Four-Component Coupling Reaction of Carbon dioxide, Amines, Cyclic Ethers and 3-Triflyloxybenzynes for the Synthesis of Functionalized Carbamates

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List of Contents

A. General methods

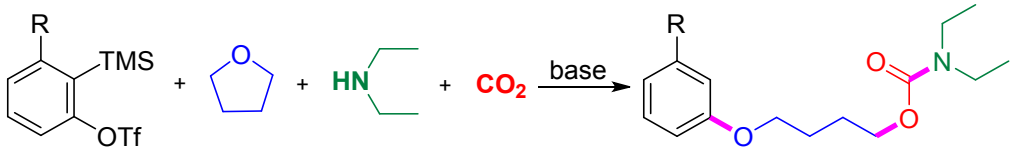
^{1}H and ^{13}C NMR spectra were recorded by using a 400 MHz NMR spectrometer. The chemical shifts are referenced to signals at 7.26 and 77.0 ppm, respectively, and $CDCl_3$ is used as a solvent with TMS as the internal standard. Mass spectra were recorded on a gas chromatograph-mass spectrometer. The data of HRMS was carried out on a high-resolution mass spectrometer (LCMS-IT-TOF). IR spectra were obtained either as potassium bromide plates or as liquid films between two potassium bromide plates with an infrared spectrometer. Melting points were determined with a digital melting point measuring instrument. Substrates **1b-1h** were prepared according to the literature procedure.[1] Substrate **1a** and other reagents were commercially purchased and used without further purification. Reagent **3m** (optical rotation (c=10, in methanol): + 30.2^{o}) was commercially purchased from Alfa Aesar. All air- and moisture-sensitive manipulations were carried out with standard Schlenk techniques under nitrogen or in a glove box.

B. General procedure for the preparation of organic carbamates

In a glove box, TBAI (0.4 mmol), 3-triflyloxybenzynes **1** (0.1 mmol), cyclic ethers **2** (anhydrous, 3 mL) were added to a 25 mL Schlenk tube equipped with a Teflon cap and a magnetic stirring bar. After the sealed tube was taken out of the glovebox, the reaction mixture was subjected to vacuum for a while and CO_2 (1 atm) was introduced into the reaction vessel. Subsequently, amines **3** (0.5 mmol) was slowly added to the resulted mixture via a syringe under stirring at room temperature. The reaction was allowed to continue at room temperature for 8 h. After the reaction was completed, the reaction mixture was quenched with saturated brine water (5 mL), then extracted with ethyl acetate (10 mL) and washed with saturated brine water. The organic layer was dried over anhydrous Na_2SO_4, then filtered and concentrated in vacuum. The crude residue was separated by column chromatography on silica gel to give the desired product **4**.

C. Optimization of reaction conditions

Table S1 Optimization of reaction conditions.[a]



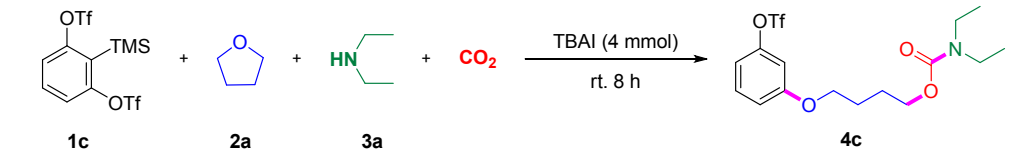
1 **2a** **3a** **4**

Entry	R	**1**	Base	T [°C]	**4**	Yield [%][b]
1	H	**1a**	CsF	r.t.	**4a**	n.d.[c]
2	F	**1b**	CsF	r.t.	**4b**	trace
3	OTf	**1c**	CsF	r.t	**4c**	79
4	OTf	**1c**	CsF	0	**4c**	47
5	OTf	**1c**	CsF	60	**4c**	trace
6[d]	OTf	**1c**	CsF	r.t.	**4c**	n.d.
7[e]	OTf	**1c**	CsF	r.t.	**4c**	trace
8[f]	OTf	**1c**	CsF	r.t.	**4c**	54
9[g]	OTf	**1c**	CsF	r.t.	**4c**	18
10	OTf	**1c**	KF	r.t.	**4c**	61
11	OTf	**1c**	Cs_2CO_3	r.t.	**4c**	80
12	OTf	**1c**	K_2CO_3	r.t.	**4c**	11
13	OTf	**1c**	TBAF	r.t.	**4c**	31
14	OTf	**1c**	TBAC	r.t.	**4c**	45
15	OTf	**1c**	TBAI	r.t.	**4c**	81
16[h]	OTf	**1c**	TBAI	r.t.	**4c**	83(78)
17[i]	OTf	**1c**	TBAI	r.t.	**4c**	63
18[j]	OTf	**1c**	TBAI	r.t.	**4c**	(55)
19	OTf	**1c**	-	r.t.	**4c**	13

[a] Reaction conditions: **1** (0.1 mmol), **2a** (THF, 3 mL), **3a** (5 equiv), base (3 equiv.), CO_2 (1 atm), 8 h. [b] GC yield with dodecane as the internal standard; the number in parentheses is the yield of the isolated product. [c] n.d. = not detected. [d] The reaction was carried out with 5 equiv. of THF using DMF (3mL) as the solvent. [e] The reaction was performed with 5 equiv. of THF using MeCN (3mL) as the solvent. [f] 4 h. [g] 18-Crown-6 (3 equiv) was added. [h] TBAI (4 equiv.). [I] TBAI (2 equiv.). [j] The

reaction was carried out on a 1 mmol scale.

D. Procedure for the larger scale synthesis of 4c

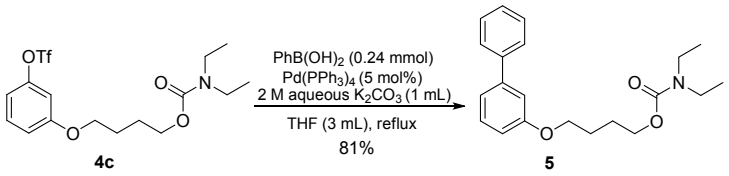


1c (0.445 g, 1 mmol) **2a** (5 mL) **3a** (0.365 g, 5 mmol) **4c** (55%, 227.1 mg)

In a glove box, TBAI (4 mmol), 2-(trimethylsilyl)-1,3-phenylene bis(trifluoromethanesulfonate) **1c** (1 mmol), anhydrous tetrahydrofuran **2a** (5 mL) were added to a 25 mL Schlenk tube equipped with a Teflon cap and a magnetic stirring bar. After the sealed tube was taken out of the glovebox, the reaction mixture was subjected to vacuum for a while and CO_2 (1 atm) was introduced into the reaction vessel. Subsequently, amines **3a** (5 mmol) was slowly added to the resulted mixture via a syringe under stirring at room temperature. The reaction was allowed to continue at room temperature for 8 h. After the reaction was completed, the reaction mixture was quenched with saturated brine water (10 mL), then extracted with ethyl acetate (30 mL) and washed with saturated brine water. The organic layer was dried over anhydrous Na_2SO_4, then filtered and concentrated in vacuum. The crude residue was separated by column chromatography on silica gel to give the desired product **4c**.

E. Procedure for the synthesis of compounds 5-8

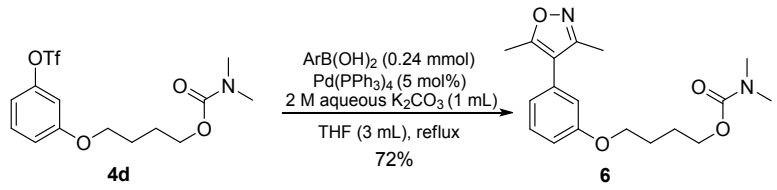
Procedure for the synthesis of compounds 5:



4c **5**

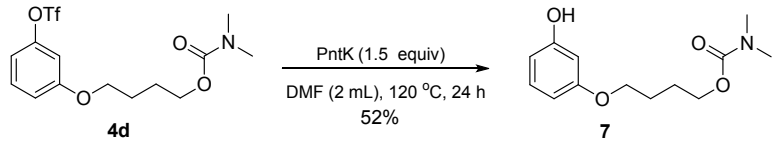
To a solution of 3-(4-((diethylcarbamoyl)oxy)butoxy)phenyl trifluoromethanesulfonate **4c** (0.2 mmol) in THF (2 mL) at room temperature was added $Pd(PPh_3)_4$ (0.01 mmol) under N_2. After the reaction was stirred for 20 minutes, 2 M aqueous K_2CO_3 (1 mL) and a solution of phenylboronic acid (0.24 mmol) in THF (1 mL) was added successively. The resulting mixture was refluxed for 12 h. The desired product **5** was concentrated and purified by column chromatography on silica gel.

Procedure for the synthesis of compounds 6:



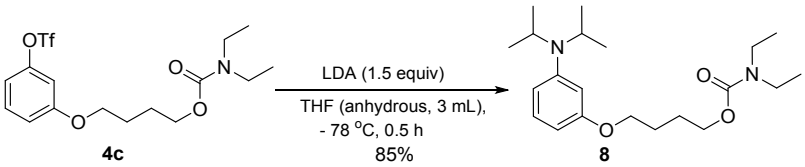
To a solution of 3-(4-((dimethylcarbamoyl)oxy)butoxy)phenyl trifluoromethanesulfonate **4d** (0.2 mmol) in THF (2 mL) at room temperature was added $Pd(PPh_3)_4$ (0.01 mmol) under N_2. After the reaction was stirred for 20 minutes, 2 M aqueous K_2CO_3 (1 mL) and a solution of (3,5-dimethylisoxazol-4-yl)boronic acid (0.24 mmol) in THF (1 mL) was added successively. The resulting mixture was refluxed for 12 h. The desired product **6** was concentrated and purified by column chromatography on silica gel.

Procedure for the synthesis of compounds 7:



To a solution of 3-(4-((dimethylcarbamoyl)oxy)butoxy)phenyl trifluoromethanesulfonate **4d** (0.2 mmol) in DMF (2 mL) was added potassium phthalimide (0.3 mmol). The mixture was stirred at 120 °C for 24 h. After the reaction was completed, the reaction mixture was quenched with 2 M HCl (2 mL), then extracted with ethyl acetate (10 mL) and washed with saturated brine water. The organic layer was dried over anhydrous Na_2SO_4, then filtered and concentrated in vacuum. The volatile compounds were removed under vacuum and the crude residue was separated by column chromatography on silica gel to give the desired product **7**.

Procedure for the synthesis of compounds 8:

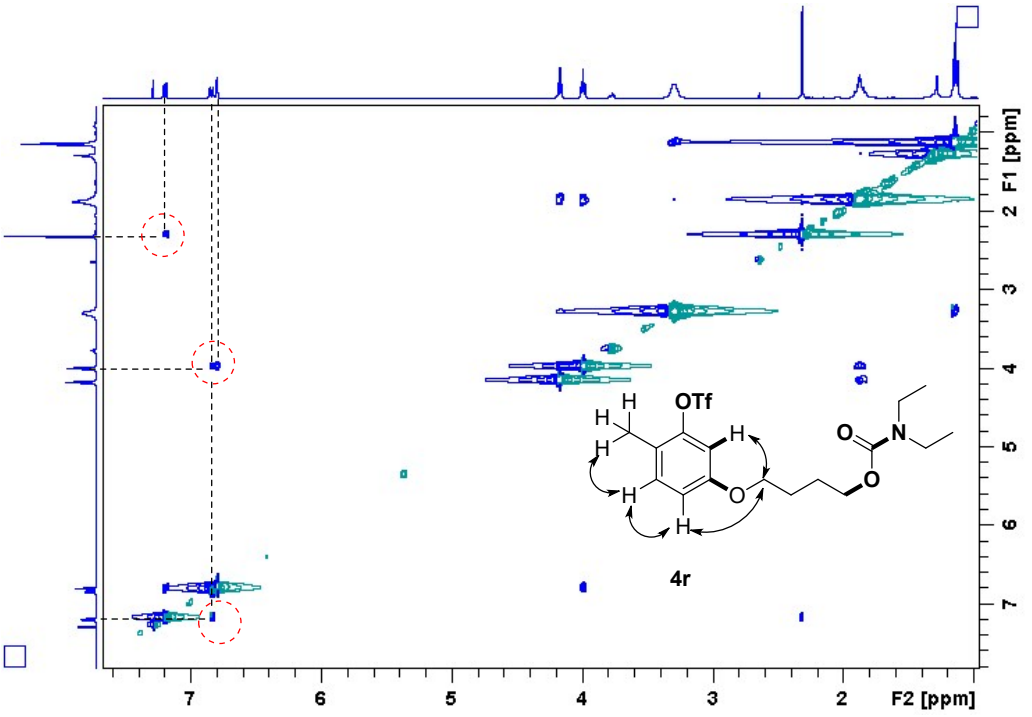


To a solution of 3-(4-((diethylcarbamoyl)oxy)butoxy)phenyl trifluoromethanesulfonate **4c** (0.2 mmol) in anhydrous THF (3 mL) at -78 °C was slowly added Lithium diisopropylamide (0.3 mmol) under N_2. The mixture was stirred at the same temperature for 0.5 h. After the reaction was completed, the reaction mixture was quenched with distilled water (5 mL), then extracted with ethyl

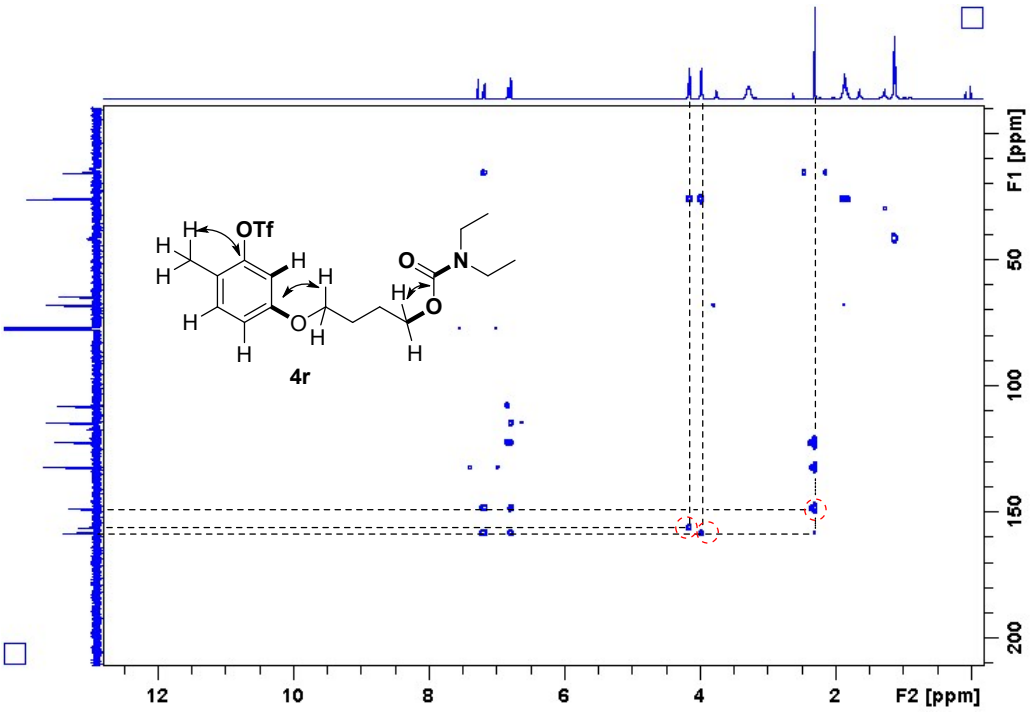
acetate (10 mL) and washed with saturated brine water. The organic layer was dried over anhydrous Na_2SO_4, then filtered and concentrated in vacuum. The volatile compounds were removed under vacuum and the crude residue was separated by column chromatography on silica gel to give the desired product **8**.

F. NOE and HMBC interactions of the 4r and 4r'

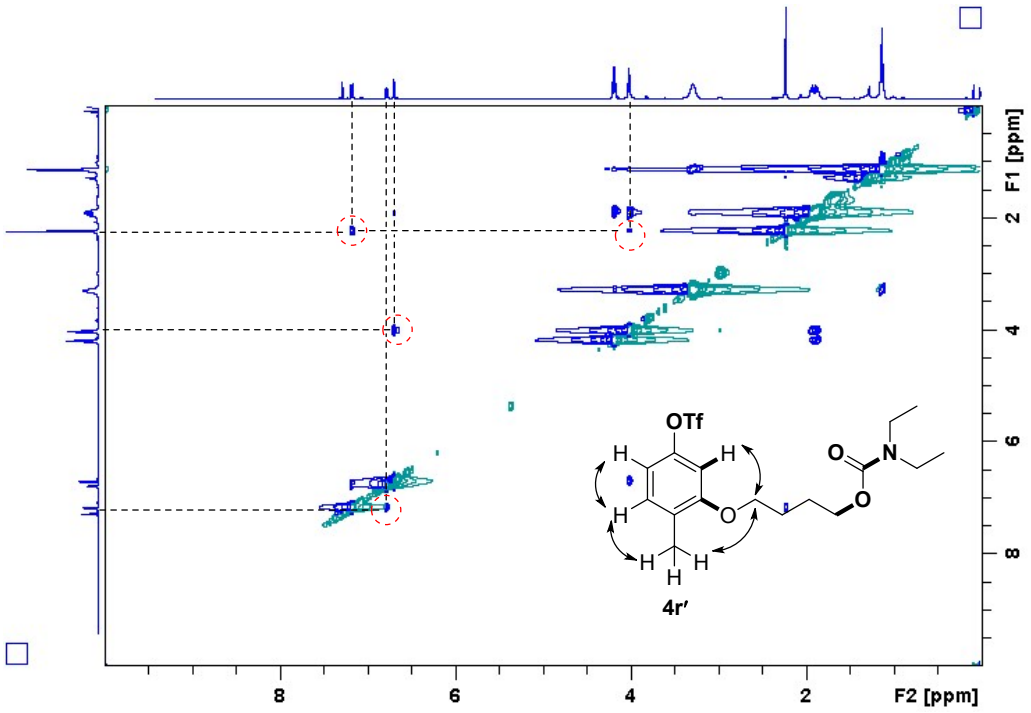
The NOE interactions of the 4r



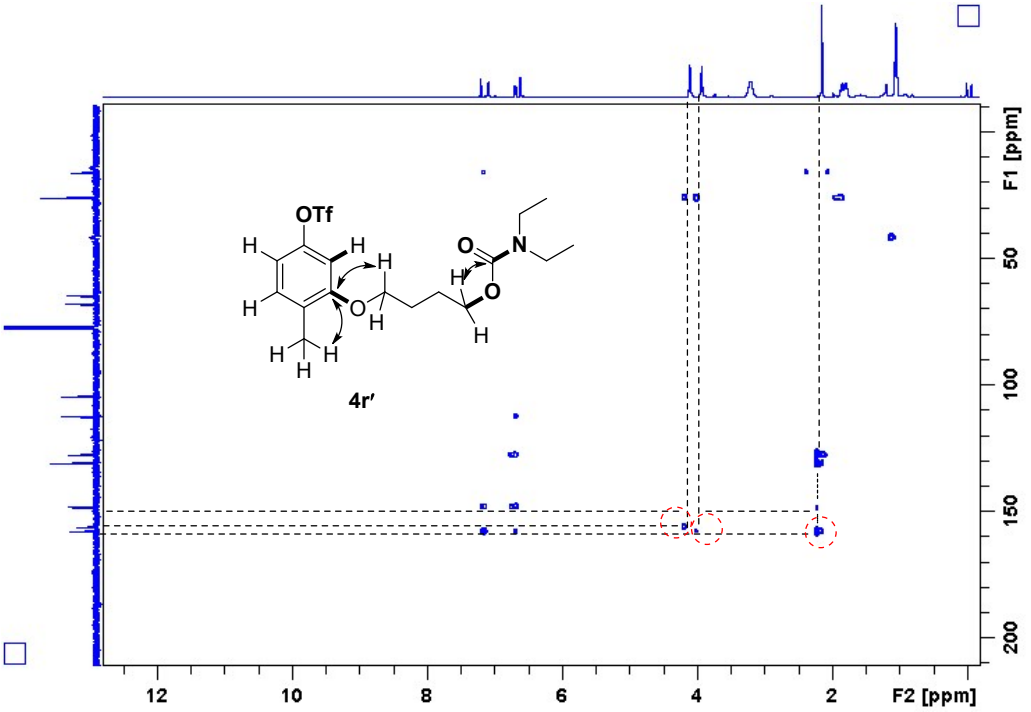
The HMBC interactions of the 4r



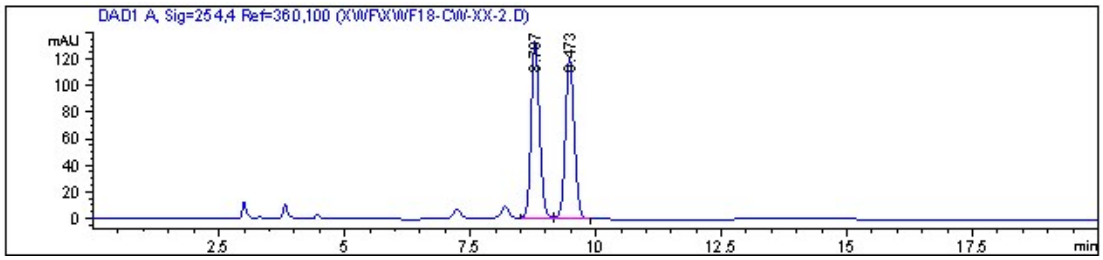
The NOE interactions of the 4r'



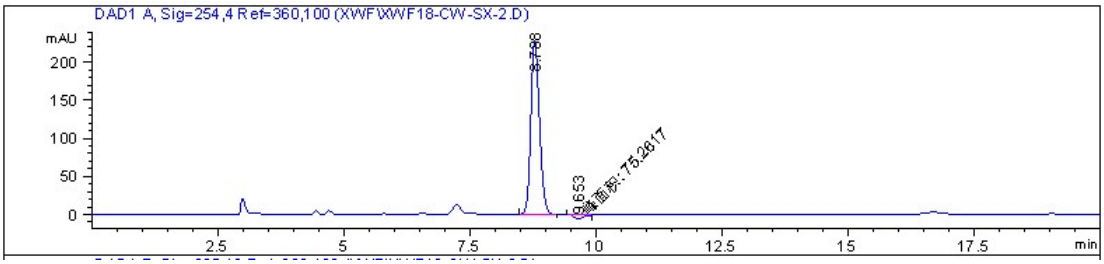
The HMBC interactions of the 4r'



G. HPLC Spectrums of 4o



Peak	Ret Time (min)	Area	Height (mAU)	Width (min)	Area (%)
1	8.787	1568.25354	133.89609	0.1806	51.0693
2	9.473	1502.57849	120.60860	0.1933	48.9307

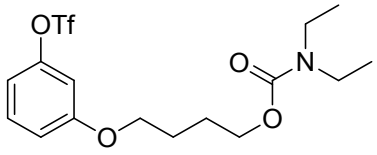


Peak	Ret Time (min)	Area	Height (mAU)	Width (min)	Area (%)
1	8.788	2728.16309	228.35535	0.1854	97.3154
2	9.653	75.26171	6.04863	0.2074	2.6846

Chiral HPLC analyses were performed on an Aglient 1200 system using a Chiralcel IA-H column (25 ^{o}C, flow rate: 1.0 mL/min, hexanes/isopropanol: 90/10, 254 nm).

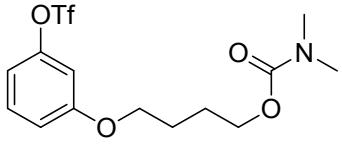
H. Analytical data

3-(4-((Diethylcarbamoyl)oxy)butoxy)phenyl trifluoromethanesulfonate) (4c)



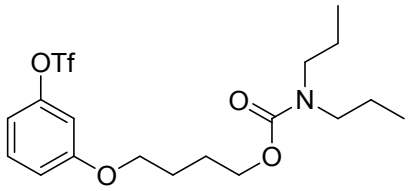
Pale yellow oil (32.2 mg, 78%). ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.32 (t, J = 8.4 Hz, 1 H), 6.91 (dd, J = 8.4 Hz, 2.2 Hz, 1 H), 6.85 (dd, J = 8.2 Hz, 2.0 Hz, 1 H), 6.80 (t, J = 2.4 Hz, 1 H), 4.16 (t, J = 6.0 Hz, 2 H), 4.01 (t, J = 6.0 Hz, 2 H), 3.27 (s, 4 H), 1.91 – 1.81 (m, 4 H), 1.12 (t, J = 7.0 Hz, 6 H).^{13}C NMR (100 MHz, $CDCl_3$) δ = 160.2, 155.9, 150.2, 130.5, 118.7 (J = 318.8 Hz), 114.5, 113.1, 107.9, 67.9, 64.4, 41.7, 41.2, 25.8, 13.9, 13.5. ^{19}F NMR (376 MHz, $CDCl_3$) δ = -72.97. IR (KBr) = 2971, 2930, 1696, 1613, 1483, 1425, 1276, 1214, 1142, 1108, 945, 846, 774, 605, 512 cm^{-1}. HRMS-ESI (*m/z*): calcd for $C_{16}H_{22}F_3NO_6SNa$ $(M + Na)^+$: 436.1012; found: 436.1017.

3-(4-((Dimethylcarbamoyl)oxy)butoxy)phenyl trifluoromethanesulfonate (4d)



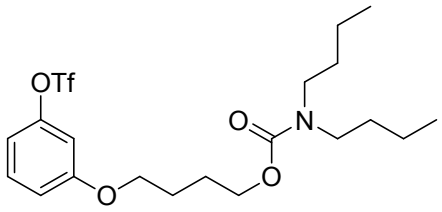
Pale yellow oil (25.0 mg, 65%). ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.32 (t, J = 8.4 Hz, 1H), 6.91 (dd, J = 8.4 Hz, 2.4 Hz, 1 H), 6.85 (dd, J = 8.0 Hz, 2.0 Hz, 1 H), 6.79 (t, J = 2.4 Hz, 1 H), 4.15 (t, J = 6.0 Hz, 2 H), 4.00 (t, J = 6.0 Hz, 2 H), 2.90 (s, 6 H), 1.92 – 1.80 (m, 4 H). ^{13}C NMR (100 MHz, $CDCl_3$) δ = 160.2, 156.7, 150.2, 130.5, 118.7 (J = 318.8 Hz), 114.6, 113.1, 107.9, 67.9, 64.8, 36.4, 35.8, 25.7. ^{19}F NMR (376 MHz, $CDCl_3$) δ = -72.93. IR (KBr) = 2923, 2856, 1704, 1582, 1489, 1420, 1209, 1142, 938, 857, 604 cm^{-1}. HRMS-ESI (*m/z*): calcd for $C_{14}H_{18}F_3NNaO_6S$ $(M + Na)^+$: 408.0699; found: 408.0704.

3-(4-((Dipropylcarbamoyl)oxy)butoxy)phenyl trifluoromethanesulfonate (4e)



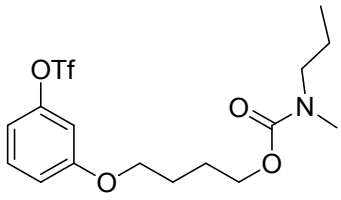
Pale yellow oil (31.2 mg, 71%). ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.32 (t, J = 8.0 Hz, 1 H), 6.91 (d, J = 8.4 Hz, 1 H), 6.85 (d, J = 8.0 Hz, 1 H), 6.79 (s, 1 H), 4.14 (t, J = 6.4 Hz, 2 H), 4.00 (t, J = 5.6 Hz, 2 H), 3.17 (s, 4 H), 1.90 – 1.79 (m, 4 H), 1.59 – 1.49 (m, 4 H), 0.88 (t, J = 7.2 Hz, 6 H). ^{13}C NMR (100 MHz, $CDCl_3$) δ = 160.2, 156.4, 150.2, 130.5, 118.7 (J = 318.8 Hz), 114.6, 113.1, 108.0, 68.0, 64.4, 49.2, 48.7, 25.8, 25.8, 21.9, 21.3, 11.2. ^{19}F NMR (376 MHz, $CDCl_3$) δ = -72.94. IR (KBr) = 2961, 2927, 1698, 1612, 1475, 1423, 1213, 1143, 1107, 946, 845, 772, 604 cm^{-1}. HRMS-ESI (*m/z*): calcd for $C_{18}H_{26}F_3NO_6SNa$ $(M + Na)^+$: 464.1325; found: 464.1332.

3-(4-((Dibutylcarbamoyl)oxy)butoxy)phenyl trifluoromethanesulfonate (4f)



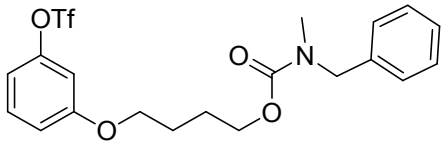
Pale yellow oil (31.5 mg, 67%). ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.32 (t, J = 8.4 Hz, 1 H), 6.90 (d, J = 8.4 Hz, 1 H), 6.85 (d, J = 8.4 Hz, 1 H), 6.79 (s, 1 H), 4.14 (t, J = 5.6 Hz, 2 H), 4.00 (t, J = 5.6 Hz, 2 H), 3.20 (s, 4 H), 1.91 – 1.79 (m, 4 H), 1.54 – 1.46 (m, 4 H), 1.33 – 1.27 (m, 4 H), 0.92 (t, J = 7.2 Hz, 6 H). ^{13}C NMR (100 MHz, $CDCl_3$) δ = 160.2, 156.4, 150.2, 130.5, 118.7 (J = 318.6 Hz), 114.6, 113.1, 108.0, 68.0, 64.4, 47.2, 46.6, 30.8, 30.3, 25.8, 20.0, 13.8. ^{19}F NMR (376 MHz, $CDCl_3$) δ = -72.94. IR (KBr) = 2957, 2933, 2875, 1697, 1612, 1477, 1424, 1216, 1145, 1107, 942, 846, 604 cm^{-1}. HRMS-ESI (*m/z*): calcd for $C_{20}H_{30}F_3NO_6SNa$ $(M + Na)^+$: 492.1638; found: 492.1643.

3-(4-((Methyl(propyl)carbamoyl)oxy)butoxy)phenyl trifluoromethanesulfonate (4g)



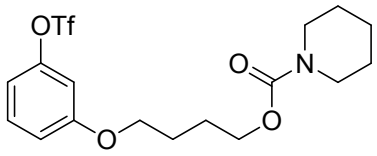
Pale yellow oil (31.4 mg, 76%). ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.32 (t, J = 8.4 Hz, 1 H), 6.91 (d, J = 8.4 Hz, 1 H), 6.85 (d, J = 8.0 Hz, 1 H), 6.79 (s, 1 H), 4.15 (t, J = 6.0 Hz, 2 H), 4.00 (t, J = 6.0 Hz, 2 H), 3.21 (s, 2 H), 2.89 (s, 3 H), 1.91 – 1.79 (m, 4 H), 1.58 – 1.49 (m, 2 H), 0.88 (t, J = 7.2 Hz, 3 H). ^{13}C NMR (100 MHz, $CDCl_3$) δ = 160.2, 156.6, 150.2, 130.5, 118.7 (J = 318.9 Hz), 114.6, 113.1, 107.9, 68.0, 64.7, 50.6, 50.3, 25.8, 21.1, 20.7, 11.1. ^{19}F NMR (376 MHz, $CDCl_3$) δ = -72.93. IR (KBr) = 2959, 2871, 1700, 1606, 1582, 1484, 1421, 1213, 1142, 1105, 941, 849, 604, 509 cm^{-1}. HRMS-ESI (*m/z*): calcd for $C_{16}H_{22}F_3NNaO_6S$ $(M + Na)^+$: 436.1012; found: 436.1011.

3-(4-((Benzyl(methyl)carbamoyl)oxy)butoxy)phenyl trifluoromethanesulfonate (4h)



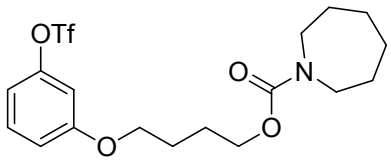
Pale yellow oil (24.0 mg, 52%). ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.36 – 7.18 (m, 6 H), 6.95 – 6.82 (m, 2 H), 6.78 (s, 1 H), 4.47 (s, 2 H), 4.21 (s, 2 H), 3.97 (d, J=24.8 Hz, 2 H), 2.86 (d, J=31.3 Hz, 3 H), 1.83 (s, 4 H). ^{13}C NMR (100 MHz, $CDCl_3$) δ = 160.1, 156.8, 156.5, 150.1, 137.5, 130.5, 128.6, 127.8, 127.3, 127.2, 127.1, 118.7 (J = 318.9 Hz), 114.5, 113.1, 107.9, 67.9, 65.0, 52.4, 52.3, 34.4, 33.5, 25.7. ^{19}F NMR (376 MHz, $CDCl_3$) δ = -72.91. IR (KBr) = 2928, 1701, 1612, 1587, 1485, 1419, 1213, 1143, 1105, 945, 848, 771, 697, 604, 511 cm^{-1}. HRMS-ESI (*m/z*): calcd for $C_{20}H_{22}F_3NNaO_6S$ $(M + Na)^+$: 484.1012; found: 484.1016.

4-(3-(((Trifluoromethyl)sulfonyl)oxy)phenoxy)butyl piperidine-1-carboxylate (4i)



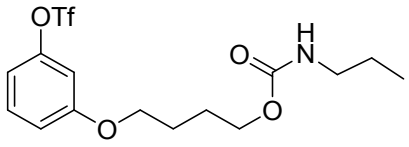
Pale yellow oil (29.6 mg, 70%). ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.32 (t, J = 8.4 Hz, 1 H), 6.93 – 6.88 (m, 1 H), 6.85 (d, J = 8.4 Hz, 1 H), 6.79 (s, 1 H), 4.15 (t, J = 6.0 Hz, 2 H), 4.00 (t, J = 6.0 Hz, 2 H), 3.49 – 3.30 (m, 4 H), 1.93 – 1.80 (m, 4 H), 1.61 – 1.48 (m, 6 H). ^{13}C NMR (100 MHz, $CDCl_3$) δ = 160.2, 155.5, 150.2, 130.5, 118.7 (J = 318.7 Hz), 114.6, 113.1, 107.9, 68.0, 64.7, 44.8, 25.8, 25.7, 24.4. ^{19}F NMR (376 MHz, $CDCl_3$) δ = -72.92. IR (KBr) = 2933, 2858, 1697, 1611, 1426, 1214, 1144, 1106, 1028, 945, 849, 604 cm^{-1}. HRMS-ESI (*m/z*): calcd for $C_{17}H_{22}F_3NNaO_6S$ $(M + Na)^+$: 448.1012; found: 448.1017.

4-(3-(((Trifluoromethyl)sulfonyl)oxy)phenoxy)butyl azepane-1-carboxylate (4j)



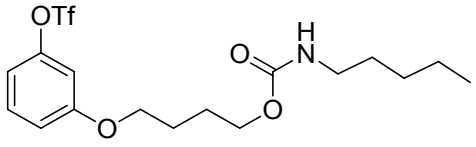
Pale yellow oil (30.1 mg, 69%). ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.32 (t, J = 8.4 Hz, 1 H), 6.92 – 6.88 (m, 1 H), 6.84 (d, J = 8.0 Hz, 1 H), 6.81 – 6.77 (m, 1 H), 4.16 (t, J = 6.0 Hz, 2 H), 4.00 (t, J = 6.0 Hz, 2 H), 3.40 (dt, J = 10.7 Hz, 5.6 Hz, 4 H), 1.91 – 1.80 (m, 4 H), 1.67 (d, J = 14.8 Hz, 4 H), 1.58 – 1.50 (m, 4 H). ^{13}C NMR (100 MHz, $CDCl_3$) δ = 160.2, 156.4, 150.2, 130.5, 118.7 (J = 319.0 Hz), 114.6, 113.1, 107.9, 68.0, 64.6, 46.9, 46.5, 28.5, 28.3, 27.4, 26.9, 25.8. ^{19}F NMR (376 MHz, $CDCl_3$) δ = -72.92. IR (KBr) = 2931, 2856, 1695, 1612, 1481, 1423, 1141, 1109, 946, 849, 769, 604 cm^{-1}. HRMS-ESI (*m/z*): calcd for $C_{18}H_{24}F_3NNaO_6S$ $(M + Na)^+$: 462.1169; found: 462.1170.

3-(4-((Propylcarbamoyl)oxy)butoxy)phenyl trifluoromethanesulfonate (4k)



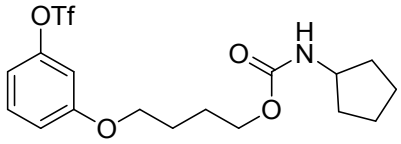
Pale yellow oil (24.3 mg, 61%). ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.32 (t, J = 8.4 Hz, 1 H), 6.91 (dd, J = 8.4 Hz, 2.0 Hz, 1 H), 6.85 (dd, J = 8.0 Hz, 2.0 Hz, 1 H), 6.79 (t, J = 2.1 Hz, 1 H), 4.67 (s, 1 H), 4.13 (t, J = 5.6 Hz, 2 H), 4.00 (t, J = 6.0 Hz, 2 H), 3.13 (d, J = 6.4 Hz, 2 H), 1.91 – 1.78 (m, 4 H), 1.56 – 1.47 (m, 2 H), 0.92 (t, J=7.2 Hz, 3 H). ^{13}C NMR (100 MHz, $CDCl_3$) δ = 160.2, 156.7, 150.2, 130.5, 118.7 (J = 318.8 Hz), 114.6, 113.1, 107.9, 67.9, 64.2, 42.7, 25.7, 25.7, 23.2, 11.1. ^{19}F NMR (376 MHz, $CDCl_3$) δ = -72.93. IR (KBr) = 3344, 2959, 2928, 2880, 1711, 1613, 1527, 1483, 1421, 1214, 1141, 1109, 1044, 947, 847, 774, 604, 510 cm^{-1}. HRMS-ESI (*m/z*): calcd for $C_{15}H_{20}F_3NNaO_6S$ $(M + Na)^+$: 422.0856; found: 422.0855.

3-(4-((Pentylcarbamoyl)oxy)butoxy)phenyl trifluoromethanesulfonate (4l)



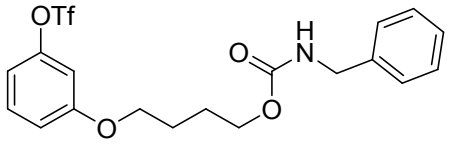
Pale yellow solid (24.8 mg, 58%, mp = 65-66 °C). ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.32 (t, J = 8.4 Hz, 1 H), 6.90 (d, J = 8.4 Hz, 1 H), 6.85 (d, J = 8.0 Hz, 1 H), 6.79 (s, 1 H), 4.65 (s, 1 H), 4.14 (t, J = 5.6 Hz, 2 H), 3.99 (t, J = 6.0 Hz, 2 H), 3.16 (q, J = 6.4 Hz, 2 H), 1.91 – 1.79 (m, 4 H), 1.53 – 1.45 (m, 2 H), 1.34 – 1.28 (m, 4 H), 0.90 (t, J = 6.4 Hz, 3 H). ^{13}C NMR (100 MHz, $CDCl_3$) δ = 160.2, 156.6, 150.2, 130.5, 118.7 (J = 318.9 Hz), 114.6, 113.1, 107.9, 67.9, 64.2, 41.0, 29.7, 28.9, 25.7, 25.7, 22.3, 13.9. ^{19}F NMR (376 MHz, $CDCl_3$) δ = -72.94. IR (KBr) = 3332, 2956, 2928, 2866, 1710, 1612, 1487, 1421, 1212, 1140, 1108, 1043, 946, 775, 680, 605, 511 cm^{-1}. HRMS-ESI (*m/z*): calcd for $C_{17}H_{24}F_3NNaO_6S$ $(M + Na)^+$: 450.1169; found: 450.1173.

3-(4-((Cyclopentylcarbamoyl)oxy)butoxy)phenyl trifluoromethanesulfonate (4m)



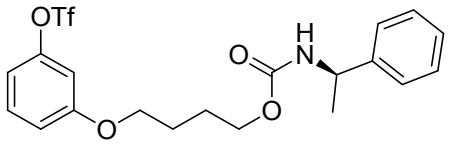
Pale yellow solid (21.6 mg, 51%, mp = 63-64 °C). ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.32 (t, J = 8.4 Hz, 1 H), 6.91 (dd, J = 8.4 Hz, 2.4 Hz, 1 H), 6.85 (dd, J = 8.0 Hz, 2.0 Hz, 1 H), 6.79 (t, J = 2.0 Hz, 1 H), 4.60 (s, 1 H), 4.12 (s, 2 H), 4.04 – 3.89 (m, 3 H), 2.01 – 1.91 (m, 2 H), 1.90 – 1.78 (m, 4 H), 1.69 – 1.56 (m, 4 H), 1.43 – 1.34 (m, 2 H). ^{13}C NMR (100 MHz, $CDCl_3$) δ = 160.2, 156.1, 150.2, 130.5, 118.7 (J = 318.8 Hz), 114.6, 113.1, 107.9, 67.9, 64.1, 52.7, 33.2, 25.7, 25.7, 23.5. ^{19}F NMR (376 MHz, $CDCl_3$) δ = -72.92. IR (KBr) = 3335, 2961, 2926, 2861, 1710, 1613, 1488, 1422, 1214, 1141, 1108, 1043, 946, 848, 774, 605, 511 cm^{-1}. HRMS-ESI (*m/z*): calcd for $C_{17}H_{22}F_3NNaO_6S$ $(M + Na)^+$: 448.1012; found: 448.1016.

3-(4-((Benzylcarbamoyl)oxy)butoxy)phenyl trifluoromethanesulfonate (4n)



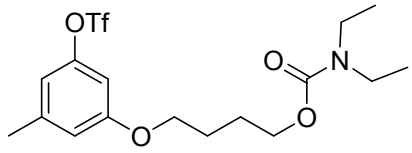
Pale yellow solid (21.3 mg, 48%, mp = 62-63 °C). ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.38 – 7.28 (m, 6 H), 6.92 (d, J = 8.4 Hz, 1 H), 6.87 (d, J = 8.4 Hz, 1 H), 6.81 (s, 1 H), 4.99 (s, 1 H), 4.39 (d, J = 5.6 Hz, 2 H), 4.20 (t, J = 6.0 Hz, 2 H), 4.01 (t, J = 5.6 Hz, 2 H), 1.93 – 1.81 (m, 4 H). ^{13}C NMR (100 MHz, $CDCl_3$) δ = 160.2, 156.6, 150.2, 138.5, 130.5, 128.7, 127.5, 118.7 (J = 318.9 Hz), 114.6, 113.1, 107.9, 67.9, 64.5, 45.1, 25.7, 25.6. ^{19}F NMR (376 MHz, CDCl3) δ = -72.89. IR (KBr) = 3329, 3073, 2923, 1716, 1587, 1531, 1420, 1209, 1136, 916, 845, 743, 600, 510 cm^{-1}. HRMS-ESI (*m/z*): calcd for $C_{19}H_{20}F_3NNaO_6S$ $(M + Na)^+$: 470.0856; found: 470.0858.

(R)-3-(4-(((1-Phenylethyl)carbamoyl)oxy)butoxy)phenyl trifluoromethanesulfonate (4o)



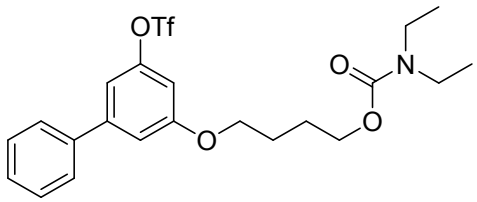
Pale yellow oil (20.6 mg, 45%). ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.36 – 7.24 (m, 6 H), 6.94 – 6.82 (m, 2 H), 6.78 (s, 1 H), 5.07 – 4.60 (m, 2 H), 4.16 – 4.07 (m, 2 H), 4.02 – 3.77 (m, 2 H), 1.90 – 1.68 (m, 4 H), 1.47 (d, *J*=6.6 Hz, 3 H). ^{13}C NMR (100 MHz, $CDCl_3$) δ = 160.2, 155.7, 150.2, 130.5, 128.6, 127.3, 125.9, 118.7 (*J* = 318.9 Hz), 114.6, 113.1, 107.9, 67.9, 64.3, 50.6, 25.6, 22.4. ^{19}F NMR (376 MHz, CDCl3) δ = -72.89. IR (KBr) = 3326, 2929, 1710, 1611, 1489, 1420, 1216, 1139, 945, 846, 770, 698, 603, 512 cm^{-1}. HRMS-ESI (*m/z*): calcd for $C_{20}H_{22}F_3NNaO_6S$ $(M + Na)^+$: 484.1012; found: 484.1015.

3-(4-((Diethylcarbamoyl)oxy)butoxy)-5-methylphenyl trifluoromethanesulfonate (4p)



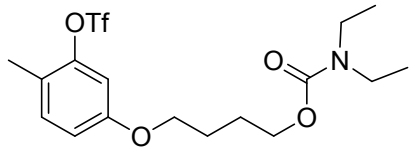
Pale yellow oil (26.1 mg, 61%). ^{1}H NMR (400 MHz, $CDCl_3$) δ = 6.65 (s, 1 H), 6.59 (s, 1 H), 6.52 (s, 1 H), 4.07 (t, *J* = 6.0 Hz, 2 H), 3.90 (t, *J* = 6.0 Hz, 2 H), 3.20 (s, 4 H), 2.27 (s, 3 H), 1.81 – 1.73 (m, 4 H), 1.04 (t, *J* = 7.2 Hz, 6 H). ^{13}C NMR (100 MHz, $CDCl_3$) δ = 159.9, 156.0, 145.0, 141.3, 118.7 (*J* = 318.6 Hz), 115.3, 113.8, 104.9, 67.9, 64.4, 41.7, 41.2, 25.8, 25.8, 21.5, 14.0, 13.6. ^{19}F NMR (376 MHz, $CDCl_3$) δ = -73.03, -73.04, -73.04. IR (KBr) = 2969, 2937, 1699, 1618, 1582, 1473, 1424, 1278, 1214, 1164, 1106, 963, 828, 771, 608 cm^{-1}. HRMS-ESI (*m/z*): calcd for $C_{17}H_{24}F_3NNaO_6S$ $(M + Na)^+$: 450.1169; found: 450.1170.

5-(4-((Diethylcarbamoyl)oxy)butoxy)-[1,1'-biphenyl]-3-yl trifluoromethanesulfonate (4q)



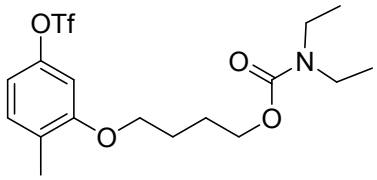
Pale yellow oil (34.8 mg, 71%). ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.56 – 7.52 (m, 2 H), 7.45 (t, *J* = 7.2 Hz, 2 H), 7.42 – 7.37 (m, 1 H), 7.14 – 7.10 (m, 1 H), 7.09 – 7.02 (m, 1 H), 6.77 (t, *J* = 2.2 Hz, 1 H), 4.17 (t, *J* = 6.4 Hz, 2 H), 4.06 (t, *J* = 6.0 Hz, 2 H), 3.27 (s, 4 H), 1.95 – 1.83 (m, 4 H), 1.11 (t, *J* = 7.2 Hz, 6 H). ^{13}C NMR (100 MHz, $CDCl_3$) δ = 160.3, 156.0, 150.4, 144.4, 139.2, 129.0, 128.4, 127.1, 118.7 (*J* = 318.8), 113.4, 112.1, 106.4, 68.1, 64.5, 41.4, 41.2, 25.8, 25.8, 13.9, 13.6. ^{19}F NMR (376 MHz, CDCl3) δ = -72.83. IR (KBr) = 2966, 2930, 1697, 1614, 1578, 1466, 1423, 1274, 1213, 1141, 912, 749, 604 cm^{-1}. HRMS-ESI (*m/z*): calcd for $C_{22}H_{26}F_3NNaO_6S$ $(M + Na)^+$: 512.1325; found: 512.1327.

5-(4-((Diethylcarbamoyl)oxy)butoxy)-2-methylphenyl trifluoromethanesulfonate(4r)



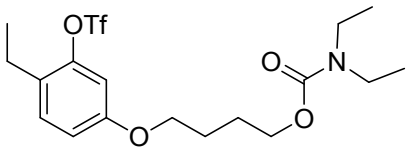
Pale yellow oil (21.3 mg, 50%). ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.17 (d, J = 8.4 Hz, 1 H), 6.82 (dd, J = 8.4 Hz, 2.4 Hz, 1 H), 6.77 (d, J = 2.4 Hz, 1 H), 4.15 (t, J = 6.0 Hz, 2 H), 3.97 (t, J = 6.0 Hz, 2 H), 3.27 (s, 4 H), 2.29 (s, 3 H), 1.88 – 1.80 (m, 4 H), 1.11 (t, J = 7.2 Hz, 6 H). ^{13}C NMR (100 MHz, $CDCl_3$) δ = 158.1, 156.0, 148.5, 132.2, 122.3, 118.6 (J = 318.3 Hz), 114.5, 107.8, 68.0, 64.5, 41.6, 41.3, 25.9, 25.8, 15.5, 13.9, 13.4. ^{19}F NMR (376 MHz, $CDCl_3$) δ = -73.86. IR (KBr) = 2966, 2928, 1698, 1608, 1270, 1212, 1139, 1001, 952, 860, 770, 602 cm^{-1}. HRMS-ESI (*m/z*): calcd for $C_{17}H_{24}F_3NNaO_6S$ $(M + Na)^+$: 450.1169; found: 450.1165.

3-(4-((Diethylcarbamoyl)oxy)butoxy)-4-methylphenyl trifluoromethanesulfonate(4r')



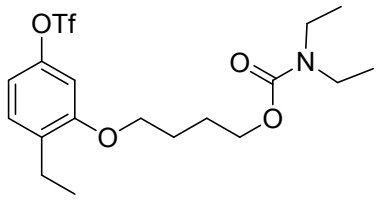
Pale yellow oil (14.9 mg, 35%). ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.08 (d, J = 8.4 Hz, 1 H), 6.68 (dd, J = 8.4 Hz, 2.4 Hz, 1 H), 6.61 (d, J = 2.0 Hz, 1 H), 4.10 (t, J = 6.4 Hz, 2 H), 3.93 (t, J = 6.0 Hz, 2 H), 3.20 (s, 4 H), 2.14 (s, 3 H), 1.87 – 1.77 (m, 4 H), 1.04 (t, J = 7.2 Hz, 6 H). ^{13}C NMR (100 MHz, $CDCl_3$) δ = 157.8, 156.0, 148.1, 130.9, 127.4, 118.7 (J = 318.9 Hz), 112.3, 104.3, 67.9, 64.6, 41.7, 41.2, 26.0, 25.9, 15.9, 14.0, 13.6. ^{19}F NMR (376 MHz, $CDCl_3$) δ = -72.88. IR (KBr) = 2928, 2866, 1699, 1626, 1507, 1477, 1422, 1213, 1143, 1072, 953, 847, 768, 606, 508 cm^{-1}. HRMS-ESI (*m/z*): calcd for $C_{17}H_{24}F_3NNaO_6S$ $(M + Na)^+$: 450.1169; found: 450.1166.

5-(4-((Diethylcarbamoyl)oxy)butoxy)-2-ethylphenyl trifluoromethanesulfonate (4s)



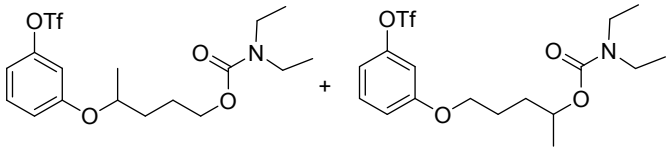
Pale yellow oil (18.0 mg, 41%). ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.21 (d, J = 8.8 Hz, 1 H), 6.85 (dd, J = 8.4 Hz, 1.6 Hz, 1 H), 6.77 (d, J = 2.0 Hz, 1 H), 4.14 (t, J = 6.0 Hz, 2 H), 3.97 (t, J = 5.6 Hz, 2 H), 3.27 (s, 4 H), 2.66 (q, J = 7.6 Hz, 2 H), 1.89 – 1.78 (m, 4 H), 1.22 (t, J = 7.6 Hz, 3 H), 1.11 (t, J = 7.2 Hz, 6 H). ^{13}C NMR (100 MHz, $CDCl_3$) δ = 158.0, 156.0, 147.9, 130.6, 128.2, 118.6 (J = 318.2 Hz), 114.7, 107.7, 67.9, 64.5, 41.7, 41.3, 25.9, 25.8, 22.3, 14.2, 14.1, 13.6. ^{19}F NMR (376 MHz, $CDCl_3$) δ = -73.94. IR (KBr) = 2961, 2926, 1699, 1624, 1506, 1469, 1422, 1274, 1214, 1174, 1142, 1075, 983, 847, 606 cm^{-1}. HRMS-ESI (*m/z*): calcd for $C_{18}H_{26}F_3NNaO_6S$ $(M + Na)^+$: 464.1325; found: 464.1322.

3-(4-((Diethylcarbamoyl)oxy)butoxy)-4-ethylphenyl trifluoromethanesulfonate (4s')



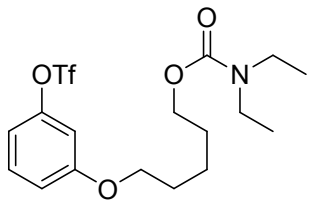
Pale yellow oil (15.5 mg, 35%). ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.17 (d, J = 8.4 Hz, 1 H), 6.79 (dd, J = 8.4 Hz, 2.0 Hz, 1 H), 6.69 (s, 1 H), 4.17 (t, J = 6.0 Hz, 2 H), 4.00 (t, J = 5.8 Hz, 2 H), 3.27 (s, 4 H), 2.63 (q, J = 7.2 Hz, 4 H), 1.94 – 1.84 (m, 4 H), 1.18 (t, J = 7.2 Hz, 3 H), 1.12 (t, J = 7.2 Hz, 6 H). ^{13}C NMR (100 MHz, $CDCl_3$) δ = 157.5, 156.0, 148.1, 133.2, 129.4, 118.7 (J = 318.5 Hz), 112.4, 104.4, 67.8, 64.5, 48.3, 41.6, 41.2, 25.9, 23.0, 13.7. ^{19}F NMR (376 MHz, CDCl3) δ = -72.90. IR (KBr) = 2925, 2851, 1700, 1605, 1466, 1424, 1377, 1212, 1174, 1140, 955, 858, 603 cm^{-1}. HRMS-ESI (*m/z*): calcd for $C_{18}H_{26}F_3NNaO_6S$ $(M + Na)^+$: 464.1325; found: 464.1320.

The mixture of 3-((5-((Diethylcarbamoyl)oxy)pentan-2-yl)oxy)phenyl trifluoromethanesulfonate (4t) and 3-((4-((Diethylcarbamoyl)oxy)pentyl)oxy)phenyl trifluoromethanesulfonate (4t')



Pale yellow oil (19.8 mg, 46%). ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.35 – 7.28 (m, 1 H), 6.90 (t, J = 7.2 Hz, 1 H), 6.84 (t, J = 7.2 Hz, 1 H), 6.79 (s, 1 H), 4.95 – 4.86 (m, 0.5 H), 4.45 – 4.36 (m, 0.5 H), 4.11 (t, J = 6.0 Hz, 1 H), 3.98 (t, J = 6.4 Hz, 1 H), 3.26 (s, 4 H), 1.87 – 1.69 (m, 4 H), 1.32 (d, J = 6.0 Hz, 1.5 H), 1.27 (d, J = 6.0 Hz, 1.5 H), 1.11 (t, J = 6.8 Hz, 6 H). ^{13}C NMR (100 MHz, $CDCl_3$) δ = 160.3, 159.3, 156.0, 155.7, 150.3, 150.2, 130.5, 130.5, 118.7 (J = 318.9 Hz), 115.7, 114.6, 113.1, 113.0, 109.1, 108.0, 74.1, 70.7, 68.2, 64.6, 41.3, 41.2, 32.7, 25.1, 20.4, 19.3, 14.1, 13.7. ^{19}F NMR (376 MHz, $CDCl_3$) δ = -72.94. IR (KBr) = 2975, 2930, 1698, 1612, 1583, 1484, 1424, 1380, 1212, 1175, 1143, 1107, 1003, 971, 854, 774, 606, 511 cm^{-1}. HRMS-ESI (*m/z*): calcd for $C_{17}H_{24}F_3NNaO_6S$ $(M + Na)^+$: 450.1169; found: 450.1167.

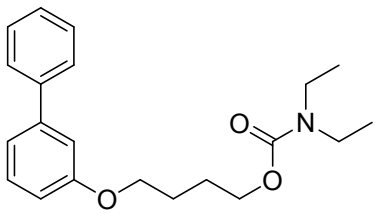
3-((5-((Diethylcarbamoyl)oxy)pentyl)oxy)phenyl trifluoromethanesulfonate (4u)



Pale yellow oil (22.2 mg, 52%). ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.32 (t, J = 8.4 Hz, 1 H), 6.90 (dd, J = 8.4 Hz, 2.0 Hz, 1 H), 6.84 (dd, J = 8.4 Hz, 2.0 Hz, 1 H), 6.78 (t, J = 2.3 Hz, 1 H), 4.11 (t, J = 6.4 Hz, 2 H), 3.97 (t, J = 6.4 Hz, 2 H), 3.27 (s, 4 H), 1.87 – 1.80 (m, 2 H), 1.73 – 1.68 (m, 2 H), 1.60 – 1.52 (m, 2 H), 1.11 (t, J = 7.2 Hz, 6 H). ^{13}C NMR (100 MHz, $CDCl_3$) δ = 160.3, 156.1, 150.2, 130.5, 118.7 (J = 318.7 Hz), 114.6, 113.0, 107.9, 68.3, 64.7, 41.7, 41.4, 28.8, 28.7, 22.5, 13.8, 13.7. ^{19}F NMR (376 MHz, $CDCl_3$) δ = -72.93. IR (KBr) = 2925, 2861, 1699, 1611, 1582, 1480, 1423, 1211, 1105, 1015, 845, 774, 680, 604, 511 cm^{-1}. HRMS-ESI (*m/z*): calcd for $C_{17}H_{24}F_3NNaO_6S$ $(M + Na)^+$: 450.1169;

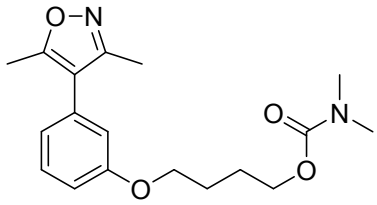
found: 450.1172.

4-([1,1'-Biphenyl]-3-yloxy)butyl diethylcarbamate (5)



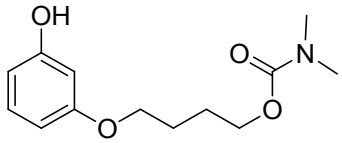
Pale yellow oil (55.3 mg, 81%). ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.58 (d, J = 7.6 Hz, 2 H), 7.42 (t, J = 7.6 Hz, 2 H), 7.33 (t, J = 8.0 Hz, 2 H), 7.17 (d, J = 7.6 Hz, 1 H), 7.12 (s, 1 H), 6.88 (dd, J = 8.0, 1.6 Hz, 1 H), 4.16 (t, J = 6.0 Hz, 2 H), 4.06 (t, J = 6.0 Hz, 2 H), 3.26 (s, 4 H), 1.93 – 1.82 (m, 4 H), 1.11 (t, J = 7.0 Hz, 6 H). ^{13}C NMR (100 MHz, $CDCl_3$) δ = 159.3, 156.0, 142.7, 141.1, 129.7, 128.7, 127.3, 127.1, 119.6, 113.5, 113.2, 67.4, 64.6, 41.6, 41.2, 26.0, 25.9, 14.1, 13.5. IR (KBr) = 3057, 2966, 2930, 1697, 1598, 1476, 1427, 1379, 1275, 1210, 1172, 1070, 1005, 760, 699 cm^{-1}. HRMS-ESI (*m/z*): calcd for $C_{21}H_{28}NO_3$ $(M + H)^+$: 342.2064; found: 342.2055.

4-(3-(3,5-Dimethylisoxazol-4-yl)phenoxy)butyl dimethylcarbamate (6)



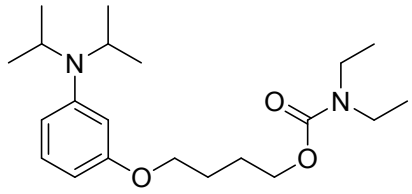
Pale yellow oil (47.8 mg, 72%). ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.34 (t, J = 8.0 Hz, 1 H), 6.89 (dd, J = 8.4 Hz, 2.4 Hz, 1 H), 6.83 (d, J = 7.2 Hz, 1 H), 6.78 (d, J = 2.4 Hz, 1 H), 4.16 (t, J = 6.0 Hz, 2 H), 4.03 (t, J = 6.0 Hz, 2 H), 2.91 (s, 6 H), 2.42 (s, 3 H), 2.28 (s, 3 H), 1.93 – 1.82 (m, 4 H). ^{13}C NMR (100 MHz, $CDCl_3$) δ = 165.1, 159.1, 158.6, 156.6, 131.7, 129.7, 121.4, 116.5, 115.5, 113.2, 67.4, 64.8, 36.3, 35.7, 25.8, 25.8, 11.5, 10.8. IR (KBr) = 2930, 2871, 1703, 1583, 1490, 1368, 1299, 1247, 1190, 1058, 967, 868, 783, 699, 617 cm^{-1}. HRMS-ESI (*m/z*): calcd for $C_{18}H_{25}N_2O_4$ $(M + H)^+$: 333.1809; found: 333.1805.

4-(3-Hydroxyphenoxy)butyl dimethylcarbamate (7)



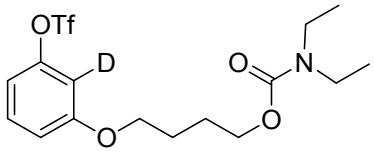
Pale yellow oil (26.3 mg, 52%). ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.09 (t, J = 8.0 Hz, 1H), 6.56 – 6.34 (m, 3 H), 4.16 (d, J = 6.0 Hz, 2 H), 3.94 (d, J = 5.2 Hz, 2 H), 2.90 (s, 6 H), 1.82 (s, 4 H). ^{13}C NMR (100 MHz, $CDCl_3$) δ = 160.2, 157.3, 157.0, 123.0, 107.8, 106.6, 102.1, 67.3, 65.2, 36.1, 36.0, 25.8, 25.8. IR (KBr) = 3352, 2927, 2861, 1678, 1600, 1495, 1463, 1406, 1369, 1285, 1201, 1153, 1056, 845, 768, 690 cm^{-1}. HRMS-ESI (*m/z*): calcd for $C_{13}H_{19}NNaO_4$ $(M + Na)^+$: 276.1206; found: 276.1207.

4-(3-(Diisopropylamino)phenoxy)butyl diethylcarbamate (8)



Pale yellow oil (61.9 mg, 85%). ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.06 (t, J = 8.2 Hz, 1 H), 6.49 (d, J = 8.2 Hz, 1 H), 6.42 (s, 1 H), 6.31 (d, J = 7.6 Hz, 1 H), 4.14 (t, J = 6.0 Hz, 2 H), 3.97 (t, J = 6.0 Hz, 2 H), 3.81 – 3.73 (m, 2 H), 3.27 (s, 4 H), 1.87 – 1.80 (m, 4 H), 1.22 (d, J = 6.8 Hz, 12 H), 1.11 (t, J = 7.2 Hz, 6 H). ^{13}C NMR (100 MHz, $CDCl_3$) δ = 159.5, 156.0, 149.4, 128.8, 111.6, 105.4, 103.2, 67.2, 64.7, 47.5, 41.6, 41.2, 26.1, 25.9, 21.3, 14.0, 13.6. IR (KBr) = 2972, 2871, 1700, 1603, 1488, 1430, 1375, 1275, 1212, 1167, 1070, 826, 768, 698 cm^{-1}. HRMS-ESI (*m/z*): calcd for $C_{21}H_{37}N_2O_3$ $(M + H)^+$: 365.2799; found: 365.2802.

2-D-3-(4-((Diethylcarbamoyl)oxy)butoxy)phenyl trifluoromethanesulfonate (4c-D)



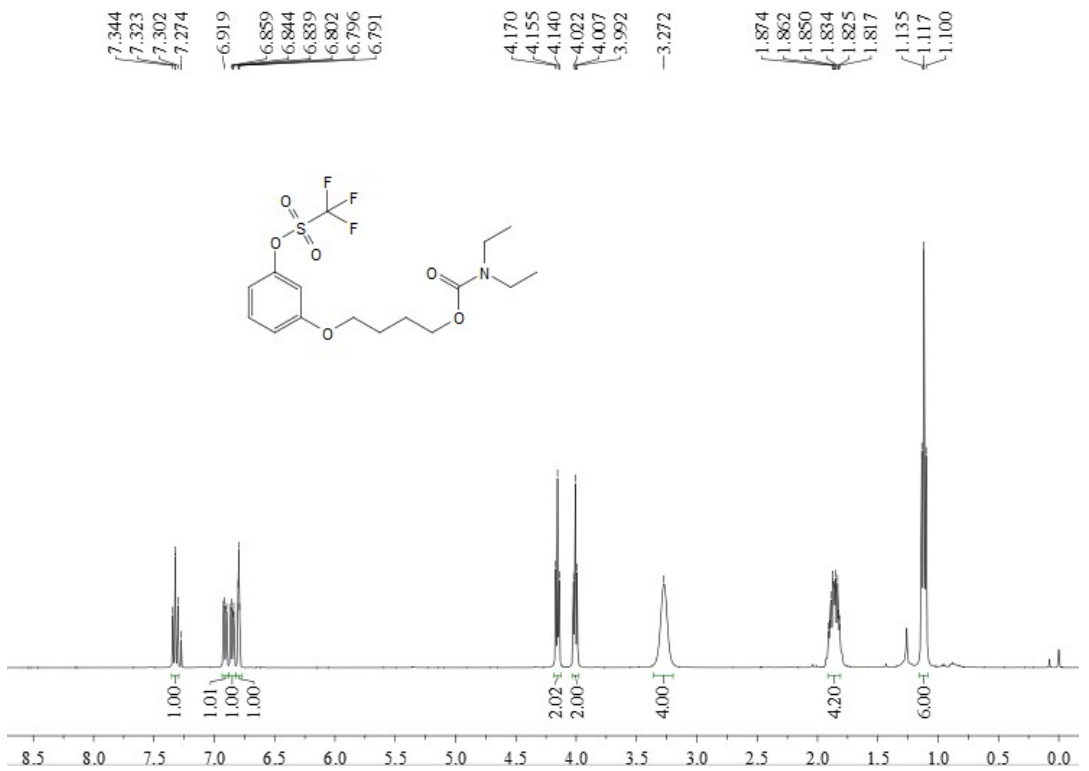
Pale yellow oil (25.4 mg, 61%). ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.32 (t, J = 8.4 Hz, 1 H), 6.91 (d, J = 8.4 Hz, 1 H), 6.85 (d, J = 8.0 Hz, 1 H), 6.80 (s, 0.07 H), 4.16 (t, J = 6.0 Hz, 2 H), 4.01 (t, J = 6.0 Hz, 2 H), 3.27 (s, 4 H), 1.92 – 1.80 (m, 4 H), 1.12 (t, J = 7.1 Hz, 6 H). ^{13}C NMR (100 MHz, CDCl3) δ = 160.2, 155.9, 150.1, 130.4, 118.7 (J = 318.7 Hz), 114.6, 113.1, 68.0, 64.4, 41.7, 41.2, 25.8, 13.9, 13.6. ^{19}F NMR (376 MHz, $CDCl_3$) δ = -72.96. IR (KBr) = 2966, 2933, 1699, 1607, 1471, 1425, 1272, 1215, 1174, 1143, 1066, 1019, 854, 788, 606, 511 cm^{-1}. HRMS-ESI (*m/z*): calcd for $C_{16}H_{21}DF_3NNaO_6S$ $(M + Na)^+$: 437.1075; found: 437.1074.

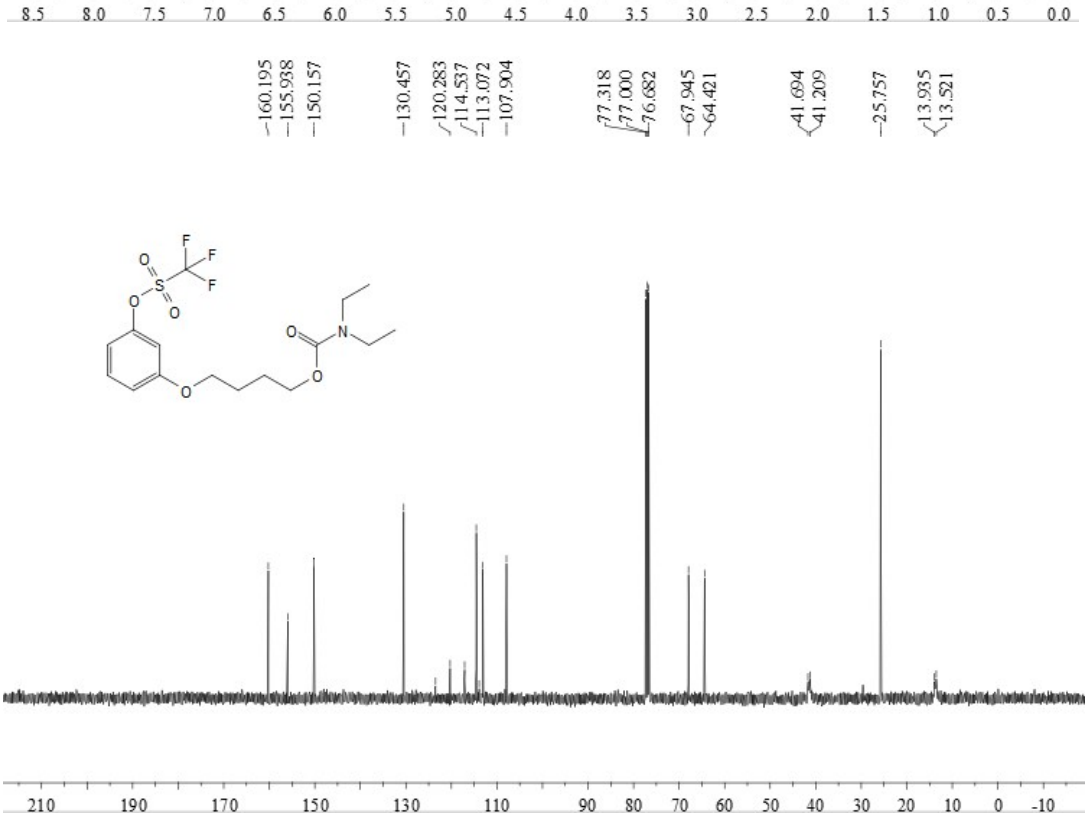
References:

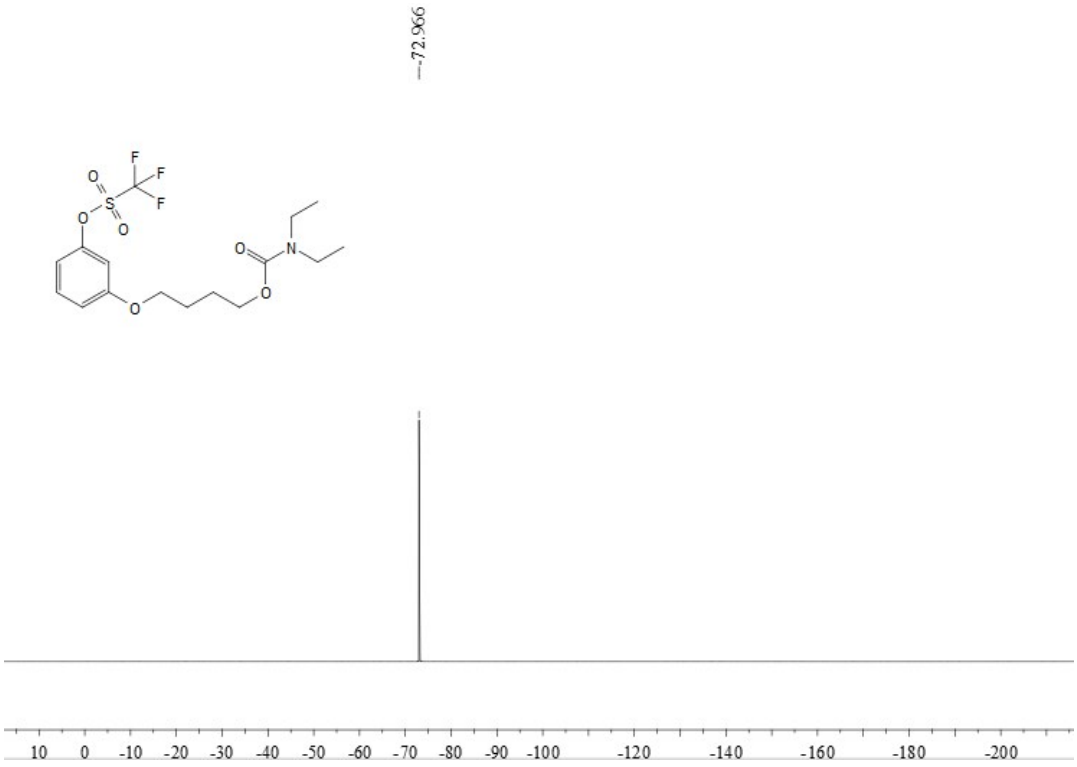
1. L. Li, D. Qiu, J. Shi, Y. Li, *Org. Lett.* 2016, **18**, 3726.

I. NMR Spetra.

3-(4-((Diethylcarbamoyl)oxy)butoxy)phenyl trifluoromethanesulfonate) (4c)






-72.966
F
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F
O
S
O
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O
N
O
O
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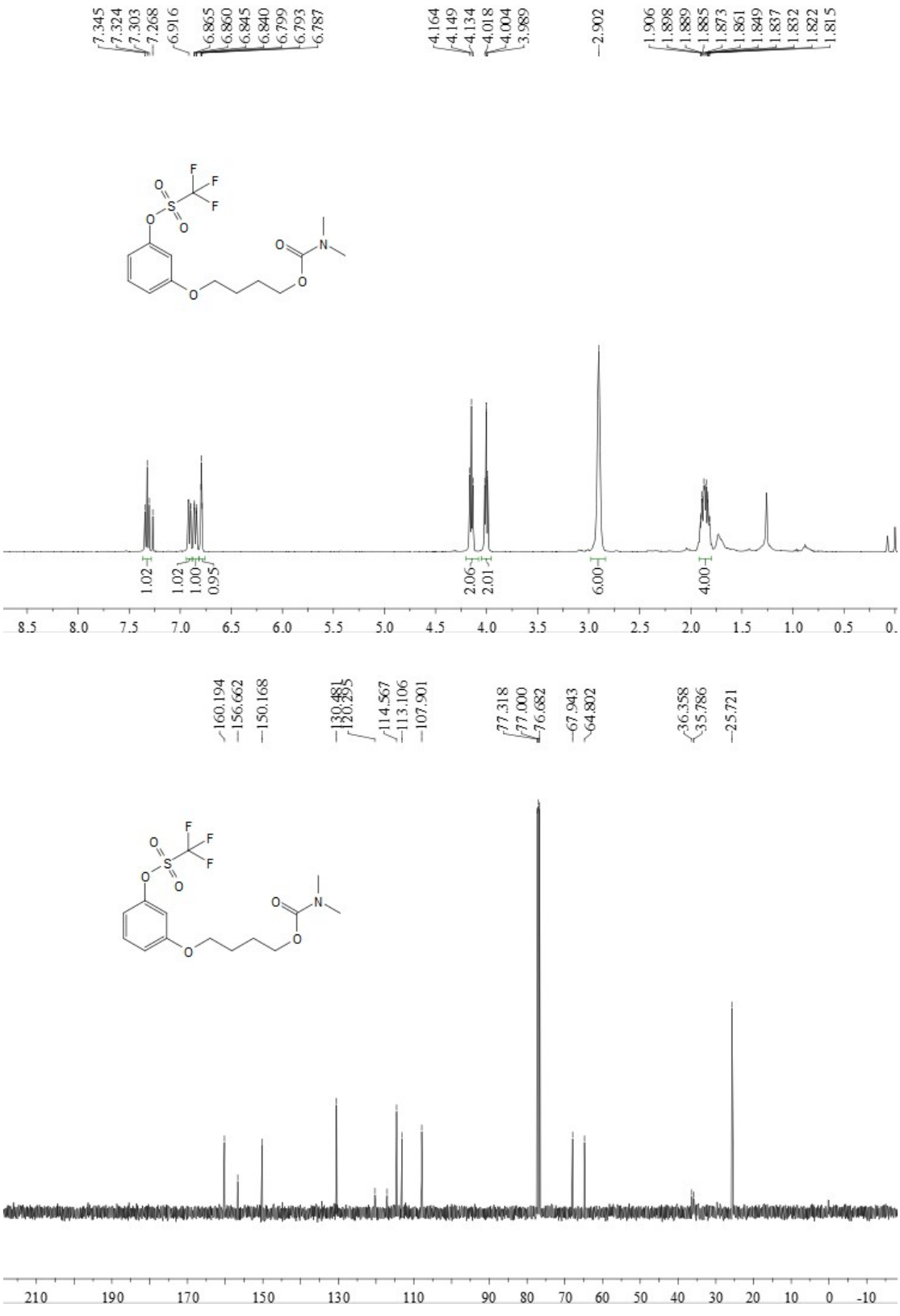
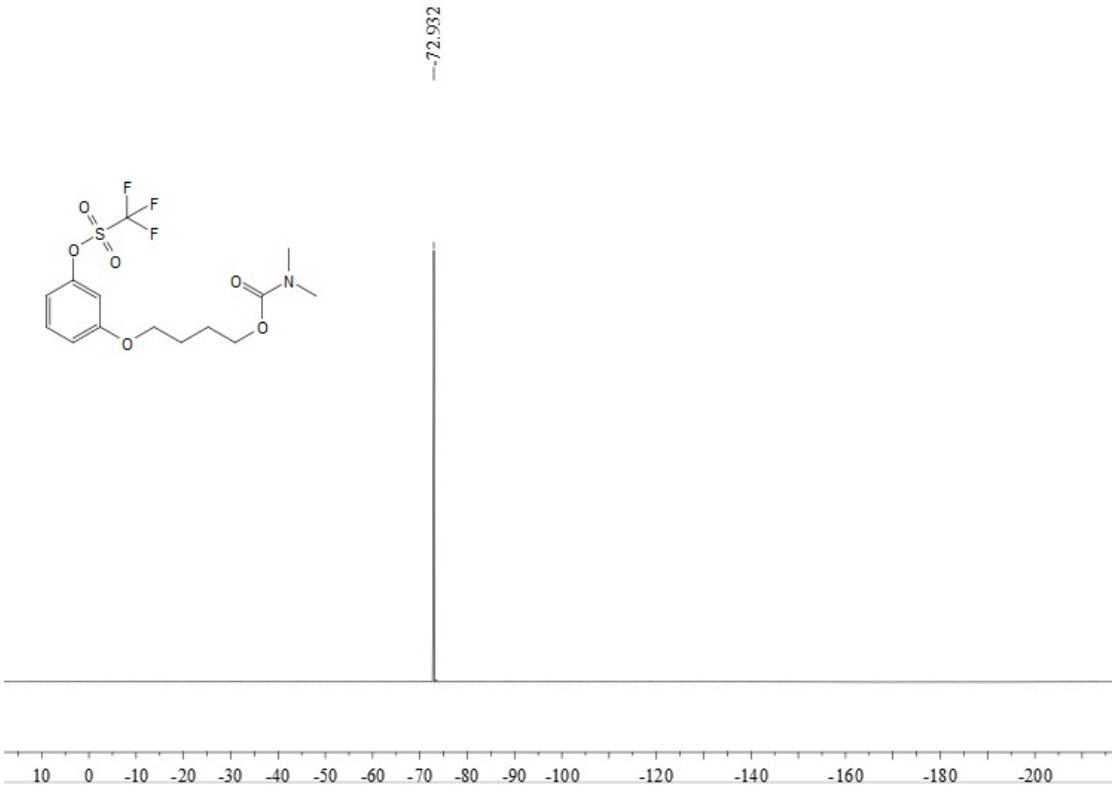
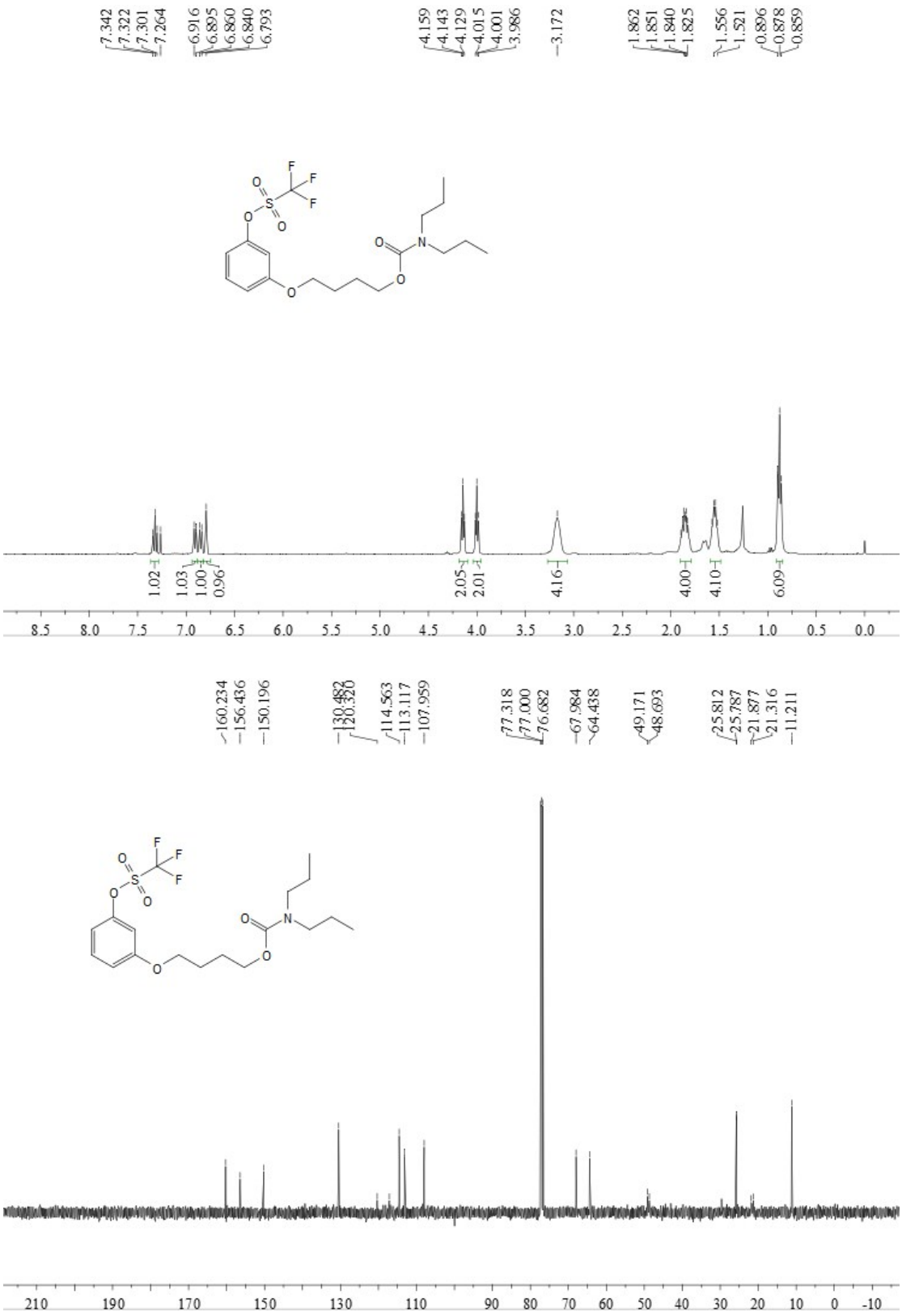
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-120
-140
-160
-180
-200

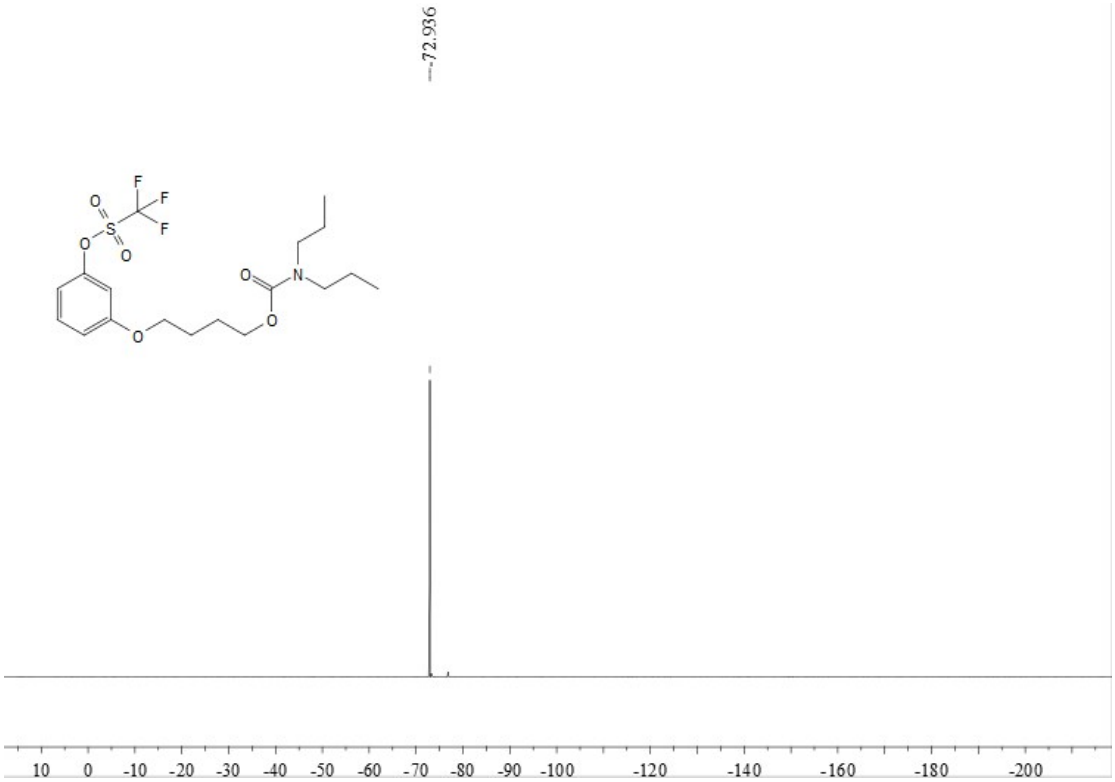
3-(4-((Dimethylcarbamoyl)oxy)butoxy)phenyl trifluoromethanesulfonate (4d)




-72.932
10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -120 -140 -160 -180 -200

3-(4-((Dipropylcarbamoyl)oxy)butoxy)phenyl trifluoromethanesulfonate (4e)

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O
S
O
O
O
N
O
O
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0
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-20
-30
-40
-50
-60
-70
-80
-90
-100
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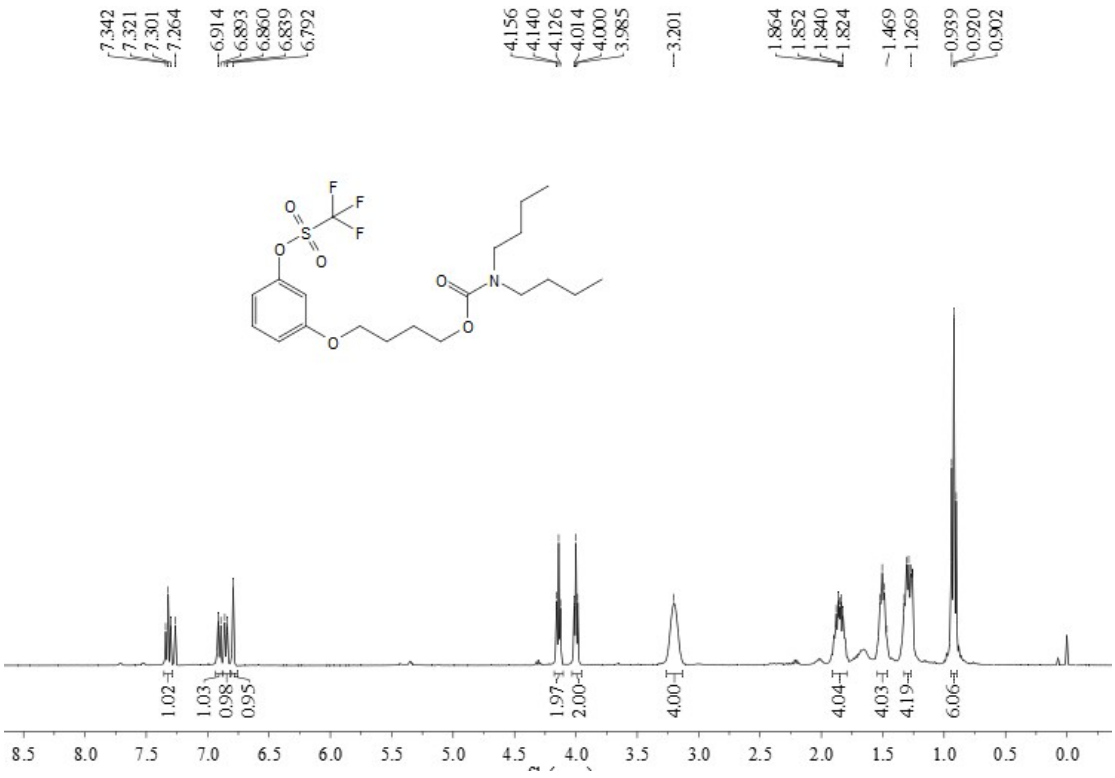
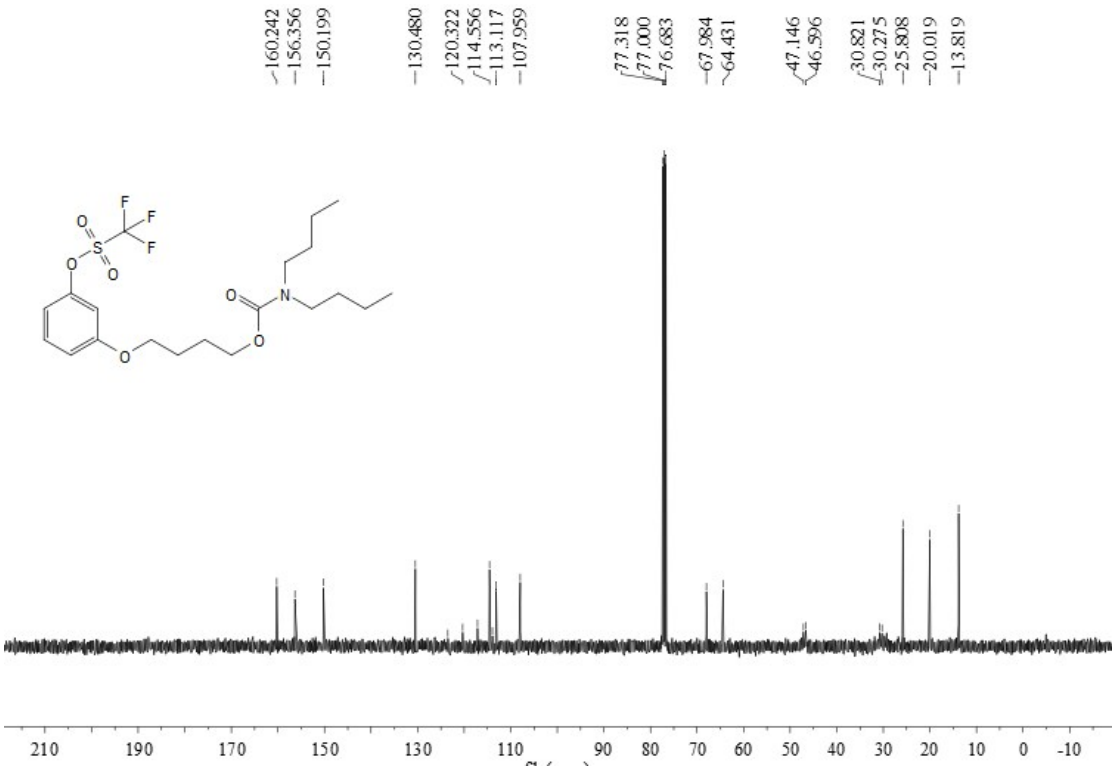
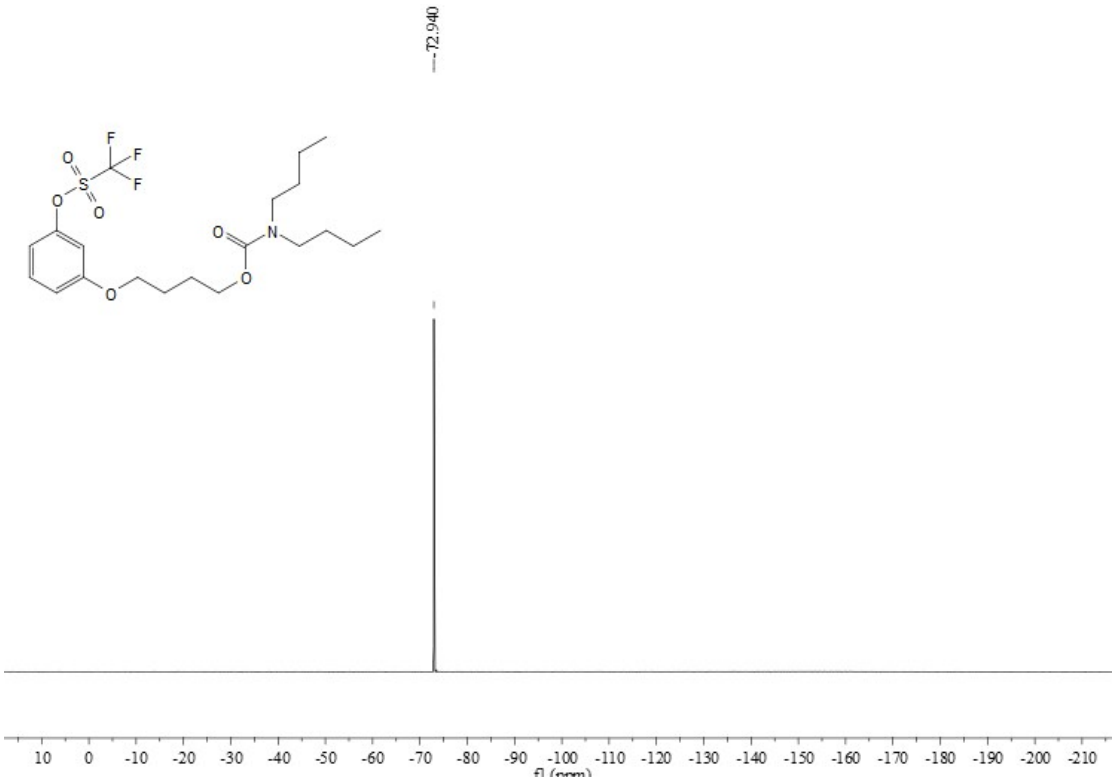
-140
-160
-180
-200

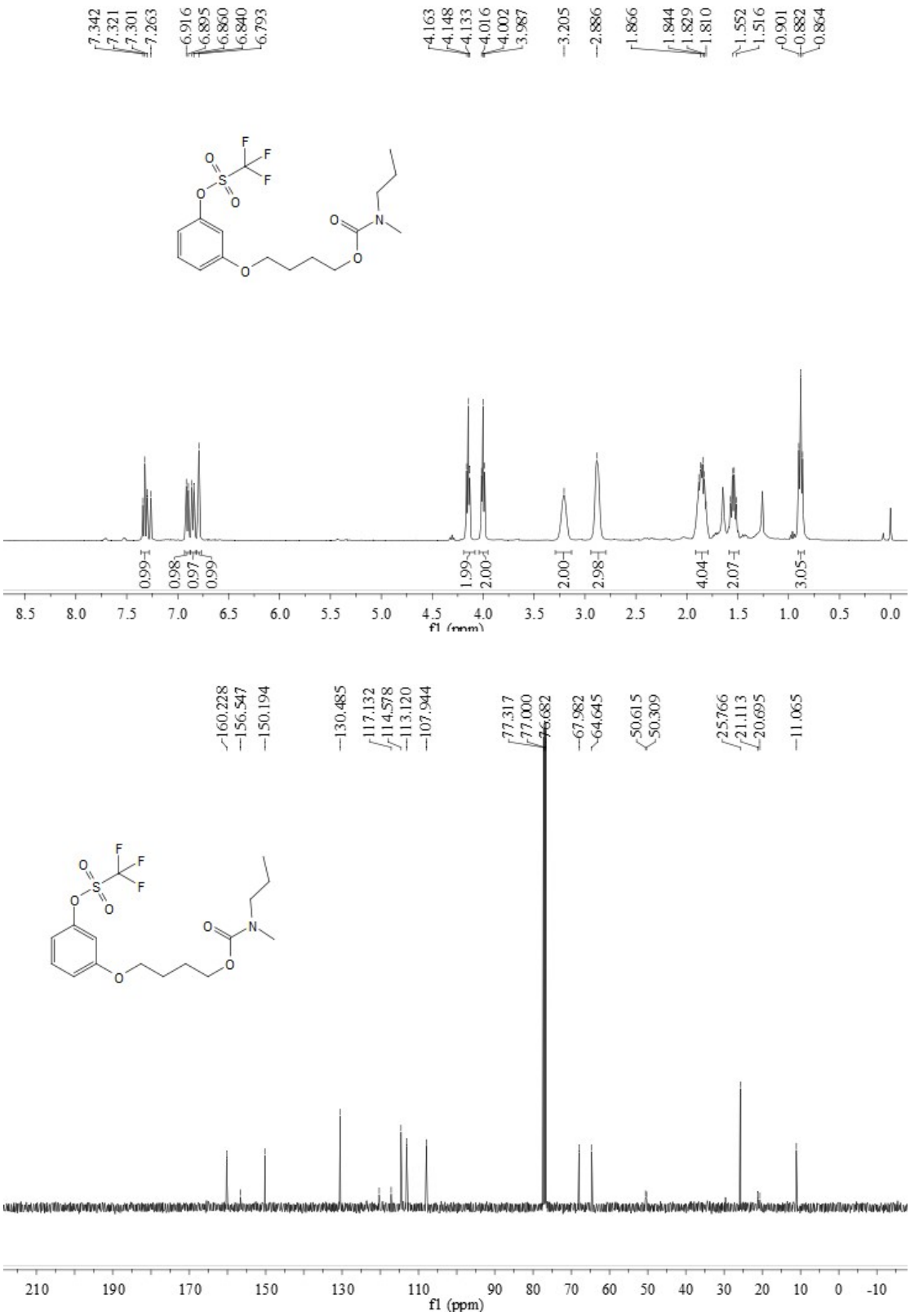
3-(4-((Dibutylcarbamoyl)oxy)butoxy)phenyl trifluoromethanesulfonate (4f)

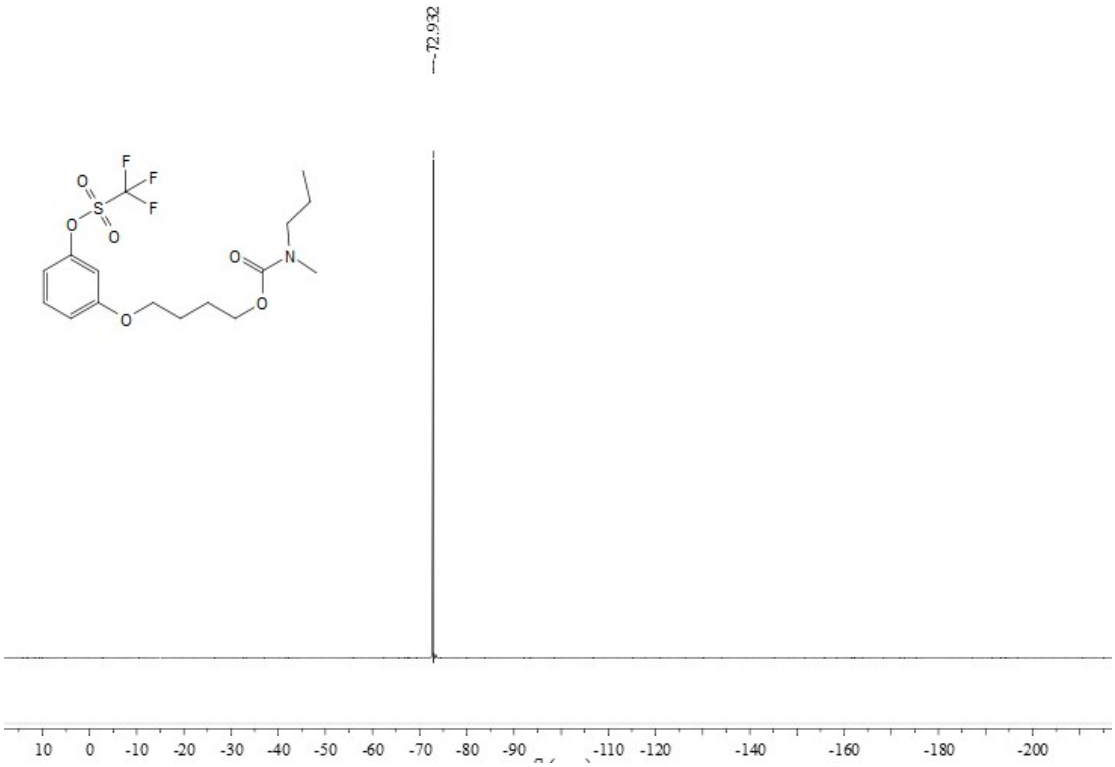




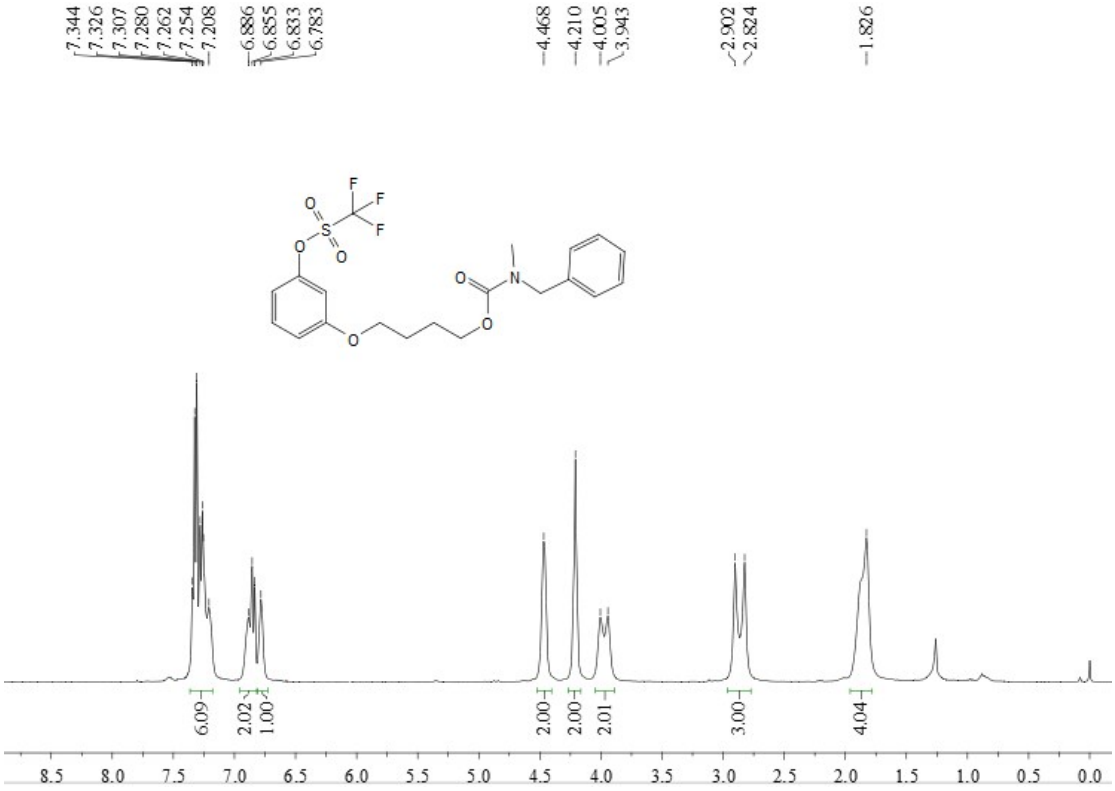

-72.940
F
F
F
O
S
O
O
O
N
O
O
10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210
f1 (ppm)

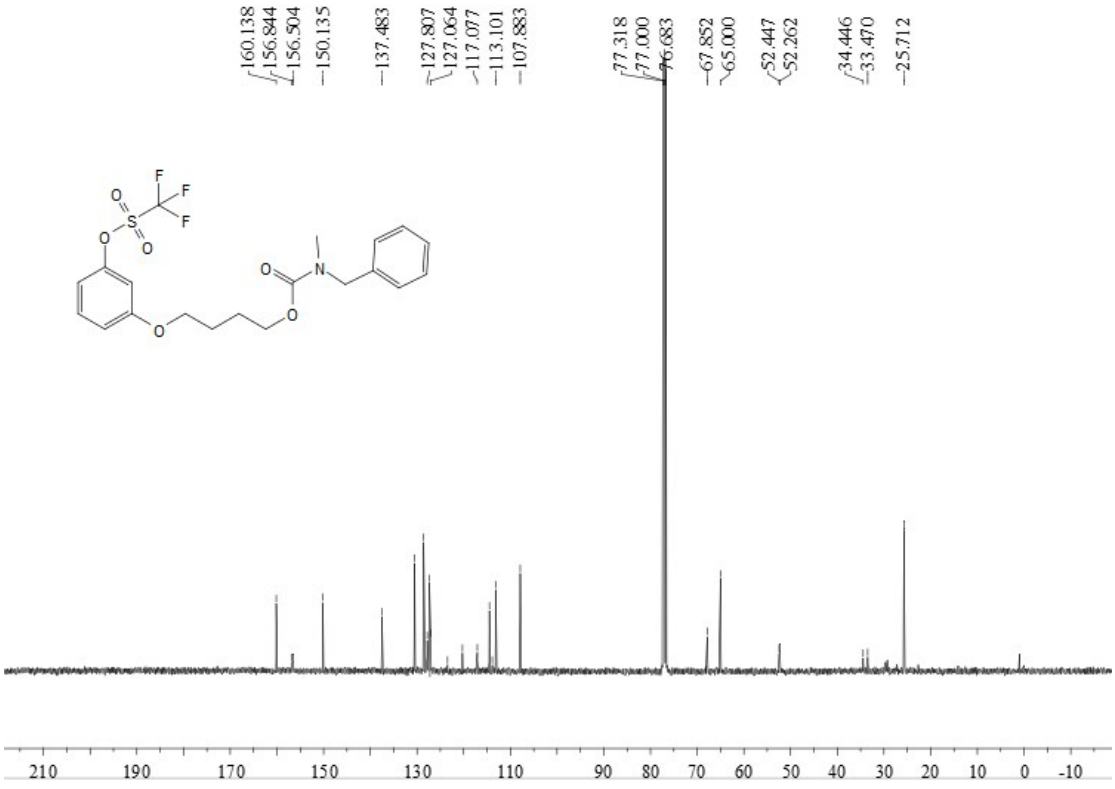
3-(4-((Methyl(propyl)carbamoyl)oxy)butoxy)phenyl trifluoromethanesulfonate (4g)

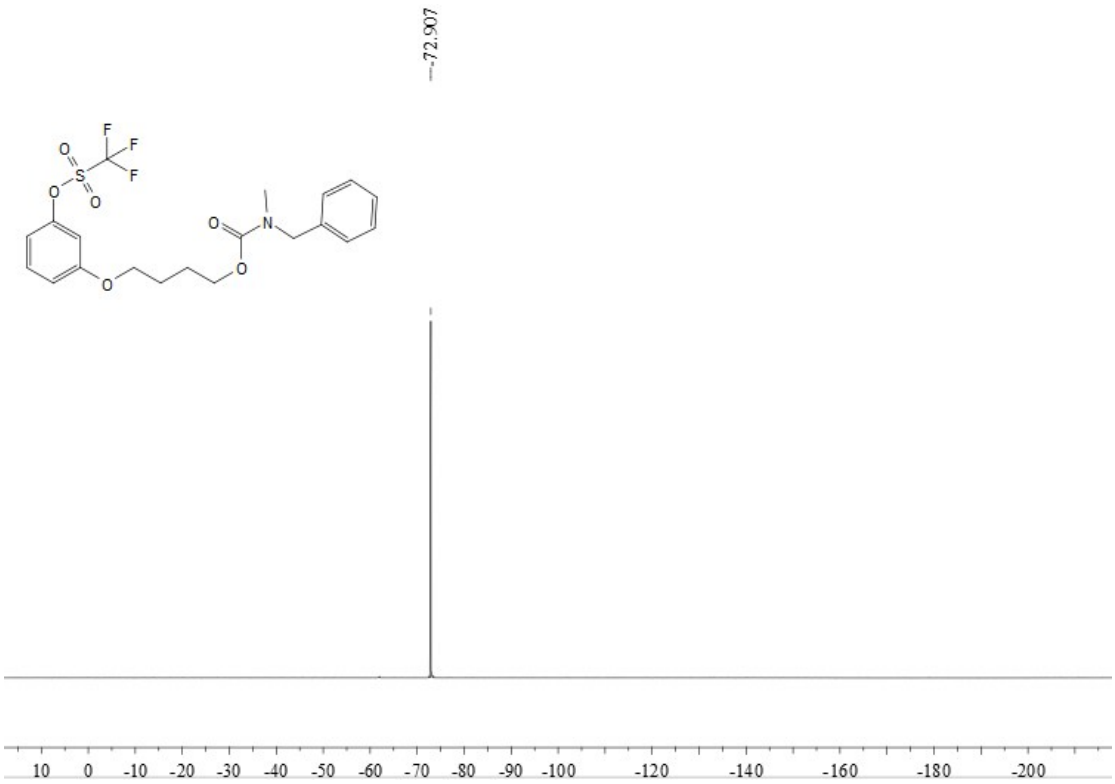



-72.932
F
F
F
O
S
O
O
O
O
N
O
O
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-110
-120
-140
-160
-180
-200

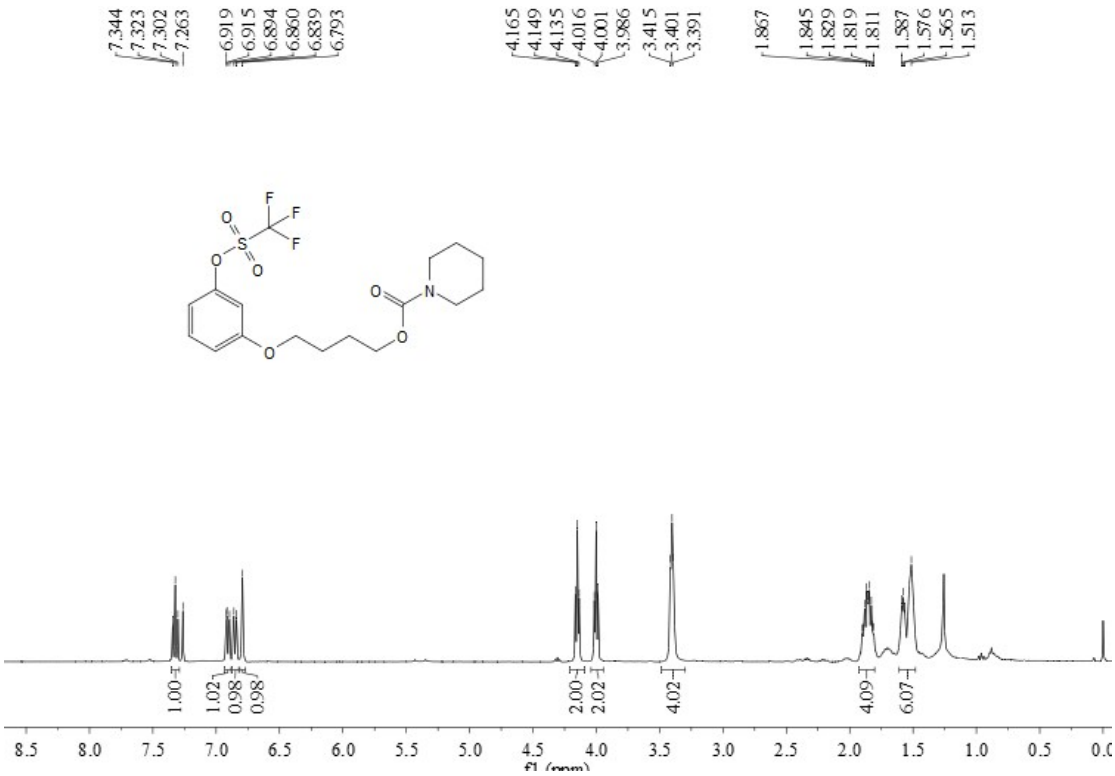
3-(4-((Benzyl(methyl)carbamoyl)oxy)butoxy)phenyl trifluoromethanesulfonate (4h)

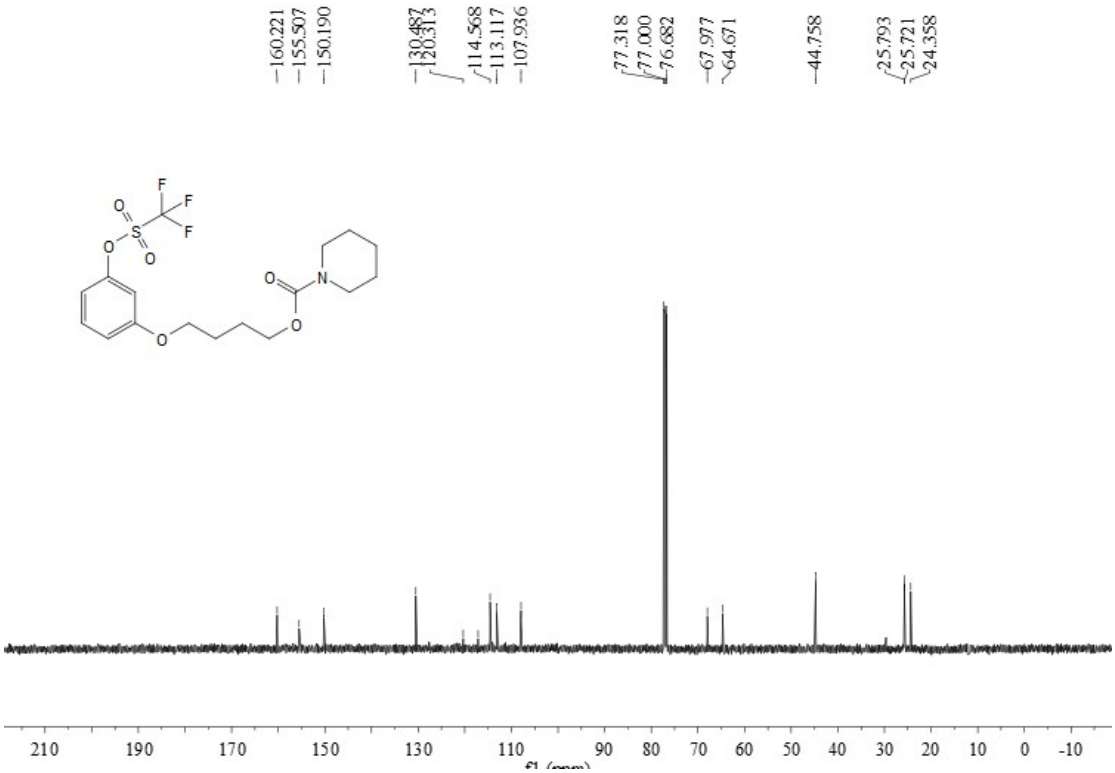


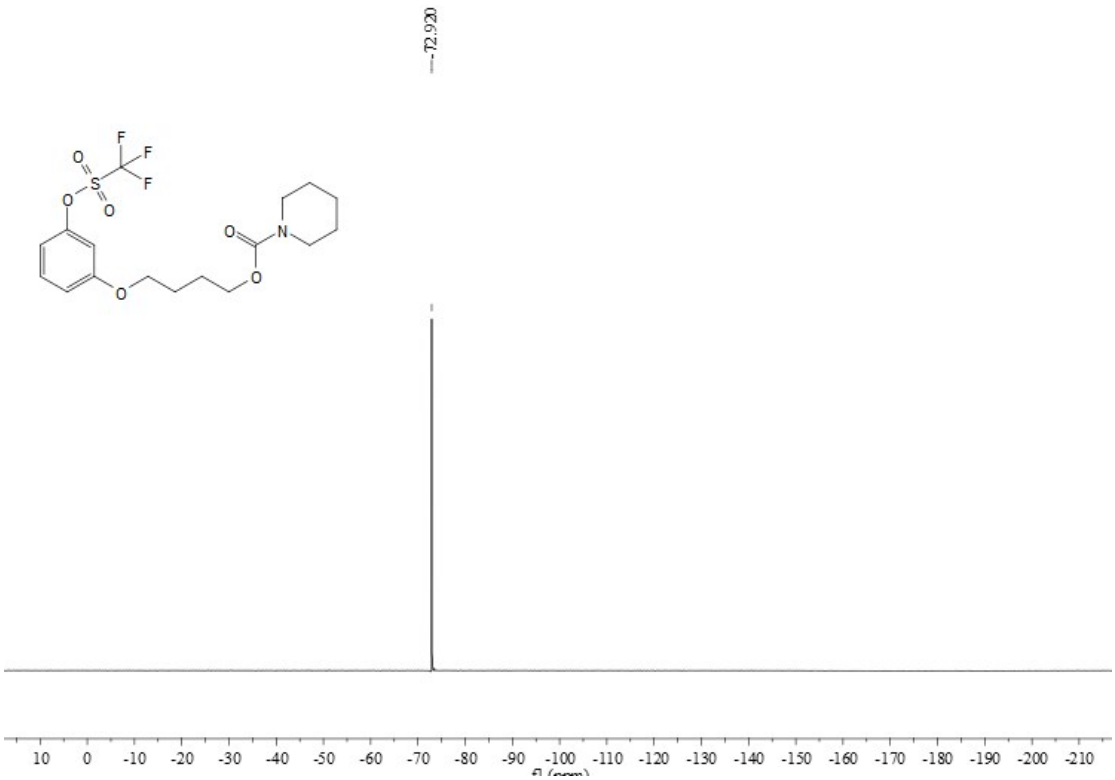



-72.907
10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -120 -140 -160 -180 -200

4-(3-(((Trifluoromethyl)sulfonyl)oxy)phenoxy)butyl piperidine-1-carboxylate (4i)



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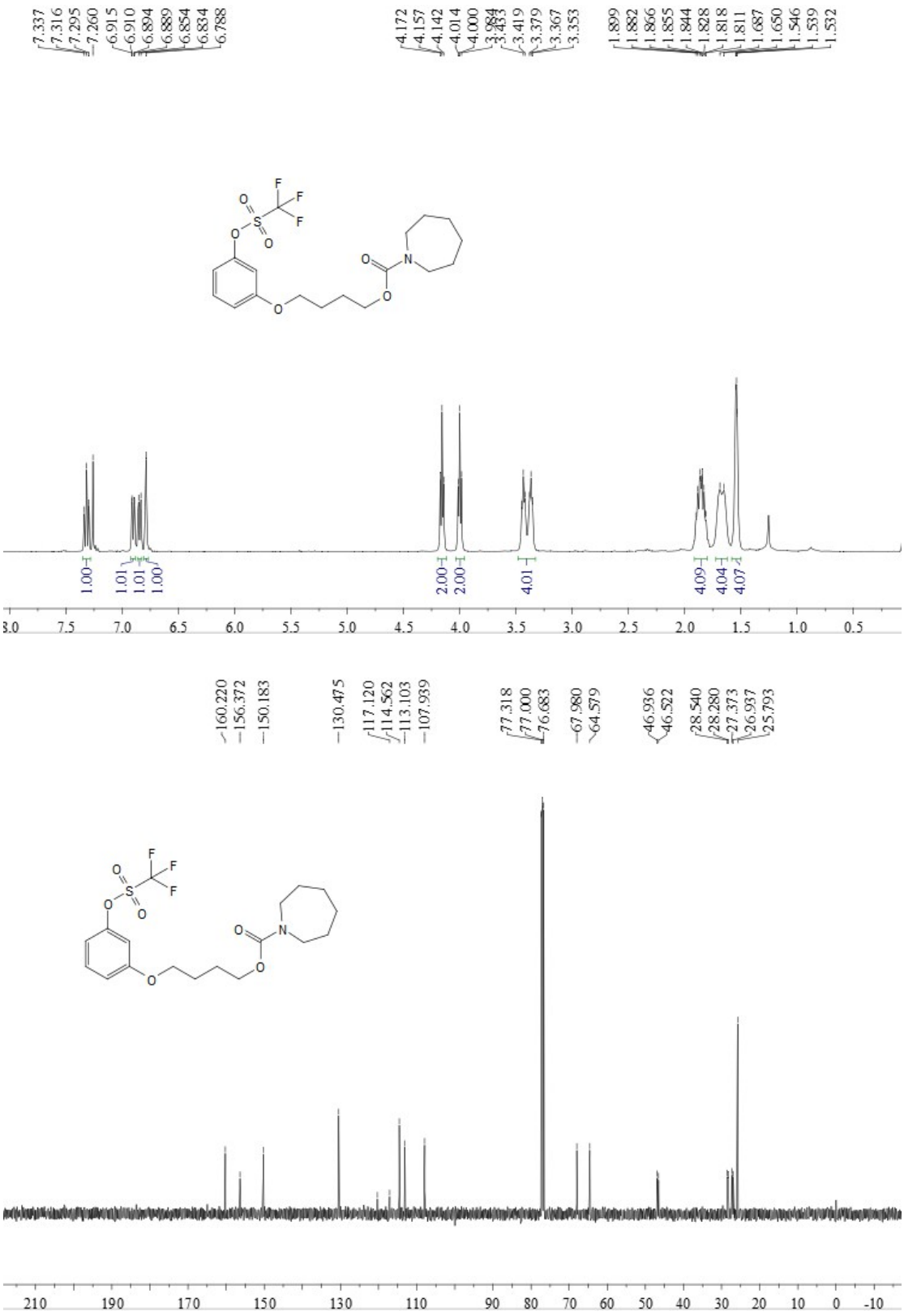
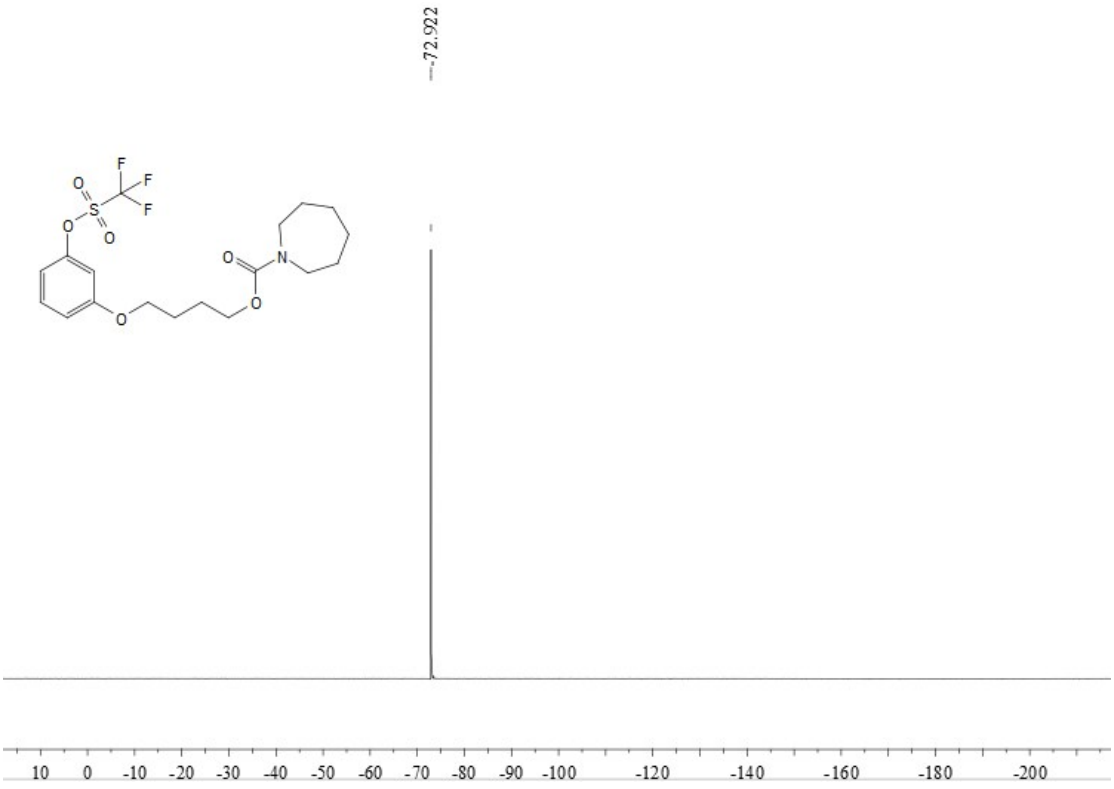
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200
-210

4-(3-(((Trifluoromethyl)sulfonyl)oxy)phenoxy)butyl azepane-1-carboxylate (4j)

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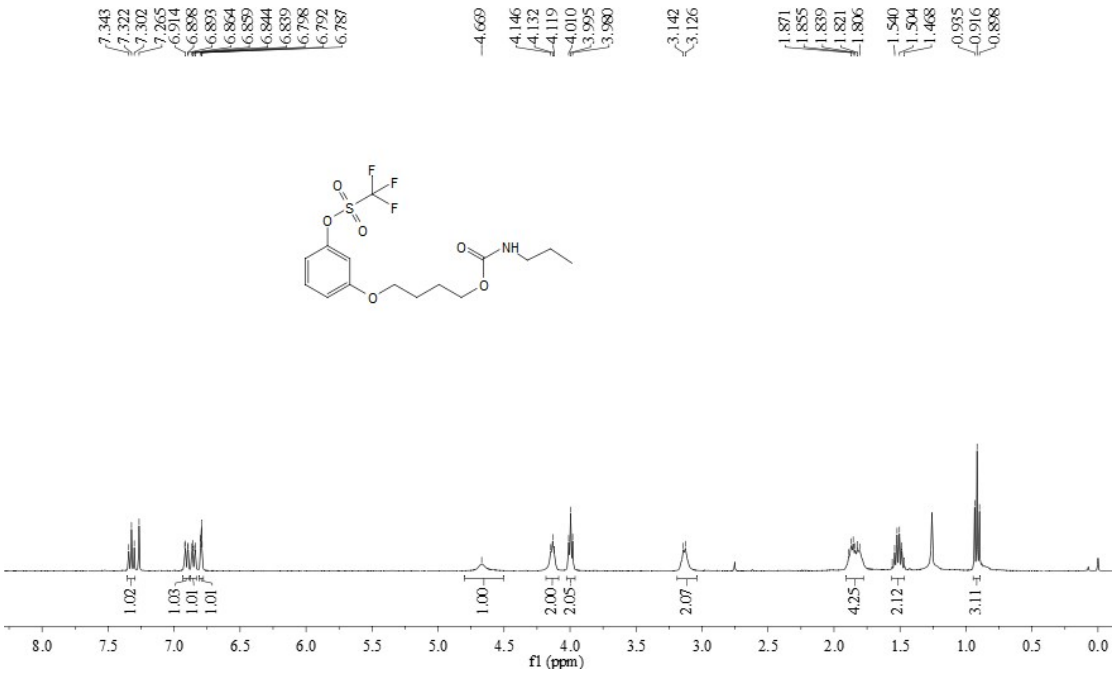
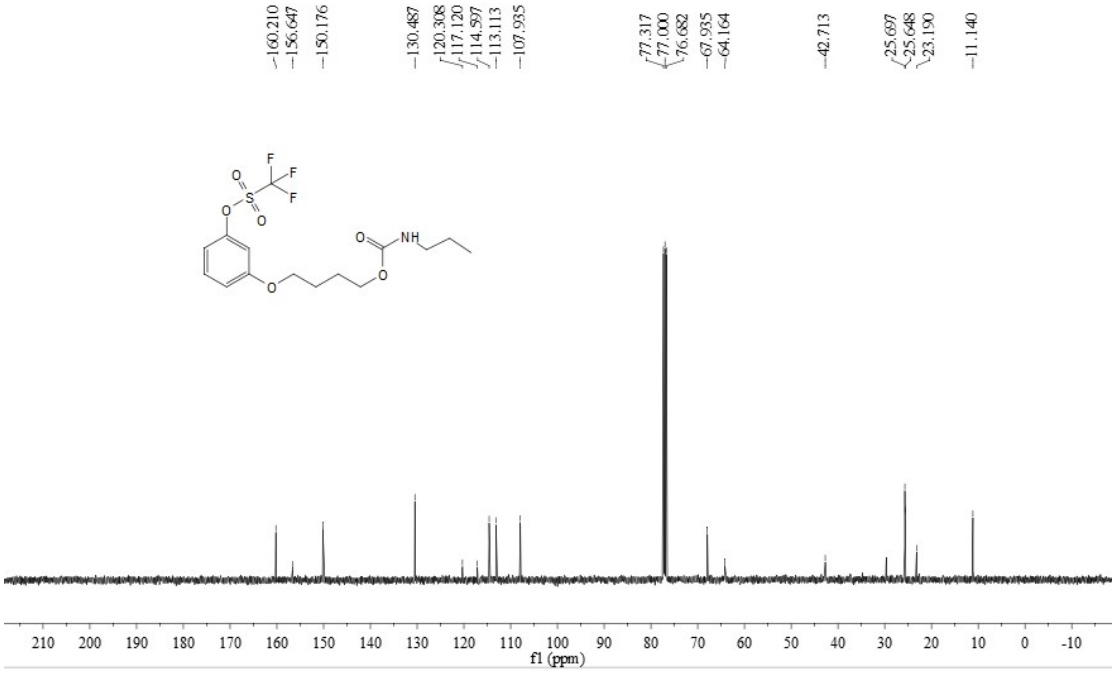
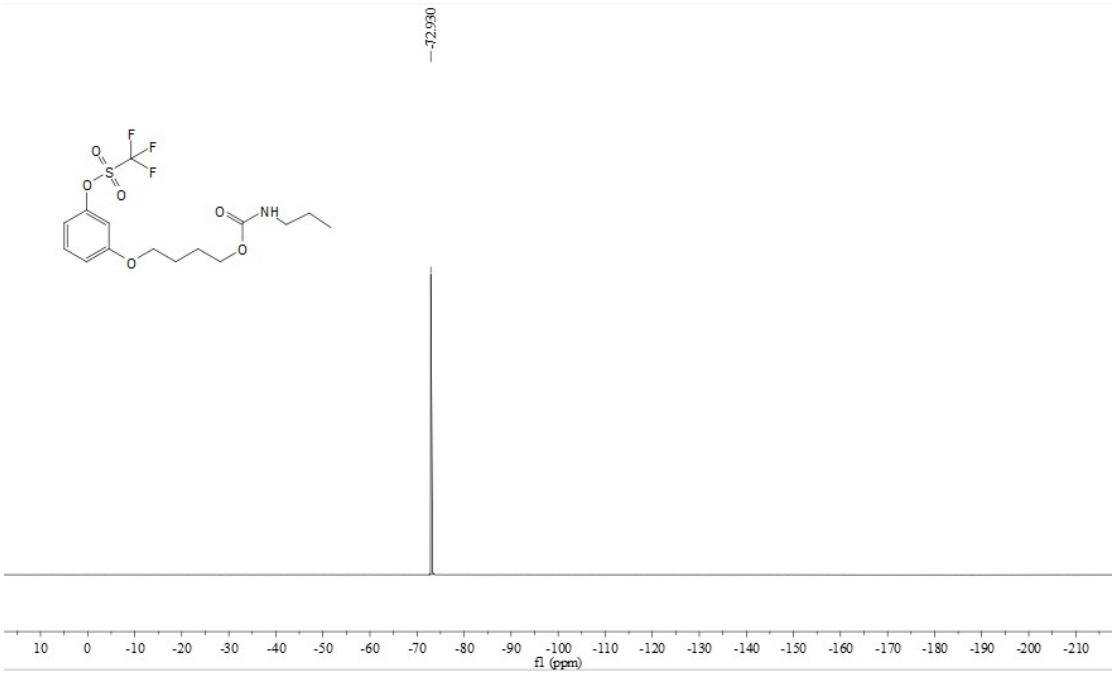
3-(4-((Propylcarbamoyl)oxy)butoxy)phenyl trifluoromethanesulfonate (4k)



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F
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S
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NH
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-100
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-130
-140
-150
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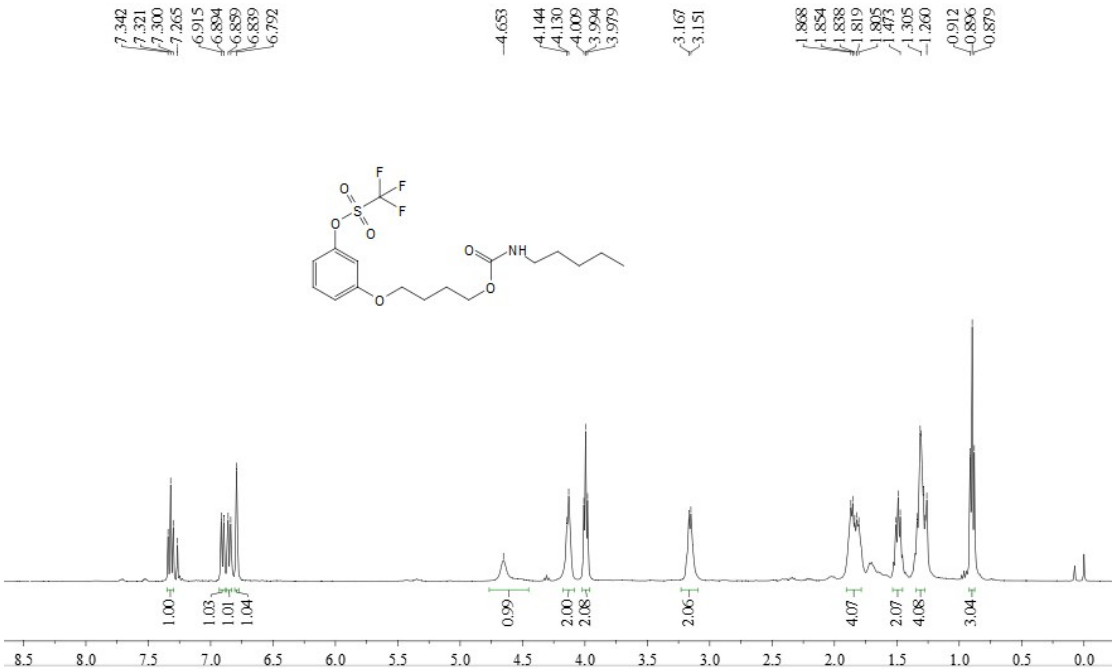
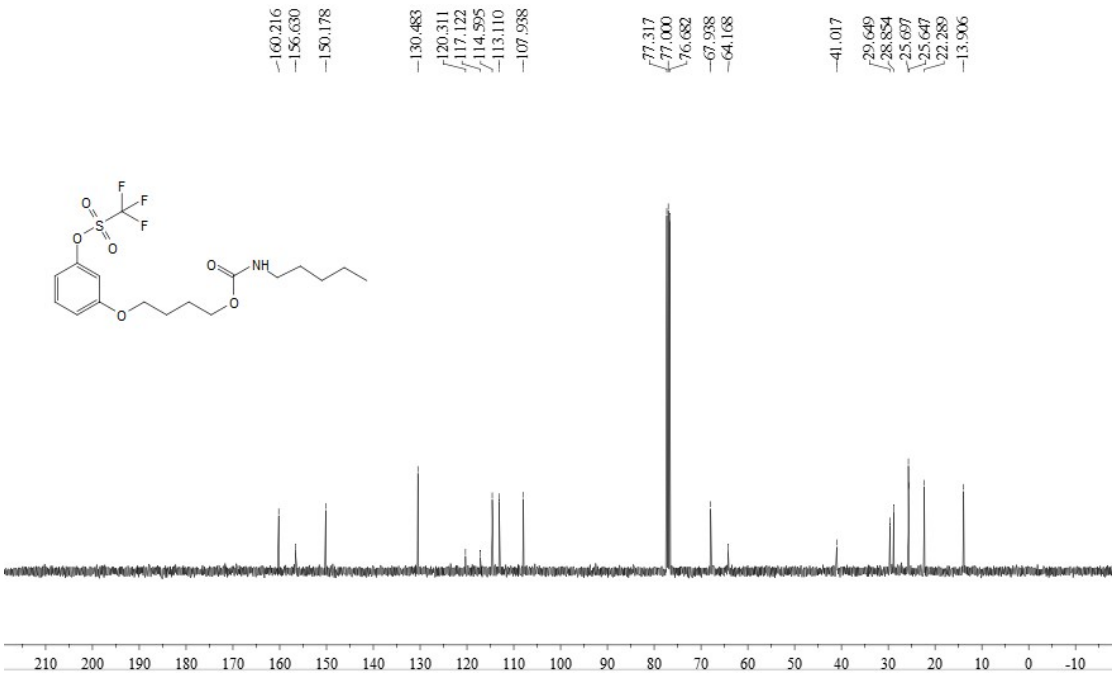
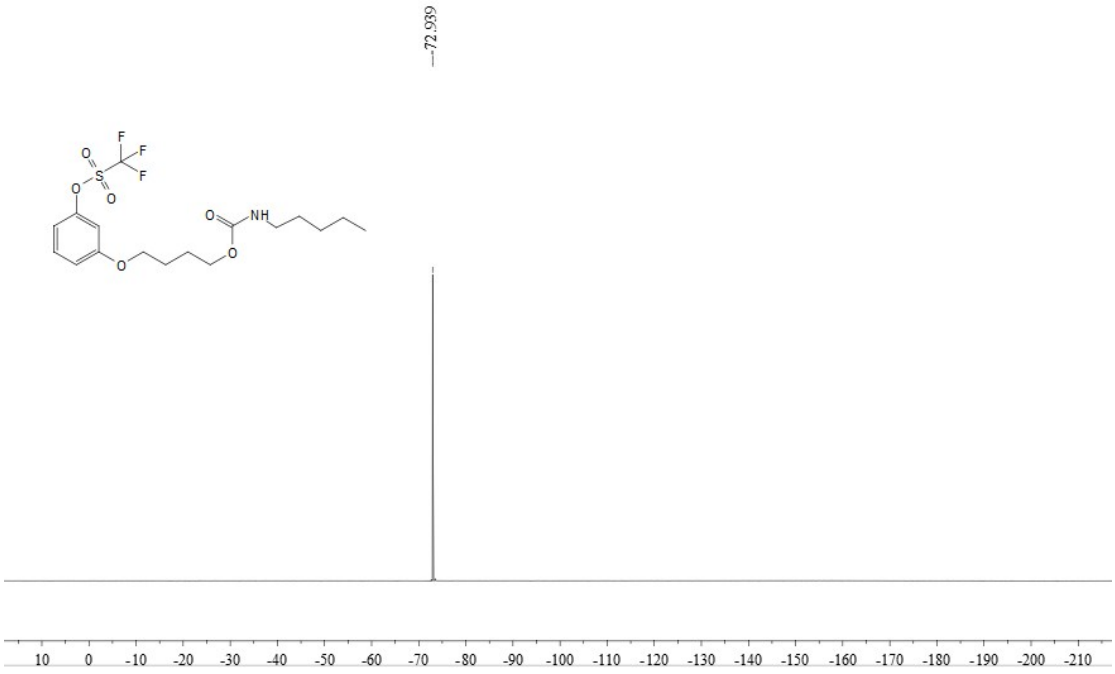
f1 (ppm)

3-(4-((Pentylcarbamoyl)oxy)butoxy)phenyl trifluoromethanesulfonate (4l)







3-(4-((Cyclopentylcarbamoyl)oxy)butoxy)phenyl trifluoromethanesulfonate (4m)


7.344
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7.302
7.266
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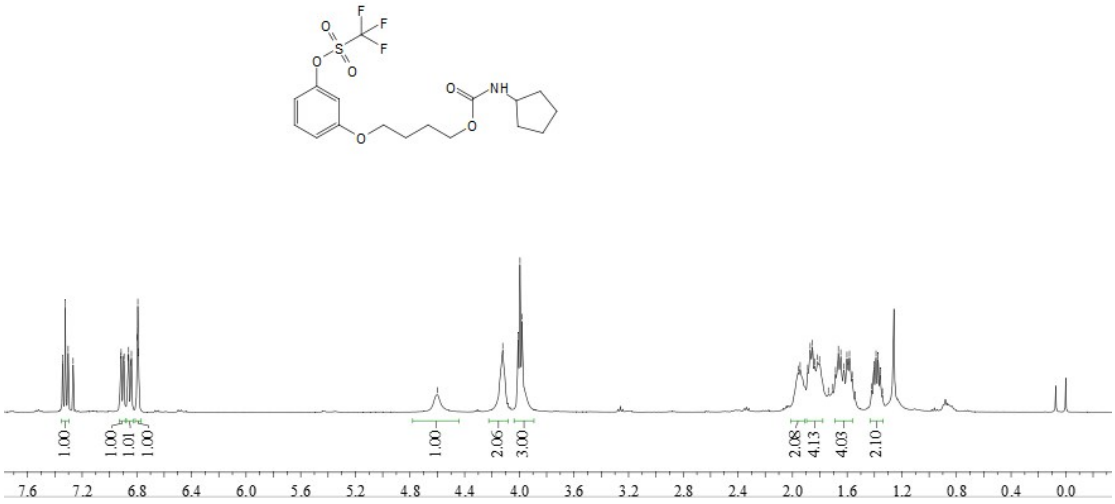
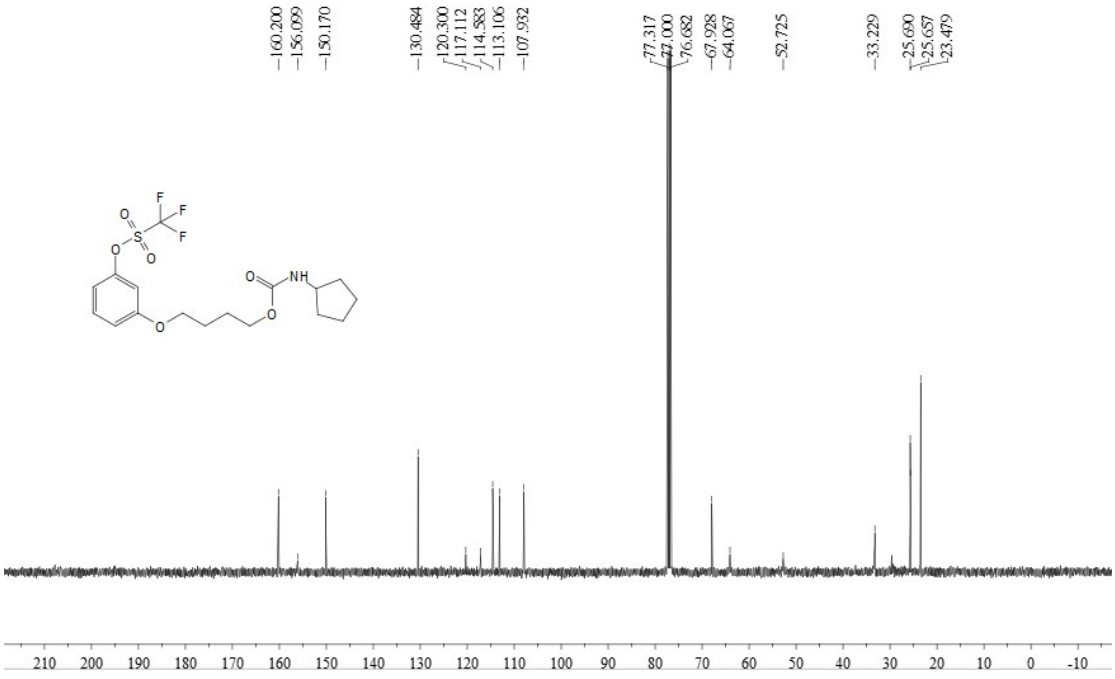
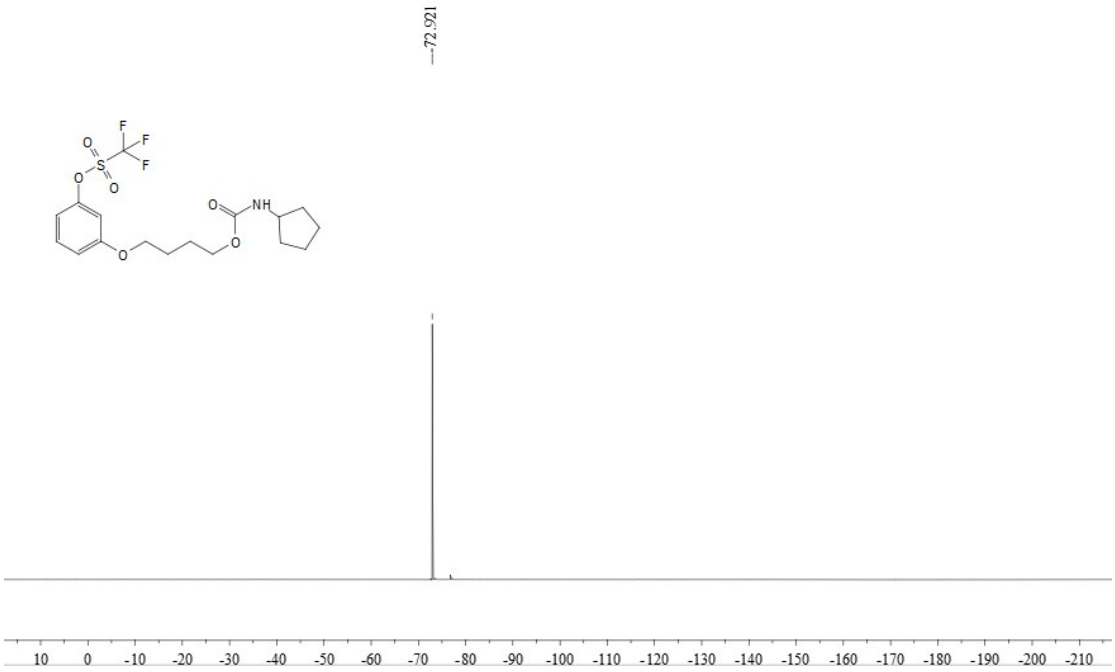
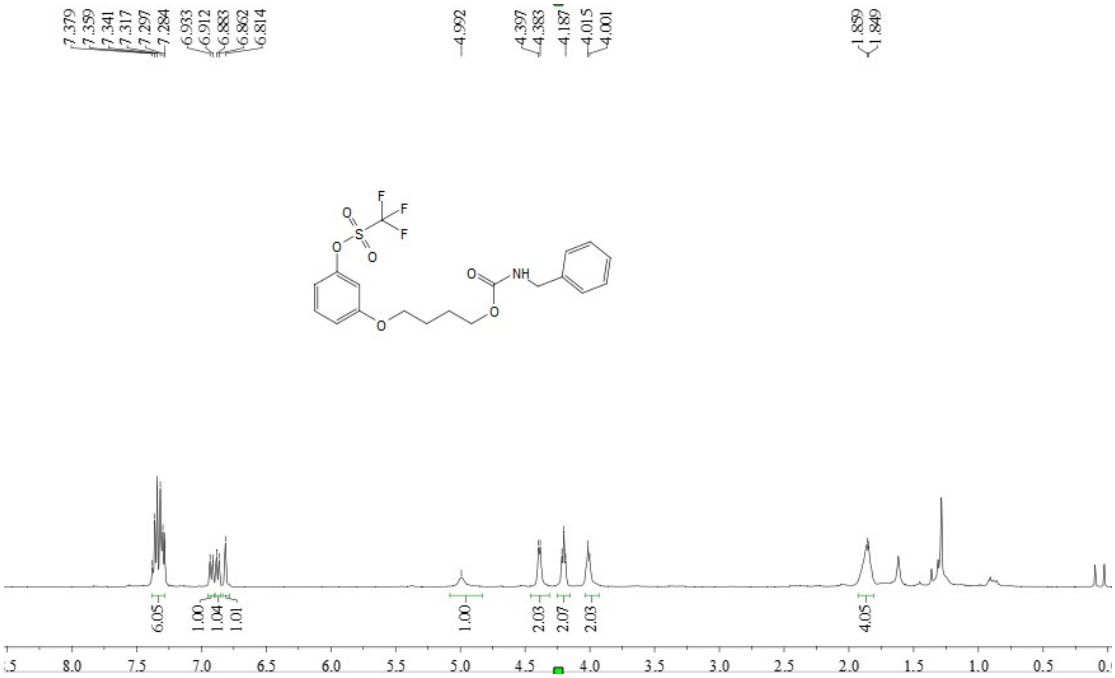
6.914
6.899
6.883
6.865
6.860
6.845
6.839
6.798
6.793
6.787
4.600
4.122
4.009
3.995
3.980
1.999
1.944
1.888
1.870
1.855
1.839
1.817
1.803
1.738
1.704
1.685
1.665
1.647
1.626
1.602
1.593
1.583
1.563
1.542
1.420
1.404
1.389
1.373
1.358
1.342

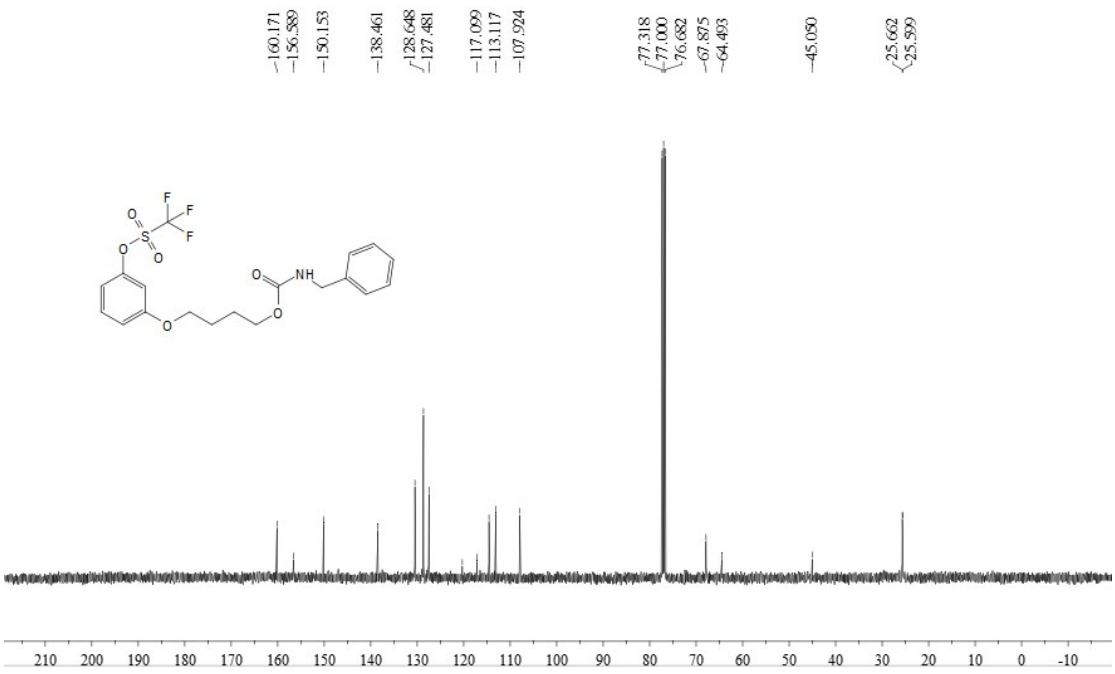

1.00
1.00
1.01
1.00
1.00
2.06
3.00
2.08
4.13
4.03
2.10
7.6
7.2
6.8
6.4
6.0
5.6
5.2
4.8
4.4
4.0
3.6
3.2
2.8
2.4
2.0
1.6
1.2
0.8
0.4
0.0

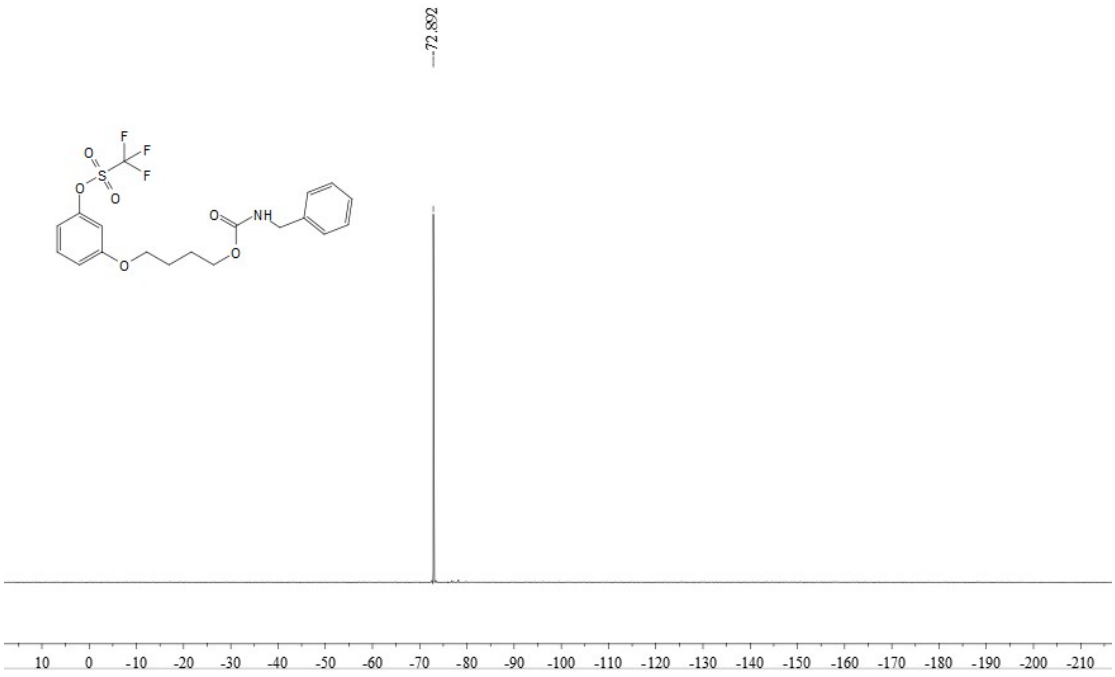

160.200
156.099
150.170
130.484
120.300
117.112
114.383
113.106
107.932
77.317
77.000
76.682
67.928
64.067
52.725
33.229
25.690
25.657
23.479
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10



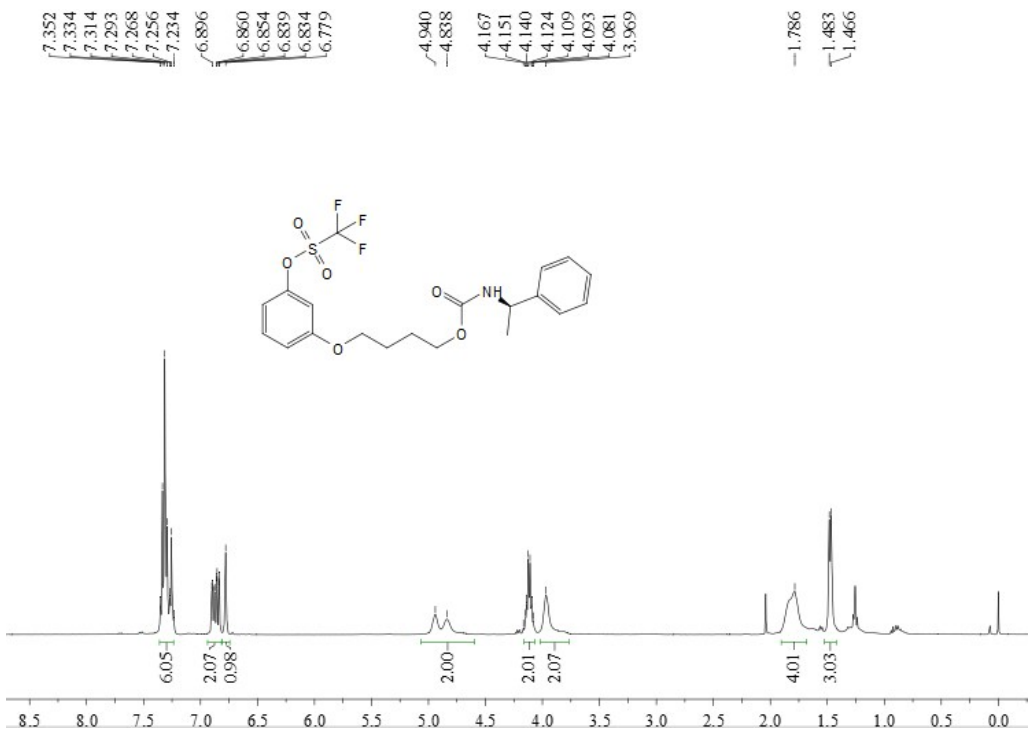
3-(4-((Benzylcarbamoyl)oxy)butoxy)phenyl trifluoromethanesulfonate (4n)

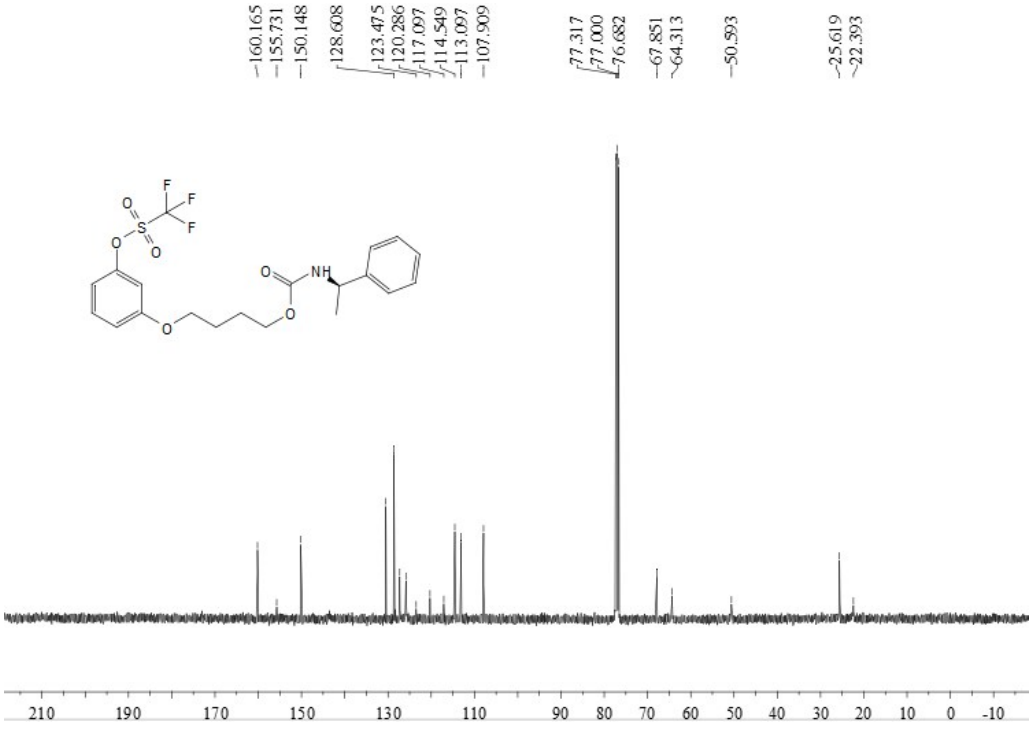

7.379
7.359
7.341
7.317
7.297
7.284
6.933
6.912
6.883
6.862
6.814
4.992
4.397
4.383
4.187
4.015
4.001
1.859
1.849
F
F
F
O
S
O
O
O
NH
O
O
6.05
1.00
1.04
1.01
1.00
2.03
2.07
2.03
4.05
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5

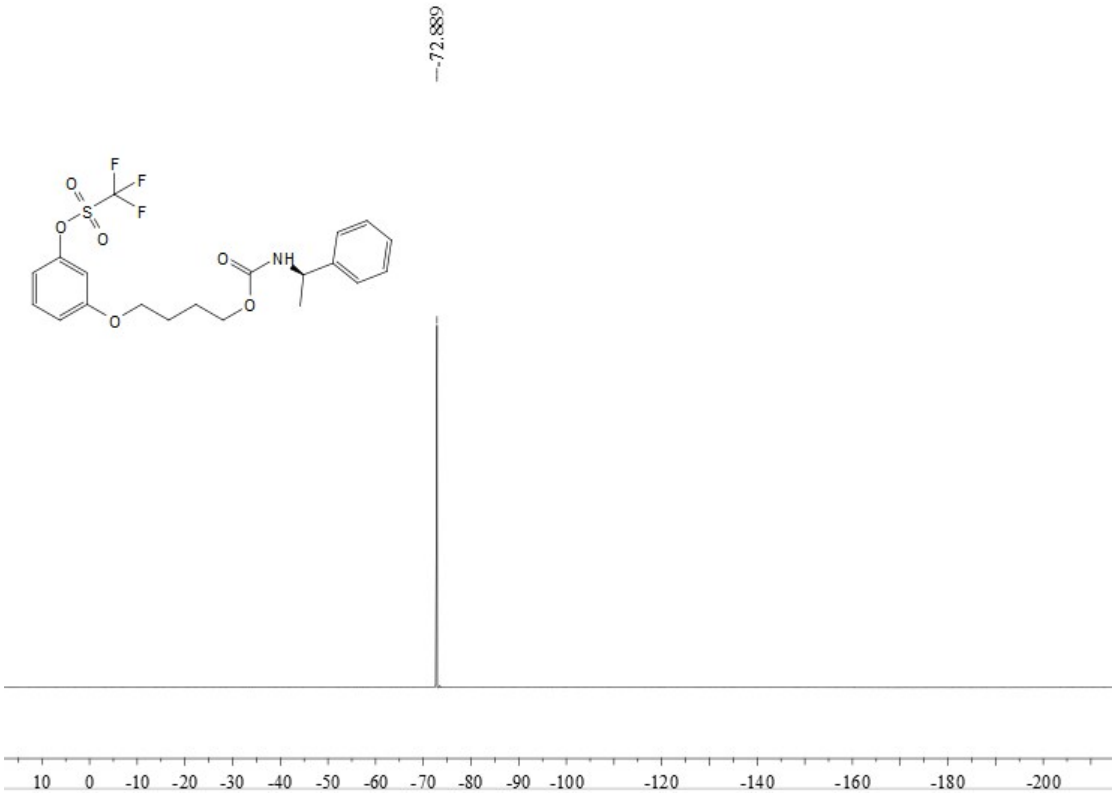

160.171
156.389
150.153
138.461
128.648
127.481
117.099
113.117
107.924
77.318
77.000
76.682
67.875
64.493
45.050
25.662
25.599
F
F
F
O
S
O
O
O
NH
O
O
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10



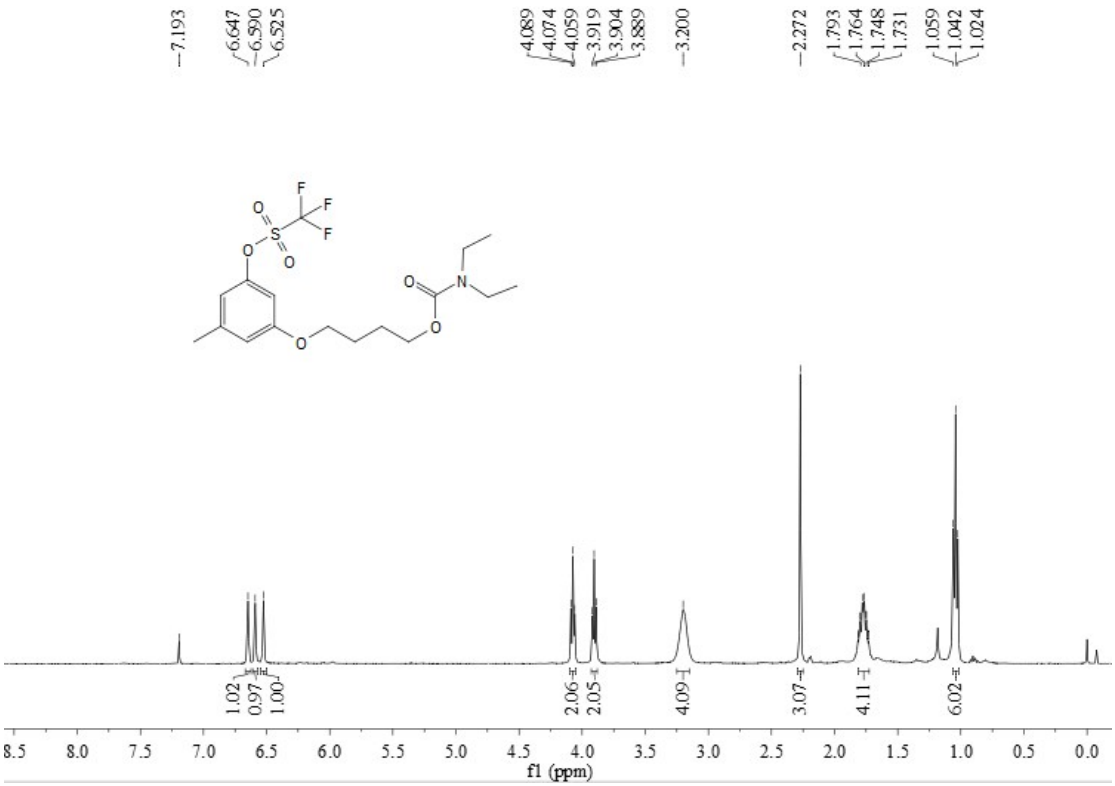
(R)-3-(4-(((1-Phenylethyl)carbamoyl)oxy)butoxy)phenyl trifluoromethanesulfonate (4o)

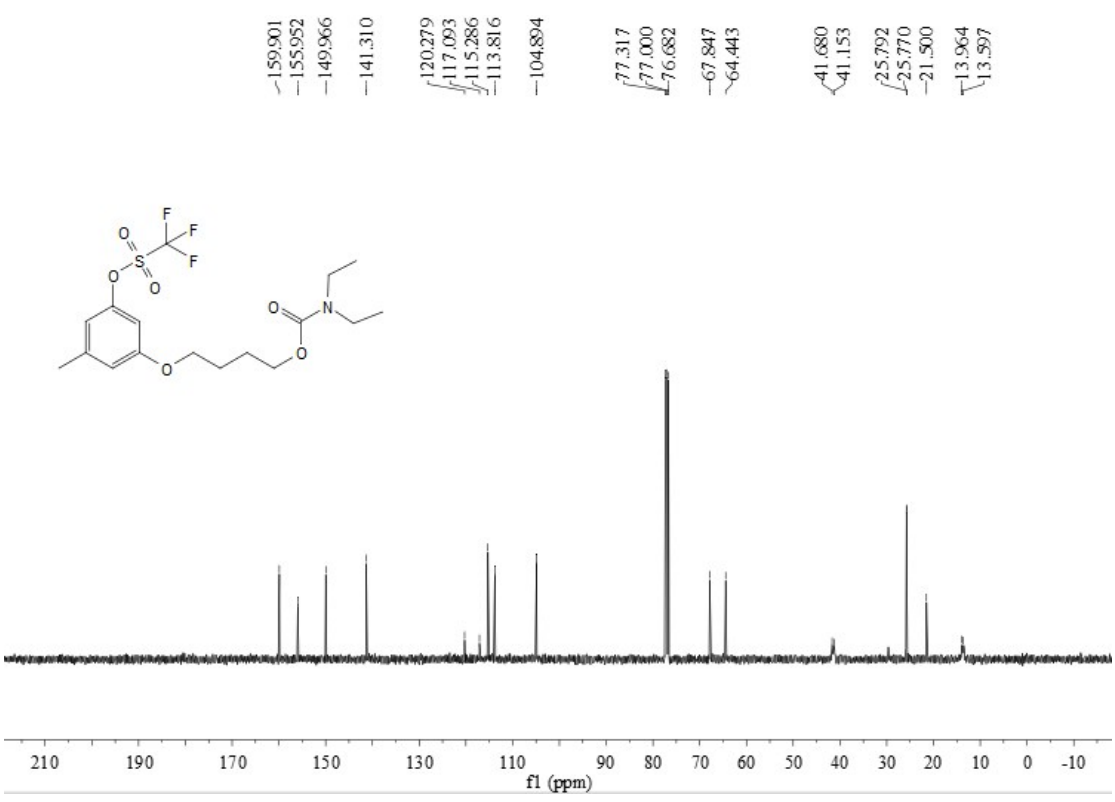

7.352
7.334
7.314
7.293
7.268
7.256
7.234
6.896
6.860
6.854
6.839
6.834
6.779
4.940
4.838
4.167
4.151
4.140
4.124
4.109
4.093
4.081
3.969
1.786
1.483
1.466
6.05
2.07
0.98
2.00
2.01
2.07
4.01
3.03
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0

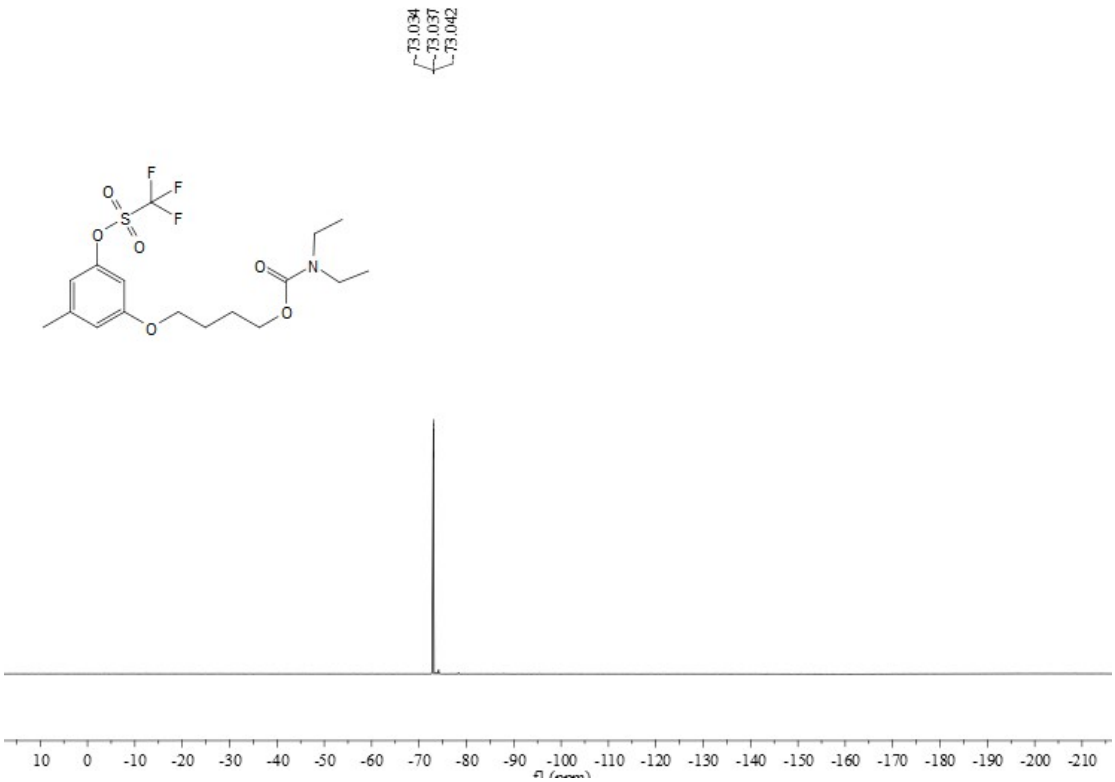

160.165
155.731
150.148
128.608
123.475
120.286
117.097
114.549
113.097
107.909
77.317
77.000
76.682
67.851
64.313
50.593
25.619
22.393
210
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0
-10



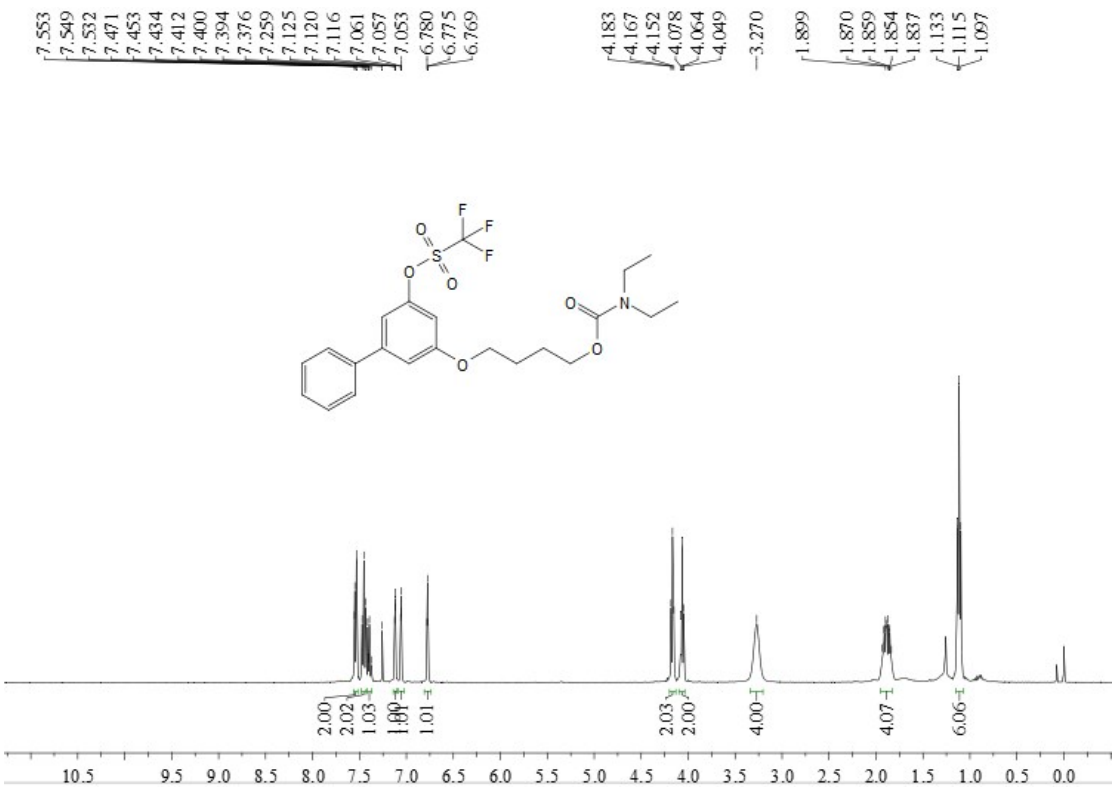
3-(4-((Diethylcarbamoyl)oxy)butoxy)-5-methylphenyl trifluoromethanesulfonate (4p)

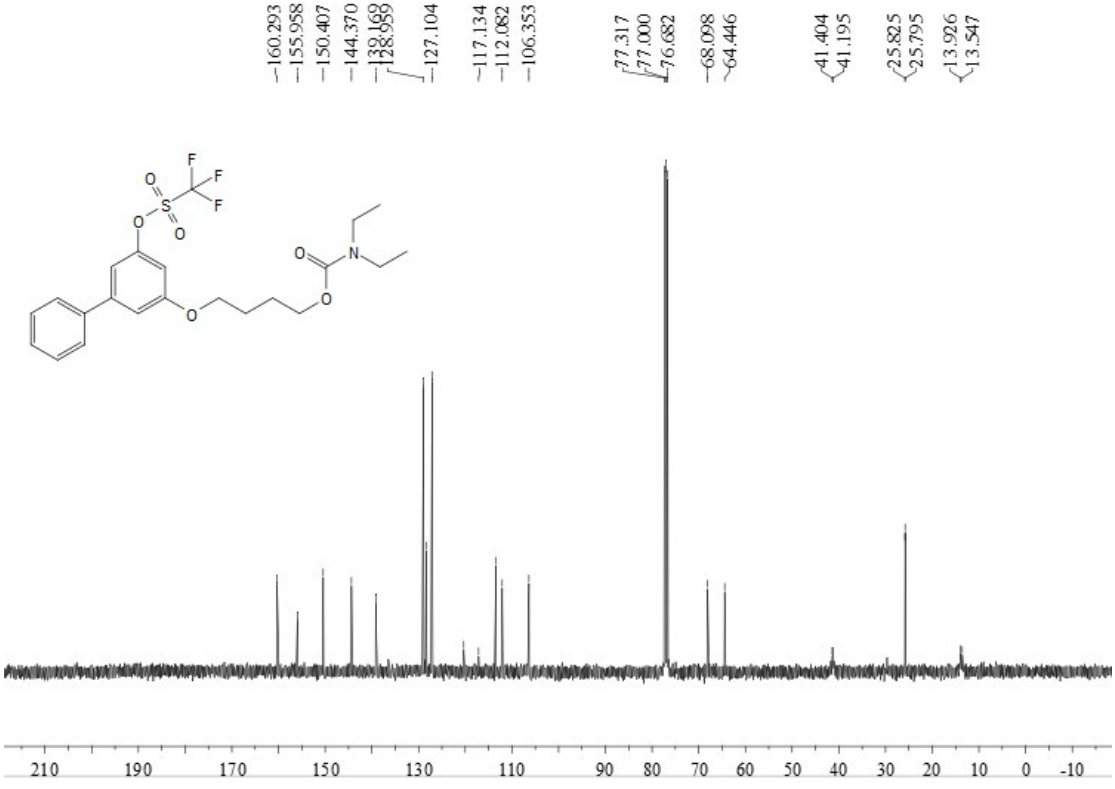

7.193
6.647
6.590
6.525
4.089
4.074
4.059
3.919
3.904
3.889
3.200
2.272
1.793
1.764
1.748
1.731
1.059
1.042
1.024
1.02
0.97
1.00
2.06
2.05
4.09
3.07
4.11
6.02
f1 (ppm)

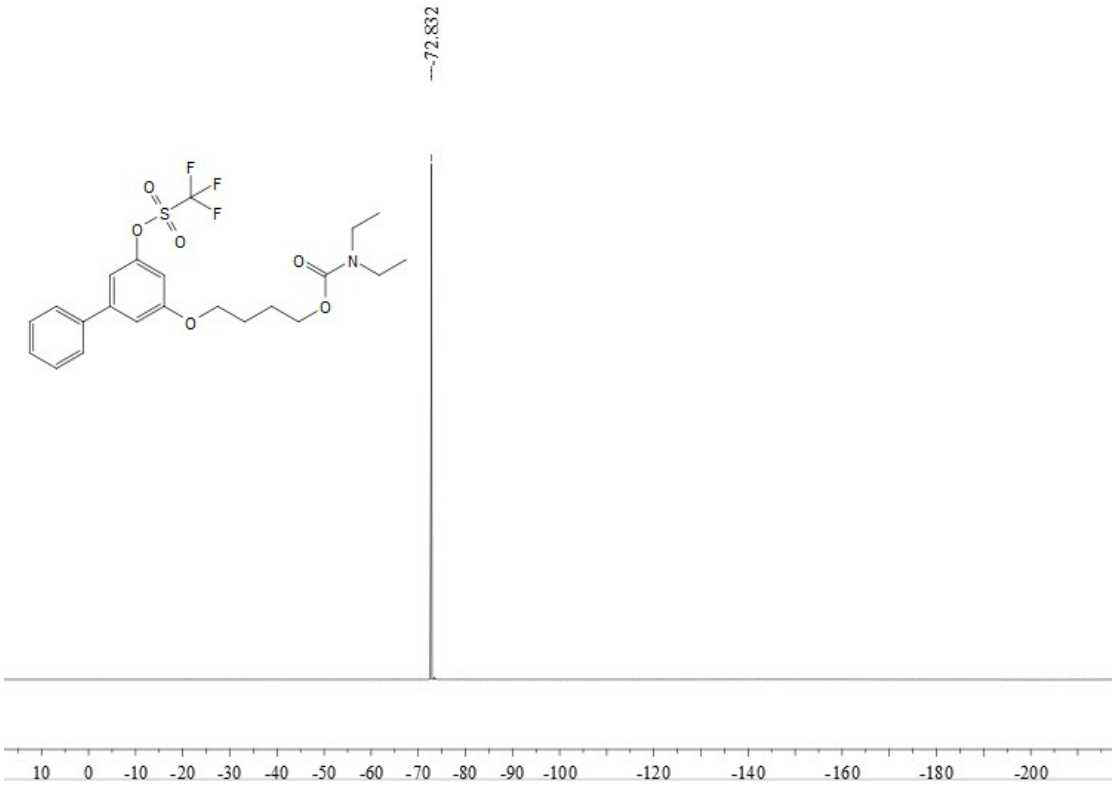

159.901
155.952
149.966
141.310
120.279
117.093
115.286
113.816
104.894
77.317
77.000
76.682
67.847
64.443
41.680
41.153
25.792
25.770
21.500
13.964
13.597
f1 (ppm)



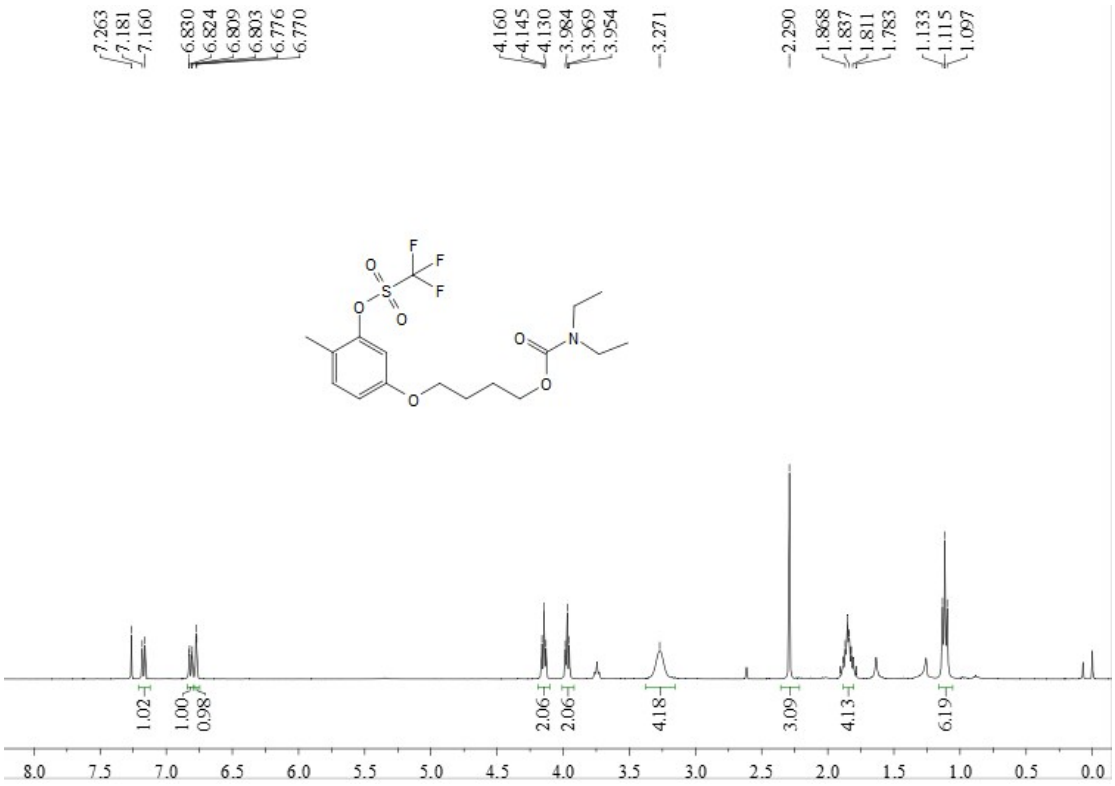
5-(4-((Diethylcarbamoyl)oxy)butoxy)-[1,1'-biphenyl]-3-yl trifluoromethanesulfonate (4q)

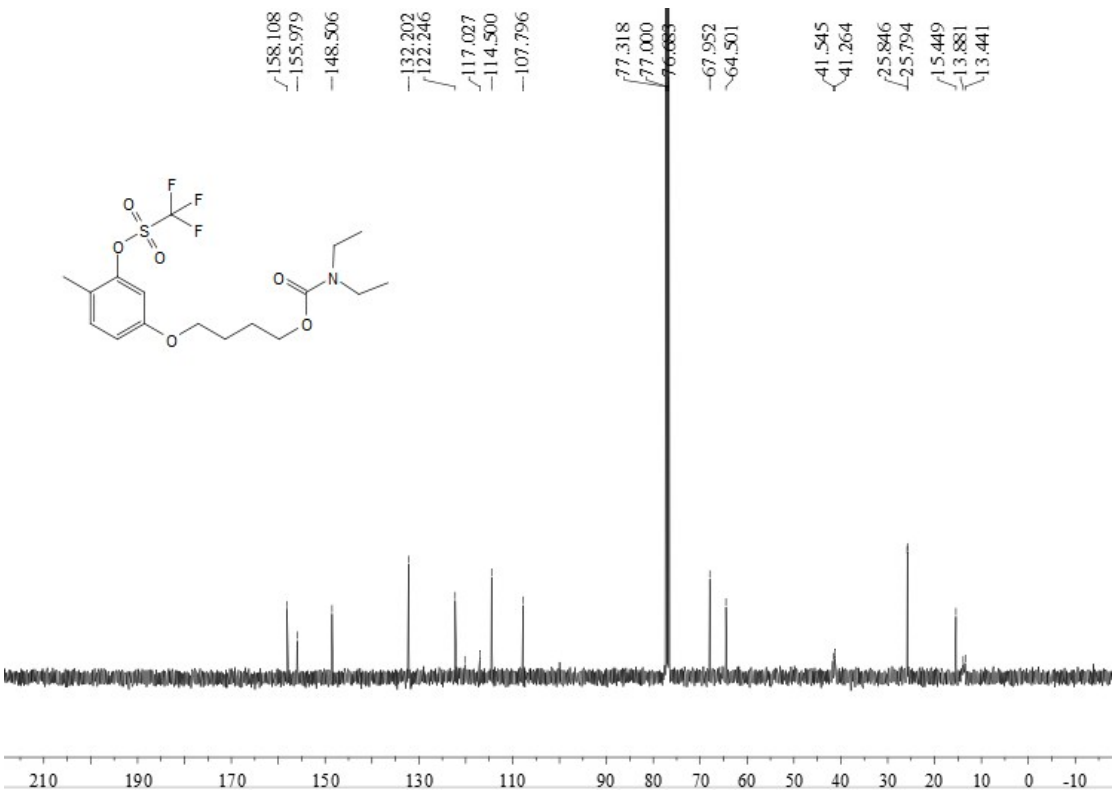

7.553
7.549
7.532
7.471
7.453
7.434
7.412
7.400
7.394
7.376
7.259
7.125
7.120
7.116
7.061
7.057
7.053
6.780
6.775
6.769
4.183
4.167
4.152
4.078
4.064
4.049
3.270
1.899
1.870
1.859
1.854
1.837
1.133
1.115
1.097
2.00
2.02
1.03
2.03
2.00
4.00
4.07
6.06
10.5
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0

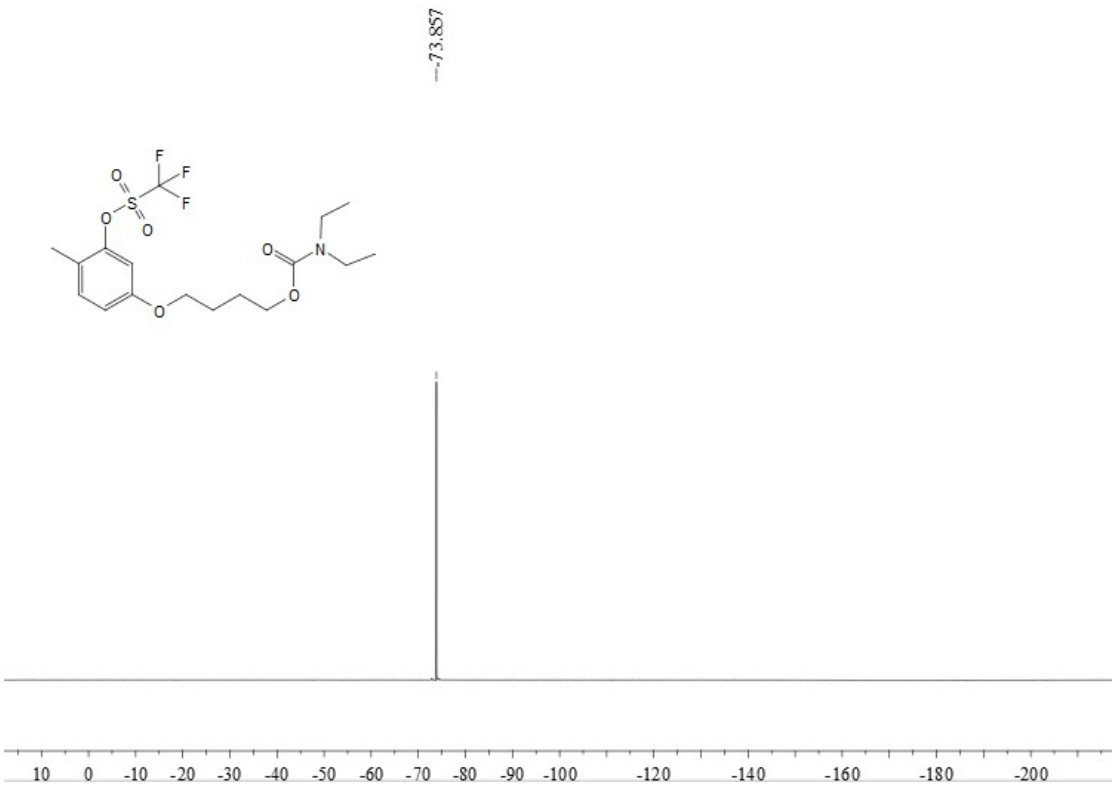

160.293
155.958
150.407
144.370
127.104
117.134
112.082
106.353
77.317
77.000
76.682
68.098
64.446
41.404
41.195
25.825
25.795
13.926
13.547
210
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0
-10



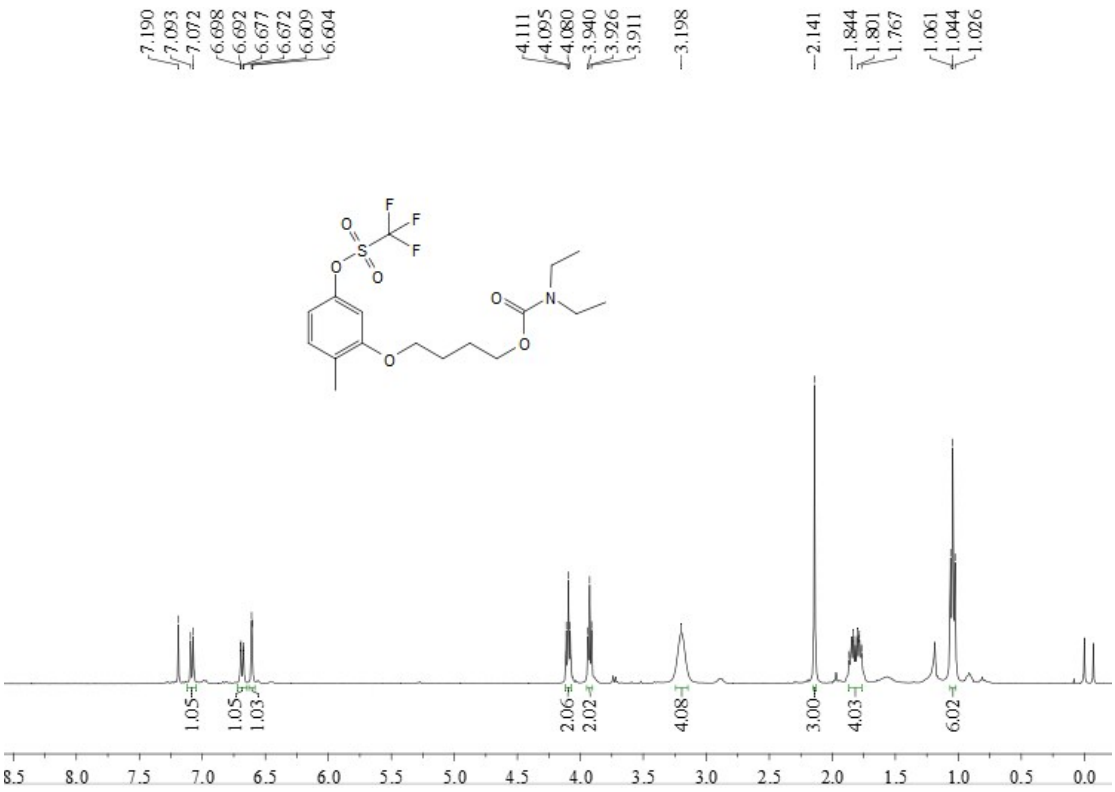
5-(4-((Diethylcarbamoyl)oxy)butoxy)-2-methylphenyl trifluoromethanesulfonate (4r)

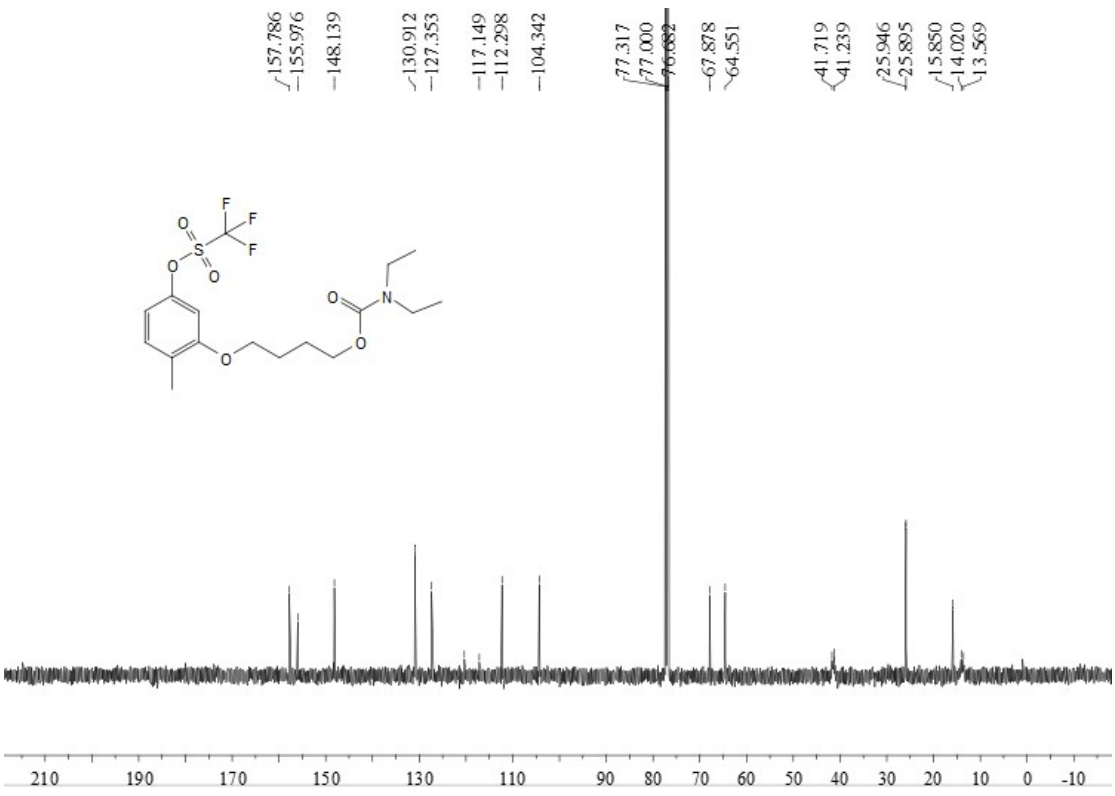

7.263
7.181
7.160
6.830
6.824
6.809
6.803
6.776
6.770
4.160
4.145
4.130
3.984
3.969
3.954
3.271
2.290
1.868
1.837
1.811
1.783
1.133
1.115
1.097
1.02
1.00
0.98
2.06
2.06
4.18
3.09
4.13
6.19
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0

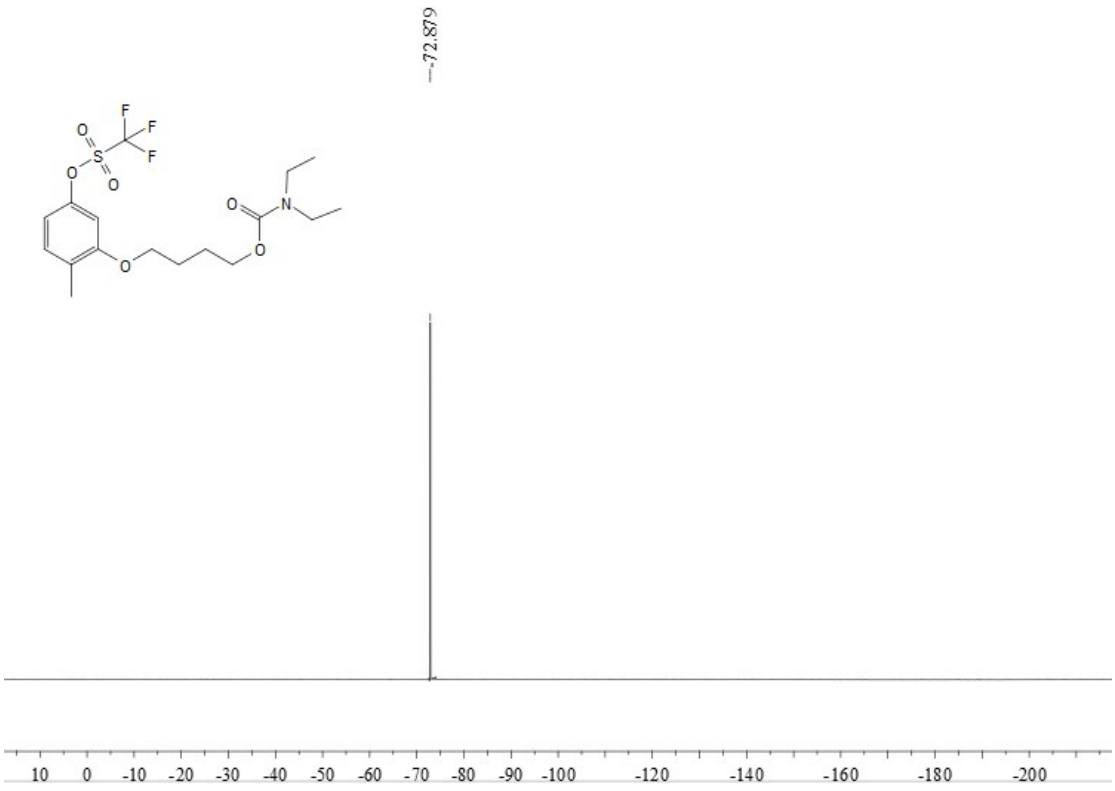

158.108
155.979
148.506
132.202
122.246
117.027
114.500
107.796
77.318
77.000
76.683
67.952
64.501
41.545
41.264
25.846
25.794
15.449
13.881
13.441
210
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0
-10



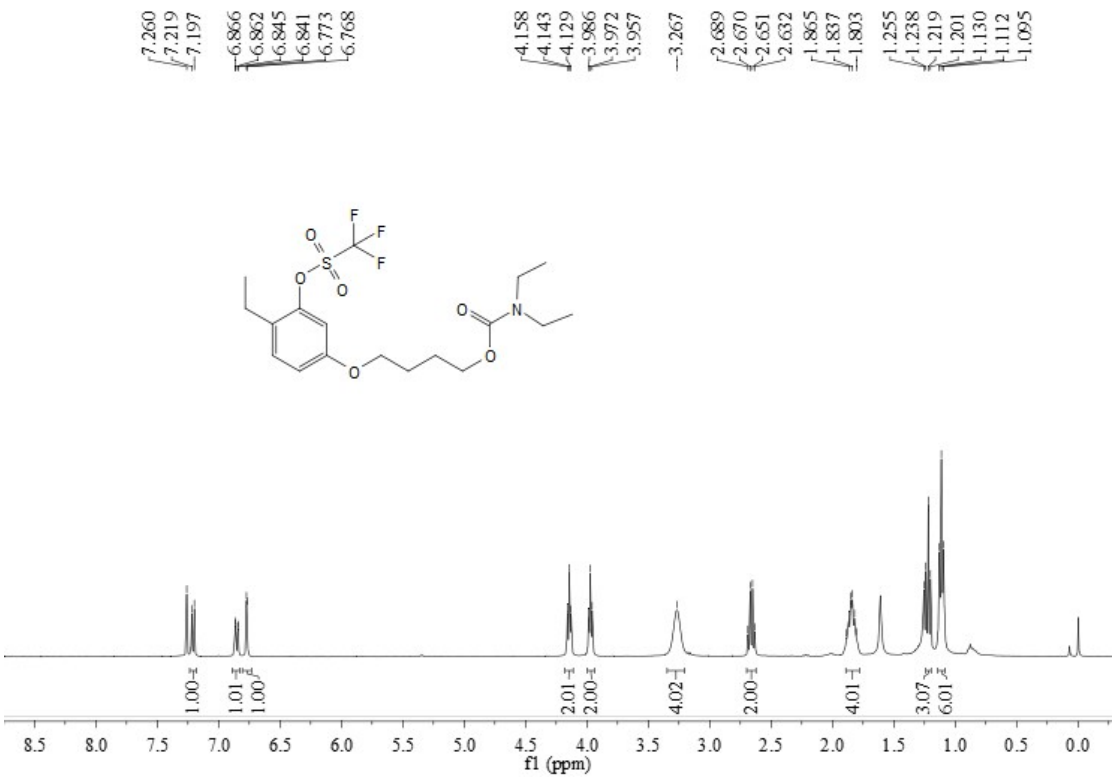
3-(4-((Diethylcarbamoyl)oxy)butoxy)-4-methylphenyl trifluoromethanesulfonate(4r')

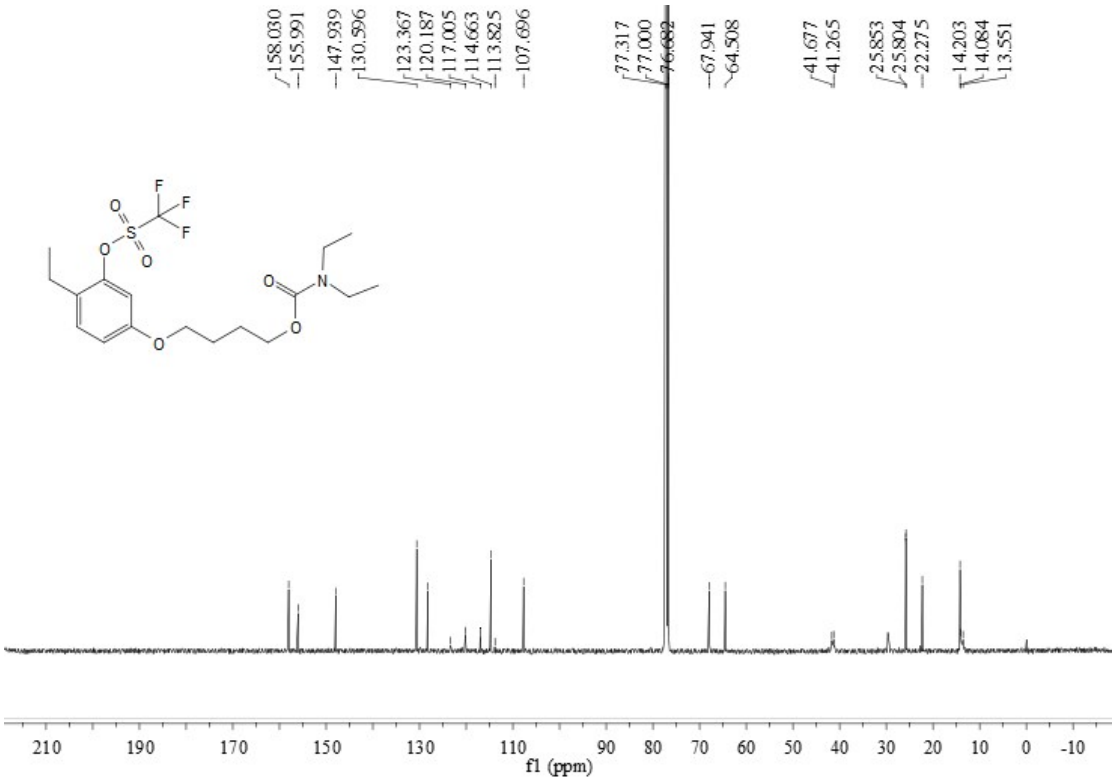

7.190
7.093
7.072
6.698
6.692
6.677
6.672
6.609
6.604
4.111
4.095
4.080
3.940
3.926
3.911
3.198
2.141
1.844
1.801
1.767
1.061
1.044
1.026
1.05
1.05
1.03
2.06
2.02
4.08
3.00
4.03
6.02
8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0

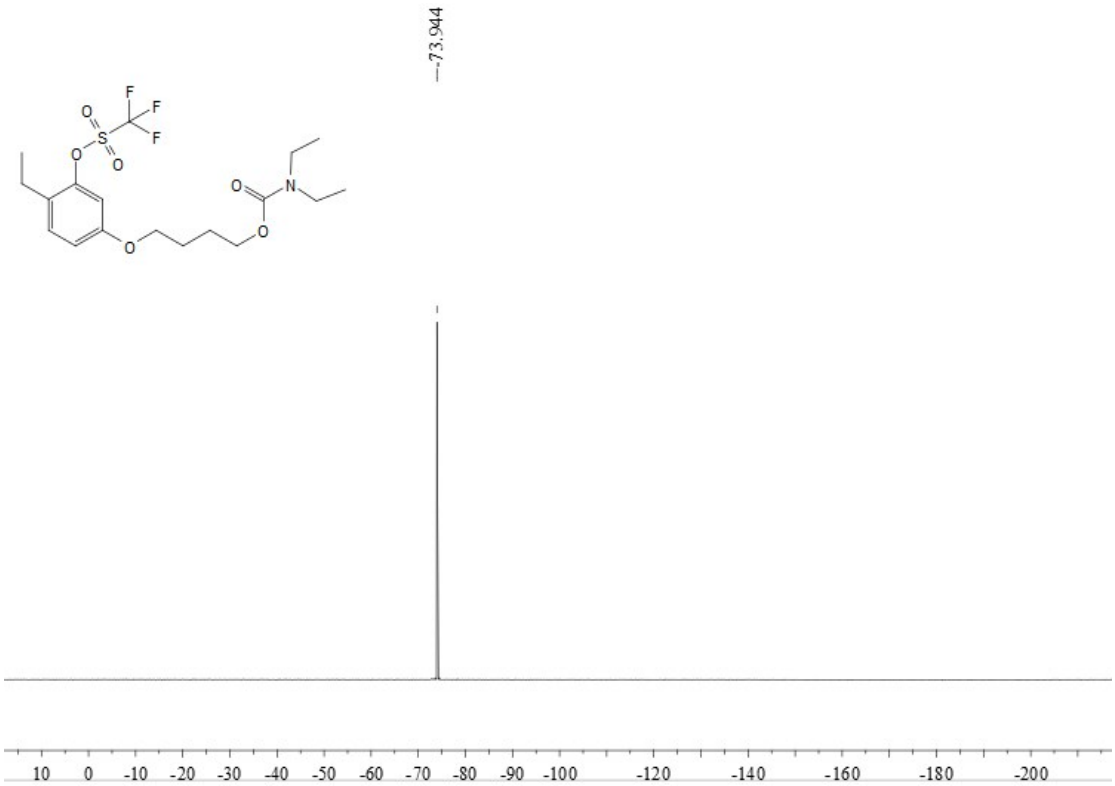

157.786
155.976
148.139
130.912
127.353
117.149
112.298
104.342
77.317
77.000
76.682
67.878
64.551
41.719
41.239
25.946
25.895
15.850
14.020
13.569
210 190 170 150 130 110 90 80 70 60 50 40 30 20 10 0 -10



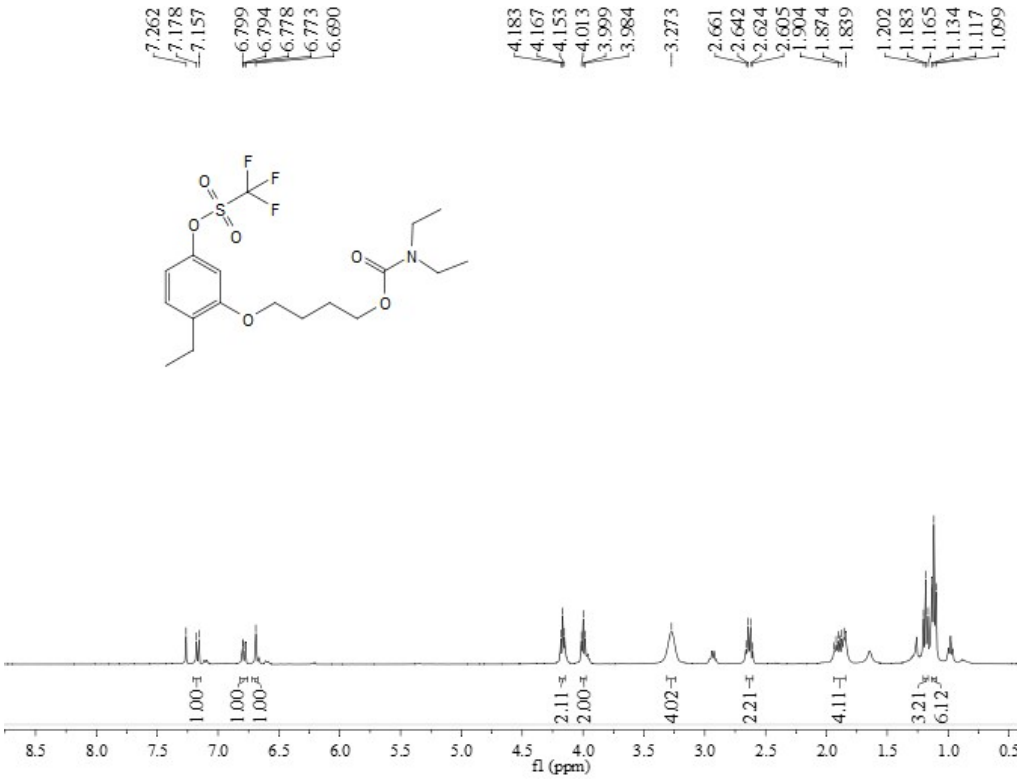
5-(4-((Diethylcarbamoyl)oxy)butoxy)-2-ethylphenyl trifluoromethanesulfonate (4s)

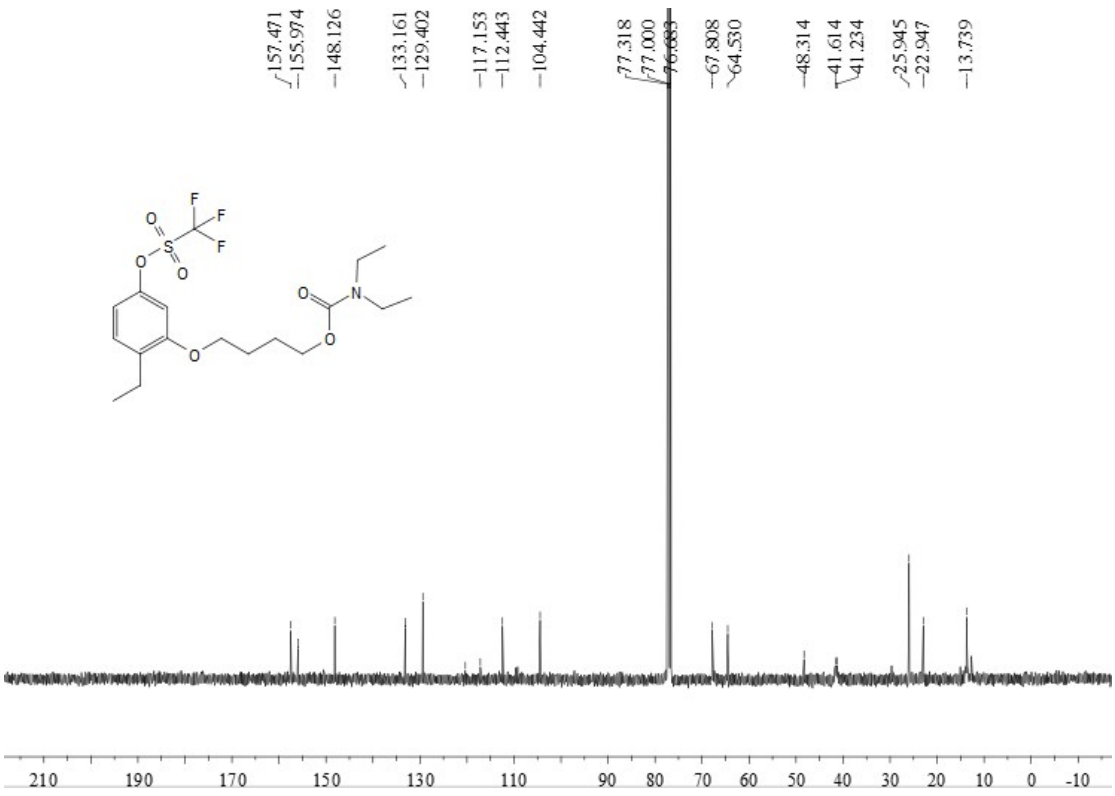

7.260
7.219
7.197
6.866
6.862
6.845
6.841
6.773
6.768
4.158
4.143
4.129
3.986
3.972
3.957
3.267
2.689
2.670
2.651
2.632
1.865
1.837
1.803
1.255
1.238
1.219
1.201
1.130
1.112
1.095
1.00
1.01
1.00
2.01
2.00
4.02
2.00
4.01
3.07
6.01
f1 (ppm)

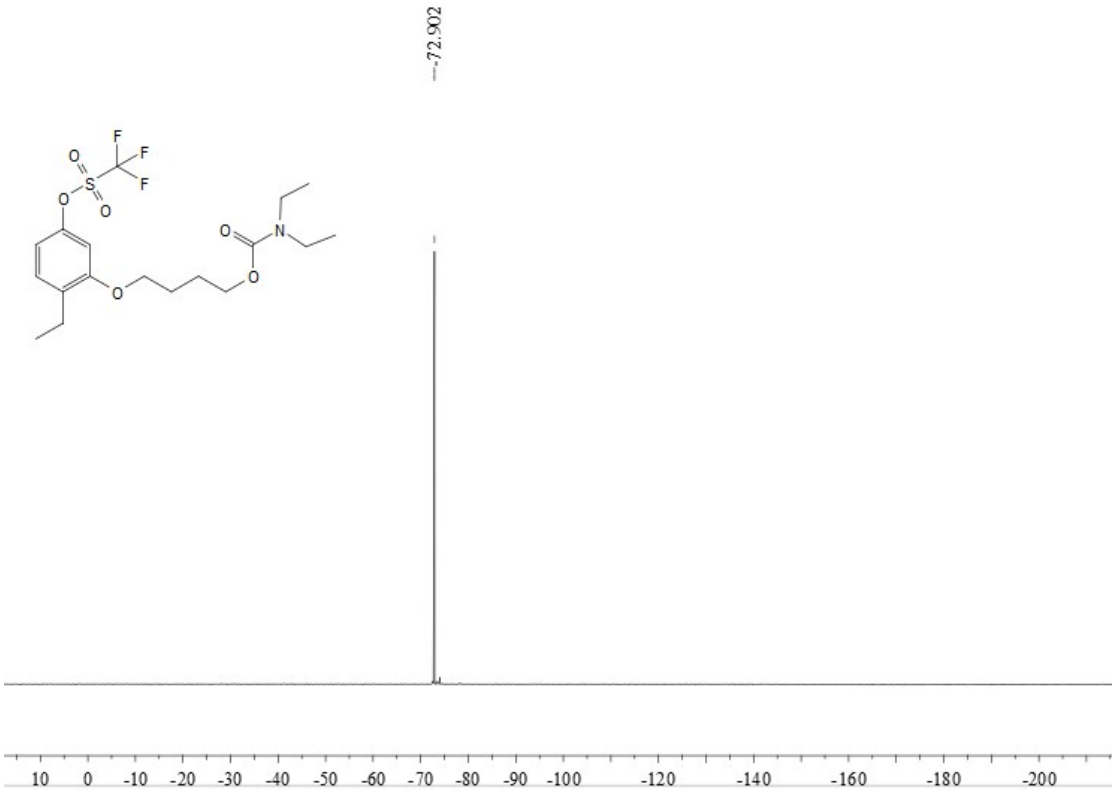

158.030
155.991
147.939
130.596
123.367
120.187
117.005
114.663
113.825
107.696
77.317
77.000
76.683
67.941
64.508
41.677
41.265
25.853
25.804
22.275
14.203
14.084
13.551
f1 (ppm)



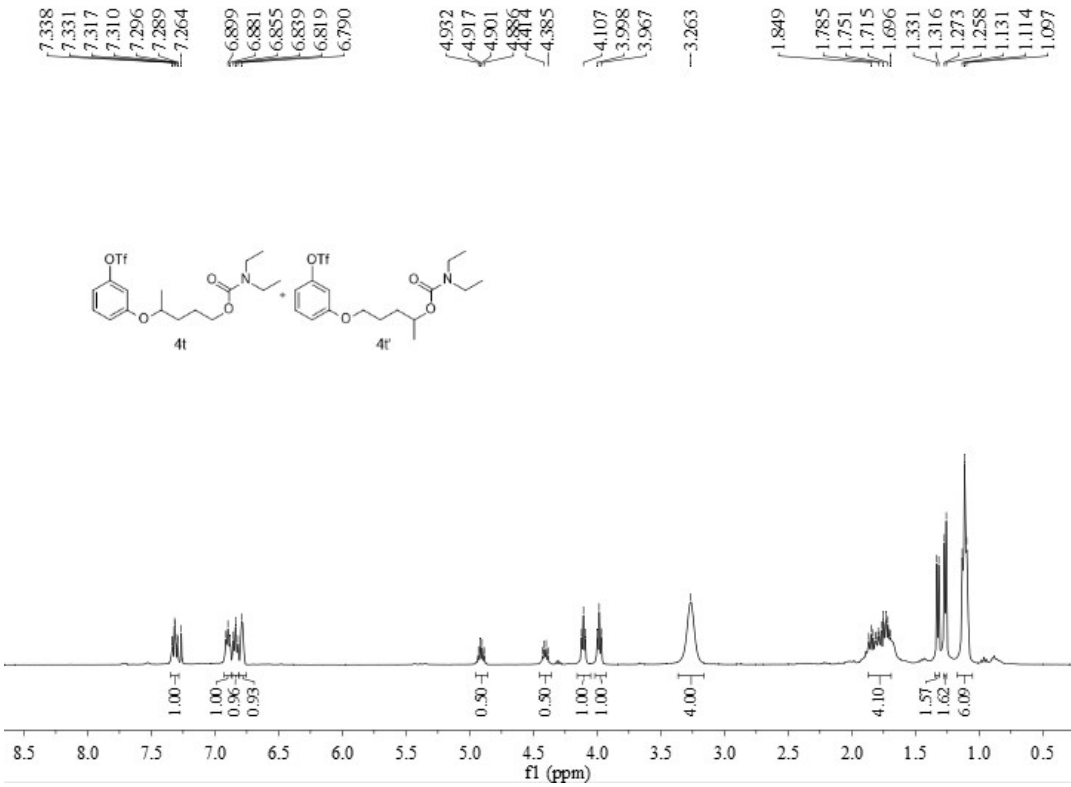
3-(4-((Diethylcarbamoyl)oxy)butoxy)-4-ethylphenyl trifluoromethanesulfonate (4s')

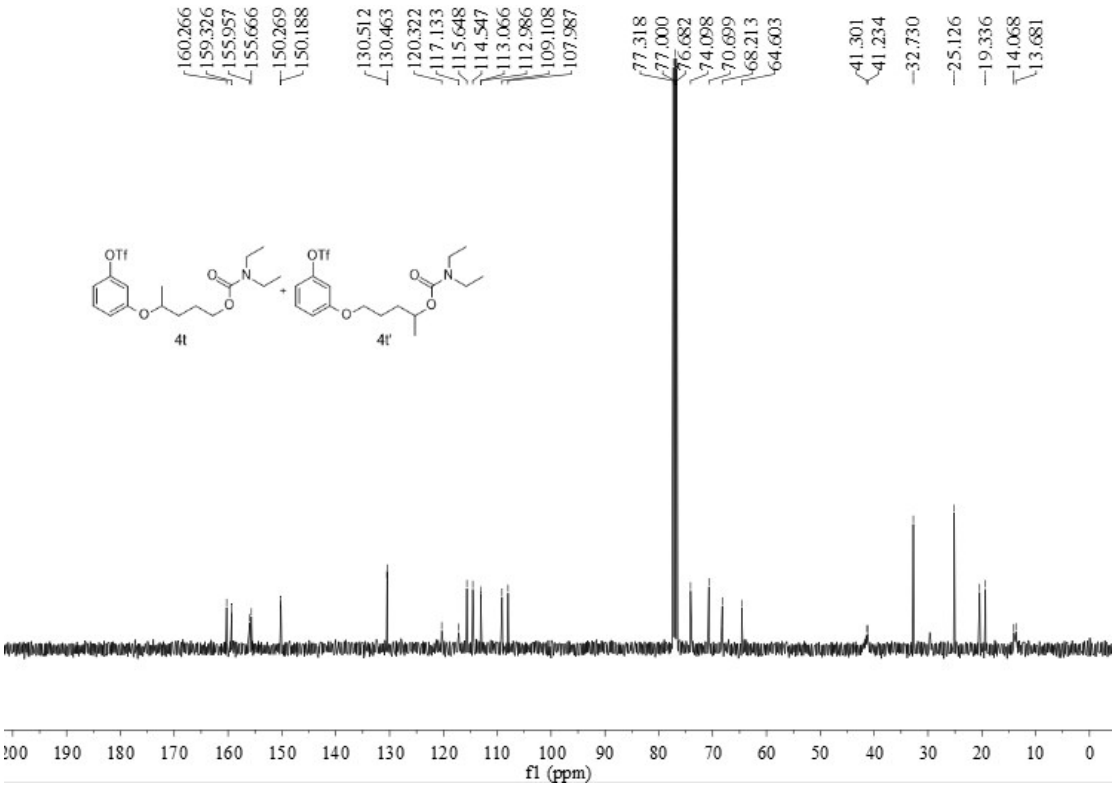

7.262
7.178
7.157
6.799
6.794
6.778
6.773
6.690
4.183
4.167
4.153
4.013
3.999
3.984
3.273
2.661
2.642
2.624
2.605
1.904
1.874
1.839
1.202
1.183
1.165
1.134
1.117
1.099
F
F
F
O
S
O
O
O
N
O
O
1.00
1.00
1.00
2.11
2.00
4.02
2.21
4.11
3.21
6.12
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

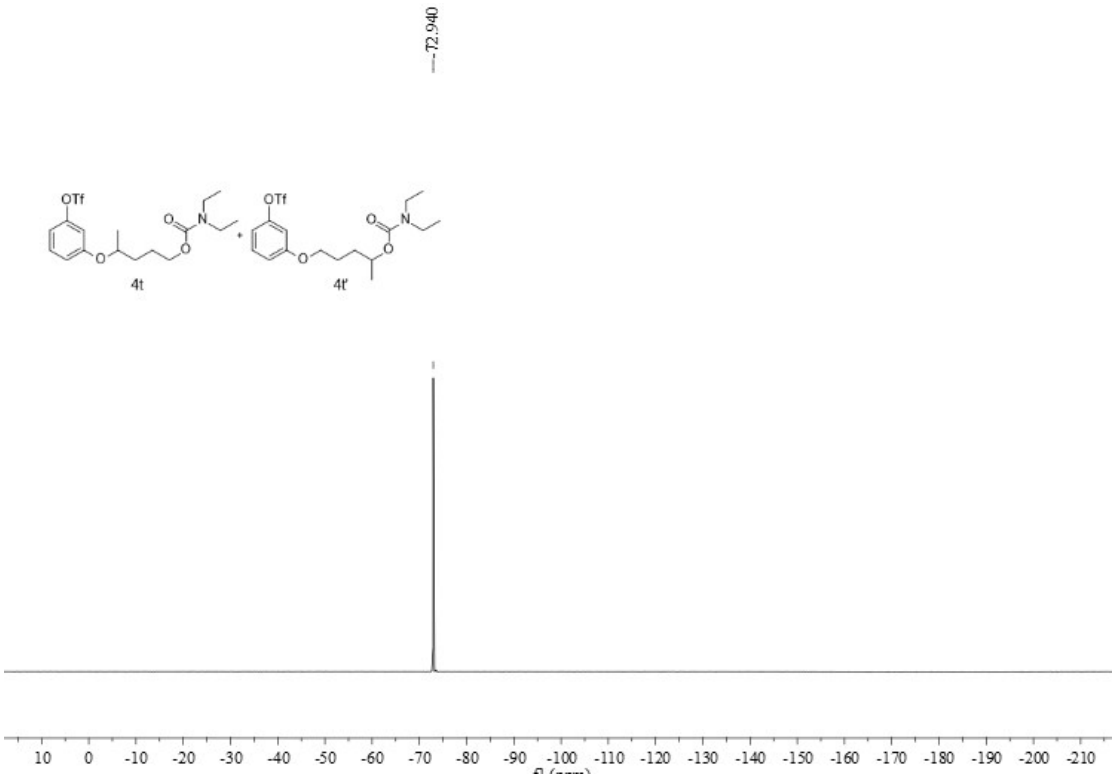

157.471
155.974
148.126
133.161
129.402
117.153
112.443
104.442
77.318
77.000
76.683
67.808
64.530
48.314
41.614
41.234
25.945
22.947
13.739
F
F
F
O
S
O
O
O
N
O
O
210
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0
-10



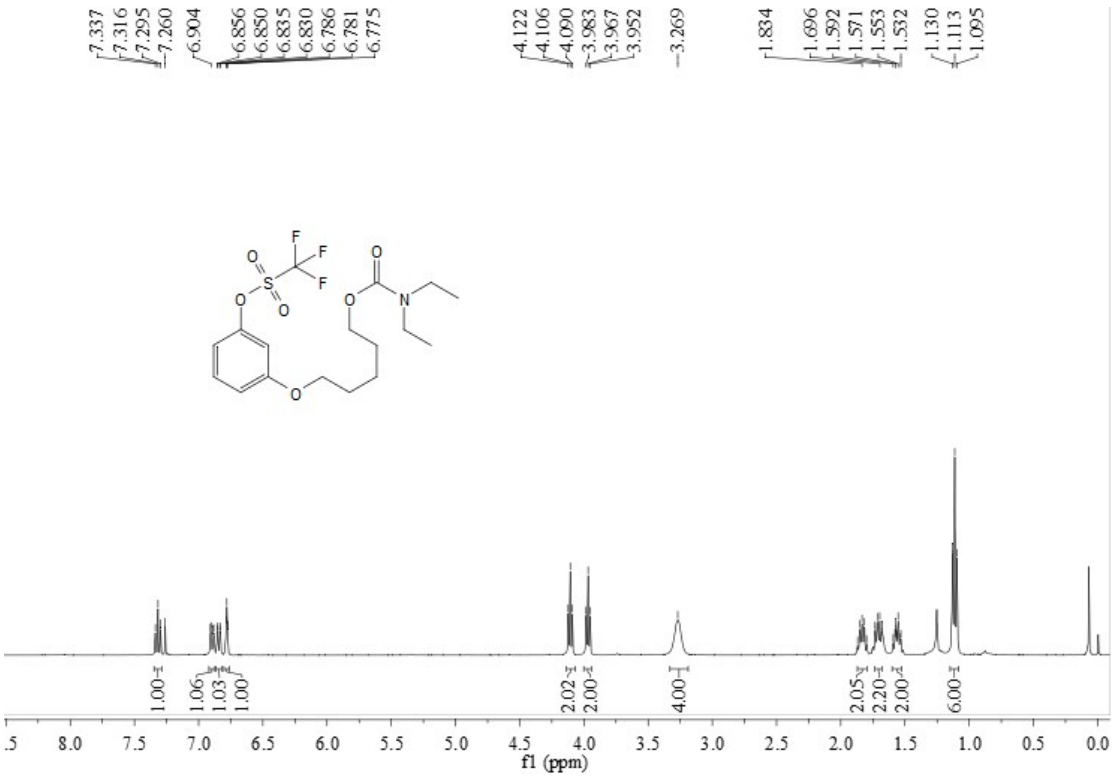
The mixture of 3-((5-((Diethylcarbamoyl)oxy)pentan-2-yl)oxy)phenyl trifluoromethanesulfonate (4t) and 3-((4-((Diethylcarbamoyl)oxy)pentyl)oxy)phenyl trifluoromethanesulfonate (4t')

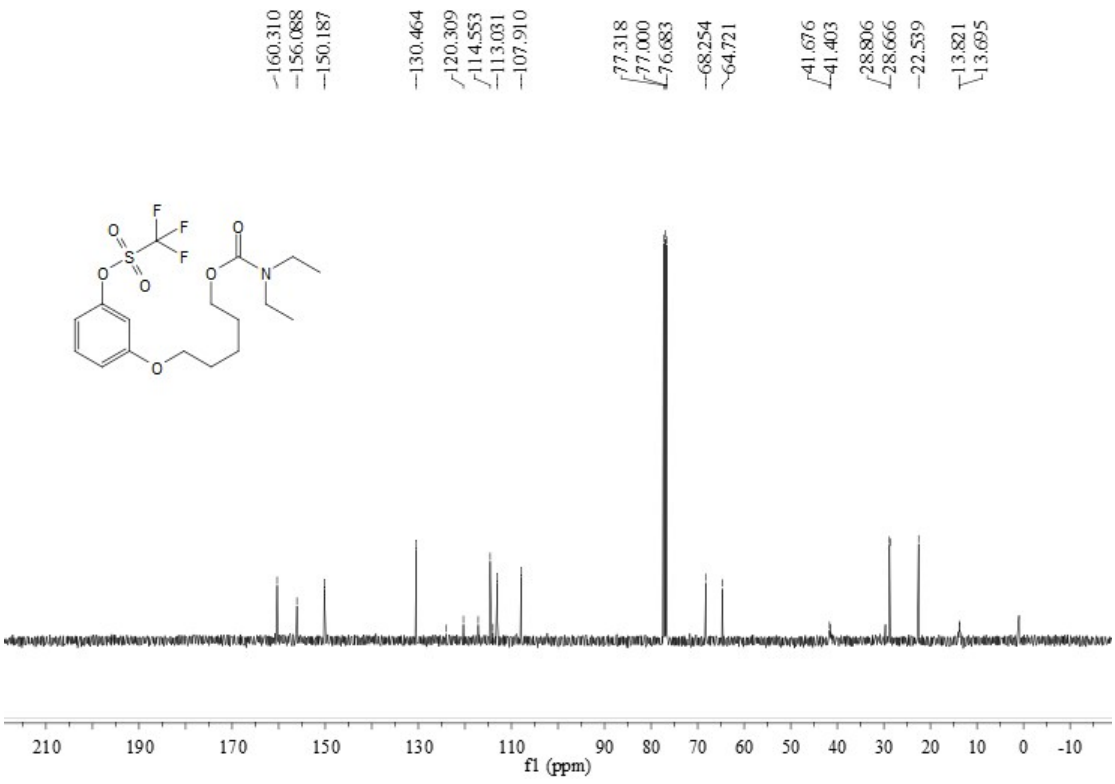

7.338
7.331
7.317
7.310
7.296
7.289
7.264
6.899
6.881
6.855
6.839
6.819
6.790
4.932
4.917
4.901
4.886
4.414
4.385
4.107
3.998
3.967
3.263
1.849
1.785
1.751
1.715
1.696
1.331
1.316
1.273
1.258
1.131
1.114
1.097
OTf
4t
4t'
1.00
1.00
0.96
0.93
0.50
0.50
1.00
1.00
4.00
4.10
1.57
1.62
6.09
f1 (ppm)

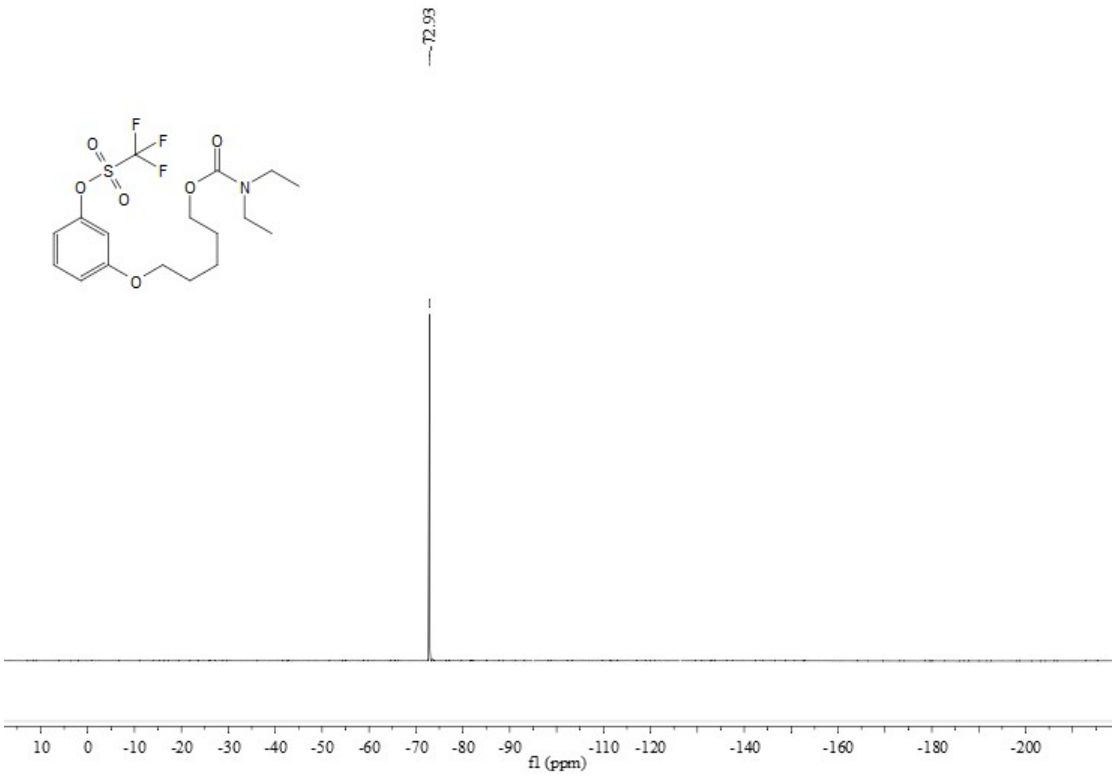

160.266
159.326
155.957
155.666
150.269
150.188
130.512
130.463
120.322
117.133
115.648
114.547
113.066
112.986
109.108
107.987
77.318
77.000
76.682
74.098
70.699
68.213
64.603
41.301
41.234
32.730
25.126
19.336
14.068
13.681
OTf
4t
4t'
f1 (ppm)



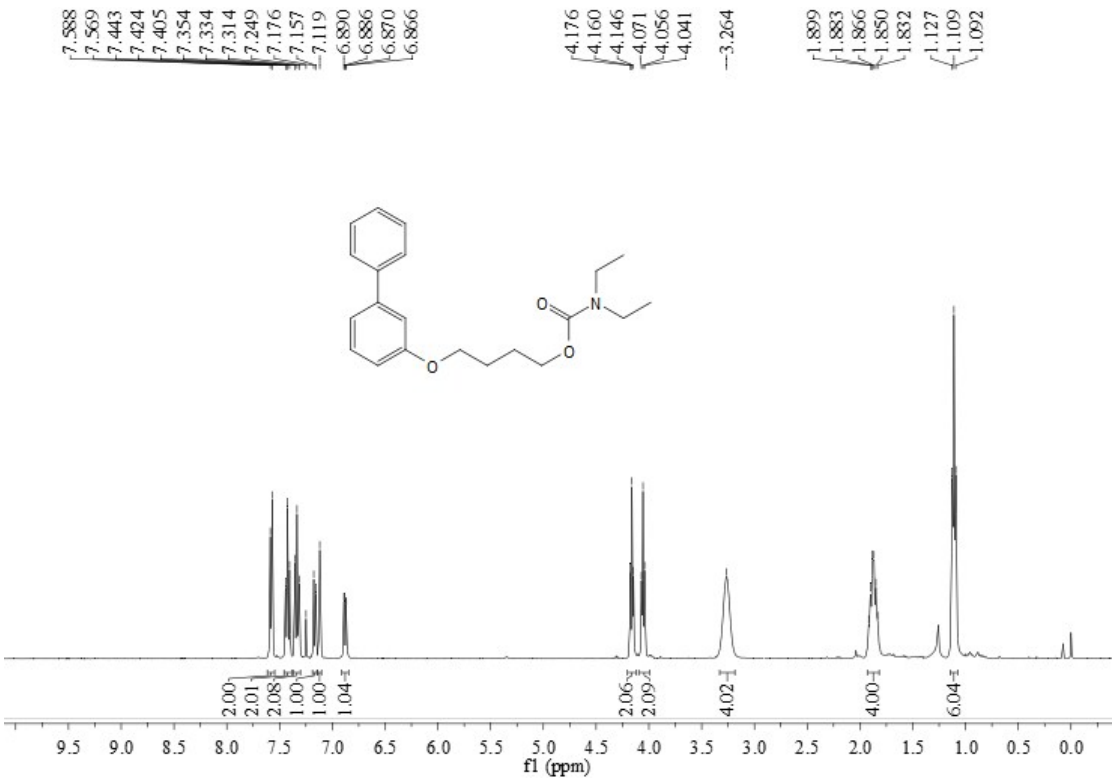
3-((5-((Diethylcarbamoyl)oxy)pentyl)oxy)phenyl trifluoromethanesulfonate (4u)

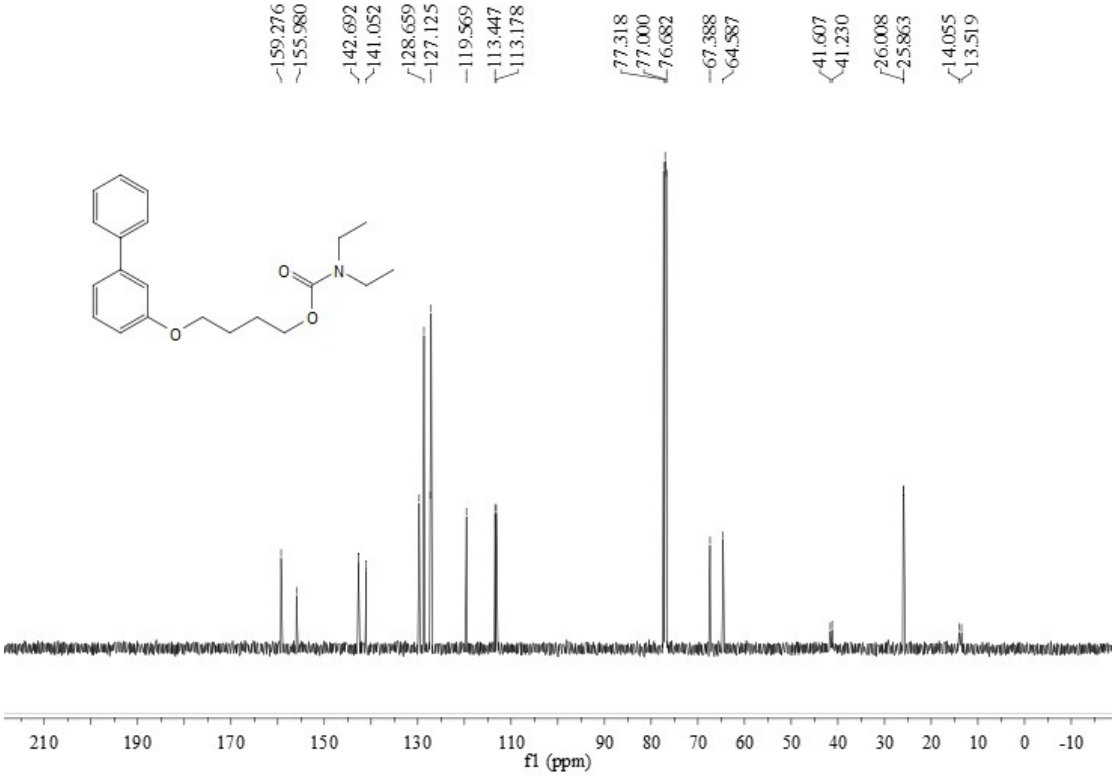

7.337
7.316
7.295
7.260
6.904
6.856
6.850
6.835
6.830
6.786
6.781
6.775
4.122
4.106
4.090
3.983
3.967
3.952
3.269
1.834
1.696
1.592
1.571
1.553
1.532
1.130
1.113
1.095
F
F
F
O
S
O
O
O
O
N
O
1.00
1.06
1.03
1.00
2.02
2.00
4.00
2.05
2.20
2.00
6.00
f1 (ppm)


160.310
156.088
150.187
130.464
120.309
114.553
113.031
107.910
77.318
77.000
76.683
68.254
64.721
41.676
41.403
28.806
28.666
22.539
13.821
13.695
F
F
F
O
S
O
O
O
O
N
f1 (ppm)

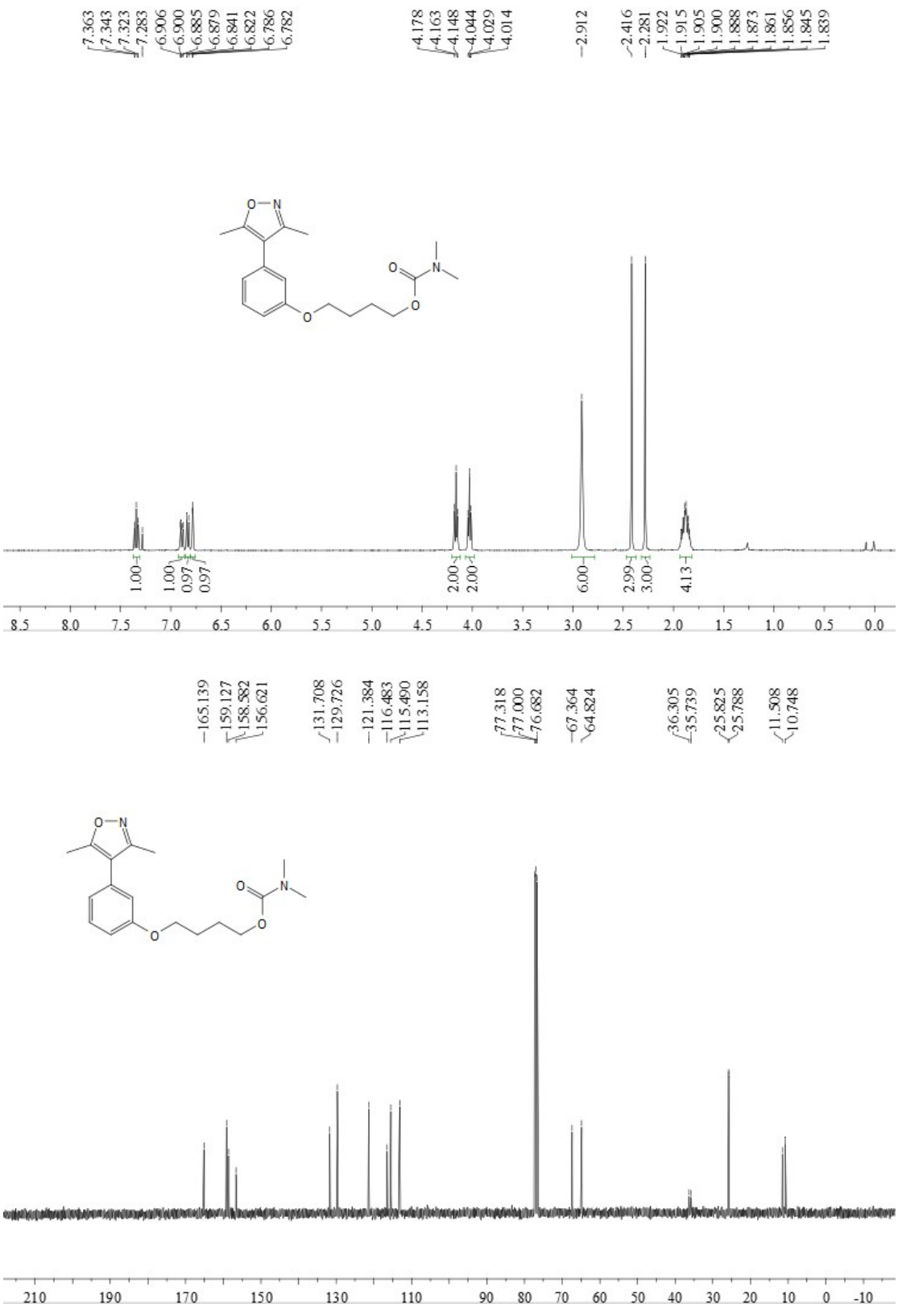


4-([1,1'-Biphenyl]-3-yloxy)butyl diethylcarbamate (5)

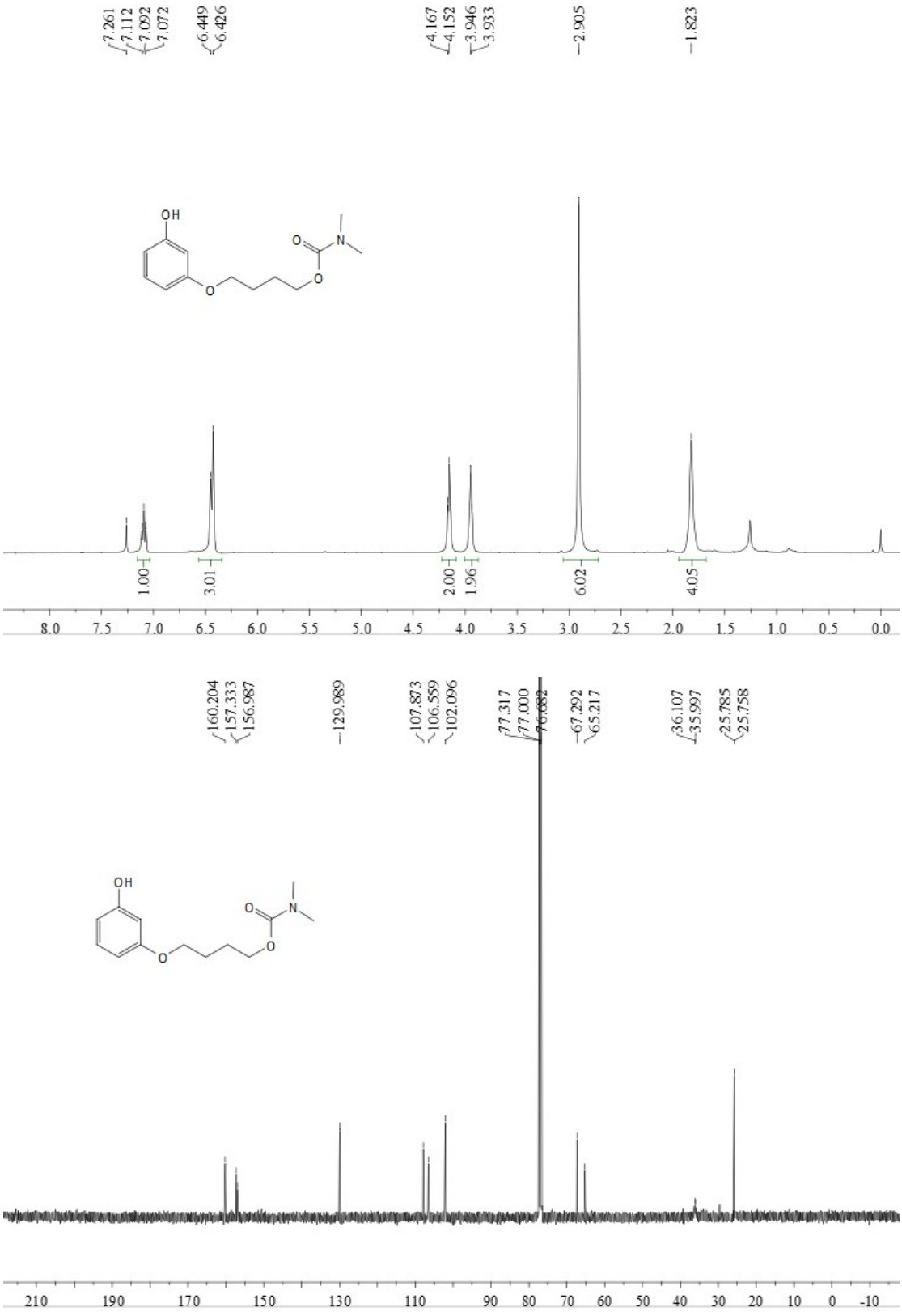




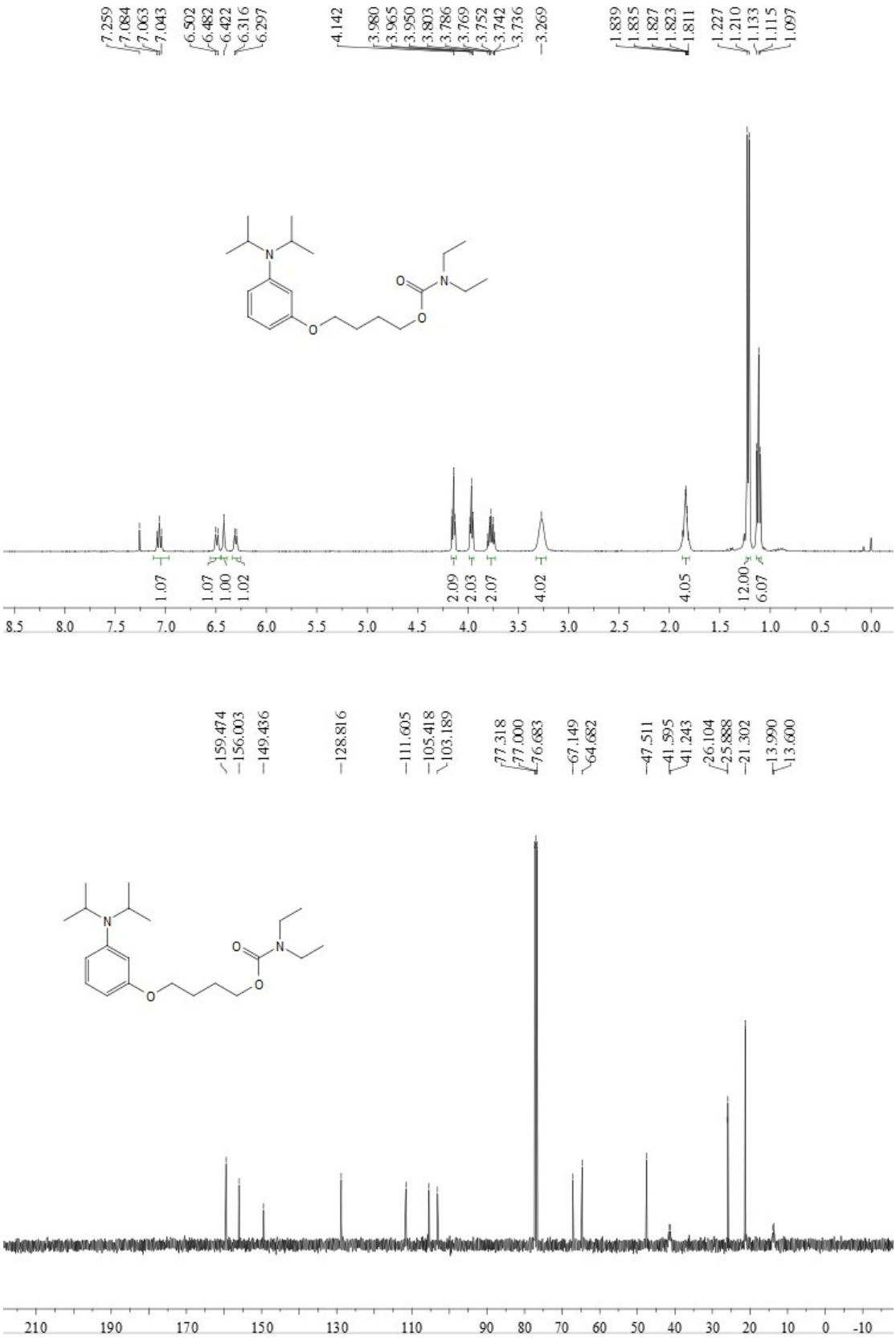
4-(3-(3,5-Dimethylisoxazol-4-yl)phenoxy)butyl dimethylcarbamate (6)



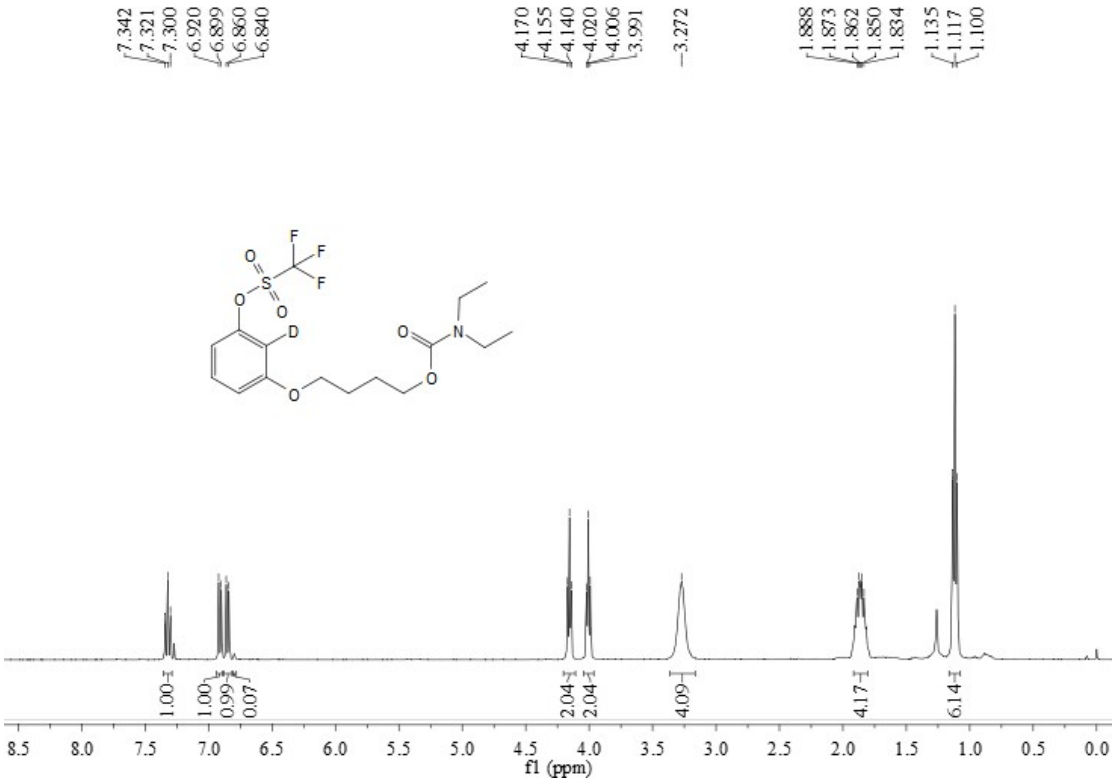
4-(3-Hydroxyphenoxy)butyl dimethylcarbamate (7)

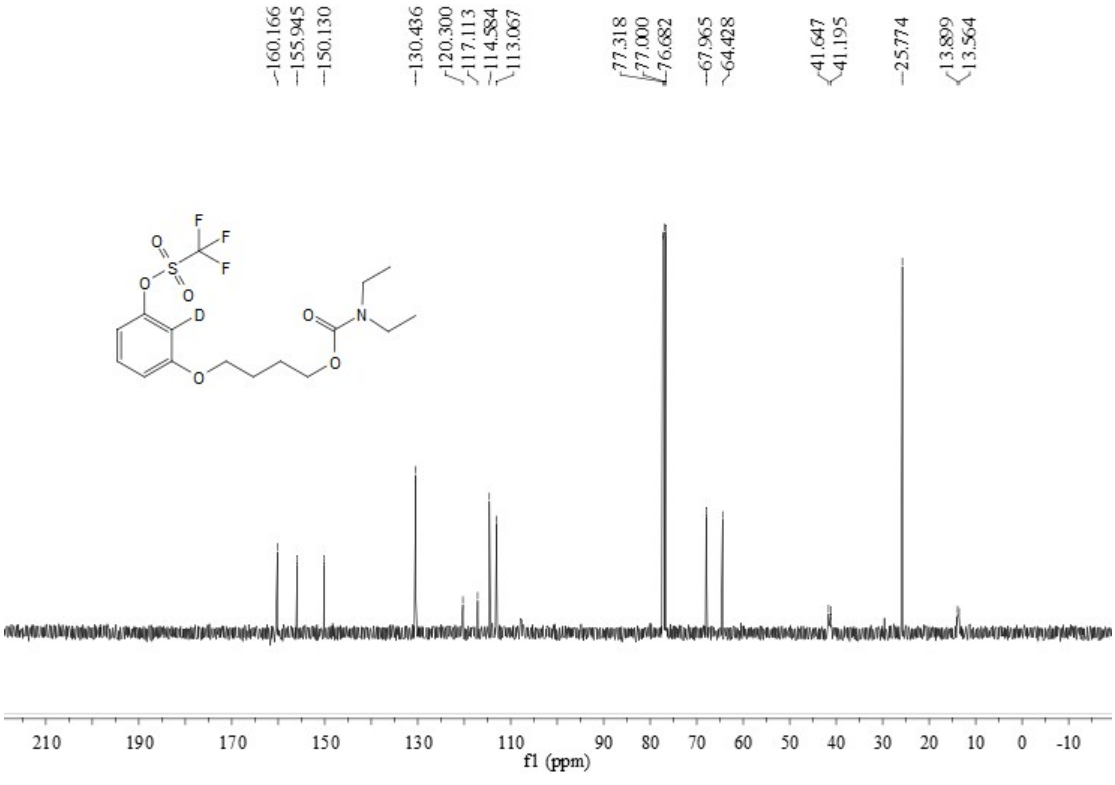


4-(3-(Diisopropylamino)phenoxy)butyl diethylcarbamate (8)



2-D-3-(4-((Diethylcarbamoyl)oxy)butoxy)phenyl trifluoromethanesulfonate (4c-D)


7.342
7.321
7.300
6.920
6.899
6.860
6.840
4.170
4.155
4.140
4.020
4.006
3.991
3.272
1.888
1.873
1.862
1.850
1.834
1.135
1.117
1.100
F
F
F
O
S
O
O
D
O
N
O
O
1.00
1.00
0.99
0.07
2.04
2.04
4.09
4.17
6.14
f1 (ppm)


160.166
155.945
150.130
130.436
120.300
117.113
114.884
113.067
77.318
77.000
76.682
67.965
64.428
41.647
41.195
25.774
13.899
13.564
F
F
F
O
S
O
O
D
O
N
O
O
f1 (ppm)


-72.96
F
F
F
O
S
O
O
D
O
N
O
O
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-110
-120
-140
-160
-180
-200
f1 (ppm)