: 284.1024; Found: 284.1026.

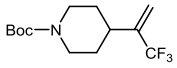


4-(Trifluoromethyl)pent-4-en-1-yl thiophene-2-carboxylate (**5k**). The compound **5k** was obtained in 73% yield (57.8 mg) as a colorless oil after flash column chromatography (hexane/EtOAc = 10/1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.82 – 7.79 (m, 1H), 7.58 – 7.55 (m, 1H), 7.13 – 7.08 (m, 1H), 5.72 (s, 1H), 5.38 (s, 1H), 4.34 (t, *J* = 6.4 Hz, 2H), 2.37 (t, *J* = 7.8 Hz, 2H), 2.03 – 1.94 (m, 2H). ^{19}F NMR (376 MHz, $CDCl_3$) δ -68.6 (s, 3F). ^{13}C NMR (101 MHz, $CDCl_3$) δ 161.7, 136.9 (q, *J* = 29.3 Hz), 133.2, 133.1, 132.0, 127.4, 123.3 (q, *J* = 274.7 Hz), 118.0 (q, *J* = 5.7 Hz), 63.5, 26.2, 25.6. MS (EI):

m/z (%) 264 (M^+), 128, 111 (100). HRMS (EI): Calculated for $C_{11}H_{11}O_2F_3S$: 264.0432; Found: 264.0433.



Ethyl 5-(trifluoromethyl)hex-5-enoate (**5l**). The compound **5l** was obtained in 76% yield (47.9 mg) as a colorless oil after flash column chromatography (hexane/EtOAc = 10/1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.69 (s, 1H), 5.34 (s, 1H), 4.14 (q, *J* = 7.1 Hz, 2H), 2.35 (t, *J* = 7.4 Hz, 2H), 2.24 (t, *J* = 7.6 Hz, 2H), 1.91 – 1.81 (m, 2H), 1.25 (t, *J* = 7.2 Hz, 3H). ^{19}F NMR (376 MHz, $CDCl_3$) δ -68.6 (s, 3F). ^{13}C NMR (101 MHz, $CDCl_3$) δ 172.6, 137.2 (q, *J* = 29.3 Hz), 123.3 (q, *J* = 274.7 Hz), 117.8 (q, *J* = 5.7 Hz), 60.0, 32.9, 28.3, 22.3, 13.8. MS (EI): m/z (%) 210 (M^+), 165 (100), 88. HRMS (EI): Calculated for $C_9H_{13}O_2F_3$: 210.0868; Found: 210.0872.



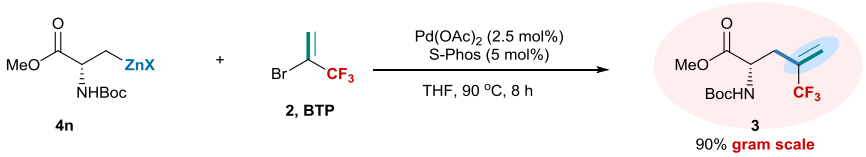
***tert*-Butyl 4-(3,3,3-trifluoroprop-1-en-2-yl)piperidine-1-carboxylate** (**5m**). The compound **5m** was obtained in 90% yield (75.4 mg) as a yellow oil after flash column chromatography (hexane/EtOAc = 10/1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.73 (s, 1H), 5.35 (s, 1H), 4.19 (d, *J* = 11.2 Hz, 2H), 2.71 (t, *J* = 12.0 Hz, 2H), 2.29 (t, *J* = 12.0 Hz, 1H), 1.80 (d, *J* = 13.2 Hz, 2H), 1.46 (s, 9H), 1.43- 1.34 (m, 2H).^{19}F NMR (376 MHz, $CDCl_3$) δ -67.2 (s, 3F). ^{13}C NMR (101 MHz, $CDCl_3$) δ 155.2, 143.1 (q, *J* = 29.3 Hz), 124.5 (q, *J* = 274.7 Hz), 118.0 (q, *J* = 5.7 Hz), 80.1, 44.5, 36.9, 32.2, 29.0. MS (EI): m/z (%) 279 (M^+), 224, 206, 57 (100). HRMS: Calculated for $C_{13}H_{20}NO_2F_3$: 279.1446; Found: 279.1448.

Procedure for the Synthesis of Alkylzinc Iodide 4n:

An oven dried 250 mL three-necked, round-bottomed flask containing an egg-shaped Teflon®-coated magnetic stir bar is equipped with a reflux condenser fitted with an argon inlet adaptor, a thermometer and a rubber septum. The apparatus is purged with argon. Keeping a positive flow of argon, the septum is removed temporarily and the flask is charged with zinc dust (182.3 mmol, 6.0 equiv). Anhydrous DMF (20.0 mL) is then added to the flask via a syringe. 1,2-Dibromoethane (18.2 mmol, 0.6 equiv) is added next to the stirred suspension via a syringe. The

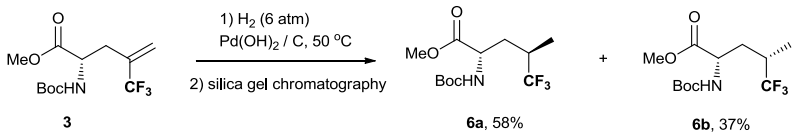
mixture is stirred and heated to 60 ℃ and stirred for 45 min. The mixture is cooled to room temperature. Chlorotrimethylsilane (6.0 mmol, 0.2 equiv) is added via a syringe to the slurry, which is stirred for 40 min at room temperature. A solution of methyl (*R*)-2-((*tert*-butoxycarbonyl)amino)-3-iodopropanoate (30.39 mmol 1.0 equiv) in anhydrous DMF (20 mL) is added via a syringe to the mixture of activated zinc, which is then heated in a 35 ℃ oil bath and stirred for 60 min. The gray solution was filtered and the filtrate was stored under argon in a Schlenk tube, the solution of alkylzinc reagent was titrated with I_2 according to Knochel's method.

Gram-Scale Synthesis of the Key Intermediate 3:

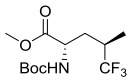


To a 100 mL of Schlenk tube were added $Pd(OAc)_2$ (32.1 mg, 2.5 mol %), S-Phos (117.3 mg, 5 mol %). The mixture was evacuated and backfilled with argon for three times, then alkylzinc reagent **4n** (6.857 mmol, 1.2 equiv), 2-bromo-3,3,3-trifluoropropane **2** (5.714 mmol, 1.0 g, 1.0 equiv) and THF (38 mL) were added subsequently. The Schlenk tube was screw capped and put into a preheated oil bath (90 ^{o}C). After stirring for 8 h, the reaction mixture was cooled to room temperature and fluorobenzene (3.0 equiv) was added. The resulting mixture was filtered concentrated, and the residue was purified with silica gel chromatography (hexane/EtOAc = 10/1) to give product **3** (1.53 g, 90%) as a yellow oil. Data for **3**: $[\alpha]_D^{26}$ = 34.88 (*c* = 0.410, $CHCl_3$). ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.81 (s, 1H), 5.46 (s, 1H), 5.05 (br, 1H), 4.55 – 4.45 (m, 1H), 3.75 (s, 3H), 2.78 (dd, *J* = 15.3 Hz, 5.1 Hz, 1H), 2.58 (dd, *J* = 15.2 Hz, 7.6 Hz, 1H), 1.43 (s, 9H). ^{19}F NMR (376 MHz, $CDCl_3$) δ -68.7 (s, 3F). ^{13}C NMR (101 MHz, $CDCl_3$) δ 172.5, 155.6, 134.1 (q, *J* = 29.3 Hz), 123.8 (q, *J* = 274.7 Hz), 122.1, 80.7, 53.0, 52.6, 32.6, 28.7. MS (ESI): m/z (%) 320.1 [M+Na^+] (100), 264.0, 242.0, 226.1, 198.1. HRMS (ESI): Calculated for $C_{12}H_{18}O_4NF_3Na$: 320.1080 [M+Na^+]; Found: 320.1082.

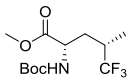
Procedure for the Synthesis of Compounds 6a and 6b:



To a 25 mL of round-bottle flask was charged with 10 % $Pd(OH)_2/C$ (14.0 mg, 0.1 mmol), **3** (297.1 mg, 1.0 mmol), and MeOH (10.0 mL). The reaction was evacuated and backfilled with H_2 (three times). The reaction mixture was stirred at 50 ^oC for 6 h. The resulting mixture was cooled to room temperature, and filtrated through a silica gel pad. The organic layer was dried over Na_2SO_4, filtered and concentrated. The residue was purified with silica gel chromatography to give the product.

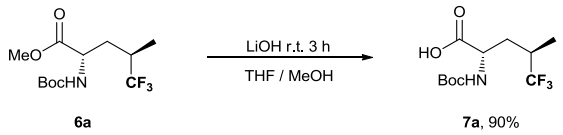


Methyl (2*S*,4*R*)-2-((*tert*-butoxycarbonyl)amino)-5,5,5-trifluoro-4-methylpentanoate (**6a**). The compound **6a** was obtained in 58% yield (173.5 mg) as a yellow oil after flash column chromatography (hexane/EtOAc = 10/1). $[\alpha]_D^{26}$ = -24.1223 (*c* = 0.9800, $CHCl_3$). ^1H NMR (400 MHz, $CDCl_3$) δ 5.08 (s, 1H), 4.42 – 4.32 (m, 1H), 3.76 (s, 3H), 2.42 – 2.30 (m, 1H), 2.21 – 2.13 (m, 1H), 1.68 – 1.60 (m, 1H), 1.44 (s, 9H), 1.16 (d, *J* = 6.8 Hz, 3H). ^{19}F NMR (376 MHz, $CDCl_3$) δ -73.7 (d, *J* = 7.9 Hz, 3F). ^{13}C NMR (101 MHz, $CDCl_3$) δ 173.1, 155.6, 128.5 (q, *J* = 279.8 Hz), 80.8, 53.0, 52.1, 35.6 (q, *J* = 7.3 Hz), 33.5, 28.8, 13.6. MS (ESI): m/z (%) 300.1 [M+H^+], 261.1, 245.1, 244.1 (100), 201.1, 200.1, 140.1. HRMS (ESI): Calculated for $C_{12}H_{21}O_4NF_3$: 300.1417 [M+H^+]; Found: 300.1418.

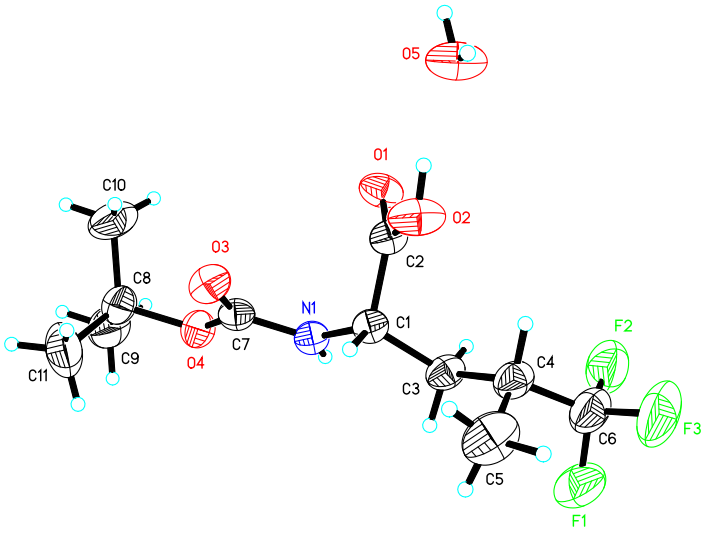


Methyl (2*S*, 4*S*)-2-((*tert*-butoxycarbonyl)amino)-5,5,5-trifluoro-4-methylpentanoate (**6b**). The compound **6b** was obtained in 37% yield (110.6 mg) as a colorless oil after flash column chromatography (hexane/EtOAc = 10/1). $[\alpha]_D^{26}$ = -14.9635 (*c* = 0.9850, $CHCl_3$). ^1H NMR (400 MHz, $CDCl_3$) δ 5.12 (s, 1H), 4.40 – 4.28 (m, 1H), 3.70 (s, 3H), 2.28 (s, 1H), 1.87 – 1.74 (m, 2H), 1.39 (s, 9H), 1.15 (d, *J* = 6.4 Hz, 3H). ^{19}F NMR (376 MHz, $CDCl_3$) δ -73.8 (d, *J* = 8.3 Hz, 3F). ^{13}C NMR (101 MHz, $CDCl_3$) δ 172.8, 155.6, 128.0 (q, *J* = 279.8 Hz), 80.2, 52.4, 50.6, 34.7 (q, *J* = 27.3 Hz), 32.6, 28.1, 11.9. MS (ESI): m/z (%) 300.1 [M+H^+], 261.1, 245.1, 244.1 (100), 201.1. HRMS (ESI): Calculated for $C_{12}H_{21}O_4NF_3$: 300.1417 [M+H^+]; Found: 300.1419.

Procedure for the Synthesis of Compound 7a:

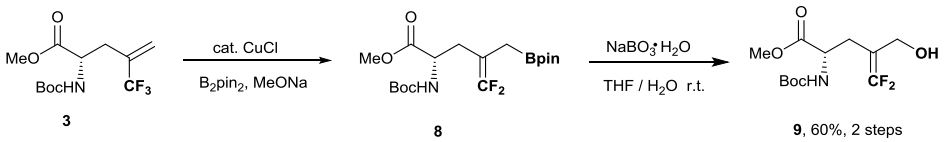


To a stirred solution of compound **6a** (89.7 mg, 0.4 mmol, 1.0 equiv) in THF-MeOH (8:2, v/v) (5.0 mL) was added aqueous LiOH (0.5 N, 5.0 mL) and the resulting mixture was stirred at room temperature for 3 h. The reaction mixture was neutralized with glacial acetic acid and extracted with EtOAc (3 x 25 mL). The organic extract was dried over anhydrous Na_2SO_4 and evaporation of the solvent afforded a crude yellow residue. The residue was purified by column chromatography on silica gel (EtOAc) to give compound **7a** was obtained in 90% yield (102.6 mg) as a yellow oil. ^{1}H NMR (400 MHz, CD_3OD) δ 4.19 (br, 1H), 2.45 – 2.42 (m, 1H), 2.19 – 2.15 (m, 1H), 1.67 – 1.60 (m, 1H), 1.45 (s, 9H), 1.16 (d, *J* = 6.0 Hz, 3H). ^{19}F NMR (376 MHz, CD_3OD) δ -73.6 (d, *J* = 8.3 Hz, 3F). ^{13}C NMR (101 MHz, CD_3OD) δ 157.9, 129.7 (t, *J* = 279.8 Hz), 80.7, 36.4 (q, *J* = 26.6 Hz), 33.1, 28.7, 13.7. MS (ESI): m/z (%) 286.1 [M+H$^+$], 247.1, 230.1 (100), 186.1. HRMS (ESI): Calculated for $C_{11}H_{19}O_4NF_3$: 286.1261 [M+H$^+$]; Found: 286.1260. Sample for the X-ray single crystal analysis was obtained from evaporation of **7a** in CH_2Cl_2/PE.



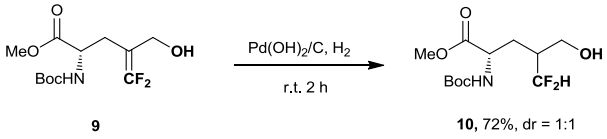
X-ray crystal structure of compound 7a

Procedure for the Synthesis of Compound 9:



Copper chloride (59.4 mg, 0.2 mmol) and bis(pinacolato)diboron (76.2 mg, 0.3 mmol) were placed in an oven-dried reaction vial. The vial was moved to an argon-filled glove box. NaOMe (40.7 mg, 0.75 mmol) was placed in a reaction vial. Then the vial was capped with a rubber septum and removed from the glove box and anhydrous THF (0.5 mL) was added in the vial through the rubber septum using a syringe. After stirring for 30 min at 30 ℃, **3** (59.4 mg, 0.2 mmol) was added to the mixture at 30 ℃. After the reaction was complete, THF/H_2O (1:1, 2.0 mL) and $NaBO_3 \cdot 4H_2O$ (153.8 mg, 1.0 mmol) were added to the reaction mixture at room temperature. The resulting solution was stirred for 2 hours, EtOAc was added then added. The organic layer was separated, dried over Na_2SO_4 and filtered. The filtrate was concentrated, the residue was purified by flash column chromatography (hexane/EtOAc = 4/1) to give compound **9** in 60% yield (two steps based on compound **3**, 35.6 mg) as a yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.47 (s, 1H), 4.57 (s, 1H), 4.31 (d, *J* = 12.1 Hz, 1H), 4.04 (d, *J* = 11.3 Hz, 1H), 3.75 (s, 3H), 3.43 (br, 1H), 2.61 – 2.36 (m, 2H), 1.41 (s, 9H). ^{19}F NMR (376 MHz, $CDCl_3$) δ - 89.2 (d, *J* = 40.6 Hz, 1F), - 91.0 (d, *J* = 40.6 Hz, 1F). ^{13}C NMR (101 MHz, $CDCl_3$) δ 172.7, 156.5, 155.8 (t, *J* = 291.8 Hz), 86.7 (dd, *J* = 17.2, 15.2 Hz), 81.1, 59.1, 53.1, 53.0, 31.1, 28.7. MS (ESI): m/z (%) 296.1 [M+H$^+$] (100), 240.1, 222.1. HRMS (ESI): Calculated for $C_{12}H_{20}O_5NF_2$: 296.1304 [M+H$^+$]; Found: 296.1304.

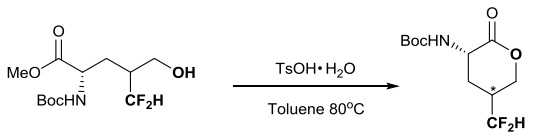
Procedure for the Synthesis of Compound 10:



To a 25 mL of round-bottle flask was charged with 10% $Pd(OH)_2$/C (14.0 mg, 0.1 mmol), **9** (297.1 mg, 1 mmol), and MeOH (10.0 mL). The reaction was evacuated and backfilled with H_2 (three times). The reaction mixture was stirred at 25 ^{o}C for 2 h. The resulting mixture was cooled to room temperature, and filtrated through a silica gel pad. After concentration under reduced pressure, the residue was subjected to purification on silica gel chromatography (hexane/EtOAc = 2/1) to give

compounds **10** in 72% yield (215.4 mg, dr = 1:1) as a yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.87 (t, *J* = 56.8 Hz, 1H), 5.60 – 5.32 (m, 1H), 4.52 – 4.26 (m, 1H), 3.82-3.60 (m, 5H), 3.22 (br, 1H), 2.22 – 1.84 (m, 2H), 1.76 (s, 1H), 1.39 (s, 9H). ^{19}F NMR (376 MHz, $CDCl_3$) δ -123.0 (ddd, *J* = 282.9 Hz, 56.3 Hz, 11.0 Hz, 1F), -126.4 (ddd, *J* = 282.9 Hz, 56.5 Hz, 14.3 Hz, 0.5F), -126.9 (ddd, *J* = 282.9 Hz, 58.8 Hz, 12.4 Hz, 0.5F, diastereoisomer). ^{13}C NMR (101 MHz, $CDCl_3$) δ 173.5 (173.3, diastereoisomer), 156.5 (156.1, diastereoisomer), 117.7 (t, *J* = 242.9 Hz) [117.6 (t, *J* = 242.9 Hz), diastereoisomer], 81.0, 60.1, 53.0, 52.1 (51.7, diastereoisomer), 42.3 (t, *J* = 19.2 Hz), 42.1 (t, *J* = 19.2 Hz), 31.9, 30.7, 28.7. MS (ESI): m/z (%) 296.0 [M-H$^+$], 282.1 (100), 207.9. HRMS (ESI): Calculated for $C_{12}H_{22}O_5NF_2$: 298.1461[M+H$^+$]; Found: 298.1461.

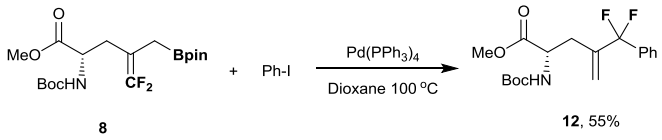
Procedure for the Synthesis of Compound 11:



10 **11**, 34%

To a solution of **10** (0.2 mmol 1.0 equiv) in toluene was added TsOH ·H_2O (0.01 mmol, 0.05 equiv) at room temperature. After stirring for 12 h at 80 ℃, the mixture was diluted with EtOAc and aqueous $NaHCO_3$ was added. The organic layer was dried over Na_2SO_4. After concentration under reduced pressure, the residue was subjected to purification on silica gel chromatography (hexane/EtOAc = 10/1) to give compound **11** obtained in 34% yield (18.0 mg) as a yellow oil. $[\alpha]_D^{26}$ = 30.52 (c = 0.310, $CHCl_3$). ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.86 (td, *J* = 55.3 Hz, 3.3 Hz, 1H), 5.39 (s, 1H), 4.43 – 4.60 (m, 2H), 4.31 (t, *J* = 11.6 Hz, 1H), 2.85 – 2.52 (m, 2H), 1.80 – 1.68 (m, 1H), 1.45 (s, 9H). ^{19}F NMR (376 MHz, $CDCl_3$) δ -122.00 (ddd, *J* = 285.8 Hz, 55.3 Hz, 11.3 Hz, 1F), -124.2 (m, 1F). ^{13}C NMR (126 MHz, $CDCl_3$) δ 172.4, 155.7, 115.9 (t, *J* = 243.1 Hz), 81.2, 64.4, 47.9, 36.9 (t, *J* = 20.8 Hz), 28.9, 26.0. MS (ESI): m/z (%) 288.0 [M+Na$^+$] (100), 232.0. HRMS (ESI): Calculated for $C_{11}H_{16}O_4NF_2$: 264.1053[M-H$^+$]; Found: 264.1051.

Procedure for the Synthesis of Compound 12:



To a 25 mL of Schlenk tube were added **8** (0.2 mmol, 1.0 equiv), $Pd(PPh_3)_4$ (0.02 mmol, 0.1 equiv), iodobenzene (0.3 mmol, 1.5 equiv), CsF (0.4 mmol, 2.0 equiv) and 1,4-dioxane (1.0 mL) under argon. The mixture was degassed with argon for 10 min, and heated at 100 ℃ for 16 h. The reaction mixture was diluted with water and extracted with EtOAc. The combined organic layers were washed with brine, dried over Na_2SO_4, filtered, and concentrated. The residue was purified by column chromatography (hexane/EtOAc = 10/1) to give compound **12** in 55% yield (39.0 mg) as a yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.50 – 7.35 (m, 5H), 5.42 (s, 1H), 5.33 (s, 1H), 4.97 (s, 1H), 4.84 (s, 1H), 3.72 (s, 3H), 2.66 (s, 1H), 2.49 – 2.44 (m, 1H), 1.43 (s, 9H). ^{19}F NMR (376 MHz, $CDCl_3$) δ -95.4 (s, 2F). ^{13}C NMR (101 MHz, $CDCl_3$) δ 173.0, 155.7, 140.7 (t, *J* = 28.8 Hz), 136.0 (t, *J* = 27.8 Hz), 130.6, 128.9, 126.4 (t, *J* = 5.1 Hz), 121.4 (t, *J* = 242.4 Hz), 120.2 (t, *J* = 8.1 Hz), 80.6, 53.0, 52.9, 33.3, 28.8. MS (EI): m/z (%) 299 [M^+-C_4H_9+H], 119, 91, 57(100). HRMS (EI): Calculated for $C_{14}H_{15}NO_4F_2$: 299.0969 [M^+-C_4H_9+H]; Found: 299.0970.

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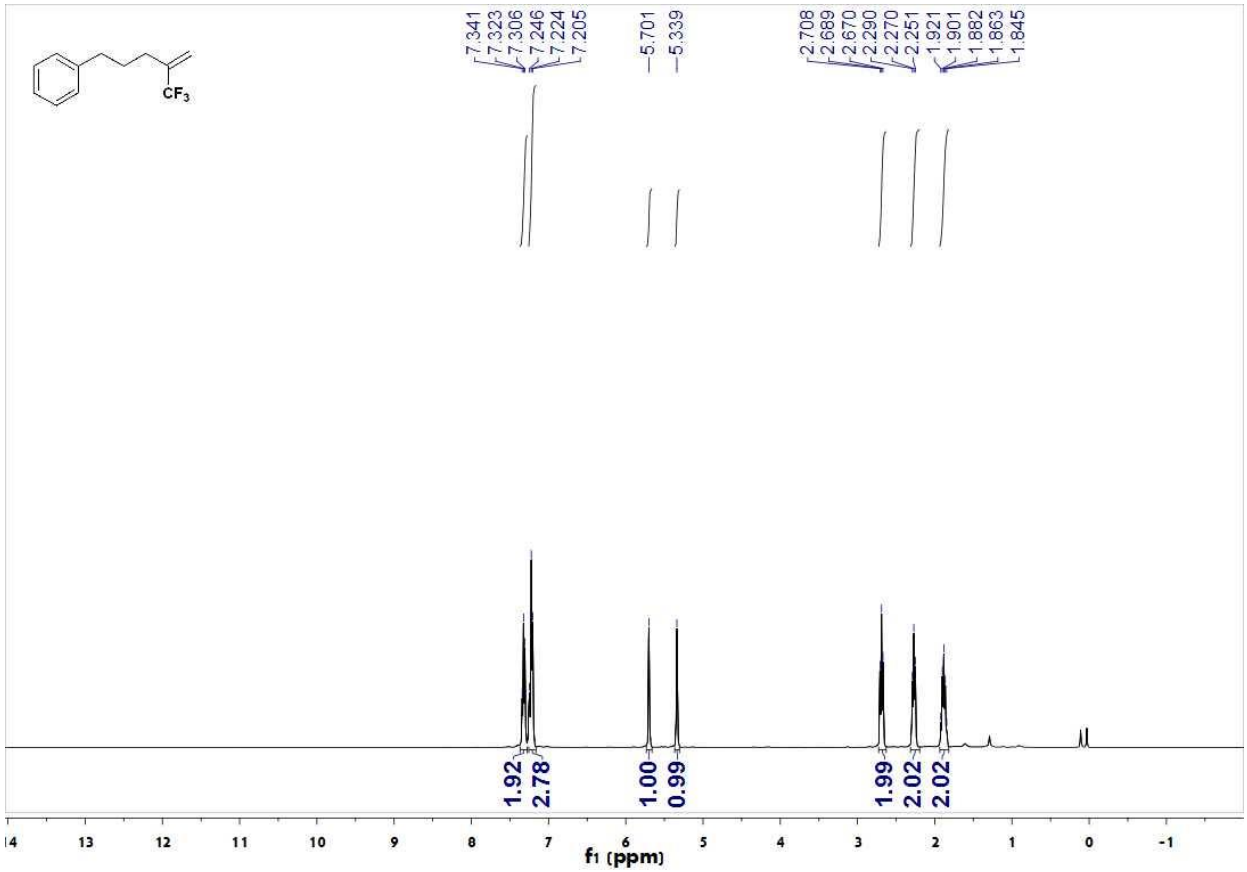
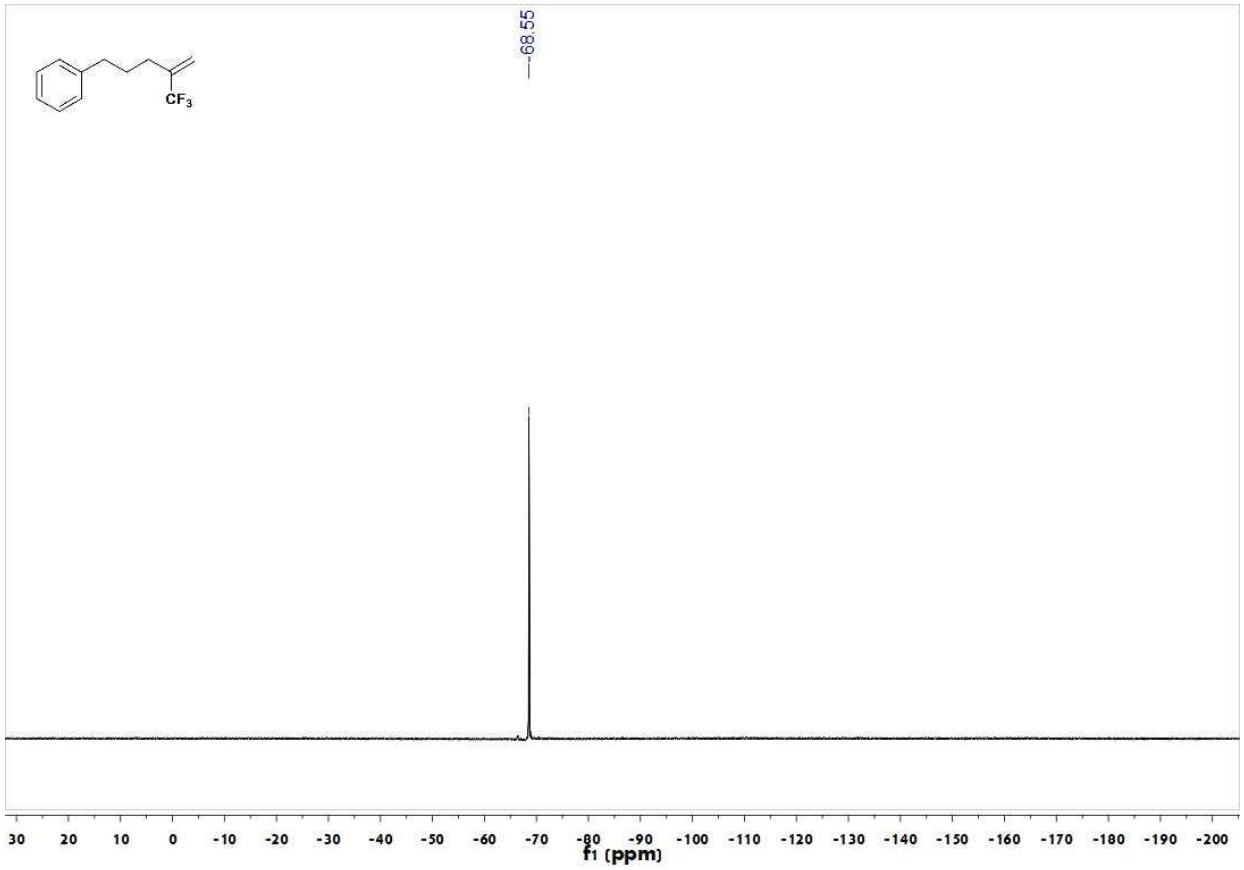
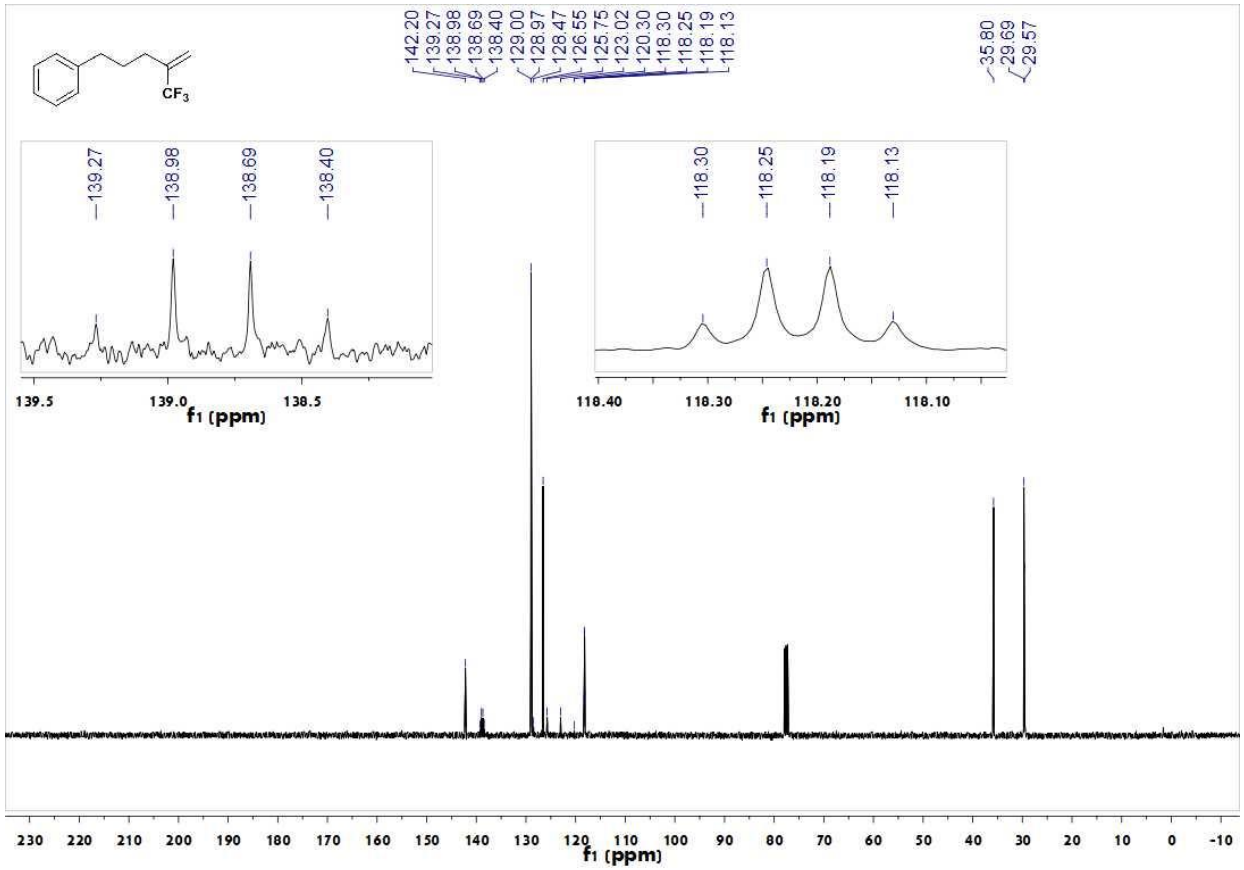
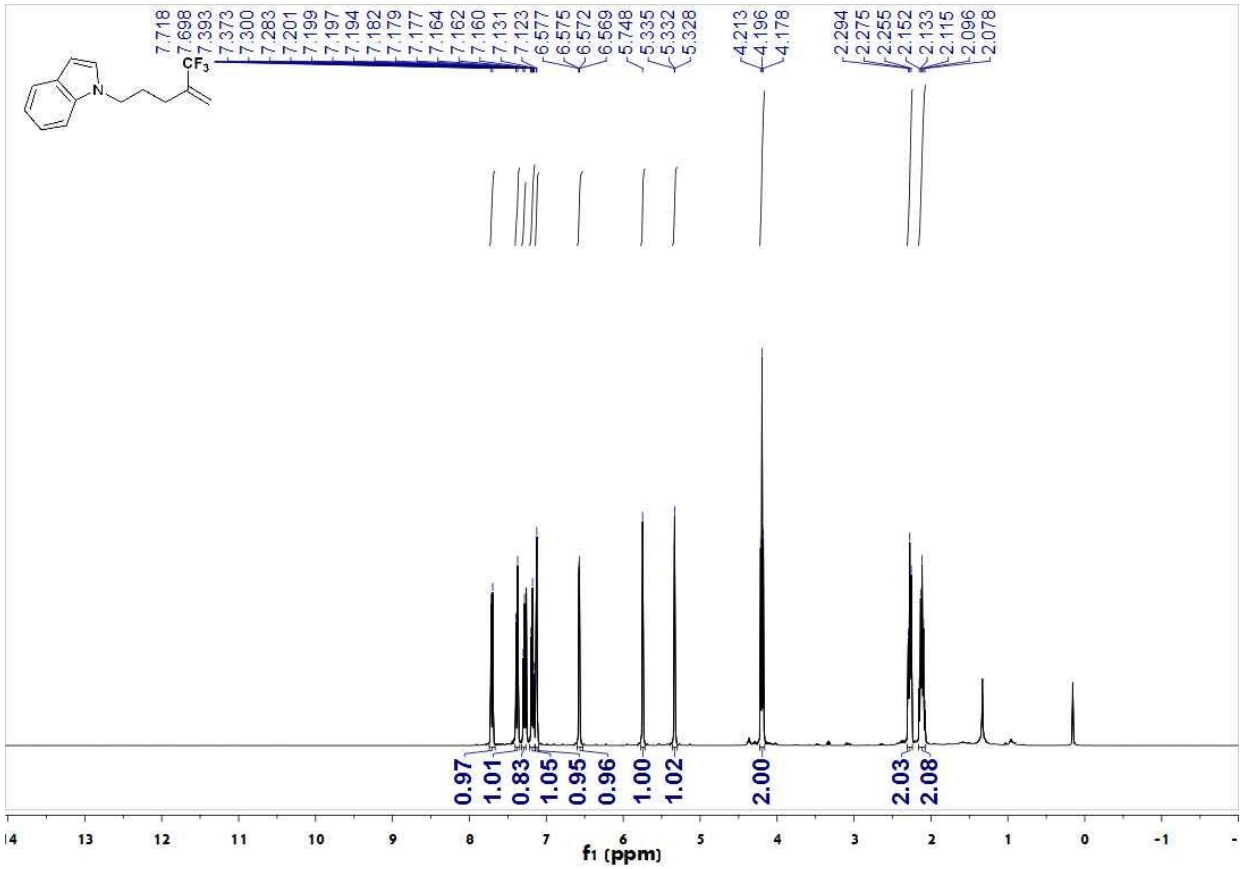
(4-(Trifluoromethyl)pent-4-en-1-yl)benzene (**5a**)

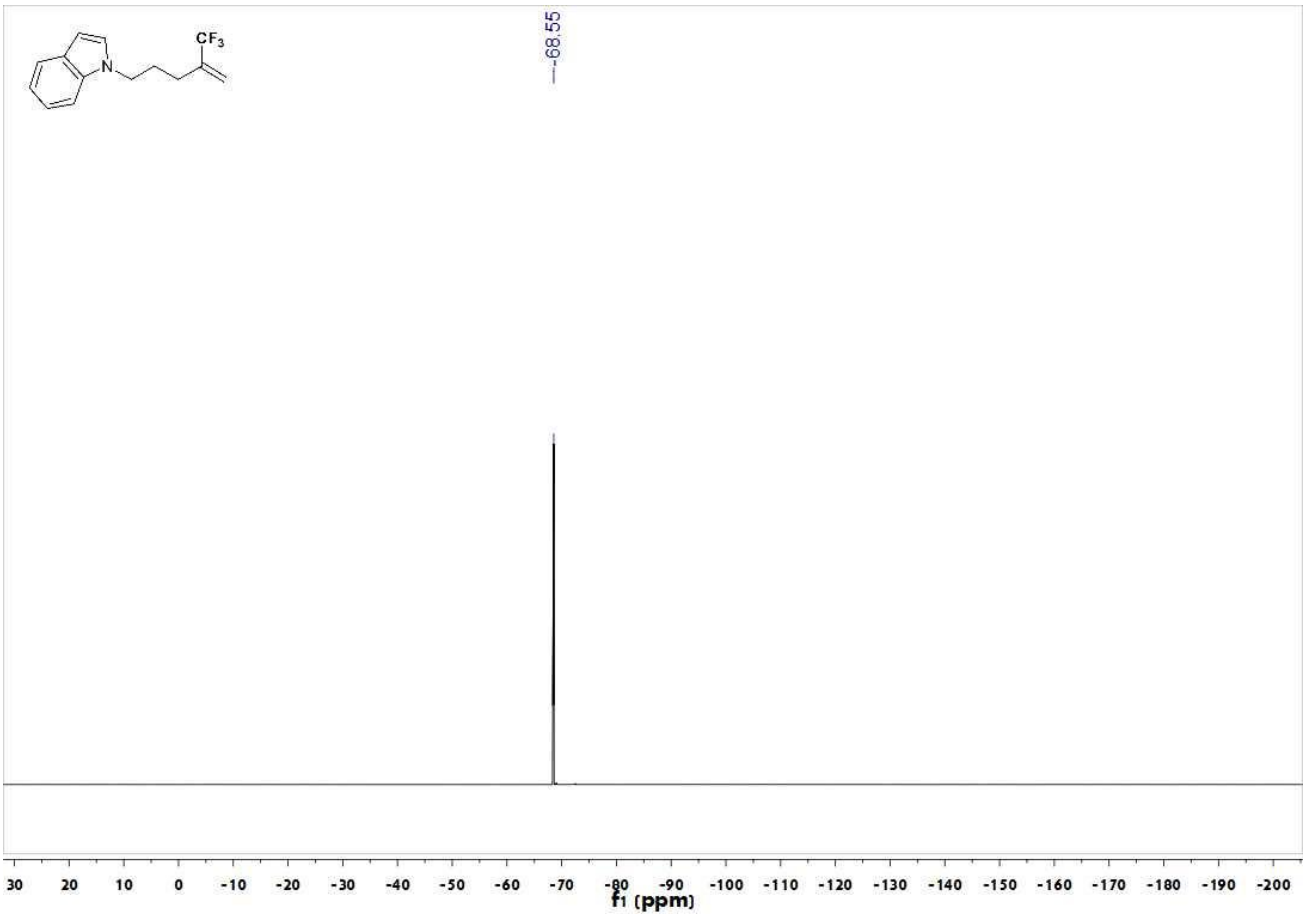


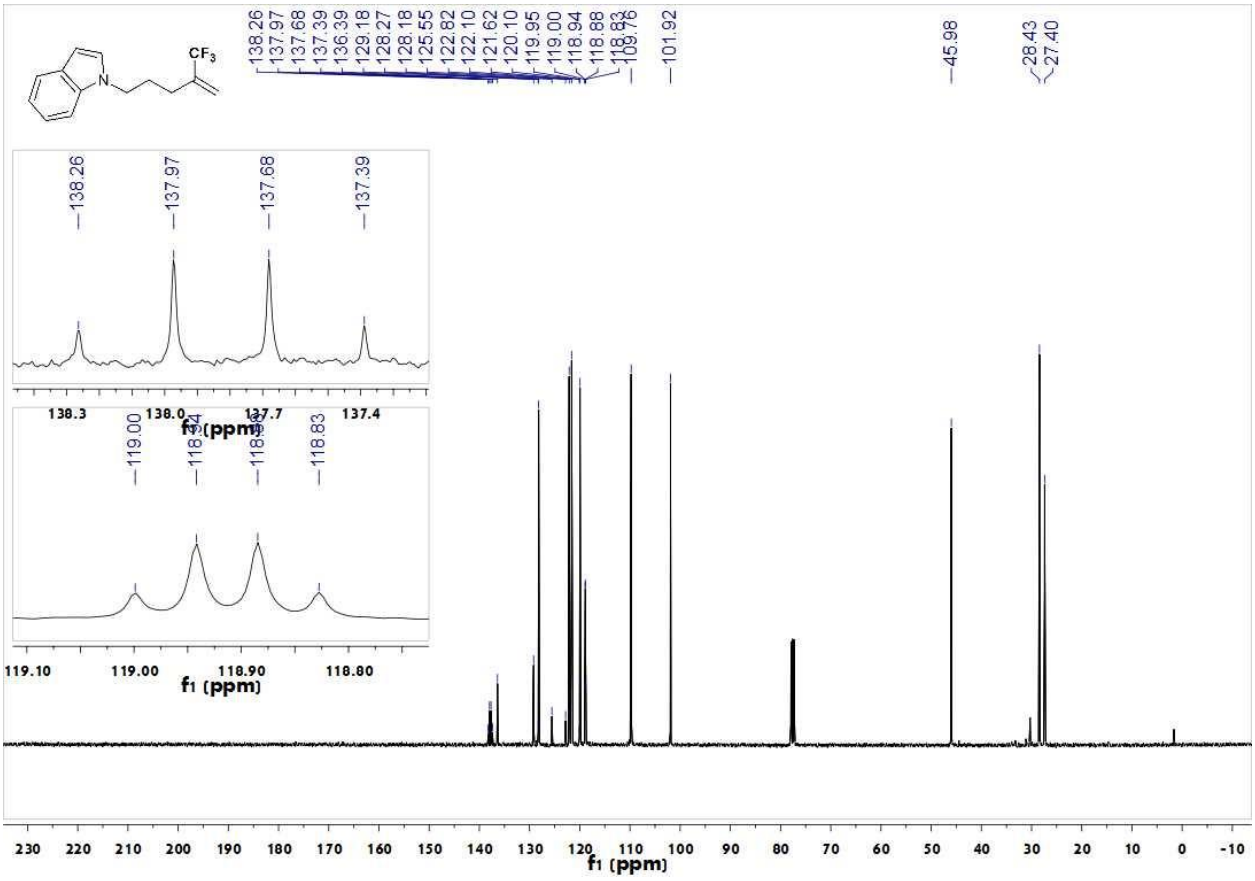




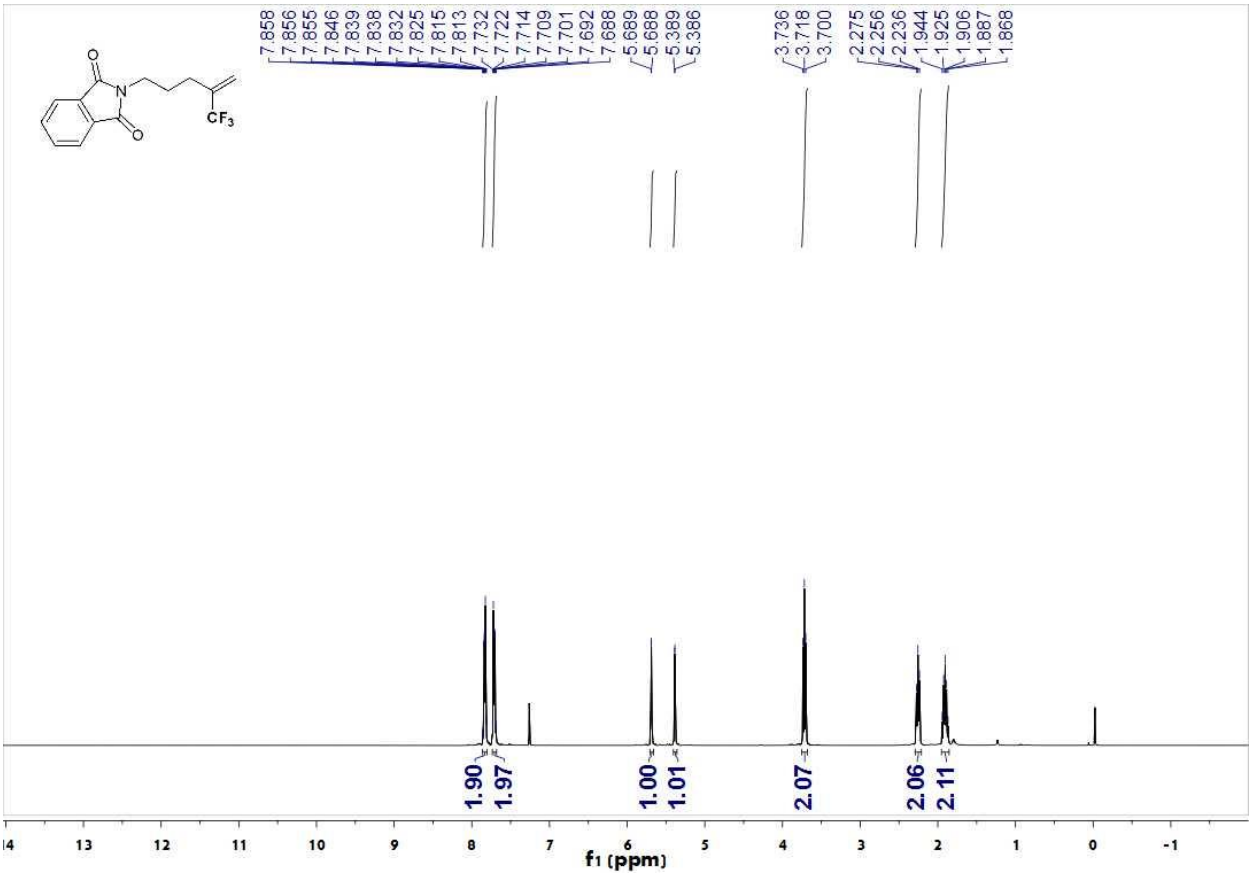
1-(4-(Trifluoromethyl)pent-4-en-1-yl)-1H-indole (**5b**).

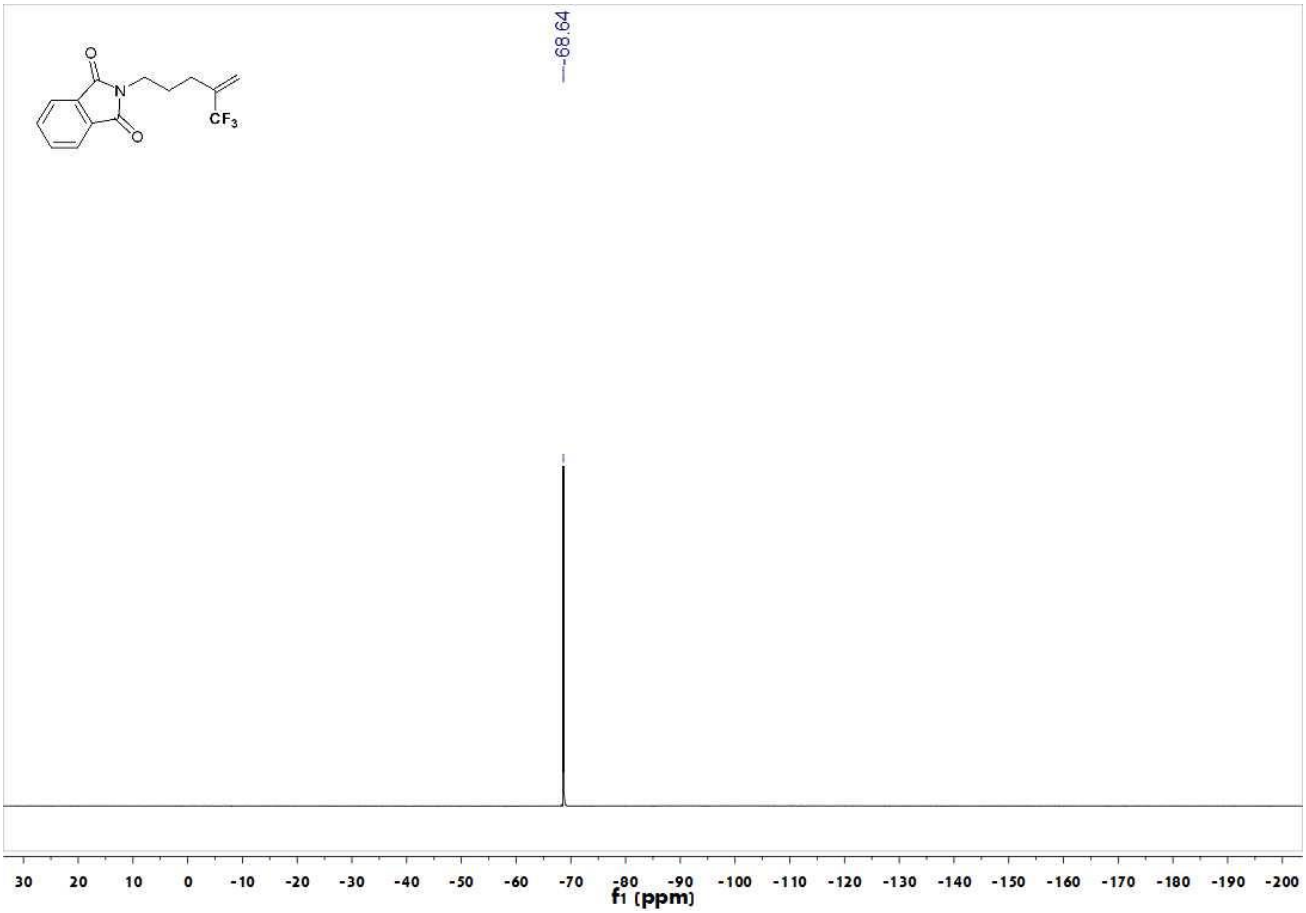


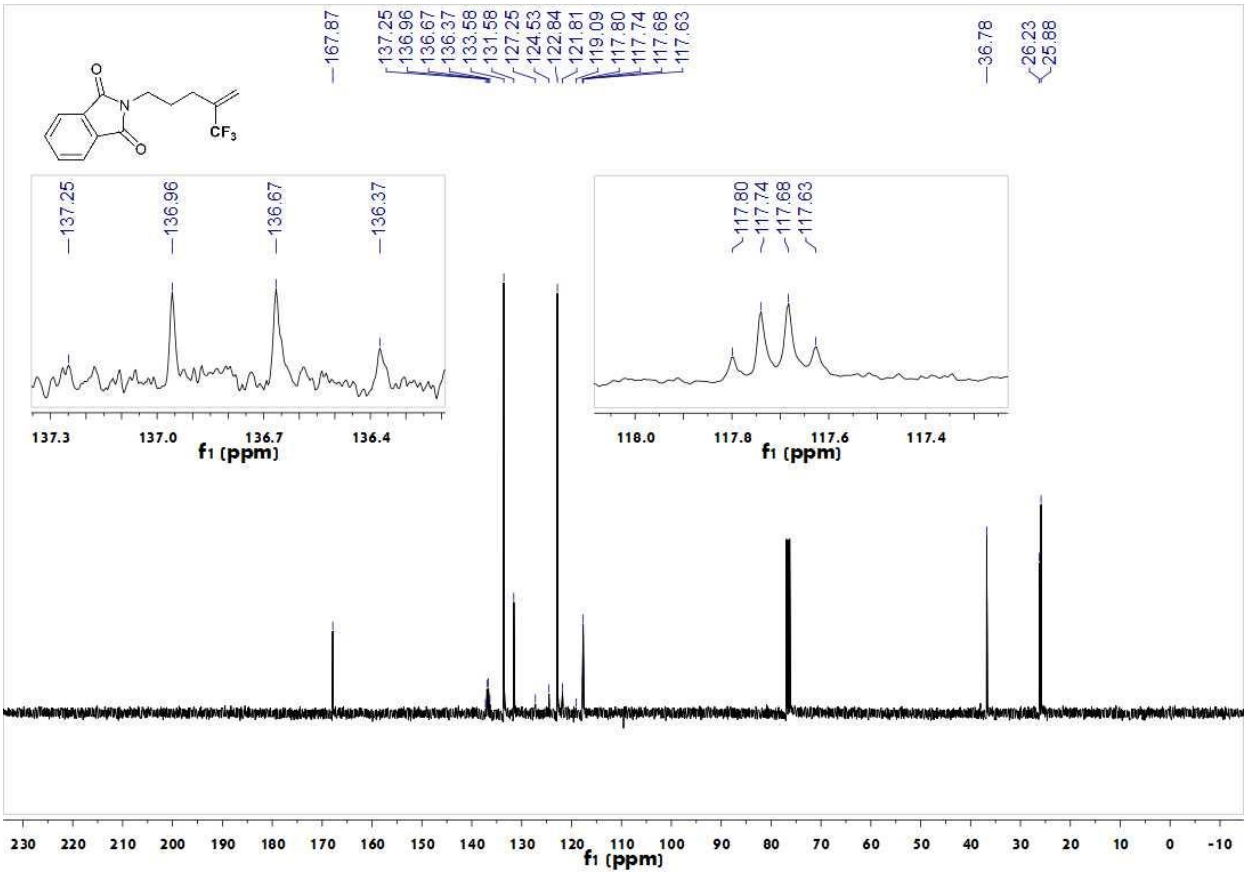

CF3
N
-68.55
30 20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200
f1 (ppm)


CF3
N
138.26
137.97
137.68
137.39
136.39
129.18
128.27
128.18
125.55
122.82
122.10
121.62
120.10
119.95
119.00
118.94
118.88
118.83
109.76
101.92
45.98
28.43
27.40
138.26
137.97
137.68
137.39
138.3 138.0 137.7 137.4
f1 (ppm)
119.00
118.83
119.10 119.00 118.90 118.80
f1 (ppm)
230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

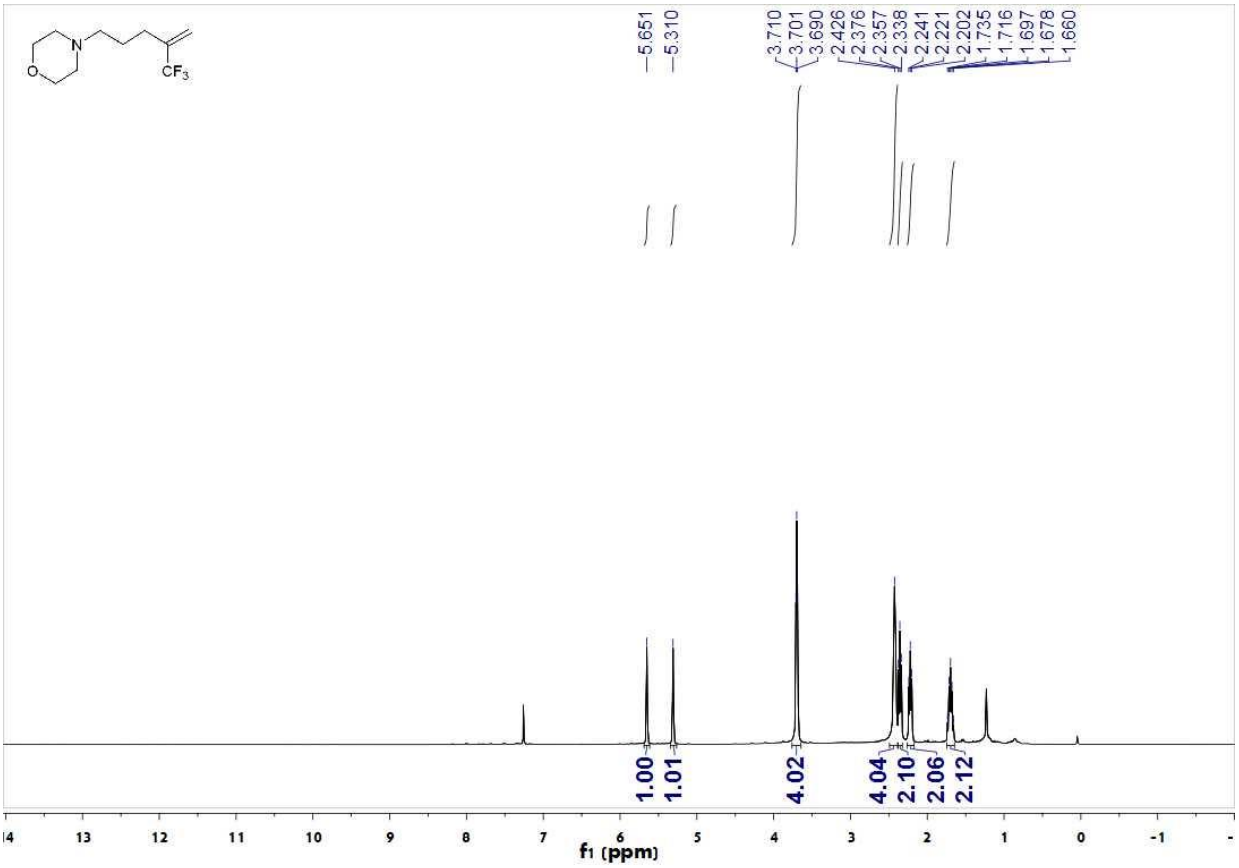
2-(4-(Trifluoromethyl)pent-4-en-1-yl)isoindoline-1,3-dione（5c)

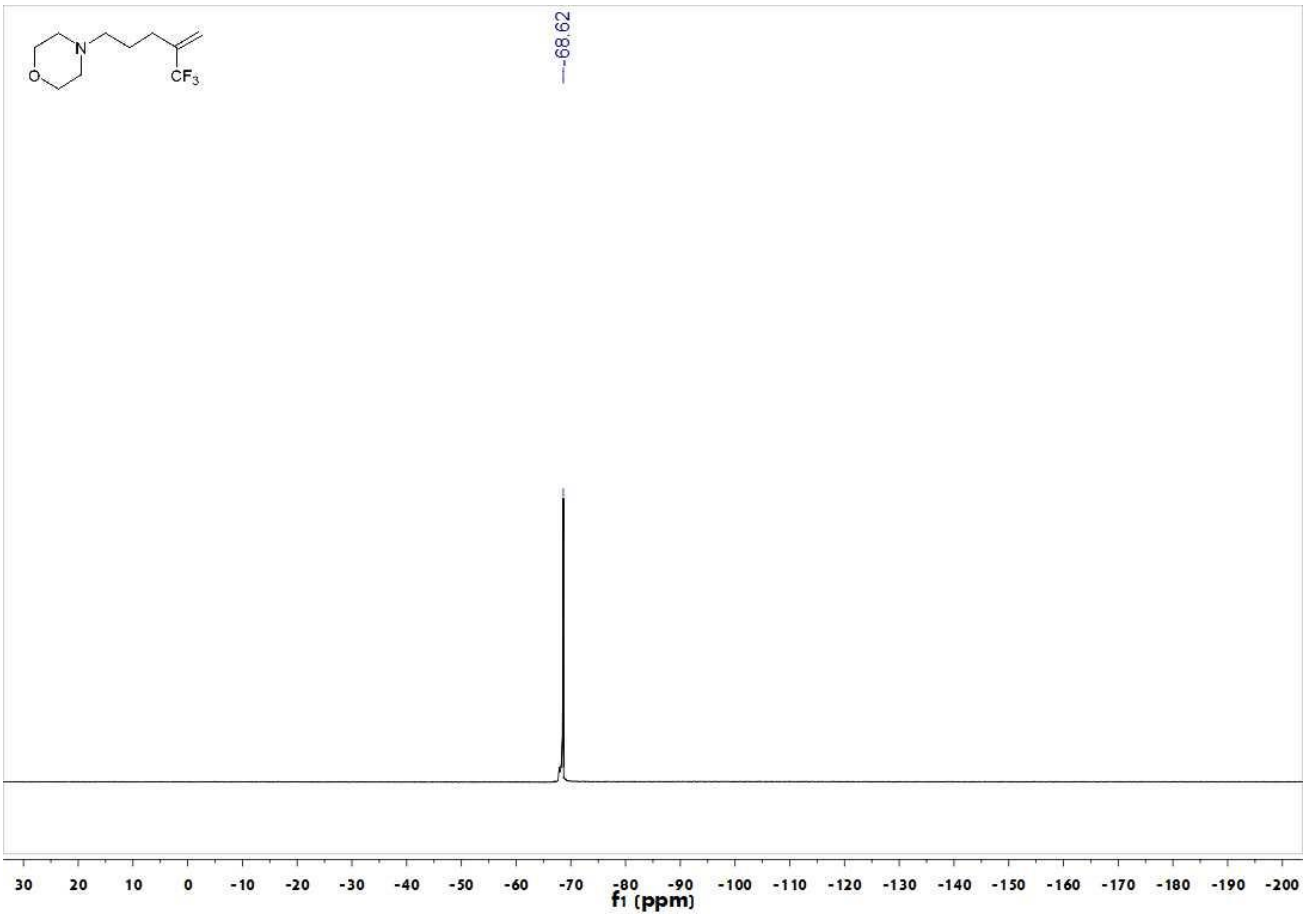


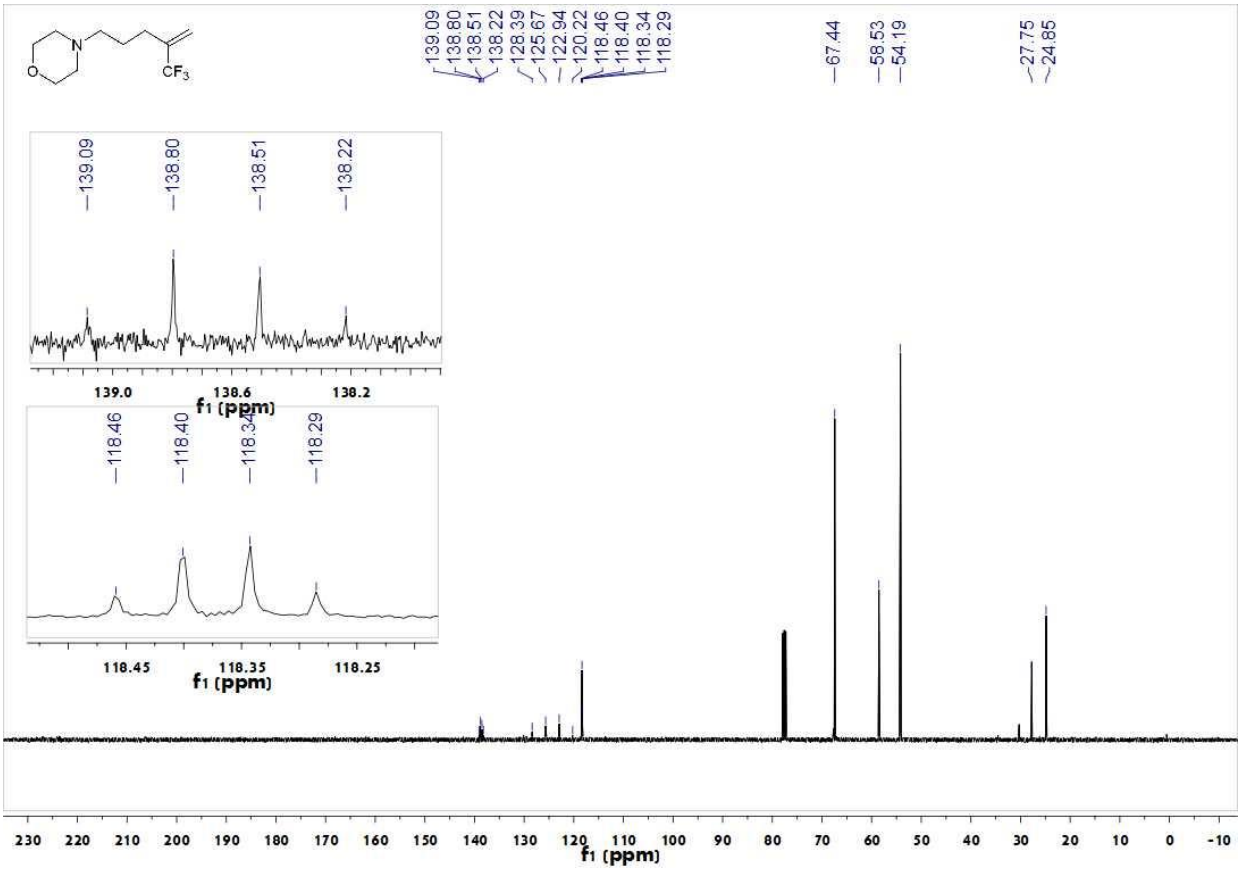




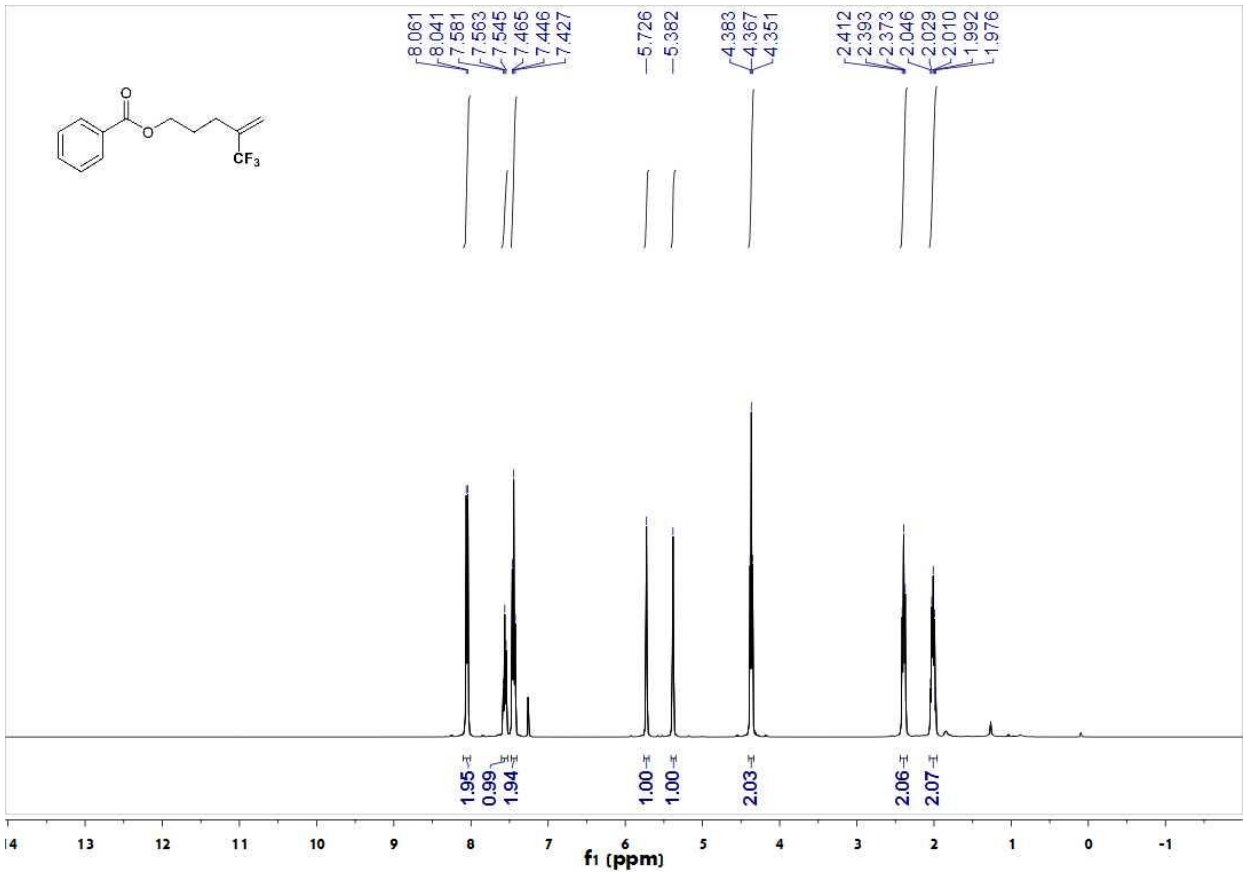
4-(4-(Trifluoromethyl)pent-4-en-1-yl)morpholine (5d)

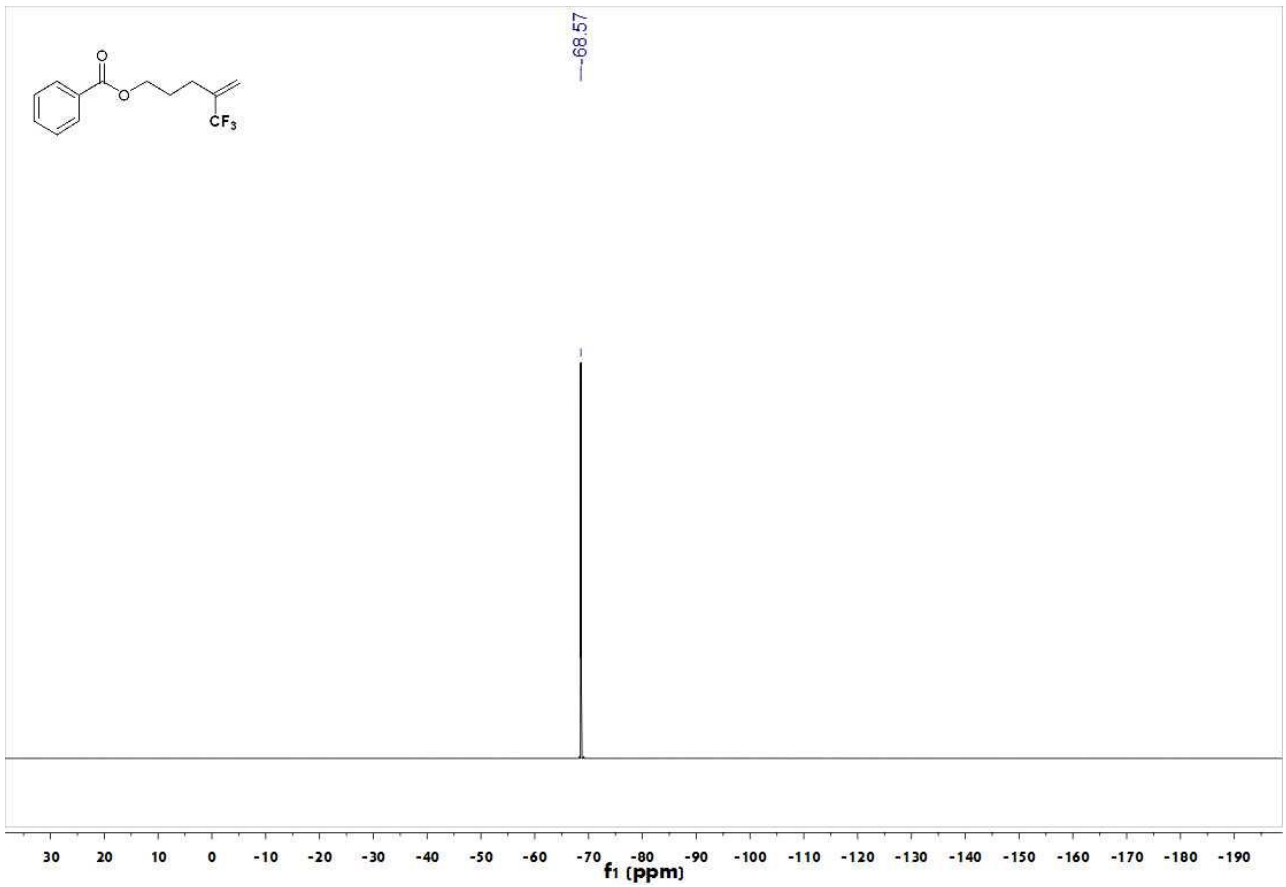


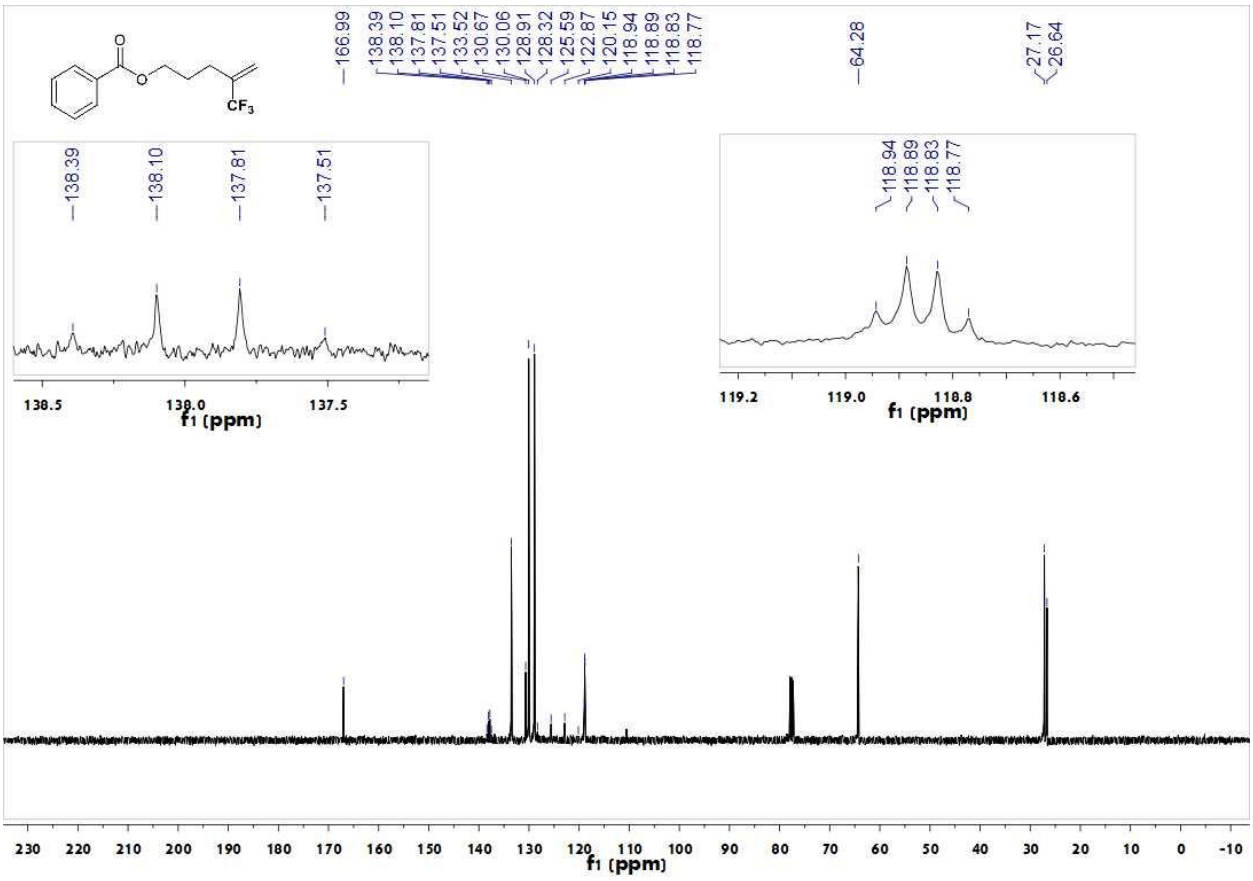

-68.62
f1 (ppm)


139.09
138.80
138.51
138.22
128.39
125.67
122.94
120.22
118.46
118.40
118.34
118.29
67.44
58.53
54.19
27.75
24.85
f1 (ppm)

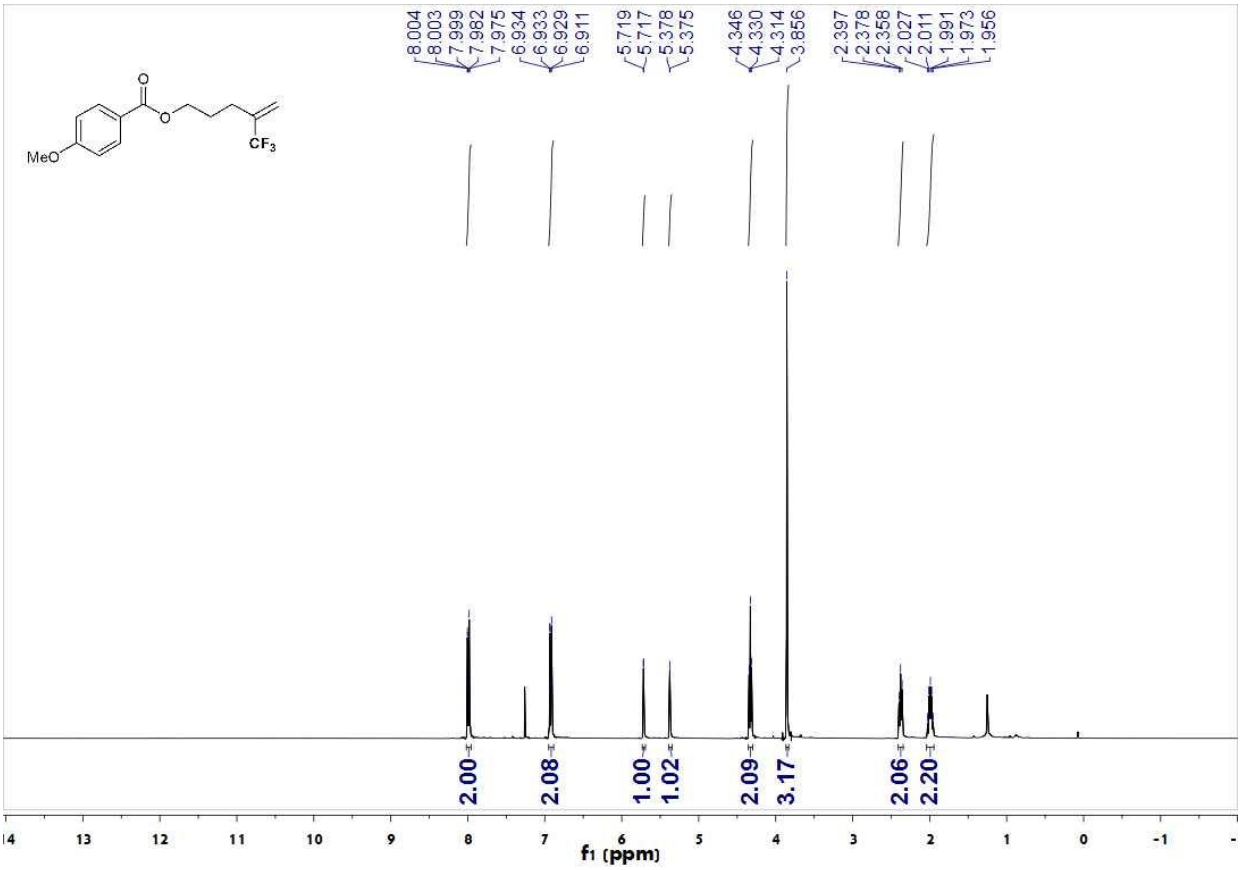
4-(Trifluoromethyl)pent-4-en-1-yl benzoate (5e)

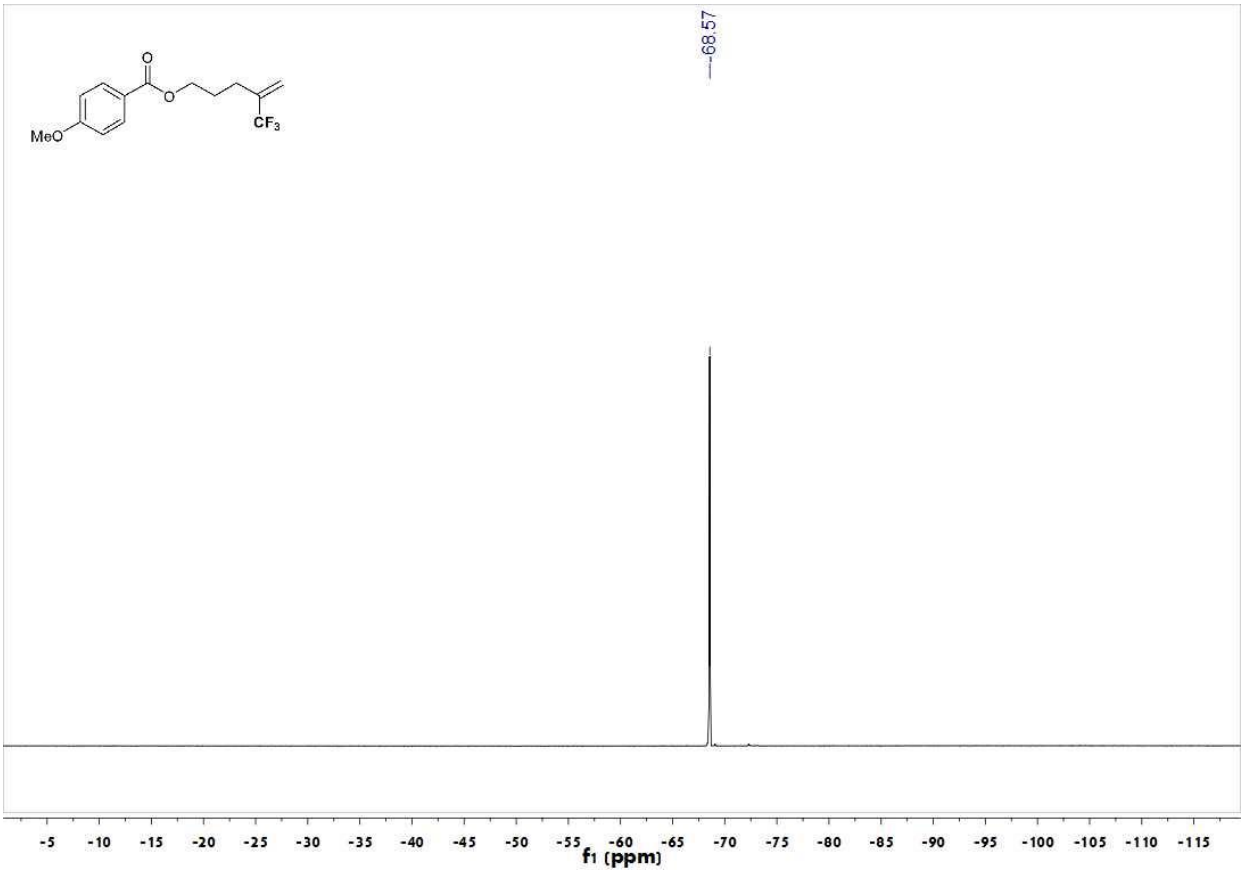


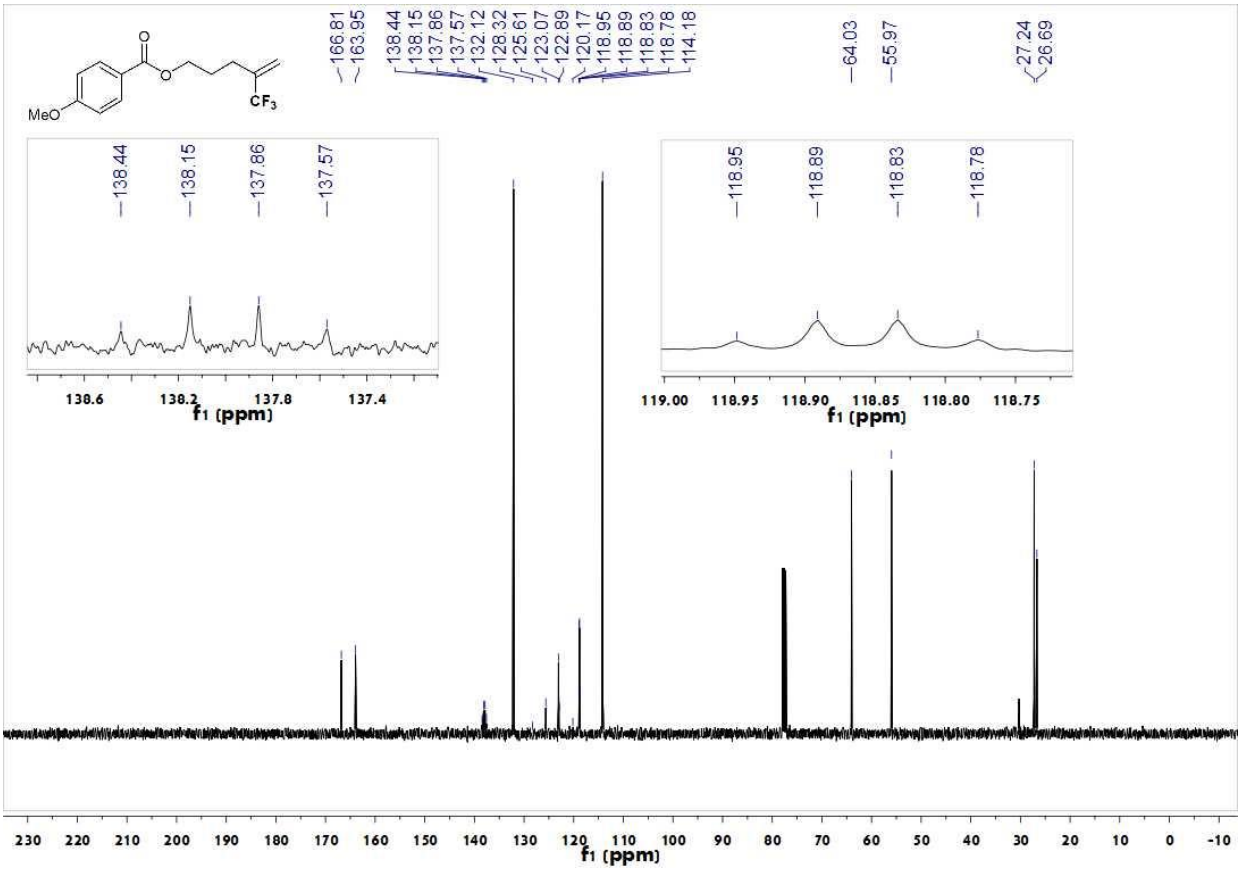




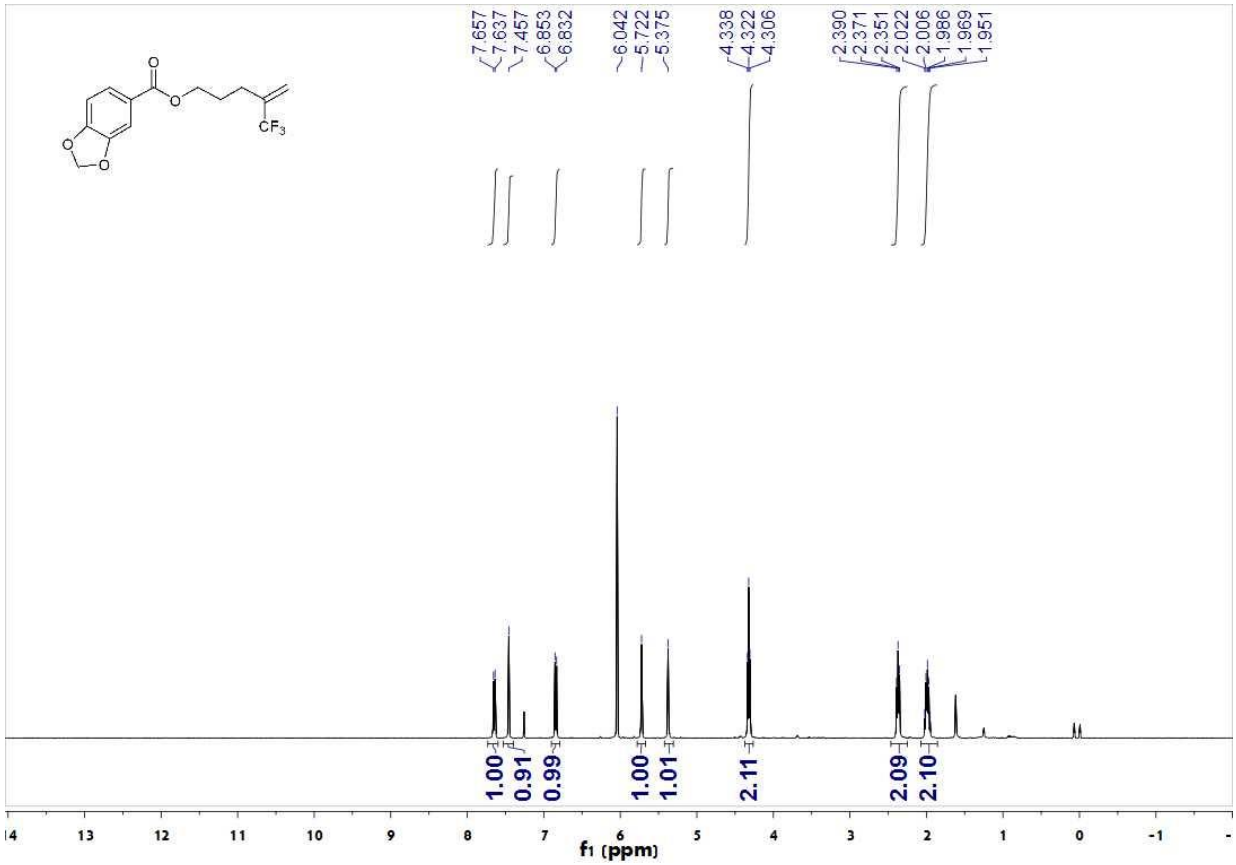
4-(Trifluoromethyl)pent-4-en-1-yl 4-methoxybenzoate (5f)

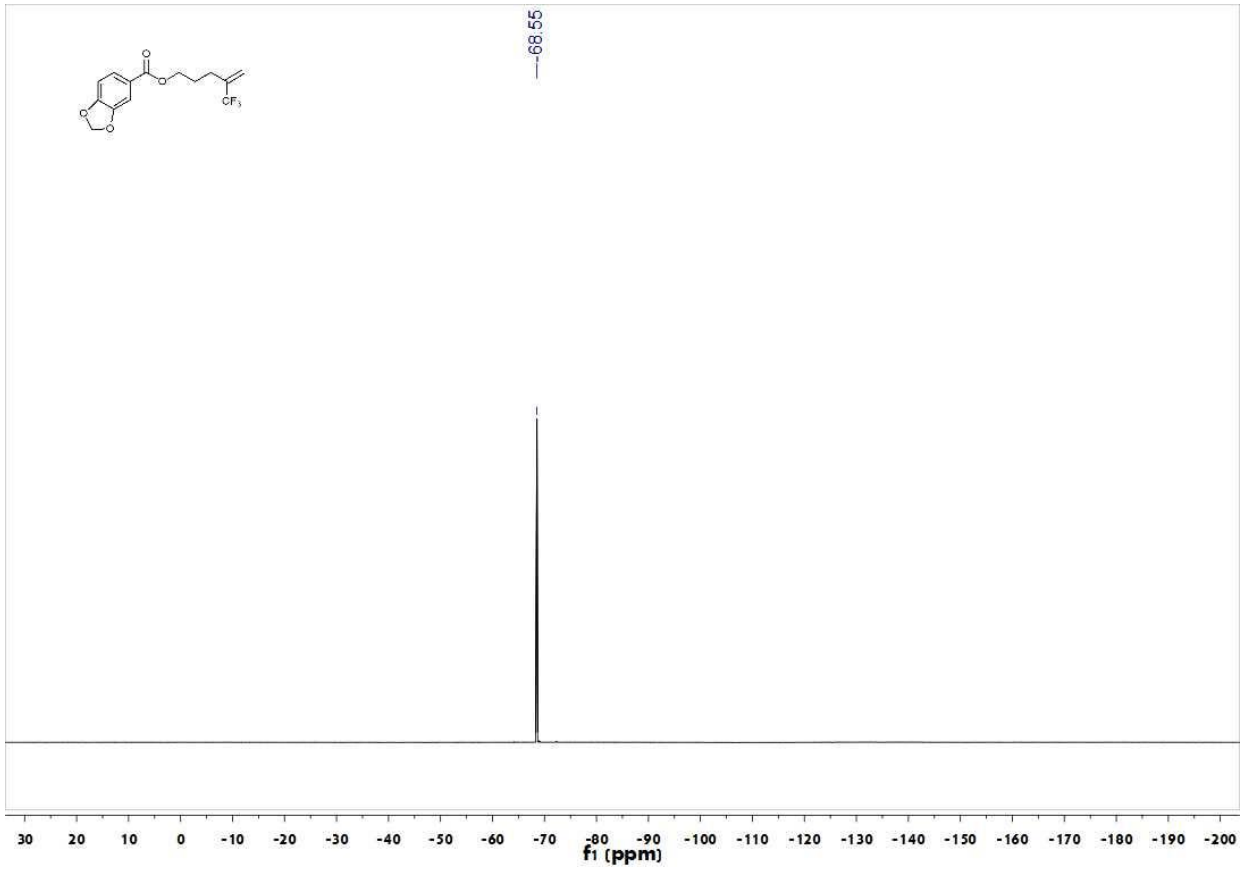


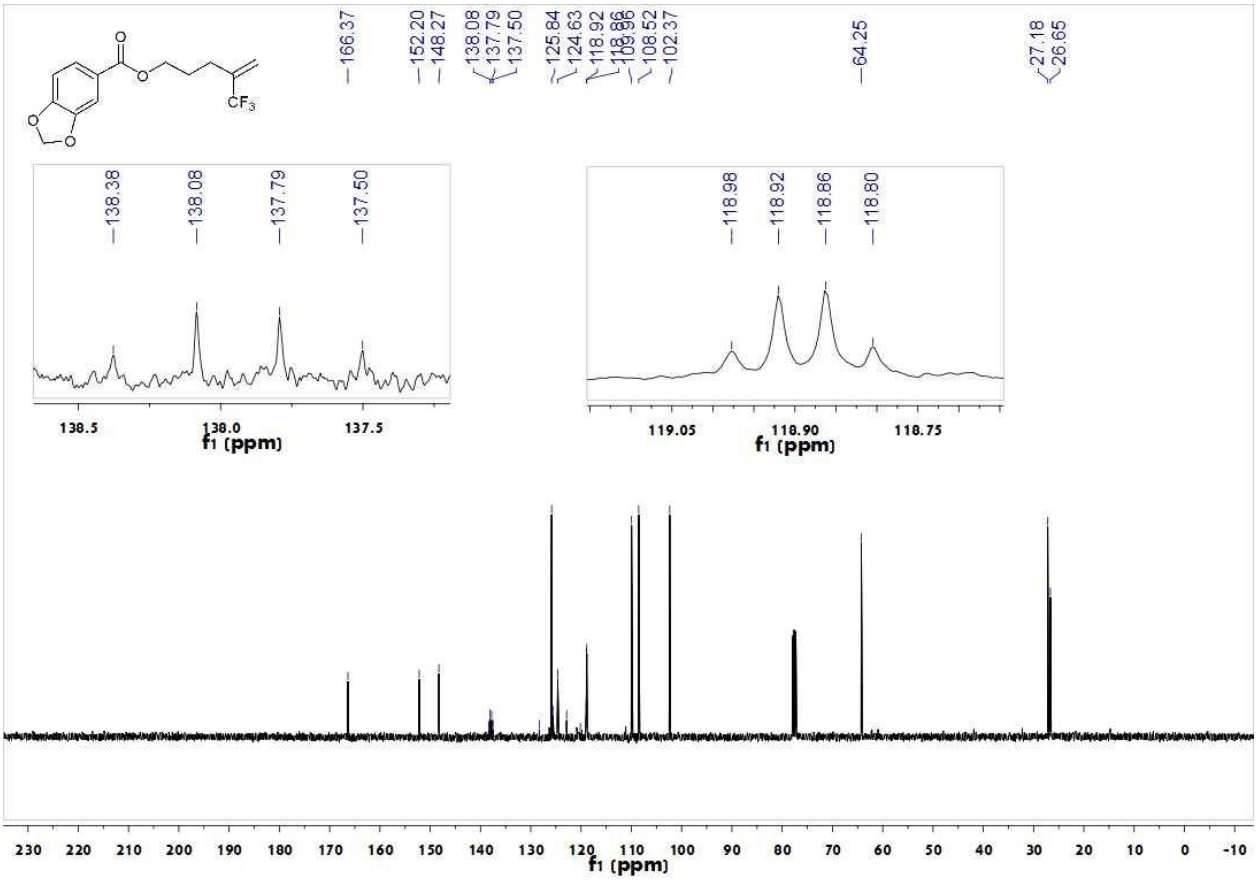

MeO
O
O
CF3
-68.57
-5 -10 -15 -20 -25 -30 -35 -40 -45 -50 -55 -60 -65 -70 -75 -80 -85 -90 -95 -100 -105 -110 -115
f1 (ppm)


MeO
O
O
CF3
166.81
163.95
138.44
138.15
137.86
137.57
132.12
128.32
125.61
123.07
122.89
120.17
118.95
118.89
118.83
118.78
114.18
64.03
55.97
27.24
26.69
138.44
138.15
137.86
137.57
138.6 138.2 137.8 137.4
f1 (ppm)
118.95
118.89
118.83
118.78
119.00 118.95 118.90 118.85 118.80 118.75
f1 (ppm)
230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

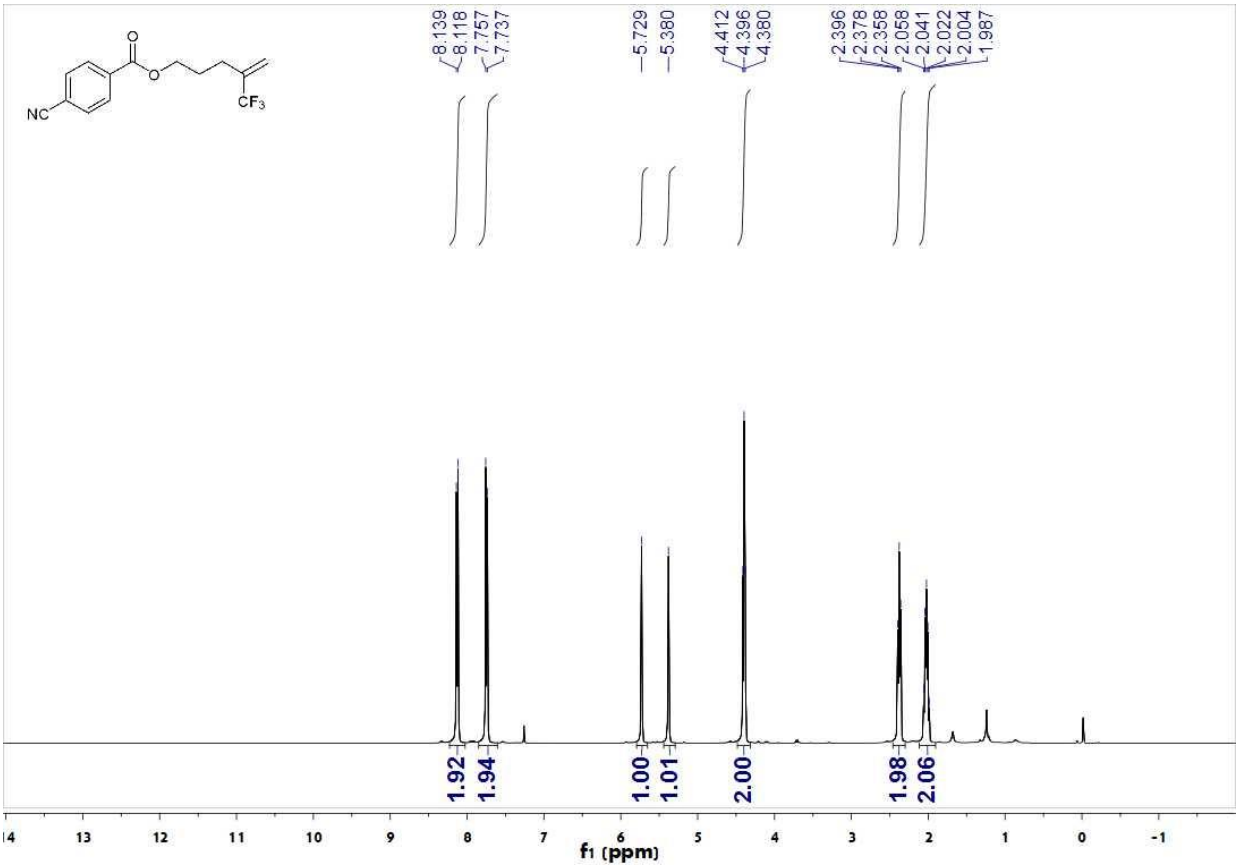
4-(Trifluoromethyl)pent-4-en-1-ylbenzo[*d*][1,3]dioxole-5-carboxylate (5g)

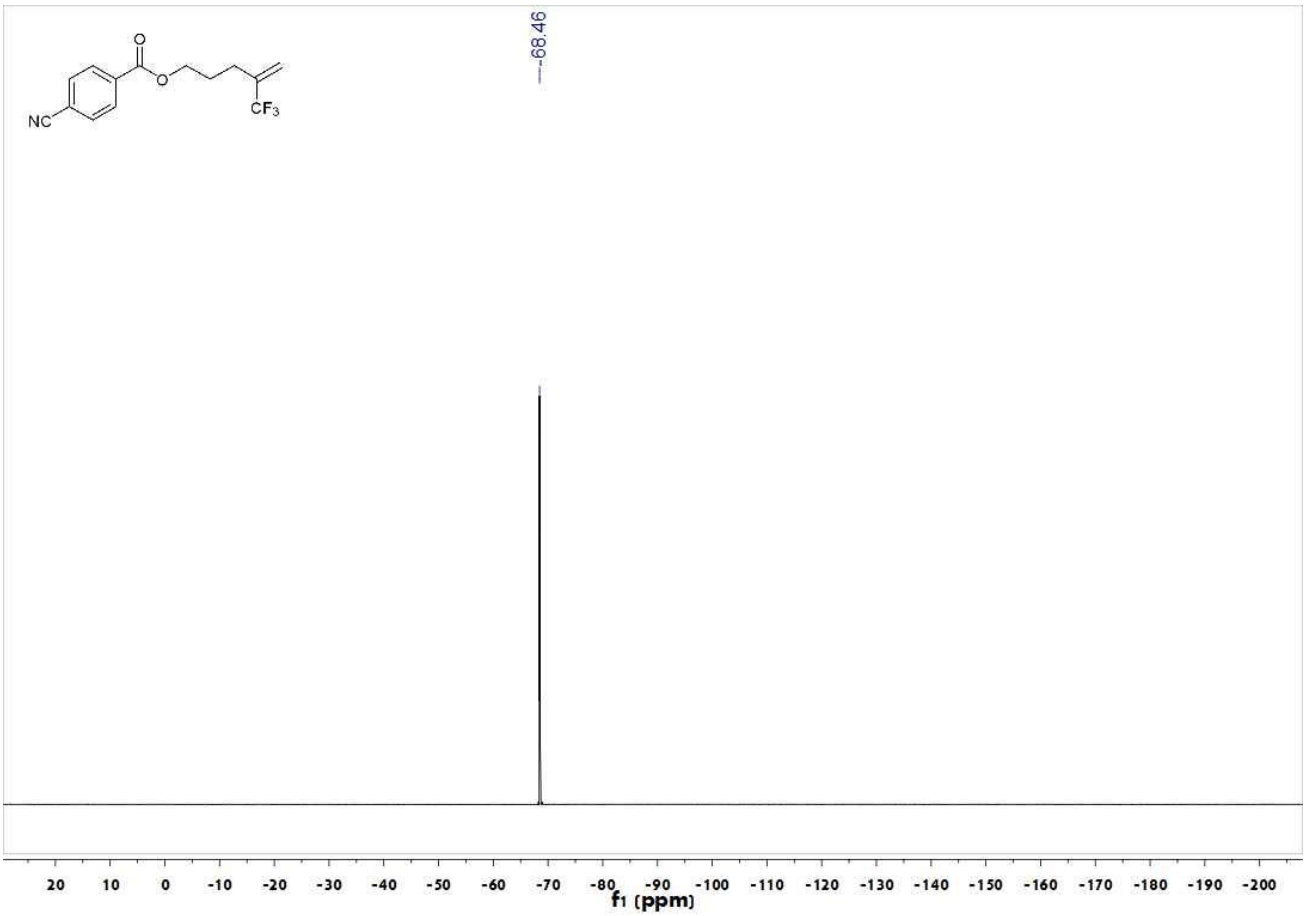


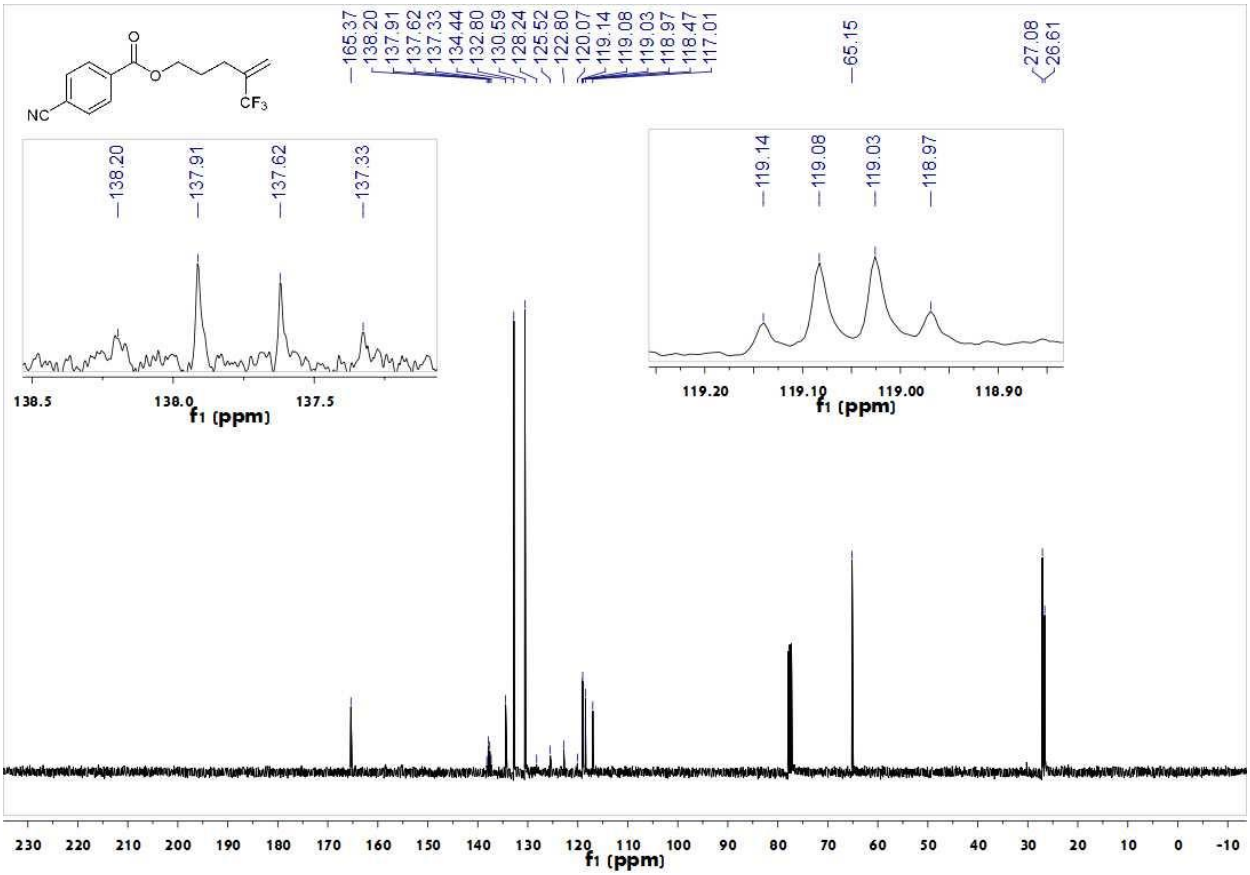




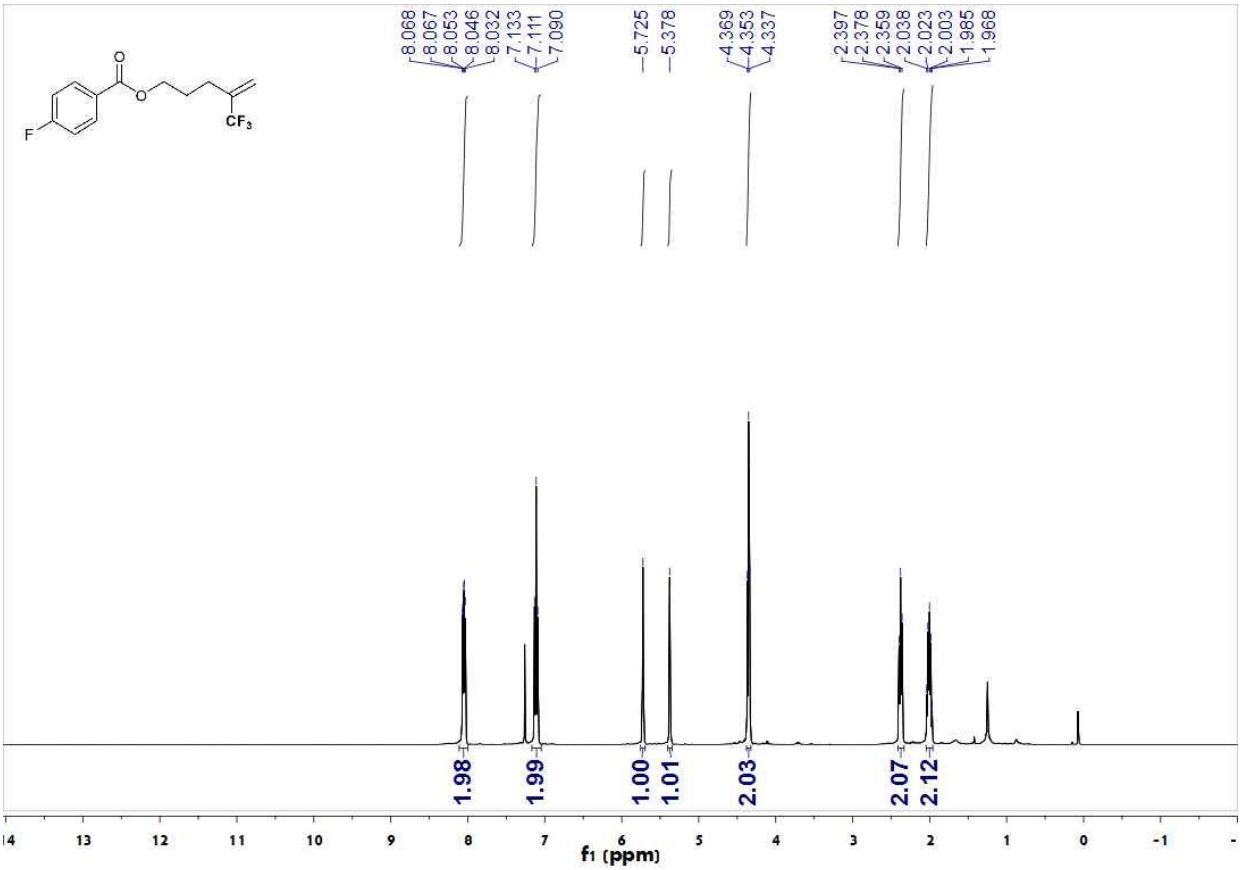
4-(Trifluoromethyl)pent-4-en-1-yl 4-cyanobenzoate (5h)

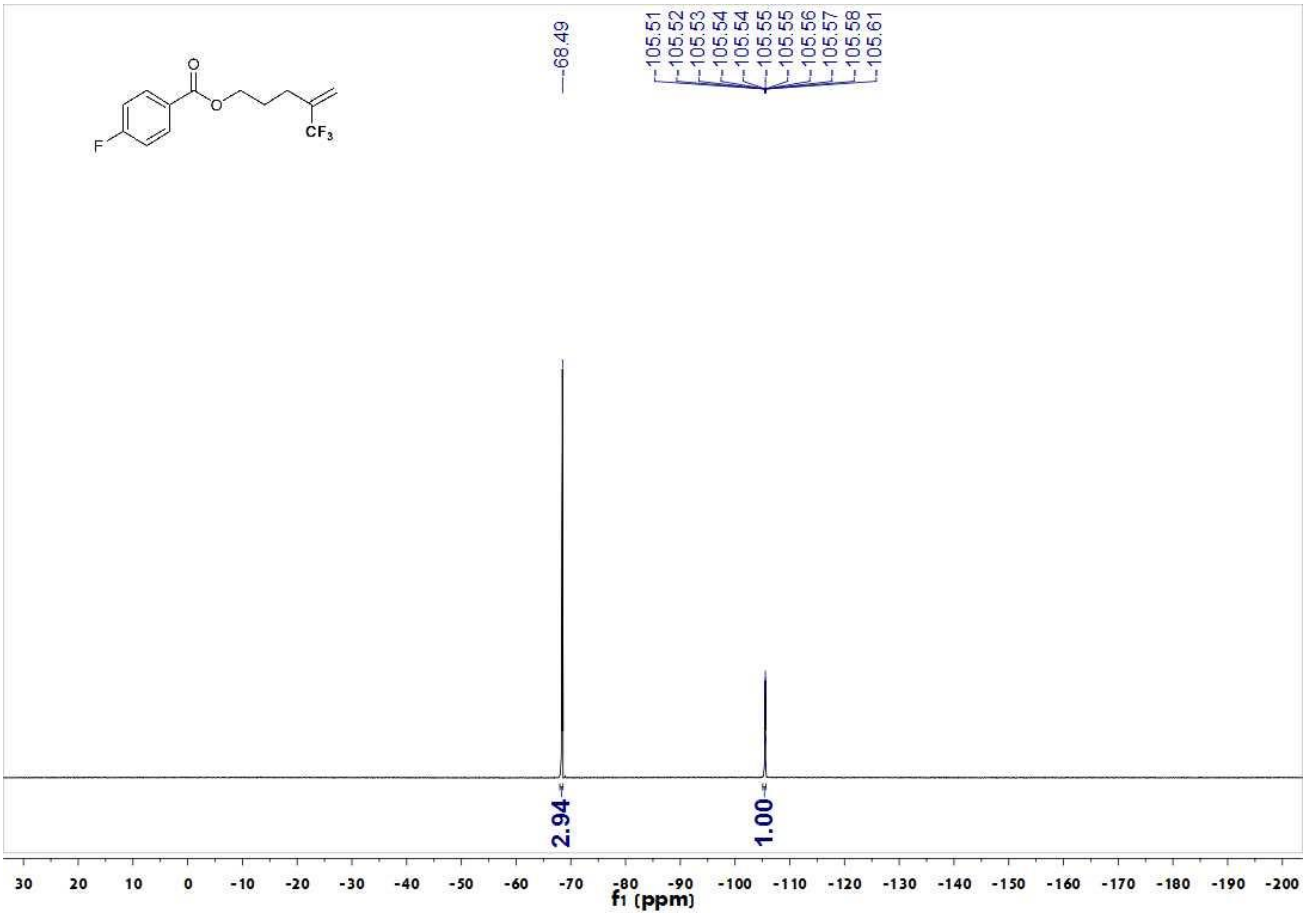


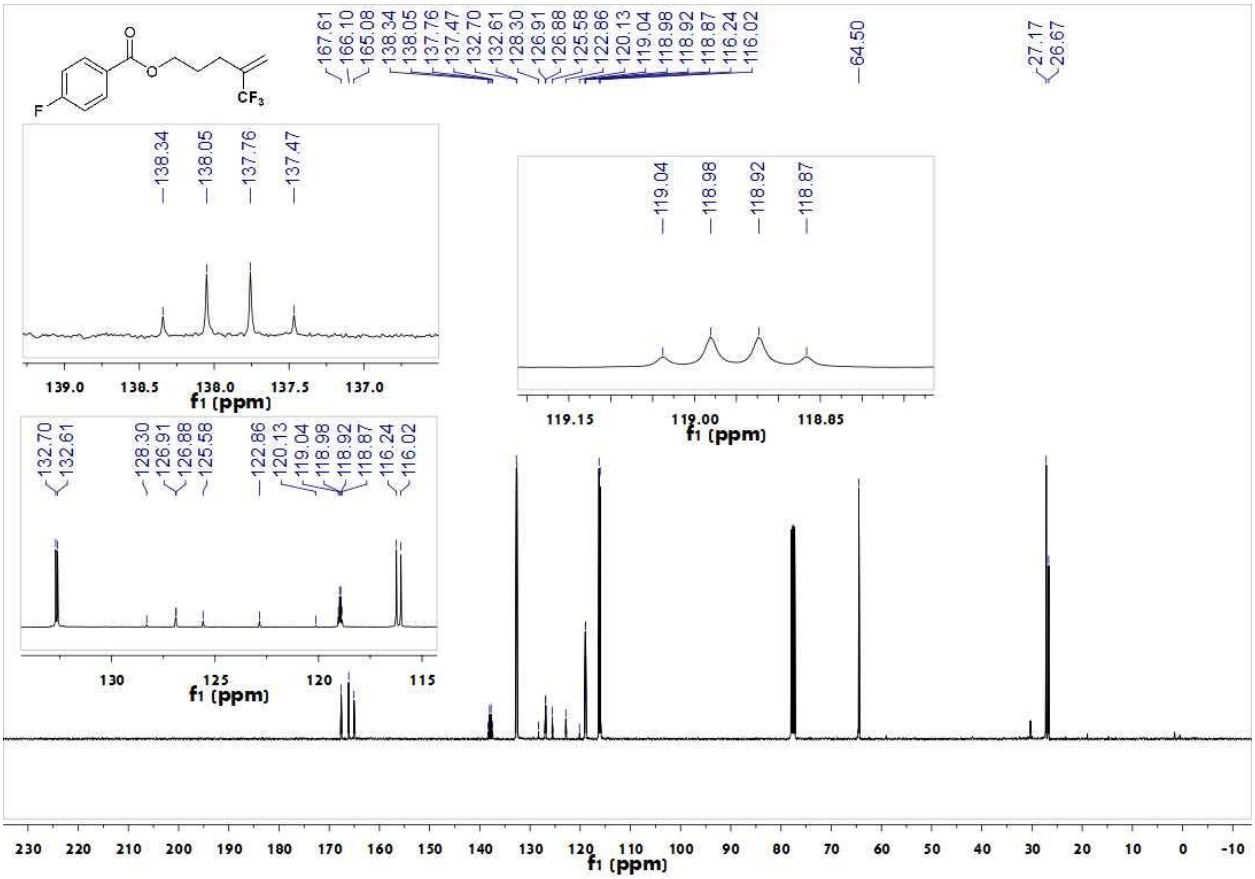

NC
CF3
-68.46
f1 (ppm)


NC
CF3
165.37
138.20
137.91
137.62
137.33
134.44
132.80
130.59
128.24
125.52
122.80
120.07
119.14
119.08
119.03
118.97
118.47
117.01
65.15
27.08
26.61
138.20
137.91
137.62
137.33
f1 (ppm)
119.14
119.08
119.03
118.97
f1 (ppm)
f1 (ppm)

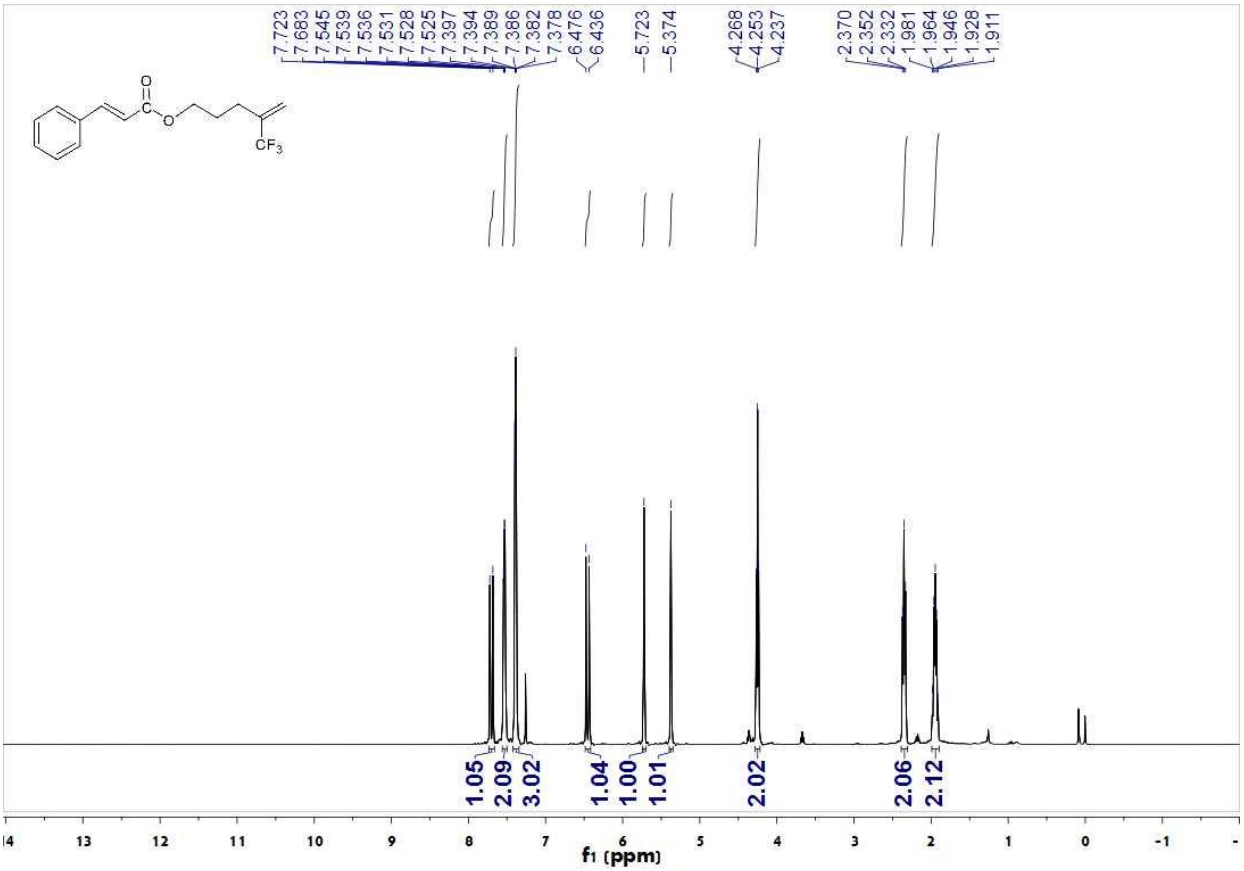
4-(Trifluoromethyl)pent-4-en-1-yl 4-fluorobenzoate(5i)

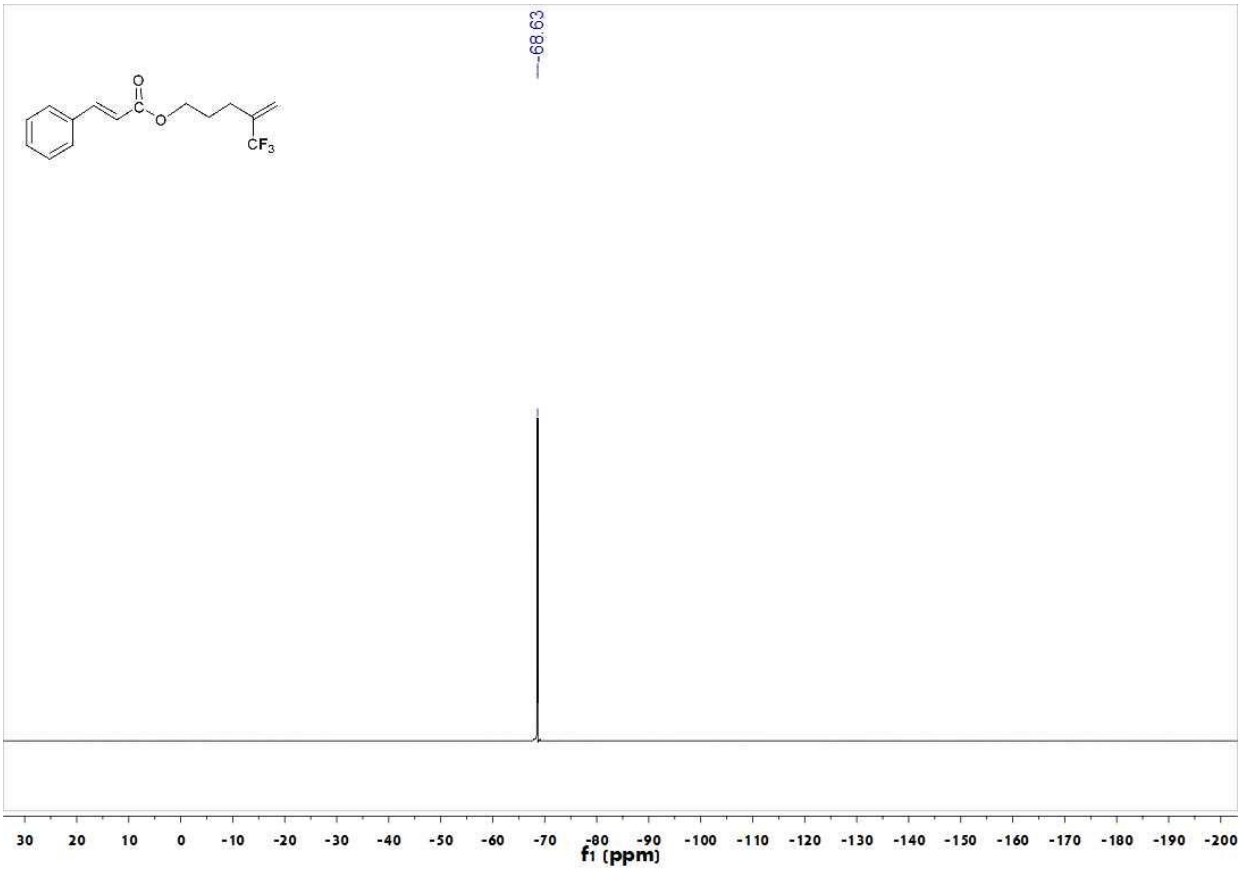


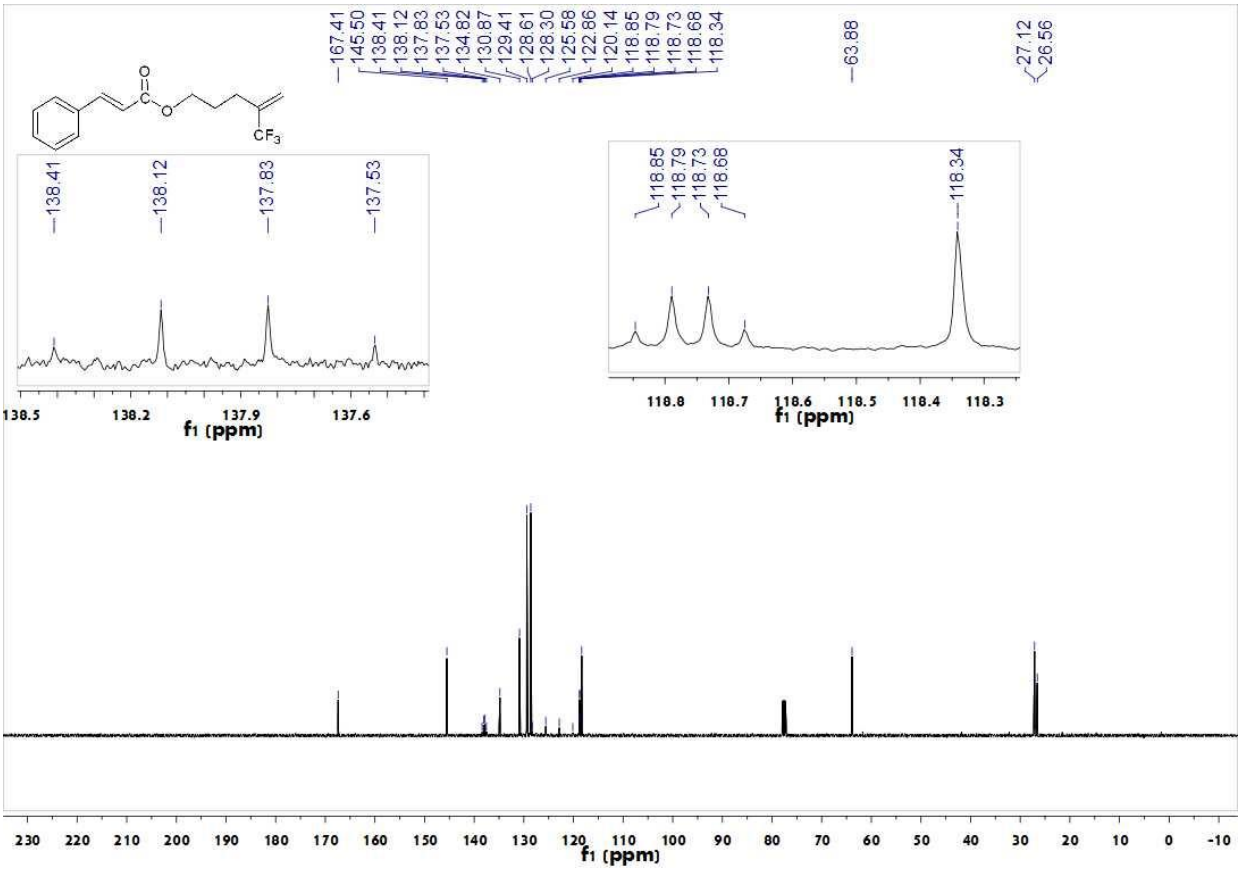




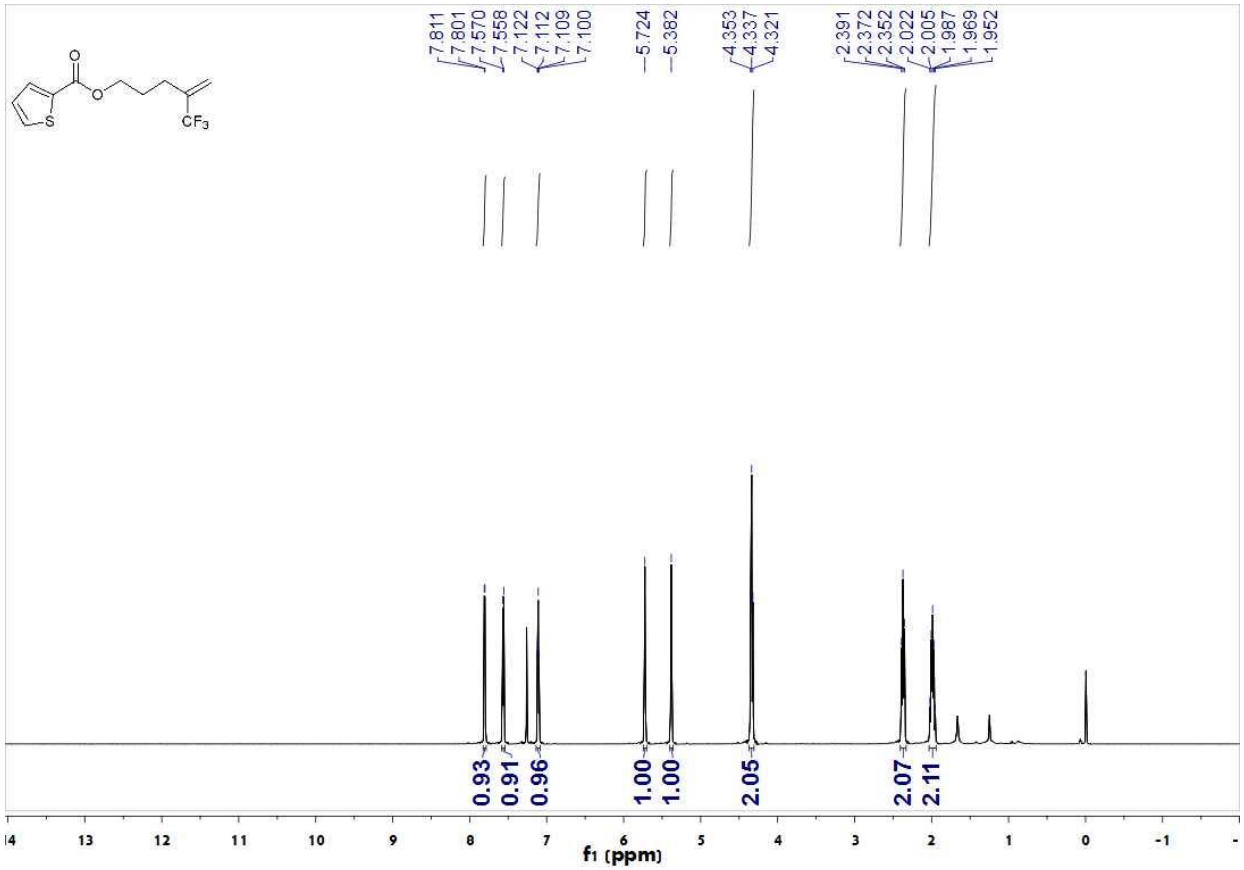
4-(Trifluoromethyl)pent-4-en-1-yl cinnamate (**5j**)

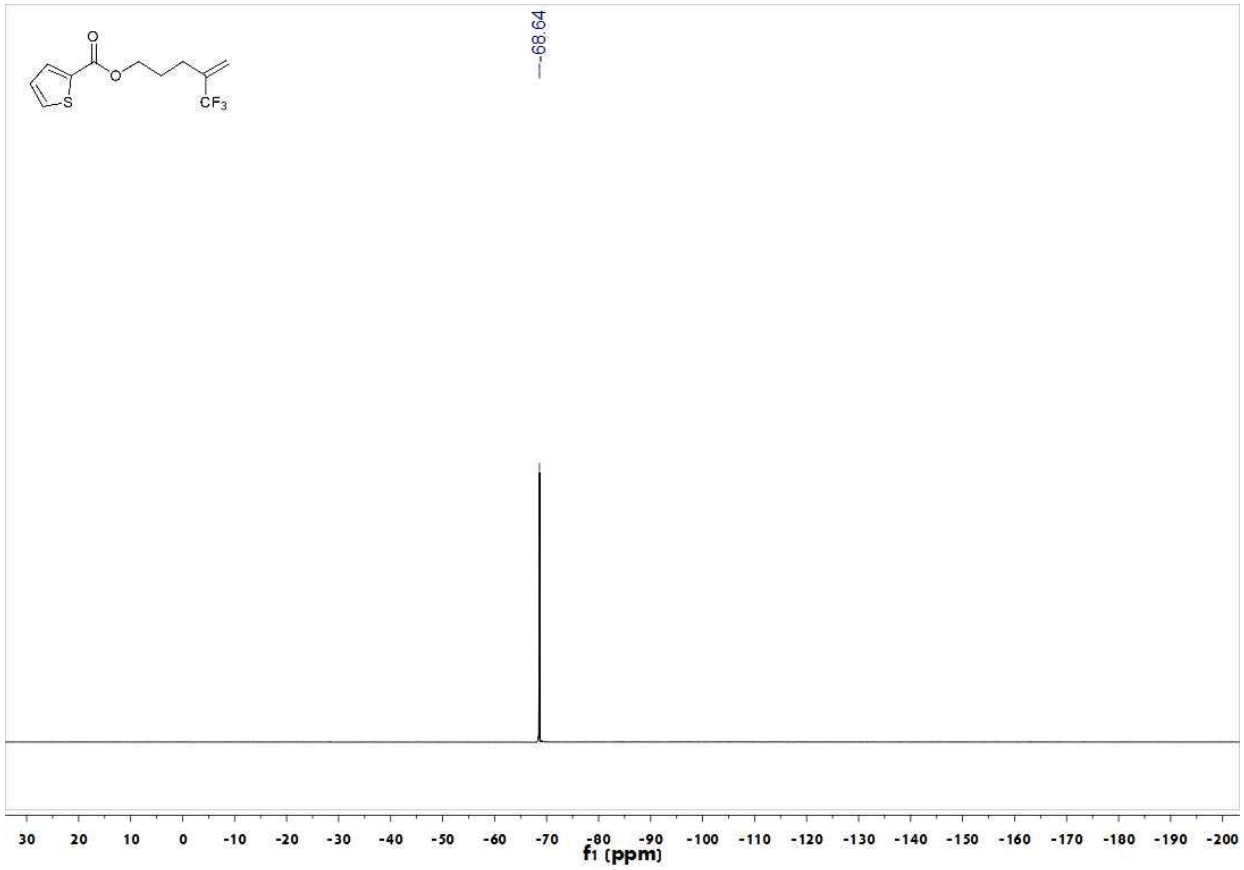


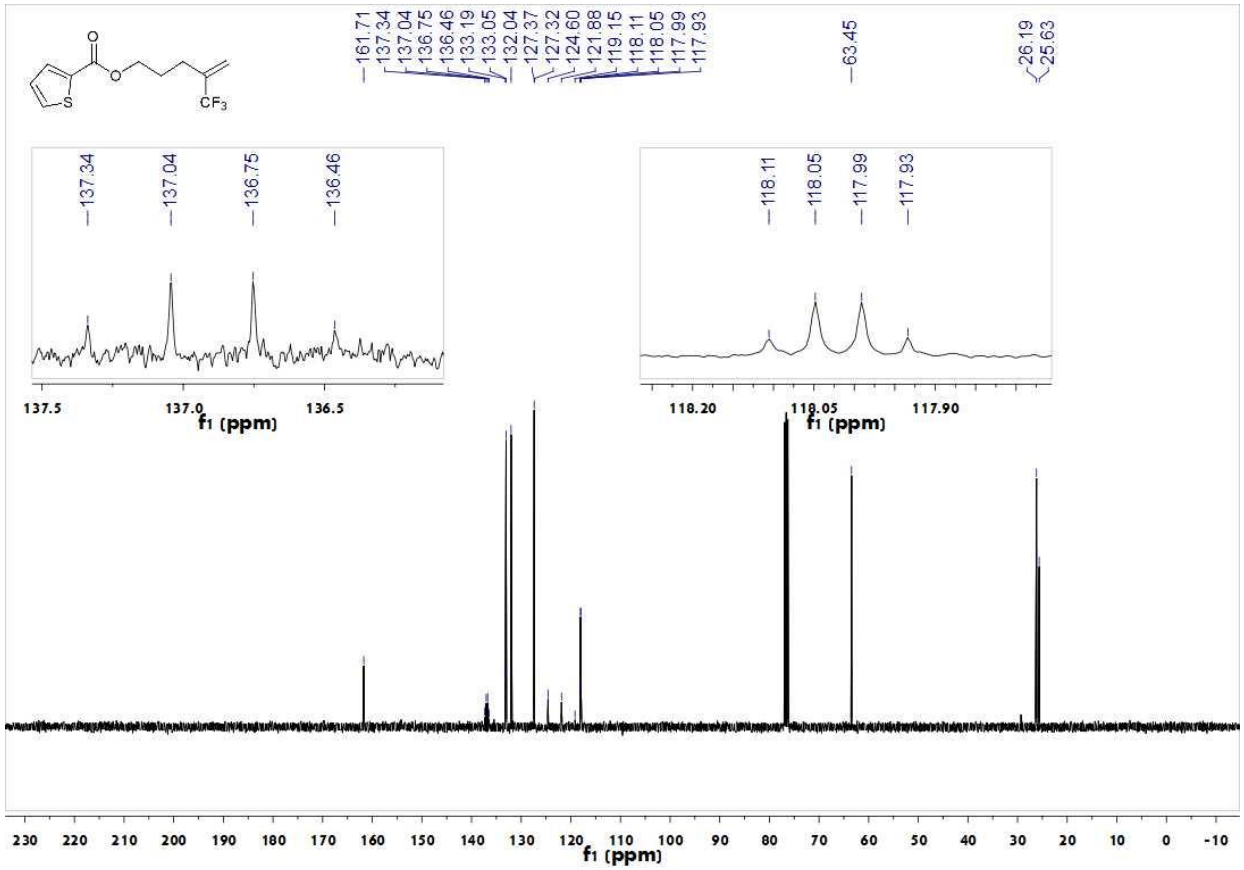

-68.63
30 20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200
f1 (ppm)


167.41
145.50
138.41
138.12
137.83
137.53
134.82
130.87
129.41
128.61
128.30
125.58
122.86
120.14
118.85
118.79
118.73
118.68
118.34
63.88
27.12
26.56
138.41
138.12
137.83
137.53
138.5 138.2 137.9 137.6
f1 (ppm)
118.85
118.79
118.73
118.68
118.34
118.8 118.7 118.6 118.5 118.4 118.3
f1 (ppm)
230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

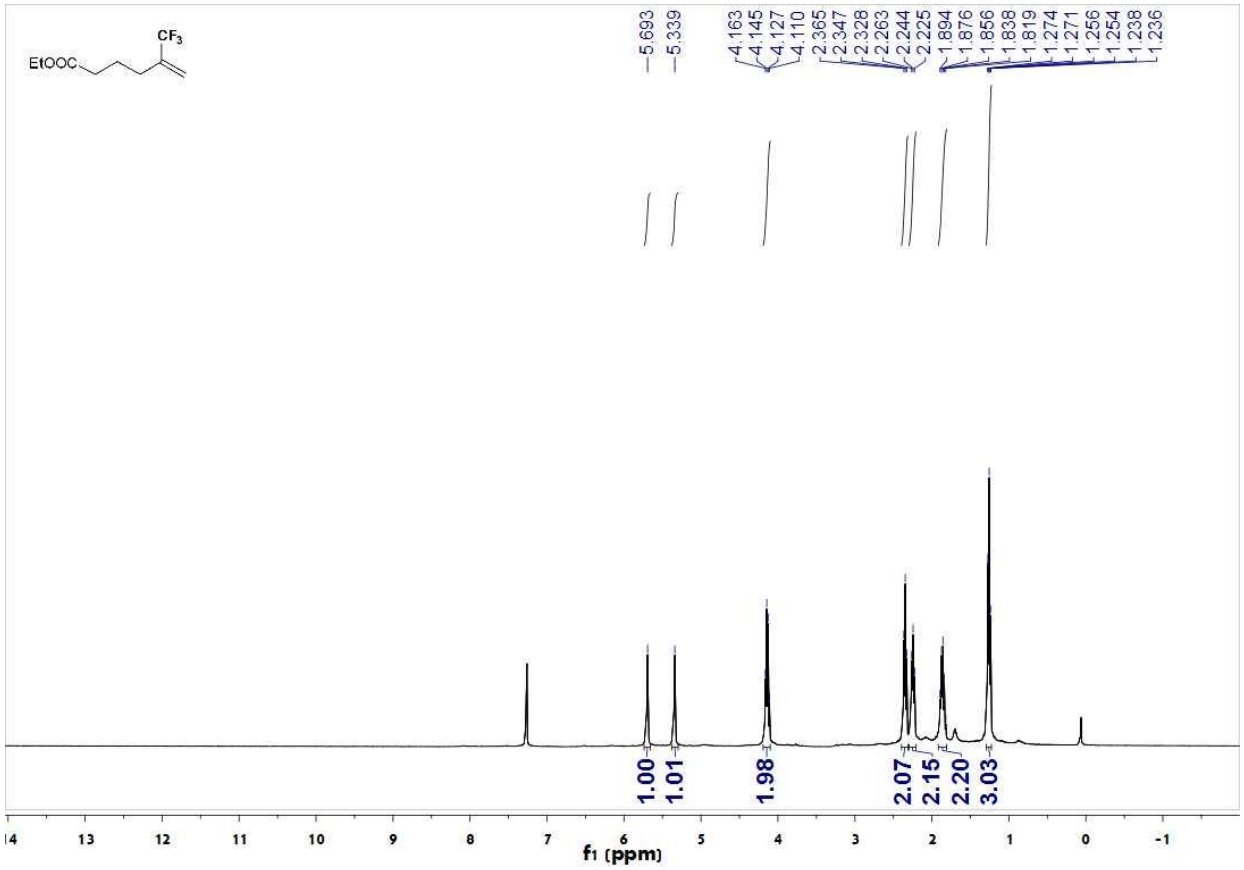
4-(Trifluoromethyl)pent-4-en-1-yl thiophene-2-carboxylate (5k)

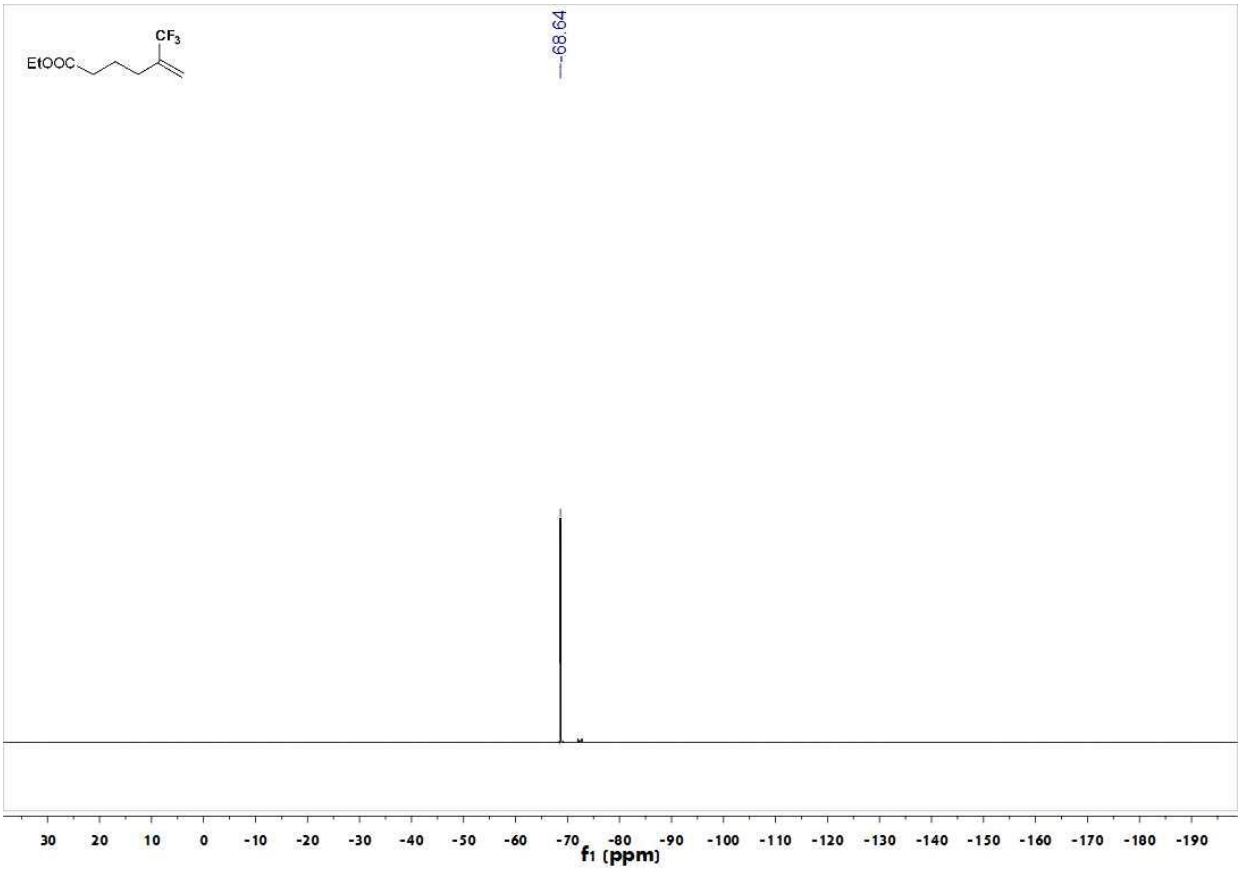


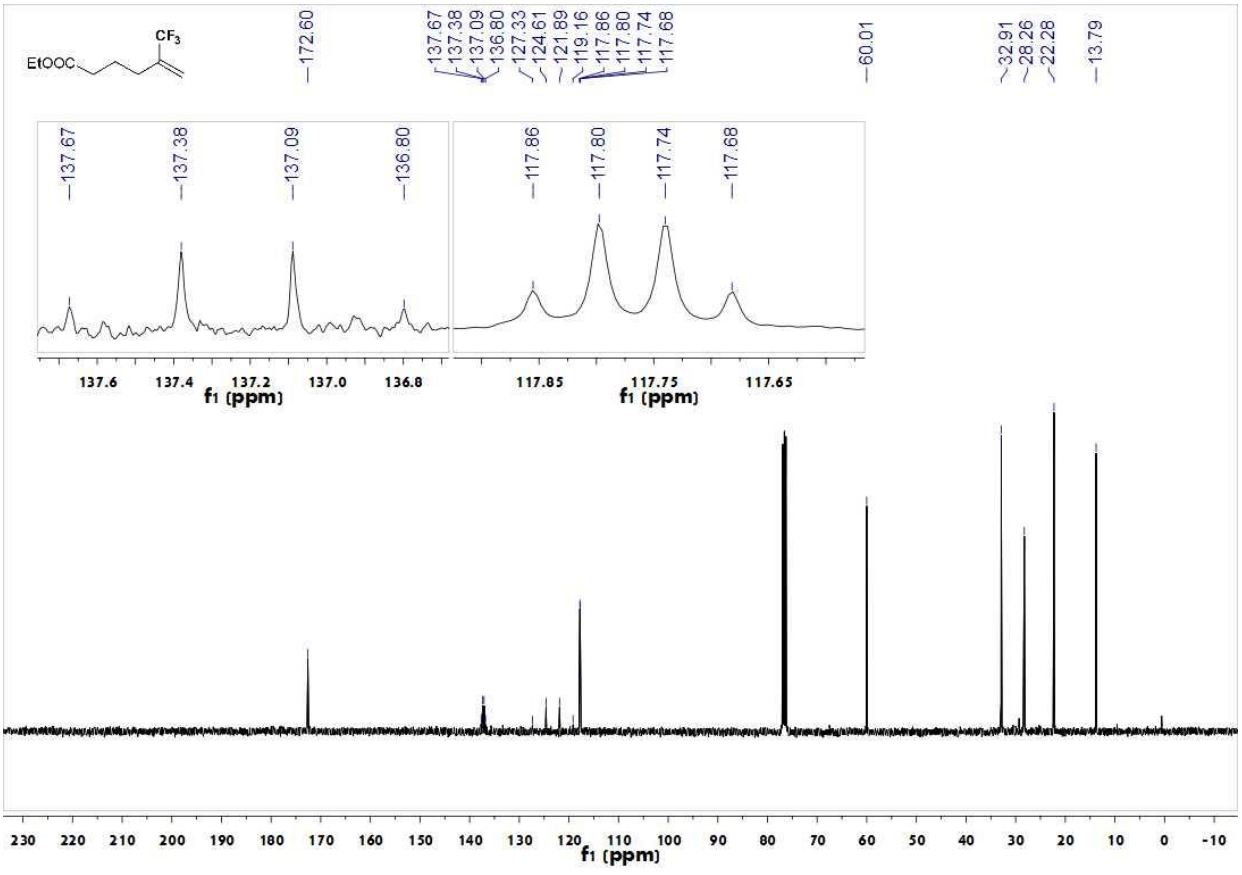




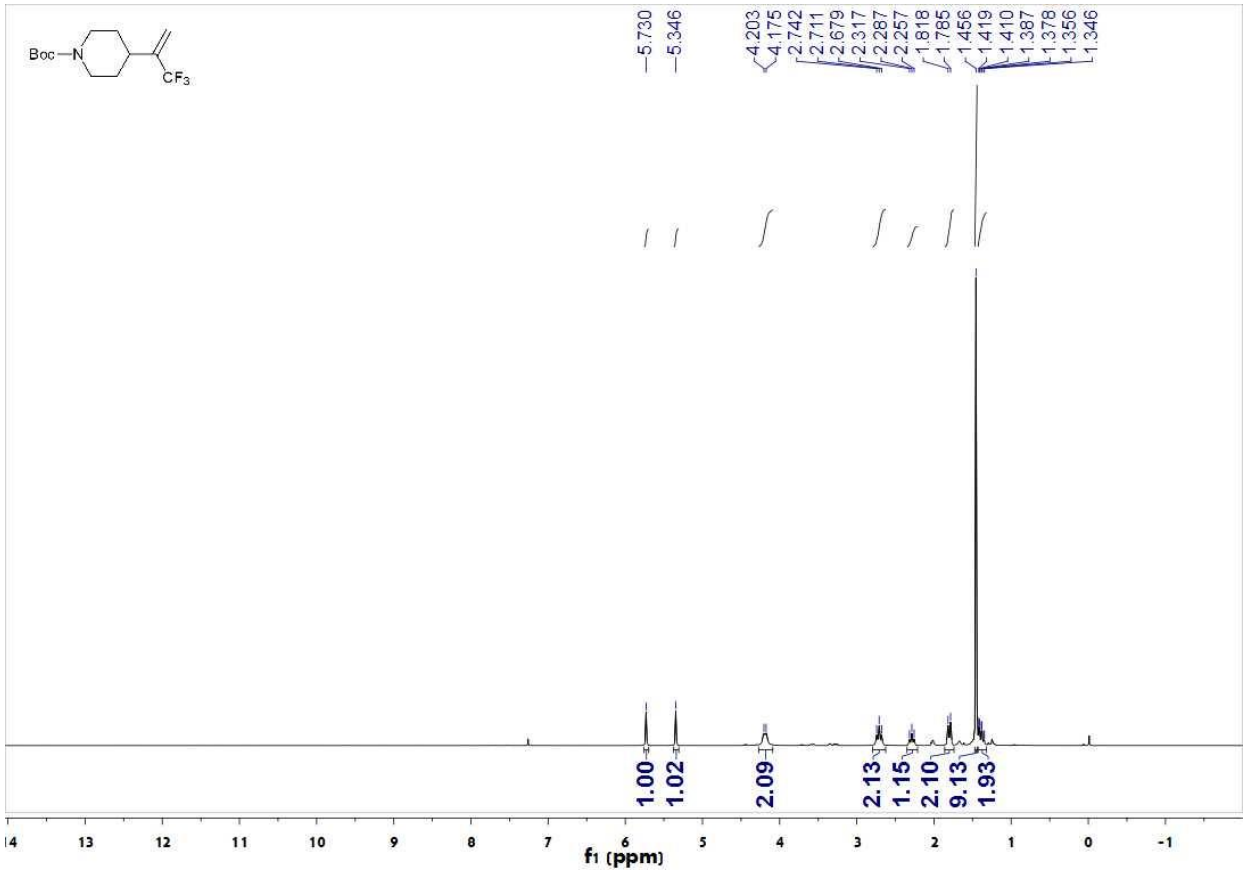
Ethyl 5-(trifluoromethyl)hex-5-enoate (5l)

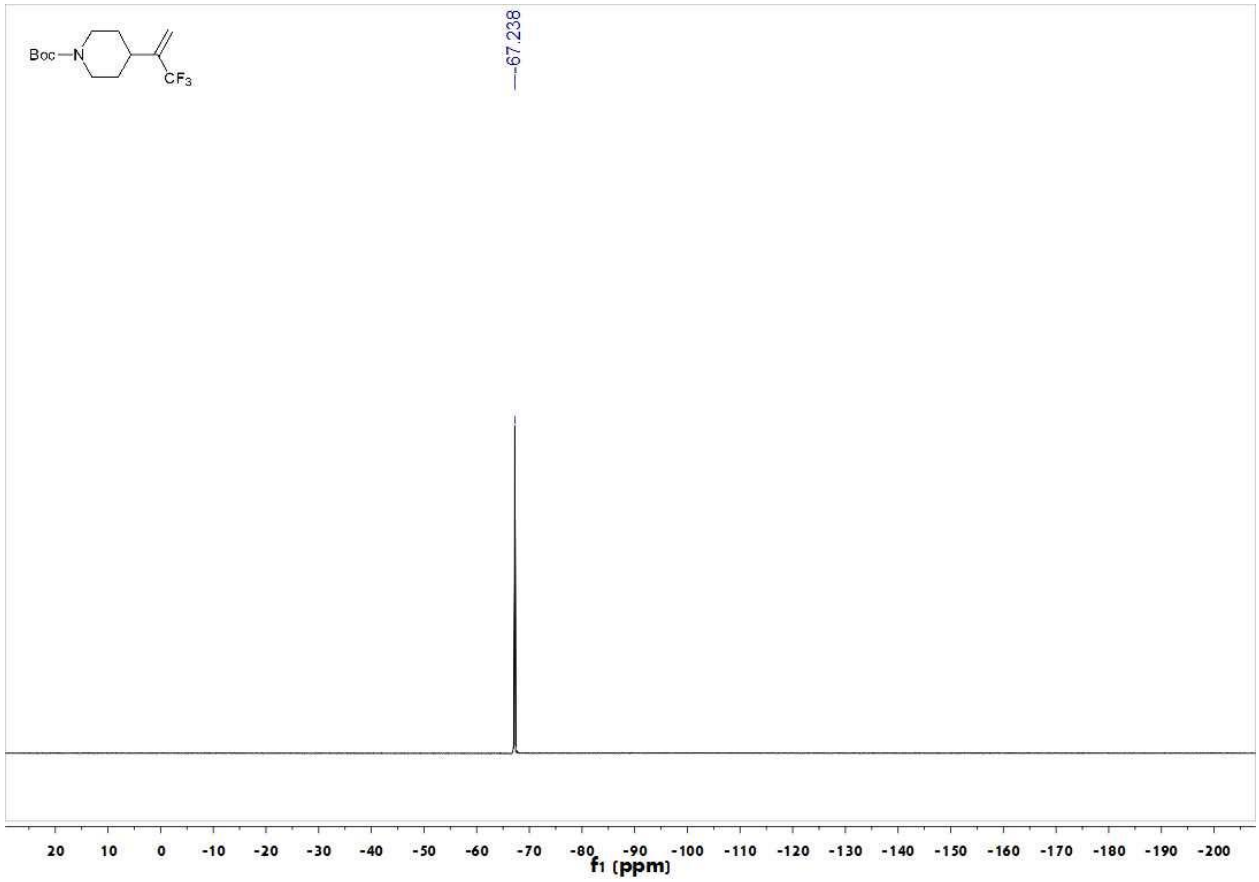


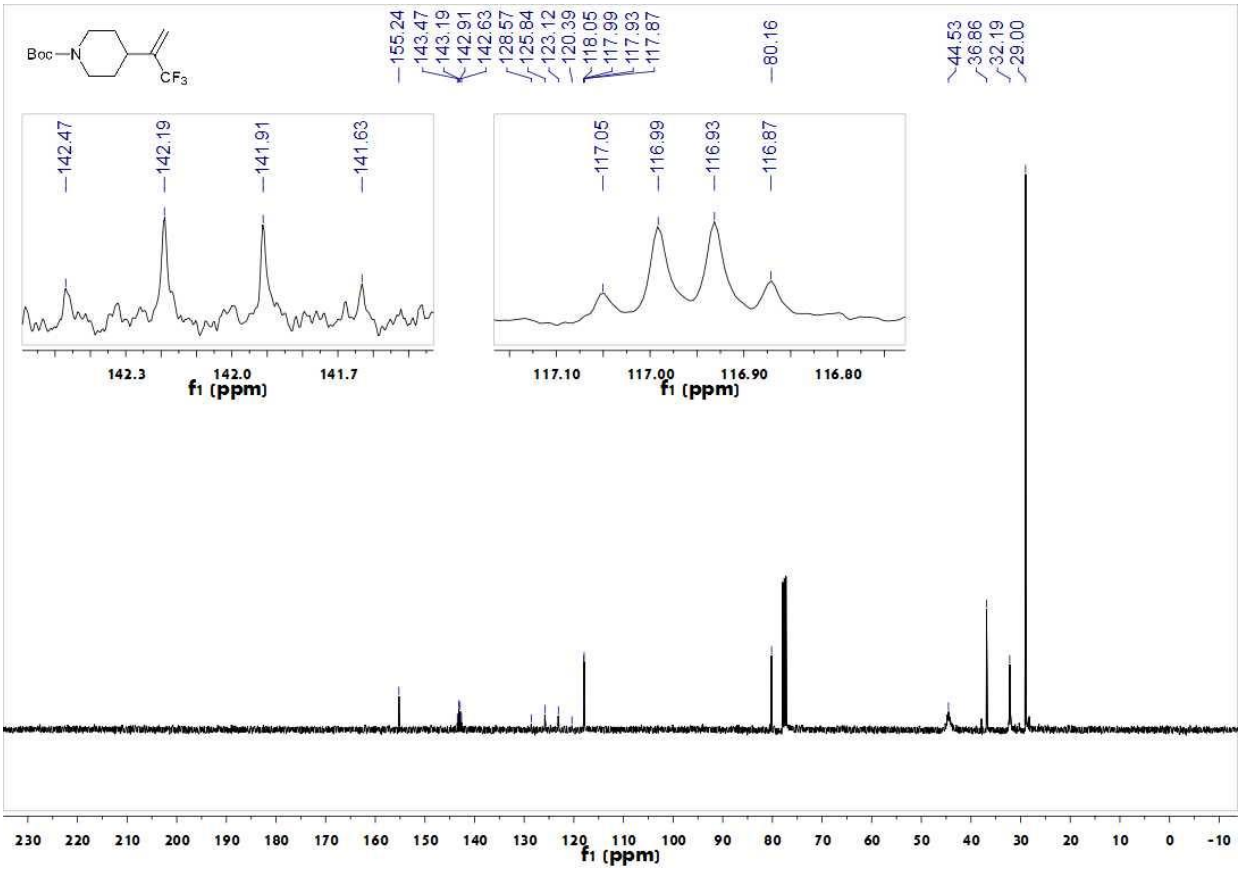

EtOOC
CF3
-68.64
f1 (ppm)


EtOOC
CF3
172.60
137.67
137.38
137.09
136.80
127.33
124.61
121.89
119.16
117.86
117.80
117.74
117.68
60.01
32.91
28.26
22.28
13.79
f1 (ppm)

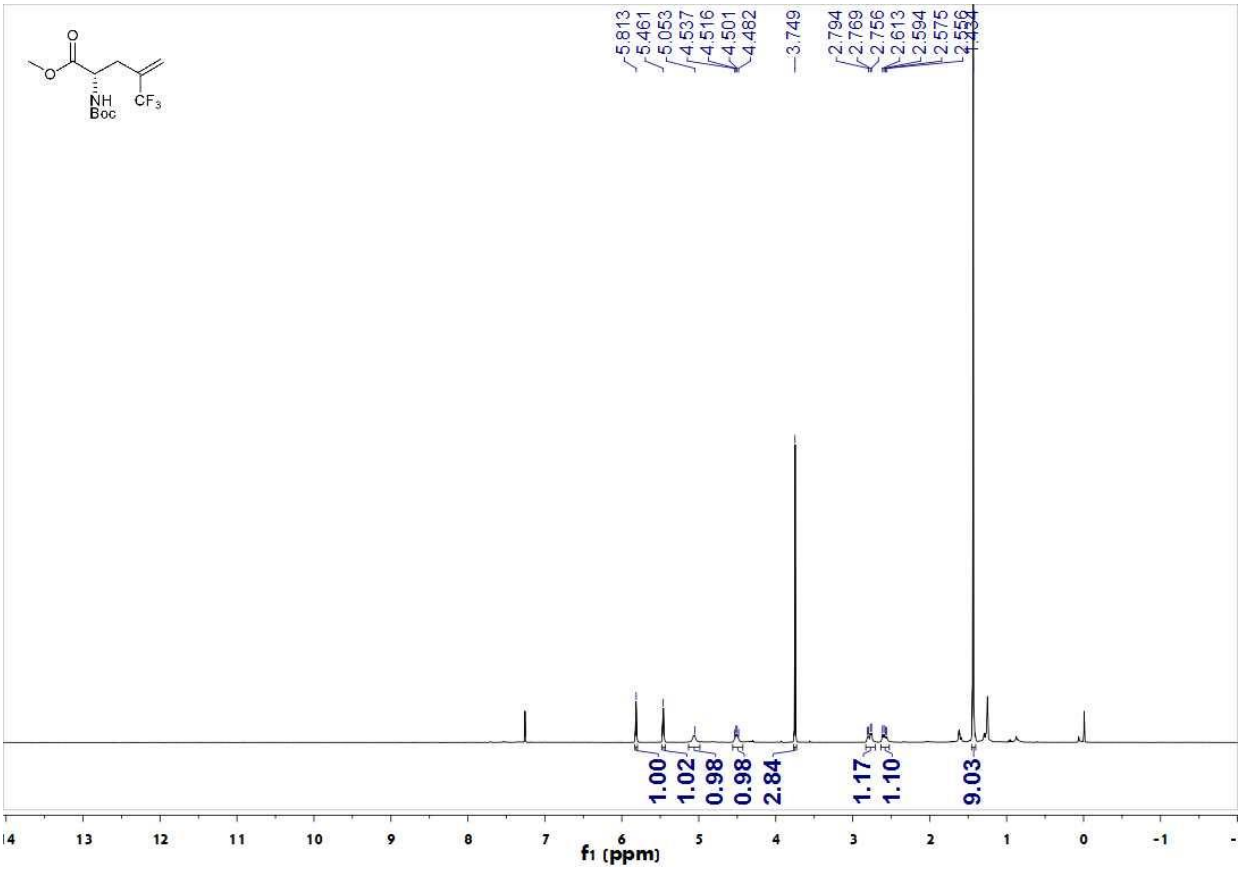
tert-Butyl 4-(3,3,3-trifluoroprop-1-en-2-yl)piperidine-1-carboxylate (5m)

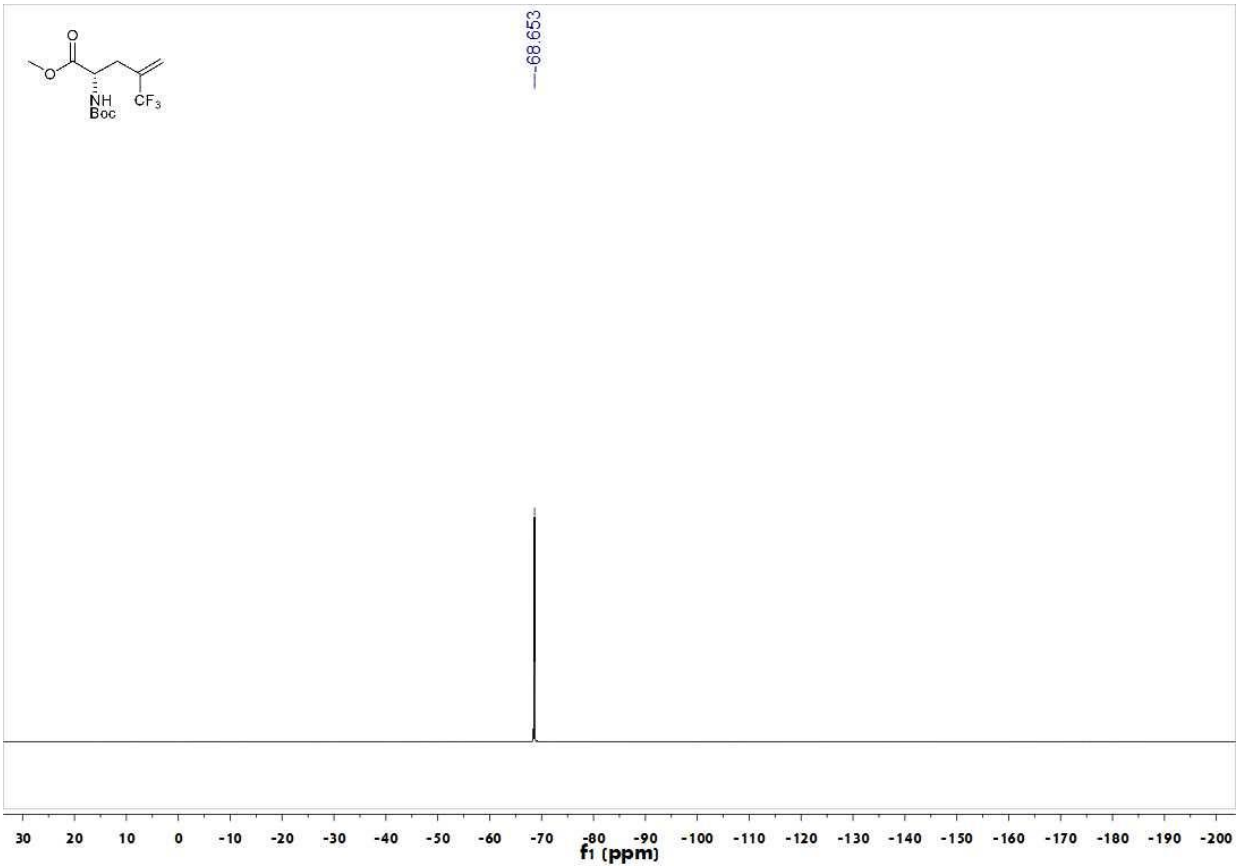


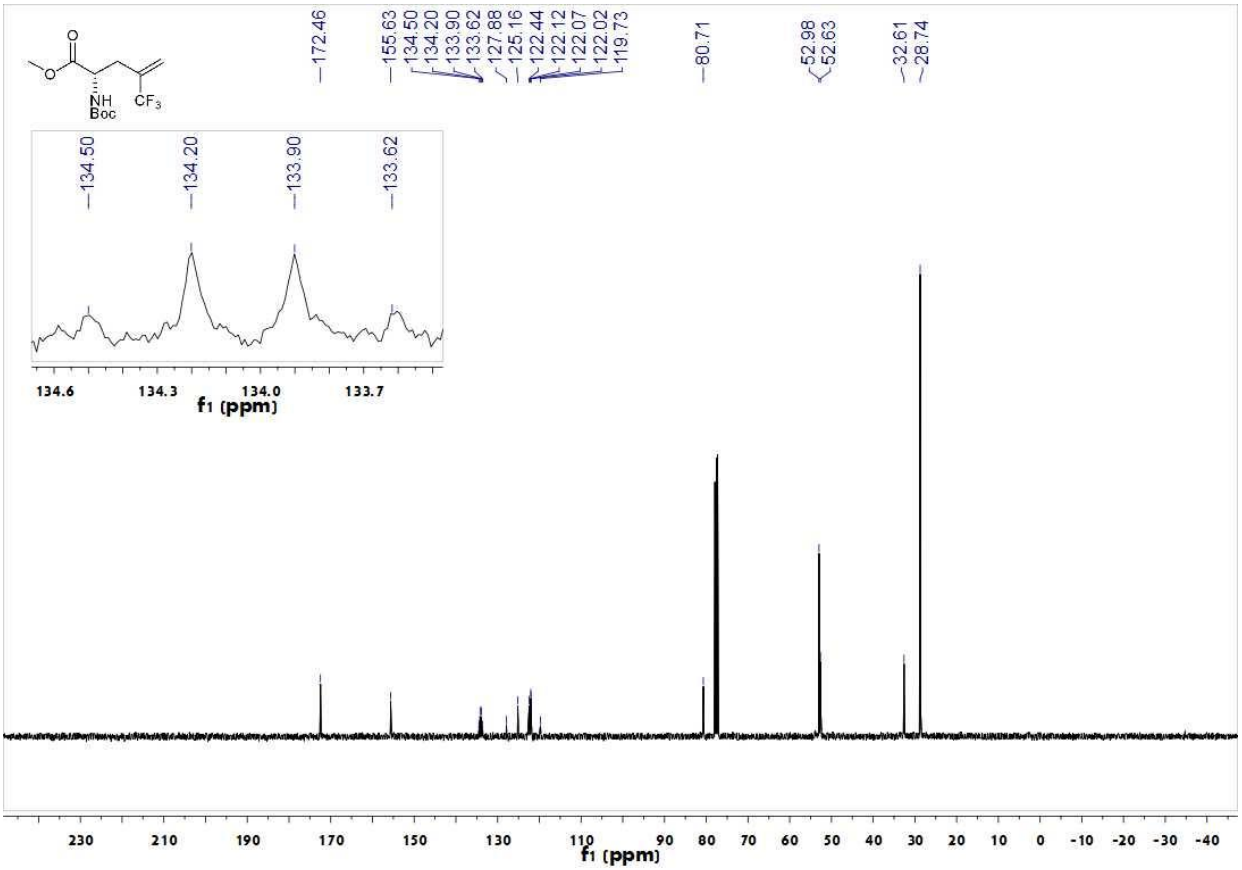




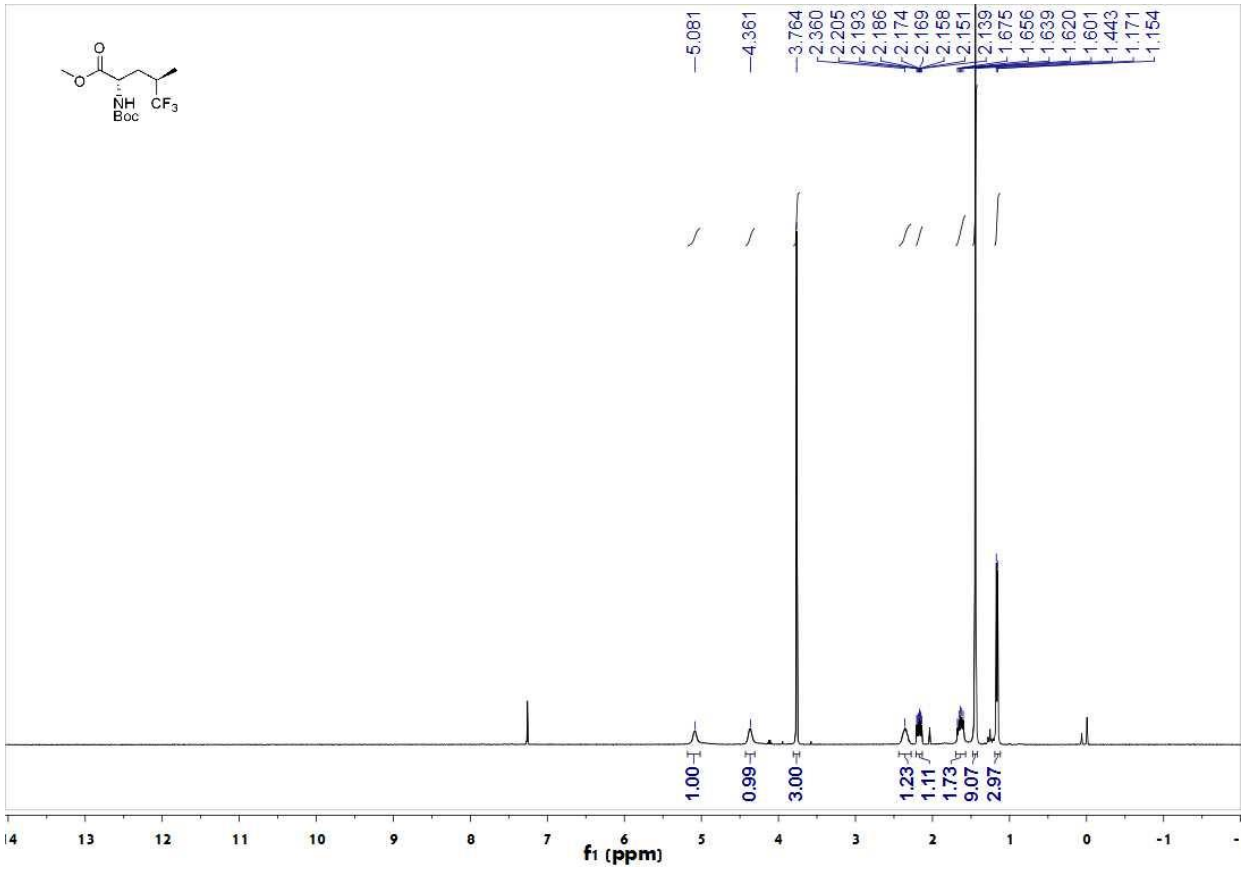
(*S*)-Methyl-2-((*tert*-butoxycarbonyl)amino)-4-(trifluoromethyl)pent-4-enoate (**3**)

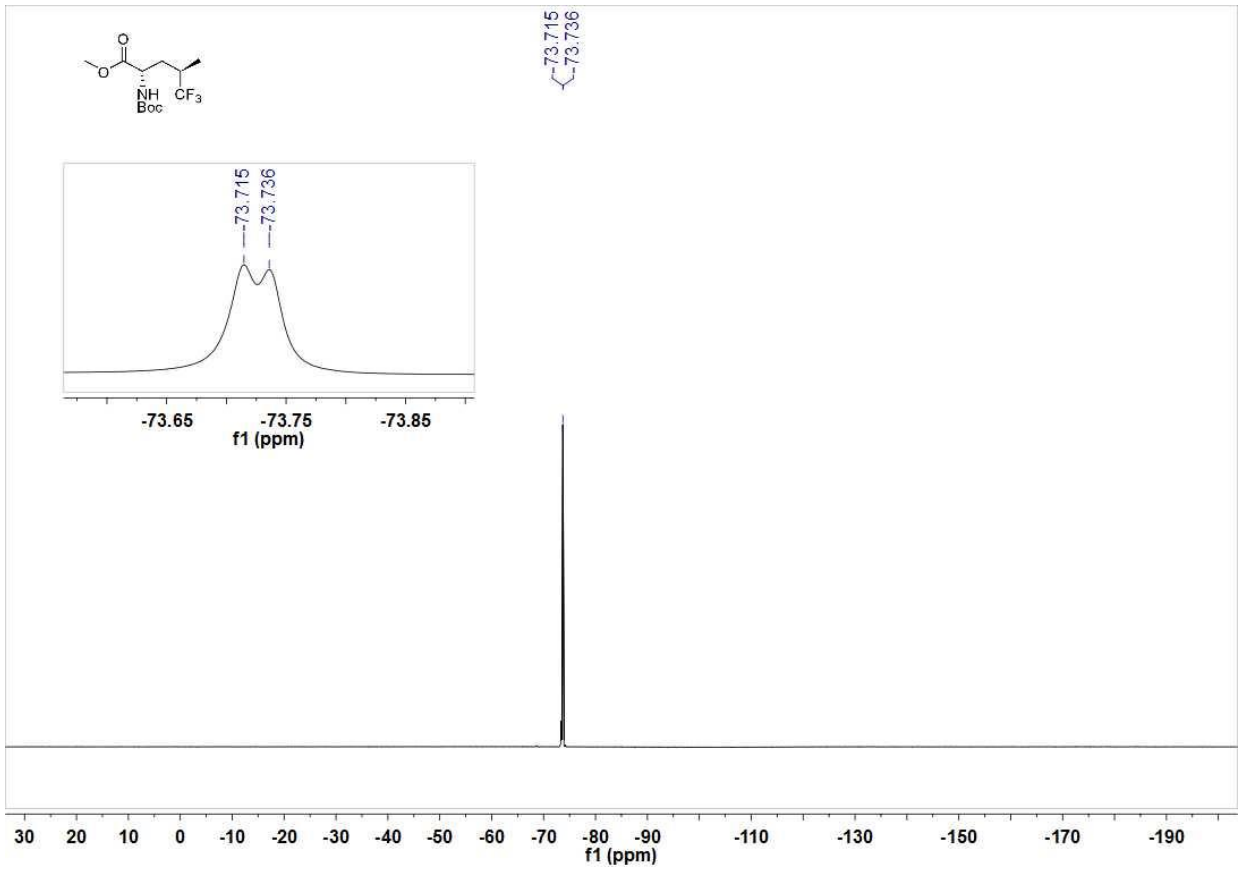


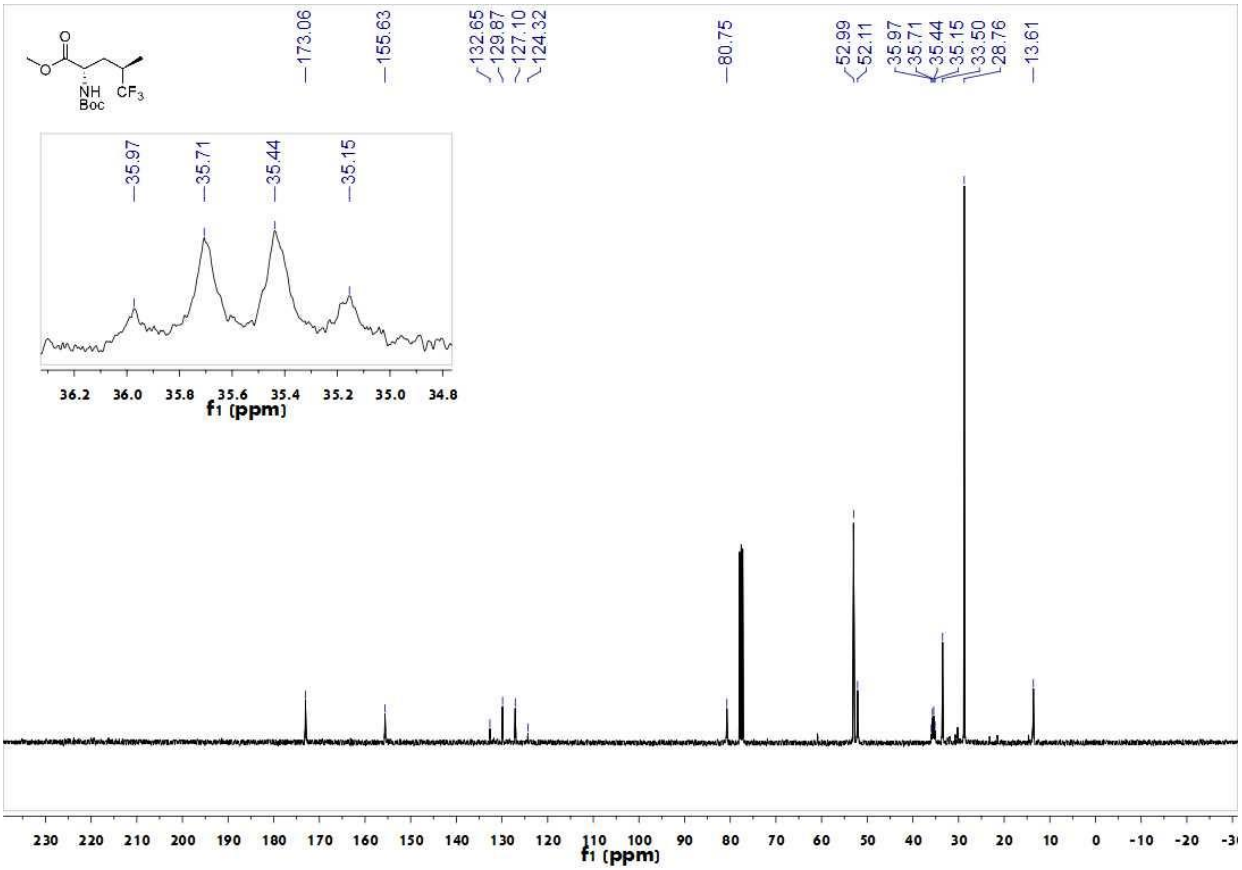

O
O
NH
Boc
CF3
-68.653
30 20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200
f1 (ppm)


O
O
NH
Boc
CF3
172.46
155.63
134.50
134.20
133.90
133.62
127.88
125.16
122.44
122.12
122.07
122.02
119.73
80.71
52.98
52.63
32.61
28.74
134.50
134.20
133.90
133.62
134.6 134.3 134.0 133.7
f1 (ppm)
230 210 190 170 150 130 110 90 80 70 60 50 40 30 20 10 0 -10 -20 -30 -40
f1 (ppm)

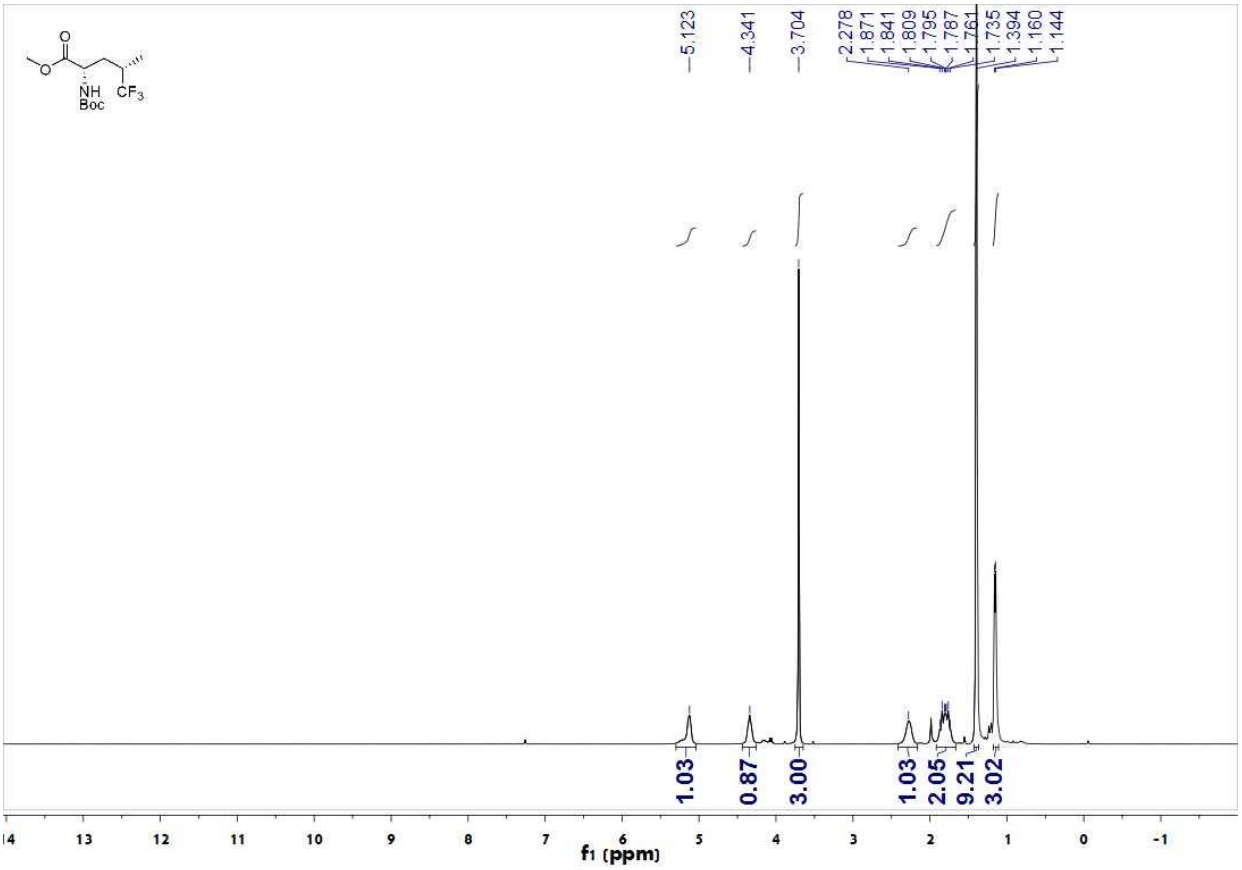
Methyl (2*S*,4*R*)-2-((*tert*-butoxycarbonyl)amino)-5,5,5-trifluoro-4-methylpentanoate (6a)

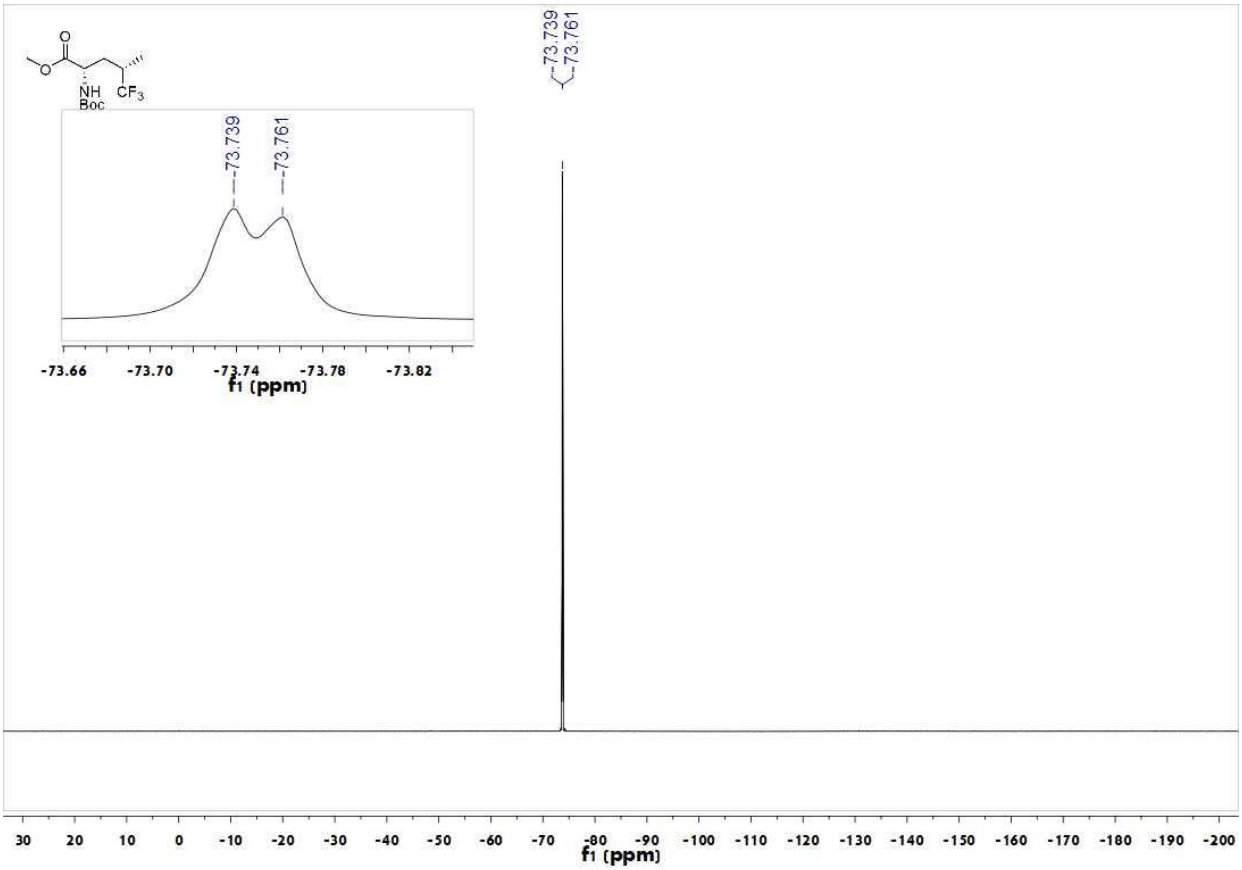


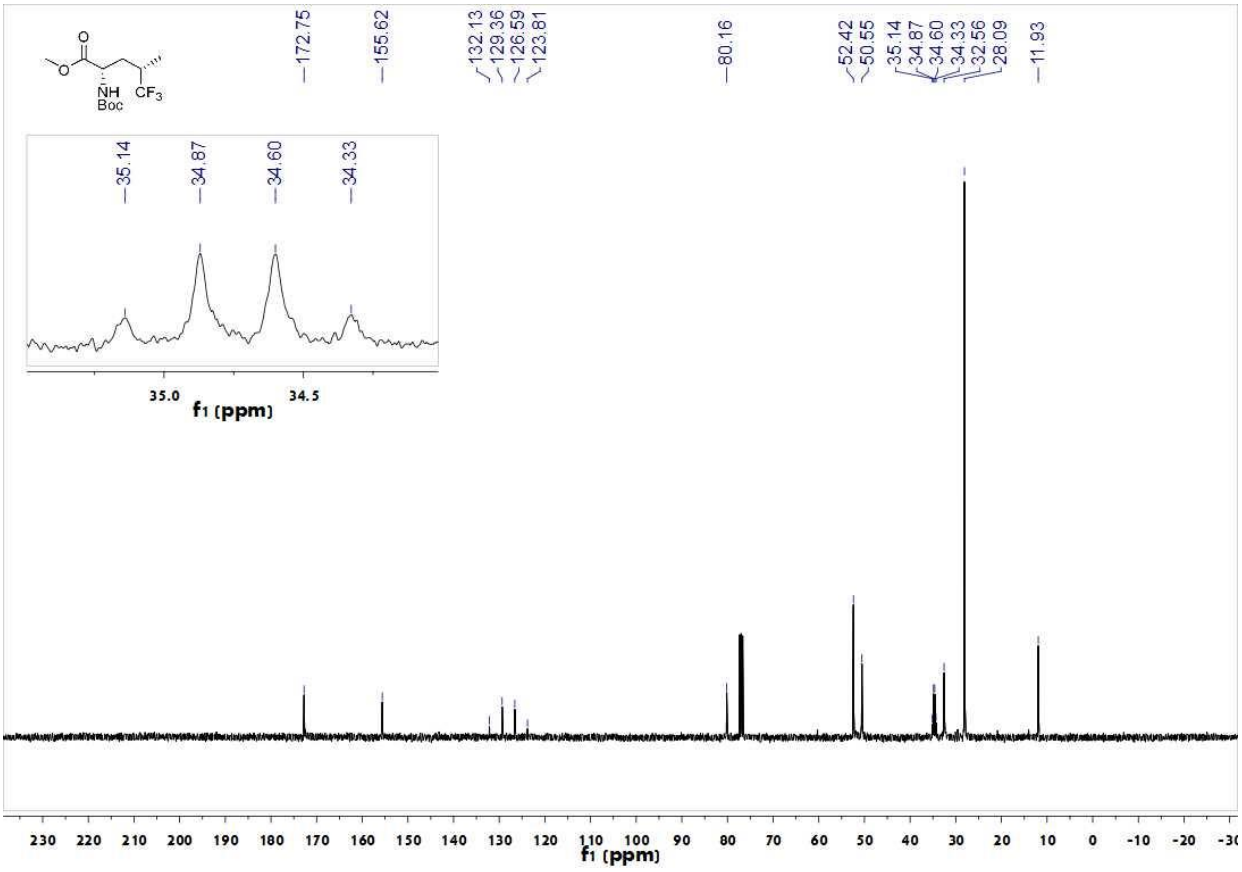




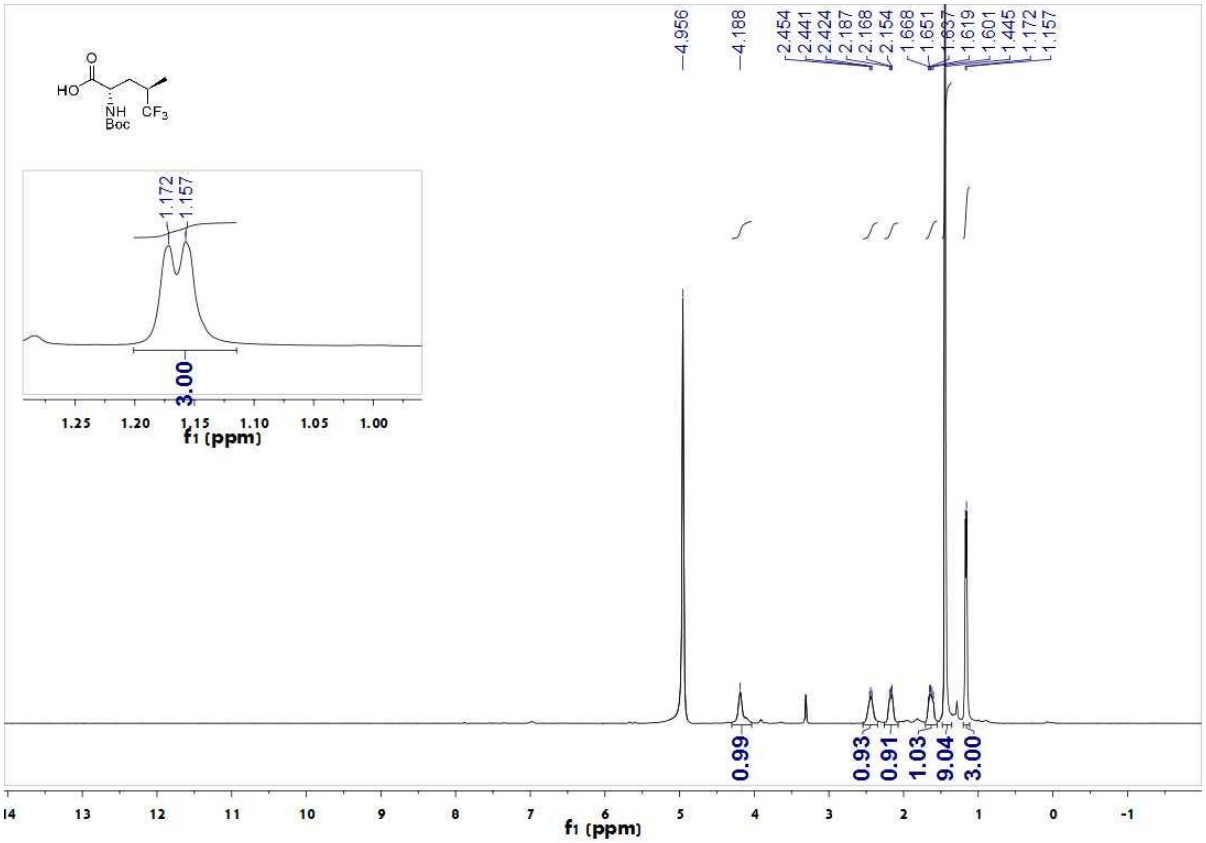
Methyl (2*S*,4*S*)-2-((*tert*-butoxycarbonyl)amino)-5,5,5-trifluoro-4-methylpentanoate (6b)

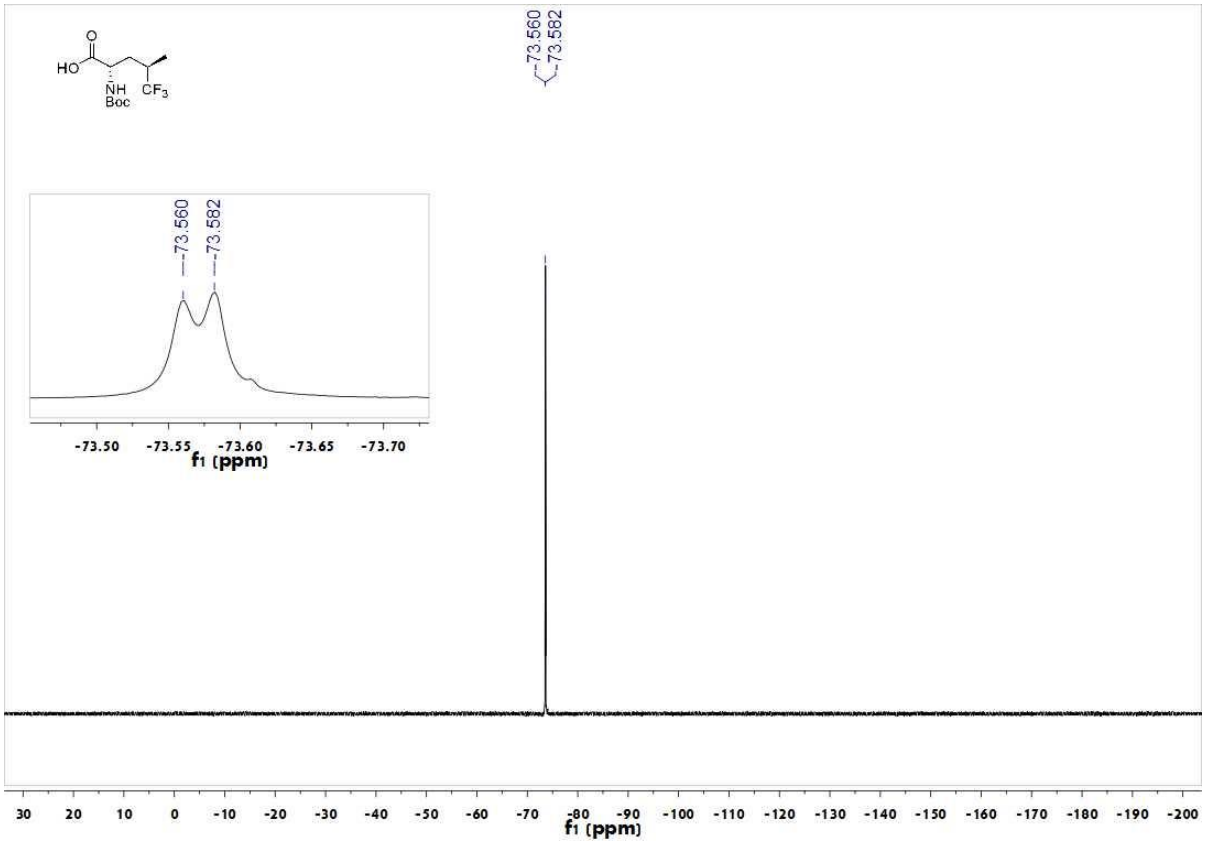


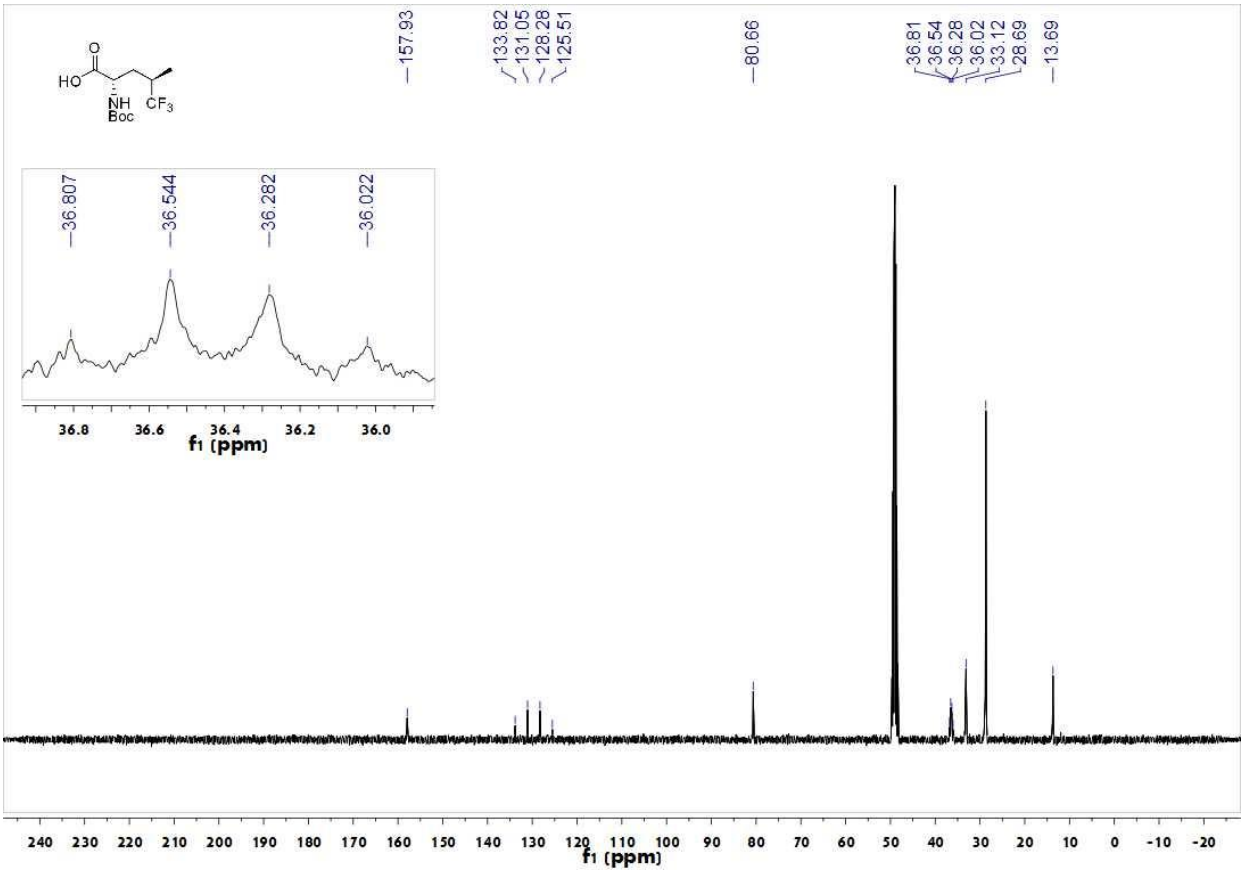

73.739
73.761
NH
Boc
CF3
-73.66
-73.70
-73.74
-73.78
-73.82
f1 (ppm)
30 20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200
f1 (ppm)


172.75
155.62
132.13
129.36
126.59
123.81
80.16
52.42
50.55
35.14
34.87
34.60
34.33
32.56
28.09
11.93
NH
Boc
CF3
35.14
34.87
34.60
34.33
35.0
34.5
f1 (ppm)
230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10 -20
f1 (ppm)

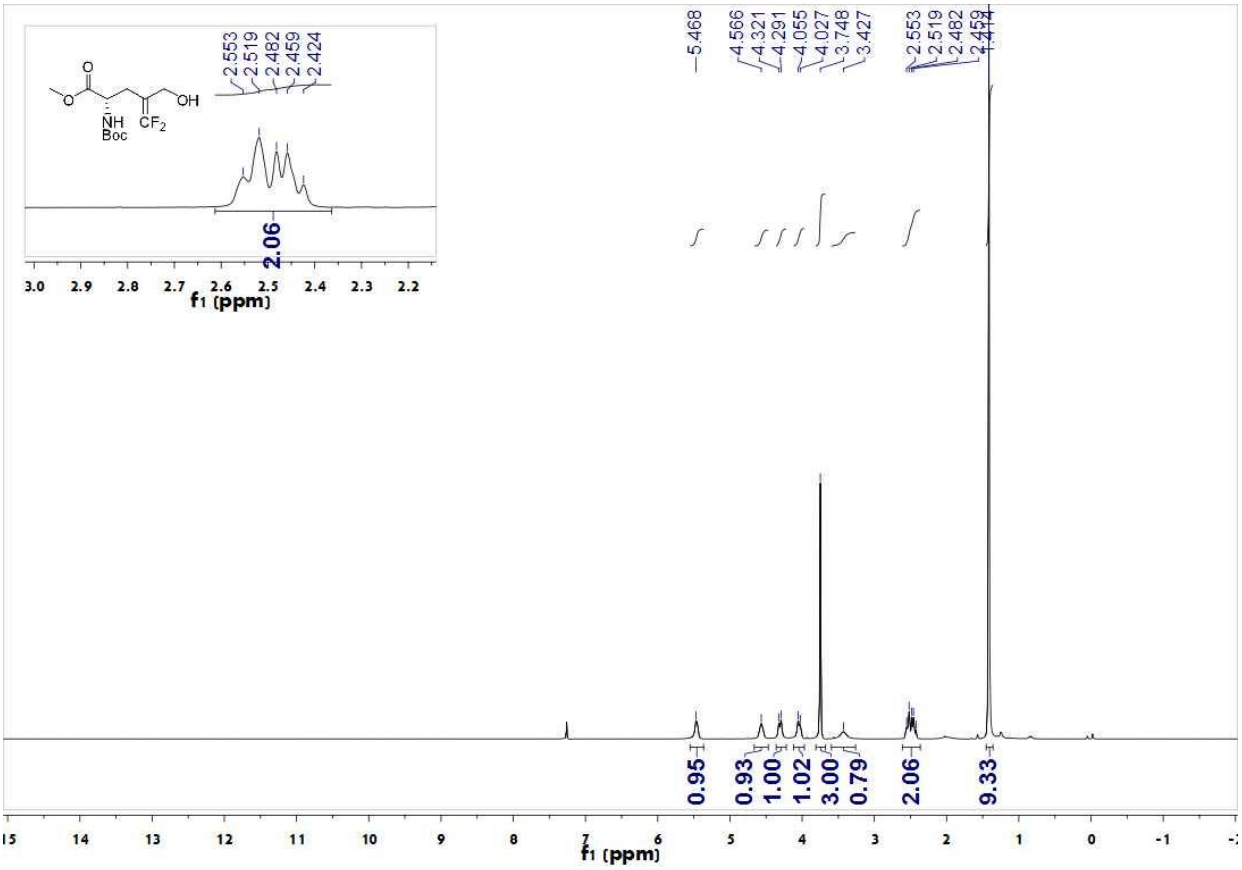
(2*S*,4*R*)-2-((*tert*-Butoxycarbonyl)amino)-5,5,5-trifluoro-4-methylpentanoic acid (7a)

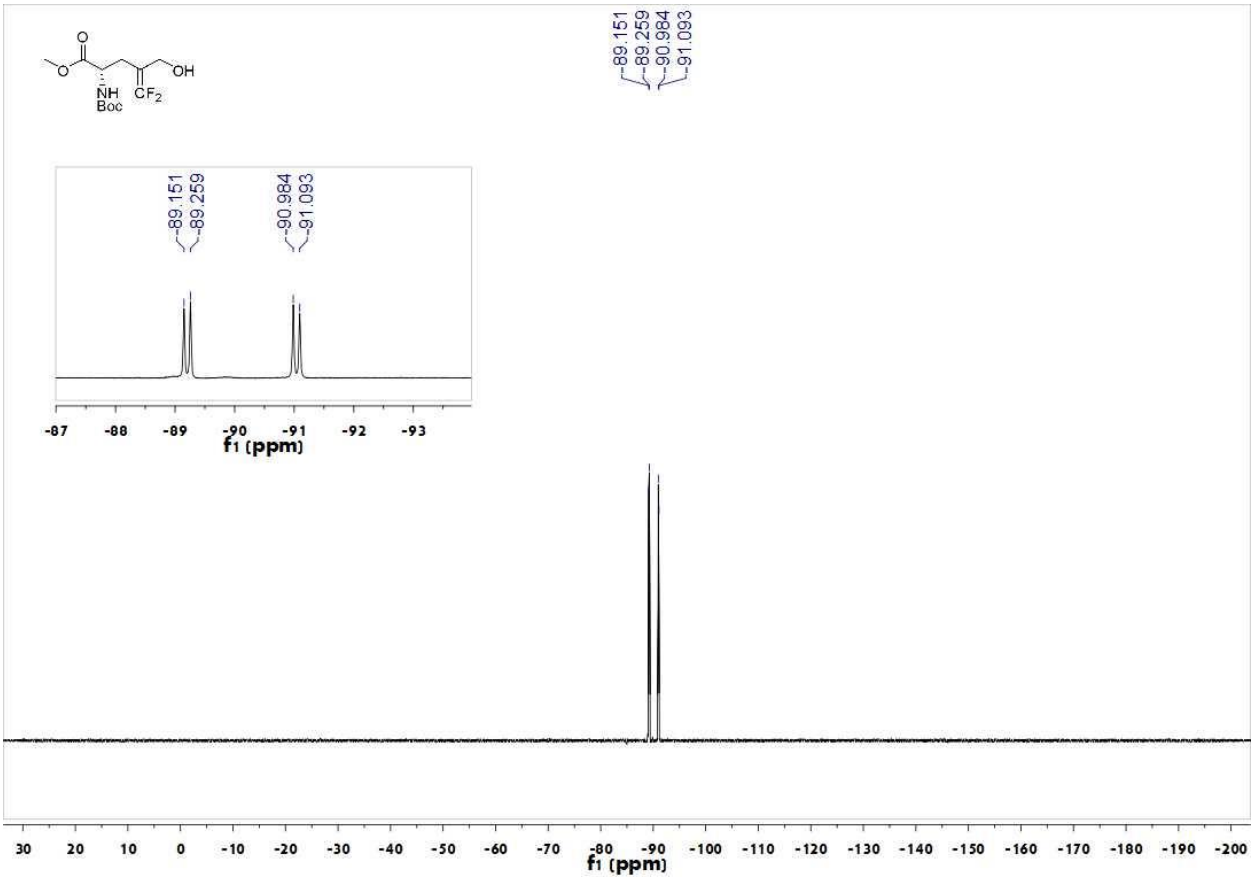


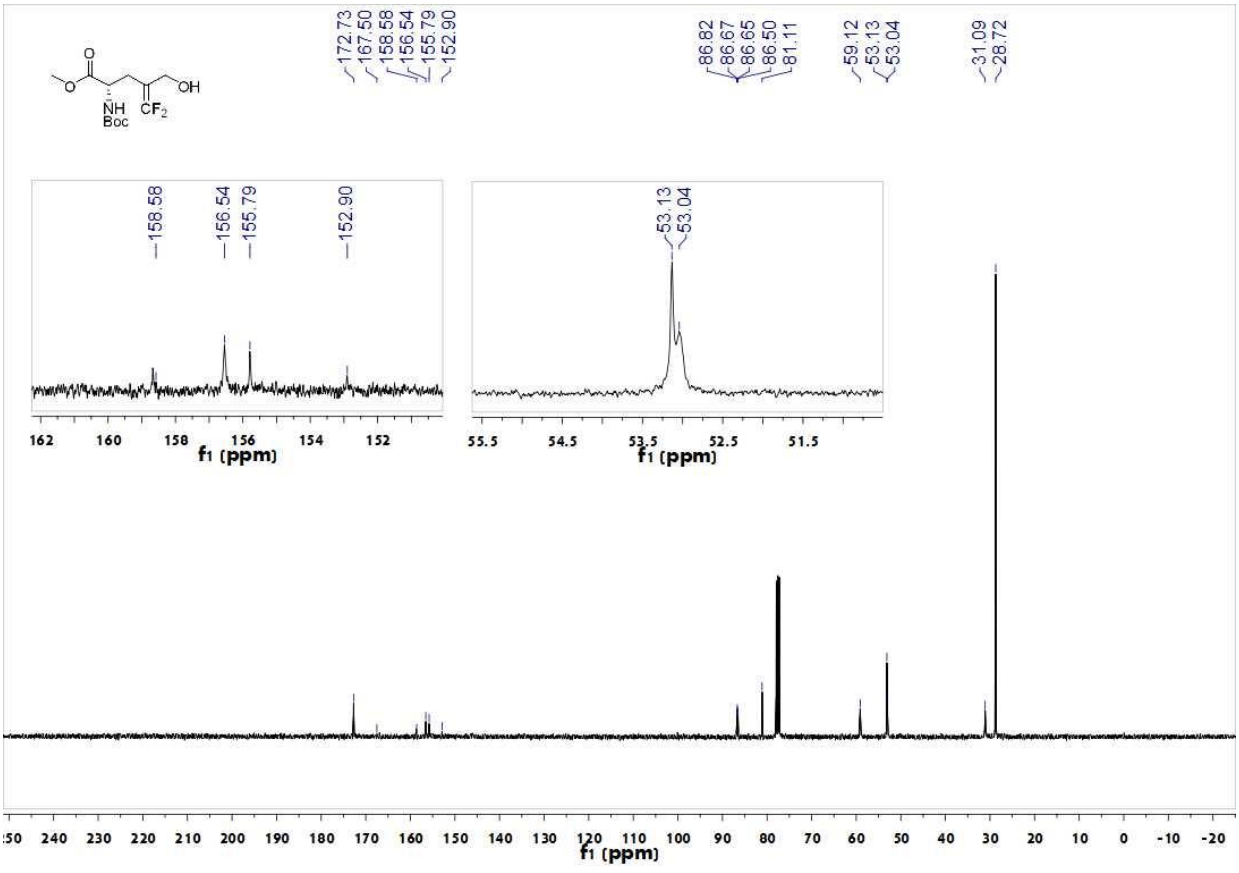




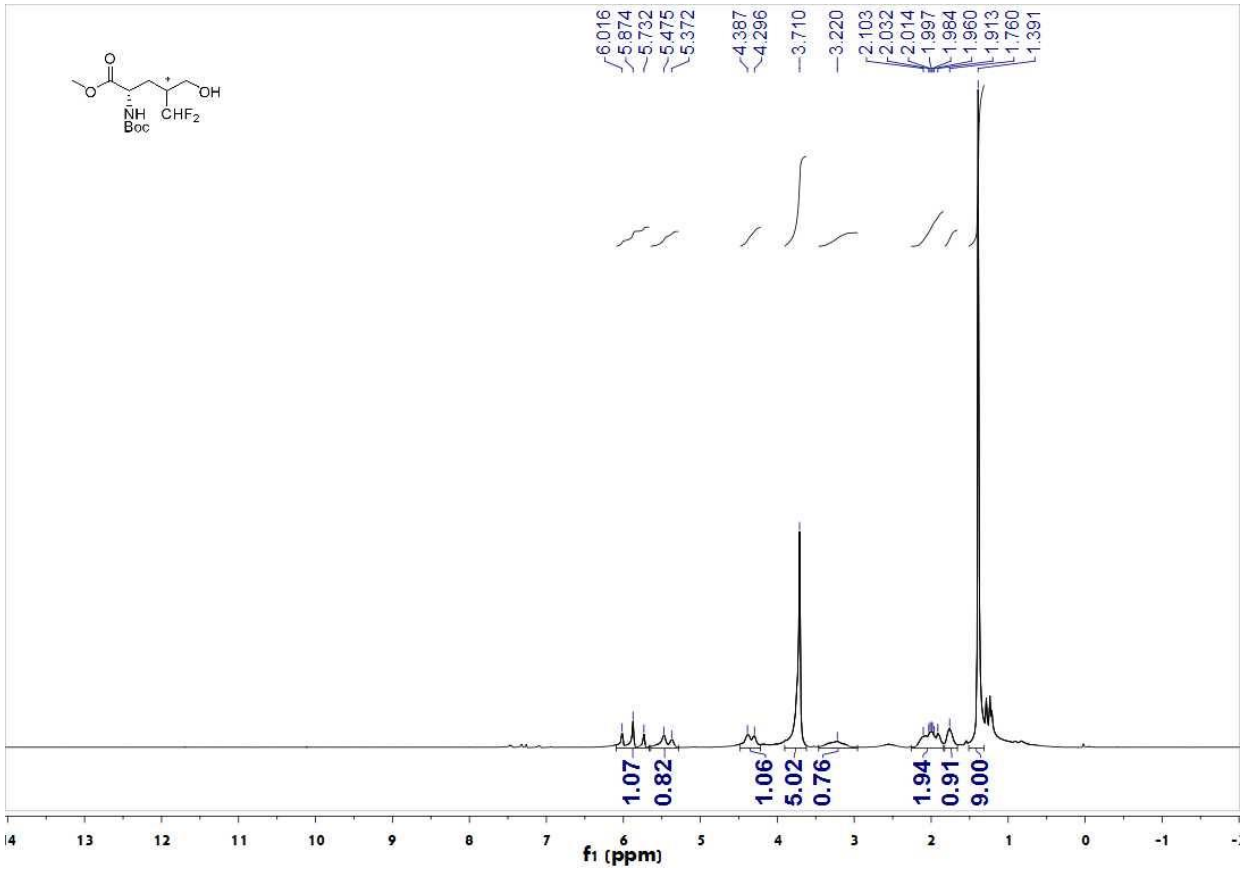
Methyl (*S*)-2-((*tert*-butoxycarbonyl)amino)-5,5-difluoro-4-(hydroxymethyl)pent-4-enoate (9)

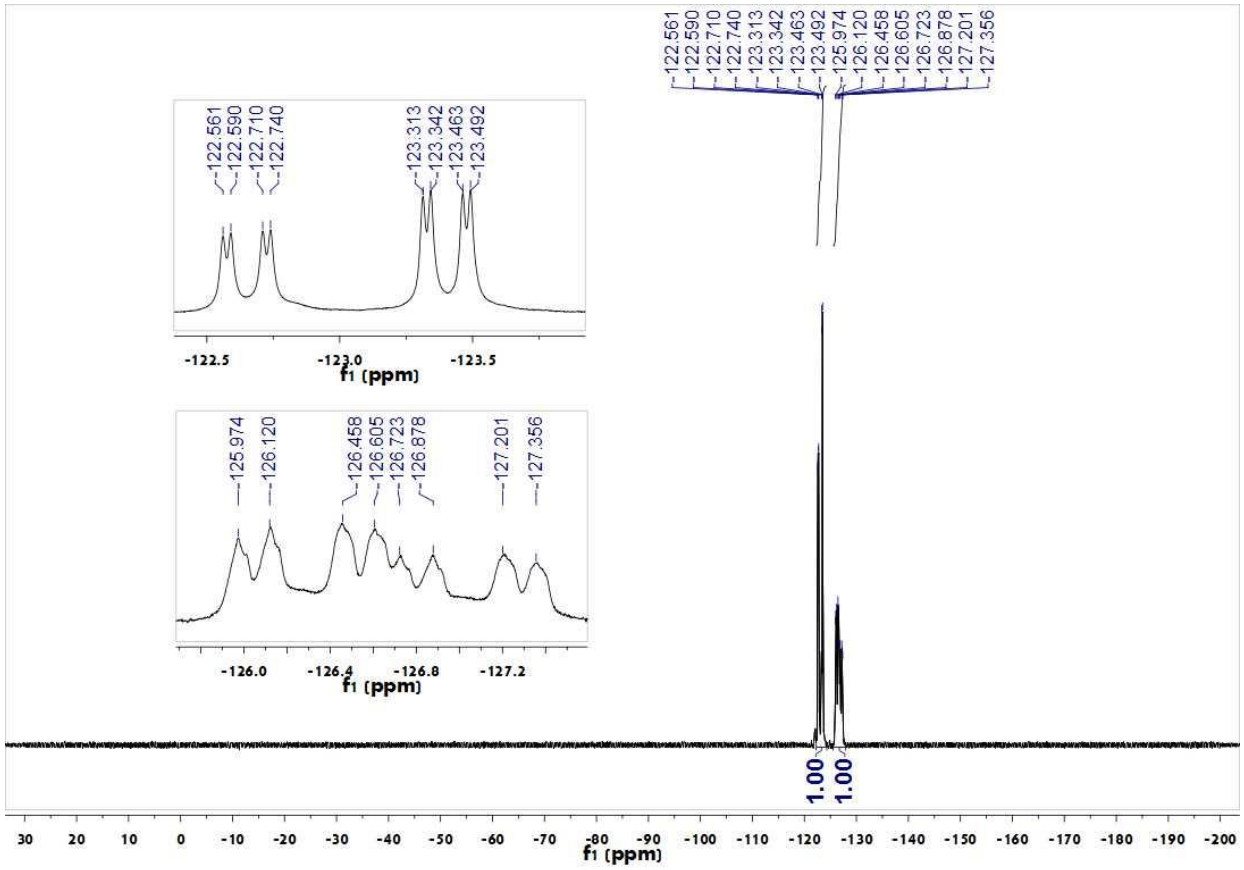


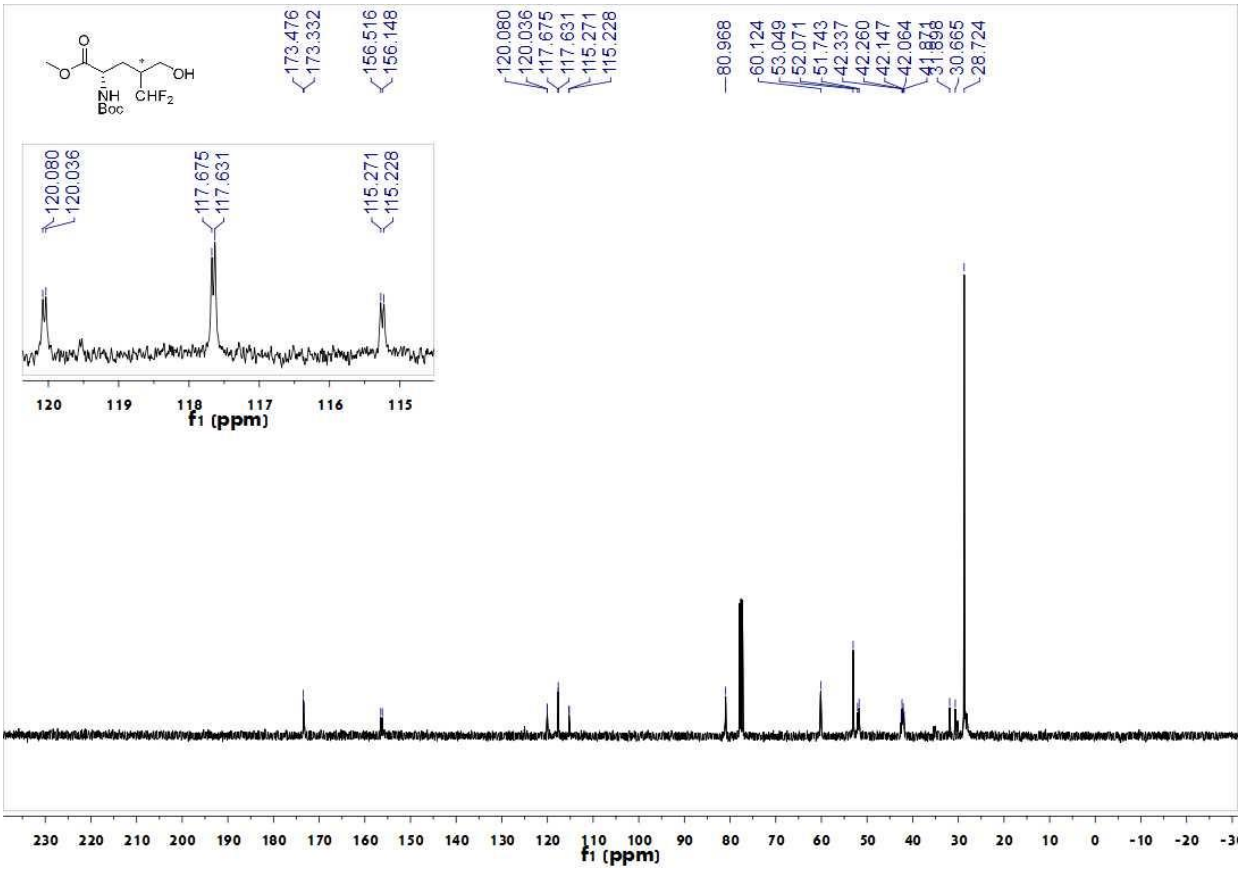

89.151
89.259
90.984
91.093
OH
NH
Boc
CF2
f1 (ppm)


172.73
167.50
158.58
156.54
155.79
152.90
86.82
86.67
86.65
86.50
81.11
59.12
53.13
53.04
31.09
28.72
OH
NH
Boc
CF2
f1 (ppm)

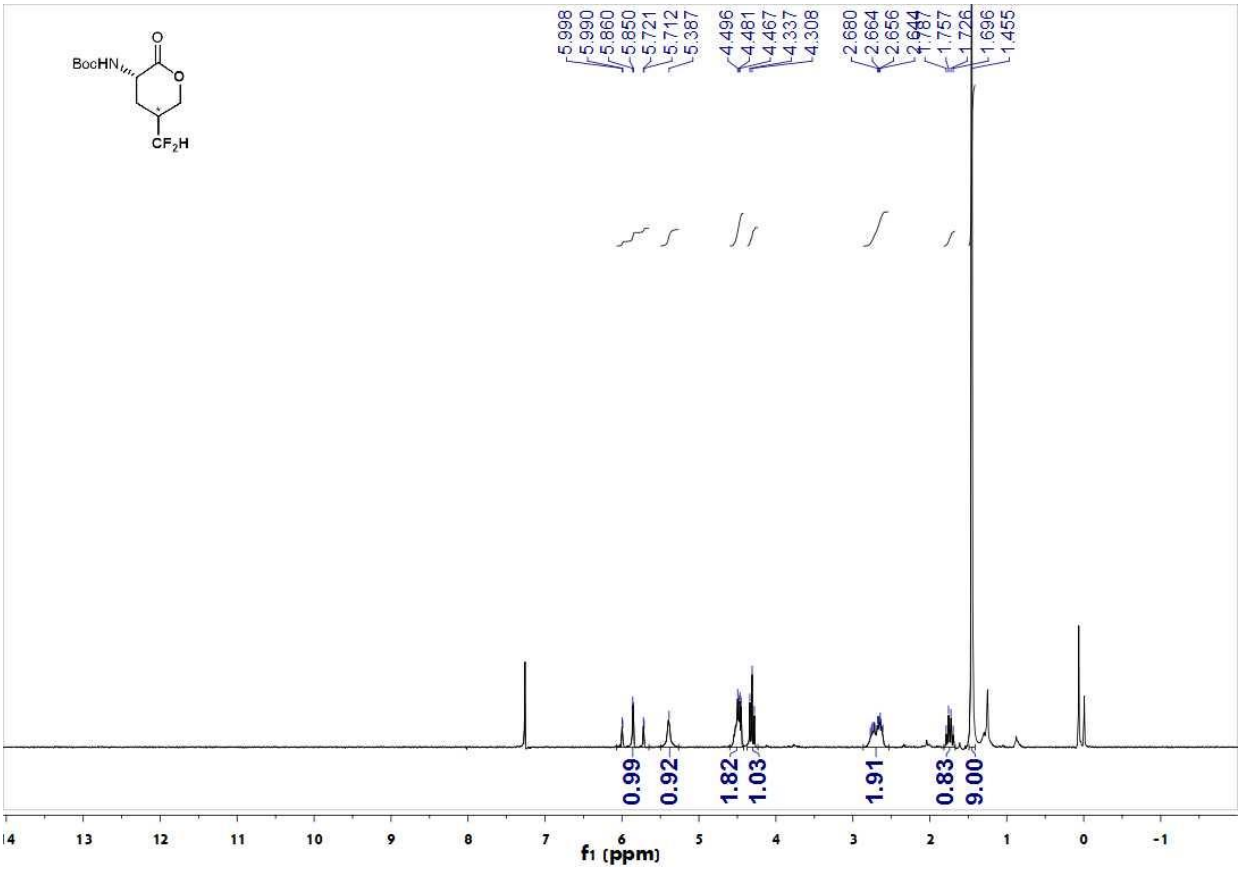
Methyl (2*S*)-2-((*tert*-butoxycarbonyl)amino)-5,5-difluoro-4-(hydroxymethyl)pentanoate (10)

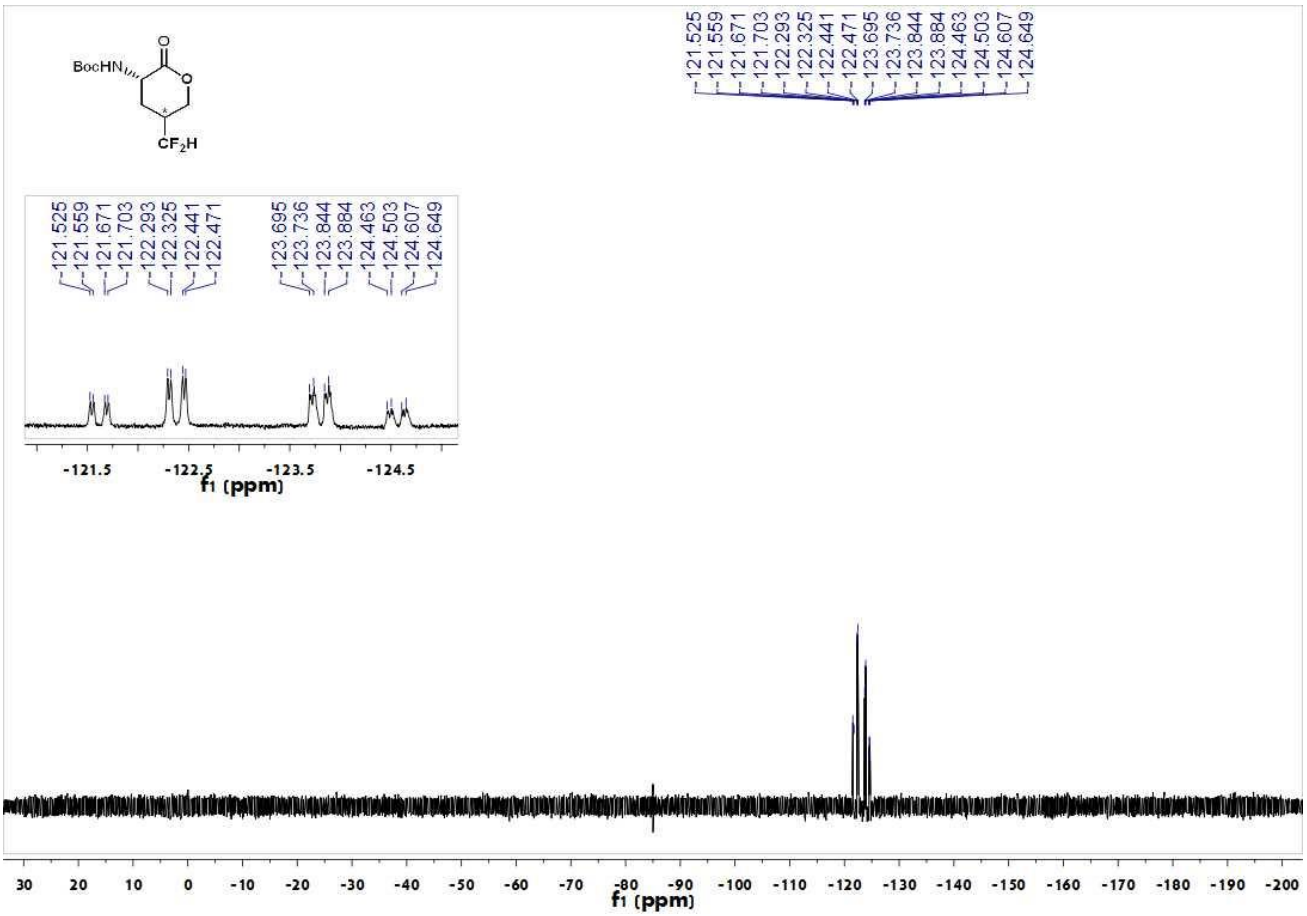


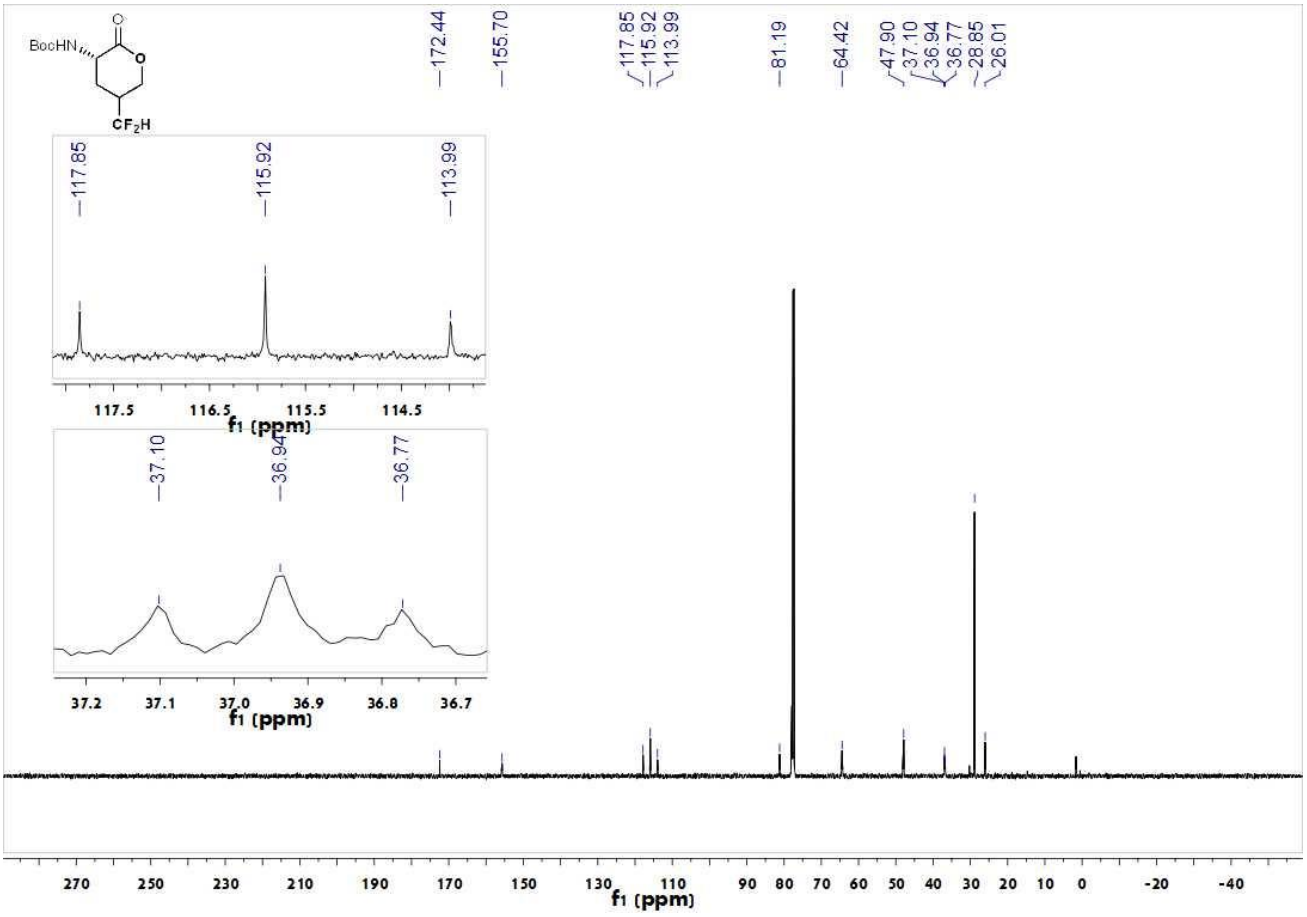




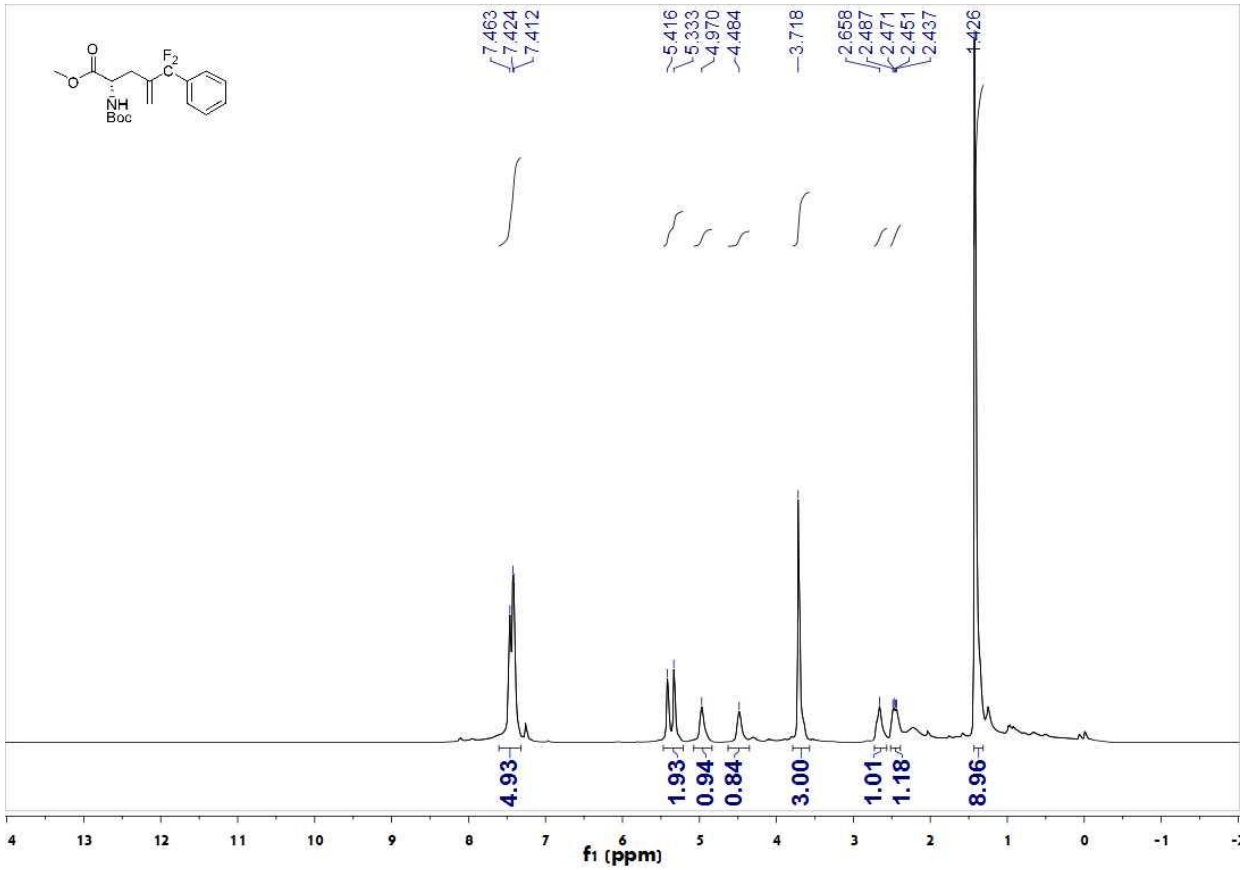
tert-Butyl ((3*S*)-5-(difluoromethyl)-2-oxotetrahydro-2H-pyran-3-yl)carbamate (11)

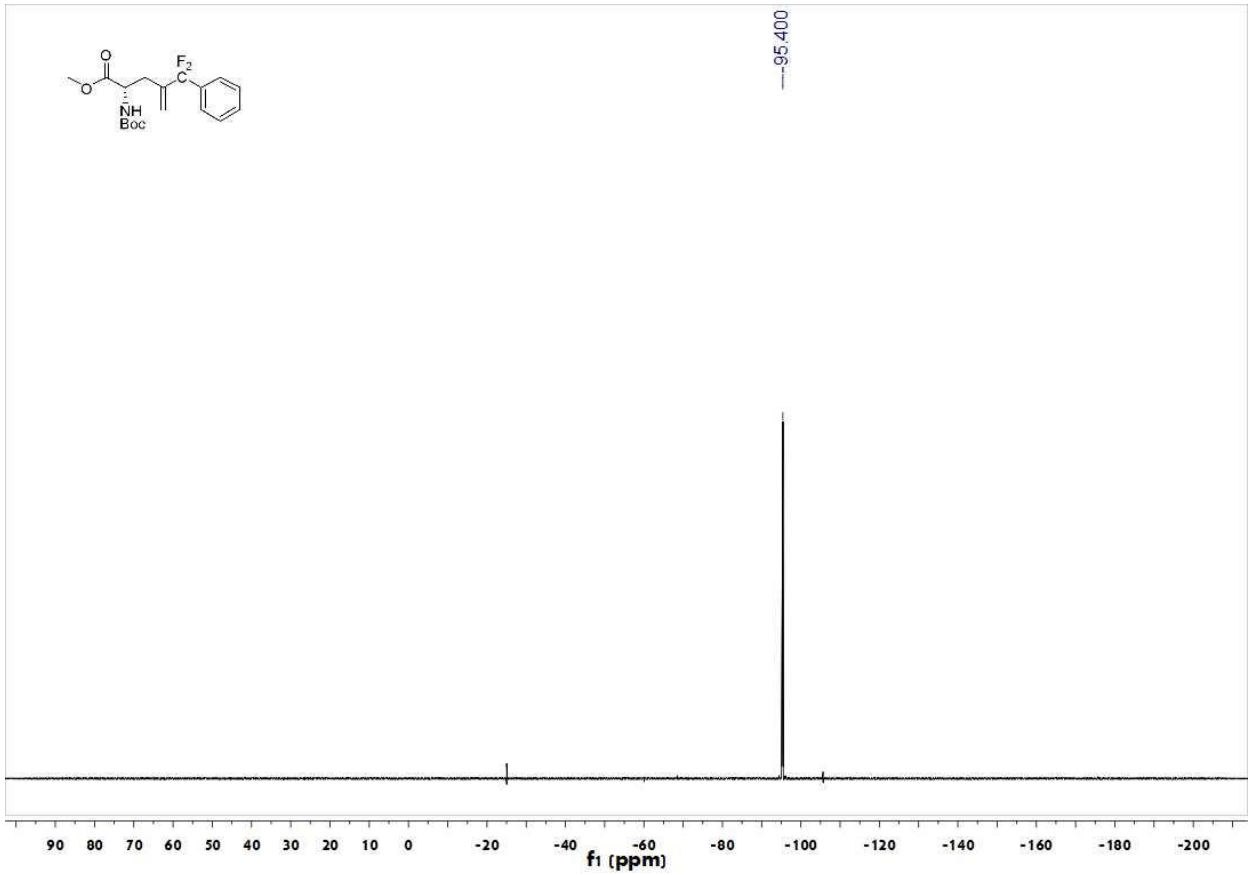


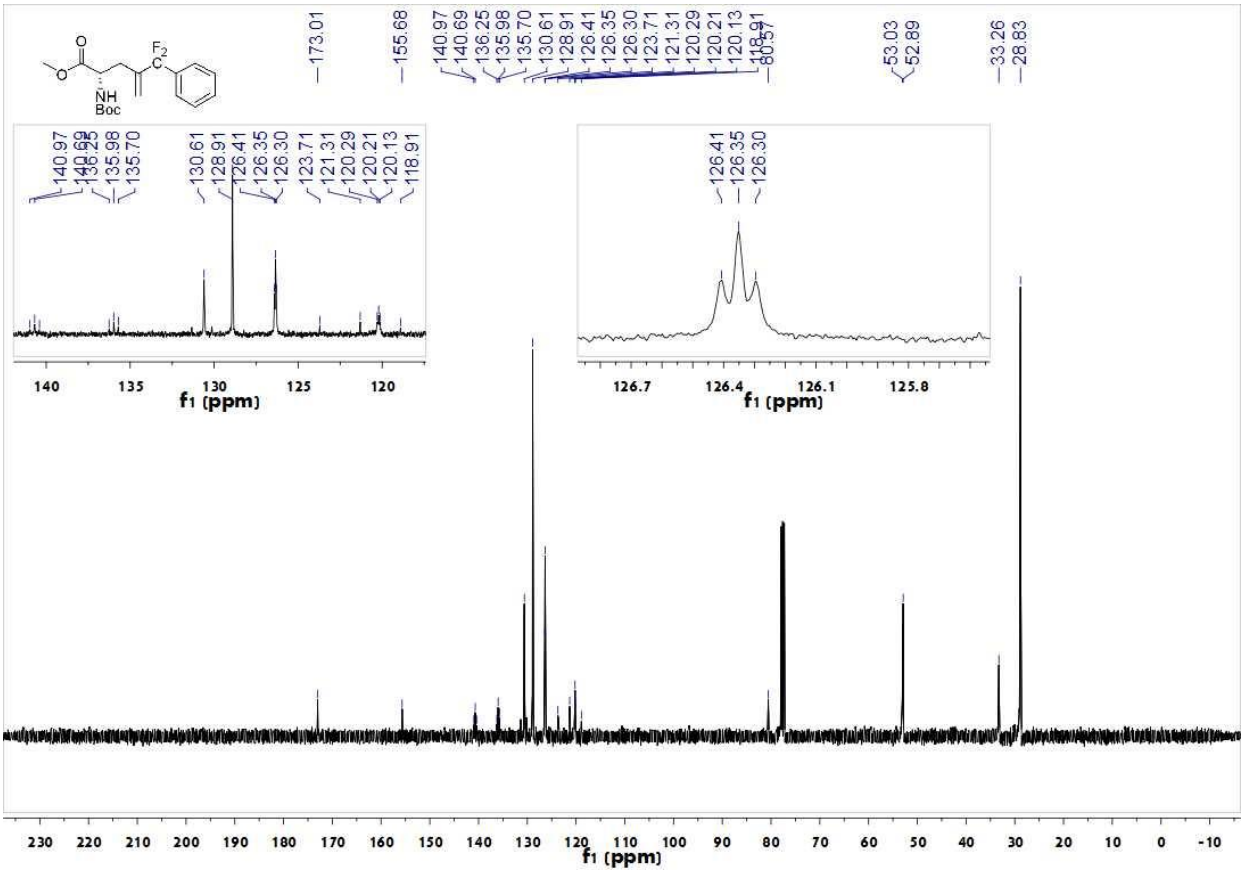

BocHN
O
O
CF2H
121.525
121.559
121.671
121.703
122.293
122.325
122.441
122.471
123.695
123.736
123.844
123.884
124.463
124.503
124.607
124.649
-121.5
-122.5
-123.5
-124.5
f1 (ppm)
30 20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200
f1 (ppm)


BocHN
O
O
CF2H
172.44
155.70
117.85
115.92
113.99
81.19
64.42
47.90
37.10
36.94
36.77
28.85
26.01
117.5
116.5
115.5
114.5
f1 (ppm)
37.2
37.1
37.0
36.9
36.8
36.7
f1 (ppm)
270 250 230 210 190 170 150 130 110 90 80 70 60 50 40 30 20 10 0 -20 -40
f1 (ppm)

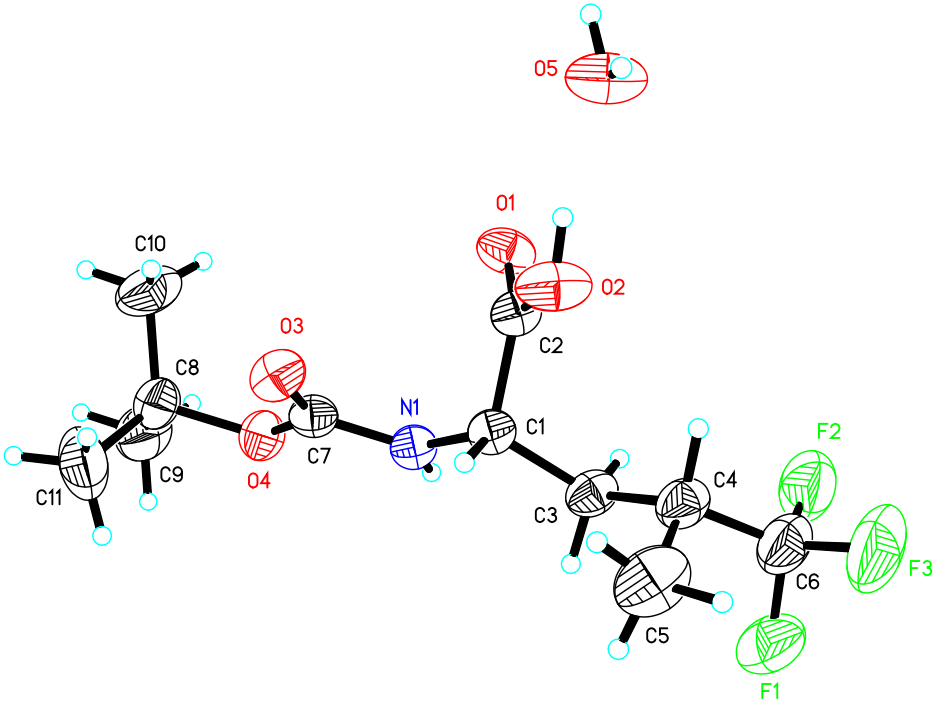
Methyl (*S*)-2-((*tert*-butoxycarbonyl)amino)-4-(difluoro(phenyl)methyl)pent-4-enoate (12)






O
O
F2
C
NH
Boc
173.01
155.68
140.97
140.69
136.25
135.98
135.70
130.61
128.91
126.41
126.35
126.30
123.71
121.31
120.29
120.21
120.13
118.91
80.57
53.03
52.89
33.26
28.83
f1 (ppm)
f1 (ppm)
f1 (ppm)

X-ray crystal structure of compound 7a:



Crystal data and structure refinement of 7a:

Table 1.Crystal data and structure refinement for cu_d8v18496_0m.

Identification code	cu_d8v18496_0m	
Empirical formula	C11 H20 F3 N O5	
Formula weight	303.28	
Temperature	296(2) K	
Wavelength	1.54178 Å	
Crystal system	Monoclinic	
Space group	P 21	
Unit cell dimensions	a = 6.6250(2) Å	α= 90 °.
	b = 9.3524(3) Å	β= 102.524(2) °.
	c = 13.0235(4) Å	γ = 90 °.
Volume	787.73(4) $Å^3$	
Z	2	
Density (calculated)	1.279 Mg/m^3	

Absorption coefficient	1.064 mm^{-1}
F(000)	320
Crystal size	0.140 x 0.120 x 0.070 mm^3
Theta range for data collection	5.873 to 66.494 °.
Index ranges	-7<=h<=7, -11<=k<=11, -15<=l<=15
Reflections collected	10507
Independent reflections	2741 [R(int) = 0.0591]
Completeness to theta = 67.679 °	97.0 %
Absorption correction	Semi-empirical from equivalents
Max. and min. transmission	0.7533 and 0.4791
Refinement method	Full-matrix least-squares on F^2
Data / restraints / parameters	2741 / 1 / 194
Goodness-of-fit on F^2	1.065
Final R indices [I>2sigma(I)]	R1 = 0.0472, wR2 = 0.1239
R indices (all data)	R1 = 0.0539, wR2 = 0.1314
Absolute structure parameter	0.21(15)
Extinction coefficient	0.021(6)
Largest diff. peak and hole	0.186 and -0.162 e.$Å^{-3}$