Supplementary Information

Ritter-Type Iodo(III)amidation of Unactivated Alkynes for the Synthesis of Multisubstituted Enamides

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Contents

Materials and Methods

General. All reactions dealing with air- or moisture-sensitive compound were performed by standard Schlenk techniques in oven-dried reaction vessels under nitrogen atmosphere or in the argon-filled glove box. Analytical thin-layer chromatography (TLC) was performed on Merck 60 F254 silica gel plates. ^{1}H and ^{13}C nuclear magnetic resonance (NMR) spectra were recorded on Bruker AV-400 (400 MHz) or Bruker AV-500 (500 MHz) spectrometers. ^{1}H and ^{13}C NMR spectra are reported in parts per million (ppm) downfield from an internal standard, tetramethylsilane (0 ppm) and $CHCl_3$ (77.0 ppm), or MeOH (3.31 ppm) and MeOH (49.00 ppm), respectively. High-resolution mass spectra (HRMS) were obtained with a Q-Tof Premier LC HR mass spectrometer. Melting points were determined using a capillary melting point apparatus and are uncorrected.

Materials. Unless otherwise noted, commercial reagents were purchased from Aldrich, Alfa Aesar, and other commercial suppliers and were used as received. MeCN and DCM were distilled over CaH_2 and stored under N_2. THF was distilled over Na and stored under N_2. Hexafluoroisopropanol (HFIP) was distilled over Mg and stored under N_2. Anhydrous DMF (Alfa Aesar) were used without further purification and stored under N_2. Deionized water was used for the reaction, while tap water was used in the workup procedure. Alkynes **2d,**[1] **2h**, [2] **2i**,[3] **2j**-**2p**,[4] and **2q**[5] were prepared according to the literature procedure, and other alkynes were purchased from commercial suppliers. All nitriles were purchased from commercial suppliers, and except for MeCN, used as received. 3,3-Bis(trifluoromethyl)-1λ^3-benzo[*d*][1,2]iodaoxol-1(3*H*)-yl trifluoromethanesulfonate (benziodoxole triflate, BXT, **1**) was prepared according to the literature procedure.[4a]

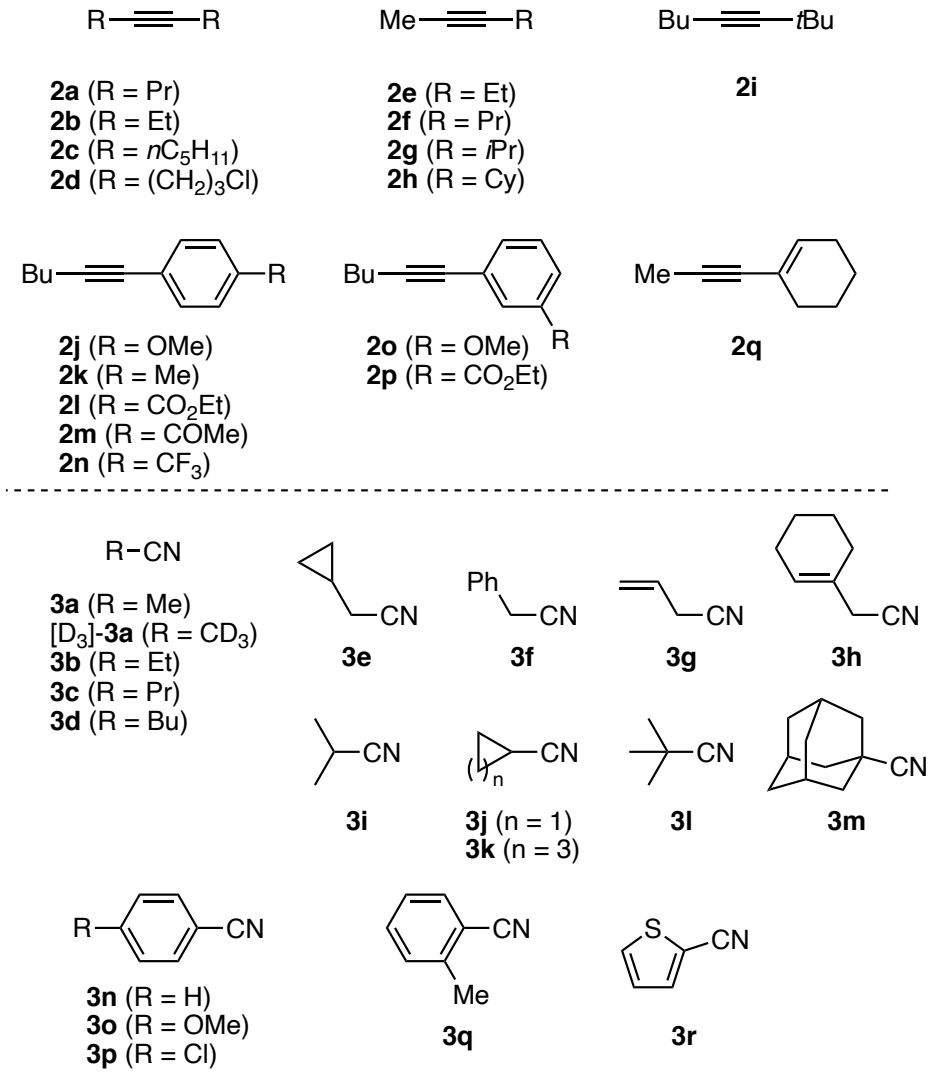
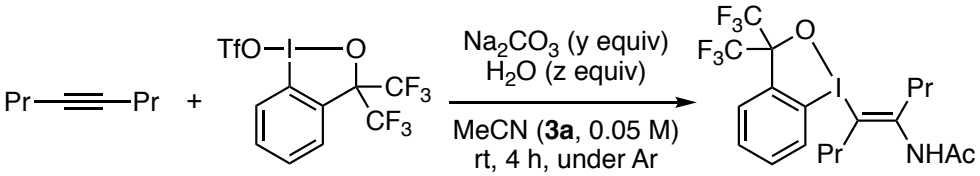


Figure S1. Alkynes and nitriles used in this study.

Optimization of Reaction Conditions

Table S1. Iodo(III)acetamidation of alkyne **2a** in MeCN[a]

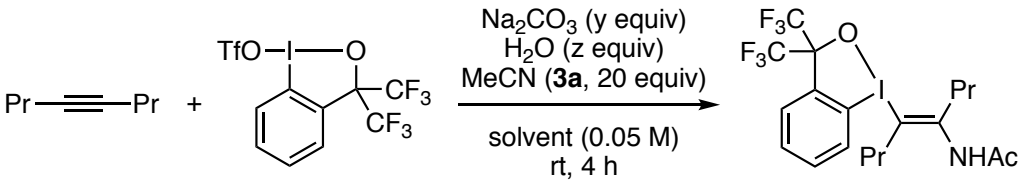


2a **1** (x equiv) **4aa**

entry	x	y	z	yield (%)[b]
1	1.5	1.0	2.0	40
2	1.5	2.0	2.0	61
3	1.5	3.0	2.0	66
4	1.5	3.0	1.5	71
5	1.5	3.0	1.0	78
6	2.0	3.0	1.0	90
7[c]	2.0	3.0	1.0	79
8[d]	2.0	3.0	1.0	83
9[e]	2.0	3.0	1.0	90
10[f]	1.5	3.0	0	31
11[f]	1.5	3.0	0.5	65
12[f]	1.5	3.0	1.0	54
13[f]	1.5	3.0	2.0	48

[a] The reaction was performed on a 0.1 mmol scale. [b] Determined by ^{19}F NMR using 1,4-bis(trifluoromethyl)benzene as the internal standard. [c] Performed at 0.4 M. [d] Performed at 0.2 M. [e] Performed at 0.1 M. [f] The reaction was set up in an open air at a concentration of 0.2 M. Caution is needed for these entries as significant batch-to-batch variation was observed.

Table S2. Iodo(III)acetamidation of alkyne **2a** in HFIP[a]

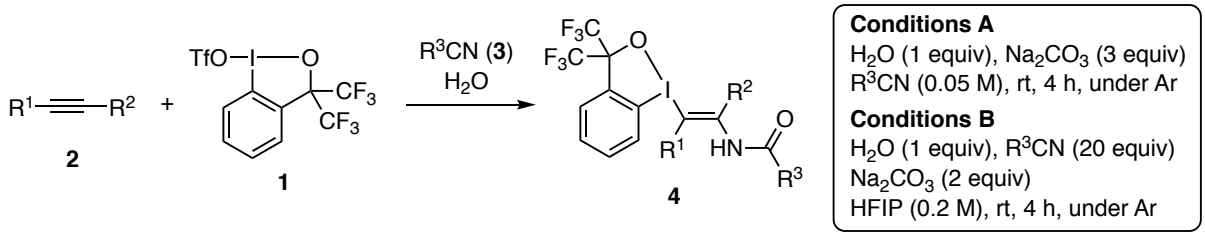


2a **1** (x equiv) **4aa**

entry	x	y	z	solvent	yield (%)[b]
1	1.5	3.0	2.0	DCE	nd[c]
2	1.5	3.0	2.0	toluene	nd[c]
3	1.5	3.0	2.0	TFE	36
4	1.5	2.0	2.0	HFIP	63
5[d]	1.5	2.0	2.0	HFIP	66
6[e]	1.5	3.0	1.0	HFIP	70
7[e]	2.0	3.0	1.0	HFIP	85
8[e]	3.0	3.0	1.0	HFIP	84
9[e]	2.0	2.0	1.0	HFIP	88
10[f]	1.5	3.0	2.0	HFIP	16
11[g]	1.5	3.0	2.0	HFIP	33
12[h]	1.5	3.0	2.0	HFIP	51

[a] The reaction was performed on a 0.1 mmol scale. [b] Determined by ^{19}F NMR using 1,4-bis(trifluoromethyl)benzene as the internal standard. [c] Not detected. [d] Performed at 0.1 M. [e] Performed at 0.2 M. [f] 2 equiv of MeCN was used. [g] 5 equiv of MeCN was used. [h] 10 equiv of MeCN was used.

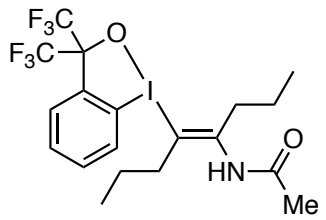
General Procedures and Product Characterization



General Procedure A: In an argon-filled glove box, an 8-mL vial equipped with a magnetic stir bar was charged sequentially with Na_2CO_3 (63.6 mg, 0.60 mmol), nitrile (4 mL), alkyne (0.20 mmol), and H_2O (3.6 mg, 0.20 mmol), followed by the addition of BXT (207 mg, 0.40 mmol). The vial was closed and taken out of the glove box. The resulting mixture was vigorously stirred (1500 rpm) at room temperature for 4 h. H_2O (10 mL) was added, and then the mixture was extracted with EtOAc (10 mL x 3). The combined organic layer was washed with H_2O (10 mL) and brine (10 mL), dried over $MgSO_4$, and concentrated under reduced pressure. The residue was purified by flash chromatography on silica gel to afford the desired product.

General Procedure B: In an argon-filled glove box, a 4-mL vial equipped with a magnetic stir bar was charged sequentially with Na_2CO_3 (42.4 mg, 0.40 mmol), hexafluoroisopropanol (HFIP, 1 mL), nitrile (4 mmol), alkyne (0.20 mmol), and H_2O (3.6 mg, 0.20 mmol), followed by the addition of BXT (207 mg, 0.40 mmol). The vial was closed and taken out of the glove box. The resulting mixture was vigorously stirred (1500 rpm) at room temperature for 4 h. H_2O (10 mL) was added, and then the mixture was extracted with EtOAc (10 mL x 3). The combined organic layer was washed with H_2O (10 mL) and brine (10 mL), dried over $MgSO_4$, and concentrated under reduced pressure. The residue was purified by flash chromatography on silica gel to afford the desired product.

Note: The yield of the reaction would be affected by the rate of stirring; Slow or inefficient stirring would lead to lower yields. In the above procedure, once all the reagents and solvents have been introduced into the vial in the glove box, it should be transferred to the stirrer outside the glovebox as quickly as possible.



(*E*)-*N*-(5-(3,3-Bis(trifluoromethyl)-1λ^3-benzo[*d*][1,2]iodaoxol-1(3*H*)-yl)oct-4-en-4 yl)acetamide (4aa): Synthesized by the general procedure A in 85% yield (91.3 mg) or by the general procedure B in 87% yield (93.5 mg); White solid; R_f 0.3 (Et_2O/EtOAc = 2/1); m.p. 162-164 °C; ^{1}H NMR (400 MHz, CD_3OD) δ 8.12 (dd, *J* = 8.0, 1.2 Hz, 1H), 7.82 (d, *J* = 7.2 Hz, 1H), 7.68-7.60 (m, 2H), 2.66 (brs, 2H), 2.45 (brs, 2H), 2.13 (s, 3H), 1.73-1.49 (brs, 2H), 1.49-1.32 (brs, 2H), 0.93 (t, *J* = 7.2 Hz, 3H), 0.83 (t, *J* = 7.3 Hz, 3H). The signal of the amide proton was merged with that of the methanol proton at 4.86 ppm. All the β-iodanyl enamides reported here displayed the same behavior in CD_3OD; ^{13}C NMR (100 MHz, CD_3OD) δ 171.8, 148.4, 133.6, 133.5, 131.5, 131.3, 130.7, 125.6 (q, $^1J_{C\text{-}F}$ = 289.7 Hz), 122.5, 110.9, 83.1-81.9 (m), 41.1, 39.3, 23.5, 22.8, 21.8, 14.0, 13.9; ^{19}F NMR (376 MHz, CD_3OD) δ -77.2; HRMS (ESI) Calcd for $C_{19}H_{23}F_6INO_2$ $[M + H]^+$ 538.0678, found 538.0670. Recrystallization from hexane/ethyl acetate afforded single crystals suitable for X-ray diffraction analysis, which unambiguously confirmed the molecular structure of **4aa** (Figure S2 and Table S3).[6]

Procedure for a 2-mmol scale reaction: In an argon-filled glove box, a 100-mL Schlenk tube equipped with a magnetic stir bar was charged sequentially with Na_2CO_3 (636 mg, 6.0 mmol), MeCN (40 mL), 4-octyne (220 mg, 2.0 mmol), and H_2O (36 mg, 2.0 mmol), followed by the addition of BXT (2.07 g, 4.0 mmol). The vial was closed and taken out of the glove box. The resulting mixture was vigorously stirred (1500 rpm) at room temperature for 8 h. H_2O (10 mL) was added, and then the mixture was extracted with EtOAc (100 mL x 3). The combined organic layer was washed with H_2O (100 mL) and brine (100 mL), dried over $MgSO_4$, and concentrated under reduced pressure. The residue was purified by flash chromatography on silica gel to afford the desired product (white solid, 0.77 g, 72%).

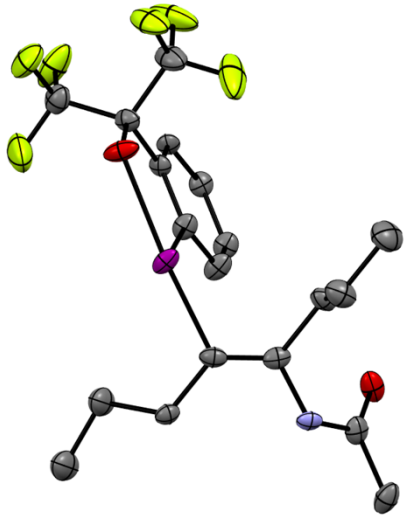
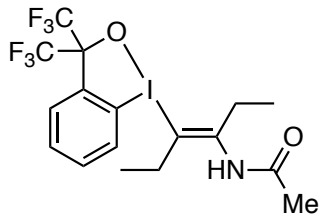


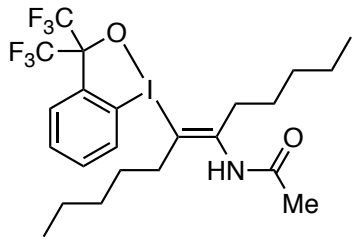
Figure S2. ORTEP drawing of **4aa** (thermal ellipsoids shown at 50% probability level).

Table S3. Crystal data and structure refinement for **4aa**

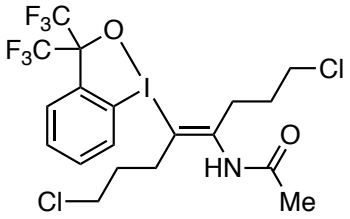
Identification code	ito117m	
Chemical formula	$C_{19}H_{22}F_6INO_2$	
Formula weight	537.27 g/mol	
Temperature	100(2) K	
Wavelength	0.71073 Å	
Crystal size	0.010 x 0.100 x 0.220 mm	
Crystal habit	colorless plate	
Crystal system	monoclinic	
Space group	P 1 21/c 1	
Unit cell dimensions	a = 10.9318(5) Å	α = 90°
	b = 28.7192(12) Å	β = 92.8262 (19)°
	c = 13.4936(5) Å	γ = 90°
Volume	4231.2(3) $Å^3$	
Z	8	
Density (calculated)	1.687 g/cm^3	
Absorption coefficient	1.580 mm^{-1}	
F (000)	2128	
Theta range for data collection	2.00 to 28.74°	
Index ranges	-14<=h<=14, -38<=k<=38, -14<=l<=18	
Reflections collected	40809	
Independent reflections	10915 [R(int) = 0.1026]	
Coverage of independent reflections	99.5%	
Max. and min. transmission	0.9840 and 0.7230	
Structure solution program	XT, VERSION 2018/2	
Refinement method	Full-matrix least-squares on F2	
Refinement program	SHELXL-2018/3 (Sheldrick, 2018)	
Function minimized	Σ w(Fo2 - Fc2)2	
Data / restraints / parameters	10915 / 2145 / 881	
Goodness-of-fit on F2	1.077	
Final R indices	7437 data; I>2σ(I)	R1 = 0.0669, wR2 = 0.1307
	all data	R1 = 0.1108, wR2 = 0.1466
Weighting scheme	$w=1/[\sigma^2(F_o^2)+(0.0398P)^2+15.6109P]$	
Largest diff. peak and hole	1.814 and -1.904 $eÅ^{-3}$	
R.M.S. deviation from mean	0.168 $eÅ^{-3}$	



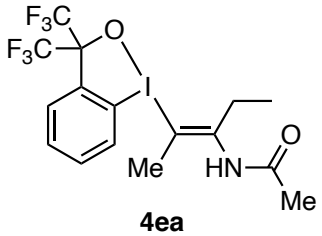
(*E*)-*N*-(4-(3,3-Bis(trifluoromethyl)-1λ^3-benzo[*d*][1,2]iodaoxol-1(3*H*)-yl)hex-3-en-3-yl) acetamide (4ba): Synthesized by the general procedure A in 81% yield (82.5 mg) or by the general procedure B in 88% yield (89.6 mg); White solid; R_f 0.2 (Et_2O/EtOAc = 2/1); m.p. 185-187 °C; ^{1}H NMR (400 MHz, CD_3OD) δ 8.12 (dd, *J* = 8.0, 0.8 Hz, 1H), 7.82 (d, *J* = 7.2 Hz, 1H), 7.67-7.59 (m, 2H), 3.00-2.25 (brs, 4H), 2.14 (s, 3H), 1.07 (t, *J* = 7.4 Hz, 3H), 0.97 (t, *J* = 7.4 Hz, 3H); ^{13}C NMR (100 MHz, CD_3OD) δ 172.1, 148.8, 133.7, 133.5, 131.5, 131.3, 130.7, 125.6 (q, $^1J_{C\text{-}F}$ = 288.7 Hz), 123.7, 110.8, 83.1-82.0 (m), 32.7, 30.5, 22.7, 13.9, 12.0; ^{19}F NMR (376 MHz, CD_3OD) δ -77.3; HRMS (ESI) Calcd for $C_{17}H_{19}F_6INO_2$ $[M + H]^+$ 510.0365, found 510.0366.



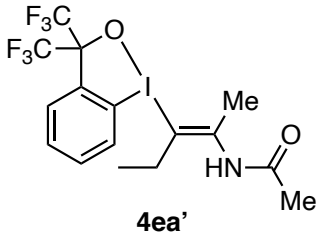
(*E*)-*N*-(7-(3,3-Bis(trifluoromethyl)-1λ^3-benzo[*d*][1,2]iodaoxol-1(3*H*)-yl)dodec-6-en-6-yl) acetamide (4ca): Synthesized by the general procedure A in 80% yield (94.9 mg) or by the general procedure B in 83% yield (98.5 mg); White solid; R_f 0.3 (Et_2O/EtOAc = 3/1); m.p. 141-143 °C; ^{1}H NMR (400 MHz, CD_3OD) δ 8.14-8.11 (m, 1H), 7.82 (d, *J* = 7.0 Hz, 1H), 7.68-7.60 (m, 2H), 2.72 (brs, 2H), 2.44 (brs, 2H), 2.13 (s, 3H), 1.65-1.44 (brs, 2H), 1.44-1.34 (brs, 2H), 1.29-1.30 (m, 4H), 1.20-1.16 (m, 4H), 0.86 (t, *J* = 6.7 Hz, 3H), 0.71 (t, *J* = 6.9 Hz, 3H); ^{13}C NMR (100 MHz, CD_3OD) δ 171.8, 148.4, 133.6, 133.5, 131.5, 131.3, 130.8, 125.6 (q, $^1J_{C\text{-}F}$ = 289.3 Hz), 122.5, 111.0, 83.1-82.0 (m), 39.1, 37.1, 32.3, 32.2, 29.7, 28.0, 23.3, 23.2, 22.8, 14.2, 14.0; ^{19}F NMR (376 MHz, CD_3OD) δ -73.2; HRMS (ESI) Calcd for $C_{23}H_{31}F_6INO_2$ $[M + H]^+$ 594.1304, found 594.1306.



(*E*)-*N*-(5-(3,3-Bis(trifluoromethyl)-1λ^3-benzo[*d*][1,2]iodaoxol-1(3*H*)-yl)-1,8-dichlorooct-4-en-4-yl)acetamide (4da): Synthesized by the general procedure A in 42% yield (50.9 mg) or by the general procedure B in 75% yield (90.9 mg); Light brown solid; R_f 0.4 (Et_2O/EtOAc = 2/1); m.p. 141-143 °C; ^{1}H NMR (400 MHz, CD_3OD) δ 8.08 (dd, *J* = 8.0, 1.6 Hz, 1H), 7.83 (d, *J* = 7.0 Hz, 1H), 7.69-7.63 (m, 2H), 3.59-3.56 (m, 2H), 3.52-3.38 (brs, 2H), 3.14-3.87 (brs, 2H), 2.76-2.60 (brs, 1H), 2.60-2.45 (brs, 1H), 2.14 (s, 3H), 2.03-1.92 (brs, 2H), 1.90-1.78 (brs, 2H); ^{13}C NMR (100 MHz, CD_3OD) δ 172.1, 147.9, 133.7, 133.6, 131.6, 131.5, 130.4, 125.5 (q, $^1J_{C-F}$ = 289.5 Hz), 122.2, 111.1, 83.1-82.0 (m), 44.8, 44.7, 36.4, 34.6, 32.6, 31.2, 22.8; ^{19}F NMR (376 MHz, CD_3OD) δ -77.2 (d, *J* = 52.7 Hz); HRMS (ESI) Calcd for $C_{19}H_{21}Cl_2F_6INO_2$ $[M + H]^+$ 605.9898, found 605.9896.



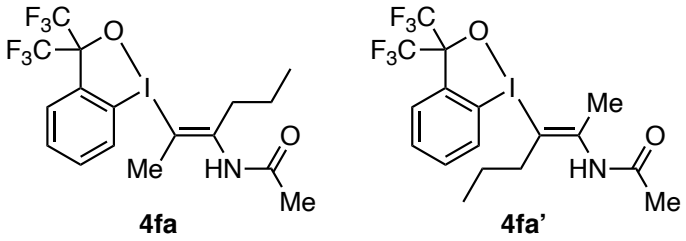
4ea



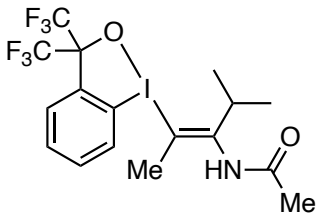
4ea'

(*E*)-*N*-(2-(3,3-Bis(trifluoromethyl)-1λ^3-benzo[*d*][1,2]iodaoxol-1(3*H*)-yl)pent-2-en-3-yl)acetamide (4ea): Synthesized as a mixture with the minor regioisomer (**4ea'**) by the general procedure A in 74% yield (73.4 mg, regioisomer ratio = 2.4:1) or by the general procedure B in 83% yield (82.3 mg, regioisomer ratio = 2:1); Light brown solid; R_f 0.3 (Et_2O/EtOAc = 2/1); m.p. 169-170 °C; ^{1}H NMR (400 MHz, CD_3OD) δ 8.11 (dd, *J* = 8.0, 1.2 Hz, 1H, major), 8.01 (dd, *J* = 8.0, 1.2 Hz, 0.5H, minor), 7.83 (app. d, *J* = 6.9 Hz, 1H + 0.5H, major + minor), 7.68-7.59 (m, 2H + 1H, major + minor), 2.80-2.47 (brs, 2H + 1H, major + minor), 2.39 (s, 3H, major), 2.27 (s, 1.5H, minor), 2.14 (s, 3H, major), 2.12 (s, 1.5H, minor), 1.08 (t, *J* = 7.4 Hz, 1.5H, minor), 0.96 (t, *J* = 7.3 Hz, 3H, major); ^{13}C NMR (100 MHz, CD_3OD) δ 171.9, 171.6,

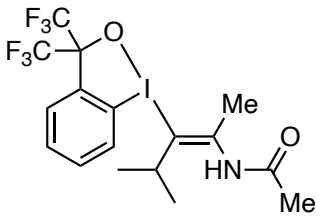
149.0, 144.6, 133.7 (two signals overlapped), 133.6, 133.5, 131.5 (two signals overlapped), 131.41, 131.38, 130.4, 130.1, 125.5 (q, $^1J_{C\text{-}F}$ = 289.5 Hz), 123.5, 113.6, 110.4, 110.0, 83.1-82.0 (m), 32.4, 30.4, 24.84, 24.75, 22.83, 22.76, 13.9, 12.1; ^{19}F NMR (376 MHz, CD_3OD) δ -77.3; HRMS (ESI) Calcd for $C_{16}H_{17}F_6INO_2$ $[M + H]^+$ 496.0208, found 496.0208. The regiochemistry of the major isomer (**4ea**) was assumed from that of the related compounds **4fa**, **4ga**, and **4ia** (vide infra).



(*E*)-*N*-(2-(3,3-Bis(trifluoromethyl)-1λ^3-benzo[*d*][1,2]iodaoxol-1(3*H*)-yl)hex-2-en-3-yl) acetamide (4fa): Synthesized as a mixture with the minor regioisomer (**4fa'**) by the general procedure A in 71% yield (72.3 mg, regioisomer ratio = 2:1) or by the general procedure B in 78% yield (79.6 mg, regioisomer ratio = 2:1); White solid; R_f 0.2 (Et_2O/EtOAc = 2/1); m.p. 154-156 °C; ^{1}H NMR (400 MHz, CD_3OD, two isomers) δ 8.09 (dd, *J* = 7.8, 1.0 Hz, 1H, major), 8.01 (dd, *J* = 7.8, 1.0 Hz, 0.5H, minor), 7.82 (app. d, *J* = 6.1 Hz, 1H + 0.5H, major + minor), 7.68-7.60 (m, 2H + 1H, major + minor), 2.80-2.45 (brs, 2H + 1H, major + minor), 2.40 (s, 3H, major), 2.27 (s, 1.5H, minor), 2.13 (s, 3H, major), 2.12 (s, 1.6H, minor), 1.61-1.47 (brs, 1.0H, minor), 1.37-1.46 (m, 2H, major), 0.94 (t, *J* = 7.4 Hz, 1.5H, minor), 0.82 (t, *J* = 7.3 Hz, 3H, major); ^{13}C NMR (100 MHz, CD_3OD) δ 171.9, 171.3, 148.0, 145.2, 133.7 (two signals overlapped), 133.6, 133.5, 131.5 (two signals overlapped), 131.34, 131.31, 130.5, 130.1, 125.6 (q, $^1J_{C\text{-}F}$ = 289.3 Hz), 121.7, 114.1, 110.6, 110.0, 83.1-82.0 (m), 40.9, 39.1, 24.92, 24.87, 23.4, 22.83, 22.81, 22.0, 14.00, 13.95; ^{19}F NMR (376 MHz, CD_3OD) δ -77.3; HRMS (ESI) Calcd for $C_{17}H_{19}F_6INO_2$ $[M + H]^+$ 510.0365, found 510.0368. The regiochemistry of the major isomer (**4fa**) was assigned by the NOESY spectrum that displayed a correlation between the allylic methyl protons and the *ortho* aryl proton of the BX group (see the attached spectrum).

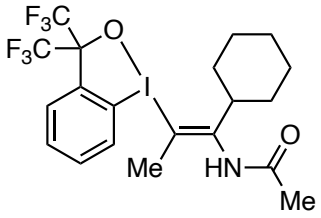


4ga

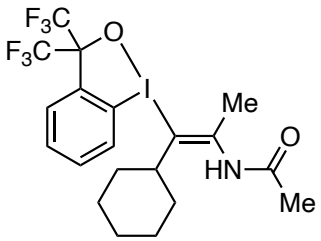


4ga'

(*E*)-*N*-(2-(3,3-Bis(trifluoromethyl)-1λ^3-benzo[*d*][1,2]iodaoxol-1(3*H*)-yl)-4-methylpent-2-en-3-yl)acetamide (4ga): Synthesized as a mixture with the minor regioisomer (**4ga'**) by the general procedure A in 73% yield (74.3 mg, regioisomer ratio = 3.4:1) or by the general procedure B in 82% yield (83.5 mg, regioisomer ratio = 2.5:1); White solid; R_f 0.3 (Et_2O/EtOAc = 2/1); m.p. 157-159 °C; ^{1}H NMR (400 MHz, CD_3OD, two isomers) δ 8.25 (dd, *J* = 7.6, 1.6 Hz, 1H, major), 8.09 (dd, *J* = 8.0, 1.2 Hz, 0.3H, minor), 7.83 (app. d, *J* = 6.3 Hz, 1H+0.3H, major + minor), 7.68-7.59 (m, 2H+0.6H, major + minor), 3.16 (sep, *J* = 6.8 Hz, 1H, major), 2.92 (sep, *J* = 6.6 Hz, 0.3H, minor), 2.37 (s, 3H, major), 2.25 (s, 0.9H, minor), 2.17 (s, 3H, major), 2.12 (s, 0.9H, minor), 1.09 (d, *J* = 6.8 Hz, 0.9H, minor), 1.10-0.95 (m, 6H, major), 0.96 (d, *J* = 6.4 Hz, 0.9H); ^{13}C NMR (100 MHz, CD_3OD, two isomers) δ 172.2, 172.0, 150.9, 144.1, 133.7, 133.6, 133.51, 133.47, 132.0, 131.6, 131.5, 131.4, 130.8, 130.0, 125.6 (q, $^1J_{C\text{-}F}$ = 289.5 Hz), 116.3 (two signals overlapped), 110.4, 109.9, 83.1-81.9 (m), 38.4, 34.2, 25.2, 24.7, 23.8, 22.8, 22.4, 21.6, 20.1 (two signals overlapped); ^{19}F NMR (376 MHz, CD_3OD) δ -77.0 (q, *J* = 8.6 Hz, minor), -77.2 (major), -77.4 (q, *J* = 8.6 Hz, minor); HRMS (ESI) Calcd for $C_{17}H_{19}F_6INO_2$ $[M + H]^+$ 510.0365, found 510.0365. The regiochemistry of the major isomer (**4ga**) was assigned by the NOESY spectrum that displayed a correlation between the allylic methyl protons and the *ortho* aryl proton of the BX group (see the attached spectrum).



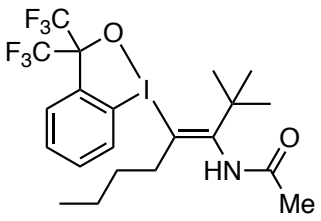
4ha



4ha'

(*E*)-*N*-(2-(3,3-Bis(trifluoromethyl)-1λ^3-benzo[*d*][1,2]iodaoxol-1(3*H*)-yl)-1-cyclohexylprop-1-en-1-yl)acetamide (4ha): Synthesized as a mixture with the minor

regioisomer (**4ha'**) by the general procedure A in 74% yield (81.3 mg, regioisomer ratio = 2.2:1) or by the general procedure B in 82% yield (90.1 mg, regioisomer ratio = 1.7:1); White solid; R_f 0.3 (Et_2O/EtOAc = 2/1); m.p. 138-140 °C; ^{1}H NMR (400 MHz, CD_3OD, two isomers) δ 8.25 (d, *J* = 8.0, 1.2 Hz, 1H, major), 8.07 (d, *J* = 8.0, 0.8 Hz, 0.6H, minor), 7.82 (app. d, *J* = 5.7 Hz, 1H + 0.6H, major + minor), 7.67-7.58 (m, 2H + 1.2H, major + minor), 2.83-2.75 (m, 1H, major), 2.60-2.53 (m, 0.6H, minor), 2.38 (s, 3H, major), 2.24 (s, 1.7H, minor), 2.15 (s, 3H, major), 2.14 (s, 1.8H, minor), 1.80-1.61 (m, 5H + 3.1H, major + minor), 1.45-1.28 (m, 3H + 1.7H, major + minor), 1.19-1.05 (m, 2H + 1.2H, major + minor); ^{13}C NMR (100 MHz, CD_3OD, two isomers) δ 172.2, 171.7, 150.3, 144.4, 133.7, 133.6, 133.5, 131.6, 131.5, 131.4, 131.3, 130.9, 130.2, 130.1, 125.6 (q, $^1J_{C\text{-}F}$ = 289.3 Hz), 116.9 (two signals overlapped), 110.9, 110.1, 83.1-82.0 (m), 44.2, 34.5, 32.5, 31.0, 27.0, 26.8, 26.7, 26.6, 25.2, 24.6, 22.8, 22.4; ^{19}F NMR (376 MHz, CD_3OD) δ -77.0 (q, *J* = 8.6 Hz, minor), - 77.2 (major), -77.3 (q, *J* = 8.6 Hz, minor); HRMS (ESI) Calcd for $C_{20}H_{23}F_6INO_2$ $[M + H]^+$ 550.0678, found 550.0673. The regiochemistry of the major isomer (**4ha**) was assumed from that of the related compounds **4fa**, **4ga**, and **4ia**.



(*E*)-*N*-(4-(3,3-Bis(trifluoromethyl)-1λ^3-benzo[*d*][1,2]iodaoxol-1(3*H*)-yl)-2,2-dimethyloct-3-en-3-yl)acetamide (4ia): Synthesized by the general procedure B in 44% yield (49.7 mg); White solid; R_f 0.4 (Et_2O/EtOAc = 3/1); m.p. 157-159 °C; ^{1}H NMR (400 MHz, CD_3OD) δ 8.58-7.98 (brs, 1H), 7.82 (app. s, 1H), 7.70-7.66 (m, 2H), 3.12-2.90 (brs, 1H), 2.37-2.19 (brs, 1H), 2.13 (s, 3H), 1.72-1.54 (brs, 1H), 1.53-1.41 (brs, 1H), 1.38-1.32 (m, 2H), 1.30 (s, 9H), 0.91 (t, *J* = 7.3 Hz, 3H); ^{13}C NMR (100 MHz, CD_3OD) δ 172.0, 153.8, 133.9, 133.3, 131.6, 131.5, 131.2, 125.6 (q, $^1J_{C\text{-}F}$ = 289.9 Hz), 125.4 (q, $^1J_{C\text{-}F}$ = 288.9 Hz), 123.2, 112.4, 83.0-81.8 (m), 40.9, 40.5, 32.2, 31.0, 23.2, 22.2, 14.1; ^{19}F NMR (376 MHz, CD_3OD) δ -77.31, -77.33; HRMS (ESI) Calcd for $C_{21}H_{27}F_6INO_2$ $[M + H]^+$ 566.0991, found 566.0994. Recrystallization

from hexane/ethyl acetate afforded single crystals suitable for X-ray diffraction analysis, which unambiguously confirmed the molecular structure of **4ia** (Figure S3 and Table S4).[6]

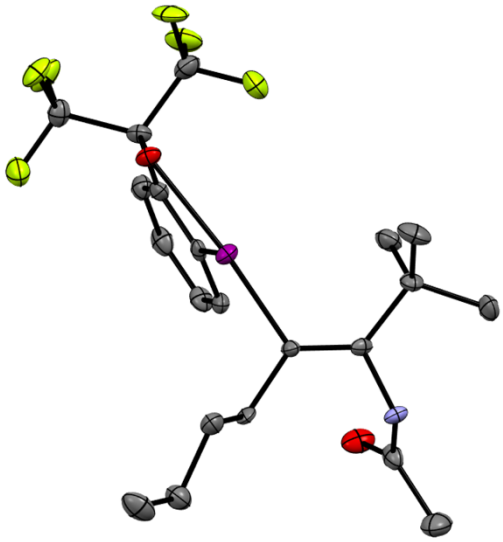
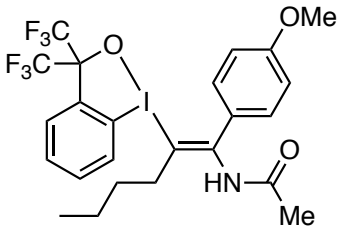


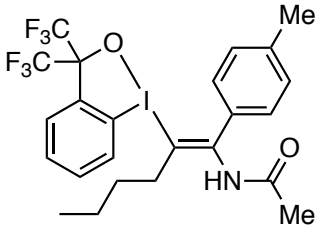
Figure S3. ORTEP drawing of **4ia** (thermal ellipsoids shown at 50% probability level).

Table S4. Crystal data and structure refinement for **4ia**

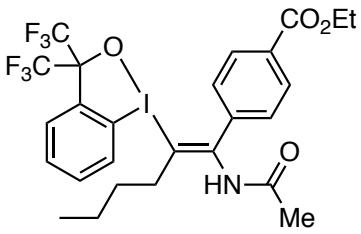
Identification code	ito123m
Chemical formula	$C_{84}H_{104}F_{24}I_4N_4O_8$
Formula weight	2261.31 g/mol
Temperature	100(2) K
Wavelength	0.71073 Å
Crystal size	0.020 x 0.040 x 0.180 mm
Crystal habit	colorless needle
Crystal system	monoclinic
Space group	P 1 21 1
Unit cell dimensions	a = 9.9670(9) Å
	b = 16.2018(14) Å
	c = 13.8919(13) Å
Volume	2243.3(4) Å3
Z	1
Density (calculated)	1.674 g/cm3
Absorption coefficient	1.494
Theta range for data collection	1.93 to 32.11°
Index ranges	-14<=h<=14, -24<=k<=24, -20<=l<=20
Reflections collected	51158
Independent reflections	15649 [R(int) = 0.1105]
Coverage of independent reflections	99.9%
Absorption correction	Multi-Scan
Max. and min. transmission	0.9710 and 0.7750
Structure solution technique	direct methods
Structure solution program	XT, VERSION 2018/2
Refinement method	Full-matrix least-squares on F^2
Refinement program	SHELXL-2018/3 (Sheldrick, 2018)
Function minimized	$\Sigma\, w(F_o^2 - F_c^2)^2$
Data / restraints / parameters	15649 / 1 / 570
Goodness-of-fit on F^2	0.965
Δ/σ_{max}	0.001
Final R indices	9720 data; I>2σ(I) R1 = 0.0543, wR2 = 0.0728
	all data R1 = 0.1273, wR2 = 0.0888
Weighting scheme	$w=1/[\sigma^2(F_o^2)+(0.0152P)^2]$
Absolute structure parameter	-0.056(15)
Largest diff. peak and hole	1.066 and -1.577 eÅ^{-3}
R.M.S. deviation from mean	0.170 eÅ^{-3}



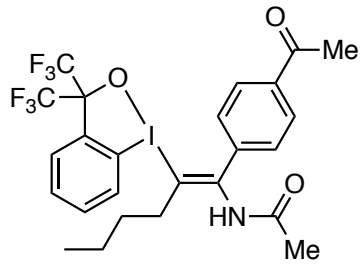
(*E*)-*N*-(2-(3,3-Bis(trifluoromethyl)-1λ^3-benzo[*d*][1,2]iodaoxol-1(3*H*)-yl)-1-(4-methoxy phenyl)hex-1-en-1-yl)acetamide (4ja): Synthesized by the general procedure A in 42% yield (51.7 mg); White solid; R_f 0.3 (Et_2O/EtOAc = 3/1); m.p. 113-115 °C; ^{1}H NMR (400 MHz, CD_3OD) δ 8.34 (d, J = 8.0 Hz, 1H), 7.73 (d, J = 7.1 Hz, 1H), 7.67-7.58 (m, 2H), 7.28-7.24 (m, 2H), 6.88-6.85 (m, 2H), 3.76 (s, 3H), 2.83-2.46 (brs, 2H), 2.14 (s, 3H), 1.66-1.59 (m, 2H), 1.46-1.37 (m, 2H), 0.93 (t, J = 7.3 Hz, 3H); ^{13}C NMR (100 MHz, CD_3OD) δ 171.5, 162.4, 147.8, 133.4, 132.5, 131.9, 131.2 (two signals overlapped), 130.9, 125.5 (q, $^1J_{C\text{-}F}$ = 289.4 Hz), 123.3, 114.8, 110.8, 82.9-81.8 (m), 55.8, 37.5, 32.6, 23.2, 22.9, 14.1; ^{19}F NMR (376 MHz, CD_3OD) δ -77.3; HRMS (ESI) Calcd for $C_{24}H_{25}F_6INO_3$ $[M + H]^+$ 616.0783, found 616.0782.



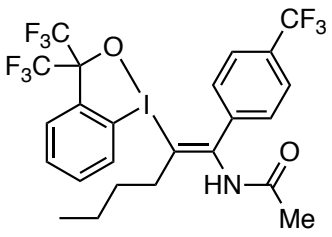
(*E*)-*N*-(2-(3,3-Bis(trifluoromethyl)-1λ^3-benzo[*d*][1,2]iodaoxol-1(3*H*)-yl)-1-(*p*-tolyl)hex-1-en-1-yl)acetamide (4ka): Synthesized by the general procedure A in 33% yield (39.6 mg); White solid; R_f 0.3 (Et_2O/EtOAc = 3/1); m.p. 158-159 °C; ^{1}H NMR (400 MHz, CD_3OD) δ 8.33 (d, J = 8.0 Hz, 1H), 7.73 (d, J = 7.2 Hz, 1H), 7.67-7.59 (m, 2H), 7.20 (app. d, J = 8.1 Hz, 2H), 7.14 (app. d, J = 8.0 Hz, 2H), 2.80-2.50 (brs, 2H), 2.30 (s, 3H), 2.14 (s, 3H), 1.67-1.59 (m, 2H), 1.46-1.37 (m, 2H), 0.93 (t, J = 7.3 Hz, 3H); ^{13}C NMR (100 MHz, CD_3OD) δ 171.5, 148.0, 141.2, 137.5, 133.5, 133.4, 131.3, 131.2, 130.9, 130.2, 130.0, 125.4 (q, $^1J_{C\text{-}F}$ = 289.0 Hz), 123.9, 110.8, 82.9-81.7 (m), 37.4, 32.5, 23.3, 22.9, 21.3, 14.1; ^{19}F NMR (376 MHz, CD_3OD) δ -77.3; HRMS (ESI) Calcd for $C_{24}H_{24}F_6INO_2$ $[M + H]^+$ 600.0834, found 600.0837.



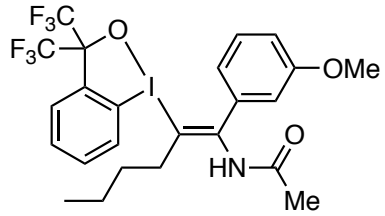
Ethyl (*E*)-4-(1-acetamido-2-(3,3-bis(trifluoromethyl)-1λ^3-benzo[*d*][1,2]iodaoxol-1(3*H*)-yl)hex-1-en-1-yl)benzoate (4la): Synthesized by the general procedure B in 51% yield (67.1 mg); White solid; R_f 0.4 (Et_2O/EtOAc = 3/1); m.p. 166-168 °C; ^{1}H NMR (400 MHz, CD_3OD) δ 8.26 (dd, *J* = 8.0, 0.8 Hz, 1H), 7.94 (app. d, *J* = 8.4 Hz, 2H), 7.73 (app. d, *J* = 7.4 Hz, 1H), 7.70-7.61 (m, 2H), 7.42 (app. d, *J* = 8.4 Hz, 2H), 4.33 (q, *J* = 7.1 Hz, 2H), 2.98-2.50 (brs, 2H), 2.14 (s, 3H), 1.69-1.61 (m, 2H), 1.49-1.40 (m, 2H), 1.34 (t, *J* = 7.1 Hz, 3H), 0.95 (t, *J* = 7.3 Hz, 3H); ^{13}C NMR (100 MHz, CD_3OD) δ 171.6, 162.2, 147.7, 144.8, 133.6, 133.4, 132.5, 131.4, 131.3, 130.7, 130.43, 130.41, 125.6, 125.5 (q, $^1J_{C\text{-}F}$ = 289.4 Hz), 110.0, 82.9-81.8 (m), 62.4, 37.3, 32.3, 23.3, 22.9, 14.5, 14.1; ^{19}F NMR (376 MHz, CD_3OD) δ -77.3; HRMS (ESI) Calcd for $C_{26}H_{27}F_6INO_4$ $[M + H]^+$ 658.0889, found 658.0894.



(*E*)-*N*-(1-(4-Acetylphenyl)-2-(3,3-bis(trifluoromethyl)-1λ^3-benzo[*d*][1,2]iodaoxol-1(3*H*)-yl)hex-1-en-1-yl)acetamide (4ma): Synthesized by the general procedure B in 53% yield (65.3 mg); White liquid; R_f 0.2 (Et_2O/EtOAc = 3/1); ^{1}H NMR (400 MHz, CD_3OD) δ 8.26 (d, *J* = 7.9 Hz, 1H), 7.92 (app. d, *J* = 8.4 Hz, 2H), 7.73 (app. d, *J* = 7.2 Hz, 1H), 7.70-7.61 (m, 2H), 7.45 (app. d, *J* = 8.3 Hz, 2H), 2.95-2.58 (brs, 2H), 2.54 (s, 3H), 2.14 (s, 3H), 1.69-1.62 (m, 2H), 1.49-1.40 (m, 2H), 0.95 (t, *J* = 7.3 Hz, 3H); ^{13}C NMR (100 MHz, CD_3OD) δ 199.5, 171.7, 146.7, 144.9, 138.8, 133.6, 133.4, 131.4, 131.3, 130.7, 130.6, 129.4, 125.6, 125.5 (q, $^1J_{C\text{-}F}$ = 289.3 Hz), 110.0, 82.9-81.7 (m), 37.3, 32.3, 26.7, 23.3, 22.9, 14.1; ^{19}F NMR (376 MHz, CD_3OD) δ -77.3; HRMS (ESI) Calcd for $C_{25}H_{25}F_6INO_3$ $[M + H]^+$ 628.0783, found 628.0777.

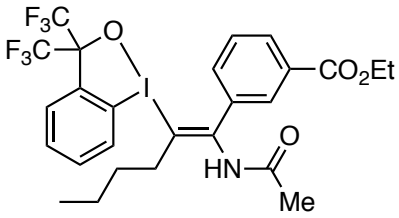


Ethyl (*E*)-4-(1-acetamido-2-(3,3-bis(trifluoromethyl)-1λ^3-benzo[*d*][1,2]iodaoxol-1(3*H*)-yl)hex-1-en-1-yl)benzoate (4na): Synthesized by the general procedure B in 51% yield (67.1 mg); White solid; R_f 0.4 (Et_2O/EtOAc = 3/1); m.p. 157-158 °C; ^{1}H NMR (400 MHz, CD_3OD) δ 8.05-8.02 (m, 1H), 7.94 (app. d, *J* = 8.5 Hz, 2H), 7.52 (d, *J* = 7.3 Hz, 1H), 7.49-7.40 (m, 2H), 7.39 (app. d, *J* = 8.2 Hz, 2H), 7.27 (app. d, *J* = 8.1 Hz, 2H), 2.81-2.26 (brs, 2H), 1.93 (s, 3H), 1.49-1.42 (m, 2H), 1.29-1.20 (m, 2H), 0.75 (t, *J* = 7.4 Hz, 3H); ^{13}C NMR (100 MHz, CD_3OD) δ 171.7, 146.3, 144.2, 133.7, 133.4, 132.3 (q, $^1J_{C\text{-}F}$ = 32.4 Hz), 131.5, 131.3, 130.9, 130.7, 126.8, 125.3 (q, $^1J_{C\text{-}F}$ = 289.4 Hz), 126.3 (q, $^3J_{C\text{-}F}$ = 3.8 Hz), 125.9, 111.1, 82.9-81.8 (m), 37.3, 32.3, 23.3, 22.8, 14.1; ^{19}F NMR (376 MHz, CD_3OD) δ -64.4, -77.4; HRMS (ESI) Calcd for $C_{24}H_{22}F_9INO_2$ $[M + H]^+$ 654.0552, found 654.0554.

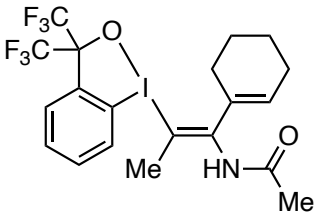


(*E*)-*N*-(2-(3,3-Bis(trifluoromethyl)-1l^3-benzo[*d*][1,2]iodaoxol-1(3*H*)-yl)-1-(3-methoxyphenyl)hex-1-en-1-yl)acetamide (4oa): Synthesized by the general procedure A in 39% yield (50.0 mg); White solid; R_f 0.3 (Et_2O/EtOAc = 3/1); m.p. 124-125 °C; ^{1}H NMR (400 MHz, CD_3OD) δ 8.32 (d, *J* = 8.0 Hz, 1H), 7.74 (d, *J* = 7.2 Hz, 1H), 7.70-7.62 (m, 2H), 7.22 (d, *J* = 8.0 Hz, 1H), 6.91-6.82 (m, 3H), 3.63 (s, 3H), 2.85-2.53 (brs, 2H), 2.13 (s, 3H), 1.68-1.60 (m, 2H), 1.47-1.38 (m, 2H), 0.94 (t, *J* = 7.3 Hz, 3H); ^{13}C NMR (100 MHz, CD_3OD) δ 171.6, 161.0, 147.6, 141.7, 133.6, 133.4, 131.3, 131.2, 130.9, 130.7, 125.5 (q, $^1J_{C\text{-}F}$ = 289.4 Hz), 124.6, 122.2, 116.5, 115.5, 111.3, 82.9-81.8 (m), 55.7, 37.4, 32.4, 23.3, 22.9, 14.1; ^{19}F NMR (376

MHz, CD_3OD) δ -77.3; HRMS (ESI) Calcd for $C_{24}H_{25}F_6INO_3$ $[M + H]^+$ 616.0783, found 616.0785.

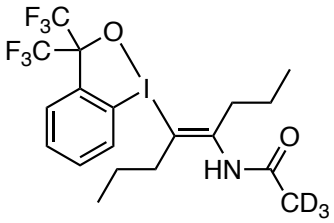


Ethyl (*E*)-4-(1-acetamido-2-(3,3-bis(trifluoromethyl)-1λ^3-benzo[*d*][1,2]iodaoxol-1(3*H*)-yl)hex-1-en-1-yl)benzoate (4pa): Synthesized by the general procedure B in 42% yield (67.1 mg); White solid; R_f 0.2 (Et_2O/EtOAc = 3/1); m.p. 163-164 °C; ^{1}H NMR (400 MHz, CD_3OD) δ 8.25 (d, J = 8.0 Hz, 1H), 7.97 (d, J = 7.8 Hz, 2H), 7.92 (app. s, 1H), 7.75-7.63 (m, 3H), 7.52 (d, J = 7.8 Hz, 1H), 7.43 (t, J = 15.4 Hz, 1H), 4.26 (q, J = 7.1 Hz, 2H), 2.99-2.53 (brs, 2H), 2.14 (s, 3H), 1.70-1.63 (m, 2H), 1.50-1.40 (m, 2H), 1.27 (t, J = 7.1 Hz, 3H), 0.96 (t, J = 7.3 Hz, 3H); ^{13}C NMR (100 MHz, CD_3OD) δ 171.8, 167.1, 146.7, 141.0, 134.4, 133.7, 133.4, 131.7, 131.5, 131.3 (two signals overlapped), 130.9, 130.8, 129.7, 125.6, 125.4 (q, $^1J_{C\text{-}F}$ = 289.4 Hz), 111.3, 82.9-81.7 (m), 62.3, 37.3, 32.2, 23.4, 22.9, 14.5, 14.1; ^{19}F NMR (376 MHz, CD_3OD) δ -77.4; HRMS (ESI) Calcd for $C_{26}H_{27}F_6INO_4$ $[M + H]^+$ 658.0889, found 658.0881.

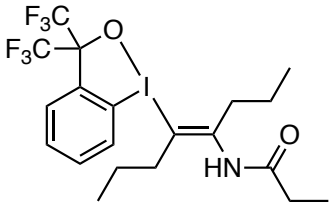


(*E*)-*N*-(2-(3,3-Bis(trifluoromethyl)-1λ^3-benzo[*d*][1,2]iodaoxol-1(3*H*)-yl)-1-(cyclohex-1-en-1-yl)prop-1-en-1-yl)acetamide (4qa): Synthesized by the general procedure A in 65% yield (71.1 mg); Light brown solid; R_f 0.3 (Et_2O/EtOAc = 2/1); m.p. 99-101 °C; ^{1}H NMR (400 MHz, CD_3OD) δ 8.20-8.18 (m, 1H), 7.79 (d, J = 4.0 Hz, 1H), 7.67-7.61 (m, 2H), 5.82-5.84 (m, 1H), 2.42 (s, 3H), 2.12 (s, 3H), 2.06 (brs, 2H), 1.93 (brs, 2H), 1.57-1.53 (m, 4H); ^{13}C NMR (100 MHz, CD_3OD) δ 171.3, 150.0, 138.5, 133.6, 133.4 (two signals overlapped), 131.3, 131.2,

130.6, 125.6 (q, $^{1}J_{C\text{-}F}$ = 289.3 Hz), 113.6, 111.7, 83.1-82.0 (m), 27.6, 25.9, 24.6, 23.2, 22.8, 22.6; ^{19}F NMR (376 MHz, CD_3OD) δ -77.3; HRMS (ESI) Calcd for $C_{20}H_{21}F_6INO_2$ $[M + H]^+$ 548.0521, found 548.0518.

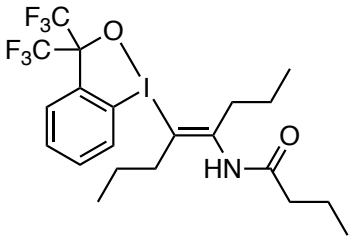


(*E*)-*N*-(5-(3,3-Bis(trifluoromethyl)-1λ^3-benzo[*d*][1,2]iodaoxol-1(3*H*)-yl)oct-4-en-4-yl)acetamide-2,2,2-*d*$_3$ ([D$_3$]-4aa): Synthesized by the general procedure B in 67% yield (72.4 mg); White solid; R_f 0.4 (Et_2O/EtOAc = 2/1); m.p. 149-150 °C; ^{1}H NMR (400 MHz, CD_3OD) δ 8.13-8.11 (m, 1H), 7.82 (app. d, *J* = 7.2 Hz, 1H), 7.68-7.60 (m, 2H), 2.89-2.55 (brs, 2H), 2.55-2.22 (brs, 2H), 1.72-1.48 (brs, 2H), 1.48-1.25 (brs, 2H), 0.93 (t, *J* = 7.2 Hz, 3H), 0.84 (t, *J* = 7.4 Hz, 3H); ^{13}C NMR (100 MHz, CD_3OD) δ 171.9, 148.4, 133.6, 133.5, 131.5, 131.3, 130.7, 125.6 (q, $^{1}J_{C\text{-}F}$ = 289.3 Hz), 122.5, 110.9, 83.1-82.0 (m), 41.1, 39.3, 23.5, 22.3-21.7 (m), 21.8, 14.0, 13.9; ^{19}F NMR (376 MHz, CD_3OD) δ -77.3; HRMS (ESI) Calcd for $C_{19}H_{20}D_3F_6INO_2$ $[M + H]^+$ 541.0866, found 541.0861.

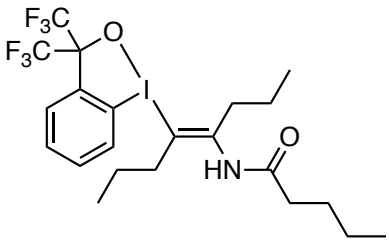


(*E*)-*N*-(5-(3,3-Bis(trifluoromethyl)-1λ^3-benzo[*d*][1,2]iodaoxol-1(3*H*)-yl)oct-4-en-4-yl)propionamide (4ab): Synthesized by the general procedure B in 89% yield (98.1 mg); White solid; R_f 0.4 (Et_2O/EtOAc = 2/1); m.p. 147-148 °C; ^{1}H NMR (400 MHz, CD_3OD) δ 8.16-8.12 (m, 1H), 7.82 (app. d, *J* = 3.1 Hz, 1H), 7.68-7.62 (m, 2H), 2.91-2.57 (brs, 2H), 2.56-2.22 (brs, 2H), 2.40 (q, *J* = 7.6 Hz, 2H), 1.70-1.47 (brs, 2H), 1.47-1.31 (brs, 2H), 1.23 (t, *J* = 7.6 Hz, 3H), 0.92 (t, *J* = 7.4 Hz, 3H), 0.83 (t, *J* = 7.4 Hz, 3H); ^{13}C NMR (100 MHz, CD_3OD) δ 175.6, 148.5, 133.62, 133.58, 131.5, 131.3, 130.7, 125.6 (q, $^{1}J_{C\text{-}F}$ = 289.5 Hz), 122.3, 110.9,

83.1-82.0 (m), 41.2, 39.3, 30.3, 23.4, 21.8, 14.0, 13.9, 10.4; ^{19}F NMR (376 MHz, CD_3OD) δ -77.2; HRMS (ESI) Calcd for $C_{20}H_{25}F_6INO_2$ $[M + H]^+$ 552.0834, found 552.0833.

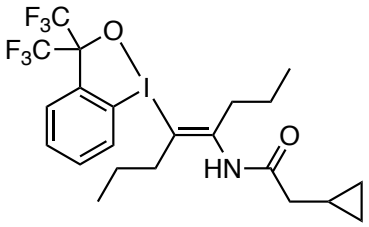


(*E*)-*N*-(5-(3,3-Bis(trifluoromethyl)-1λ^3-benzo[*d*][1,2]iodaoxol-1(3*H*)-yl)oct-4-en-4-yl)butyramide (4ac): Synthesized by the general procedure B in 92% yield (104.1 mg); White solid; R_f 0.4 (Et_2O/EtOAc = 2/1); m.p. 143-144 °C; ^{1}H NMR (400 MHz, CD_3OD) δ 8.16-8.12 (m, 1H), 7.82 (app. s, 1H), 7.69-7.62 (m, 2H), 2.91-2.56 (brs, 2H), 2.56-2.22 (brs, 2H), 2.36 (t, *J* = 7.4 Hz, 2H), 1.79-1,70 (m, 2H), 1.71-1.48 (brs, 2H), 1.48-1.32 (brs, 2H), 1.02 (t, *J* = 7.4 Hz, 3H), 0.93 (t, *J* = 7.4 Hz, 3H), 0.83 (t, *J* = 7.4 Hz, 3H); ^{13}C NMR (100 MHz, CD_3OD) δ 174.7, 148.4, 133.63, 133.59, 131.5, 131.3, 130.8, 125.6 (q, $^1J_{C\text{-}F}$ = 290.1 Hz), 122.4, 110.9, 83.1-82.0 (m), 41.2, 39.5, 39.0, 23.5, 20.4, 14.1, 14.0, 13.9; ^{19}F NMR (376 MHz, CD_3OD) δ -77.3; HRMS (ESI) Calcd for $C_{21}H_{27}F_6INO_2$ $[M + H]^+$ 566.0991, found 566.0989.

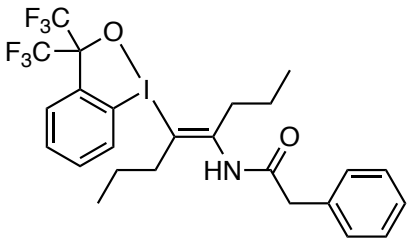


(*E*)-*N*-(5-(3,3-Bis(trifluoromethyl)-1λ^3-benzo[*d*][1,2]iodaoxol-1(3*H*)-yl)oct-4-en-4-yl) pentanamide (4ad): Synthesized by the general procedure B in 83% yield (96.1 mg); White solid; R_f 0.4 (Et_2O/EtOAc = 2/1); m.p. 140-141 °C; ^{1}H NMR (400 MHz, CD_3OD) δ 8.16-8.12 (m, 1H), 7.82 (app. d, *J* = 3.9 Hz, 1H), 7.69-7.62 (m, 2H), 2.91-2.56 (brs, 2H), 2.56-2.23 (brs + t, *J* = 7.5 Hz, 2H + 2H), 1.73-1.66 (m, 2H), 1.62-1.48 (brs, 2H), 1.48-1.32 (m, 4H), 0.98 (t, *J* = 7.3 Hz, 3H), 0.92 (t, *J* = 7.3 Hz, 3H), 0.83 (t, *J* = 7.4 Hz, 3H); ^{13}C NMR (100 MHz, CD_3OD) δ 174.9, 148.4, 133.62, 133.59, 131.5, 131.3, 130.8, 125.6 (q, $^1J_{C\text{-}F}$ = 289.4 Hz), 122.4, 110.9,

83.1-81.9 (m), 41.2, 39.4, 36.8, 29.1, 23.4, 21.8, 14.1, 14.0, 13.9; ^{19}F NMR (376 MHz, CD_3OD) δ -77.2; HRMS (ESI) Calcd for $C_{22}H_{29}F_6INO_2$ $[M + H]^+$ 580.1147, found 580.1146.

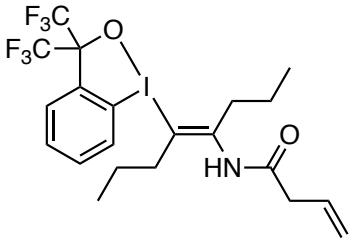


(*E*)-*N*-(5-(3,3-Bis(trifluoromethyl)-1λ^3-benzo[*d*][1,2]iodaoxol-1(3*H*)-yl)oct-4-en-4-yl)-2-cyclopropylacetamide (4ae): Synthesized by the general procedure B in 71% yield (81.9 mg); White solid; R_f 0.3 (Et_2O/EtOAc = 2/1); m.p. 152-153 °C; ^{1}H NMR (400 MHz, CD_3OD) δ 8.17-8.14 (m, 1H), 7.82 (app. s, 1H), 7.68-7.63 (m, 2H), 2.89-2.58 (brs, 2H), 2.58-2.32 (brs, 2H), 2.26 (d, J = 7.2 Hz, 2H), 1.72-1.49 (brs, 2H), 1.49-1.31 (brs, 2H), 1.21-1.10 (m, 1H), 0.94 (t, J = 7.3 Hz, 3H), 0.84 (t, J = 7.4 Hz, 3H), 0.62-0.58 (m, 2H), 0.29-0.25 (m, 2H); ^{13}C NMR (100 MHz, CD_3OD) δ 174.4, 148.4, 133.62, 133.58, 131.5, 131.3, 130.8, 125.6 (q, $^1J_{C\text{-}F}$ = 289.6 Hz), 122.6, 110.9, 83.1-82.0 (m), 42.2, 41.2, 39.4, 23.4, 21.8, 14.1, 14.0, 8.9, 4.9; ^{19}F NMR (376 MHz, CD_3OD) δ -77.2; HRMS (ESI) Calcd for $C_{22}H_{27}F_6INO_2$ $[M + H]^+$ 578.0991, found 578.0984.

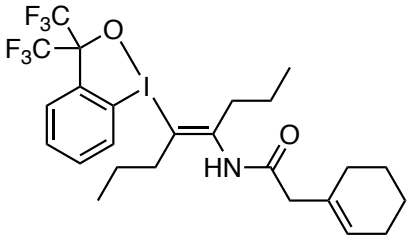


(*E*)-*N*-(5-(3,3-Bis(trifluoromethyl)-1λ^3-benzo[*d*][1,2]iodaoxol-1(3*H*)-yl)oct-4-en-4-yl)-2-phenylacetamide (4af): Synthesized by the general procedure B in 61% yield (74.8 mg); White solid; R_f 0.3 (Et_2O/EtOAc = 2/1); m.p. 154-155 °C; ^{1}H NMR (400 MHz, CD_3OD) δ 8.11-8.07 (m, 1H), 7.80 (app. s, 1H), 7.65-7.59 (m, 2H), 7.40-7.32 (m, 4H), 7.27 (t, J = 7.1 Hz, 1H), 3.66 (s, 2H), 2.47 (app. t, J = 58.7 Hz, 4H), 1.55-1.22 (brs, 4H), 0.80 (t, J = 7.4 Hz, 3H), 0.77 (t, J = 7.3 Hz, 3H); ^{13}C NMR (100 MHz, CD_3OD) δ 172.5, 148.2, 136.5, 133.6, 133.5,

131.5, 131.3, 130.7, 130.1, 129.8, 128.2, 125.6 (q, $^{1}J_{C\text{-}F}$ = 289.5 Hz), 122.8, 110.8, 83.1-82.0 (m), 44.2, 41.1, 39.3, 23.3, 21.7, 14.0, 13.8; ^{19}F NMR (376 MHz, CD_3OD) δ -77.2; HRMS (ESI) Calcd for $C_{25}H_{27}F_6INO_2$ $[M + H]^+$ 614.0991, found 614.0984.

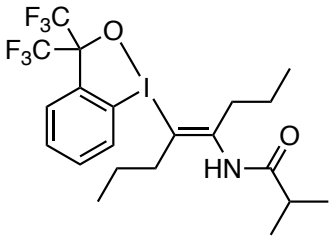


(*E*)-*N*-(5-(3,3-Bis(trifluoromethyl)-1λ^3-benzo[*d*][1,2]iodaoxol-1(3*H*)-yl)oct-4-en-4-yl)but-3-enamide (4ag): Synthesized by the general procedure B in 58% yield (65.3 mg); White solid; R_f 0.3 (Et_2O/EtOAc = 2/1); m.p. 137-138 °C; ^{1}H NMR (400 MHz, CD_3OD) δ 8.14-8.11 (m, 1H), 7.82 (app. d, *J* = 6.3 Hz, 1H), 7.68-7.62 (m, 2H), 6.06-5.96 (m, 1H), 5.28 (dd, *J* = 17.1, 1.4 Hz, 1H), 5.22 (dd, *J* = 10.1, 1.1Hz, 1H), 3.16 (d, *J* = 7.0 Hz, 2H), 2.96-2.55 (brs, 2H), 2.55-2.19 (brs, 2H), 1.71-1.48 (brs, 2H), 1.48-1.30 (brs, 2H), 0.92 (t, *J* = 7.3 Hz, 3H), 0.83 (t, *J* = 7.3 Hz, 3H); ^{13}C NMR (100 MHz, CD_3OD) δ 172.3, 148.3, 133.61, 133.58, 132.5, 131.5, 131.3, 130.7, 125.6 (q, $^{1}J_{C\text{-}F}$ = 289.6 Hz), 122.7, 119.3, 110.8, 83.1-82.0 (m), 42.1, 41.1, 39.3, 23.4, 21.8, 14.0, 13.9; ^{19}F NMR (376 MHz, CD_3OD) δ -77.2; HRMS (ESI) Calcd for $C_{21}H_{25}F_6INO_2$ $[M + H]^+$ 564.0834, found 564.0828.

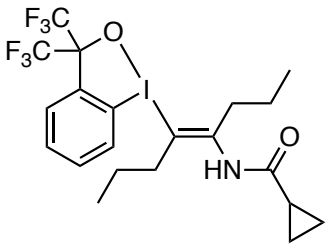


(*E*)-*N*-(5-(3,3-Bis(trifluoromethyl)-1λ^3-benzo[*d*][1,2]iodaoxol-1(3*H*)-yl)oct-4-en-4-yl)-2-(cyclohex-1-en-1-yl)acetamide (4ah): Synthesized by the general procedure B in 66% yield (81.4 mg); White solid; R_f 0.3 (Et_2O/EtOAc = 2/1); m.p. 151-152 °C; ^{1}H NMR (400 MHz, CD_3OD) δ 8.15-8.11 (m, 1H), 7.81 (app. s, 1H), 7.68-7.62 (m, 2H), 5.71 (s, 1H), 3.0 (s, 2H), 2.83-2.31 (brs, 4H), 2.08 (app. s, 4H), 1.71-1.66 (m, 2H), 1.63-1.57 (m, 2H), 1.57-1.47 (brs,

2H), 1.42 (app. d, J = 5.2 Hz, 2H), 0.93 (t, J = 7.4 Hz, 3H), 0.83 (t, J = 7.4 Hz, 3H); ^{13}C NMR (100 MHz, CD_3OD) δ 172.8, 148.4, 133.6 (two signals overlapped), 133.2, 131.5, 131.3, 130.8, 127.2, 125.6 (q, $^1J_{C\text{-}F}$ = 289.5 Hz), 122.6, 110.9, 83.1-82.0 (m), 46.5, 41.1, 39.4, 29.5, 26.4, 23.9, 23.5, 23.1, 21.8, 14.1, 14.0; ^{19}F NMR (376 MHz, CD_3OD) δ -77.2; HRMS (ESI) Calcd for $C_{25}H_{31}F_6INO_2$ $[M + H]^+$ 618.1304, found 618.1306.

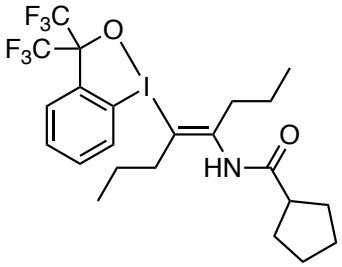


(*E*)-*N*-(5-(3,3-Bis(trifluoromethyl)-1λ^3-benzo[*d*][1,2]iodaoxol-1(3*H*)-yl)oct-4-en-4-yl)isobutyramide (4ai): Synthesized by the general procedure B in 71% yield (80.2 mg); White solid; R_f 0.3 (Et_2O/EtOAc = 2/1); m.p. 85-86 °C; ^{1}H NMR (400 MHz, CD_3OD) δ 8.17-8.13 (m, 1H), 7.82 (app. s, 1H), 7.69-7.64 (m, 2H), 2.93-2.55 (brs + m, 2H + 1H), 2.55-2.24 (brs, 2H), 1.68-1.46 (brs, 2H), 1.46-1.34 (brs, 2H), 1.23 (s, 3H), 1.21 (s, 3H), 0.92 (t, J = 7.4 Hz, 3H), 0.83 (t, J = 7.5 Hz, 3H); ^{13}C NMR (100 MHz, CD_3OD) δ 177.7, 148.4, 133.64, 133.61, 131.5, 131.3, 130.8, 125.6 (q, $^1J_{C\text{-}F}$ = 289.5 Hz), 122.4, 110.9, 83.1-82.0 (m), 41.2, 39.4, 36.4, 23.4, 21.8, 19.9, 14.04, 13.96; ^{19}F NMR (376 MHz, CD_3OD) δ -77.2; HRMS (ESI) Calcd for $C_{21}H_{27}F_6INO_2$ $[M + H]^+$ 566.0991, found 566.0984.

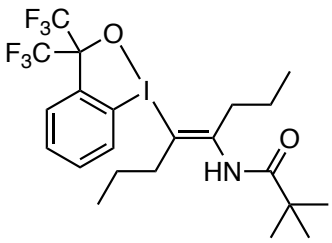


(*E*)-*N*-(5-(3,3-Bis(trifluoromethyl)-1λ^3-benzo[*d*][1,2]iodaoxol-1(3*H*)-yl)oct-4-en-4-yl)cyclopropanecarboxamide (4aj): Synthesized by the general procedure B in 71% yield (80.0 mg); White solid; R_f 0.3 (Et_2O/EtOAc = 2/1); m.p. 116-117 °C; ^{1}H NMR (400 MHz, CD_3OD) δ 8.11-8.07 (m, 1H), 7.81 (app. s, 1H), 7.67-7.61 (m, 2H), 2.94-2.57 (brs, 2H), 2.58-

2.19 (brs, 2H), 1.80-1.76 (m, 1H), 1.66-1.48 (brs, 2H), 1.48-1.30 (brs, 2H), 0.99-0.87 (m, 7H), 0.84 (t, J = 7.4 Hz, 3H); ^{13}C NMR (100 MHz, CD_3OD) δ 175.2, 148.6, 133.6 (two signals overlapped), 131.5, 131.3, 130.7, 125.6 (q, $^1J_{C\text{-}F}$ = 289.5 Hz), 121.9, 110.8, 83.1-82.0 (m), 41.2, 39.3, 23.4, 21.9, 15.0, 14.0, 13.9, 8.0; ^{19}F NMR (376 MHz, CD_3OD) δ -77.2; HRMS (ESI) Calcd for $C_{21}H_{25}F_6INO_2$ $[M + H]^+$ 564.0834, found 564.0836.

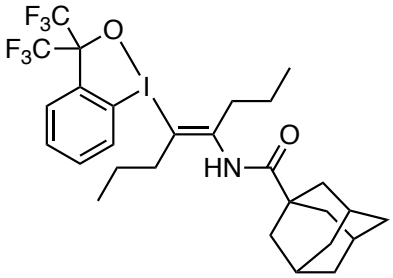


(*E*)-*N*-(5-(3,3-Bis(trifluoromethyl)-1λ^3-benzo[*d*][1,2]iodaoxol-1(3*H*)-yl)oct-4-en-4-yl)cyclopentanecarboxamide (4ak): Synthesized by the general procedure B in 65% yield (76.8 mg); White solid; R_f 0.3 (Et_2O/EtOAc = 2/1); m.p. 142-143 °C; ^{1}H NMR (400 MHz, CD_3OD) δ 8.16-8.12 (m, 1H), 7.82 (app. s, 1H), 7.69-7.64 (m, 2H), 2.87-2.80 (m, 1H), 2.78-2.56 (brs, 2H), 2.56-2.25 (brs, 2H), 2.01-1.94 (m, 2H), 1.87-1.75 (m, 4H), 1.71-1.62 (m, 2H), 1.60-1.47 (brs, 2H), 1.47-1.32 (brs, 2H), 0.92 (t, J = 7.4 Hz, 3H), 0.83 (t, J = 7.5 Hz, 3H); ^{13}C NMR (100 MHz, CD_3OD) δ 177.8, 148.6, 133.64, 133.61, 131.5, 131.3, 130.8, 125.6 (q, $^1J_{C\text{-}F}$ = 289.5 Hz), 122.2, 110.8, 83.1-82.0 (m), 46.5, 41.2, 39.4, 31.6, 27.1, 23.4, 21.8, 14.04, 13.97; ^{19}F NMR (376 MHz, CD_3OD) δ -77.2; HRMS (ESI) Calcd for $C_{23}H_{29}F_6INO_2$ $[M + H]^+$ 592.1147, found 592.1149.

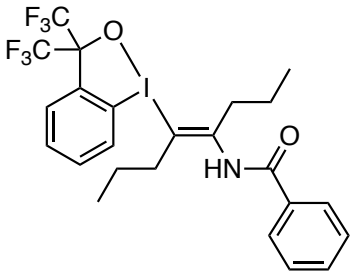


(*E*)-*N*-(5-(3,3-Bis(trifluoromethyl)-1λ^3-benzo[*d*][1,2]iodaoxol-1(3*H*)-yl)oct-4-en-4-yl)pivalamide (4al): Synthesized by the general procedure B in 67% yield (77.6 mg); White solid; R_f 0.3 (Et_2O/EtOAc = 2/1); m.p. 65-67 °C; ^{1}H NMR (400 MHz, CD_3OD) δ 8.18-8.16 (m,

1H), 7.82 (app. d, J = 6.7 Hz, 1H), 7.71-7.64 (m, 2H), 2.95-2.21 (brs + m, 2H + 2H), 1.67-1.46 (brs, 2H), 1.46-1.35 (brs, 2H), 1.30 (s, 9H), 0.92 (t, J = 7.3 Hz, 3H), 0.83 (t, J = 7.4 Hz, 3H); ^{13}C NMR (100 MHz, CD_3OD) δ 180.0, 149.1, 133.7, 133.6, 131.5, 131.3, 130.9, 125.6 (q, J_{C-F} = 289.6 Hz), 123.2, 110.9, 83.1-81.9 (m), 41.2, 40.3, 39.3, 27.8, 23.3, 21.7, 14.1, 14.0; ^{19}F NMR (376 MHz, CD_3OD) δ -77.2; HRMS (ESI) Calcd for $C_{22}H_{29}F_6INO_2$ $[M + H]^+$ 580.1147, found 580.1145.

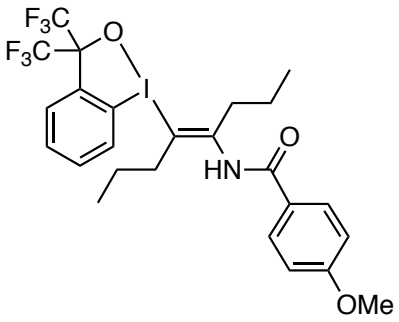


(*E*)-*N*-(5-(3,3-Bis(trifluoromethyl)-1λ^3-benzo[*d*][1,2]iodaoxol-1(3*H*)-yl)oct-4-en-4-yl)-(1-Ad)amide (4am): Synthesized by the general procedure B in 26% yield (34.2 mg); White solid; R_f 0.3 (Et_2O/EtOAc = 2/1); m.p. 161-162 °C; ^{1}H NMR (400 MHz, CD_3OD) δ 8.19-8.14 (m, 1H), 7.82 (app. d, J = 6.4 Hz, 1H), 7.71-7.64 (m, 2H), 2.55 (app. d, J = 34.6 Hz, 4H), 2.09 (brs, 3H), 1.99 (app. d, J = 2.6 Hz, 6H), 1.82 (app. t, J = 15.1 Hz, 6H), 1.63-1.45 (brs, 2H), 1.45-1.31 (brs, 2H), 0.92 (t, J = 7.3 Hz, 3H), 0.82 (t, J = 7.4 Hz, 3H); ^{13}C NMR (100 MHz, CD_3OD) δ 179.5, 149.1, 133.7, 133.6, 131.5, 131.3, 130.9, 125.6 (q, $^1J_{C-F}$ = 289.9 Hz), 123.1, 110.9, 83.1-81.9 (m), 42.6, 41.2, 40.3, 39.4, 37.5, 29.7, 23.3, 21.7, 14.1, 14.0; ^{19}F NMR (376 MHz, CD_3OD) δ -77.3; HRMS (ESI) Calcd for $C_{28}H_{35}F_6INO_2$ $[M + H]$+ 658.1617, found 658.1616.

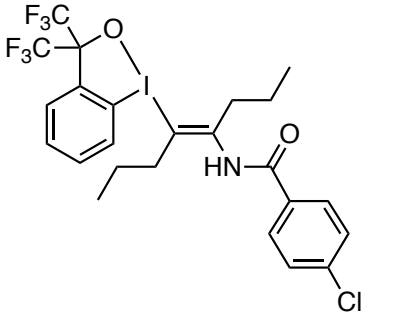


(*E*)-*N*-(5-(3,3-Bis(trifluoromethyl)-1λ^3-benzo[*d*][1,2]iodaoxol-1(3*H*)-yl)oct-4-en-4-yl) benzamide (4an): Synthesized by the general procedure B in 46% yield (55.1 mg); White solid;

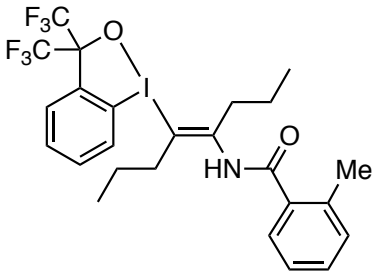
R_f 0.3 (Et_2O/EtOAc = 2/1); m.p. 136-137 °C; ^{1}H NMR (400 MHz, CD_3OD) δ 8.28-8.26 (m, 1H), 7.94-7.92 (m, 2H), 7.85 (app. d, J = 6.8 Hz, 1H), 7.73-7.66 (m, 2H), 7.63-7.59 (m, 1H), 7.55-7.52 (m, 2H), 2.80-2.51 (app. q, J = 37.7 Hz, 4H), 1.74-1.52 (brs, 2H), 1.52-1.36 (brs, 2H), 0.91 (t, J = 7.3 Hz, 3H), 0.85 (t, J = 7.4 Hz, 3H); ^{13}C NMR (100 MHz, CD_3OD) δ 169.0, 148.8, 135.0, 133.7, 133.6, 133.4, 131.5, 131.4, 130.9, 129.8, 128.7, 125.6 (q, $^1J_{C\text{-}F}$ = 289.9 Hz), 123.3, 110.9, 83.1-82.0 (m), 41.3, 39.4, 23.5, 21.9, 14.1, 14.0; ^{19}F NMR (376 MHz, CD_3OD) δ -77.2; HRMS (ESI) Calcd for $C_{24}H_{25}F_6INO_2$ $[M + H]^+$ 600.0834, found 600.0830.



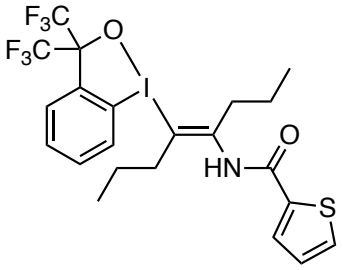
(*E*)-*N*-(5-(3,3-Bis(trifluoromethyl)-1λ^3-benzo[*d*][1,2]iodaoxol-1(3*H*)-yl)oct-4-en-4-yl)-4-methoxybenzamide (4ao): Synthesized by the general procedure B in 45% yield (56.6 mg); White solid; R_f 0.3 (Et_2O/EtOAc = 2/1); m.p. 136-137 °C; ^{1}H NMR (400 MHz, CD_3OD) δ 8.28-8.26 (m, 1H), 7.94-7.90 (m, 2H), 7.84 (app. d, J = 6.7 Hz, 1H), 7.73-7.67 (m, 2H), 7.08-7.04 (m, 2H), 4.89 (s, 3H), 3.11-2.22 (brs, 4H), 1.68-1.51(brs, 2H), 1.51-1.36 (brs, 2H), 0.91 (t, J = 7.3 Hz, 3H), 0.85 (t, J = 7.4 Hz, 3H); ^{13}C NMR (100 MHz, CD_3OD) δ 168.5, 164.6, 149.1, 133.7, 133.6, 131.5, 131.3, 131.0, 130.8, 126.9, 125.6 (q, $^1J_{C\text{-}F}$ = 290.3 Hz), 122.9, 115.0, 111.0, 82.9-82.3 (m), 56.0, 41.3, 39.4, 23.5, 21.9, 14.1, 14.0; ^{19}F NMR (376 MHz, CD_3OD) δ -77.2; HRMS (ESI) Calcd for $C_{25}H_{27}F_6INO_2$ $[M + H]^+$ 630.0940, found 630.0937.



(*E*)-*N*-(5-(3,3-Bis(trifluoromethyl)-1λ^3-benzo[*d*][1,2]iodaoxol-1(3*H*)-yl)oct-4-en-4-yl)-4-chlorobenzamide (4ap): Synthesized by the general procedure B in 54% yield (68.4 mg); White solid; R_f 0.3 (Et_2O/EtOAc = 2/1); m.p. 130-131 °C; ^{1}H NMR (400 MHz, CD_3OD) δ 8.27-8.23 (m, 1H), 7.93-7.91 (m, 2H), 7.86-7.84 (m, 2H), 7.72-7.66 (m, 2H), 7.57-7.53 (m, 2H), 7.47-7.53 (m, 1H), 3.31-2.22 (brs, 4H), 1.71-1.52 (brs, 2H), 1.51-1.32 (brs, 2H), 0.91 (t, J = 7.3 Hz, 3H), 0.85 (t, J = 7.4 Hz, 3H); ^{13}C NMR (100 MHz, CD_3OD) δ 167.7, 148.6, 139.5, 133.64, 133.60, 131.5, 131.3, 130.9, 130.44, 130.36, 129.7, 125.6 (q, $^1J_{C\text{-}F}$ = 290.3 Hz), 123.3, 111.0, 82.9-82.3 (m), 41.2, 39.4, 23.5, 21.9, 14.1, 14.0; ^{19}F NMR (376 MHz, CD_3OD) δ -77.2; HRMS (ESI) Calcd for $C_{24}H_{24}ClF_6INO_2$ $[M + H]^+$ 634.0444, found 634.0446.

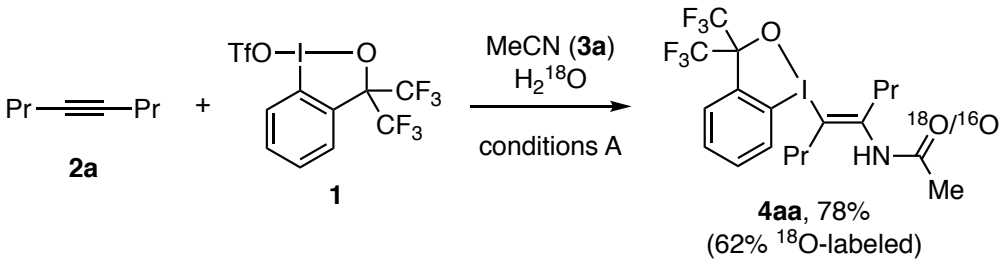


(*E*)-*N*-(5-(3,3-Bis(trifluoromethyl)-1λ^3-benzo[*d*][1,2]iodaoxol-1(3*H*)-yl)oct-4-en-4-yl)-4-methylbenzamide (4aq): Synthesized by the general procedure B in 53% yield (65.0 mg); White solid; R_f 0.3 (Et_2O/EtOAc = 2/1); m.p. 158-159 °C; ^{1}H NMR (400 MHz, CD_3OD) δ 8.26-8.22 (m, 1H), 7.85 (app. s, 1H), 7.70-7.66 (m, 2H), 7.46 (d, J = 7.6 Hz, 1H), 7.41 (t, J = 6.7 Hz, 1H), 7.34-7.29 (m, 2H), 3.00-2.69 (brs, 2H), 2.69-2.33 (brs + s, 2H +3H), 1.74-1.39 (brs, 4H), 0.98 (t, J = 7.4 Hz, 3H), 0.89 (t, J = 7.4 Hz, 3H); ^{13}C NMR (100 MHz, CD_3OD) δ 171.5, 148.3, 137.2, 137.1, 133.7, 133.6, 132.1, 131.6, 131.5, 131.4, 130.9, 128.1, 127.0, 125.6 (q, $J_{C\text{-}F}$ = 289.6 Hz), 123.3, 111.0, 83.1-82.0 (m), 41.3, 39.4, 23.5, 21.9, 14.1, 14.0; ^{19}F NMR (376 MHz, CD_3OD) δ -77.2; HRMS (ESI) Calcd for $C_{25}H_{27}F_6INO_2$ $[M + H]^+$ 614.0991, found 614.0990.

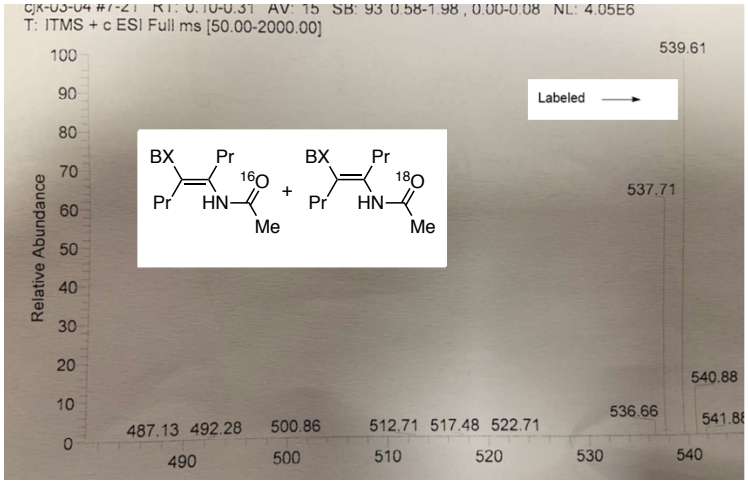


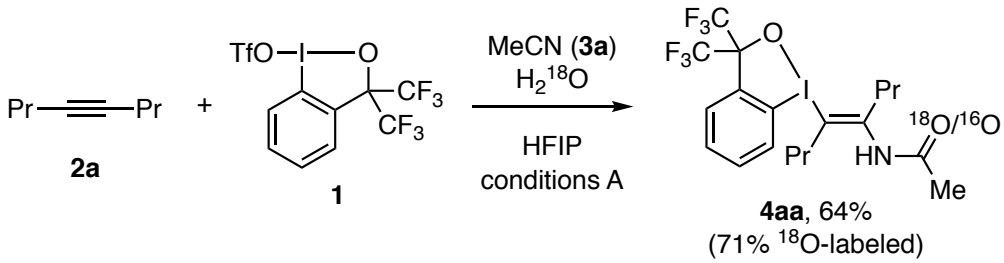
(*E*)-*N*-(5-(3,3-Bis(trifluoromethyl)-1λ^3-benzo[*d*][1,2]iodaoxol-1(3*H*)-yl)-oct-4-en-4-yl)thiophene-2-carboxamide (4ar): Synthesized by the general procedure B in 54% yield (65.4 mg); White solid; R_f 0.3 (Et_2O/EtOAc = 2/1); m.p. 107-108 °C; ^{1}H NMR (400 MHz, CD_3OD) δ 8.23-8.21 (m, 1H), 7.87-7.83 (m, 2H), 7.76-7.75 (m, 1H), 7.72-7.65 (m, 2H), 7.19 (q, J = 4.8Hz, 1H), 2.64 (app. q, J = 40.2 Hz, 4H), 1.71-1.51 (brs, 2H), 1.51-1.31 (brs, 2H), 0.90 (t, J = 7.4 Hz, 3H), 0.84 (t, J = 7.4 Hz, 3H); ^{13}C NMR (100 MHz, CD_3OD) δ 162.9, 148.3, 139.3, 133.7, 133.6, 133.1, 131.5, 131.3, 130.9, 130.8, 129.1, 125.6 (q, $^1J_{C\text{-}F}$ = 289.7 Hz), 123.6, 111.0, 83.1-82.0 (m), 41.2, 39.7, 23.5, 21.9, 19.9, 14.1, 14.0; ^{19}F NMR (376 MHz, CD_3OD) δ -77.2; HRMS (ESI) Calcd for $C_{22}H_{23}F_6INO_2S$ $[M + H]^+$ 606.0398, found 606.0396.

Control Experiments

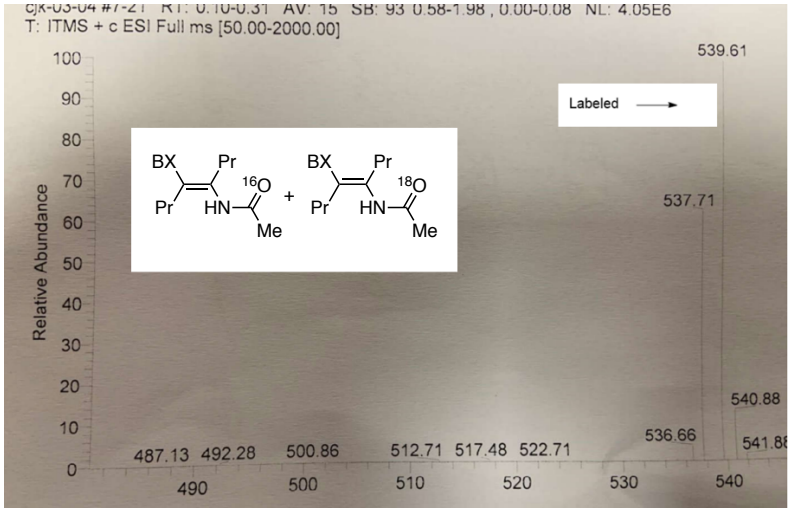


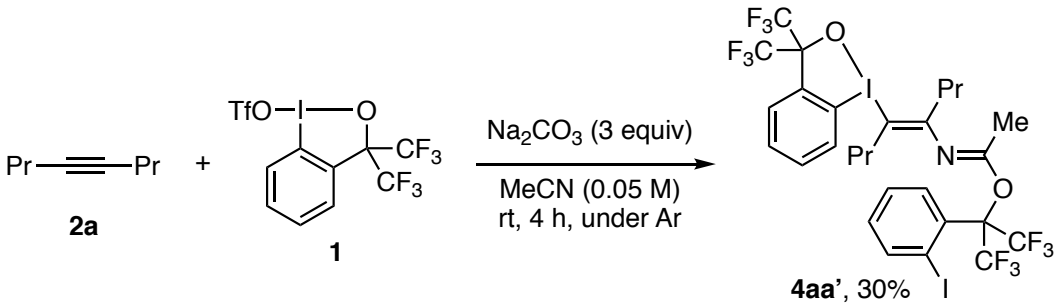
Reactions using ^{18}O-labeled water (conditions A): The reaction between **1** and **2a** in MeCN was performed on a 0.2 mmol scale under conditions A, except using $H_2{}^{18}O$ instead of H_2O. Standard workup and purification afforded the product **4aa** (83.5 mg, 78%). Analysis of the peak intensities in the ESI-MS spectrum of this product indicated 62% incorporation of ^{18}O isotope (see below).





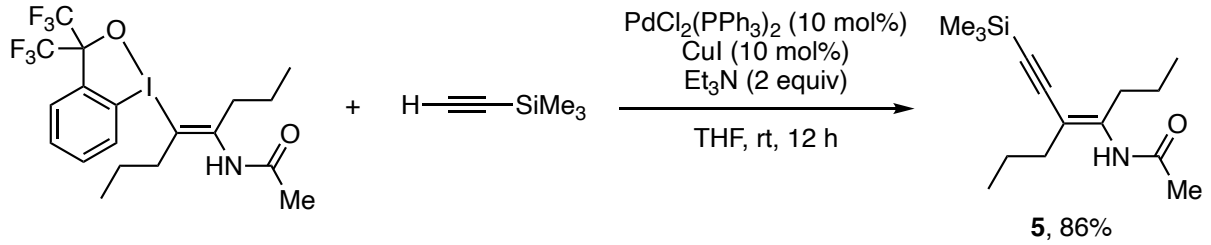
Reactions using ^{18}O-labeled water (conditions B): The reaction between **1**, **2a** and MeCN in HFIP was performed under conditions B, except using $H_2{}^{18}O$ instead of H_2O. Standard workup and purification afforded the product **4aa** (68.7 mg, 64%). Analysis of the peak intensities in the ESI-MS spectrum of this product indicated 71% incorporation of ^{18}O isotope (see below).





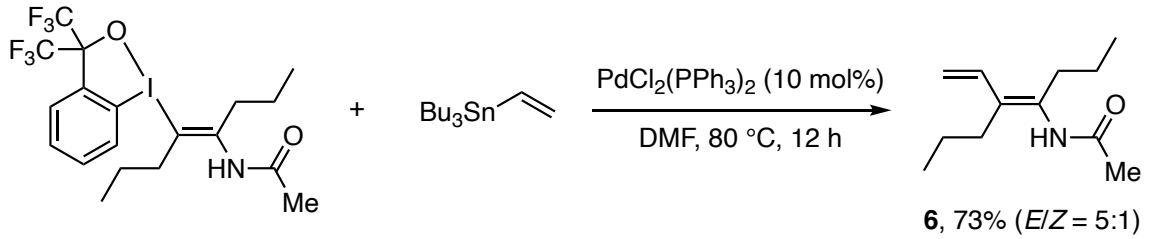
Reaction in the absence of H_2O: 1,1,1,3,3,3-Hexafluoro-2-(2-iodophenyl)propan-2-yl (*E*)-*N*-((*E*)-5-(3,3-bis(trifluoromethyl)-1λ^3-benzo[*d*][1,2]iodaoxol-1(3*H*)-yl)oct-4-en-4-yl)acetimidate (4aa'). The reaction between **1** and **2a** in MeCN was performed on a 0.1 mmol scale under conditions A, except for the omission of H_2O. Standard workup and purification afforded the acetimidate derivative **4ax** as a white solid (26.7 mg, 30%). R_f 0.2 (hexane/EtOAc = 3/1); m.p. 218-220 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.16-8.04 (m, 1H), 7.85 (d, J = 7.6 Hz, 1H), 7.57 (t, J = 7.4 Hz, 1H), 7.53-7.41 (m, 3H), 7.34 (d, J = 8.1 Hz, 1H), 7.12-7.02 (m, 1H), 2.47- 2.12 (m, 7H), 1.44-1.25 (m, 2H), 1.02-0.89 (m, 2H), 0.86 (t, J = 7.3 Hz, 3H), 0.65 (t, J = 7.3 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 156.2, 153.5, 144.2, 132.2, 131.5, 130.8, 130.5 (two signals overlapped), 130.2, 128.9, 127.9, 126.5, 124.2 (q, $J_{C\text{-}F}$ = 290.8 Hz), 122.1 (q, $J_{C\text{-}F}$ = 289.4 Hz), 109.9, 107.5, 92.1, 84.7-83.5 (m), 81.8-80.6 (m), 41.1, 36.2, 23.0, 21.7, 17.9, 13.40, 13.39; ^{19}F NMR (376 MHz, $CDCl_3$) δ -76.0 (two signals overlapped); HRMS (ESI) Calcd for $C_{28}H_{26}F_{12}I_2NO_2$ $[M + H]^+$ 889.9861, found 889.9852.

Product Transformations



5, 86%

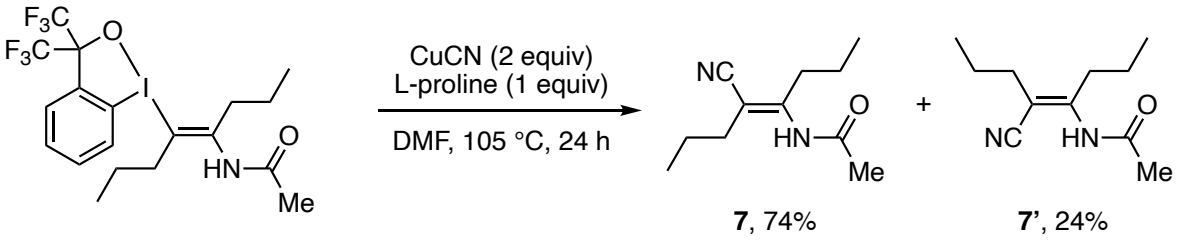
(*E*)-*N*-(5-((Trimethylsilyl)ethynyl)oct-4-en-4-yl)acetamide (5): Under N_2 atmosphere, an 8-mL vial equipped with a stir bar was charged sequentially with **4aa** (53.7 mg, 0.10 mmol), $PdCl_2(PPh_3)_2$ (7.0 mg, 0.010 mmol), CuI (1.9 mg, 0.010 mmol), and THF (0.5 mL). To the mixture was added trimethylsilylacetylene (19.6 mg, 0.20 mmol) and Et_3N (20.2 mg, 0.20 mmol), and the resulting mixture was stirred at room temperature for 12 h. The mixture was diluted with EtOAc (10 mL) and washed with H_2O (5 mL) and brine (5 mL). The organic layer was dried over $MgSO_4$ and concentrated under reduced pressure. The residue was purified by flash column chromatography on silica gel (eluent: hexane/EtOAc = 3/1) to afford the title compound as a yellow oil (22.8 mg, 86% yield); ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.69-6.35 (brs, 1H), 2.71 (brs, 2H), 2.06-2.01 (m, 5H), 1.59-1.45 (m, 4H), 0.94-0.90 (m, 6H), 0.18 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 167.7, 143.2, 113.6, 104.4, 98.5, 34.4, 32.5, 24.1, 21.1 (two signals overlapped), 13.7 (two signals overlapped), 0.00; HRMS (ESI) Calcd for $C_{15}H_{28}NOSi$ $[M + H]^+$ 267.1936, found 267.1956.



6, 73% (*E*/*Z* = 5:1)

(*E*)-(1-Methoxy-2-methylbuta-1,3-dien-1-yl)benzene (6): Under N_2 atmosphere, a 10-mL Schlenk tube equipped with a stir bar was charged sequentially with **4aa** (53.7 mg, 0.10 mmol), $PdCl_2(PPh_3)_2$ (7.0 mg, 0.01 mmol), and DMF (0.5 mL). To the solution was added tributyl(vinyl)tin (63.4 mg, 0.20 mmol), and the resulting mixture was stirred at 80 °C for 12 h. The mixture was cooled to room temperature, diluted with Et_2O (10 mL), and washed with

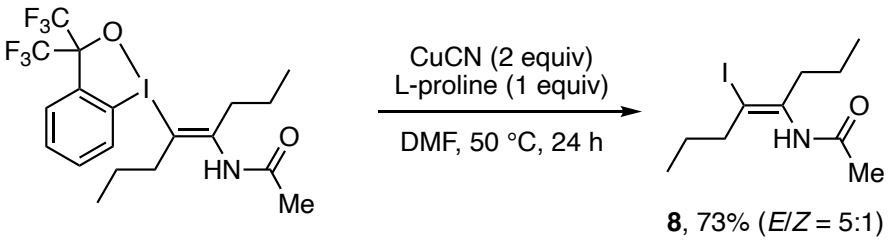
H_2O (5 mL) and brine (5 mL). The organic layer was dried over $MgSO_4$ and concentrated under reduced pressure. The residue was purified by flash column chromatography on silica gel (eluent: hexane/EtOAc = 3/1) to afford the title compound **5** as a white solid (14.2 mg, 73% yield, *E*/*Z* = 5:1); ^{1}H NMR (400 MHz, $CDCl_3$, two isomers) δ 6.40 (app. dd, *J* = 17.2, 11.0 Hz, 1H + 0.2H, major + minor), 6.57-6.53 (brs, 1H, major), 6.42-6.30 (brs, 1H, minor), 5.34 (d, *J* = 18.3 Hz, 0.2H, minor), 5.23 (app. d, *J* = 17.3 Hz, 1H + 0.2H, major + minor), 5.10 (d, *J* = 11.1 Hz, 1H, major), 2.54 (t, *J* = 7.6 Hz, 2H, major), 2.20 (app. t, *J* = 8.0 Hz, 2H + 0.4H, major + minor), 2.08 (s, 3H, major), 1.99-1.88 (brs, 0.6H, minor), 1.50-1.37 (m, 4H + 0.8H, major + minor), 0.94-0.88 (m, 6H + 1.2H, major + minor); ^{13}C NMR (100 MHz, $CDCl_3$, major isomer) δ 168.4, 134.9, 133.1, 129.9, 113.7, 31.4, 29.0, 23.9, 21.7, 14.3, 13.8; HRMS (ESI) Calcd for $C_{12}H_{22}NO$ $[M + H]^+$ 196.1701, found 196.1699.



(*E*)-*N*-(5-Cyanooct-4-en-4-yl)acetamide (7): Under N_2 atmosphere, an 8-mL vial equipped with a stir bar was charged sequentially with CuCN (17.9 mg, 0.20 mmol), L-proline (11.5 mg, 0.10 mmol), and DMF (0.5 mL). After stirring at room temperature for 10 min, **4aa** (53.7 mg, 0.10 mmol) was added, and the resulting mixture was stirred at 105 °C for 24 h. The mixture was cooled to room temperature, diluted with EtOAc (15 mL), and washed with saturated aq. NH_4Cl (5 mL), H_2O (5 mL) and brine (5 mL). The organic layer was dried over $MgSO_4$ and concentrated under reduced pressure. The residue was purified by flash column chromatography on silica gel (eluent: hexane/EtOAc = 3/1) to afford the title compound as a colorless oil (14.4 mg, 74% yield) and its isomer **7'** as a white solid (4.7 mg, 24% yield); ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.84 (s, 1H), 2.84 (t, *J* = 7.7 Hz, 2H), 2.12 (s, 3H), 2.10 (t, *J* = 7.6 Hz, 2H), 1.66-1.51 (m, 4H), 0.970 (t, *J* = 7.6 Hz, 3H), 0.965 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 167.5, 151.6, 119.0, 100.3, 35.0, 30.2, 24.4, 21.4, 21.0, 13.5, 13.4; HRMS (ESI)

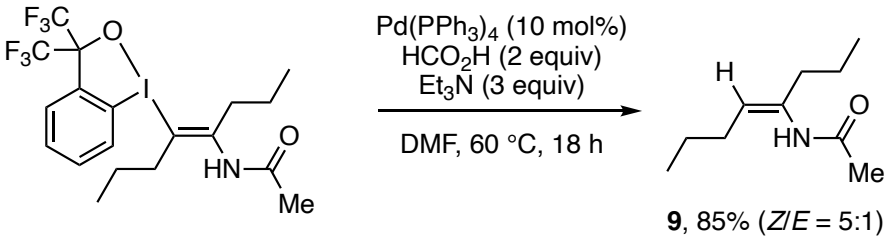
Calcd for $C_{11}H_{19}N_2O$ [M + H]$^+$ 195.1497, found 195.1498.

(*Z*)-*N*-(5-Cyanooct-4-en-4-yl)acetamide (7'): ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.33 (s, 1H), 2.73 (t, *J* = 7.8 Hz, 2H), 2.17 (t, *J* = 7.8 Hz, 2H), 2.13 (s, 3H), 1.59-1.48 (m, 4H), 0.97 (t, *J* = 7.0 Hz, 3H), 0.95 (t, *J* = 7.0 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 168.0, 153.5, 118.2, 95.8, 30.4, 29.5, 24.7, 22.1, 21.4, 13.8, 13.4; HRMS (ESI) Calcd for $C_{11}H_{19}N_2O$ [M + H]$^+$ 195.1497, found 195.1494.



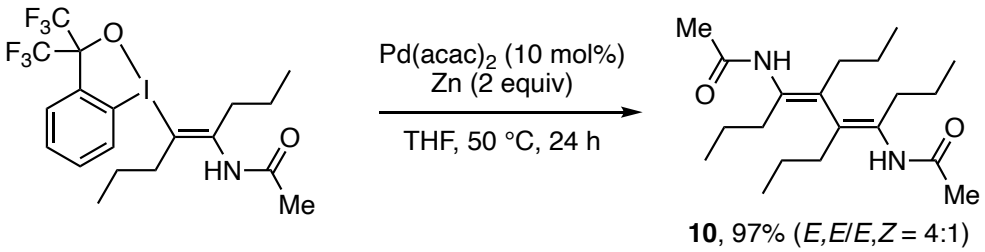
8, 73% (*E*/*Z* = 5:1)

(*E*)-*N*-(5-Iodooct-4-en-4-yl)acetamide (8): Under N_2 atmosphere, an 8-mL vial equipped with a stir bar was charged sequentially with CuCN (17.9 mg, 0.20 mmol), L-proline (11.5 mg, 0.10 mmol), and DMF (0.5 mL). After stirring at room temperature for 10 min, **4aa** (53.7 mg, 0.10 mmol) was added, and the resulting mixture was stirred at 50 °C for 24 h. The mixture was cooled to room temperature, diluted with EtOAc (15 mL), and washed with saturated aq. NH_4Cl (5 mL), H_2O (5 mL) and brine (5 mL). The organic layer was dried over $MgSO_4$ and concentrated under reduced pressure. The residue was purified by flash column chromatography on silica gel (eluent: hexane/EtOAc = 3/1) to afford the title compound as a colorless solid (21.6 mg, 73% yield, *E*/*Z* = 5:1); ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.40 (s, 1H, major), 6.24 (s, 0.2H, minor), 2.58 (t, *J* = 7.5 Hz, 2H, major), 2.51-2.41 (m, 2H + 0.8H, major + minor), 2.06 (s, 3H, major), 1.94 (s, 0.6H, minor), 1.59-1.42 (m, 4H + 0.8 H, major + minor), 0.96-0.87 (m, 6H + 1.2 H, major + minor); ^{13}C NMR (100 MHz, $CDCl_3$, both isomers) δ 172.0, 168.0, 137.5, 136.9, 109.1, 104.0, 42.7, 41.5, 41.2, 40.3, 29.7, 23.3, 22.7, 22.5, 20.4, 20.2, 20.0, 13.7, 13.0, 12.8; HRMS (ESI) Calcd for $C_{10}H_{19}INO$ [M + H]$^+$ 296.0511, found 296.0510.



9, 85% (*Z*/*E* = 5:1)

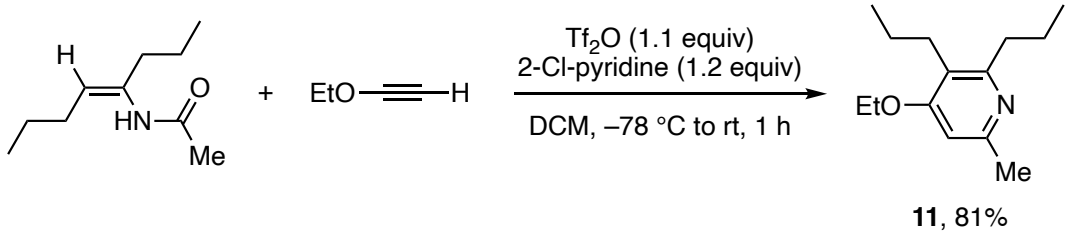
(*Z*)-*N*-(Oct-4-en-4-yl)acetamide (9): Under N_2 atmosphere, a Schlenk tube equipped with a stir bar was charged sequentially with HCO_2H (9.2 mg, 0.20 mmol), Et_3N (30.3 mg, 0.30 mmol), and DMF (0.5 mL). After stirring at room temperature for 10 min, **4aa** (53.7 mg, 0.10 mmol) and $Pd(PPh_3)_4$ (11.6 mg, 0.010 mmol) were added, and the resulting mixture was stirred at 60 °C for 18 h. The mixture was cooled to room temperature, diluted with Et_2O (15 mL), and washed with H_2O (5 mL) and brine (5 mL). The organic layer was dried over $MgSO_4$ and concentrated under reduced pressure. The residue was purified by flash column chromatography on silica gel (eluent: hexane/EtOAc = 3/1) to afford the title compound as a colorless liquid (14.4 mg, 85% yield, *E*/*Z* = 5:1); ^{1}H NMR (400 MHz, $CDCl_3$, two isomers) δ 6.42 (s, 1H, major), 6.19 (s, 0.2H, minor), 5.32 (t, *J* = 5.5 Hz, 0.2H, minor), 5.05 (t, *J* = 7.0 Hz, 1H, major), 2.28 (t, *J* = 7.4 Hz, 2H, major), 2.05 (s, 3H), 1.97-1.91 (m, 2H + 0.4H, major + minor), 1.83 (s, 0.6H, minor), 1.47-1.34 (m, 4H + 0.8H, major + minor), 0.92-0.87 (m, 6H + 1.2H, major + minor); ^{13}C NMR (100 MHz, $CDCl_3$, both isomers) δ 172.6, 168.1, 134.7, 134.3, 127.3, 121.5, 39.3, 36.9, 29.3, 29.0, 23.7, 22.4, 22.2, 20.6, 20.3, 20.2, 19.8, 13.8, 13.7, 13.5; HRMS (ESI) Calcd for $C_{10}H_{20}NO$ $[M + H]^+$ 170.1545, found 170.1544.



10, 97% (*E*,*E*/*E*,*Z* = 4:1)

***N*, *N*'-((4*E*, 6*E*)-5,6-Dipropyldeca-4,6-diene-4,7-diyl)diacetamide (10):** Under N_2 atmosphere, a 10-mL Schlenk tube equipped with a stir bar was charged sequentially with **4aa** (53.7 mg, 0.10 mmol), $Pd(acac)_2$ (3.0 mg, 0.10 mmol), Zn (13.0 mg, 0.20 mmol), and THF (1 mL). The resulting mixture was stirred at 50 °C for 24 h. The mixture was cooled to room

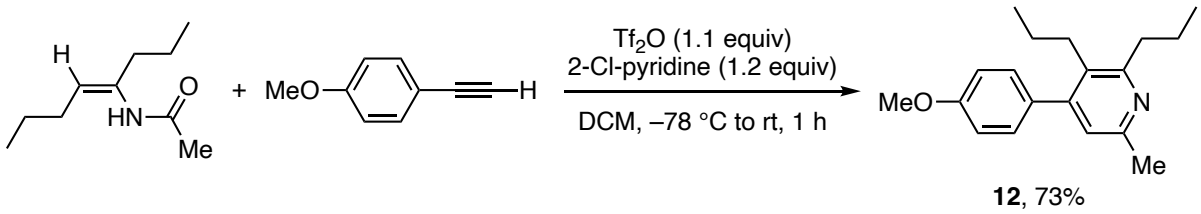
temperature, diluted with EtOAc (15 mL), and washed with H_2O (5 mL) and brine (5 mL). The organic layer was dried over $MgSO_4$ and concentrated under reduced pressure. The residue was purified by flash column chromatography on silica gel (eluent: hexane/EtOAc = 3/1) to afford the title compound as a colorless solid (16.3 mg, 97% yield, (*E*,*E*)/(*E*,*Z*) = 4:1); ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.31 (s, 2H, major), 6.16 (s, 0.5H, minor), 2.59 (t, *J* = 7.8 Hz, 4H, major), 2.48-2.41 (m, 4H + 1H, major + minor), 2.06 (s, 6H, major), 1.94 (s, 1.6H, minor), 1.57-1.44 (m, 8H + 2H, major + minor), 0.96-0.87 (m, 12H + 3H, major + minor); ^{13}C NMR (100 MHz, $CDCl_3$, major isomer) δ 167.9, 136.8, 104.0, 41.5, 40.3, 23.4, 22.5, 20.4, 13.7, 13.0; HRMS (ESI) Calcd for $C_{20}H_{37}N_2O_2$ $[M + H]^+$ 337.2855, found 337.2857.



11, 81%

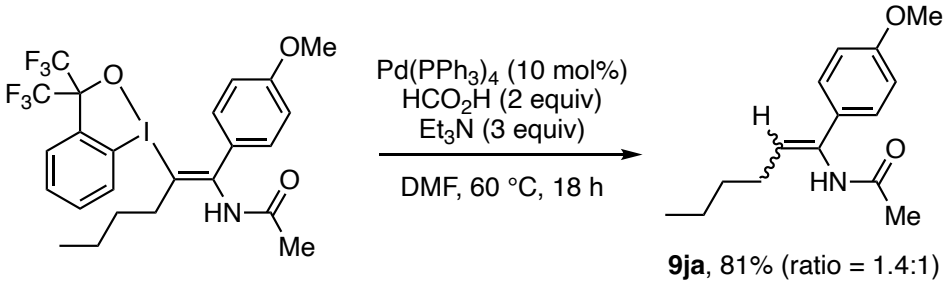
4-Ethoxy-6-methyl-2,3-dipropylpyridine (11): This and other pyridine syntheses were performed according to the literature procedure.[7] Under N_2 atmosphere, a 10-mL Schlenk tube equipped with a stir bar was charged sequentially with the enamide **9** (14.4 mg, 0.08 mmol) and 2-chloropyridine (9.6 μL, 0.10 mmol), and DCM (0.5 mL). The mixture was cooled to -78 °C, and trifluoromethanesulfonic anhydride (Tf_2O, 15.8 μL, 0.09 mmol) was added dropwise via syringe. After 5 min, the reaction mixture was placed in an ice-water bath, and then ethyl ethynyl ether (33.0 μL, 0.17 mmol, 50% wt. in hexane) was added via syringe. The resulting solution was allowed to warm to ambient temperature. After 1 h, triethylamine (80 μL) was introduced to neutralize the trifluoromethanesulfonate salts. DCM (5 mL) was added to dilute the mixture and the layers were separated. The organic layer was washed with brine (2 mL) and dried over $MgSO_4$. The volatiles were removed under reduced pressure and the residue was purified by flash column chromatography on silica gel (eluent: hexane/EtOAc/Et_3N = 100/30/1) to give the title compound as a yellow liquid (15.2 mg, 81% yield); ^{1}H NMR (500 MHz, $CDCl_3$) δ 6.45 (s, 1H), 4.02 (q, *J* = 7.0 Hz, 2H), 2.71-2.67 (m, 2H),

2.57-2.54 (m, 2H), 2.45 (s, 3H), 1.71-1.63 (m, 2H), 1.54-1.46 (m, 2H), 1.42 (t, J = 7.0 Hz, 3H), 0.99 (t, J = 7.3 Hz, 3H), 0.96 (t, J = 7.4 Hz, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 163.4, 160.2, 156.2, 121.0, 103.8, 63.2, 37.3, 27.2, 24.7, 23.7, 23.1, 14.6, 14.3; HRMS (ESI) Calcd for $C_{14}H_{24}NO$ $[M + H]^+$ 222.1858, found 222.1853.



12, 73%

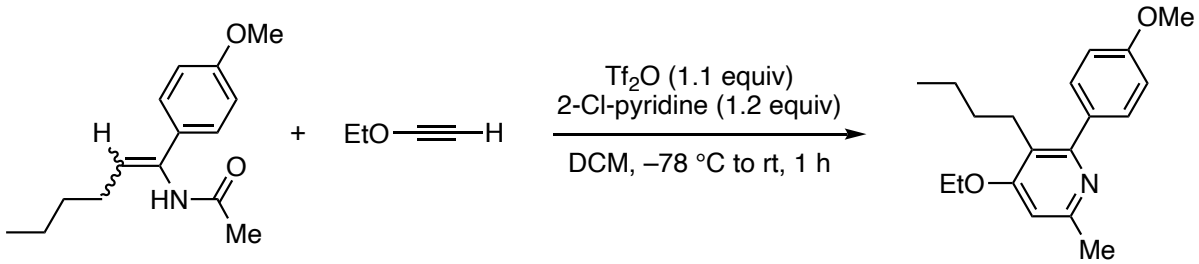
4-(4-Methoxyphenyl)-6-methyl-2,3-dipropylpyridine (12): The reaction between the enamide **9** (13.9 mg, 0.082 mmol) and 4-ethynylanisole (20.7 μL, 0.16 mmol) was performed by the same procedure as described for the synthesis of **11**. Purification of the crude product by flash column chromatography on silica gel (eluent: hexane/EtOAc/Et_3N = 100/10/1) afforded the title compound as a yellow liquid (16.9 mg, 73% yield); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.18 (d, J = 8.6 Hz, 2H), 6.94 (d, J = 8.5 Hz, 2H), 6.78 (s, 1H), 3.86 (s, 3H), 2.80-2.76 (m, 2H), 2.53-2.49 (m, 2H), 2.49 (s, 3H), 1.80-1.72 (m, 2H), 1.41-1.31 (m, 2H), 1.04 (t, J = 7.2 Hz, 3H), 0.79 (t, J = 7.3 Hz, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 160.2, 158.9, 154.2, 150.1, 133.0, 130.2, 129.6, 122.4, 113.5, 55.3, 37.6, 30.6, 24.3, 24.0, 23.8, 14.43, 14.38; HRMS (ESI) Calcd for $C_{19}H_{26}NO$ $[M + H]^+$ 284.2014, found 284.2036.



9ja, 81% (ratio = 1.4:1)

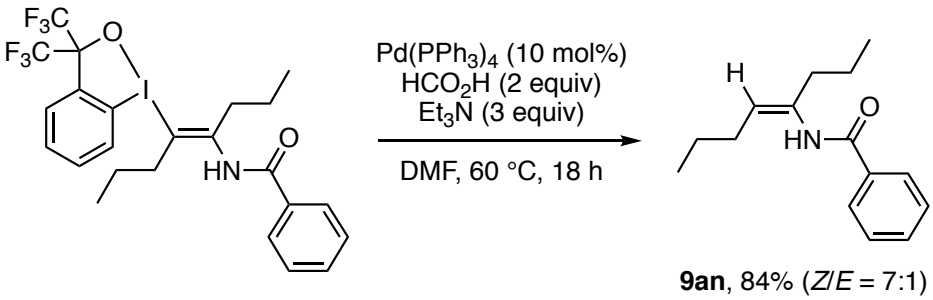
***N*-(1-(4-Methoxyphenyl)hex-1-en-1-yl)acetamide (9ja):** The hydrodehalogenation of **4ja** (61.5 mg, 0.10 mmol) was performed by the same procedure as described for **4aa**. The crude product was purified by flash column chromatography on silica gel (eluent: hexane/EtOAc = 3/1) to afford the title compound as a colorless solid (20.0 mg, 81% yield, stereoisomer ratio =

1.4:1); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.36 (d, *J* = 8.6 Hz, 1.4H, minor), 7.30 (d, *J* = 8.8 Hz, 2H, major), 6.87 (d, *J* = 8.7 Hz, 1.4H, minor), 6.83 (d, *J* = 8.7 Hz, 2H, major), 6.71 (s, 0.6H, minor), 6.63 (s, 1H, major), 5.81 (t, *J* = 7.5 Hz, 0.7H, minor), 5.05 (t, *J* = 7.3 Hz, 1H, major), 3.82 (s, 2.2H, minor), 3.79 (s, 3H, major), 2.24-2.19 (m, 1.5H, minor), 2.15-2.11 (s + m, 3H + 1.9H, major + minor), 1.78 (s, 2.1H, minor), 1.48-1.32 (m, 4H + 3.1H, major + minor), 0.94-0.90 (m, 3H + 2.2H, major + minor); ^{13}C NMR (100 MHz, $CDCl_3$, both isomers) δ 173.6, 168.3, 159.6, 159.3, 134.2, 132.4, 130.8, 130.7, 126.7, 126.6, 125.9, 125.2, 114.1, 113.7, 55.31, 55.26, 31.24, 31.21, 28.0, 27.6, 23.4, 22.5, 22.4, 20.6, 13.94, 13.90; HRMS (ESI) Calcd for $C_{15}H_{22}NO$ $[M + H]^+$ 248.1650, found 248.1652.



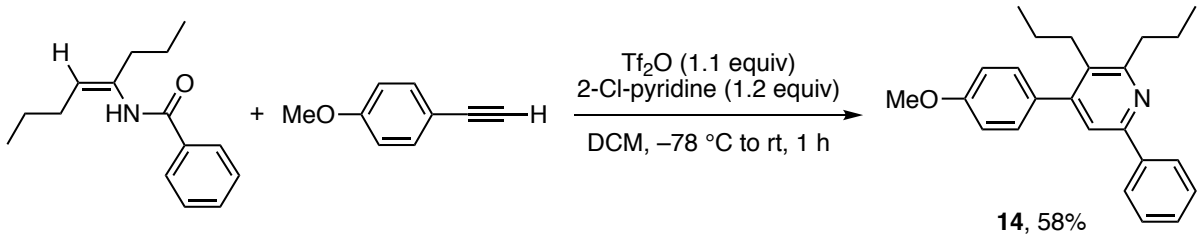
13, 65%

3-Butyl-4-ethoxy-2-(4-methoxyphenyl)-6-methylpyridine (13): The reaction between the enamide **9ja** (14.4 mg, 0.081 mmol) and ethyl ethynyl ether (30.6 μL, 0.16 mmol, 50% wt. in hexane) was performed by the same procedure as described for the synthesis of **11**. The crude product was purified by flash column chromatography on silica gel (eluent: hexane/EtOAc/Et_3N = 100/30/1) to give the title compound as a yellow liquid (19.6 mg, 81% yield); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.35 (d, *J* = 8.6 Hz, 2H), 6.94 (d, *J* = 8.6 Hz, 2H), 6.58 (s, 1H), 4.09 (q, *J* = 7.0 Hz, 2H), 3.84 (s, 3H), 2.54-2.50 (m, 2H), 2.51 (s, 3H), 1.45 (t, *J* = 7.2 Hz, 3H), 1.45-1.38 (m, 2H), 1.28-1.18 (m, 2H), 0.82 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 163.9, 159.0, 158.7, 156.4, 133.9, 130.0, 121.9, 113.4, 104.6, 63.4, 55.3, 31.9, 25.9, 24.8, 22.7, 14.6, 13.8; HRMS (ESI) Calcd for $C_{19}H_{26}NO_2$ $[M + H]^+$ 300.1964, found 300.1962.



9an, 84% (*Z*/*E* = 7:1)

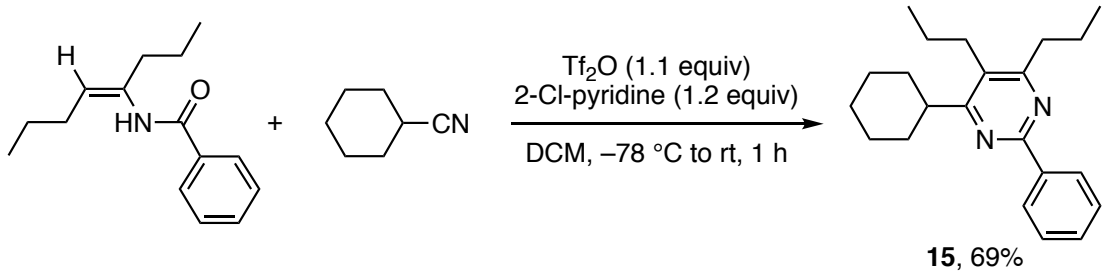
(*Z*)-*N*-(Oct-4-en-4-yl)acetamide (9an): The hydrodehalogenation of **4an** (59.9 mg, 0.10 mmol) was performed by the same procedure as described for **4aa**. The crude product was purified by flash column chromatography on silica gel (eluent: hexane/EtOAc = 3/1) to afford the title compound as a colorless solid (19.4 mg, 84% yield, *Z*/*E* = 7:1); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.82-7.79 (m, 2H, major), 7.77-7.75 (m, 0.3H, minor), 7.54-7.50 (m, 1H + 0.1H, major + minor), 7.47-7.44 (m, 2H + 0.4H, major + minor), 7.12-6.92 (brs, 1H + 0.1H, major + minor), 5.95 (t, *J* = 7.6 Hz, 0.2H, minor), 5.12 (t, *J* = 6.9 Hz, 1H, minor), 2.42 (t, *J* = 7.7 Hz, 2H, major), 2.35 (t, *J* = 7.6 Hz, 0.4H, minor), 2.17-2.06 (m, 0.4H, minor), 2.04-1.98 (m, 2H, major), 1.56-1.38 (m, 4H + 0.7H, major + minor), 1.03-0.88 (m, 6H + 1H, major + minor); ^{13}C NMR (100 MHz, $CDCl_3$, both isomers) δ 166.0, 165.4, 135.5, 134.9, 134.7, 134.1, 131.5, 131.4, 128.64, 128.61, 127.0, 126.8, 123.1, 121.2, 36.9, 31.8, 29.3, 29.1, 23.1, 22.4, 21.2, 20.8, 13.9, 13.8, 13.7, 13.6; HRMS (ESI) Calcd for $C_{15}H_{22}NO$ $[M + H]^+$ 232.1701, found 232.1702.



14, 58%

4-(4-methoxyphenyl)-6-phenyl-2,3-dipropylpyridine (14): The reaction between the enamide **9an** (19.4 mg, 0.084 mmol) and 4-ethynylanisole (20.7 μL, 0.17 mmol) was performed by the same procedure as described for the synthesis of **11**. The crude product was purified by flash column chromatography on silica gel (eluent: hexane/EtOAc/Et_3N = 100/3/1) to give the title compound as a yellow liquid (16.9 mg, 58% yield); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.03-8.00 (m, 2H), 7.42 (t, *J* = 7.8 Hz, 2H), 7.37-7.33 (m, 2H), 7.26-7.23 (m, 2H), 6.98-6.96 (m, 2H), 3.87 (s, 3H), 2.95-2.87 (m, 2H), 2.60-2.56 (m, 2H), 1.97-1.85 (m, 2H), 1.50-1.38 (m,

2H), 1.08 (t, J = 7.4 Hz, 3H), 0.83 (t, J = 7.4 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.5, 159.0, 153.3, 150.3, 139.8, 133.1, 132.0, 129.7, 128.5, 128.3, 127.6, 119.5, 113.6, 55.3, 37.2, 30.8, 24.1, 22.9, 14.1; HRMS (ESI) Calcd for $C_{24}H_{28}NO$ $[M + H]^+$ 346.2171, found 346.2179.

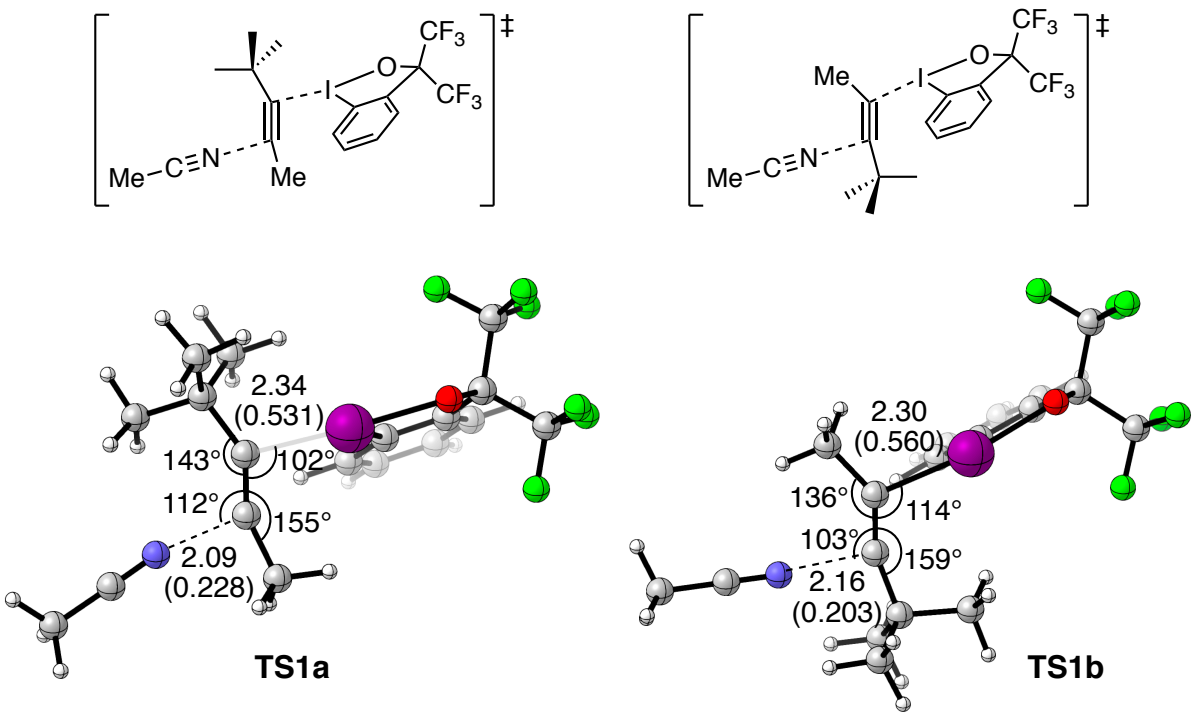


15, 69%

4-cyclohexyl-2-phenyl-5,6-dipropylpyrimidine (15): The pyrimidine synthesis was performed according to the literature procedure.[8] Under N_2 gas, a 10 mL Schlenk tube equipped with a stir bar was charged sequentially with the enamide **9an** (19.0 mg, 0.082 mmol), cyclohexanecarbonitrile (10.7 μL,0.16 mmol), 2-chloropyridine (9.3 μL, 0.09 mmol) and DCM (0.5 mL). Then the trifluoromethanesulfonic anhydride (Tf_2O, 15.3 μL, 0.09 mmol) was added dropwise via syringe at -78 ºC. After 5 min, the reaction mixture was placed in an ice-water bath and warmed to 0 ºC for 5 min. The resulting solution was allowed to warm to ambient temperature. After 1 h, triethylamine (80 μL) was introduced to neutralize the trifluoromethanesulfonate salts. DCM (5 mL) was added to dilute the mixture and the layers were separated. The organic layer was washed with brine (2 mL) and dried over $MgSO_4$. The volatiles were removed under reduced pressure and the residue was purified by flash column chromatography on silica gel (eluent: hexane/EtOAc/Et_3N = 100/3/1) to give the title compound as a colorless liquid (16.9 mg, 69% yield); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.50-8.47 (m, 2H), 7.47-7.39 (m, 1H), 2.89-2.82 (m, 1H), 2.80-2.75 (m, 2H), 2.64-2.60 (m, 2H), 1.91-1.81 (m, 6H), 1.79-1.72 (m, 3H), 1.56-1.48 (m, 2H), 1.44-1.38 (m, 3H), 1.07-1.03 (m, 5H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 171.6, 167.9, 160.8, 138.9, 129.6, 128.2, 127.9, 127.4, 41.6, 36.7, 32.2, 29.0, 26.6, 26.0, 24.2, 22.0, 14.5, 14.3; HRMS (ESI) Calcd for $C_{22}H_{31}N_2$ $[M + H]^+$ 323.2487, found 323.2471.

DFT Calculations

All the density functional theory (DFT) calculations were carried out using Gaussian 16 program.[9] Geometry optimizations were performed with the M06-2X functional[10] and a combined basis set B1 (i.e. the SDD effective core potential[11] for iodine, the 6-31G(d) basis set for all other atoms). Harmonic frequency calculations were performed for each stationary point to ensure that it is either an energy minimum (no imaginary frequency) or a transition state (only one imaginary frequency). For each transition state, intrinsic reaction coordinate (IRC)[12] analysis was performed to ensure that it connects the correct reactant and product. The single-point energy calculations were further performed with the M06-2X functional and a combined basis set B2 (i.e. the SDD effective core potential for iodine, the 6-311++G(2df,2p) basis set for all other atoms). The SMD model[13] with 1,1,1,3,3,3-Hexafluoro-2-propanol (HFIP) as the solvent was used for all the calculations. Because HFIP is not a built-in solvent in Gaussian 16, several parameters (eps = 16.7,[14] epsinf = 1.63,[15] SurfaceTensionAtInterface = 23.2,[14] CarbonAromaticity = 0, ElectronegativeHalogenicity = 0.6) were used to customize it. The HBondAcidity and HBondBasicity of HFIP used the values of 2,2,2-trifluoroethanol (TFE) instead because there is no data available and TFE is the closest to HFIP among the built-in solvents in Gaussian 16. The single-point energies corrected by the thermal correction to Gibbs free energies (TCG, obtained from frequency calculations) were used as the Gibbs free energies reported in this work, corresponding to the reference state of 1 mol/L, 298.15 K. The Mayer bond orders and ADCH atomic charges were calculated using Multiwfn 3.8.[16] The 3-D structures were drawn using CYLview software.[17]



G(**TS1a**) – G(**TS1b**) = 1.7 kcal mol^{-1}

Figure S4. Structures of regioisomeric transition states for the addition of MeCN to 4,4-dimethylpent-2-yne activated by BX^+. Gibbs free energies were calculated at the SMD(HFIP)-M06-2X/B2//SMD(HFIP)-M06-2X/B1 level. Bond distances are in Å. Mayer bond orders are shown in the parentheses.

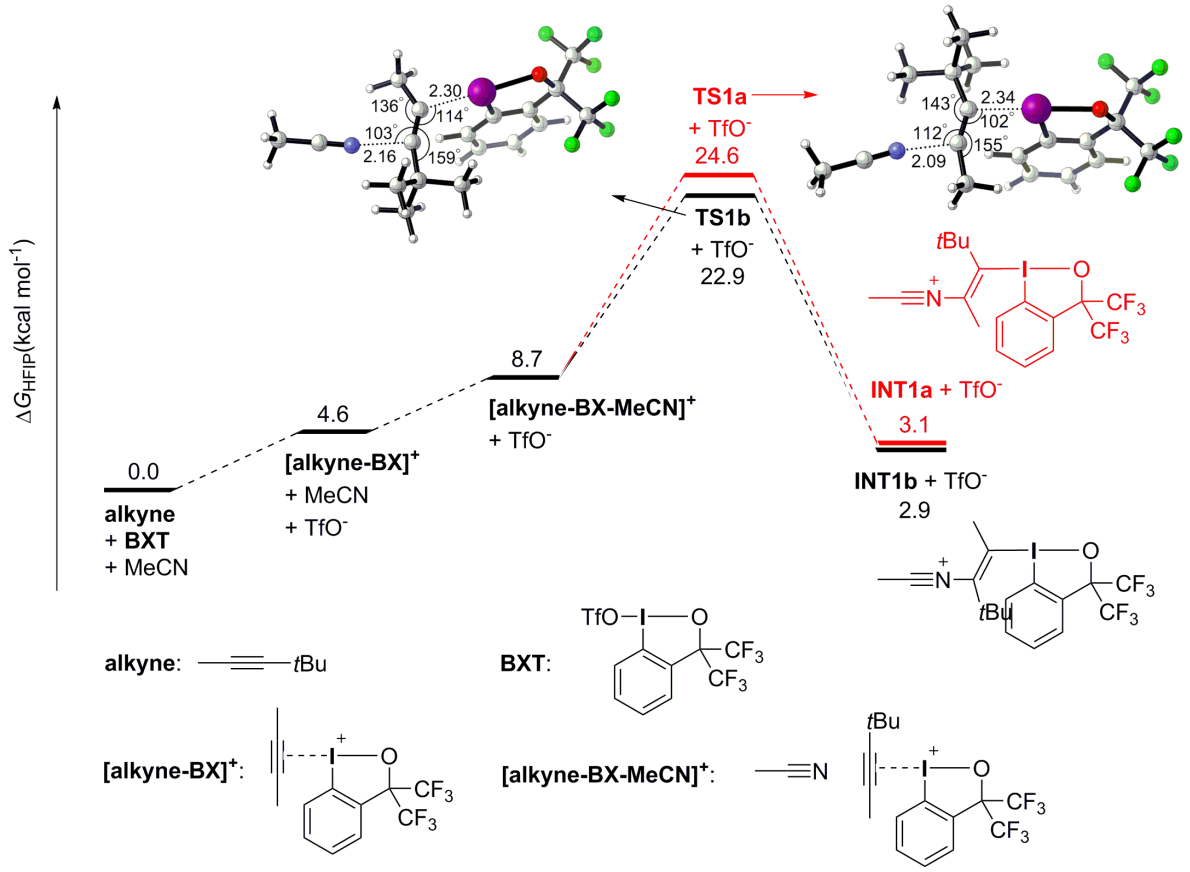


Figure S5. Gibbs free energy diagram for the BXT-mediated addition of MeCN to 4,4-dimethylpent-2-yne.

Thermal correction to Gibbs free energies (TCG), single-point electronic energies (E) and Cartesian coordinates

alkyne (4,4-dimethylbut-2-yne)

TCG = 0.137681 a.u.

E = -273.8810416 a.u.

C	1.786593000	-0.000010000	0.000930000
C	0.576935000	-0.000007000	0.001211000
C	3.250783000	-0.000001000	0.000172000
H	3.641083000	0.006924000	-1.022274000
H	3.642193000	0.881788000	0.516914000
H	3.642203000	-0.888704000	0.504923000
C	-0.900247000	-0.000001000	0.000063000
C	-1.409854000	-0.000501000	1.449411000
C	-1.407375000	1.256067000	-0.724973000
C	-1.407396000	-1.255555000	-0.725848000
H	-1.060676000	-0.888481000	1.986230000
H	-1.060726000	0.887139000	1.986823000
H	-2.505684000	-0.000536000	1.456674000
H	-1.056213000	1.277449000	-1.761705000
H	-2.503196000	1.263663000	-0.730570000

H	-1.058063000	2.164508000	-0.223633000
H	-2.503217000	-1.263111000	-0.731469000
H	-1.056214000	-1.276239000	-1.762587000
H	-1.058126000	-2.164349000	-0.225120000

BXT

TCG = 0.095756 a.u.

E = -1992.470134 a.u.

I	0.374912000	-0.814505000	-0.613220000
O	-1.568458000	-1.355187000	-0.307789000
C	-0.466093000	1.119513000	-0.318516000
C	-1.808735000	1.040483000	0.014984000
C	-2.488500000	2.232438000	0.272497000
C	-1.814913000	3.446621000	0.173501000
C	-0.471603000	3.485592000	-0.187088000
C	0.229349000	2.306234000	-0.441658000
H	0.045799000	4.434896000	-0.277029000
H	1.269545000	2.338240000	-0.742259000
H	-3.536985000	2.216345000	0.545835000
H	-2.349813000	4.368648000	0.374545000
C	-2.447006000	-0.338371000	0.071383000
C	-2.904969000	-0.662034000	1.505077000
C	-3.618452000	-0.428277000	-0.924749000
F	-1.860984000	-0.586427000	2.332692000
F	-3.841084000	0.190857000	1.934120000
F	-3.404800000	-1.895209000	1.583227000
F	-4.121686000	-1.661768000	-0.961870000
F	-4.611083000	0.410900000	-0.611516000
F	-3.182890000	-0.122929000	-2.148225000
O	3.968137000	1.886599000	-0.040047000
S	3.264549000	0.648639000	0.251986000
O	2.369286000	0.233791000	-0.911314000
O	2.593541000	0.508896000	1.536610000
C	4.525862000	-0.675234000	0.196994000
F	5.390671000	-0.500581000	1.185703000
F	3.929130000	-1.853247000	0.334760000
F	5.164796000	-0.639617000	-0.962941000

MeCN

TCG = 0.023084 a.u.

E = -132.7500944 a.u.

C	0.000000000	0.000000000	-1.179326000
H	0.000000000	1.028926000	-1.546349000
H	0.891076000	-0.514463000	-1.546349000
H	-0.891076000	-0.514463000	-1.546349000
C	0.000000000	0.000000000	0.278832000
N	0.000000000	0.000000000	1.434573000

[alkyne-BX]$^{+}$

TCG = 0.241553 a.u.

E = -1304.67904 a.u.

I	0.809551000	-0.746899000	0.818035000
O	-1.189196000	-1.205245000	0.649282000
C	0.091521000	1.097065000	0.006301000
C	-1.255199000	1.021763000	-0.311399000
C	-1.851423000	2.146270000	-0.885913000

C	-1.095985000	3.294308000	-1.106284000
C	0.250906000	3.334554000	-0.760006000
C	0.870283000	2.219580000	-0.193517000
H	0.835257000	4.232837000	-0.929224000
H	1.921362000	2.244972000	0.067171000
H	-2.899602000	2.128570000	-1.160225000
H	-1.568099000	4.163179000	-1.552038000
C	-1.988028000	-0.278321000	-0.020123000
C	-3.180474000	-0.023529000	0.922468000
C	-2.440793000	-0.944413000	-1.332202000
F	-2.745856000	0.580935000	2.029921000
F	-4.111292000	0.753124000	0.359217000
F	-3.761981000	-1.168257000	1.277545000
F	-3.027676000	-2.117053000	-1.095706000
F	-3.300203000	-0.179235000	-2.011744000
F	-1.375827000	-1.164856000	-2.108104000
C	3.311487000	0.016113000	0.324235000
C	3.068443000	0.471562000	1.440231000
C	2.933266000	1.099356000	2.755247000
H	3.869162000	1.614868000	2.991398000
H	2.118868000	1.830177000	2.748729000
H	2.735959000	0.348785000	3.524797000
C	3.828245000	-0.434787000	-0.988264000
C	2.975301000	0.142806000	-2.126925000
C	3.843924000	-1.968250000	-1.051686000
H	2.978166000	1.236955000	-2.108319000
H	3.396294000	-0.188914000	-3.081312000
H	1.939328000	-0.208036000	-2.066930000
H	4.434692000	-2.389431000	-0.232528000
H	2.829491000	-2.376332000	-1.001709000
H	4.292999000	-2.276977000	-2.000773000
C	5.266593000	0.108612000	-1.082113000
H	5.277676000	1.201282000	-1.031296000
H	5.890117000	-0.290489000	-0.276799000
H	5.692836000	-0.201895000	-2.041541000

OTf^-

TCG = -0.00405 a.u.

E = -961.6689107 a.u.

O	1.223588000	-0.876823000	-1.131058000
S	0.888810000	0.000143000	-0.000067000
O	1.223788000	1.418203000	-0.193460000
O	1.223576000	-0.541667000	1.324581000
C	-0.937830000	0.000032000	0.000008000
F	-1.405878000	-1.236880000	0.168264000
F	-1.405972000	0.764189000	0.986995000
F	-1.406106000	0.472671000	-1.155202000

$[MeCN\text{-}alkyne\text{-}BX]^+$

TCG = 0.281243 a.u.

E = -1437.43606592 a.u.

I	-0.198120000	-0.966122000	-0.853148000
O	1.857273000	-1.031443000	-0.813746000
C	0.192201000	0.838686000	0.229074000
C	1.546514000	1.007832000	0.465796000
C	1.941063000	2.141059000	1.180596000
C	0.984329000	3.053733000	1.616848000
C	-0.365930000	2.848057000	1.351231000
C	-0.784048000	1.719279000	0.645537000
H	-1.112251000	3.559880000	1.689195000
H	-1.837190000	1.559276000	0.448345000
H	2.989114000	2.313605000	1.395160000
H	1.301985000	3.932081000	2.168464000

C	2.502470000	-0.051046000	-0.059320000
C	3.535561000	0.579934000	-1.012405000
C	3.190268000	-0.777399000	1.111803000
F	2.899621000	1.233429000	-1.986804000
F	4.336139000	1.444492000	-0.380800000
F	4.301650000	-0.353411000	-1.574780000
F	4.005159000	-1.735307000	0.670379000
F	3.905863000	0.059191000	1.868852000
F	2.262515000	-1.349043000	1.884361000
C	-2.800273000	-0.805756000	-0.248083000
C	-2.673492000	-0.107664000	-1.252104000
C	-2.675755000	0.799701000	-2.401604000
H	-3.711716000	1.042328000	-2.659044000
H	-2.145753000	1.724503000	-2.151272000
H	-2.199251000	0.333944000	-3.268141000
C	-3.174942000	-1.565006000	0.967714000
C	-2.426719000	-1.000987000	2.184381000
C	-2.867160000	-3.056957000	0.783280000
H	-2.656188000	0.059688000	2.328967000
H	-2.742592000	-1.550402000	3.076967000
H	-1.342957000	-1.117295000	2.072998000
H	-3.399812000	-3.462806000	-0.082293000
H	-1.794664000	-3.229463000	0.648220000
H	-3.192350000	-3.597277000	1.677730000
C	-4.690814000	-1.366223000	1.154475000
H	-4.928379000	-0.312779000	1.329444000
H	-5.247894000	-1.723134000	0.283076000
H	-5.008401000	-1.941398000	2.030385000
N	-3.977034000	2.506572000	0.572838000
C	-4.850528000	2.050393000	-0.032669000
C	-5.950921000	1.469068000	-0.793165000
H	-6.814337000	1.327700000	-0.138554000
H	-6.223309000	2.136304000	-1.614329000
H	-5.642104000	0.500880000	-1.197525000

TS1a

TCG = 0.282382 a.u.

E = -1437.411951 a.u.

I	0.290973000	0.599873000	-0.855169000
O	-1.827757000	0.629700000	-1.204995000
C	-0.416060000	-0.752817000	0.653750000
C	-1.797091000	-0.834169000	0.715887000
C	-2.356256000	-1.670201000	1.686136000
C	-1.532294000	-2.399023000	2.538489000
C	-0.148161000	-2.300273000	2.438143000
C	0.430490000	-1.463672000	1.483717000
H	0.494120000	-2.871341000	3.100485000
H	1.508151000	-1.380734000	1.405889000
H	-3.432652000	-1.754864000	1.777692000
H	-1.978641000	-3.047745000	3.284736000
C	-2.614982000	0.011103000	-0.258846000
C	-3.602759000	-0.875496000	-1.041407000
C	-3.365151000	1.106749000	0.522509000
F	-2.936605000	-1.863401000	-1.646231000
F	-4.538126000	-1.428313000	-0.257701000
F	-4.233050000	-0.171412000	-1.982995000
F	-4.061152000	1.895233000	-0.298966000
F	-4.215618000	0.605329000	1.426775000
F	-2.482117000	1.872932000	1.173083000
C	2.494438000	0.447215000	-0.068468000
C	2.912914000	-0.600768000	-0.652609000
C	2.762584000	-1.835223000	-1.430899000
H	3.094885000	-2.691979000	-0.839595000
H	1.704289000	-1.971962000	-1.673883000
H	3.339450000	-1.782910000	-2.357167000
C	2.916071000	1.600058000	0.820881000
C	2.021406000	1.629120000	2.070256000
C	2.772211000	2.916010000	0.040138000
H	2.151897000	0.722304000	2.669489000
H	2.304258000	2.490410000	2.683904000

H	0.961415000	1.729663000	1.814806000
H	3.361619000	2.890829000	-0.882153000
H	1.729854000	3.130997000	-0.214256000
H	3.140664000	3.736894000	0.663757000
C	4.374167000	1.445477000	1.264185000
H	4.539373000	0.498409000	1.785097000
H	5.061529000	1.509670000	0.417388000
H	4.604328000	2.263650000	1.954661000
N	4.966651000	-0.885567000	-0.387651000
C	6.080336000	-1.167667000	-0.485932000
C	7.490156000	-1.509171000	-0.592976000
H	8.083672000	-0.592172000	-0.578585000
H	7.771458000	-2.142943000	0.251154000
H	7.662155000	-2.044889000	-1.529370000

TS1b

TCG = 0.280977 a.u.

E = -1437.413296 a.u.

I	-0.199116000	0.269543000	-1.134332000
O	1.935750000	0.507895000	-1.274844000
C	0.464555000	-0.766338000	0.622787000
C	1.834261000	-0.707457000	0.814261000
C	2.361196000	-1.340480000	1.943560000
C	1.518725000	-2.011480000	2.824765000
C	0.146796000	-2.052938000	2.596744000
C	-0.400898000	-1.420465000	1.480571000
H	-0.510331000	-2.575051000	3.284467000
H	-1.470511000	-1.446433000	1.306970000
H	3.426942000	-1.311228000	2.137295000
H	1.940166000	-2.501992000	3.695805000
C	2.674560000	0.069303000	-0.199708000
C	3.274613000	1.311660000	0.484526000
C	3.783797000	-0.830117000	-0.775669000
F	2.283181000	2.082492000	0.946066000
F	4.070151000	1.004342000	1.516863000
F	3.989705000	2.038603000	-0.376612000
F	4.454486000	-0.202874000	-1.743291000
F	4.674845000	-1.213678000	0.148965000
F	3.238942000	-1.930376000	-1.303016000
C	-2.338321000	-0.459412000	-0.733883000
C	-3.040650000	0.366322000	-0.066518000
N	-5.009875000	-0.517076000	-0.135429000
C	-6.031360000	-1.017696000	-0.326149000
C	-7.321441000	-1.648244000	-0.560867000
H	-7.920382000	-1.009323000	-1.213890000
H	-7.166273000	-2.619205000	-1.036810000
H	-7.835257000	-1.783869000	0.393536000
C	-2.563488000	-1.780602000	-1.389242000
H	-2.484485000	-1.671033000	-2.475060000
H	-1.791019000	-2.486151000	-1.067002000
H	-3.548190000	-2.171993000	-1.129924000
C	-3.365976000	1.527995000	0.775756000
C	-2.048087000	2.320634000	0.962681000
C	-4.400353000	2.437463000	0.099518000
C	-3.850698000	1.061660000	2.157745000
H	-1.264722000	1.701983000	1.411252000
H	-1.689572000	2.732139000	0.016300000
H	-2.270375000	3.148644000	1.641922000
H	-5.368709000	1.939403000	0.012469000
H	-4.525433000	3.335056000	0.712844000
H	-4.065029000	2.740339000	-0.896982000
H	-4.001693000	1.945799000	2.784680000
H	-4.796735000	0.520662000	2.084807000
H	-3.107321000	0.417421000	2.637609000

INT1a

TCG = 0.28849 a.u.

E = -1437.452246 a.u.

I	-0.410135000	-0.697871000	-0.786755000
O	1.859737000	-0.759571000	-1.158672000

C	0.384186000	0.806523000	0.535694000
C	1.765414000	0.877566000	0.607074000
C	2.317355000	1.817831000	1.484012000
C	1.497126000	2.656630000	2.231759000
C	0.113353000	2.565623000	2.122688000
C	-0.458882000	1.626103000	1.266564000
H	-0.530569000	3.219988000	2.701308000
H	-1.537034000	1.547679000	1.183247000
H	3.393349000	1.898400000	1.583038000
H	1.944888000	3.383144000	2.901891000
C	2.608299000	-0.080522000	-0.252698000
C	3.669891000	0.715917000	-1.039589000
C	3.296506000	-1.095444000	0.682607000
F	3.080447000	1.697129000	-1.733567000
F	4.611056000	1.278856000	-0.262749000
F	4.304587000	-0.070078000	-1.913368000
F	4.057175000	-1.952827000	-0.006366000
F	4.076771000	-0.524987000	1.613199000
F	2.363523000	-1.810578000	1.326365000
C	-2.492899000	-0.370589000	-0.146467000
C	-3.113855000	0.654275000	-0.752209000
C	-2.576680000	1.721649000	-1.670984000
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INT1b

TCG = 0.288337 a.u.

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Reference

(1) Ding, Z.; Yoshikai, N. *Org. Lett.* **2010,** *12*, 4180-4183; (b) Scott, L. T.; Cooney, M. J.; Otte, C.; Puls, C.; Haumann, T.; Boese, R.; Smith, A. B.; Carroll, P. J.; de Meijere, A. *J. Am. Chem. Soc.* **2002**, *116*, 10275-10283.

(2) Lu, B.; Li, C.; Zhang, L. *J. Am. Chem. Soc.* **2010,** *132*, 14070-14072.

(3) (a) Pfeifer, L.; Gouverneur, V. *Org. Lett.* **2018**, *20*, 1576-1579; (b) McLaughlin, E. C.; Doyle, M. P. *J. Org. Chem.* **2008**, *73*, 4317-4319.

(4) (a) Ding, W.; Chai, J.; Wang, C.; Wu, J.; Yoshikai, N. *J. Am. Chem. Soc.* **2020,** *142*, 8619-8624; (b) Chai, J.; Ding, W.; Wu, J.; Yoshikai, N. *Chem. Asian J.* **2020**, 15, 2166-2169.

(5) (a) Zhao, T. S.; Yang, Y.; Lessing, T.; Szabo, K. J. *J. Am. Chem. Soc.* **2014**, *136*, 7563-7566; (b) Cao, C.; Li, Y.; Shi, Y.; Odom, A. L. *Chem Commun.* **2004**, *17*, 2002-2003.

(6) CCDC 2093231 (**4aa**) and 2100970 (**4ia**) provide supplementary crystallographic data for this paper. These data can be obtained free of charge from The Cambridge Crystallographic Data Centre.

(7) M. Movassaghi, M. D. Hill, O. K. Ahmad, *J. Am. Chem. Soc.* **2007**, *129*, 10096-10097.

(8) M. Movassaghi, M. D. Hill, *J. Am. Chem. Soc.* **2006**, *128*, 14254-14255.

(9) M. J. Frisch, G. W. Trucks, H. B. Schlegel, G. E. Scuseria, M. A. Robb, J. R. Cheeseman, G. Scalmani, V. Barone, G. A. Petersson, H. Nakatsuji, X. Li, M. Caricato, A. V. Marenich, J. Bloino, B. G. Janesko, R. Gomperts, B. Mennucci, H. P. Hratchian, J. V. Ortiz, A. F. Izmaylov, J. L. Sonnenberg, D. Williams-Young, F. Ding, F. Lipparini, F. Egidi, J. Goings, B. Peng, A. Petrone, T. Henderson, D. Ranasinghe, V. G. Zakrzewski, J. Gao, N. Rega, G. Zheng, W. Liang, M. Hada, M. Ehara, K. Toyota, R. Fukuda, J. Hasegawa, M. Ishida, T. Nakajima, Y. Honda, O. Kitao, H. Nakai, T. Vreven, K. Throssell, J. A. Montgomery, Jr., J. E. Peralta, F. Ogliaro, M. J. Bearpark, J. J. Heyd, E. N. Brothers, K. N. Kudin, V. N. Staroverov, T. A. Keith, R. Kobayashi, J. Normand, K. Raghavachari, A. P. Rendell, J. C. Burant, S. S. Iyengar, J. Tomasi, M. Cossi, J. M. Millam, M. Klene, C. Adamo, R. Cammi, J. W. Ochterski, R. L. Martin, K. Morokuma, O. Farkas, J. B. Foresman, and D. J. Fox, Gaussian 16 Rev. C.01, Wallingford, CT, **2016**.

(10) (a) Y. Zhao and D. G. Truhlar, *J*. *Phys*. *Chem*. *A* **2006**, *110*, 13126-13130. (b) Y. Zhao and D. G. Truhlar, *Acc*. *Chem*. *Res*. **2008**, *41*, 157-167. (c) Y. Zhao and D. G. Truhlar, *Chem*. *Phys*. *Lett*. **2011**, *502*, 1-13.

(11) M. Dolg, U. Wedig, H. Stoll and H. Preuss, *J. Chem. Phys.* **1987**, *86*, 866.

(12) K. Fukui, *Acc*. *Chem*. *Res*. **1981**, *14*, 363-368.

(13) A. V. Marenich; C. J. Cramer and D. G. Truhlar, *J. Phys*. *Chem*. *B* **2009**, *113*, 6378-

6396.

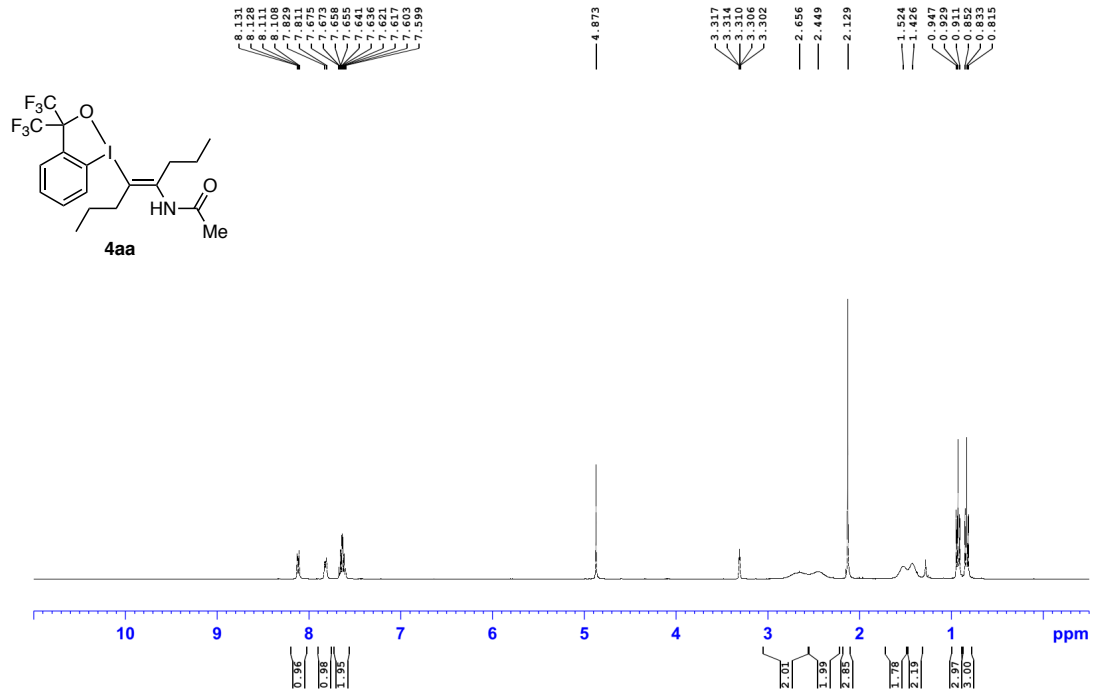
(14) X. Gu, X. Song, C. Shao, P. Zeng, X. Lu, X. Shen, Q. Yang, *Int. J. Electrochem. Sci.* **2014**, *9*, 8045-8056.

(15) I. Tanabe, Y. Y. Tanaka, K. Watari, T. Hanulia, T. Goto, W. Inami, Y. Kawata, Y. Ozaki, *Sci. Rep.* **2017**, *7*, 5934.

(16) (a) T. Lu, F. Chen, *J. Comput. Chem.* **2012**, *33*, 580−592. (b) I. Mayer, *Chem. Phys. Lett.* **1983**, *97*, 270−274. (c) I. Mayer, *Chem. Phys. Lett.* **2012**, *544*, 83−86. (d) T. Lu, F. Chen, *J. Theor. Comput. Chem.* **2012**, *11*, 163−183.

(17) C. Y. Legault, CYLView, 1.0b; Universitéde Sherbrooke: Québec, Montreal, Canada, 2009; http://www.cylview.org

NMR Spectra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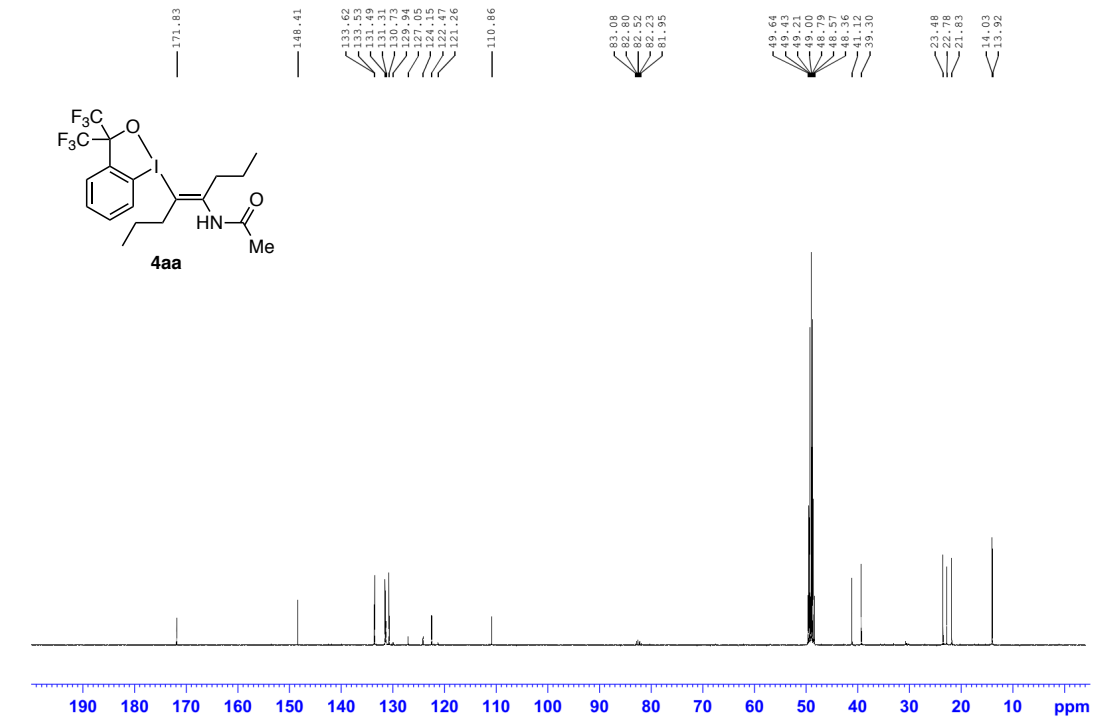
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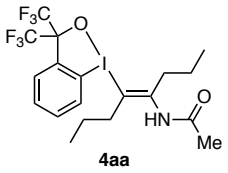

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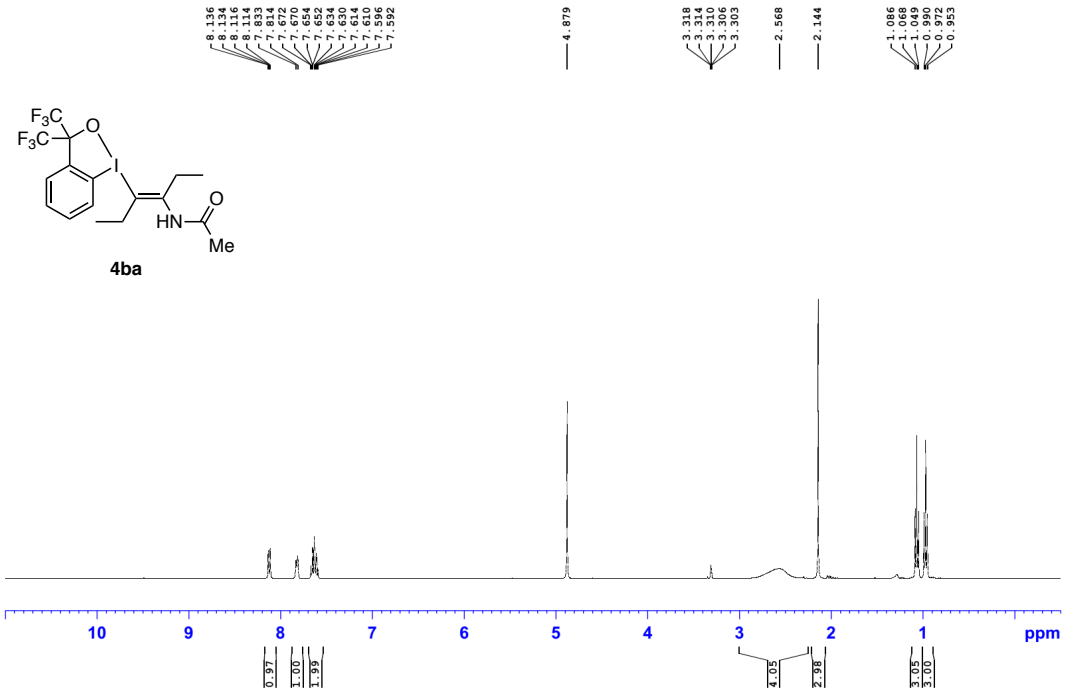
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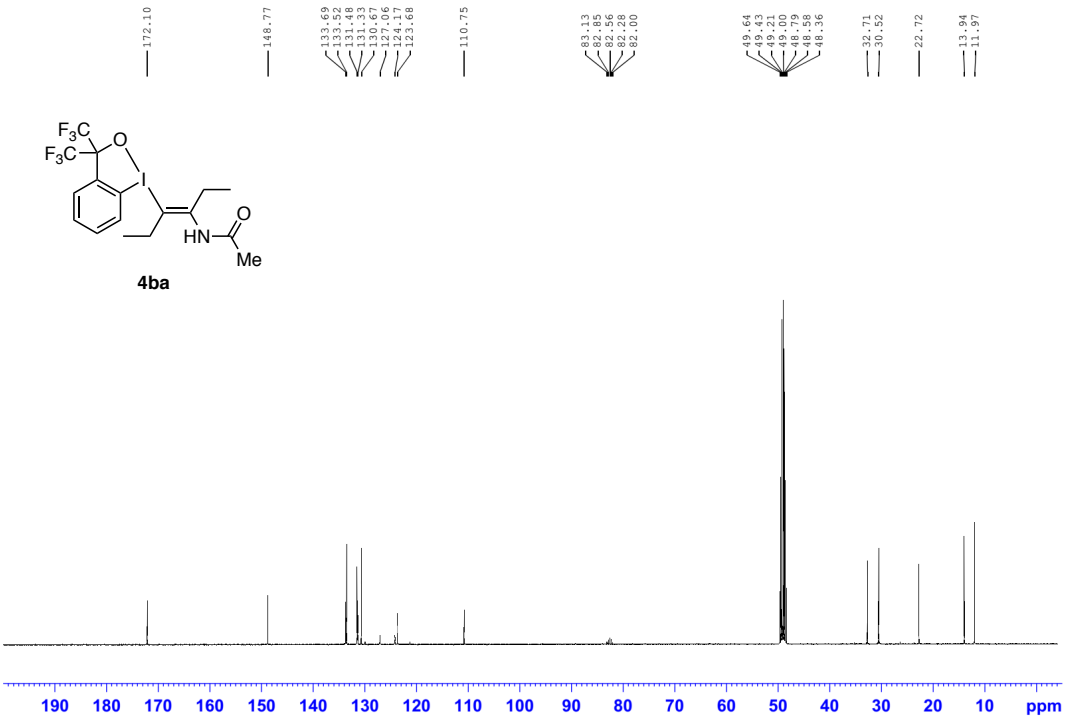
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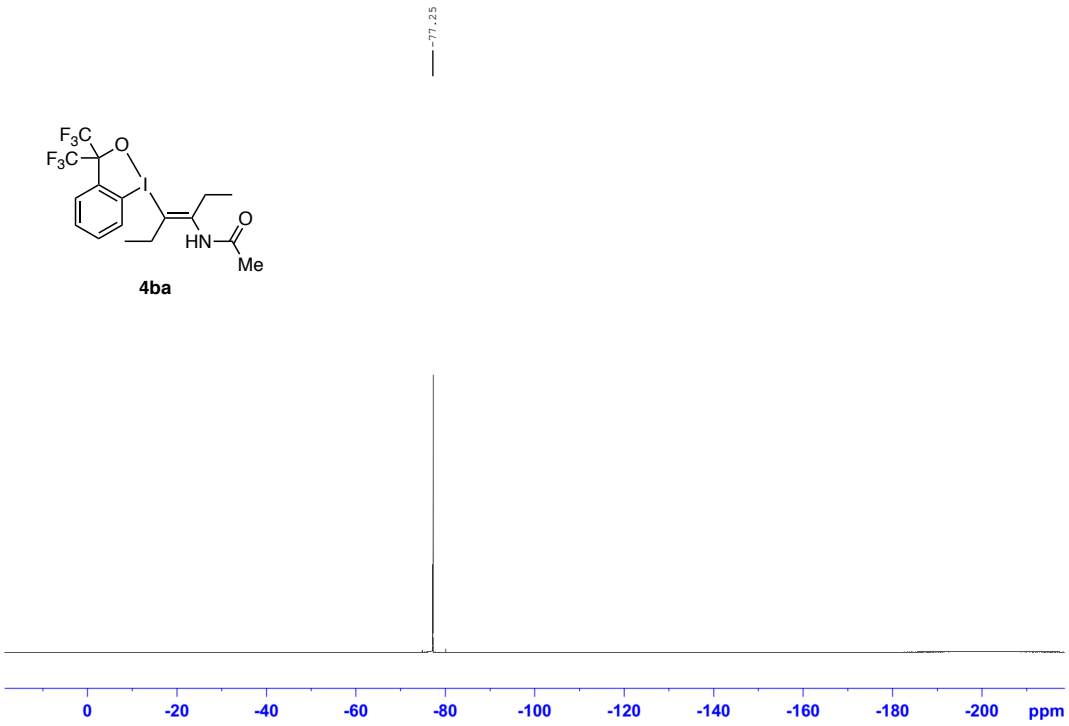
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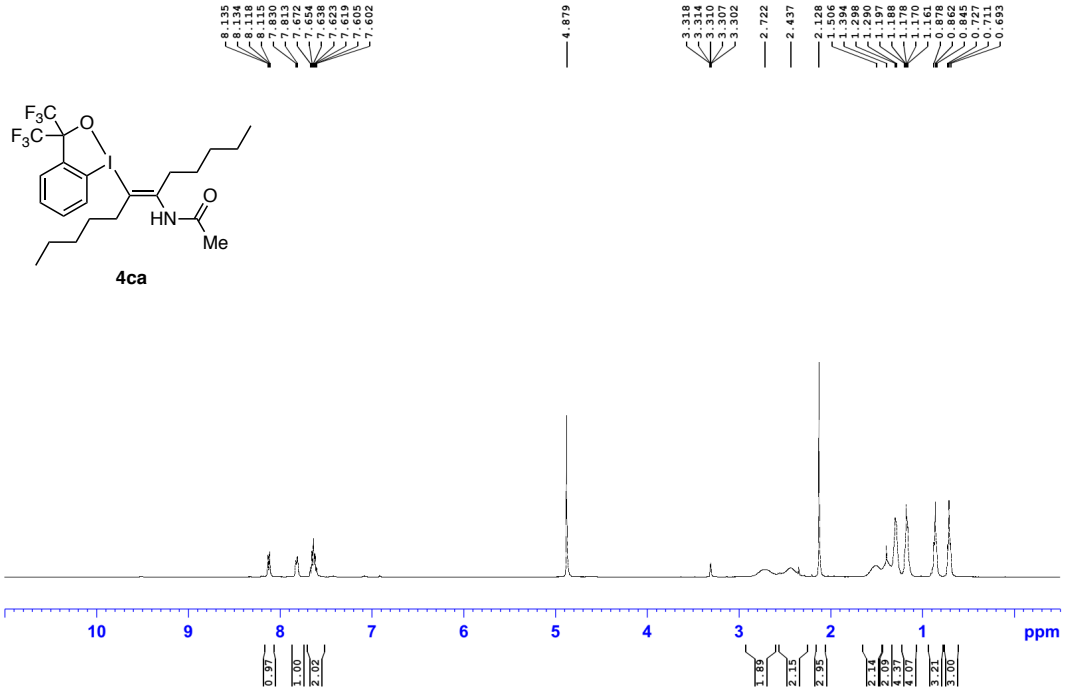
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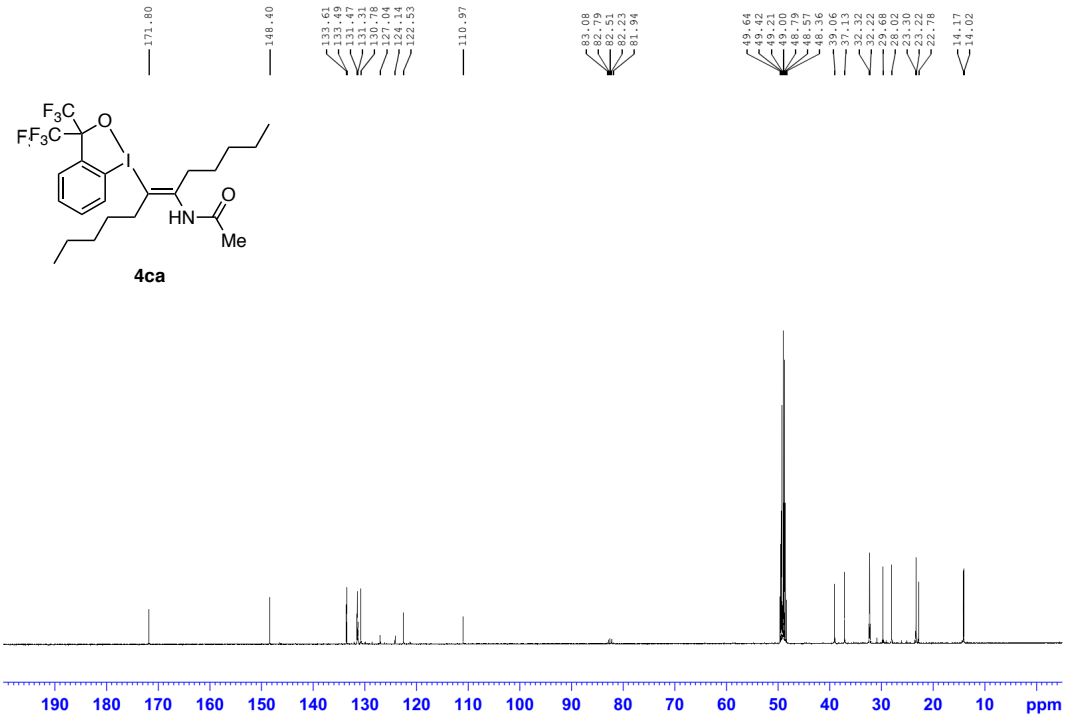
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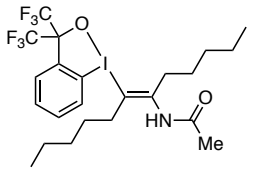

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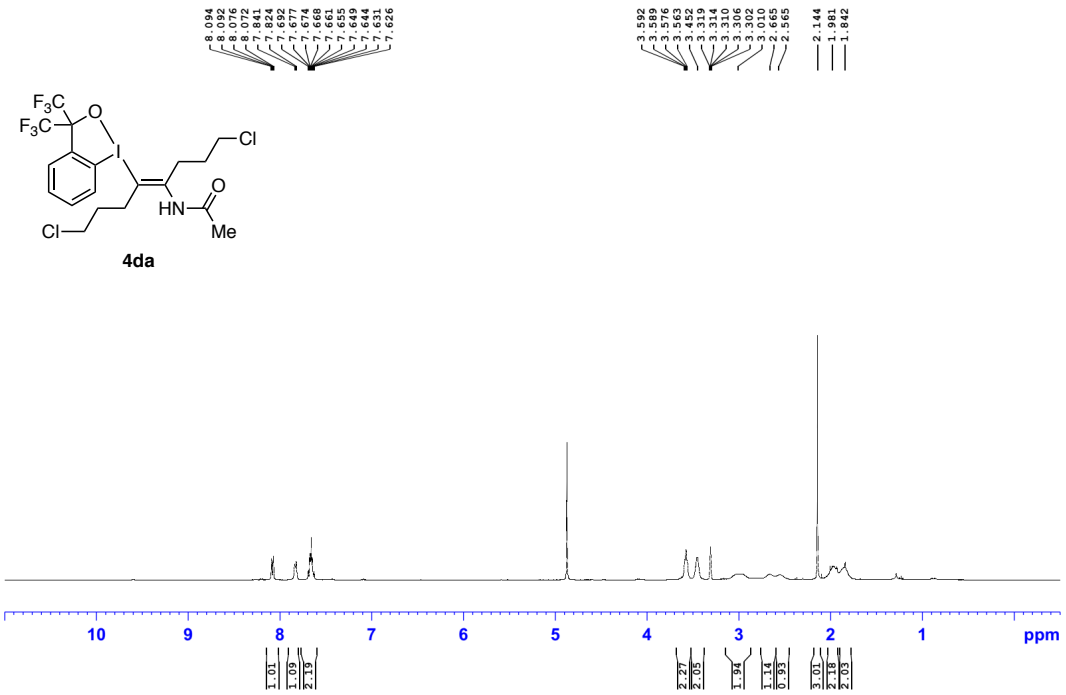
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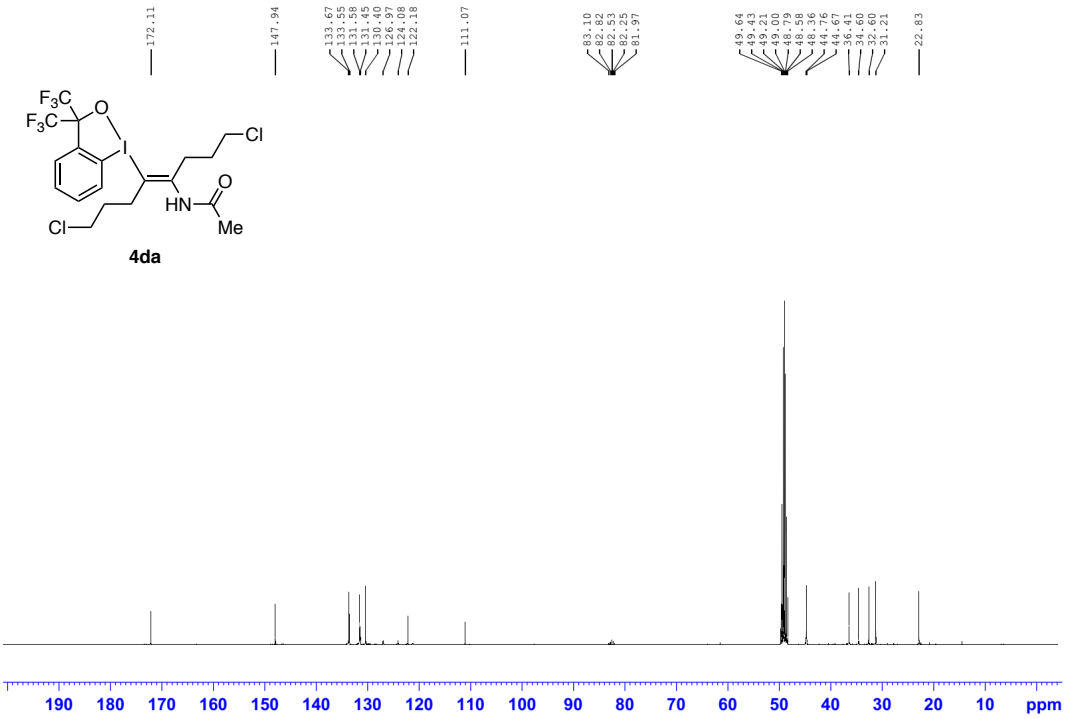
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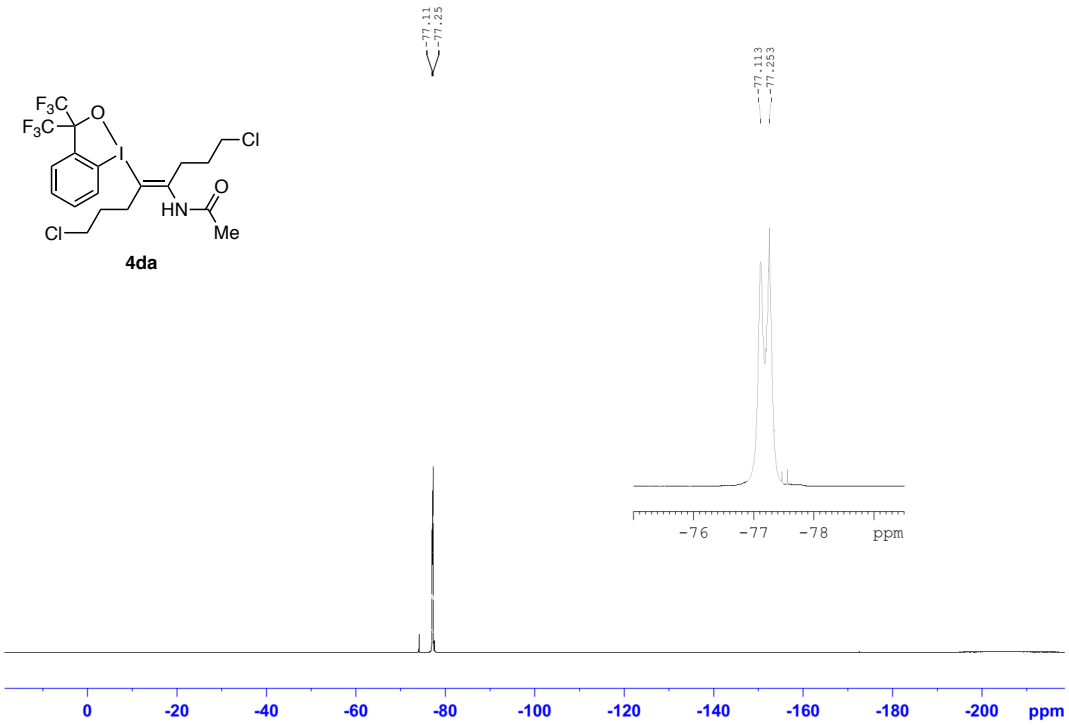
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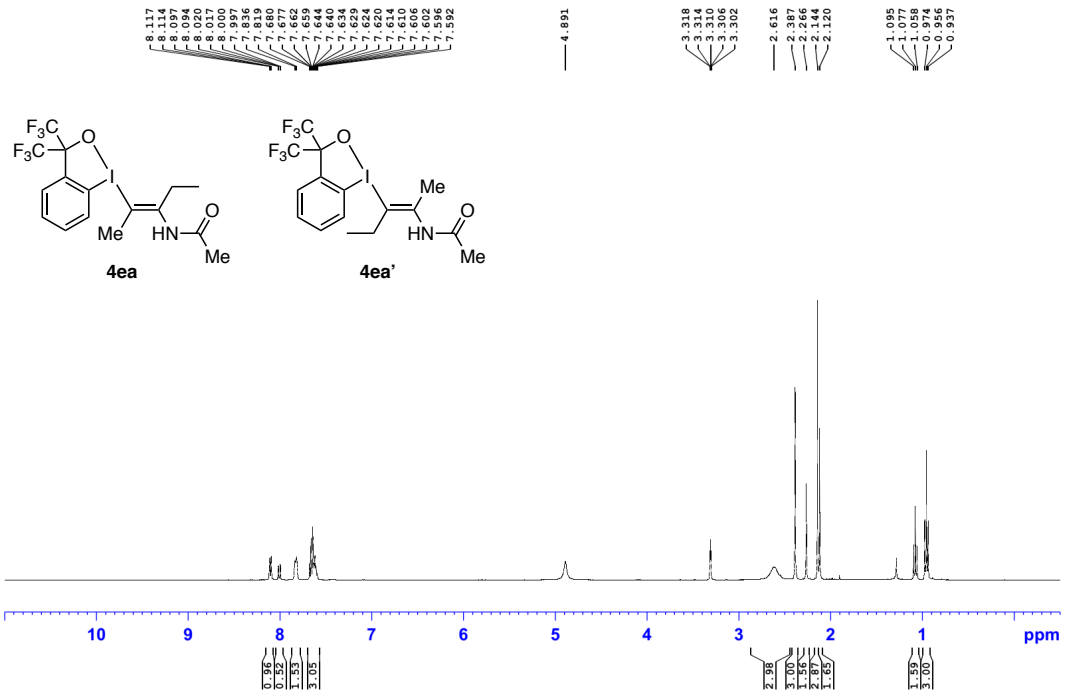
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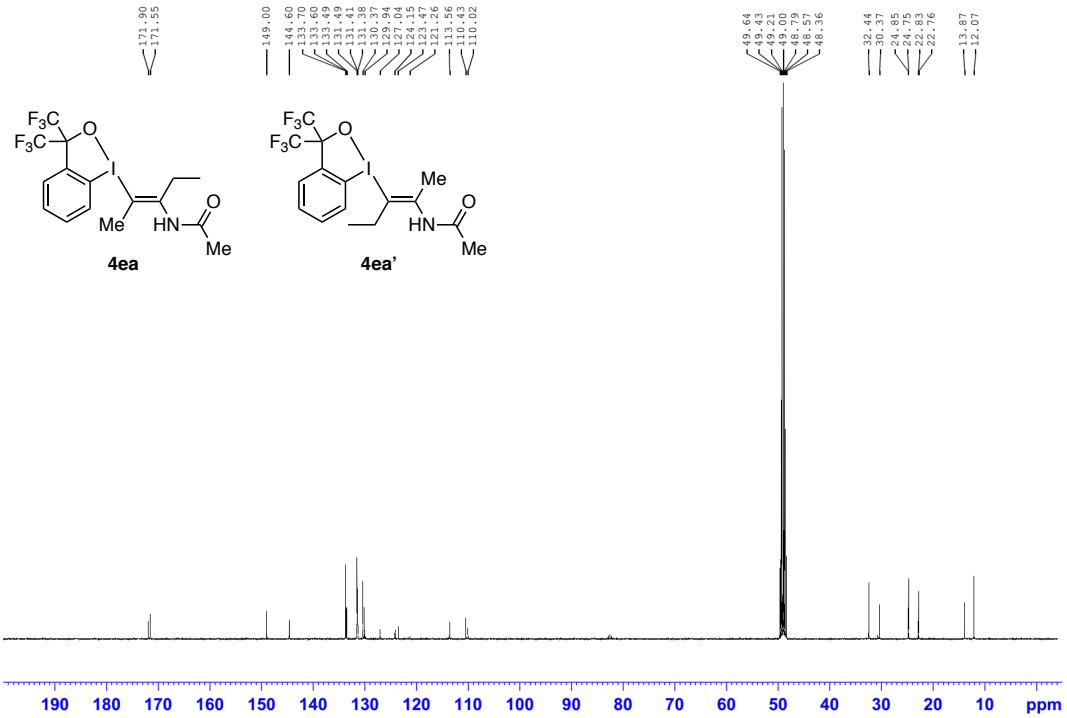
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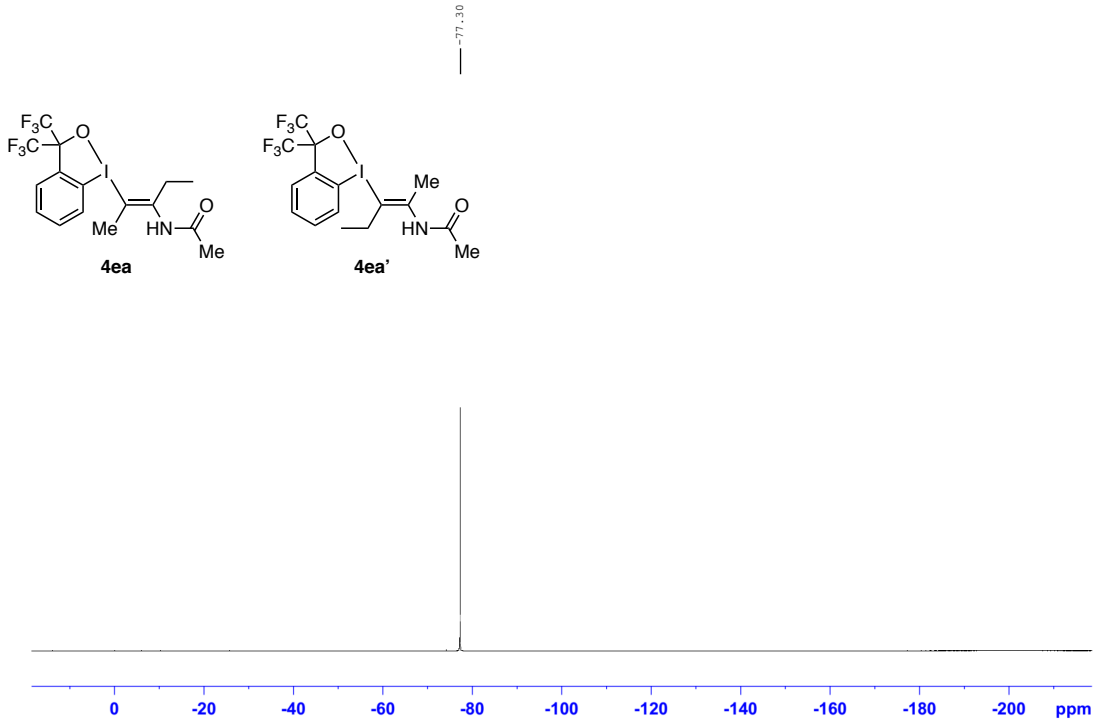
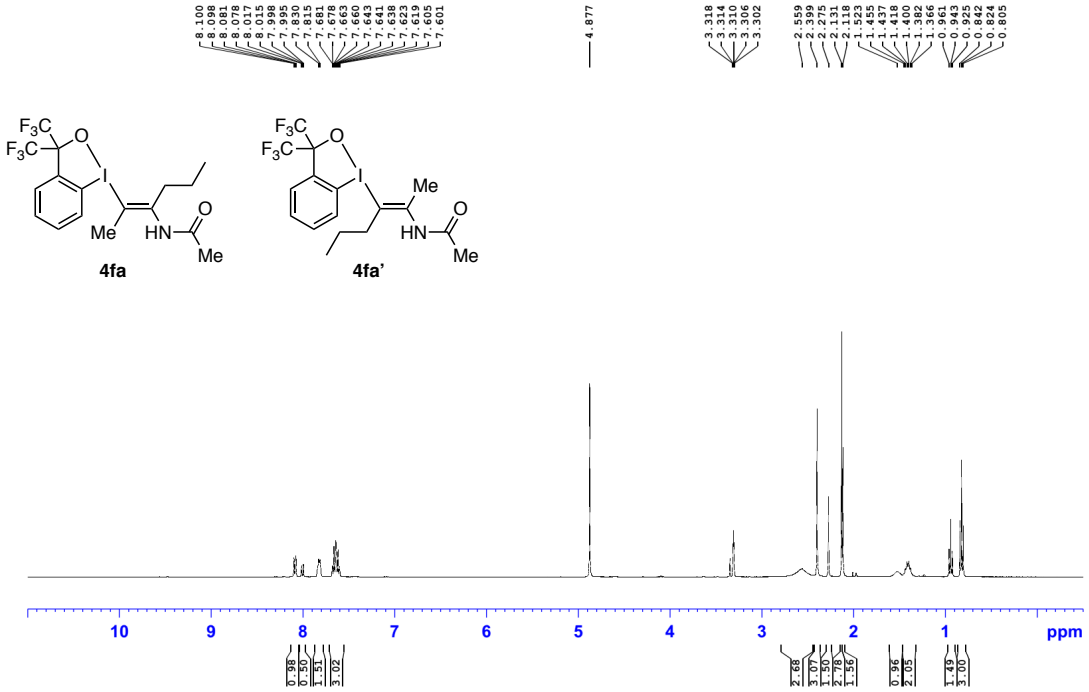
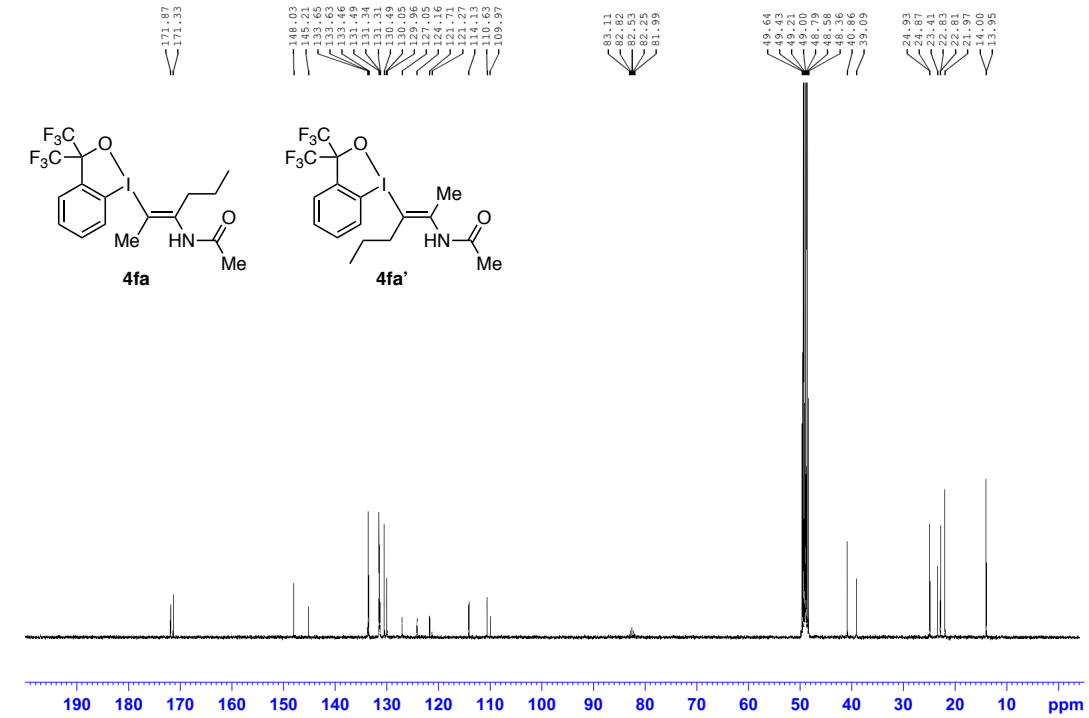
10
ppm


-77.30
F3C
F3C
O
I
Me
HN
O
Me
4ea
F3C
F3C
O
I
Me
HN
O
Me
4ea'
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
ppm


8.100
8.098
8.091
8.078
8.017
8.015
7.998
7.995
7.830
7.815
7.681
7.678
7.663
7.660
7.643
7.641
7.638
7.623
7.619
7.605
7.601
4.877
3.318
3.314
3.310
3.306
3.302
2.559
2.399
2.275
2.131
2.118
1.523
1.455
1.437
1.418
1.400
1.382
1.366
0.961
0.943
0.925
0.842
0.824
0.805
F3C
F3C
O
I
Me
HN
O
Me
4fa
4fa'
10
9
8
7
6
5
4
3
2
1
ppm
0.98
0.50
1.51
3.02
2.68
3.07
1.70
1.56
0.96
2.05
1.49
3.00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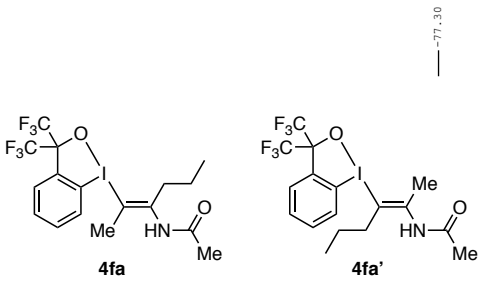
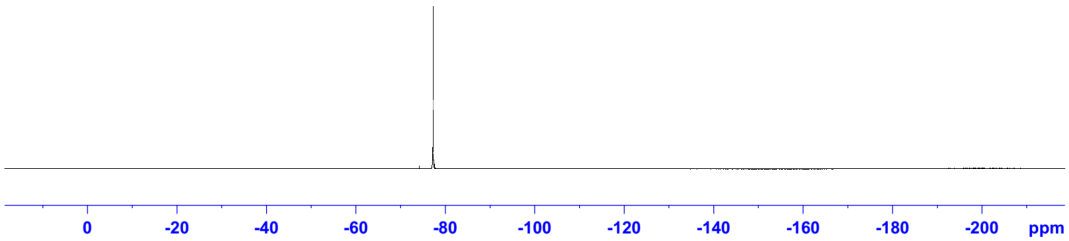
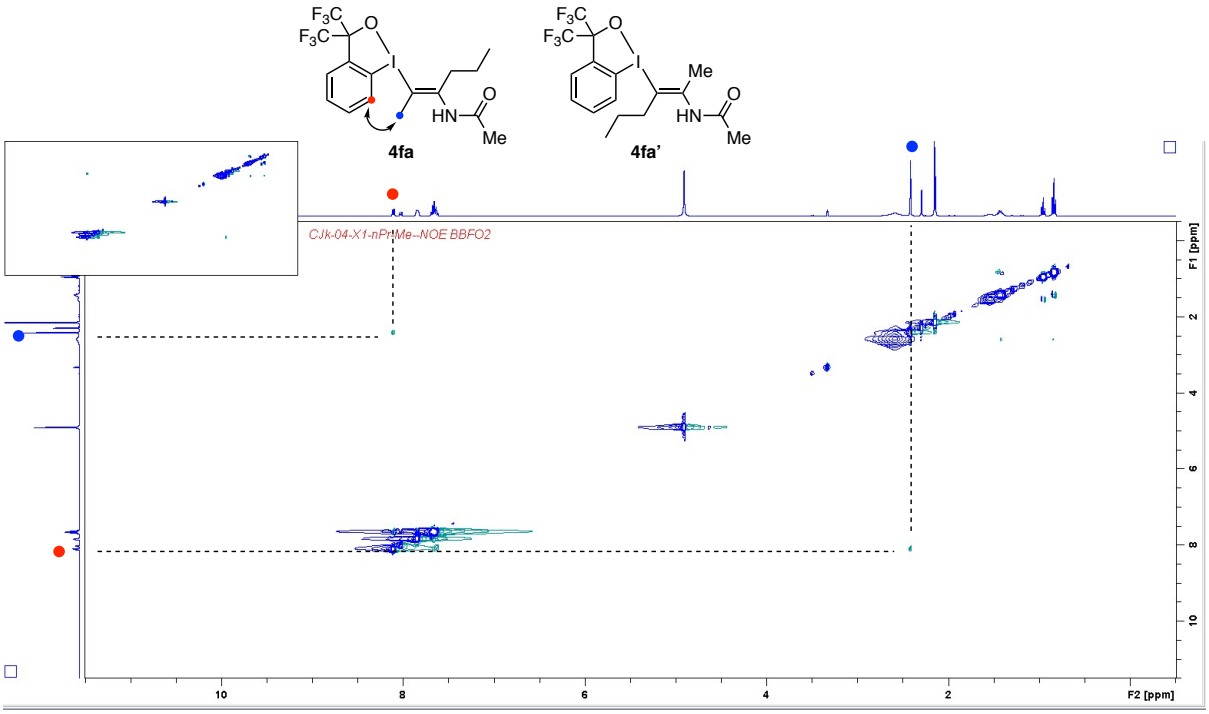
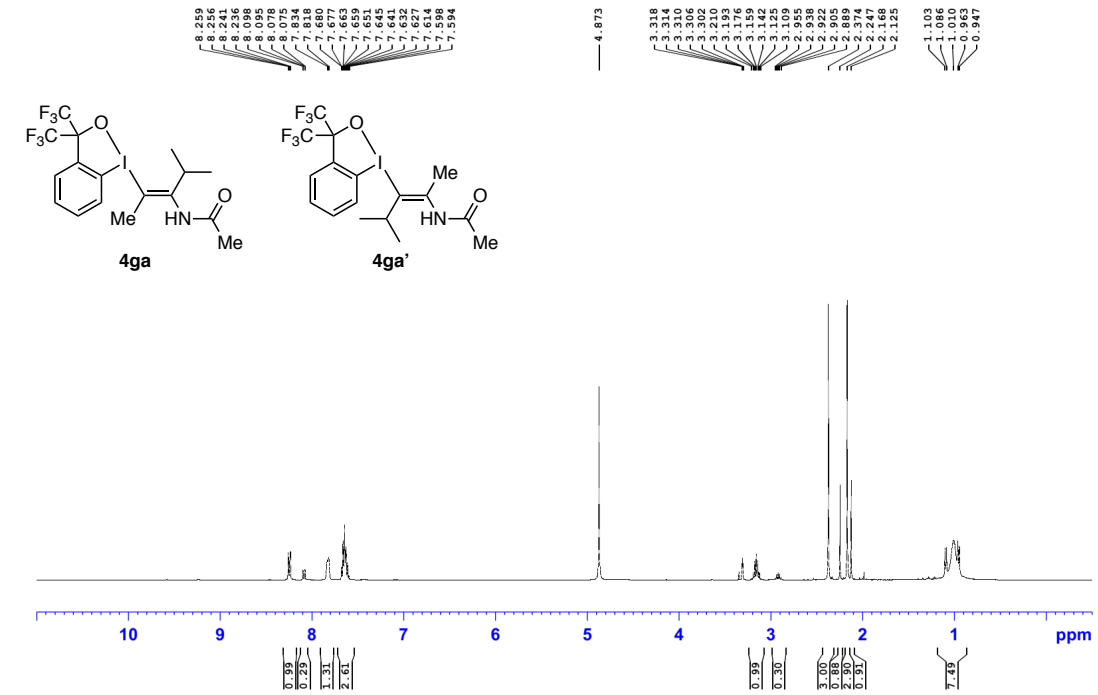
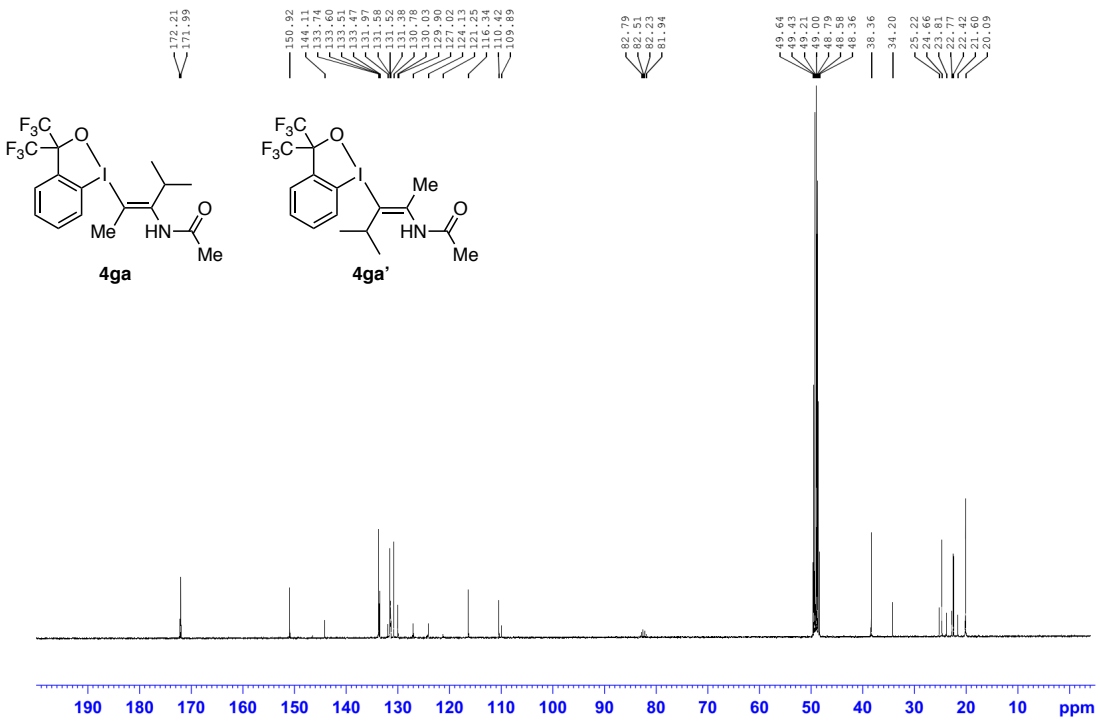
171.33
148.03
145.21
133.65
133.63
133.46
131.49
131.34
131.31
130.49
130.05
129.96
127.05
124.16
121.71
121.27
114.13
110.63
109.97
83.11
82.82
82.53
82.25
81.99
49.64
49.43
49.21
49.00
48.79
48.58
48.36
48.15
39.09
24.93
24.87
23.41
22.83
22.81
21.97
14.00
13.95
F3C
F3C
O
I
Me
HN
O
Me
4fa
4fa'
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

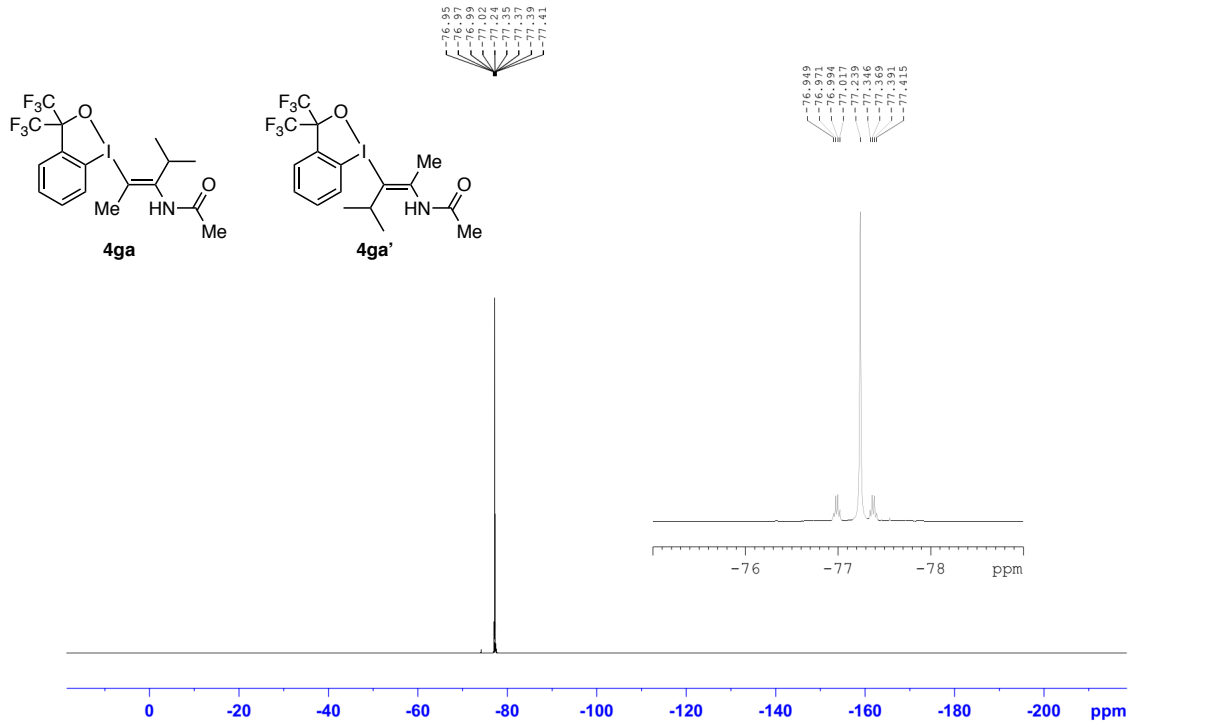

-77.30
F3C
F3C
O
I
Me
HN
O
Me
4fa
4fa'

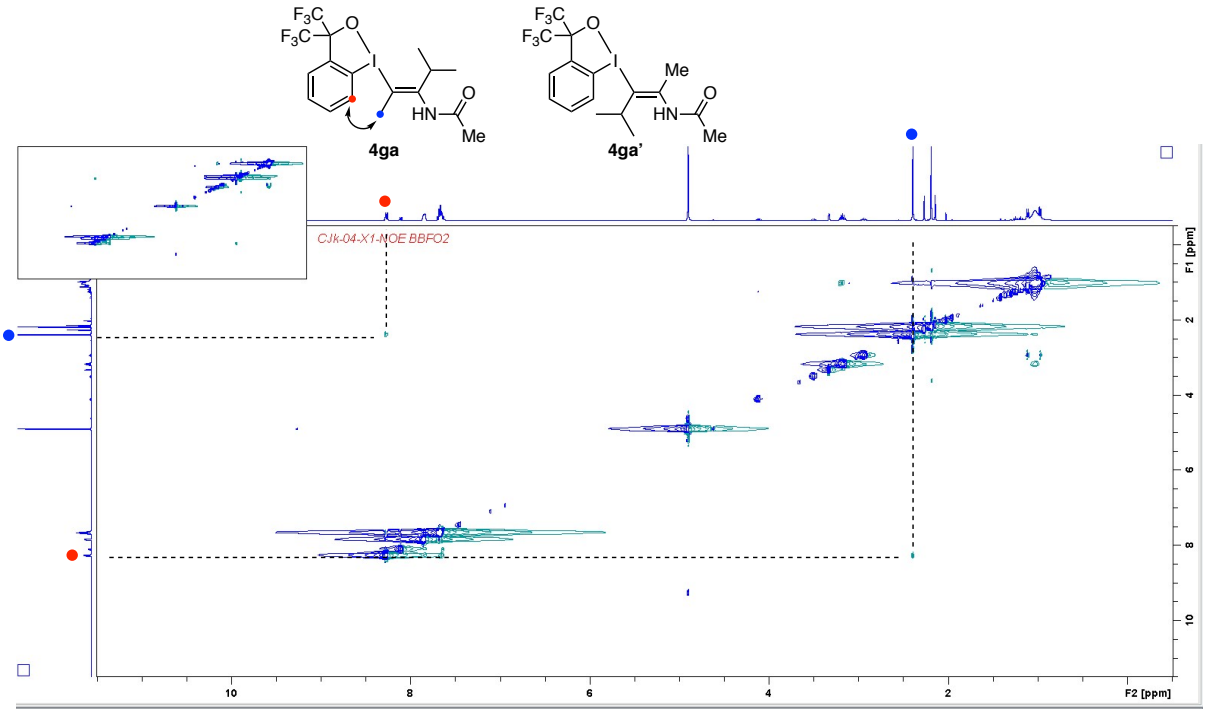

0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
ppm

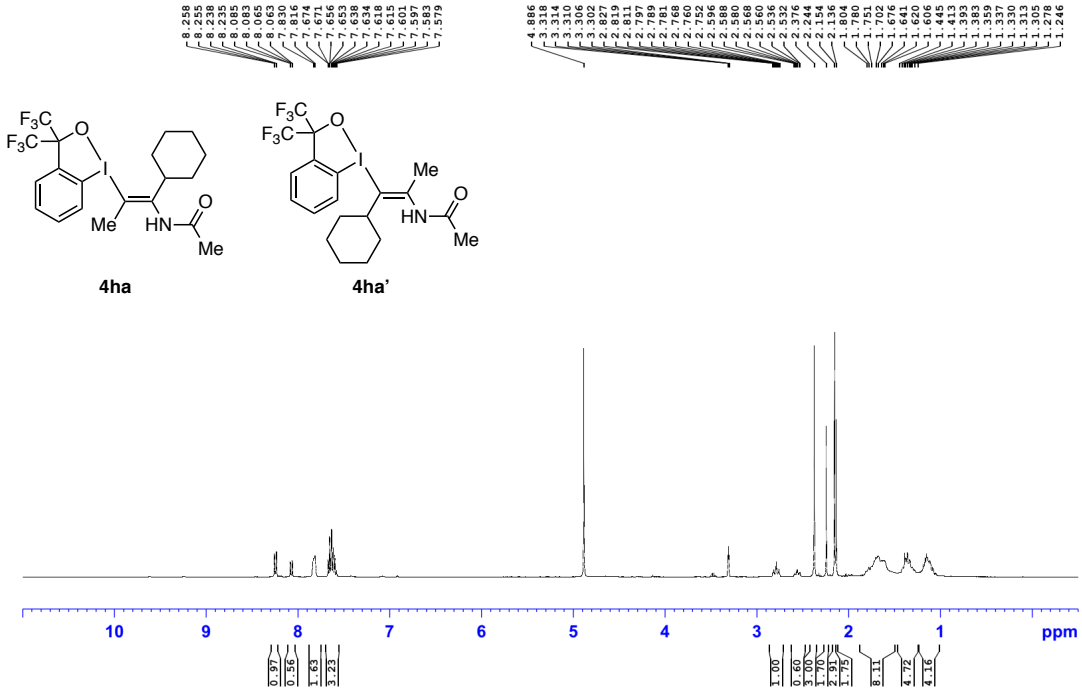

4fa
4fa'
CJk-04-X1-nPrMe--NOE BBFO2
F1 [ppm]
F2 [ppm]

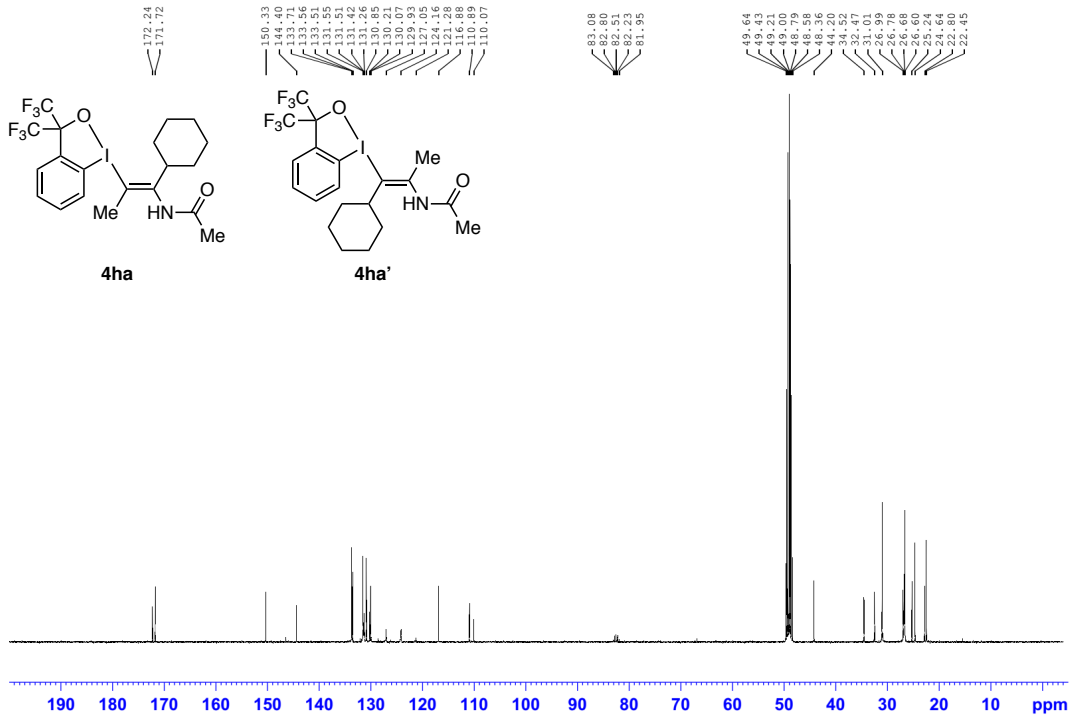

8.259
8.256
8.241
8.236
8.098
8.095
8.078
8.075
7.834
7.818
7.680
7.677
7.665
7.659
7.651
7.645
7.641
7.632
7.627
7.614
7.598
7.594
4.873
3.318
3.314
3.310
3.306
3.302
3.210
3.193
3.176
3.159
3.142
3.125
3.109
2.955
2.938
2.922
2.905
2.889
2.374
2.247
2.168
2.125
1.103
1.086
1.010
0.963
0.947
F3C
F3C
O
I
Me
HN
O
Me
4ga
4ga'
10
9
8
7
6
5
4
3
2
1
ppm
0.99
0.29
1.31
2.61
0.99
0.30
3.00
1.88
1.80
2.91
7.49

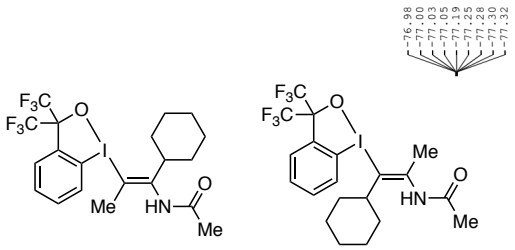

172.21
171.99
150.92
146.11
143.74
133.60
133.51
133.47
131.97
131.58
131.52
131.38
130.78
130.03
129.90
127.02
124.13
124.25
116.34
110.42
109.89
82.79
82.51
82.23
81.94
49.64
49.43
49.21
49.00
48.79
48.58
48.36
38.36
34.20
25.22
24.66
23.81
22.77
22.42
21.60
20.09
F3C
F3C
O
I
Me
HN
O
Me
4ga
4ga'
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm


4ga
4ga'
-76.95
-76.97
-76.99
-77.02
-77.24
-77.35
-77.37
-77.39
-77.41
-76.949
-76.971
-76.994
-77.017
-77.038
-77.346
-77.369
-77.391
-77.415
-76
-77
-78
ppm
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
ppm

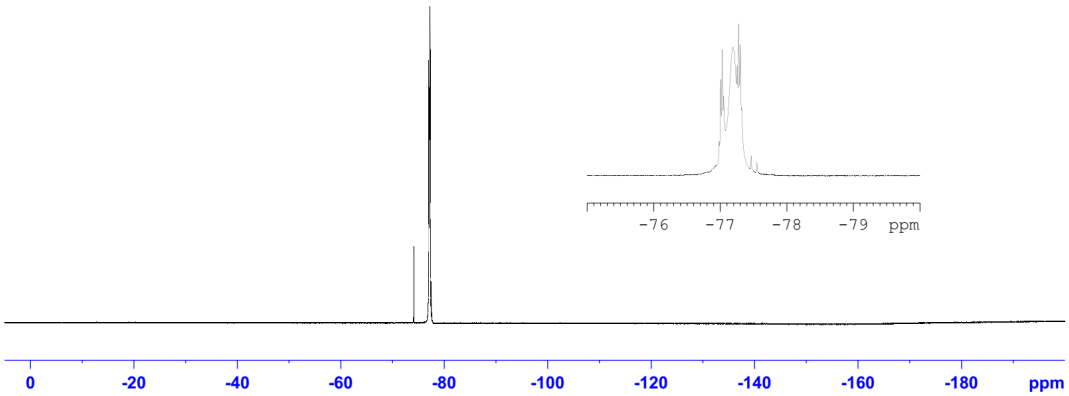

4ga
4ga'
CJk-04-X1-NOE BBFO2
F1 [ppm]
F2 [ppm]
10
8
6
4
2

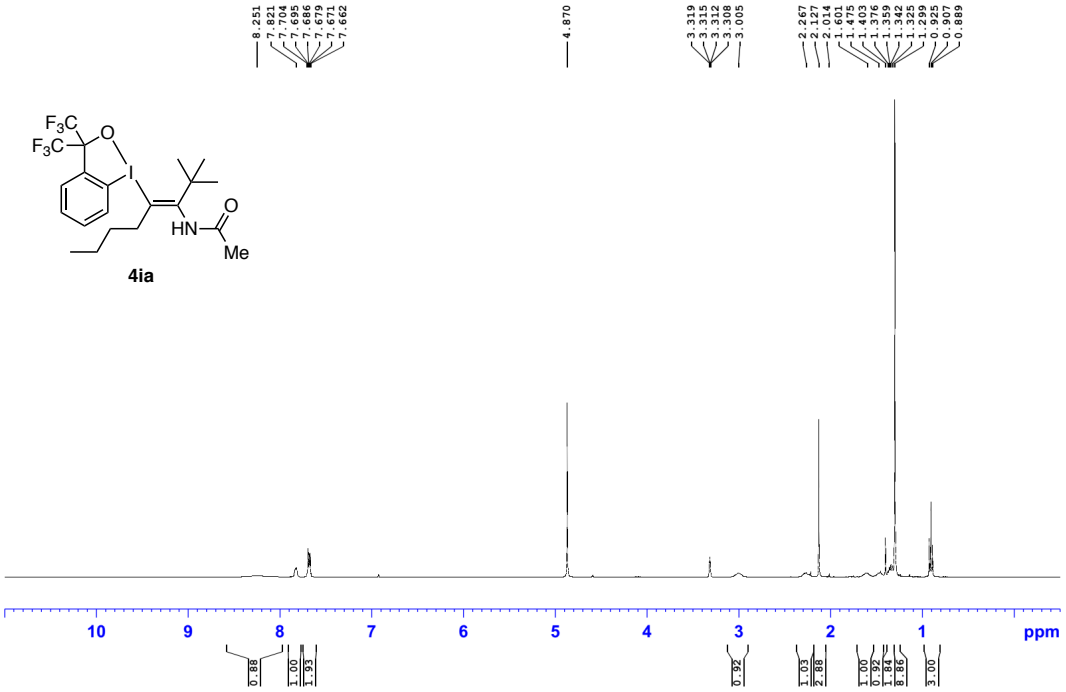

4ha
4ha'
ppm

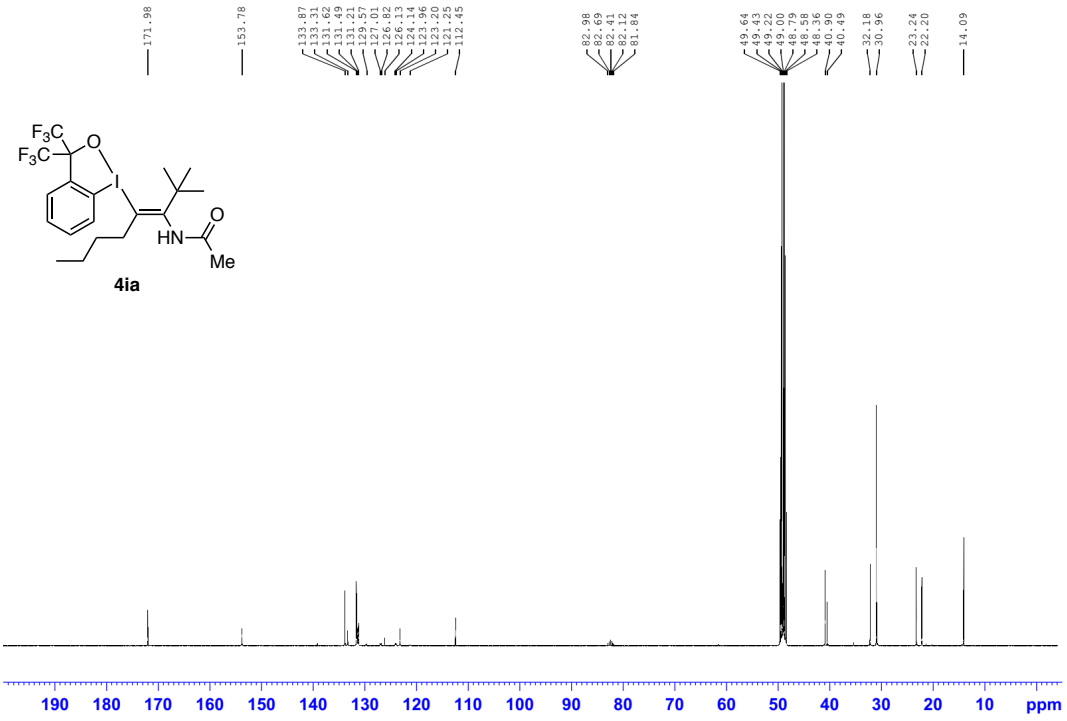

4ha
4ha'
ppm

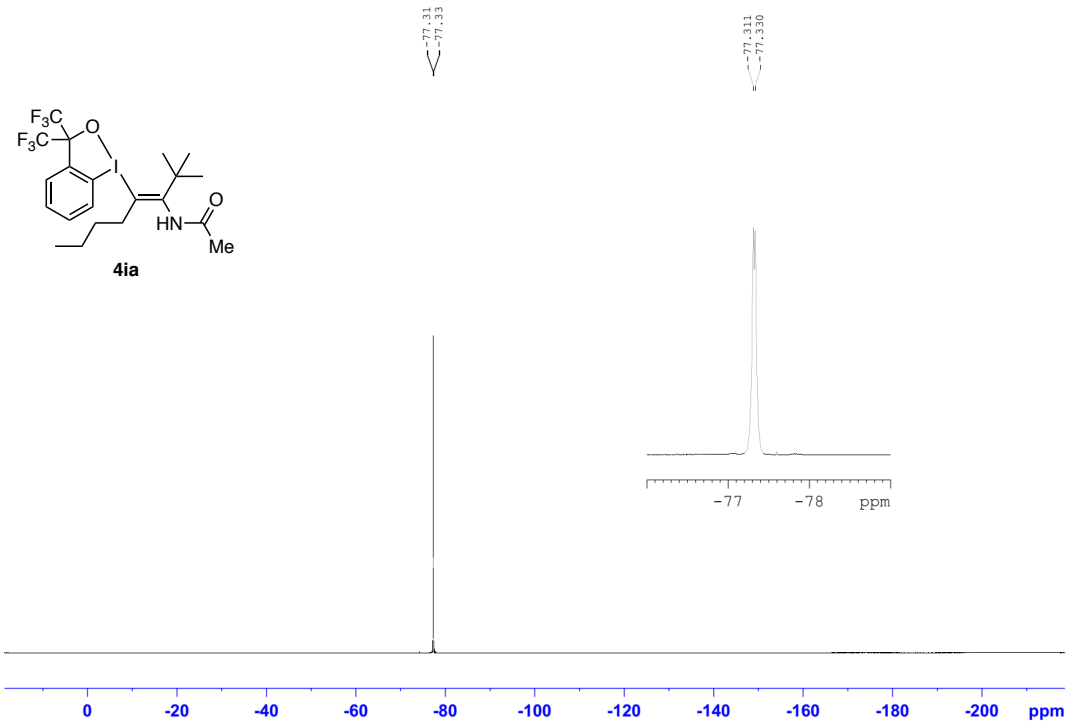

F3C
F3C
O
I
Me
HN
O
Me
F3C
F3C
O
I
Me
HN
O
Me

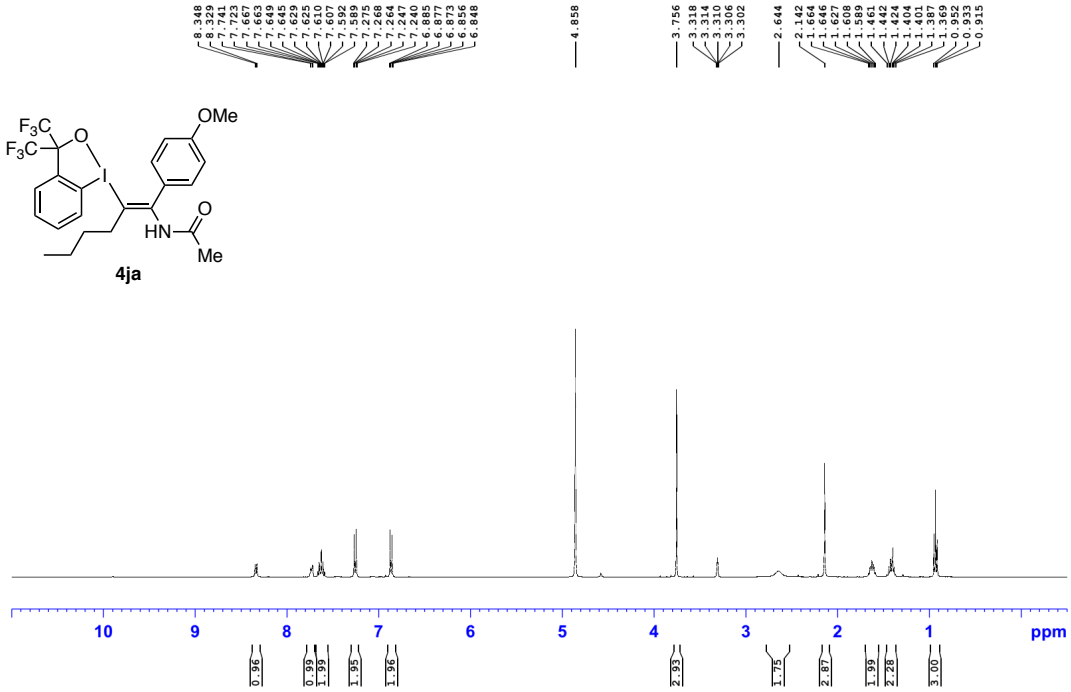
4ha **4ha'**

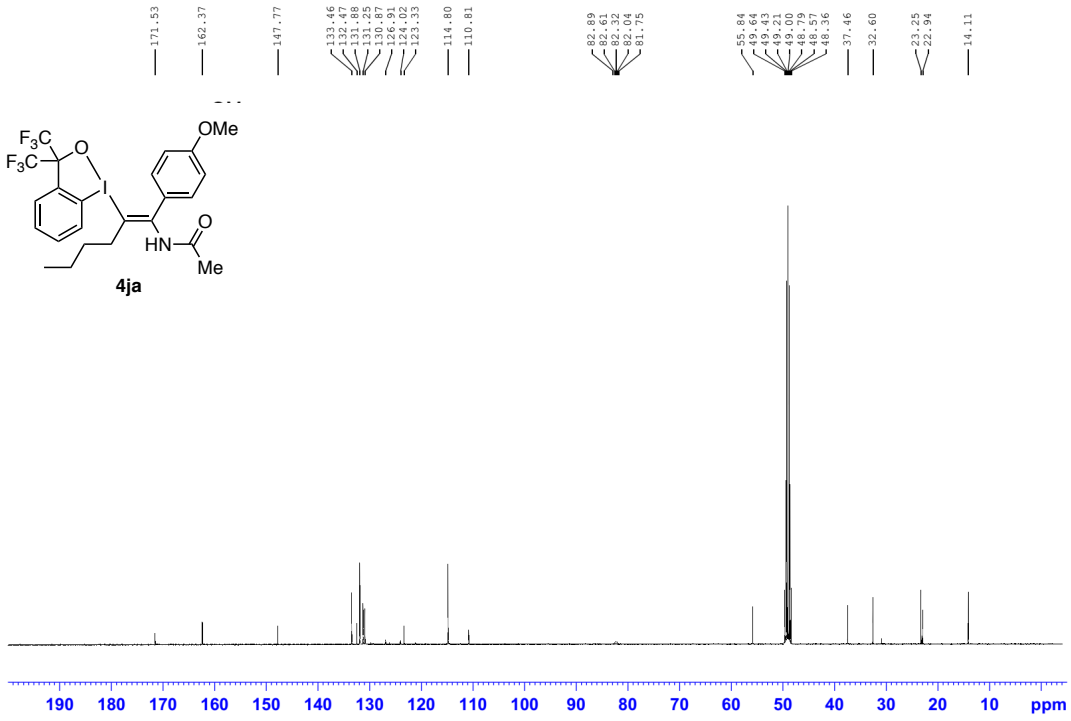

-76
-77
-78
-79
ppm
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
ppm

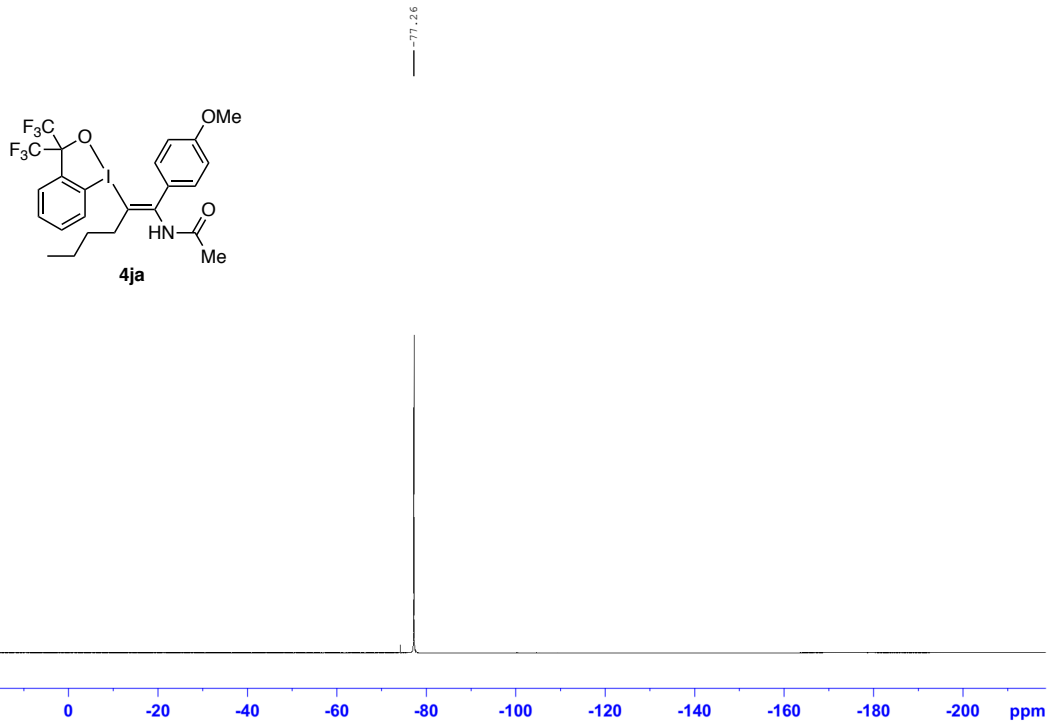

8.251
7.921
7.904
7.695
7.686
7.679
7.671
7.662
4.870
3.319
3.315
3.312
3.308
3.005
2.267
2.127
2.014
1.601
1.475
1.403
1.376
1.359
1.342
1.325
1.299
0.925
0.907
0.889
F3C
F3C
O
I
HN
O
Me
4ia
10
9
8
7
6
5
4
3
2
1
ppm
0.88
1.00
1.93
0.92
1.03
2.88
1.00
0.92
1.84
0.86
3.00

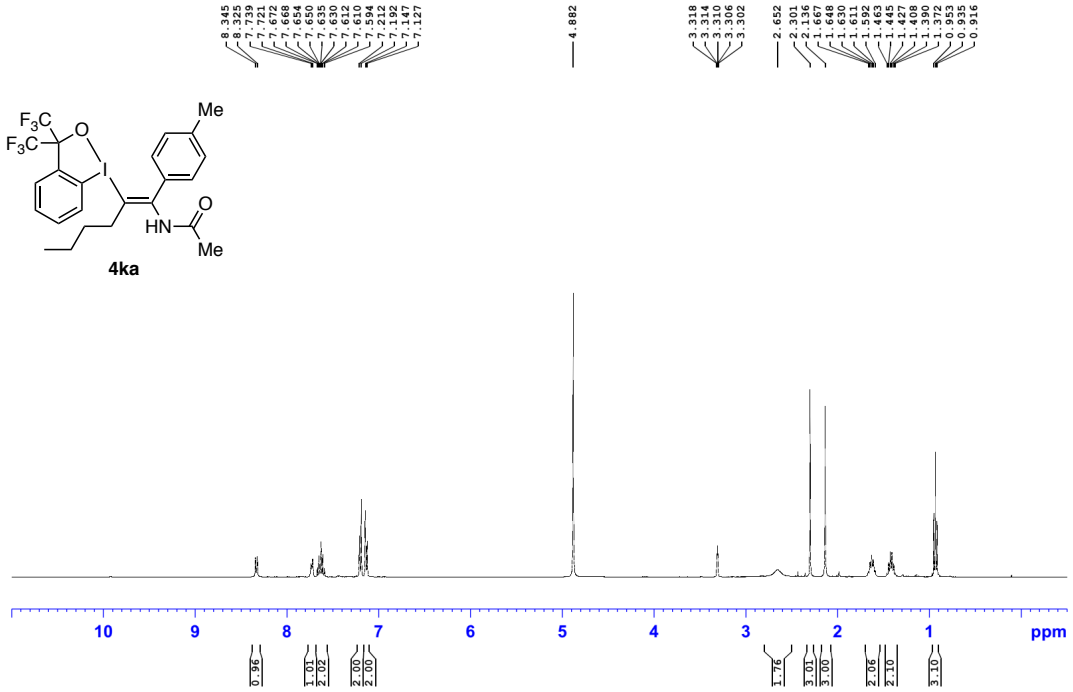

171.98
153.78
133.87
133.31
131.62
131.49
131.21
129.57
127.01
126.82
126.13
124.14
123.96
123.20
121.25
112.45
82.98
82.69
82.41
82.12
81.84
49.64
49.43
49.22
49.00
48.79
48.58
48.36
40.90
40.49
32.18
30.96
23.24
22.20
14.09
F3C
F3C
O
I
HN
O
Me
4ia
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

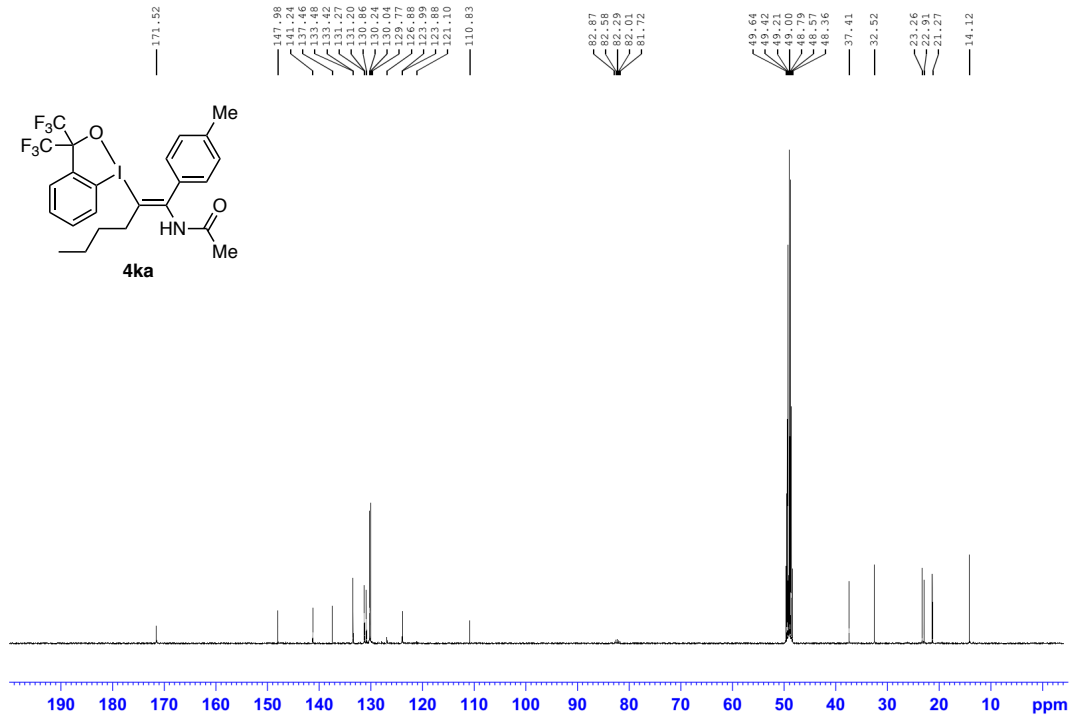

-77.31
-77.33
-77.311
-77.330
F3C
F3C
O
I
HN
O
Me
4ia
-77
-78
ppm
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
ppm

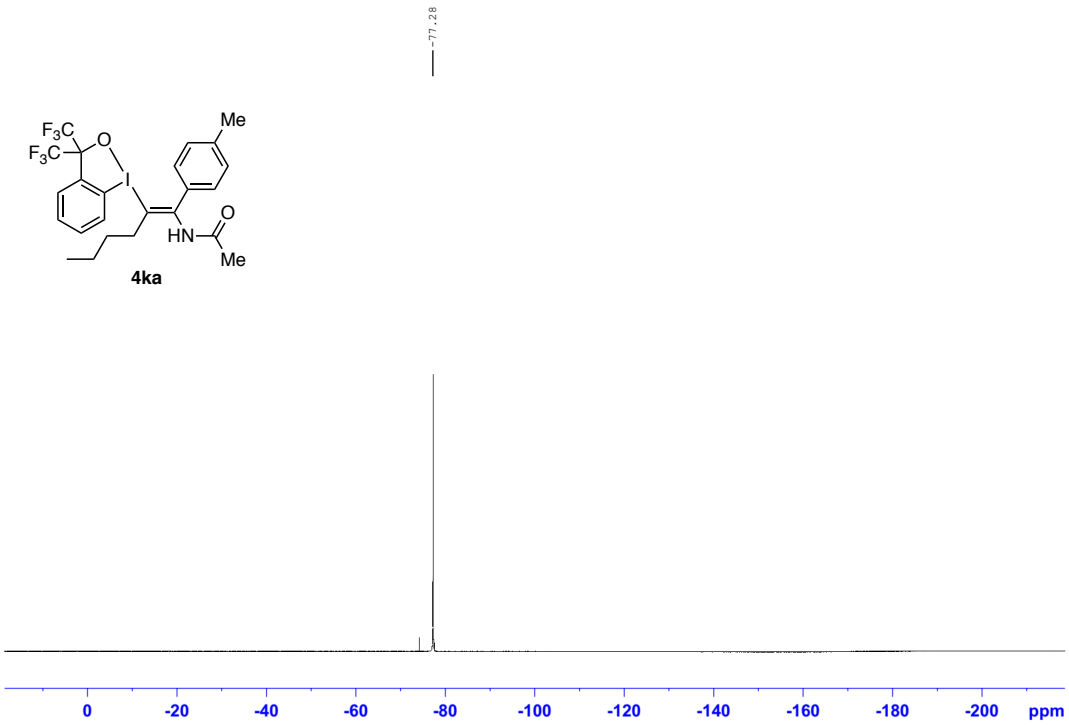

8.348
8.329
7.741
7.723
7.667
7.663
7.649
7.645
7.629
7.625
7.610
7.607
7.592
7.589
7.275
7.268
7.264
7.247
7.240
6.885
6.877
6.873
6.856
6.848
4.858
3.756
3.318
3.314
3.310
3.306
3.302
2.644
2.142
1.664
1.646
1.627
1.608
1.589
1.461
1.442
1.424
1.404
1.401
1.387
1.369
0.952
0.933
0.915
F3C
F3C
O
I
OMe
O
HN
Me
4ja
10
9
8
7
6
5
4
3
2
1
ppm
0.96
0.99
1.99
1.95
1.96
2.93
1.75
2.87
1.99
2.28
3.00

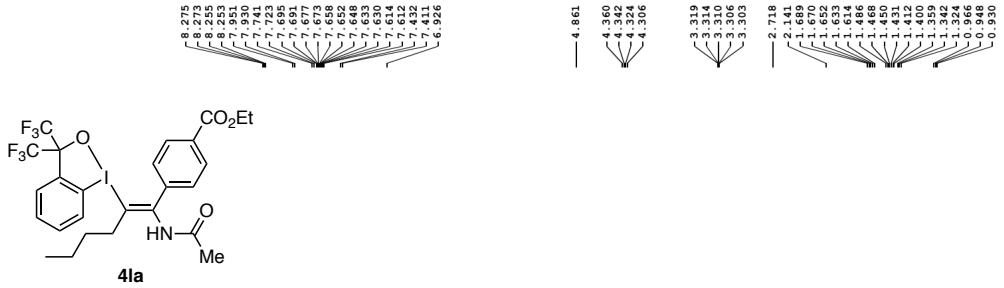

171.53
162.37
147.77
133.46
132.47
131.88
131.25
130.87
126.91
124.02
123.33
114.80
110.81
82.89
82.61
82.32
82.04
81.75
55.84
49.64
49.43
49.21
49.00
48.79
48.57
48.36
37.46
32.60
23.25
22.94
14.11
F3C
F3C
O
I
OMe
O
HN
Me
4ja
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm


-77.26
F3C
F3C
O
I
OMe
HN
O
Me
4ja
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
ppm


8.345
8.325
7.739
7.721
7.672
7.668
7.654
7.650
7.635
7.630
7.612
7.610
7.594
7.212
7.192
7.147
7.127
4.882
3.318
3.314
3.310
3.306
3.302
2.652
2.301
2.136
1.667
1.648
1.630
1.611
1.592
1.563
1.445
1.427
1.408
1.390
1.372
0.953
0.935
0.916
F3C
F3C
O
I
Me
HN
O
Me
4ka
10
9
8
7
6
5
4
3
2
1
ppm
0.96
1.01
2.02
2.00
2.00
1.76
3.01
3.00
2.06
2.10
3.10

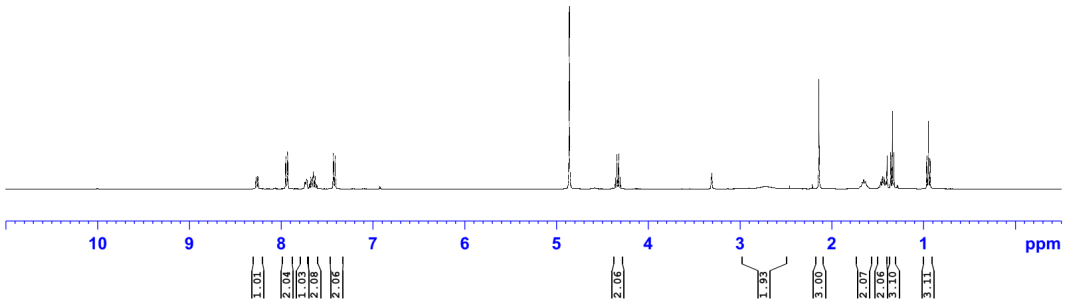

171.52
147.98
141.24
137.46
133.48
133.42
131.27
131.20
130.86
130.24
130.04
129.77
126.88
123.99
123.88
121.10
110.83
82.87
82.58
82.29
82.01
81.72
49.64
49.42
49.21
49.00
48.79
48.57
48.36
37.41
32.52
23.26
22.91
21.27
14.12
F3C
F3C
O
I
Me
HN
O
Me
4ka
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm


-77.28
F3C
F3C
O
I
Me
HN
O
Me
4ka
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
ppm

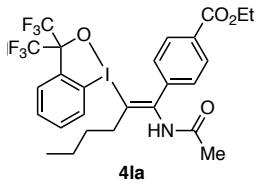

8.275
8.273
8.255
8.253
7.951
7.930
7.741
7.723
7.695
7.691
7.677
7.673
7.658
7.652
7.648
7.633
7.630
7.614
7.612
7.432
7.411
6.926
4.861
4.360
4.342
4.324
4.306
3.319
3.314
3.310
3.306
3.303
2.718
2.141
1.689
1.670
1.652
1.633
1.614
1.486
1.468
1.450
1.431
1.412
1.400
1.359
1.342
1.324
0.966
0.948
0.930

F3C
F3C
O
I
CO2Et
HN
O
Me

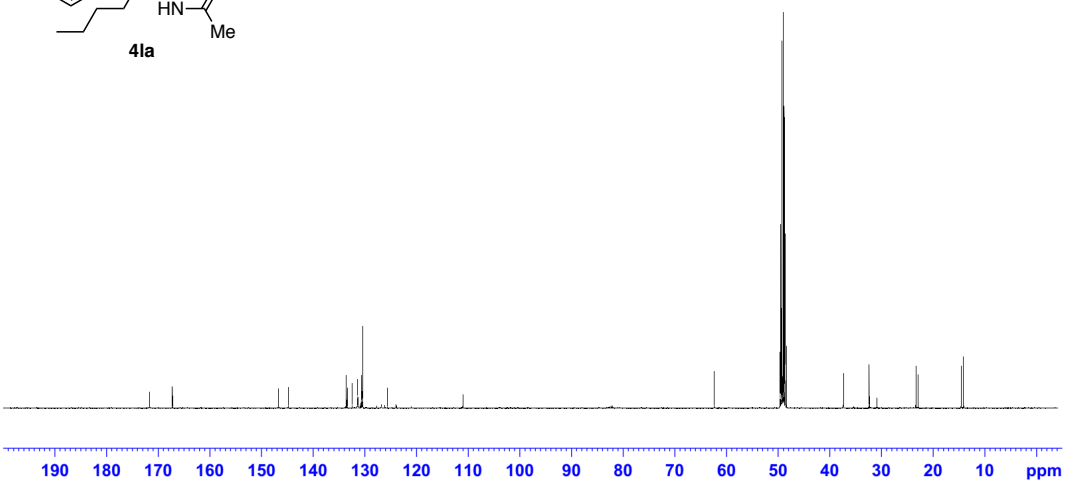
4la


10
9
8
7
6
5
4
3
2
1
ppm
1.01
2.04
1.03
2.08
2.06
2.06
1.93
3.00
2.07
2.06
3.10
3.11


171.65
167.22
146.75
144.79
133.63
133.40
132.46
131.43
131.28
130.70
130.43
130.41
126.82
125.62
123.92
121.02
111.01
82.88
82.59
82.30
82.02
81.73
62.36
49.64
49.43
49.21
49.00
48.79
48.58
48.36
37.33
32.34
23.30
22.87
14.50
14.11


F3C
F3C
O
I
CO2Et
HN
O
Me

4la


190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
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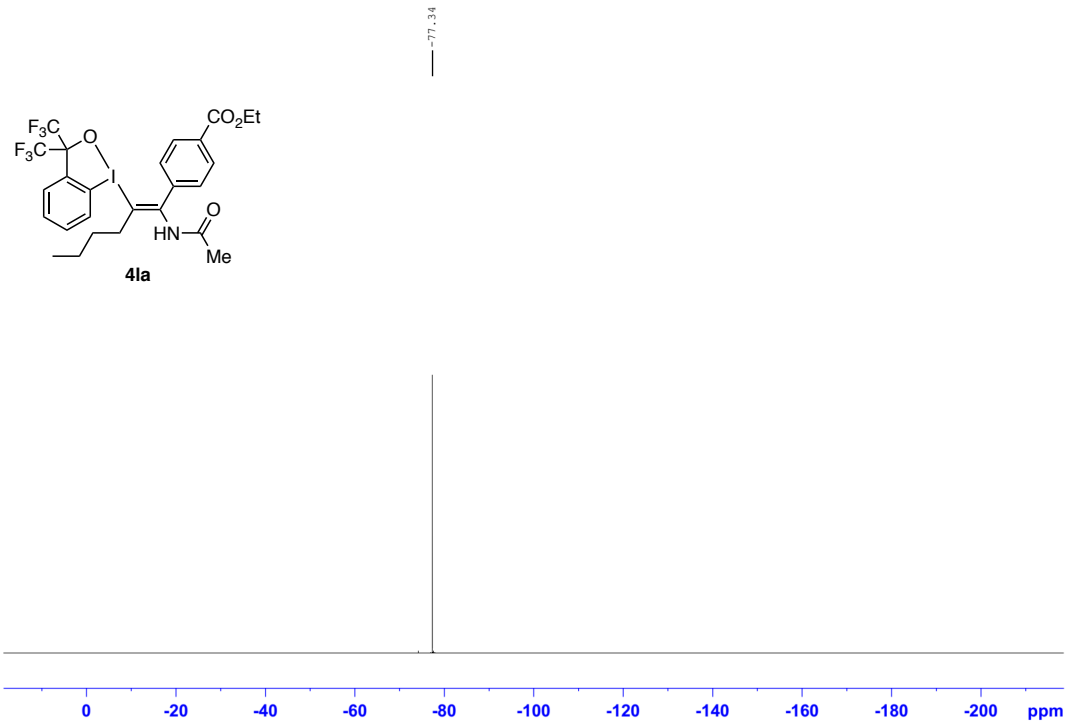
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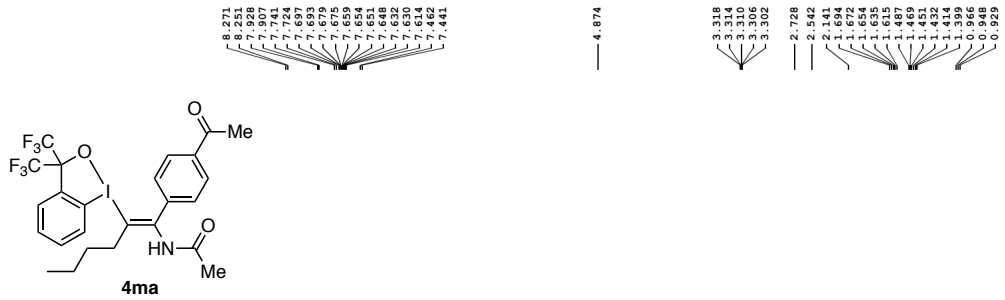
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7.648
7.632
7.630
7.614
7.462
7.441
4.874
3.318
3.314
3.310
3.306
3.302
2.728
2.542
2.141
1.694
1.672
1.654
1.635
1.615
1.487
1.469
1.451
1.432
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0.929
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Me
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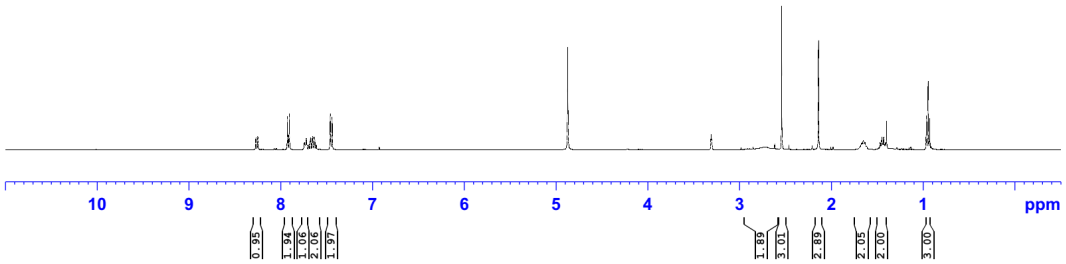
F3C
O
I
HN
O
Me
4ma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4
3
2
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ppm
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3.01
2.89
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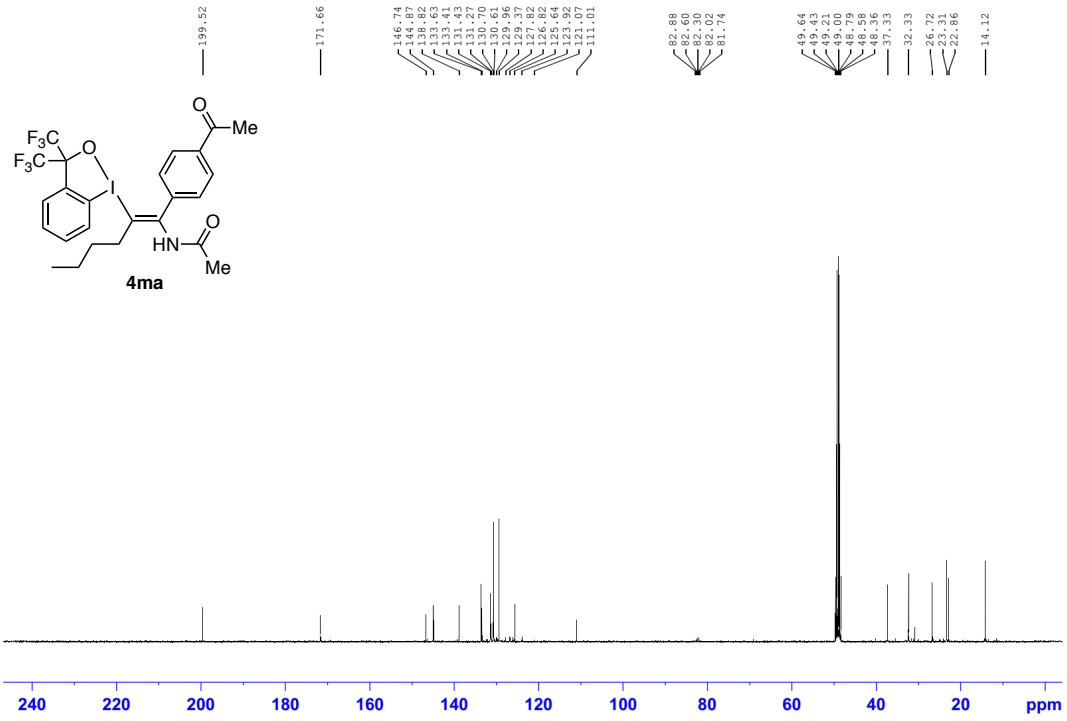
2.00
3.00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129.96
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125.64
123.92
121.07
111.01
82.88
82.60
82.30
82.02
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49.64
49.43
49.21
49.00
48.79
48.58
48.36
37.33
32.33
26.72
26.31
22.66
14.12
O
Me
F3C
F3C
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I
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O
Me
4ma
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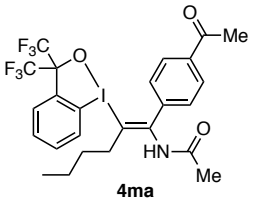
60
40
20
ppm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F3C
O
I
HN
O
Me

4ma

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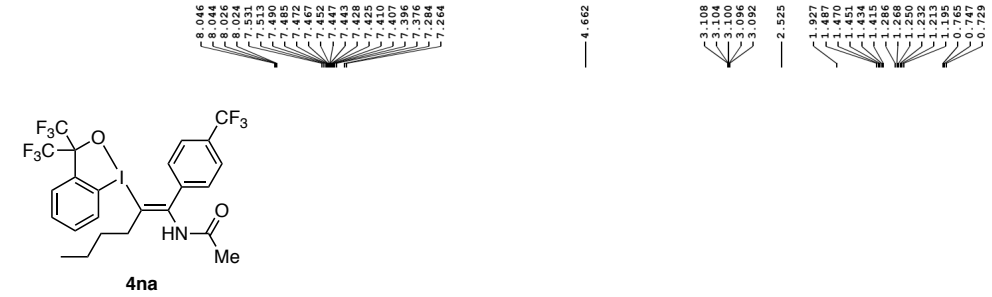
ppm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7.425
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7.407
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7.376
7.284
7.264
4.662
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3.104
3.100
3.096
3.092
2.525
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1.487
1.470
1.451
1.434
1.415
1.266
1.250
1.232
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0.729

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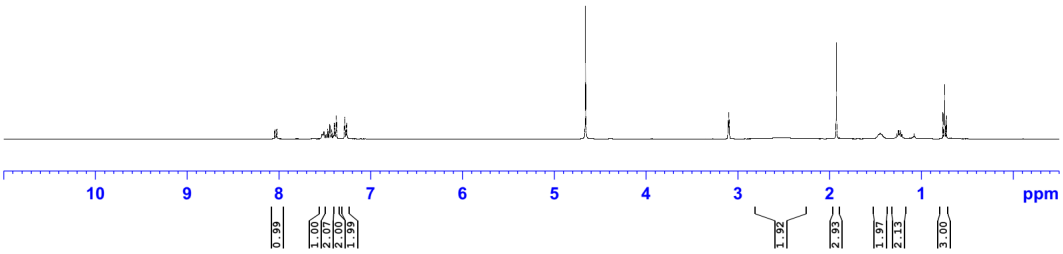
I
CF3
HN
O
Me

4na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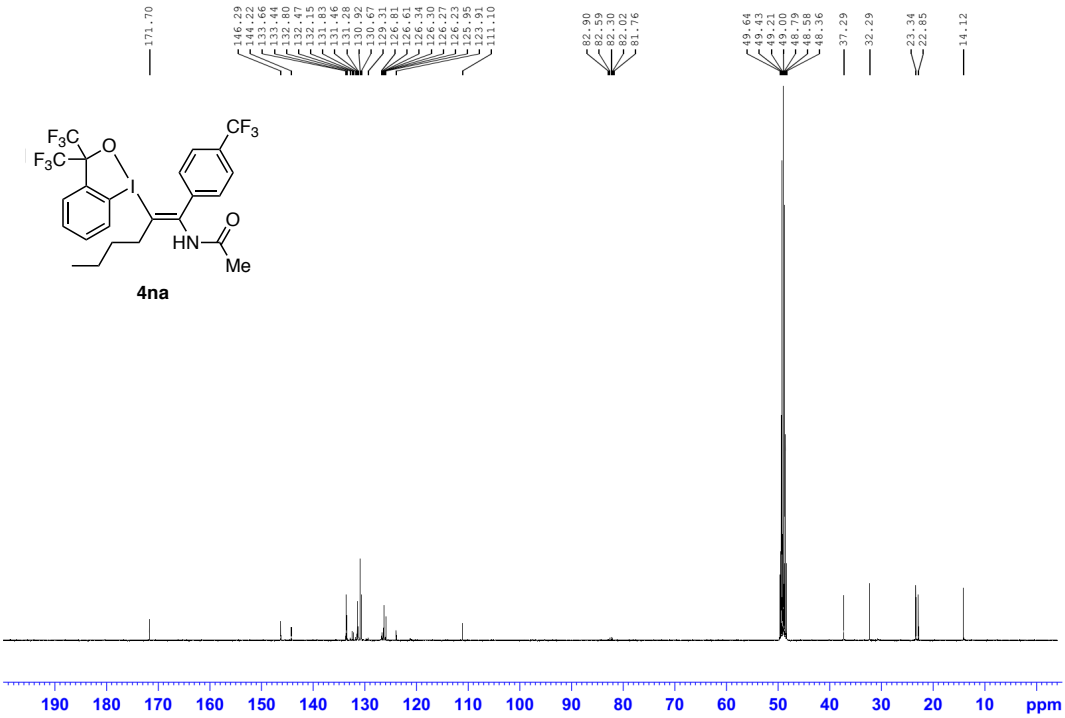
3.00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126.61
126.34
126.30
126.27
126.23
125.95
123.91
111.10
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82.59
82.30
82.02
81.76
49.64
49.43
49.21
49.00
48.79
48.58
48.36
37.29
32.29
23.34
22.85
14.12
190
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150
140
130
120
110
100
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40
30
20
10
ppm

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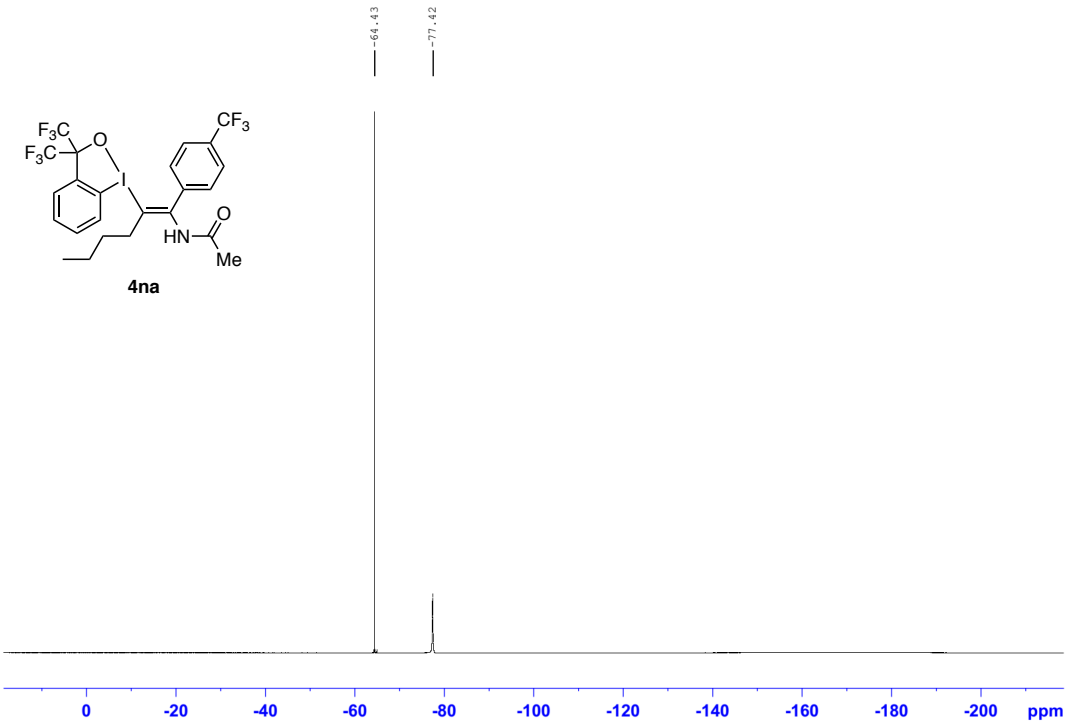
O
I
CF3
HN
O
Me

4na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CF3
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Me
4na
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-120
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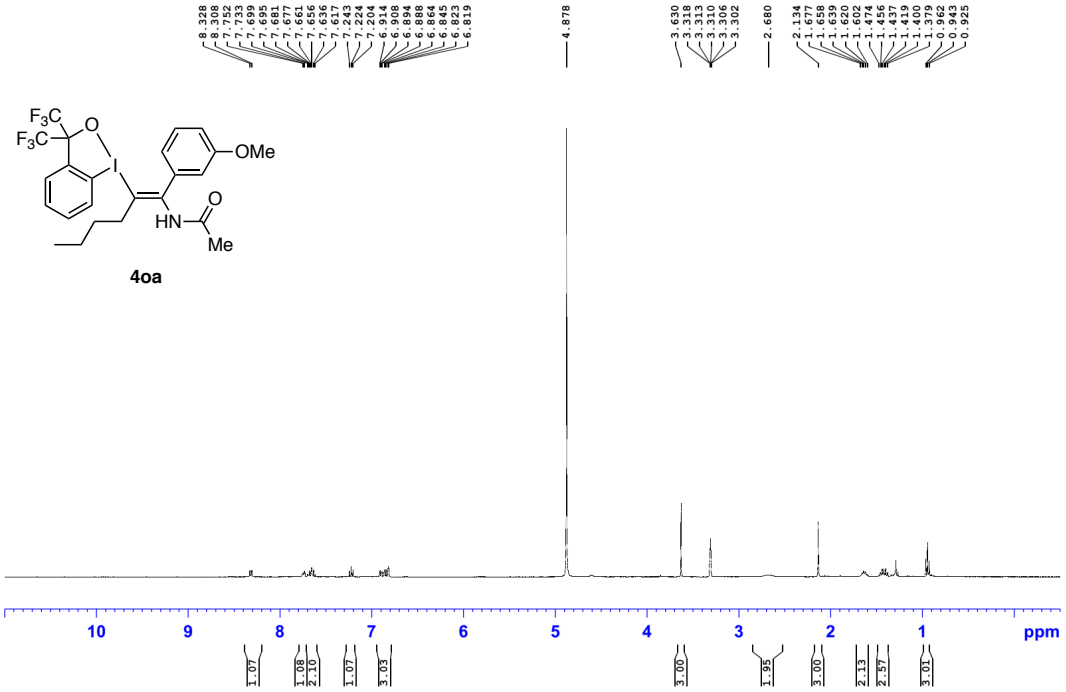
-160
-180
-200
ppm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7.224
7.204
6.914
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6.894
6.888
6.864
6.845
6.823
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3.313
3.310
3.306
3.302
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2.134
1.677
1.658
1.639
1.620
1.602
1.474
1.456
1.437
1.419
1.400
1.379
1.362
0.943
0.925
F3C
F3C
O
I
OMe
O
HN
Me
4oa
10
9
8
7
6
5
4
3
2
1
ppm
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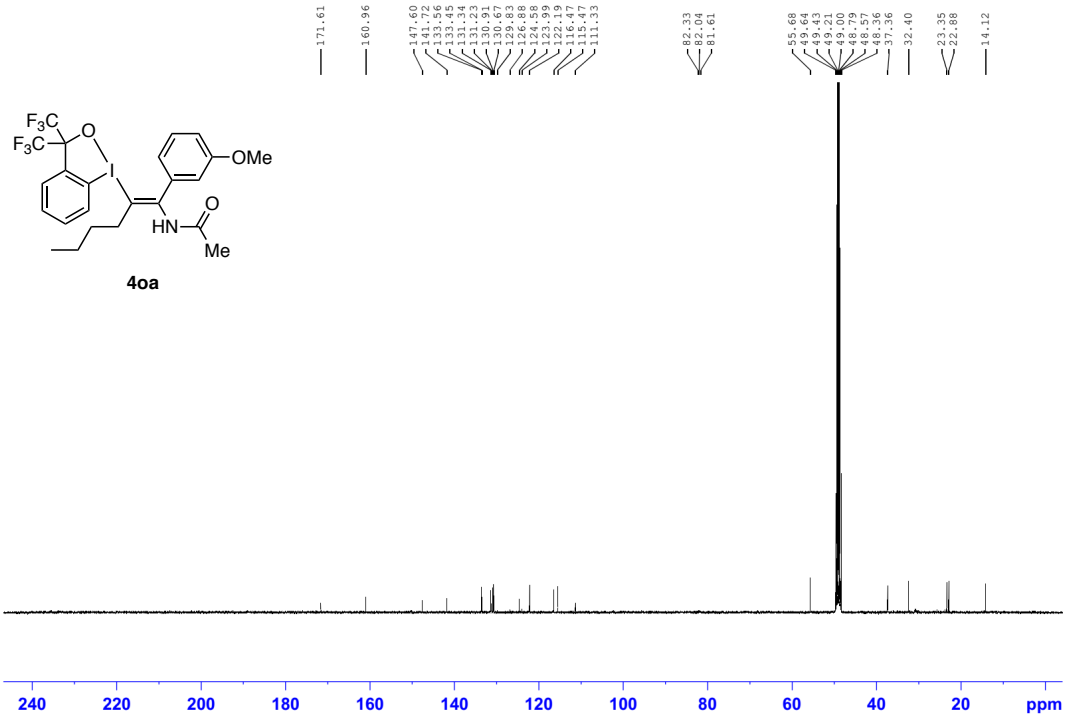
1.08
2.10
1.07
3.03
3.00
1.95
3.00
2.13
2.57
3.01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124.58
123.99
122.19
116.47
115.47
111.33
82.33
82.04
81.61
55.68
49.64
49.43
49.21
49.00
48.79
48.57
48.36
37.36
32.40
23.35
22.88
14.12
F3C
F3C
O
I
OMe
O
HN
Me
4oa
240
220
200
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140
120
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60
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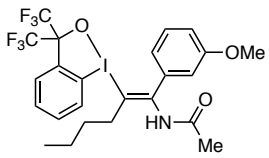
20
ppm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F3C
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I
OMe
HN
O
Me

4oa

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-40
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-80
-100
-120
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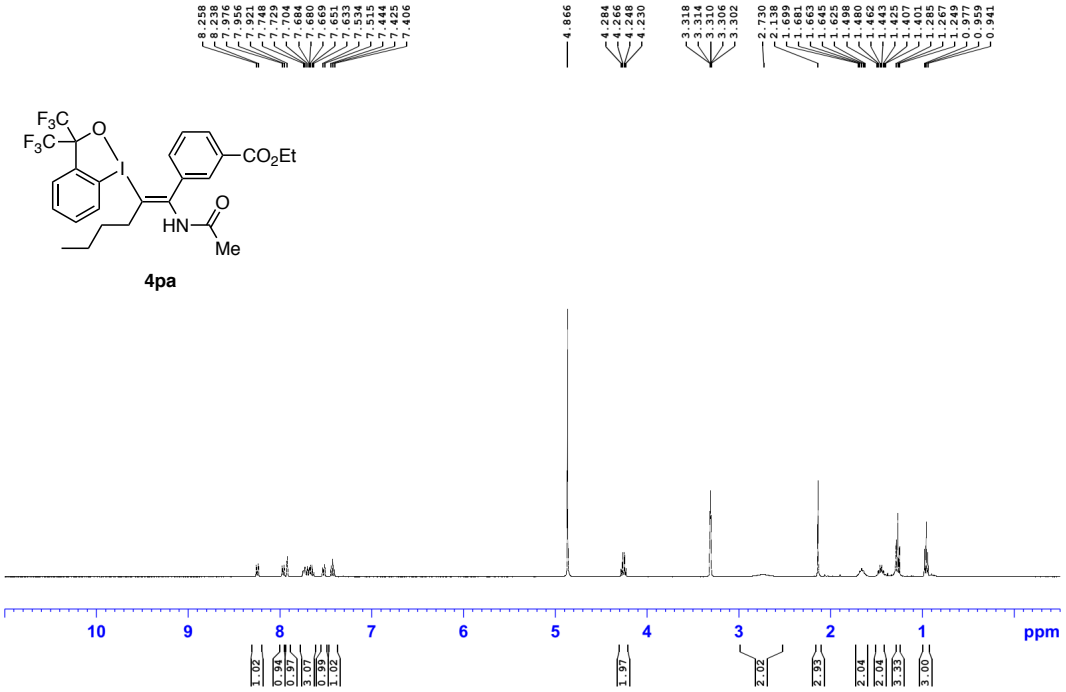
-160
-180
-200
ppm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7.669
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7.633
7.534
7.515
7.444
7.425
7.406
4.866
4.284
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4.248
4.230
3.318
3.314
3.310
3.306
3.302
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2.338
2.298
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1.663
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1.625
1.498
1.480
1.462
1.443
1.425
1.407
1.401
1.285
1.277
1.249
0.977
0.959
0.941
F3C
F3C
O
I
CO2Et
HN
O
Me
4pa
10
9
8
7
6
5
4
3
2
1
ppm
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0.99
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1.97
2.02
2.93
2.04
2.04
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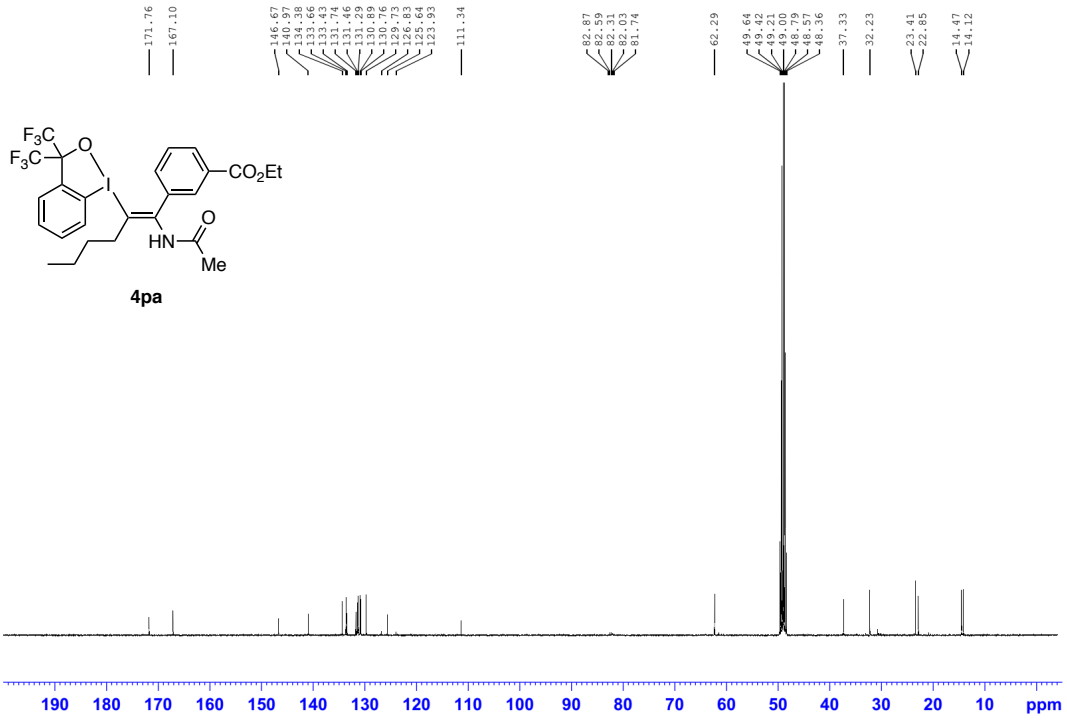
3.00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129.73
126.83
125.64
123.93
111.34
82.87
82.59
82.31
82.03
81.74
62.29
49.64
49.42
49.21
49.00
48.79
48.57
48.36
37.33
32.23
23.41
22.85
14.47
14.12
F3C
F3C
O
I
CO2Et
HN
O
Me
4pa
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150
140
130
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110
100
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70
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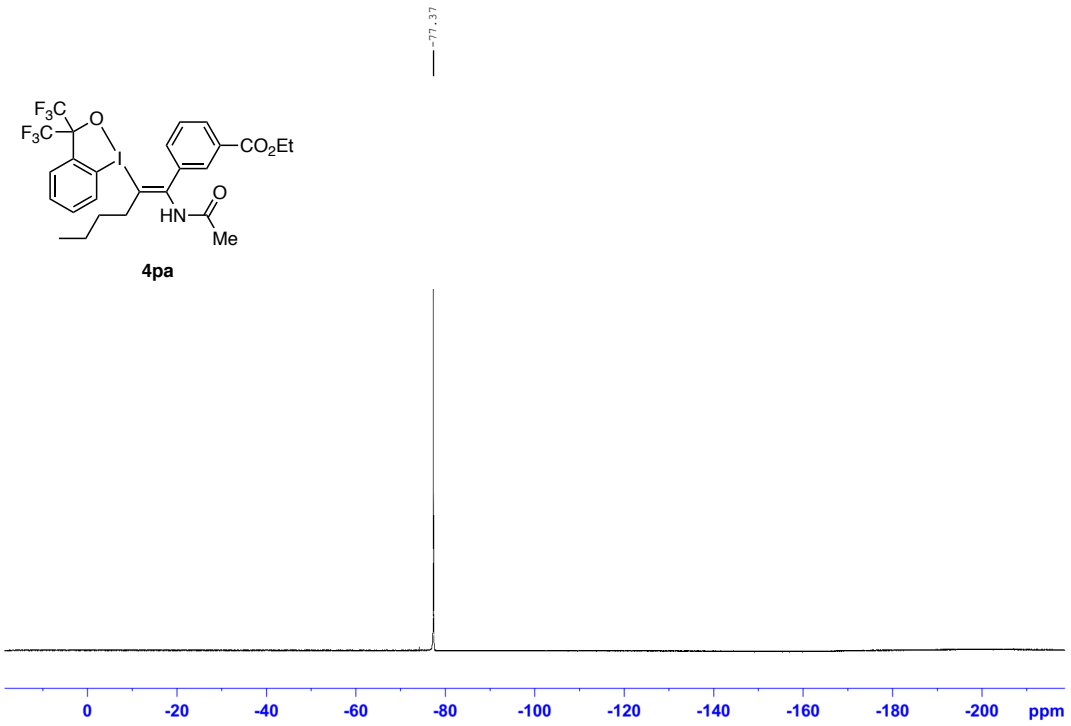
30
20
10
ppm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CO2Et
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4pa
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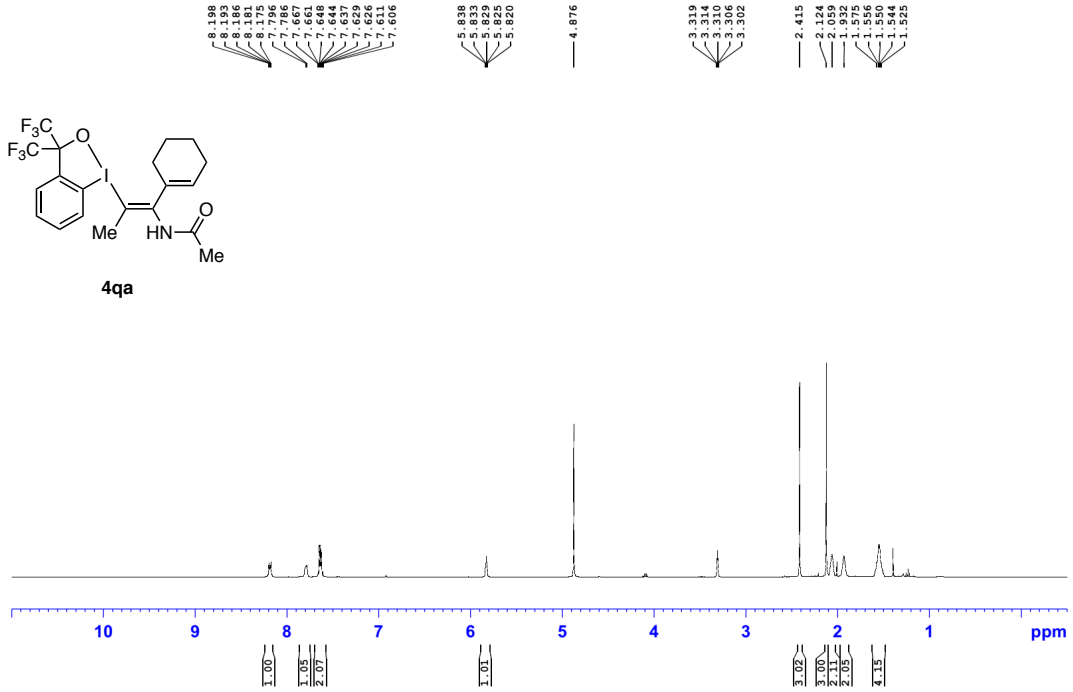
ppm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7.644
7.637
7.629
7.626
7.611
7.606
5.838
5.833
5.829
5.825
5.820
4.876
3.319
3.314
3.310
3.306
3.302
2.415
2.124
2.059
1.932
1.575
1.556
1.550
1.544
1.525
F3C
F3C
O
I
Me
HN
O
Me
4qa
10
9
8
7
6
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4
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ppm
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1.05
2.07
1.01
3.02
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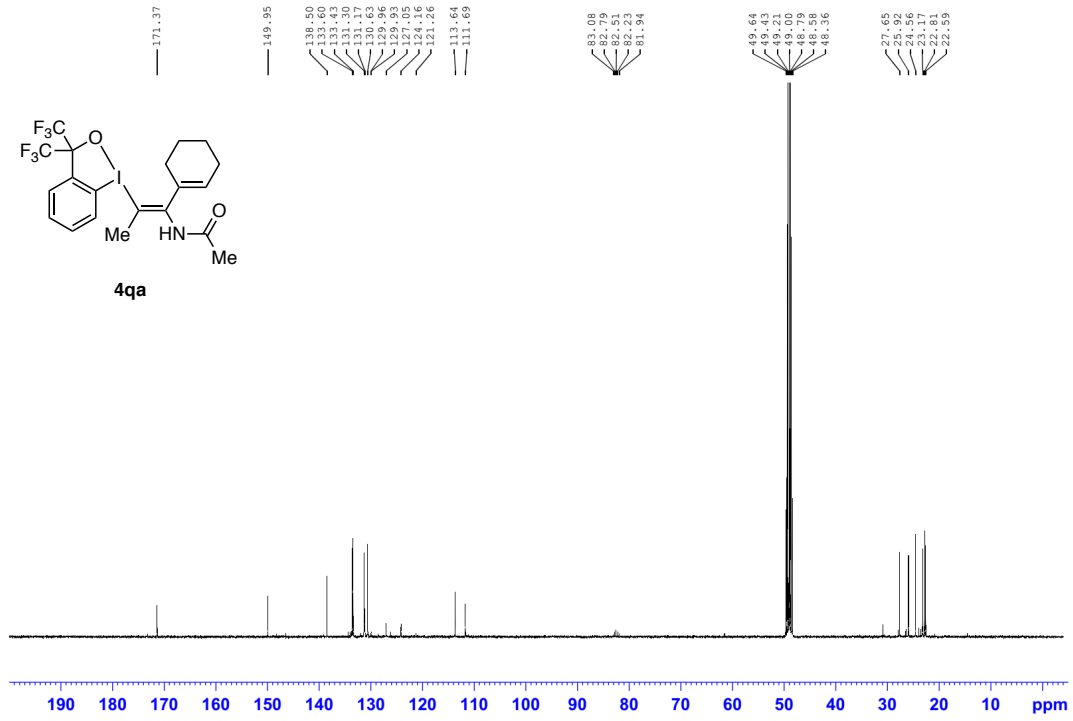
2.05
4.15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130.63
129.96
129.93
127.05
124.16
121.26
113.64
111.69
83.08
82.79
82.51
82.23
81.94
49.64
49.43
49.21
49.00
48.79
48.58
48.36
27.65
25.92
24.56
23.17
22.81
22.59
F3C
F3C
O
I
Me
HN
O
Me
4qa
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150
140
130
120
110
100
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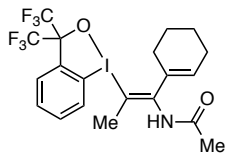
20
10
ppm



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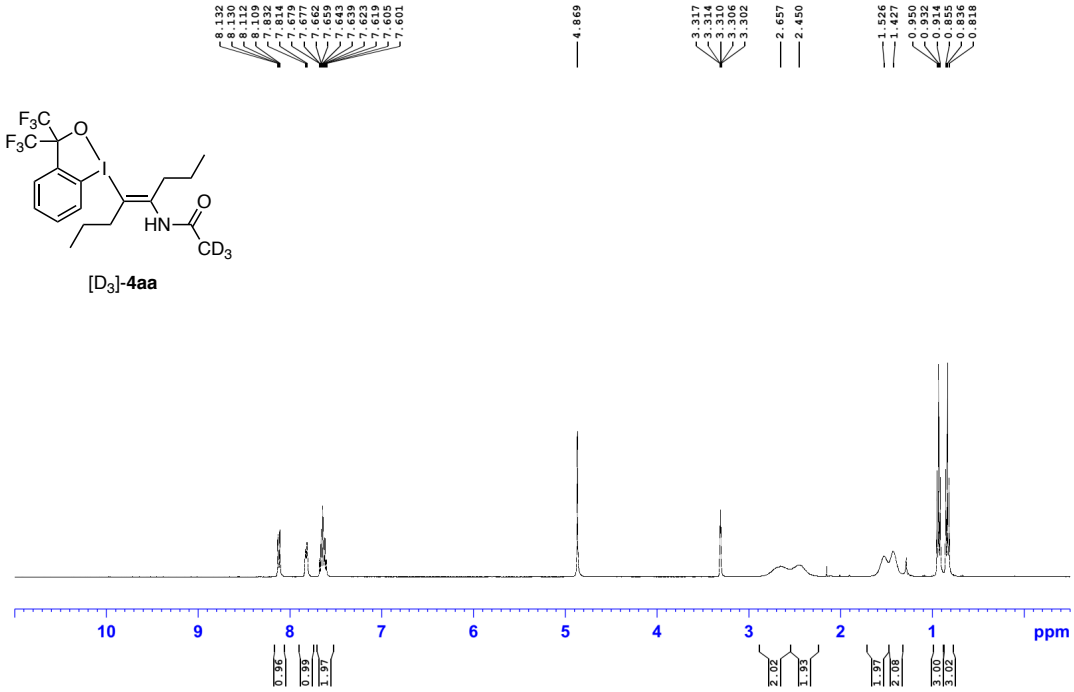
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7.677
7.662
7.659
7.643
7.639
7.623
7.619
7.605
7.601
4.869
3.317
3.314
3.310
3.306
3.302
2.657
2.450
1.526
1.427
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0.932
0.914
0.855
0.836
0.818
F3C
F3C
O
I
HN
O
CD3
[D3]-4aa
10
9
8
7
6
5
4
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ppm
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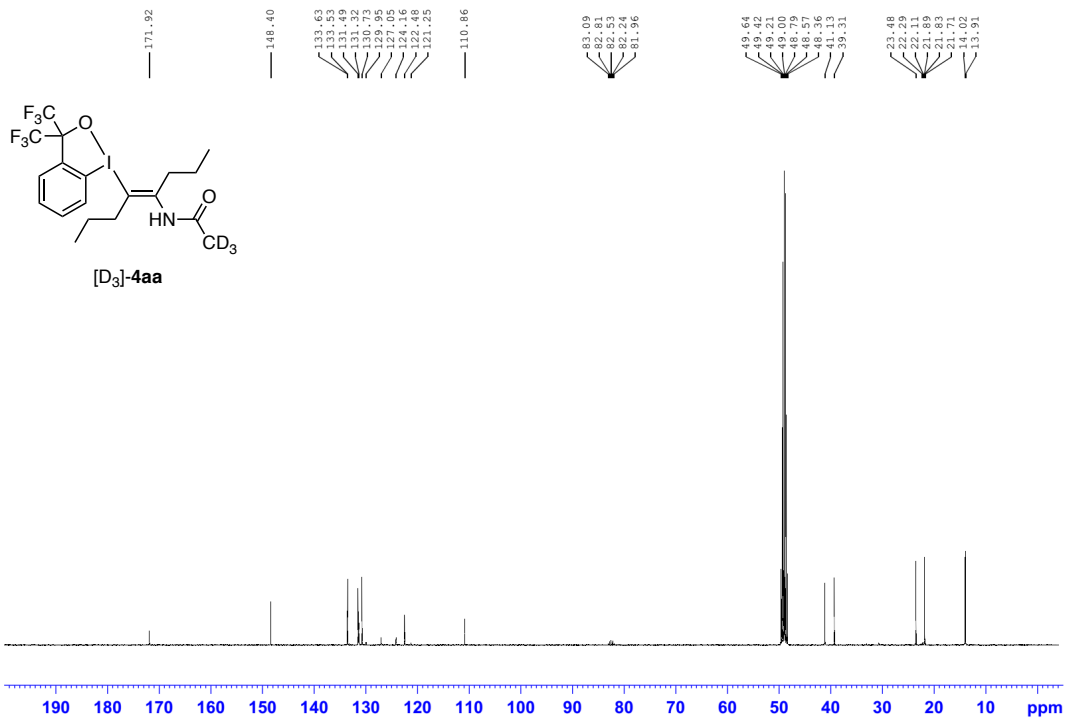
1.93
1.97
2.08
3.00
3.02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124.16
122.48
121.25
110.86
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82.53
82.24
81.96
49.64
49.42
49.21
49.00
48.79
48.57
48.36
48.15
41.13
39.31
23.48
22.29
22.11
21.89
21.83
21.71
14.02
13.91
F3C
F3C
O
I
HN
O
CD3
[D3]-4aa
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170
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150
140
130
120
110
100
90
80
70
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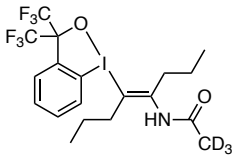
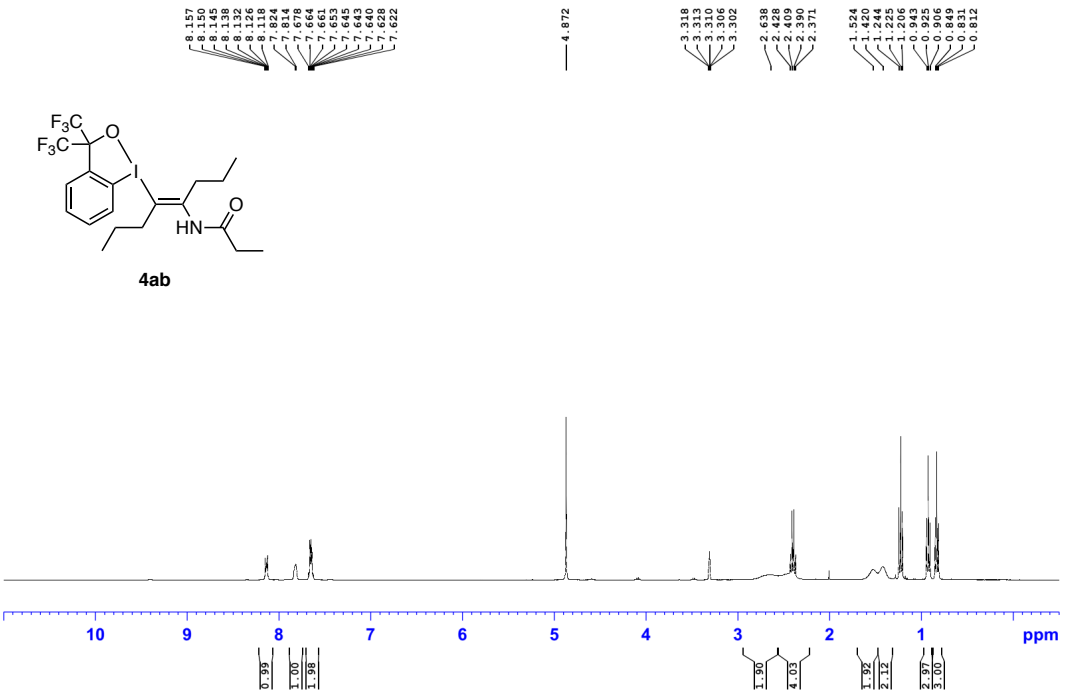
40
30
20
10
ppm



[D_3]-**4aa**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8.126
8.118
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7.814
7.678
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7.653
7.645
7.643
7.640
7.628
7.622
4.872
3.318
3.313
3.310
3.306
3.302
2.638
2.428
2.409
2.390
2.371
1.524
1.420
1.244
1.225
1.206
0.943
0.925
0.906
0.849
0.831
0.812
F3C
F3C
O
I
HN
O
4ab
10
9
8
7
6
5
4
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ppm
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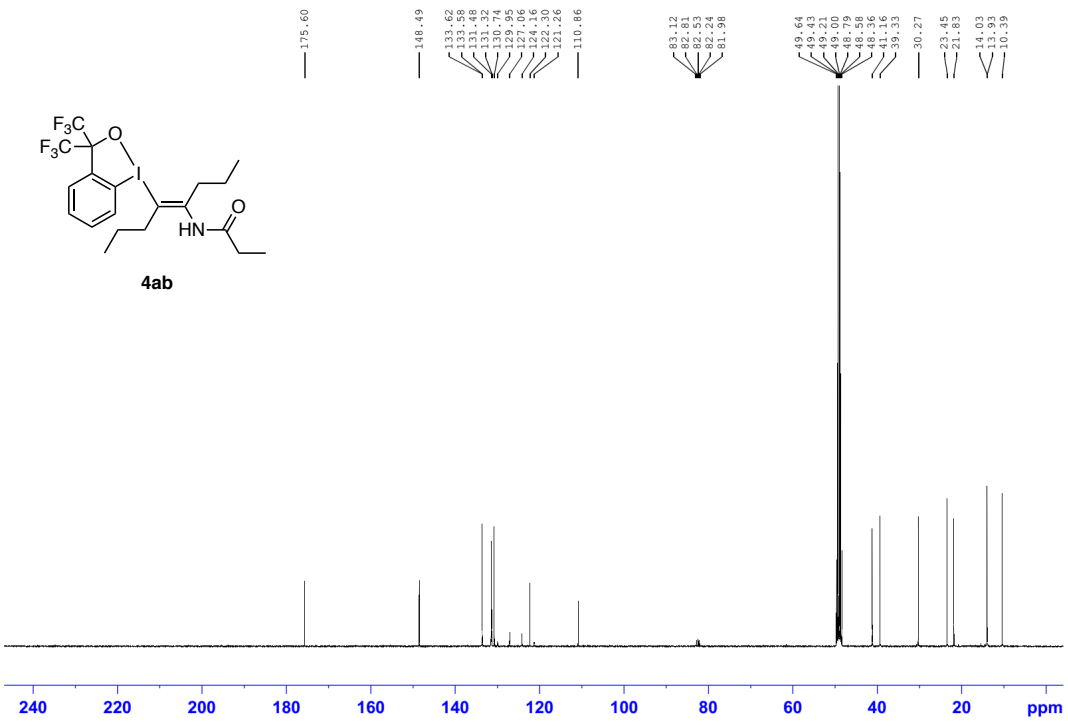
1.98
1.90
4.03
1.92
2.12
2.97
3.00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130.55
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124.16
122.30
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110.86
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82.53
82.24
81.98
49.64
49.43
49.21
49.00
48.79
48.58
48.36
41.16
39.33
30.27
23.45
21.83
14.03
13.93
10.39
F3C
F3C
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I
HN
O
4ab
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200
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140
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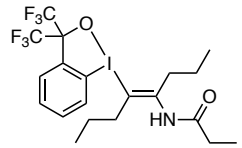
80
60
40
20
ppm



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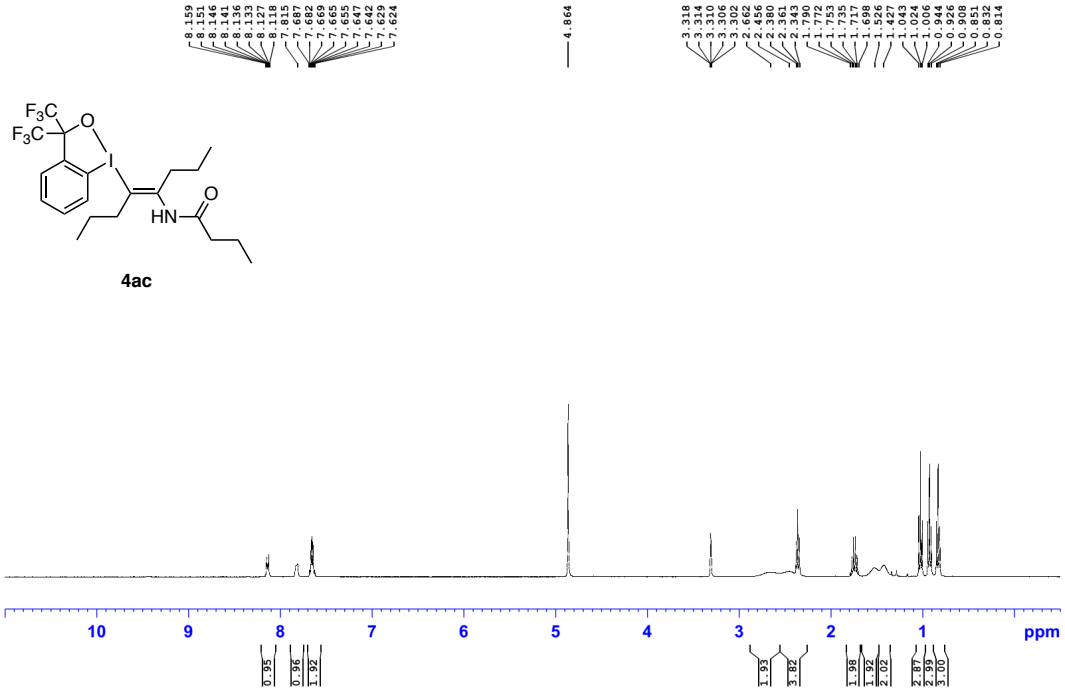
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8.133
8.127
8.118
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7.687
7.682
7.669
7.665
7.655
7.647
7.642
7.629
7.624
4.864
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2.662
2.456
2.380
2.361
2.343
2.330
1.772
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1.735
1.717
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1.526
1.427
1.043
1.024
1.006
0.944
0.926
0.908
0.851
0.832
0.814
F3C
F3C
O
I
HN
O
10
9
8
7
6
5
4
3
2
1
ppm
0.95
0.96
1.92
1.93
3.82
1.98
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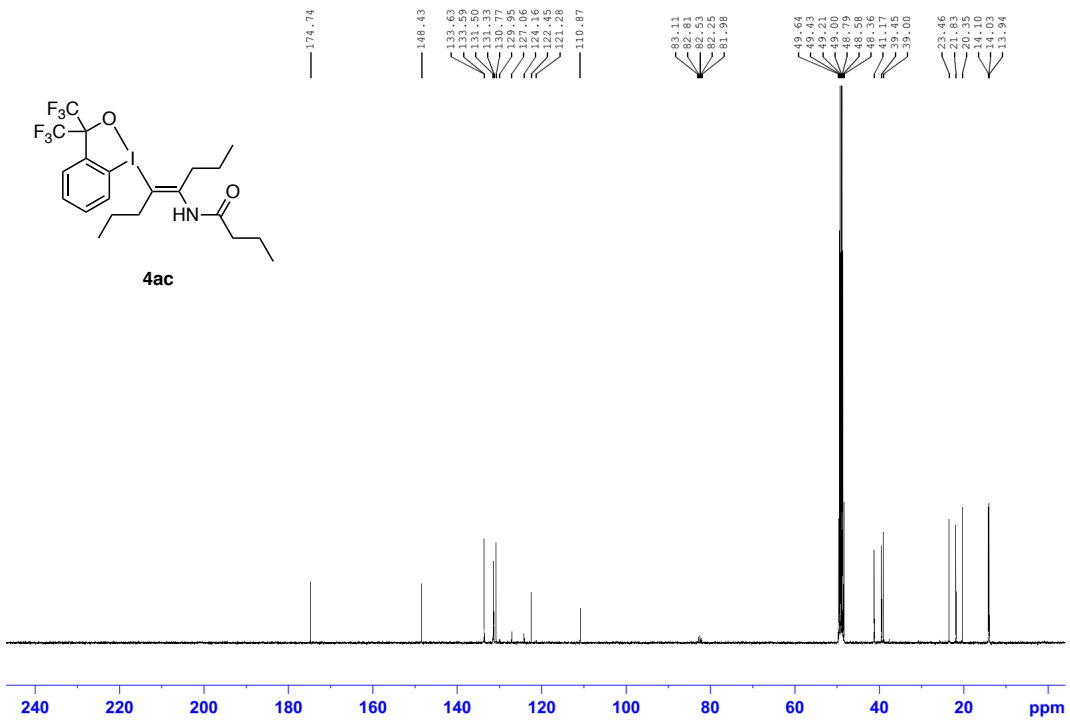
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82.53
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39.00
23.46
21.83
20.35
14.10
14.03
13.94
F3C
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20
ppm

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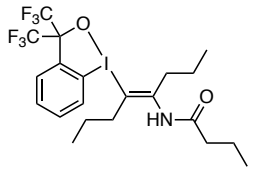

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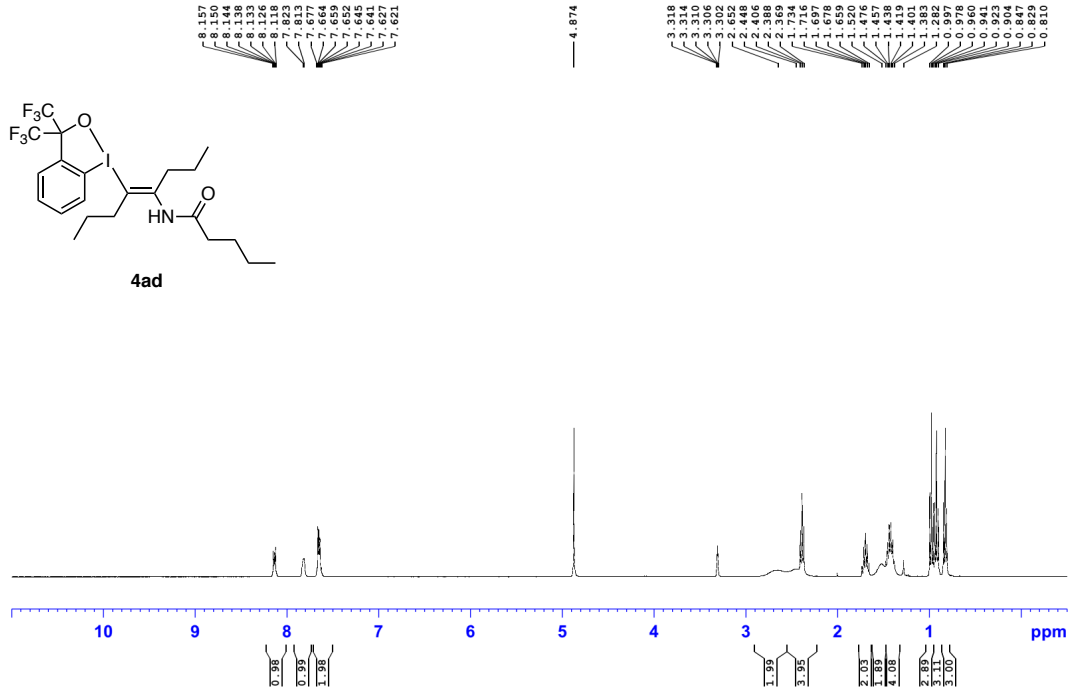
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3.310
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3.302
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1.697
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F3C
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I
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9
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7
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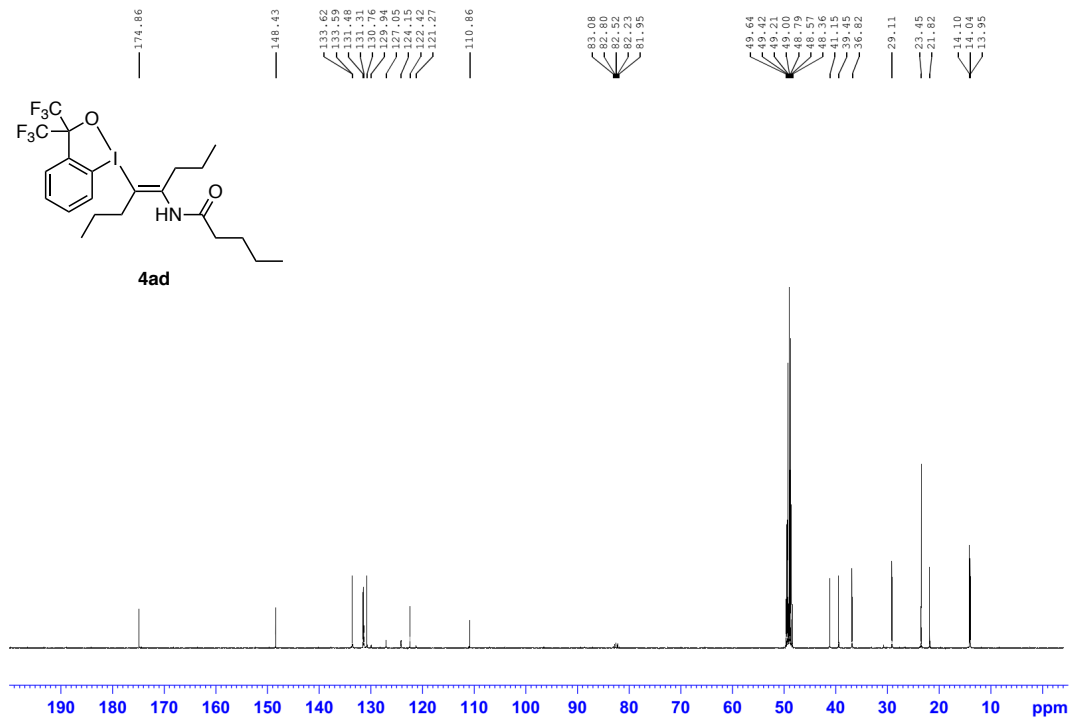
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29.11
23.45
21.82
14.10
14.04
13.95
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F3C
O
I
HN
O
4ad
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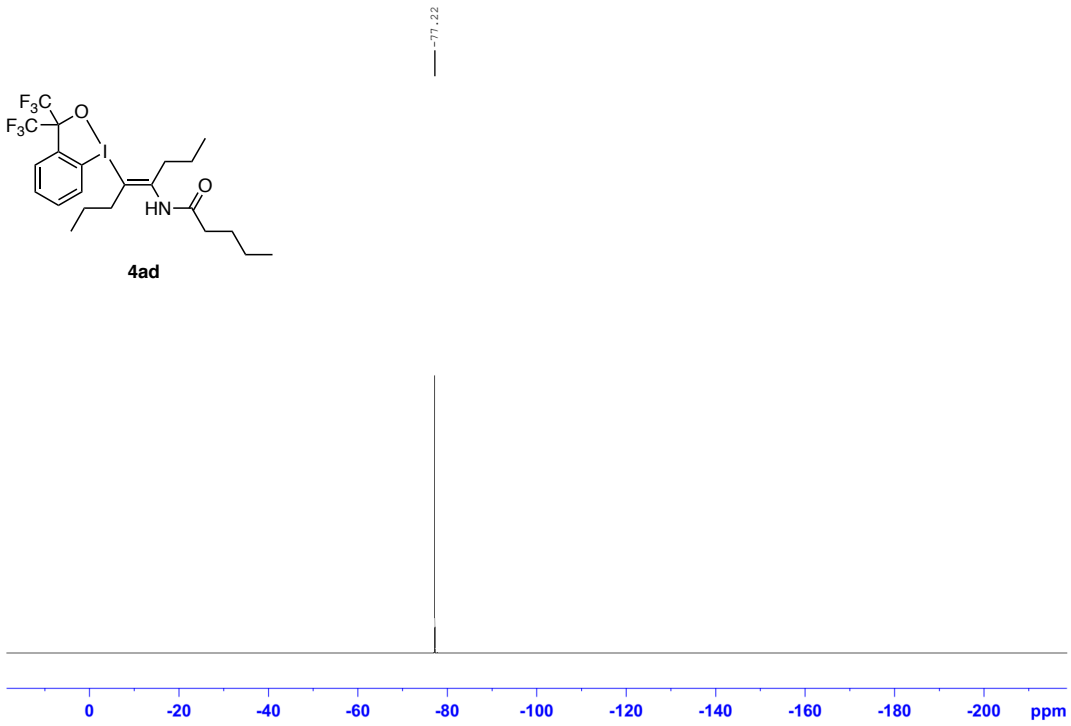
10
ppm



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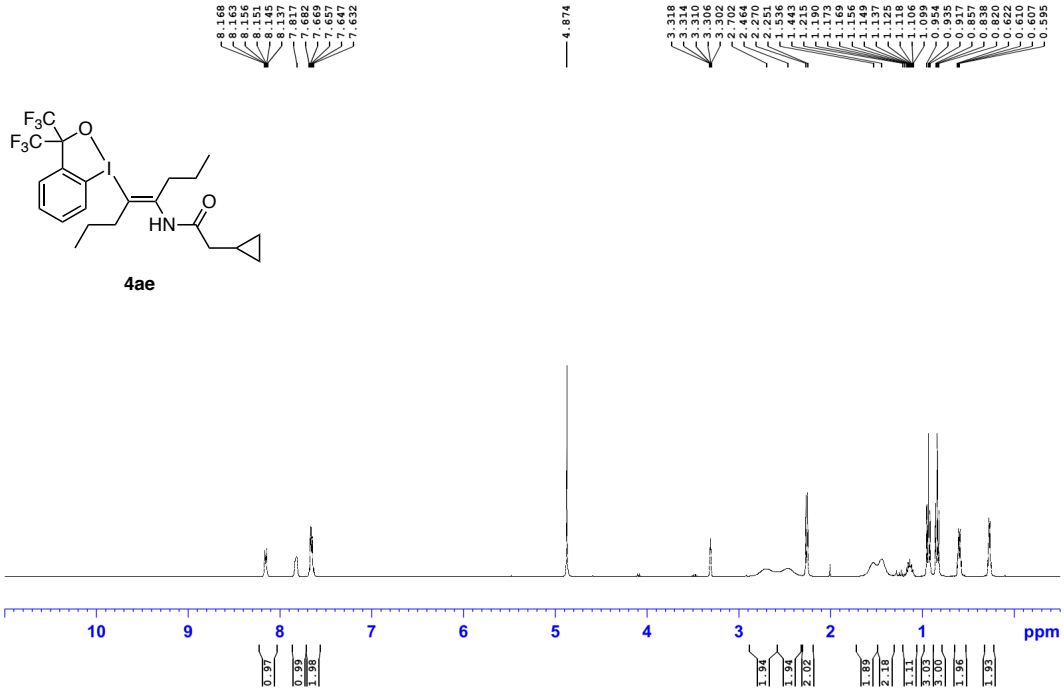
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7.632
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3.314
3.310
3.306
3.302
3.092
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2.270
2.251
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1.443
1.215
1.190
1.173
1.169
1.156
1.149
1.137
1.125
1.118
1.106
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0.917
0.857
0.838
0.820
0.622
0.610
0.607
0.595
F3C
F3C
O
I
HN
O
4ae
10
9
8
7
6
5
4
3
2
1
ppm
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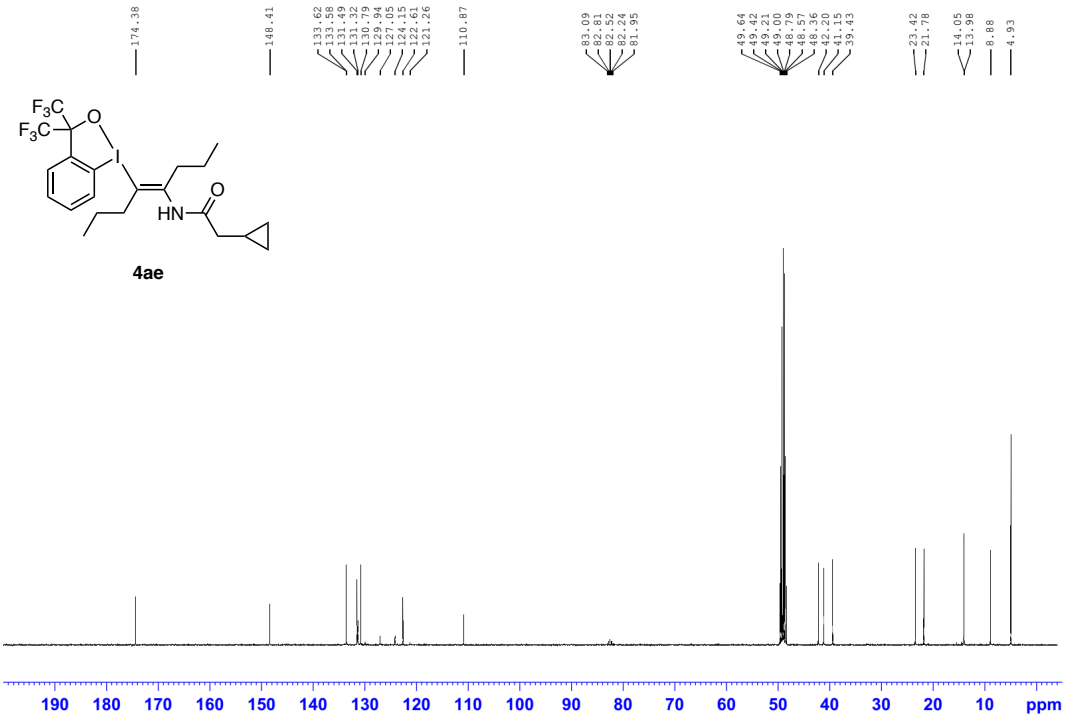
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82.52
82.24
81.95
49.64
49.42
49.21
49.00
48.79
48.57
48.36
42.20
41.15
39.43
23.42
21.78
14.05
13.98
8.88
4.93
F3C
F3C
O
I
HN
O
4ae
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140
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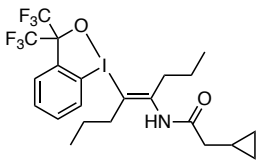
30
20
10
ppm



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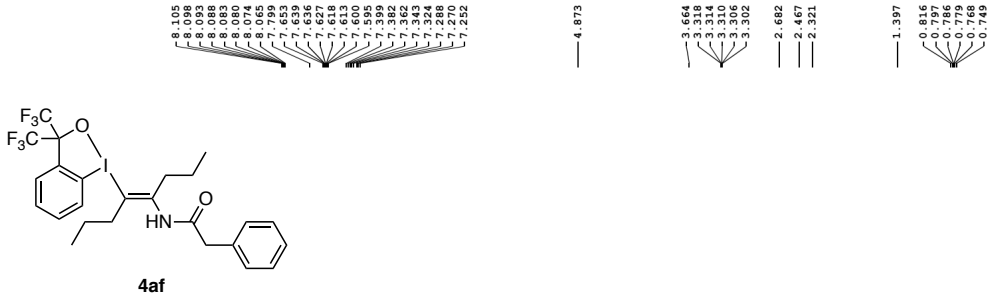
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7.613
7.600
7.595
7.399
7.382
7.362
7.343
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7.270
7.252
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3.310
3.306
3.302
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0.786
0.779
0.768
0.749
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F3C
O
I
HN
O
4af
10
9
8
7
6
5
4
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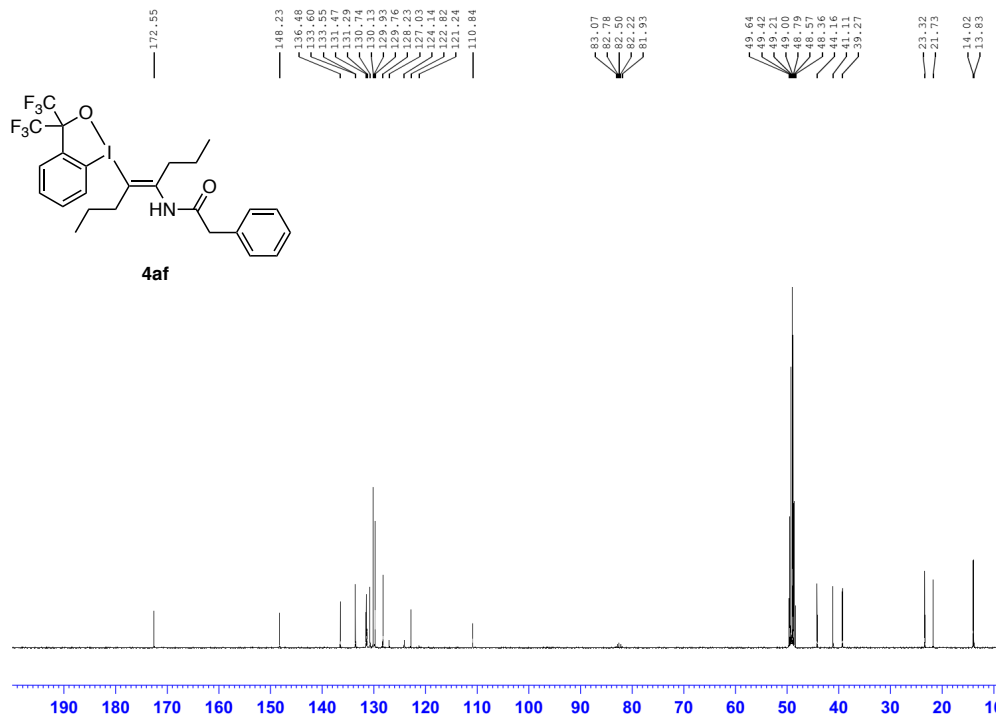
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128.23
127.03
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122.82
121.24
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82.50
82.22
81.93
49.64
49.42
49.21
49.00
48.79
48.57
48.36
44.16
41.11
39.27
23.32
21.73
14.02
13.83
F3C
F3C
O
I
HN
O
4af
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150
140
130
120
110
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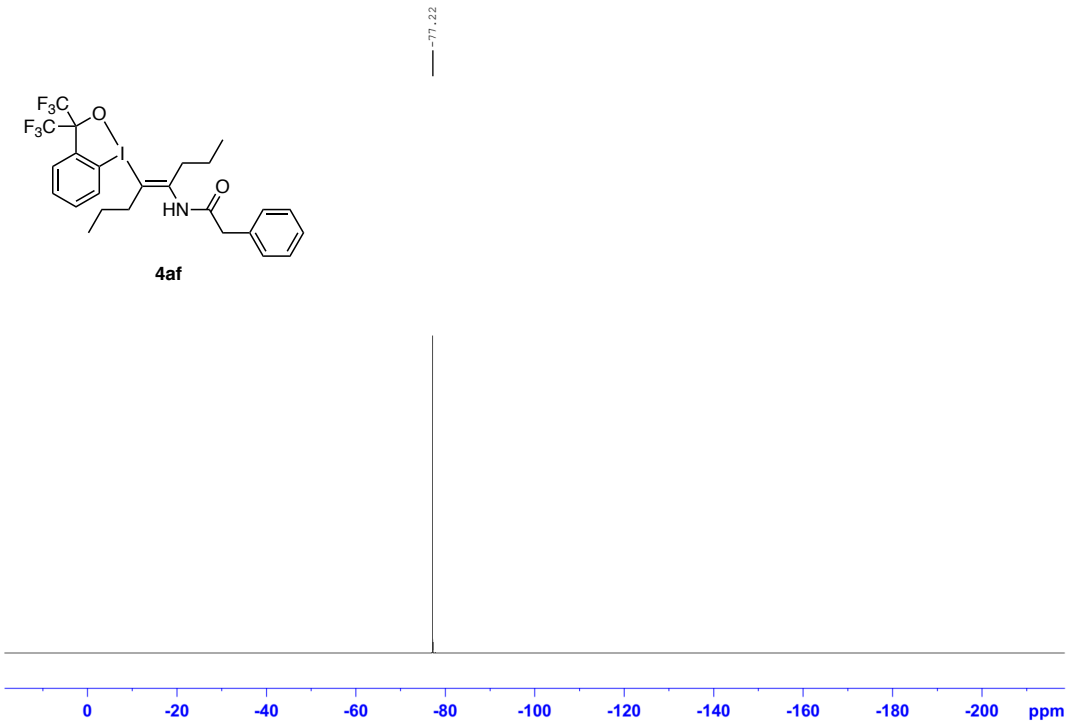
30
20
10
ppm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HN
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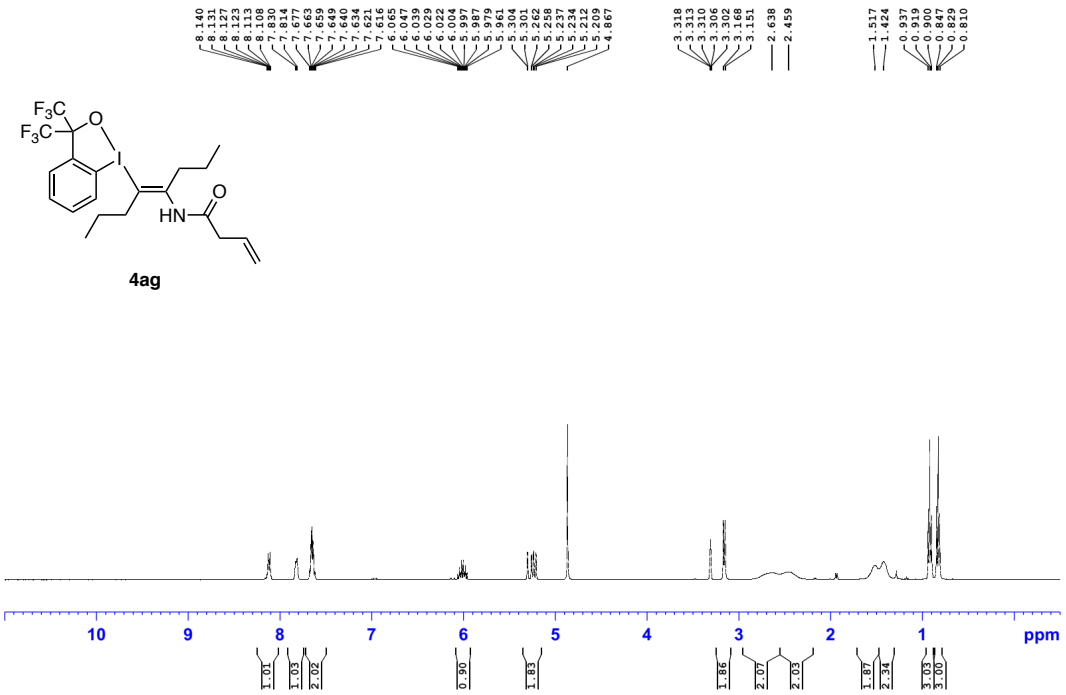
ppm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7.640
7.634
7.621
7.615
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6.039
6.029
6.022
6.004
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5.979
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5.301
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5.234
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3.313
3.310
3.306
3.302
3.168
3.151
2.638
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1.424
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0.919
0.900
0.847
0.829
0.810
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F3C
O
I
HN
O
4ag
10
9
8
7
6
5
4
3
2
1
ppm
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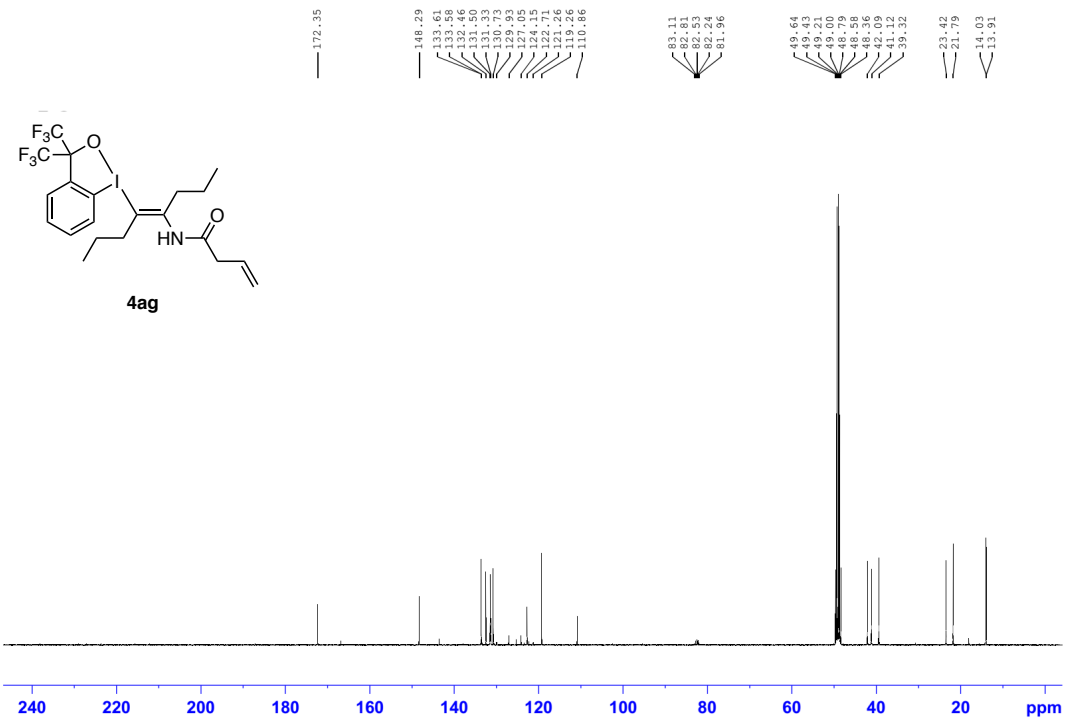
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82.53
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49.43
49.21
49.00
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48.58
48.36
42.09
41.12
39.32
23.42
21.79
14.03
13.91
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HN
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4ag
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60
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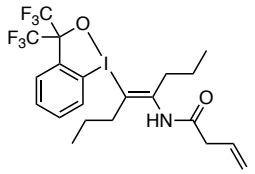
20
ppm



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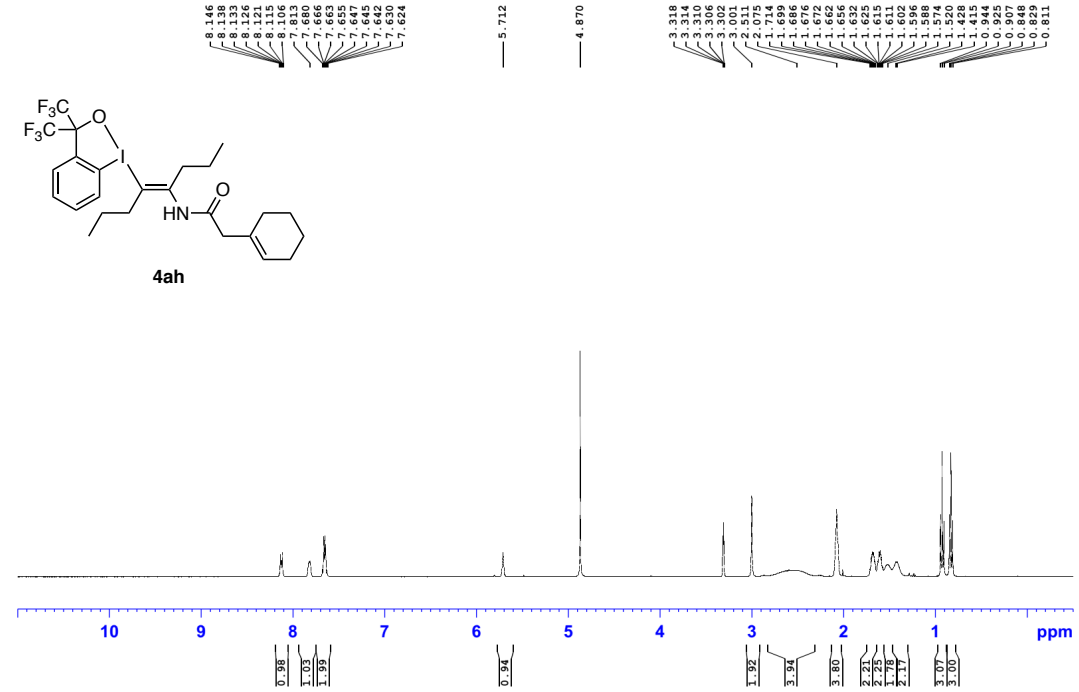
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7.663
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7.642
7.630
7.624
5.712
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3.314
3.310
3.306
3.302
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1.662
1.656
1.632
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1.615
1.611
1.602
1.596
1.588
1.574
1.520
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1.415
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0.925
0.907
0.848
0.829
0.811
F3C
F3C
O
I
HN
O
4ah
10
9
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7
6
5
4
3
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ppm
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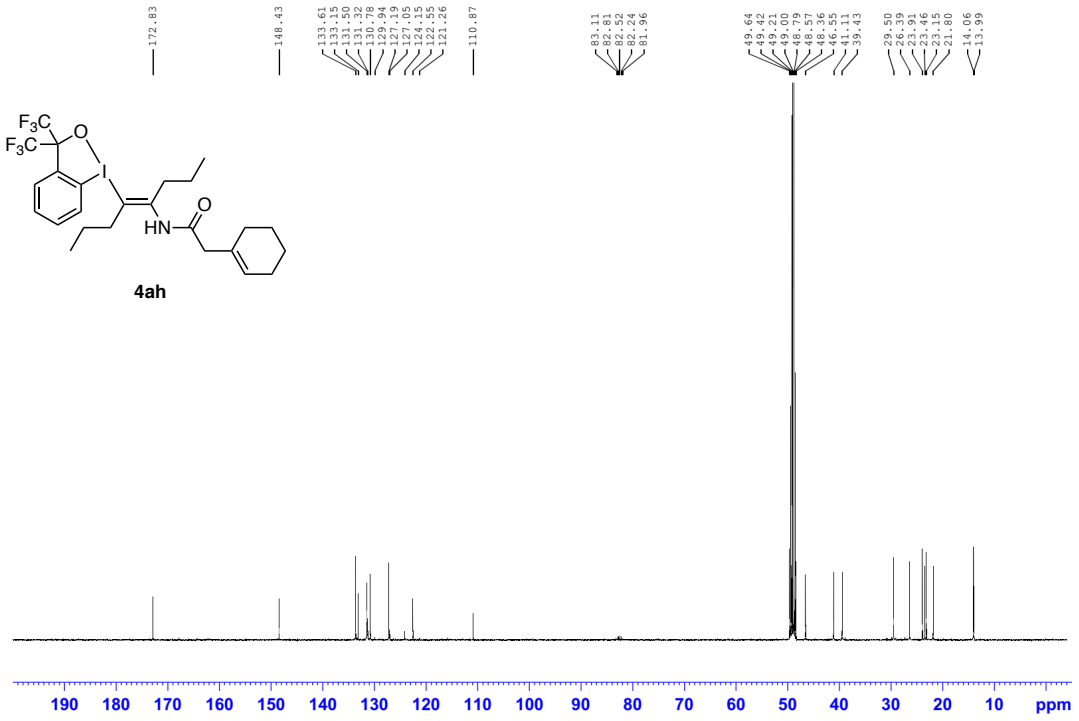
3.00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127.05
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122.55
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82.52
82.24
81.96
49.64
49.42
49.21
49.00
48.79
48.57
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46.55
41.11
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29.50
26.39
25.91
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23.15
21.80
14.06
13.99
F3C
F3C
O
I
HN
O
4ah
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30
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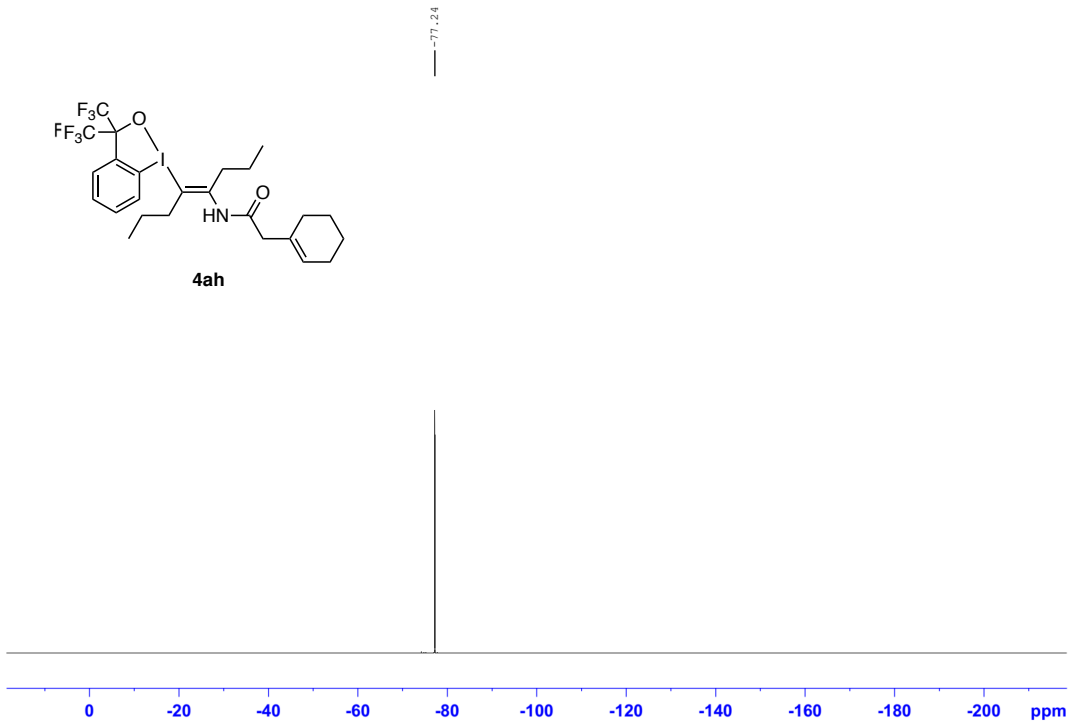
10
ppm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-120
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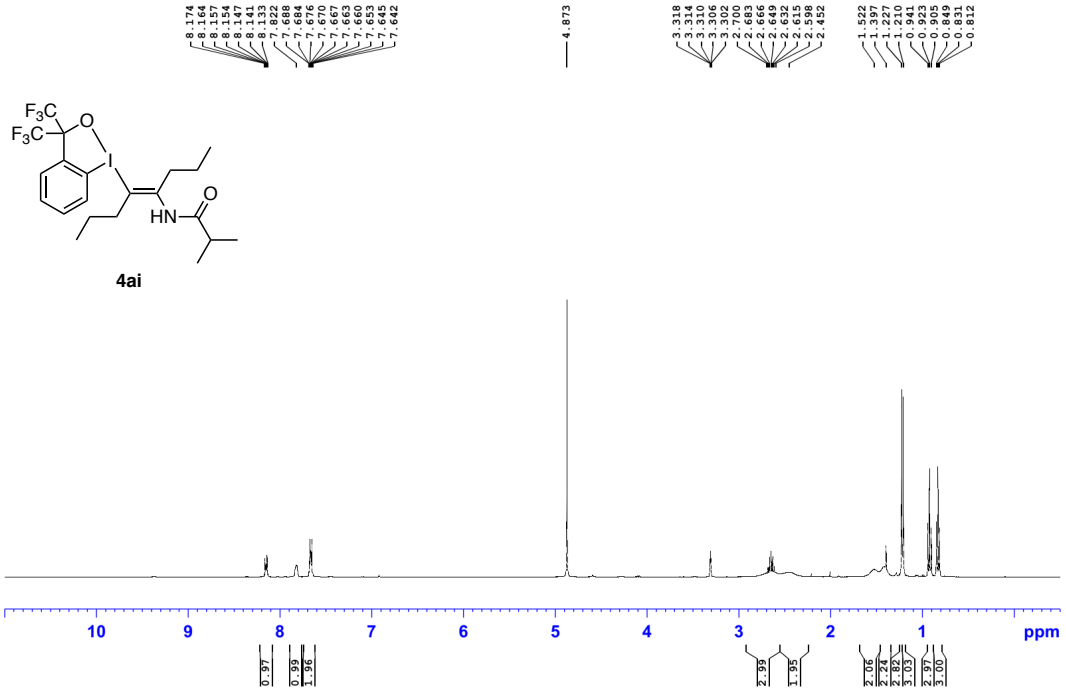
-180
-200
ppm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7.660
7.653
7.645
7.642
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3.314
3.310
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2.452
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1.377
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1.210
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0.923
0.905
0.849
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F3C
F3C
O
I
HN
O
4ai
10
9
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7
6
5
4
3
2
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2.24
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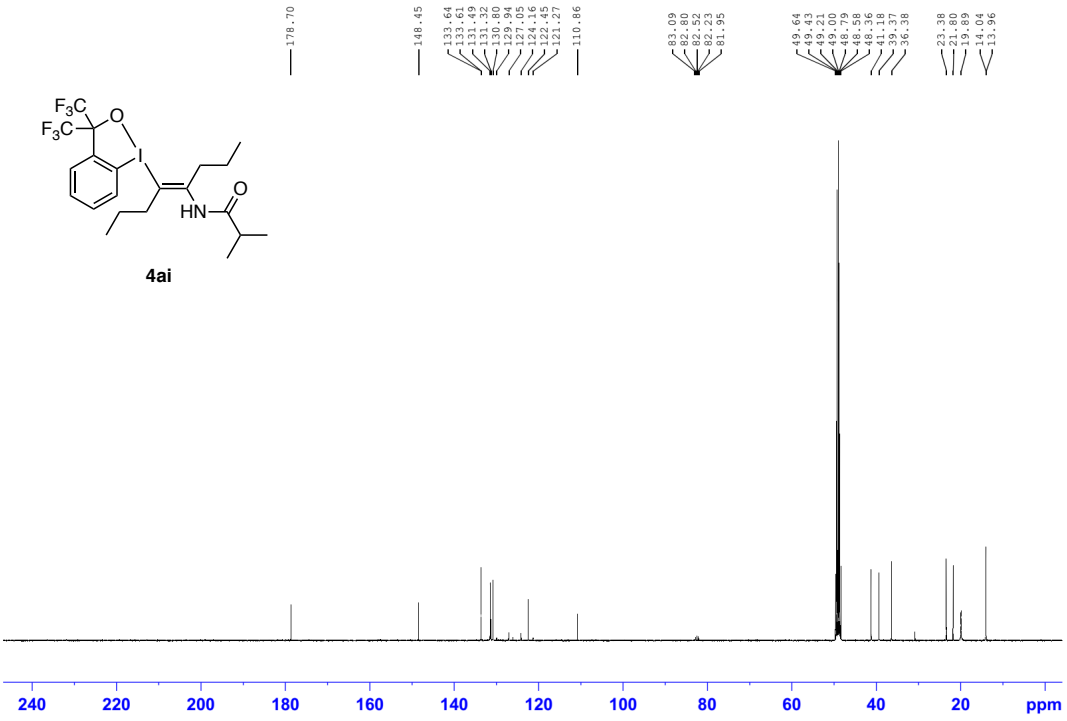
3.00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82.23
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49.64
49.43
49.21
49.00
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48.36
41.18
39.37
36.38
23.38
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14.04
13.96
F3C
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HN
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4ai
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220
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120
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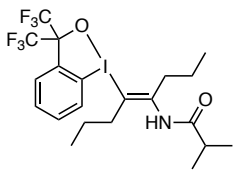
60
40
20
ppm



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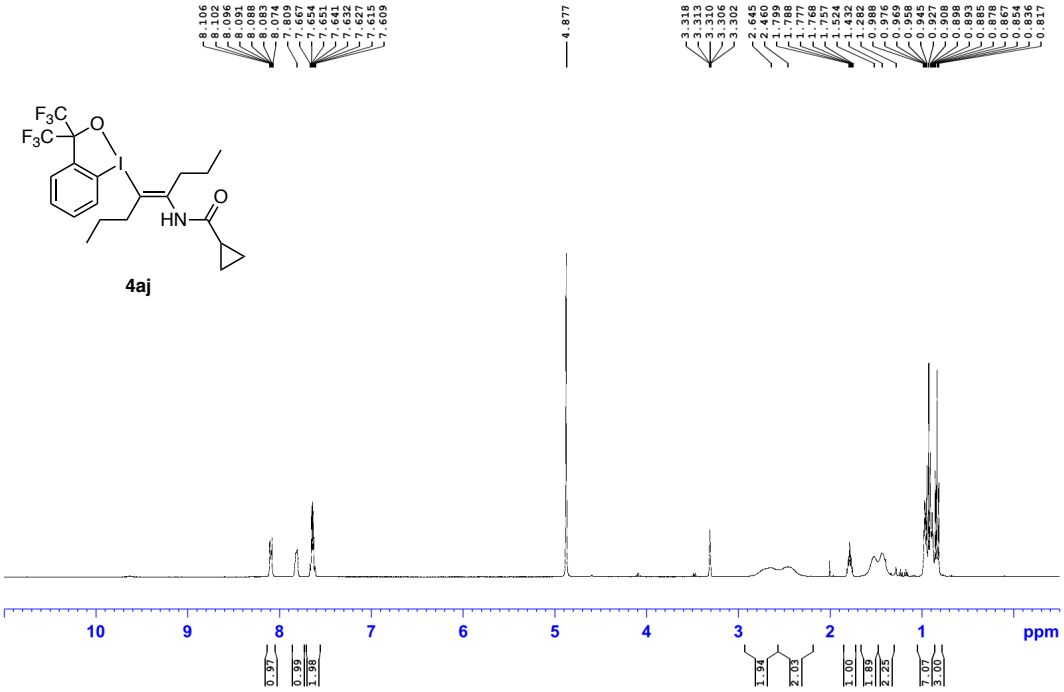
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7.627
7.615
7.609
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3.313
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F3C
F3C
O
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4aj
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6
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4
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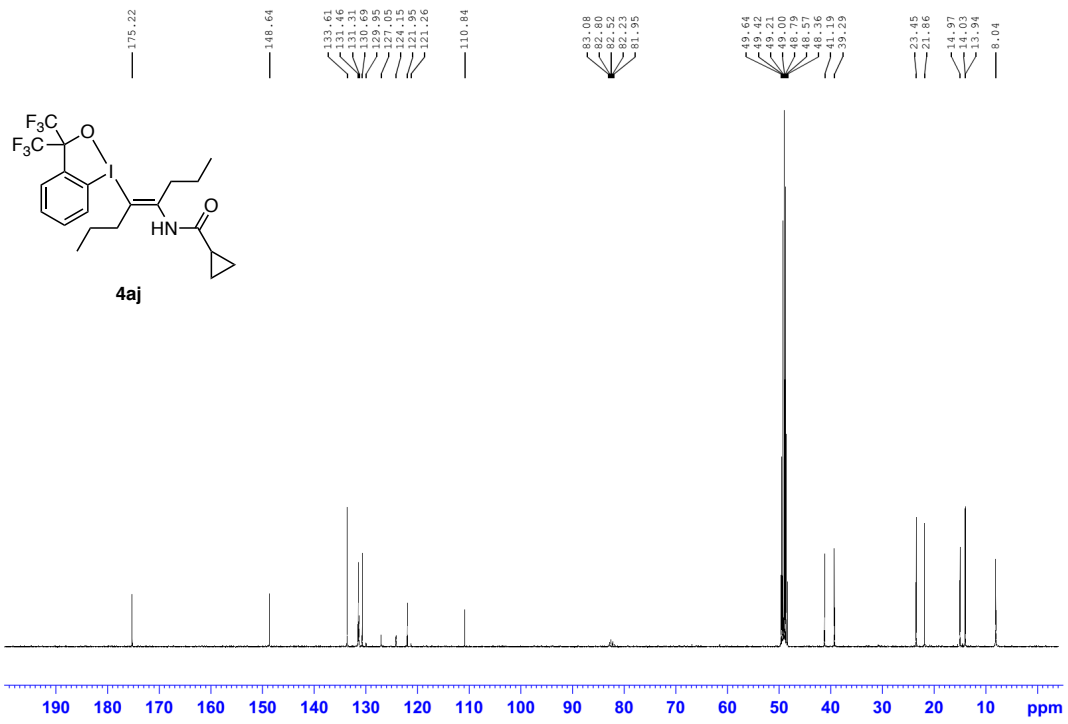
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49.42
49.21
49.00
48.79
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41.19
39.29
23.45
21.86
14.97
14.03
13.94
8.04
F3C
F3C
O
I
HN
O
4aj
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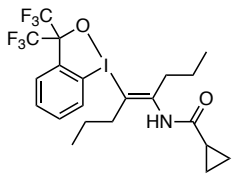

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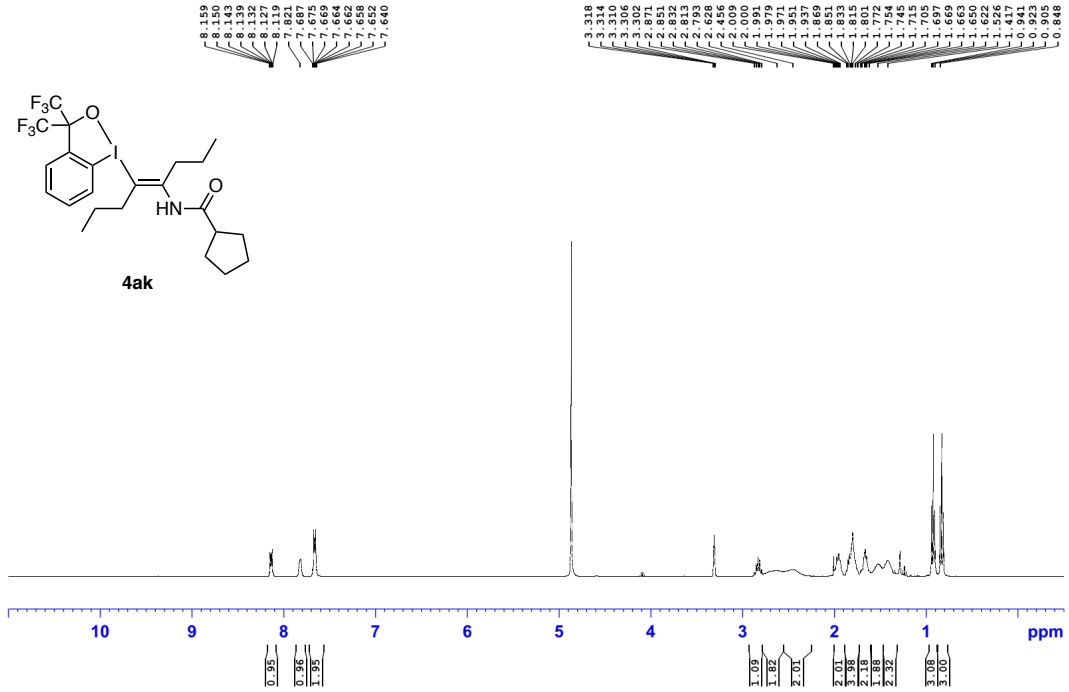
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2.813
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0.905
0.848
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F3C
O
I
HN
O
4ak
10
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4
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ppm
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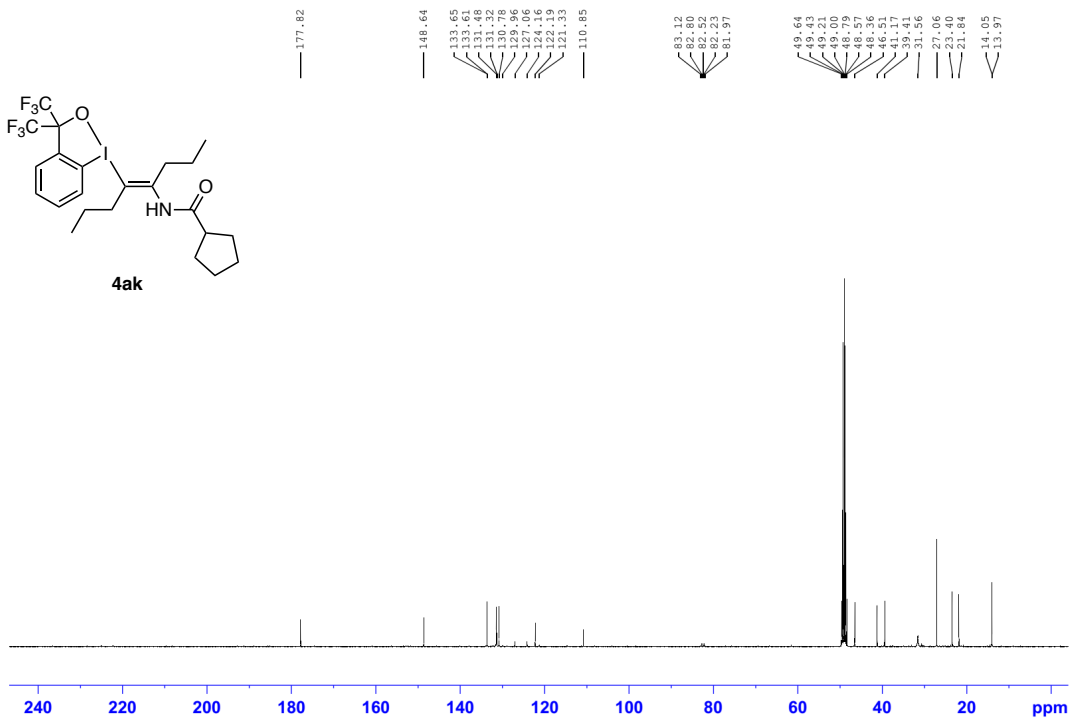
3.00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82.52
82.23
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49.64
49.43
49.21
49.00
48.79
48.57
48.36
46.51
41.17
40.41
31.56
27.06
23.40
21.84
14.05
13.97
F3C
F3C
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O
4ak
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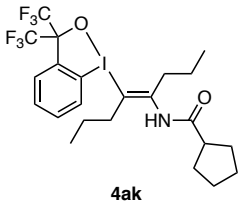
20
ppm



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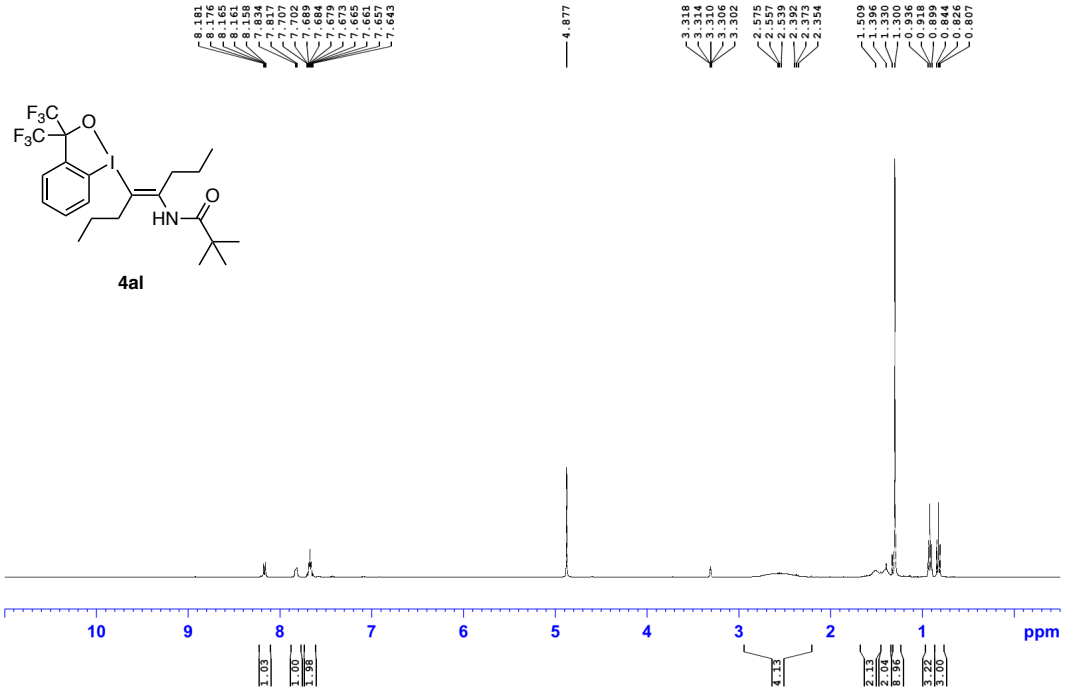
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7.661
7.657
7.643
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3.314
3.310
3.306
3.302
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2.557
2.539
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2.354
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1.496
1.330
1.300
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F3C
F3C
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I
HN
O
4al
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9
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6
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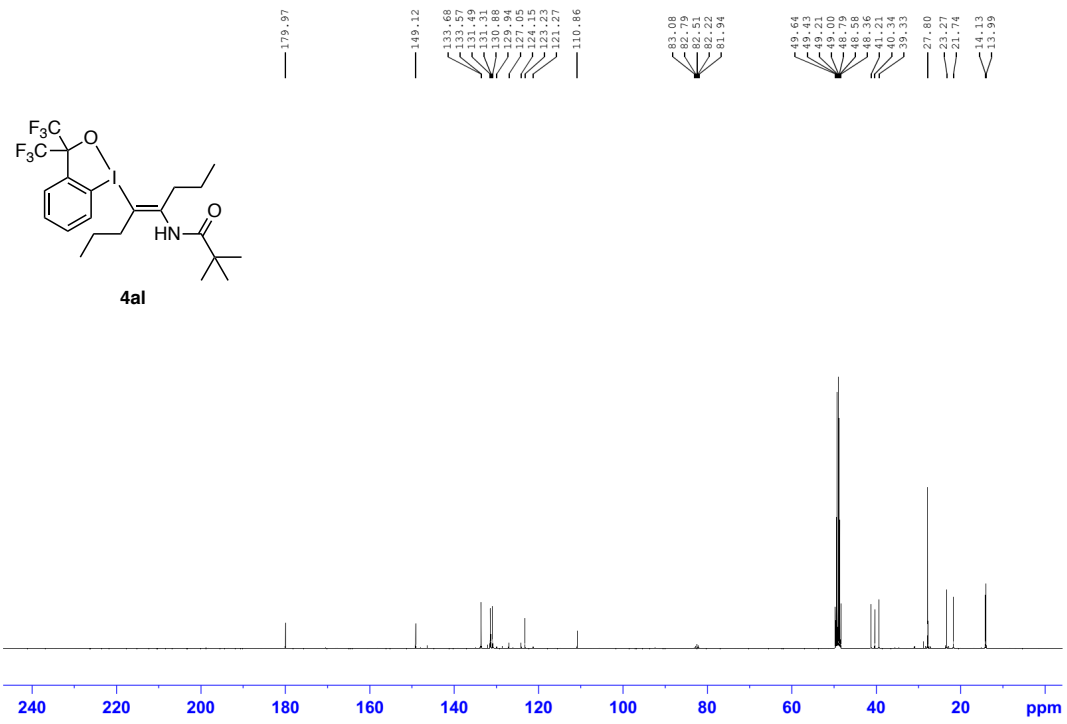
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49.21
49.00
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41.21
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39.33
27.80
23.27
21.74
14.13
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F3C
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HN
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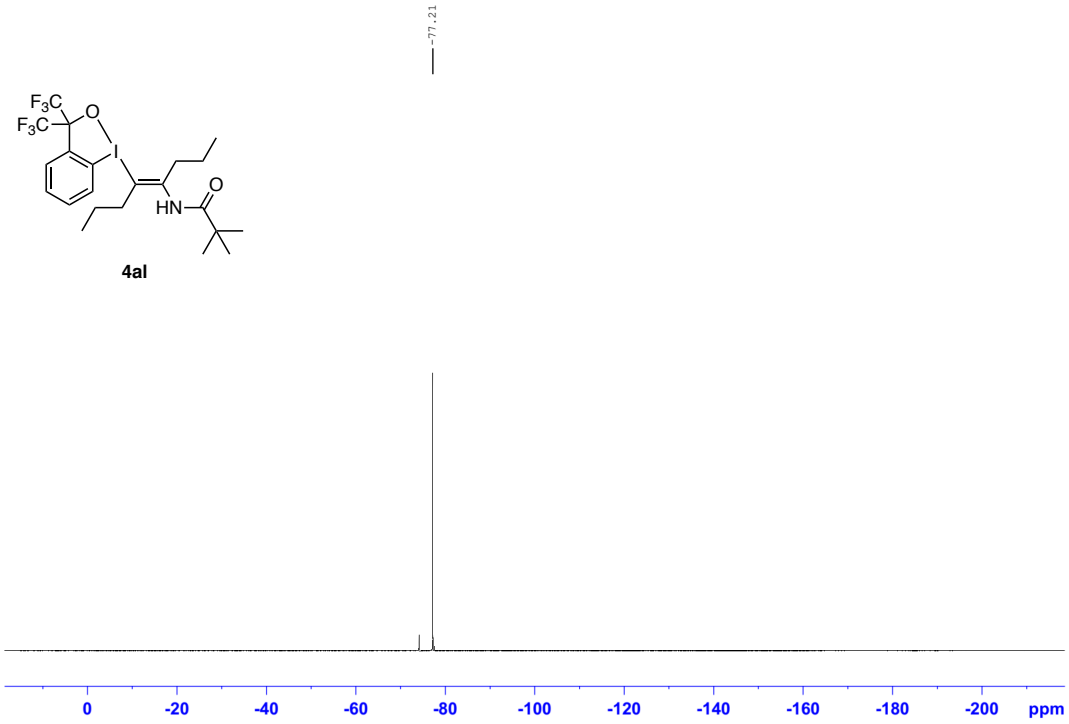
ppm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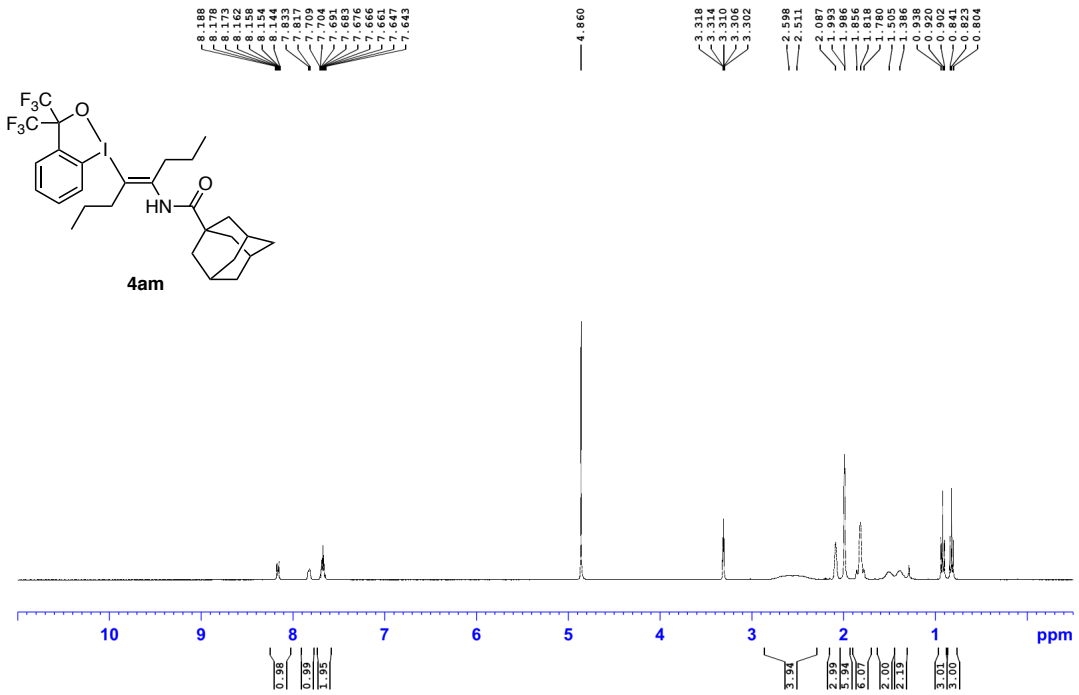
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7.704
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7.666
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7.647
7.643
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3.314
3.310
3.306
3.302
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2.511
2.087
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1.856
1.818
1.780
1.505
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0.902
0.841
0.823
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F3C
O
I
HN
O
4am
10
9
8
7
6
5
4
3
2
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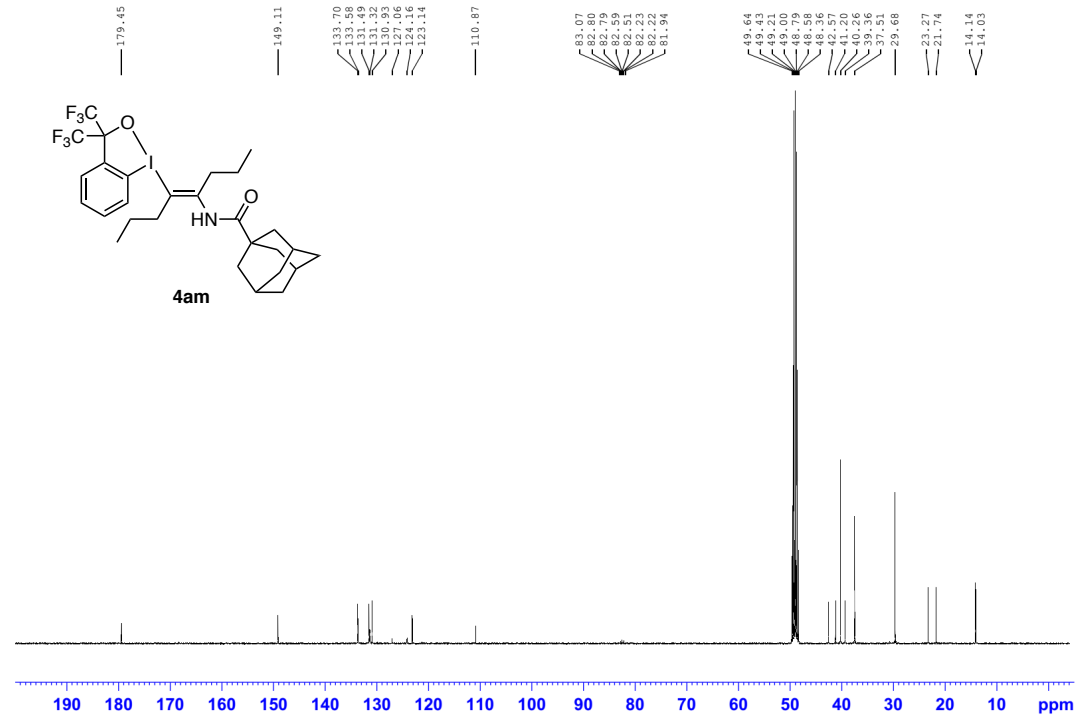
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82.59
82.51
82.23
82.22
81.94
49.64
49.43
49.21
49.00
48.79
48.58
48.36
42.57
41.20
40.26
39.36
37.51
29.68
23.27
21.74
14.14
14.03
F3C
F3C
O
I
HN
O
4am
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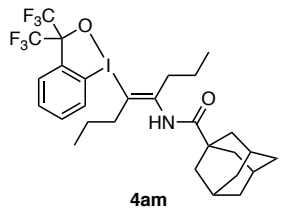
20
10
ppm



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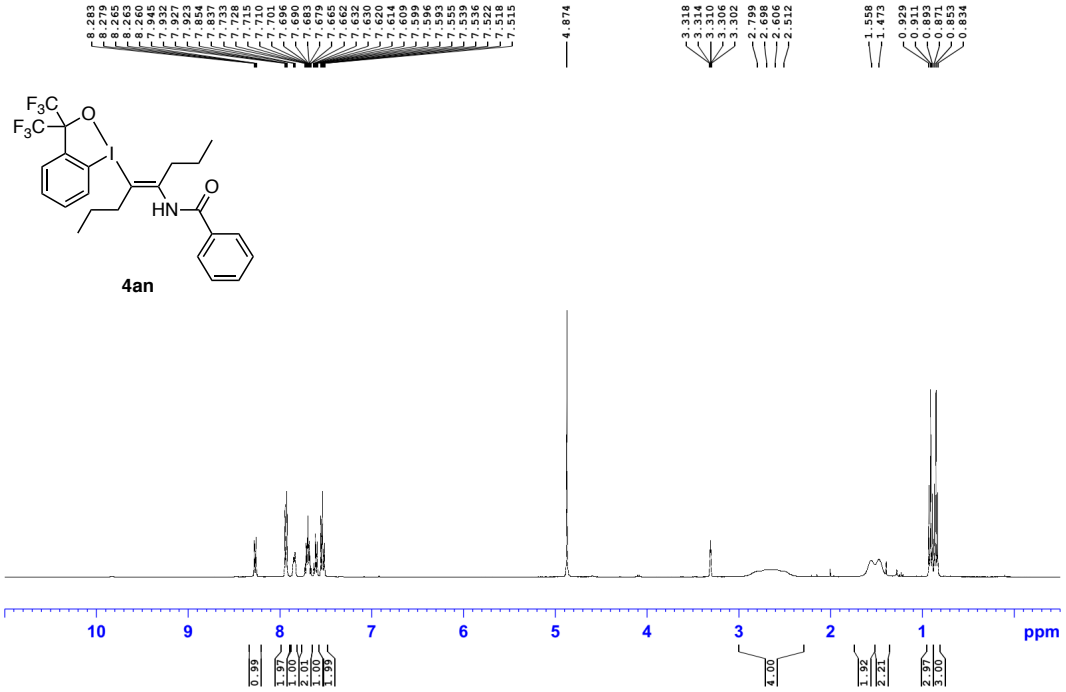
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7.927
7.923
7.854
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7.733
7.728
7.715
7.710
7.701
7.696
7.690
7.683
7.679
7.665
7.662
7.632
7.630
7.620
7.614
7.609
7.599
7.596
7.593
7.555
7.539
7.536
7.522
7.518
7.515
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3.310
3.306
3.302
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2.606
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0.893
0.871
0.853
0.834
F3C
F3C
O
I
HN
O
4an
10
9
8
7
6
5
4
3
2
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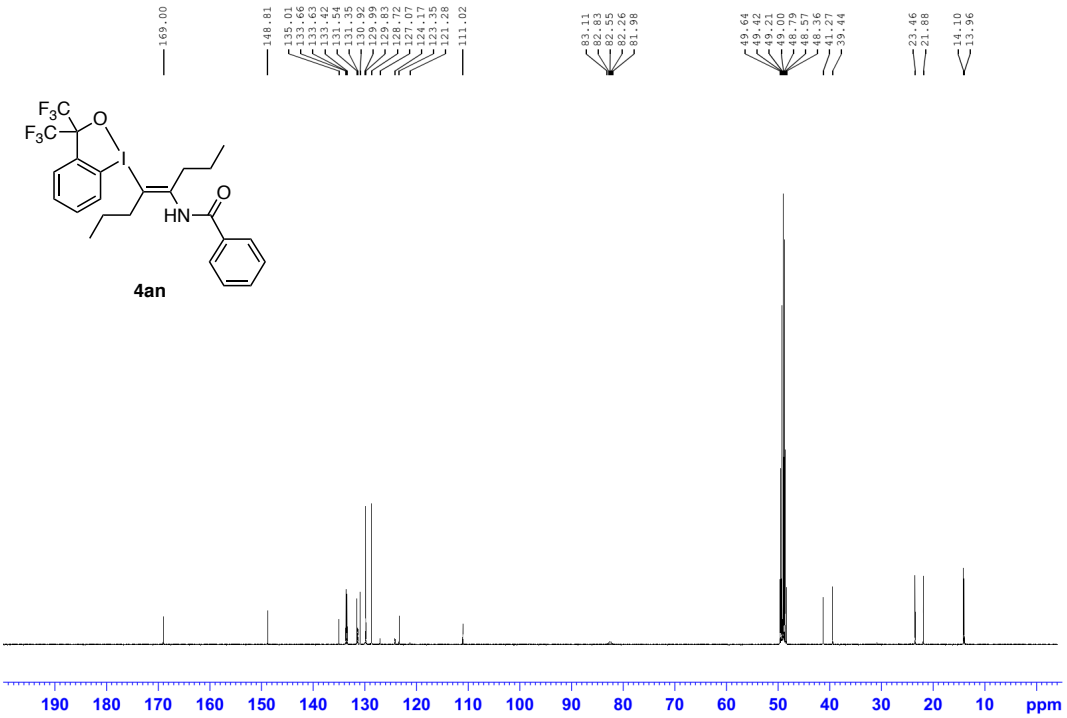
2.97
3.00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123.35
121.28
111.02
83.11
82.83
82.55
82.26
81.98
49.64
49.42
49.21
49.00
48.79
48.57
48.36
41.27
39.44
23.46
21.88
14.10
13.96
F3C
F3C
O
I
HN
O
4an
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150
140
130
120
110
100
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70
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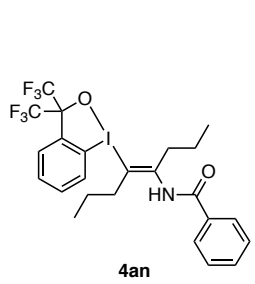
30
20
10
ppm



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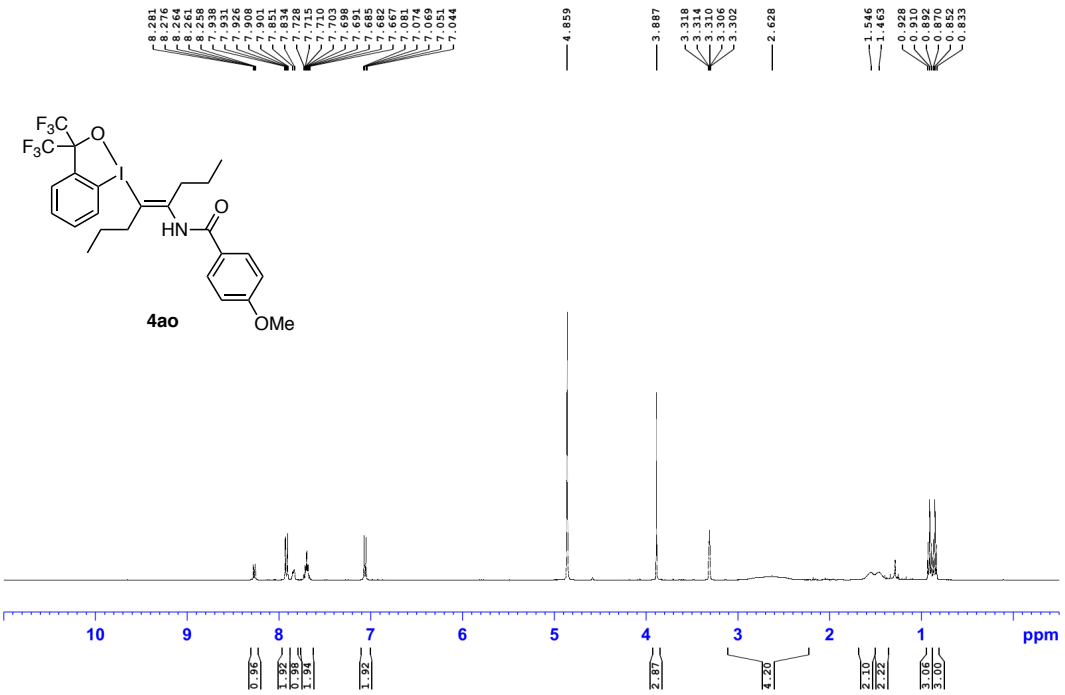
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7.728
7.715
7.710
7.703
7.698
7.691
7.685
7.682
7.667
7.081
7.074
7.069
7.051
7.044
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3.318
3.314
3.310
3.306
3.302
2.628
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1.463
0.928
0.910
0.892
0.870
0.852
0.833
F3C
F3C
O
I
HN
O
OMe
4ao
10
9
8
7
6
5
4
3
2
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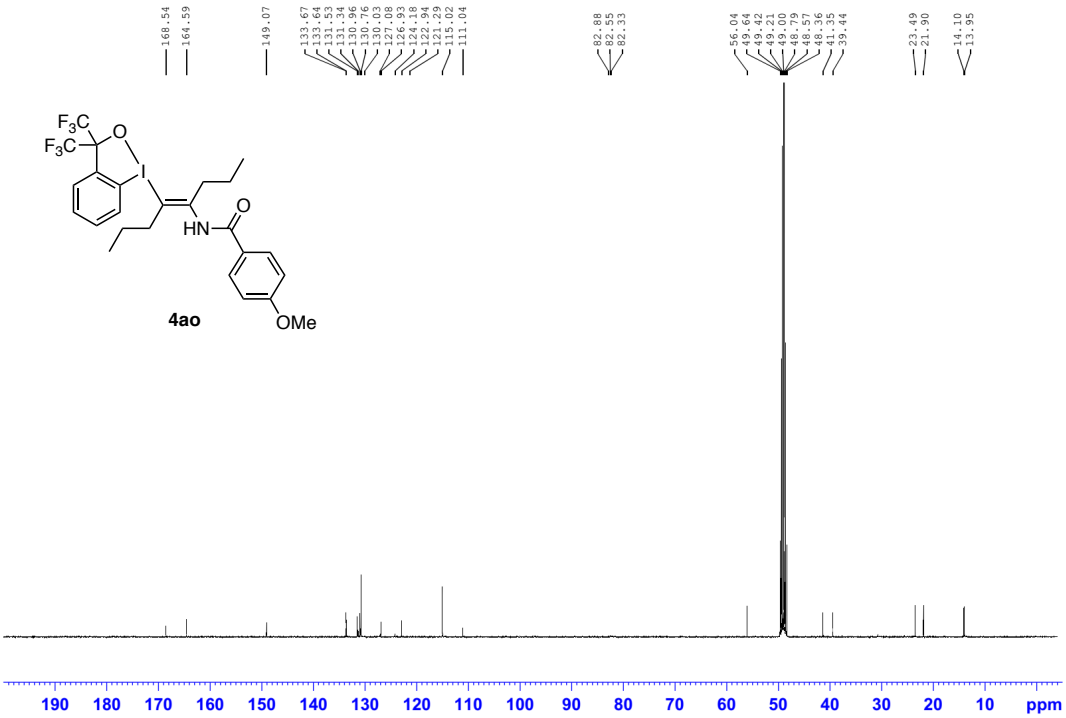
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126.93
124.18
122.94
121.29
115.02
111.04
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82.55
82.33
56.04
49.64
49.42
49.21
49.00
48.79
48.57
48.36
41.35
39.44
23.49
21.90
14.10
13.95
F3C
F3C
O
I
HN
O
OMe
4ao
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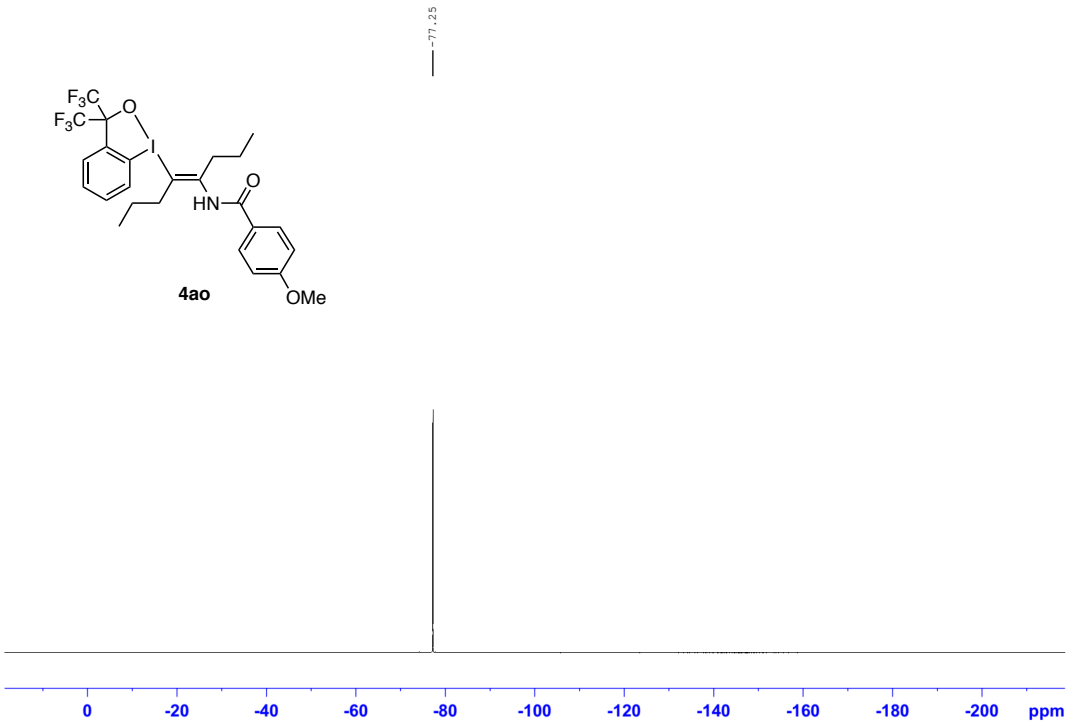
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F3C
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HN
O
OMe
4ao
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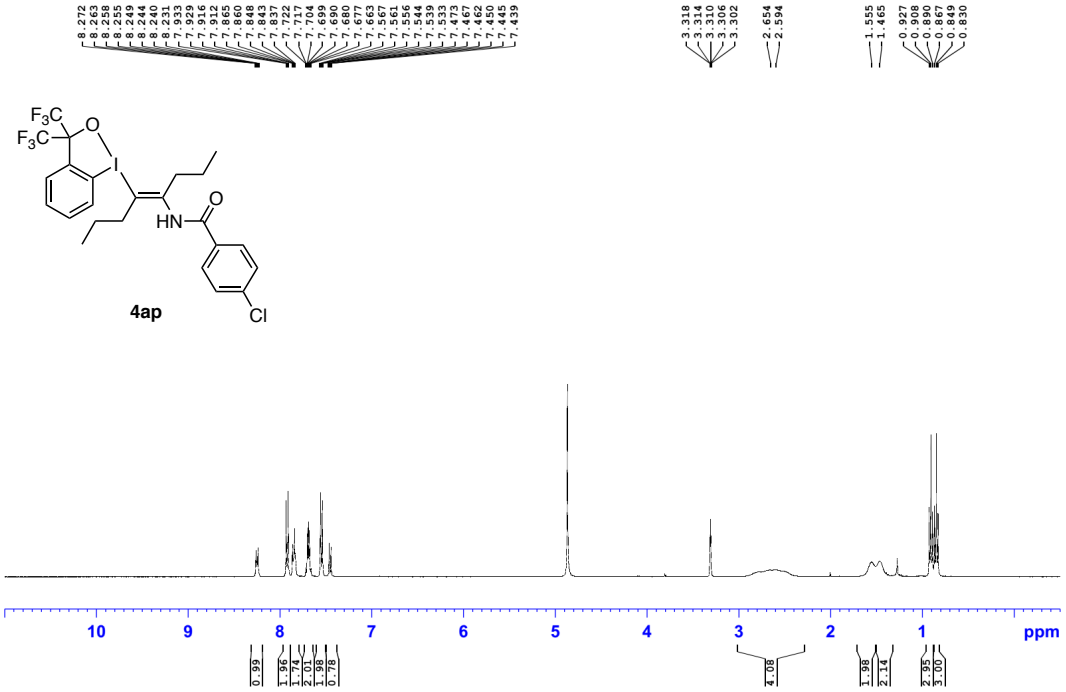
-200
ppm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7.929
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7.912
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7.848
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7.837
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7.717
7.704
7.699
7.690
7.680
7.677
7.663
7.567
7.561
7.556
7.544
7.539
7.533
7.473
7.467
7.462
7.450
7.445
7.439
3.318
3.314
3.310
3.306
3.302
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1.465
0.927
0.908
0.890
0.867
0.849
0.830
F3C
F3C
O
I
HN
O
Cl
4ap
10
9
8
7
6
5
4
3
2
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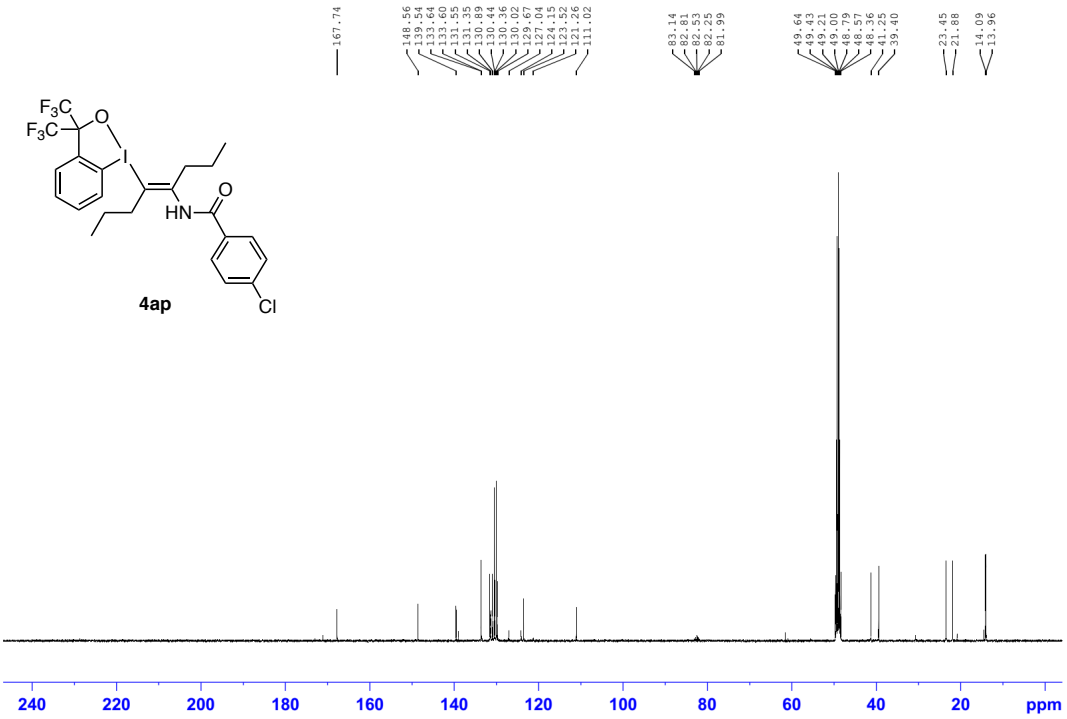
3.00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123.52
121.26
111.02
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82.25
81.99
49.64
49.43
49.21
49.00
48.79
48.57
48.36
41.25
39.40
23.45
21.88
14.09
13.96
F3C
F3C
O
I
HN
O
Cl
4ap
240
220
200
180
160
140
120
100
80
60
40
20
ppm


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F3C
O
I
HN
O
Cl
4ap
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-120
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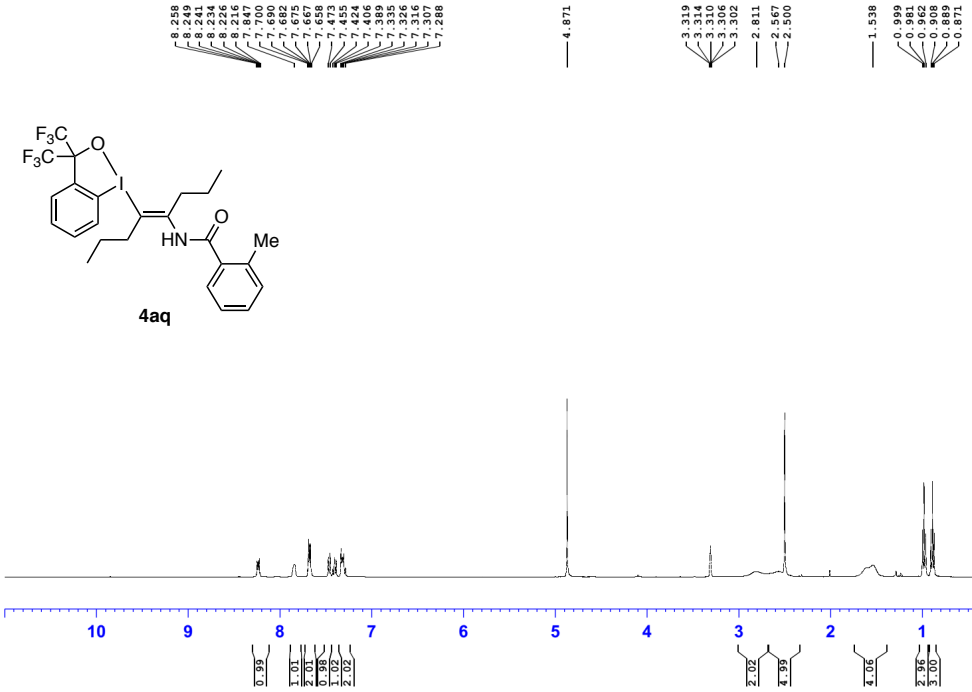
-180
-200
ppm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7.690
7.682
7.675
7.667
7.658
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7.455
7.424
7.406
7.389
7.335
7.326
7.316
7.307
7.288
4.871
3.319
3.314
3.310
3.306
3.302
2.811
2.567
2.500
1.538
0.999
0.981
0.962
0.908
0.889
0.871
F3C
F3C
O
I
HN
O
Me
4aq
10
9
8
7
6
5
4
3
2
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2.02
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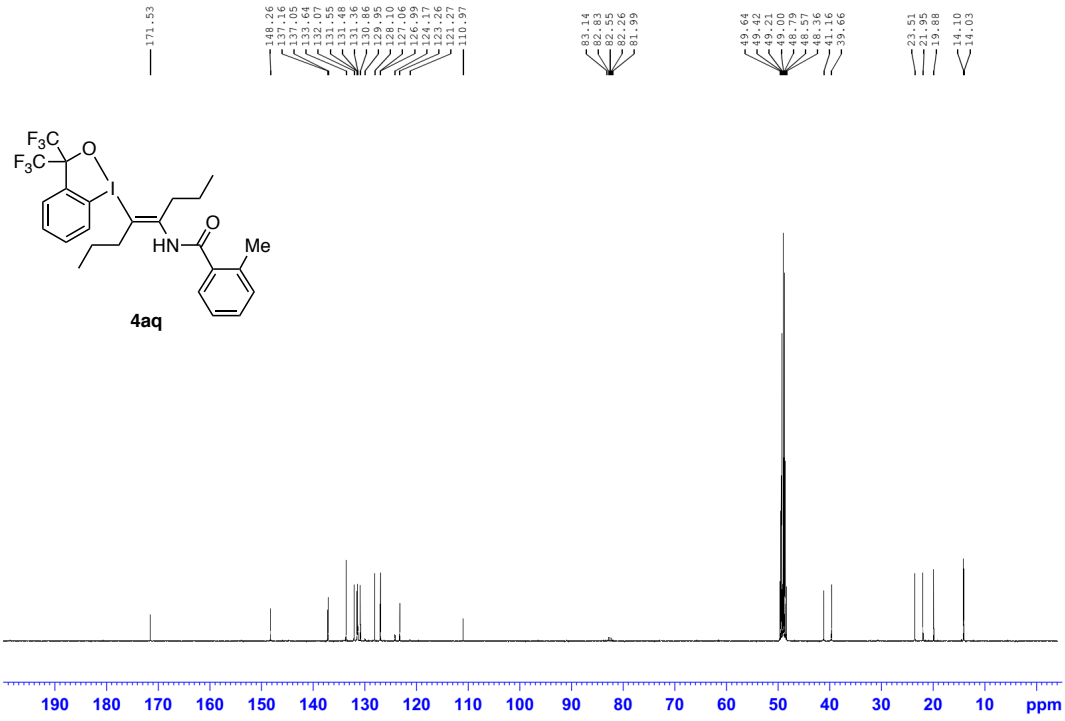
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130.86
129.95
128.10
127.06
126.99
124.17
123.26
121.27
110.97
83.14
82.83
82.55
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81.99
49.64
49.42
49.21
49.00
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48.57
48.36
41.16
39.66
23.51
21.95
19.88
14.10
14.03
F3C
F3C
O
I
HN
O
Me
4aq
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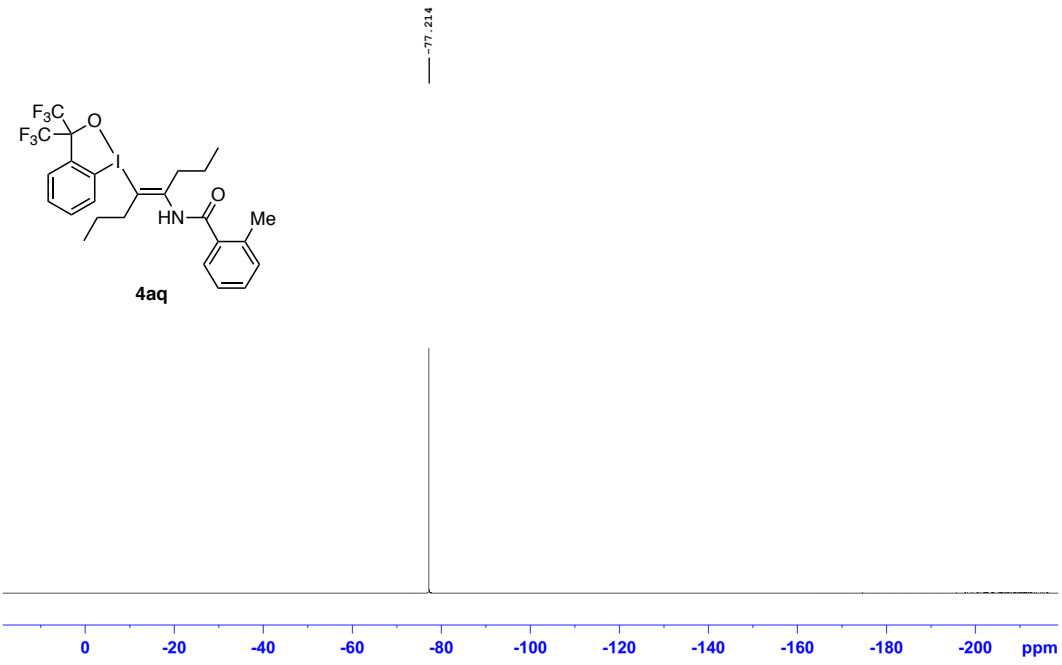
10
ppm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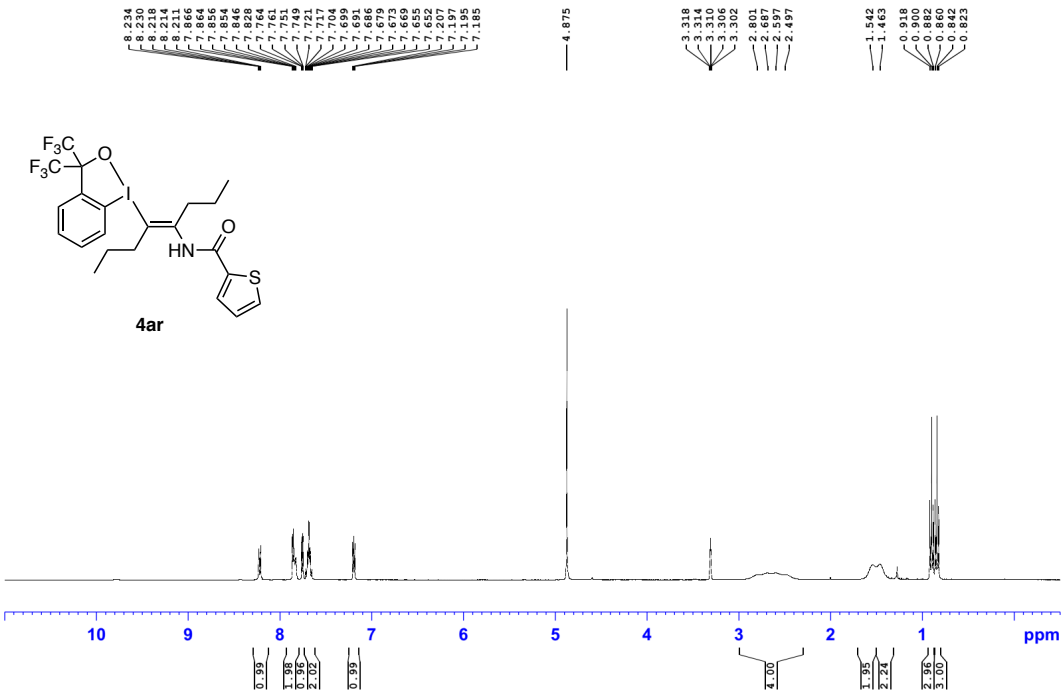
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7.751
7.749
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7.717
7.704
7.699
7.691
7.686
7.679
7.673
7.669
7.655
7.652
7.207
7.197
7.195
7.185
4.875
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3.314
3.310
3.306
3.302
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2.597
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1.463
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0.900
0.882
0.860
0.842
0.823
F3C
F3C
O
I
HN
O
S
4ar
10
9
8
7
6
5
4
3
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4.00
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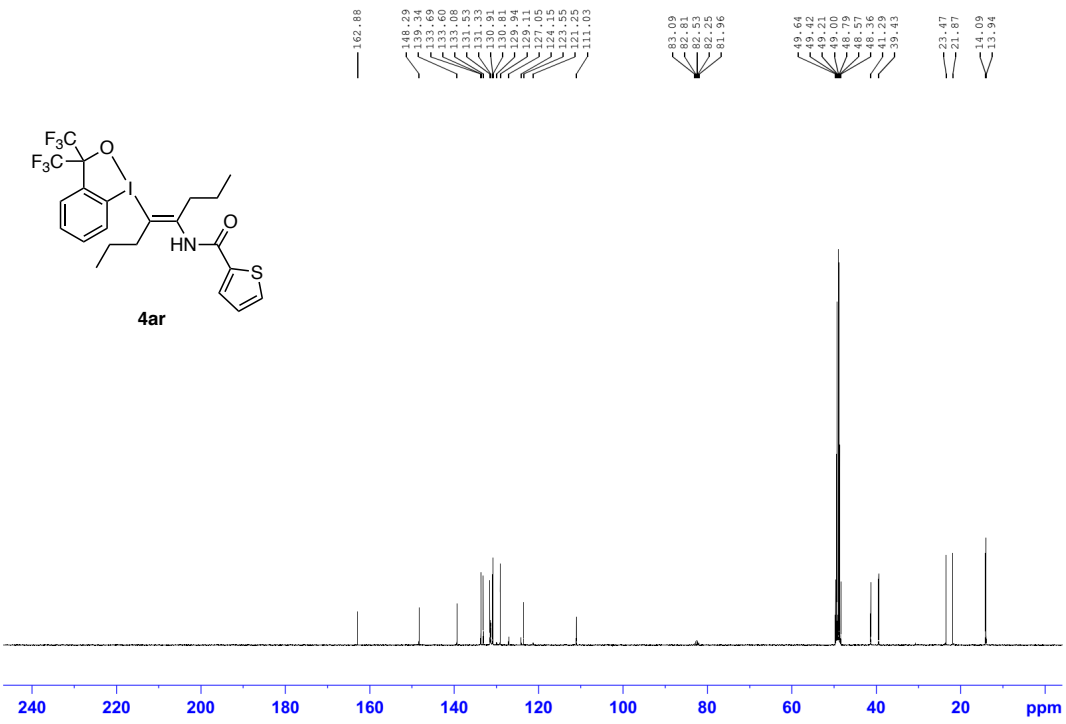
3.00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129.94
129.11
127.05
124.15
123.55
121.25
111.03
83.09
82.81
82.53
82.25
81.96
49.64
49.42
49.21
49.00
48.79
48.57
48.36
41.29
39.43
23.47
21.87
14.09
13.94
F3C
F3C
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I
HN
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S
4ar
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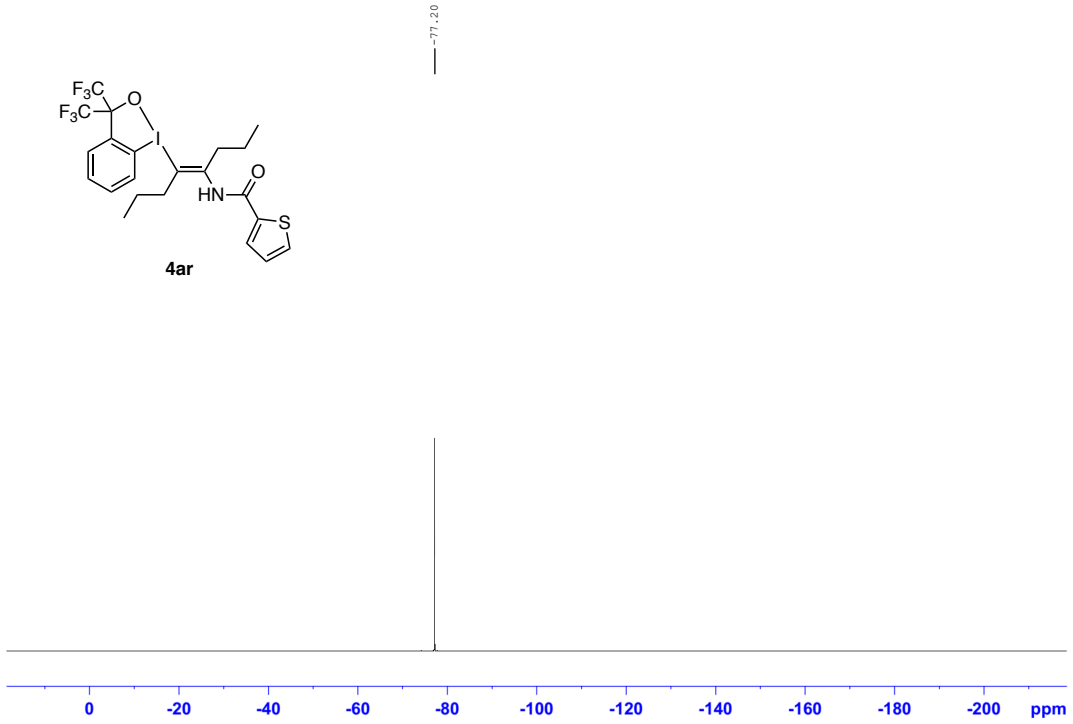
20
ppm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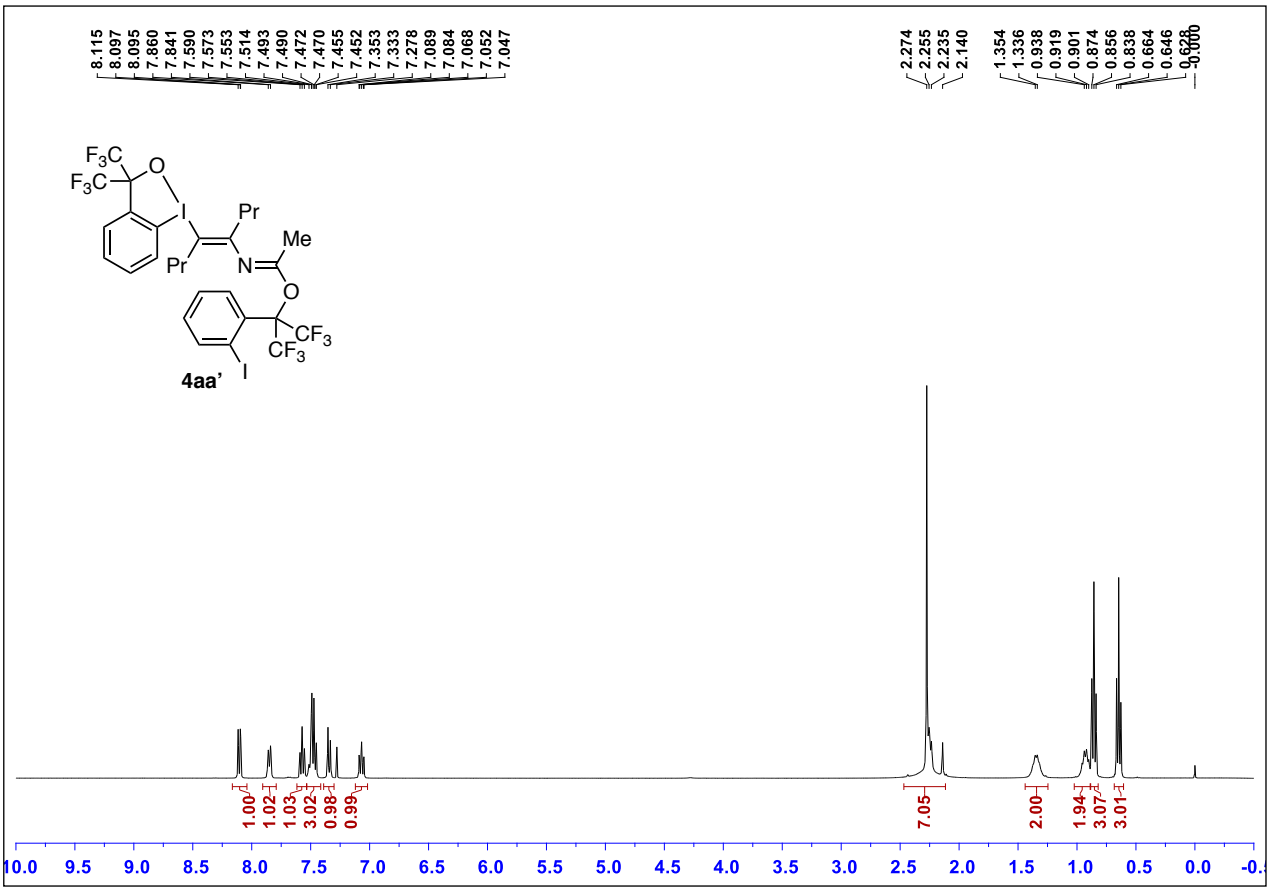
ppm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7.455
7.452
7.353
7.333
7.278
7.089
7.084
7.068
7.052
7.047
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2.255
2.235
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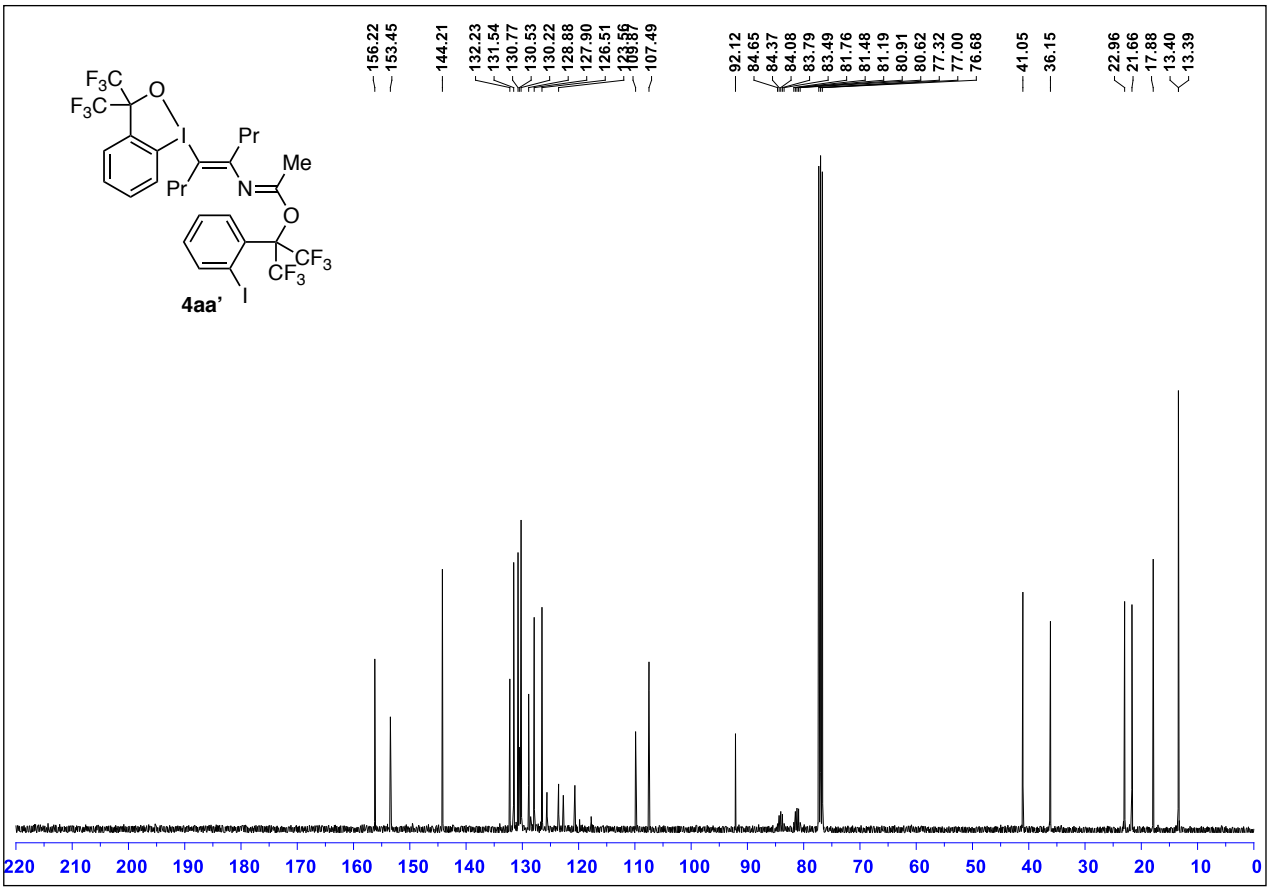
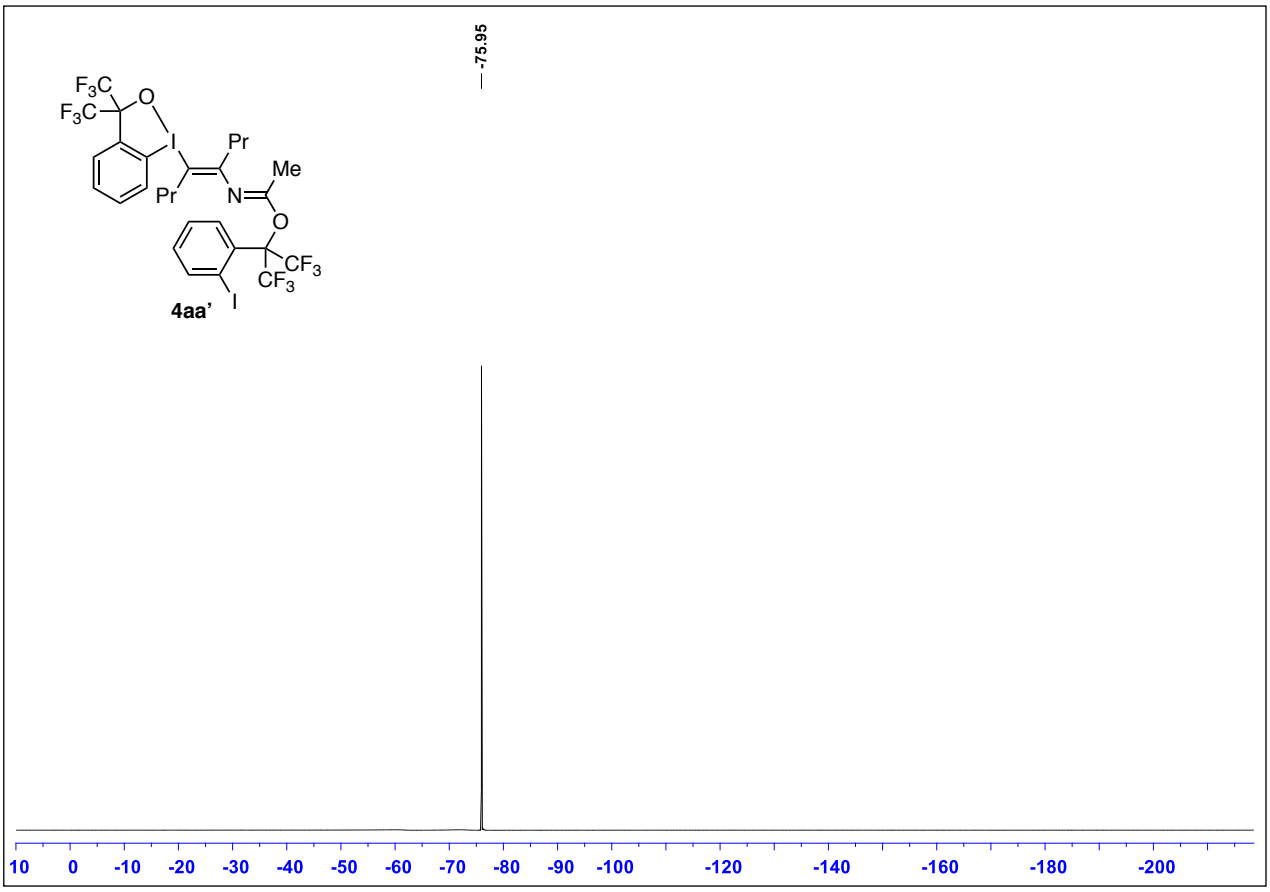
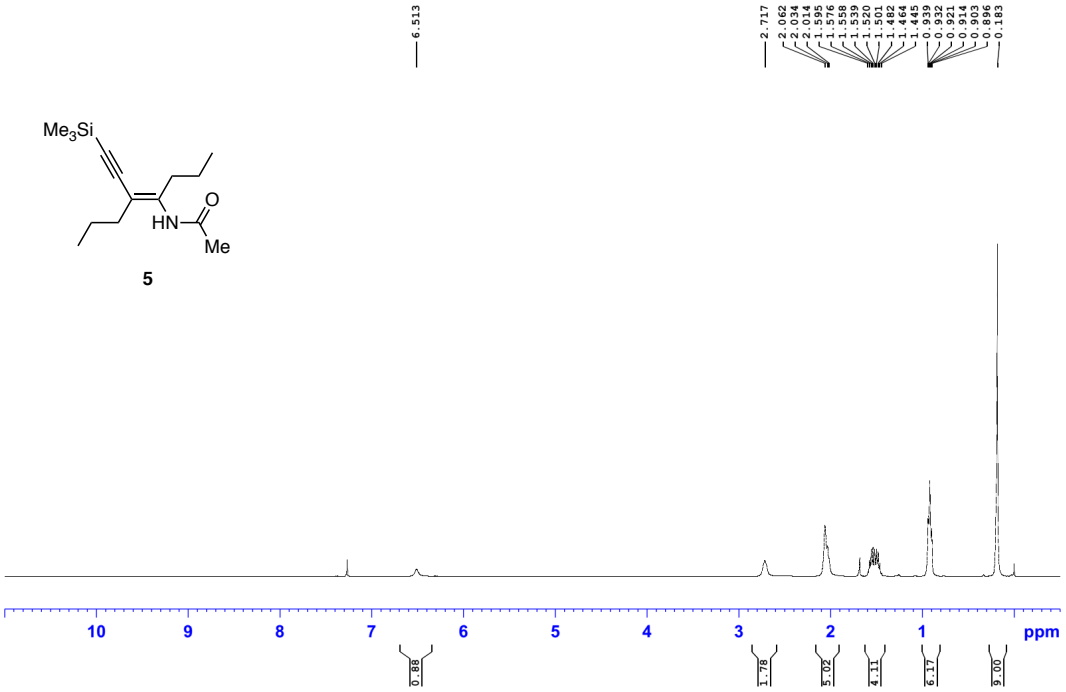
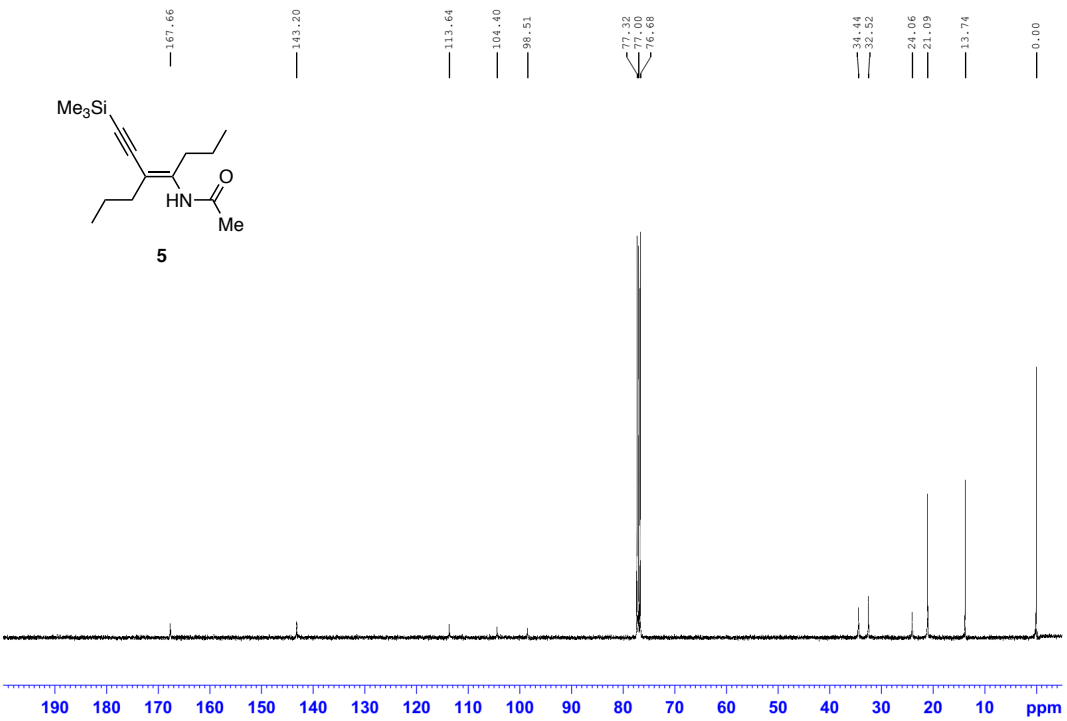
0.901
0.874
0.856
0.838
0.664
0.646
0.000
F3C
F3C
O
I
Pr
Pr
N
Me
O
CF3
CF3
I
4aa'
1.00
1.02
1.03
3.02
0.98
0.99
7.05
2.00
1.94
3.07
3.01
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0


156.22
153.45
144.21
132.23
131.54
130.77
130.53
130.22
128.88
127.90
126.51
107.49
92.12
84.65
84.37
84.08
83.79
83.49
81.76
81.48
81.19
80.91
80.62
77.32
77.00
76.68
41.05
36.15
22.96
21.66
17.88
13.40
13.39
F3C
F3C
O
I
Pr
Pr
N
Me
O
CF3
CF3
I
4aa'
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0

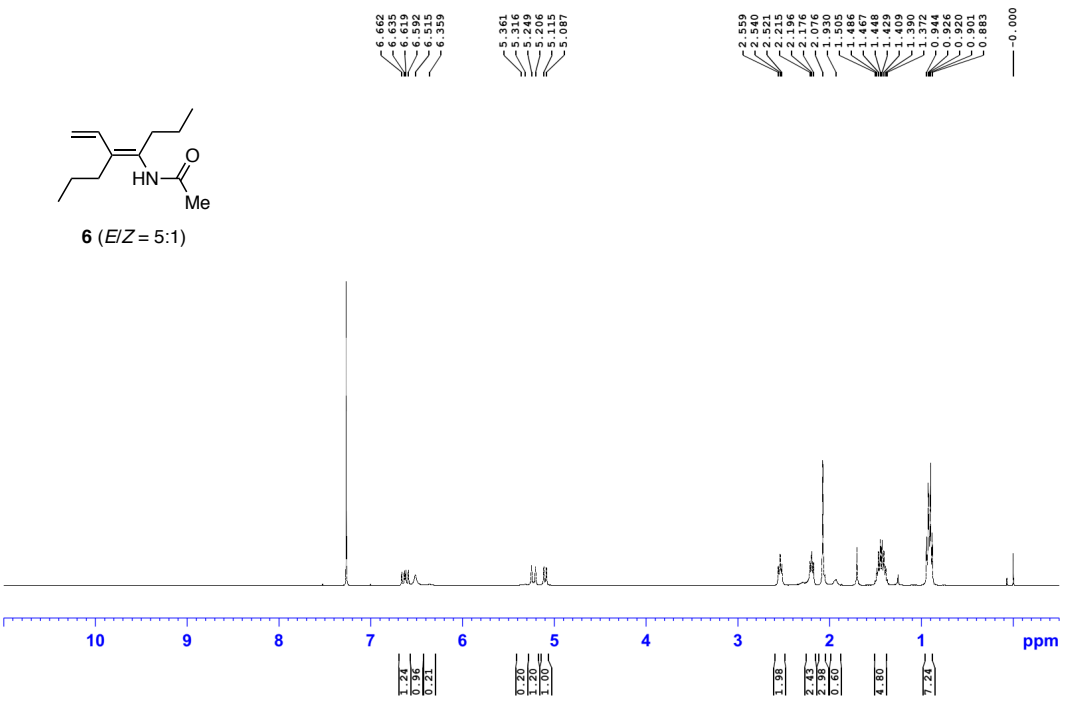

-75.95
F3C
F3C
O
I
Pr
Pr
N
Me
O
CF3
CF3
I
4aa'
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-120
-140
-160
-180
-200


6.513
2.717
2.062
2.034
2.014
1.595
1.576
1.558
1.539
1.520
1.501
1.482
1.464
1.445
0.939
0.932
0.921
0.914
0.903
0.896
0.183
Me3Si
O
HN
Me
10
9
8
7
6
5
4
3
2
1
ppm
0.88
1.78
5.02
4.11
6.17
9.00

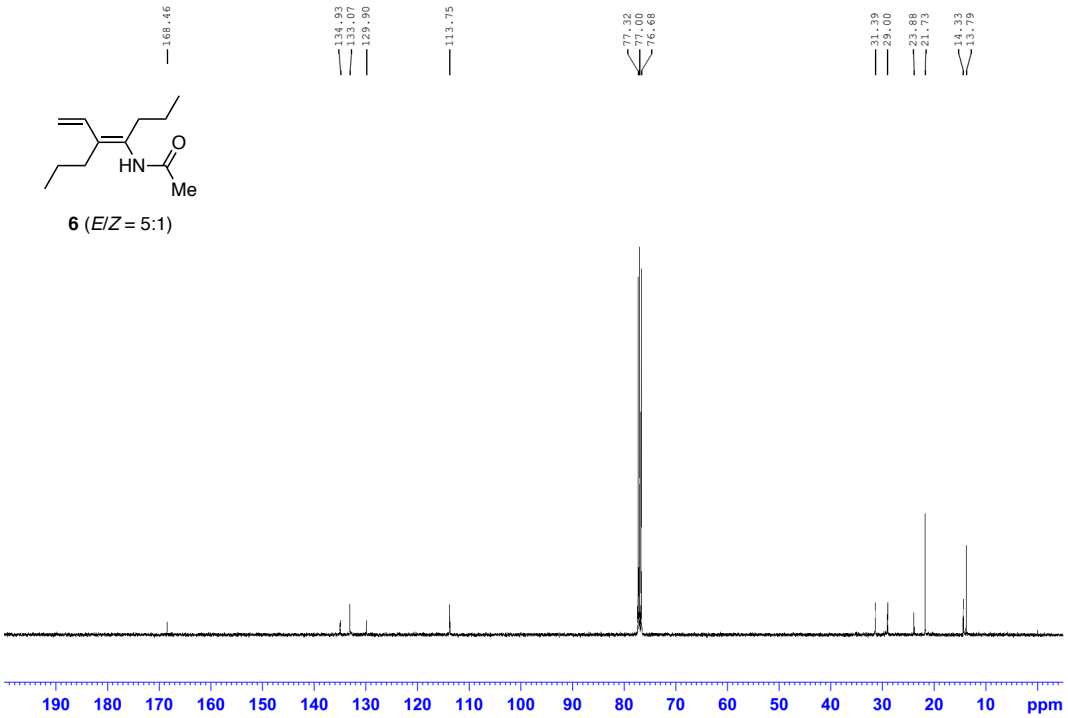
5


167.66
143.20
113.64
104.40
98.51
77.32
77.00
76.68
34.44
32.52
24.06
21.09
13.74
0.00
Me3Si
O
HN
Me
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

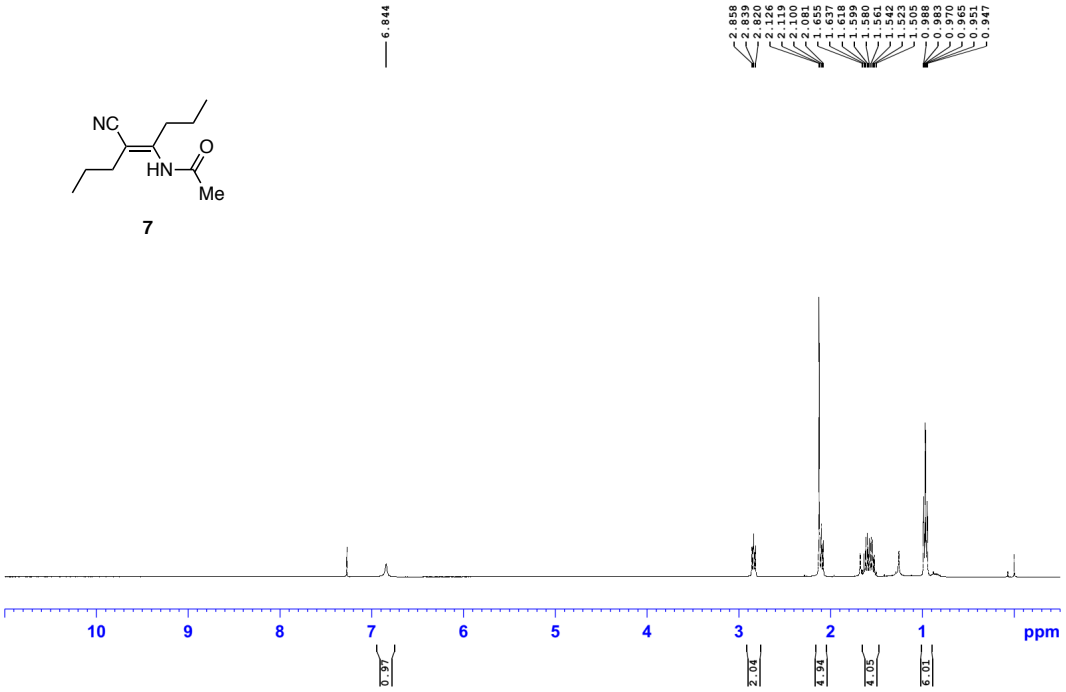
5

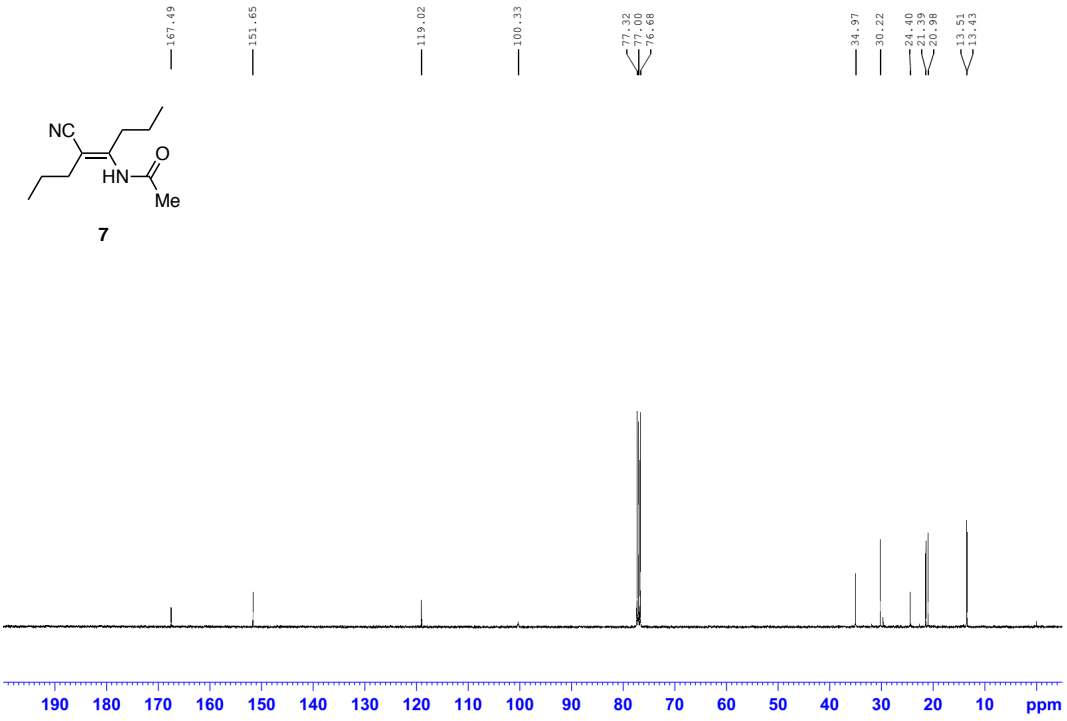

6.662
6.635
6.619
6.592
6.515
6.359
5.361
5.316
5.249
5.206
5.115
5.087
2.559
2.540
2.521
2.215
2.196
2.176
2.076
1.930
1.505
1.486
1.467
1.448
1.429
1.409
1.390
1.372
0.944
0.926
0.920
0.901
0.883
-0.000
HN
O
Me
10
9
8
7
6
5
4
3
2
1
ppm
1.24
0.96
0.21
0.20
1.20
1.00
1.98
2.43
2.98
0.60
4.80
7.24

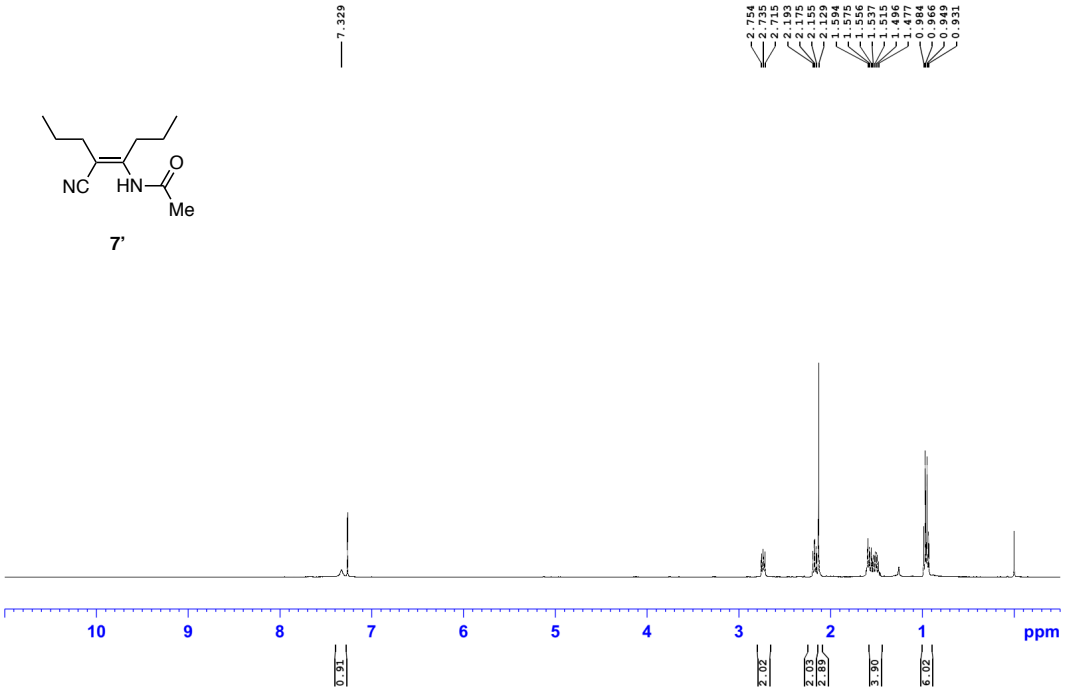
6 (*E*/*Z* = 5:1)

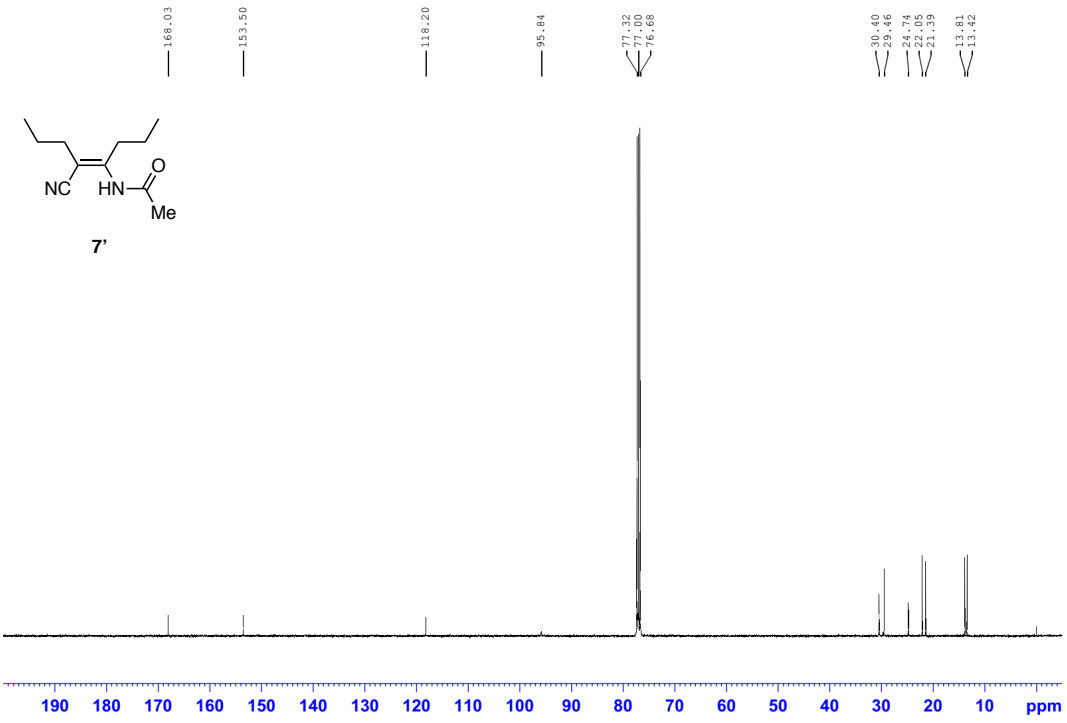

168.46
134.93
133.07
129.90
113.75
77.32
77.00
76.68
31.39
29.00
23.88
21.73
14.33
13.79
HN
O
Me
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

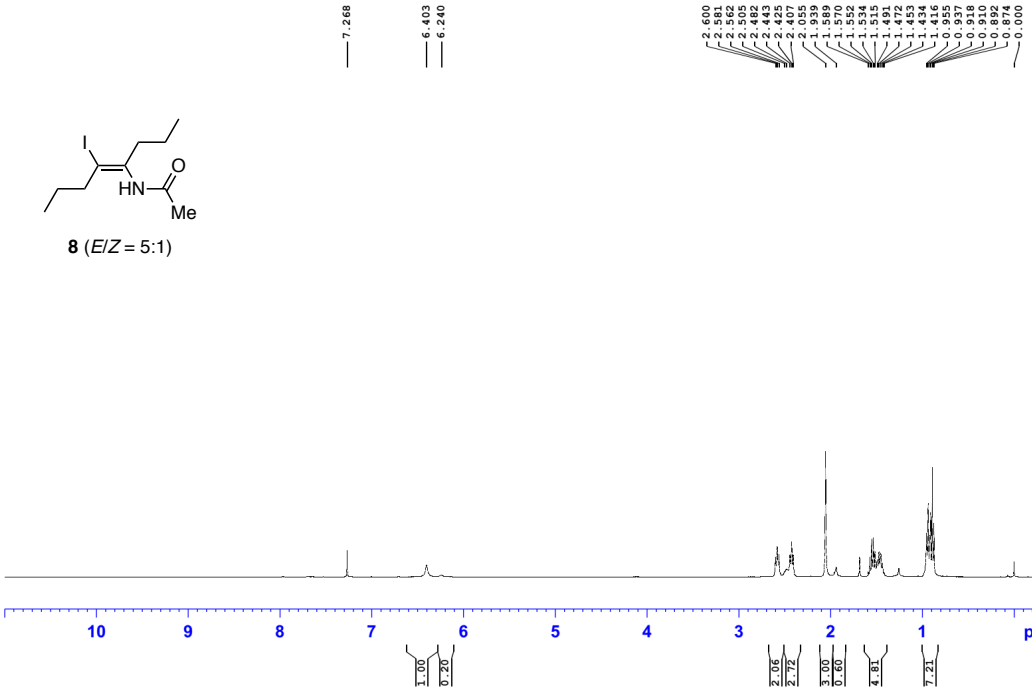
6 (*E*/*Z* = 5:1)


6.844
2.858
2.839
2.820
2.126
2.119
2.100
2.081
1.655
1.637
1.618
1.599
1.580
1.561
1.542
1.523
1.505
0.988
0.983
0.970
0.965
0.951
0.947
NC
HN
O
Me
7
10
9
8
7
6
5
4
3
2
1
ppm
0.97
2.04
4.94
4.05
6.01

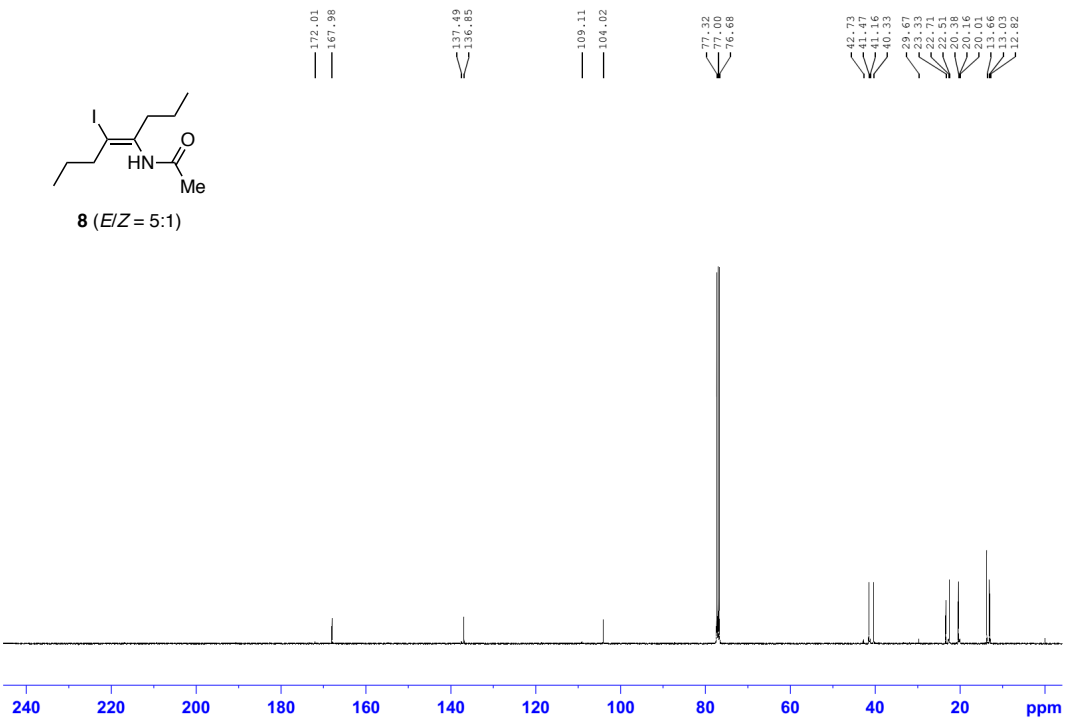

167.49
151.65
119.02
100.33
77.32
77.00
76.68
34.97
30.22
24.40
21.39
20.98
13.51
13.43
NC
HN
O
Me
7
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm


7.329
2.754
2.735
2.715
2.193
2.175
2.155
2.129
1.594
1.575
1.556
1.537
1.515
1.496
1.477
0.984
0.966
0.949
0.931
NC
HN
O
Me
7'
10
9
8
7
6
5
4
3
2
1
ppm
0.91
2.02
2.03
2.89
3.90
6.02

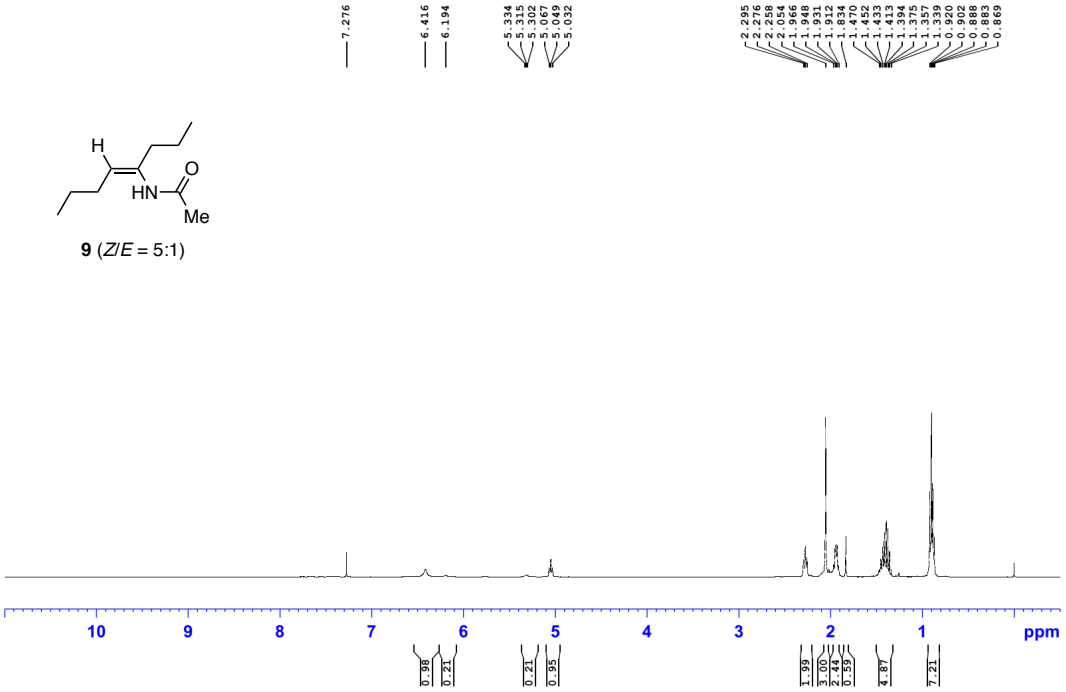

168.03
153.50
118.20
95.84
77.32
77.00
76.68
30.40
29.46
24.74
22.05
21.39
13.81
13.42
NC
HN
O
Me
7'
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm


7.268
6.403
6.240
2.600
2.581
2.562
2.505
2.482
2.443
2.425
2.407
2.055
1.939
1.589
1.570
1.552
1.534
1.515
1.491
1.472
1.453
1.434
1.416
0.955
0.937
0.918
0.910
0.892
0.874
0.000
I
HN
O
Me
10
9
8
7
6
5
4
3
2
1
ppm
1.00
0.20
2.06
2.72
3.00
0.60
4.81
7.21

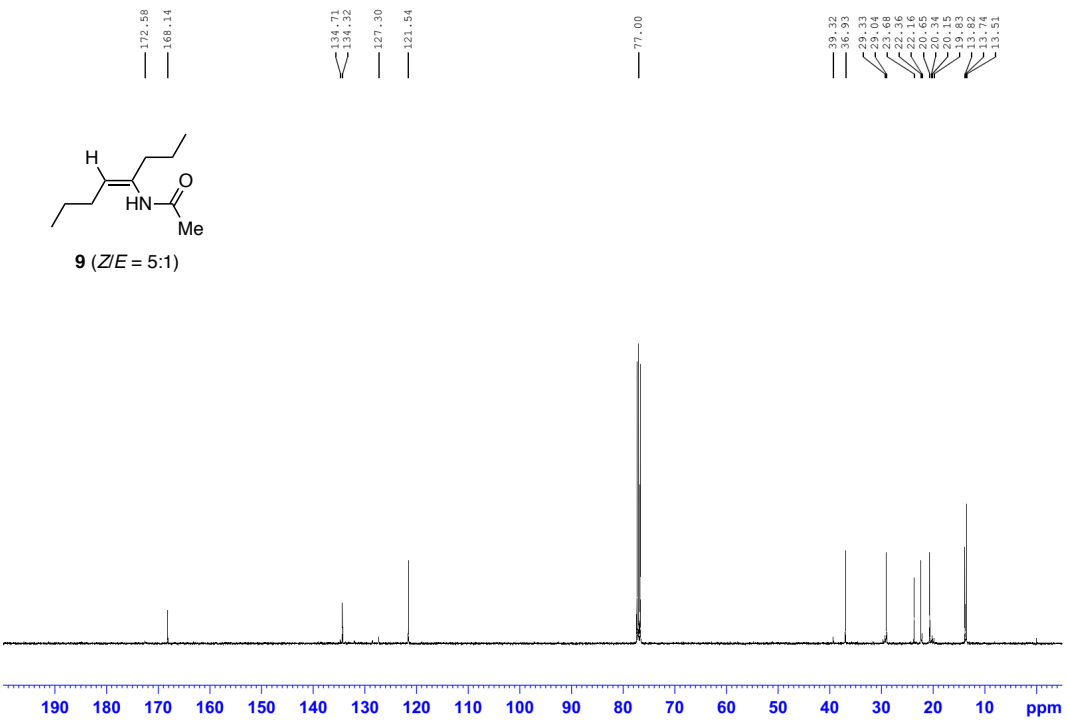
8 (*E*/*Z* = 5:1)


172.01
167.98
137.49
136.85
109.11
104.02
77.32
77.00
76.68
42.73
41.47
41.16
40.33
29.67
23.33
22.71
22.51
20.38
20.16
20.01
13.66
13.03
12.82
I
HN
O
Me
240
220
200
180
160
140
120
100
80
60
40
20
ppm

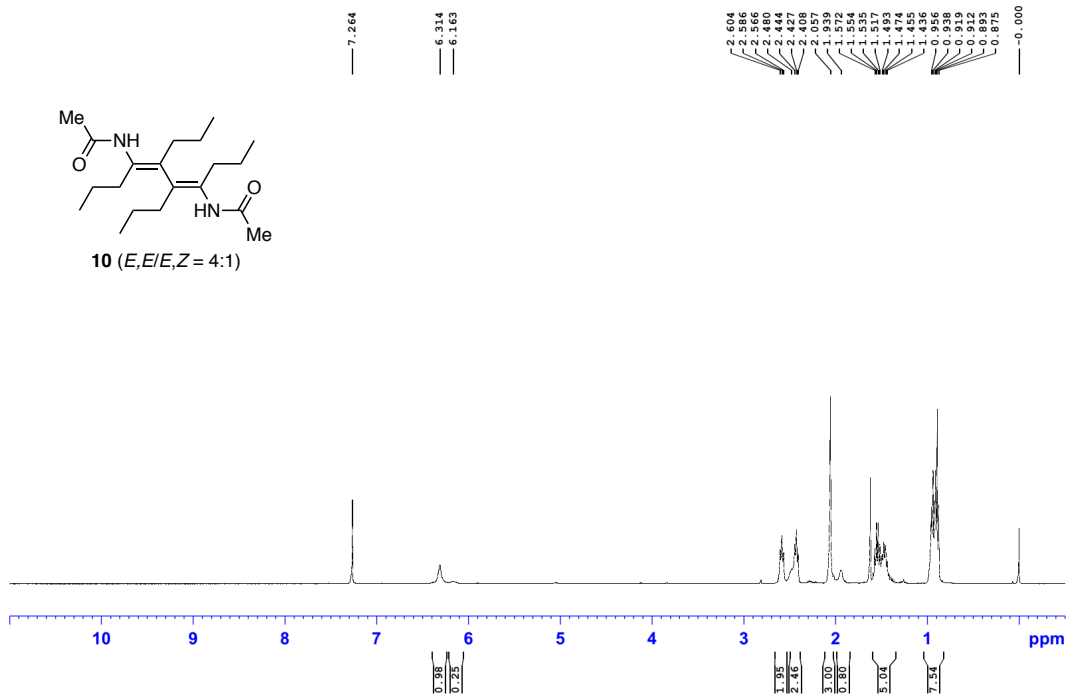
8 (*E*/*Z* = 5:1)

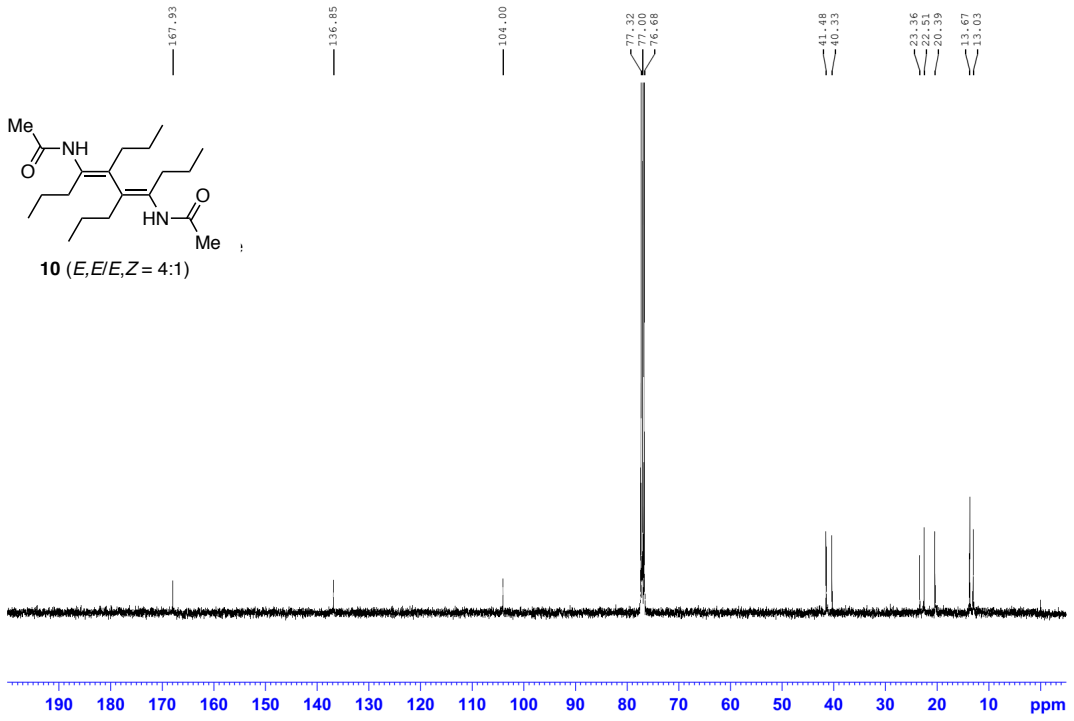

7.276
6.416
6.194
5.334
5.315
5.302
5.067
5.049
5.032
2.295
2.276
2.258
2.054
1.966
1.948
1.931
1.912
1.834
1.470
1.452
1.433
1.413
1.394
1.375
1.357
1.339
0.920
0.902
0.888
0.883
0.869
H
O
HN
Me
10
9
8
7
6
5
4
3
2
1
ppm
0.98
0.21
0.21
0.95
1.99
3.00
2.44
0.59
4.87
7.21

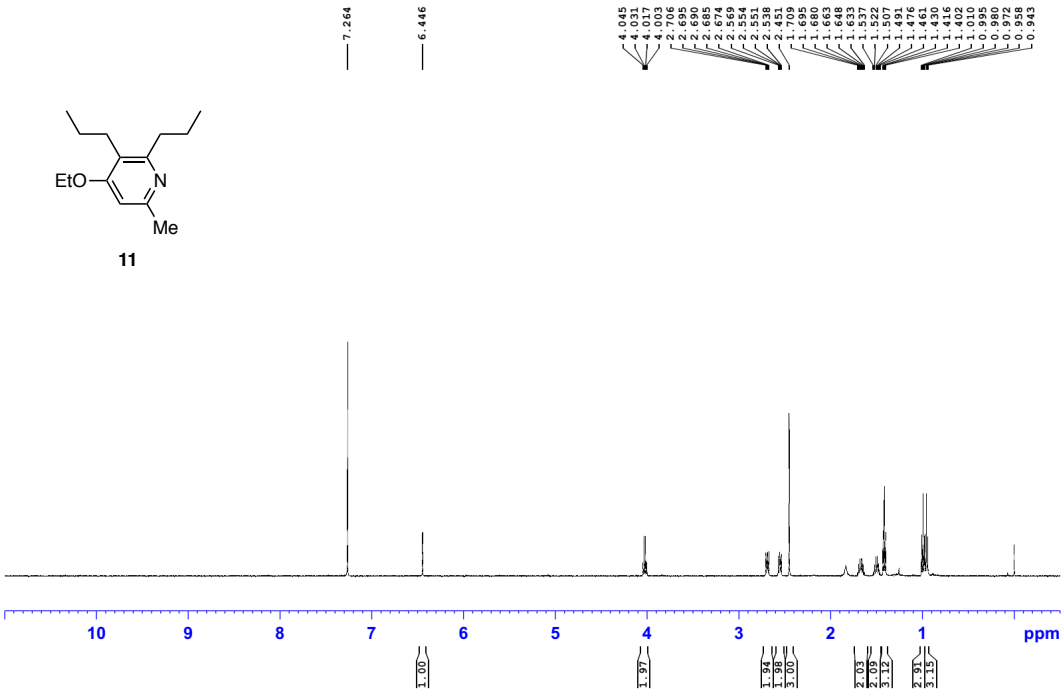
9 (*Z*/*E* = 5:1)

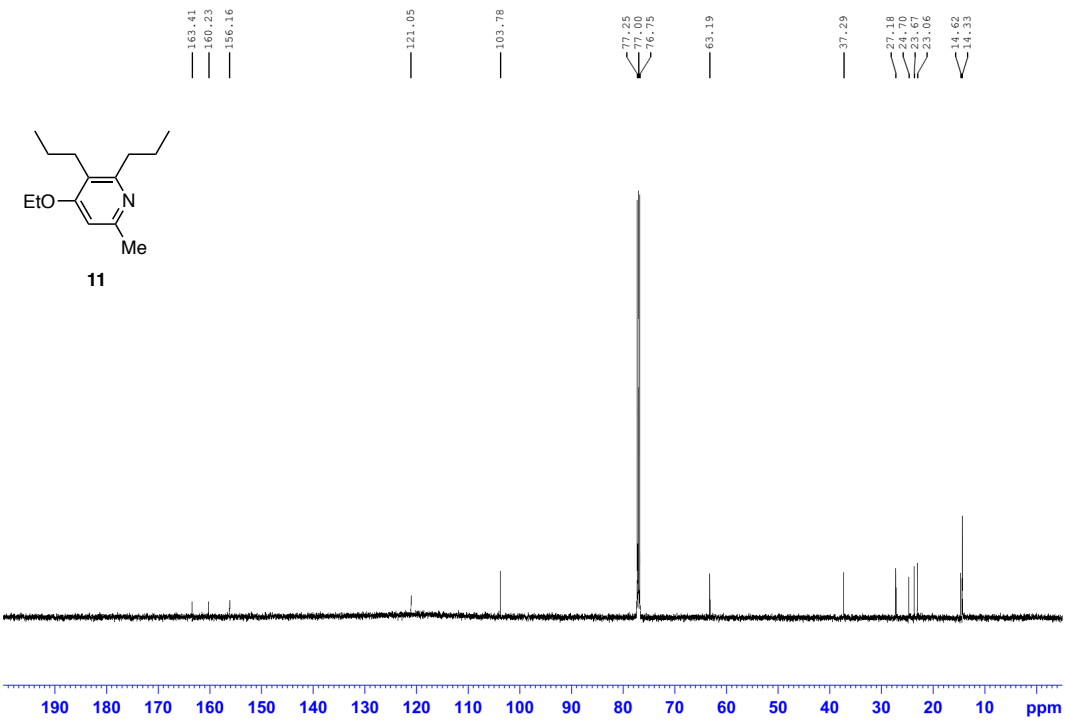

172.58
168.14
134.71
134.32
127.30
121.54
77.00
39.32
36.93
29.33
29.04
23.66
22.36
22.16
20.65
20.34
20.15
19.83
13.82
13.74
13.51
H
O
HN
Me
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

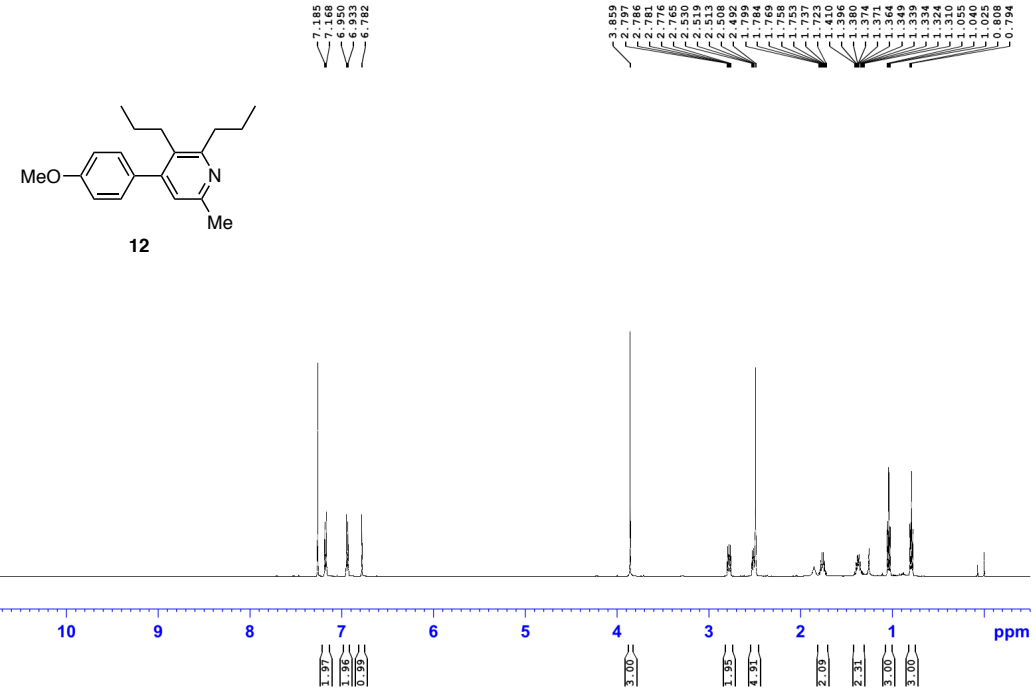
9 (*Z*/*E* = 5:1)

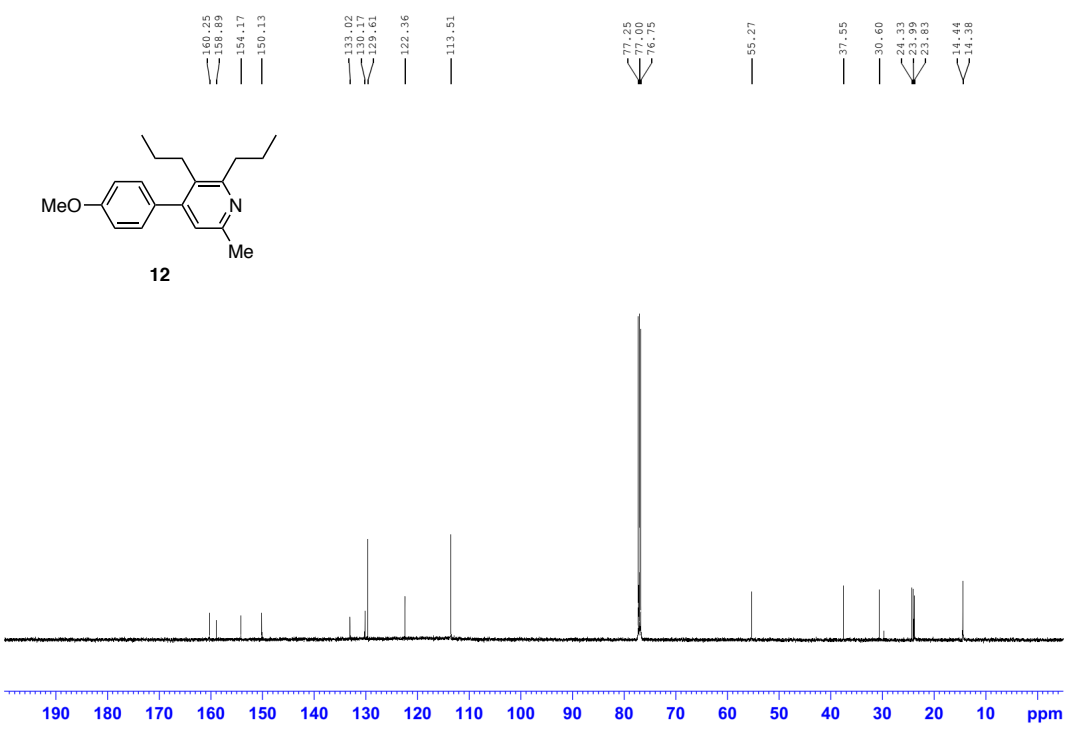

7.264
6.314
6.163
2.604
2.586
2.566
2.480
2.444
2.427
2.408
2.057
1.939
1.572
1.554
1.535
1.517
1.493
1.474
1.455
1.436
0.956
0.938
0.919
0.912
0.893
0.875
-0.000
Me
NH
O
O
HN
Me
10 (E,E/E,Z = 4:1)
10
9
8
7
6
5
4
3
2
1
ppm
0.98
0.25
1.95
2.46
3.00
0.80
5.04
7.54

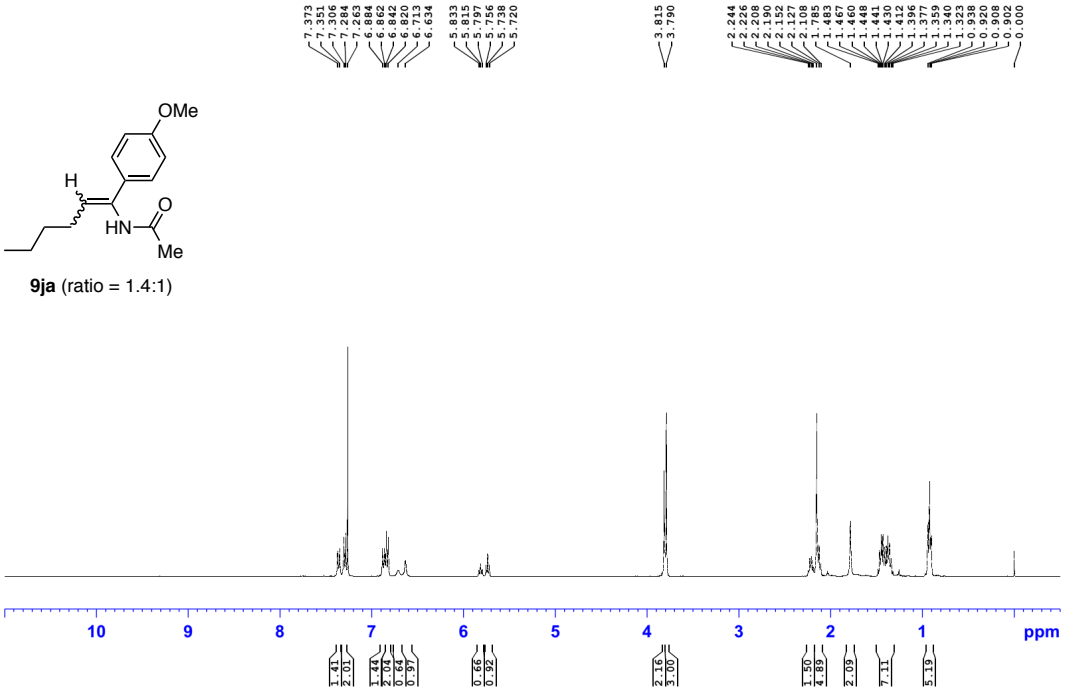

167.93
136.85
104.00
77.32
77.00
76.68
41.48
40.33
23.36
22.51
20.39
13.67
13.03
Me
NH
O
O
HN
Me
10 (E,E/E,Z = 4:1)
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

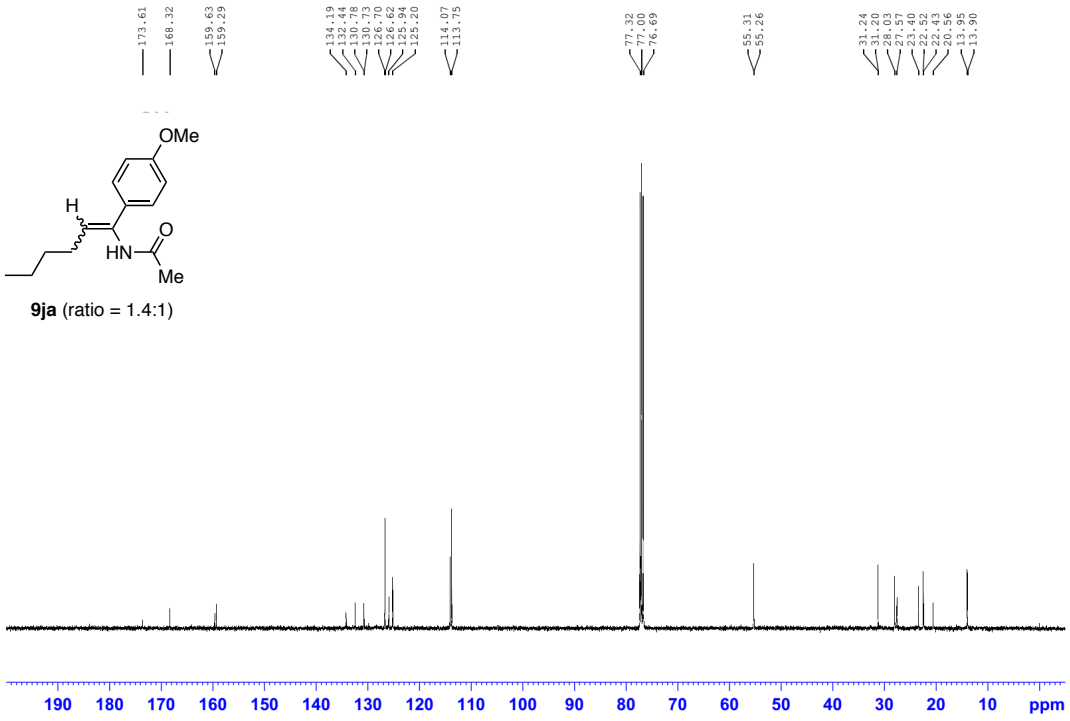

7.264
6.446
4.045
4.031
4.017
4.003
2.706
2.695
2.690
2.685
2.674
2.569
2.554
2.551
2.538
2.451
1.709
1.695
1.680
1.663
1.648
1.633
1.537
1.522
1.507
1.491
1.476
1.461
1.430
1.416
1.402
1.010
0.995
0.980
0.972
0.958
0.943
EtO
N
Me
11
10
9
8
7
6
5
4
3
2
1
ppm
1.00
1.97
1.94
1.98
3.00
2.03
2.09
3.12
2.91
5.15

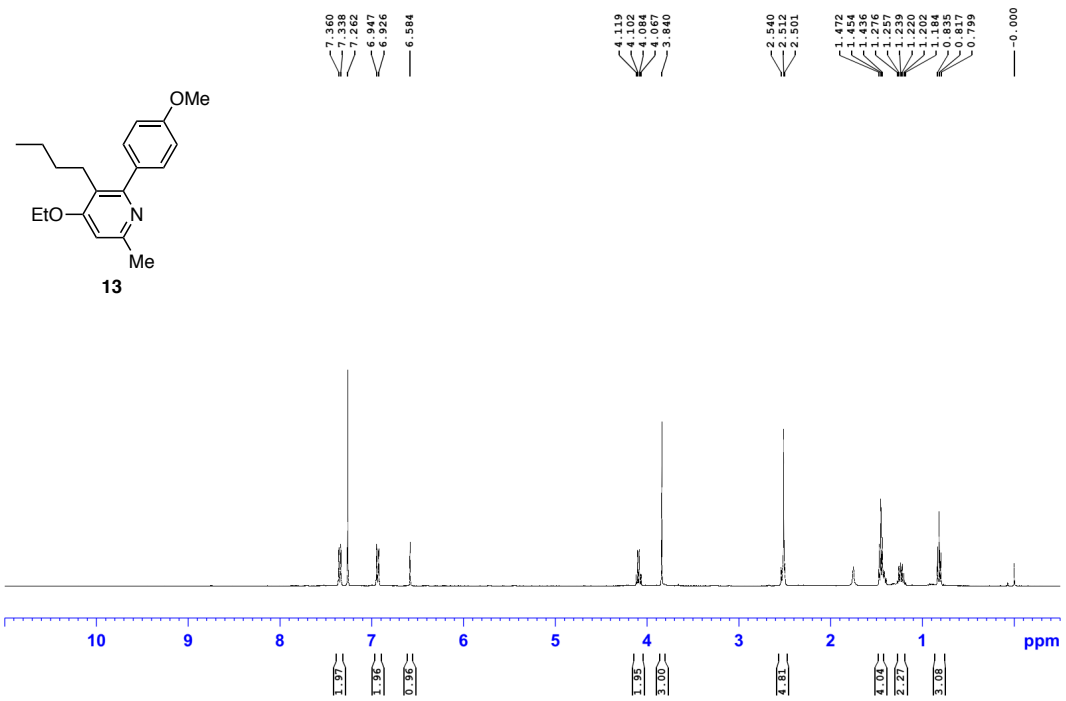

163.41
160.23
156.16
121.05
103.78
77.25
77.00
76.75
63.19
37.29
27.18
24.70
23.67
23.06
14.62
14.33
EtO
N
Me
11
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

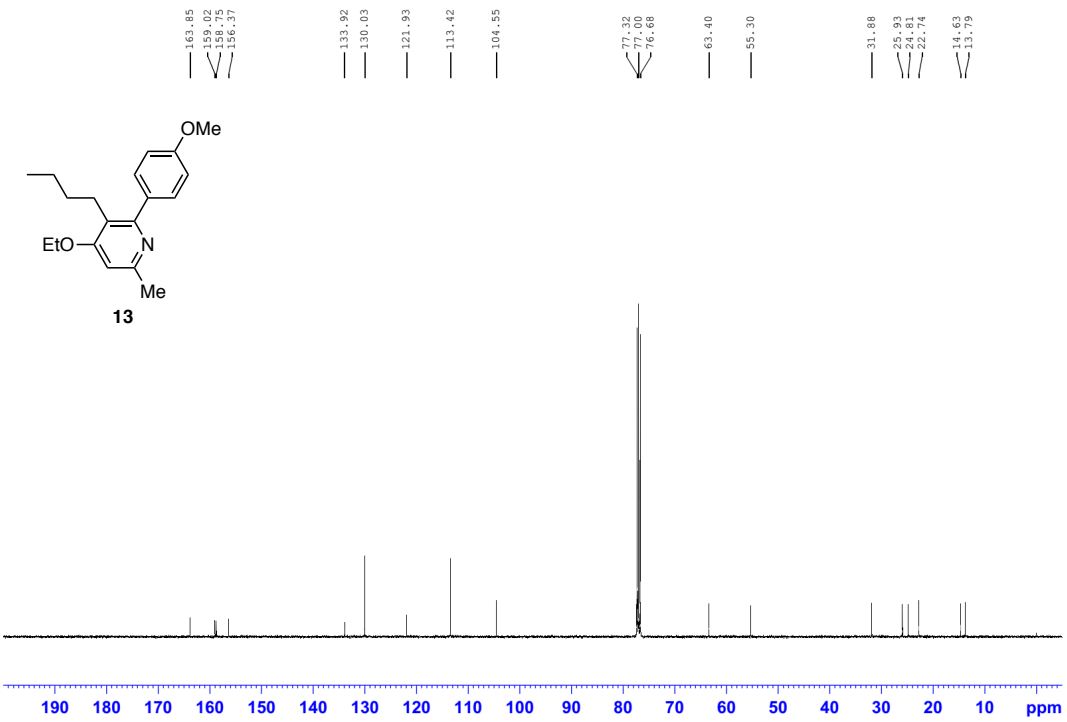

7.185
7.168
6.950
6.933
6.782
3.859
2.797
2.786
2.781
2.776
2.765
2.530
2.519
2.513
2.508
2.492
1.799
1.784
1.769
1.758
1.753
1.737
1.723
1.410
1.396
1.380
1.374
1.371
1.364
1.349
1.339
1.334
1.324
1.310
1.055
1.040
1.025
0.808
0.794
MeO
N
Me
12
10
9
8
7
6
5
4
3
2
1
ppm
1.97
1.96
0.99
3.00
1.95
4.91
2.09
2.31
3.00
3.00


160.25
158.89
154.17
150.13
133.02
130.17
129.61
122.36
113.51
77.25
77.00
76.75
55.27
37.55
30.60
24.33
23.99
23.83
14.44
14.38
MeO
N
Me
12
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm


7.373
7.351
7.306
7.284
7.263
6.864
6.862
6.842
6.820
6.713
6.634
5.833
5.815
5.797
5.756
5.738
5.720
3.815
3.790
2.244
2.226
2.208
2.190
2.152
2.127
2.108
1.895
1.483
1.467
1.460
1.448
1.441
1.430
1.412
1.396
1.377
1.359
1.340
1.323
0.938
0.920
0.908
0.902
0.000
OMe
H
O
HN
Me
9ja (ratio = 1.4:1)
10
9
8
7
6
5
4
3
2
1
ppm
1.41
2.01
1.44
2.04
0.64
0.97
0.66
0.92
2.16
3.00
1.50
4.89
2.09
7.11
5.19


173.61
168.32
159.63
159.29
134.19
132.44
130.78
130.73
126.70
126.62
125.94
125.20
114.07
113.75
77.32
77.00
76.69
55.31
55.26
31.24
31.03
28.03
27.57
23.40
22.52
22.43
20.56
13.95
13.90
OMe
H
O
HN
Me
9ja (ratio = 1.4:1)
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm


7.360
7.338
7.262
6.947
6.926
6.584
4.119
4.102
4.084
4.067
3.840
2.540
2.512
2.501
1.472
1.454
1.436
1.276
1.257
1.238
1.220
1.202
1.184
0.835
0.817
0.799
-0.000
OMe
EtO
N
Me
13
10
9
8
7
6
5
4
3
2
1
ppm
1.97
1.96
0.96
1.95
3.00
4.81
4.04
2.27
3.08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159.02
158.75
156.37
133.92
130.03
121.93
113.42
104.55
77.32
77.00
76.68
63.40
55.30
31.88
25.93
24.81
22.74
14.63
13.79
OMe
EtO
N
Me
13
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
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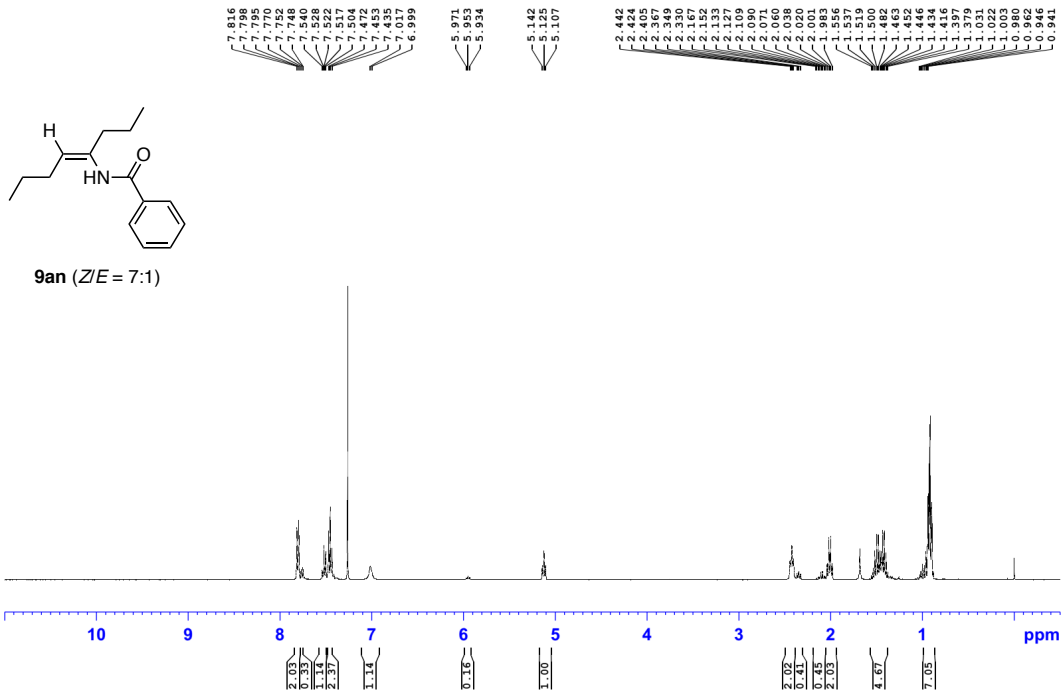
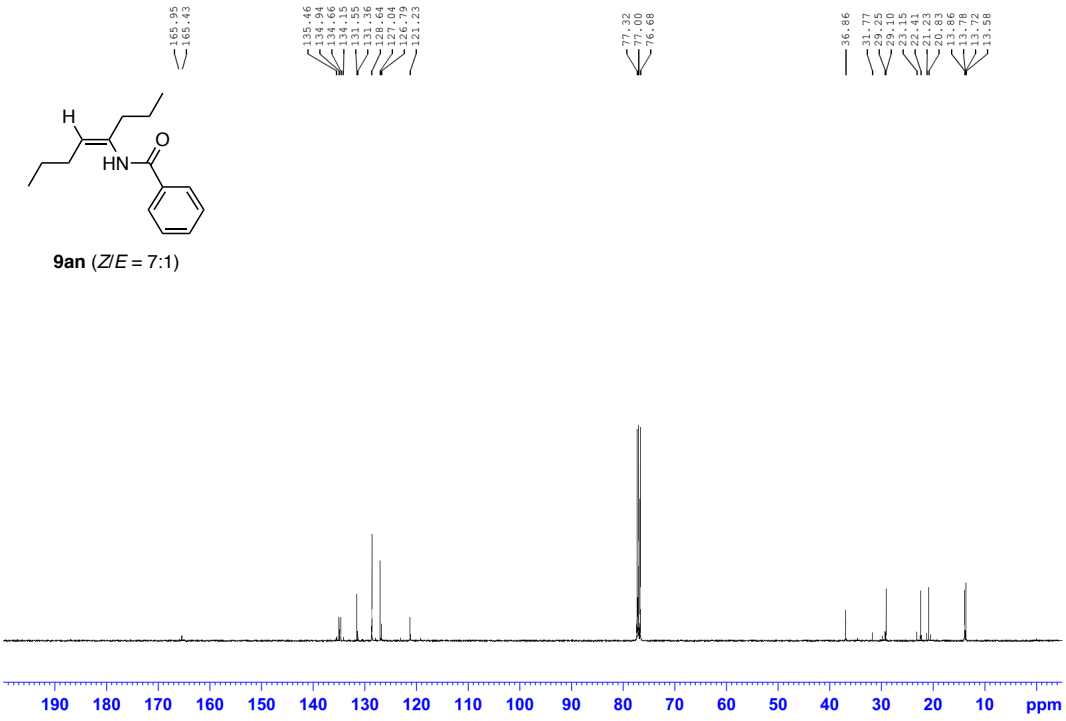
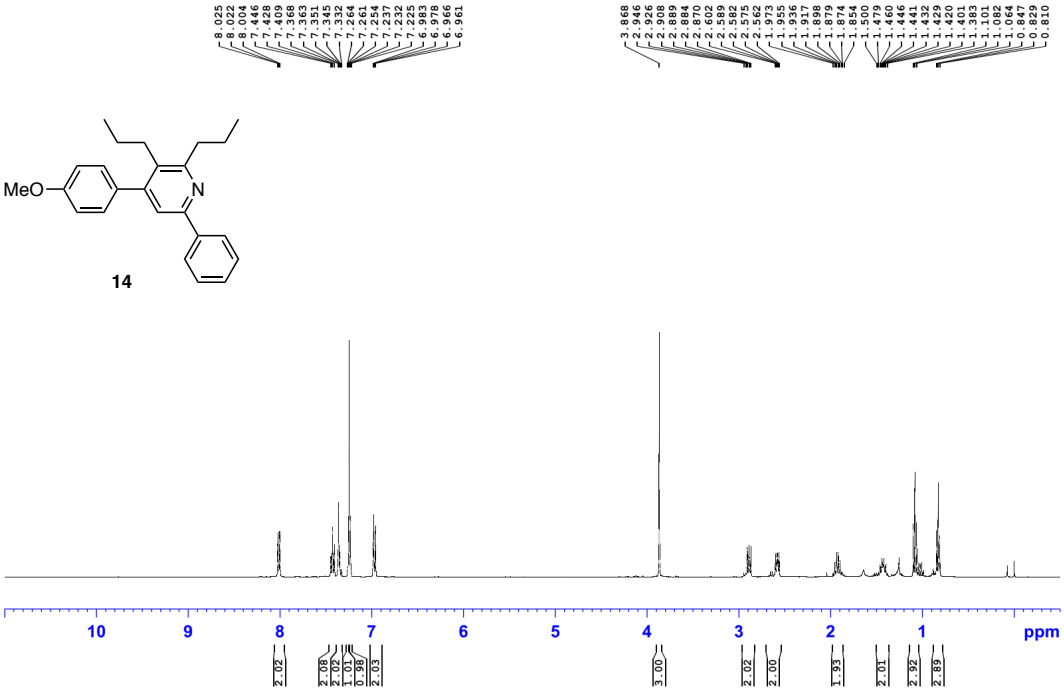
30
20
10
ppm



9an (*Z*/*E* = 7:1)



9an (*Z*/*E* = 7:1)


MeO
N
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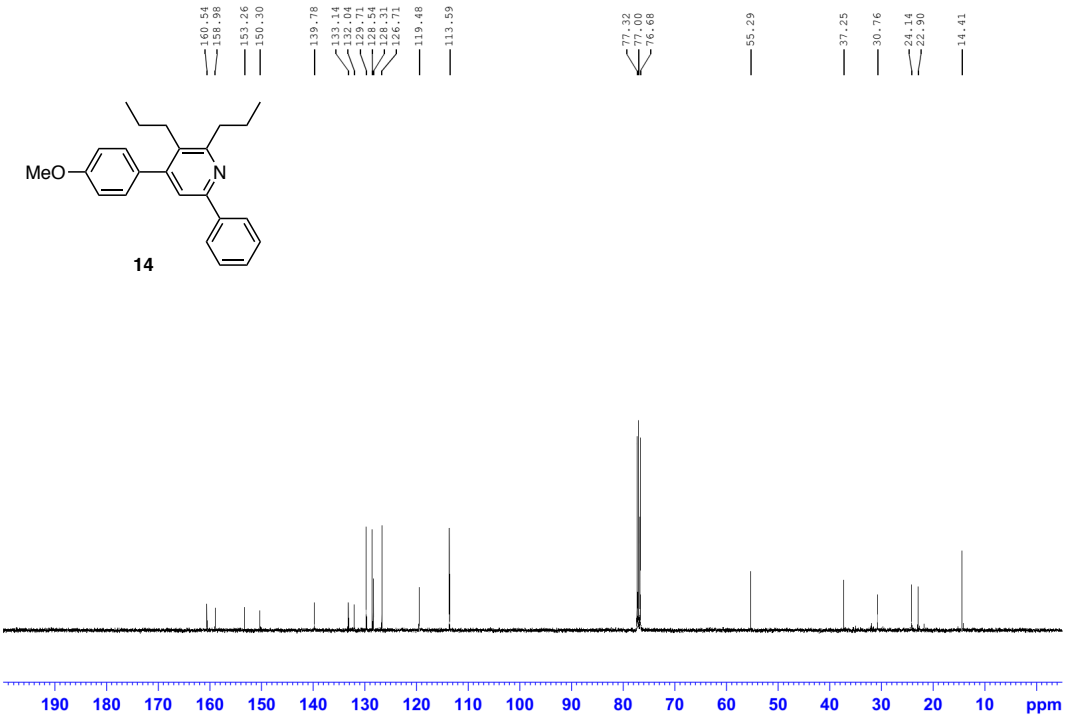
10
9
8
7
6
5
4
3
2
1
ppm


MeO
N
14
190
180
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160
150
140
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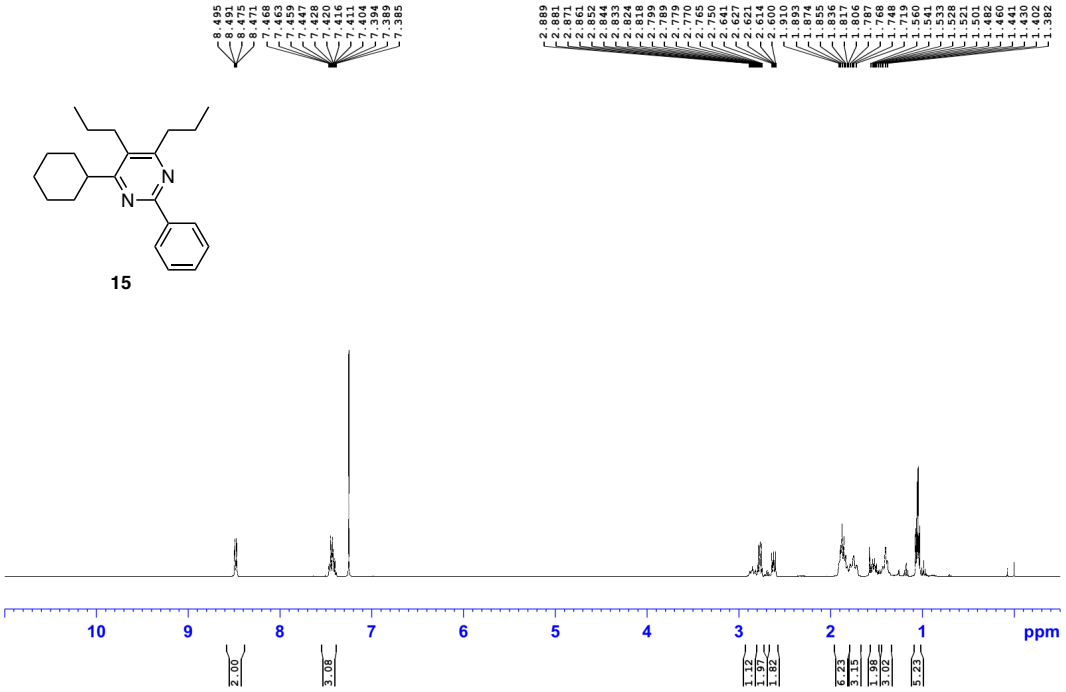
120
110
100
90
80
70
60
50
40
30
20
10
ppm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8.491
8.475
8.471
7.468
7.463
7.459
7.447
7.428
7.420
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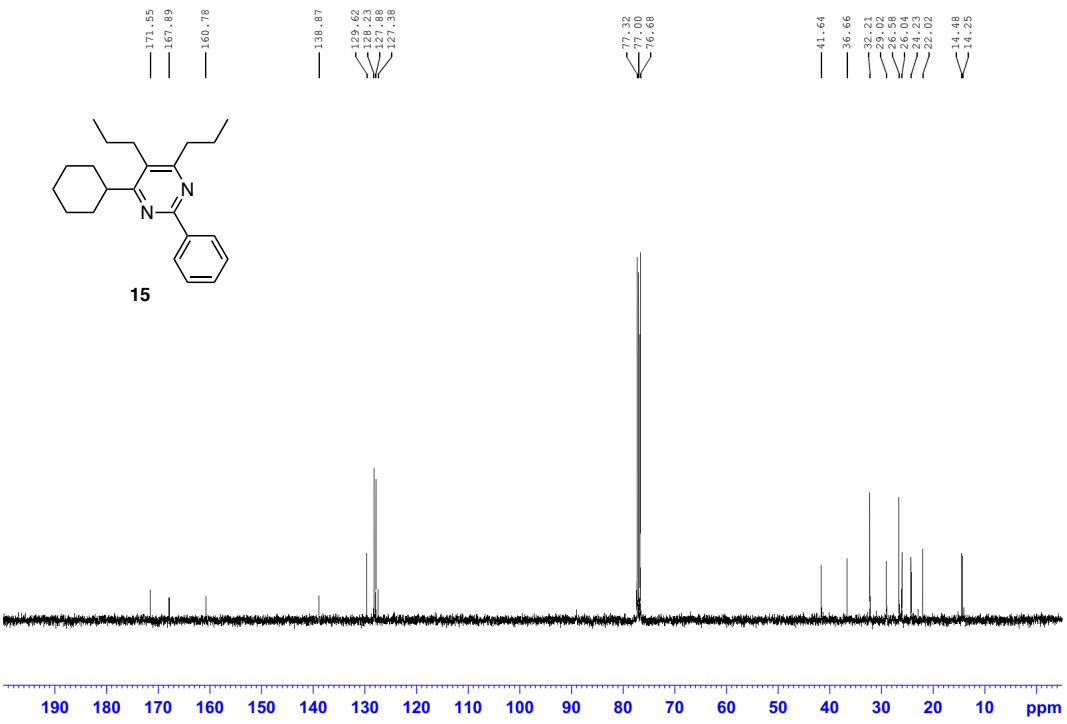
7.411
7.404
7.394
7.389
7.385
2.889
2.881
2.871
2.861
2.852
2.844
2.833
2.824
2.818
2.799
2.789
2.779
2.770
2.765
2.750
2.641
2.627
2.621
2.614
2.600
1.910
1.893
1.874
1.855
1.836
1.817
1.806
1.787
1.768
1.748
1.719
1.560
1.541
1.535
1.528
1.521
1.501
1.482
1.460
1.441
1.430
1.402
1.382
N
N
15
10
9
8
7
6
5
4
3
2
1
ppm
2.00
3.08
1.12
1.07
1.02
6.23
3.15
1.98
3.02
5.23


171.55
167.89
160.78
138.87
129.62
128.23
127.88
127.38
77.32
77.00
76.68
41.64
36.66
32.21
29.02
26.58
26.04
24.23
22.02
14.48
14.25
N
N
15
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm