Supporting Information

for *ortho*-Substituent Effect on 2,4-Bis(trifluoromethyl)phenylboronic Acid Catalysed-Dehydrative Condensation between Carboxylic Acids and Amines

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Contents

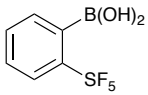
1. General Methods.

IR spectra were recorded on a JASCO FT/IR-460 plus spectrometer. ^{1}H NMR spectra were measured on a JEOL ECS-400 (400 MHz) or BRUKER Ascend-500 spectrometer (500 MHz). Data were recorded as follows: chemical shift in ppm from internal tetramethysilane on the δ scale, multiplicity (s = singlet; d = doublet; t = triplet; m = multiplet), coupling constant (Hz), and integration. ^{13}C NMR spectra were taken on a JEOL ECS-400 (101 MHz) or BRUKER Ascend-500 spectrometer (126 MHz). Chemical shifts were recorded in ppm from the solvent resonance employed as the internal standard ($CDCl_3$ at 77.16 ppm, CD_3OD at 49.00 ppm, DMSO-d_6 at 39.52 ppm). ^{11}B NMR spectra were taken on a JEOL ECS-400 (128 MHz) spectrometer. Chemical shifts were recorded in ppm from the solvent resonance employed as the internal standard ($BF_3.OEt_2$ at 0 ppm). For ^{11}B NMR analysis, a quartz glass NMR tube was used. ^{19}F NMR spectra were taken on a BRUKER Ascend-500 spectrometer (470 MHz). Chemical shifts were recorded in ppm from the solvent resonance employed as the internal standard (CF_3Cl at 0 ppm). Analytical HPLC was performed on a Shimadzu Model LC-10AD instrument coupled diode array-detector SPD-MA-10A-VP. For TLC analysis, Merck precoated TLC plates (silica gel 60 F254 0.25 mm) were used. High resolution mass spectral analysis (HRMS) was performed at Chemical Instrument Facility, Nagoya University (Bruker Daltonics micrOTOF-QII (ESI)). *In-situ* IR analysis was conducted on a Mettler-Toledo ReactIR 15 instruments, equipped with a DiComp(diamond) probe connected by an AgX (silver halide) fiber and inserted through a PTFE-lined septum fitted on the reaction vial.

Dry toluene and dichloromethane were purchased from Kanto chemical as the “anhydrous” and stored under nitrogen. Fluorobenzene was purchased from Sigma–Aldrich and used directly. 1,2-Dichloroethane was purchased from Kanto chemical and used directly. Molecular sieves (pellets) were activated by heating in a microwave oven for 1 min and then placed under high vacuum for 10 min. Molecular sieves (powder) were activated by heating with a heatgun (450 °C) under vacuum for 10 min.

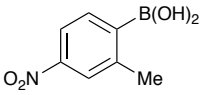
3,5-Bis(trifluoromethyl)phenylboronic acid (**1b**) (TCI), 2,4-bis(trifluoromethyl)phenylboronic acid (**1c**) (TCI), 2,6-bis(trifluoromethyl)phenylboronic acid (**1d**) (Aldrich), 2-(trifluoromethyl)phenylboronic acid (**1e**) (TCI), 2-nitrophenylboronic acid (**1g**) (TCI) and *o*-tolylboronic acid (**1f**) (Aldrich) were obtained from commercial supplies and used without further purification. 2-[(*N*,*N*-Diisopropylamino)methyl]phenylboronic acid (**1l**)[1] and 2-iodo-5-methoxyphenylboronic acid (**1m**)[2] were prepared according to the reported procedures.

2. Synthetic Procedures and Characterization of Catalysts

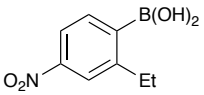


2-(Pentafluorosulfanyl)phenylboronic acid (1h): A dry 30-mL, round-bottom flask was charged with 2-hydroxy(pentafluorosulfanyl)benzene (4.0 mmol, 0.88 g, 1.0 equiv) and pyridine (8 mmol, 0.64 mL, 2.0 equiv) in anhydrous dichloromethane (20 mL). The mixture was stirred at 0 °C for 5 min and then trifluoromethanesulfonic anhydride (4.8 mmol, 0.79 mL, 1.2 equiv) was added. The reaction was allowed to warm to room temperature. After stirring at room temperature for 4 hours, the reaction was quenched with water (20 mL). The two layers were separated and the aqueous layer was extracted with dichloromethane (10 x 2 mL). The combined organic layer was washed with brine, dried over anhydrous sodium sulfate, filtered and evaporated in vacuum to give the crude product. It was further purified by flash chromatography on a silica gel column (hexane : ethyl acetate = 10 : 1) to give 2-(pentafluorosulfanyl)phenyl trifluoromethanesulfonate (1.33 g, 95% yield). A 10-mL, round-bottom flask was charged with 2-(pentafluorosulfanyl)phenyl trifluoromethanesulfonate (3.8 mmol, 1.3 g, 1.0 equiv), bis(pinacolato)diboron (12 mmol, 3.1 g, 3.0 equiv), potassium phosphate (12 mmol, 2.5 g, 3.0 equiv), $Pd_2(dba)_3$ (0.12 mmol, 0.11 g, 0.030 equiv), 2-dicyclohexylphosphino-2',6'-dimethoxybiphenyl (SPhos) (0.24 mmol, 208 mg, 0.060 equiv) in toluene (8 mL). The mixture was degassed and charged with nitrogen. The reaction mixture was heated to reflux (bath temperature 110 °C) for 4 hours. After cooling to room temperature, the resulting mixture was diluted with ethyl acetate (8 mL) and filtered through a tight pad of celite. The filtrate was washed with water, brine and dried over anhydrous sodium sulfate. The solvent was then evaporated in vacuum to give the crude product. It was further purified through flash chromatography on a silica gel column (hexane : ethyl acetate = 5: 1) to provide the desired triflate product (1.14 g, 91% yield). A 30-mL, round-bottom flask was charged with the 2-(pentafluorosulfanyl)phenyl trifluoromethanesulfonate (3.5 mmol, 1.1 g) in 1,4-dioxane (4 mL), and then a solution of 4 *M* HCl (20 mL) was added. The reaction mixture was heated to reflux (bath temperature 110 °C) over night. After cooling to room temperature, the reaction mixture was extracted with ethyl ether (10 x 3 mL) and the organic layer was separated, washed with water, brine, and dried over anhydrous sodium sulfate. The solvent was evaporated in vacuum to give the crude product. It was further purified through a flash chromatography on a silica gel column (hexane : ethyl acetate = 3 : 1) to provide the 2-(pentafluorosulfanyl)phenylboronic acid **1h** as a white solid (0.62 g, 73% yield). ^{1}H NMR (500 MHz, DMSO-d_6) δ 8.37 (s, 2H), 7.83 (dd, J = 8.3, 1.1 Hz, 1H), 7.59 (t, J = 7.3 Hz, 1H), 7.57 – 7.51 (m, 1H), 7.49 (d, J = 7.2 Hz, 1H); ^{13}C NMR (126 MHz, DMSO-d_6) δ 155.15 (t, $J_{C\text{-}F}$ = 13.8 Hz, 1C), 136.86, 132.55, 131.19, 128.46, 125.69; IR

(KBr) 3340, 1602, 1354, 1117, 1063, 1008 cm^{-1}; HRMS (ESI) calcd for $C_6H_5BF_5O_2S$ $[M-H]^-$ 247.0030, found 247.0030.

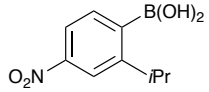


2-Methyl-4-nitrophenylboronic acid (1i): A dry 300-mL, round-bottom flask was charged with 1-bromo-2-methyl-4-nitrobenzene (17 mmol, 3.7 g, 1.0 equiv), bis(pinacolato)diboron (26 mmol, 6.6 g, 1.5 equiv), potassium acetate (51 mmol, 5.0 g, 3.0 equiv), $PdCl_2$(dppf) (0.51 mmol, 0.42 g, 0.03 equiv) in *N,N*-dimethylformamide (85 mL). The mixture was degassed and charged with nitrogen. The reaction mixture was stirred in an oil bath at 85 °C overnight. The resulting mixture was filtered through a tight pad of celite. The filtrate was diluted with ethyl acetate and washed with water to remove *N,N*-dimethylformamide. The organic layer was then washed with brine and dried over anhydrous sodium sulfate. The solvent was evaporated in vacuum to give the crude product. The product was further purified by flash chromatography on a silica gel column (hexane : ethyl acetate = 20 : 1) to provide the desired product (3.7 g, 88% yield). A 300-mL, round-bottom flask was charged with 4,4,5,5-tetramethyl-2-(2-methyl-4-nitrophenyl)-1,3,2-dioxaborolane (15 mmol, 3.7 g) in 1,4-dioxane (15 mL), and then a solution of 4 *M* HCl (75 mL) was added. The mixture was heated to reflux (bath temperature 110 °C) over night. The reaction mixture was extracted with ethyl ether (75 x 2 mL) and the organic layer was separated, washed with water, brine, and dried over sodium sulfate. The solvent was evaporated in vacuum to give the crude product. The product was further purified by flash chromatography on a silica gel column (hexane : ethyl acetate = 3 : 1) to provide the 2-methyl-4-nitrophenylboronic acid **1i** (containing some amount of anhydride) as a yellow solid (1.9 g, 71% yield). ^{1}H NMR (500 MHz, DMSO-d_6) δ 8.08–7.95 (m, 2H), 7.64 (d, J = 8.0 Hz, 1H), 2.50 (s, 3H); ^{13}C NMR (126 MHz, DMSO-d_6) δ 147.65, 145.17, 143.01, 133.81, 123.01, 119.16, 21.80; IR (KBr) 3514, 1509, 1336, 1024 cm^{-1}; HRMS (ESI) calcd for $C_7H_7BNO_4$ $[M-H]^-$ 180,0475, found 180,0473.



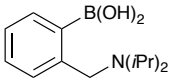
2-Ethyl-4-nitrophenylboronic acid (1j): A dry 300-mL, round-bottom flask was charged with 2-ethylphenol (30 mmol, 3.6 mL, 1.0 equiv) in ethyl acetate (120 mL). Nitrous acid (60%, d = 1.360 g cm^{-3}) (30 mmol, 2.3 mL, 1.0 equiv), zinc chloride (30 mmol, 4.1 g, 1.0 equiv) were added to the flask at 0 °C. The mixture was warmed up to room temperature and stirred overnight. The resulting mixture was filtered through a tight pad of celite. The filtrate was washed with water, brine, and dried over anhydrous sodium sulfate. The crude product was

further purified by flash chromatography on a silica gel column (hexane : ethyl acetate = 5 : 1) to provide 2-ethyl-4-nitrophenol (3.0 g, 60% yield). A dry 200-mL, round-bottom flask was charged with 2-ethyl-4-nitrophenol (18 mmol, 3.0 g, 1.0 equiv) and pyridine (36 mmol, 2.9 mL, 1.2 equiv) in anhydrous dichloromethane (72 mL). The mixture was stirring at 0 °C for 5 min and then trifluoromethanesulfonic anhydride (22 mmol, 1.8 mL, 1.2 equiv) was added. The reaction was allowed to warm to room temperature. After stirring at room temperature for 4 hours, the reaction was quenched with water. The two layers were separated and the aqueous layer was extracted with ethyl acetate. The combined organic layer was washed with brine, dried over anhydrous sodium sulfate, filtered and evaporated in vacuum to give the crude product. The product was further purified by flash chromatography on a silica gel column to give 2-ethyl-4-nitrophenyl trifluoromethanesulfonate (4.0 g, 75% yield). A 50-mL, round-bottom flask was charged with 2-ethyl-4-nitrophenyl trifluoromethanesulfonate (13 mmol, 4.0 g, 1.0 equiv), bis(pinacolato)diboron (40 mmol, 10 g, 3.0 equiv), potassium phosphate (40 mmol, 8.4 g, 3.0 equiv), $Pd_2(dba)_3$ (0.40 mmol, 0.37 g, 0.03 equiv), SPhos (0.80 mmol, 0.33 g, 0.06 equiv) in toluene (27 mL). The mixture was degassed and charged with nitrogen. The reaction mixture was heated to reflux (bath temperature 110 °C) for 4 hours. The resulting mixture was diluted with ethyl acetate (10 mL) and filtered through a tight pad of celite. The filtrate was washed with water, brine and dried over anhydrous sodium sulfate. The solvent was then evaporated in vacuum to give the crude product. The product was further purified by flash chromatography on a silica gel column (hexane : ethyl acetate = 20 : 1) to provide the desired product (2.8 g, 71% yield). A 100-mL, round-bottom flask was charged with the 2-(2-ethyl-4-nitrophenyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (9.0 mmol, 2.5 g, 1.0 equiv) in 1,4-dioxane (9 mL), and then a solution of 4 *M* HCl (45 mL) was added. The mixture was heated to reflux (bath temperature 110 °C) over night. The reaction mixture was extracted with ethyl ether and the organic layer was separated, washed with water, brine, and dried over sodium sulfate. The solvent was evaporated in vacuum to give the crude product. The product was further purified by flash chromatography on a silica gel column (hexane : ethyl acetate = 3 : 1) to provide the 2-ethyl-4-nitrophenylboronic acid **1j** (containing some amount of anhydride) as a light yellow solid (1.3 g, 74% yield). ^{1}H NMR (500 MHz, DMSO-d_6) δ 8.44 (br, 1H), 8.07–7.97 (m, 2H), 7.63 (d, J = 8.0 Hz, 1H), 2.85 (q, J = 7.5 Hz, 2H), 1.19 (t, J = 7.6 Hz, 3H); ^{13}C NMR (126 MHz, DMSO-d_6) δ 149.17, 147.79, 145.02, 133.76, 121.63, 119.33, 28.31, 16.12; IR (KBr) 3513, 1509, 1338, 1023 cm^{-1}; HRMS (ESI) calcd for $C_8H_9BNO_4$ $[M-H]^-$ 194,0632, found 194.0633.

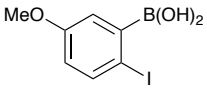


2-Isopropyl-4-nitrophenylboronic acid (1k): A dry 300-mL, round-bottom flask was charged with 2-isopropylphenol (22 mmol, 3.0 mL, 1.0 equiv) in ethyl acetate (88 mL).

Nitrous acid (1.38 g/mL) (22 mmol, 1.7 mL, 1.0 equiv), zinc chloride (22 mmol, 3.0 g, 1.0 equiv) were added to the flask at 0 °C. The mixture was warmed up to room temperature and stirred for 1.5 h. The resulting mixture was filtered through a tight pad of celite. The filtrate was washed with water, brine, and dried over anhydrous sodium sulfate. The crude product was further purified by flash chromatography on a silica gel column (hexane : ethyl acetate = 5 : 1) to provide 2-isopropyl-4-nitrophenol (2.7 g, 67% yield). A dry 200-mL, round-bottom flask was charged with 2-isopropyl-4-nitrophenol (15 mmol, 2.7 g, 1.0 equiv) and pyridine (30 mmol, 2.4 mL, 2.0 equiv.) in anhydrous dichloromethane (75 mL). The mixture was stirring at 0 °C for 5 min and then trifluoromethanesulfonic anhydride (18 mmol, 3.0 g, 1.2 equiv.) was added. The reaction was allowed to warm back to room temperature. After stirring at room temperature for 1.5 h, the reaction was quenched with water. The two layers were separated and the aqueous layer was extracted with ethyl acetate. The combined organic layer was washed with brine, dried over anhydrous sodium sulfate, filtered and evaporated in vacuum to give the crude product. The product was further purified by flash chromatography on a silica gel column to give 2-isopropyl-4-nitrophenyl trifluoromethanesulfonate (3.5 g, 76% yield). A 50-mL, round-bottom flask was charged with 2-isopropyl-4-nitrophenyl trifluoromethanesulfonate (11 mmol, 3.5 g, 1.0 equiv), bis(pinacolato)diboron (33 mmol, 8.4 g, 3.0 equiv), potassium phosphate (33 mmol, 7.0 g, 3.0 equiv), $Pd_2(dba)_3$ (0.66 mmol, 0.30 g, 0.030 equiv), SPhos (0.66 mmol, 0.27 g, 0.06 equiv) in toluene (22 mL). The mixture was degassed and charged with nitrogen. The reaction mixture was heated (bath temperature 110 °C) overnight. The resulting mixture was diluted with ethyl acetate and filtered through a tight pad of celite. The filtrate was washed with water, brine and dried over anhydrous sodium sulfate. The solvent was then evaporated in vacuum to give the crude product. The product was further purified by flash chromatography on a silica gel column (hexane : ethyl acetate = 20 : 1) to provide the desired triflate product (2.6 g, 82% yield). A 100-ml, round-bottom flask was charged with the triflate (9.0 mmol, 2.6 g) in 1,4-dioxane (9 mL), and then a solution of 4 *M* HCl (45 mL) was added. The mixture was heated (bath temperature 110 °C) for 22 h. The reaction mixture was extracted with ethyl ether and the organic layer was separated, washed with water, brine, and dried over sodium sulfate. The solvent was evaporated in vacuum to give the crude product. The product was further purified by flash chromatography on a silica gel column (hexane : ethyl acetate = 3 : 1) to provide the (2-isopropyl-4-nitrophenyl)boronic acid **1k** (containing some amount of anhydride) as a light yellow solid (1.4 g, 72% yield). ^{1}H NMR (500 MHz, DMSO-d_6) δ 8.48 (brs, 2H), δ 8.03 (d, J = 2.2 Hz, 1H), 7.98 (dd, J = 8.1, 2.2 Hz, 1H), 7.57 (d, J = 8.1 Hz, 1H), 3.29 (hept, J = 6.9 Hz, 1H), 1.24 (d, J = 6.9 Hz, 7H). ^{13}C NMR (126 MHz, DMSO-d_6) δ 153.13, 147.95, 145.54, 133.15, 119.48, 118.47, 32.78, 23.75 (2C); IR (KBr) 3311, 1520, 1350 cm^{-1}; HRMS (ESI) calcd for $C_9H_{11}BNO_4$ $[M\text{-}H]^-$ 208.0788, found 208.0794.



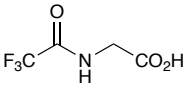
2-[(*N*,*N*-Diisopropylamino)methyl]phenylboronic acid (1l):[1] white solid; ^{1}H NMR (500 MHz, DMSO-d_6) δ 9.74 (brs, 2H), 7.73 (d, J = 6.8 Hz, 1H), 7.35–7.29 (m, 2H), 7.24 (m, 1H), 3.78 (s, 2H), 3.02 (hept, J = 6.7 Hz, 1H), 1.04 (d, J = 6.6 Hz, 12H); ^{13}C NMR (126 MHz, DMSO-d_6) δ 142.79, 135.72, 130.60, 129.59, 126.42, 50.99, 46.86, 19.58; IR (KBr) 3314, 1597, 1385 cm^{-1}.



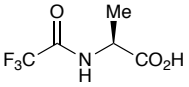
2-Iodo-5-methoxyphenylboronic acid (1m):[2] white solid (containing some amount of anhydride); ^{1}H NMR (500 MHz, DMSO-d_6) δ 8.25 (brs, 2H), 7.60 (d, J = 8.6 Hz, 1H), 6.81 (d, J = 3.2 Hz, 1H), 6.68 (dd, J = 8.6, 3.2 Hz, 1H), 3.72 (s, 3H); ^{13}C NMR (126 MHz, DMSO-d_6) δ 158.40, 138.55, 118.92, 116.26, 87.55, 55.11; IR (KBr) 3331, 1583, 1467, 1392, 1345, 1237, 1042 cm^{-1}.

3. Synthetic Procedures and Characterization of Starting Materials

General procedure for preparing 2,2,2-trifluoroacetyl masked amino acids:[3] A single-necked, round-bottomed flask equipped with a Teflon-coated magnetic stirring bar was charged with α-amino acid (10 mmol, 1.0 equiv.), triethylamine (10 mmol, 1.0 equiv.) in methanol (2 *M*). The mixture was stirred for 5 min, and ethyl trifluoroacetate (13 mmol, 1.3 equiv.) was gradually added. The reaction mixture was then stirred at ambient temperature for almost 20 h. The solvent was then removed in vacuum and the white residue was dissolved in 1 *M* hydrogen chloride solution (20 mL). The aqueous solution was extracted with ethyl acetate (20 x 2 mL), and the combined organic layer was washed with brine, dried over anhydrous sodium sulfate. The solvent was evaporated to provide the *N*-trifluoroacetyl amino acids.

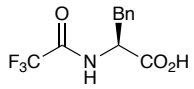


***N*-2-Trifluoroacetylglycine (2g):** white solid; ^{1}H NMR (500 MHz, DMSO-d_6) δ 12.92 (brs, 1H), 9.77 (t, J = 6.0 Hz, 1H), 3.88 (d, J = 6.0 Hz, 2H); ^{13}C NMR (126 MHz, DMSO-d_6) δ 169.66, 156.85 (q, $J_{C\text{-}F}$ = 36.4 Hz, 1C), 115.96 (q, $J_{C\text{-}F}$ = 287.8 Hz, 1C), 40.90; ^{19}F NMR (470 MHz, DMSO-d_6) δ -74.60; IR (KBr) 3445, 1717, 1637, 1220, 1194 cm^{-1}; HRMS (ESI) calcd for $C_4H_3F_3NNa_2O_3$ $[M+2Na-H]^+$ 215.9855, found 215.9864.

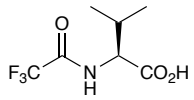


***N*-Trifluoroacetyl-*L*-alanine (2h):** white solid; ^{1}H NMR (500 MHz, DMSO-d_6) δ 9.71 (d, J = 7.4 Hz, 1H), 4.31 (m, 1H), 1.36 (d, J = 7.3 Hz, 3H); ^{13}C NMR (126 MHz, DMSO-d_6) δ 172.39, 156.11 (q, J = 36.5 Hz), 115.81 (q, J = 288.1 Hz), 48.16, 16.18; ^{19}F NMR (470 MHz,

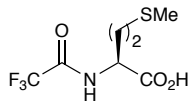
DMSO-d_6) δ -74.26; IR (KBr) 3434, 1709, 1638, 1191 cm^{-1}; HRMS (ESI) calcd for $C_5H_5F_3NNa_2O_3$ $[M+2Na-H]^+$ 230.0011, found 230.0020.



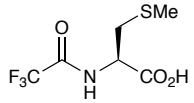
***N*-Trifluoroacetyl-*L*-phenylalanine (2i):** white solid; ^1H NMR (500 MHz, DMSO-d_6) δ 9.76 (d, J = 8.3 Hz, 1H), 7.31–7.19 (m, 5H), 4.52 (m, 1H), 3.22 (dd, J = 13.9, 4.4 Hz, 1H), 2.99 (dd, J = 13.9, 11.0 Hz, 1H); ^{13}C NMR (126 MHz, DMSO-d_6) δ 171.38, 156.25 (q, J = 36.6 Hz, 1C), 137.29, 128.98 (2C), 128.24 (2C), 126.58, 115.74 (q, J = 288.2 Hz, 1C), 53.99, 35.62; ^{19}F NMR (470 MHz, DMSO-d_6) δ -74.35; IR (KBr) 3539, 3319, 1711, 1559, 1180 cm^{-1}; HRMS (ESI) calcd for $C_{11}H_9F_3NNa_2O_3$ $[M+2Na-H]^+$ 306.0324, found 306.0324.



***N*-Trifluoroacetyl-*L*-valine (2j):** white solid; ^1H NMR (500 MHz, DMSO-d_6) δ 9.59 (d, J = 8.2 Hz, 1H), 4.14 (dd, J = 8.2, 6.9 Hz, 1H), 2.31–2.05 (m, 1H), 0.92 (d, J = 6.9 Hz, 6H); ^{13}C NMR (126 MHz, DMSO-d_6) δ 171.46, 156.76 (q, J = 36.8 Hz, 1C), 115.91 (q, J = 287.9 Hz, 1C), 58.43, 29.19, 19.00, 18.39; ^{19}F NMR (470 MHz, DMSO-d_6) δ -73.70; IR (KBr) 3278, 1701, 1556, 1186 cm^{-1}; HRMS (ESI) calcd for $C_7H_9F_3NNa_2O_3$ $[M+2Na-H]^+$ 258.0324, found 258.0330.



***N*-Trifluoroacetyl-*L*-methionine (2k):** white solid; ^1H NMR (500 MHz, DMSO-d_6) δ 9.69 (d, J = 7.8 Hz, 1H), 4.42–4.38 (m, 1H), 2.56–2.43 (m, 2H), 2.08–1.99 (m, 5H); ^{13}C NMR (126 MHz, DMSO-d_6) δ 171.72, 156.59 (q, J_{C-F} = 36.6 Hz, 1C), 115.82 (q, J_{C-F} = 288.1 Hz, 1C), 51.56, 29.75, 29.47, 14.45; ^{19}F NMR (470 MHz, DMSO-d_6) δ -74.18; IR (KBr) 3291, 1747, 1707, 1560, 1223, 1184, 1158 cm^{-1}; HRMS (ESI) calcd for $C_7H_9F_3NNa_2O_3S$ $[M+2Na-H]^+$ 290.0045, found 290.0045.

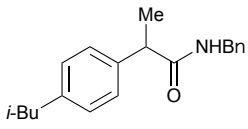


***S*-Methyl-*N*-trifluoroacetyl-*L*-cysteine (2l):** white solid; ^1H NMR (500 MHz, DMSO-d_6) δ 9.76 (d, J = 8.2 Hz, 1H), 4.46 (m, 1H), 3.00 (dd, J = 14.0, 4.2 Hz, 1H), 2.84 (dd, J = 14.0, 10.5 Hz, 1H), 2.07 (s, 3H); ^{13}C NMR (126 MHz, DMSO-d_6) δ 170.62, 156.53 (q, J_{C-F} = 36.7 Hz, 1C), 115.87 (q, J_{C-F} = 288.1 Hz, 1C), 51.97, 33.98, 14.84; ^{19}F NMR (470 MHz, DMSO-d_6) δ –74.27; IR (KBr) 3304, 1712, 1559, 1185 cm^{-1}; HRMS (ESI) calcd for $C_6H_7F_3NNa_2O_3S$ $[M+2Na-H]^+$ 275.9889, found 275,9889.

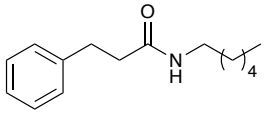
4. General Methods for the Dehydrative Condensation and Characterization of Amide Products (Tables 1 and 2)

General procedure for the amide condensation at room temperature: A 20-mL, single-necked, round-bottomed flask equipped with a Teflon-coated magnetic stirring bar was charged with carboxylic acid (0.50 mmol, 1.0 equiv), $ArB(OH)_2$ (**1**) (0.050 mmol, 0.1 equiv) and 1 g of activated molecular sieves 3Å (powder) in dichloromethane (0.07 *M*). After the mixture was stirred for 5 min, amine was added. The resulting mixture was stirred for several hours at room temperature. The reaction mixture was filtered through a pad of celite, and washed with dichloromethane. The filtrate was purified by short flash chromatography on silica gel column (normal silica : NH silica = 9 : 1, hexane : ethyl acetate = 1 : 1) to give the desired amide products.

General procedure for the amide condensation under azeotropic reflux conditions: A 20-mL, single-necked, round-bottomed flask equipped with a Teflon-coated magnetic stirring bar and a 5-mL pressure-equalized addition funnel [containing a cotton plug and 2 g of activated molecular sieves 3Å (pellets)] surmounted by a reflux condenser was charged with carboxylic acid (1.0 mmol, 1.0 equiv) and **1** (0.10 mmol, 0.10 equiv) in fluorobenzene or toluene (0.2 *M*). After the mixture was stirred at ambient temperature for 5 min, amine (1.0 mmol, 1.0 equiv) was added. The resulting mixture was heated under azeotropic reflux conditions with the removal of water for several hours. After the reaction mixture was cooled to ambient temperature, the solvent was evaporated. The residue was purified by short flash chromatography on silica gel column (normal silica : NH silica = 9 : 1, hexane : ethyl acetate = 1 : 1) to give the desired amide products **5**.

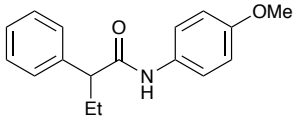


***N*-Benzyl-2-(4-isobutylphenyl)propanamide (5aa):**[4] white solid; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.30–7.17 (m, 5H), 7.13–7.10 (m, 4H), 5.67 (brs, 1H), 4.38 (d, *J* = 5.8 Hz, 2H), 3.57 (q, *J* = 7.2 Hz, 1H), 2.45 (d, *J* = 7.2 Hz, 2H), 1.83 (m, 1H), 1.54 (d, *J* = 7.2 Hz, 3H), 0.89 (d, *J* = 6.6 Hz, 6H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 174.47, 140.91, 138.58, 138.49, 129.78 (2C), 128.70 (2C), 127.49 (2C), 127.42, 46.92, 45.12, 43.62, 30.31, 22.50 (2C), 18.56; IR (KBr) 3307, 1644, 1542 cm^{-1}.

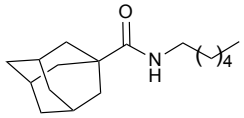


3-Phenyl-*N*-propylpropanamide (5bb):[5] white solid; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.36–7.24 (m, 2H), 7.21–7.18 (m, 3H), 5.42 (brs, 1H), 3.19 (td, *J* = 7.2, 5.8 Hz, 2H), 2.96 (t, *J* = 7.7 Hz, 2H), 2.45 (dd, *J* = 8.4, 7.0 Hz, 2H), 1.40 (m, 2H), 1.33–1.17 (m, 6H), 0.87 (t, *J* = 7.0

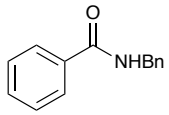
Hz, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 172.06, 141.05, 128.60 (2C), 128.46 (2C), 126.31, 39.65, 38.71, 31.93, 31.58, 29.64, 26.64, 22.65, 14.14; IR (KBr) 3325, 1637, 1541 cm^{-1}.



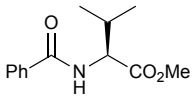
***N*-(4-Methoxyphenyl)-2-phenylbutanamide (5cc):**[6] white solid; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.35–7.23 (m, 7H), 6.78 (d, J = 9.0 Hz, 2H), 3.74 (s, 3H), 3.37 (t, J = 7.3 Hz, 1H), 2.31–2.21 (m, 1H), 1.91–1.80 (m, 1H), 0.92 (t, J = 7.4 Hz, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 171.64, 156.49, 139.79, 131.12, 129.10 (2C), 128.21 (2C), 127.57, 121.75 (2C), 114.17 (2C), 56.13, 55.61, 26.59, 12.52; IR (KBr) 3282, 1654, 1512cm^{-1}.



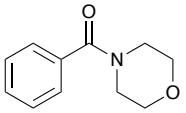
***N*-Propyladamantane-1-carboxamide (5db):** white solid; ^{1}H NMR (500 MHz, $CDCl_3$) δ 5.58 (brs, 1H), 3.22 (td, J = 7.2, 5.6 Hz, 2H), 2.04 (s, 3H), 1.85 (d, J = 2.9 Hz, 6H), 1.77–1.68 (m, 6H), 1.55–1.42 (m, 2H), 1.29 (s, 6H), 0.94–0.83 (m, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 177.91, 40.67, 39.45 (3C), 39.42, 36.68 (3C), 31.61, 29.74, 28.29 (3C), 26.69, 22.67, 14.14; IR (KBr) 3312, 1634, 1557 cm^{-1}; HRMS (ESI) calcd for $C_{17}H_{30}NO$ $[M+H]^+$ 264,2322, found 262.2329.



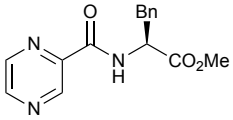
***N*-Benzylbenzamide (5ea):**[7] white solid; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.83–7.72 (m, 2H), 7.54–7.46 (m, 1H), 7.46–7.38 (m, 2H), 7.37–7.26 (m, 5H), 6.55 (brs, 1H), 4.63 (d, J = 5.7 Hz, 2H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 167.48, 138.32, 134.49, 131.64, 128.88 (2C), 128.69 (2C), 128.01 (2C), 127.71, 127.09 (2C), 44.23; IR (KBr) 3294, 1638, 1551 cm^{-1}.



Methyl benzoyl-*L*-valinate (5ed):[8] white solid; HPLC (Daicel Chiral AD-H, hexane/ethanol = 95:5, flow rate = 1.0 mL/min), t_R = 23.878 (minor enantiomer), t_R = 27.475 (major enantiomer) min, 99% ee; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.82–7.80 (m, 2H), 7.53–7.50 (m, 1H), 7.46–7.43 (m, 2H), 6.67 (brd, J = 8.6 Hz, 1H), 4.79 (dd, J = 8.7, 4.9 Hz, 1H), 3.77 (s, 3H), 2.31–2.24 (m, 1H), 1.02–0.98 (m, 6H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 172.76, 167.37, 134.27, 131.82, 128.71 (2C), 127.15 (2C), 57.52, 52.34, 31.74, 19.11, 18.08; IR (KBr) 3342, 1738, 1638, 1519 cm^{-1}.



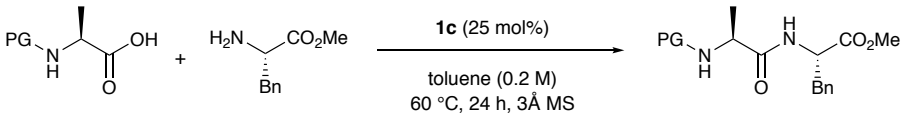
Morpholino(phenyl)methanone (5ee):[9] colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.45–7.39 (m, 5H), 3.78–3.46 (m, 8H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 170.57, 135.46, 130.01, 128.71 (2C), 127.22 (2C), 67.05; IR (KBr) 2856, 1632, 1430, 1279, 1258, 1114, 1017, 842, 789, 710 cm^{-1}.

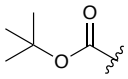
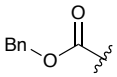
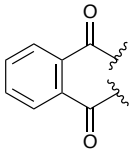


Methyl *N*-pyrazine-2-carbonyl-*L*-phenylalaninate (5ff):[10] light yellow oil; HPLC (Daicel Chiral OD-3 x 2, hexane/isopropanol = 95:5, flow rate = 1.0 mL/min), t_R = 81.688 (minor enantiomer), t_R = 94.704 (major enantiomer) min, 99% ee; ^{1}H NMR (500 MHz, $CDCl_3$) δ 9.37 (d, J = 1.5 Hz, 1H), 8.75 (d, J = 2.3 Hz, 1H), 8.53 (m, 1 H), 8.21 (brd, J = 8.2 Hz, 1H), 7.30–7.24 (m, 3H), 7.17–7.15 (m, 2H), 5.10–5.06 (m, 1H), 3.75 (s, 3H), 3.30–3.20 (m, 2H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 171.66, 162.77, 147.62, 144.55, 144.14, 142.87, 135.86, 129.37 (2C), 128.79 (2C), 127.35, 53.49, 52.59, 38.33; IR (KBr) 3388, 1743, 1679, 1521 cm^{-1}.

5. Optimization of Reaction Conditions for Dipeptide Synthesis

5-1. Screening of *N*-Protecting Groups for Amino Acids

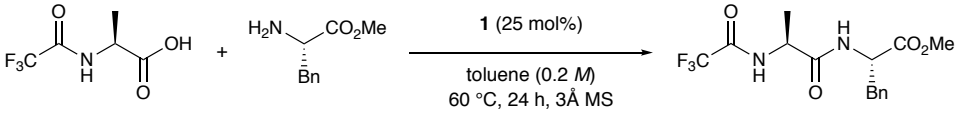


entry	PG	yield (%)	dr	entry	PG	yield (%)	dr
1		<5	-	4		65	>95:5
2		<5	-	5		61	>95:5
3		<5	-	6		35	>95:5

A 20-mL, single-necked, round-bottomed flask equipped with a Teflon-coated magnetic stirring bar was charged with *N*-protected α-amino acid (0.50 mmol, 1.0 equiv), **1c** (0.13 mmol, 32 mg, 0.25 equiv) and ca. 0.75 g of activated molecular sieves 3Å (powder) in toluene (0.2 *M*). After the mixture was stirred for 5 min, α-amino ester (0.50 mmol, 90 mg, 1.0 equiv) was added. The resulting mixture was stirred for 24 hours at 60 °C. After cooling to room temperature, the

reaction mixture was then filtered through a tight pad of celite, and washed with ethyl acetate (5 mL). The filtrate was purified by flash chromatography on silica gel column (normal silica: NH silica = 9 : 1, hexane : ethyl acetate = 1 : 1) to give the desired dipeptide products.

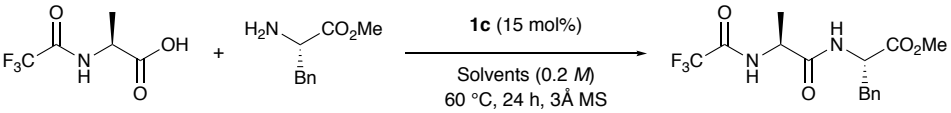
5-2. Activity of Several Boronic Acid Catalysts in Dipeptide Synthesis



entry	catalyst	yield (%)	dr
1 (This work)	**1c**	65	>95:5
2 (Hall's cat.)	**1m**	38	>95:5
3 (Yamamoto's cat.)	**1b**	<5	-

A 20-mL, single-necked, round-bottomed flask equipped with a Teflon-coated magnetic stirring bar was charged with *N*-protected α-amino acid (0.50 mmol, 93 mg, 1.0 equiv), **1** (0.13 mmol, 0.25 equiv.) and ca. 0.75 g of activated molecular sieves 3Å (powder) in Toluene (0.2 *M*). After the mixture was stirred for 5 min, α-amino ester (0.50 mmol, 90 mg, 1.0 equiv) was added. The resulting mixture was stirred for 48 hours at 60 °C. After cooling to room temperature, the reaction mixture was then filtered through a celite pad, and washed with ethyl acetate (5 mL). The filtrate was purified by flash chromatography on silica gel column (normal silica: NH silica = 9 : 1, hexane : ethyl acetate = 1 : 1) to give the desired dipeptide products **5**.

5-3. Optimization of Solvents for 1c-Catalysed Dipeptide Synthesis



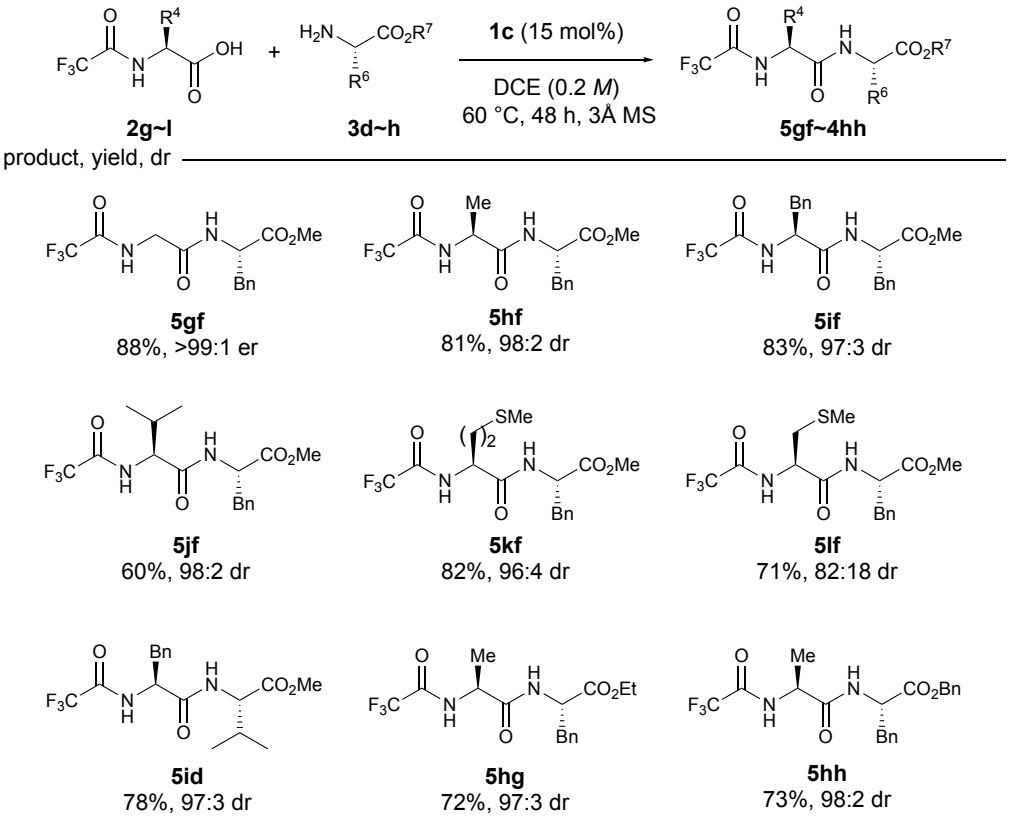
entry	solvent	yield (%)	dr
1	**1,2-dichloroethane**	81	>95:5
2	**Toluene**	33	>95:5
3	**PhF**	21	>95:5
4	**THF**	9	>95:5
5	**Chloroform**	<5	-
6	**DMF**	<5	-

A 20-mL, single-necked, round-bottomed flask equipped with a Teflon-coated magnetic stirring bar was charged with *N*-protected α-amino acid (0.50 mmol, 1.0 equiv), $ArB(OH)_2$ (0.075 mmol, 0.15 equiv) and 0.75 g of activated molecular sieves 3Å (powder) in reaction solvent (0.2 *M*).

After stirred at ambient temperature for 5 min, α-amino ester (0.50 mmol, 1.0 equiv) was added. The resulting mixture was stirred for 48 hours at 60 °C. After cooling to room temperature, the reaction mixture was then filtered through a tight pad of celite, and washed with ethyl acetate (5 mL). The filtrate was concentrated and purified by flash chromatography on silica gel column (normal silica: NH silica = 9 : 1, hexane : ethyl acetate = 1 : 1) to give the desired dipeptide products **5**. Diastereoselectivities were determined by ^{1}H-NMR or ^{19}F-NMR.

6. General Methods for the Dehydrative Condensation and Characterization of Dipeptides.

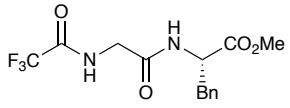
6-1. Dipeptide synthesis by using α-amino esters as amines:



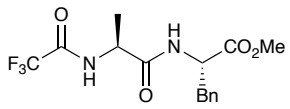
A 20-mL, single-necked, round-bottomed flask equipped with a Teflon-coated magnetic stirring bar was charged with *N*-protected α-amino acid (0.50 mmol, 1.0 equiv), **1c** (0.075 mmol, 0.15 equiv) and 0.75 g of activated molecular sieves 3Å (powder) in 1,2-dichloroethane (0.2 *M*). After the mixture was stirred at ambient temperature for 5 min, α-amino ester (0.50 mmol, 1.0 equiv) was added. The resulting mixture was stirred for 48 hours at 60 °C. After cooling to room temperature, the reaction mixture was then filtered through a tight pad of celite, and washed with ethyl acetate (5 mL). The filtrate was concentrated and purified by flash chromatography on silica gel column (normal silica: NH silica = 9 : 1, hexane : ethyl acetate = 1 : 1) to give the desired dipeptide products **5**. Diastereoselectivities were determined by ^{1}H-NMR or ^{19}F-NMR. (shown below)**6-2. Dipeptide synthesis by using α-amino ester hydrochlorides as amines (Table 3):**

A 20-mL, single-necked, round-bottomed flask equipped with a Teflon-coated magnetic stirring bar was charged with *N*-protected α-amino acid (0.50 mmol, 1.0 equiv), **1c** (0.075 mmol, 0.15 equiv) and 0.75 g of activated molecular sieves 3Å (powder) in 1,2-dichloroethane (0.2 *M*). After the mixture was stirred at ambient temperature for 5 min, α-amino ester hydrochloride (0.50 mmol, 1.0 equiv) was added. The resulting mixture was stirred for 48 hours at 60 °C. After cooling to room temperature, the reaction mixture was then filtered through a tight pad of celite, and washed with ethyl acetate (5 mL). The filtrate was concentrated and purified by flash chromatography on silica gel column (normal silica: NH silica 9 : 1, hexane : ethyl acetate = 1 : 1) to give the desired dipeptide products **5**. Diastereoselectivities were determined by HPLC analysis. Authentic samples were independently prepared from *L*- or *D*-amino acids, and their mixture was used as reference.

As reported by Shibasaki and Kumagai *et. al*,[11] we also found that hydrochloride was slightly more reactive as an amine source. And we think molecular seives perhaps help to absorb the hydrochloride, that force the progress of amidation.

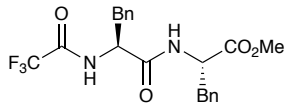


***N*-Trifluoroacetyl-glycinyl-*L*-phenylalanine methyl ester (5gf):** white solid; HPLC (Daicel Chiral IC-3, hexane/isopropanol = 80:20, flow rate = 1.0 mL/min), t_R = 7.245 (major enantiomer), t_R = 9.890 (minor enantiomer) min, 99:1 er; ^{1}H NMR (400 MHz, DMSO-d_6, 80 °C) δ 9.51 (brs, 1H), 8.48 (brs, 1H), 7.25 (m, 5H), 4.51 (d, J = 7.6 Hz, 1H), 3.81 (m, 2H), 3.61 (s, 3H), 3.04 (dd, J = 13.8, 5.8 Hz, 1H), 2.93 (dd, J = 13.8, 8.6 Hz, 1H); ^{13}C NMR (126 MHz, DMSO-d_6) δ 171.74, 167.11, 156.63 (q, $J_{C\text{-}F}$ = 36.3 Hz, 1C), 136.94, 129.08 (2C), 128.29 (2C), 126.63, 115.89 (q, $J_{C\text{-}F}$ = 287.9 Hz, 1C), 53.73, 51.91, 41.45, 36.75; ^{19}F NMR (470 MHz, DMSO-d_6) δ –74.38; IR (KBr) 3357, 1732, 1709, 1654, 1549 cm^{-1}; HRMS (ESI) calcd for $C_{14}H_{15}F_3N_2NaO_4$ $[M+Na]^+$ 355,0876, found 355.0886.

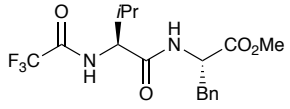


***N*-Trifluoroacetyl-*L*-alanyl-*L*-phenylalanine methyl ester (5hf):** white solid; HPLC (Daicel Chiral IC-3, hexane/isopropanol = 80:20, flow rate = 1.0 mL/min), t_R = 5.128 (major enantiomer), t_R = 6.856 (minor enantiomer) min, 98:2 dr; major isomer: ^{1}H NMR (400 MHz, DMSO-d_6, 80 °C) δ 9.16 (brs, 1H), 8.18 (brs, 1H), 7.24 (m, 5H), 4.53 (q, J = 7.5 Hz, 1H), 4.39 (q, J = 7.1 Hz, 1H), 3.61 (s, 3H), 3.02 (m, 2H), 1.31 (d, J = 7.1 Hz, 3H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 171.76, 170.95, 155.94 (q, $J_{C\text{-}F}$ = 36.7 Hz, 1C), 137.02, 129.13 (2C), 128.28 (2C), 126.62, 115.83 (q, $J_{C\text{-}F}$ = 287.6 Hz, 1C), 53.81, 51.88, 48.60, 36.50, 17.27; ^{19}F NMR (470 MHz,

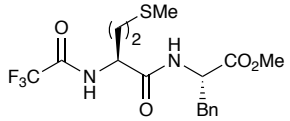
DMSO-d_6) δ –74.04; IR (KBr) 3303, 1742, 1707, 1648, 1543 cm^{-1}; HRMS (ESI) calcd for $C_{15}H_{17}F_3N_2NaO_4$ $[M+Na]^+$ 369.1033, found 369.1032.



***N*-Trifluoroacetyl-*L*-phenyl-*L*-phenylalanine methyl ester (5if):** white solid; HPLC (Daicel Chiral IC-3, hexane/isopropanol = 80:20, flow rate = 1.0 mL/min), t_R = 4.129 (major enantiomer), t_R = 5.380 (minor enantiomer) min, 95:5 dr; major isomer: ^{1}H NMR (400 MHz, DMSO-d_6, 80 °C) δ 9.24 (brs, 1H), 8.40 (brd, J = 7.7 Hz, 1H), 7.24 (m, 10H), 4.64 (dd, J = 10.4, 4.6 Hz, 1H), 4.57 (q, J = 7.6 Hz, 1H), 3.61 (s, 3H), 3.01 (m, 4H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 172.18, 170.46, 156.51 (q, J_{C-F} = 36.7 Hz, 1C), 137.77, 137.48, 129.60 (4C), 128.78 (2C), 128.60 (2C), 127.14, 127.01, 116.21 (q, J_{C-F} = 288.3 Hz, 1C), 54.80, 54.33, 52.44, 37.14, 36.99; ^{19}F NMR (470 MHz, DMSO-d_6) δ –74.07; IR (KBr) 3289, 1735, 1703, 1666, 1551 cm^{-1}; HRMS (ESI) calcd for $C_{21}H_{21}F_3N_2NaO_4$ $[M+Na]^+$ 445.1346, found 445.1345.

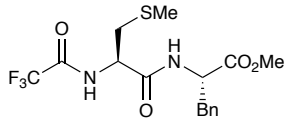


***N*-Trifluoroacetyl-*L*-valinyl-*L*-phenylalanine methyl ester (5jf):** white solid; HPLC (Daicel Chiral IC-3, hexane/isopropanol = 80:20, flow rate = 1.0 mL/min), t_R = 3.817 (major enantiomer), t_R = 4.783 (minor enantiomer) min, 99:1 dr; major isomer: ^{1}H NMR (400 MHz, DMSO-d_6, 80 °C) δ 8.96 (brs, 1H), 8.33 (brd, J = 7.2 Hz, 1H), 7.25–7.19 (m, 5H), 4.57 (q, J = 7.6 Hz, 1H), 4.19 (d, J = 8.1 Hz, 1H), 3.60 (s, 3H), 3.10–3.05 (m, 1H), 2.96 (dd, J = 14.1, 8.6 Hz, 1H), 2.10–2.05 (m, 1H), 0.87 (dd, J = 6.7, 5.1 Hz, 6H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 171.63, 169.65, 156.18 (q, J_{C-F} = 37.1 Hz, 1C), 136.99, 129.07 (2C), 128.17 (2C), 126.56, 115.92 (q, J_{C-F} = 287.5 Hz, 1C), 58.80, 53.53, 51.82, 36.53, 29.84, 18.78, 18.54; ^{19}F NMR (470 MHz, DMSO-d_6) δ –68.86; IR (KBr) 3282, 1744, 1708, 1655, 1553 cm^{-1}; HRMS (ESI) calcd for $C_{17}H_{21}F_3N_2NaO_4$ $[M+Na]^+$ 397.1346, found 397.1345.

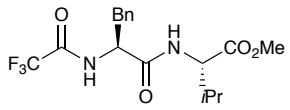


***N*-Trifluoroacetyl-*L*-methionyl-*L*-phenylalanine methyl ester (5kf):** white solid; HPLC (Daicel Chiral IC-3, hexane/isopropanol = 80:20, flow rate = 1.0 mL/min), t_R = 4.503 (major enantiomer), t_R = 5.516 (minor enantiomer) min, 96:4 dr; major isomer: ^{1}H NMR (400 MHz, DMSO-d_6, 80 °C) δ 9.25 (brs, 1H), 8.30 (brs, 1H), 7.29–7.20 (m, 5H), 4.54 (q, J = 7.5 Hz, 1H), 4.44 (m, 1H), 3.61 (s, 3H), 3.09–3.05 (m, 1H), 2.98 (dd, J = 14.1, 8.3 Hz, 1H), 2.44 (q, J = 6.3 Hz, 2H), 2.05 (s, 3H), 1.98 – 1.95 (m, 2H); ^{13}C NMR (126 MHz, DMSO-d_6) δ 171.68, 169.89,

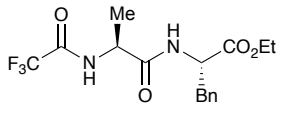
156.29 (q, J = 36.6 Hz, 1C), 136.97, 129.05 (2C), 128.22 (2C), 126.57, 115.78 (q, J = 288.2 Hz, 1C), 53.71, 52.36, 51.87, 36.36, 30.75, 29.49, 14.61; ^{19}F NMR (470 MHz, DMSO-d_6) δ –73.91; IR (KBr) 3336, 3249, 1730, 1650, 1559 cm^{-1}; HRMS (ESI) calcd for $C_{17}H_{21}F_3N_2NaO_4S$ $[M+Na]^+$ 429.1066, found 429.1065.



***N*-Trifluoroacetyl-*S*-methyl-*L*-cysteinyl-*L*-phenylalanine methyl ester (5lf):** white solid; Diastereoselectivities were determined by ^{1}H-NMR or ^{19}F-NMR, dr = 78 : 22; major isomer: ^{1}H NMR (400 MHz, DMSO-d_6, 80 °C) δ 9.27 (brs, 1H), 8.41 (brd, J = 7.8 Hz, 1H), 7.24 (m, 5H), 4.55 (q, J = 7.9 Hz, 2H), 3.61 (s, 3H), 3.14–3.06 (m, 1H), 3.03–2.92 (m, 1H), 2.89 (dd, J = 13.9, 4.7 Hz, 1H), 2.76 (dd, J = 13.7, 9.7 Hz, 1H), 2.09 (s, 3H); ^{13}C NMR (126 MHz, DMSO-d_6) δ 171.53, 168.97, 156.36 (q, $J_{C\text{-}F}$ = 36.6 Hz, 1C), 136.92, 129.07 (2C), 128.24 (2C), 126.61, 115.85 (q, $J_{C\text{-}F}$ = 288.1 Hz, 1C), 53.81, 52.17, 51.92, 36.42, 34.85, 14.86; ^{19}F NMR (470 MHz, DMSO-d_6) δ –73.96; IR (KBr) 3288, 1738, 1708, 1662, 1551 cm^{-1}; HRMS (ESI) calcd for $C_{16}H_{19}F_3N_2NaO_4S$ $[M+Na]^+$ 415.0910, found 415.0912.

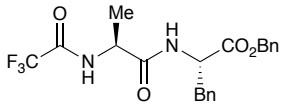


***N*-Trifluoroacetyl-*L*-phenylalanyl-*L*-valine methyl ester (5id):** white solid; HPLC (Daicel Chiral IC-3, hexane/isopropanol = 80:20, flow rate = 1.0 mL/min), t_R = 3.811 (major enantiomer), t_R = 4.914 (minor enantiomer) min, 95:5 dr; major isomer: ^{1}H NMR (400 MHz, DMSO-d_6, 80 °C) δ 9.29 (brs, 1H), 8.17 (brs, 1H), 7.29–7.20 (m, 5H), 4.77–4.71 (m, 1H), 4.26–4.22 (m, 1H), 3.66 (s, 3H), 3.15–3.07 (m, 2H), 2.97 (dd, J = 14.1, 10.3 Hz, 1H), 2.09 (m, 1H), 0.92 (t, J = 7.4 Hz, 6H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 171.78, 170.34, 156.14 (q, $J_{C\text{-}F}$ = 36.6 Hz, 1C), 137.32, 129.13 (2C), 128.09 (2C), 126.52, 115.73 (q, $J_{C\text{-}F}$ = 288.0 Hz, 1C), 57.67, 54.33, 51.80, 36.62, 29.87, 18.93, 18.26; ^{19}F NMR (470 MHz, DMSO-d_6) δ –74.07; IR (KBr) 3310, 1716, 1661, 1543 cm^{-1}; HRMS (ESI) calcd for $C_{17}H_{21}F_3N_2NaO_4$ $[M+Na]^+$ 397.1346, found 397.1349.



***N*-Trifluoroacetyl-*L*-alanyl-*L*-phenylalanine ethyl ester (5hg):** white solid; HPLC (Daicel Chiral IC-3, hexane/isopropanol = 80:20, flow rate = 1.0 mL/min), t_R = 4.435 (major enantiomer), t_R = 5.997 (minor enantiomer) min, 97:3 dr; major isomer: ^{1}H NMR (400 MHz, DMSO-d_6, 80 °C) δ 9.18 (brs, 1H), 8.19 (brd, J = 7.7 Hz, 1H), 7.29–7.20 (m, 5H), 4.50 (dd, J = 14.6, 7.5 Hz, 1H), 4.44–4.37 (m, 1H), 4.06 (q, J = 7.1 Hz, 2H), 3.08–3.03 (m, 1H), 2.99 (dd, J =

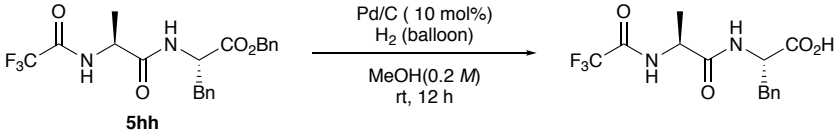
13.9, 8.1 Hz, 1H), 1.32 (d, J = 7.2 Hz, 3H), 1.13 (t, J = 7.1 Hz, 3H); ^{13}C NMR (126 MHz, DMSO-d_6) δ 171.17, 170.89, 155.89 (q, $J_{C\text{-}F}$ = 36.5 Hz, 1C), 136.99, 129.11 (2C), 128.20 (2C), 126.55, 115.79 (q, $J_{C\text{-}F}$ = 288.1 Hz, 1C), 60.49, 53.81, 48.57, 36.50, 17.28, 13.88; ^{19}F NMR (470 MHz, DMSO-d_6) δ –74.05; IR (KBr) 3308, 1736, 1709, 1651 cm^{-1}; HRMS (ESI) calcd for $C_{16}H_{19}F_3N_2NaO_4$ $[M+Na]^+$ 393.1189, found 383.1191.



***N*-Trifluoroacetyl-*L*-alanyl-*L*-phenylalanine benzyl ester (5hh):** white solid; HPLC (Daicel Chiral IC-3, hexane/isopropanol = 80:20, flow rate = 1.0 mL/min), t_R = 5.190 (major enantiomer), t_R = 6.709 (minor enantiomer) min, 97:3 dr; major isomer: ^{1}H NMR (400 MHz, DMSO-d_6, 80 °C) δ 9.19 (brs, 1H), 8.28 (brd, J = 7.7 Hz, 1H), 7.36–7.19 (m, 10H), 5.13–5.06 (m, 2H), 4.59 (q, J = 7.2 Hz, 1H), 4.44–4.38 (m, 1H), 3.12–3.07 (m, 1H), 3.01 (dd, J = 14.0, 8.2 Hz, 1H), 1.29 (d, J = 7.2 Hz, 3H); ^{13}C NMR (126 MHz, DMSO-d_6) δ 171.08, 170.91, 155.89 (q, $J_{C\text{-}F}$ = 36.5 Hz, 1C), 136.90, 135.67, 129.12 (2C), 128.35 (2C), 128.25 (2C), 128.04, 127.87 (2C), 126.58, 115.80 (q, $J_{C\text{-}F}$ = 288.1 Hz, 1C), 66.06, 53.84, 48.54, 36.45, 17.29; ^{19}F NMR (470 MHz, DMSO-d_6) δ –74.02; IR (KBr) 3304, 1732, 1709, 1651, 1542 cm^{-1}; HRMS (ESI) calcd for $C_{21}H_{21}F_3N_2NaO_4$ $[M+Na]^+$ 445.1346, found 445.1351.

7. Selective Deprotection of Benzyloxycarbonyl Moiety or *N*-Trifluoroacetyl Moiety of Dipeptides

7-1. Selective deprotection of benzyl moiety of 5hh:

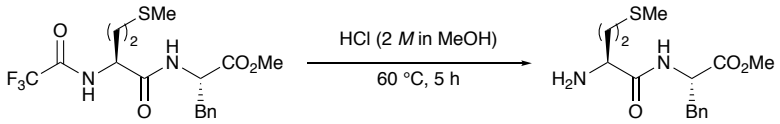


5hh

To a single-necked, round-bottomed flask equipped with a Teflon-coated magnetic stirring bar was added *N*-Trifluoroacetyl-*L*-alanyl-*L*-phenylalanine benzyl ester **5hh** (0.10 mmol, 42 mg, 1.0 equiv) and Pd/C (4.0 mg, 10 w/w%) in methanol (0.2 *M*). The reaction mixture was stirred at ambient temperature in a H_2 atmosphere for 12 h. The resulting mixture was filtered through a Celite pad, and the solvent was removed in vacuum to provide the deprotected product (33 mg, 98% yield). ***N*-Trifluoroacetyl-*L*-alanyl-*L*-phenylalanine:** dr = 98 : 2; major isomer: ^{1}H NMR (500 MHz, Methanol-d_4) δ 7.22 (m, 5H), 4.64 (dd, J = 8.1, 5.2 Hz, 1H), 4.44 (q, J = 7.2 Hz, 1H), 3.19 (dd, J = 14.0, 5.2 Hz, 1H), 3.02 (dd, J = 14.0, 8.1 Hz, 1H), 1.38 (d, J = 7.1 Hz, 3H); ^{13}C NMR (126 MHz, Methanol-d_4) δ174.43, 173.22, 158.52 (q, J = 37.4 Hz, 1H), 138.19, 130.40 (2C), 129.40 (2C), 127.75, 117.33 (q, J = 286.6 Hz, 1C), 55.22, 38.32, 17.59; ^{19}F NMR (470 MHz, Methanol-d_4) δ –

77.06; IR (KBr) 3302, 1704, 1654, 1552 cm^{-1}; HRMS (ESI) calcd for $C_{14}H_{15}F_3KN_2NaO_4$ $[M+K]^+$ 371.0615, found 371.0616.

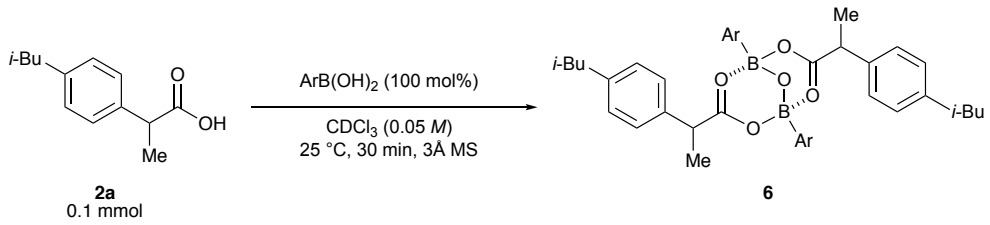
7-2. Selective deprotection of *N*-trifluoroacetyl moiety:



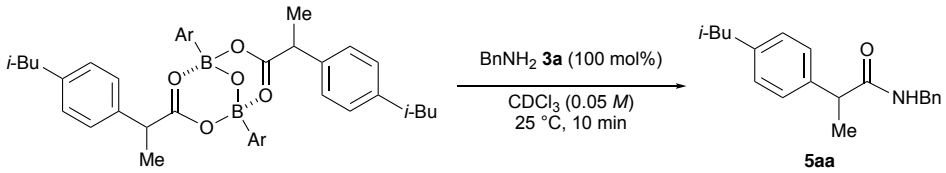
To a single-necked, round-bottomed flask equipped with a Teflon-coated magnetic stirring bar was added *N*-trifluoroacetyl-*L*-methionyl-*L*-phenylalanine methyl ester **5kf** (1.0 mmol, 0.41 g, 1.0 equiv) and hydrogen chloride solution (2 *M* in MeOH). The reaction mixture was stirred at 60 °C for 5 h. The solvent was removed in vacuum, and the resulting white solid was dissolved in saturated sodium hydrogen carbonate aqueous solution (4 mL). The aqueous solution was extracted with ethyl acetate (4 x 2 mL). The combined organic layer was washed with brine, dried over anhydrous sodium sulfate, and evaporated in vacuum to provide the deprotected product (0.36 g, 92% yield).

***L*-Methionyl-*L*-phenylalanine methyl ester:** dr = 96 : 4, major compound: ^{1}H NMR (500 MHz, Methanol-d_4) δ 7.33–7.26 (m, 2H), 7.23–7.21 (m, 3H), 4.70 (dd, J = 8.8, 5.6 Hz, 1H), 3.70 (s, 3H), 3.39 (dd, J = 7.1, 5.9 Hz, 1H), 3.31 (s, 1H), 3.19 (dd, J = 13.9, 5.6 Hz, 1H), 3.00 (dd, J = 13.9, 8.9 Hz, 1H), 2.48–2.44 (m, 2H), 2.05 (s, 3H), 1.91–1.84 (m, 1H), 1.76–1.68 (m, 1H); ^{13}C NMR (126 MHz, Methanol-d_4) δ 177.17, 173.39, 138.06, 130.24 (2C), 129.55 (2C), 127.97, 55.07, 54.98, 52.73, 38.33, 35.66, 30.83, 15.14; IR (KBr) 1742, 1668 cm^{-1}; HRMS (ESI) calcd for $C_{15}H_{22}N_2NaO_3S$ $[M+Na]^+$ 333.1243, found 333.1244.

8. Experiments for Mechanistic Study (Table 4)

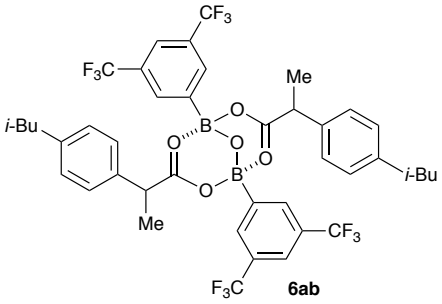


A 20-mL, single-necked, round-bottomed flask equipped with a Teflon-coated magnetic stirring bar was charged with **2a** (0.2 mmol, 41 mg, 1.0 equiv), $ArB(OH)_2$ (0.2 mmol, 1.0 equiv) and 0.5 g of activated molecular sieves 3Å (powder) in $CDCl_3$ (0.05 *M*). The mixture was stirred at room temperature for 30 min, and then the generation and yield of dimeric (acyloxy)boronate intermediate **6** was determined by ^{1}H, and ^{11}B NMR (See attached NMR charts for more details).



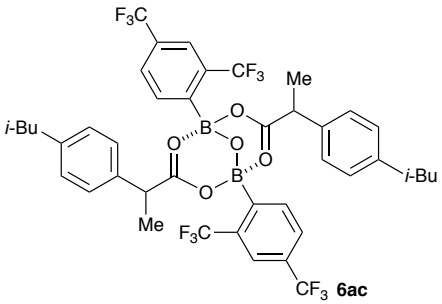
6

A 20-mL, single-necked, round-bottomed flask equipped with a Teflon-coated magnetic stirring bar was charged with **2a** (0.2 mmol, 41 mg, 1.0 equiv), $ArB(OH)_2$ (0.20 mmol, 1.0 equiv) and 0.5 g of activated activated molecular sieves 3Å (powder) in $CDCl_3$ (0.05 *M*). After the full conversion to dimeric (acyloxy)boronate intermediate **6**, benzyl amine **3a** (0.20 mmol, 22 μL, 1.0 equiv) was added to this reaction. The mixture was stirred at room temperature for 10 min, the yield of amide **5aa** was then confirmed by ^{1}H NMR (See attached NMR charts for more details).



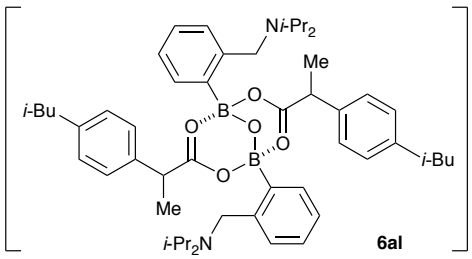
6ab

Dimeric 3,5-Bis(trifluoromethyl)phenylboronic 2-(4-isobutylphenyl)propanoic anhydride (6ab): ^{1}H NMR (400 MHz, Benzene-d_6) δ 8.37 (brs, 2H), 7.89 (brs, 1H), 6.94 – 6.89 (m, 4H), 3.29 – 3.22 (m, 1H), 2.30 (d, *J* = 7.3 Hz, 2H), 1.70 (dt, *J* = 13.4, 6.7 Hz, 1H), 1.05 (d, *J* = 6.9 Hz, 3H), 0.80 (d, *J* = 6.6 Hz, 6H).

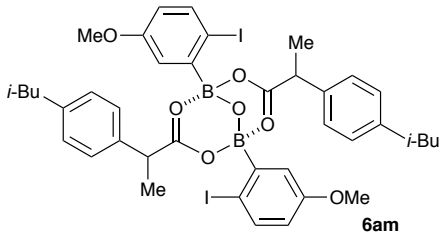


6ac

Dimeric 2,4-Bis(trifluoromethyl)phenylboronic 2-(4-isobutylphenyl)propanoic anhydride (6ac): ^{1}H NMR (400 MHz, Benzene-d_6) δ 8.28 – 8.19 (m, 1H), 8.12 (s, 1H), 7.46 (d, *J* = 8.1 Hz, 1H), 6.98 – 6.87 (m, 4H), 3.37 – 3.34 (m, 1H), 2.26 (d, *J* = 7.2 Hz, 2H), 1.70 – 1.64 (m, 1H), 1.16 (d, *J* = 7.1 Hz, 3H), 0.79 (d, *J* = 6.4 Hz, 6H).



Dimeric 3,5-Bis(trifluoromethyl)phenylboronic 2-(4-isobutylphenyl)propanoic anhydride (6al): ^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.09 – 6.64 (m, 8H), 4.18 (s, 1H), 3.63 (d, *J* = 7.4 Hz, 1H), 3.30 (s, 1H), 3.14 (q, *J* = 8.3 Hz, 1H), 2.42 (d, *J* = 7.2 Hz, 2H), 2.02–1.70 (m, 1H), 1.42 (s, 3H), 1.24 – 0.79 (m, 18H). The chemical structure of **6al** is not clear.

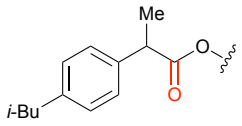


Dimeric 2-Iodo-5-methoxyphenylboronic 2-(4-isobutylphenyl)propanoic anhydride (6am): ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.72 (dd, *J* = 8.3 Hz, 1H), 7.29 – 7.16 (m, 3H), 7.11 – 7.06 (m, 2H), 6.58 (m, 1H), 3.88 (q, *J* = 6.9 Hz, 1H), 3.76 – 3.72 (m, 3H), 2.44 (dd, *J* = 7.0, 3.2 Hz, 2H), 1.85 – 1.81 (m, 1H), 1.54 (d, *J* = 7.0, 3H), 0.89 (d, *J* = 6.8 Hz, 6H).

9. *In Situ* IR Analysis and NMR Experiments of Mixed Anhydride Intermediate with Amine (Scheme 4)

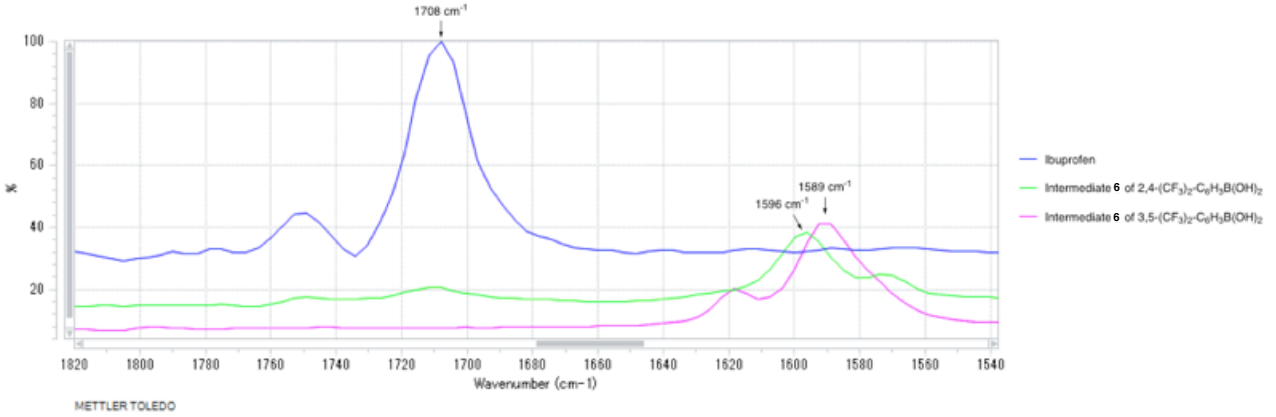
9-1. IR spectra library

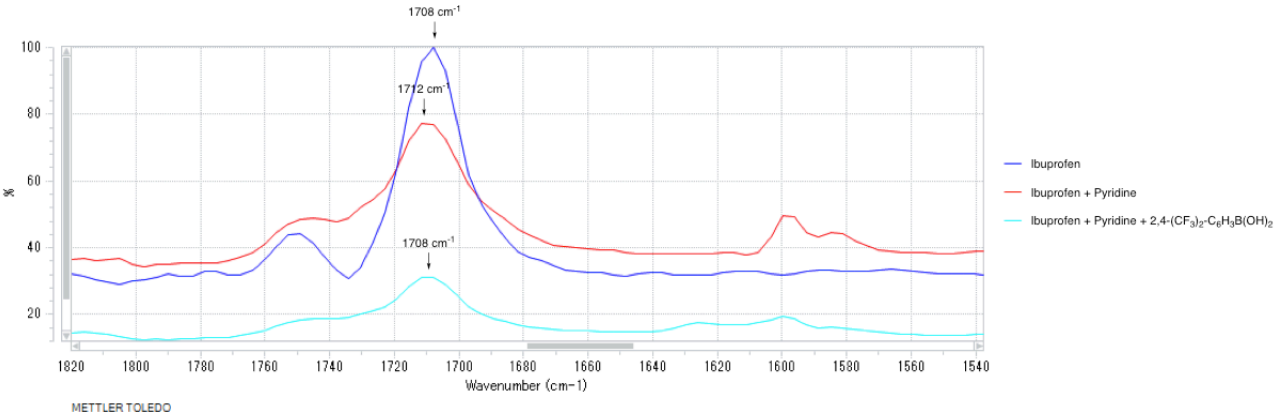
Target moiety:



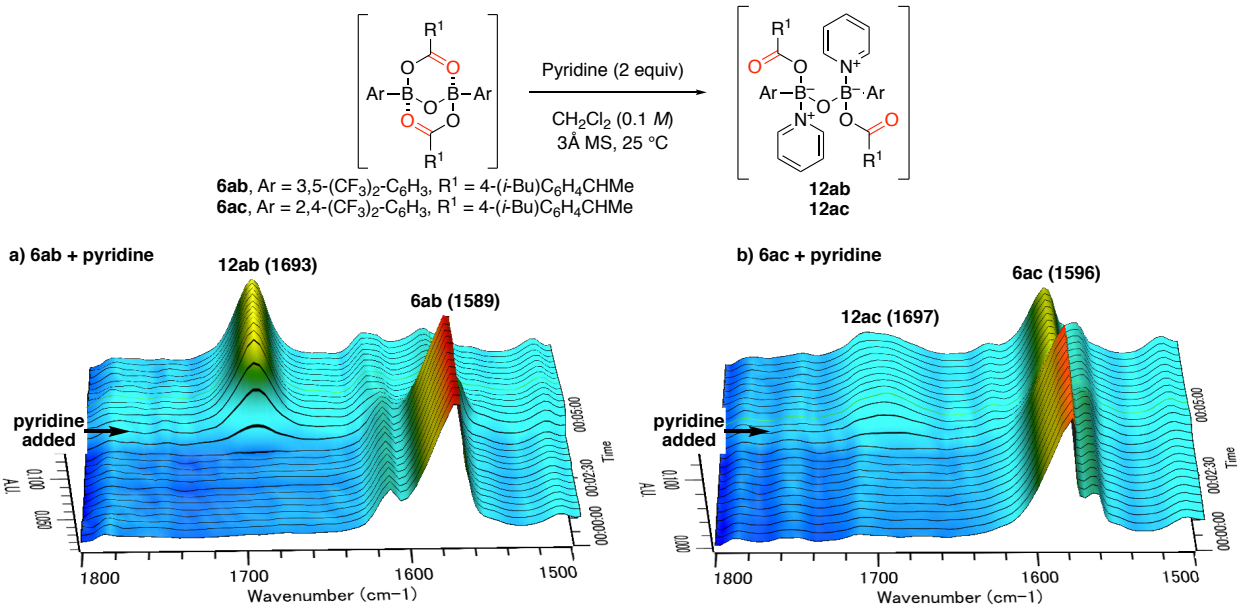
Stretching vibration of C=O bond
(1720 ~ 1700 cm^{-1})

Ibuprofen **2a** (1708 cm^{-1}), **6ab** (1589 cm^{-1}), **6ac** (1596 cm^{-1}), **2a**/pyridine (1712 cm^{-1}), **2a**/pyridine/**1c** (1708 cm^{-1})





9-2. Mechanistic study of *ortho*-substituent effect through *in situ* IR analysis (Scheme 4)



A 20-mL, single-necked, round-bottomed flask, equipped with a Teflon-coated magnetic stirring bar and inserted with a Mettler-Toledo ReactIR 15 Dicomp(diamond) probe through a PTFE-lined septum, was charged with **2a** (1.0 mmol, 206 mg, 1.0 equiv), **1** (1.0 mmol, 1.0 equiv) and 1.0 g of activated molecular sieves 3Å (powder) in DCM (0.2 *M*). After full conversion to a mixed anhydride intermediate was achieved, ReactIR started. At the point of 3.5 minute, pyridine (1.0 mmol, 1.0 equiv) was added dropwisely to the reaction solution [vigorous environmental change might cause machine error]. The coordinated intermediate was formed immediately and the ReactIR detection was stopped after 3 more minutes of stirring.

Data of *in situ* IR analysis by using 6ab. During the plateau in late-stage, an arbitrary timing (Relative time = 05:56) was chosen to compare the ratio of intermediate with coordinated intermediate. With elimination of baseline, the ratio of intermediate is 26%, and that of coordinated intermediate is 74%.

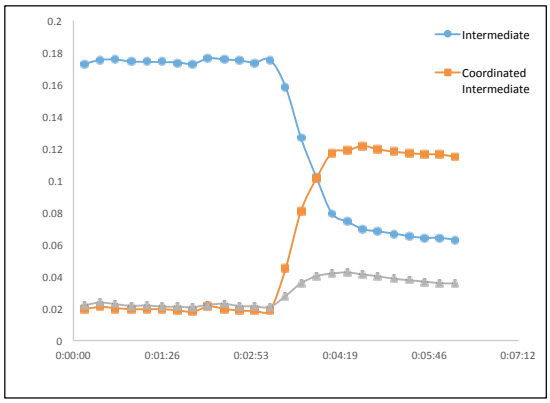
Data of *in situ* IR analysis by using 6ac. During the plateau in late-stage, an arbitrary timing (Relative time = 05:55) was chosen to compare the ratio of intermediate with coordinated intermediate. With elimination of baseline, the ratio of intermediate is 77%, and that of coordinated intermediate is 23%.

Raw data of *in situ* IR detection (6ab + pyridine):

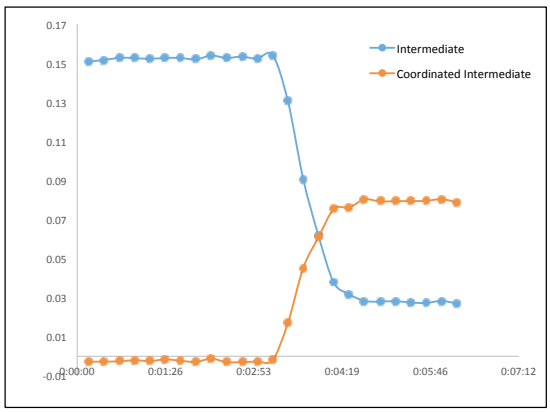
Raw data of ReactIR detection by using 1b
(Intermediate at 1589 cm^{-1}, Baseline at 1652 cm^{-1}, Coordinated intermediate at 1693 cm^{-1}, Peak intensity is described with A.U.)

Relative Time	Peak at 1589 cm−1	Peak at 1652 cm−1	Peak at 1693 cm−1
0:00:11	0.172992	0.0221123	0.0194665
0:00:26	0.175346	0.0237055	0.0210081
0:00:41	0.175509	0.0227627	0.020204
0:00:56	0.174265	0.0216294	0.0196325
0:01:11	0.174162	0.0219309	0.0194945
0:01:26	0.173889	0.021172	0.0196081
0:01:41	0.173788	0.0211189	0.0188779
0:01:56	0.172776	0.0208394	0.017947
0:02:11	0.176298	0.0223987	0.0212408
0:02:26	0.175655	0.0229399	0.0199641
0:02:41	0.174938	0.0215731	0.0186324
0:02:56	0.173692	0.0213366	0.0187076
0:03:11	0.175241	0.0209962	0.0190787
0:03:26	0.158505	0.0278145	0.0448302
0:03:41	0.126554	0.0357475	0.0808785
0:03:56	0.101866	0.0402226	0.101252
0:04:11	0.0795004	0.041873	0.117239
0:04:26	0.0742792	0.042531	0.118756
0:04:41	0.0696319	0.0412621	0.121571
0:04:56	0.0681294	0.040126	0.119432
0:05:11	0.0668497	0.0386091	0.118001
0:05:26	0.065223	0.0376618	0.117119
0:05:41	0.0640928	0.0368166	0.1164
0:05:56	0.0641896	0.0358105	0.116233
0:06:11	0.0627876	0.0356759	0.11467

Time-Intensity Curve



Time-Intensity Curve (with elimination of baseline)

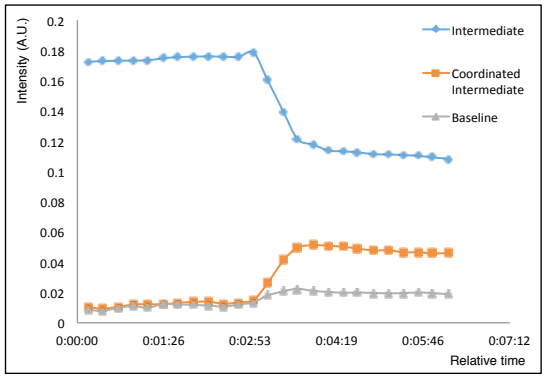


Raw data of *in situ* IR detection (6ac + pyridine):

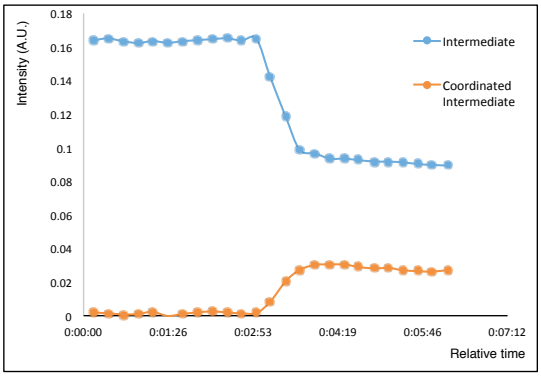
Raw data of ReactIR detection by using 1c
(Intermediate at 1596 cm^{-1}, Baseline at 1652 cm^{-1}, Coordinated intermediate at 1697 cm^{-1}, Peak intensity is described with A.U.)

Relative Time	Peak at 1596 cm−1	Peak at 1652 cm−1	Peak at 1697 cm−1
0:00:11	0.172458	0.00831518	0.0100545
0:00:25	0.17291	0.00786808	0.00930737
0:00:41	0.173108	0.0097962	0.0104974
0:00:56	0.173314	0.0110277	0.0120282
0:01:10	0.173444	0.00995363	0.0122314
0:01:26	0.174805	0.0123538	0.0121849
0:01:40	0.175528	0.0121679	0.0131894
0:01:56	0.175833	0.0117657	0.0136914
0:02:11	0.176016	0.0113947	0.0139394
0:02:26	0.175808	0.0106629	0.0125744
0:02:41	0.175774	0.0119875	0.0133839
0:02:56	0.178398	0.0135266	0.0151107
0:03:10	0.160365	0.0180278	0.0261941
0:03:26	0.139195	0.0208042	0.041362
0:03:40	0.121319	0.0224043	0.0496303
0:03:56	0.117563	0.0210142	0.0512819
0:04:11	0.113835	0.0203569	0.0508495
0:04:26	0.113284	0.0197965	0.0502404
0:04:40	0.112586	0.019978	0.0489818
0:04:56	0.111445	0.0196613	0.0478173
0:05:11	0.111163	0.0194704	0.0478721
0:05:26	0.110858	0.0195888	0.0465703
0:05:41	0.110227	0.0200039	0.0465559
0:05:55	0.109321	0.0195649	0.0457594
0:06:11	0.108289	0.0189197	0.0461111

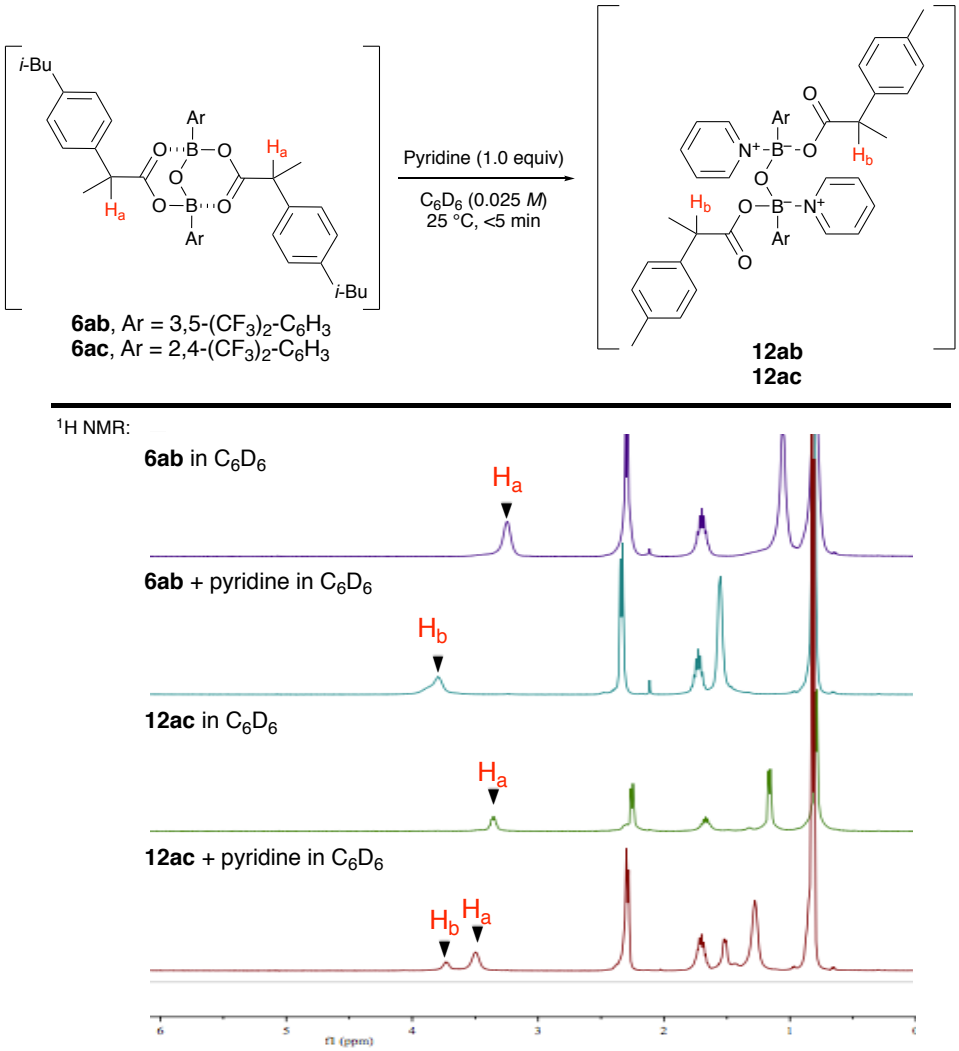
Time-Intensity Curve



Time-Intensity Curve (with elimination of baseline)



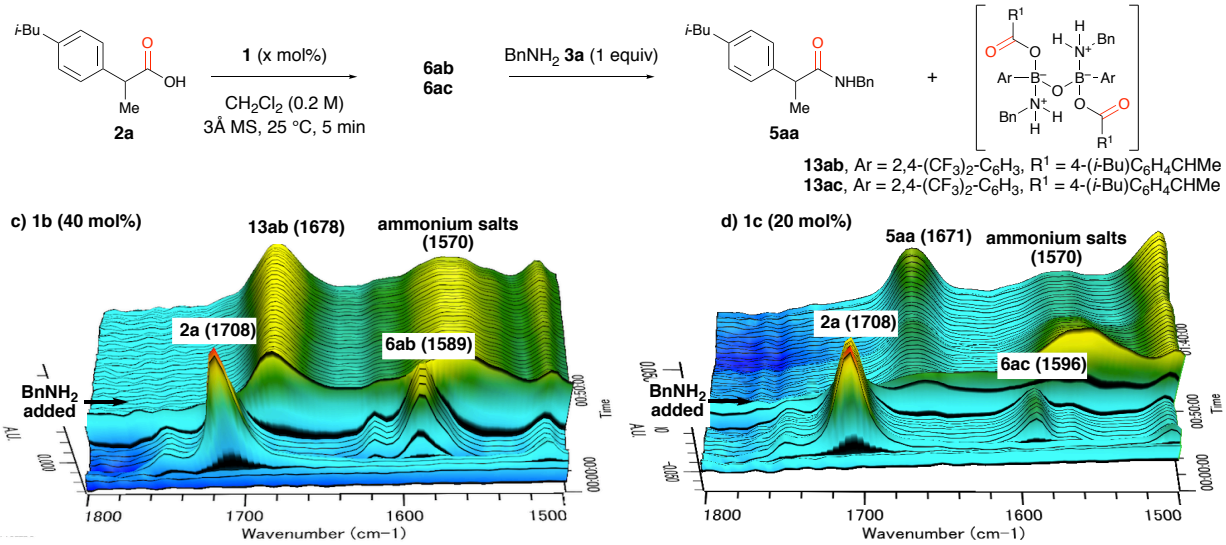
9-3. Mechanistic study of *ortho*-substituent effect through NMR experiments



A 20-mL, single-necked, round-bottomed flask equipped with a Teflon-coated magnetic stirring bar was charged with ibuprofen **2a** (0.20 mmol, 41 mg, 1.0 equiv), **1** (0.20 mmol, 1.0 equiv) and 0.5 g of activated molecular sieves 3Å (powder) in C_6D_6 (0.05 *M*). After the full conversion to dimeric acyloxy boronate intermediate **6**, pyridine (0.20 mmol, 16 μL, 1.0 equiv) was added to this reaction. The percentage of remained active intermediate was then determined by ^{1}H and ^{11}B NMR (See attached NMR charts for more details).

An obvious perturbation of chemical shift was observed from an equimolecular mixture of intermediate **6ab** and pyridine. This observation suggests that intermediate **6ab**, generated from carboxylic acid **2a** and boronic acid **1b**, was completely coordinated with pyridine to form a new ate complex. Meanwhile, only less than 30% of an ate complex was observed for **6ac**, generated from **1c**.

9-4. Mechanistic study of amidation reaction through *in-situ* IR analysis



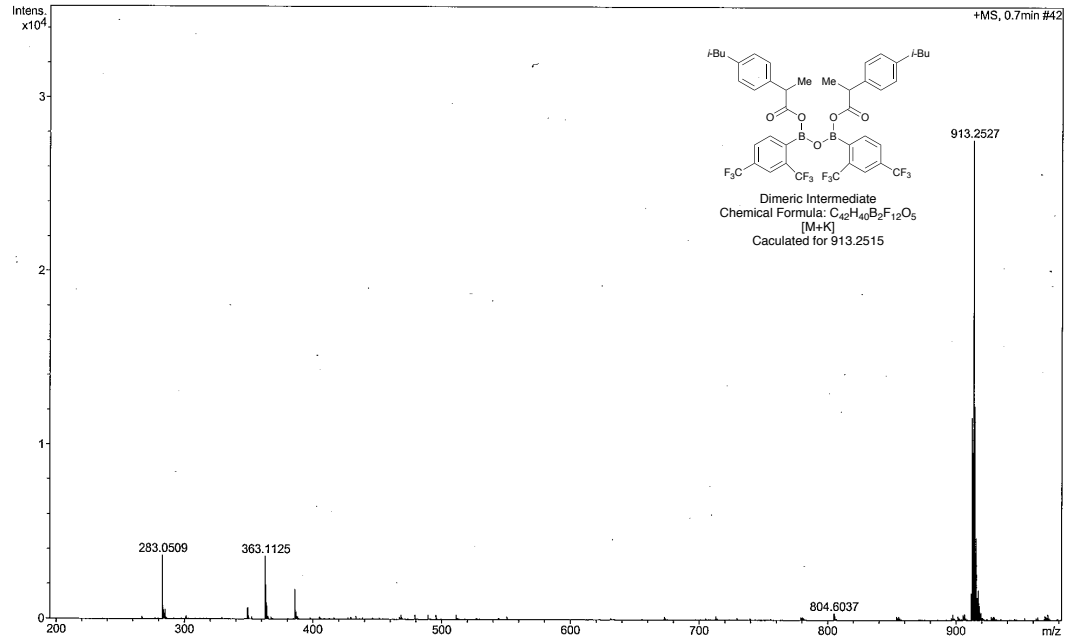
A 20-mL, single-necked, round-bottomed flask, equipped with a Teflon-coated magnetic stirring bar and inserted with a Mettler-Toledo ReactIR 15 Dicomp(diamond) probe through a PTFE-lined septum, was charged with carboxylic acid **2a** (1.0 mmol, 206 mg, 1.0 equiv) and 1.0 g of activated molecular sieves 3Å (powder) in DCM (0.2 *M*). *In-situ* ReactIR detection started, followed by the addition of $ArB(OH)_2$ **1** (0.4 mmol, 104 mg, 0.4 equiv for **1b**; 0.2 mmol, 52 mg, 0.2 equiv for **1c**). The generation of mix-anhydride intermediate **6** was then observed. After full conversion of **1** to **6** was achieved, benzylamine **3a** (1.0 mmol, 1.0 equiv) was added dropwisely to the reaction solution. [vigorous environmental change might cause machine error] The *in-situ* ReactIR detection was stopped over 30 more minutes of stirring.

10. ESI-MS analysis of mixed anhydride intermediates (Scheme 3)

Proposed mixed anhydride intermediates were observed in ESI-MS analysis (positive mode). A solution of a mixed anhydride intermediate was prepared in $ClCH_2CH_2Cl$ through general experimental procedure (as described in the Section 8). Then, 50 mL of the solution was diluted with eluent ($ClCH_2CH_2Cl$, 200 mL) in a syringe, and injected to ESI-MS (positive mode).

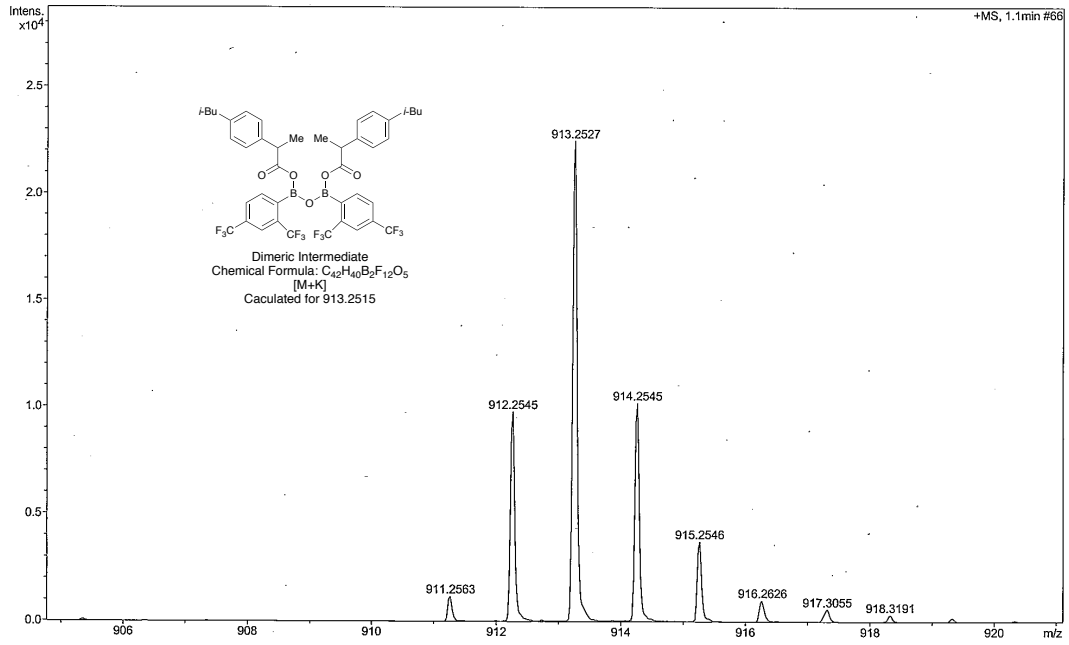
The spectrum of dimeric mixed anhydride intermediate 6ac, consisting of 1c and ibuprofen 2a. Only the peak (*m/z* = 913.2527) of dimeric intermediate was observed, which was identified as $[M + K]^+$ (calculated for *m/z* = 913.2515).

Window Display Report



Bruker Compass DataAnalysis 4.0 printed: 3/24/2018 4:30:19 PM Page 1 of 1

Window Display Report



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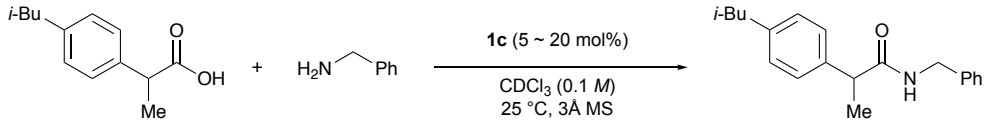
11. Initial Rate Kinetic Experiments (Figure 3)

11-1. Initial rate kinetic experiments of catalyst 1c



2a
0.5 mmol
(100 m*M*)

3a
0.5 mmol
(100 m*M*)

5aa

A 20-mL, double-necked, round-bottomed flask equipped with a Teflon-coated magnetic stirring bar was charged with **2a** (0.50 mmol, 103.2 mg, 1.0 equiv), **1c** (0.025 mmol, 0.050 mmol, 0.075 mmol, 0.10 mmol, respectively) and 1g of activated molecular sieves 3Å (powder) in chloroform-*d* (5 mL, 0.1 *M*). After the mixture was stirred for 10 min, then **3a** (0.50 mmol, 53.6 mg, 1.0 equiv) was added. The resulting mixture was continuously stirred at room temperature. Reaction samples (0.1 mL) were collected by using syringes in 0.5 min, 3 min, 6 min, 9 min, 12 min, 15 min, respectively. Those samples were directly filtered through a disposable memberane filter unit (13JP050AN) into NMR tubes, and a portion of D_2O (0.1 mL), chloroform-*d* (0.3 mL) was followingly added. Reaction conversion and the concentration of product **5aa** was then determined by ^{1}H NMR.

Raw data:

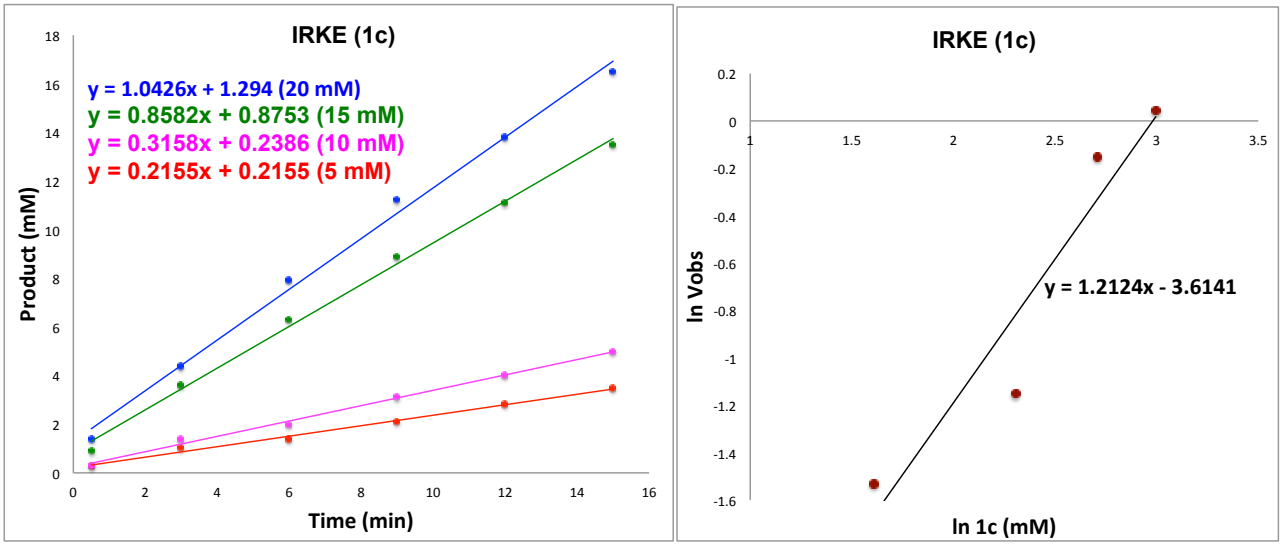
Raw data for determing the reaction order in catalyst 1c

5 mol% **1c** [**1c**] = 5 m*M*	
Time (min)	[**5aa**] (m*M*)
0.5	0.3
3	1.0
6	1.4
9	2.1
12	2.8
15	3.5

10 mol% **1c** [**1c**] = 10 m*M*	
Time (min)	[**5aa**] (m*M*)
0.5	0.3
3	1.4
6	2.0
9	3.1
12	4.0
15	5.0

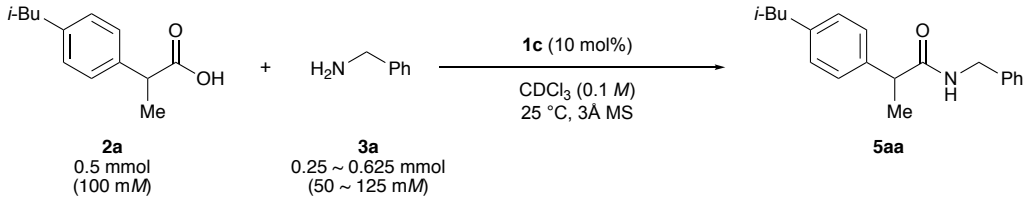
15 mol% **1c** [**1c**] = 15 m*M*	
Time (min)	[**5aa**] (m*M*)
0.5	0.9
3	3.6
6	6.3
9	8.9
12	11.1
15	13.5

20 mol% **1c** [**1c**] = 20 m*M*	
Time (min)	[**5aa**] (m*M*)
0.5	1.4
3	4.4
6	7.9
9	11.2
12	13.8
15	16.5



After data handling: Order in catalyst 1c = 1.2

11-2. Initial rate kinetic experiments of amine 3a



2a
0.5 mmol
(100 m*M*)

3a
0.25 ~ 0.625 mmol
(50 ~ 125 m*M*)

5aa

A 20-mL, double-necked, round-bottomed flask equipped with a Teflon-coated magnetic stirring bar was charged with **2a** (0.50 mmol, 103.2 mg, 1.0 equiv), **1c** (0.050 mmol, 129.0 mg, 0.1 equiv) and 1 g of activated molecular sieves 3Å (powder) in chloroform-*d* (5 ml, 0.1 *M*). After the mixture was stirred for 10 min, then **3a** (0.25 mmol, 0.375 mmol, 0.50 mmol, 0.625 mmol, respectively) was added. The resulting mixture was continuously stirred at room temperature. Reaction samples (0.1 mL) were collected by using syringes in 0.5 min, 3 min, 6 min, 9 min, 12 min, 15 min, respectively. Those samples were directly filtered through a disposable memberane filter unit (13JP050AN) into NMR tubes, and a portion of D_2O (0.1 mL), chloroform-*d* (0.3 mL) was followingly added. Reaction conversion and the concentration of product **5aa** was then determined by ^{1}H-NMR. [Attention. Because of the salt formation between acid and amine, concentration scope better be narrow down to 50 ~ 125 m*M*. Otherwise may cause bad linearity]
Raw data:

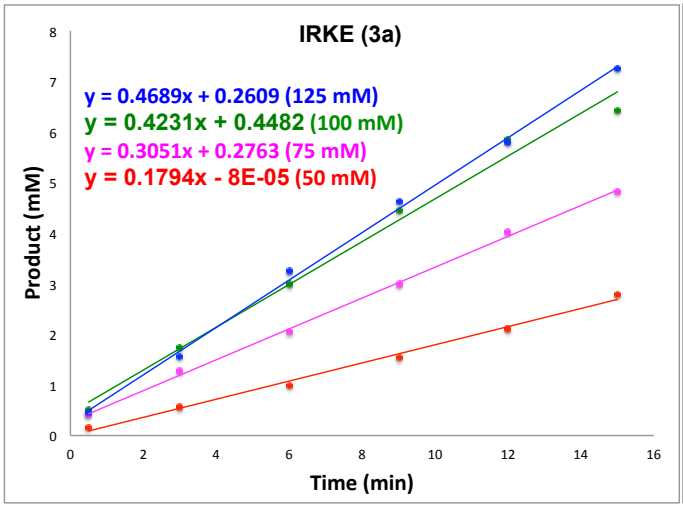
Raw data for determing the reaction order in amine 3a

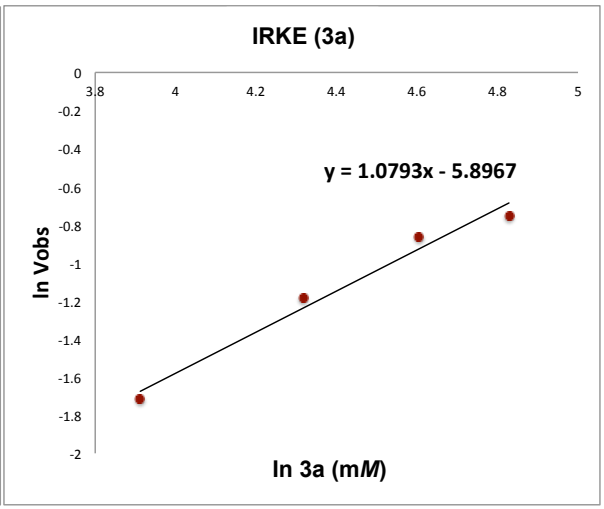
0.25 mmol **3a** [**3a**] = 50 m*M*	
Time (min)	[**5aa**] (m*M*)
0.5	0.2
3	0.6
6	1.0
9	1.5
12	2.1
15	2.8

0.375 mmol **3a** [**3a**] = 75 m*M*	
Time (min)	[**5aa**] (m*M*)
0.5	0.4
3	1.3
6	2.1
9	3.0
12	4.0
15	4.8

0.50 mmol **3a** [**3a**] = 100 m*M*	
Time (min)	[**5aa**] (m*M*)
0.5	0.5
3	1.7
6	3.0
9	4.4
12	5.8
15	6.4

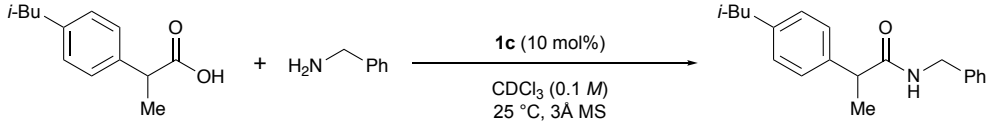
0.625 mmol **3a** [**3a**] = 125 m*M*	
Time (min)	[**5aa**] (m*M*)
0.5	1.4
3	4.4
6	7.9
9	11.2
12	13.8
15	16.5





After data handling: Order in amine 3a = 1.1

11-3. Initial rate kinetic experiments of acid 2a



2a
0.25 ~ 0.625 mmol
(50 ~ 125 m*M*)

4a
0.5 mmol
(100 m*M*)

5aa

A 20-mL, double-necked, round-bottomed flask equipped with a Teflon-coated magnetic stirring bar was charged with **2a** (0.25 mmol, 0.375 mmol, 0.50 mmol, 0.625 mmol, respectively), **1c** (0.050 mmol, 129.0 mg, 0.1 equiv) and 1 g of activated molecular sieves 3Å (powder) in chloroform-*d* (5 ml, 0.1 *M*). After the mixture was stirred for 10 min, then **3a** (0.50 mmol, 53.6 mg, 1.0 equiv) was

added. The resulting mixture was continuously stirred at room temperature. Reaction samples (0.1 mL) were collected by using syringes in 0.5 min, 3 min, 6 min, 9 min, 12 min, 15 min, respectively. Those samples were directly filtered through a disposable memberane filter unit (13JP050AN) into NMR tubes, and a portion of D_2O (0.1 mL), chloroform-*d* (0.3 mL) was followingly added. Reaction conversion and the concentration of product **5aa** was then determined by ^{1}H-NMR. [Attention. Because of the salt formation between **2a** and **3a**, concentration scope better be narrow down to 50 ~ 125 m*M*. Otherwise may cause bad linearity]

Raw data:

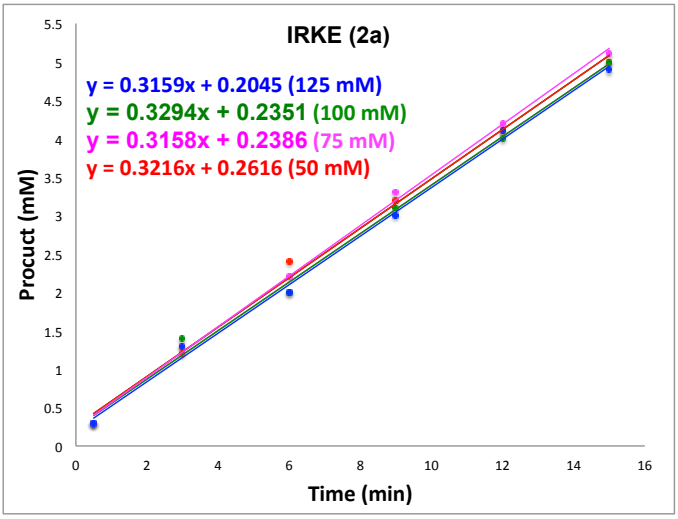
Raw data for determing the reaction order in acid 2a

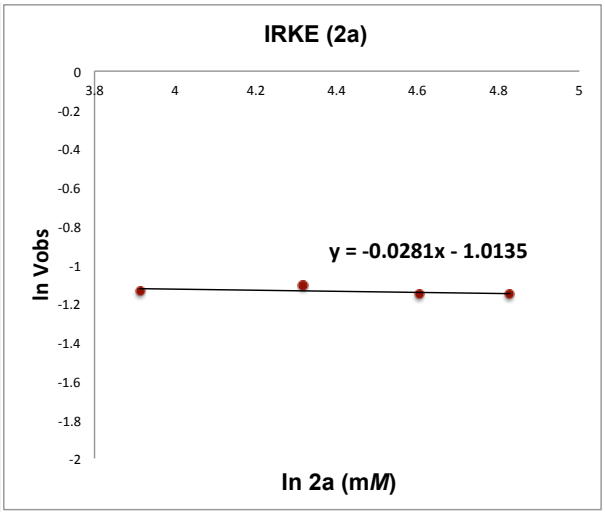
0.25 mmol **2a** [**2a**] = 50 m*M*	
Time (min)	[**5aa**] (m*M*)
0.5	0.3
3	1.2
6	2.4
9	3.2
12	4.1
15	5.0

0.375 mmol **2a** [**2a**] = 75 m*M*	
Time (min)	[**5aa**] (m*M*)
0.5	0.3
3	1.3
6	2.2
9	3.3
12	4.2
15	5.1

0.50 mmol **2a** [**2a**] = 100 m*M*	
Time (min)	[**5aa**] (m*M*)
0.5	0.3
3	1.4
6	2.0
9	3.1
12	4.0
15	5.0

0.625 mmol **2a** [**2a**] = 125 m*M*	
Time (min)	[**5aa**] (m*M*)
0.5	0.3
3	1.3
6	2.0
9	3.0
12	4.1
15	4.9





After data handling: Order in acid 2a = 0

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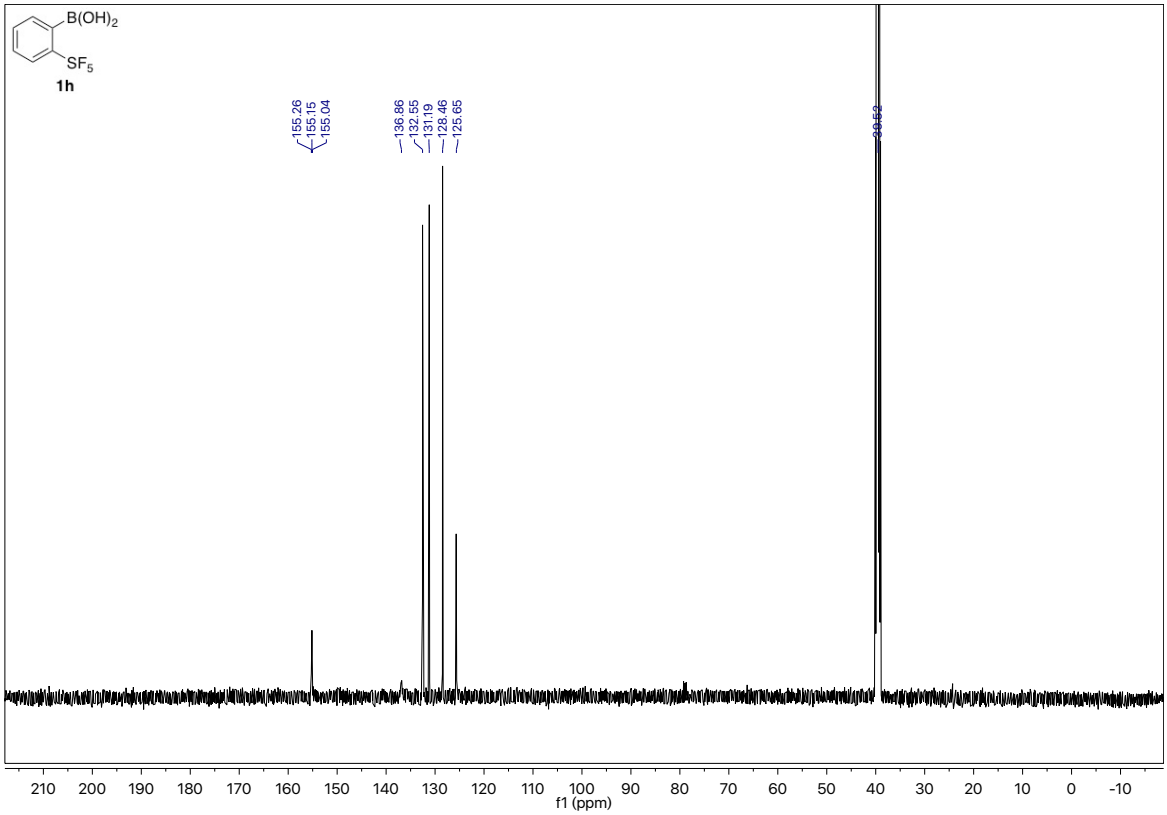
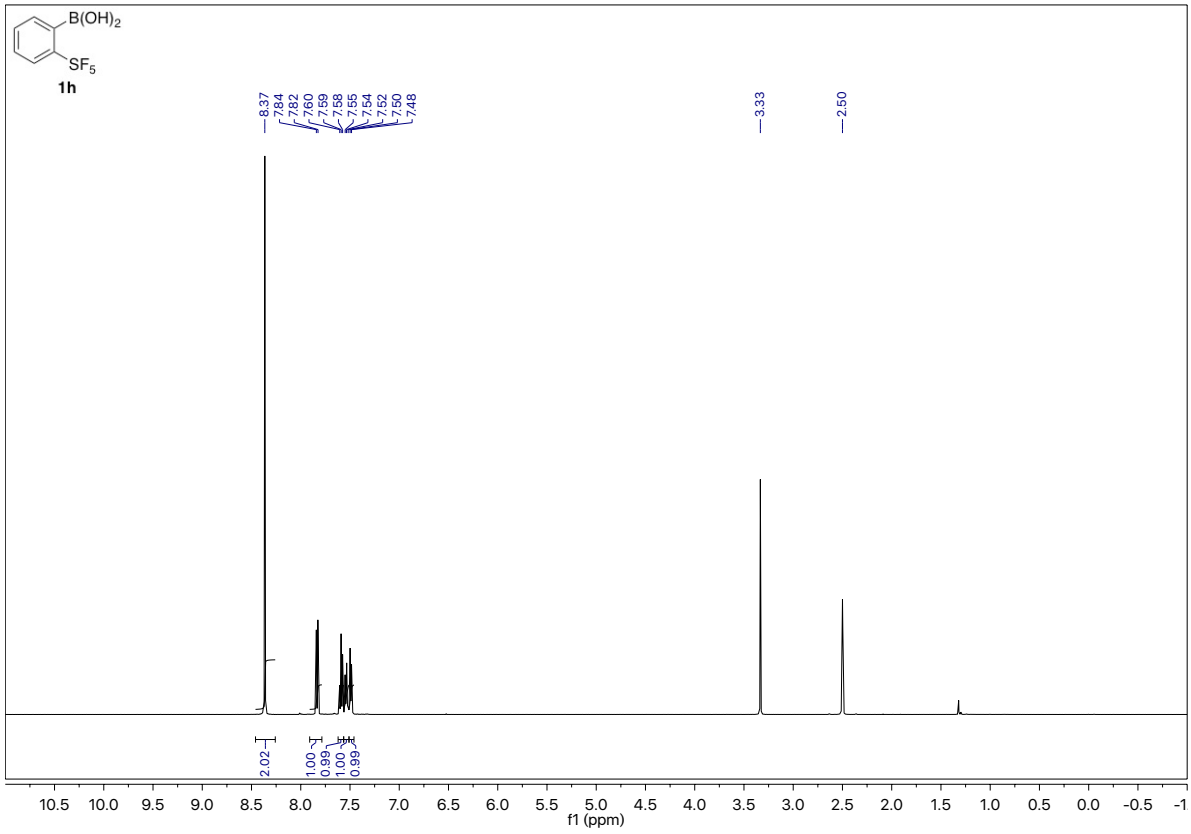
13. ^{1}H, ^{11}B, ^{19}F and ^{13}C NMR Charts of New Compounds

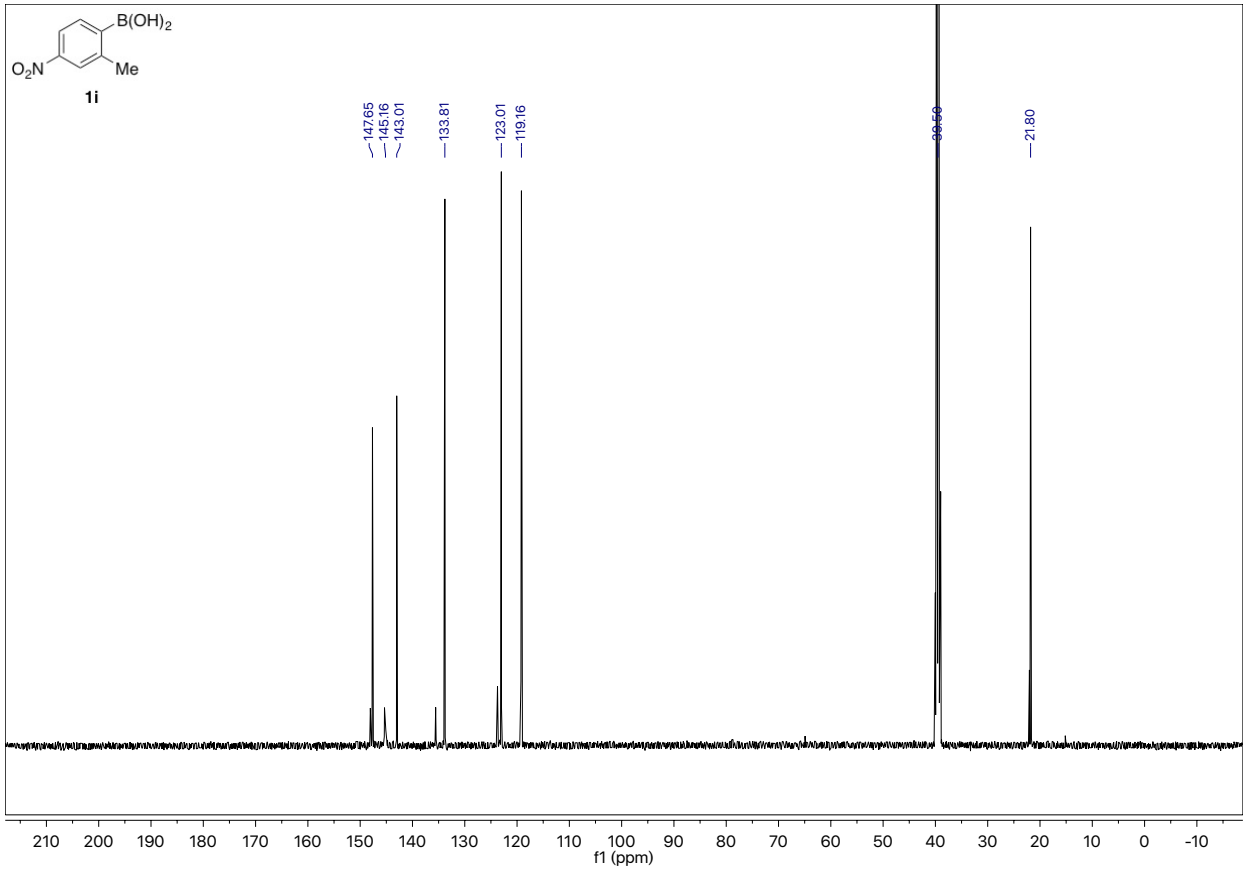
^{13}C NMR (126 MHz, DMSO-d_6)



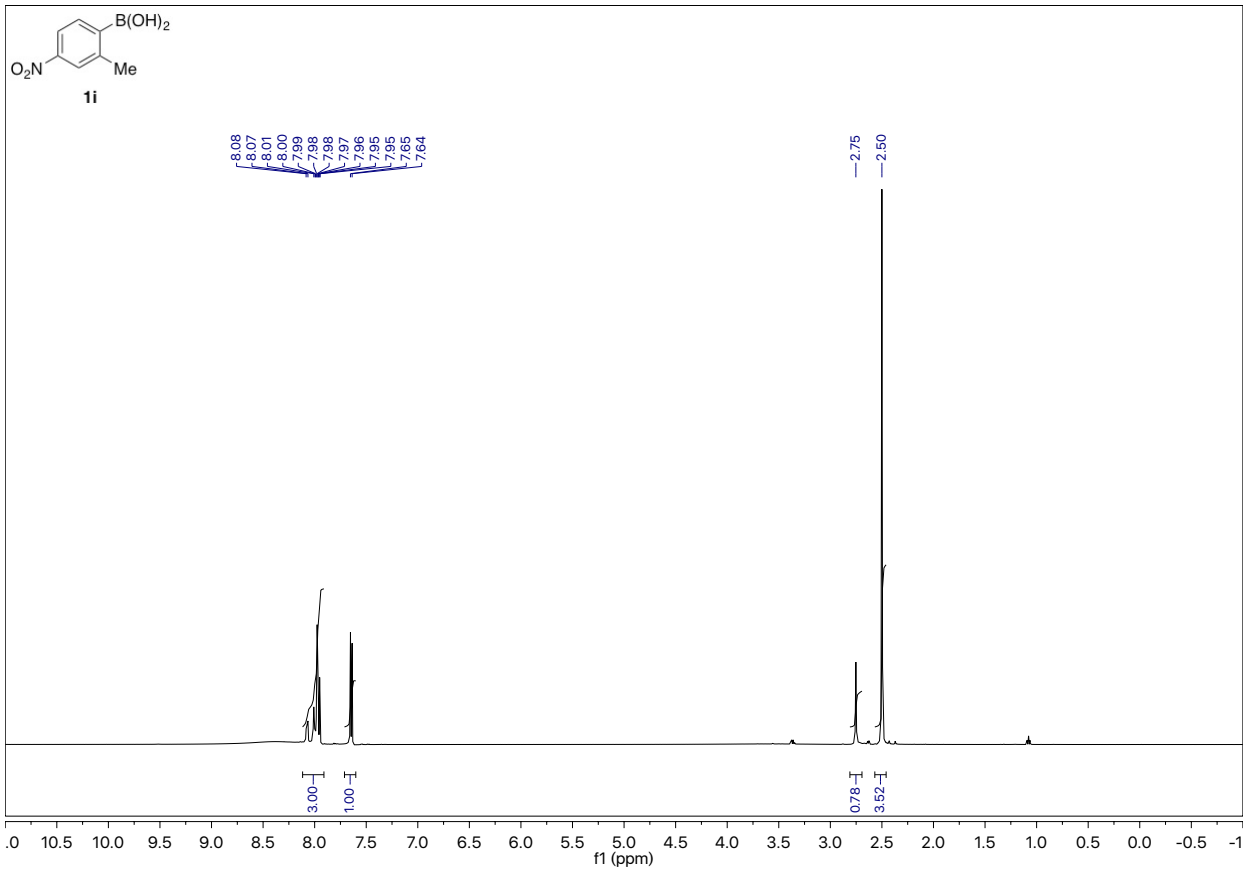
^{1}H NMR (500 MHz, DMSO-d_6)



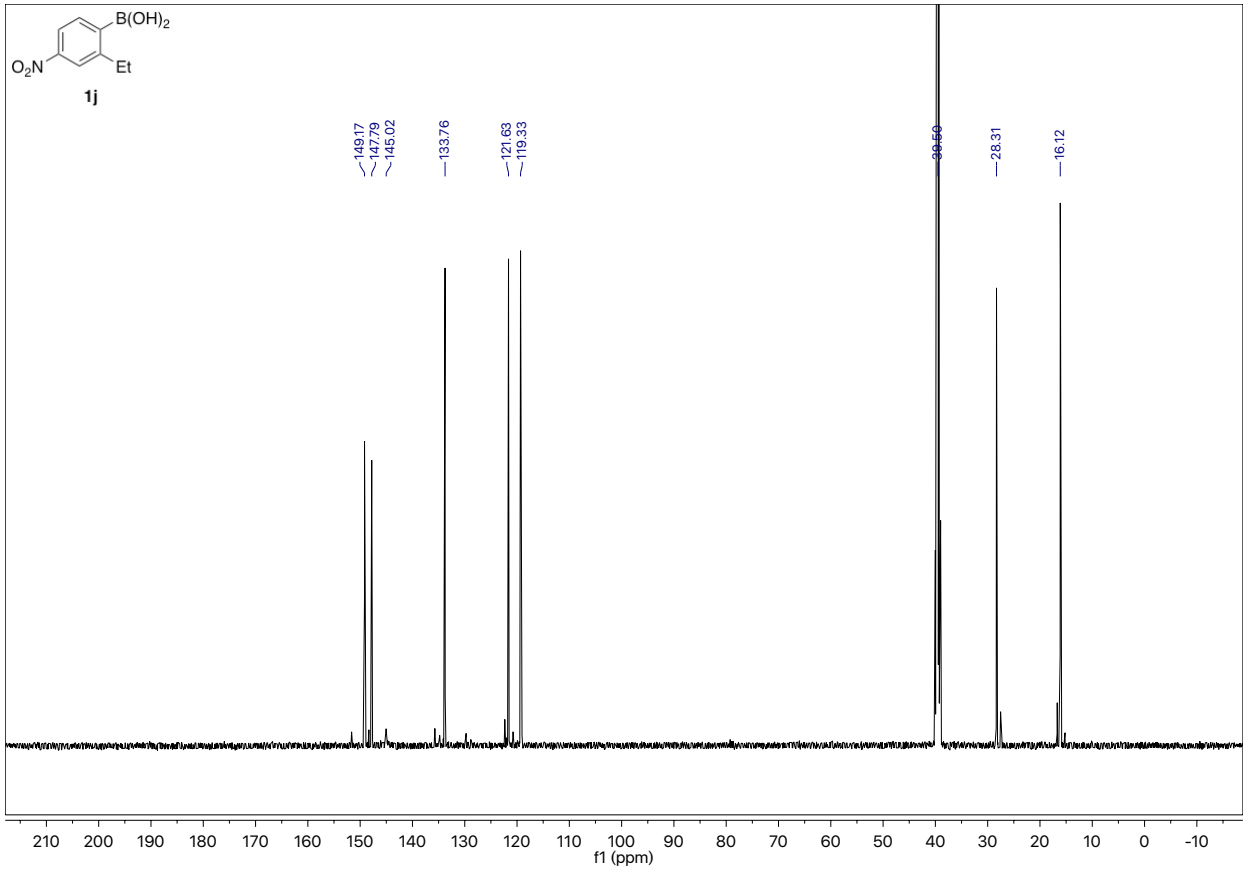
^{13}C NMR (126 MHz, DMSO-d_6)



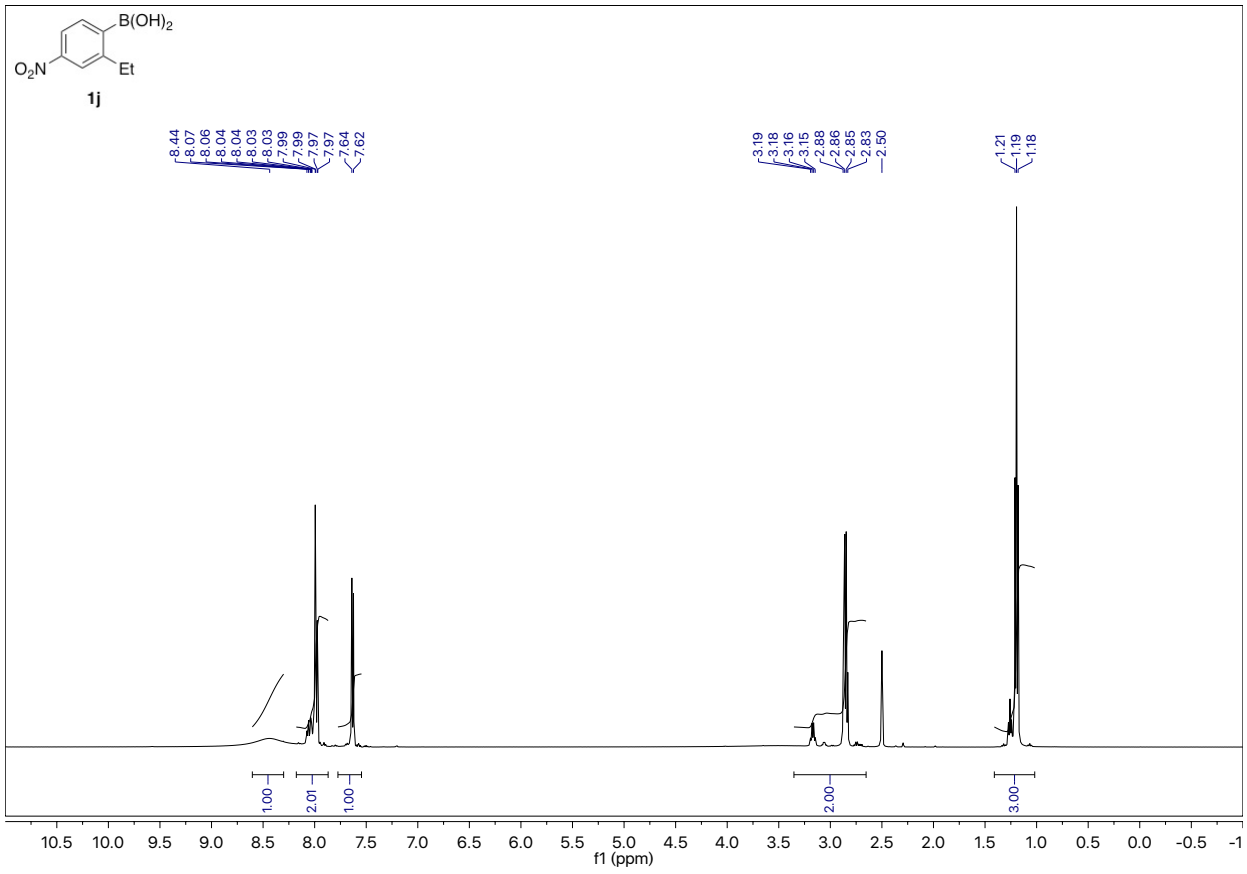
^{1}H NMR (500 MHz, DMSO-d_6)



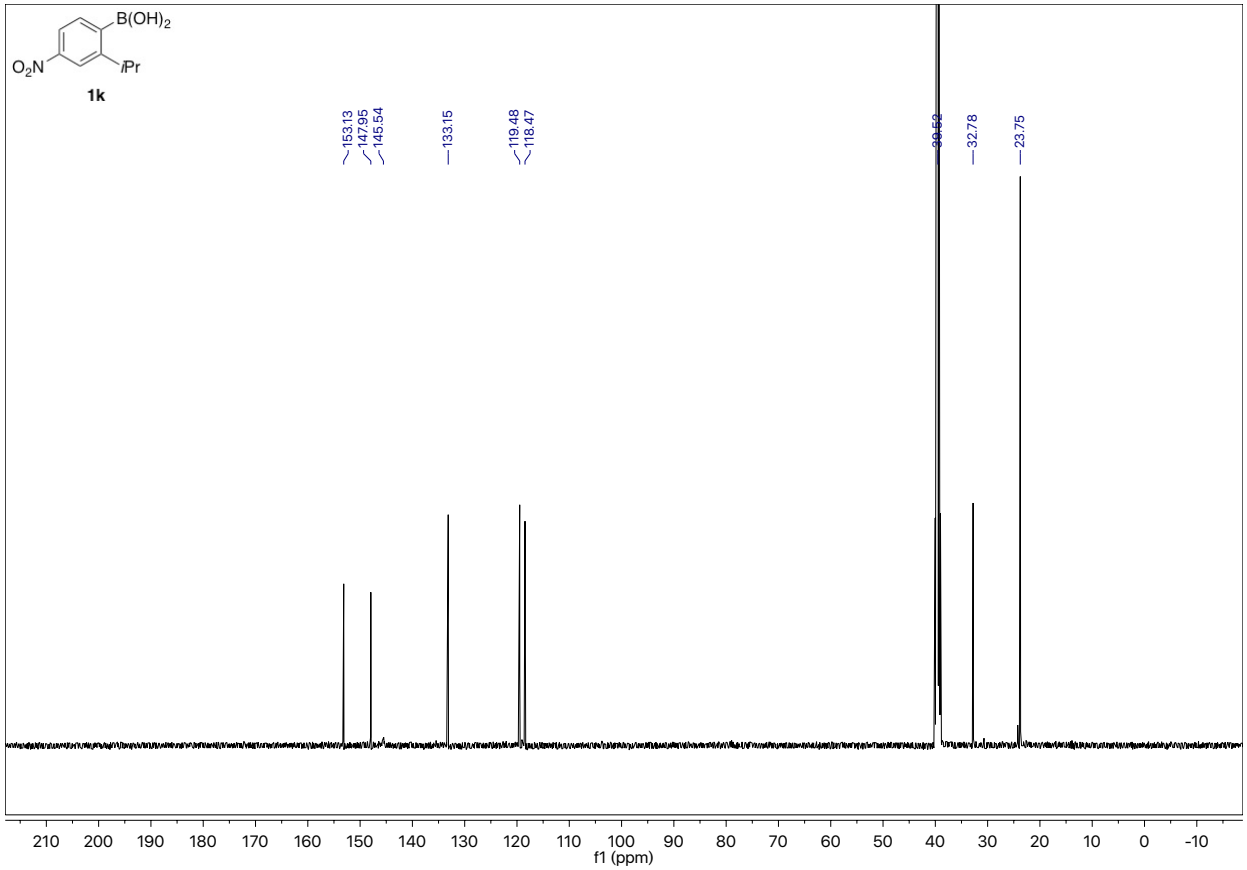
^{13}C NMR (126 MHz, DMSO-d_6)



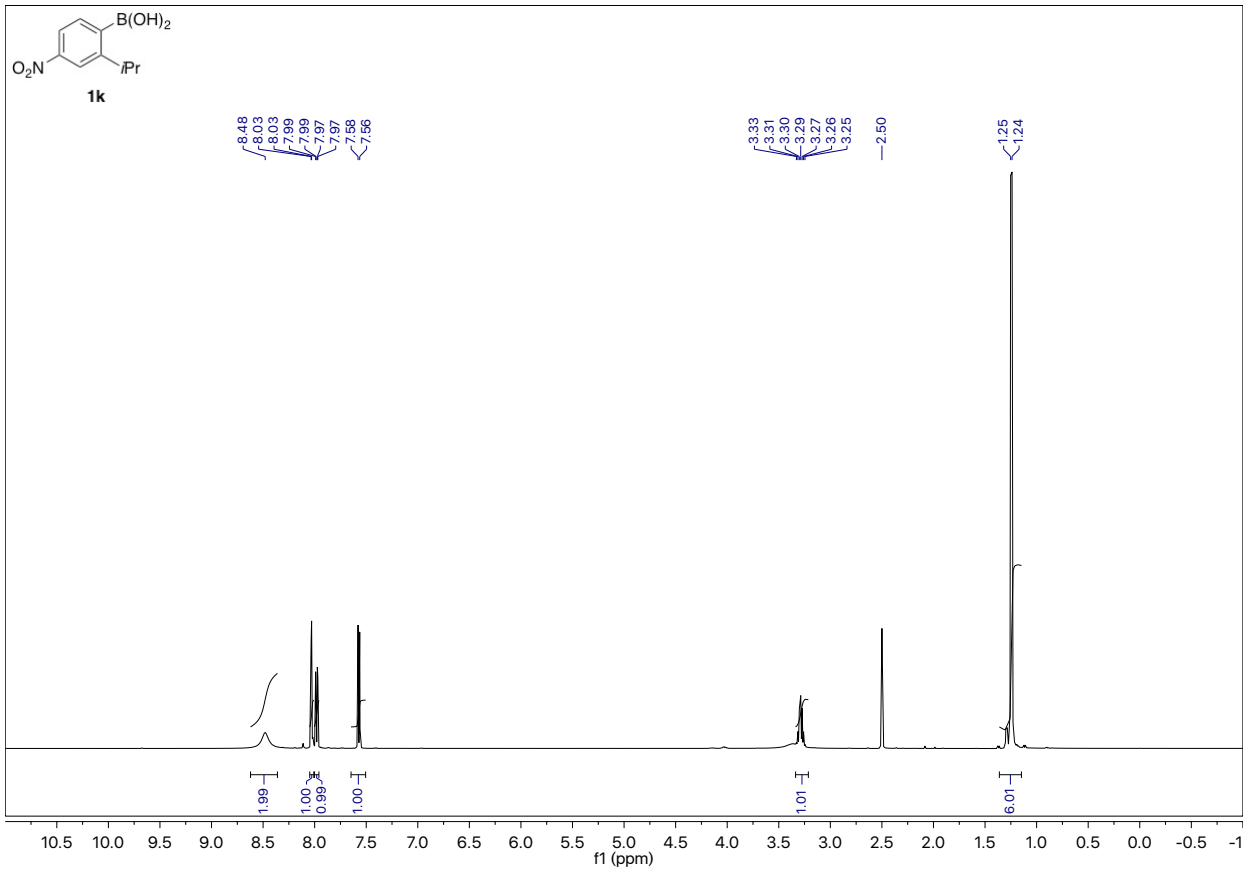
^{1}H NMR (500 MHz, DMSO-d_6)



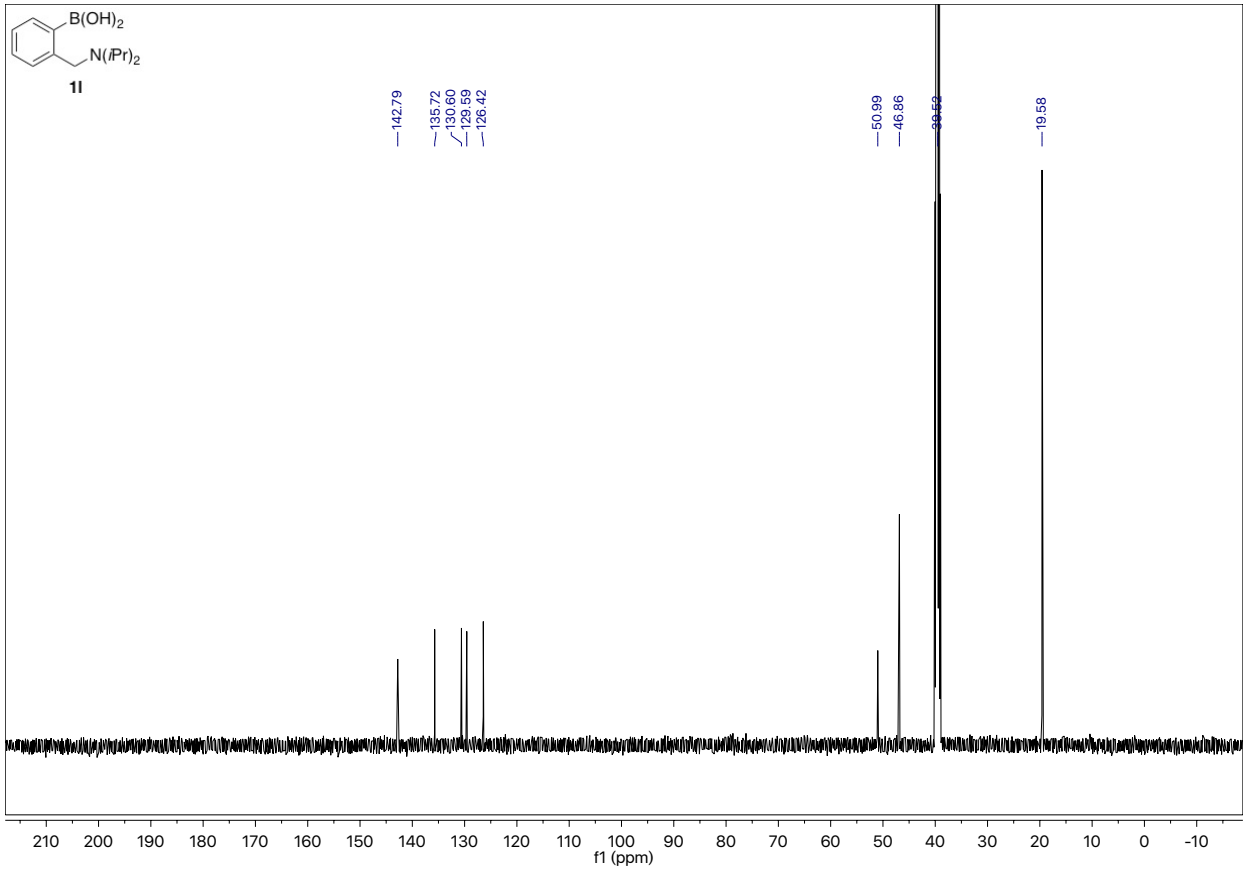
^{13}C NMR (500 MHz, DMSO-d_6)



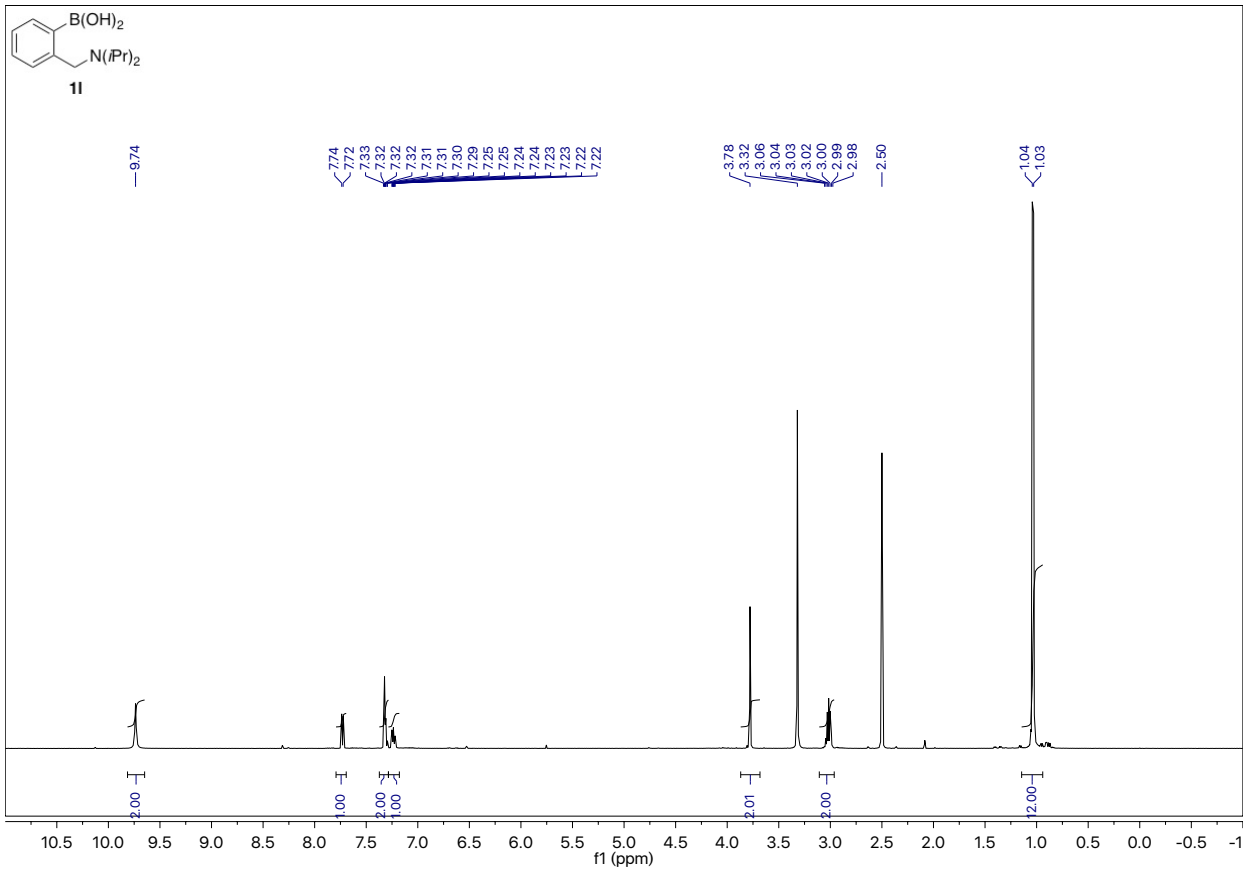
^{1}H NMR (126 MHz, DMSO-d_6)



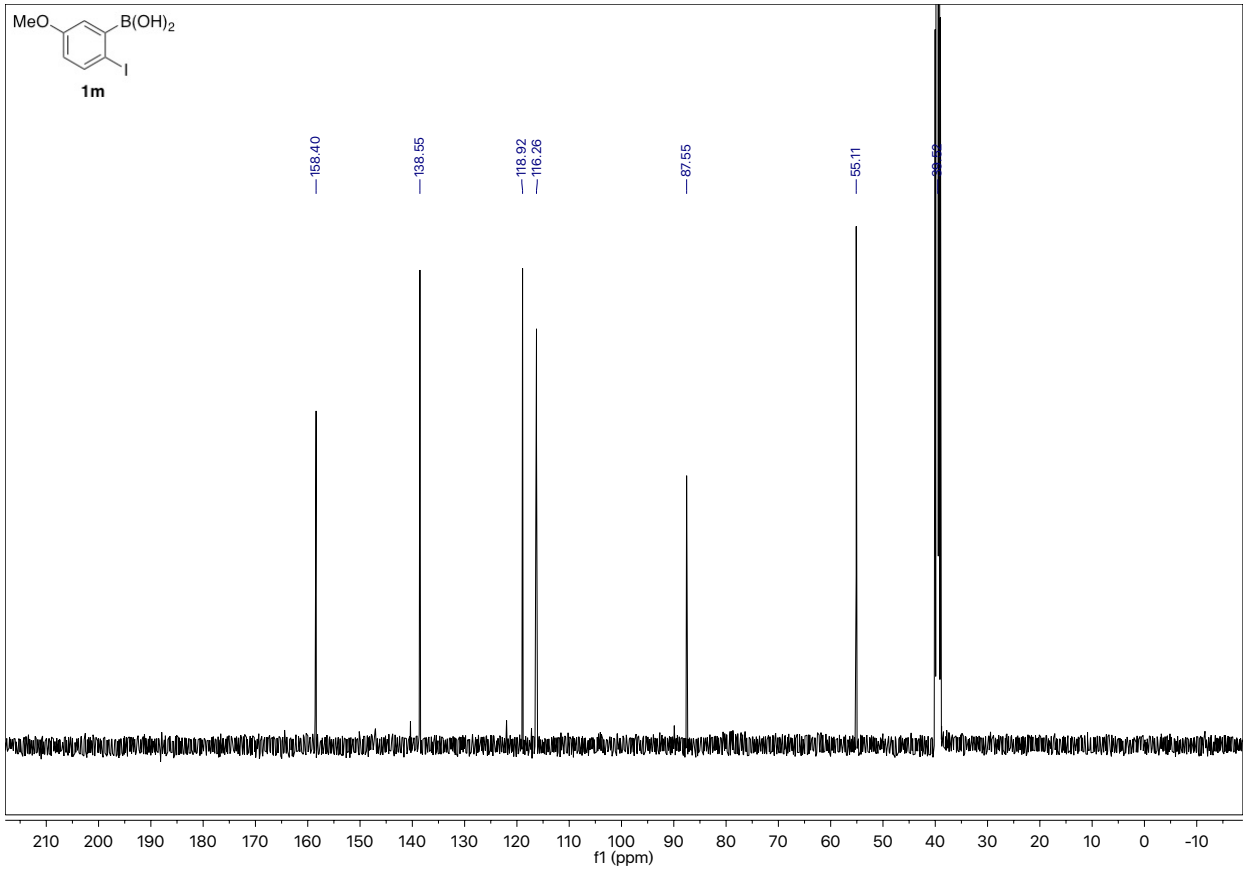
^{13}C NMR (126 MHz, DMSO-d_6)



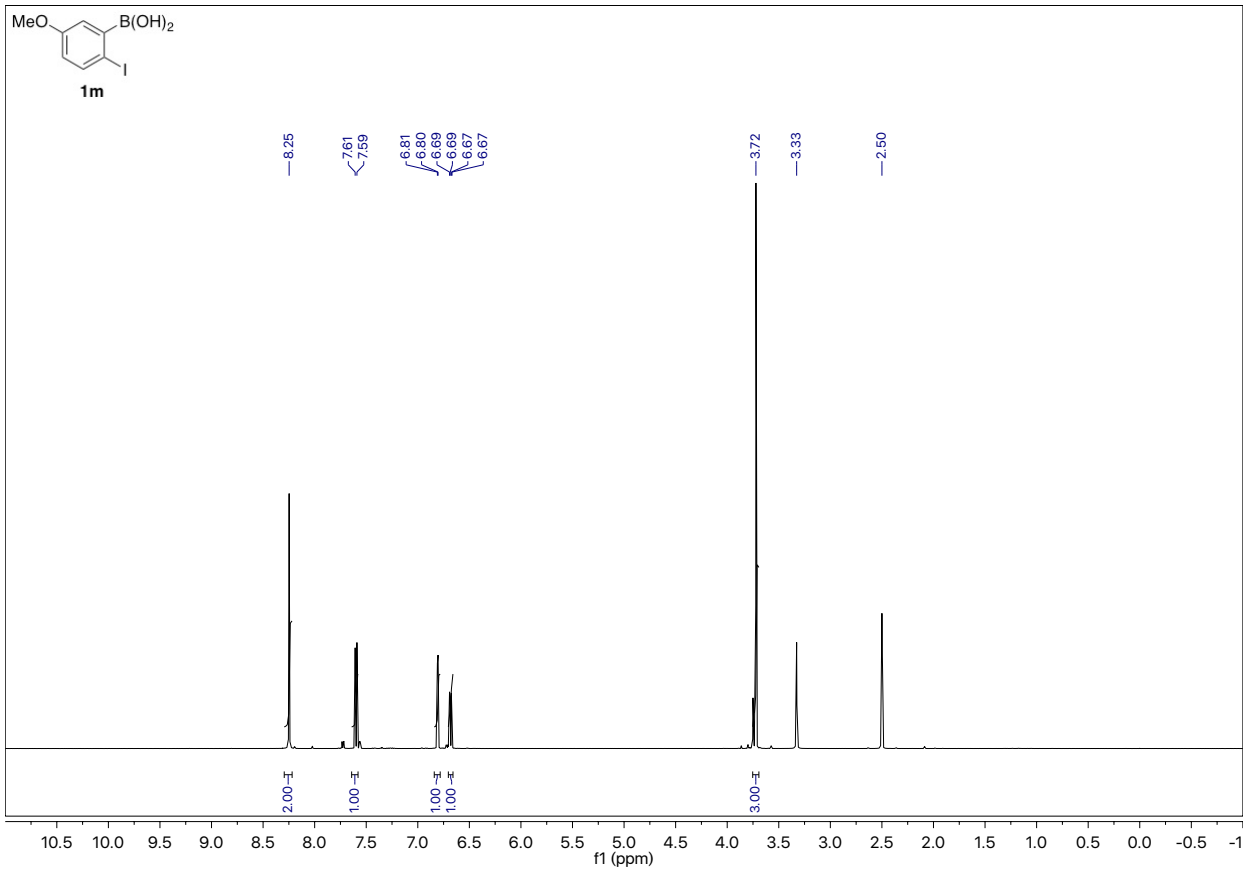
^{1}H NMR (500 MHz, DMSO-d_6)



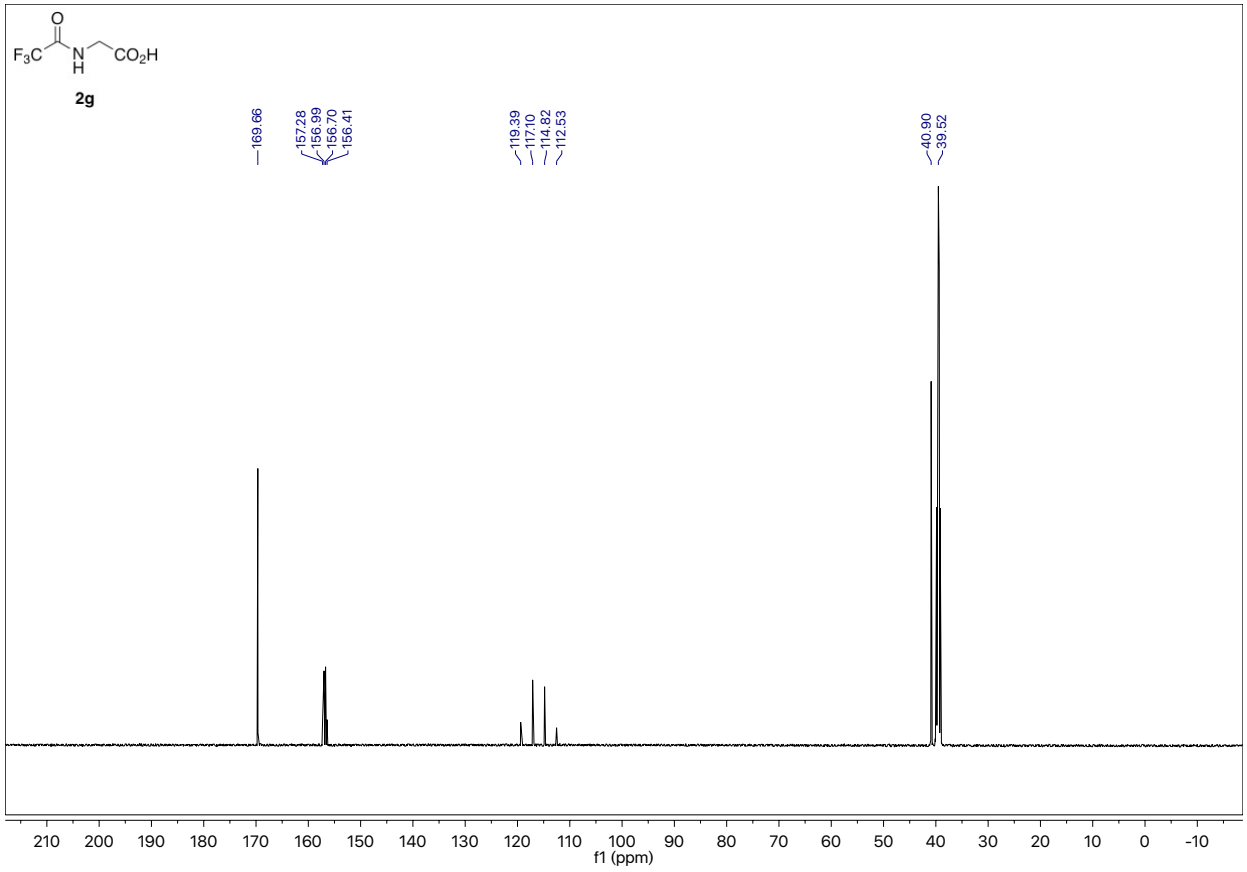
^{13}C NMR (126 MHz, DMSO-d_6)



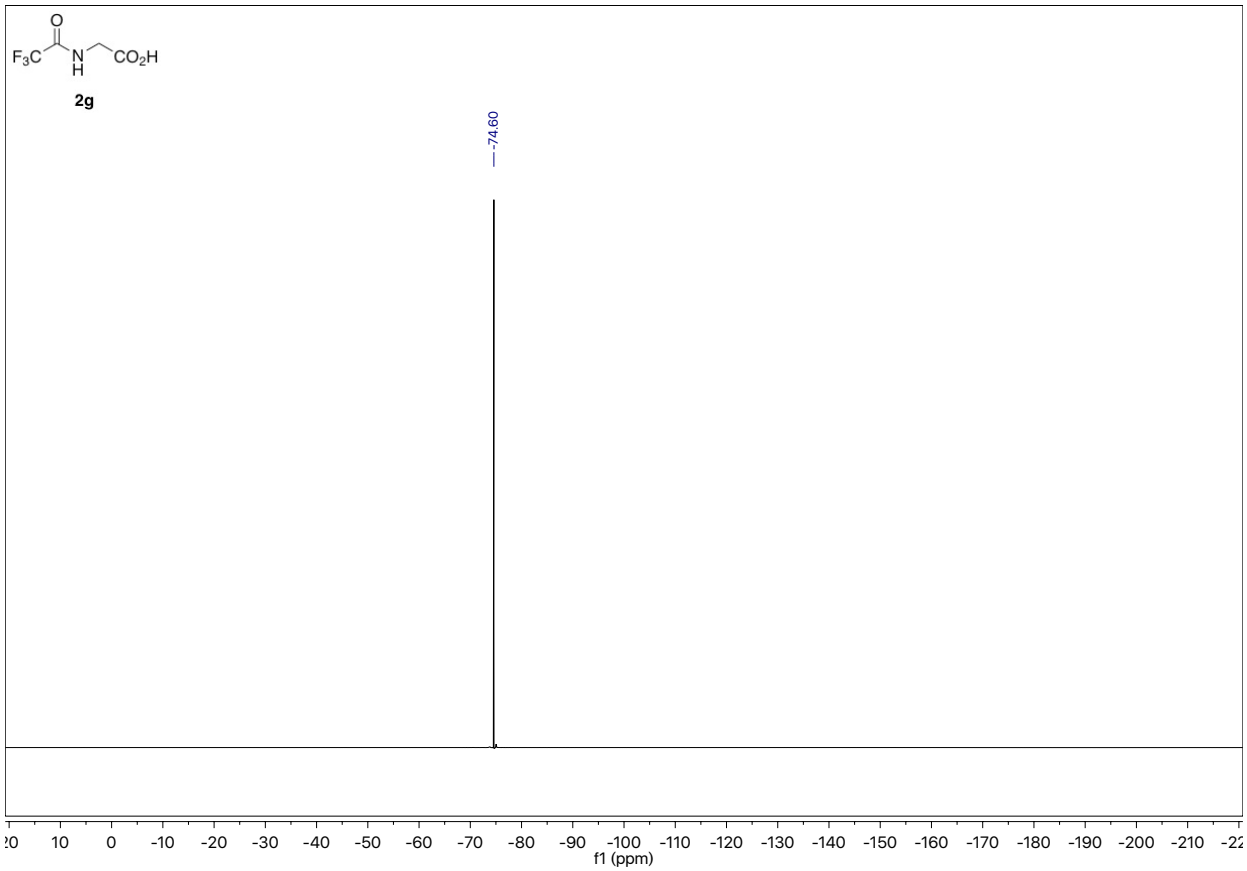
^{1}H NMR (500 MHz, DMSO-d_6)



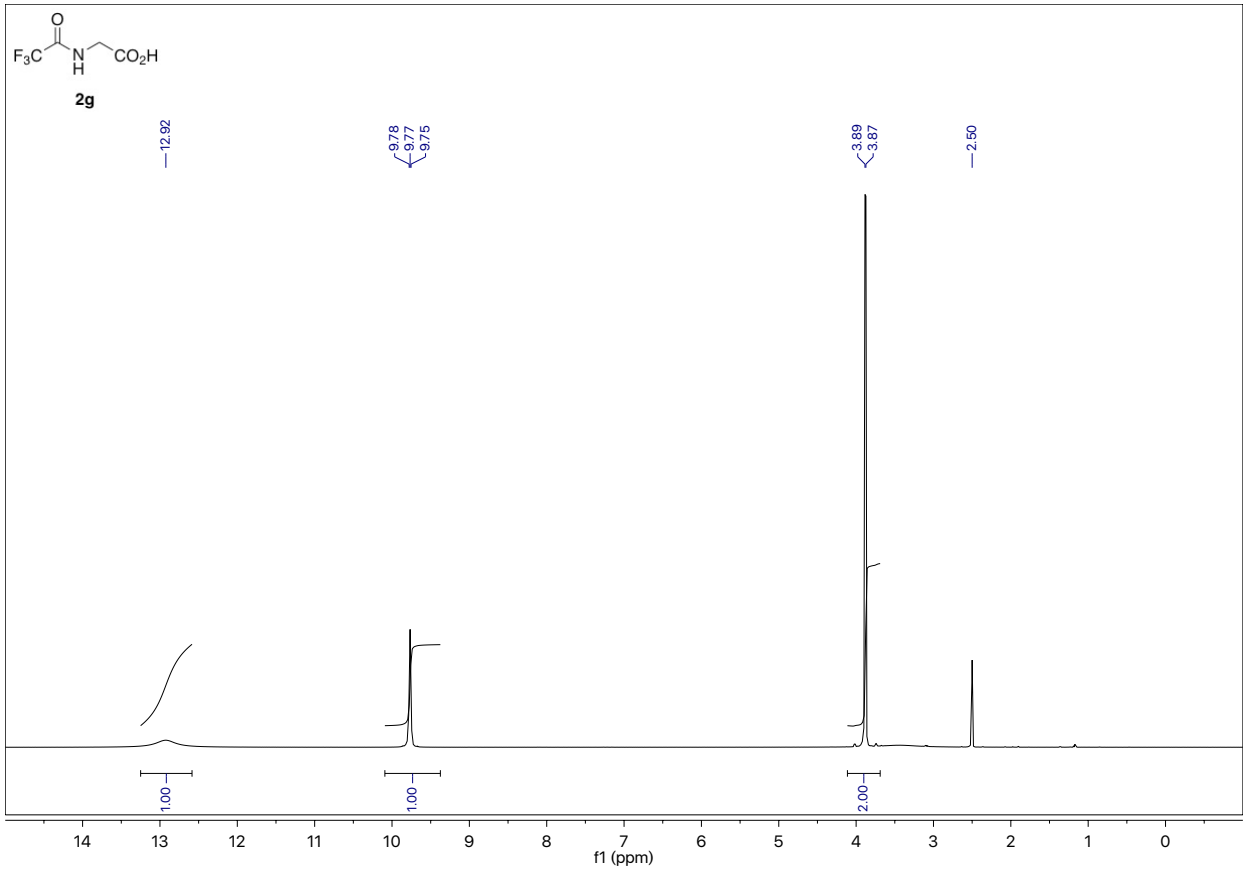
^{13}C NMR (126 MHz, DMSO-d_6)



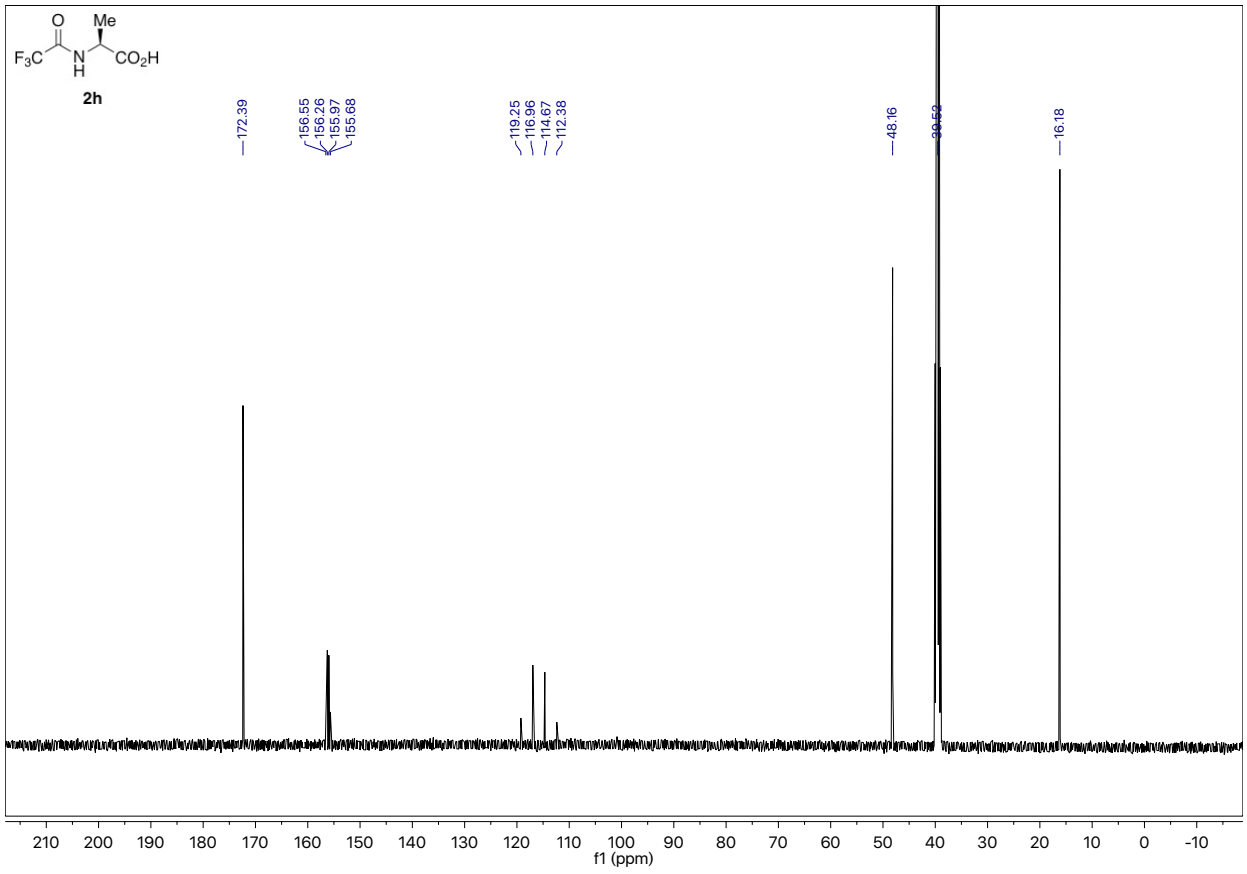
^{19}F NMR (470 MHz, DMSO-d_6)



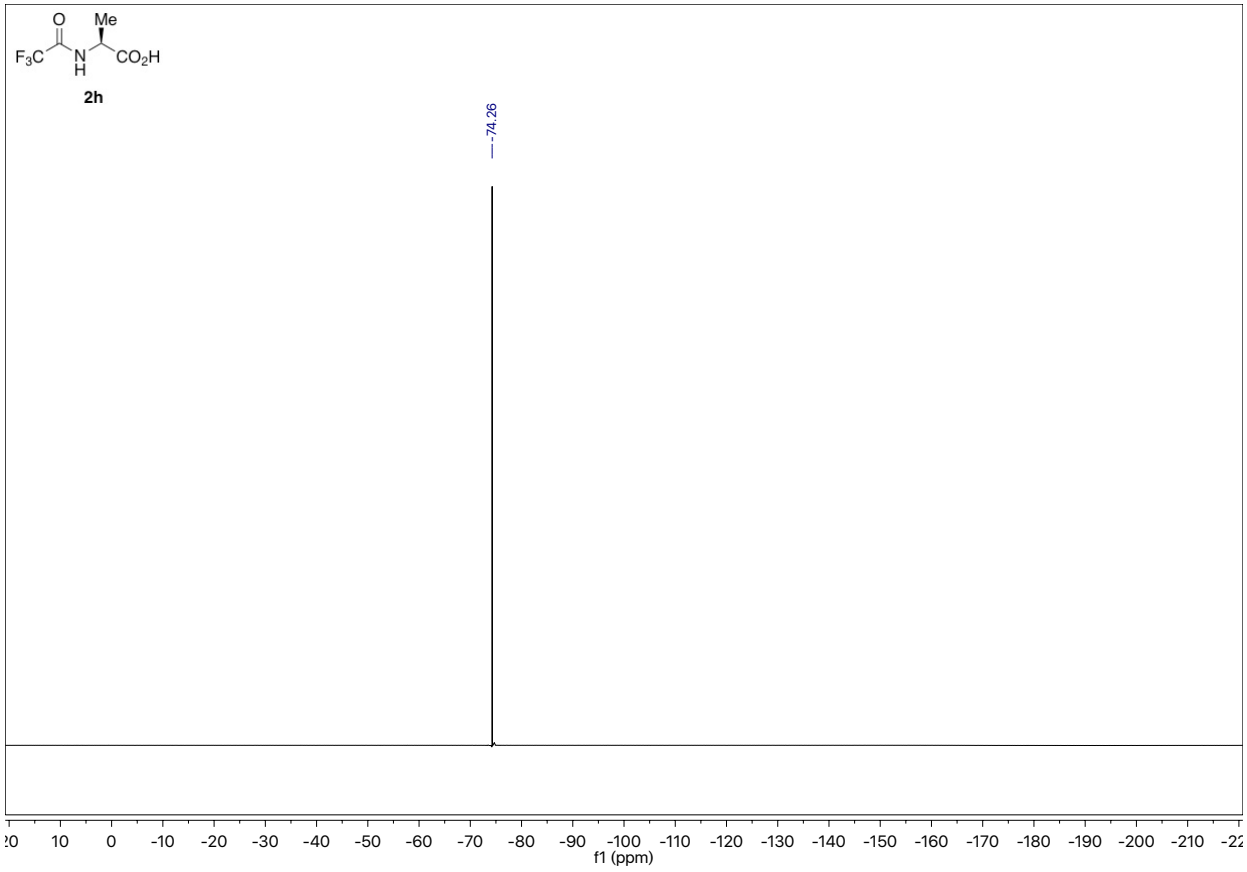
^{1}H NMR (500 MHz, DMSO-d_6)



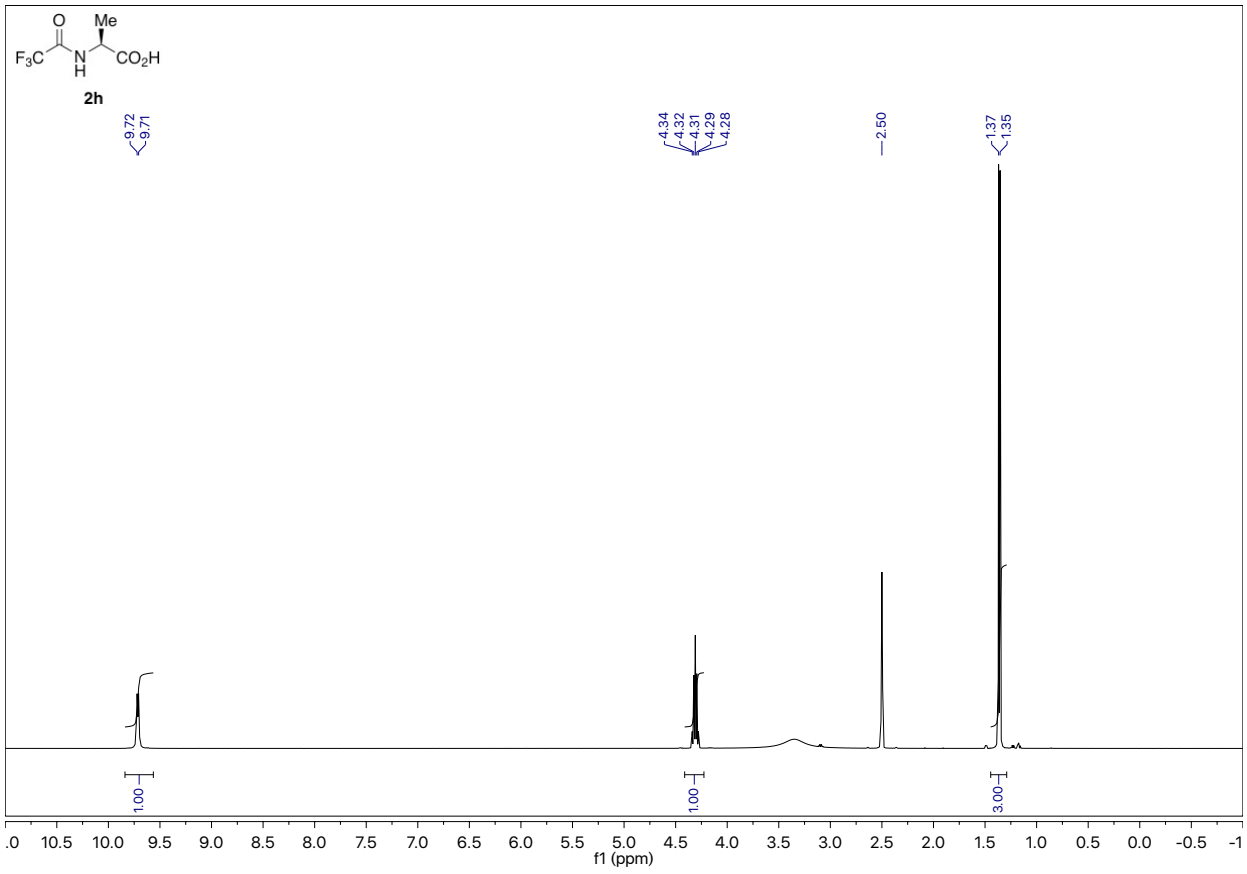
^{13}C NMR (126 MHz, DMSO-d_6)



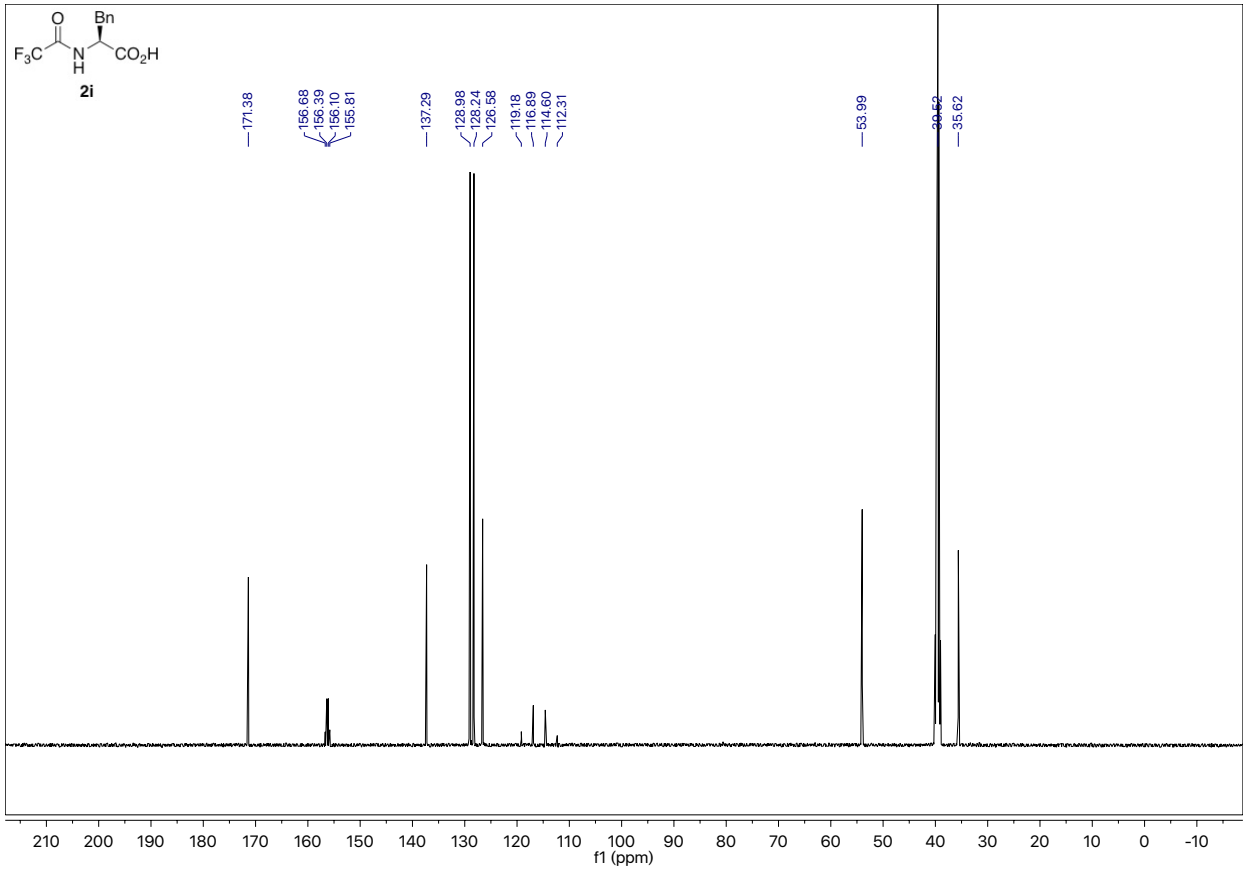
^{19}F NMR (470 MHz, DMSO-d_6)



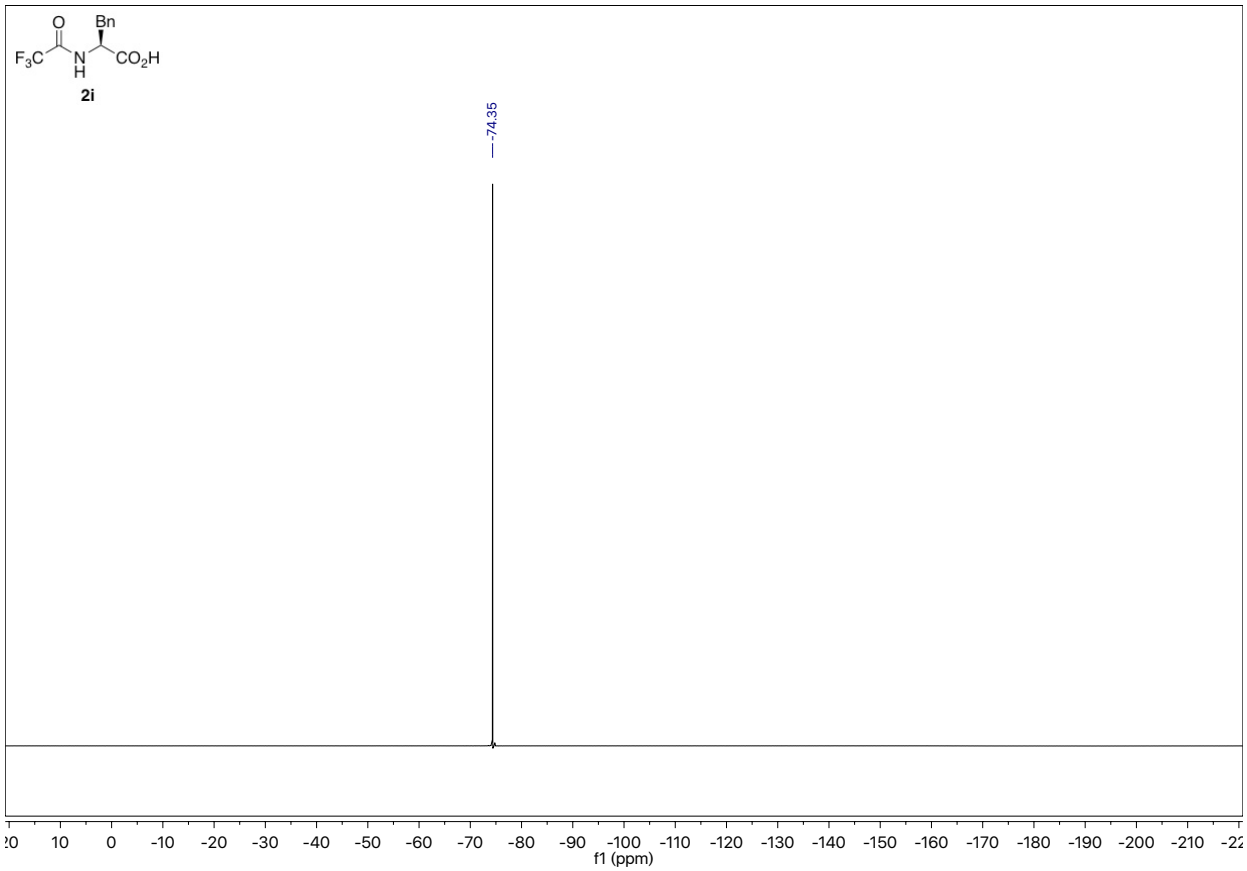
^{1}H NMR (500 MHz, DMSO-d_6)



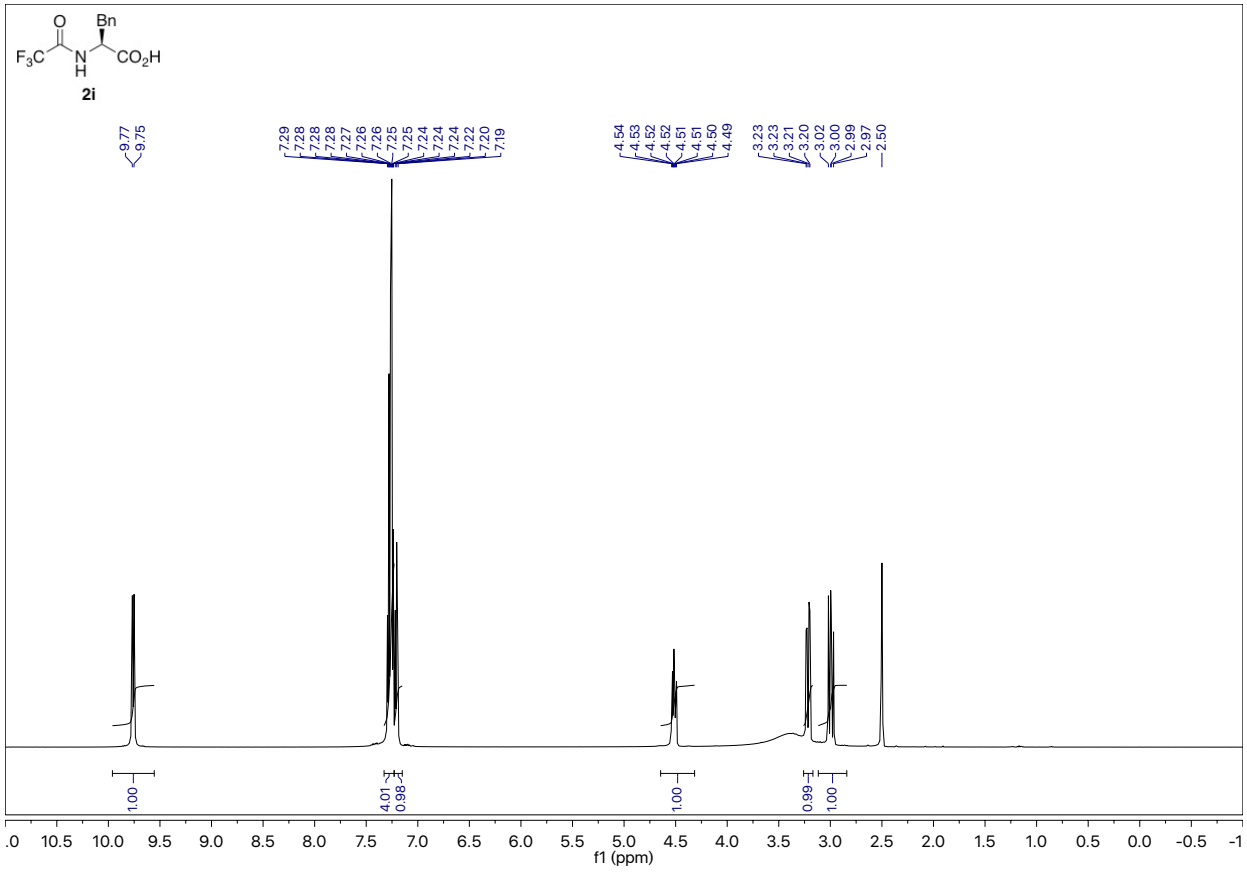
^{13}C NMR (126 MHz, DMSO-d_6)



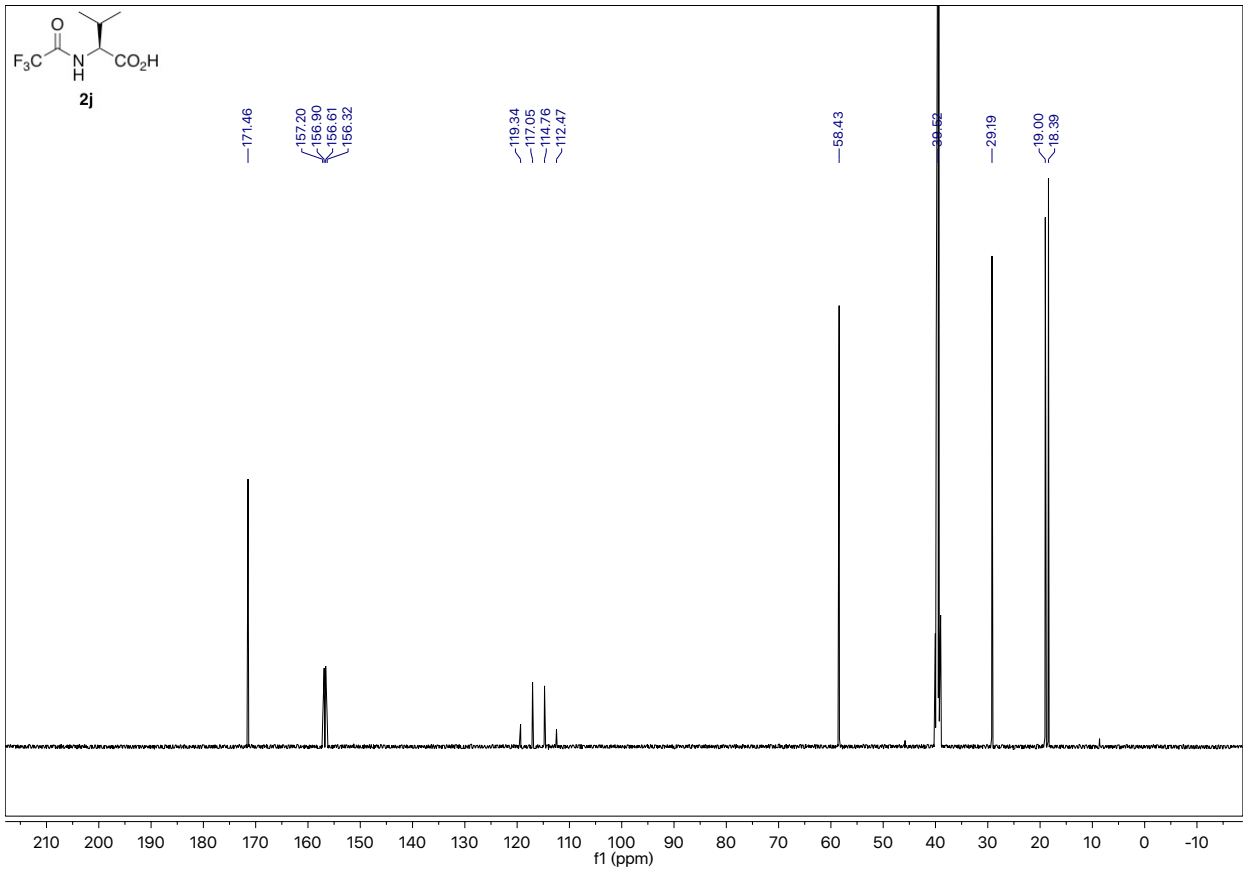
^{19}F NMR (470 MHz, DMSO-d_6)



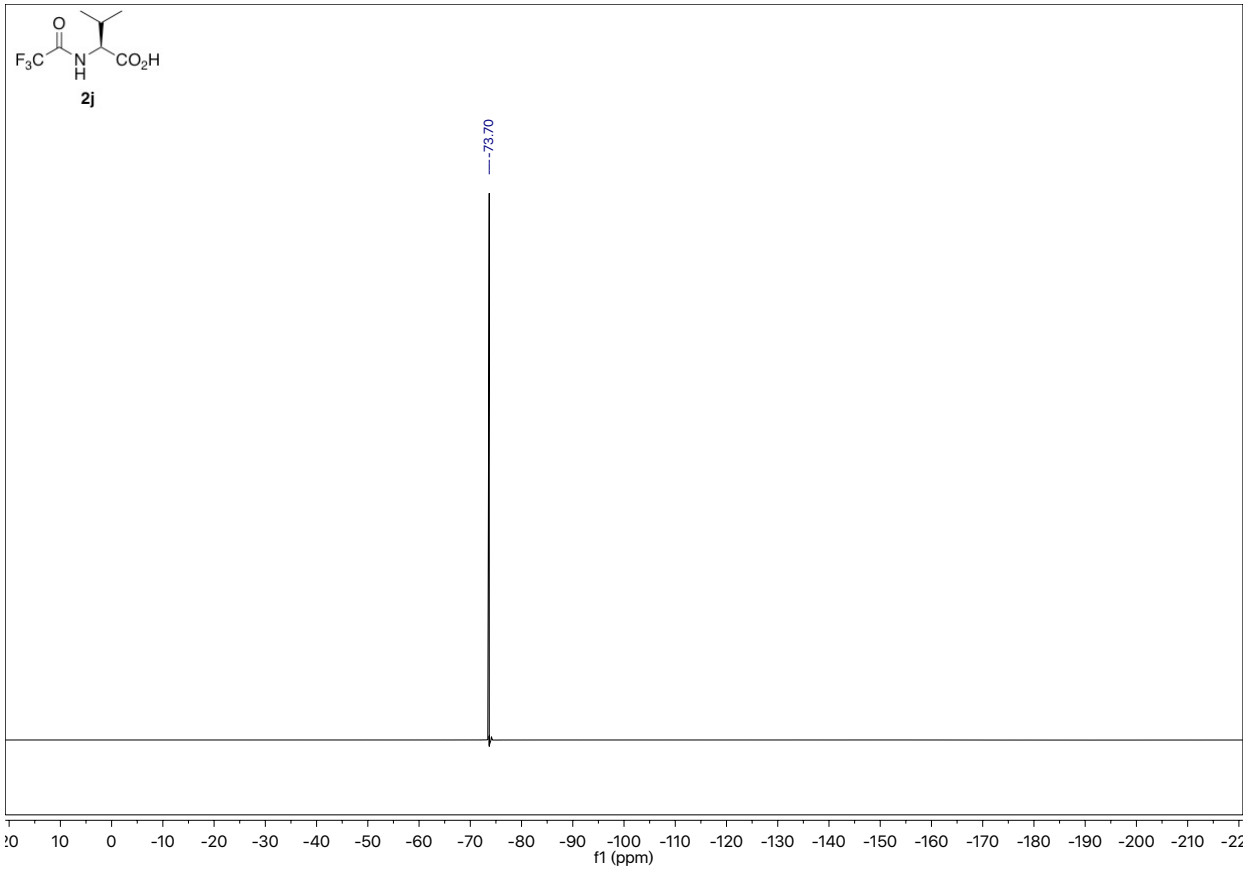
^{1}H NMR (500 MHz, DMSO-d_6)



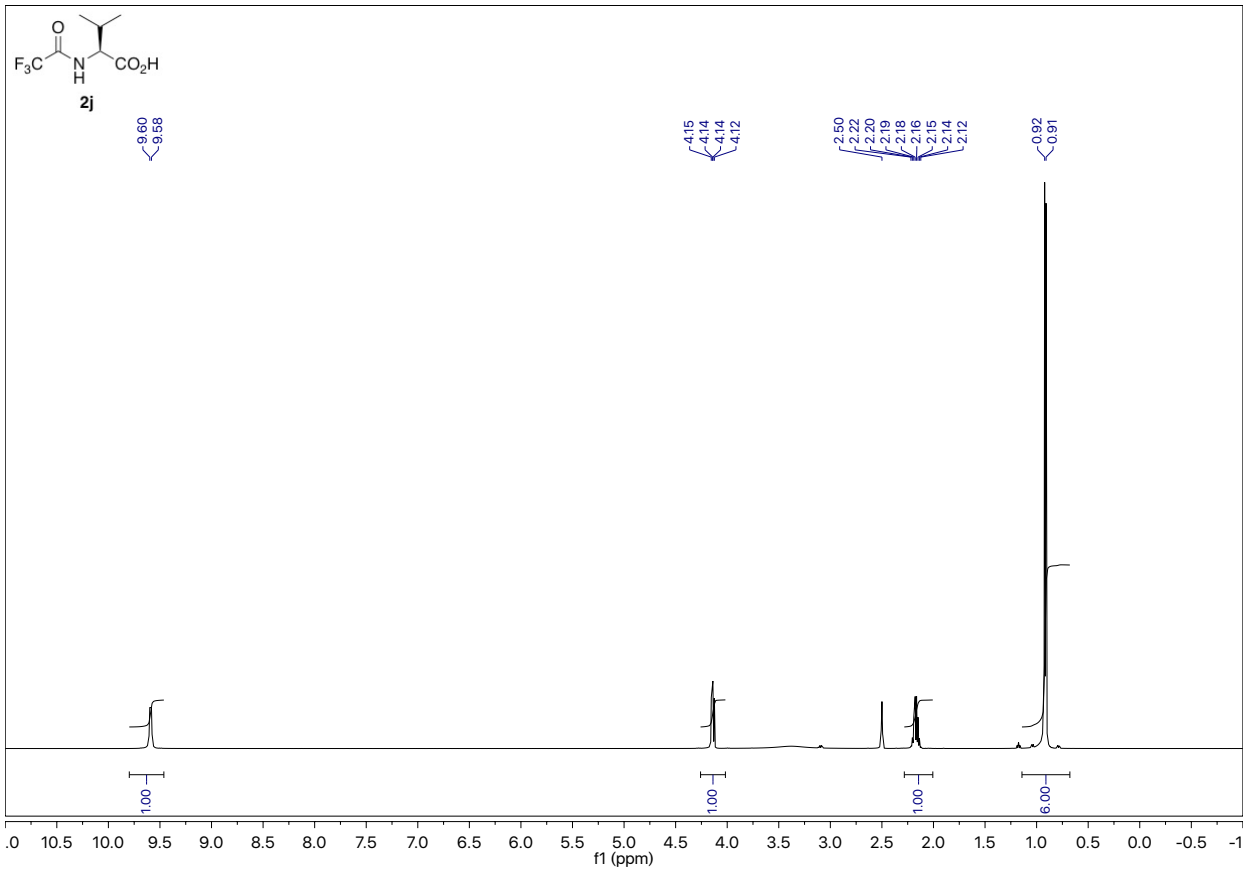
^{13}C NMR (126 MHz, DMSO-d_6)



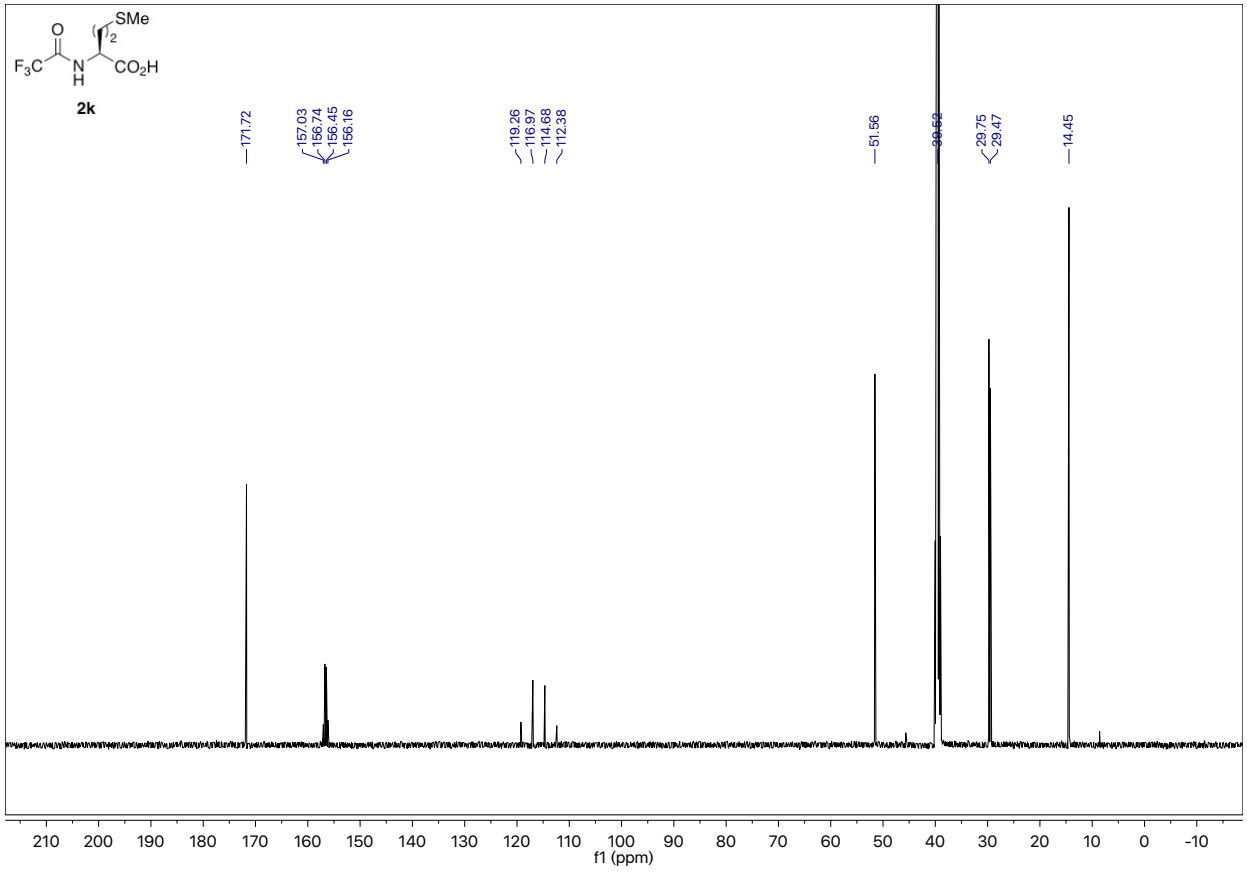
^{19}F NMR (470 MHz, DMSO-d_6)



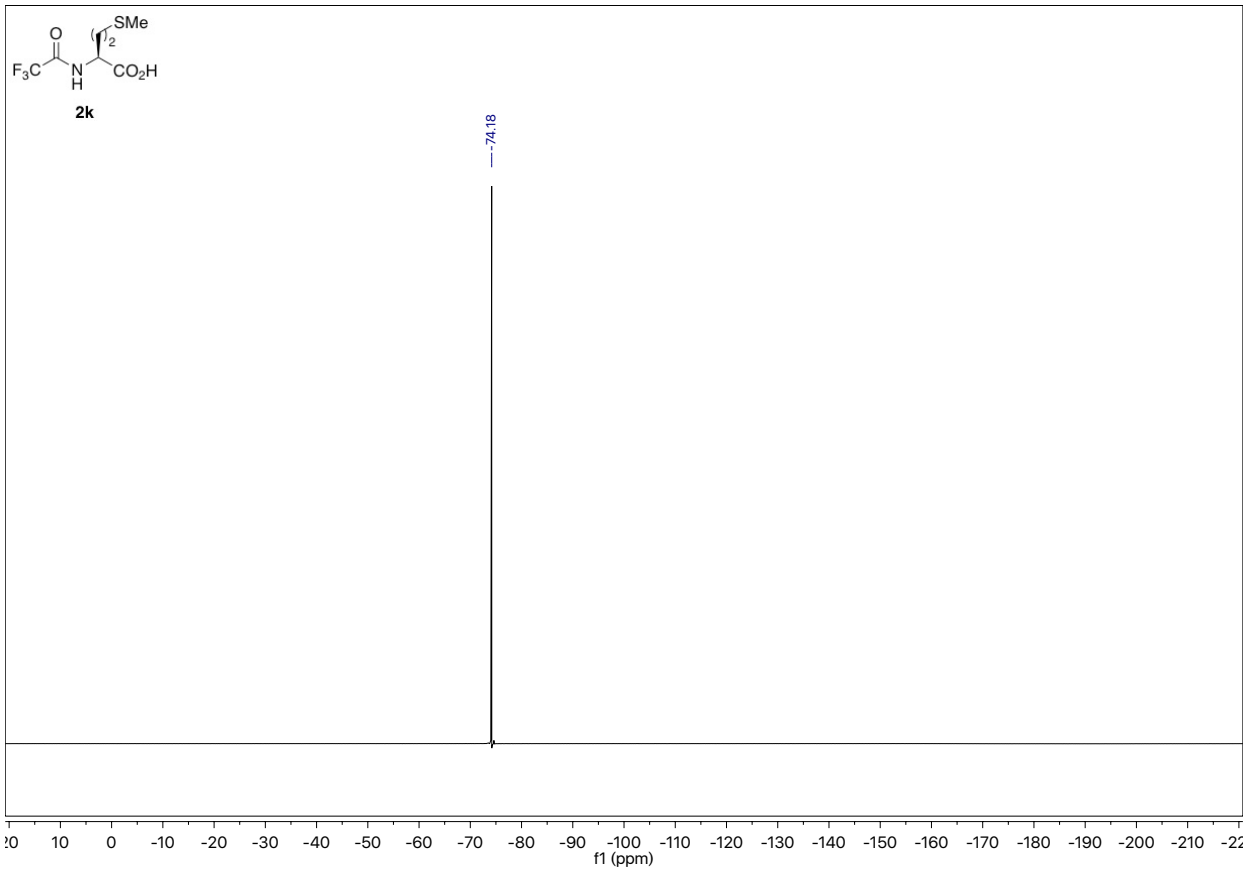
^{1}H NMR (500 MHz, DMSO-d_6)



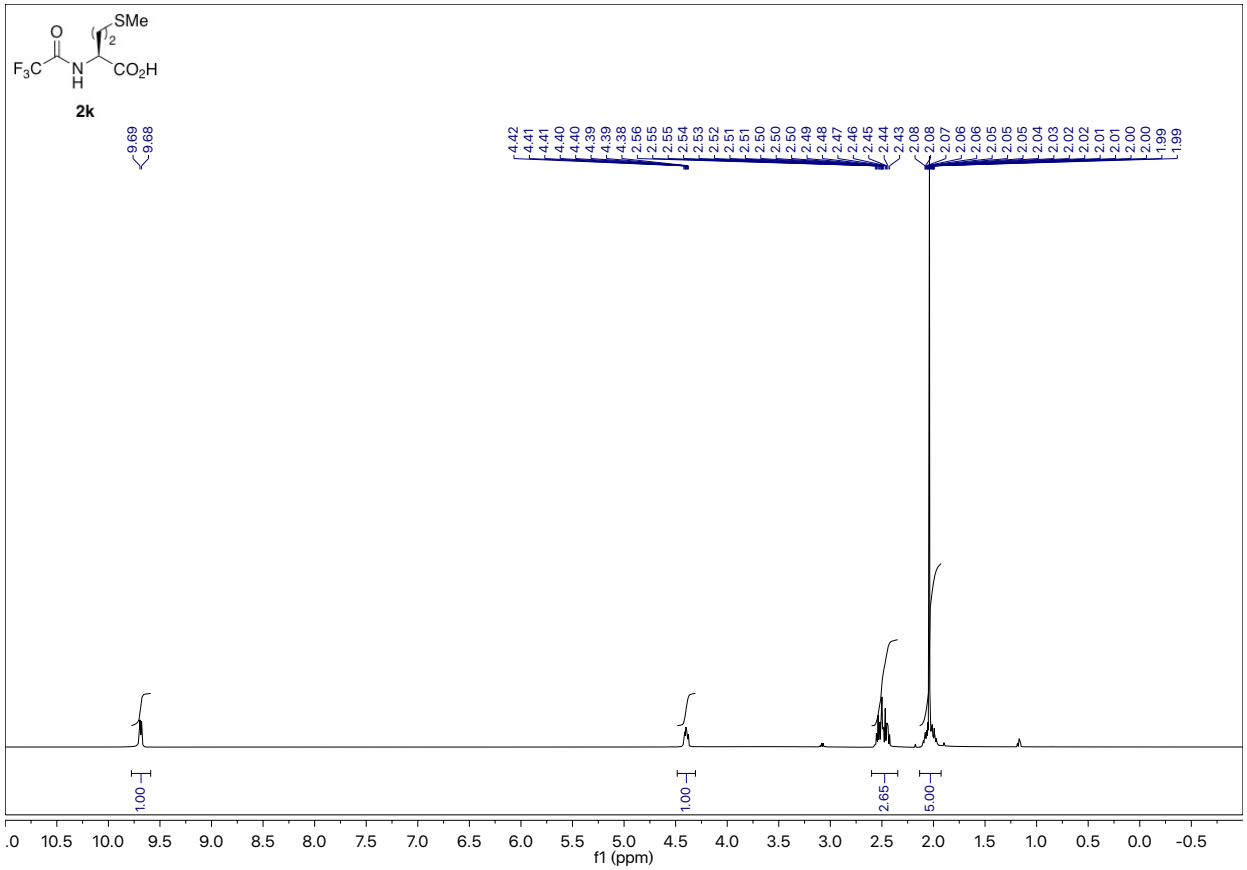
^{13}C NMR (126 MHz, DMSO-d_6)



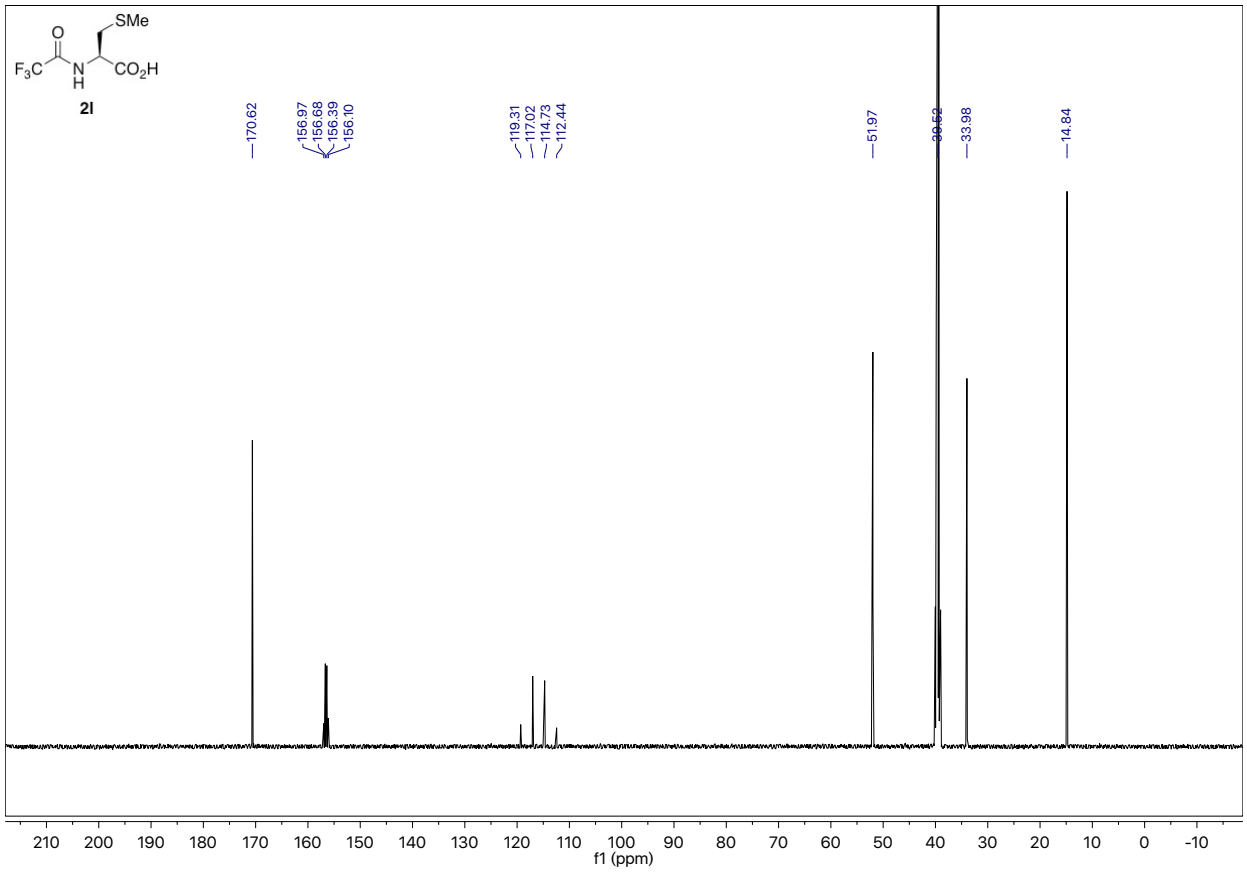
^{19}F NMR (470 MHz, DMSO-d_6)



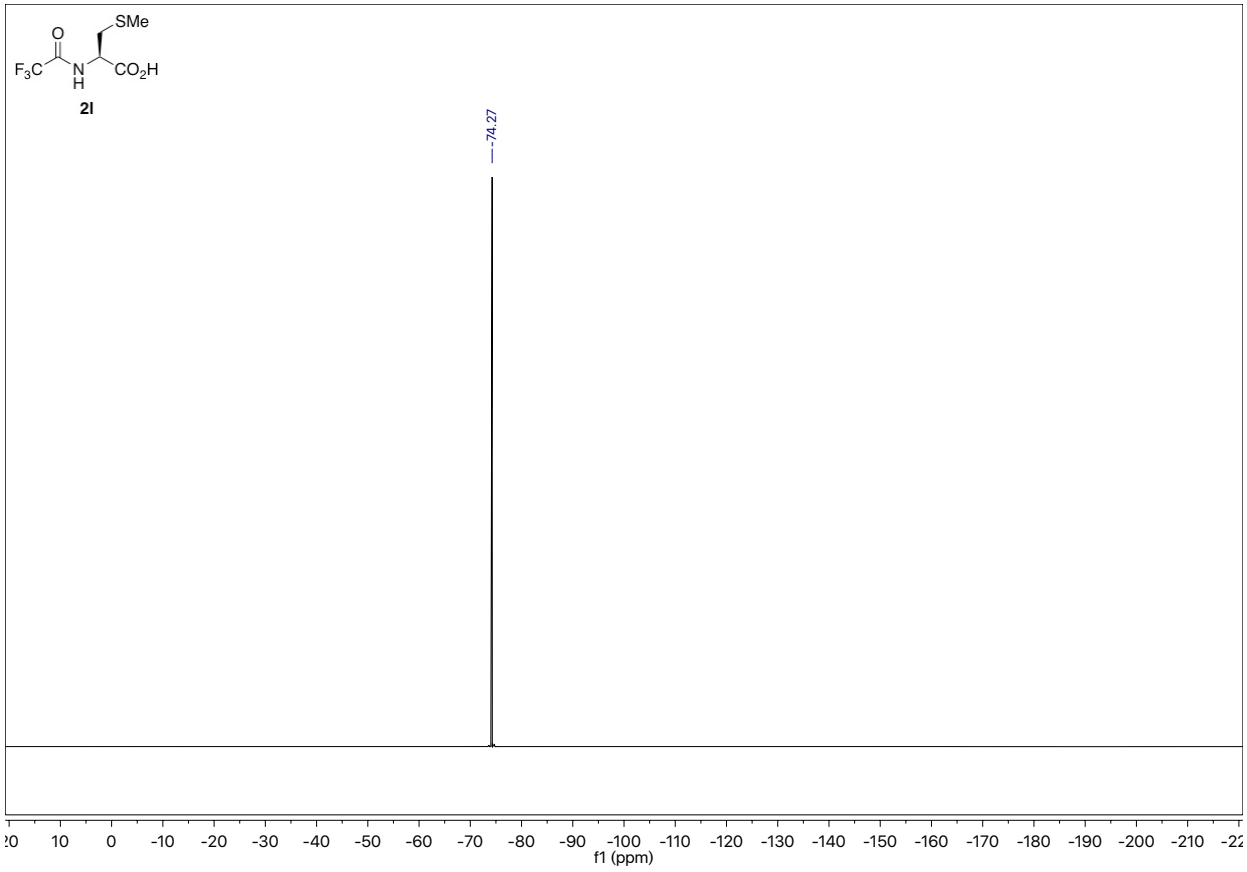
^{1}H NMR (500 MHz, DMSO-d_6)



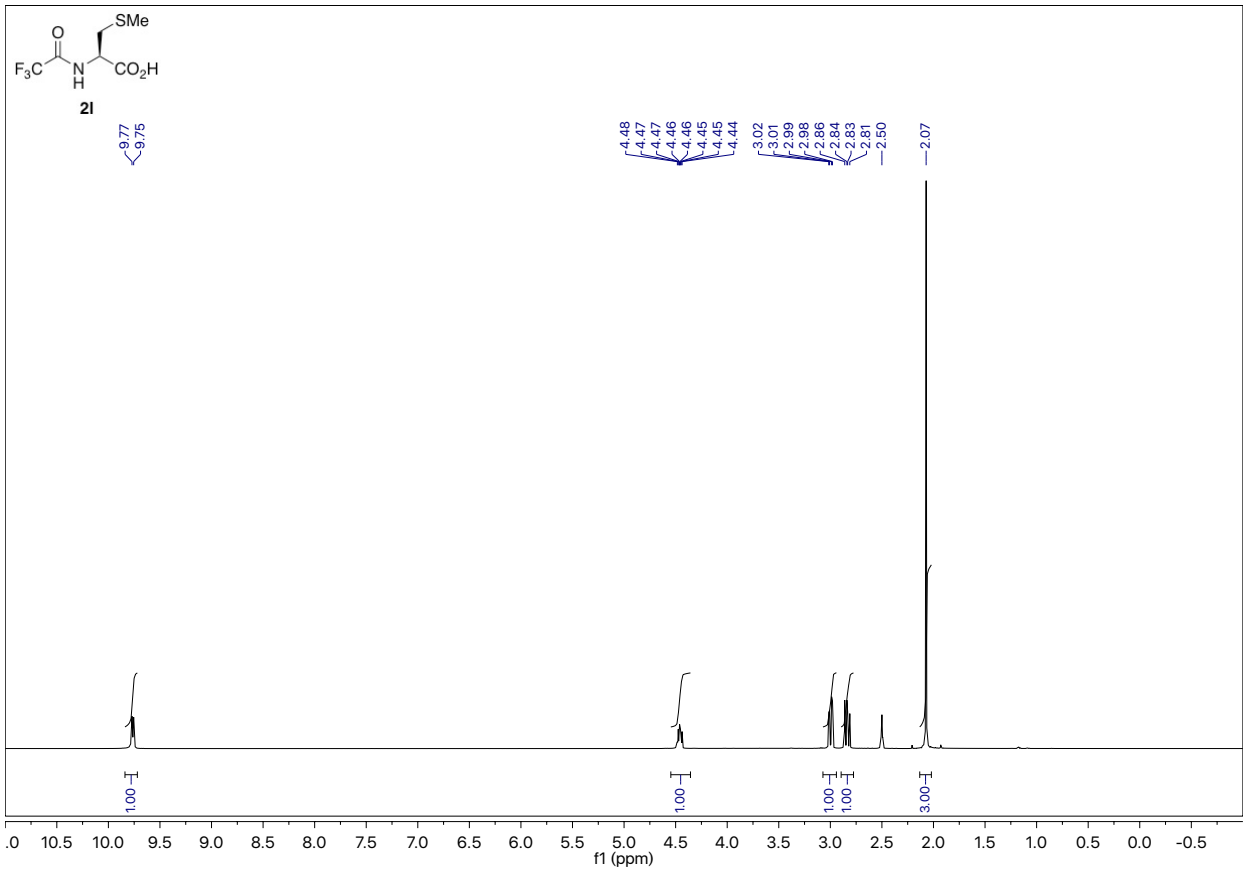
^{13}C NMR (126 MHz, DMSO-d_6)



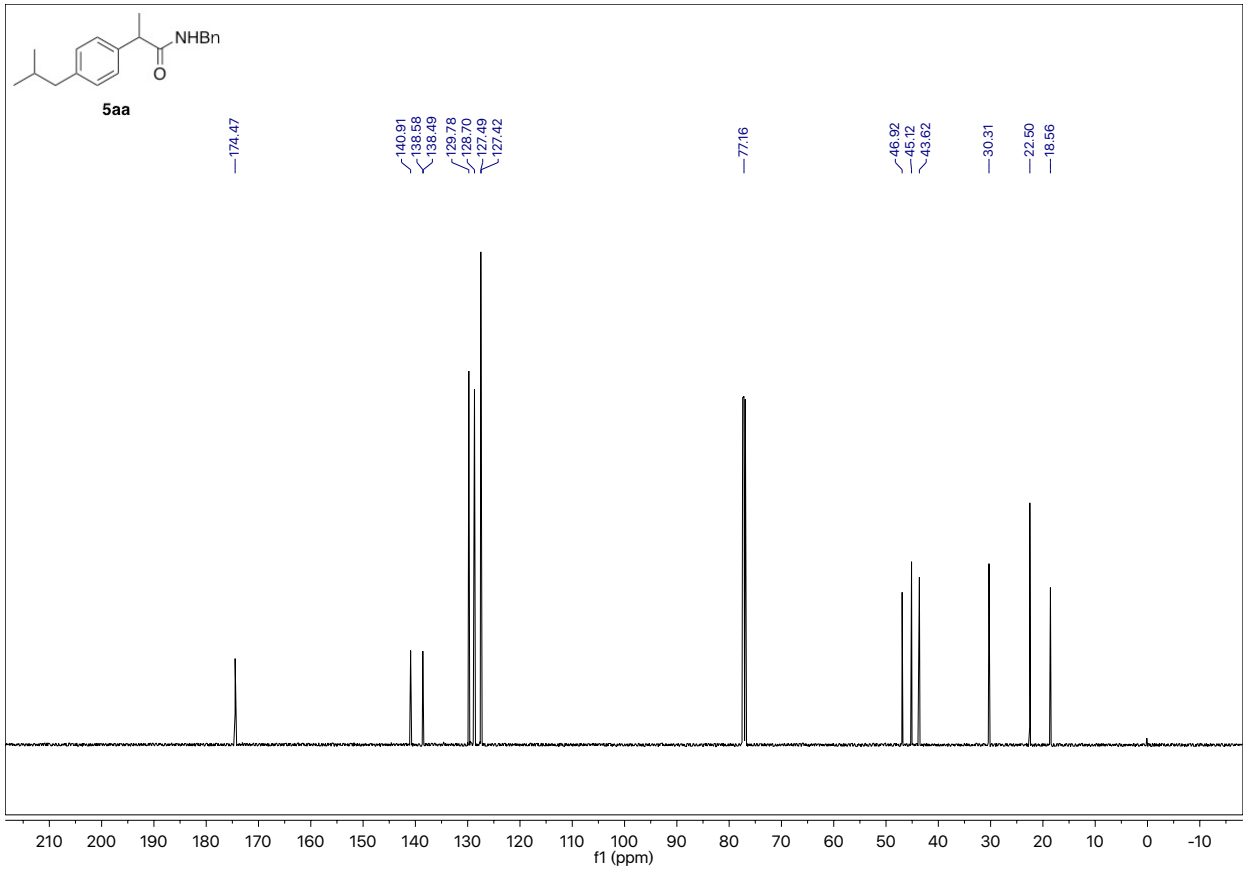
^{19}F NMR (470 MHz, DMSO-d_6)



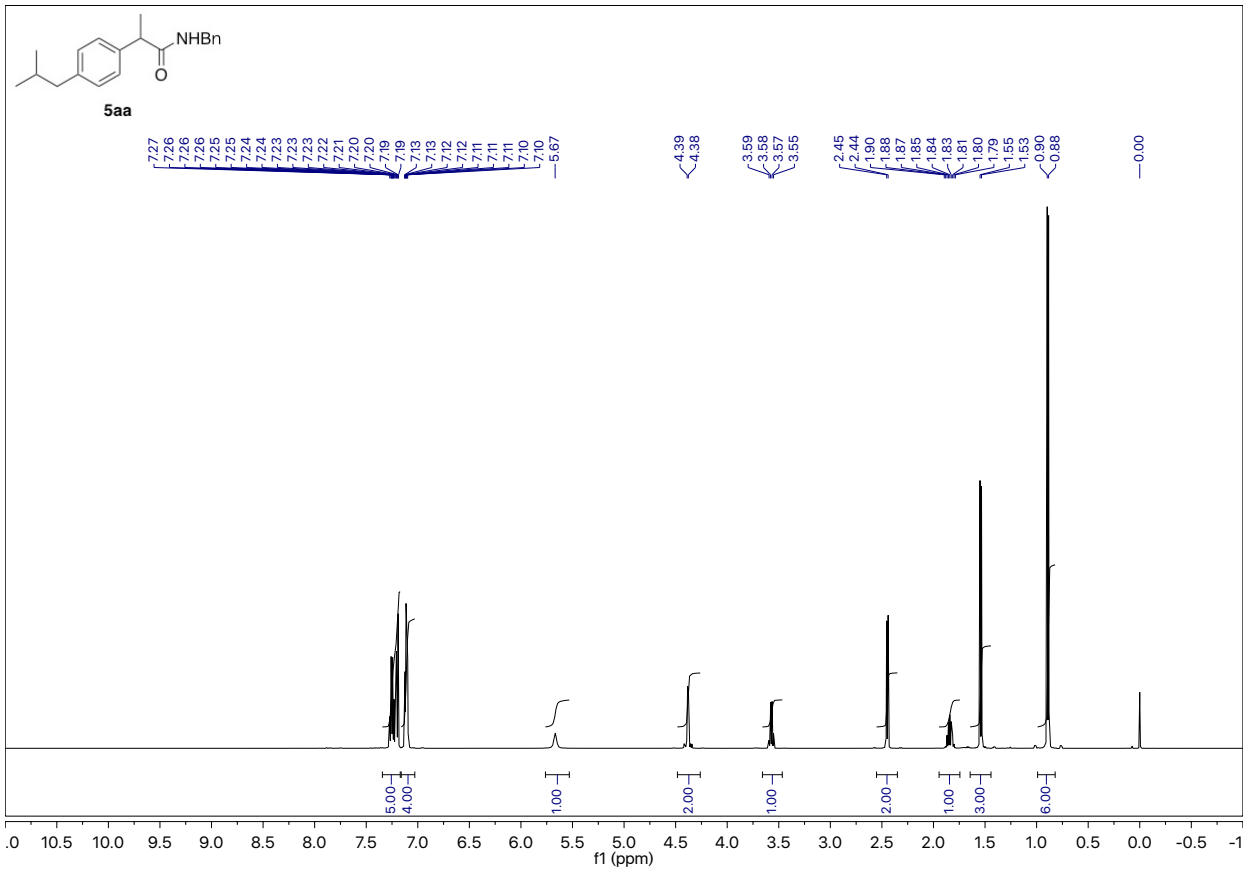
^{1}H NMR (500 MHz, DMSO-d_6)



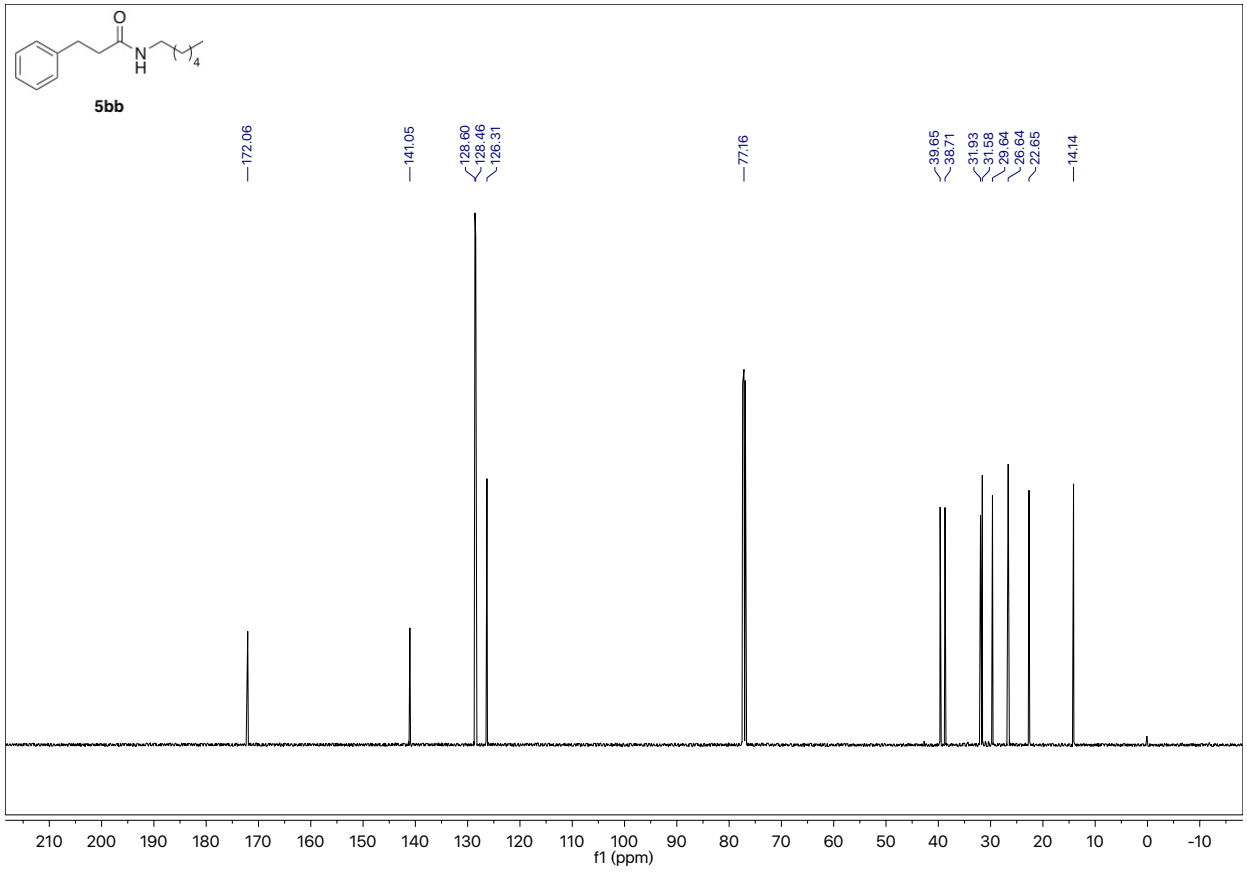
^{13}C NMR (126 MHz, $CDCl_3$) in Table 1



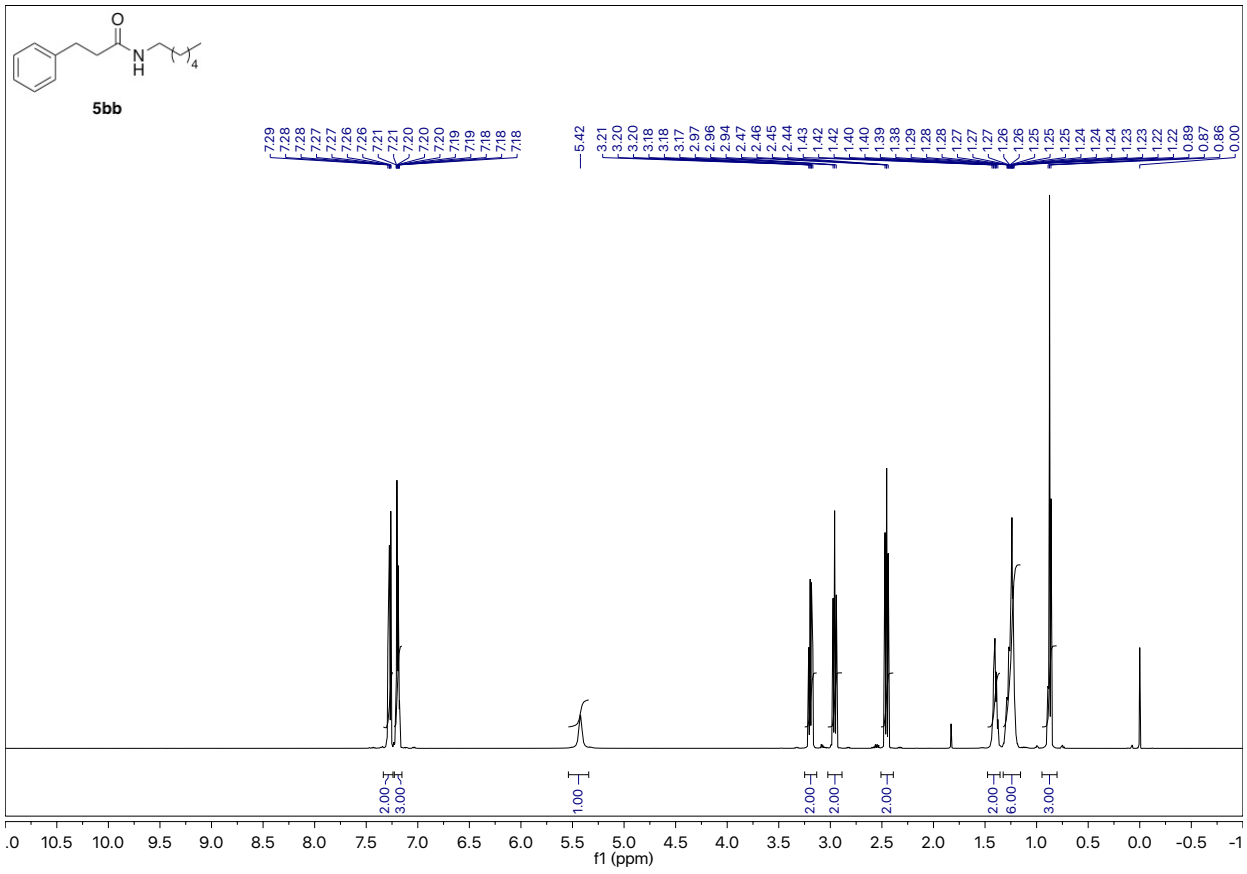
^{1}H NMR (500 MHz, $CDCl_3$) in Table 1



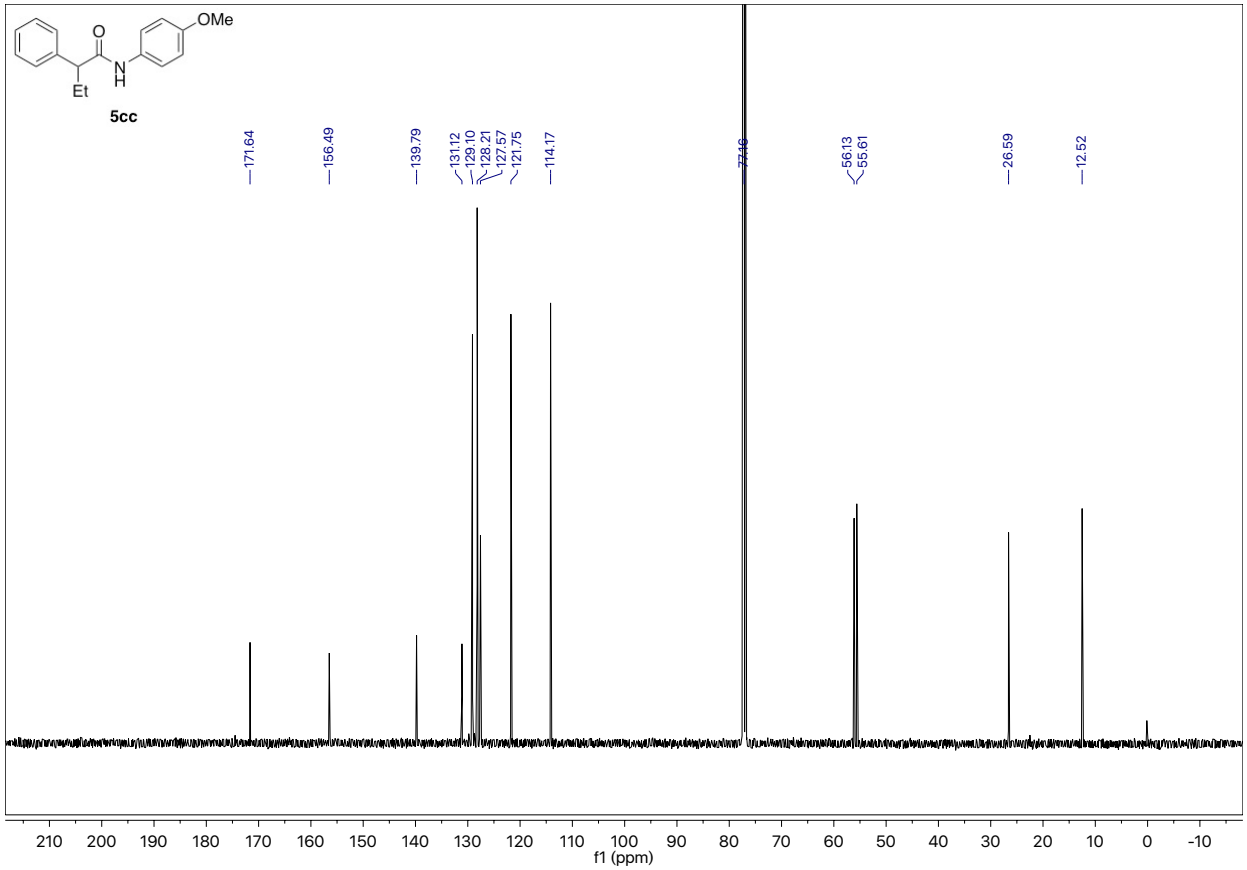
^{13}C NMR (126 MHz, $CDCl_3$), Table 2



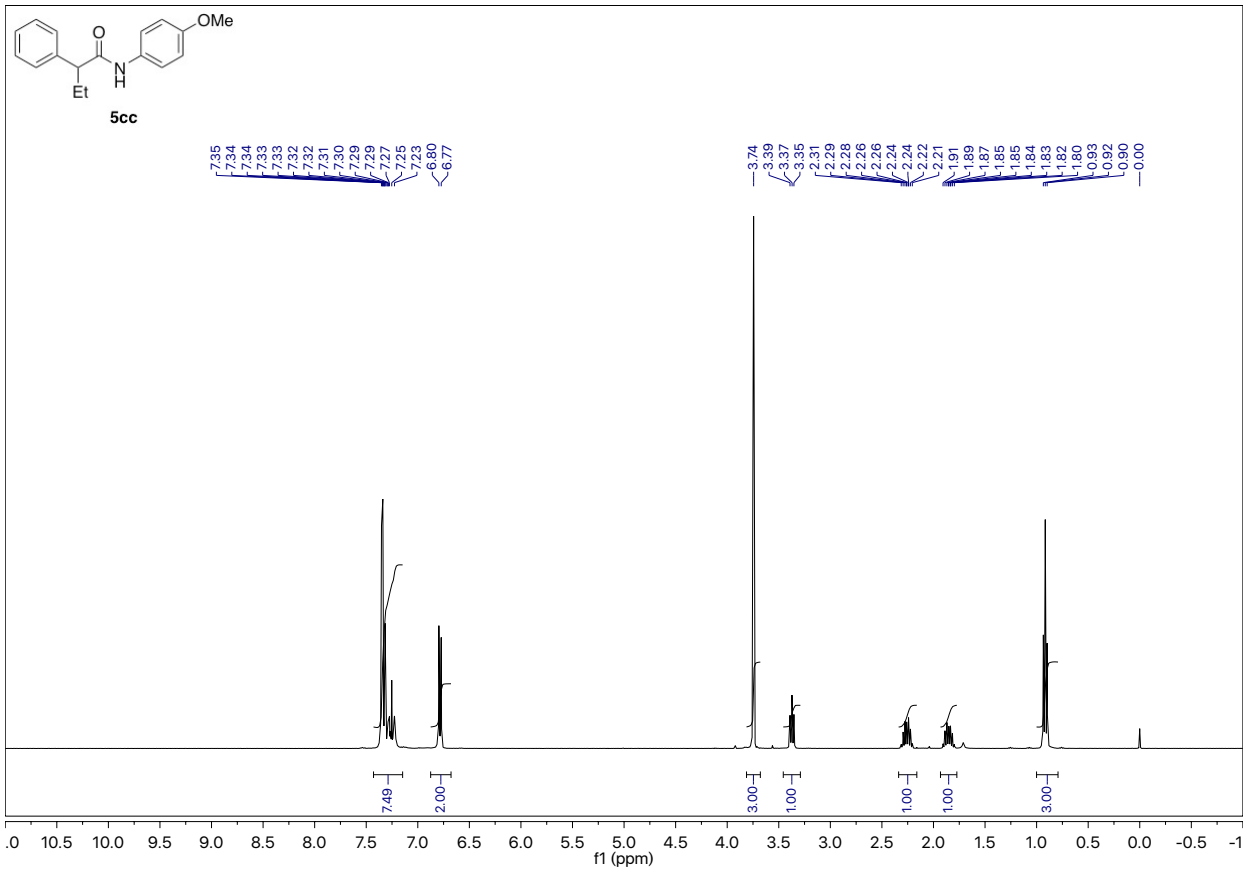
^{1}H NMR (500 MHz, $CDCl_3$), Table 2



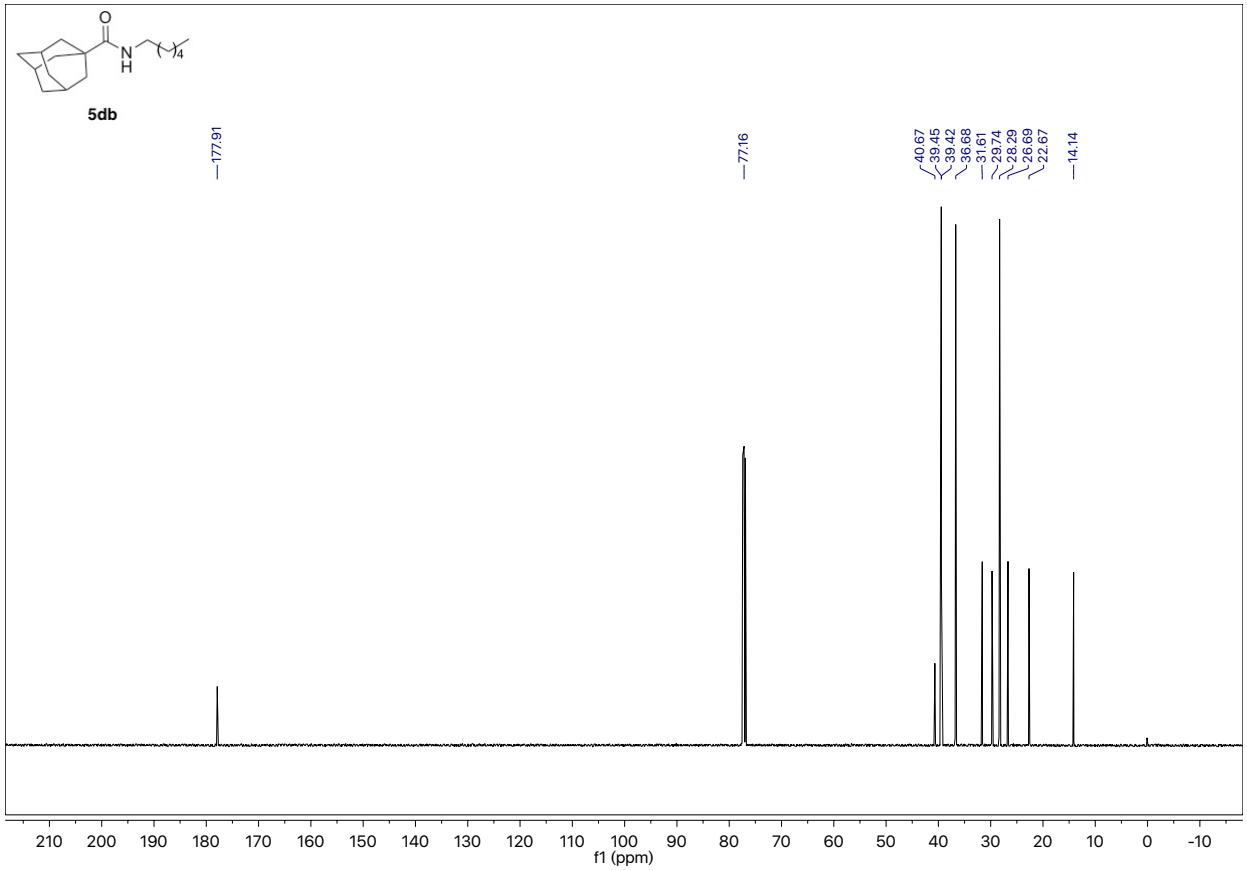
^{13}C NMR (126 MHz, $CDCl_3$), in Table 2



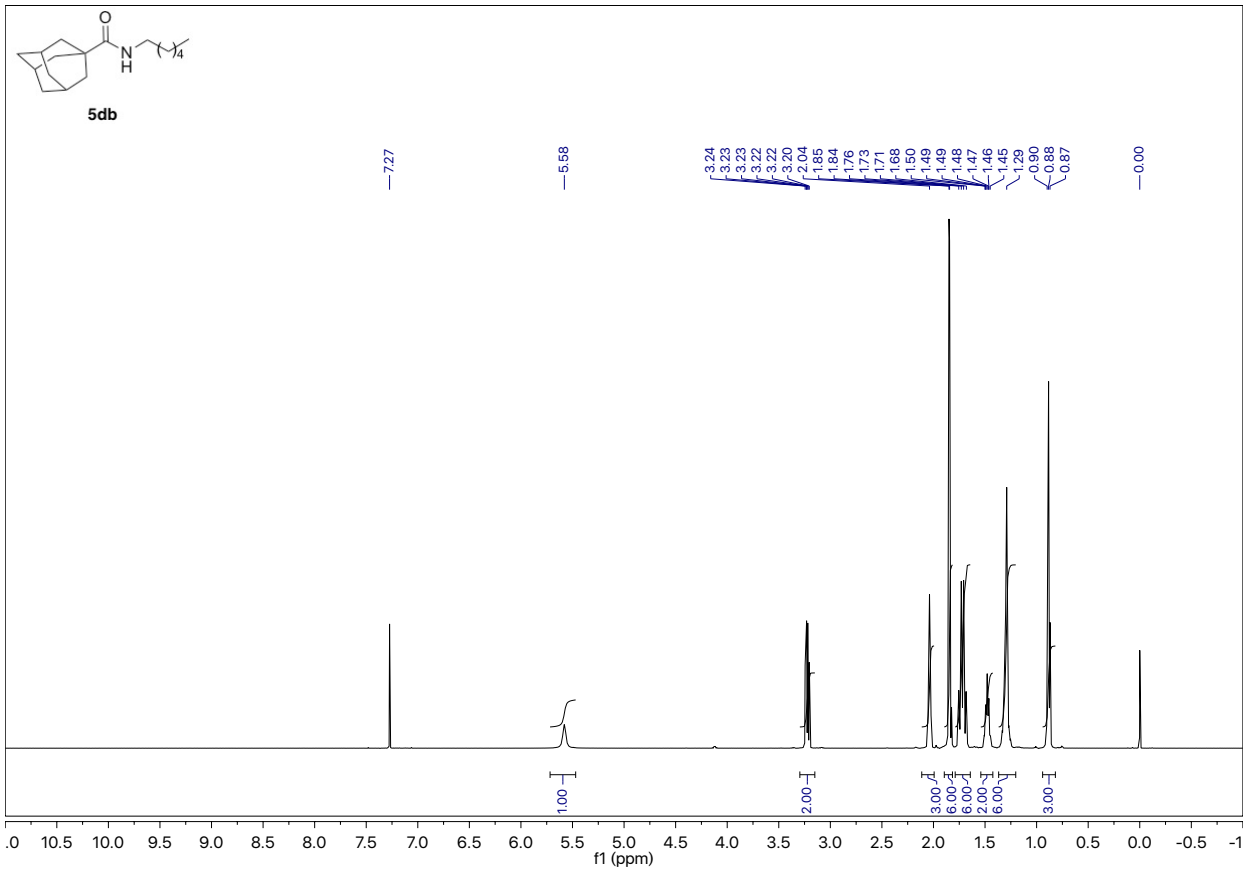
^{1}H NMR (500 MHz, $CDCl_3$), Table 2



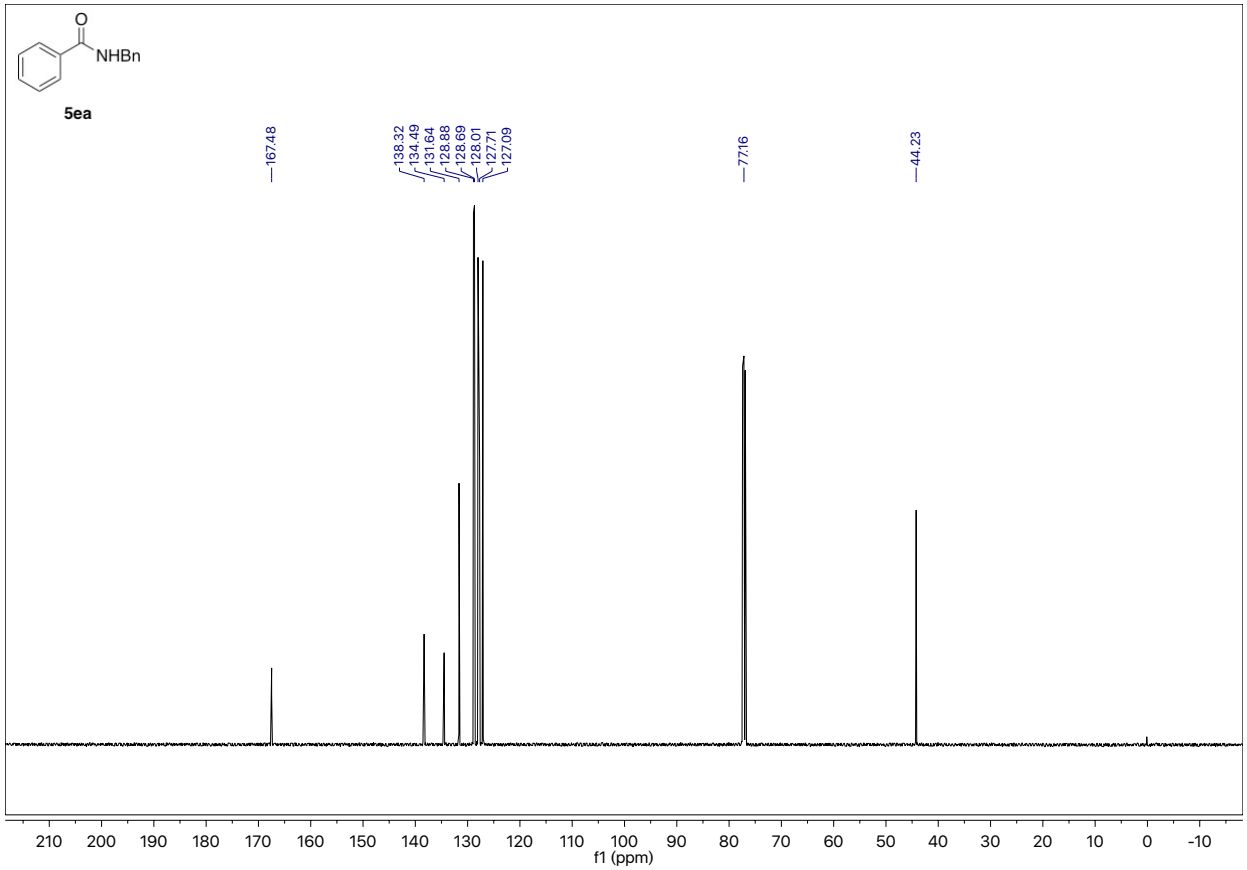
^{13}C NMR (126 MHz, $CDCl_3$), entry 3 in Table 2



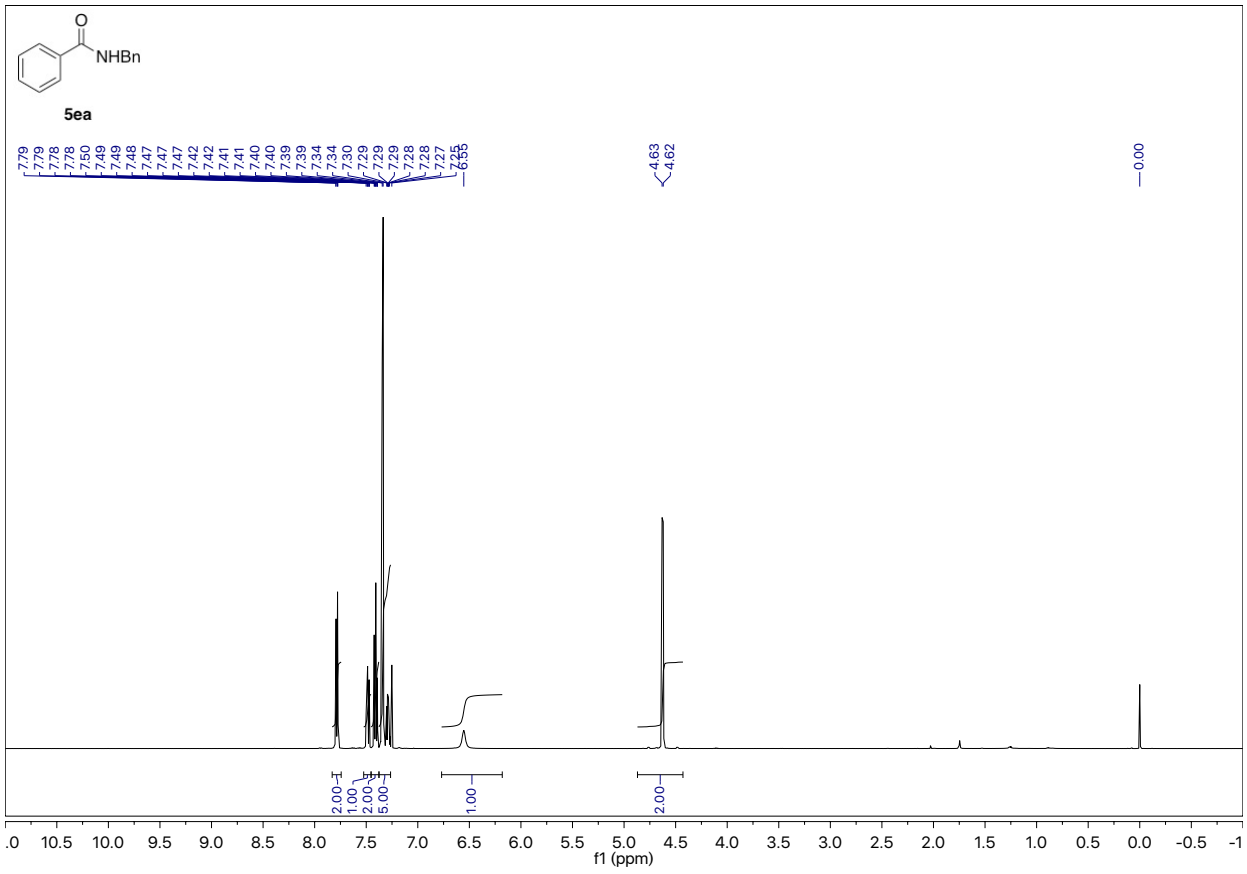
^{1}H NMR (500 MHz, $CDCl_3$), Table 2



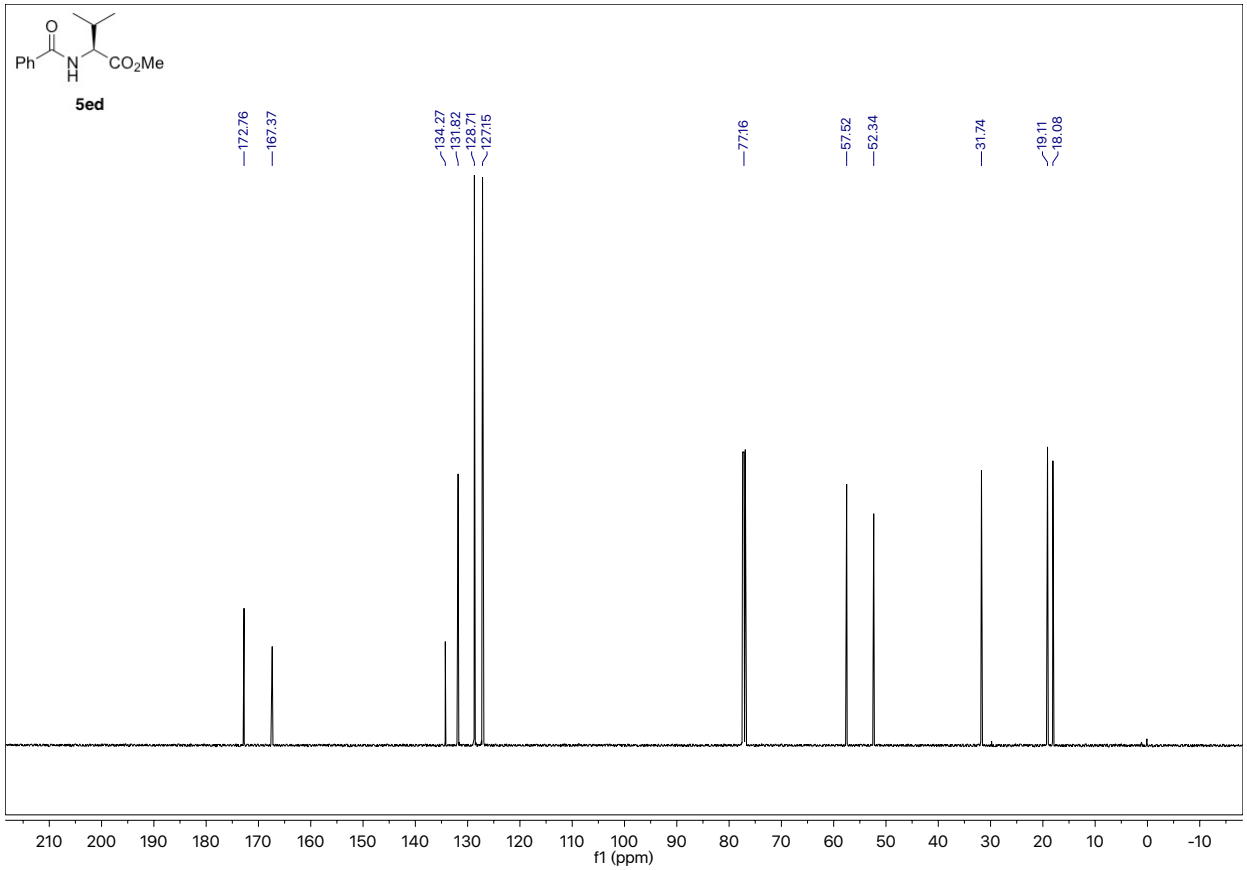
^{13}C NMR (126 MHz, $CDCl_3$), Table 2



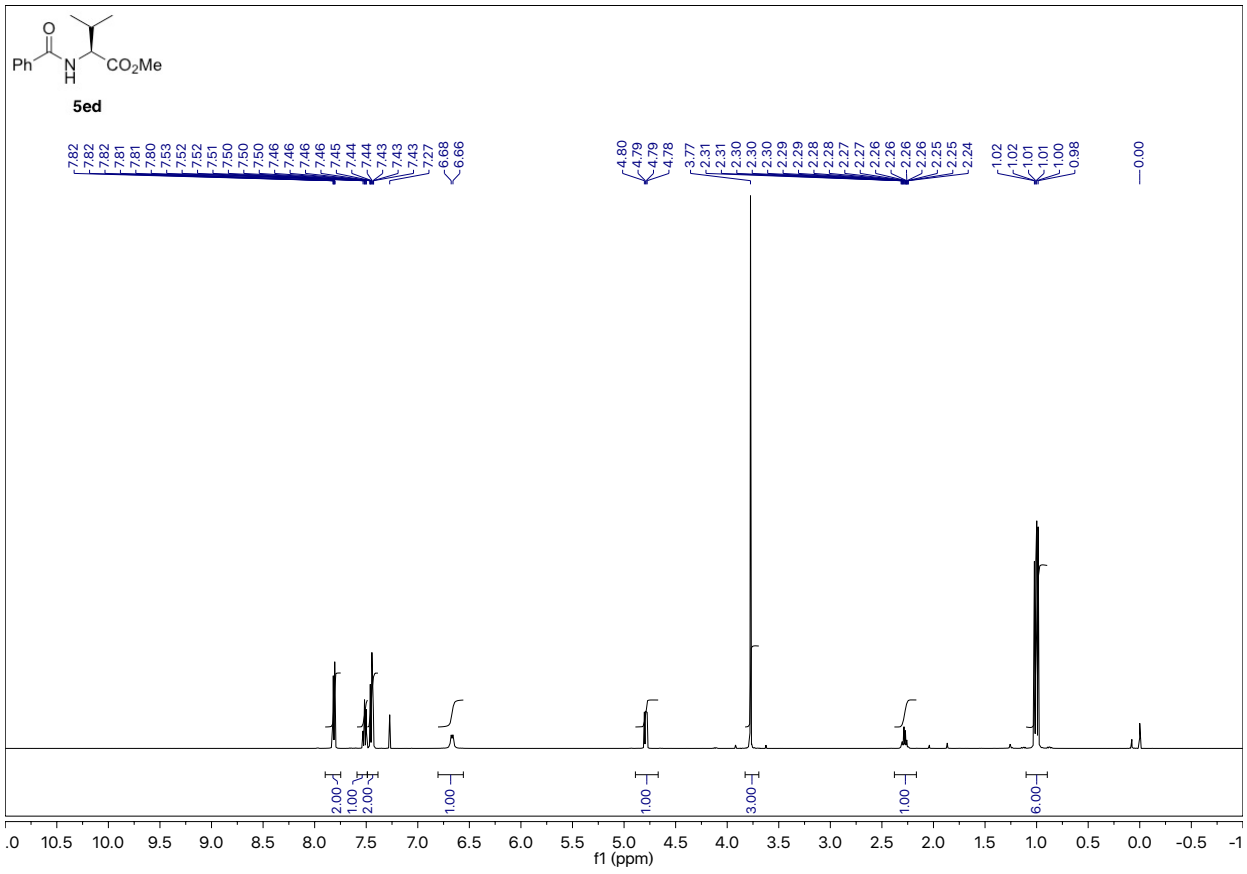
^{1}H NMR (500 MHz, $CDCl_3$), entry 4 in Table 2



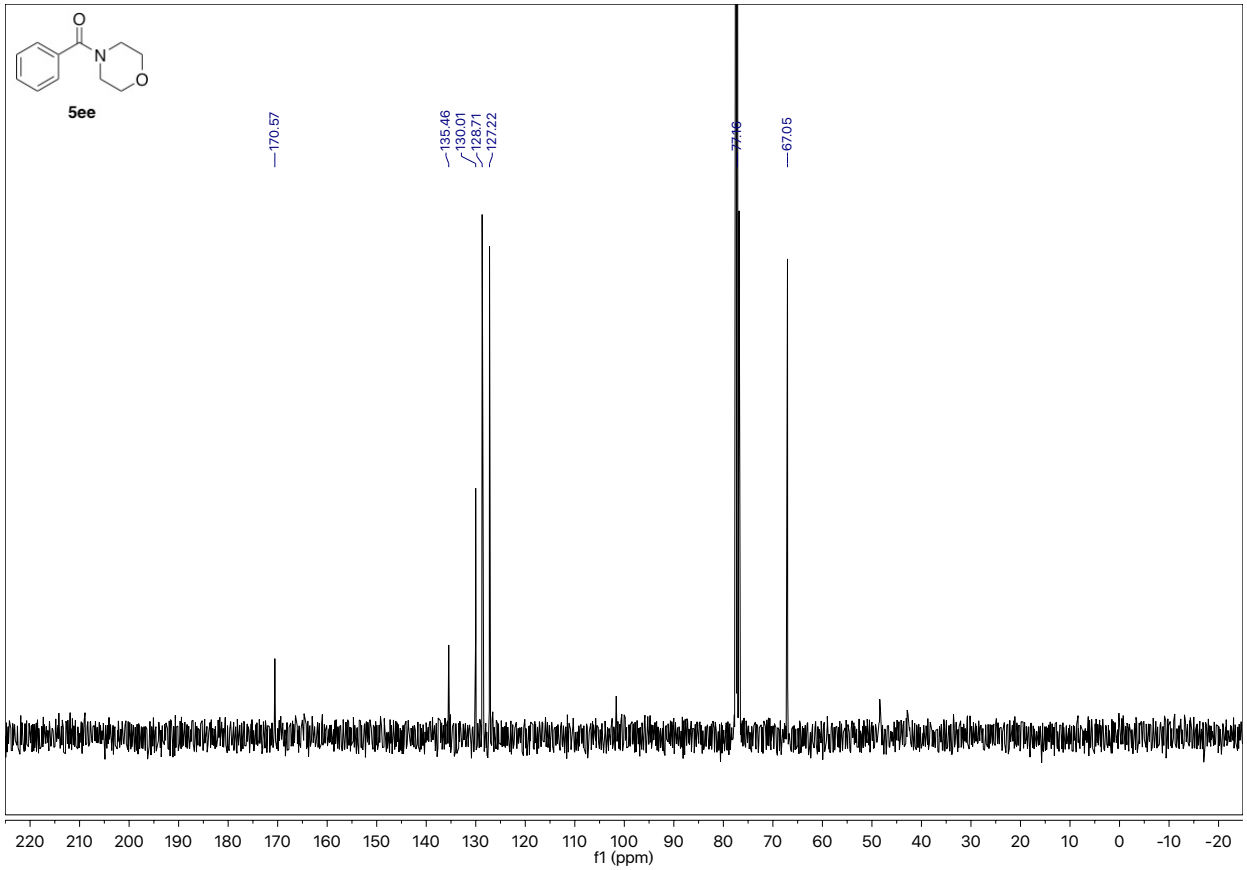
^{13}C NMR (126 MHz, $CDCl_3$), Table 2



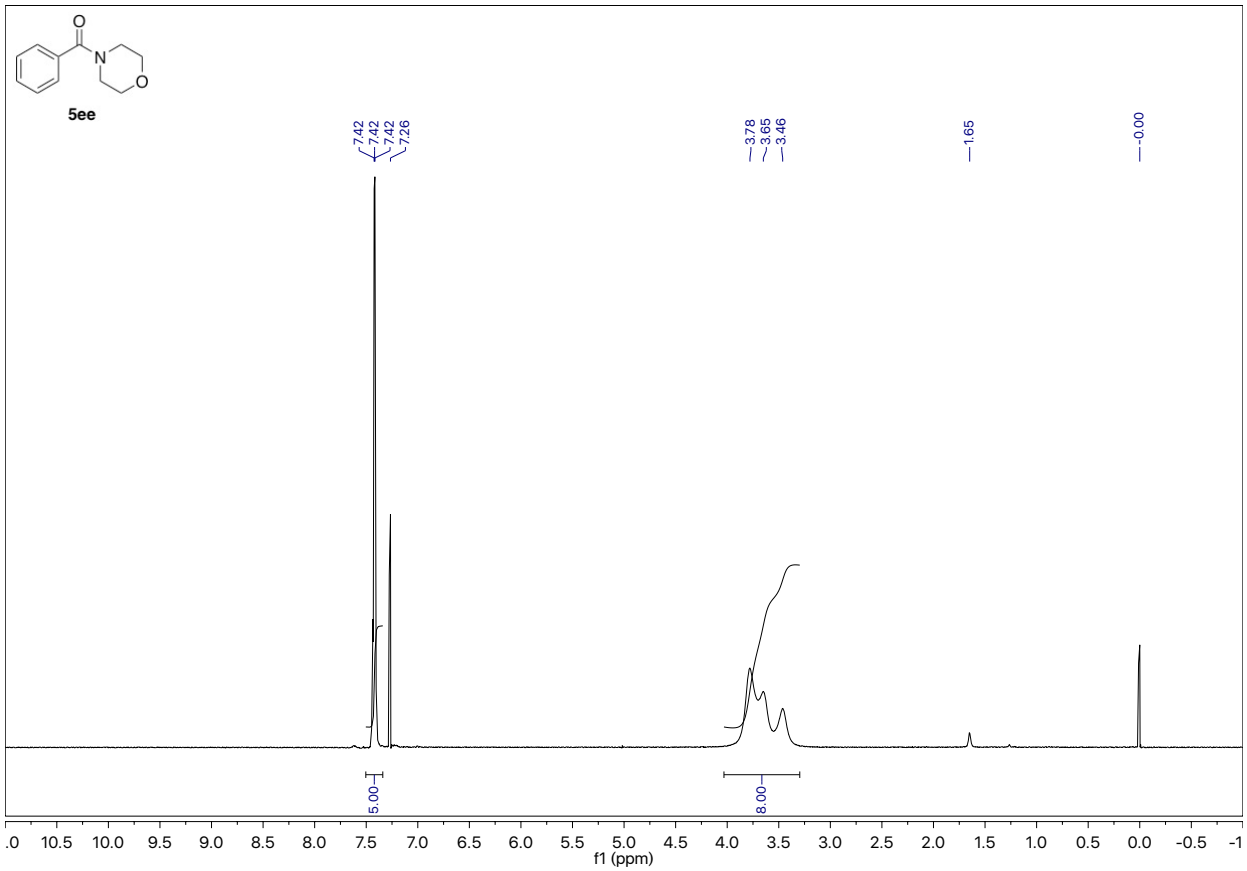
^{1}H NMR (500 MHz, $CDCl_3$), Table 2



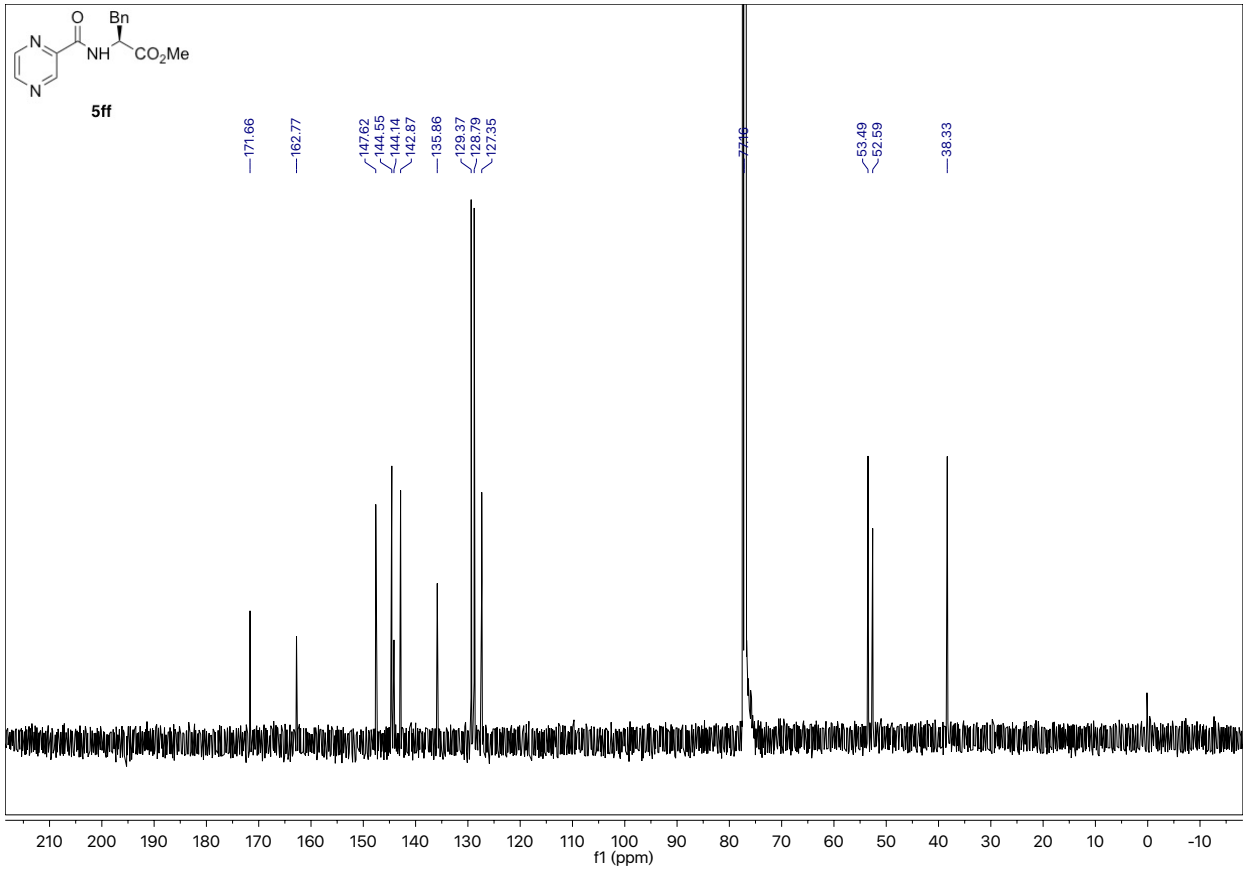
^{13}C NMR (126 MHz, $CDCl_3$), Table 2



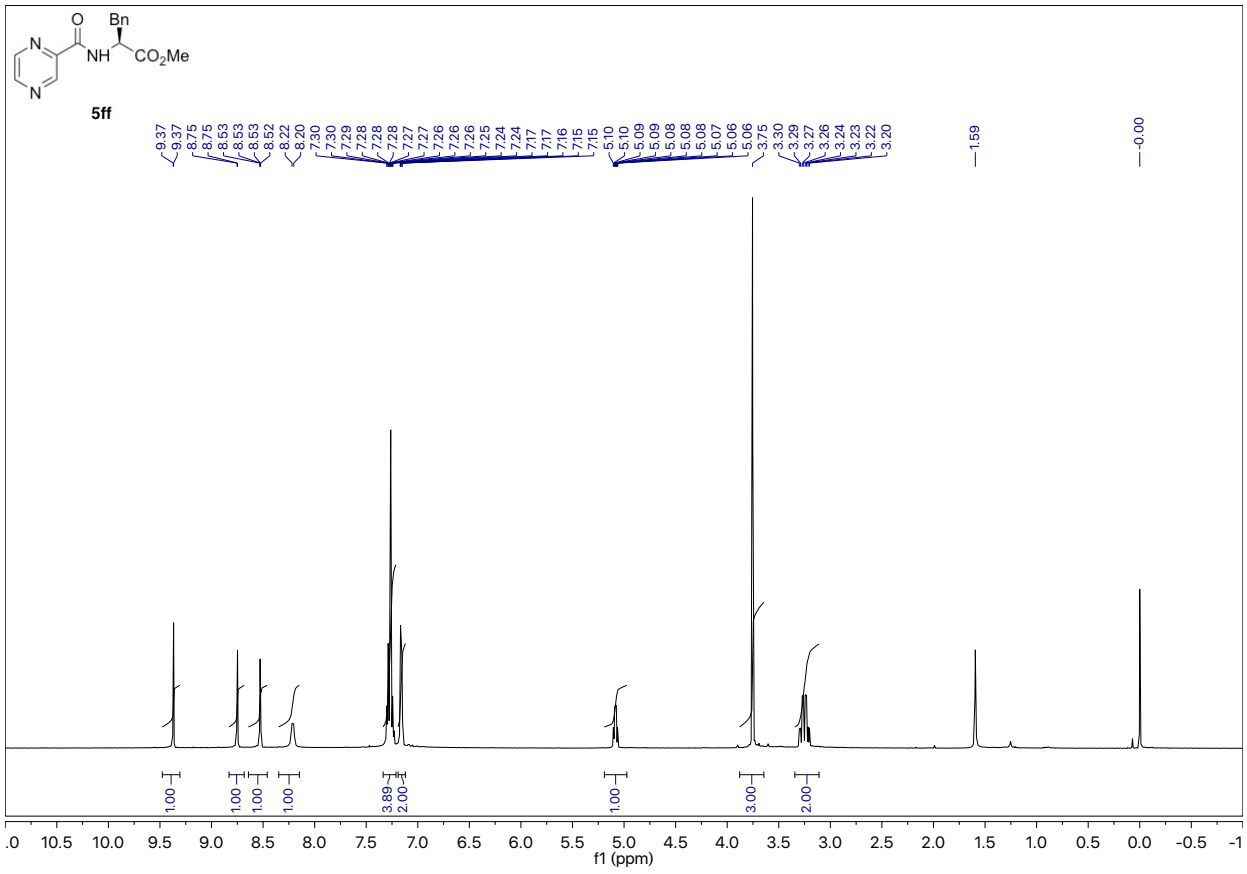
^{1}H NMR (500 MHz, $CDCl_3$), Table 2



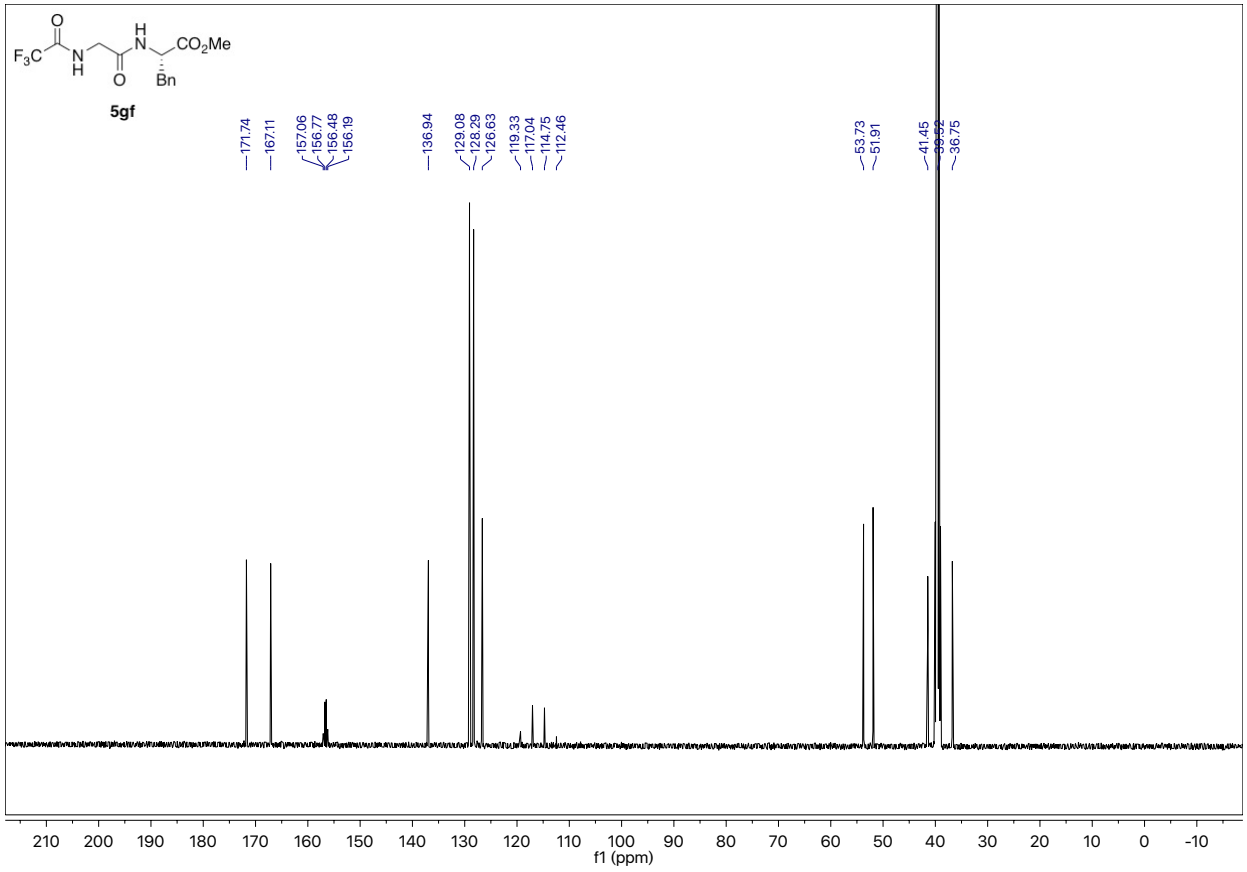
^{13}C NMR (126 MHz, $CDCl_3$), Table 2



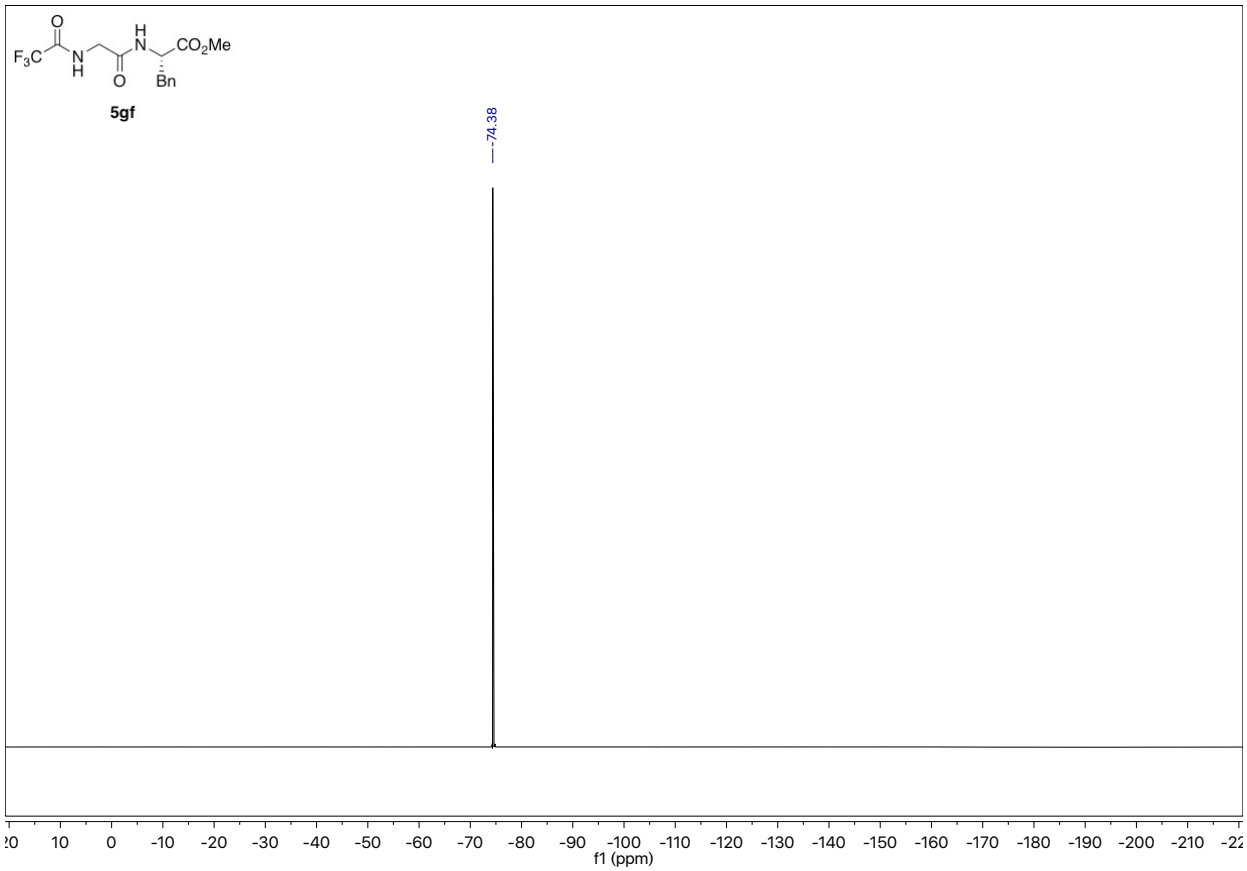
^{1}H NMR (500 MHz, $CDCl_3$), Table 2



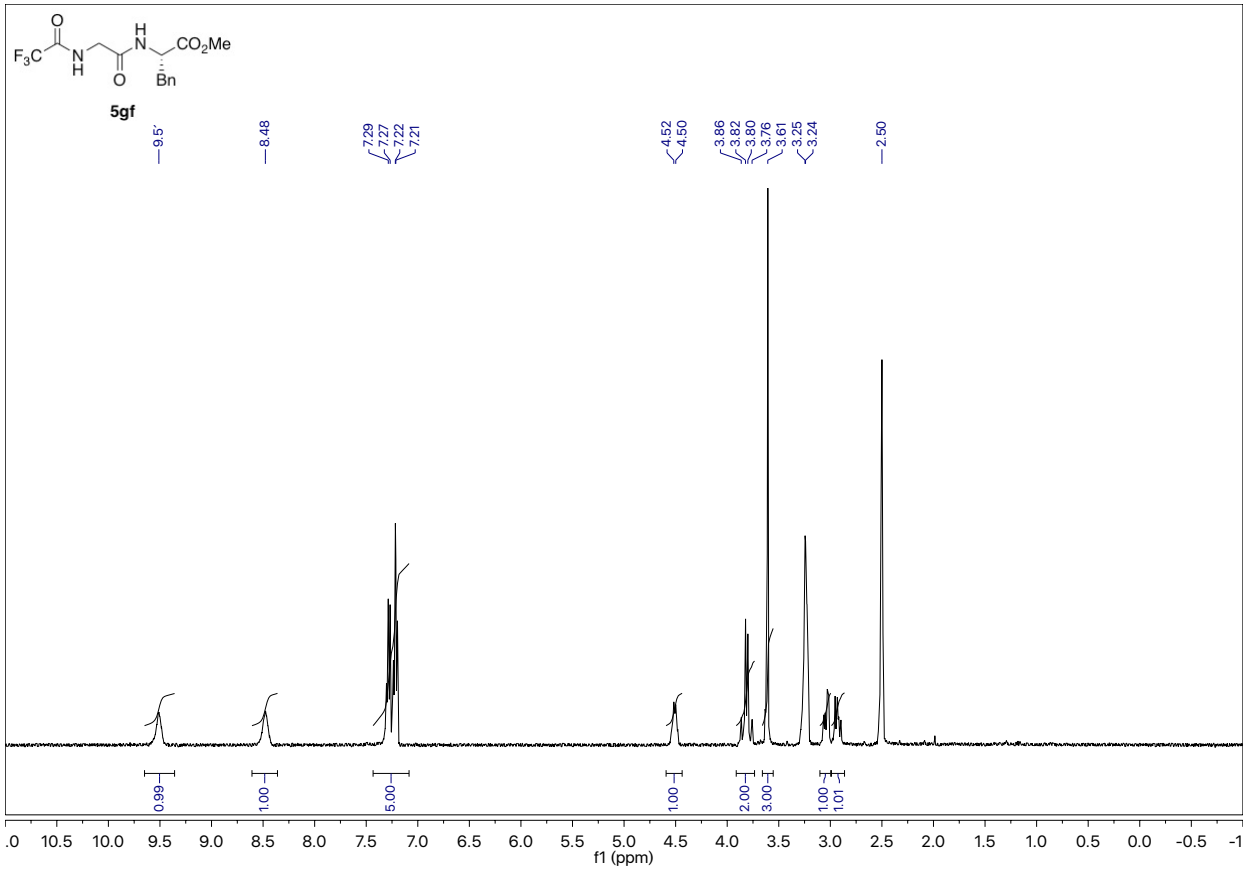
^{13}C NMR (126 MHz, DMSO-d_6) in Table 3



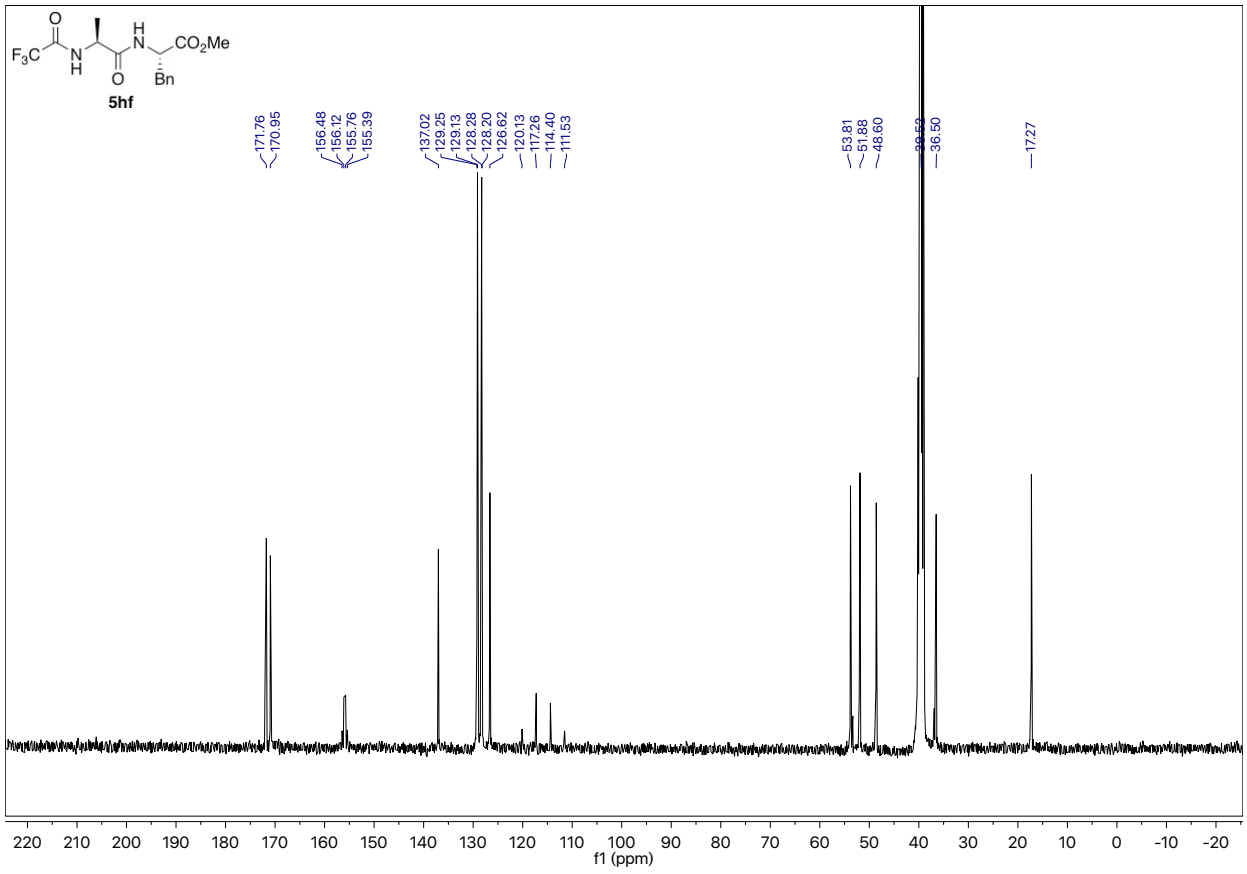
^{19}F NMR (470 MHz, DMSO-d_6) in Table 3



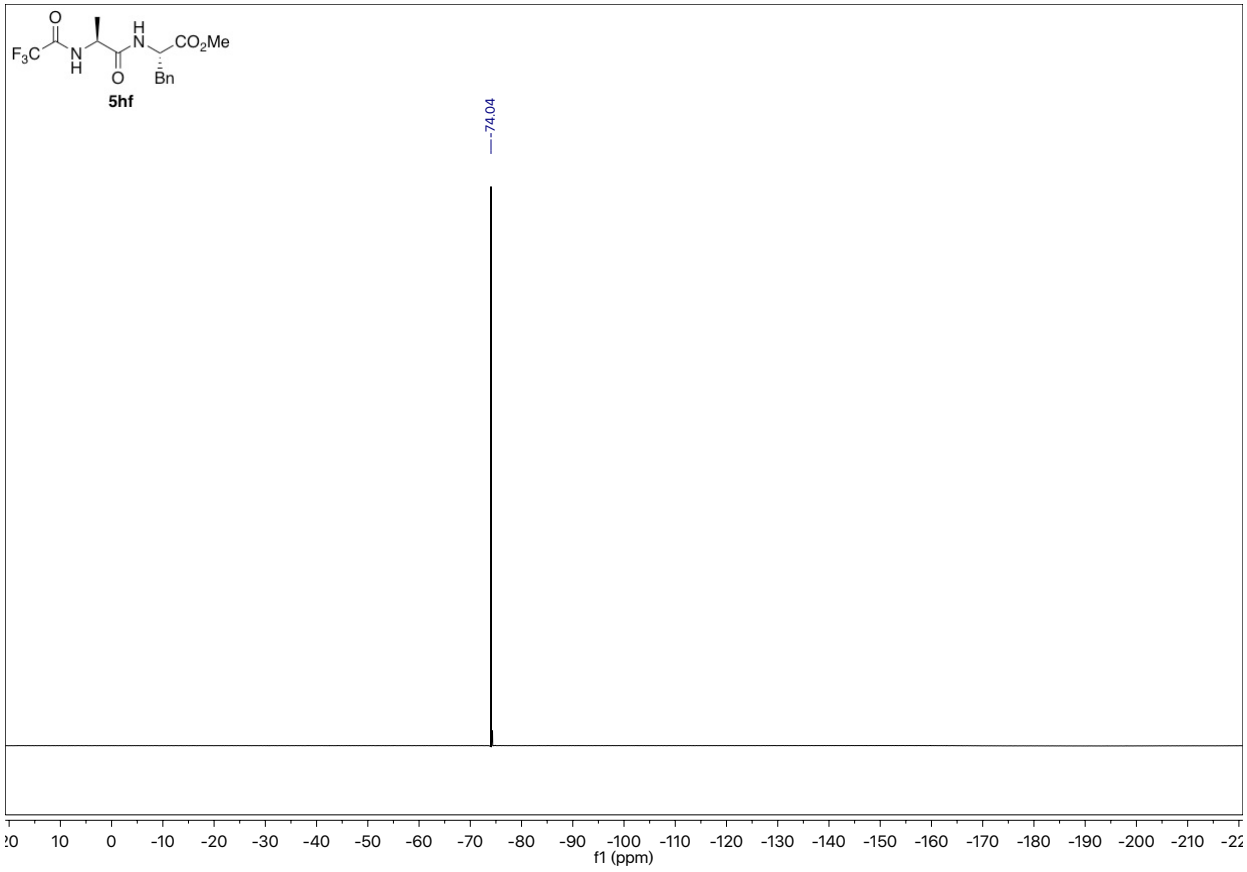
^{1}H NMR (400 MHz, DMSO-d_6) in Table 3



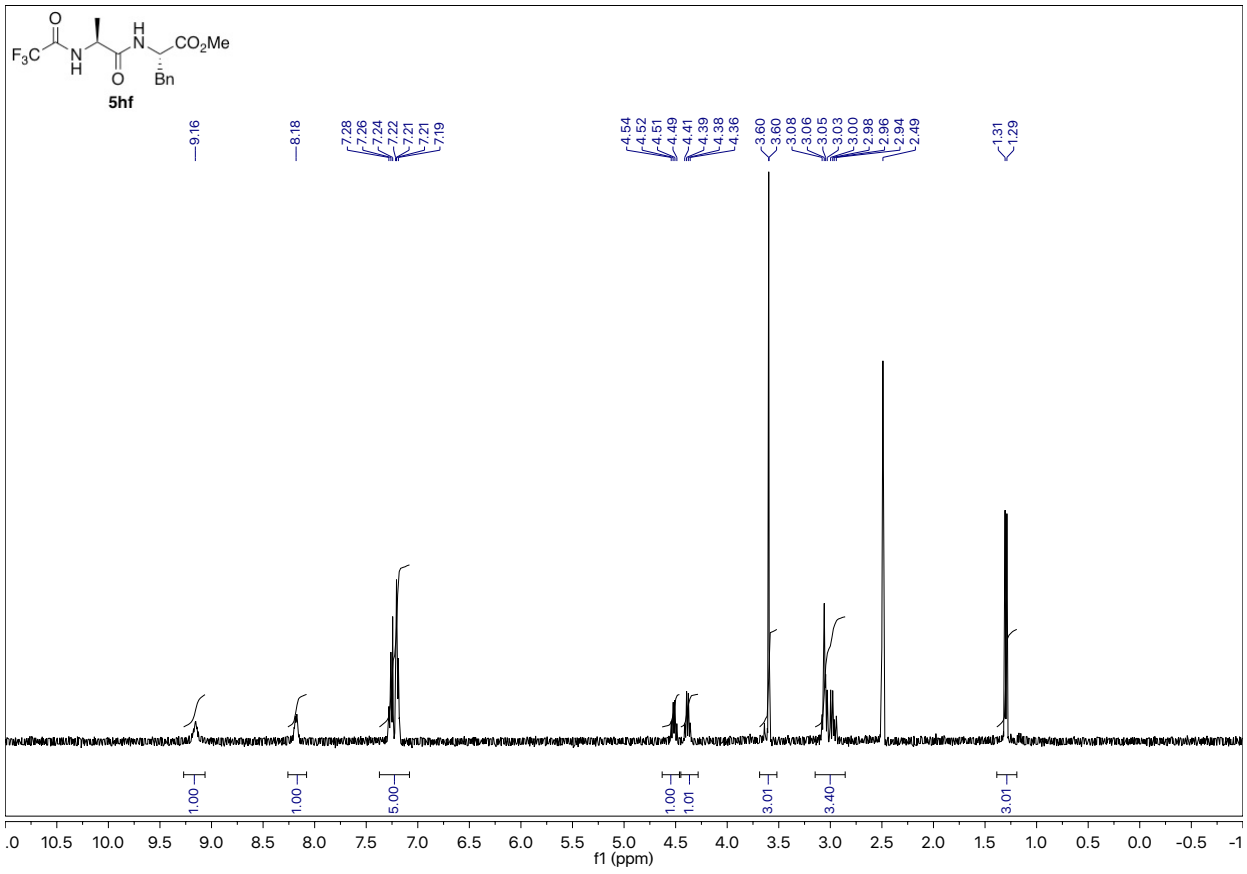
^{13}C NMR (101 MHz, DMSO-d_6) in Table 3



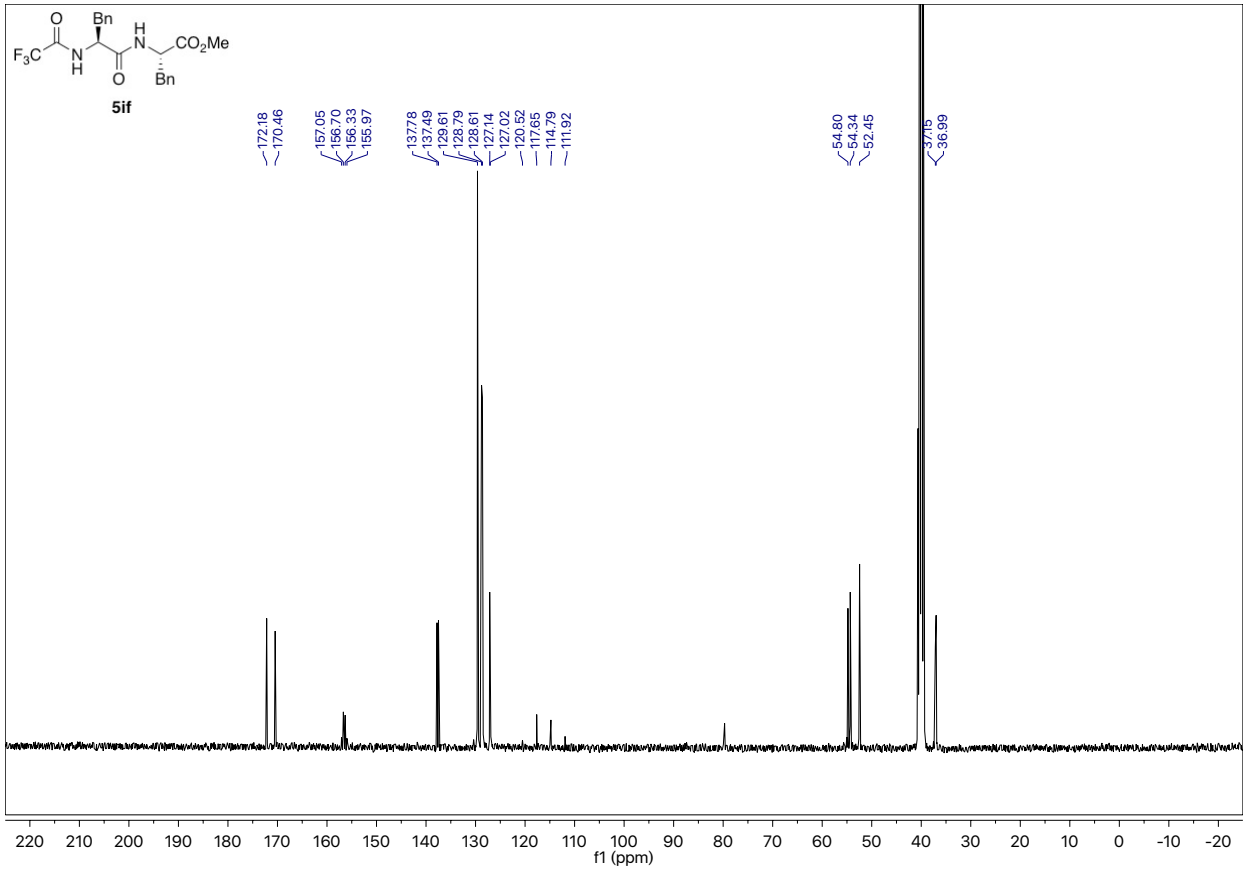
^{19}F NMR (470 MHz, DMSO-d_6) in Table 3



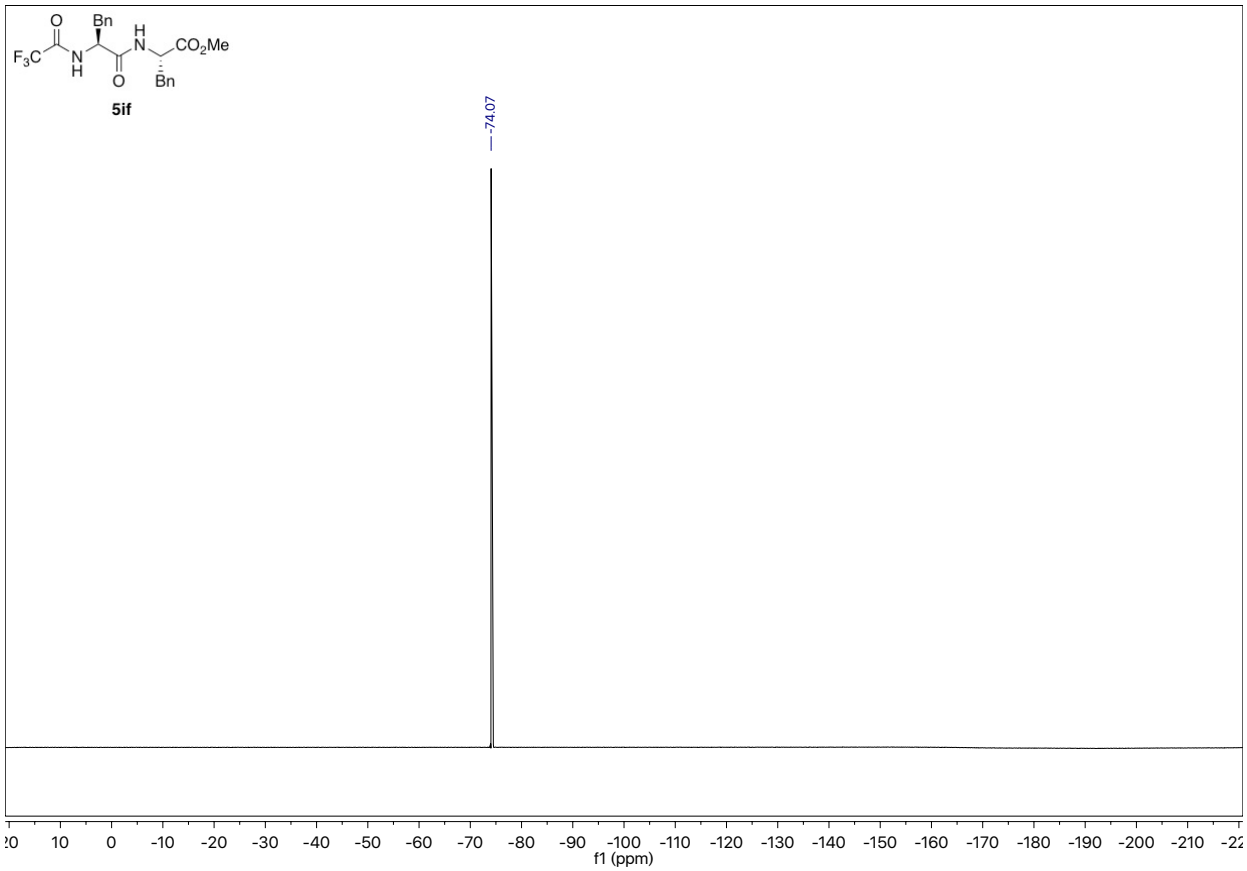
^{1}H NMR (400 MHz, DMSO-d_6) in Table 3



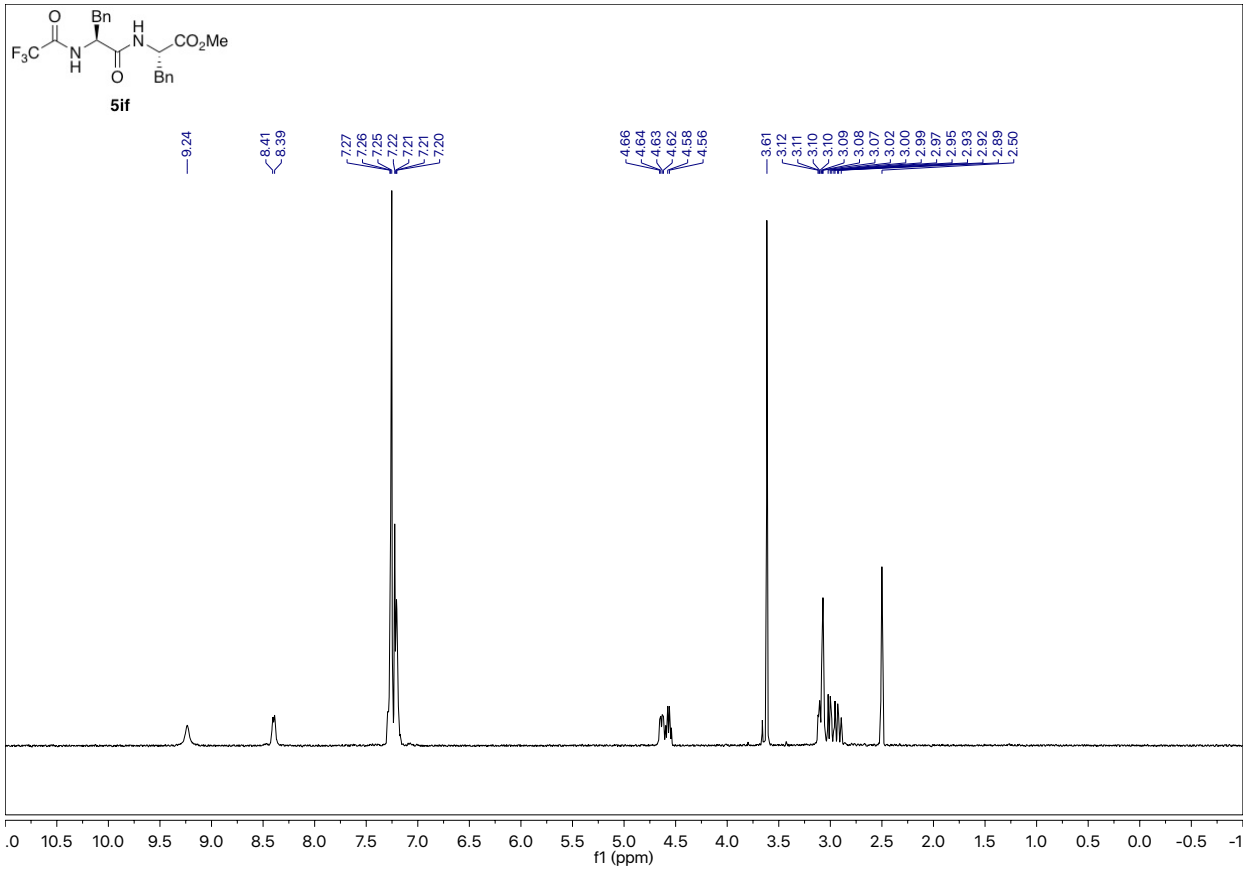
^{13}C NMR (101 MHz, DMSO-d_6) in Table 3



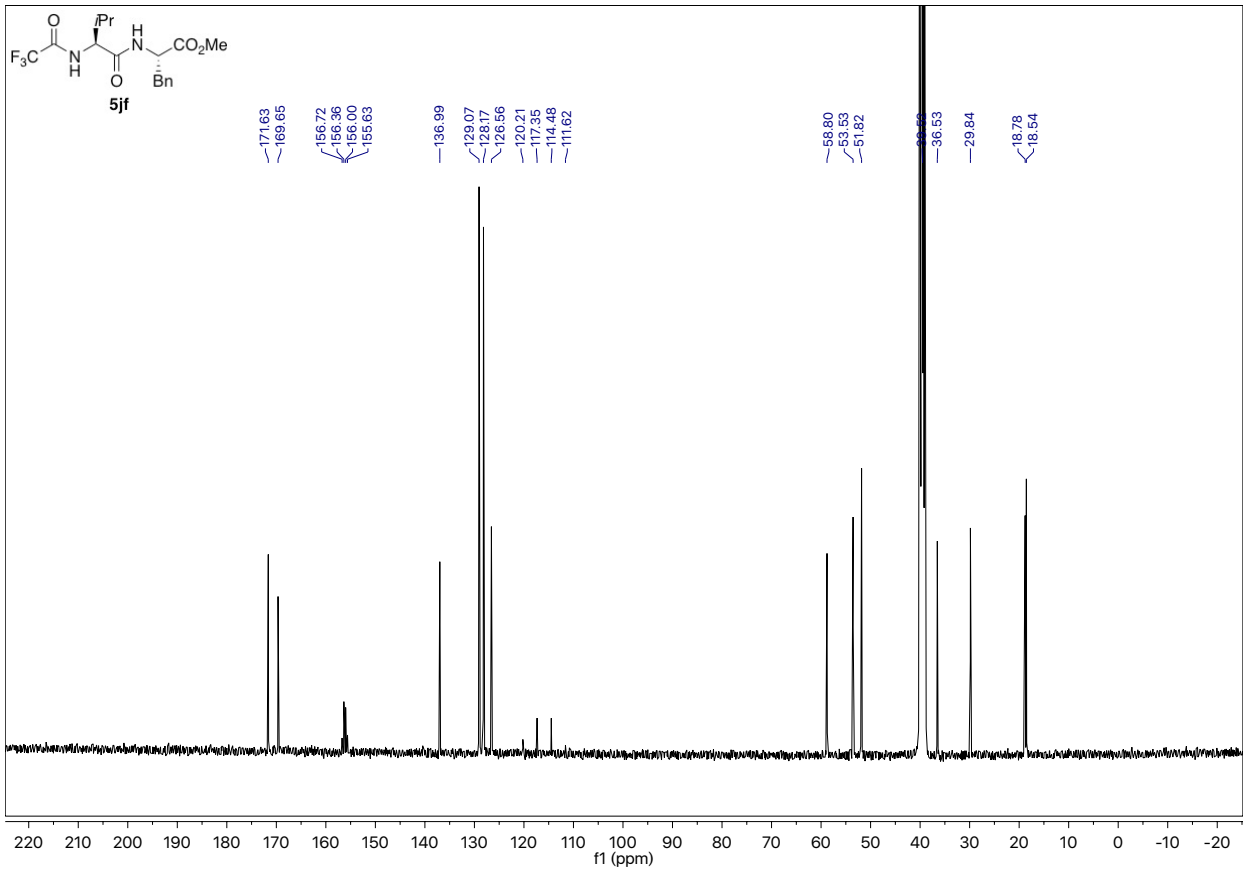
^{19}F NMR (470 MHz, DMSO-d_6) in Table 3



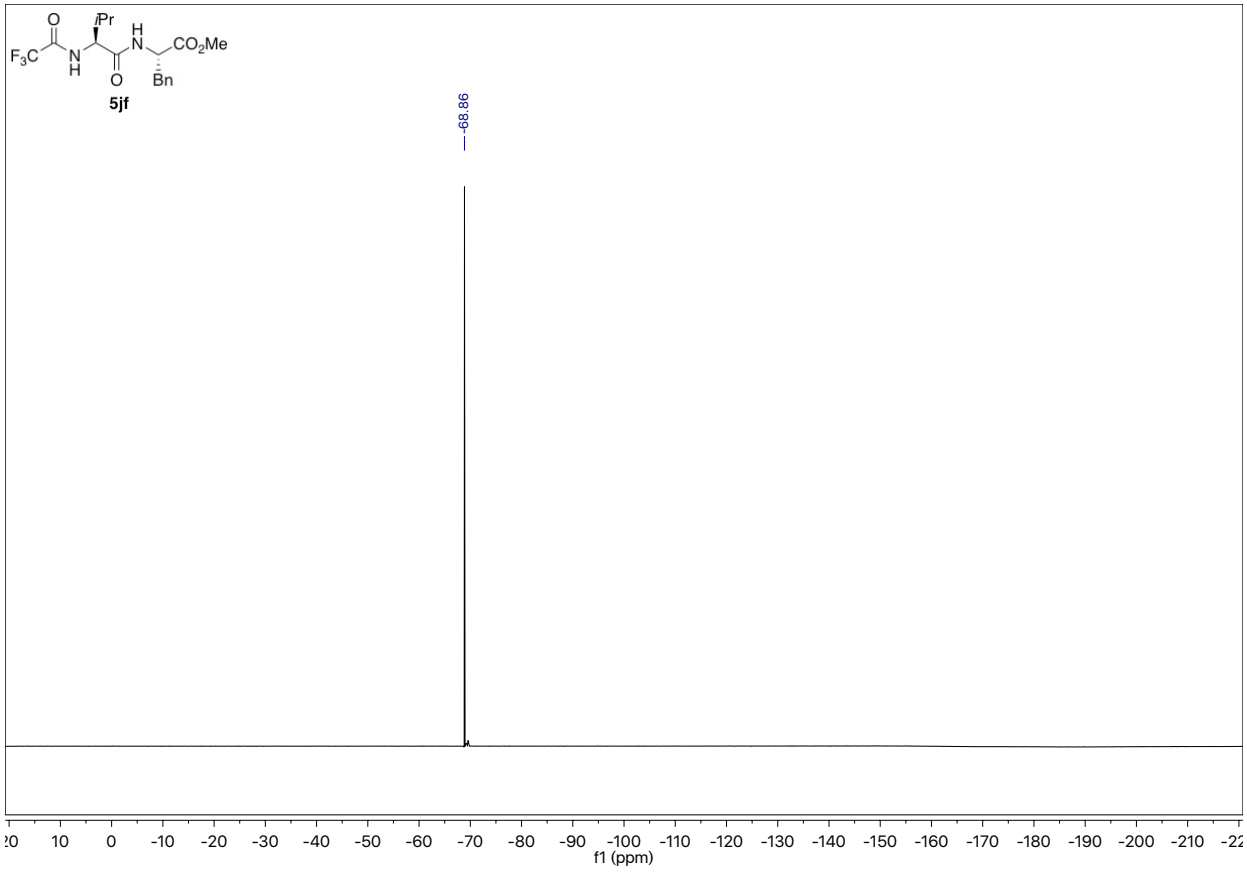
^{1}H NMR (400 MHz, DMSO-d_6) in Table 3



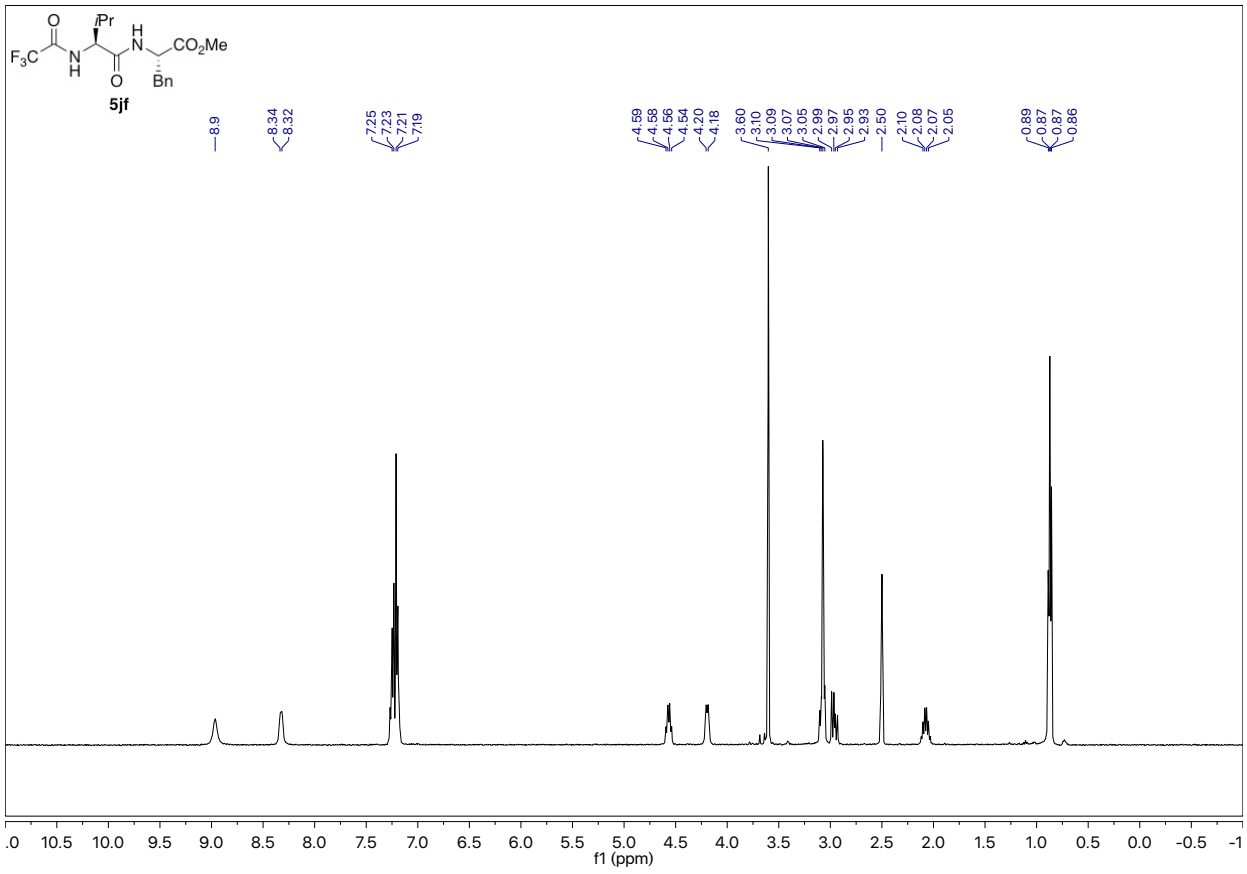
^{13}C NMR (101 MHz, DMSO-d_6) in Table 3



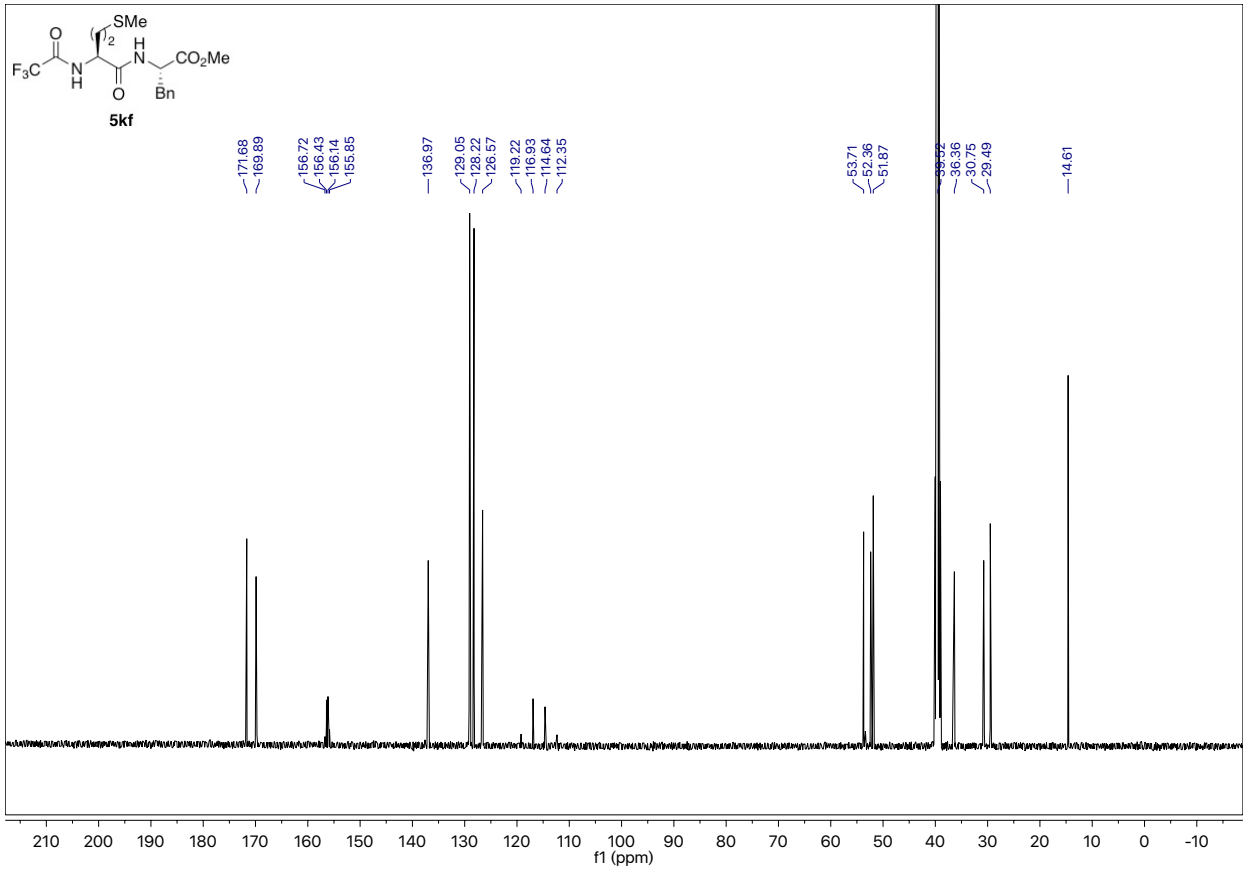
^{19}F NMR (470 MHz, DMSO-d_6) in Table 3



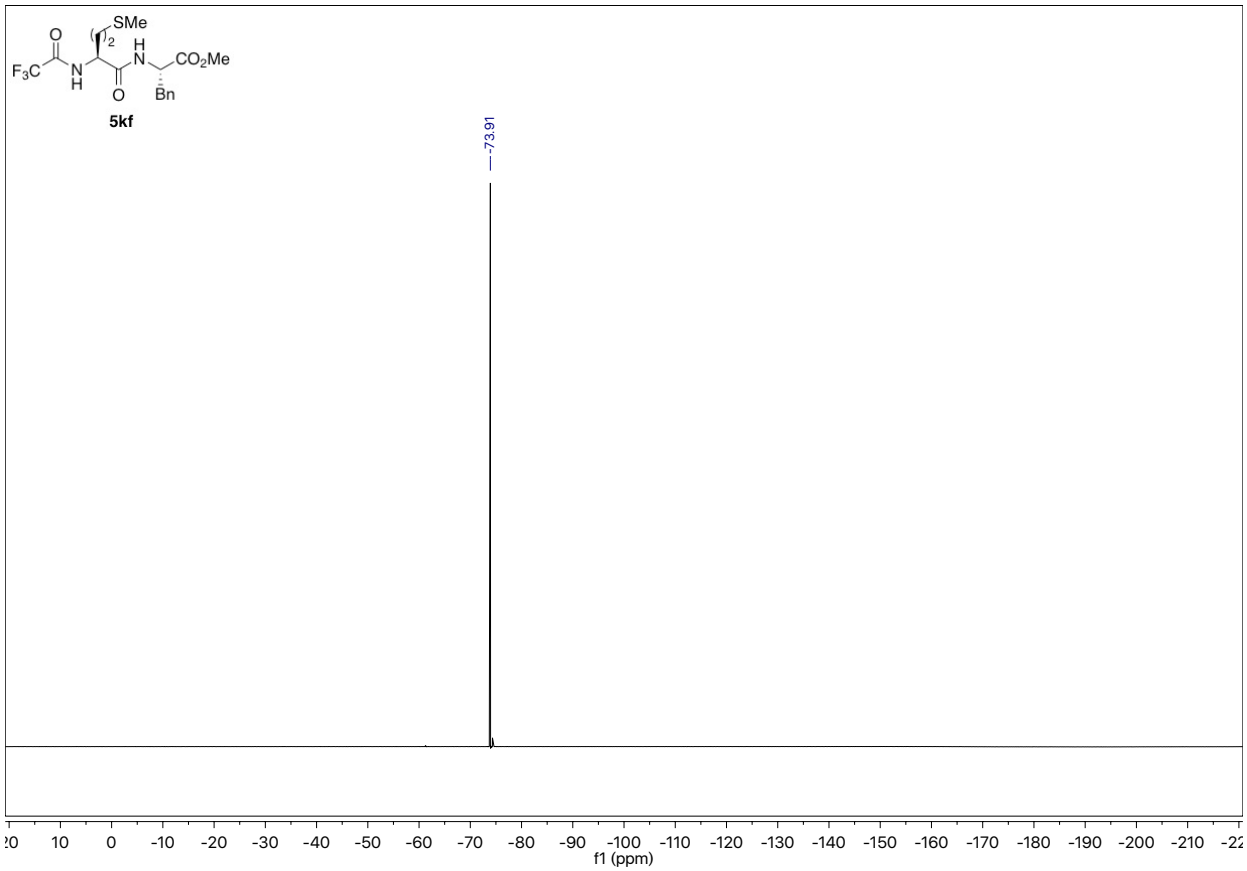
^{1}H NMR (400 MHz, DMSO-d_6) in Table 3



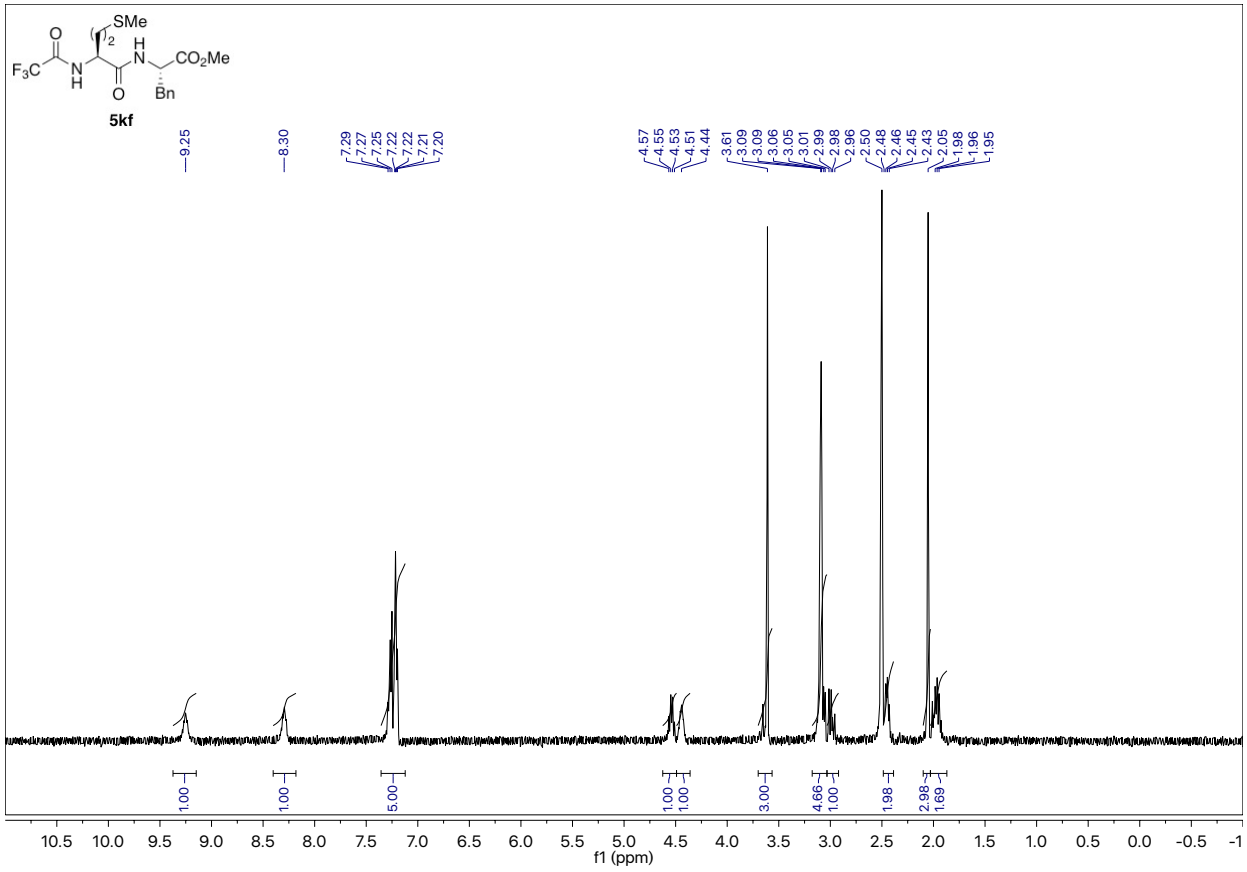
^{13}C NMR (126 MHz, DMSO-d_6) in Table 3



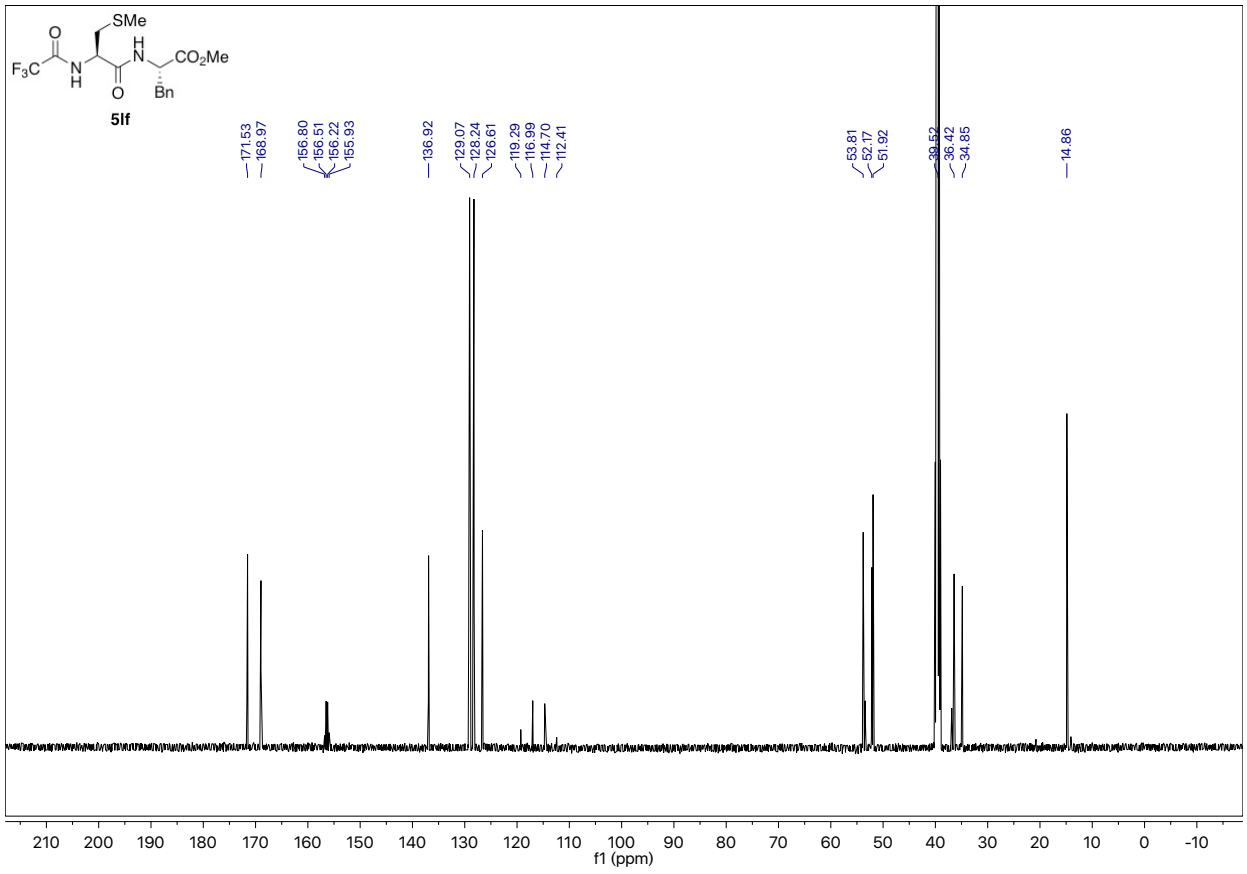
^{19}F NMR (470 MHz, DMSO-d_6) in Table 3



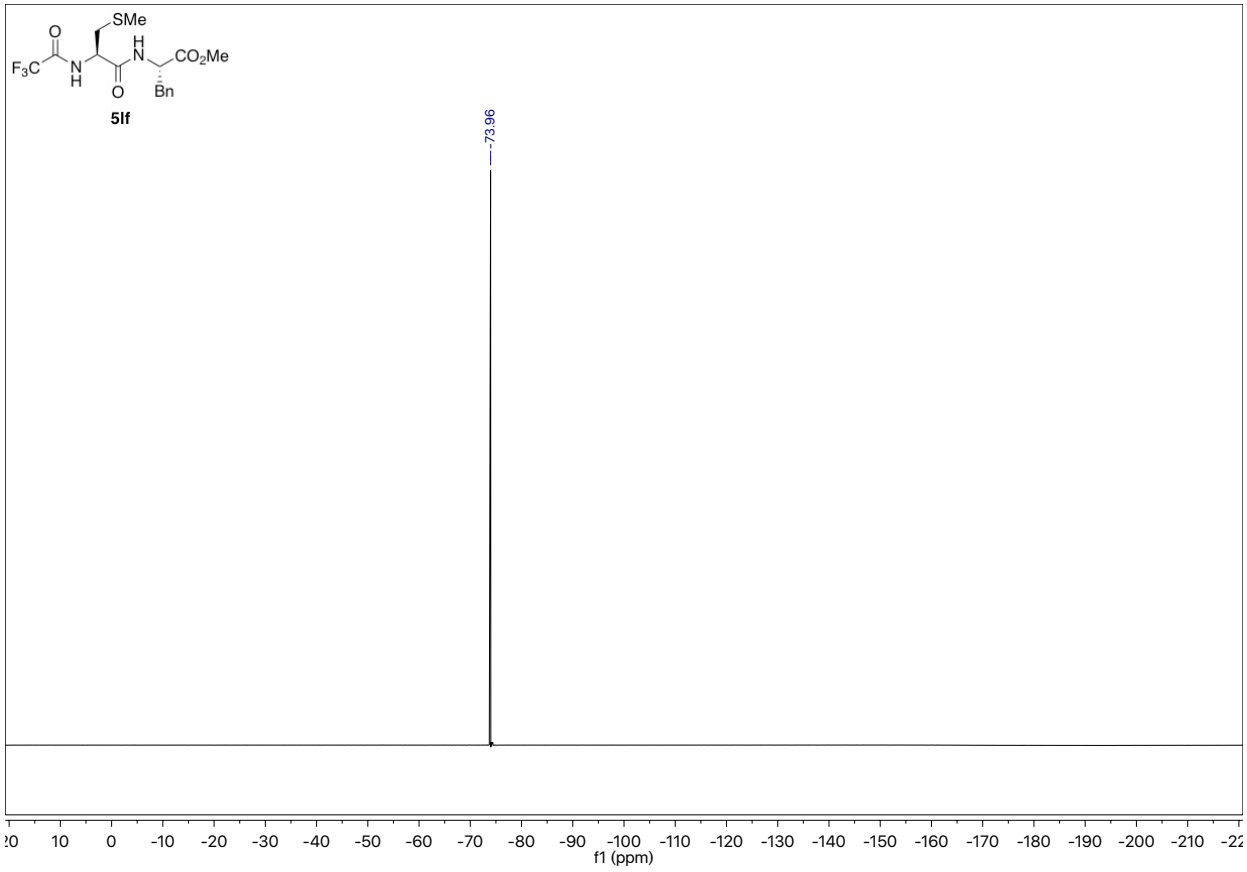
^{1}H NMR (400 MHz, DMSO-d_6) in Table 3



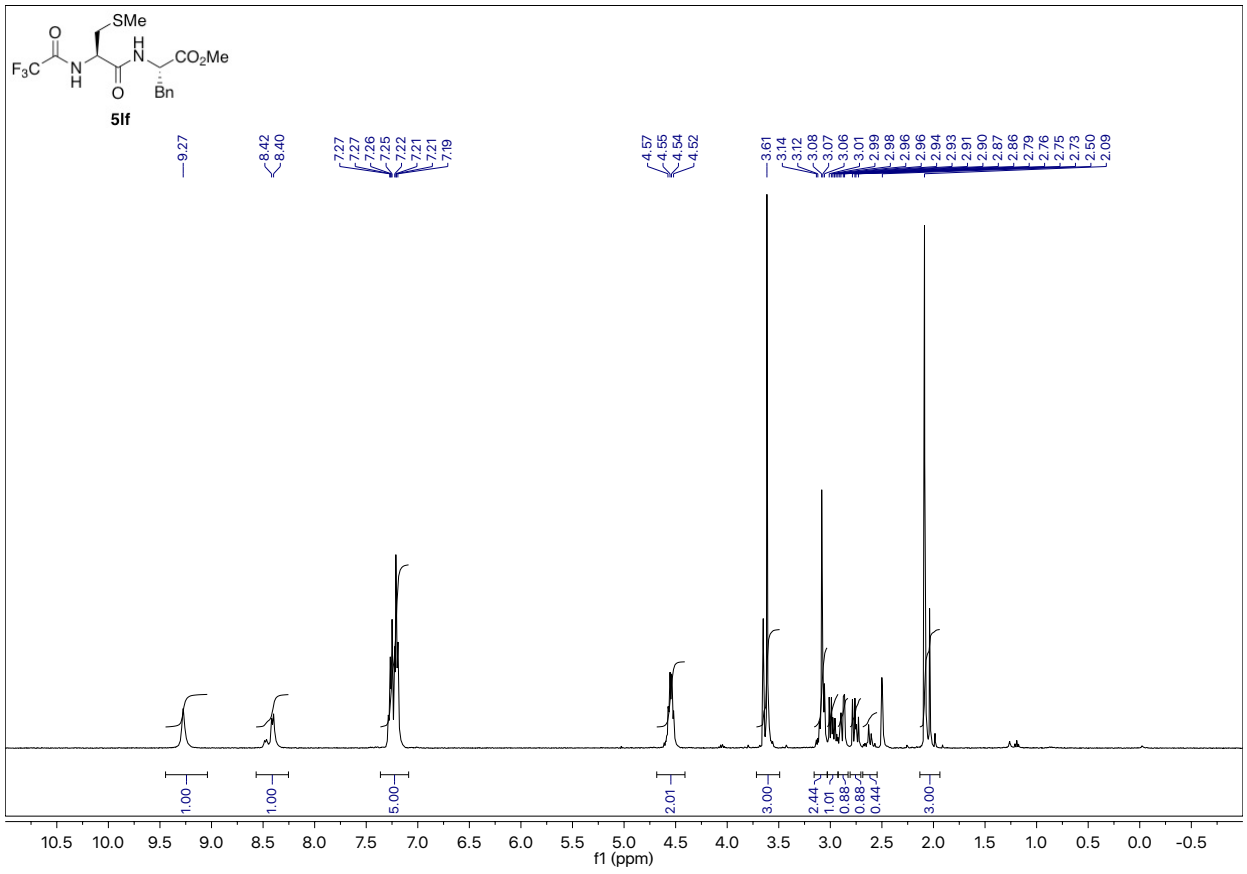
^{13}C NMR (126 MHz, DMSO-d_6) in Table 3



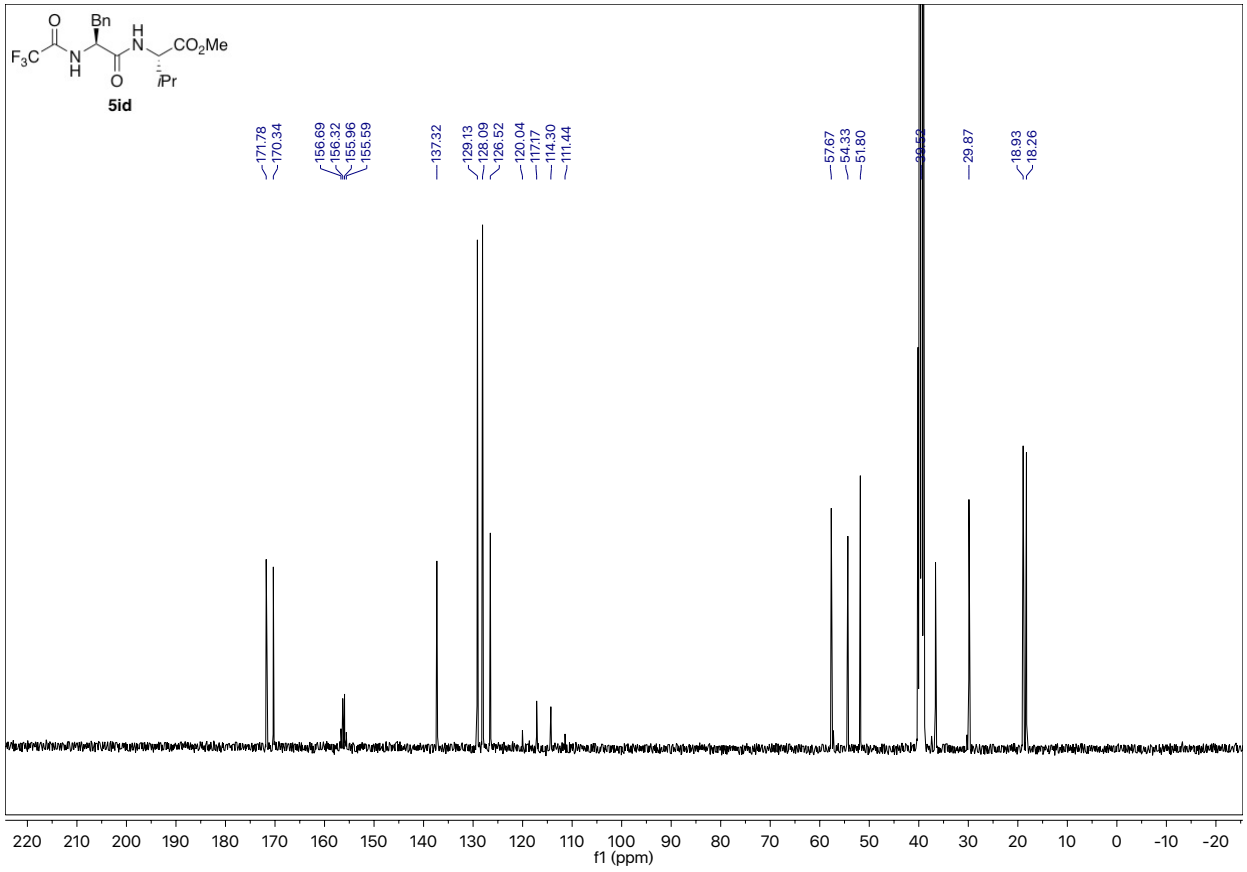
^{19}F NMR (470 MHz, DMSO-d_6) in Table 3



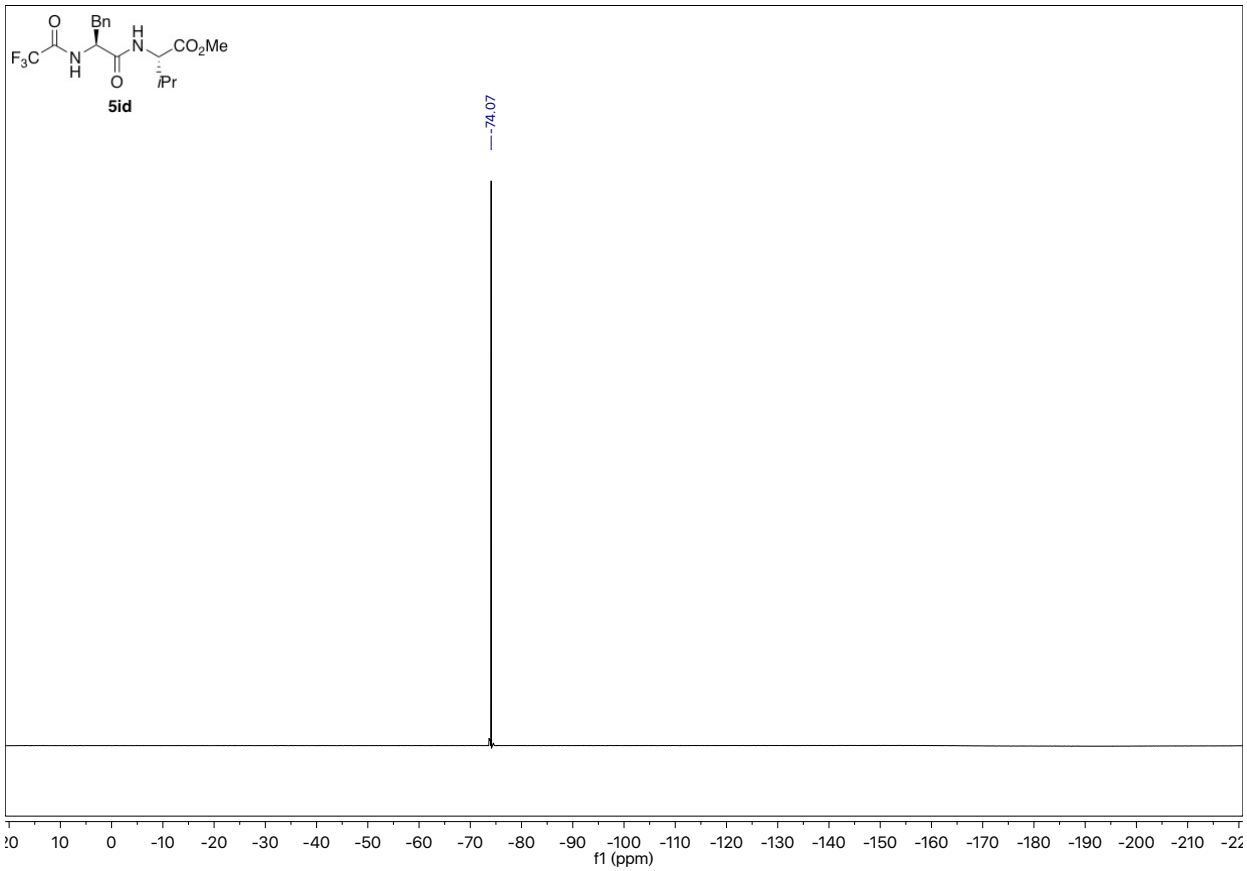
^{1}H NMR (400 MHz, DMSO-d_6) in Table 3



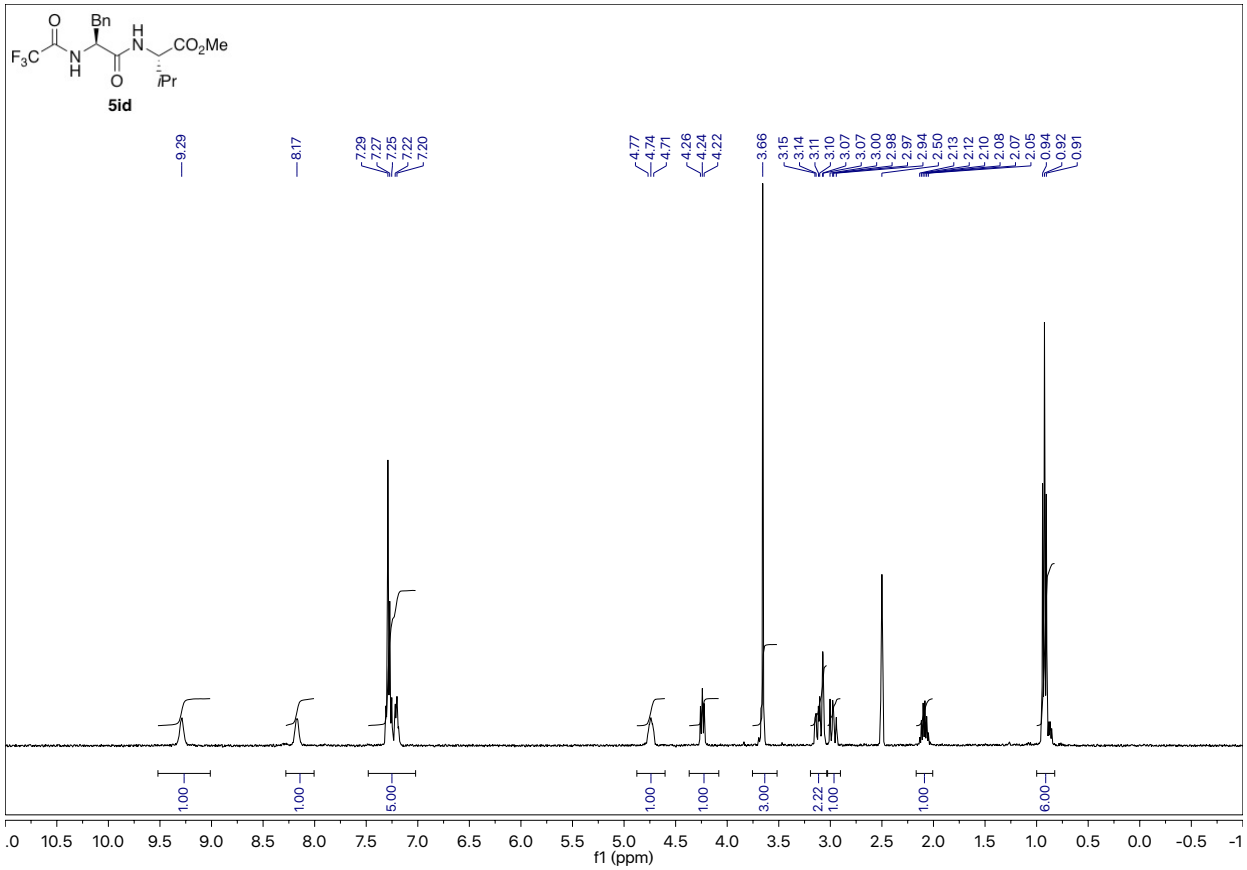
^{13}C NMR (101 MHz, DMSO-d_6) in Table 3



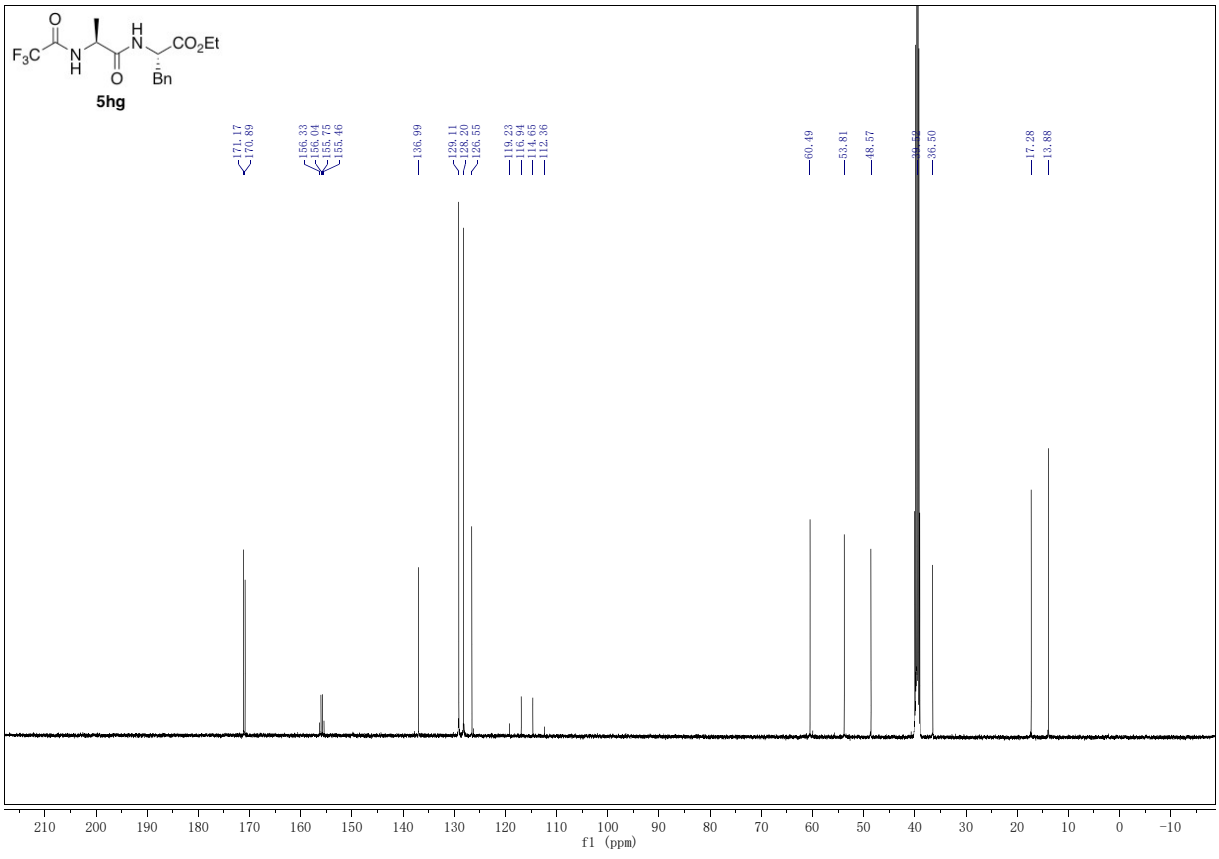
^{19}F NMR (470 MHz, DMSO-d_6) in Table 3



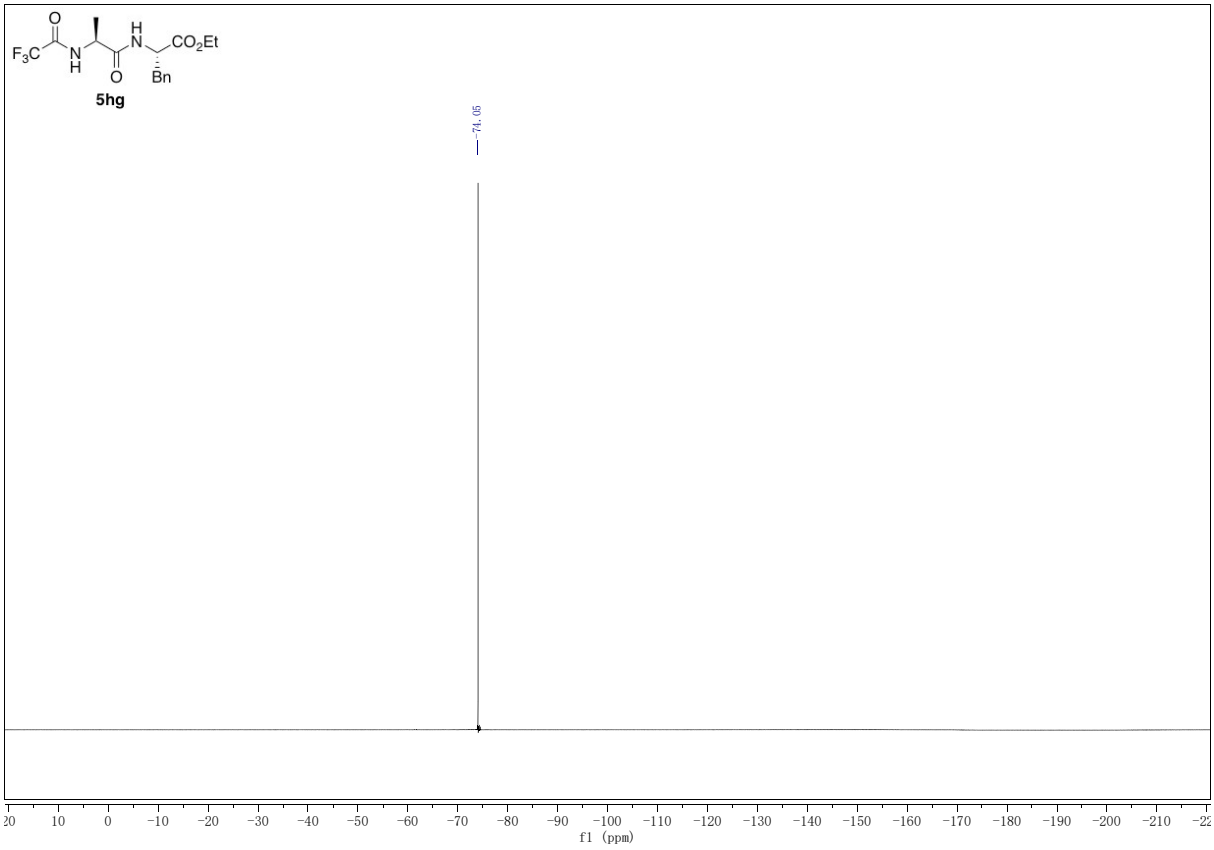
^{1}H NMR (400 MHz, DMSO-d_6) in Table 3



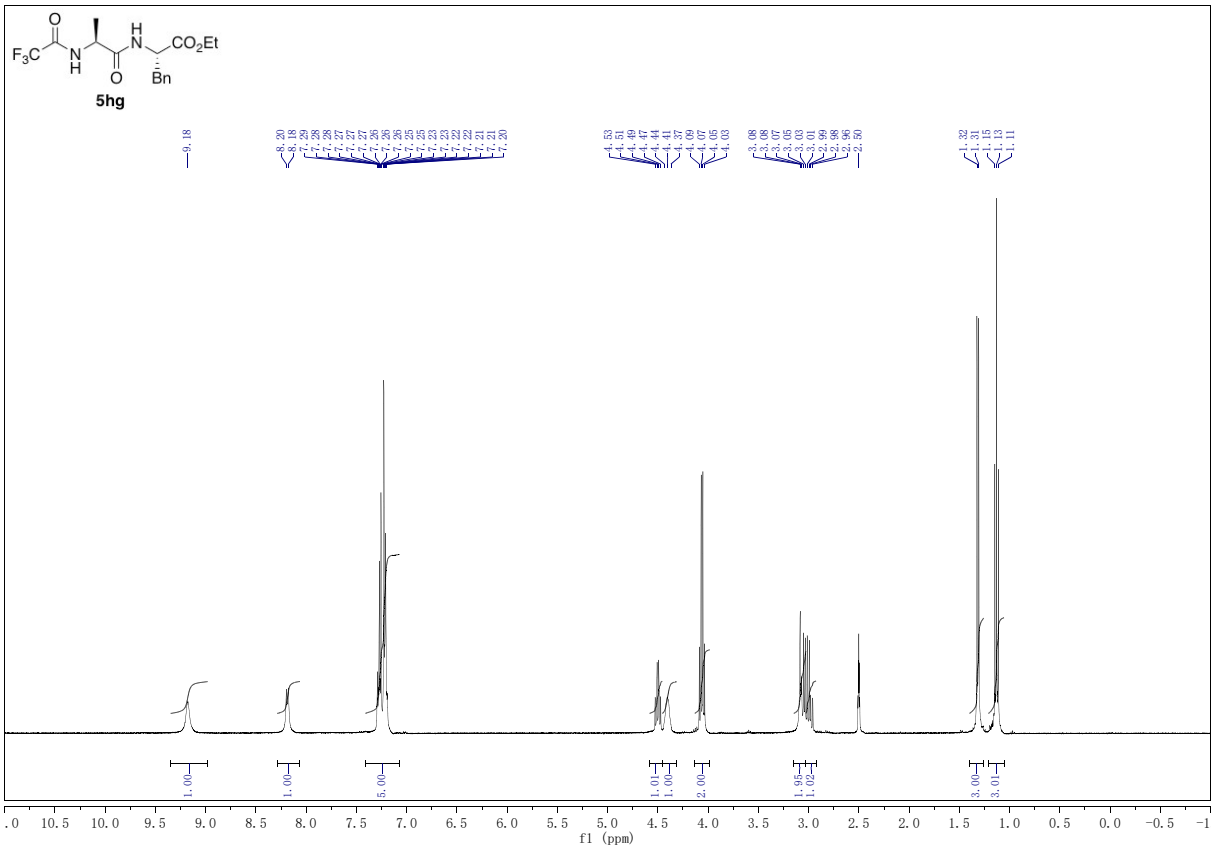
^{13}C NMR (126 MHz, DMSO-d_6) in Table 3



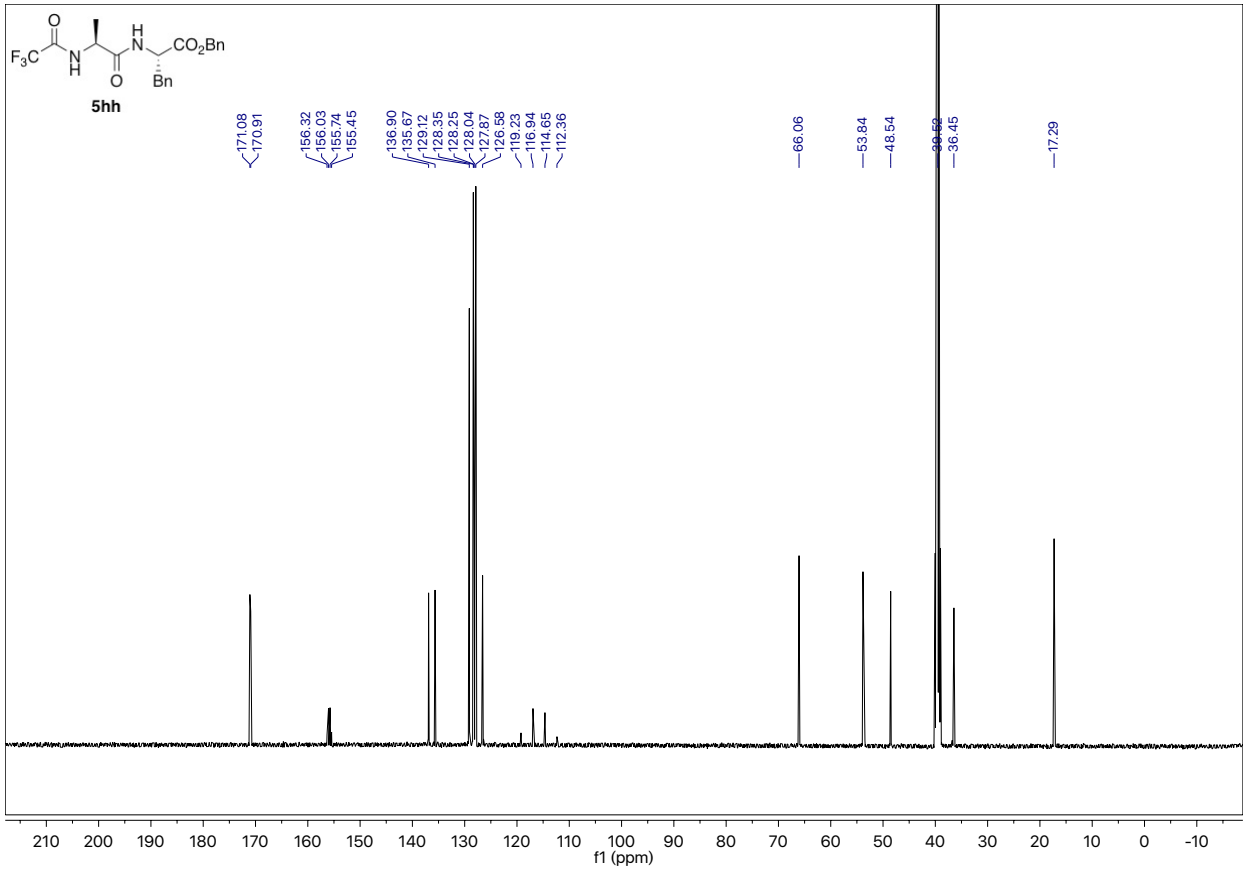
^{19}F NMR (470 MHz, DMSO-d_6) in Table 3



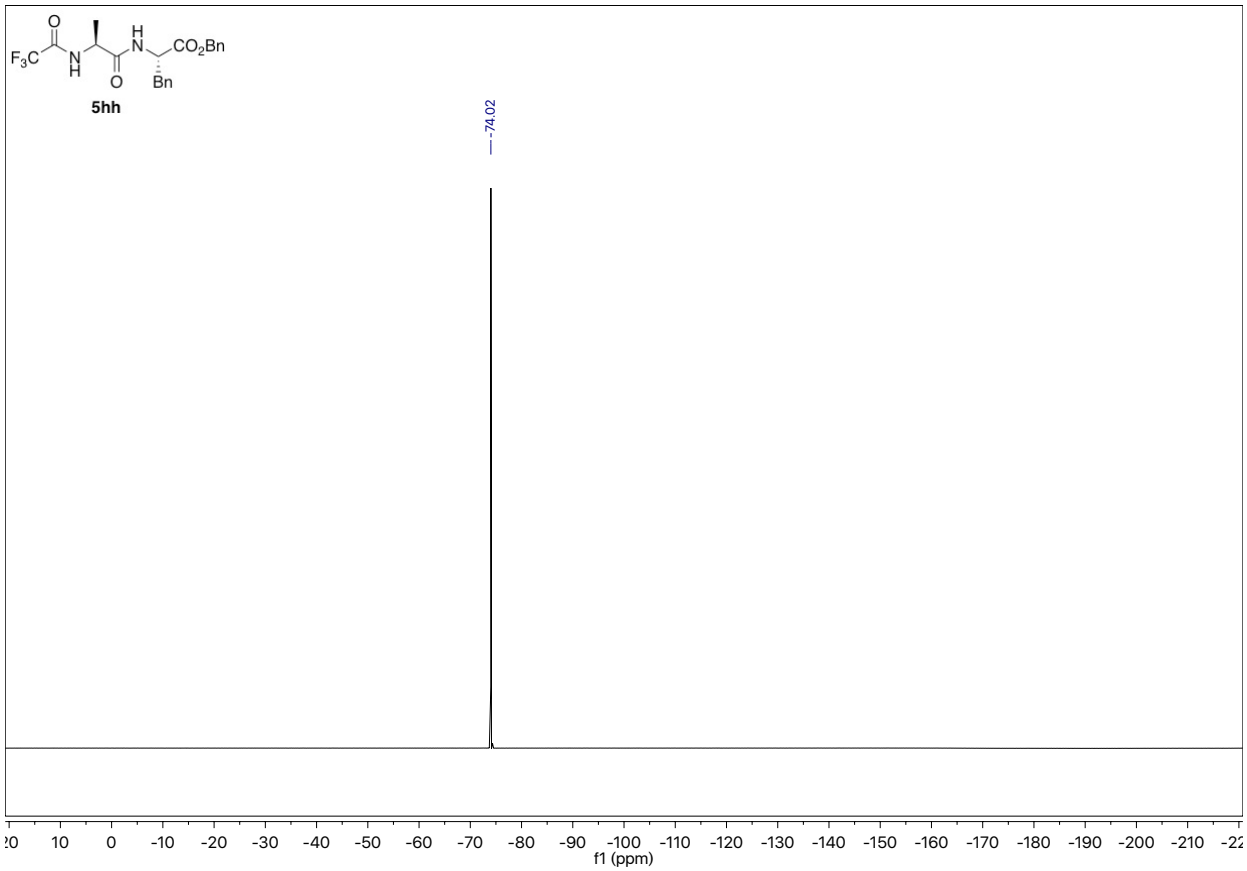
^{1}H NMR (400 MHz, DMSO-d_6) in Table 3



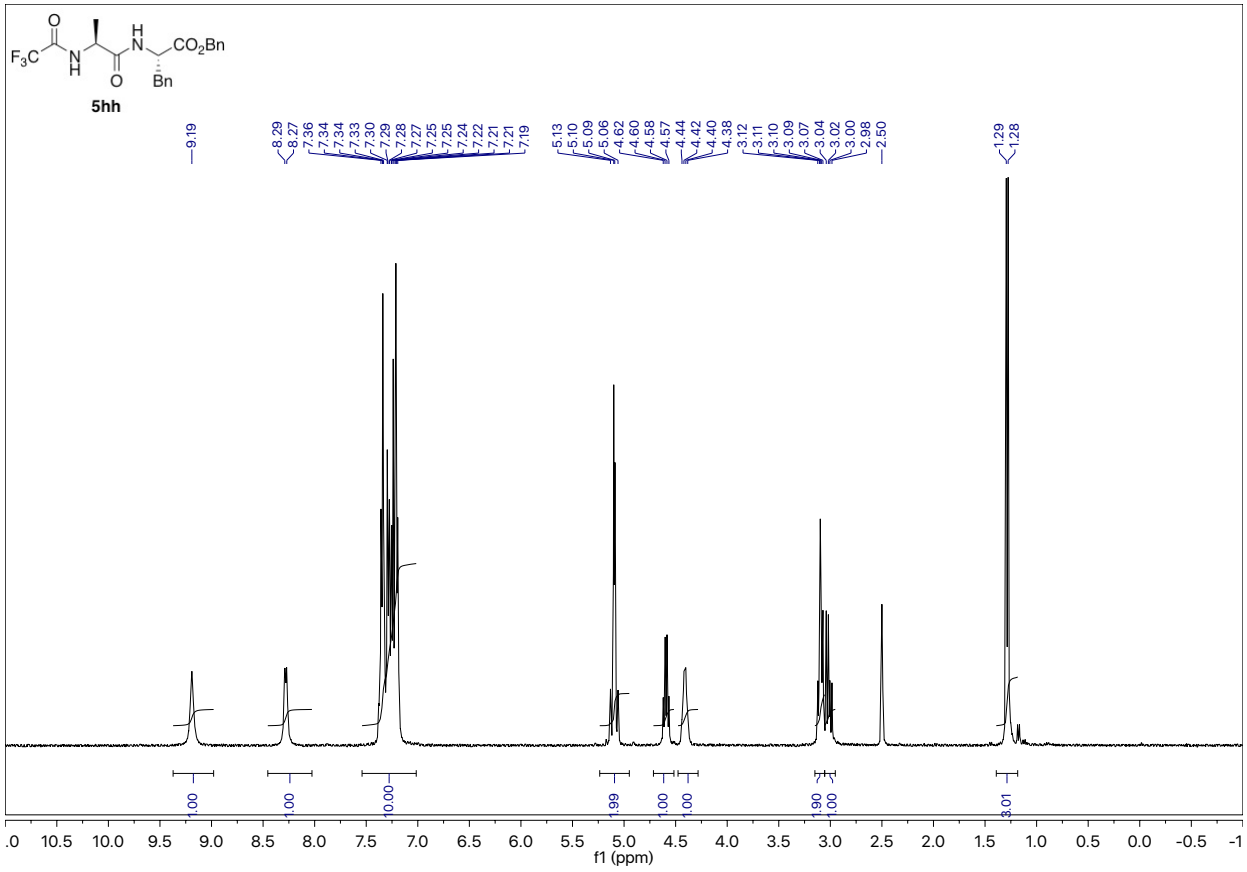
^{13}C NMR (126 MHz, DMSO-d_6) in Table 3



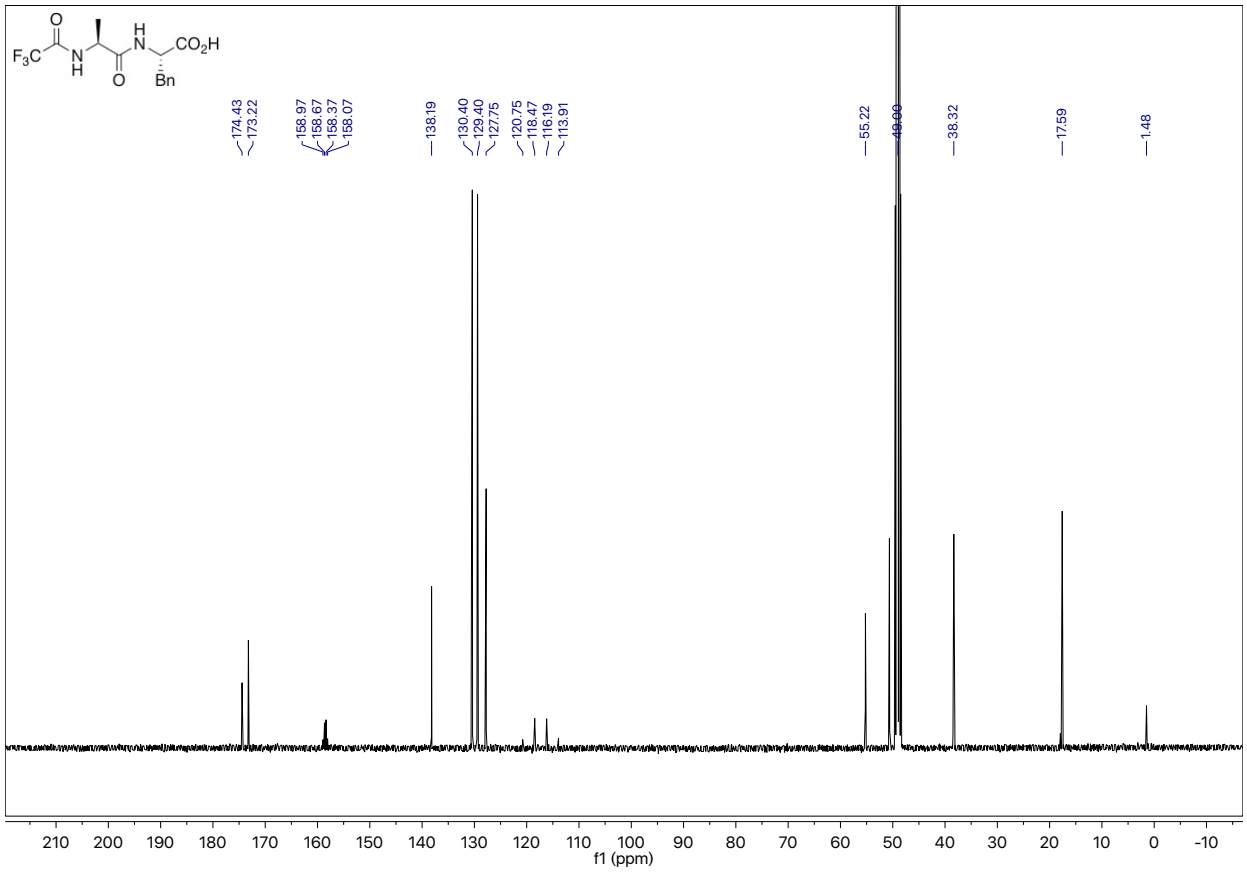
^{19}F NMR (470 MHz, DMSO-d_6) in Table 3



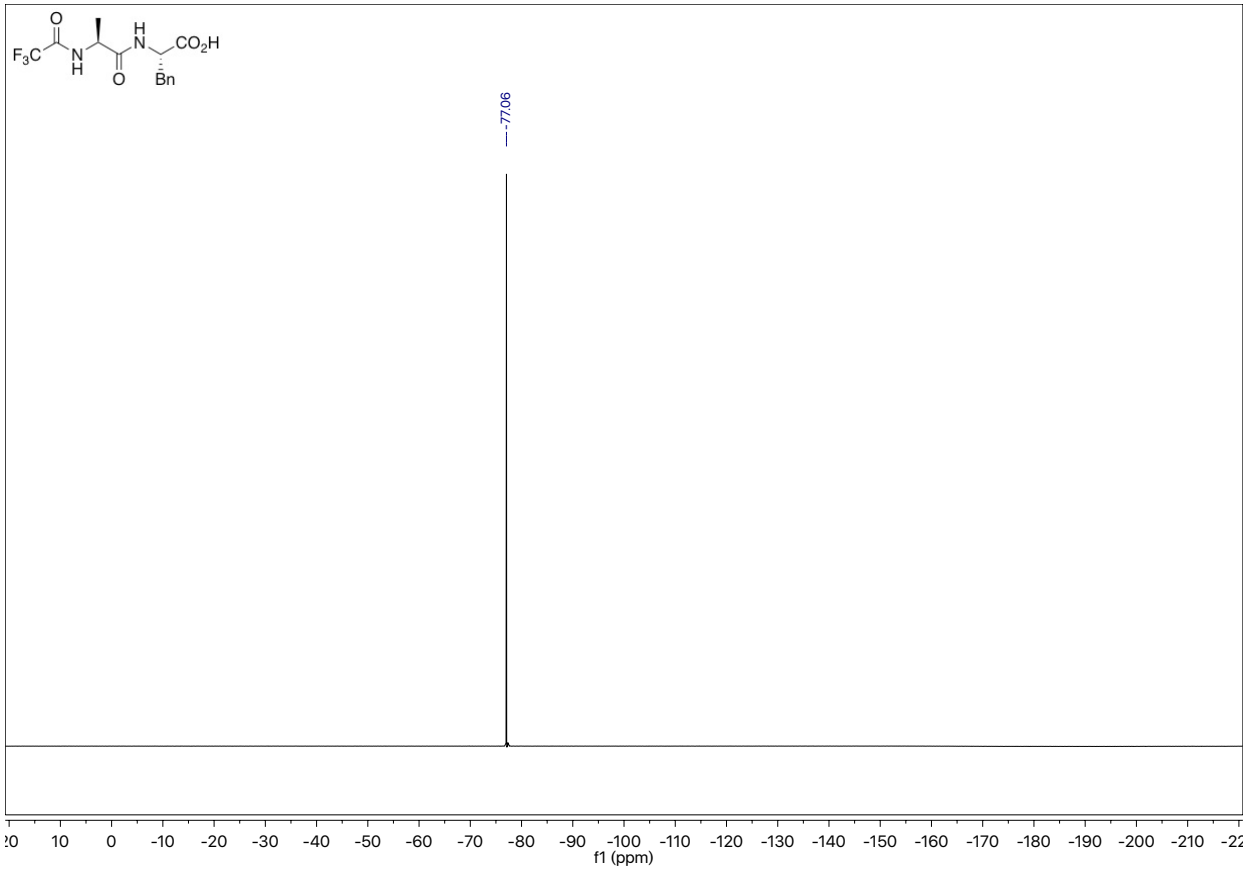
^{1}H NMR (400 MHz, DMSO-d_6) in Table 3



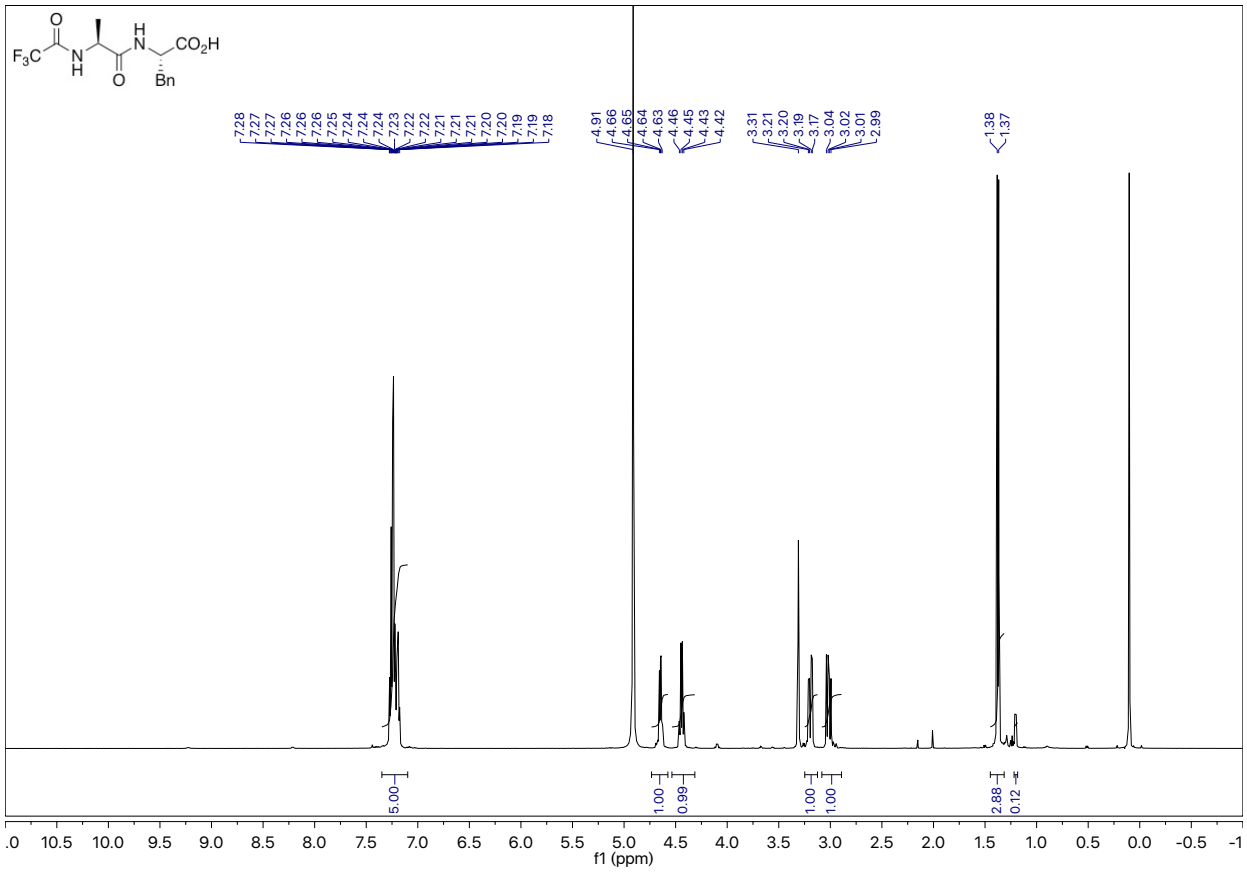
^{13}C NMR (126 MHz, CD_3OD)



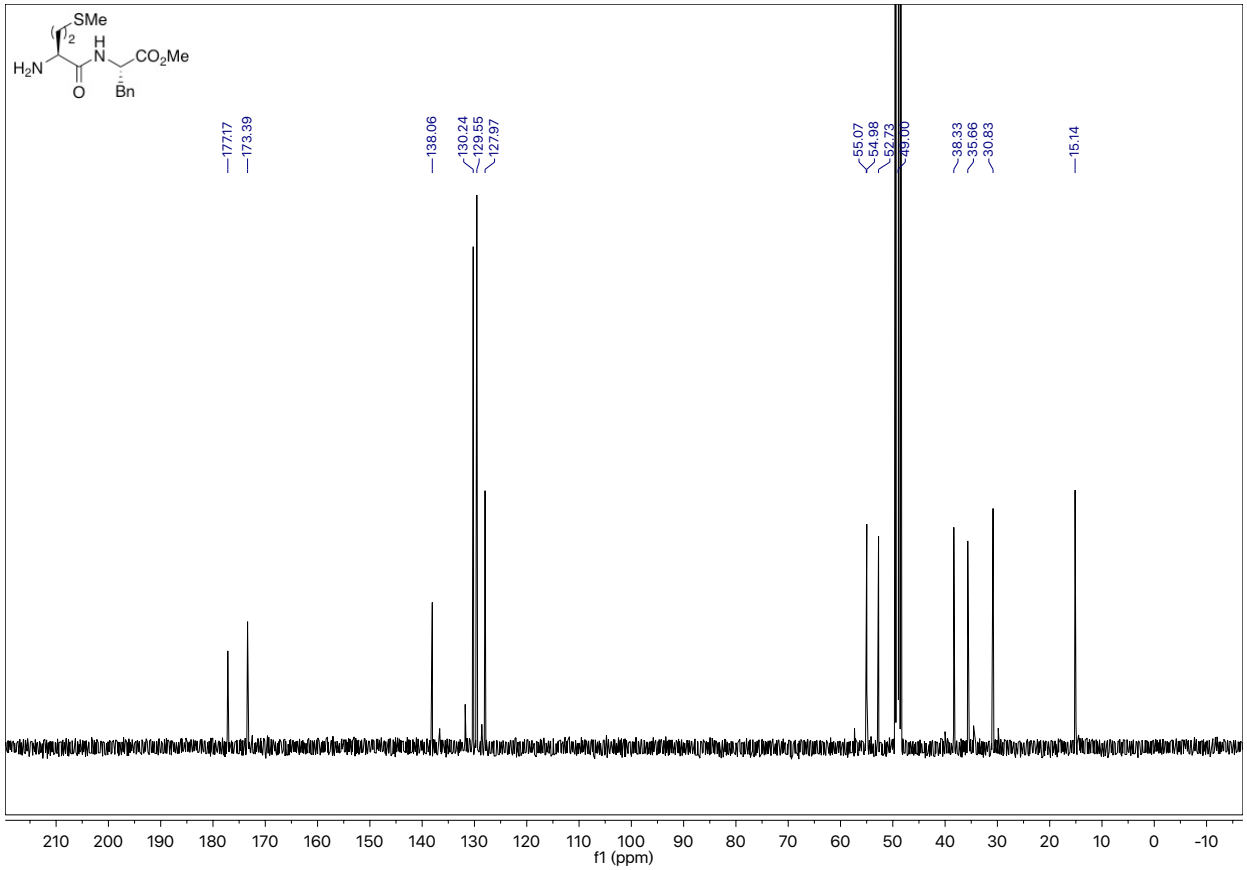
^{19}F NMR (470 MHz, CD_3OD)



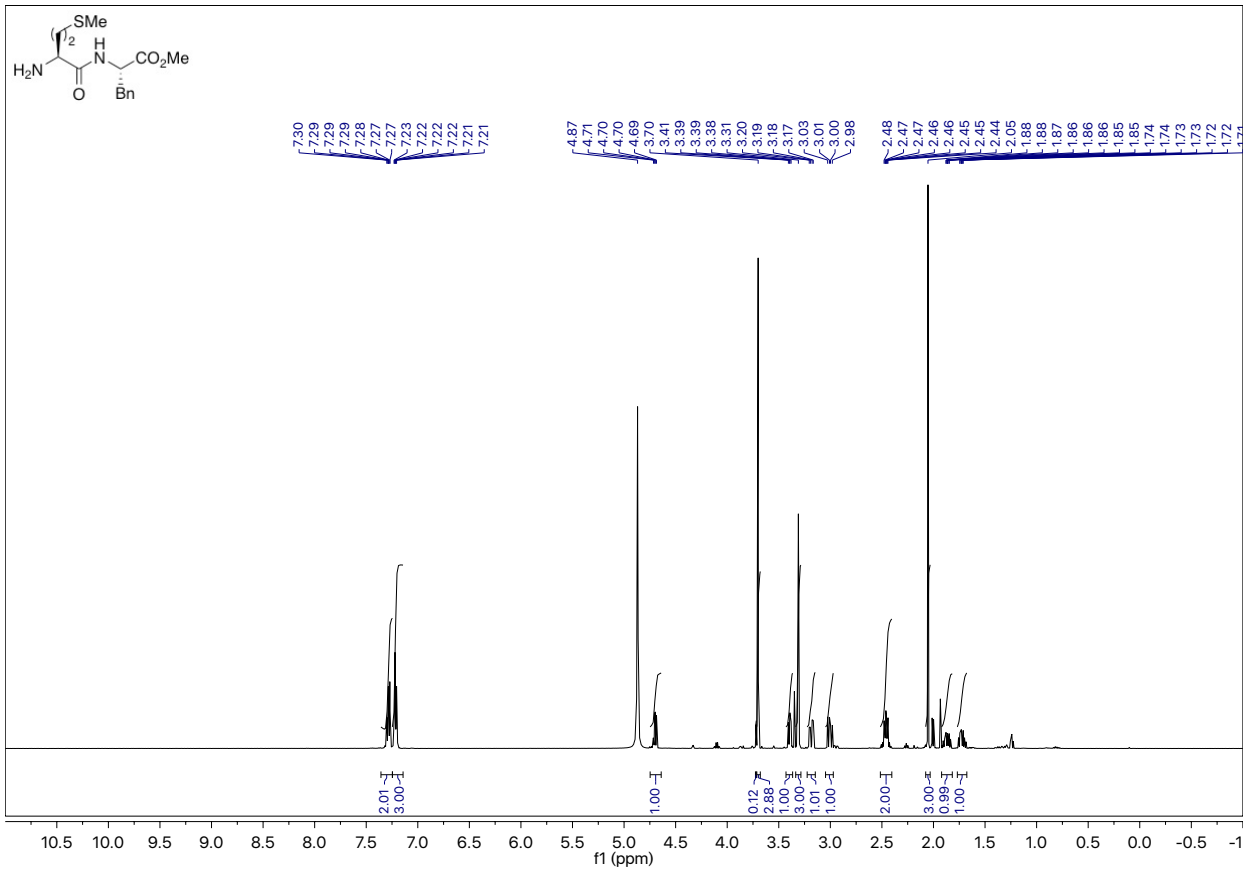
^{1}H NMR (500 MHz, CD_3OD)



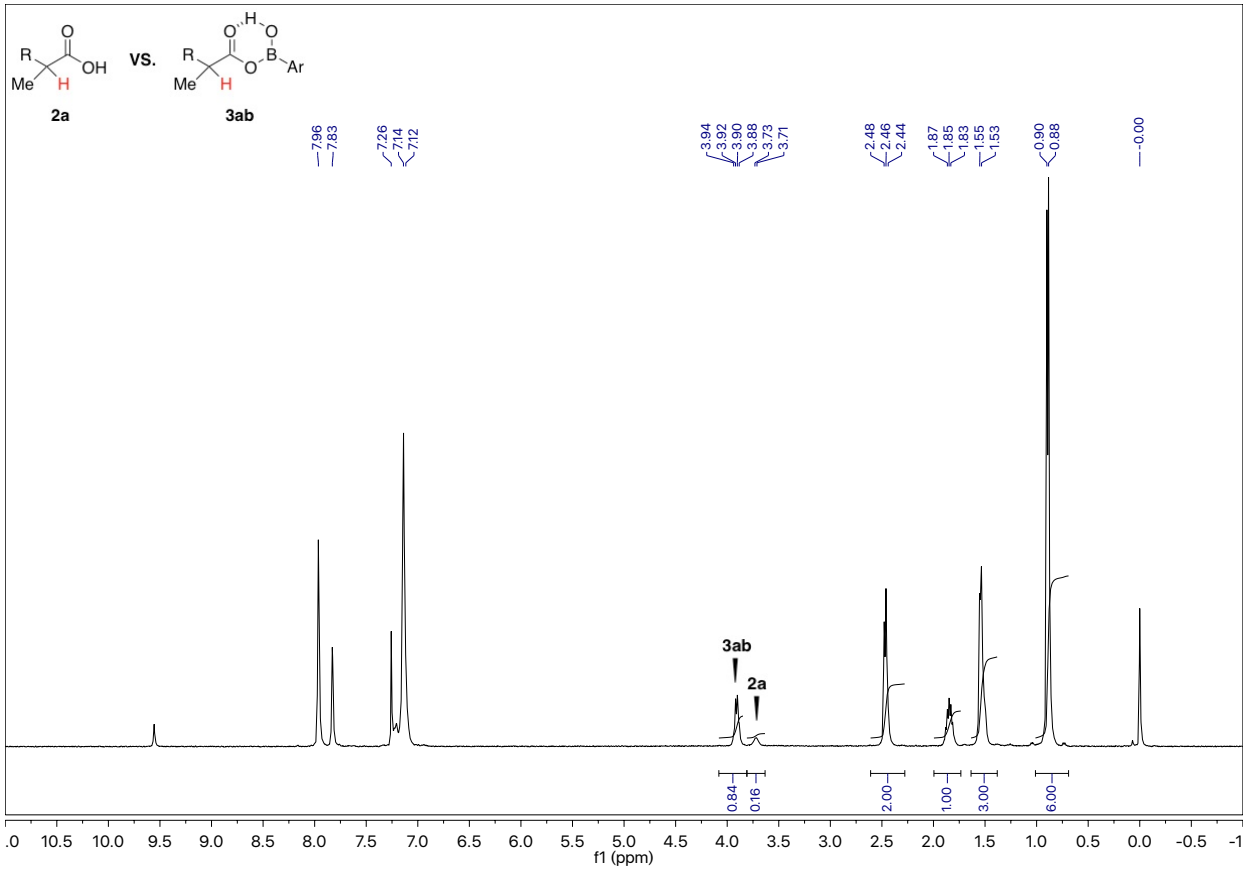
^{13}C NMR (126 MHz, CD_3OD)



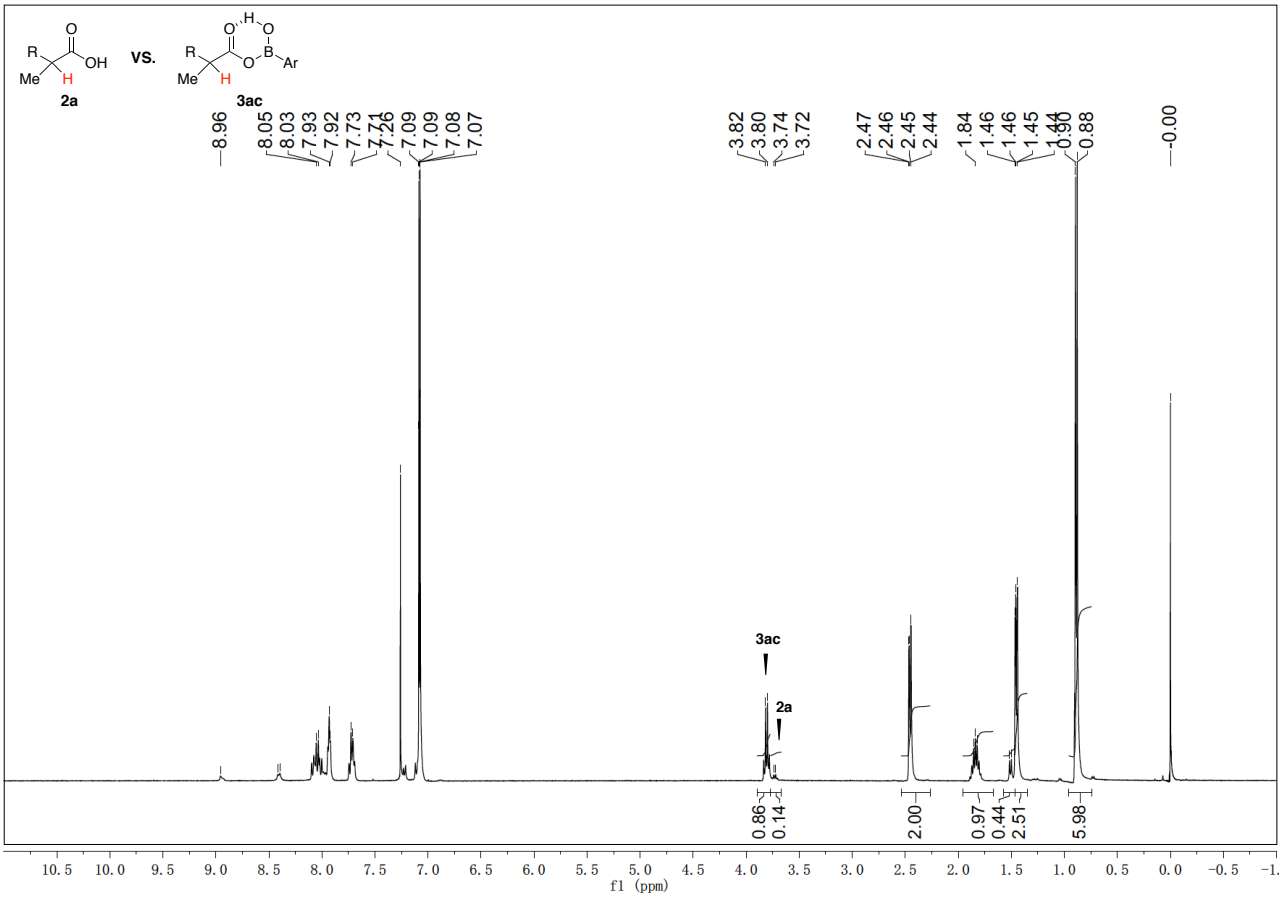
^{1}H NMR (500 MHz, CD_3OD)



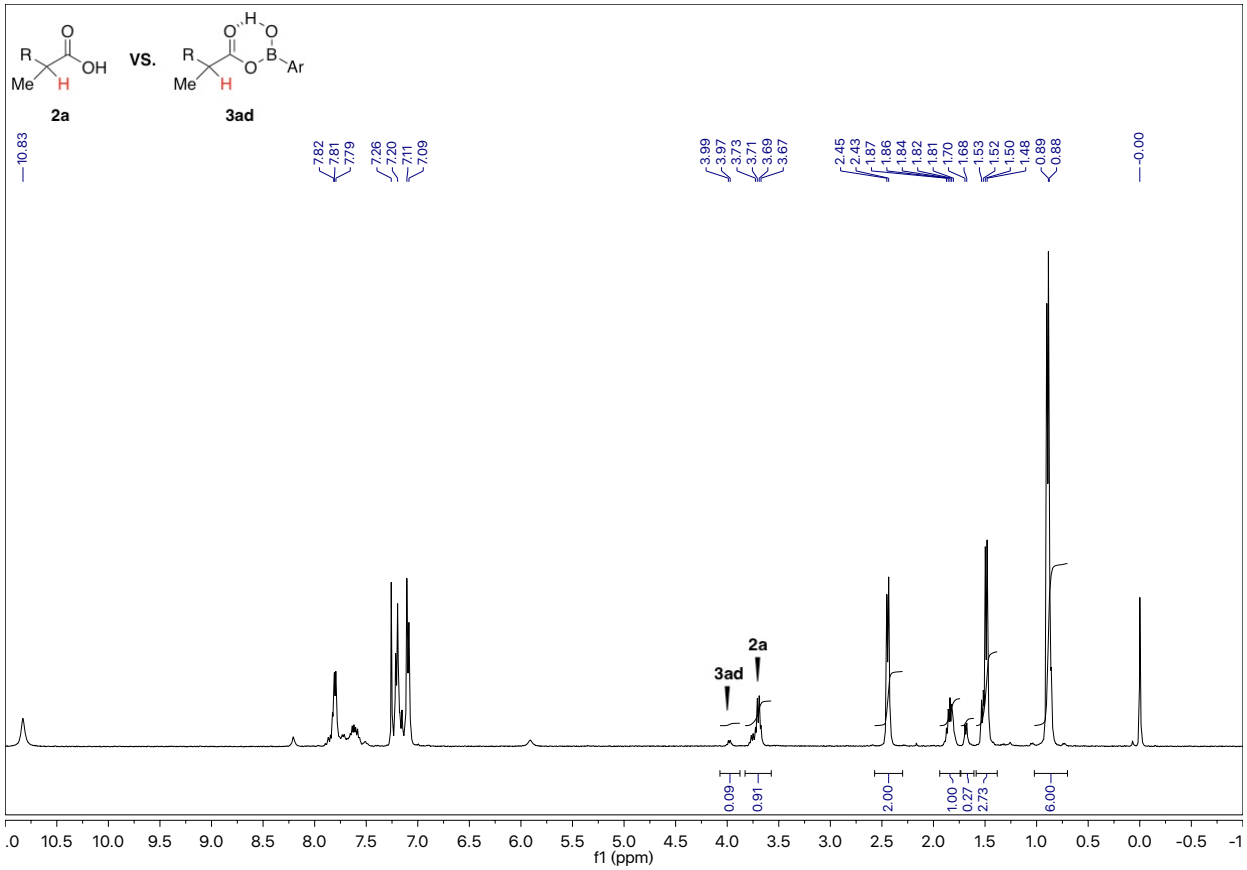
^{1}H NMR (400 MHz, $CDCl_3$), entry 1 (1^{st} step) in Table 4



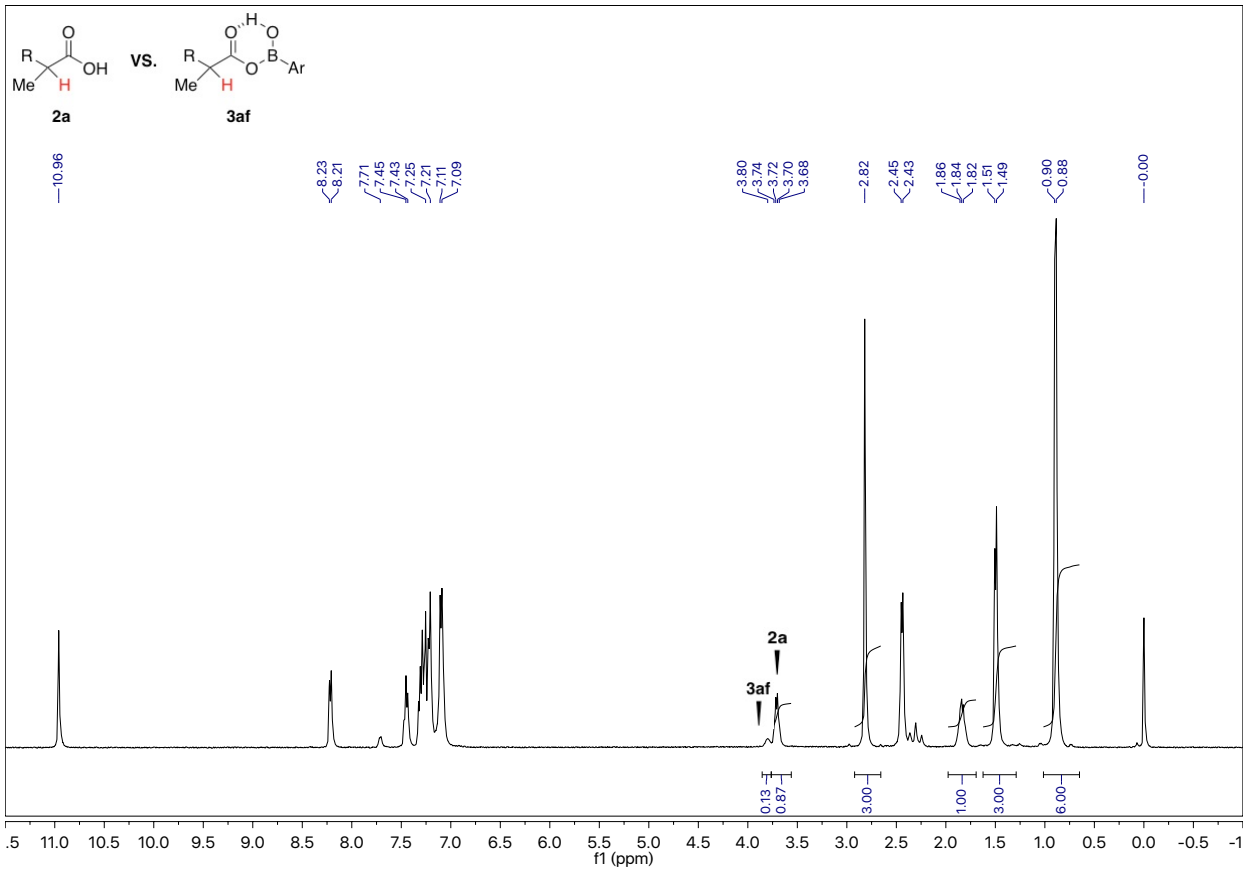
^{1}H NMR (400 MHz, $CDCl_3$), entry 2 (1^{st} step) in Table 4



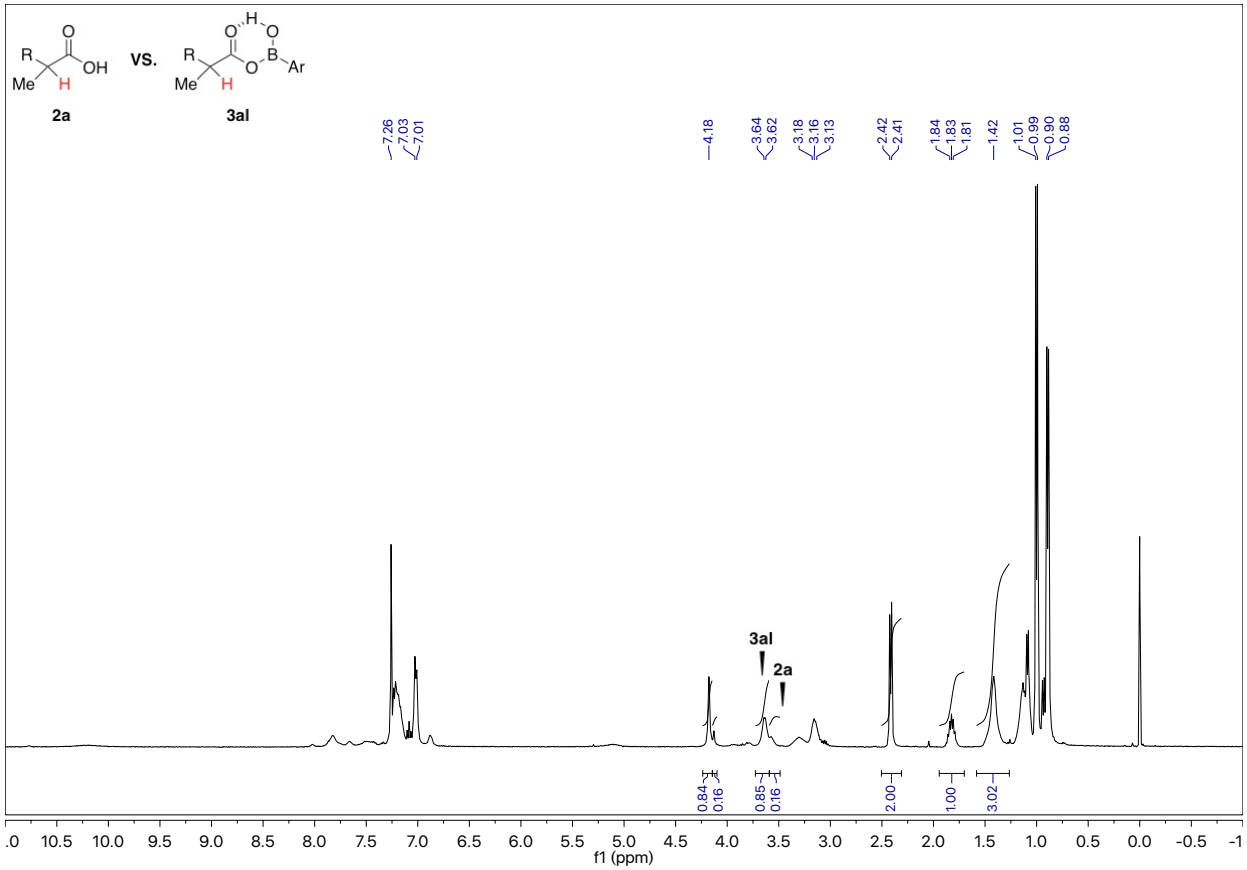
^{1}H NMR (400 MHz, $CDCl_3$), entry 3 (1st step) in Table 4



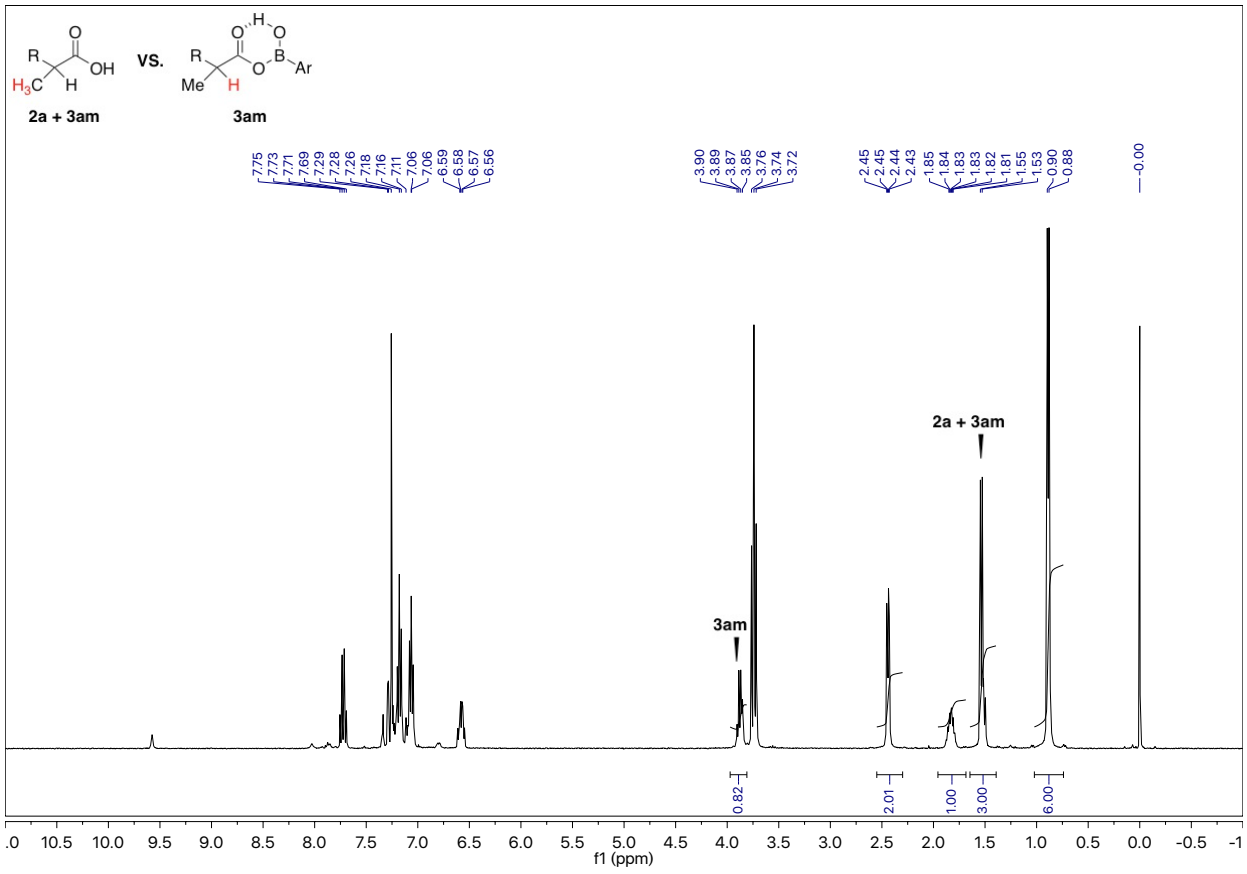
^{1}H NMR (400 MHz, $CDCl_3$), entry 4 (1st step) in Table 4



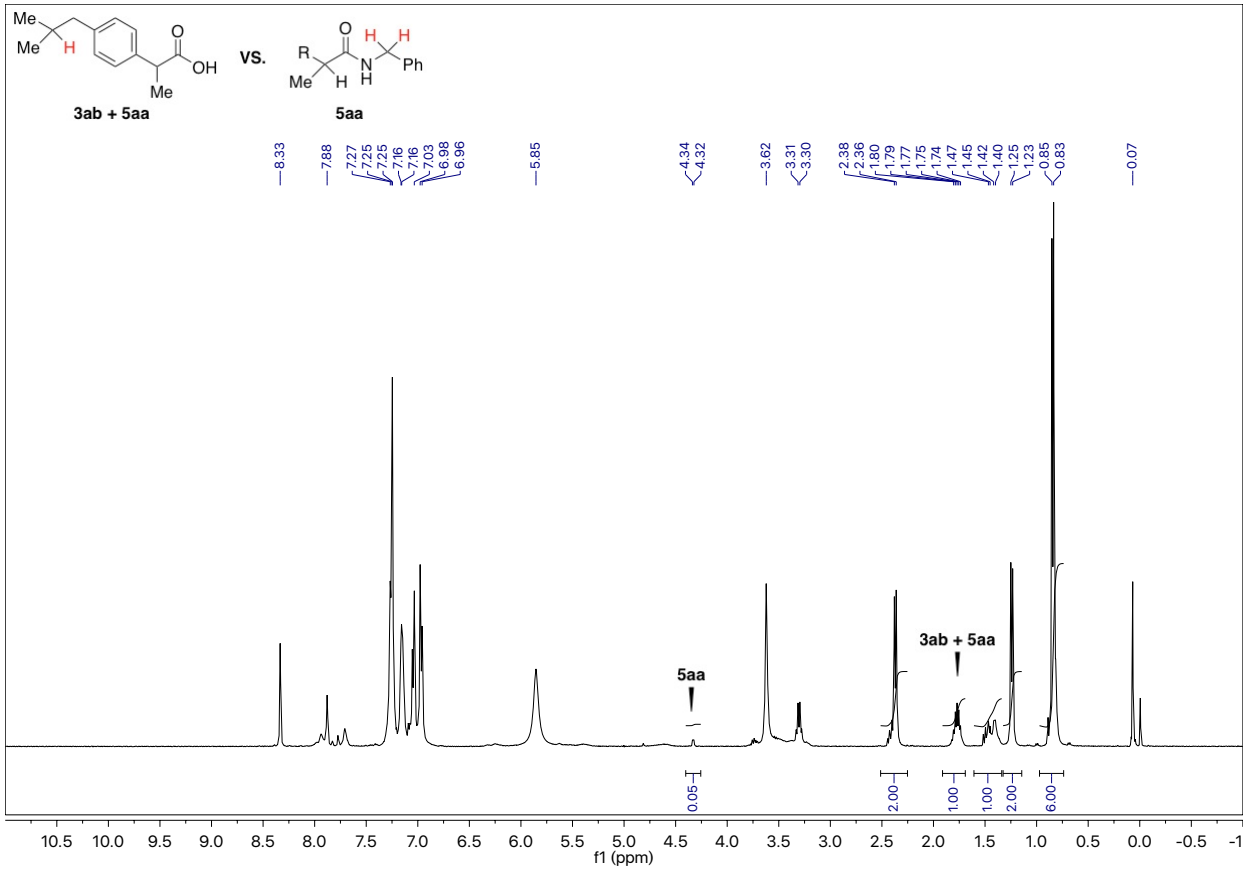
^{1}H NMR (400 MHz, $CDCl_3$), entry 5 (1st step) in Table 4



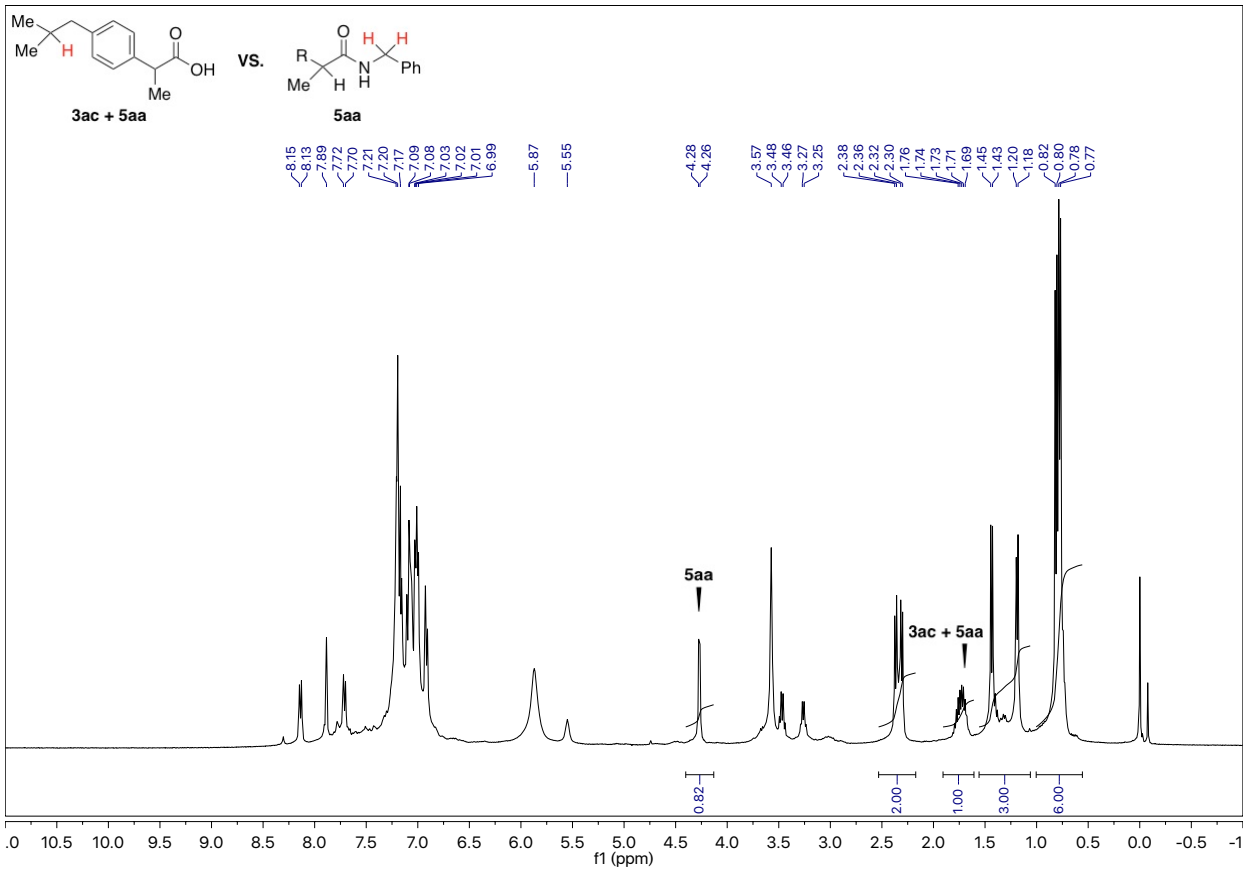
^{1}H NMR (400 MHz, $CDCl_3$), entry 6 (1st step) in Table 4



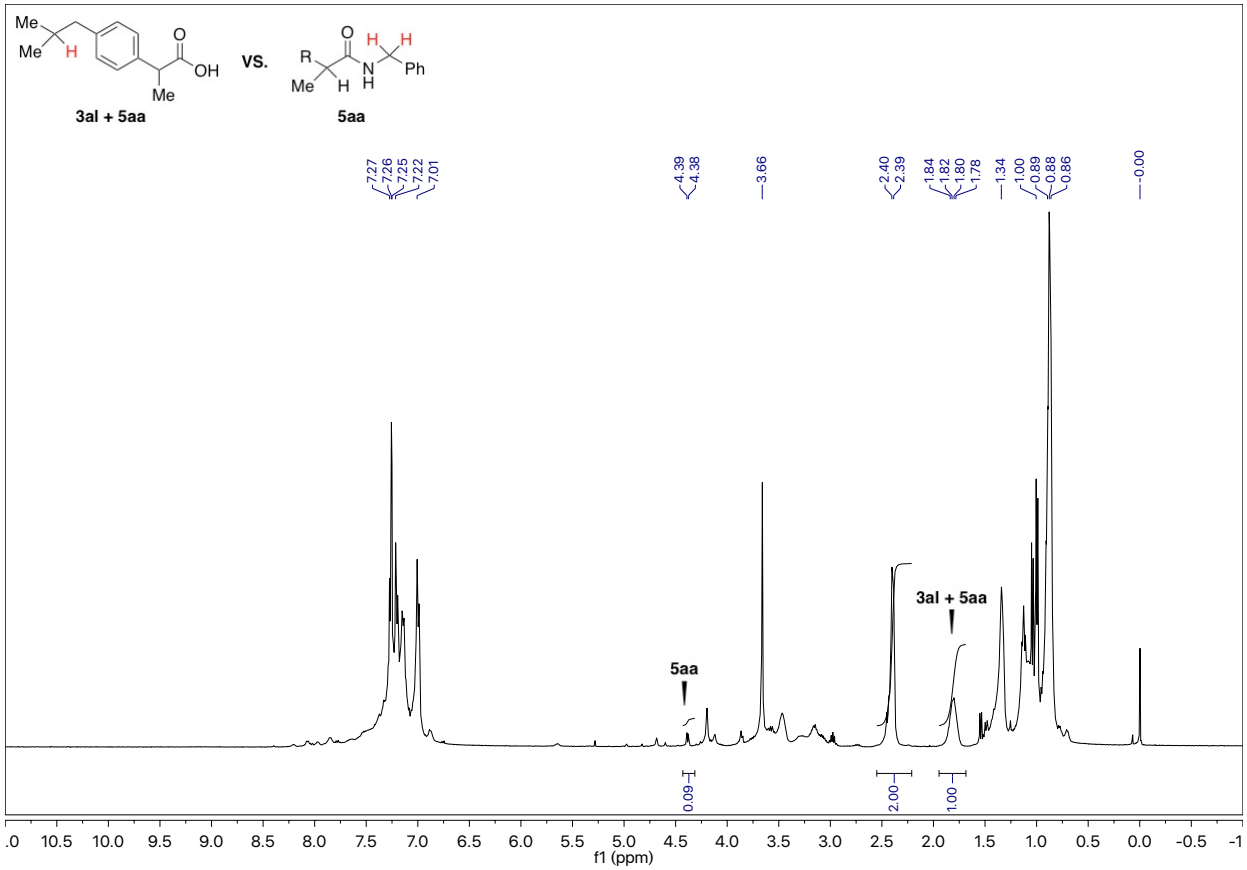
^{1}H NMR (400 MHz, $CDCl_3$), entry 1 (2^{nd} step) in Table 4



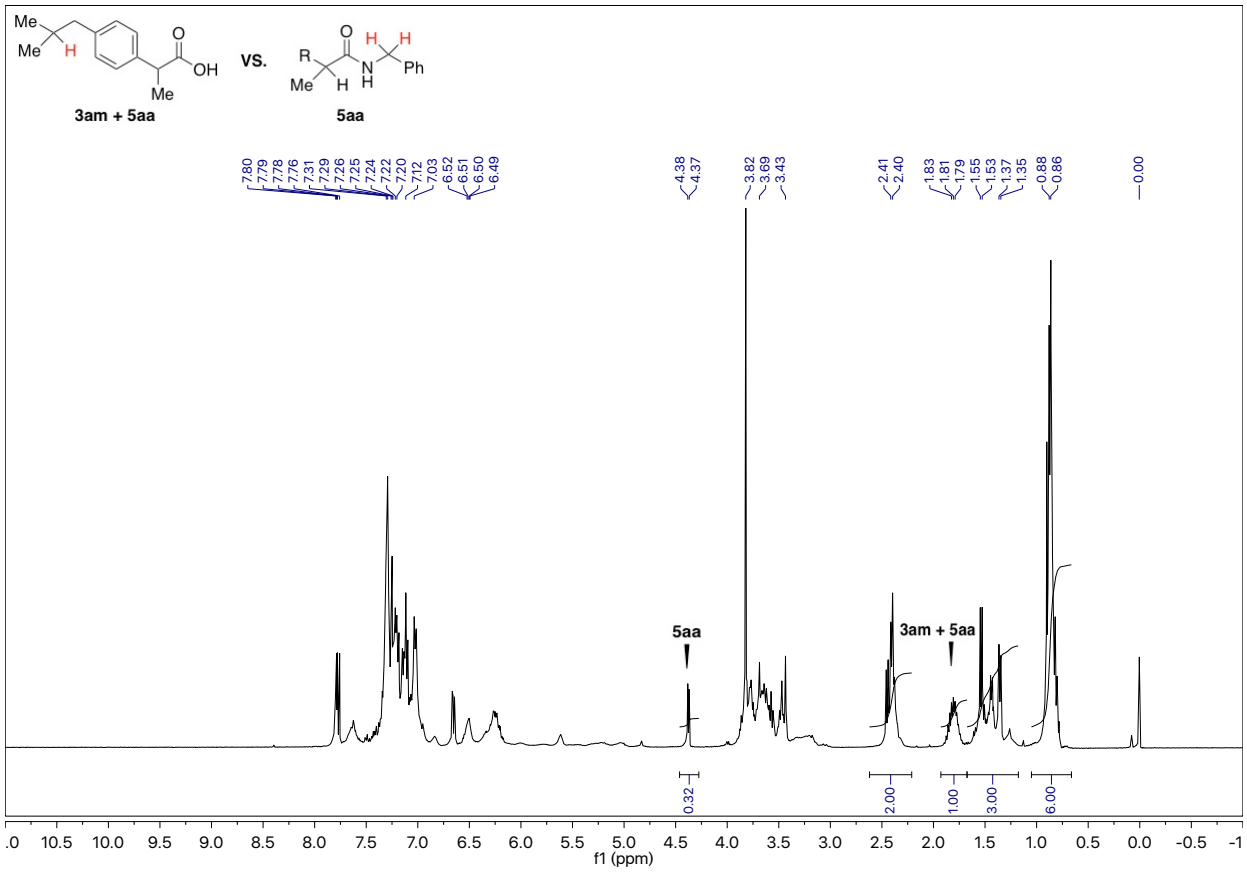
^{1}H NMR (400 MHz, $CDCl_3$), entry 2 (2^{nd} step) in Table 4



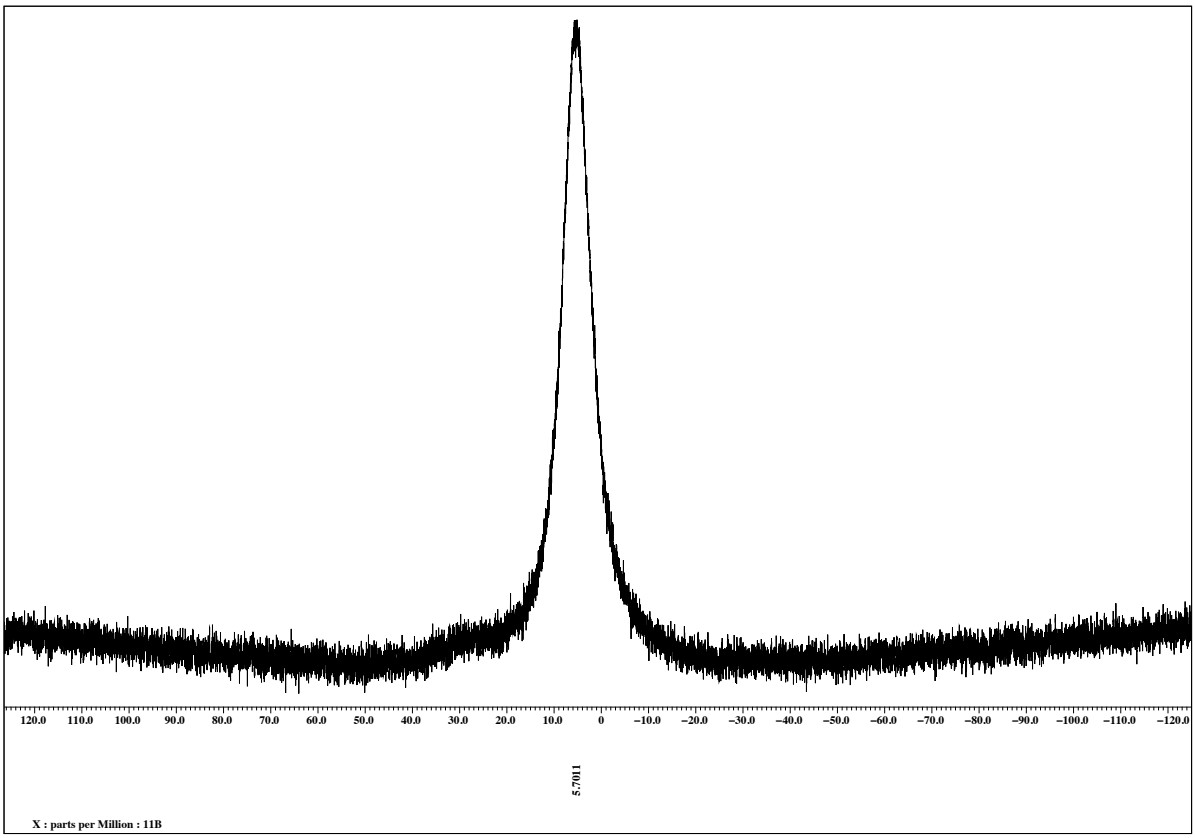
^{1}H NMR (400 MHz, $CDCl_3$), entry 5 (2nd step) in Table 4



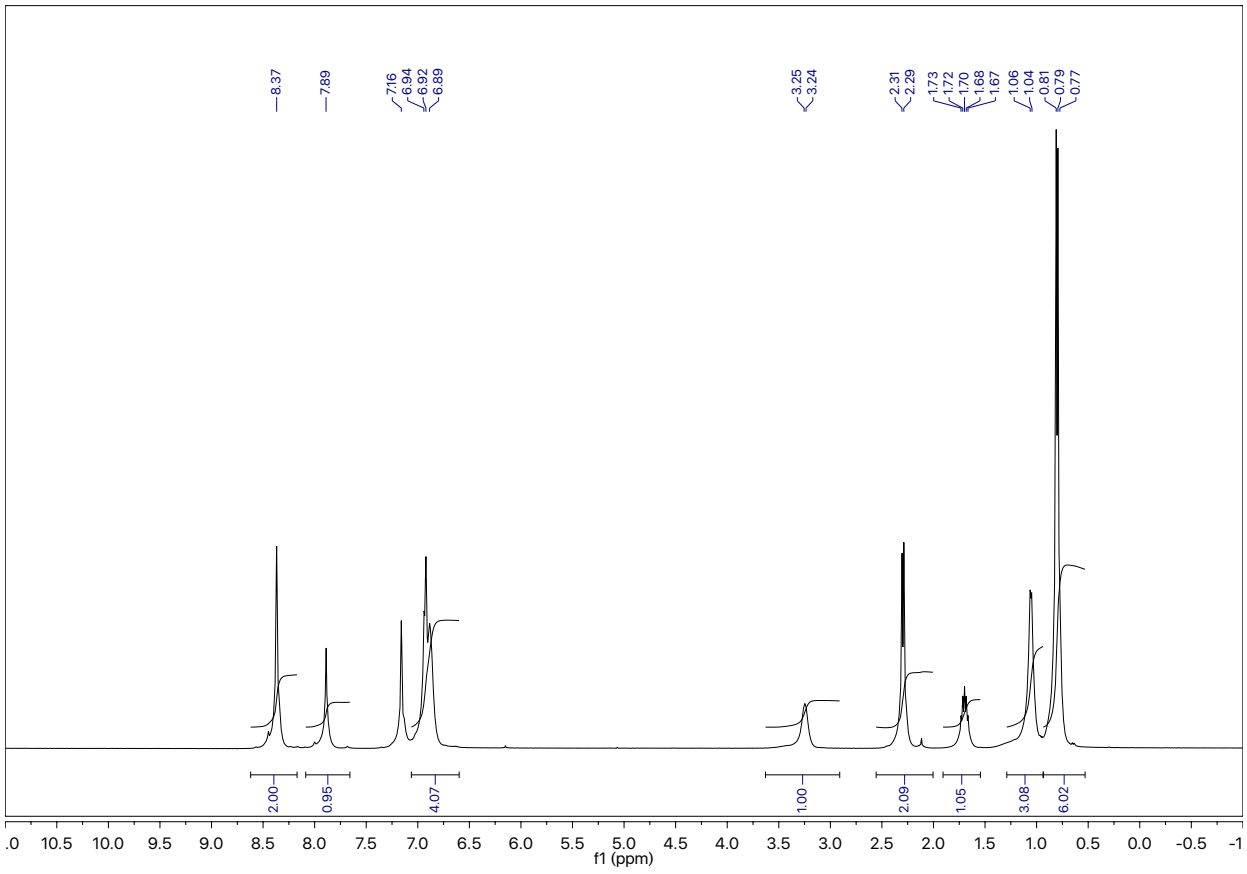
^{1}H NMR (400 MHz, $CDCl_3$), entry 6 (2nd step) in Table 4



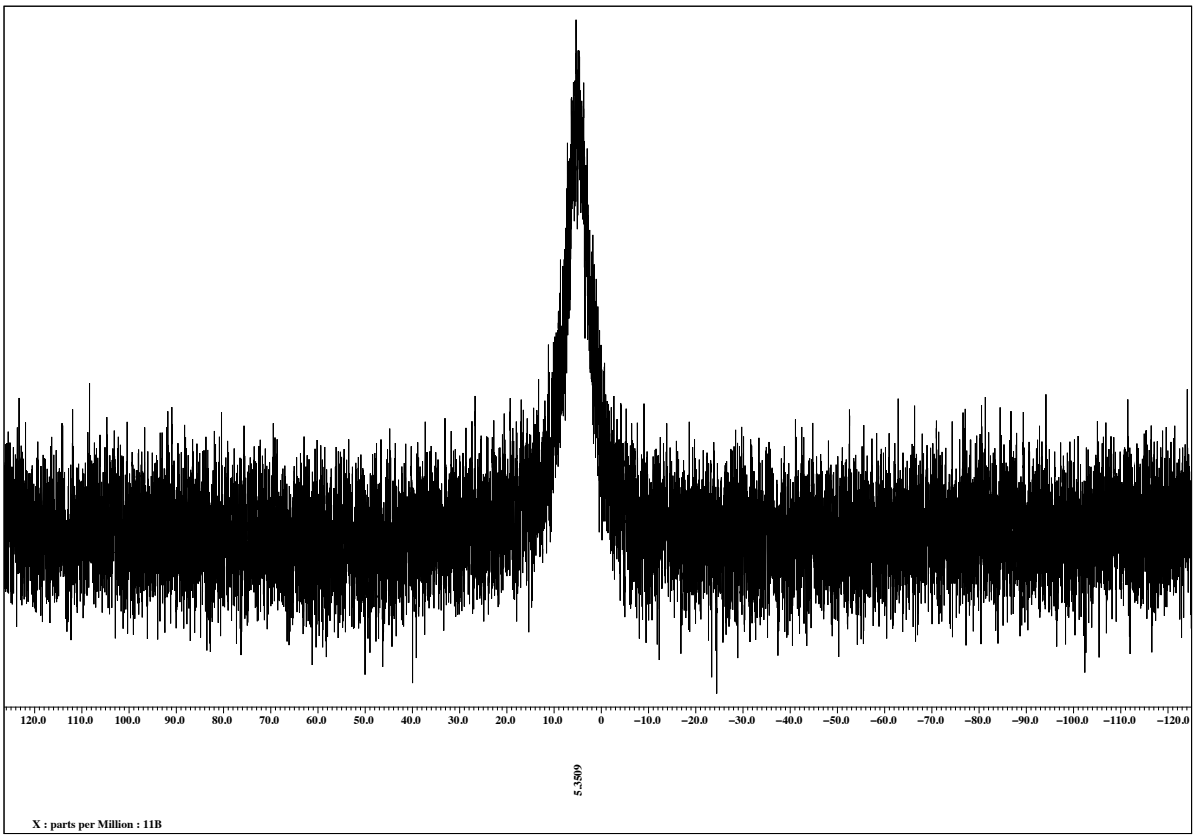
^{11}B NMR (128 MHz, C_6D_6), **6ab** in Scheme 4



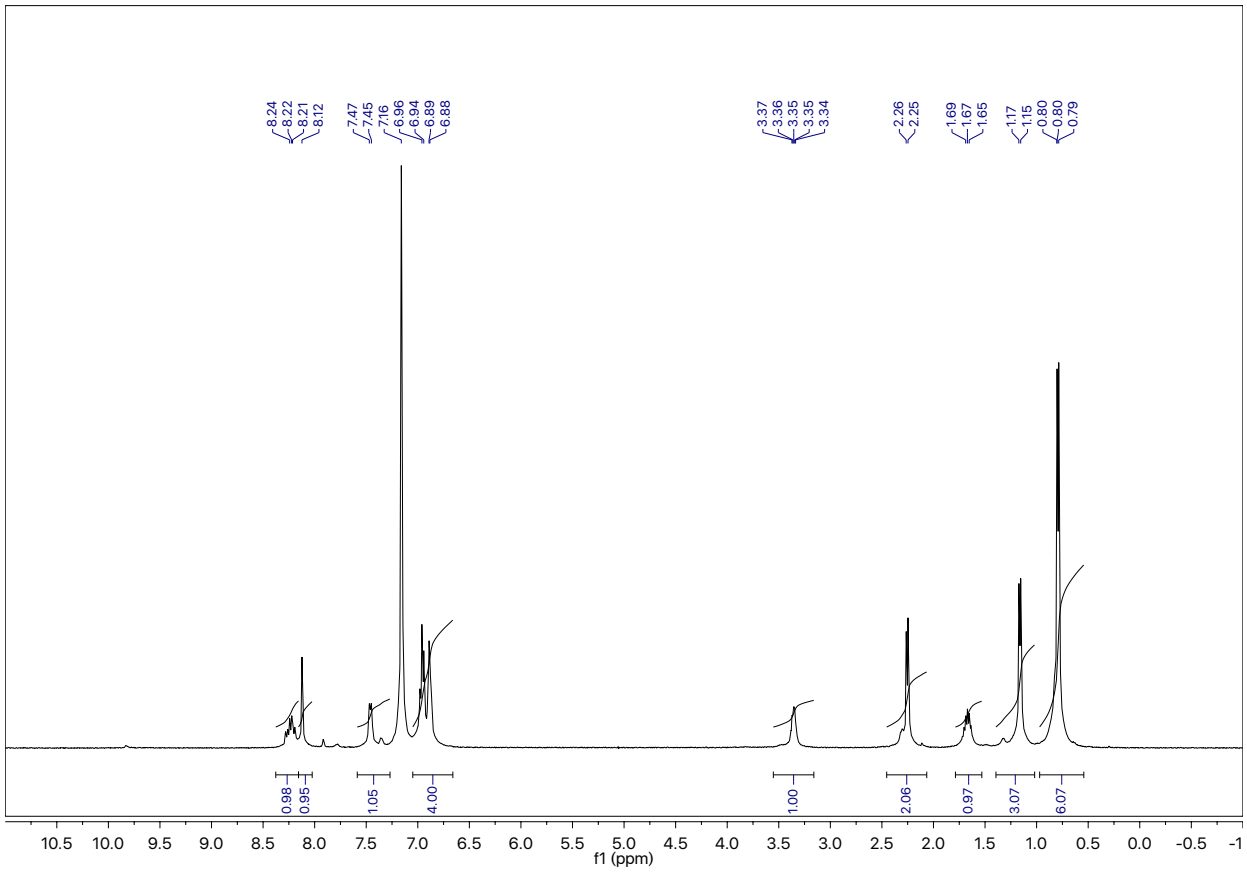
^{1}H NMR (400 MHz, C_6D_6), **6ab** in Scheme 4



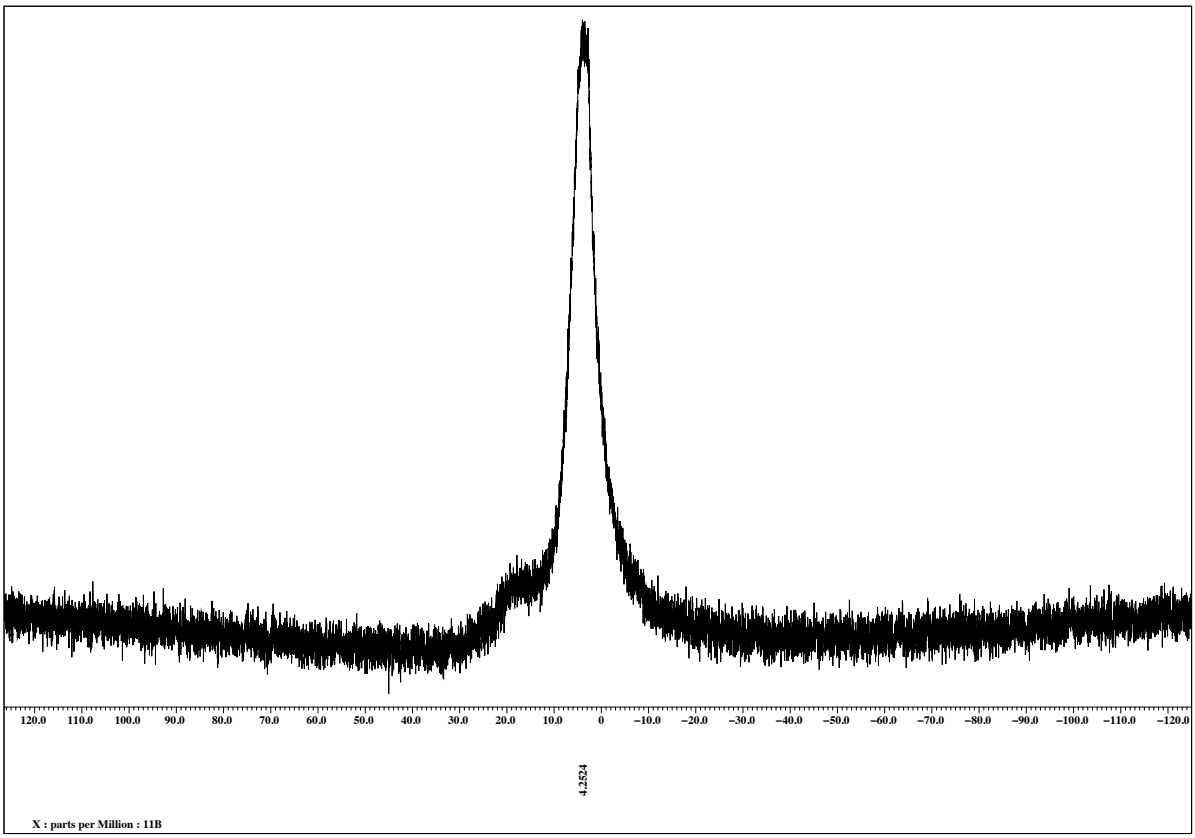
^{11}B NMR (128 MHz, C_6D_6), **6ac** in Scheme 4



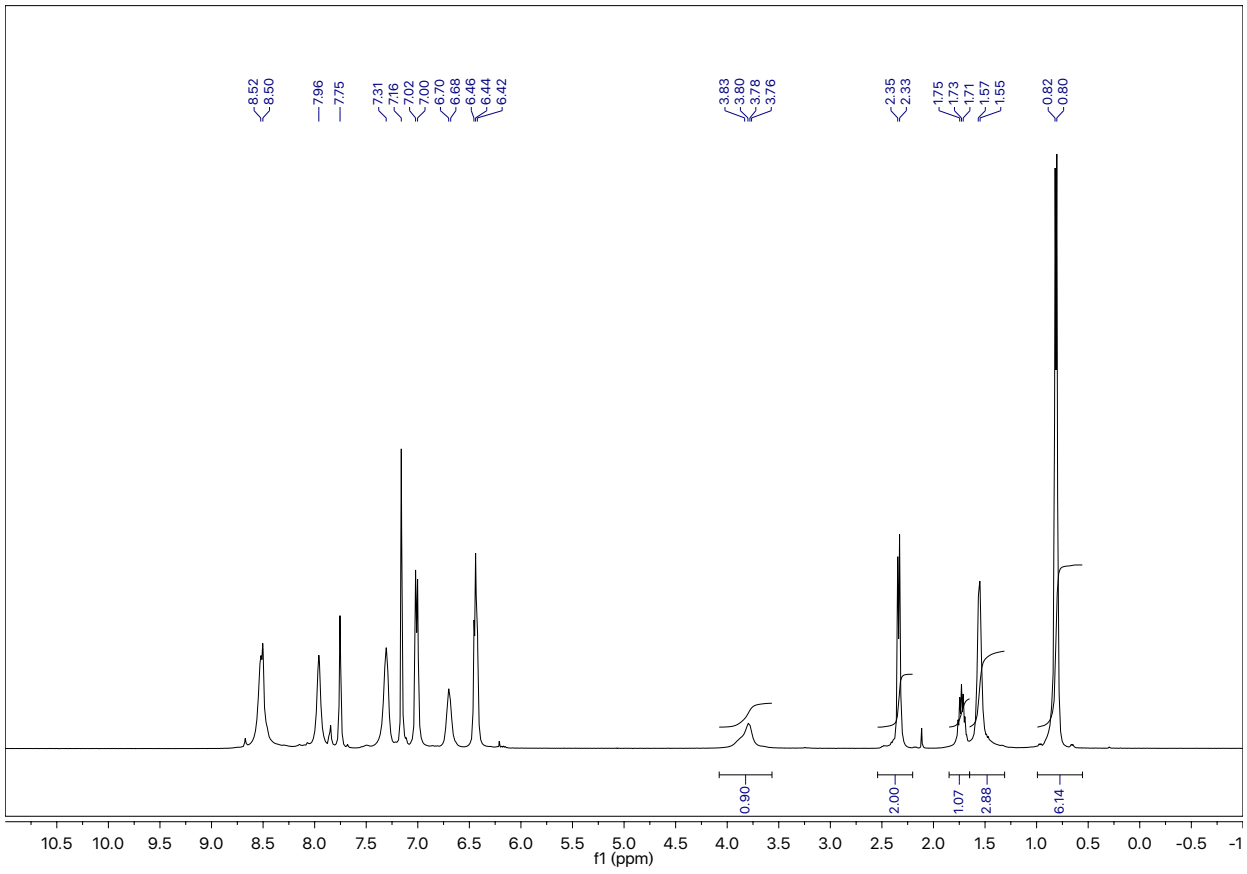
^{1}H NMR (400 MHz, C_6D_6), **6ac** in Scheme 4



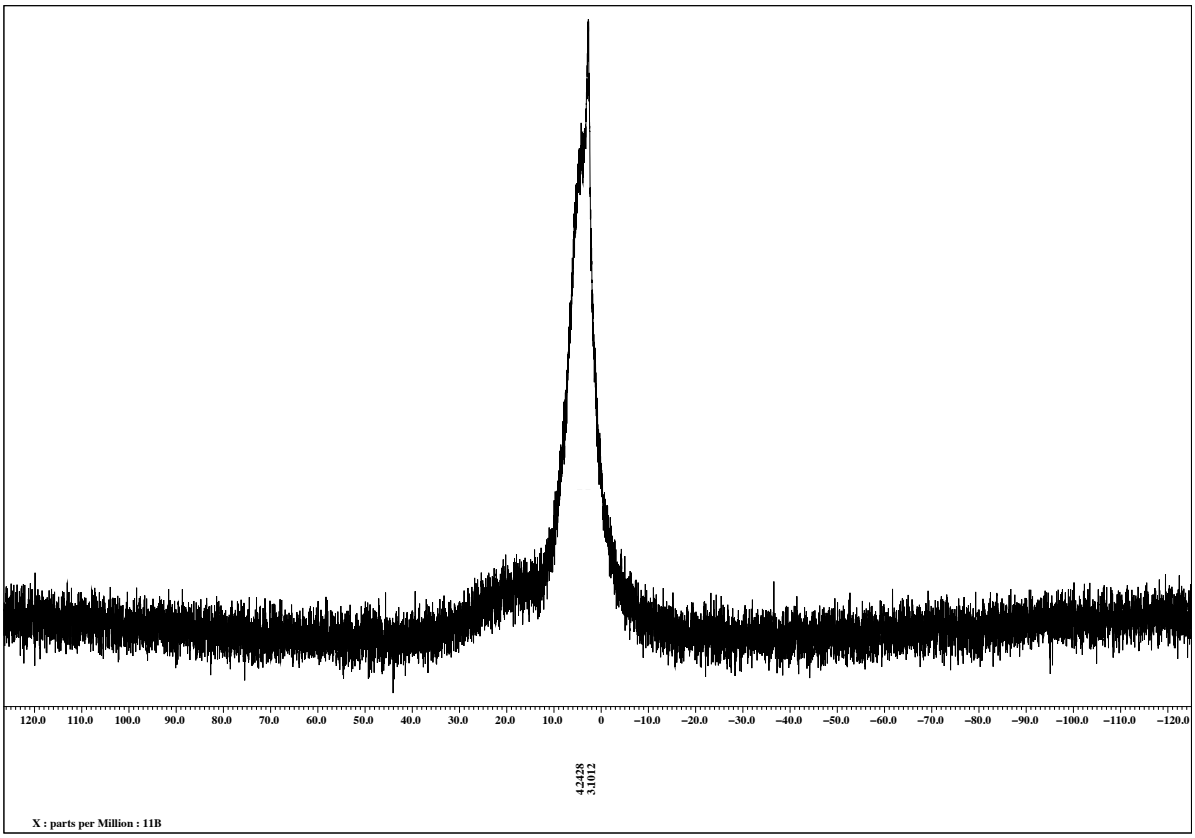
^{11}B NMR (128 MHz, C_6D_6), **6ab** + pyridine in Scheme 4



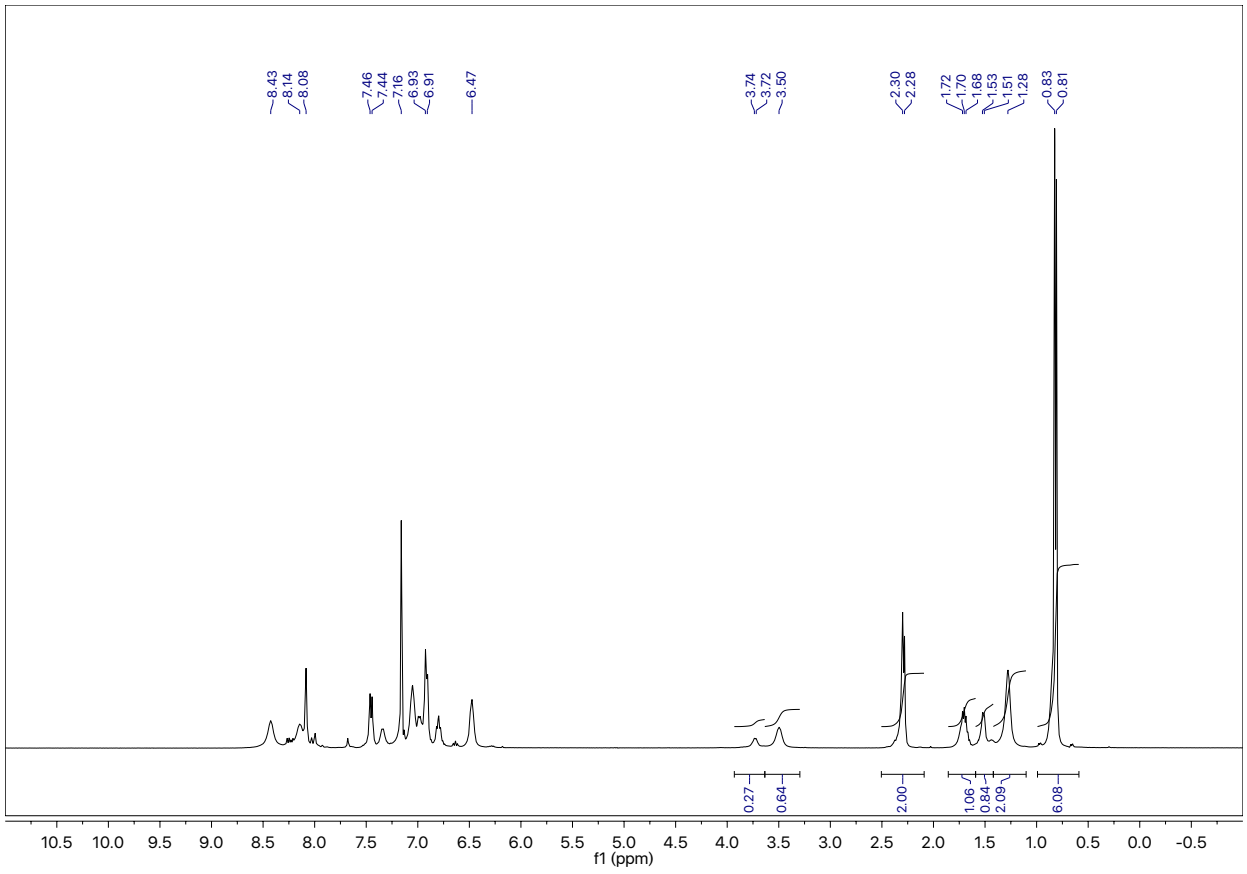
^{1}H NMR (400 MHz, C_6D_6), **6ab** + pyridine in Scheme 4



^{11}B NMR (128 MHz, C_6D_6), **6ac** + pyridine in Scheme 4

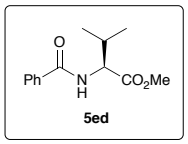


^{1}H NMR (400 MHz, C_6D_6), **6ac** + pyridine in Scheme 4



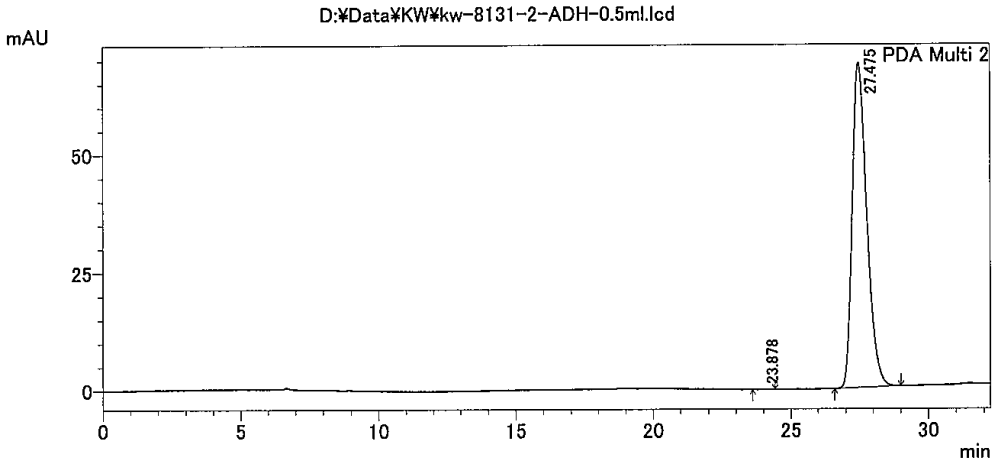
15. HPLC Charts of Amides 5ed, 5f and dipeptides 5.

Amide **5ed** in Table 2



5ed

Operator	: System Administrator
Sample	: kw-8131-2-ADH-0.5ml
ID	: kw-8131-2-ADH-0.5ml
Vial Number	:
Inj. Volume	: 1 uL
Data Name	: kw-8131-2-ADH-0.5ml.lcd
Method Name	: Chk.lcm
Batch Name	:
Report Name	: English Format 7115.lcr
Acquisition Date	: 2018/01/31 19:23:53
Modified Date	: 2018/01/31 20:44:22



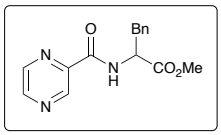
1 PDA Multi 2/210nm 4nm

PDA Ch2 210nm 4nm

Peak No	RT (min)	Area	Height (mV)	% Area
1	23.878	1243	73	0.049
2	27.475	2529763	68839	99.951
Total		2531006	68912	100.000

D:¥Data¥KW¥kw-8131-2-ADH-0.5ml.lcd

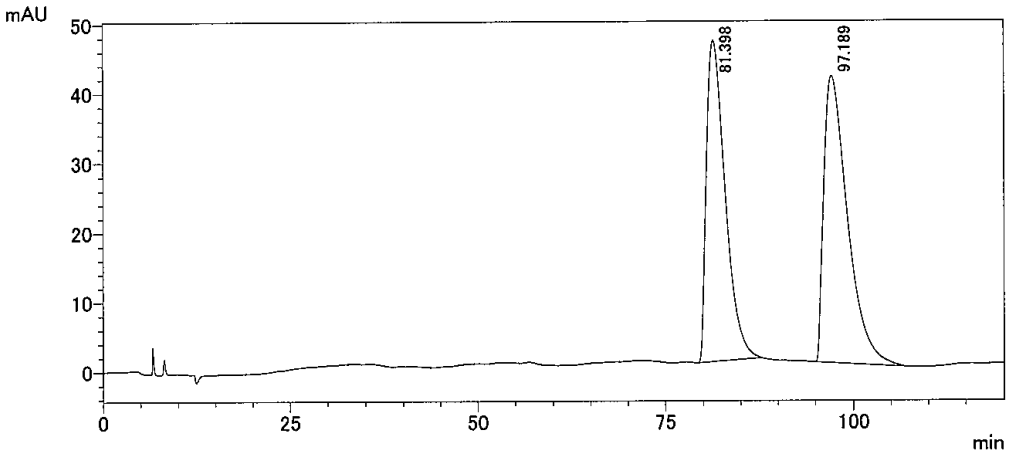
Racemic sample of amide **5ff** in Table 2



=== Shimadzu LabSolutions 分析レポート ===

Sample	:		
ID	:		
Data Name	: 8205-1-OD3-double-B5-1mL.lcd		
Method Name	: B5 c1 1.0ml-120min.lcm		
Batch Nam	: KW-autopurge-OD3-double-B5.lcb		
Vial	: 1-66	サンプルタイプ	: Unknown
Inj. Volume	: 1 uL		
Acquisition Date	: 2018/02/06 10:19:16	分析者	: System Administrator
Modified Date	: 2018/02/06 12:19:18	解析者	: System Administrator

<クロマトグラム>

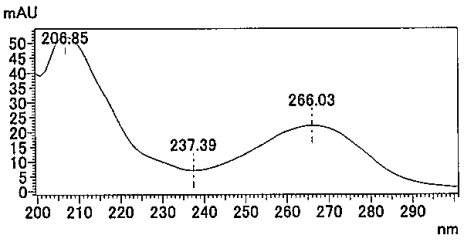


PDA Ch1 210nm

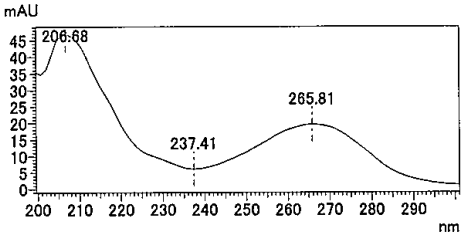
Peak No.	RT (min)	Area	Height	% Area
1	81.398	8061411	46186	47.317
2	97.189	8975494	41194	52.683
Total		17036906	87379	100.000

UVスペクトル

保持時間 : 81.398 min

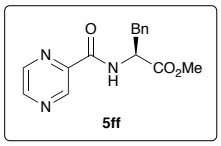


保持時間 : 97.189 min



D:¥Data¥KW¥Method¥8205-1-OD3-double-B5-1mL.lcd

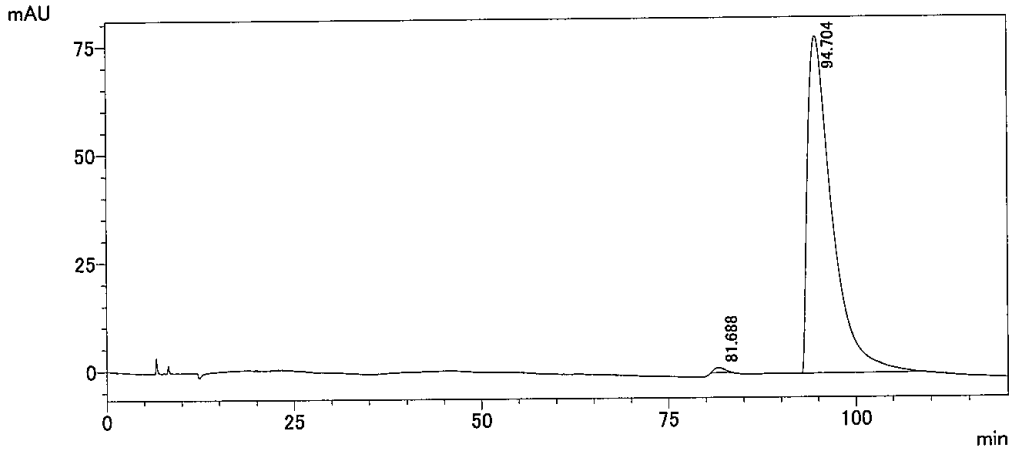
Amide **5ff** in Table 2



=== Shimadzu LabSolutions 分析レポート ===

Sample	:		
ID	:		
Data Name	: 8208-1-OD3-double-B5-1mL.lcd		
Method Name	: B5 c1 1.0ml-120min.lcm		
Batch Nam	: KW-OD3-double-B5.lcb		
Vial	: 1-66	サンプルタイプ	: Unknown
Inj. Volume	: 1 uL		
Acquisition Date	: 2018/02/08 11:18:27	分析者	: System Administrator
Modified Date	: 2018/02/08 13:18:31	解析者	: System Administrator

<クロマトグラム>

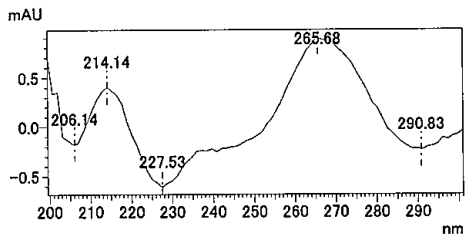


PDA Ch1 210nm

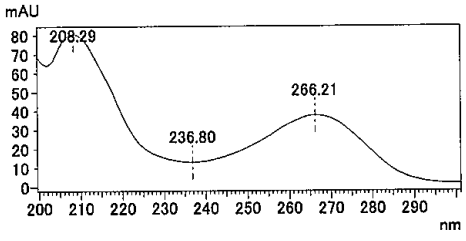
Peak No.	RT (min)	Area	Height	% Area
1	81.688	109889	1149	0.617
2	94.704	17693100	77721	99.383
Total		17802989	78870	100.000

UVスペクトル

保持時間 : 81.688 min

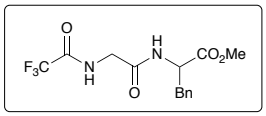


保持時間 : 94.704 min



D:¥Data¥KW¥Method¥8208-1-OD3-double-B5-1mL.lcd

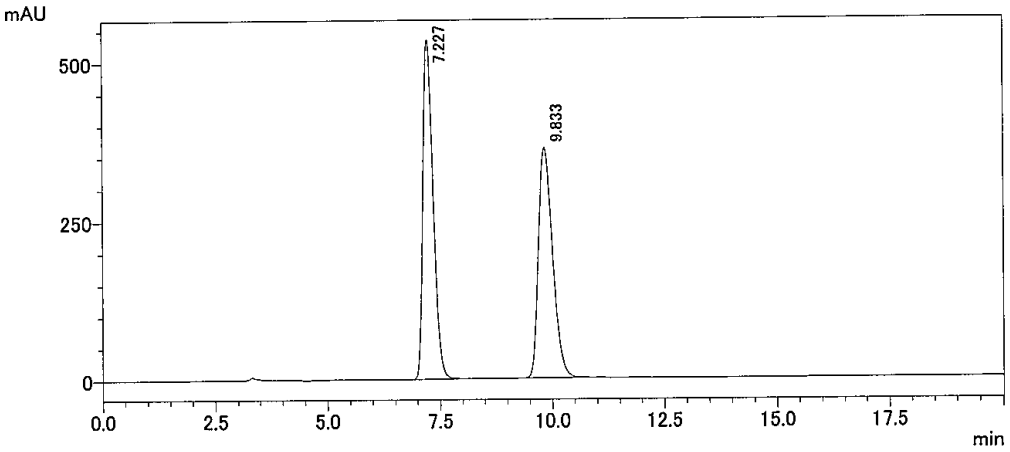
Racemic sample of dipeptide **5gf** in Table 3



=== Shimadzu LabSolutions 分析レポート ===

Sample	:		
ID	:		
Data Name	: 8316-Gly-DL-Phe-IC-B20-1mL.lcd		
Method Name	: B20 c5 1.0ml-20min.lcm		
Batch Nam	: KW-IC-8314-68vial.lcb		
Vial	: 1-68	サンプルタイプ	: Unknown
Inj. Volume	: 1 uL		
Acquisition Date	: 2018/03/16 20:55:16	分析者	: System Administrator
Modified Date	: 2018/03/16 21:15:18	解析者	: System Administrator

<クロマトグラム>

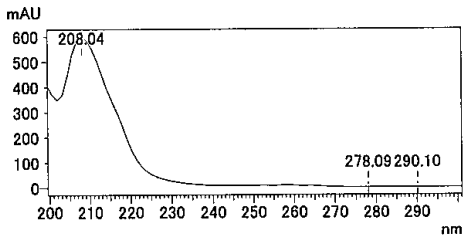


PDA Ch1 210nm

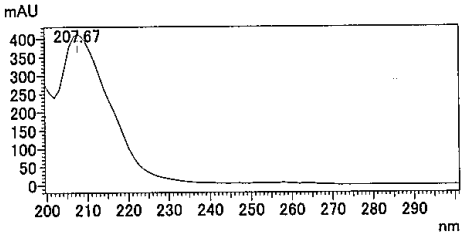
Peak No.	RT (min)	Area	Height	% Area
1	7.227	8505584	535287	51.416
2	9.833	8037132	362349	48.584
Total		16542716	897635	100.000

UVスペクトル

保持時間 : 7.227 min

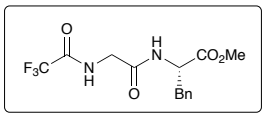


保持時間 : 9.833 min



D:¥Data¥KW¥Method¥8316-Gly-DL-Phe-IC-B20-1mL.lcd

Dipeptide **5gf** in Table 3



=== Shimadzu LabSolutions 分析レポート ===

Sample	:		
ID	:		
Data Name	: 8316-Gly-L-Phe-IC-B20-1mL.lcd		
Method Name	: B20 c5 1.0ml-20min.lcm		
Batch Nam	: KW-IC-8314-69vial.lcb		
Vial	: 1-69	サンプルタイプ	: Unknown
Inj. Volume	: 1 uL		
Acquisition Date	: 2018/03/16 22:57:07	分析者	: System Administrator
Modified Date	: 2018/03/16 23:17:10	解析者	: System Administrator

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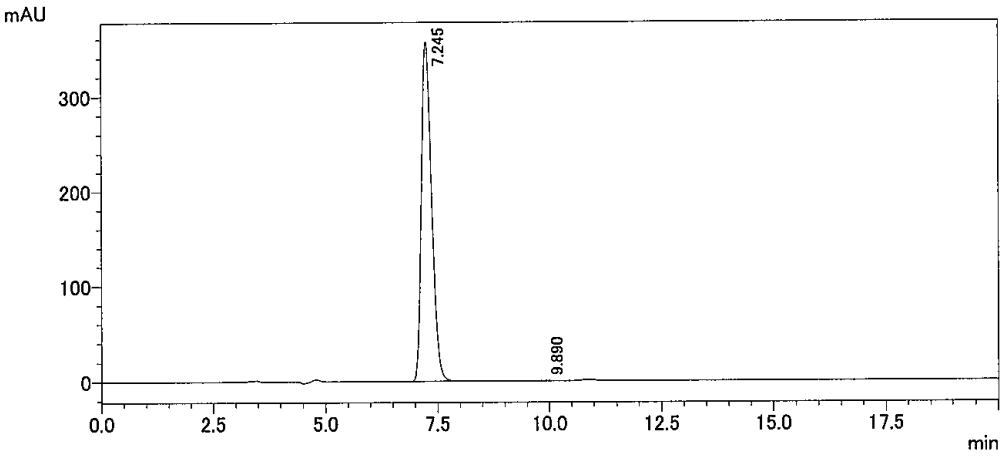
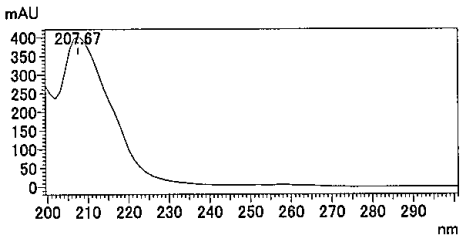


PDA Ch1 210nm

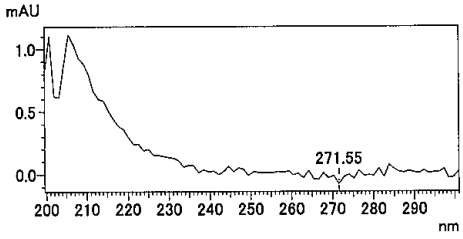
Peak No.	RT (min)	Area	Height	% Area
1	7.245	5613606	356615	99.876
2	9.890	6961	373	0.124
Total		5620567	356988	100.000

UVスペクトル

保持時間 : 7.245 min

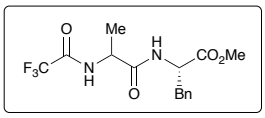


保持時間 : 9.890 min



D:¥Data¥KW¥Method¥8316-Gly-L-Phe-IC-B20-1mL.lcd

Racemic sample of dipeptide **5hf** in Table 3



=== Shimadzu LabSolutions 分析レポート ===

Sample	:		
ID	:		
Data Name	: 8312-1-IC-B20-1mL.lcd		
Method Name	: B20 c5 1.0ml-60min.lcm		
Batch Nam	: KW-IC-IA-8313.lcb		
Vial	: 1-66	サンプルタイプ	: Unknown
Inj. Volume	: 1 uL		
Acquisition Date	: 2018/03/13 19:18:51	分析者	: System Administrator
Modified Date	: 2018/03/13 20:18:53	解析者	: System Administrator

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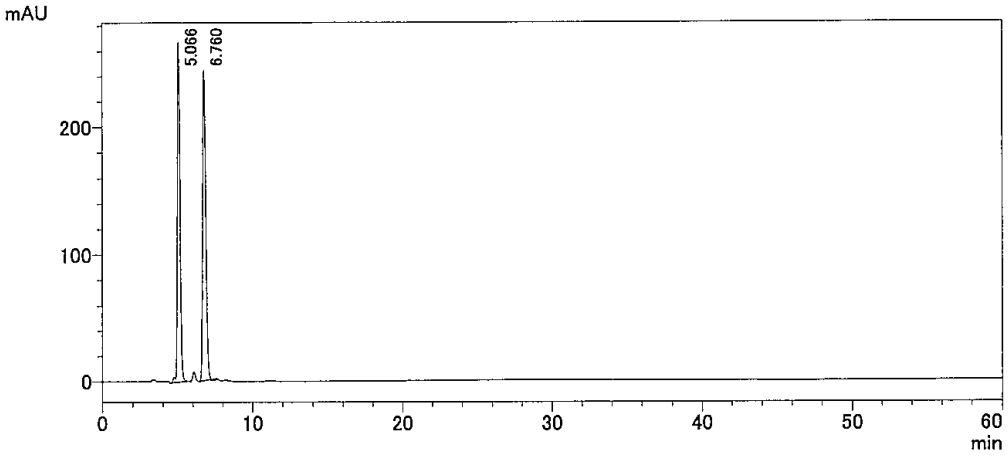
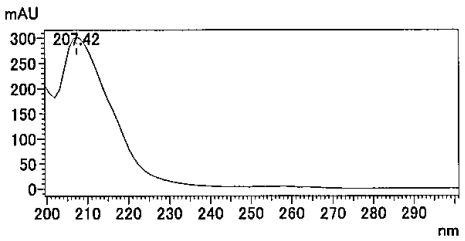


PDA Ch1 210nm

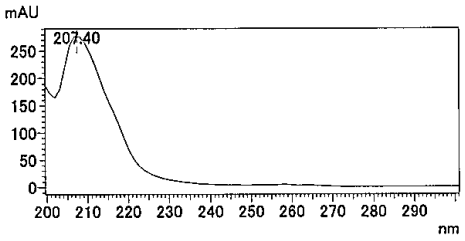
Peak No.	RT (min)	Area	Height	% Area
1	5.066	3244079	267716	47.919
2	6.760	3525899	244043	52.081
Total		6769978	511759	100.000

UVスペクトル

保持時間 : 5.066 min

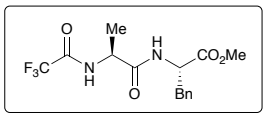


保持時間 : 6.760 min



D:¥Data¥KW¥Method¥8312-1-IC-B20-1mL.lcd

Dipeptide **5hf** in Table 3



=== Shimadzu LabSolutions 分析レポート ===

Sample	:		
ID	:		
Data Name	: 8312-1-CP-IC-B20-1mL.lcd		
Method Name	: B20 c5 1.0ml-20min.lcm		
Batch Nam	: KW-IC-8314.lcb		
Vial	: 1-66	サンプルタイプ	: Unknown
Inj. Volume	: 1 uL		
Acquisition Date	: 2018/03/14 10:34:30	分析者	: System Administrator
Modified Date	: 2018/03/14 10:54:32	解析者	: System Administrator

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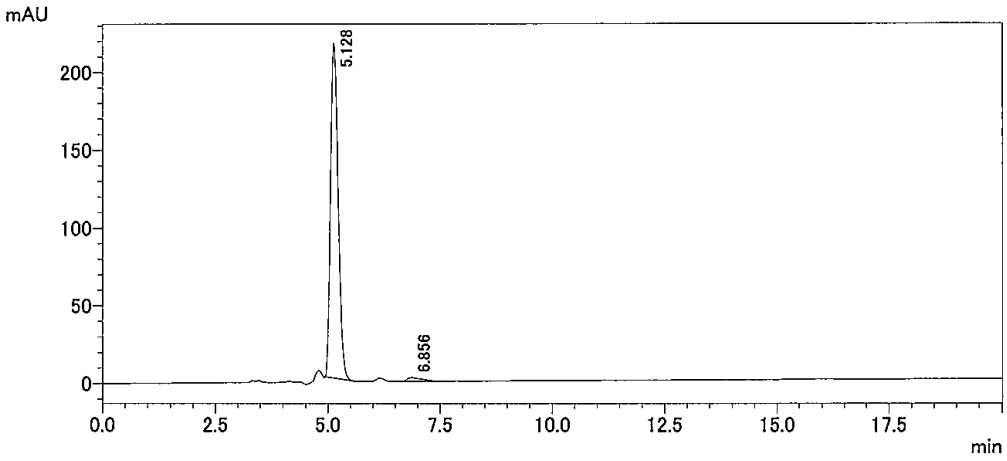
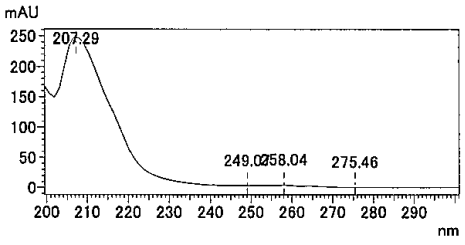


PDA Ch1 210nm

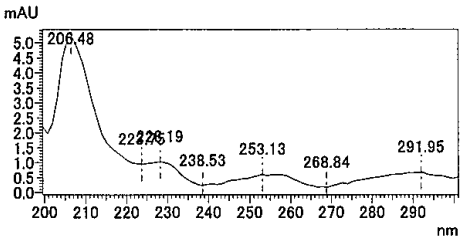
Peak No.	RT (min)	Area	Height	% Area
1	5.128	2518413	215196	97.784
2	6.856	57079	2414	2.216
Total		2575493	217609	100.000

UVスペクトル

保持時間 : 5.128 min

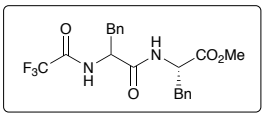


保持時間 : 6.856 min



D:¥Data¥KW¥Method¥8312-1-CP-IC-B20-1mL.lcd

Racemic sample of dipeptide **5if** in Table 3



3/16/2018 3:49:20 PM Page 1 / 1

=== Shimadzu LabSolutions 分析レポート ===

Sample	:		
ID	:		
Data Name	: 8314-2-IC-B20-1mL.lcd		
Method Name	: B20 c5 1.0ml-20min.lcm		
Batch Nam	: KW-IC-8314-68vial.lcb		
Vial	: 1-68	サンプルタイプ	: Unknown
Inj. Volume	: 1 uL		
Acquisition Date	: 2018/03/15 20:58:31	分析者	: System Administrator
Modified Date	: 2018/03/15 21:18:33	解析者	: System Administrator

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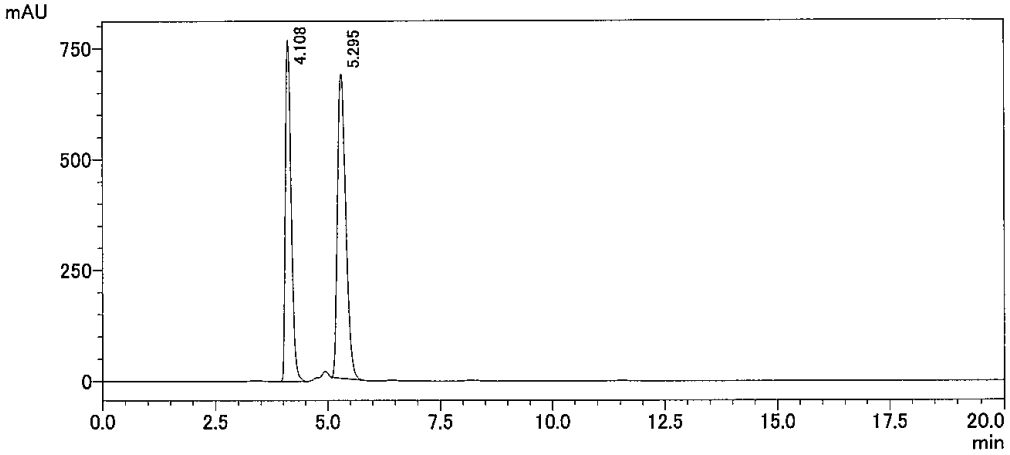
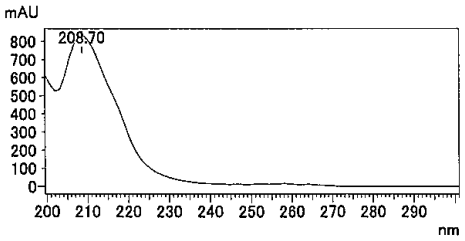


PDA Ch1 210nm

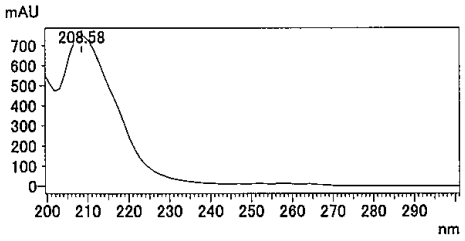
Peak No.	RT (min)	Area	Height	% Area
1	4.108	6975494	768069	44.265
2	5.295	8782960	686393	55.735
Total		15758454	1454463	100.000

UVスペクトル

保持時間 : 4.108 min

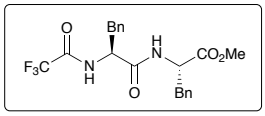


保持時間 : 5.295 min



D:¥Data¥KW¥Method¥8314-2-IC-B20-1mL.lcd

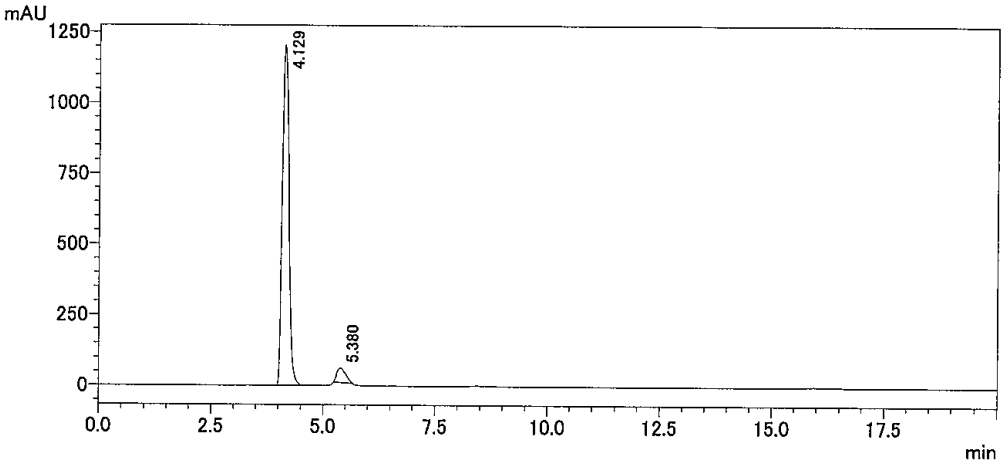
Dipeptide **5if** in Table 3



=== Shimadzu LabSolutions 分析レポート ===

Sample	:		
ID	:		
Data Name	: 8314-2-CP2nd-IC-B20-1mL.lcd		
Method Name	: B20 c5 1.0ml-20min.lcm		
Batch Nam	: KW-IC-8314-67vial.lcb		
Vial	: 1-67	サンプルタイプ	: Unknown
Inj. Volume	: 1 uL		
Acquisition Date	: 2018/03/16 15:20:45	分析者	: System Administrator
Modified Date	: 2018/03/16 15:40:48	解析者	: System Administrator

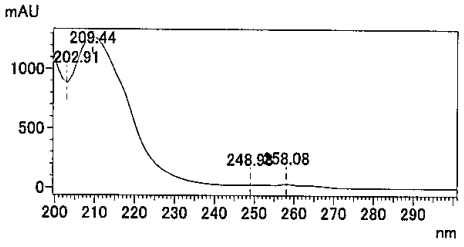
〈クロマトグラム〉



PDA Ch1 210nm

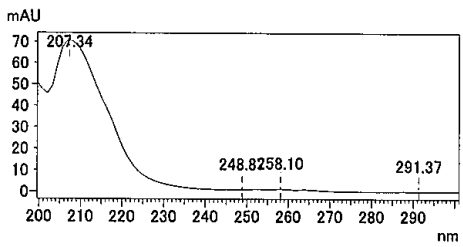
Peak No.	RT (min)	Area	Height	% Area
1	4.129	12419990	1205840	94.598
2	5.380	709184	51520	5.402
Total		13129174	1257361	100.000

保持時間 : 4.129 min



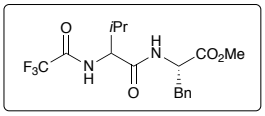
UVスペクトル

保持時間 : 5.380 min



D:¥Data¥KW¥Method¥8314-2-CP2nd-IC-B20-1mL.lcd

Racemic sample of dipeptide **5jf** in Table 3



=== Shimadzu LabSolutions 分析レポート ===

Sample	:		
ID	:		
Data Name	: 8314-1-IC-B20-1mL.lcd		
Method Name	: B20 c5 1.0ml-20min.lcm		
Batch Nam	: KW-IC-8314-67vial.lcb		
Vial	: 1-67	サンプルタイプ	: Unknown
Inj. Volume	: 1 uL		
Acquisition Date	: 2018/03/15 19:57:34	分析者	: System Administrator
Modified Date	: 2018/03/15 20:17:37	解析者	: System Administrator

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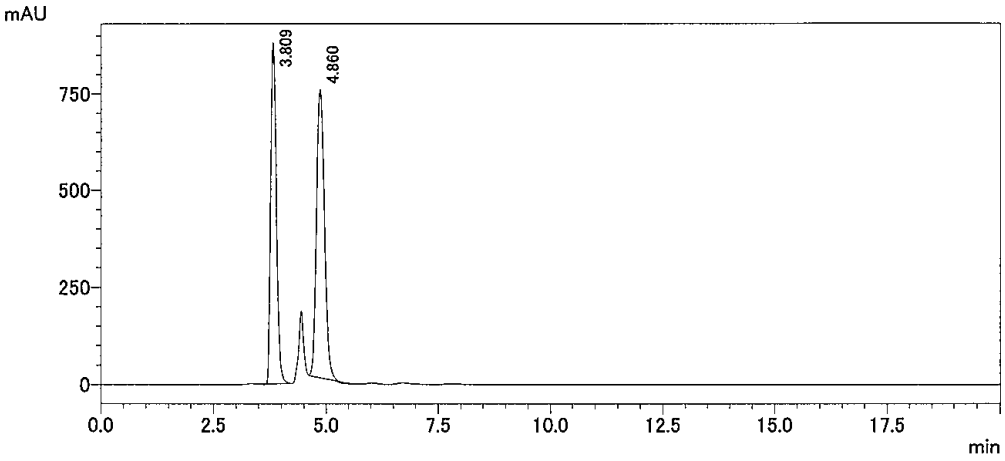
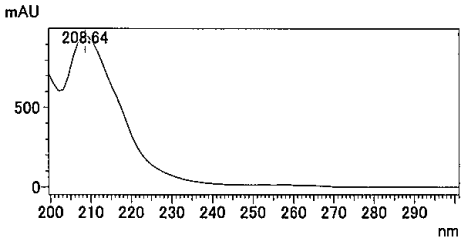


PDA Ch1 210nm

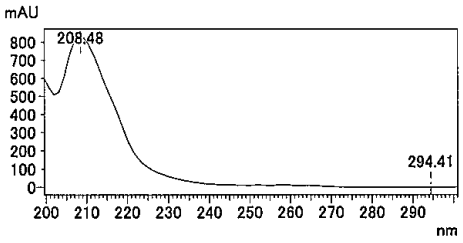
Peak No.	RT (min)	Area	Height	% Area
1	3.809	7688330	879937	45.685
2	4.860	9140792	744607	54.315
Total		16829123	1624544	100.000

UVスペクトル

保持時間 : 3.809 min

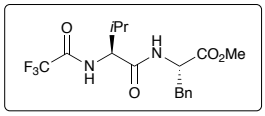


保持時間 : 4.860 min



D:¥Data¥KW¥Method¥8314-1-IC-B20-1mL.lcd

Dipeptide **5jf** in Table 3



=== Shimadzu LabSolutions 分析レポート ===

Sample	:		
ID	:		
Data Name	: 8314-1-CP2th-IC-B20-1mL.lcd		
Method Name	: B20 c5 1.0ml-20min.lcm		
Batch Nam	: KW-IC-8314.lcb		
Vial	: 1-66	サンプルタイプ	: Unknown
Inj. Volume	: 1 uL		
Acquisition Date	: 2018/03/16 14:19:49	分析者	: System Administrator
Modified Date	: 2018/03/16 14:39:52	解析者	: System Administrator

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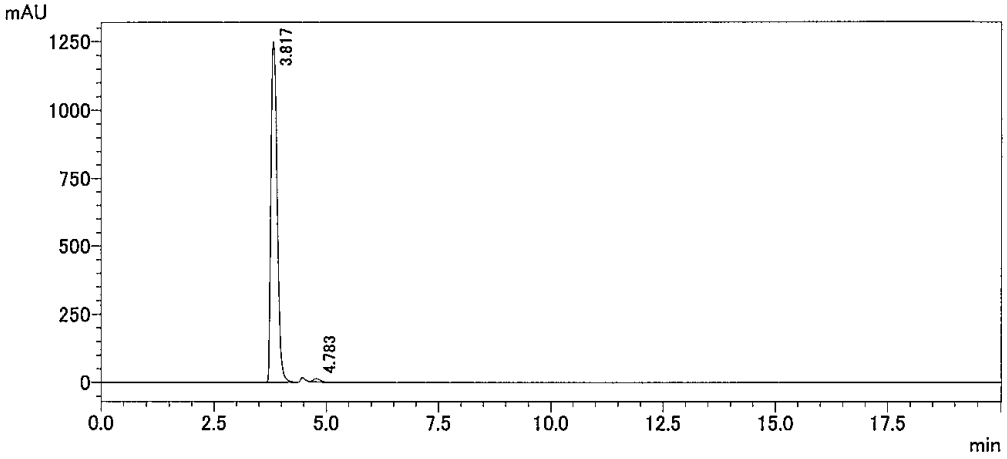
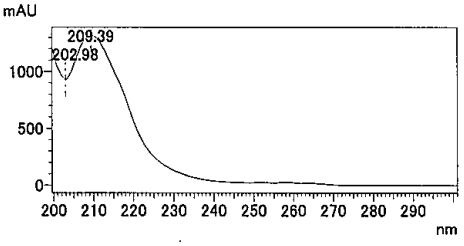


PDA Ch1 210nm

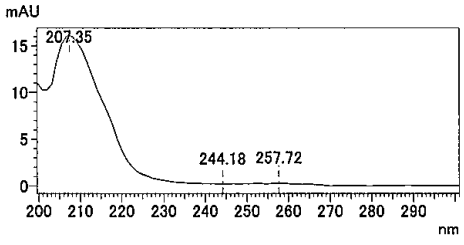
Peak No.	RT (min)	Area	Height	% Area
1	3.817	12278852	1248908	99.057
2	4.783	116938	11173	0.943
Total		12395791	1260081	100.000

UVスペクトル

保持時間 : 3.817 min

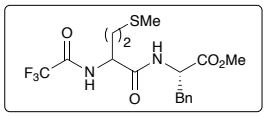


保持時間 : 4.783 min



D:¥Data¥KW¥Method¥8314-1-CP2th-IC-B20-1mL.lcd

Racemic sample of dipeptide **5kf** in Table 3



=== Shimadzu LabSolutions 分析レポート ===

Sample	:		
ID	:		
Data Name	: 8312-2-IC-B20-1mL.lcd		
Method Name	: B20 c5 1.0ml-20min.lcm		
Batch Nam	: KW-IC-8314-67vial.lcb		
Vial	: 1-67	サンプルタイプ	: Unknown
Inj. Volume	: 1 uL		
Acquisition Date	: 2018/03/14 11:35:26	分析者	: System Administrator
Modified Date	: 2018/03/14 11:55:29	解析者	: System Administrator

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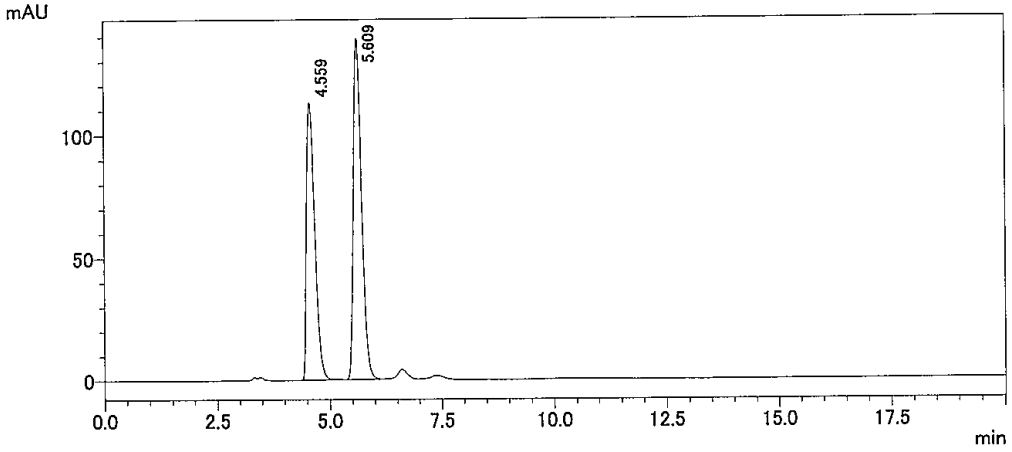
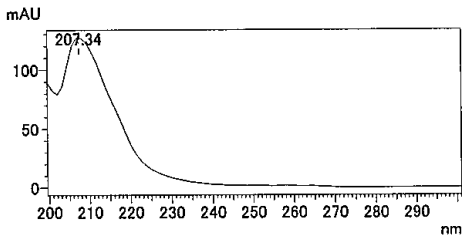


PDA Ch1 210nm

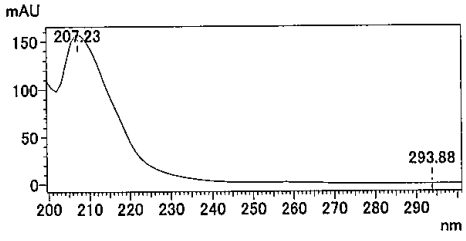
Peak No.	RT (min)	Area	Height	% Area
1	4.559	1432573	113072	44.718
2	5.609	1771029	138765	55.282
Total		3203602	251837	100.000

UVスペクトル

保持時間 : 4.559 min

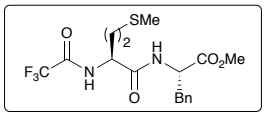


保持時間 : 5.609 min



D:¥Data¥KW¥Method¥8312-2-IC-B20-1mL.lcd

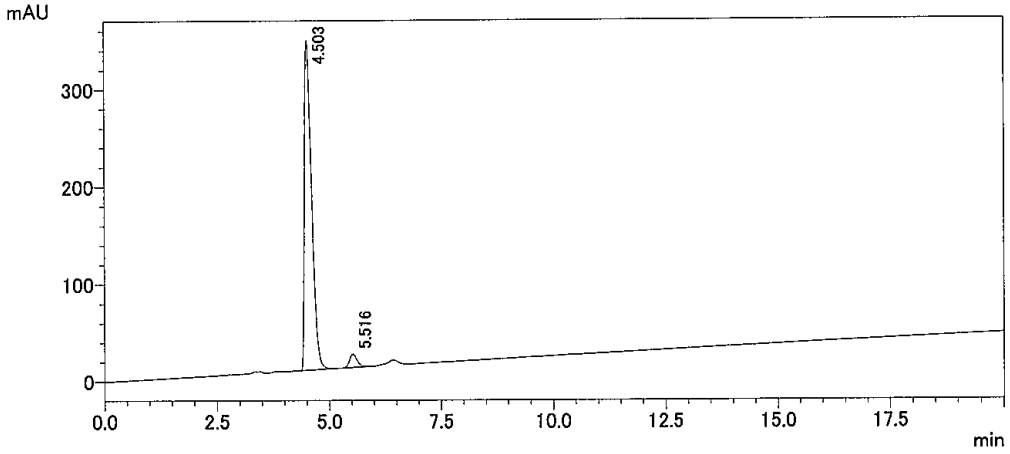
Dipeptide **5kf** in Table 3



=== Shimadzu LabSolutions 分析レポート ===

Sample	:		
ID	:		
Data Name	: 8312-2-CP-IC-B20-1mL.lcd		
Method Name	: B20 c5 1.0ml-20min.lcm		
Batch Nam	: KW-IC-8314.lcb		
Vial	: 1-66	サンプルタイプ	: Unknown
Inj. Volume	: 1 uL		
Acquisition Date	: 2018/03/14 14:16:29	分析者	: System Administrator
Modified Date	: 2018/03/14 14:36:32	解析者	: System Administrator

<クロマトグラム>

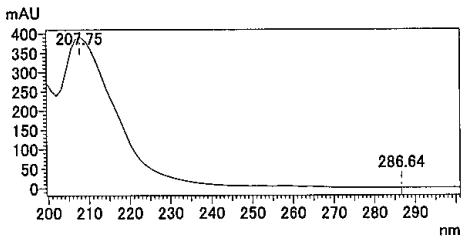


PDA Ch1 210nm

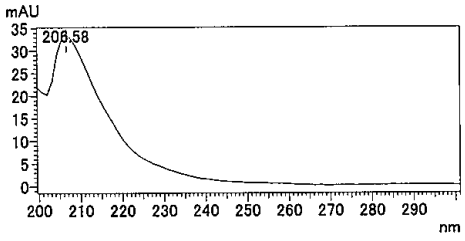
Peak No.	RT (min)	Area	Height	% Area
1	4.503	3769490	339055	95.832
2	5.516	163948	13743	4.168
Total		3933437	352798	100.000

UVスペクトル

保持時間 : 4.503 min

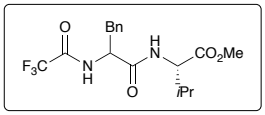


保持時間 : 5.516 min



D:¥Data¥KW¥Method¥8312-2-CP-IC-B20-1mL.lcd

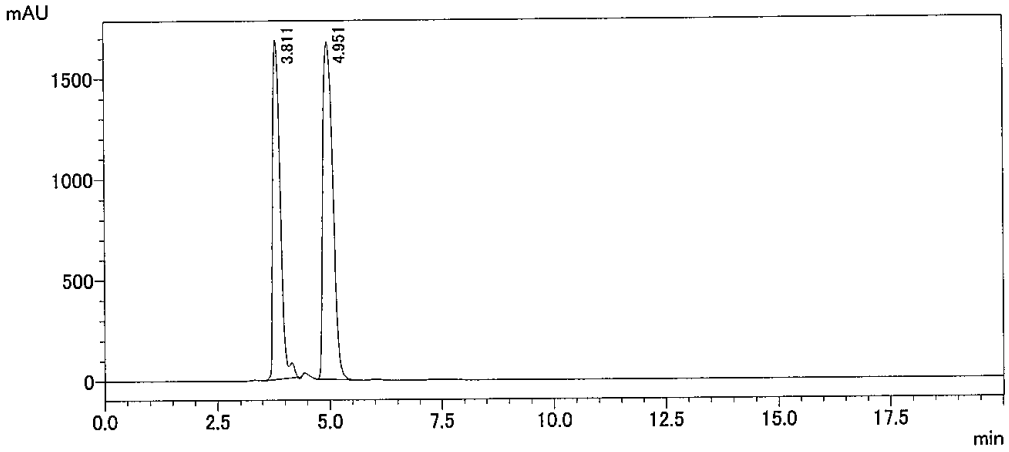
Racemic sample of dipeptide **5id** in Table 3



=== Shimadzu LabSolutions 分析レポート ===

Sample	:		
ID	:		
Data Name	: 8314-4-IC-B20-1mL.lcd		
Method Name	: B20 c5 1.0ml-20min.lcm		
Batch Nam	: KW-IC-8314-70vial.lcb		
Vial	: 1-70	サンプルタイプ	: Unknown
Inj. Volume	: 1 uL		
Acquisition Date	: 2018/03/15 23:00:25	分析者	: System Administrator
Modified Date	: 2018/03/15 23:20:27	解析者	: System Administrator

<クロマトグラム>

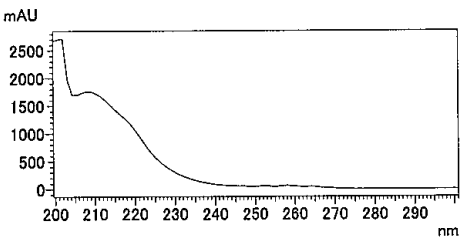


PDA Ch1 210nm

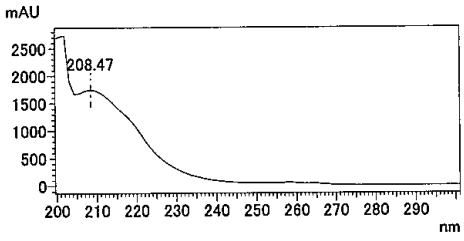
Peak No.	RT (min)	Area	Height	% Area
1	3.811	19603050	1682371	43.582
2	4.951	25376458	1673025	56.418
Total		44979508	3355396	100.000

UVスペクトル

保持時間 : 3.811 min

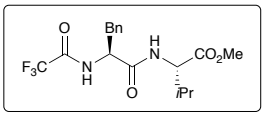


保持時間 : 4.951 min



D:¥Data¥KW¥Method¥8314-4-IC-B20-1mL.lcd

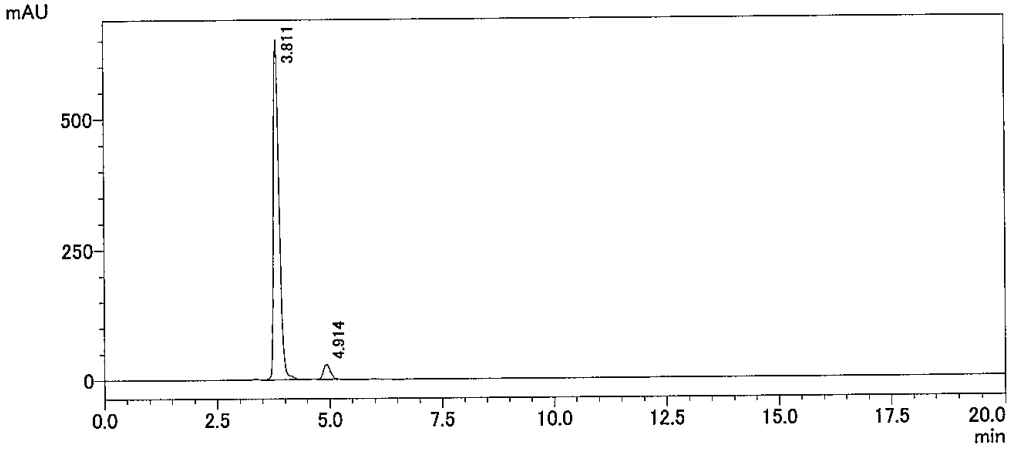
Dipeptide **5id** in Table 3



=== Shimadzu LabSolutions 分析レポート ===

Sample	:		
ID	:		
Data Name	: 8314-4-CP-IC-B20-1mL.lcd		
Method Name	: B20 c5 1.0ml-20min.lcm		
Batch Nam	: KW-IC-8314-68vial.lcb		
Vial	: 1-68	サンプルタイプ	: Unknown
Inj. Volume	: 1 uL		
Acquisition Date	: 2018/03/14 21:00:44	分析者	: System Administrator
Modified Date	: 2018/03/14 21:20:48	解析者	: System Administrator

<クロマトグラム>

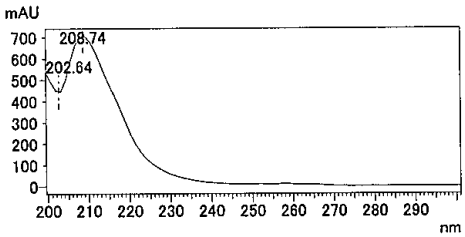


PDA Ch1 210nm

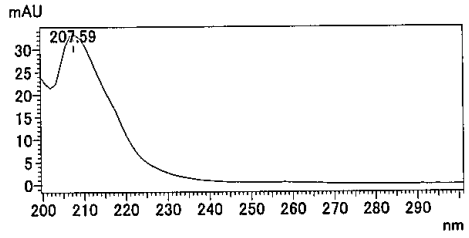
Peak No.	RT (min)	Area	Height	% Area
1	3.811	5657417	651943	94.699
2	4.914	316678	28771	5.301
Total		5974095	680713	100.000

UVスペクトル

保持時間 : 3.811 min

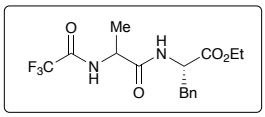


保持時間 : 4.914 min



D:¥Data¥KW¥Method¥8314-4-CP-IC-B20-1mL.lcd

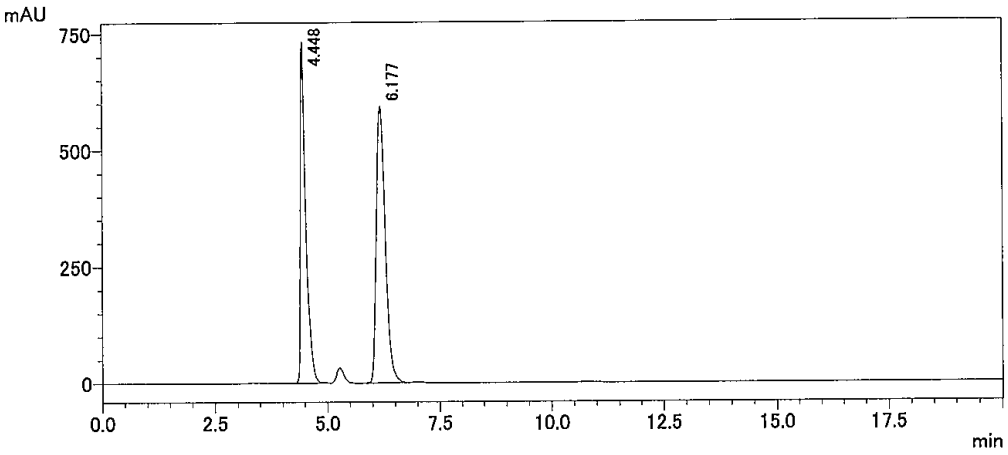
Racemic sample of dipeptide **5hg** in Table 3



=== Shimadzu LabSolutions 分析レポート ===

Sample	:		
ID	:		
Data Name	: 8314-3-IC-B20-1mL.lcd		
Method Name	: B20 c5 1.0ml-20min.lcm		
Batch Nam	: KW-IC-8314-69vial.lcb		
Vial	: 1-69	サンプルタイプ	: Unknown
Inj. Volume	: 1 uL		
Acquisition Date	: 2018/03/15 21:59:28	分析者	: System Administrator
Modified Date	: 2018/03/15 22:19:30	解析者	: System Administrator

〈クロマトグラム〉

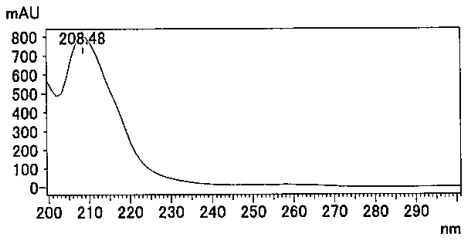


PDA Ch1 210nm

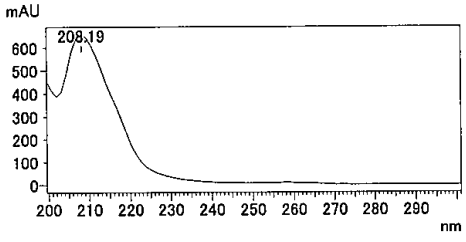
Peak No.	RT (min)	Area	Height	% Area
1	4.448	5971002	731750	42.364
2	6.177	8123473	592503	57.636
Total		14094476	1324253	100.000

UVスペクトル

保持時間 : 4.448 min

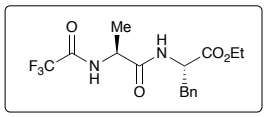


保持時間 : 6.177 min



D:¥Data¥KW¥Method¥8314-3-IC-B20-1mL.lcd

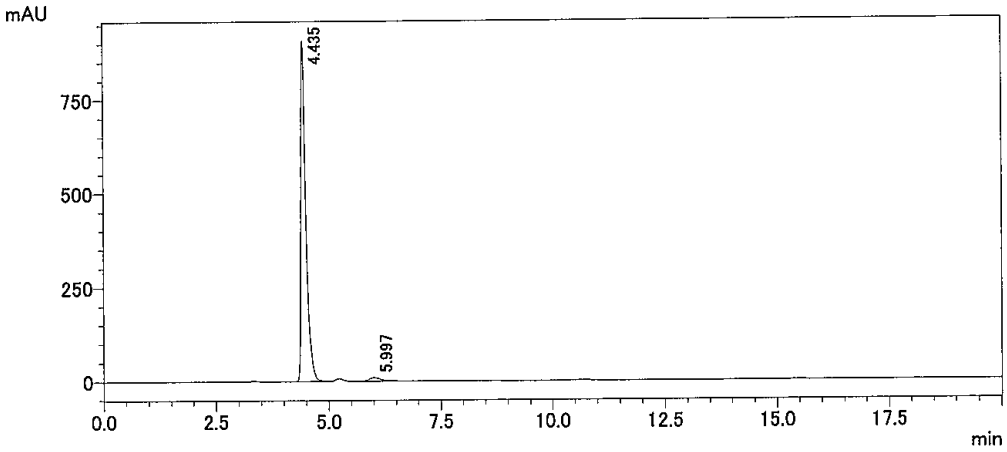
Dipeptide **5hg** in Table 3



=== Shimadzu LabSolutions 分析レポート ===

Sample	:		
ID	:		
Data Name	: 8314-3-CP-IC-B20-1mL.lcd		
Method Name	: B20 c5 1.0ml-20min.lcm		
Batch Nam	: KW-IC-8314-69vial.lcb		
Vial	: 1-69	サンプルタイプ	: Unknown
Inj. Volume	: 1 uL		
Acquisition Date	: 2018/03/14 22:01:42	分析者	: System Administrator
Modified Date	: 2018/03/14 22:21:45	解析者	: System Administrator

<クロマトグラム>

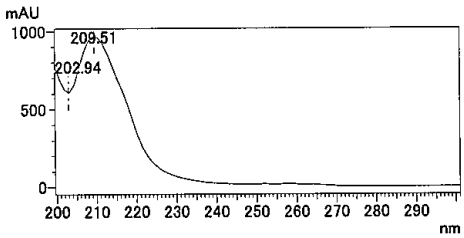


PDA Ch1 210nm

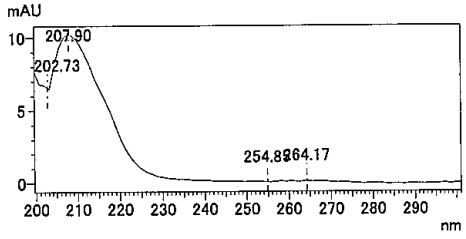
Peak No.	RT (min)	Area	Height	% Area
1	4.435	6886991	908290	97.293
2	5.997	191593	9436	2.707
Total		7078585	917726	100.000

UVスペクトル

保持時間 : 4.435 min

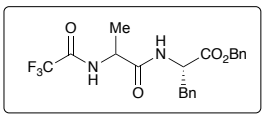


保持時間 : 5.997 min



D:¥Data¥KW¥Method¥8314-3-CP-IC-B20-1mL.lcd

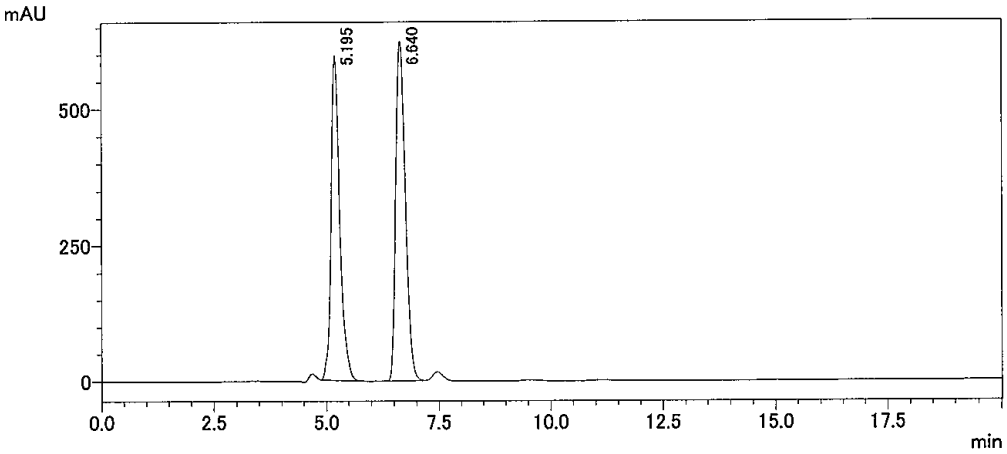
Racemic sample of dipeptide **5hh** in Table 3



=== Shimadzu LabSolutions 分析レポート ===

Sample	:		
ID	:		
Data Name	: 8313-3-IC-B20-1mL.lcd		
Method Name	: B20 c5 1.0ml-20min.lcm		
Batch Nam	: KW-IC-8314.lcb		
Vial	: 1-66	サンプルタイプ	: Unknown
Inj. Volume	: 1 uL		
Acquisition Date	: 2018/03/15 18:56:37	分析者	: System Administrator
Modified Date	: 2018/03/15 19:16:40	解析者	: System Administrator

<クロマトグラム>

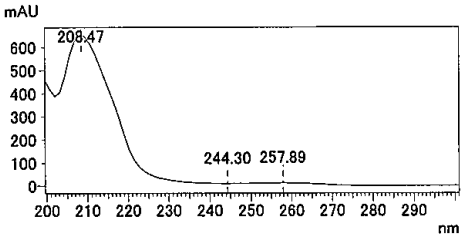


PDA Ch1 210nm

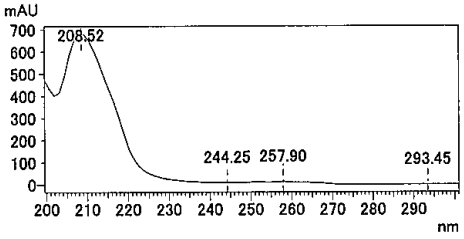
Peak No.	RT (min)	Area	Height	% Area
1	5.195	8121429	596004	47.045
2	6.640	9141597	623883	52.955
Total		17263026	1219887	100.000

UVスペクトル

保持時間 : 5.195 min

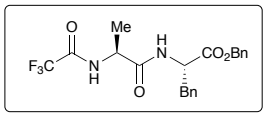


保持時間 : 6.640 min



D:¥Data¥KW¥Method¥8313-3-IC-B20-1mL.lcd

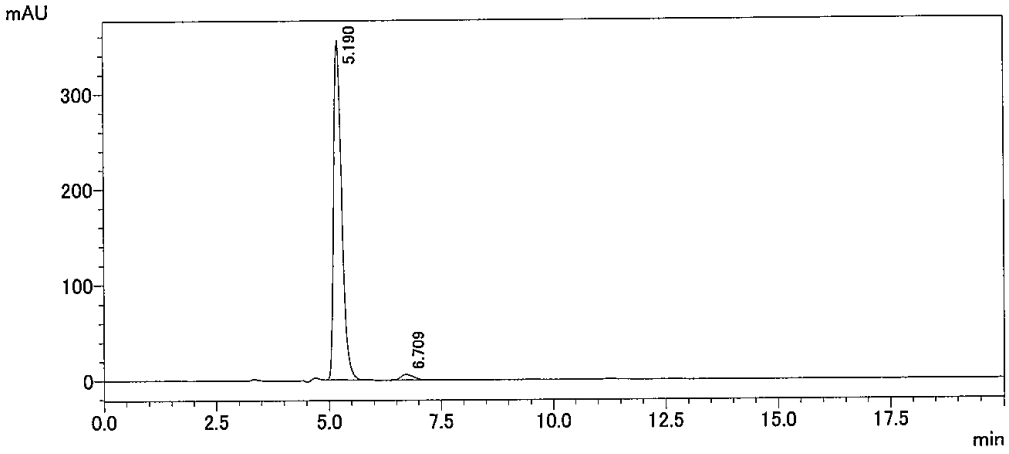
Dipeptide **5hh** in Table 3



=== Shimadzu LabSolutions 分析レポート ===

Sample	:		
ID	:		
Data Name	: 8313-3-CP-IC-B20-1mL.lcd		
Method Name	: B20 c5 1.0ml-20min.lcm		
Batch Nam	: KW-IC-8314-70vial.lcb		
Vial	: 1-70	サンプルタイプ	: Unknown
Inj. Volume	: 1 uL		
Acquisition Date	: 2018/03/14 23:02:39	分析者	: System Administrator
Modified Date	: 2018/03/14 23:22:42	解析者	: System Administrator

<クロマトグラム>

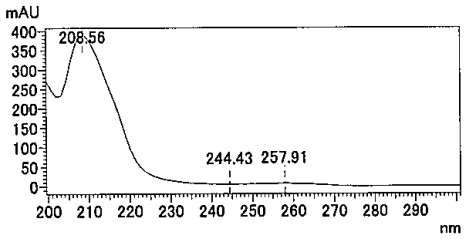


PDA Ch1 210nm

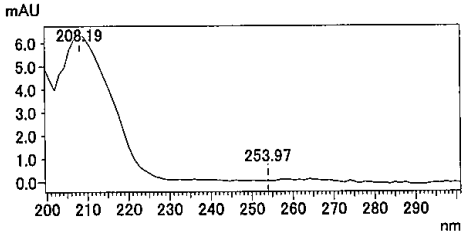
Peak No.	RT (min)	Area	Height	% Area
1	5.190	4394984	355667	97.454
2	6.709	114819	5765	2.546
Total		4509803	361431	100.000

UVスペクトル

保持時間 : 5.190 min



保持時間 : 6.709 min



D:¥Data¥KW¥Method¥8313-3-CP-IC-B20-1mL.lcd